Supporting Information

Microwave irradiation: A green approach for synthesis of functionalized N-methyl-1,4-dihydropyridines

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I. Single-crystal X-ray crystallographic structure of compound 3n:

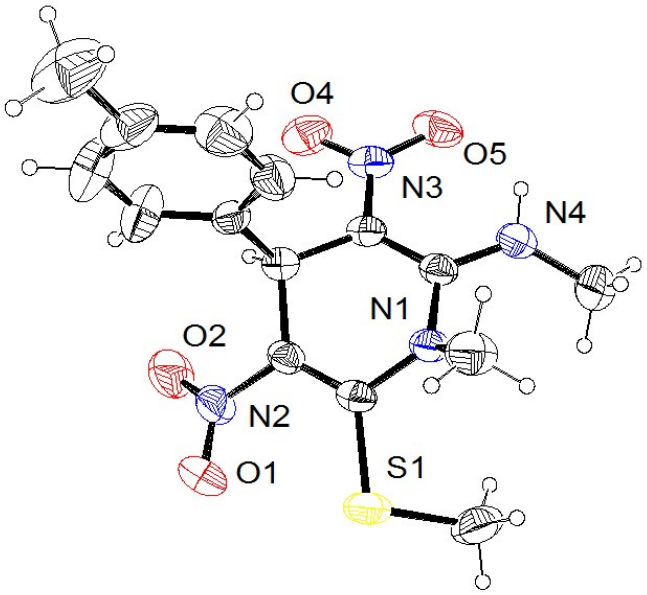


Fig. S1 Crystal structure of compound **3n** (CCDC 1841358)

Table S1. Crystal data for **3n** (CCDC 1841358)

Empirical formula	$C_{15}H_{18}N_4O_4S$
Formula weight	350.40
Wavelength	0.71073 Å
Temperature	293 K
Crystal system, space group	Triclinic, P-1
Unit cell dimension	a = 7.3596(3) alpha = 104.253(4) deg. b = 9.2464(6) beta = 90.749(3) deg. c = 14.1726 (5) gamma = 111.461 deg.
Volume	864.24(8) $Å^3$
Z, Calculated density	2, 1.3464 g/cm^3
Absorption coefficient	0.214 mm^{-1}
F (000)	368.4235
Absorption correction	multi-scan
Reflection collected	3695
Theta range for data collection	27.2190 to 3.5210 deg.
Goodness-of-fit on F^2	1.0504

II. ^{1}H and ^{13} NMR peak assignment of compound 3n

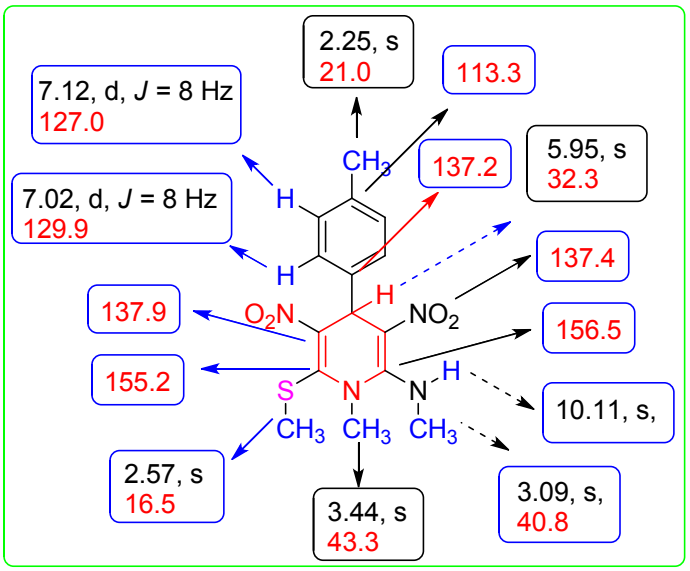


Fig. S2. Characteristic ^{1}H and ^{13}C NMR peak assignment of compound **3n**

III. Materials used for green metrics calculations

A. Formula used for calculations:

The following formulae were used for evaluating green chemistry metrics such as atom economy (AE), carbon efficiency (CE), reaction mass efficiency (RME), overall efficiency (OE), process mass intensity (PMI) solvent intensity (SI) and E-factor.[1,2]

1. % Atom Economy (AE) *= (Mol Wt. of desired product/ Mol Wt. of all reactants) × 100*

2. % Carbon Efficiency (CE) *= (Amount of carbon in the product)/ Total carbon present in reactant) × 100*

3. % Reaction Mass Efficiency (RME) *= (Mass of isolated product)/ Total mass of reactants) × 100*

4. % Overall Efficiency (OE) *= (RME/AE) × 100*

5. % Process Mass Intensity (PMI) *= (Total mass of input materials in a process)/ Mass of product) × 100*

6. ***Solvent Intensity (SI)*** *= (Total mass of input solvents in a process)/ Mass of product)*

7. ***E-Factor*** *= PMI-1*

B. Details of reactants and products used for metric calculations:

a) Reactants: NMSM, Molecular Weight = 148.18 g/mol, weight used = 0.148g;

Weight of different aromatic aldehydes: Benzaldehyde = 0.106g, 4-Cholorobenzaldehyde = 0.140g, 3-Cholorobenzaldehyde = 0.140g, 4-Nitrobenzaldehyde = 0.151g, 3-

Nitrobenzaldehyde = 0.151g, 2-Nitrobenzaldehyde = 0.151g, 4-Bromobenzaldehyde = 0.185g, 3-Bromobenzaldehyde = 0.185g, 4-Fluorobenzaldehyde = 0.124, 4-Methoxybenzaldehyde = 0.136g, 3-Methoxybenzaldehyde = 0.136g, 3,4-Dimethoxybenzaldehyde = 0.166g, 3,4,5-Trimethoxybenzaldehyde = 0.196g, 4-Methylbenzaldehyde = 0.120g, 4-Ethylbenzaldehyde = 0.134g, pyridine-3-carbaldehyde = 0.107g, Thiophene-2-carbaldehyde = 0.112g, Indole-3-carbaldehyde = 0.145, 2-naphthaldehyde = 0.156g.

b). Products:

Compounds	**3a**	**3b**	**3c**	**3d**	**3e**	**3f**	**3g**
Molecular Formula	$C_{14}H_{16}N_4O_4S$	$C_{14}H_{15}N_5O_6S$	$C_{14}H_{15}N_5O_6S$	$C_{14}H_{15}N_5O_6S$	$C_{14}H_{15}ClN_4O_4S$	$C_{14}H_{15}ClN_4O_4S$	$C_{14}H_{15}BrN_4O_4S$
Molecular Weight (g/mol)	336.36	381.36	381.36	381.36	370.81	370.81	415.26
Weight (g)	0.317	0.325	0.329	0.325	0.323	0.316	0.358
Yield (%)	94	85	86	85	87	85	86

Compounds	**3h**	**3i**	**3j**	**3k**	**3l**	**3m**	**3n**
Molecular Formula	$C_{14}H_{15}BrN_4O_4S$	$C_{14}H_1FN_4O_4S$	$C_{15}H_{18}N_4O_5S$	$C_{15}H_{18}N_4O_5S$	$C_{16}H_{20}N_4O_6S$	$C_{17}H_{22}N_4O_7S$	$C_{15}H_{18}N_4O_4S$
Molecular Weight (g/mol)	415.26	354.35	366.39	366.39	396.41	426.44	350.39
Weight (g)	0.366	0.319	0.338	0.323	0.357	0.393	0.330
%Yield	88	90	92	88	90	92	94

Compounds	**3o**	**3p**	**3q**	**3r**	**3s**
Molecular Formula	$C_{16}H_{20}N_4O_4S$	$C_{12}H_{14}N_4O_4S_2$	$C_{15}H_{18}N_4O_5S$	$C_{15}H_{18}N_4O_5S$	$C_{16}H_{20}N_4O_6S$
Molecular Weight (g/mol)	364.41	342.39	337.35	375.40	386.42
Weight (g)	0.336	0.295	0.270	0.323	0.341
%Yield	92	86	80	86	88

IV. Green metrics calculation:

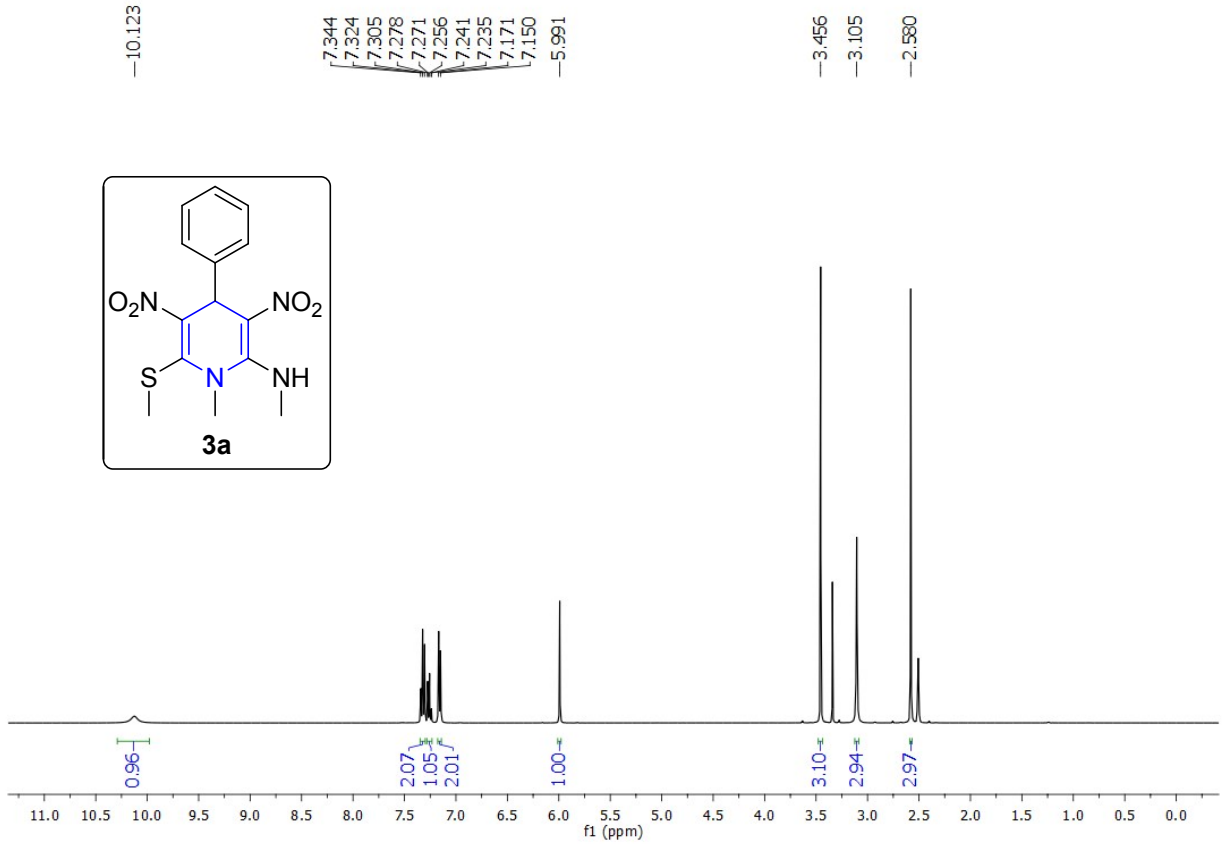
Table S2. Summary of green metrics calculations of the synthesized compounds (**3a-s**)

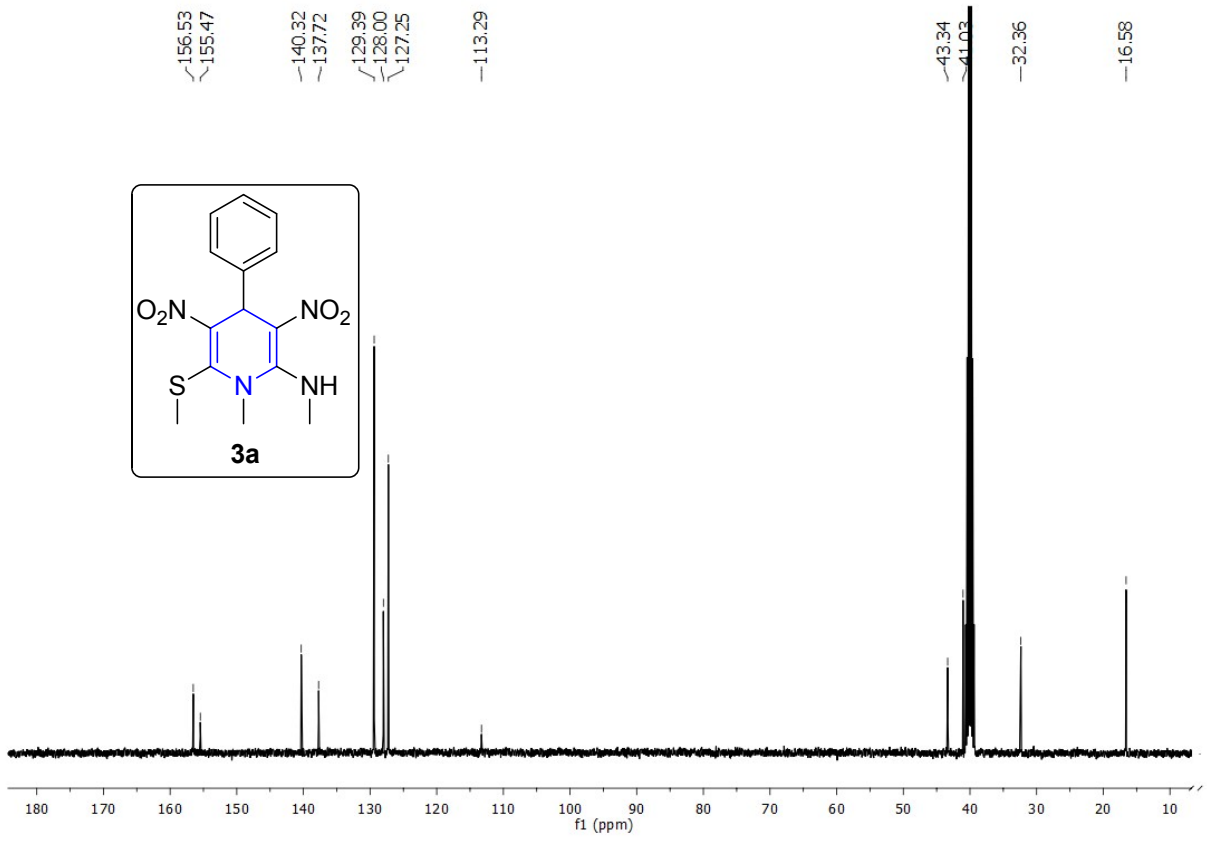
Entry	%Yield[a]	%AE[a]	%CE[a]	%RME[a]	%OE[a]	PMI[b]	SI[b]	E-Factor[b]
3a	94	83.59	93.33	78.78	94.24	5.00	3.73	4.00
3b	85	85.24	93.33	72.65	85.23	5.01	3.64	4.01
3c	86	85.24	93.33	73.54	86.27	4.95	3.59	3.95
3d	85	85.24	93.33	72.65	85.23	5.01	3.64	4.01
3e	87	84.97	93.33	74.02	87.11	5.01	3.66	4.01
3f	85	84.97	93.33	72.41	85.21	5.12	3.74	4.12
3g	86	86.26	93.33	74.37	86.21	4.65	3.30	3.65
3h	88	86.26	93.33	76.03	88.14	4.54	3.23	3.54
3i	90	84.29	93.33	75.88	90.02	5.02	3.71	4.02
3j	92	84.74	93.75	78.17	92.24	4.78	3.50	3.78
3k	88	84.74	93.75	74.70	88.15	5.00	3.66	4.00
3l	90	85.73	94.11	77.21	90.06	4.61	3.31	3.61
3m	92	86.61	94.44	79.82	92.16	4.26	3.01	3.26
3n	94	84.15	93.75	79.25	94.17	4.84	3.58	3.84
3o	92	84.67	94.11	78.07	92.20	4.80	3.52	3.80
3p	86	83.84	92.30	72.24	86.16	5.39	4.01	4.39
3q	80	83.63	92.85	66.93	80.03	5.87	4.38	4.87
3r	86	85.05	94.11	73.18	86.04	5.03	3.66	4.03
3s	88	85.42	94.73	75.38	88.24	4.79	3.47	3.79

Considerations:
1. *a* = values are close to 100 for these green metrics (Ideal values = 100) and *b* = values are close to 1for these green metrics (Ideal values = 1).
2. Calculations up to the crude product in all cases.

V. Copy of ^{1}H and ^{13}C NMR spectra:

Compound 3a:





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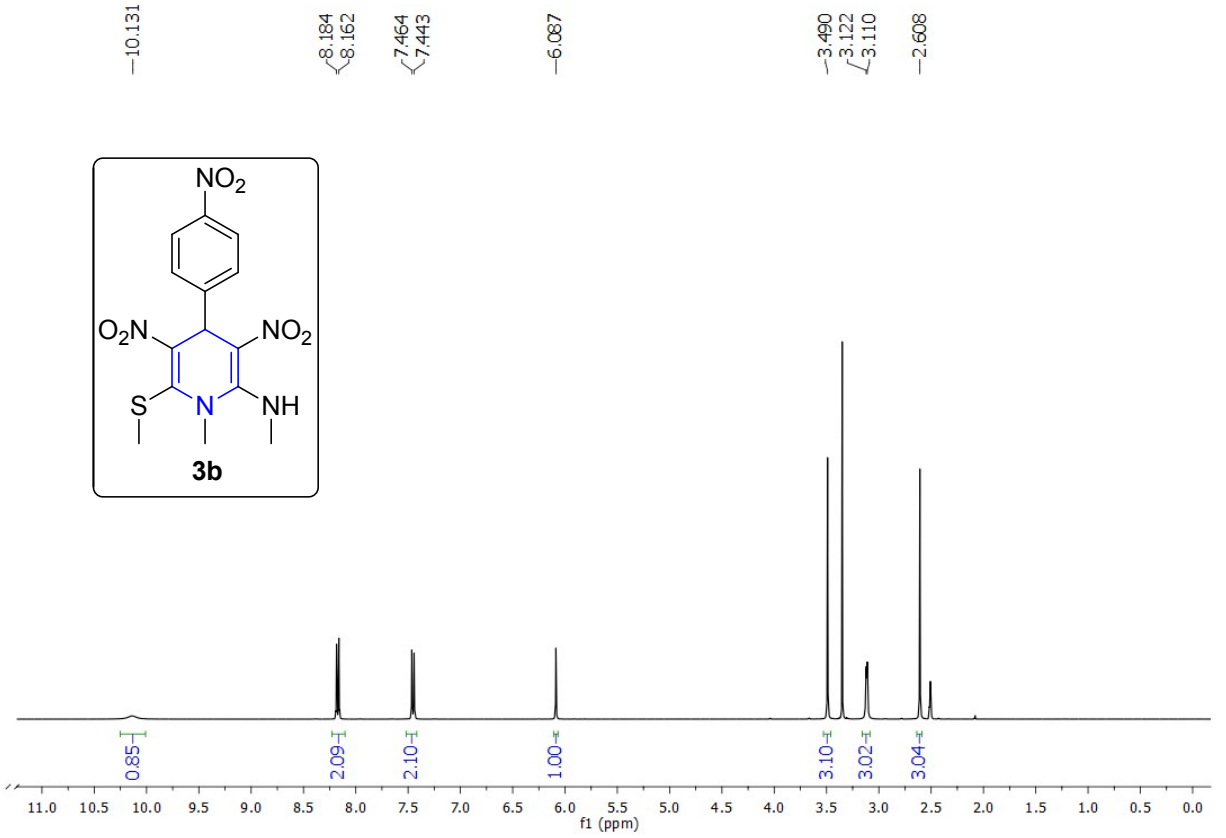
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6.087
3.490
3.122
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O2N
NO2
S
N
NH
3b
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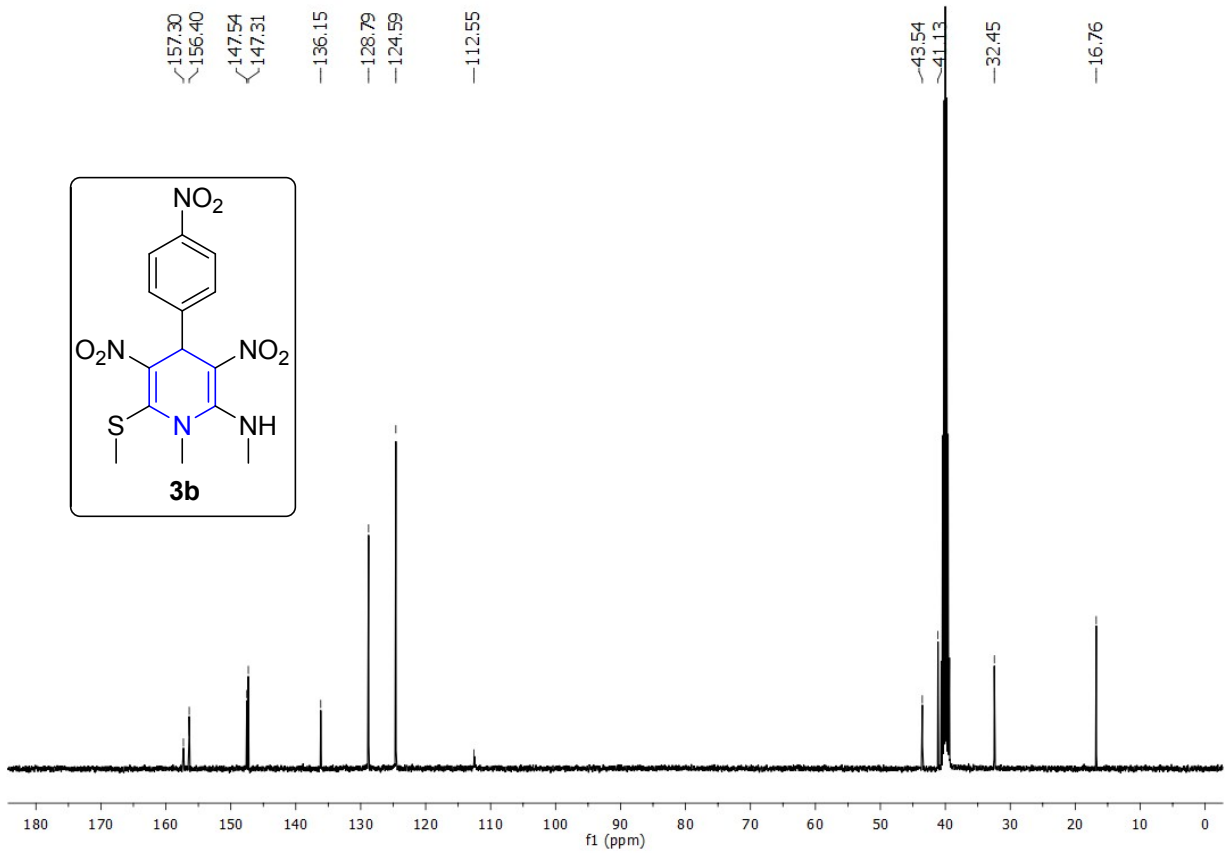
2.10
1.00
3.10
3.02
3.04
f1 (ppm)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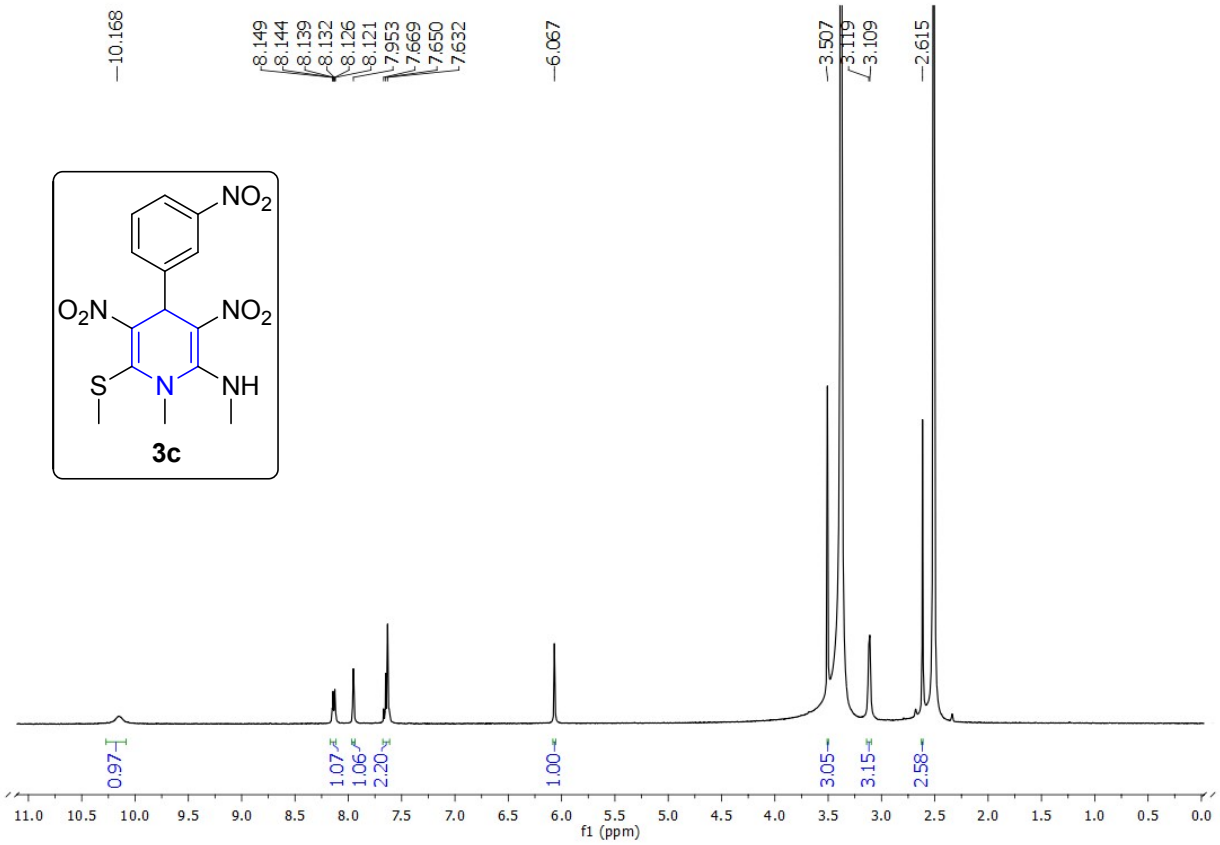
NO2
S
N
NH
3b
f1 (ppm)

Compound 3c: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8.139
8.132
8.126
8.121
7.953
7.669
7.650
7.632
6.067
3.507
3.119
3.109
2.615
NO2
O2N
NO2
S
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3c
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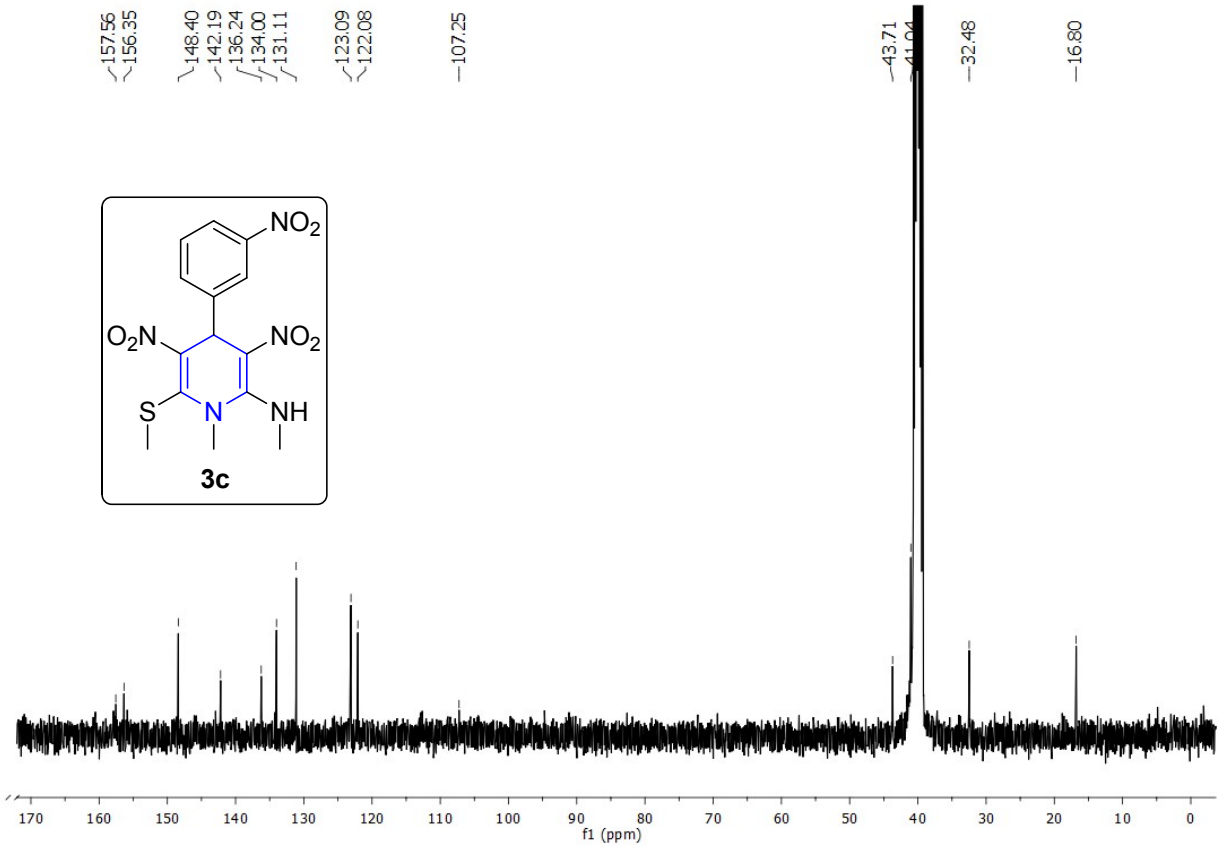
1.06
2.20
1.00
3.05
3.15
2.58
f1 (ppm)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123.09
122.08
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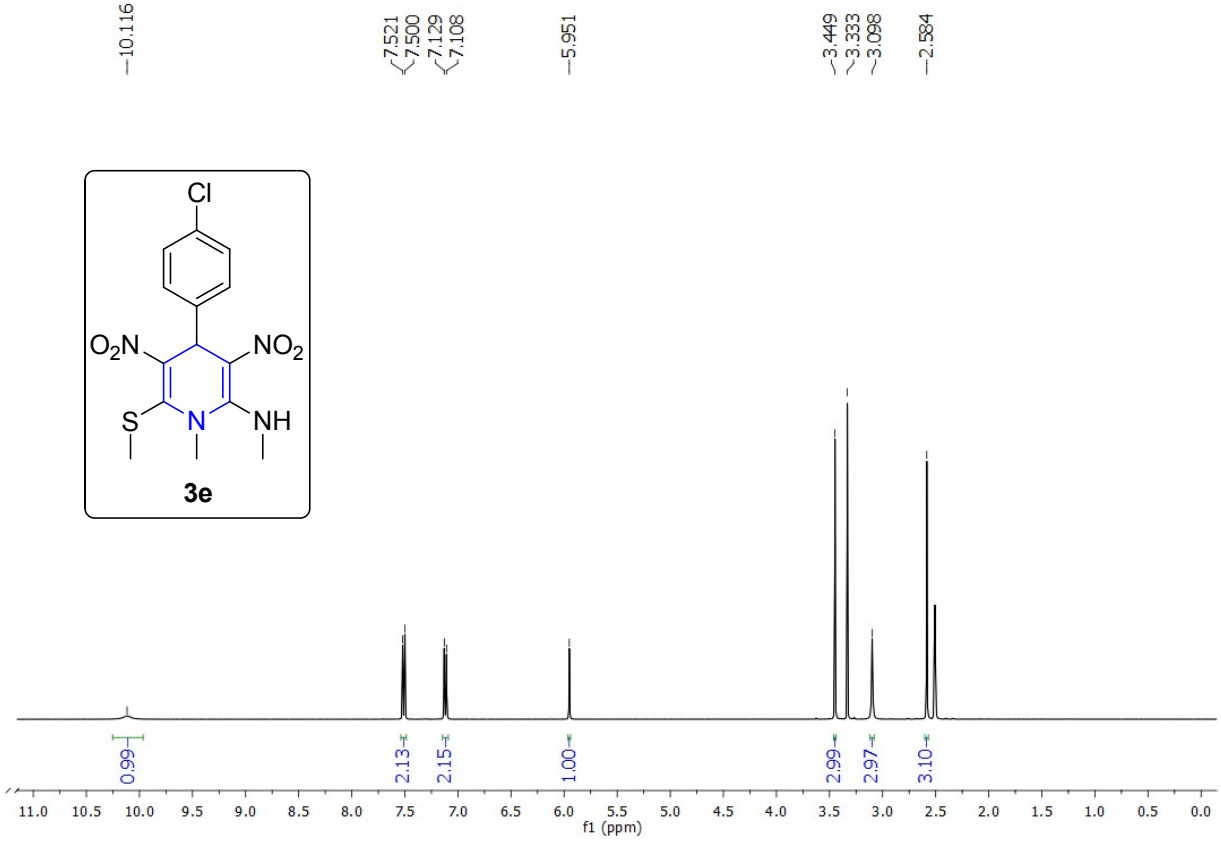
NO2
S
N
NH
3c
f1 (ppm)

Compound 3e: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3.449
3.333
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2.584
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S
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NH
3e
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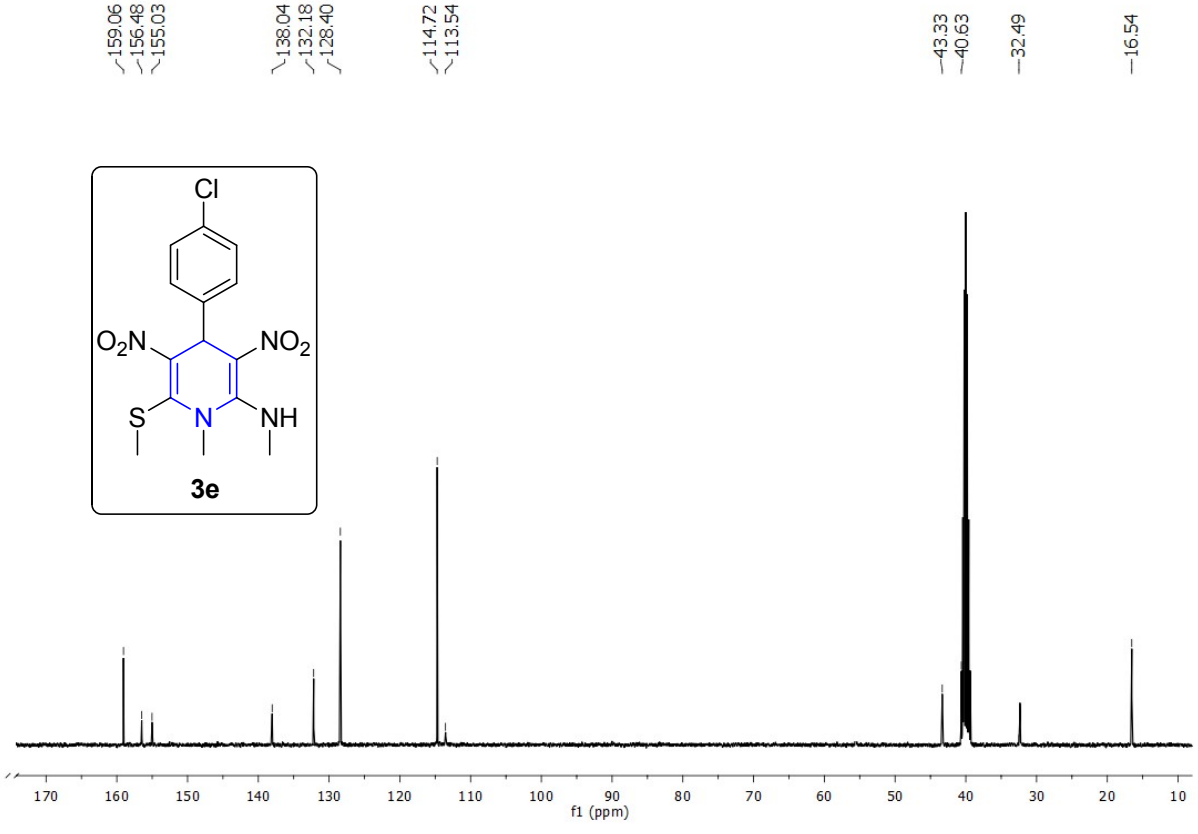
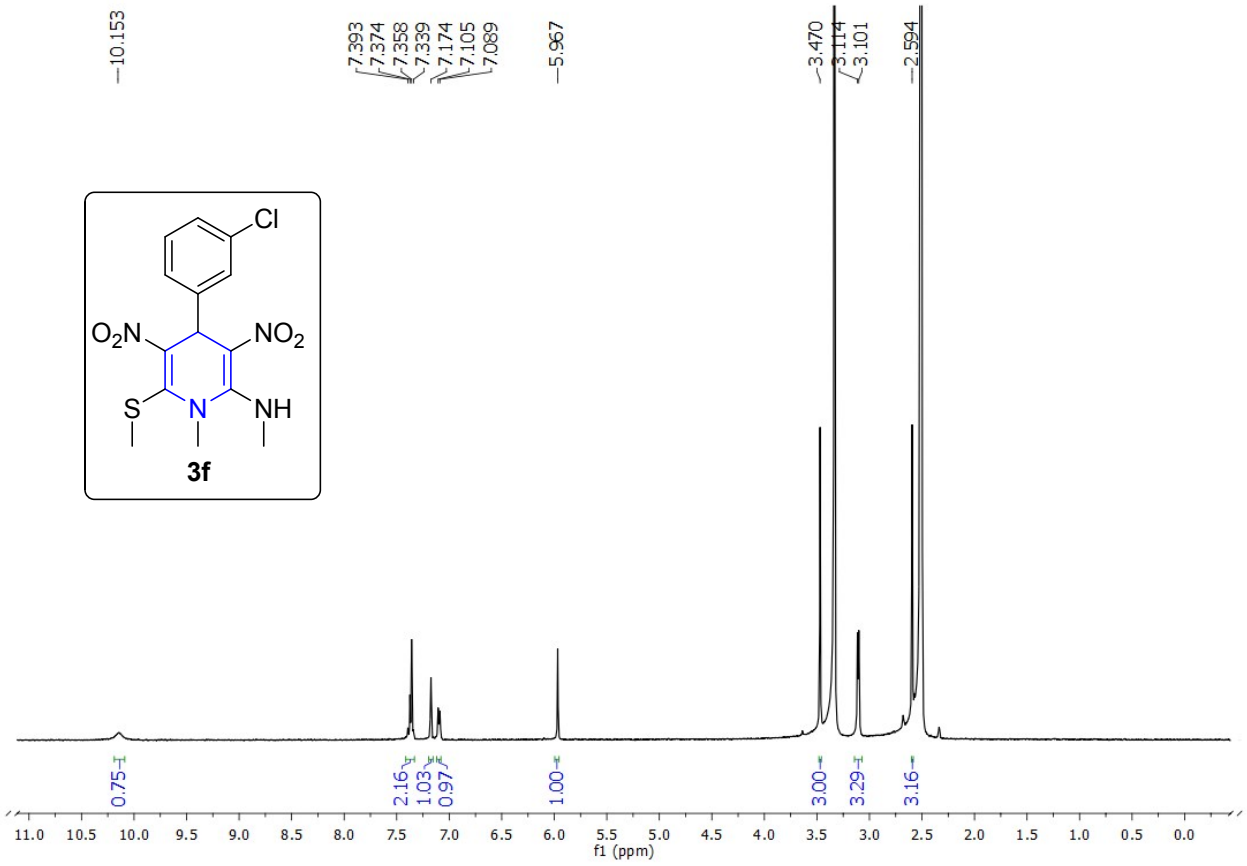
1.00
2.99
2.97
3.10
f1 (ppm)


159.06
156.48
155.03
138.04
132.18
128.40
114.72
113.54
43.33
40.63
32.49
16.54
Cl
O2N
NO2
S
N
NH
3e
f1 (ppm)

Compound 3f: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7.339
7.174
7.105
7.089
5.967
3.470
3.114
3.101
2.594
Cl
O2N
NO2
S
N
NH
3f
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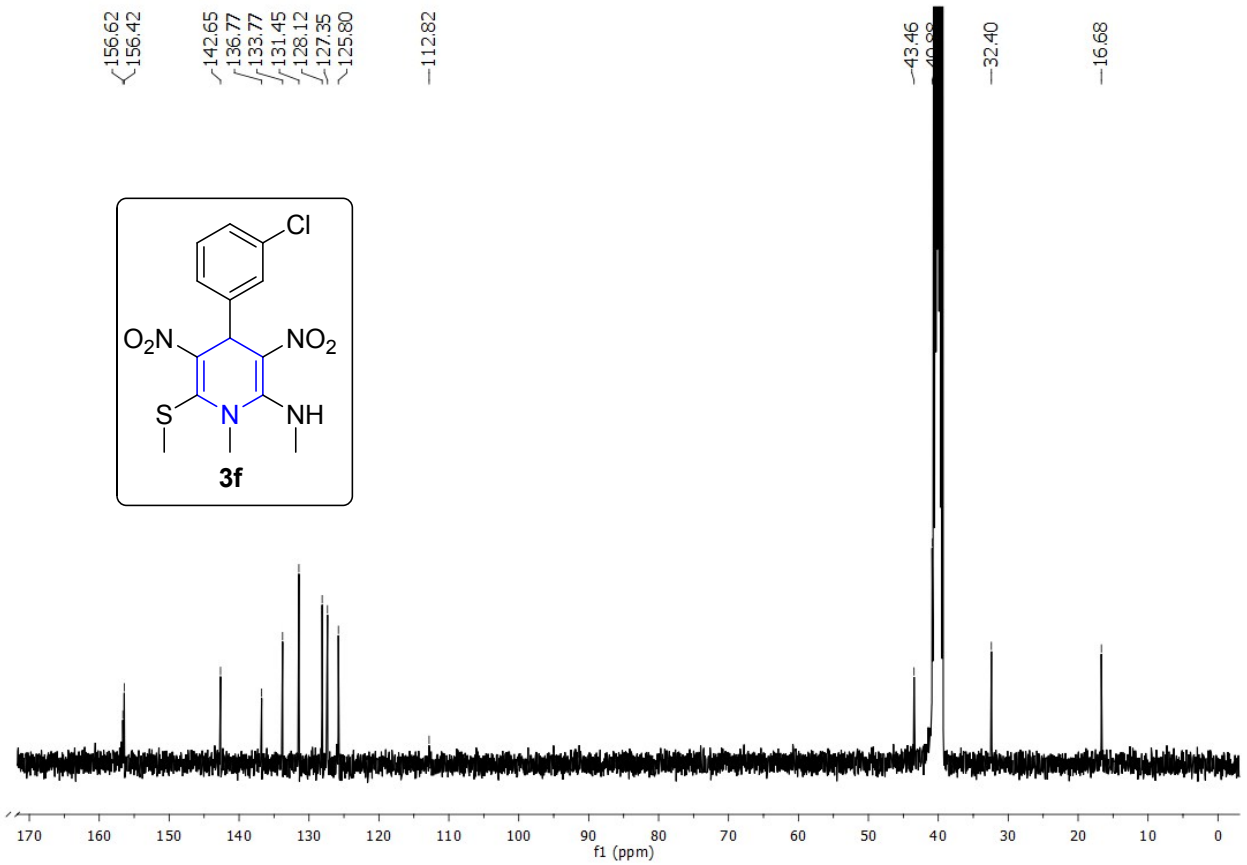
1.00
3.00
3.29
3.16
f1 (ppm)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127.35
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16.68
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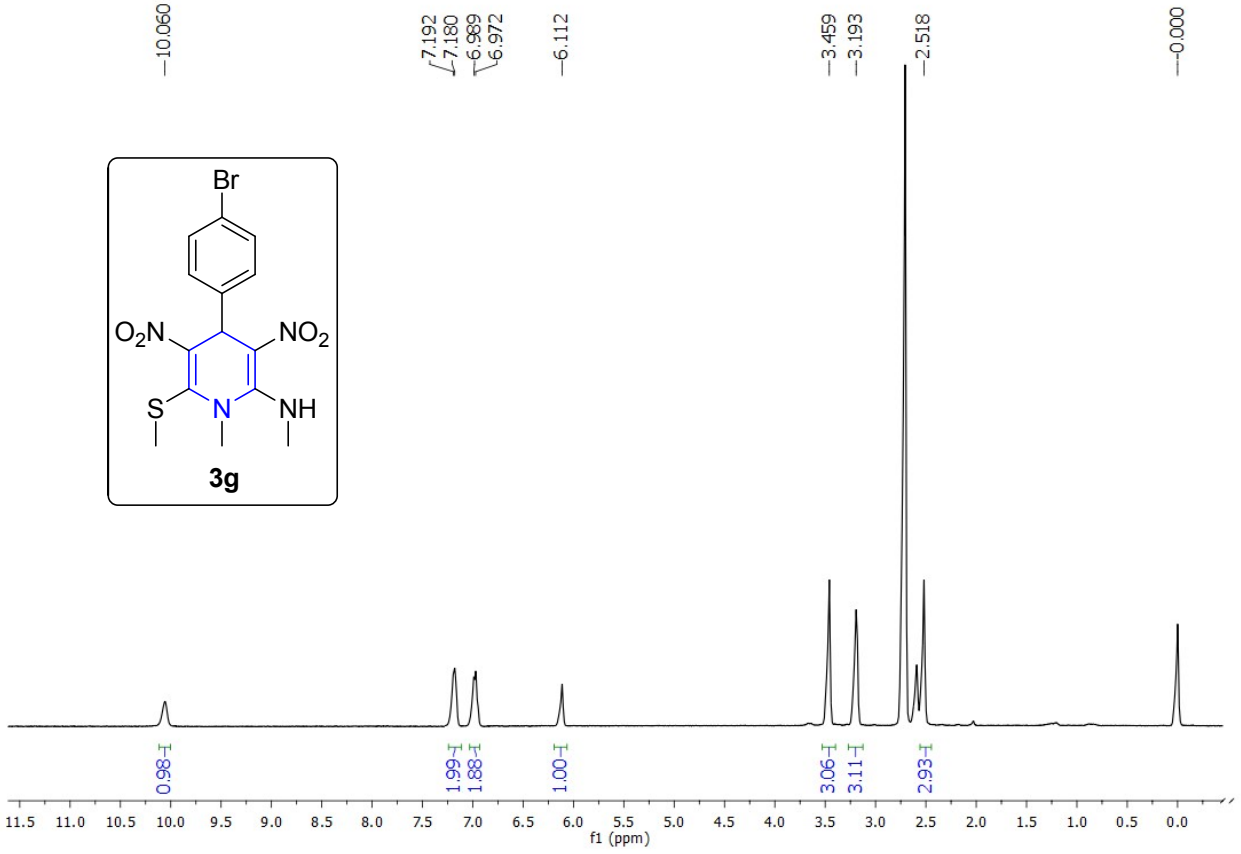
NO2
S
N
NH
3f
f1 (ppm)

Compound 3g: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S
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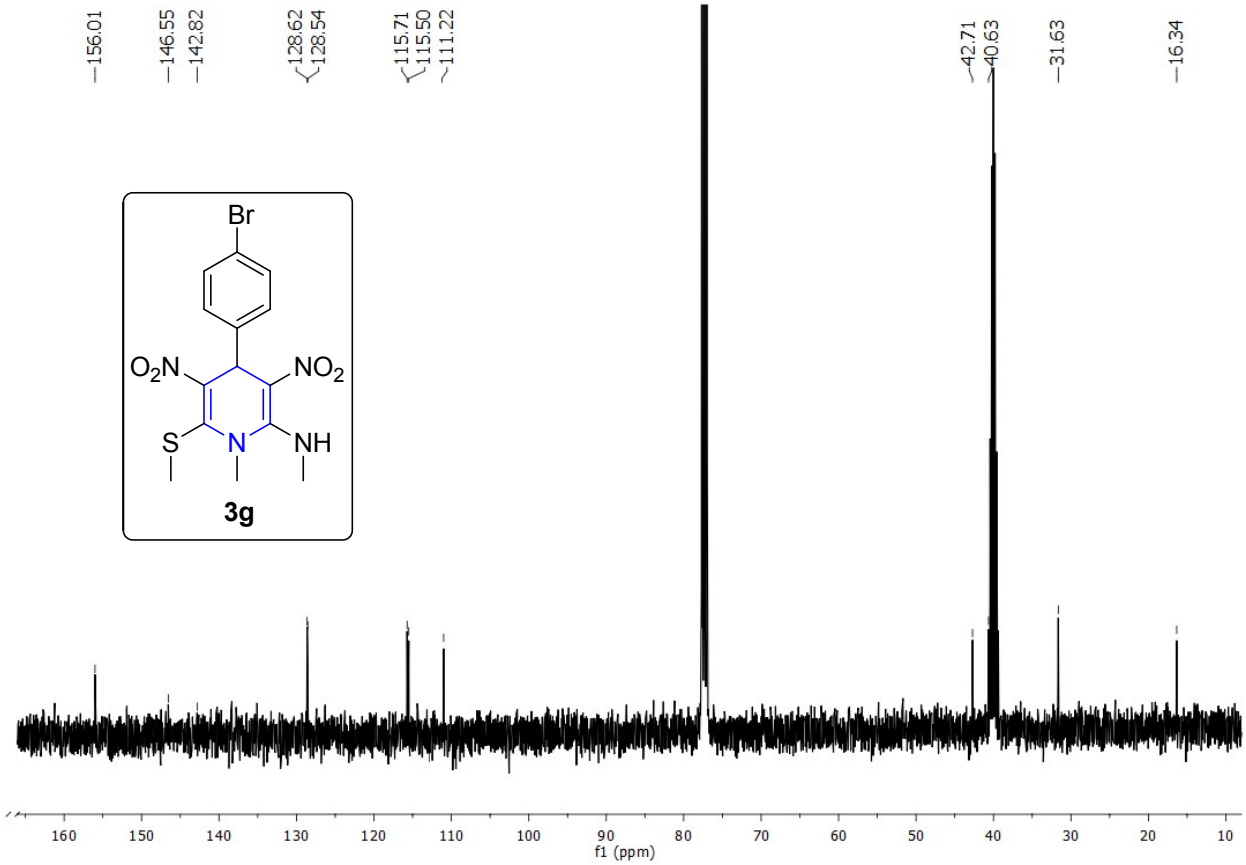
f1 (ppm)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111.22
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Br
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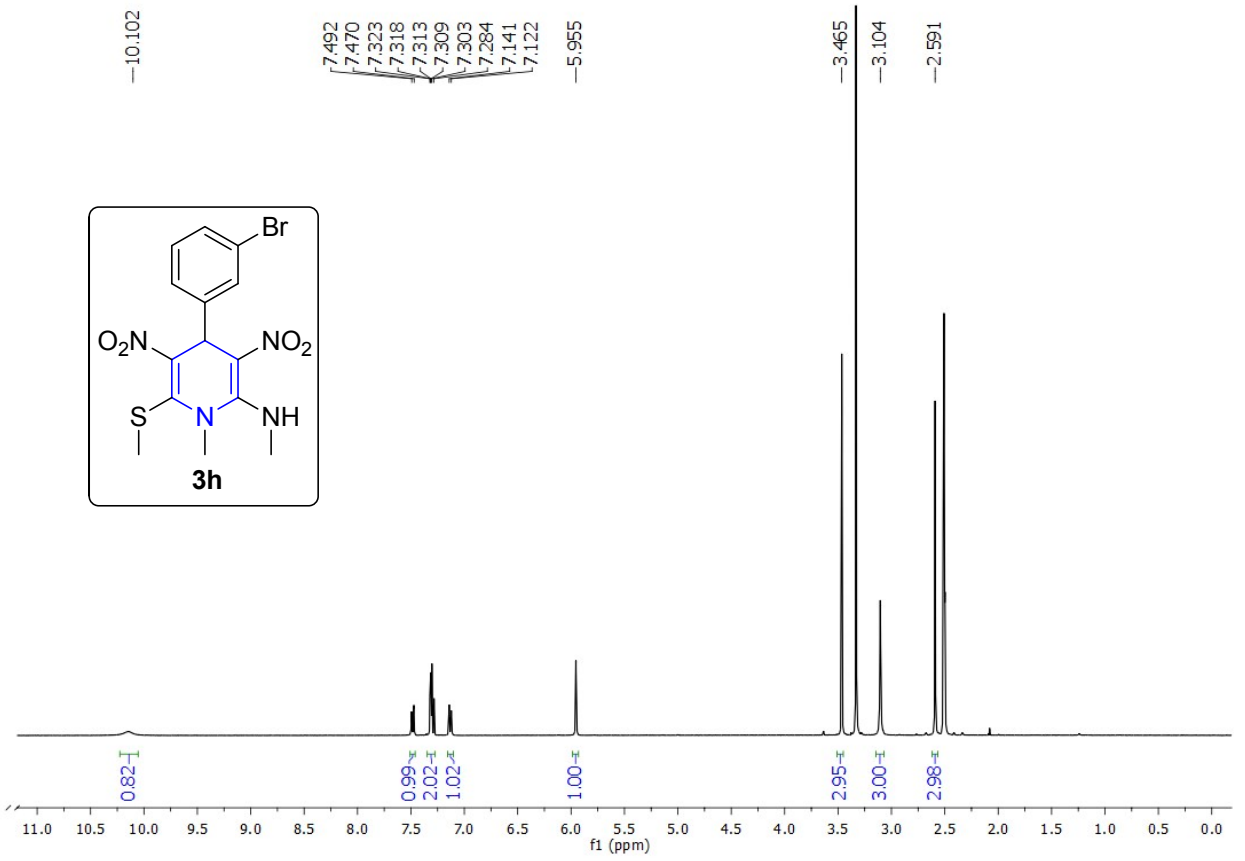
NO2
S
N
NH
3g
f1 (ppm)

Compound 3h: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3.465
3.104
2.591
Br
O2N
NO2
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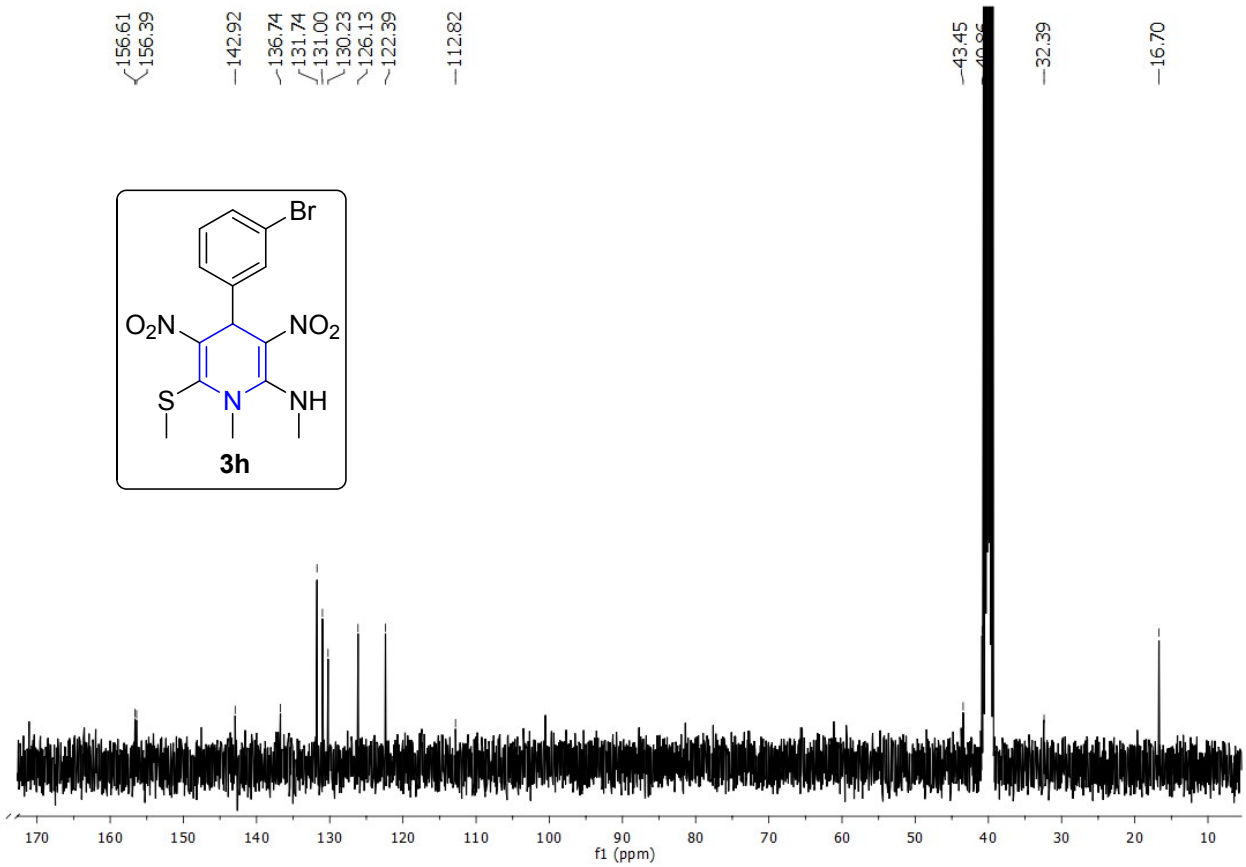
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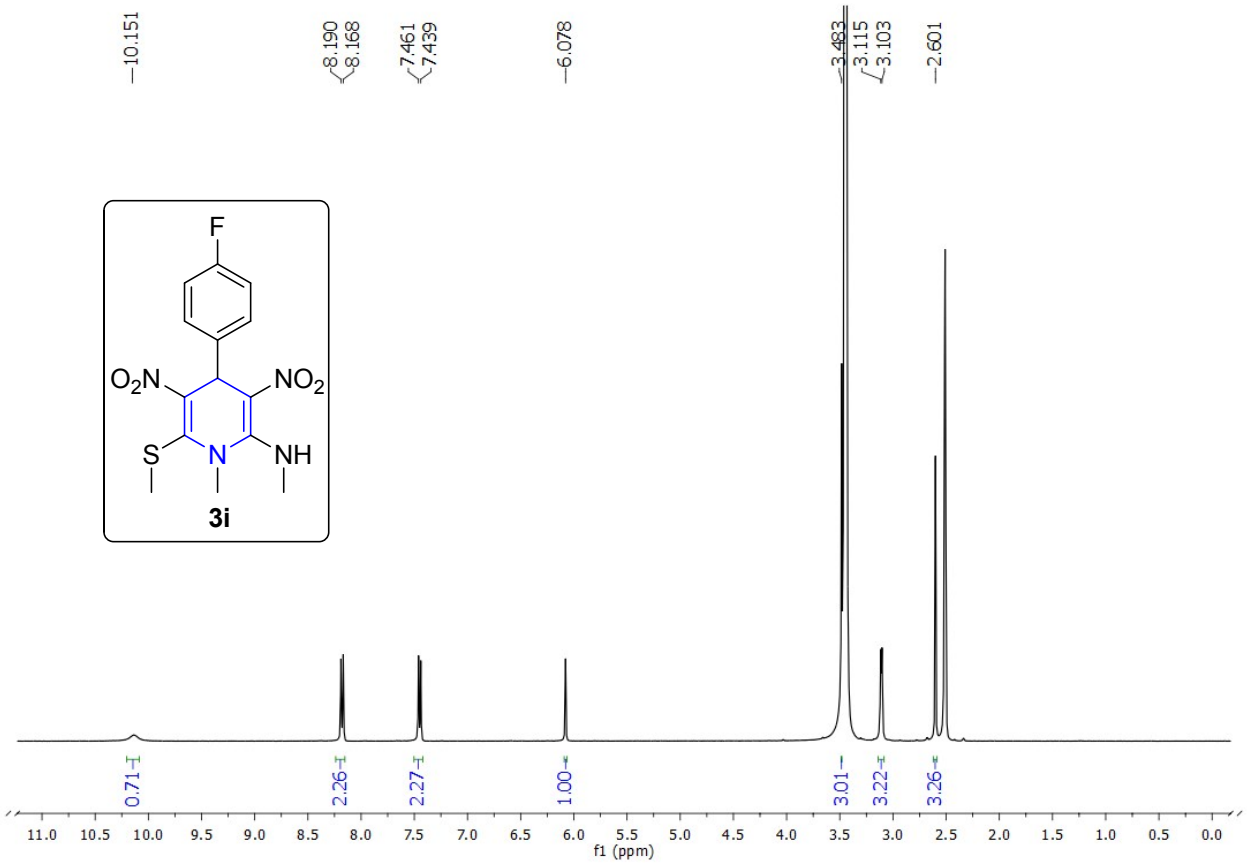
NH
3h
f1 (ppm)

Compound 3i: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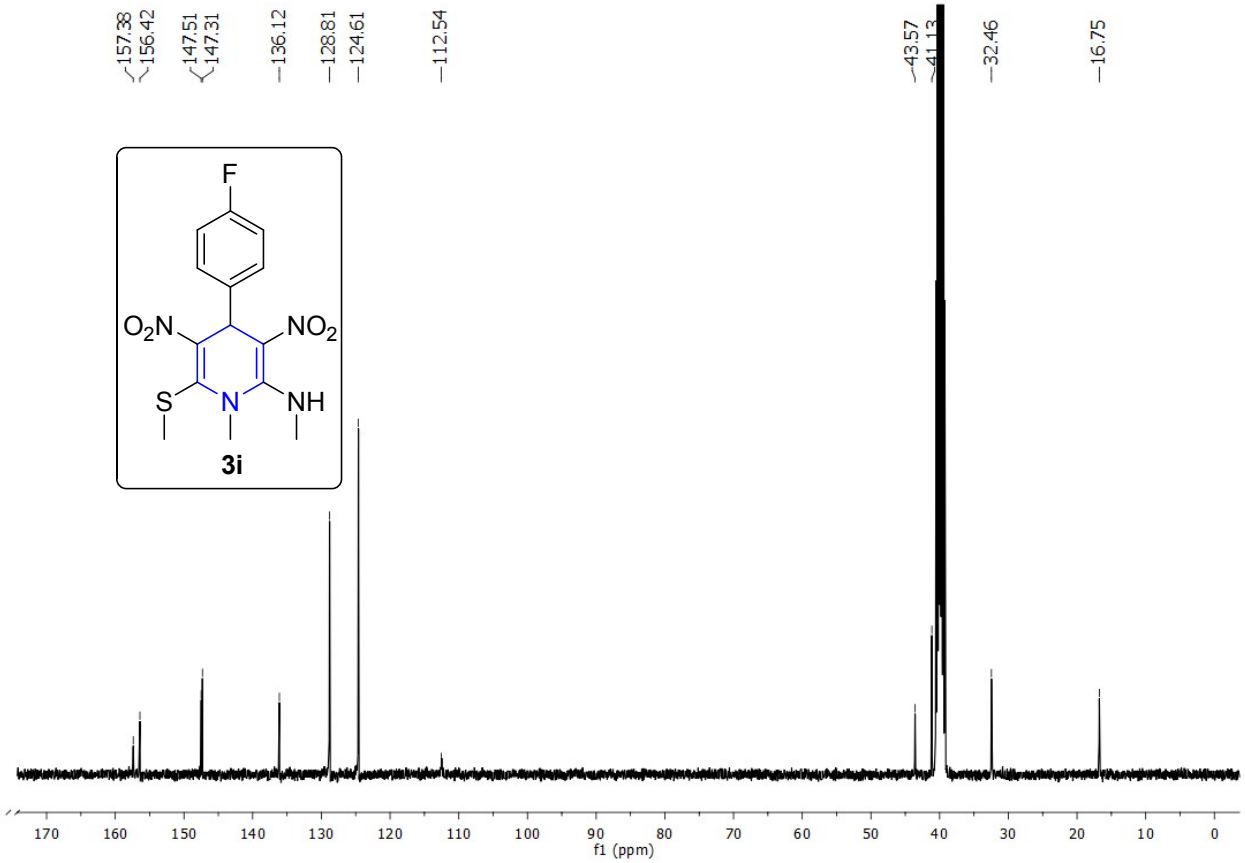
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S
N
NH
3i
f1 (ppm)

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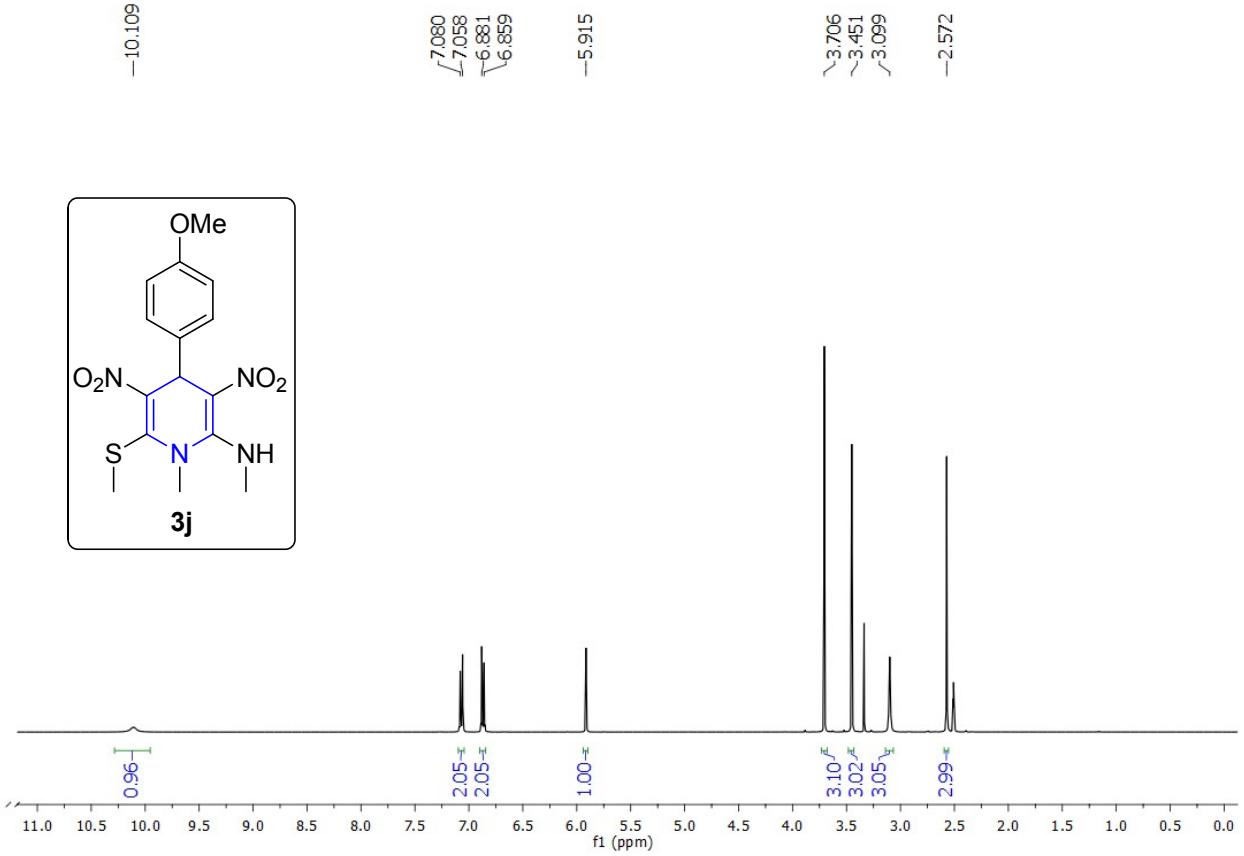
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2.572
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NO2
S
N
NH
3j
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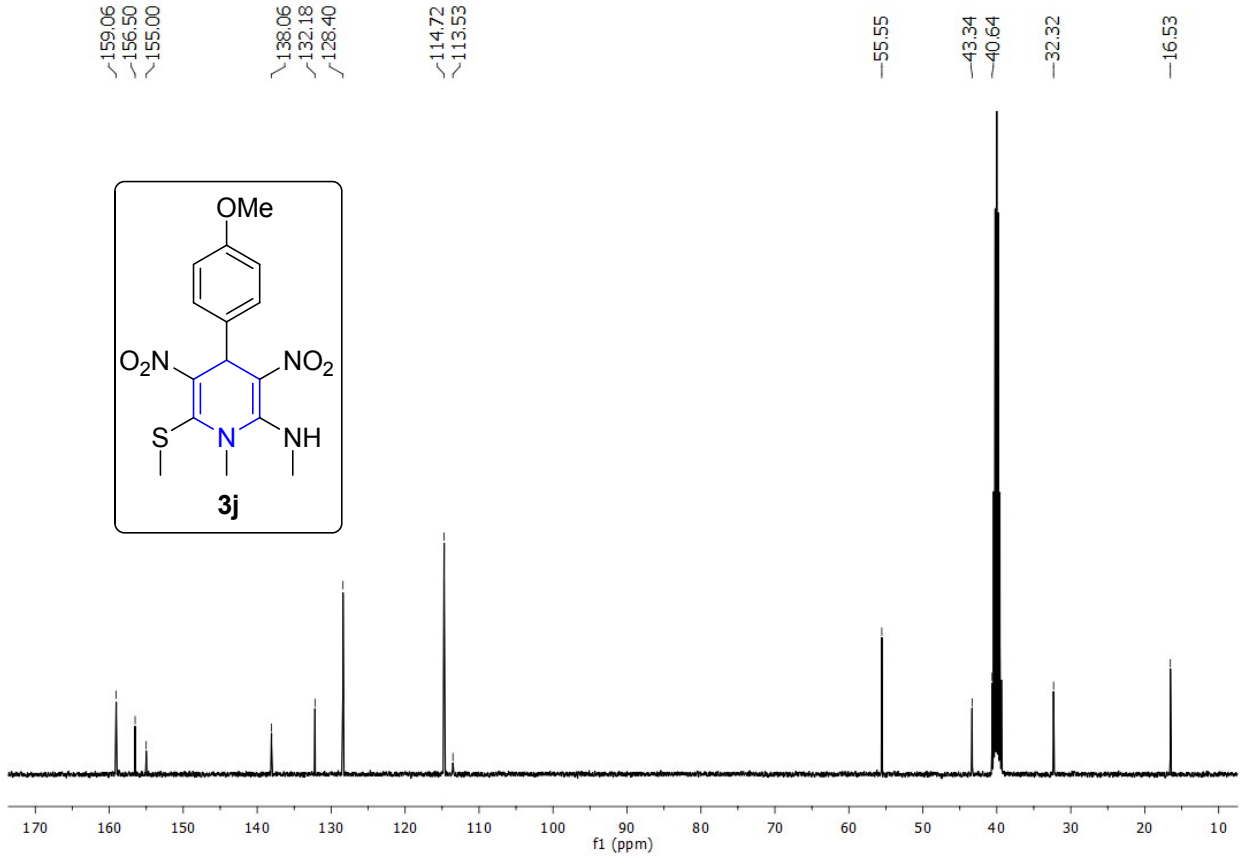
3.10
3.02
3.05
2.99
f1 (ppm)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128.40
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16.53
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O2N
NO2
S
N
NH
3j
f1 (ppm)

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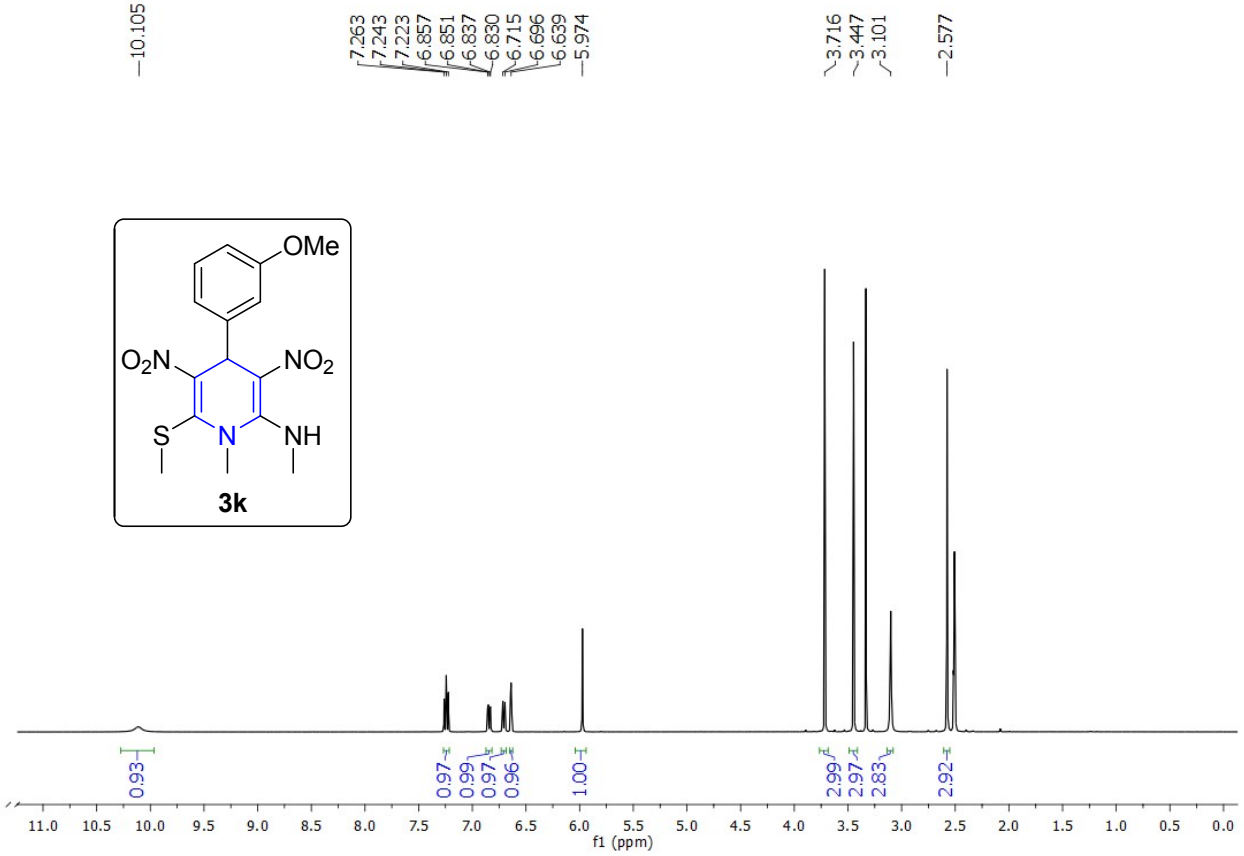
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7.223
6.857
6.851
6.837
6.830
6.715
6.696
6.639
5.974
3.716
3.447
3.101
2.577
OMe
O2N
NO2
S
N
NH
3k
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0.99
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0.96
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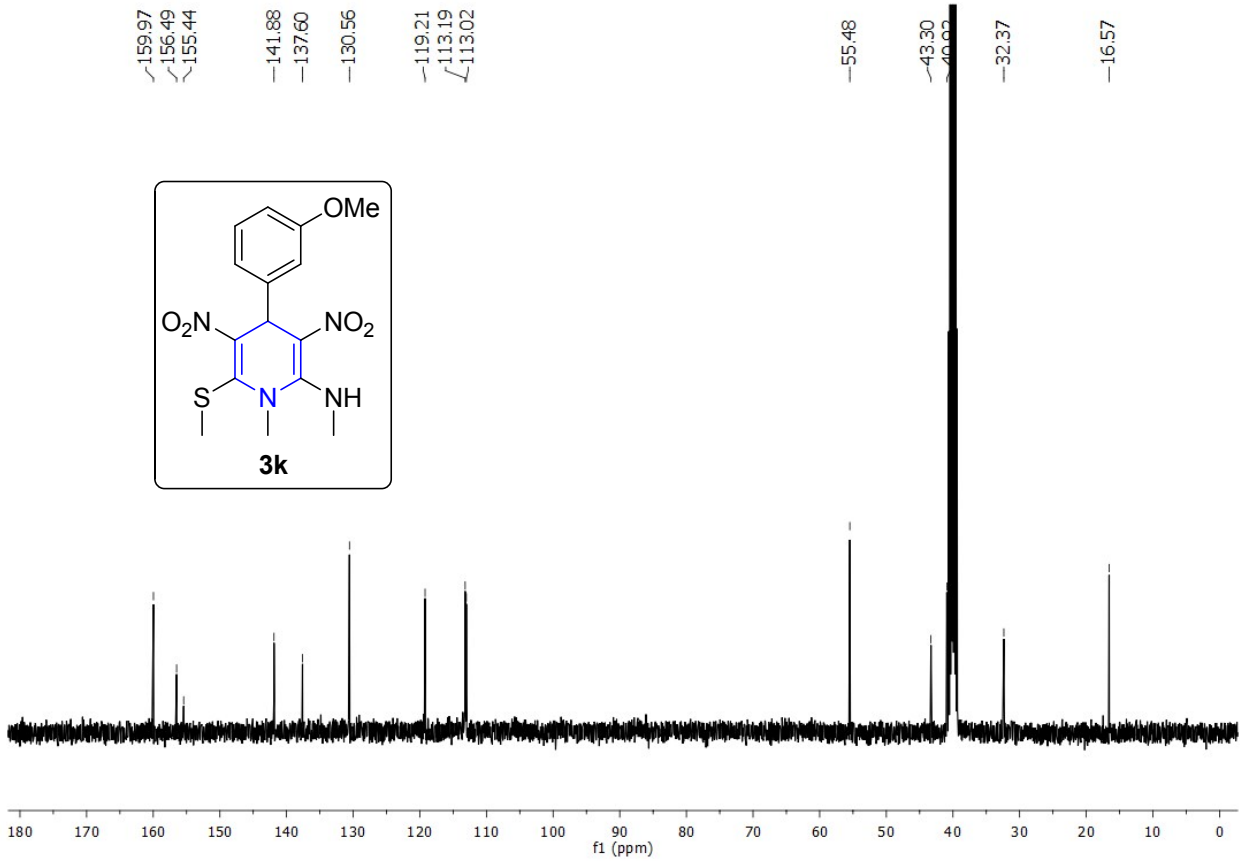
2.97
2.83
2.92
f1 (ppm)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113.19
113.02
55.48
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16.57
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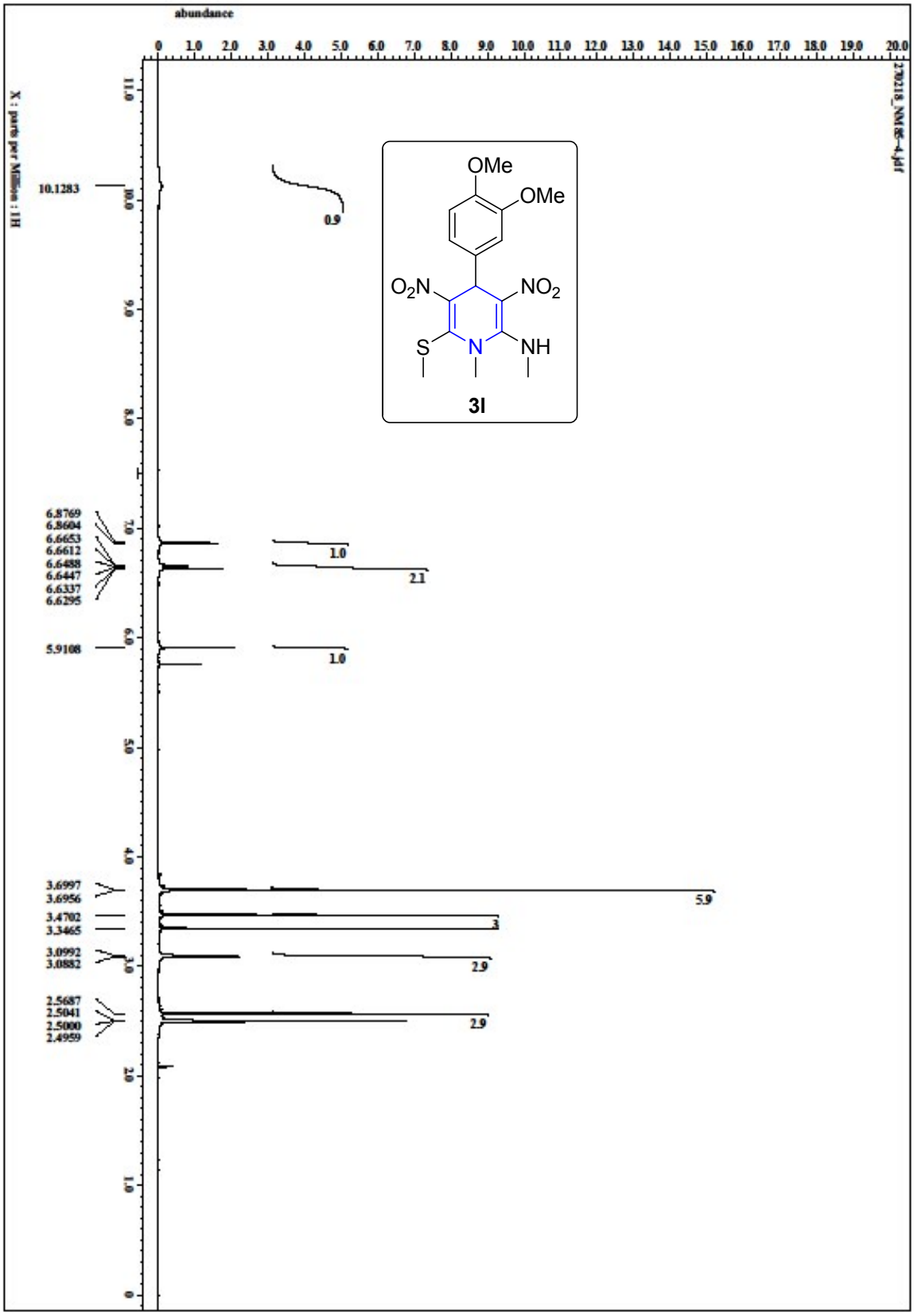
NO2
S
N
NH
3k
f1 (ppm)

Compound 3l: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OMe
O2N
NO2
S
N
NH
3l
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6.8769
6.8604
6.6653
6.6612
6.6488
6.6447
6.6337
6.6295
5.9108
3.6997
3.6956
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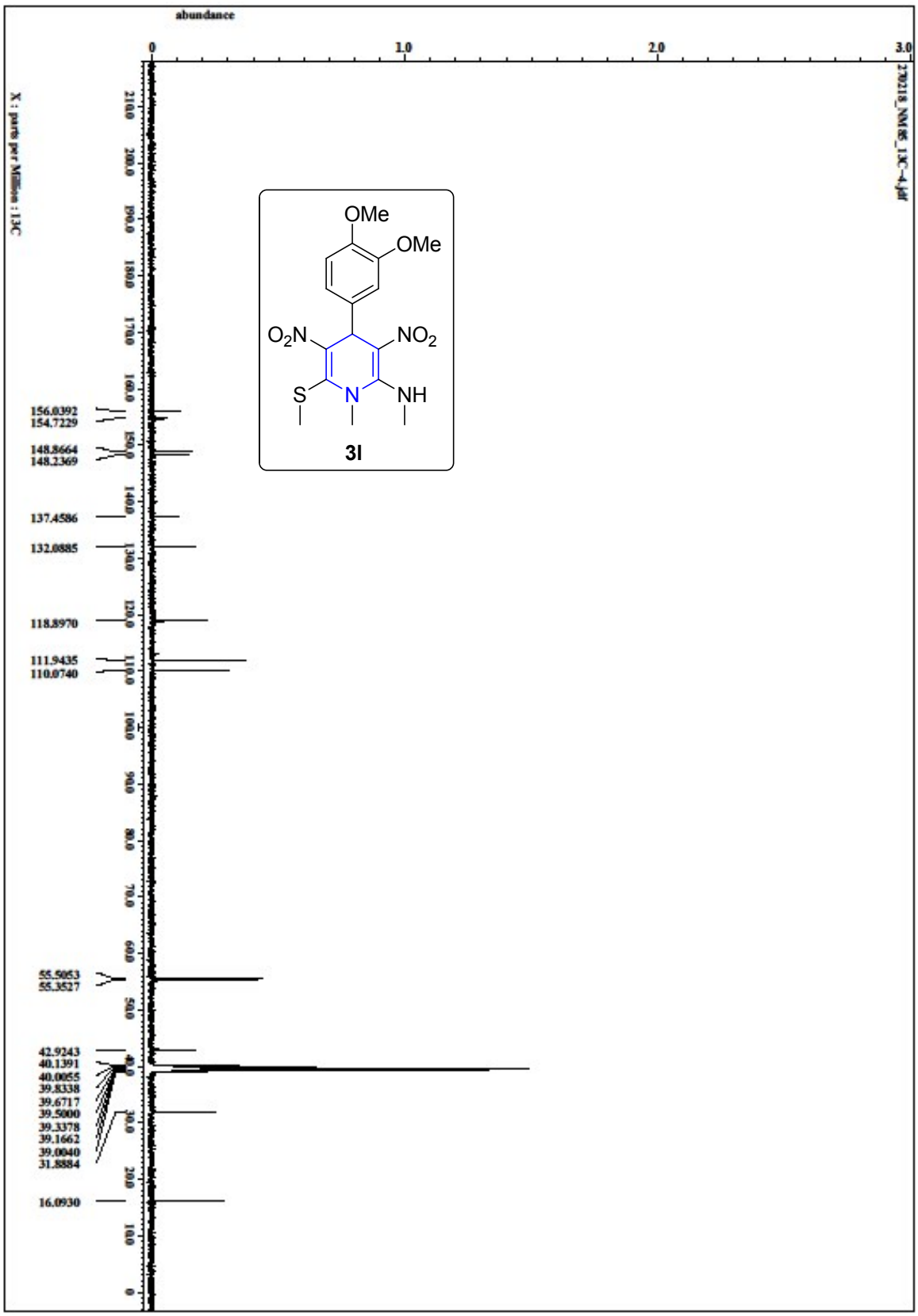
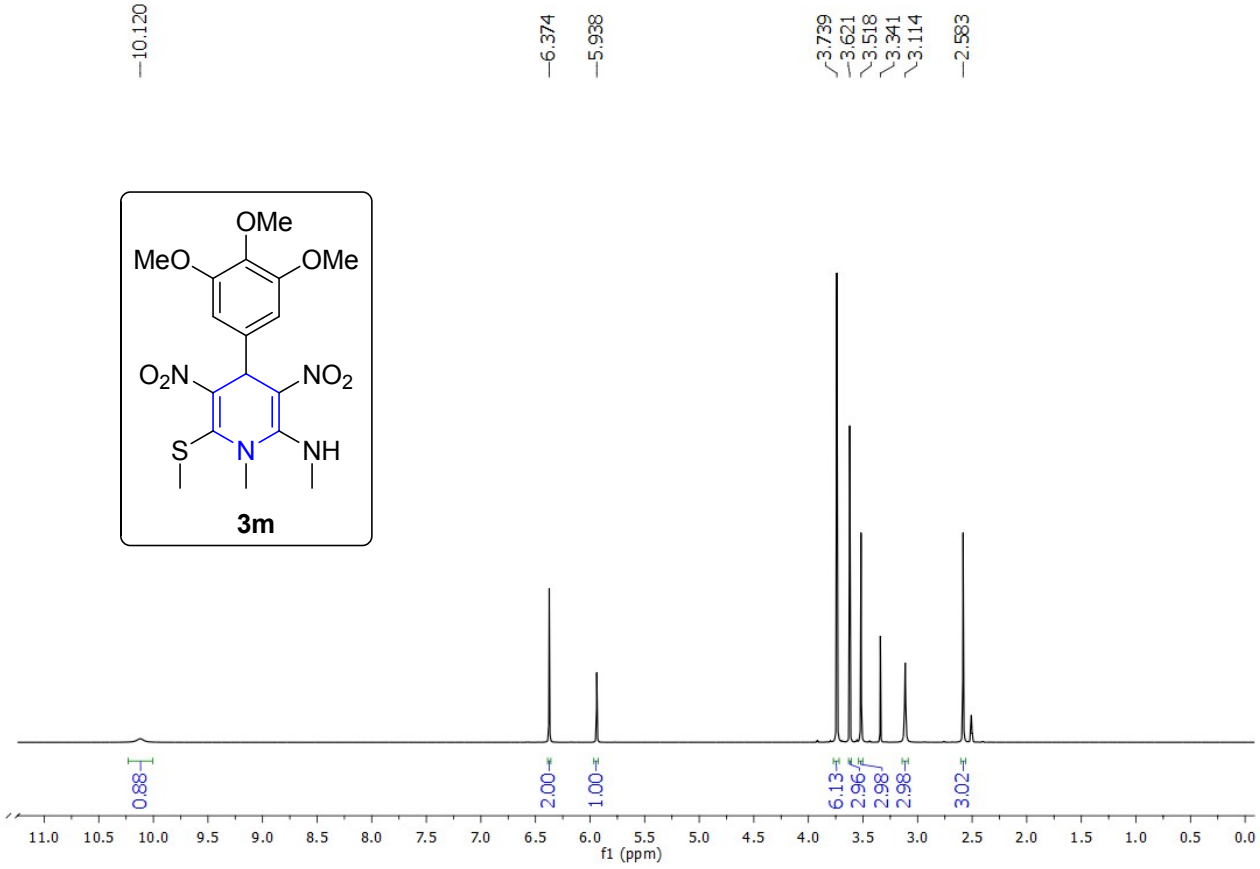
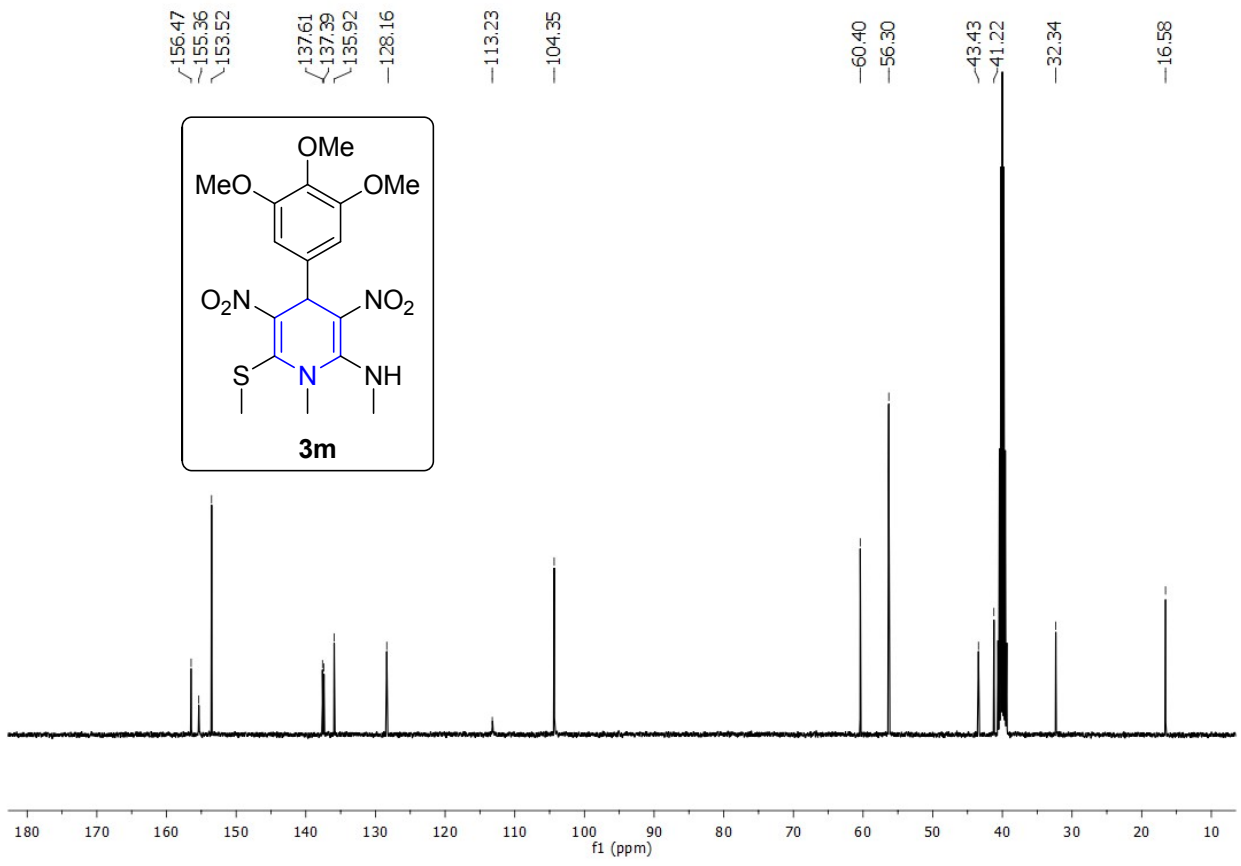
2.5687
2.5041
2.5000
2.4959

Compound 3l:

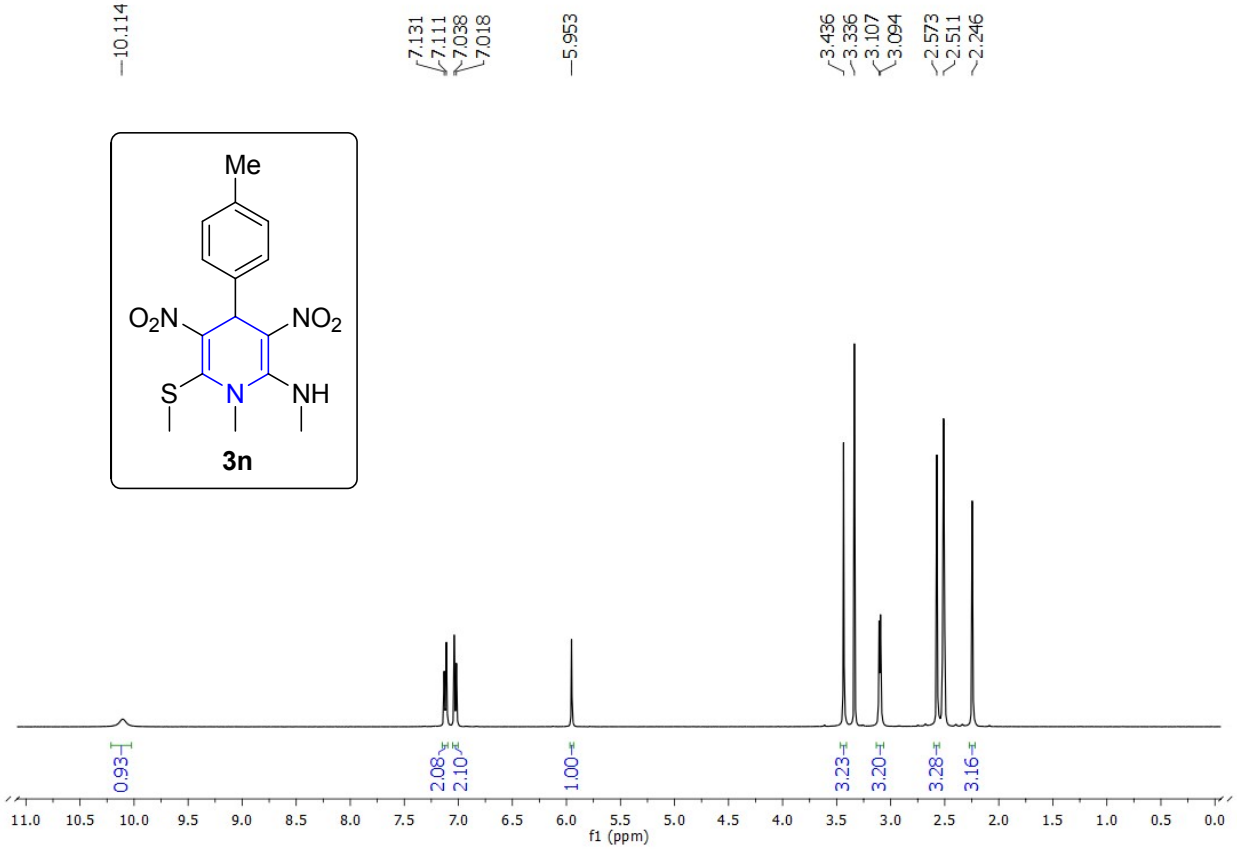

abundance
0
1.0
2.0
3.0
X : parts per Million : 13C
270218_NM85_13C-4.jdf
OMe
OMe
O2N
NO2
S
N
NH
3l
156.0392
154.7229
148.8664
148.2369
137.4586
132.0885
118.8970
111.9435
110.0740
55.5053
55.3527
42.9243
40.1391
40.0055
39.8338
39.6717
39.5000
39.3378
39.1662
39.0040
31.8884
16.0930

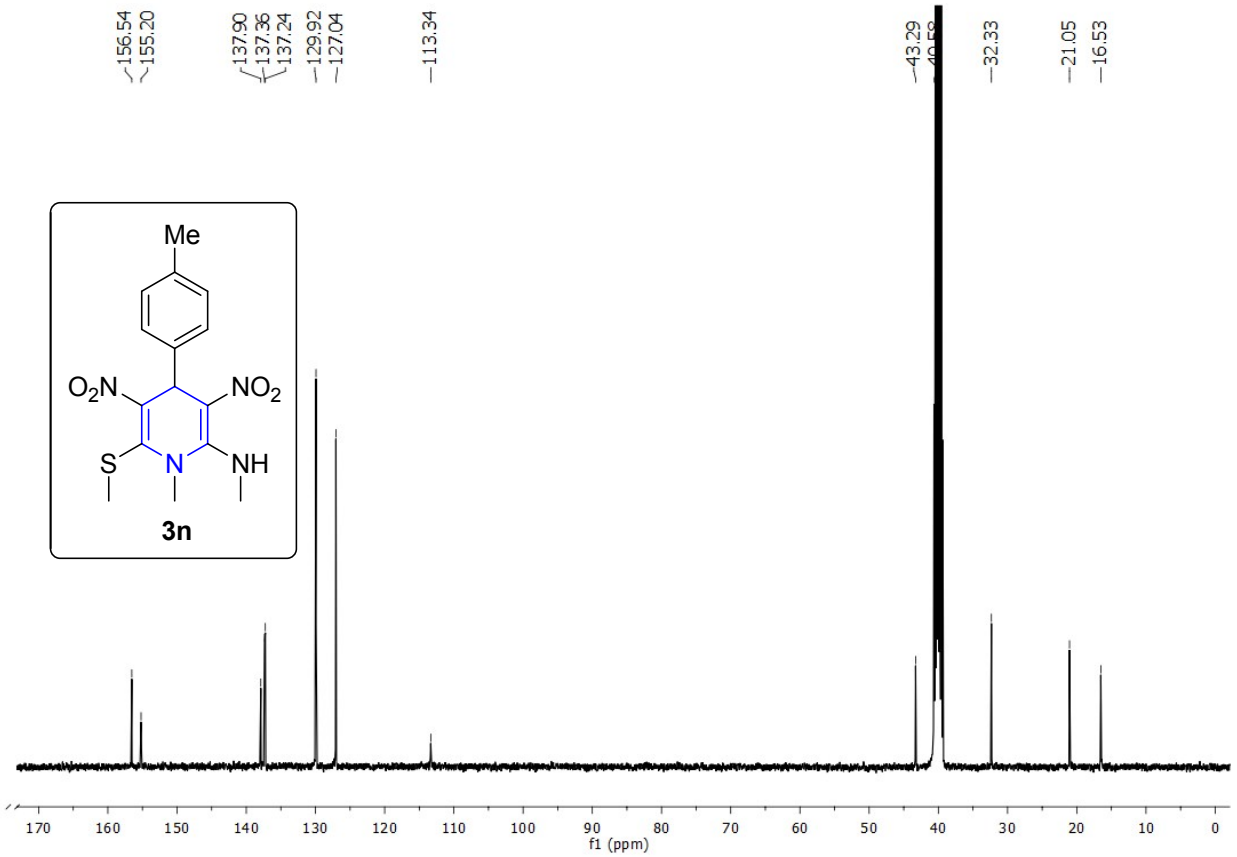
Compound 3m:


10.120
6.374
5.938
3.739
3.621
3.518
3.341
3.114
2.583
OMe
MeO
OMe
O2N
NO2
S
N
NH
3m
0.88
2.00
1.00
6.13
2.96
2.98
2.98
3.02
f1 (ppm)

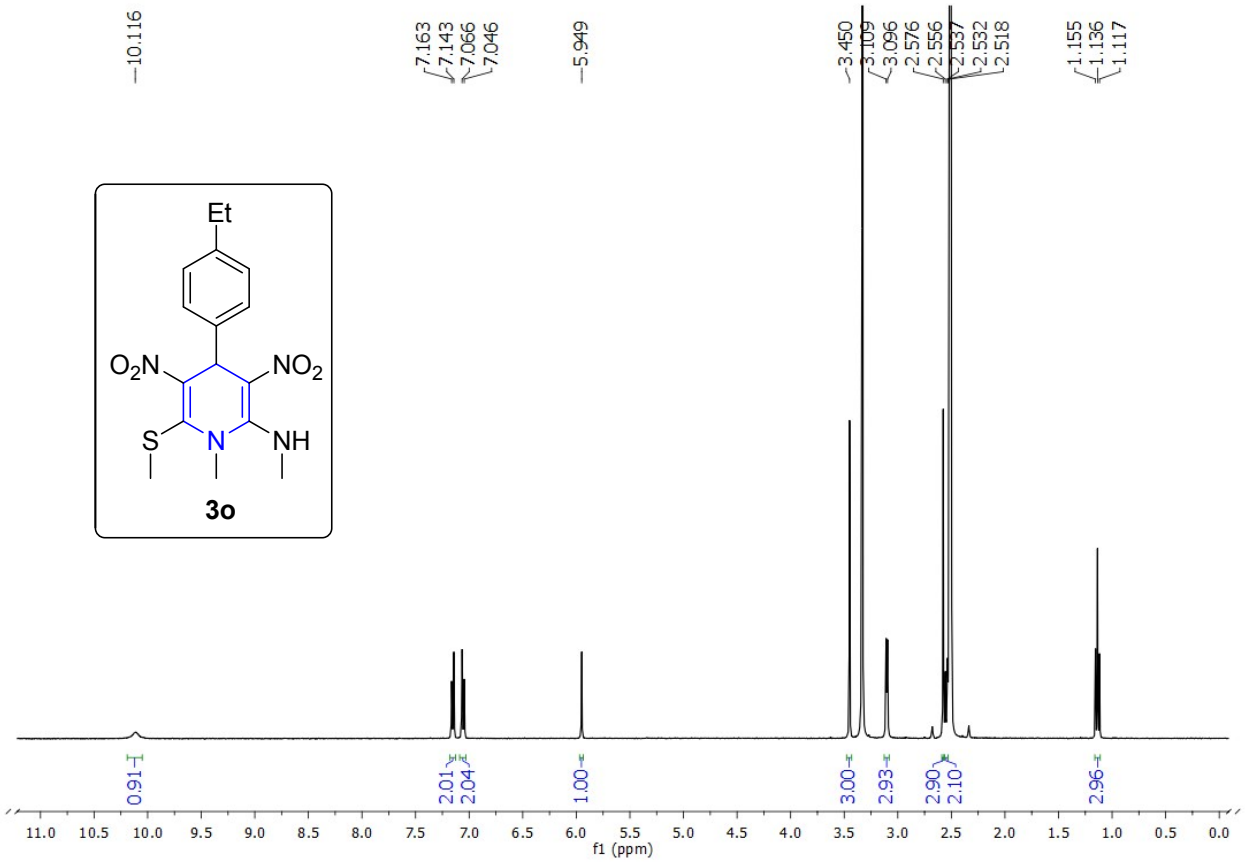

156.47
155.36
153.52
137.61
137.39
135.92
128.16
113.23
104.35
60.40
56.30
43.43
41.22
32.34
16.58
OMe
MeO
OMe
O2N
NO2
S
N
NH
3m
f1 (ppm)

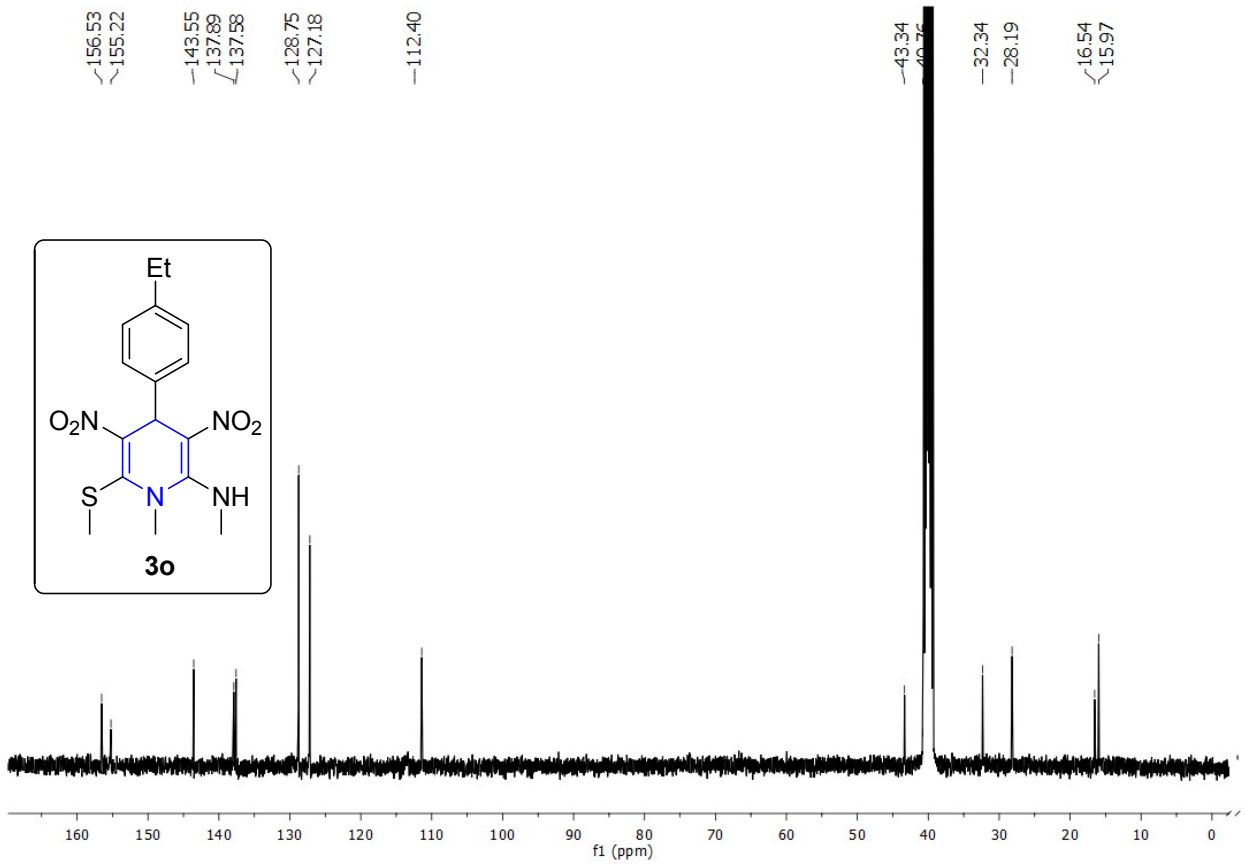
Compound 3n:


10.114
7.131
7.111
7.038
7.018
5.953
3.436
3.336
3.107
3.094
2.573
2.511
2.246
Me
O2N
NO2
S
N
NH
3n
0.93
2.08
2.10
1.00
3.23
3.20
3.28
3.16
f1 (ppm)

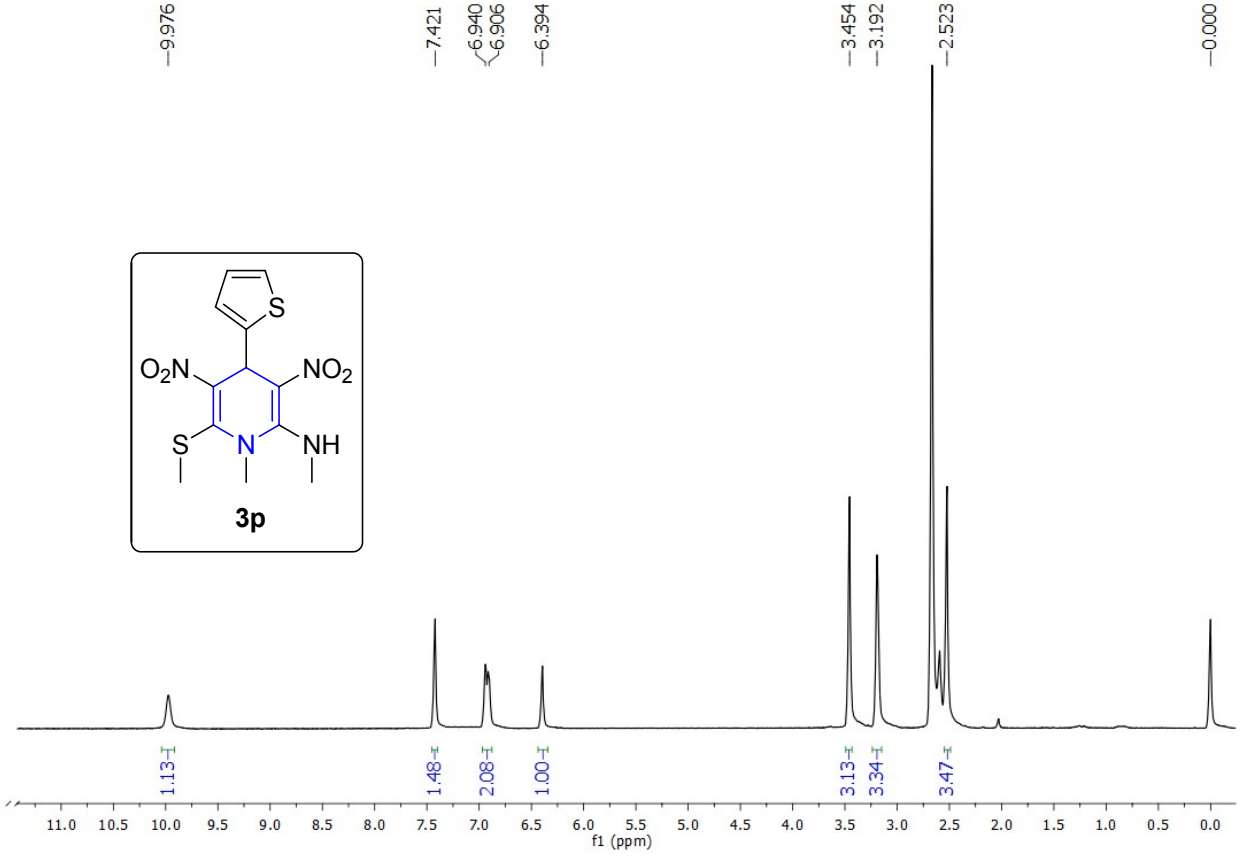

156.54
155.20
137.90
137.36
137.24
129.92
127.04
113.34
43.29
32.33
21.05
16.53
Me
O2N
NO2
S
N
NH
3n
f1 (ppm)

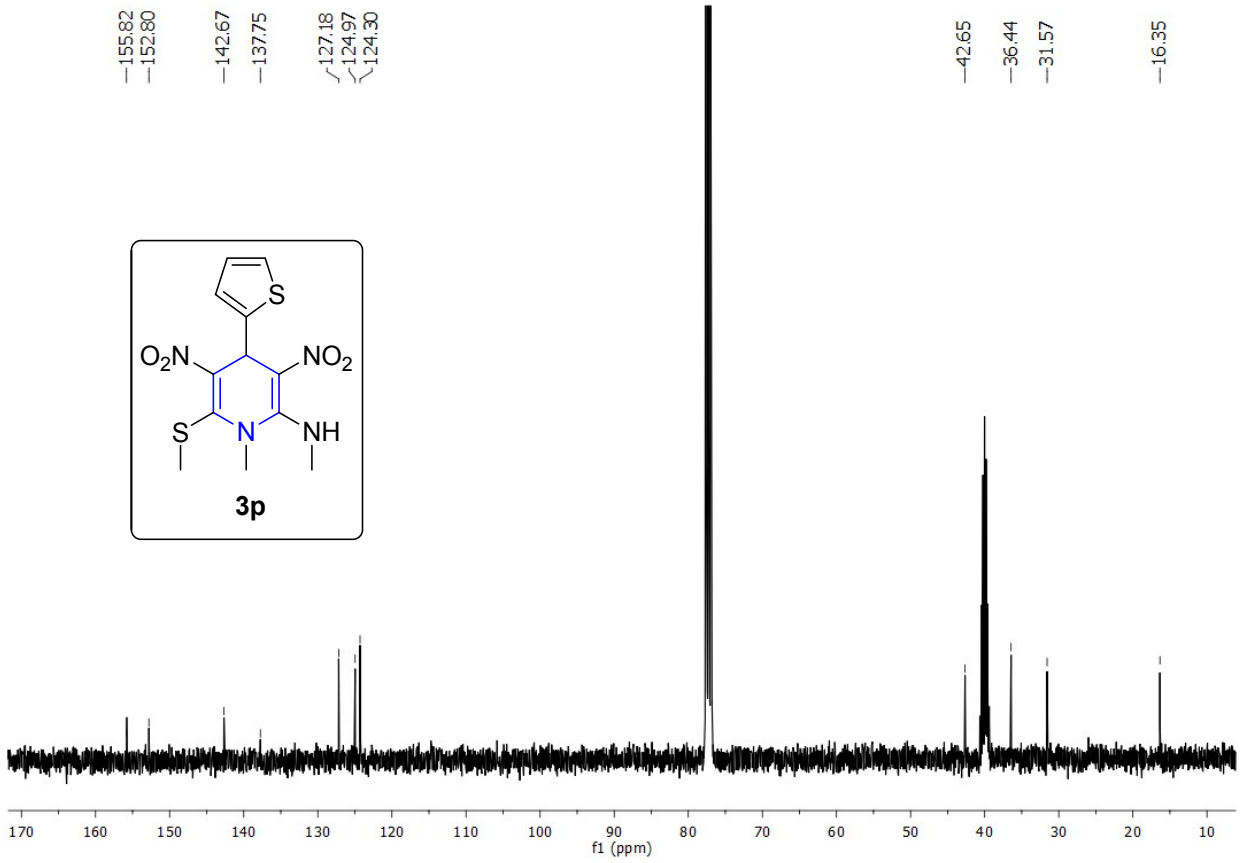
Compound 3o:


10.116
7.163
7.143
7.066
7.046
5.949
3.450
3.109
3.096
2.576
2.556
2.537
2.532
2.518
1.155
1.136
1.117
Et
O2N
NO2
S
N
NH
3o
0.91
2.01
2.04
1.00
3.00
2.93
2.90
2.10
2.96
f1 (ppm)


156.53
155.22
143.55
137.89
137.58
128.75
127.18
112.40
43.34
32.34
28.19
16.54
15.97
Et
O2N
NO2
S
N
NH
3o
f1 (ppm)

Compound 3p:

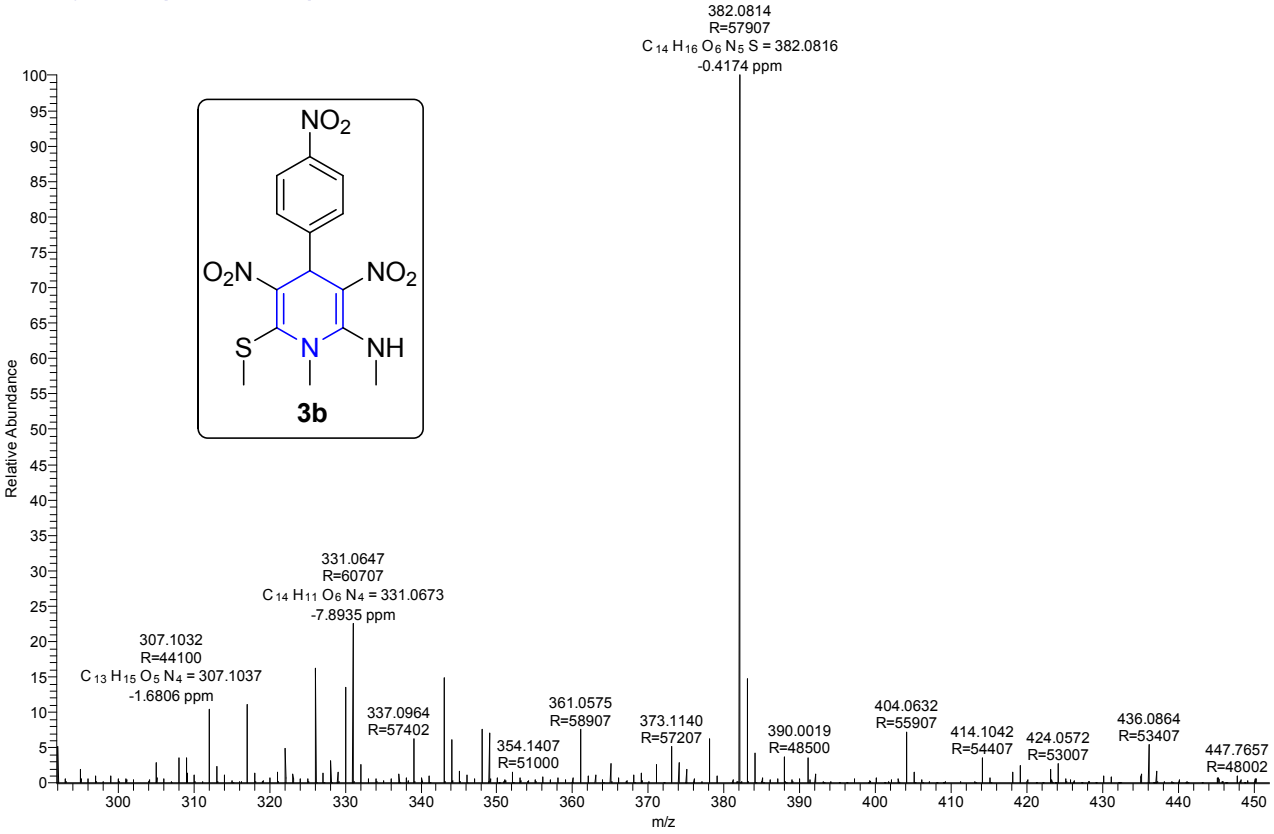

9.976
7.421
6.940
6.906
6.394
3.454
3.192
2.523
0.000
1.13
1.48
2.08
1.00
3.13
3.34
3.47
f1 (ppm)
3p


155.82
152.80
142.67
137.75
127.18
124.97
124.30
42.65
36.44
31.57
16.35
f1 (ppm)
3p

VI. Copy of HRMS spectra:

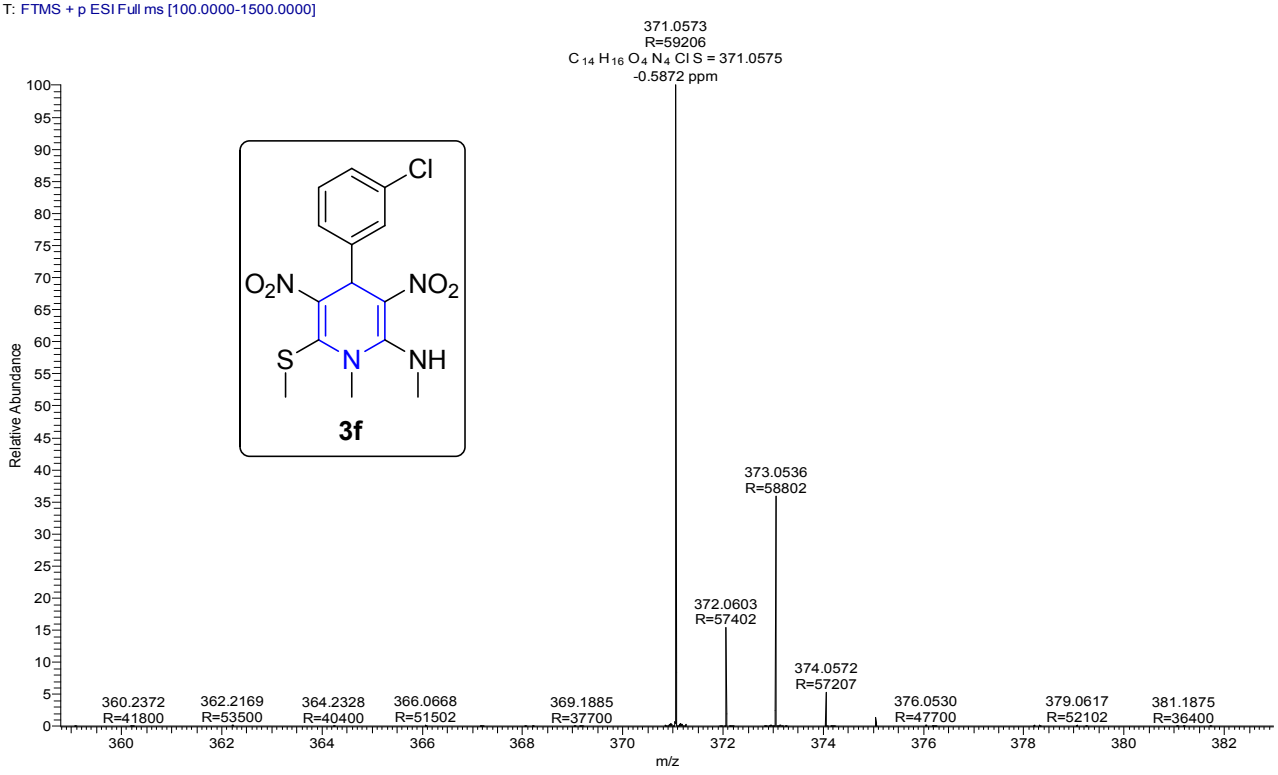
Compound 3b:

NMG-14 #258 RT: 1.15 AV: 1 NL: 3.46E7
T: FTMS + p ESI Full ms [100.0000-1500.0000]



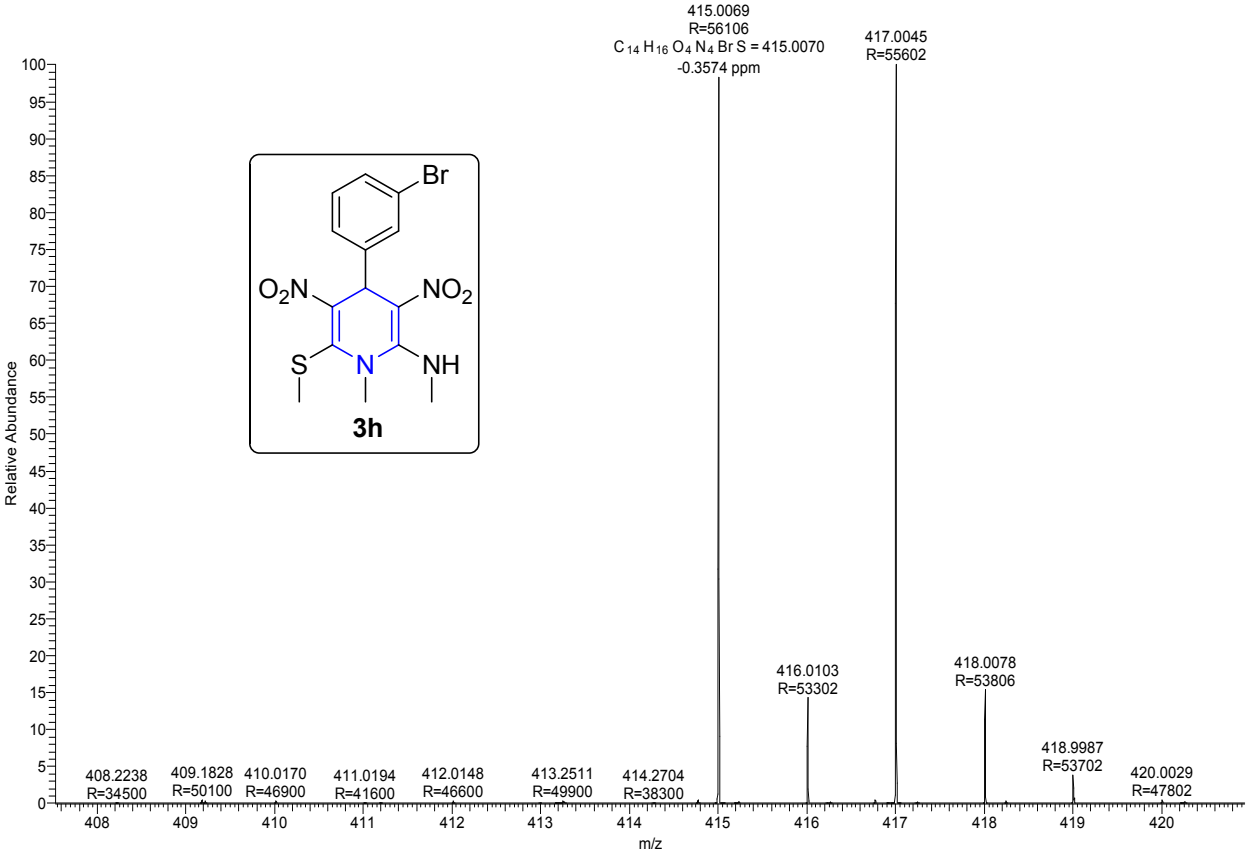
Compound 3f:

NMG-11 #263 RT: 1.18 AV: 1 NL: 7.81E7
T: FTMS + p ESI Full ms [100.0000-1500.0000]



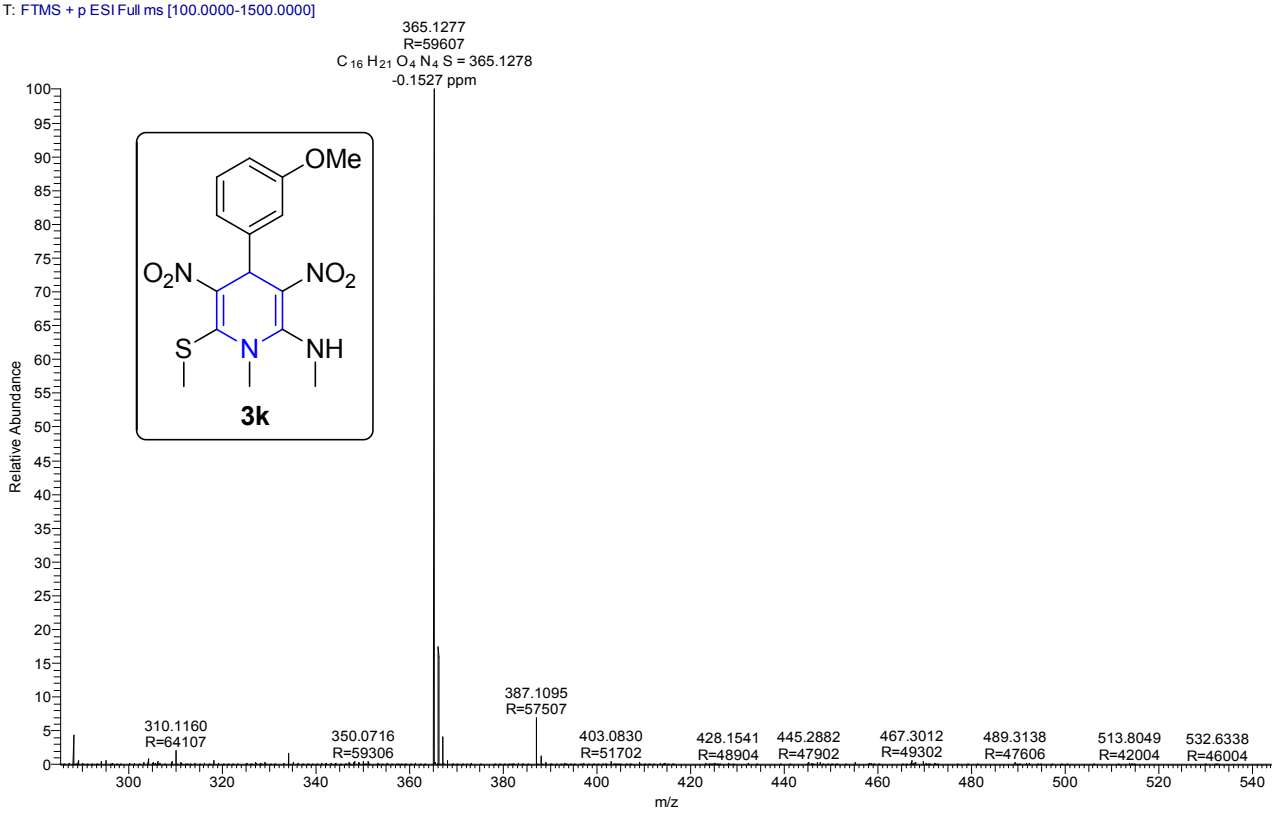
Compound 3h:

NMG-17 #275 RT: 1.22 AV: 1 NL: 2.29E7
T: FTMS + p ESI Full ms [100.0000-1500.0000]

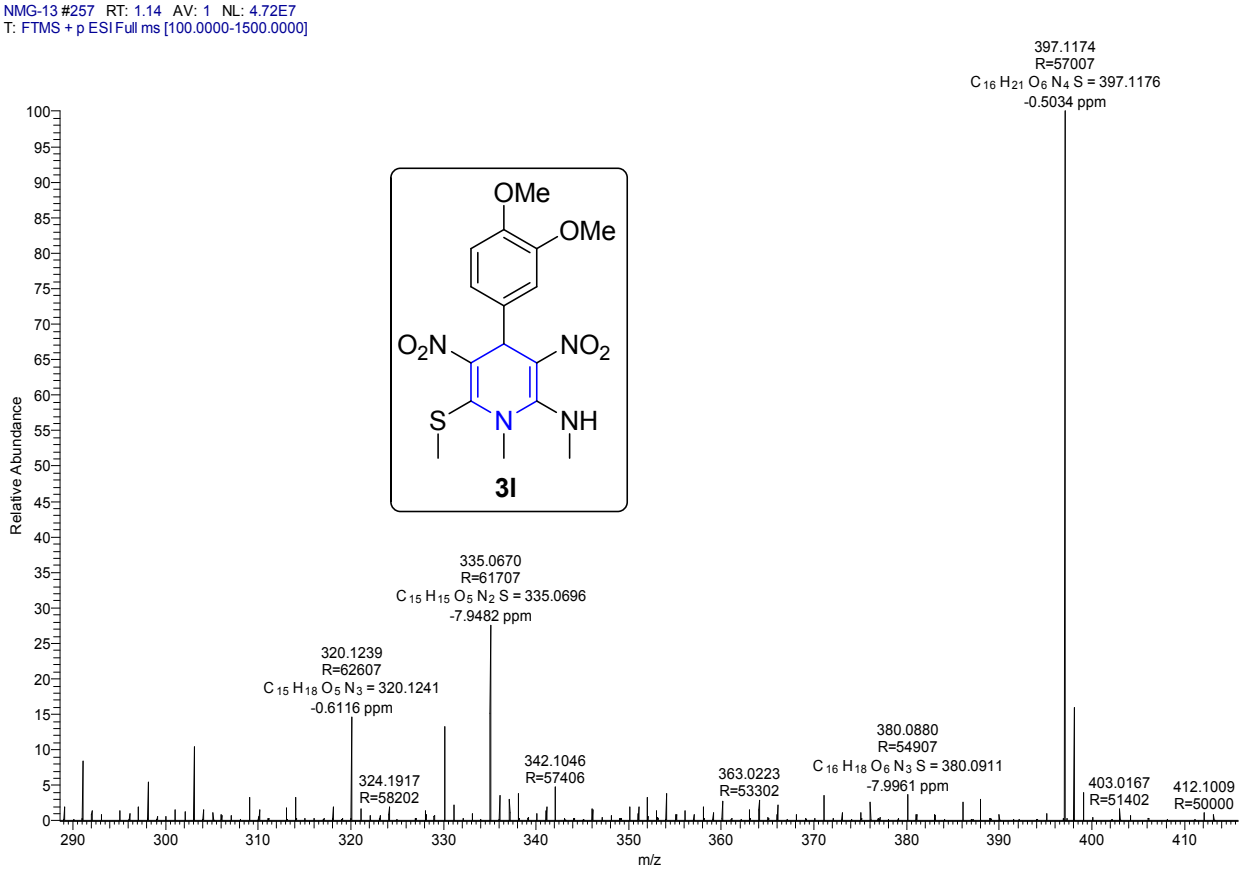


Compound 3k:

NMG-12 #264 RT: 1.18 AV: 1 NL: 9.26E7
T: FTMS + p ESI Full ms [100.0000-1500.0000]



Compound 3l:



VII. References:

1. Green metrics reviews, see: (a) F. Roschangar, R. A. Sheldon and C. H. Senanayake, *Green Chem*., 2015, **17**, 752-768; (b) J. Augé, *Green Chem.,* 2008, **10**, 225-231; (c) C. Jimenez-Gonzalez, C. S. Ponder, Q. B. Broxterman and J. B. Manley, *Org. Process Res. Dev*., 2011, **15**, 912-917.
2. (a) X. Zhang, G. Dhawan, A. Muthengi, S. Liu, W. Wang, M. Legris and W. Zhang, *Green Chem*., 2017, **19**, 3851-3855. (b) P. Wadhwa, T. Kaur and A. Sharma, *RSC Adv.,* 2015, **5**, 44353-44360.