Copper(II)-Catalyzed Cascade Approach for the Synthesis of Pyrrolo[2,1-*f*][1,2,4]triazine-Fused Isoquinolines

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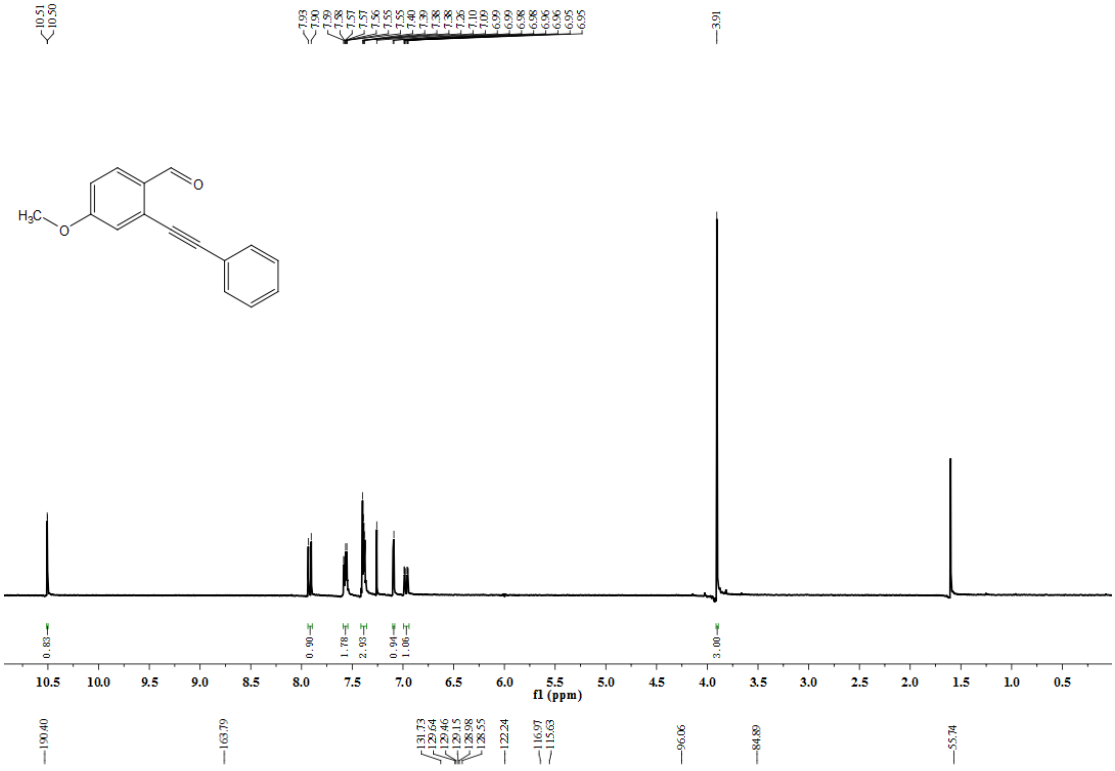
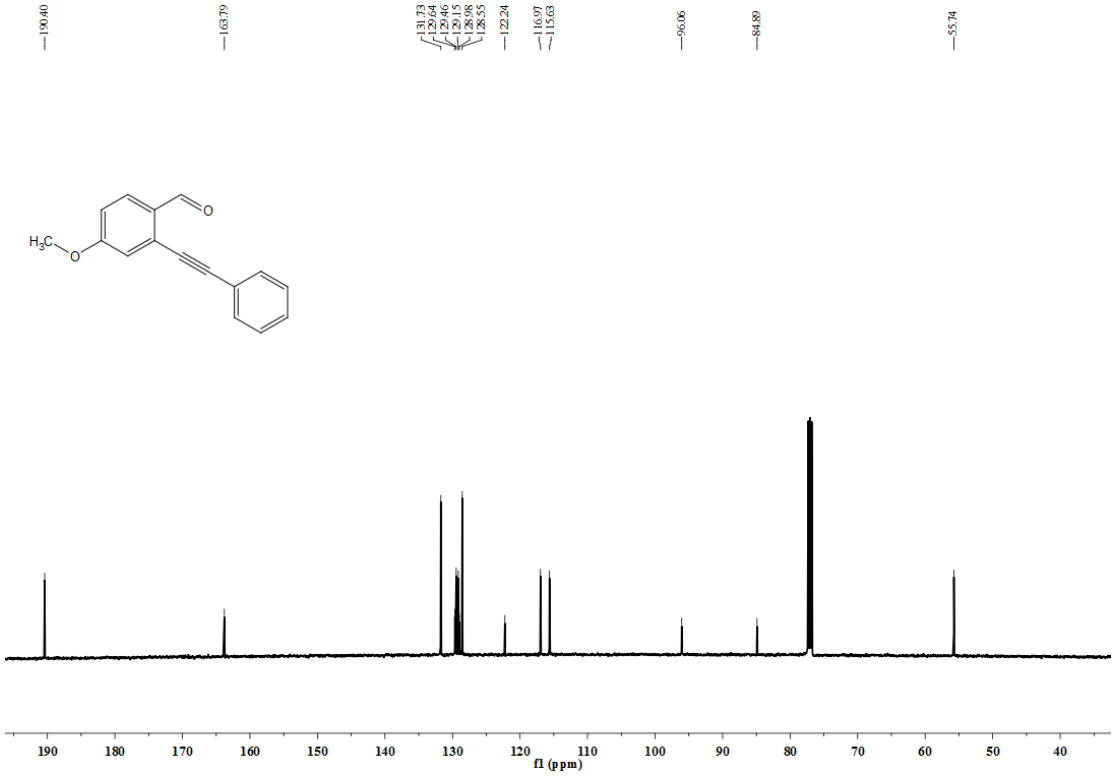
Supporting information

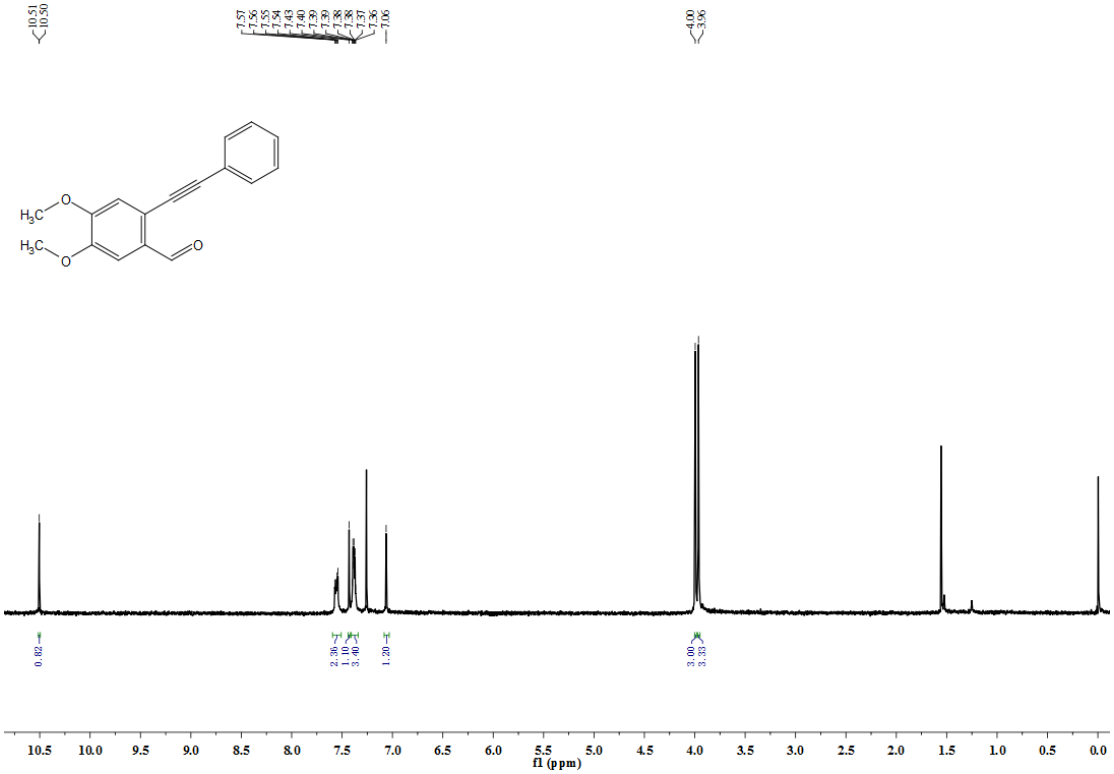
^{1}H NMR and ^{13}C NMR Spectrum of Compounds

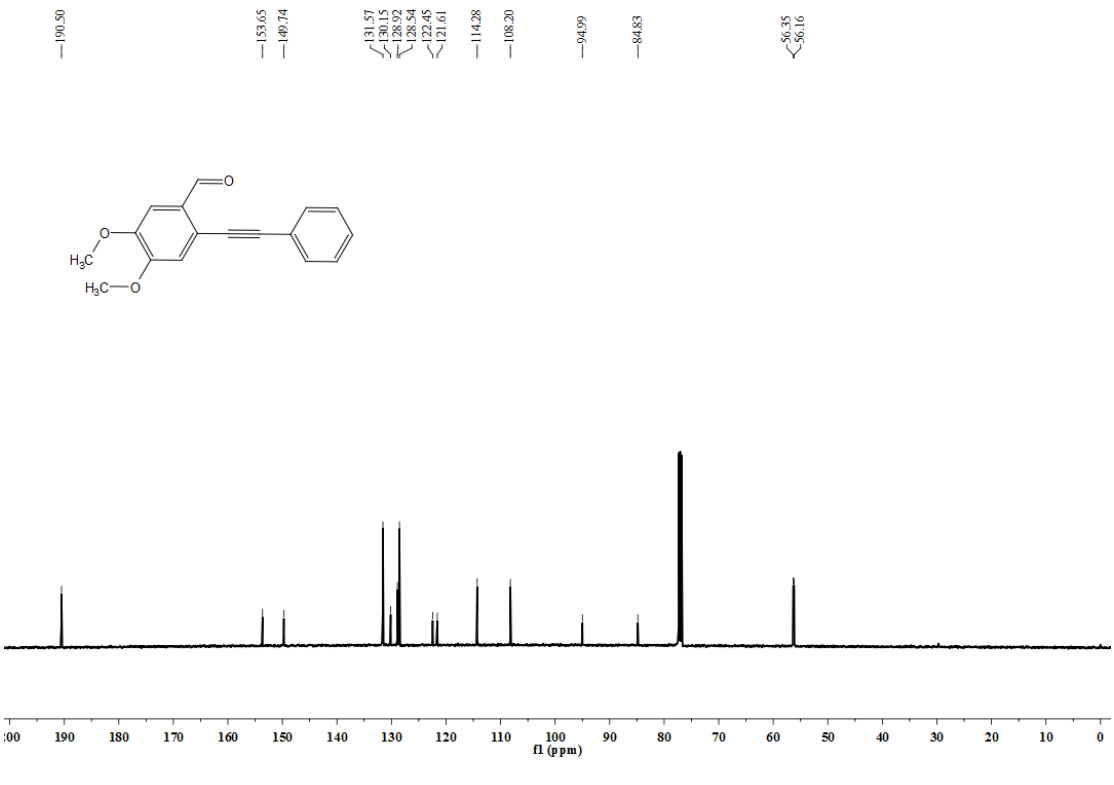
Compound 2f



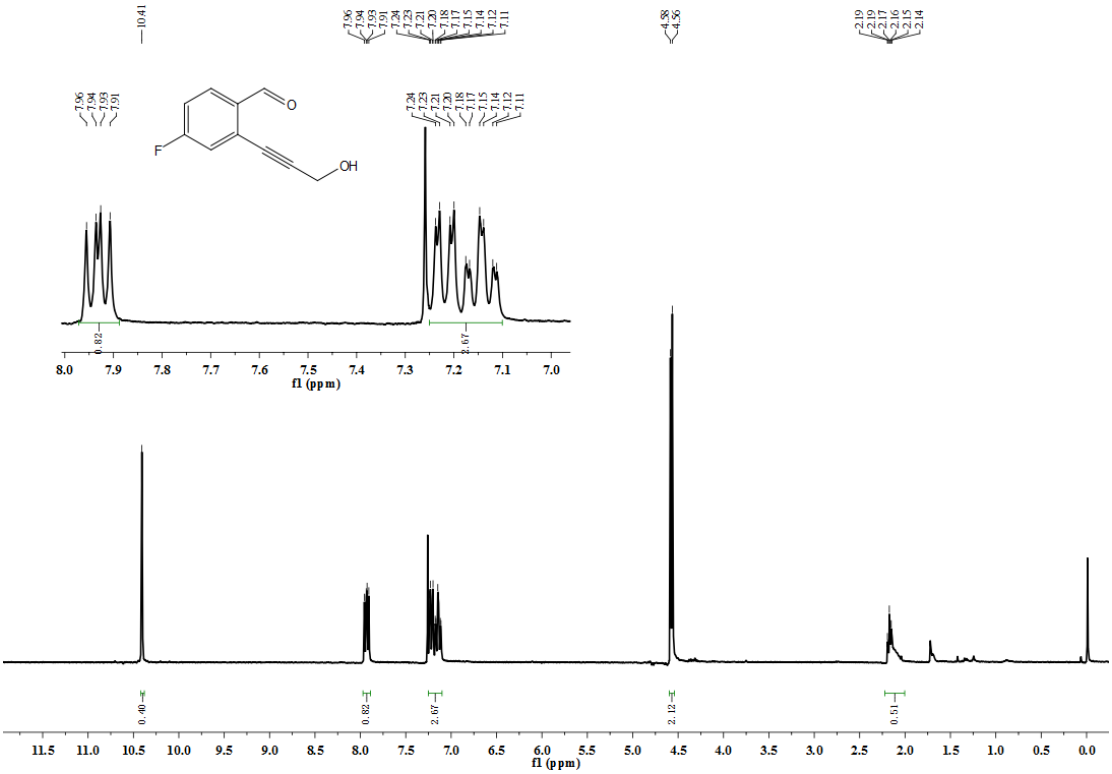


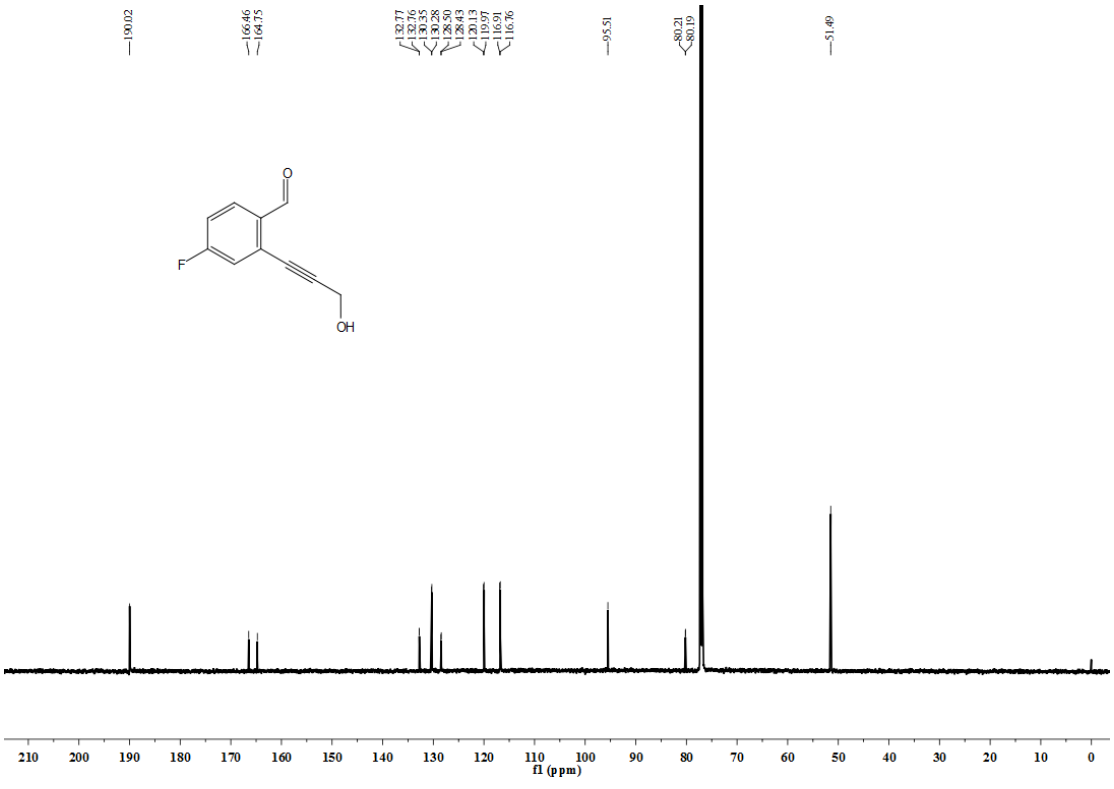
Compound 2g


10.51
10.50
7.57
7.56
7.55
7.54
7.43
7.40
7.39
7.39
7.38
7.38
7.37
7.36
7.06
4.00
3.96
0.82
2.30
1.10
3.40
1.20
3.00
3.33
f1 (ppm)

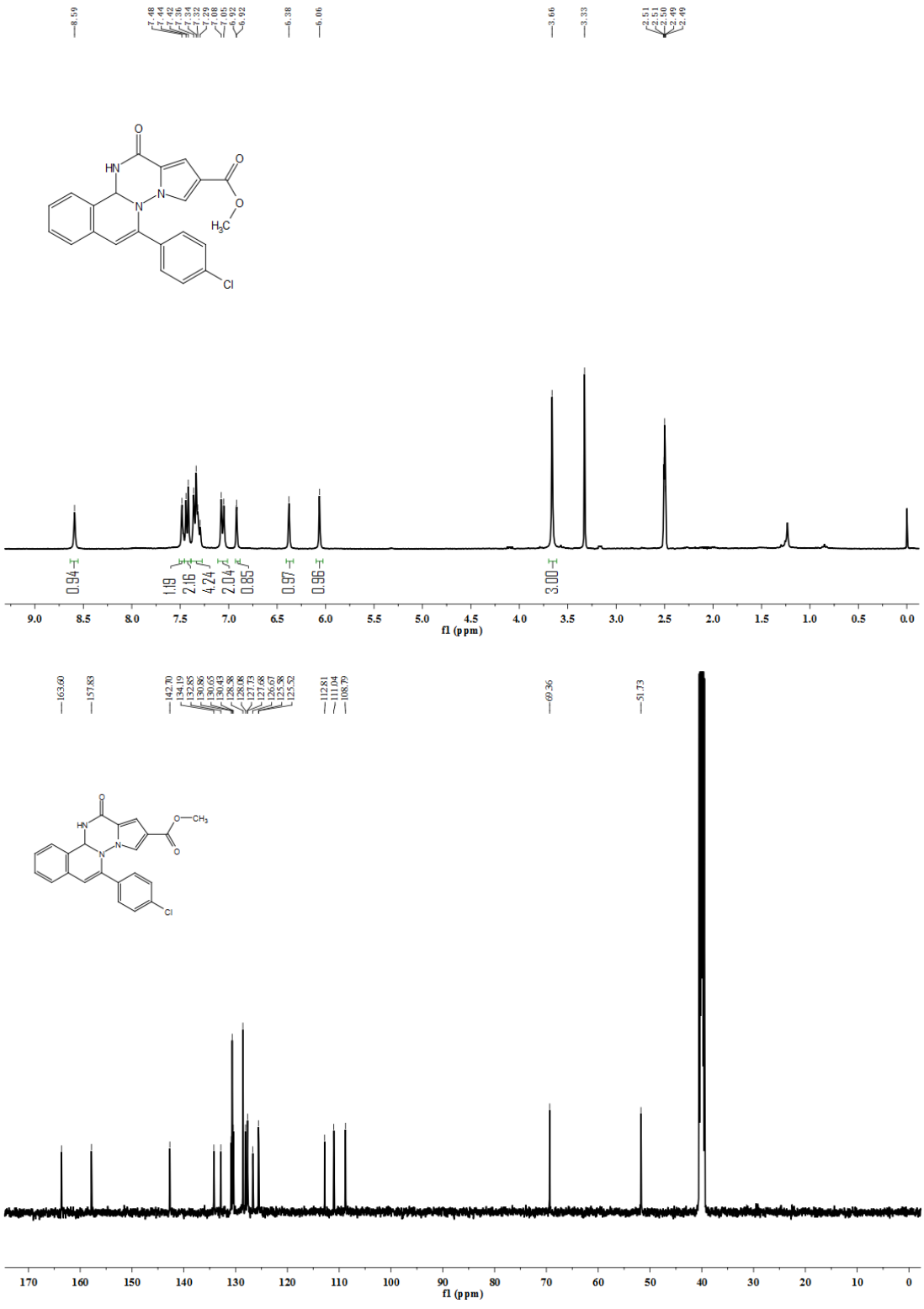

190.50
153.65
149.74
131.57
130.15
128.92
128.54
122.45
121.61
114.28
108.20
94.99
84.83
56.35
56.16
f1 (ppm)

Compound 2l

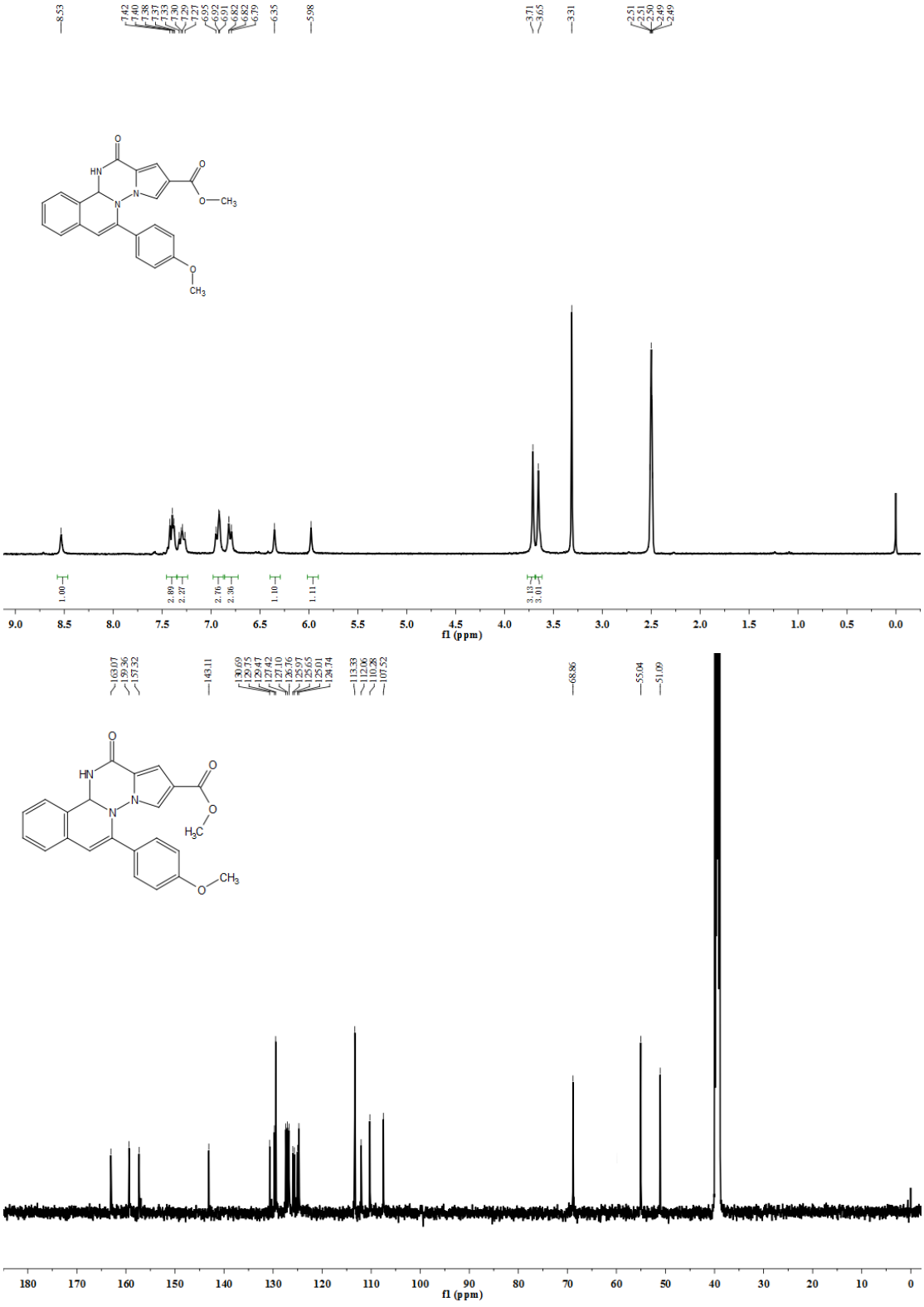

10.41
7.96
7.94
7.93
7.91
7.24
7.23
7.21
7.20
7.18
7.17
7.15
7.14
7.12
7.11
4.58
4.56
2.19
2.19
2.17
2.16
2.15
2.14
O
F
OH
0.82
2.67
f1 (ppm)
0.40
0.82
2.67
2.12
0.51
f1 (ppm)


190.02
166.46
164.75
132.77
132.76
130.55
130.28
128.50
128.43
120.13
119.97
116.91
116.76
95.51
80.21
80.19
51.49
O
F
OH
f1 (ppm)

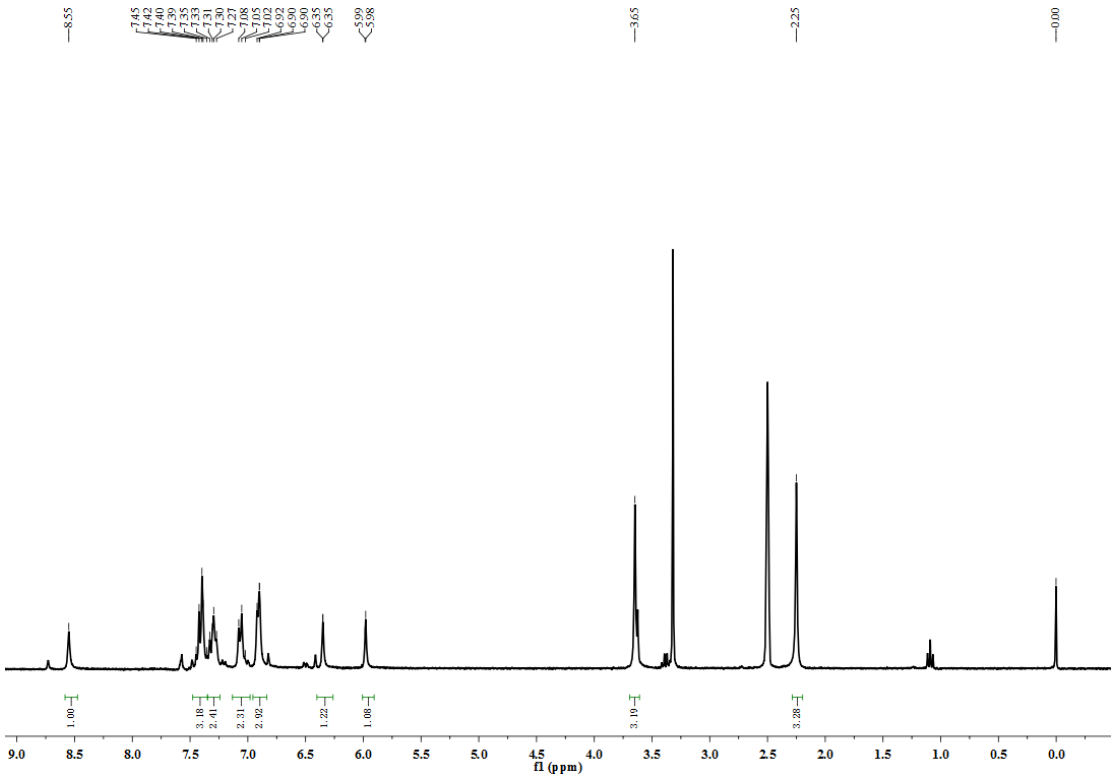
Compound **3a**

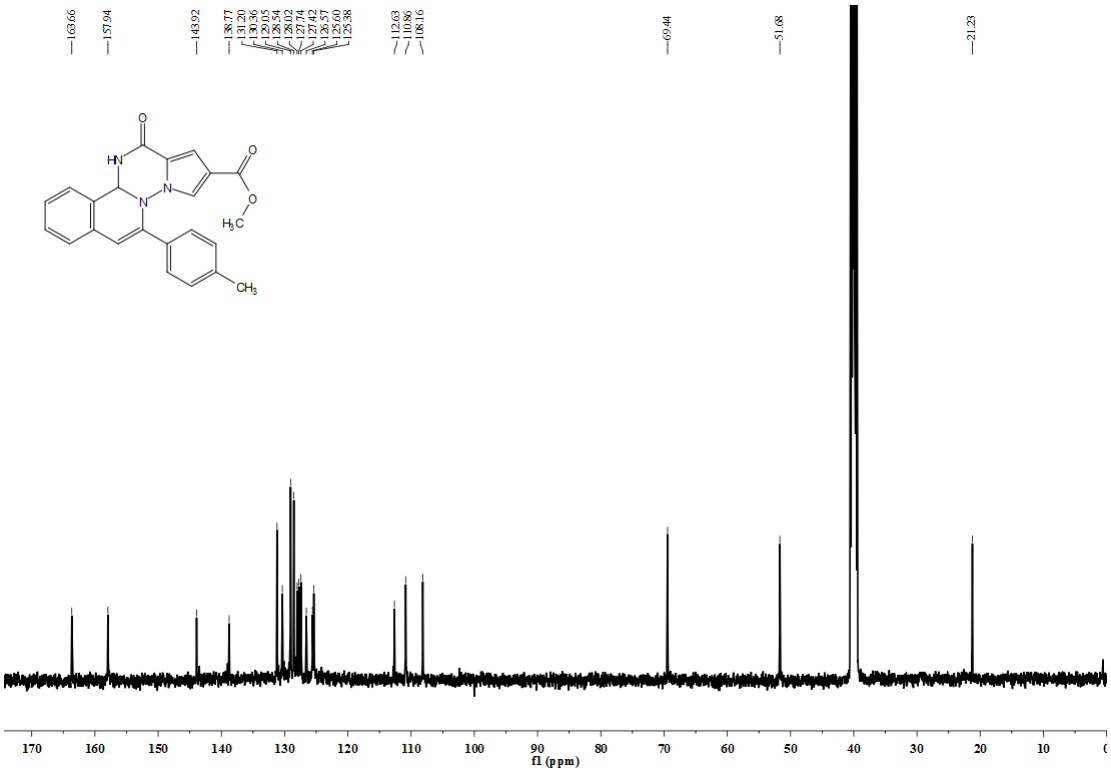

8.59
7.48
7.44
7.42
7.36
7.34
7.32
7.29
7.08
7.05
6.92
6.92
6.38
6.06
3.66
3.33
2.51
2.51
2.50
2.49
2.49
HN
N
N
O
O
O
H3C
Cl
0.94
1.19
2.16
4.24
2.04
0.85
0.97
0.96
3.00
f1 (ppm)
163.60
157.83
142.70
134.19
132.85
130.86
130.65
130.43
128.98
128.06
127.73
127.68
126.67
125.58
125.52
112.81
111.04
108.79
69.36
51.73
f1 (ppm)

Compound 3b

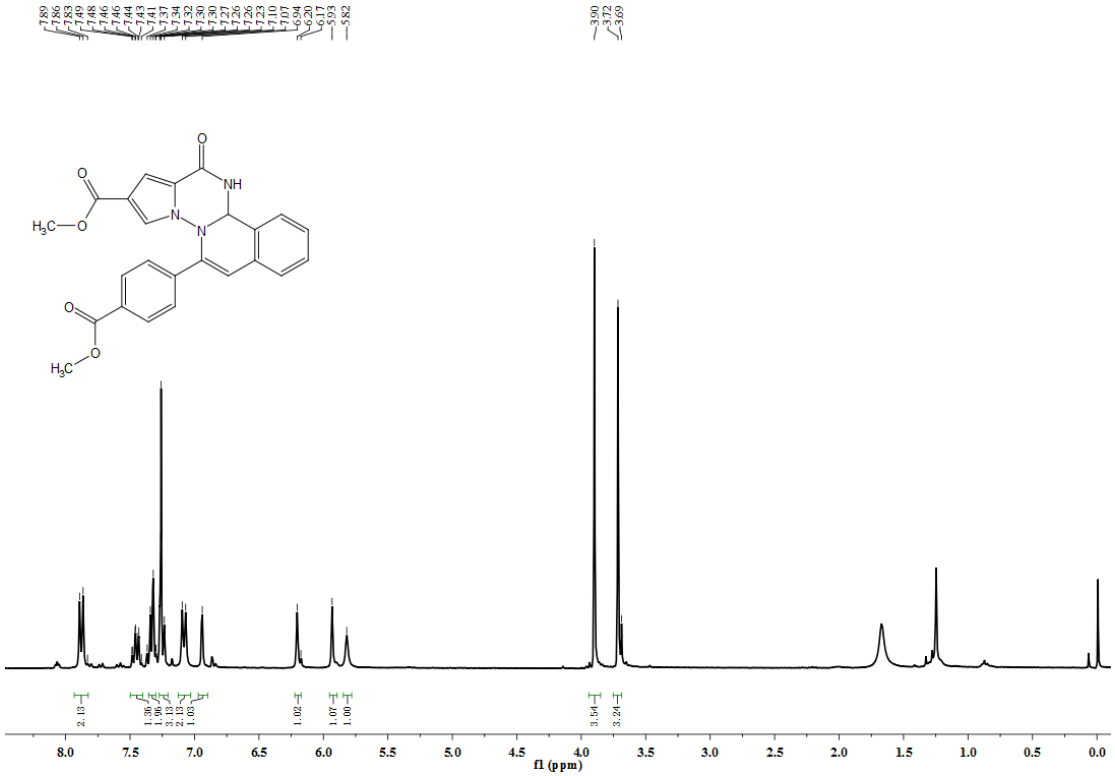

8.53
7.42
7.40
7.38
7.37
7.33
7.30
7.29
7.27
6.95
6.92
6.91
6.82
6.82
6.79
6.35
5.98
3.71
3.65
3.31
2.51
2.51
2.50
2.49
2.49
1.00
2.89
2.27
2.76
2.36
1.10
1.11
3.13
3.01
f1 (ppm)
163.07
159.36
157.32
143.11
130.69
129.75
129.47
127.42
127.10
126.76
125.97
125.65
125.01
124.74
113.33
112.06
110.28
107.52
68.86
55.04
51.09
f1 (ppm)

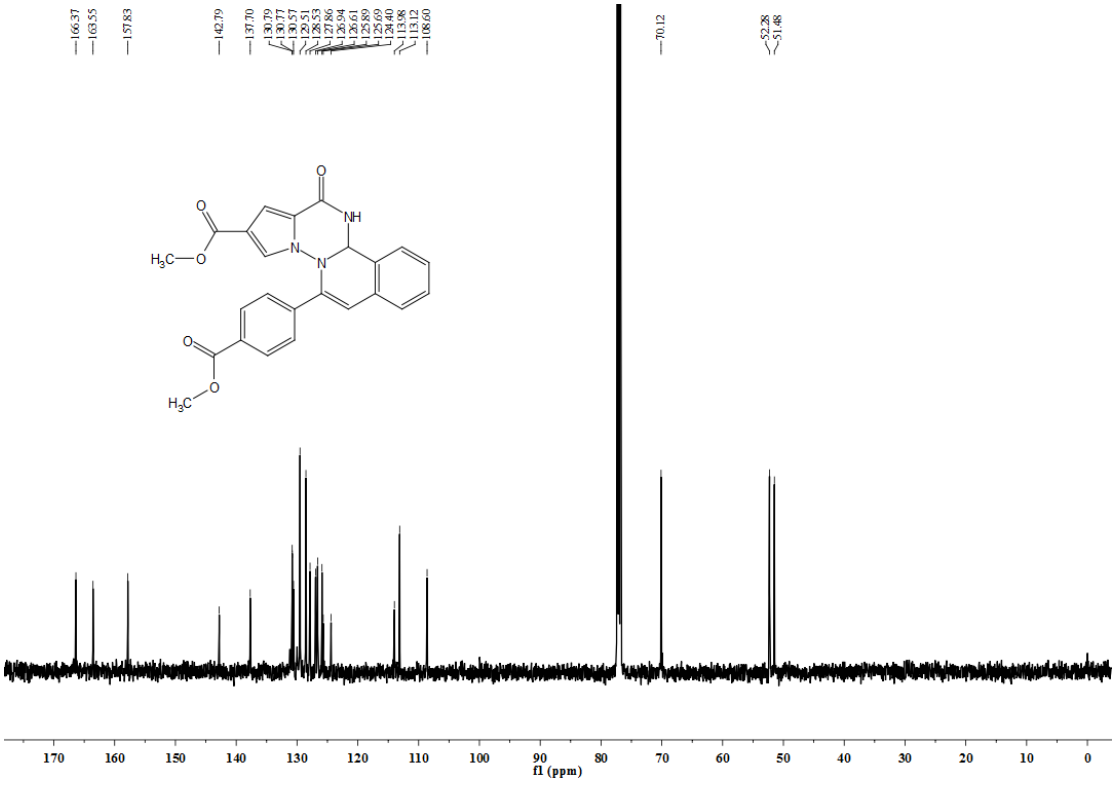
Compound 3c


8.55
7.45
7.42
7.40
7.39
7.35
7.33
7.31
7.30
7.27
7.08
7.05
7.02
6.92
6.90
6.90
6.35
6.35
5.99
5.98
3.65
2.25
0.00
1.00
3.18
2.41
2.31
2.92
1.22
1.08
3.10
3.28
f1 (ppm)

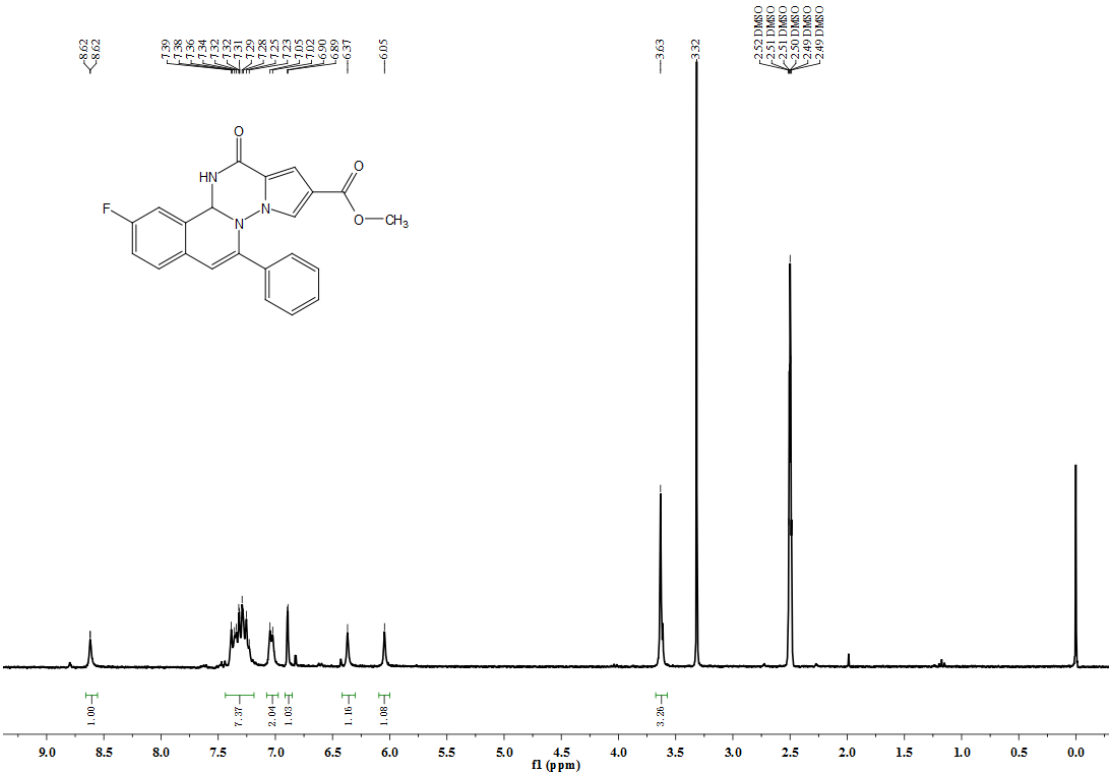

163.66
157.94
143.92
138.77
131.20
130.36
129.05
128.54
128.02
127.74
127.42
126.57
125.60
125.38
112.63
110.96
108.16
69.44
51.68
21.23
HN
N
N
O
O
O
H3C
CH3
f1 (ppm)

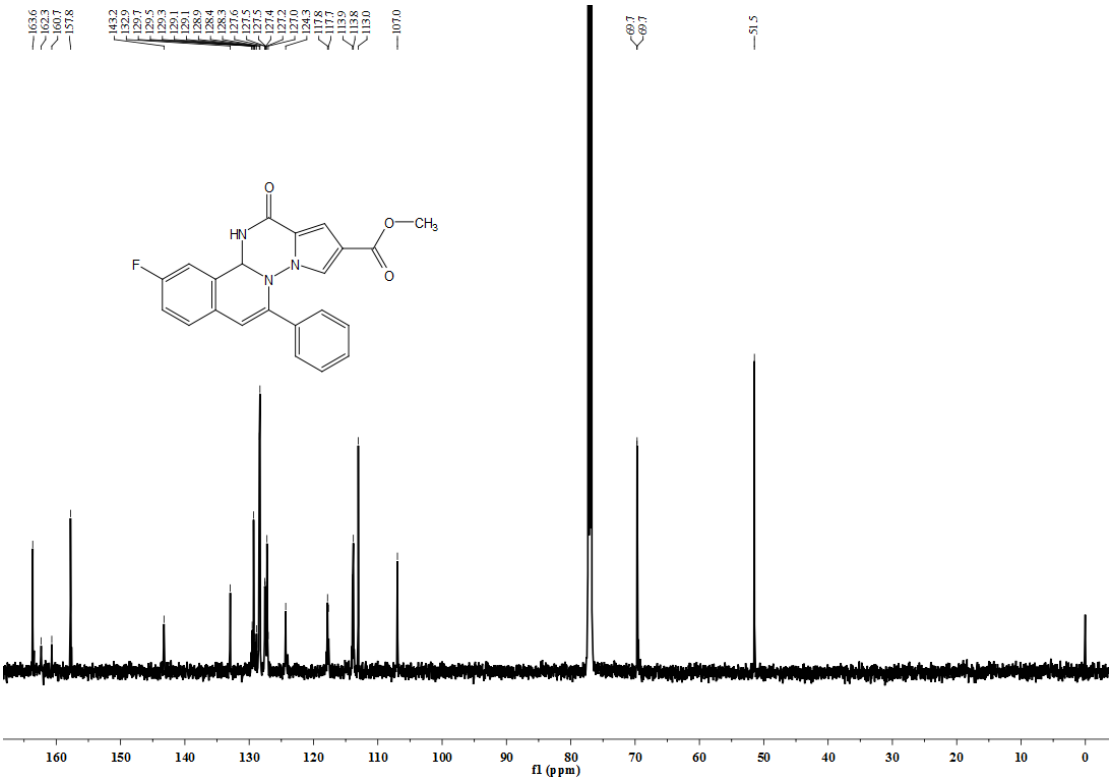
Compound 3d


7.89
7.86
7.83
7.49
7.48
7.46
7.44
7.43
7.41
7.37
7.34
7.32
7.30
7.27
7.26
7.23
7.10
7.07
6.94
6.90
6.17
5.93
5.82
3.90
3.72
3.69
O
NH
N
N
O
H3C—O
O
O
H3C
2.13
1.98
1.13
2.13
1.03
1.02
1.07
1.00
3.94
3.24
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

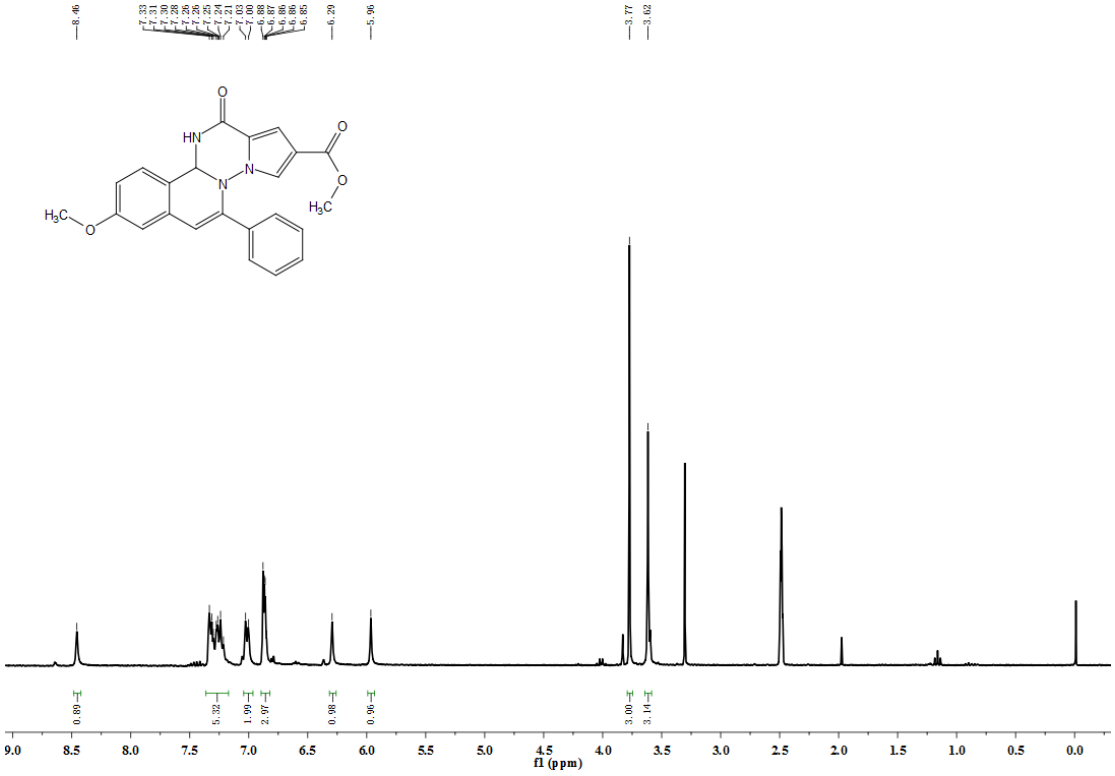

166.37
163.55
157.83
142.79
137.70
130.79
130.77
130.57
129.51
128.53
127.86
126.94
126.61
125.89
125.69
124.40
113.98
113.12
108.60
70.12
52.28
51.48
O
NH
N
N
O
H3C—O
O
O
H3C
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

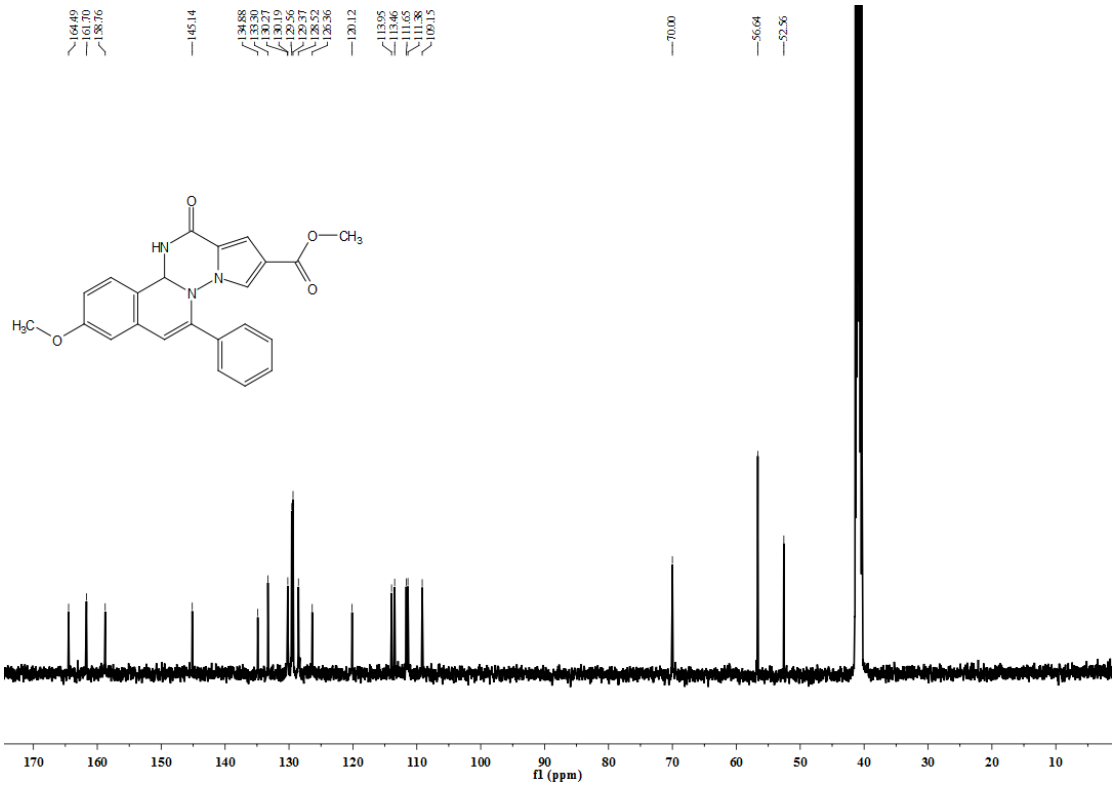
Compound 3e


8.62
8.62
7.39
7.38
7.36
7.34
7.32
7.32
7.31
7.29
7.28
7.25
7.23
7.05
7.02
6.99
6.99
6.37
6.05
3.63
3.32
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
2.49 DMSO
2.49 DMSO
O
HN
N
N
F
O
O—CH3
1.00
7.37
2.04
1.03
1.16
1.08
3.26
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

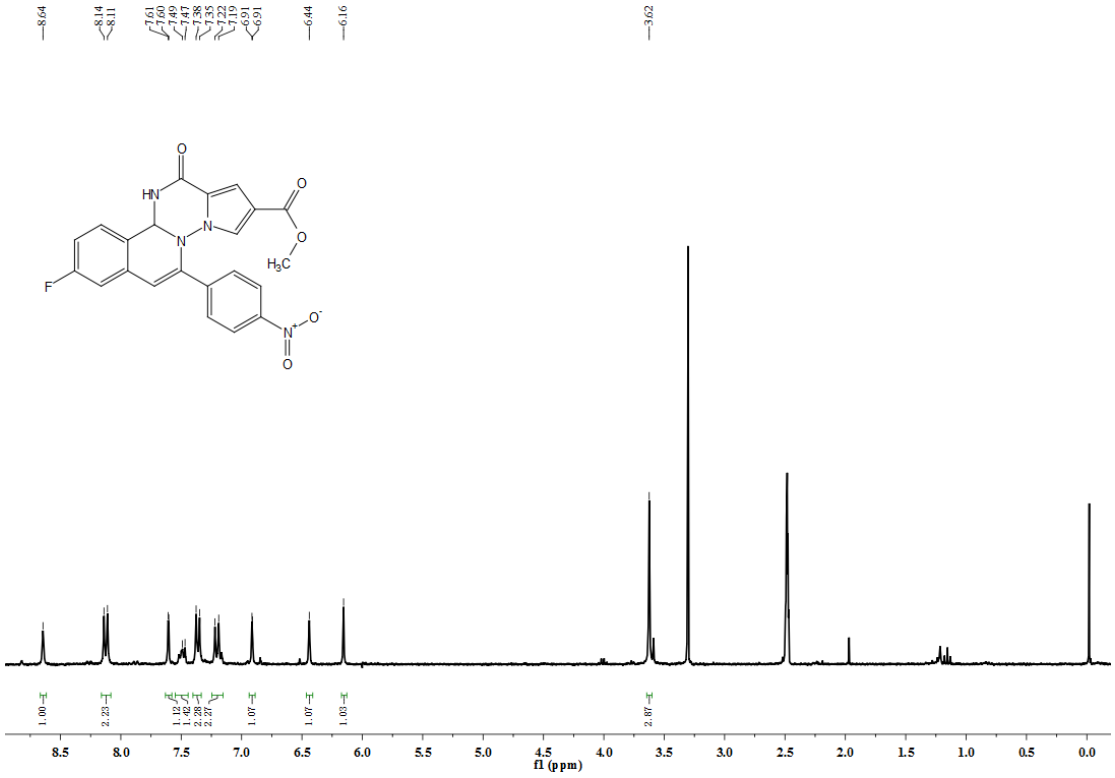

163.6
162.3
160.7
157.8
143.2
132.9
129.7
129.5
129.3
129.1
129.1
128.9
128.4
128.3
127.6
127.5
127.5
127.4
127.2
127.0
124.3
117.8
117.7
113.9
113.8
113.0
107.0
69.7
69.7
51.5
O
HN
N
N
F
O—CH3
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

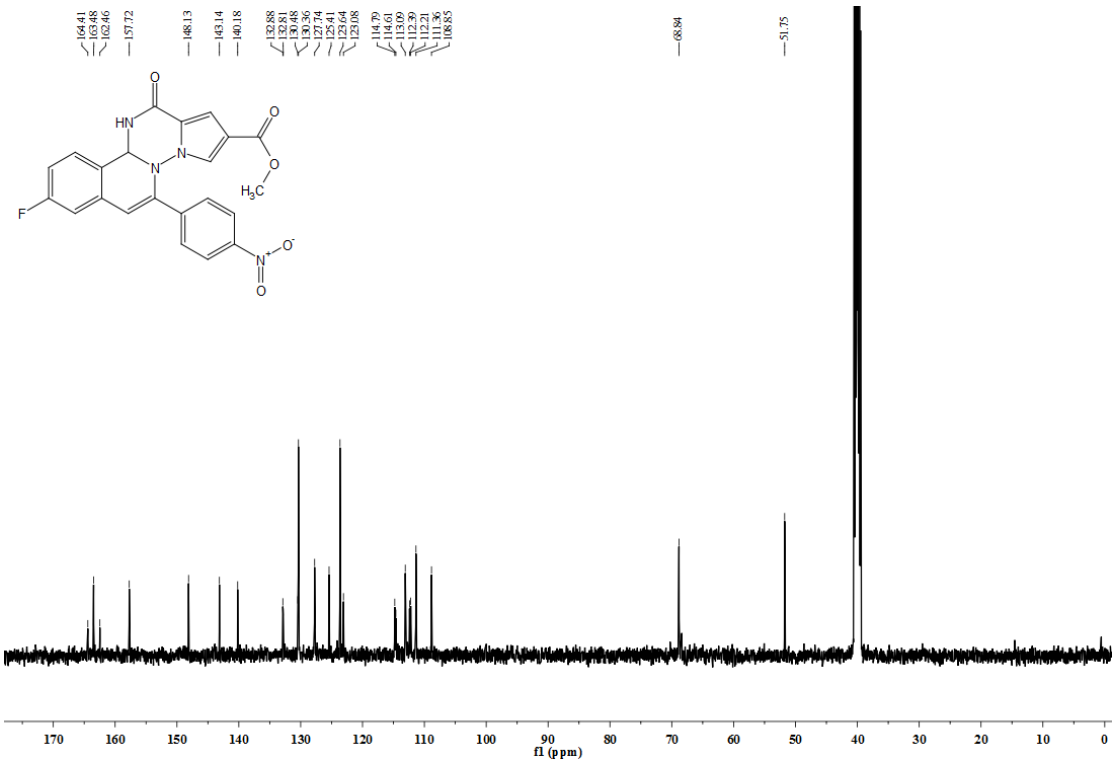
Compound 3f


8.46
7.33
7.31
7.30
7.28
7.26
7.25
7.24
7.21
7.03
6.88
6.87
6.86
6.86
6.85
6.29
5.96
3.77
3.62
O
HN
N
N
O
O
H3C
H3C
O
0.89
5.32
1.99
2.97
0.98
0.96
3.00
3.14
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

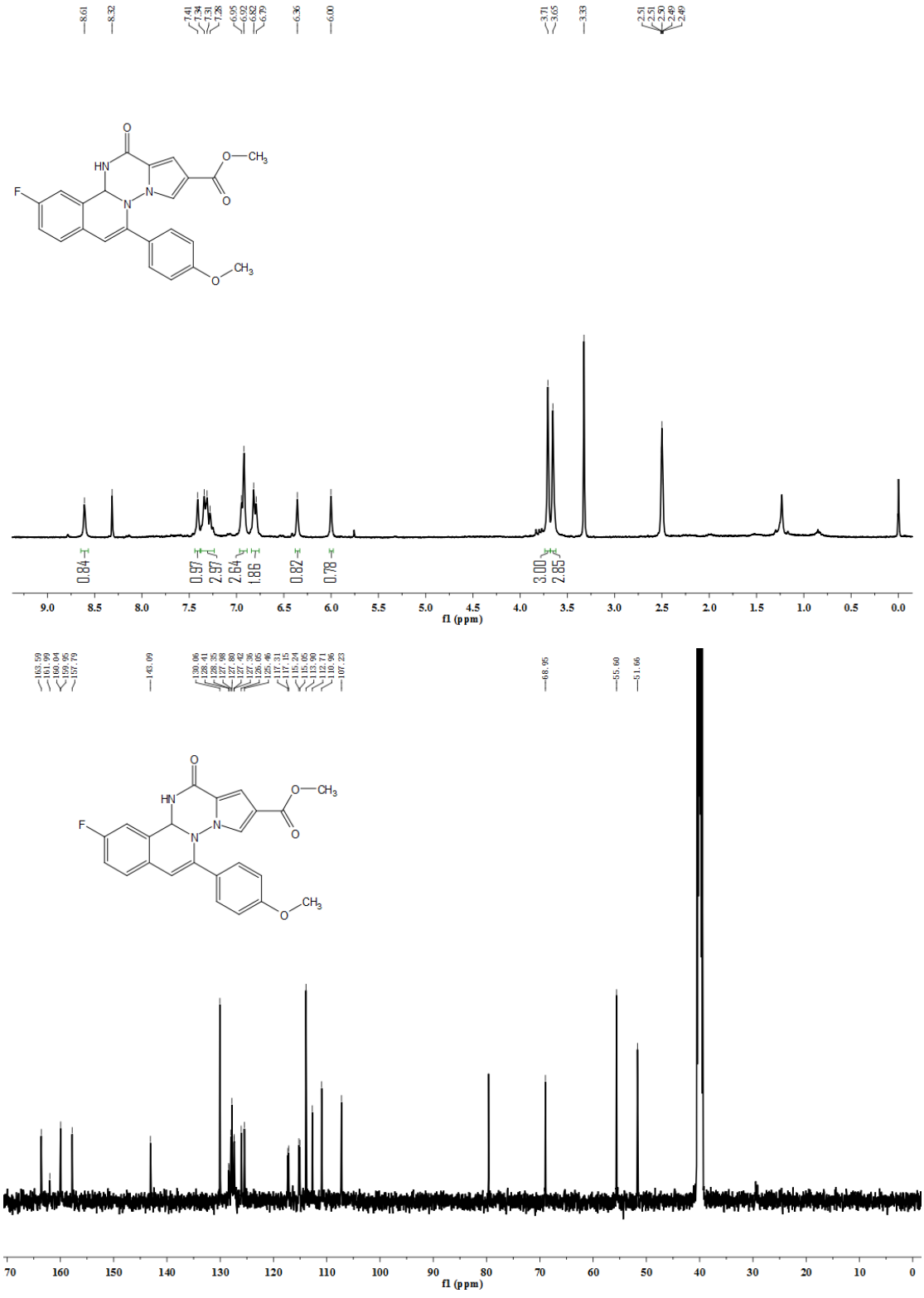

164.49
161.70
138.76
145.14
134.88
133.30
130.27
130.19
129.56
129.37
128.52
126.36
120.12
113.95
113.46
111.65
111.38
109.15
70.00
56.64
52.56
O
HN
N
N
O
O—CH3
H3C
O
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

Compound 3h

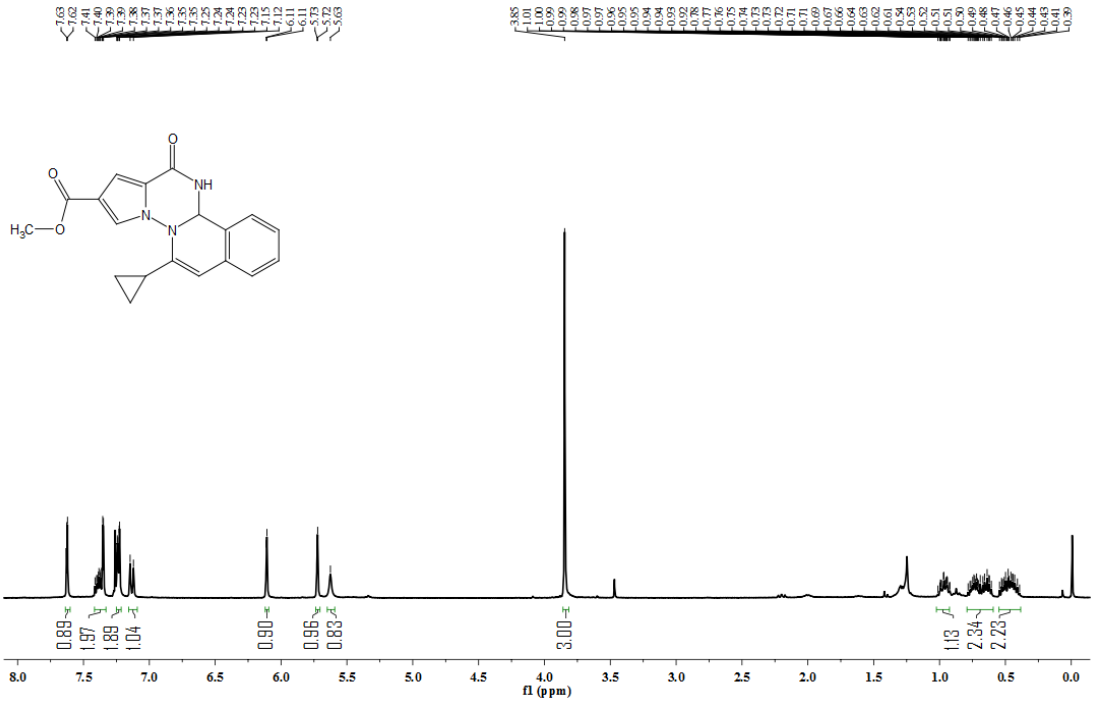

8.64
8.14
8.11
7.61
7.60
7.49
7.47
7.38
7.35
7.22
7.19
6.91
6.91
6.44
6.16
3.62
1.00
2.23
1.12
1.92
2.04
2.27
1.07
1.07
1.03
2.87
f1 (ppm)

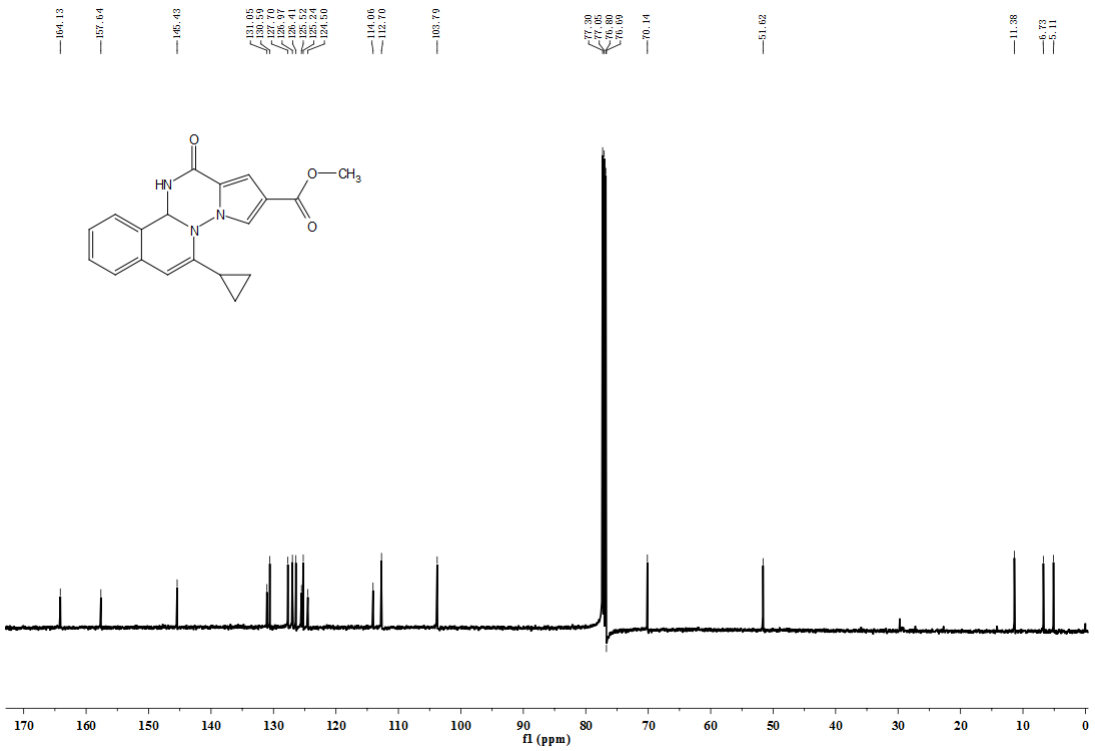

164.41
163.48
162.46
157.72
148.13
143.14
140.18
132.88
130.81
130.68
130.36
127.74
125.41
123.64
123.08
114.79
114.61
113.09
112.39
112.21
111.86
111.63
108.85
68.84
51.75
f1 (ppm)

Compound 3i

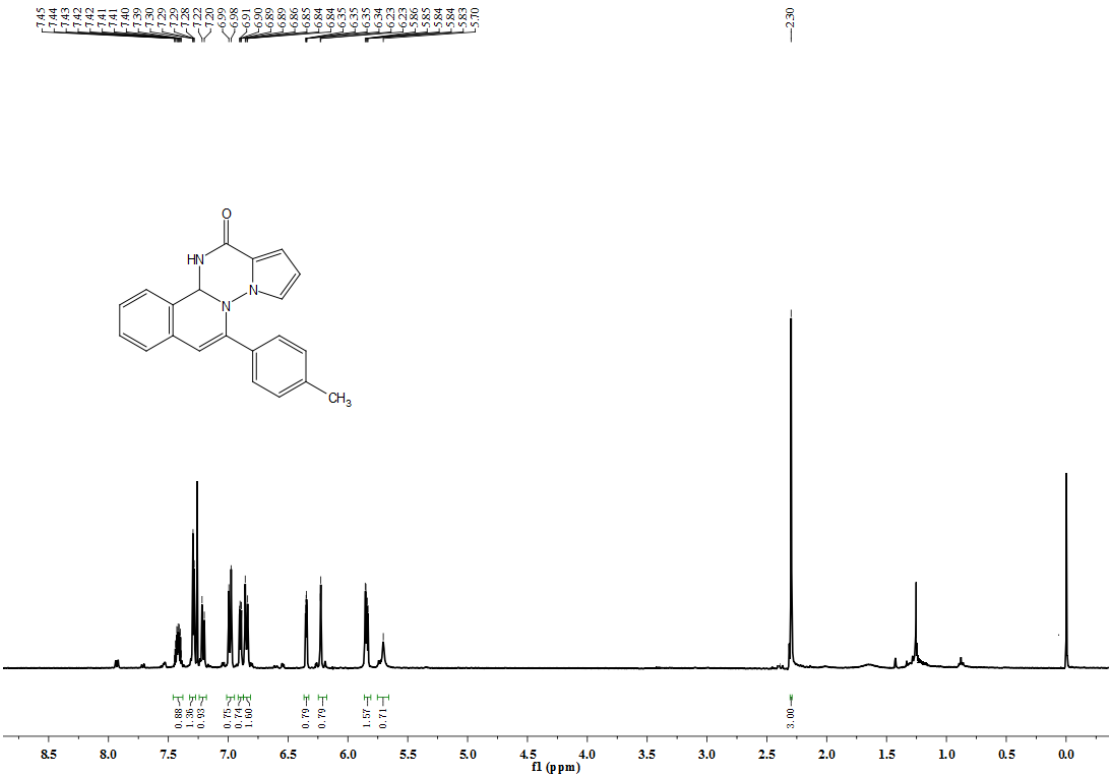

8.61
8.32
7.41
7.34
7.31
7.28
6.95
6.92
6.82
6.79
6.36
6.00
3.71
3.65
3.33
2.51
2.51
2.50
2.49
2.49
O
HN
N
N
F
O
O—CH3
O
CH3
0.84
0.97
2.57
2.64
1.86
0.82
0.78
3.00
2.85
f1 (ppm)
163.59
161.99
160.04
159.95
157.79
143.09
130.06
128.41
128.35
127.88
127.80
127.42
127.36
126.05
125.46
117.31
117.15
115.24
115.05
114.99
113.99
112.71
110.96
107.23
68.95
55.60
51.66
f1 (ppm)

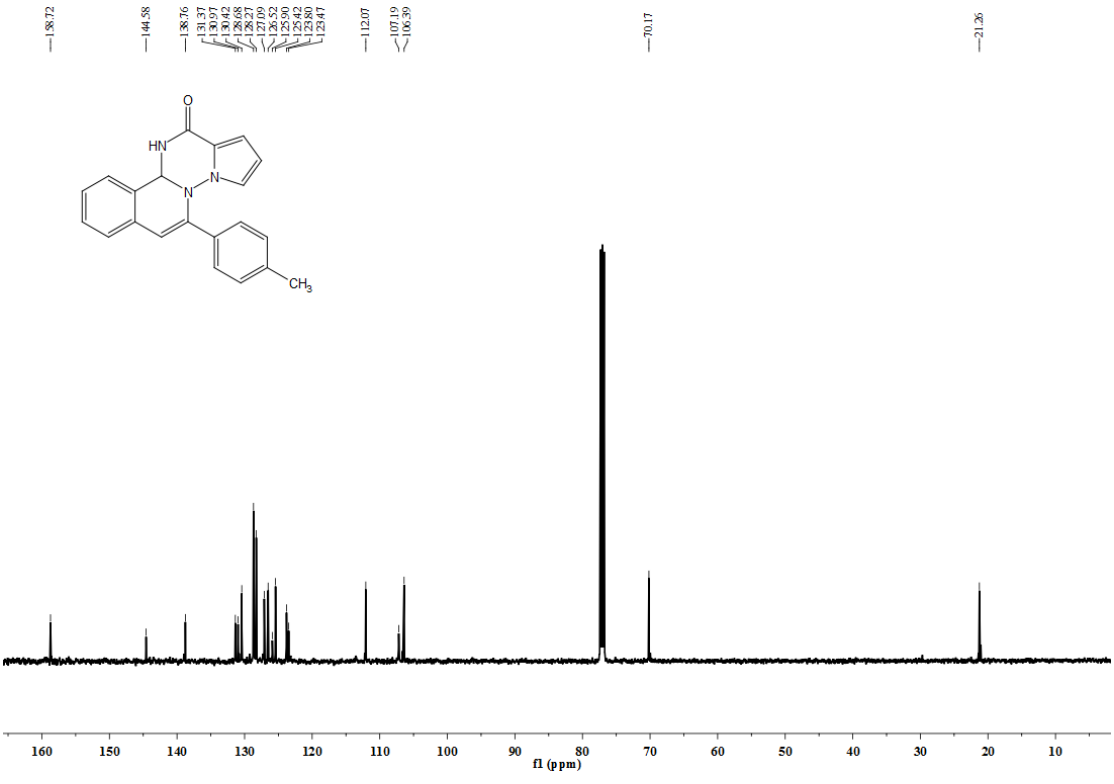
Compound 3j


O
NH
N
N
O
O
H3C—O
0.88
1.97
1.89
1.04
0.90
0.96
0.83
3.00
1.18
2.34
2.23
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

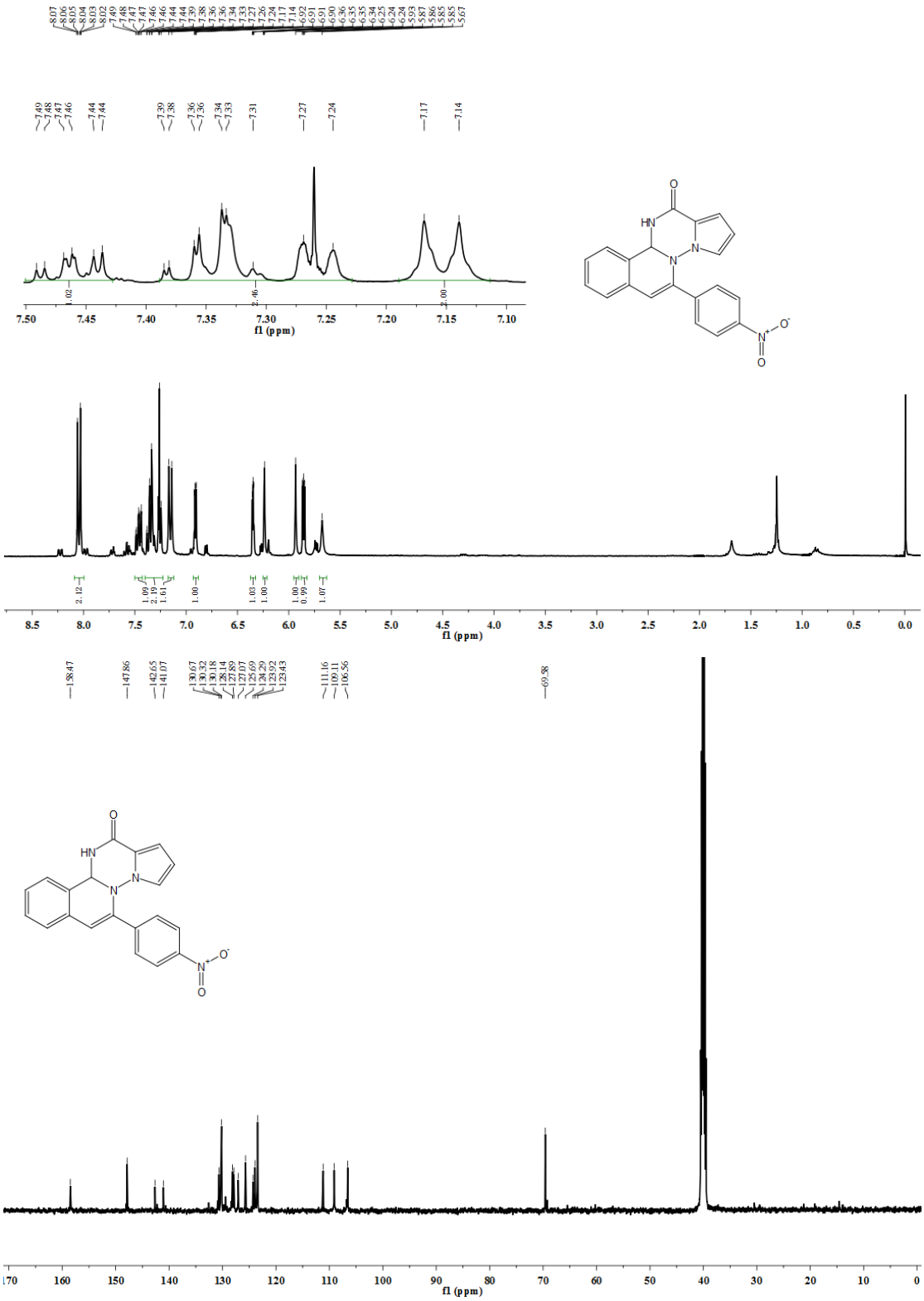

164.13
157.64
145.43
131.05
130.59
127.70
126.97
126.41
125.52
125.34
124.50
114.06
112.70
103.79
77.30
77.05
76.80
76.69
70.14
51.62
11.38
6.73
5.11
O
HN
N
N
O
O—CH3
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 3k


7.45
7.44
7.43
7.42
7.42
7.41
7.41
7.40
7.39
7.30
7.29
7.29
7.28
7.22
7.20
7.00
6.99
6.98
6.91
6.90
6.89
6.89
6.86
6.85
6.84
6.84
6.35
6.35
6.34
6.34
6.23
6.23
5.86
5.85
5.84
5.84
5.83
5.70
2.30
O
HN
N
N
CH3
0.88
1.36
0.93
0.75
0.74
1.60
0.79
0.79
1.57
0.71
3.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

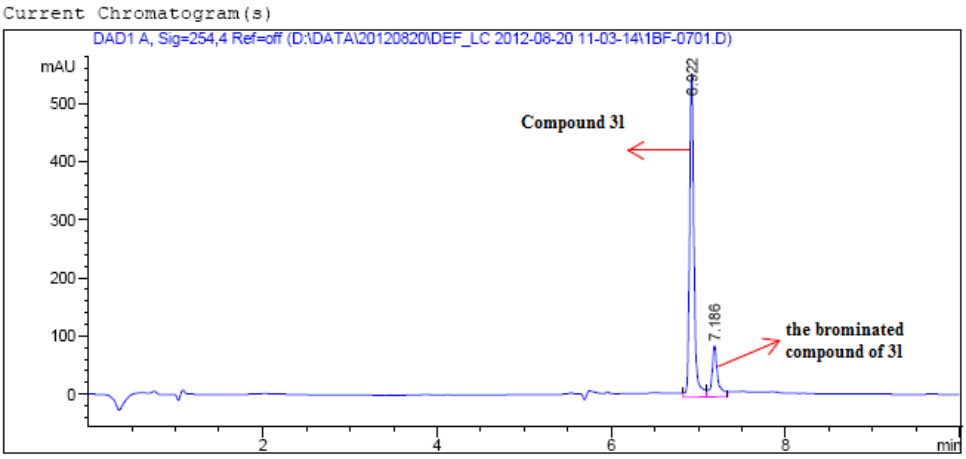

138.72
144.58
138.76
131.37
130.97
130.42
128.68
128.27
127.09
126.52
125.90
125.42
124.90
123.47
112.07
107.19
106.39
70.17
21.26
O
HN
N
N
CH3
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

Compound 3l


8.07
8.06
8.05
8.04
8.03
8.02
7.49
7.48
7.47
7.46
7.44
7.44
7.39
7.38
7.36
7.36
7.34
7.33
7.31
7.27
7.24
7.17
7.14
1.02
2.46
2.00
7.50
7.45
7.40
7.35
7.30
7.25
7.20
7.15
7.10
f1 (ppm)
HN
N
N
O
O
N
O
2.12
1.09
2.19
1.61
1.00
1.03
1.00
1.00
0.99
1.07
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
158.47
147.86
142.65
141.07
130.67
130.32
130.18
128.14
127.88
127.07
125.69
124.29
123.92
123.43
111.16
109.11
106.56
69.58
HN
N
N
O
O
N
O
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Detection of brominated product of compound 3l

Analytical HPLC: Agilent 1200 series, Eclipse XDB-C_{18} Column (4.6 × 150 mm, 5 micron particle size), molile phase: CH_3OH / 0.1% aqueous HCOOH in water linear gradient over 15 min (the gradient of CH_3OH is from 5% to 95% over 0-6 min); Flow = 1.0 ml /min, Detected by UV at 254 nm; 40 ℃ Column Temperature;



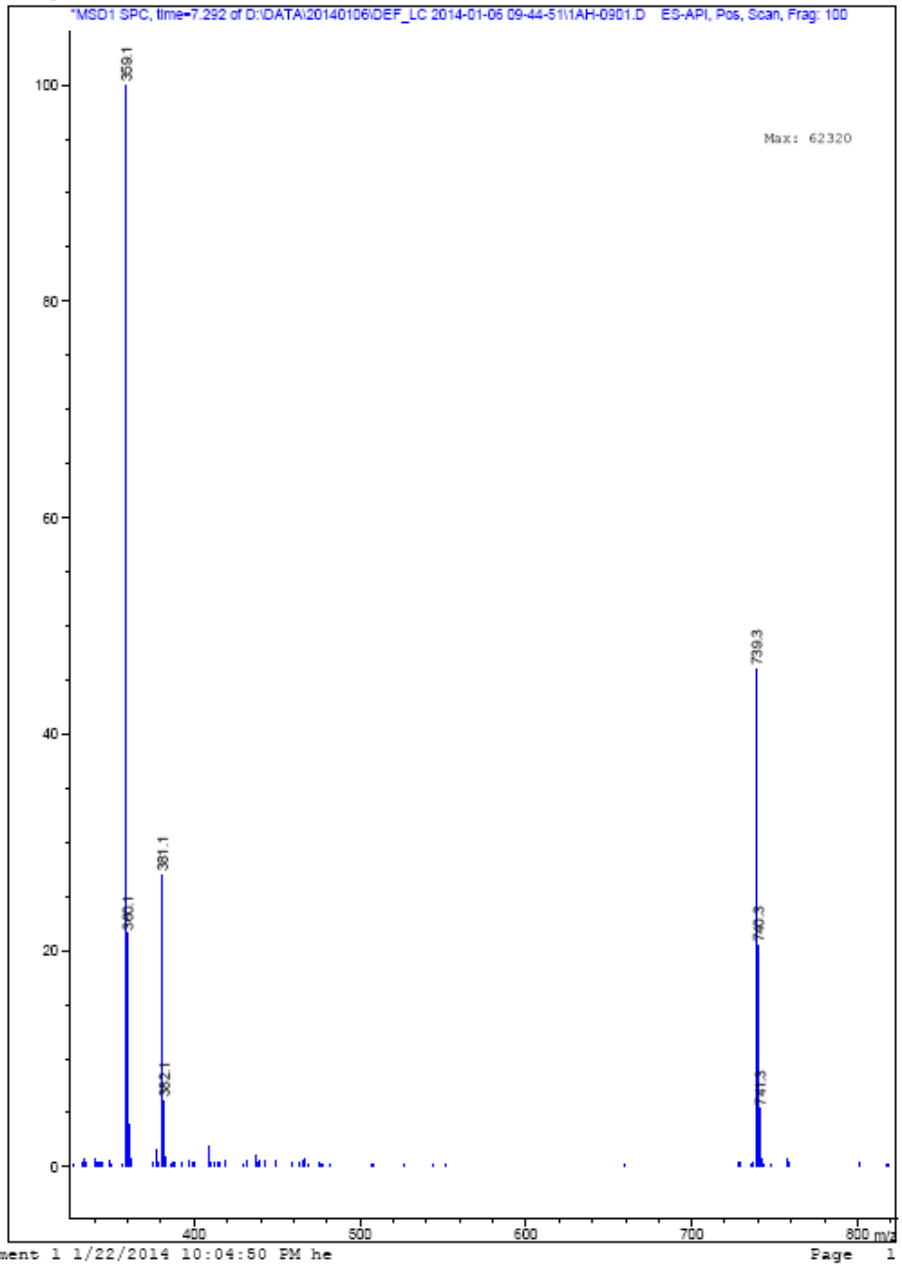
Signal 1: DAD1 A, Sig=254,4 Ref=off

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.922	BV	0.0556	1988.89404	557.20325	83.1344
2	7.186	VV	0.0660	403.48920	87.17760	16.8656
Totals :				2392.38324	644.38084	

LR-MS(ESI): For **3l**: Found, 359.1(100%, $[M+H]^+$), t = 7.292 min; For the brominated product of compound **3l** : Found, 459.1(25%, $[M+Na]^+$), 461.1 (25%, $[M+2+Na]^+$), t = 7.563 min.

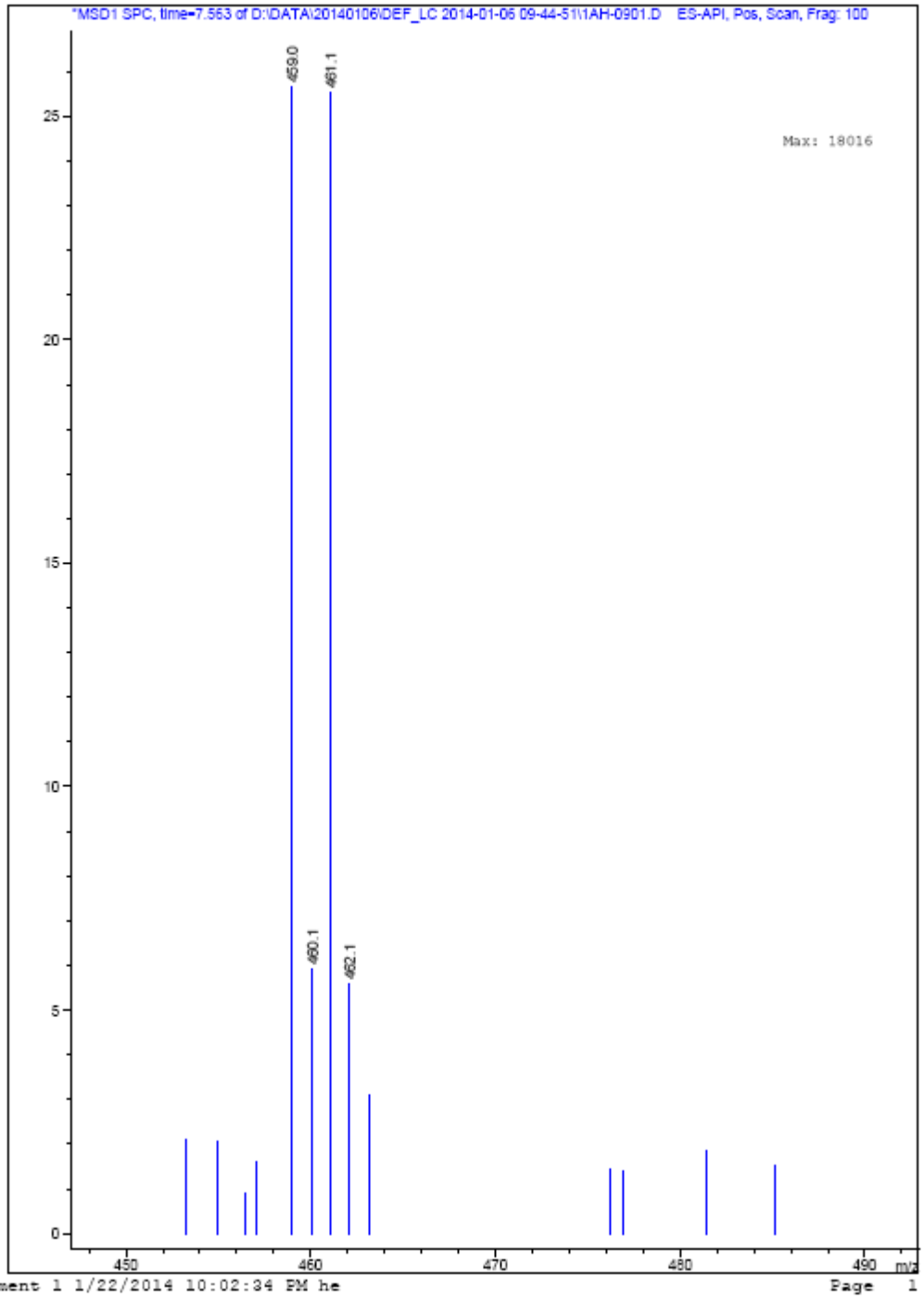
Print of window 80: MS Spectrum

MS Spectrum



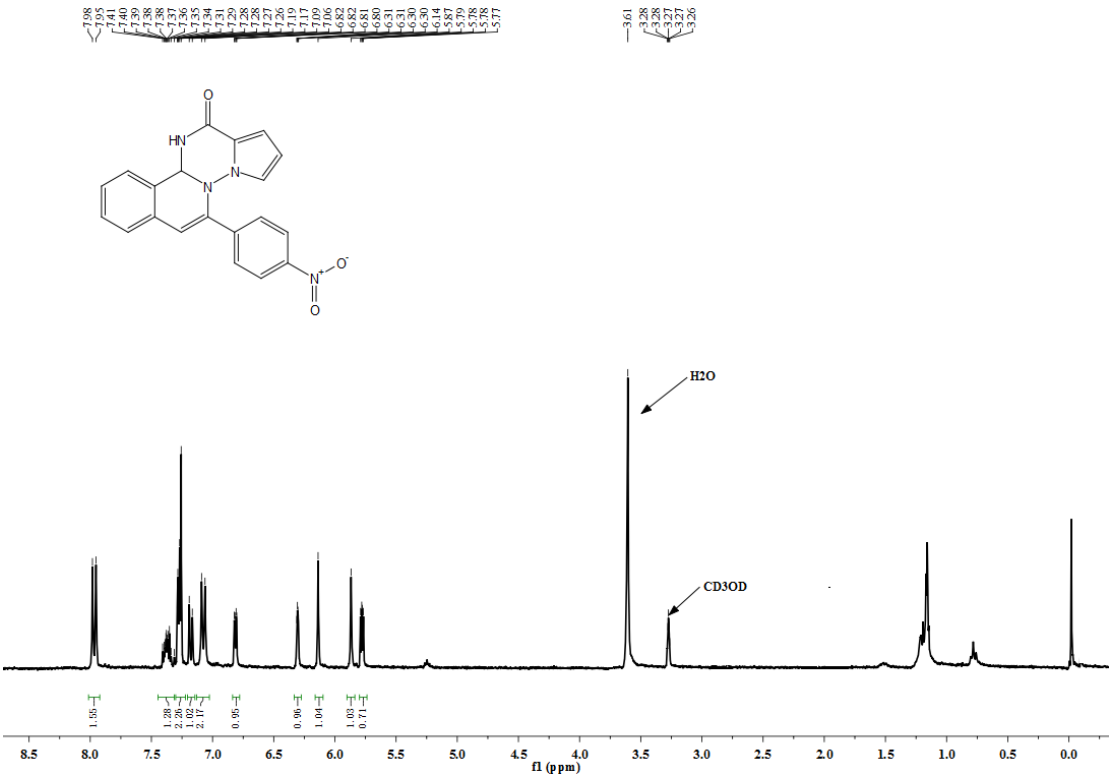
Print of window 80: MS Spectrum

MS Spectrum

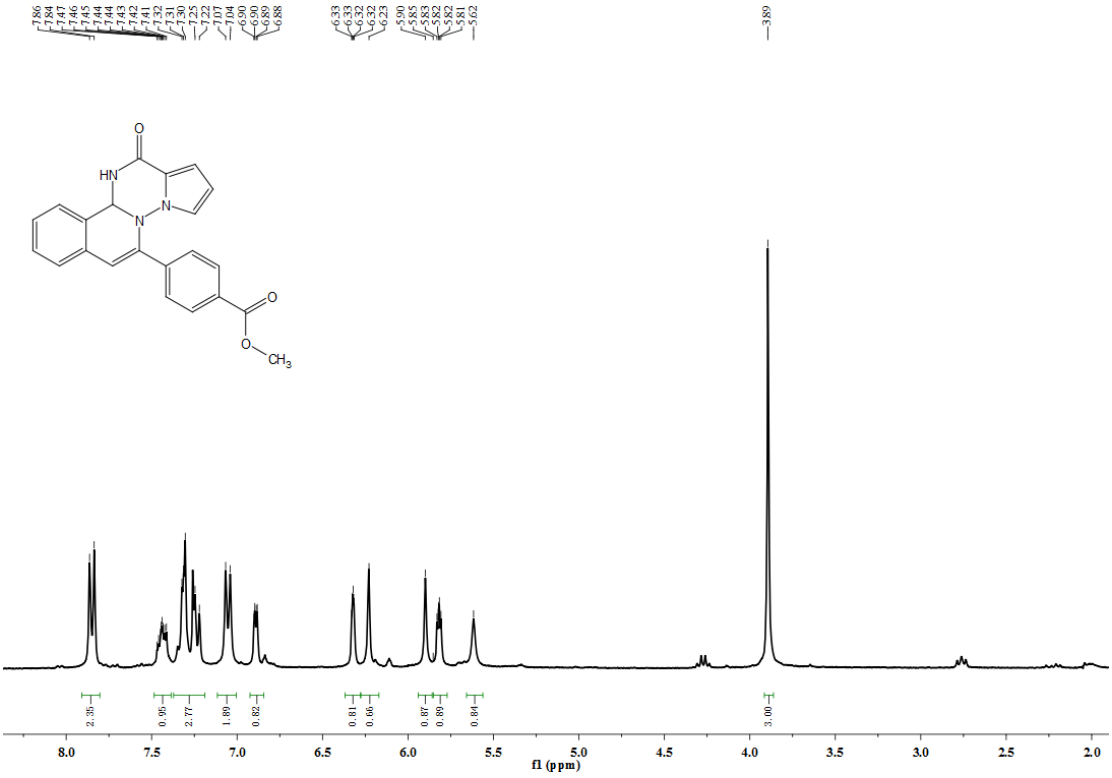


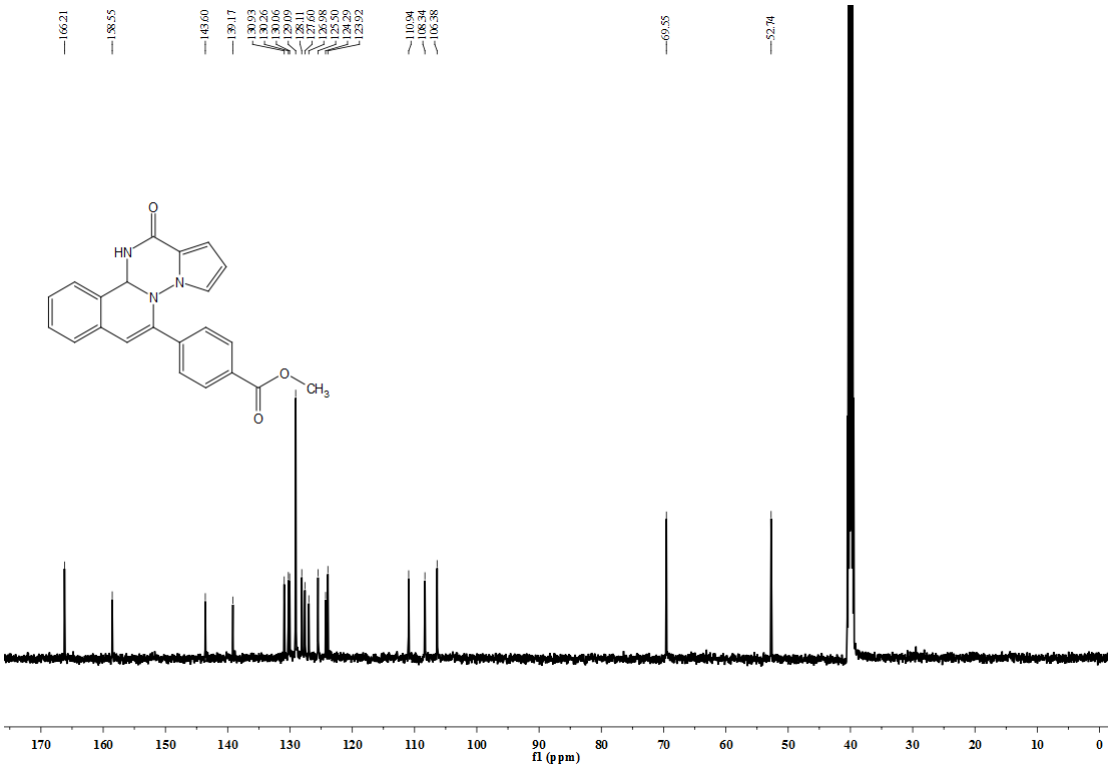
Instrument 1 1/22/2014 10:02:34 PM he

The [1]H-NMR of the pure compound **3l**:

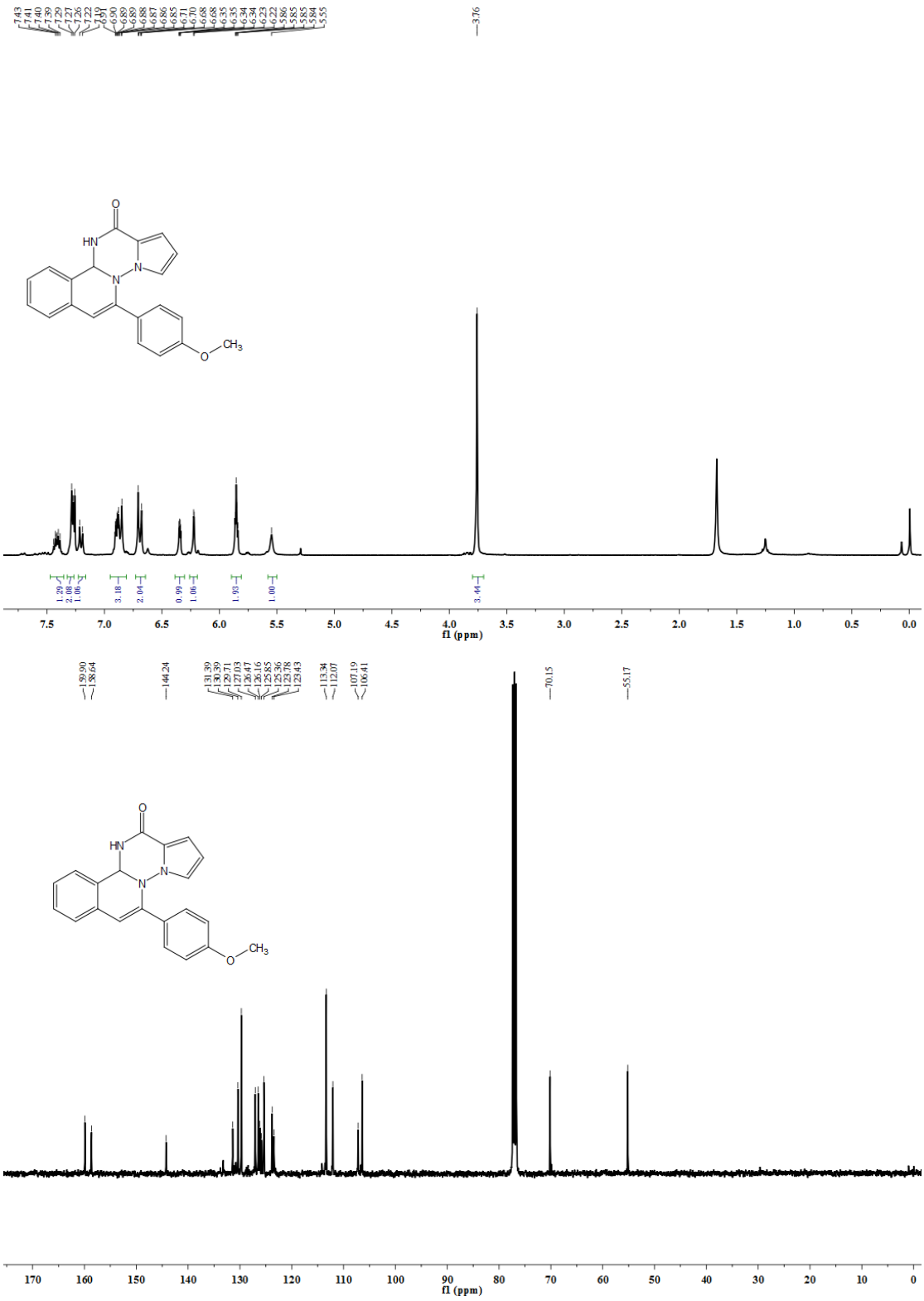


Compound 3m

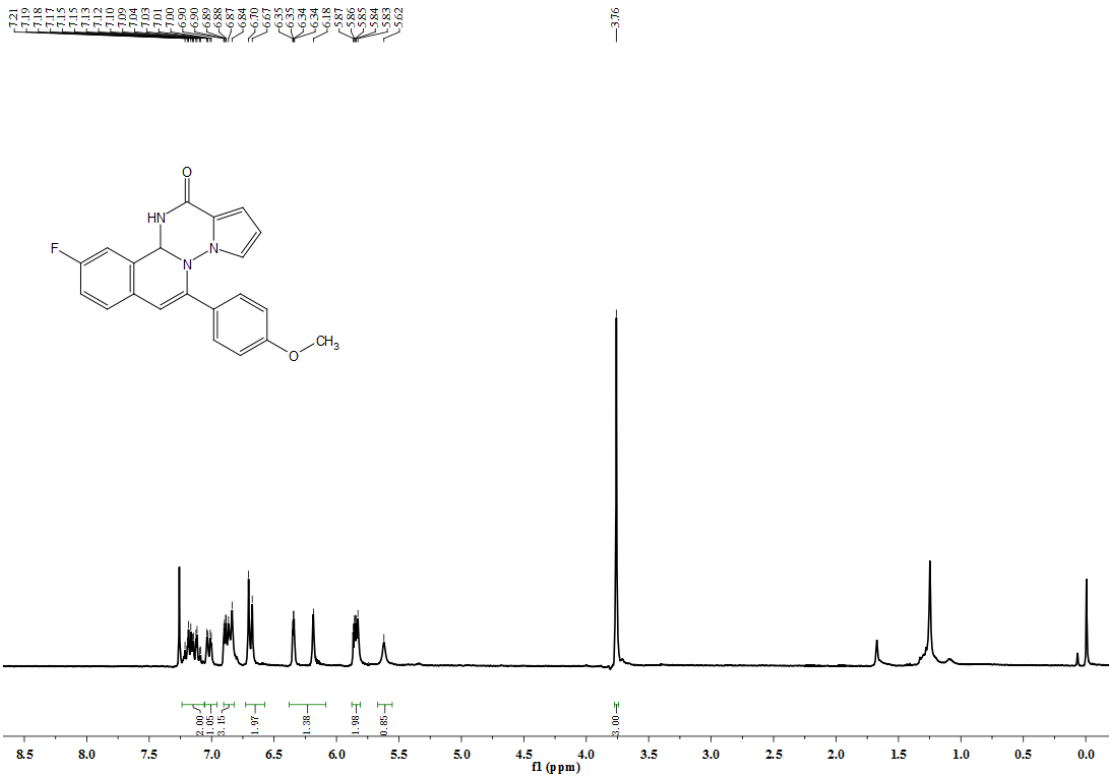

7.86
7.84
7.47
7.46
7.45
7.44
7.44
7.43
7.42
7.41
7.32
7.31
7.30
7.25
7.22
7.07
7.04
6.90
6.90
6.89
6.88
6.33
6.33
6.32
6.32
6.23
5.90
5.85
5.83
5.82
5.82
5.81
5.62
3.89
HN
N
N
O
O
O
CH3
2.35
0.99
2.77
1.89
0.82
0.81
0.66
0.87
0.89
0.84
3.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
f1 (ppm)

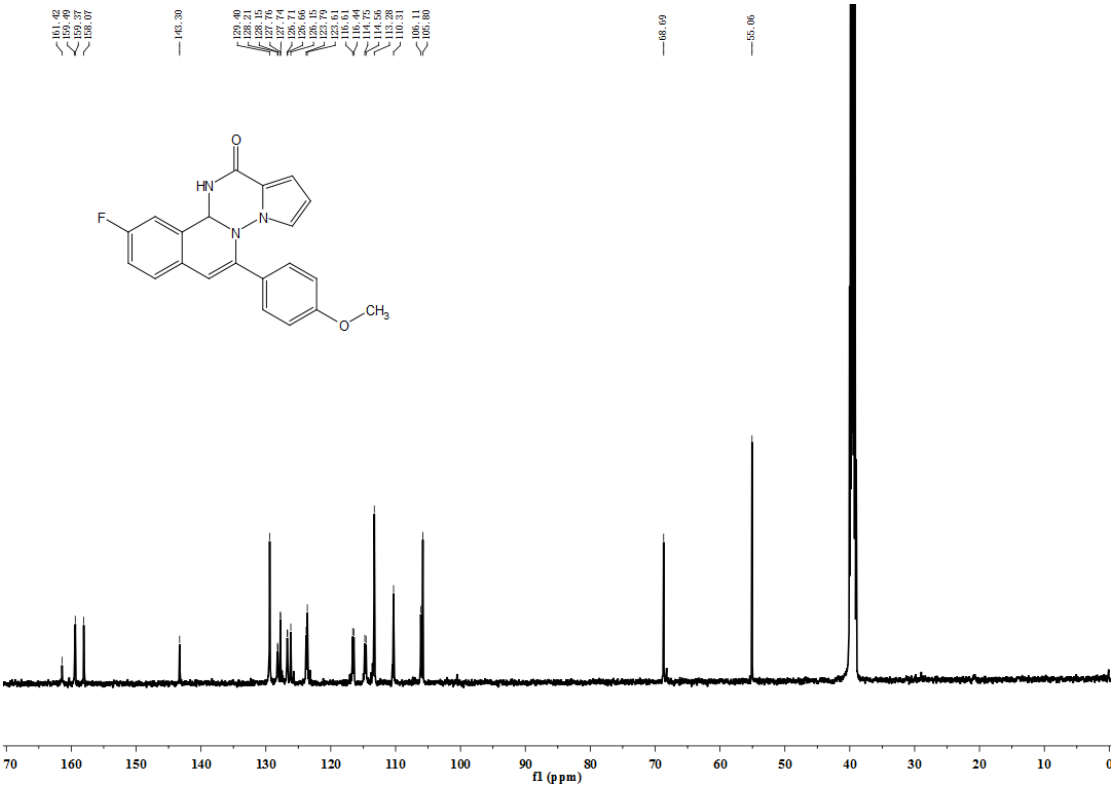

166.21
158.55
143.60
139.17
130.93
130.26
130.06
129.09
128.11
127.60
125.98
125.50
120.29
123.92
110.94
108.34
106.38
69.55
52.74
HN
N
N
O
O
O
CH3
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 3n

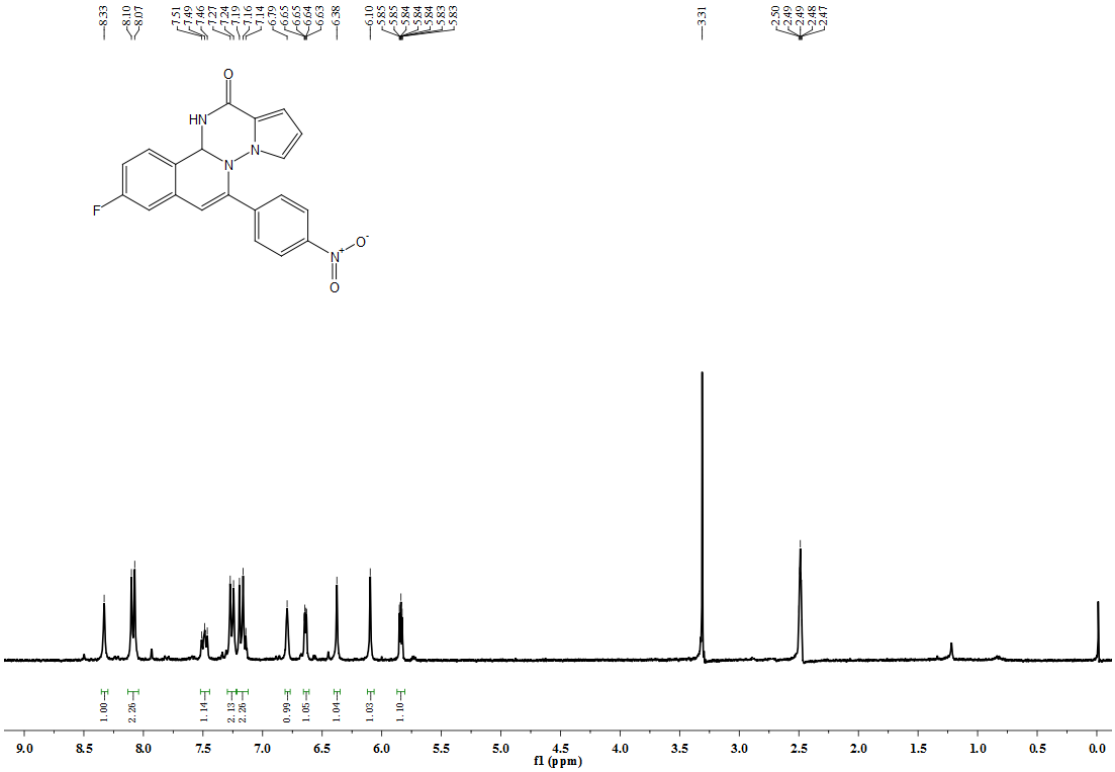

7.43
7.41
7.40
7.39
7.28
7.27
7.26
7.22
7.10
7.09
6.90
6.89
6.89
6.88
6.87
6.86
6.85
6.71
6.70
6.68
6.68
6.35
6.35
6.34
6.34
6.23
6.22
5.86
5.85
5.85
5.84
5.84
5.55
3.76
HN
N
N
O
CH3
1.20
2.08
1.06
3.18
2.04
0.99
1.06
1.93
1.00
3.44
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
159.90
158.64
144.24
131.39
130.39
129.71
127.03
126.47
126.16
125.55
125.36
123.78
123.43
113.34
112.07
107.19
106.41
70.15
55.17
HN
N
N
O
CH3
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

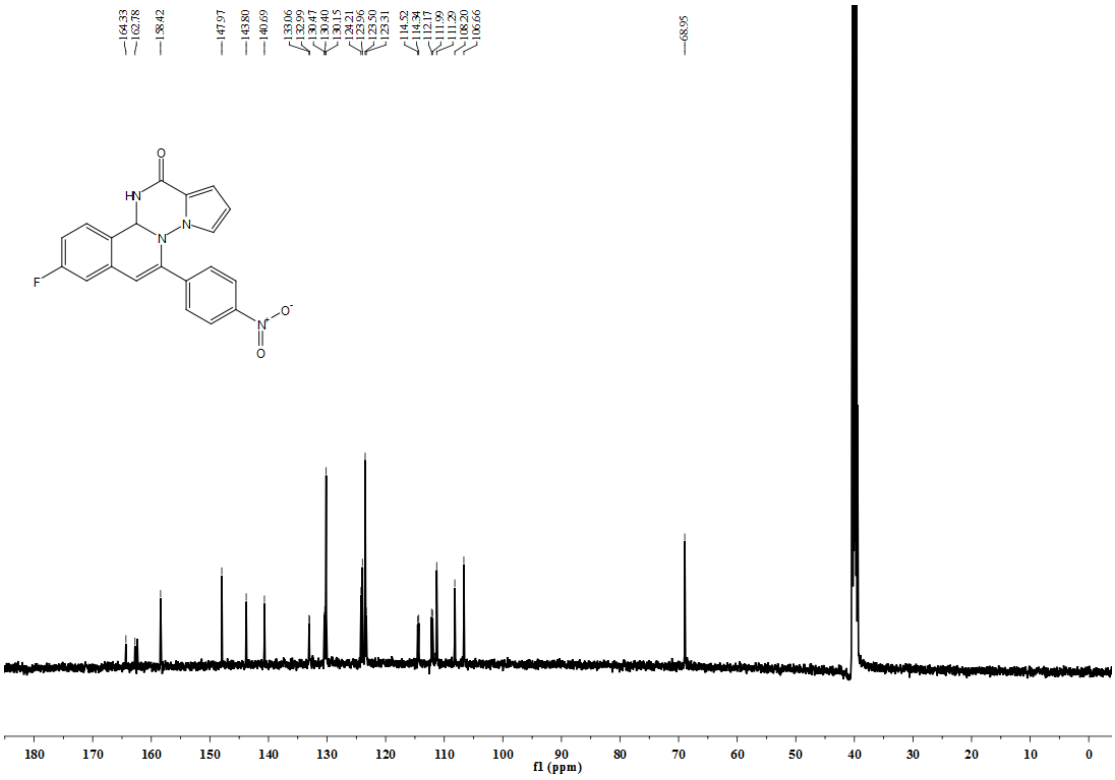
Compound 3o


7.21
7.19
7.18
7.17
7.15
7.15
7.13
7.12
7.10
7.09
7.04
7.03
7.01
7.00
6.90
6.89
6.88
6.87
6.84
6.70
6.67
6.35
6.34
6.34
6.18
5.87
5.86
5.85
5.84
5.83
5.62
3.76
O
HN
N
N
F
O
CH3
2.00
1.05
3.15
1.97
1.38
1.98
0.85
3.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

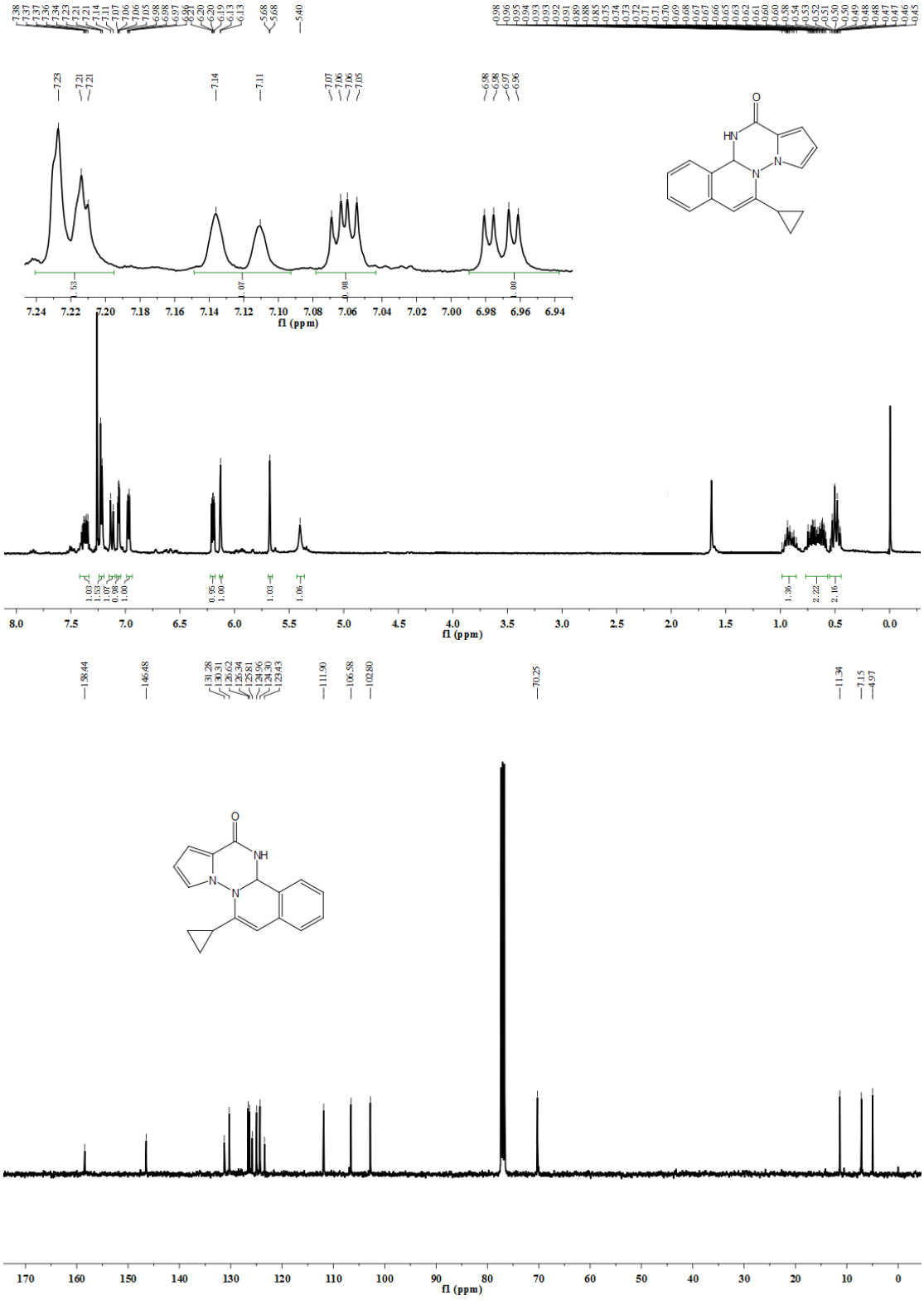

161.42
159.49
159.37
158.07
143.30
129.40
128.21
128.15
127.76
127.74
126.71
126.66
126.15
125.79
125.61
116.61
116.44
114.75
114.56
113.28
110.31
106.11
105.80
68.69
55.06
O
HN
N
N
F
O
CH3
70
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 3p

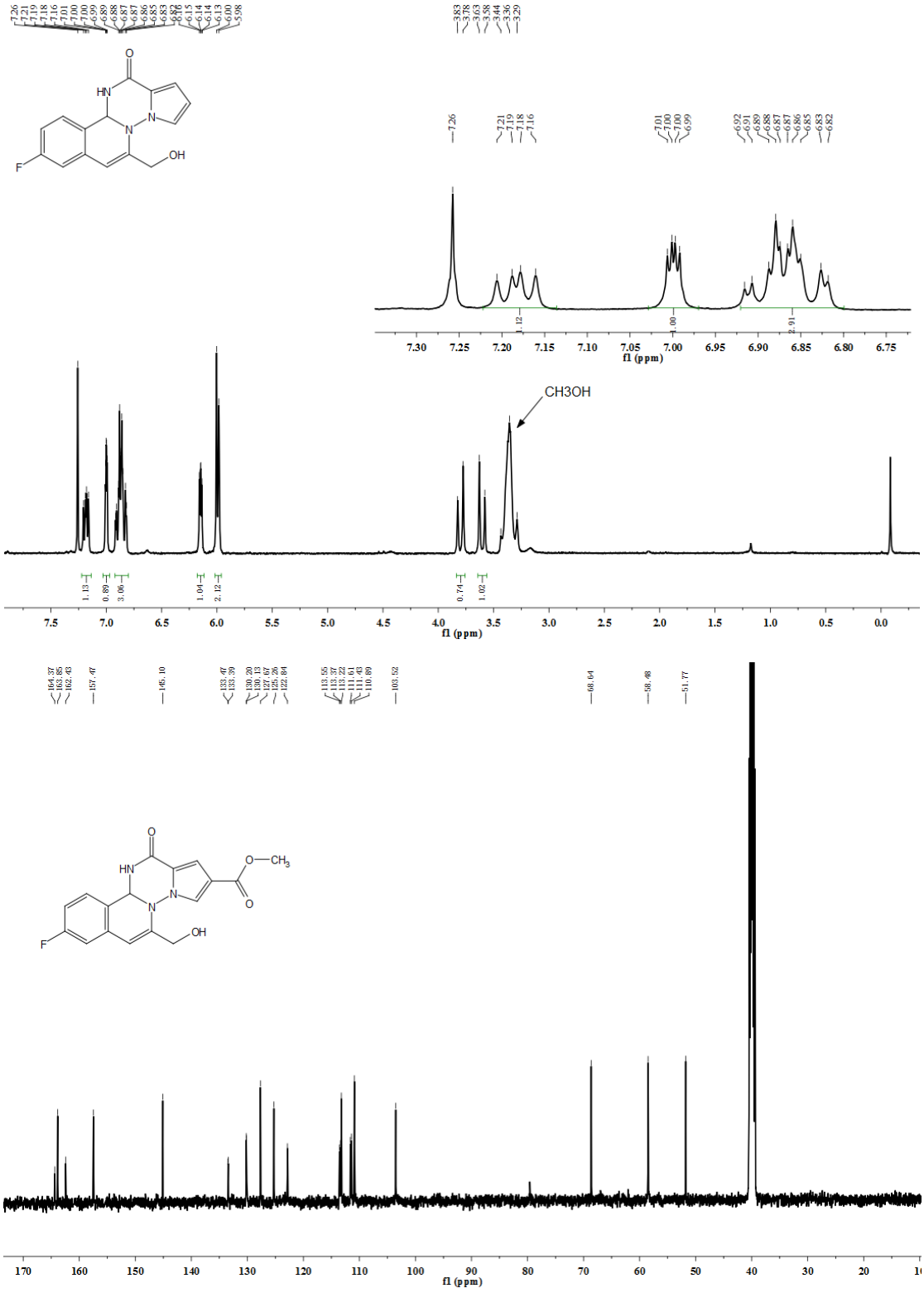

8.33
8.10
8.07
7.51
7.49
7.46
7.27
7.26
7.19
7.16
7.14
6.79
6.65
6.65
6.64
6.63
6.38
6.10
5.85
5.85
5.84
5.84
5.84
5.83
5.83
3.31
2.50
2.49
2.49
2.48
2.47
O
HN
N
N
F
N+
O-
O
1.00
2.26
1.14
2.13
2.26
0.99
1.05
1.04
1.03
1.10
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


164.33
162.78
158.42
147.97
143.80
140.69
133.06
132.99
130.47
130.40
130.15
124.21
123.96
123.50
123.31
114.52
114.34
112.17
111.99
111.29
108.20
106.66
68.95
O
HN
N
N
F
N+
O-
O
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

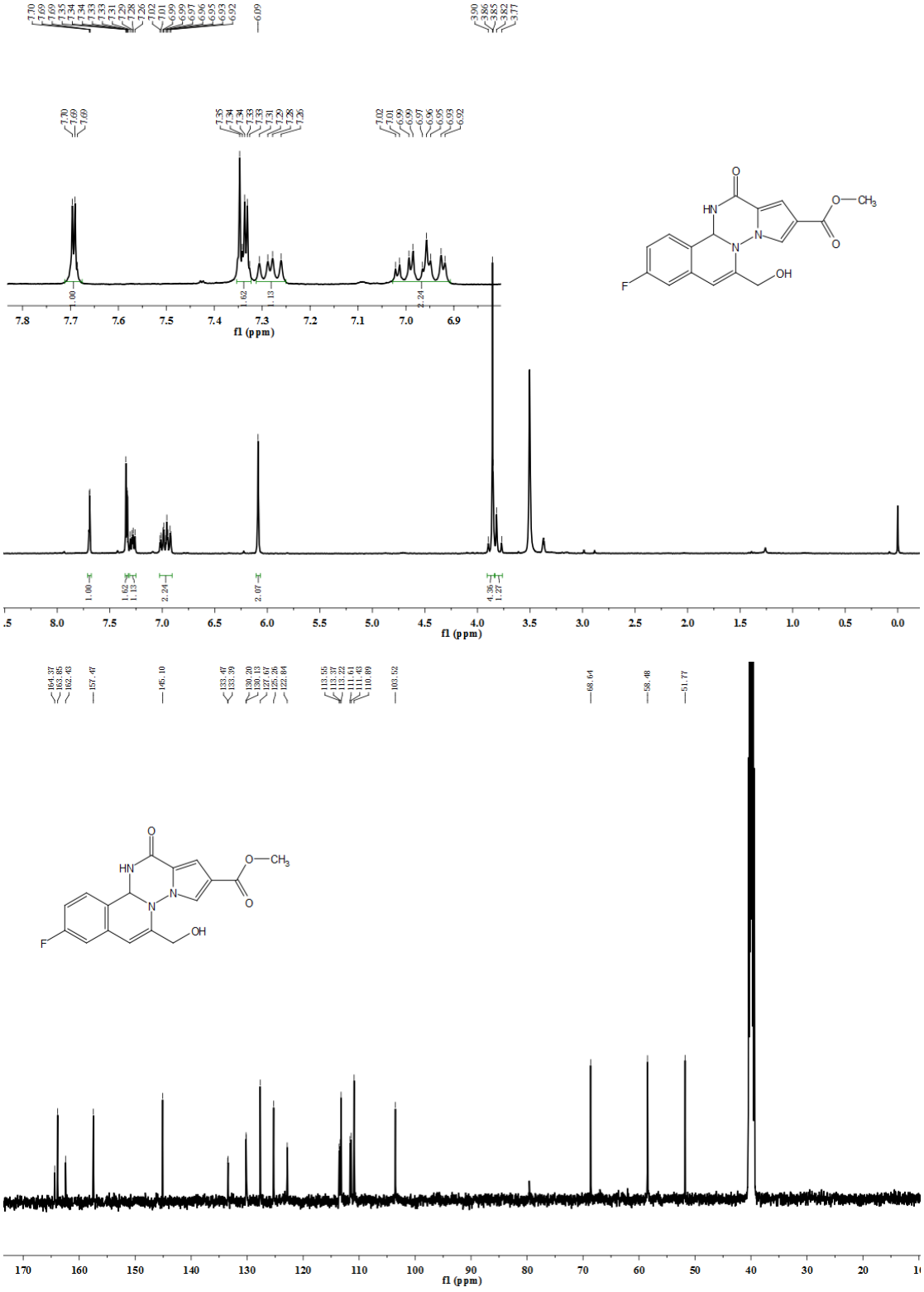
Compound 3q


7.38
7.37
7.37
7.36
7.34
7.23
7.21
7.21
7.14
7.11
7.07
7.06
7.06
7.05
6.98
6.98
6.97
6.96
6.20
6.20
6.13
6.13
5.68
5.68
5.40
0.98
0.96
0.95
0.94
0.93
0.93
0.92
0.91
0.89
0.88
0.85
0.75
0.74
0.73
0.72
0.71
0.71
0.70
0.69
0.68
0.67
0.67
0.66
0.65
0.63
0.62
0.61
0.60
0.60
0.58
0.54
0.53
0.52
0.51
0.50
0.50
0.49
0.48
0.48
0.47
0.47
0.46
0.45
7.23
7.21
7.21
7.14
7.11
7.07
7.06
7.06
7.05
6.98
6.98
6.97
6.96
1.53
1.07
0.98
1.00
7.24 7.22 7.20 7.18 7.16 7.14 7.12 7.10 7.08 7.06 7.04 7.02 7.00 6.98 6.96 6.94
f1 (ppm)
O
HN
N
N
1.03
1.53
1.07
0.98
1.00
0.95
1.00
1.03
1.00
1.30
2.22
2.16
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
158.44
146.48
131.28
130.31
126.62
126.34
125.81
124.96
124.30
123.43
111.90
106.58
102.80
70.25
11.34
7.15
4.97
O
NH
N
N
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

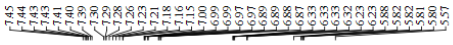
Compound 3r

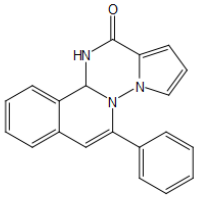


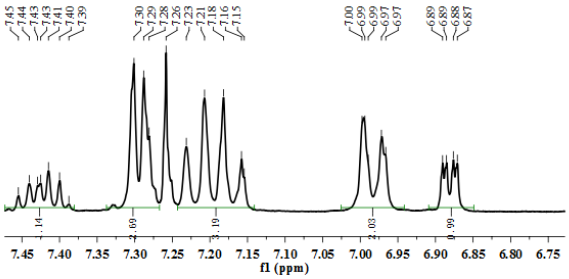
Compound 3s

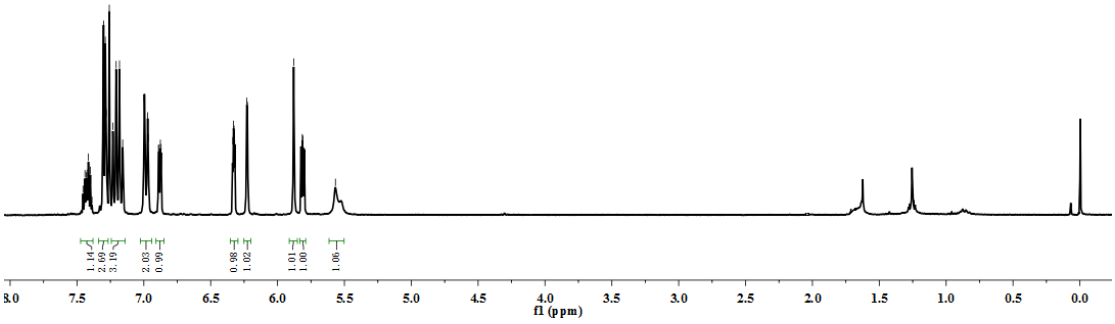

7.70
7.69
7.69
7.35
7.34
7.34
7.33
7.33
7.31
7.29
7.28
7.26
7.02
7.01
6.99
6.99
6.97
6.97
6.95
6.95
6.93
6.92
6.09
3.90
3.86
3.85
3.82
3.77
1.00
1.62
1.13
2.24
2.07
4.38
1.27
f1 (ppm)
O
HN
N
N
O
O—CH3
OH
F
164.37
162.85
162.43
157.47
145.10
133.47
133.39
130.20
130.13
127.62
125.26
122.84
115.55
115.37
113.22
111.61
111.46
110.89
103.52
68.64
58.48
51.77
f1 (ppm)

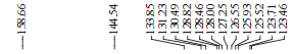
Compound 3t

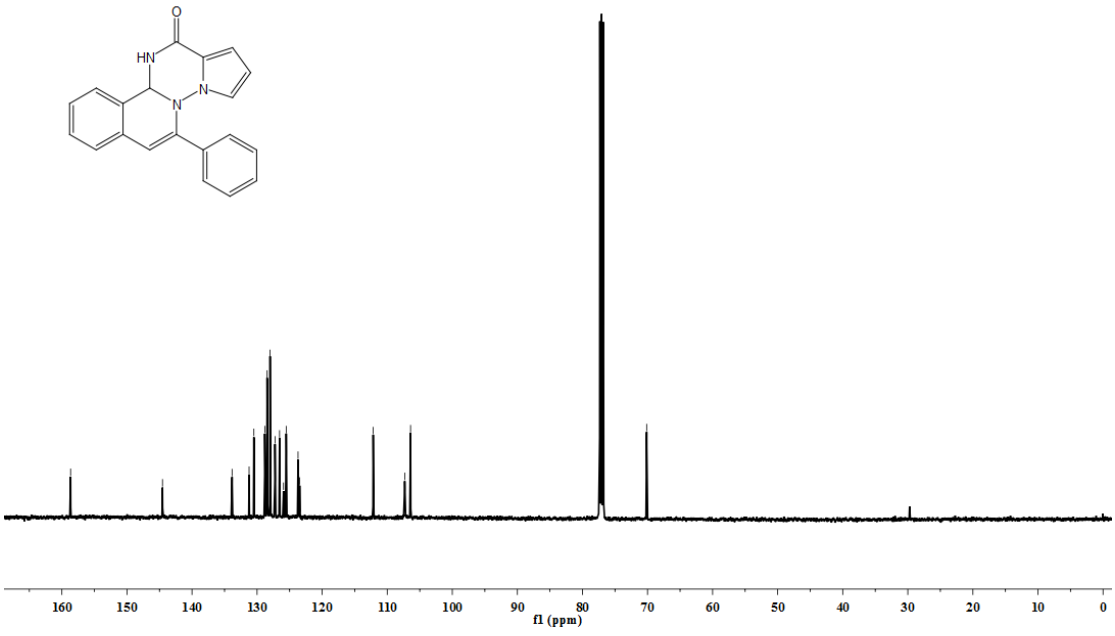




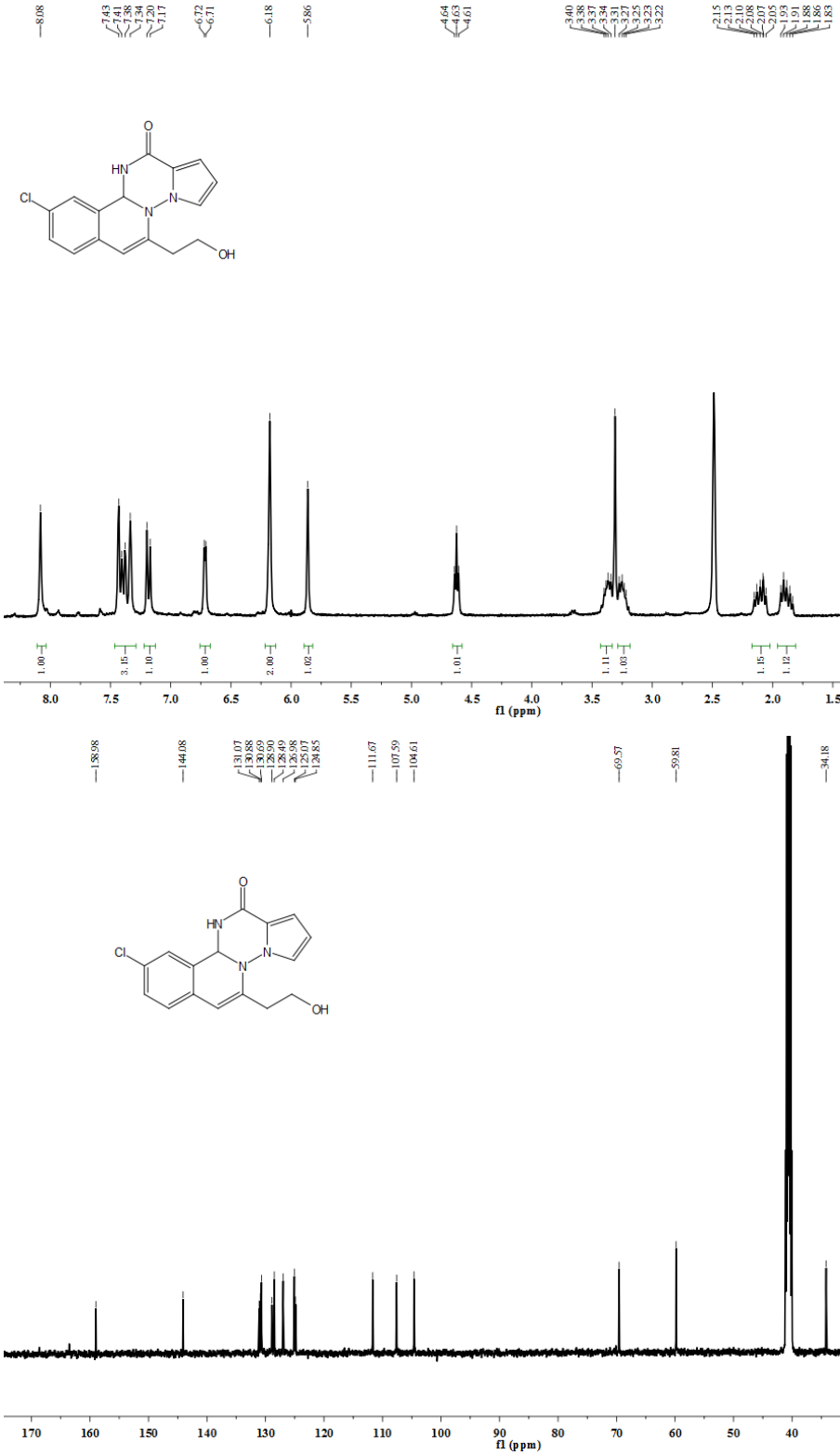




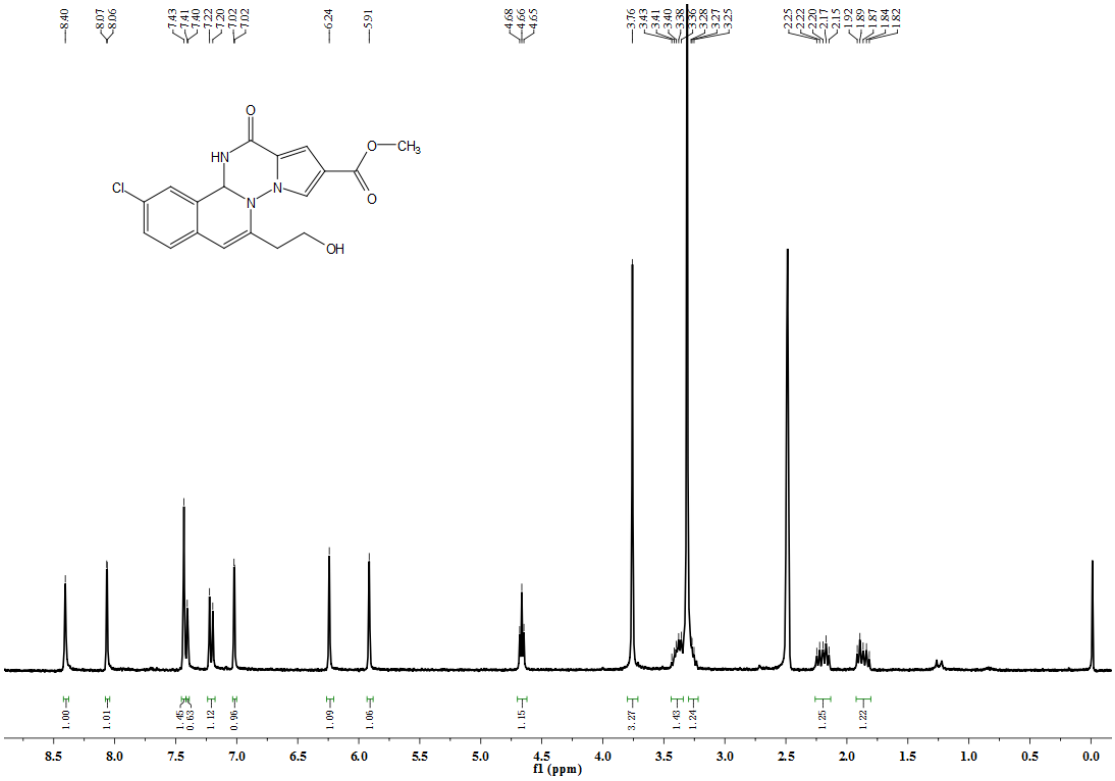


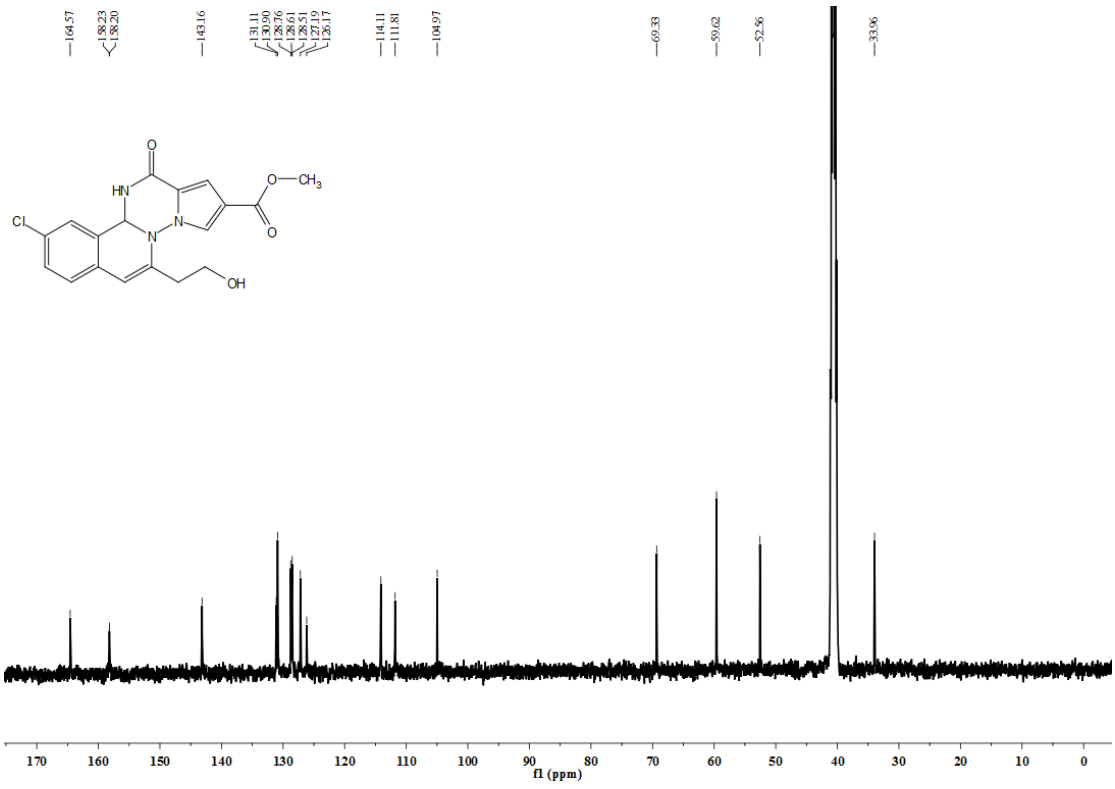


Compound 3u

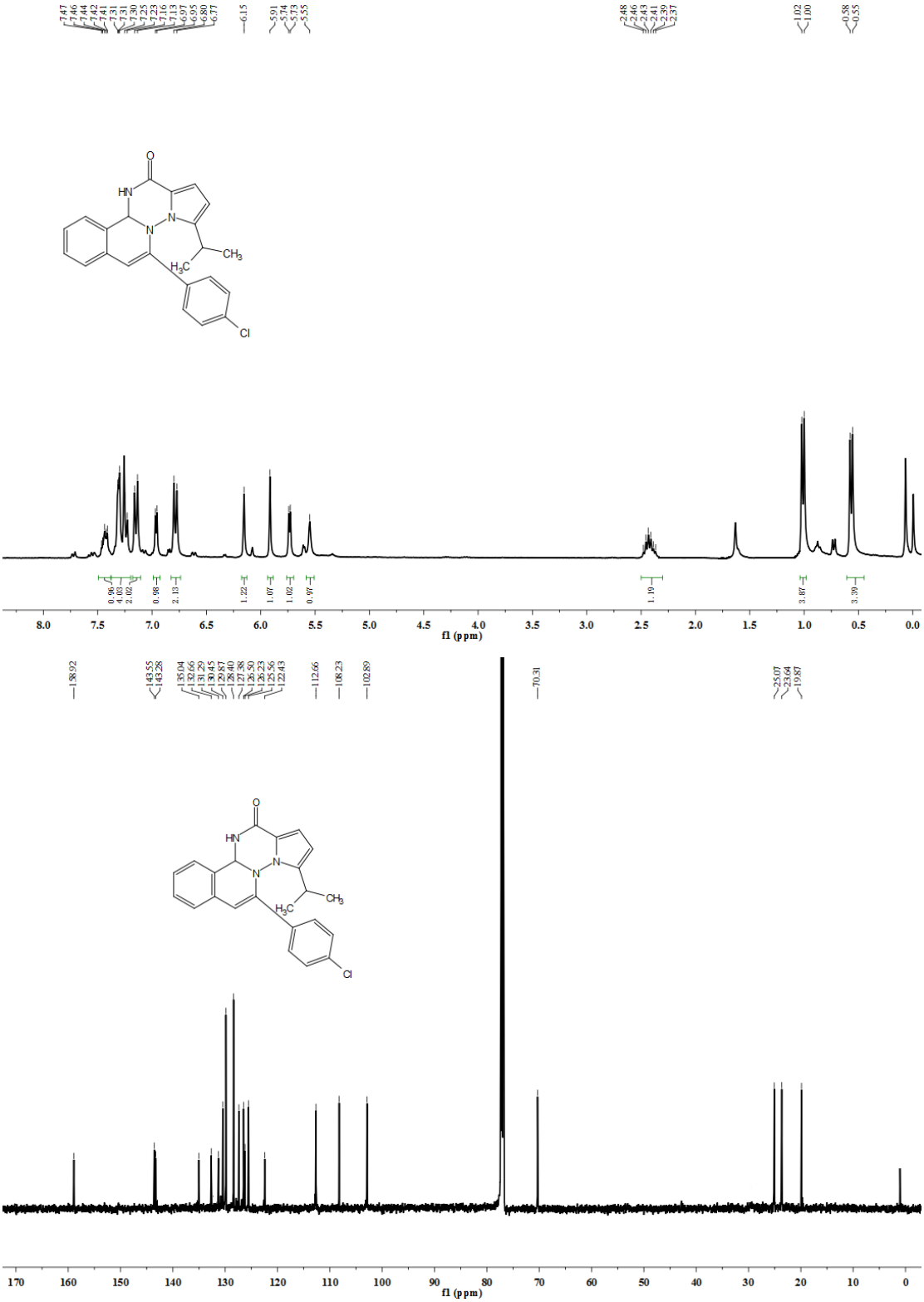

8.08
7.43
7.41
7.38
7.34
7.20
7.17
6.72
6.71
6.18
5.86
4.64
4.63
4.61
3.40
3.38
3.37
3.34
3.31
3.27
3.25
3.23
3.22
2.15
2.13
2.10
2.08
2.07
2.05
1.93
1.91
1.88
1.86
1.83
O
HN
N
N
Cl
OH
1.00
3.16
1.10
1.00
2.00
1.02
1.01
1.11
1.03
1.15
1.12
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
158.98
144.08
131.07
130.88
130.69
128.90
128.49
126.98
125.07
124.85
111.67
107.59
104.61
69.57
59.81
34.18
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 3v

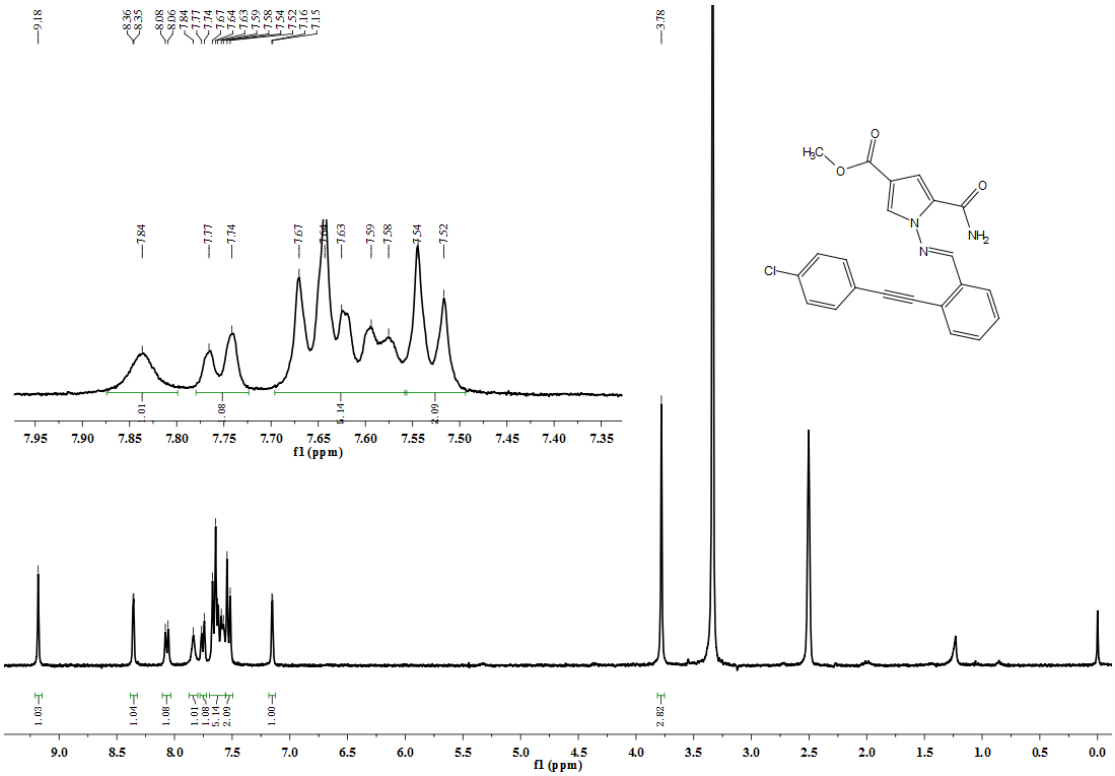

8.40
8.07
8.06
7.43
7.41
7.40
7.22
7.20
7.02
7.02
6.24
5.91
4.68
4.66
4.65
3.76
3.43
3.41
3.40
3.38
3.36
3.28
3.27
3.25
2.25
2.22
2.20
2.17
2.15
1.92
1.89
1.87
1.84
1.82
HN
N
N
Cl
O
O
O—CH3
OH
1.00
1.01
1.45
0.63
1.12
0.96
1.09
1.06
1.15
3.27
1.43
1.24
1.25
1.22
f1 (ppm)

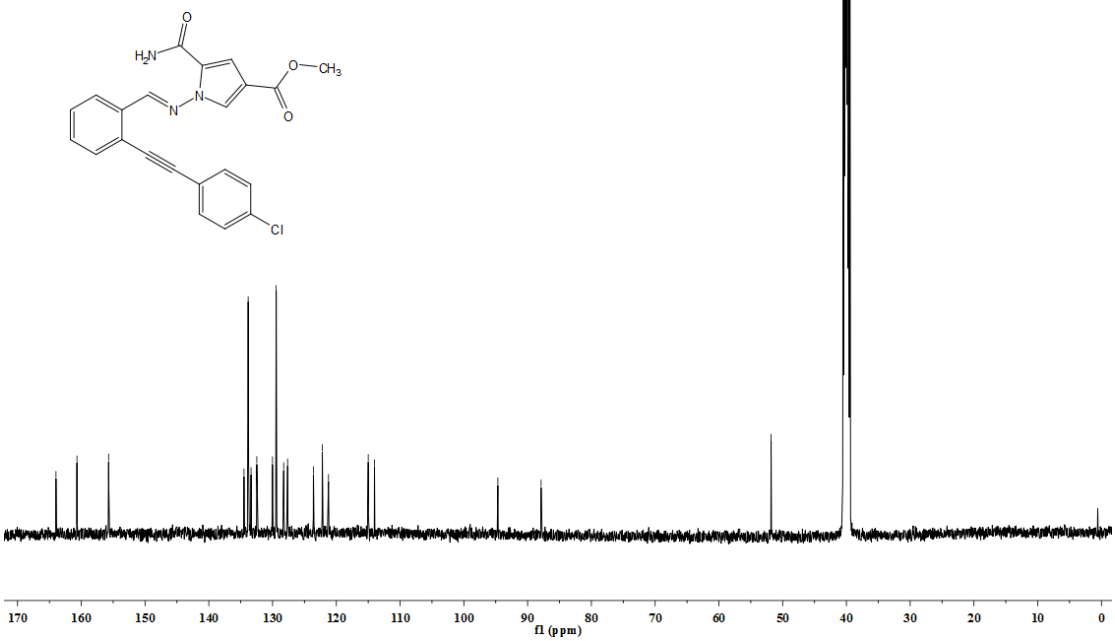

164.57
158.23
158.20
143.16
131.11
130.90
128.76
128.61
128.51
127.19
126.17
114.11
111.81
104.97
69.33
59.62
52.56
33.96
HN
N
N
Cl
O
O
O—CH3
OH
f1 (ppm)

Compound 3w


7.47
7.46
7.44
7.42
7.41
7.31
7.30
7.25
7.23
7.16
7.13
6.97
6.95
6.80
6.77
6.15
5.91
5.74
5.73
5.55
2.48
2.46
2.43
2.41
2.39
2.37
1.02
1.00
0.58
0.55
O
HN
N
N
CH3
H3C
Cl
0.96
4.03
2.02
0.98
2.13
1.22
1.07
1.02
0.97
1.19
3.87
3.39
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
158.92
143.55
143.28
135.04
132.66
131.29
130.45
129.57
128.40
127.38
126.50
126.23
125.56
122.43
112.66
108.23
102.89
70.31
25.07
23.64
19.87
O
HN
N
N
CH3
H3C
Cl
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 4a


9.18
8.36
8.35
8.08
8.06
7.84
7.77
7.74
7.67
7.64
7.63
7.59
7.58
7.54
7.52
7.16
7.15
3.78
f1 (ppm)


163.97
160.68
155.72
134.49
133.83
133.76
133.37
132.47
130.01
129.43
128.26
127.64
125.59
122.20
121.23
115.00
114.02
94.67
87.89
51.81
f1 (ppm)

Compound 4b