ELECTRONING SUPPORTING INFORMATION

Novel regioselective synthesis of 1,3,4,5-tetrasubstituted pyrazoles and biochemical valuation on F_1F_O-ATPase and mitochondrial permeability transition pore formation

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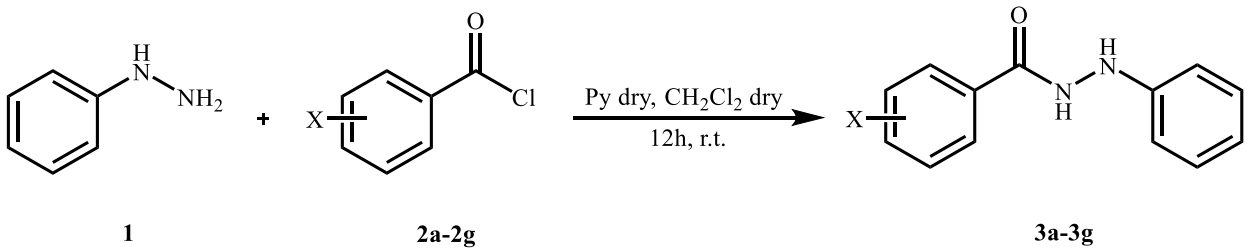
General procedure for synthesis of benzoyl phenylhydrazines

In according to the reaction described in **Scheme S1,** benzoyl phenylhydrazines were synthesized through a modified procedure reported in literature [1].



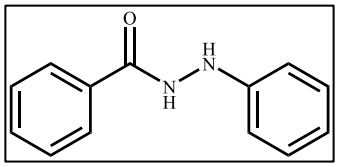
1 **2a-2g** **3a-3g**

Entry	X	Reagent	Product
1	H	**2a**	**3a**
2	4-OCH_3	**2b**	**3b**
3	4-CH_3	**2c**	**3c**
4	4-NO_2	**2d**	**3d**
5	2-Cl	**2e**	**3e**
6	3-Cl	**2f**	**3f**
7	4-Cl	**2g**	**3g**

Scheme S1. *Synthesis of variously substituted benzoyl phenylhydrazines **3a-3g**.*

In a 500 ml three-necked round-bottomed flask, equipped with dropping funnel and magnetic stir bar, freshly distilled phenylhydrazine **1** (16.485 g, 0.1524 mol, 1 eq) was dissolved under nitrogen in dry CH_2Cl_2 (100 ml) and fresh distilled dry pyridine (1.1 eq) was added dropwise at 0 °C for 30 min under vigorously stirring. Subsequently, temperature is kept at 0 °C and a solution of benzoyl chloride **2a-2g** (1.1 eq) in dry CH_2Cl_2 (60 ml) was added dropwise for 3h. The reaction was gently warmed to room temperature and stirred for 16h. The mixture was extracted with CH_2Cl_2 (3 x 100 ml) after addition of water (250 ml) and the combined organic layers were further washed with brine (3 x 30 ml), dried over anhydrous Na_2SO_4 and the solvent was removed under reduced pressure. The crude solid was then purified by recrystallization with EtOH.

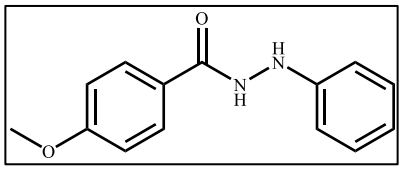
***N*'-phenylbenzohydrazide (3a).** White solid. Yield 88%.



^{1}H NMR (DMSO-d_6, 300 MHz): δ (ppm) 6.67-6.76 (m, 1H, Ar), 6.76-6.88 (m, 2H, Ar), 7.10-7.22 (m, 2H, Ar), 7.43-7.64 (m, 3H, Ar), 7.84-8.06 (m, 3H, Ar and NH), 10.39 (s, 1H, NH).

^{13}C NMR (DMSO-d_6, 125 MHz): δ (ppm) 113.12, 119.56, 127.97, 129.22, 129.47, 132.41, 133.59, 150.06, 167.16.

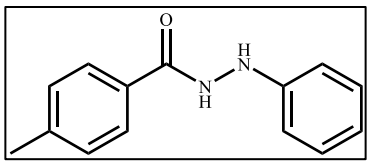
4-methoxy-*N*'-phenylbenzohydrazide (3b). White solid. Yield 80%.



^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 3.82 (s, 3H, CH$_3$), 6.66-6.74 (m, 1H, Ar), 6.74-6.82 (m, 2H, Ar), 6.97-7.08 (m, 2H, Ar), 7.08-7.21 (m, 2H, Ar), 7.86 (d, J= 2.74Hz, 1H, NH), 7.88-7.97 (m, 2H, Ar), 10.24 (d, J= 2.74Hz, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 55.88, 112.82, 114.20, 119.06, 125.65, 129.21, 129.65, 150.20, 162.39, 166.34.

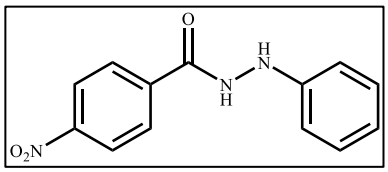
4-methyl-*N*'-phenylbenzohydrazide (3c). White solid. Yield 85%.



^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 2.37 (s, 3H, CH$_3$), 6.67-6.75 (m, 1H, Ar), 6.75-6.84 (m, 2H, Ar), 7.10-7.20 (m, 2H, Ar), 7.24-7.37 (m, 2H, Ar), 7.77-7.86 (m, 2H, Ar), 7.88 (d, J= 2.30Hz, 1H, NH), 10.30 (d, J= 2.30Hz, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 21.78, 113.17, 119.61, 128.09, 129.58, 129.86, 130.87, 142.58, 150.25, 167.35.

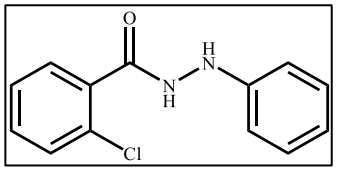
4-nitro-*N*'-phenylbenzohydrazide (3d). Orange solid. Yield 85%.



^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 6.67-6.78 (m, 1H, Ar), 6.78-6.87 (m, 2H, Ar), 7.10-7.24 (m, 2H, Ar), 8.05 (bs, 1H, NH), 8.11-8.21 (m, 2H, Ar), 8.28-8.43 (m, 2H, Ar), 10.70 (s, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 112.88, 119.37, 124.16, 129.29, 129.35, 139.20, 149.57, 149.77, 165.30.

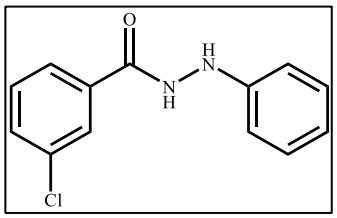
2-chloro-*N*'-phenylbenzohydrazide (3e). White solid. Yield 86%.



^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 3.65 (bs, 1H, NH), 6.67-6.79 (m, 1H, Ar), 6.81-6.91 (m, 2H, Ar), 7.13-7.24 (m, 2H, Ar), 7.39-7.61 (m, 4H, Ar), 10.22 (s, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 112.82, 119.17, 127.75, 129.24, 129.68, 130.26, 130.75, 131.75, 135.76, 149.58, 166.77.

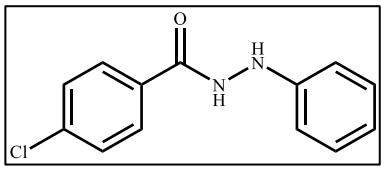
3-chloro-*N*'-phenylbenzohydrazide (3f). White solid. Yield 88%.



^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 6.65-6.77 (m, 1H, Ar), 6.77-6.88 (m, 2H, Ar), 7.09-7.24 (m, 2H, Ar), 7.48-7.61 (m, 1H, Ar), 7.61-7.73 (m, 1H, Ar), 7.83-7.95 (m, 1H, Ar), 7.95-8.06 (m, 1H, Ar), 10.53 (s, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 112.86, 119.26, 126.54, 127.61, 129.25, 131.02, 131.99, 133.84, 135.48, 149.75, 165.47.

4-chloro-*N*'-phenylbenzohydrazide (3g). White solid. Yield 90%.

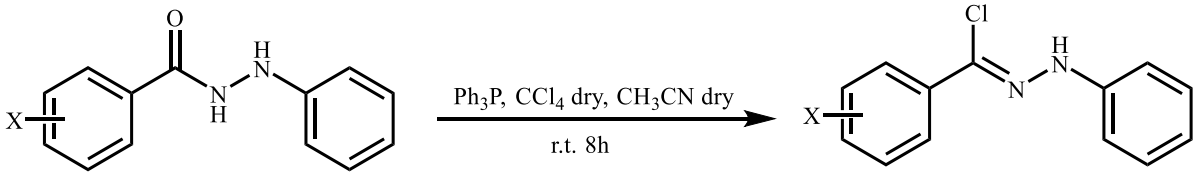


^{1}H NMR (DMSO-d$_6$, 300 MHz): δ (ppm) 6.66-6.76 (m, 1H, Ar), 6.76-6.85 (m, 2H, Ar), 7.10-7.21 (m, 2H, Ar), 7.53-7.65 (m, 2H, Ar), 7.89-8.03 (m, 3H, Ar and NH), 10.47 (s, 1H, NH).

^{13}C NMR (DMSO-d$_6$, 125 MHz): δ (ppm) 112.83, 119.22, 129.08, 129.25, 129.73, 132.25, 136.97, 149.85, 165.84.

General procedure for synthesis of hydrazonyl chlorides

In according to the reaction depicted in **Scheme S2,** hydrazonyl chlorides were synthesized through a modified procedure reported in literature [2].



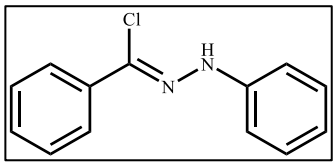
3a-3g **4a-4g**

Entry	R^1	Reagent	Product
1	H	**3a**	**4a**
2	4-OCH_3	**3b**	**4b**
3	4-CH_3	**3c**	**4c**
4	4-NO_2	**3d**	**4d**
5	2-Cl	**3e**	**4e**
6	3-Cl	**3f**	**4f**
7	4-Cl	**3g**	**4g**

Scheme S2. *Synthesis of variously substituted hydrazonyl chlorides* ***4a-4g***.

In 500 ml two-necked round-bottomed flask, equipped with magnetic stir bar, opportune benzoyl phenylhydrazine **3a-3g** (59.7 mmol, 1 eq) was suspended under nitrogen in dry acetonitrile (100 ml). Subsequently, triphenylphosphine (74.6 mmol, 1.25 eq) and dry carbon tetrachloride (89.6 mmol, 1.5 eq) were respectively added. The reaction mixture was stirred at room temperature for 4h. During the reaction course, suspended benzoyl phenylhydrazine completely dissolved and then, the formation of a solid was observed. At the end of the reaction, the solution was cooled in an ice-bath and the solid was recuperate by filtration and washed with small quantity of acetonitrile. The obtained solid was recrystallized with acetonitrile.

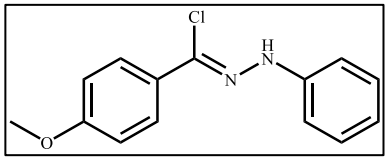
***N*-phenylbenzohydrazonyl chloride (4a).** White solid. Yield 80%.



^{1}H NMR (DMSO-d_6, 300 MHz): δ (ppm) 6.82-6.96 (m, 1H, Ar), 7.23-7.33 (m, 2H, Ar), 7.33-7.41 (m, 2H, Ar), 7.42-7.60 (m, 3H, Ar), 7.83-8.00 (m, 2H, Ar), 9.92 (s, 1H, NH).

^{13}C NMR (DMSO-d_6, 125 MHz): δ (ppm) 114.06, 120.96, 122.73, 126.44, 129.22, 129.59, 129.65, 134.82, 144.61.

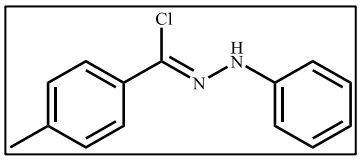
4-methoxy-*N*-phenylbenzohydrazonyl chloride (4b). White solid. Yield 88%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 3.84 (s, 3H, CH_3), 6.86-6.98 (m, 3H, Ar), 7.11-7.20 (m, 2H, Ar), 7.25-7.35 (m, 2H, Ar), 7.80-7.89 (m, 2H, Ar), 7.93 (bs, 1H, NH).

^{13}C NMR ($CDCl_3$, 125 MHz): δ (ppm) 55.36, 113.27, 113.77, 120.83, 124.71, 127.15, 127.88, 129.31, 143.57, 160.54.

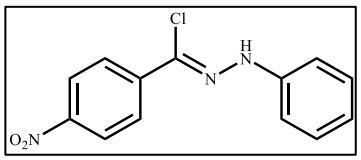
4-methyl-*N*-phenylbenzohydrazonyl chloride (4c). White solid. Yield 84%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 2.38 (s, 3H, CH_3), 6.87-6.98 (m, 1H, Ar), 7.11-7.25 (m, 4H, Ar), 7.25-7.36 (m, 2H, Ar), 7.75-7.87 (m, 2H, Ar), 7.98 (bs, 1H, NH).

^{13}C NMR ($CDCl_3$, 125 MHz): δ (ppm) 21.25, 113.35, 120.98, 124.93, 126.36, 129.09, 129.34, 131.76, 139.38, 143.46.

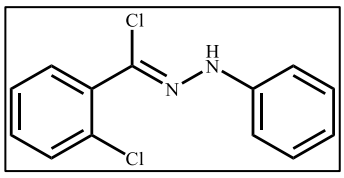
4-nitro-*N*-phenylbenzohydrazonyl chloride (4d). Red solid. Yield 80%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 6.95-7.08 (m, 1H, Ar), 7.16-7.24 (m, 2H, Ar), 7.30-7.41 (m, 2H, Ar), 8.00-8.10 (m, 2H, Ar), 8.19-8.33 (m, 3H, Ar and NH).

^{13}C NMR ($CDCl_3$, 125 MHz): δ (ppm) 113.79, 122.10, 122.22, 123.72, 126.58, 129.51, 140.14, 142.39, 147.60.

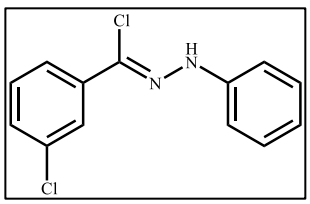
2-chloro-*N*-phenylbenzohydrazonyl chloride (4e). White solid. Yield 78%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 6.88-6.99 (m, 1H, Ar), 7.09-7.19 (m, 2H, Ar), 7.21-7.37 (m, 4H, Ar), 7.40-7.50 (m, 1H, Ar), 7.55-7.64 (m, 1H, Ar), 8.07 (bs, 1H, NH).

^{13}C NMR ($CDCl_3$, 125 MHz): δ (ppm) 113.48, 120.41, 121.35, 126.68, 129.35, 130.24, 130.57, 131.24, 132.91, 134.19, 143.12.

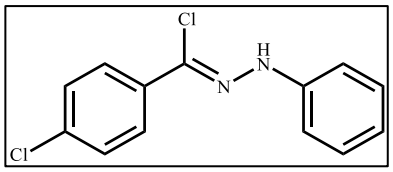
3-chloro-*N*-phenylbenzohydrazonyl chloride (4f). White solid. Yield 83%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 6.90-7.01 (m, 1H, Ar), 7.12-7.21 (m, 2H, Ar), 7.26-7.38 (m, 4H, Ar), 7.74-7.83 (m, 1H, Ar), 7.85-7.94 (m, 1H, Ar), 8.06 (bs, 1H, NH).

^{13}C NMR ($CDCl_3$, 125 MHz): δ (ppm) 113.53, 121.51, 122.97, 124.41, 126.22, 129.03, 129.41, 129.56, 134.52, 136.15, 142.96.

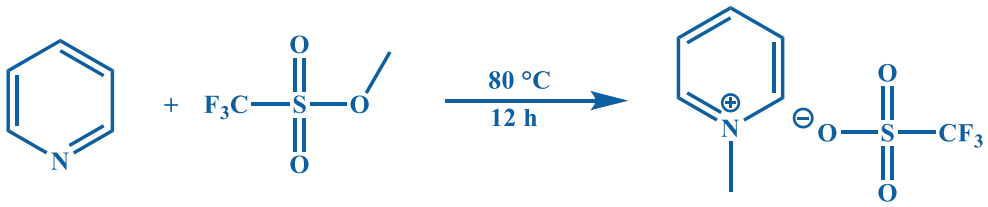
4-chloro-*N*-phenylbenzohydrazonyl chloride (4g). White solid. Yield 84%.



^{1}H NMR ($CDCl_3$, 300 MHz): δ (ppm) 6.90-7.00 (m, 1H, Ar), 7.12-7.21 (m, 2H, Ar), 7.26-7.41 (m, 4H, Ar), 7.79-7.89 (m, 2H, Ar), 8.03 (bs, 1H, NH).

^{13}C-NMR ($CDCl_3$, 125 MHz): δ (ppm) 113.46, 121.38, 123.47, 127.49, 128.59, 129.39, 132.94, 135.10, 143.09.

General procedure for synthesis of [mPy]OTf

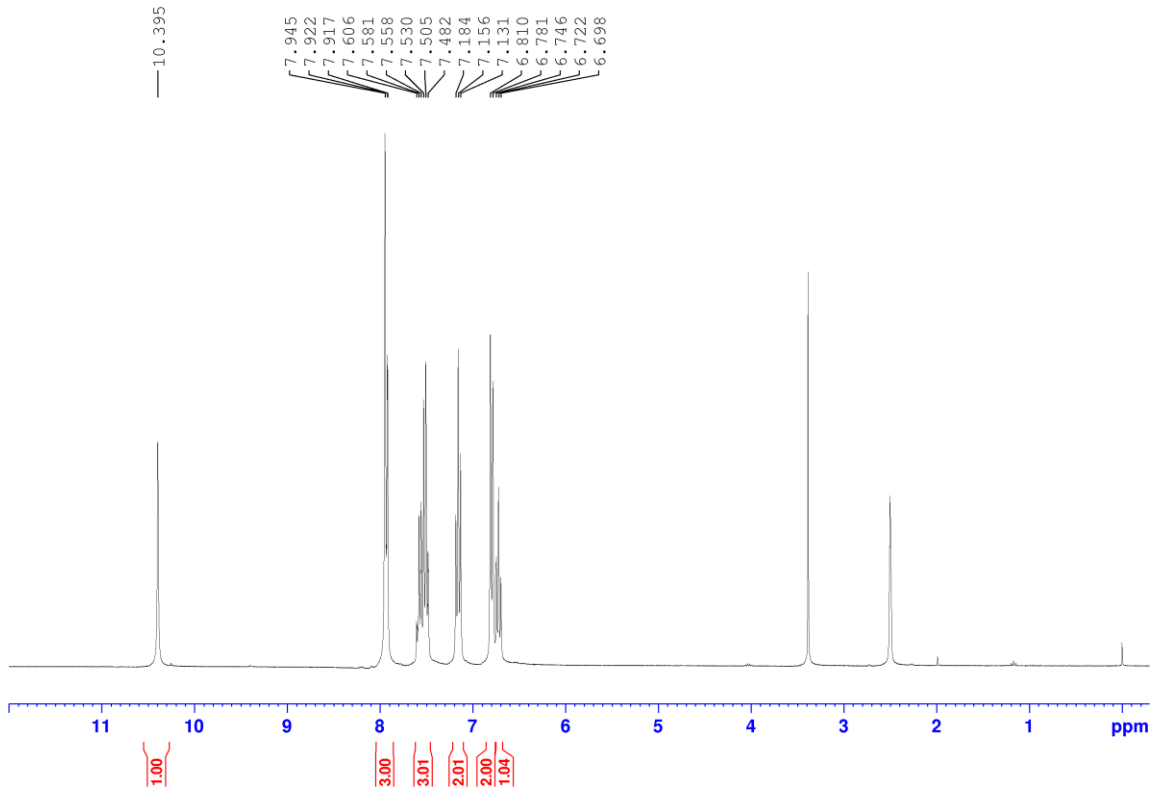


The ionic liquid [mPy][OTf] was prepared in total halide free direct synthesis in according to literature procedure [3]. Specifically, 0.29 mols of dry pyridine was placed in a two-necked flask and 0.30 mols of methyltrifluoromethanesulfonate dropwise was added. The mixture was reacted at 80 °C for 12 hours. The crude product was washed with diethyl ether and dried under vacuum, providing 68.04 gr (yield 96%) of pure ionic liquid.

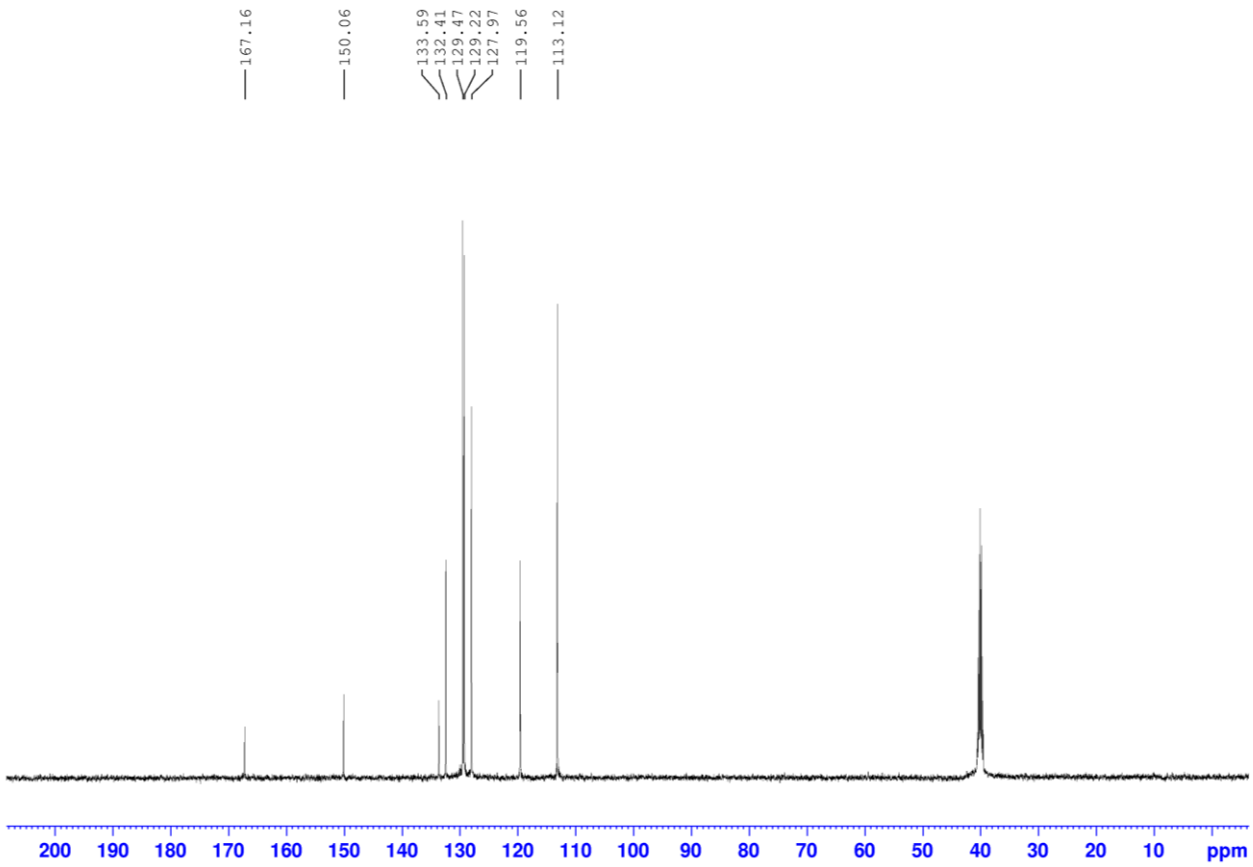
Characterization spectra of benzoyl phenylhydrazines

N'-phenylbenzohydrazide (3a)

^{1}H NMR

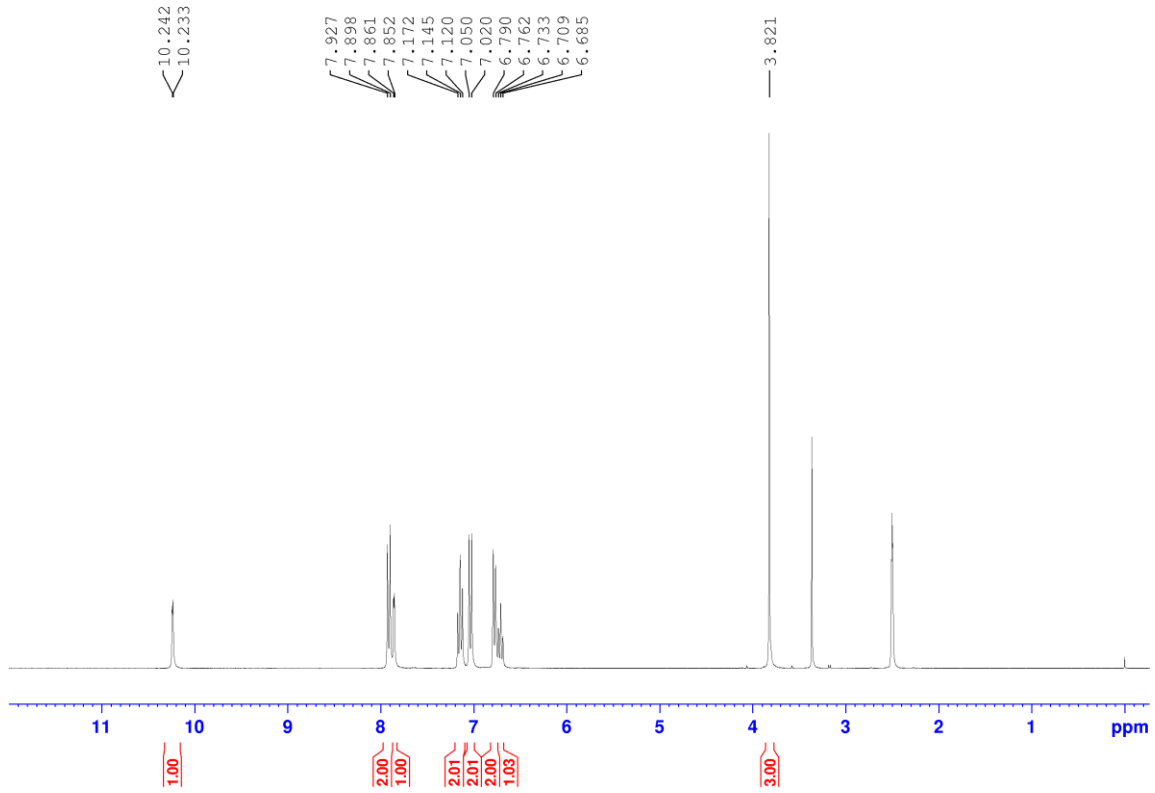


^{13}C NMR

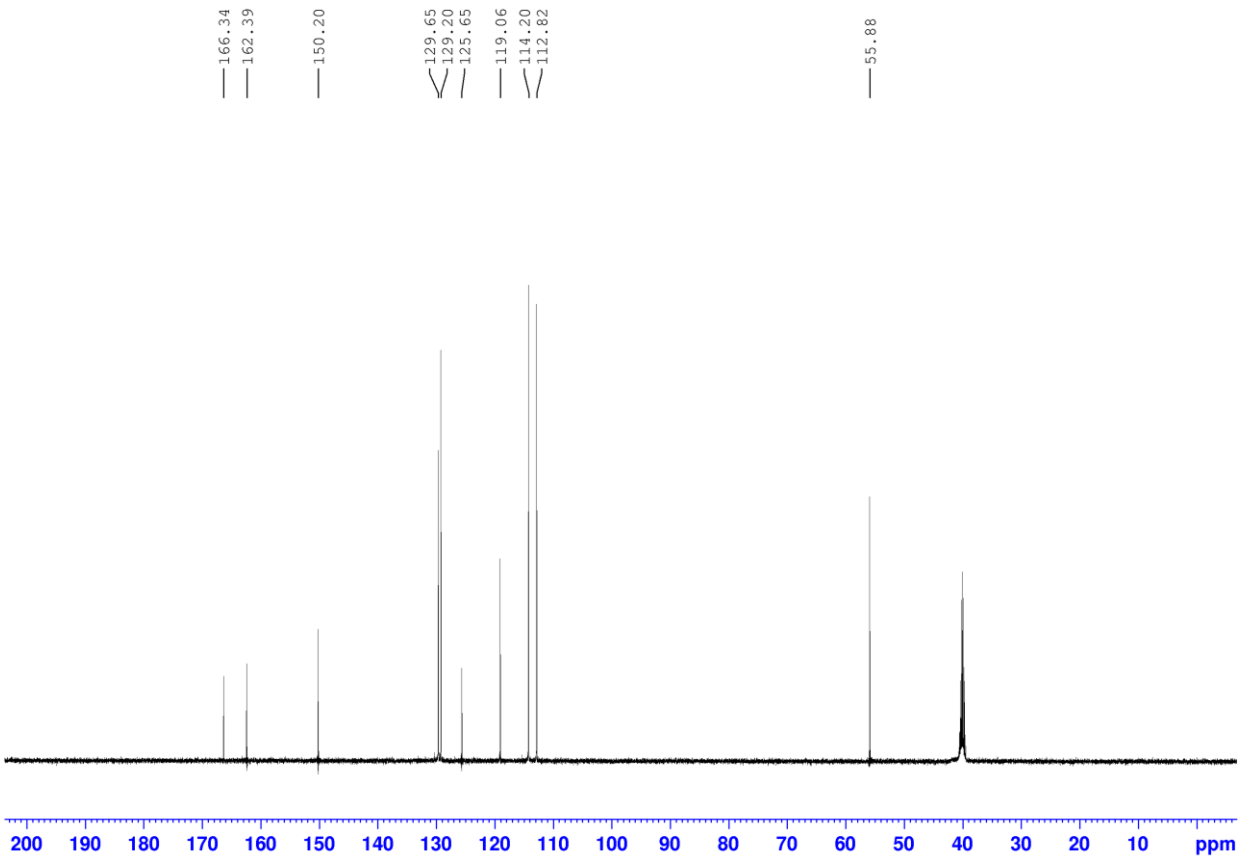

167.16
150.06
133.59
132.41
129.47
129.22
127.97
119.56
113.12
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-methoxy-N'-phenylbenzohydrazide (3b)

^{1}H NMR

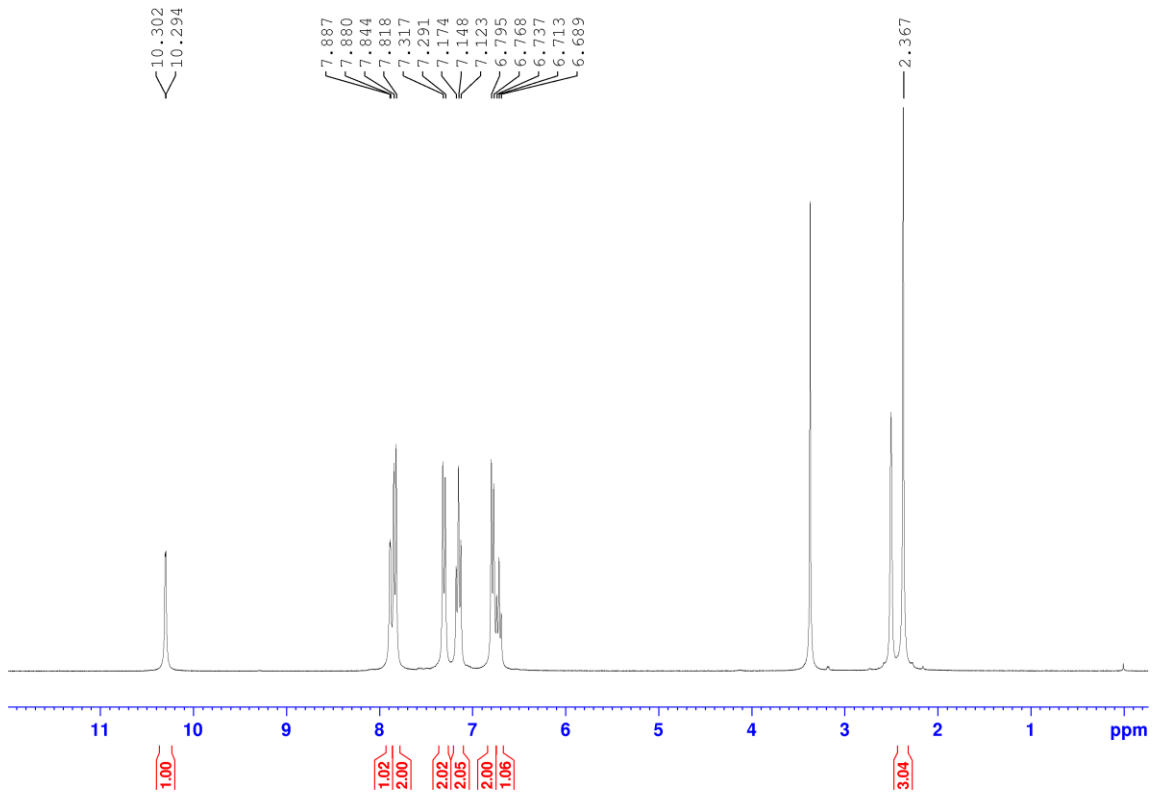


^{13}C NMR

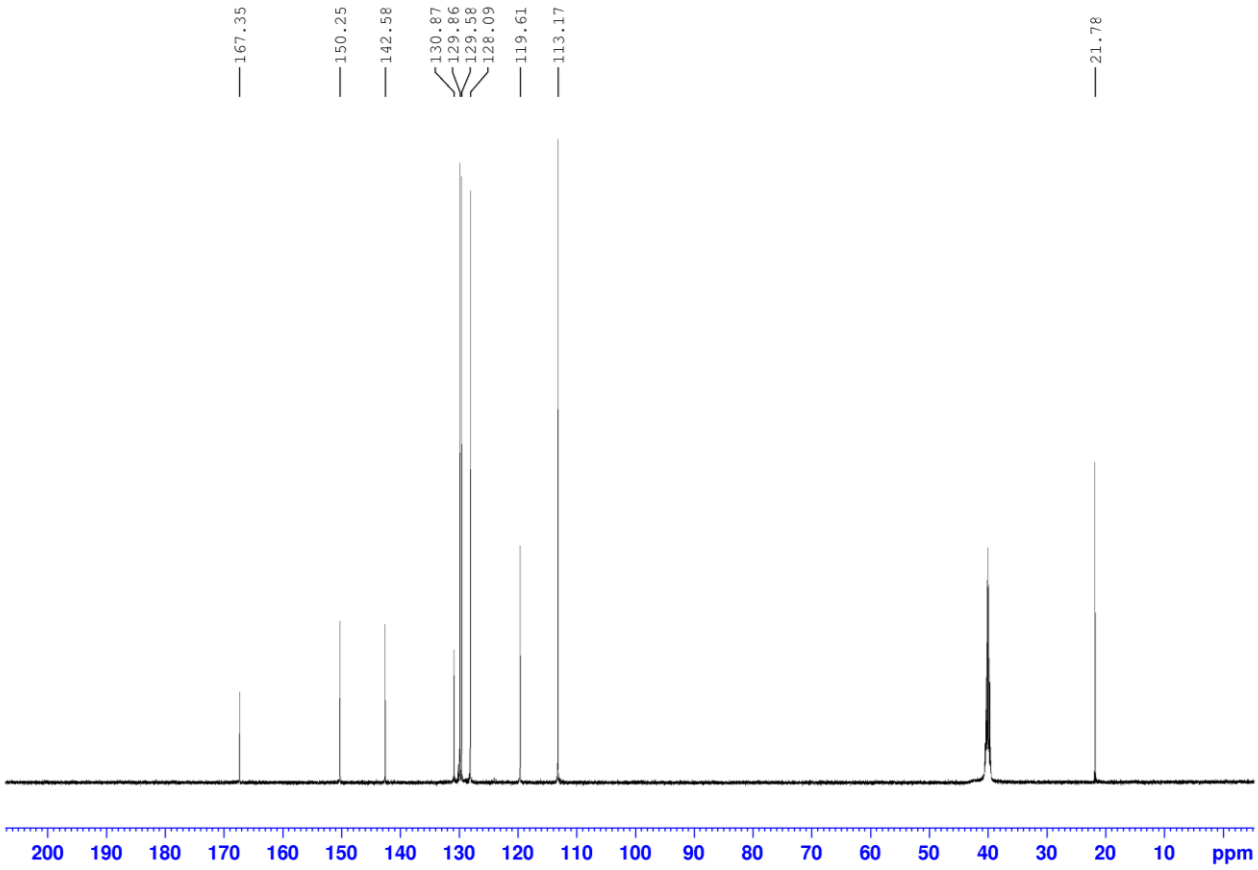

166.34
162.39
150.20
129.65
129.20
125.65
119.06
114.20
112.82
55.88
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-methyl-N'-phenylbenzohydrazide (3c)

^{1}H NMR

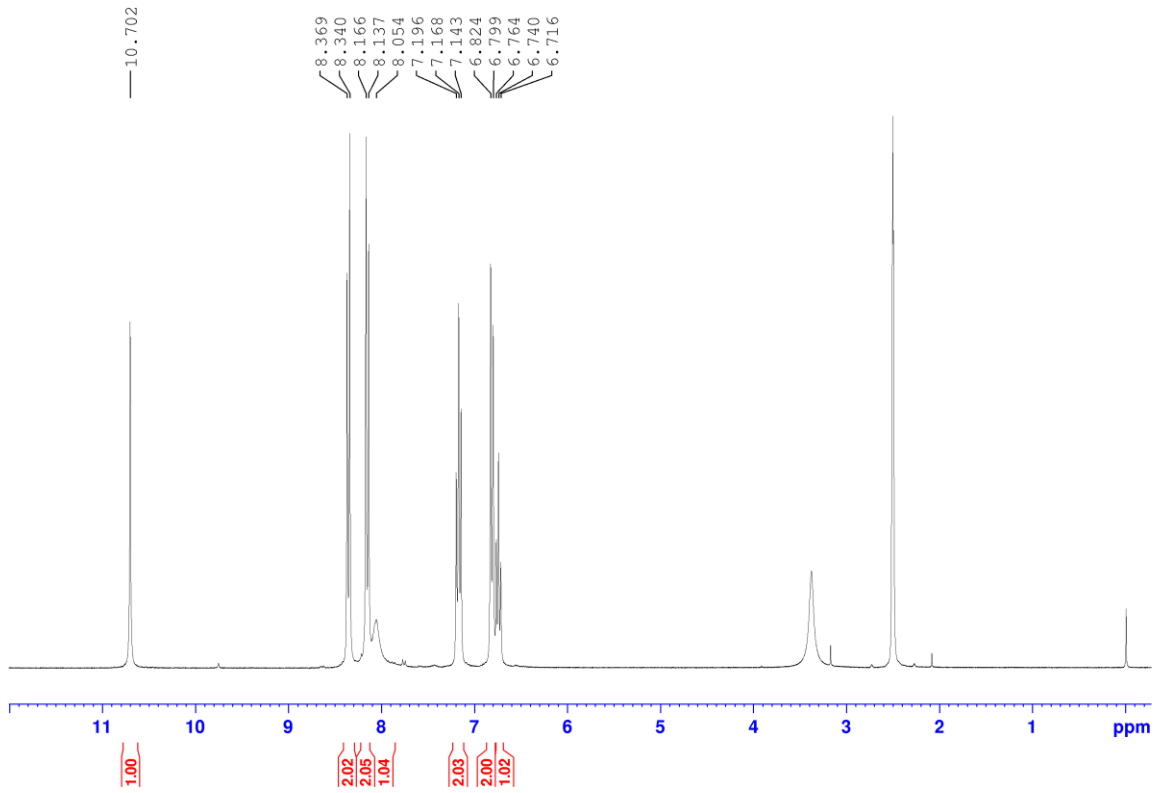


^{13}C NMR

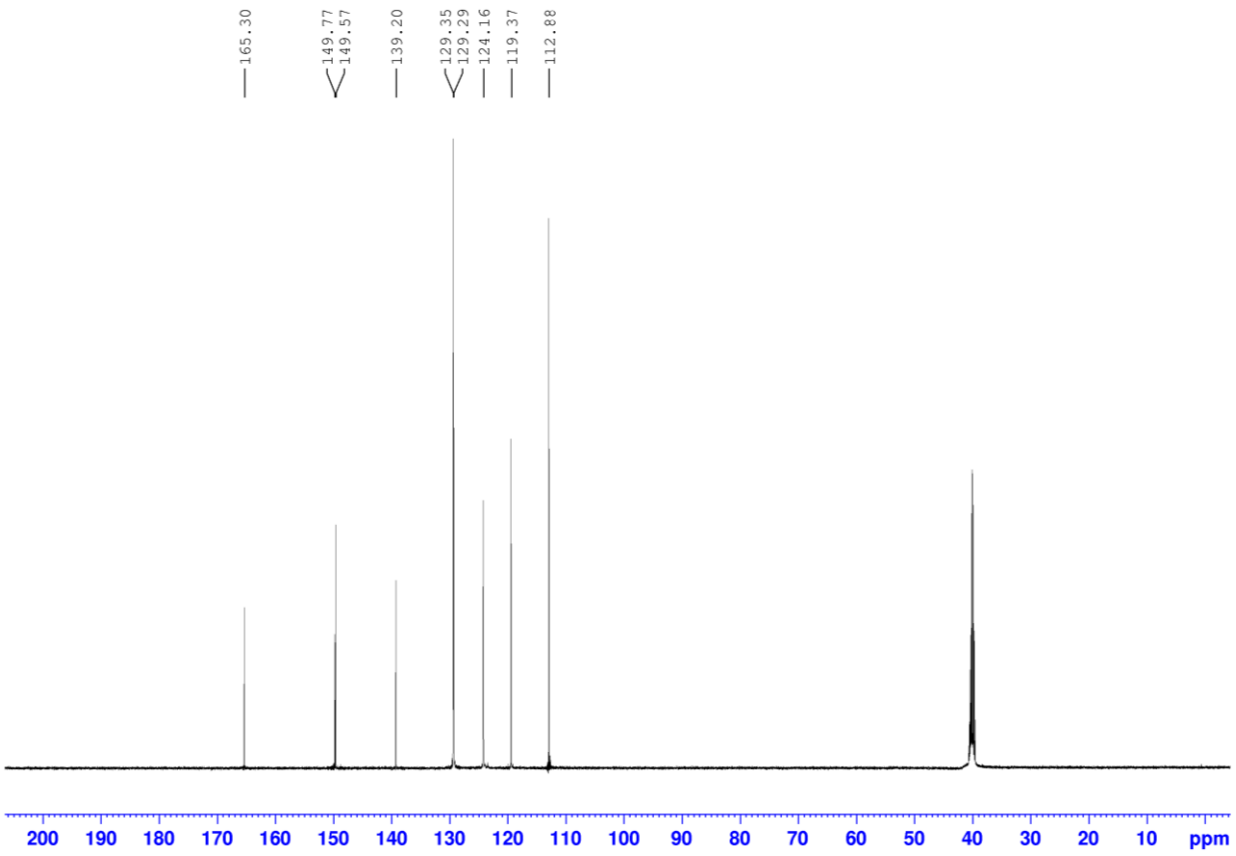

167.35
150.25
142.58
130.87
129.86
129.58
128.09
119.61
113.17
21.78
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-nitro-N'-phenylbenzohydrazide (3d)

^{1}H NMR

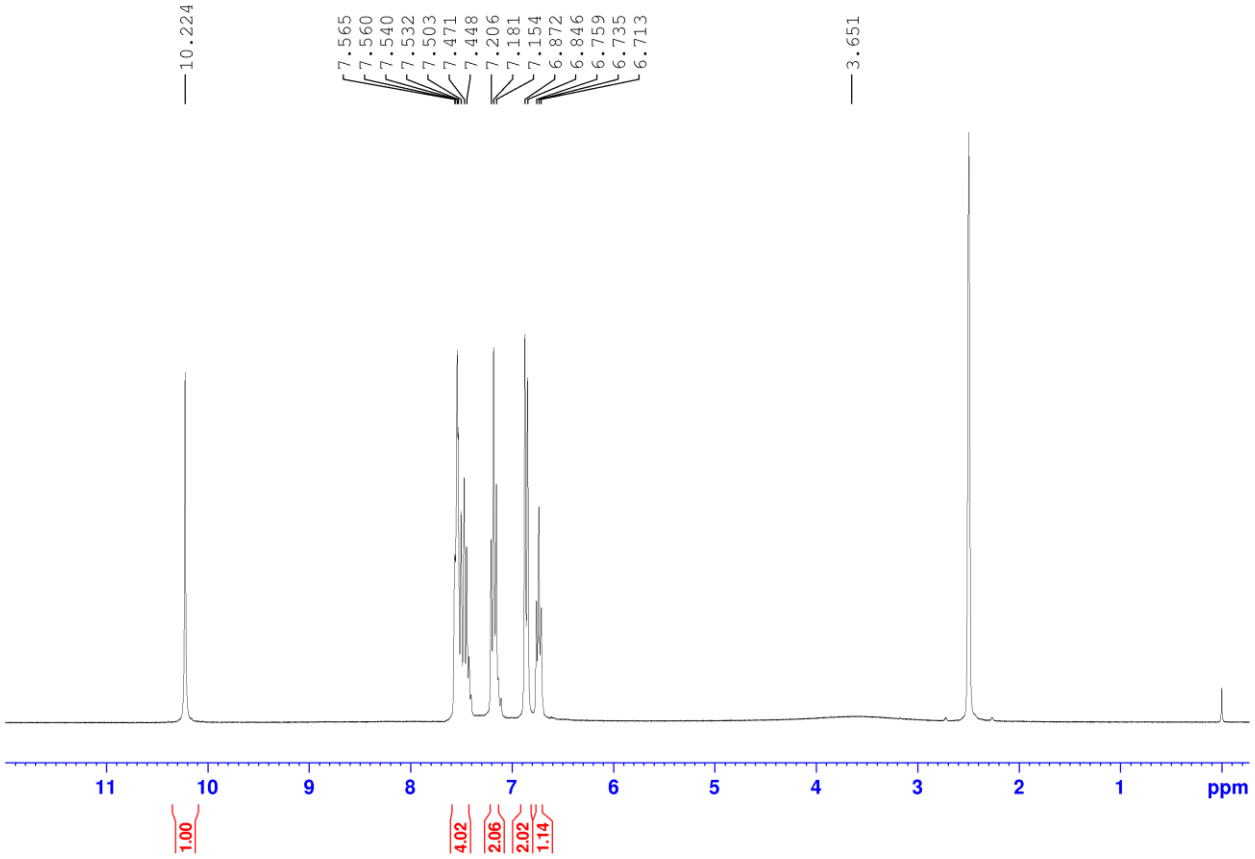


^{13}C NMR

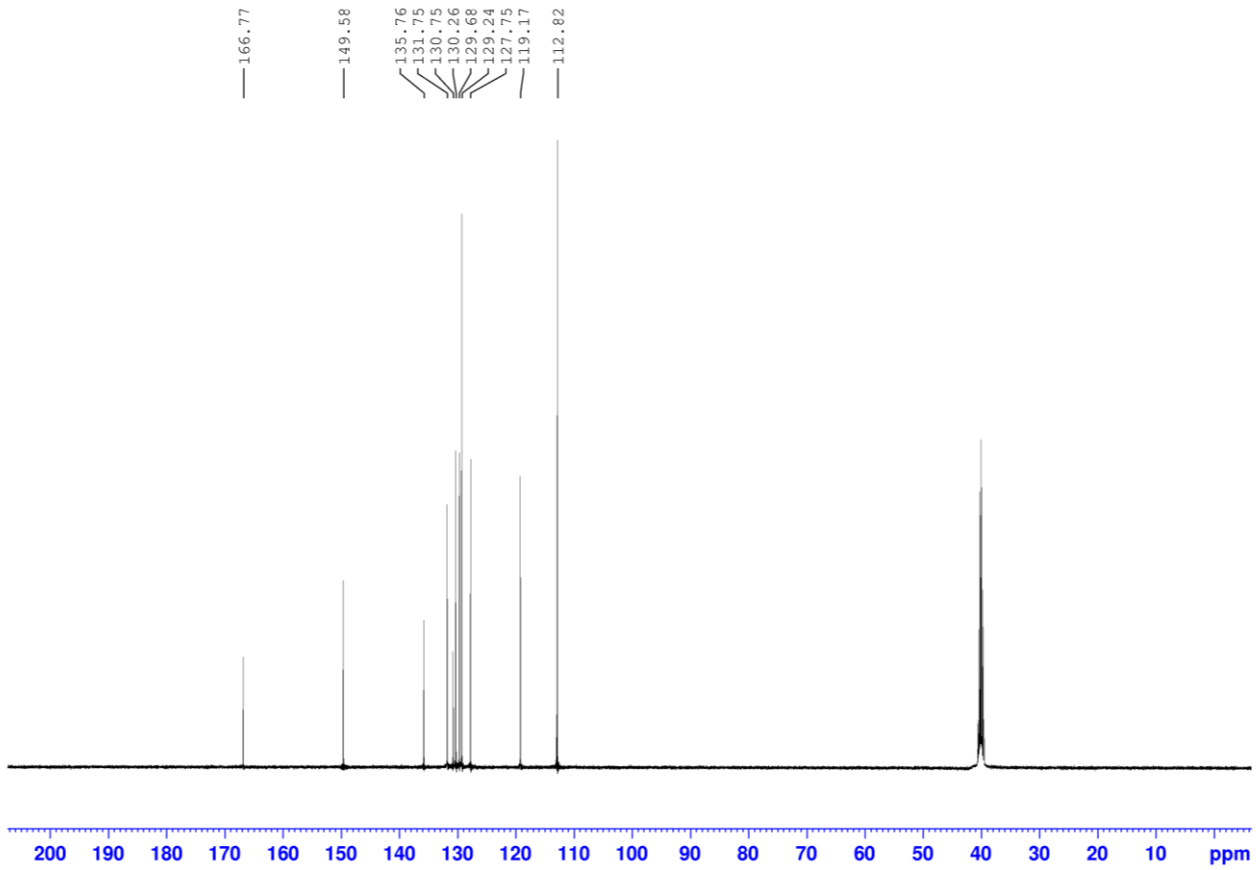

165.30
149.77
149.57
139.20
129.35
129.29
124.16
119.37
112.88
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

2-chloro-N'-phenylbenzohydrazide (3e)

^{1}H NMR

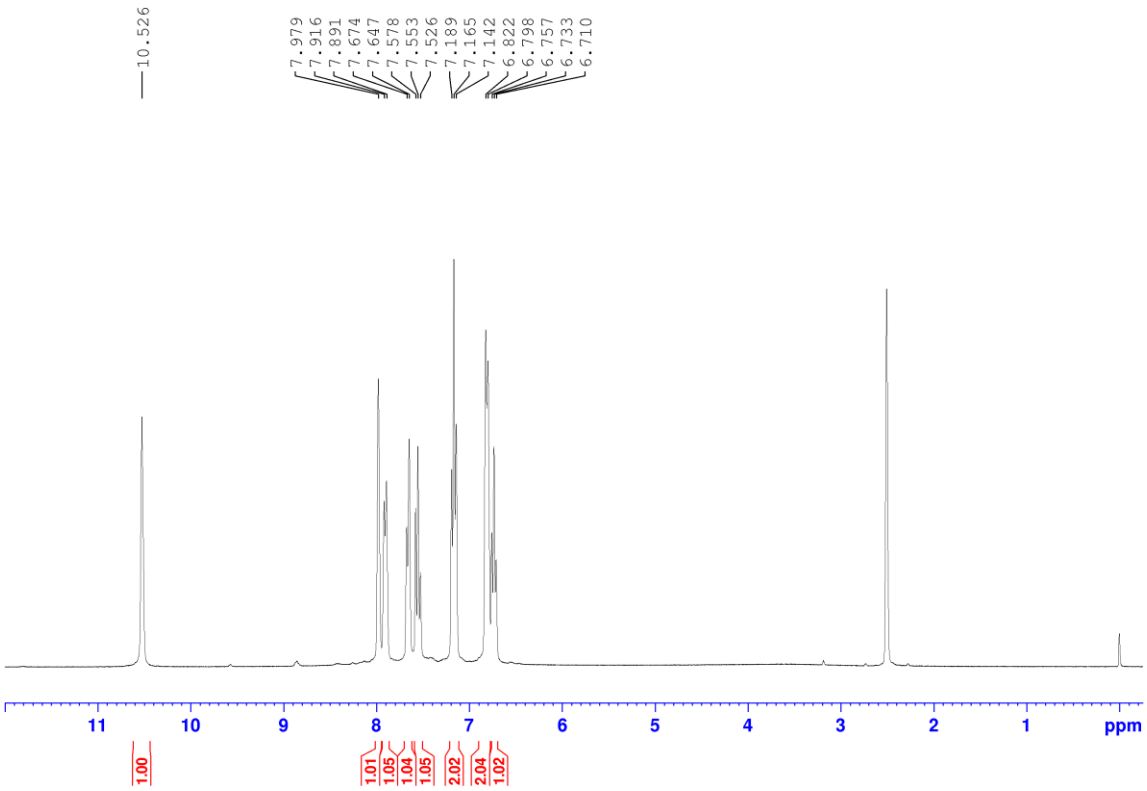


^{13}C NMR

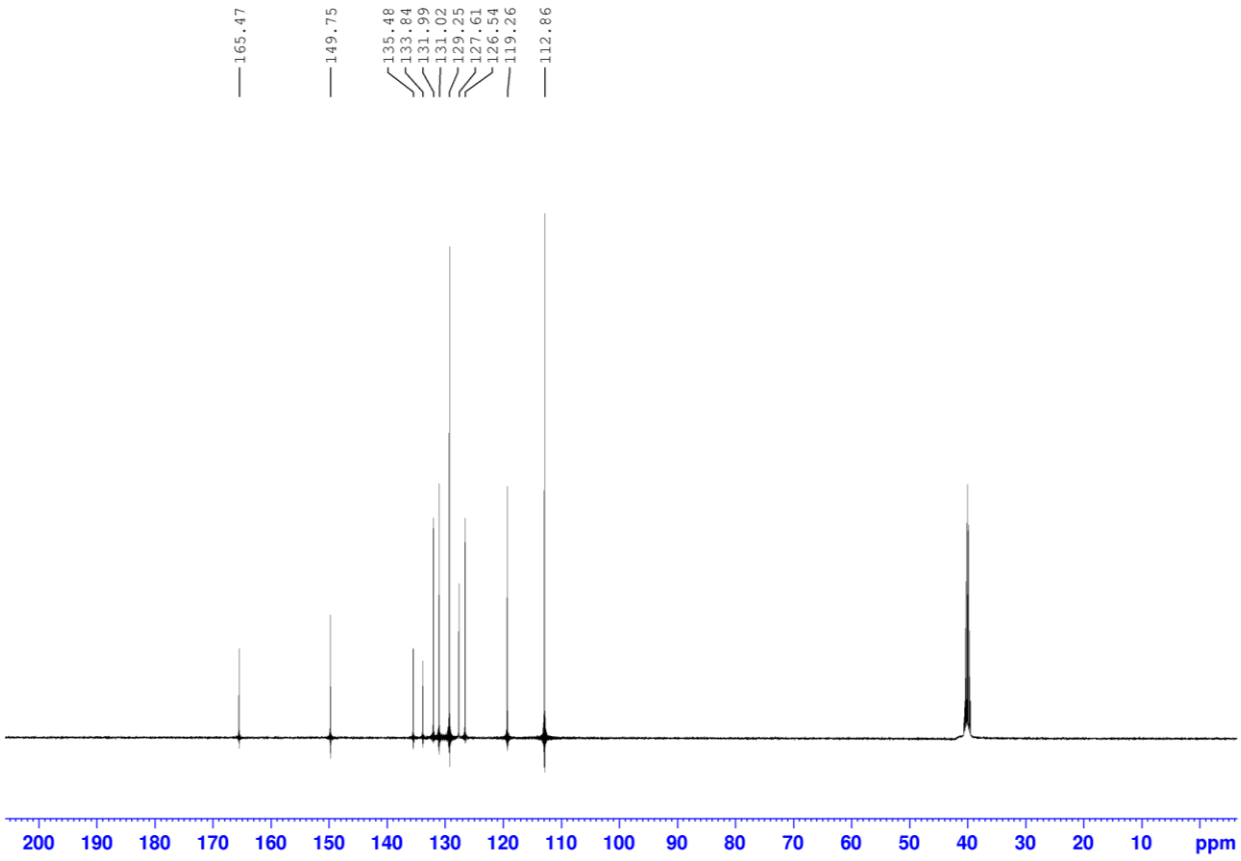

166.77
149.58
135.76
131.75
130.75
130.26
129.68
129.24
127.75
119.17
112.82
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

3-chloro-N'-phenylbenzohydrazide (3f)

^{1}H NMR

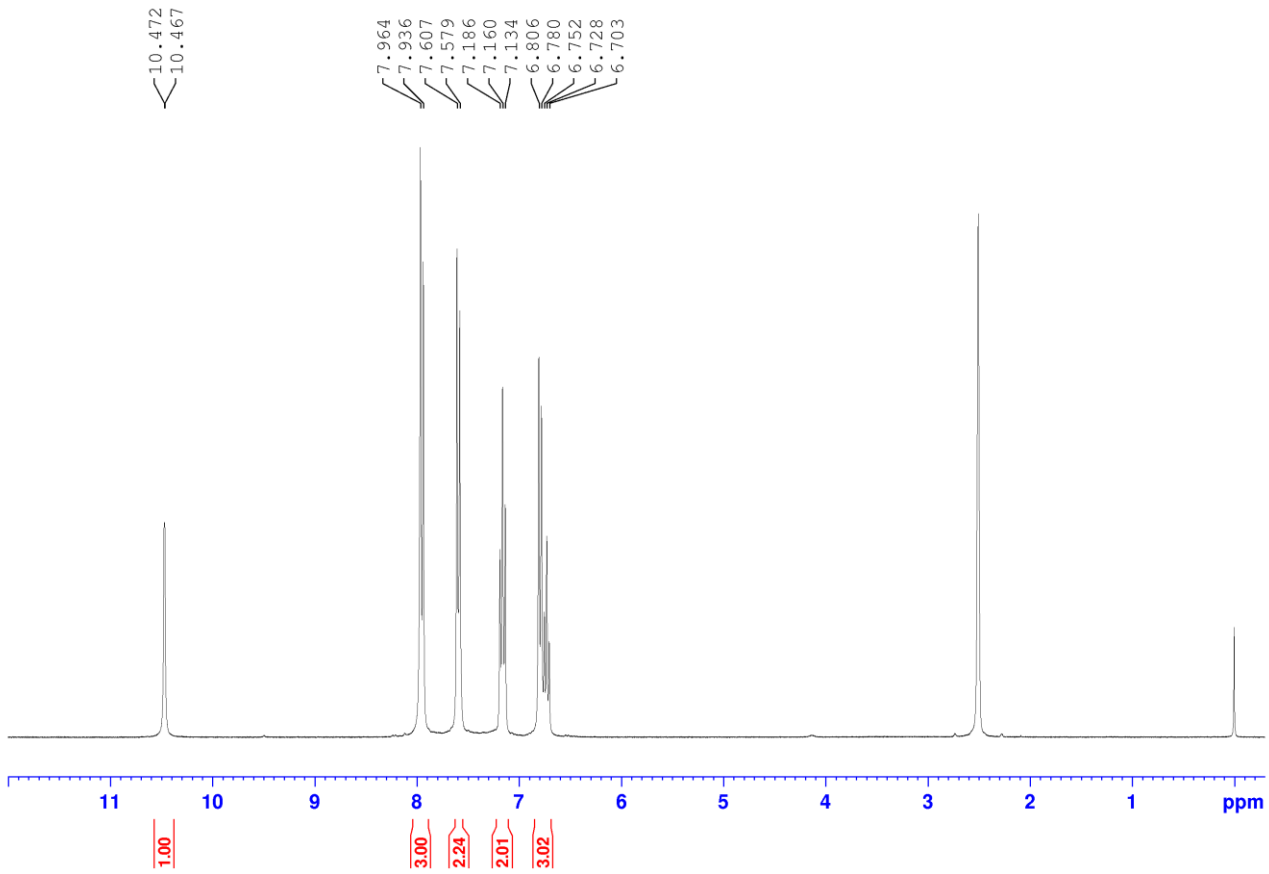


^{13}C NMR

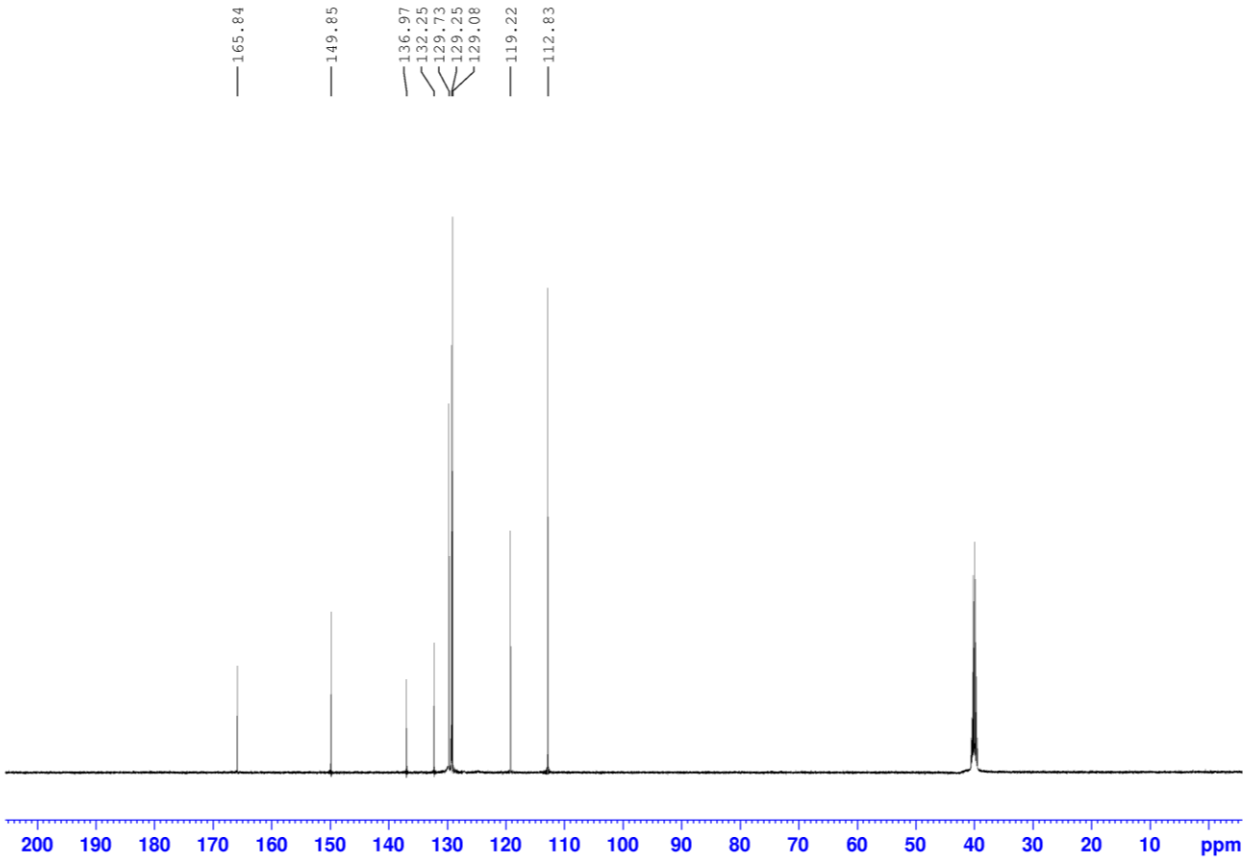

165.47
149.75
135.48
133.84
131.99
131.02
129.25
127.61
126.54
119.26
112.86
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-chloro-N'-phenylbenzohydrazide (3g)

^{1}H NMR



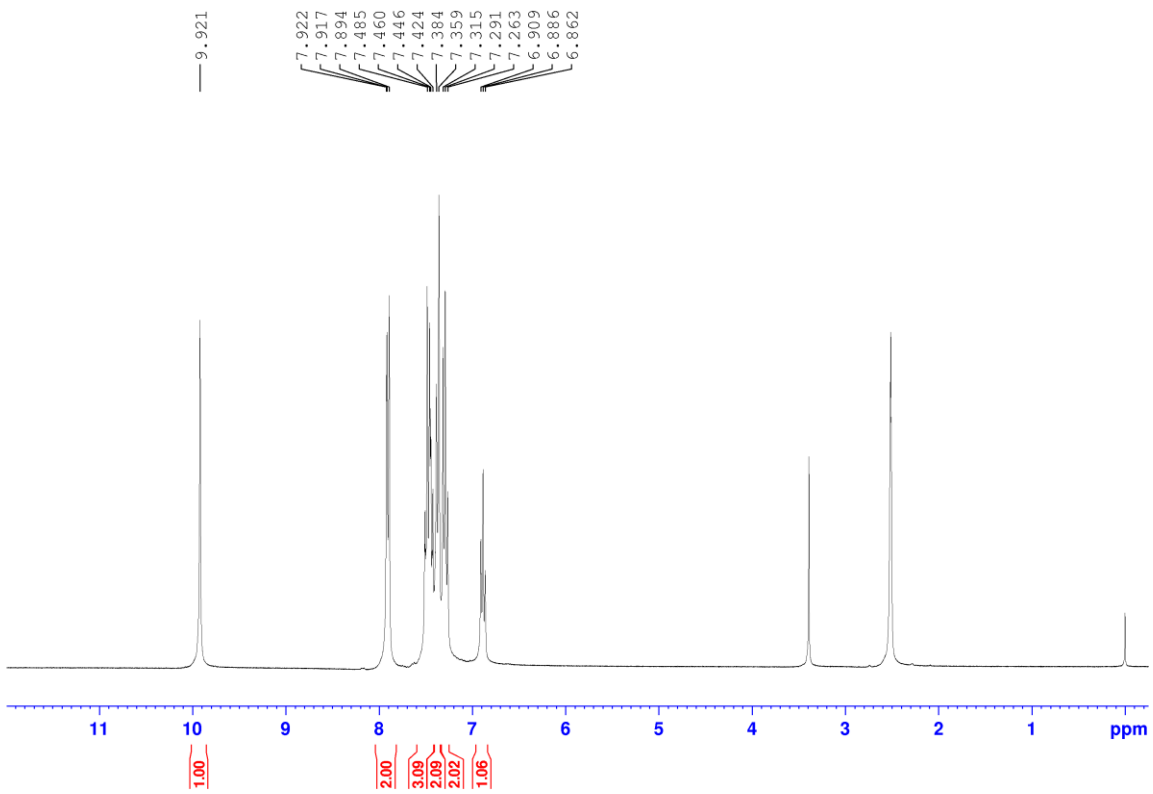
^{13}C NMR


165.84
149.85
136.97
132.25
129.73
129.25
129.08
119.22
112.83
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

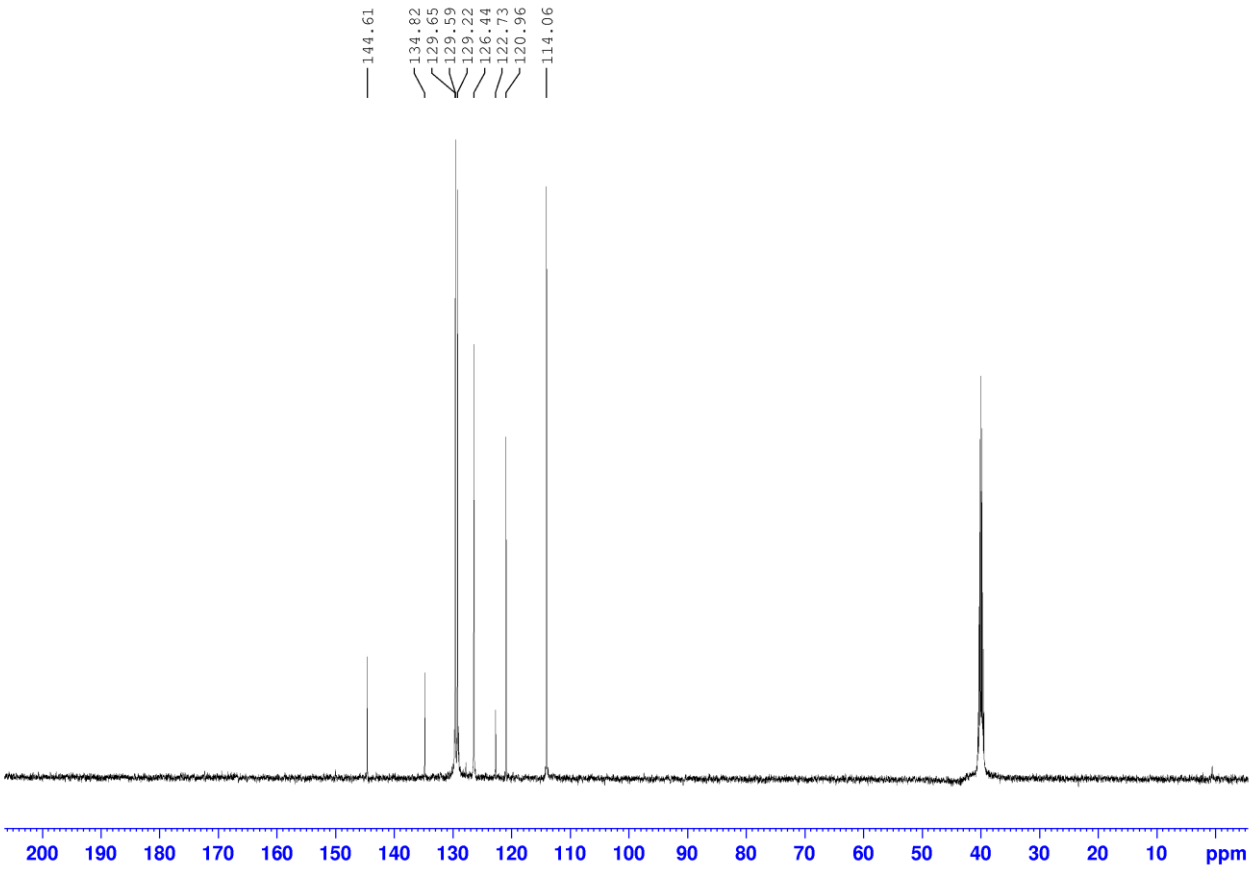
Characterization spectra of hydrazonyl chlorides

N-phenylbenzohydrazonyl chloride (4a)

^{1}H NMR

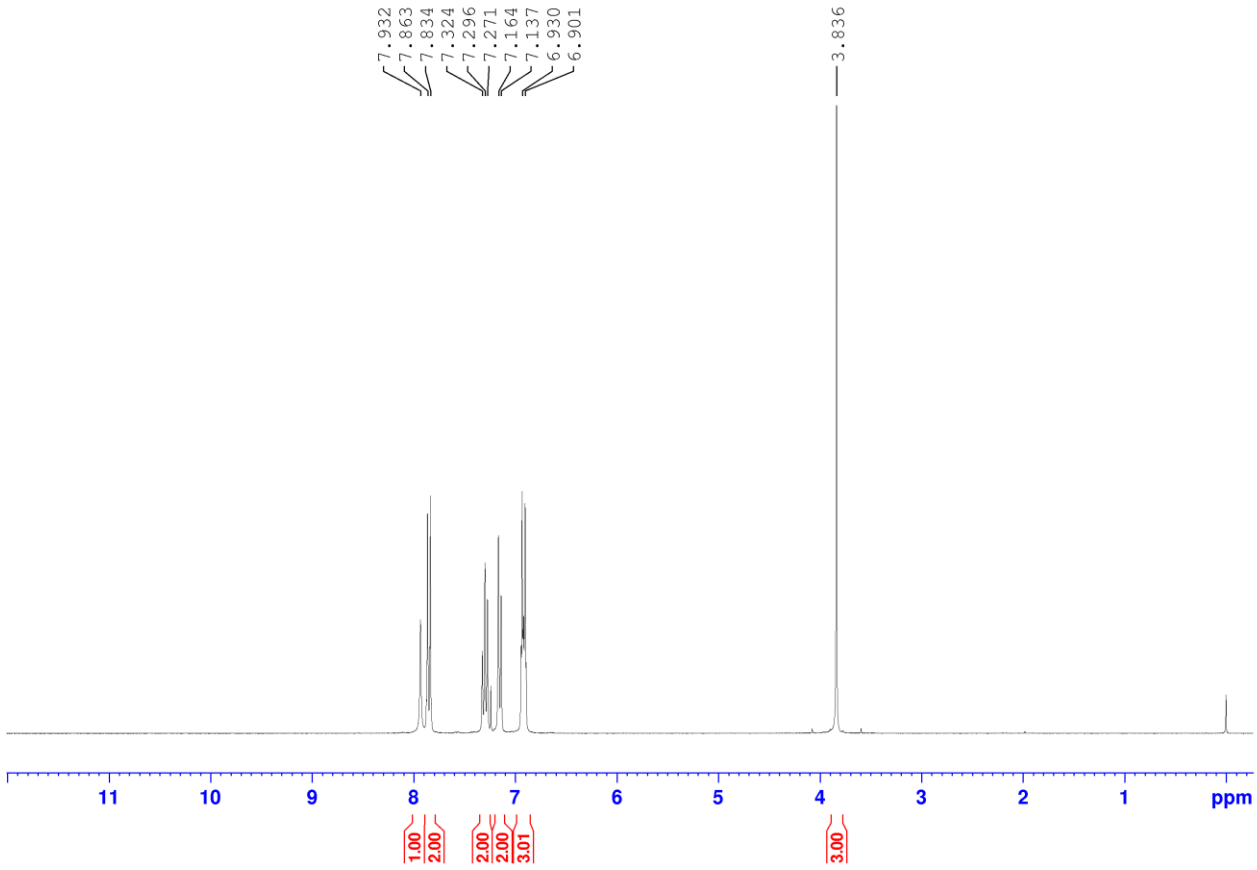


^{13}C NMR

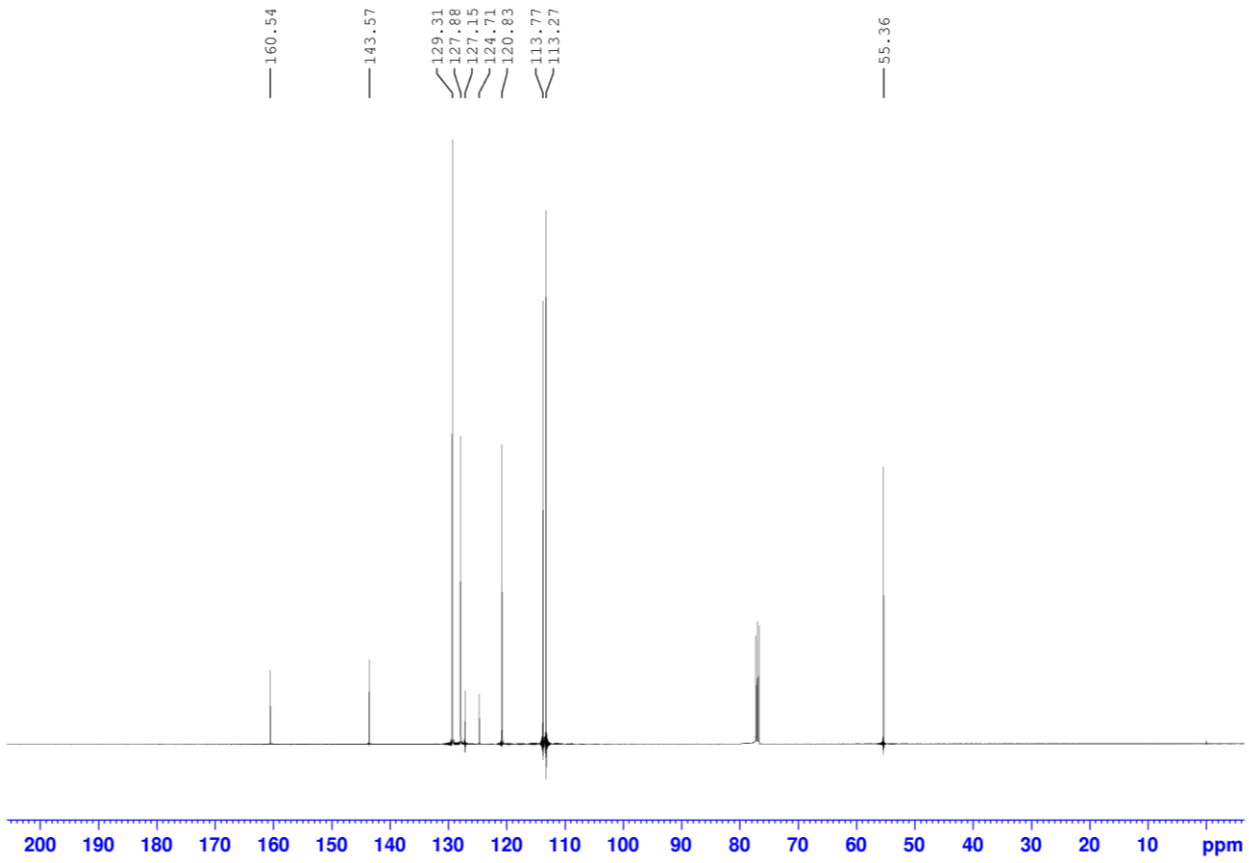

144.61
134.82
129.65
129.59
129.22
126.44
122.73
120.96
114.06
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-methoxy-N-phenylbenzohydrazonyl chloride (4b)

^{1}H NMR

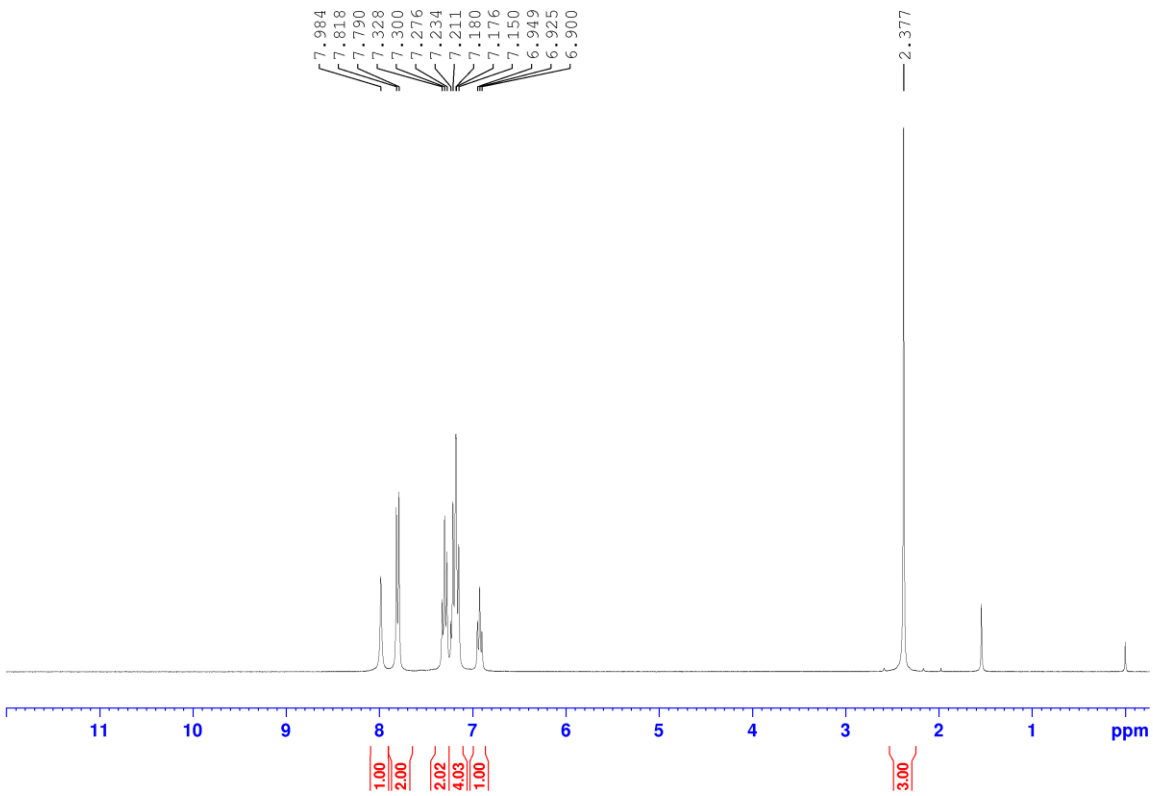


^{13}C NMR

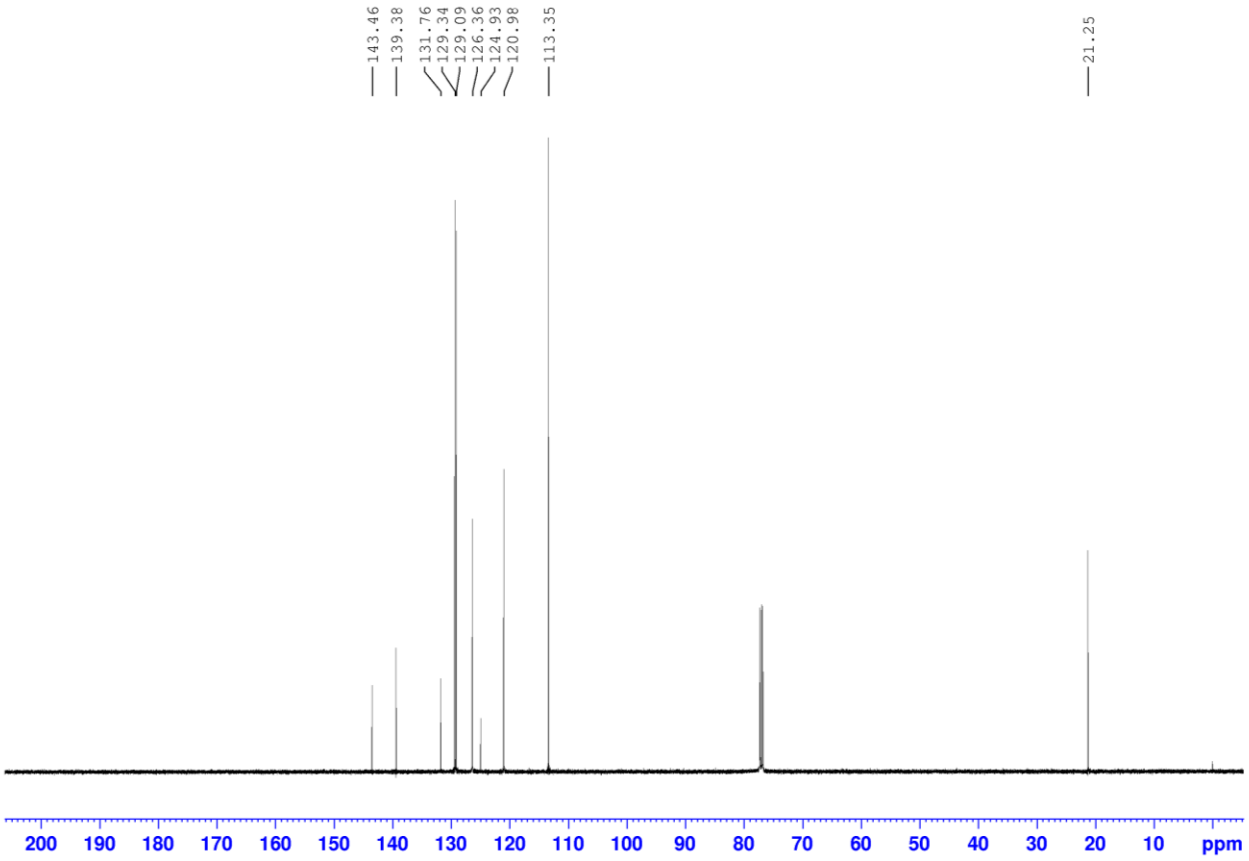

160.54
143.57
129.31
127.88
127.15
124.71
120.83
113.77
113.27
55.36
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-methyl-N-phenylbenzohydrazonyl chloride (4c)

^{1}H NMR

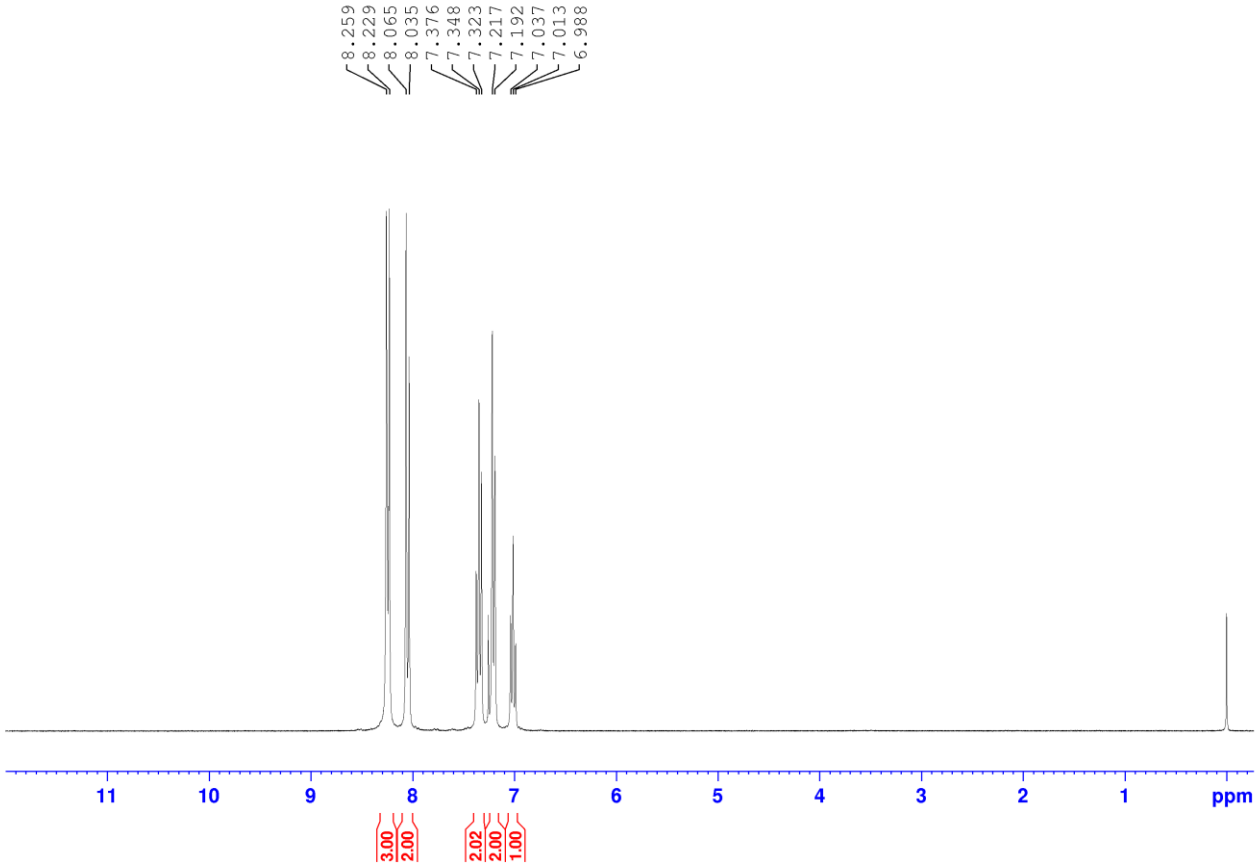


^{13}C NMR

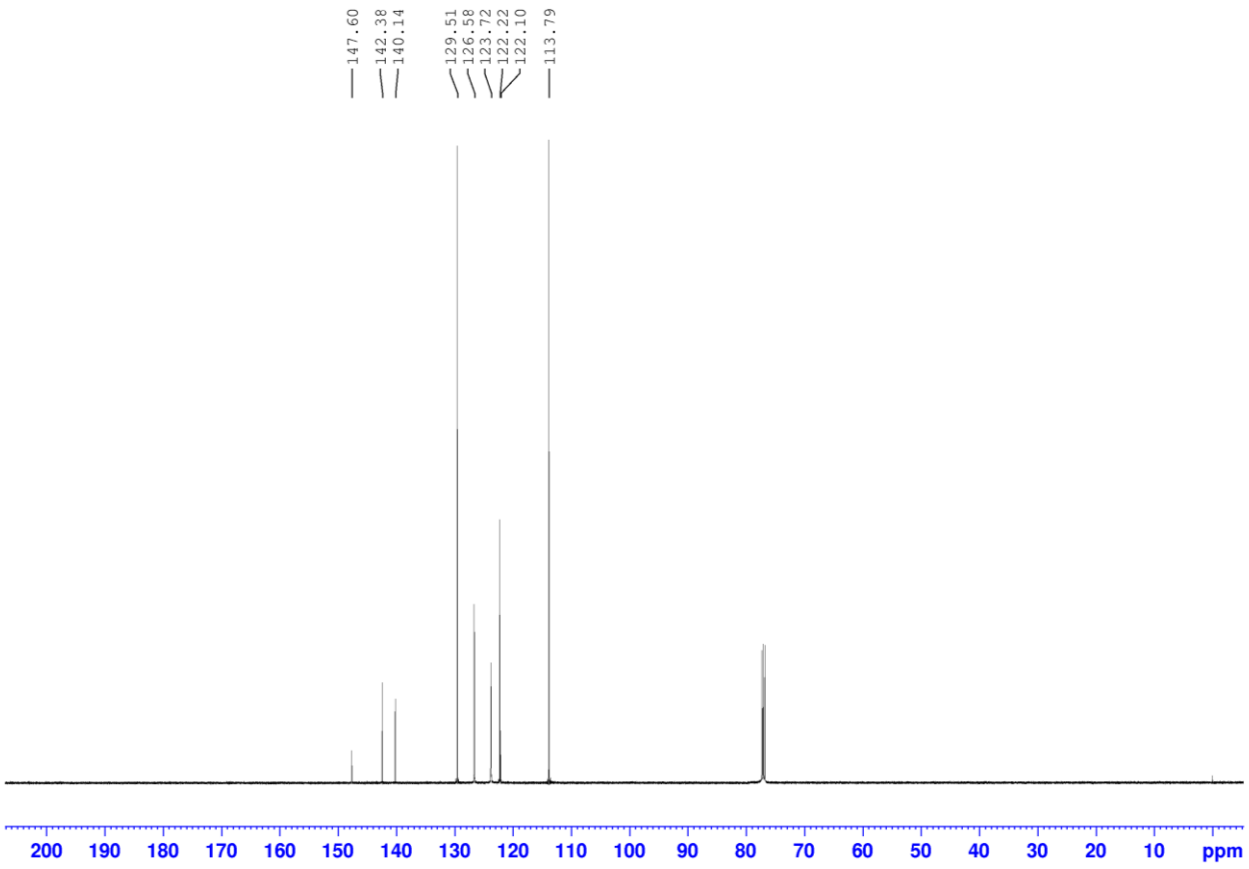

143.46
139.38
131.76
129.34
129.09
126.36
124.93
120.98
113.35
21.25
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-nitro-N-phenylbenzohydrazonyl chloride (4d)

^{1}H NMR

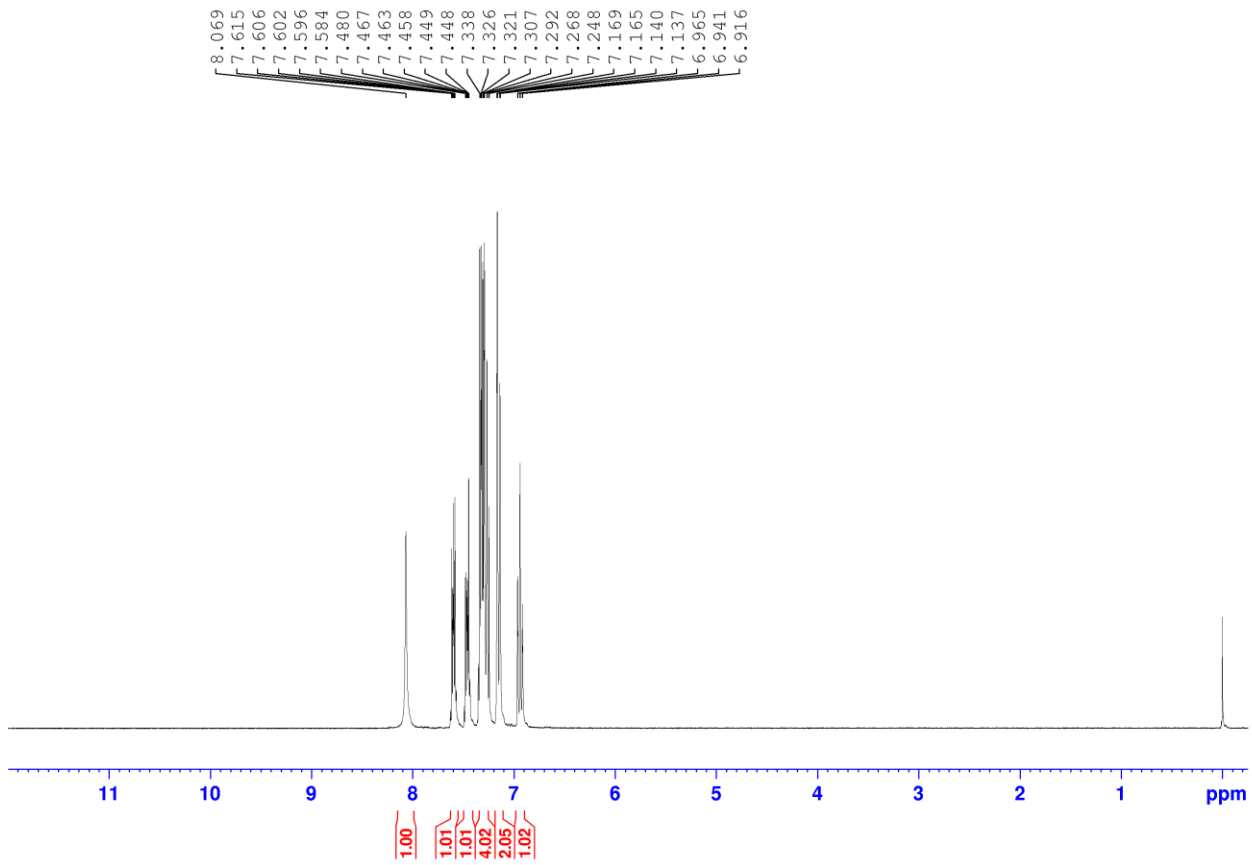


^{13}C NMR

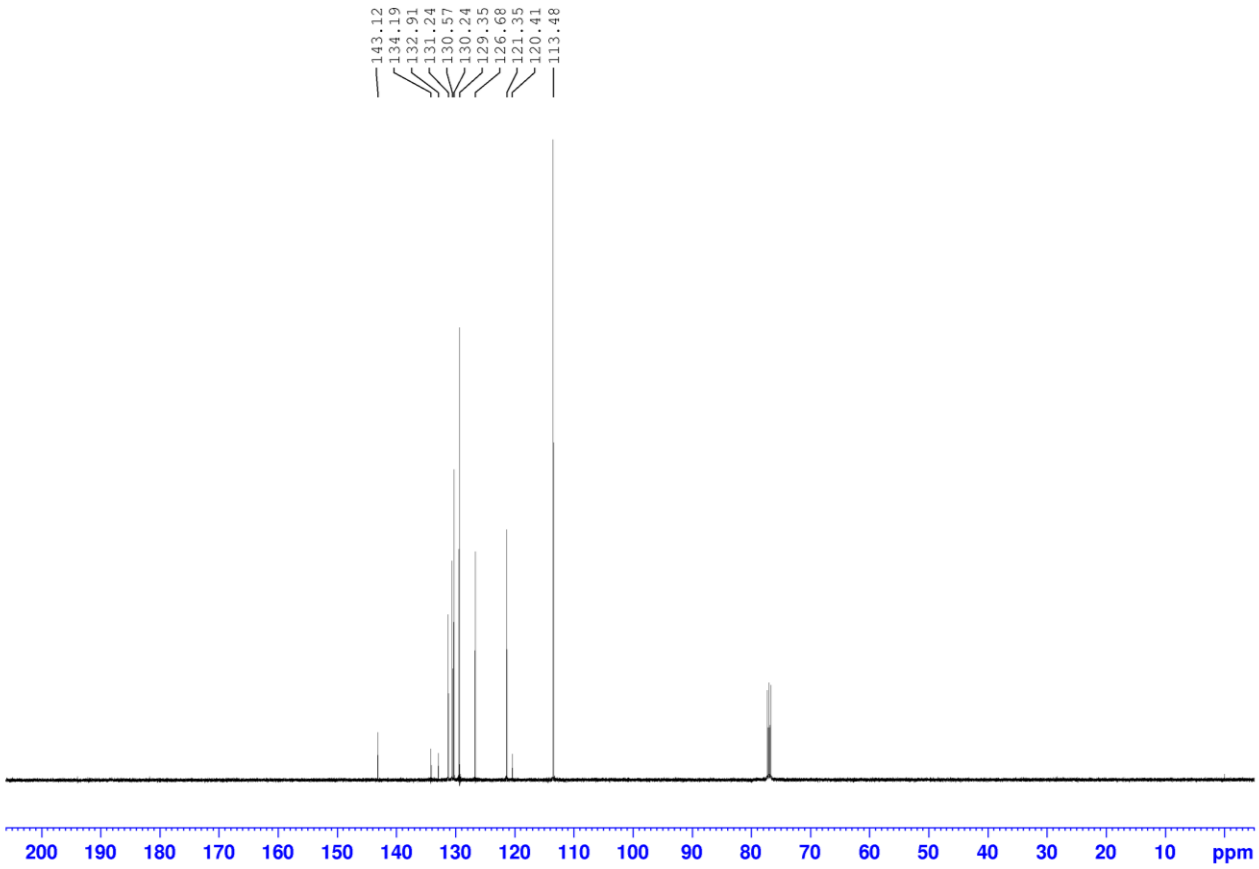

147.60
142.38
140.14
129.51
126.58
123.72
122.22
122.10
113.79
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

2-chloro-N-phenylbenzohydrazonyl chloride (4e)

^{1}H NMR

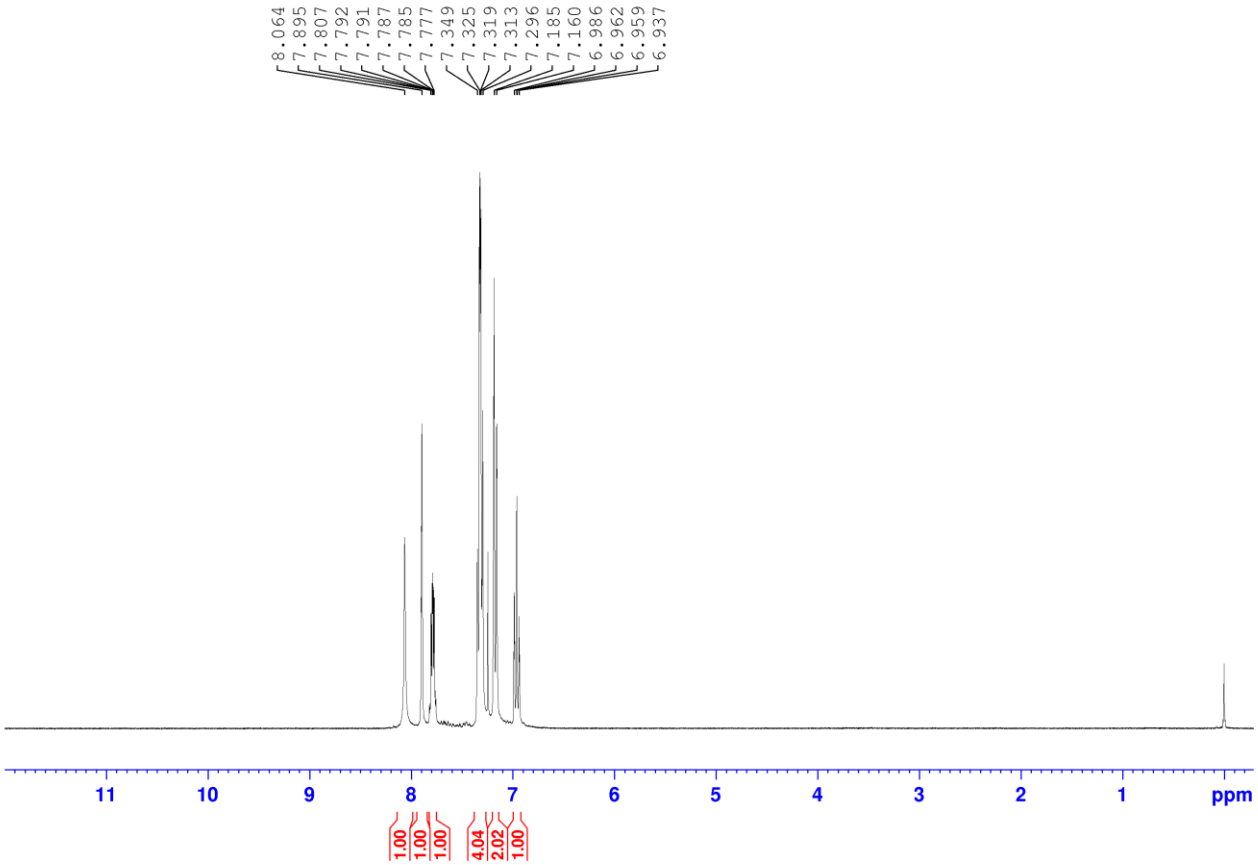


^{13}C NMR

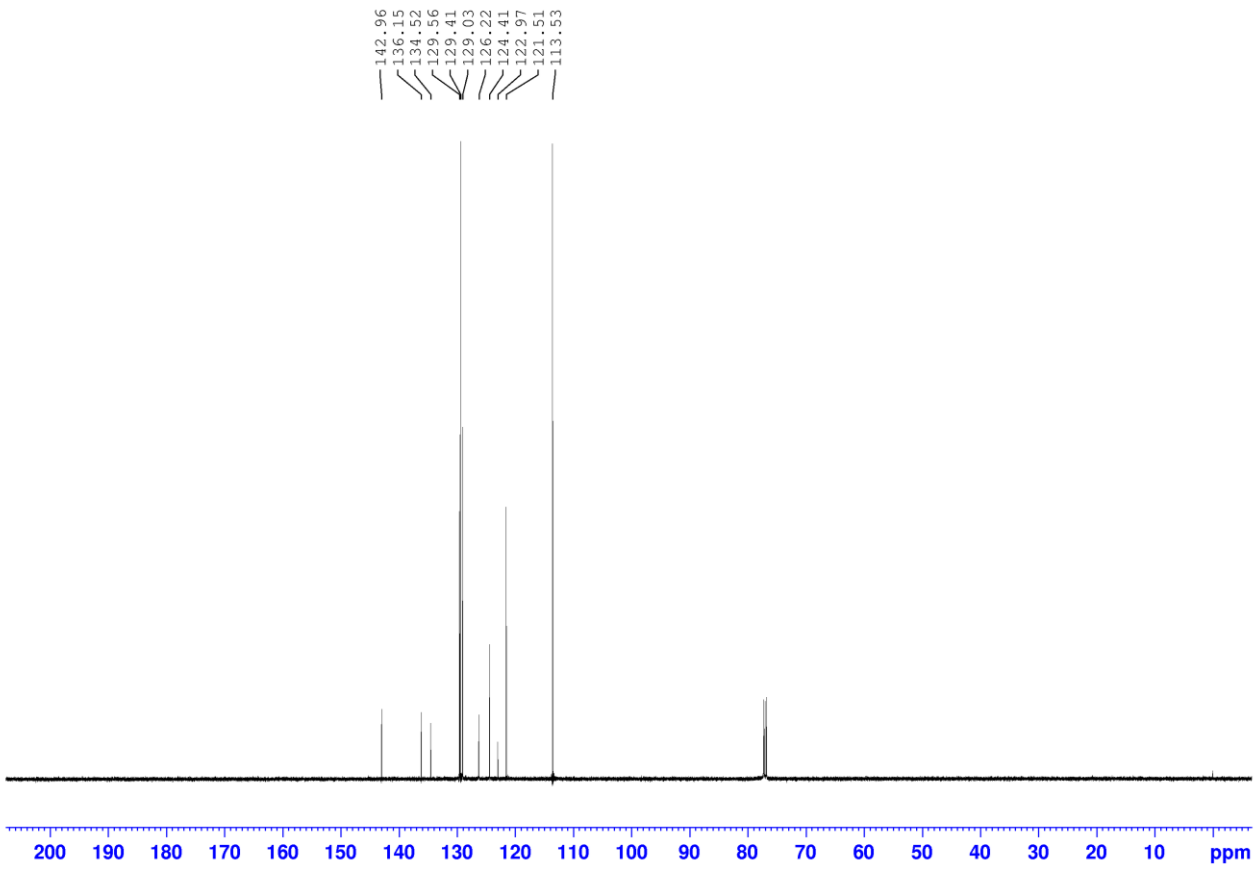

143.12
134.19
132.91
131.24
130.57
130.24
129.35
126.68
121.35
120.41
113.48
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

3-chloro-N-phenylbenzohydrazonyl chloride (4f)

^{1}H NMR

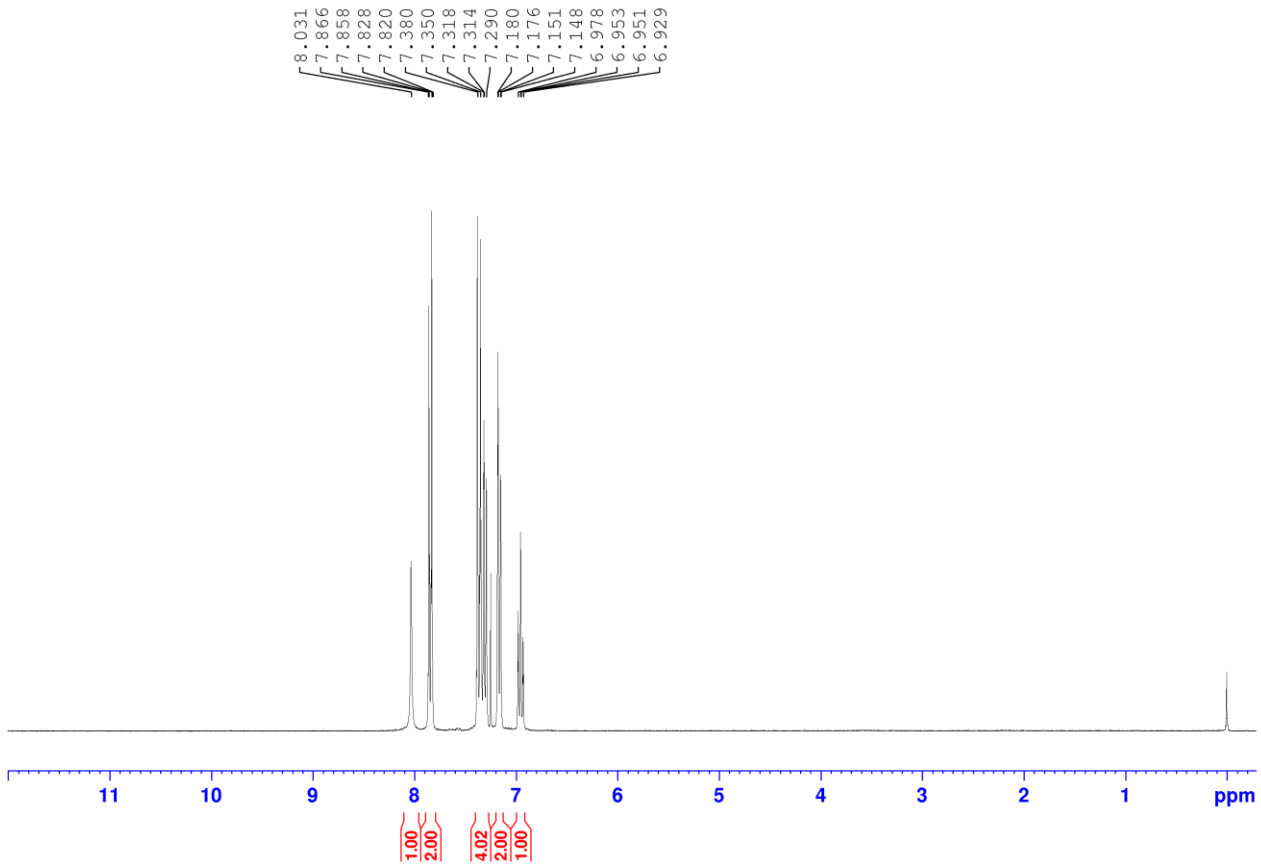


^{13}C NMR

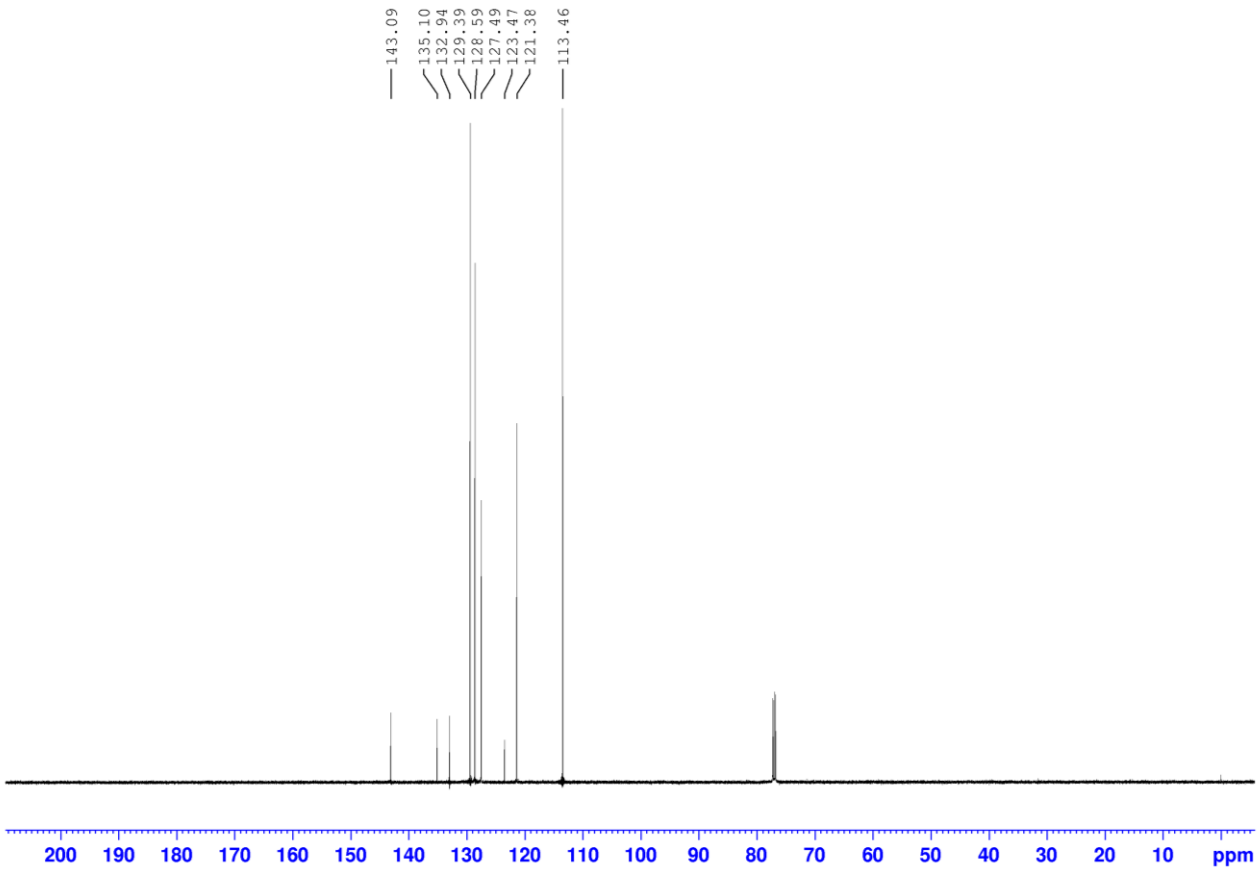

142.96
136.15
134.52
129.56
129.41
129.03
126.22
124.41
122.97
121.51
113.53
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

4-chloro-N-phenylbenzohydrazonyl chloride (4g)

^{1}H NMR



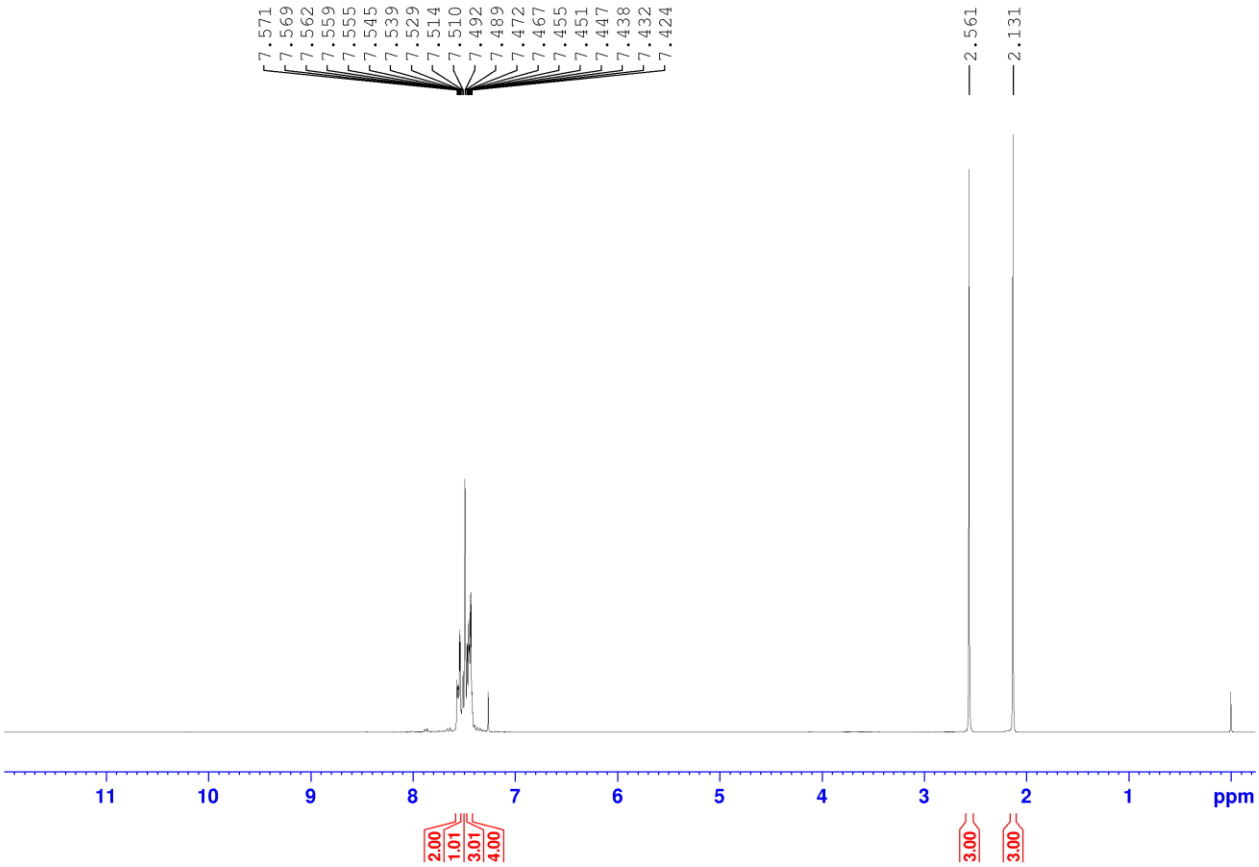
^{13}C NMR


143.09
135.10
132.94
129.39
128.59
127.49
123.47
121.38
113.46
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

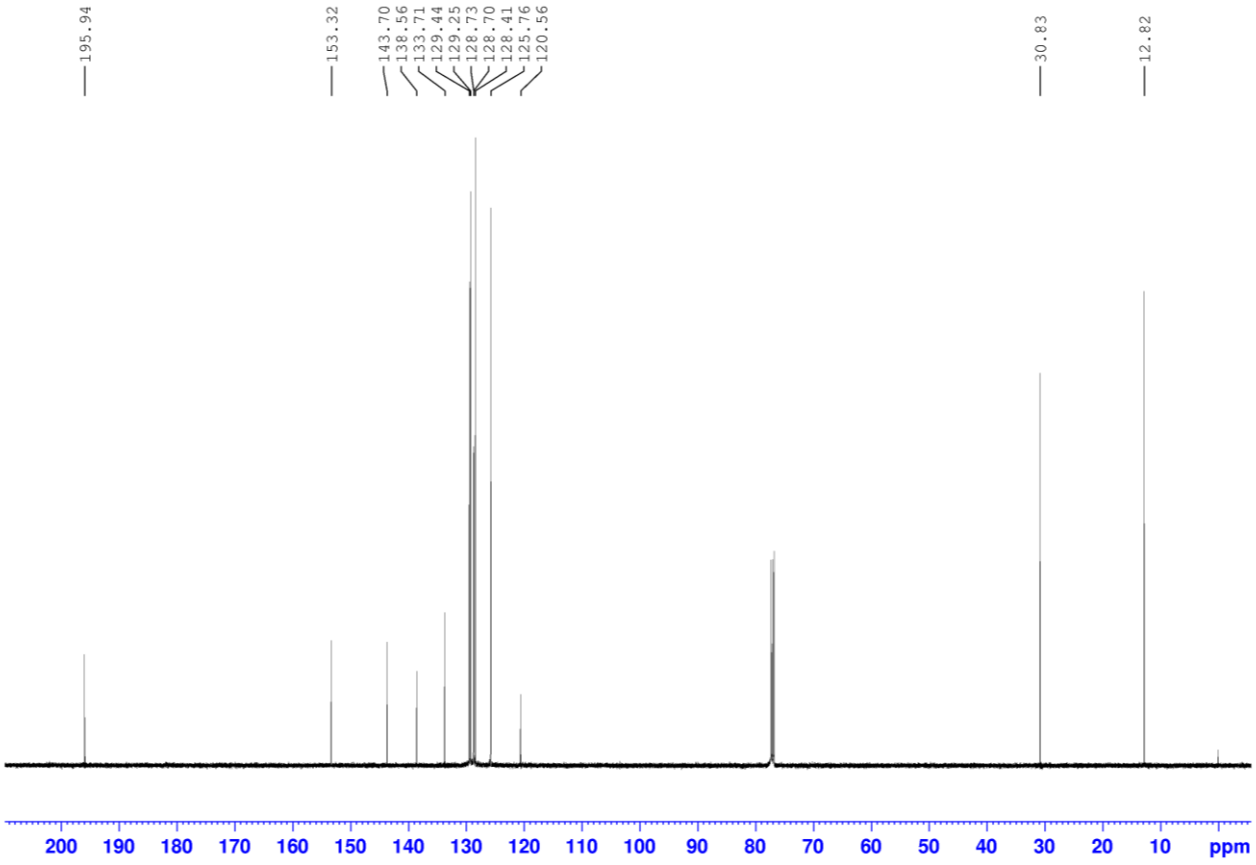
Characterization spectra of 1,3,4,5-tetrasubstituted pyrazoles

1-(5-Methyl-1,3-diphenyl-1*H*-pyrazol-4-yl)ethanone (6a)

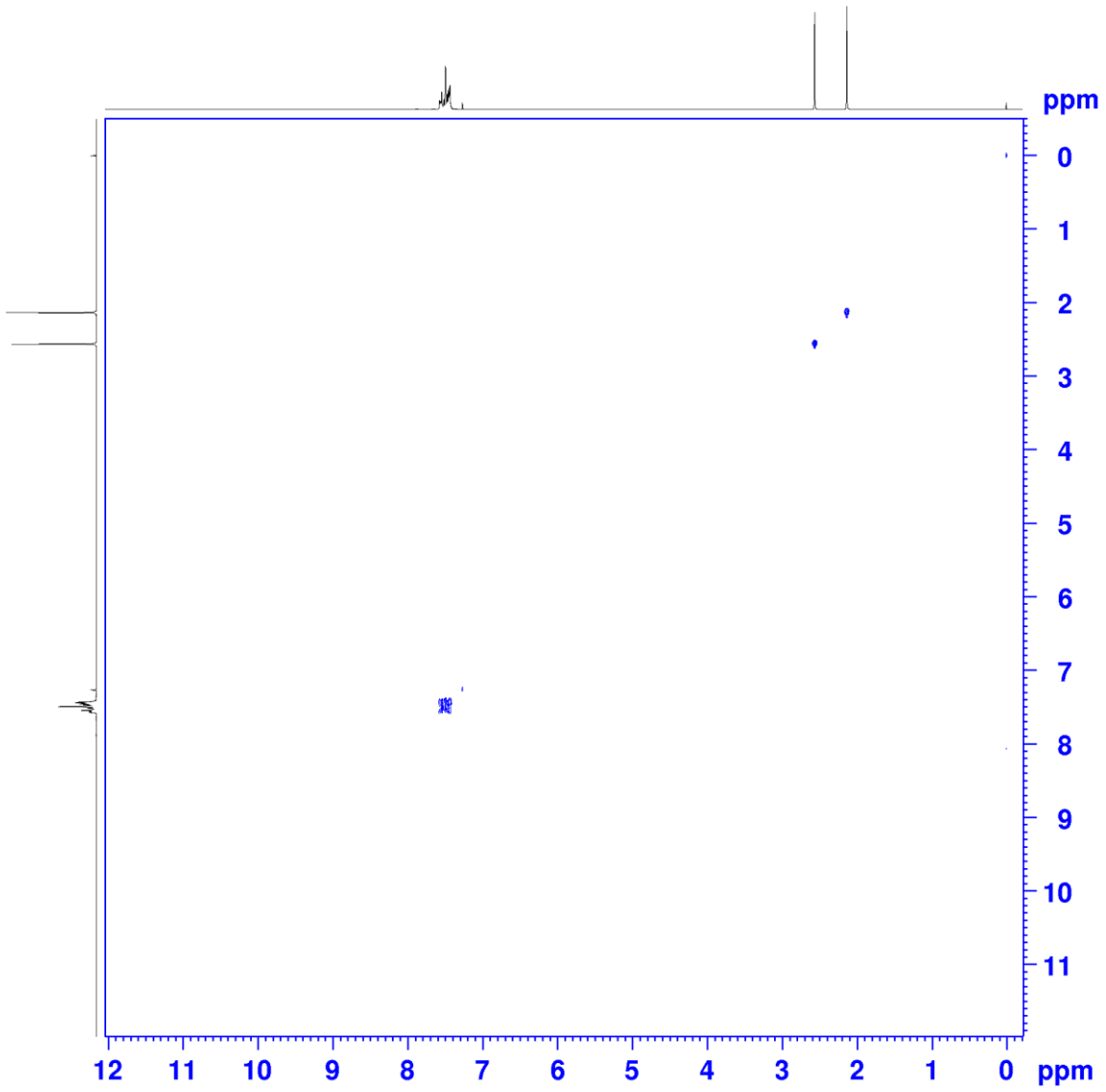
^{1}H NMR



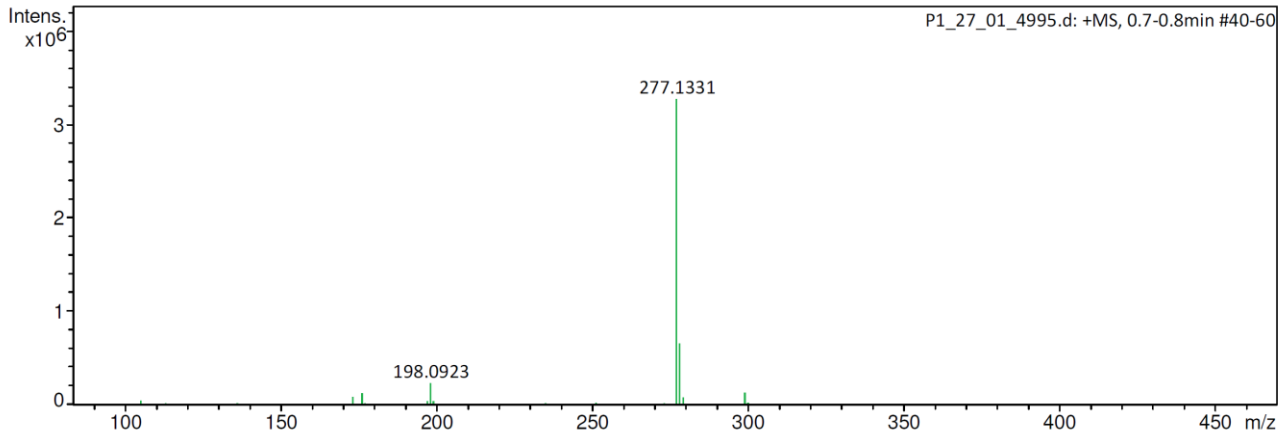
^{13}C NMR


195.94
153.32
143.70
138.56
133.71
129.44
129.25
128.73
128.70
128.41
125.76
120.56
30.83
12.82
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

COSY NMR

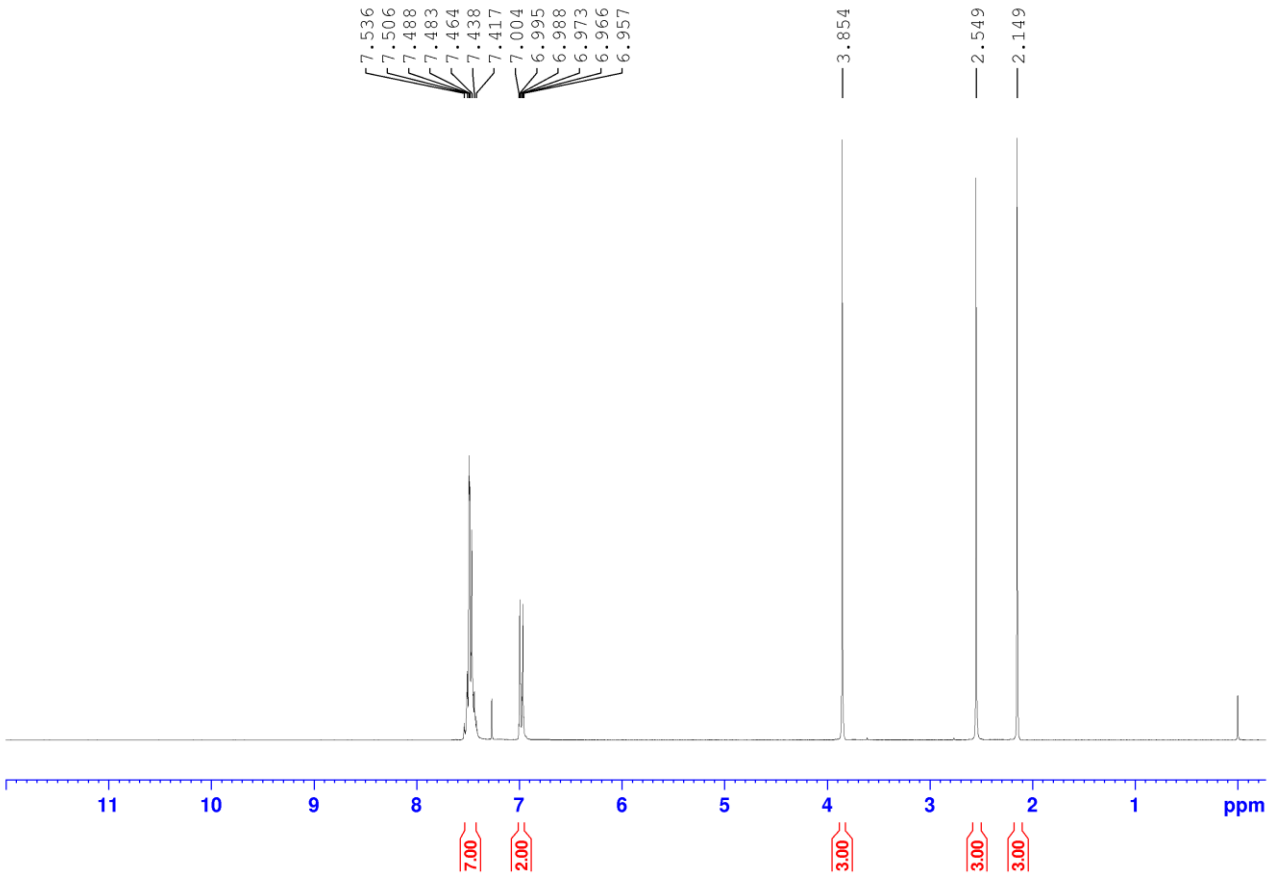


HRMS

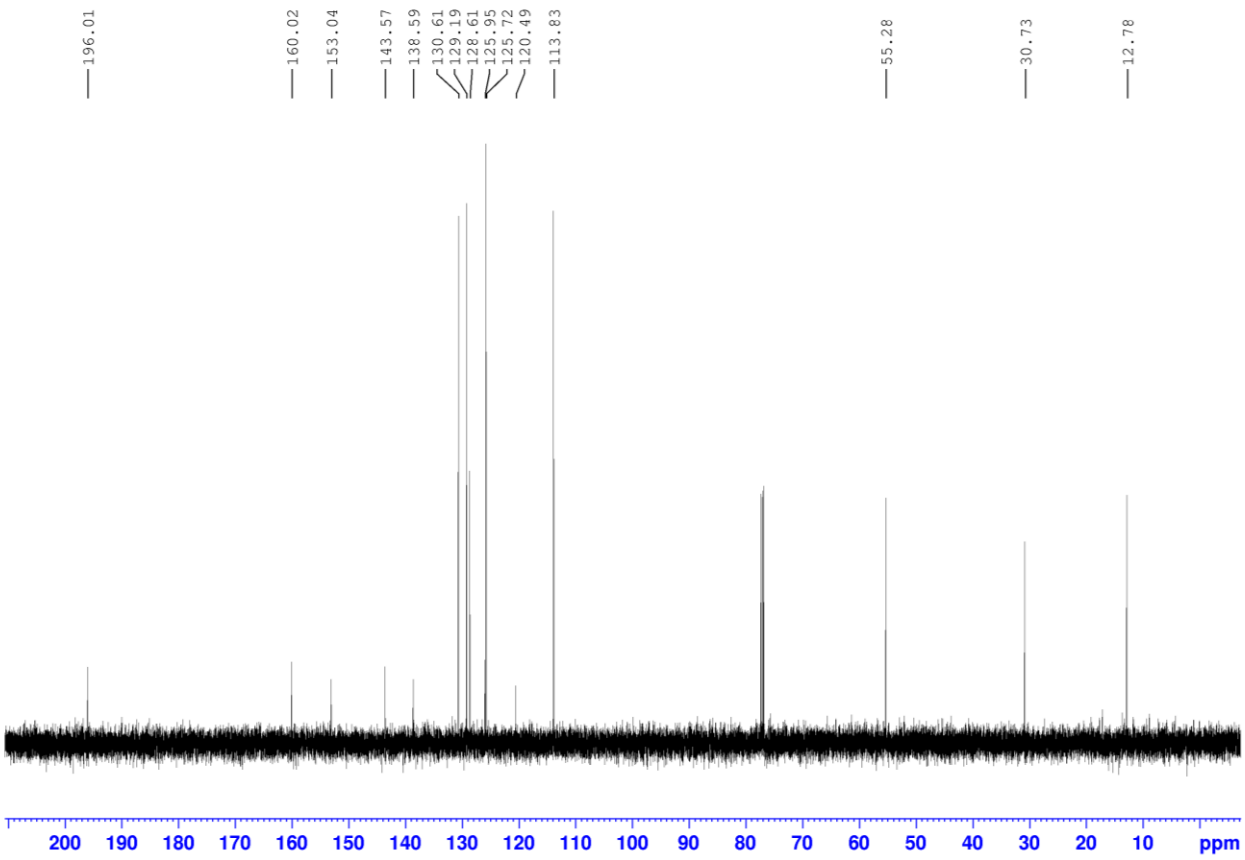

Intens.
x10^6
P1_27_01_4995.d: +MS, 0.7-0.8min #40-60
277.1331
198.0923
0
1
2
3
100
150
200
250
300
350
400
450
m/z

1-(3-(4-Methoxyphenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone (6b)

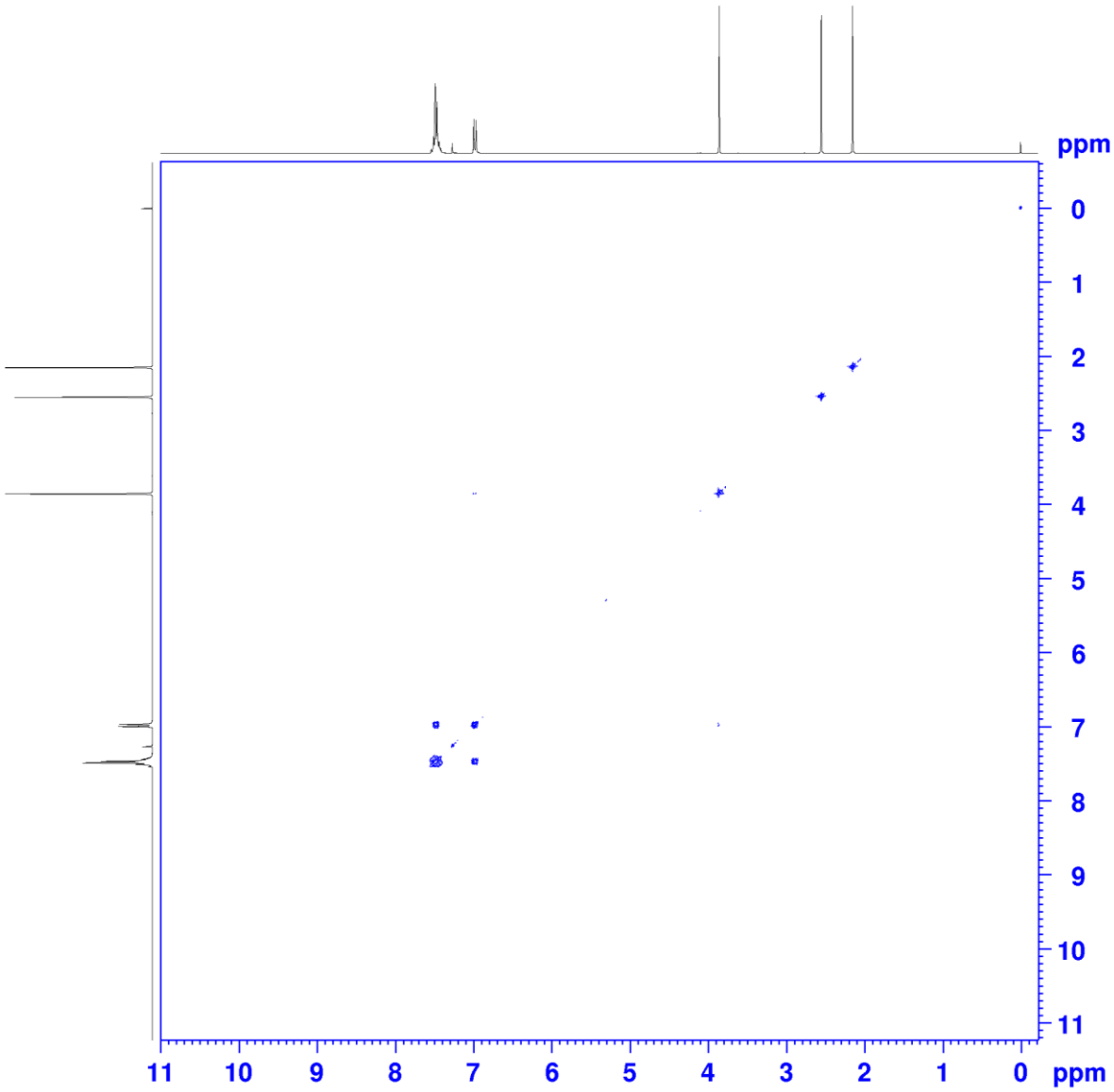
^{1}H NMR



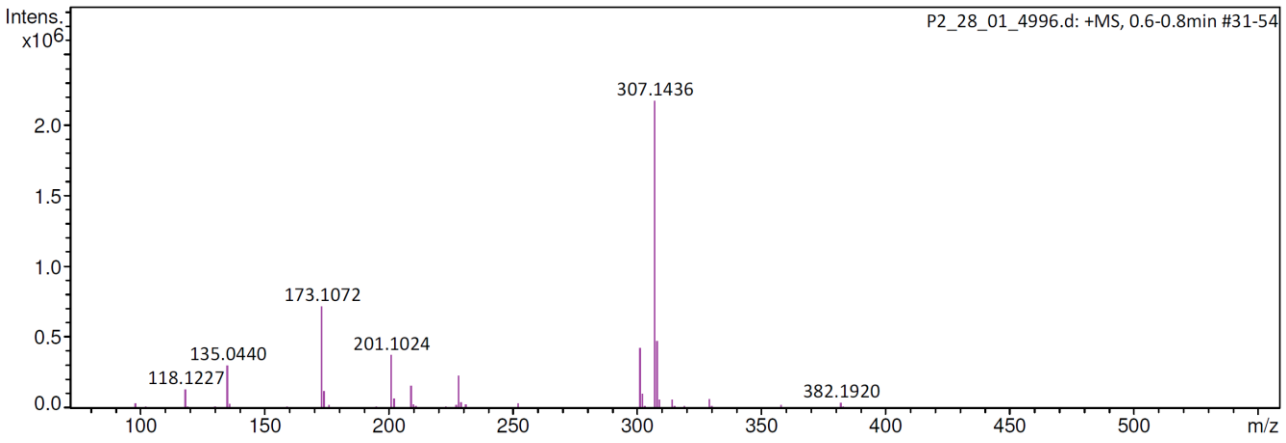
^{13}C NMR


196.01
160.02
153.04
143.57
138.59
130.61
129.19
128.61
125.95
125.72
120.49
113.83
55.28
30.73
12.78
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

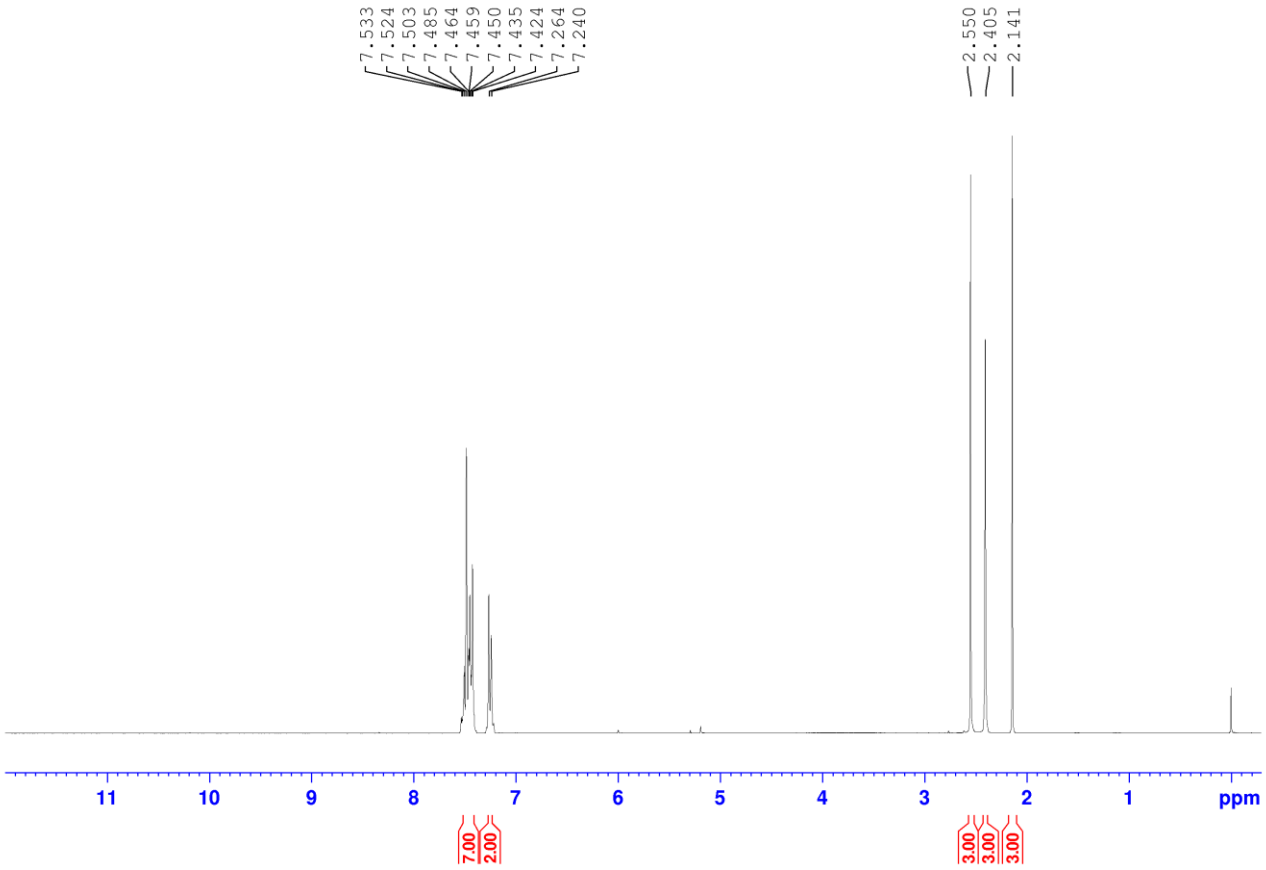


HRMS

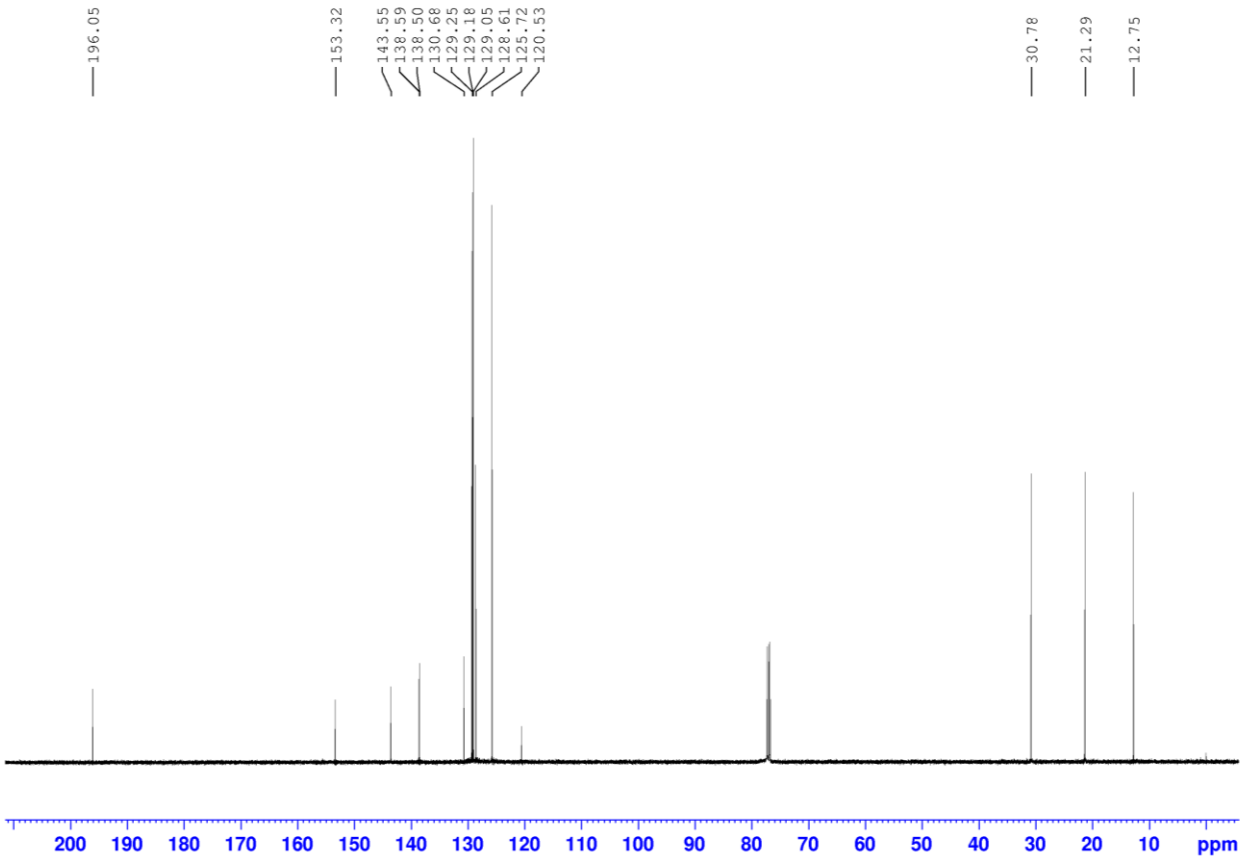

Intens.
x10^6
P2_28_01_4996.d: +MS, 0.6-0.8min #31-54
307.1436
173.1072
201.1024
135.0440
118.1227
382.1920
m/z

1-(5-Methyl-1-phenyl-3-(*p*-tolyl)-1*H*-pyrazol-4-yl)ethanone (6c)

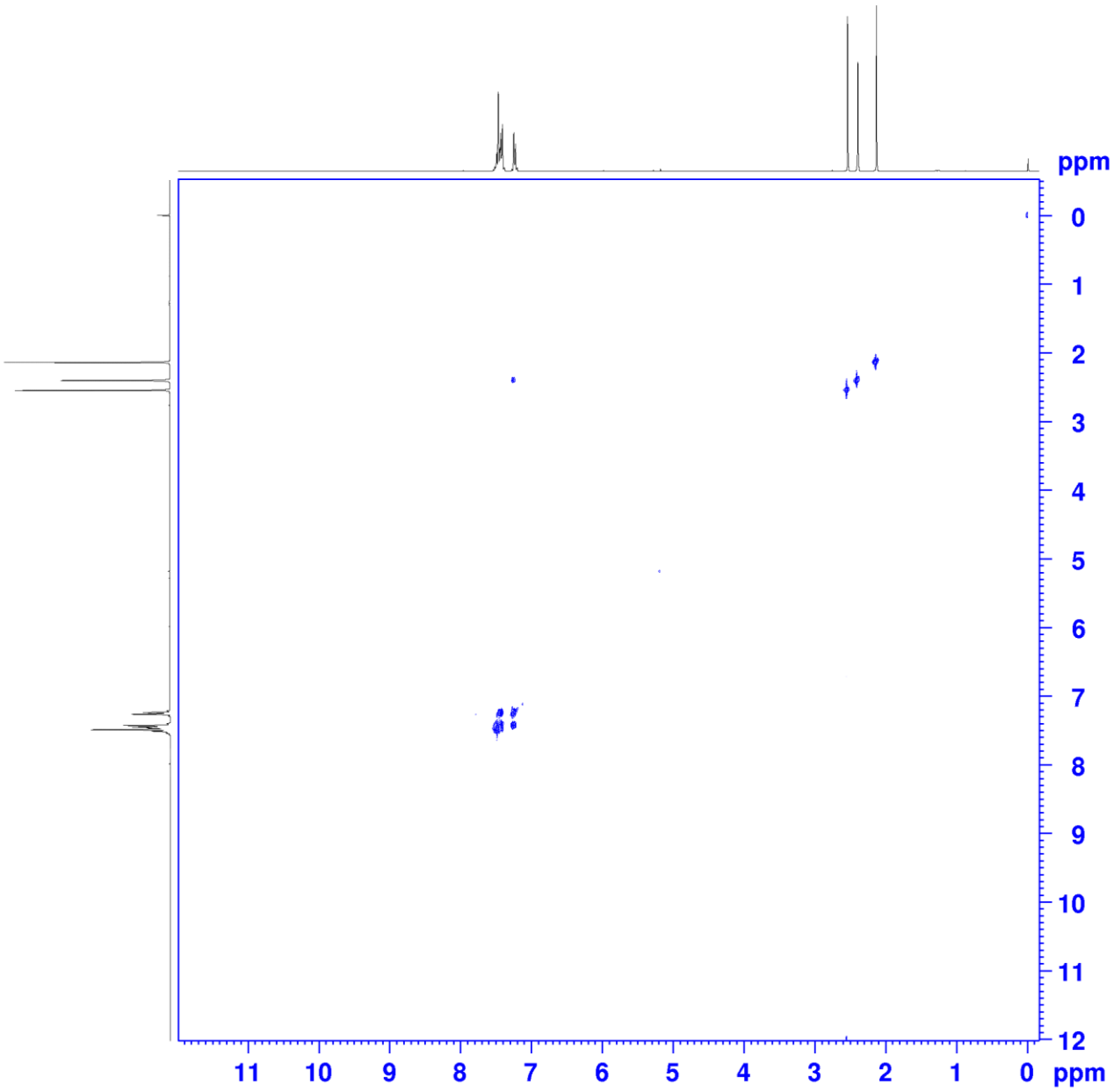
^{1}H NMR



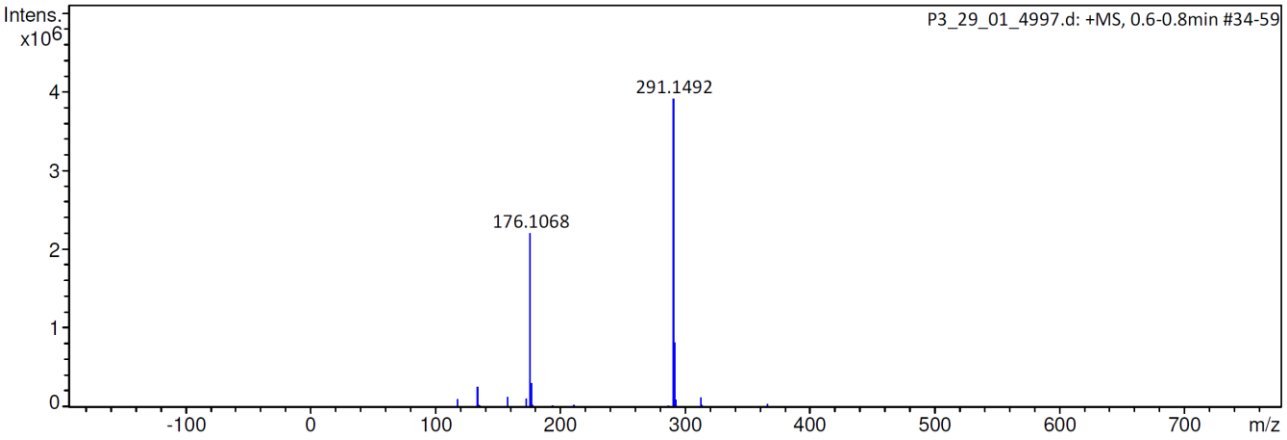
^{13}C NMR


196.05
153.32
143.55
138.59
138.50
130.68
129.25
129.18
129.05
128.61
125.72
120.53
30.78
21.29
12.75
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

COSY NMR

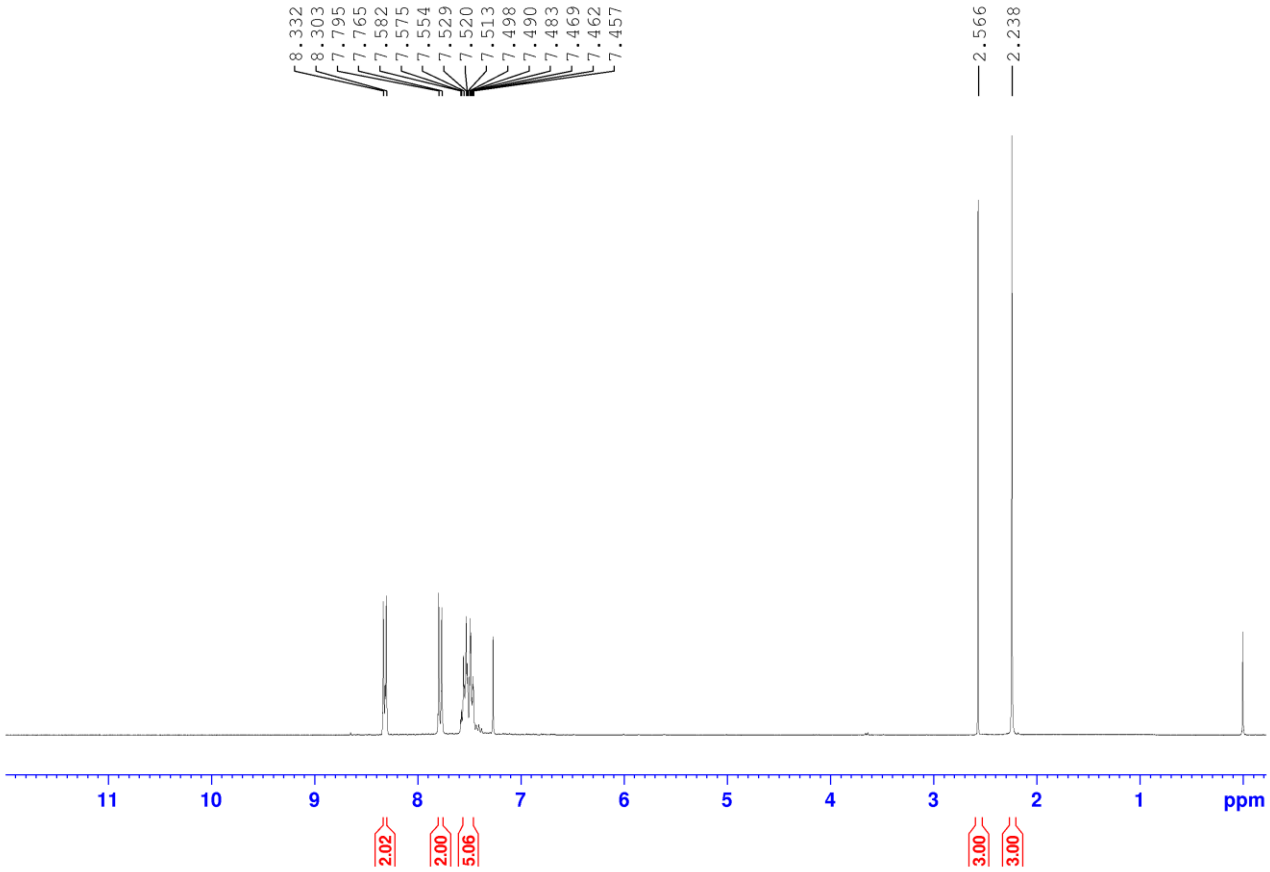


HRMS

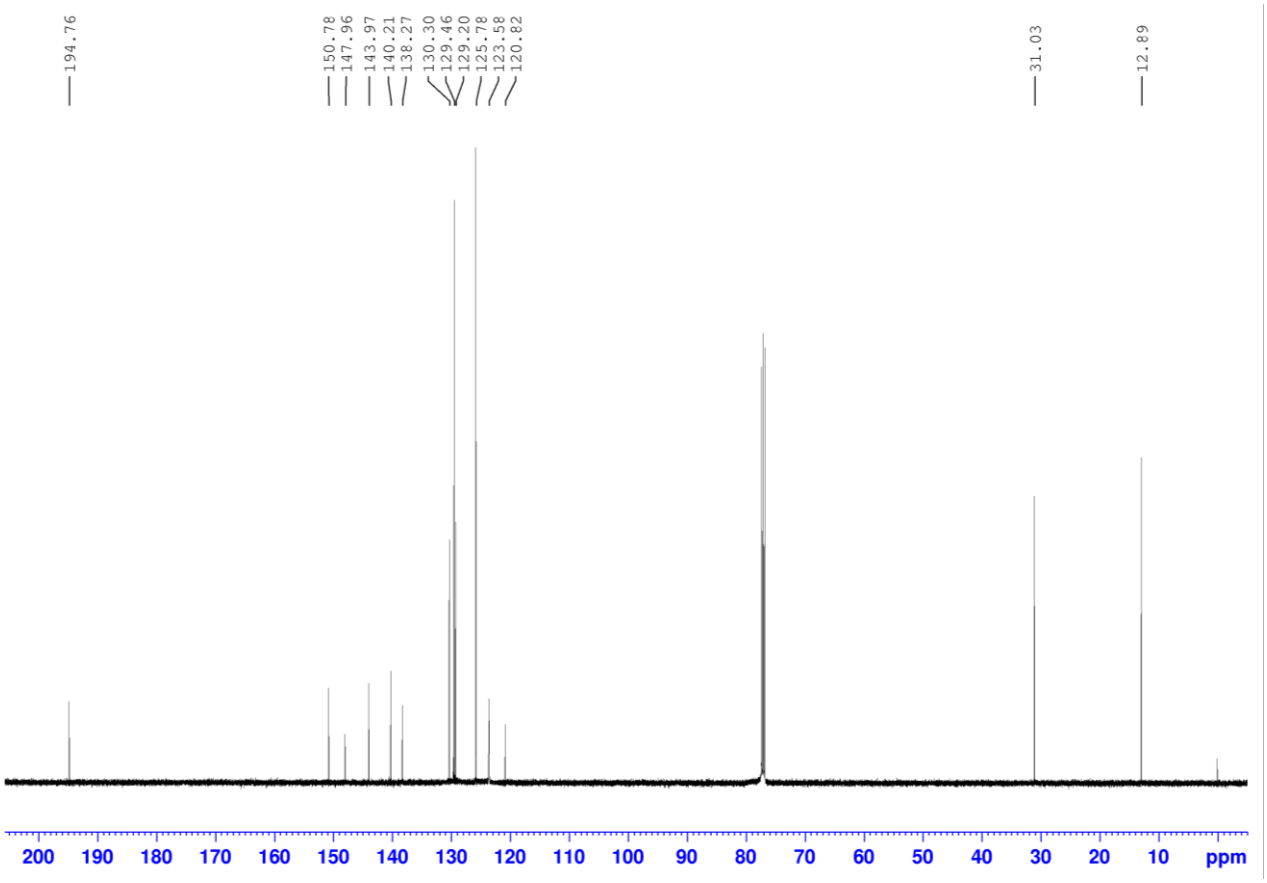

Intens.
x10^6
4
3
2
1
0
P3_29_01_4997.d: +MS, 0.6-0.8min #34-59
291.1492
176.1068
-100
0
100
200
300
400
500
600
700
m/z

1-(5-Methyl-3-(4-nitrophenyl)-1-phenyl-1*H*-pyrazol-4-yl)ethanone (6d)

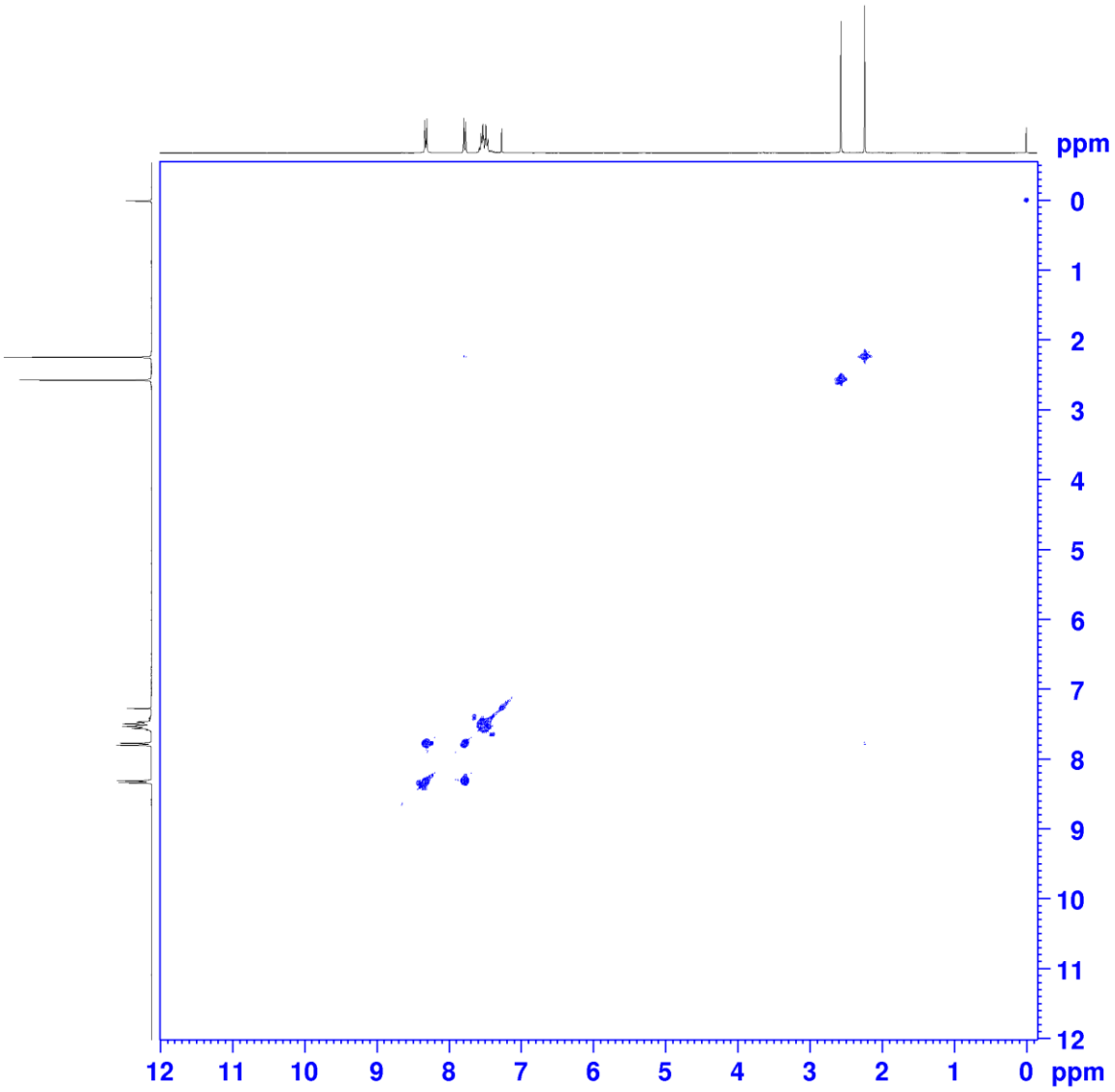
^{1}H NMR



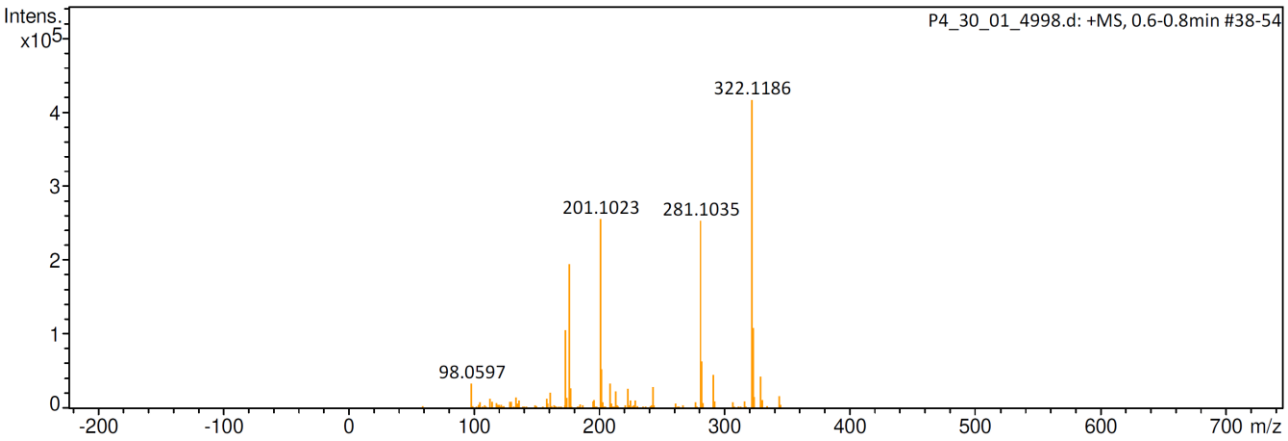
^{13}C NMR


194.76
150.78
147.96
143.97
140.21
138.27
130.30
129.46
129.20
125.78
123.58
120.82
31.03
12.89
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

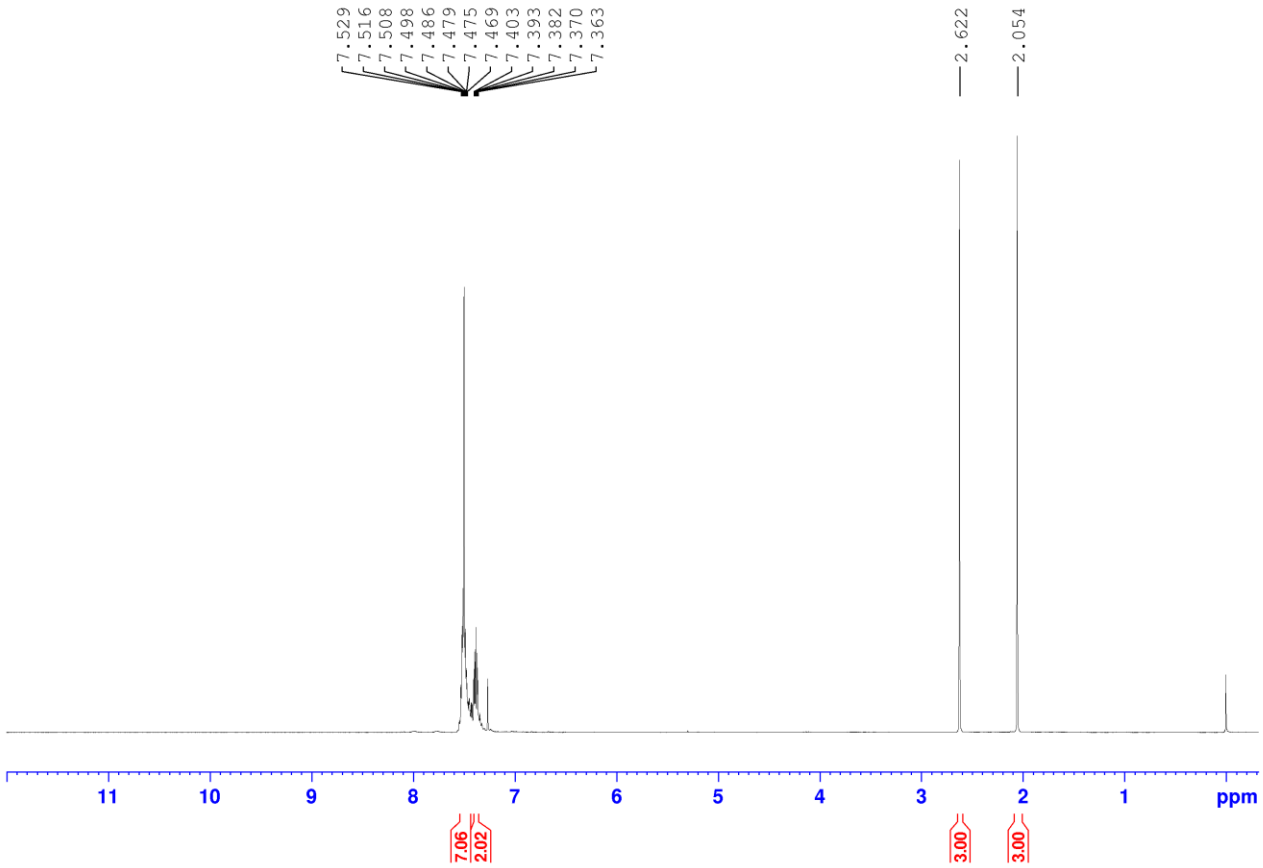


HRMS

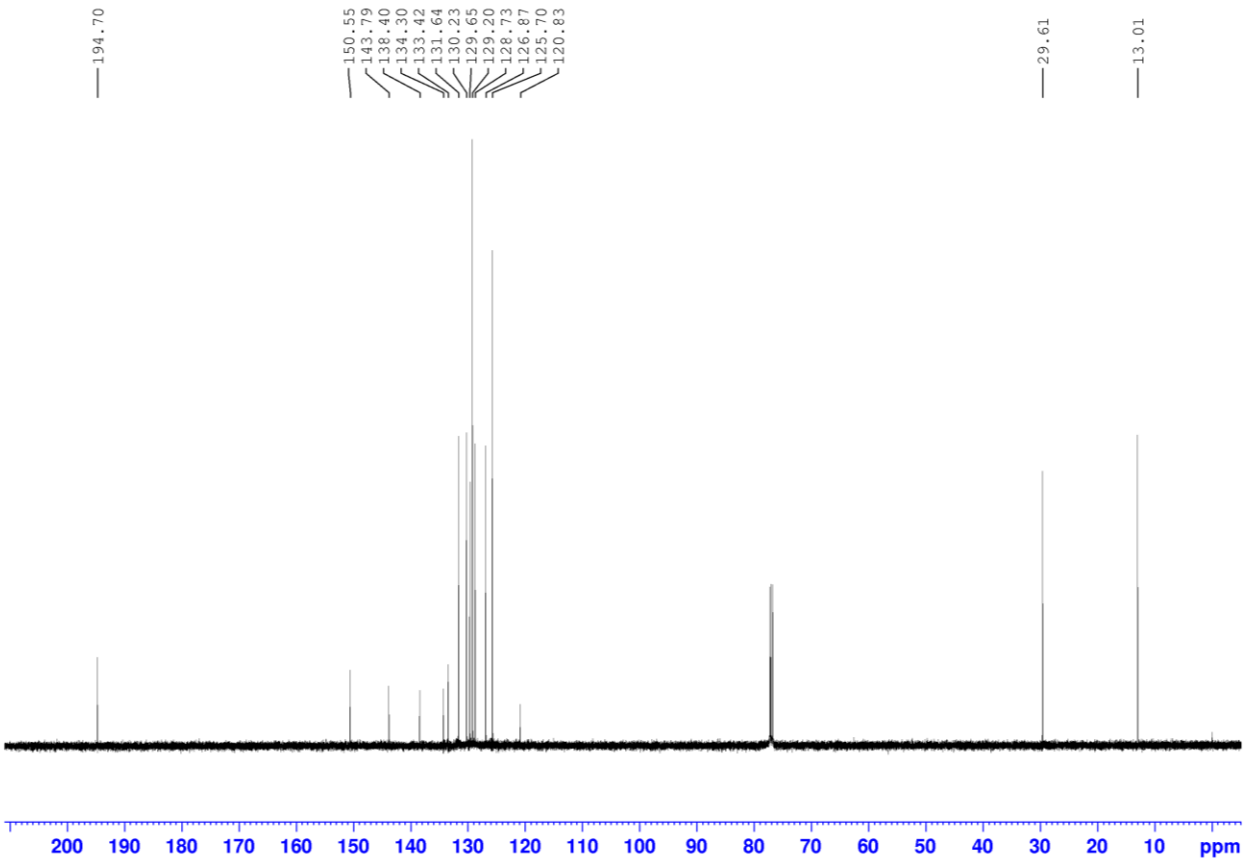

Intens.
x10^5
P4_30_01_4998.d: +MS, 0.6-0.8min #38-54
322.1186
201.1023
281.1035
98.0597
0
1
2
3
4
-200
-100
0
100
200
300
400
500
600
700 m/z

1-(3-(2-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone (6e)

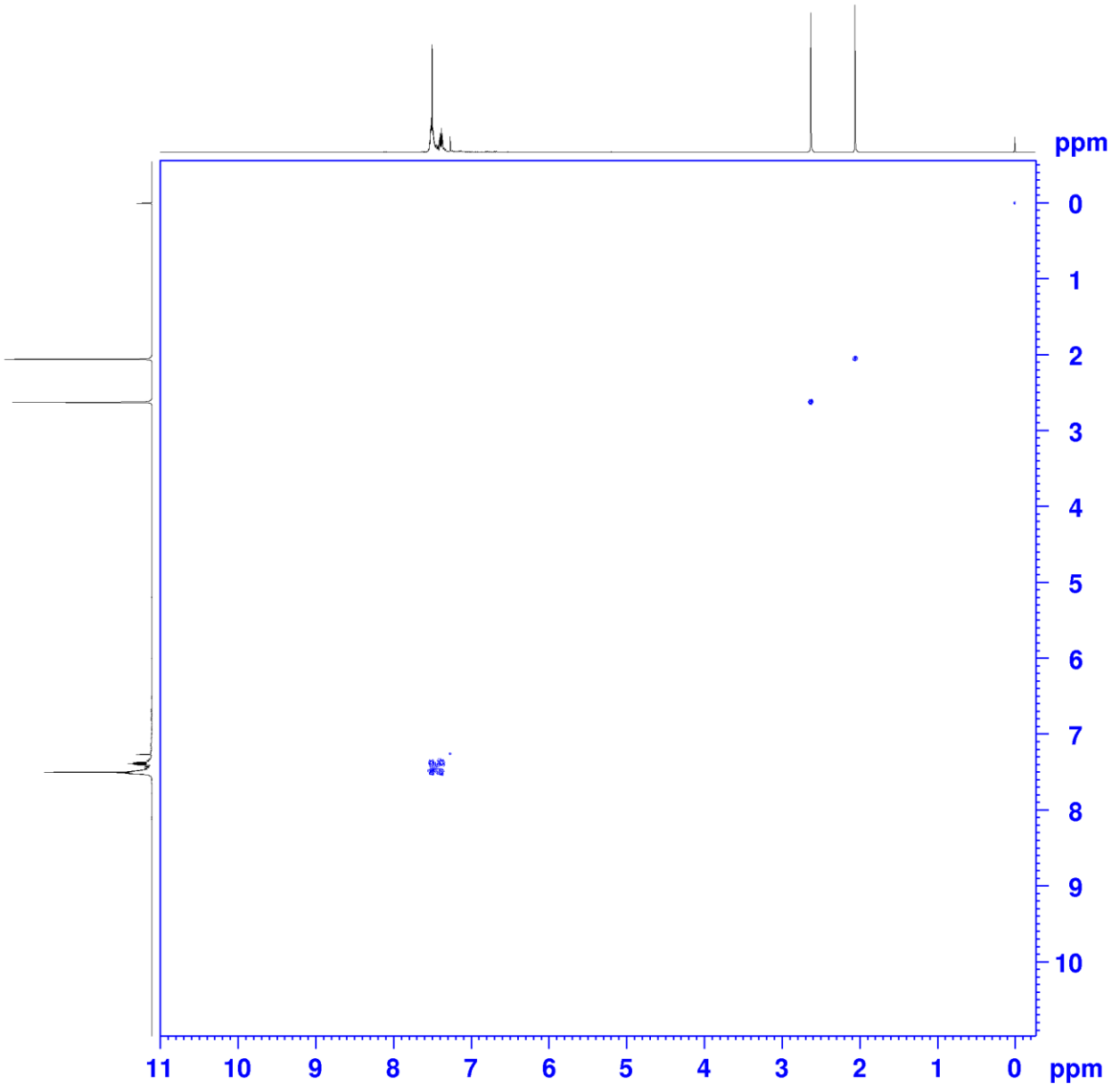
^{1}H NMR



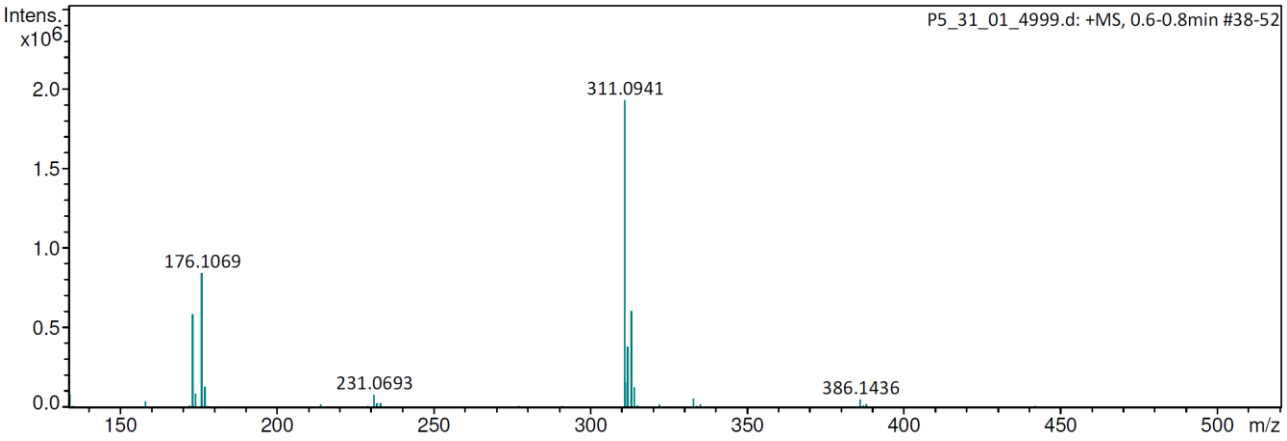
^{13}C NMR


194.70
150.55
143.79
138.40
134.30
133.42
131.64
130.23
129.65
129.20
128.73
126.87
125.70
120.83
29.61
13.01
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

COSY NMR

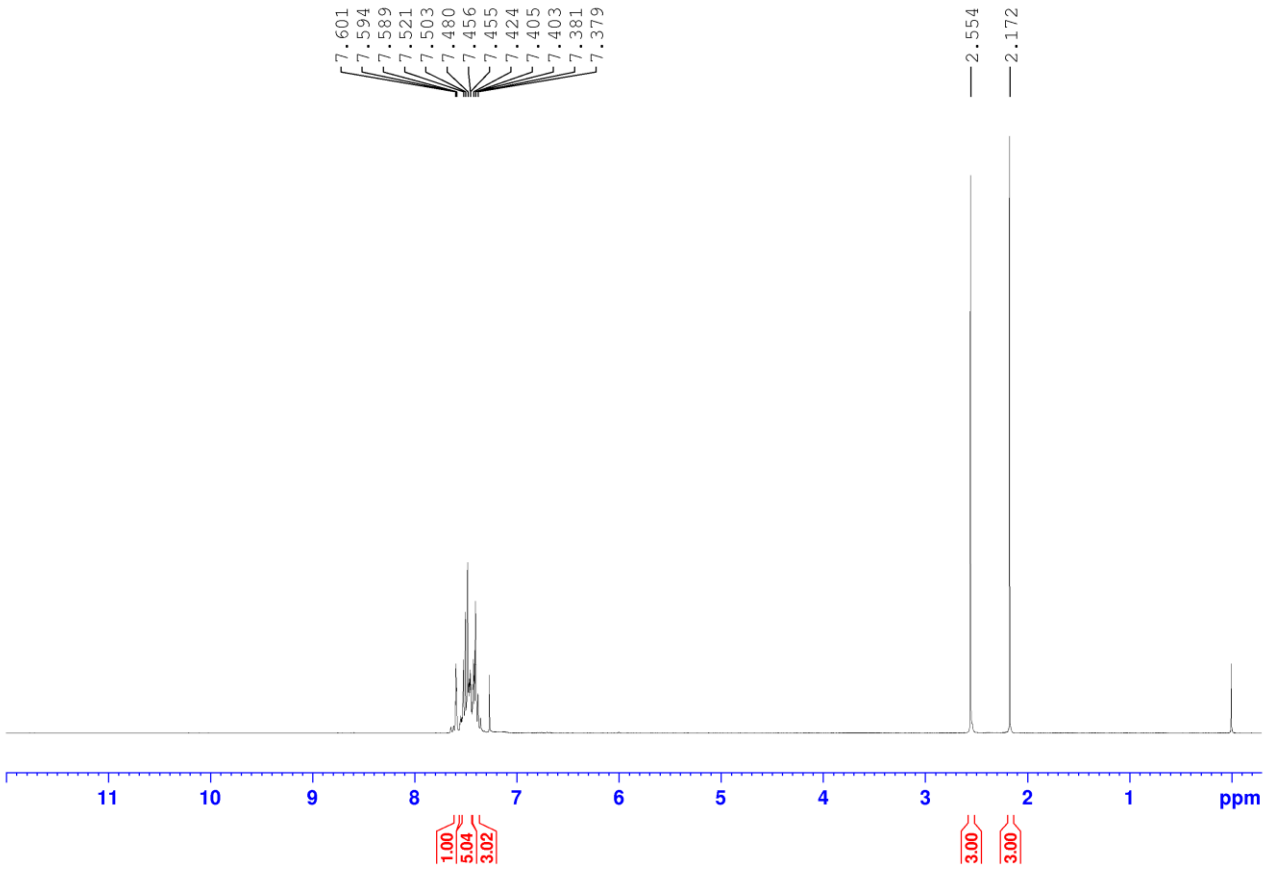


HRMS

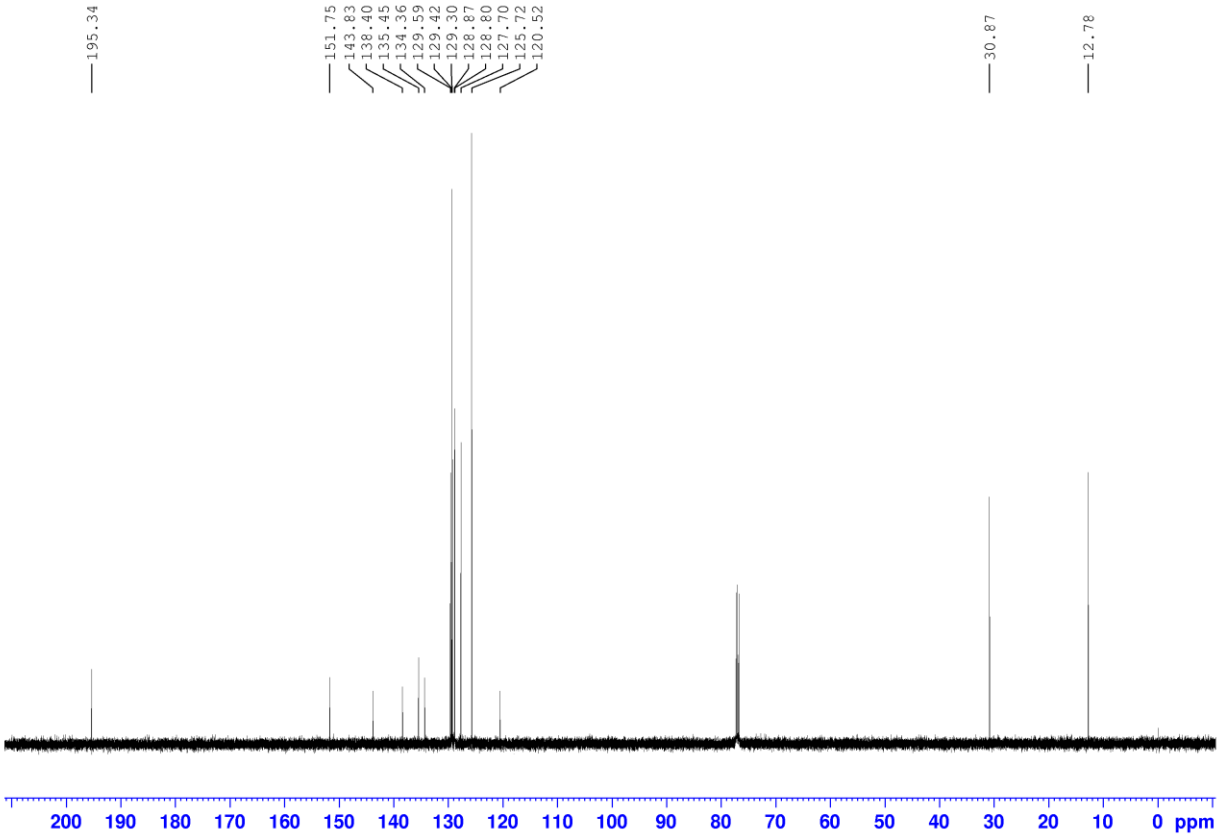

Intens.
x10^6
2.0
1.5
1.0
0.5
0.0
P5_31_01_4999.d: +MS, 0.6-0.8min #38-52
311.0941
176.1069
231.0693
386.1436
150
200
250
300
350
400
450
500
m/z

1-(3-(3-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone (6f)

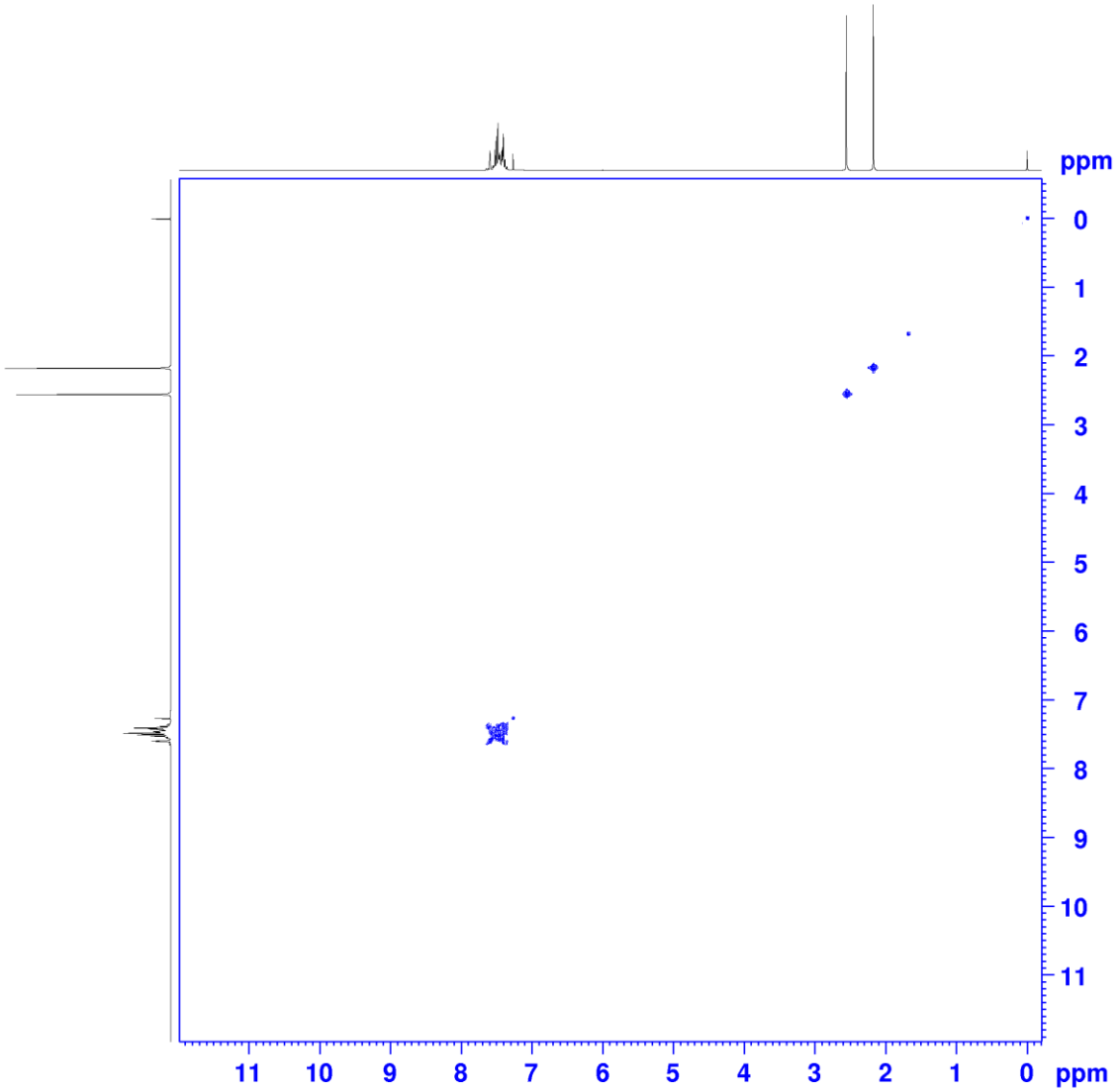
^{1}H NMR



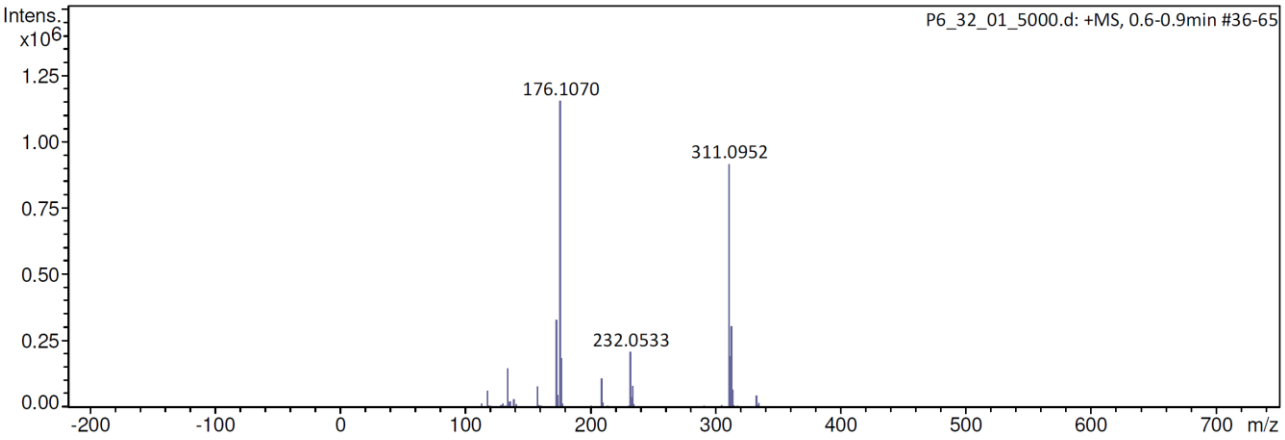
^{13}C NMR


195.34
151.75
143.83
138.40
135.45
134.36
129.59
129.42
129.30
128.87
128.80
127.70
125.72
120.52
30.87
12.78
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

COSY NMR

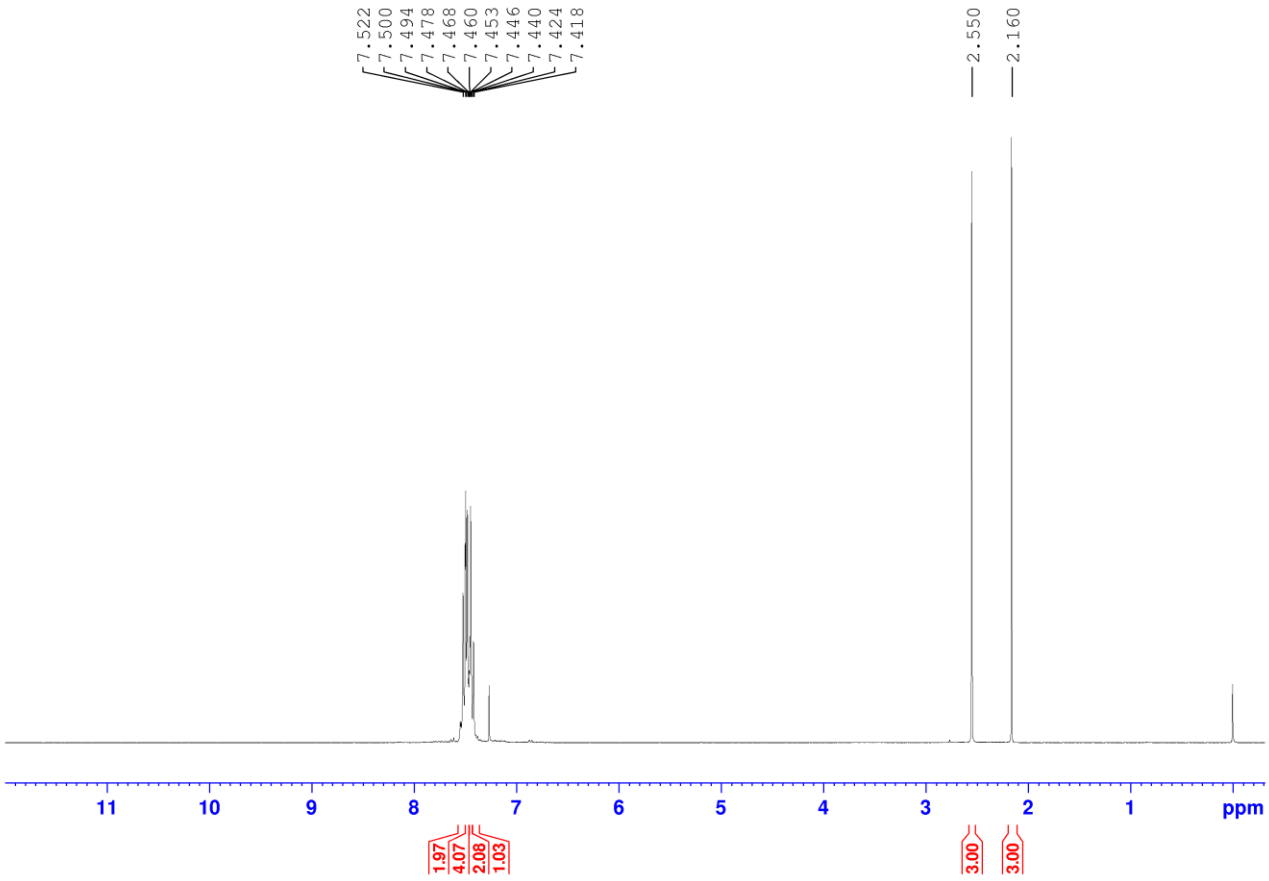


HRMS

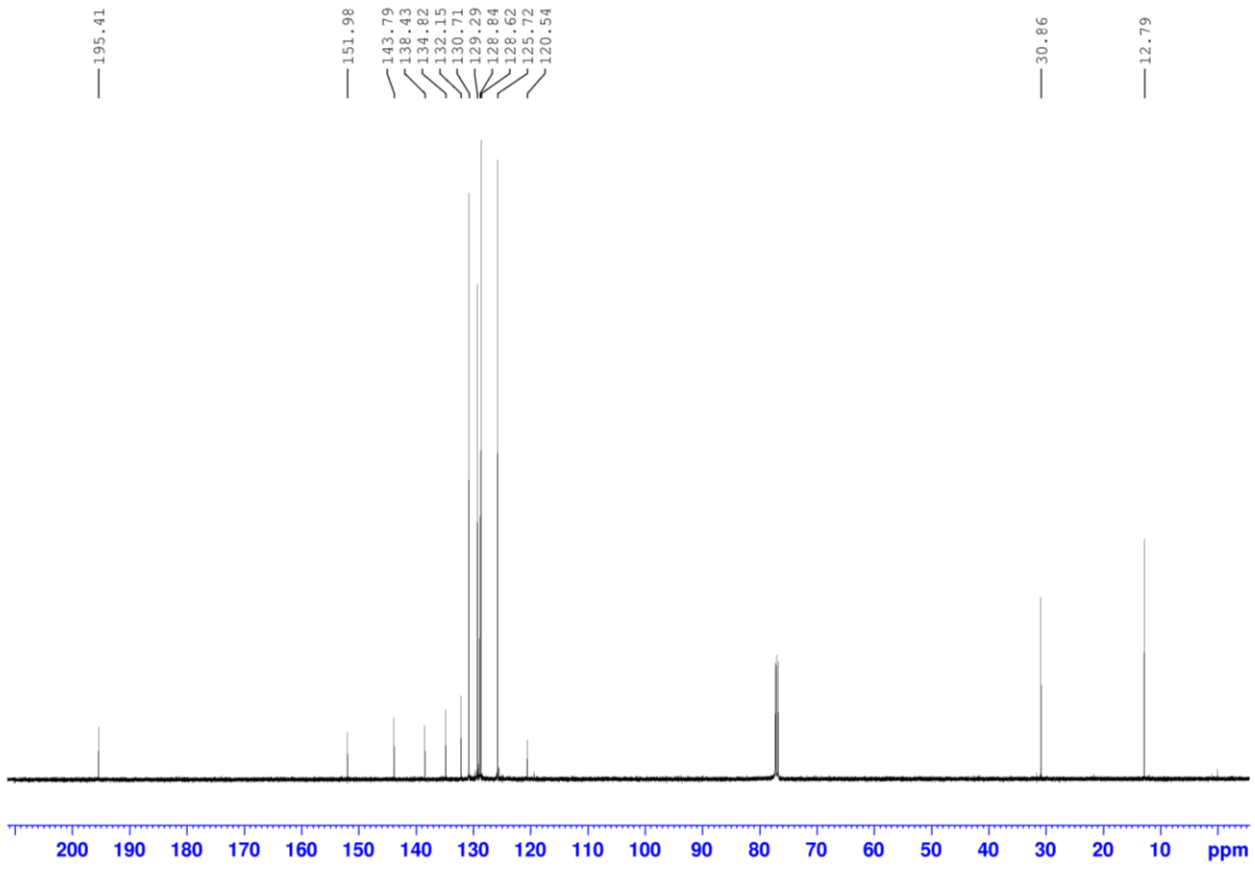

Intens.
x10^6
1.25
1.00
0.75
0.50
0.25
0.00
P6_32_01_5000.d: +MS, 0.6-0.9min #36-65
176.1070
311.0952
232.0533
-200
-100
0
100
200
300
400
500
600
700
m/z

1-(3-(4-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)ethanone (6g)

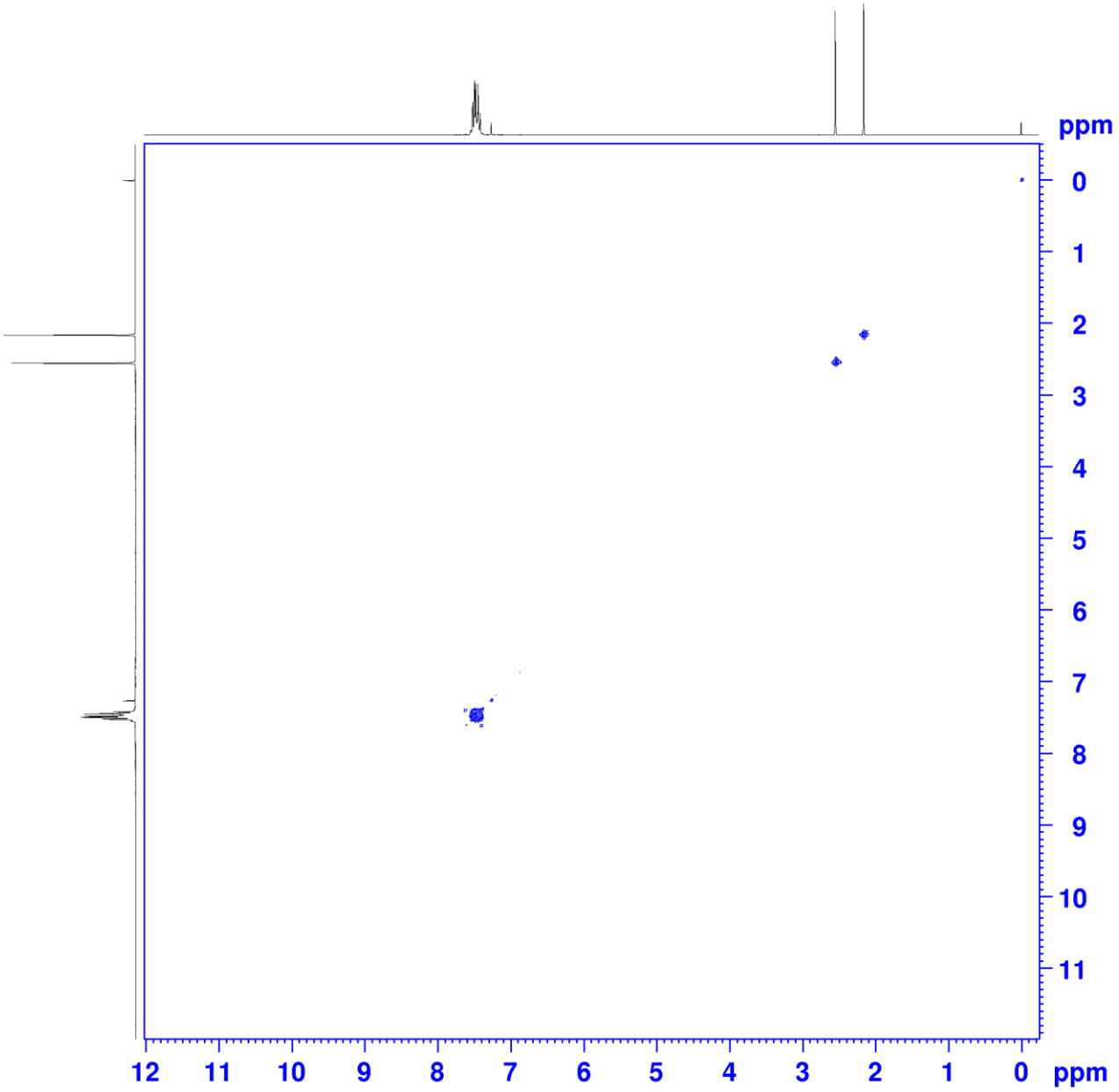
^{1}H NMR



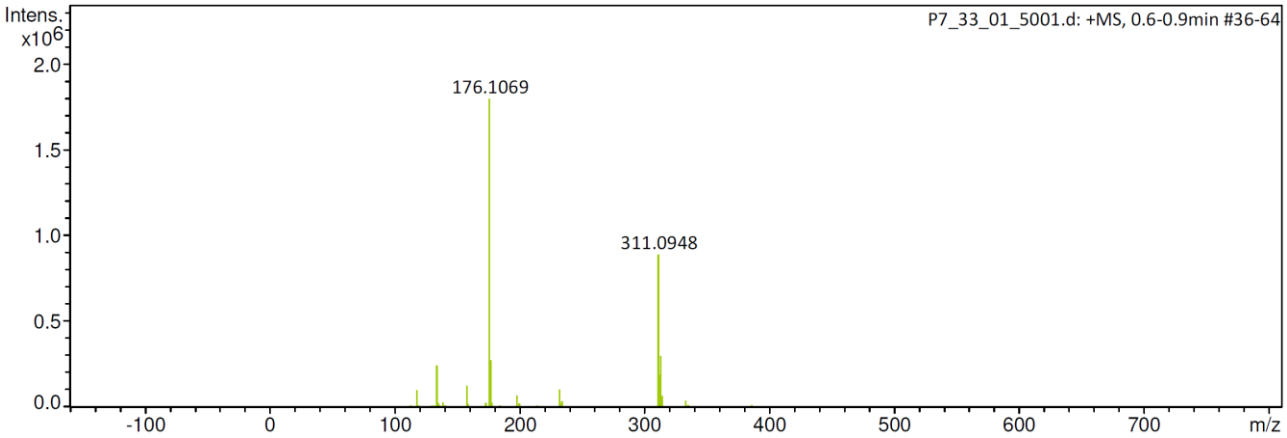
^{13}C NMR


195.41
151.98
143.79
138.43
134.82
132.15
130.71
129.29
128.84
128.62
125.72
120.54
30.86
12.79
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

COSY NMR



HRMS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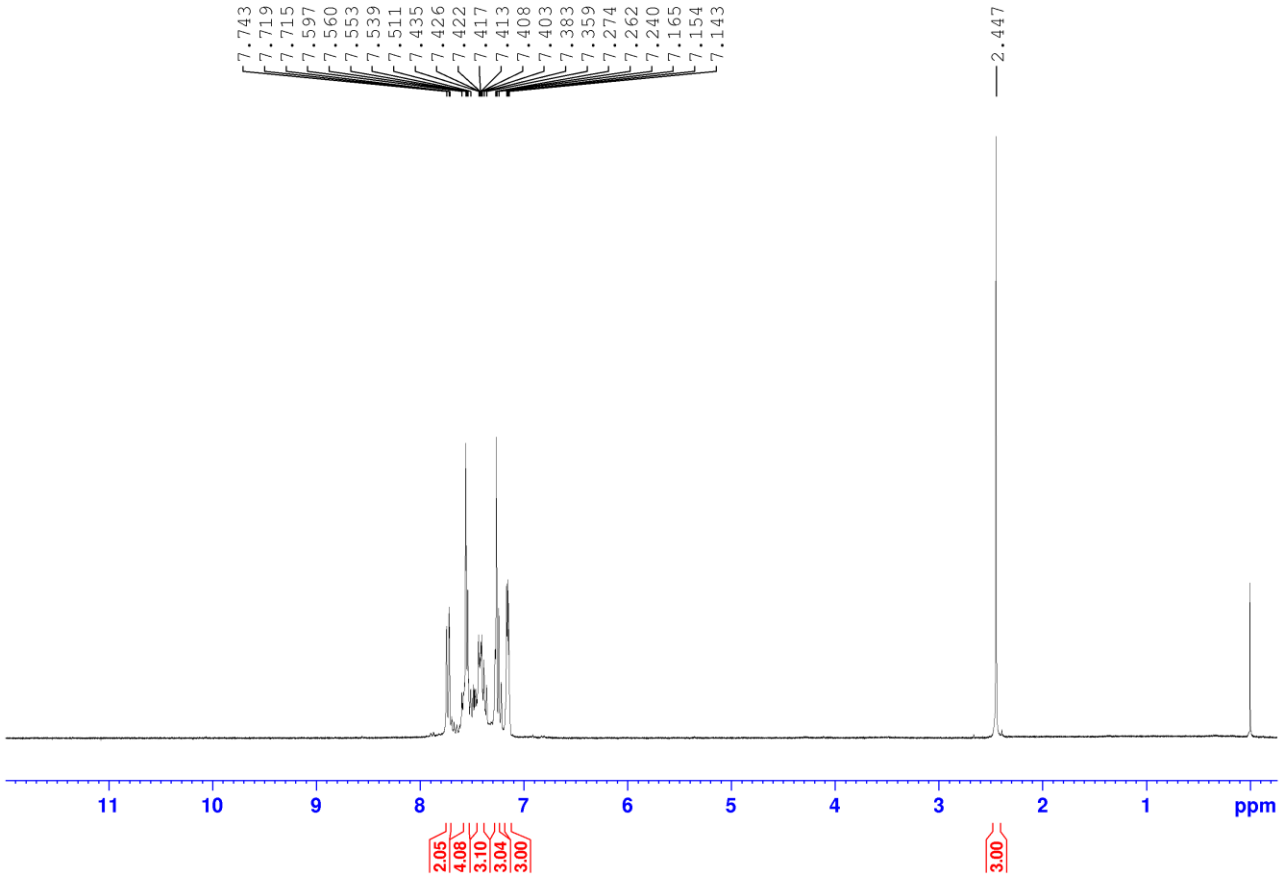
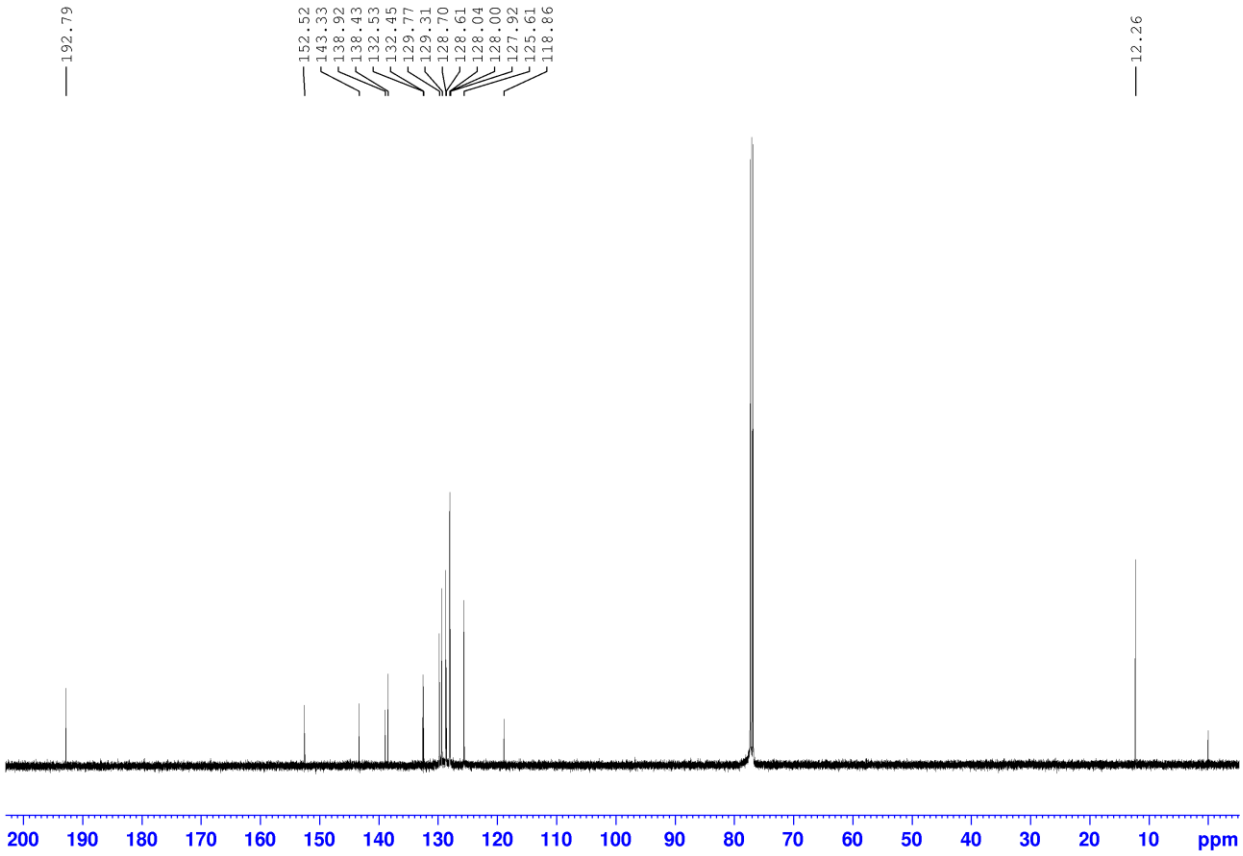
x10^6
2.0
1.5
1.0
0.5
0.0
P7_33_01_5001.d: +MS, 0.6-0.9min #36-64
176.1069
311.0948
-100
0
100
200
300
400
500
600
700
m/z

(5-Methyl-1,3-diphenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6h)

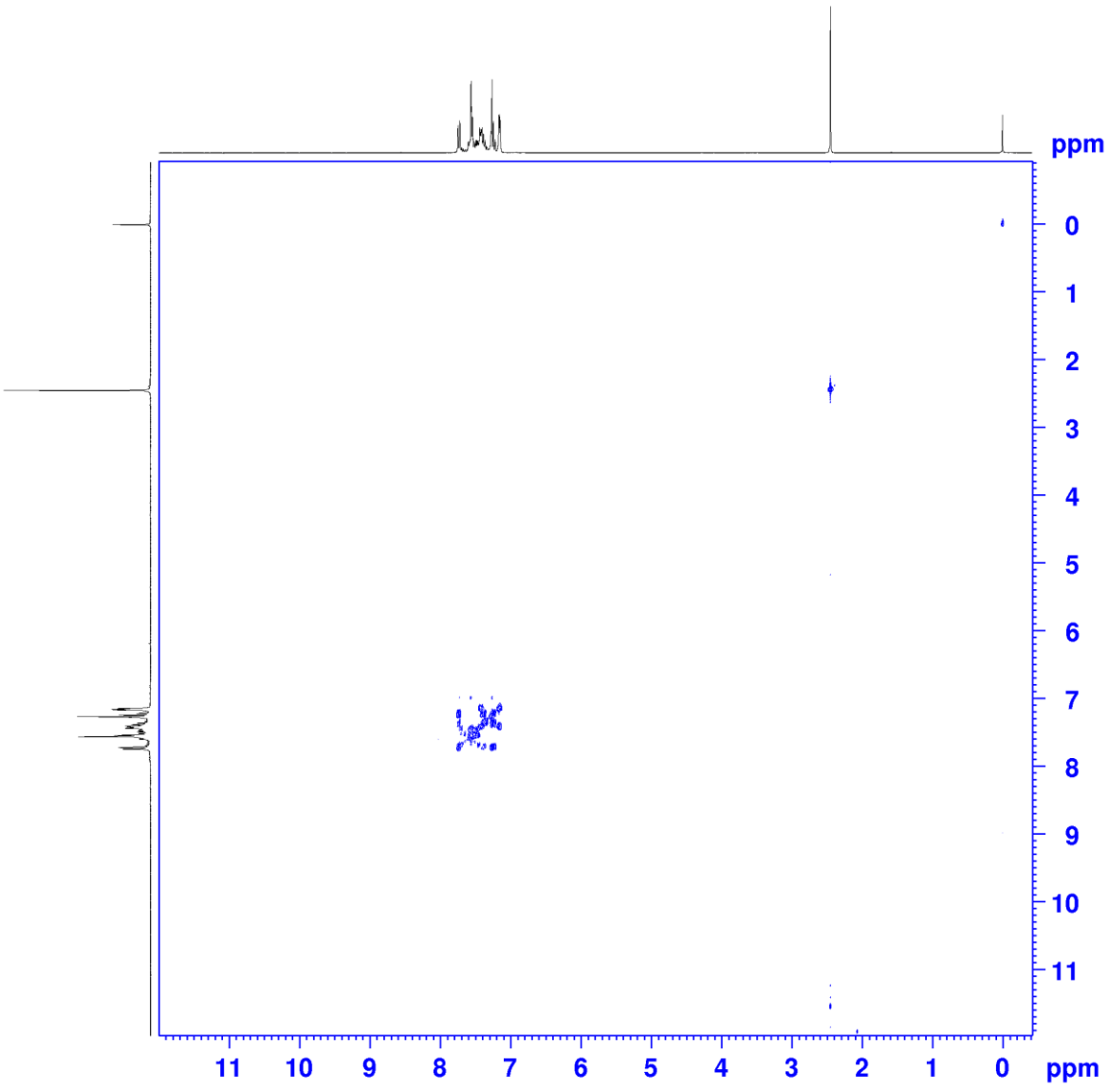
^{1}H NMR



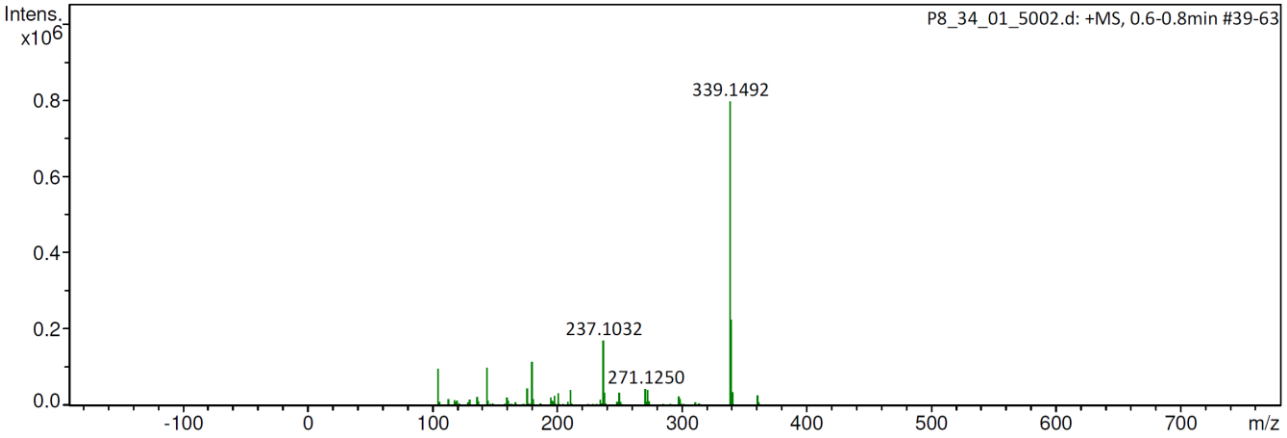
^{13}C NMR


192.79
152.52
143.33
138.92
138.43
132.53
132.45
129.77
129.31
128.70
128.61
128.04
128.00
127.92
125.61
118.86
12.26
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

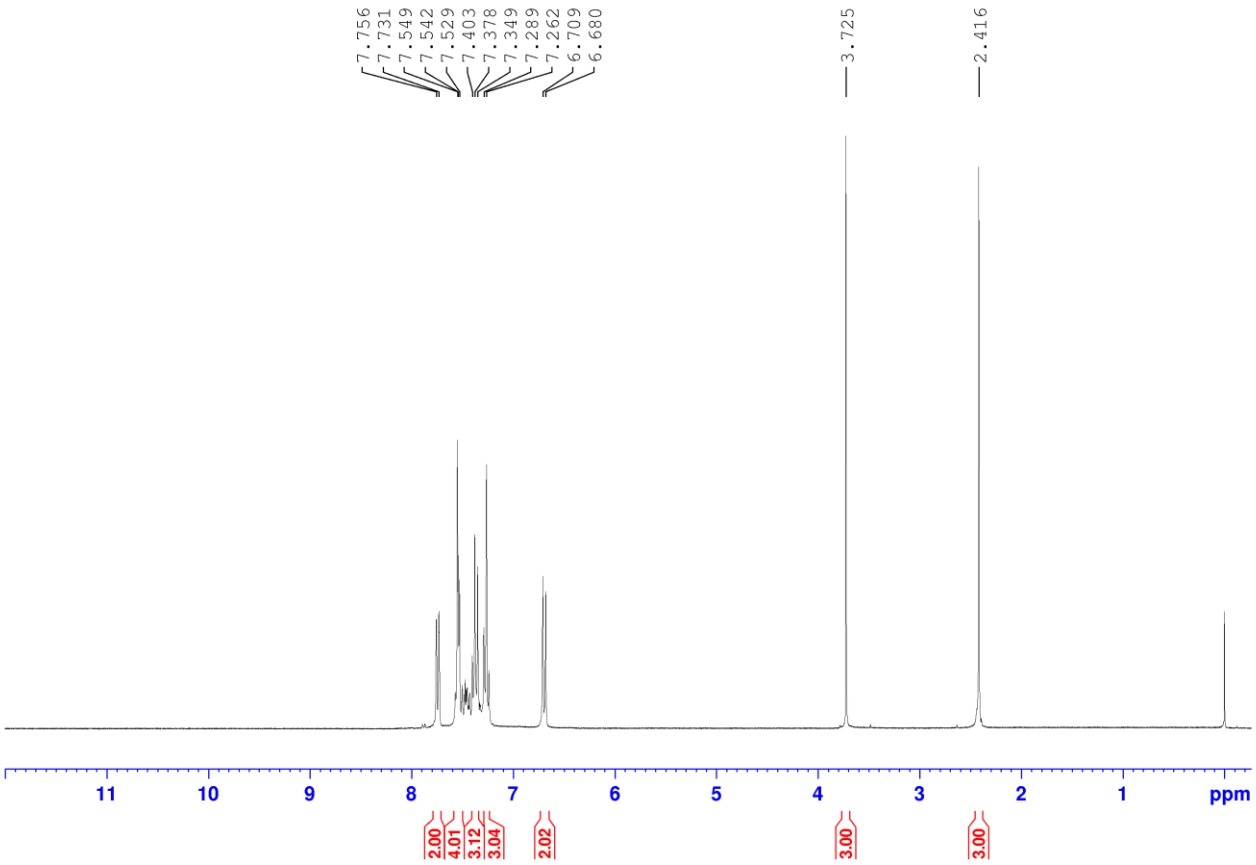


HRMS

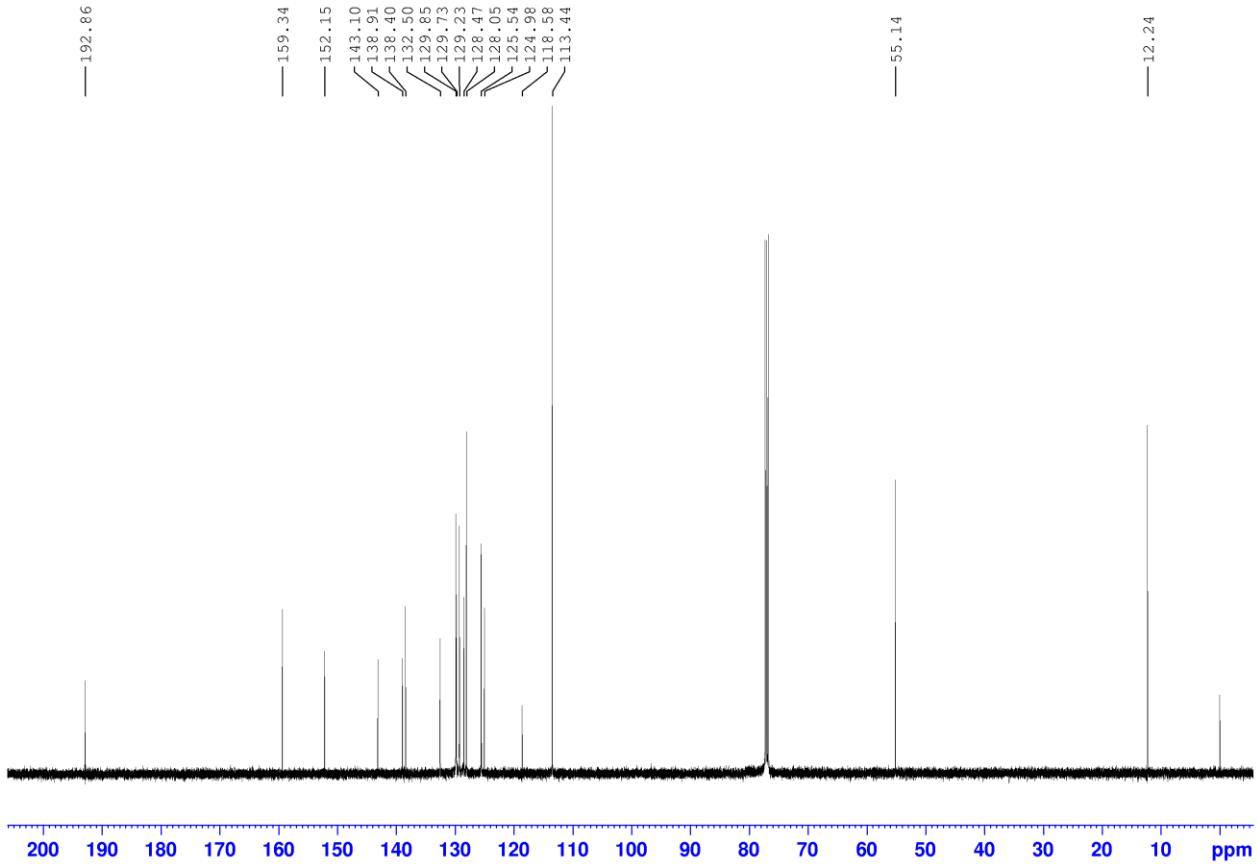

Intens.
x10^6
P8_34_01_5002.d: +MS, 0.6-0.8min #39-63
0.8
0.6
0.4
0.2
0.0
339.1492
237.1032
271.1250
-100
0
100
200
300
400
500
600
700
m/z

(3-(4-Methoxyphenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6i)

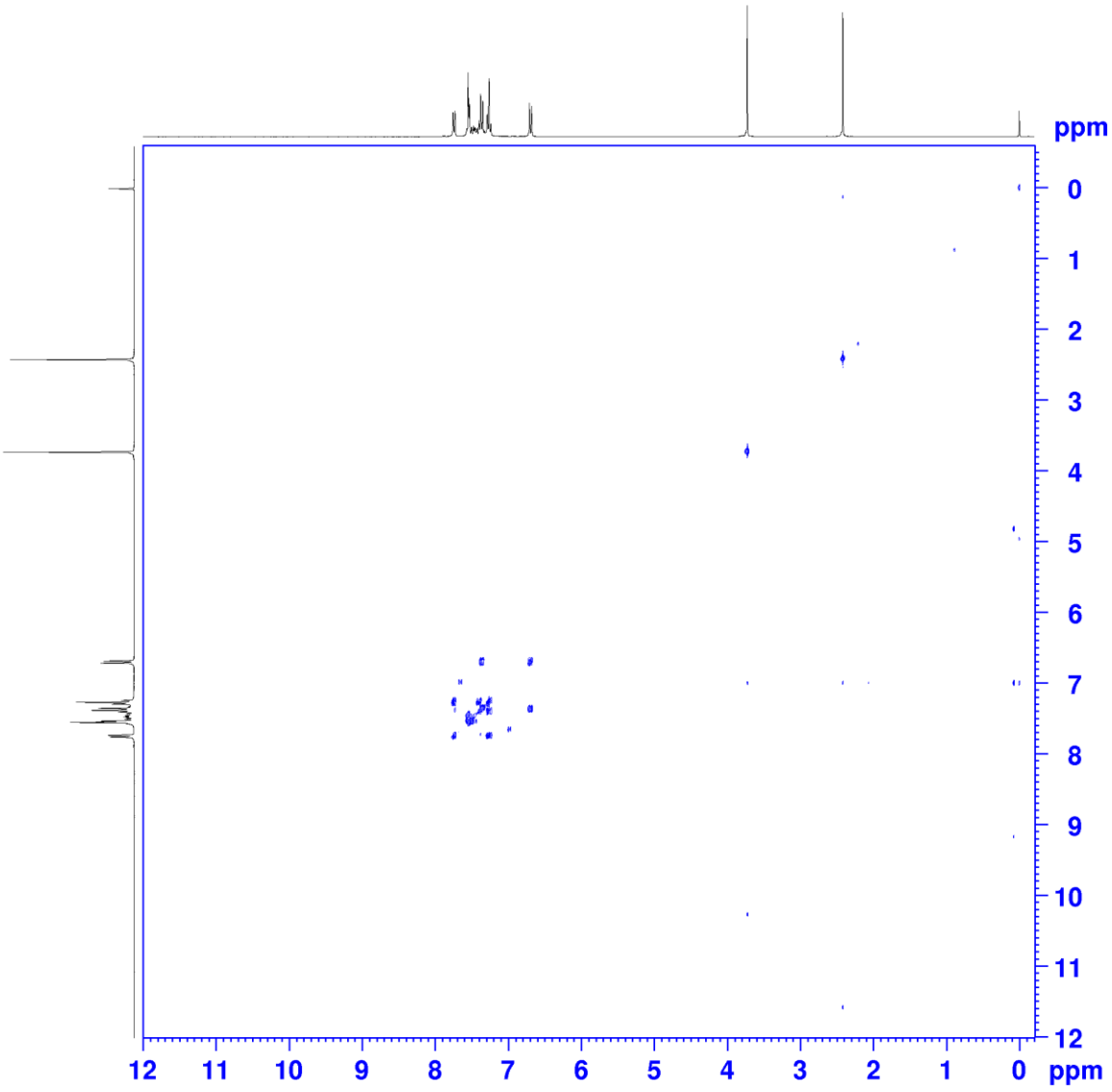
^{1}H NMR



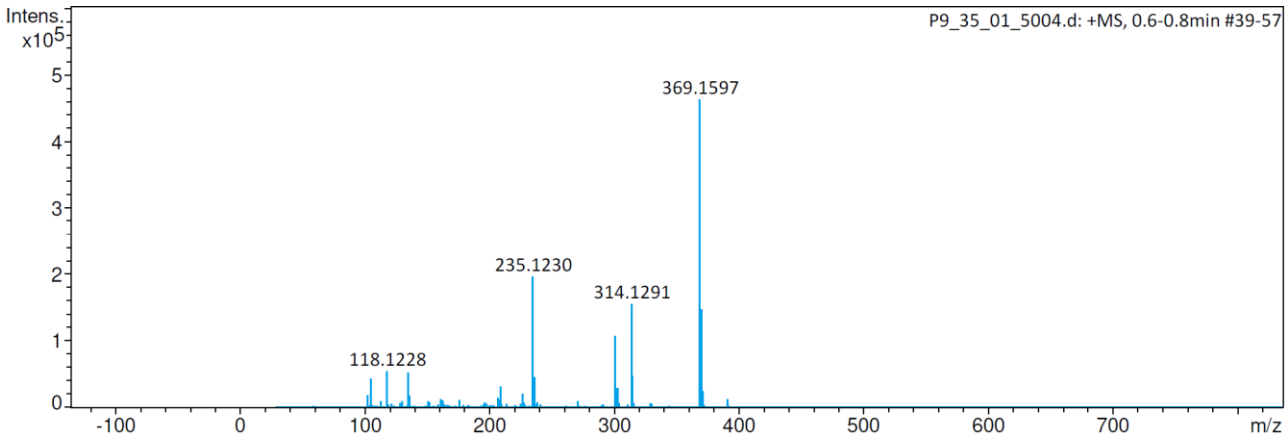
^{13}C NMR


192.86
159.34
152.15
143.10
138.91
138.40
132.50
129.85
129.73
129.23
128.47
128.05
125.54
124.98
118.58
113.44
55.14
12.24
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

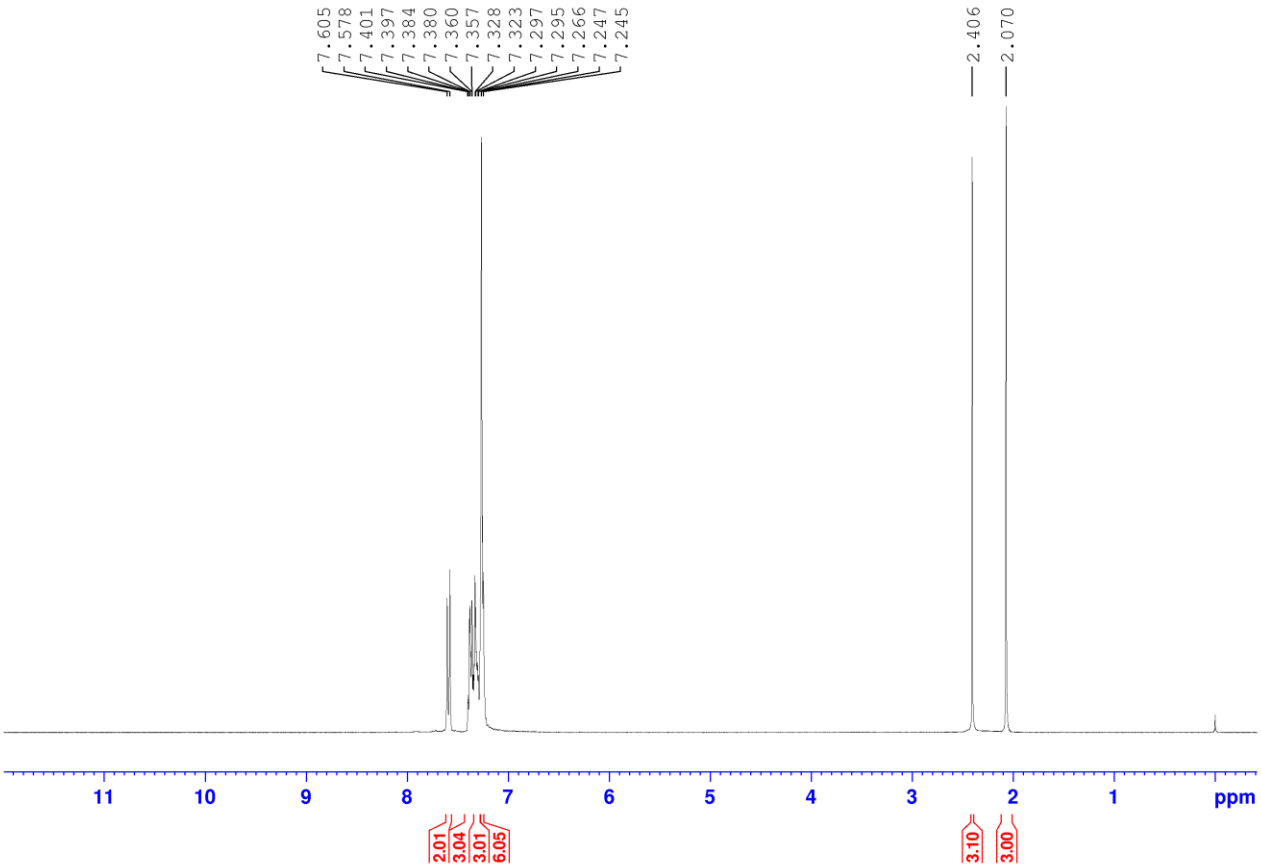


HRMS

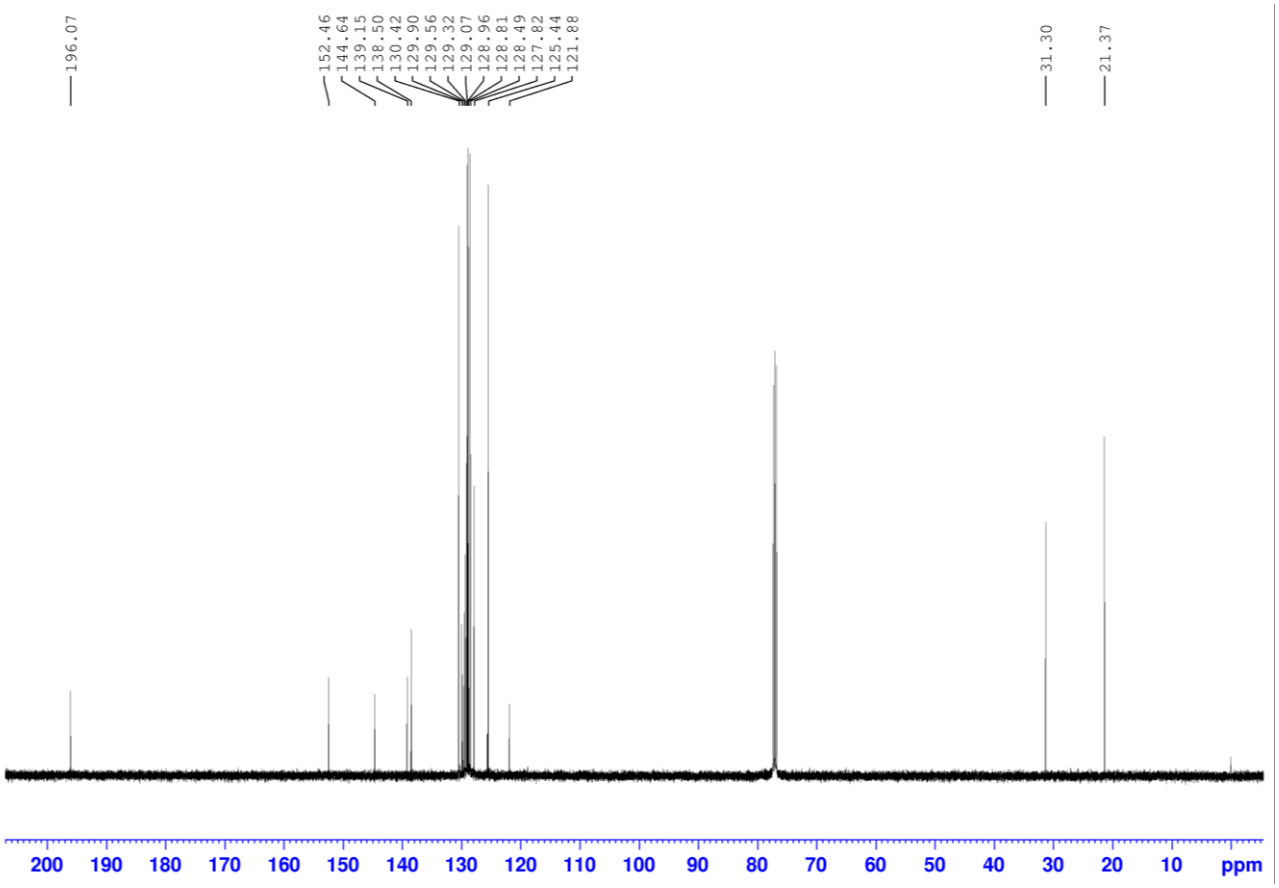

Intens.
x10^5
5
4
3
2
1
0
P9_35_01_5004.d: +MS, 0.6-0.8min #39-57
369.1597
235.1230
314.1291
118.1228
-100
0
100
200
300
400
500
600
700
m/z

(5-Methyl-1-phenyl-3-(*p*-tolyl)-1*H*-pyrazol-4-yl)(phenyl)methanone (6j)

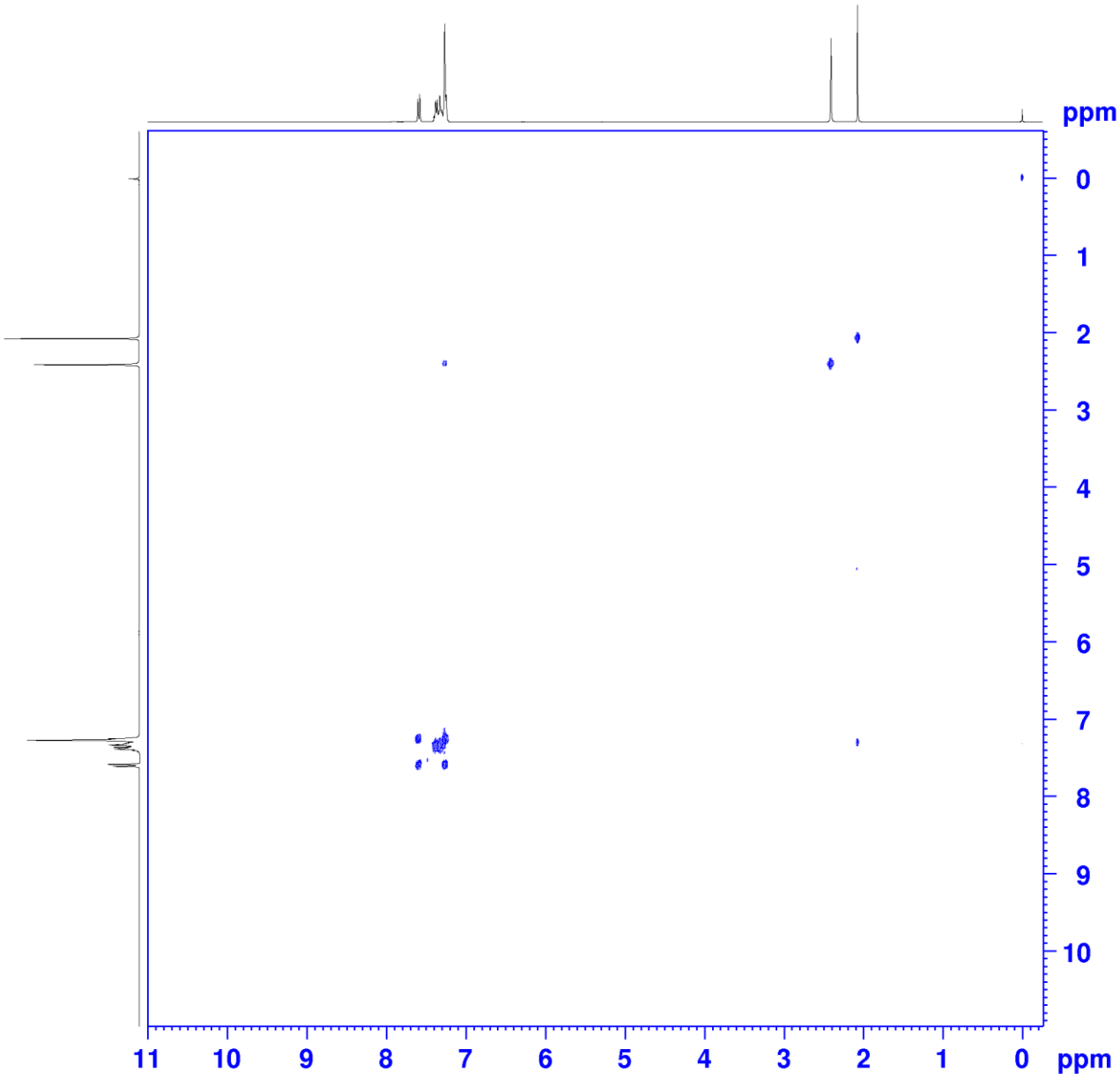
^{1}H NMR



^{13}C NMR

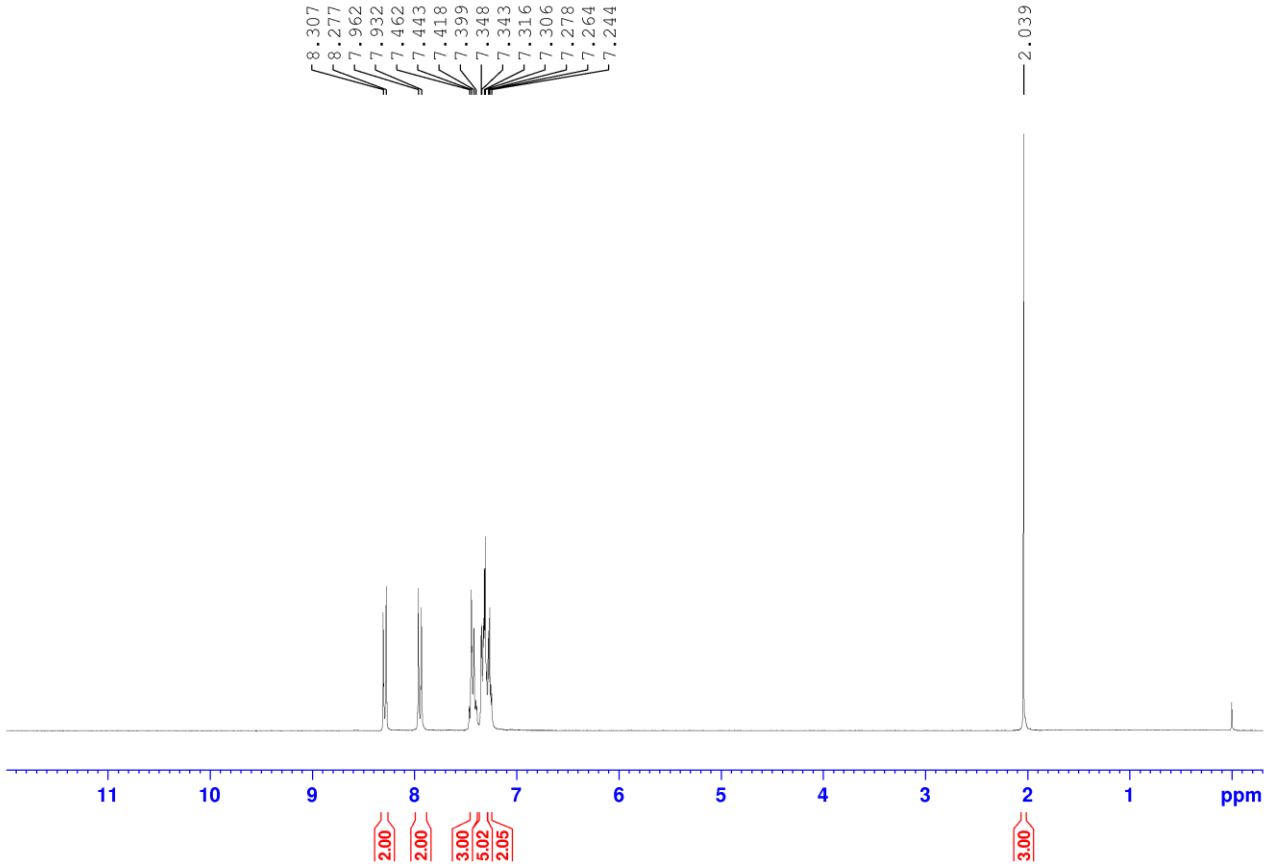

196.07
152.46
144.64
139.15
138.50
130.42
129.90
129.56
129.32
129.07
128.96
128.81
128.49
127.82
125.44
121.88
31.30
21.37
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

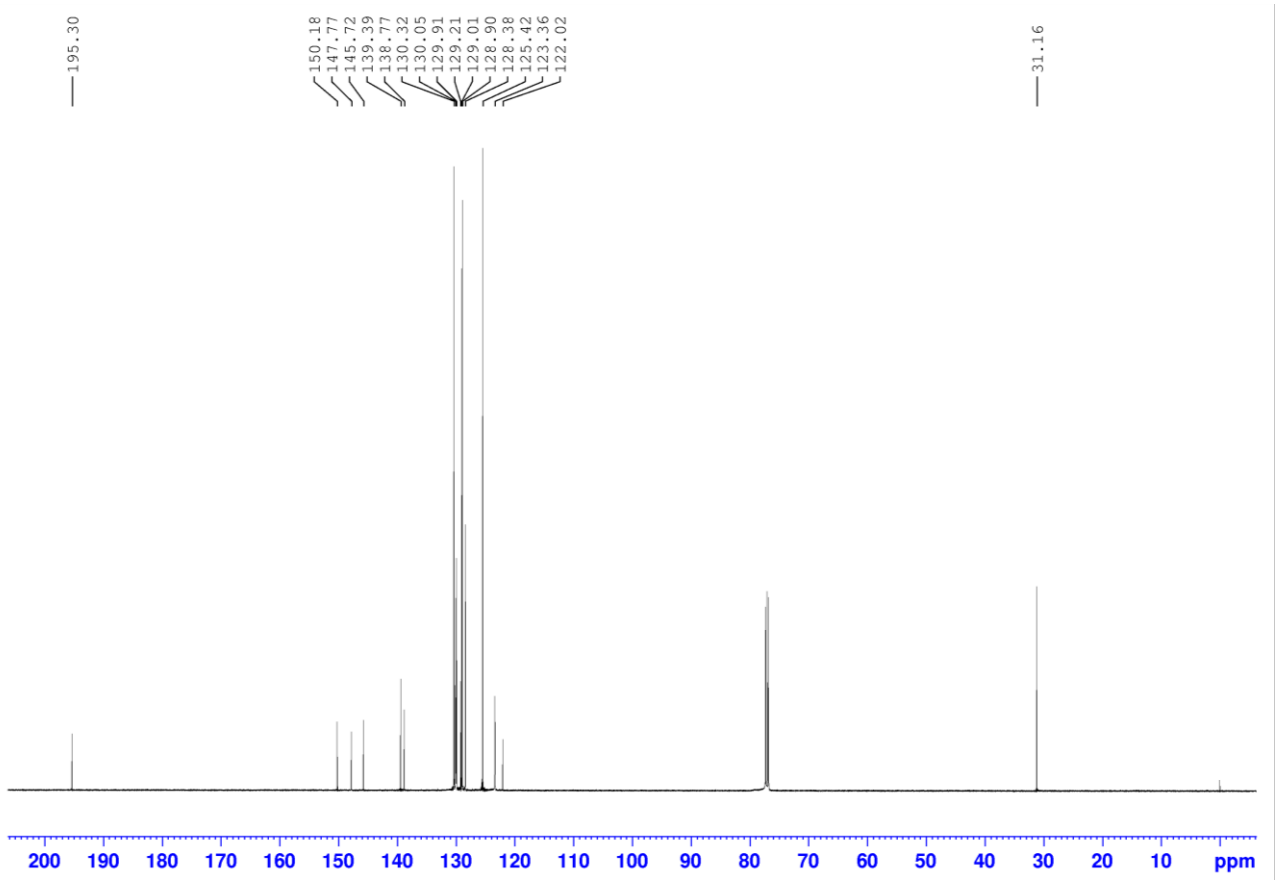


(5-Methyl-3-(4-nitrophenyl)-1-phenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6k)

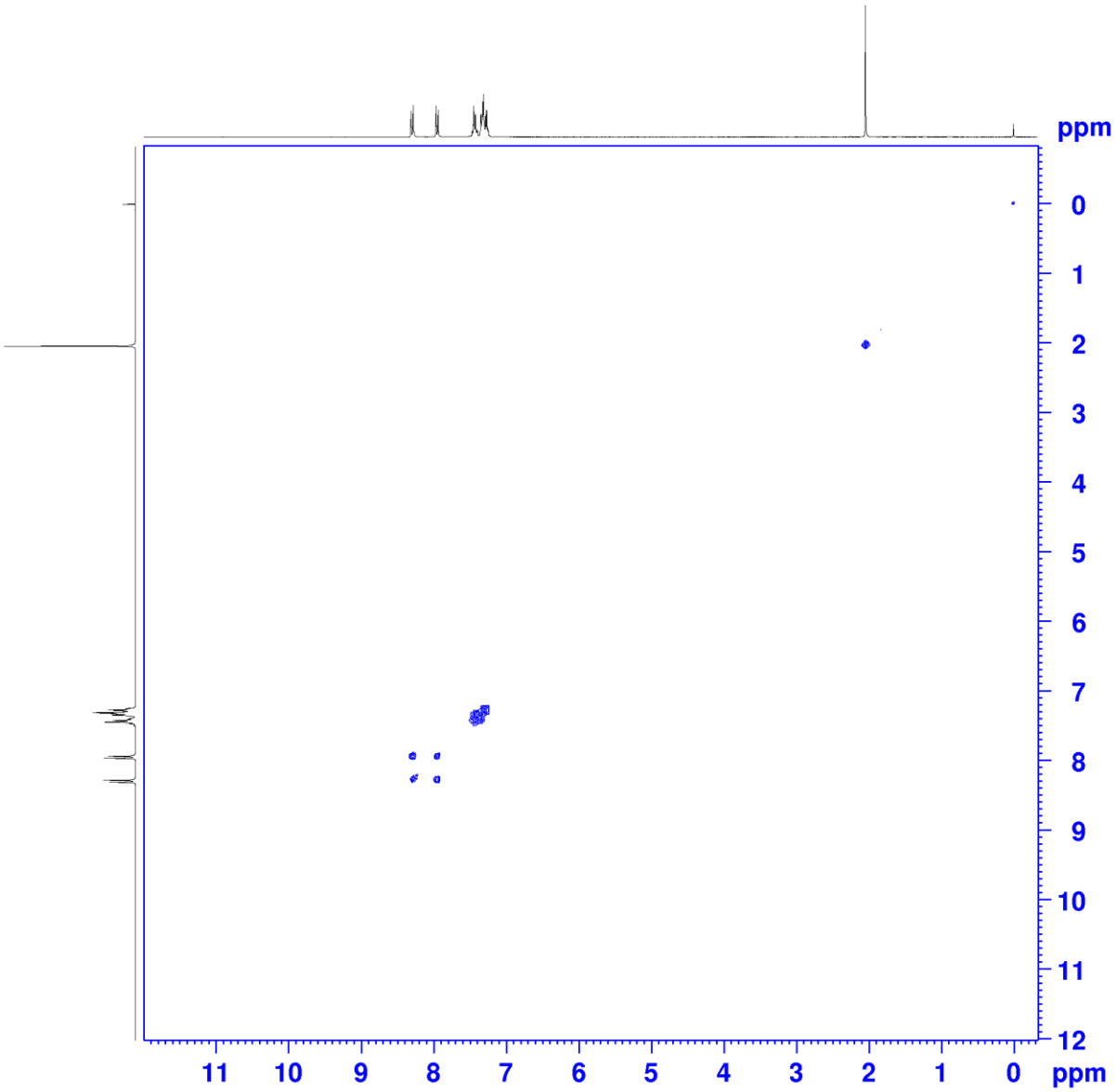
^{1}H NMR



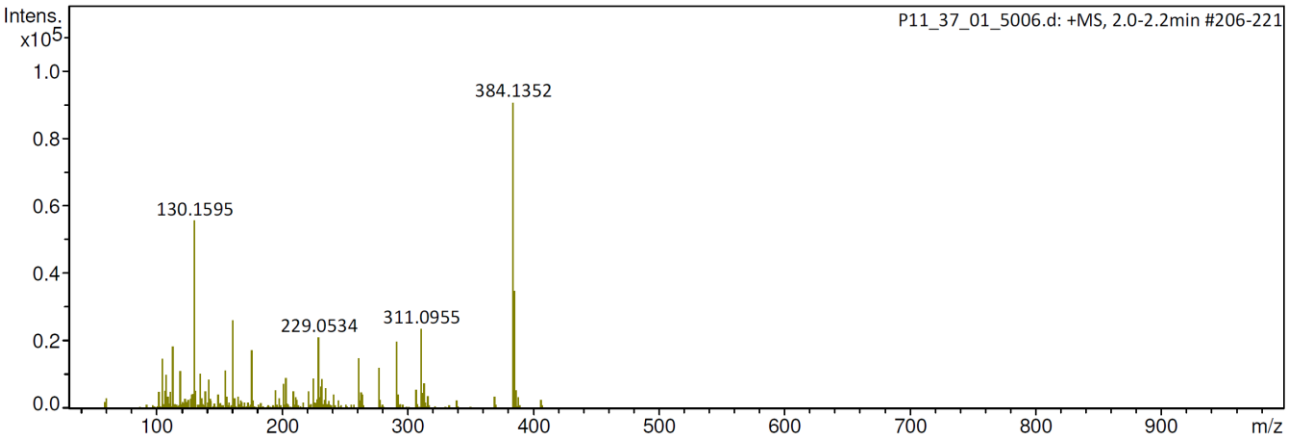
^{13}C NMR


195.30
150.18
147.77
145.72
139.39
138.77
130.32
130.05
129.91
129.21
129.01
128.90
128.38
125.42
123.36
122.02
31.16
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

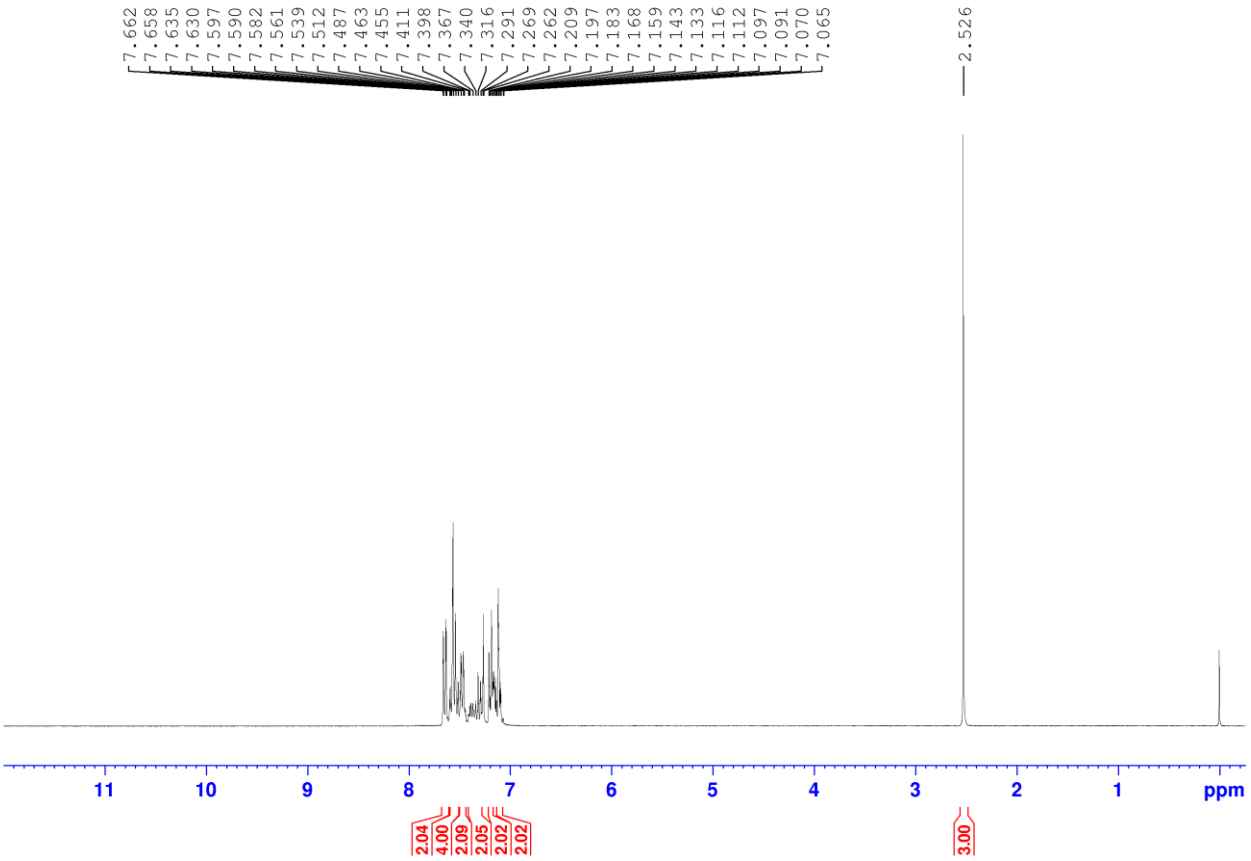


HRMS

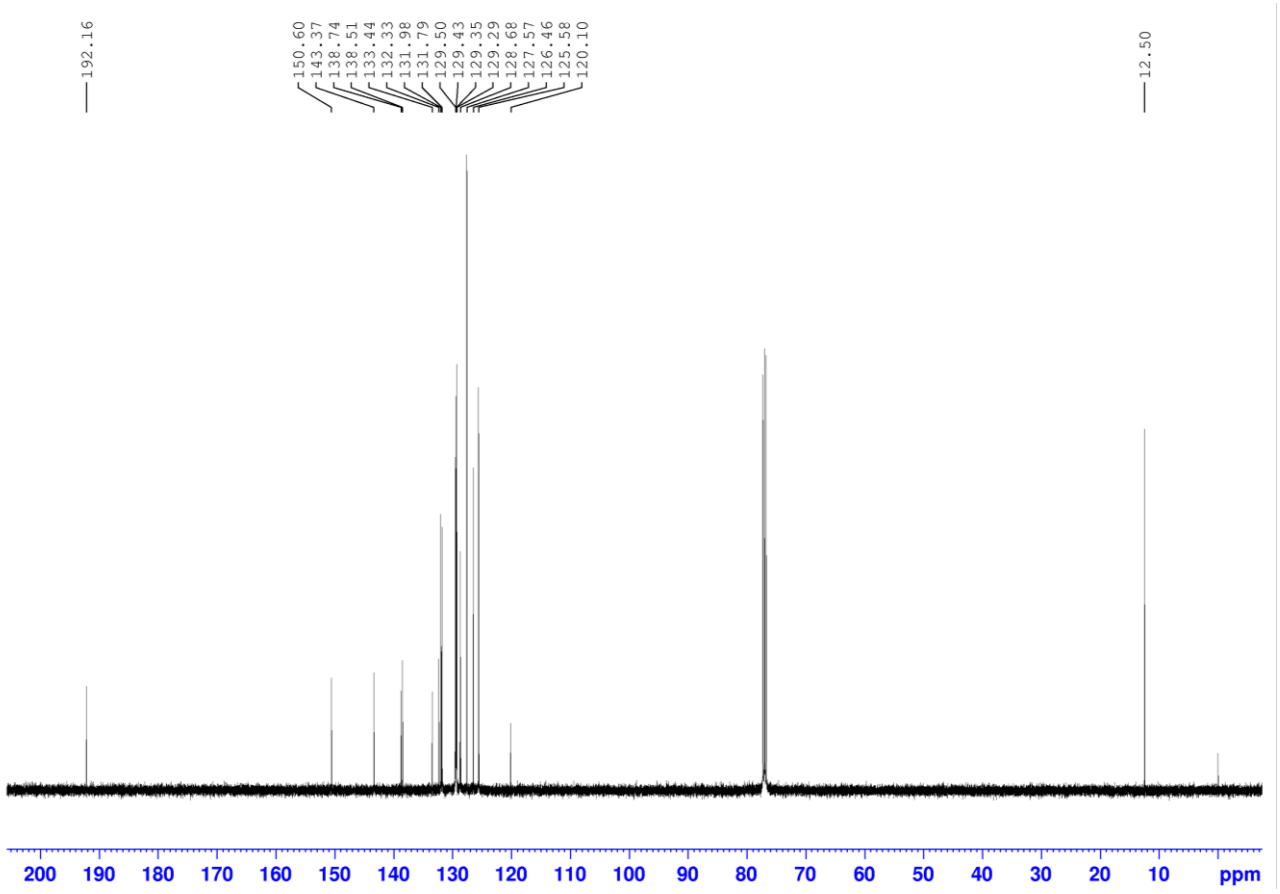

Intens.
x10^5
1.0
0.8
0.6
0.4
0.2
0.0
P11_37_01_5006.d: +MS, 2.0-2.2min #206-221
384.1352
130.1595
229.0534
311.0955
100
200
300
400
500
600
700
800
900
m/z

(3-(2-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6l)

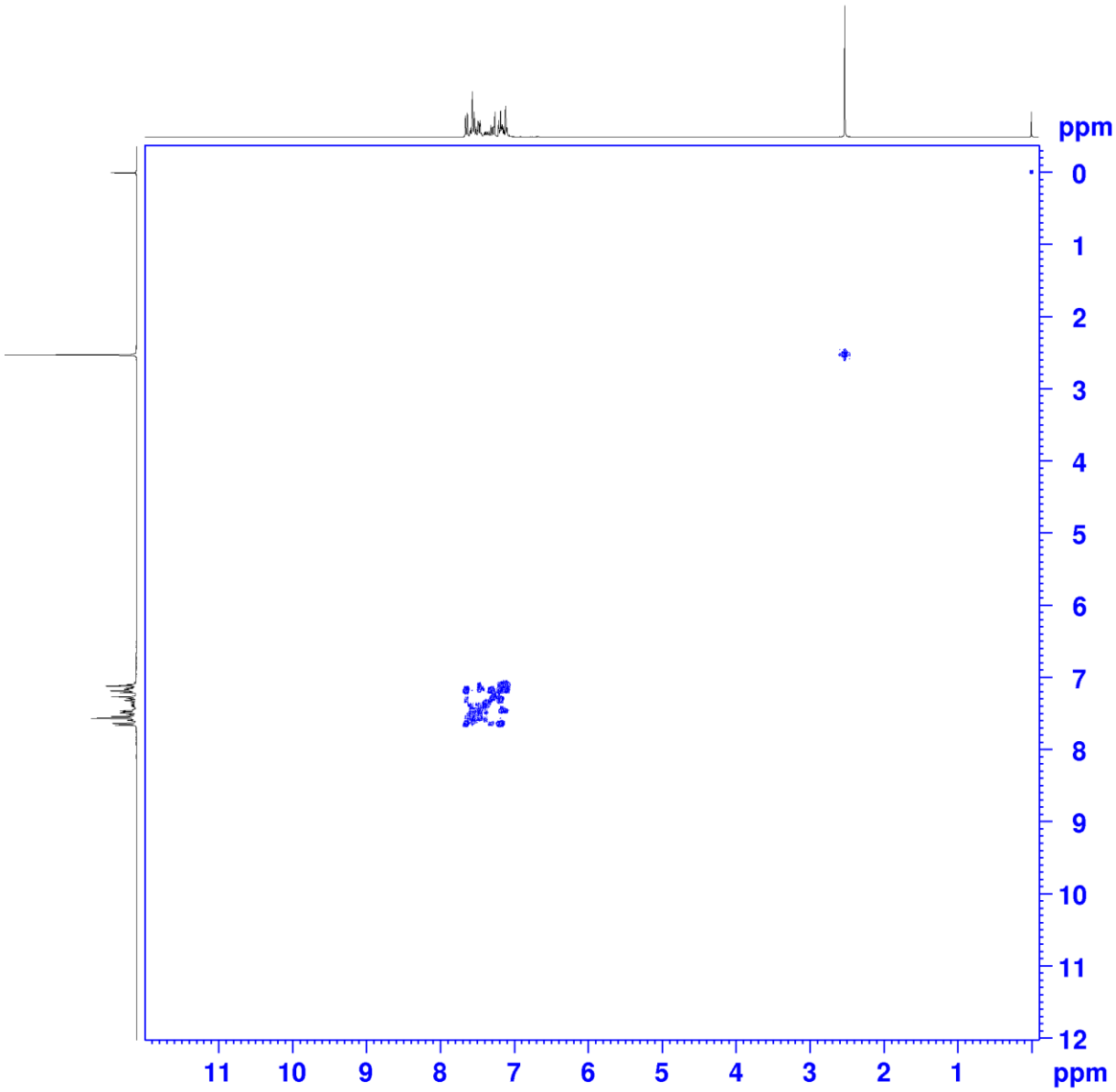
^{1}H NMR



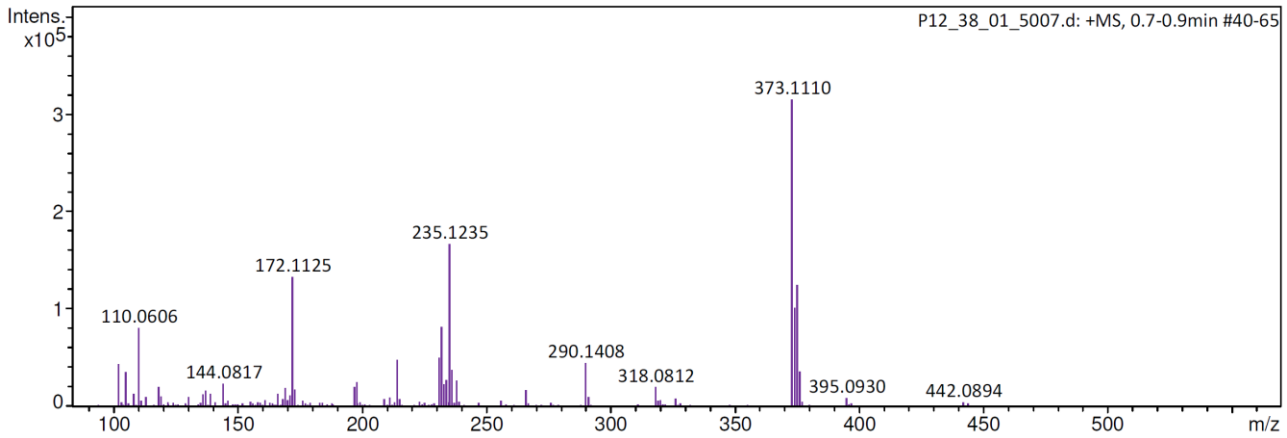
^{13}C NMR


192.16
150.60
143.37
138.74
138.51
133.44
132.33
131.98
131.79
129.50
129.43
129.35
129.29
128.68
127.57
126.46
125.58
120.10
12.50
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

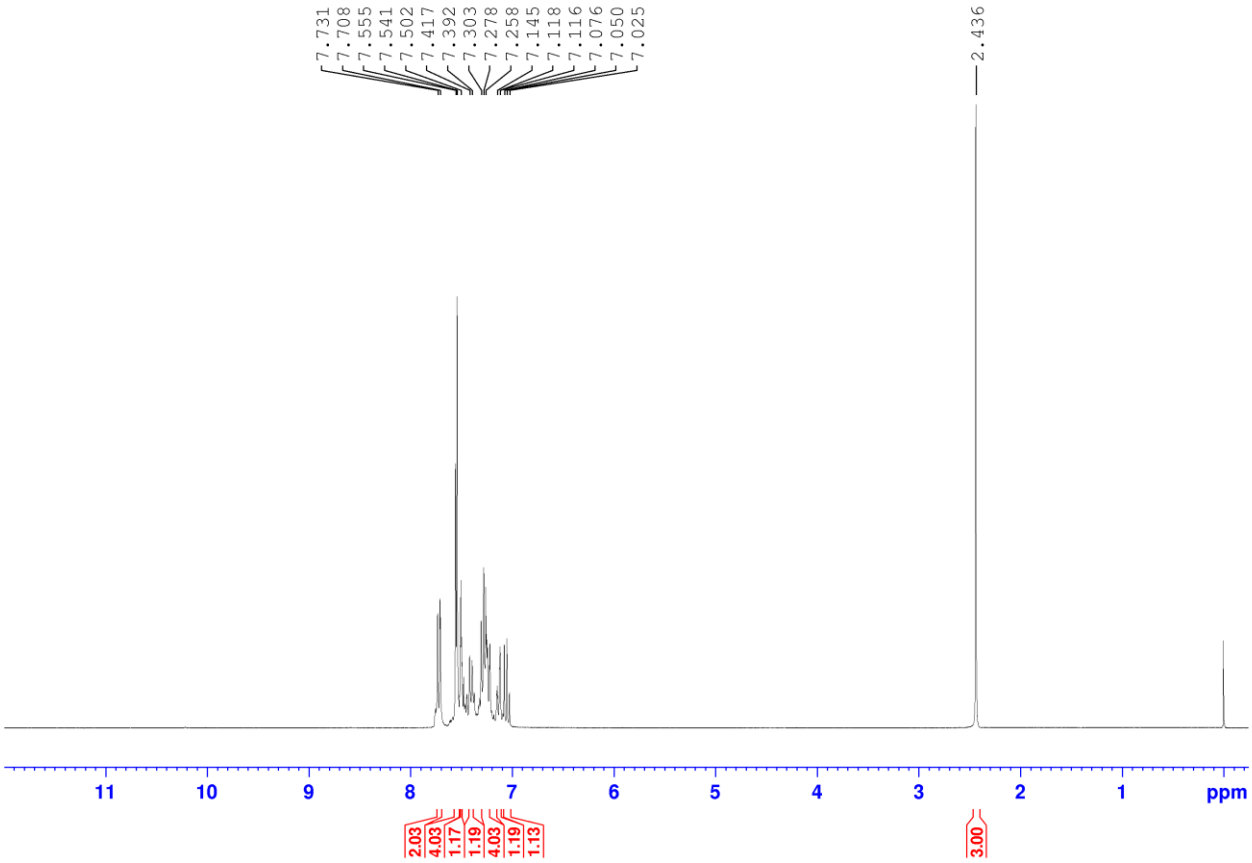


HRMS

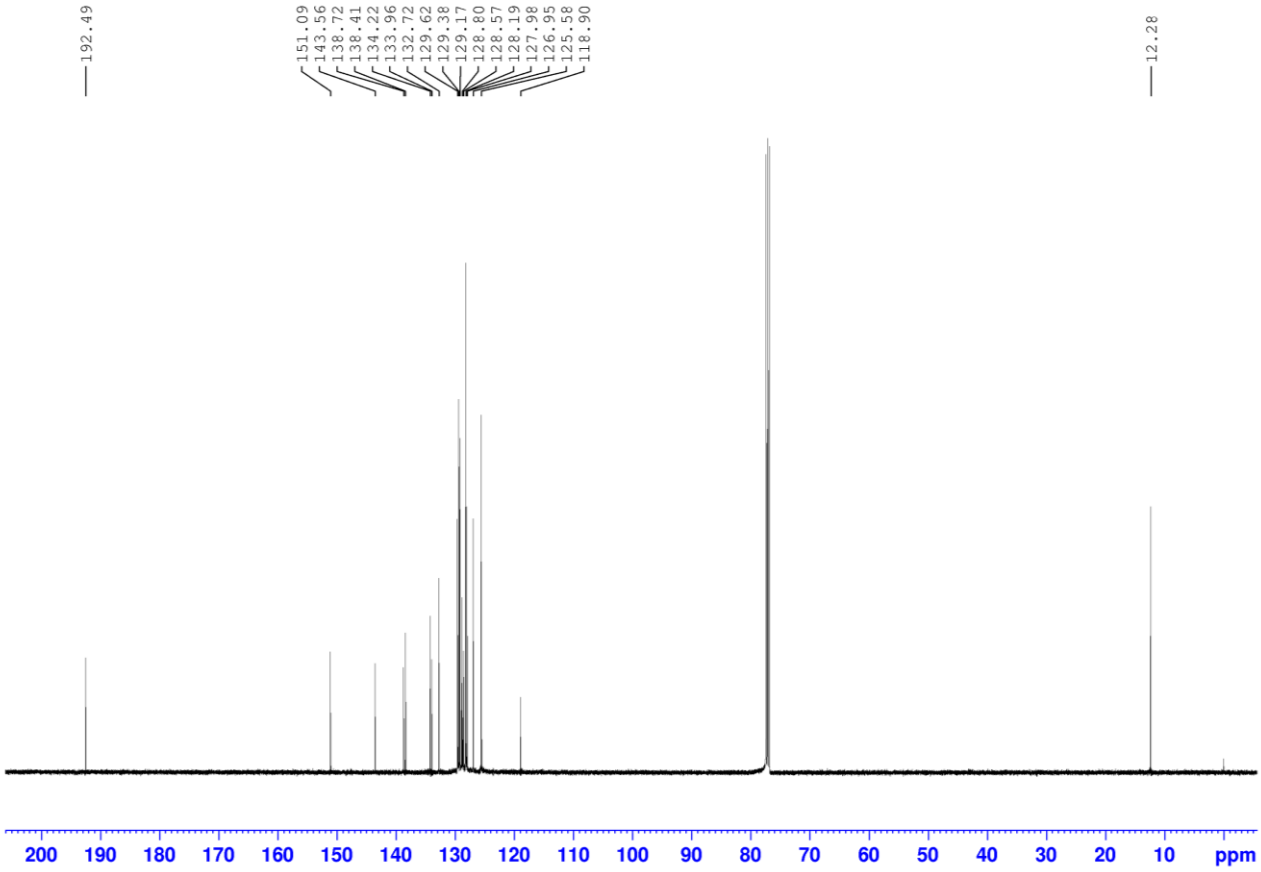

Intens.
x10^5
P12_38_01_5007.d: +MS, 0.7-0.9min #40-65
373.1110
235.1235
172.1125
110.0606
290.1408
144.0817
318.0812
395.0930
442.0894
m/z

(3-(3-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6m)

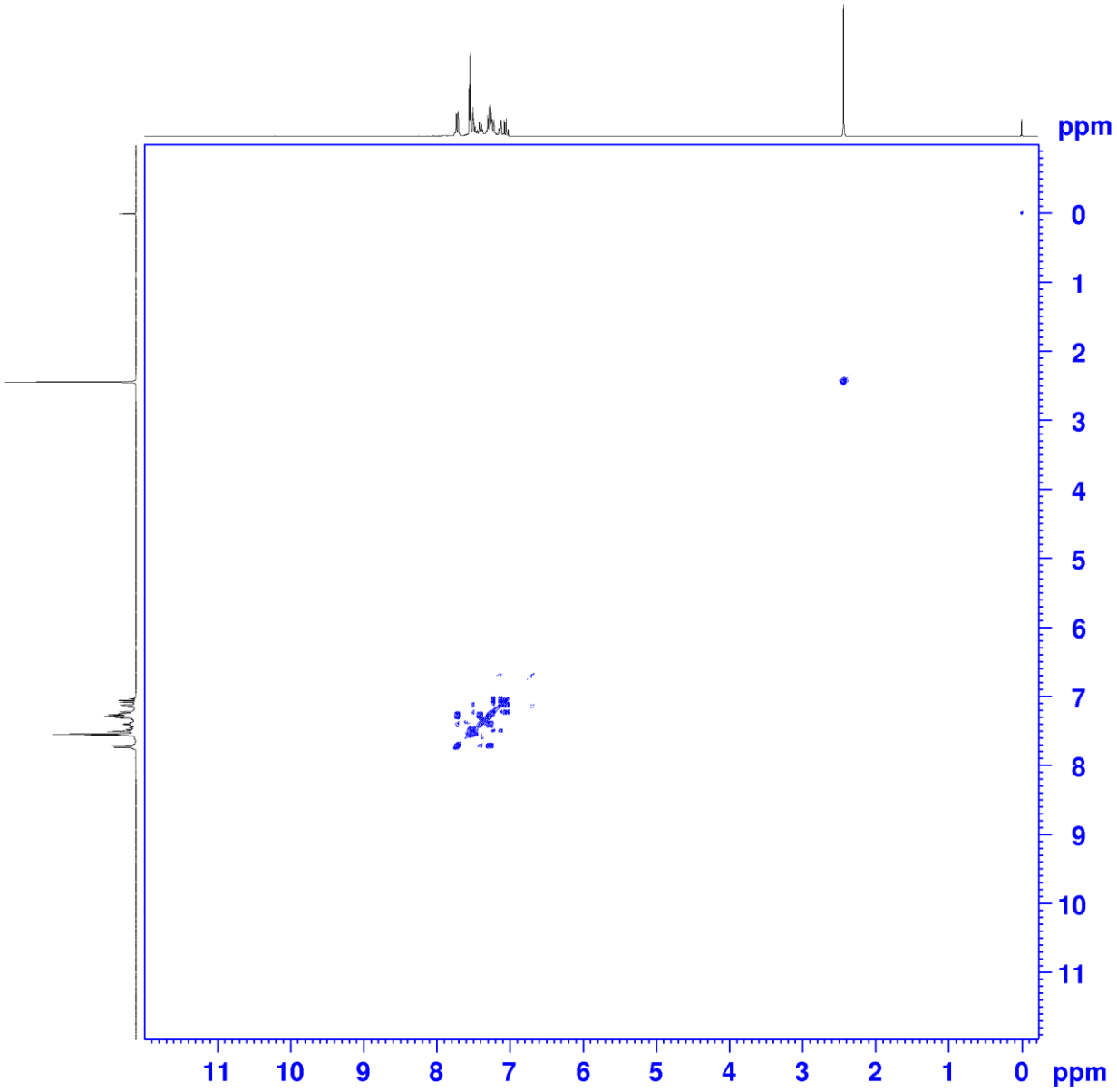
^{1}H NMR



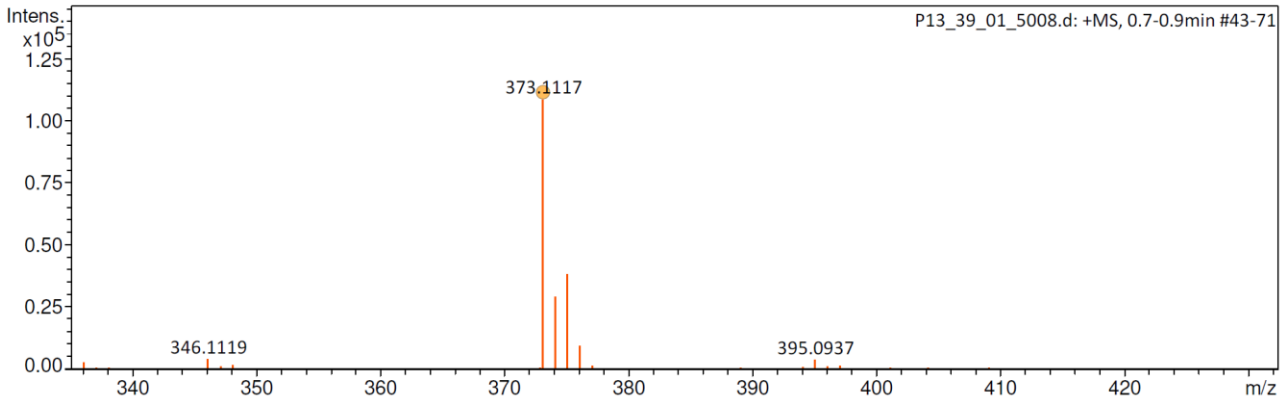
^{13}C NMR


192.49
151.09
143.56
138.72
138.41
134.22
133.96
132.72
129.62
129.38
129.17
128.80
128.57
128.19
127.98
126.95
125.58
118.90
12.28
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

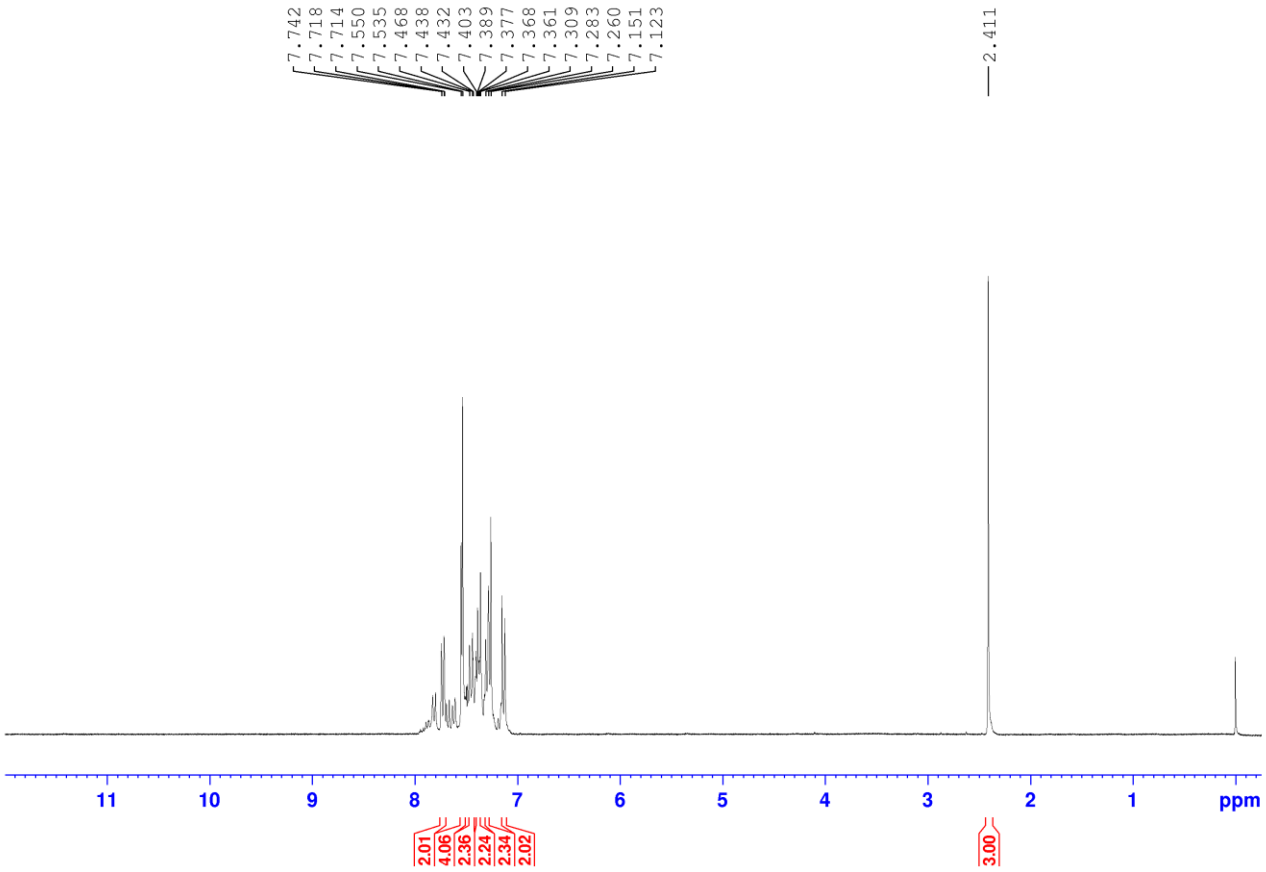


HRMS

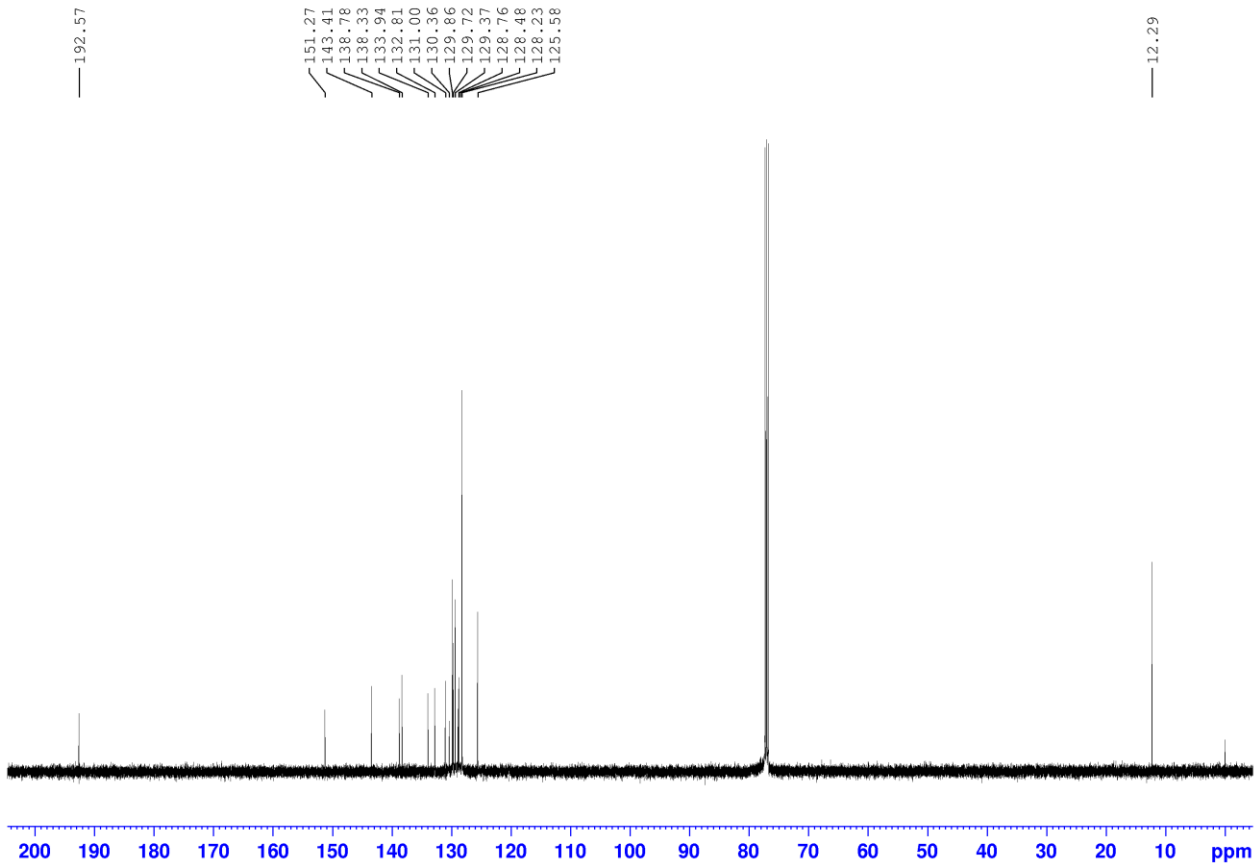

Intens.
x10^5
1.25
1.00
0.75
0.50
0.25
0.00
P13_39_01_5008.d: +MS, 0.7-0.9min #43-71
373.1117
346.1119
395.0937
340
350
360
370
380
390
400
410
420
m/z

(3-(4-Chlorophenyl)-5-methyl-1-phenyl-1*H*-pyrazol-4-yl)(phenyl)methanone (6n)

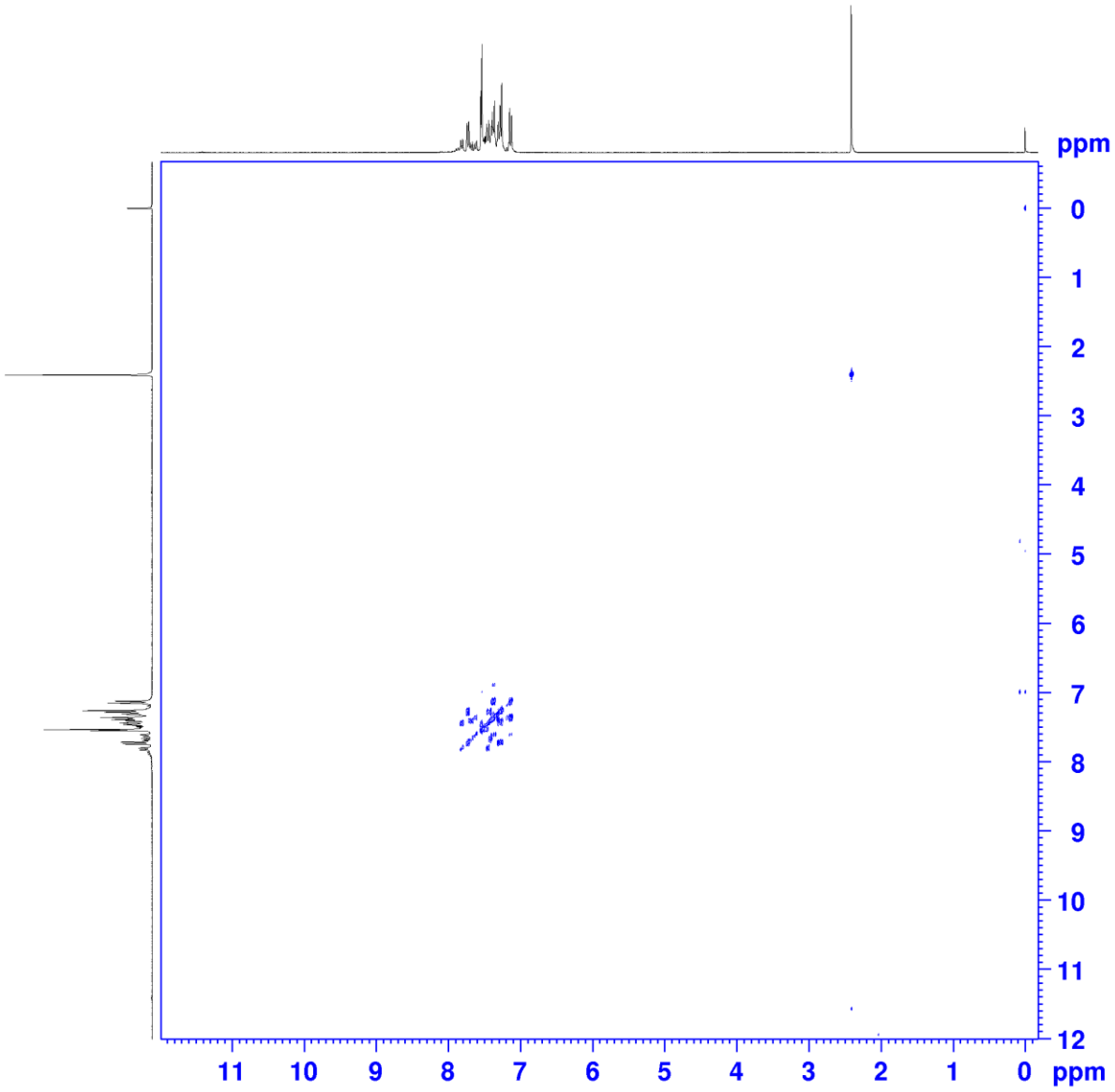
^{1}H NMR



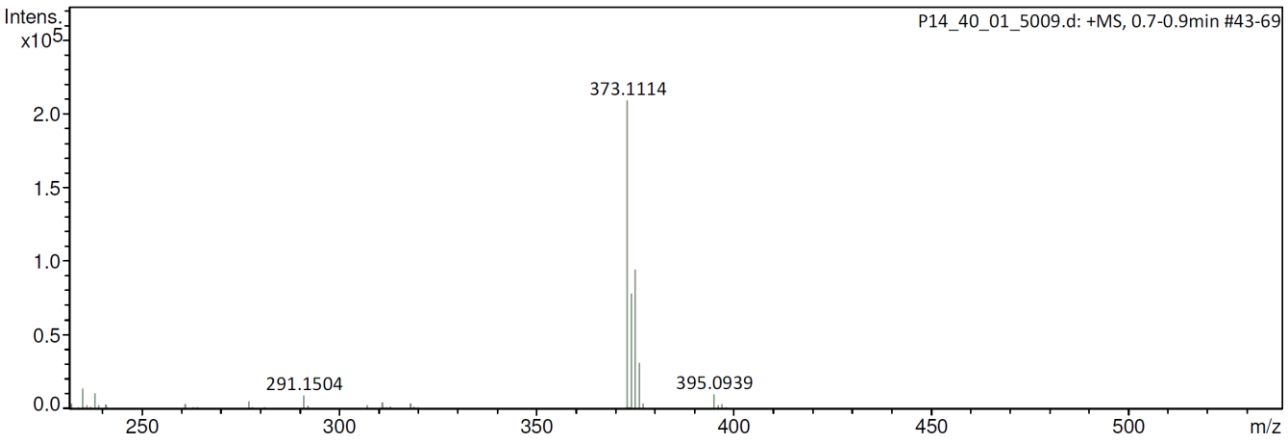
^{13}C NMR


192.57
151.27
143.41
138.78
138.33
133.94
132.81
131.00
130.36
129.86
129.72
129.37
128.76
128.48
128.23
125.58
12.29
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

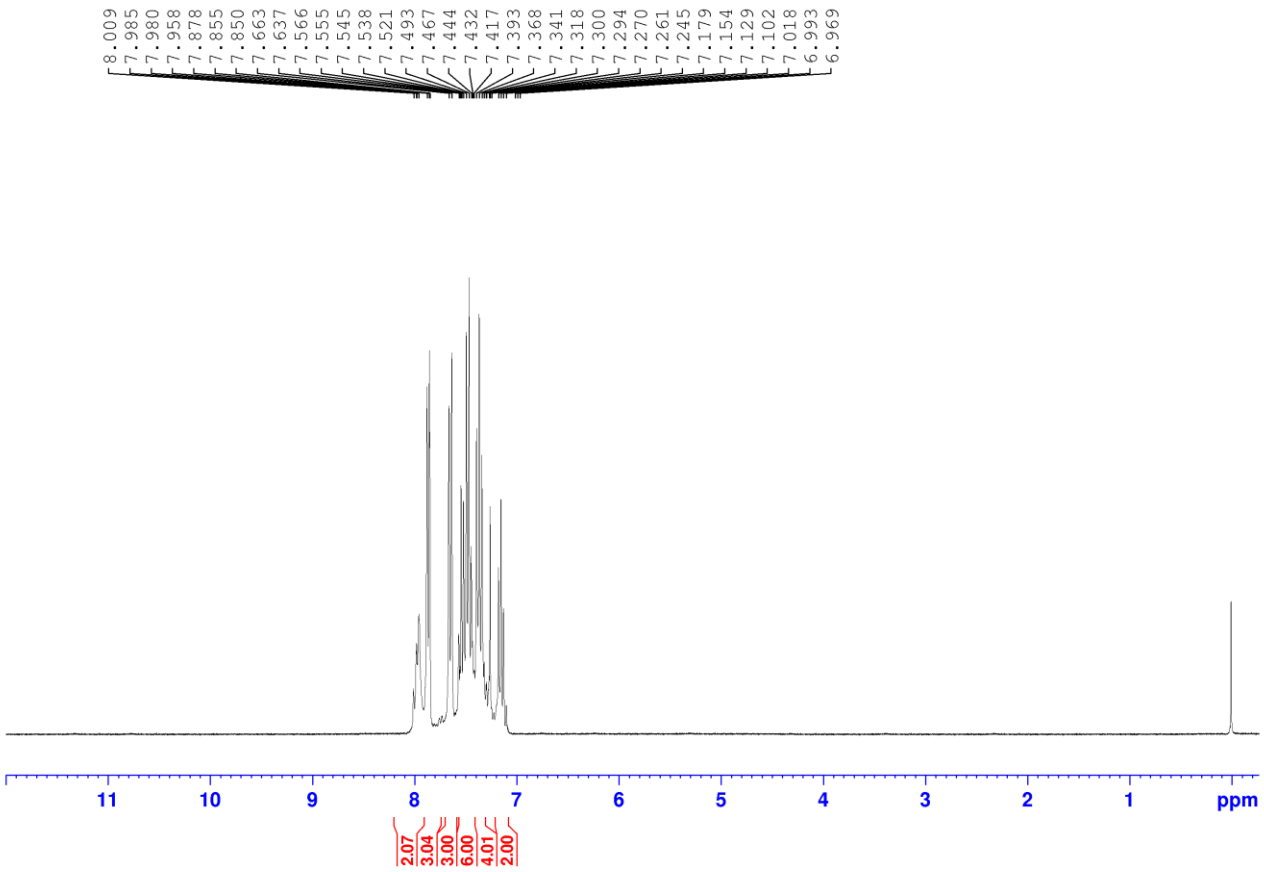


HRMS

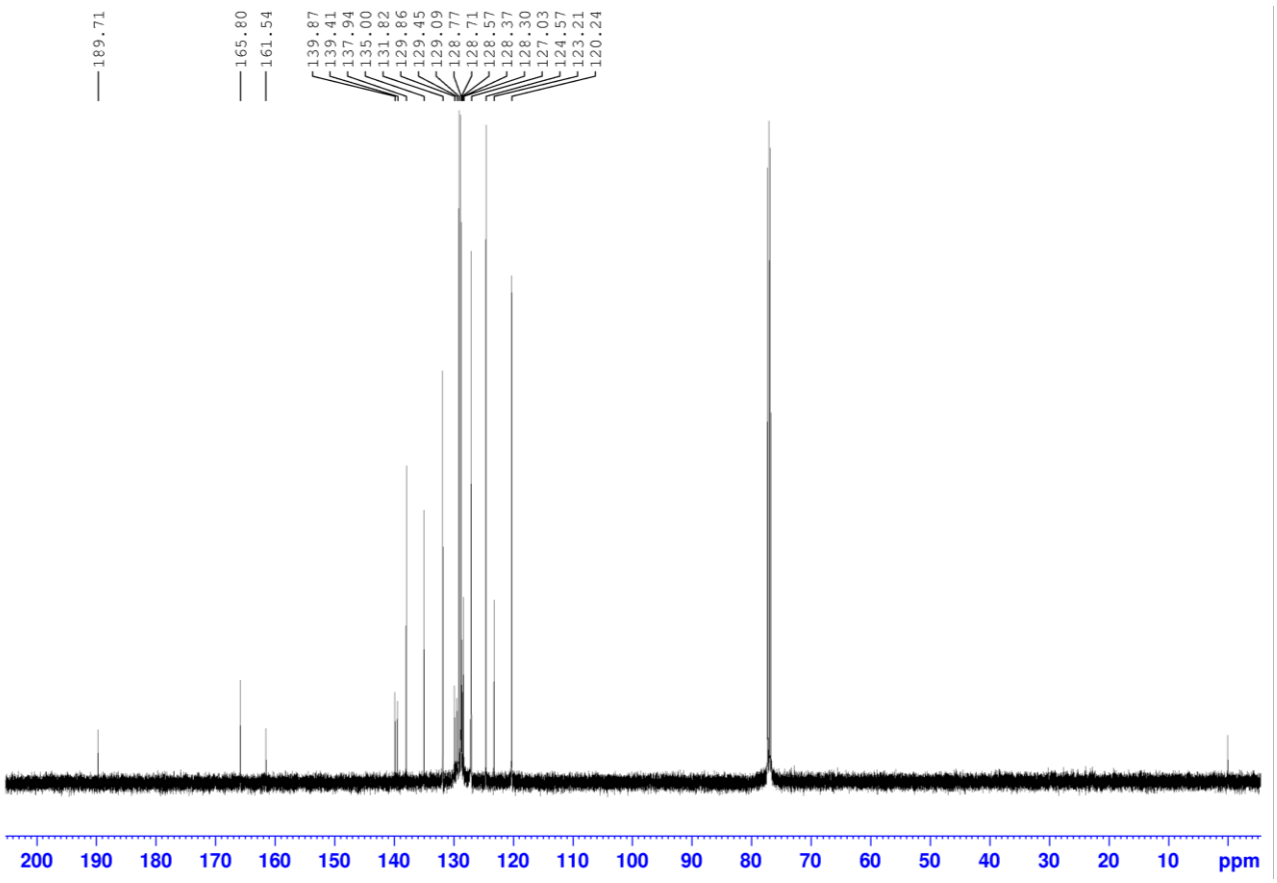

Intens.
x10^5
2.0
1.5
1.0
0.5
0.0
P14_40_01_5009.d: +MS, 0.7-0.9min #43-69
373.1114
291.1504
395.0939
250
300
350
400
450
500
m/z

Phenyl(1,3,5-triphenyl-1*H*-pyrazol-4-yl)methanone (6o)

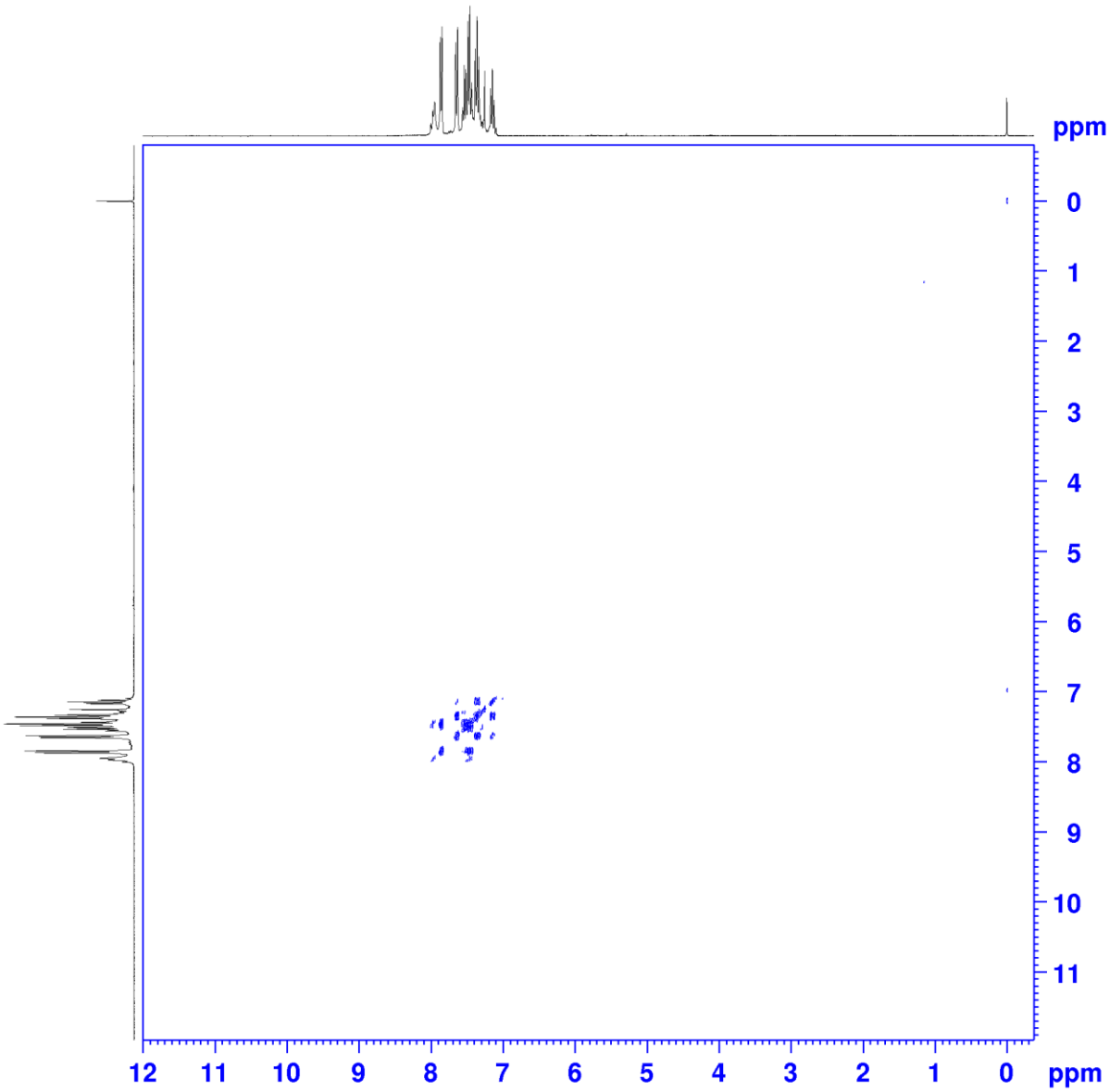
^{1}H NMR



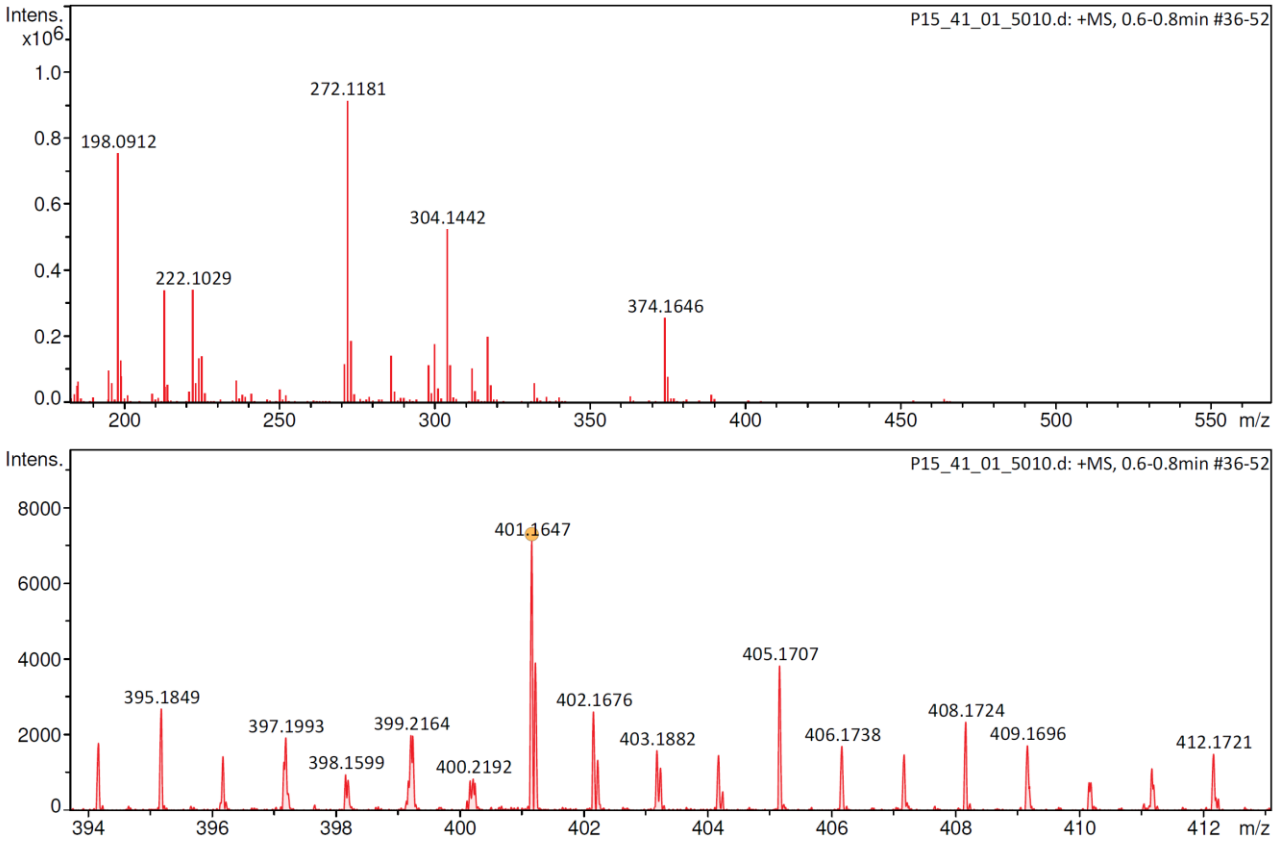
^{13}C NMR


189.71
165.80
161.54
139.87
139.41
137.94
135.00
131.82
129.86
129.45
129.09
128.77
128.71
128.57
128.37
128.30
127.03
124.57
123.21
120.24
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

COSY NMR

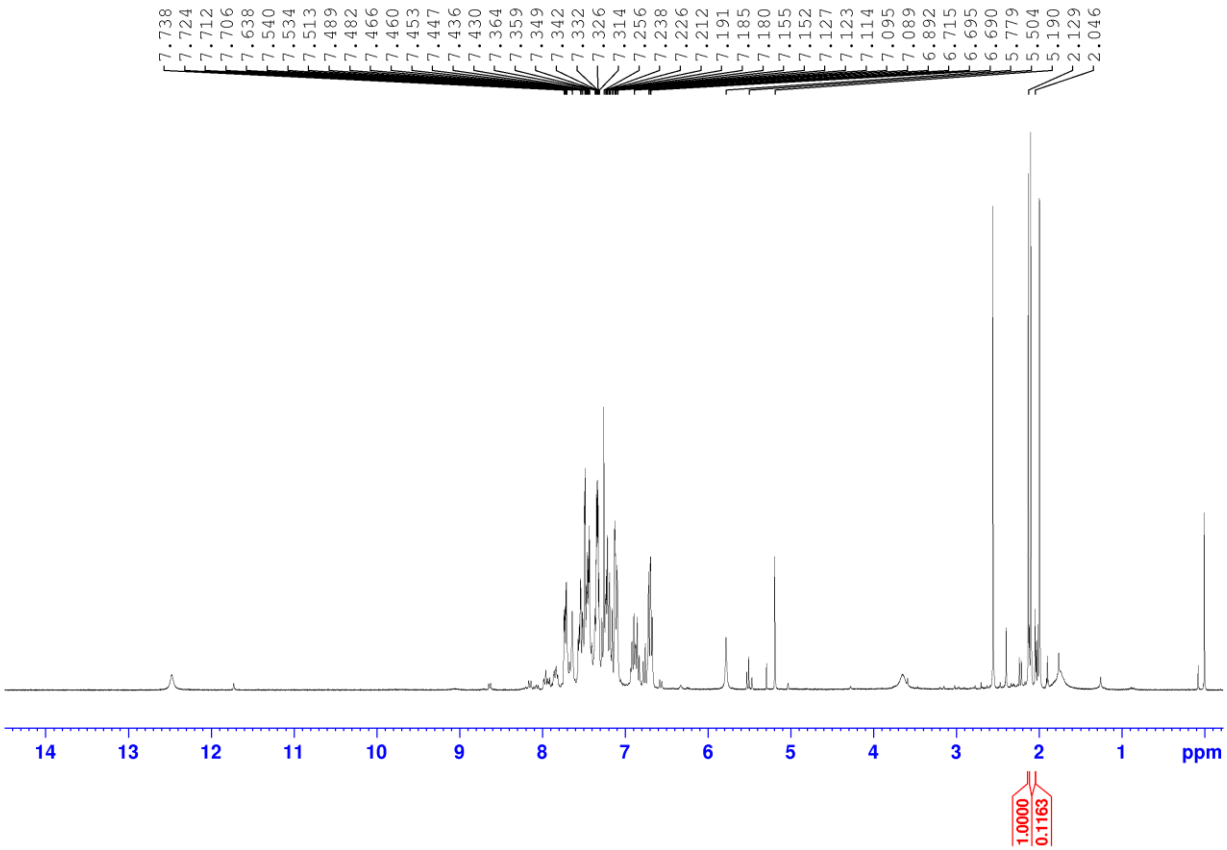


HRMS

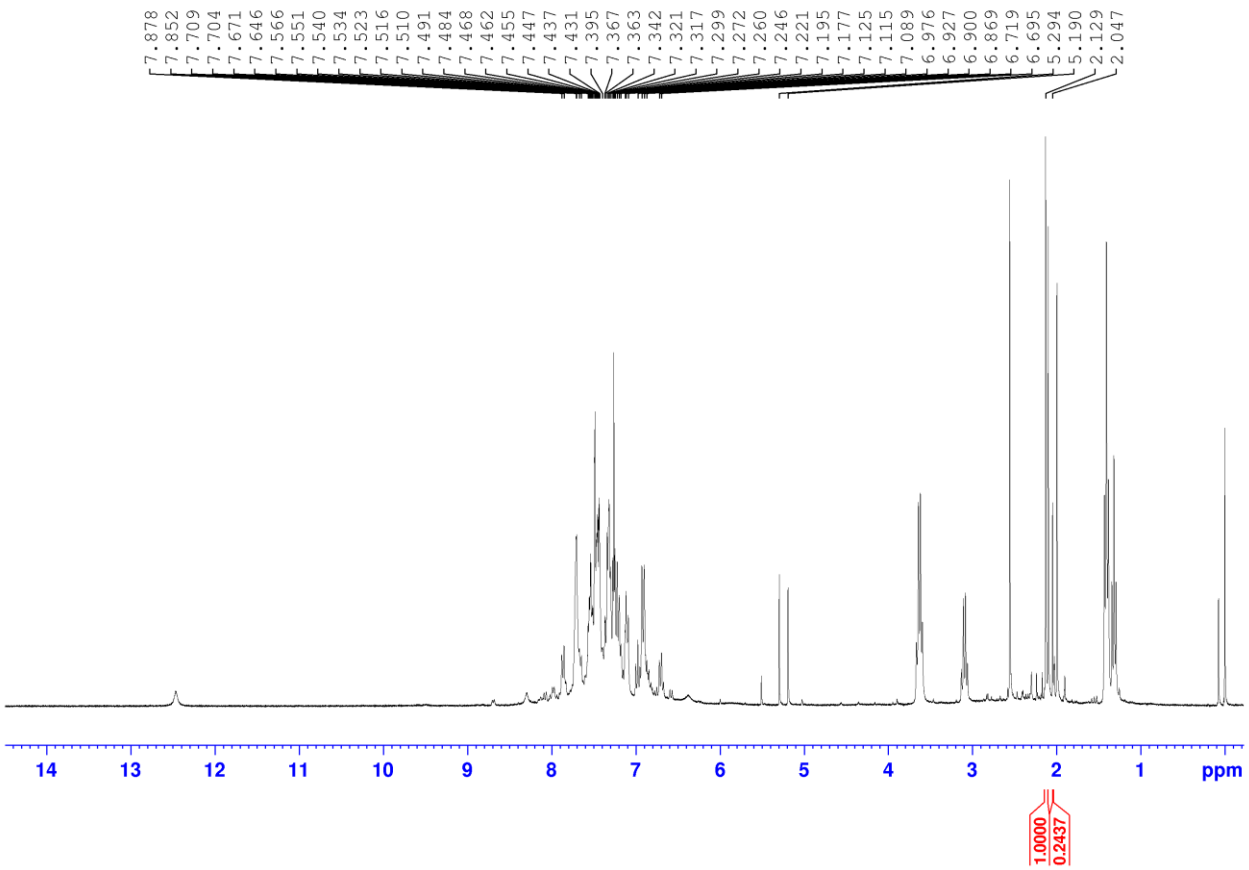

Intens.
x10^6
P15_41_01_5010.d: +MS, 0.6-0.8min #36-52
272.1181
198.0912
304.1442
222.1029
374.1646
m/z
Intens.
P15_41_01_5010.d: +MS, 0.6-0.8min #36-52
401.1647
405.1707
395.1849
402.1676
408.1724
397.1993
399.2164
403.1882
406.1738
409.1696
412.1721
398.1599
400.2192
m/z

^{1}H NMR spectra of crude reaction mixtures illustrated in Table 1.

Entry 1



Entry 2


7.878
7.852
7.709
7.704
7.671
7.646
7.566
7.551
7.540
7.534
7.523
7.516
7.510
7.491
7.484
7.468
7.462
7.455
7.447
7.437
7.431
7.395
7.367
7.363
7.342
7.321
7.317
7.299
7.272
7.260
7.246
7.221
7.195
7.177
7.125
7.115
7.089
6.976
6.927
6.900
6.869
6.719
6.695
5.294
5.190
2.129
2.047
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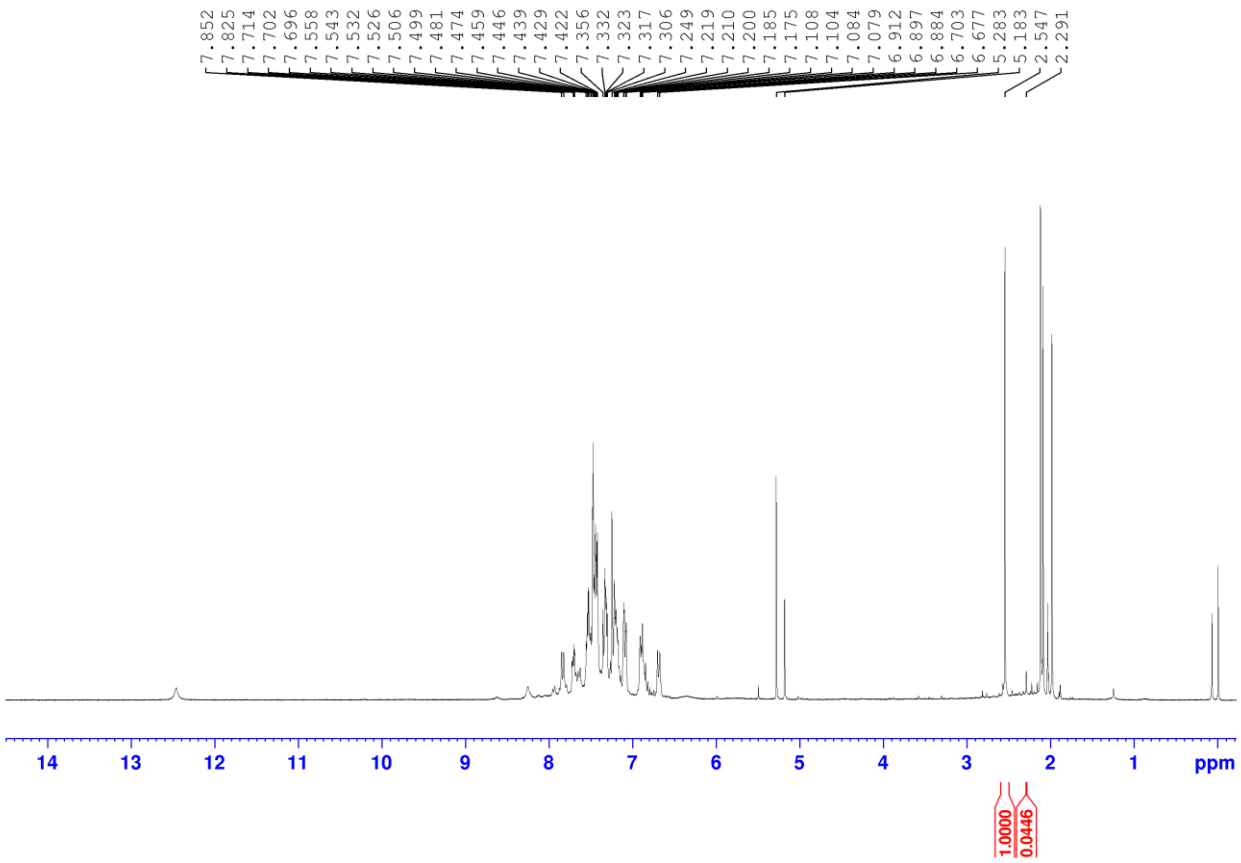
Entry 3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7.532
7.526
7.506
7.499
7.481
7.474
7.459
7.446
7.439
7.429
7.422
7.356
7.332
7.323
7.317
7.306
7.249
7.219
7.210
7.200
7.185
7.175
7.108
7.104
7.084
7.079
6.912
6.897
6.884
6.703
6.677
5.283
5.183
2.547
2.291
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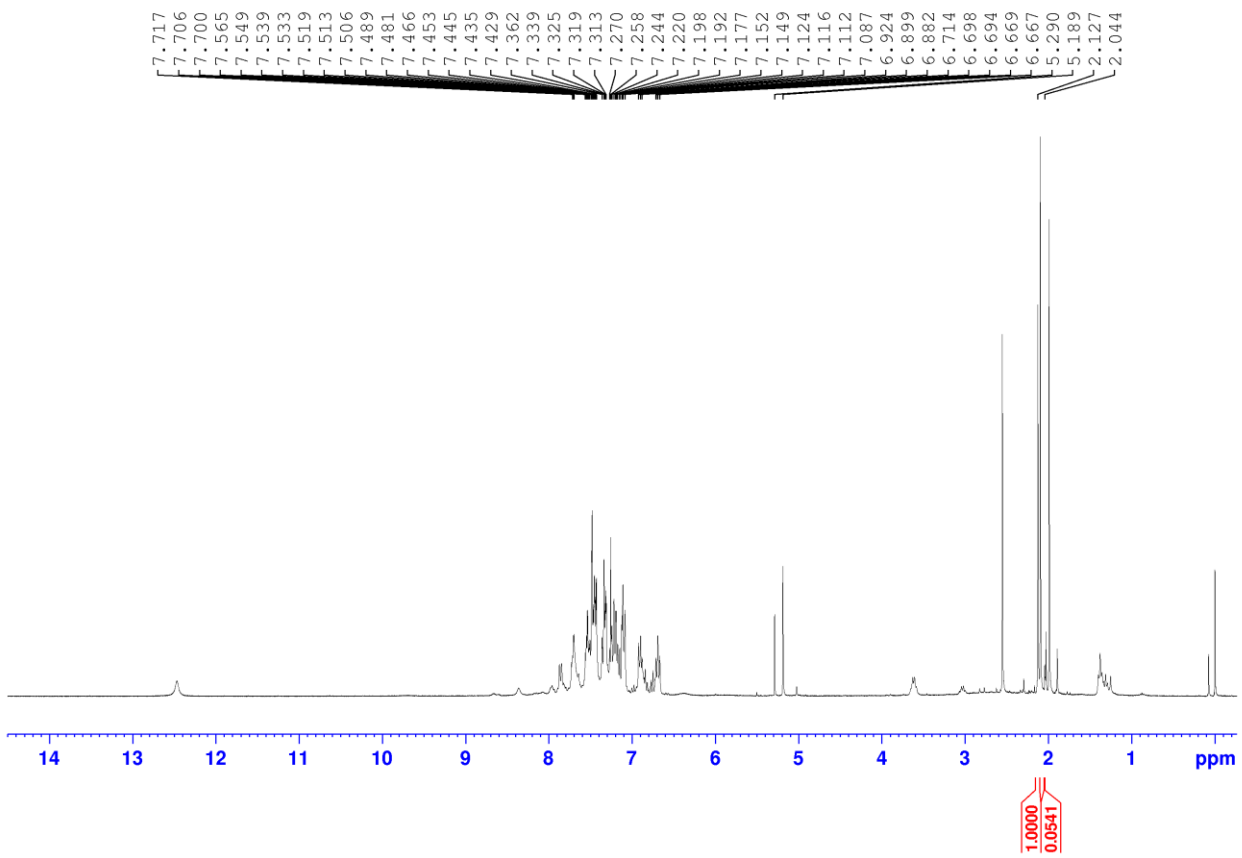
Entry 4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7.700
7.565
7.549
7.539
7.533
7.519
7.513
7.506
7.489
7.481
7.466
7.453
7.445
7.435
7.429
7.362
7.339
7.325
7.319
7.313
7.270
7.258
7.244
7.220
7.198
7.192
7.177
7.152
7.149
7.124
7.116
7.112
7.087
6.924
6.899
6.882
6.714
6.698
6.694
6.669
6.667
5.290
5.189
2.127
2.044
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9
8
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6
5
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2
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ppm
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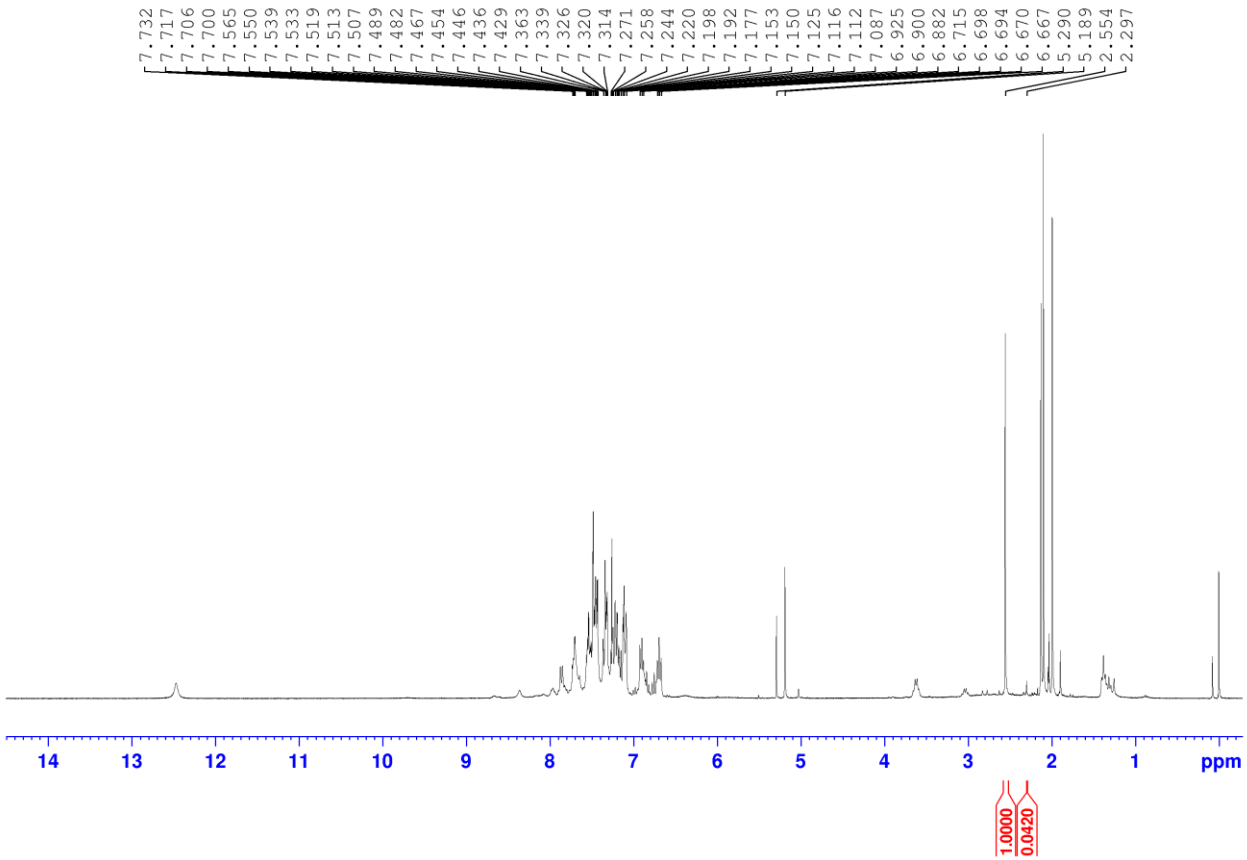
0.0541

Entry 5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7.513
7.507
7.489
7.482
7.467
7.454
7.446
7.436
7.429
7.363
7.339
7.326
7.320
7.314
7.271
7.258
7.244
7.220
7.198
7.192
7.177
7.153
7.150
7.125
7.116
7.112
7.087
6.925
6.900
6.882
6.715
6.698
6.694
6.670
6.667
5.290
5.189
2.554
2.297
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9
8
7
6
5
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ppm
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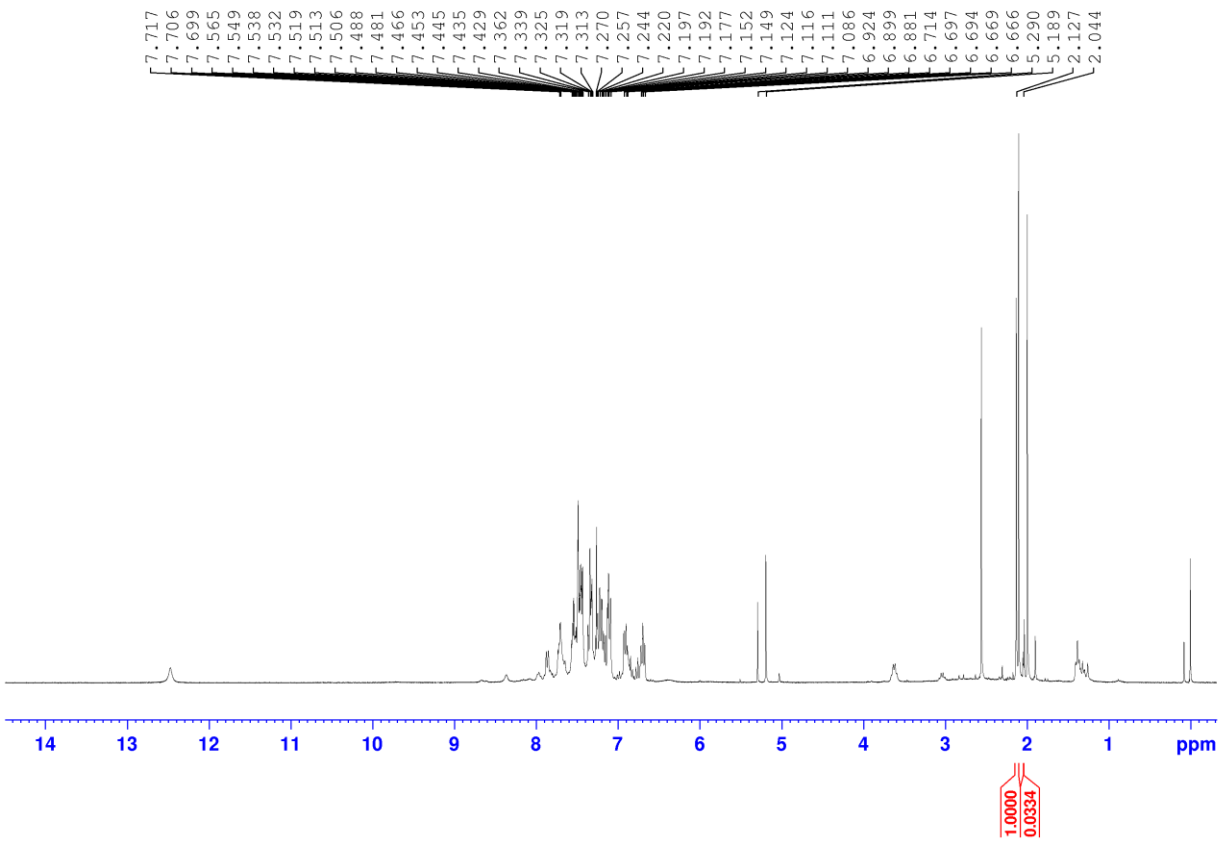
0.0420

Entry 6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7.549
7.538
7.532
7.519
7.513
7.506
7.488
7.481
7.466
7.453
7.445
7.435
7.429
7.362
7.339
7.325
7.319
7.313
7.270
7.257
7.244
7.220
7.197
7.192
7.177
7.152
7.149
7.124
7.116
7.111
7.086
6.924
6.899
6.881
6.714
6.697
6.694
6.669
6.666
5.290
5.189
2.127
2.044
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2
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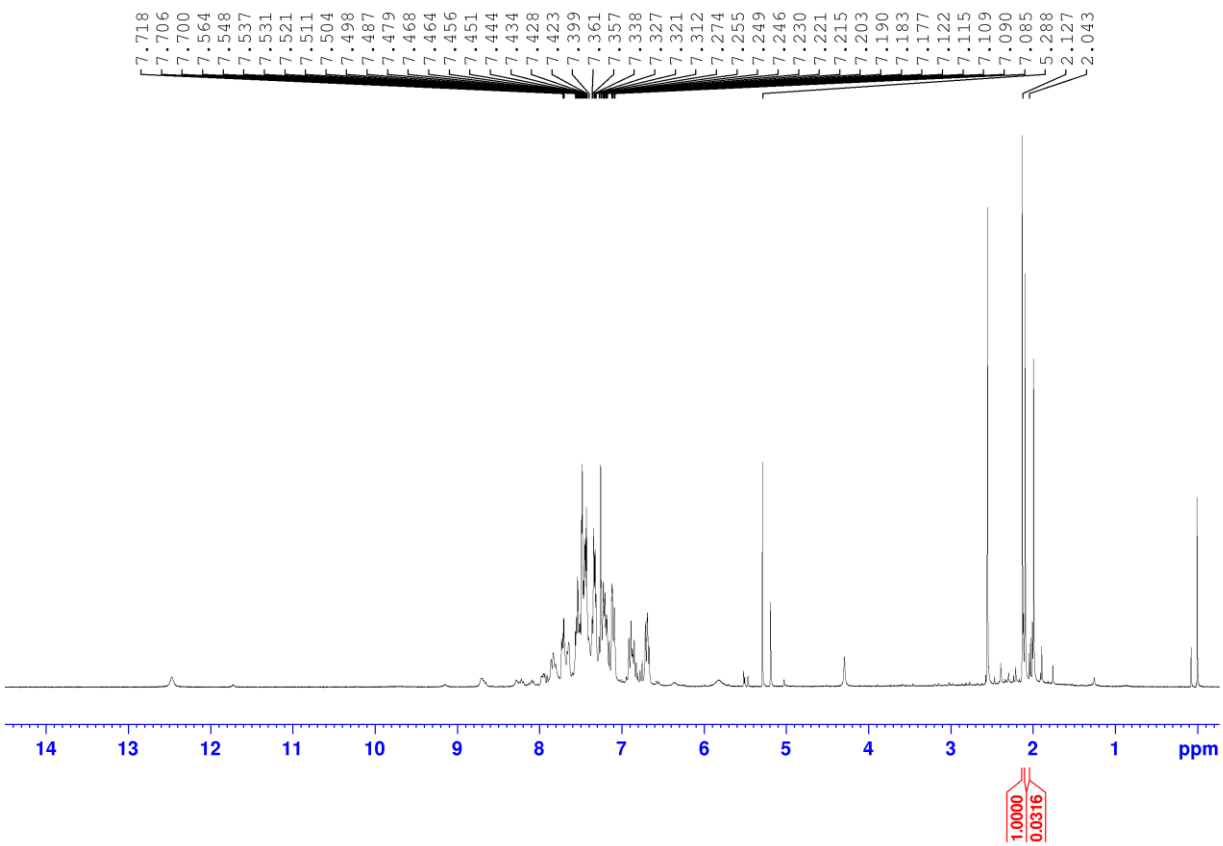
Entry 8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7.537
7.531
7.521
7.511
7.504
7.498
7.487
7.479
7.468
7.464
7.456
7.451
7.444
7.434
7.428
7.423
7.399
7.361
7.357
7.338
7.327
7.321
7.312
7.274
7.255
7.249
7.246
7.230
7.221
7.215
7.203
7.190
7.183
7.177
7.122
7.115
7.109
7.090
7.085
5.288
2.127
2.043
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ppm
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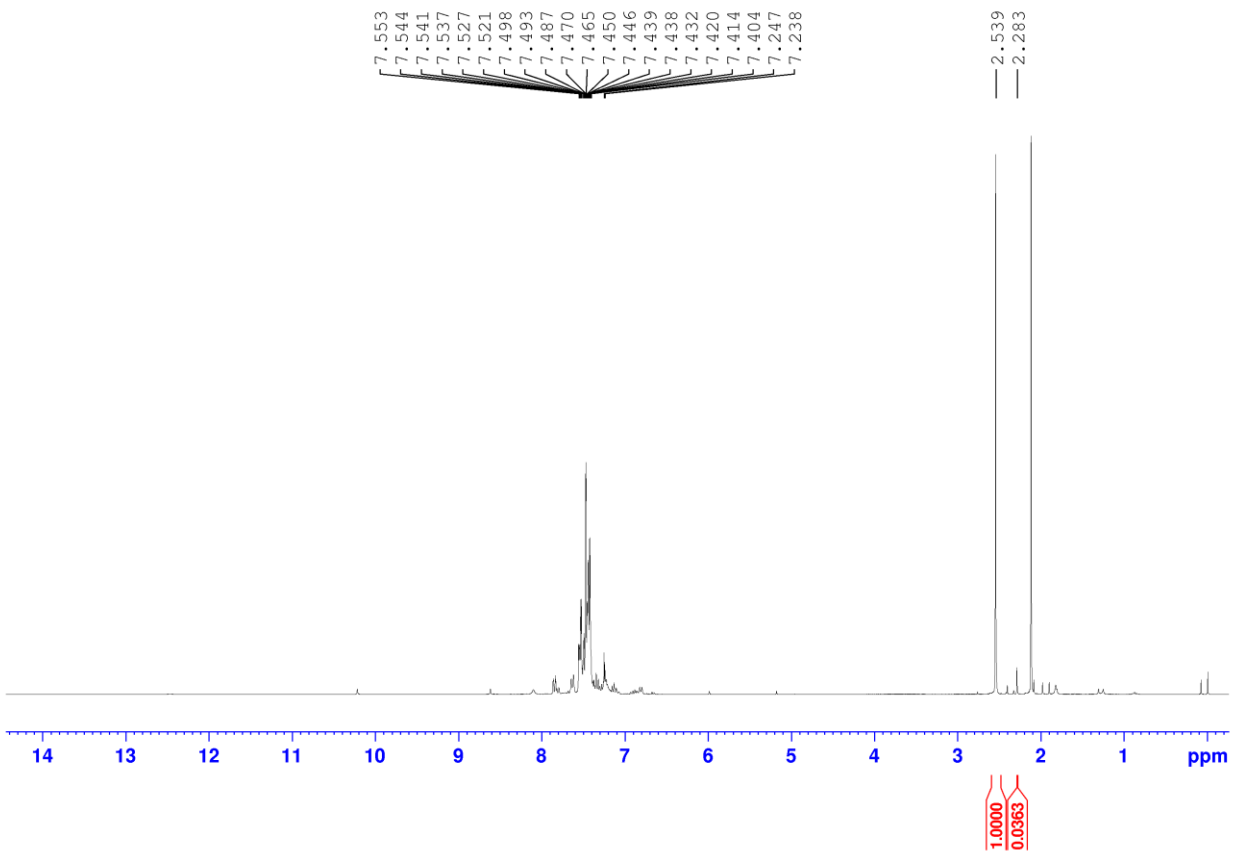
Entry 9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7.544
7.541
7.537
7.527
7.521
7.498
7.493
7.487
7.470
7.465
7.450
7.446
7.439
7.438
7.432
7.420
7.414
7.404
7.247
7.238
2.539
2.283
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12
11
10
9
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6
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ppm
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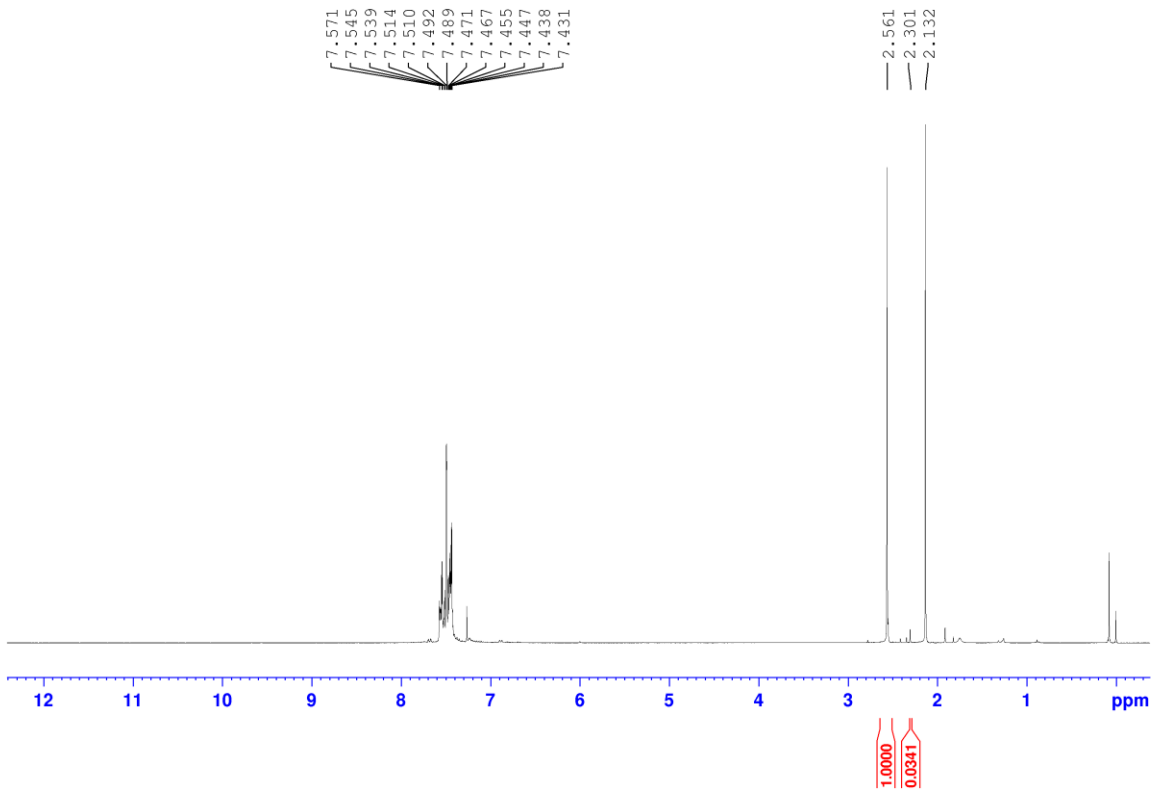
0.0363

Entry 10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7.539
7.514
7.510
7.492
7.489
7.471
7.467
7.455
7.447
7.438
7.431
2.561
2.301
2.132
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10
9
8
7
6
5
4
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2
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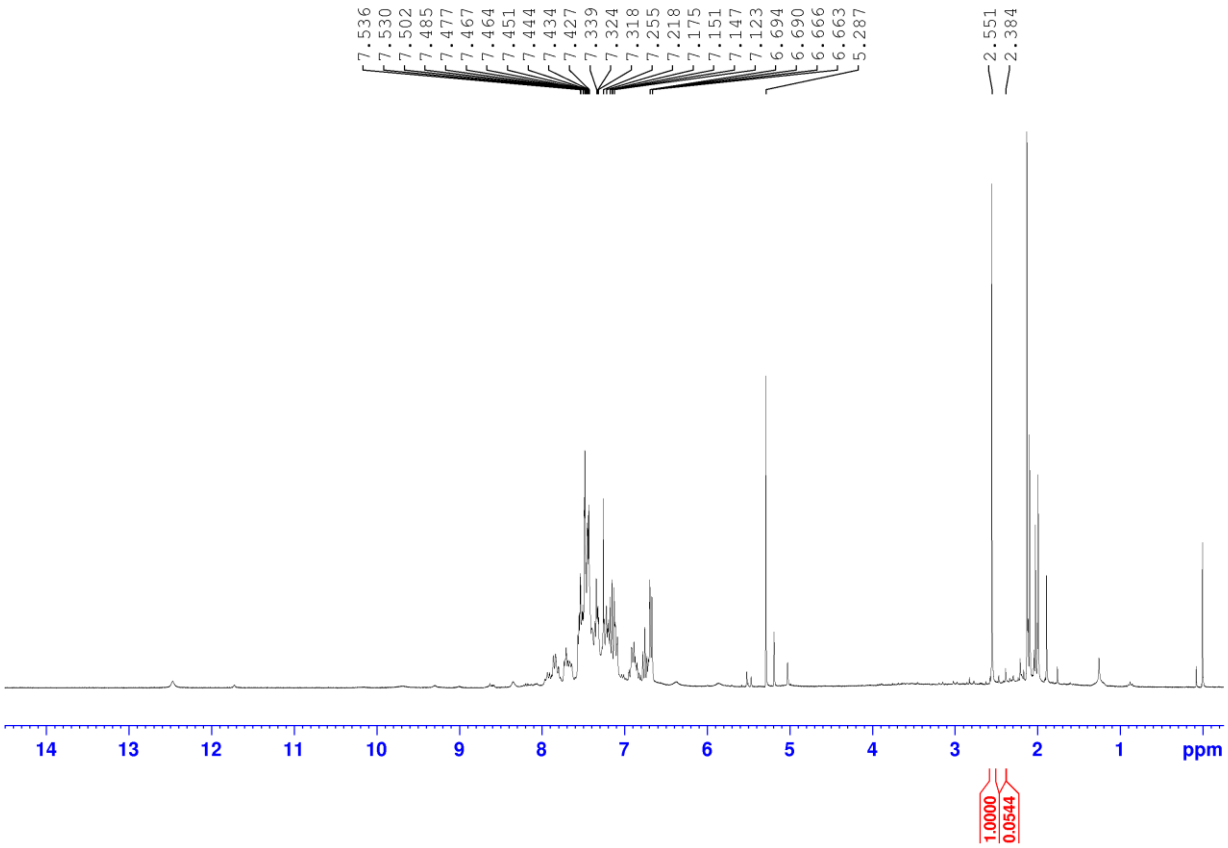
0.0341

Entry 11


7.536
7.530
7.502
7.485
7.477
7.467
7.464
7.451
7.444
7.434
7.427
7.339
7.324
7.318
7.255
7.218
7.175
7.151
7.147
7.123
6.694
6.690
6.666
6.663
5.287
2.551
2.384
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9
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1
ppm
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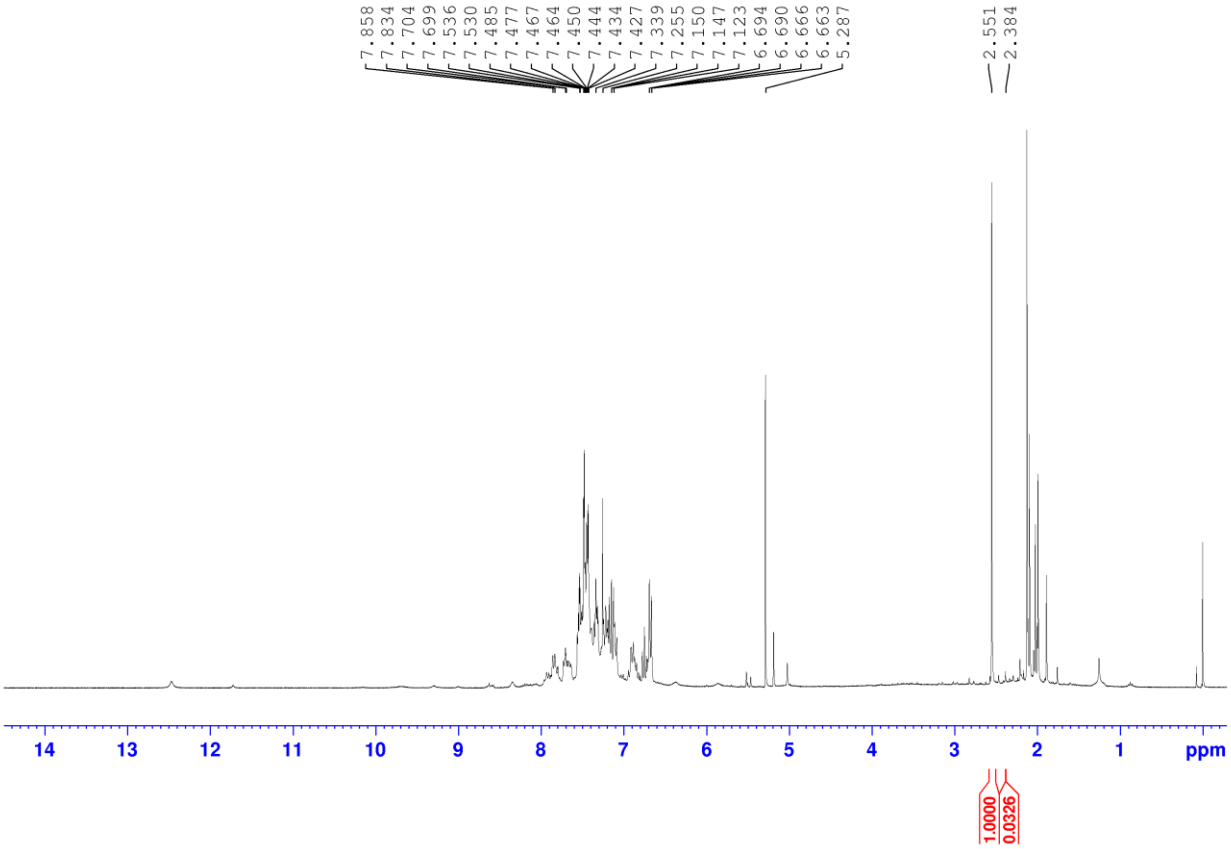
0.0544

Entry 12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7.477
7.467
7.464
7.450
7.444
7.434
7.427
7.339
7.255
7.150
7.147
7.123
6.694
6.690
6.666
6.663
5.287
2.551
2.384
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10
9
8
7
6
5
4
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2
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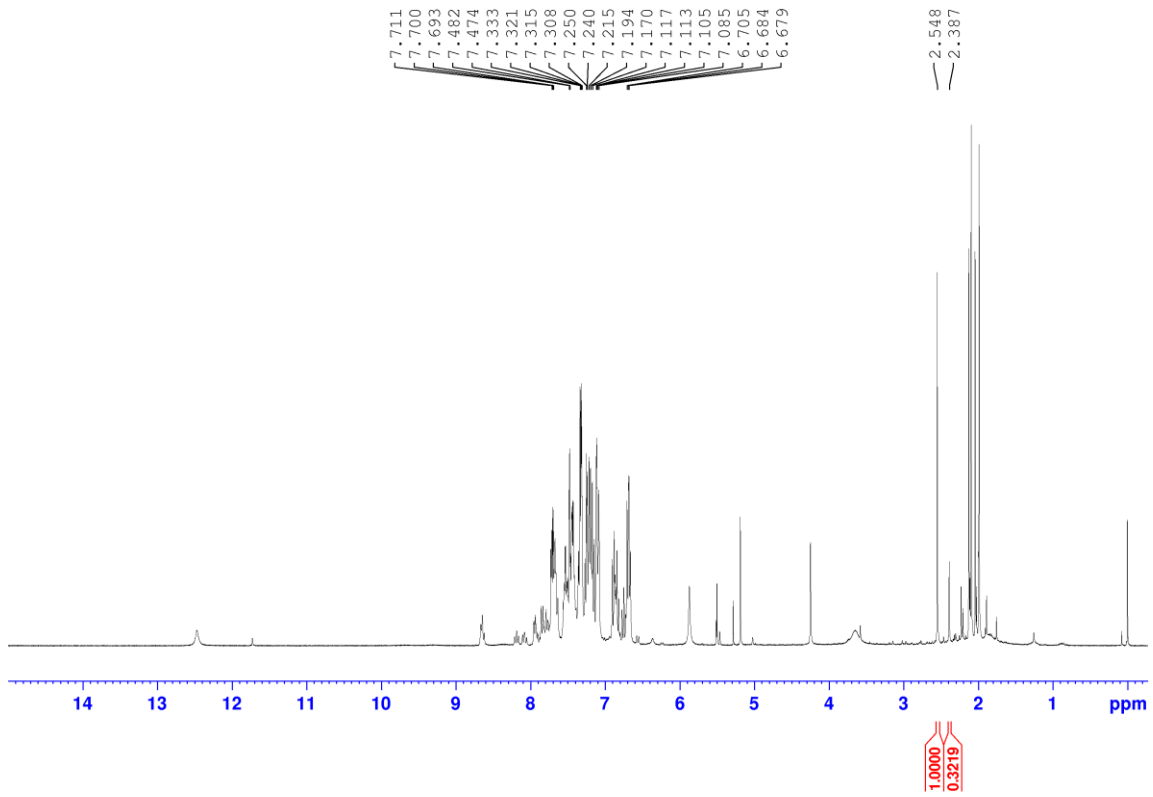
ppm
1.0000
0.0326

Entry 13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7.700
7.693
7.482
7.474
7.333
7.321
7.315
7.308
7.250
7.240
7.215
7.194
7.170
7.117
7.113
7.105
7.085
6.705
6.684
6.679
2.548
2.387
14
13
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11
10
9
8
7
6
5
4
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2
1
ppm
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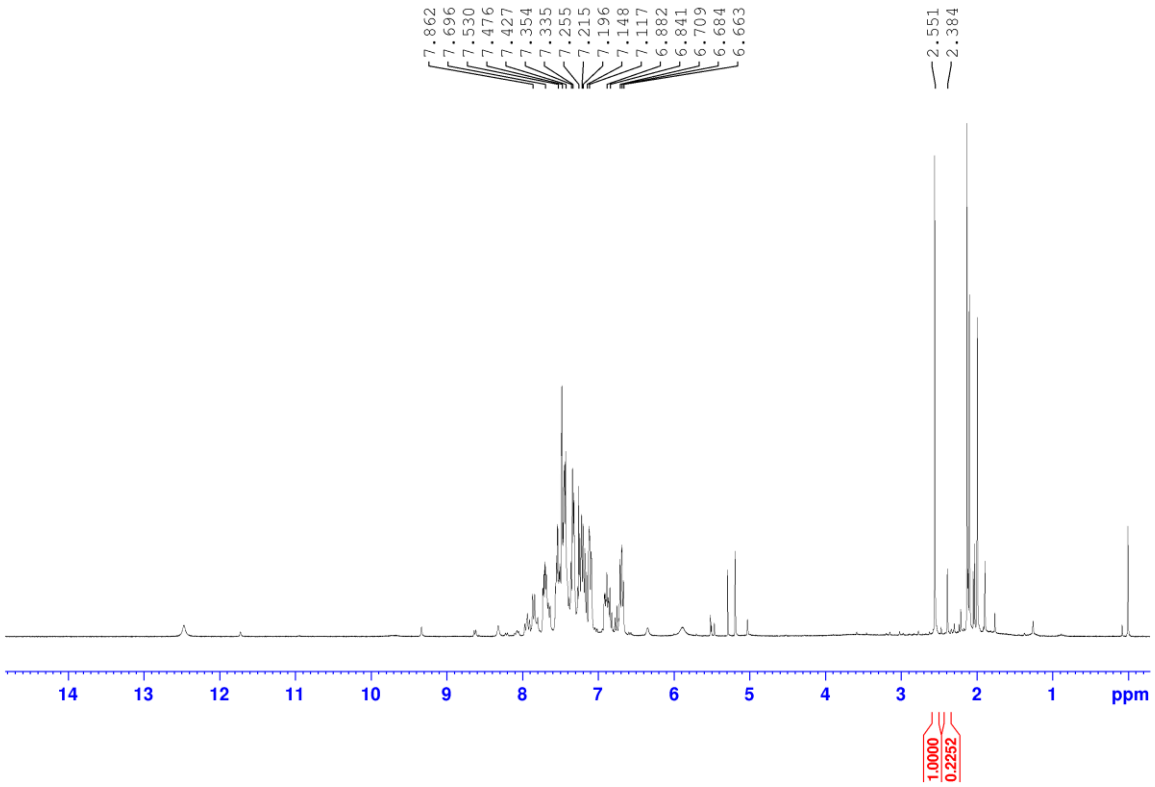
0.3219

Entry 14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7.427
7.354
7.335
7.255
7.215
7.196
7.148
7.117
6.882
6.841
6.709
6.684
6.663
2.551
2.384
14
13
12
11
10
9
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5
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3
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ppm
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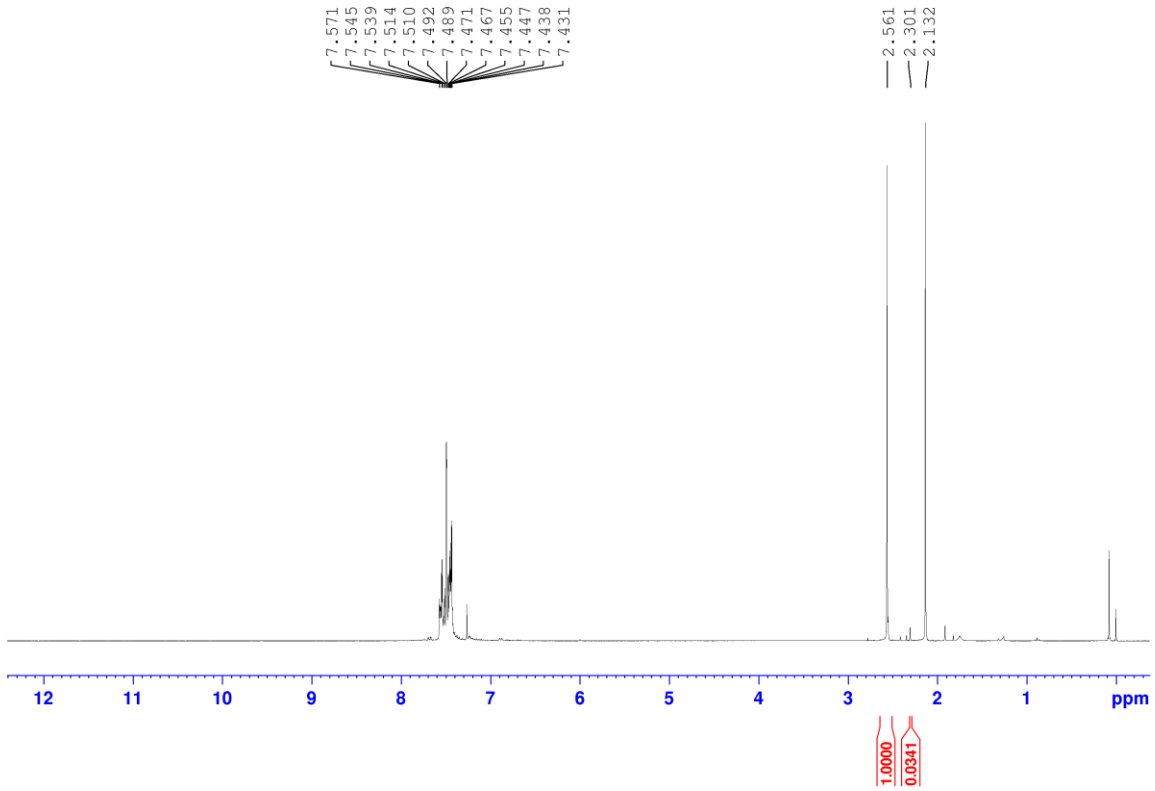
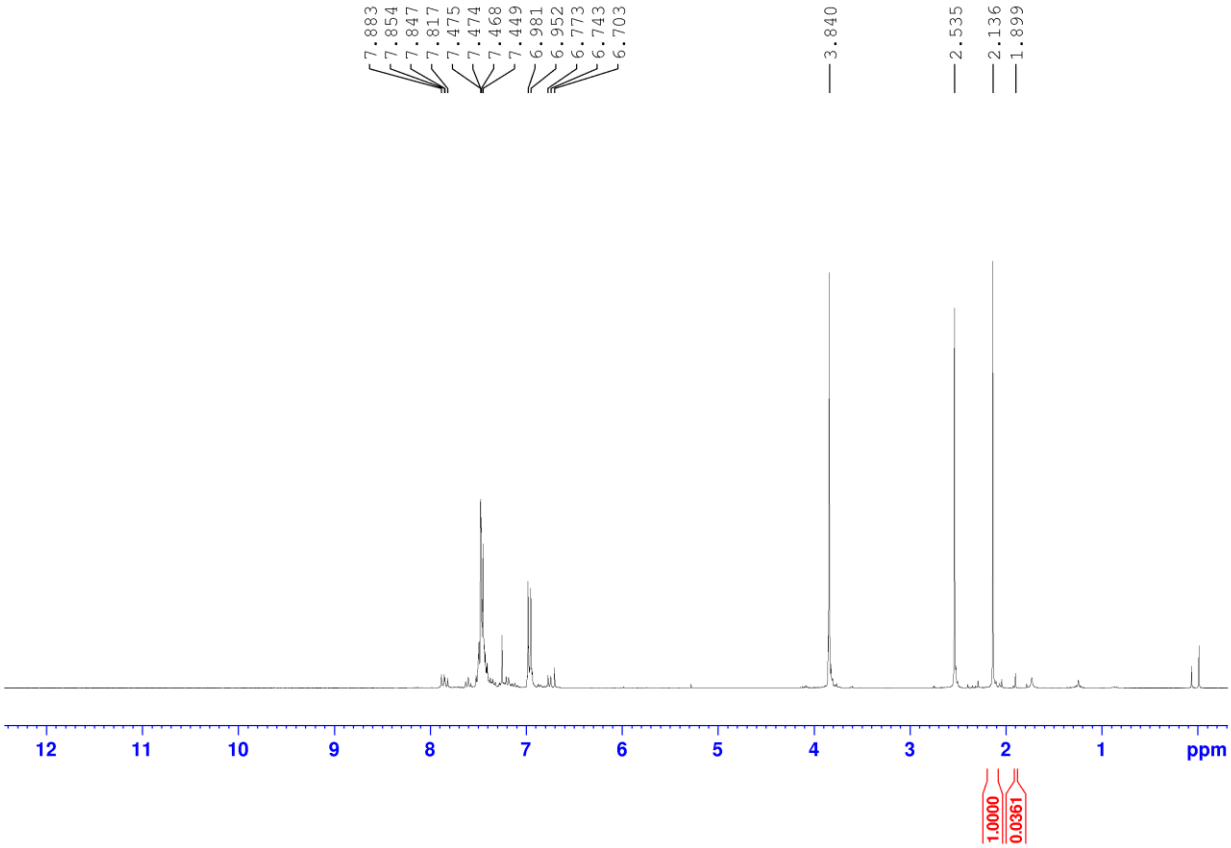
0.2252

^{1}H NMR spectra of crude reaction mixtures illustrated in Table 2.

Entry 1



Entry 2


7.883
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7.474
7.468
7.449
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6.952
6.773
6.743
6.703
3.840
2.535
2.136
1.899
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11
10
9
8
7
6
5
4
3
2
1
ppm
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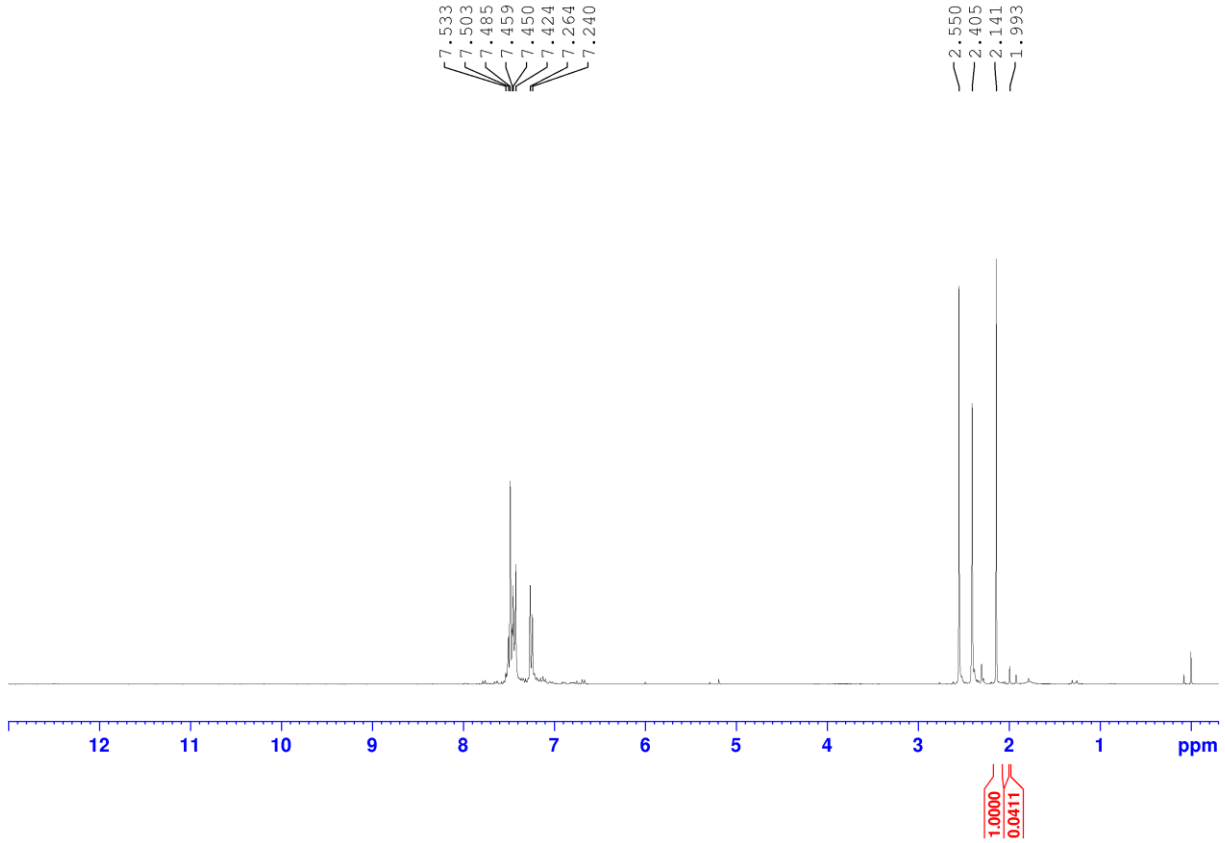
0.0361

Entry 3


7.533
7.503
7.485
7.459
7.450
7.424
7.264
7.240
2.550
2.405
2.141
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9
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2
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ppm
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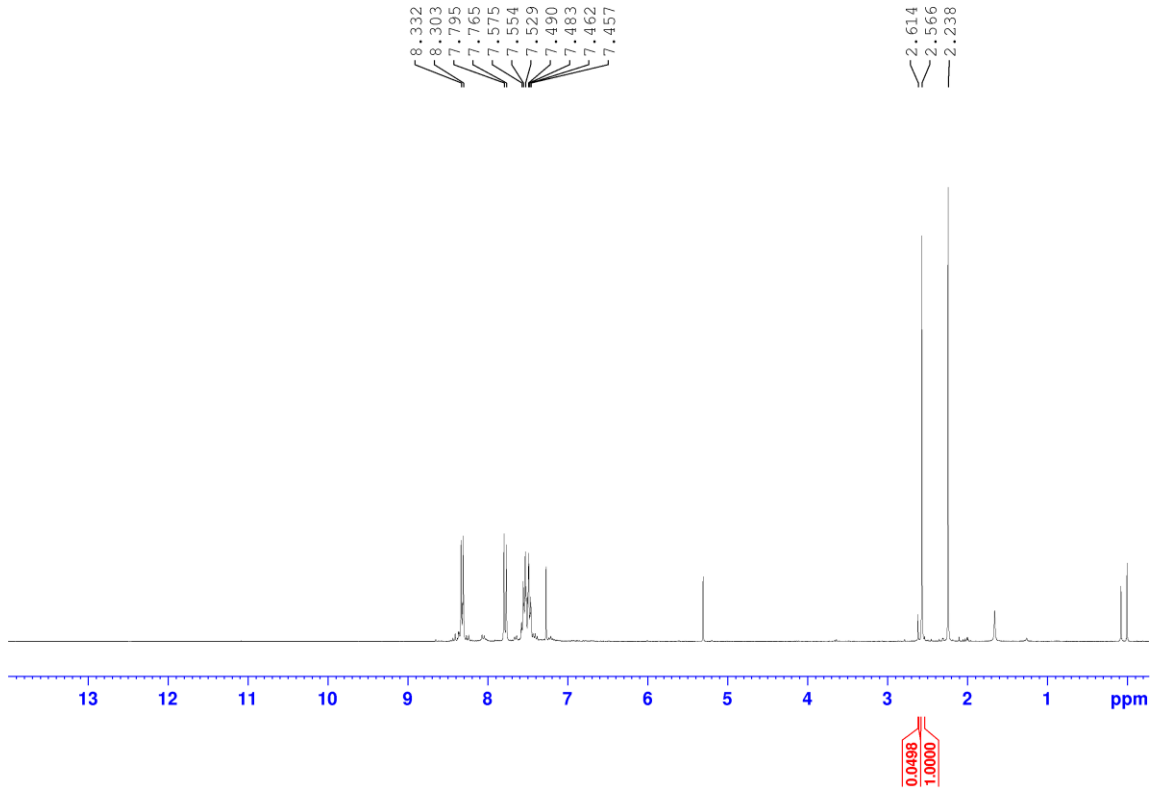
0.0411

Entry 4


8.332
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7.765
7.575
7.554
7.529
7.490
7.483
7.462
7.457
2.614
2.566
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10
9
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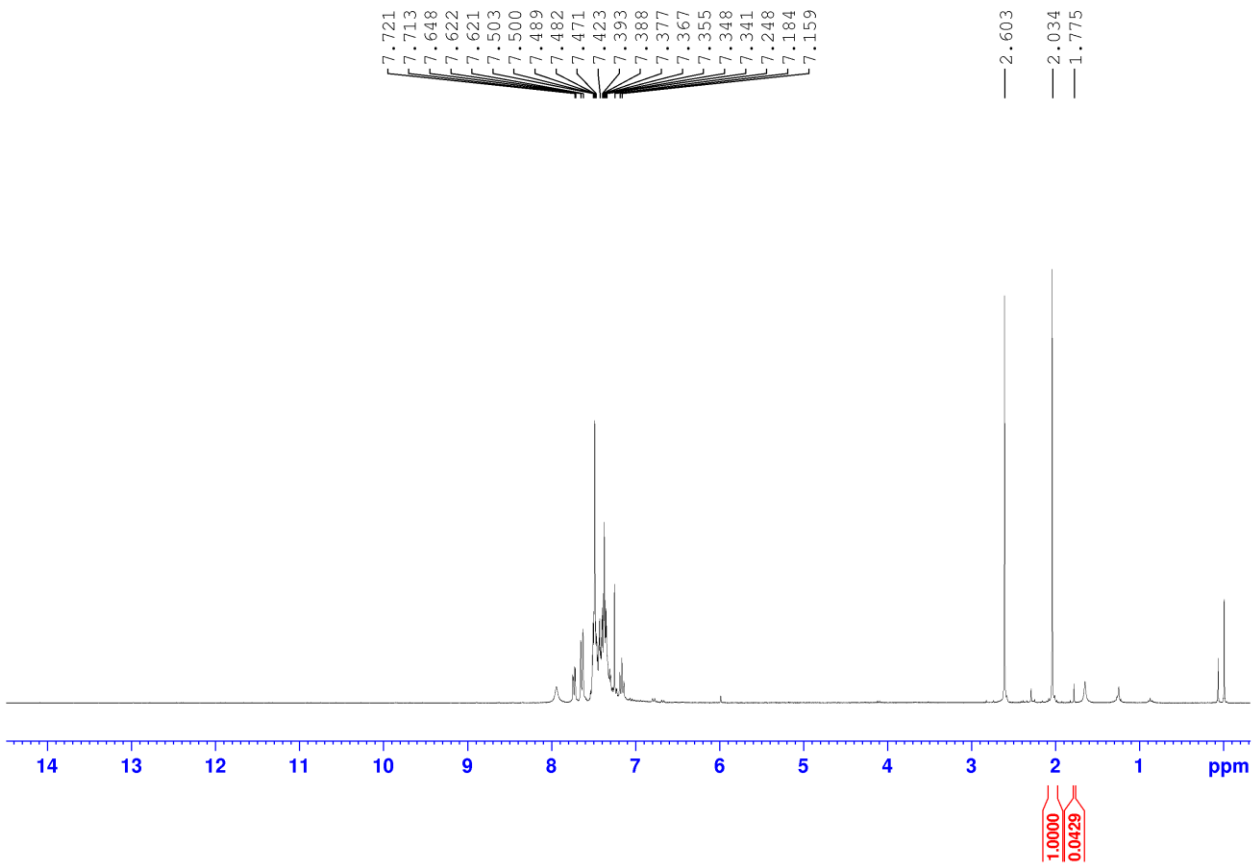
1.0000

Entry 5


7.721
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7.621
7.503
7.500
7.489
7.482
7.471
7.423
7.393
7.388
7.377
7.367
7.355
7.348
7.341
7.248
7.184
7.159
2.603
2.034
1.775
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10
9
8
7
6
5
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2
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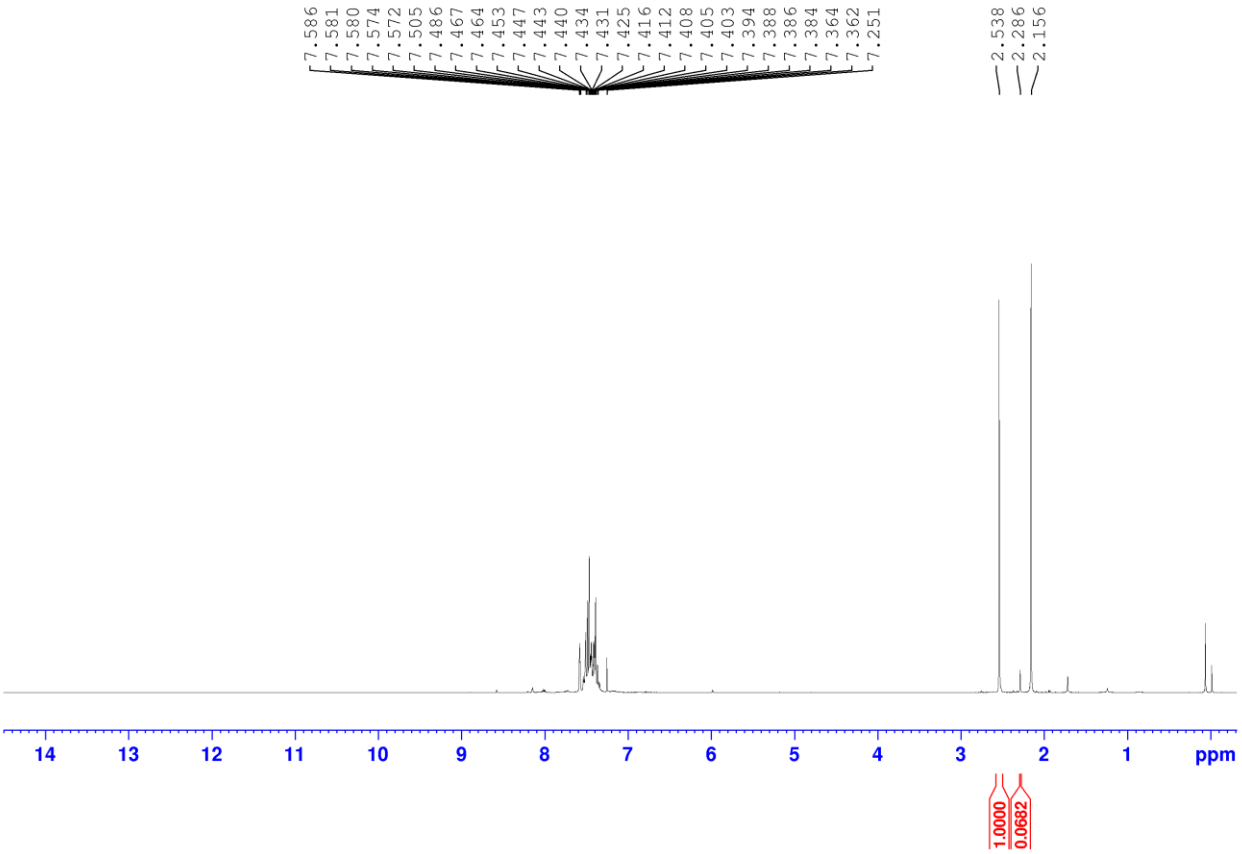
ppm
1.0000
0.0429

Entry 6


7.586
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7.453
7.447
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7.440
7.434
7.431
7.425
7.416
7.412
7.408
7.405
7.403
7.394
7.388
7.386
7.384
7.364
7.362
7.251
2.538
2.286
2.156
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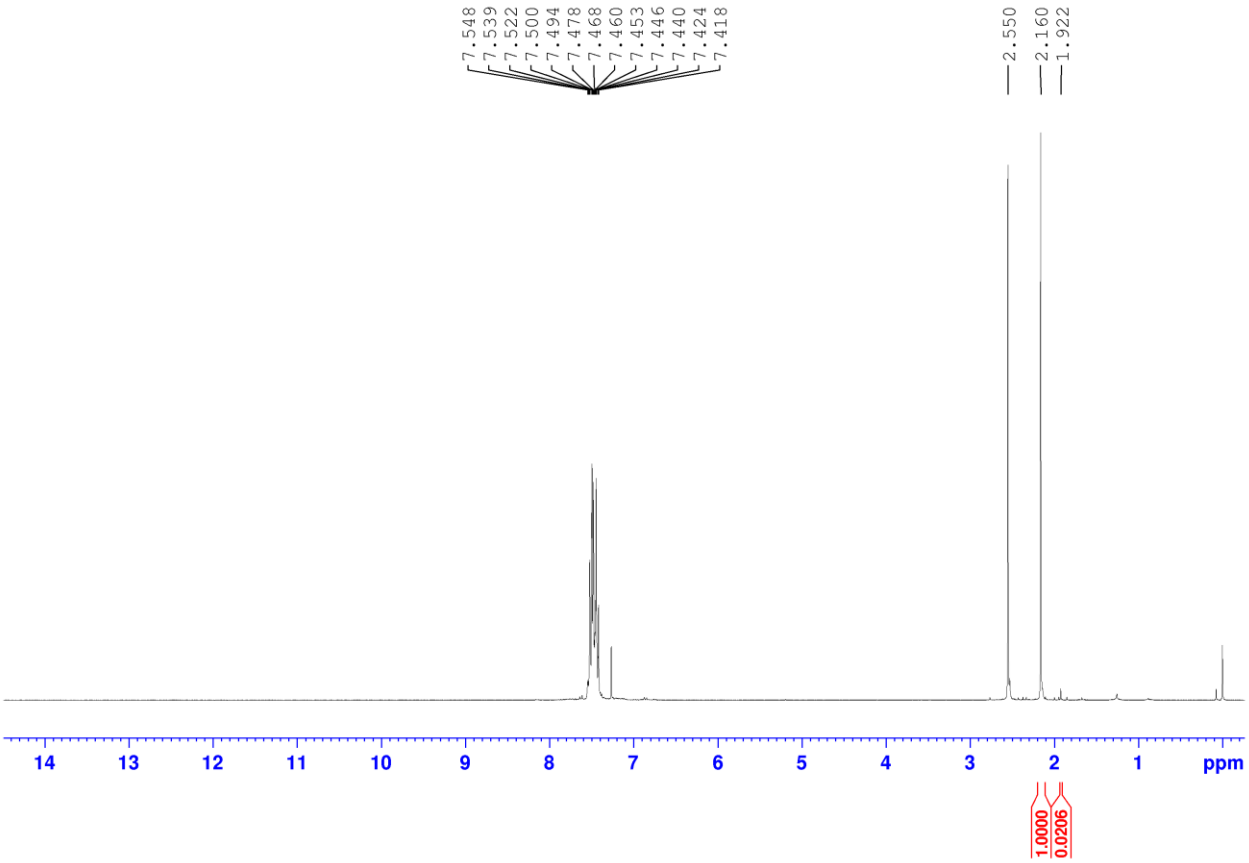
Entry 7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7.468
7.460
7.453
7.446
7.440
7.424
7.418
2.550
2.160
1.922
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10
9
8
7
6
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4
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2
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ppm
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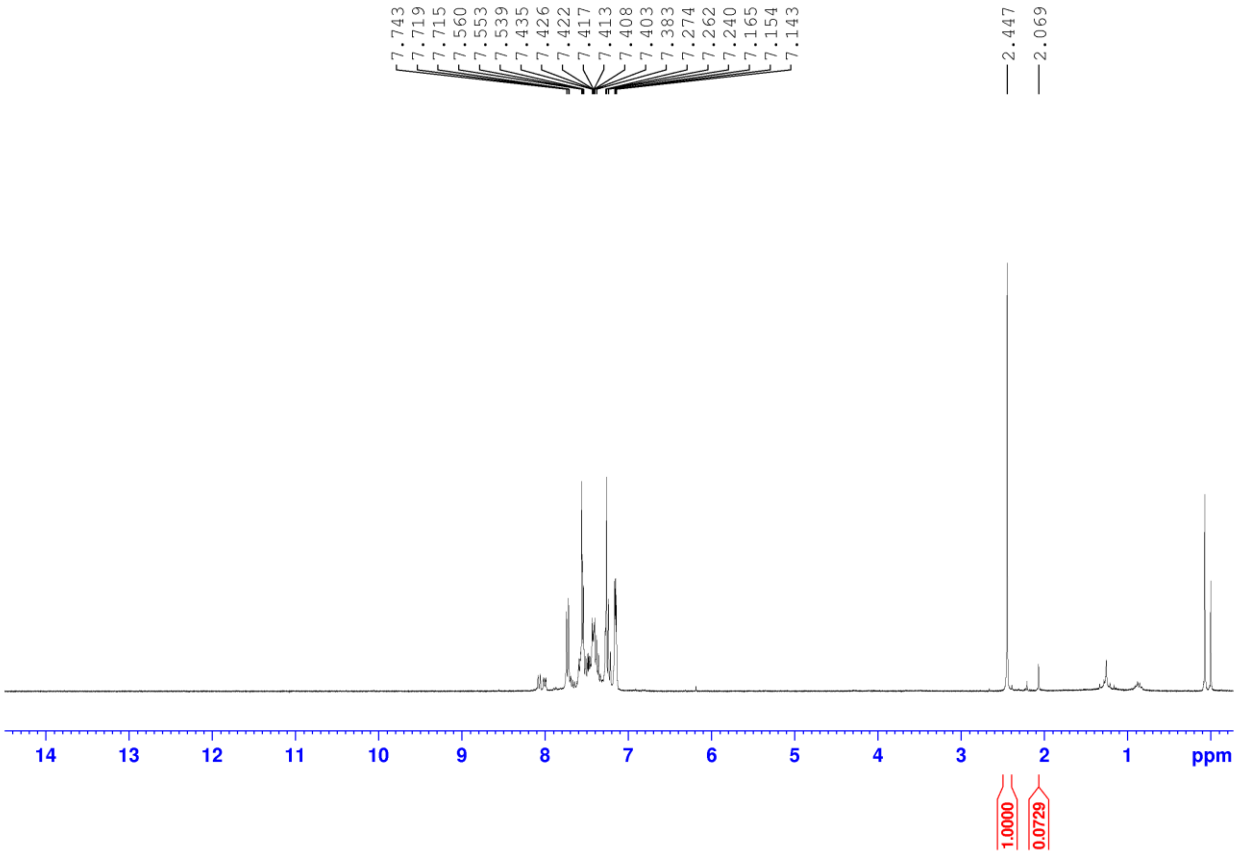
Entry 8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7.539
7.435
7.426
7.422
7.417
7.413
7.408
7.403
7.383
7.274
7.262
7.240
7.165
7.154
7.143
2.447
2.069
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10
9
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7
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4
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2
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ppm
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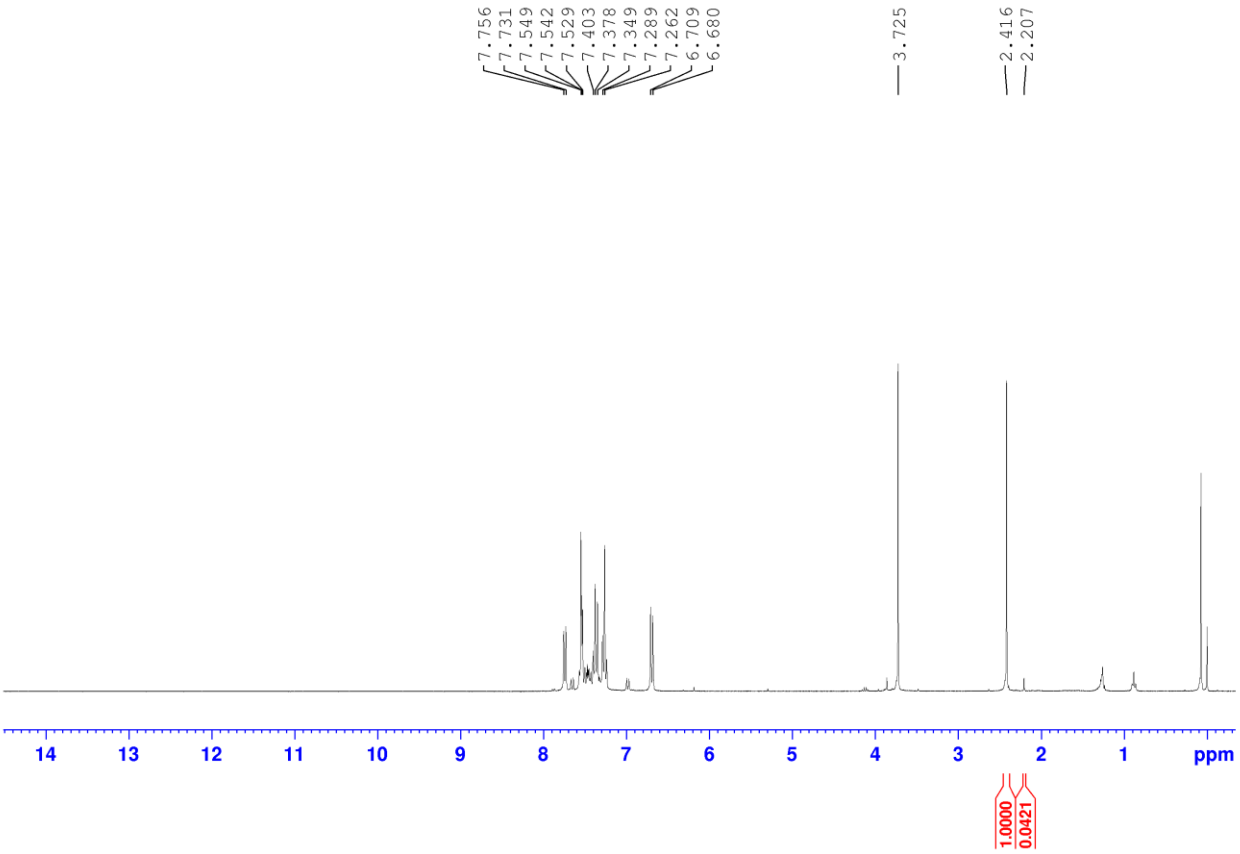
0.0729

Entry 9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7.403
7.378
7.349
7.289
7.262
6.709
6.680
3.725
2.416
2.207
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10
9
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6
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2
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ppm
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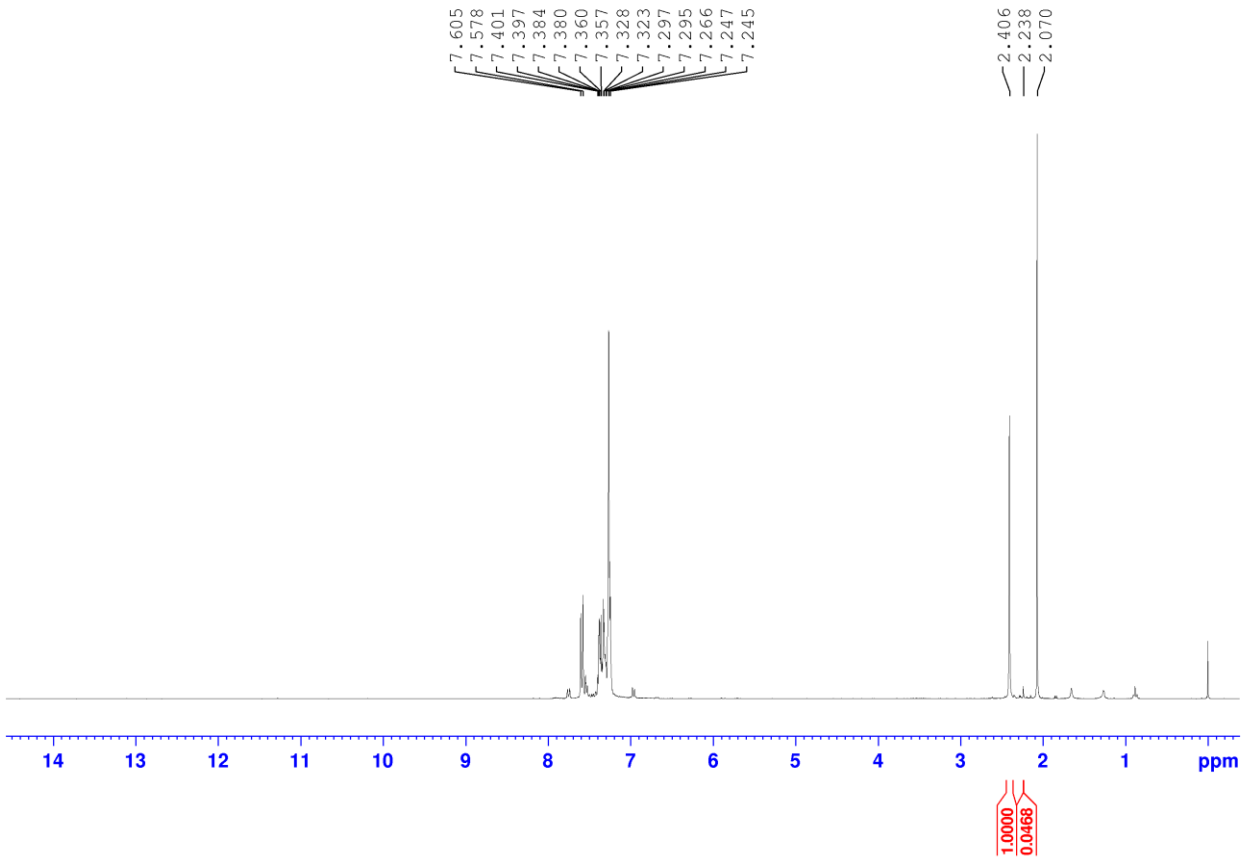
0.0421

Entry 10


7.605
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7.384
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7.357
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7.323
7.297
7.295
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7.247
7.245
2.406
2.238
2.070
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10
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6
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2
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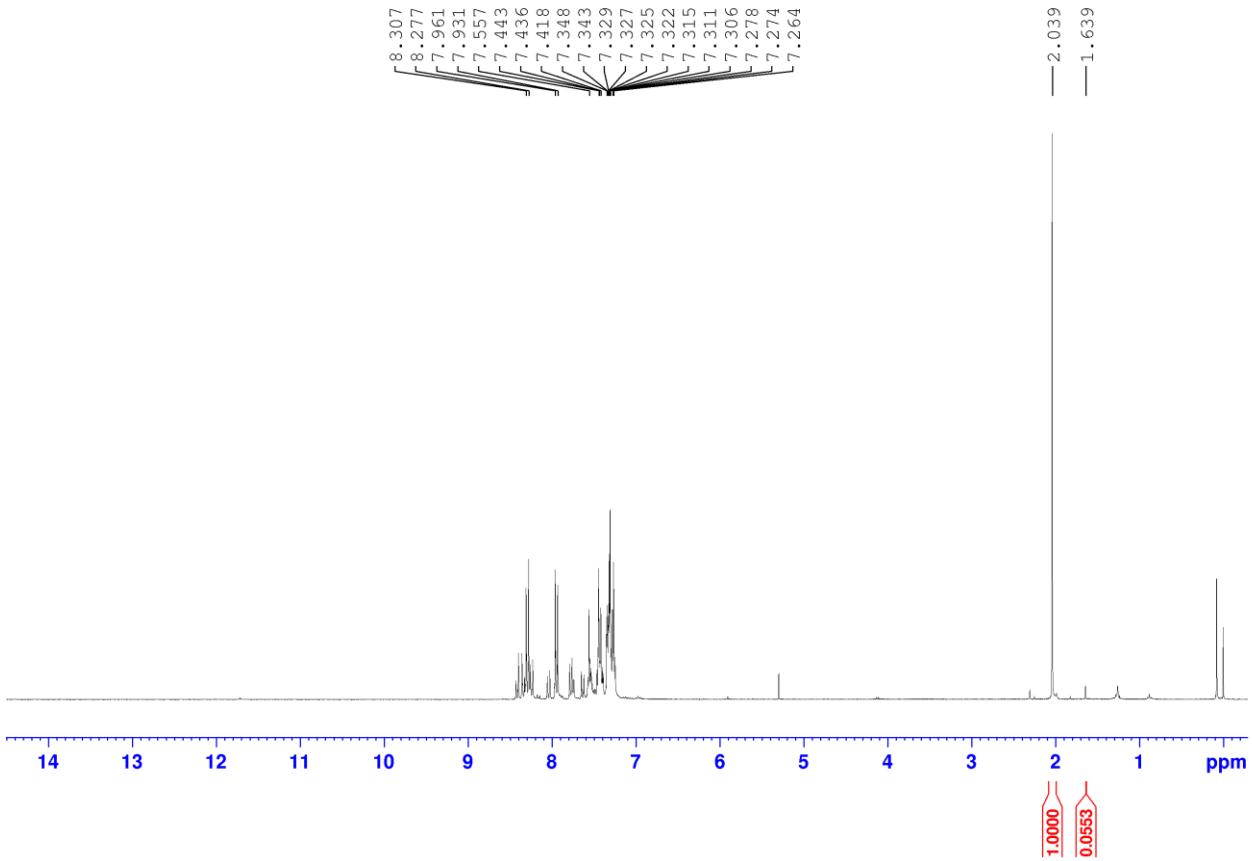
0.0468

Entry 11


8.307
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7.961
7.931
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7.436
7.418
7.348
7.343
7.329
7.327
7.325
7.322
7.315
7.311
7.306
7.278
7.274
7.264
2.039
1.639
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10
9
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ppm
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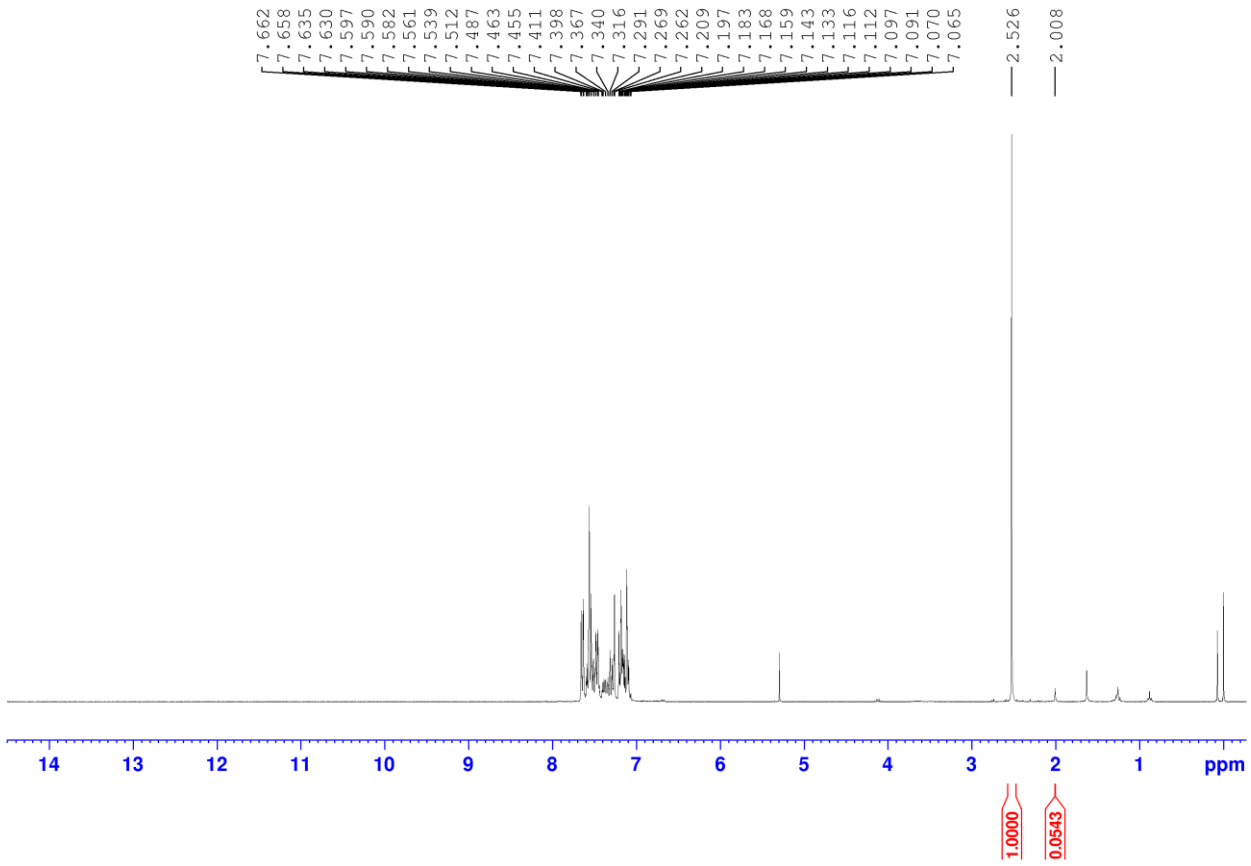
Entry 12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7.590
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7.561
7.539
7.512
7.487
7.463
7.455
7.411
7.398
7.367
7.340
7.316
7.291
7.269
7.262
7.209
7.197
7.183
7.168
7.159
7.143
7.133
7.116
7.112
7.097
7.091
7.070
7.065
2.526
2.008
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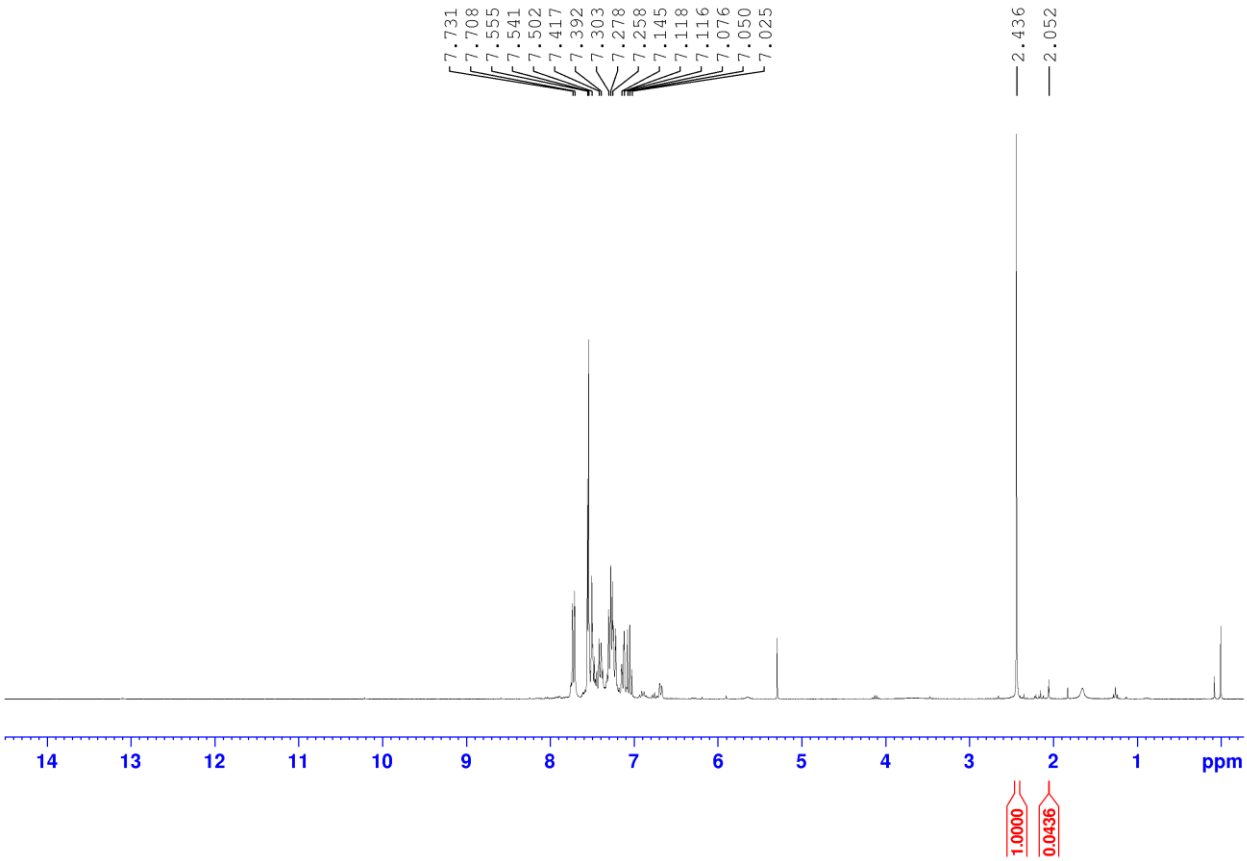
Entry 13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7.303
7.278
7.258
7.145
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7.116
7.076
7.050
7.025
2.436
2.052
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9
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7
6
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2
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ppm
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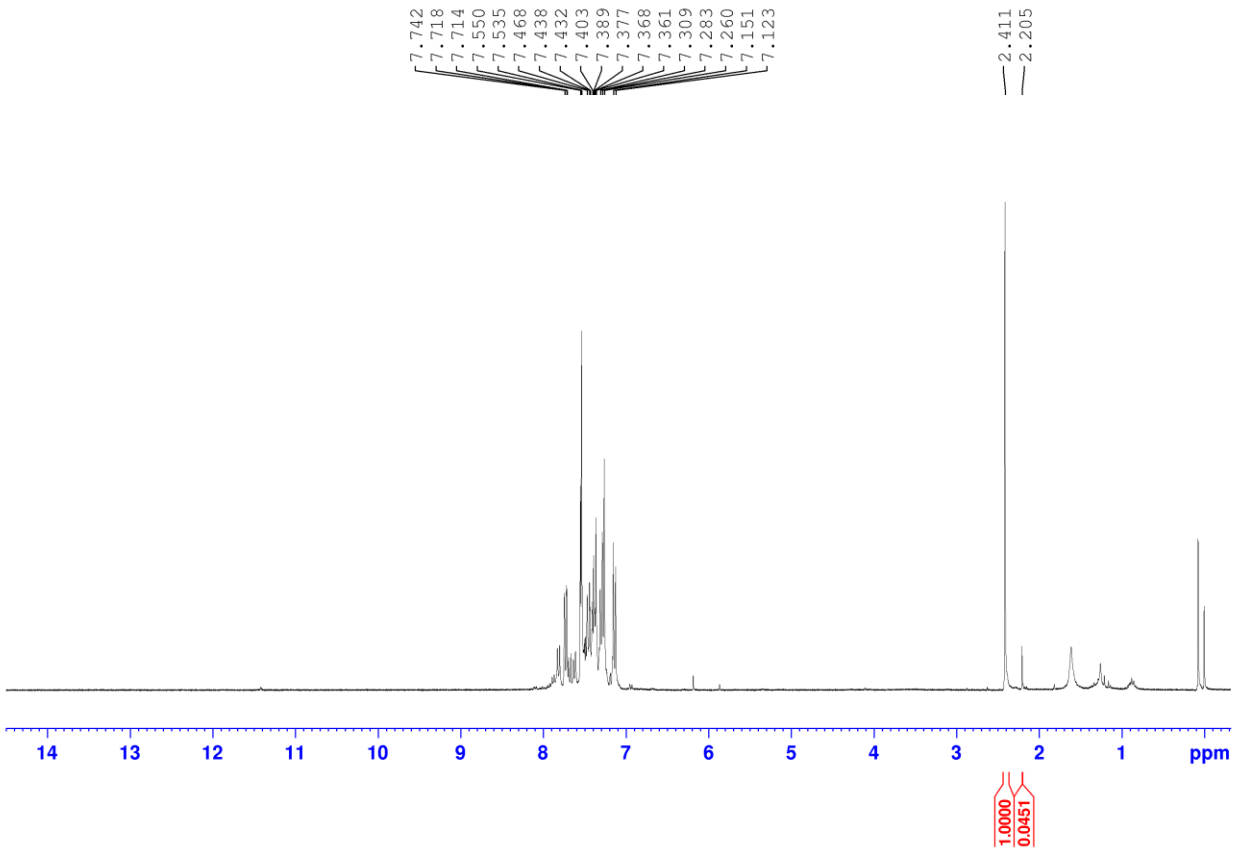
Entry 14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7.432
7.403
7.389
7.377
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7.361
7.309
7.283
7.260
7.151
7.123
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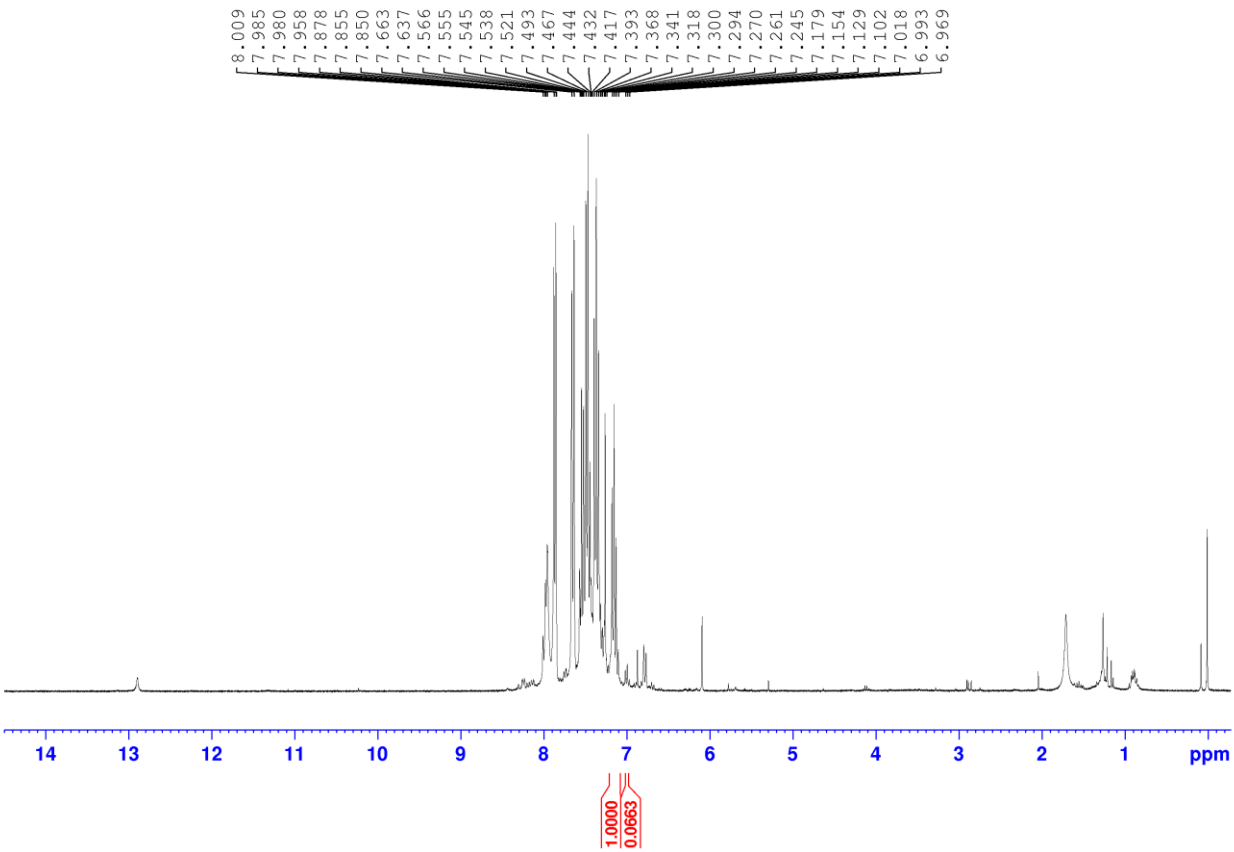
14
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.0000
0.0451

Entry 15


8.009
7.985
7.980
7.958
7.878
7.855
7.850
7.663
7.637
7.566
7.555
7.545
7.538
7.521
7.493
7.467
7.444
7.432
7.417
7.393
7.368
7.341
7.318
7.300
7.294
7.270
7.261
7.245
7.179
7.154
7.129
7.102
7.018
6.993
6.969
14
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.0000
0.0663

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