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Supporting information

Synthesis of 4,8-dihydro-1*H*-pyrazolo[3,4-*e*][1,4]thiazepin -7(6*H*)-one derivatives by solid acid-catalyzed multi-component reaction in water

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Materials and Methods. All commercially available chemicals were used without further purification, unless otherwise stated. Analytical thin layer chromatography (TLC) was performed using Merck silica gel GF254 plates. IR spectra were taken on a FT-IR-Tensor 27 spectrometer in KBr pellets and reported in cm^{-1}. NMR-data were recorded on Bruker Avance 400 Spectrometer. ^{1}H- and ^{13}C-spectra were referenced to the residue solvent signals in the deuterated solvent. ^{1}H NMR spectra were recorded on a 400 MHz instrument. Chemical shifts (δ) are given in ppm relative to TMS as the internal reference, with coupling constants (J) in Hz. ^{13}C NMR spectra were recorded at 100 MHz. Chemical shift were reported in ppm with the internal chloroform signal at 77.0 ppm as a standard. HRMS (ESI) was measured with a Bruker Daltonics APEXII instrument.

Preparation and characterization of the solid acid (C-SO_3H) catalyst

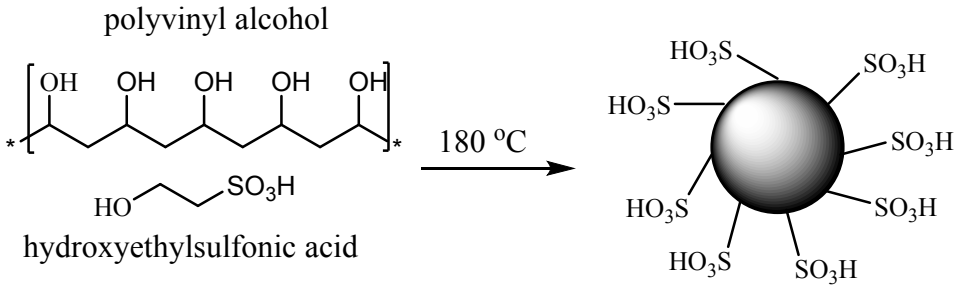


Fig. 1. The preparation of the carbon functinalized material

According to literature method,[1] the polyvinyl alcohol (5.0 g), hydroxyethylsulfuric acid (3.5 g) and deionized water (50 mL) was mixed in Teflon-lined stainless steel autoclaves, which was heated at 180 °C for 4 h. Then, the resulting mixture were filtered, washed with water and methanol, and dried in a vacuum oven at 100 °C for 4 h. The goal product was obtained as black solid with 50% yield according to polyvinyl alcohol (Fig. 1).

The acidity of the sulfonated carbonaceous materials was 2.4 mmol/g by neutralization titration. According to XPS analysis, the S content of 7.6% indicated almost all the S existed in the forms of sulfonic acid groups and the O content was as high as 24% indicated that many oxygen-containing groups besides the carbonyl acid groups were exist. The BET surface of the solid acid was 146 m^2/g. The 1040 and 1195 cm^{-1} absorbability of IR spectra indicated the existence of the sulfuric acid groups. FT-IR spectra showed that the sulfonated carbonaceous materials contains resident functionalities such as hydroxyl (3500 cm^{-1}), carboxylate (1704 cm^{-1}), C=C groups (1604

cm^{-1}) and C-O groups (1204 cm^{-1}).

General procedure for synthesis of 4,8-dihydro-1*H*-pyrazolo [3,4-*e*][1,4]thiazepin-7(6*H*)-one derivatives (4)

3-Methyl-1*H*-pyrazol-5-amine (**1**, 1.0 mmol) was added to a 10-mL reaction vial in water (3.0 mL), to the resulting solution were sequentially added aldehydes (**2**, 1.0 mmol), thioglycollic acid (**3**, 1.0 mmol), and C-SO_3H (10 mg). The mixture was stirred at the indicated temperature until TLC showed that the conversion of the substrates was complete about 5-6 h. Then, the mixture was cooled to room temperature and the solid was filtered. The result solid was resolved in hot ethanol, filtered, and the mother liquor was concentrated and recrystallized to give goal products (**4**).

General procedure for synthesis of 2-(((2,4-diamino-6-oxo-1,6-dihydropyrimidin- 5-yl)(*p*-tolyl)methyl)thio)acetic acid (5)

2,6-Diaminopyrimidin-4(3*H*)-one (**1c**, 1.0 mmol) was added to a 10-mL reaction vial in water (3.0 mL), to the resulting solution were sequentially added 4-methylbenzaldehyde (**2o**, 1.0 mmol), thioglycollic acid (**3**, 1.0 mmol), and C-SO_3H (10 mg). The mixture was stirred at the indicated temperature until TLC showed that the conversion of the substrates was complete about 6 h. Then, the mixture was cooled to room temperature and the solid was filtered. The result solid was resolved in hot ethanol, filtered, and the mother liquor was concentrated and recrystallized to give product (**5**).

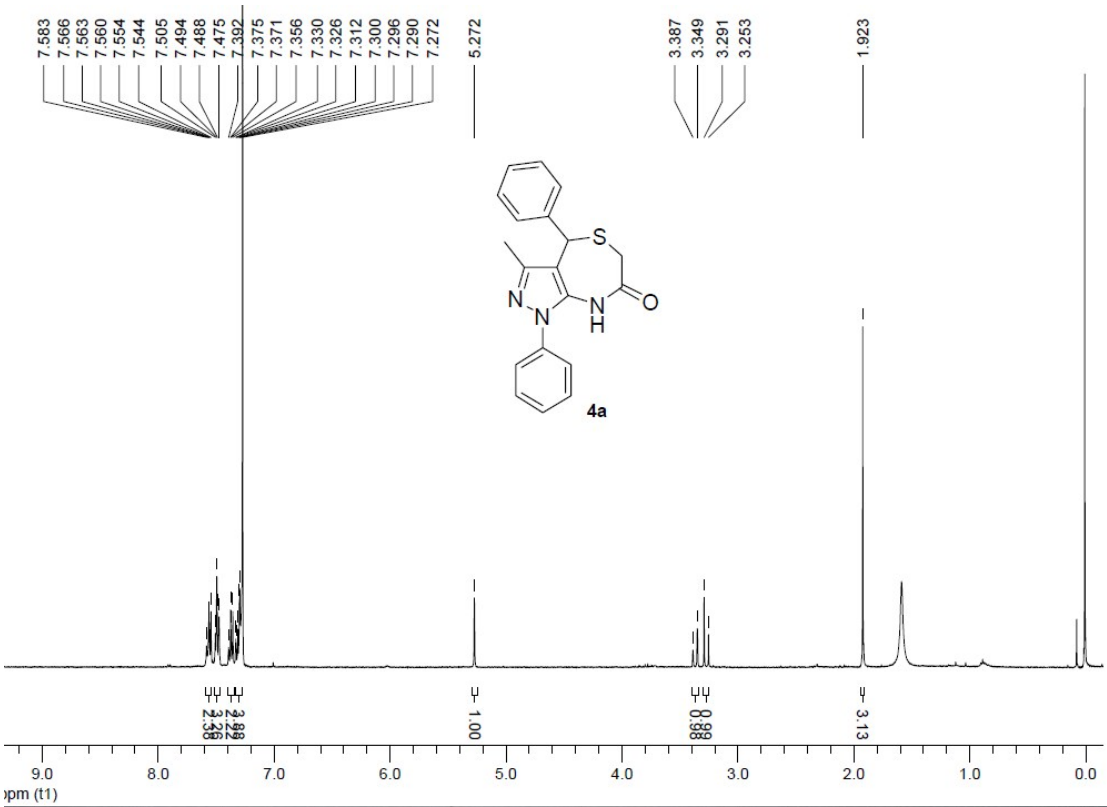
General procedure for synthesis of ethyl 2-(((5-amino-3-methyl-1-phenyl-1*H* -pyrazol-4-yl)(aryl)methyl)thio)acetate (7)

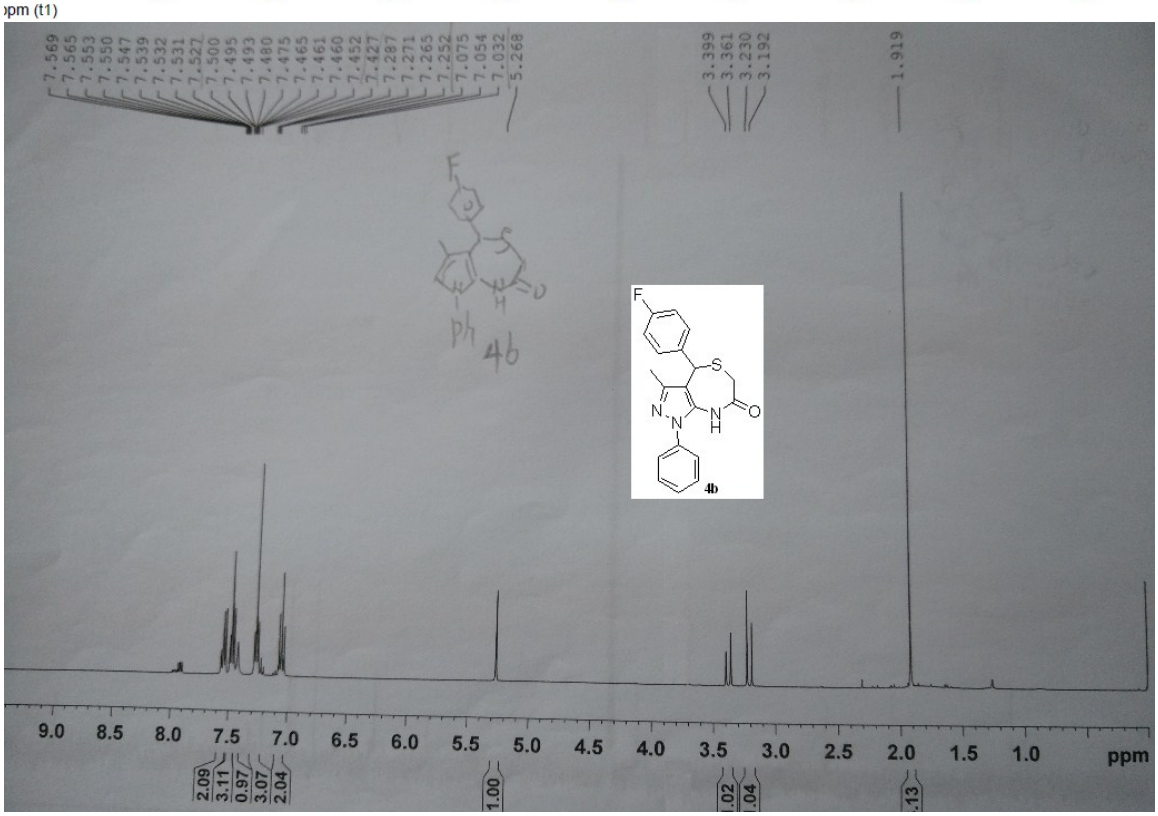
3-Methyl-1-phenyl-1*H*-pyrazol-5-amine (**1a**, 1.0 mmol) was added to a 10-mL reaction vial in water (3.0 mL), to the resulting solution were sequentially added aromatic aldehydes (**2**, 1.0 mmol), thioglycollic acid (**3**, 1.0 mmol), ethanol (**6**, 3.0 mmol), and C-SO_3H (10 mg). The mixture was stirred at the indicated temperature until TLC showed that the conversion of the substrates was complete about 6 h. Then, the mixture was cooled to room temperature and the solid was filtered. The result solid was resolved in hot ethanol, filtered, and the mother liquor was concentrated. The residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent (ethyl acetate/petroleum ether = 1:20~1:4) to provide desired product (**7**).

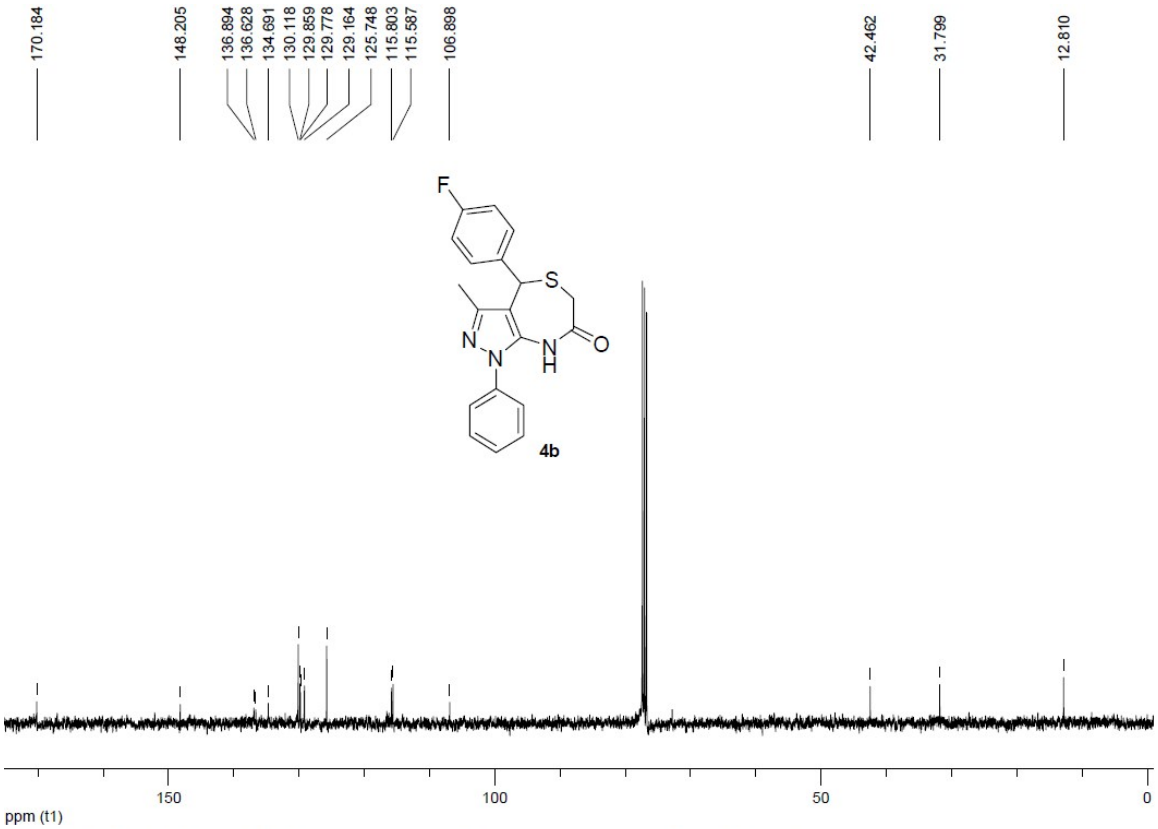
References

1 X. Z. Liang, H. Q. Xiao, Y. S. Shen and C. Z. Qi, *Mater. Lett.*, 2010, **64**, 953-955.

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



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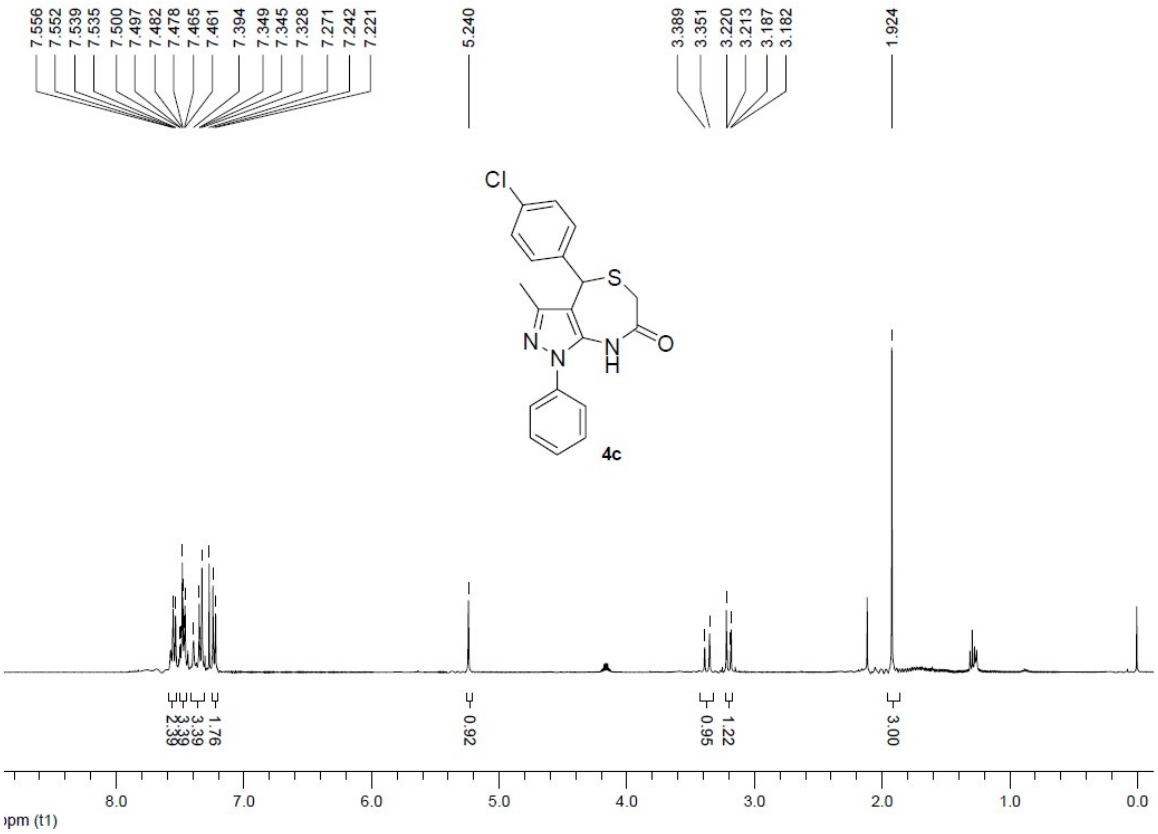
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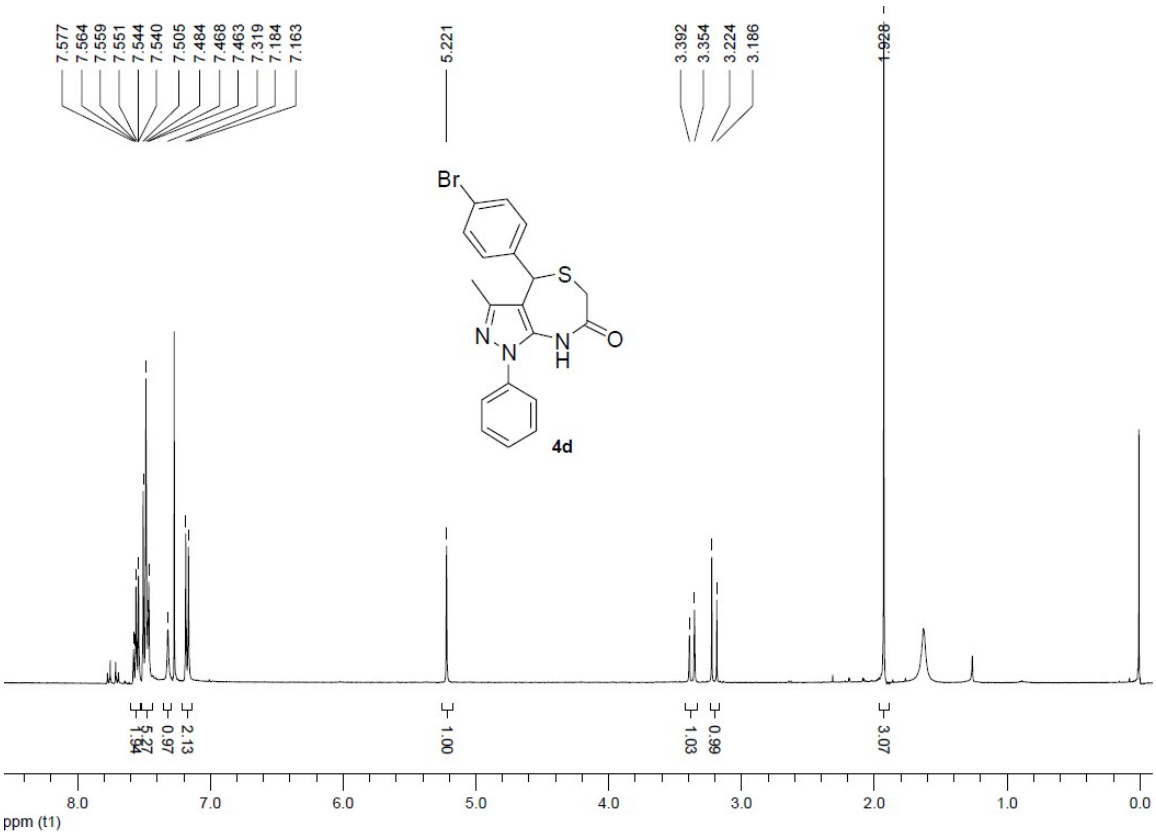
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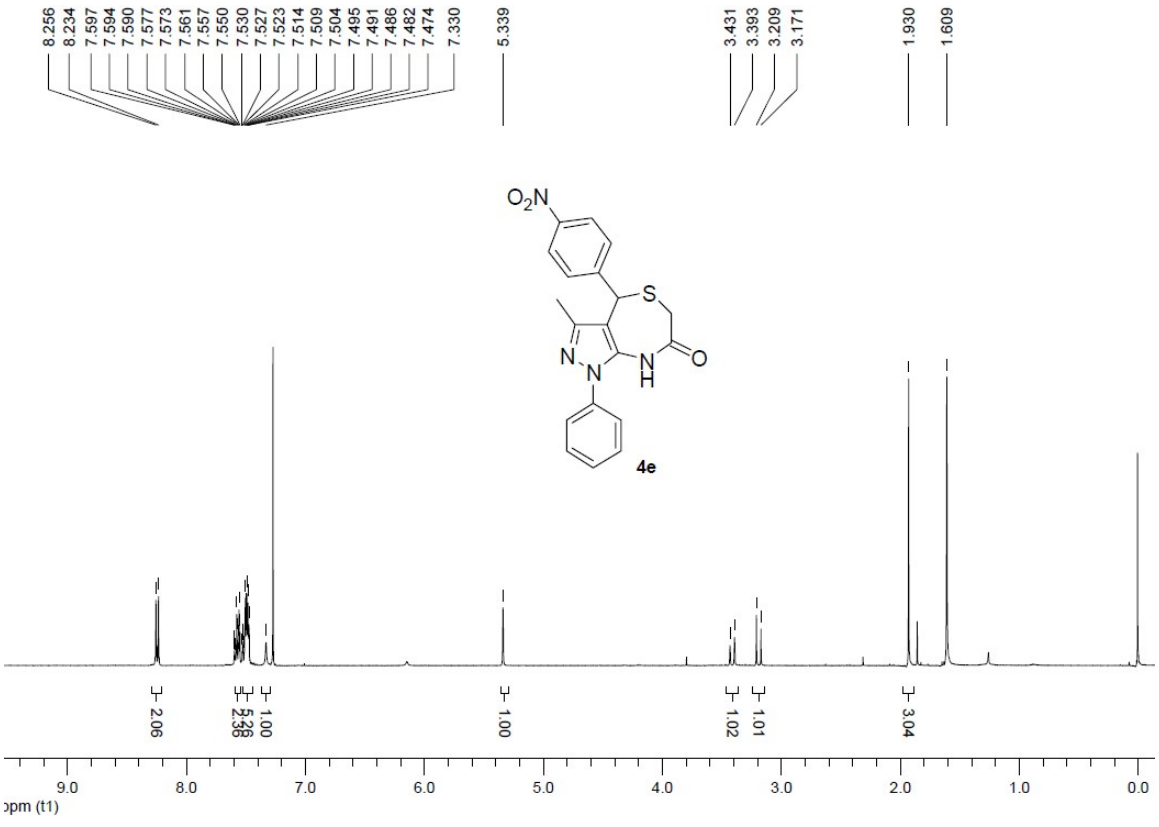
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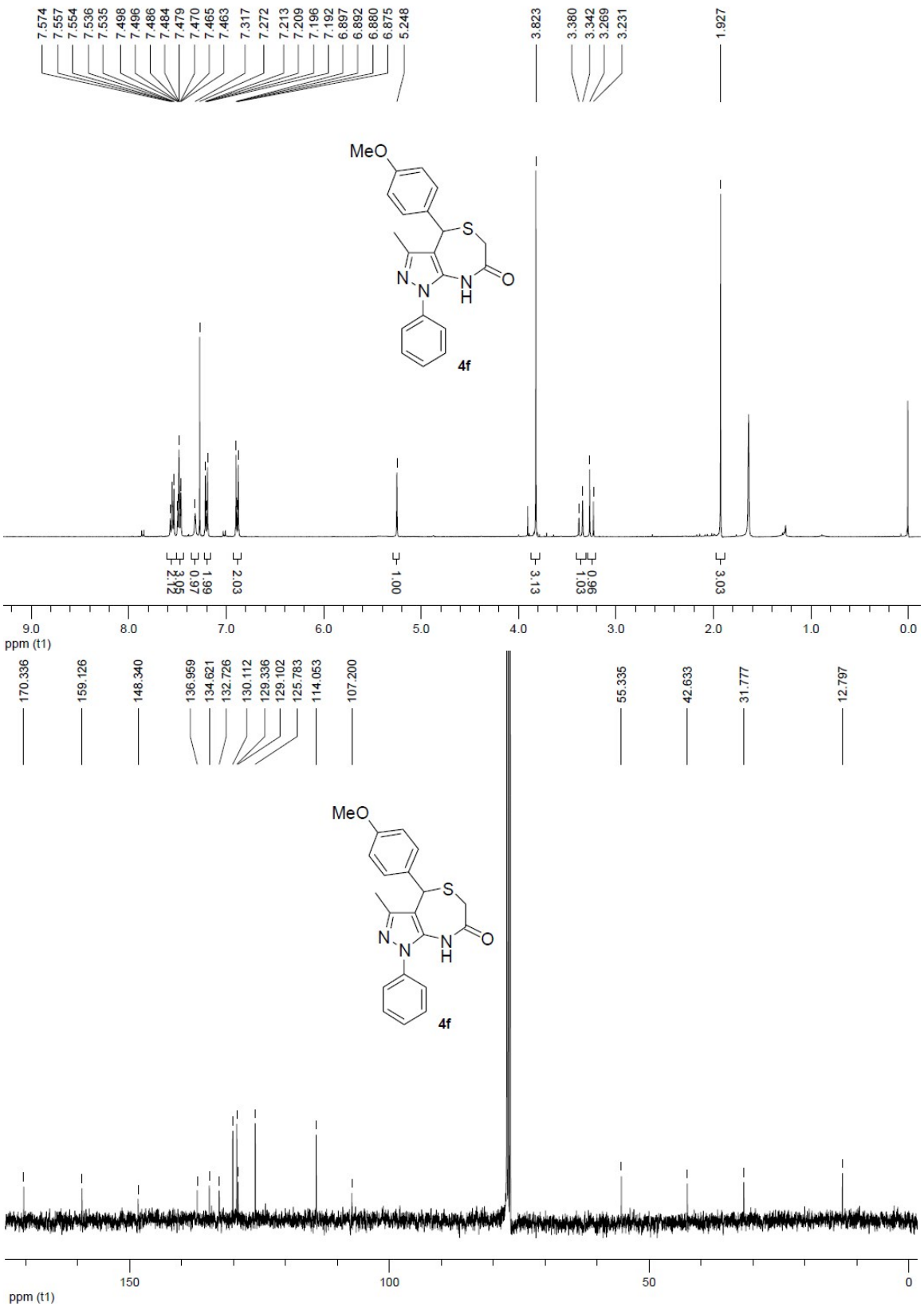
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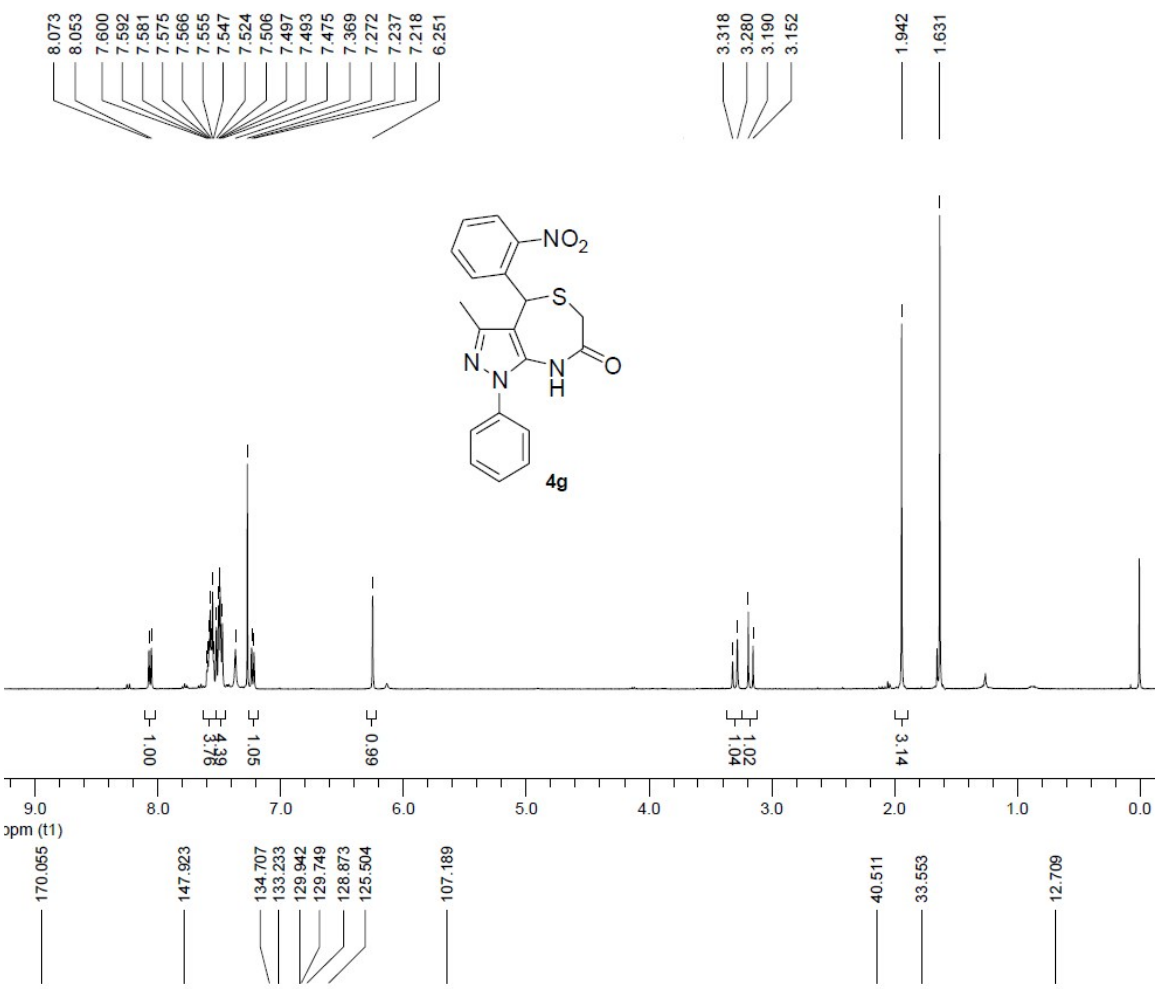
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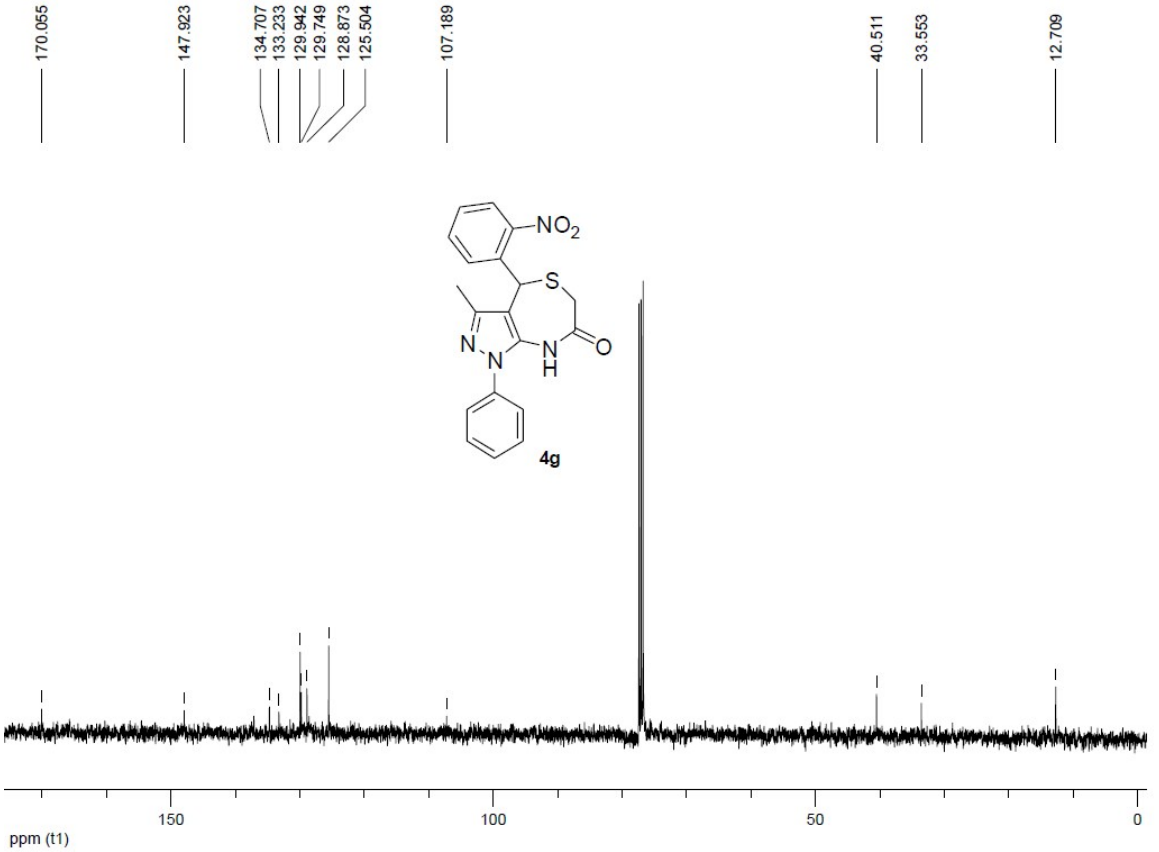
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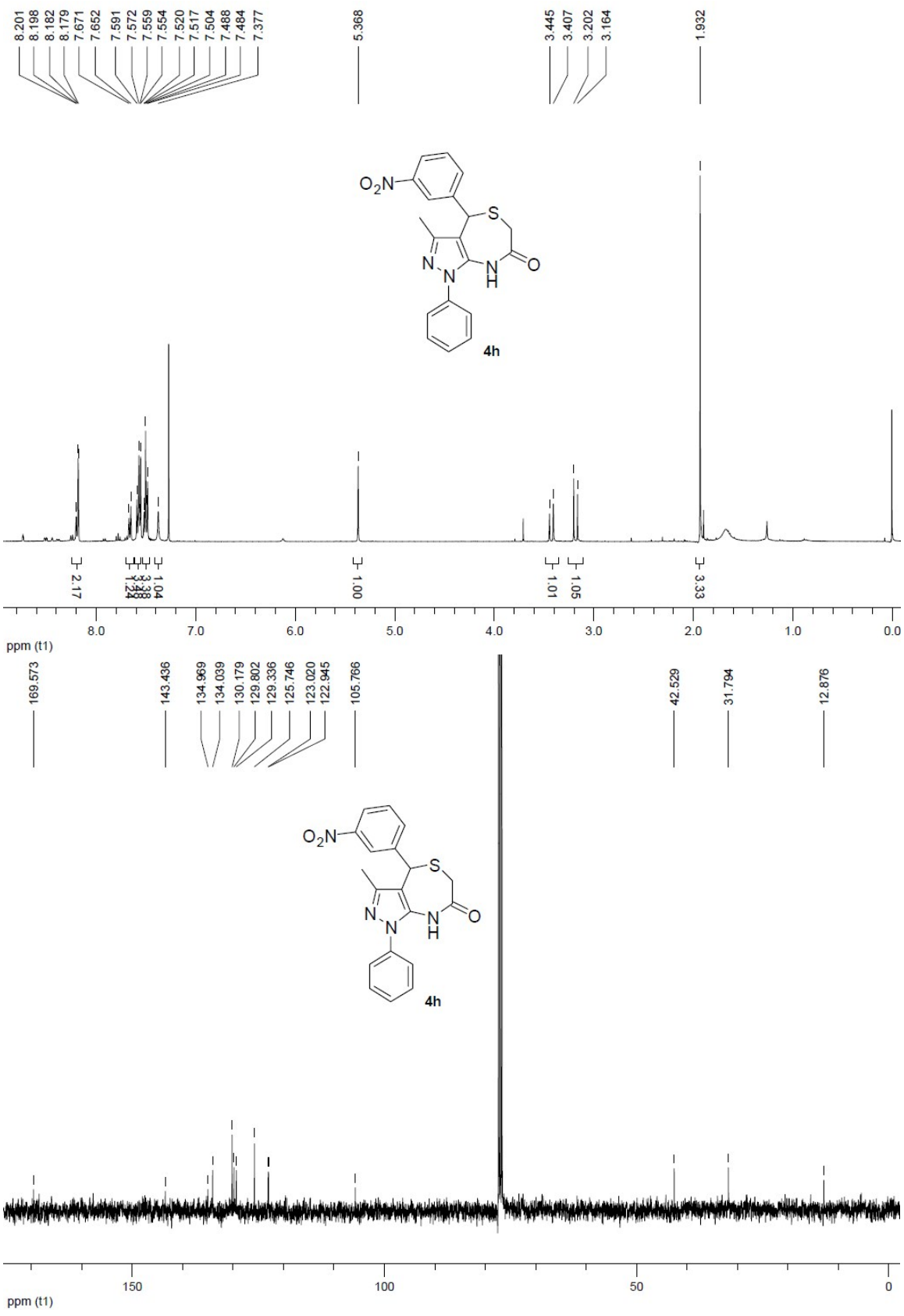
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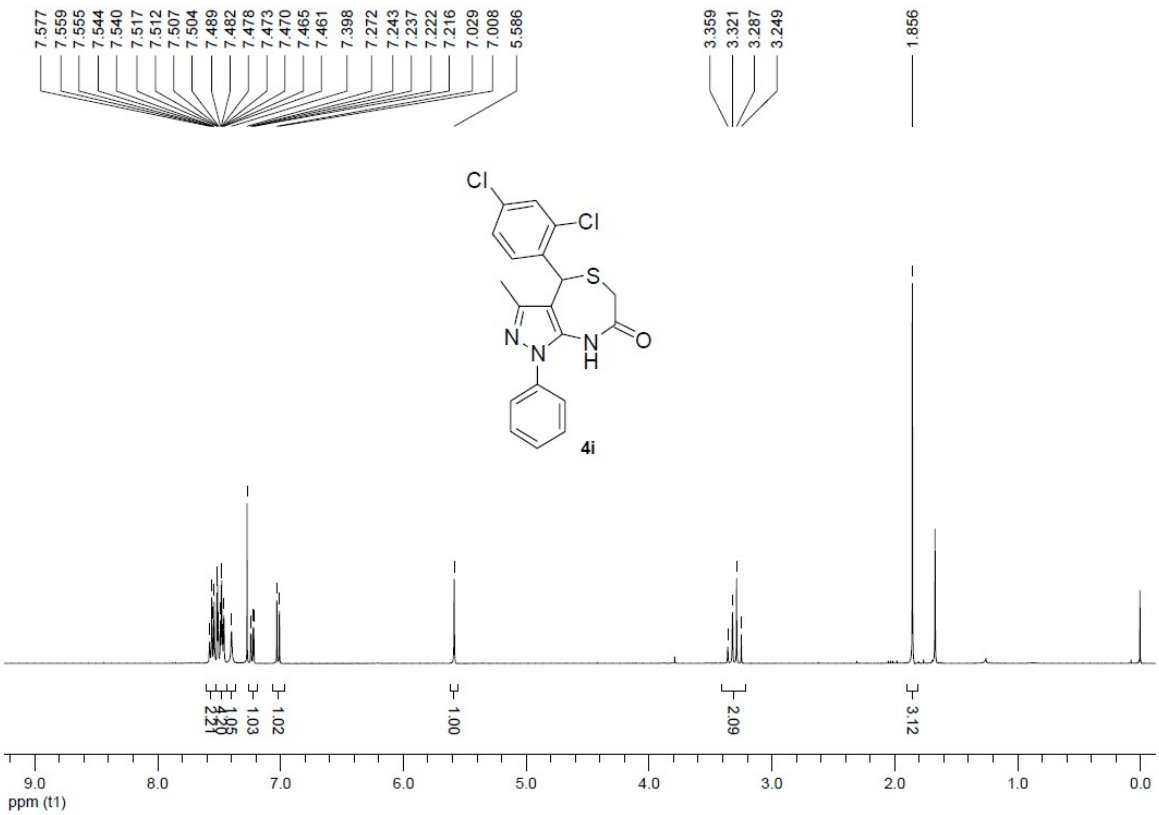
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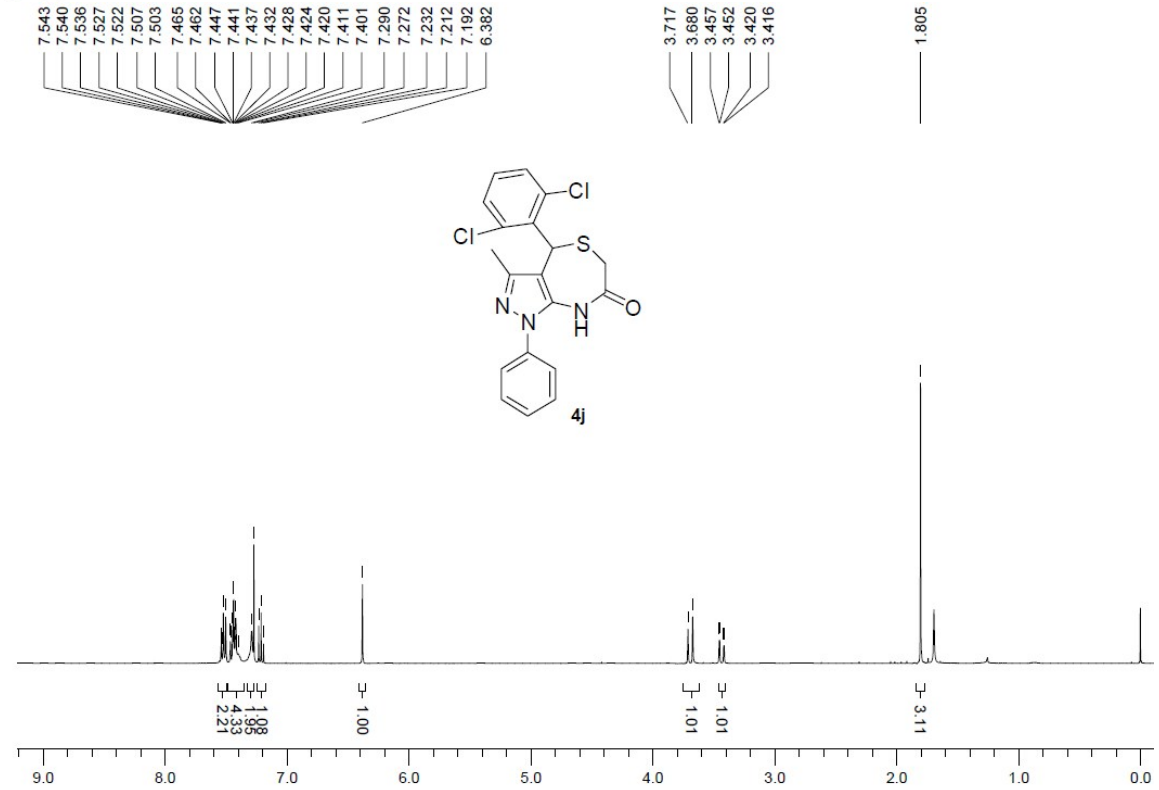
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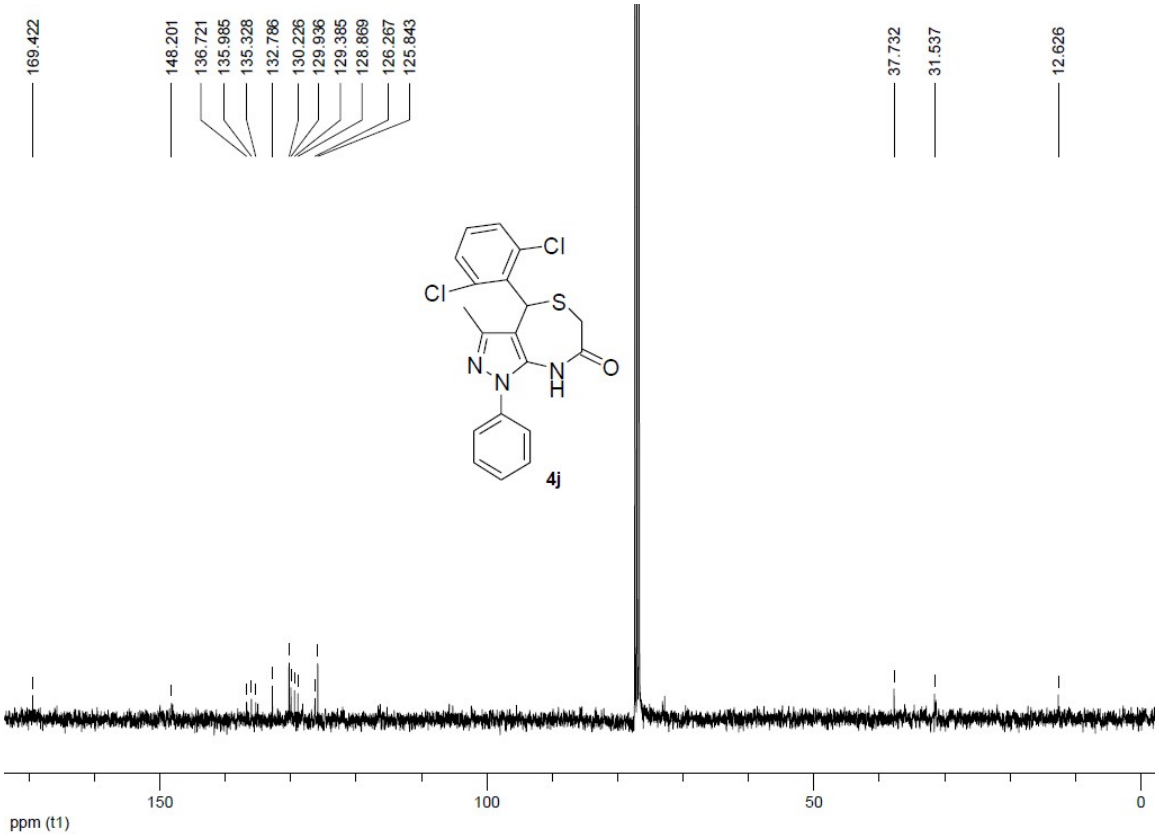
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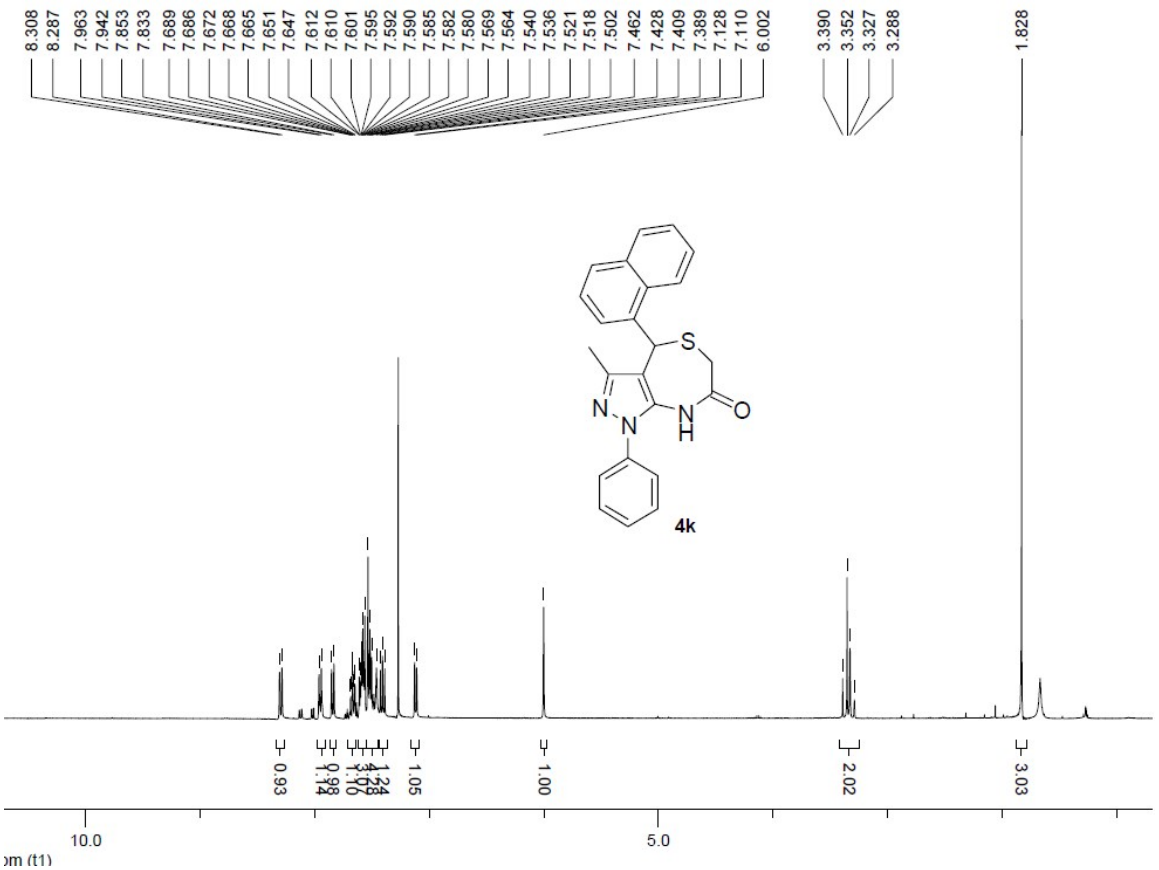
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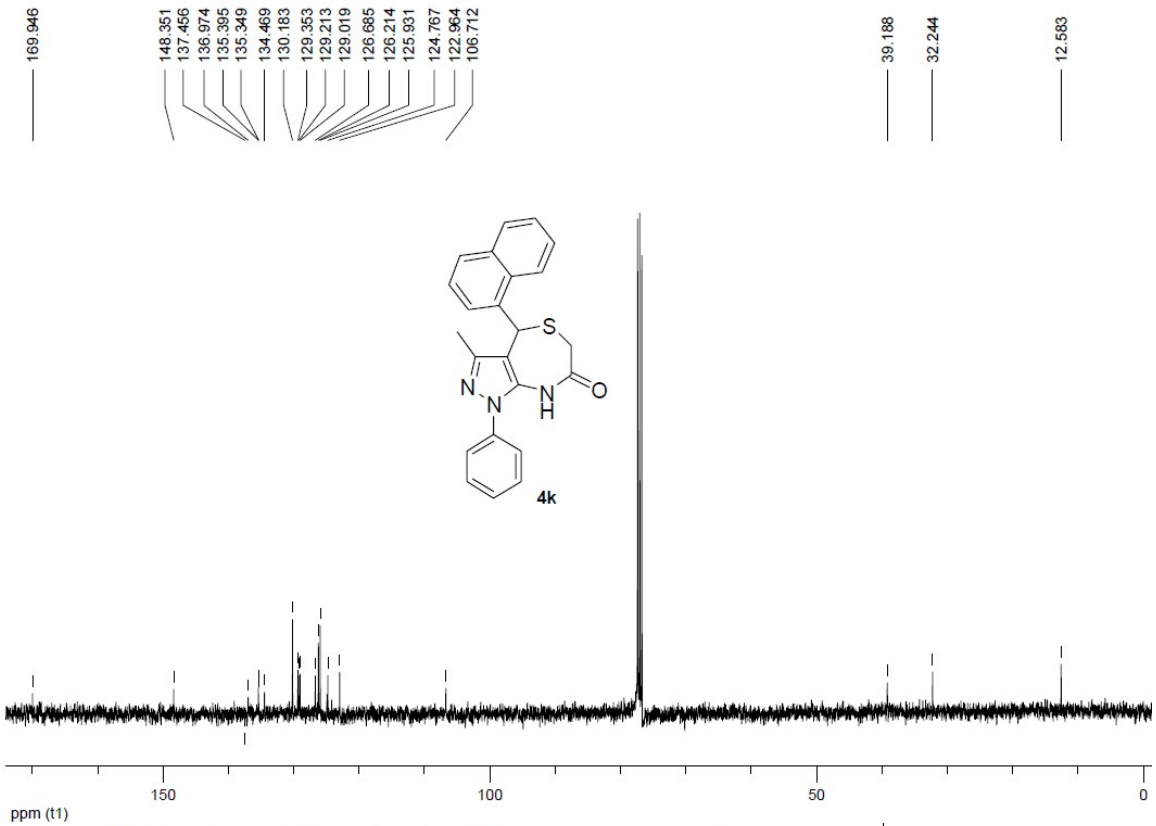
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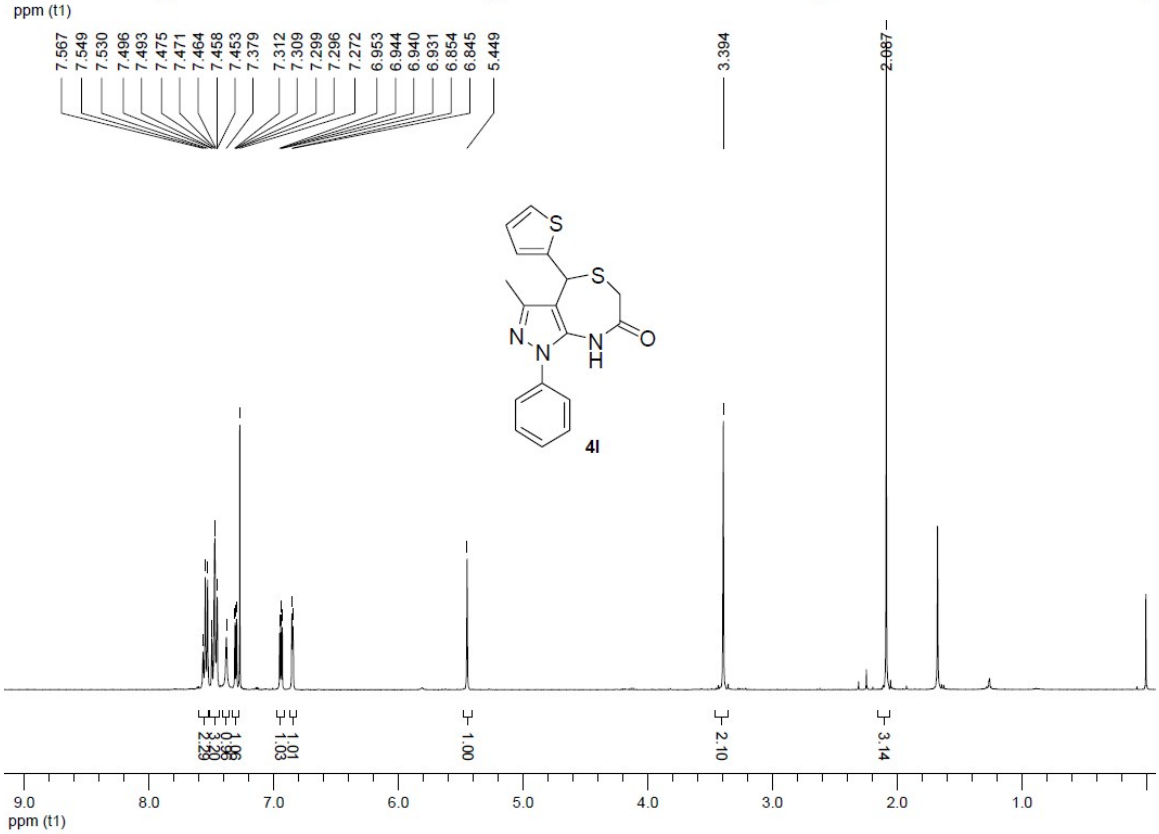
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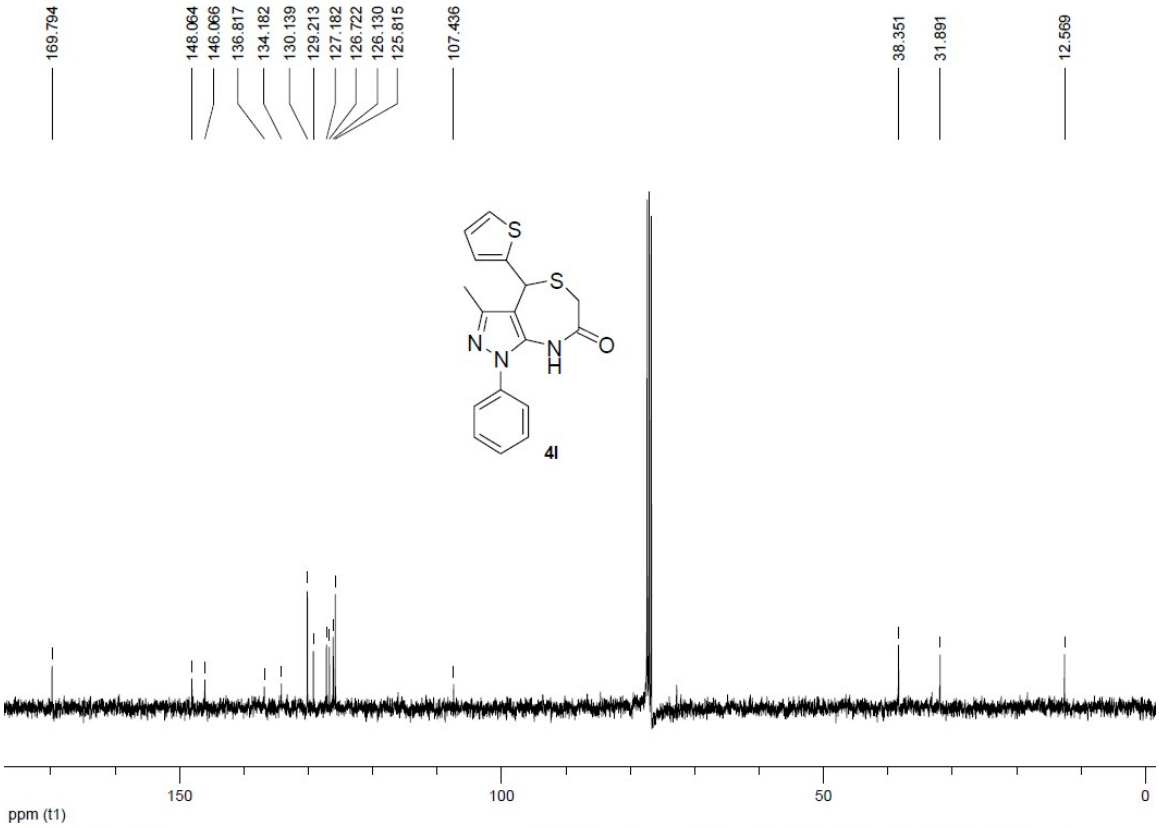
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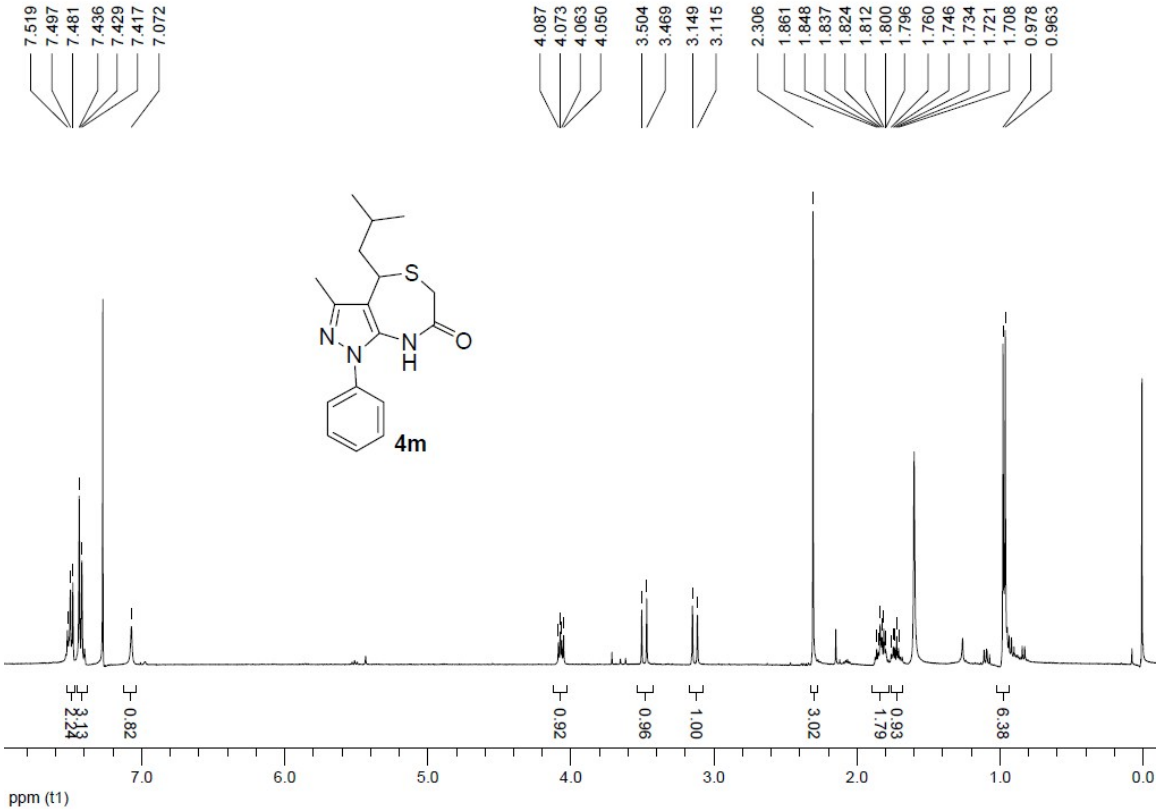
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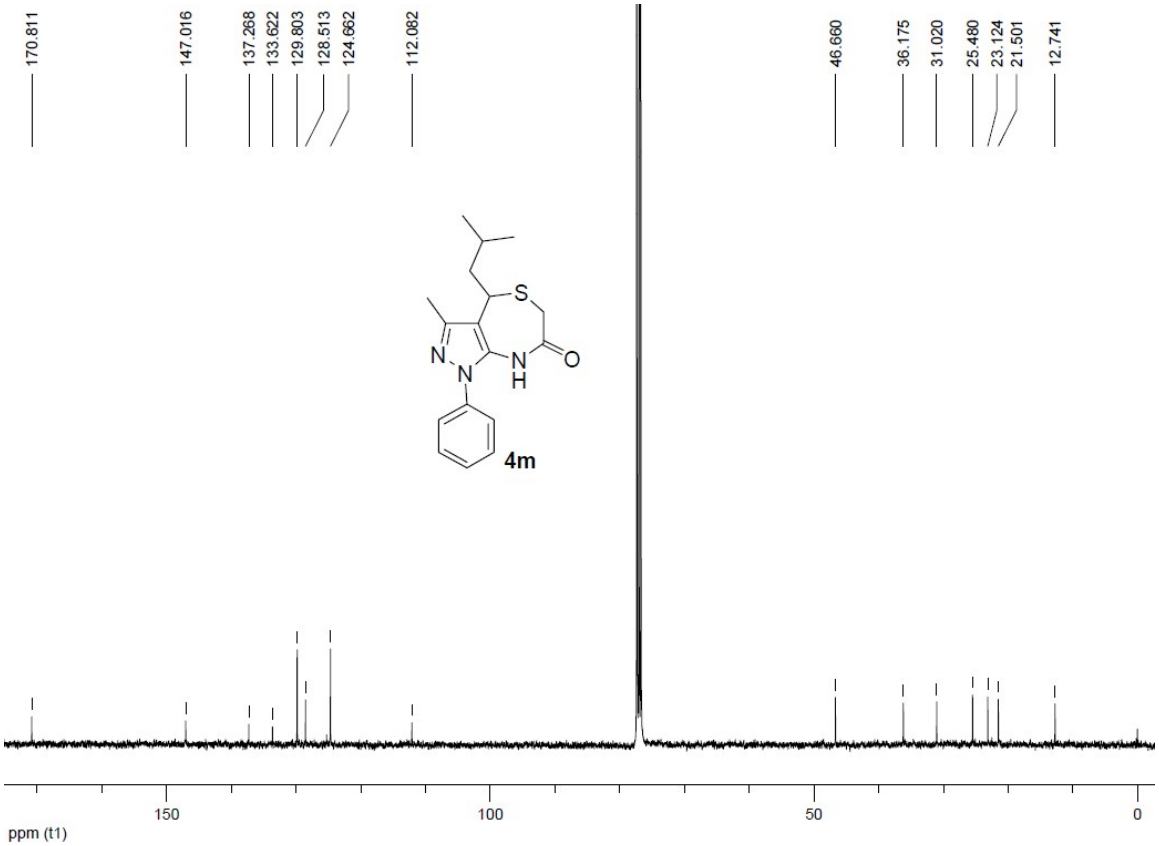
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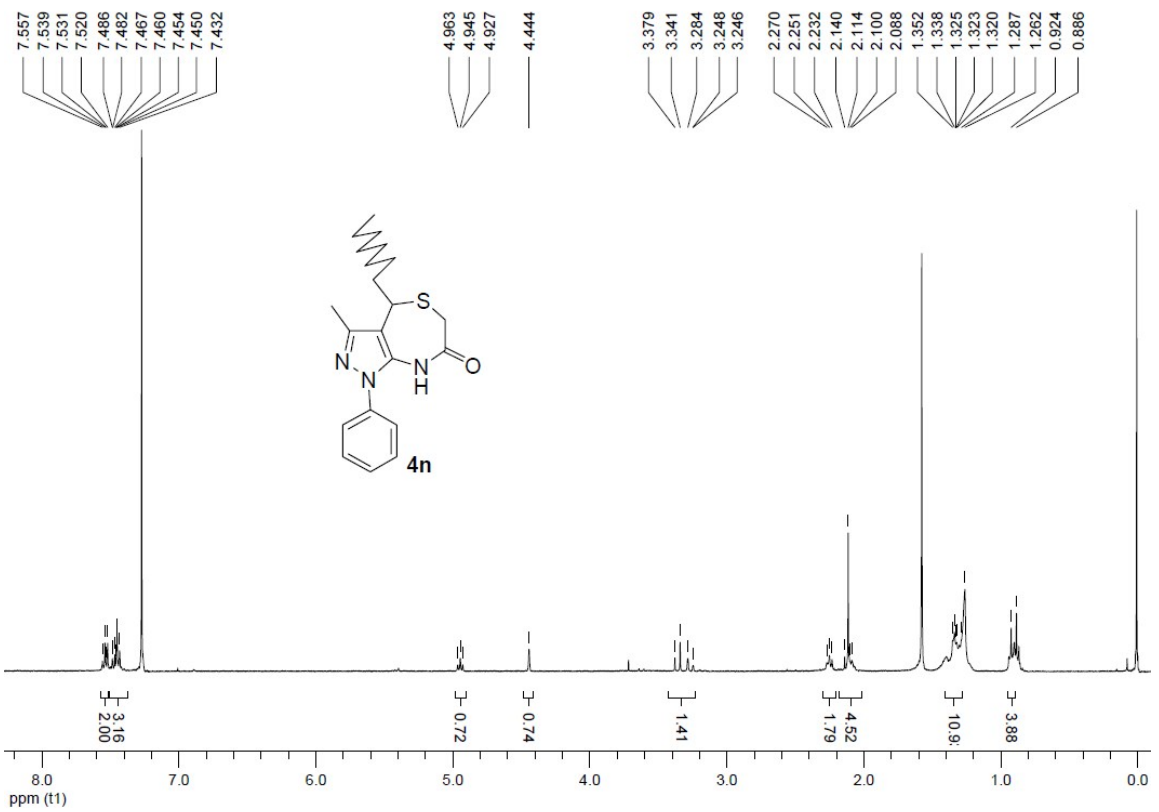
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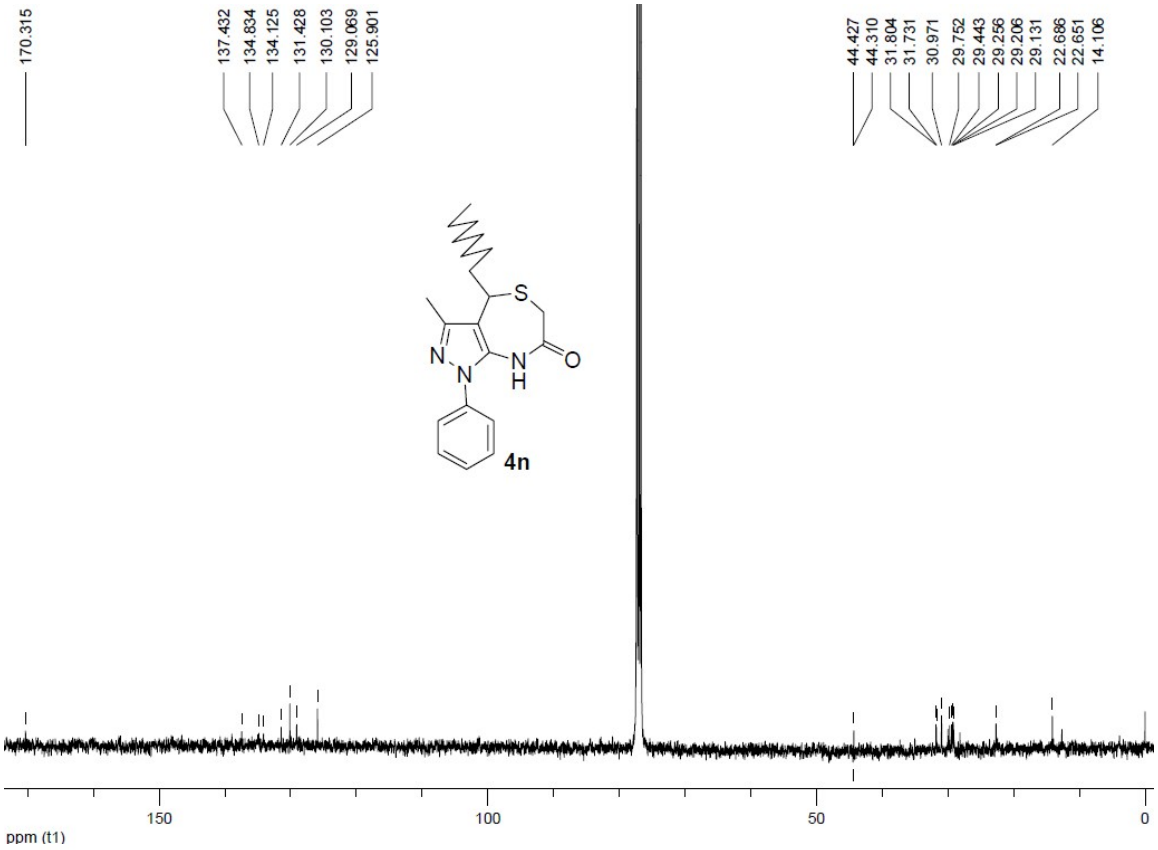
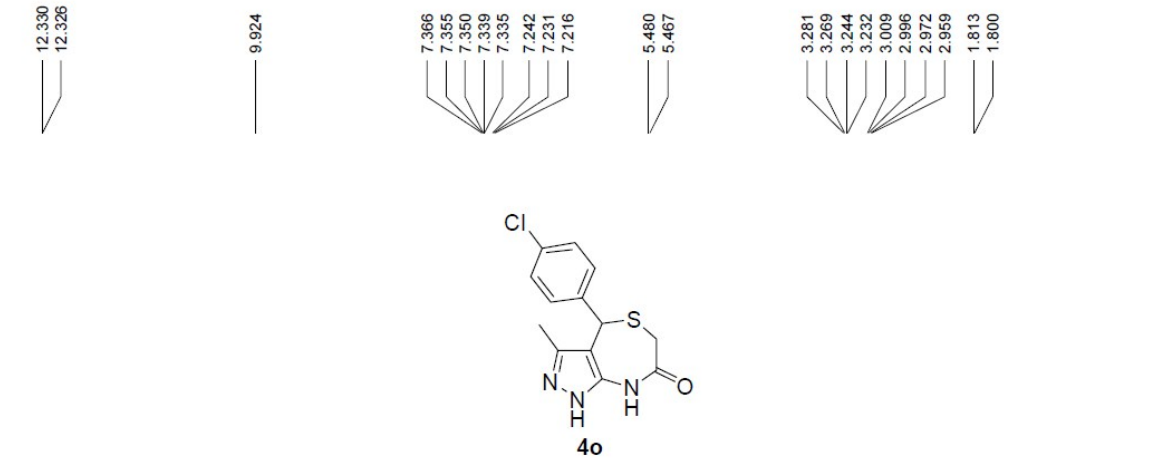
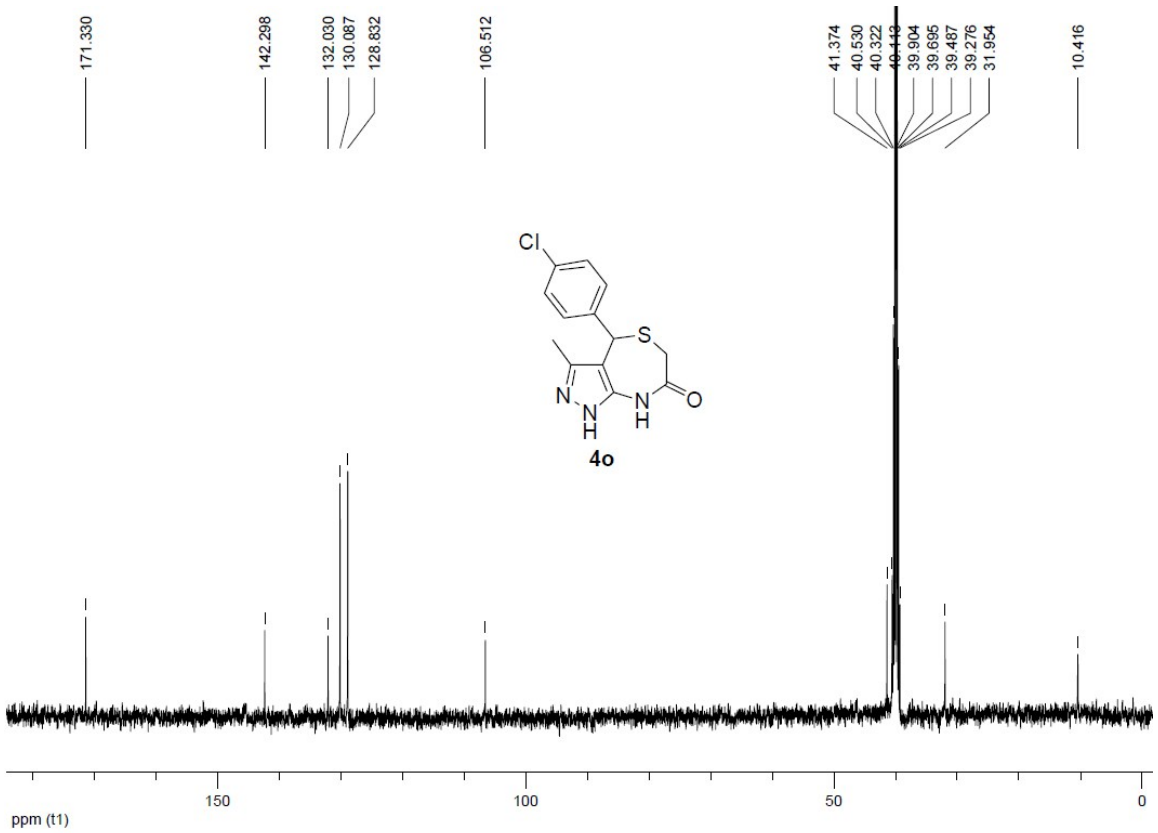
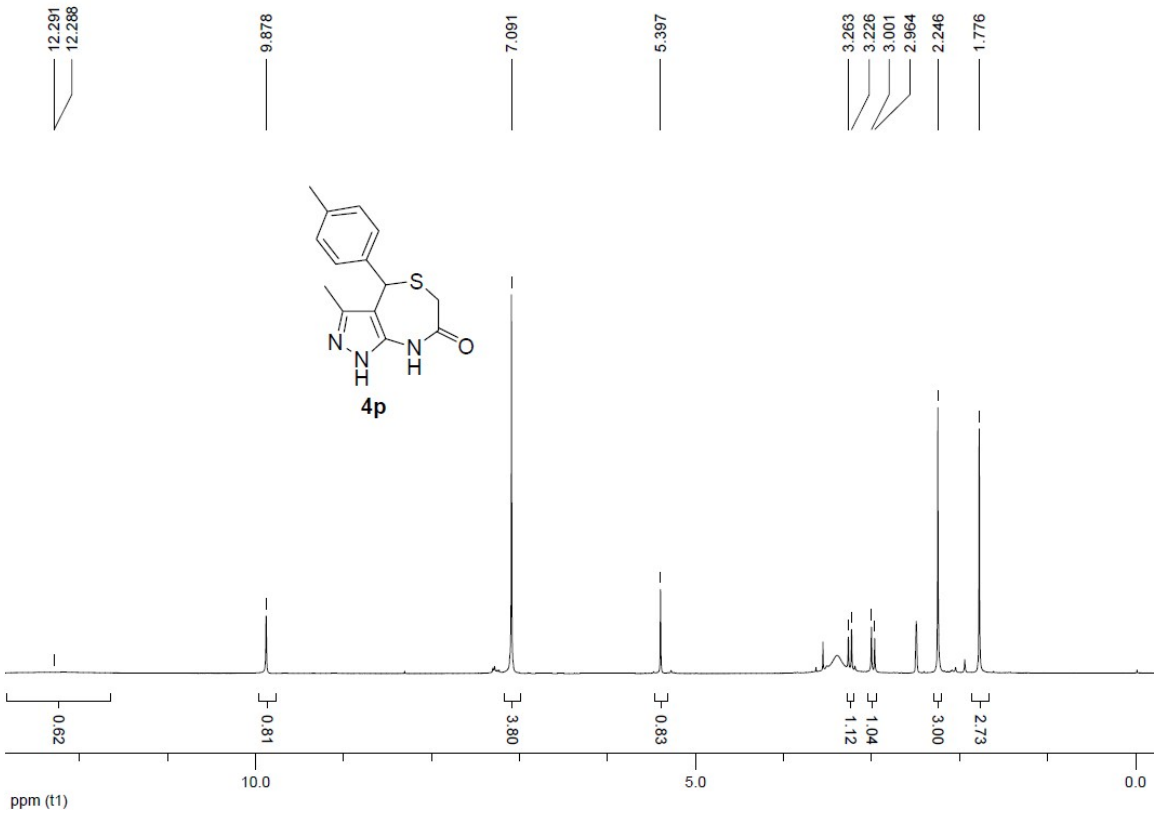
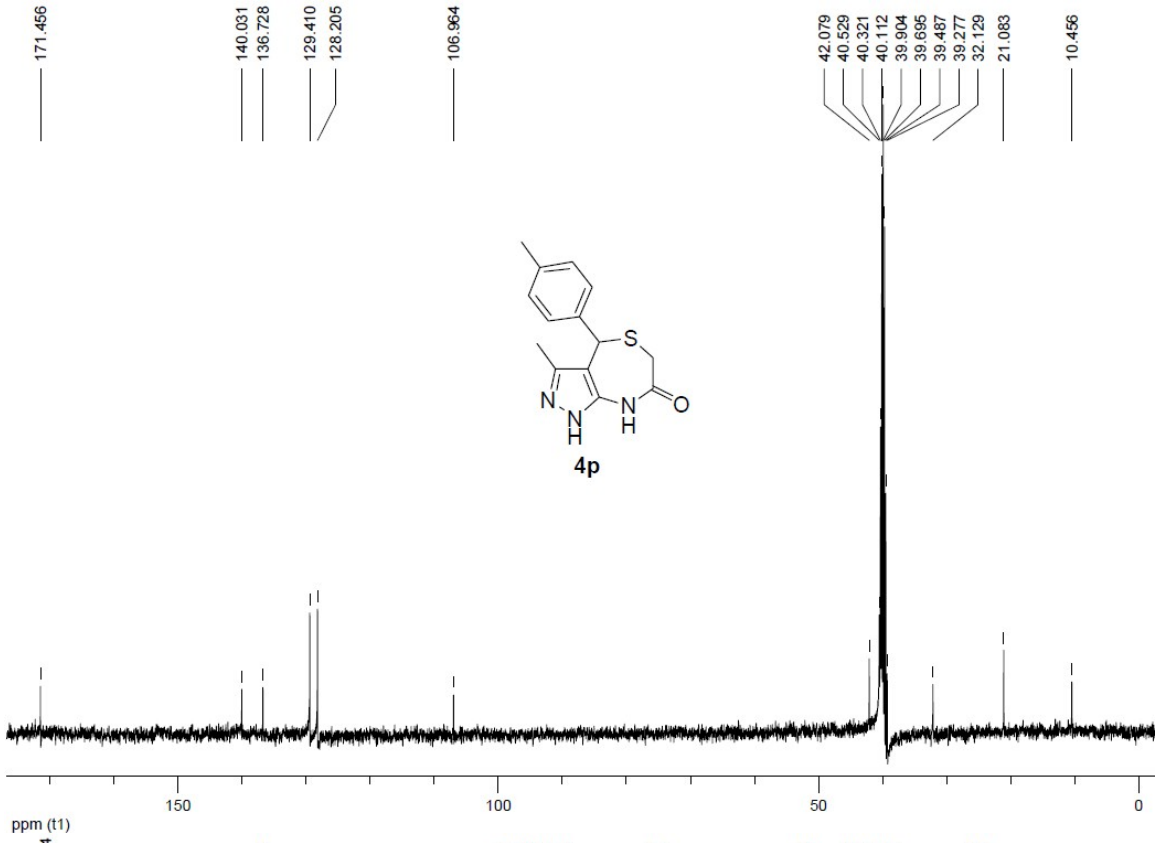

170.315
137.432
134.834
134.125
131.428
130.103
129.069
125.901
44.427
44.310
31.804
31.731
30.971
29.752
29.443
29.256
29.206
29.131
22.686
22.651
14.106
4n
150
100
50
0
ppm (t1)


12.330
12.326
9.924
7.366
7.355
7.350
7.339
7.335
7.242
7.231
7.216
5.480
5.467
3.281
3.269
3.244
3.232
3.009
2.996
2.972
2.959
1.813
1.800

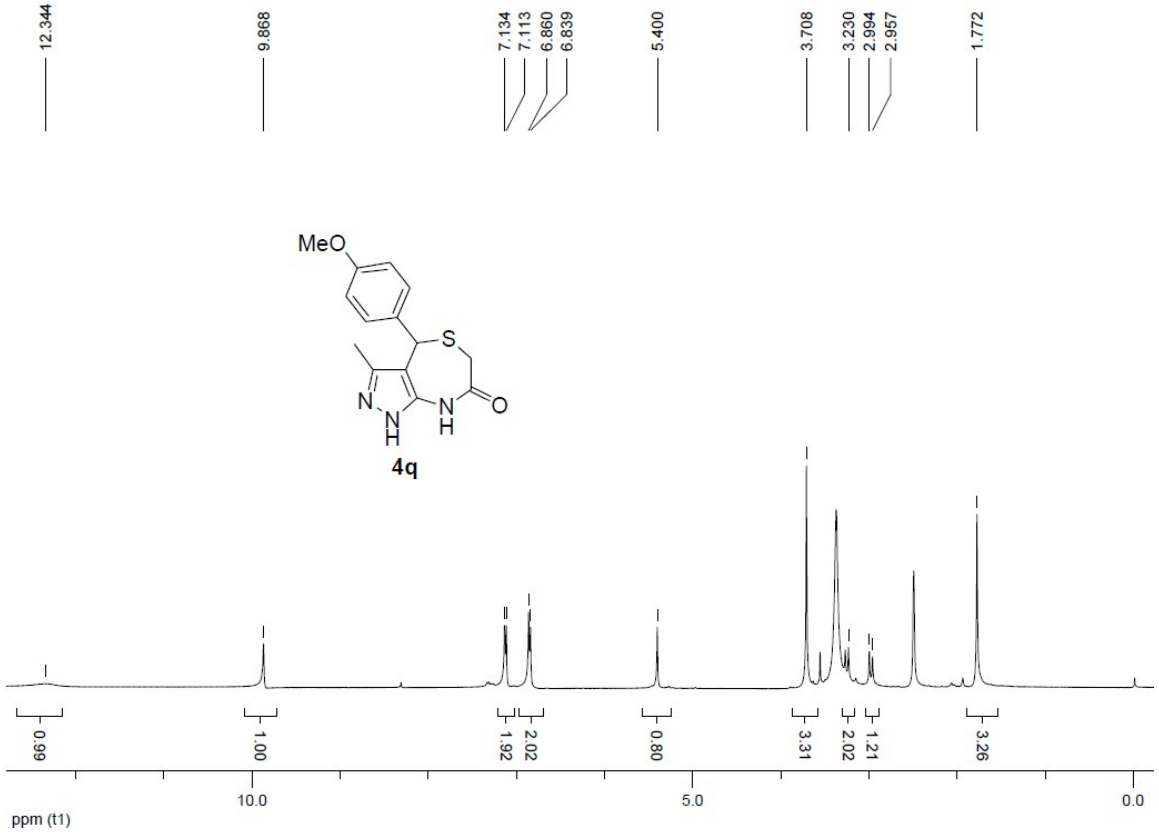
Cl
4o
0.68
0.84
1.79
2.00
0.81
1.07
1.03
2.79
10.0
5.0
0.0
ppm (t1)


171.330
142.298
132.030
130.087
128.832
106.512
41.374
40.530
40.322
39.904
39.695
39.487
39.276
31.954
10.416
Cl
S
N
N
H
N
H
O
4o
150
100
50
0
ppm (t1)

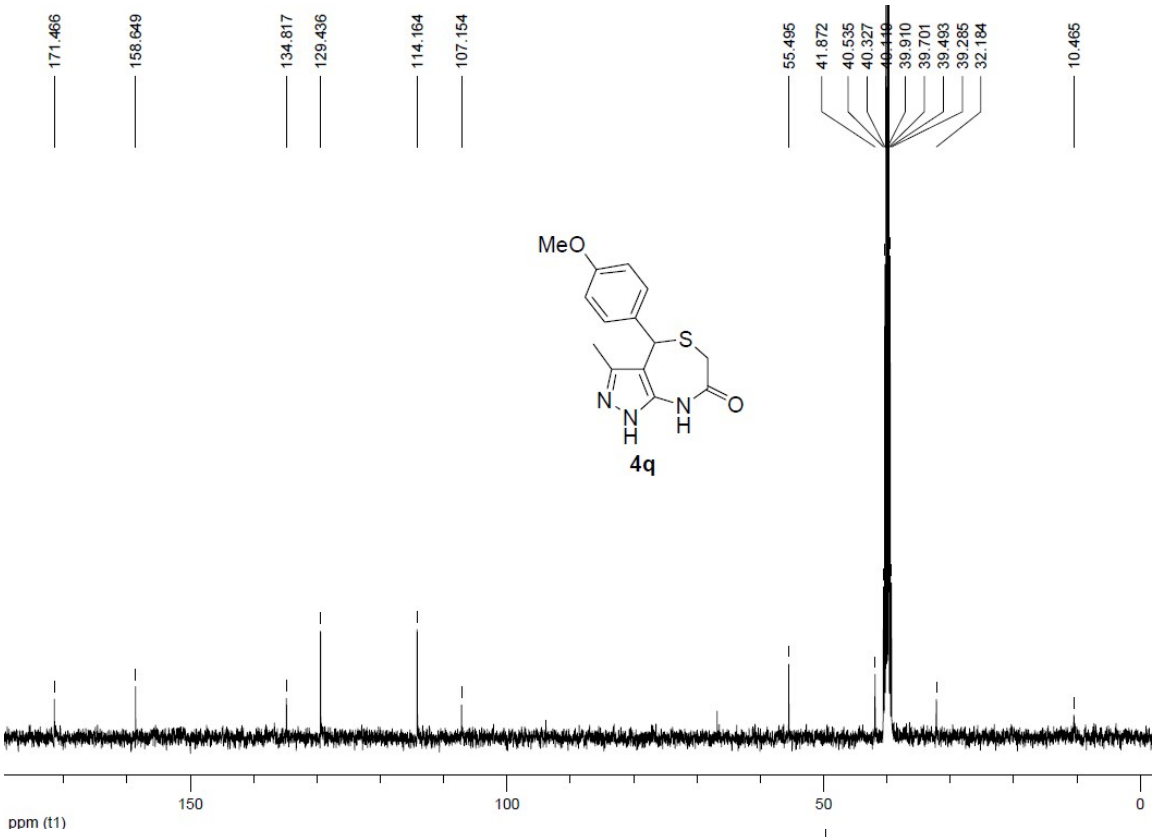

12.291
12.288
9.878
7.091
5.397
3.263
3.226
3.001
2.964
2.246
1.776
S
N
N
H
N
H
O
4p
0.62
0.81
3.80
0.83
1.12
1.04
3.00
2.73
10.0
5.0
0.0
ppm (t1)

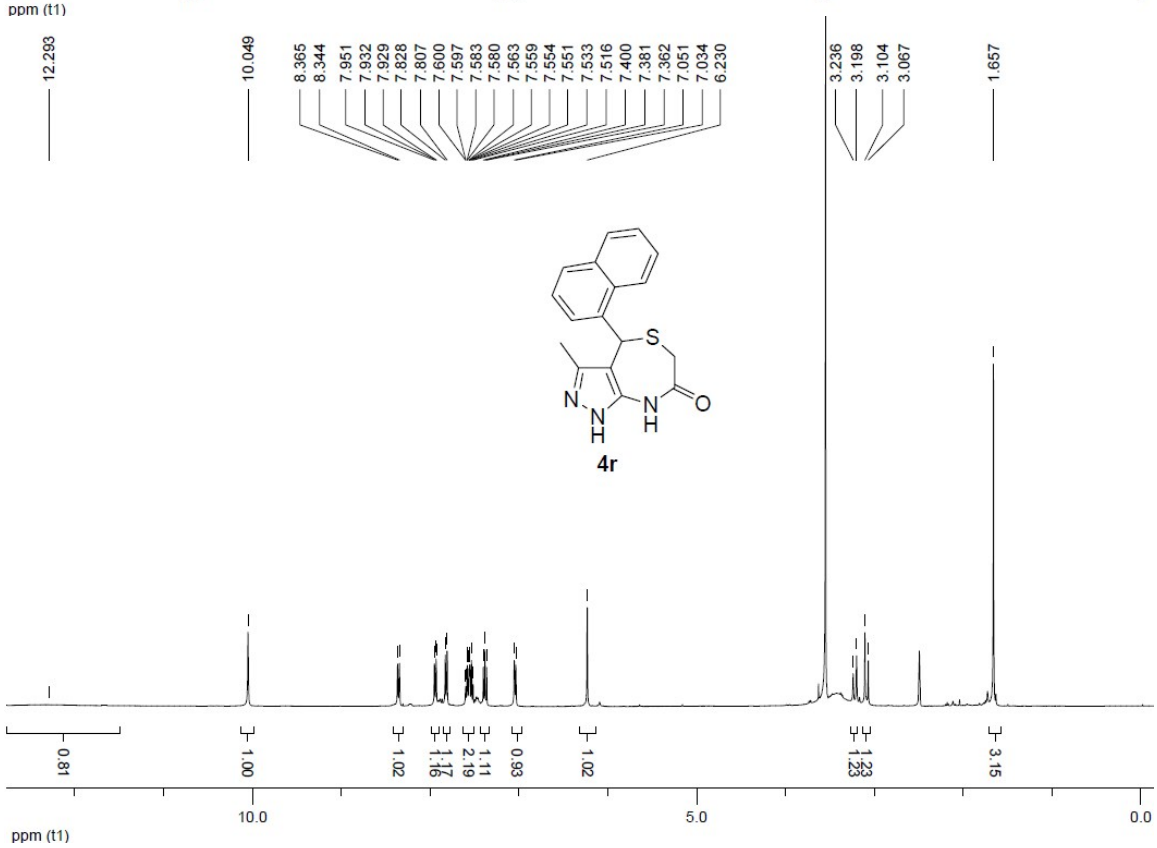

171.456
140.031
136.728
129.410
128.205
106.964
42.079
40.529
40.321
40.112
39.904
39.695
39.487
39.277
32.129
21.083
10.456
S
N
N
H
N
H
O
150
100
50
0
ppm (t1)

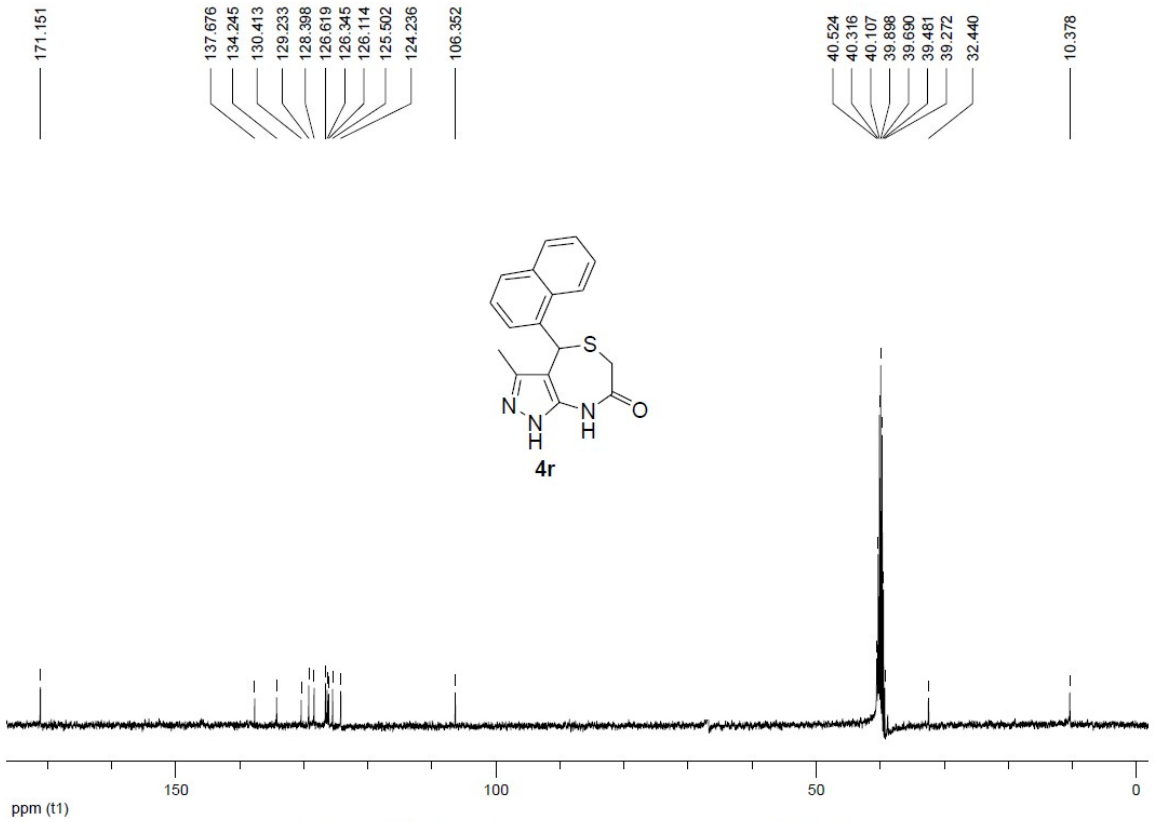
4p

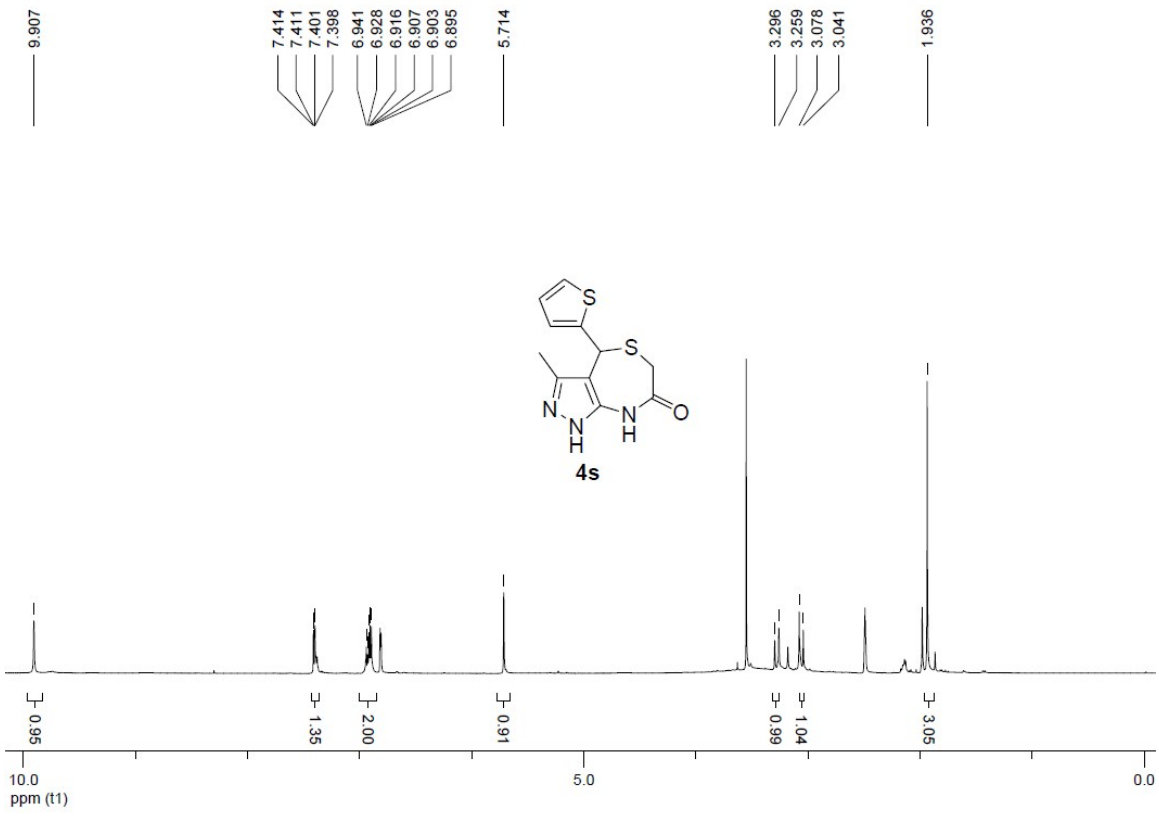

12.344
9.868
7.134
7.113
6.860
6.839
5.400
3.708
3.230
2.994
2.957
1.772
MeO
S
N
N
H
N
H
O
0.99
1.00
1.92
2.02
0.80
3.31
2.02
1.21
3.29
10.0
5.0
0.0
ppm (t1)

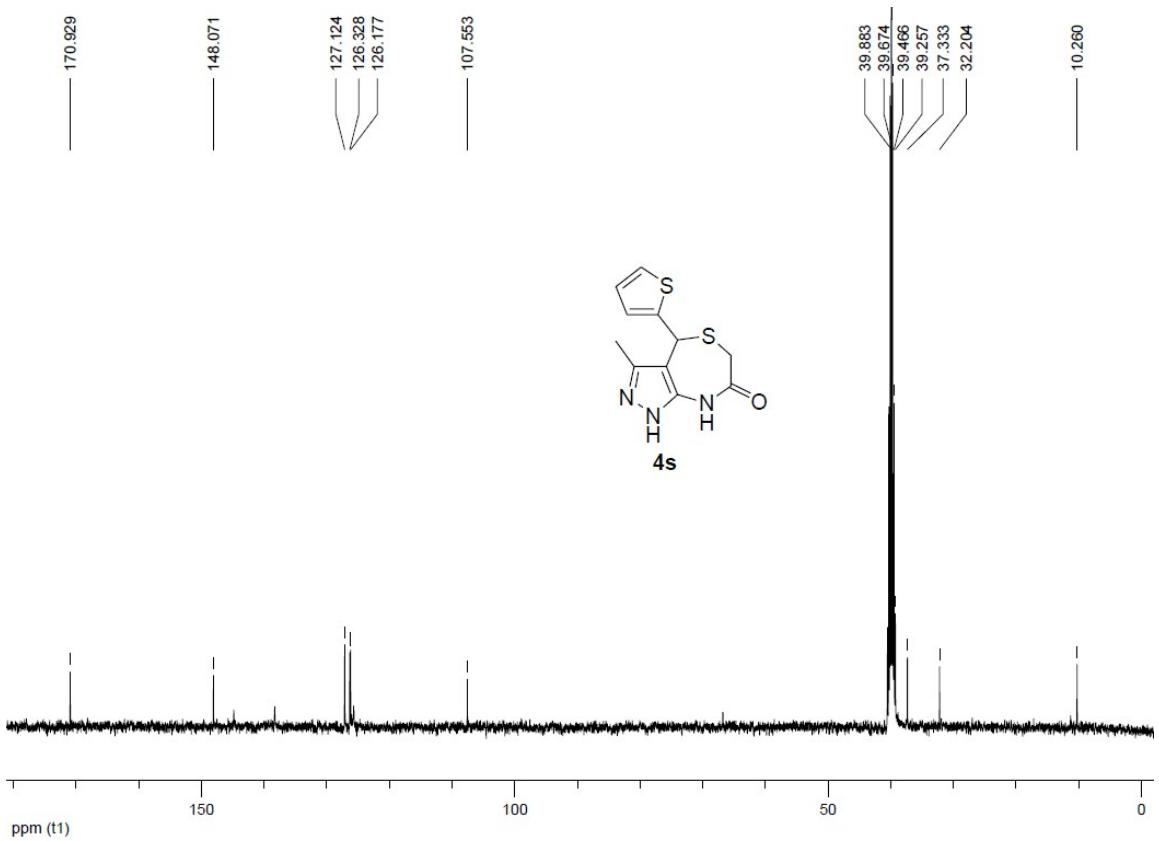
4q

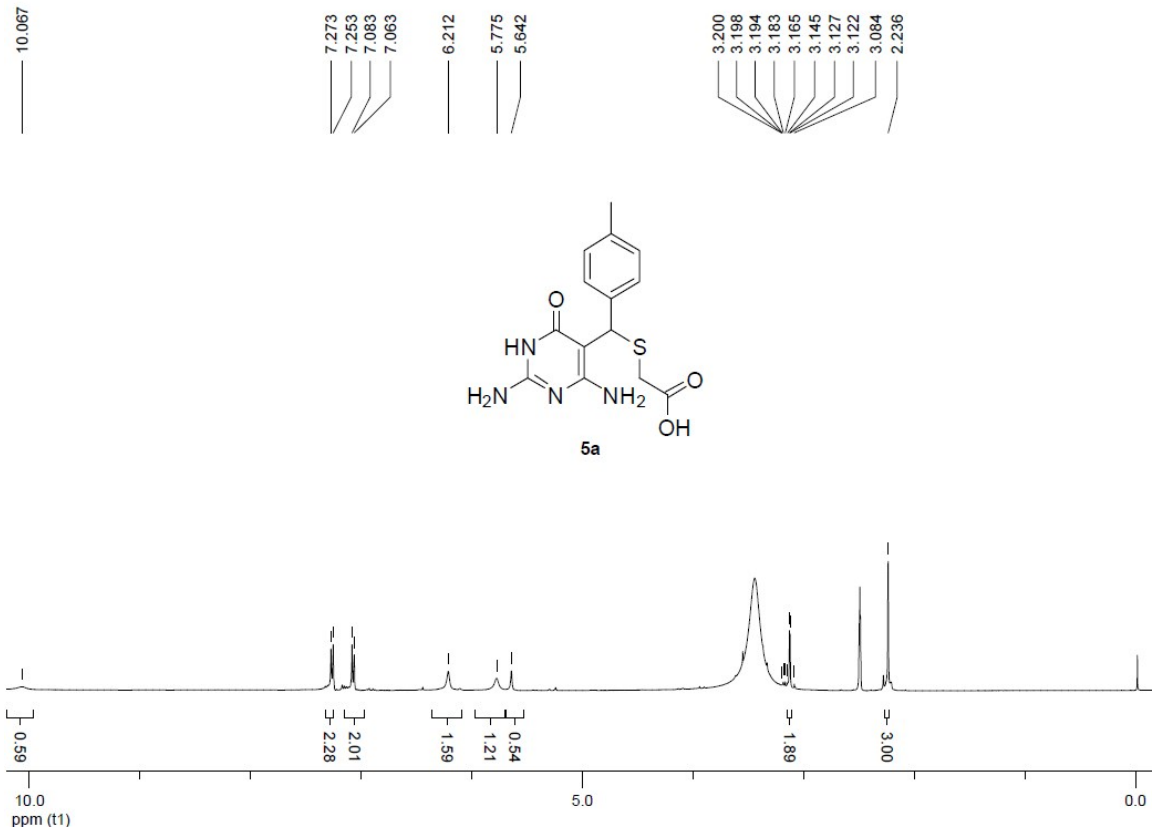

171.466
158.649
134.817
129.436
114.164
107.154
55.495
41.872
40.535
40.327
39.910
39.701
39.493
39.285
32.184
10.465
MeO
S
N
N
H
N
H
O
4q
150
100
50
0
ppm (t1)

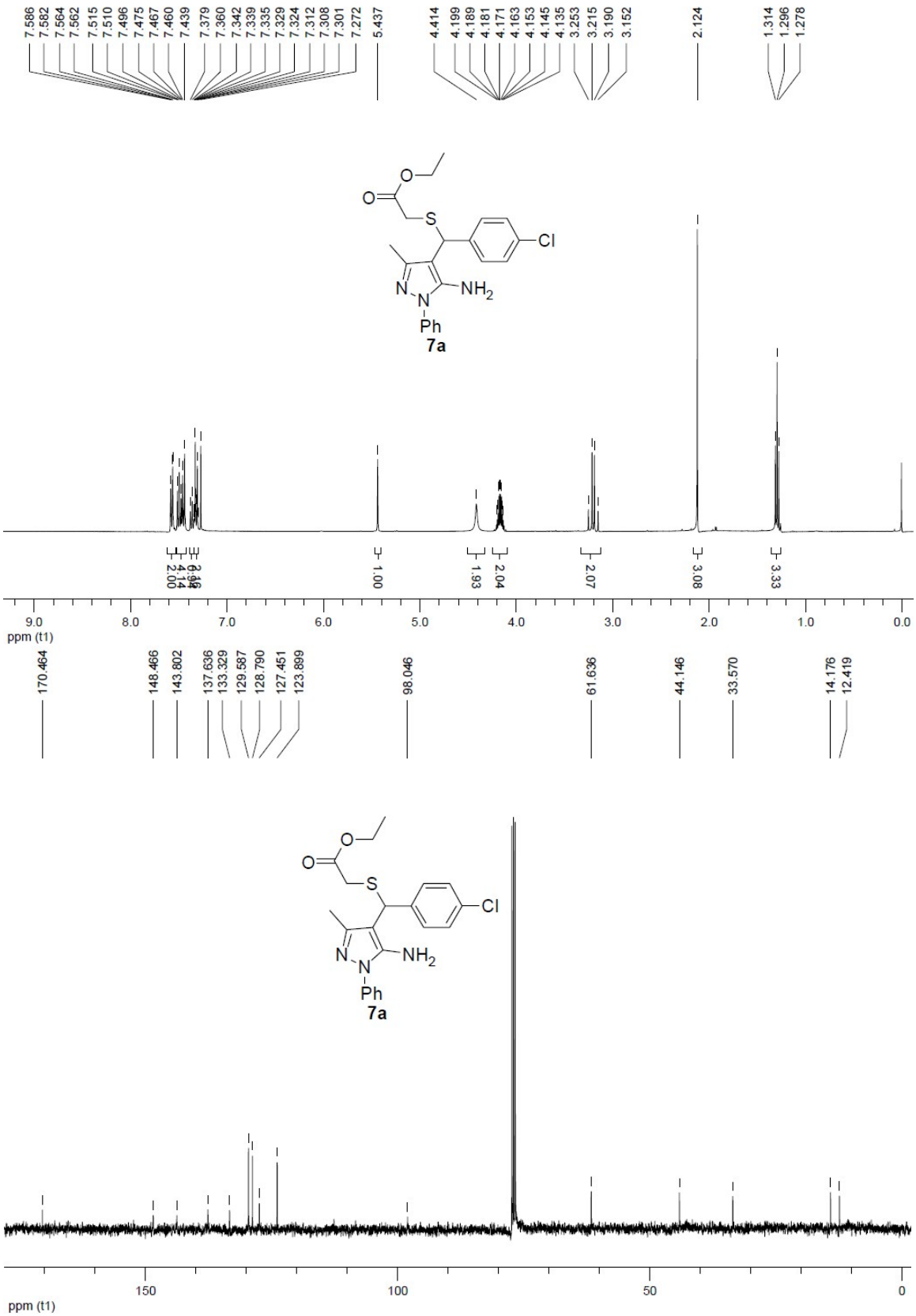

12.293
10.049
8.365
8.344
7.951
7.932
7.929
7.828
7.807
7.600
7.597
7.583
7.580
7.563
7.559
7.554
7.551
7.533
7.516
7.400
7.381
7.362
7.051
7.034
6.230
3.236
3.198
3.104
3.067
1.657
S
N
N
H
N
H
O
4r
0.81
1.00
1.02
1.17
1.16
2.19
1.11
0.93
1.02
1.23
1.23
3.15
10.0
5.0
0.0
ppm (t1)

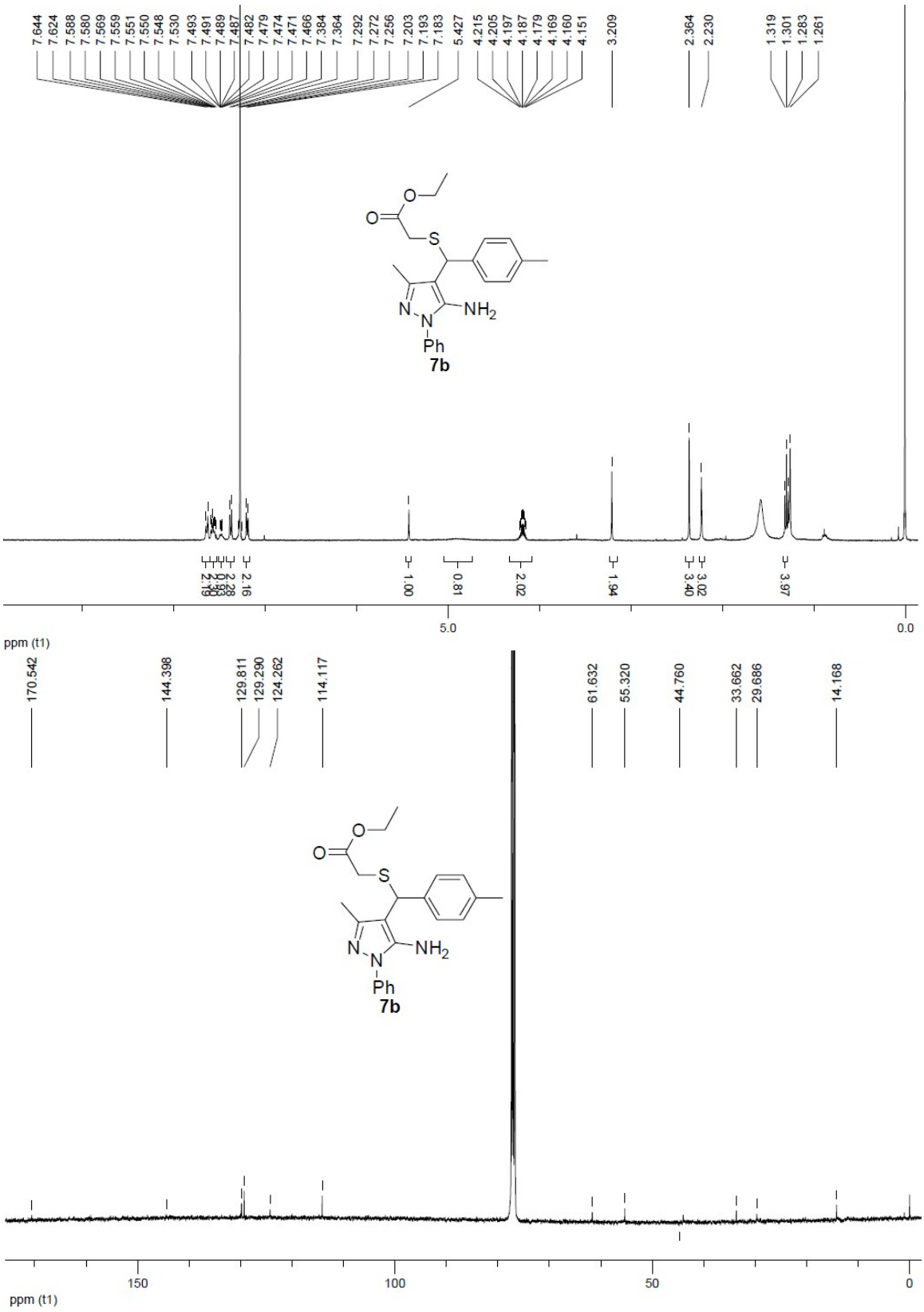

171.151
137.676
134.245
130.413
129.233
128.398
126.619
126.345
126.114
125.502
124.236
106.352
40.524
40.316
40.107
39.898
39.690
39.481
39.272
32.440
10.378
4r
150
100
50
0
ppm (t1)

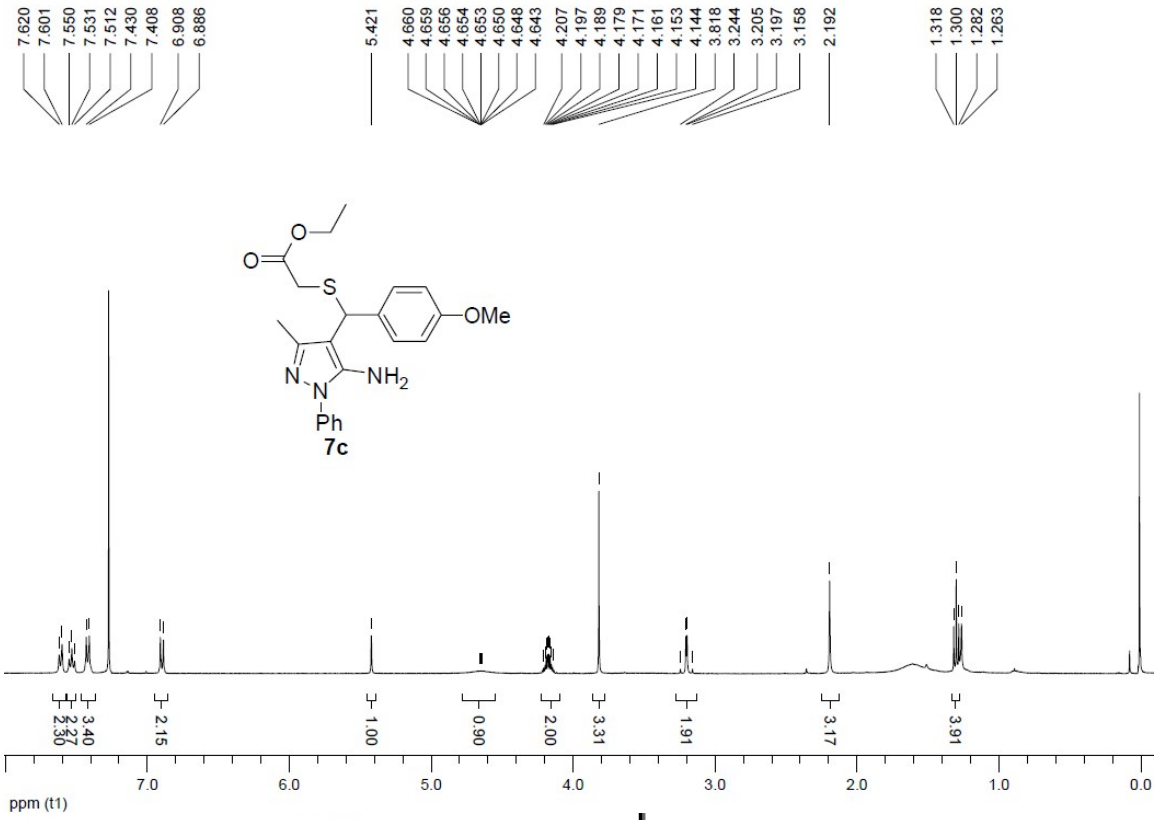

9.907
7.414
7.411
7.401
7.398
6.941
6.928
6.916
6.907
6.903
6.895
5.714
3.296
3.259
3.078
3.041
1.936
4s
0.95
1.35
2.00
0.91
0.99
1.04
3.05
10.0
5.0
0.0
ppm (t1)

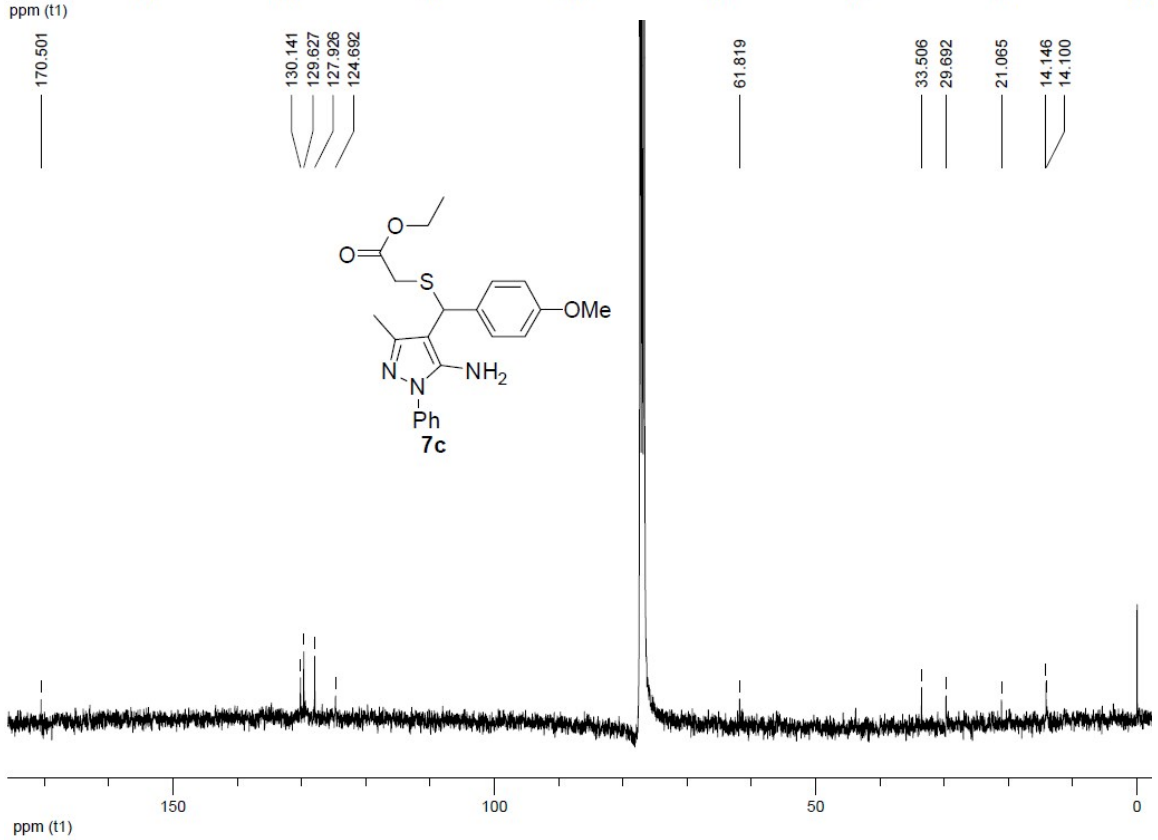

170.929
148.071
127.124
126.328
126.177
107.553
39.883
39.674
39.466
39.257
37.333
32.204
10.260
4s
150
100
50
0
ppm (t1)

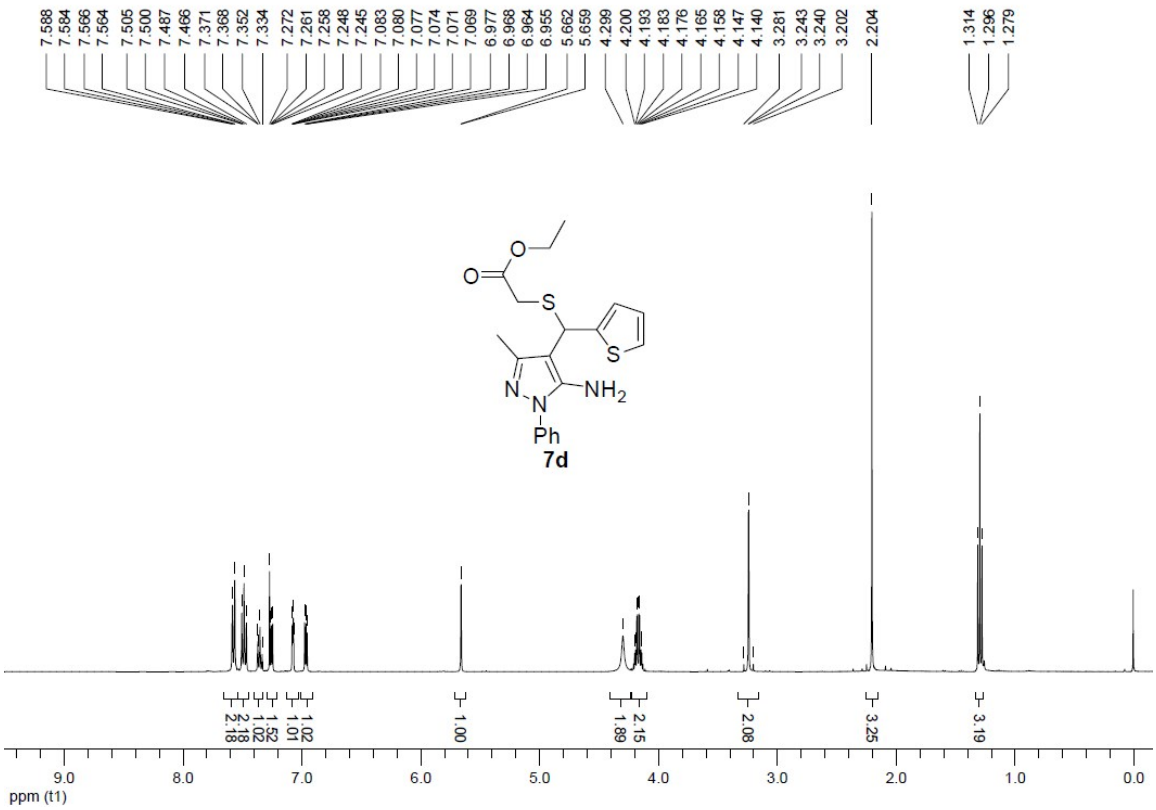

10.067
7.273
7.253
7.083
7.063
6.212
5.775
5.642
3.200
3.198
3.194
3.183
3.165
3.145
3.127
3.122
3.084
2.236
5a
0.59
2.28
2.01
1.59
1.21
0.54
1.89
3.00
10.0
5.0
0.0
ppm (t1)

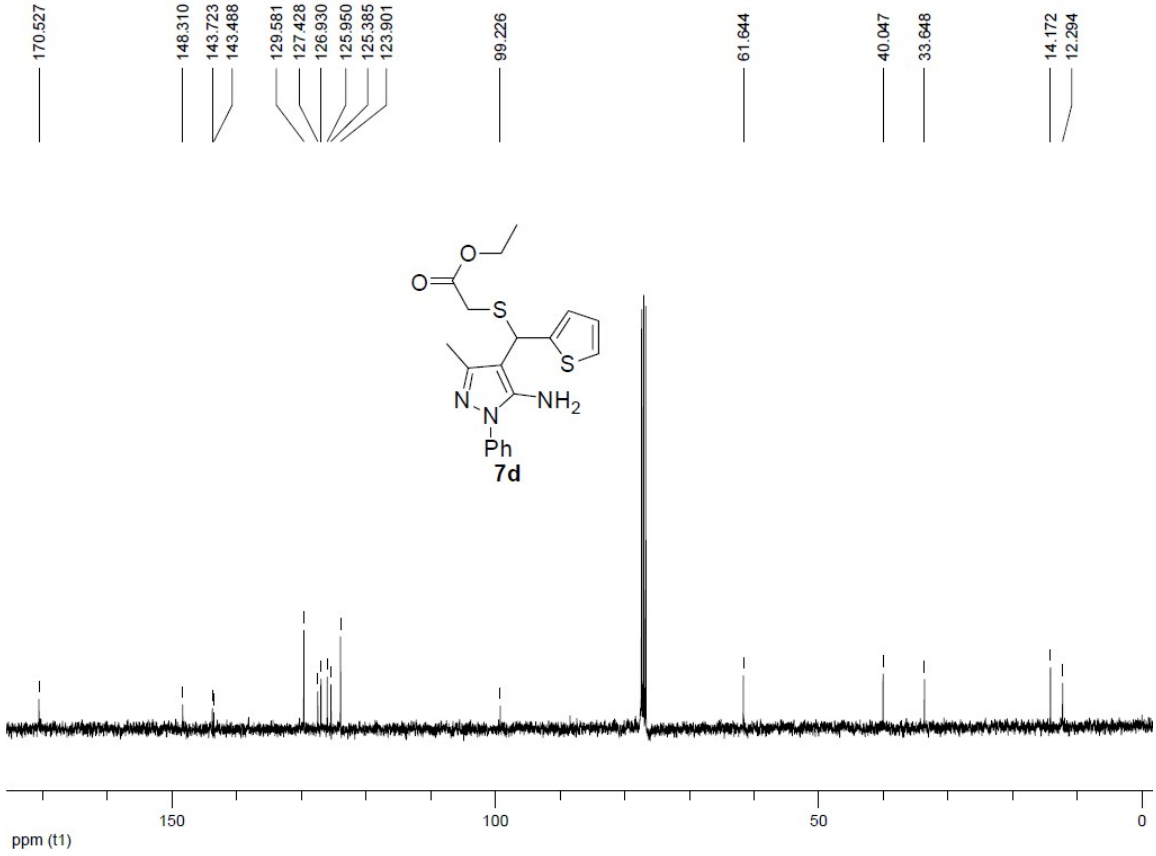

7.586
7.582
7.564
7.562
7.515
7.510
7.496
7.475
7.467
7.460
7.439
7.379
7.360
7.342
7.339
7.335
7.329
7.324
7.312
7.308
7.301
7.272
5.437
4.414
4.199
4.189
4.181
4.171
4.163
4.153
4.145
4.135
3.253
3.215
3.190
3.152
2.124
1.314
1.296
1.278
O
O
S
Cl
N
N
NH2
Ph
7a
2.00
1.00
1.93
2.04
2.07
3.08
3.33
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)
170.464
148.466
143.802
137.636
133.329
129.587
128.790
127.451
123.899
98.046
61.636
44.146
33.570
14.176
12.419
O
O
S
Cl
N
N
NH2
Ph
7a
150
100
50
0
ppm (t1)


7.644
7.624
7.588
7.580
7.569
7.559
7.551
7.550
7.548
7.530
7.493
7.491
7.489
7.487
7.482
7.479
7.474
7.471
7.466
7.384
7.364
7.292
7.272
7.256
7.203
7.193
7.183
5.427
4.215
4.205
4.197
4.187
4.179
4.169
4.160
4.151
3.209
2.364
2.230
1.319
1.301
1.283
1.261
O
O
S
N
N
NH2
Ph
7b
2.16
1.00
0.81
2.02
1.94
3.40
3.02
3.97
5.0
0.0
ppm (t1)
170.542
144.398
129.811
129.290
124.262
114.117
61.632
55.320
44.760
33.662
29.686
14.168
O
O
S
N
N
NH2
Ph
7b
150
100
50
0
ppm (t1)


7.620
7.601
7.550
7.531
7.512
7.430
7.408
6.908
6.886
5.421
4.660
4.659
4.656
4.654
4.653
4.650
4.648
4.643
4.207
4.197
4.189
4.179
4.171
4.161
4.153
4.144
3.818
3.244
3.205
3.197
3.158
2.192
1.318
1.300
1.282
1.263
O
O
S
OMe
N
N
NH2
Ph
7c
2.30
2.27
3.40
2.15
1.00
0.90
2.00
3.31
1.91
3.17
3.91
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


170.501
130.141
129.627
127.926
124.692
61.819
33.506
29.692
21.065
14.146
14.100
O
O
S
OMe
N
N
NH2
Ph
7c
150
100
50
0
ppm (t1)


7.588
7.584
7.566
7.564
7.505
7.500
7.487
7.466
7.371
7.368
7.352
7.334
7.272
7.261
7.258
7.248
7.245
7.083
7.080
7.077
7.074
7.071
7.069
6.977
6.968
6.964
6.955
5.662
5.659
4.299
4.200
4.193
4.183
4.176
4.165
4.158
4.147
4.140
3.281
3.243
3.240
3.202
2.204
1.314
1.296
1.279
O
O
S
S
N
N
NH2
Ph
7d
2.18
2.18
1.25
1.02
1.01
1.02
1.00
1.89
2.15
2.08
3.25
3.19
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


170.527
148.310
143.723
143.488
129.581
127.428
126.930
125.950
125.385
123.901
99.226
61.644
40.047
33.648
14.172
12.294
O
O
S
S
N
N
NH2
Ph
7d
150
100
50
0
ppm (t1)