Synthesis of 2-oxophosphorindolines *via* the copper-catalyzed intramolecular aromatic C-H insertion of diazophosphonamidates

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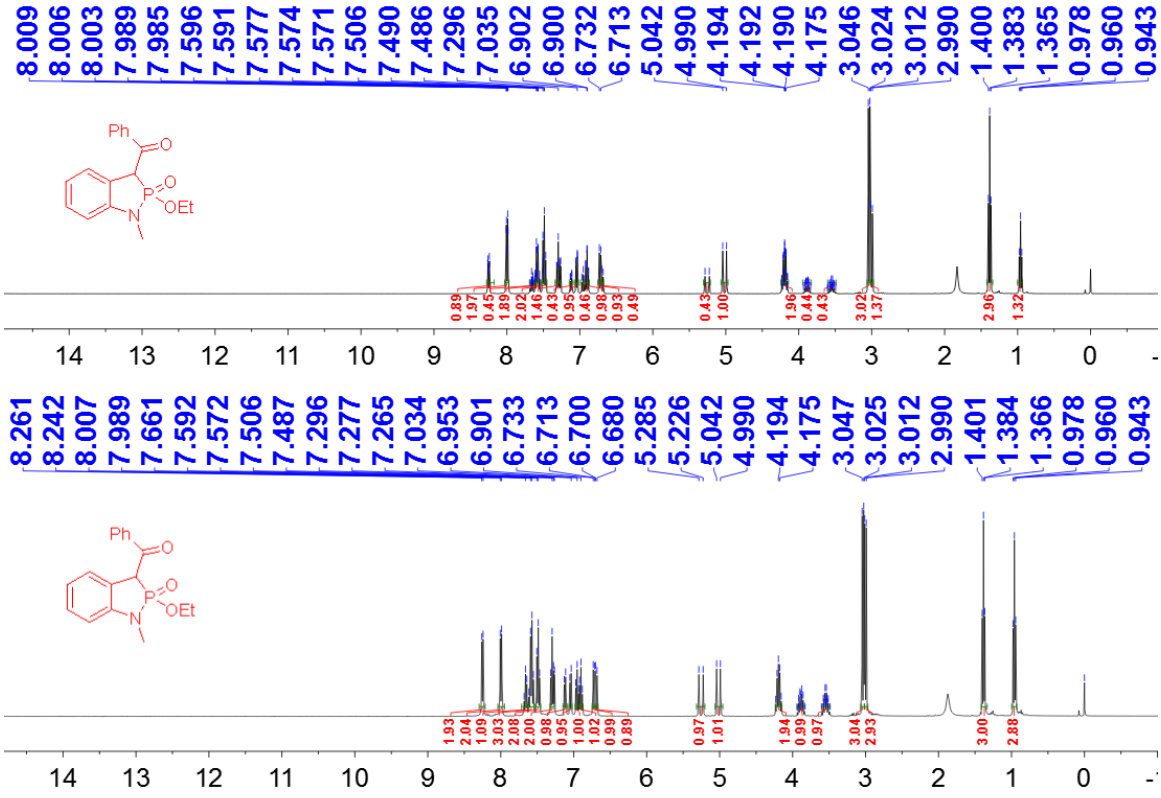
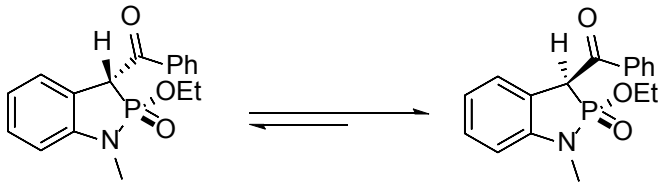
Contents

1. **Figure S1. ^{1}H NMR spectra of diastereomeric 2a after standing for a period of time**



2. Figure S2. Structures and free energies (ΔG) calculated at the M06-2X/6-311++G(d,p)/SMD(Toluene)//M06-2X/6-31G(d)/SMD(Toluene) level.

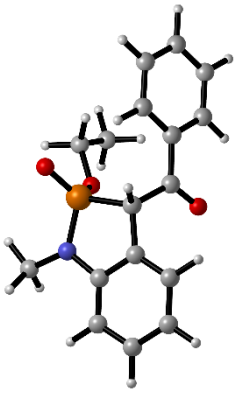


***cis*-2a**

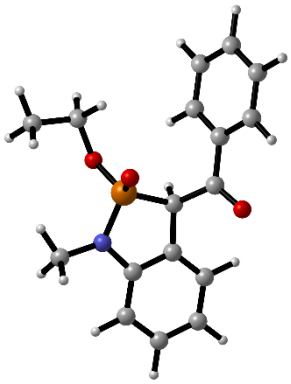
ΔG = 2.4 kcal/mol

***trans*-2a**

ΔG = 0 kcal/mol



***cis*-2a**



***trans*-2a**

***trans*-2a**

C	-4.525796	-1.529742	-0.209498
C	-4.028126	-0.246878	0.025054
H	-4.697068	0.567997	0.281351
H	-5.595438	-1.701897	-0.136829
C	-3.675045	-2.584098	-0.525034
H	-4.076868	-3.577226	-0.695852
C	-2.297819	-2.365760	-0.613364
H	-1.624304	-3.185368	-0.843247
C	-1.787091	-1.097093	-0.393372
C	-2.655771	-0.039502	-0.071855
N	-2.010794	1.189799	0.125182
C	-2.726750	2.371400	0.565785
H	-3.515609	2.617937	-0.151441
H	-3.169481	2.228937	1.558012
H	-2.031815	3.213534	0.608044
P	-0.345700	1.019849	0.252673
O	0.297051	1.179747	1.579319
O	0.227556	2.045370	-0.849165
C	1.362668	2.880743	-0.526674
H	2.048124	2.332781	0.125296
H	1.855442	3.066495	-1.484448

C	0.908691	4.169902	0.123036
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H	0.455352	3.965037	1.097437
H	1.767129	4.830810	0.278894
C	-0.340719	-0.671622	-0.487738
H	-0.046092	-0.563188	-1.538934
C	0.663412	-1.571505	0.229706
O	0.291539	-2.468944	0.952794
C	2.121902	-1.299573	0.019116
C	3.036323	-2.045503	0.770400
H	2.653864	-2.785642	1.465478
C	4.400542	-1.830876	0.628234
H	5.104575	-2.410174	1.217295
C	4.865245	-0.867986	-0.267820
H	5.932064	-0.698278	-0.377752
C	3.961878	-0.123516	-1.021372
H	4.320203	0.624729	-1.721610
C	2.593327	-0.338606	-0.880983
H	1.905969	0.251180	-1.480744

***cis*-2a**

C	-1.933829	1.764536	2.469302
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H	3.620955	2.696675	-0.789390
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C	2.717461	0.112347	-0.185386
C	4.061464	-0.031146	0.144818
H	4.701187	0.837508	0.259996
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H	4.159150	-3.430832	0.355754
C	2.403196	-2.280676	-0.126783

H	1.754507	-3.146552	-0.215405
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C	0.462501	-0.666164	-0.695993
H	0.258679	-0.913409	-1.745697
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O	-0.304558	-1.960037	1.162883
C	-2.044075	-1.073363	-0.167748
C	-3.013843	-1.512009	0.742420
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H	-5.108143	-1.637852	1.199194
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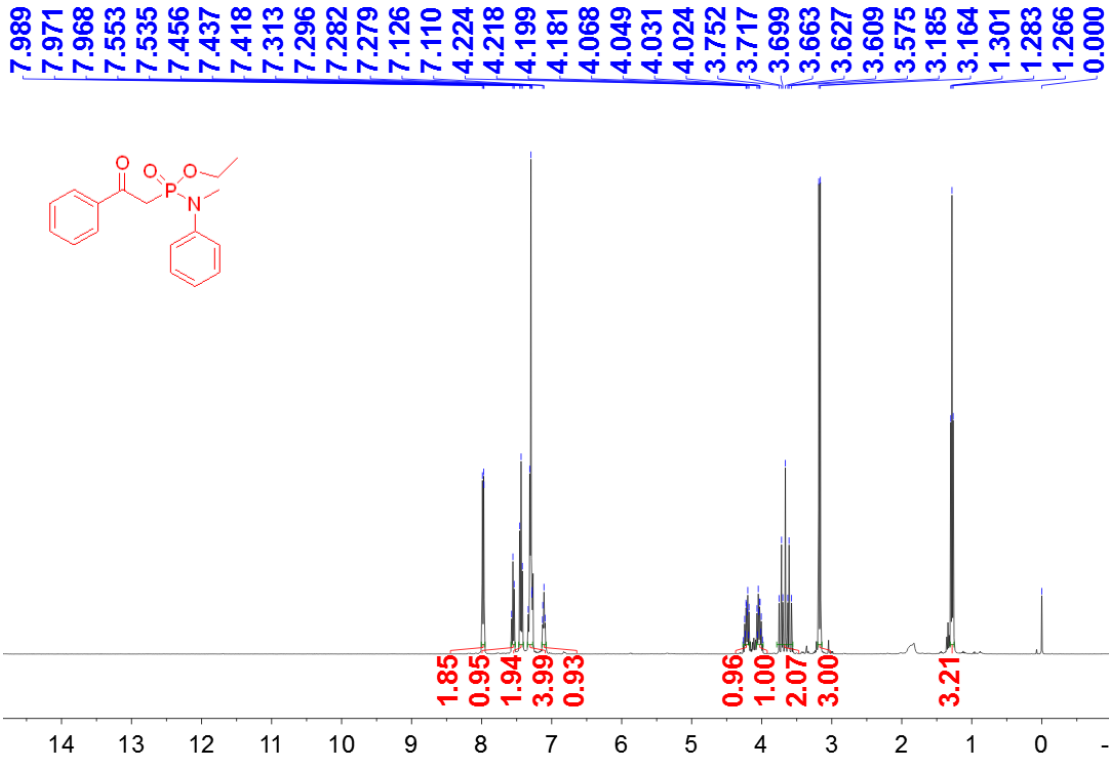
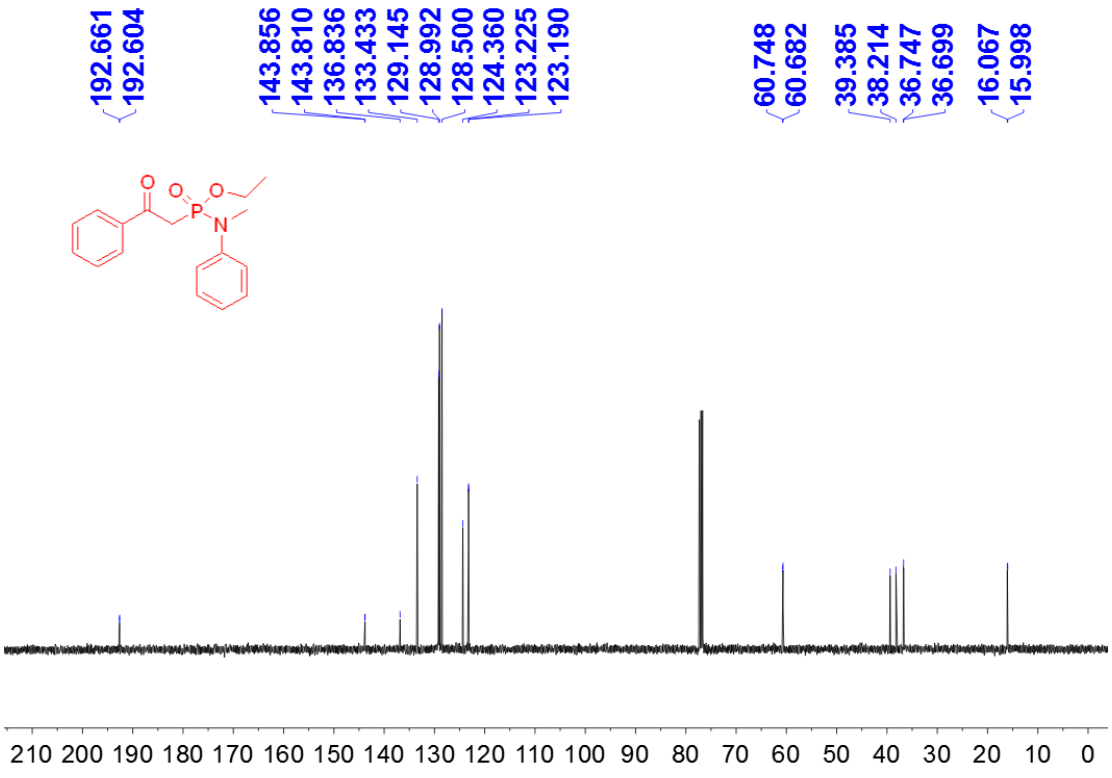
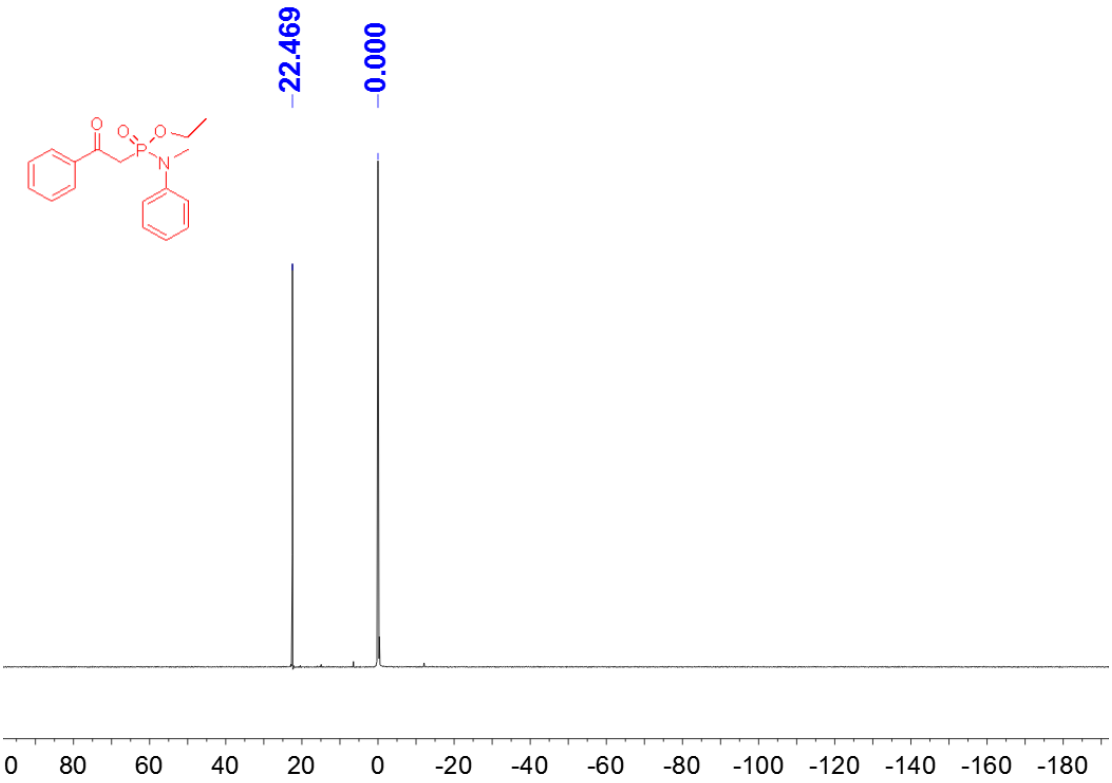
C	-3.796366	-0.219832	-1.598225
H	-4.098720	0.284871	-2.510118
C	-2.442515	-0.428024	-1.343782
H	-1.712524	-0.061916	-2.058319

3. Copies of ^{1}H, ^{13}C, ^{31}P, and ^{19}F spectra of unknown compounds 3, 1, and 2

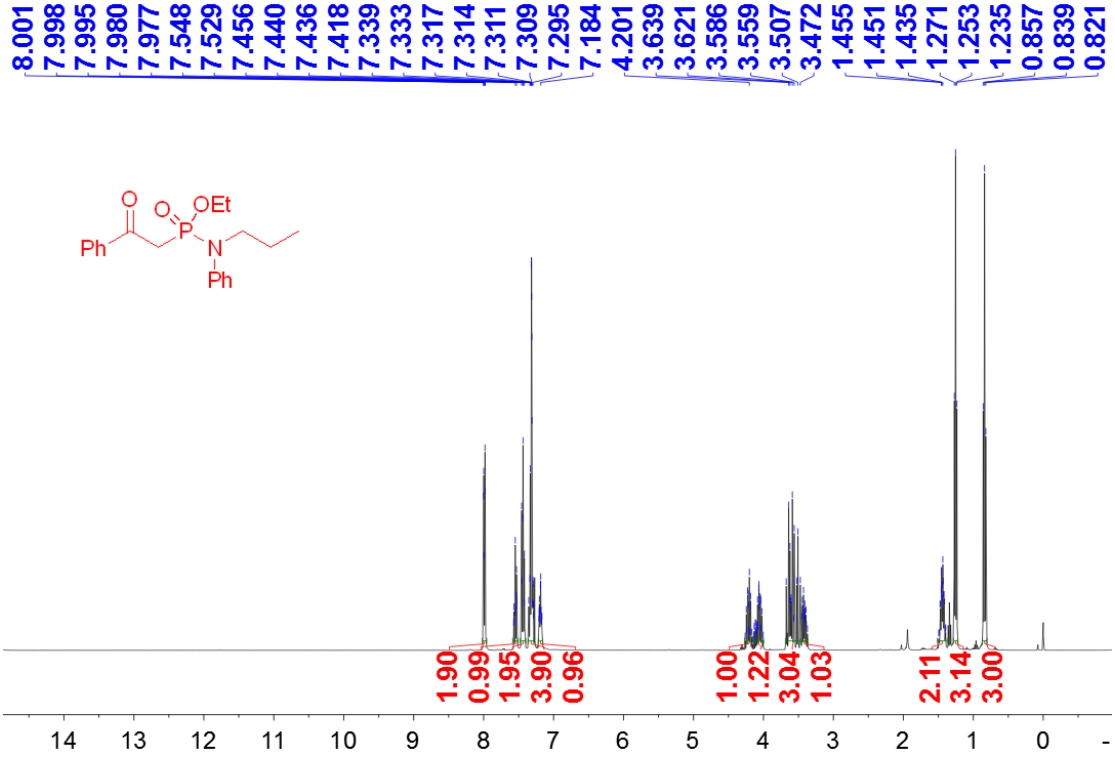
Ethyl *N*-methyl-*P*-(2-oxo-2-phenylethyl)-*N*-phenylphosphonamidate (3a)

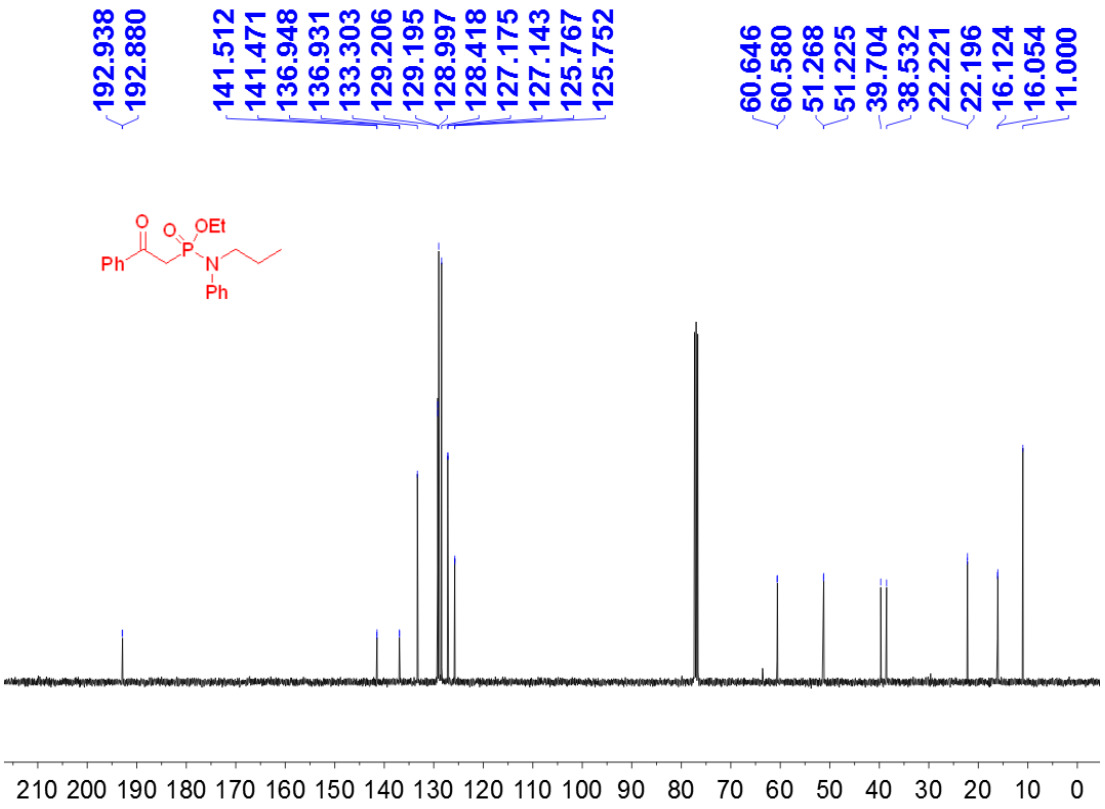






Ethyl *P*-(2-oxo-2-phenylethyl)-*N*-phenyl-*N*-propylphosphonamidate (3b)

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38.532
22.221
22.196
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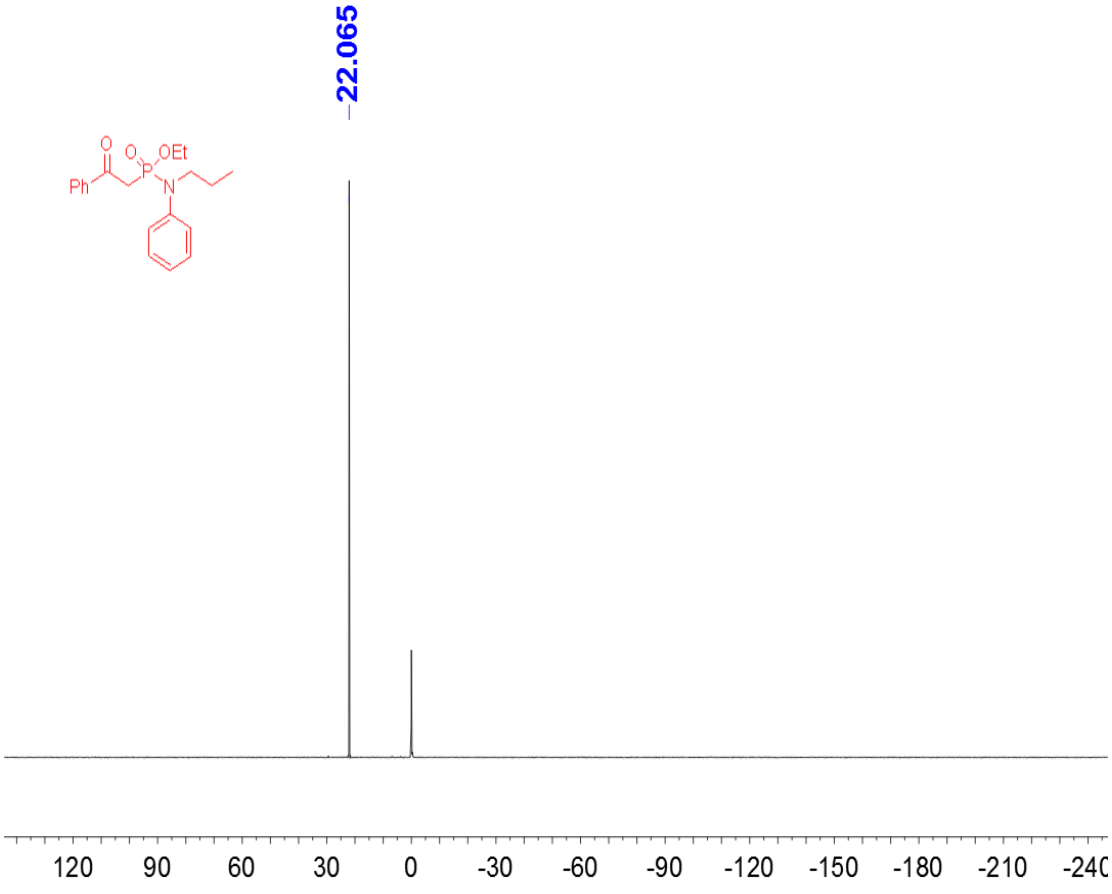
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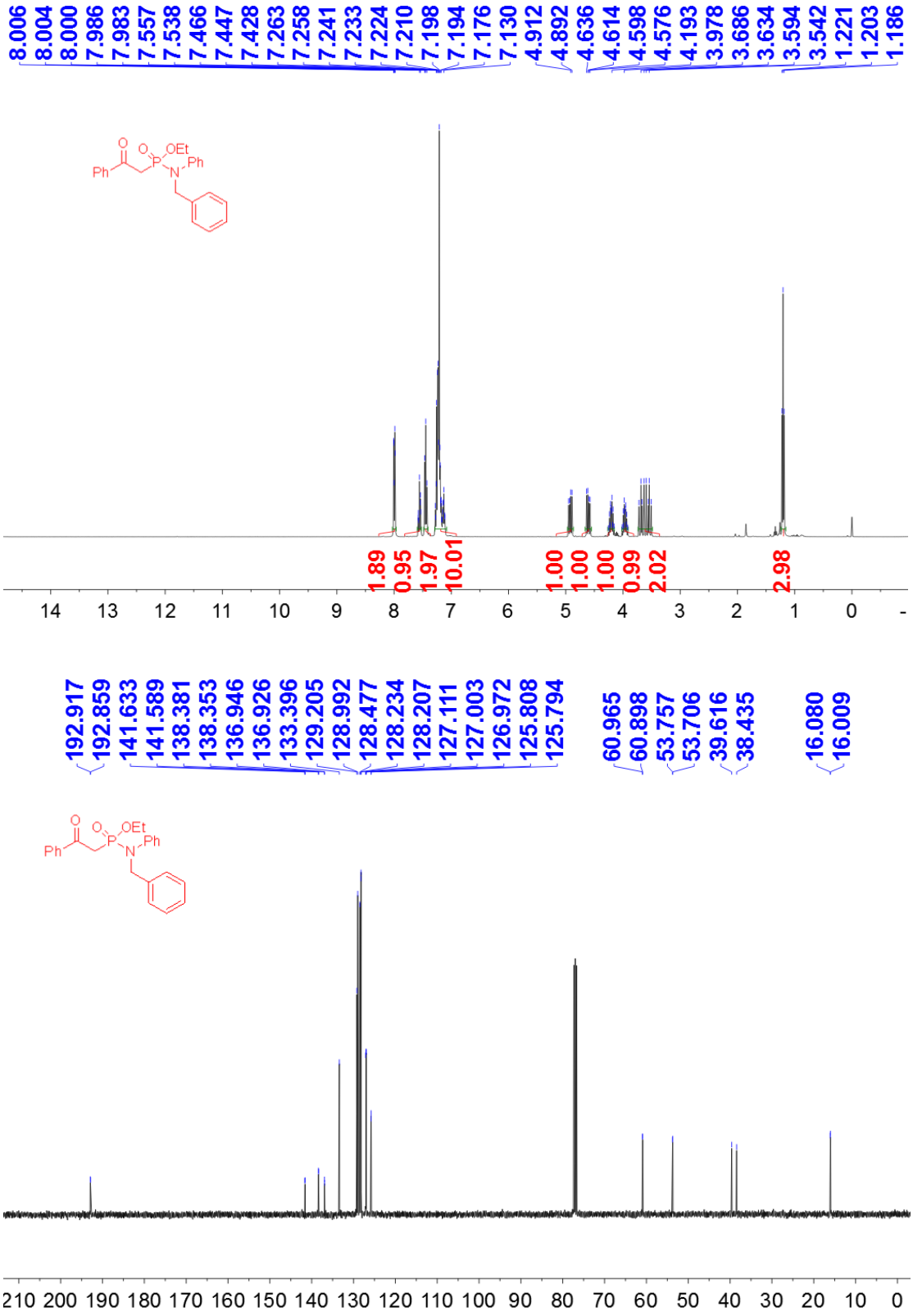
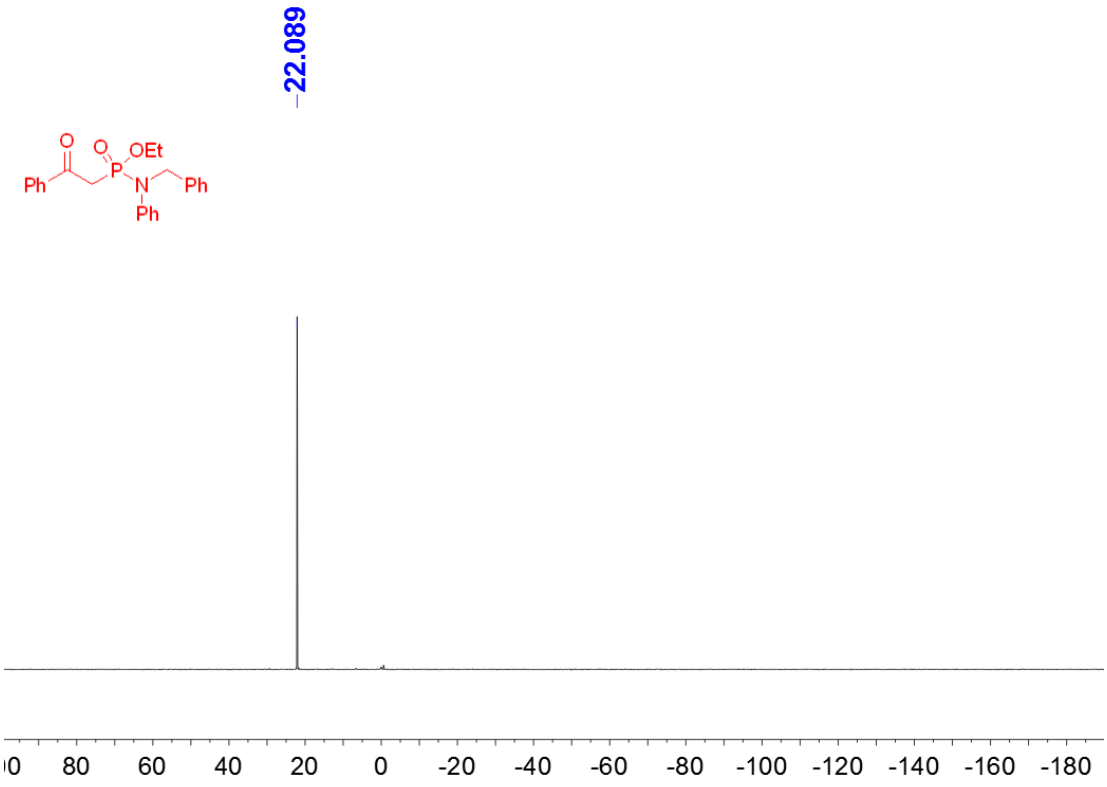
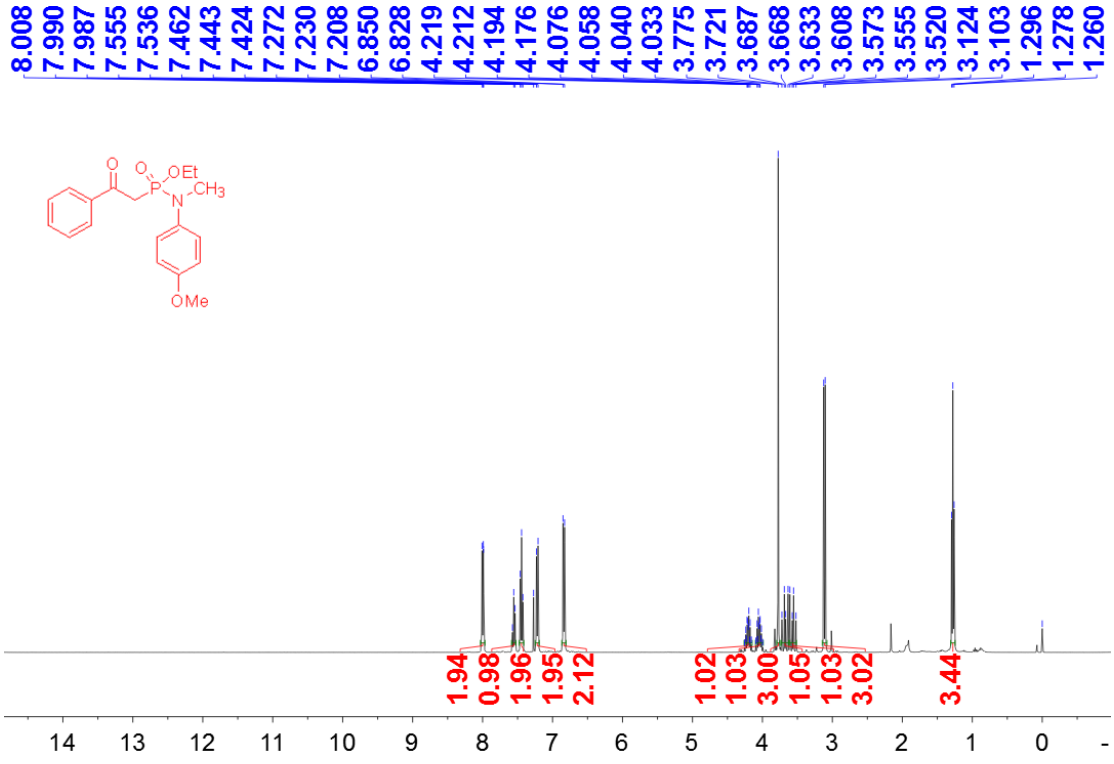
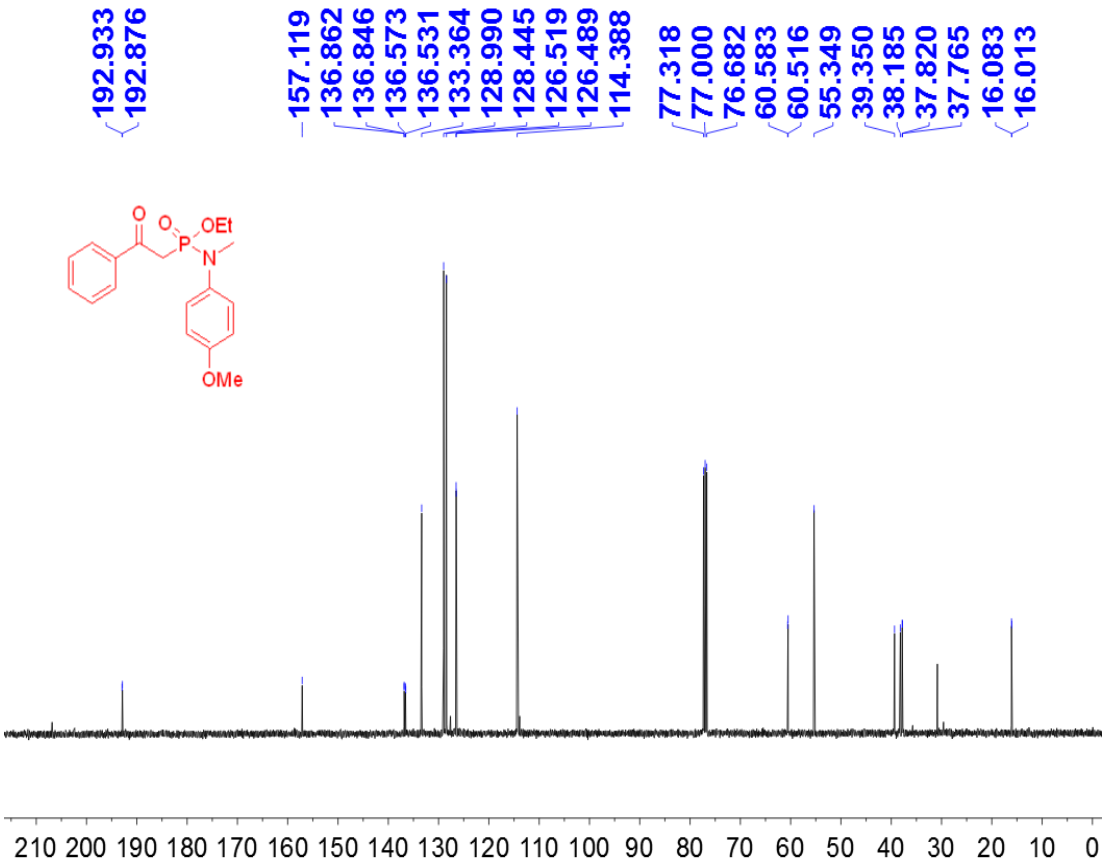
Ethyl *N*-benzyl-*P*-(2-oxo-2-phenylethyl)-*N*-phenylphosphonamidate (3c)





Ethyl *N*-(4-methoxyphenyl)-*N*-methyl-*P*-(2-oxo-2-phenylethyl)phosphonamidate (3d)

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77.000
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60.583
60.516
55.349
39.350
38.185
37.820
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16.013
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O
OEt
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N
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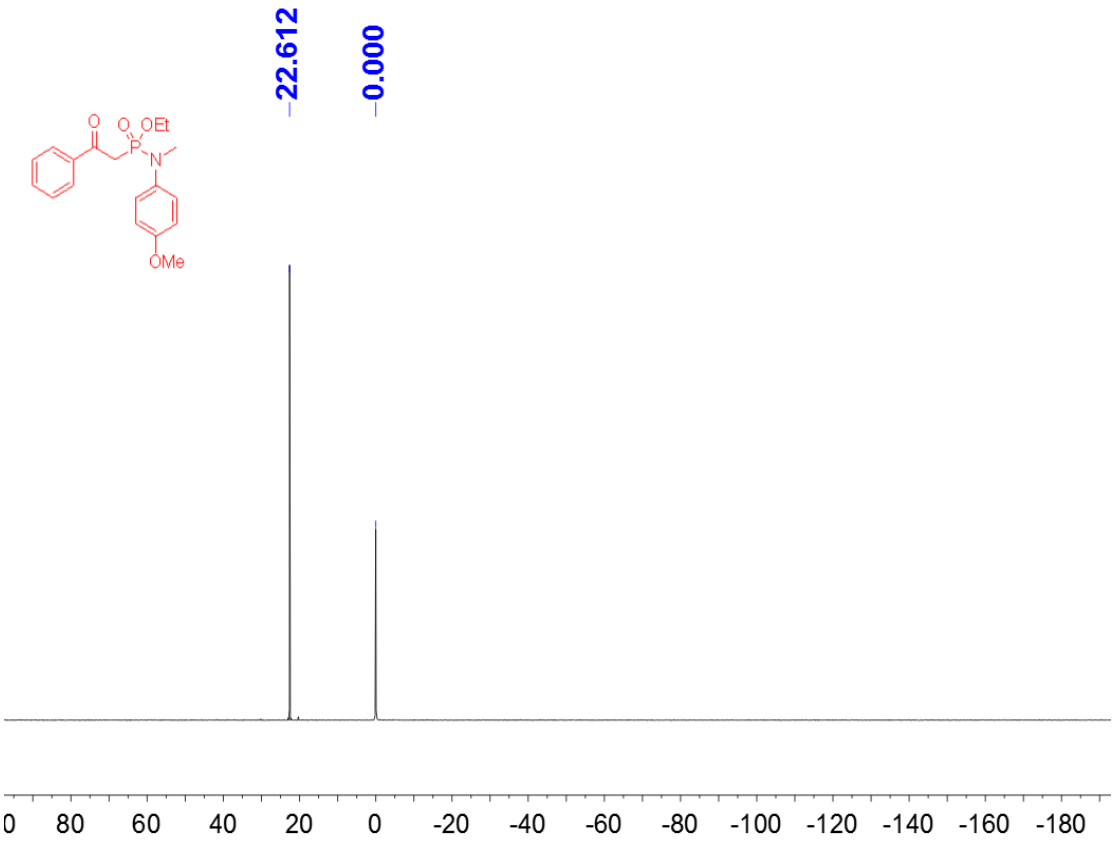
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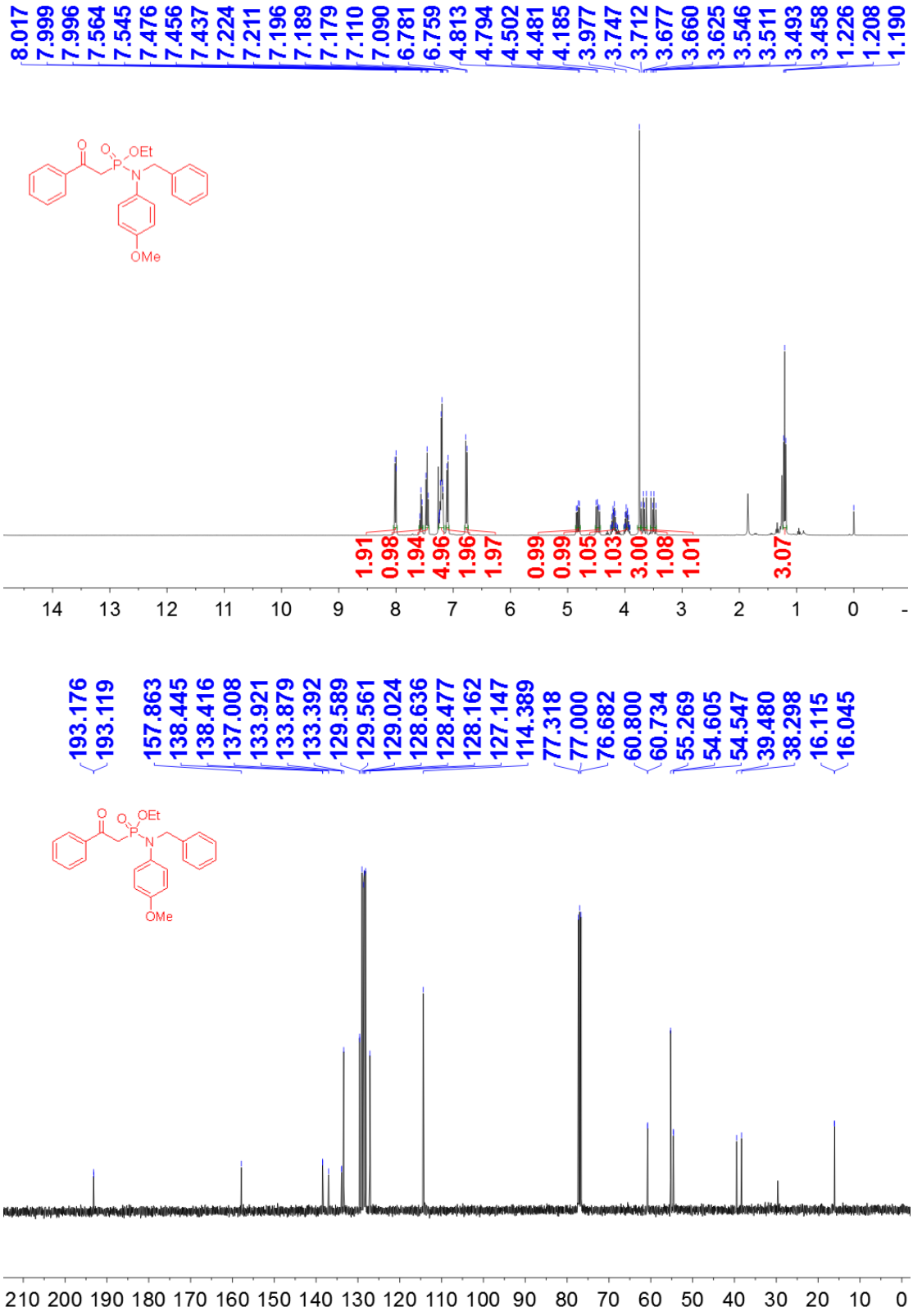
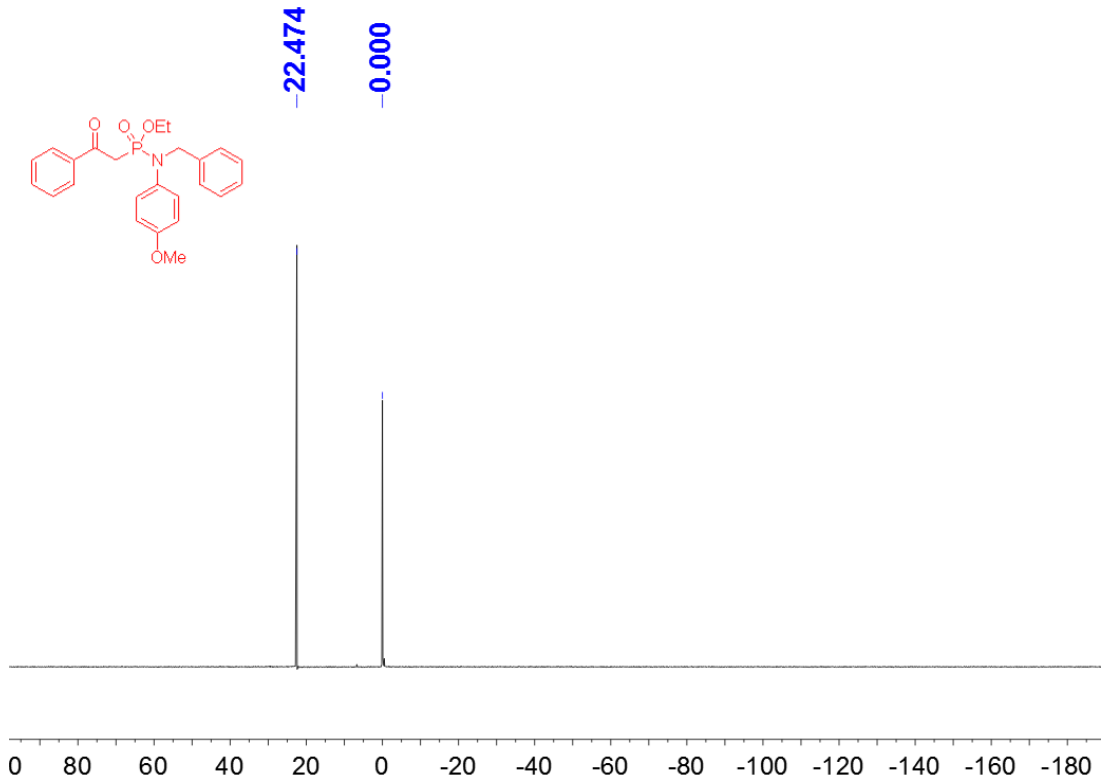
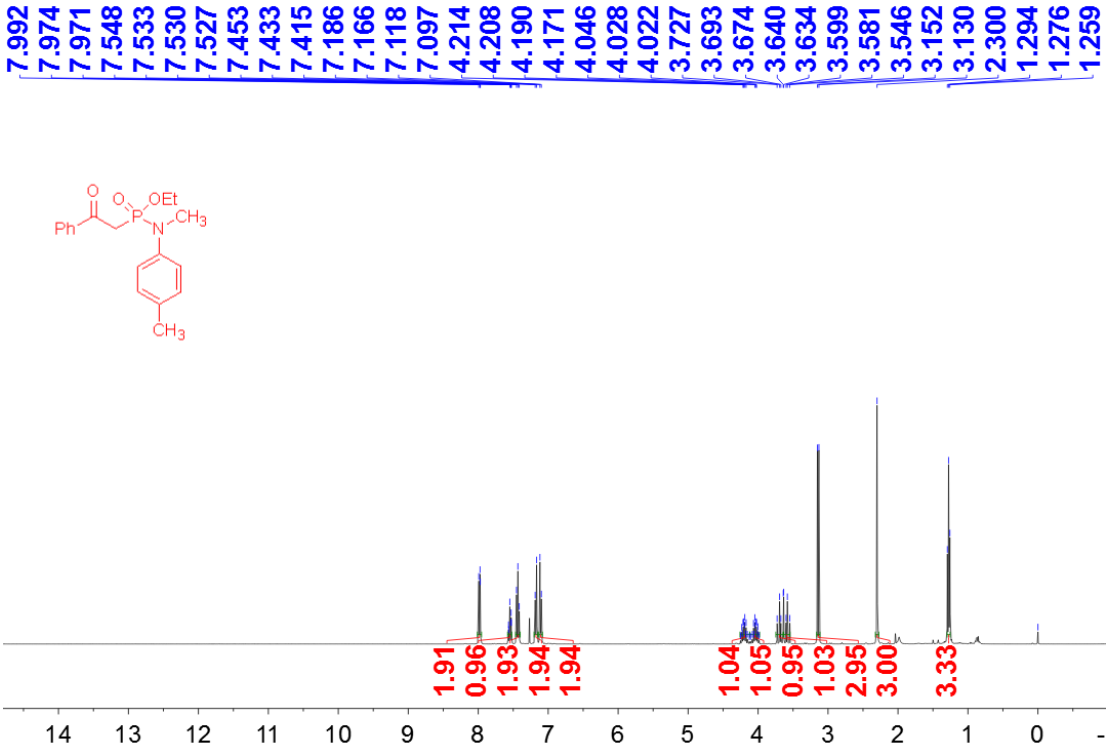
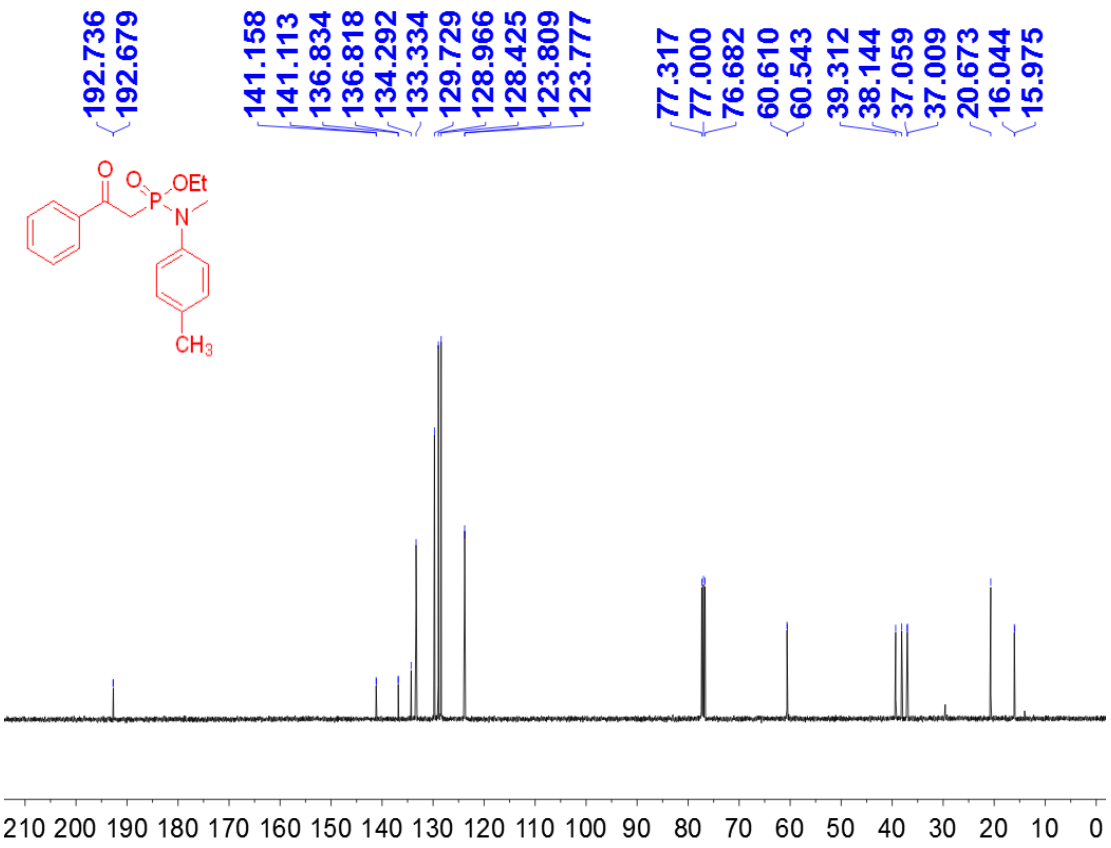
Ethyl *N*-benzyl-*N*-(4-methoxyphenyl)-*P*-(2-oxo-2-phenylethyl)phosphonamidate (3e)





Ethyl *N*-methyl-*P*-(2-oxo-2-phenylethyl)-*N*-(4-methylphenyl)phosphonamidate (3f)

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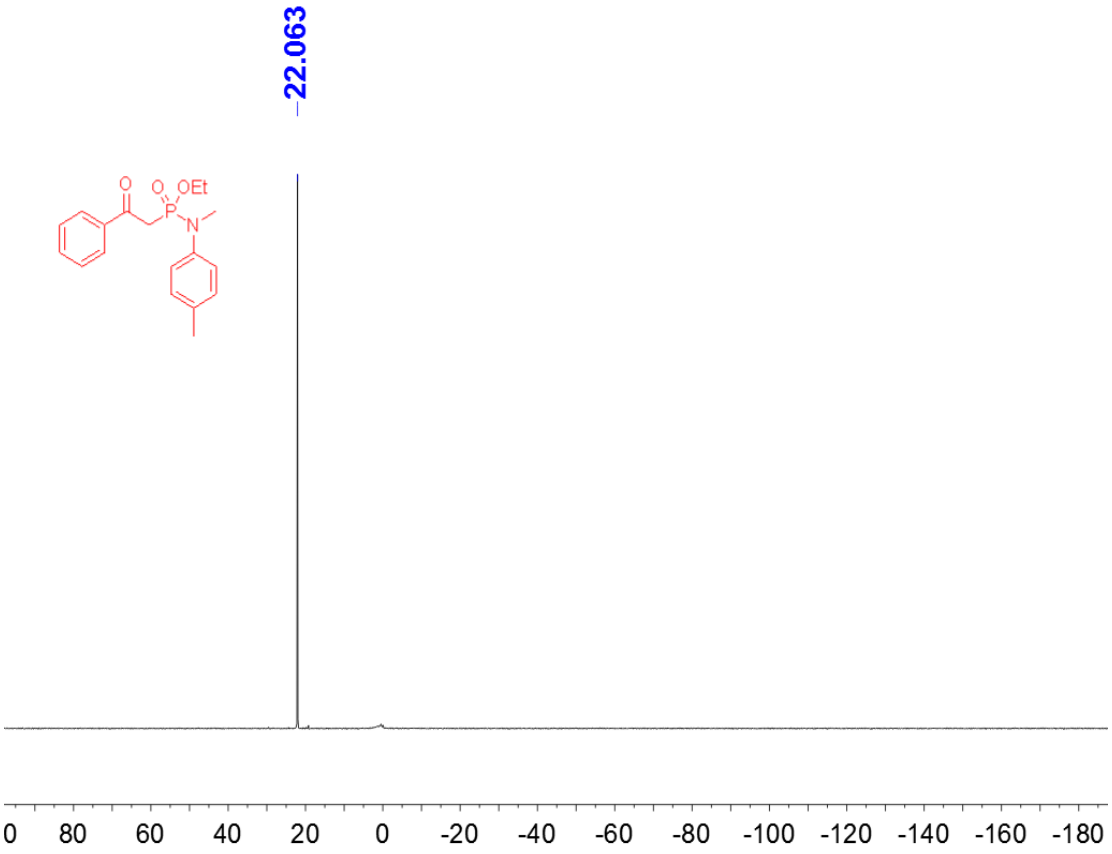
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OEt
P
N
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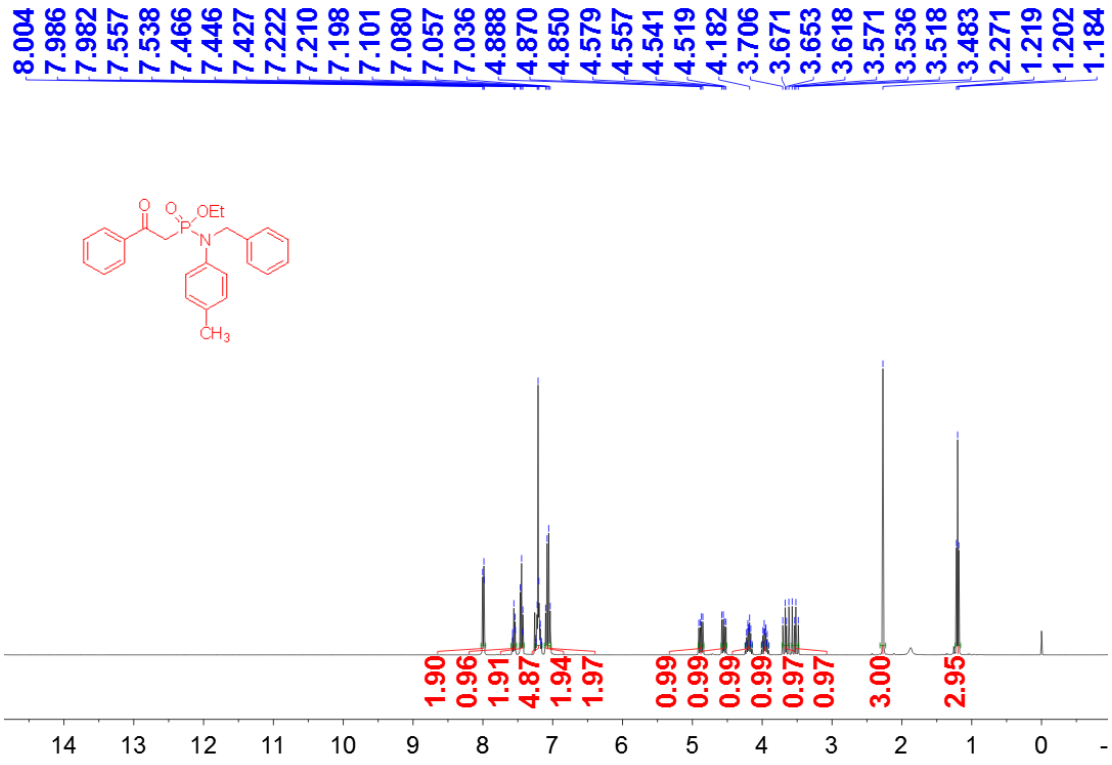
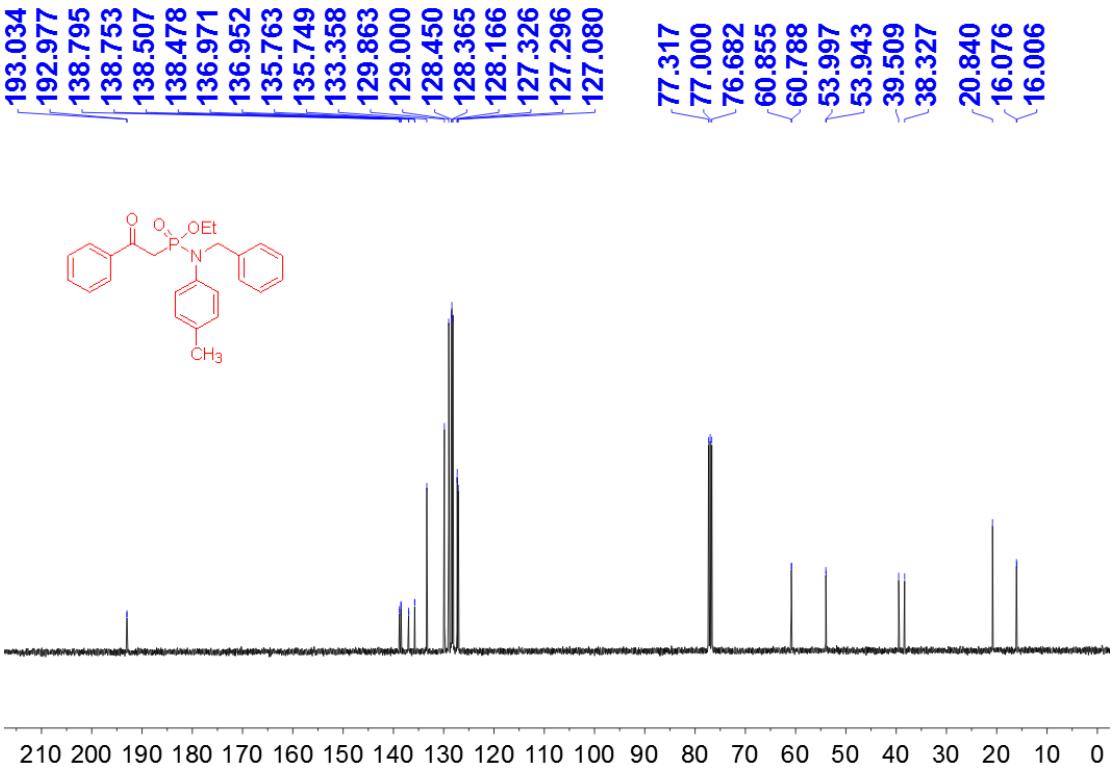
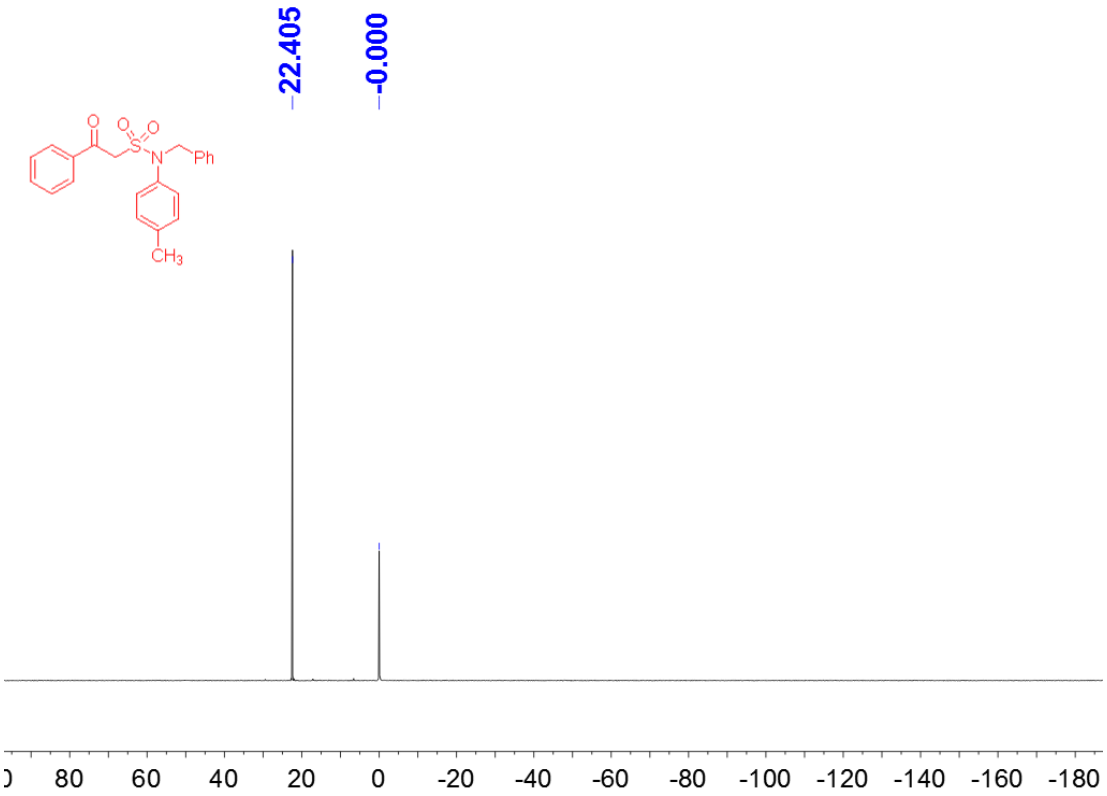
Ethyl *N*-benzyl-*P*-(2-oxo-2-phenylethyl)-*N*-(4-methylphenyl)phosphonamidate (3g)







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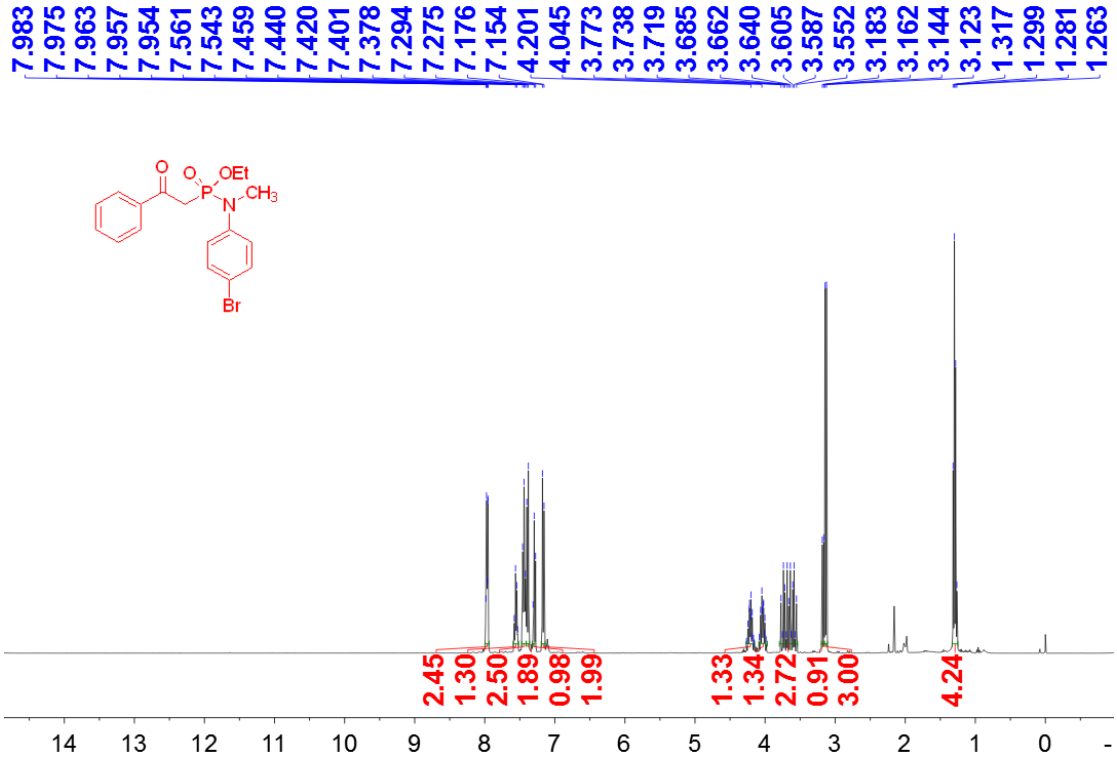

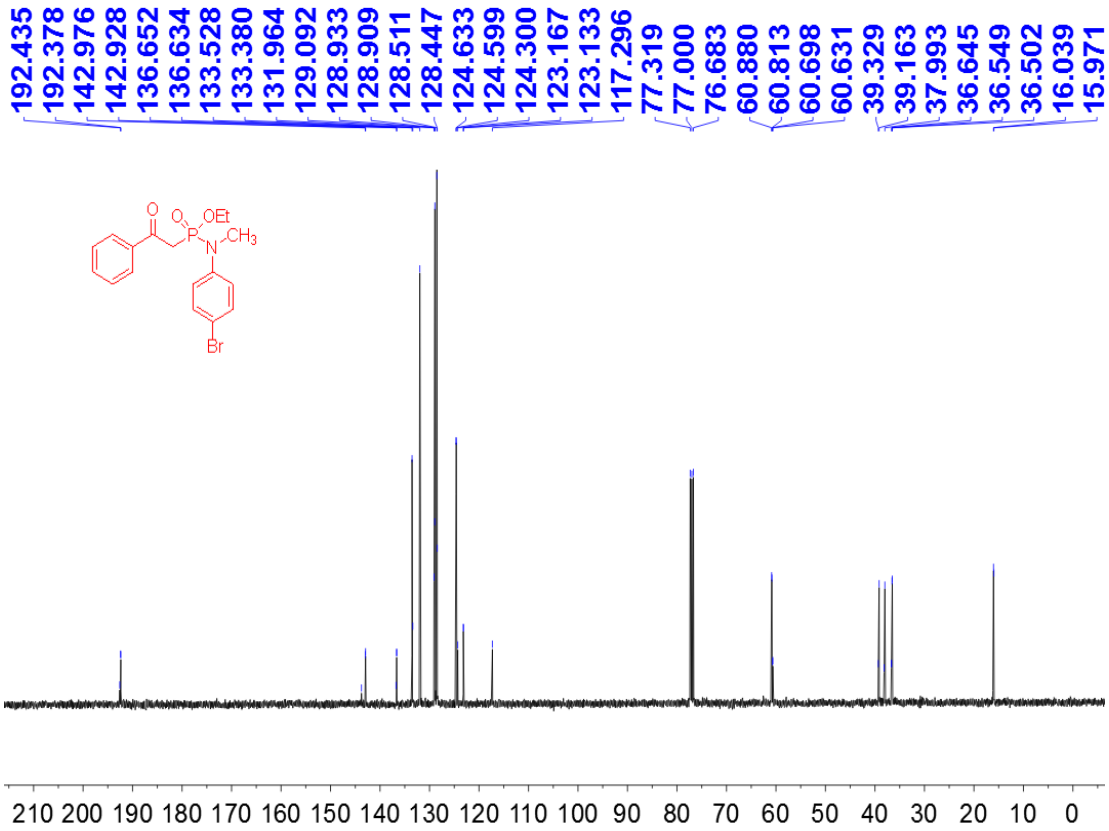
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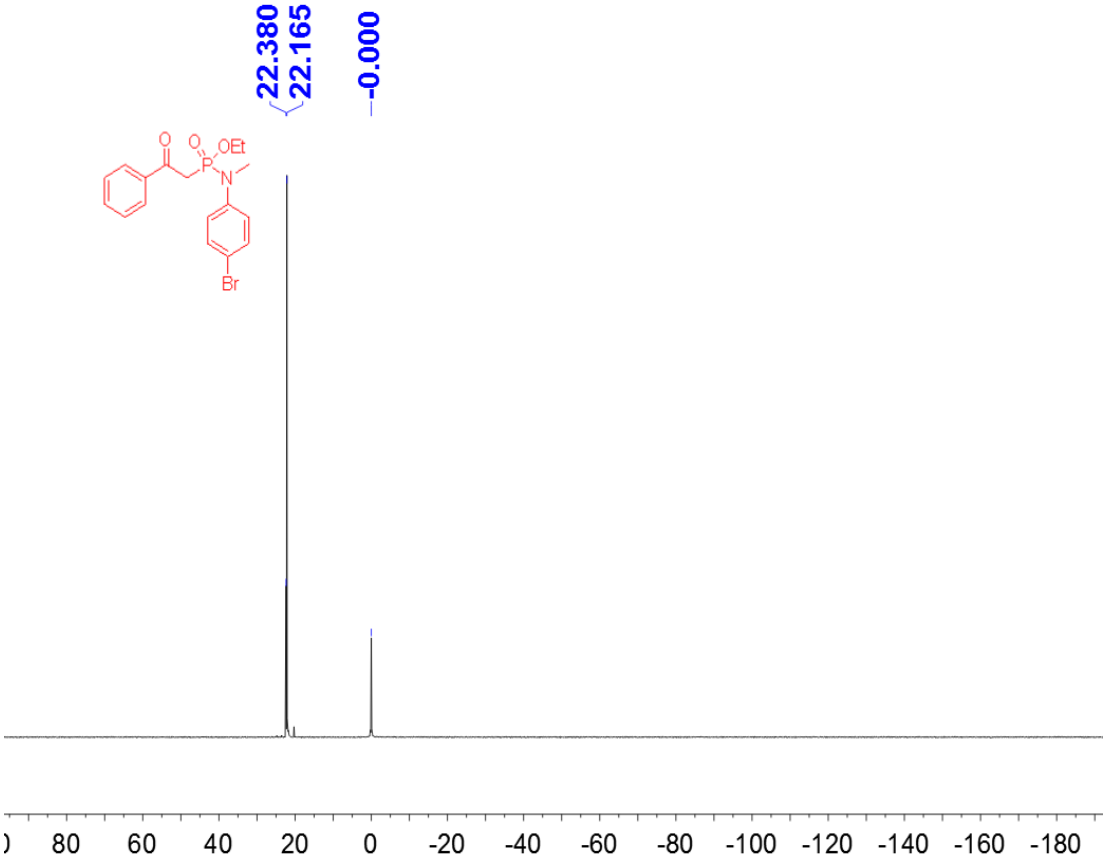
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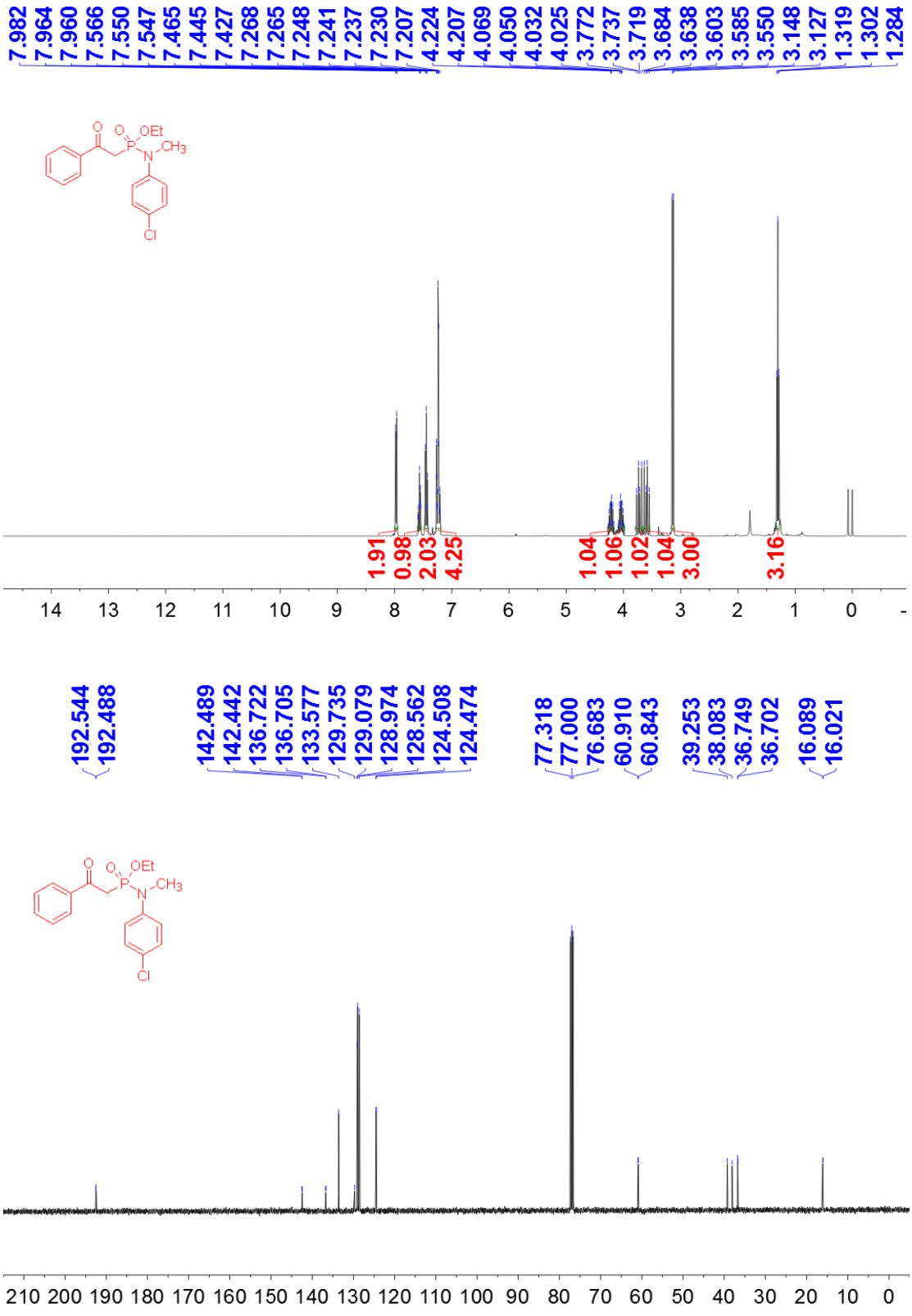

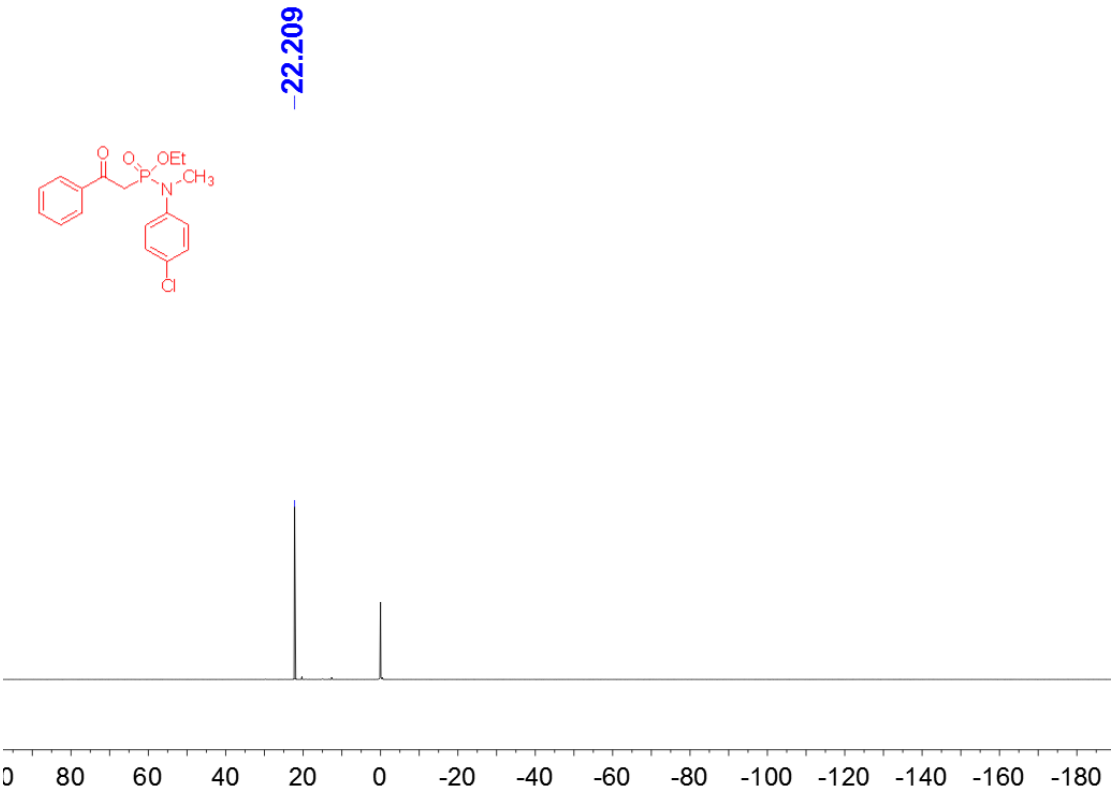

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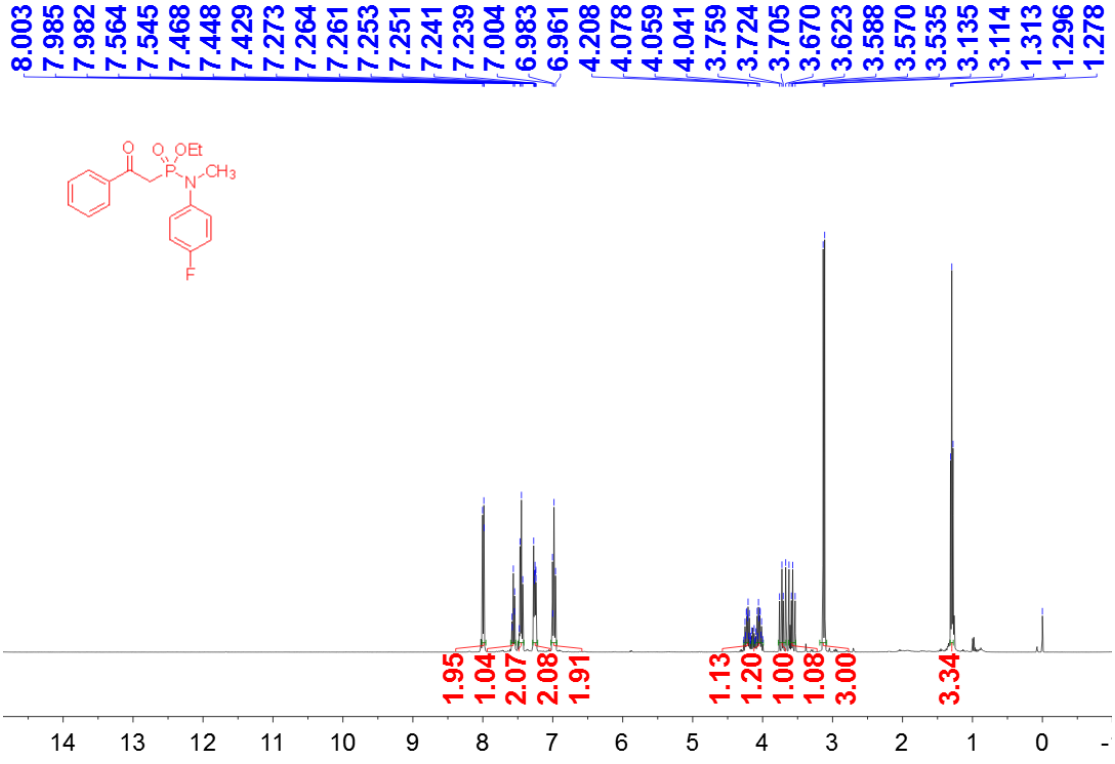

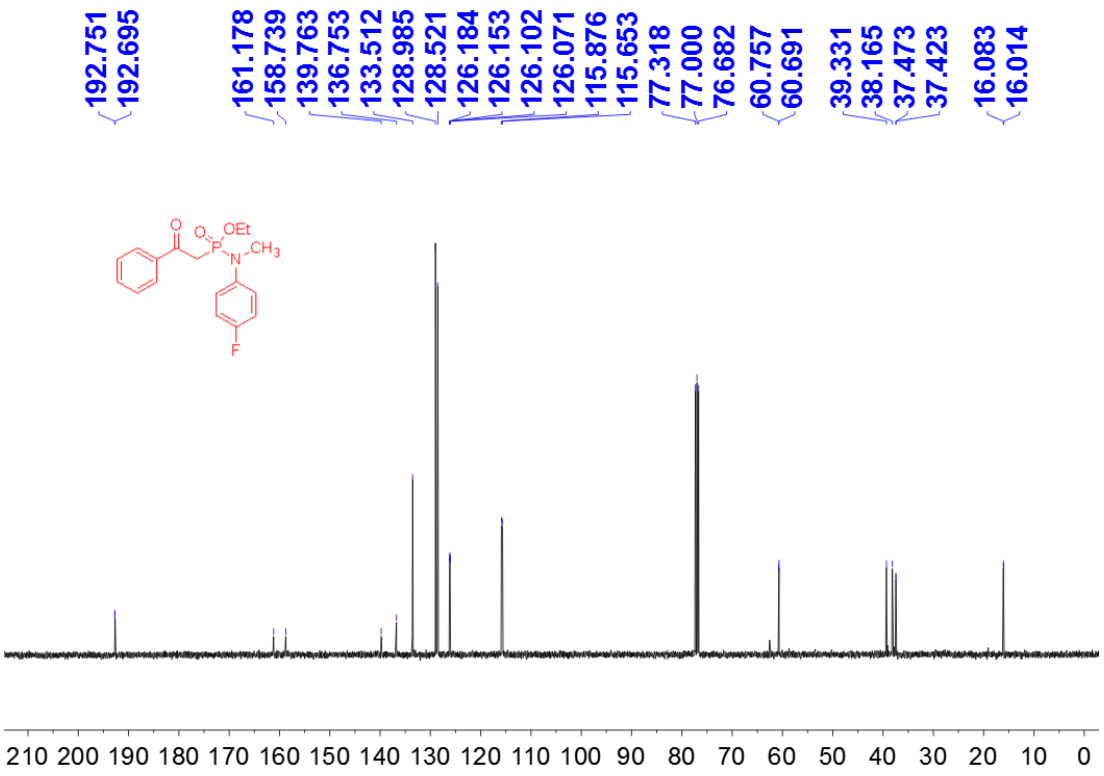
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115.653
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60.757
60.691
39.331
38.165
37.473
37.423
16.083
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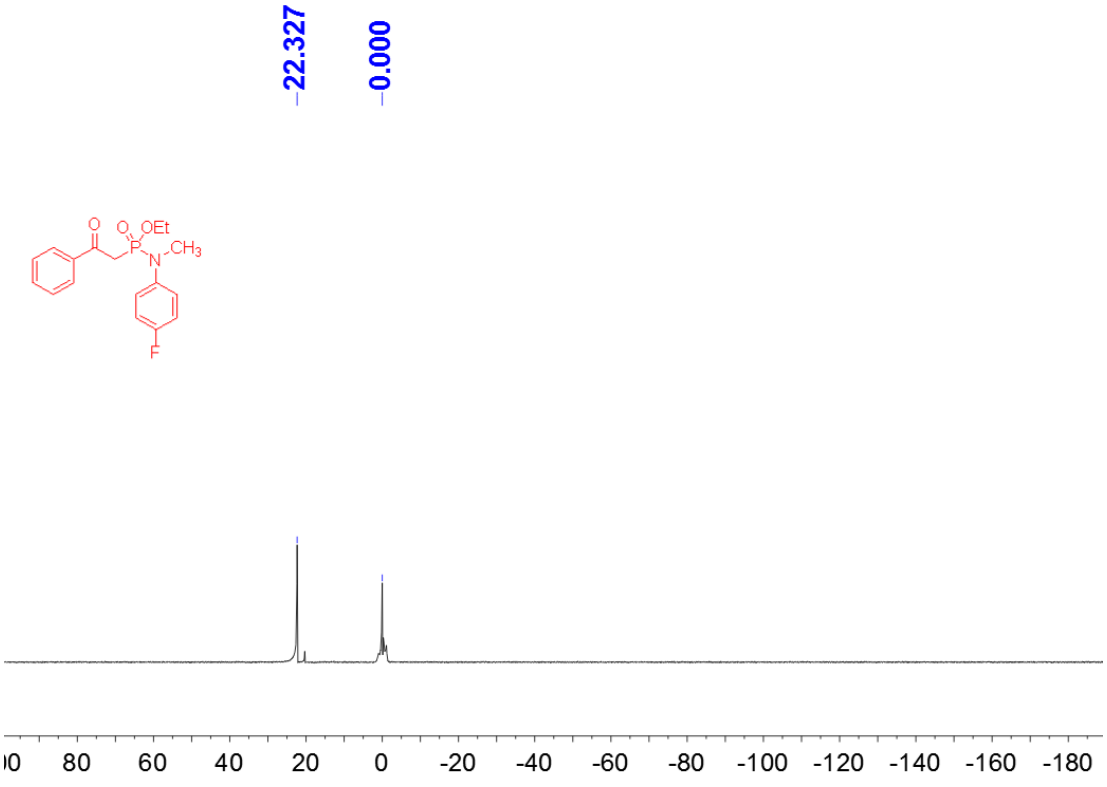
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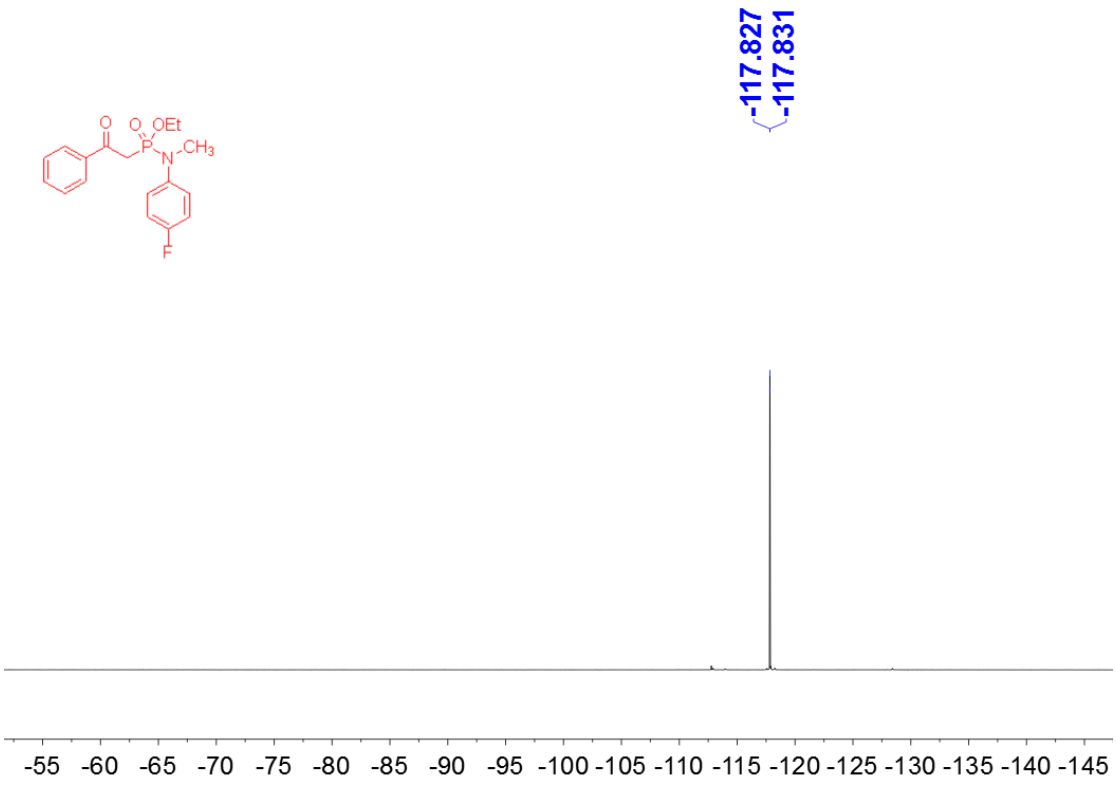

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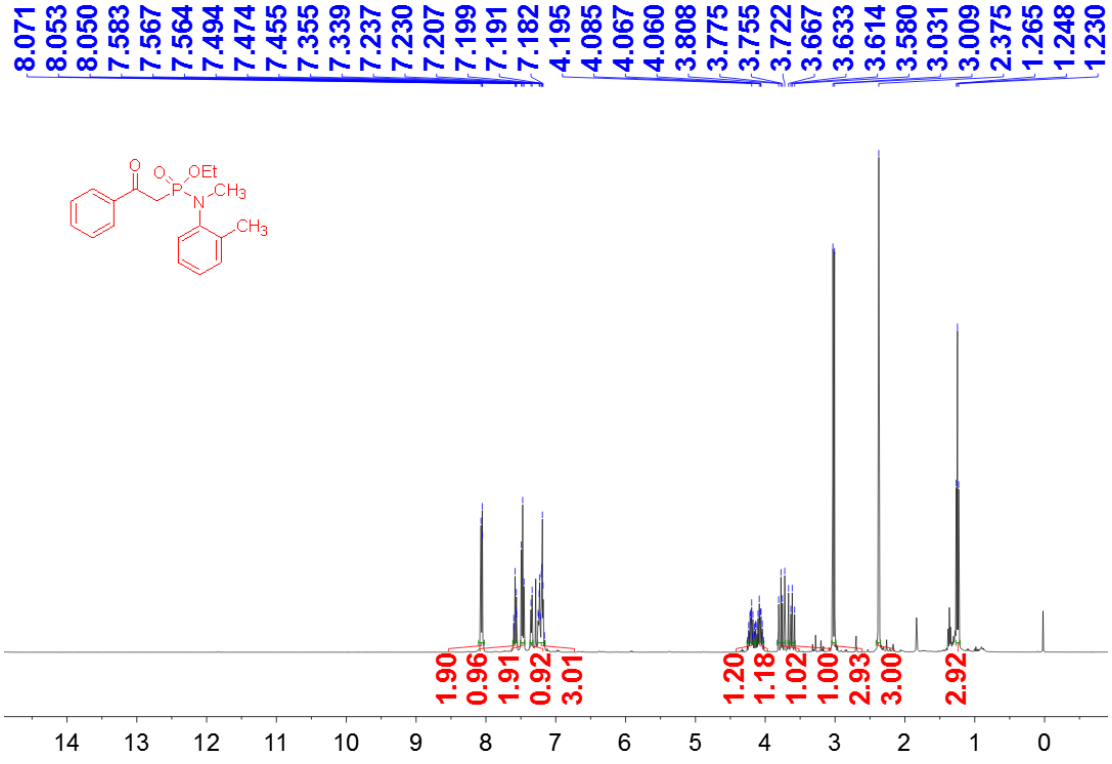

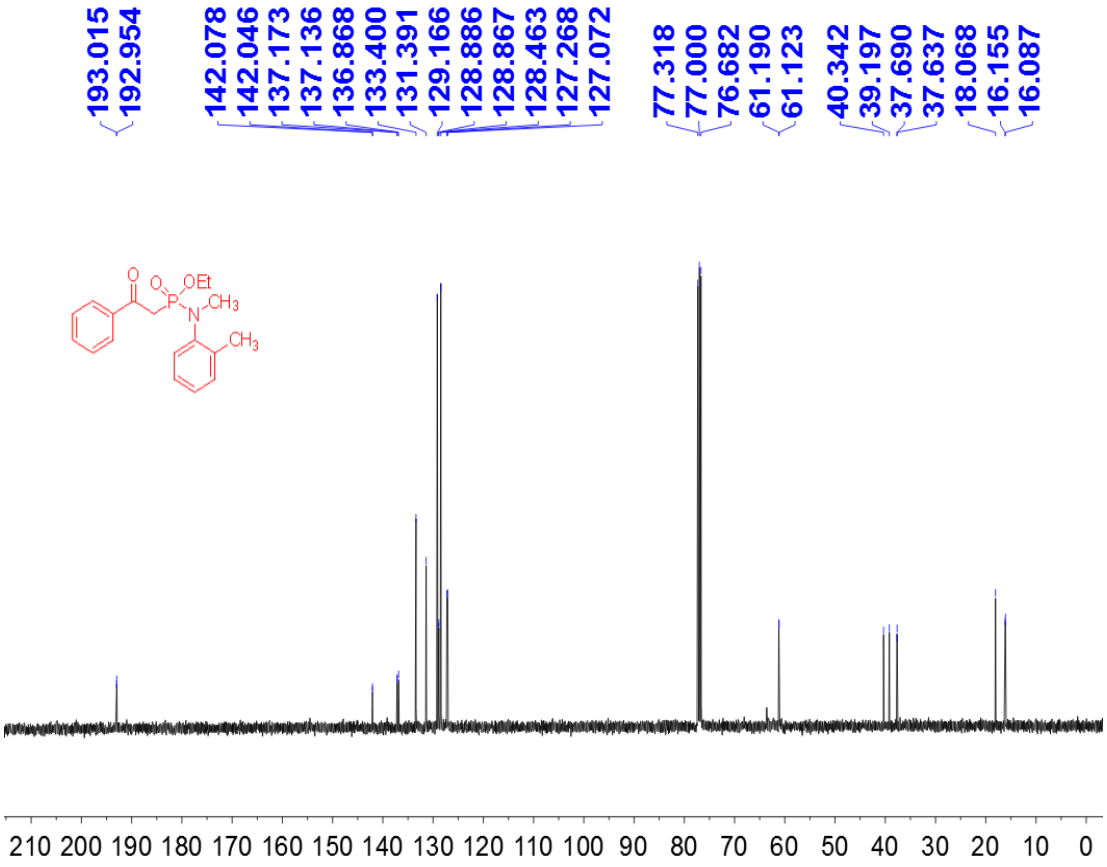
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136.868
133.400
131.391
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128.886
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128.463
127.268
127.072
77.318
77.000
76.682
61.190
61.123
40.342
39.197
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16.087
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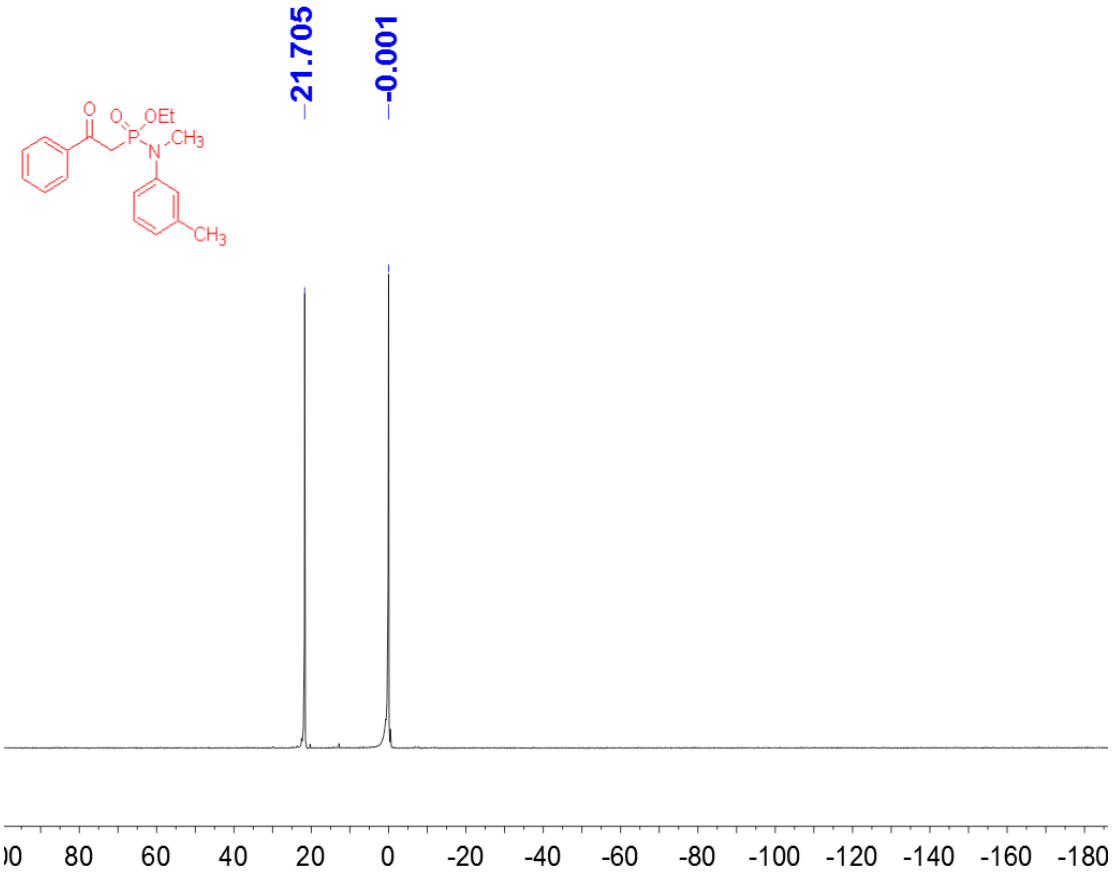
21.705
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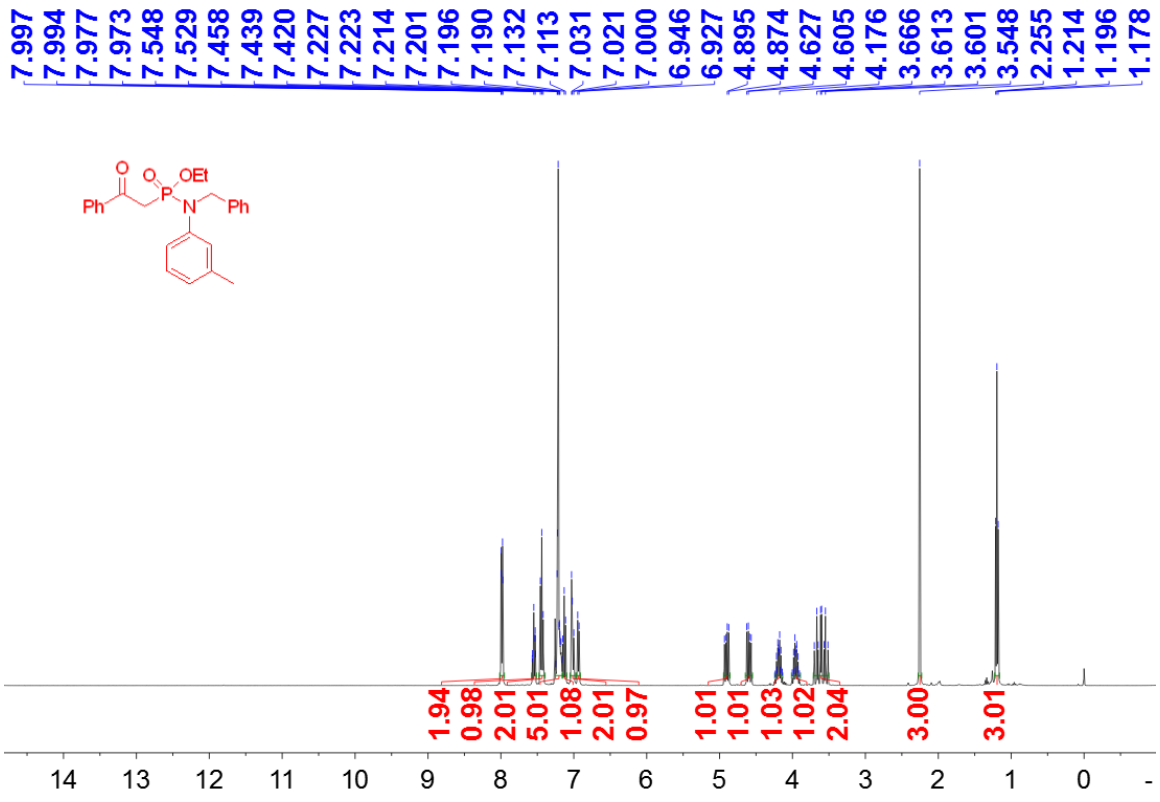
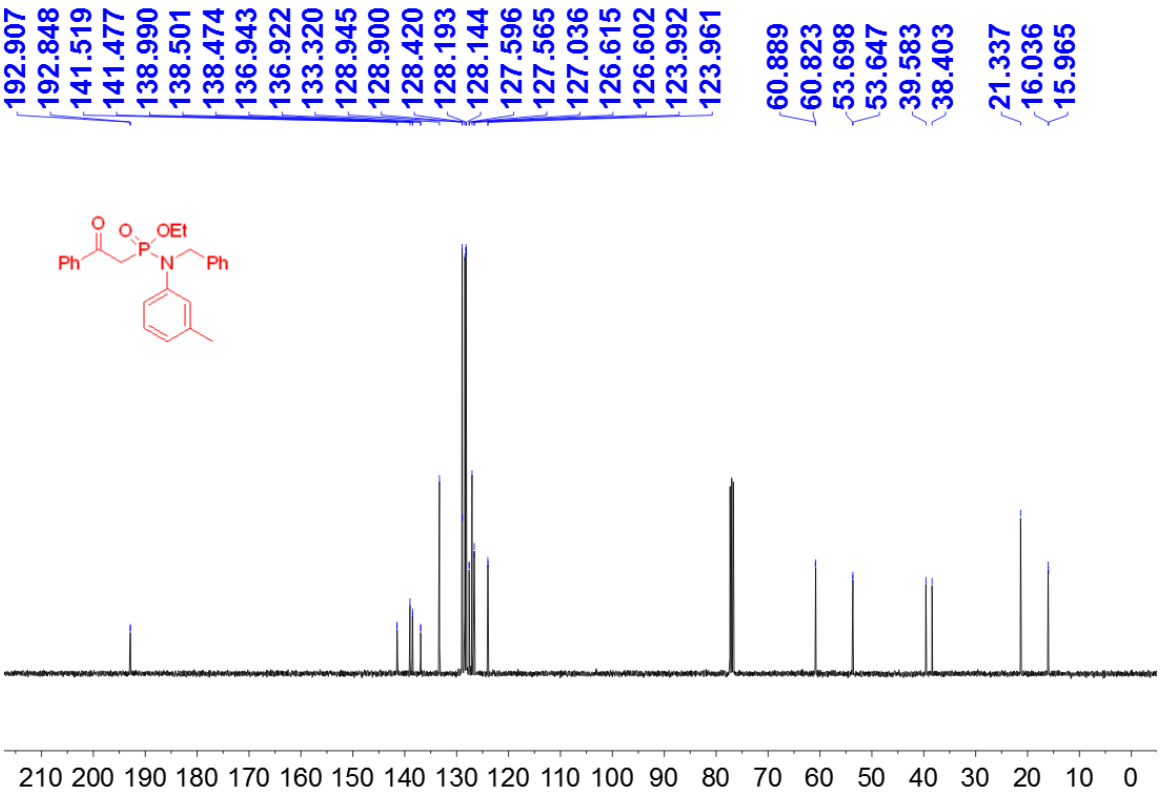
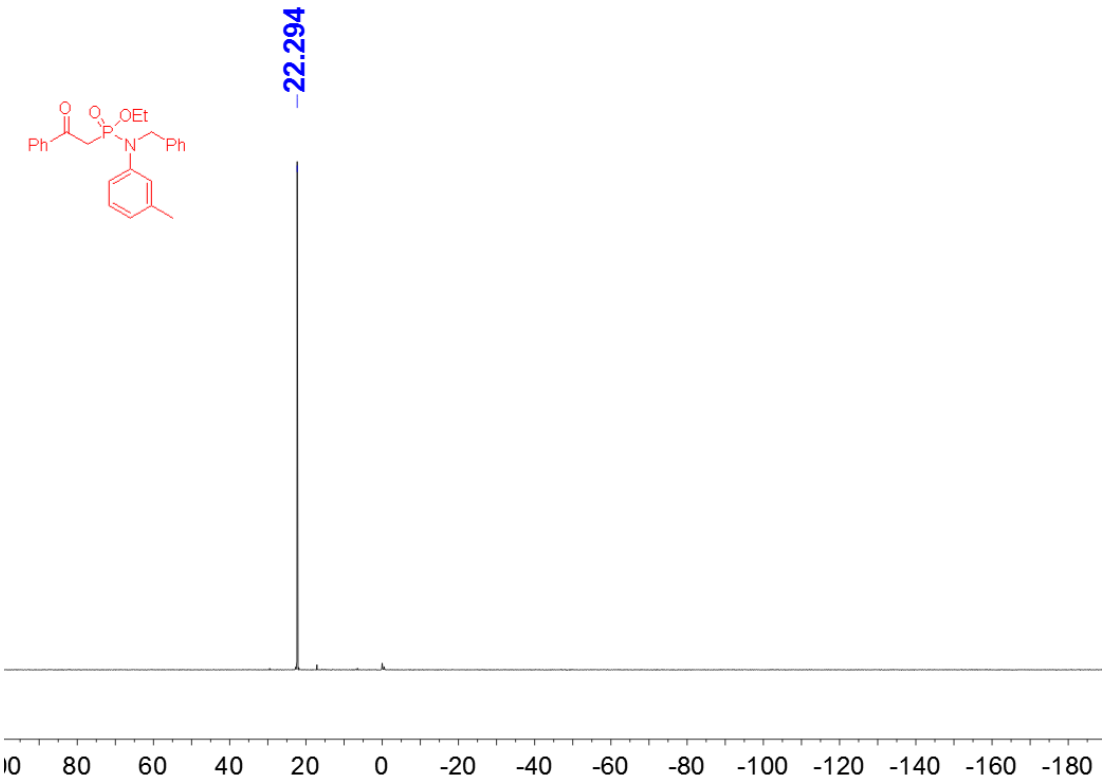
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

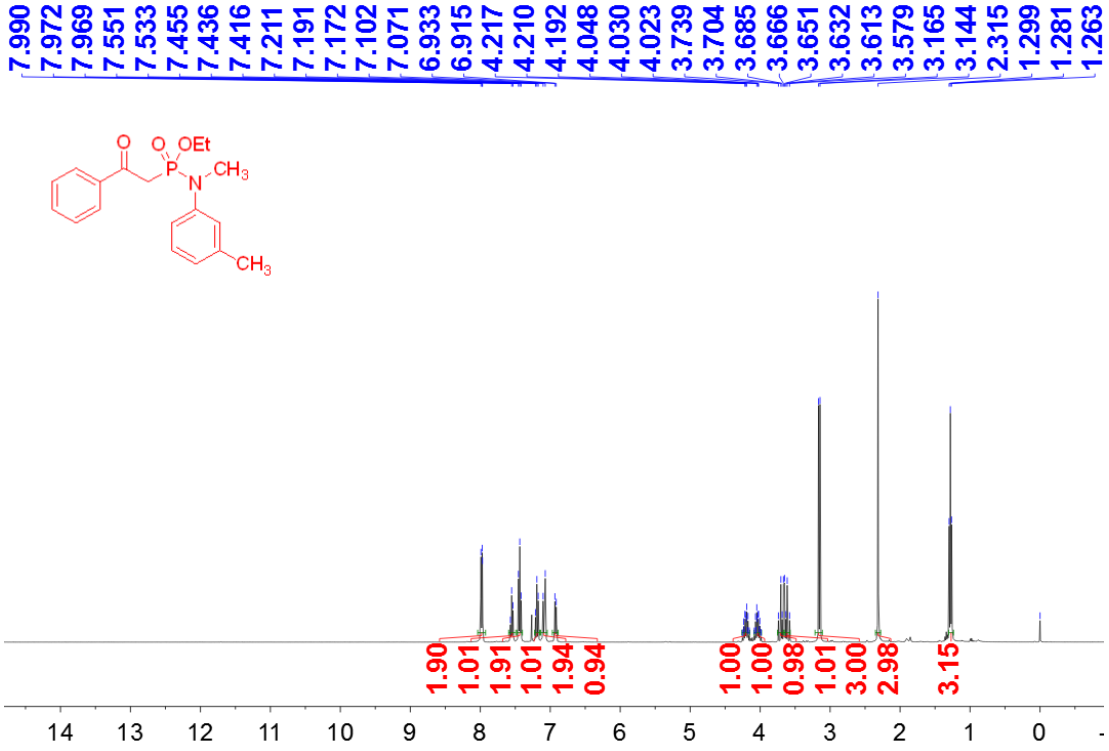
Ethyl *N*-benzyl-*P*-(2-oxo-2-phenylethyl)-*N*-(3-methylphenyl)phosphonamidate (3l)

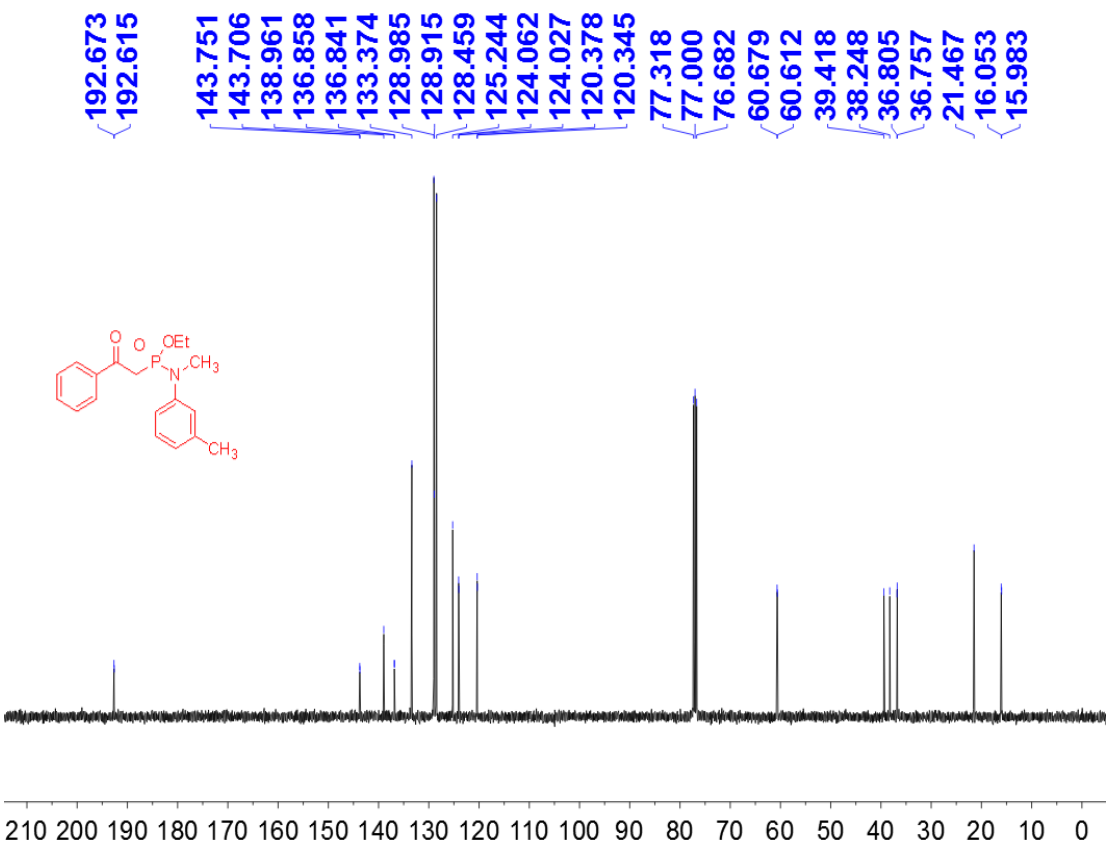






Ethyl *N*-methyl-*P*-(2-oxo-2-phenylethyl)-*N*-(3-methylphenyl)phosphonamidate (3m)

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143.706
138.961
136.858
136.841
133.374
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128.915
128.459
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124.062
124.027
120.378
120.345
77.318
77.000
76.682
60.679
60.612
39.418
38.248
36.805
36.757
21.467
16.053
15.983
OEt
CH3
CH3
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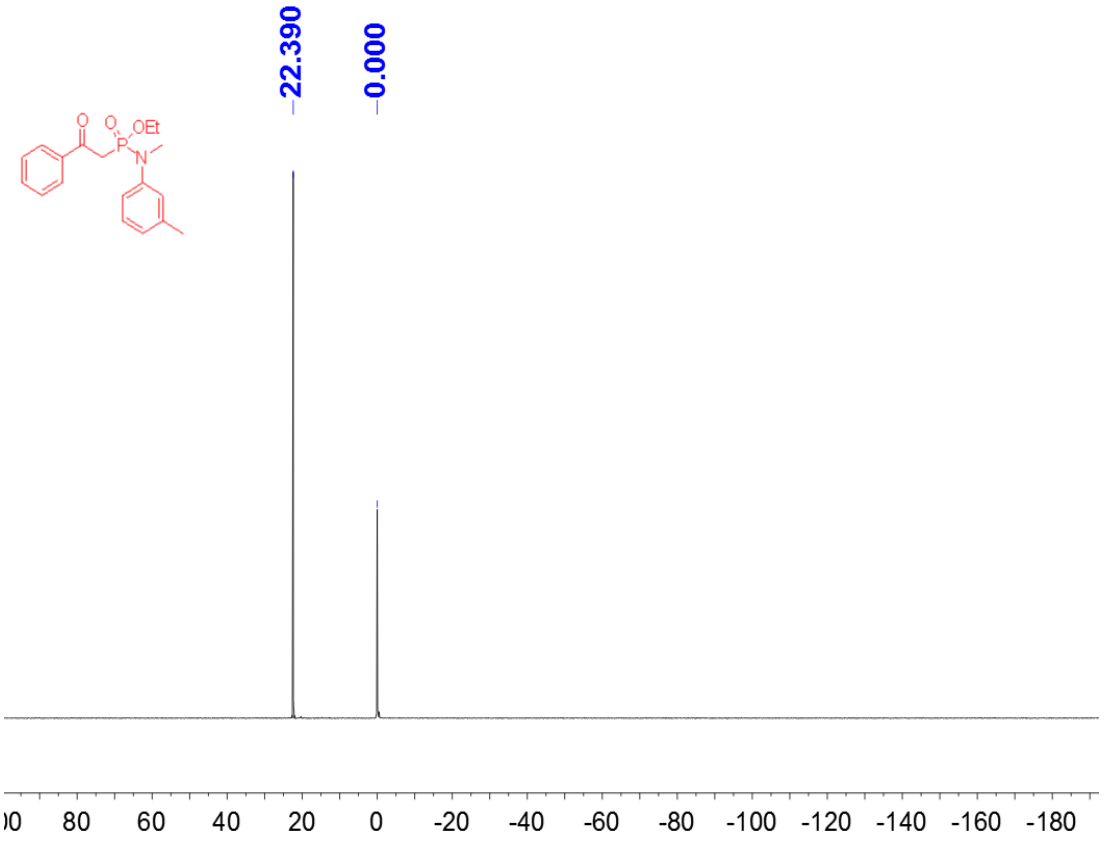
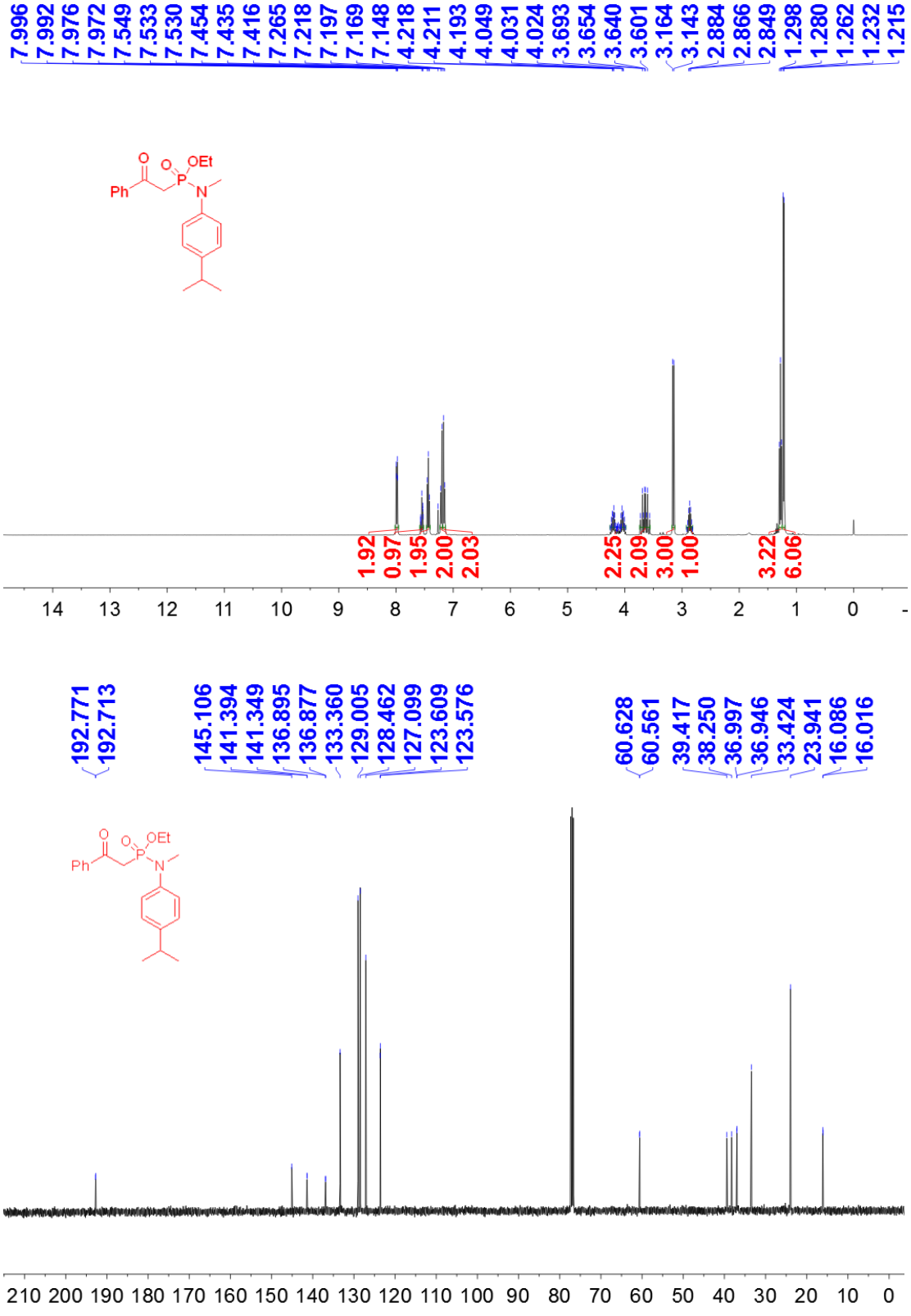
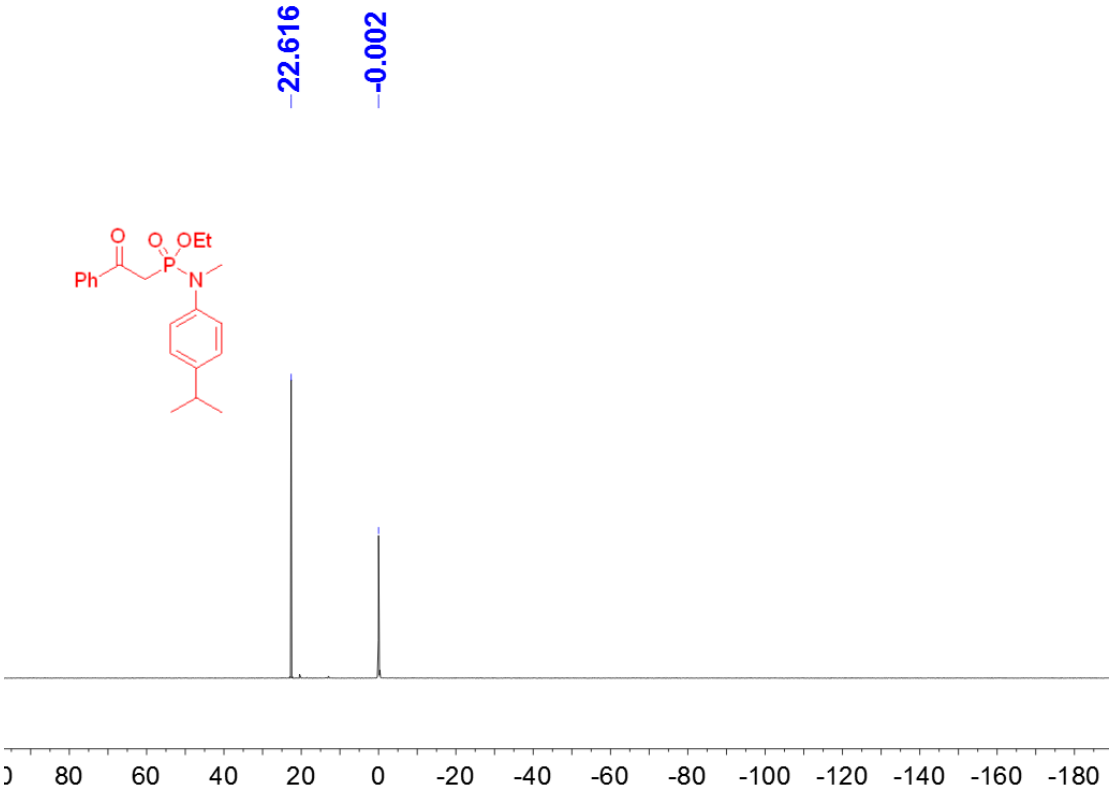
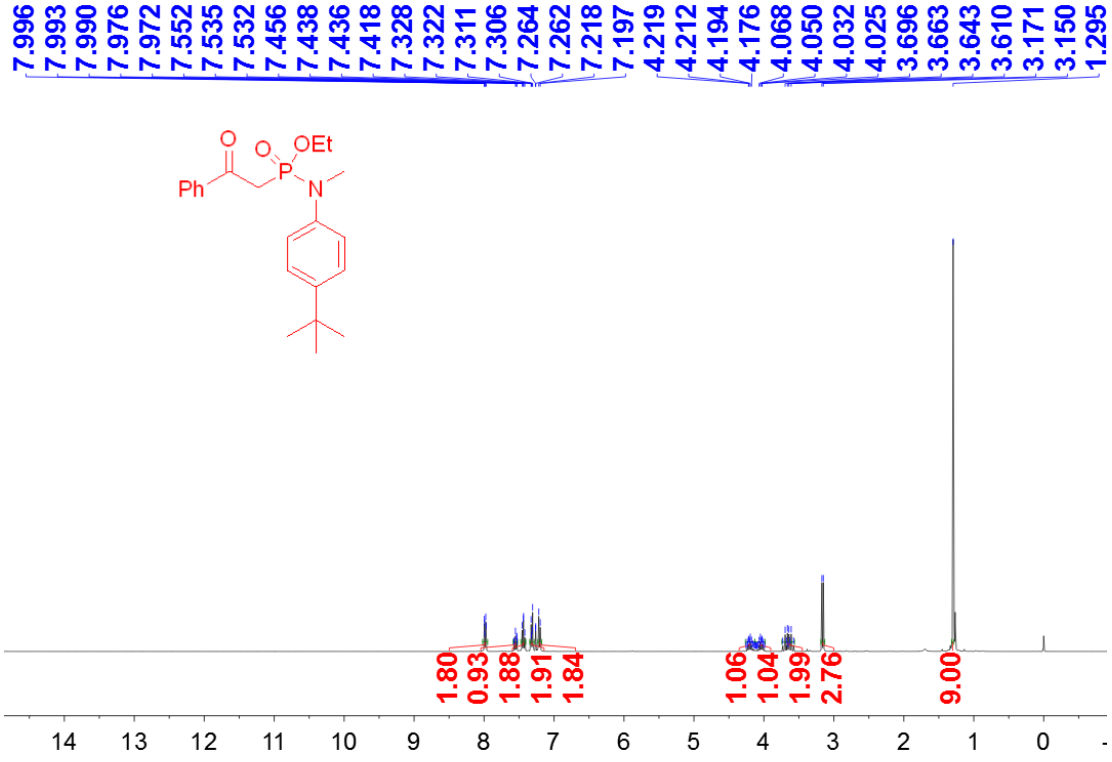

22.390
0.000
OEt
)0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

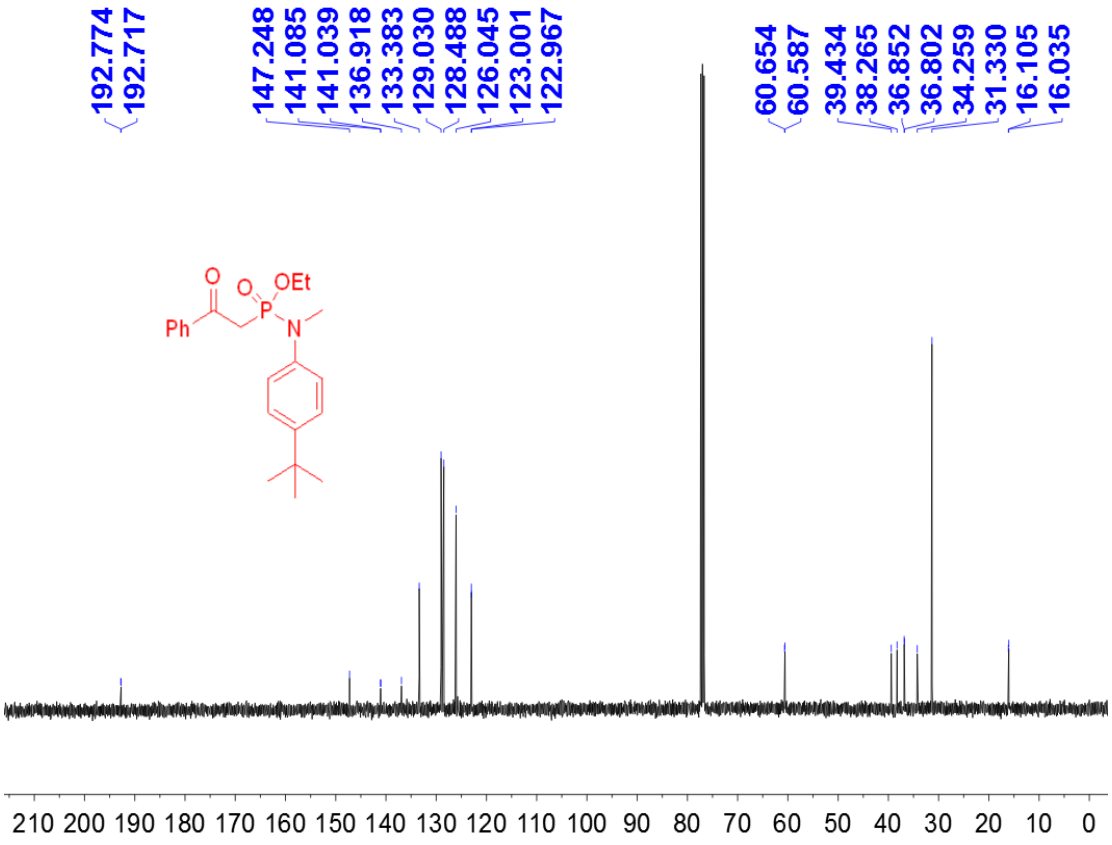
Ethyl *N*-(4-isopropylphenyl)-*N*-methyl-*P*-(2-oxo-2-phenylethyl)phosphonamidate (3n)





Ethyl *N*-[4-(*tert*-butyl)phenyl]-*N*-methyl-*P*-(2-oxo-2-phenylethyl)phosphonamidate (3o)

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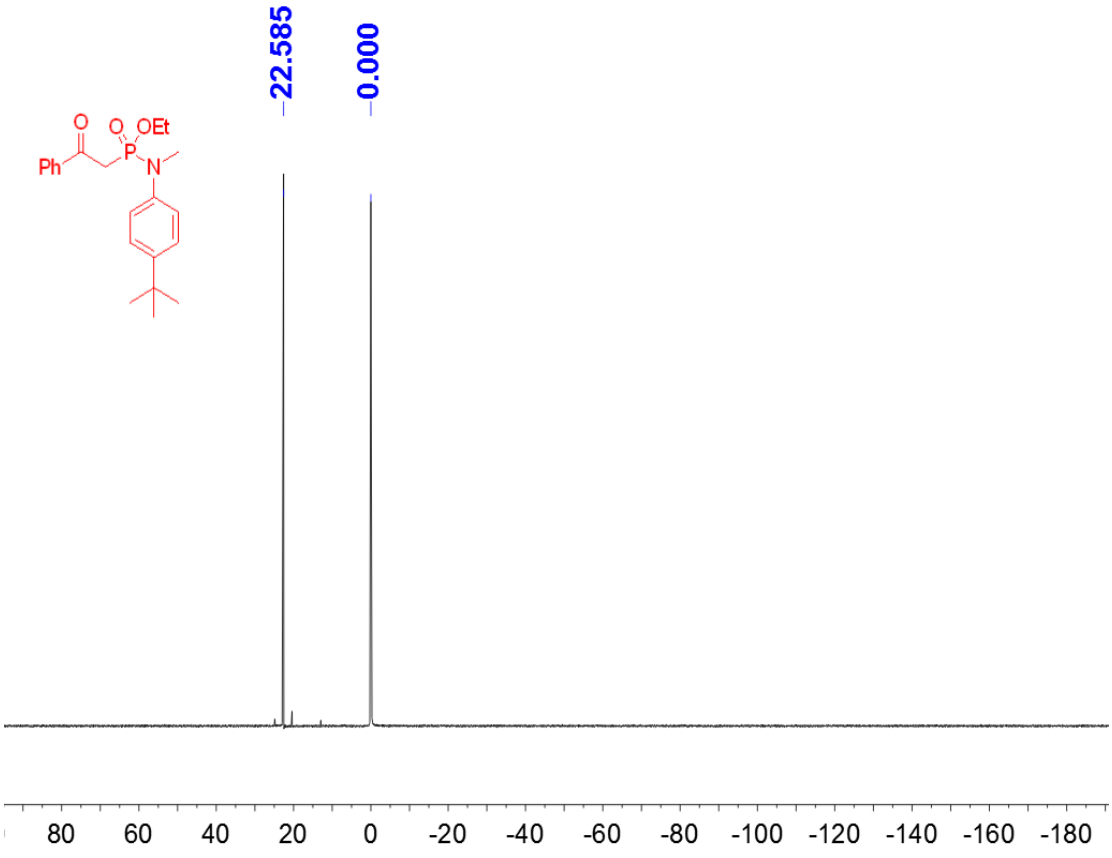
141.039
136.918
133.383
129.030
128.488
126.045
123.001
122.967
60.654
60.587
39.434
38.265
36.852
36.802
34.259
31.330
16.105
16.035
O
O
OEt
Ph
P
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


22.585
0.000
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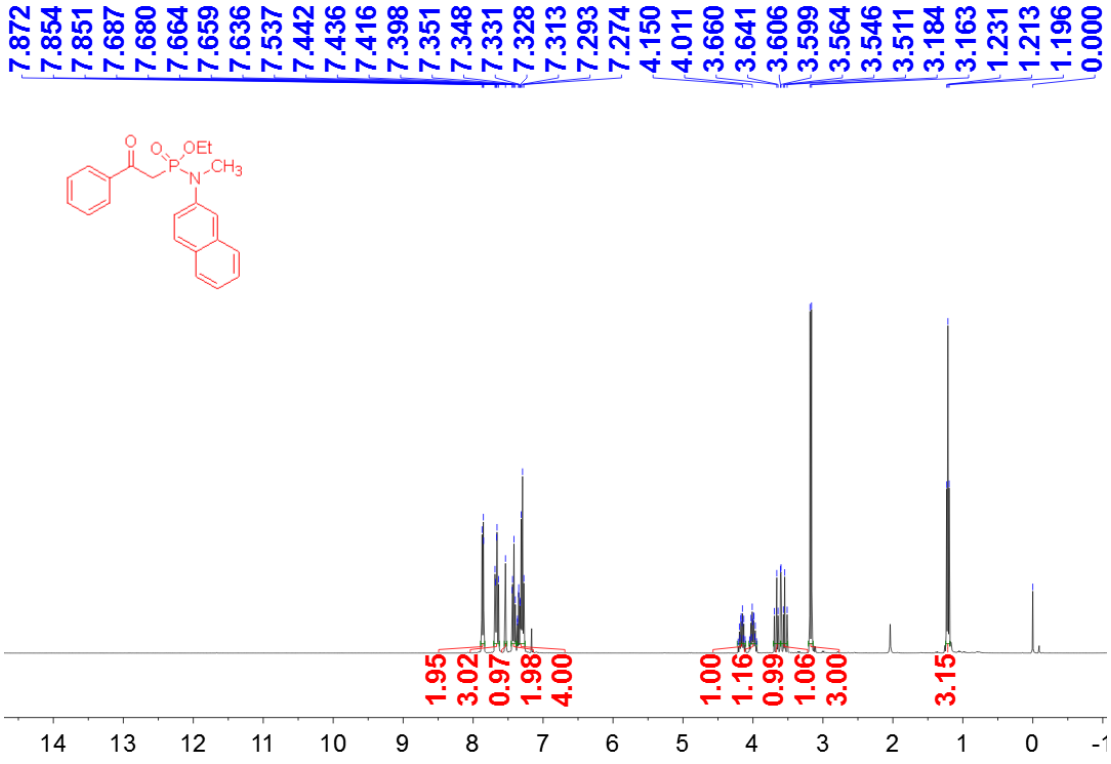
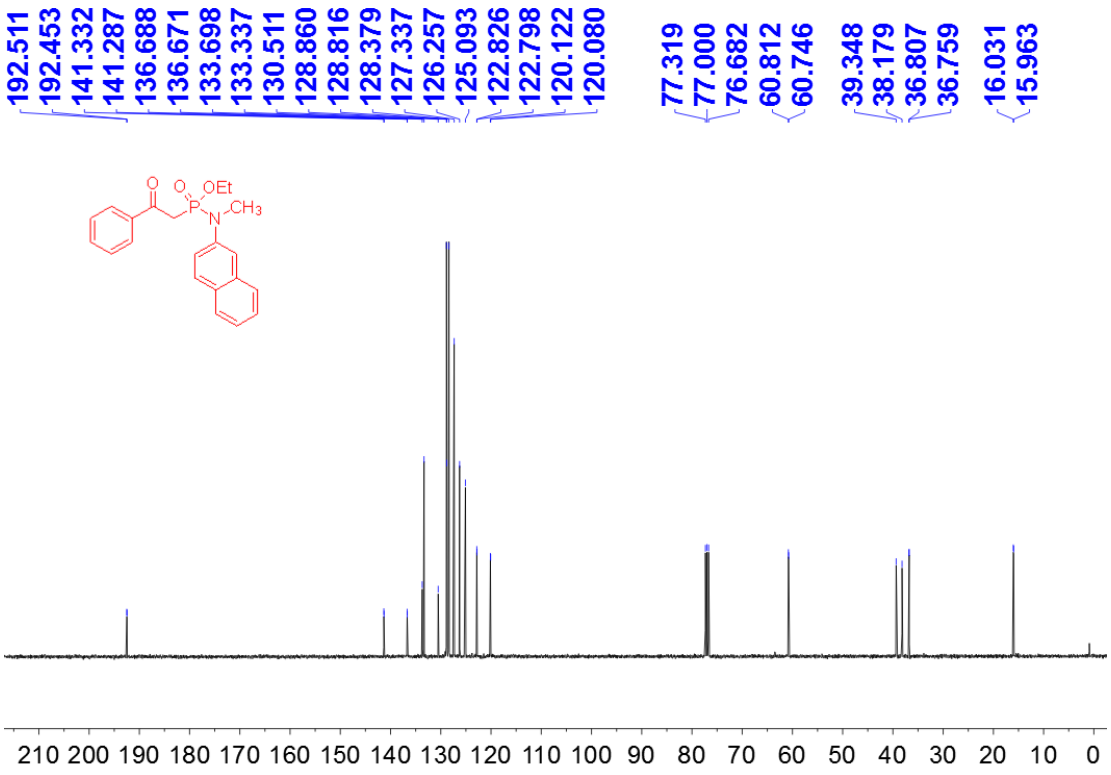
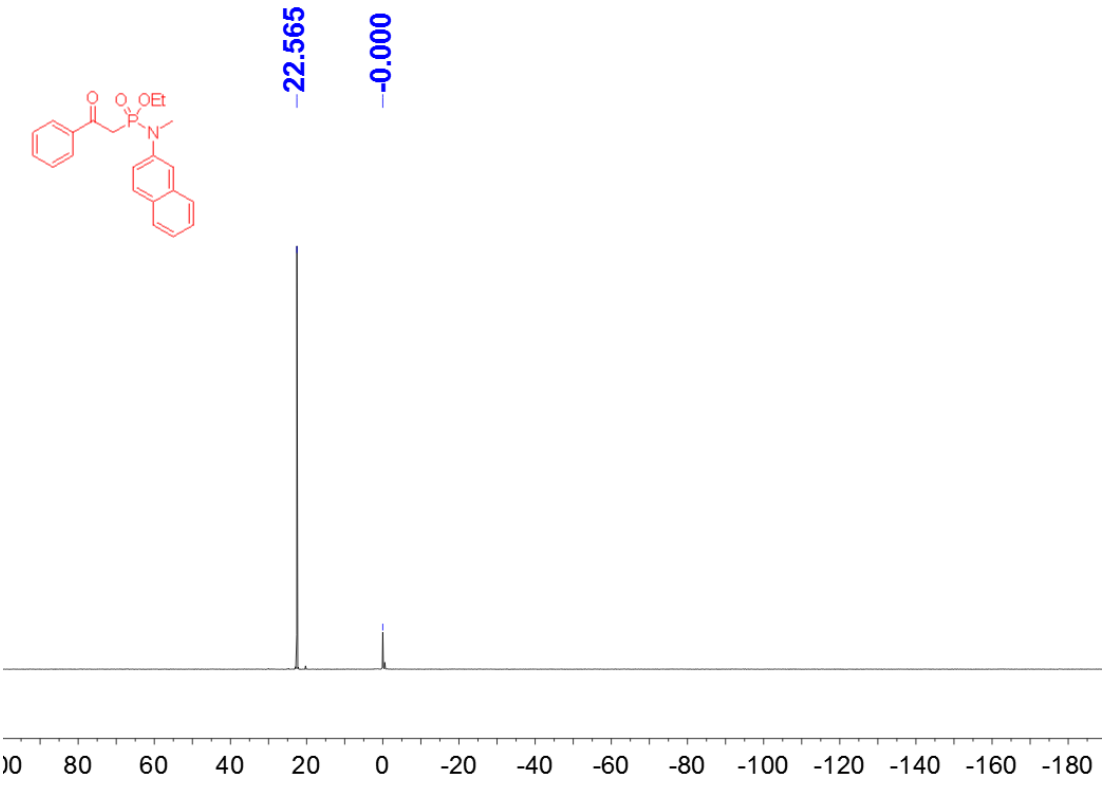
OEt
Ph
P
N
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

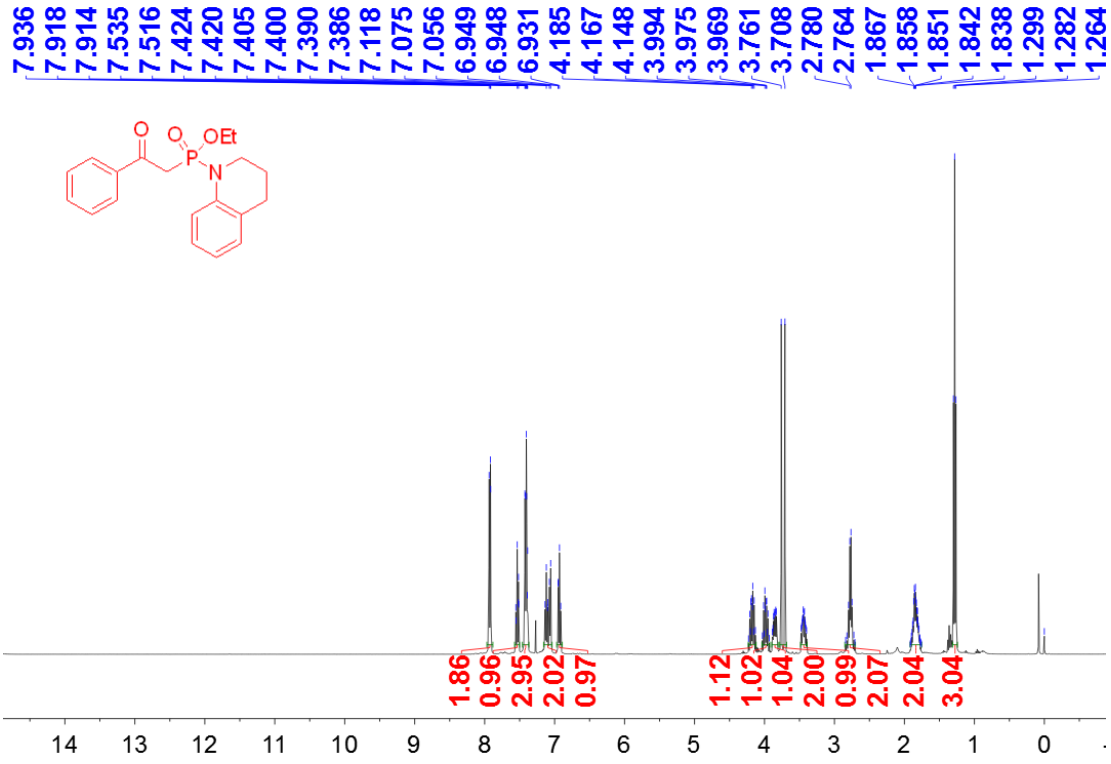
Ethyl *N*-methyl-*N*-(naphthalen-2-yl)-*P*-(2-oxo-2-phenylethyl)phosphonamidate (3p)

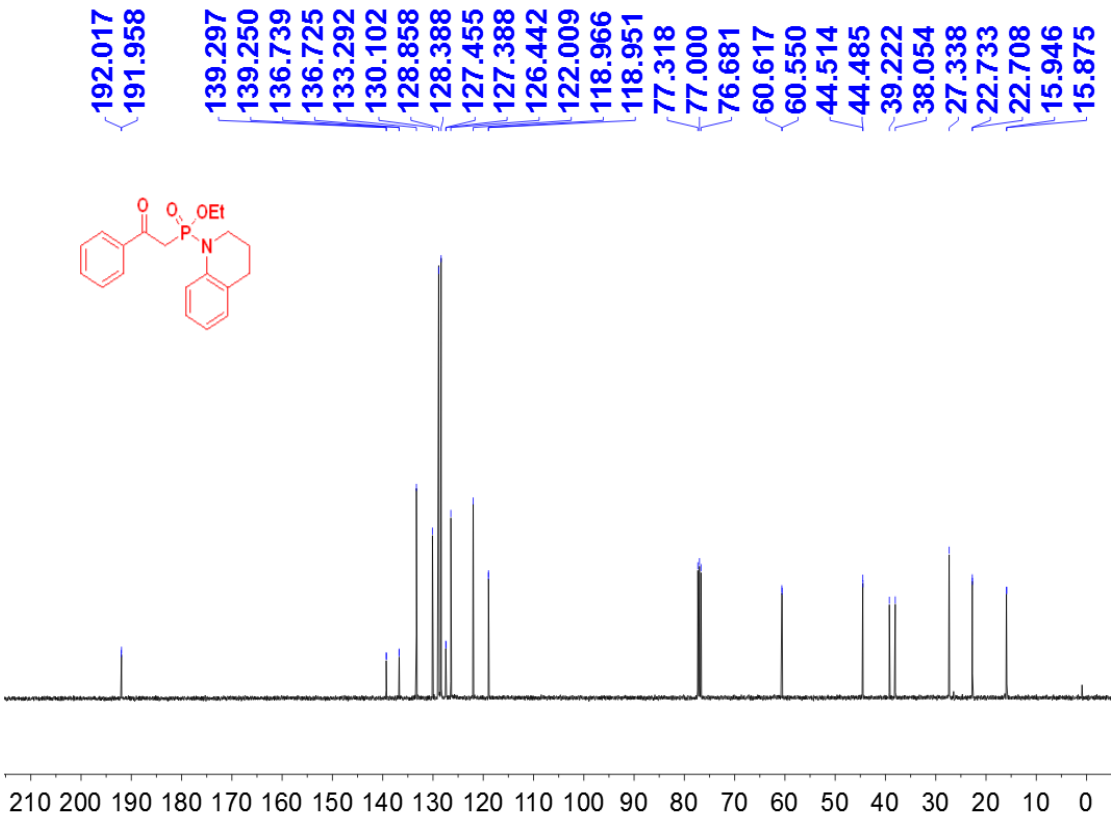






Ethyl (3,4-dihydroquinolin-1(2*H*)-yl)(2-oxo-2-phenylethyl)phosphinate (3q)

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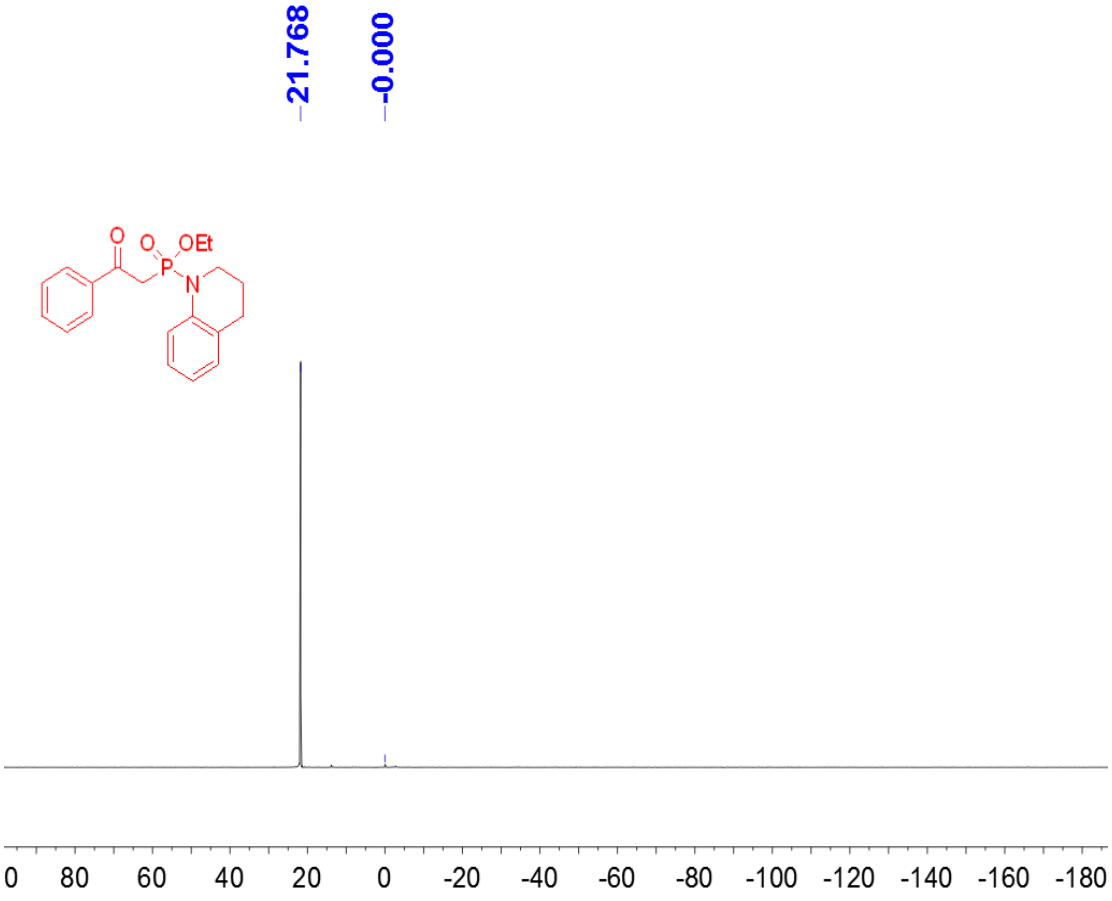
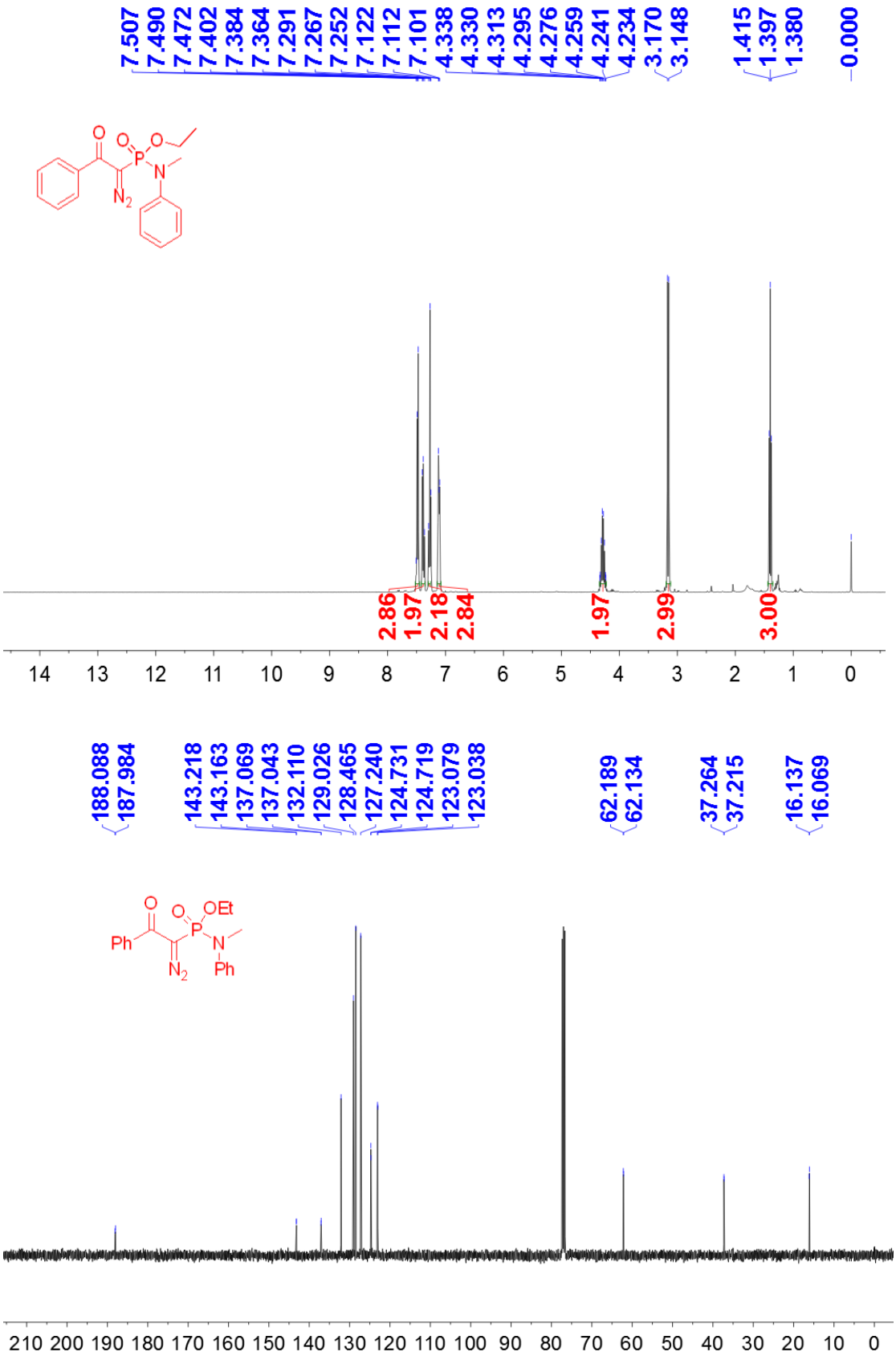
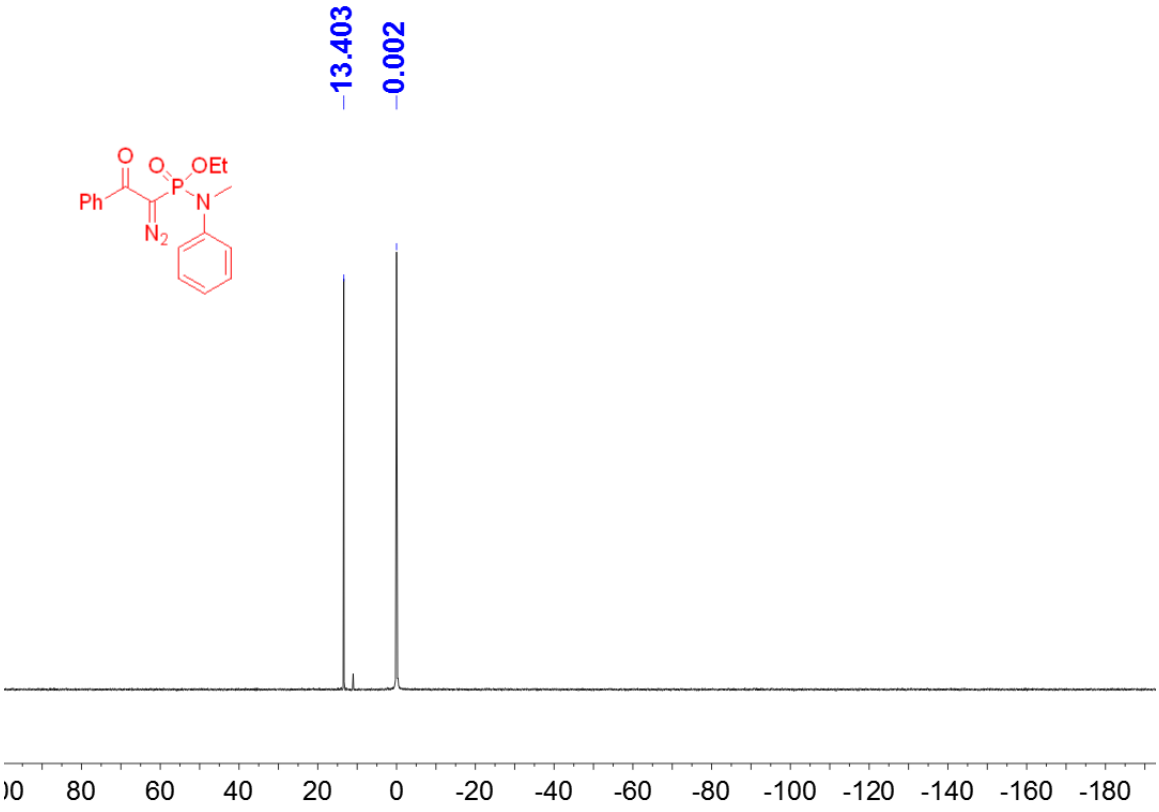
136.725
133.292
130.102
128.858
128.388
127.455
127.388
126.442
122.009
118.966
118.951
77.318
77.000
76.681
60.617
60.550
44.514
44.485
39.222
38.054
27.338
22.733
22.708
15.946
15.875
O
O
OEt
P
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

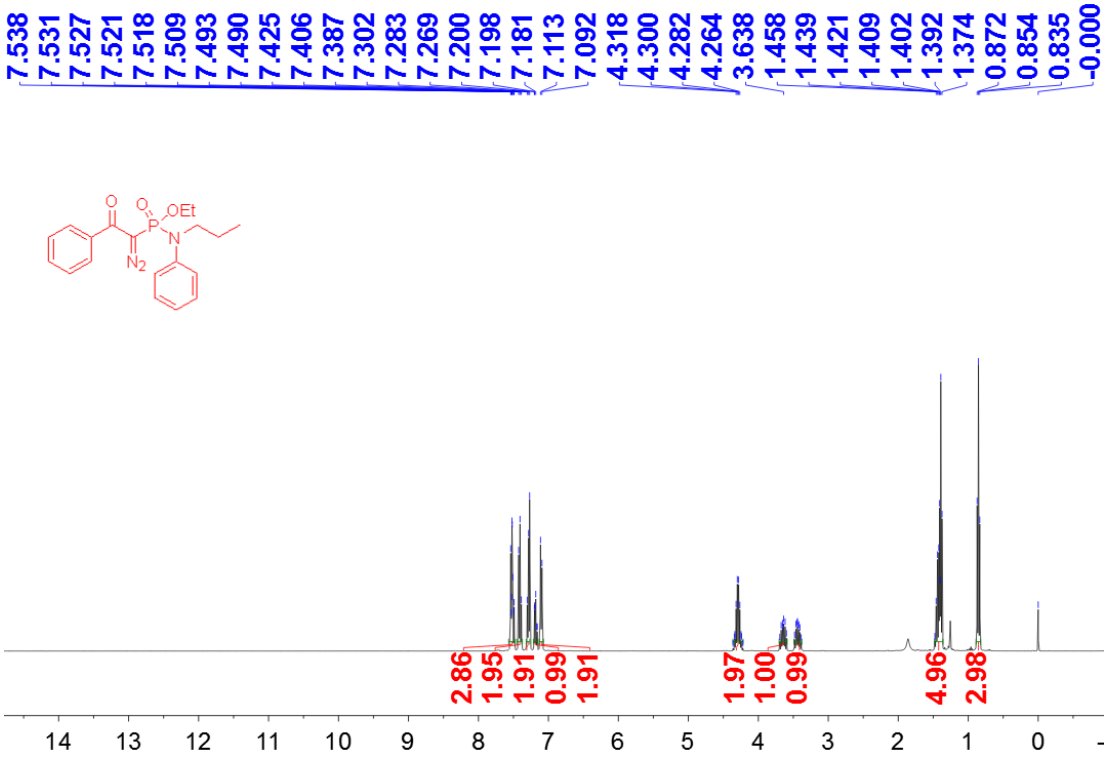

21.768
-0.000
O
O
OEt
P
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

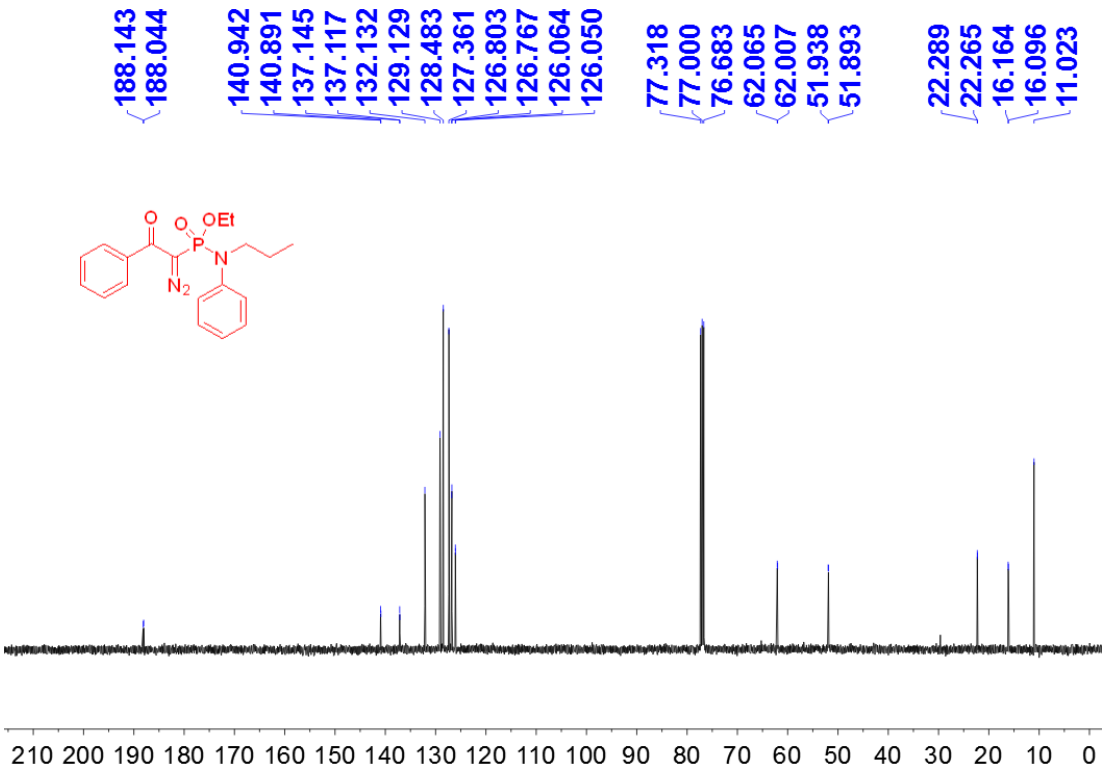
Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methyl-*N*-phenylphosphonamidate (1a)

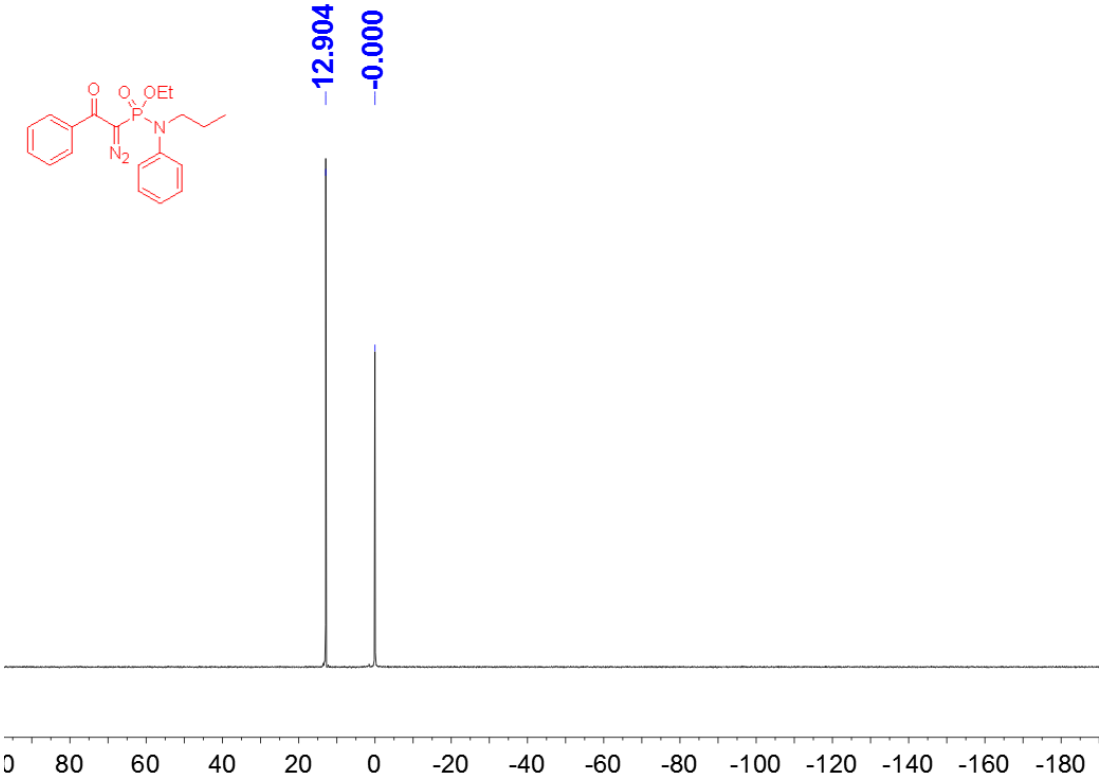




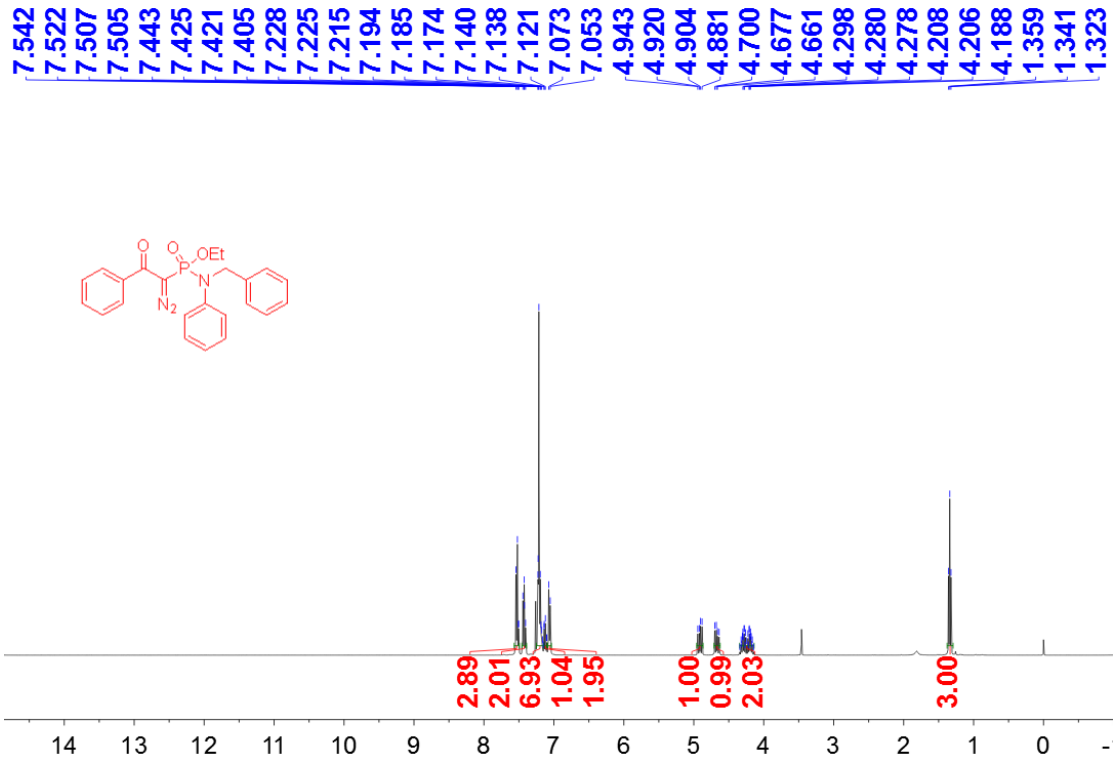
Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-phenyl-*N*-propylphosphonamidate (1b)







Ethyl *N*-benzyl-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-phenylphosphonamidate (1c)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7.421
7.405
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7.225
7.215
7.194
7.185
7.174
7.140
7.138
7.121
7.073
7.053
4.943
4.920
4.904
4.881
4.700
4.677
4.661
4.298
4.280
4.278
4.208
4.206
4.188
1.359
1.341
1.323
OEt
N2
2.89
2.01
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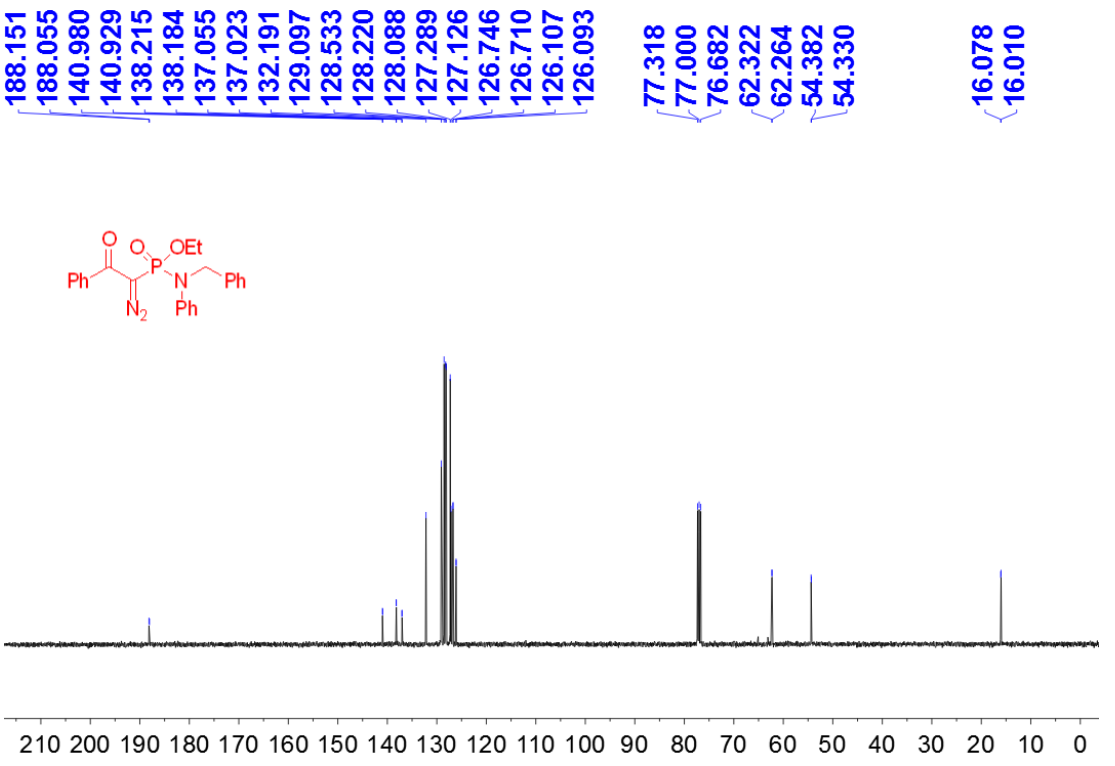
1.04
1.95
1.00
0.99
2.03
3.00
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -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140.929
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138.184
137.055
137.023
132.191
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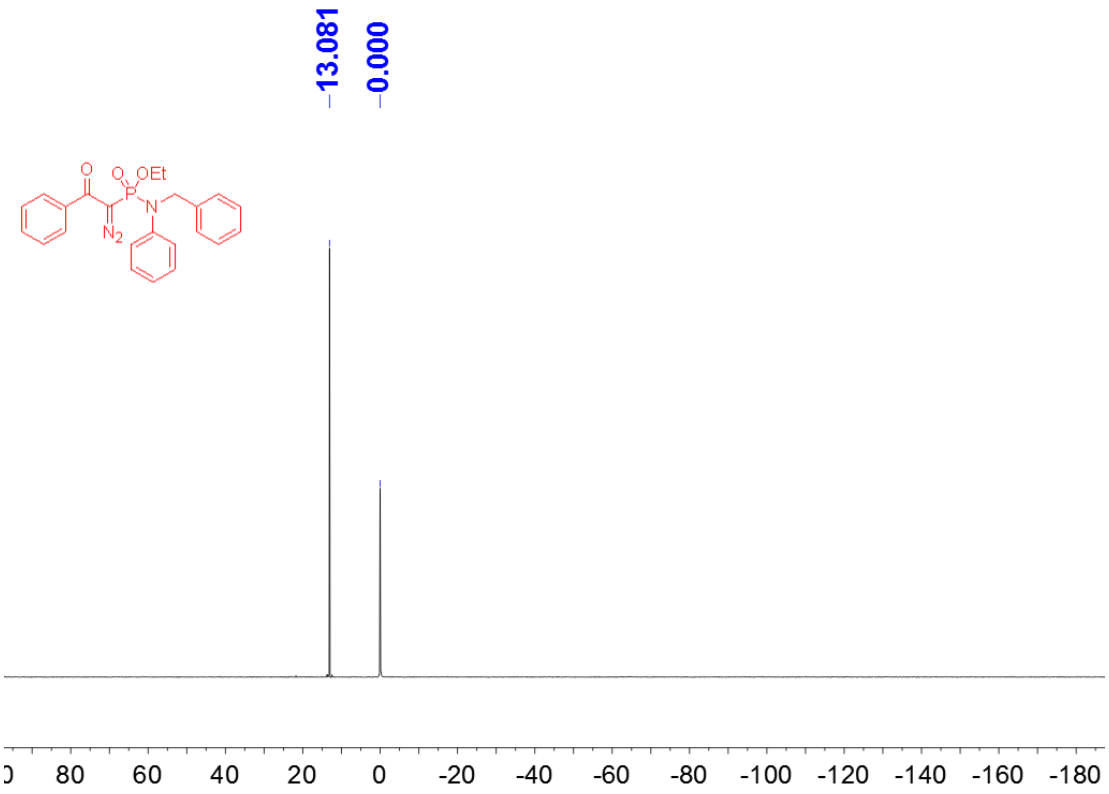
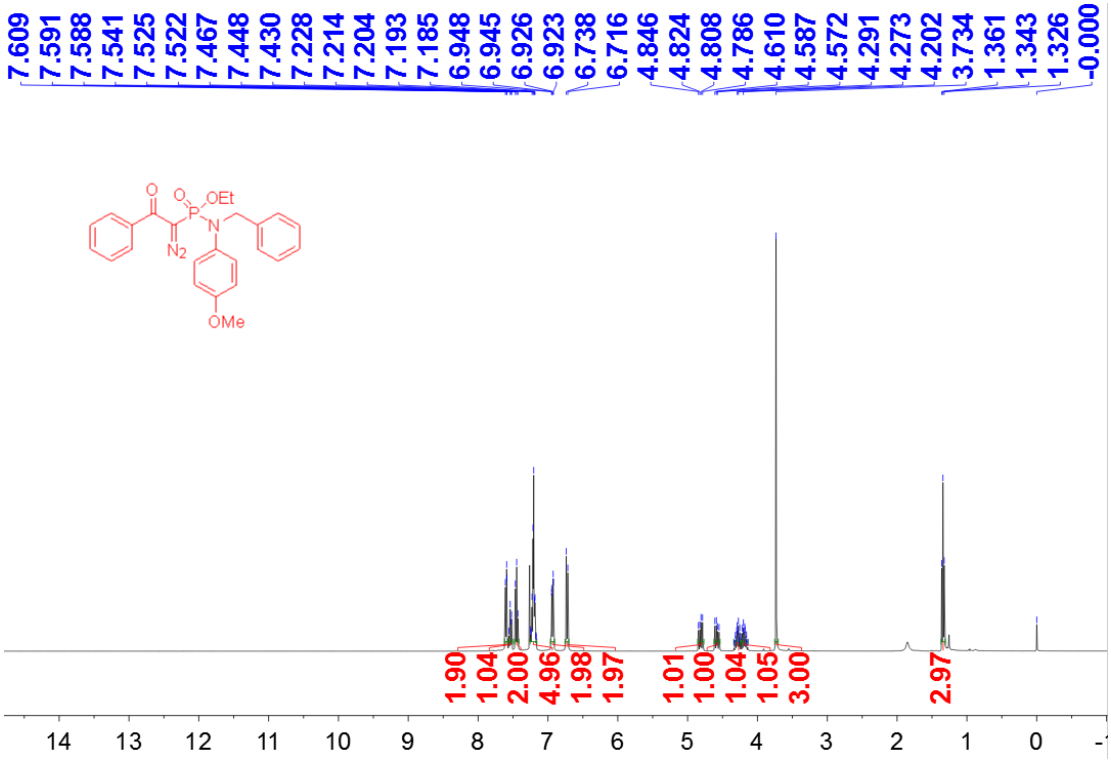
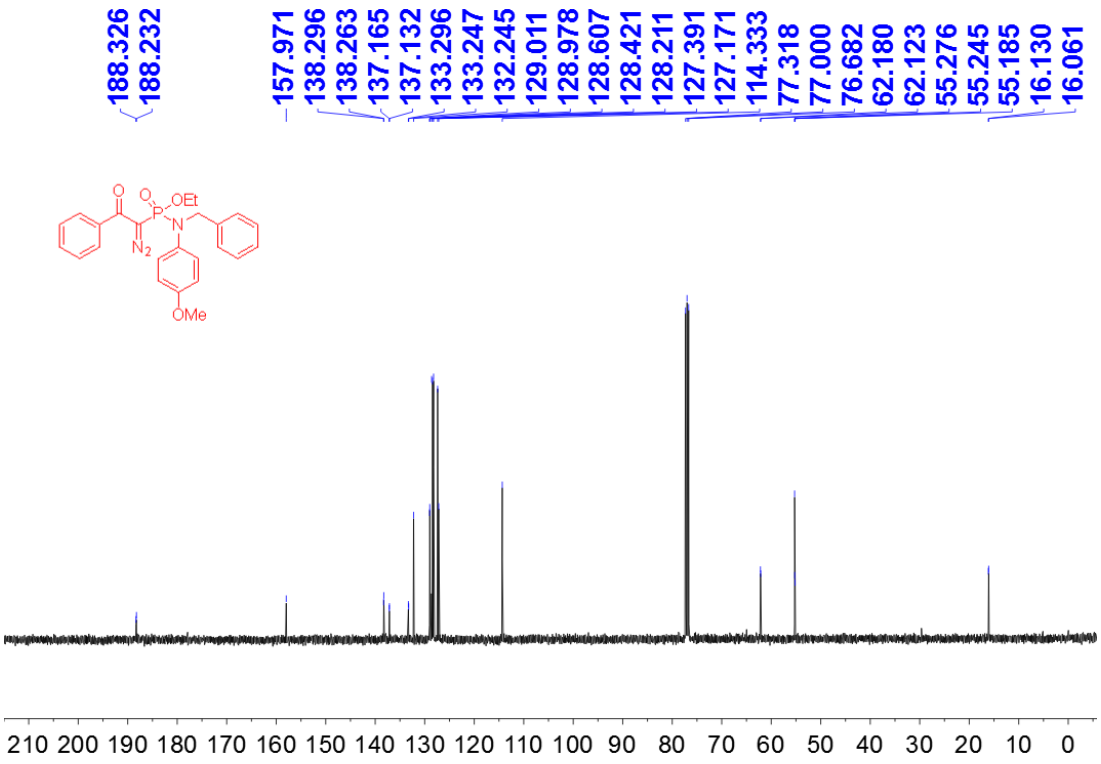
128.533
128.220
128.088
127.289
127.126
126.746
126.710
126.107
126.093
77.318
77.000
76.682
62.322
62.264
54.382
54.330
16.078
16.010
O
OEt
Ph
N2
Ph
Ph
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0



Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(4-methoxyphenyl)-*N*-methylphosphonamidate (1d)

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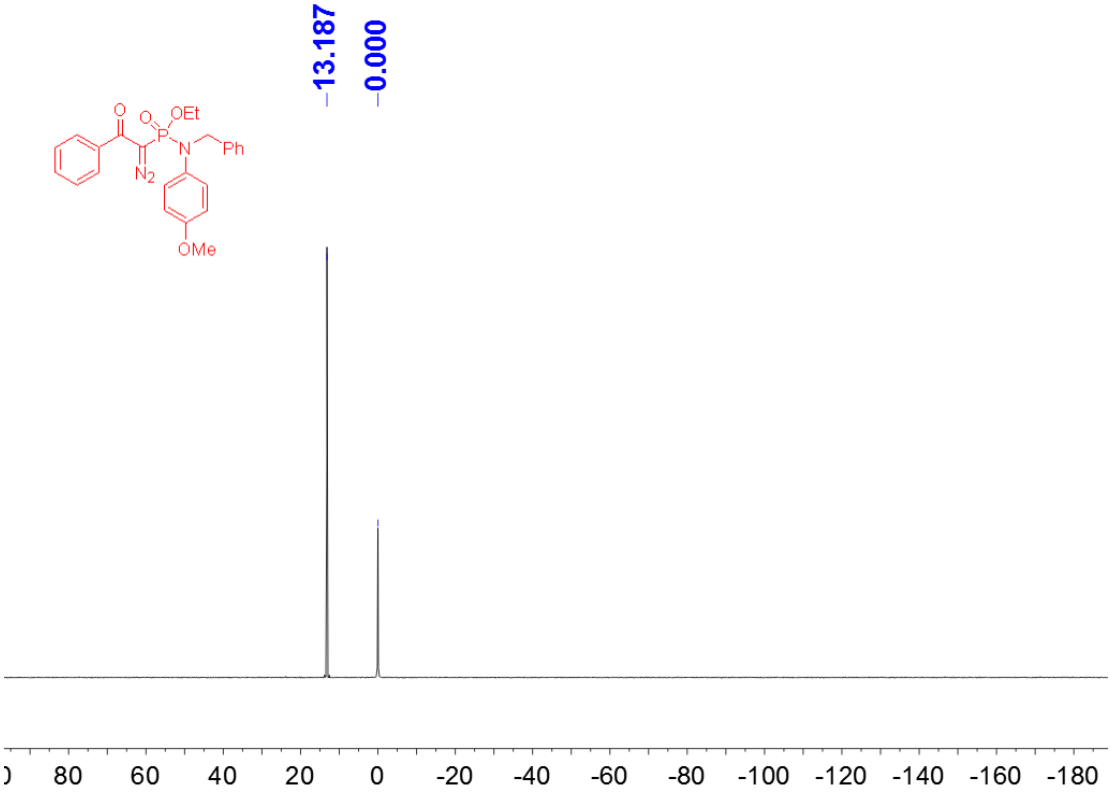
137.165
137.132
133.296
133.247
132.245
129.011
128.978
128.607
128.421
128.211
127.391
127.171
114.333
77.318
77.000
76.682
62.180
62.123
55.276
55.245
55.185
16.130
16.061
OEt
N2
OMe
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0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0.000
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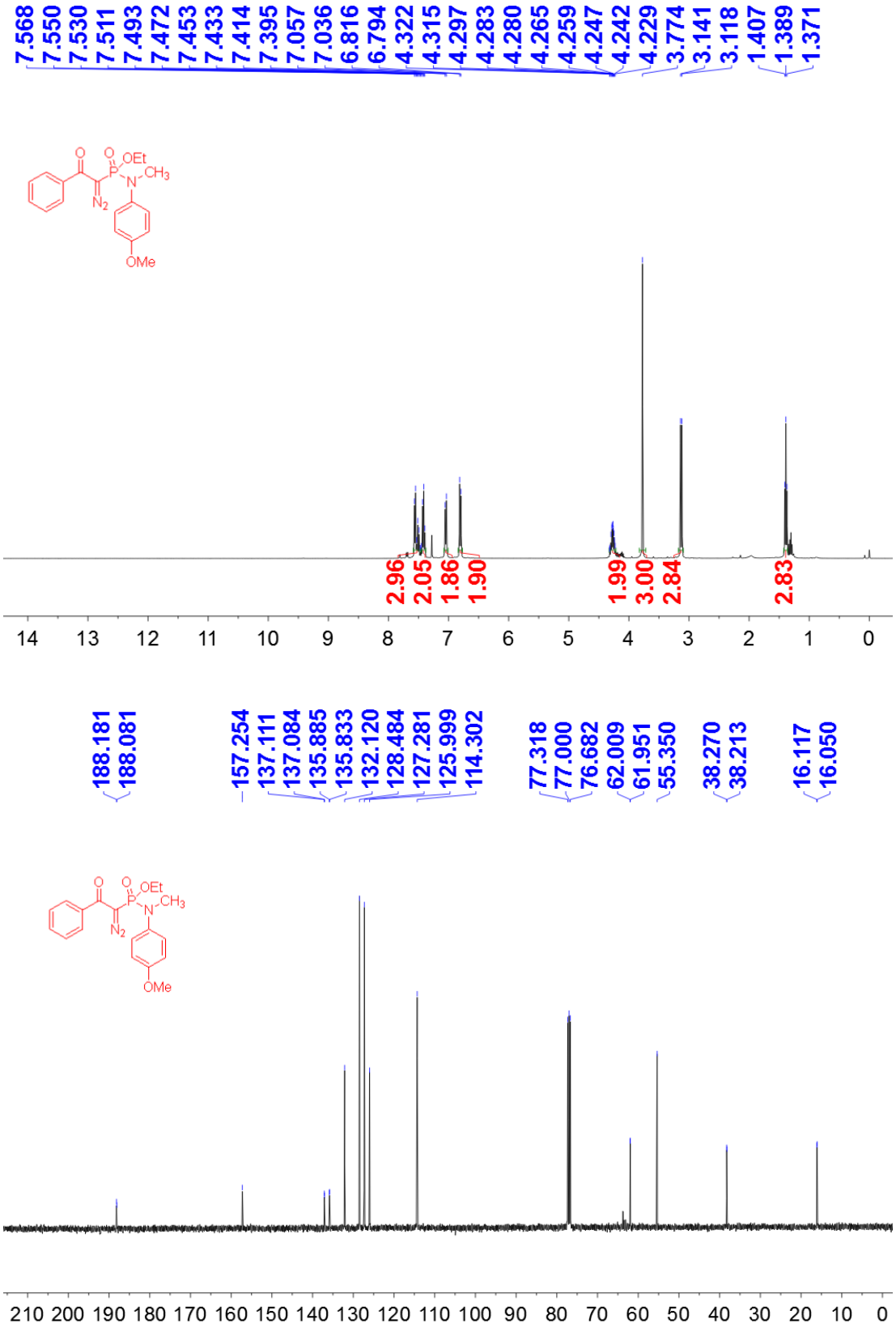
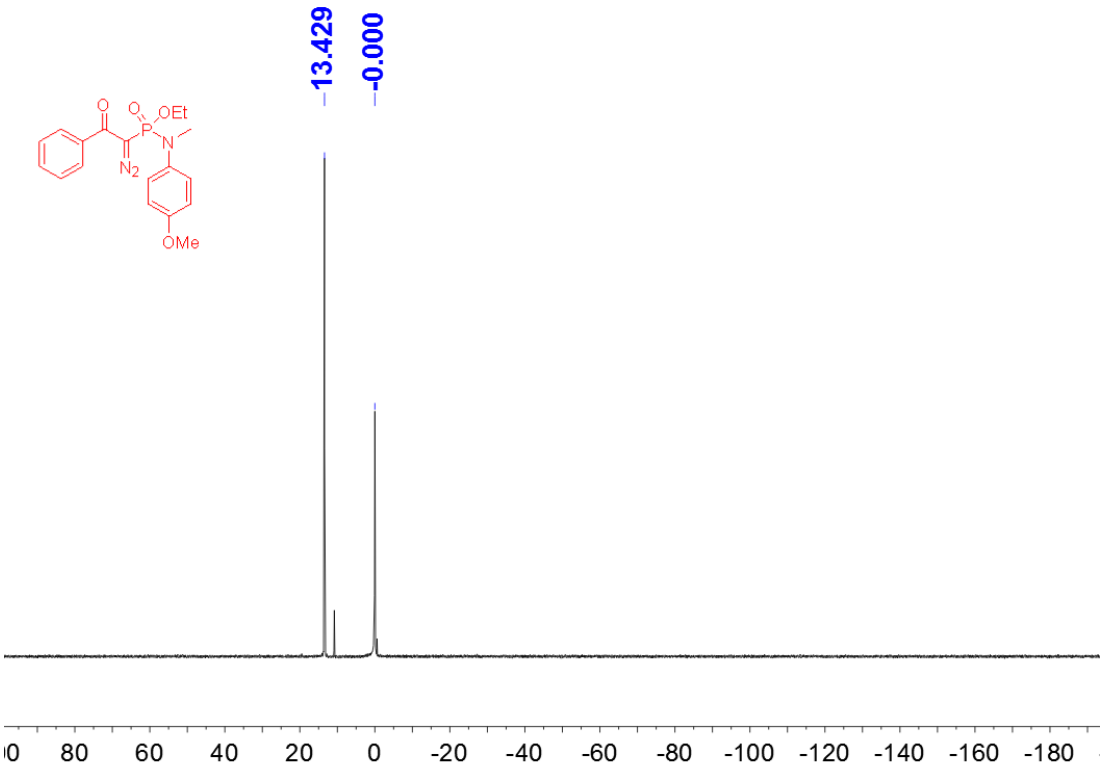
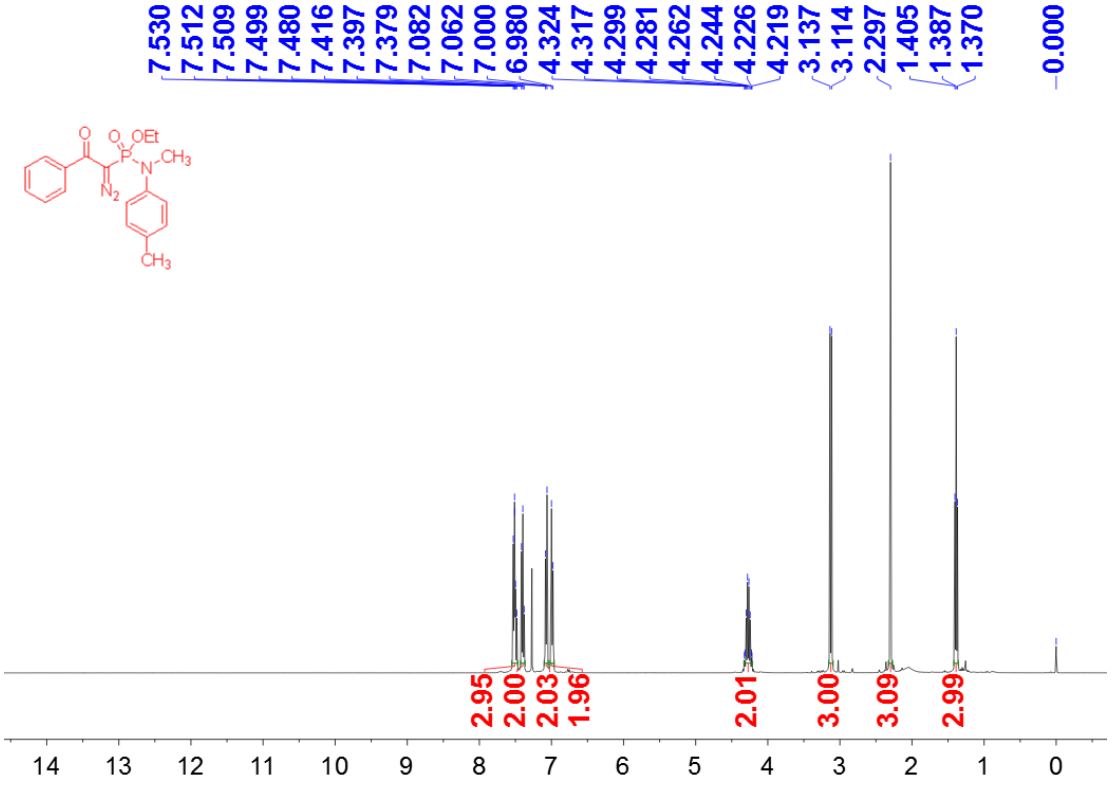
Ph
N2
OMe
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

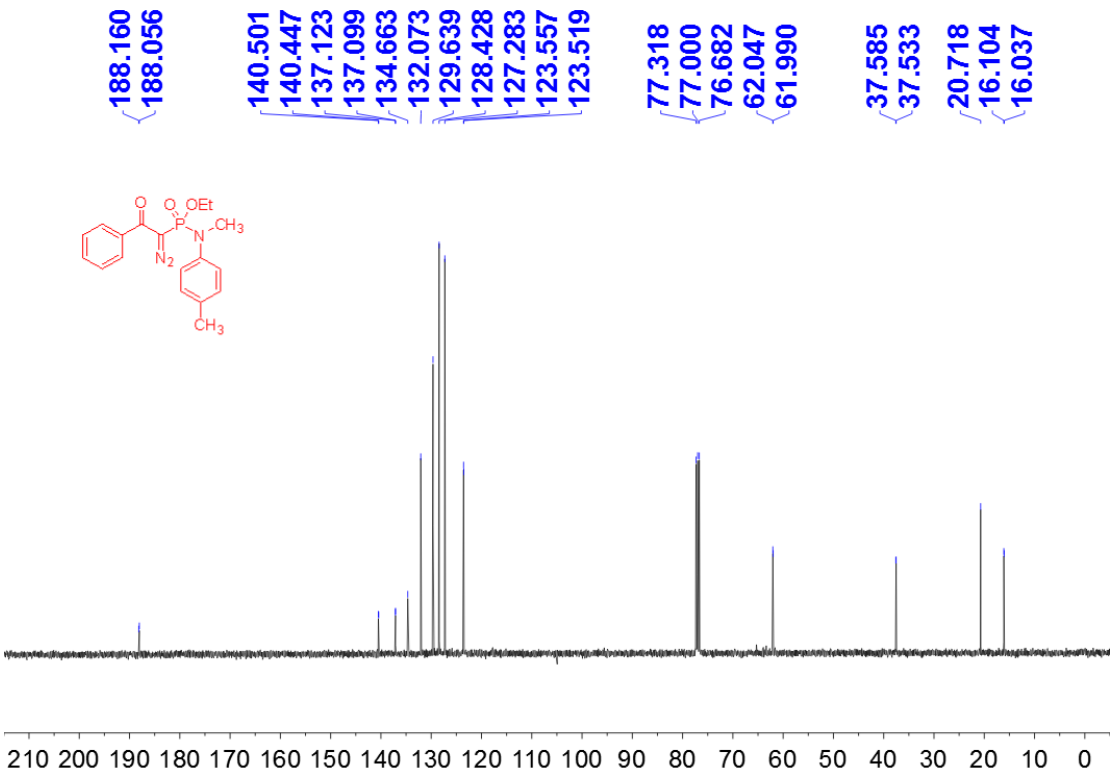
Ethyl *N*-benzyl-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(4-methoxyphenyl)phosphonamidate (1e)





Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methyl-*N*-(4-methylphenyl)phosphonamidate (1f)

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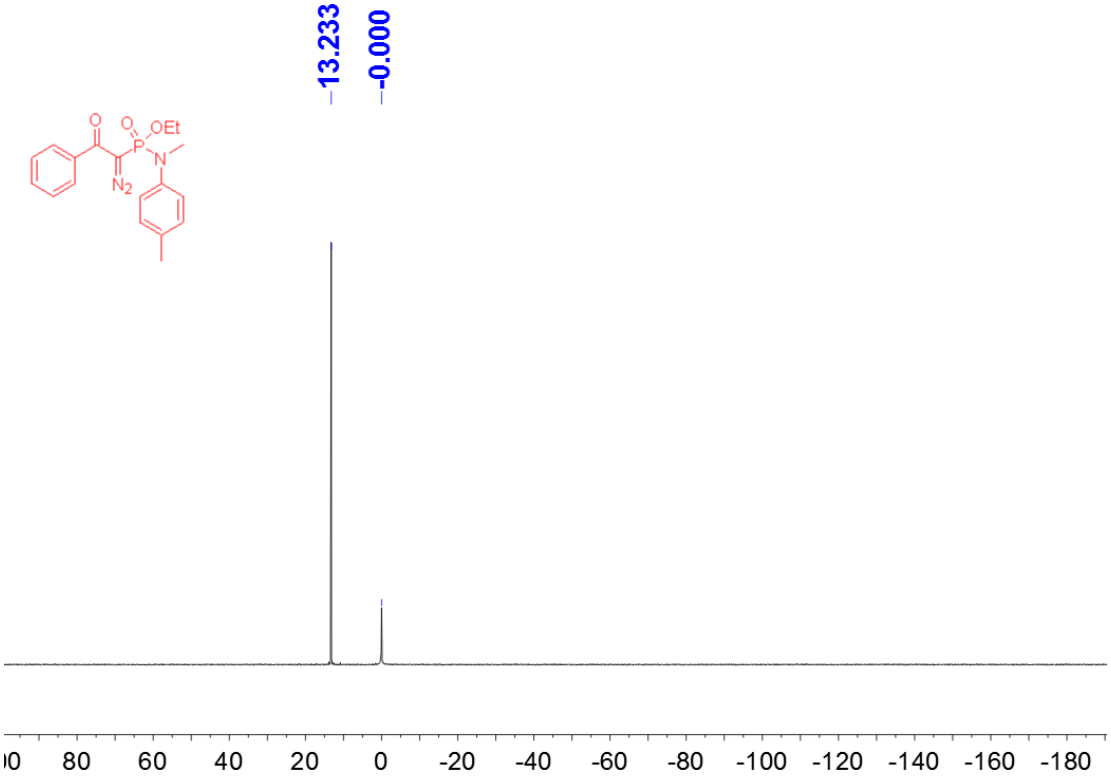
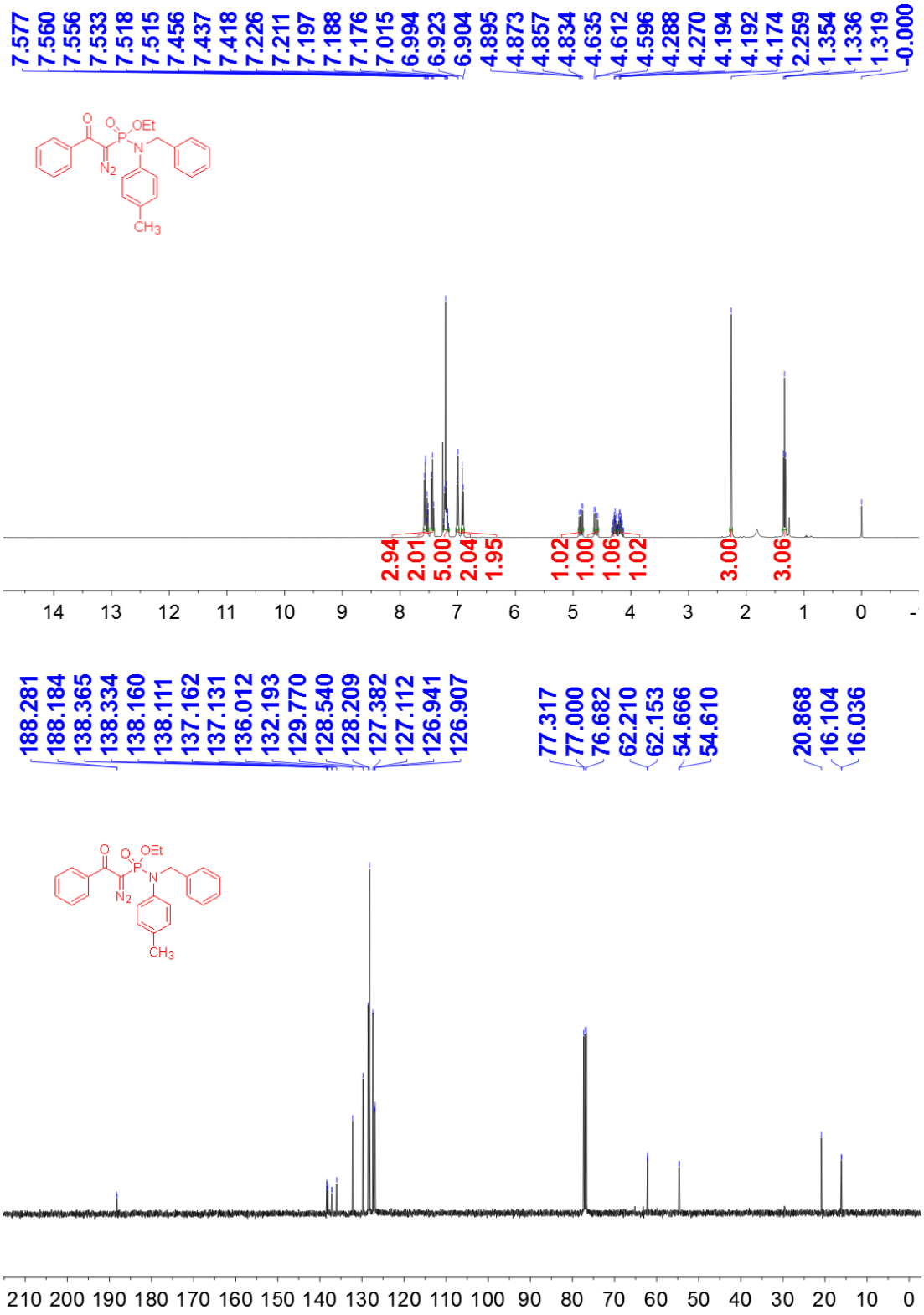
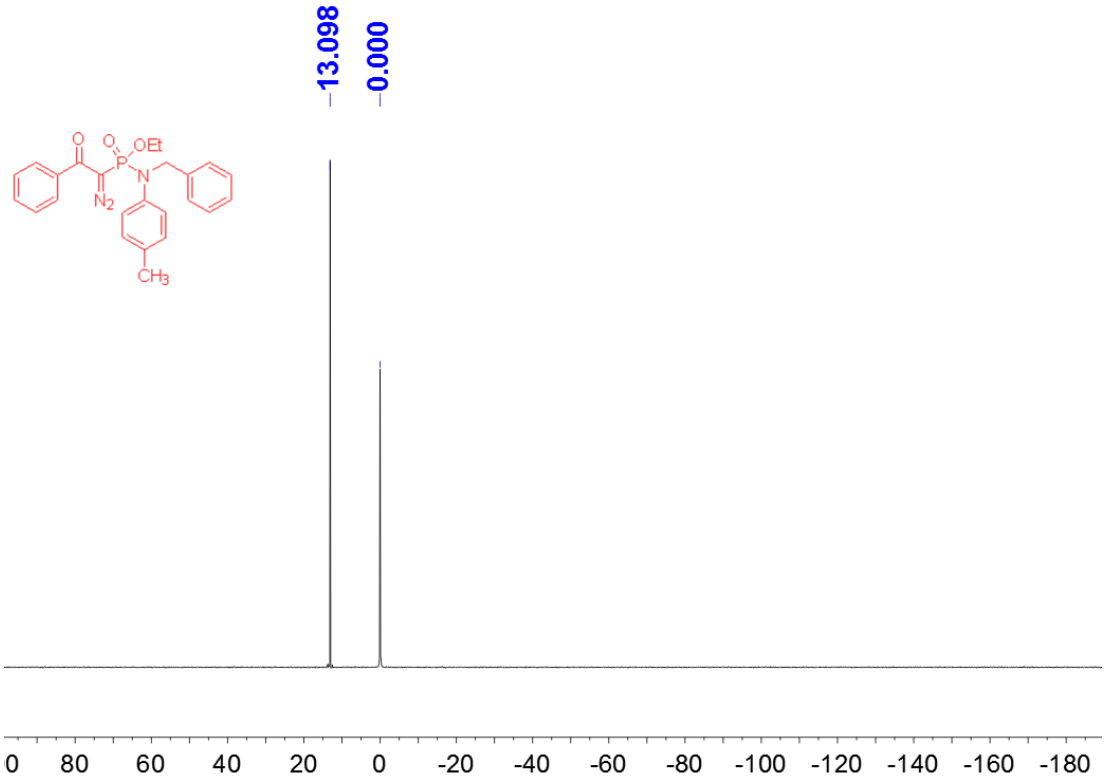
128.428
127.283
123.557
123.519
77.318
77.000
76.682
62.047
61.990
37.585
37.533
20.718
16.104
16.037
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

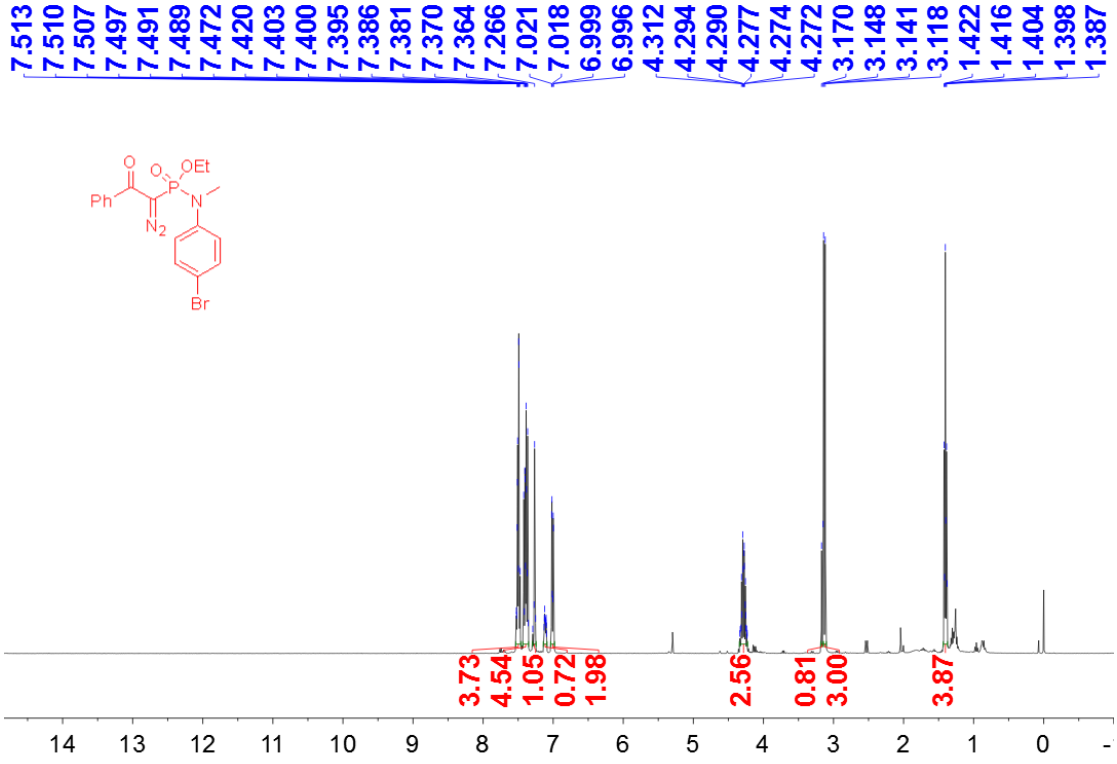

13.233
0.000
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

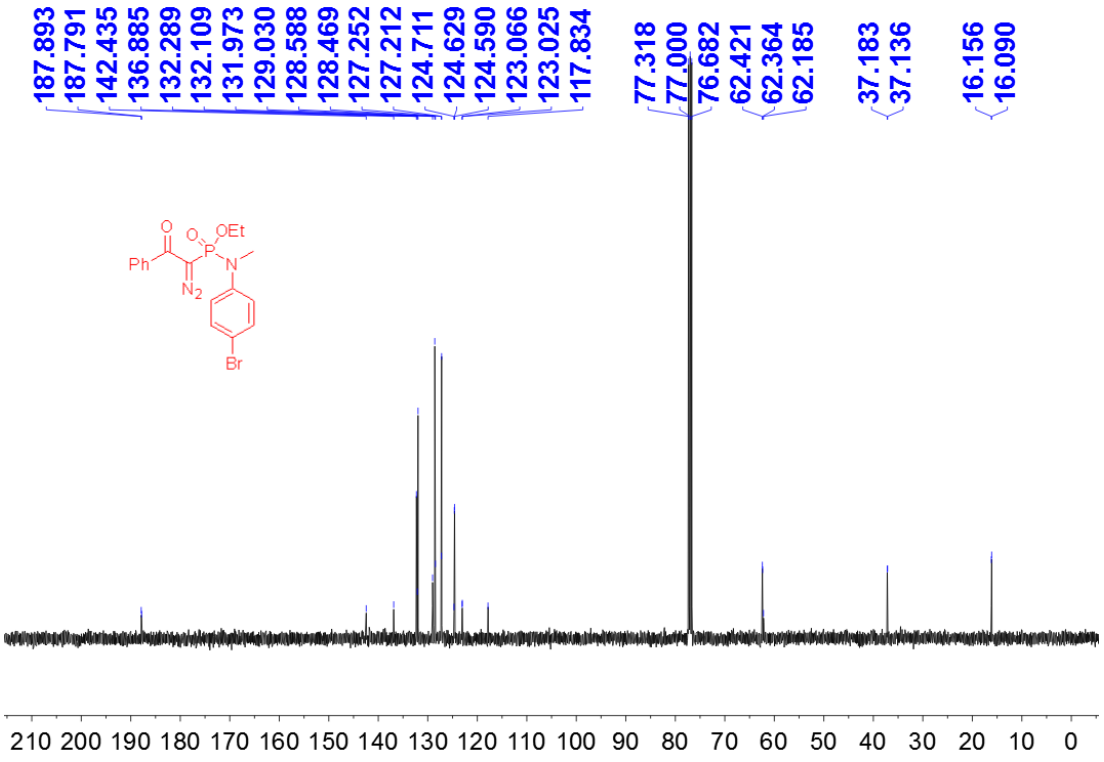
Ethyl *N*-benzyl-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(4-methylphenyl)phosphonamidate (1g)





Ethyl *N*-(4-bromophenyl)-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methylphosphonamidate (1h)

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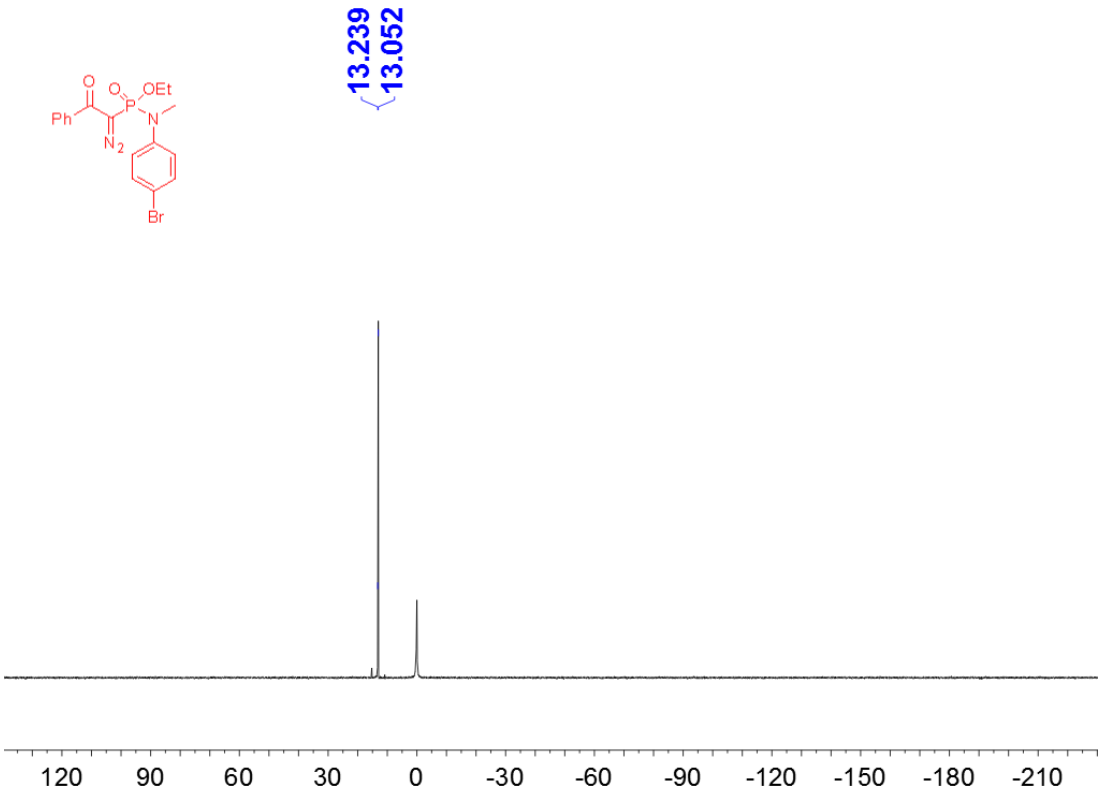
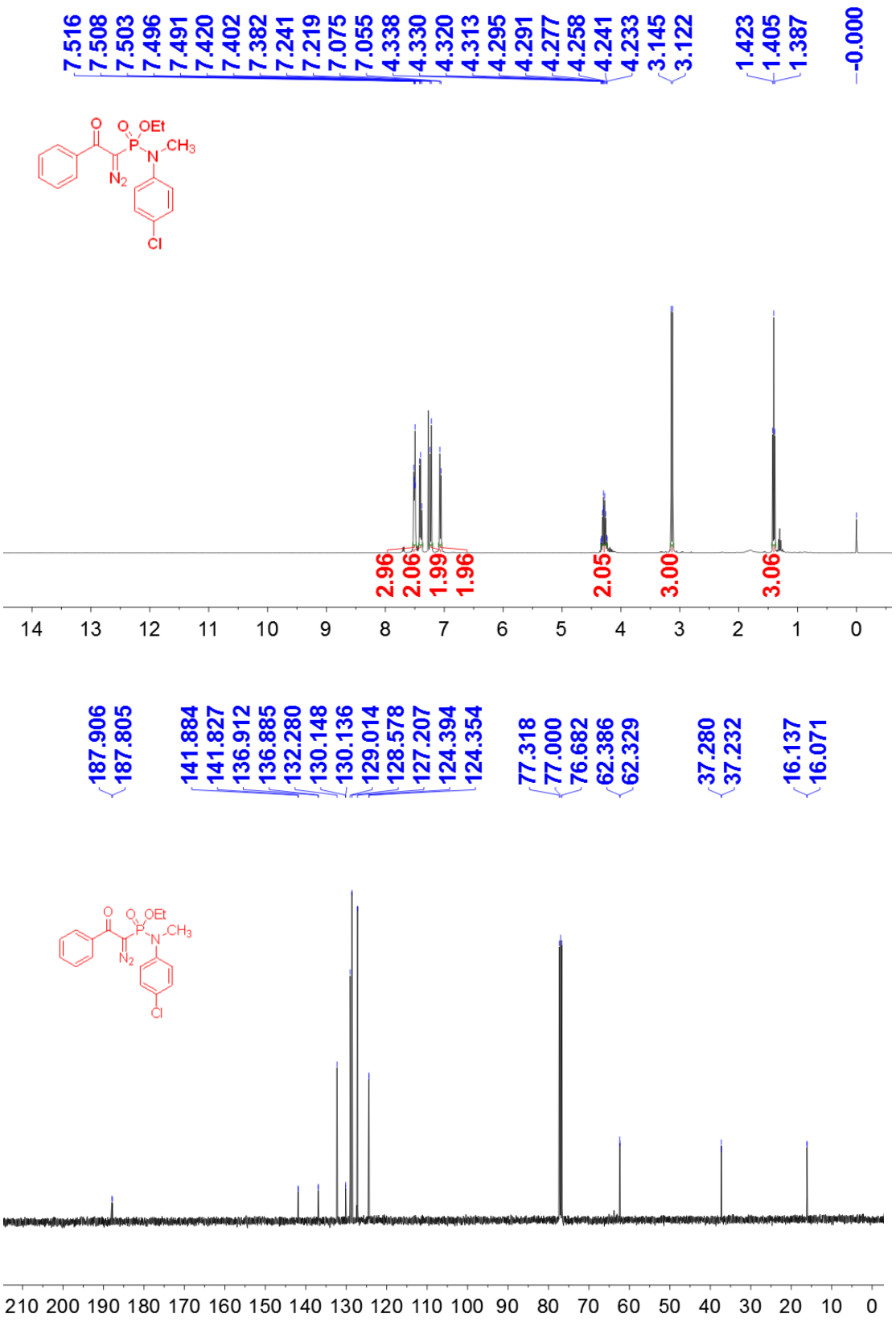
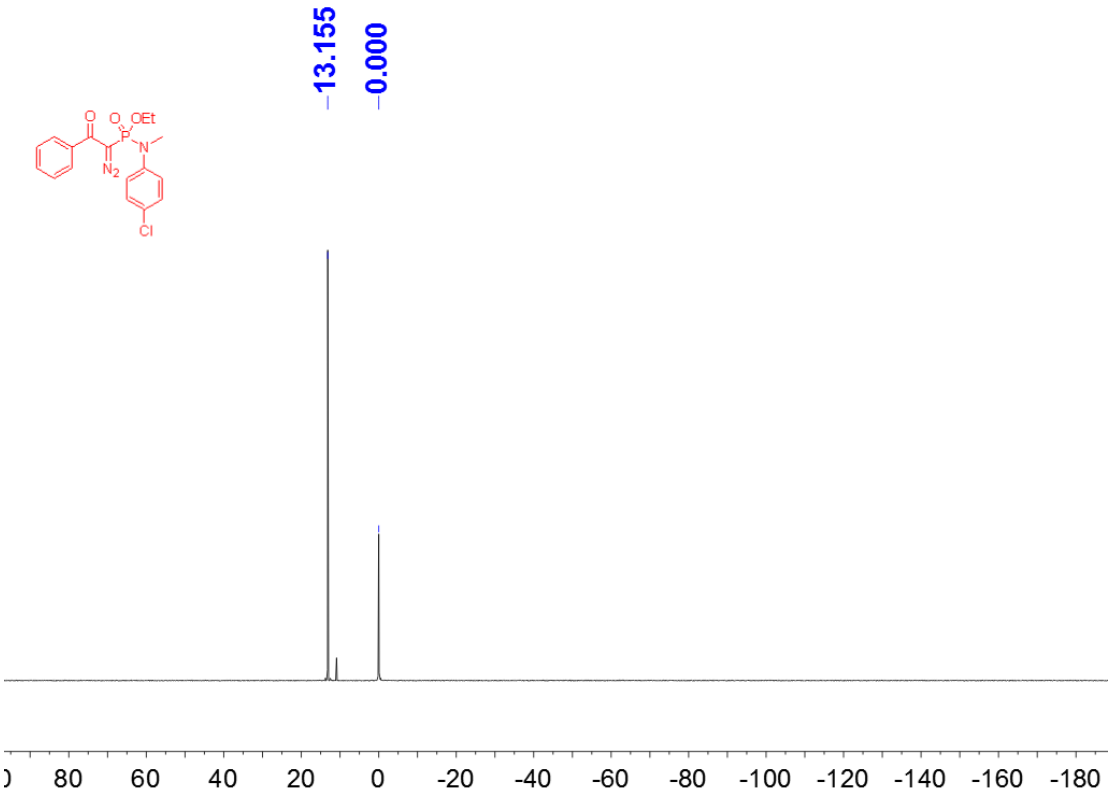
123.066
123.025
117.834
77.318
77.000
76.682
62.421
62.364
62.185
37.183
37.136
16.156
16.090
O
Ph
O
P
OEt
N
N2
Br
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

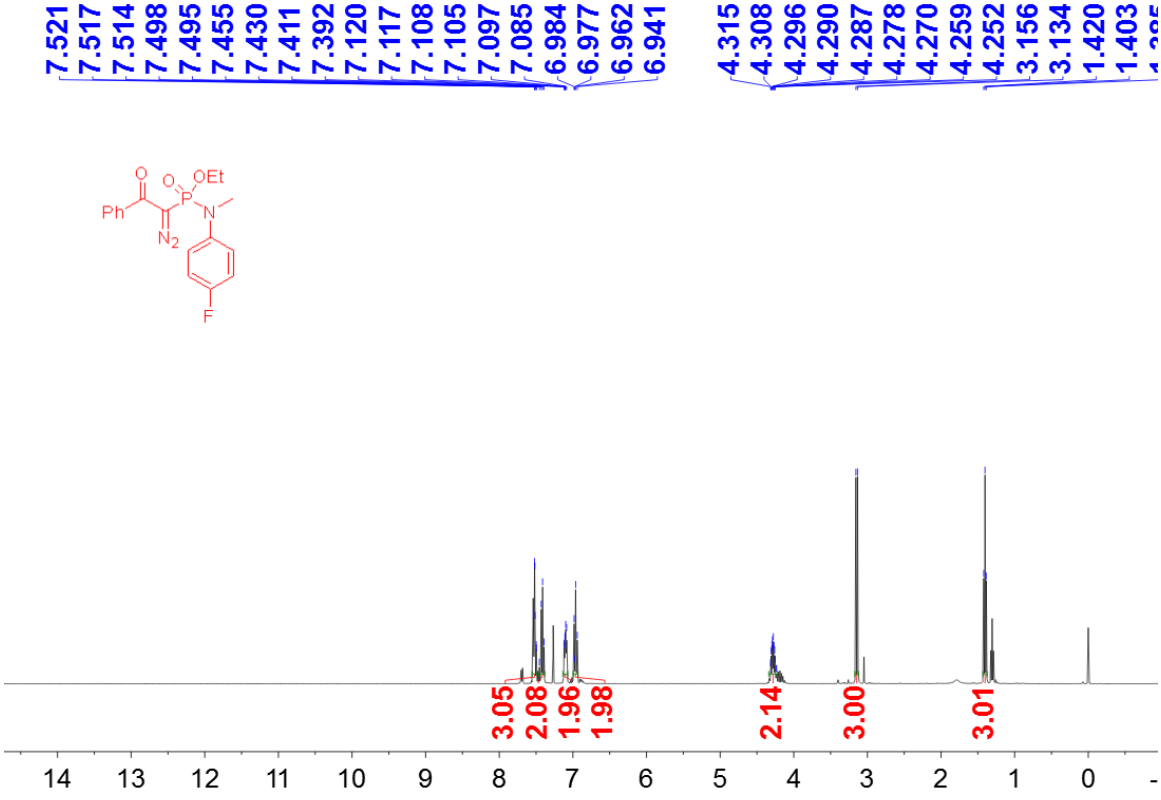

13.239
13.052
O
Ph
O
P
OEt
N
N2
Br
120 90 60 30 0 -30 -60 -90 -120 -150 -180 -210

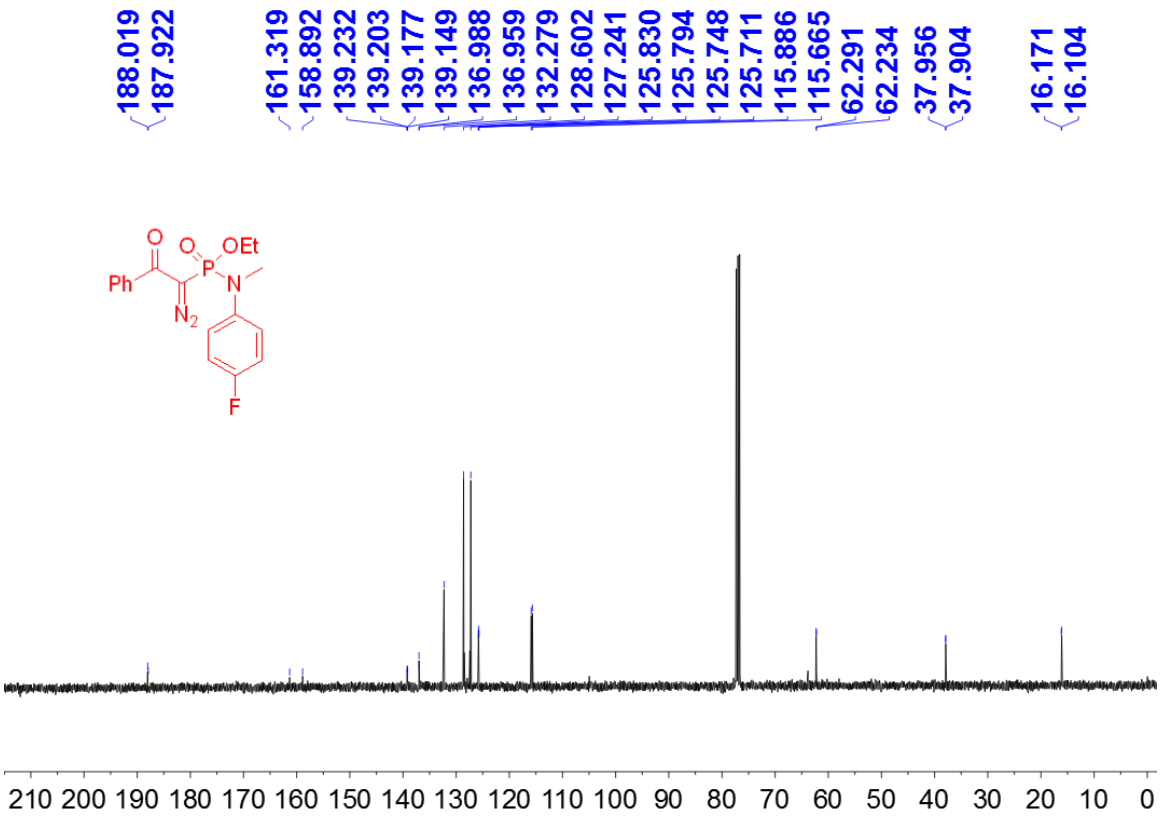
Ethyl *N*-(4-chlorophenyl)-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methylphosphonamidate (1i)

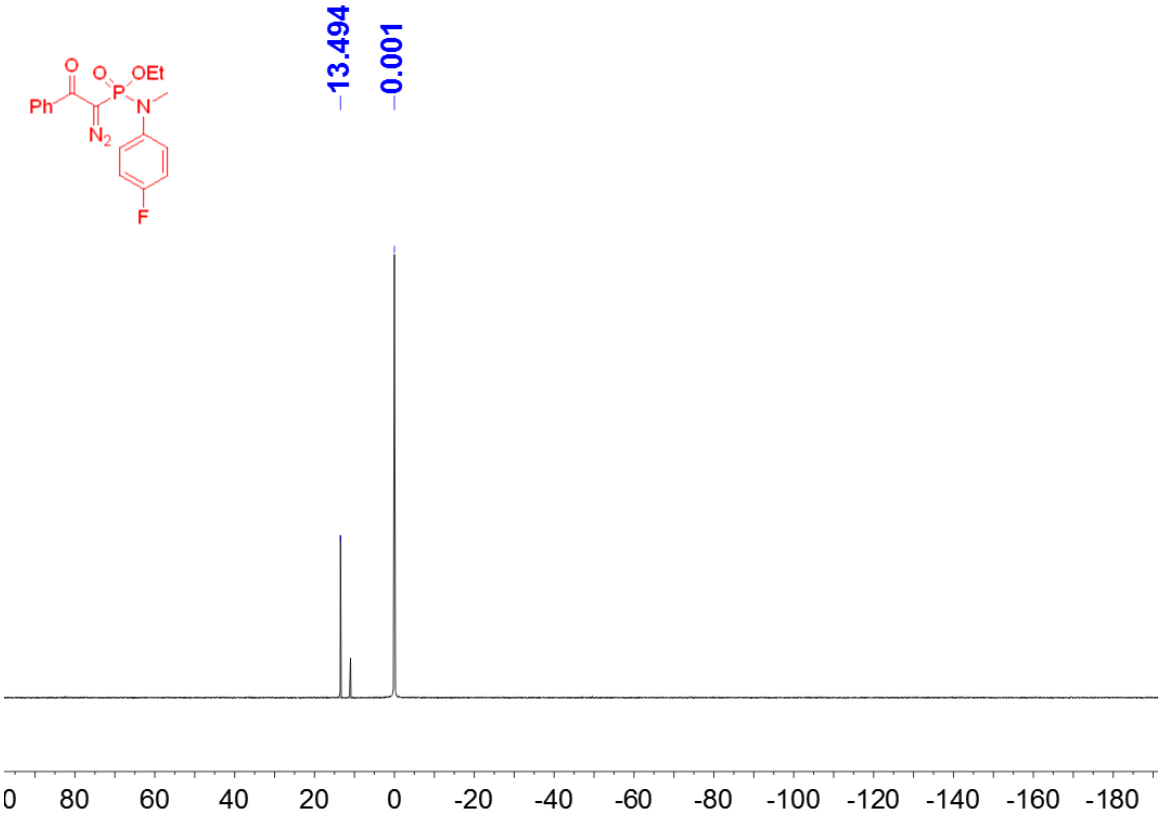


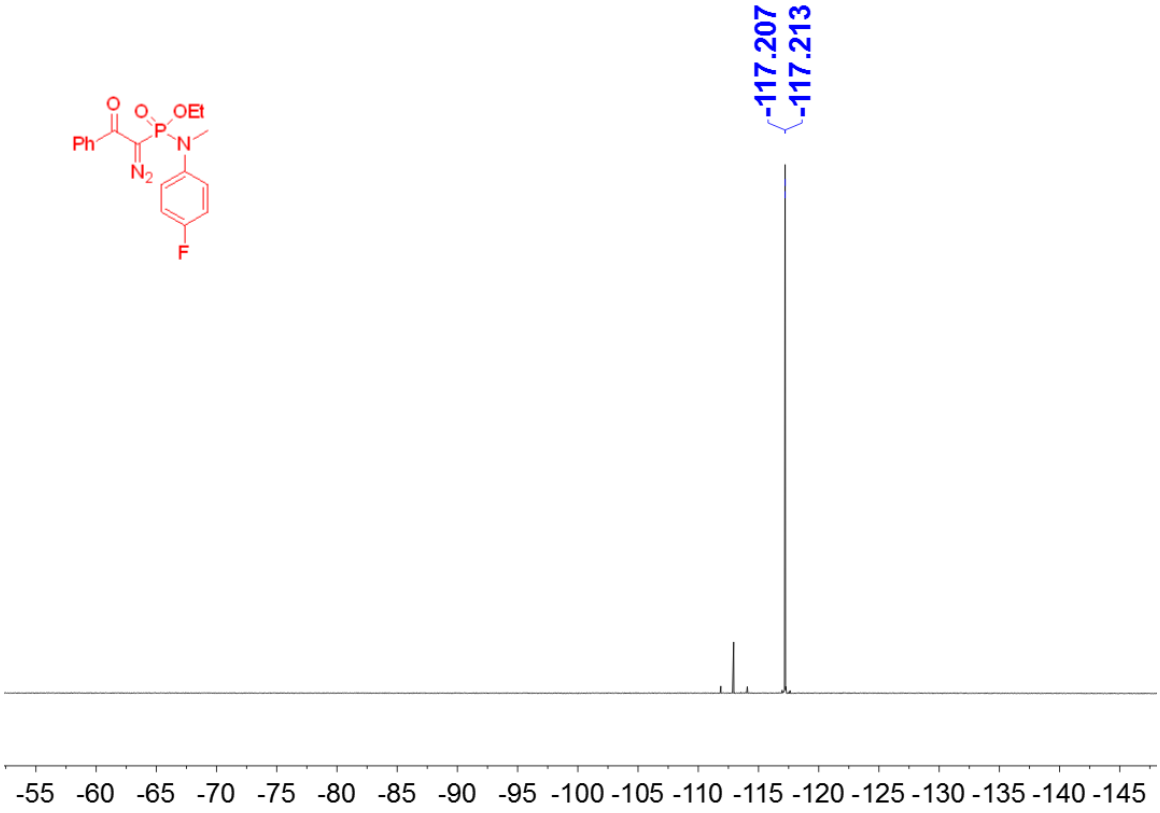


Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(4-fluorophenyl)-*N*-methylphosphonamidate (1j)

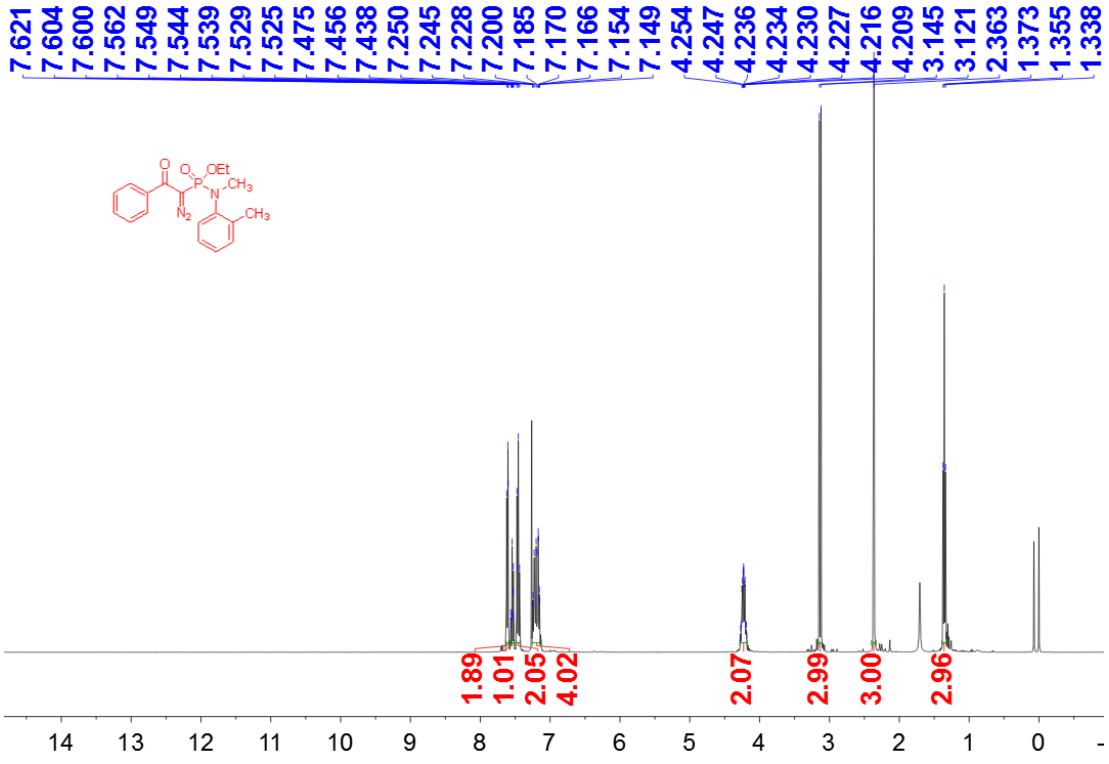


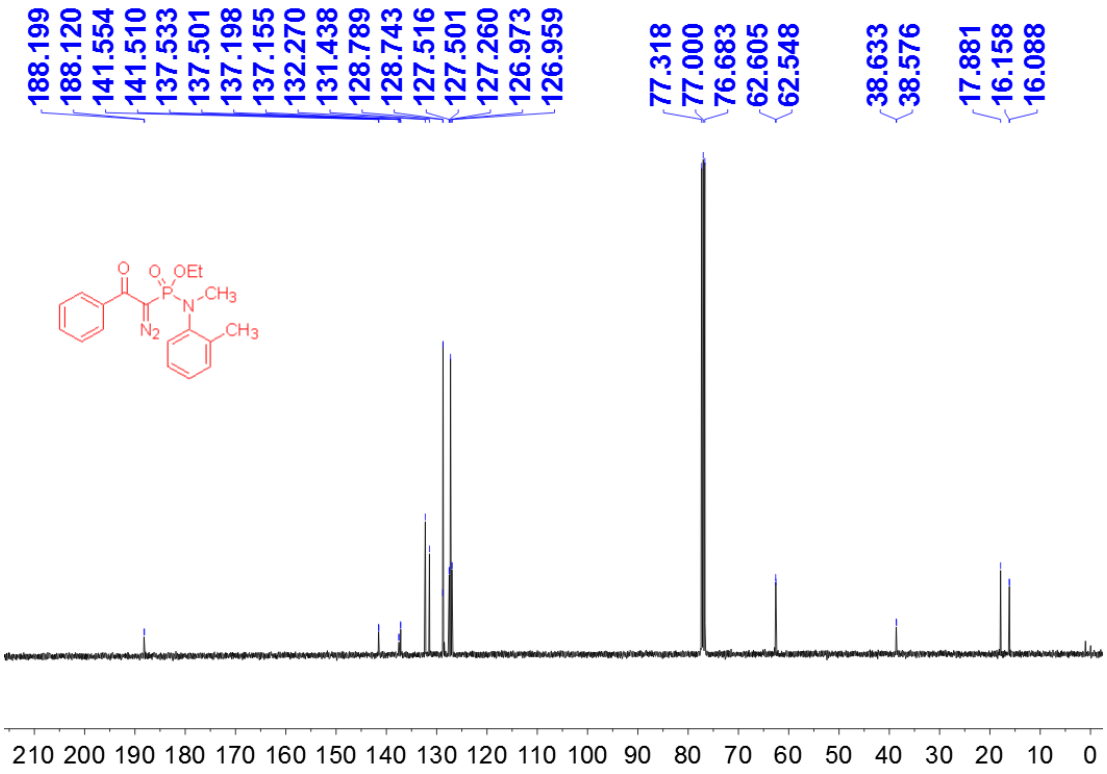

188.019
187.922
161.319
158.892
139.232
139.203
139.177
139.149
136.988
136.959
132.279
128.602
127.241
125.830
125.794
125.748
125.711
115.886
115.665
62.291
62.234
37.956
37.904
16.171
16.104
O
O
OEt
Ph
P
N
N2
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


-13.494
-0.001
O
O
OEt
Ph
P
N
N2
F
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180



Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methyl-*N*-(2-methylphenyl)phosphonamidate (1k)

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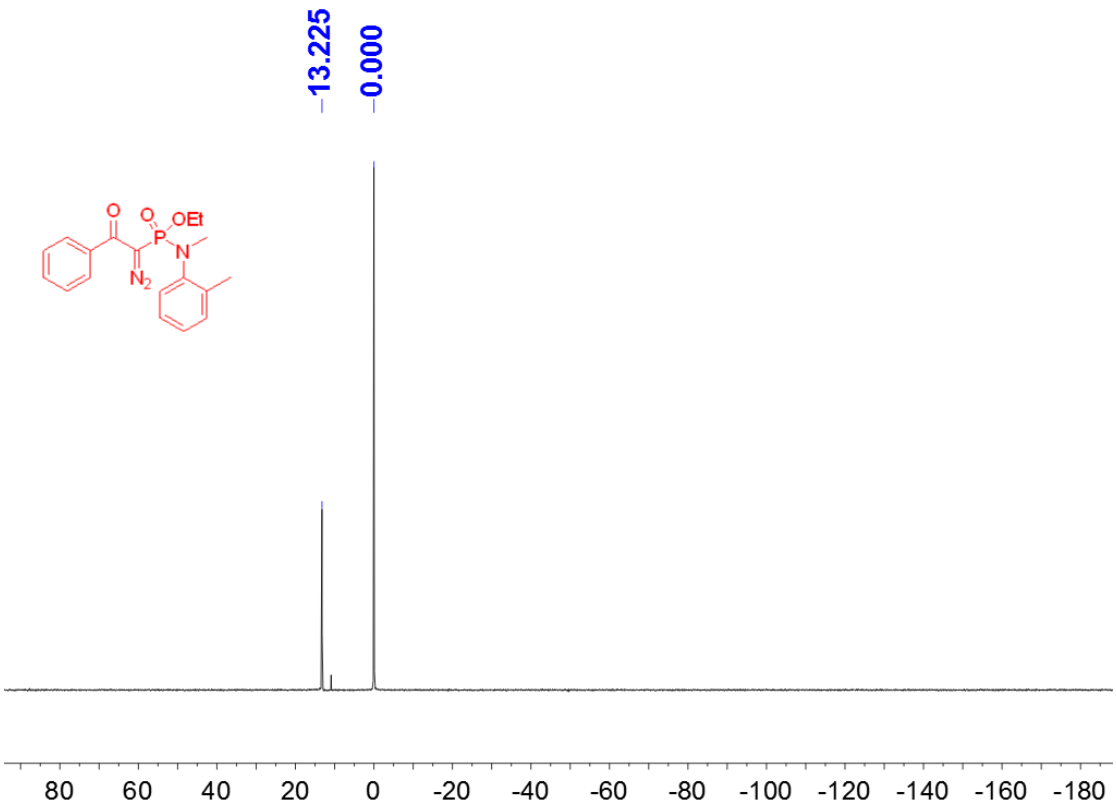
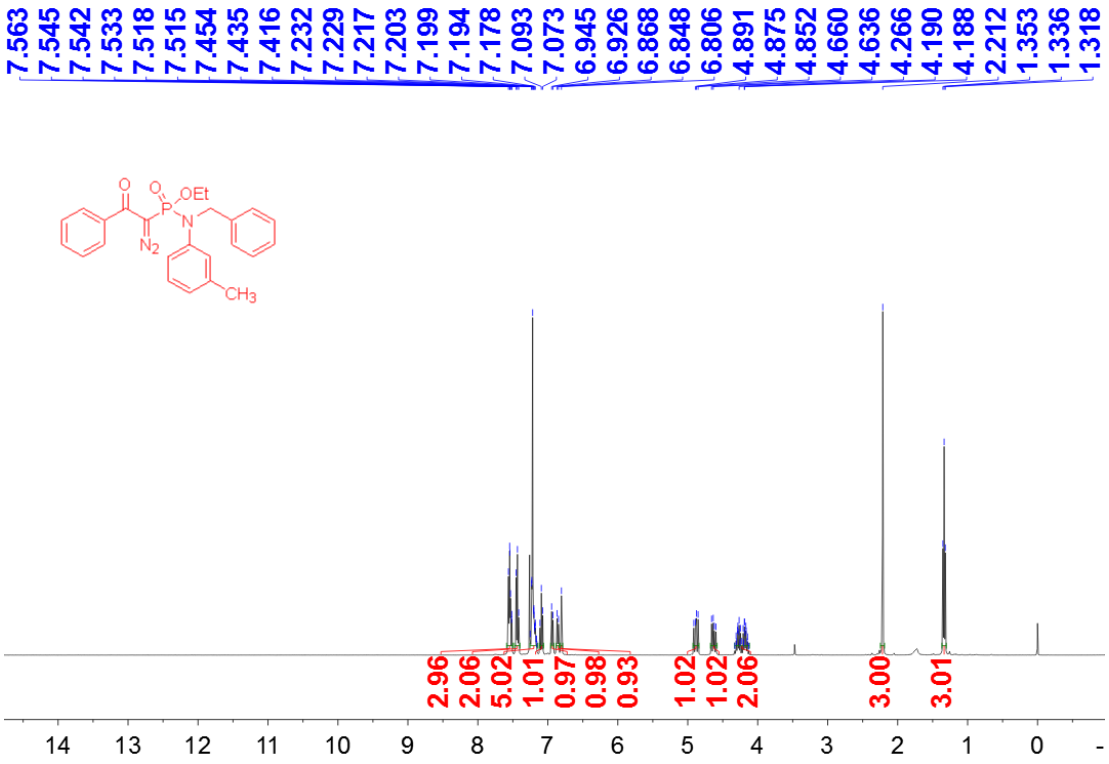
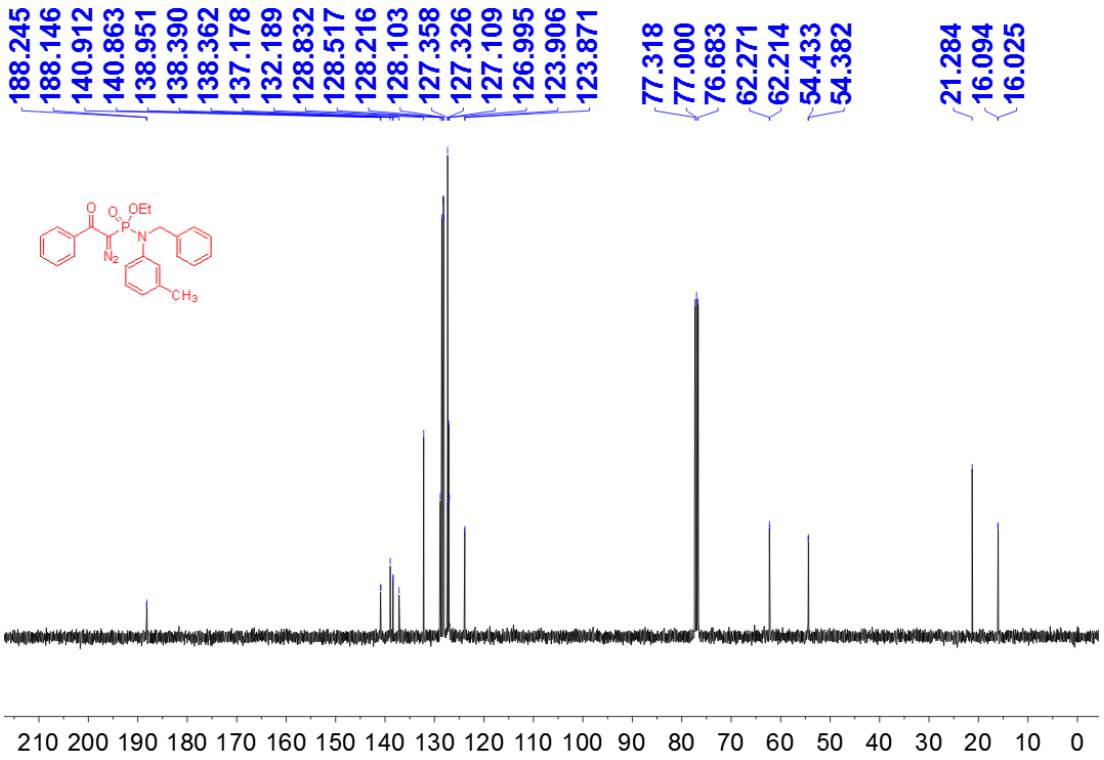
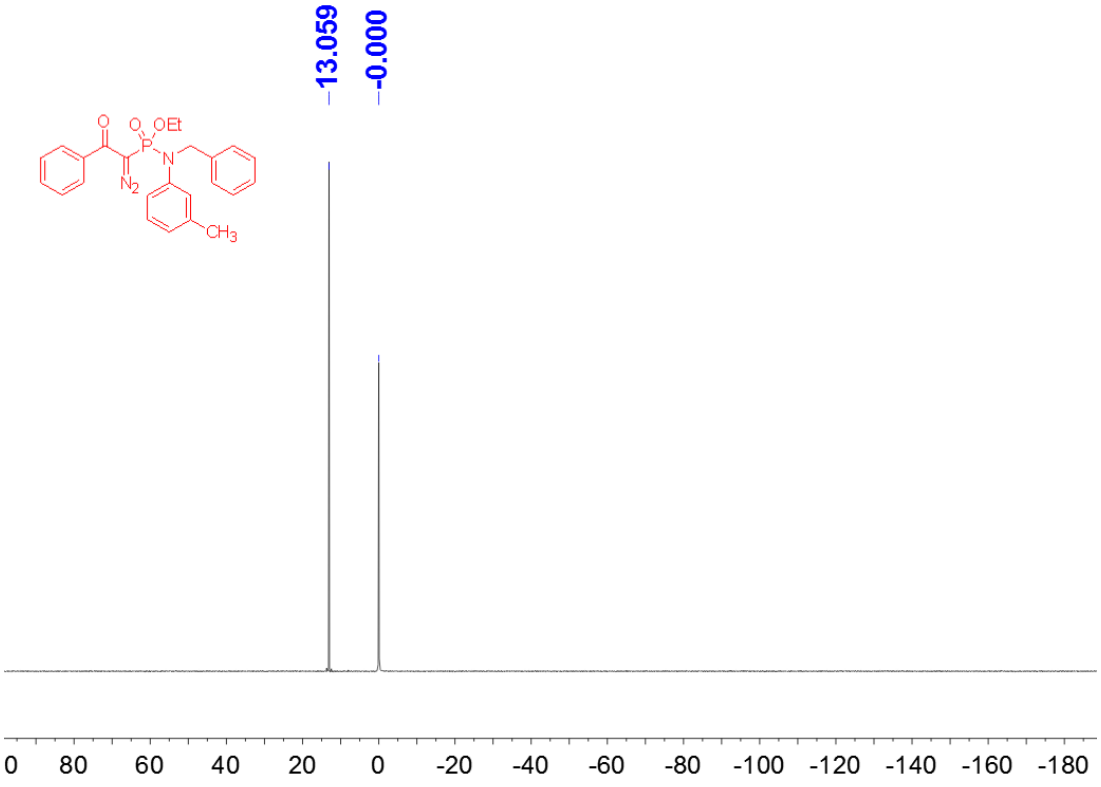
188.120
141.554
141.510
137.533
137.501
137.198
137.155
132.270
131.438
128.789
128.743
127.516
127.501
127.260
126.973
126.959
77.318
77.000
76.683
62.605
62.548
38.633
38.576
17.881
16.158
16.088
O
O
OEt
P
N
CH3
N2
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


13.225
0.000
O
O
OEt
P
N
N2
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

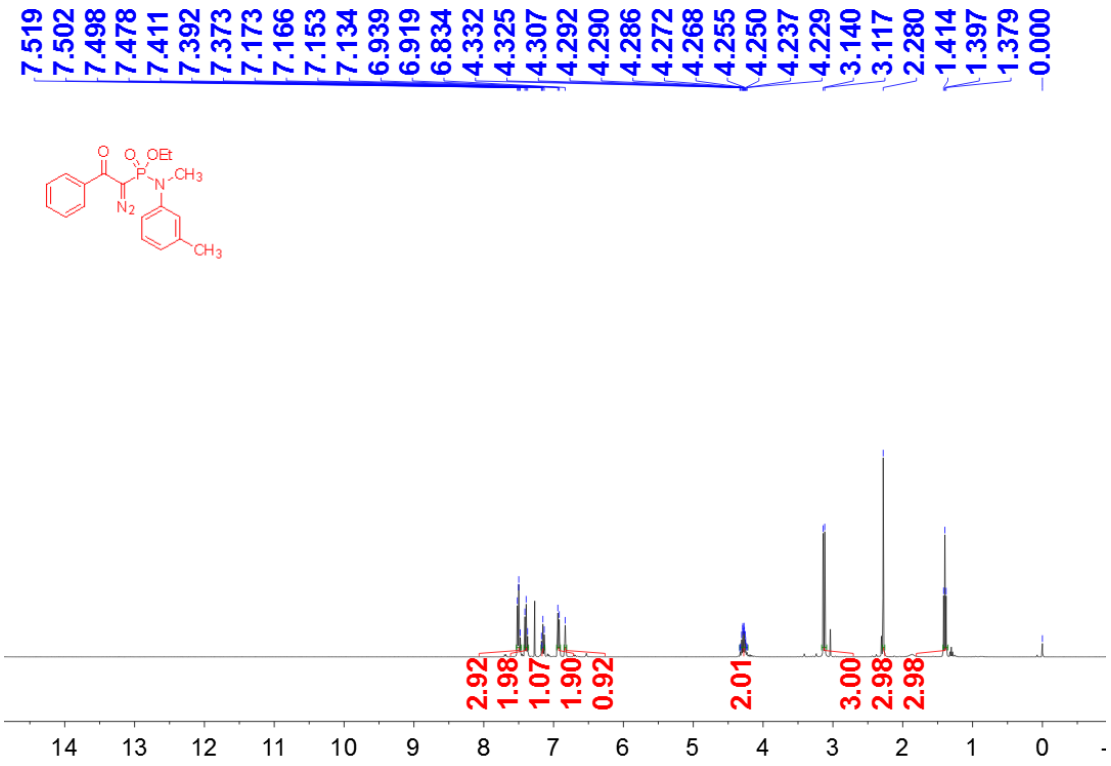
Ethyl *N*-benzyl-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(3-methylphenyl)phosphonamidate (1l)

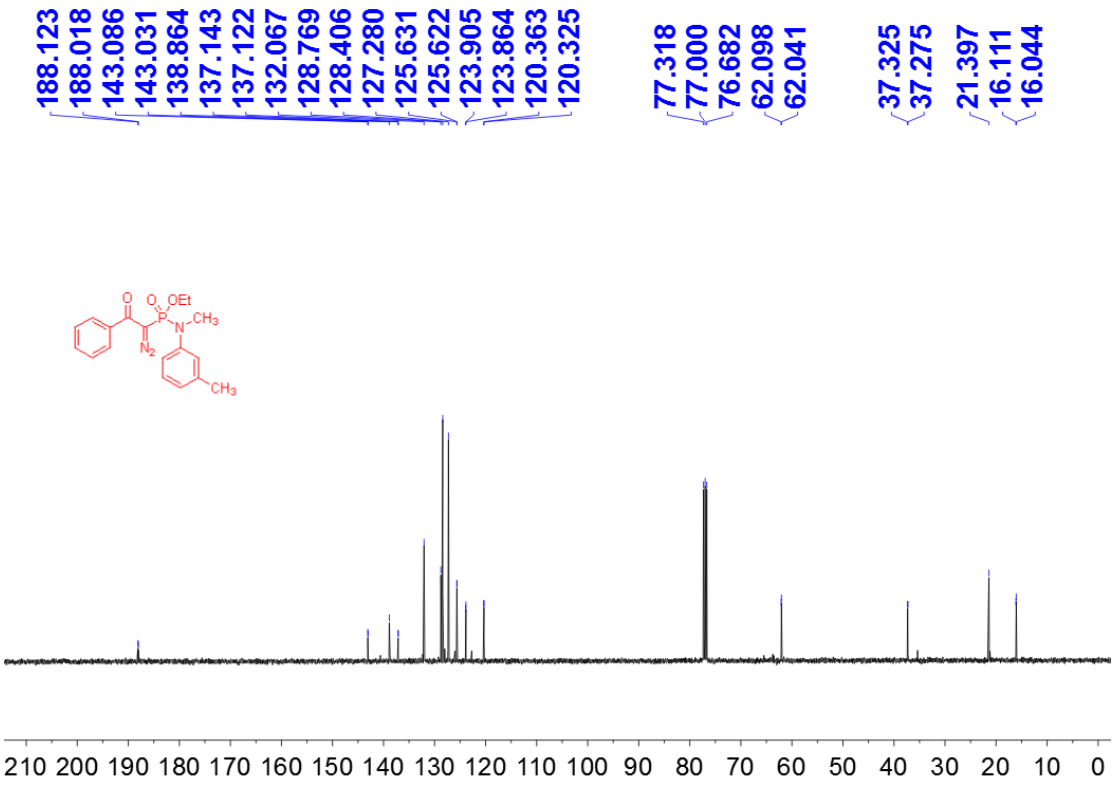






Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methyl-*N*-(3-methylphenyl)phosphonamidate (1m)

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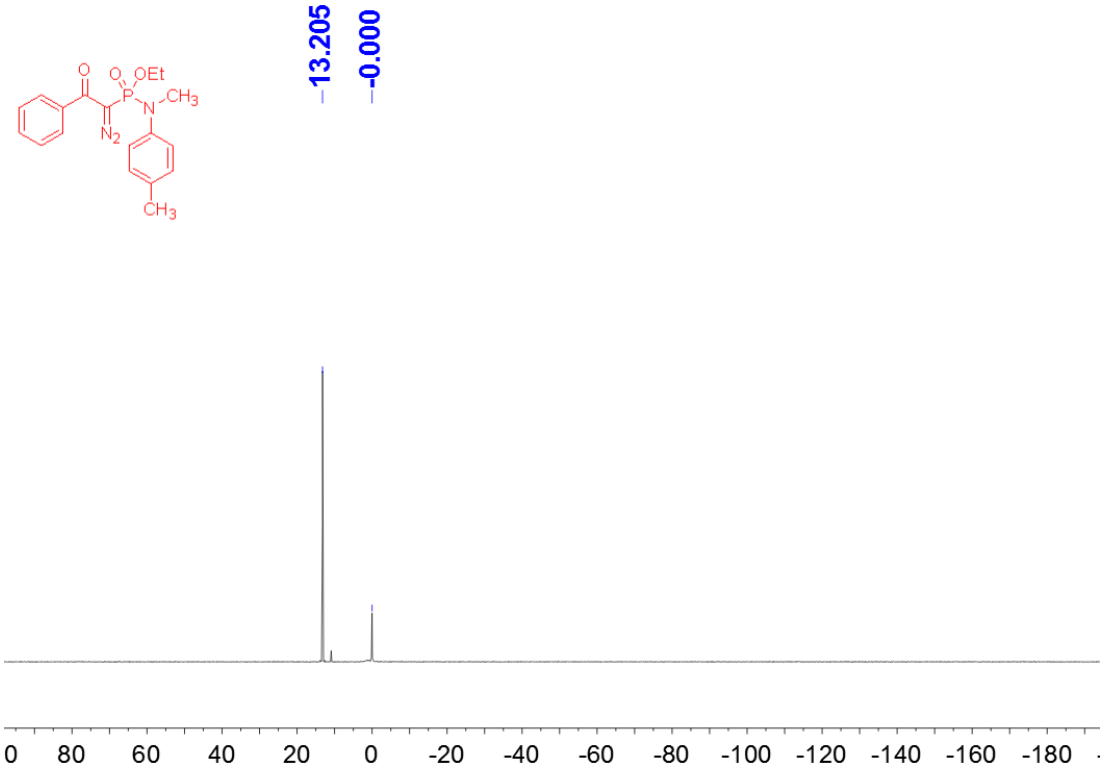
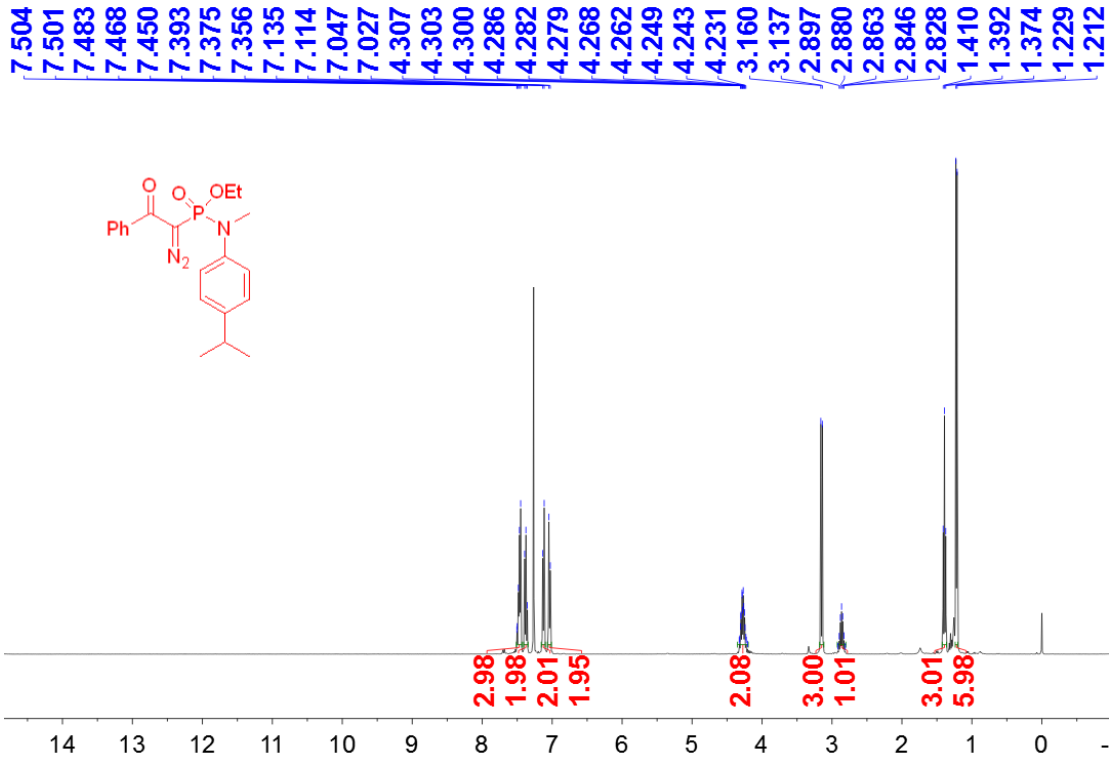
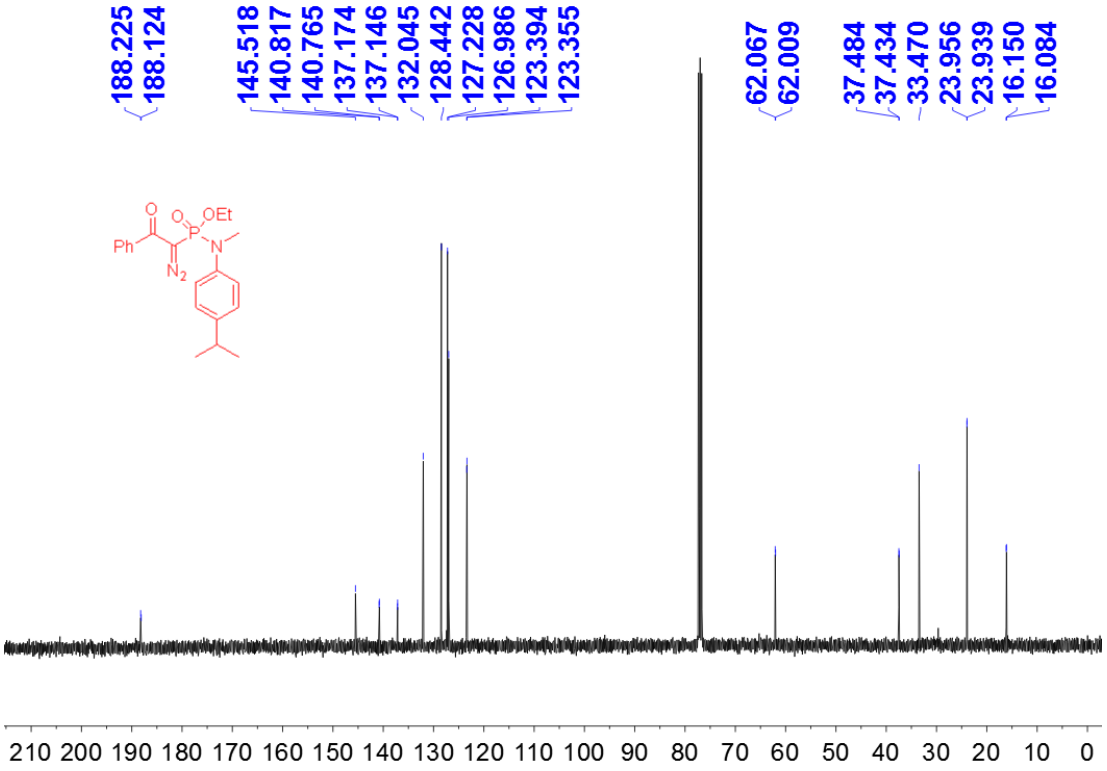
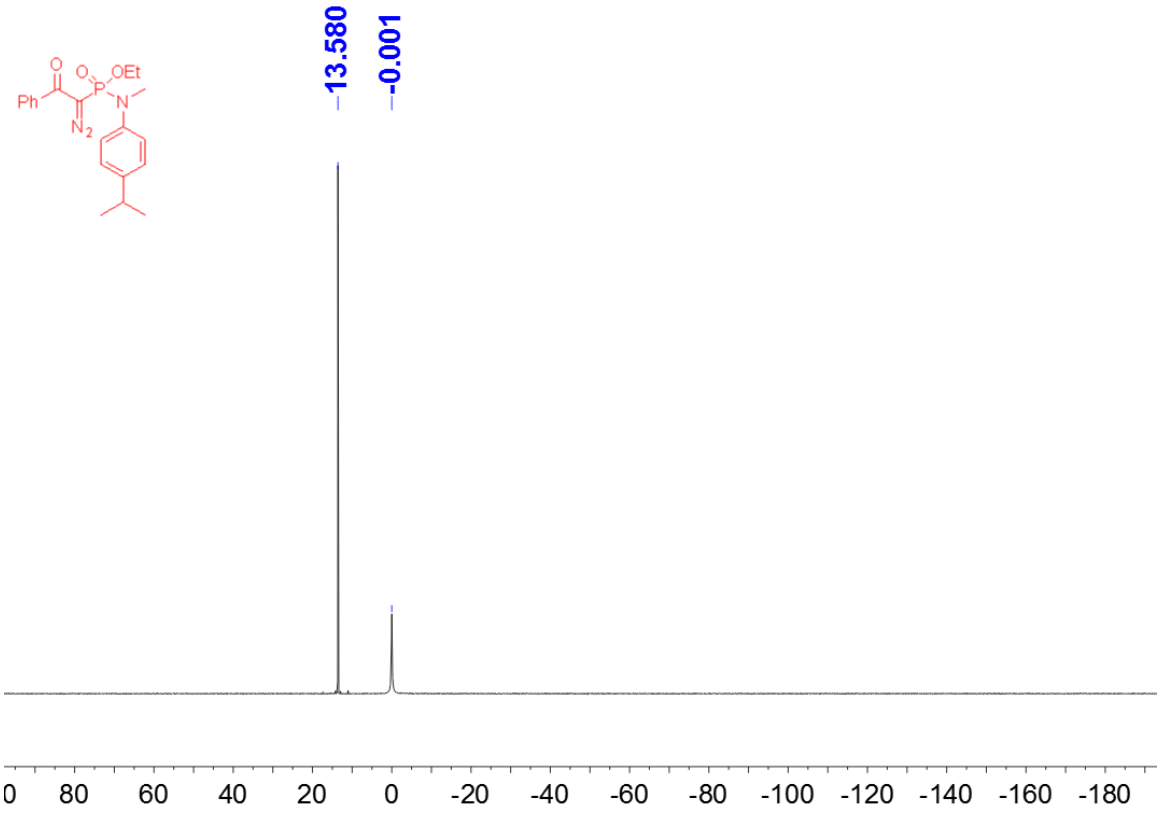
188.018
143.086
143.031
138.864
137.143
137.122
132.067
128.769
128.406
127.280
125.631
125.622
123.905
123.864
120.363
120.325
77.318
77.000
76.682
62.098
62.041
37.325
37.275
21.397
16.111
16.044
O
O
OEt
P
N
CH3
N2
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


13.205
-0.000
O
O
OEt
P
N
CH3
N2
CH3
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

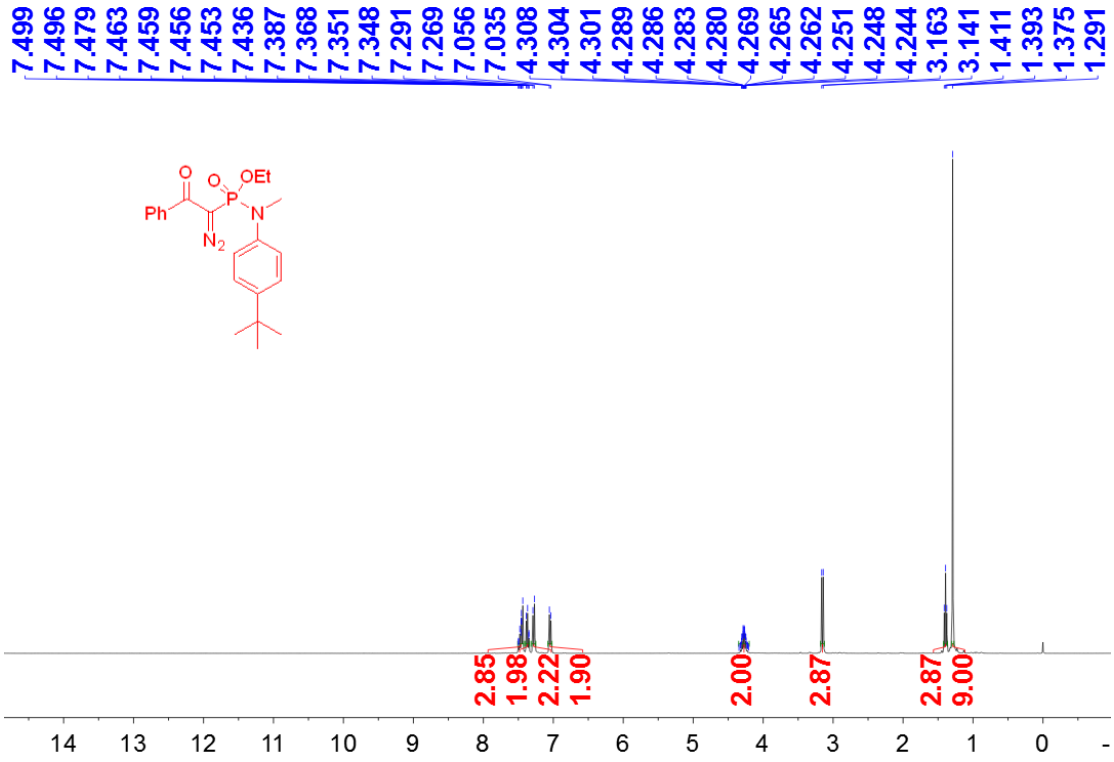
Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-(4-isopropylphenyl)-*N*-methylphosphonamidate (1n)

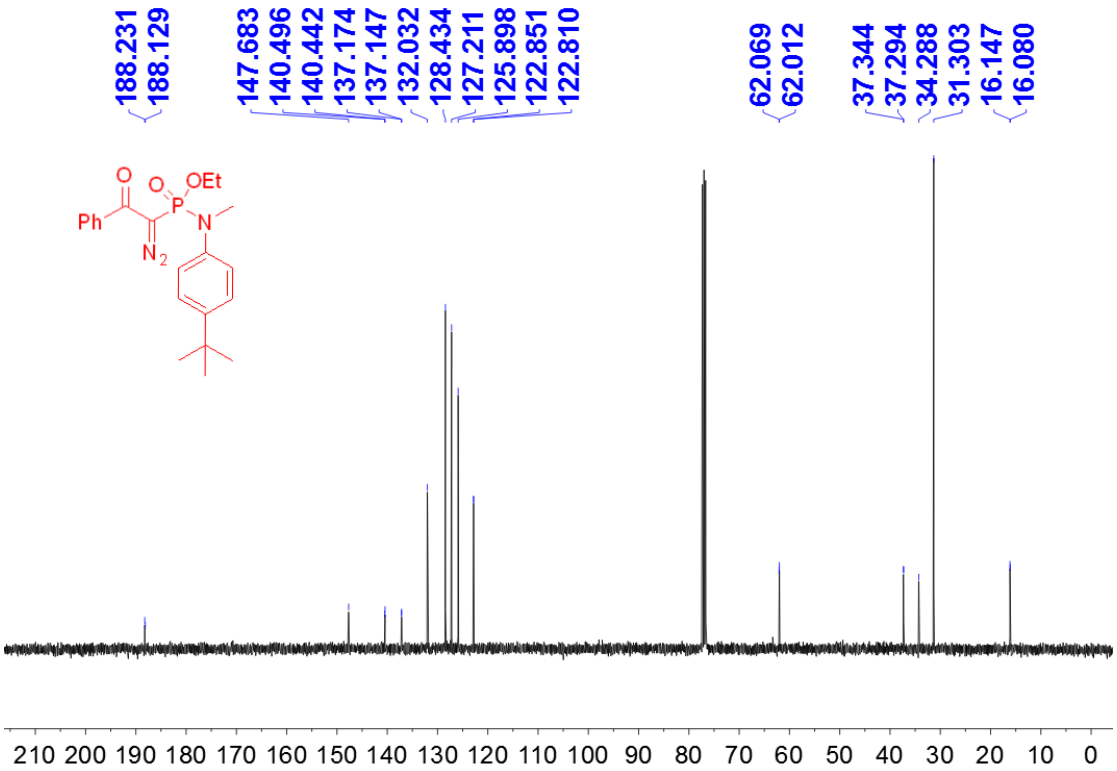


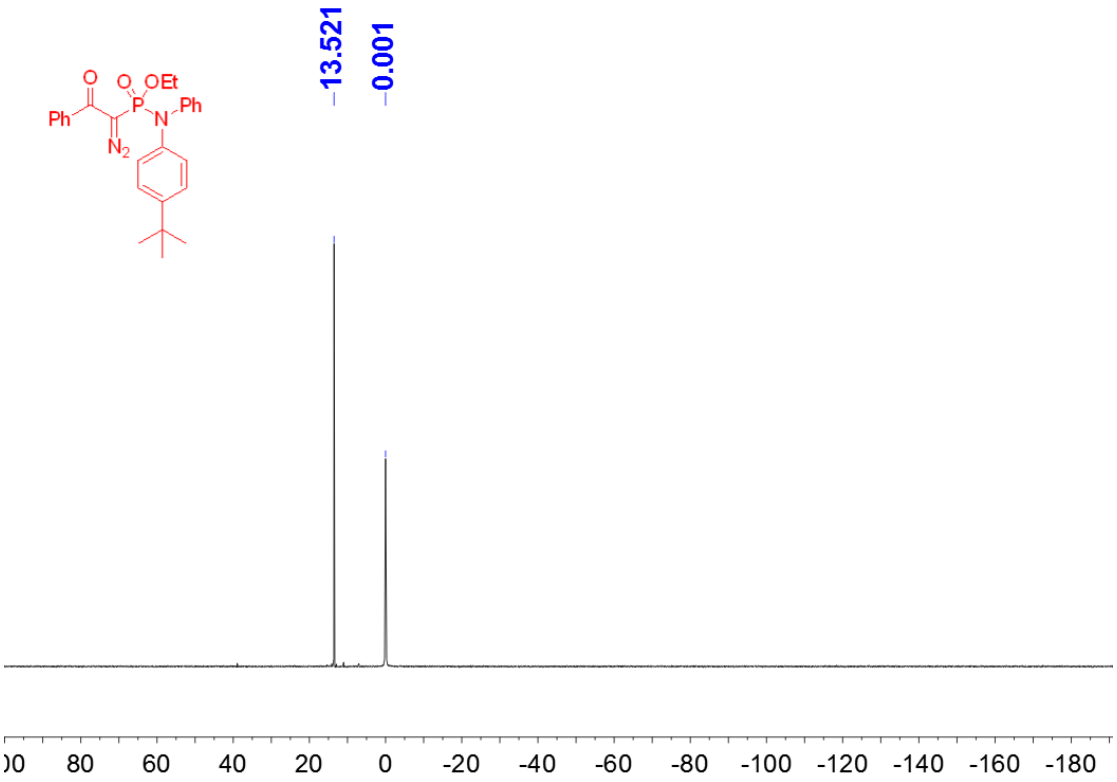




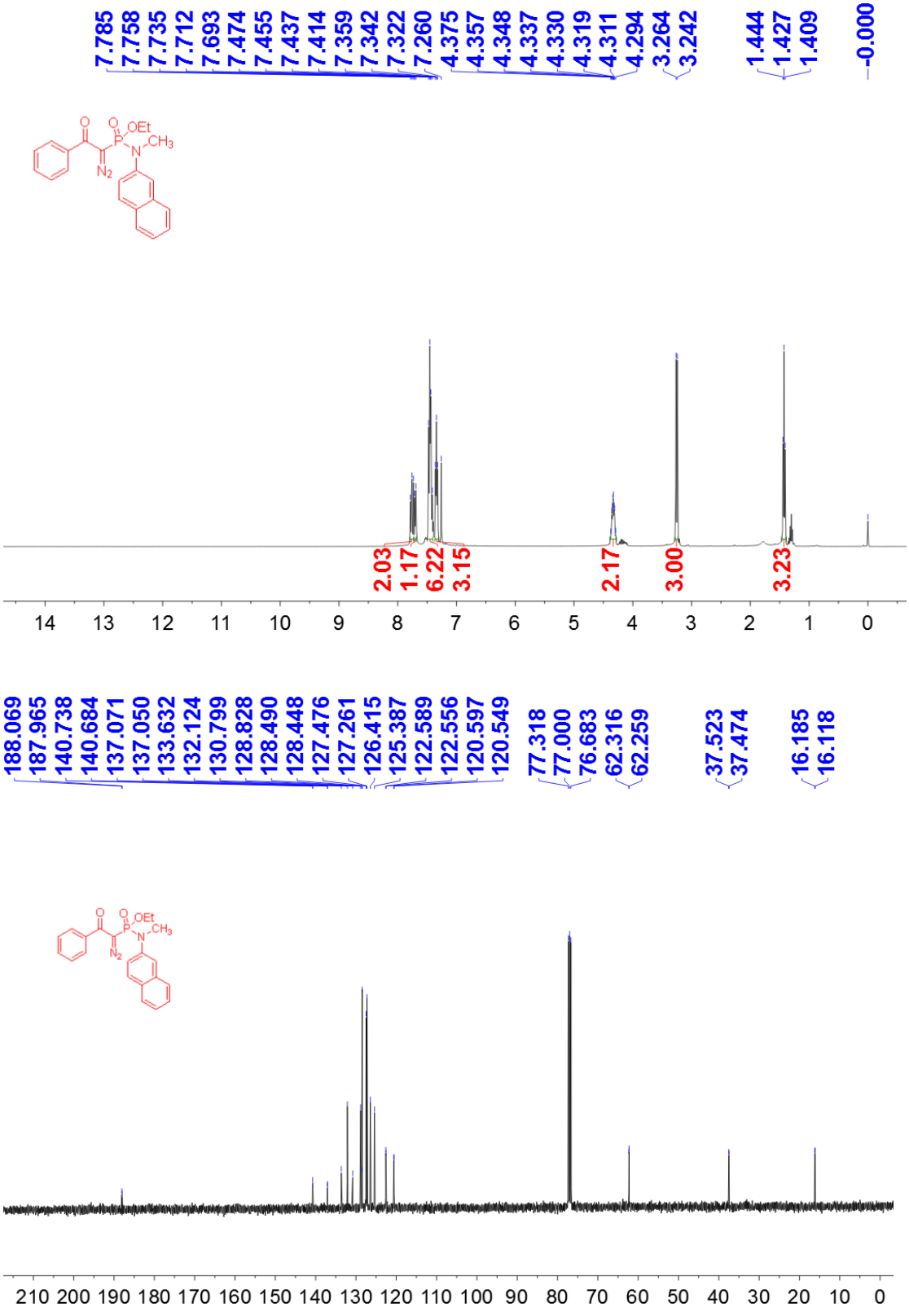
Ethyl *N*-[4-(*tert*-butyl)phenyl]-*P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methylphosphonamidate (1o)

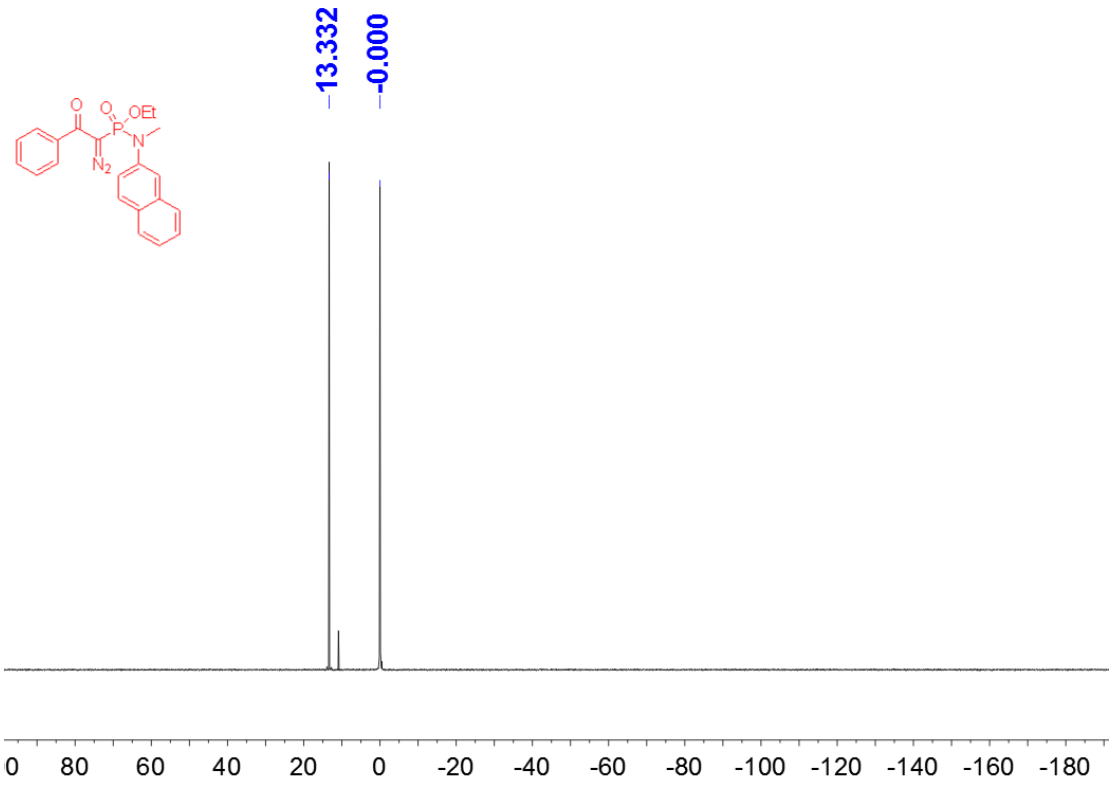



188.231
188.129
147.683
140.496
140.442
137.174
137.147
132.032
128.434
127.211
125.898
122.851
122.810
62.069
62.012
37.344
37.294
34.288
31.303
16.147
16.080
O
O
OEt
Ph
P
N
N2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

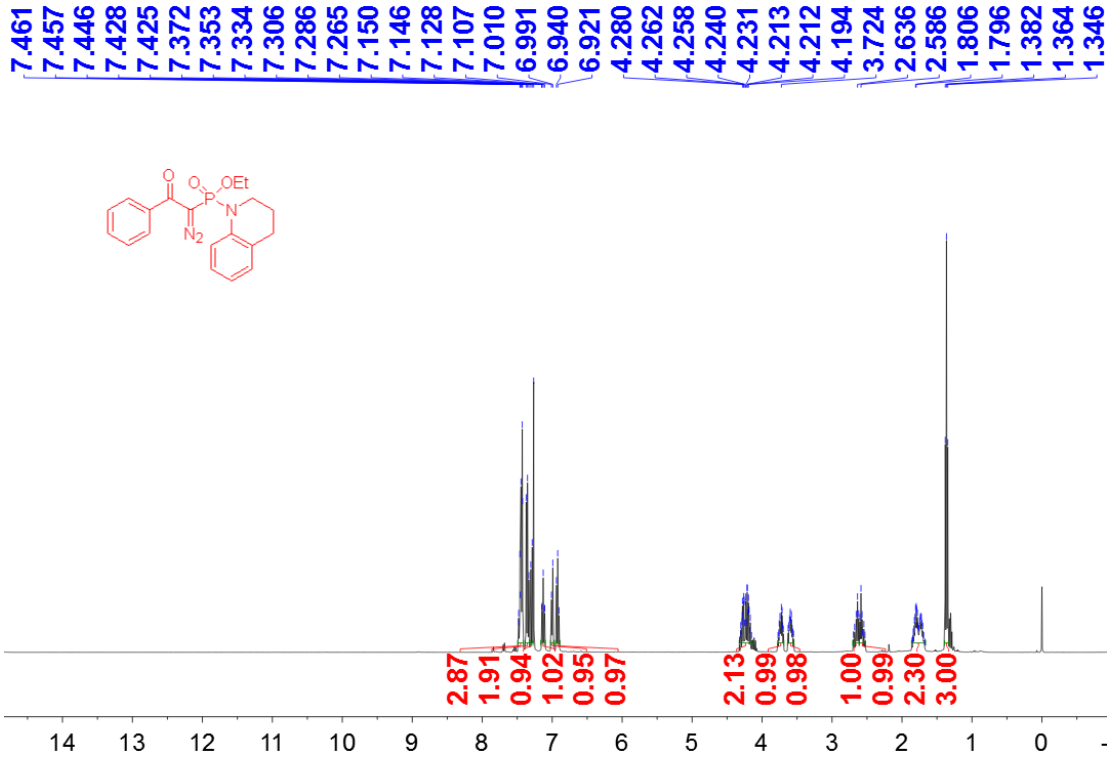

13.521
0.001
O
O
OEt
Ph
P
N
Ph
N2
)0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

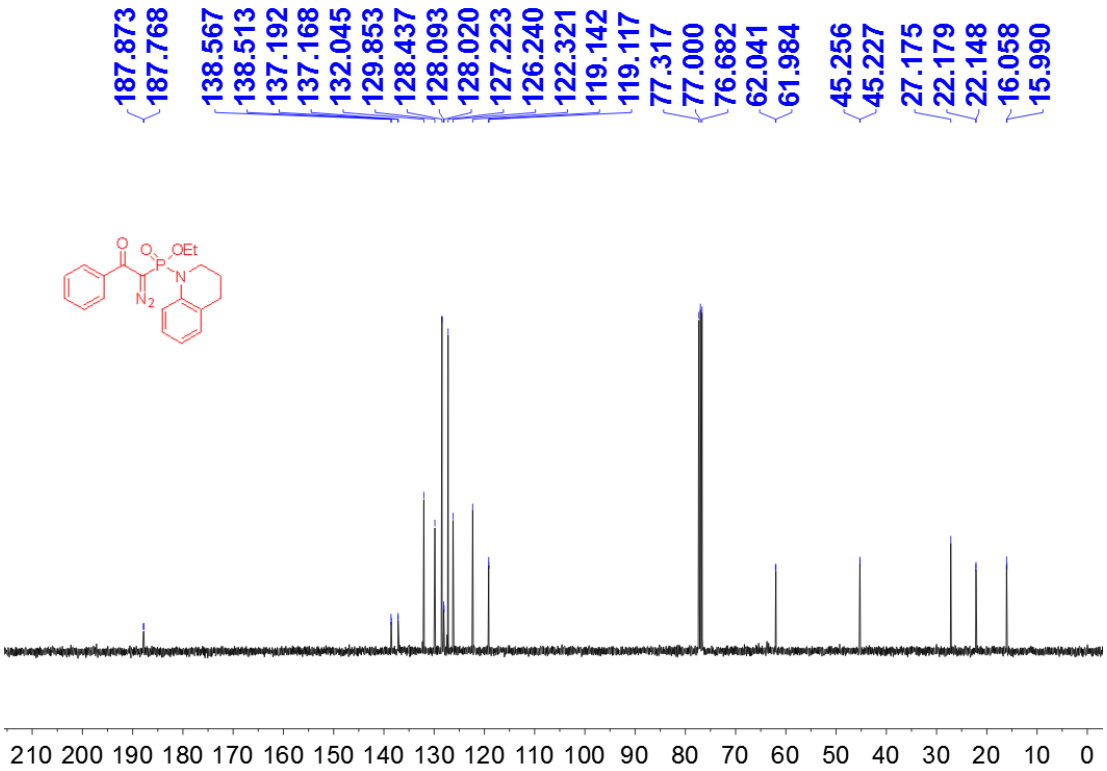
Ethyl *P*-(1-diazo-2-oxo-2-phenylethyl)-*N*-methyl-*N*-(naphthalen-2-yl)phosphonamidate (1p)

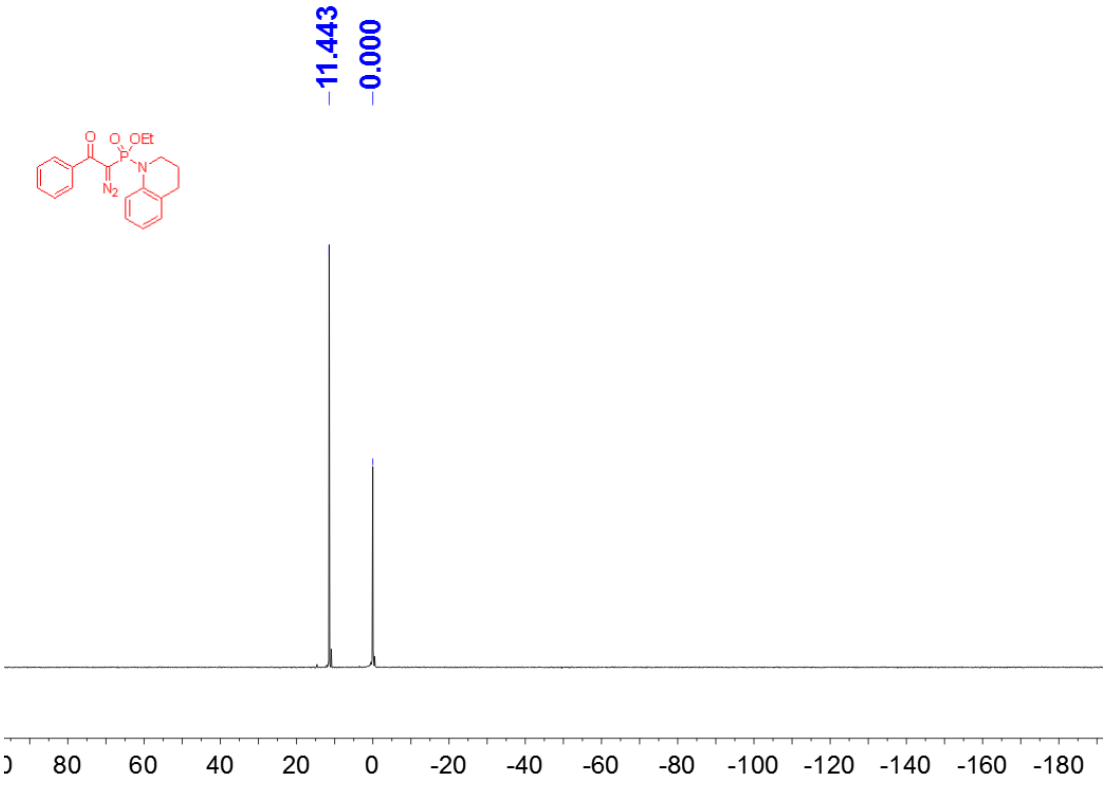




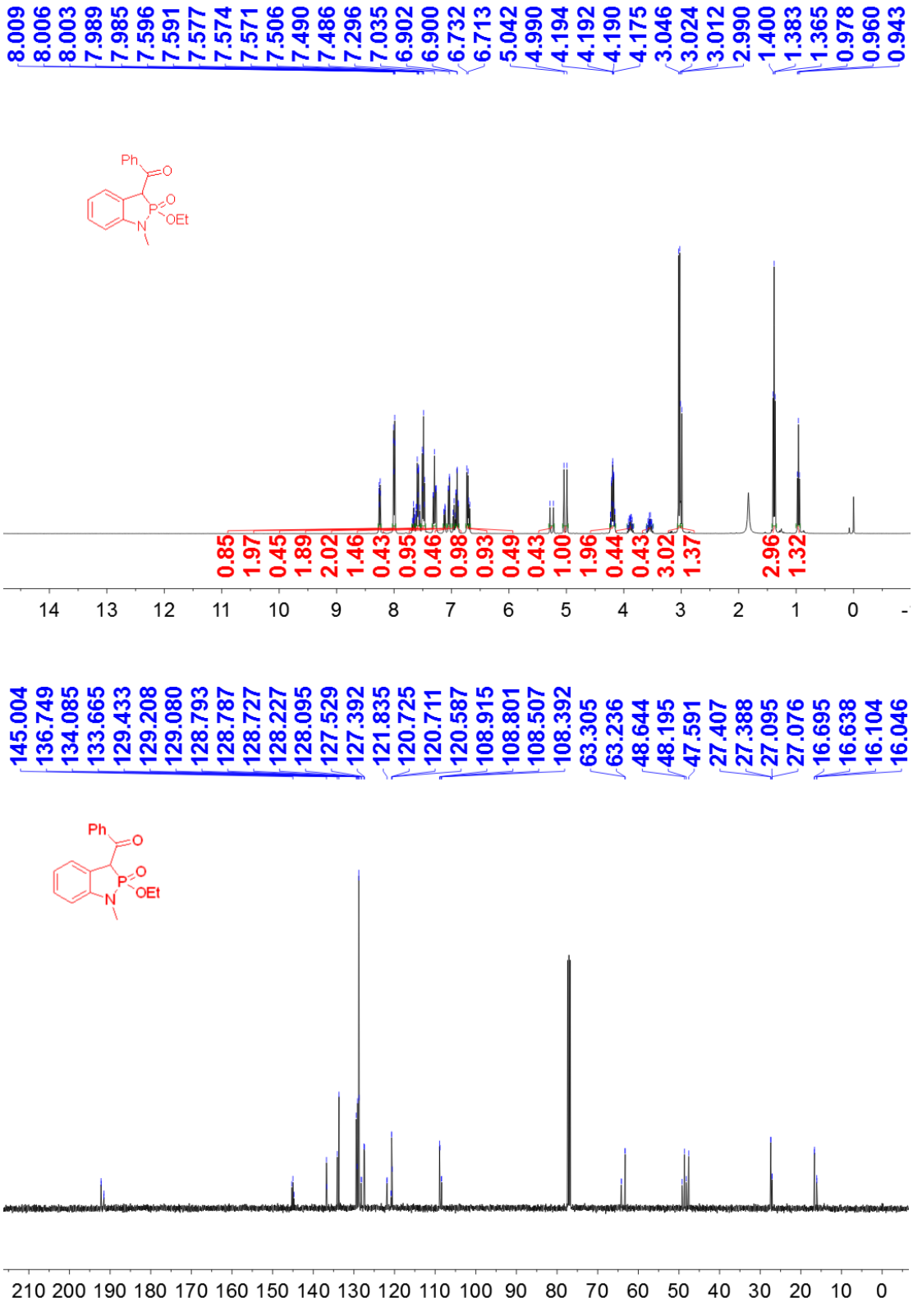
Ethyl (1-diazo-2-oxo-2-phenylethyl)(3,4-dihydroquinolin-1(2*H*)-yl)phosphinate (1q)

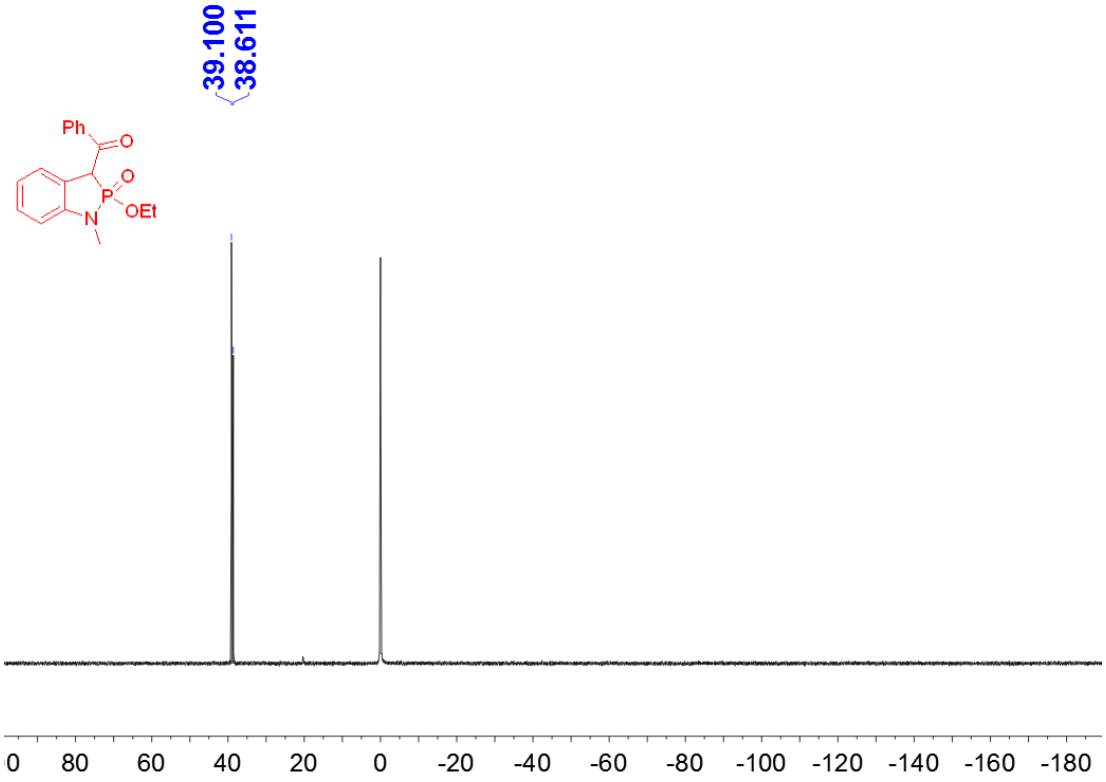



187.873
187.768
138.567
138.513
137.192
137.168
132.045
129.853
128.437
128.093
128.020
127.223
126.240
122.321
119.142
119.117
77.317
77.000
76.682
62.041
61.984
45.256
45.227
27.175
22.179
22.148
16.058
15.990
O
O
P
OEt
N
N2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

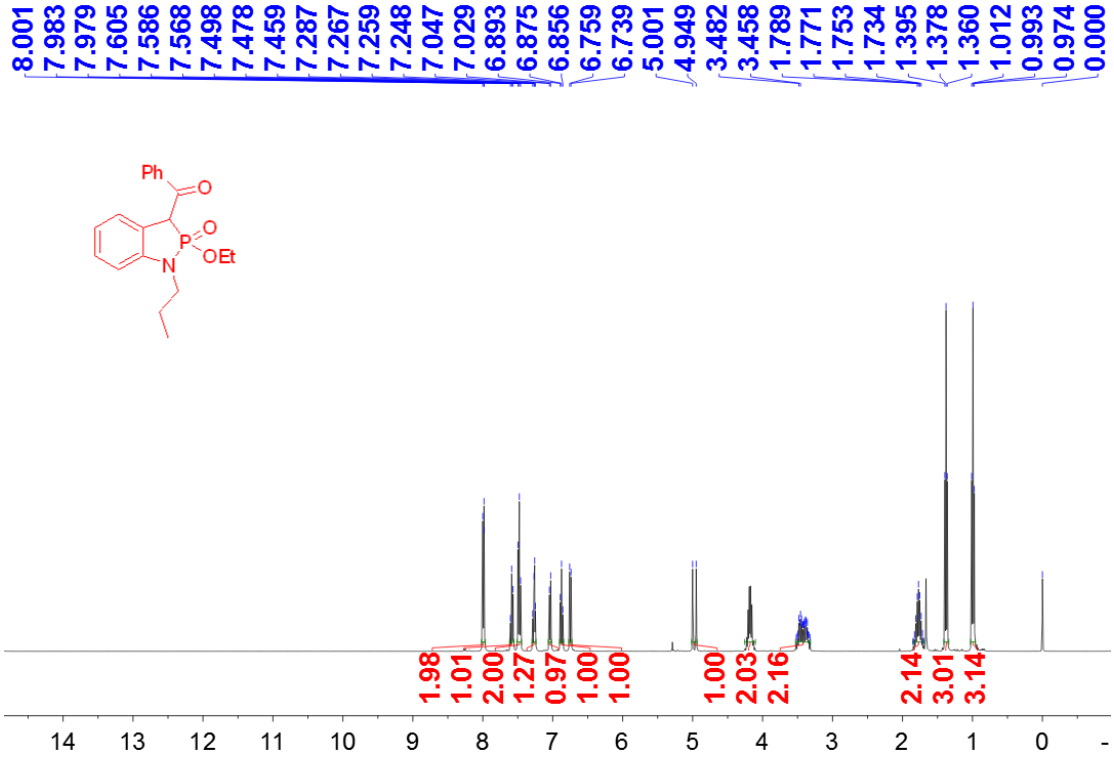

11.443
0.000
O
O
P
OEt
N
N2
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

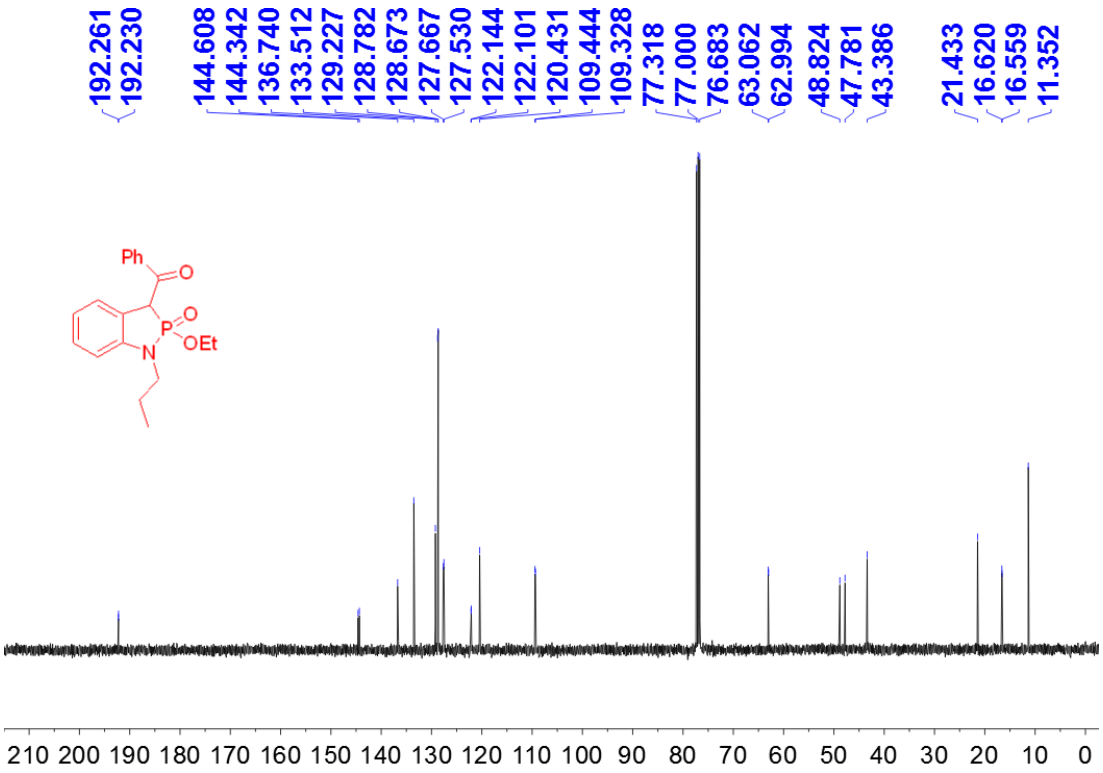
3-Benzoyl-2-ethoxy-1-methyl-2-oxophosphorindoline (2a)





3-Benzoyl-2-ethoxy-2-oxo-1-propylphosphorindoline (2b)

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144.342
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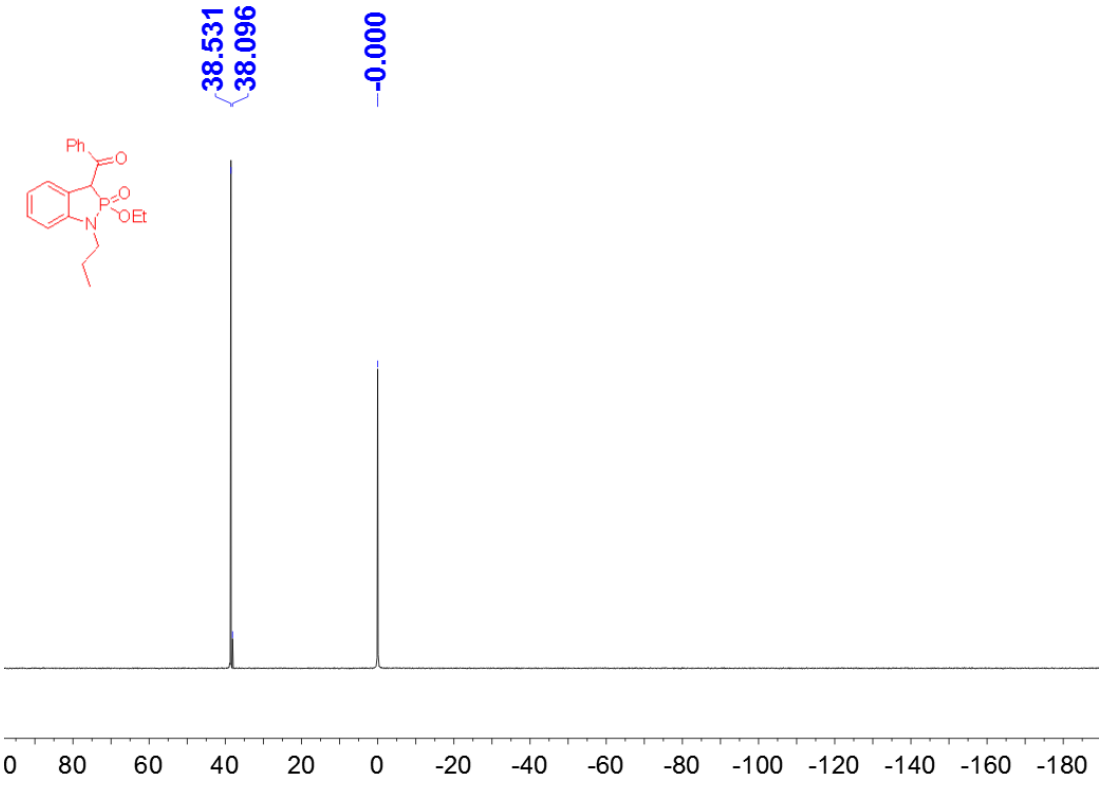
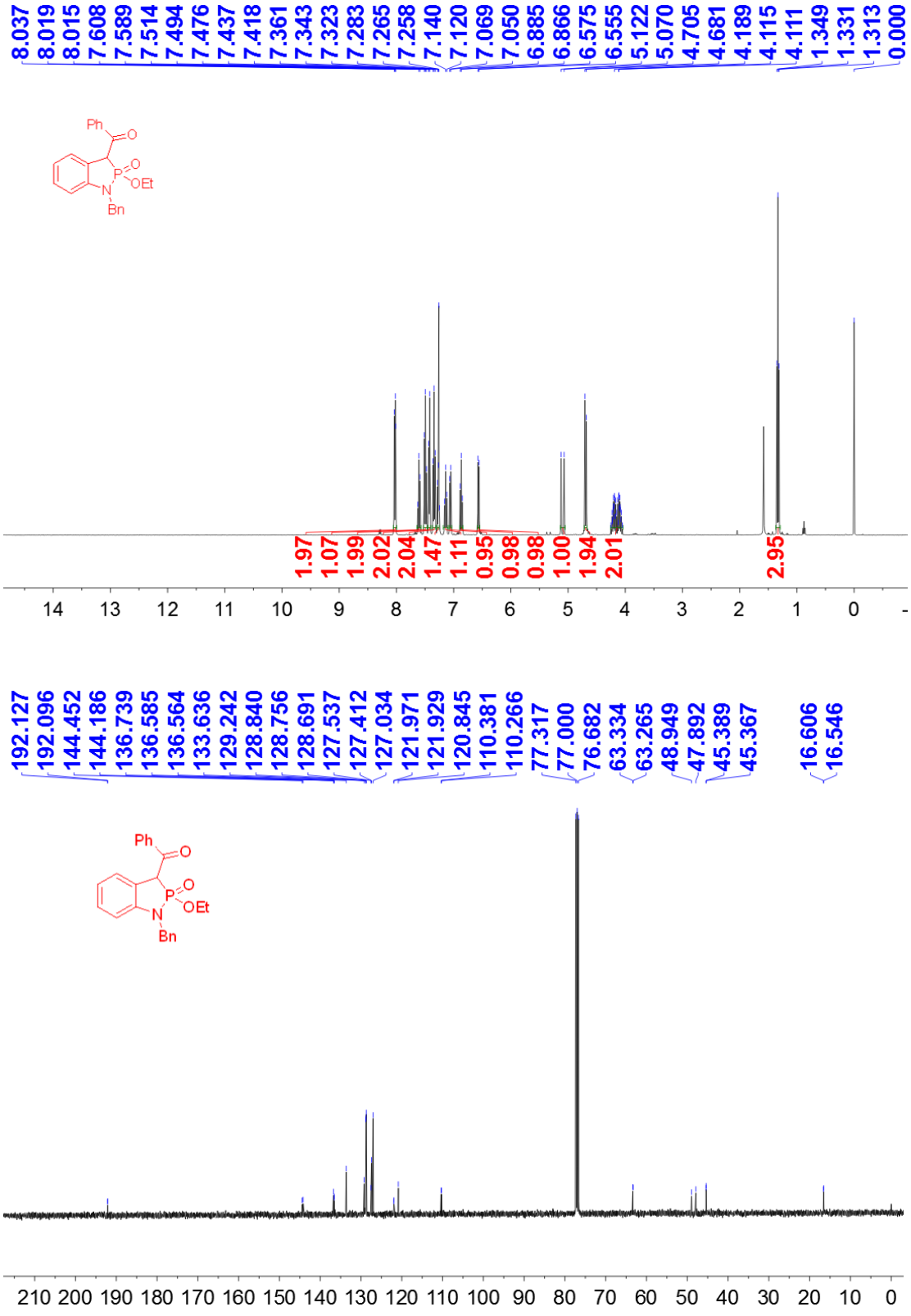
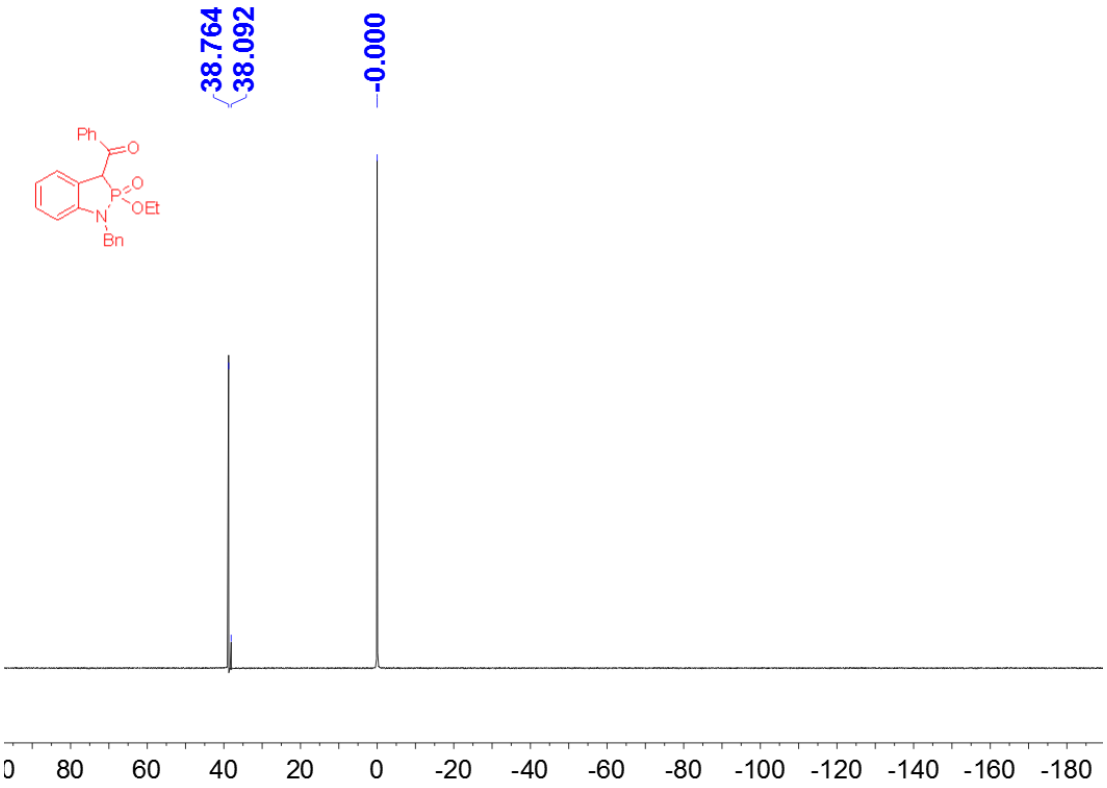
133.512
129.227
128.782
128.673
127.667
127.530
122.144
122.101
120.431
109.444
109.328
77.318
77.000
76.683
63.062
62.994
48.824
47.781
43.386
21.433
16.620
16.559
11.352
Ph
O
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

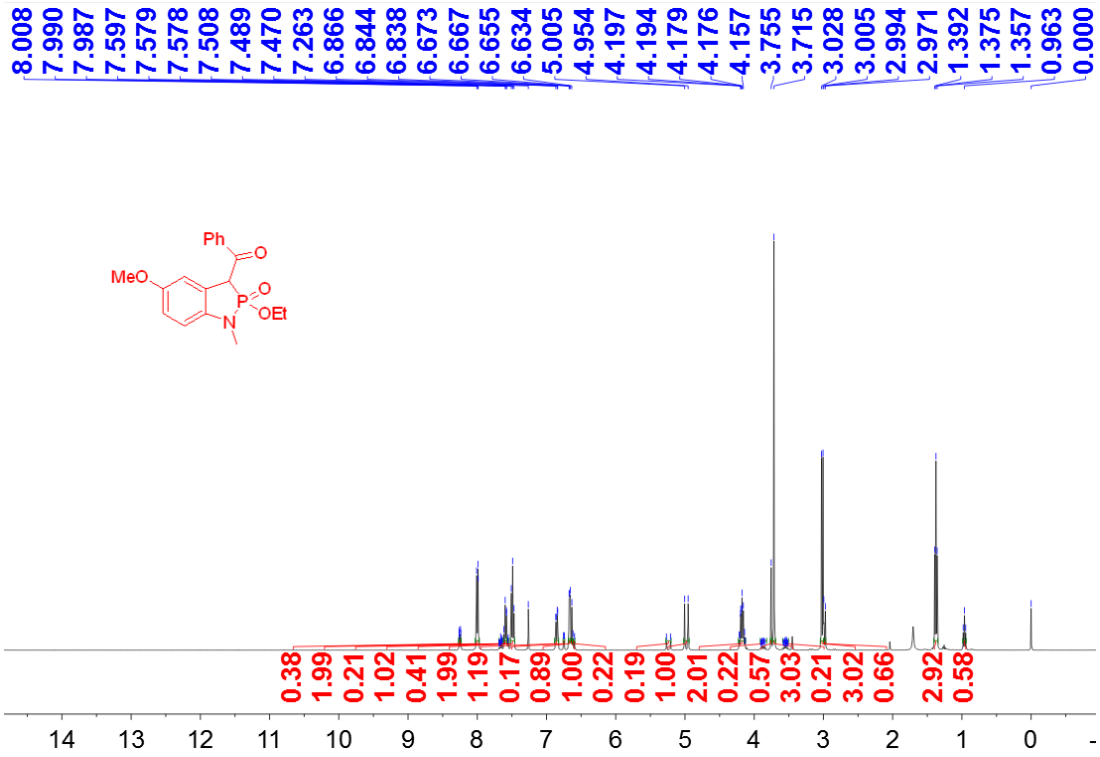

38.531
38.096
-0.000
Ph
O
P
O
OEt
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

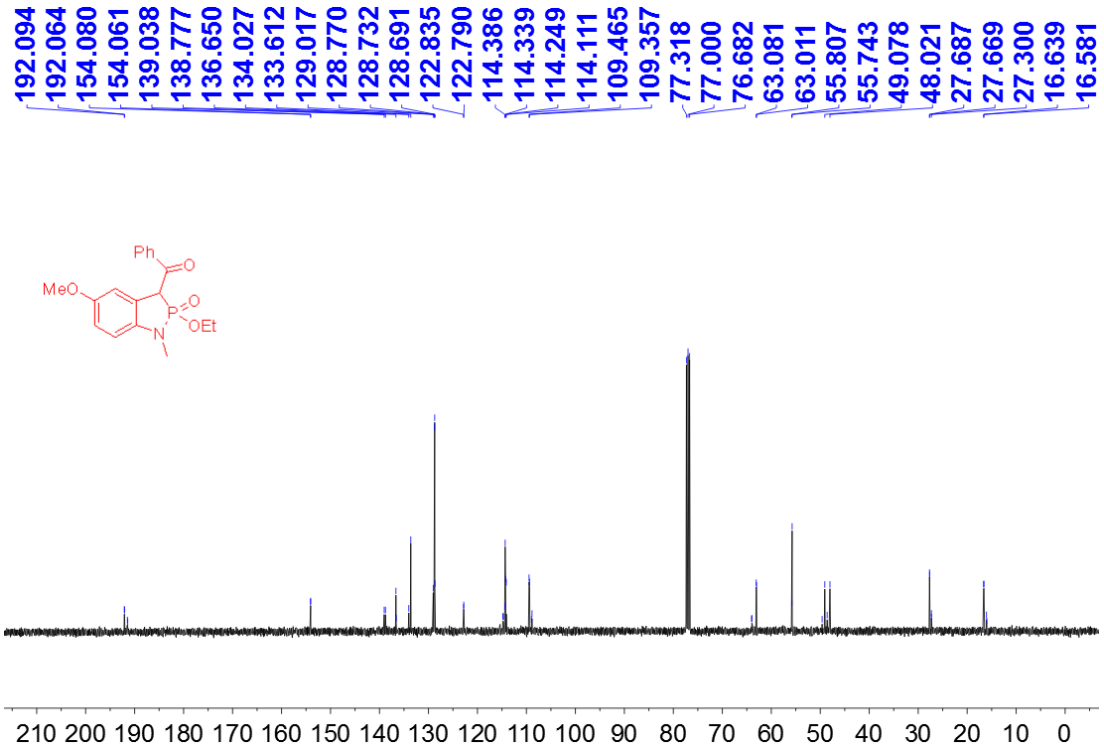
3-Benzoyl-1-benzyl-2-ethoxy-2-oxophosphorindoline (2c)





3-Benzoyl-2-ethoxy-5-methoxy-1-methyl-2-oxophosphorindoline (2d)

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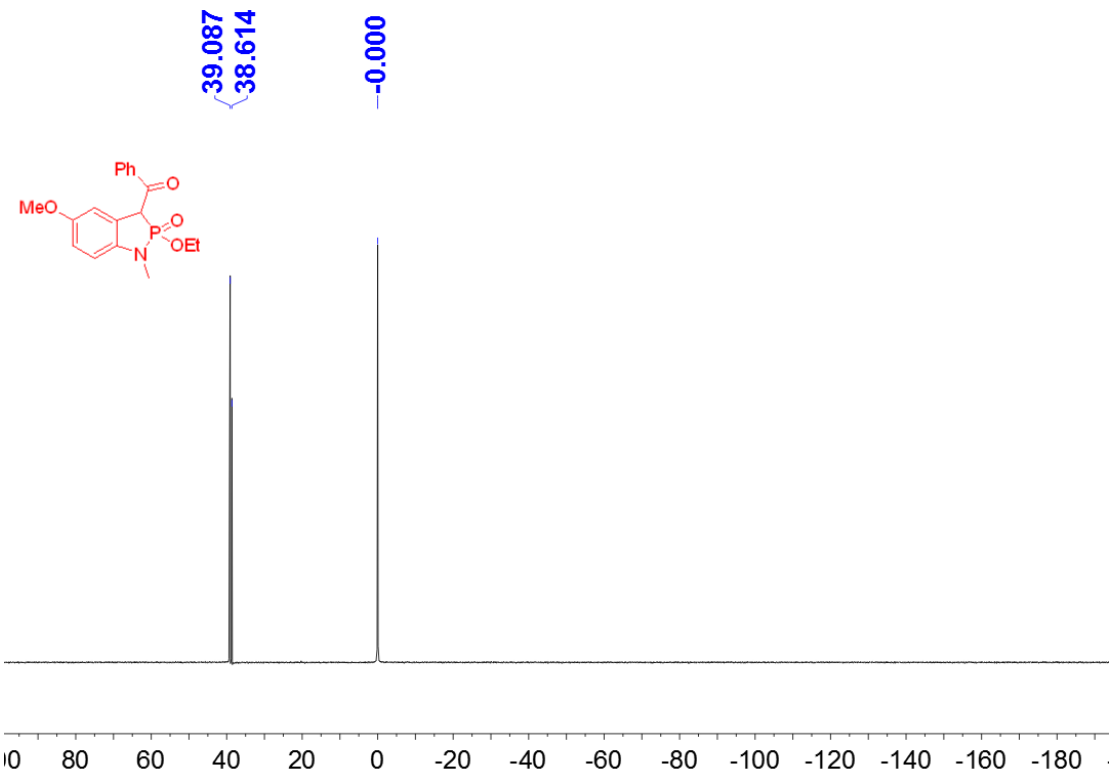
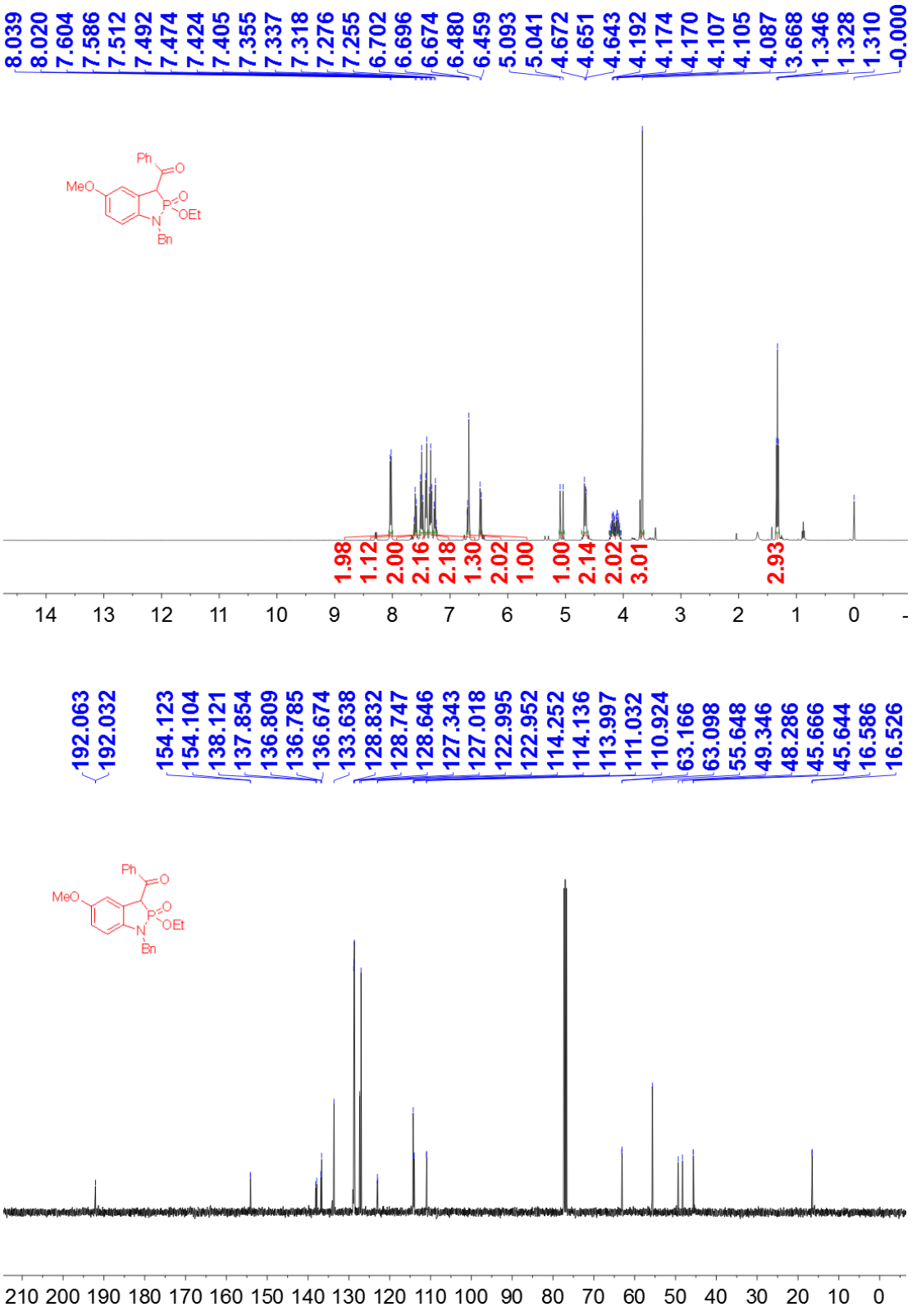
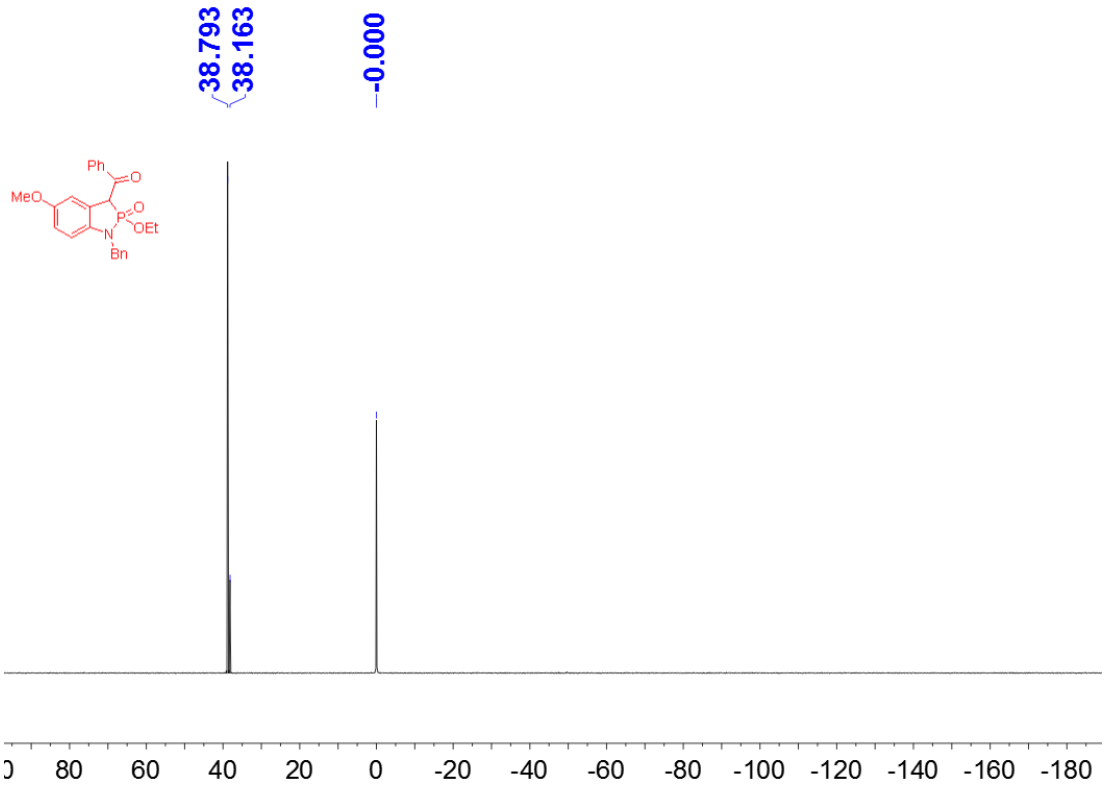
192.064
154.080
154.061
139.038
138.777
136.650
134.027
133.612
129.017
128.770
128.732
128.691
122.835
122.790
114.386
114.339
114.249
114.111
109.465
109.357
77.318
77.000
76.682
63.081
63.011
55.807
55.743
49.078
48.021
27.687
27.669
27.300
16.639
16.581
Ph
O
MeO
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

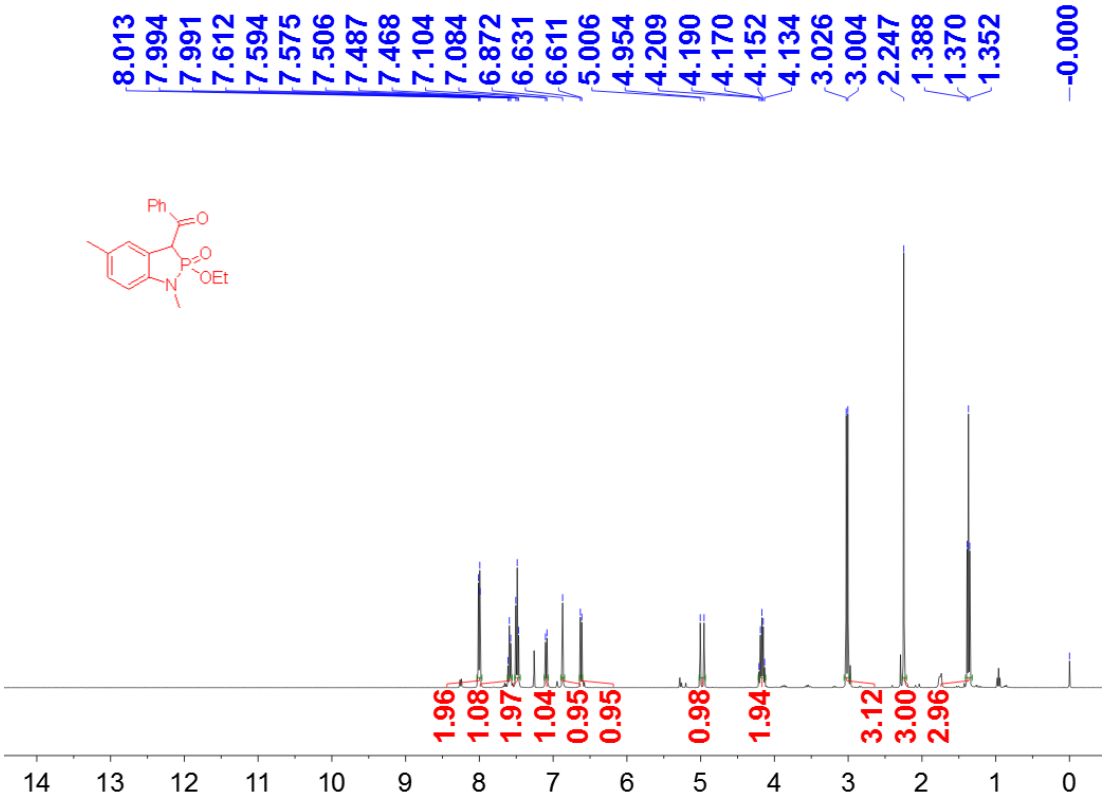

39.087
38.614
-0.000
Ph
O
MeO
P
O
OEt
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

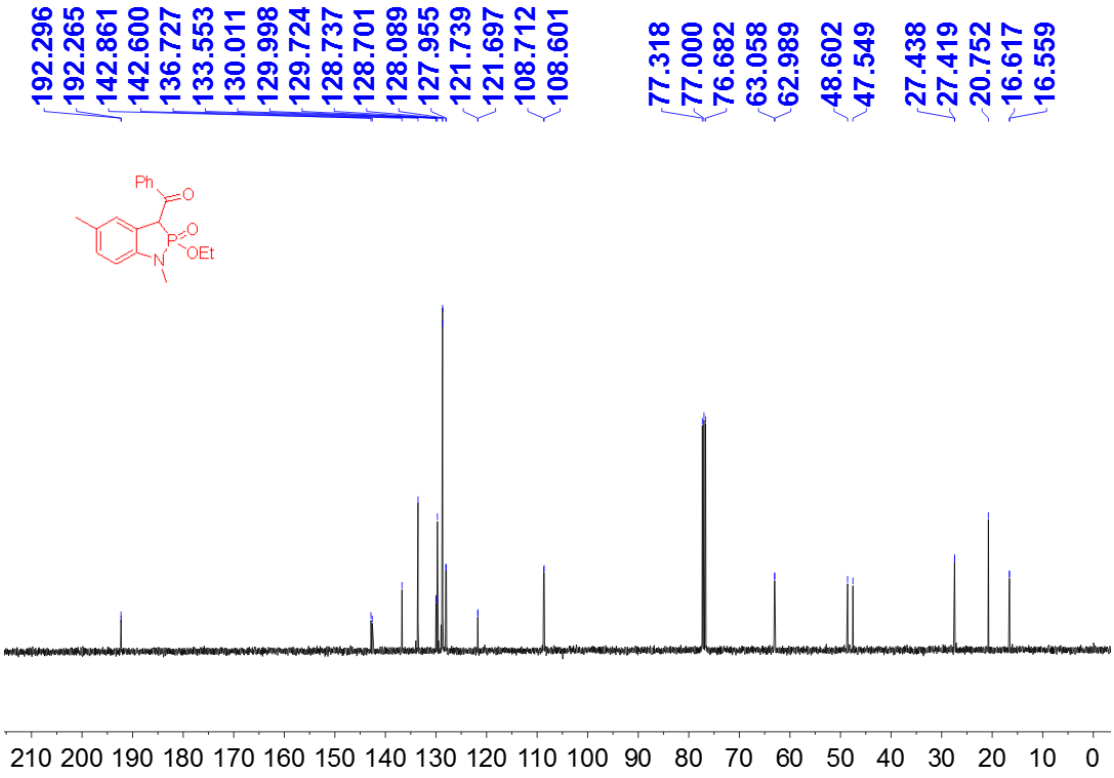
3-Benzoyl-1-benzyl-2-ethoxy-5-methoxy-2-oxophosphorindoline (2e)

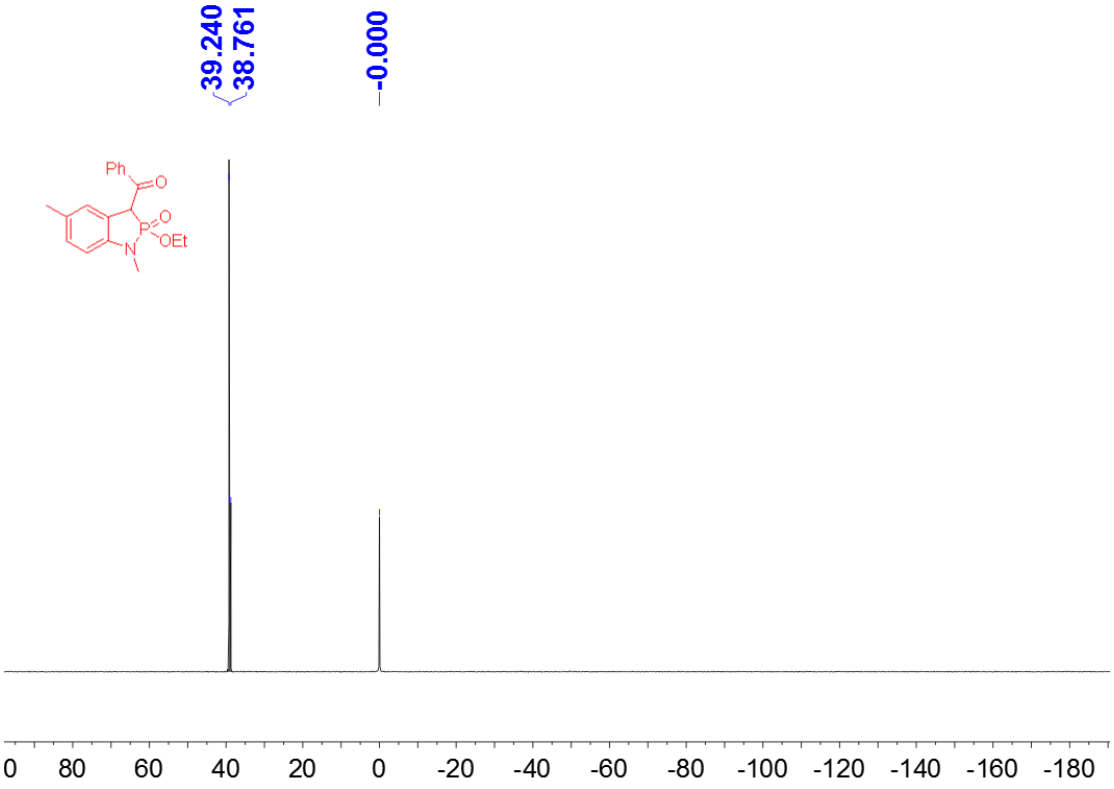




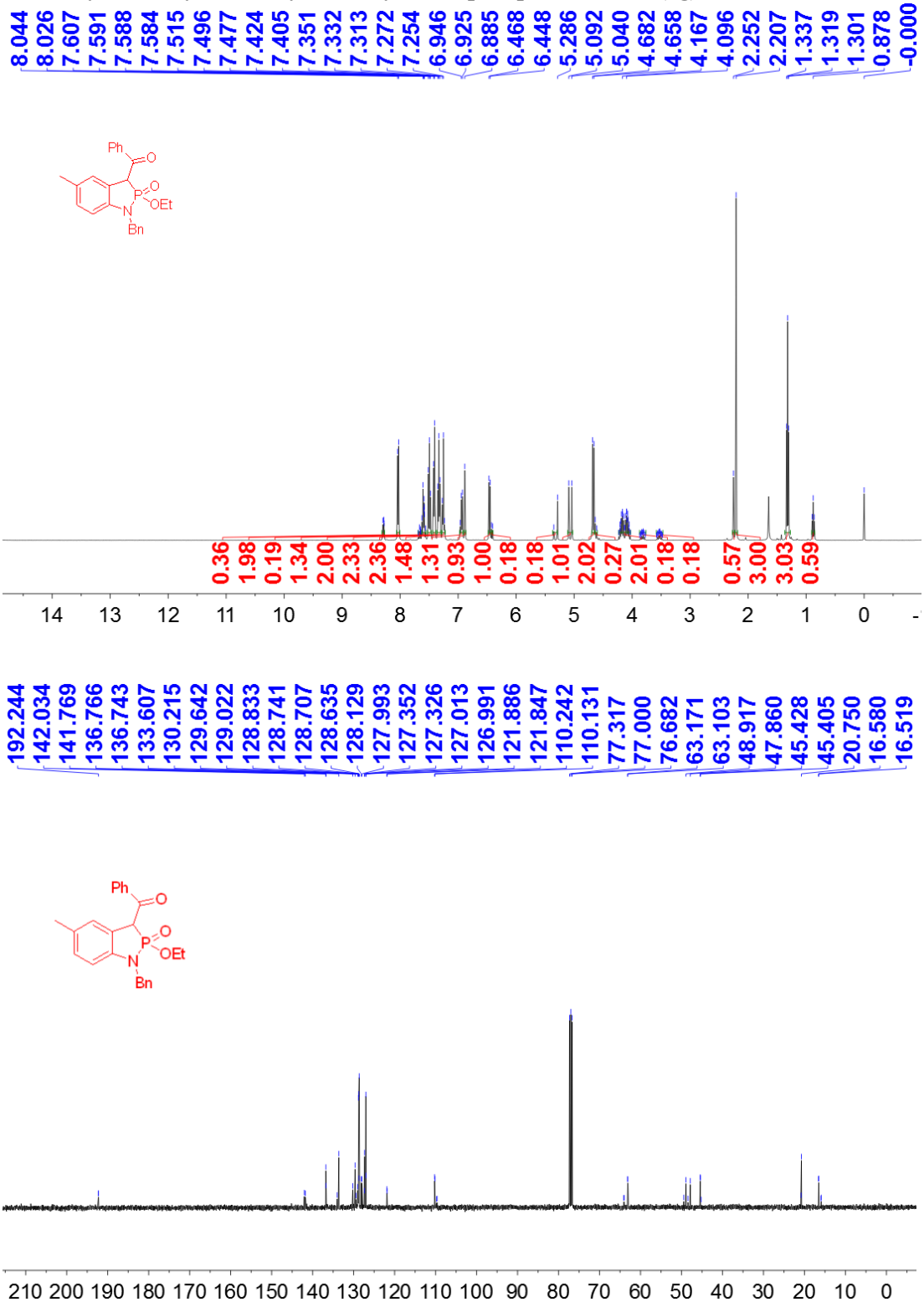
3-Benzoyl-2-ethoxy-1,5-dimethyl-2-oxophosphorindoline (2f)

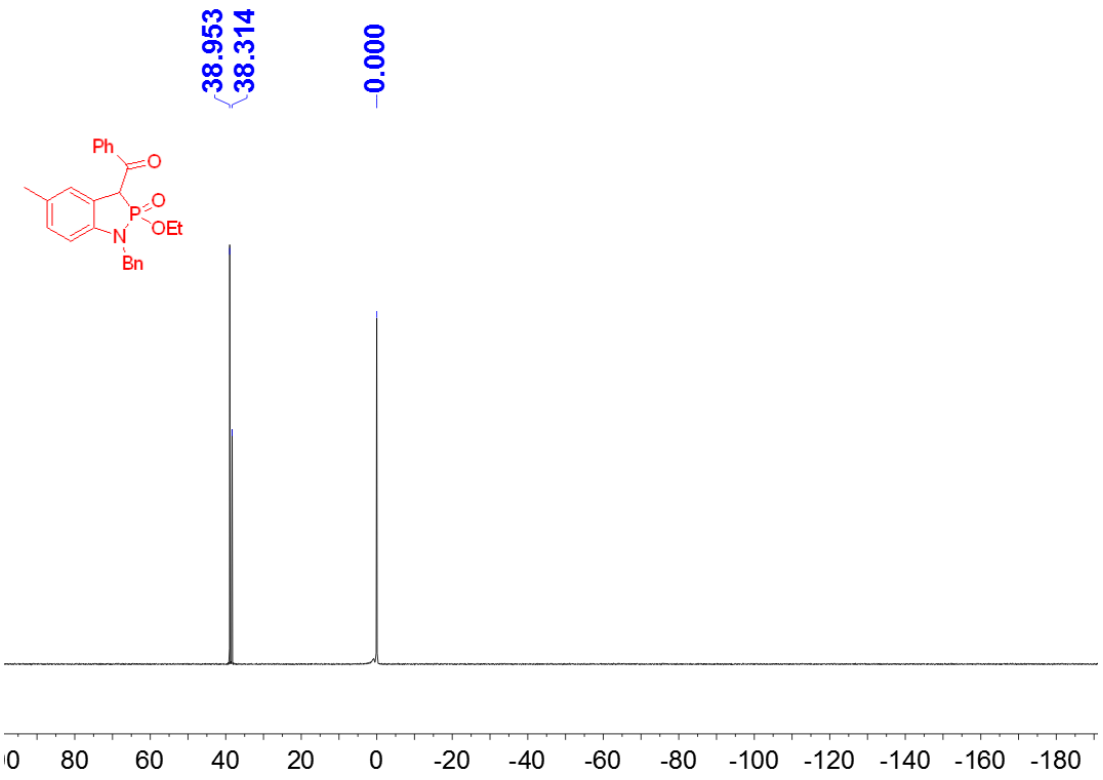



192.296
192.265
142.861
142.600
136.727
133.553
130.011
129.998
129.724
128.737
128.701
128.089
127.955
121.739
121.697
108.712
108.601
77.318
77.000
76.682
63.058
62.989
48.602
47.549
27.438
27.419
20.752
16.617
16.559
Ph
O
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

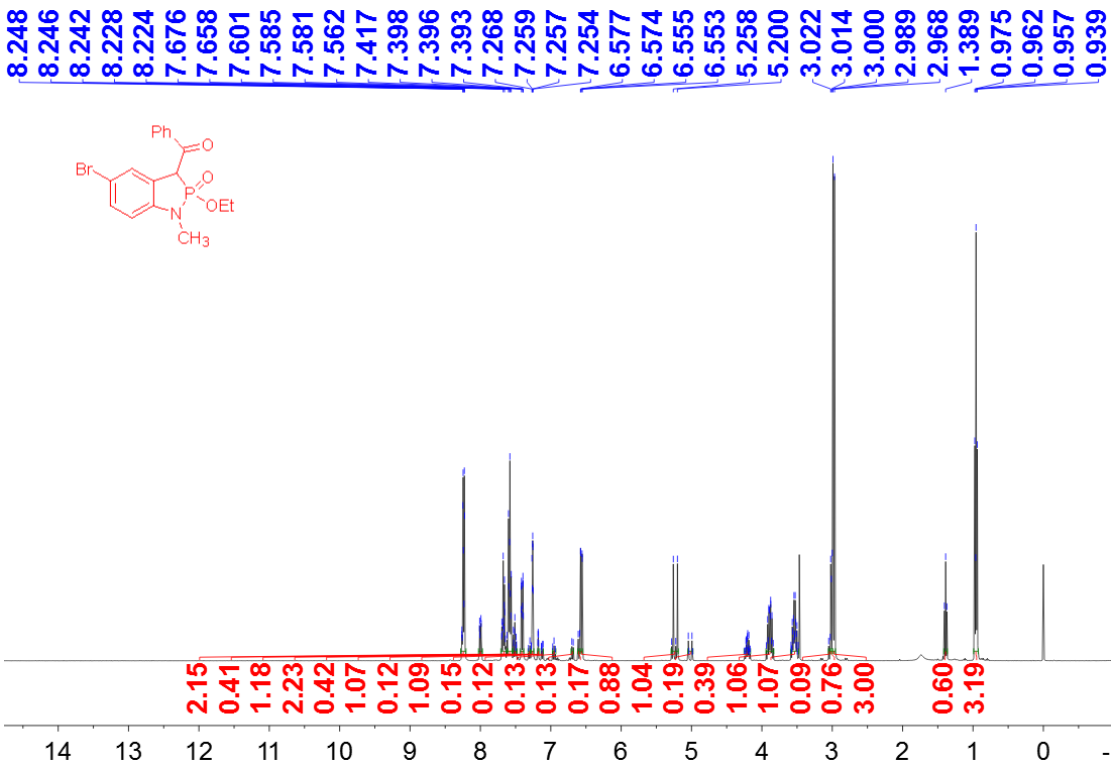

39.240
38.761
-0.000
Ph
O
P
O
OEt
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

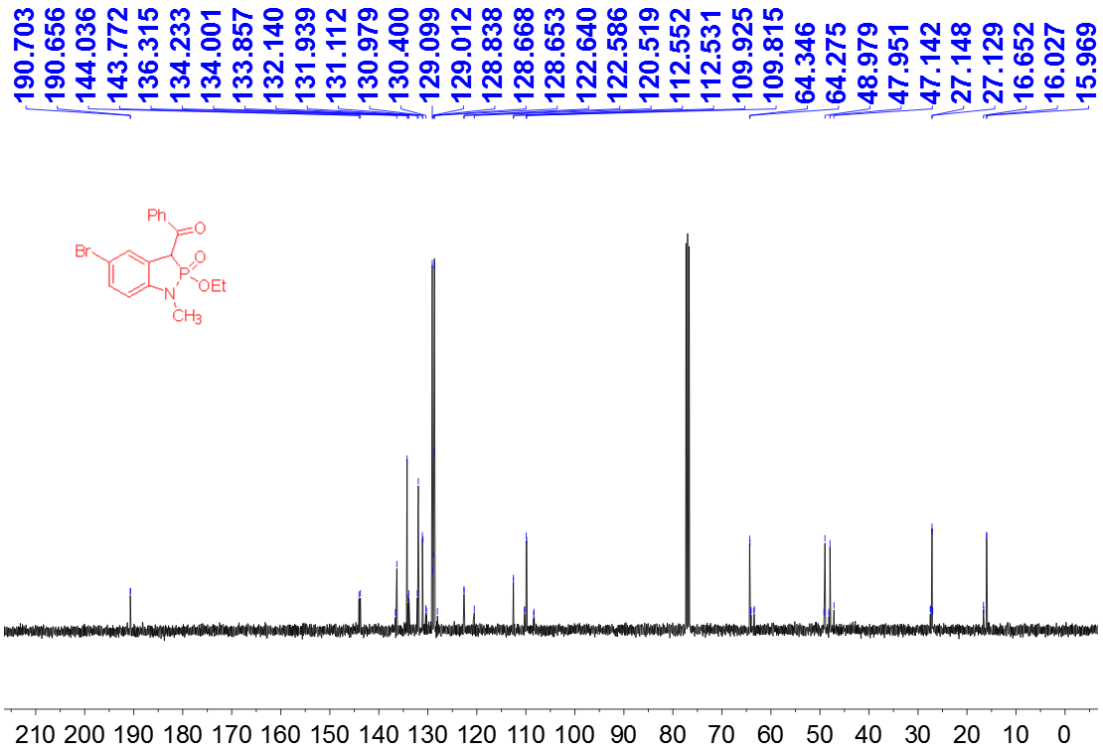
3-Benzoyl-1-benzyl-2-ethoxy-5-methyl-2-oxophosphorindoline (2g)

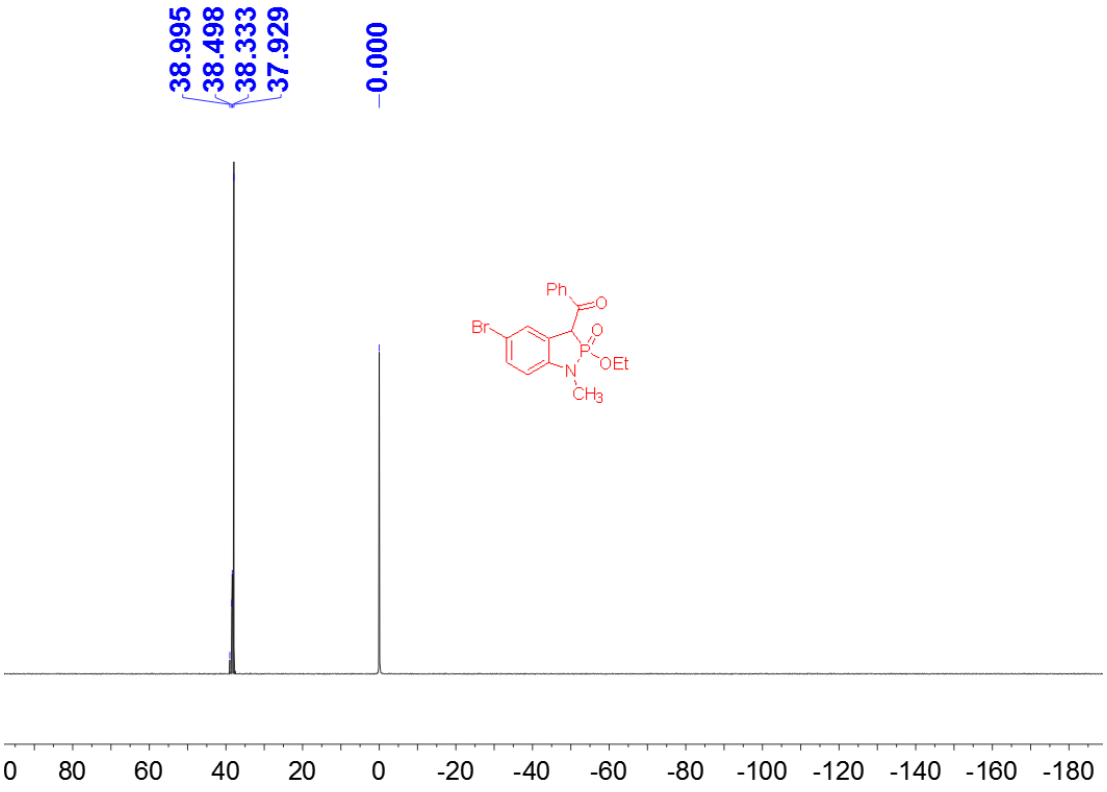




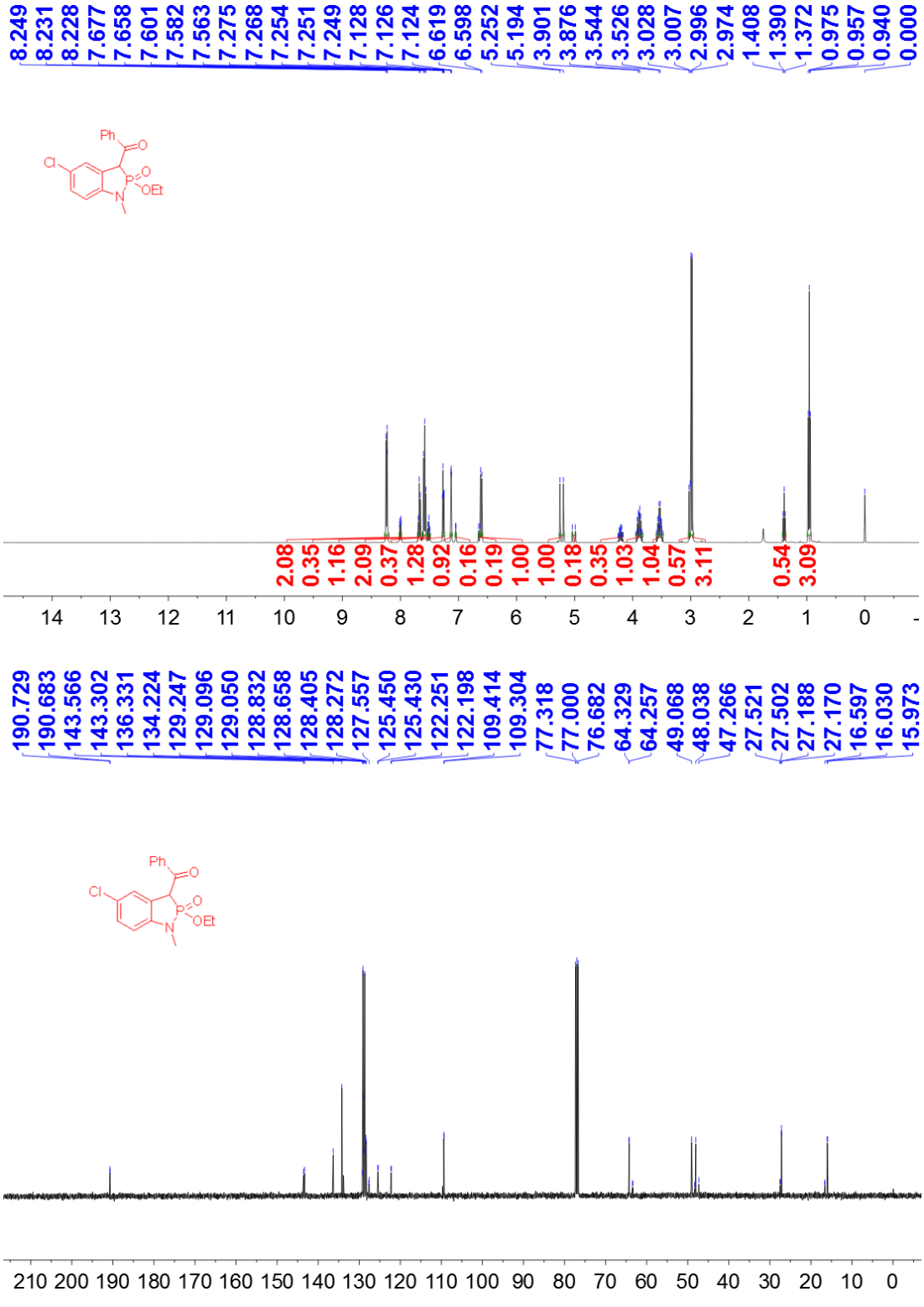
3-Benzoyl-5-bromo-2-ethoxy-1-methyl-2-oxophosphorindoline (2h)

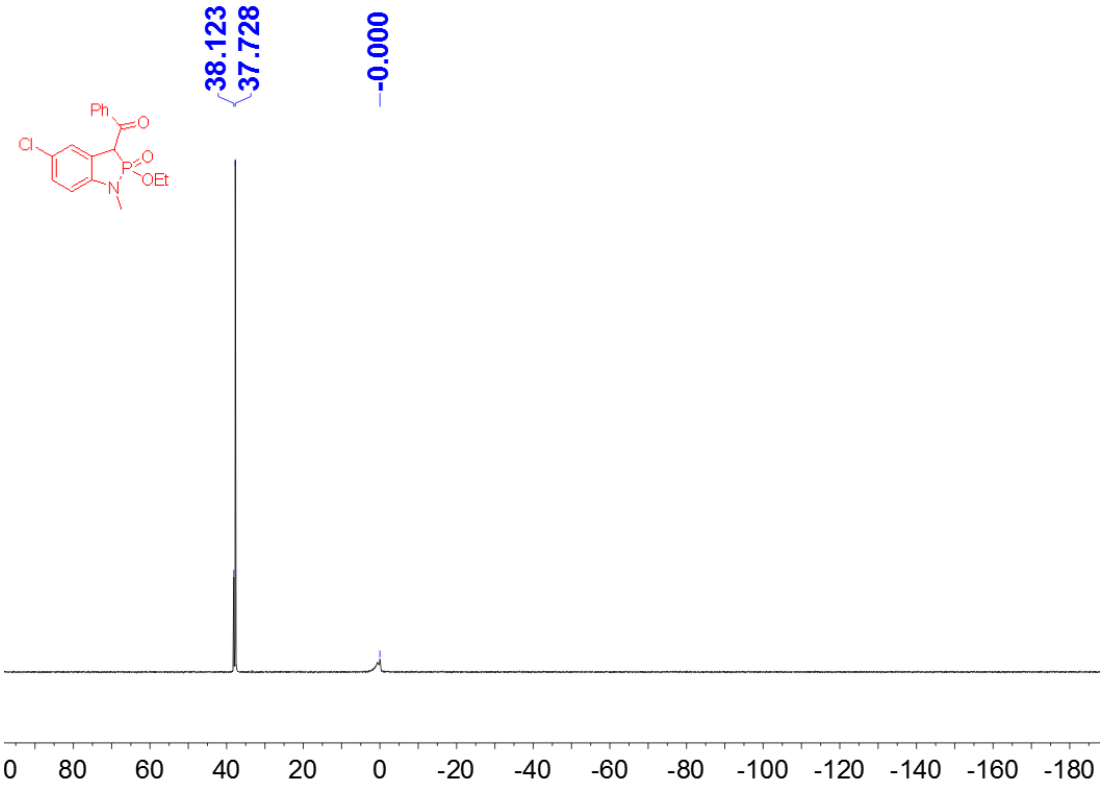



190.703
190.656
144.036
143.772
136.315
134.233
134.001
133.857
132.140
131.939
131.112
130.979
130.400
129.099
129.012
128.838
128.668
128.653
122.640
122.586
120.519
112.552
112.531
109.925
109.815
64.346
64.275
48.979
47.951
47.142
27.148
27.129
16.652
16.027
15.969
Ph
O
Br
O
P
OEt
N
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

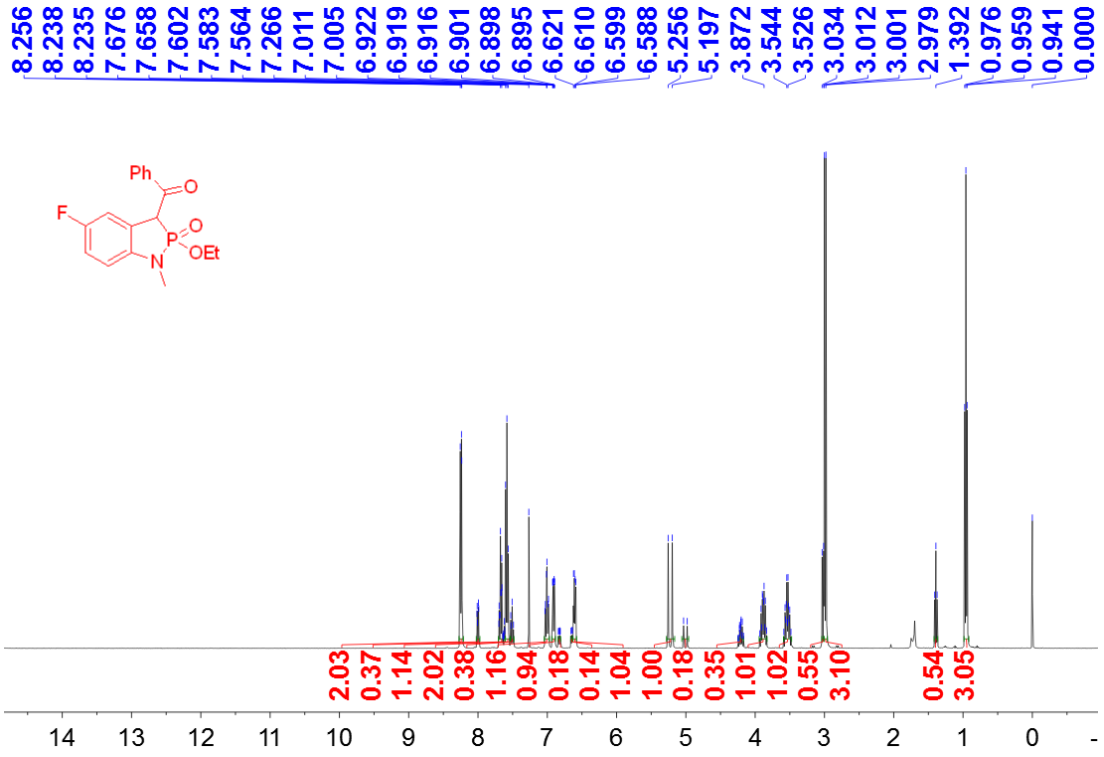

38.995
38.498
38.333
37.929
0.000
Ph
O
Br
O
P
OEt
N
CH3
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

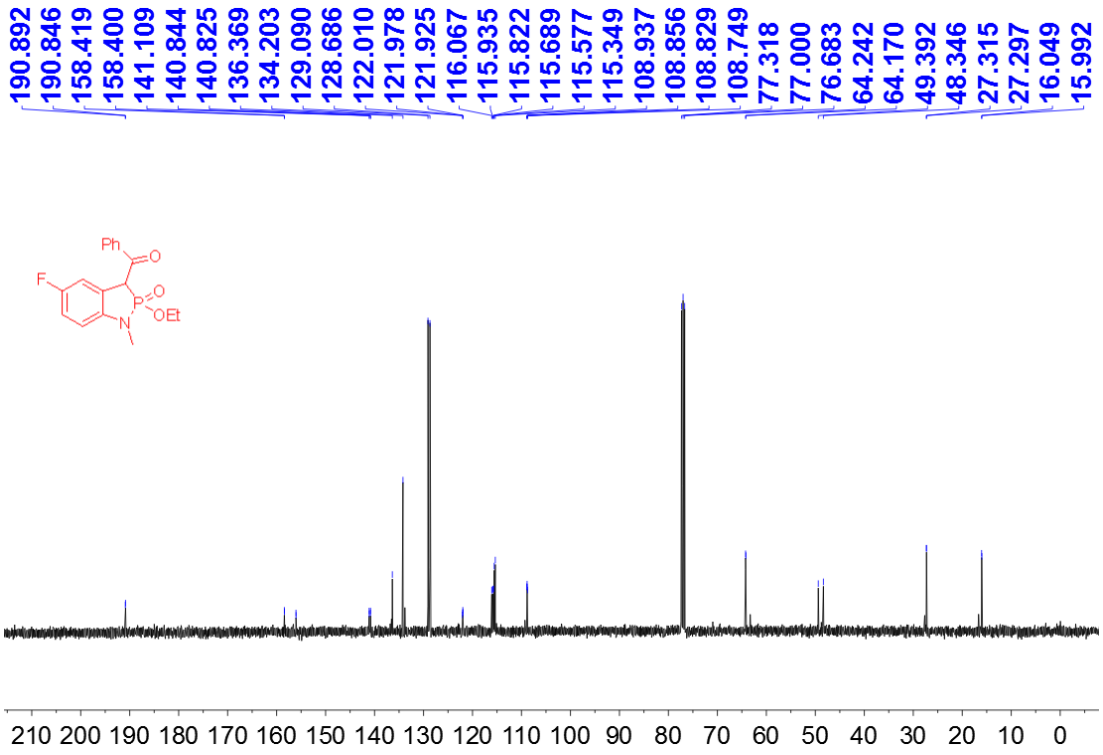
3-Benzoyl-5-chloro-2-ethoxy-1-methyl-2-oxophosphorindoline (2i)





3-Benzoyl-2-ethoxy-5-fluoro-1-methyl-2-oxophosphorindoline (2j)

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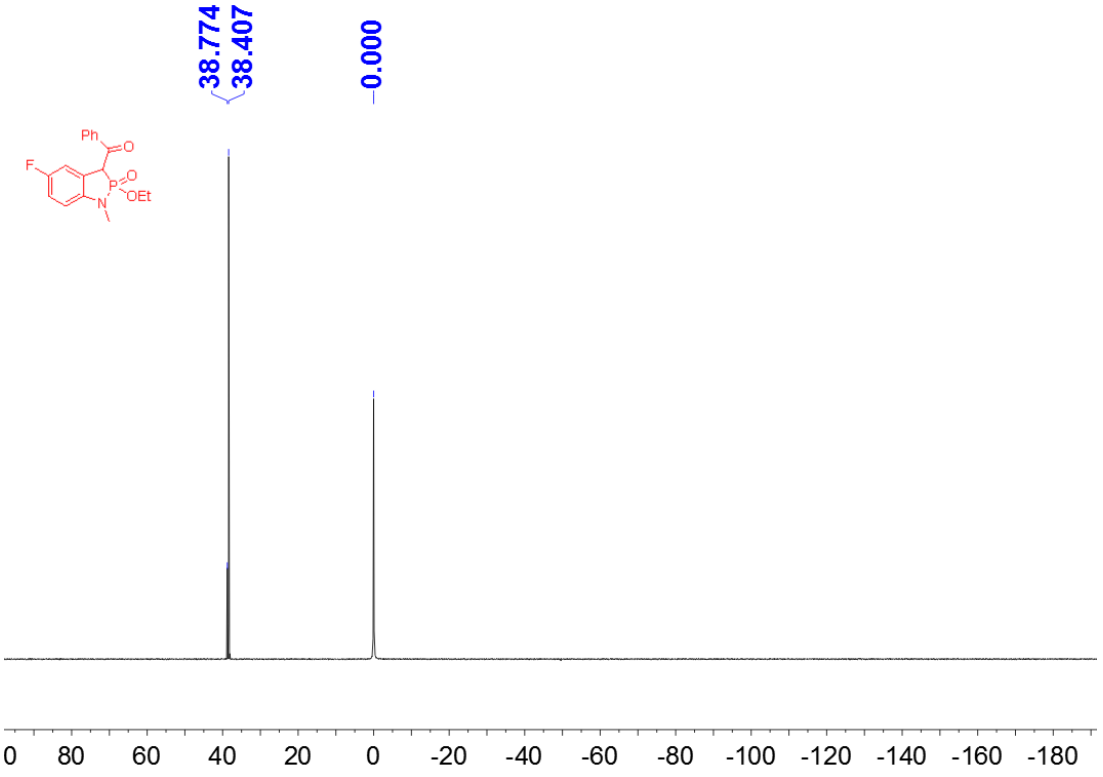
190.846
158.419
158.400
141.109
140.844
140.825
136.369
134.203
129.090
128.686
122.010
121.978
121.925
116.067
115.935
115.822
115.689
115.577
115.349
108.937
108.856
108.829
108.749
77.318
77.000
76.683
64.242
64.170
49.392
48.346
27.315
27.297
16.049
15.992
Ph
O
F
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


38.774
38.407
0.000
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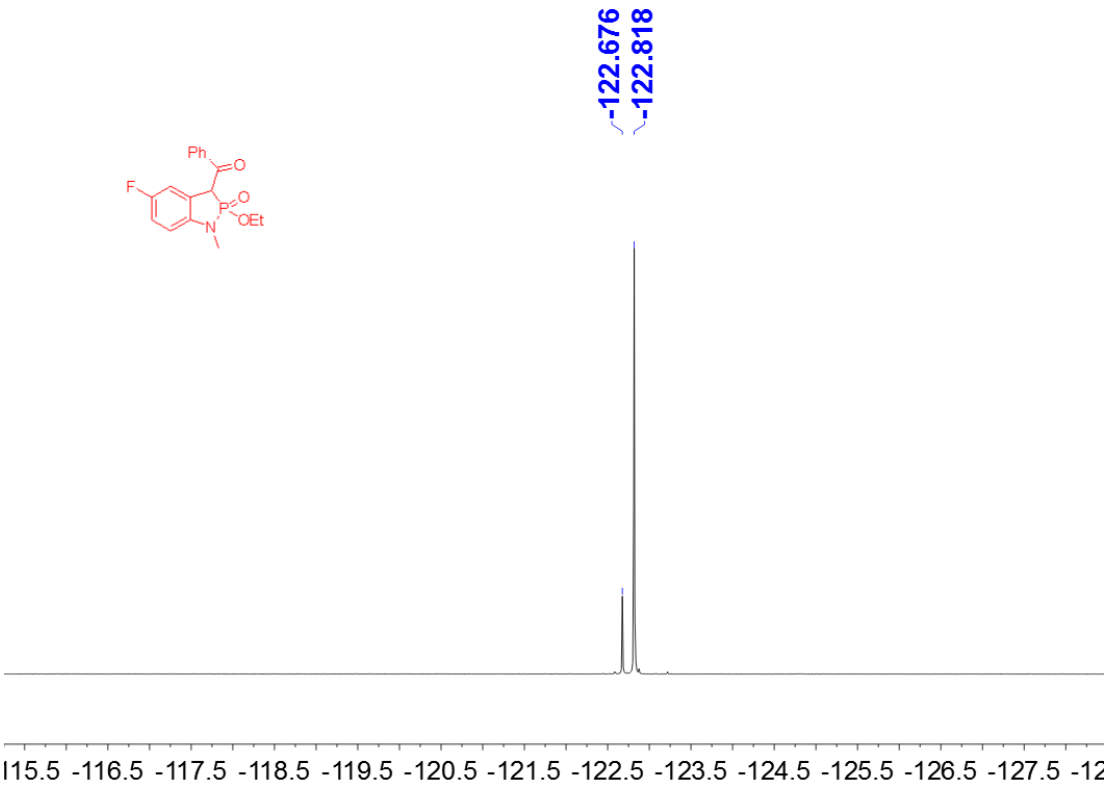
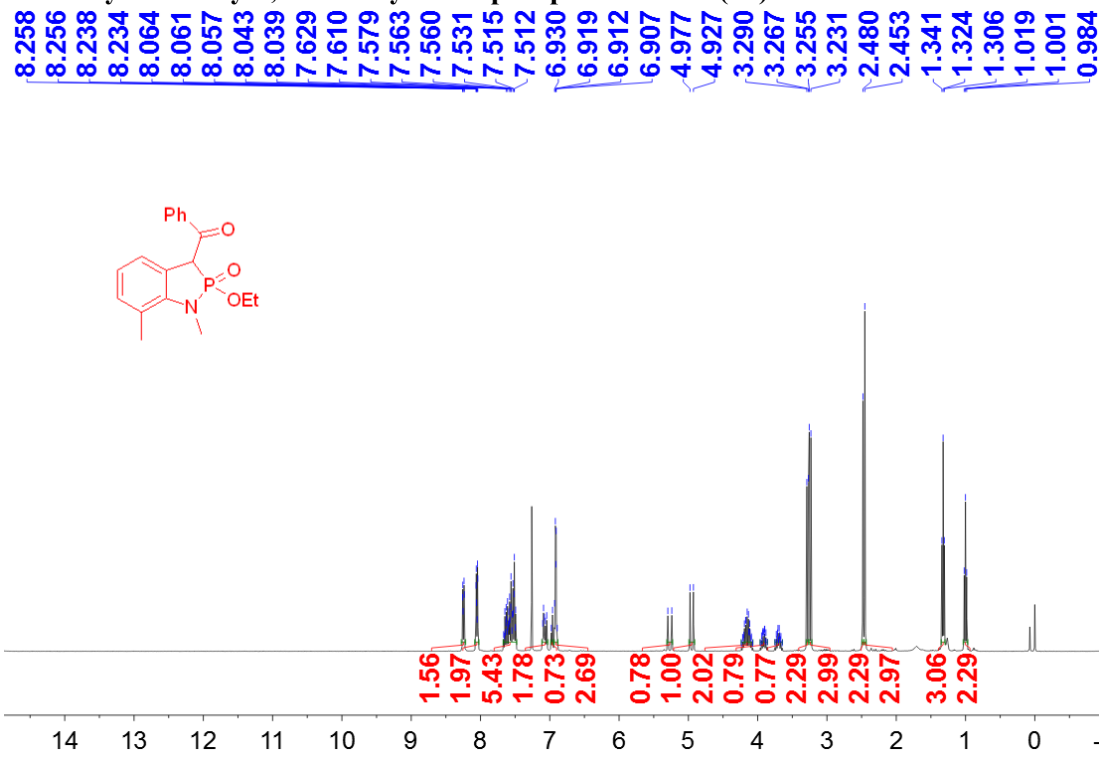
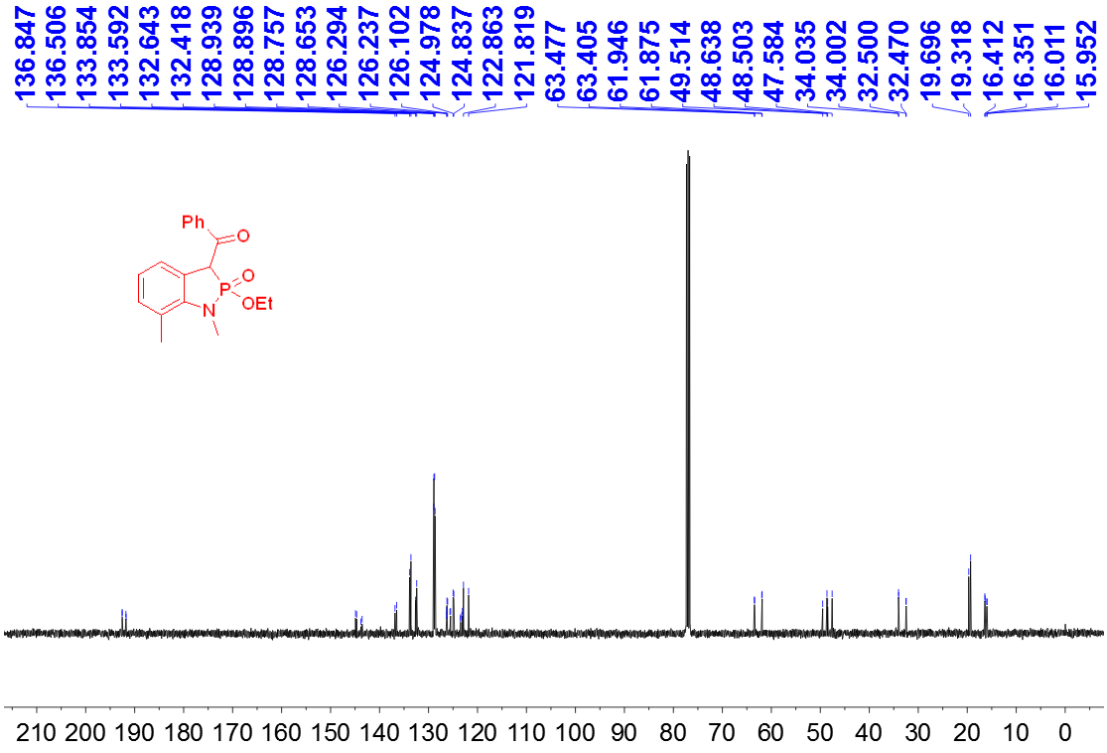
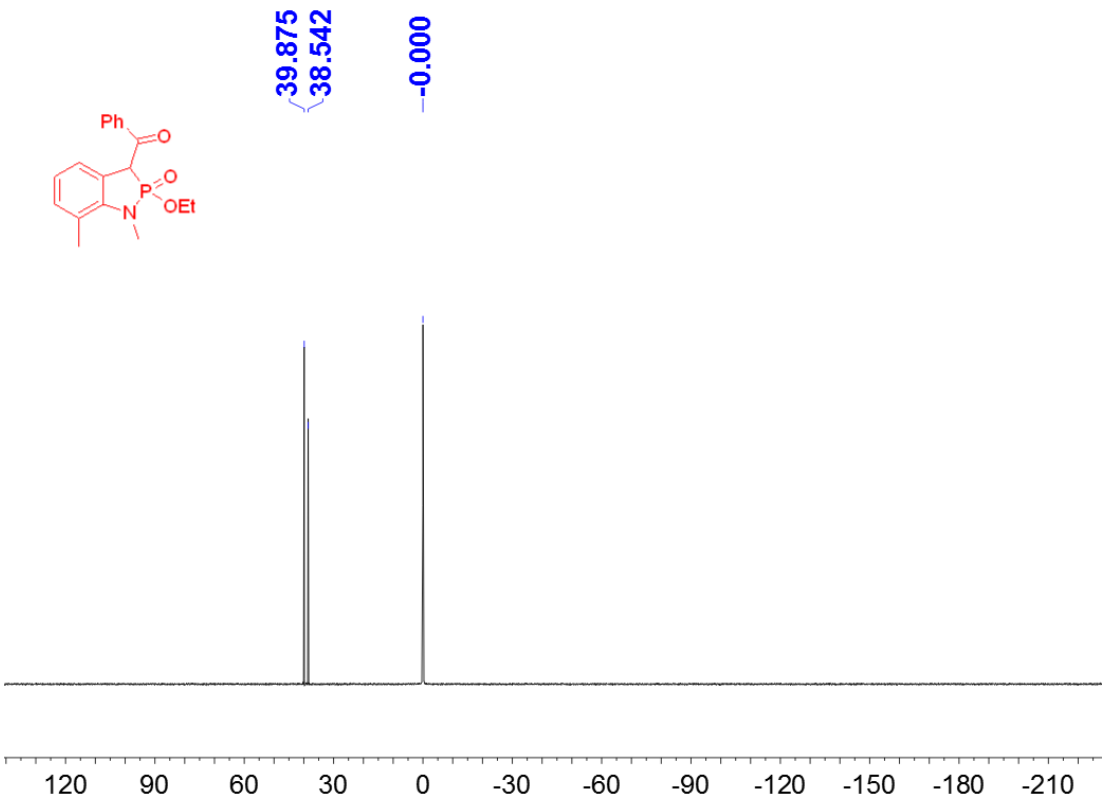
O
F
P
O
OEt
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180



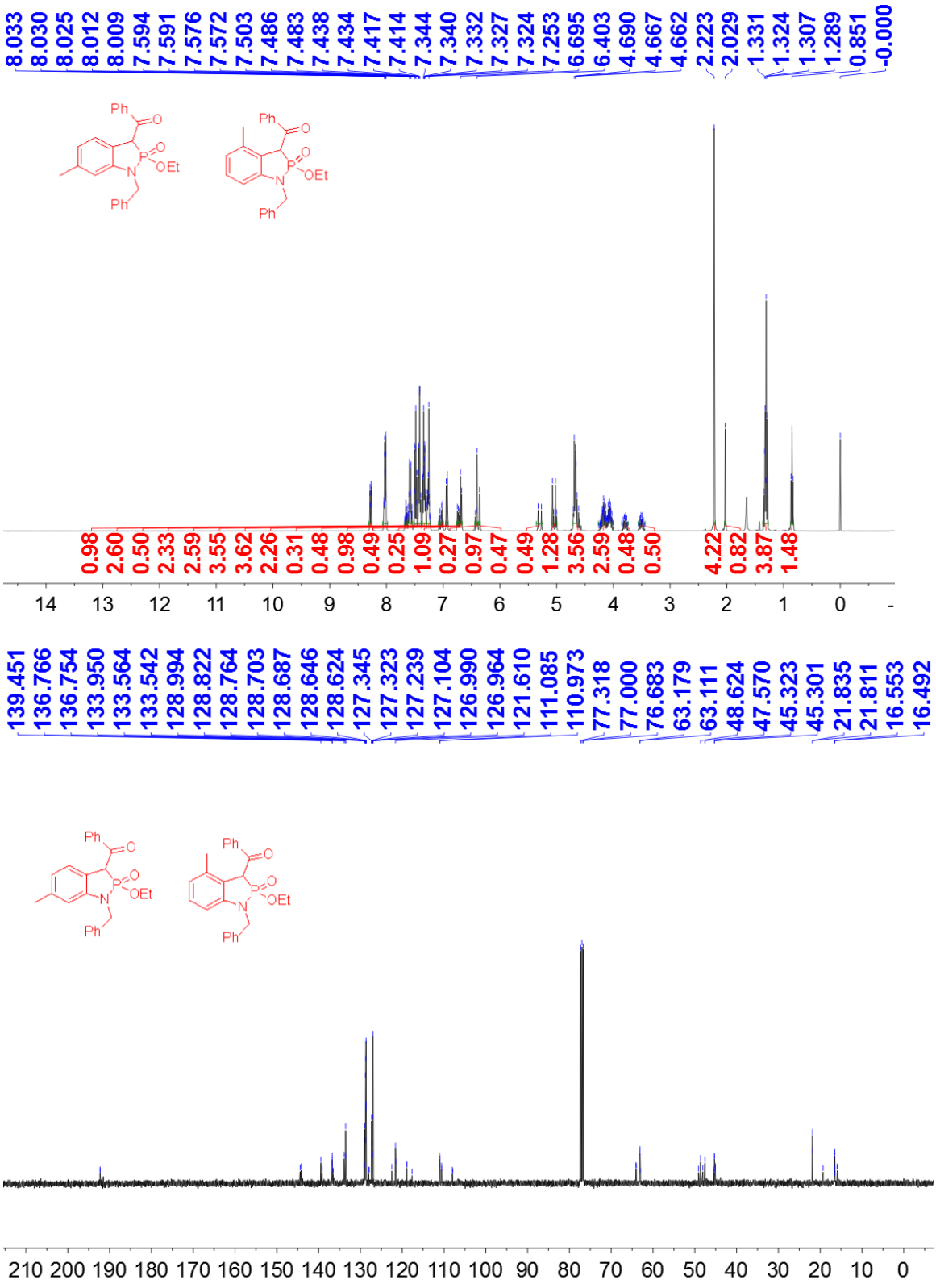
3-Benzoyl-2-ethoxy-1,7-dimethyl-2-oxophosphorindoline (2k)

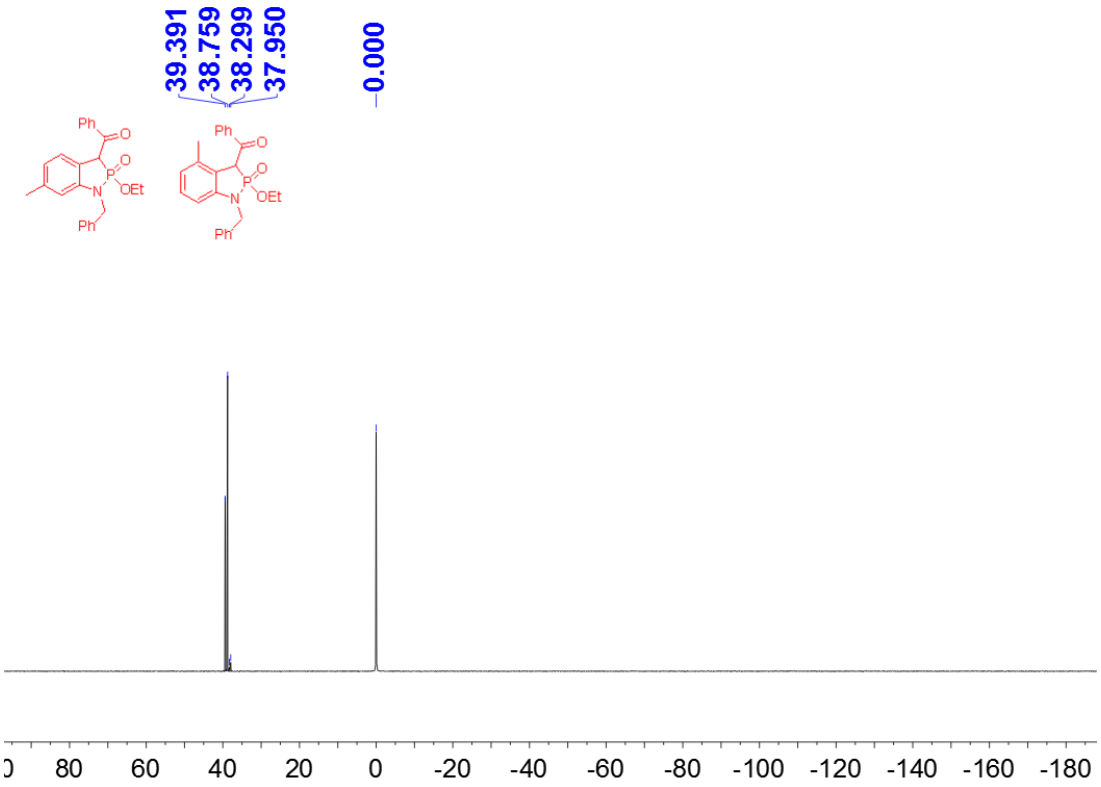



136.847
136.506
133.854
133.592
132.643
132.418
128.939
128.896
128.757
128.653
126.294
126.237
126.102
124.978
124.837
122.863
121.819
63.477
63.405
61.946
61.875
49.514
48.638
48.503
47.584
34.035
34.002
32.500
32.470
19.696
19.318
16.412
16.351
16.011
15.952
Ph
O
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

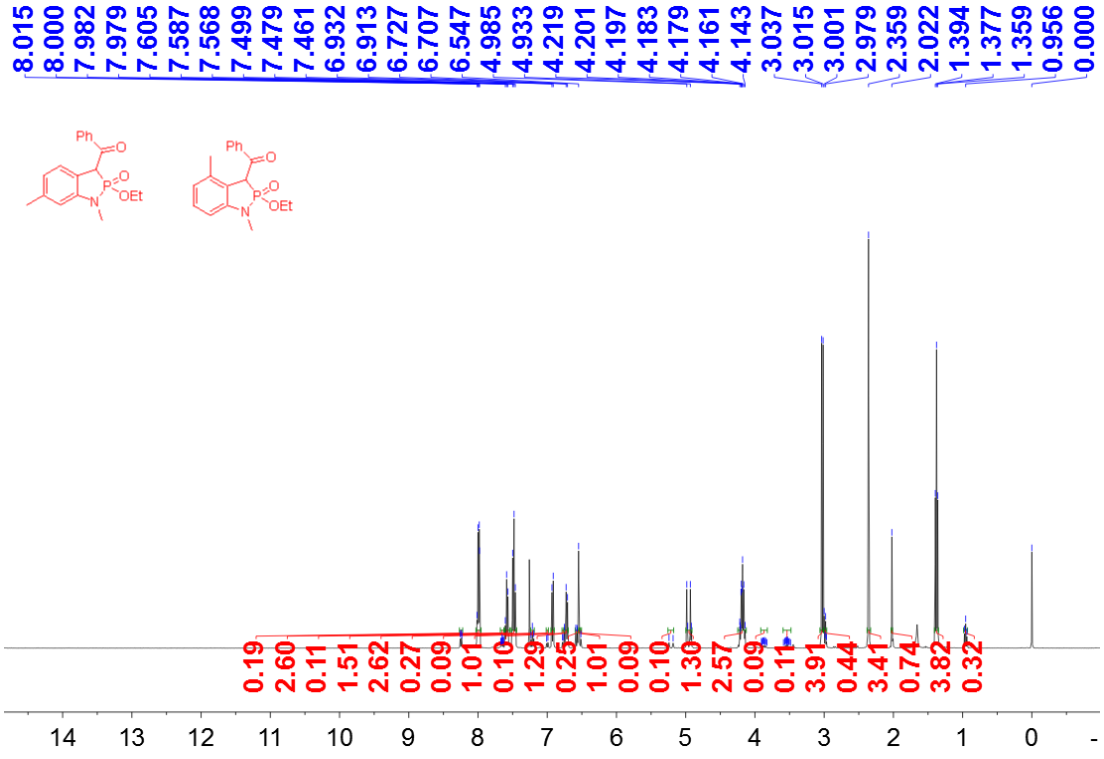

39.875
38.542
-0.000
Ph
O
P
O
OEt
N
120 90 60 30 0 -30 -60 -90 -120 -150 -180 -210

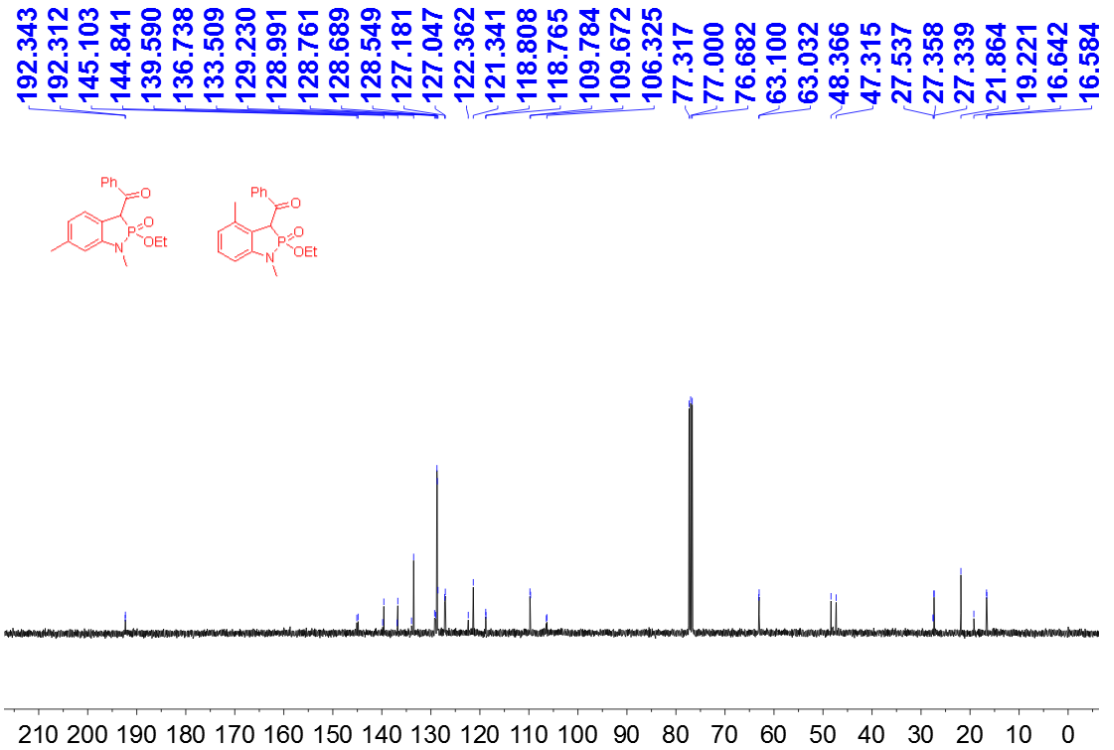
Mixture of 3-benzoyl-1-benzyl-2-ethoxy-6-methyl-2-oxophosphorindoline (2la) and 3-benzoyl-1-benzyl-2-ethoxy-4-methyl-2-oxophosphorindoline (2lb)

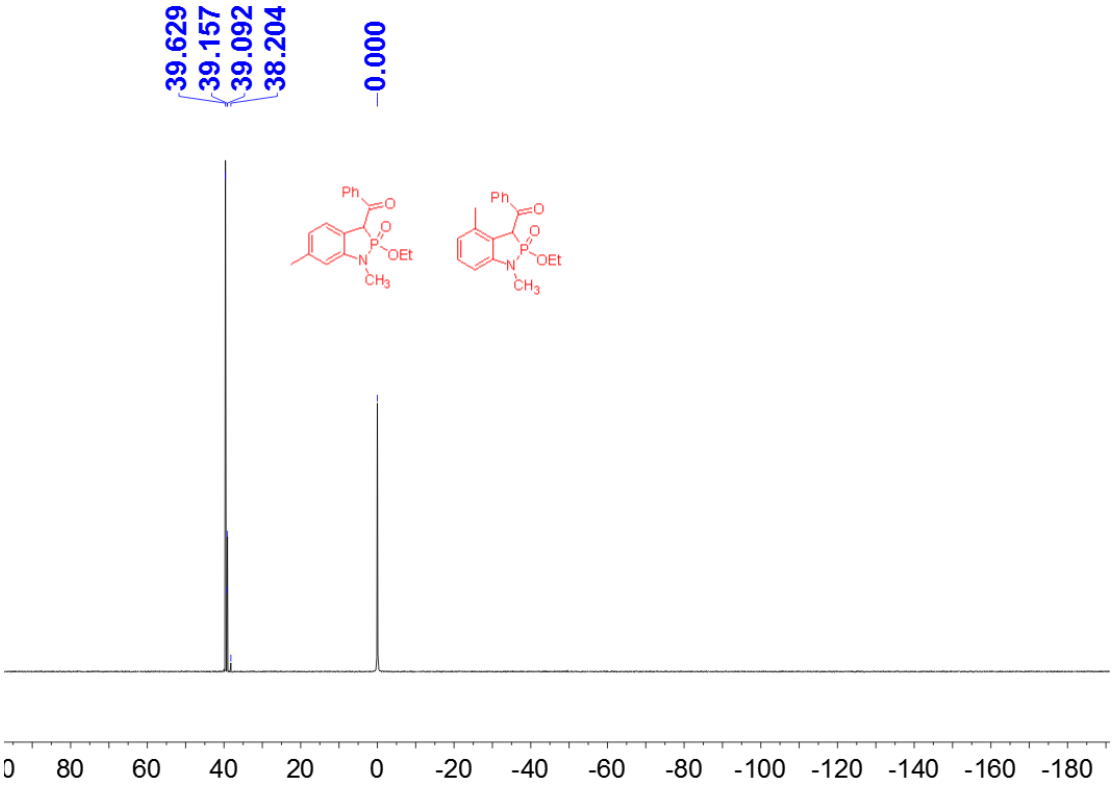




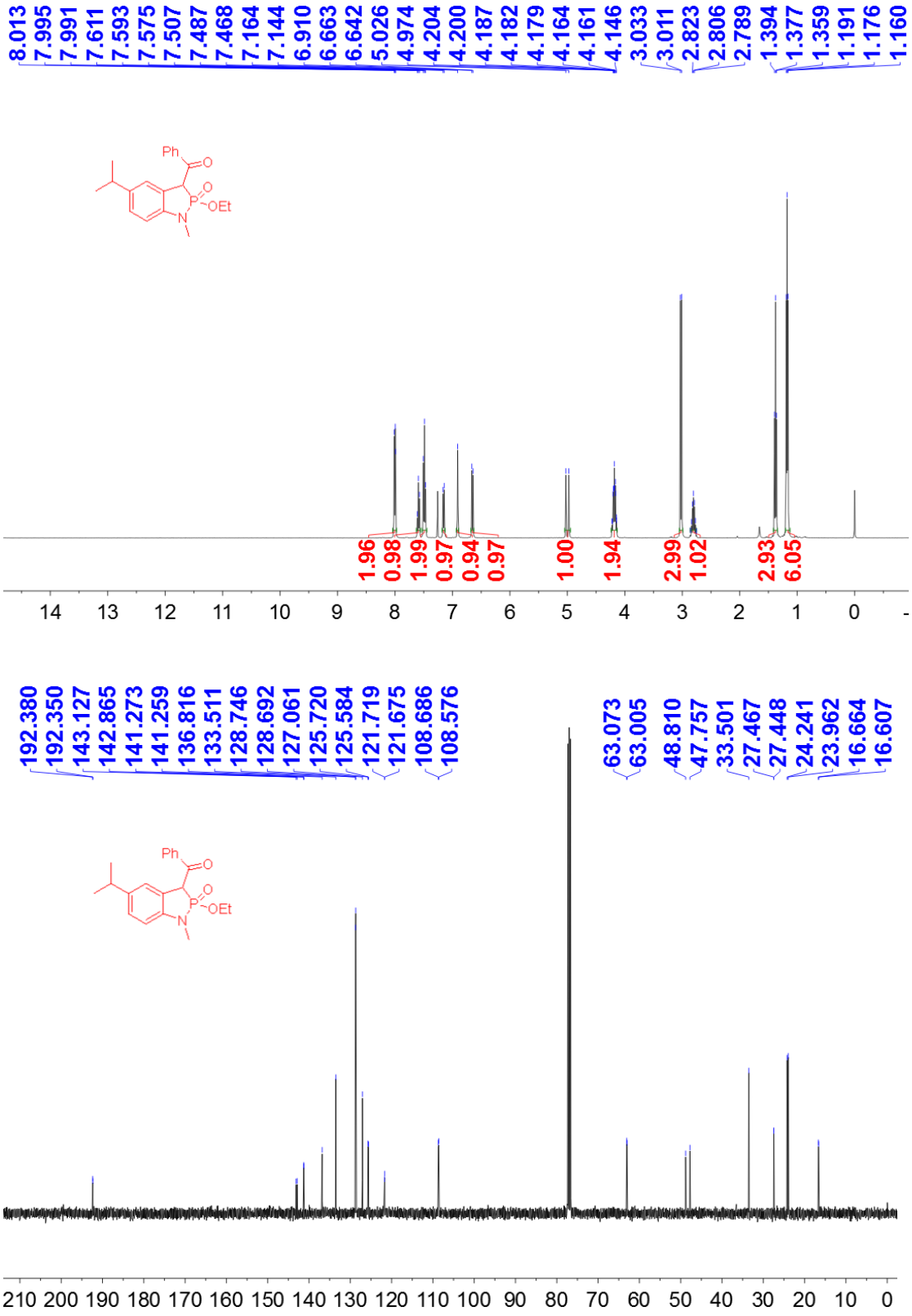
Mixture of 3-benzoyl-2-ethoxy-1,6-dimethyl-2-oxophosphorindoline (2ma) and 3-benzoyl-2-ethoxy-1,4-dimethyl-2-oxophosphorindoline (2mb)

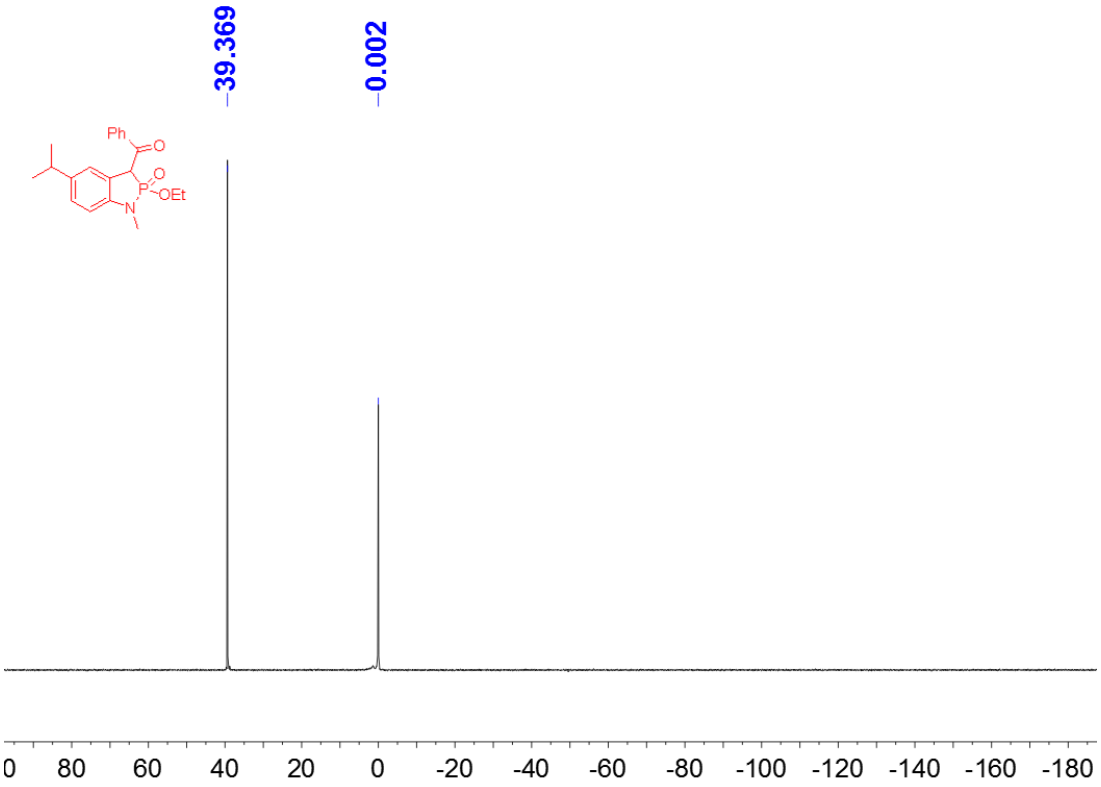



192.343
192.312
145.103
144.841
139.590
136.738
133.509
129.230
128.991
128.761
128.689
128.549
127.181
127.047
122.362
121.341
118.808
118.765
109.784
109.672
106.325
77.317
77.000
76.682
63.100
63.032
48.366
47.315
27.537
27.358
27.339
21.864
19.221
16.642
16.584
Ph
O
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

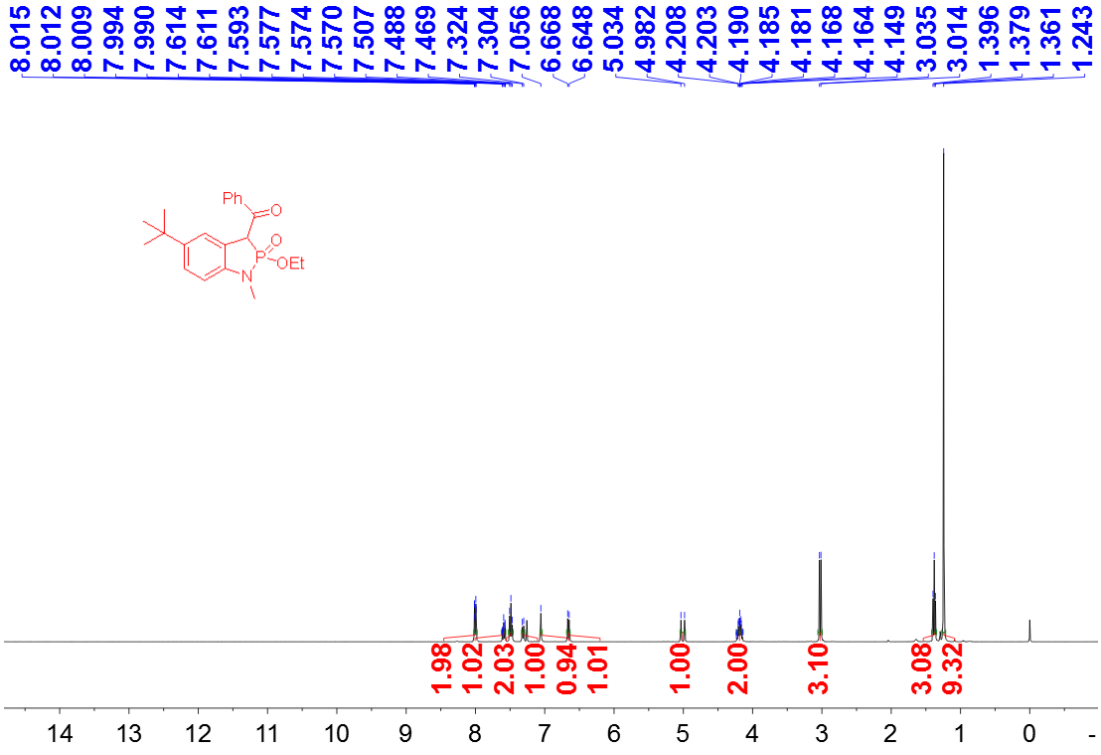

39.629
39.157
39.092
38.204
0.000
Ph
O
P
O
OEt
N
CH3
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

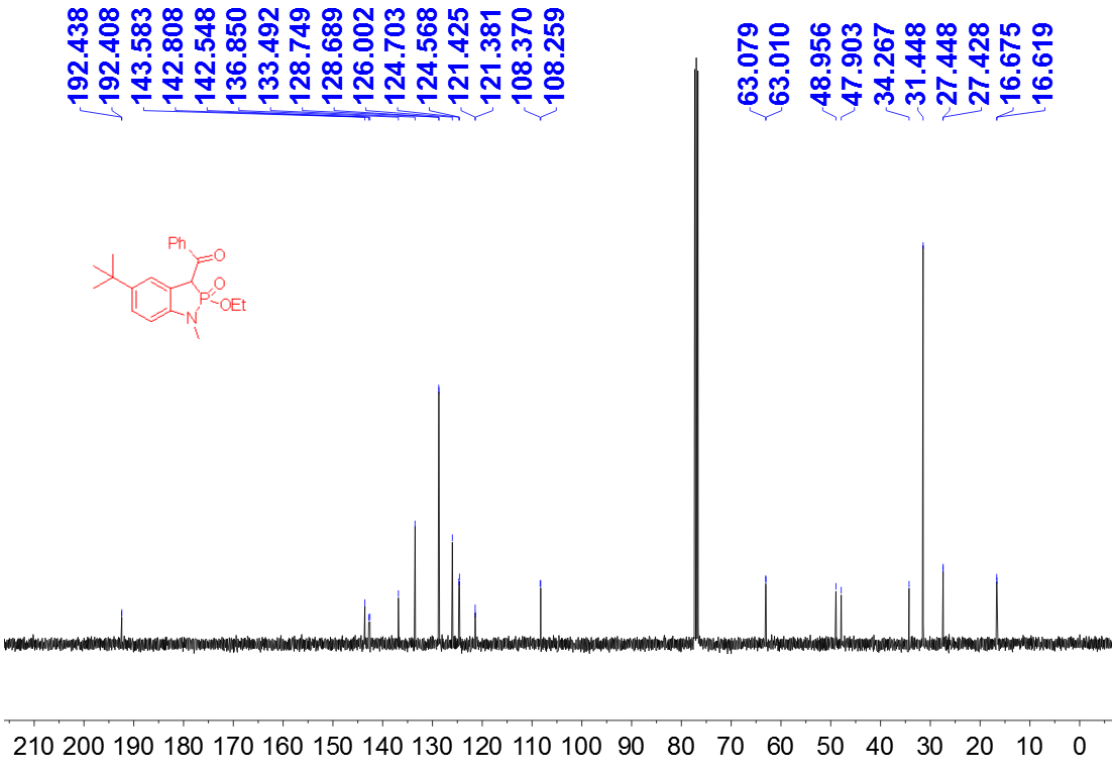
3-Benzoyl-2-ethoxy-5-isopropyl-1-methyl-2-oxophosphorindoline (2n)





3-Benzoyl-5-(*tert*-butyl)-2-ethoxy-1-methyl-2-oxophosphorindoline (2o)

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142.808
142.548
136.850
133.492
128.749
128.689
126.002
124.703
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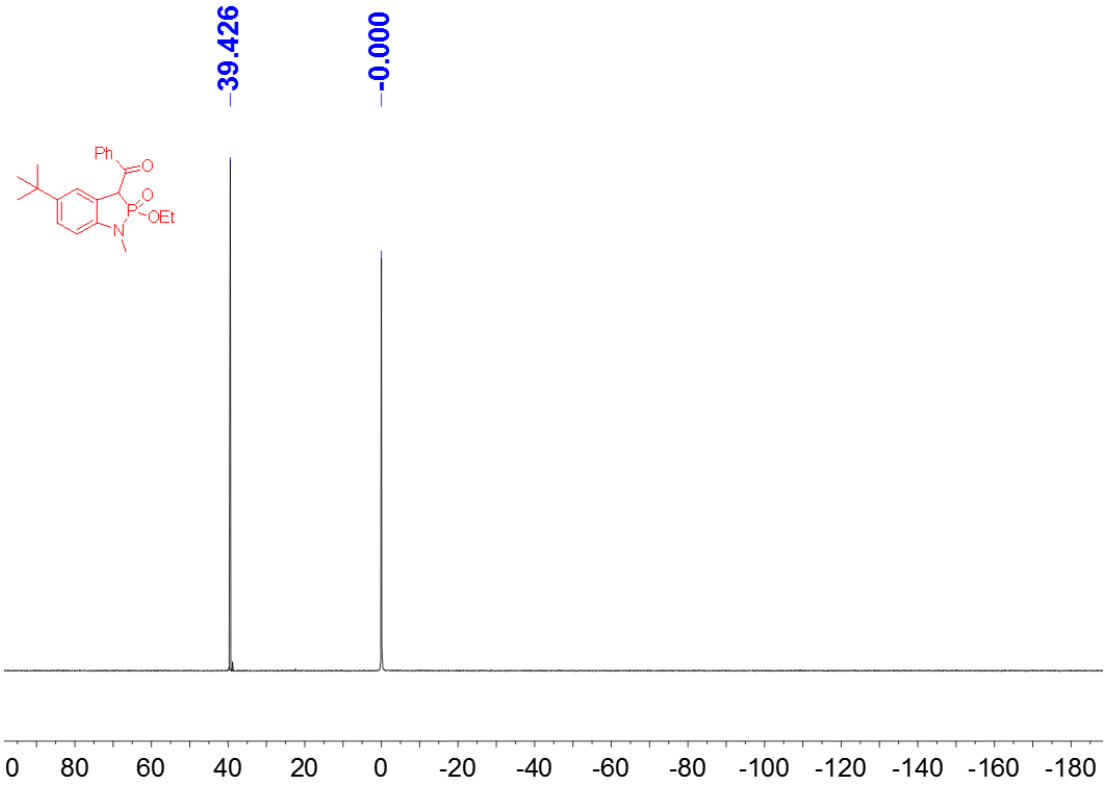
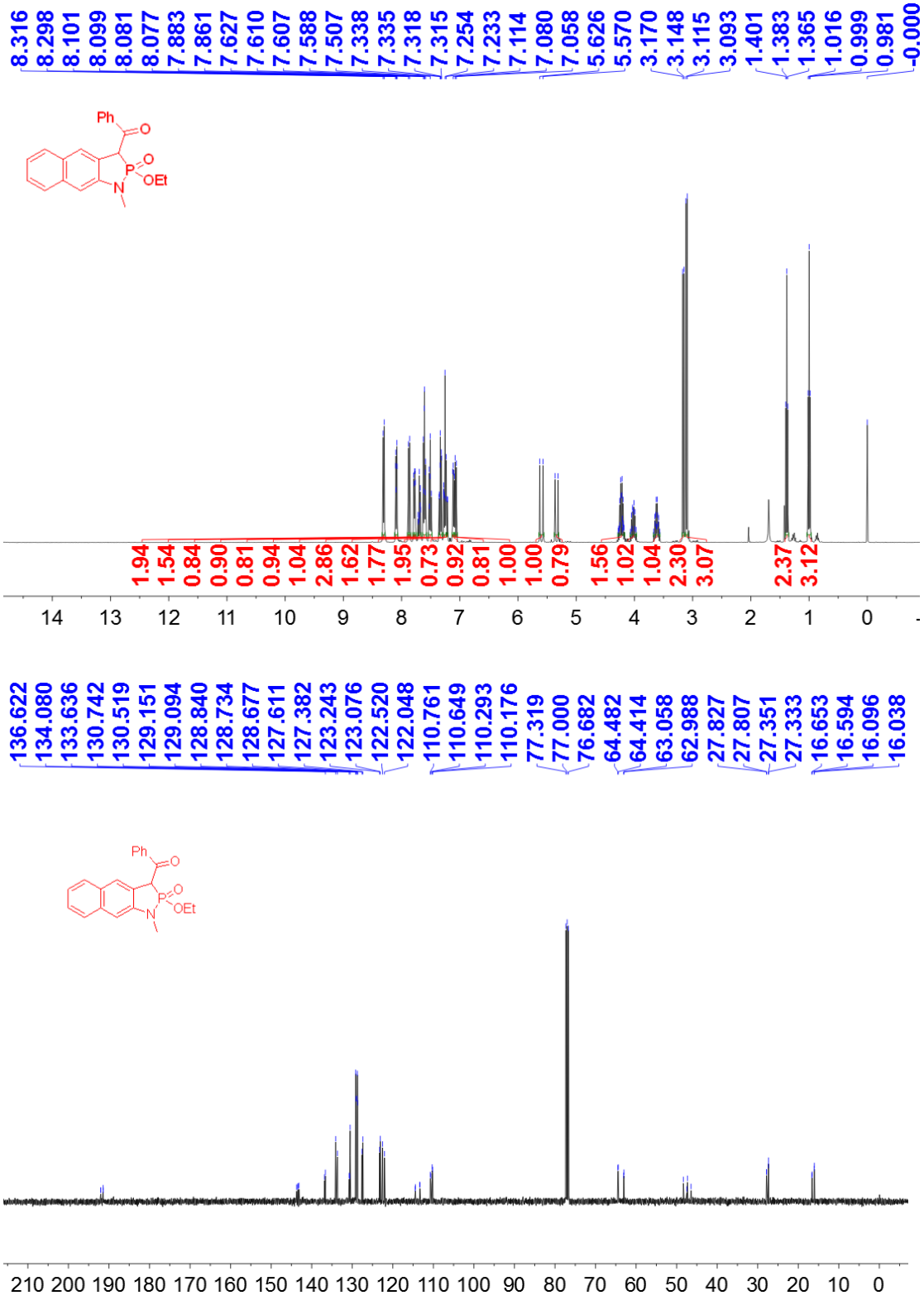
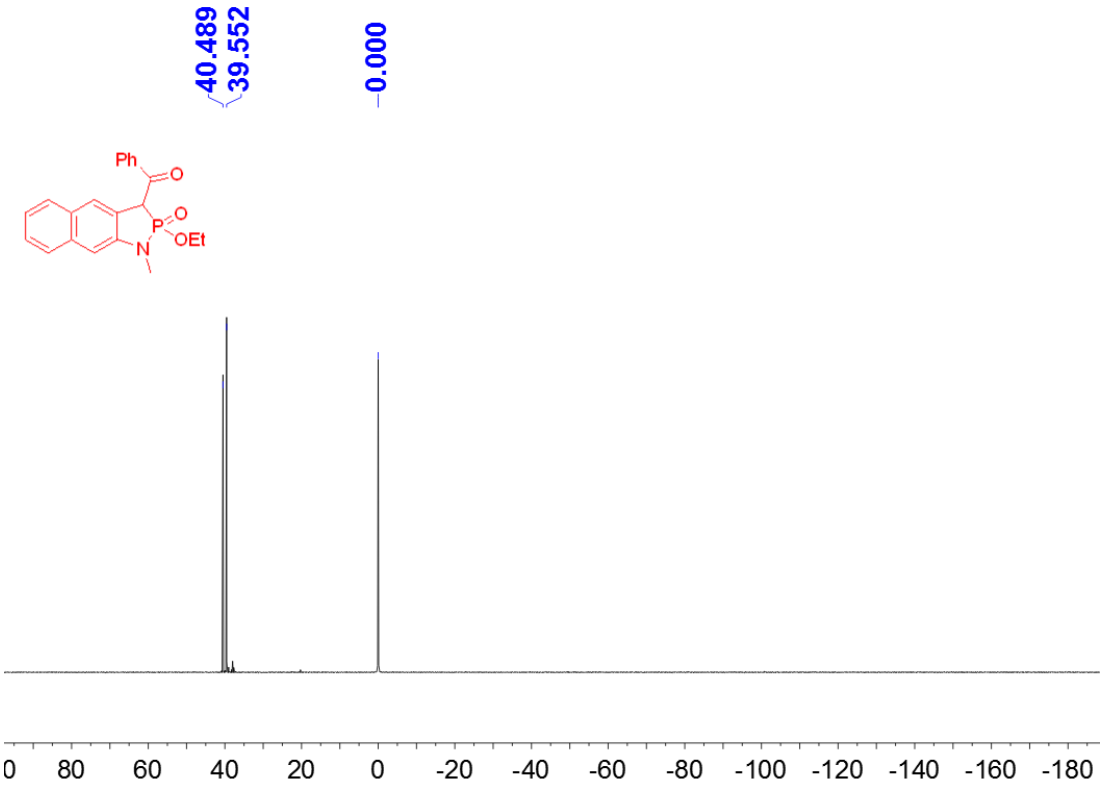
121.381
108.370
108.259
63.079
63.010
48.956
47.903
34.267
31.448
27.448
27.428
16.675
16.619
Ph
O
O
P
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

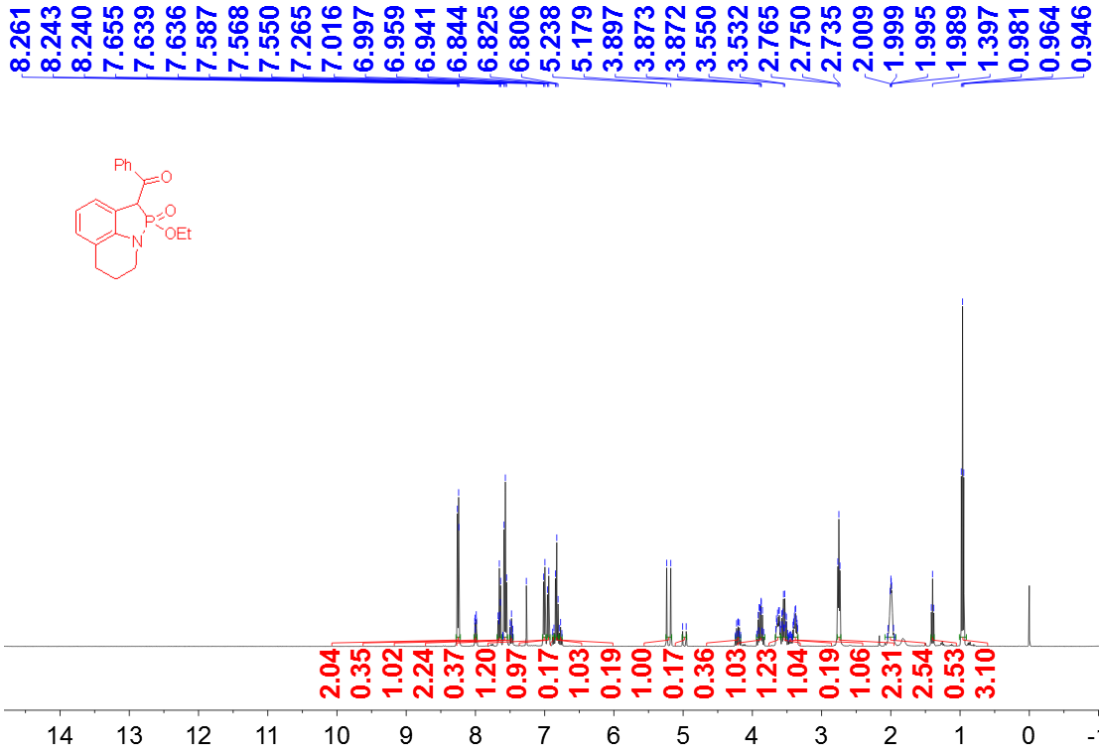

39.426
-0.000
Ph
O
O
P
OEt
N
0 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180

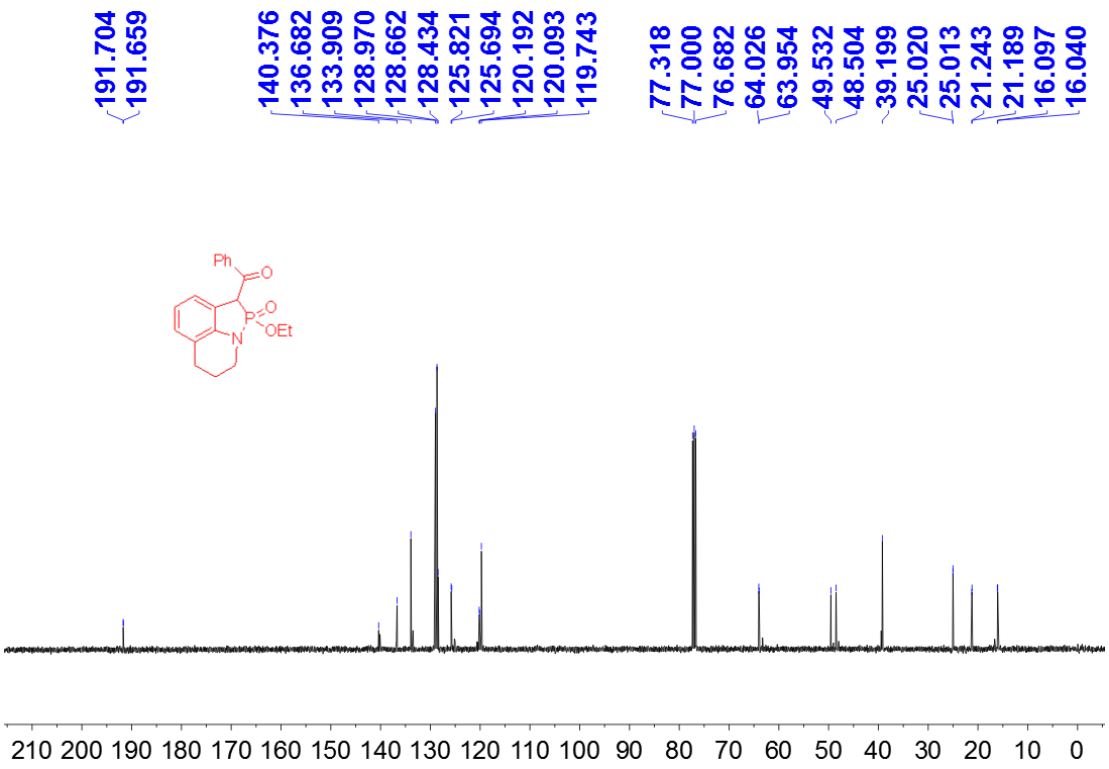
3-Benzoyl-2-ethoxy-1-methyl-2-oxobenzo[*f*]phosphorindoline (2p)





2-Benzoyl-1-ethoxy-1-oxoazacyclohexano[3,2,1-*h,i*]phosphorindoline (2q)

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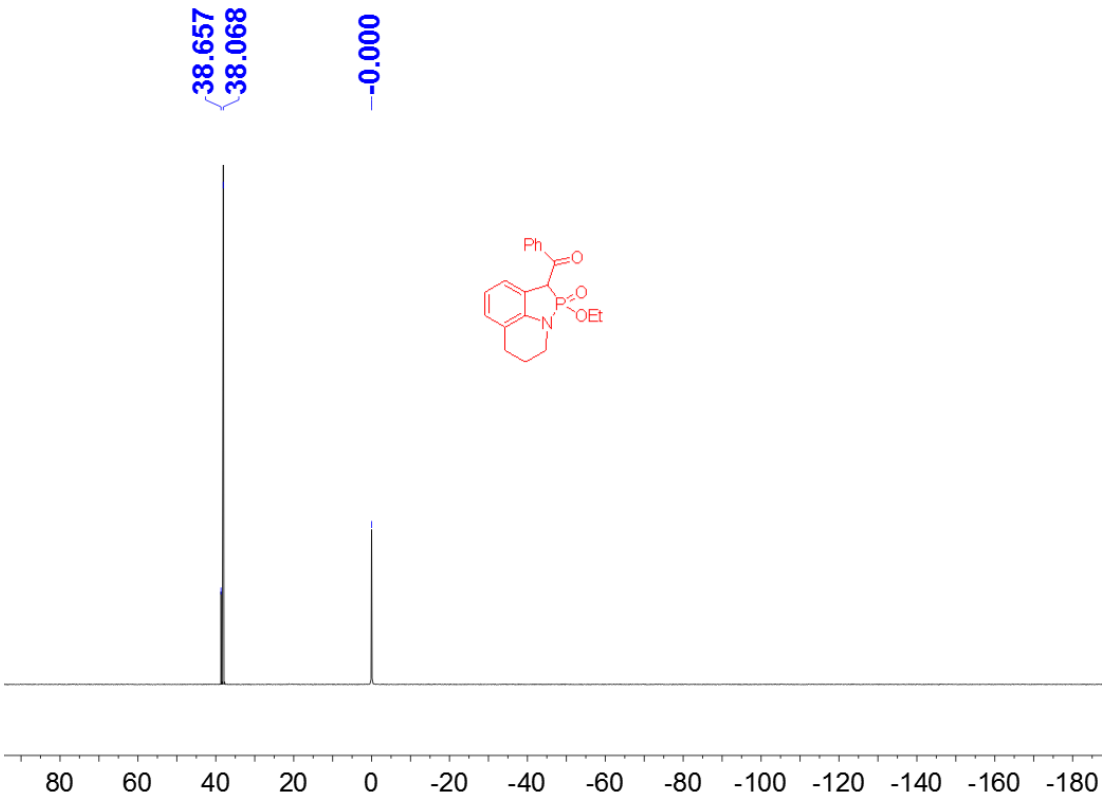
136.682
133.909
128.970
128.662
128.434
125.821
125.694
120.192
120.093
119.743
77.318
77.000
76.682
64.026
63.954
49.532
48.504
39.199
25.020
25.013
21.243
21.189
16.097
16.040
Ph
O
P
O
OEt
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0


38.657
38.068
-0.000
Ph
O
P
O
OEt
N
80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180