Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supprting Information

Stereoselective Formation of Chiral *trans*-4-Hydroxy-5-Substituted 2-Pyrrolidinones: Syntheses of Streptopyrrolidine and 3-*epi*-Epohelmin A

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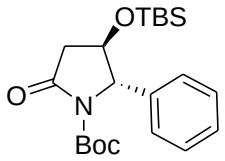
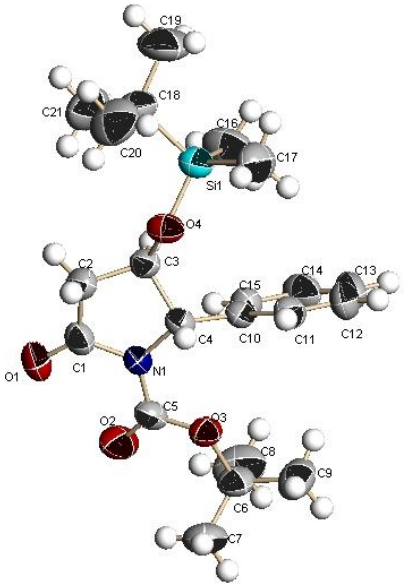
[c]*College of Science, Northwest Agriculture and Forestry University, Shaanxi, Yangling, 712100, China*

Table of Contents

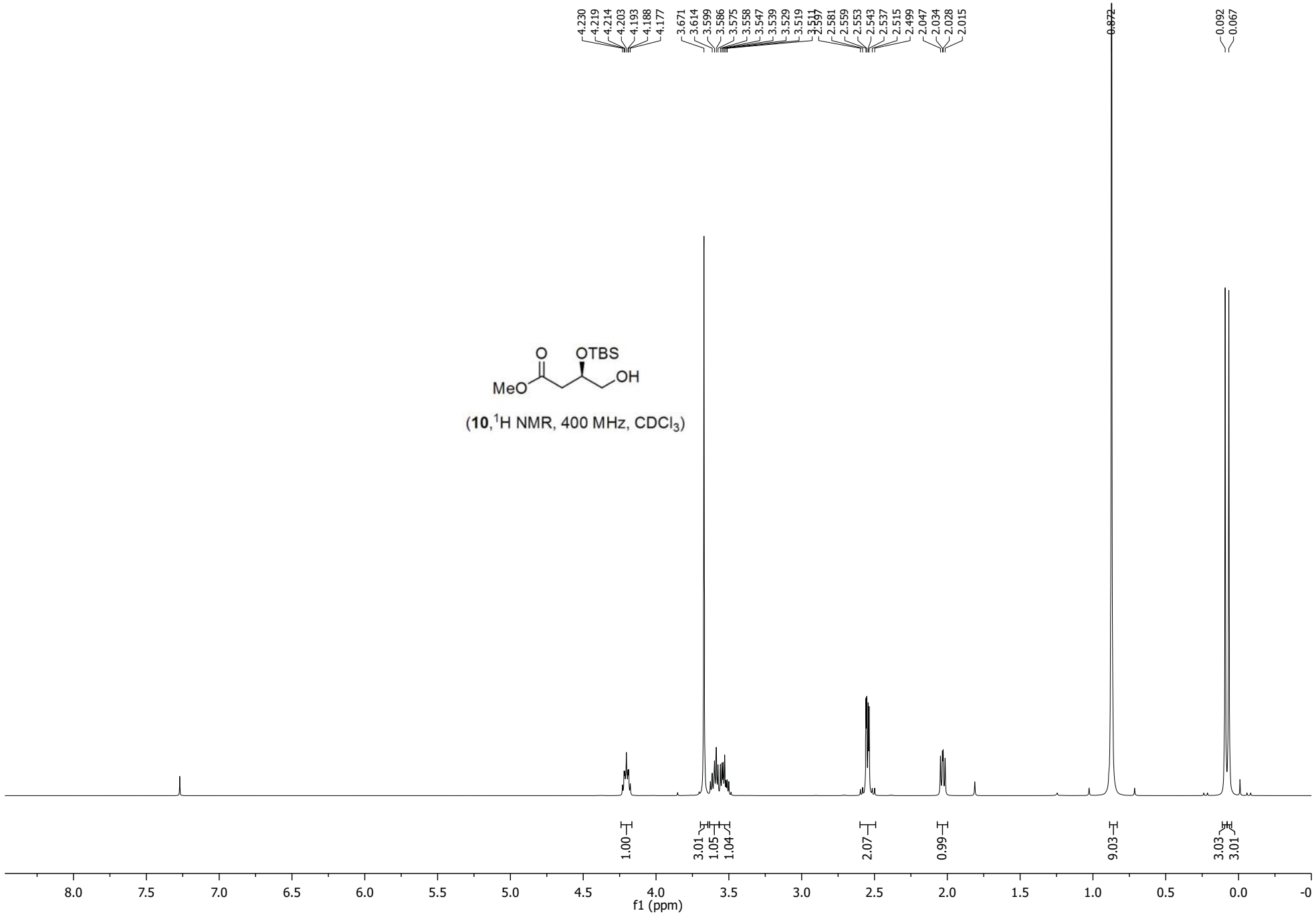
ORTEP drawing of the X-ray crystallographic structure of *trans*-**4a**





CCDC-1417164. For detailed crystallographic data, please refer to the Cambridge Crystallographic Data Centre at:

http://www.ccdc.cam.ac.uk/data_request/cif.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3.671
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3.599
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3.558
3.547
3.539
3.529
3.519
3.511
2.597
2.581
2.559
2.553
2.543
2.537
2.515
2.499
2.047
2.034
2.028
2.015
0.872
0.092
0.067
O
OTBS
MeO
OH
(10,1H NMR, 400 MHz, CDCl3)
1.00
3.01
1.05
1.04
2.07
0.99
9.03
3.03
3.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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3.0
2.5
2.0
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1.0
0.5
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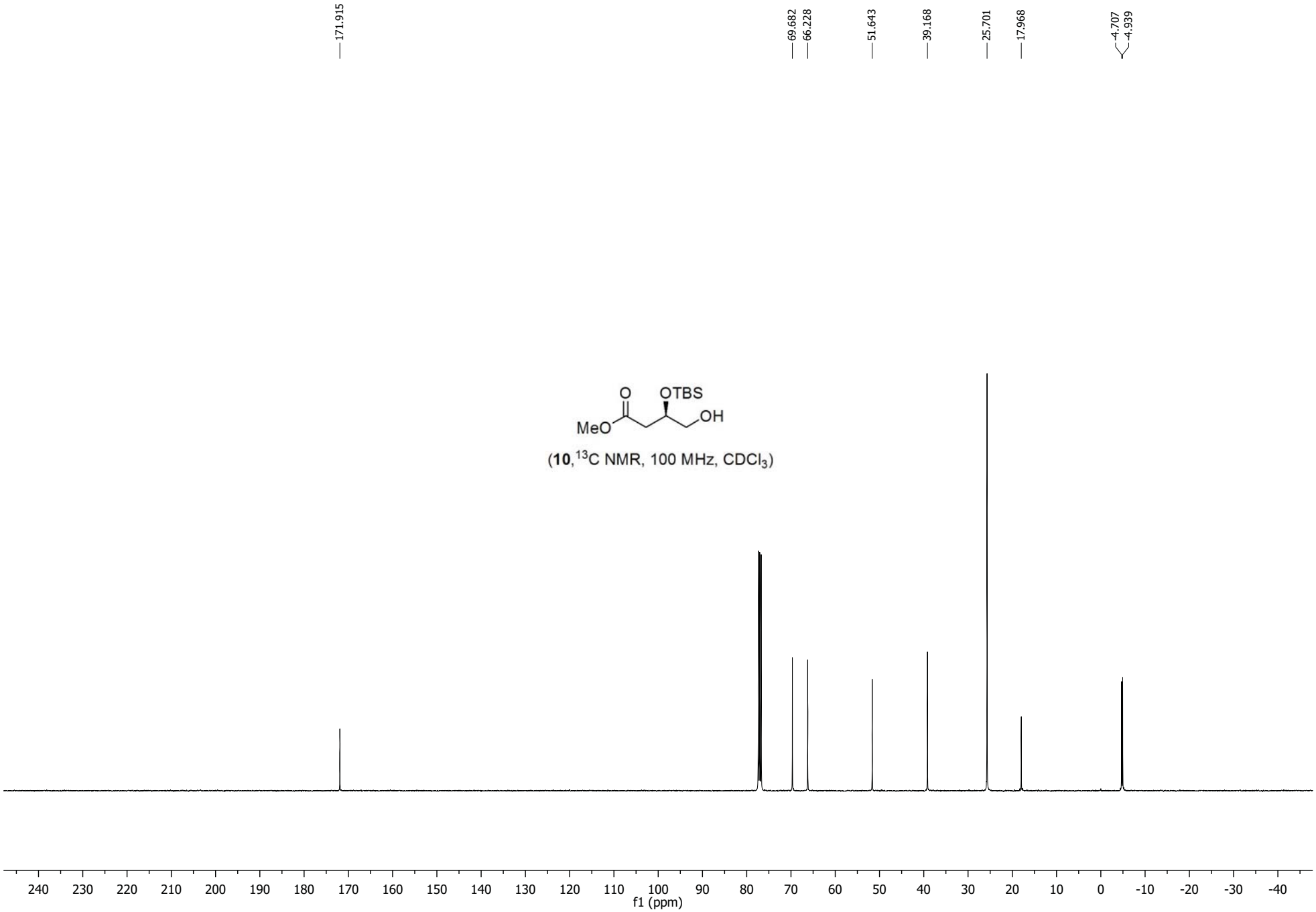
-0
f1 (ppm)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66.228
51.643
39.168
25.701
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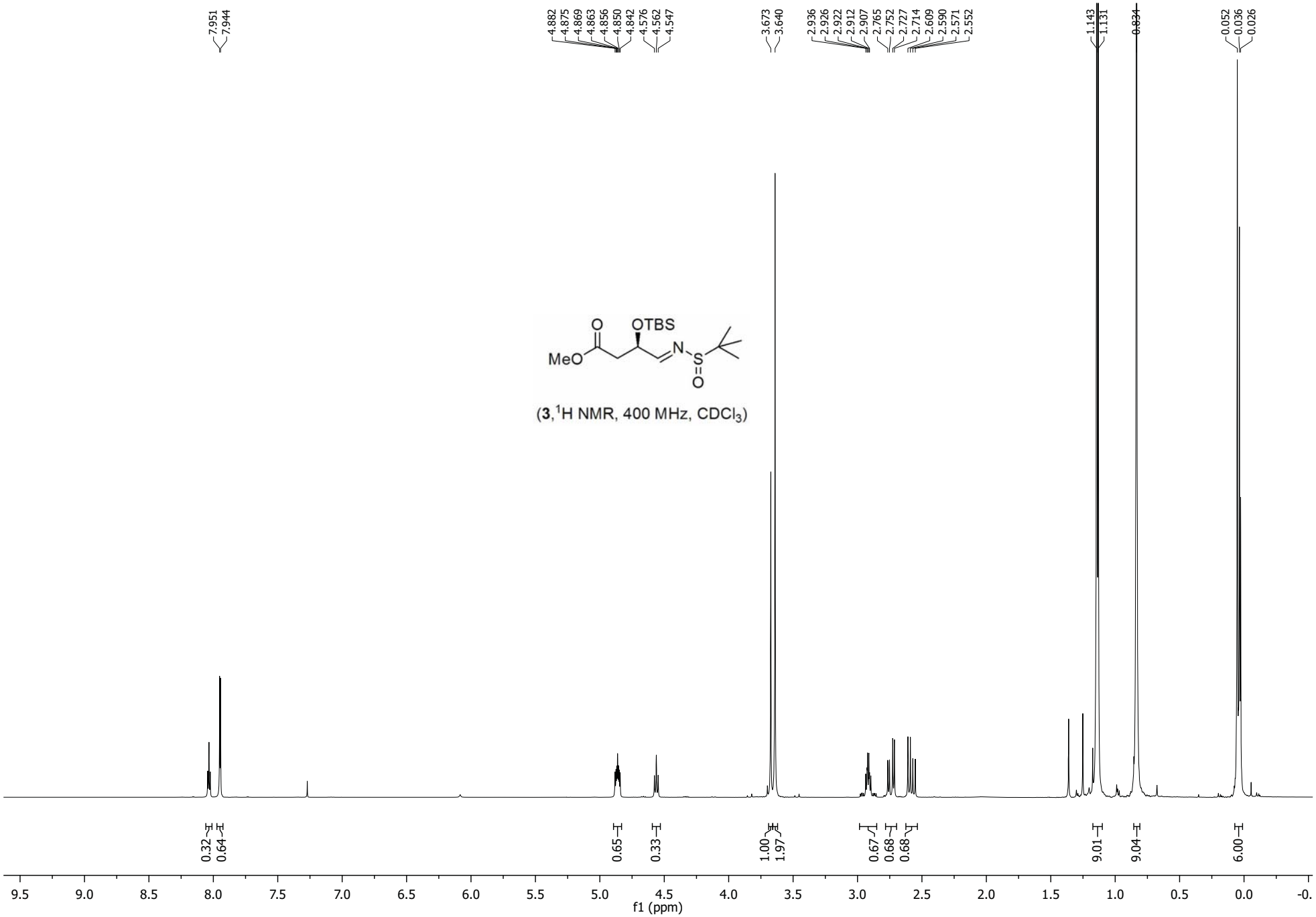
O
OTBS
MeO
OH
(10, 13C NMR, 100 MHz, CDCl3)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)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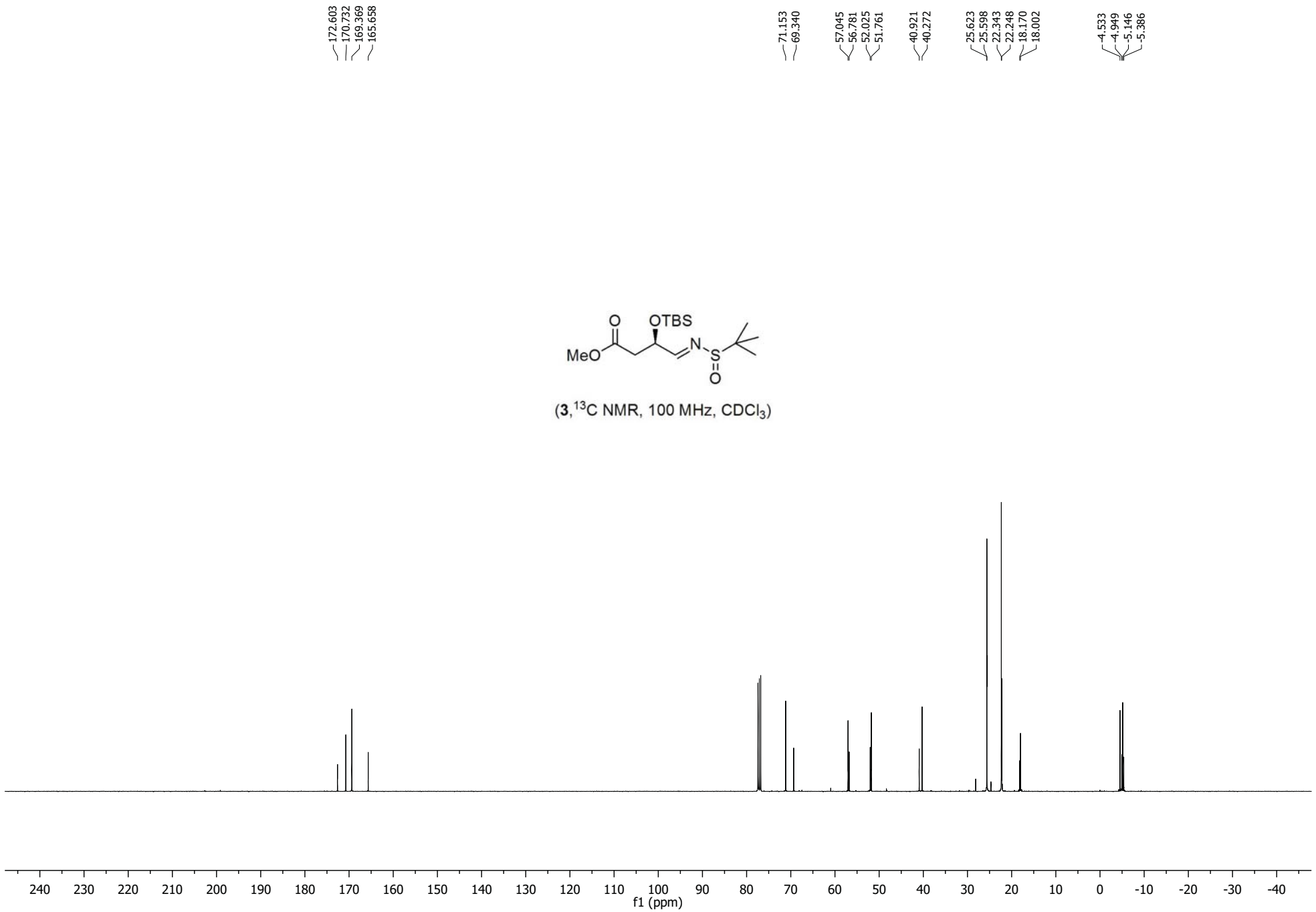
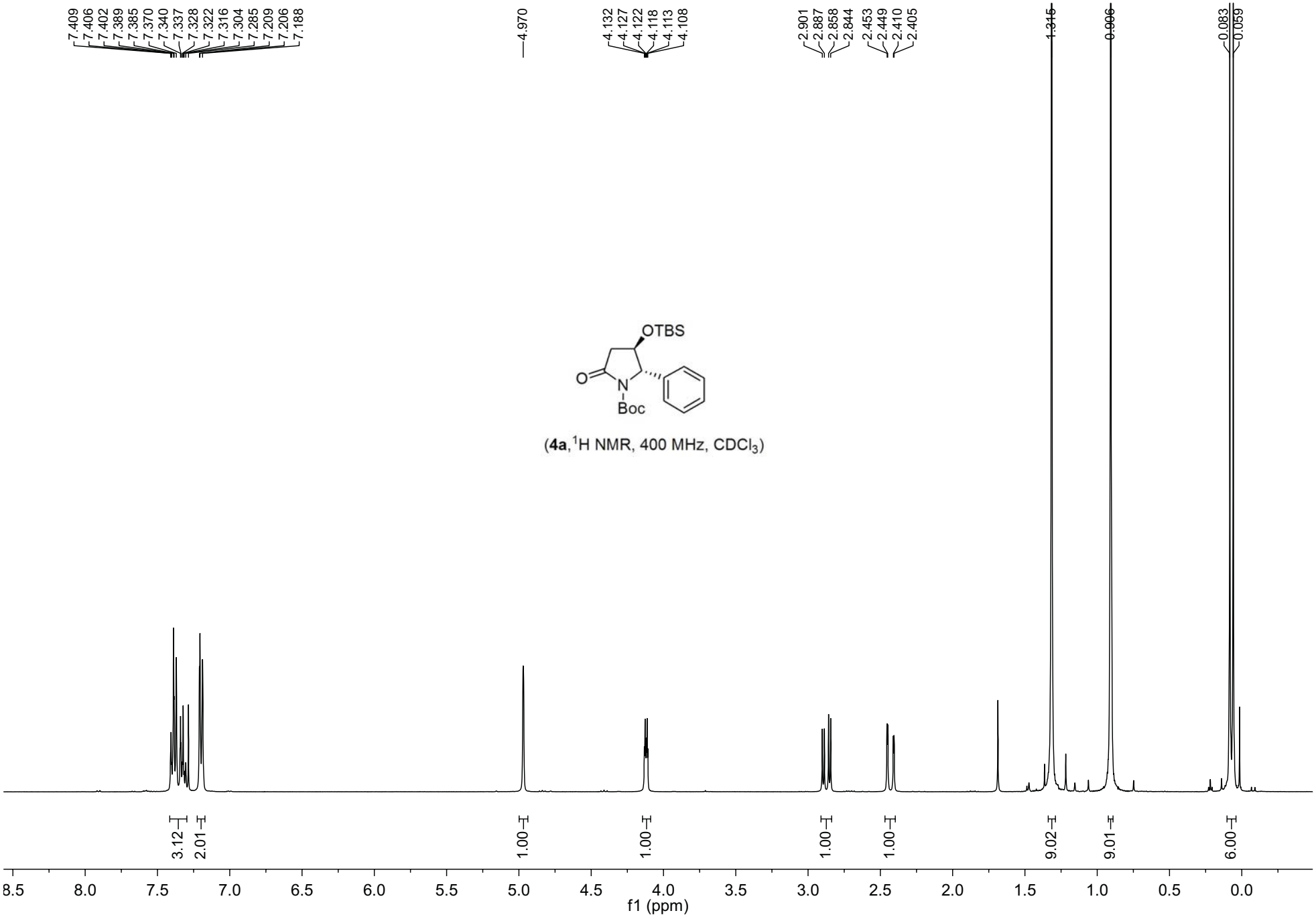
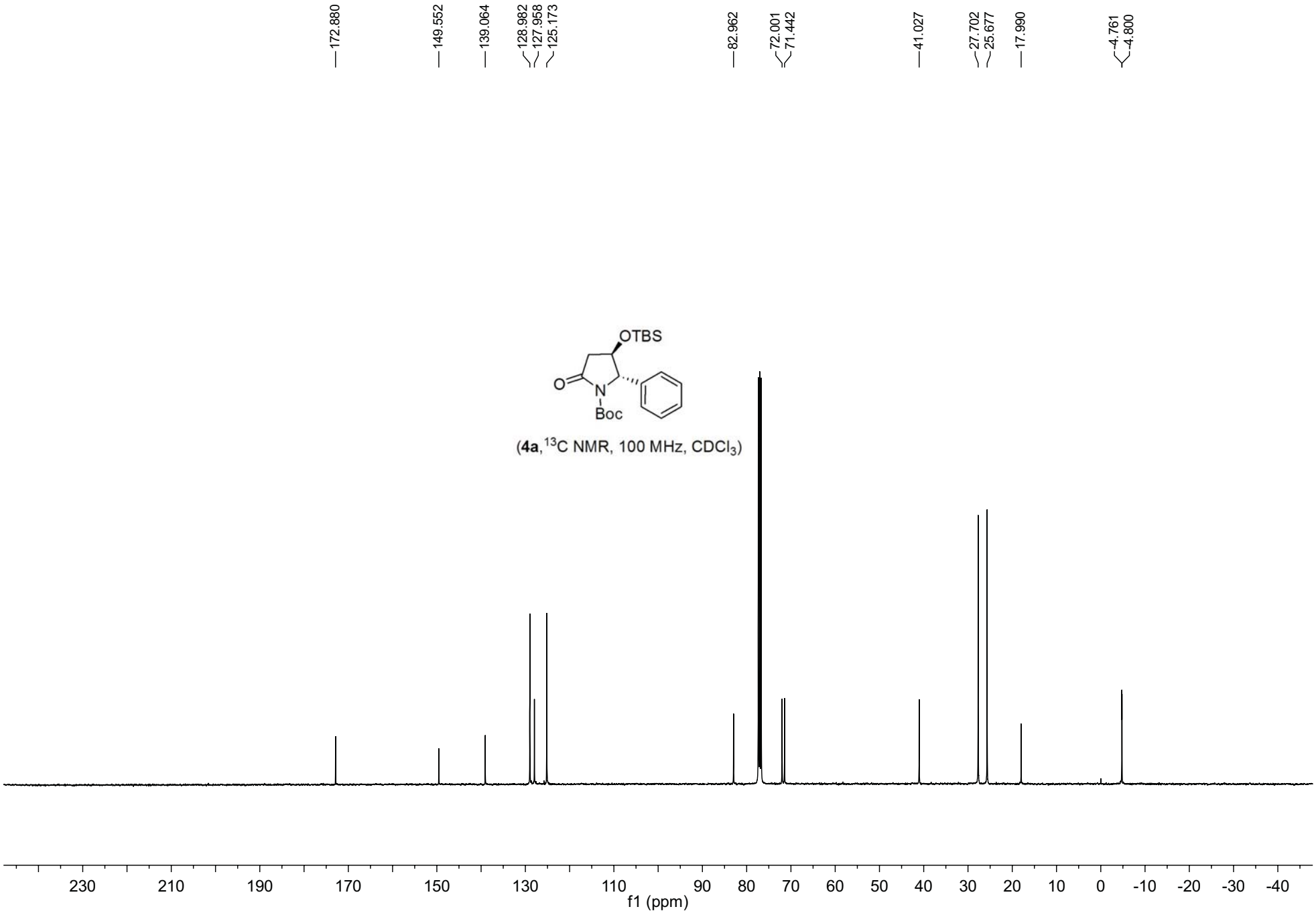
4.875
4.869
4.863
4.856
4.850
4.842
4.576
4.562
4.547
3.673
3.640
2.936
2.926
2.922
2.912
2.907
2.765
2.752
2.727
2.714
2.609
2.590
2.571
2.552
1.143
1.131
0.834
0.052
0.036
0.026
O
OTBS
MeO
N
S
O
(3,1H NMR, 400 MHz, CDCl3)
0.32
0.64
0.65
0.33
1.00
1.97
0.67
0.68
0.68
9.01
9.04
6.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)



(**3**, ^{13}C NMR, 100 MHz, $CDCl_3$)



(**4a**, ^{1}H NMR, 400 MHz, $CDCl_3$)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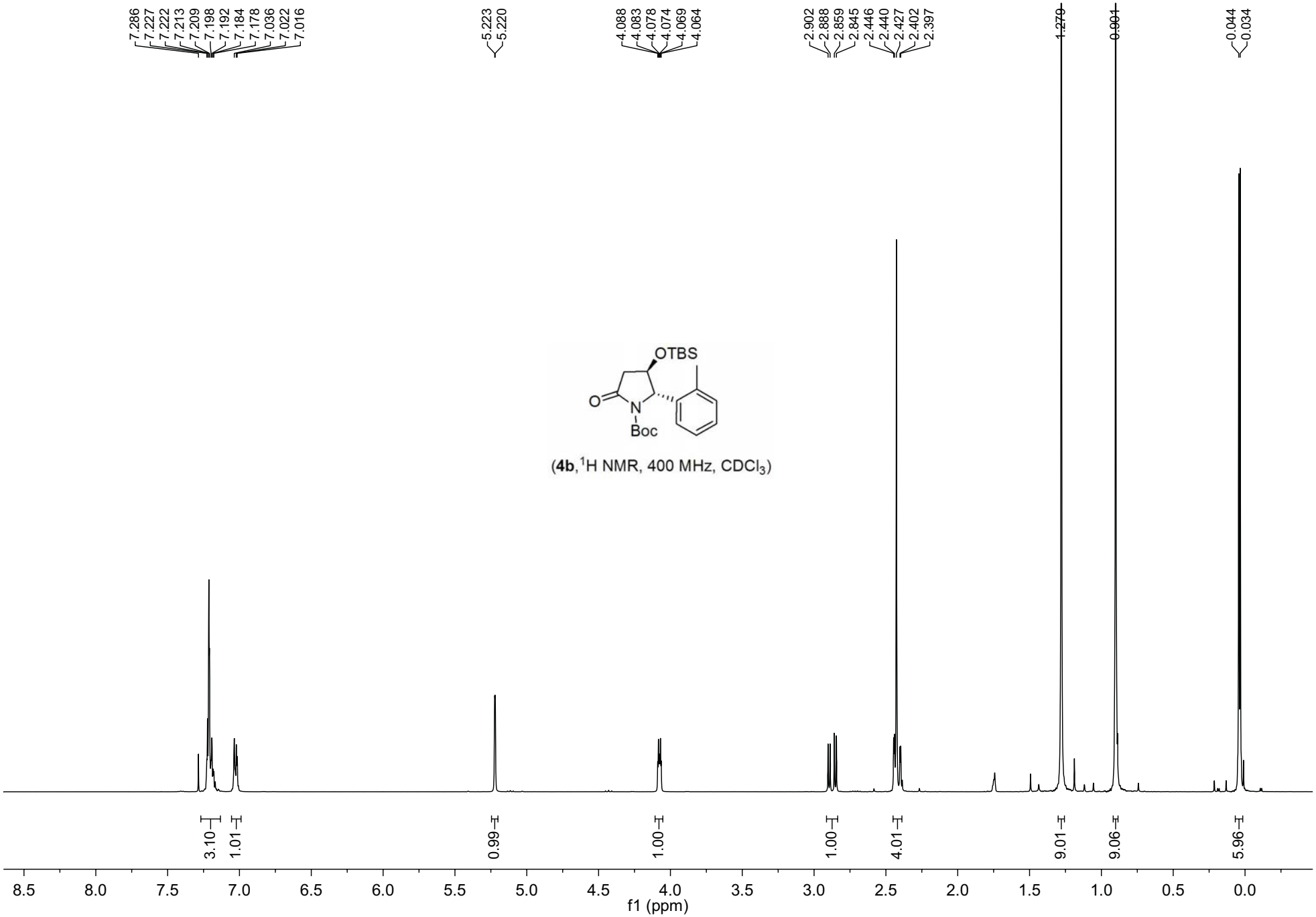
139.064
128.982
127.958
125.173
82.962
72.001
71.442
41.027
27.702
25.677
17.990
-4.761
-4.800
OTBS
O
N
Boc
(4a, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)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7.227
7.222
7.213
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7.198
7.192
7.184
7.178
7.036
7.022
7.016
5.223
5.220
4.088
4.083
4.078
4.074
4.069
4.064
2.902
2.888
2.859
2.845
2.446
2.440
2.427
2.402
2.397
1.270
0.901
0.044
0.034
OTBS
O
N
Boc
(4b, 1H NMR, 400 MHz, CDCl3)
3.10
1.01
0.99
1.00
1.00
4.01
9.01
9.06
5.96
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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2.5
2.0
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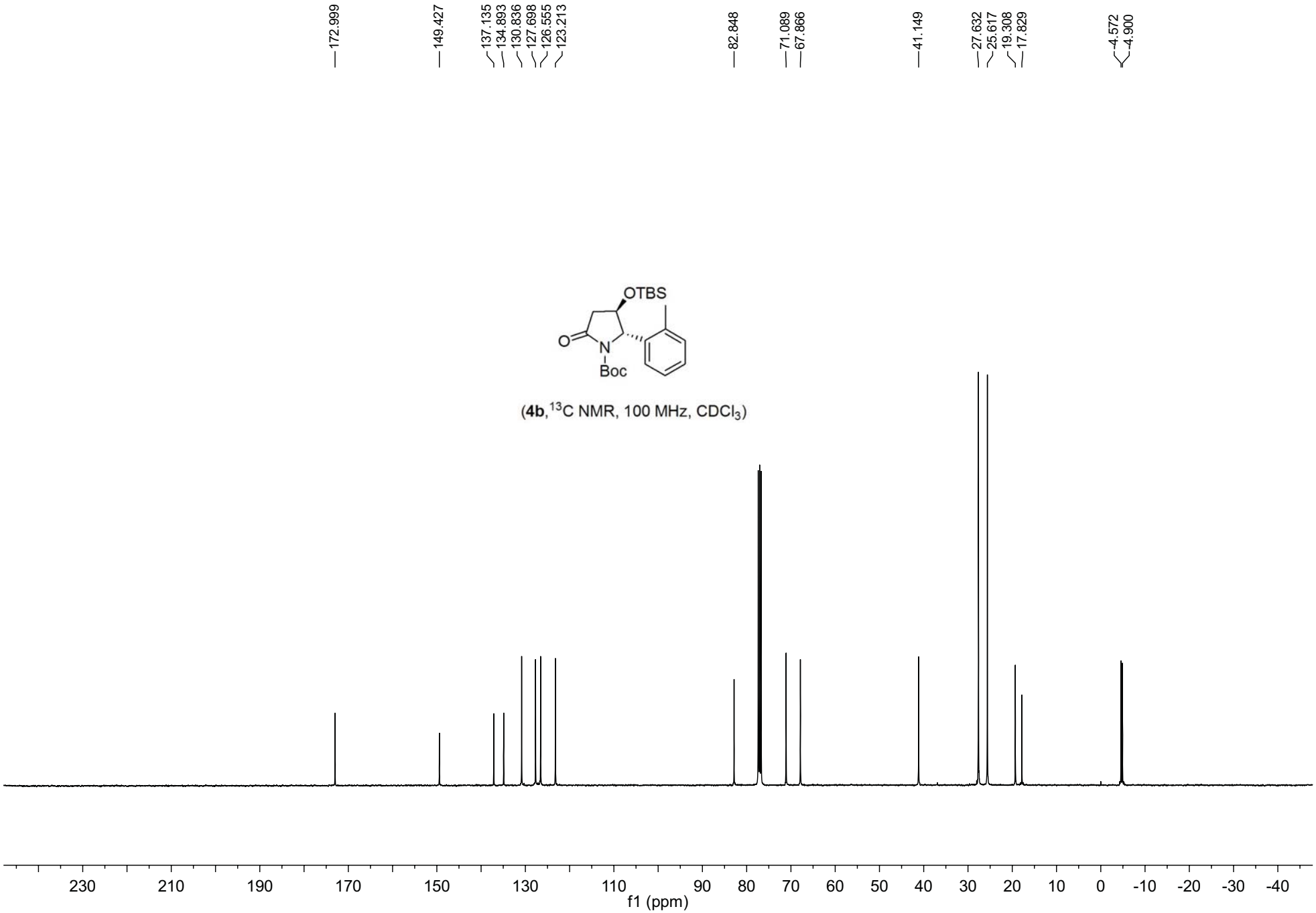
1.0
0.5
0.0
f1 (ppm)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137.135
134.893
130.836
127.698
126.555
123.213
82.848
71.089
67.866
41.149
27.632
25.617
19.308
17.829
-4.572
-4.900
OTBS
O
N
Boc
(4b,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
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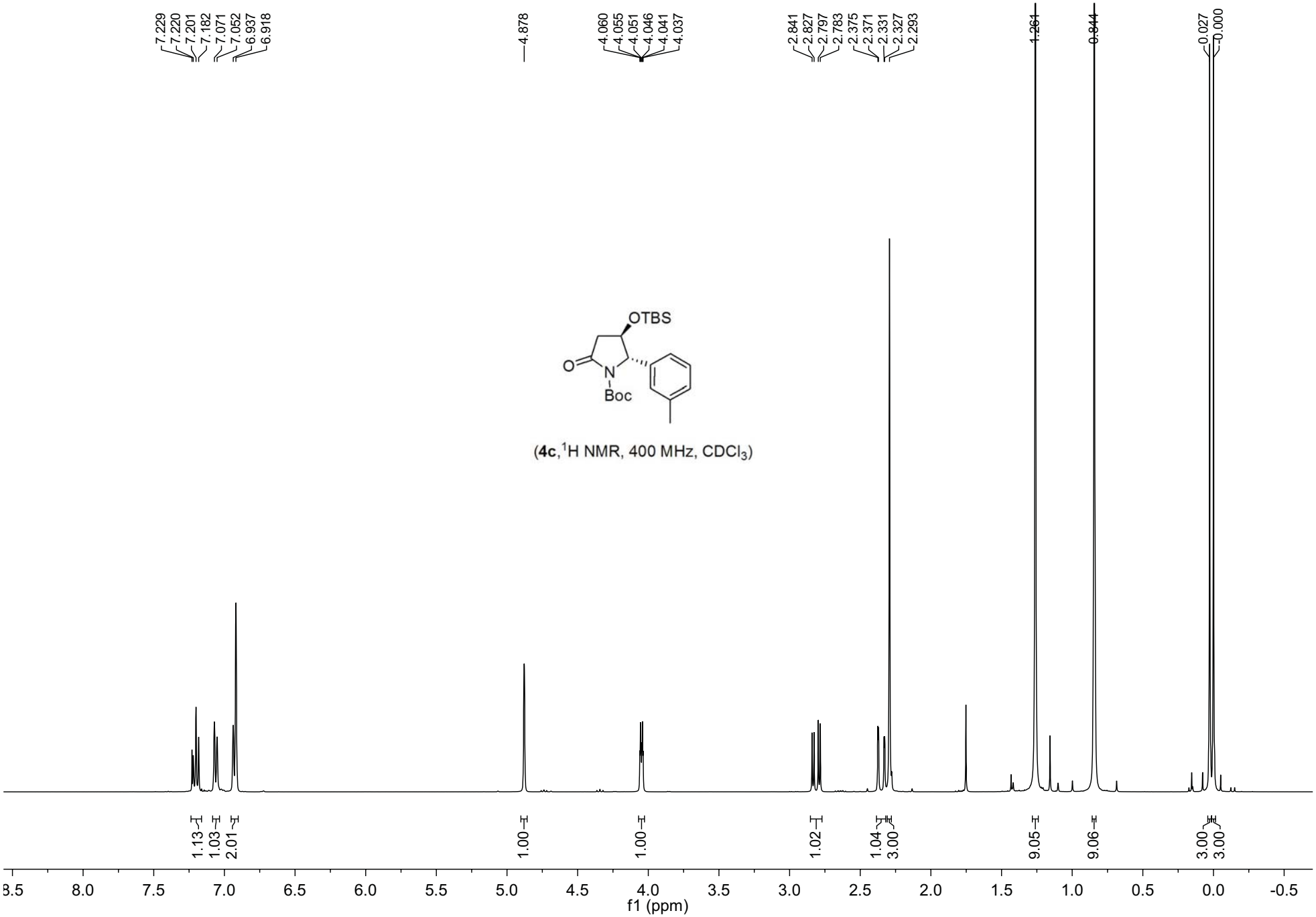
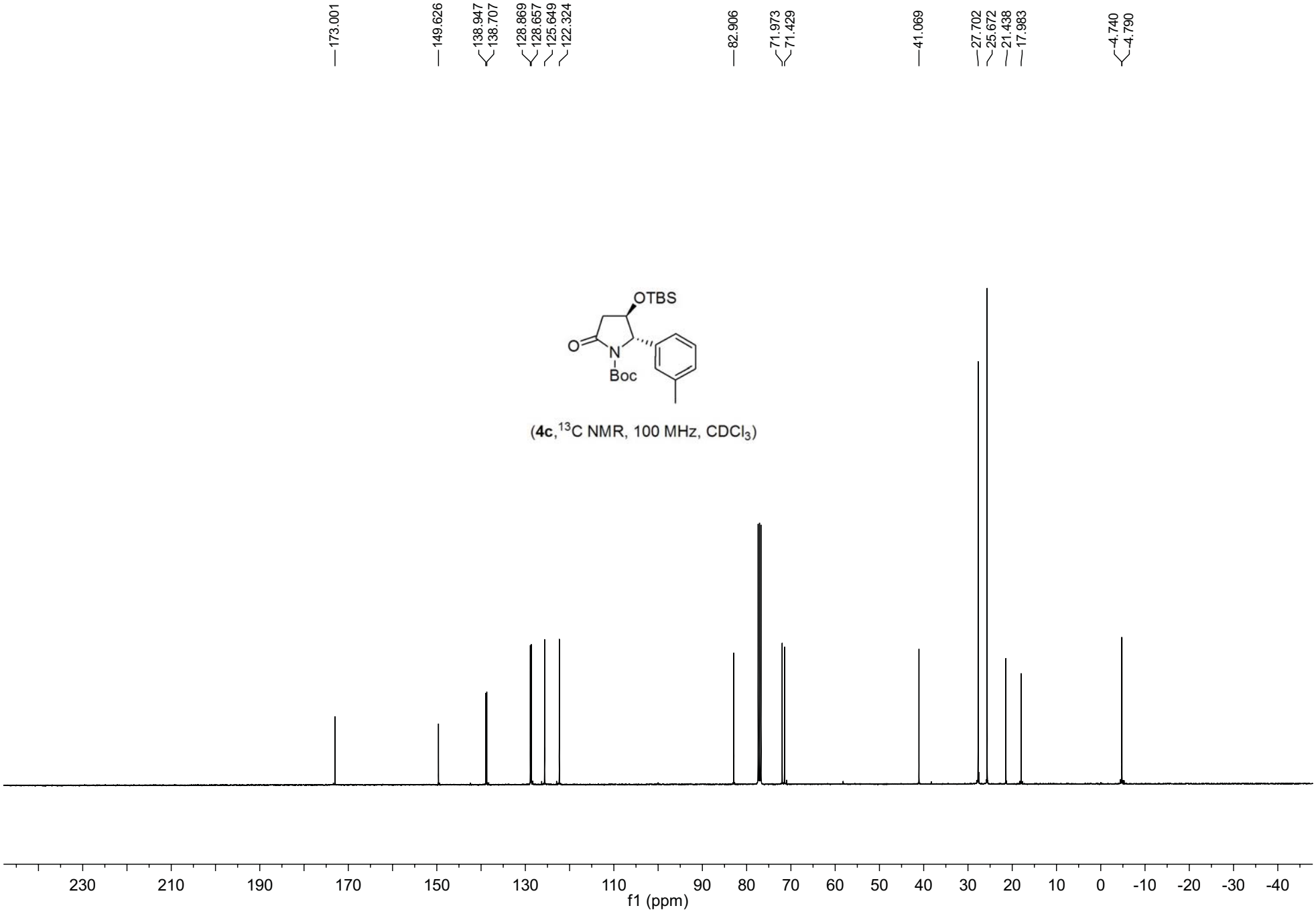
10
0
-10
-20
-30
-40
f1 (ppm)



(**4c**,^{1}H NMR, 400 MHz, $CDCl_3$)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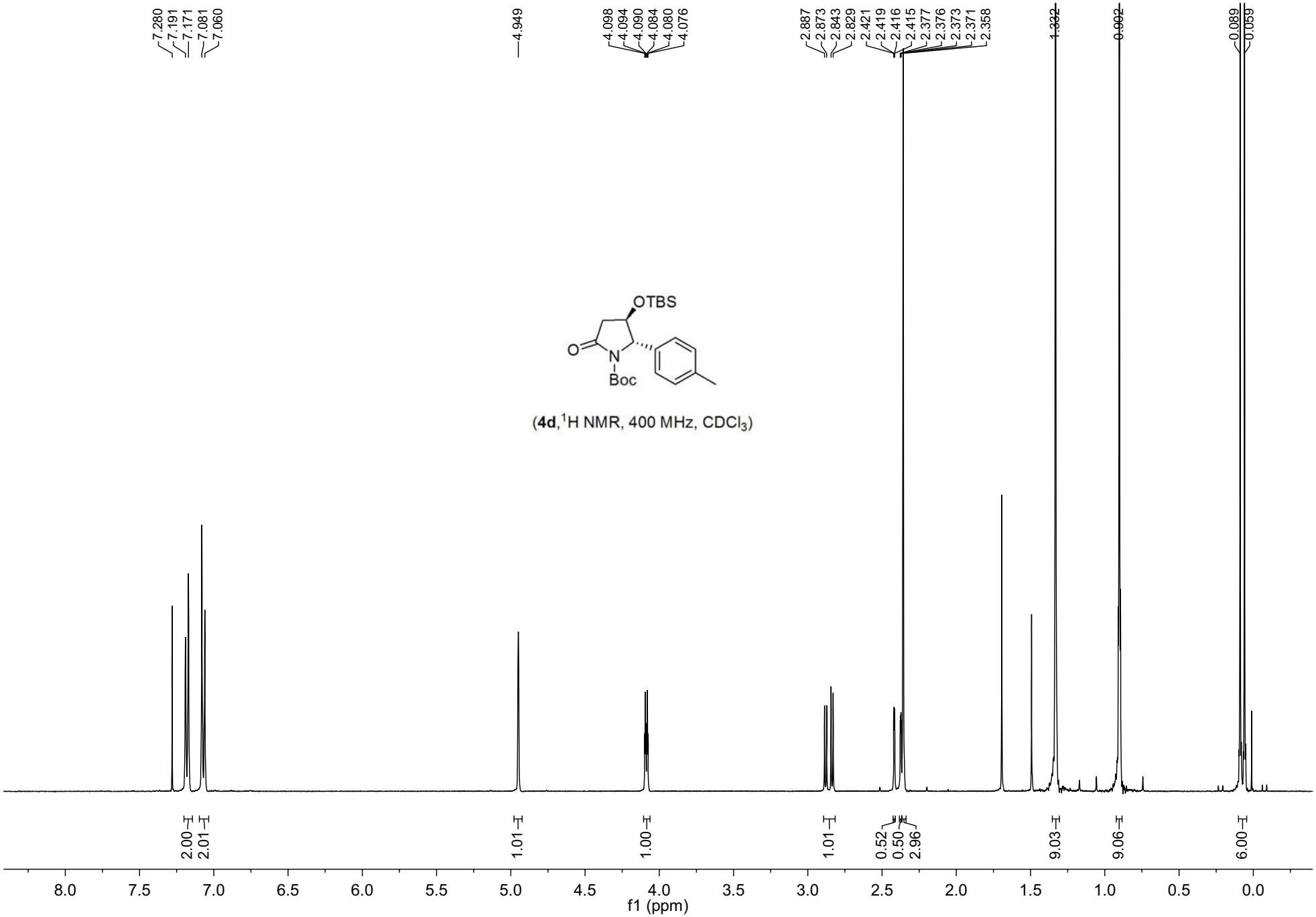
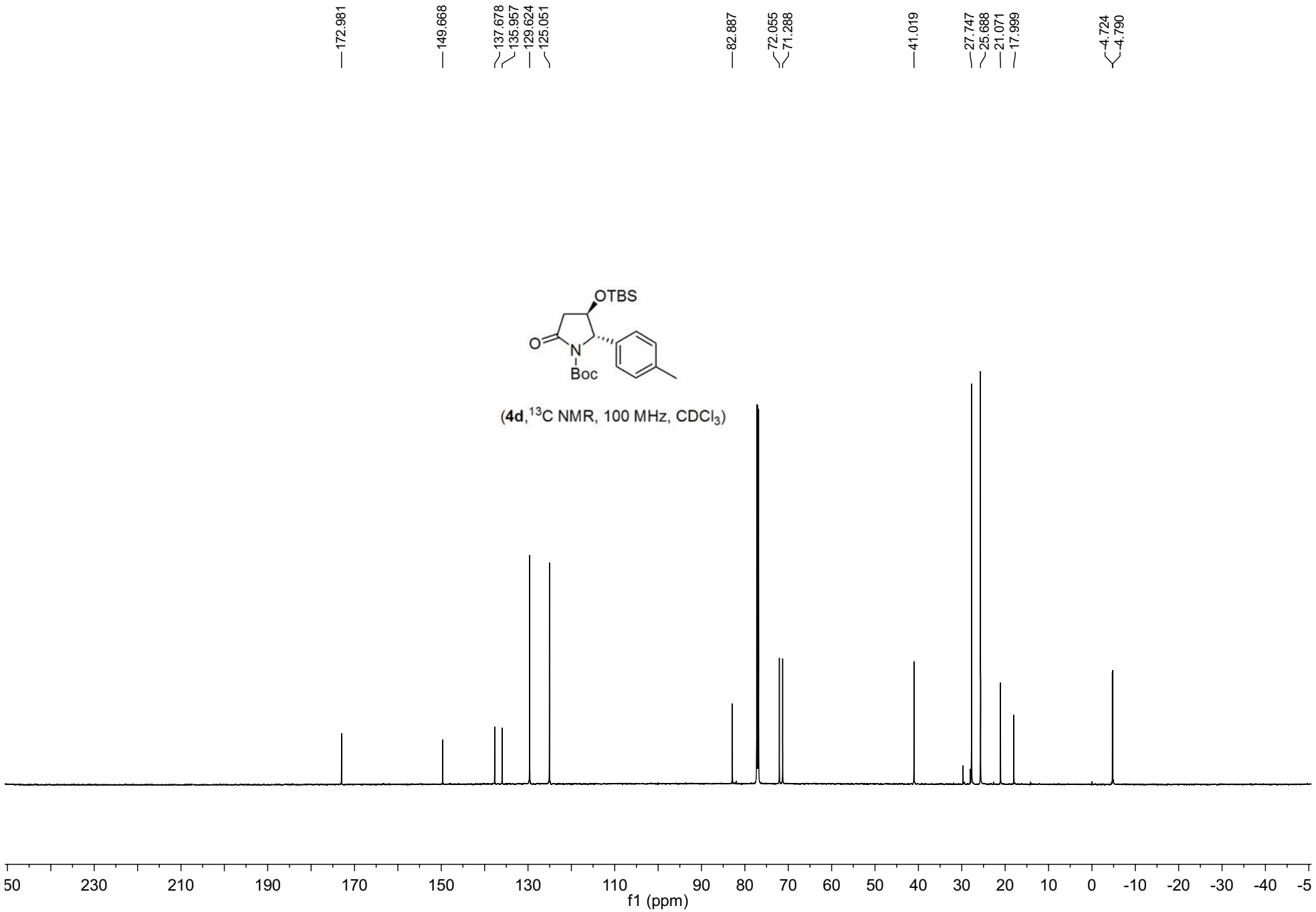
149.626
138.947
138.707
128.869
128.657
125.649
122.324
82.906
71.973
71.429
41.069
27.702
25.672
21.438
17.983
-4.740
-4.790
OTBS
O
N
Boc
(4c,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)



(**4d**,^{1}H NMR, 400 MHz, $CDCl_3$)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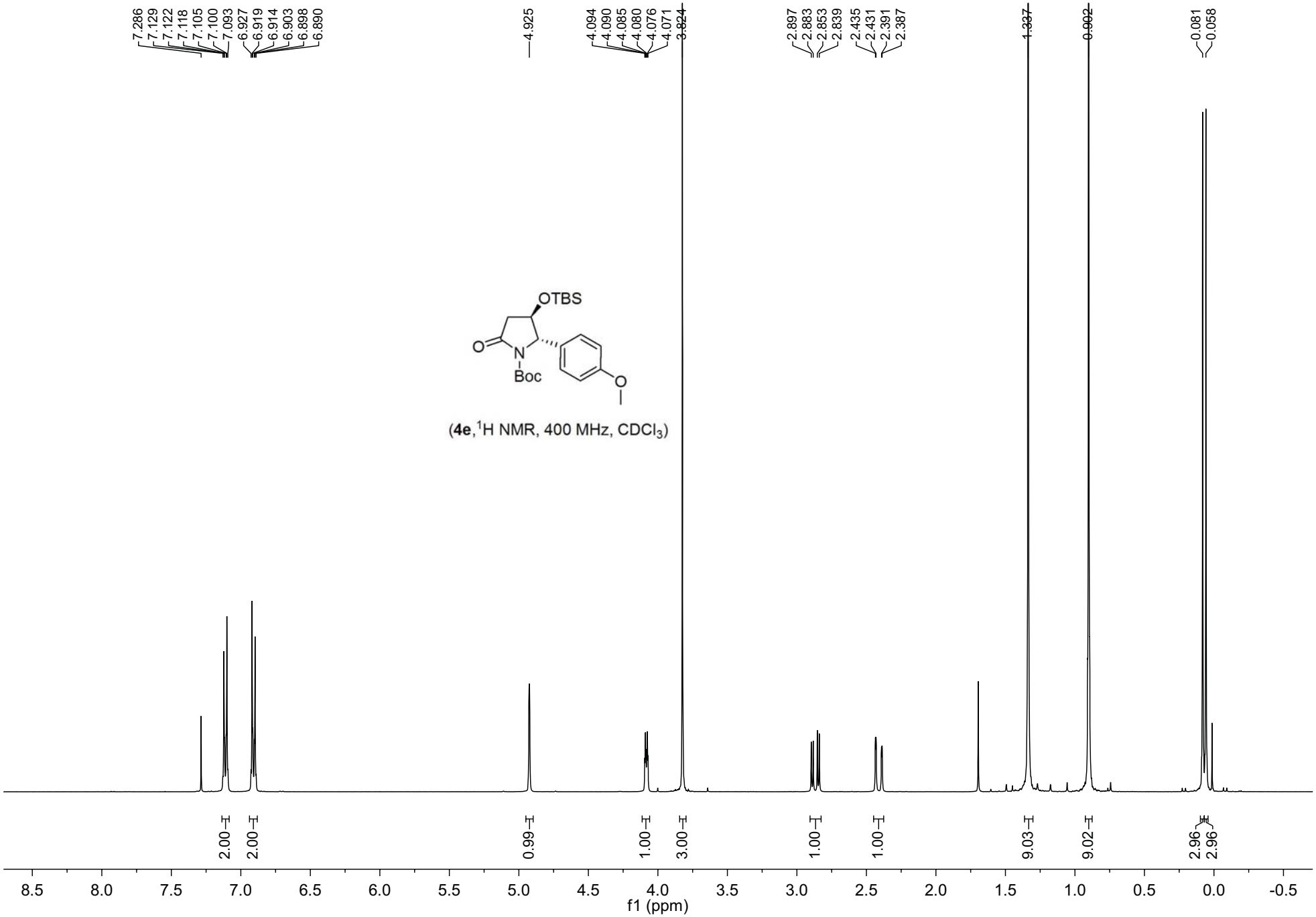
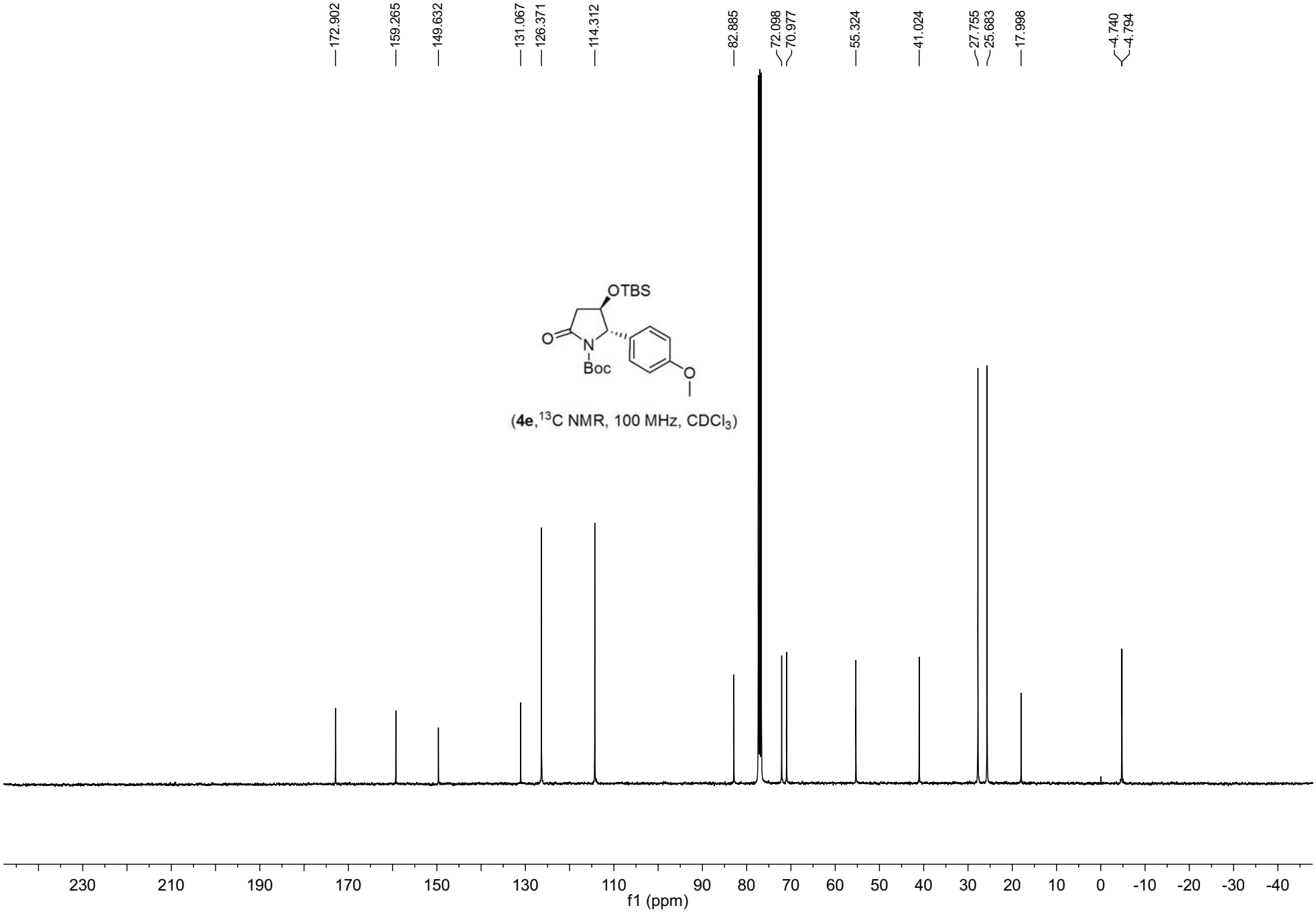
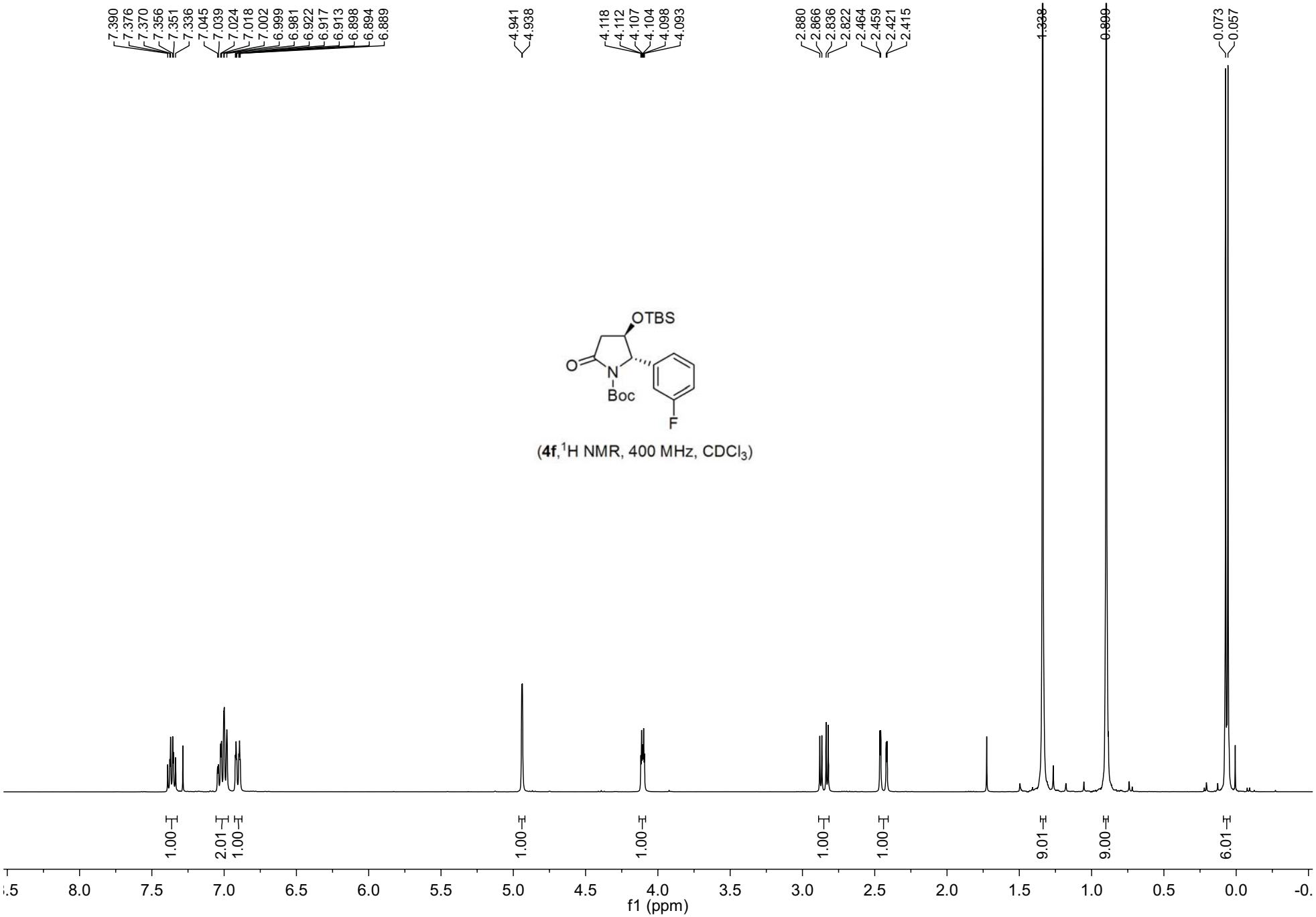
135.957
129.624
125.051
82.887
72.055
71.288
41.019
27.747
25.688
21.071
17.999
4.724
4.790
OTBS
O
N
Boc
(4d,13C NMR, 100 MHz, CDCl3)
50
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-5
f1 (ppm)

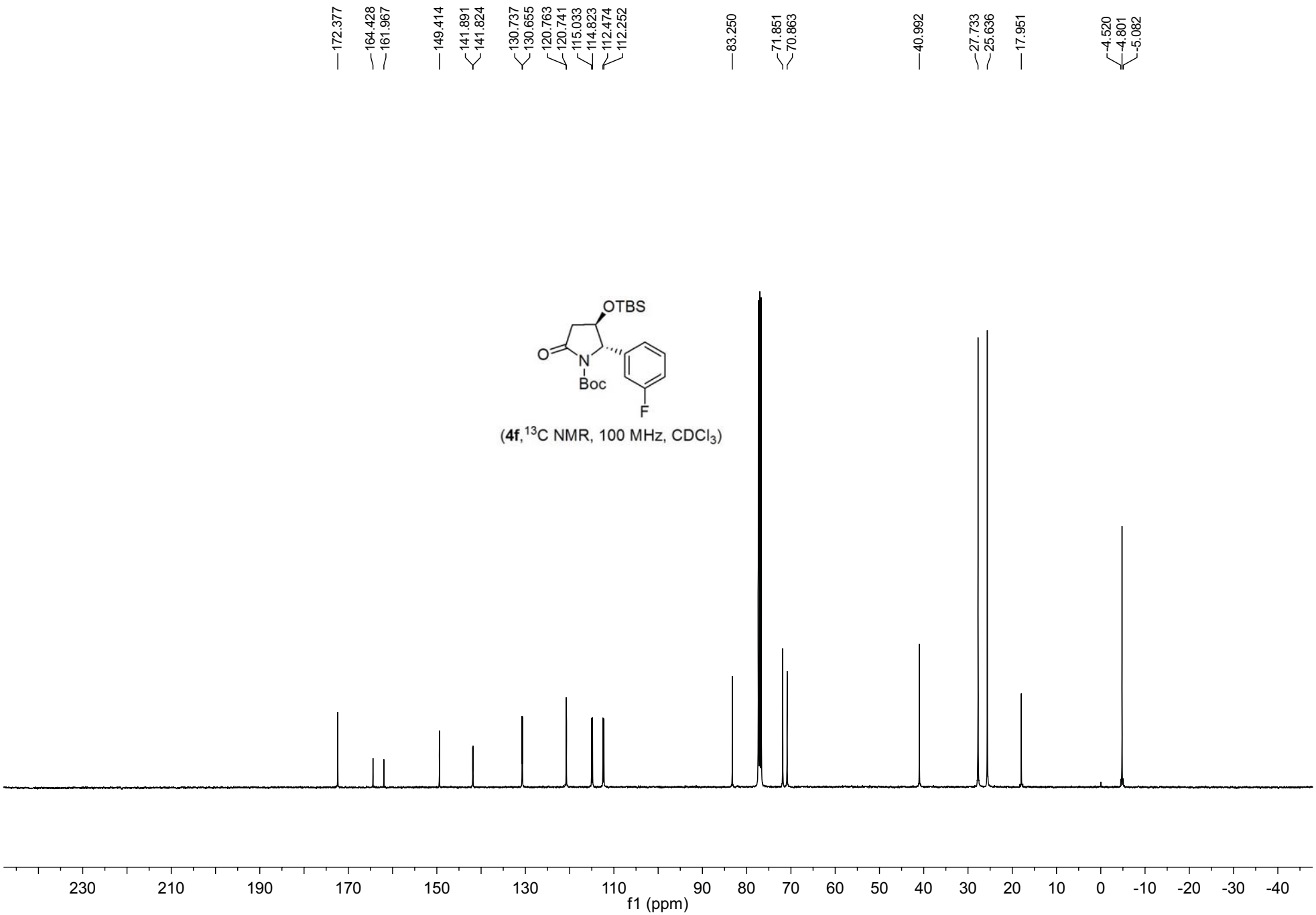


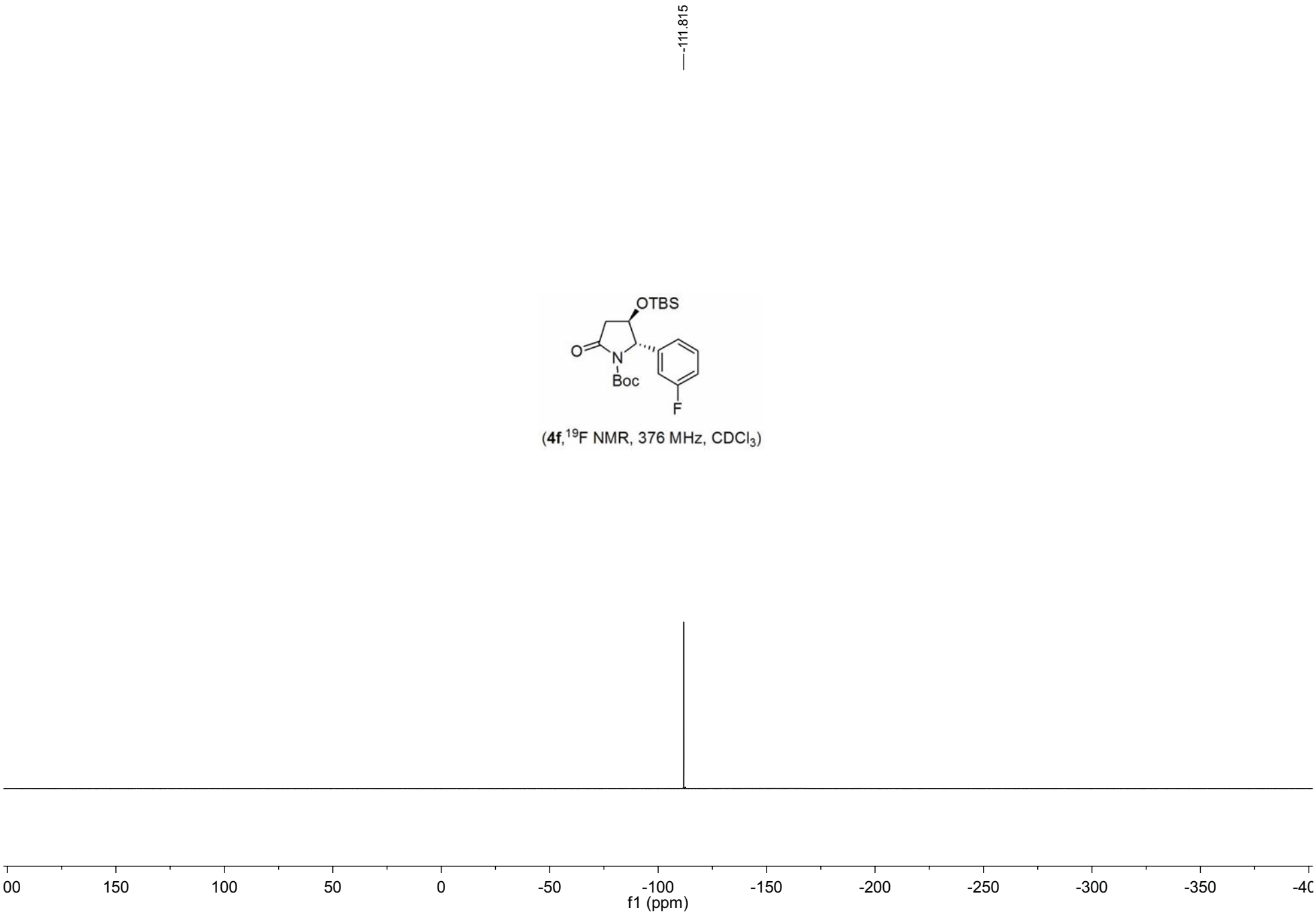
(**4e**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.902
159.265
149.632
131.067
126.371
114.312
82.885
72.098
70.977
55.324
41.024
27.755
25.683
17.998
-4.740
-4.794
OTBS
O
N
Boc
O
(4e, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

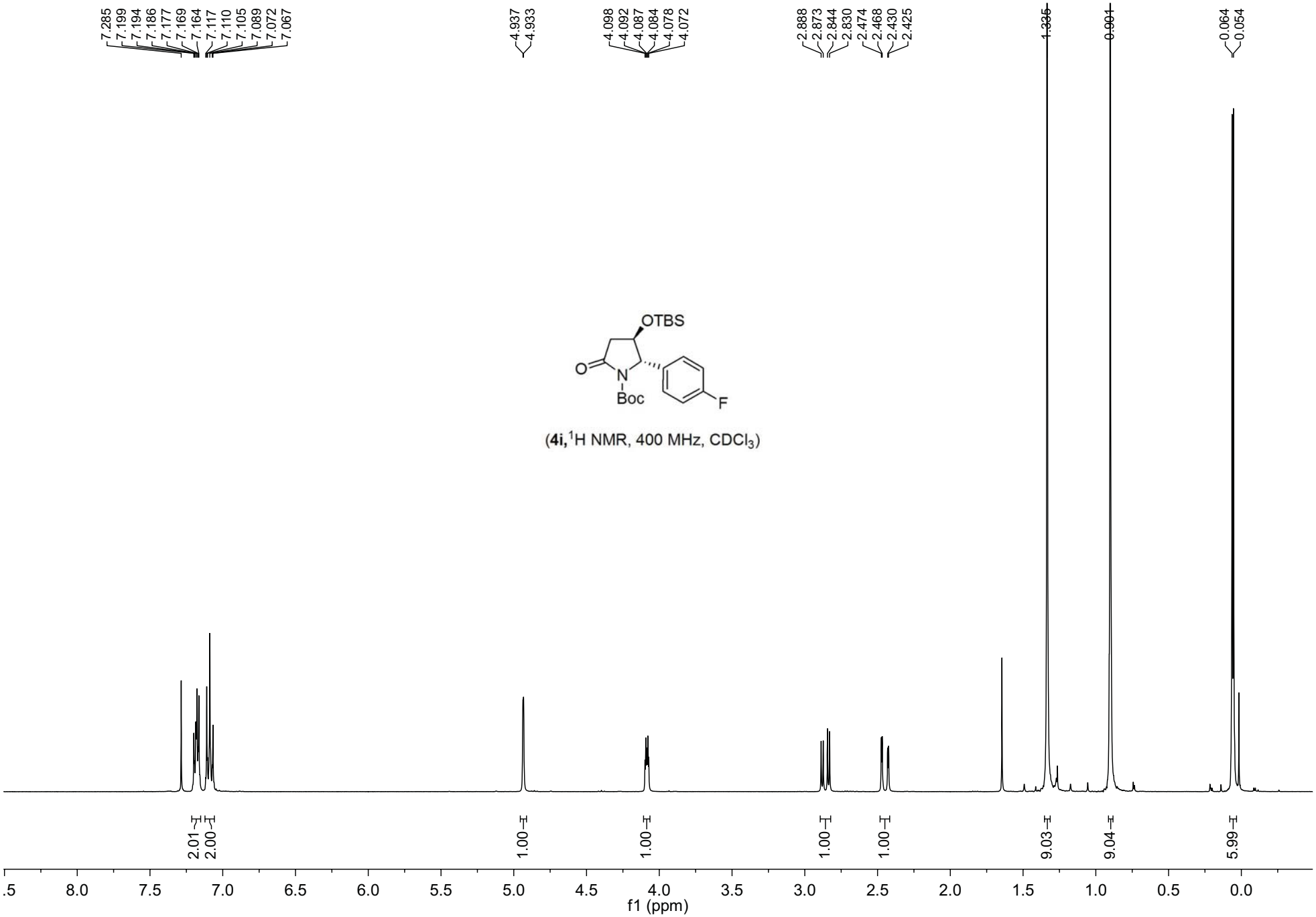


(**4f**, ^{1}H NMR, 400 MHz, $CDCl_3$)

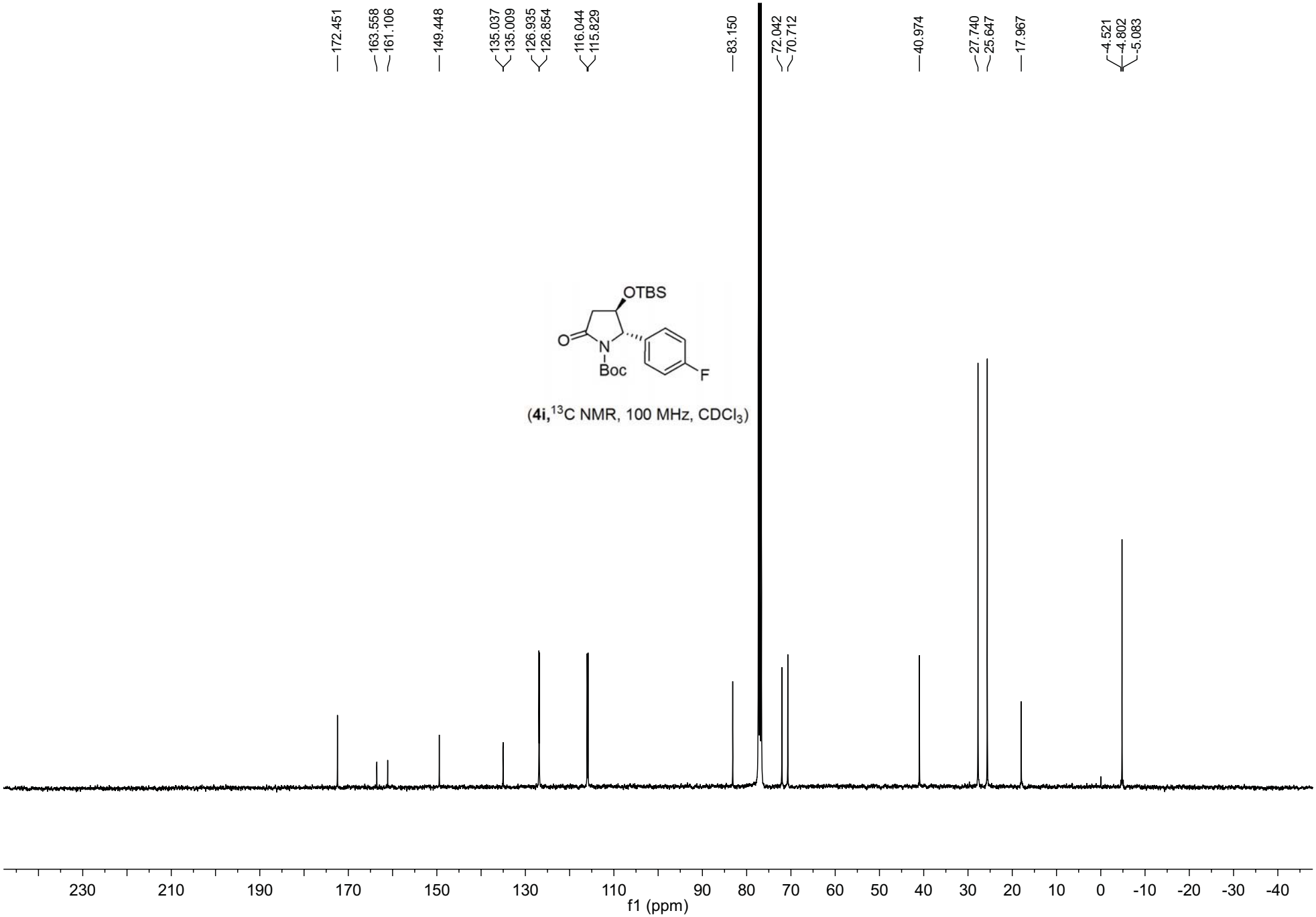

172.377
164.428
161.967
149.414
141.891
141.824
130.737
130.655
120.763
120.741
115.033
114.823
112.474
112.252
83.250
71.851
70.863
40.992
27.733
25.636
17.951
-4.520
-4.801
-5.082
OTBS
O
N
Boc
F
(4f, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)



(**4f**,^{19}F NMR, 376 MHz, $CDCl_3$)



(**4i**,^{1}H NMR, 400 MHz, $CDCl_3$)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163.558
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149.448
135.037
135.009
126.935
126.854
116.044
115.829
83.150
72.042
70.712
40.974
27.740
25.647
17.967
4.521
4.802
-5.083
OTBS
O
N
Boc
F
(4i, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
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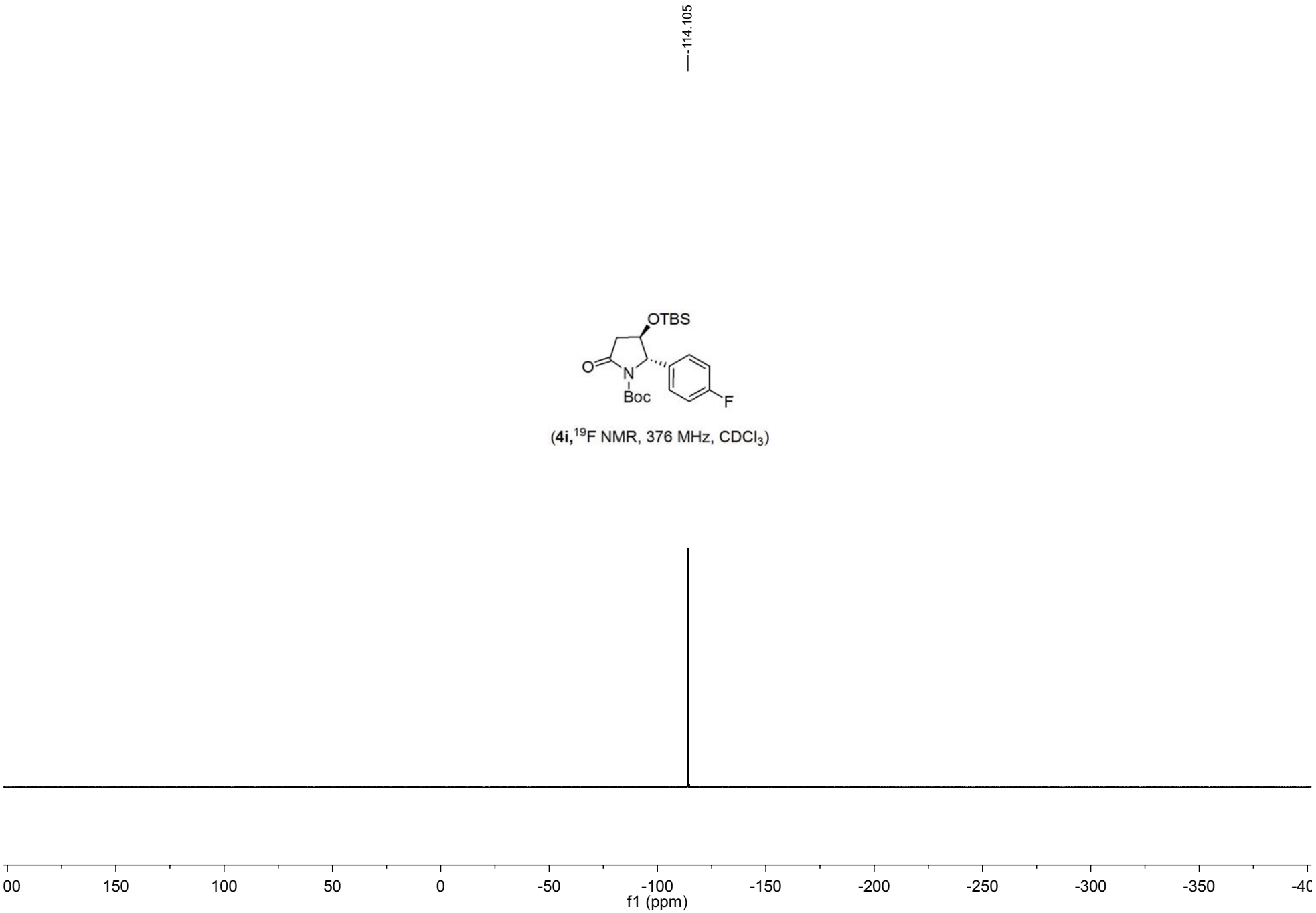
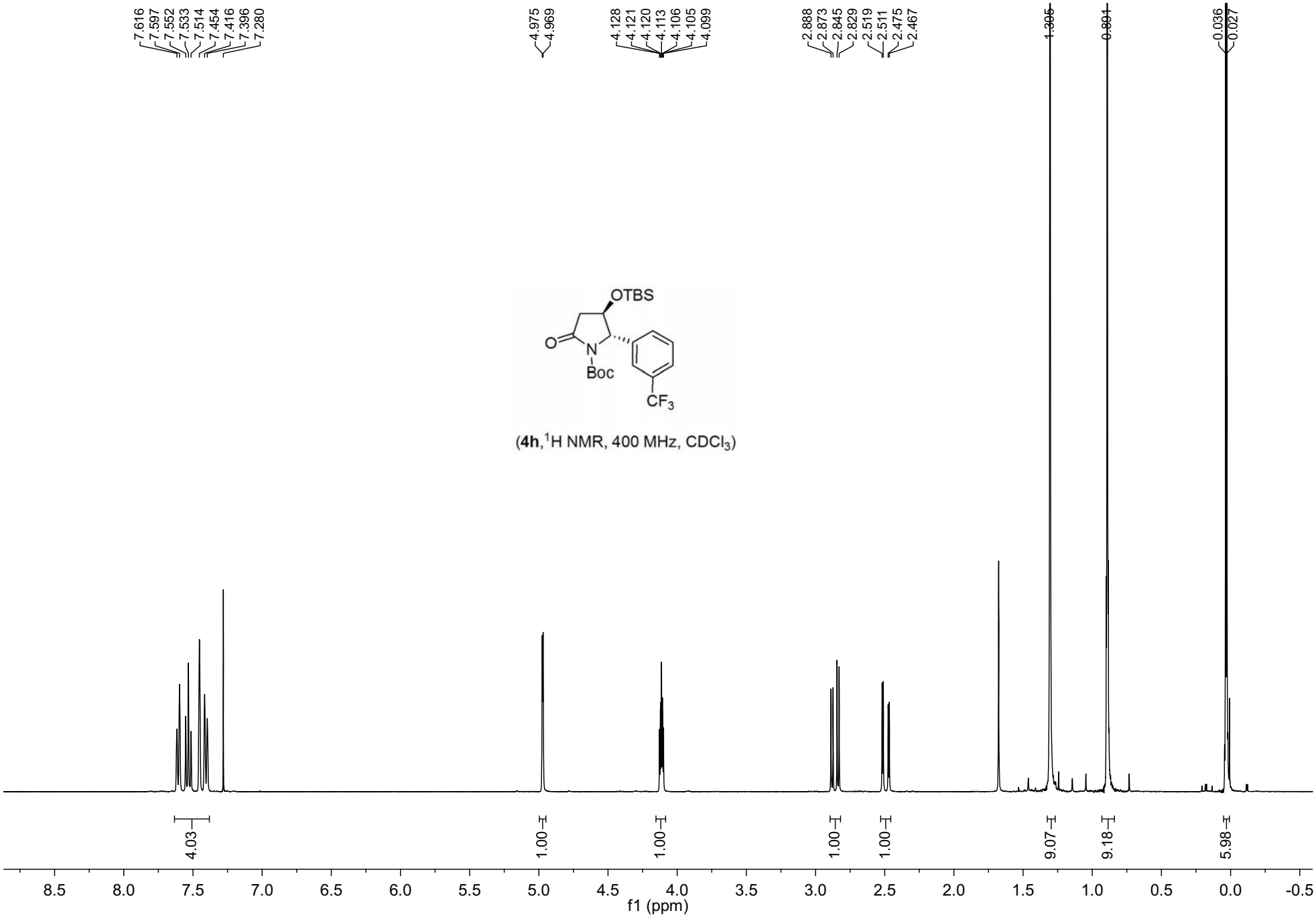
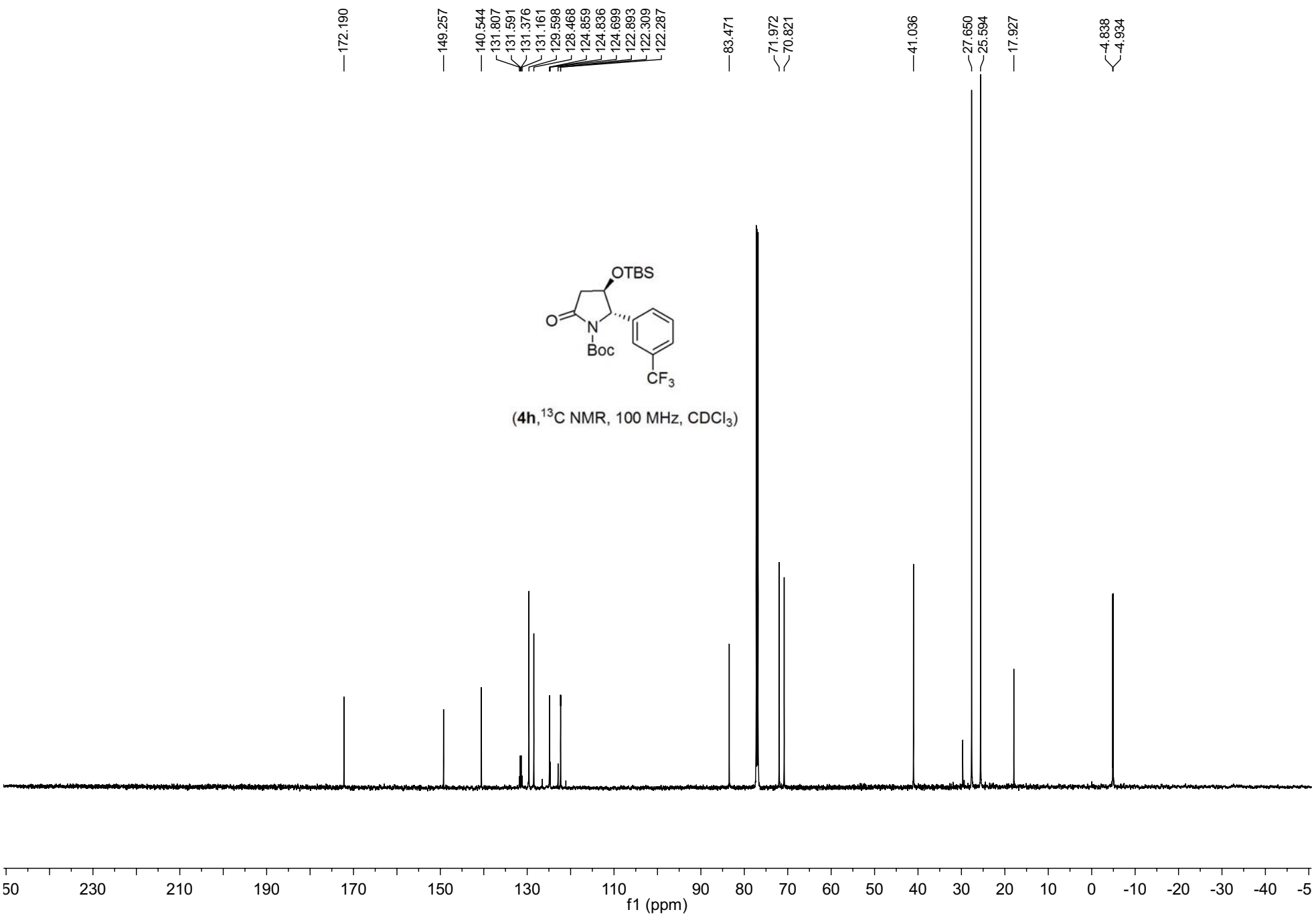
0
-10
-20
-30
-40
f1 (ppm)



(**4i**,^{19}F NMR, 376 MHz, $CDCl_3$)



(**4h**,^{1}H NMR, 400 MHz, $CDCl_3$)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124.859
124.836
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122.893
122.309
122.287
83.471
71.972
70.821
41.036
27.650
25.594
17.927
4.838
4.934
OTBS
O
N
Boc
CF3
(4h,13C NMR, 100 MHz, CDCl3)
50
230
210
190
170
150
130
110
90
80
70
60
50
40
30
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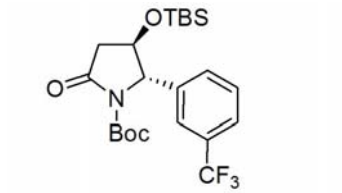
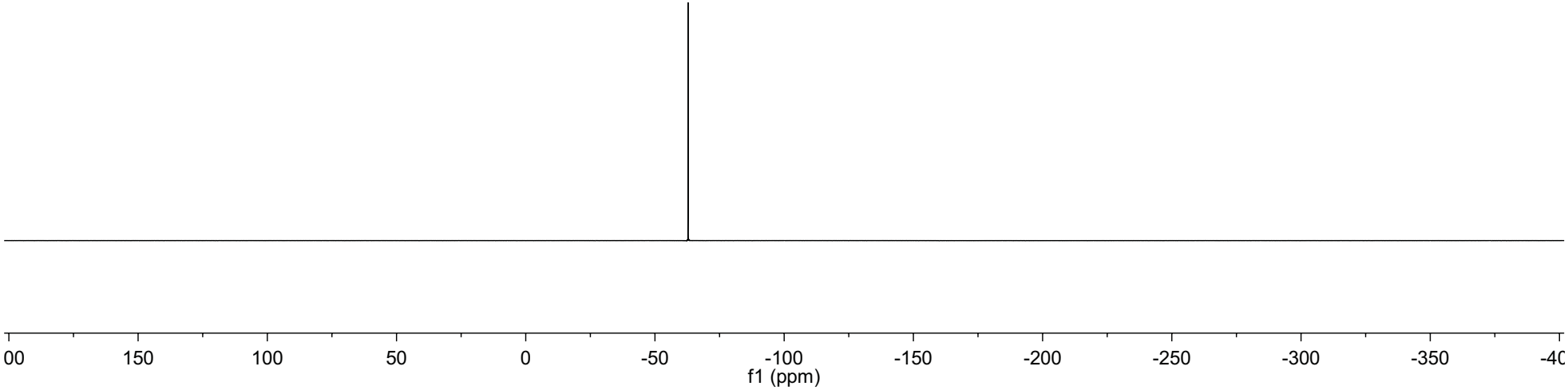
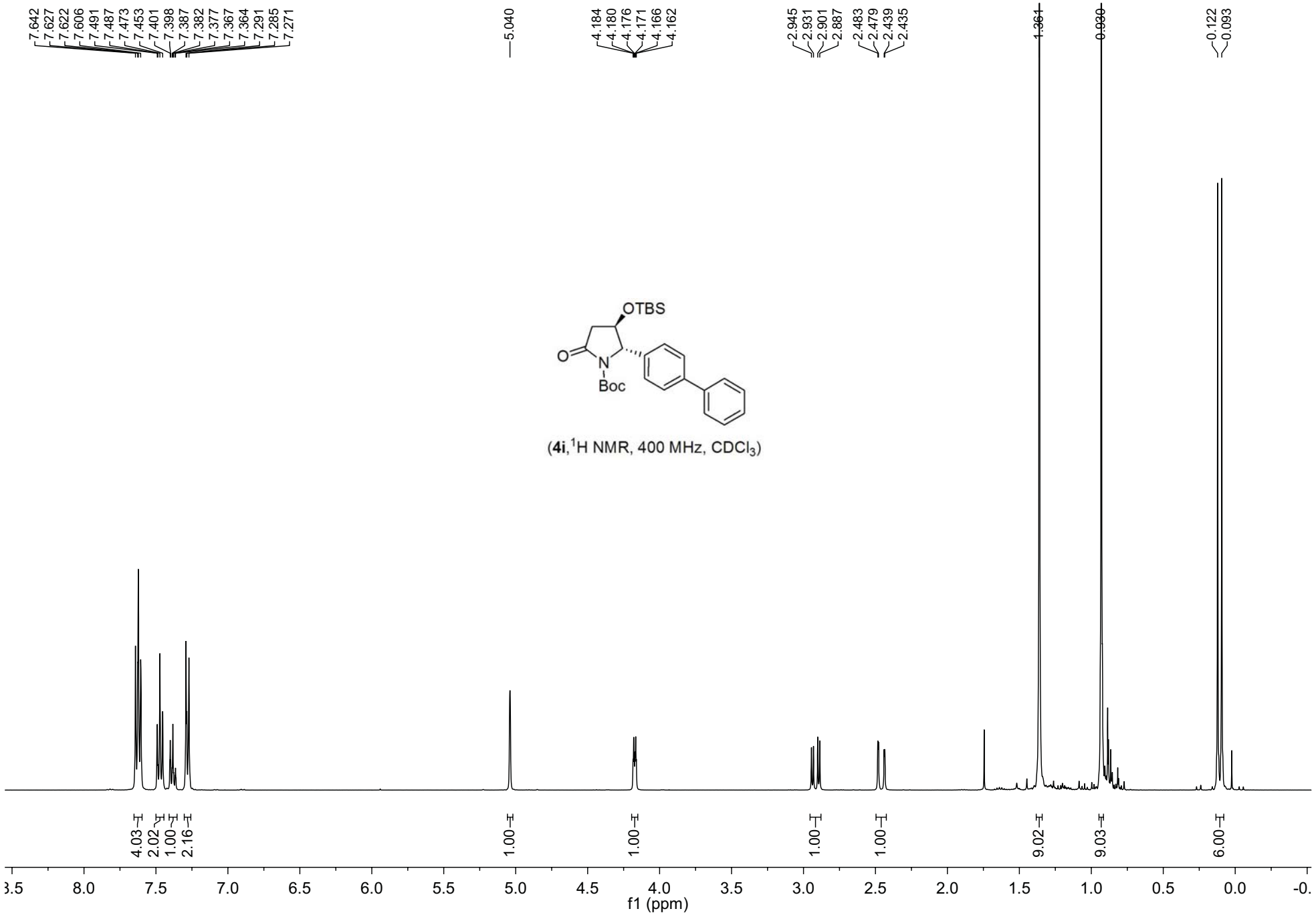
-10
-20
-30
-40
-5
f1 (ppm)

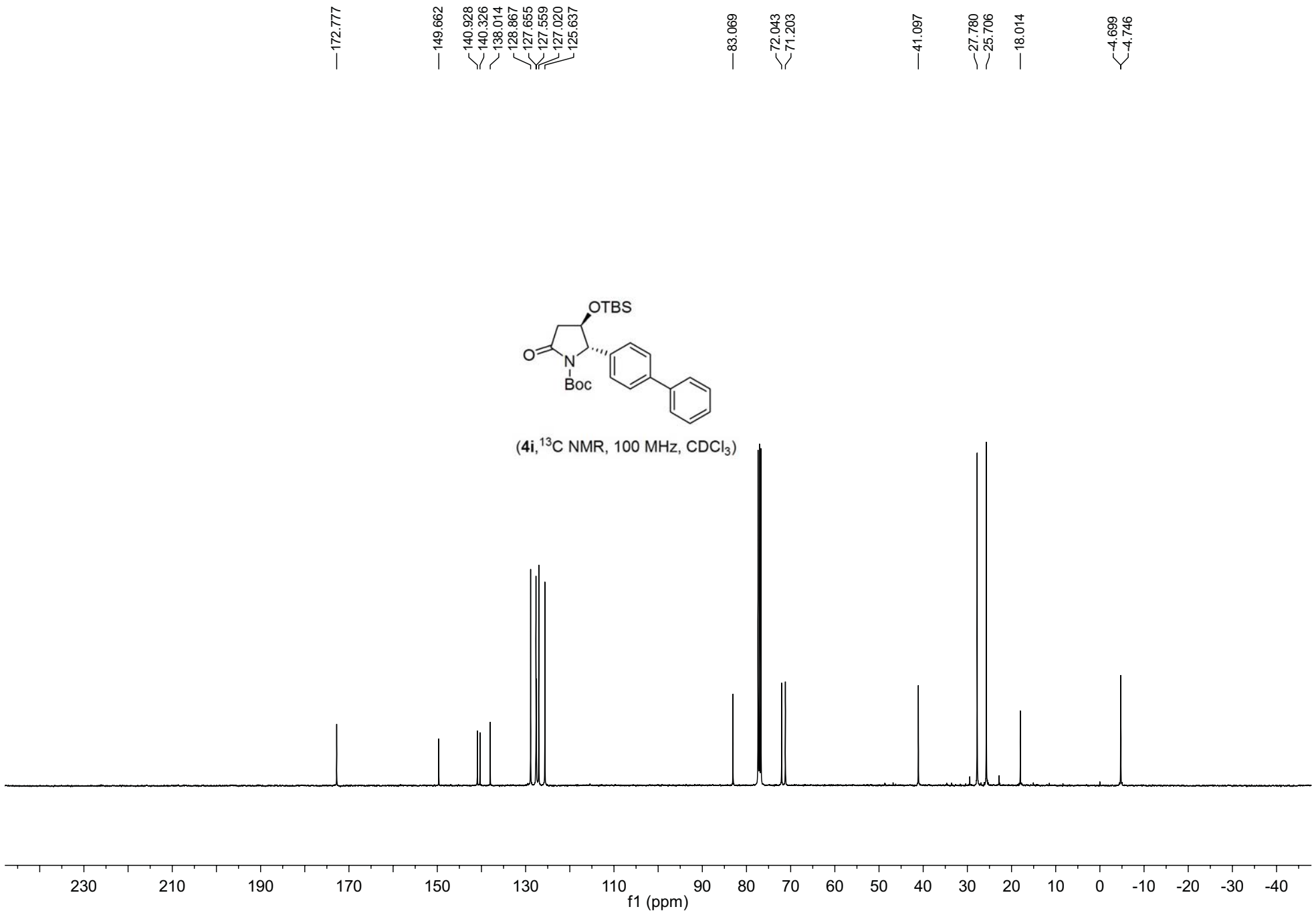


(**4h**, ^{19}F NMR, 376 MHz, $CDCl_3$)





(**4i**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.777
149.662
140.928
140.326
138.014
128.867
127.655
127.559
127.020
125.637
83.069
72.043
71.203
41.097
27.780
25.706
18.014
-4.699
-4.746
OTBS
O
N
Boc
(4i, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
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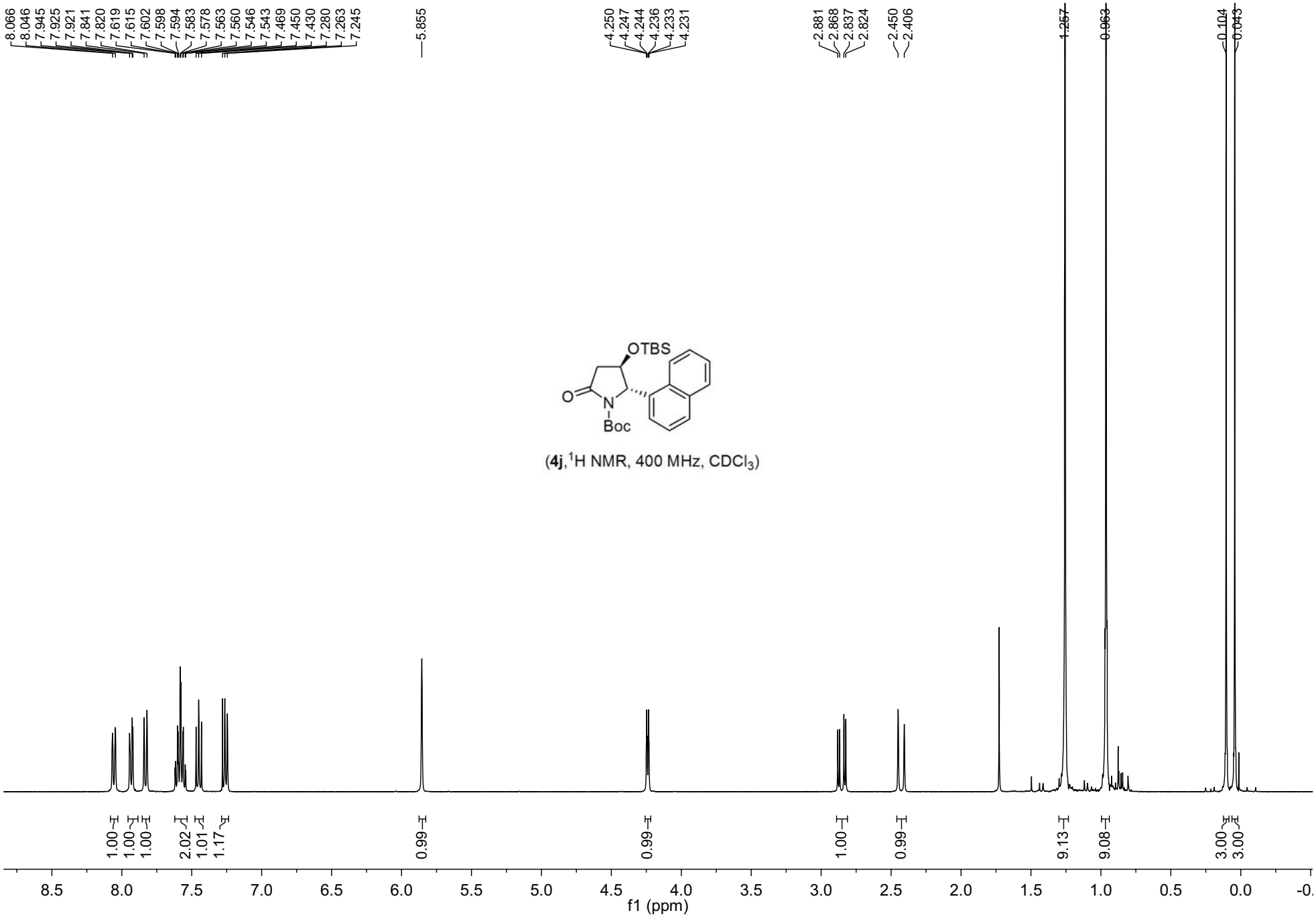
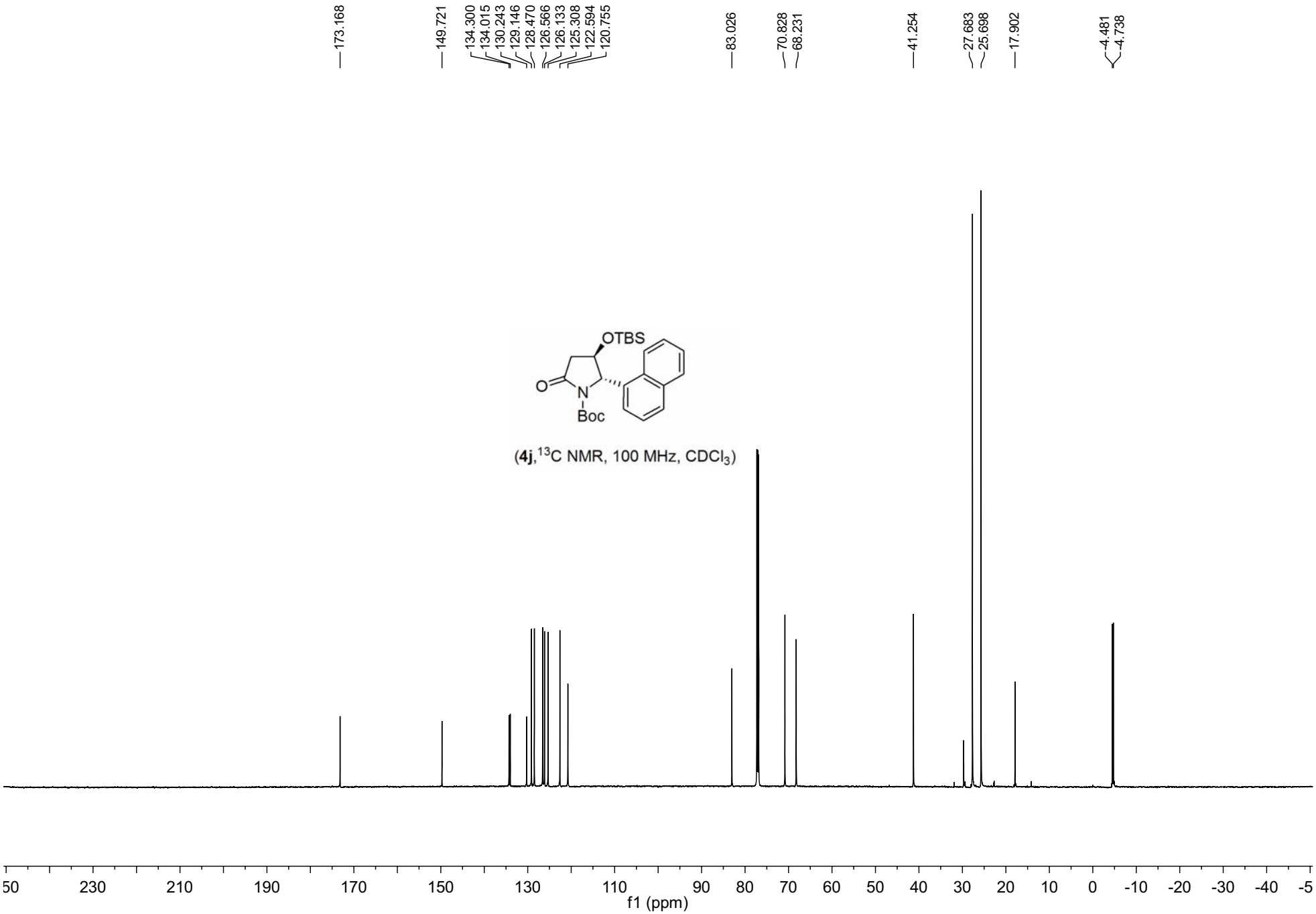
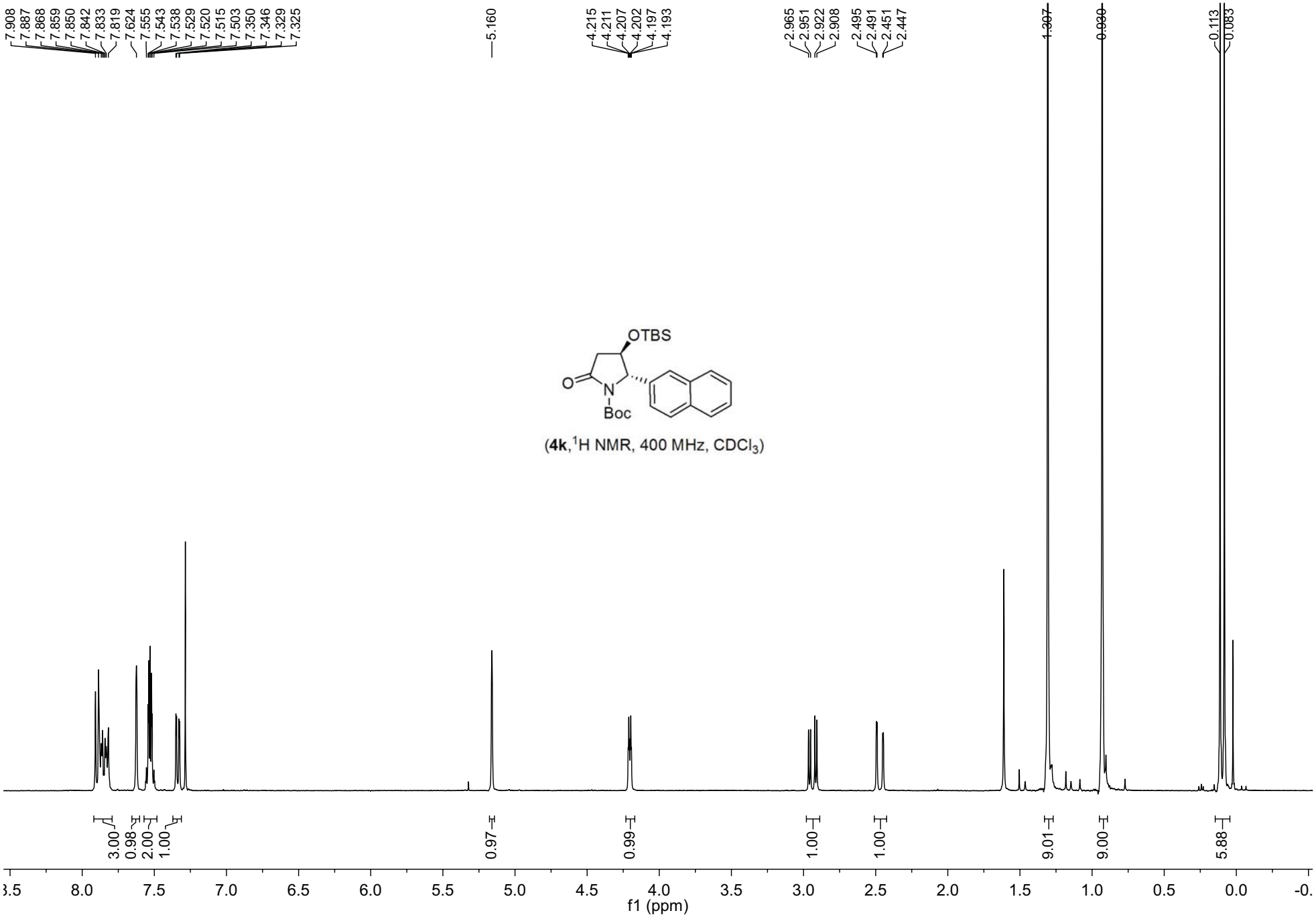
0
-10
-20
-30
-40
f1 (ppm)

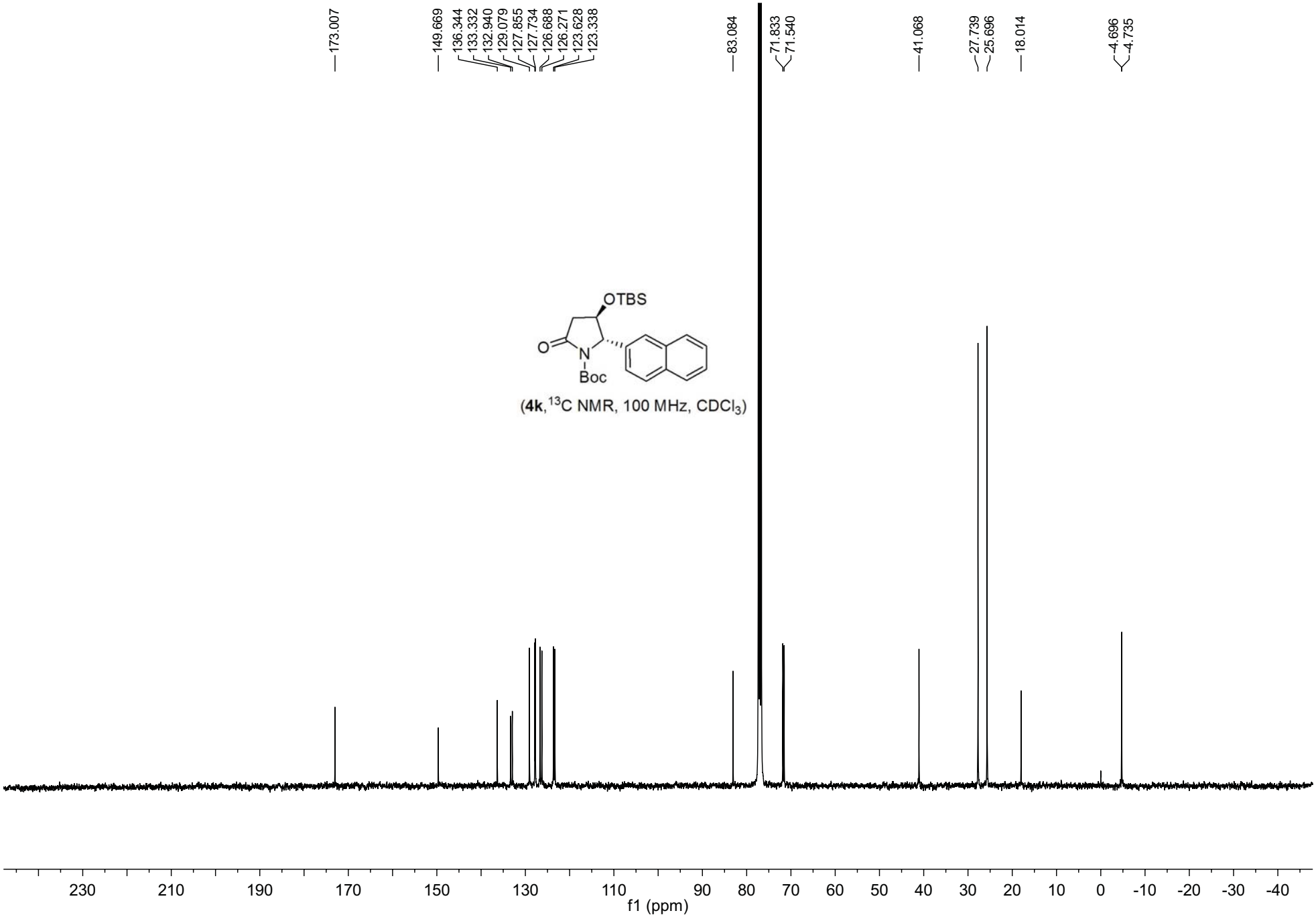


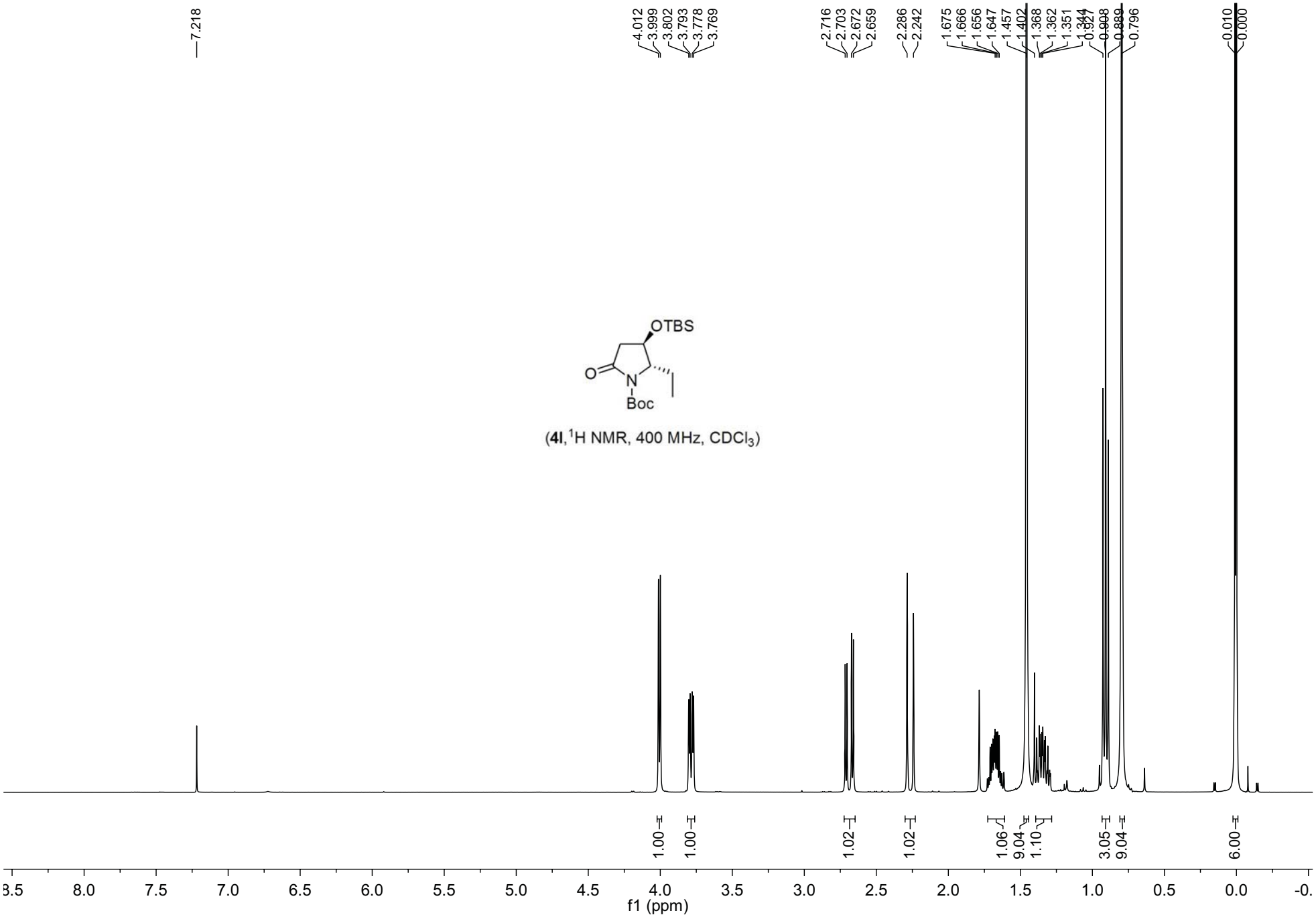
(**4j**,^{1}H NMR, 400 MHz, $CDCl_3$)


173.168
149.721
134.300
134.015
130.243
129.146
128.470
126.566
126.133
125.308
122.594
120.755
83.026
70.828
68.231
41.254
27.683
25.698
17.902
4.481
4.738
OTBS
O
N
Boc
(4j,13C NMR, 100 MHz, CDCl3)
f1 (ppm)

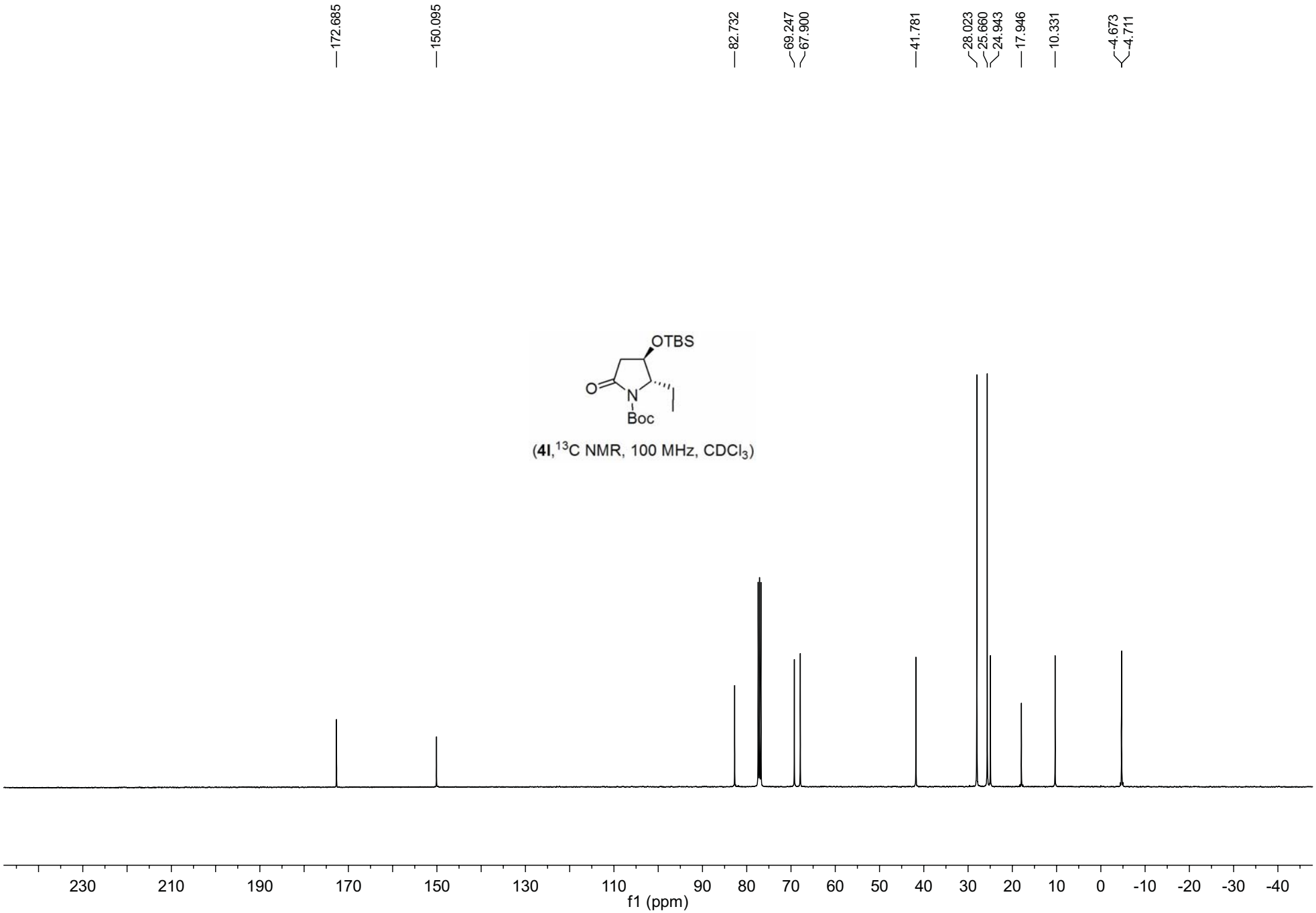


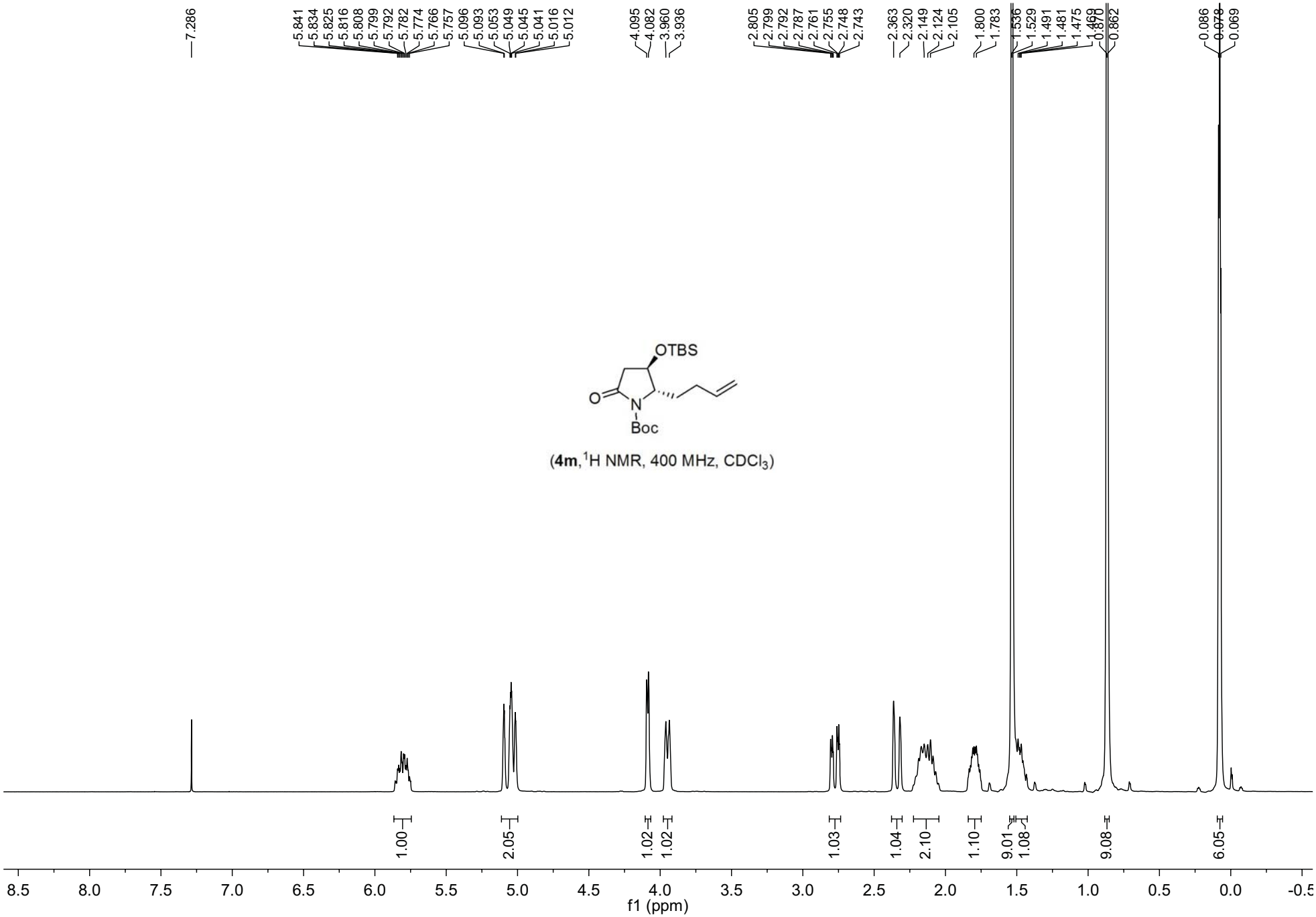
(**4k**,^{1}H NMR, 400 MHz, $CDCl_3$)


173.007
149.669
136.344
133.332
132.940
129.079
127.855
127.734
126.688
126.271
123.628
123.338
83.084
71.833
71.540
41.068
27.739
25.696
18.014
-4.696
-4.735
OTBS
O
N
Boc
(4k, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

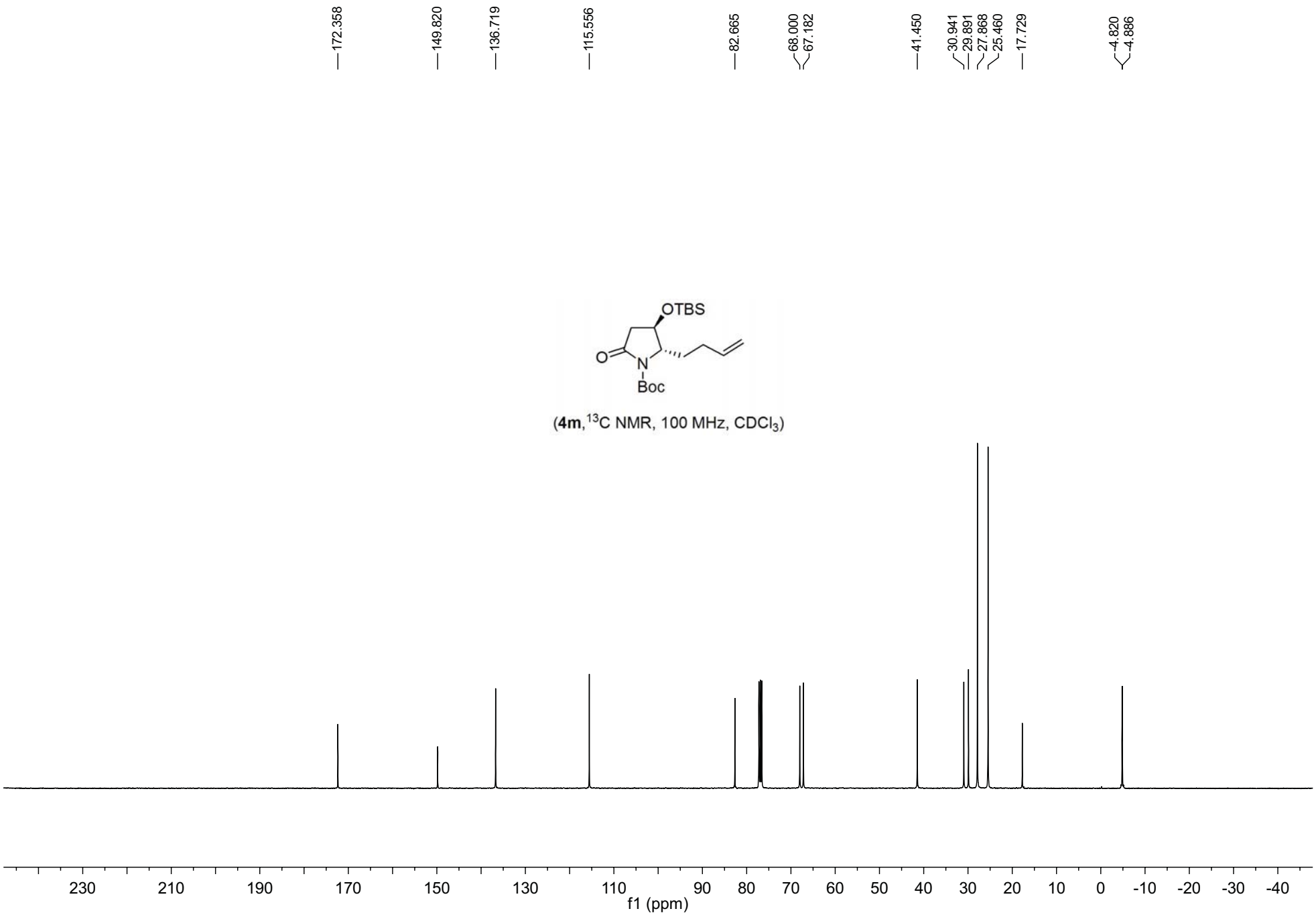


(**4l**,^{1}H NMR, 400 MHz, $CDCl_3$)

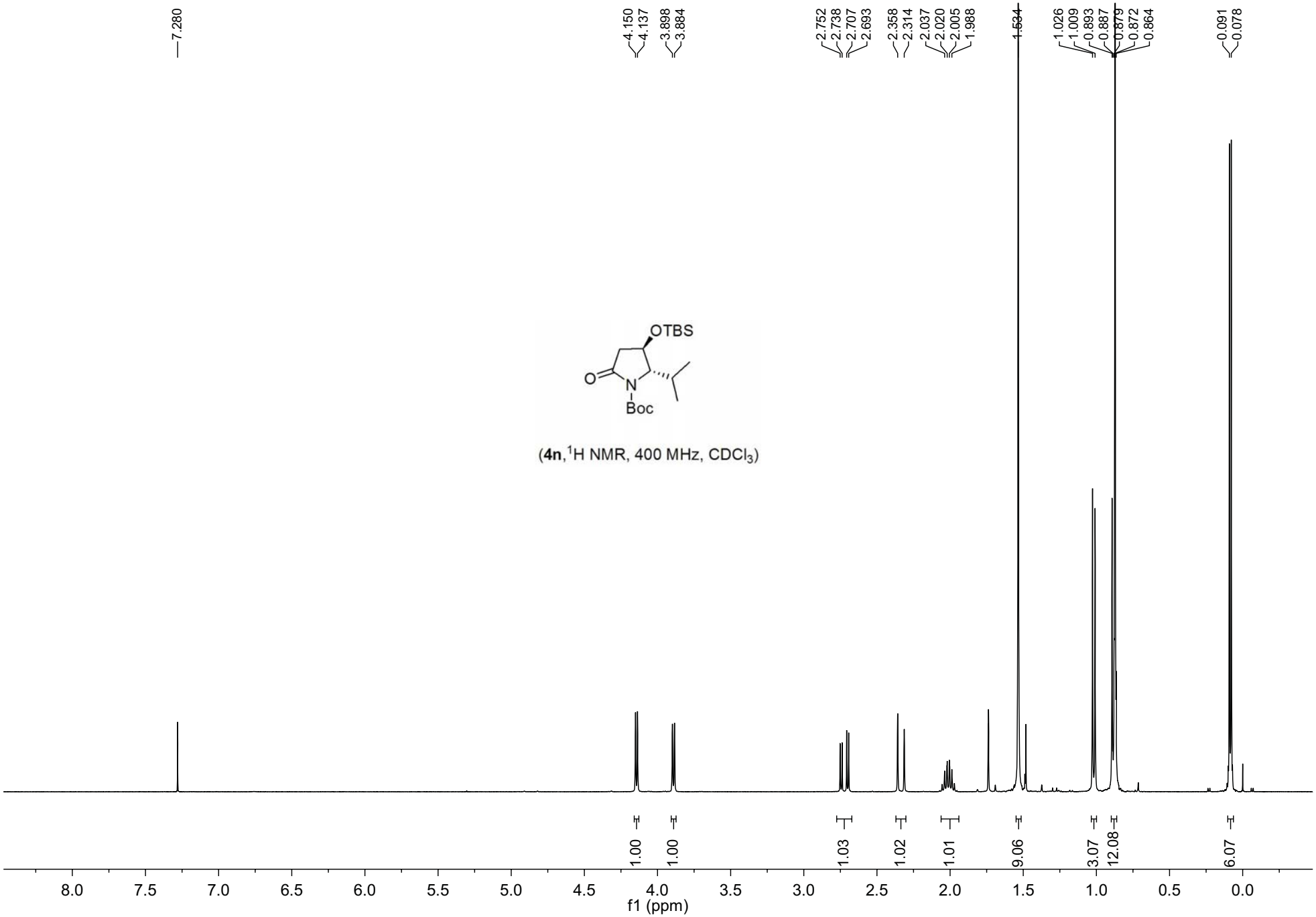

172.685
150.095
82.732
69.247
67.900
41.781
28.023
25.660
24.943
17.946
10.331
4.673
4.711
OTBS
O
N
Boc
(4l,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)



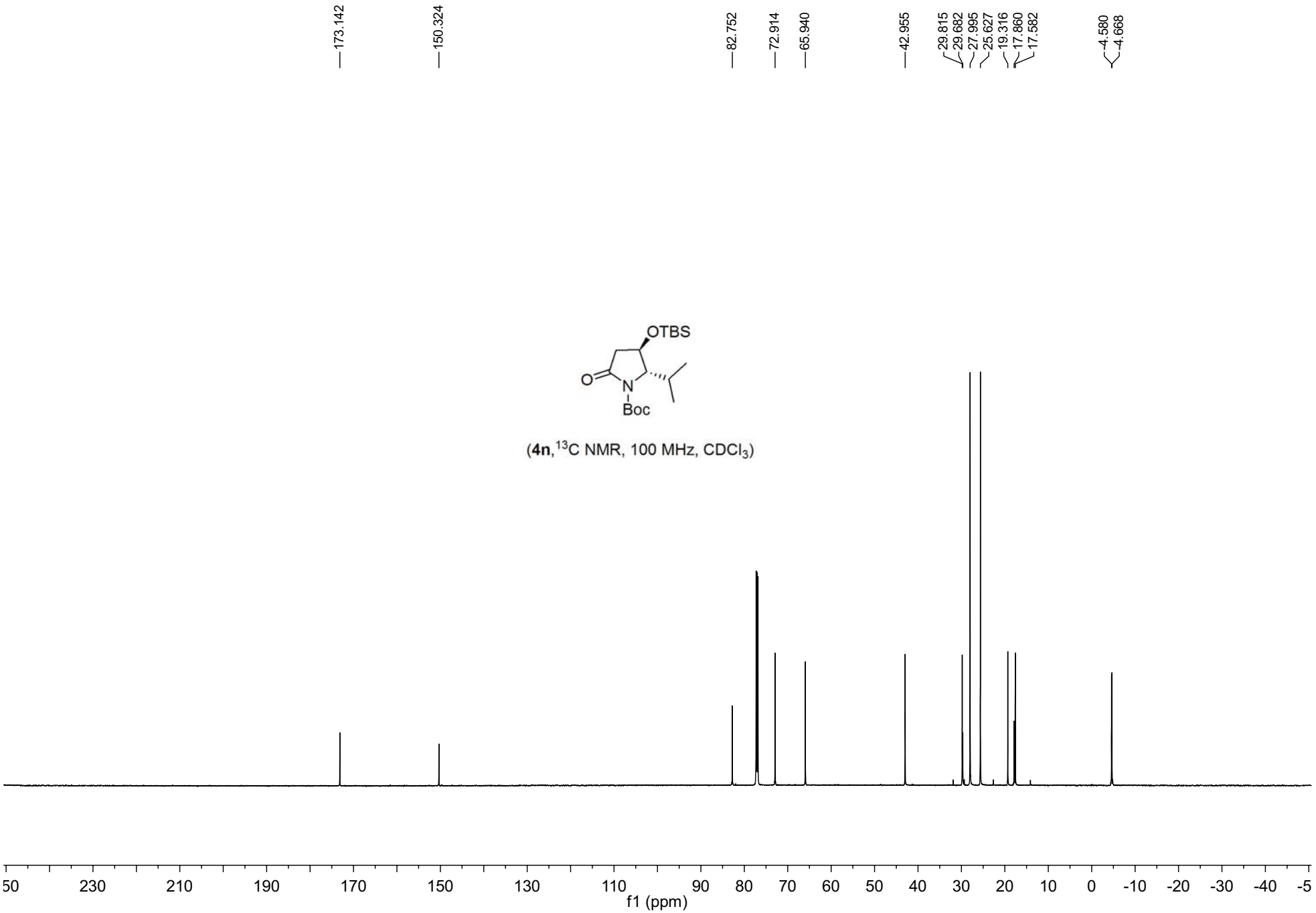
(**4m**,^{1}H NMR, 400 MHz, $CDCl_3$)



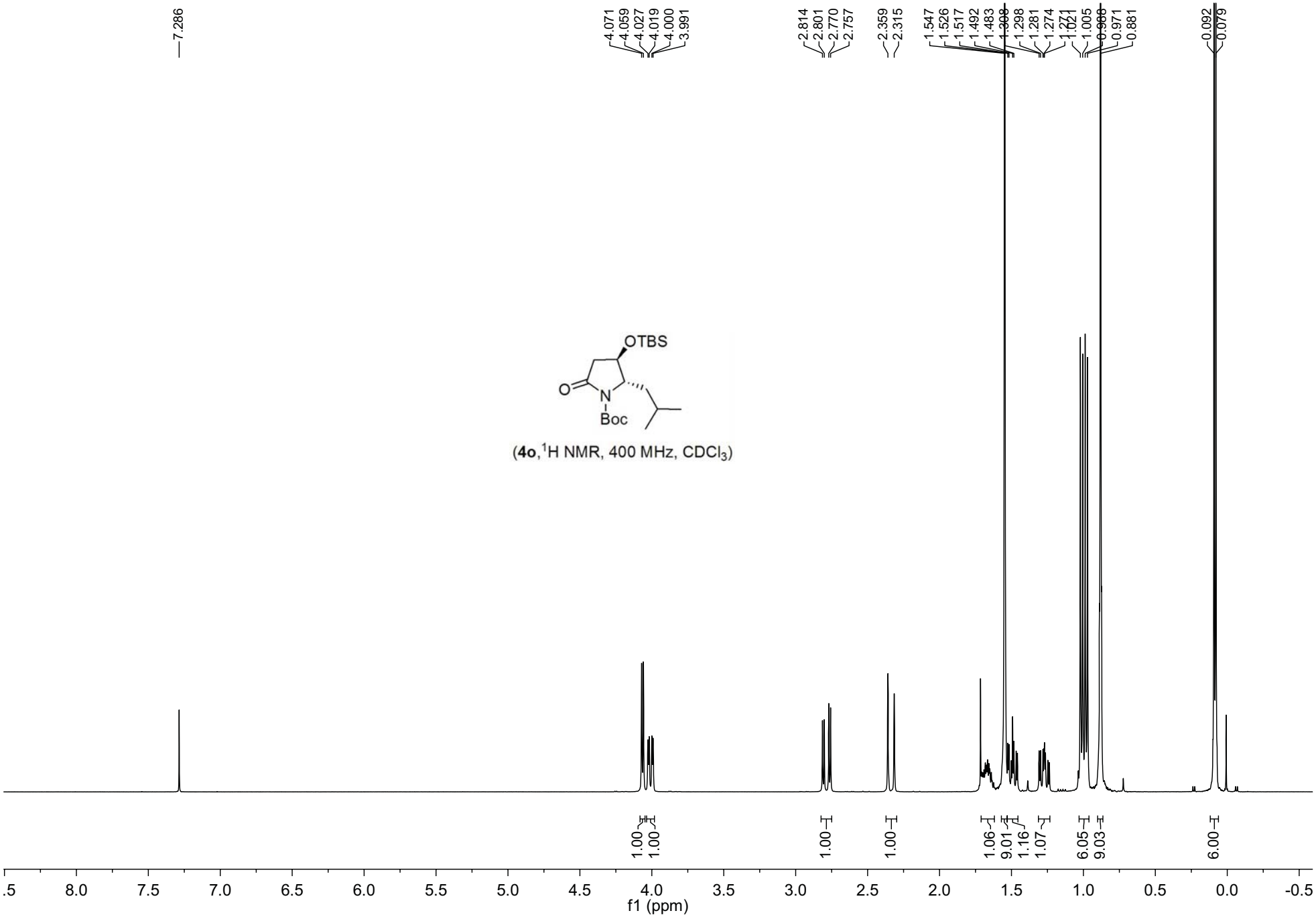
(**4m**, ^{13}C NMR, 100 MHz, $CDCl_3$)



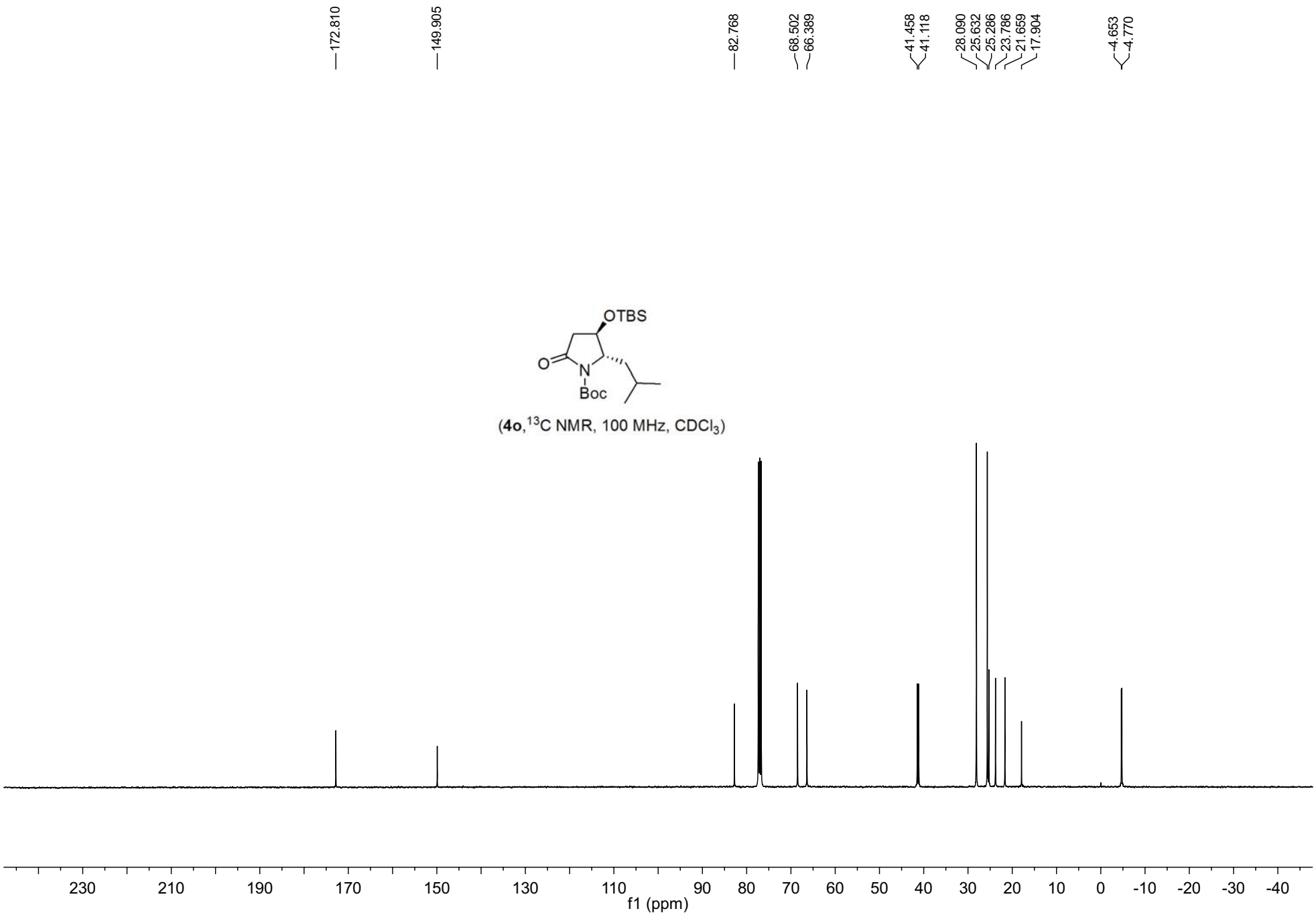
(**4n**,^{1}H NMR, 400 MHz, $CDCl_3$)

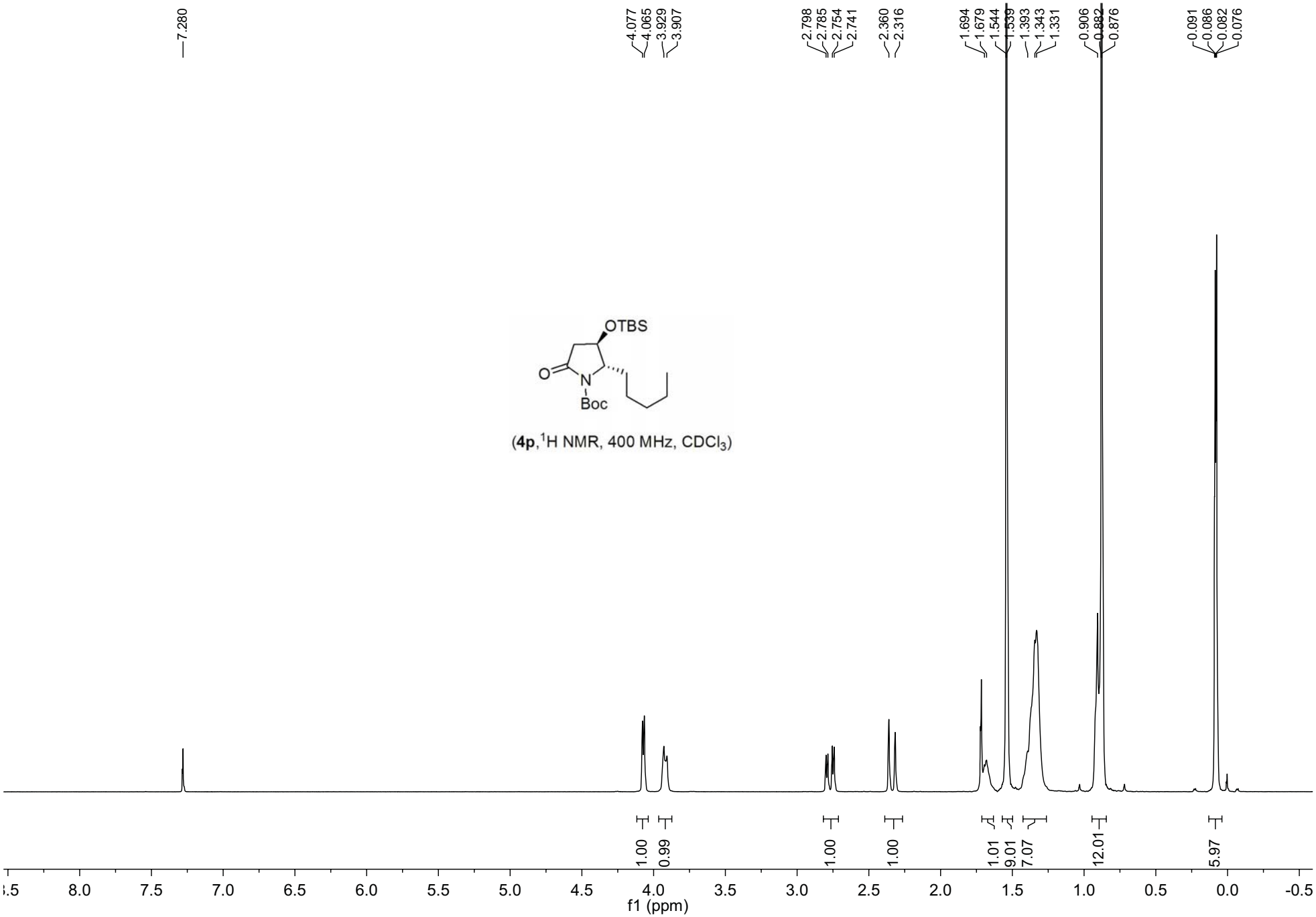


(**4n**, ^{13}C NMR, 100 MHz, $CDCl_3$)

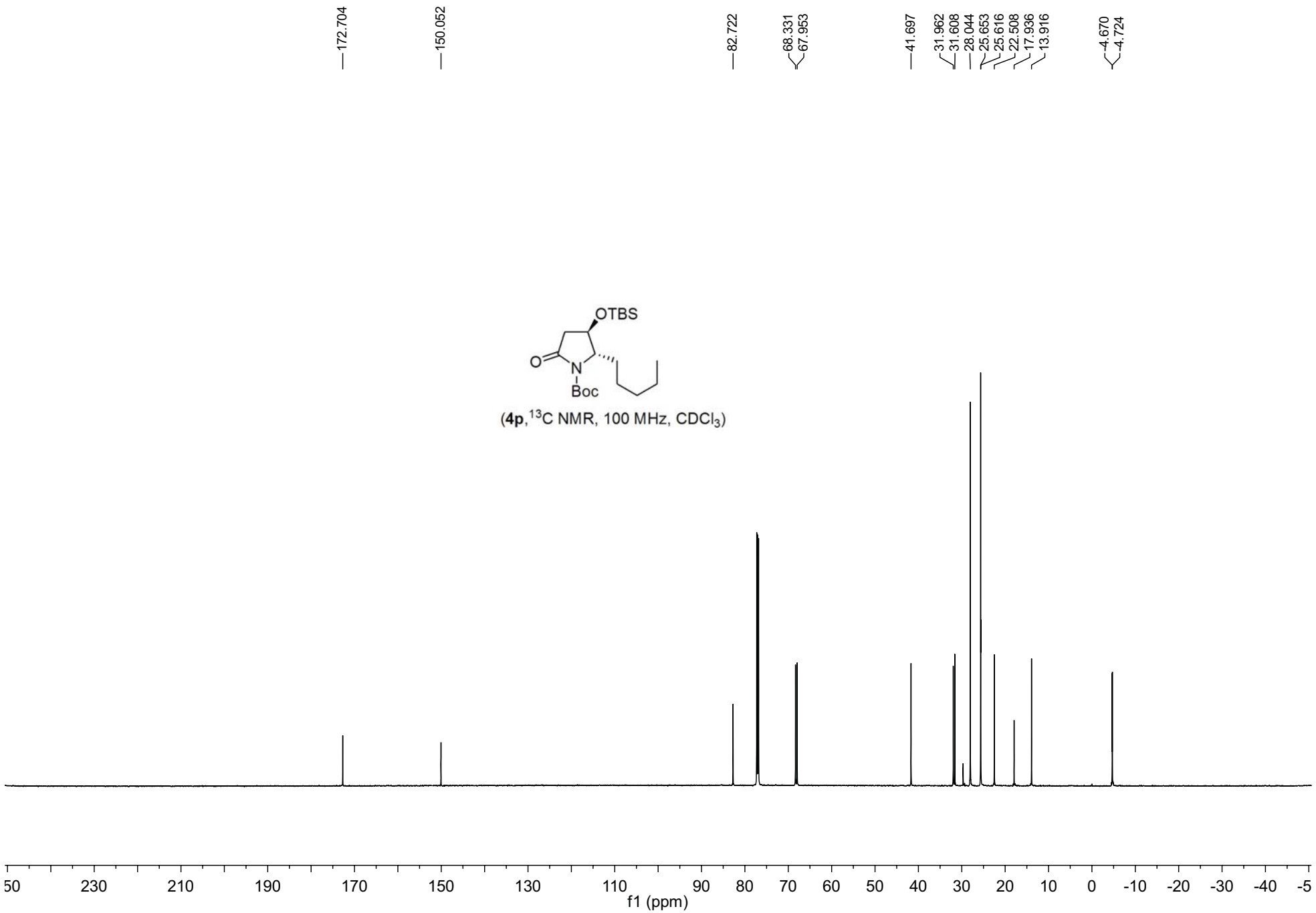


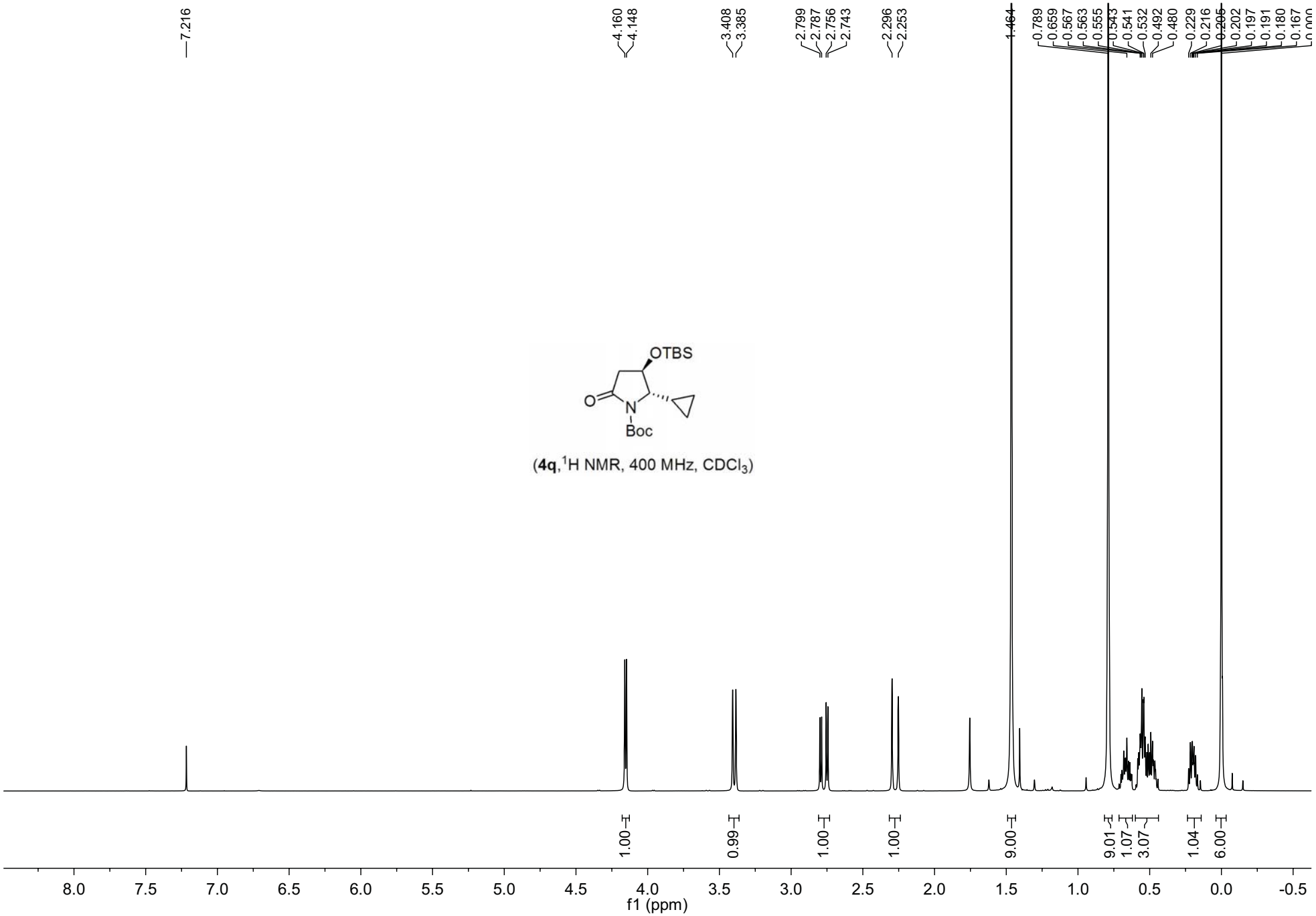
(**4o**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.810
149.905
82.768
68.502
66.389
41.458
41.118
28.090
25.632
25.286
23.786
21.659
17.904
-4.653
-4.770
OTBS
O
N
Boc
(4o, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

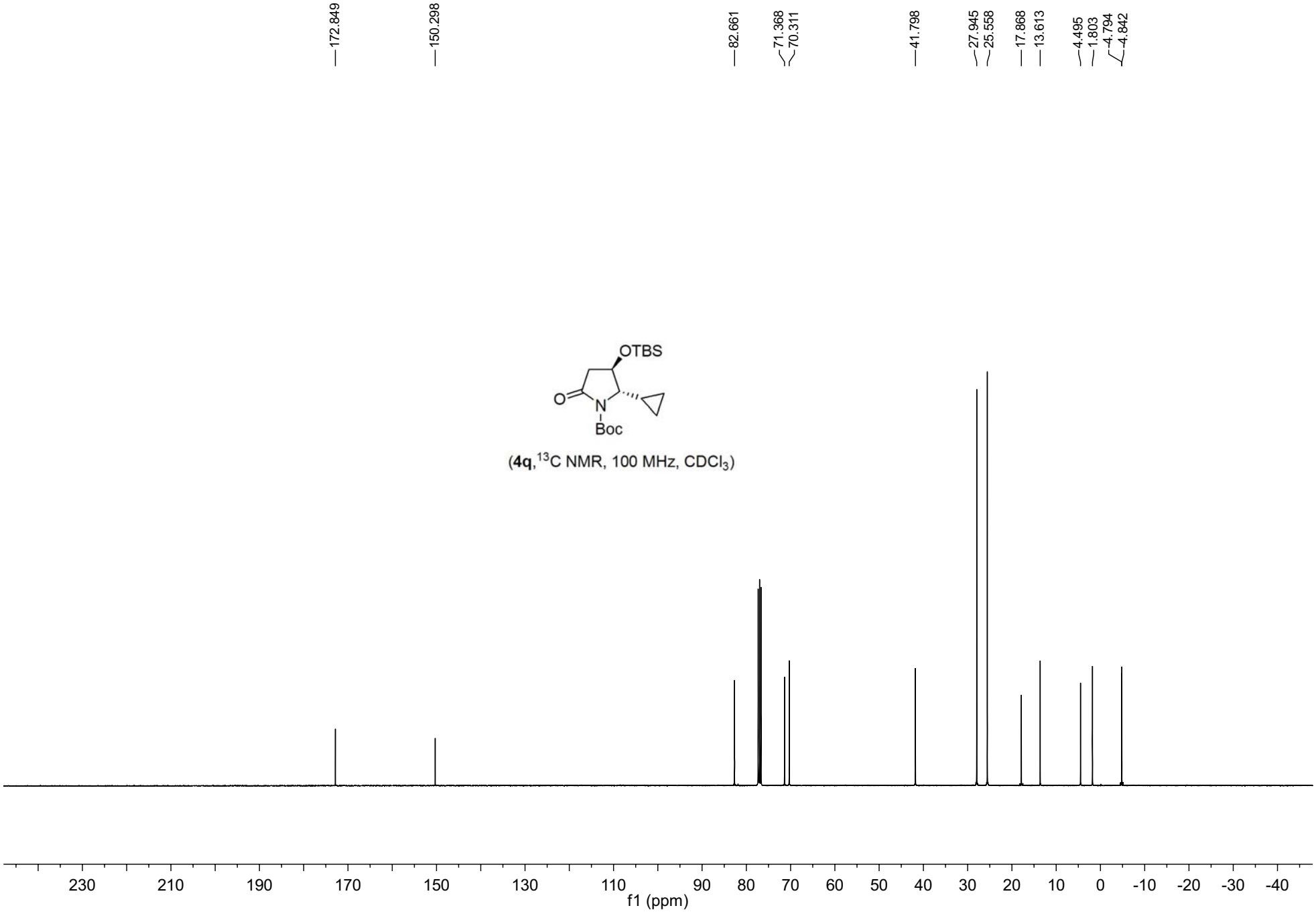


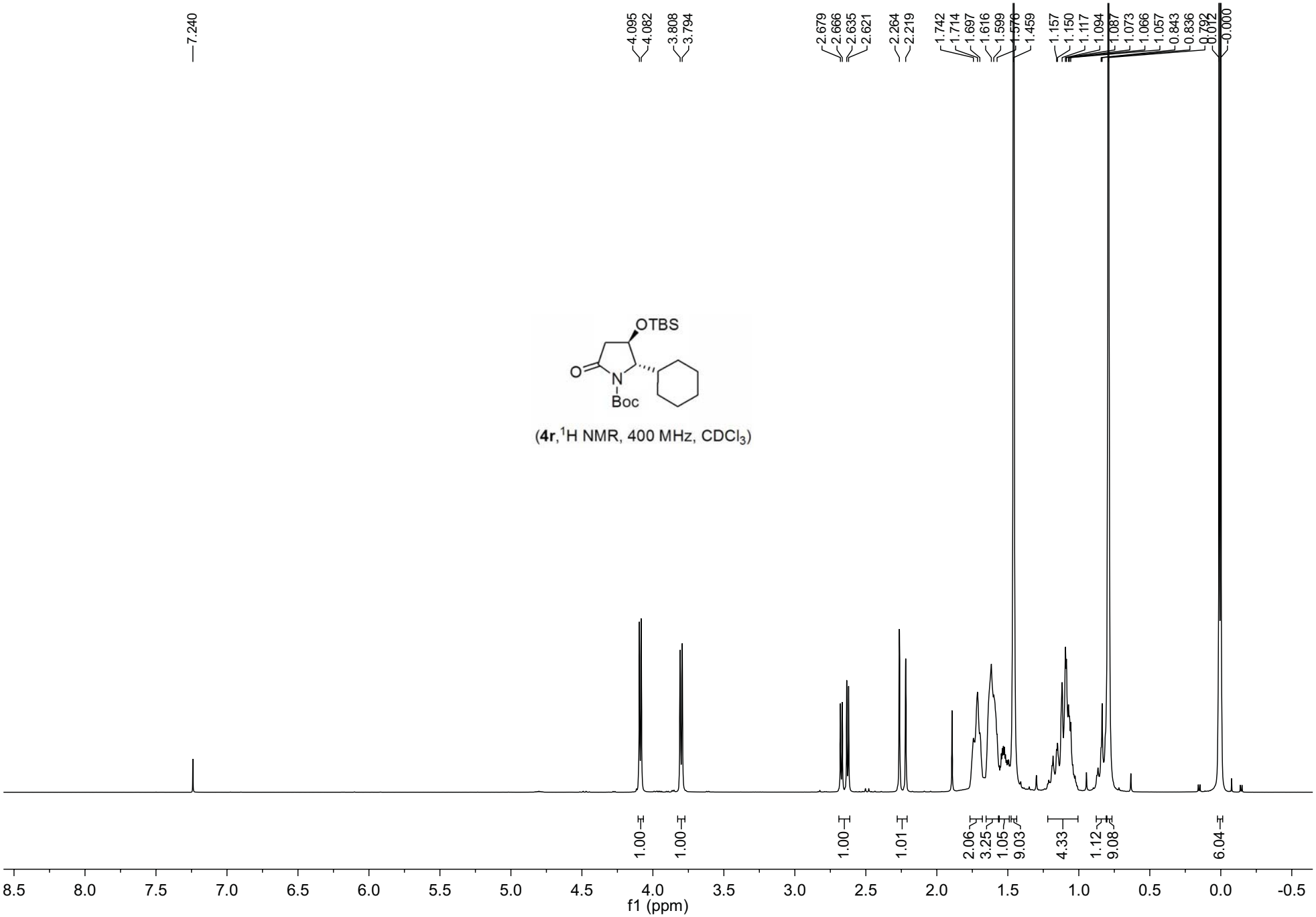
(**4p**,^{1}H NMR, 400 MHz, $CDCl_3$)

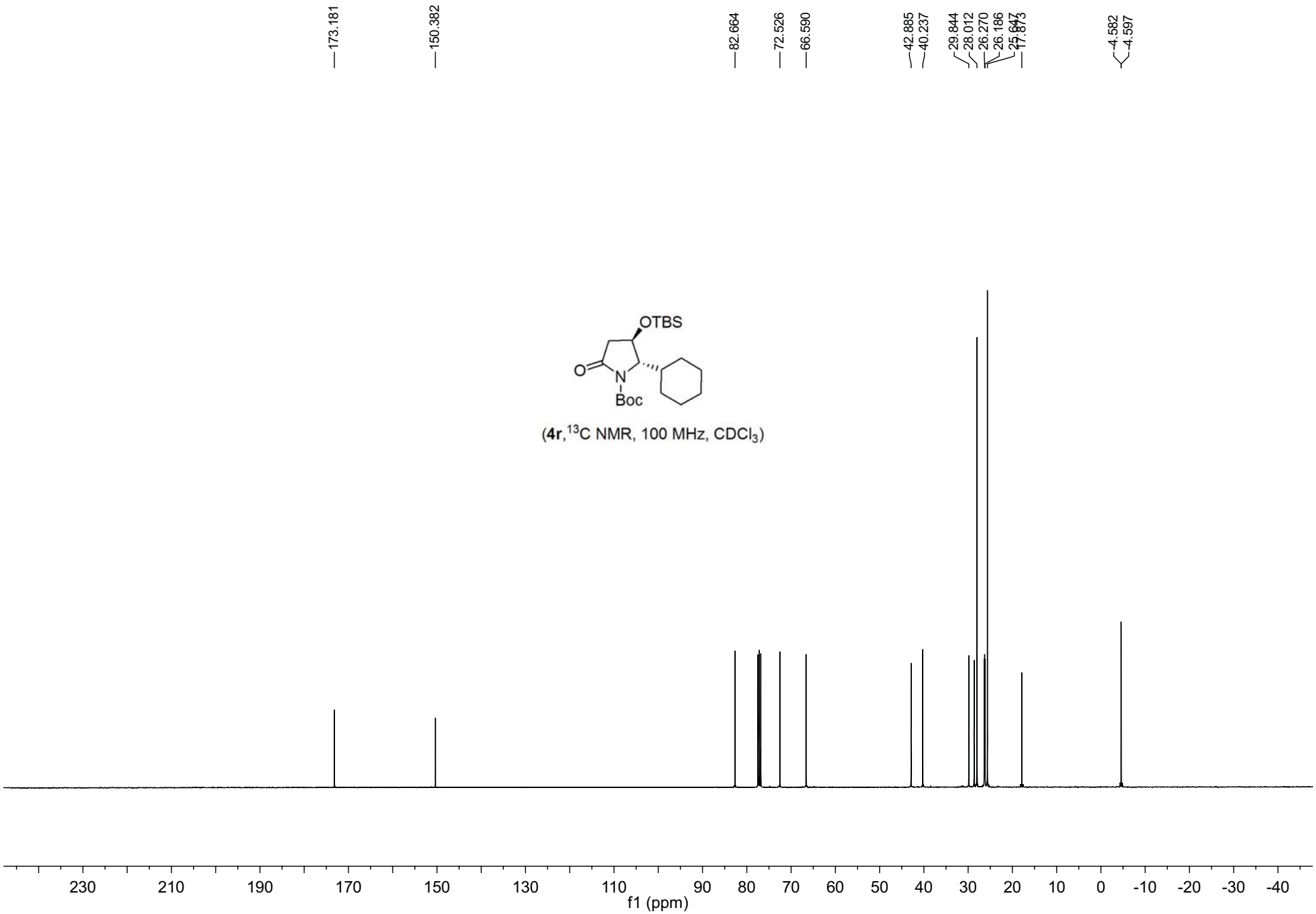

172.704
150.052
82.722
68.331
67.953
41.697
31.962
31.608
28.044
25.653
25.616
22.508
17.936
13.916
-4.670
-4.724
OTBS
O
N
Boc
(4p, 13C NMR, 100 MHz, CDCl3)
f1 (ppm)

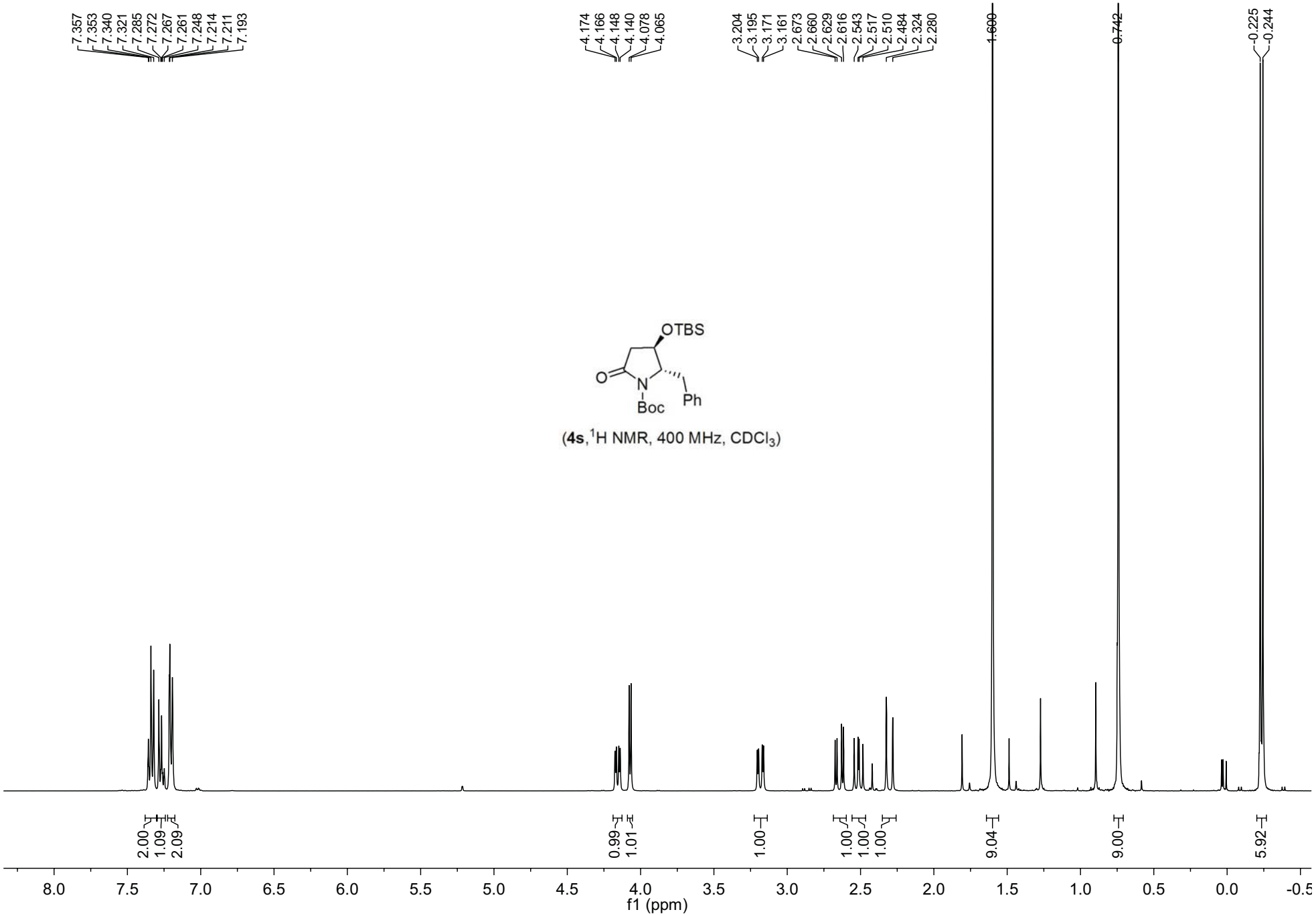


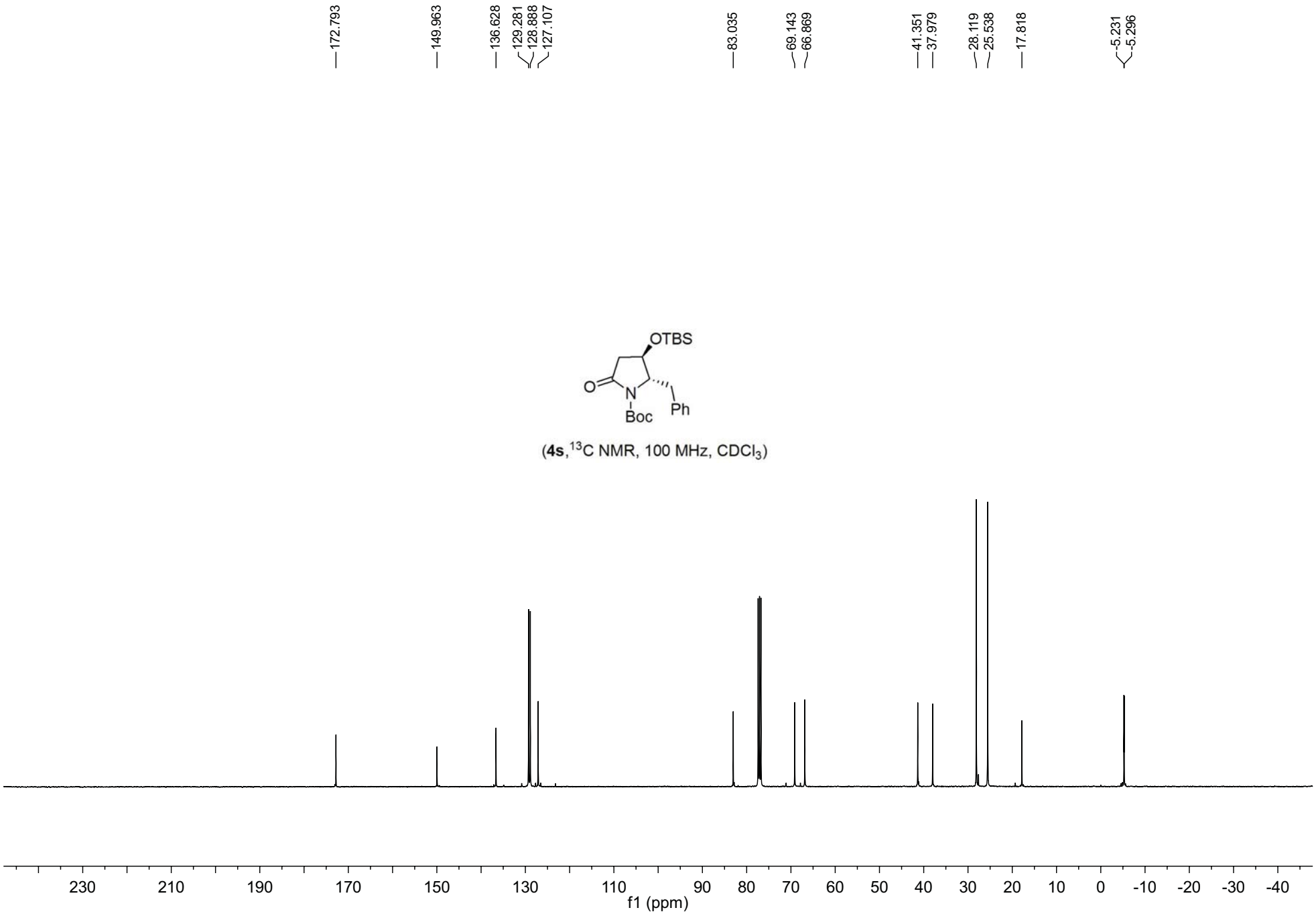
(**4q**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.849
150.298
82.661
71.368
70.311
41.798
27.945
25.558
17.868
13.613
4.495
1.803
4.794
4.842
OTBS
O
N
Boc
(4q,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

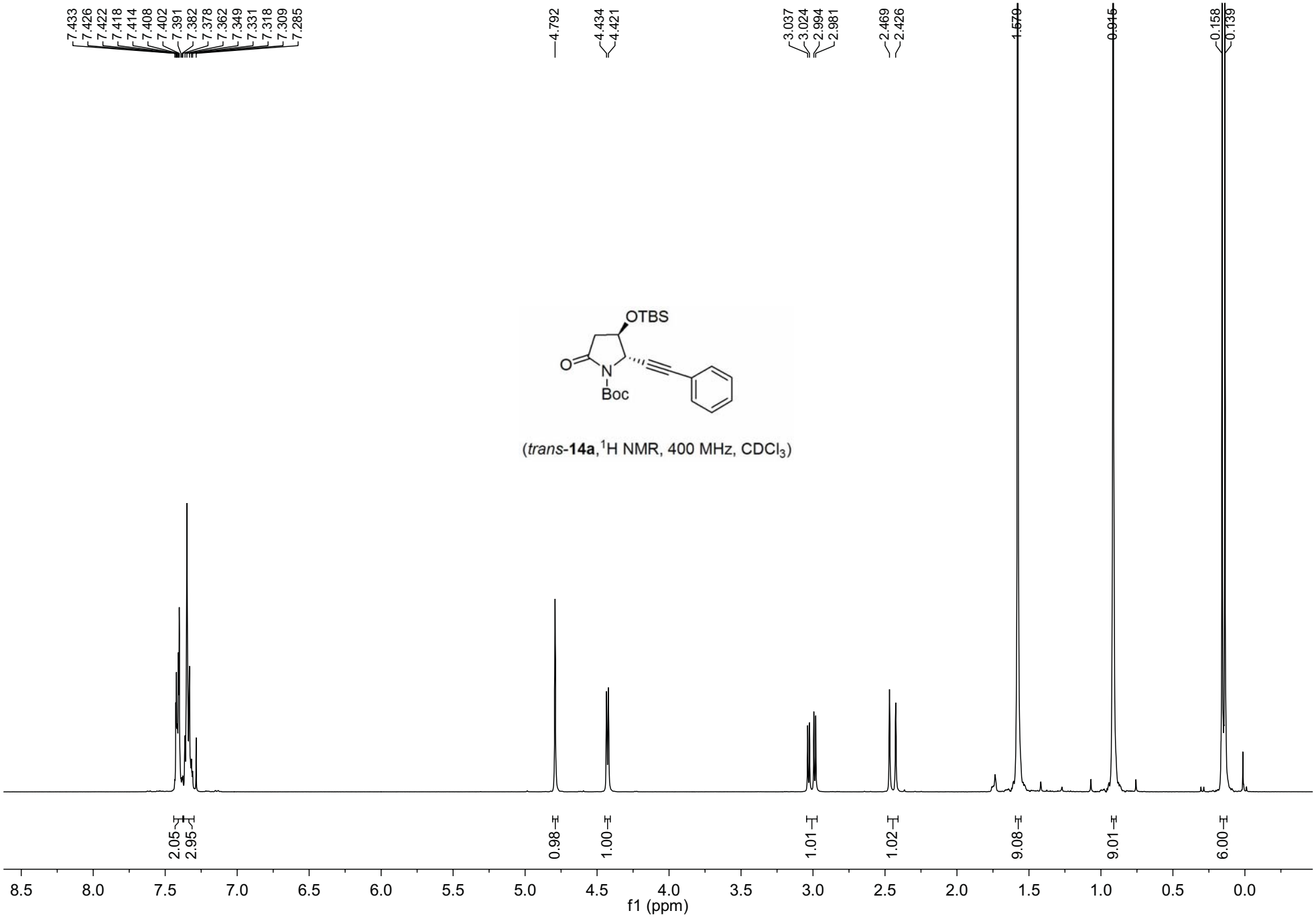

7.240
4.095
4.082
3.808
3.794
2.679
2.666
2.635
2.621
2.264
2.219
1.742
1.714
1.697
1.616
1.599
1.576
1.459
1.157
1.150
1.117
1.094
1.087
1.073
1.066
1.057
0.843
0.836
0.792
0.012
-0.000
OTBS
O
N
Boc
(4r,1H NMR, 400 MHz, CDCl3)
1.00
1.00
1.00
1.01
2.06
3.25
1.05
9.03
4.33
1.12
9.08
6.04
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


173.181
150.382
82.664
72.526
66.590
42.885
40.237
29.844
28.012
26.270
26.186
25.647
17.873
-4.582
-4.597
OTBS
O
N
Boc
(4r,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

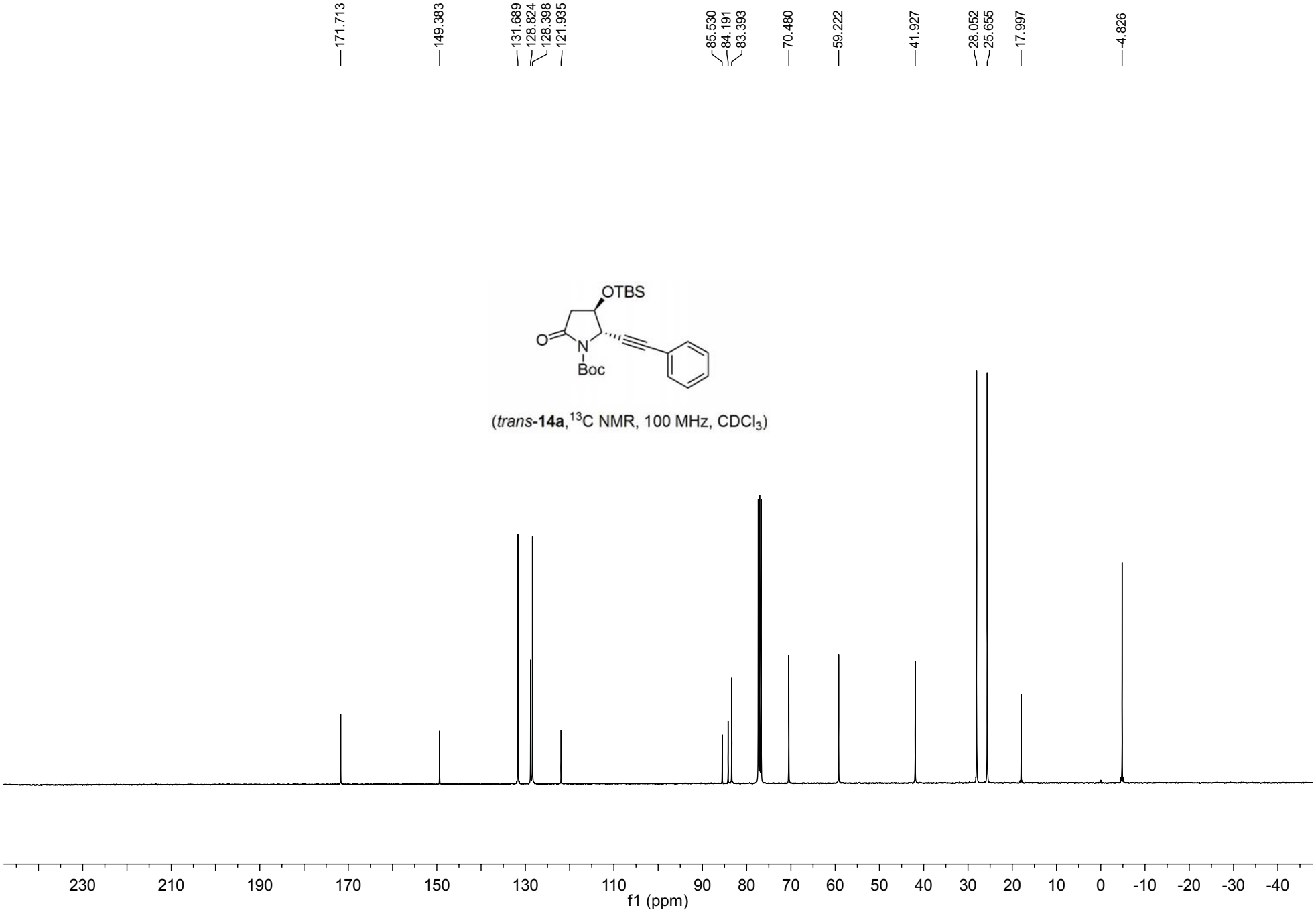

7.357
7.353
7.340
7.321
7.285
7.272
7.267
7.261
7.248
7.214
7.211
7.193
4.174
4.166
4.148
4.140
4.078
4.065
3.204
3.195
3.171
3.161
2.673
2.660
2.629
2.616
2.543
2.517
2.510
2.484
2.324
2.280
1.600
0.742
-0.225
-0.244
OTBS
O
N
Boc
Ph
(4s, 1H NMR, 400 MHz, CDCl3)
2.00
1.09
2.09
0.99
1.01
1.00
1.00
1.00
1.00
9.04
9.00
5.92
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



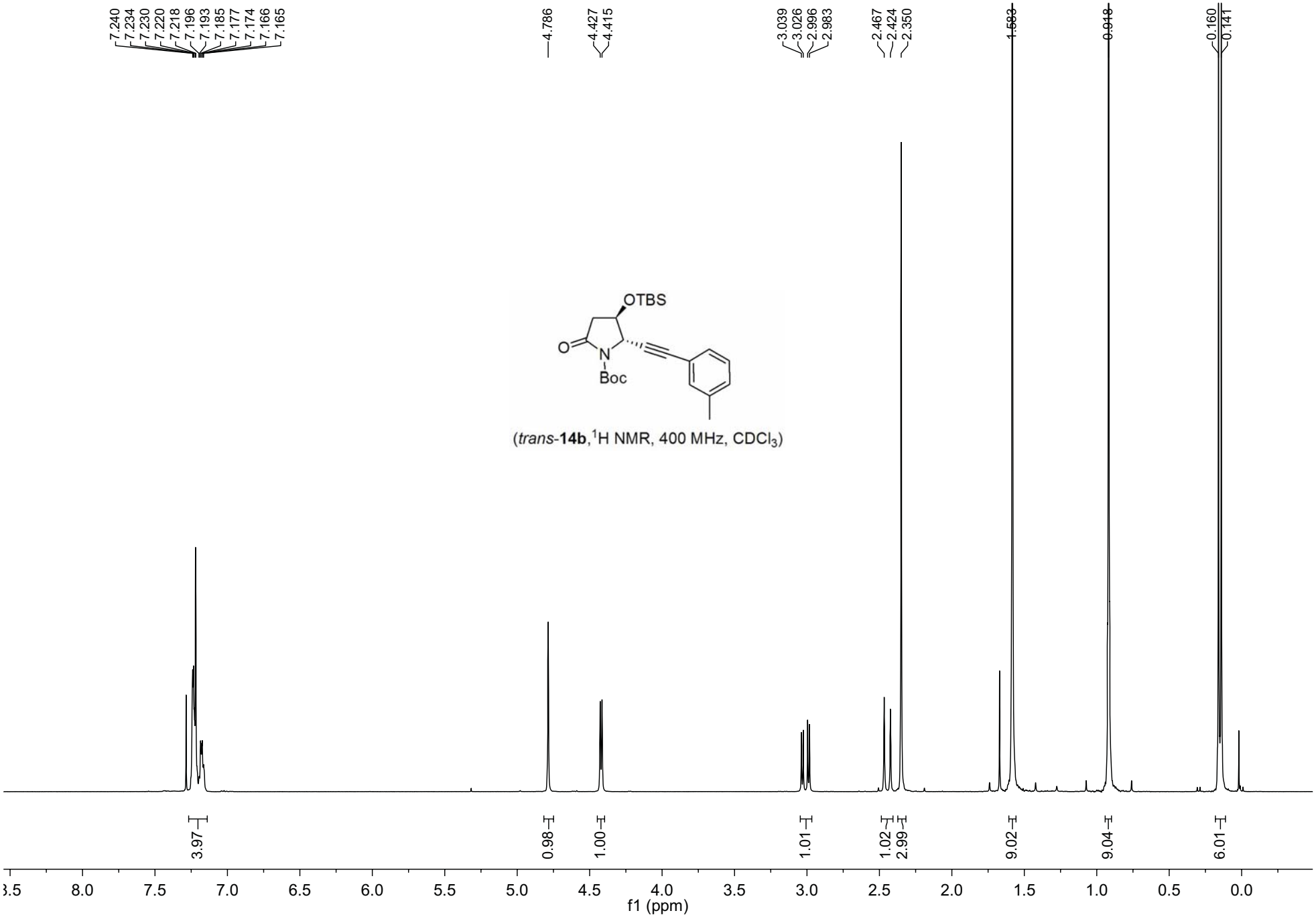
(**4s**,^{13}C NMR, 100 MHz, $CDCl_3$)



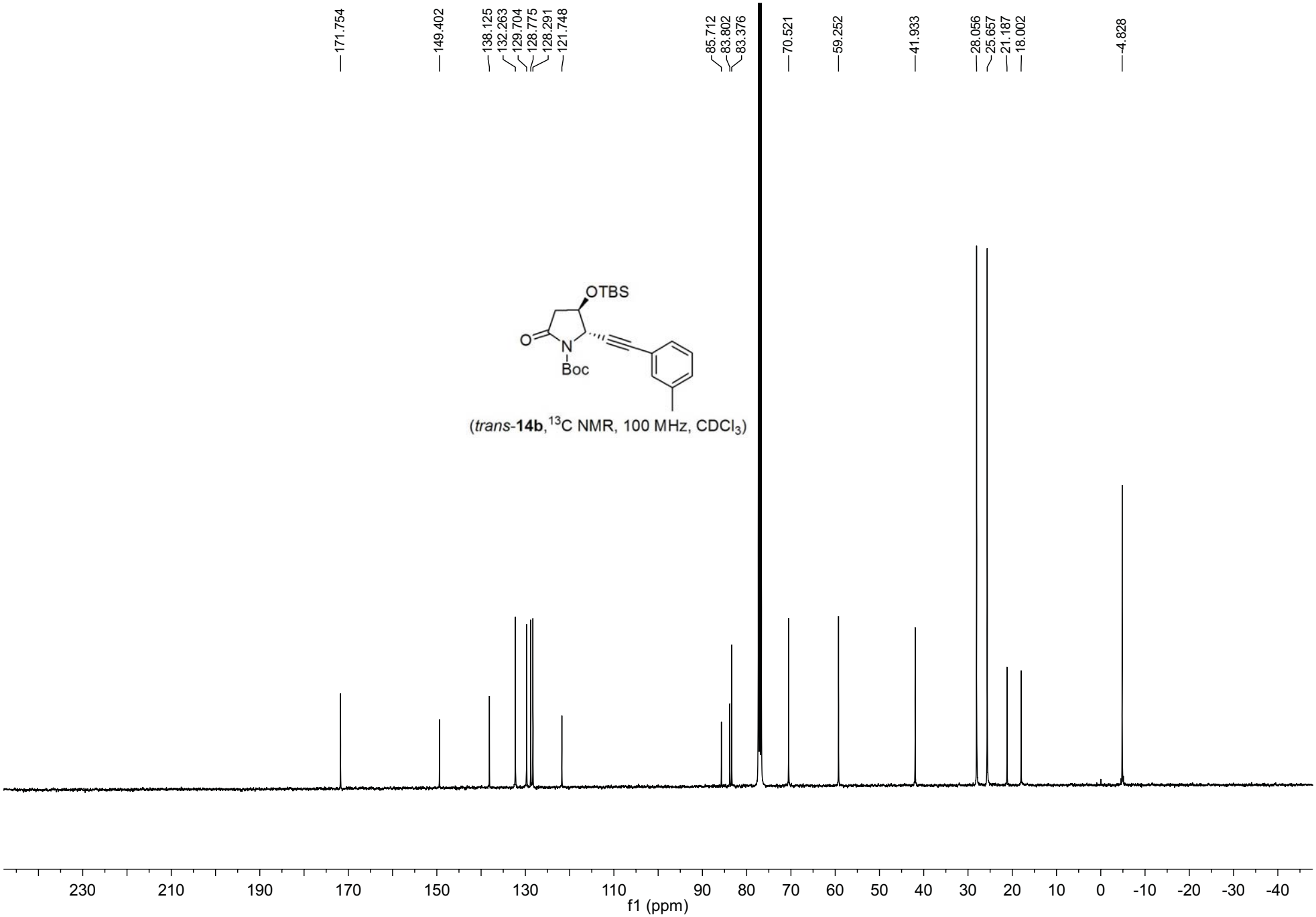
(*trans*-**14a**, ^{1}H NMR, 400 MHz, $CDCl_3$)

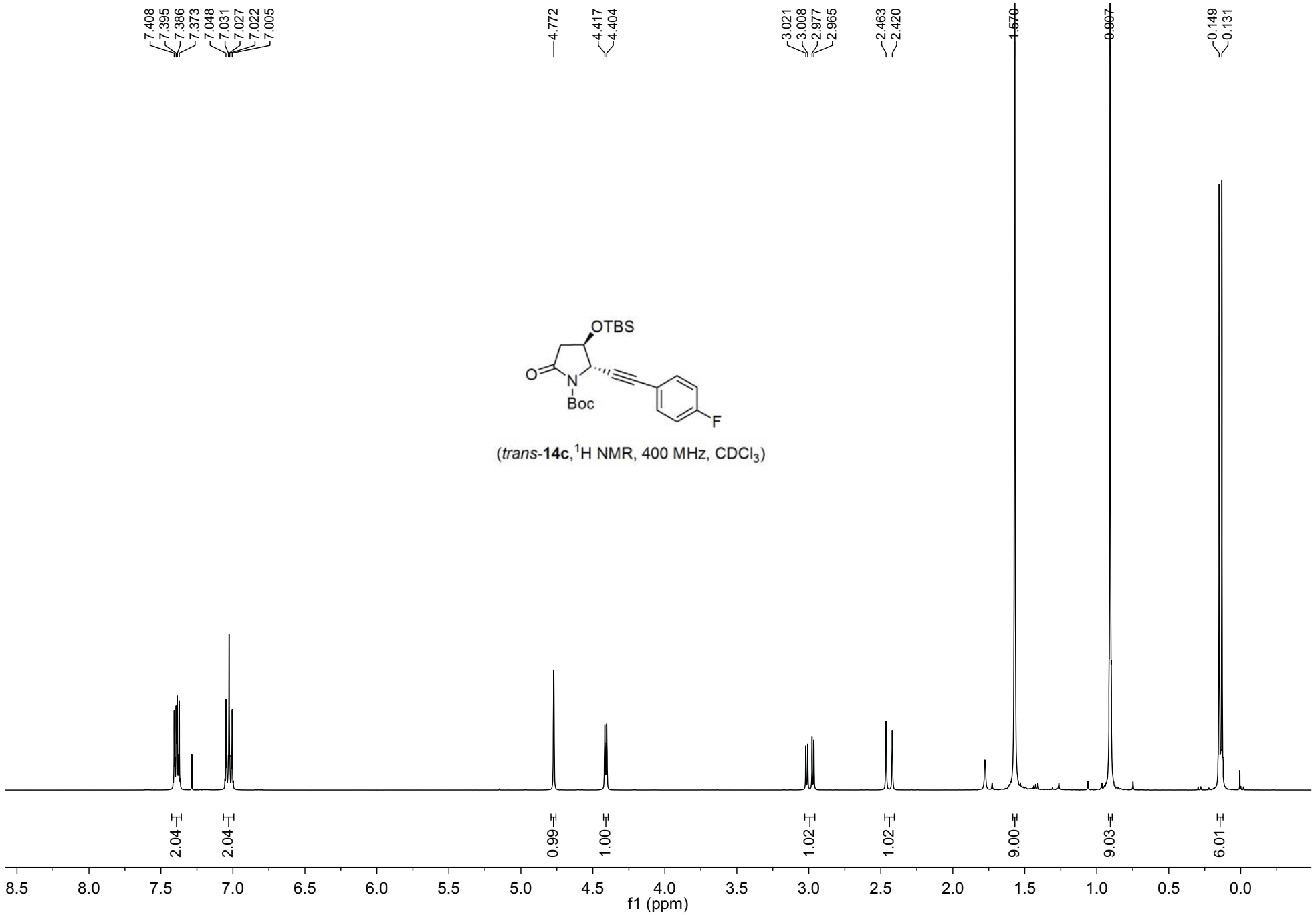


(*trans*-**14a**, ^{13}C NMR, 100 MHz, $CDCl_3$)

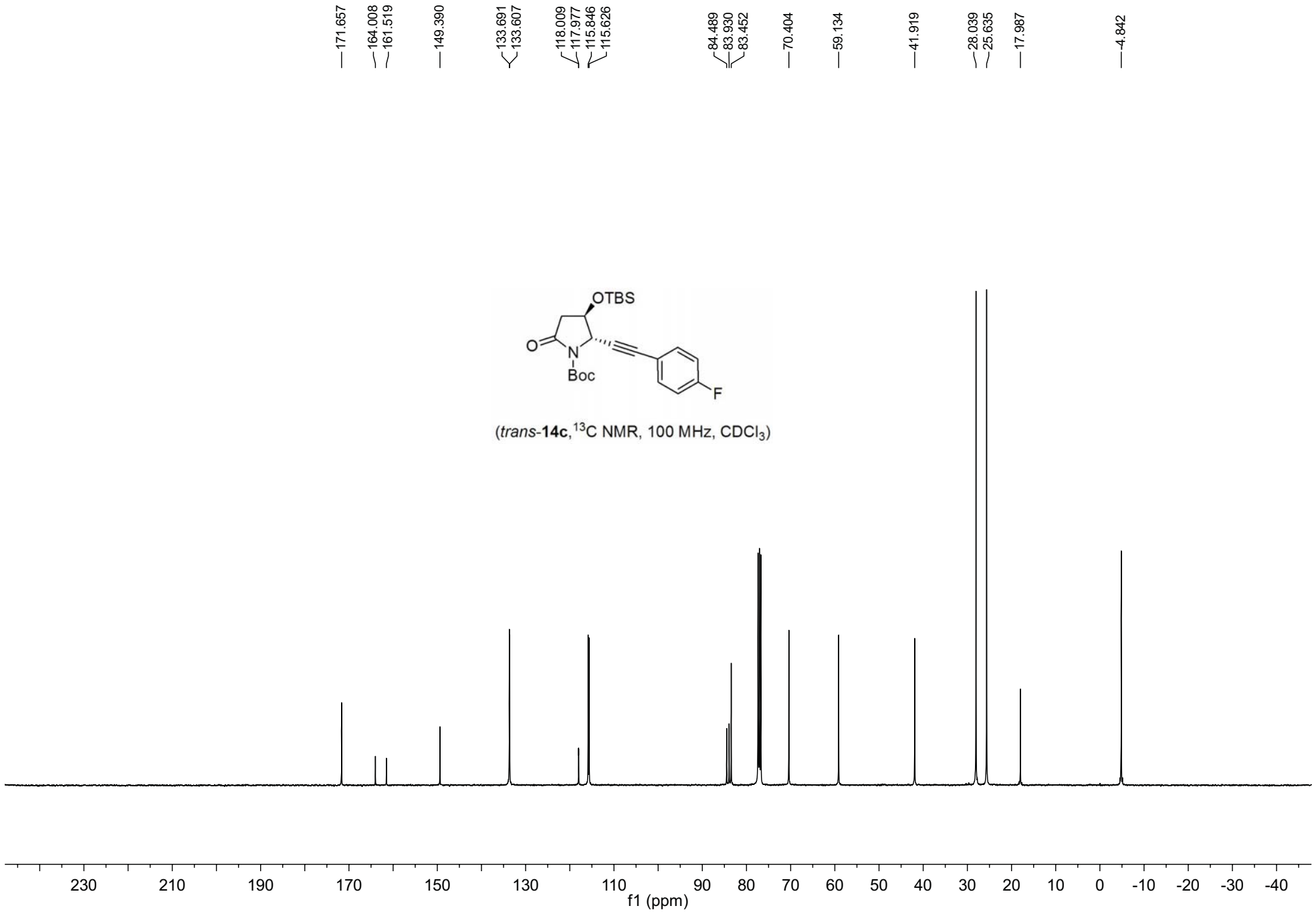


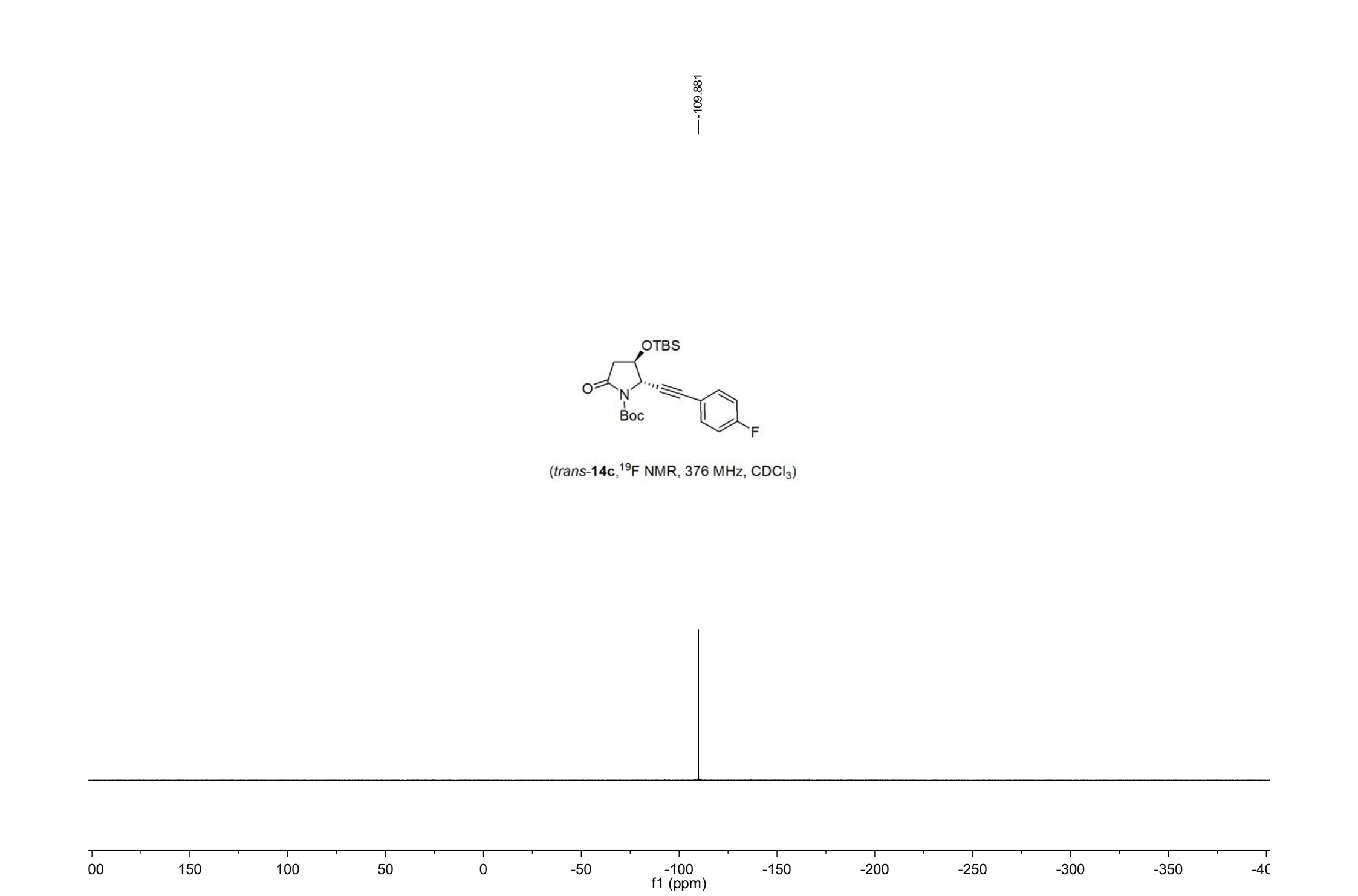
(*trans*-**14b**,^{1}H NMR, 400 MHz, $CDCl_3$)


171.754
149.402
138.125
132.263
129.704
128.775
128.291
121.748
85.712
83.802
83.376
70.521
59.252
41.933
28.056
25.657
21.187
18.002
4.828
OTBS
O
N
Boc
(trans-14b, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

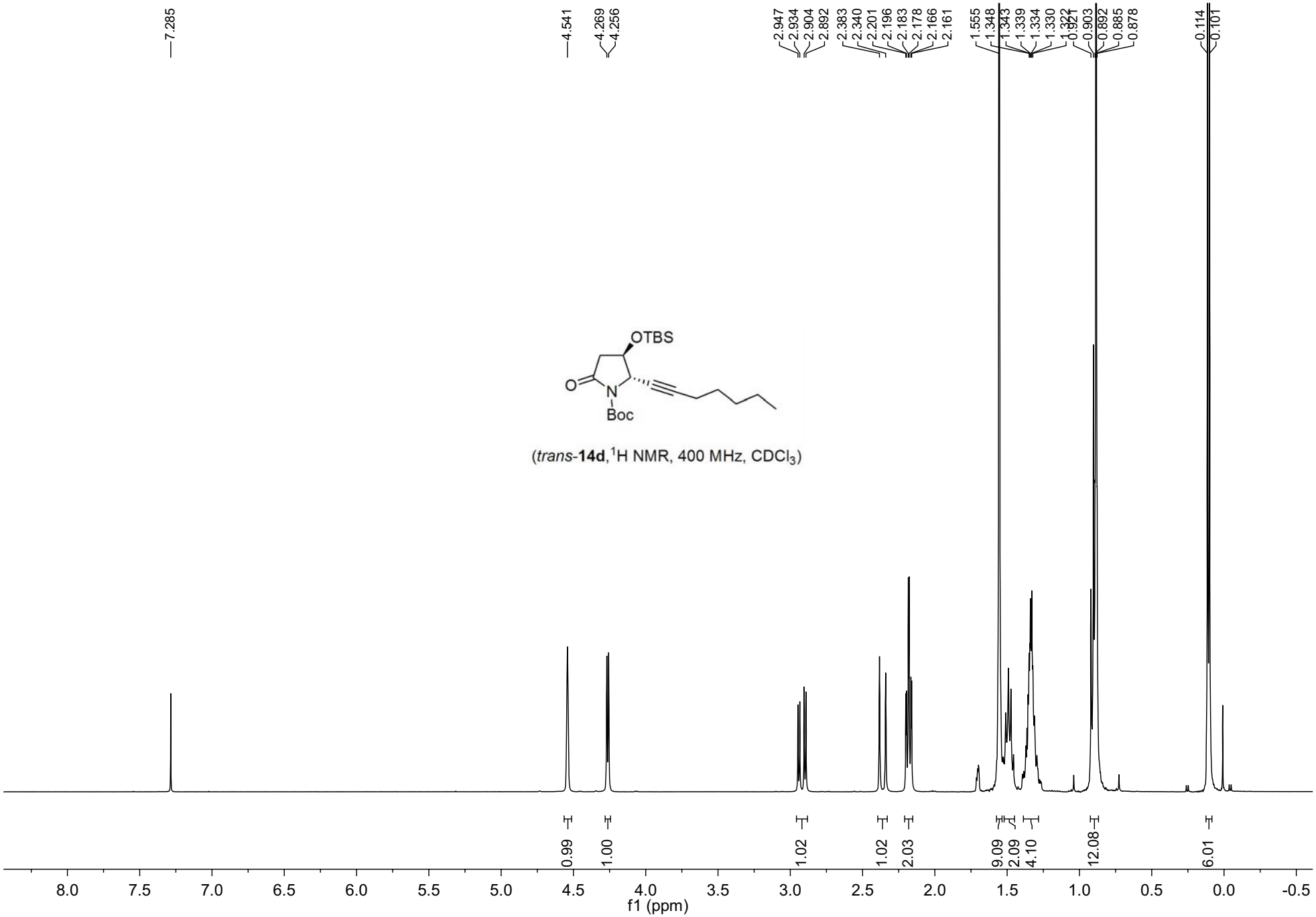


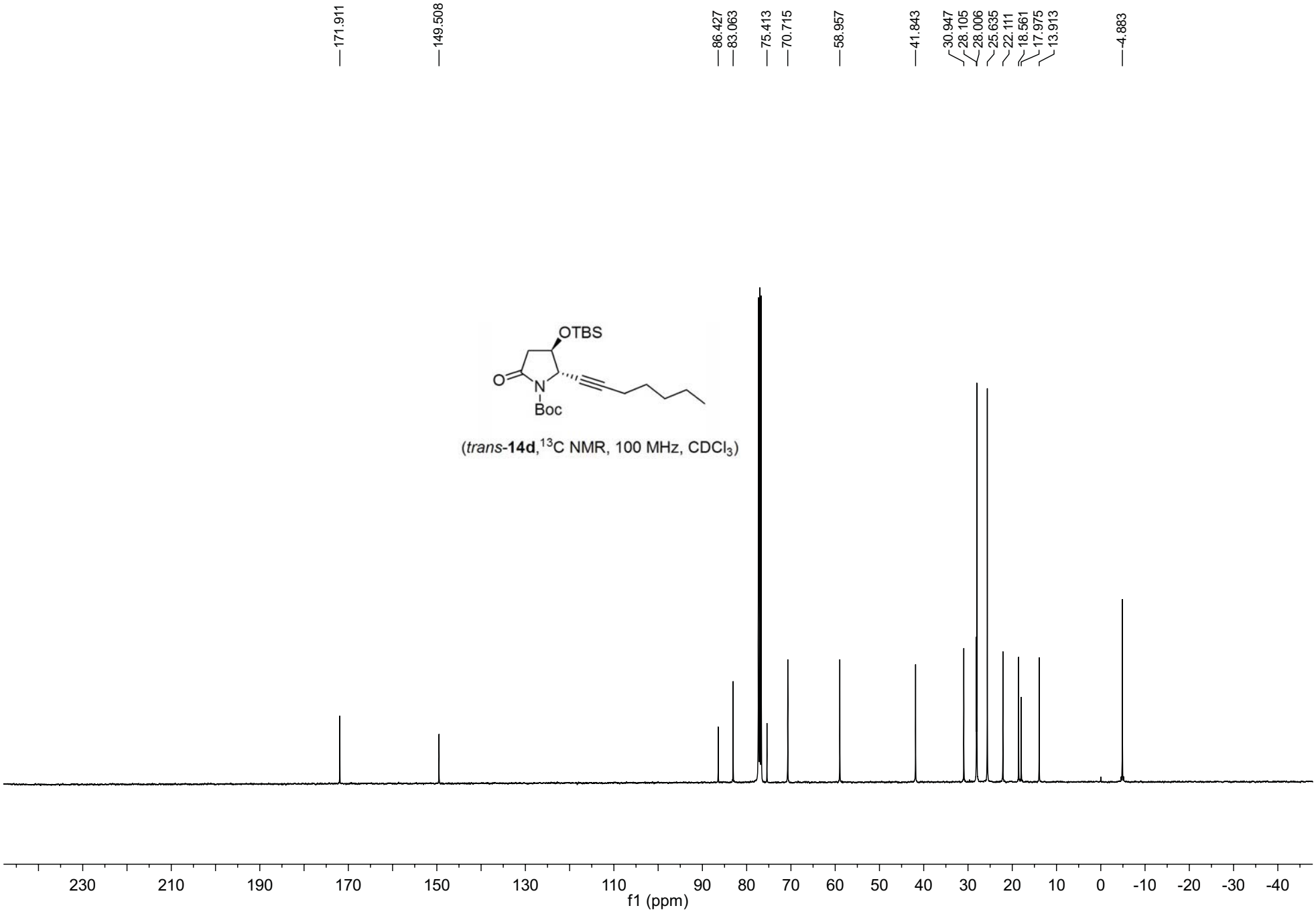
(*trans*-**14c**, ^{1}H NMR, 400 MHz, $CDCl_3$)

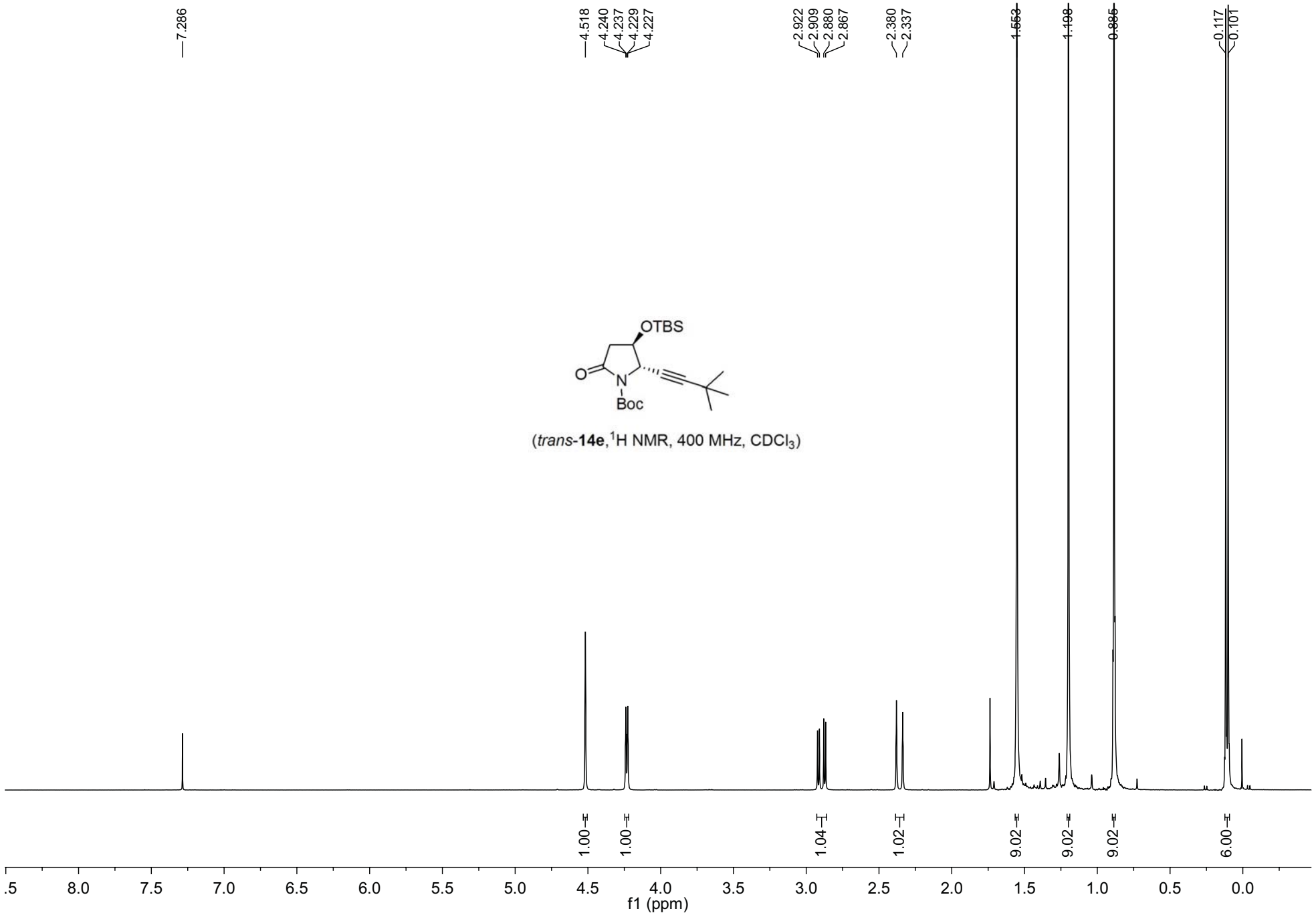

171.657
164.008
161.519
149.390
133.691
133.607
118.009
117.977
115.846
115.626
84.489
83.930
83.452
70.404
59.134
41.919
28.039
25.635
17.987
4.842
OTBS
O
N
Boc
F
(trans-14c, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)



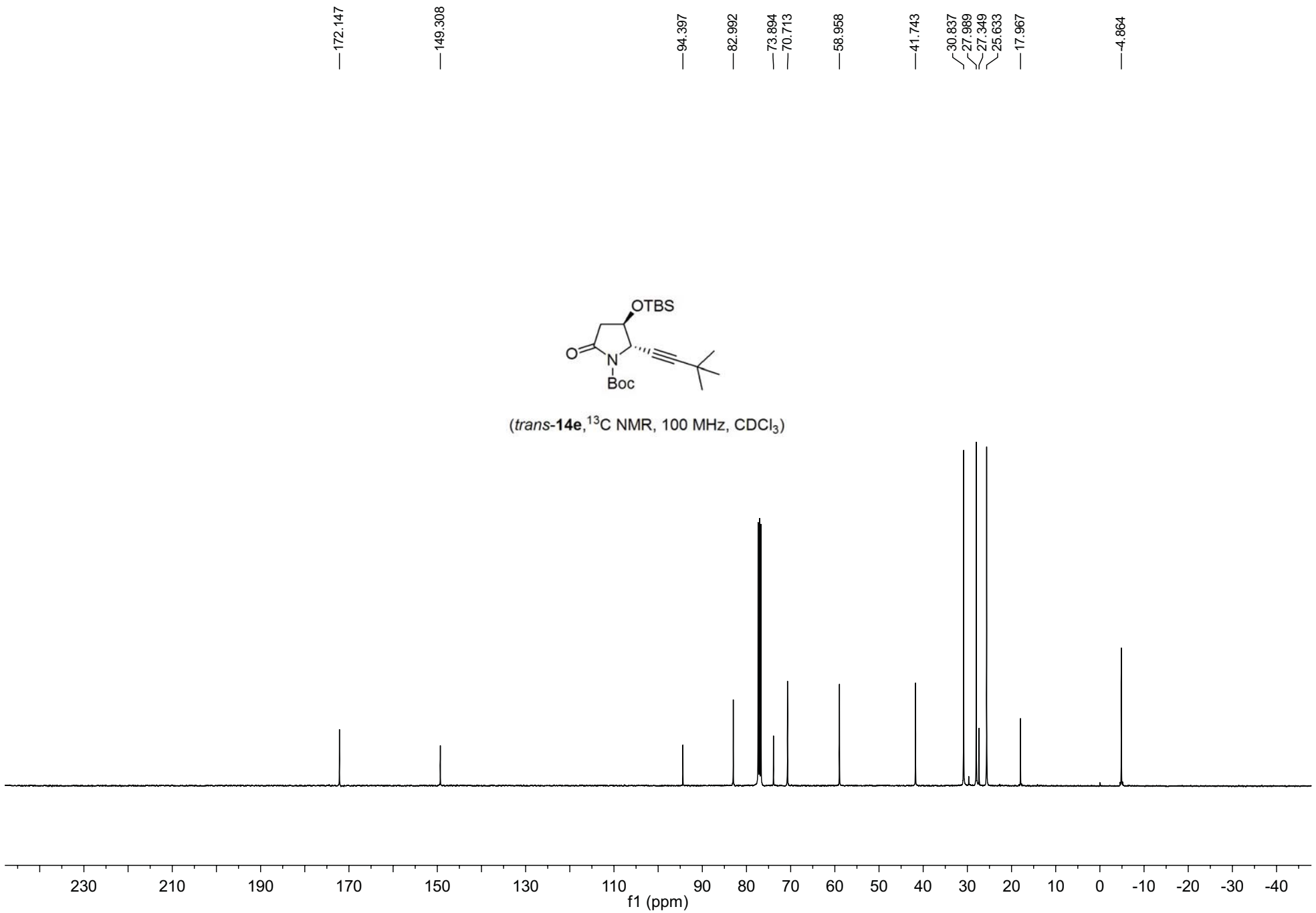
(*trans*-**14c**, ^{19}F NMR, 376 MHz, $CDCl_3$)

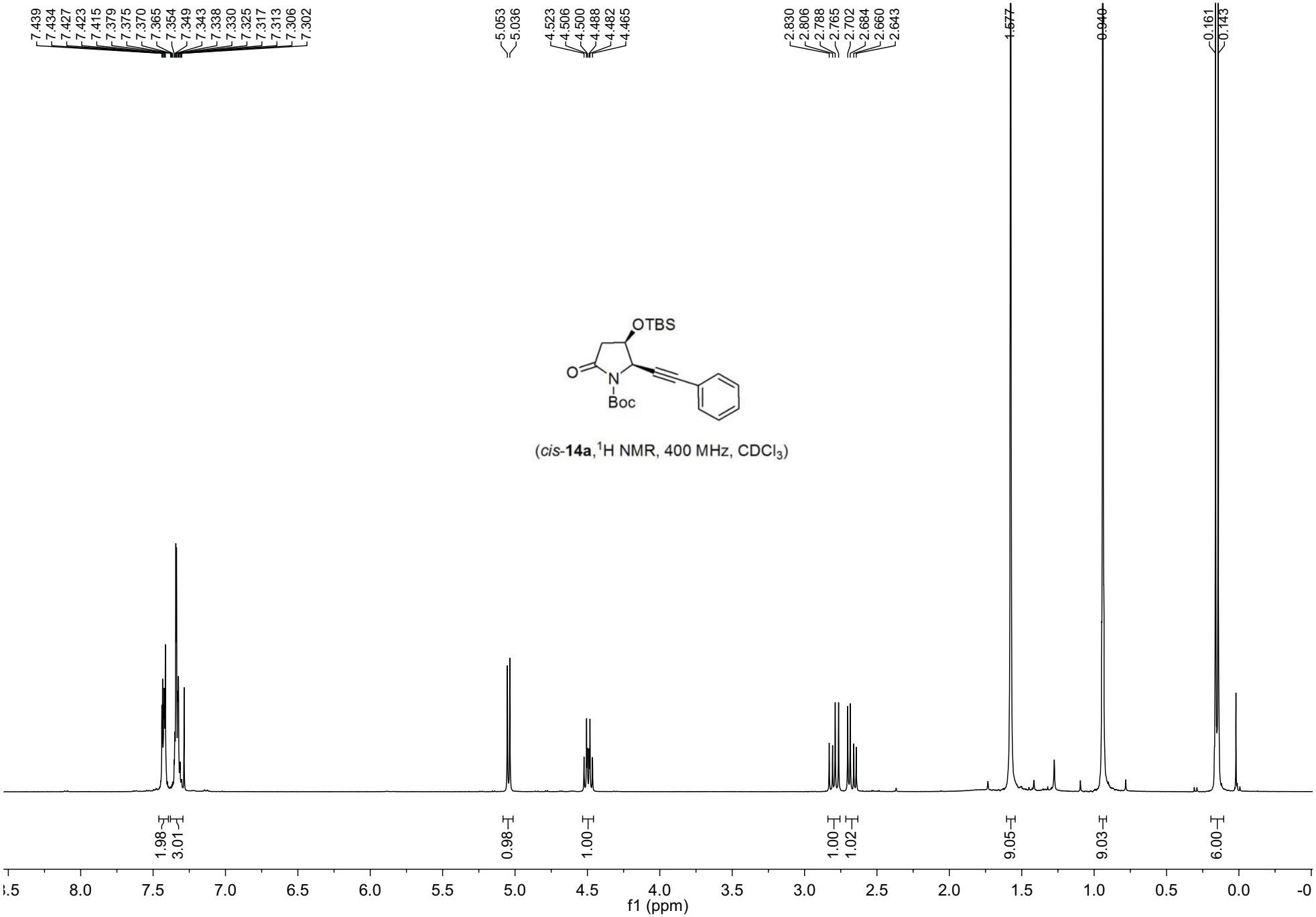

7.285
4.541
4.269
4.256
2.947
2.934
2.904
2.892
2.383
2.340
2.201
2.196
2.183
2.178
2.166
2.161
1.555
1.348
1.343
1.339
1.334
1.330
0.903
0.892
0.885
0.878
0.114
0.101
OTBS
O
N
Boc
(trans-14d, 1H NMR, 400 MHz, CDCl3)
0.99
1.00
1.02
1.02
2.03
9.09
2.09
4.10
12.08
6.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


171.911
149.508
86.427
83.063
75.413
70.715
58.957
41.843
30.947
28.105
28.006
25.635
22.111
18.561
17.975
13.913
4.883
OTBS
O
N
Boc
(trans-14d,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

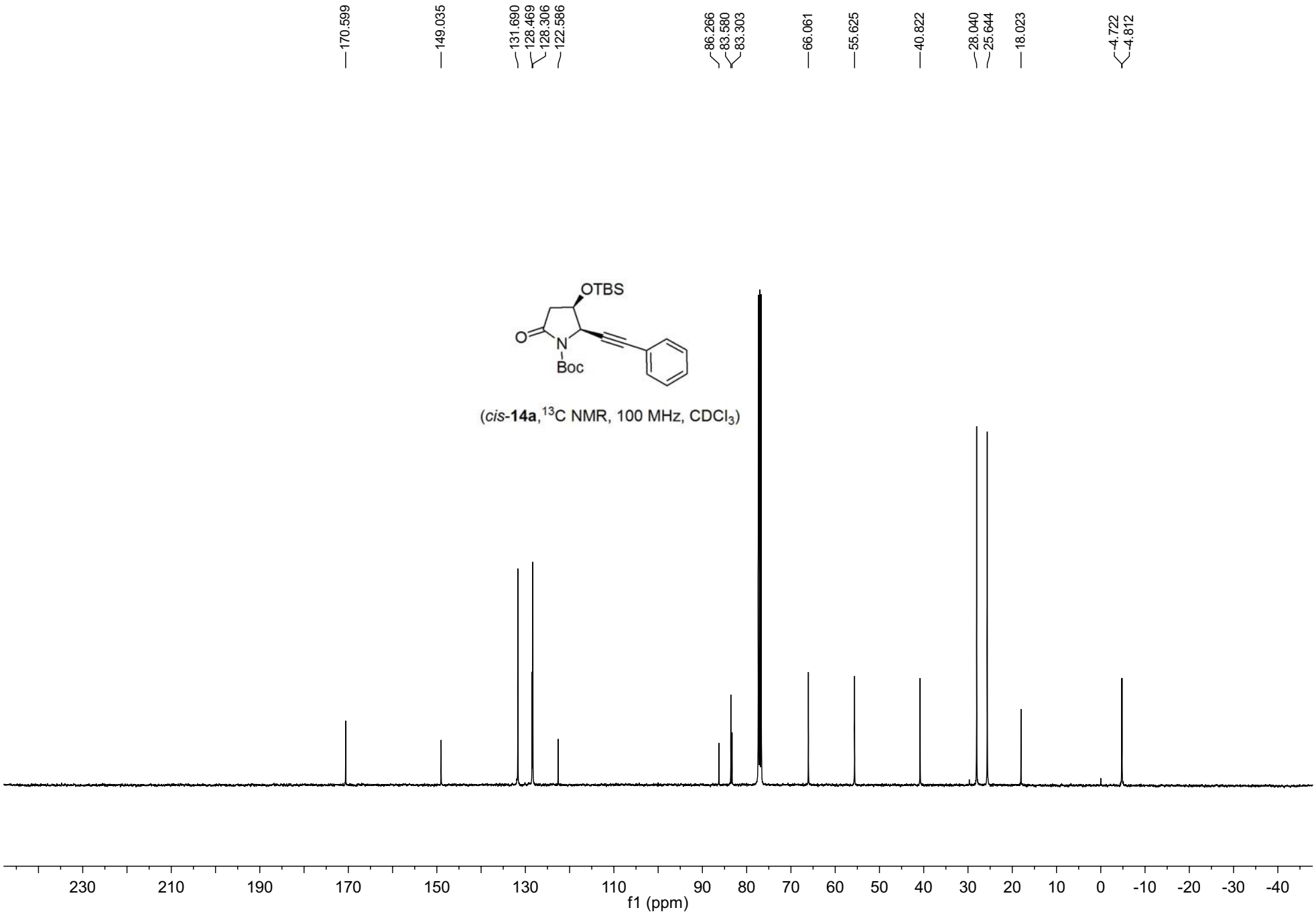


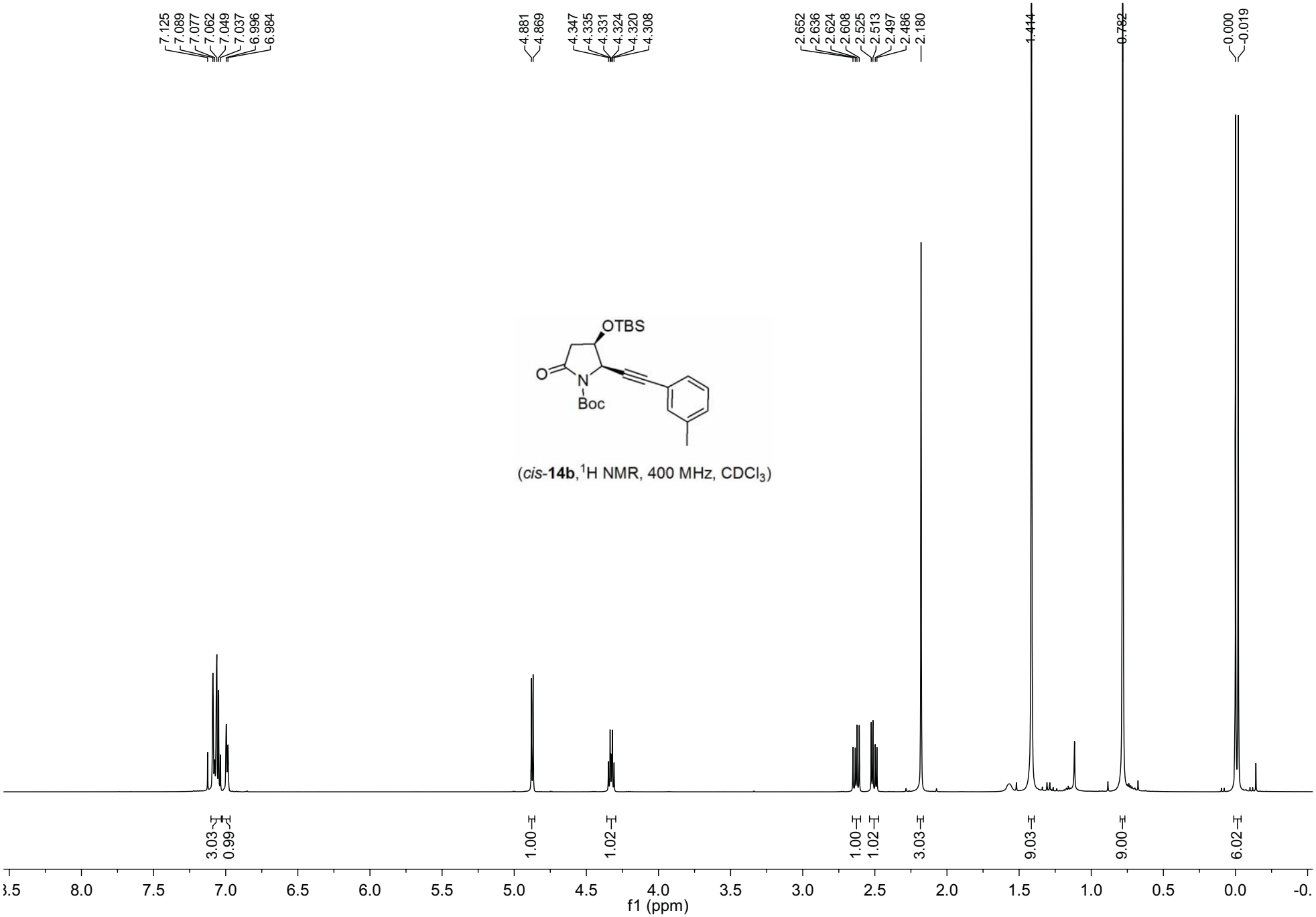
(*trans*-**14e**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.147
149.308
94.397
82.992
73.894
70.713
58.958
41.743
30.837
27.989
27.349
25.633
17.967
4.864
OTBS
O
N
Boc
(trans-14e,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

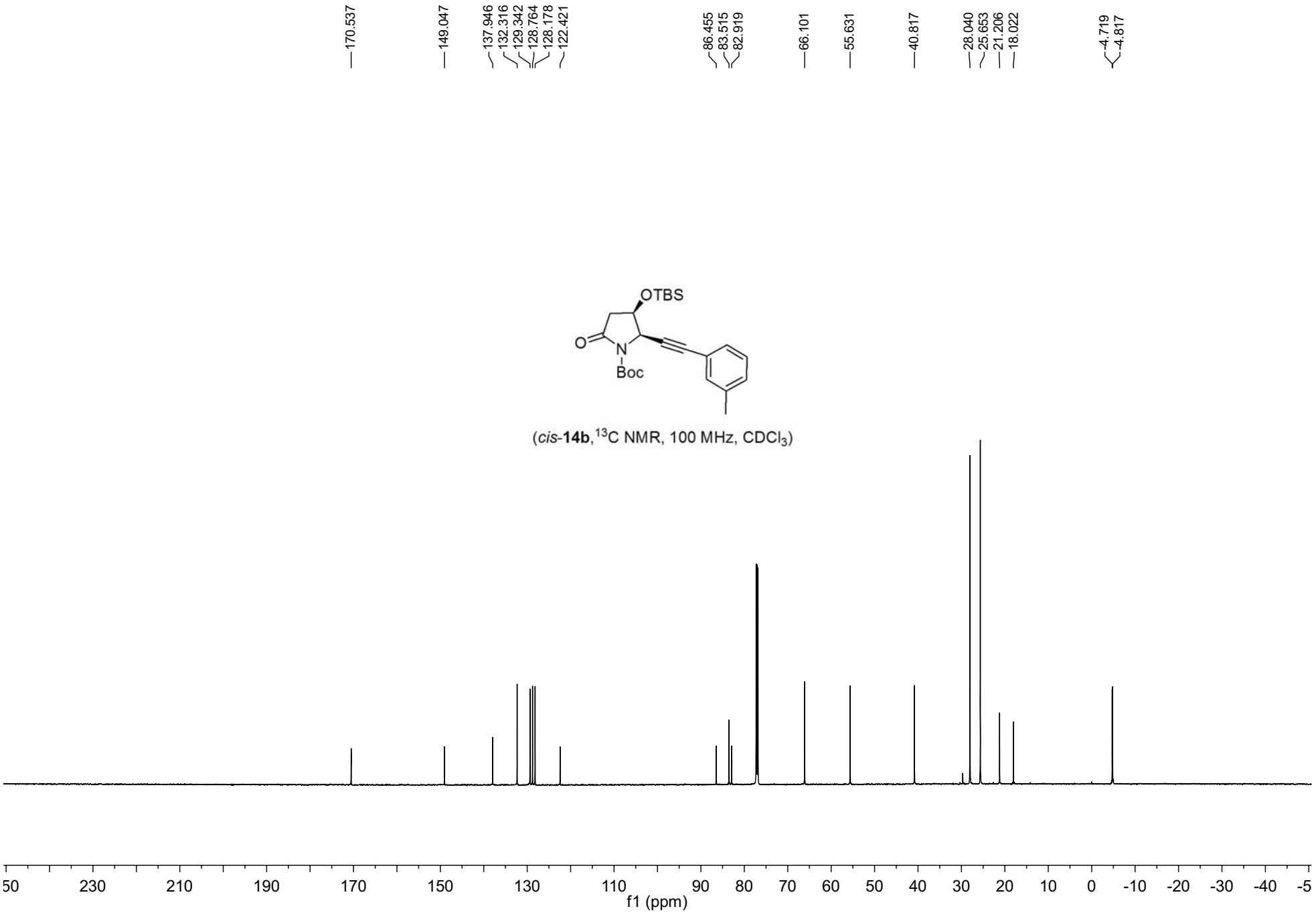


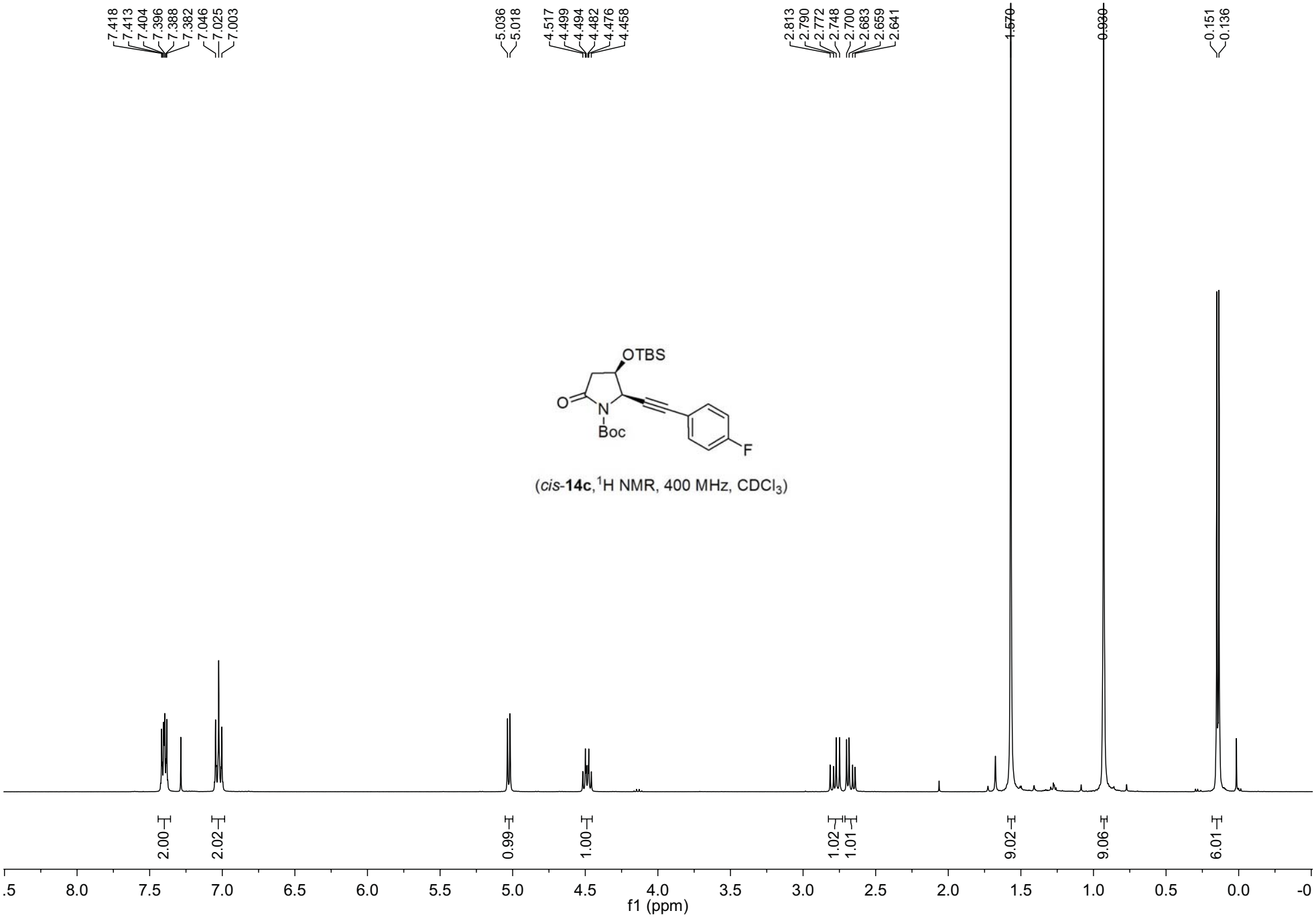
(*cis*-**14a**,^{1}H NMR, 400 MHz, $CDCl_3$)


170.599
149.035
131.690
128.469
128.306
122.586
86.266
83.580
83.303
66.061
55.625
40.822
28.040
25.644
18.023
-4.722
-4.812
OTBS
O
N
Boc
(cis-14a, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

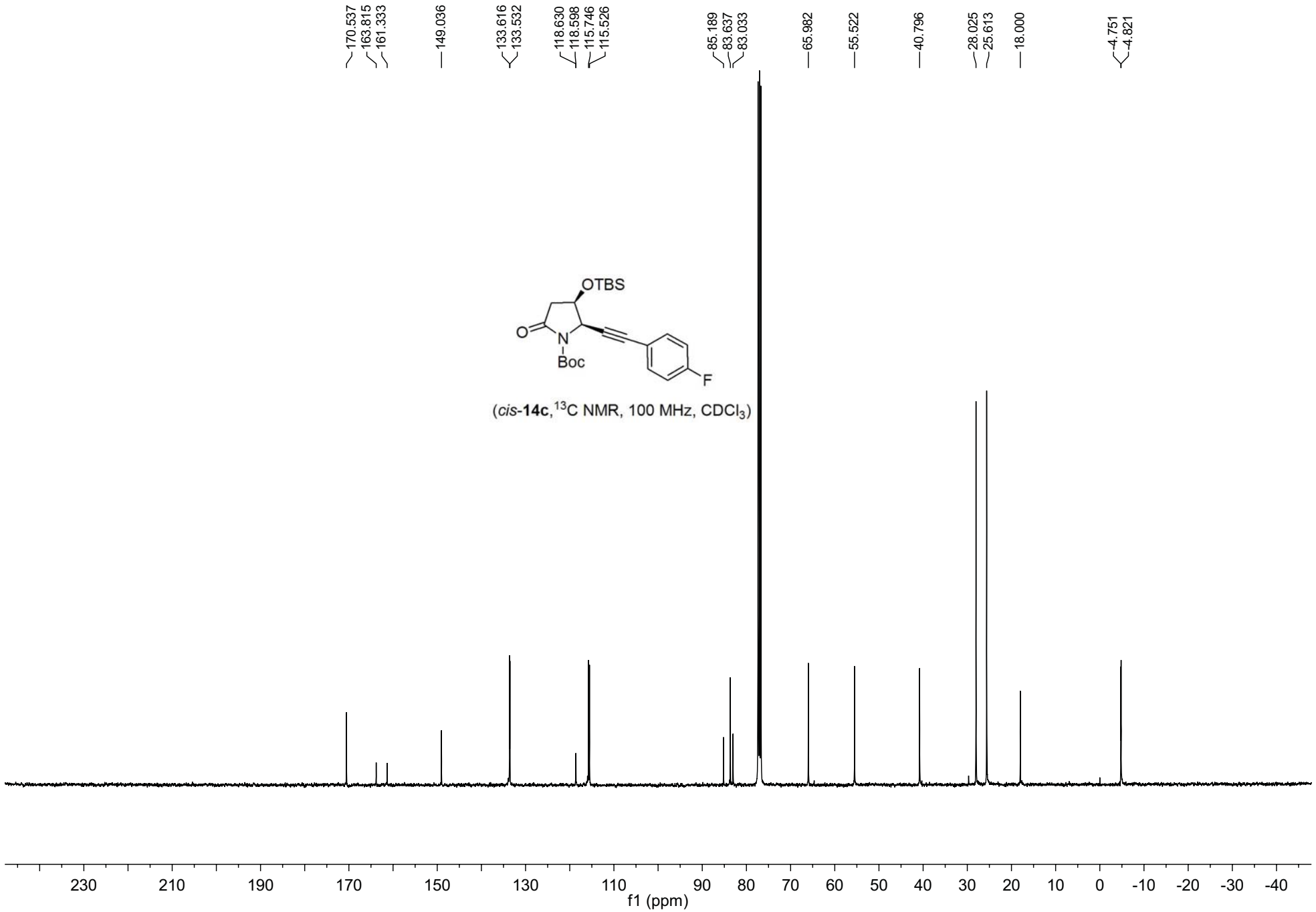


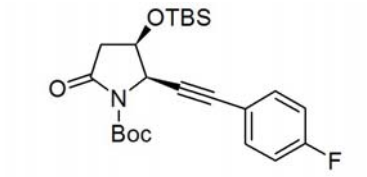
(*cis*-**14b**, ^{1}H NMR, 400 MHz, $CDCl_3$)


170.537
149.047
137.946
132.316
129.342
128.764
128.178
122.421
86.455
83.515
82.919
66.101
55.631
40.817
28.040
25.653
21.206
18.022
4.719
4.817
OTBS
O
N
Boc
(cis-14b,13C NMR, 100 MHz, CDCl3)
50
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-5
f1 (ppm)

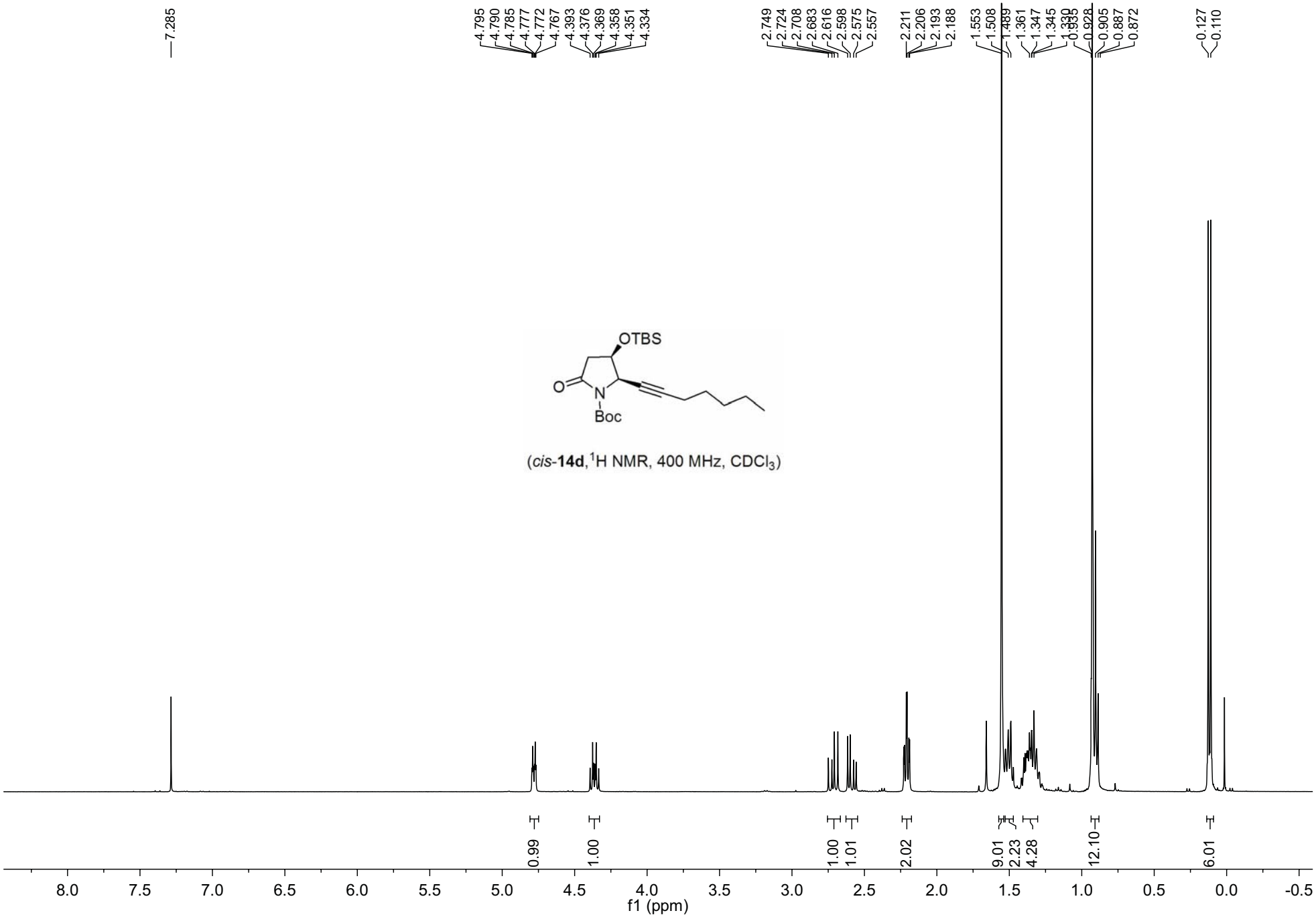


(*cis*-**14c**,^{1}H NMR, 400 MHz, $CDCl_3$)

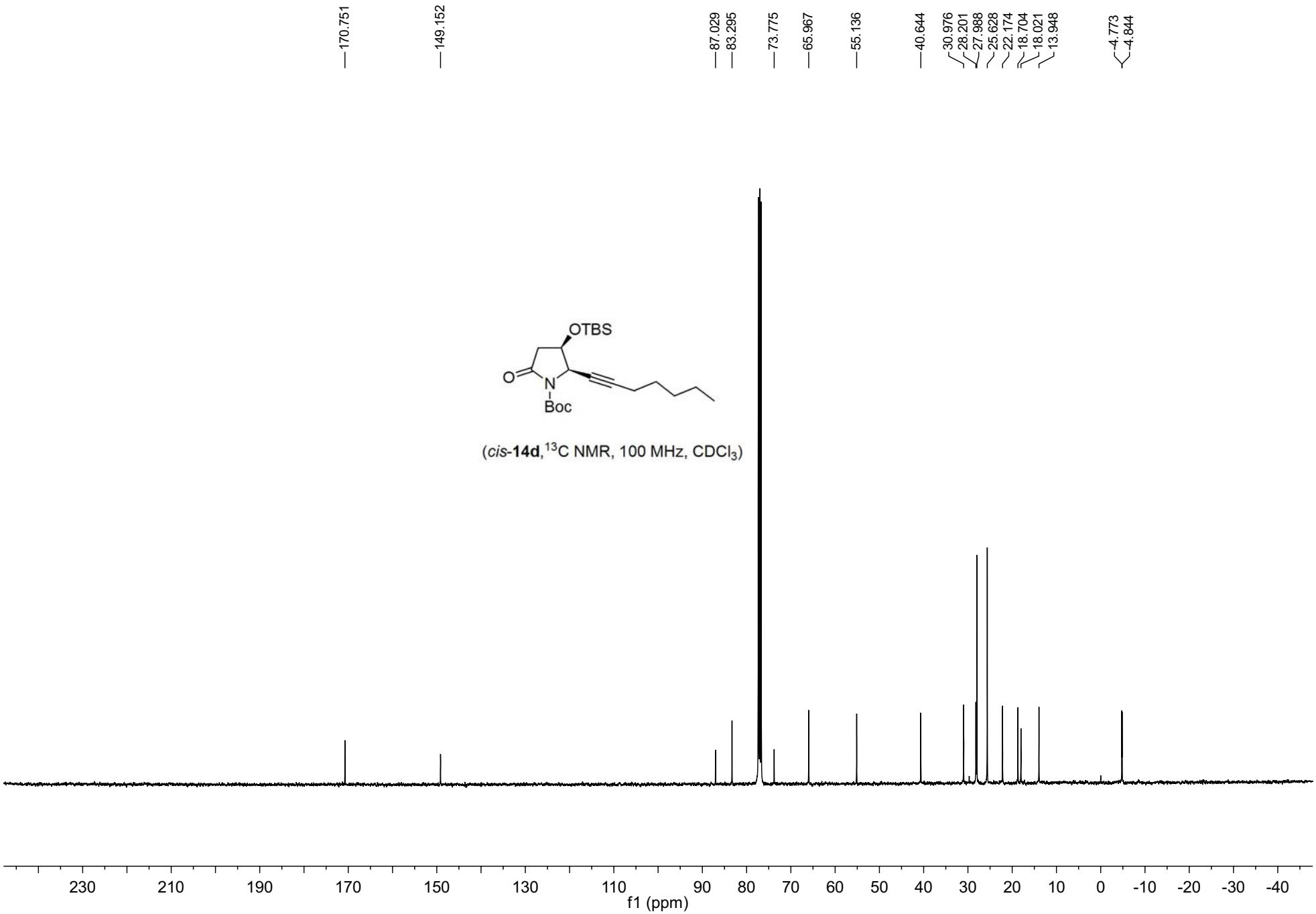

170.537
163.815
161.333
149.036
133.616
133.532
118.630
118.598
115.746
115.526
85.189
83.637
83.033
65.982
55.522
40.796
28.025
25.613
18.000
-4.751
-4.821
OTBS
O
N
Boc
F
(cis-14c, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

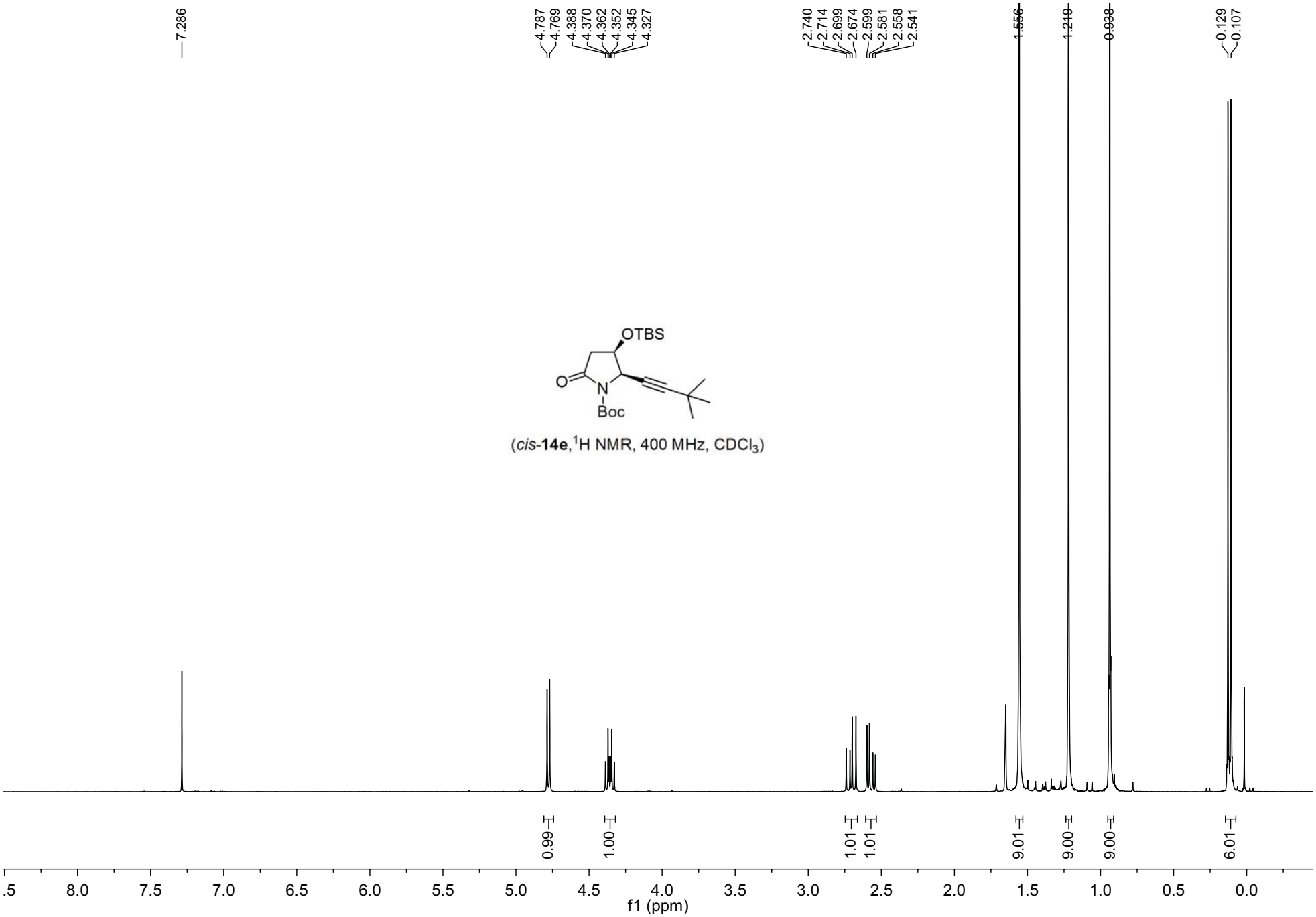


(*cis*-**14c**, ^{19}F NMR, 376 MHz, $CDCl_3$)

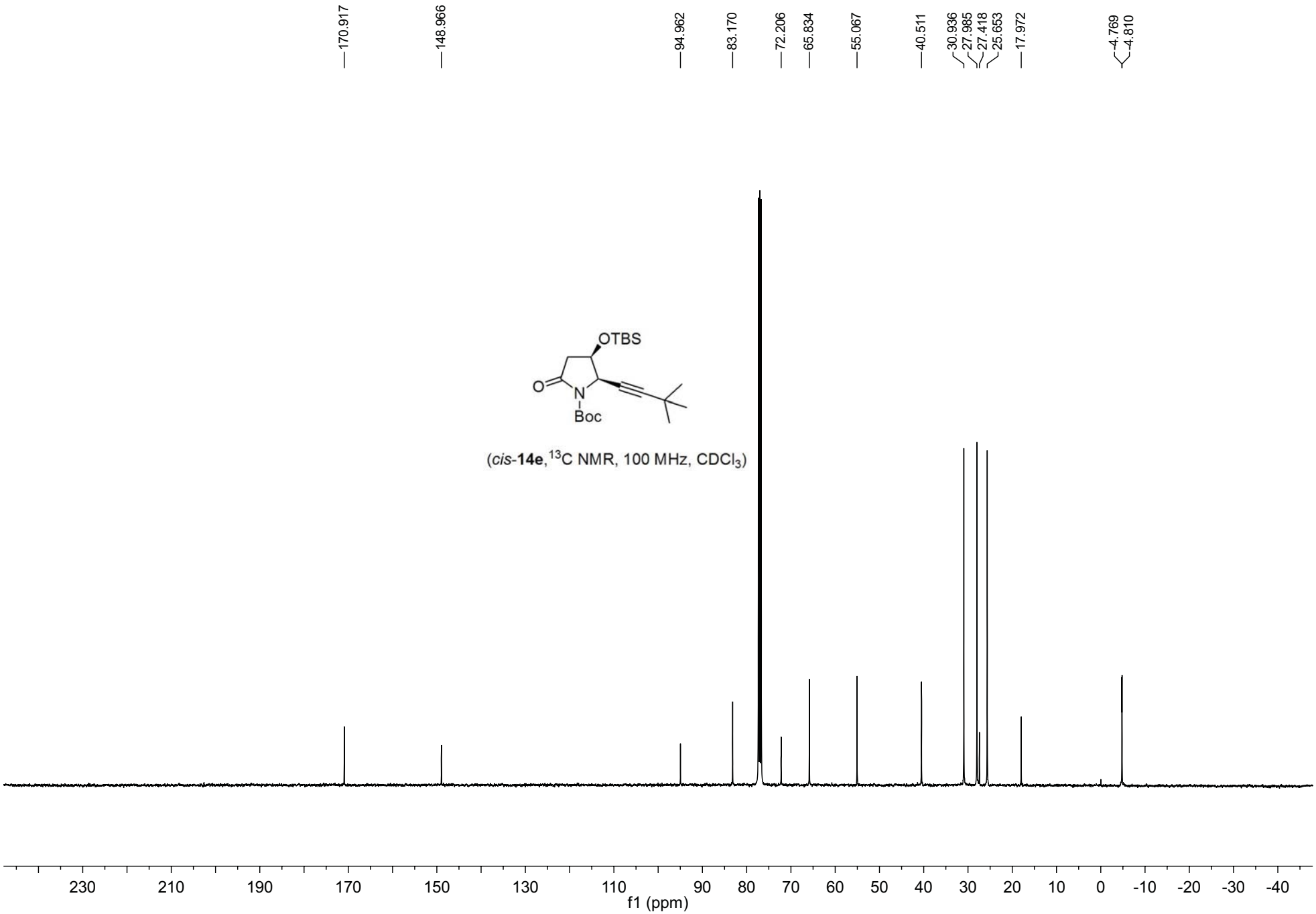


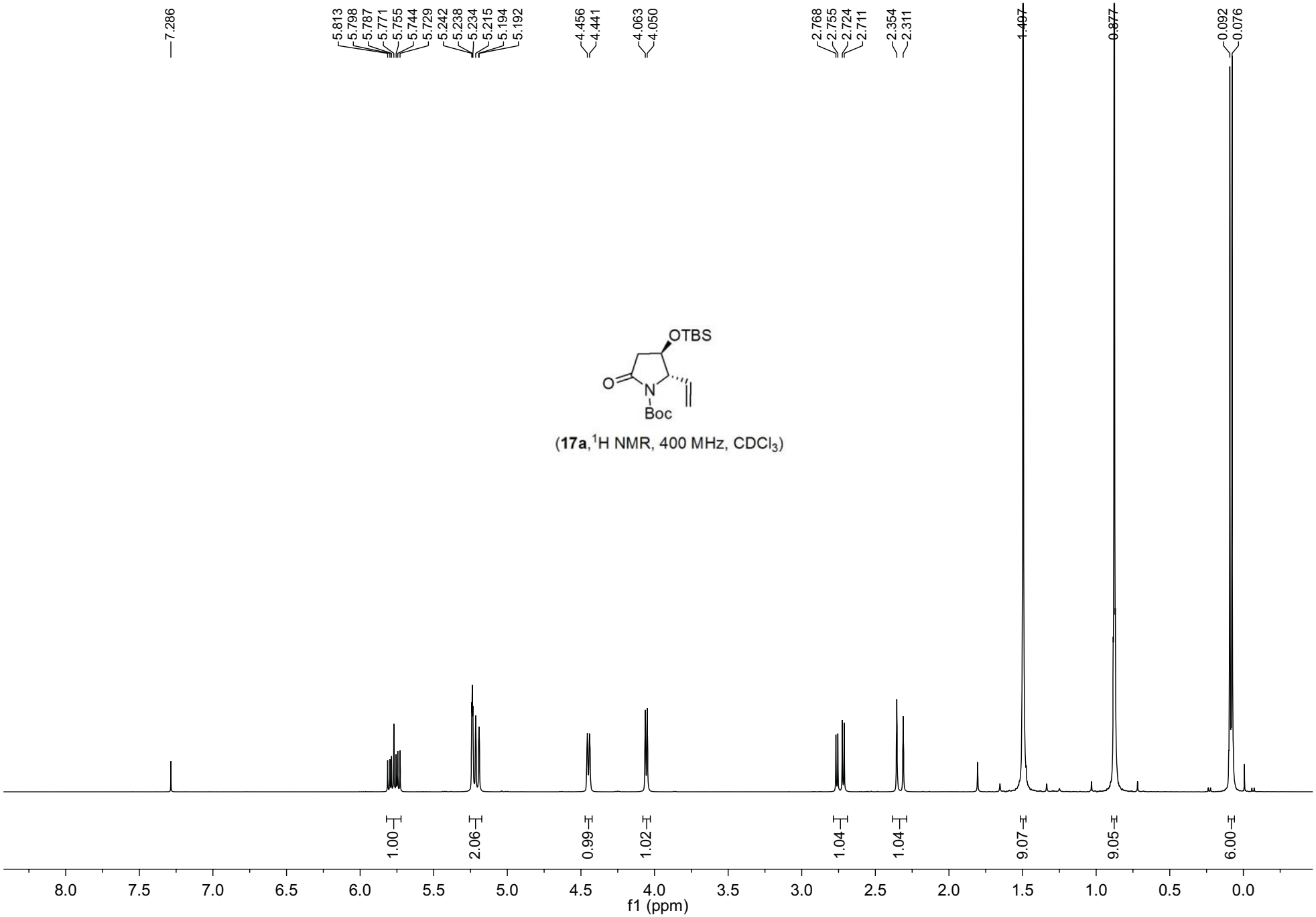
(*cis*-**14d**,^{1}H NMR, 400 MHz, $CDCl_3$)

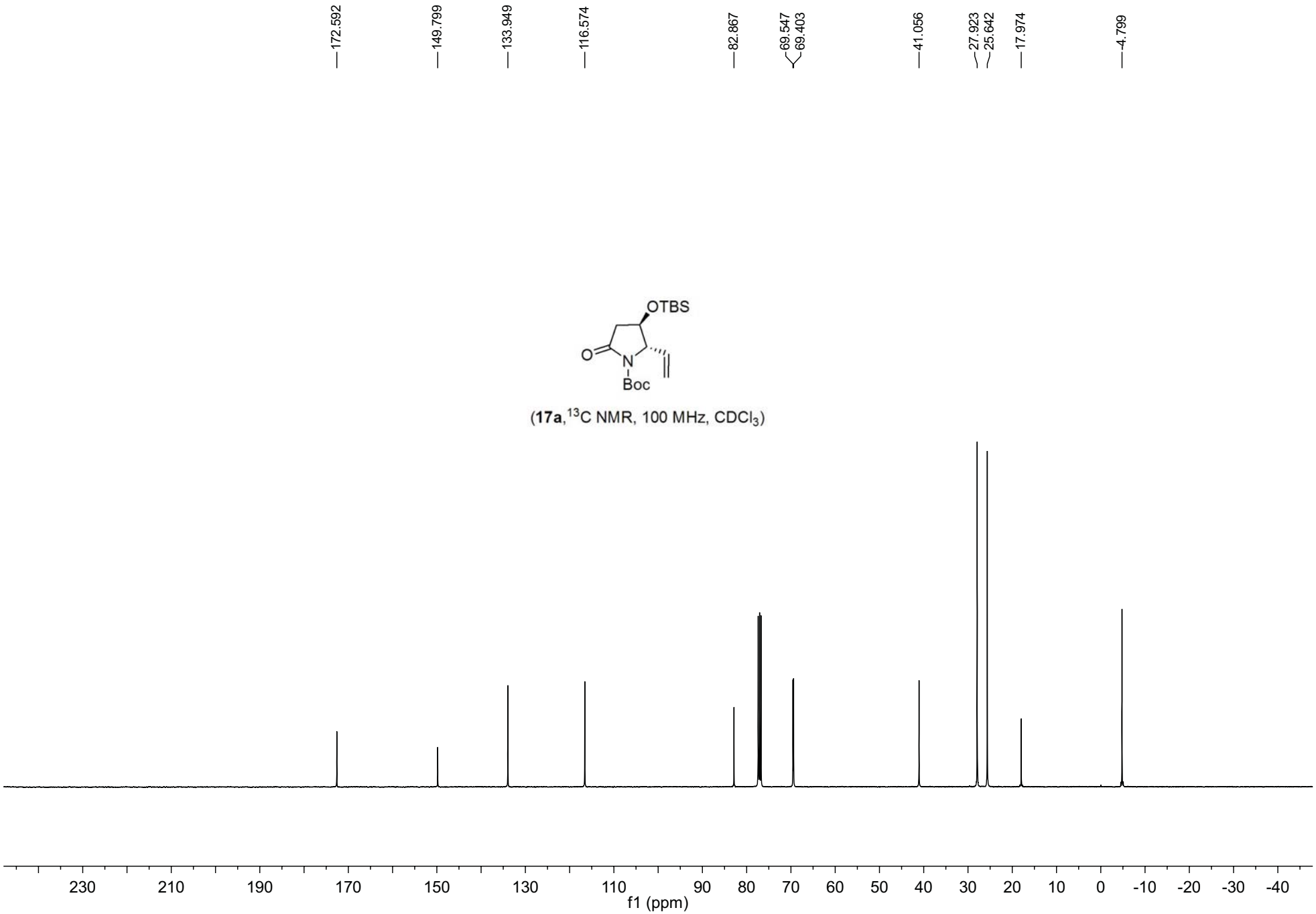

170.751
149.152
87.029
83.295
73.775
65.967
55.136
40.644
30.976
28.201
27.988
25.628
22.174
18.704
18.021
13.948
4.773
-4.844
OTBS
O
N
Boc
(cis-14d, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)



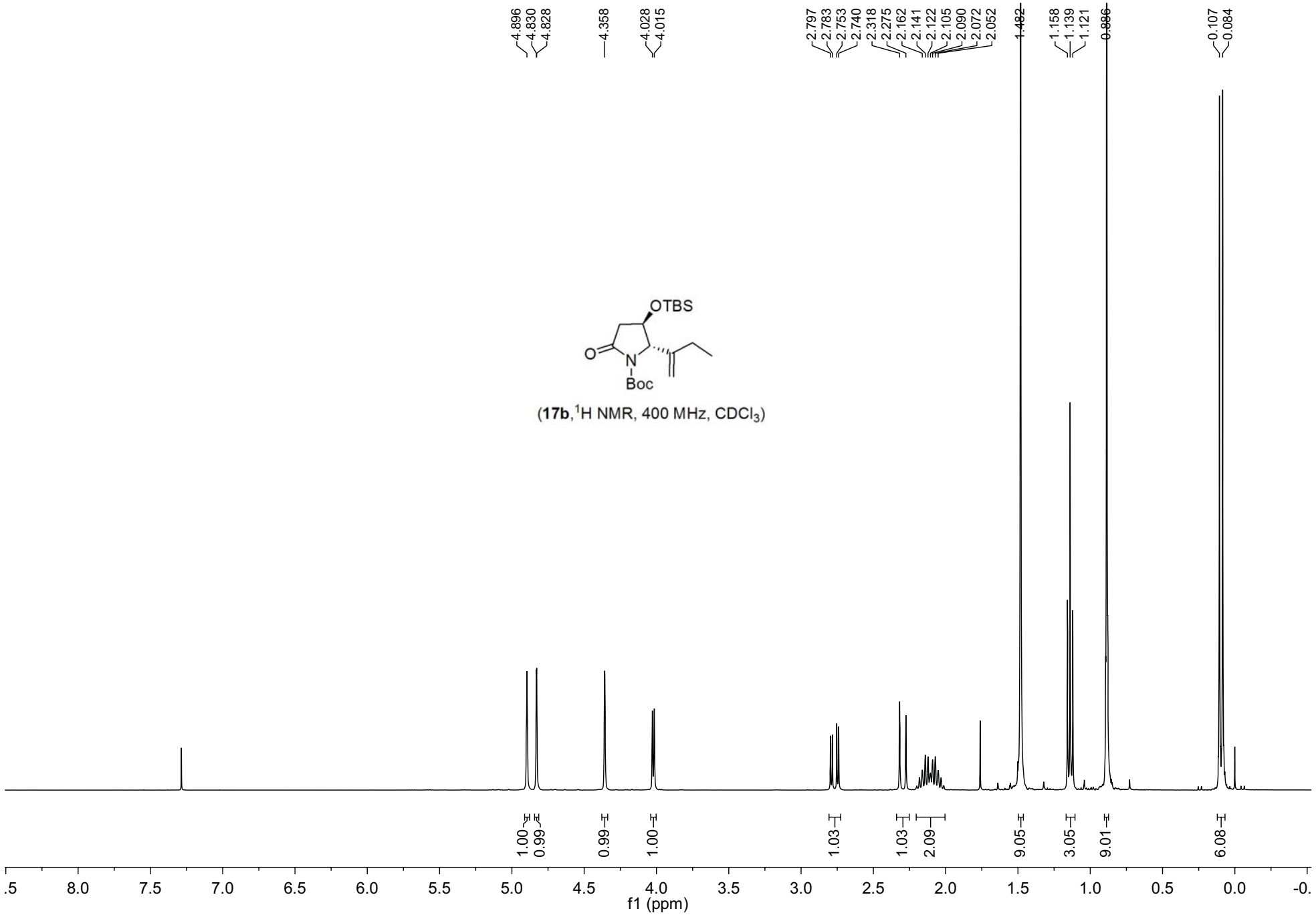
(*cis*-**14e**,^{1}H NMR, 400 MHz, $CDCl_3$)

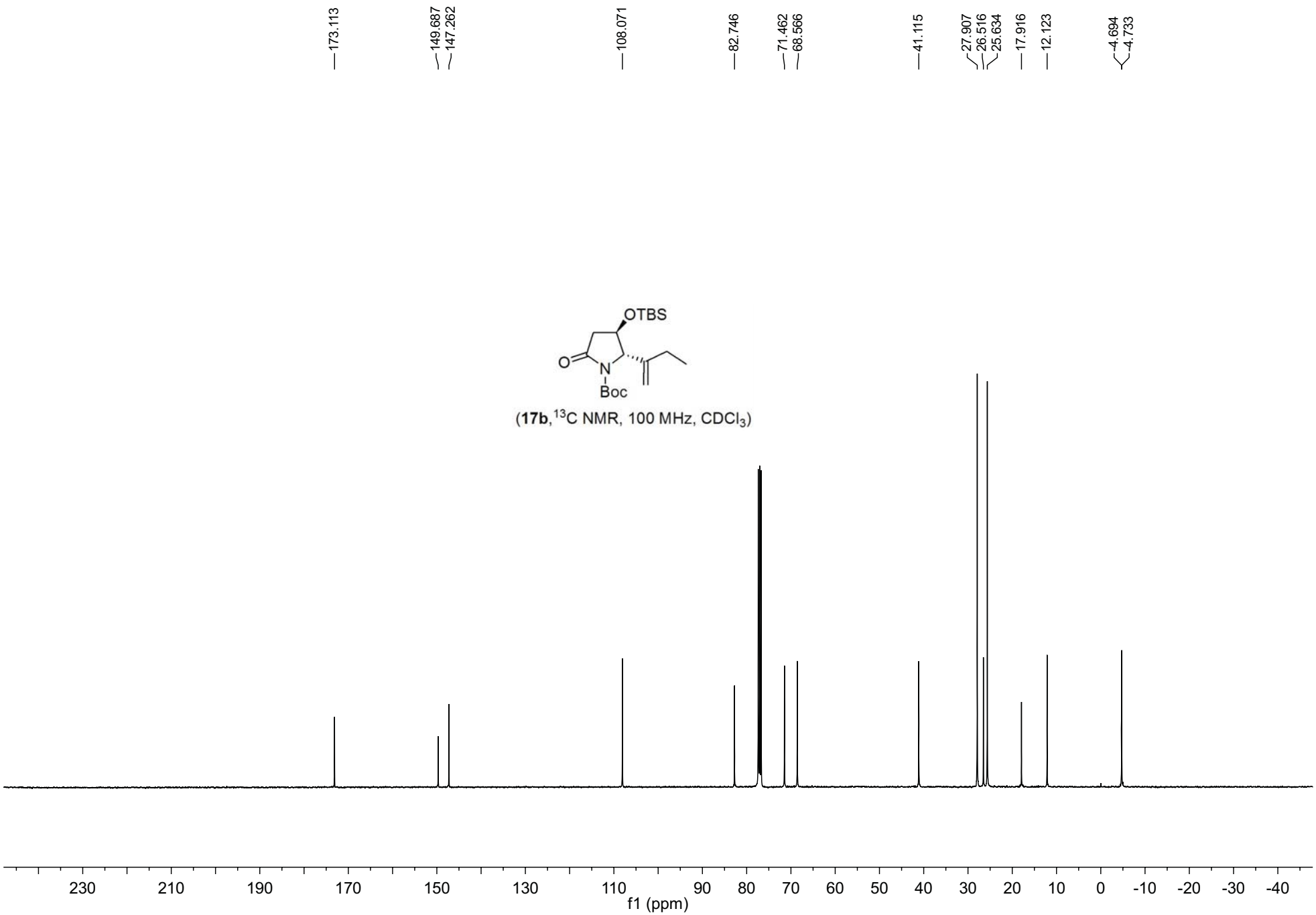

170.917
148.966
94.962
83.170
72.206
65.834
55.067
40.511
30.936
27.985
27.418
25.653
17.972
4.769
4.810
OTBS
O
N
Boc
(cis-14e, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

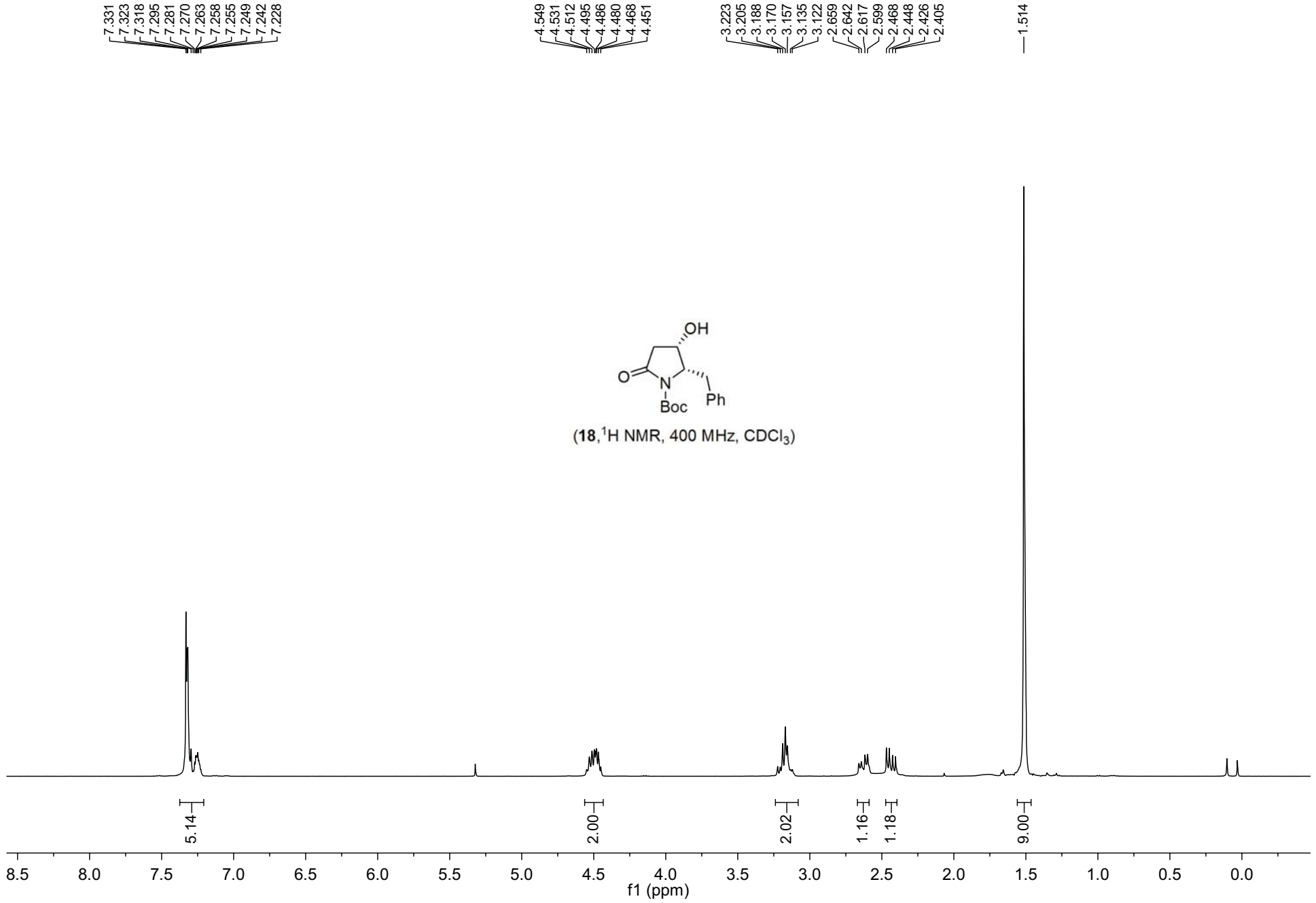

7.286
5.813
5.798
5.787
5.771
5.755
5.744
5.729
5.242
5.238
5.234
5.215
5.194
5.192
4.456
4.441
4.063
4.050
2.768
2.755
2.724
2.711
2.354
2.311
1.497
0.877
0.092
0.076
OTBS
O
N
Boc
(17a,1H NMR, 400 MHz, CDCl3)
1.00
2.06
0.99
1.02
1.04
1.04
9.07
9.05
6.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

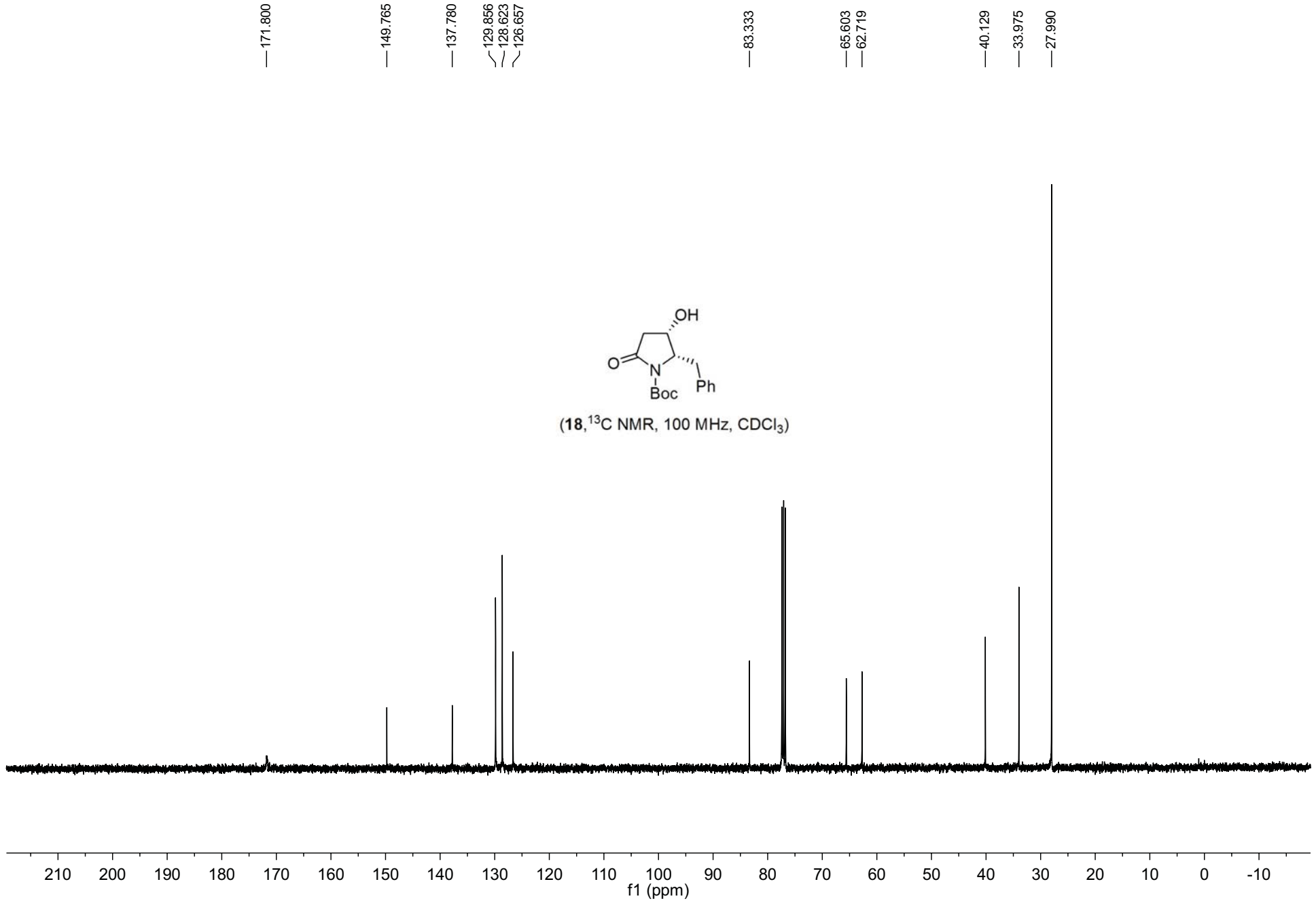


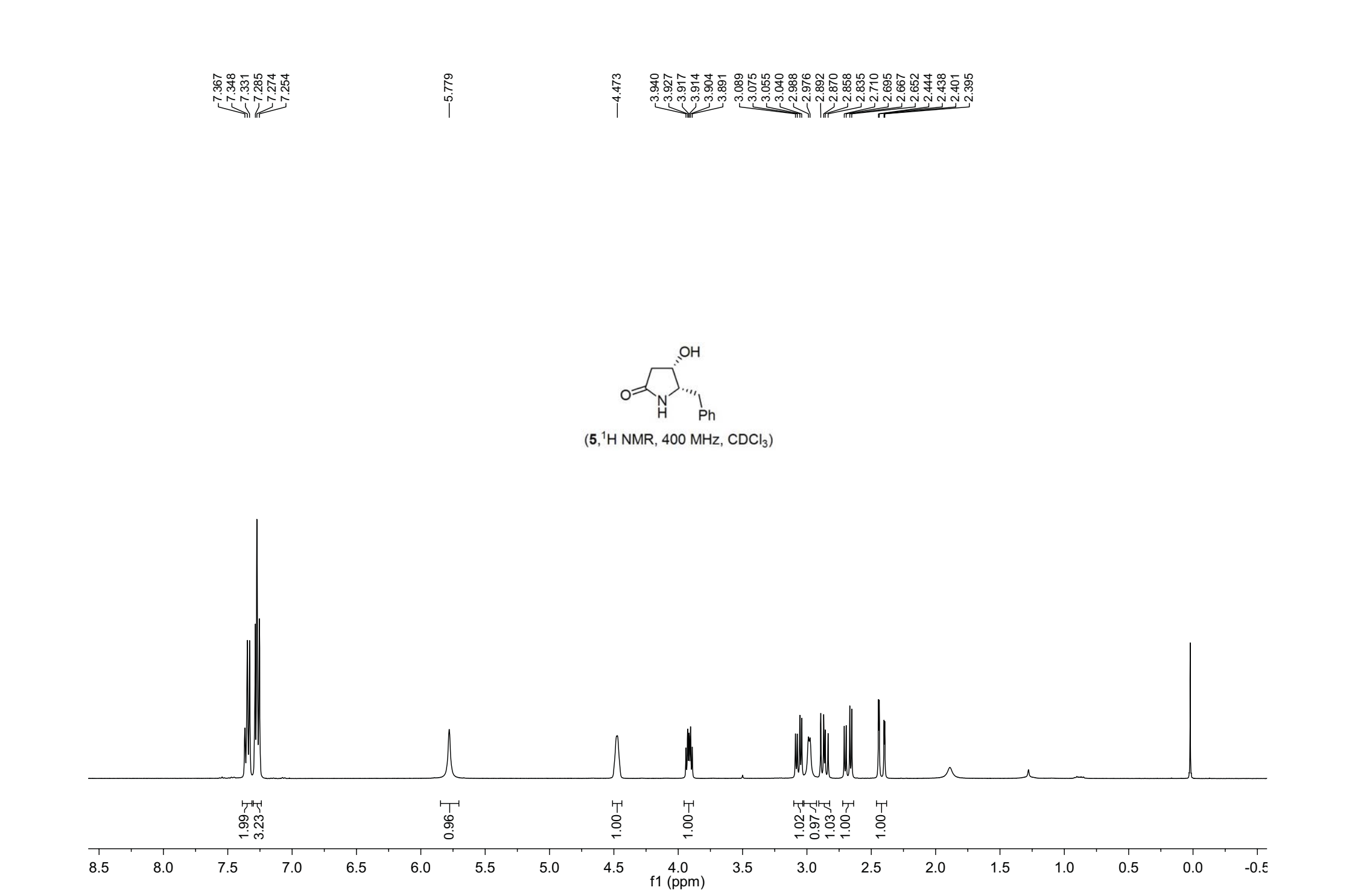
(**17a**, ^{13}C NMR, 100 MHz, $CDCl_3$)


4.896
4.830
4.828
4.358
4.028
4.015
2.797
2.783
2.753
2.740
2.318
2.275
2.162
2.141
2.122
2.105
2.090
2.072
2.052
1.482
1.158
1.139
1.121
0.886
0.107
0.084
OTBS
O
N
Boc
(17b,1H NMR, 400 MHz, CDCl3)
1.00
0.99
0.99
1.00
1.03
1.03
2.09
9.05
3.05
9.01
6.08
f1 (ppm)

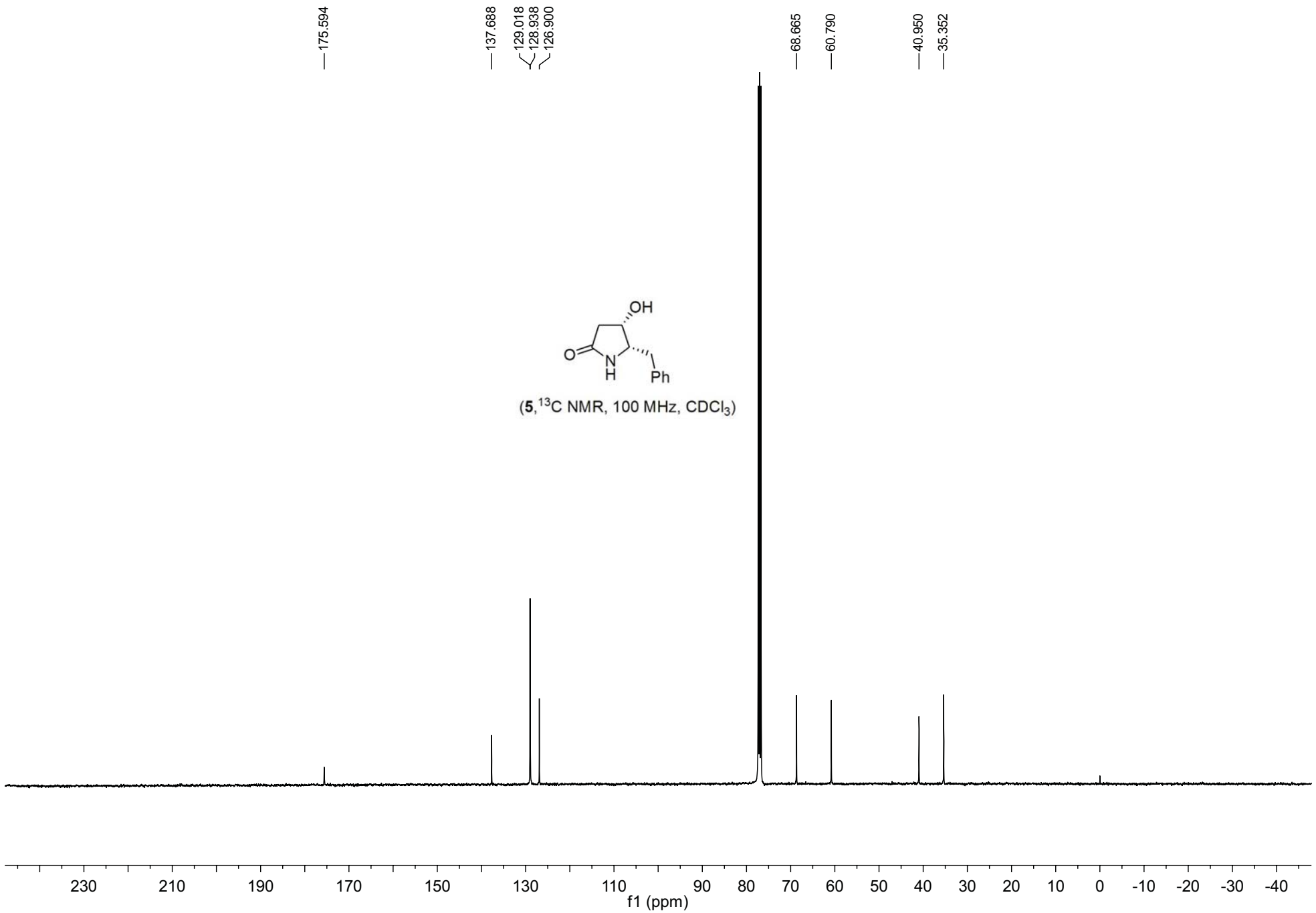

173.113
149.687
147.262
108.071
82.746
71.462
68.566
41.115
27.907
26.516
25.634
17.916
12.123
-4.694
-4.733
OTBS
O
N
Boc
(17b, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

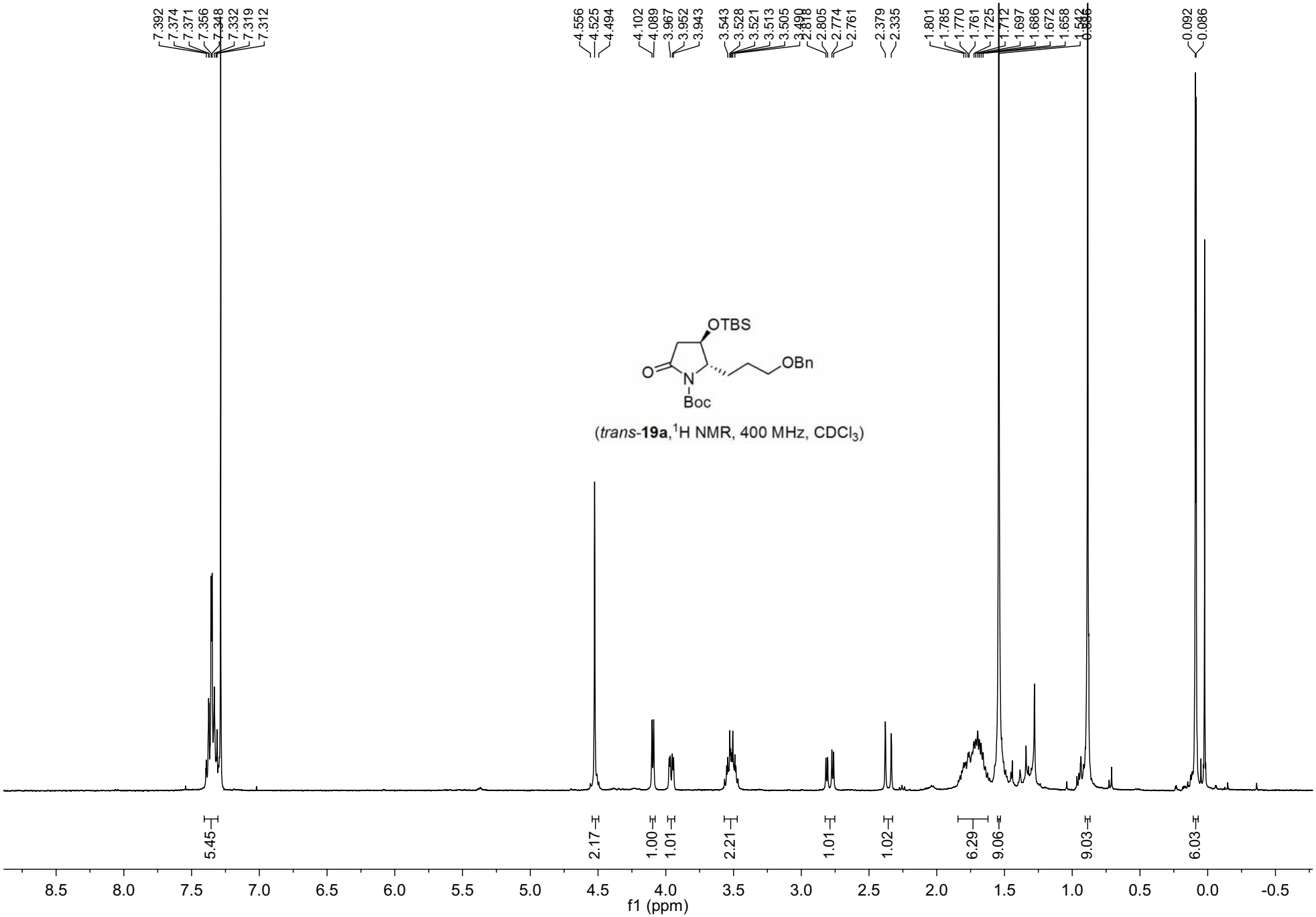

7.331
7.323
7.318
7.295
7.281
7.270
7.263
7.258
7.255
7.249
7.242
7.228
4.549
4.531
4.512
4.495
4.486
4.480
4.468
4.451
3.223
3.205
3.188
3.170
3.157
3.135
3.122
2.659
2.642
2.617
2.599
2.468
2.448
2.426
2.405
1.514
OH
O
N
Boc
Ph
(18,1H NMR, 400 MHz, CDCl3)
5.14
2.00
2.02
1.16
1.18
9.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


171.800
149.765
137.780
129.856
128.623
126.657
83.333
65.603
62.719
40.129
33.975
27.990
OH
O
N
Boc
Ph
(18,13C NMR, 100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

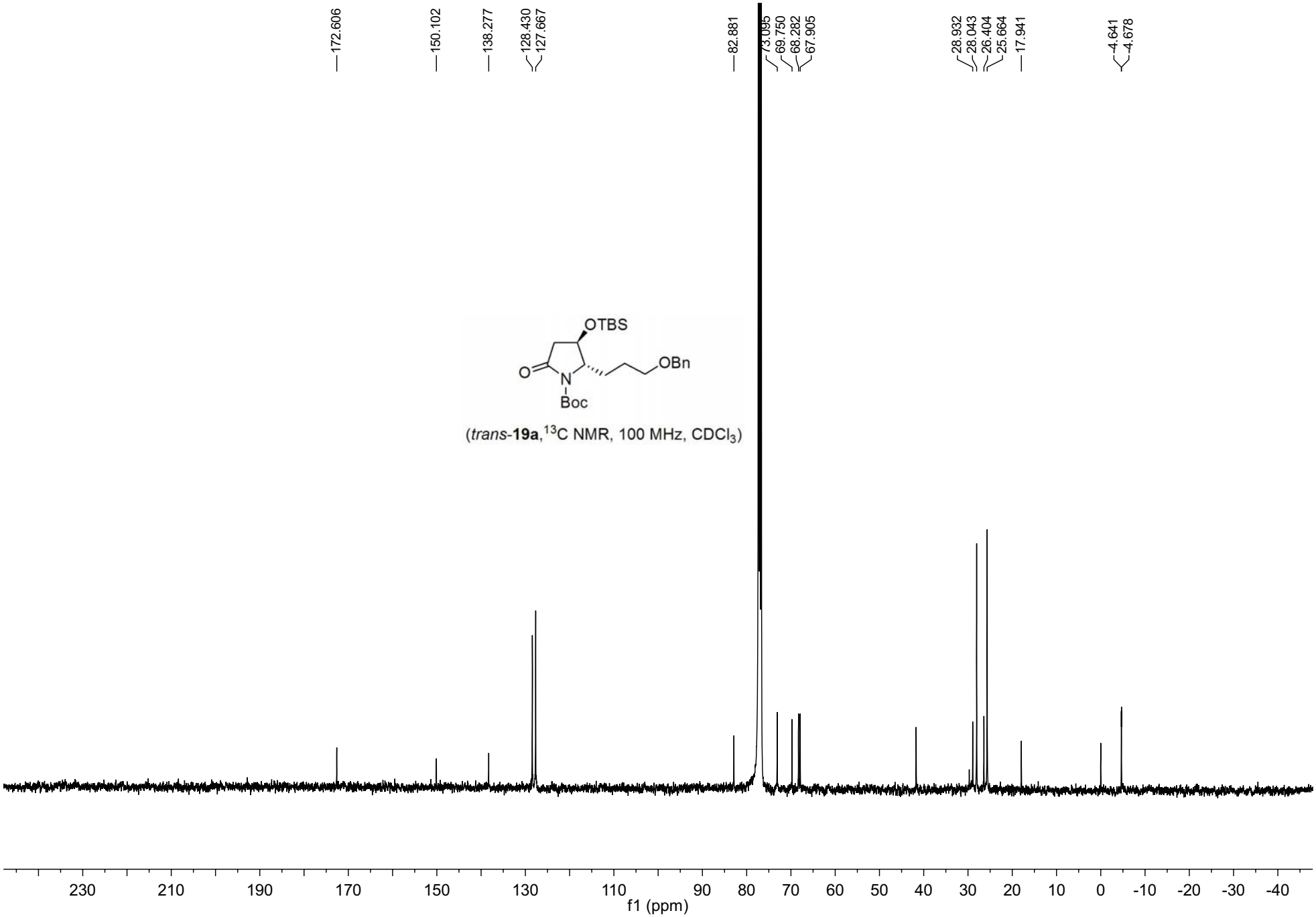


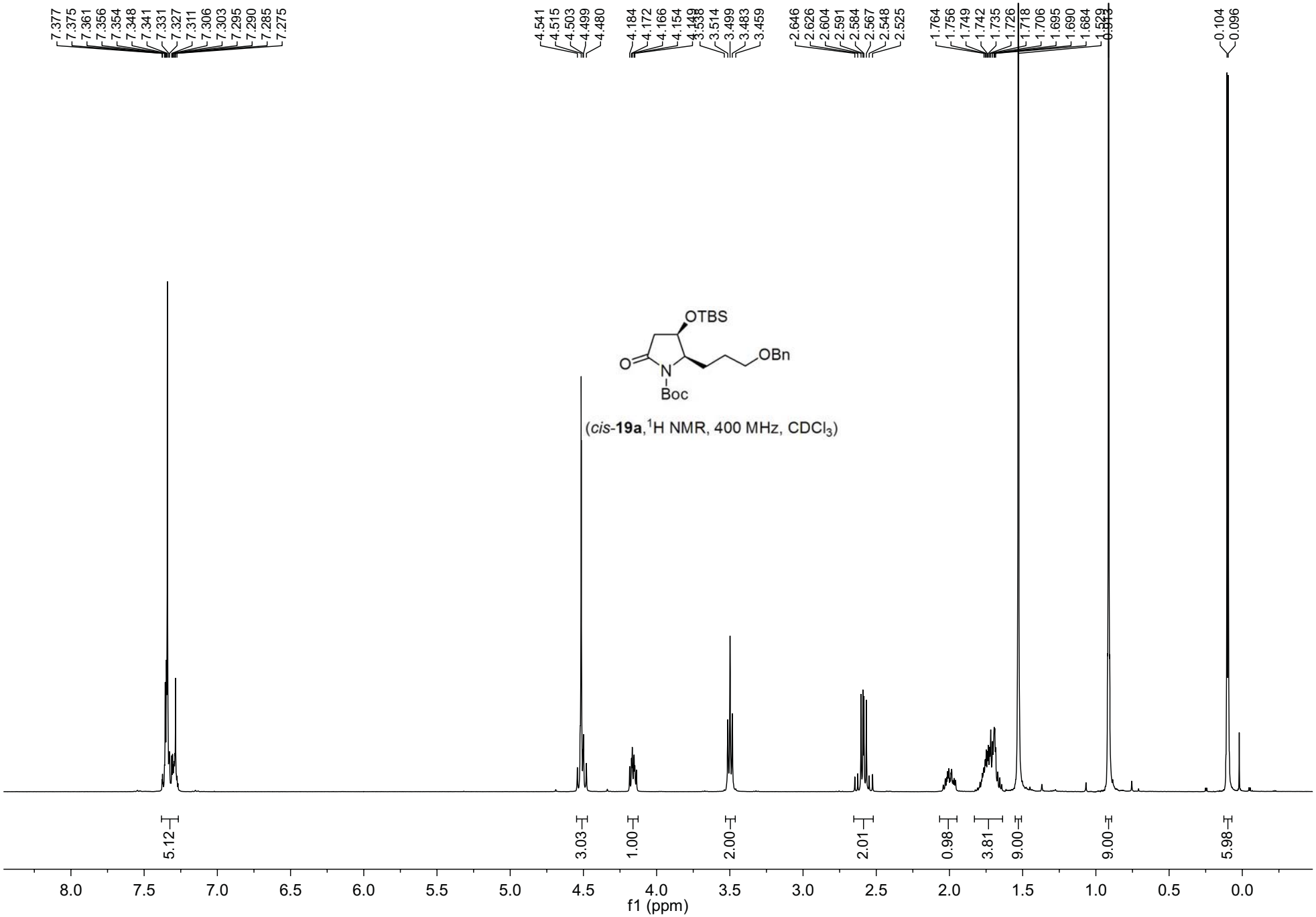
(**5**,^{1}H NMR, 400 MHz, $CDCl_3$)

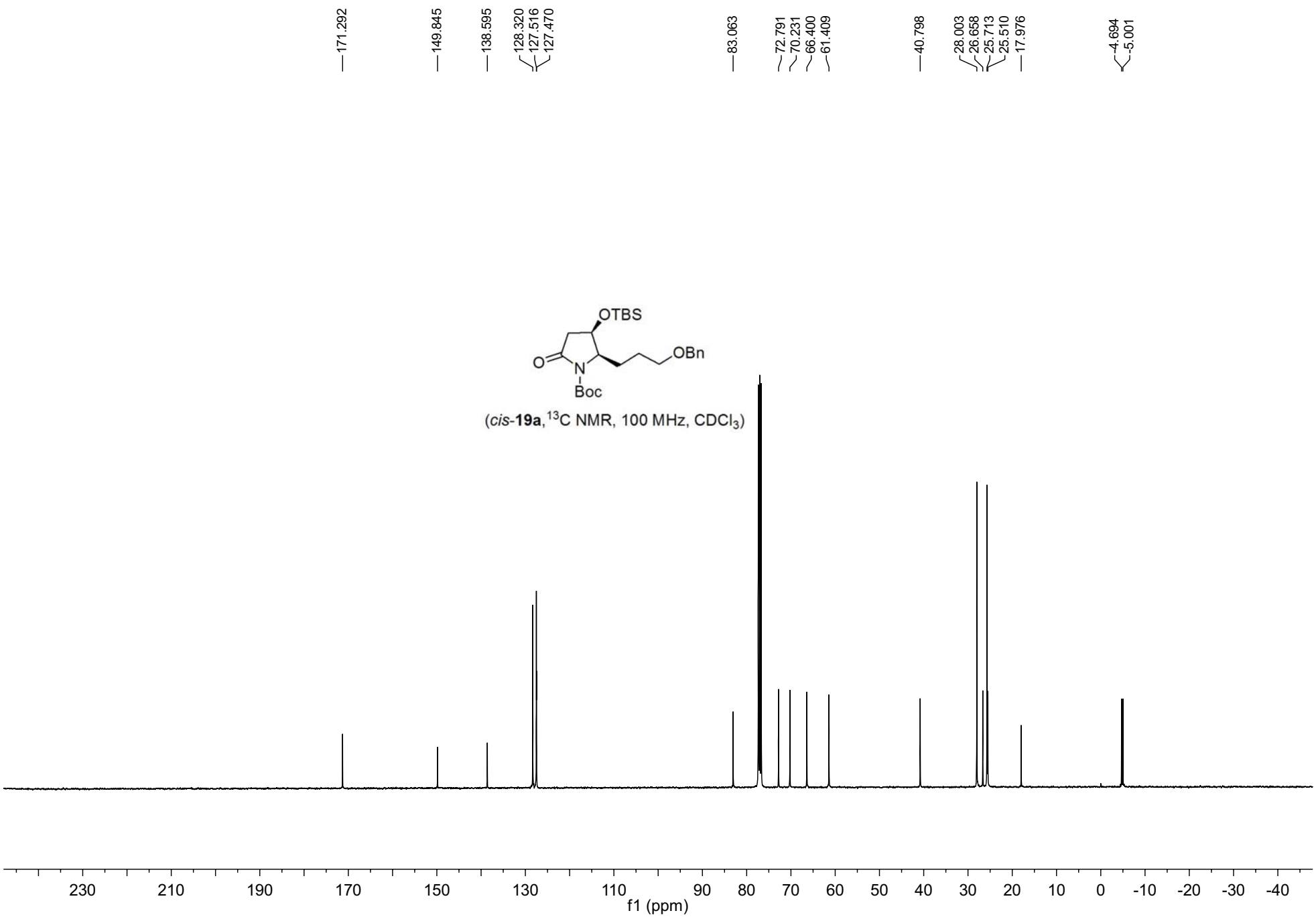

175.594
137.688
129.018
128.938
126.900
68.665
60.790
40.950
35.352
OH
O
N
H
Ph
(5,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

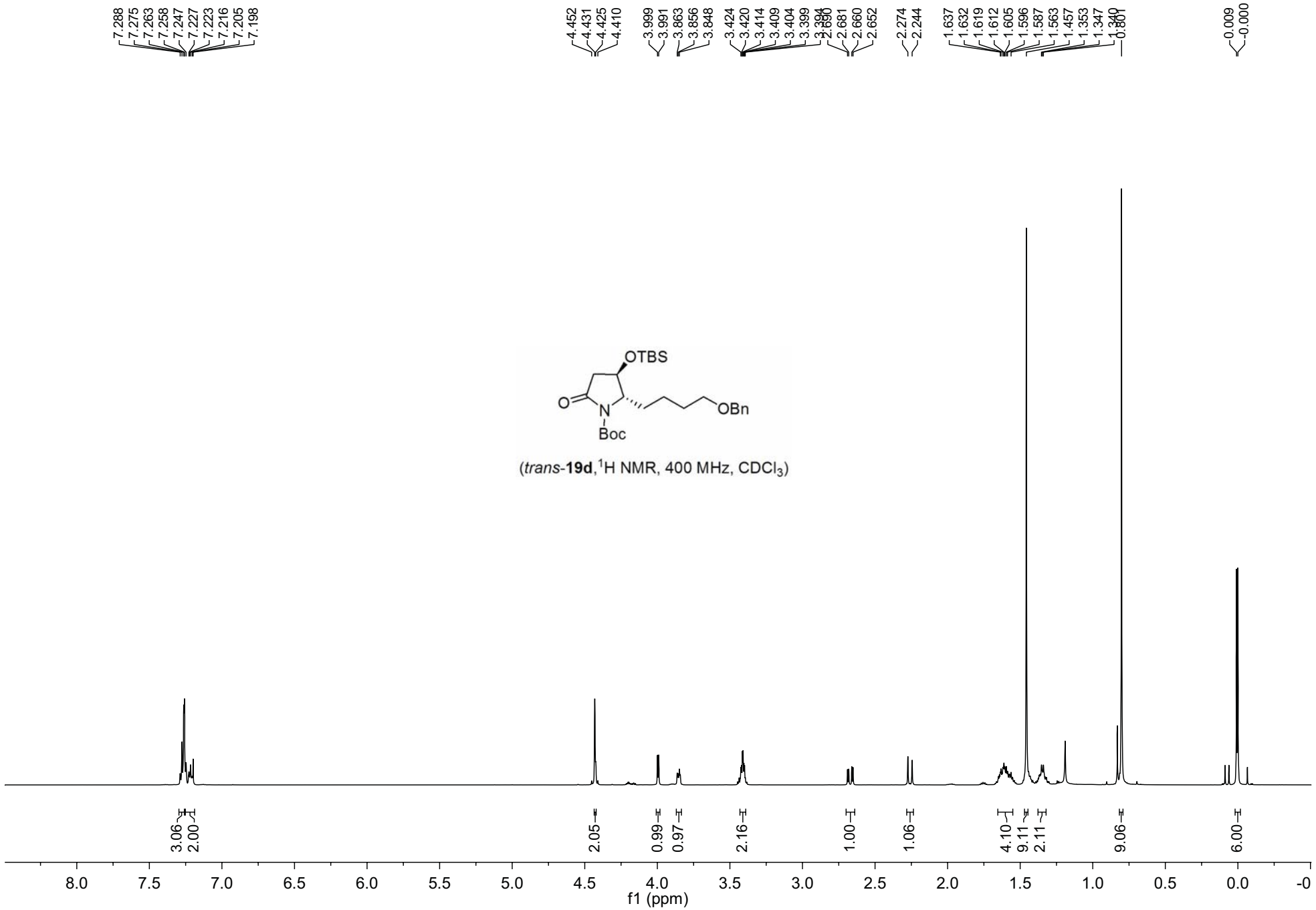


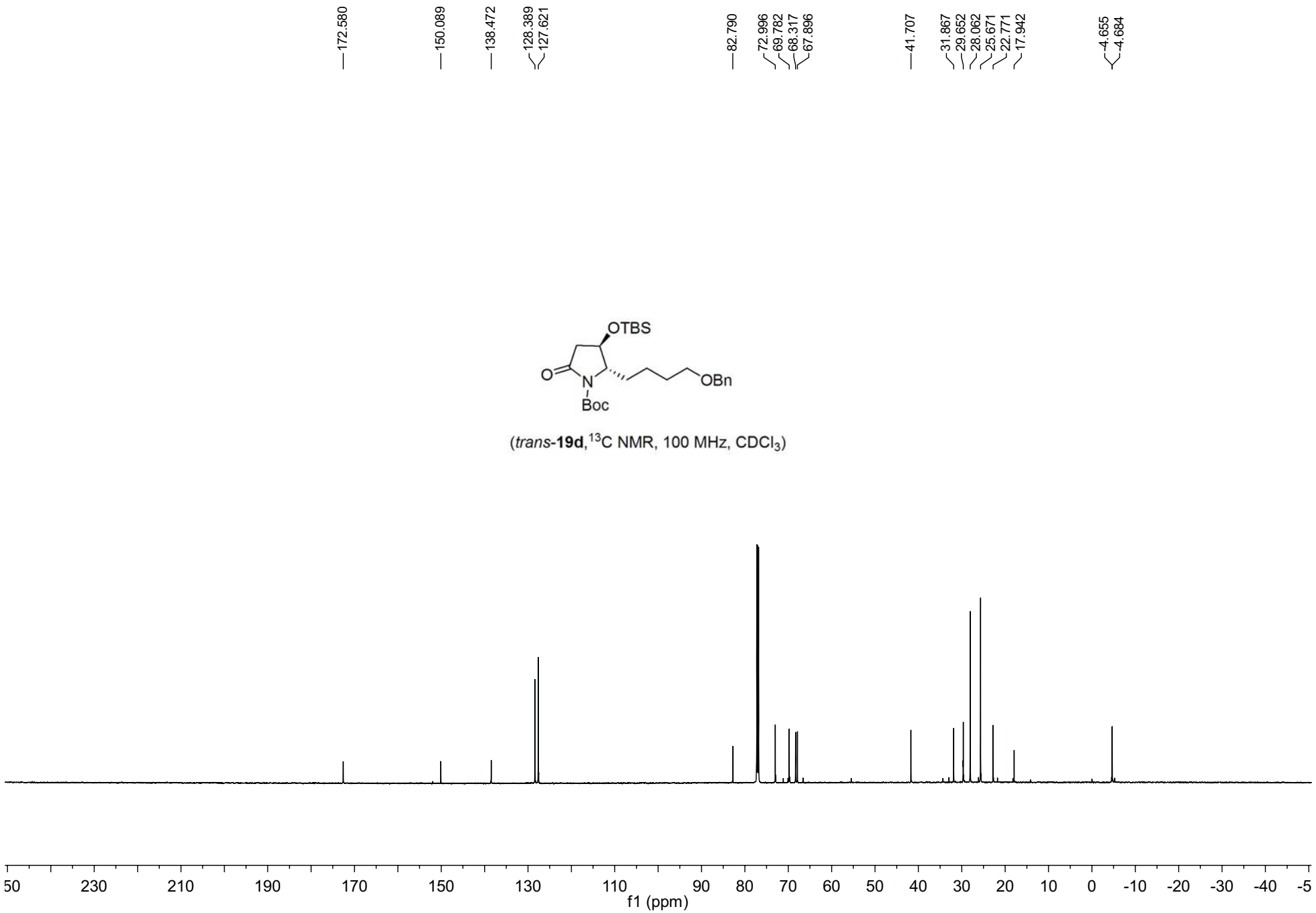
(*trans*-**19a**,^{1}H NMR, 400 MHz, $CDCl_3$)


172.606
150.102
138.277
128.430
127.667
82.881
73.095
69.750
68.282
67.905
28.932
28.043
26.404
25.664
17.941
-4.641
-4.678
OTBS
OBn
O
N
Boc
(trans-19a,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

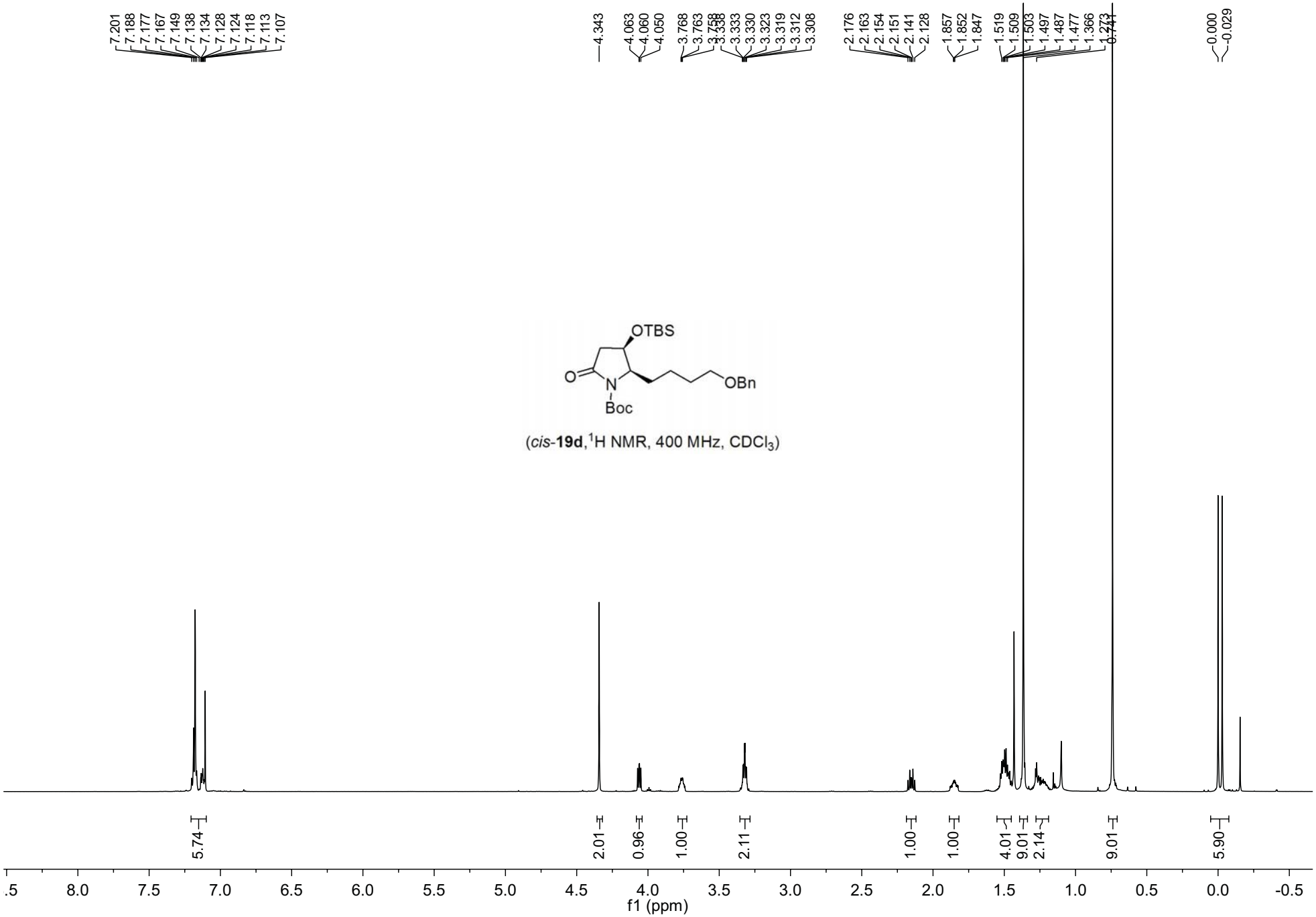

7.377
7.375
7.361
7.356
7.354
7.348
7.341
7.331
7.327
7.311
7.306
7.303
7.295
7.290
7.285
7.275
4.541
4.515
4.503
4.499
4.480
4.184
4.172
4.166
4.154
3.538
3.514
3.499
3.483
3.459
2.646
2.626
2.604
2.591
2.584
2.567
2.548
2.525
1.764
1.756
1.749
1.742
1.735
1.726
1.718
1.706
1.695
1.690
1.684
1.529
0.104
0.096
OTBS
OBn
O
N
Boc
(cis-19a,1H NMR, 400 MHz, CDCl3)
5.12
3.03
1.00
2.00
2.01
0.98
3.81
9.00
9.00
5.98
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

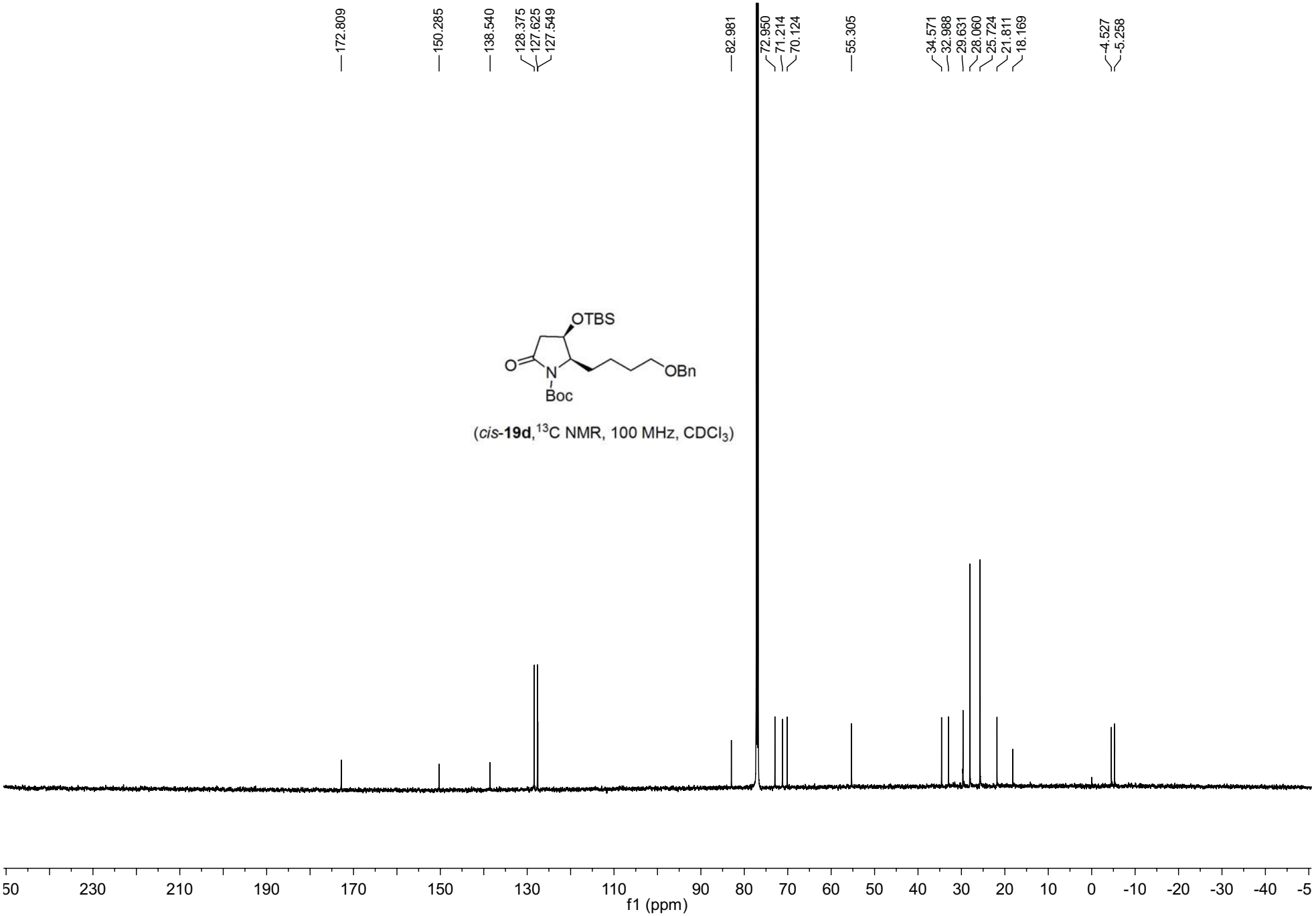

171.292
149.845
138.595
128.320
127.516
127.470
83.063
72.791
70.231
66.400
61.409
40.798
28.003
26.658
25.713
25.510
17.976
-4.694
-5.001
OTBS
OBn
O
N
Boc
(cis-19a, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

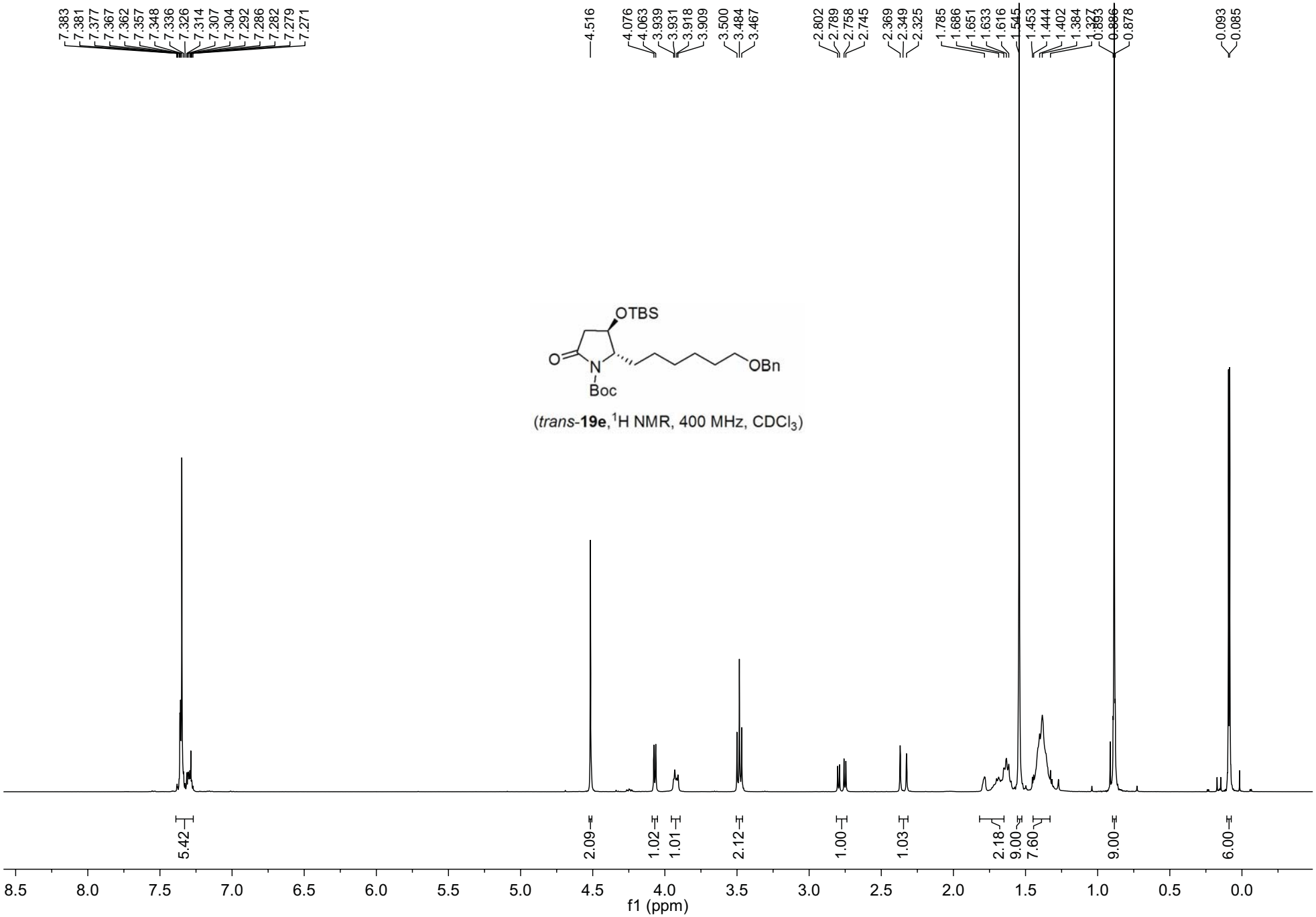

7.288
7.275
7.263
7.258
7.247
7.227
7.223
7.216
7.205
7.198
4.452
4.431
4.425
4.410
3.999
3.991
3.863
3.856
3.848
3.424
3.420
3.414
3.409
3.404
3.399
2.681
2.660
2.652
2.274
2.244
1.637
1.632
1.619
1.612
1.605
1.596
1.587
1.563
1.457
1.353
1.347
0.801
0.009
-0.000
OTBS
O
N
Boc
OBn
(trans-19d,1H NMR, 400 MHz, CDCl3)
3.06
2.00
2.05
0.99
0.97
2.16
1.00
1.06
4.10
9.11
2.11
9.06
6.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

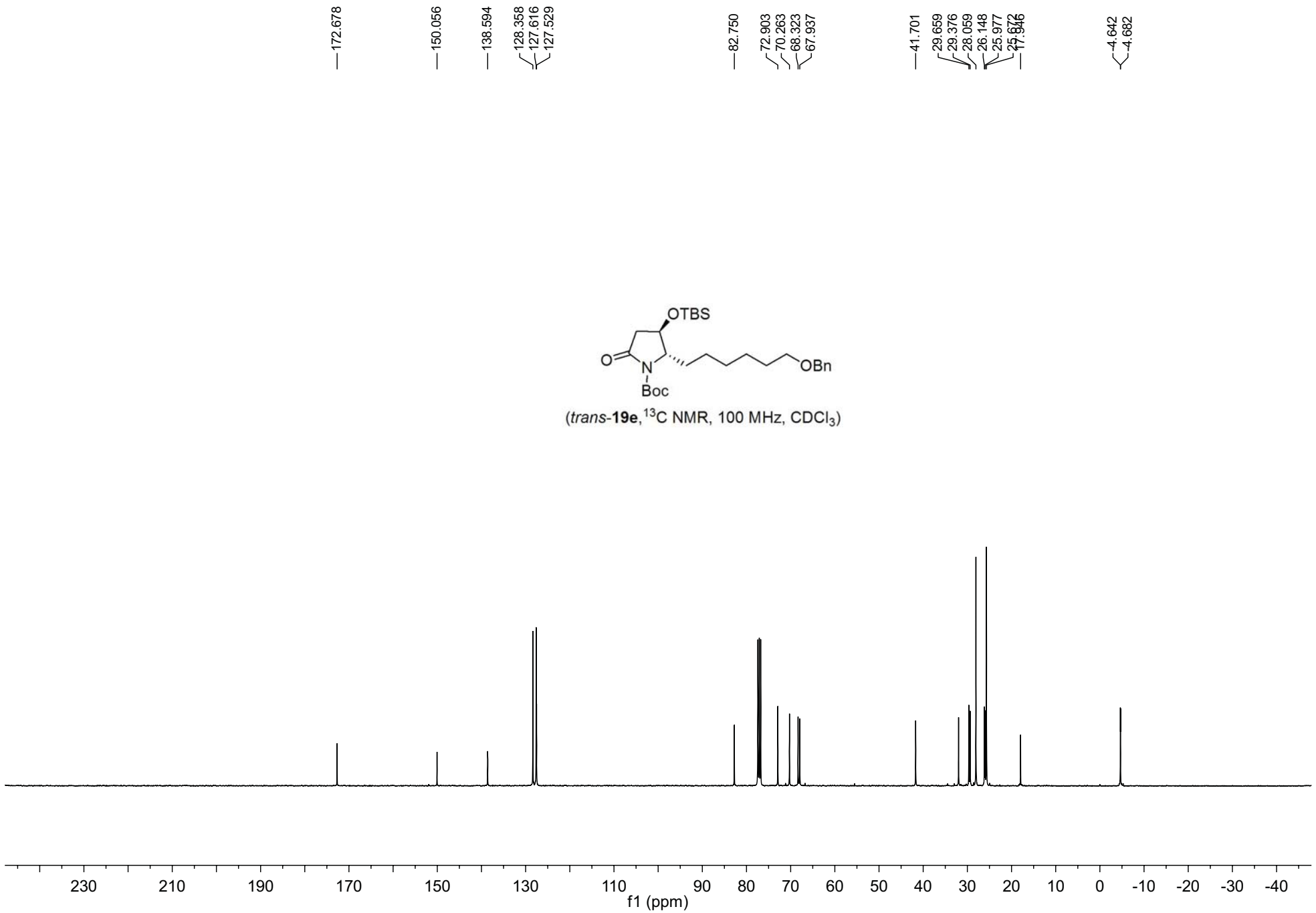


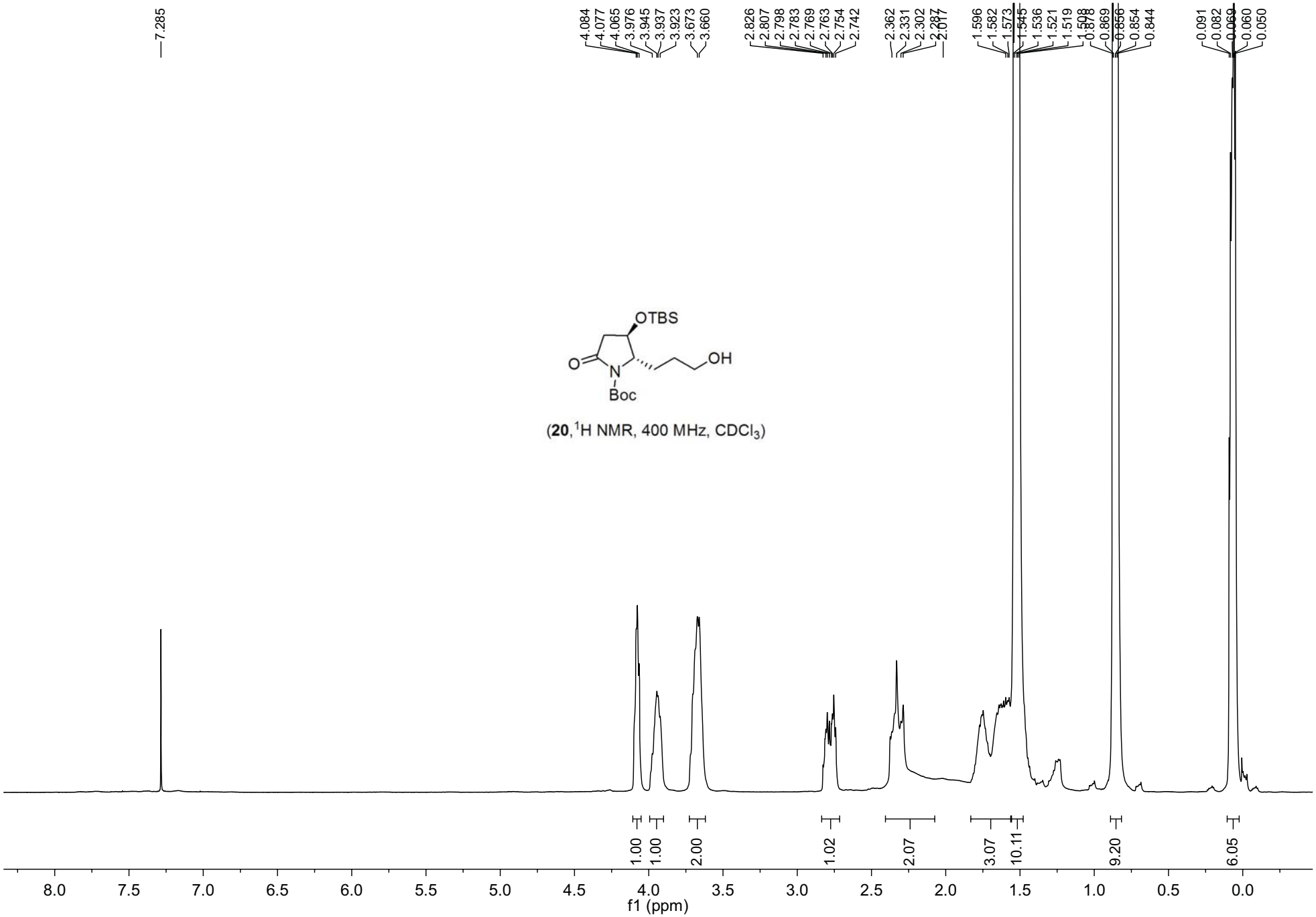
(*trans*-**19d**,^{13}C NMR, 100 MHz, $CDCl_3$)


7.201
7.188
7.177
7.167
7.149
7.138
7.134
7.128
7.124
7.118
7.113
7.107
4.343
4.063
4.060
4.050
3.768
3.763
3.333
3.330
3.323
3.319
3.312
3.308
2.176
2.163
2.154
2.151
2.141
2.128
1.857
1.852
1.847
1.519
1.509
1.503
1.497
1.487
1.477
1.366
1.273
0.741
0.000
-0.029
OTBS
O
N
Boc
OBn
(cis-19d,1H NMR, 400 MHz, CDCl3)
5.74
2.01
0.96
1.00
2.11
1.00
1.00
4.01
9.01
2.14
9.01
5.90
f1 (ppm)

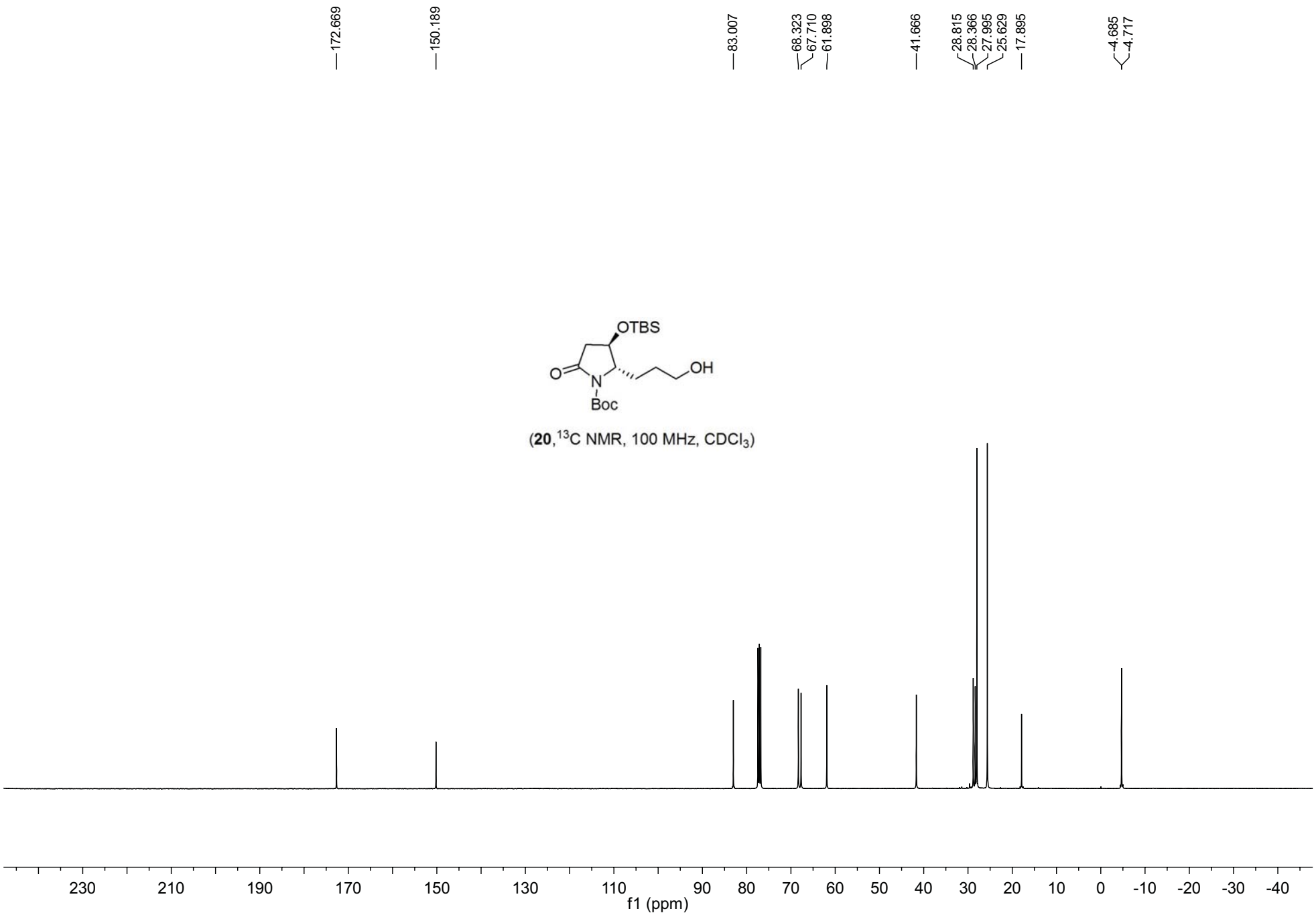

172.809
150.285
138.540
128.375
127.625
127.549
82.981
72.950
71.214
70.124
55.305
34.571
32.988
29.631
28.060
25.724
21.811
18.169
-4.527
-5.258
OTBS
O
N
Boc
OBn
(cis-19d,13C NMR, 100 MHz, CDCl3)
f1 (ppm)

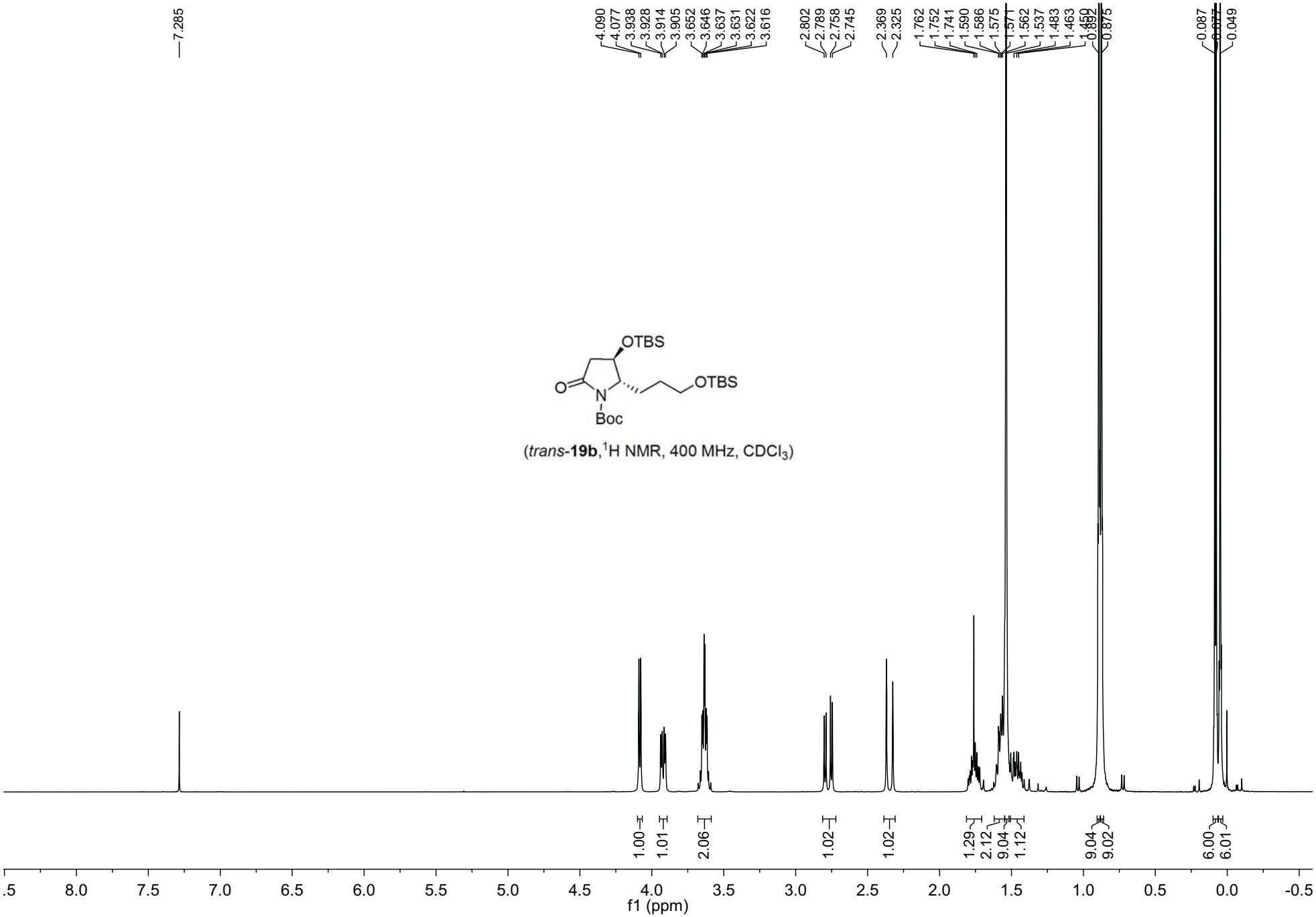

7.383
7.381
7.377
7.367
7.362
7.357
7.348
7.336
7.326
7.314
7.307
7.304
7.292
7.286
7.282
7.279
7.271
4.516
4.076
4.063
3.939
3.931
3.918
3.909
3.500
3.484
3.467
2.802
2.789
2.758
2.745
2.369
2.349
2.325
1.785
1.686
1.651
1.633
1.616
1.545
1.453
1.444
1.402
1.384
0.893
0.886
0.878
0.093
0.085
OTBS
O
N
Boc
OBn
(trans-19e, 1H NMR, 400 MHz, CDCl3)
5.42
2.09
1.02
1.01
2.12
1.00
1.03
2.18
9.00
7.60
9.00
6.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

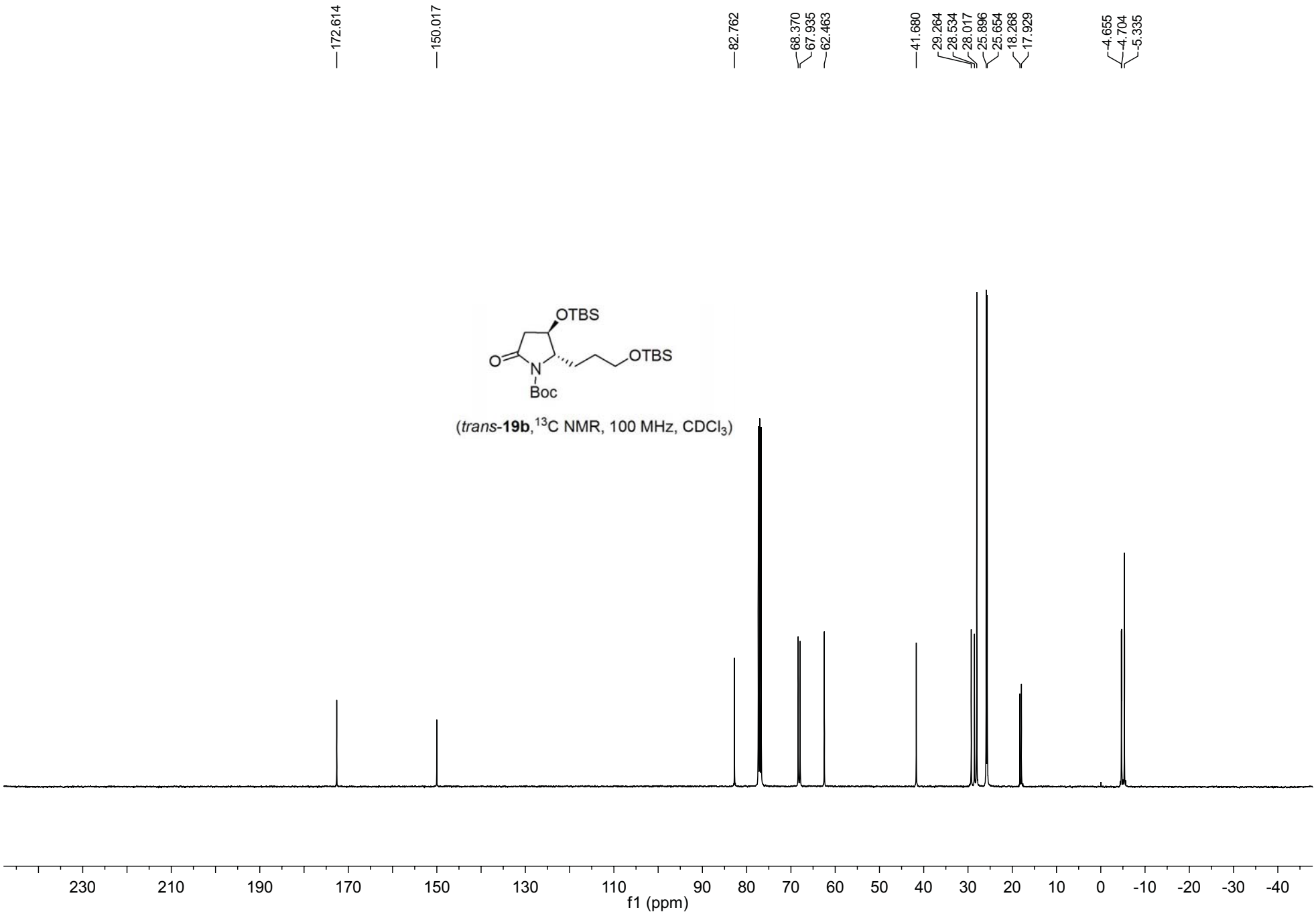

172.678
150.056
138.594
128.358
127.616
127.529
82.750
72.903
70.263
68.323
67.937
41.701
29.659
29.376
28.059
26.148
25.977
17.946
-4.642
-4.682
OTBS
O
N
Boc
OBn
(trans-19e, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

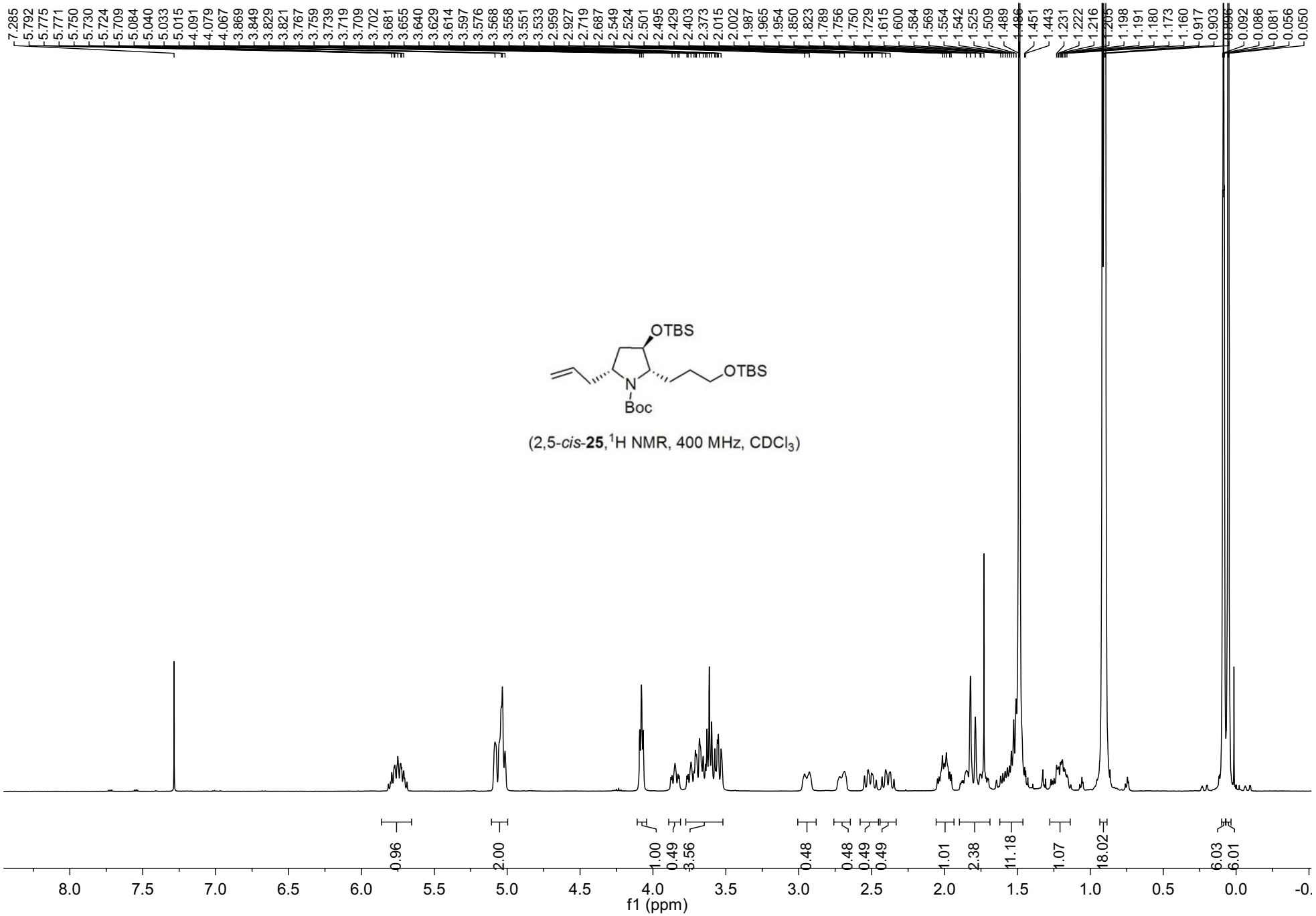


(**20**, ^{1}H NMR, 400 MHz, $CDCl_3$)

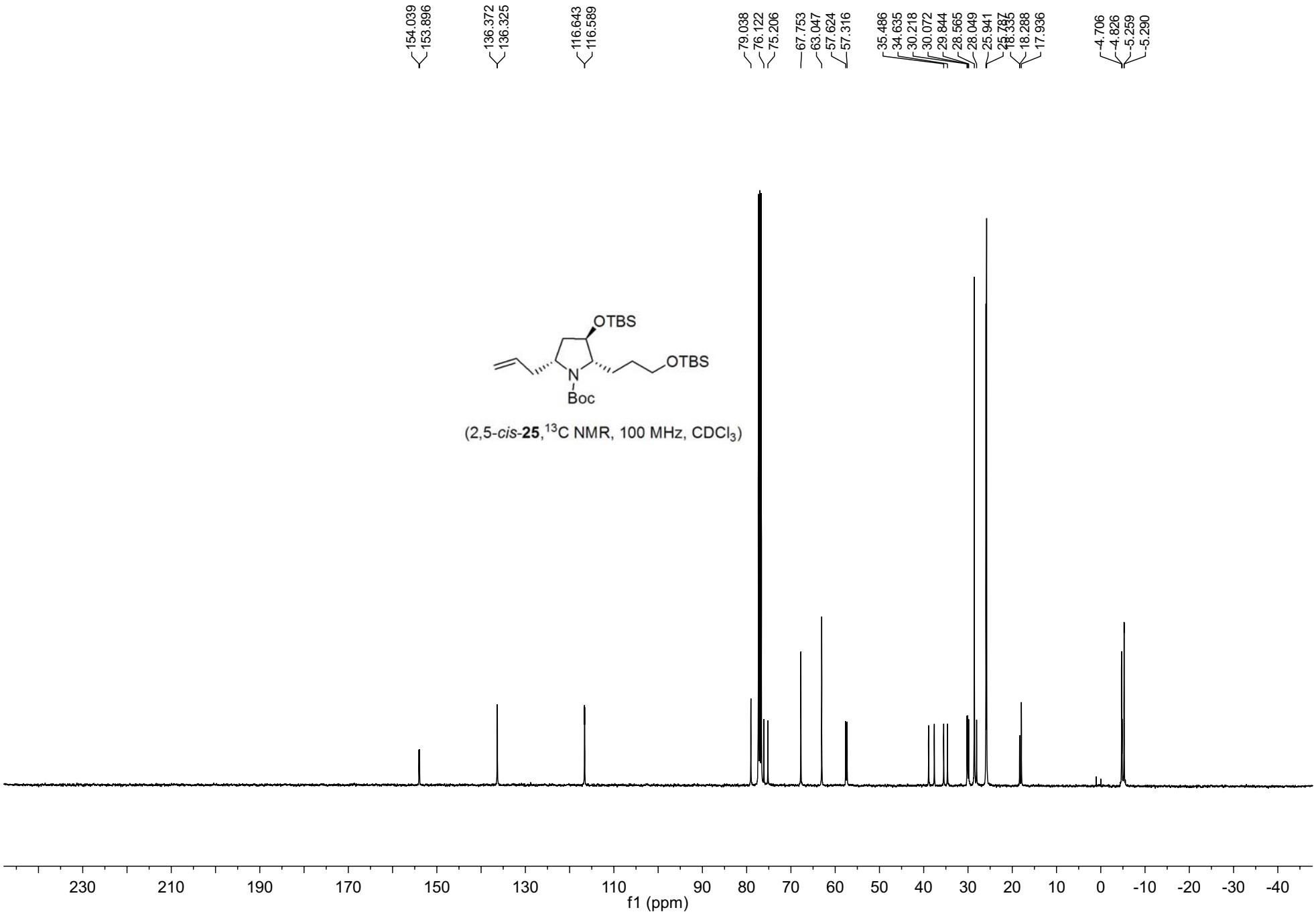

172.669
150.189
83.007
68.323
67.710
61.898
41.666
28.815
28.366
27.995
25.629
17.895
-4.685
-4.717
OTBS
OH
O
N
Boc
(20,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

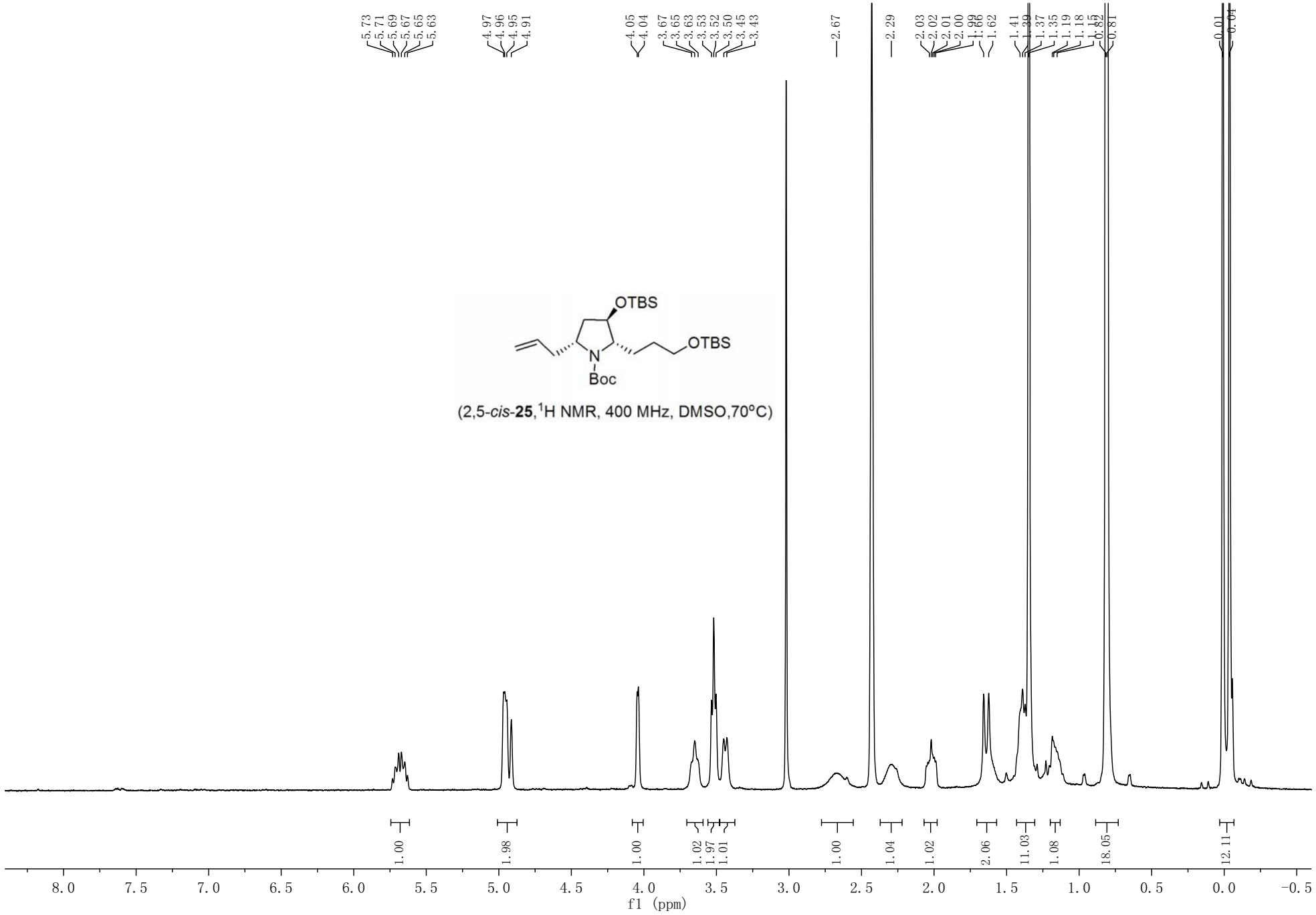

7.285
4.090
4.077
3.938
3.928
3.914
3.905
3.652
3.646
3.637
3.631
3.622
3.616
2.802
2.789
2.758
2.745
2.369
2.325
1.762
1.752
1.741
1.590
1.586
1.575
1.571
1.562
1.537
1.483
1.463
0.875
0.087
0.077
0.049
OTBS
OTBS
O
N
Boc
(trans-19b,1H NMR, 400 MHz, CDCl3)
1.00
1.01
2.06
1.02
1.02
1.29
2.12
9.04
1.12
9.04
9.02
6.00
6.01
f1 (ppm)

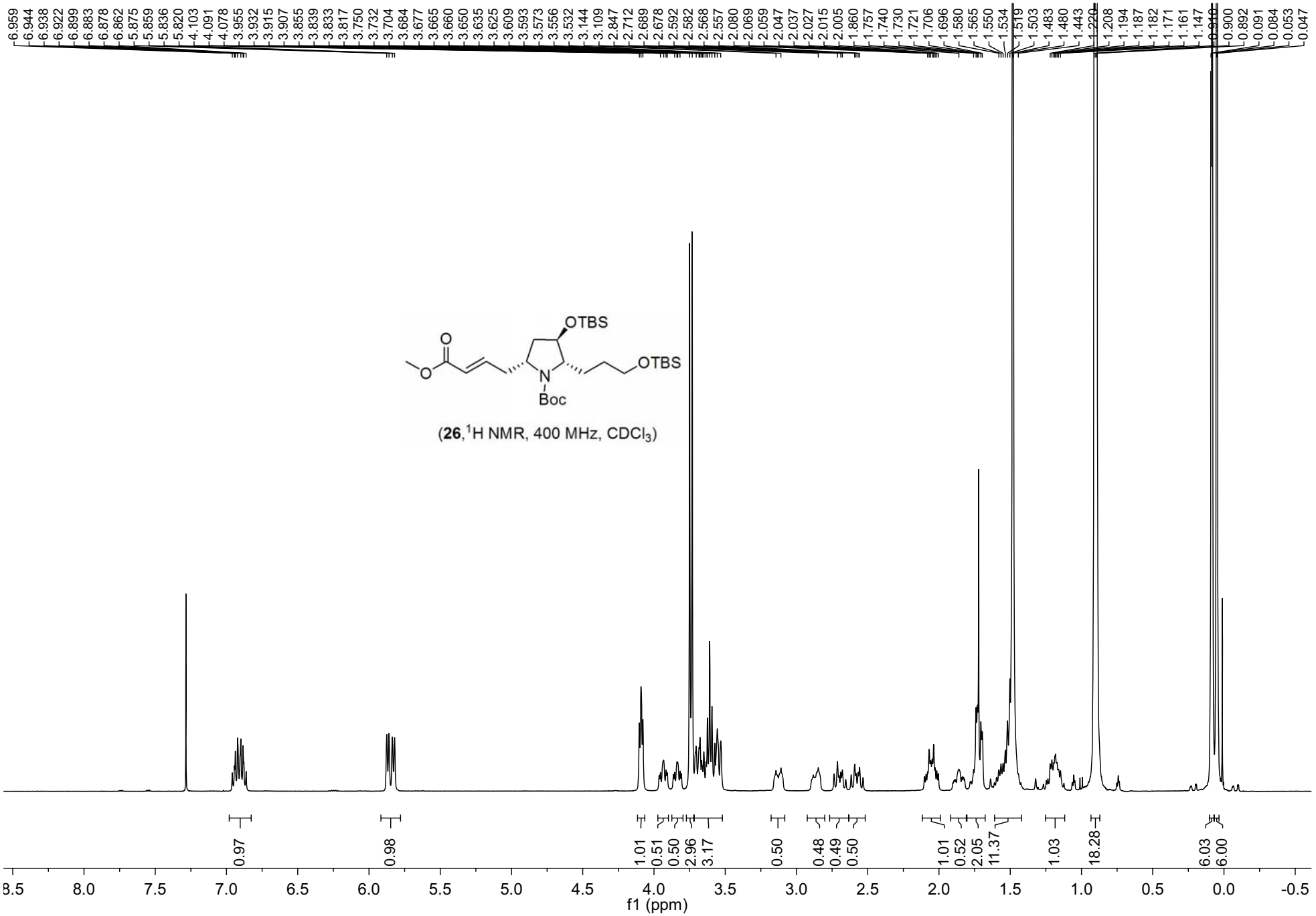

172.614
150.017
82.762
68.370
67.935
62.463
41.680
29.264
28.534
28.017
25.896
25.654
18.268
17.929
-4.655
-4.704
-5.335
OTBS
OTBS
O
N
Boc
(trans-19b,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

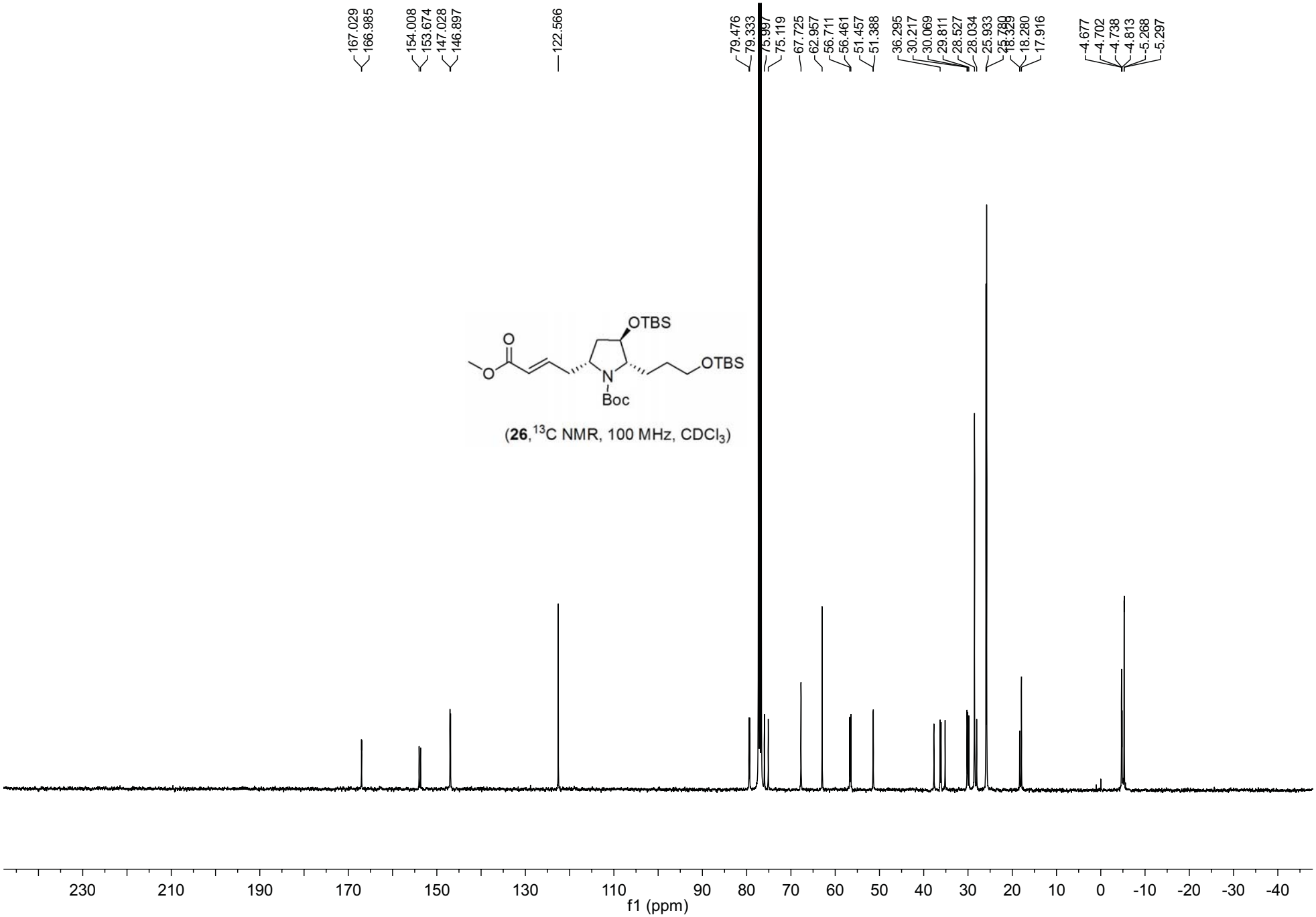


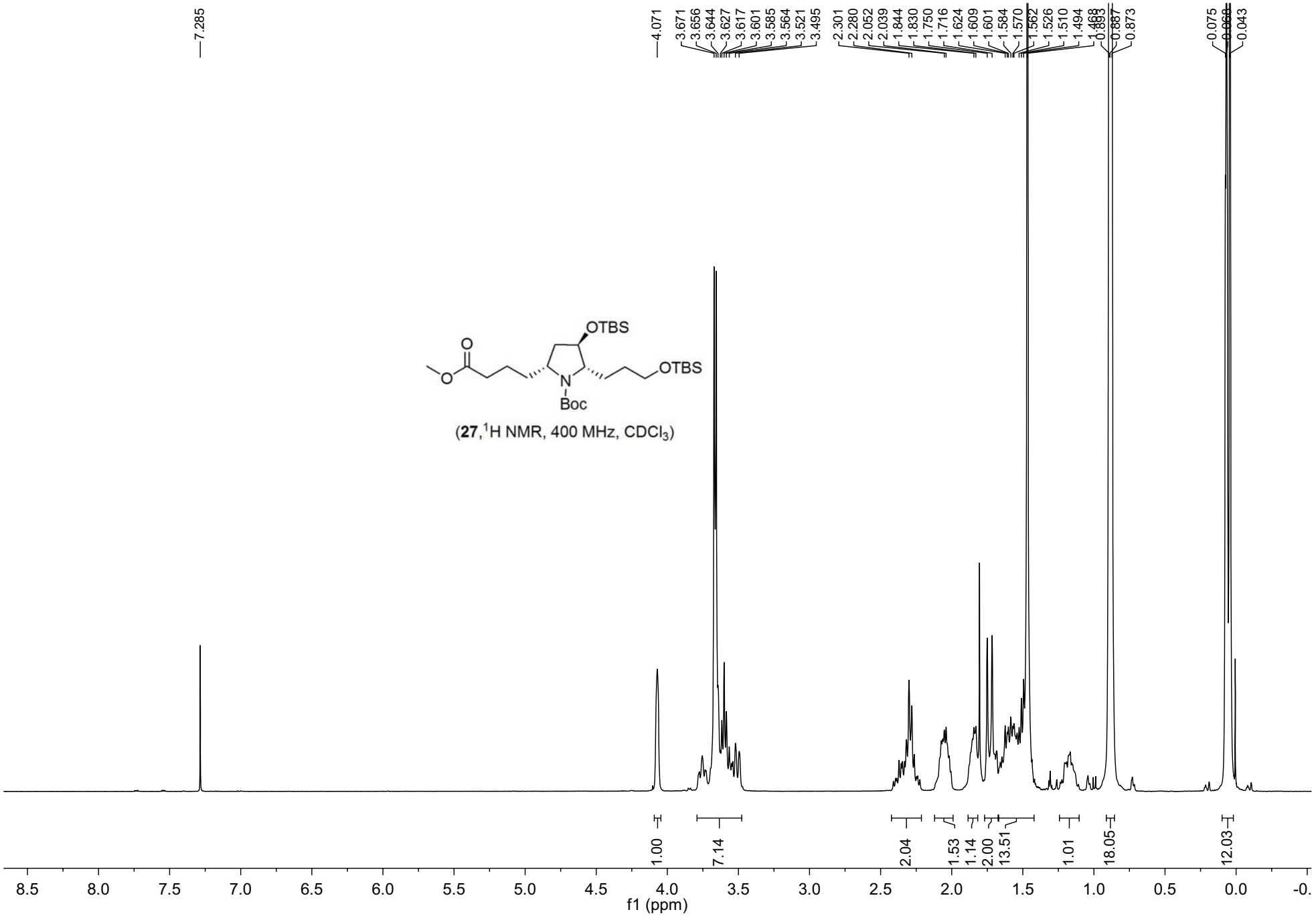
(2,5-*cis*-**25**, ^{1}H NMR, 400 MHz, $CDCl_3$)

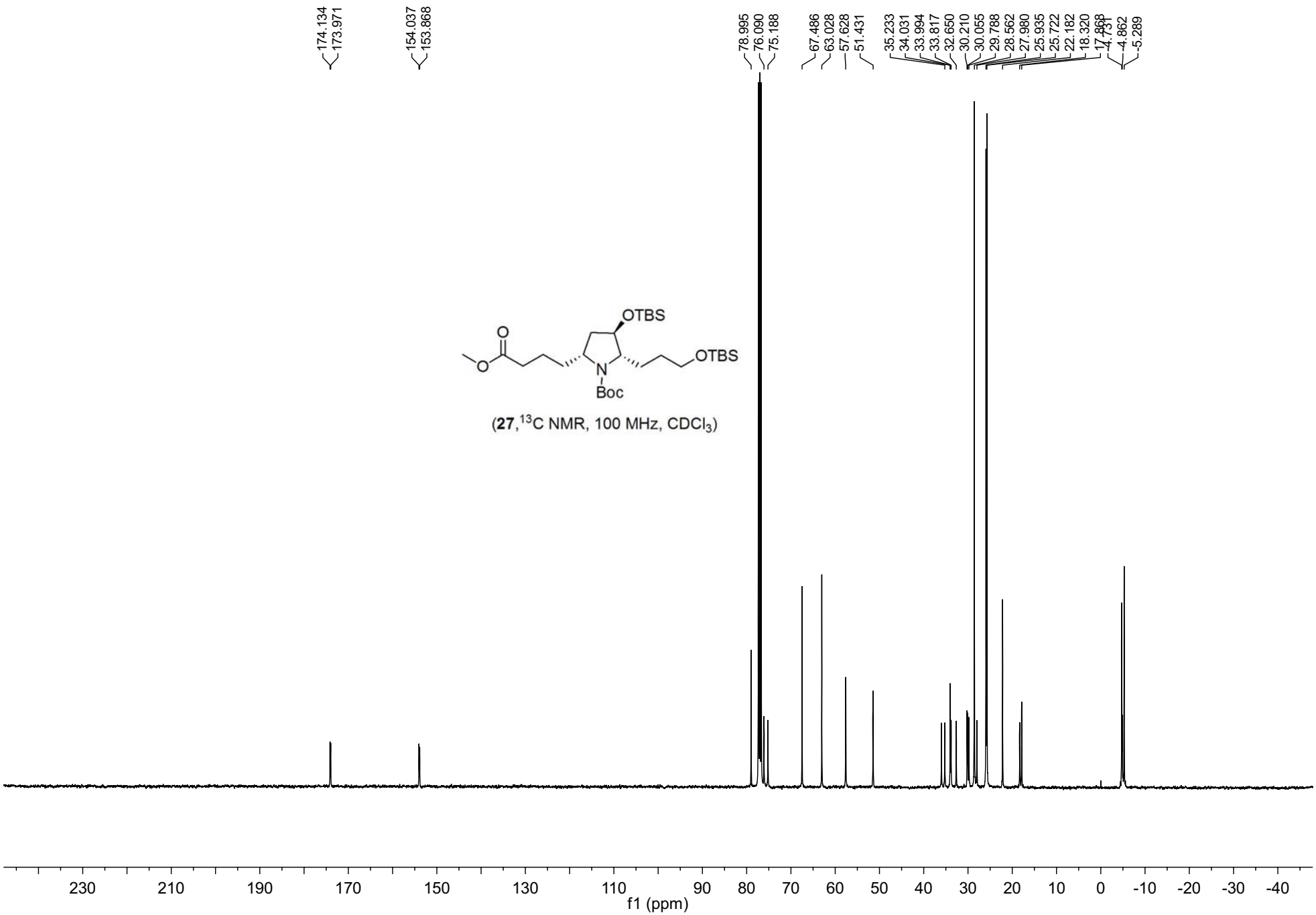

154.039
153.896
136.372
136.325
116.643
116.589
79.038
76.122
75.206
67.753
63.047
57.624
57.316
35.486
34.635
30.218
30.072
29.844
28.565
28.049
25.941
25.787
18.335
18.288
17.936
-4.706
-4.826
-5.259
-5.290
OTBS
OTBS
N
Boc
(2,5-cis-25,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)

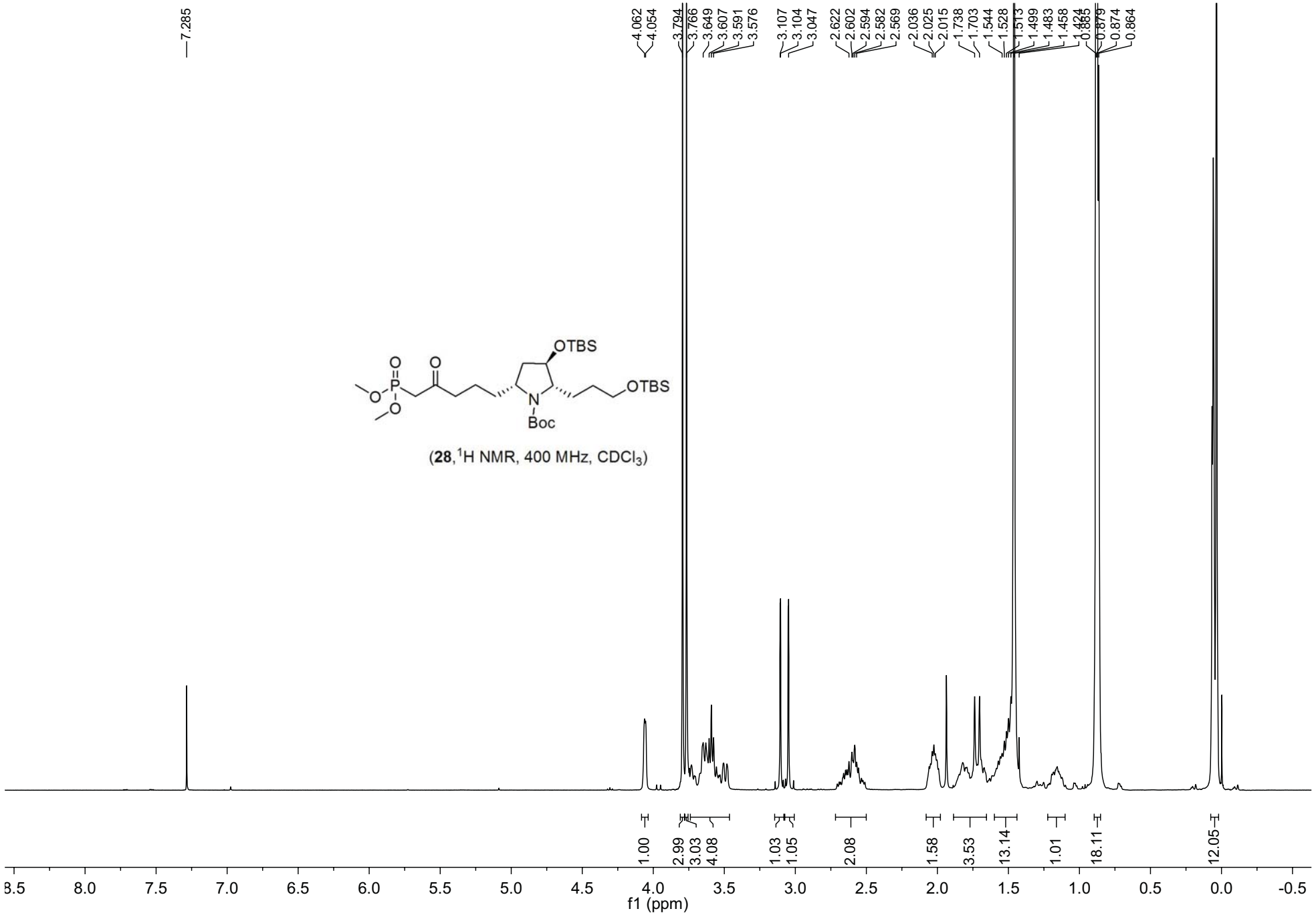

OTBS
OTBS
N
Boc
(2,5-cis-25,1H NMR, 400 MHz, DMSO,70°C)
f1 (ppm)

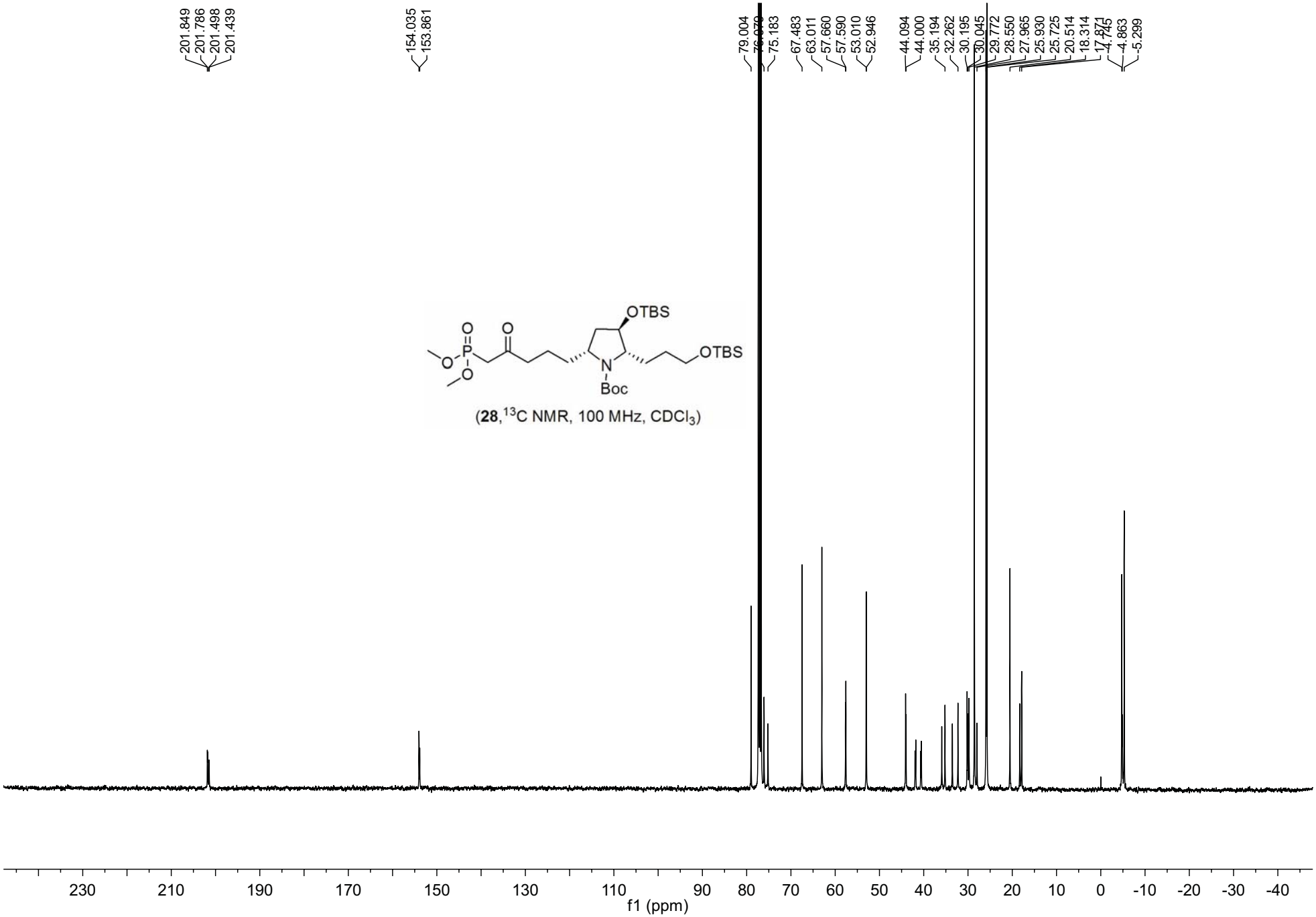

OTBS
O
O
N
Boc
OTBS
(26,1H NMR, 400 MHz, CDCl3)
f1 (ppm)


167.029
166.985
154.008
153.674
147.028
146.897
122.566
79.476
79.333
75.997
75.119
67.725
62.957
56.711
56.461
51.457
51.388
36.295
30.217
30.069
29.811
28.527
28.034
25.933
18.280
17.916
-4.677
-4.702
-4.738
-4.813
-5.268
-5.297
OTBS
OTBS
O
O
N
Boc
(26, 13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)


7.285
4.071
3.671
3.656
3.644
3.627
3.617
3.601
3.585
3.564
3.521
3.495
2.301
2.280
2.052
2.039
1.844
1.830
1.750
1.716
1.624
1.609
1.601
1.584
1.570
1.562
1.526
1.510
1.494
0.887
0.873
0.075
0.043
OTBS
OTBS
O
O
N
Boc
(27,1H NMR, 400 MHz, CDCl3)
1.00
7.14
2.04
1.53
1.14
2.00
13.51
1.01
18.05
12.03
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

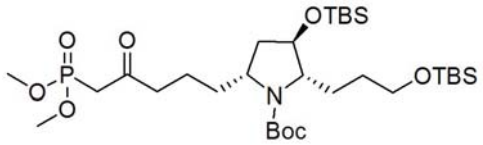

174.134
173.971
154.037
153.868
78.995
76.090
75.188
67.486
63.028
57.628
51.431
35.233
34.031
33.994
33.817
32.650
30.210
30.055
29.788
28.562
27.980
25.935
25.722
22.182
18.320
17.968
17.731
-4.862
-5.289
OTBS
O
O
N
Boc
OTBS
(27,13C NMR, 100 MHz, CDCl3)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)


7.285
4.062
4.054
3.794
3.766
3.649
3.607
3.591
3.576
3.107
3.104
3.047
2.622
2.602
2.594
2.582
2.569
2.036
2.025
2.015
1.738
1.703
1.544
1.528
1.513
1.499
1.483
1.458
1.424
0.885
0.879
0.874
0.864
OTBS
OTBS
N
Boc
(28, 1H NMR, 400 MHz, CDCl3)
1.00
2.99
3.03
4.08
1.03
1.05
2.08
1.58
3.53
13.14
1.01
18.11
12.05
f1 (ppm)

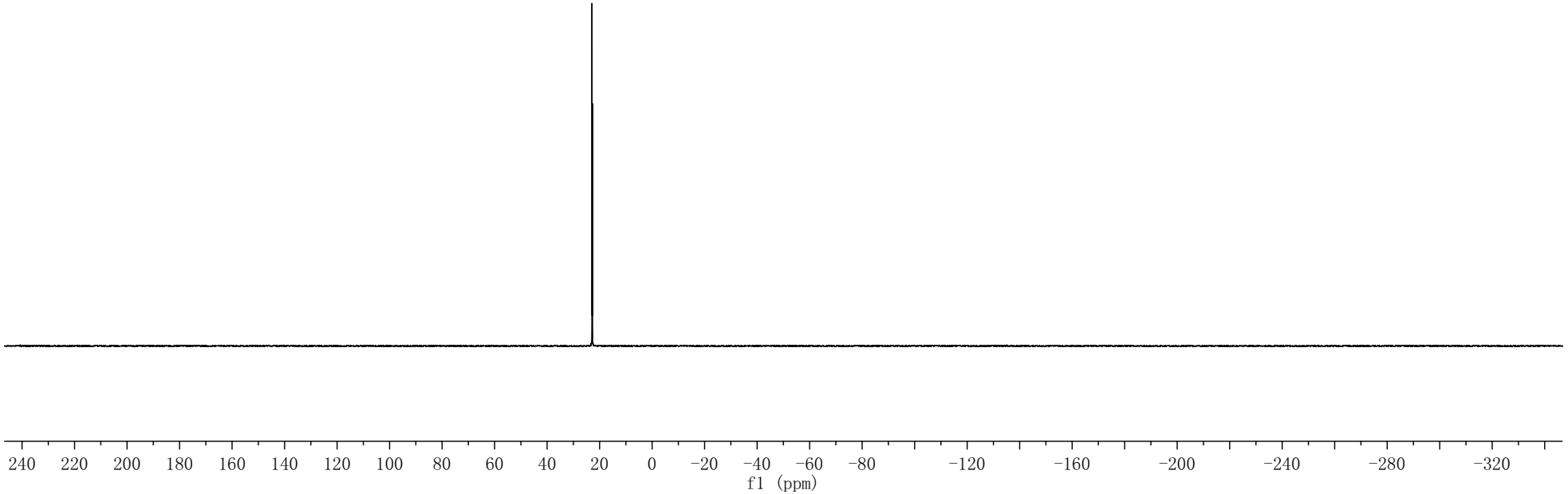


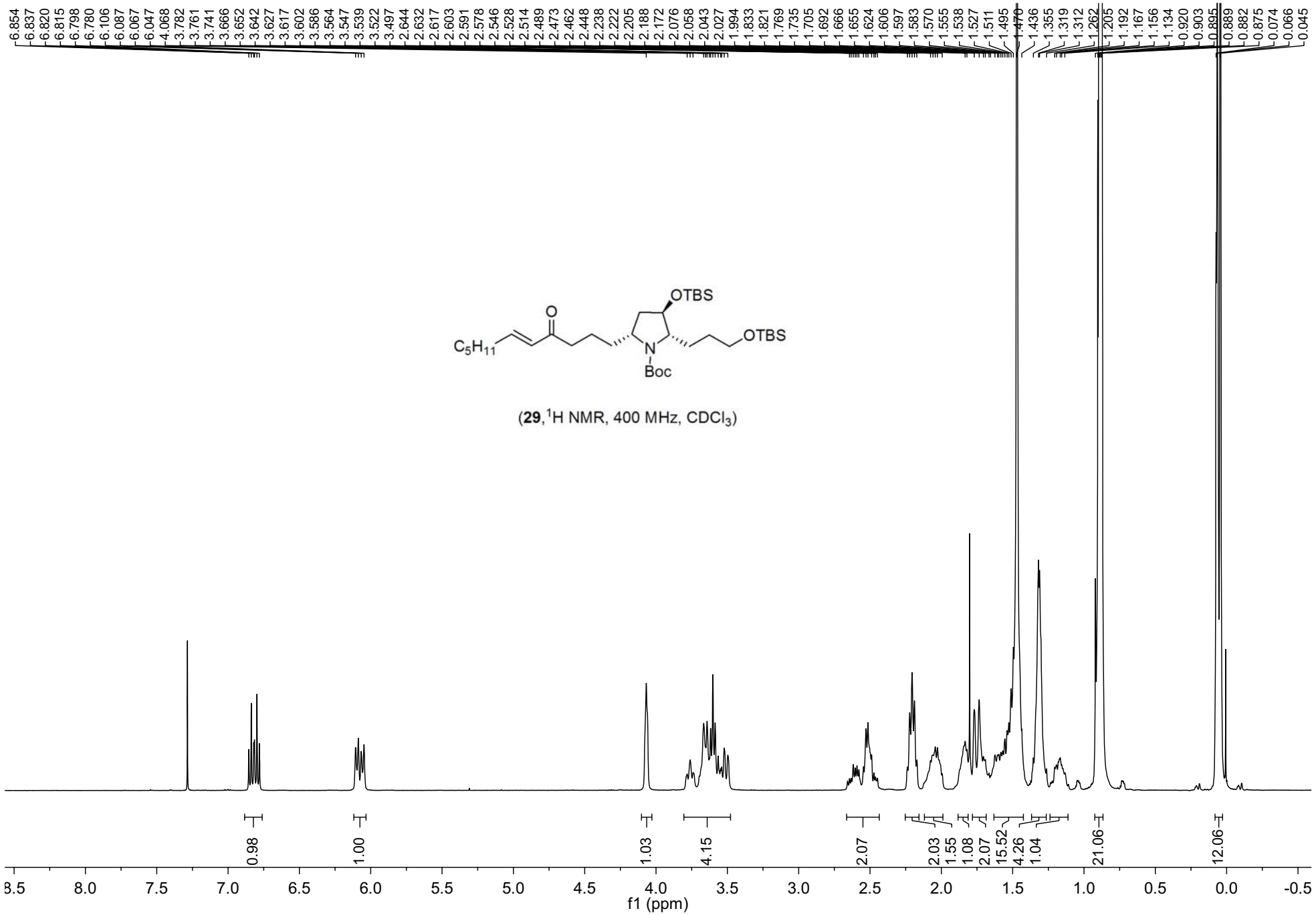
(**28**,^{13}C NMR, 100 MHz, $CDCl_3$)

22.89
22.73

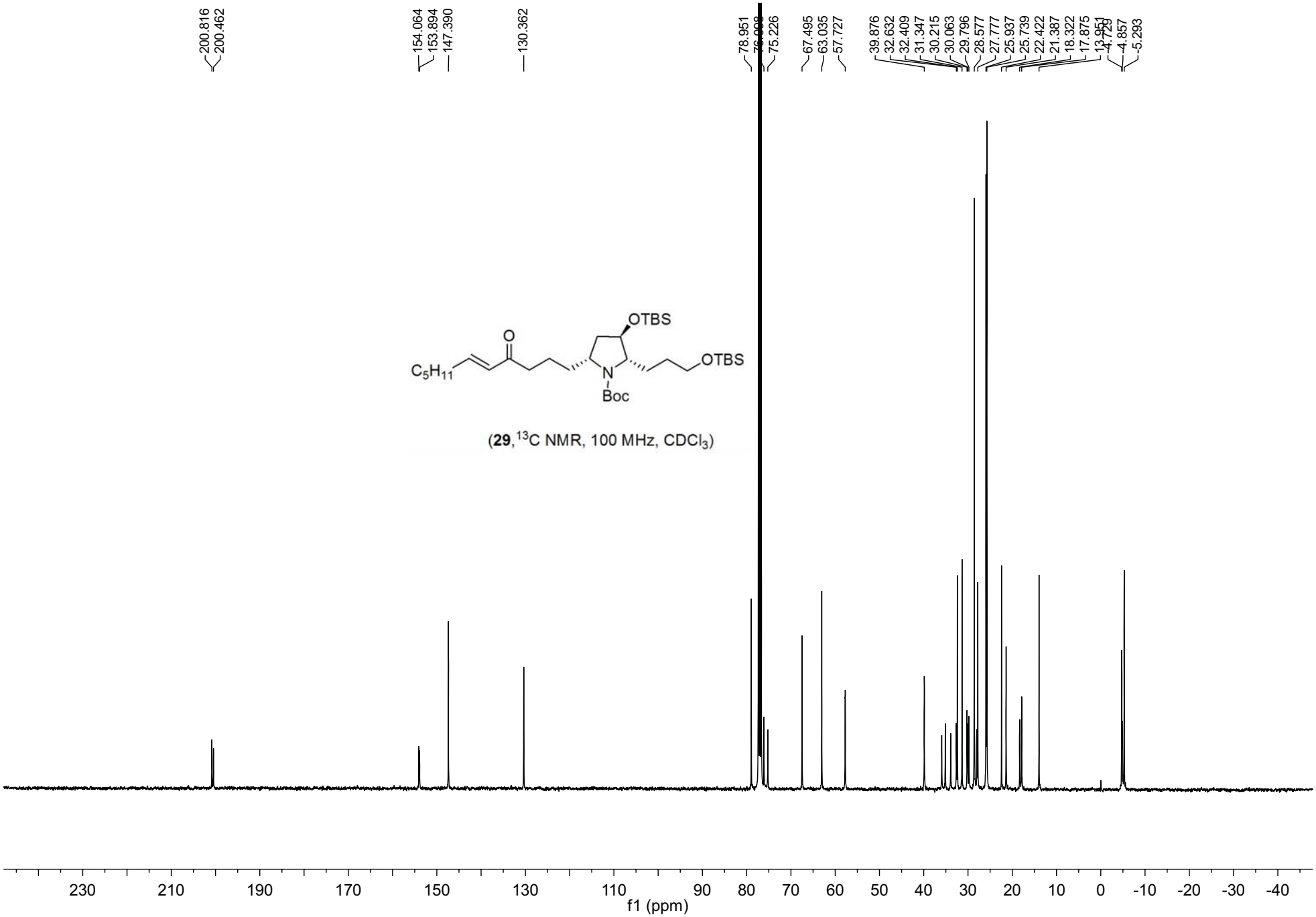


(**28**,^{31}P NMR, 121.5 MHz, $CDCl_3$)

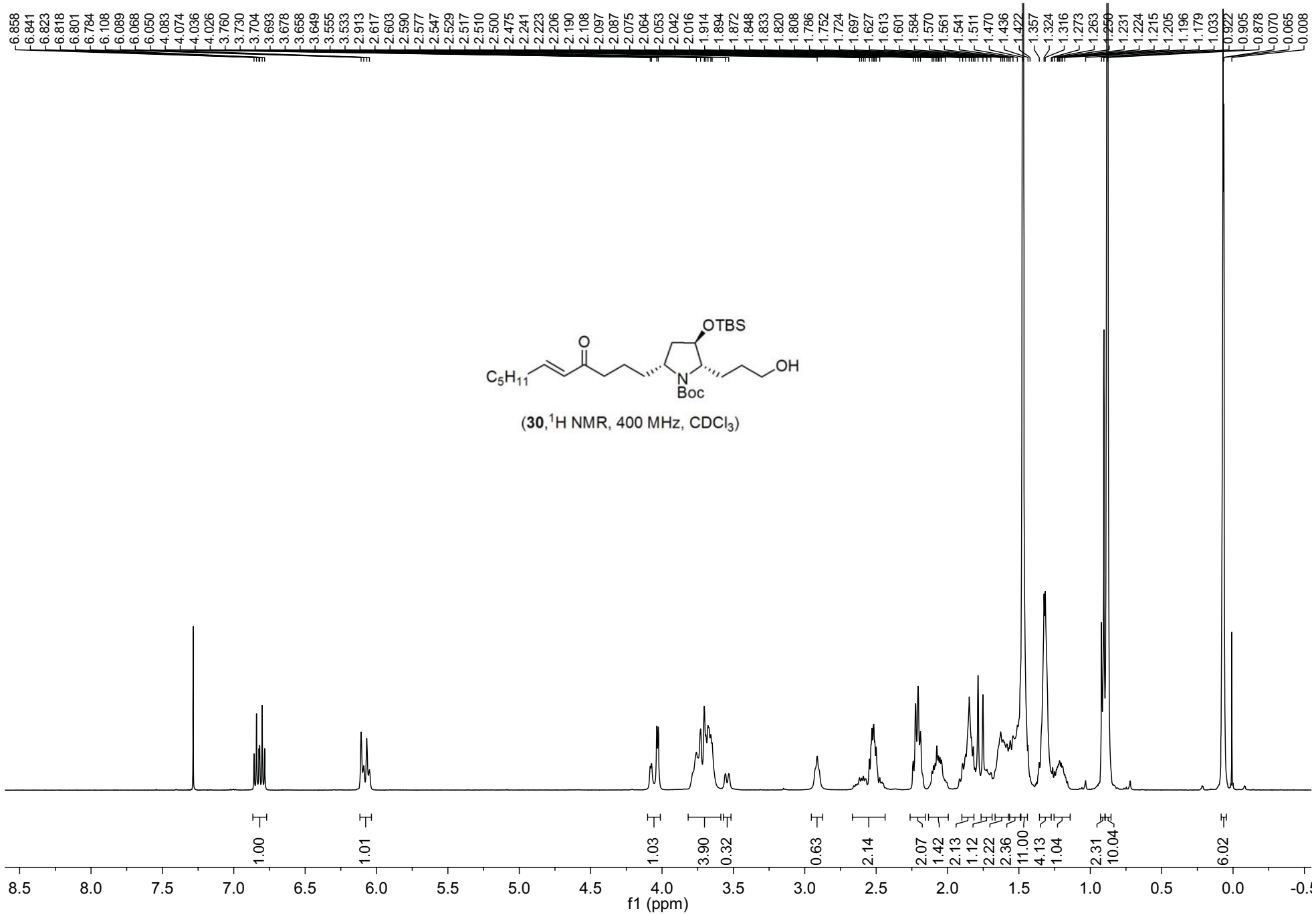


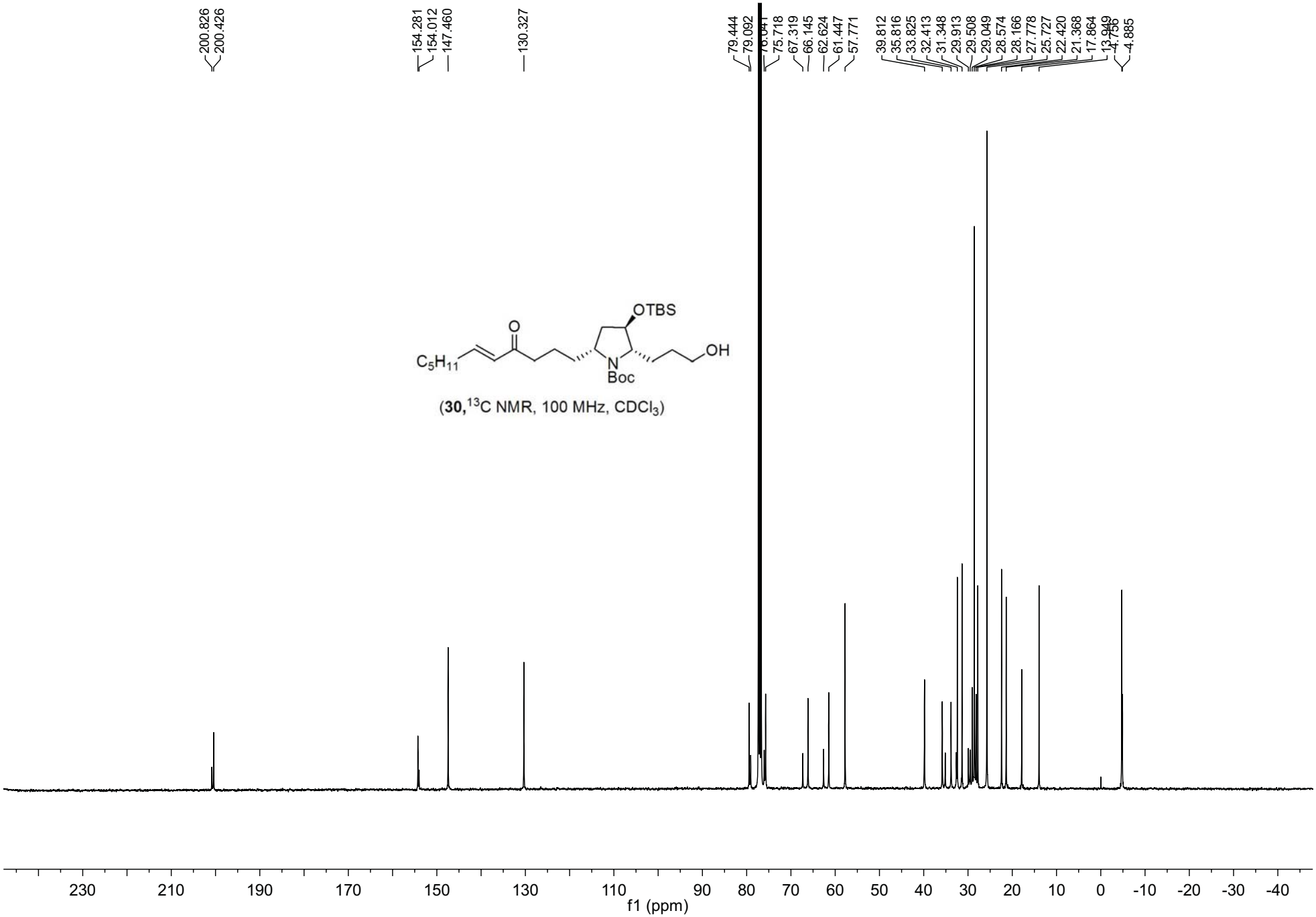


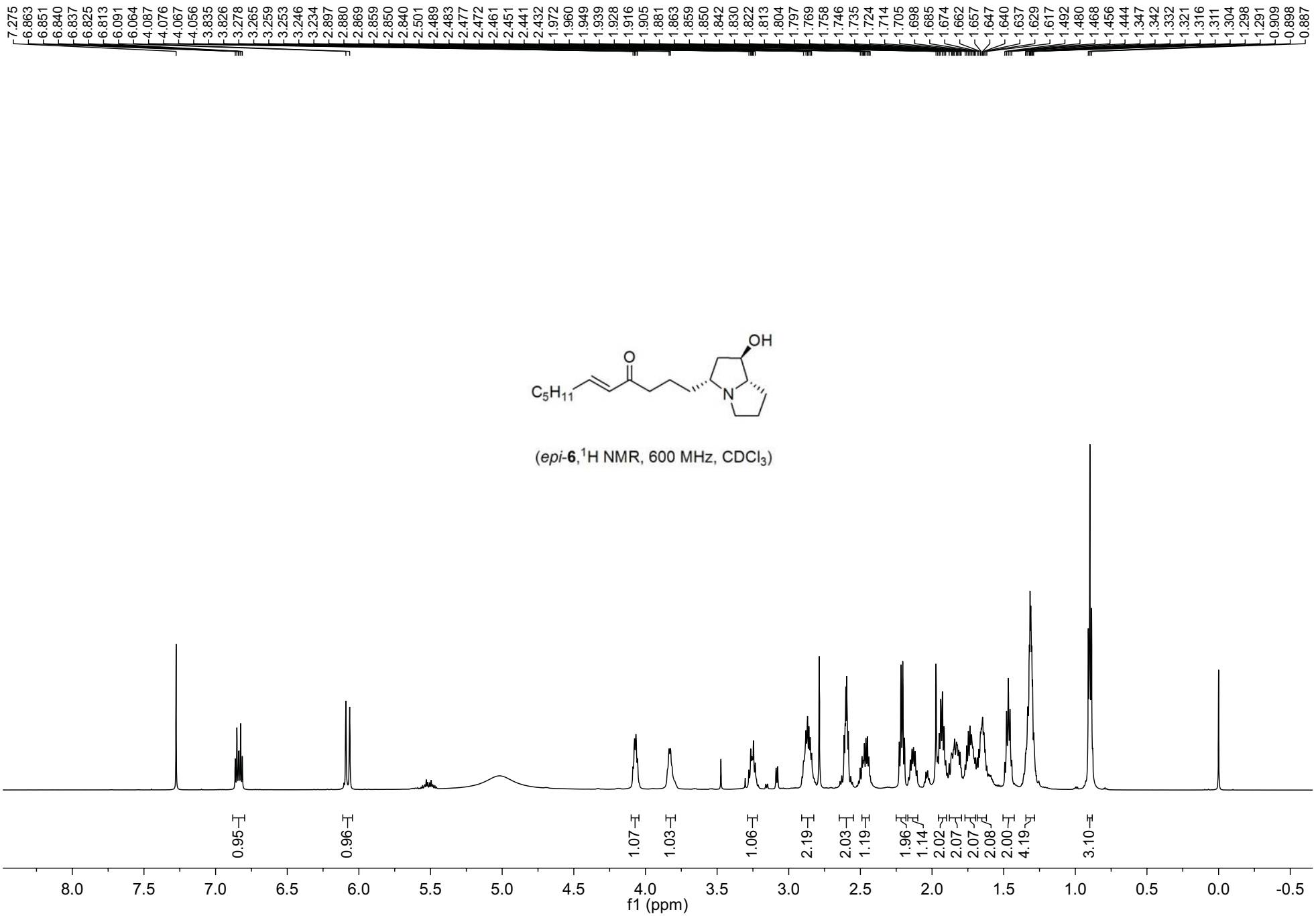
(**29**, ^{1}H NMR, 400 MHz, $CDCl_3$)

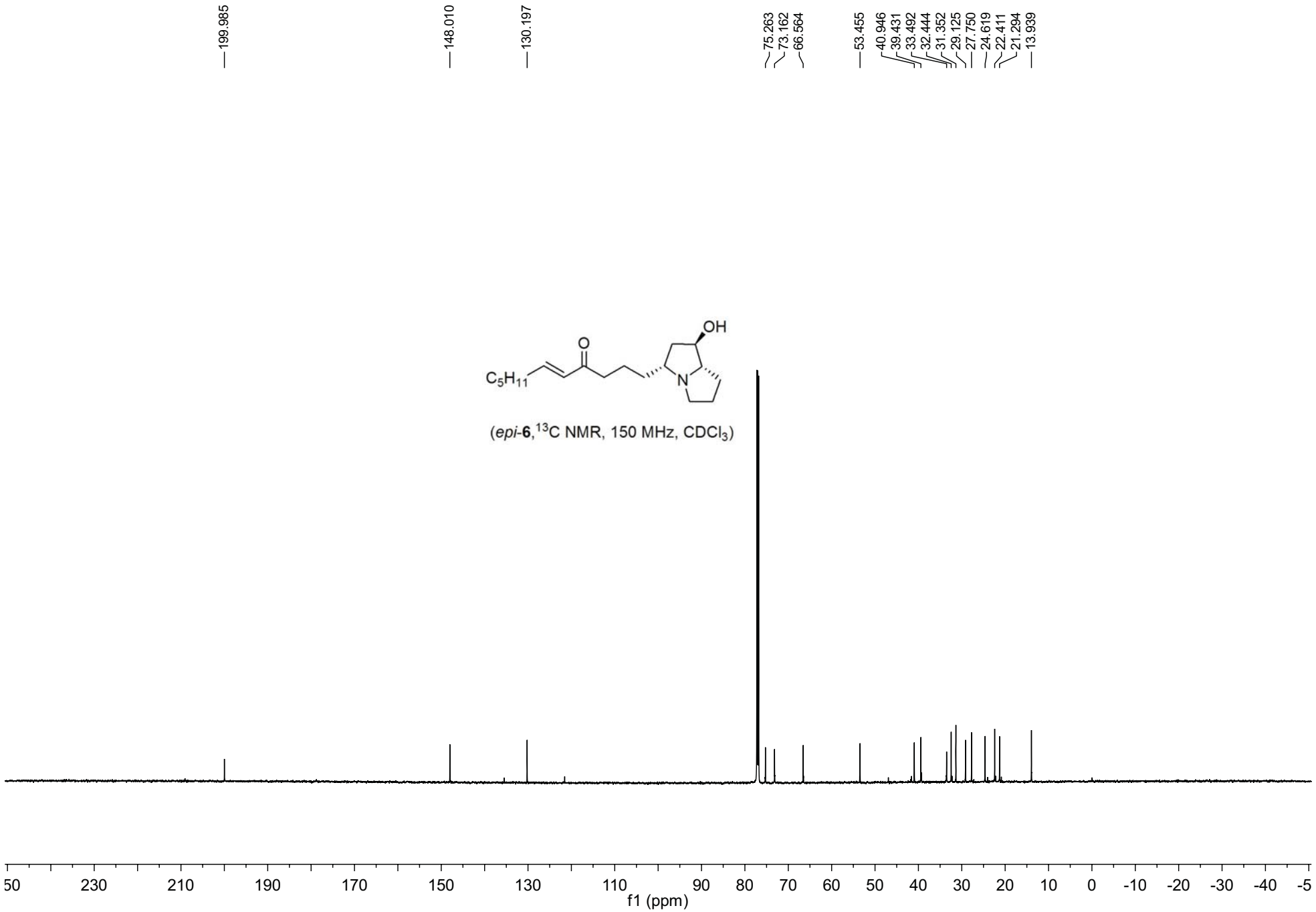


(**29**, ^{13}C NMR, 100 MHz, $CDCl_3$)


6.858 6.841 6.823 6.818 6.801 6.784 6.108 6.089 6.068 6.050 4.083 4.074 4.036 4.026 3.760 3.730 3.704 3.693 3.678 3.658 3.649 3.555 3.533 2.913 2.617 2.603 2.590 2.577 2.547 2.529 2.517 2.510 2.500 2.475 2.241 2.223 2.206 2.190 2.108 2.097 2.087 2.075 2.064 2.053 2.042 2.016 1.914 1.894 1.872 1.848 1.833 1.820 1.808 1.786 1.752 1.724 1.697 1.627 1.613 1.601 1.584 1.570 1.561 1.541 1.511 1.470 1.436 1.422 1.357 1.324 1.316 1.273 1.263 1.250 1.231 1.224 1.215 1.205 1.196 1.179 1.033 0.922 0.905 0.878 0.070 0.065 0.008
OTBS
O
OH
N
Boc
C_5H_{11}
(**30**,^{1}H NMR, 400 MHz, $CDCl_3$)
1.00 1.01 1.03 3.90 0.32 0.63 2.14 2.07 1.42 2.13 1.12 2.22 2.36 11.00 4.13 1.04 2.31 10.04 6.02
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


200.826
200.426
154.281
154.012
147.460
130.327
79.444
79.092
78.041
75.718
67.319
66.145
62.624
61.447
57.771
39.812
35.816
33.825
32.413
31.348
29.913
29.508
29.049
28.574
28.166
27.778
25.727
22.420
21.368
17.864
13.949
-4.755
-4.885
OTBS
O
OH
N
Boc
C_5H_{11}
(**30**,^{13}C NMR, 100 MHz, $CDCl_3$)
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
f1 (ppm)


7.275
6.863
6.851
6.840
6.837
6.825
6.813
6.091
6.064
4.087
4.076
4.067
4.056
3.835
3.826
3.278
3.265
3.259
3.253
3.246
3.234
2.897
2.880
2.869
2.859
2.850
2.840
2.501
2.489
2.483
2.477
2.472
2.461
2.451
2.441
2.432
1.972
1.960
1.949
1.939
1.928
1.916
1.905
1.881
1.863
1.859
1.850
1.842
1.830
1.822
1.813
1.804
1.797
1.769
1.758
1.746
1.735
1.724
1.714
1.705
1.698
1.685
1.674
1.662
1.657
1.647
1.640
1.637
1.629
1.617
1.492
1.480
1.468
1.456
1.444
1.347
1.342
1.332
1.321
1.316
1.311
1.304
1.298
1.291
0.909
0.898
0.887
OH
O
C5H11
N
(epi-6,1H NMR, 600 MHz, CDCl3)
0.95
0.96
1.07
1.03
1.06
2.19
2.03
1.19
1.96
1.14
2.02
2.07
2.07
2.08
2.00
4.19
3.10
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


199.985
148.010
130.197
75.263
73.162
66.564
53.455
40.946
39.431
33.492
32.444
31.352
29.125
27.750
24.619
22.411
21.294
13.939
OH
O
C_5H_{11}
N
(*epi*-**6**, ^{13}C NMR, 150 MHz, $CDCl_3$)
f1 (ppm)