Electronic Supplementary Information

Syntheses of Polynorbornadienes by Ring-Opening Metathesis Polymerizations (ROMP) of Symmetric and Non-symmetric 2,3-Bis(alkoxycarbonyl)norbornadienes and Their Conversion to Half-Ester Derivatives

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Diester **1** (isolated yield: 91%). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 2.08 (1H, dt, J = 7.0 Hz and 2.0 Hz), 2.25 (1H, dt, J = 7.0 Hz and 2.0 Hz), 3.76 (6H, s), 3.92 (2H, m), 6.89 (2H, t, J = 1.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 52.11, 53.37, 73.06, 142.45, 152.52, 165.50.

Diester **2** (isolated yield: 89%). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 1.29 (6H, t, J = 7.0 Hz), 2.07 (1H, d, J = 6.5 Hz), 2.27 (1H, d, J = 7.0 Hz), 3.92 (2H, m), 4.22 (4H, q, J = 7.0 Hz), 6.91 (2H, t, J = 2.0 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 14.25, 53.54, 61.11, 73.00, 142.53, 152.26, 165.40.

Diester **3** (isolated yield: 82%). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 0.95 (6H, t, J = 7.0 Hz), 1.69 (4H, m), 2.08 (1H, d, J = 7.0 Hz), 2.28 (1H, d, J = 6.0 Hz), 3.92 (2H, m), 4.12 (4H, t, J = 6.0 Hz), 6.91 (2H, t, J = 1.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 10.54, 22.03, 53.58, 66.73, 72.94, 142.55, 152.24, 165.47.

Diester **4** (isolated yield: 86%). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 1.28 (12H, d, J = 7.0 Hz), 2.05 (1H, dt, J = 6.5 Hz and 1.5Hz), 2.27 (1H, dt, J = 6.5 Hz and 1.5Hz), 3.89 (2H, m), 5.08 (2H, m), 6.90 (2H, t, J = 2.0 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 21.95, 53.56, 68.77, 72.87, 142.56, 152.07, 165.06.

Diester **5** (isolated yield: 79%). White solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 1.48 (18H, s), 1.99 (1H, d, J = 7.0 Hz), 2.26 (1H, d, J = 7.0 Hz), 3.82 (2H, m), 6.87 (2H, t, J = 1.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ=28.25, 53.61, 72.41, 81.53, 142.47, 152.06, 164.58.

Diester **6**. (isolated yield: 62%). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 2.02 (1H, d, J = 5.5 Hz), 2.22 (1H, d, J = 5.5Hz), 3.97 (2H, s), 5.03 (4H, m), 6.85 (2H, s), 7.25 (10H, m); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 53.63, 66.89, 73.08, 128.39, 128.43, 128.63, 135.59, 142.53, 152.38, 165.12. HRMS Calcd for $C_{23}H_{20}O_4(M+H)^+$: 360.1362. Found: 360.1366.

Polymer **1a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 5.41 (d, 2H, *trans* =CH), 3.94 (br, 2H, =CHC*H*), 3.74 (s, 6H, OCH_3), 2.50 and 1.44 (m, 2H,$CHCH_2CH$); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 38.85 (-*C*H_2-), 44.34 (C=C-*C*H), 52.25 (CH_3), 131.57 (C=C), 142.40 (*C=C*-C=O), 165.40 (C=O).

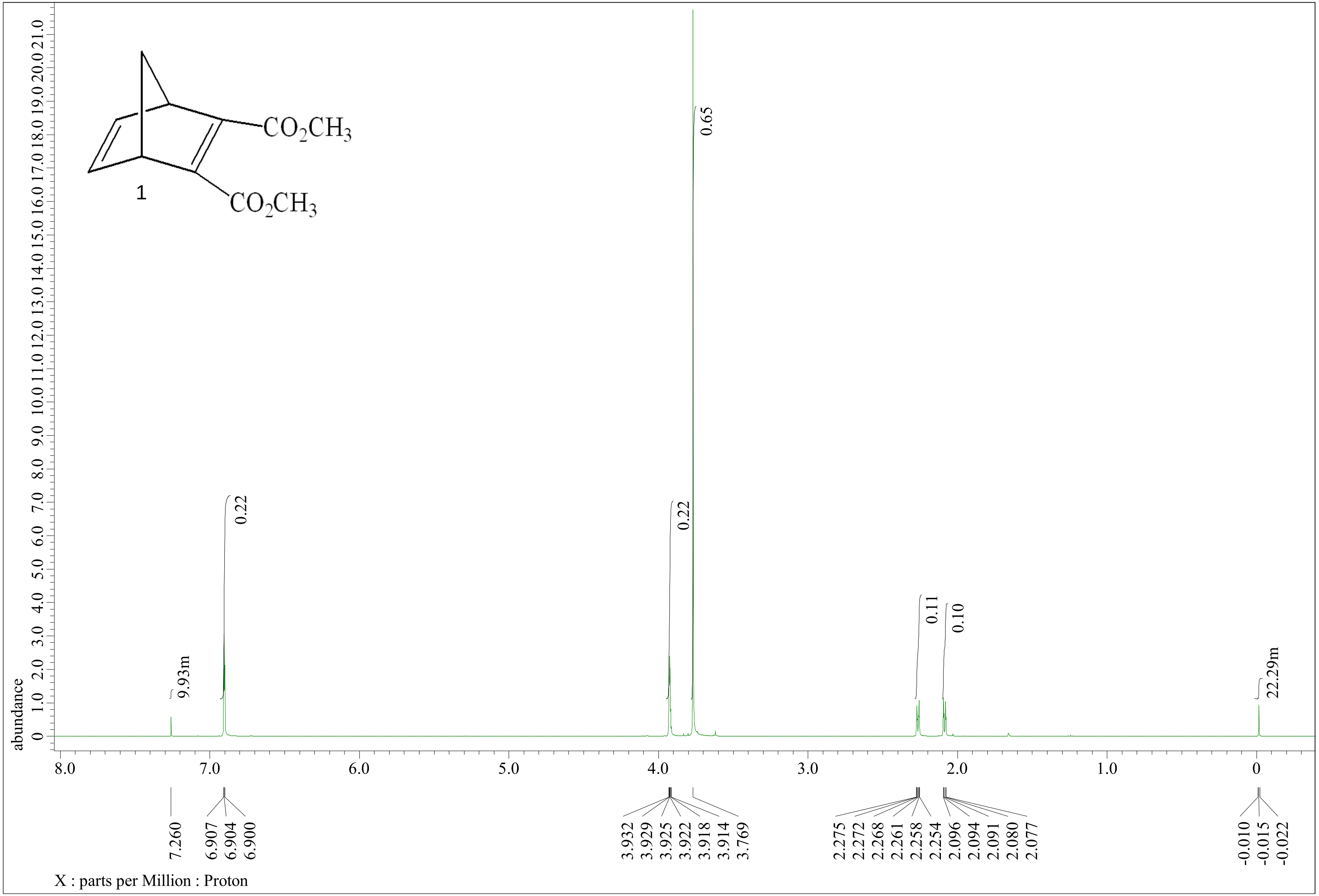
Polymer **2a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 5.45 (br, 2H, *trans* =CH), 4.20 (q, 4H, OCH_2-CH_3), 3.95 (br, 2H, =CHC*H*), 2.50 and 1.44 (m, 2H,$CHCH_2CH$), 1.26 (t, 6H, -CH_2CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 14.21 (CH_3), 38.94 (-*C*H_2-), 44.46 (C=C-*C*H), 61.09 (OCH_2), 131.60 (C=C), 142.17 (*C=C*-C=O), 164.95 (C=O).

Polymer **3a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 5.57 and 5.43 (br, 2H, *cis* and *trans* =CH), 4.06 (m, 4H, OCH_2-CH_2), 3.94 (d, 2H, =CHC*H*), 2.50 and 1.44 (m, 2H, $CHCH_2CH$), 0.91 (t, 6H, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 10.56 (CH_3), 21.92 (-CH_2-CH_3), 38.93 (-*C*H_2-), 44.48 (C=C-*C*H), 66.73 (OCH_2), 131.61 (C=C), 142.09 (*C=C*-C=O), 165.00 (C=O).

Polymer **4a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 5.57 and 5.46 (br, 2H, *cis* and *trans* =CH), 5.29 (m, 2H, $OCH(CH_3)_2$), 3.91 (d, 2H, =CHC*H*), 2.50 and 1.23 (d, 12H, $OCH(CH_3)_2$); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 21.92 (CH_3), 39.21 (-*C*H_2-), 44.55 (C=C-*C*H), 68.80 ($OCH(CH_3)_2$), 131.61 (C=C), 142.05 (*C=C*-C=O), 164.48 (C=O).

Polymer **5a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 5.54 and 5.50 (br, 2H, *cis* and *trans* =CH), 3.84 (d, 2H, =CHC*H*), 2.50 and 1.48 (m, 2H, $CHCH_2CH$), 1.45 (s, 18H, $OC(CH_3)_3$); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 28.34 ($C(CH_3)_3$), 39.75 (-*C*H_2-), 44.65 (C=C-*C*H), 81.79 ($C(CH_3)_2$), 131.71 (C=C), 142.25 (*C=C*-C=O), 164.35 (C=O).

Polymer **6a**. Pale white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ= 7.22 (t, 10H, C_6H_5), 5.49 and 5.40 (br, 2H, *cis* and *trans* =CH), 4.94 (s, 4H, $CH_2C_6H_5$), 3.91 (m, 2H, =CHC*H*), 2.36 and 1.38 (m, 2H, $CHCH_2CH$); ^{13}C NMR (125 MHz, $CDCl_3$) δ= 38.69 (-*C*H_2-), 44.50 (C=C-*C*H), 66.9 (*C*-C_6H_5), 128.43, 128.60, 128.72 (C_6H_5), 131.61 (C=C), 131.61 (C_6H_5), 135.50 (*C=C*-C=O), 164.82 (C=O)



CO2CH3
CO2CH3
1
abundance
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0.22
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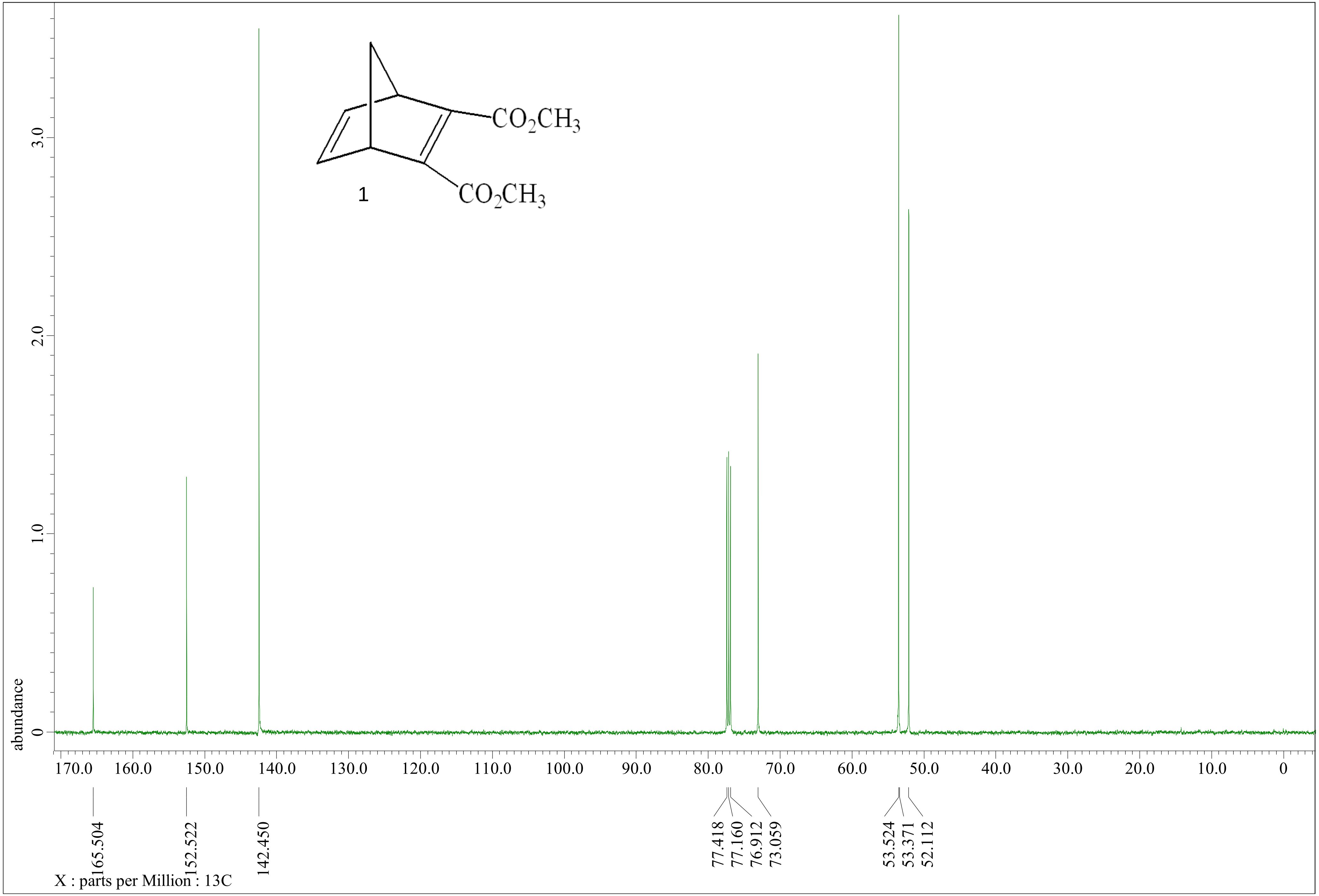
0.10
9.93m
22.29m
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
6.907
6.904
6.900
3.932
3.929
3.925
3.922
3.918
3.914
3.769
2.275
2.272
2.268
2.261
2.258
2.254
2.096
2.094
2.091
2.080
2.077
-0.010
-0.015
-0.022
X : parts per Million : Proton



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CO_2CH_3
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abundance
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2.0
3.0
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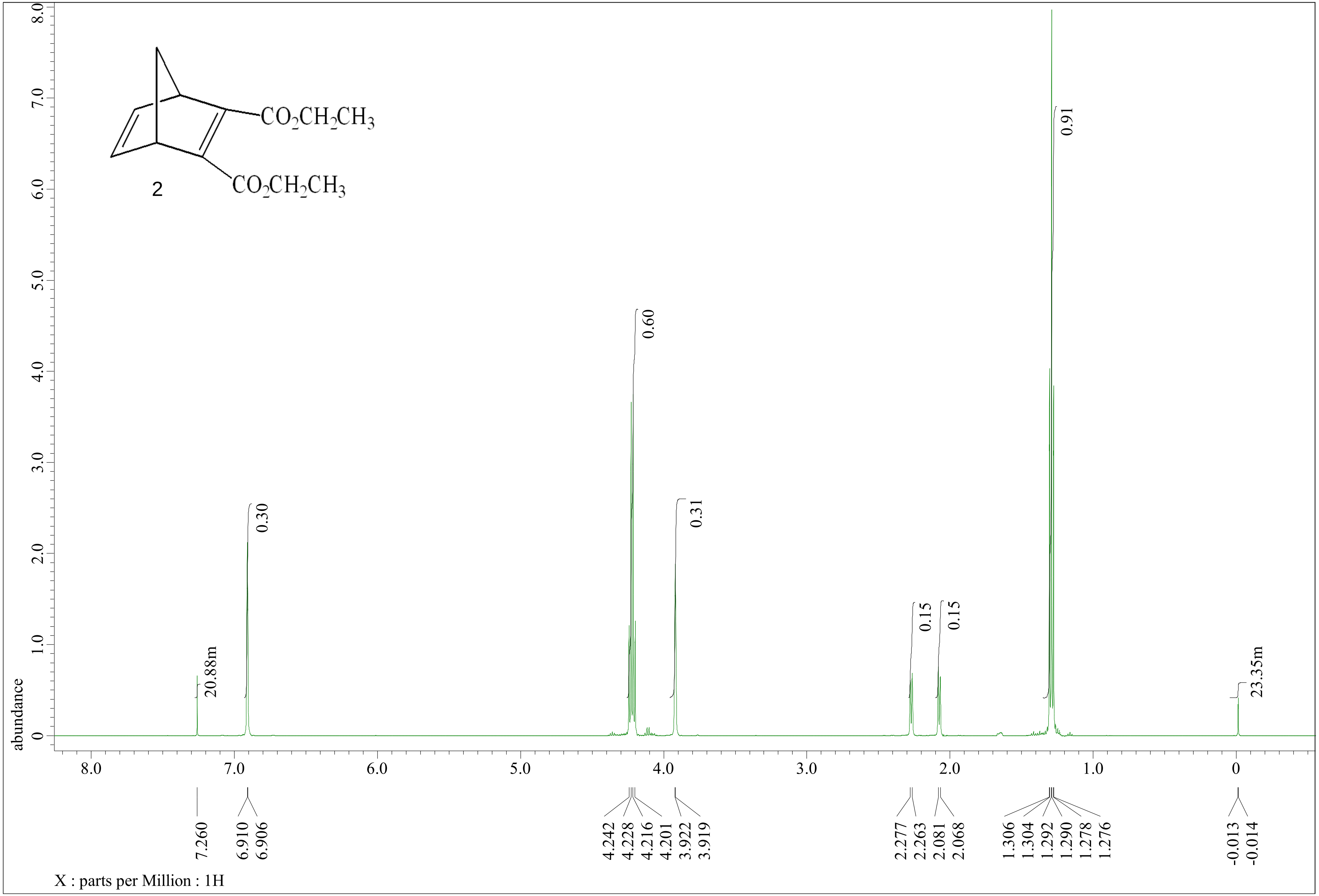
165.504
152.522
142.450
77.418
77.160
76.912
73.059
53.524
53.371
52.112
X : parts per Million : 13C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CO2CH2CH3
2
abundance
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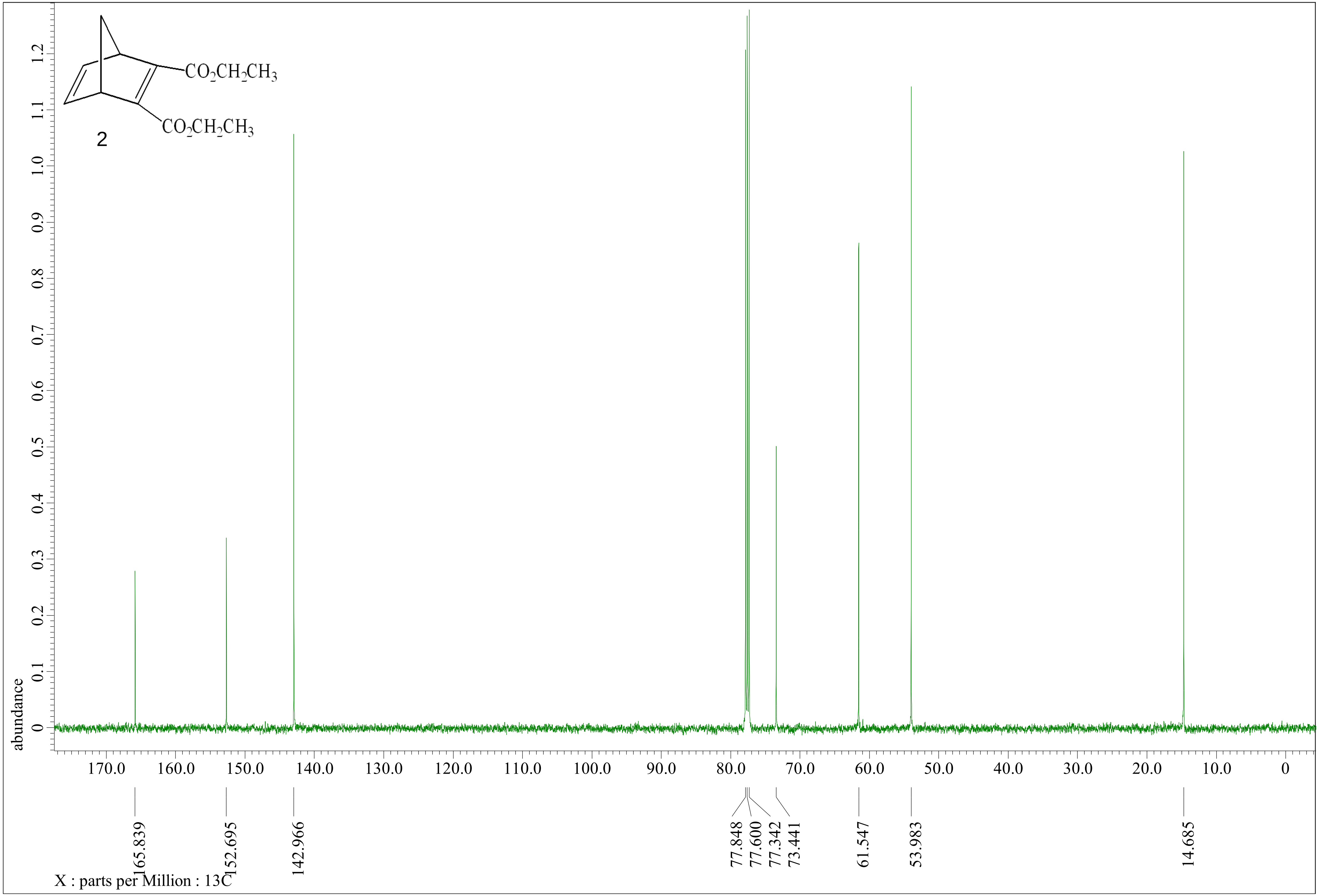
2.0
3.0
4.0
5.0
6.0
7.0
8.0
20.88m
0.30
0.60
0.31
0.15
0.15
0.91
23.35m
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
6.910
6.906
4.242
4.228
4.216
4.201
3.922
3.919
2.277
2.263
2.081
2.068
1.306
1.304
1.292
1.290
1.278
1.276
-0.013
-0.014
X : parts per Million : 1H


CO2CH2CH3
CO2CH2CH3
2
abundance
X : parts per Million : 13C
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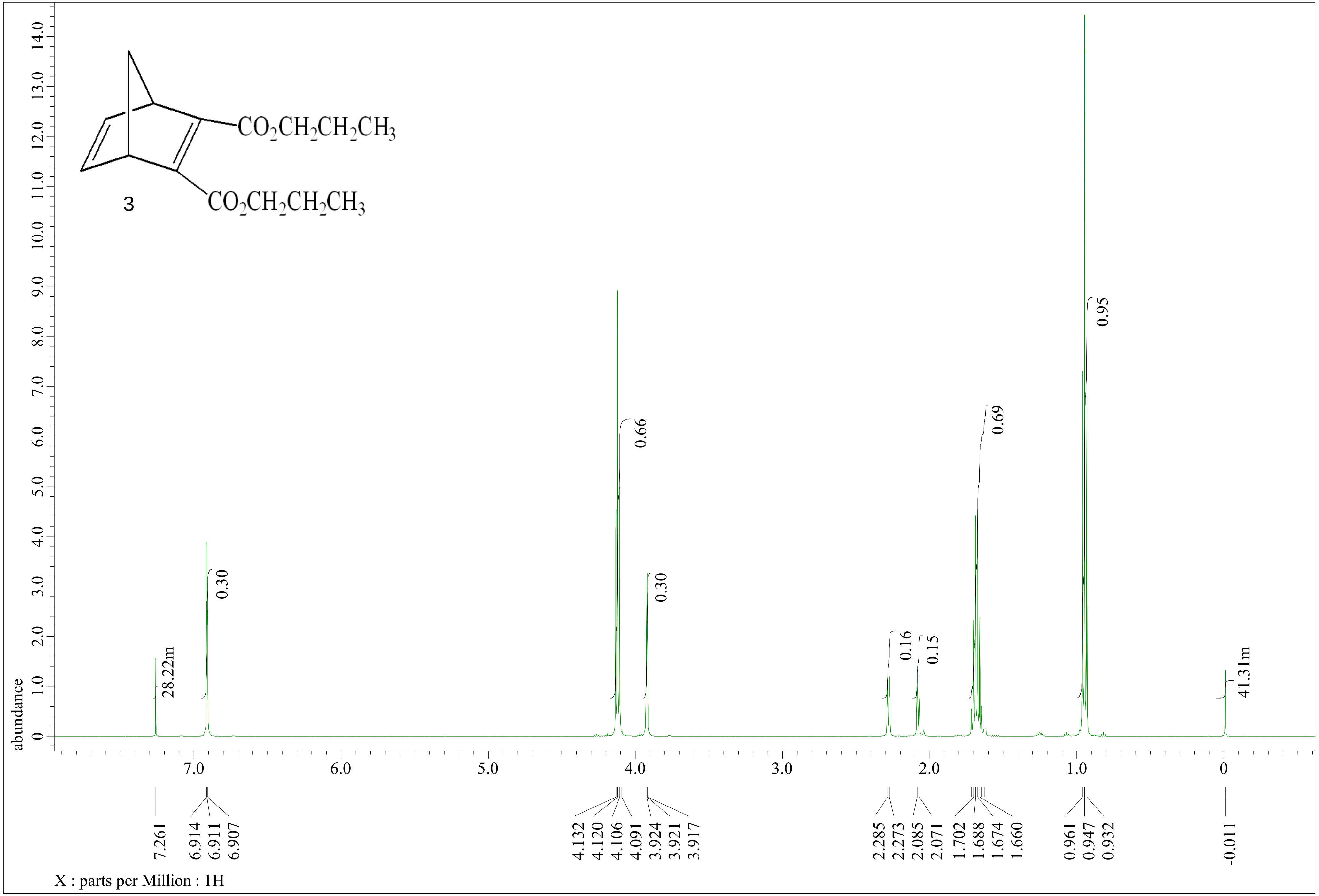
61.547
53.983
14.685


3
CO2CH2CH2CH3
CO2CH2CH2CH3
abundance
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
28.22m
0.30
0.66
0.30
0.16
0.15
0.69
0.95
41.31m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.261
6.914
6.911
6.907
4.132
4.120
4.106
4.091
3.924
3.921
3.917
2.285
2.273
2.085
2.071
1.702
1.688
1.674
1.660
0.961
0.947
0.932
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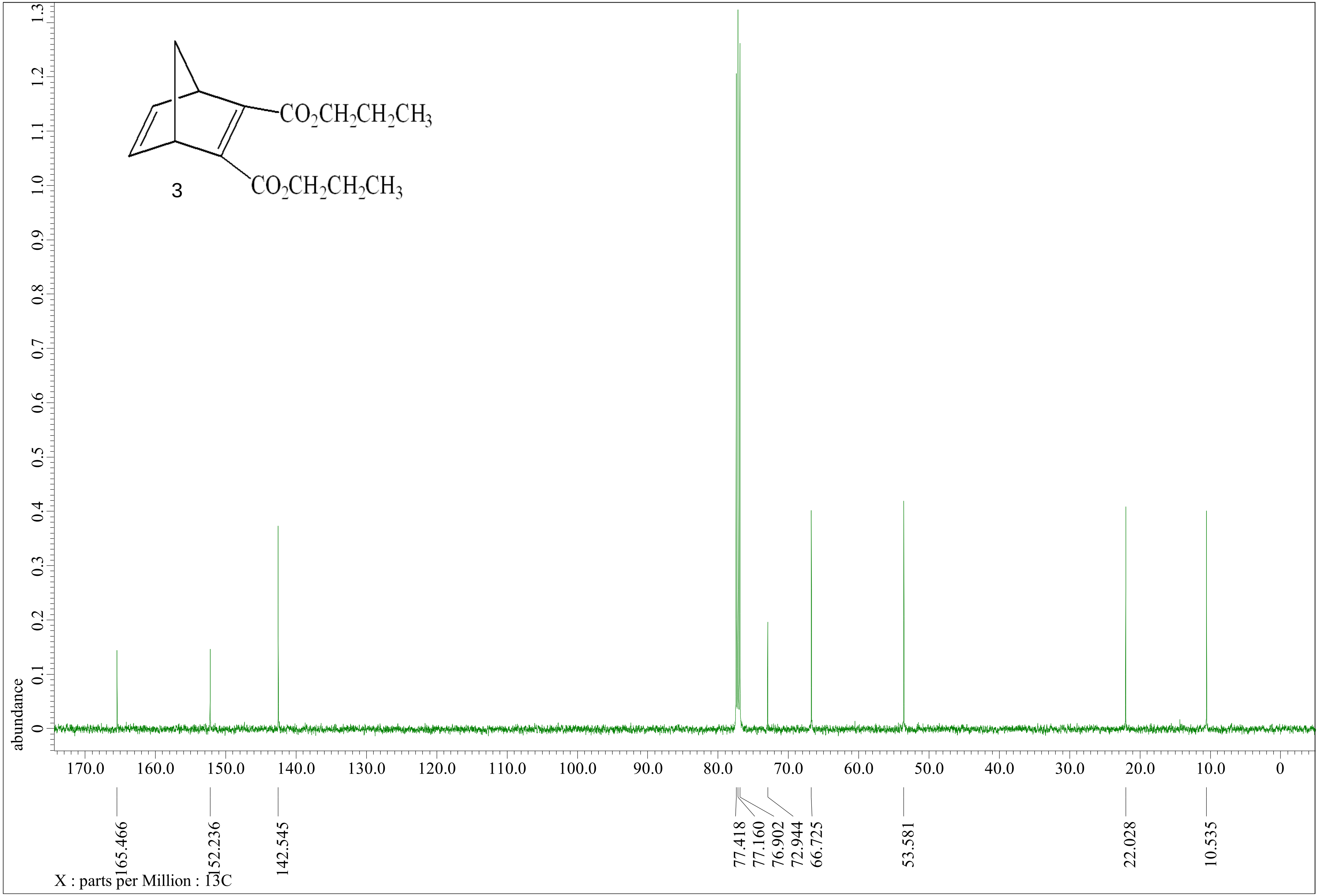
X : parts per Million : 1H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CO2CH2CH2CH3
3
abundance
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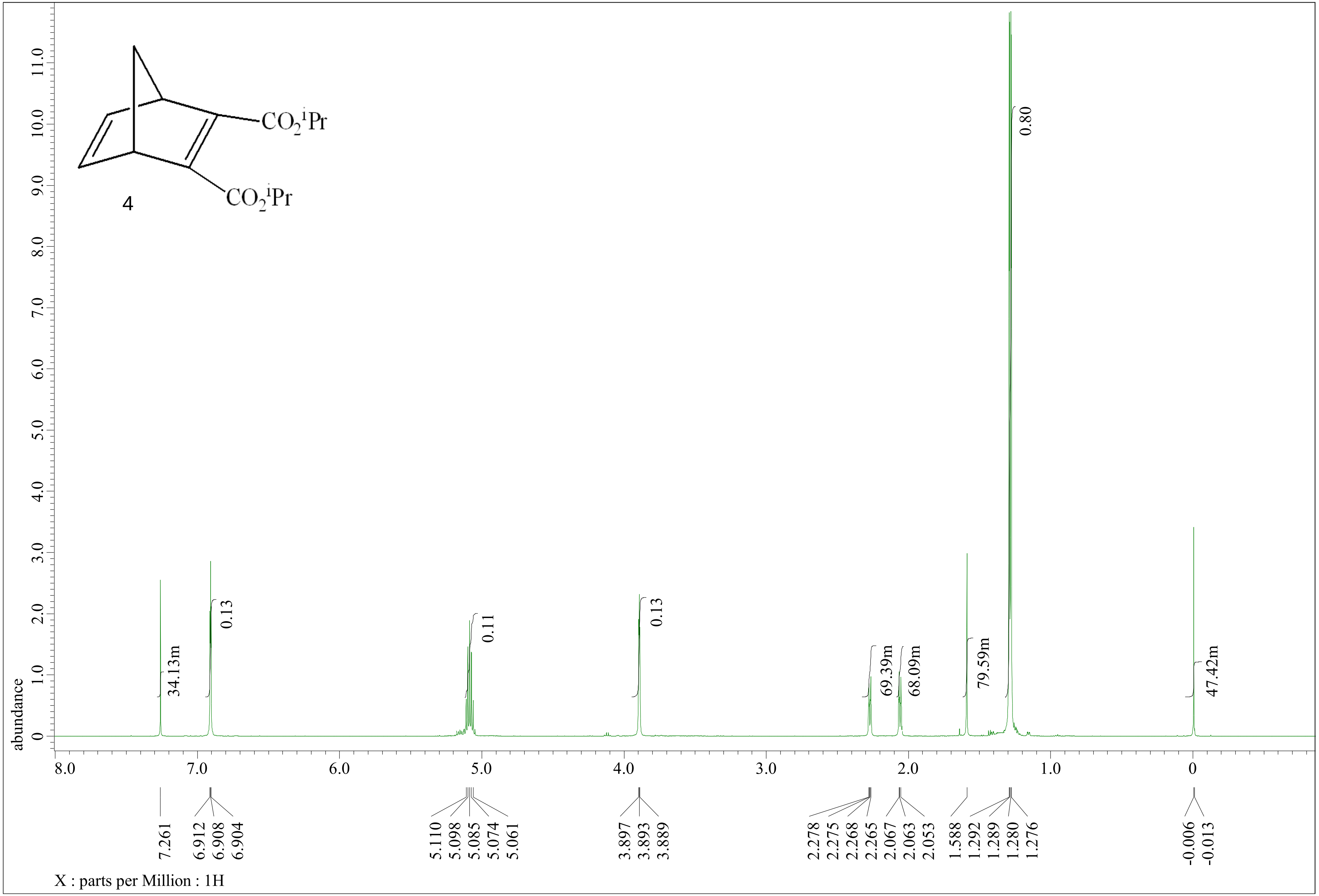
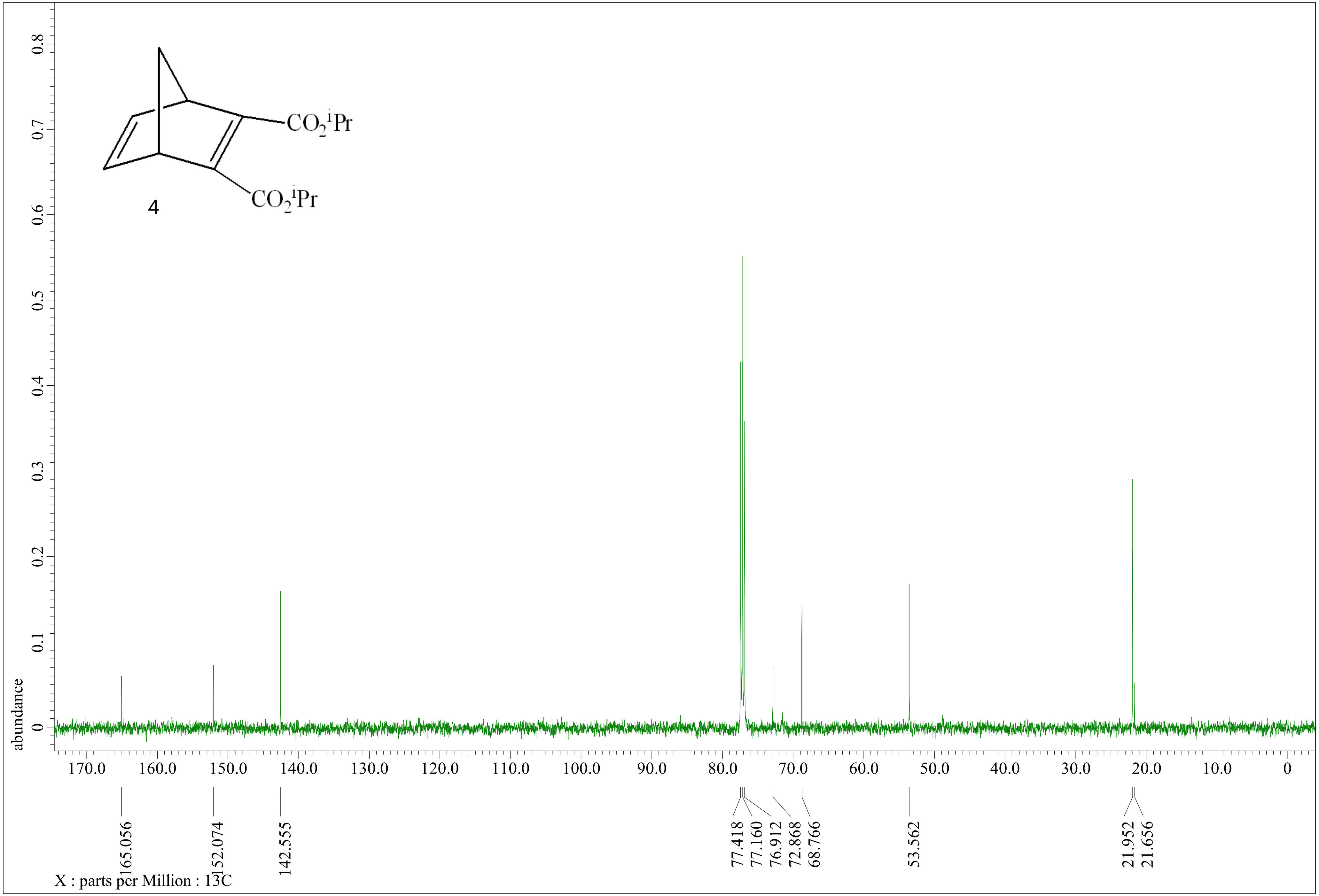
72.944
66.725
53.581
22.028
10.535
X : parts per Million : 13C



CO2iPr
CO2iPr
4
abundance
0.80
0.13
0.11
0.13
34.13m
69.39m
68.09m
79.59m
47.42m
7.261
6.912
6.908
6.904
5.110
5.098
5.085
5.074
5.061
3.897
3.893
3.889
2.278
2.275
2.268
2.265
2.067
2.063
2.053
1.588
1.292
1.289
1.280
1.276
-0.006
-0.013
X : parts per Million : 1H


CO2iPr
CO2iPr
4
abundance
0
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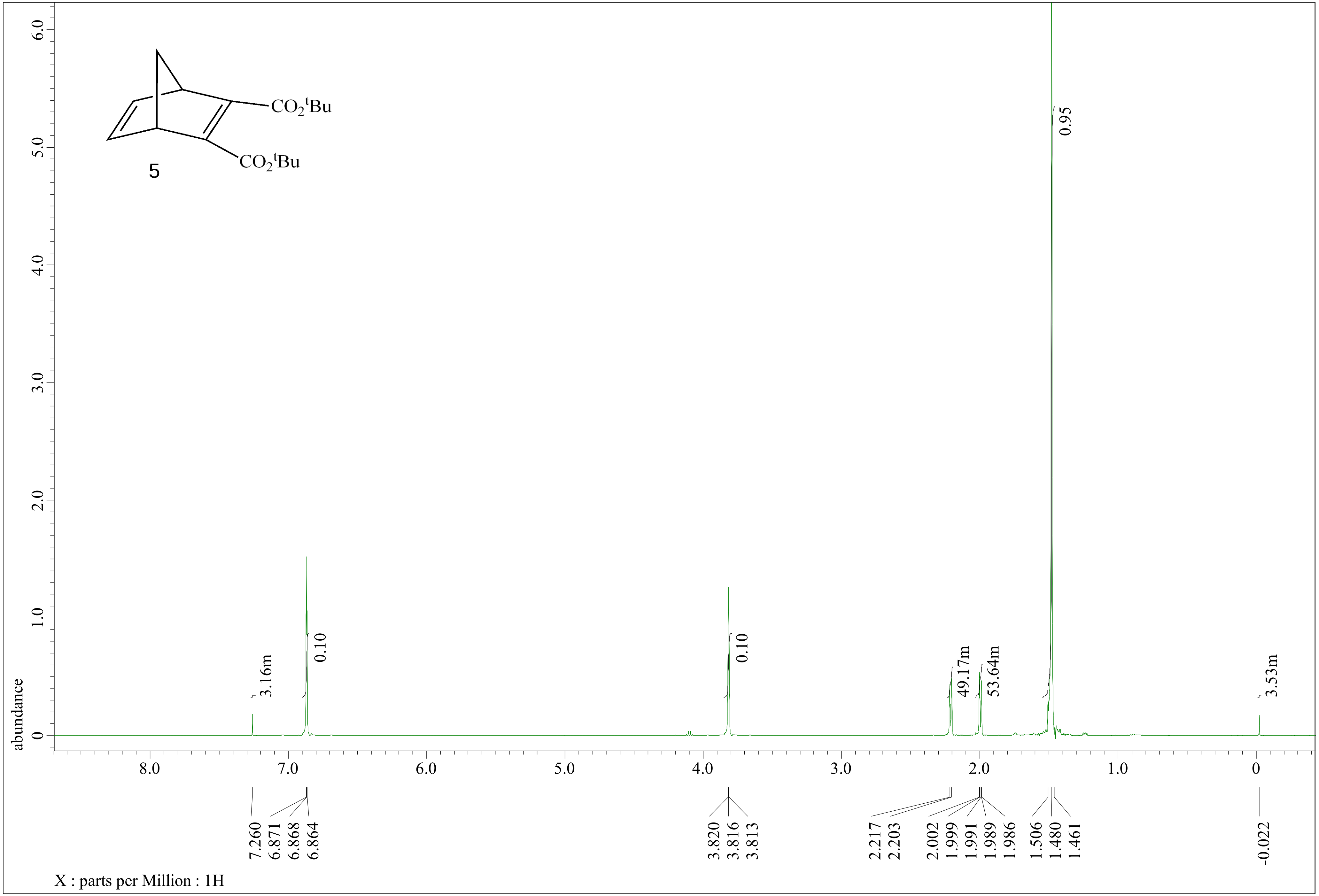
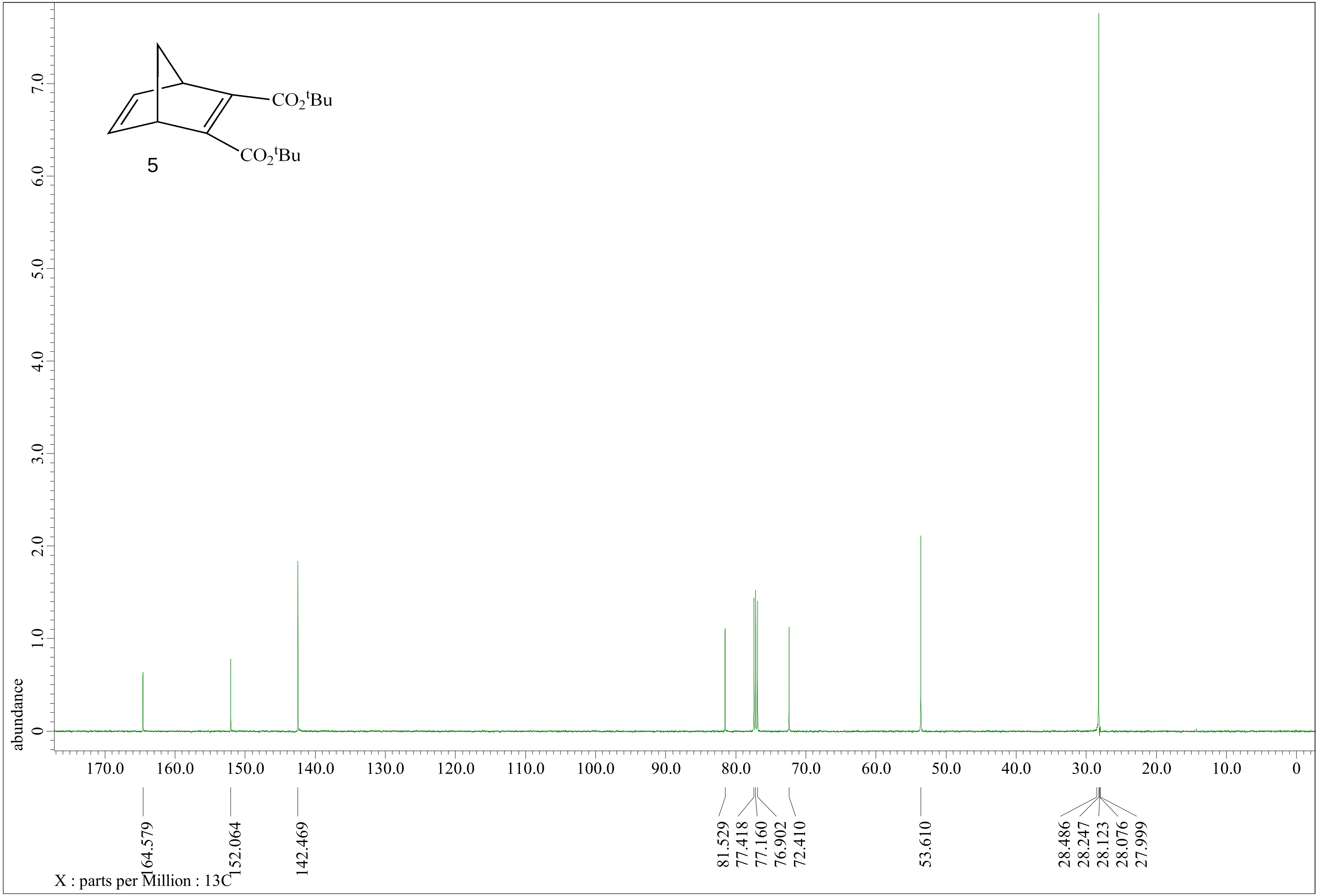
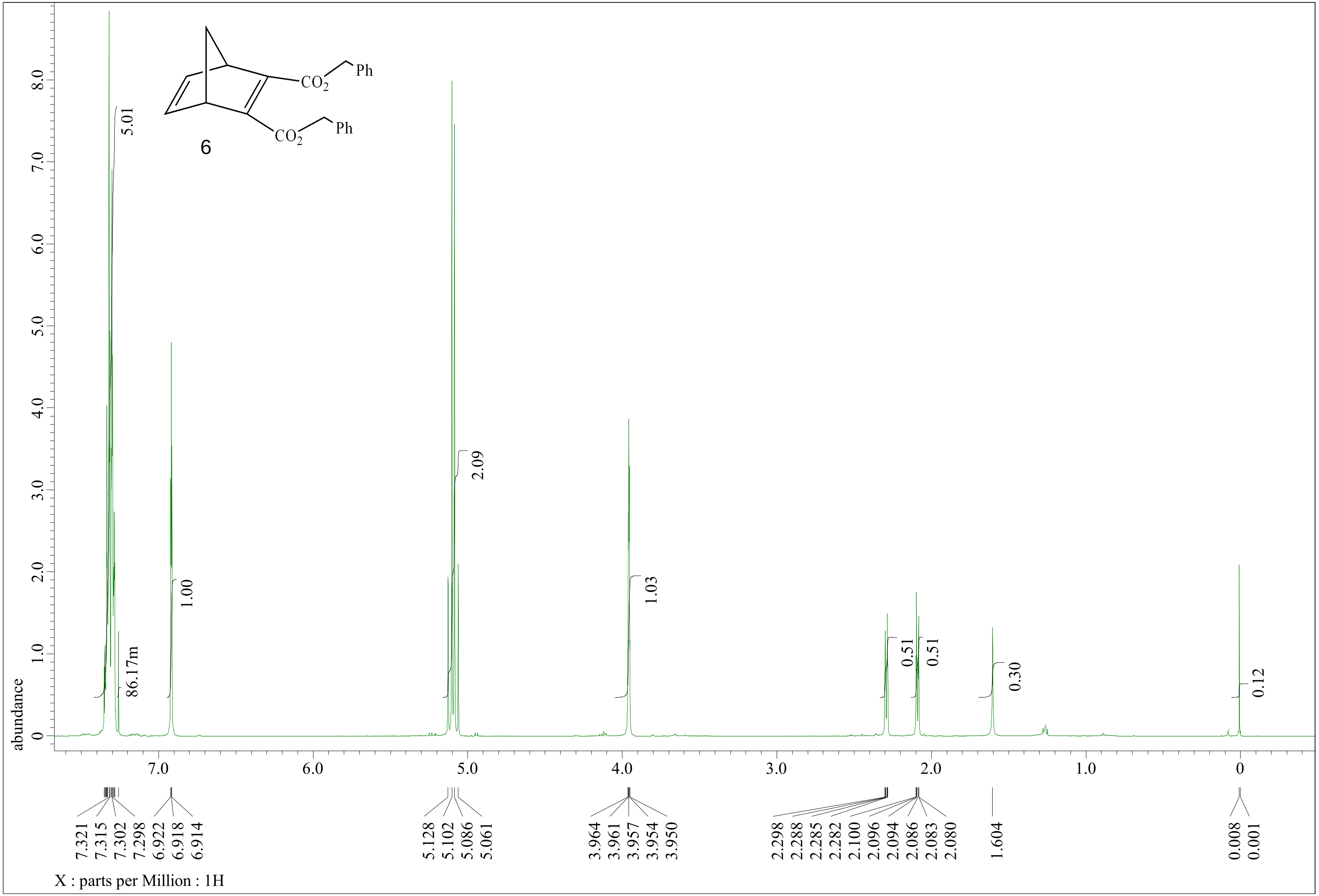
0.2
0.3
0.4
0.5
0.6
0.7
0.8
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.056
152.074
142.555
77.418
77.160
76.912
72.868
68.766
53.562
21.952
21.656
X : parts per Million : 13C


CO2tBu
CO2tBu
5
abundance
X : parts per Million : 1H


CO2tBu
CO2tBu
5
abundance
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.579
152.064
142.469
81.529
77.418
77.160
76.902
72.410
53.610
28.486
28.247
28.123
28.076
27.999
X : parts per Million : 13C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Ph
CO2
Ph
6
abundance
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1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
5.01
86.17m
1.00
2.09
1.03
0.51
0.51
0.30
0.12
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.321
7.315
7.302
7.298
6.922
6.918
6.914
5.128
5.102
5.086
5.061
3.964
3.961
3.957
3.954
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2.298
2.288
2.285
2.282
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2.094
2.086
2.083
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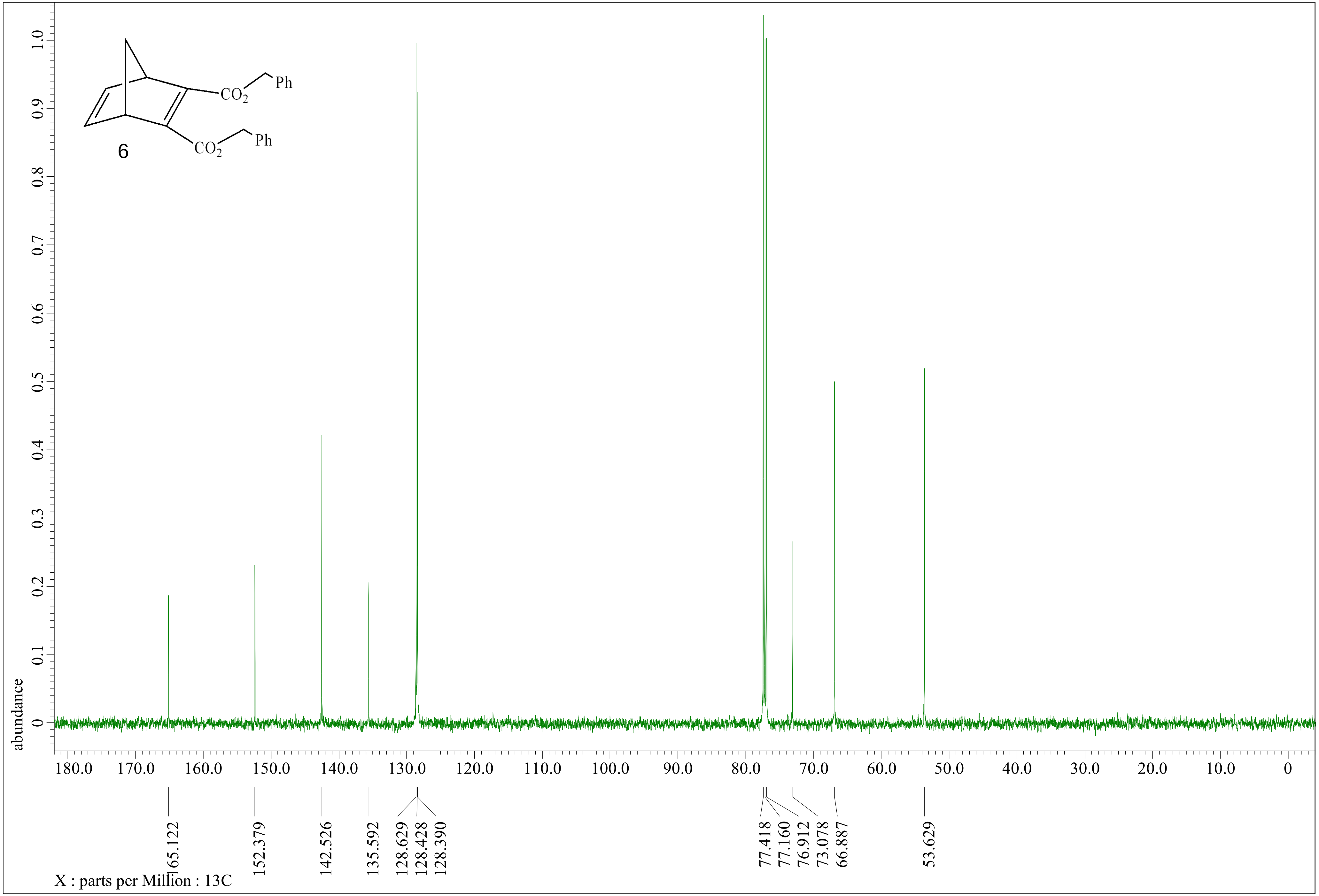
0.008
0.001
X : parts per Million : 1H


6
CO2
Ph
CO2
Ph
abundance
X : parts per Million : 13C
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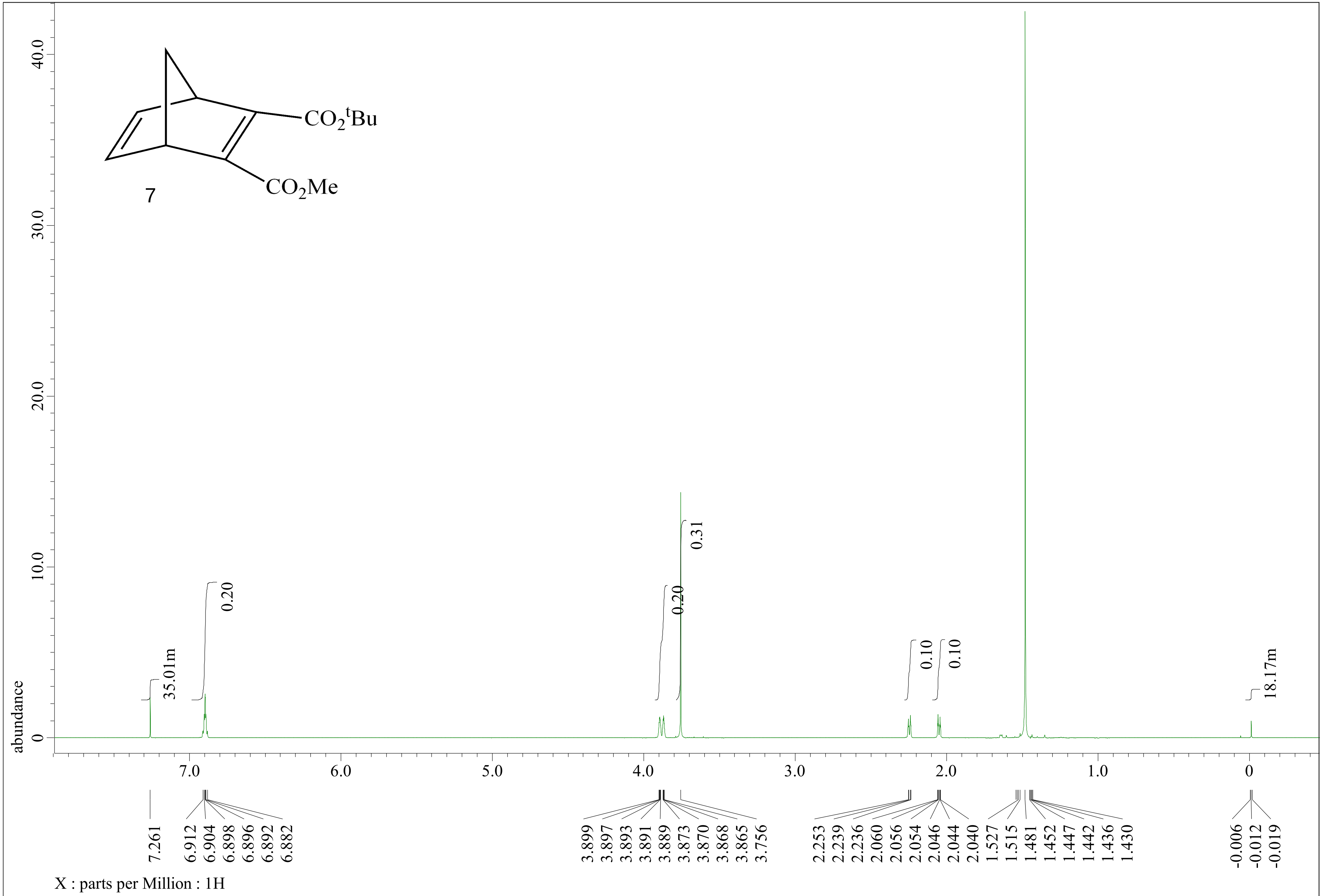
73.078
66.887
53.629



CO2tBu
CO2Me
7
abundance
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30.0
20.0
10.0
0
35.01m
0.20
0.20
0.31
0.10
0.10
18.17m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.261
6.912
6.904
6.898
6.896
6.892
6.882
3.899
3.897
3.893
3.891
3.889
3.873
3.870
3.868
3.865
3.756
2.253
2.239
2.236
2.060
2.056
2.054
2.046
2.044
2.040
1.527
1.515
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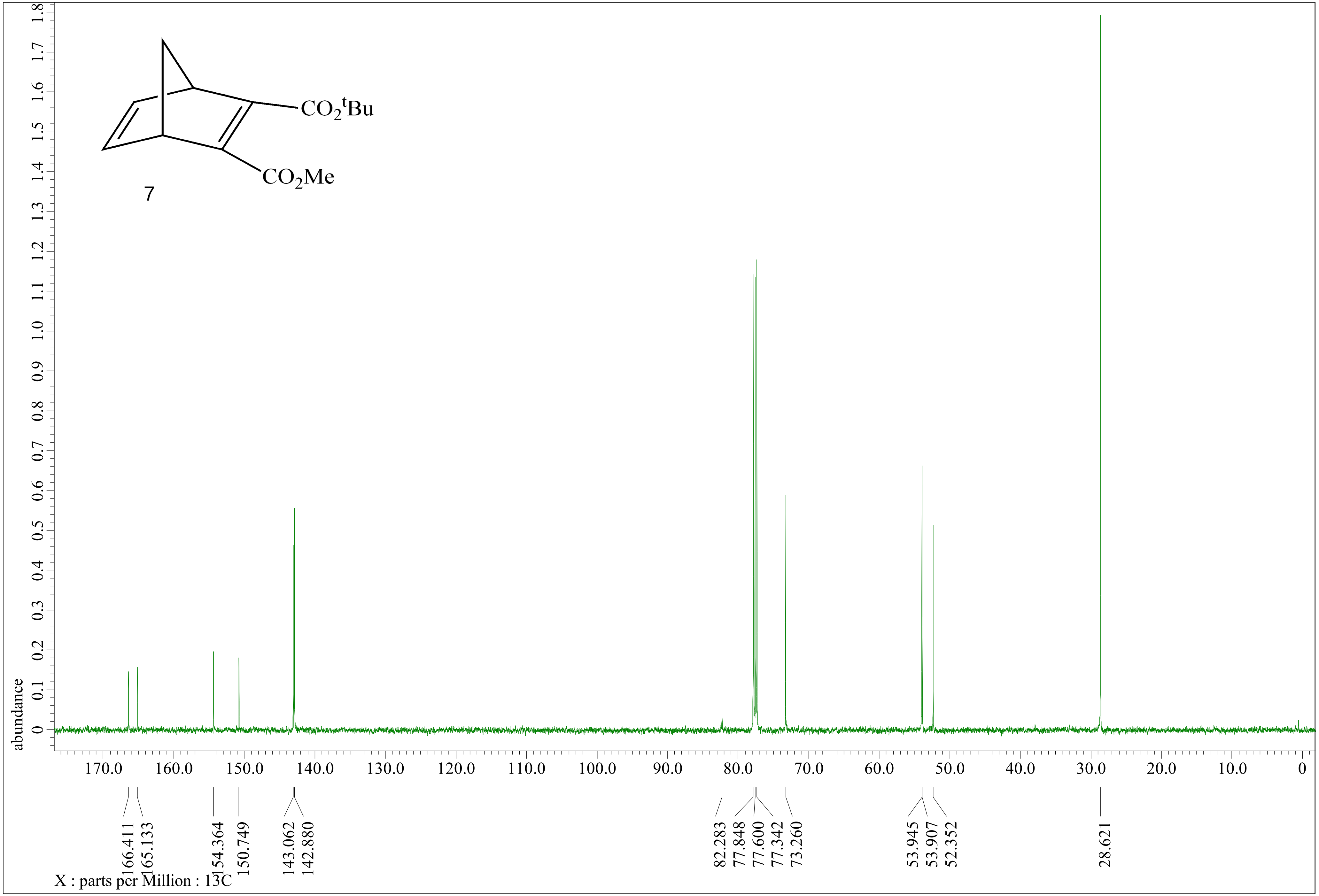
-0.012
-0.019
X : parts per Million : 1H


CO2tBu
CO2Me
7
abundance
X : parts per Million : 13C
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165.133
154.364
150.749
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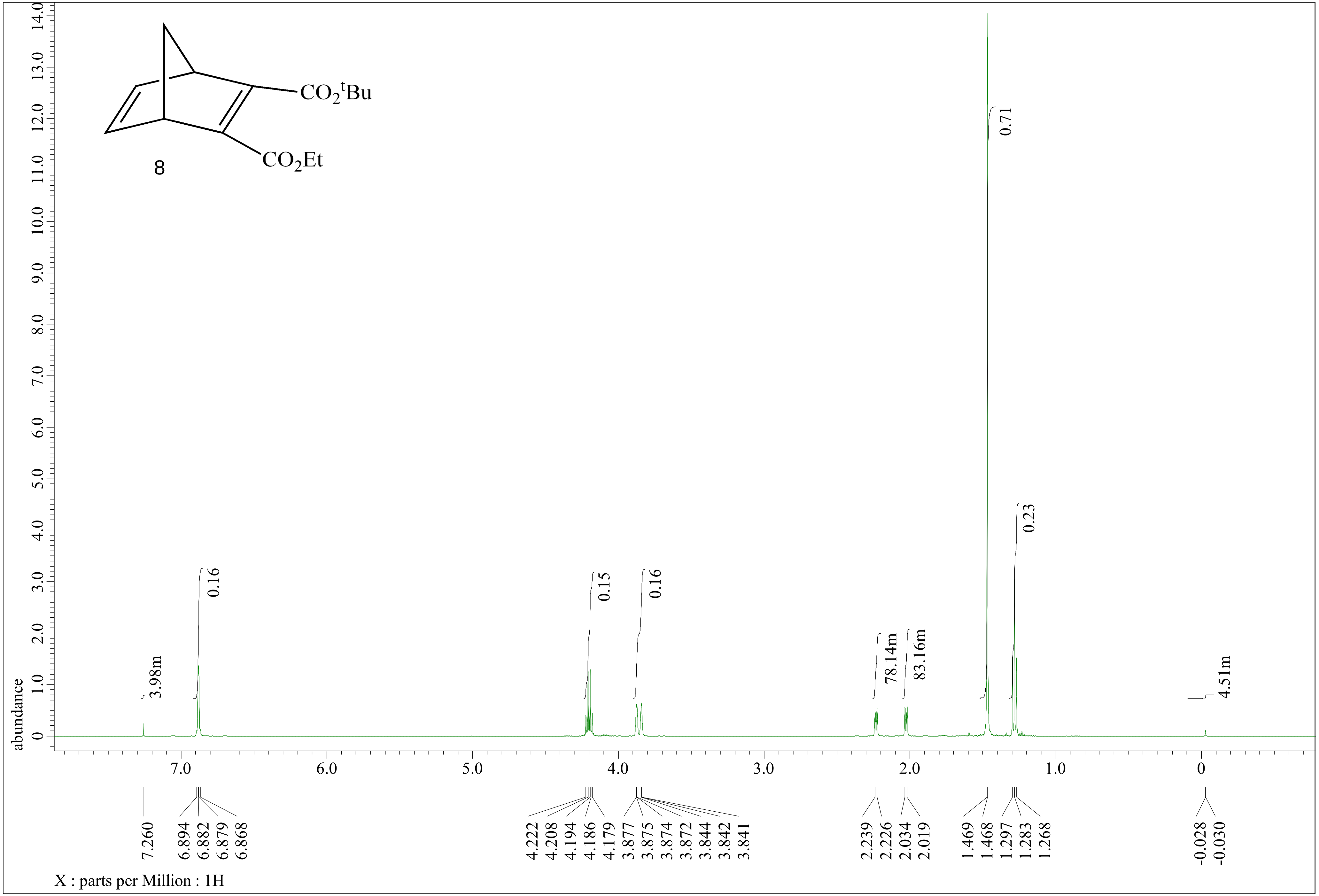
77.848
77.600
77.342
73.260
53.945
53.907
52.352
28.621



CO2tBu
CO2Et
8
abundance
14.0
13.0
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11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
3.98m
0.16
0.15
0.16
78.14m
83.16m
0.71
0.23
4.51m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
6.894
6.882
6.879
6.868
4.222
4.208
4.194
4.186
4.179
3.877
3.875
3.874
3.872
3.844
3.842
3.841
2.239
2.226
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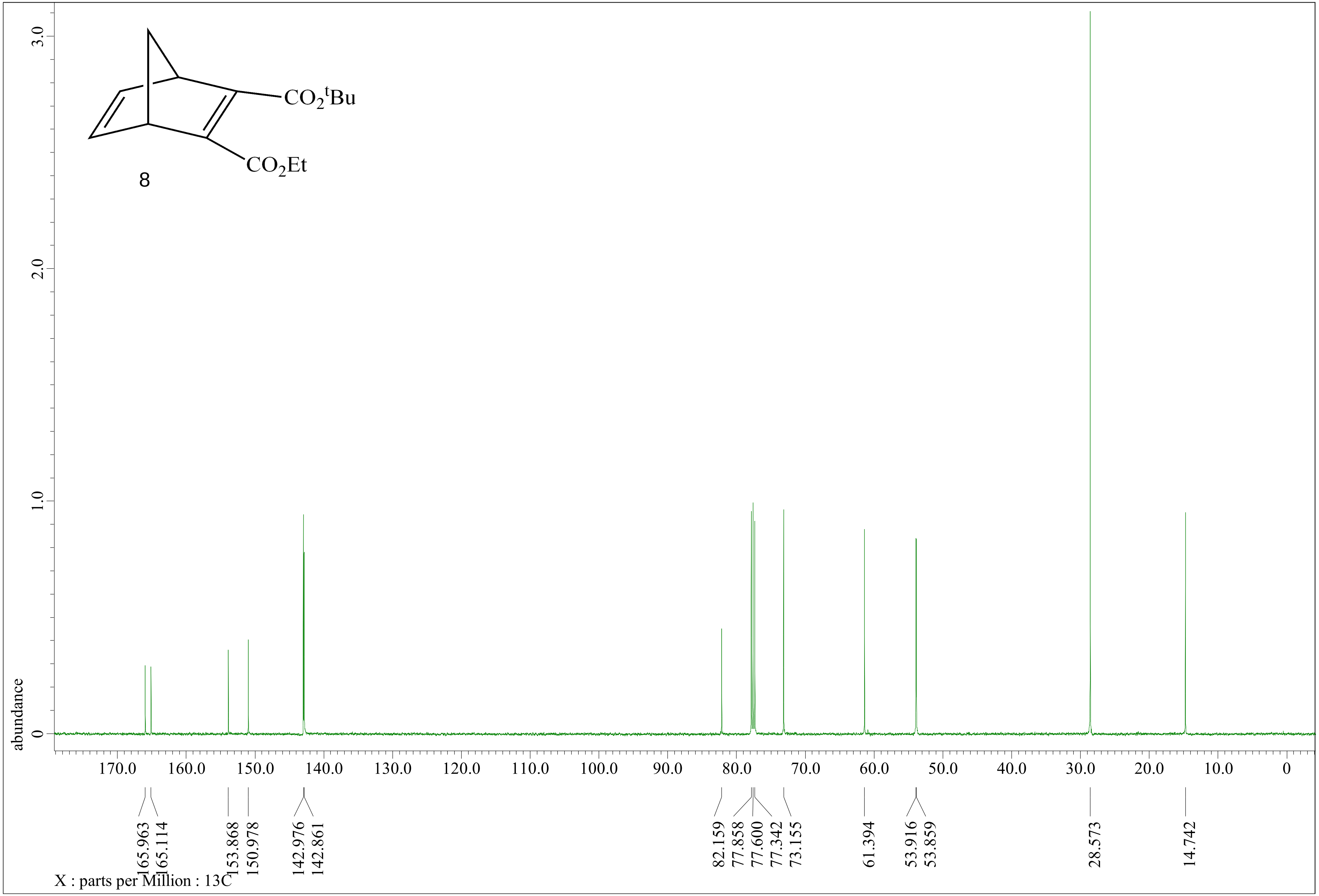
2.019
1.469
1.468
1.297
1.283
1.268
-0.028
-0.030
X : parts per Million : 1H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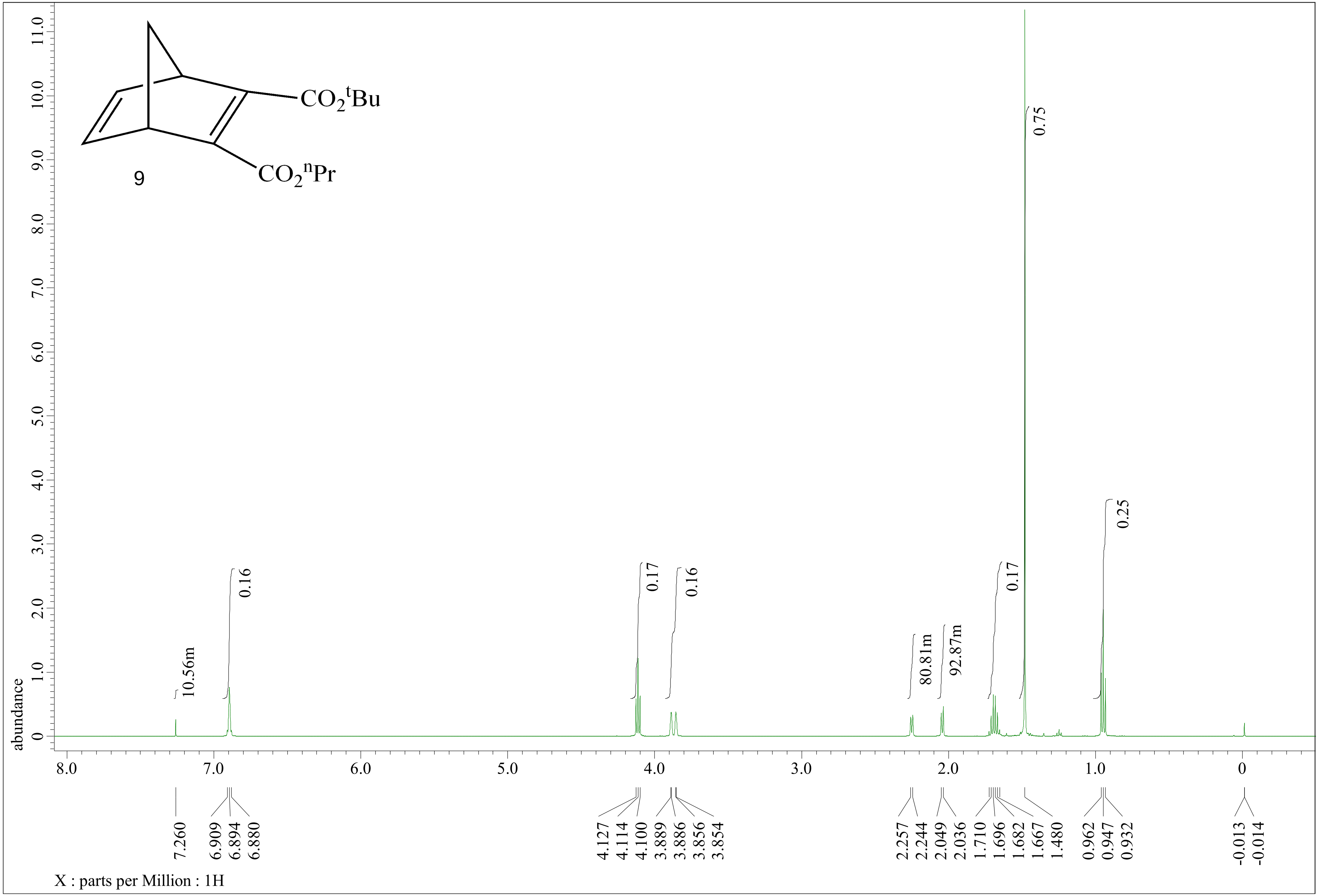
CO2Et
8
3.0
2.0
1.0
0
abundance
170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
165.963
165.114
153.868
150.978
142.976
142.861
82.159
77.858
77.600
77.342
73.155
61.394
53.916
53.859
28.573
14.742
X : parts per Million : 13C


CO2tBu
CO2nPr
9
abundance
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0.17
0.16
0.17
0.75
0.25
10.56m
80.81m
92.87m
7.260
6.909
6.894
6.880
4.127
4.114
4.100
3.889
3.886
3.856
3.854
2.257
2.244
2.049
2.036
1.710
1.696
1.682
1.667
1.480
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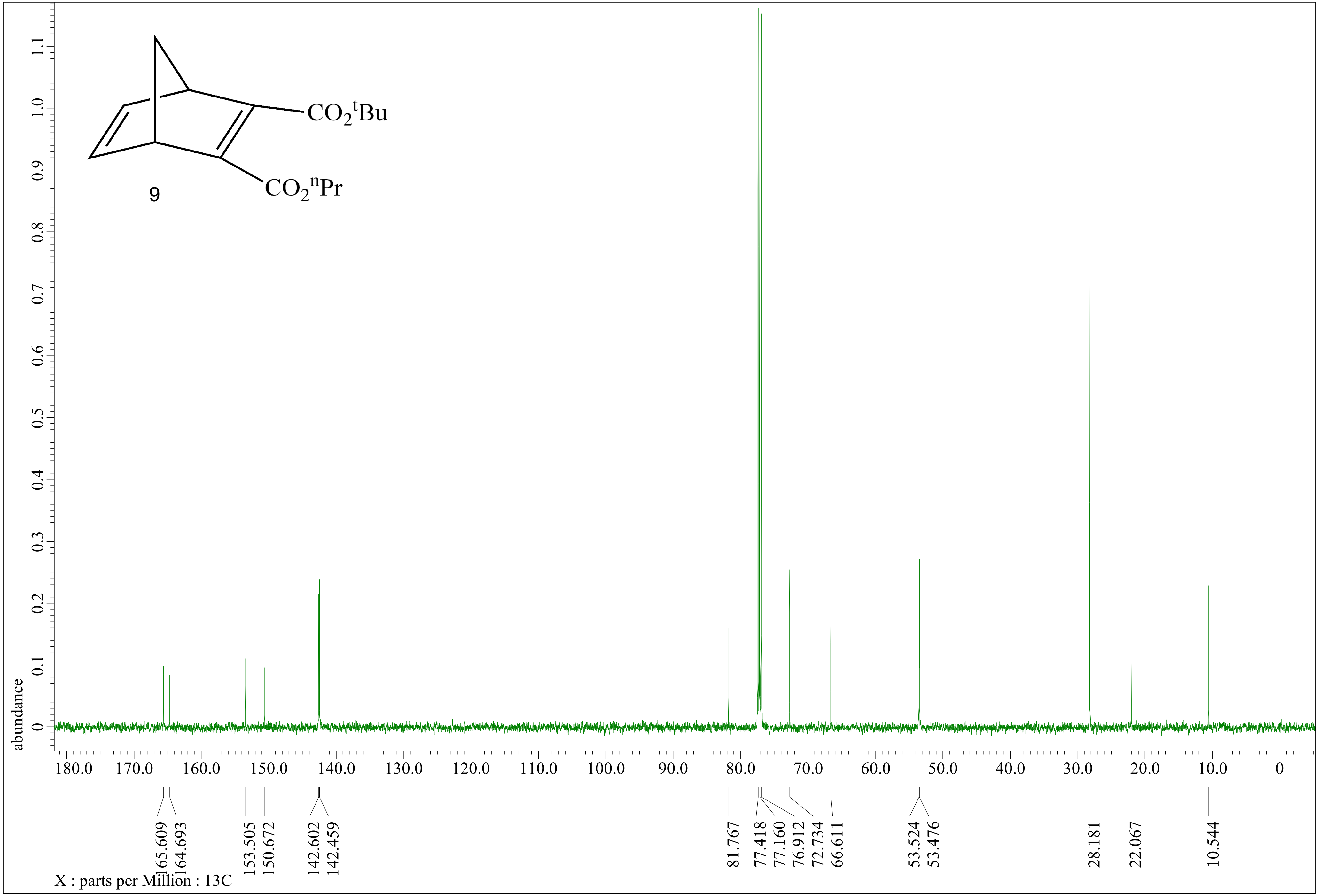
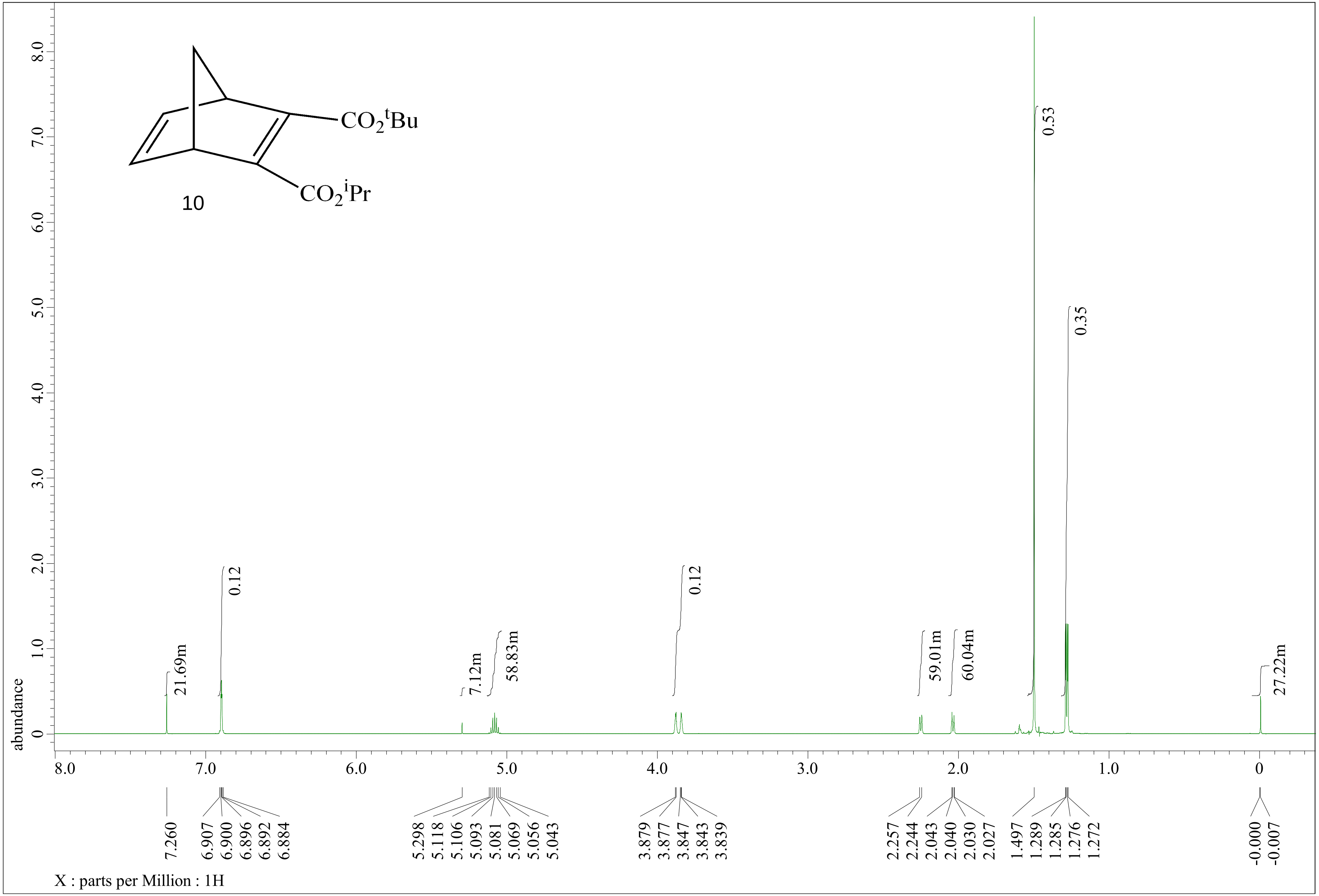
0.947
0.932
-0.013
-0.014
X : parts per Million : 1H


CO2tBu
CO2nPr
9
abundance
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
165.609
164.693
153.505
150.672
142.602
142.459
81.767
77.418
77.160
76.912
72.734
66.611
53.524
53.476
28.181
22.067
10.544
X : parts per Million : 13C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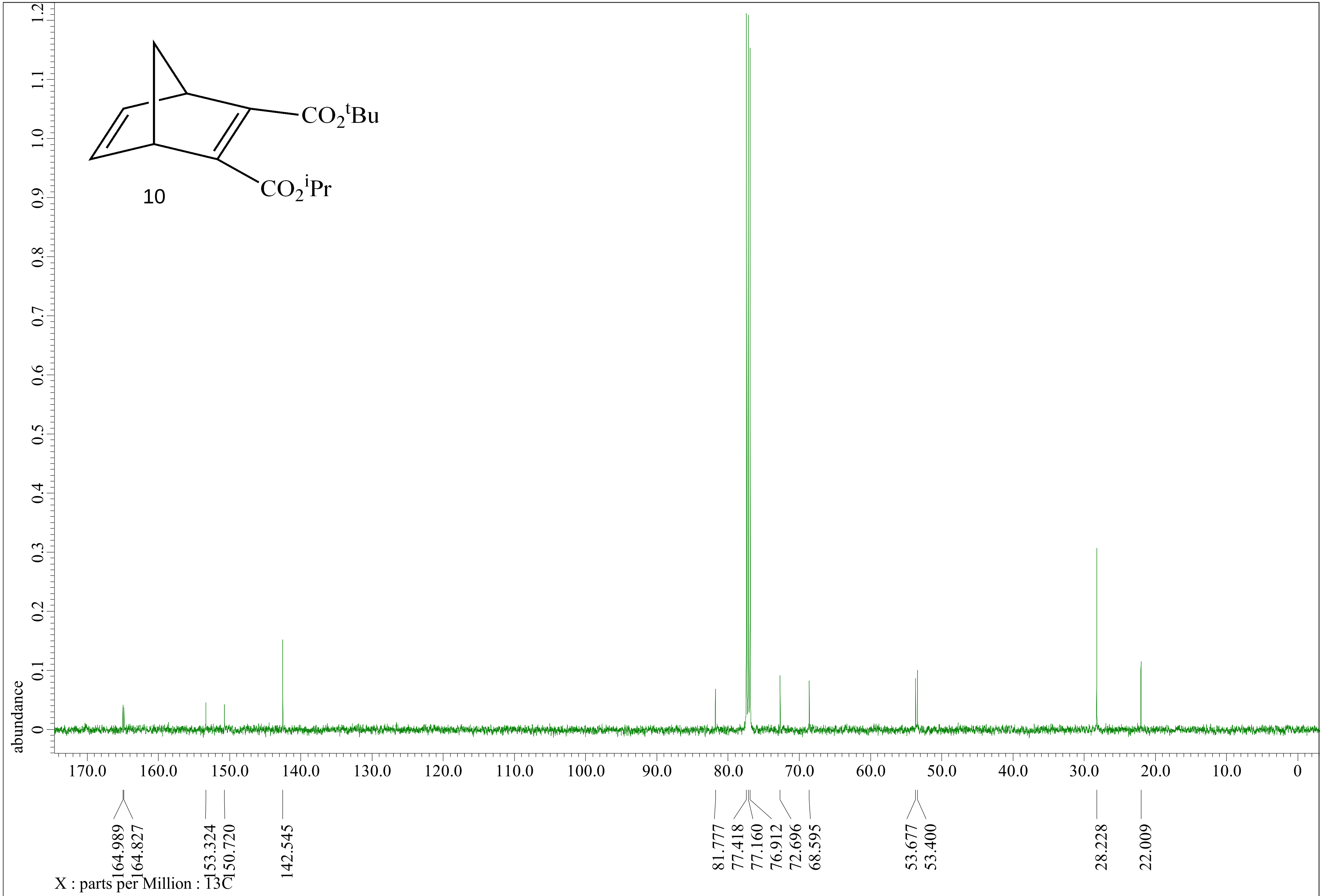
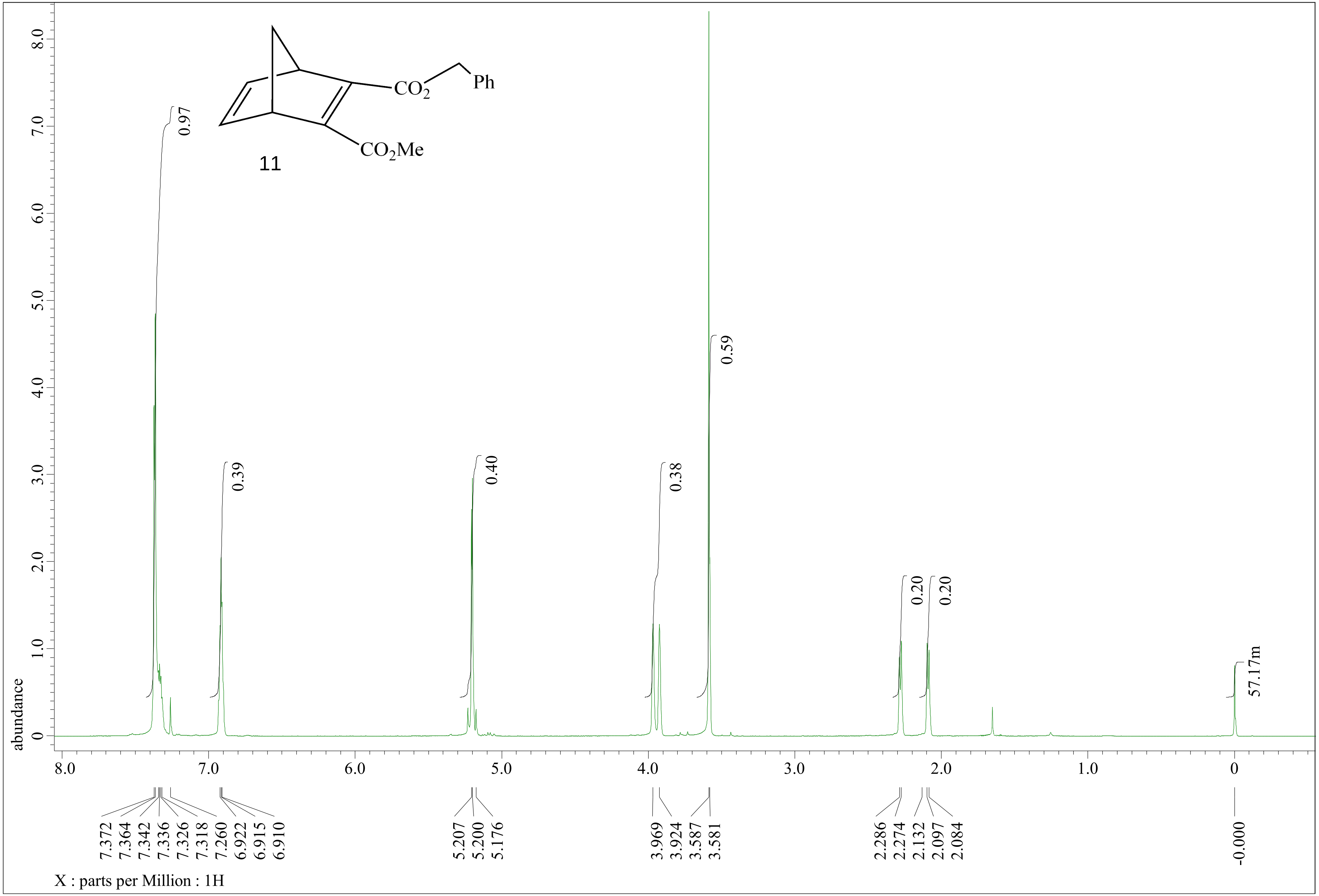
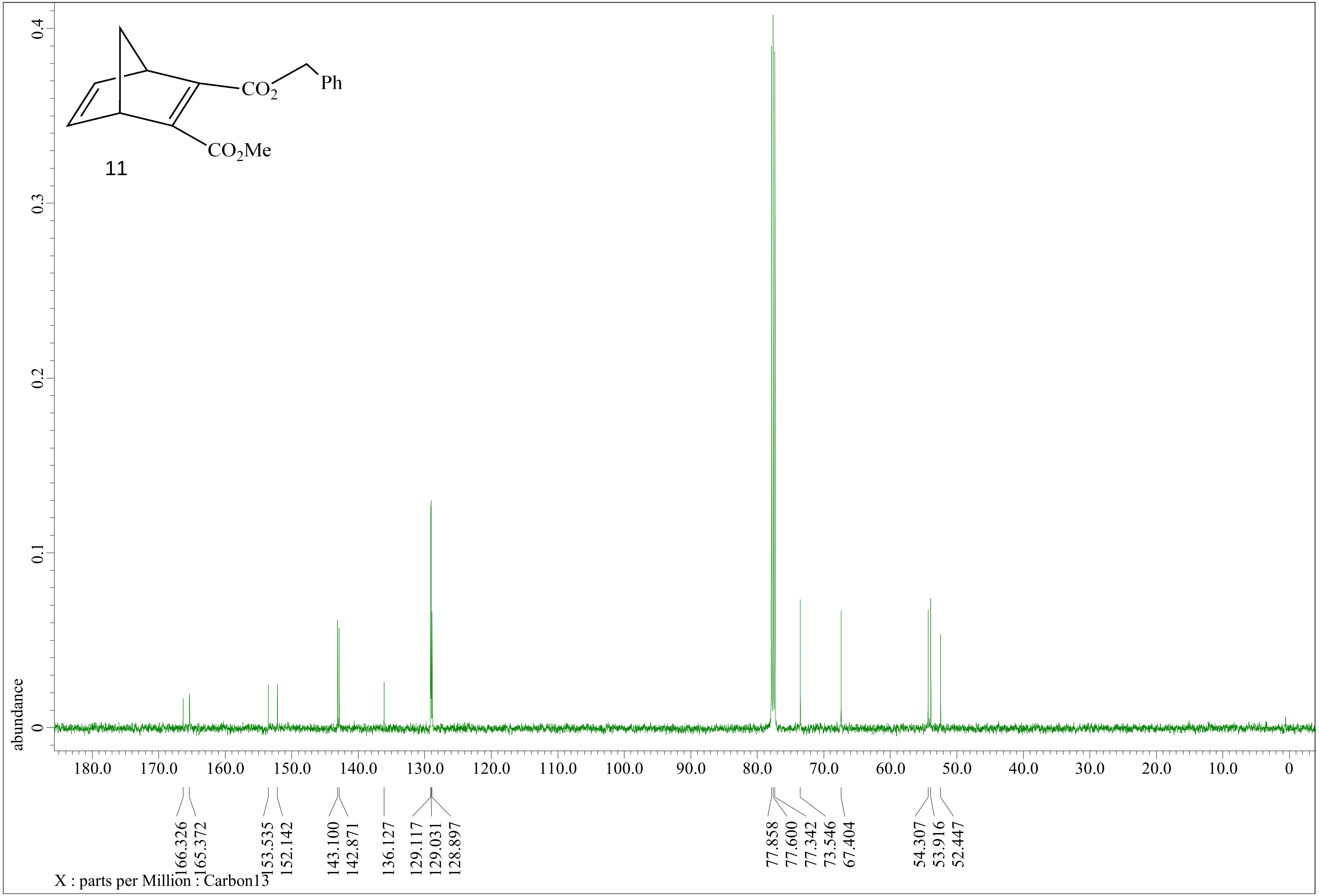
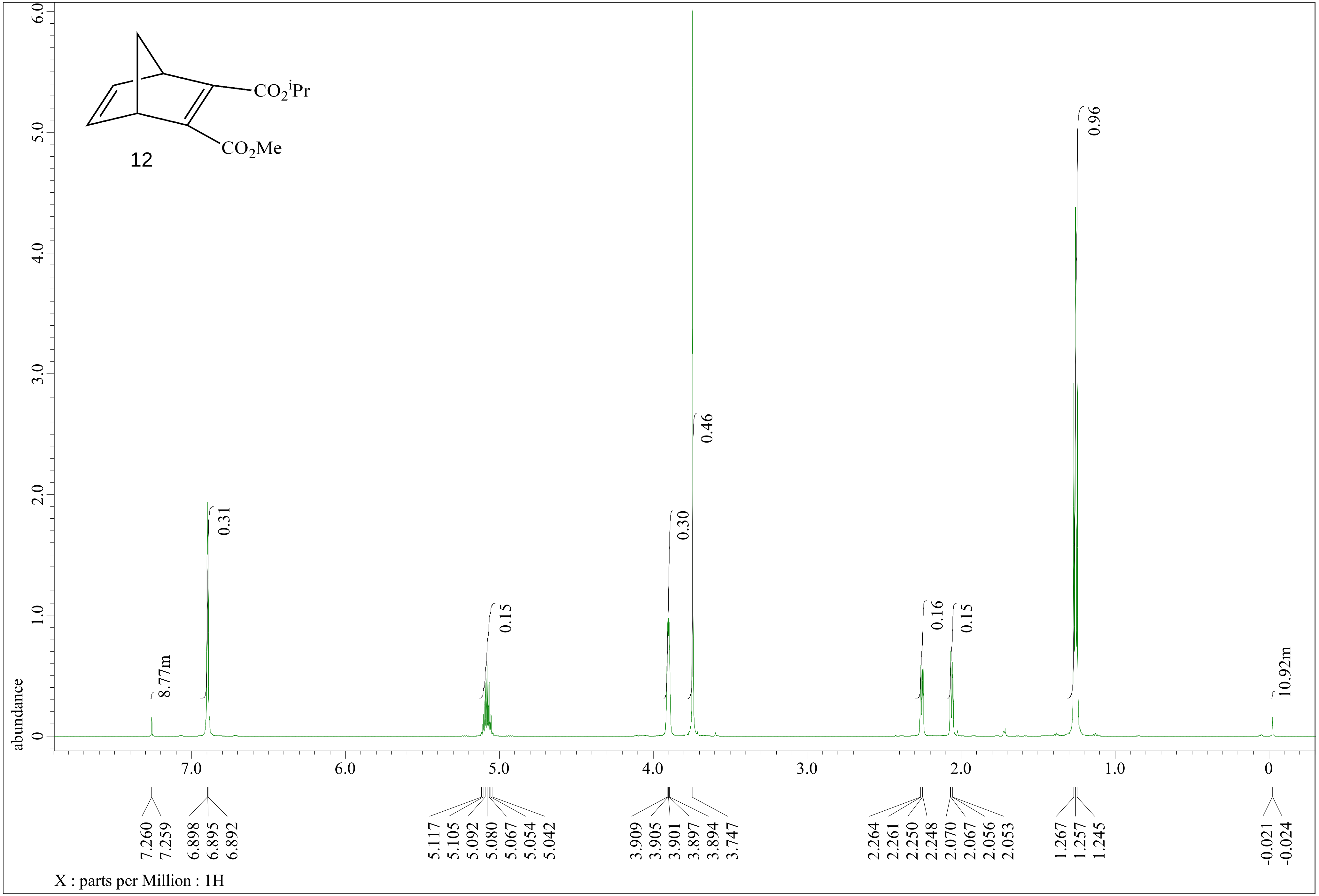
CO2iPr
10
abundance
X : parts per Million : 1H
21.69m
0.12
7.12m
58.83m
0.12
59.01m
60.04m
0.53
0.35
27.22m
7.260
6.907
6.900
6.896
6.892
6.884
5.298
5.118
5.106
5.093
5.081
5.069
5.056
5.043
3.879
3.877
3.847
3.843
3.839
2.257
2.244
2.043
2.040
2.030
2.027
1.497
1.289
1.285
1.276
1.272
-0.000
-0.007

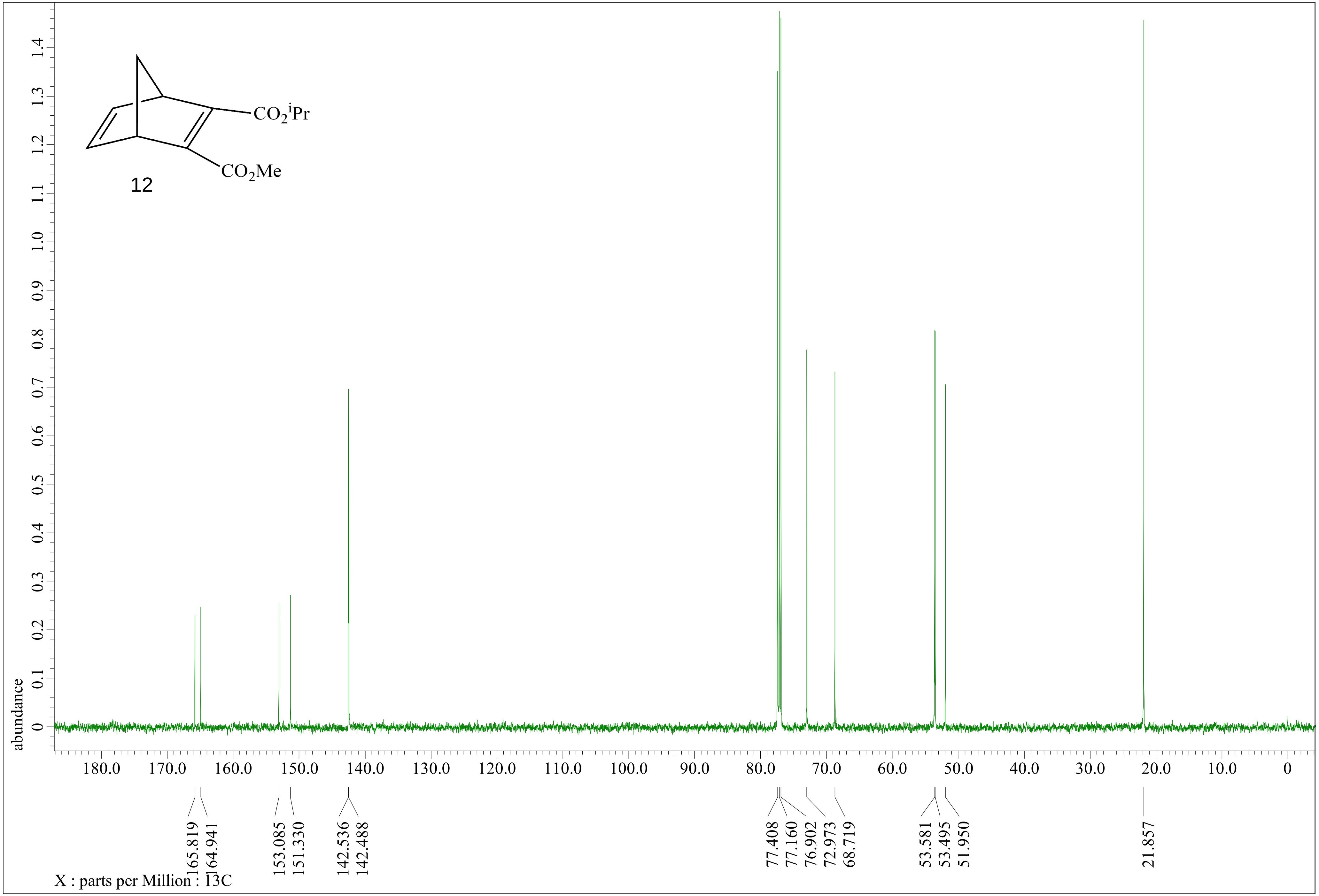


CO2tBu
CO2iPr
10
abundance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.989
164.827
153.324
150.720
142.545
81.777
77.418
77.160
76.912
72.696
68.595
53.677
53.400
28.228
22.009
X : parts per Million : 13C

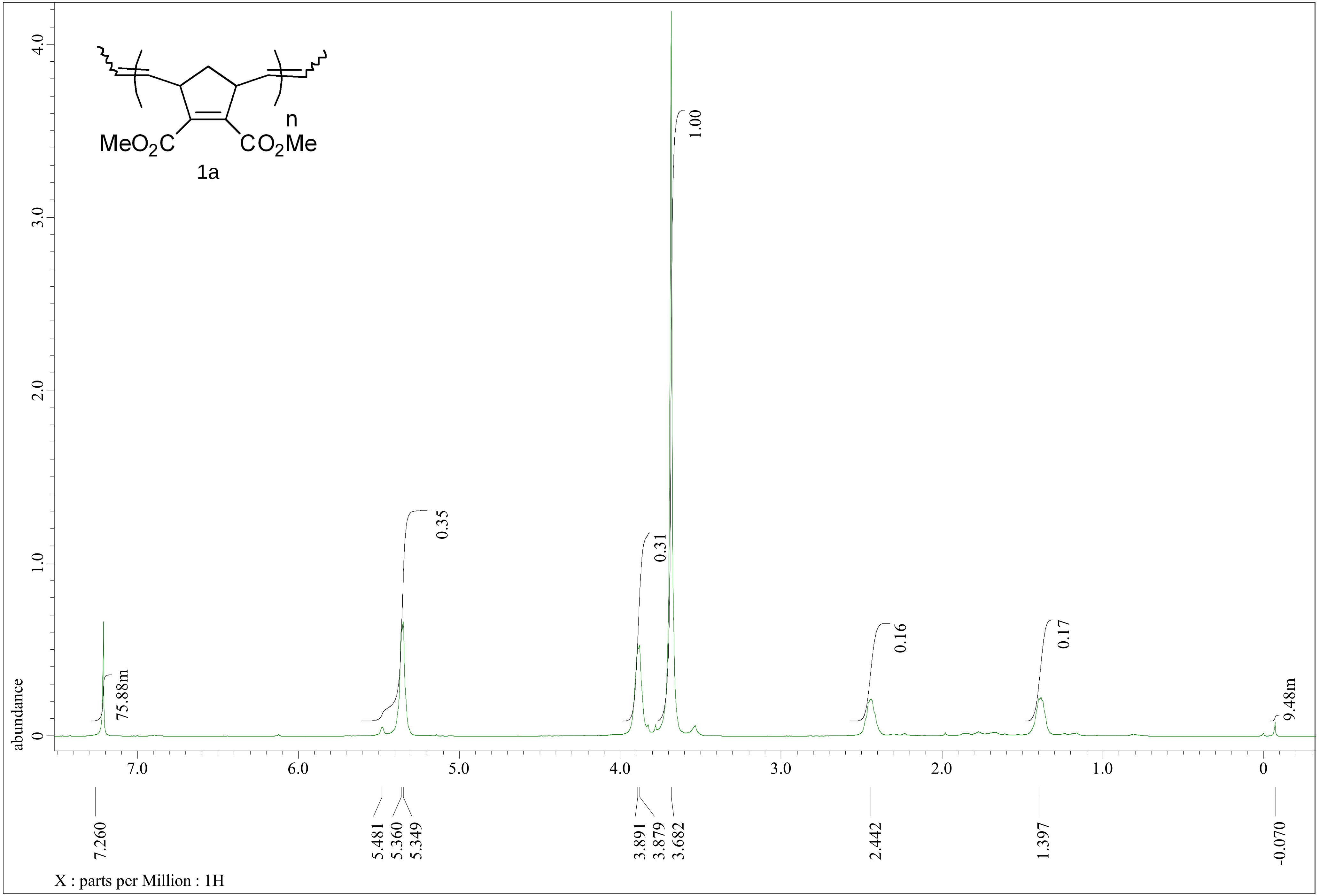

CO2
Ph
CO2Me
11
abundance
X : parts per Million : 1H
0.97
0.39
0.40
0.38
0.59
0.20
0.20
57.17m
7.372
7.364
7.342
7.336
7.326
7.318
7.260
6.922
6.915
6.910
5.207
5.200
5.176
3.969
3.924
3.587
3.581
2.286
2.274
2.132
2.097
2.084
-0.000

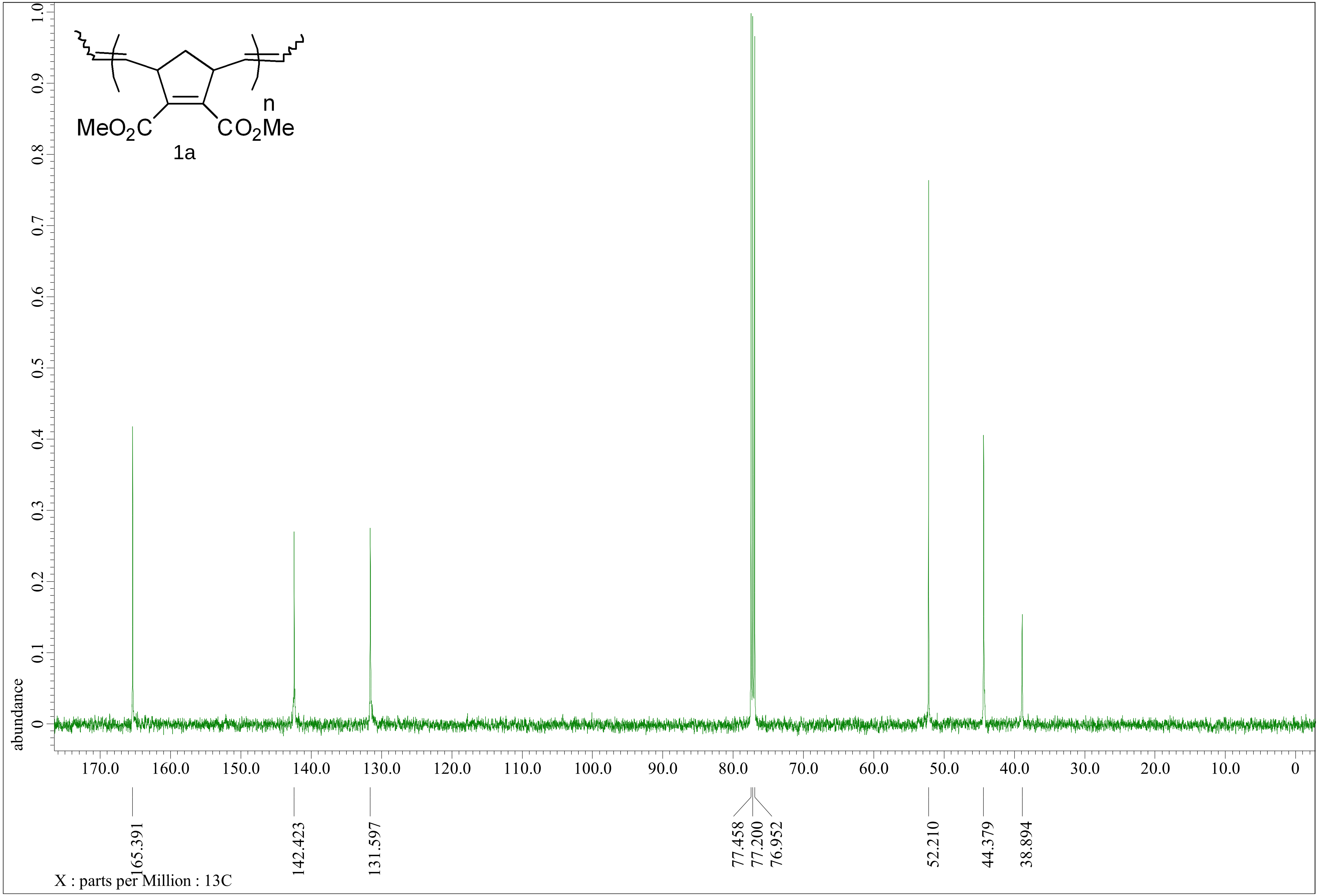

CO2
Ph
CO2Me
11
abundance
0.4
0.3
0.2
0.1
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
166.326
165.372
153.535
152.142
143.100
142.871
136.127
129.117
129.031
128.897
77.858
77.600
77.342
73.546
67.404
54.307
53.916
52.447
X : parts per Million : Carbon13

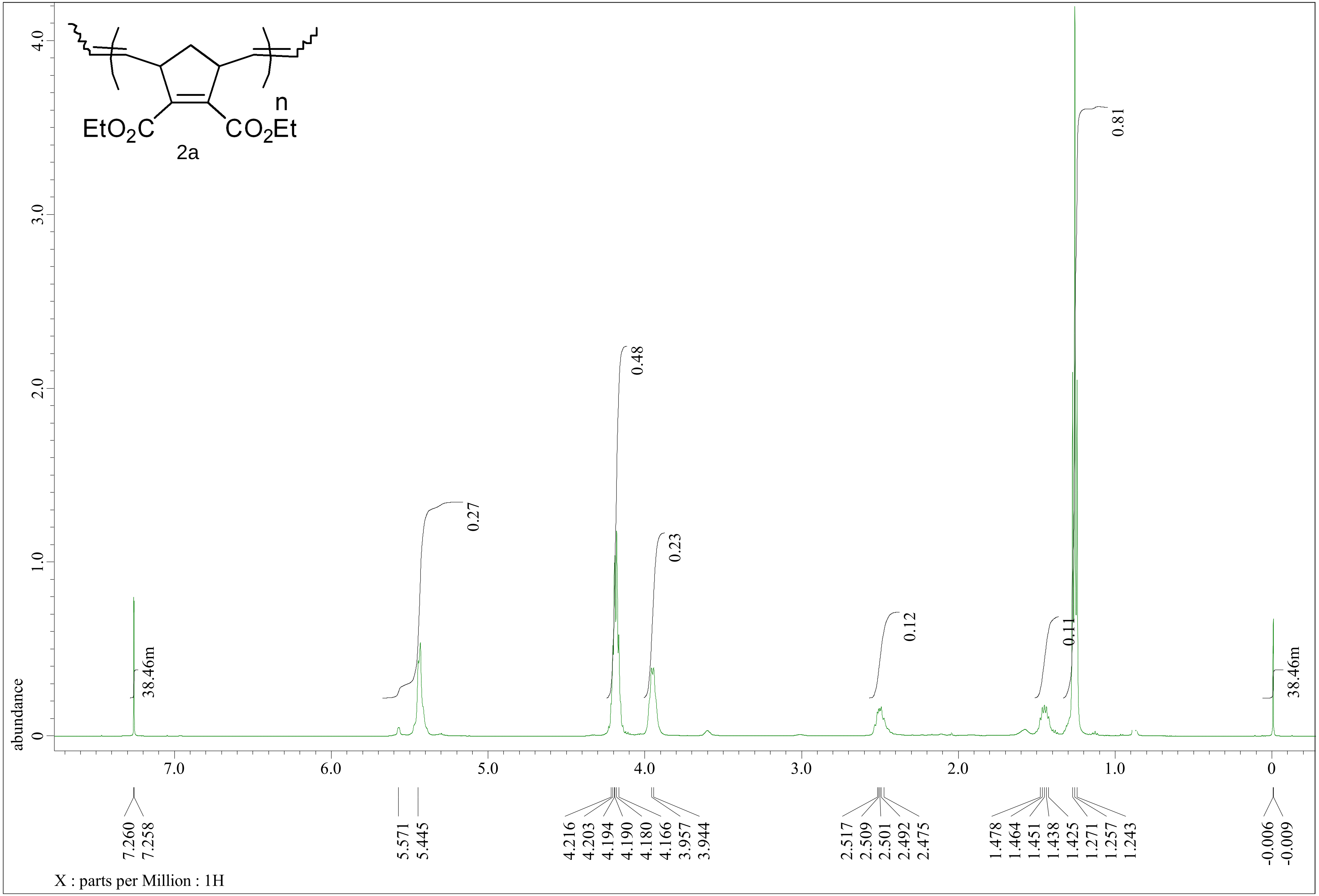

CO2iPr
CO2Me
12
abundance
X : parts per Million : 1H
0.31
0.15
0.30
0.46
0.16
0.15
0.96
8.77m
10.92m
7.260 7.259 6.898 6.895 6.892 5.117 5.105 5.092 5.080 5.067 5.054 5.042 3.909 3.905 3.901 3.897 3.894 3.747 2.264 2.261 2.250 2.248 2.070 2.067 2.056 2.053 1.267 1.257 1.245 -0.021 -0.024

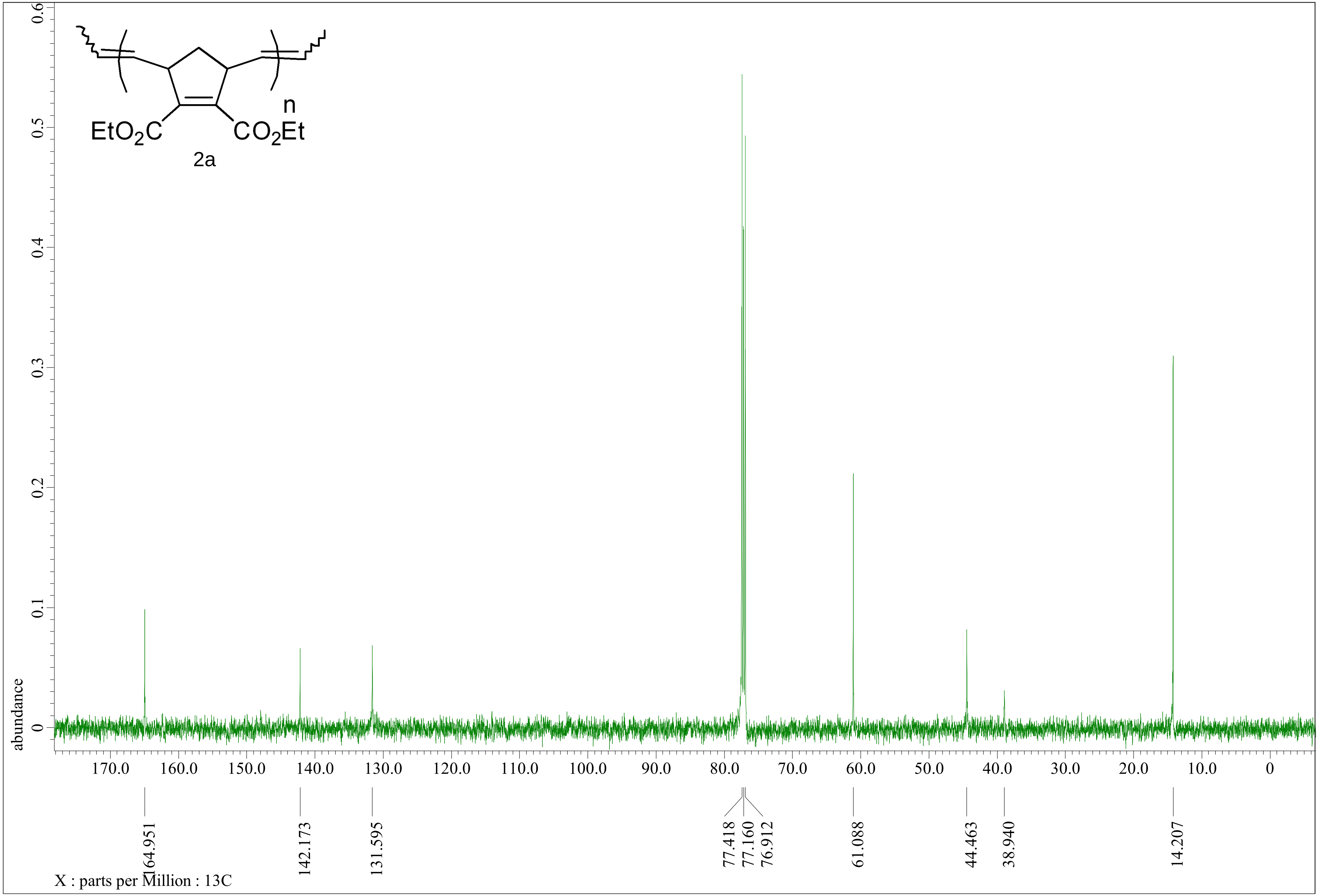


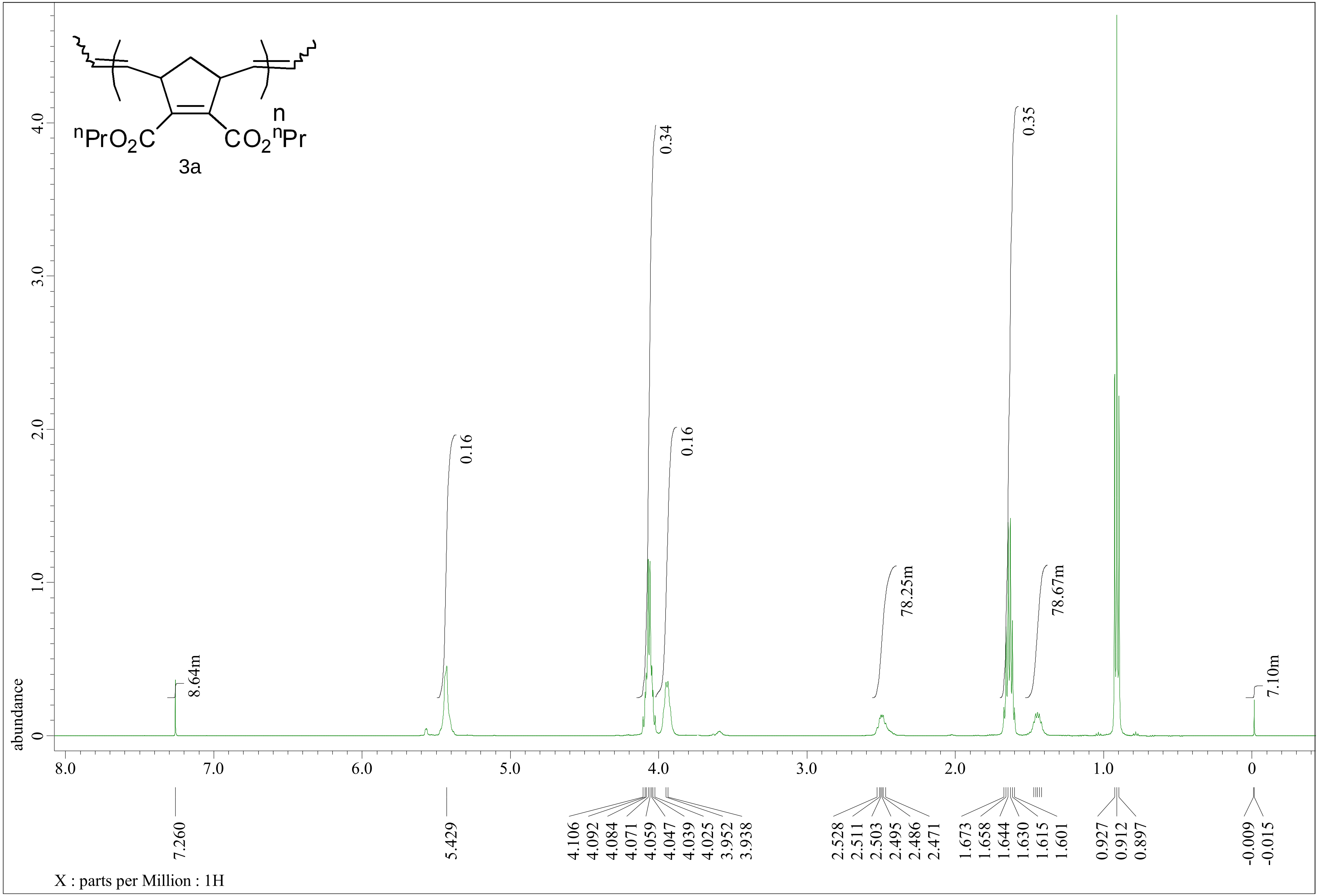
CO2iPr
CO2Me
12
abundance
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.819
164.941
153.085
151.330
142.536
142.488
77.408
77.160
76.902
72.973
68.719
53.581
53.495
51.950
21.857
X : parts per Million : 13C


MeO2C
CO2Me
n
1a
4.0
3.0
2.0
1.0
0
abundance
75.88m
0.35
0.31
1.00
0.16
0.17
9.48m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.481
5.360
5.349
3.891
3.879
3.682
2.442
1.397
-0.070
X : parts per Million : 1H

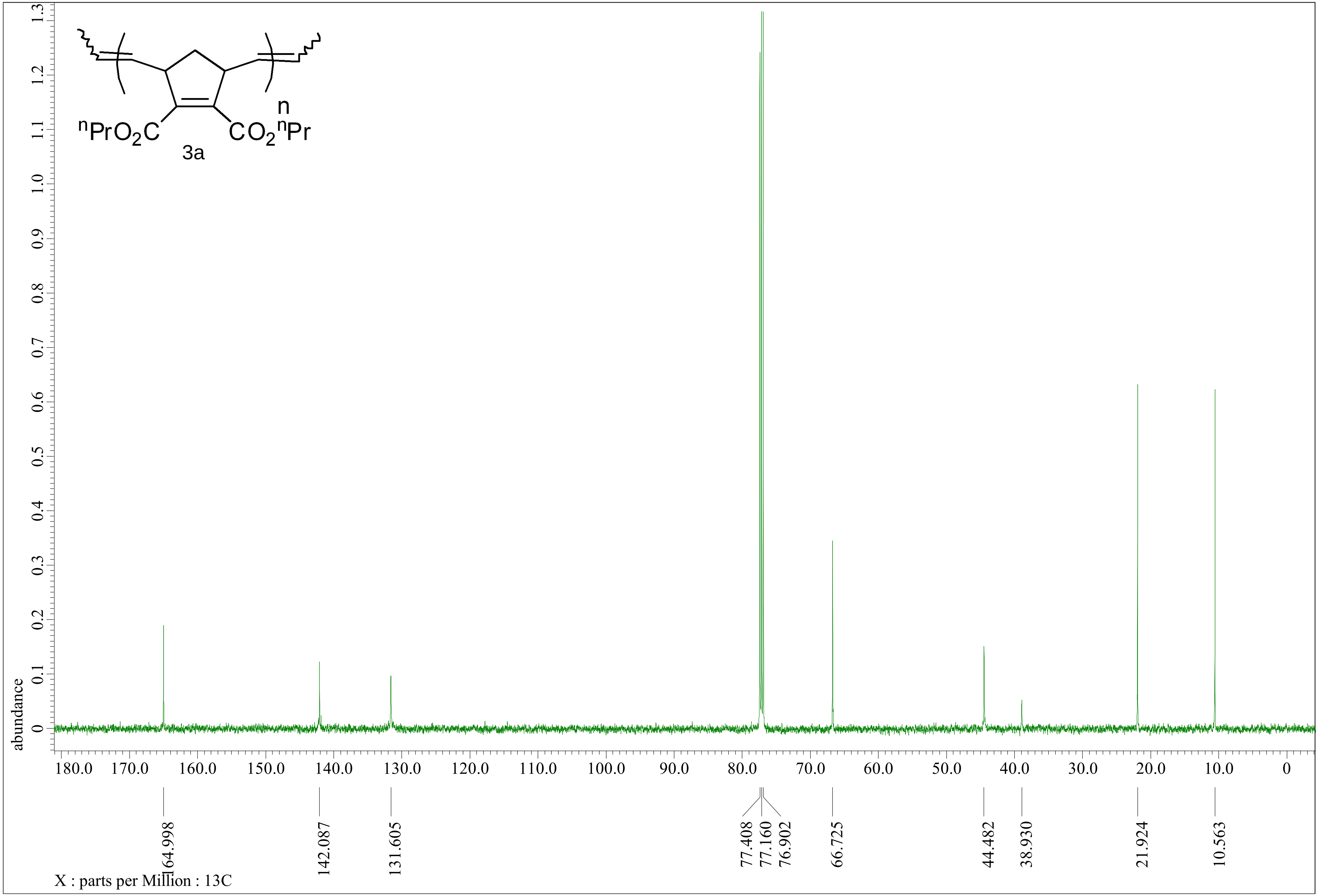

MeO2C
CO2Me
n
1a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.391
142.423
131.597
77.458
77.200
76.952
52.210
44.379
38.894
X : parts per Million : 13C


EtO2C
CO2Et
n
2a
abundance
4.0
3.0
2.0
1.0
0
0.81
0.48
0.27
0.23
0.12
0.11
38.46m
38.46m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
7.258
5.571
5.445
4.216
4.203
4.194
4.190
4.180
4.166
3.957
3.944
2.517
2.509
2.501
2.492
2.475
1.478
1.464
1.451
1.438
1.425
1.271
1.257
1.243
-0.006
-0.009
X : parts per Million : 1H

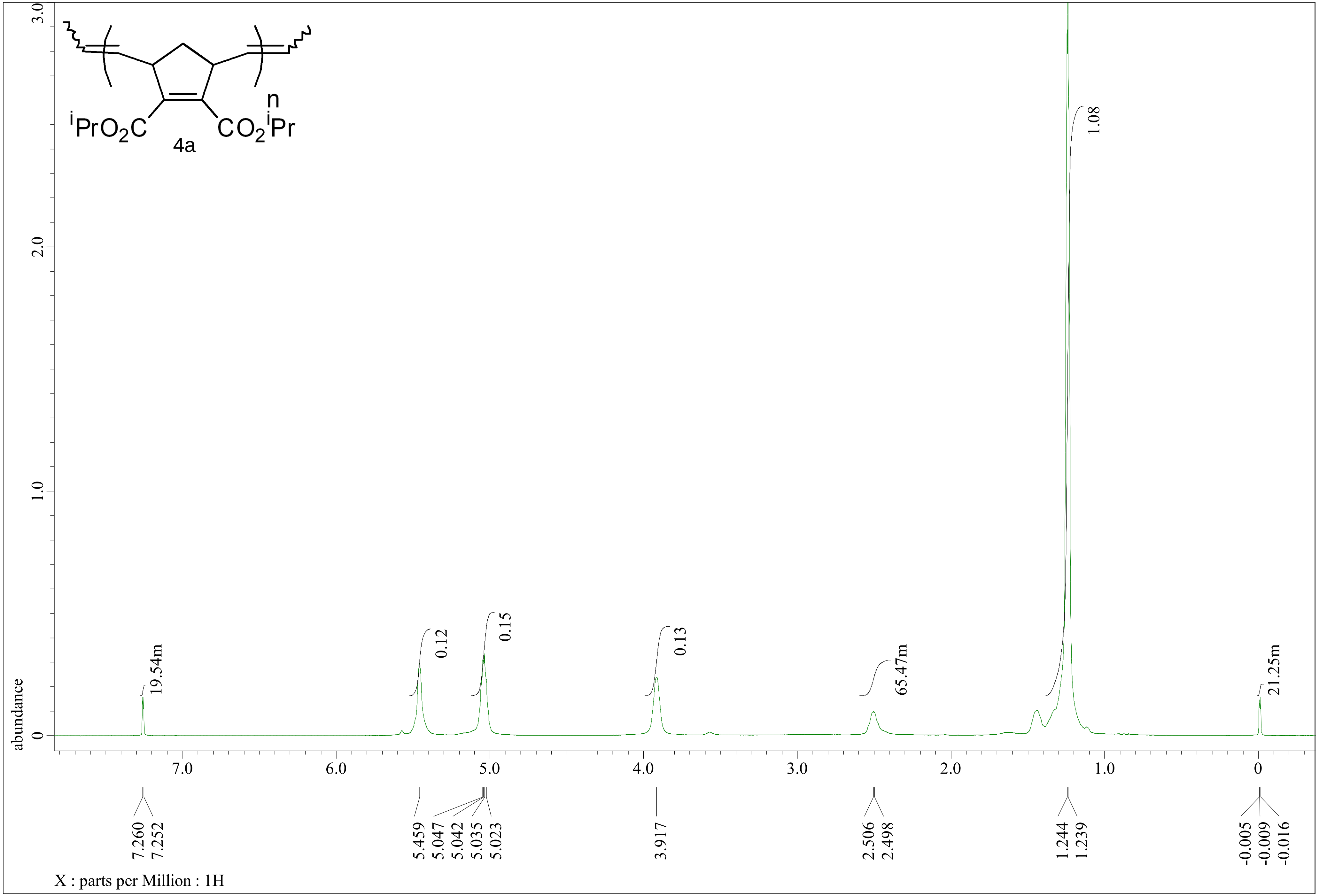

EtO2C
CO2Et
n
2a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.951
142.173
131.595
77.418
77.160
76.912
61.088
44.463
38.940
14.207
X : parts per Million : 13C



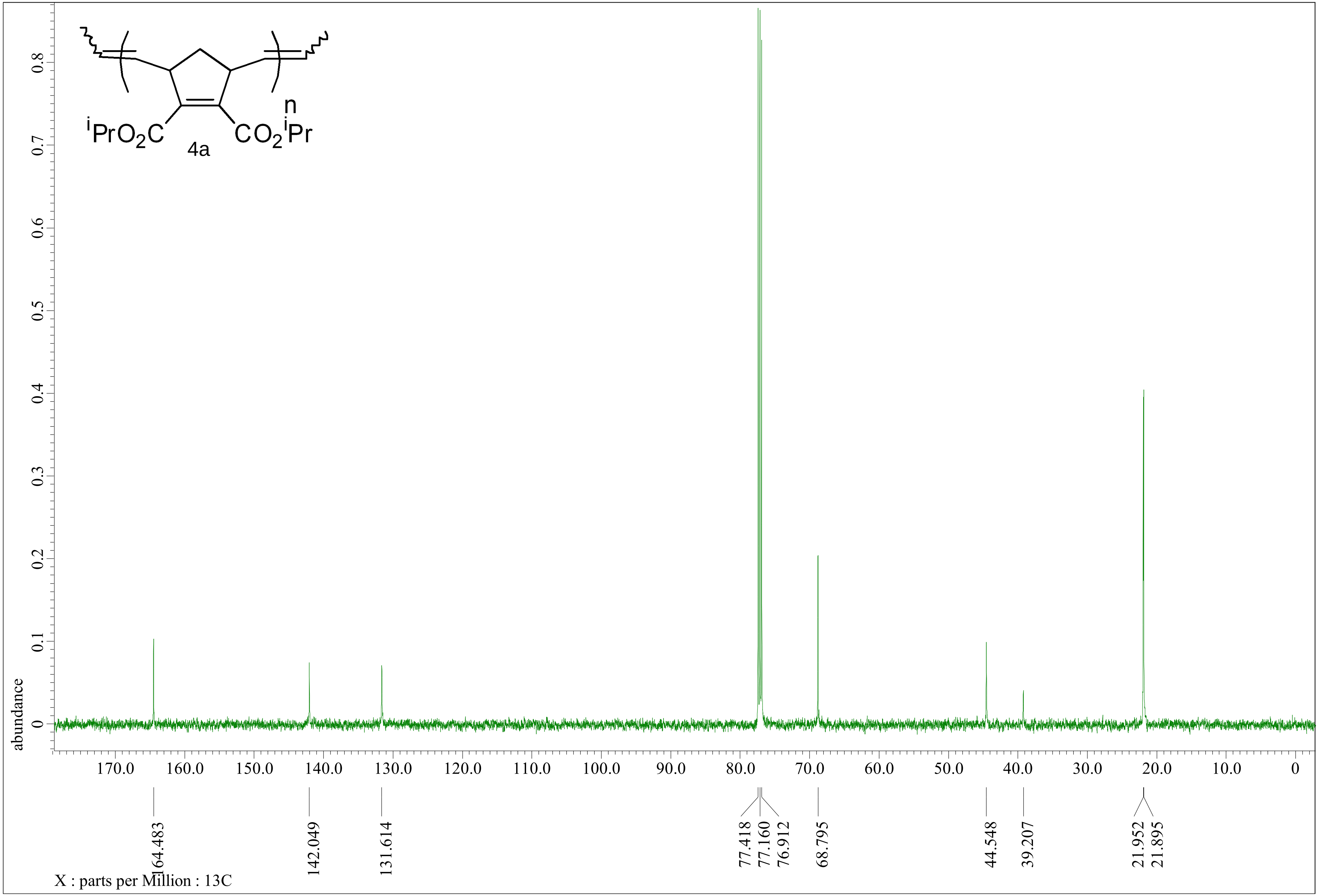
3a



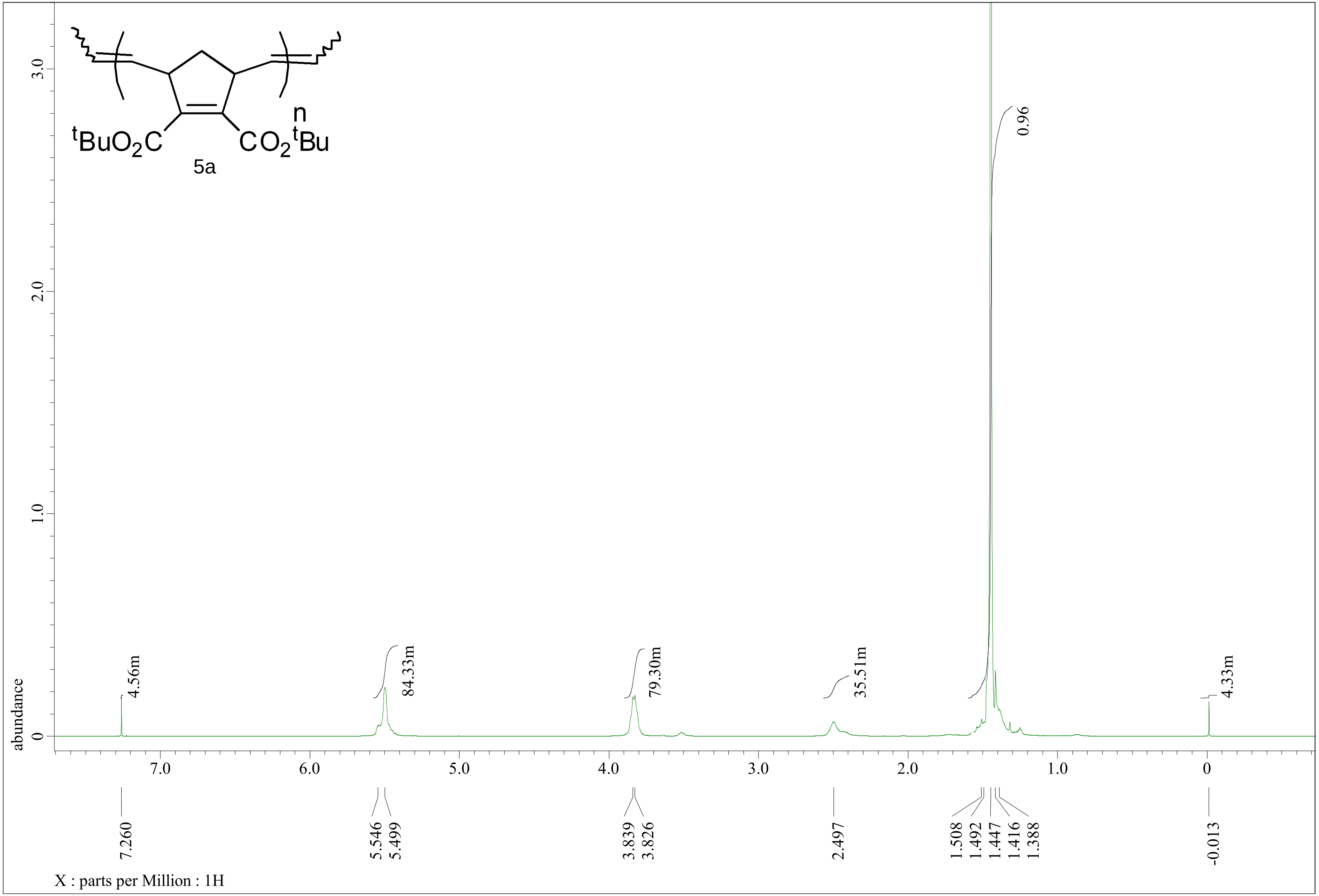
$^nPrO_2C$
$CO_2{}^nPr$
n
3a
abundance
X : parts per Million : 13C
164.998
142.087
131.605
77.408
77.160
76.902
66.725
44.482
38.930
21.924
10.563



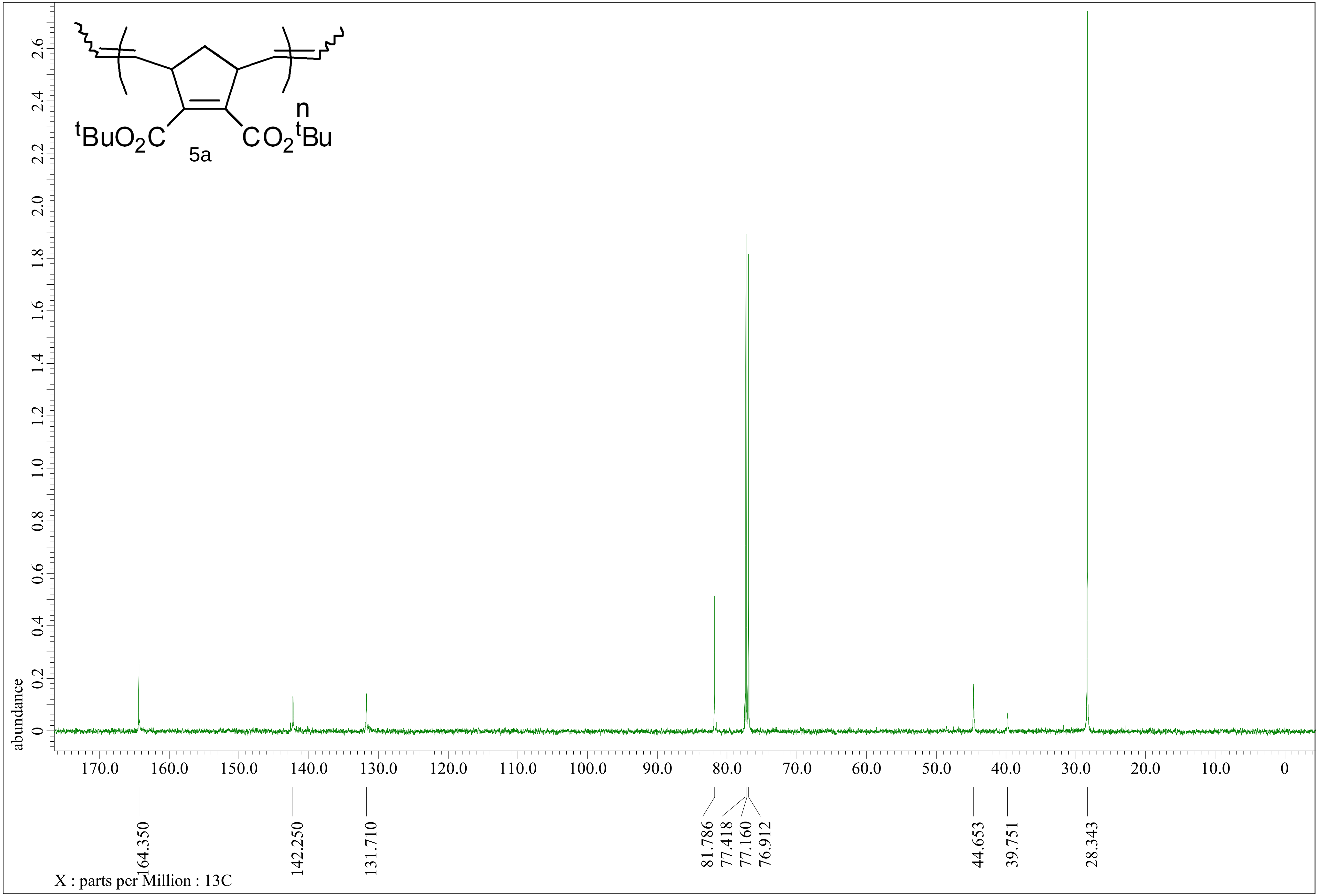
ⁱPrO₂C
CO₂ⁱPr
n
4a
abundance
X : parts per Million : 1H
7.260
7.252
5.459
5.047
5.042
5.035
5.023
3.917
2.506
2.498
1.244
1.239
-0.005
-0.009
-0.016
19.54m
0.12
0.15
0.13
65.47m
1.08
21.25m



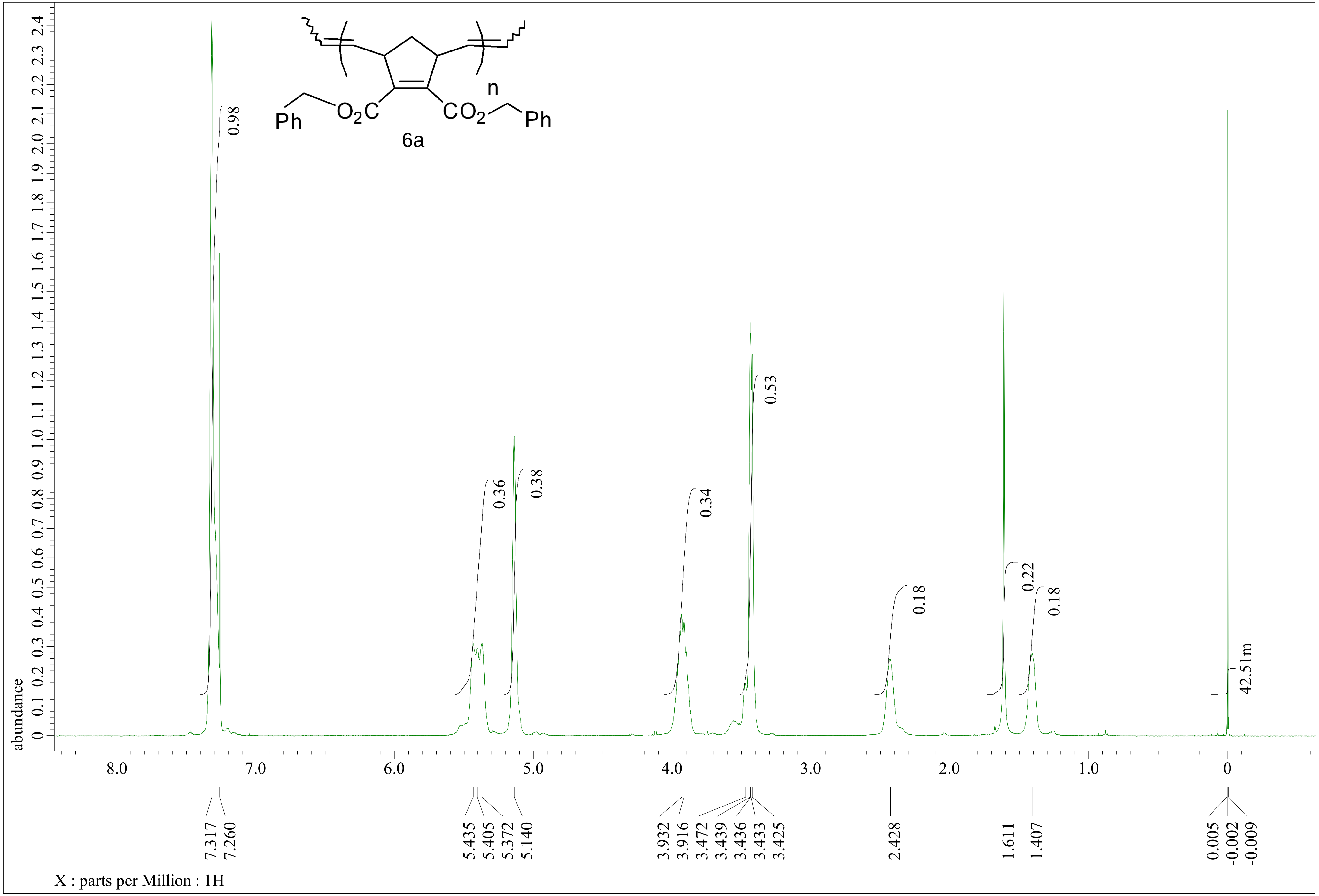
$^{i}PrO_2C$
$CO_2{}^{i}Pr$
n
4a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.483
142.049
131.614
77.418
77.160
76.912
68.795
44.548
39.207
21.952
21.895
X : parts per Million : 13C



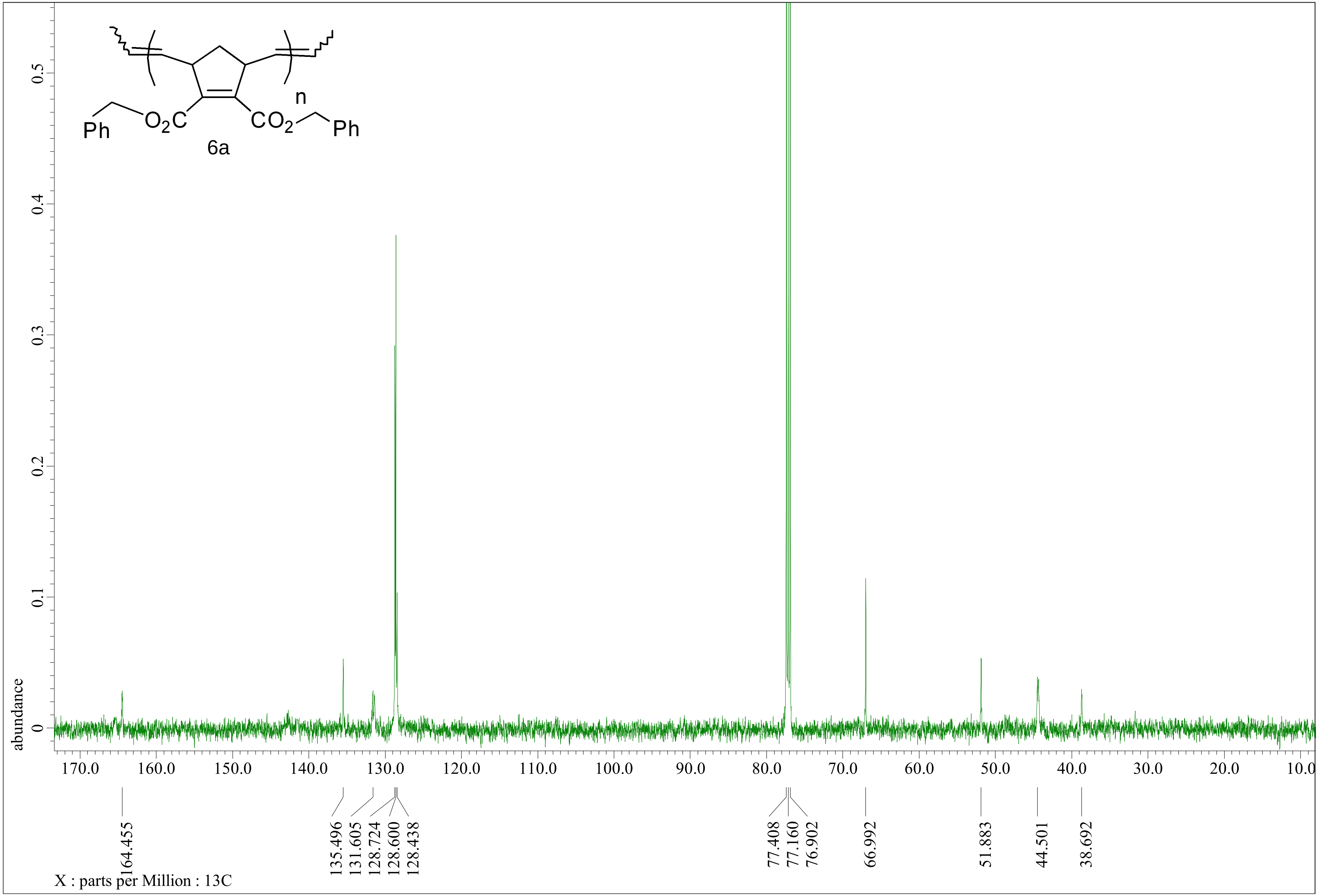
tBuO2C
CO2tBu
n
5a
3.0
2.0
1.0
0
abundance
4.56m
84.33m
79.30m
35.51m
0.96
4.33m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.546
5.499
3.839
3.826
2.497
1.508
1.492
1.447
1.416
1.388
-0.013
X : parts per Million : 1H

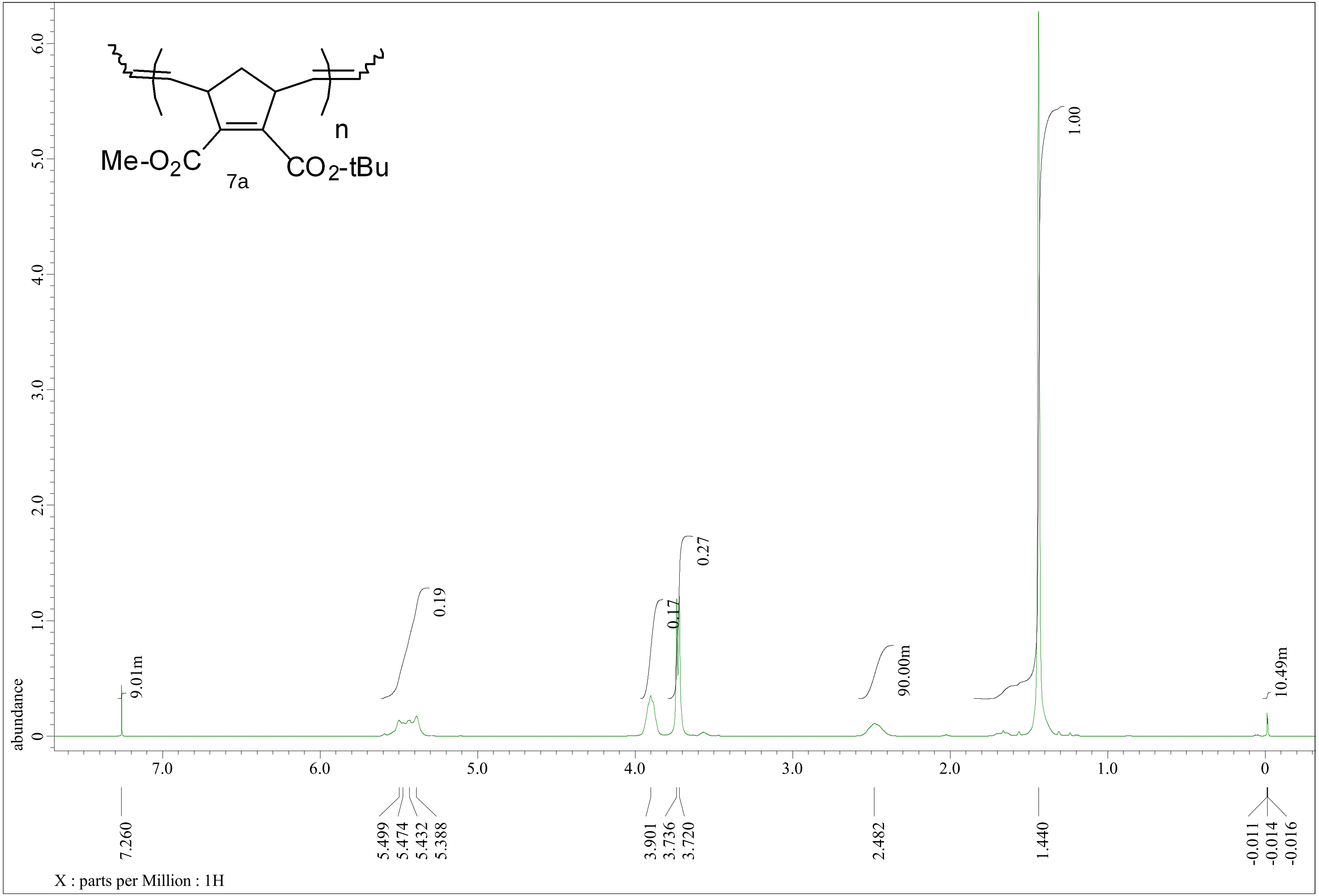


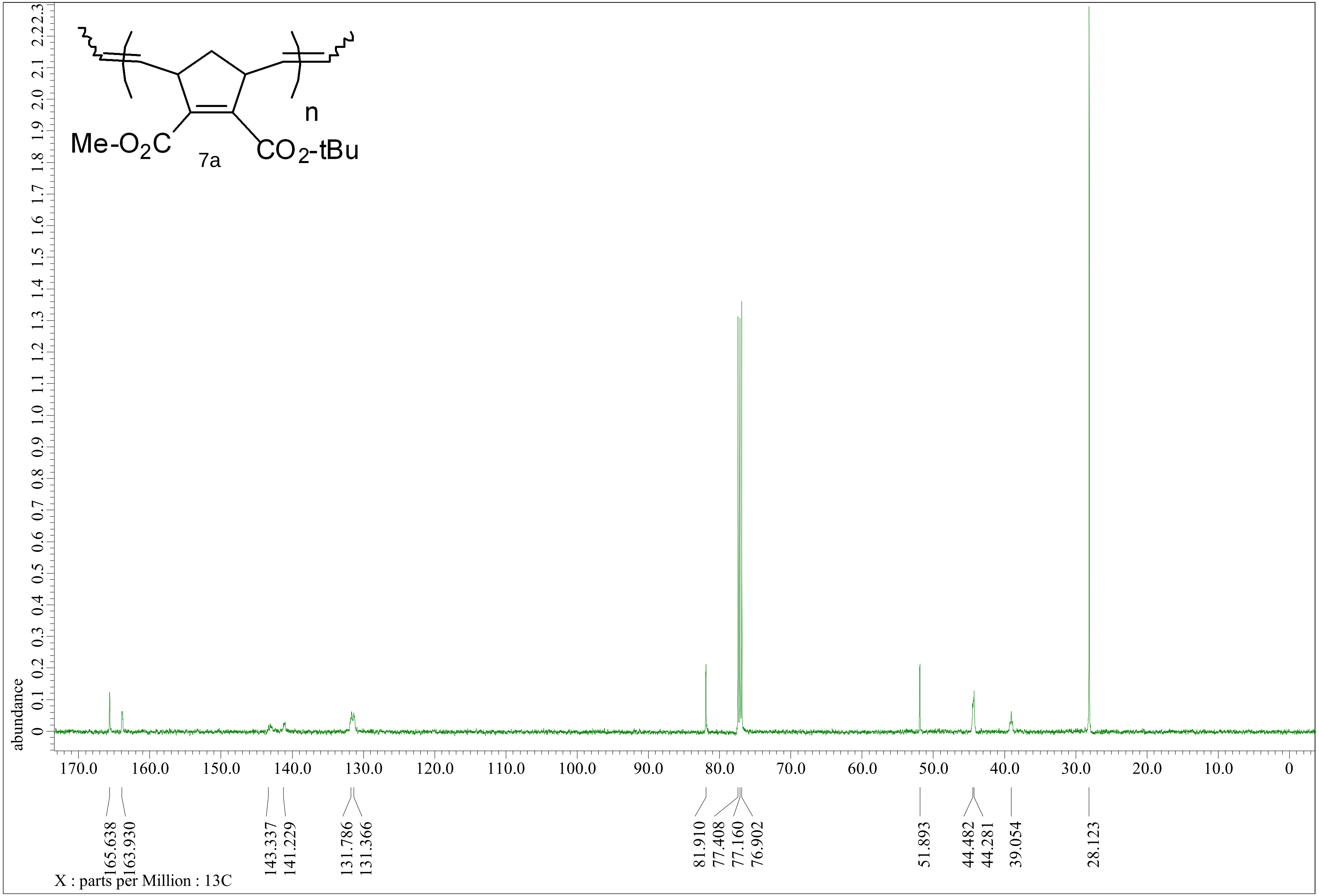
ᵗBuO₂C
CO₂ᵗBu
n
5a
abundance
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.350
142.250
131.710
81.786
77.418
77.160
76.912
44.653
39.751
28.343
X : parts per Million : 13C

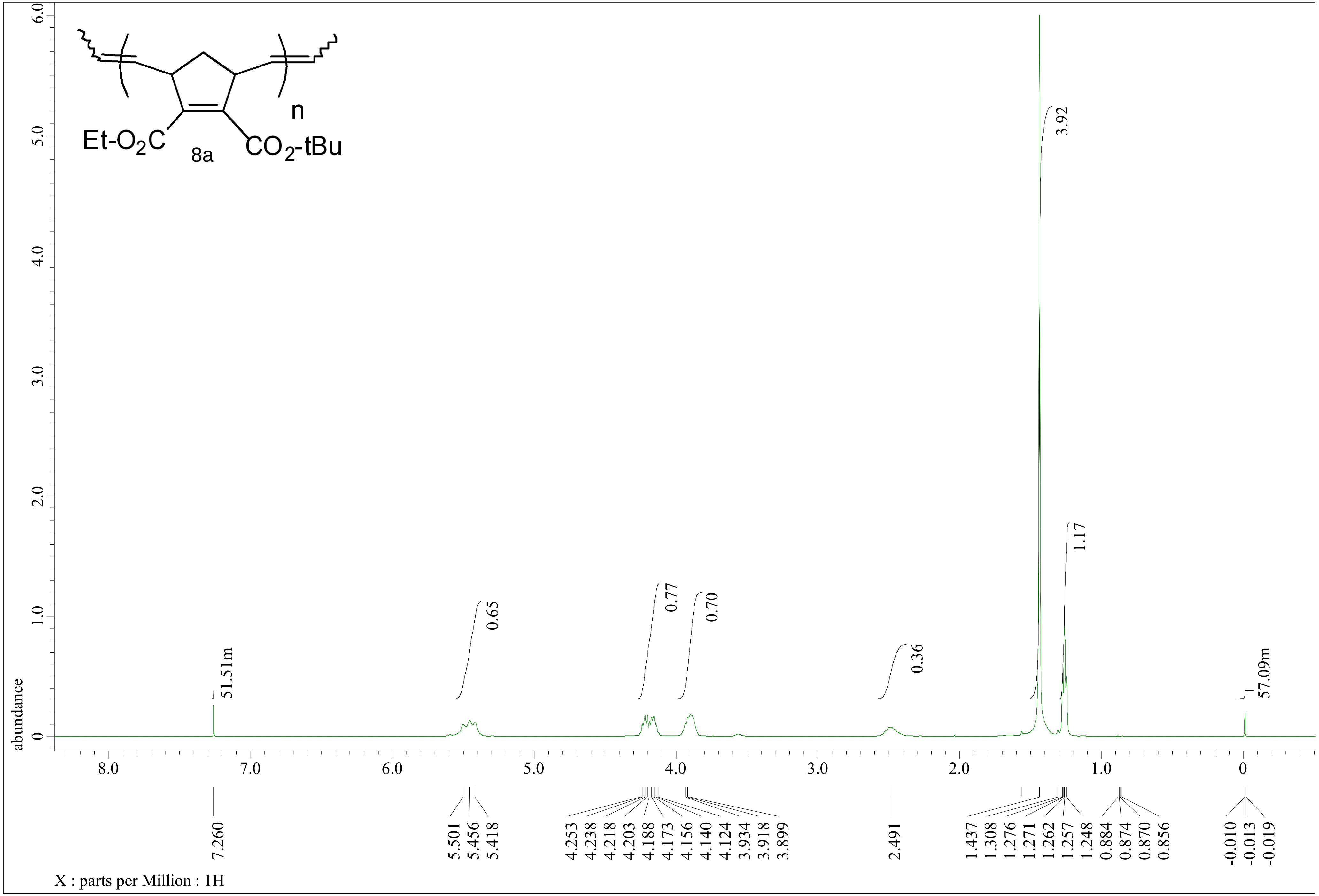


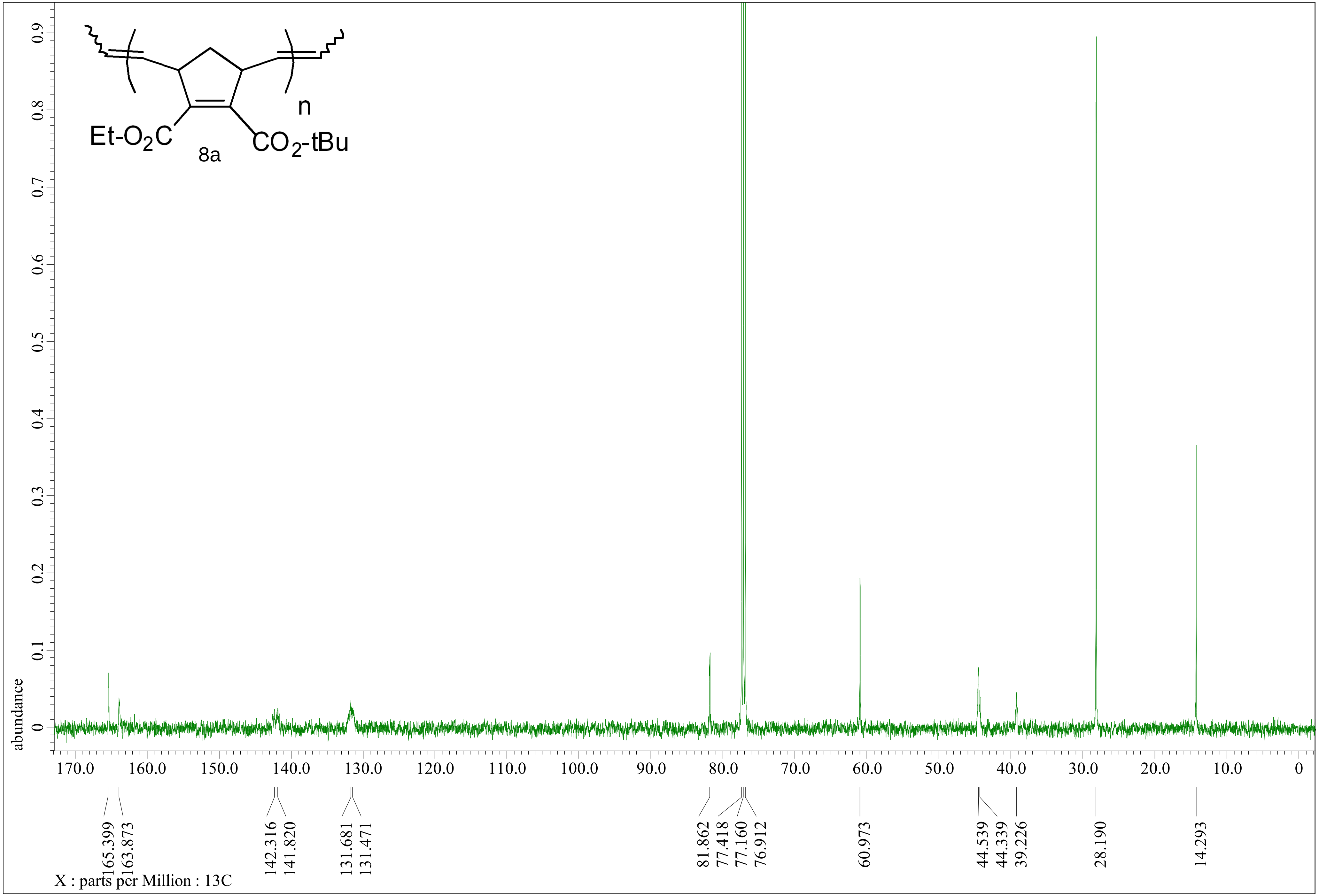
n
Ph
O_2C
CO_2
Ph
6a
0.98
0.36
0.38
0.34
0.53
0.18
0.22
0.18
42.51m
abundance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.317
7.260
5.435
5.405
5.372
5.140
3.932
3.916
3.472
3.439
3.436
3.433
3.425
2.428
1.611
1.407
0.005
-0.002
-0.009
X : parts per Million : 1H


6a
n
Ph
O_2C
CO_2
Ph
abundance
0.5
0.4
0.3
0.2
0.1
0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
164.455
135.496
131.605
128.724
128.600
128.438
77.408
77.160
76.902
66.992
51.883
44.501
38.692
X : parts per Million : 13C

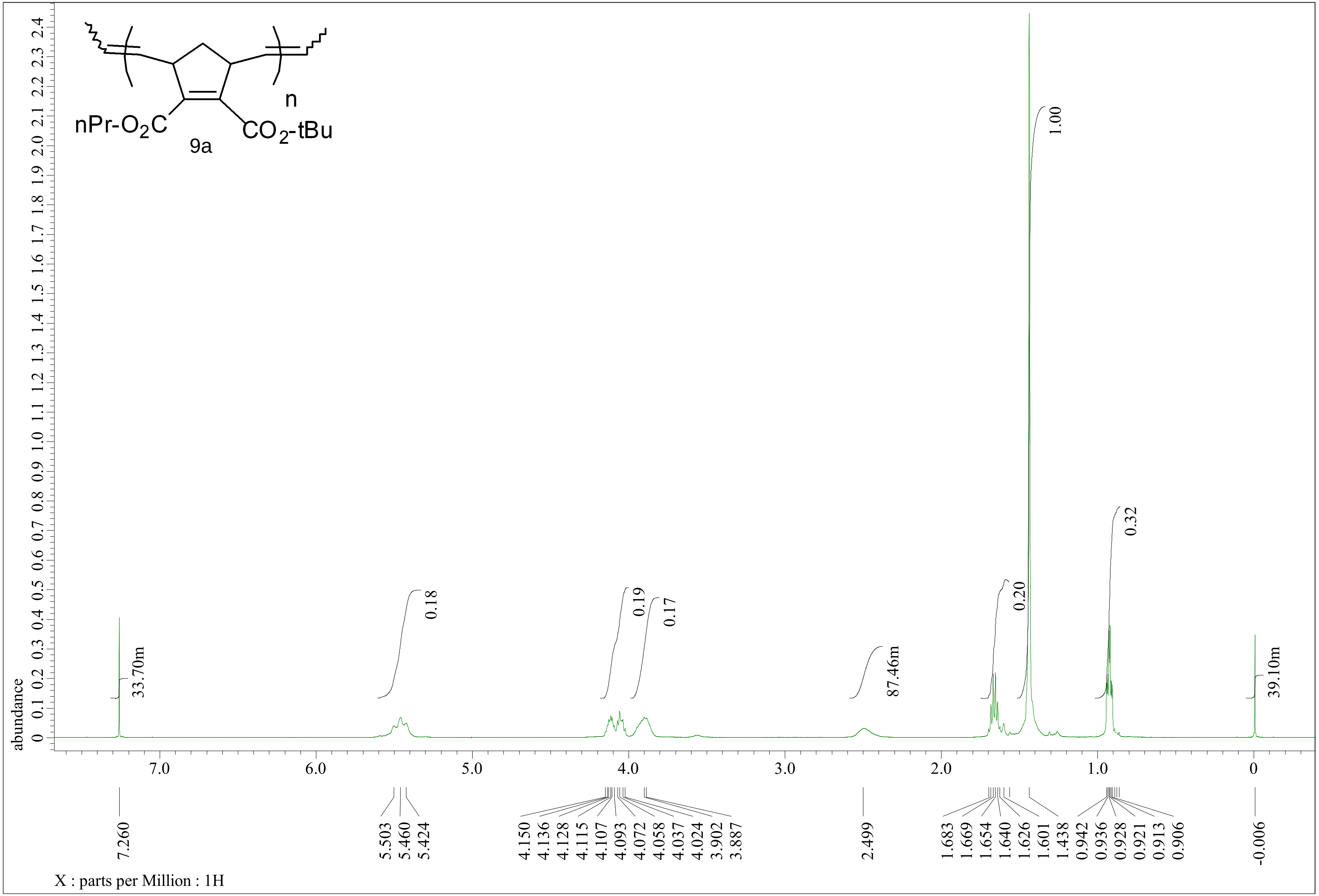

Me-O2C
CO2-tBu
7a
n
abundance
X : parts per Million : 1H
9.01m
0.19
0.17
0.27
90.00m
1.00
10.49m
7.260
5.499
5.474
5.432
5.388
3.901
3.736
3.720
2.482
1.440
-0.011
-0.014
-0.016

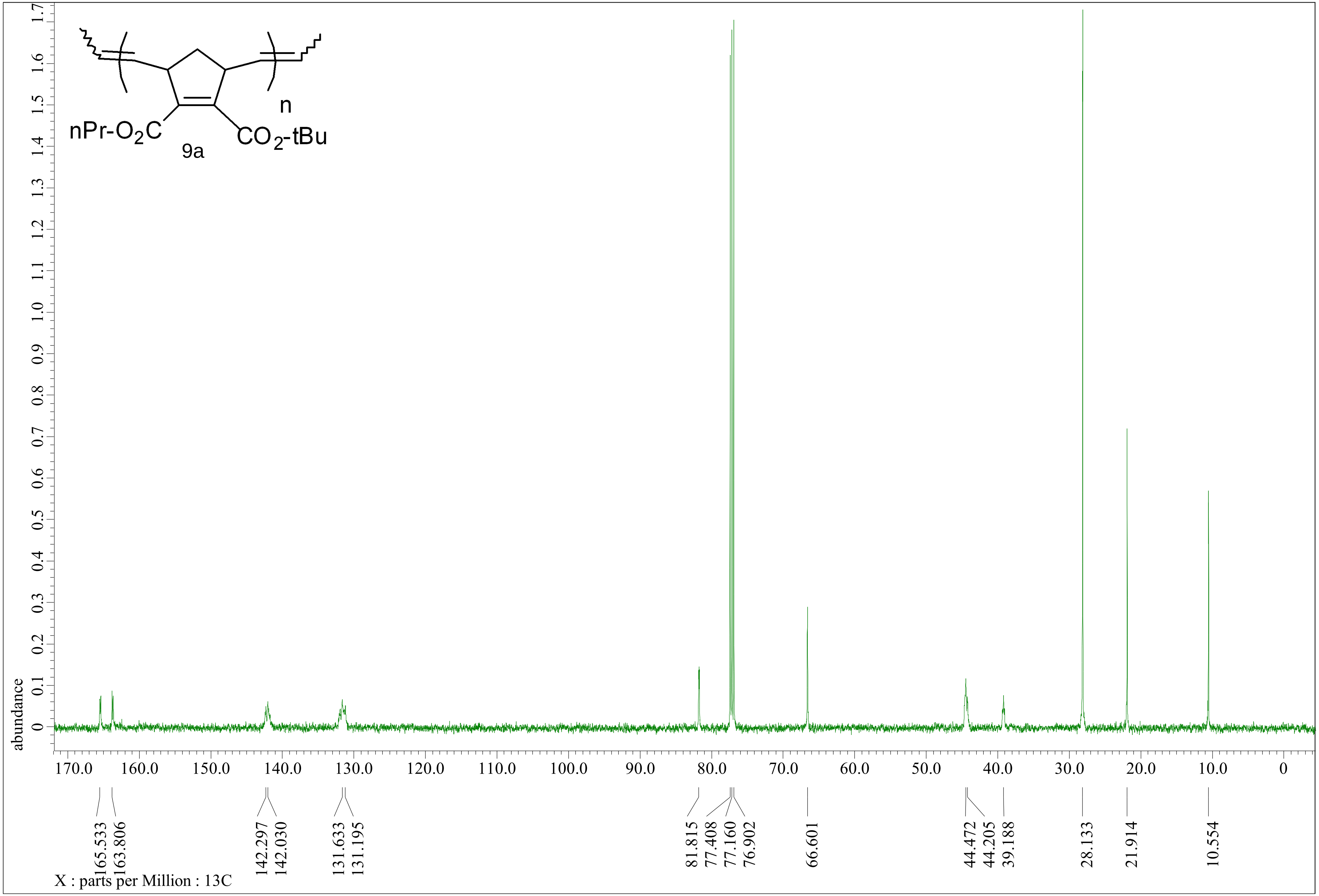

Me-O2C
7a
CO2-tBu
n
abundance
X : parts per Million : 13C
165.638
163.930
143.337
141.229
131.786
131.366
81.910
77.408
77.160
76.902
51.893
44.482
44.281
39.054
28.123

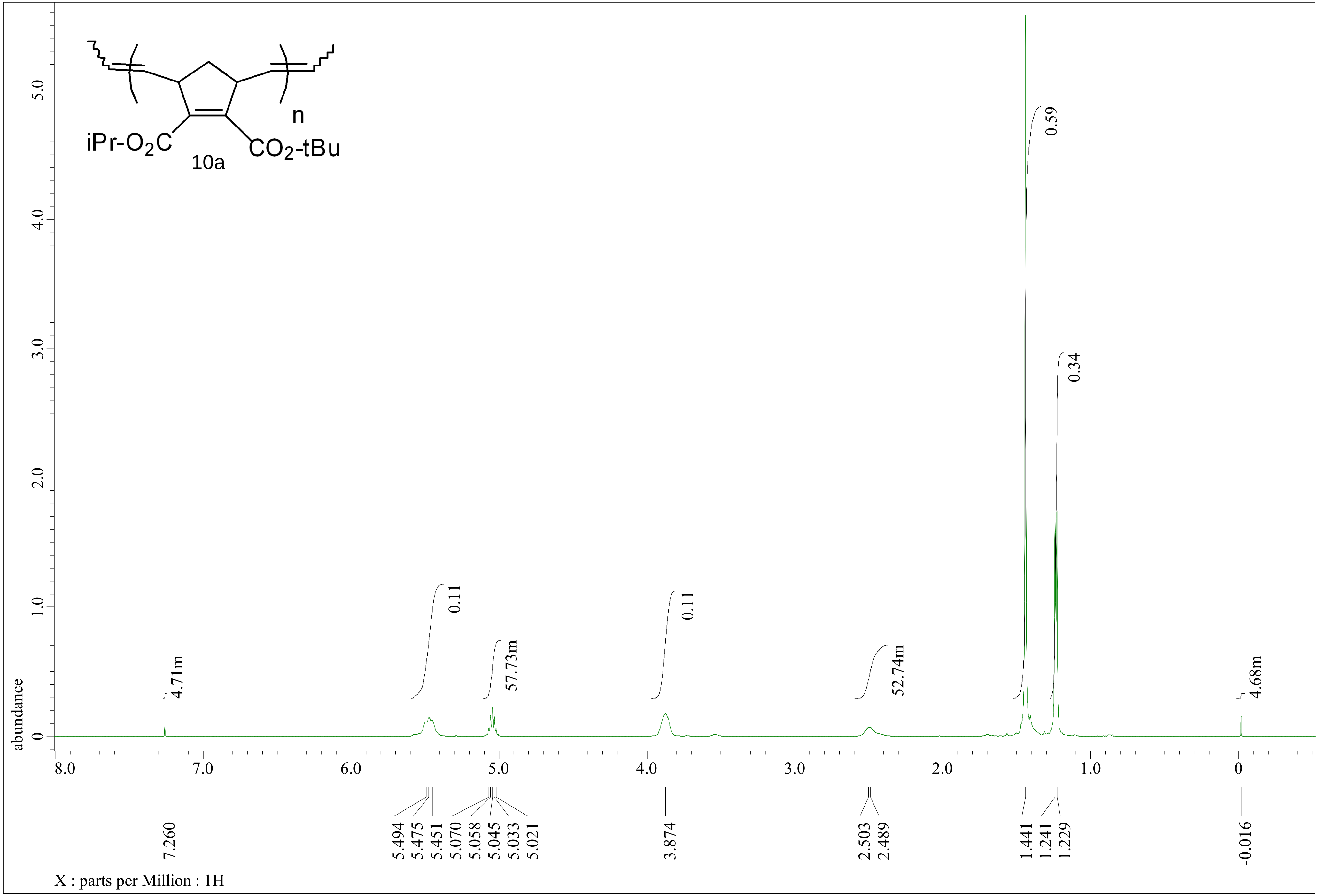

Et-O2C
8a
CO2-tBu
n
abundance
X : parts per Million : 1H
3.92
1.17
0.77
0.70
0.65
0.36
51.51m
57.09m
7.260
5.501
5.456
5.418
4.253
4.238
4.218
4.203
4.188
4.173
4.156
4.140
4.124
3.934
3.918
3.899
2.491
1.437
1.308
1.276
1.271
1.262
1.257
1.248
0.884
0.874
0.870
0.856
-0.010
-0.013
-0.019

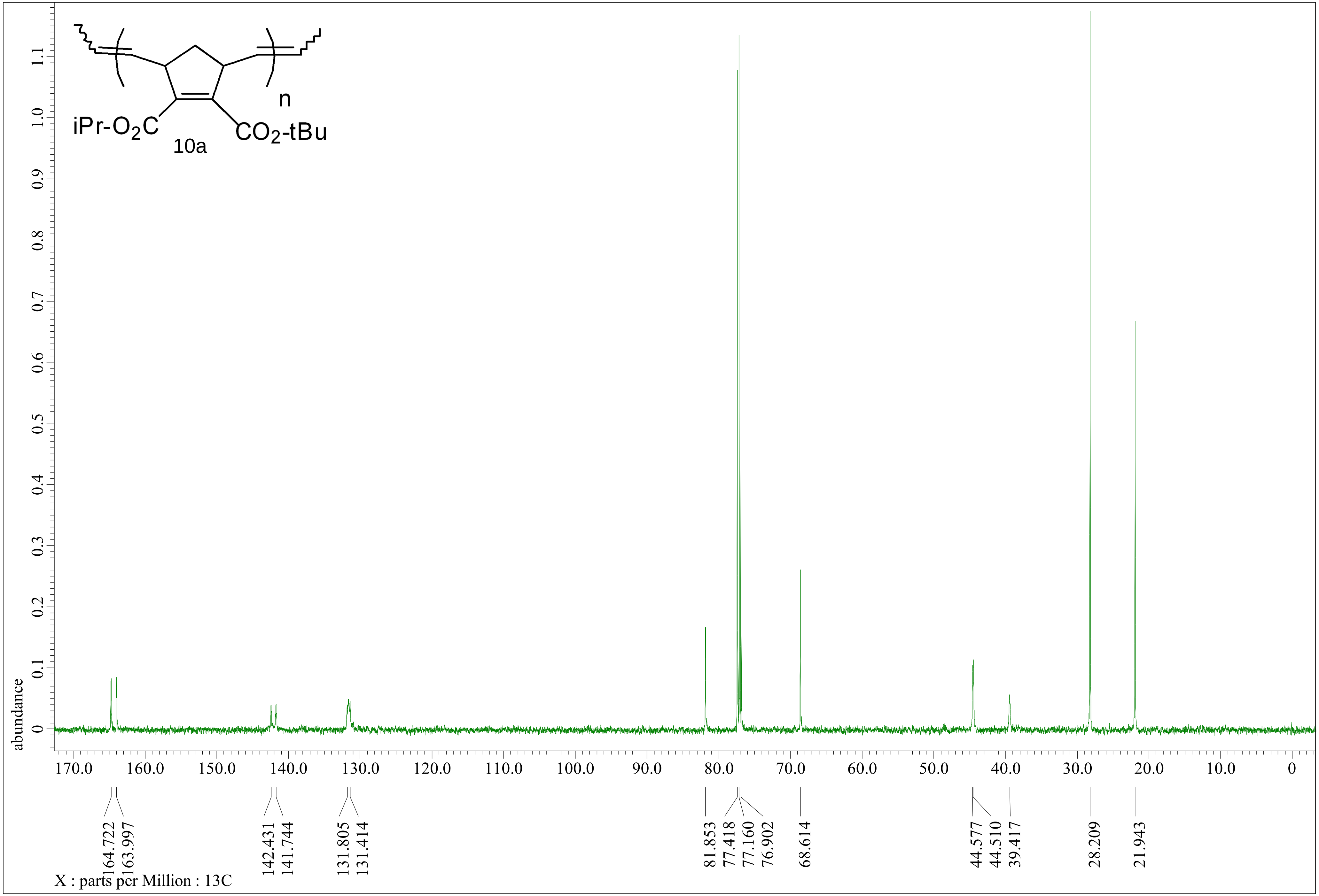


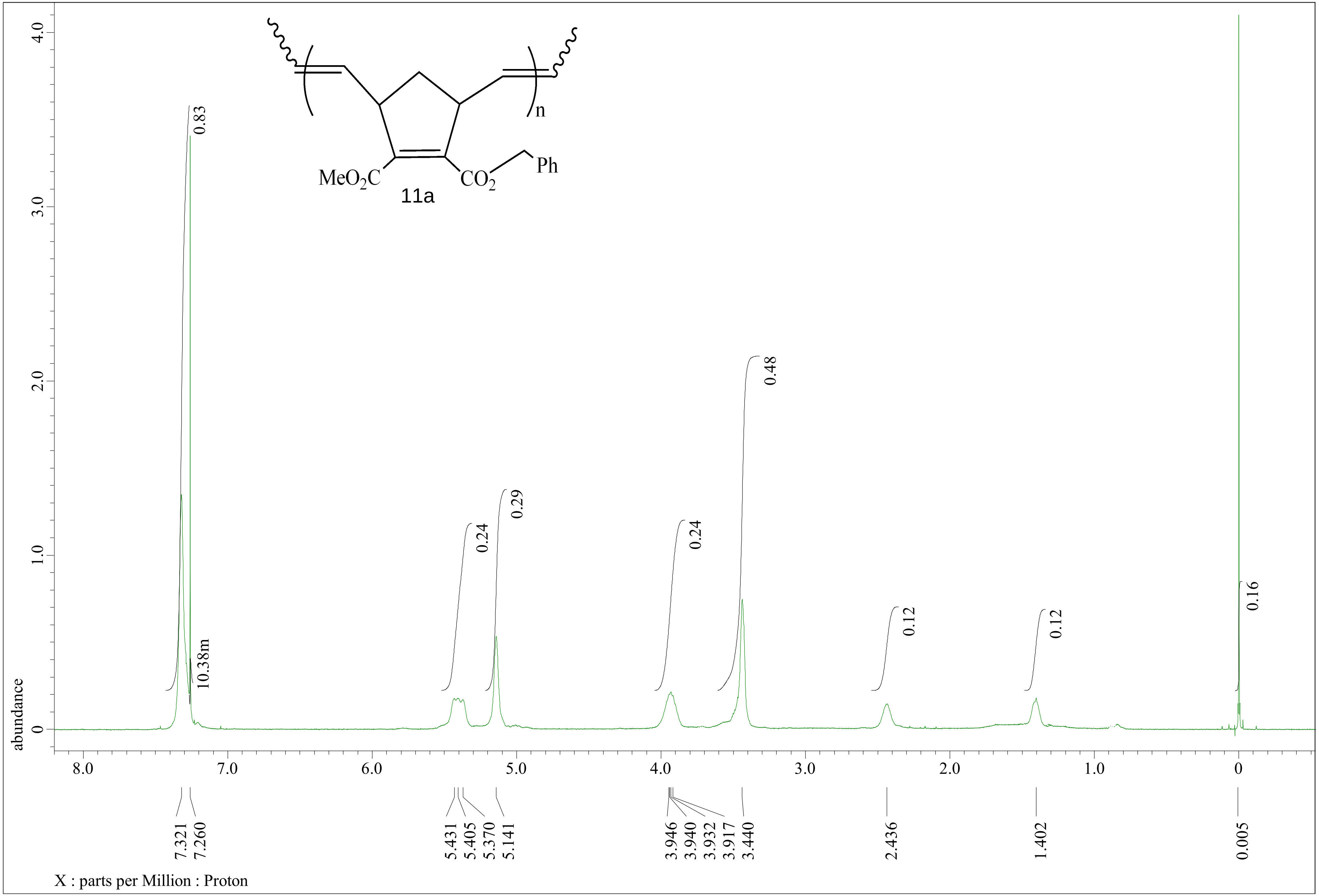
Et-O2C
CO2-tBu
n
8a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.399
163.873
142.316
141.820
131.681
131.471
81.862
77.418
77.160
76.912
60.973
44.539
44.339
39.226
28.190
14.293
X : parts per Million : 13C


nPr-O2C
CO2-tBu
n
9a
abundance
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4
7.0 6.0 5.0 4.0 3.0 2.0 1.0 0
X : parts per Million : 1H
33.70m
0.18
0.19
0.17
87.46m
0.20
1.00
0.32
39.10m
7.260
5.503
5.460
5.424
4.150
4.136
4.128
4.115
4.107
4.093
4.072
4.058
4.037
4.024
3.902
3.887
2.499
1.683
1.669
1.654
1.640
1.626
1.601
1.438
0.942
0.936
0.928
0.921
0.913
0.906
-0.006

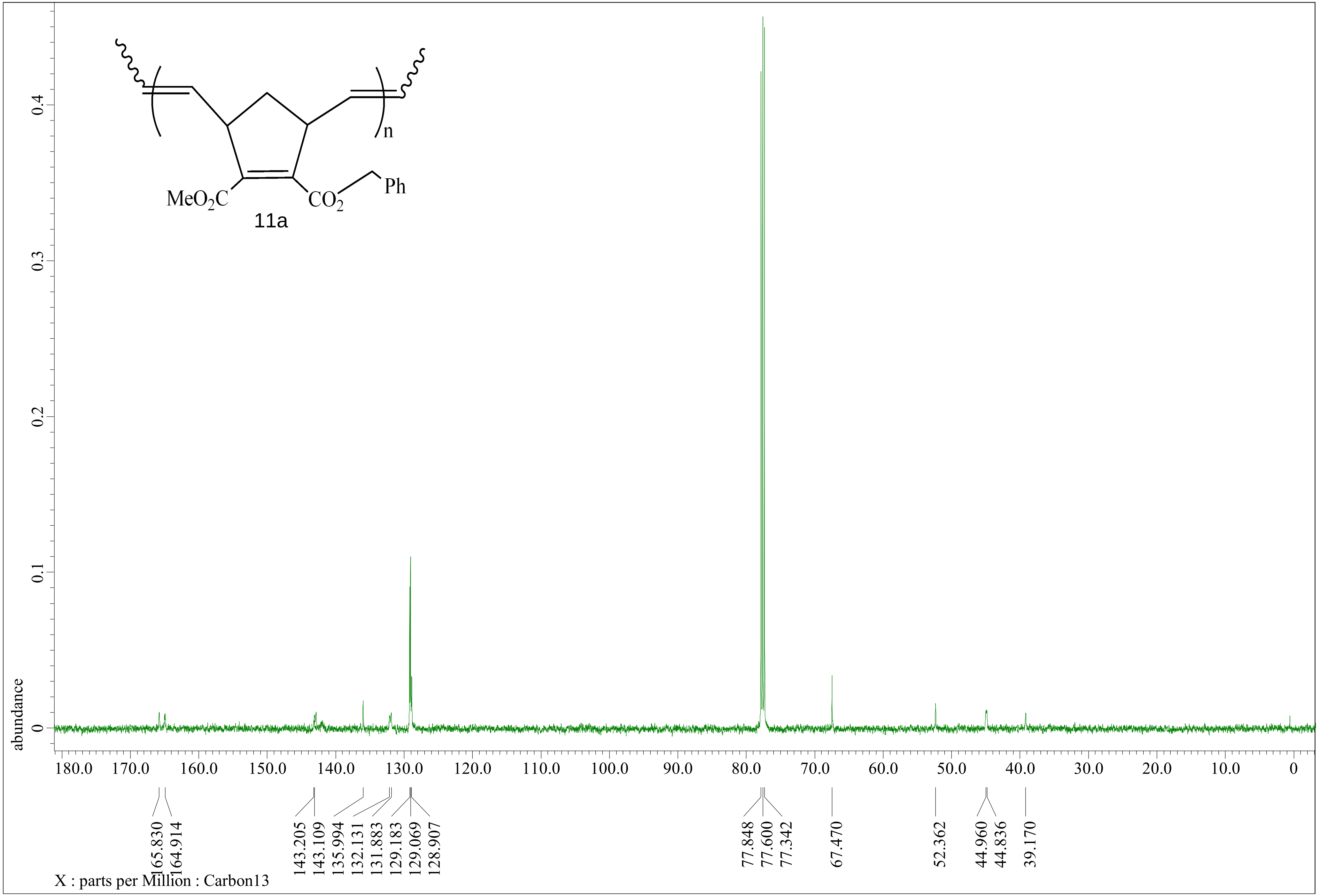

nPr-O2C
CO2-tBu
n
9a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.533
163.806
142.297
142.030
131.633
131.195
81.815
77.408
77.160
76.902
66.601
44.472
44.205
39.188
28.133
21.914
10.554
X : parts per Million : 13C


iPr-O2C
CO2-tBu
n
10a
abundance
X : parts per Million : 1H
0.11
57.73m
0.11
52.74m
0.59
0.34
4.71m
4.68m
7.260
5.494
5.475
5.451
5.070
5.058
5.045
5.033
5.021
3.874
2.503
2.489
1.441
1.241
1.229
-0.016

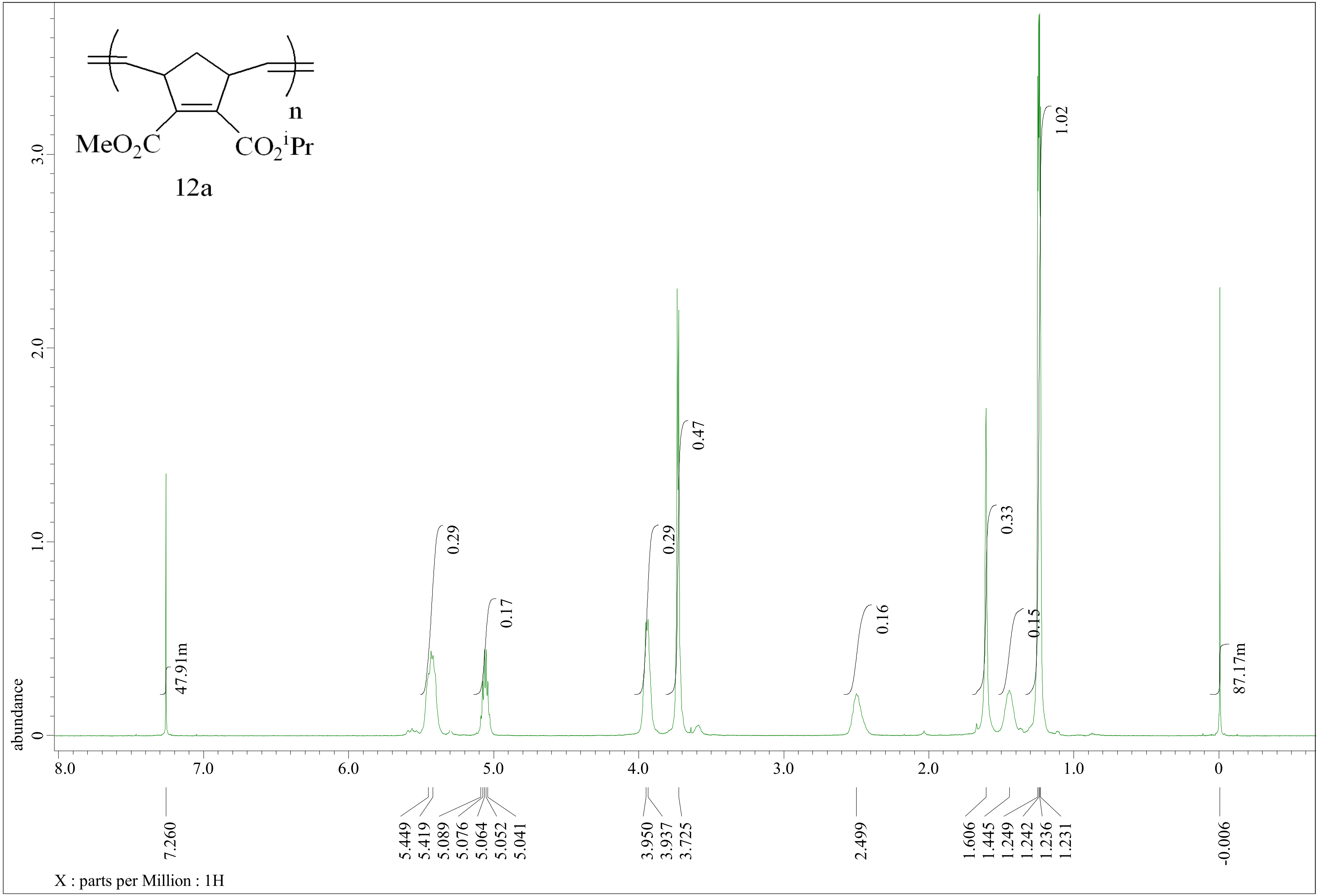

iPr-O2C
CO2-tBu
n
10a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.722
163.997
142.431
141.744
131.805
131.414
81.853
77.418
77.160
76.902
68.614
44.577
44.510
39.417
28.209
21.943
X : parts per Million : 13C



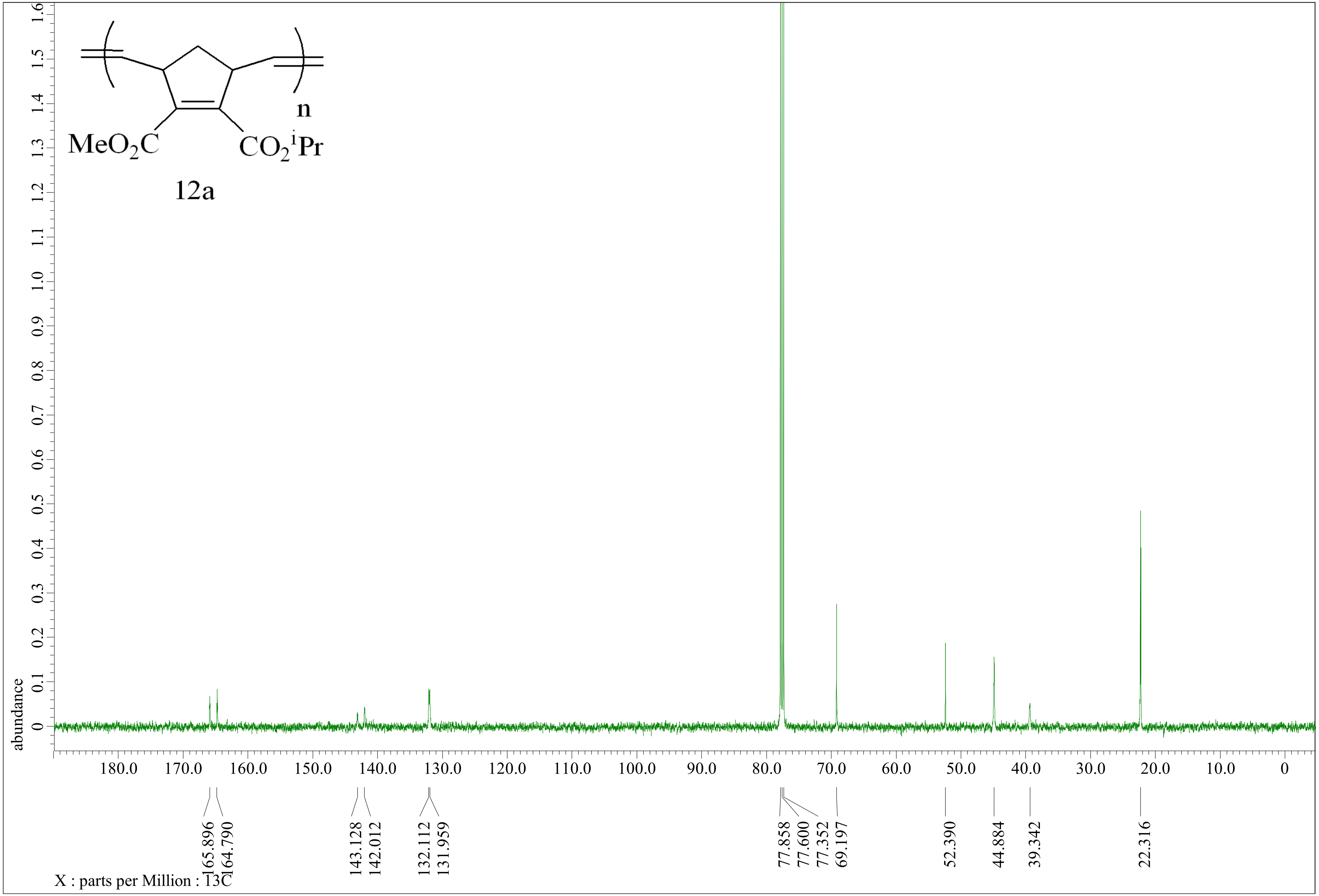
MeO2C
CO2
Ph
n
11a
abundance
4.0
3.0
2.0
1.0
0
0.83
10.38m
0.24
0.29
0.24
0.48
0.12
0.12
0.16
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.321
7.260
5.431
5.405
5.370
5.141
3.946
3.940
3.932
3.917
3.440
2.436
1.402
0.005
X : parts per Million : Proton

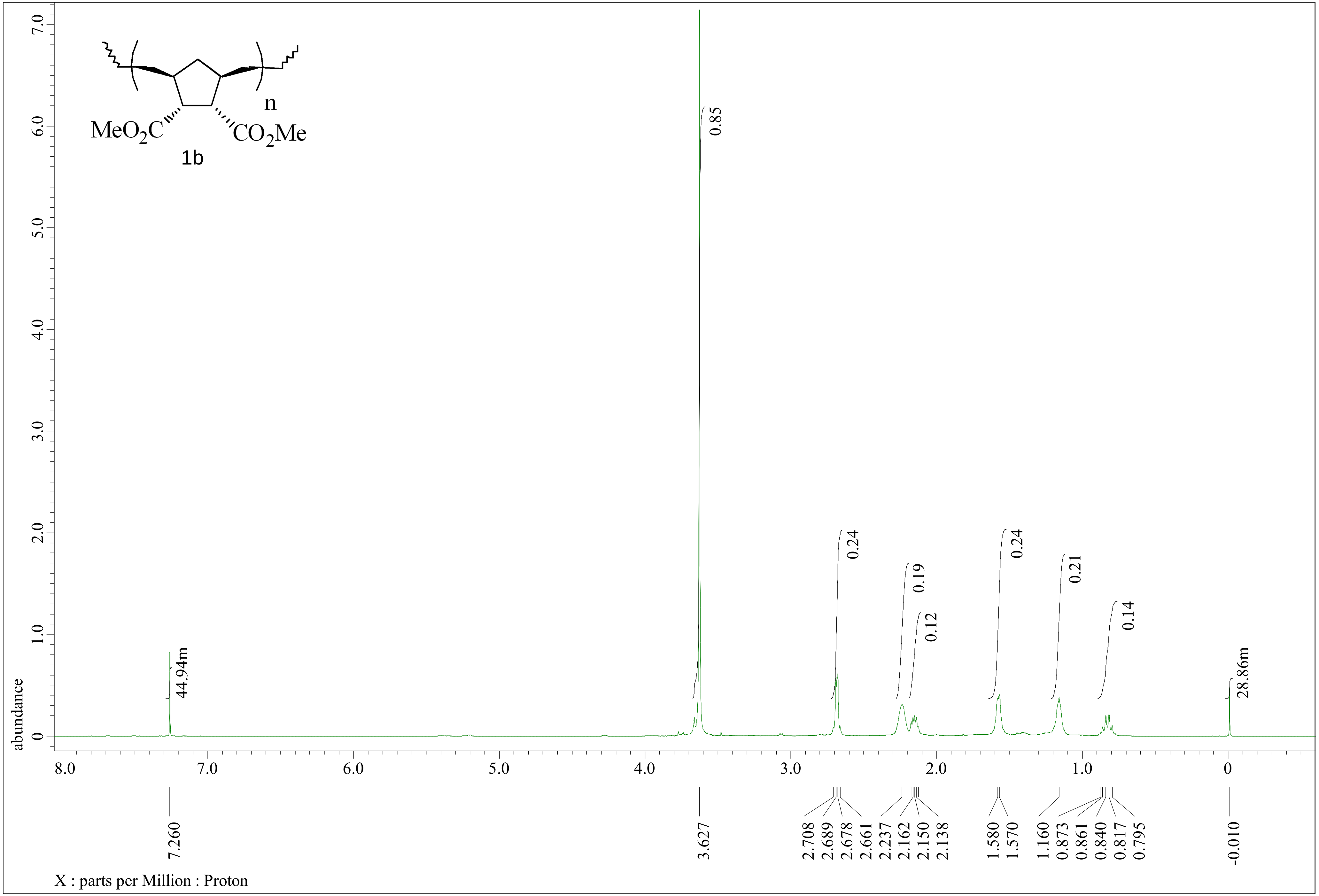


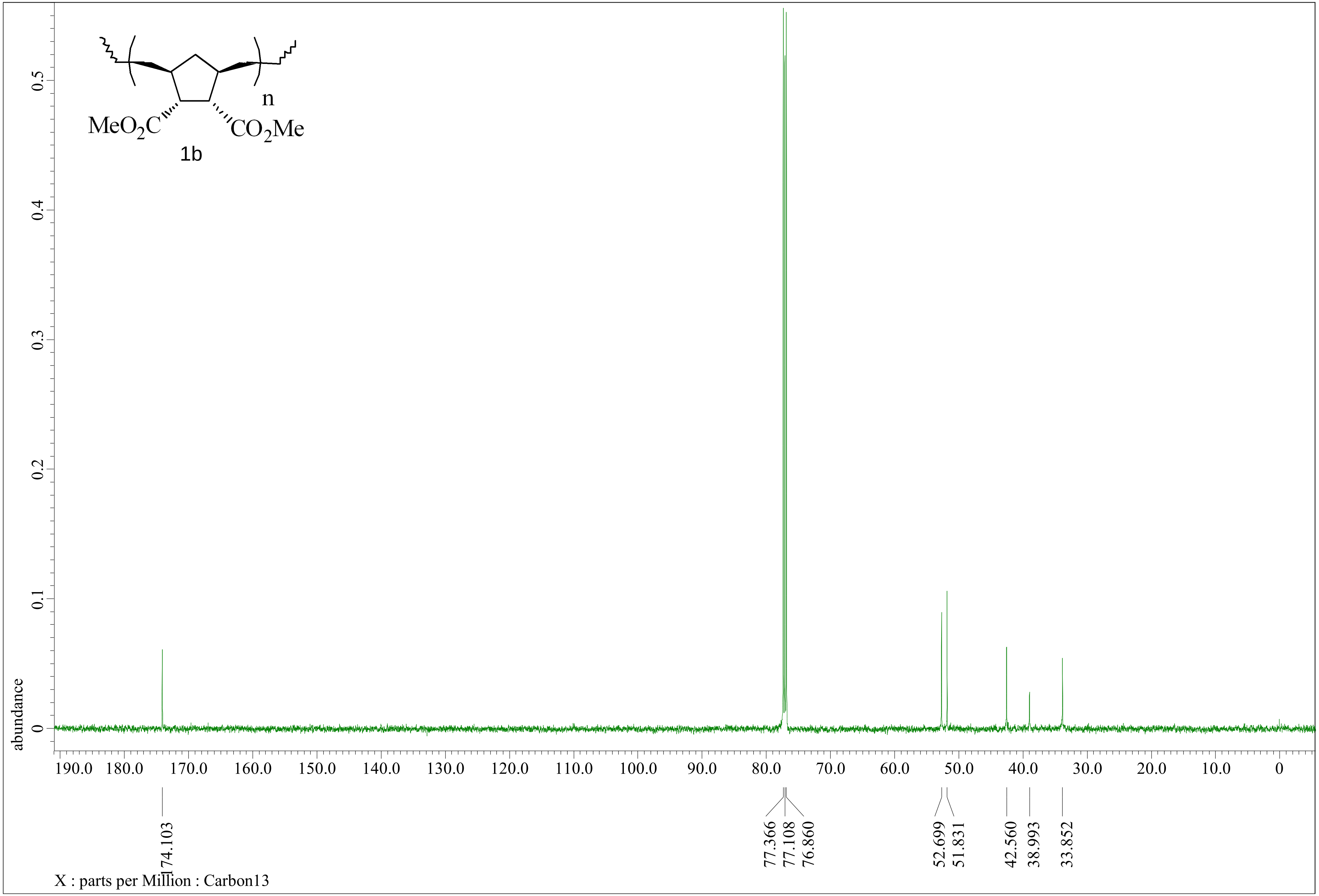
MeO2C
CO2
Ph
n
11a
abundance
0
0.1
0.2
0.3
0.4
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
165.830
164.914
143.205
143.109
135.994
132.131
131.883
129.183
129.069
128.907
77.848
77.600
77.342
67.470
52.362
44.960
44.836
39.170
X : parts per Million : Carbon13

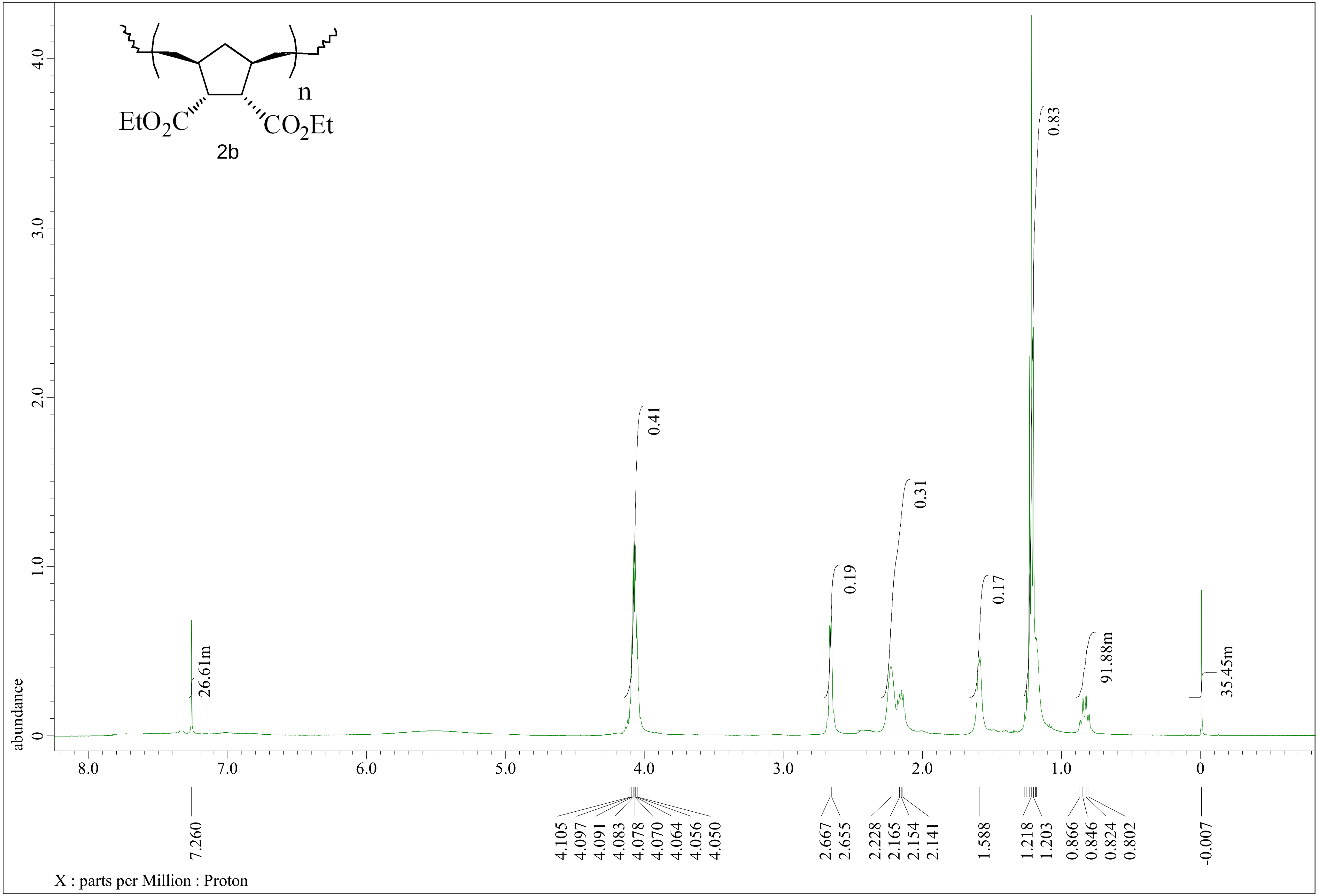


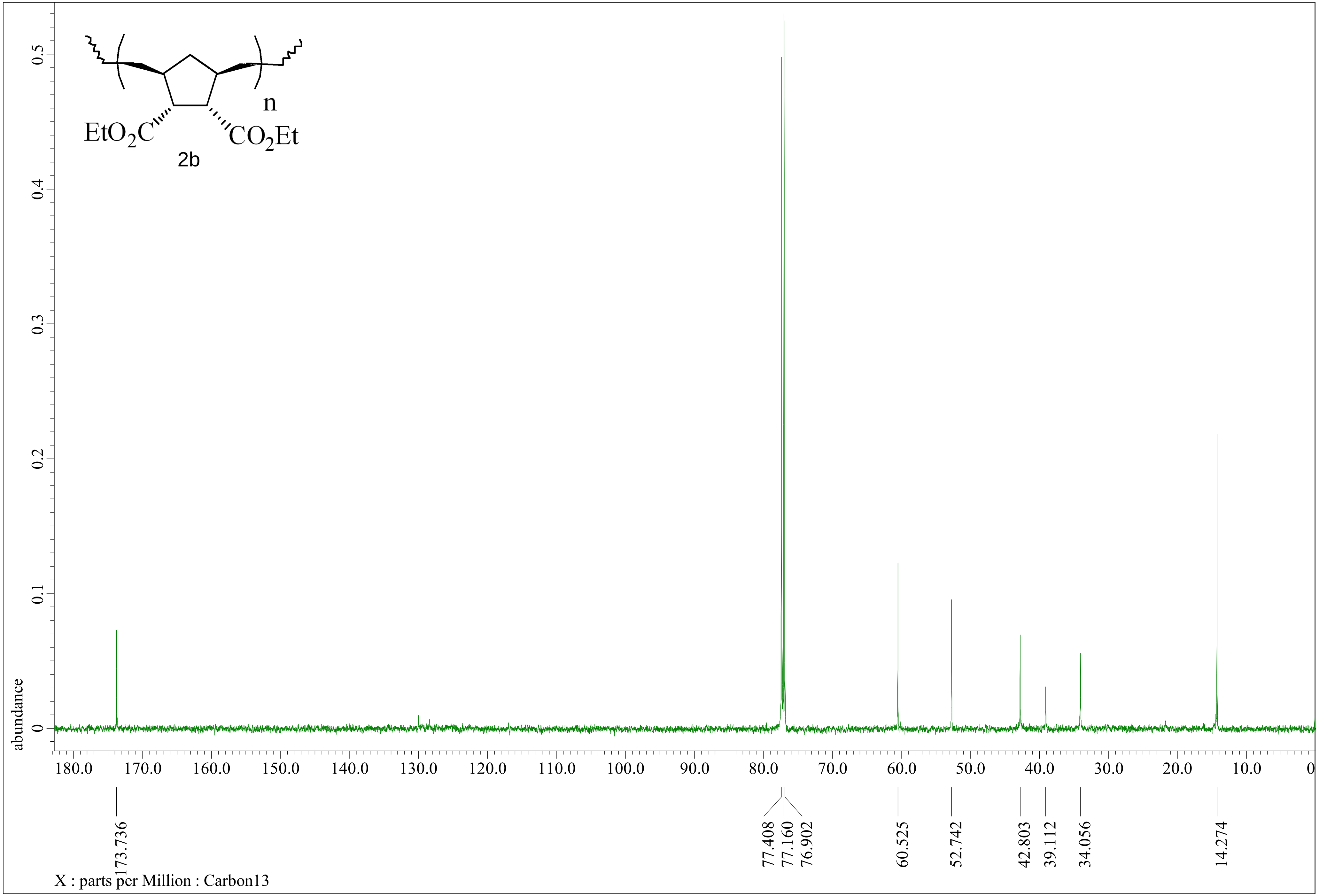
MeO2C
CO2iPr
n
12a
abundance
0
1.0
2.0
3.0
47.91m
0.29
0.17
0.29
0.47
0.16
0.33
0.15
1.02
87.17m
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.449
5.419
5.089
5.076
5.064
5.052
5.041
3.950
3.937
3.725
2.499
1.606
1.445
1.249
1.242
1.236
1.231
-0.006
X : parts per Million : 1H


MeO2C
CO2iPr
n
12a
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.896
164.790
143.128
142.012
132.112
131.959
77.858
77.600
77.352
69.197
52.390
44.884
39.342
22.316
X : parts per Million : 13C

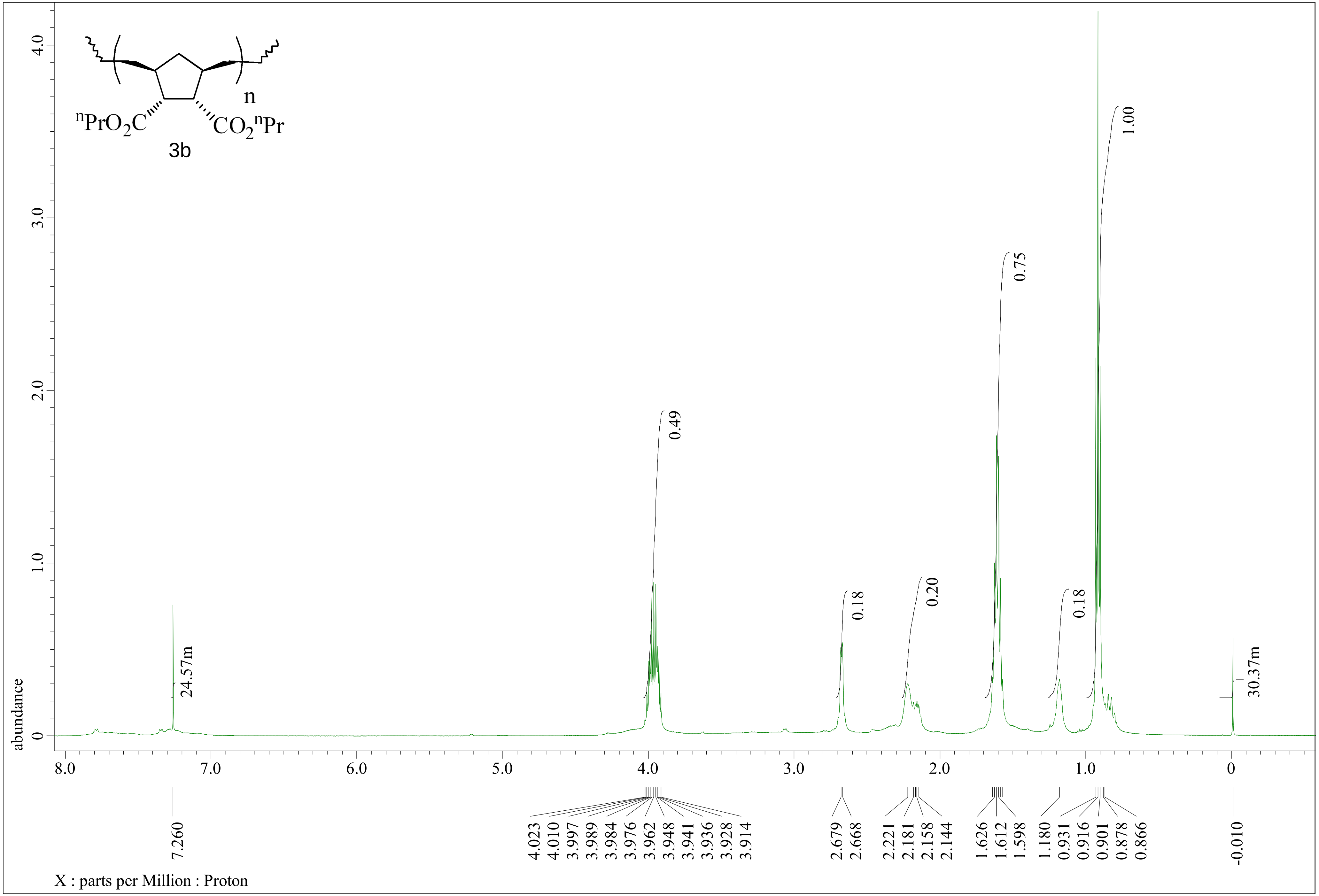

MeO2C
CO2Me
n
1b
abundance
X : parts per Million : Proton
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
0.85
0.24
0.19
0.12
0.24
0.21
0.14
44.94m
28.86m
7.260
3.627
2.708
2.689
2.678
2.661
2.237
2.162
2.150
2.138
1.580
1.570
1.160
0.873
0.861
0.840
0.817
0.795
-0.010


MeO2C
CO2Me
n
1b
abundance
0.5
0.4
0.3
0.2
0.1
0
190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
174.103
77.366
77.108
76.860
52.699
51.831
42.560
38.993
33.852
X : parts per Million : Carbon13

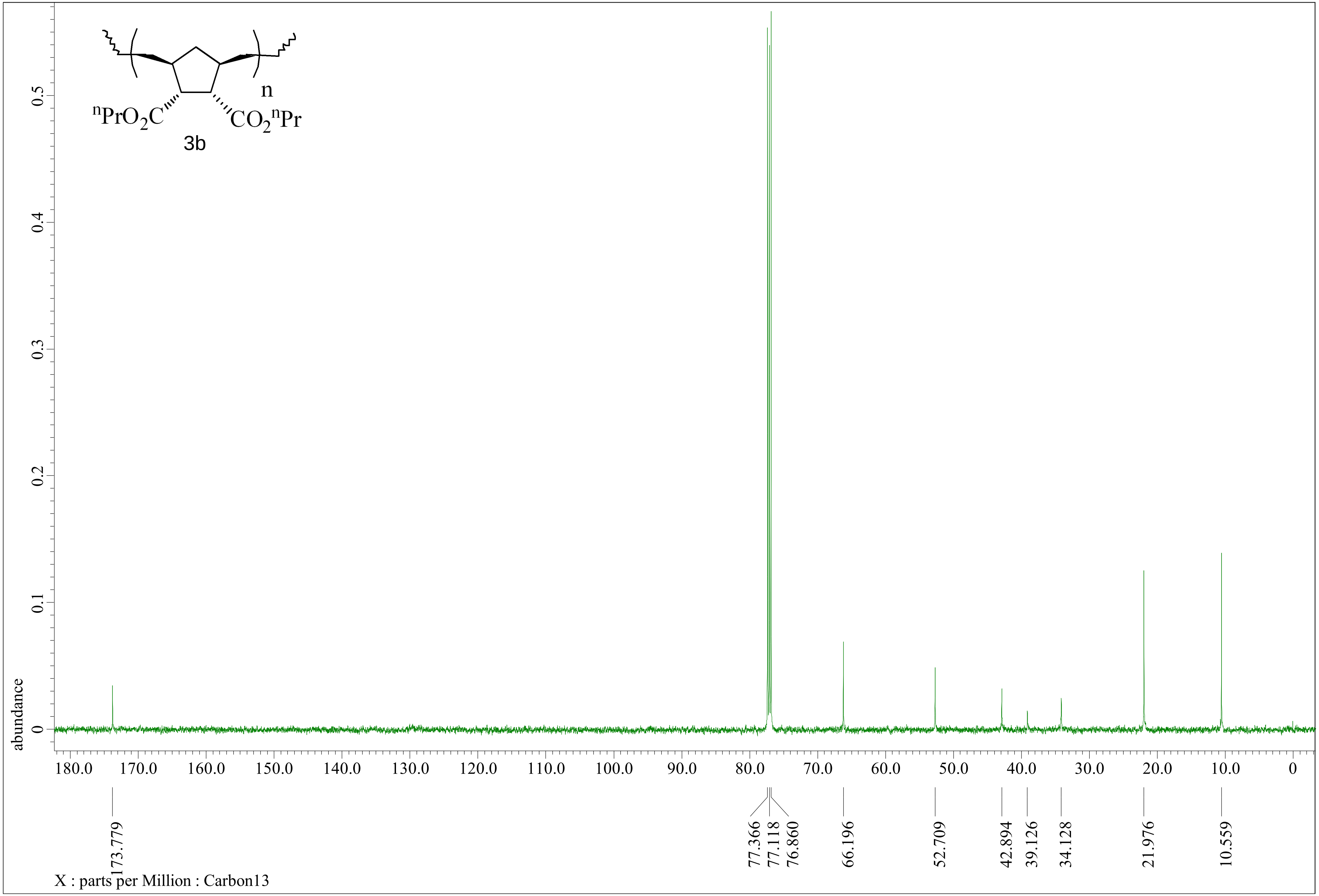

EtO2C
CO2Et
n
2b
abundance
X : parts per Million : Proton
0.41
0.31
0.19
0.17
0.83
26.61m
91.88m
35.45m
7.260
4.105 4.097 4.091 4.083 4.078 4.070 4.064 4.056 4.050
2.667 2.655
2.228 2.165 2.154 2.141
1.588
1.218 1.203
0.866 0.846 0.824 0.802
-0.007



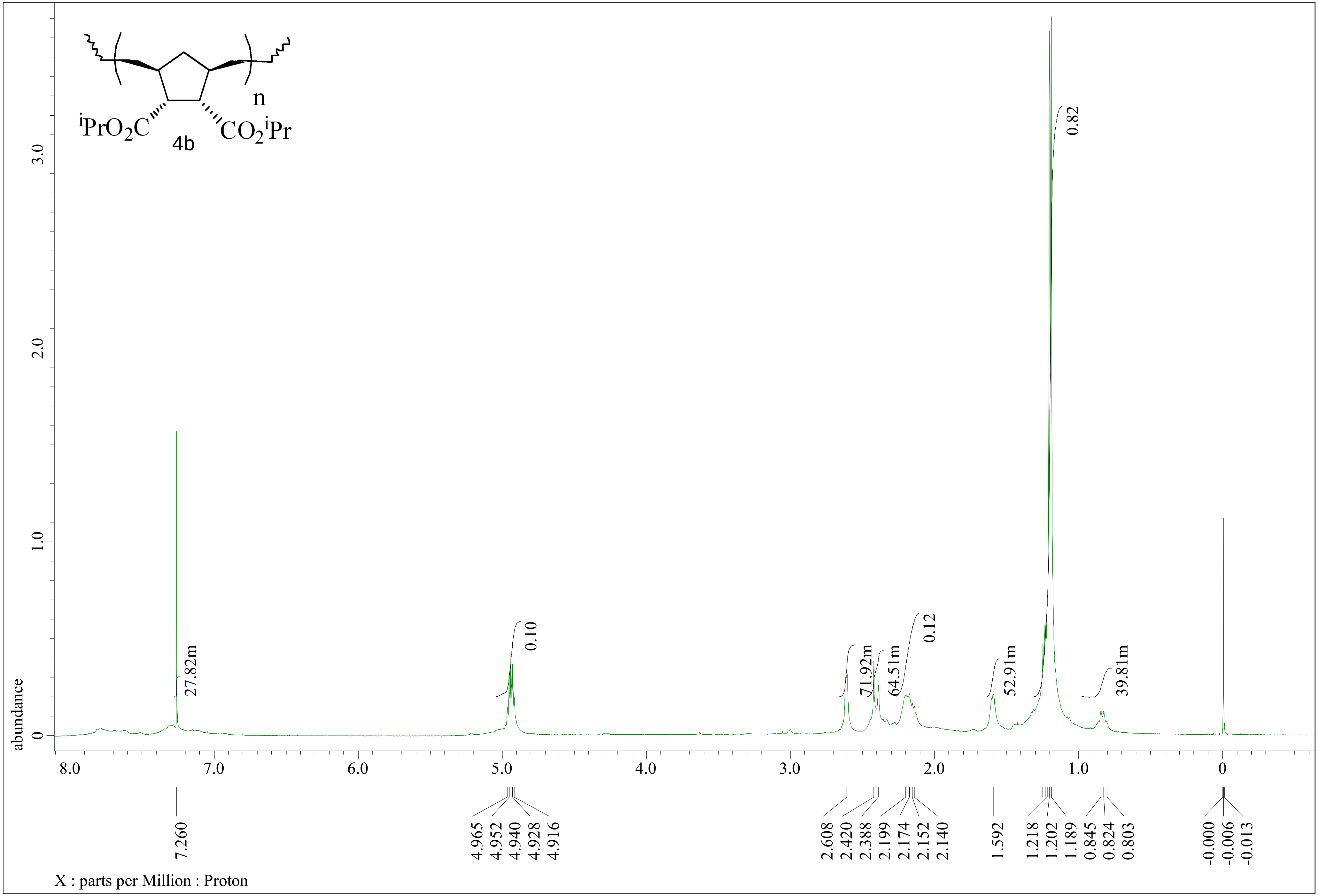
n
EtO_2C
CO_2Et
2b
abundance
0
0.1
0.2
0.3
0.4
0.5
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
173.736
77.408
77.160
76.902
60.525
52.742
42.803
39.112
34.056
14.274
X : parts per Million : Carbon13



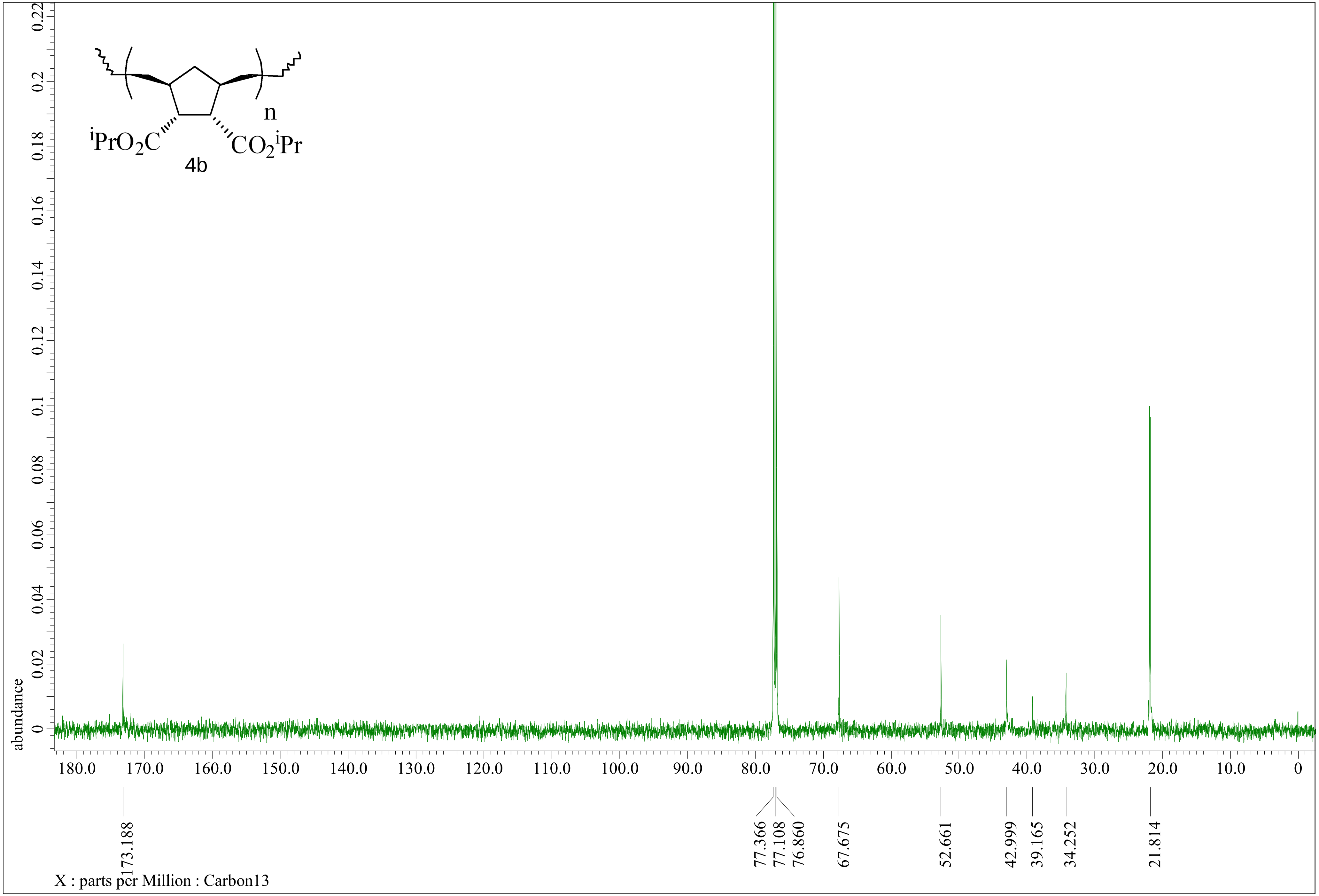
nPrO2C
CO2nPr
n
3b
abundance
4.0
3.0
2.0
1.0
0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
24.57m
0.49
0.18
0.20
0.75
0.18
1.00
30.37m
7.260
4.023
4.010
3.997
3.989
3.984
3.976
3.962
3.948
3.941
3.936
3.928
3.914
2.679
2.668
2.221
2.181
2.158
2.144
1.626
1.612
1.598
1.180
0.931
0.916
0.901
0.878
0.866
-0.010
X : parts per Million : Proton



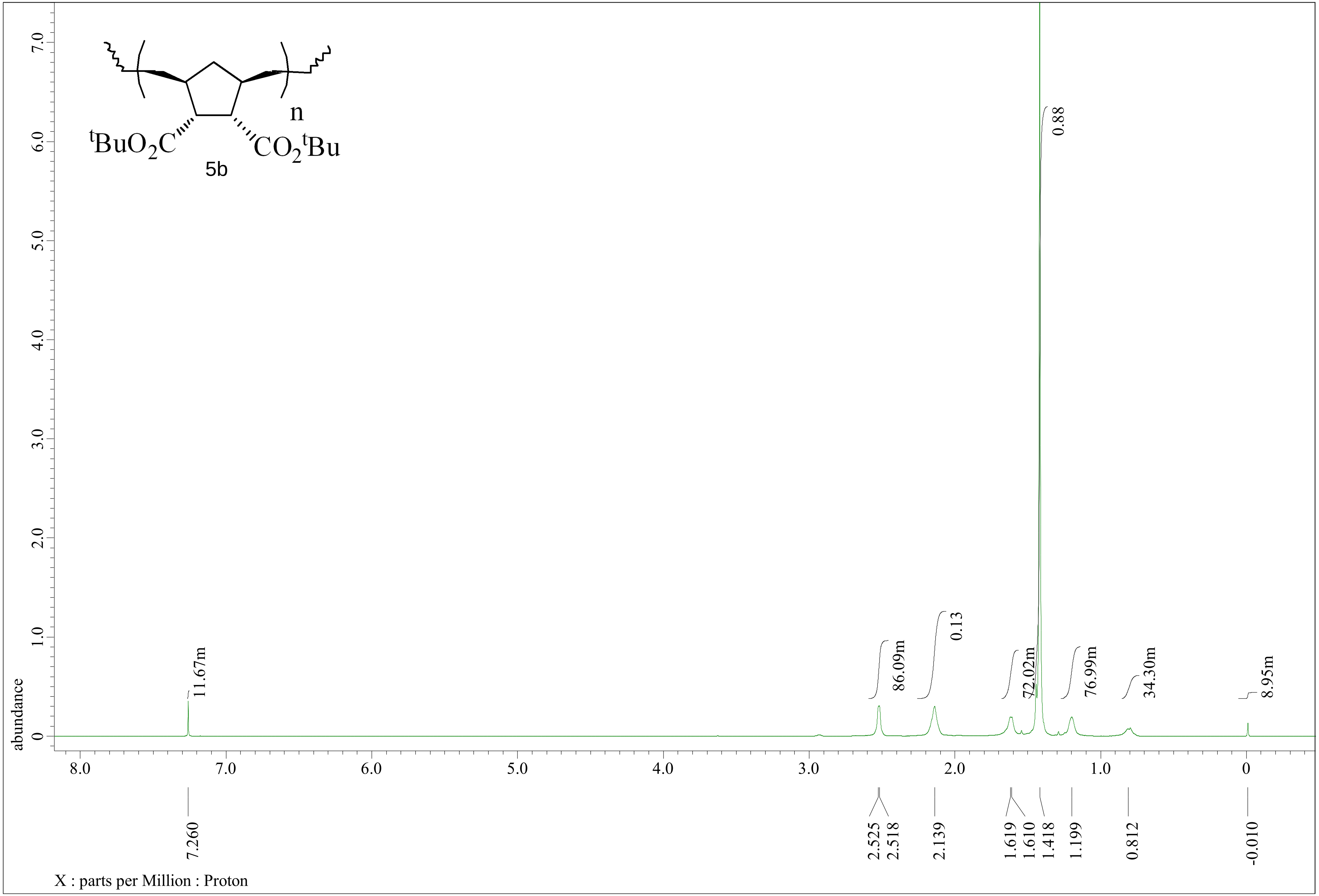
ⁿPrO2C
CO2ⁿPr
n
3b
abundance
0.5
0.4
0.3
0.2
0.1
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
173.779
77.366
77.118
76.860
66.196
52.709
42.894
39.126
34.128
21.976
10.559
X : parts per Million : Carbon13



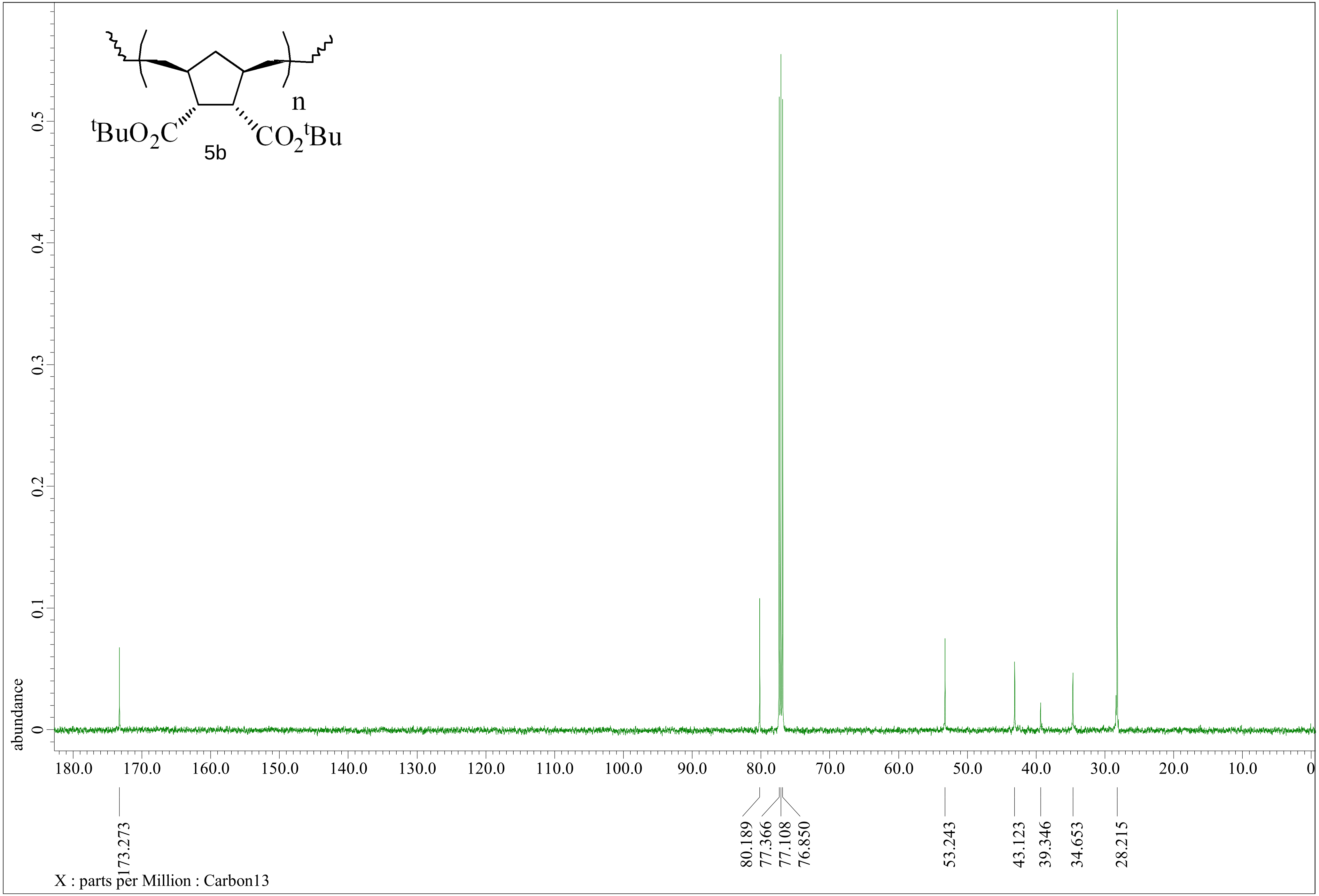
$^{i}PrO_2C$
$CO_2{}^{i}Pr$
n
4b
abundance
3.0
2.0
1.0
0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
27.82m
0.10
71.92m
64.51m
0.12
52.91m
0.82
39.81m
7.260
4.965
4.952
4.940
4.928
4.916
2.608
2.420
2.388
2.199
2.174
2.152
2.140
1.592
1.218
1.202
1.189
0.845
0.824
0.803
-0.000
-0.006
-0.013
X : parts per Million : Proton



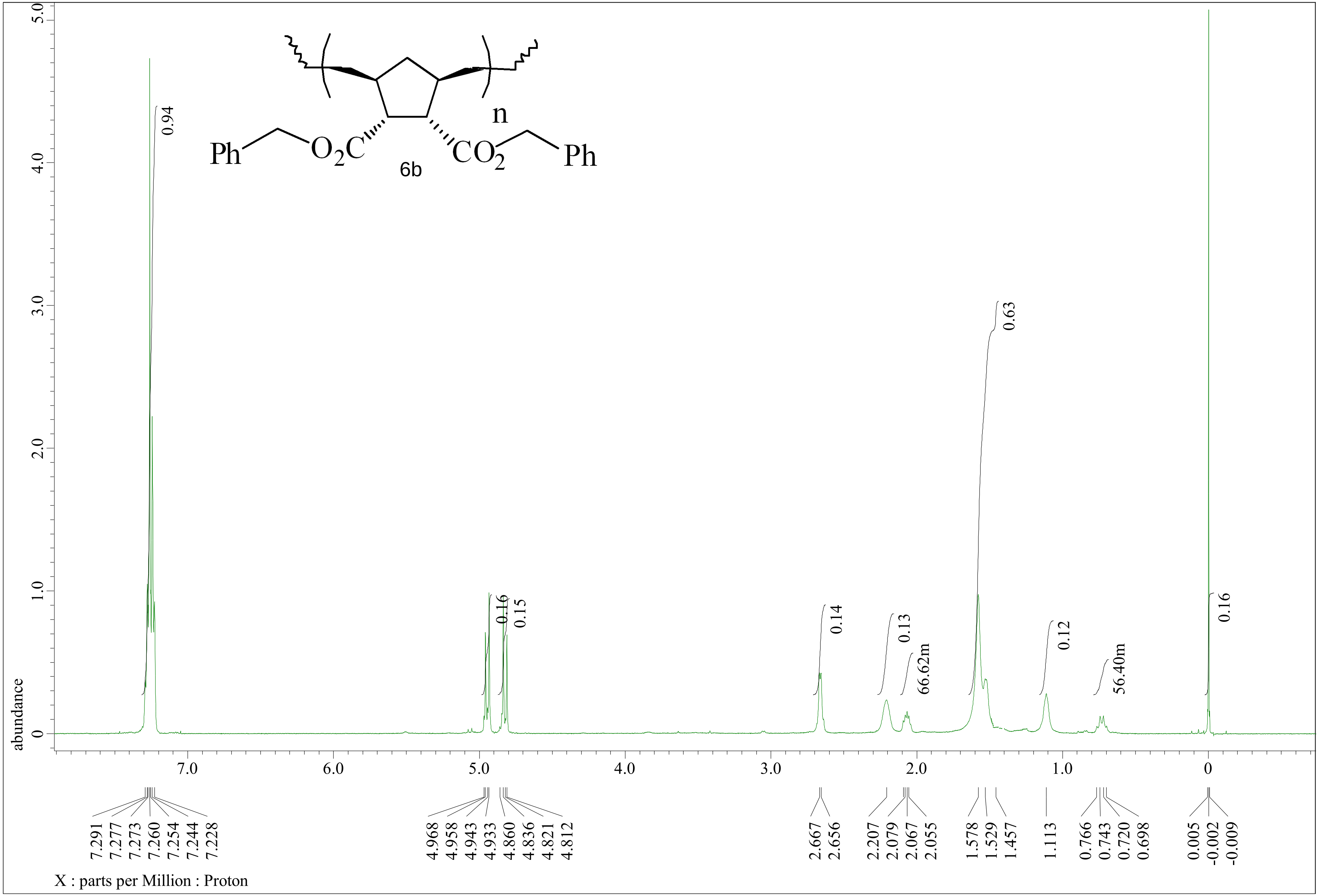
4b
n
$^{i}PrO_2C$
$CO_2{}^{i}Pr$
abundance
173.188
77.366
77.108
76.860
67.675
52.661
42.999
39.165
34.252
21.814
X : parts per Million : Carbon13



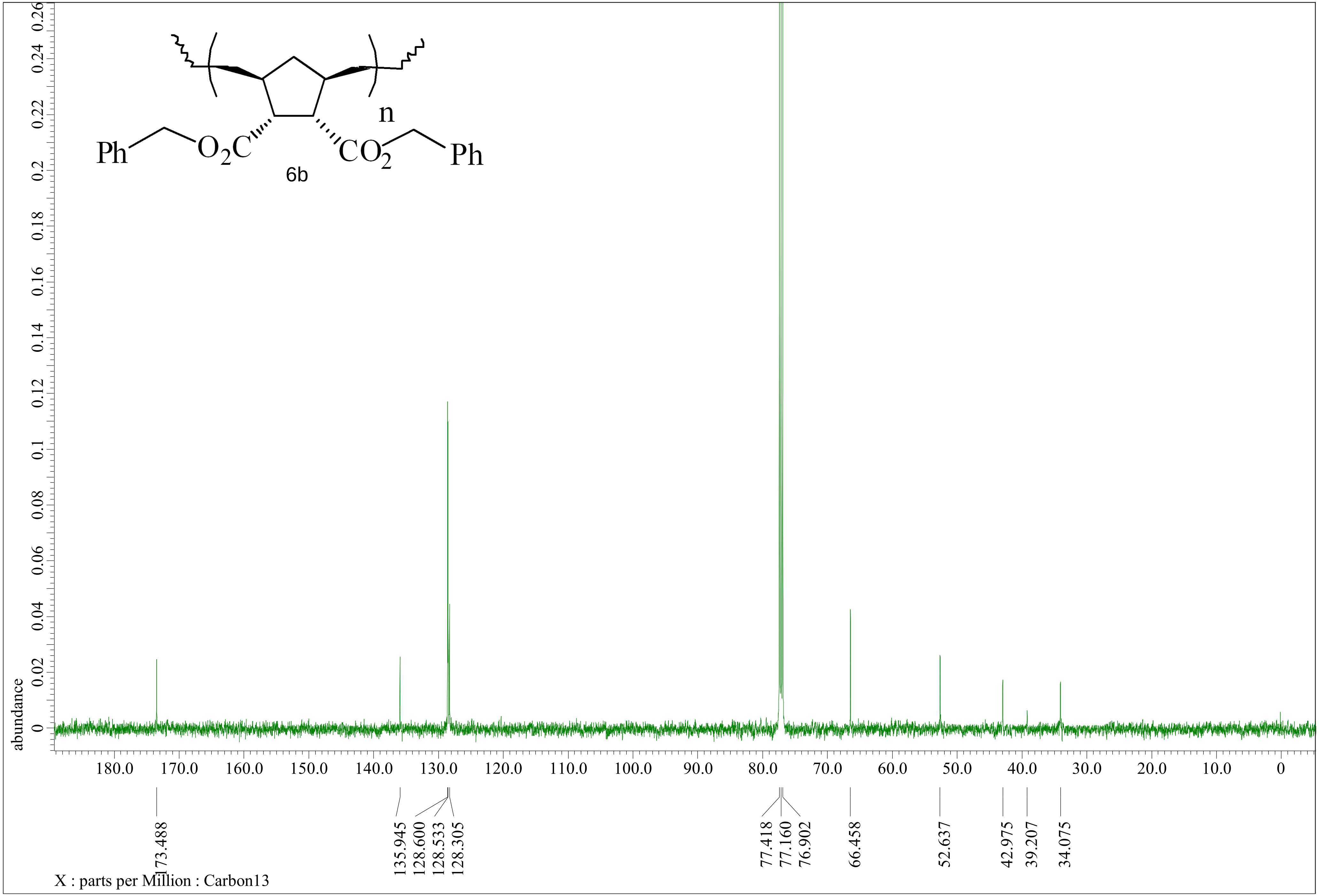
tBuO2C
CO2tBu
n
5b
abundance
X : parts per Million : Proton
0.88
0.13
11.67m
86.09m
72.02m
76.99m
34.30m
8.95m
7.260
2.525
2.518
2.139
1.619
1.610
1.418
1.199
0.812
-0.010



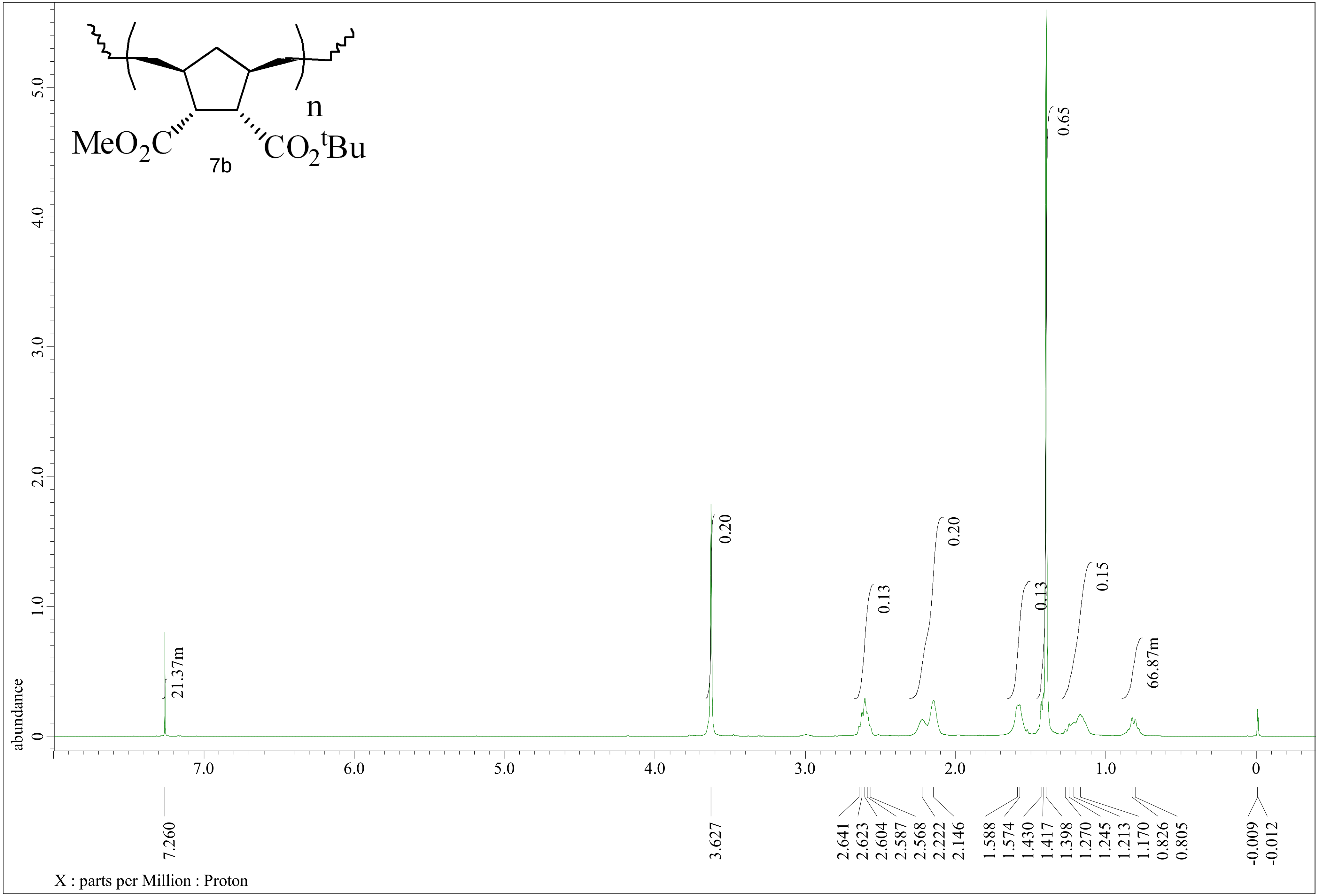
ᵗBuO₂C
CO₂ᵗBu
n
5b
abundance
0
0.1
0.2
0.3
0.4
0.5
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
173.273
80.189
77.366
77.108
76.850
53.243
43.123
39.346
34.653
28.215
X : parts per Million : Carbon13



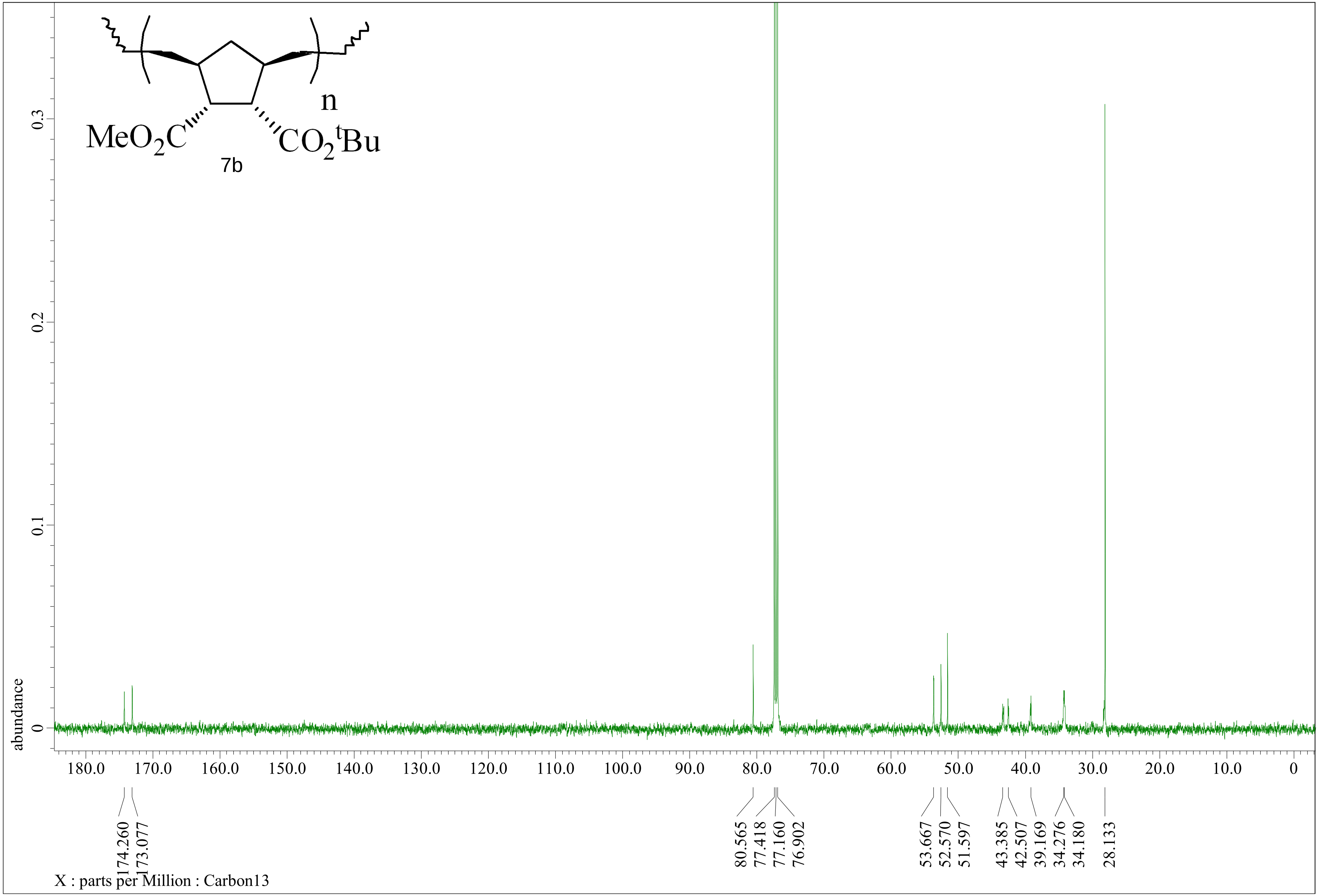
6b
n
Ph
O_2C
CO_2
0.94
0.16
0.15
0.14
0.13
66.62m
0.63
0.12
56.40m
0.16
abundance
7.291
7.277
7.273
7.260
7.254
7.244
7.228
4.968
4.958
4.943
4.933
4.860
4.836
4.821
4.812
2.667
2.656
2.207
2.079
2.067
2.055
1.578
1.529
1.457
1.113
0.766
0.743
0.720
0.698
0.005
-0.002
-0.009
X : parts per Million : Proton



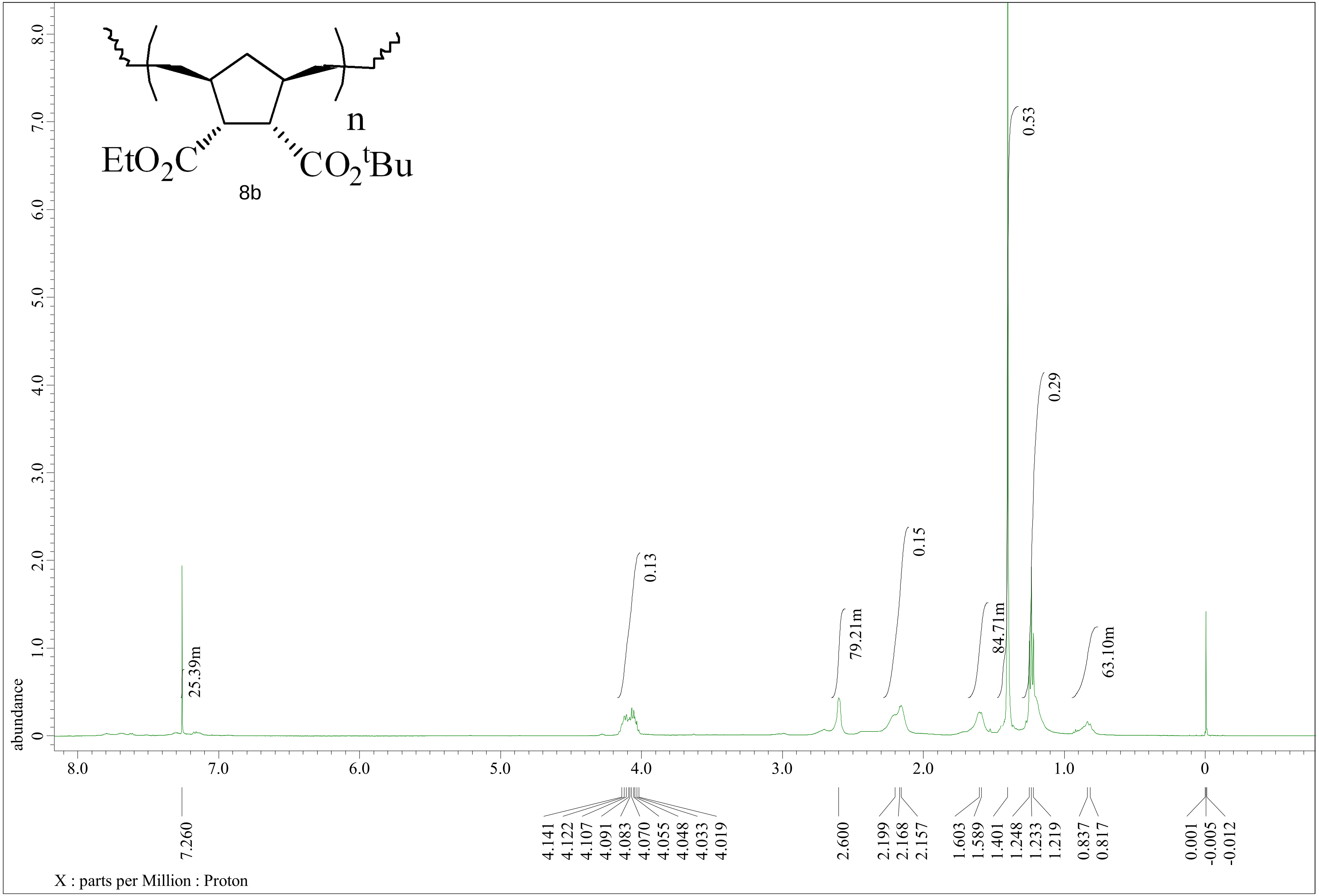
n
Ph
O_2C
6b
CO_2
Ph
abundance
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
173.488
135.945
128.600
128.533
128.305
77.418
77.160
76.902
66.458
52.637
42.975
39.207
34.075
X : parts per Million : Carbon13

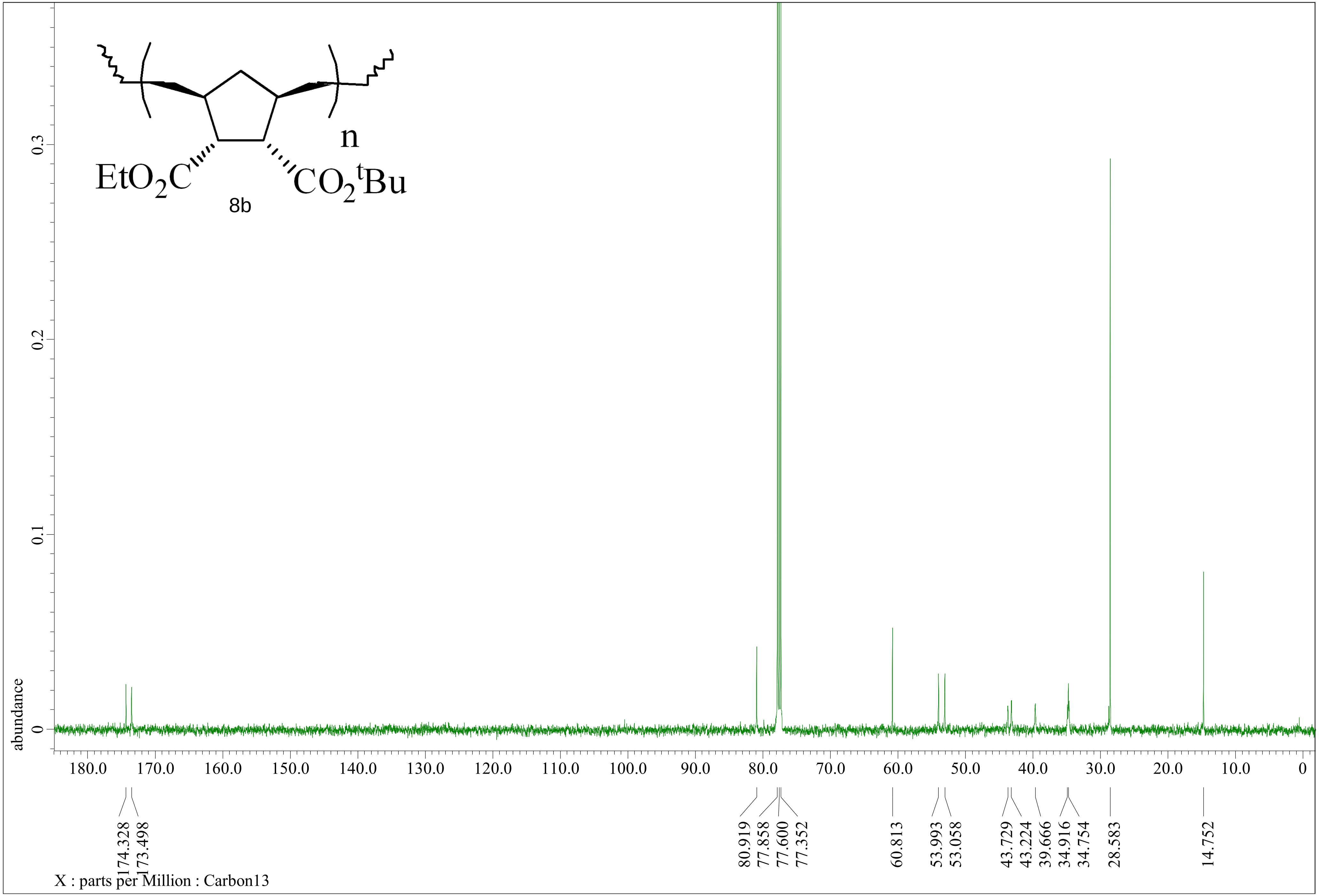


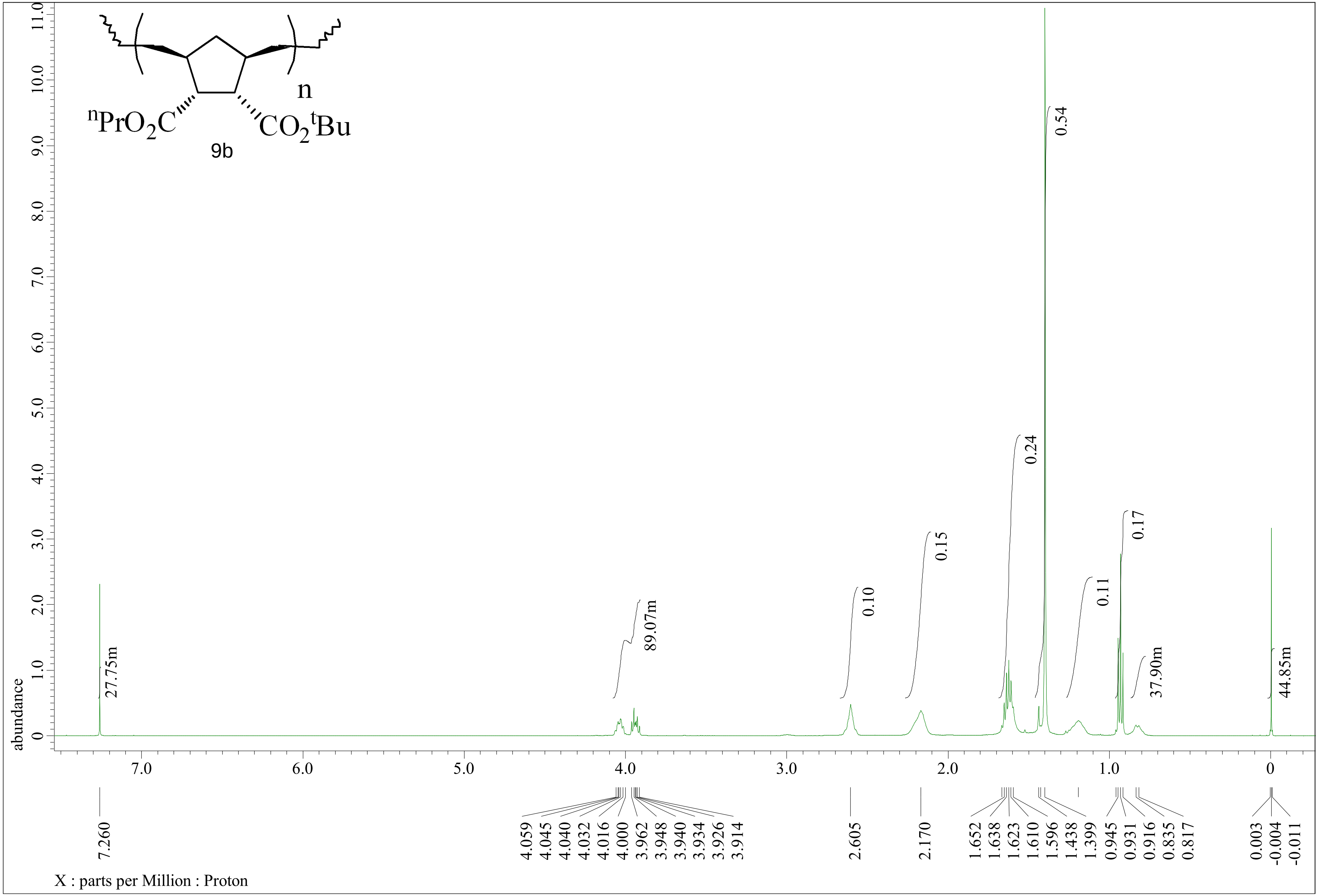
MeO2C
CO2tBu
n
7b
abundance
X : parts per Million : Proton
21.37m
0.20
0.13
0.20
0.13
0.65
0.15
66.87m
7.260
3.627
2.641
2.623
2.604
2.587
2.568
2.222
2.146
1.588
1.574
1.430
1.417
1.398
1.270
1.245
1.213
1.170
0.826
0.805
-0.009
-0.012



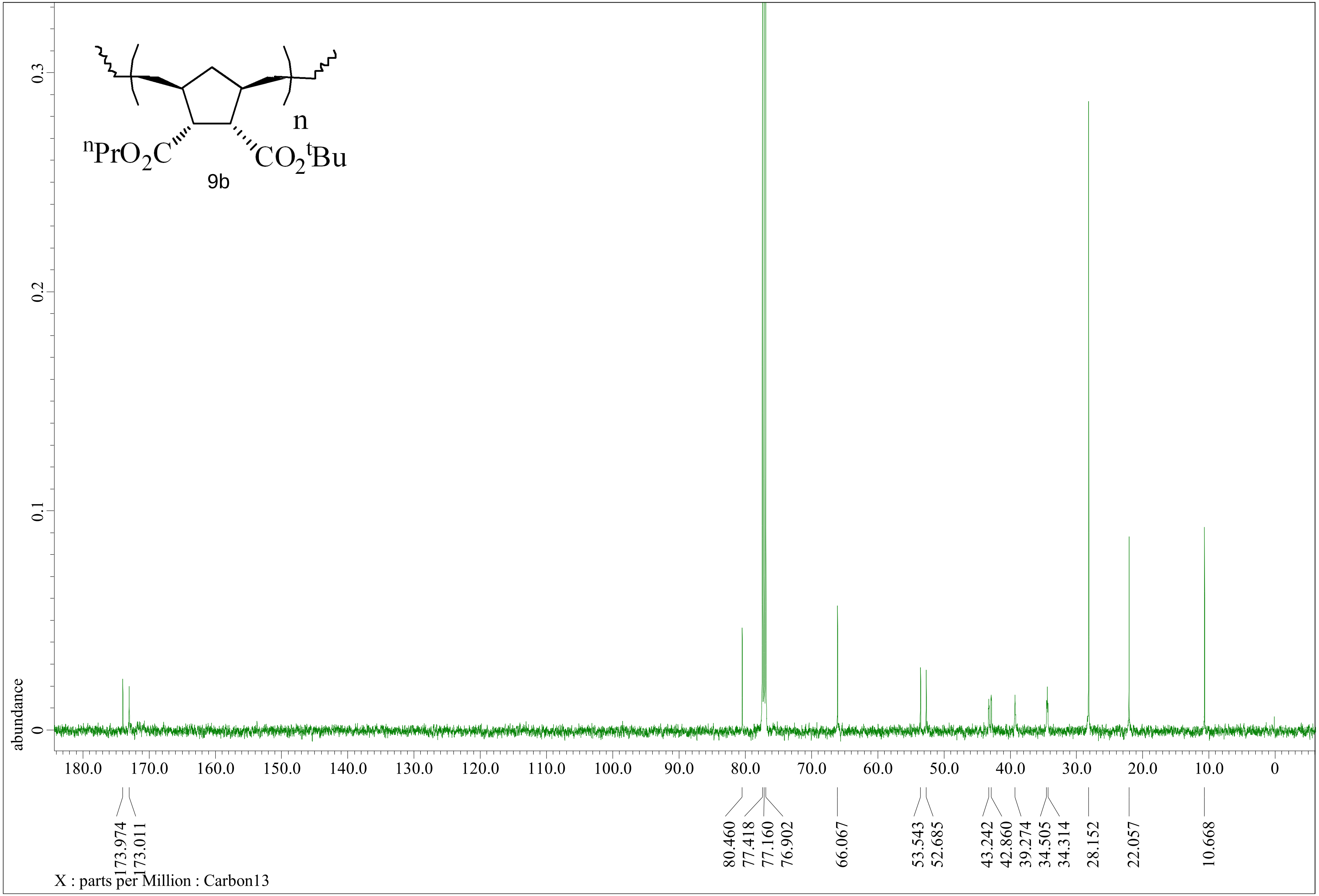
MeO2C
CO2tBu
n
7b
abundance
0.3
0.2
0.1
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
174.260
173.077
80.565
77.418
77.160
76.902
53.667
52.570
51.597
43.385
42.507
39.169
34.276
34.180
28.133
X : parts per Million : Carbon13


EtO2C
CO2tBu
n
8b
abundance
X : parts per Million : Proton
0.13
79.21m
0.15
84.71m
0.53
0.29
63.10m
25.39m
7.260
4.141 4.122 4.107 4.091 4.083 4.070 4.055 4.048 4.033 4.019
2.600
2.199 2.168 2.157
1.603 1.589 1.401 1.248 1.233 1.219
0.837 0.817
0.001 -0.005 -0.012

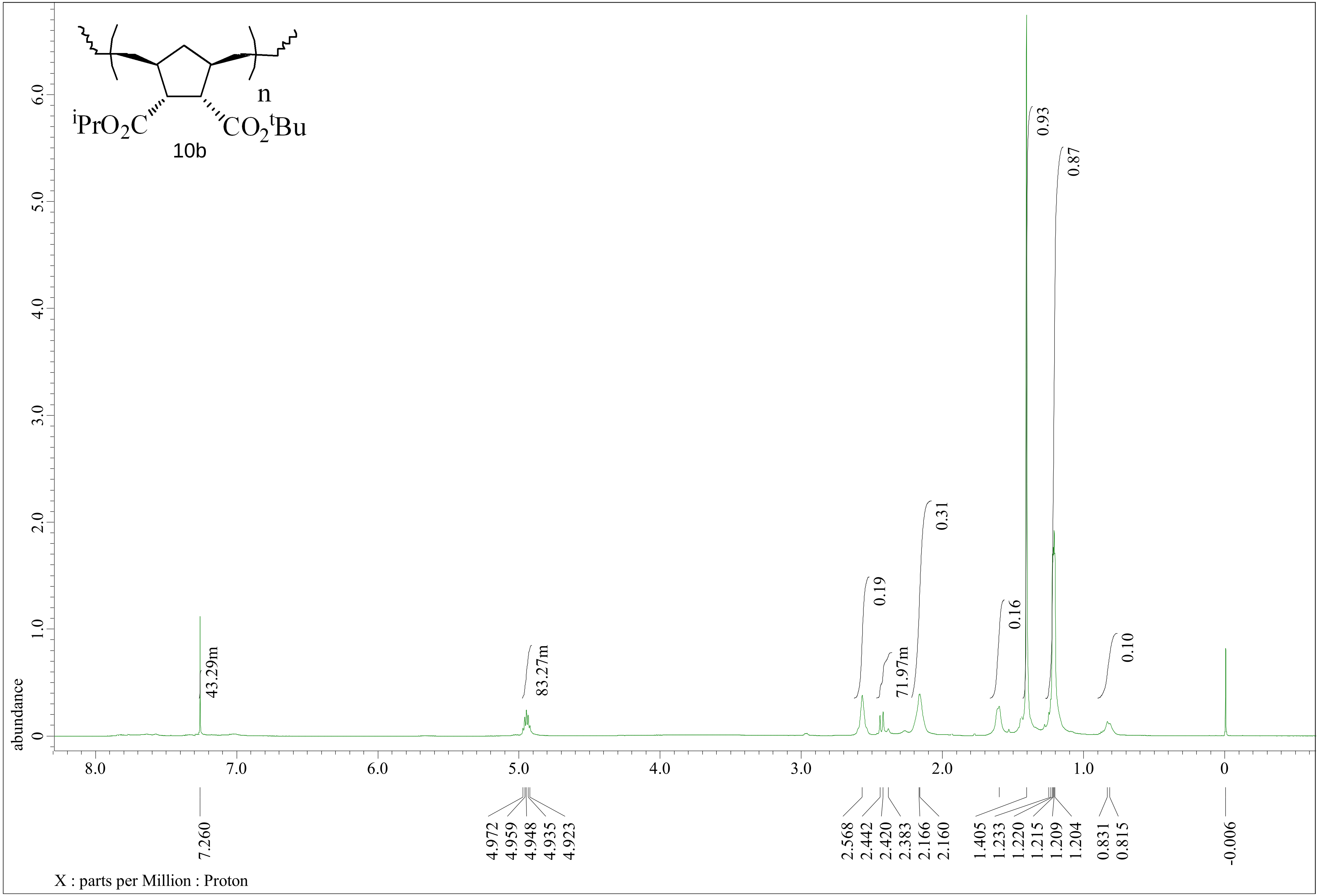

EtO2C
CO2tBu
n
8b
abundance
0.3
0.2
0.1
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
174.328
173.498
80.919
77.858
77.600
77.352
60.813
53.993
53.058
43.729
43.224
39.666
34.916
34.754
28.583
14.752
X : parts per Million : Carbon13



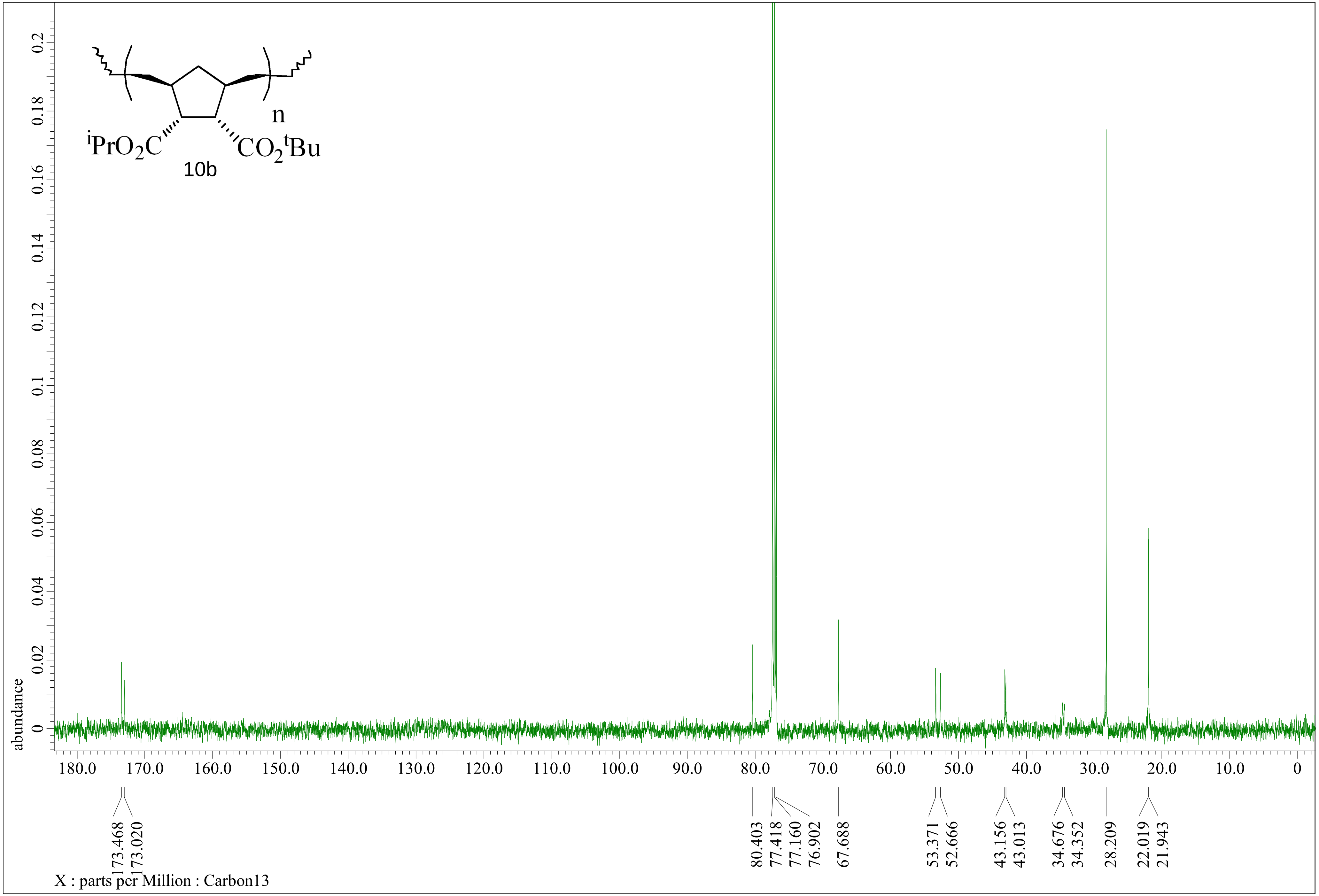
9b
abundance
X : parts per Million : Proton
27.75m
89.07m
0.10
0.15
0.24
0.54
0.11
0.17
37.90m
44.85m
7.260
4.059
4.045
4.040
4.032
4.016
4.000
3.962
3.948
3.940
3.934
3.926
3.914
2.605
2.170
1.652
1.638
1.623
1.610
1.596
1.438
1.399
0.945
0.931
0.916
0.835
0.817
0.003
-0.004
-0.011

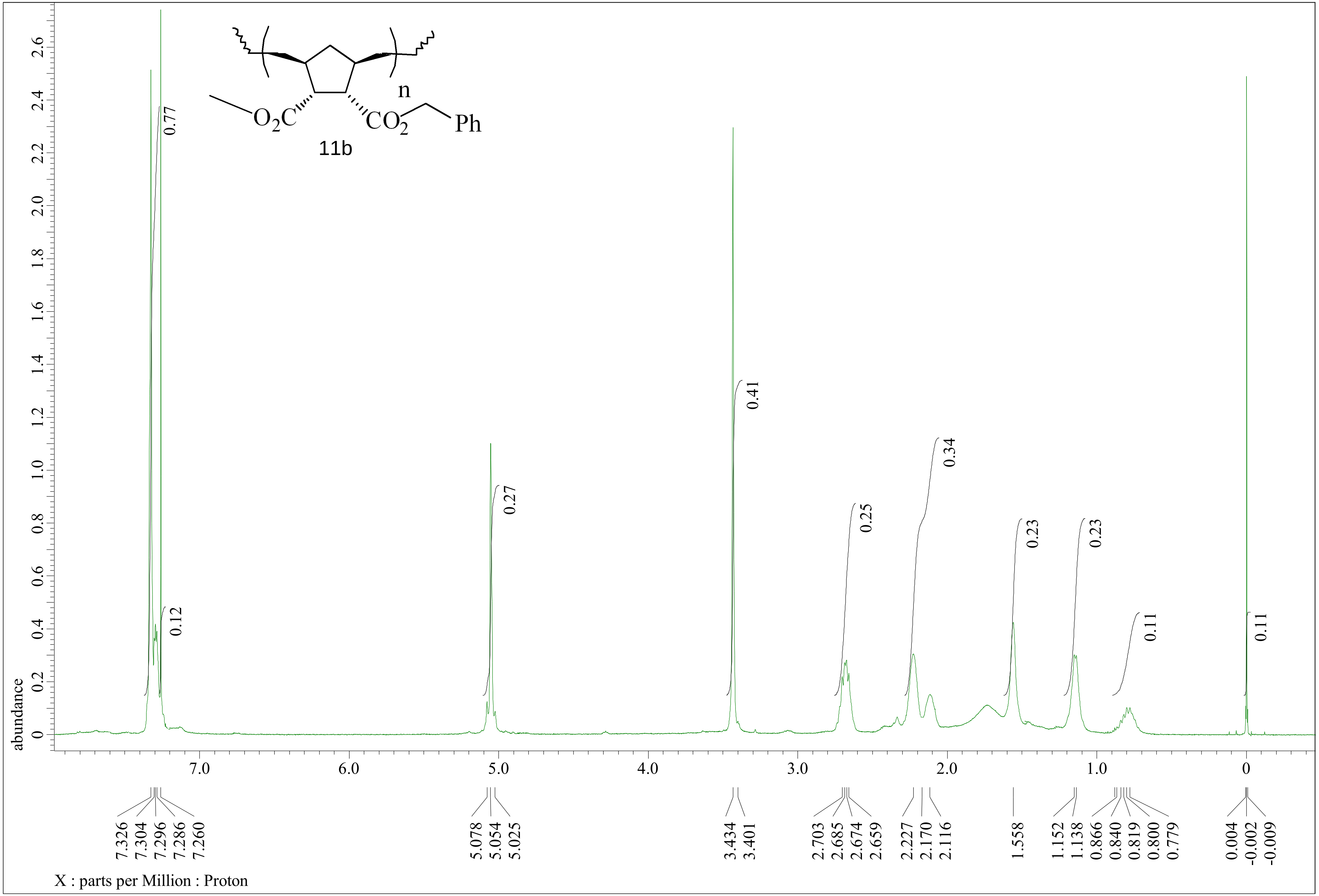


$^{n}PrO_2C$
$CO_2{}^{t}Bu$
n
9b
abundance
0.3
0.2
0.1
0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
173.974
173.011
80.460
77.418
77.160
76.902
66.067
53.543
52.685
43.242
42.860
39.274
34.505
34.314
28.152
22.057
10.668
X : parts per Million : Carbon13

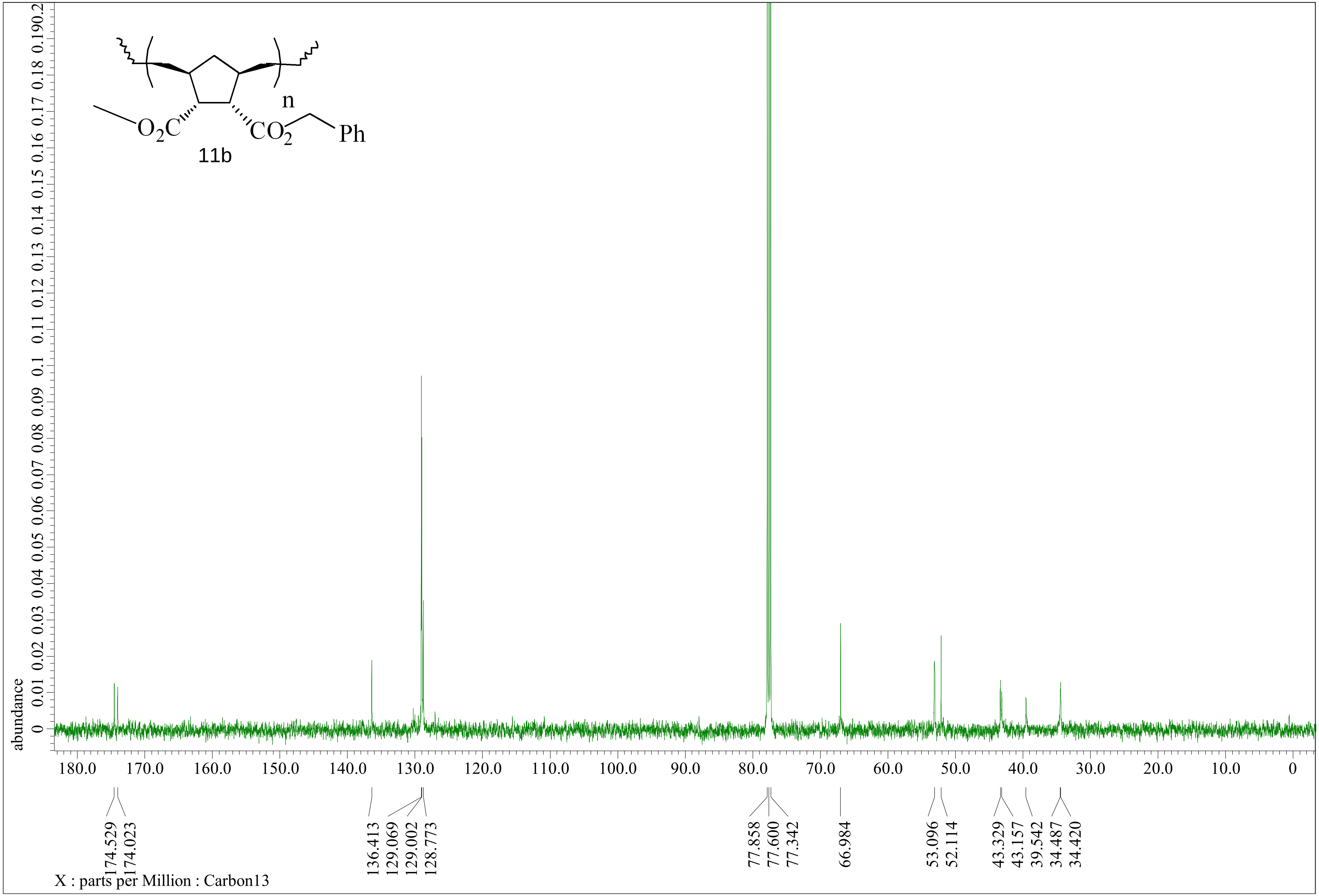


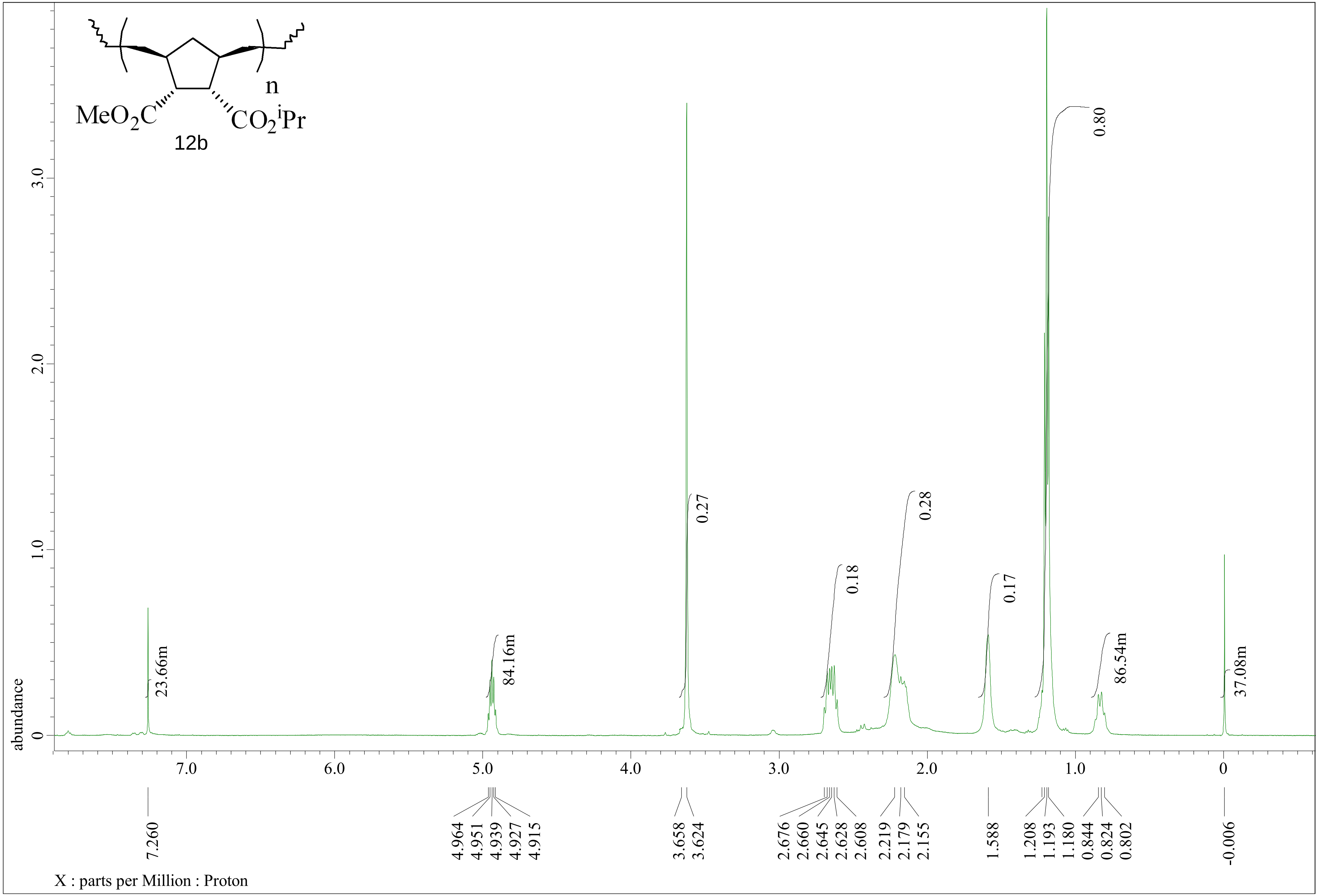
iPrO2C
CO2tBu
n
10b
abundance
X : parts per Million : Proton
43.29m
83.27m
0.19
71.97m
0.31
0.16
0.93
0.87
0.10
7.260
4.972
4.959
4.948
4.935
4.923
2.568
2.442
2.420
2.383
2.166
2.160
1.405
1.233
1.220
1.215
1.209
1.204
0.831
0.815
-0.006

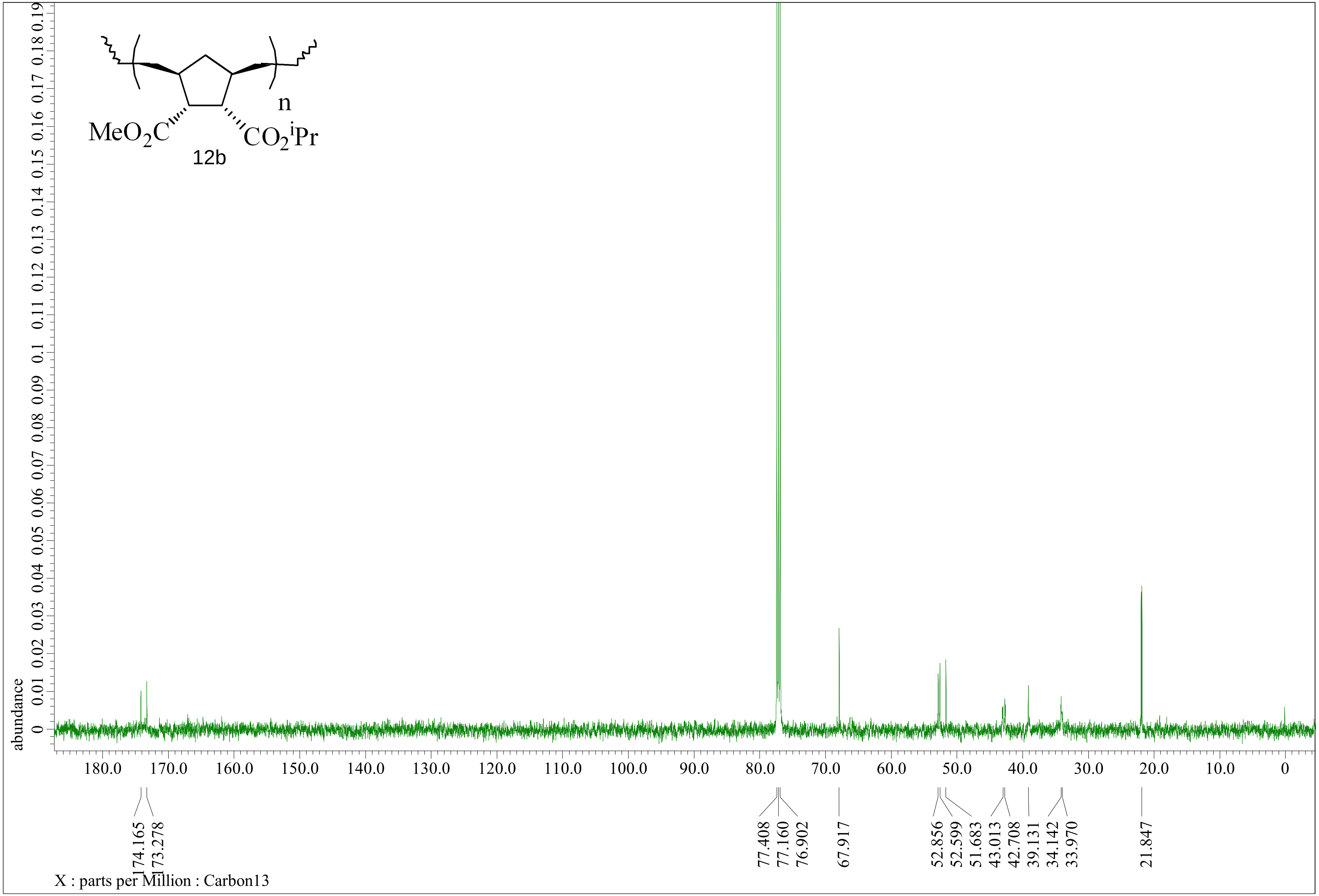

n
iPrO2C
CO2tBu
10b
abundance
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
173.468
173.020
80.403
77.418
77.160
76.902
67.688
53.371
52.666
43.156
43.013
34.676
34.352
28.209
22.019
21.943
X : parts per Million : Carbon13

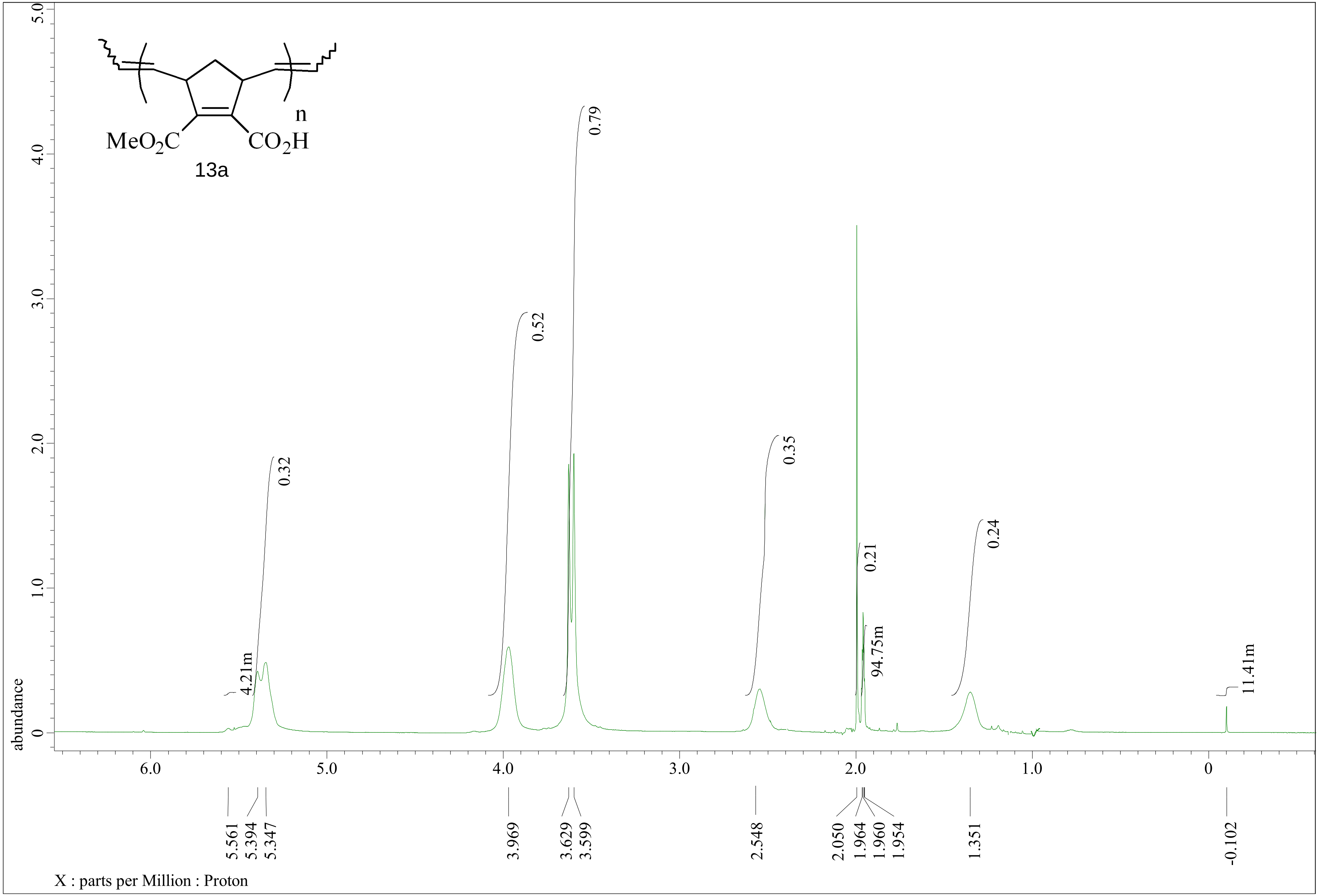


11b
0.77
0.12
0.27
0.41
0.25
0.34
0.23
0.23
0.11
0.11
7.326
7.304
7.296
7.286
7.260
5.078
5.054
5.025
3.434
3.401
2.703
2.685
2.674
2.659
2.227
2.170
2.116
1.558
1.152
1.138
0.866
0.840
0.819
0.800
0.779
0.004
-0.002
-0.009
abundance
X : parts per Million : Proton

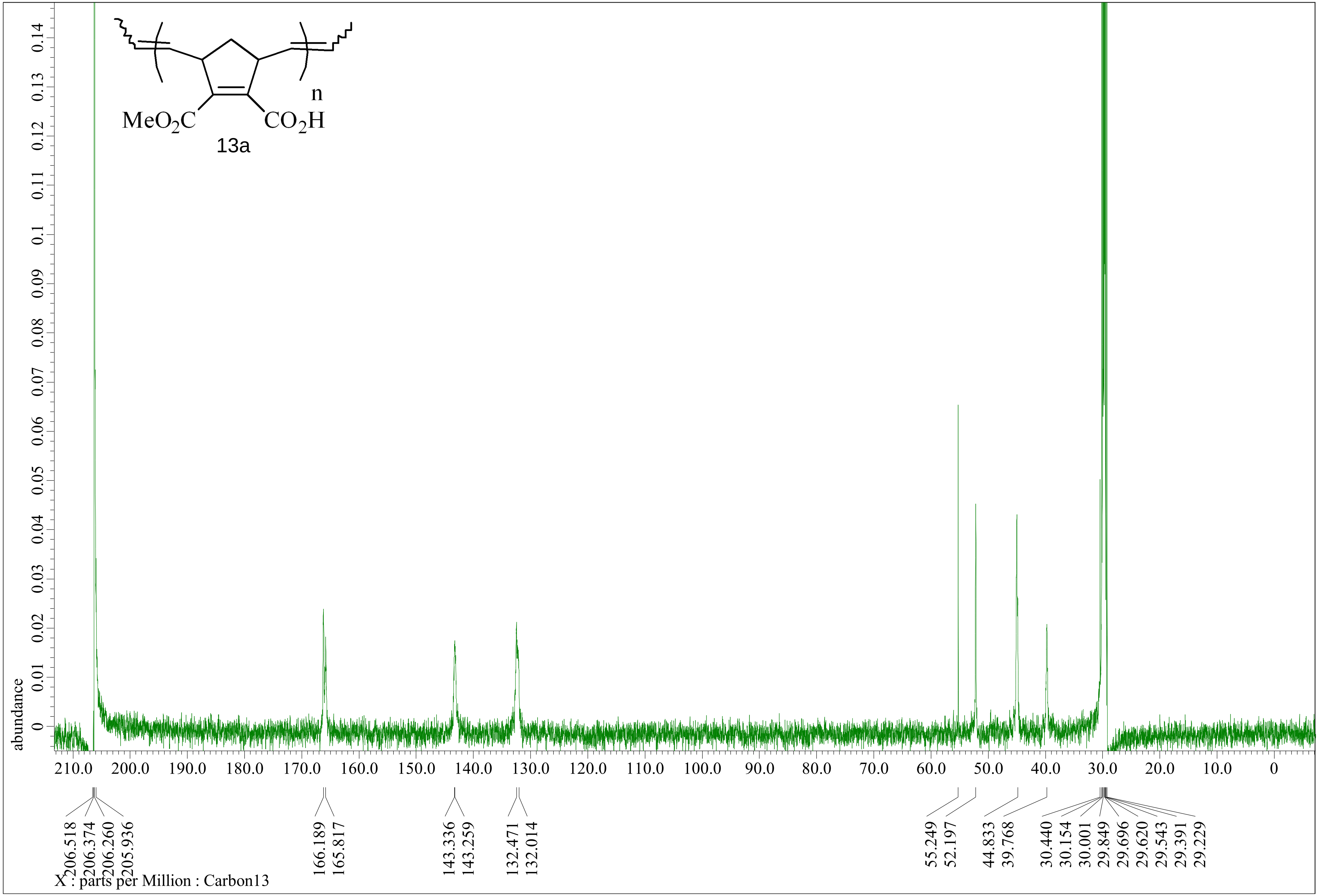

n
O_2C
CO_2
Ph
11b
abundance
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.2
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
174.529
174.023
136.413
129.069
129.002
128.773
77.858
77.600
77.342
66.984
53.096
52.114
43.329
43.157
39.542
34.487
34.420
X : parts per Million : Carbon13

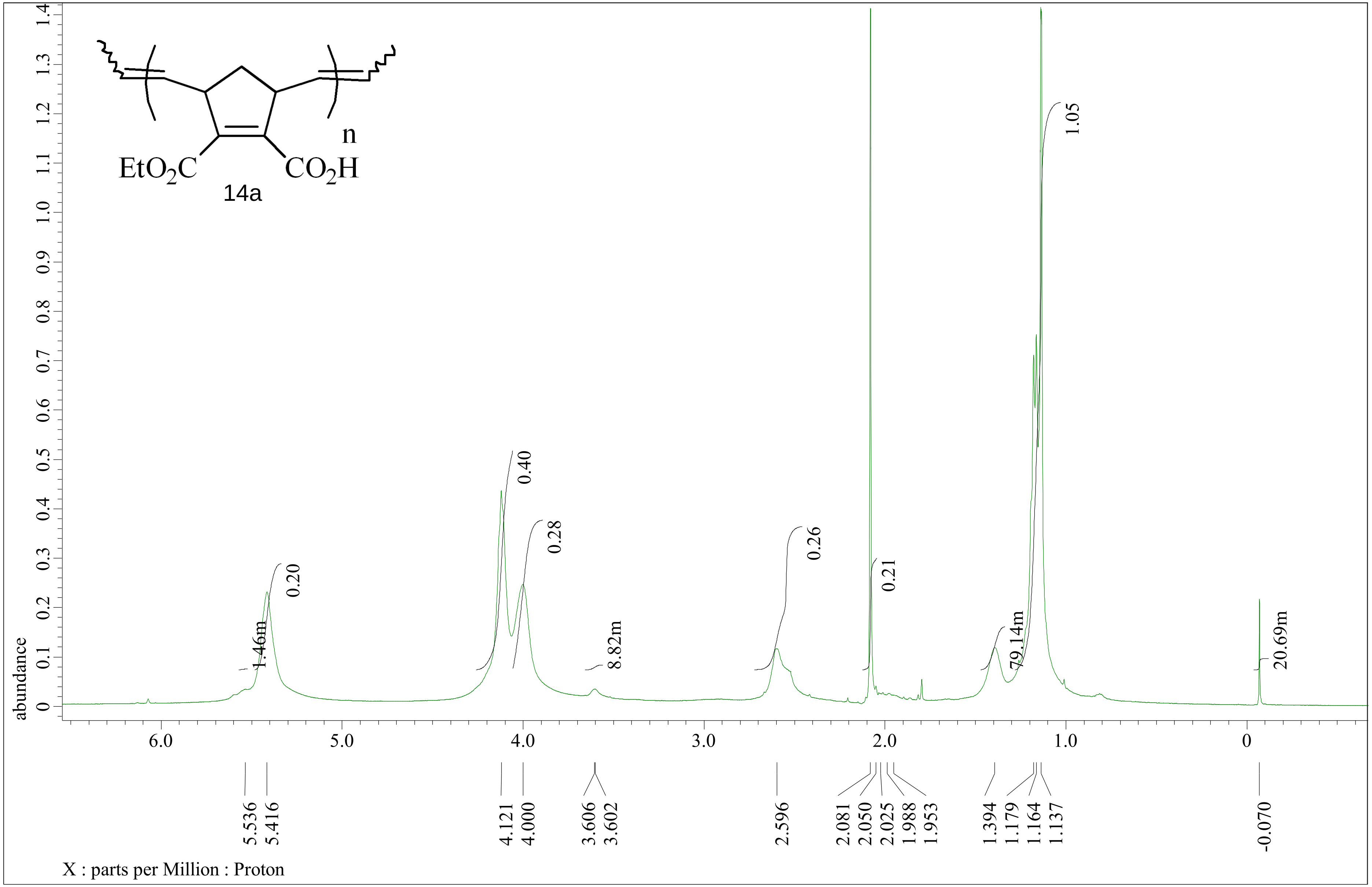

MeO2C
CO2iPr
n
12b
abundance
3.0
2.0
1.0
0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
23.66m
84.16m
0.27
0.18
0.28
0.17
0.80
86.54m
37.08m
7.260
4.964
4.951
4.939
4.927
4.915
3.658
3.624
2.676
2.660
2.645
2.628
2.608
2.219
2.179
2.155
1.588
1.208
1.193
1.180
0.844
0.824
0.802
-0.006
X : parts per Million : Proton

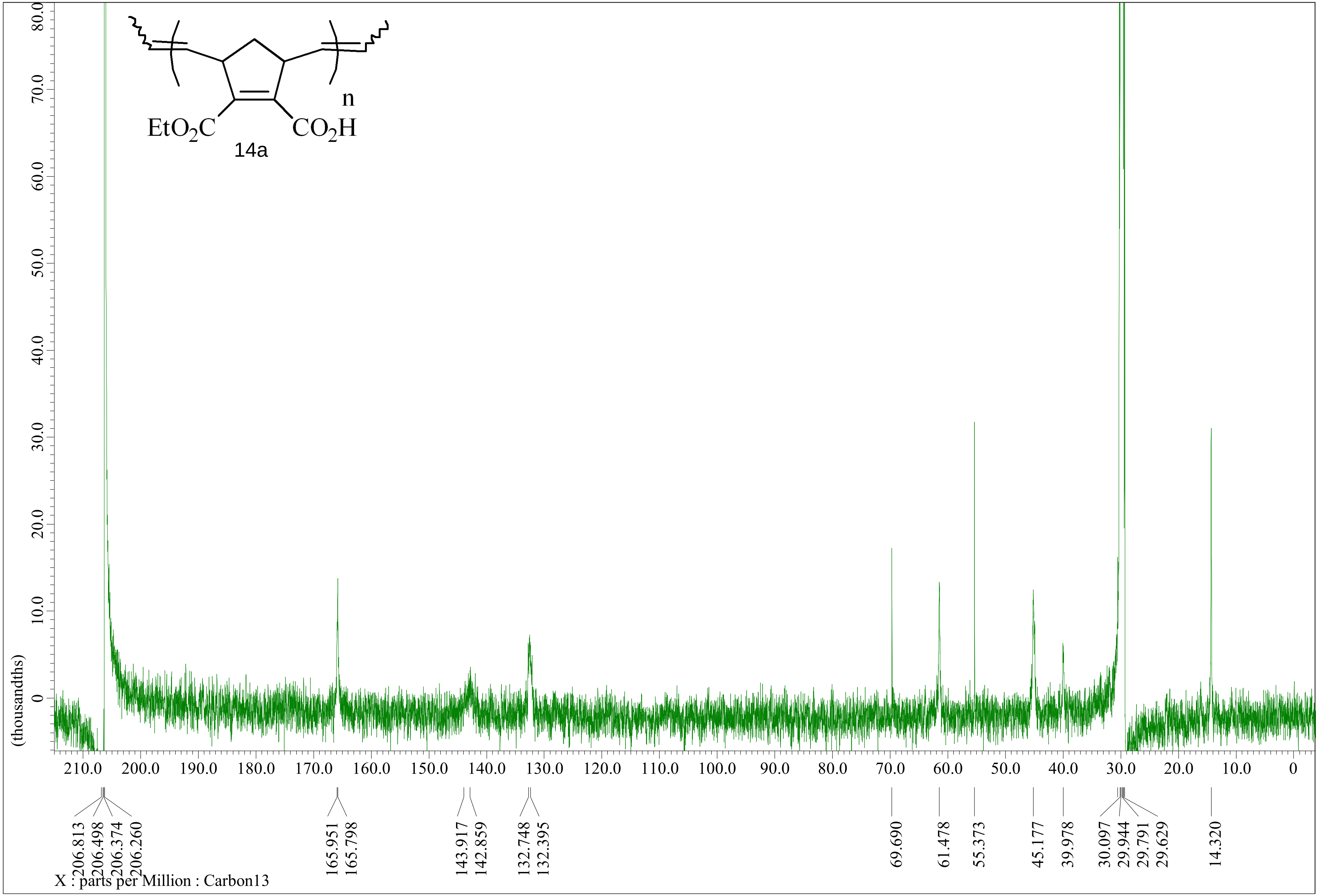

MeO2C
CO2iPr
n
12b
abundance
X : parts per Million : Carbon13
174.165
173.278
77.408
77.160
76.902
67.917
52.856
52.599
51.683
43.013
42.708
39.131
34.142
33.970
21.847



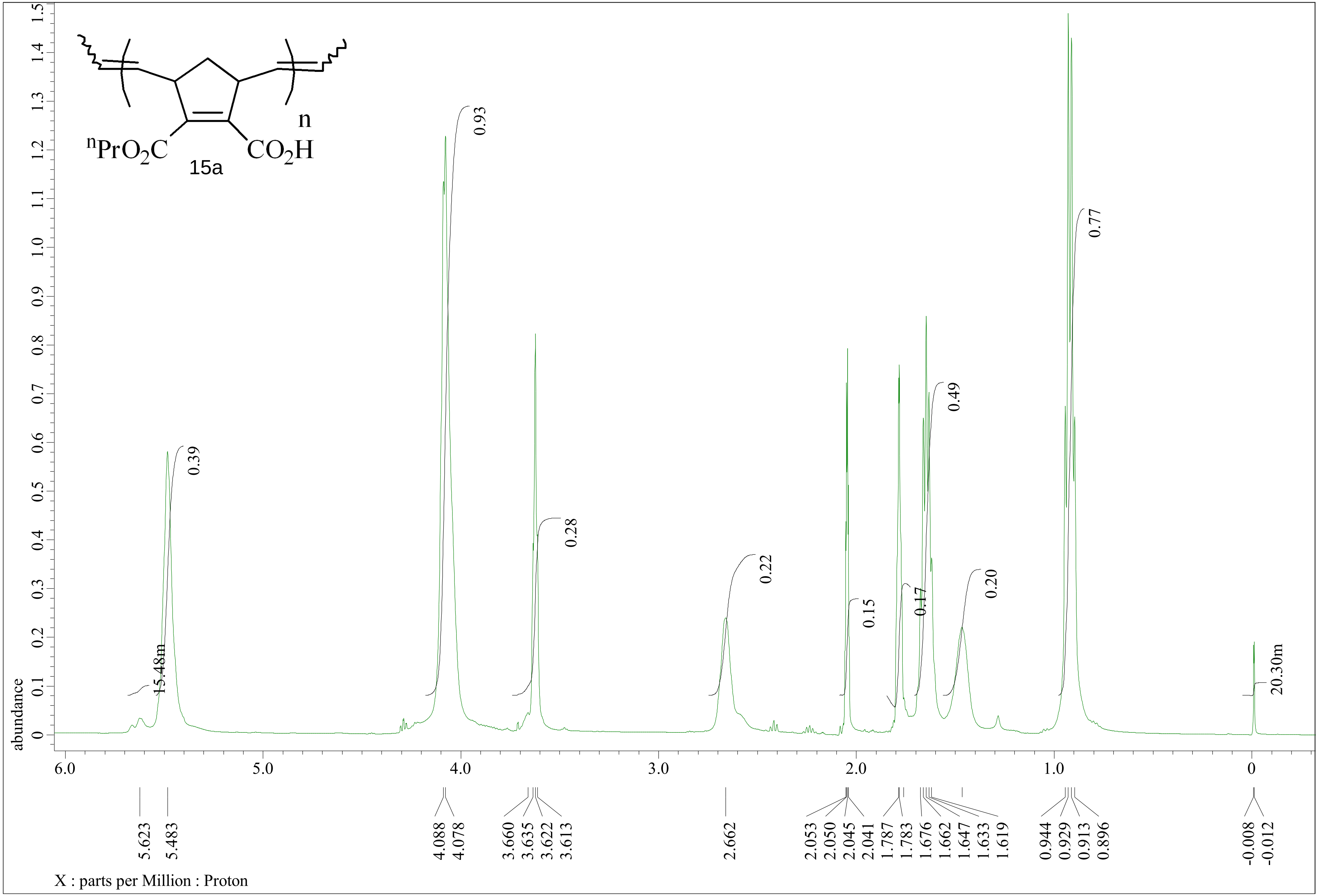
n
MeO2C
CO2H
13a
5.0
4.0
3.0
2.0
1.0
0
abundance
0.32
4.21m
0.52
0.79
0.35
0.21
94.75m
0.24
11.41m
6.0
5.0
4.0
3.0
2.0
1.0
0
5.561
5.394
5.347
3.969
3.629
3.599
2.548
2.050
1.964
1.960
1.954
1.351
-0.102
X : parts per Million : Proton


MeO2C
CO2H
n
13a
abundance
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
206.518
206.374
206.260
205.936
166.189
165.817
143.336
143.259
132.471
132.014
55.249
52.197
44.833
39.768
30.440
30.154
30.001
29.849
29.696
29.620
29.543
29.391
29.229
X : parts per Million : Carbon13

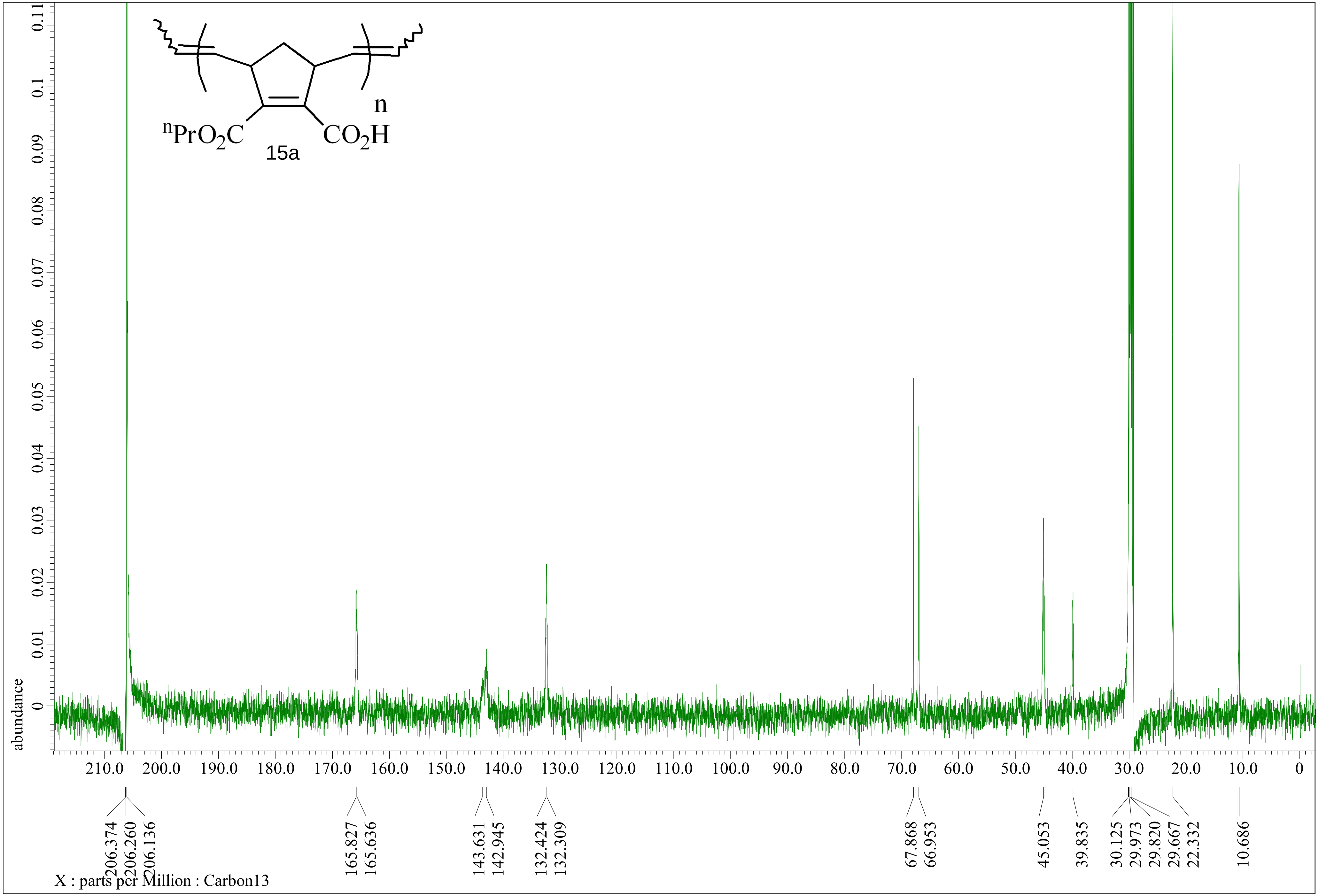

EtO2C
CO2H
n
14a
abundance
X : parts per Million : Proton
0.20
0.40
0.28
0.26
0.21
1.05
1.46m
8.82m
79.14m
20.69m
5.536
5.416
4.121
4.000
3.606
3.602
2.596
2.081
2.050
2.025
1.988
1.953
1.394
1.179
1.164
1.137
-0.070

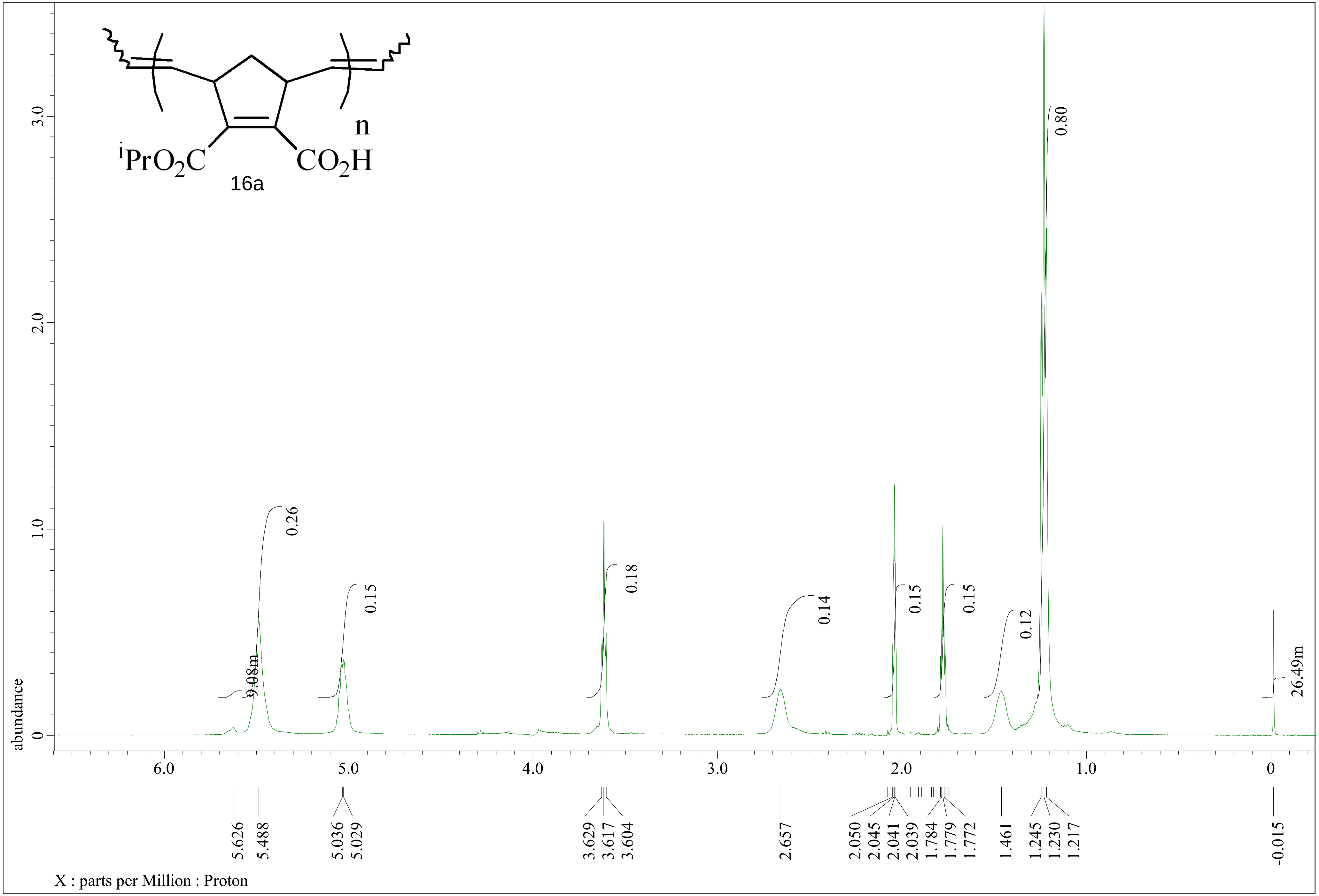


EtO2C
CO2H
n
14a
(thousandths)
X : parts per Million : Carbon13
206.813
206.498
206.374
206.260
165.951
165.798
143.917
142.859
132.748
132.395
69.690
61.478
55.373
45.177
39.978
30.097
29.944
29.791
29.629
14.320

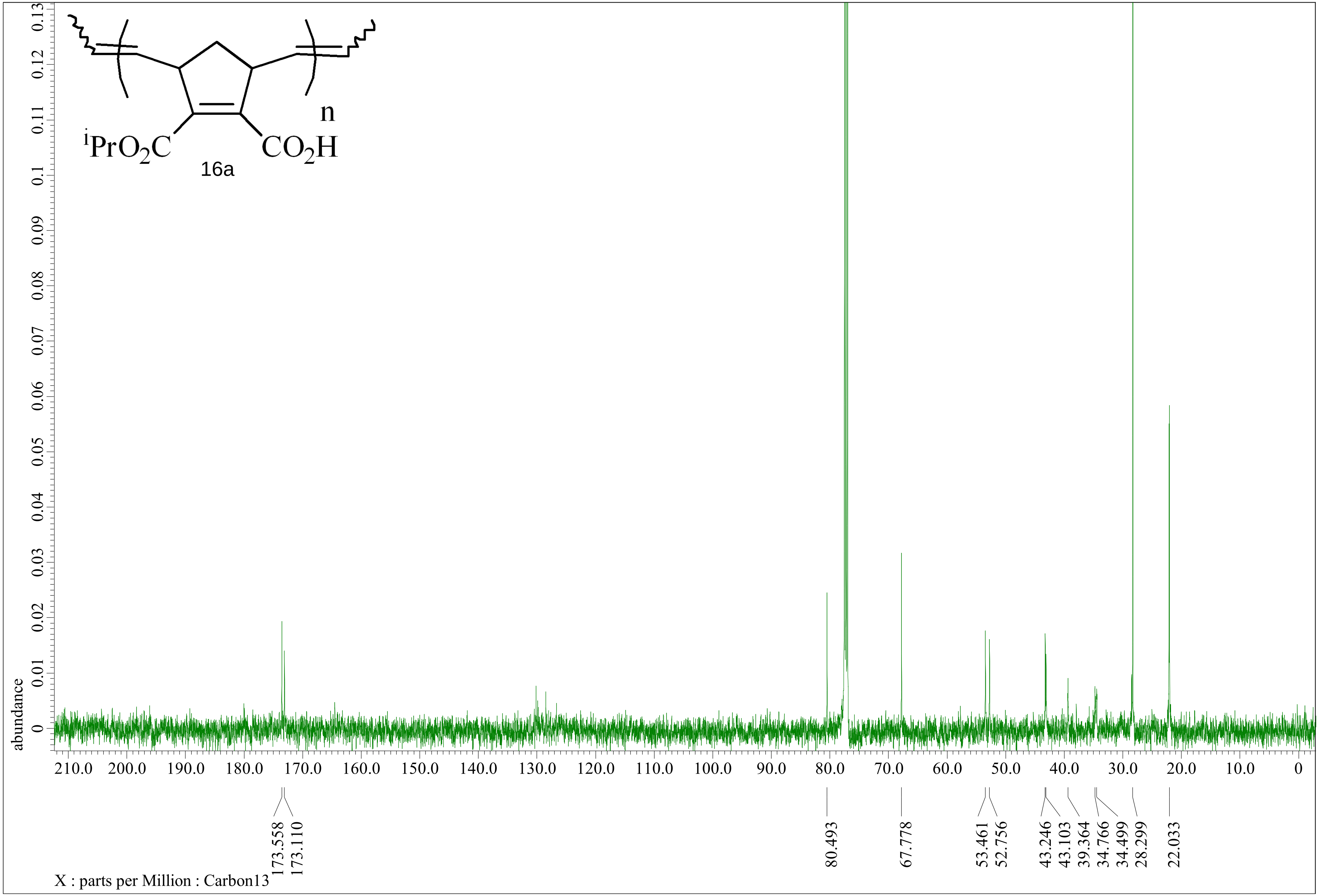


nPrO2C
CO2H
n
15a
0.39
0.93
0.28
0.22
0.15
0.17
0.49
0.20
0.77
15.48m
20.30m
abundance
X : parts per Million : Proton
5.623
5.483
4.088
4.078
3.660
3.635
3.622
3.613
2.662
2.053
2.050
2.045
2.041
1.787
1.783
1.676
1.662
1.647
1.633
1.619
0.944
0.929
0.913
0.896
-0.008
-0.012

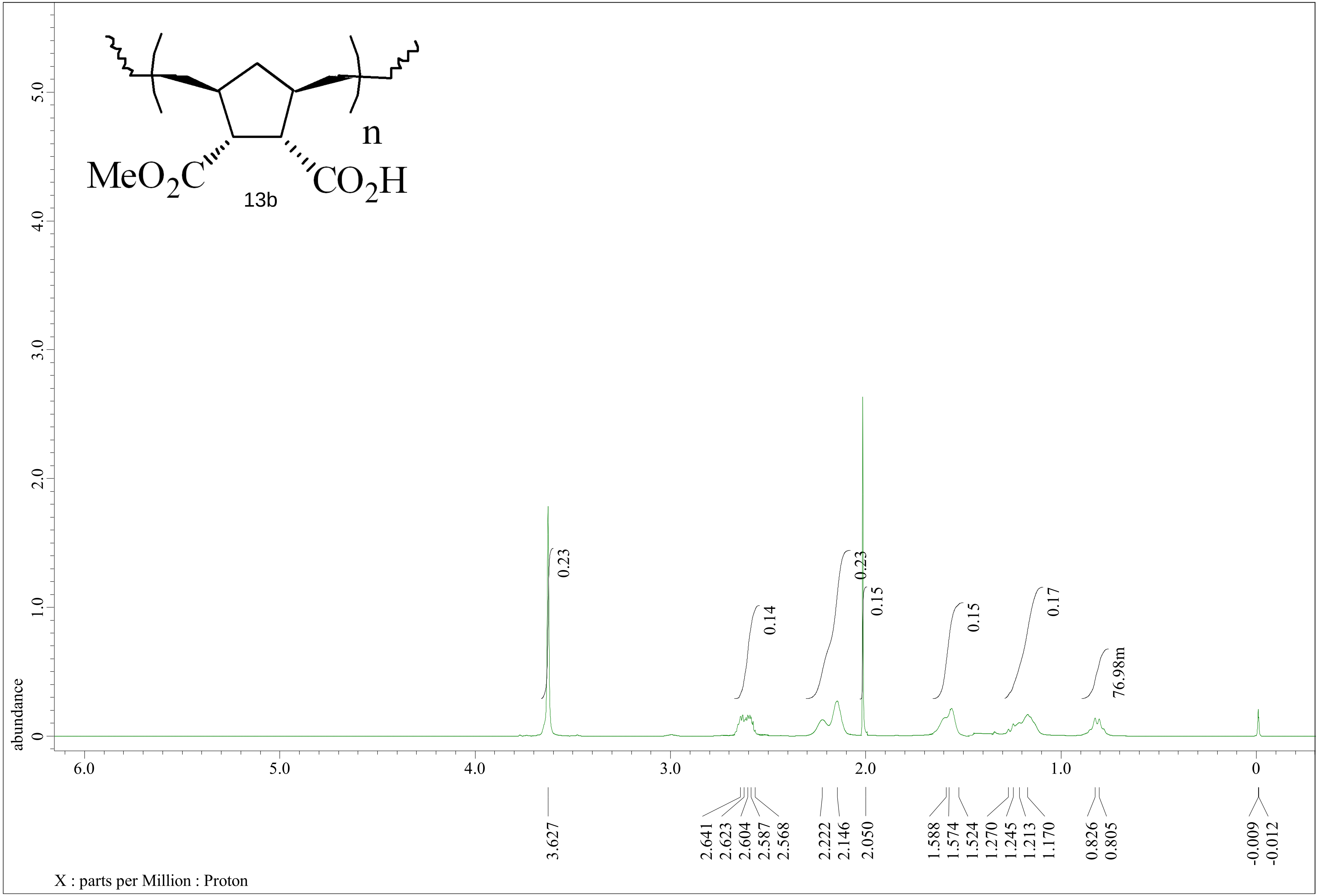

nPrO2C
CO2H
n
15a
206.374
206.260
206.136
165.827
165.636
143.631
142.945
132.424
132.309
67.868
66.953
45.053
39.835
30.125
29.973
29.820
29.667
22.332
10.686
abundance
X : parts per Million : Carbon13

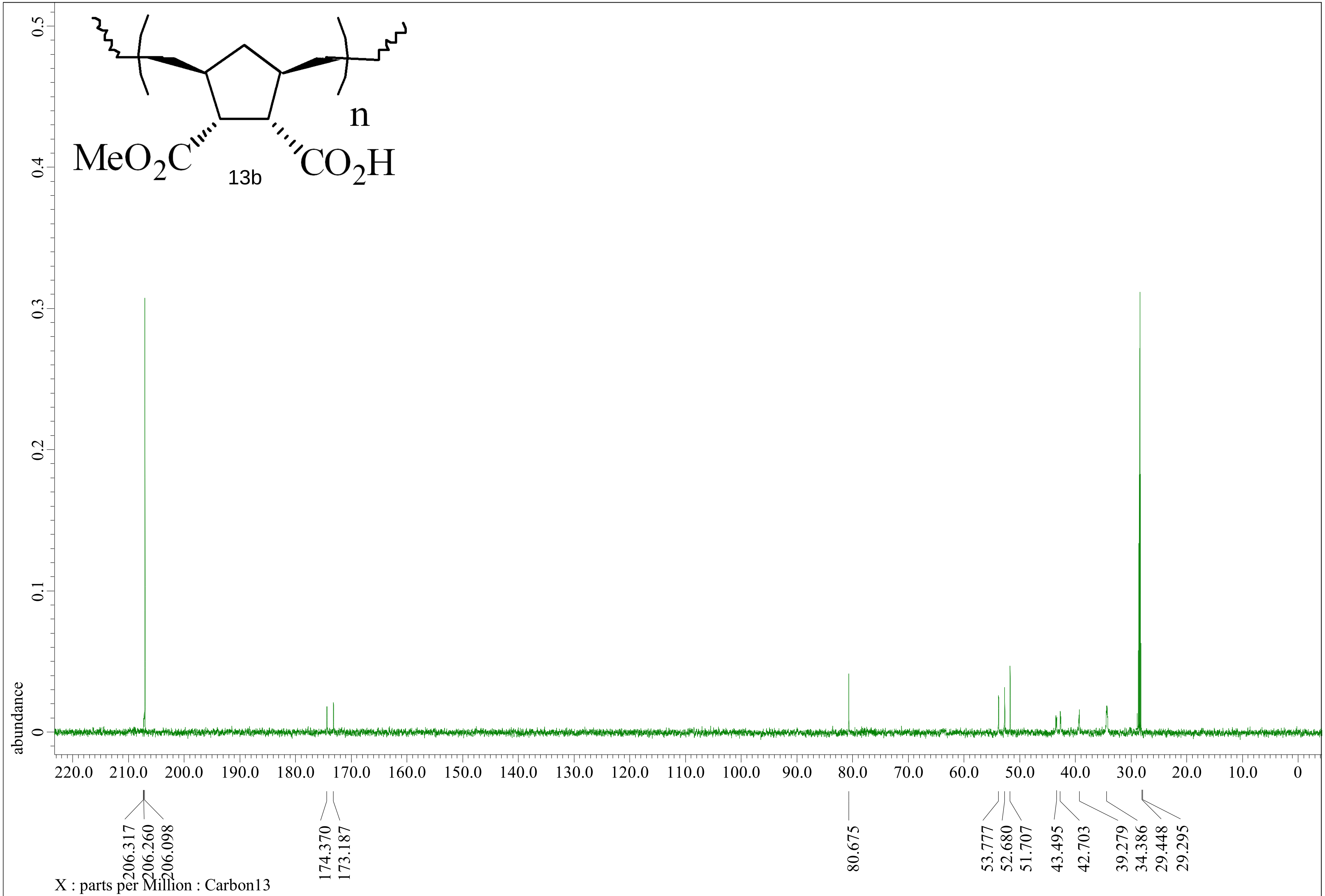


iPrO2C
CO2H
n
16a
abundance
3.0
2.0
1.0
0
6.0
5.0
4.0
3.0
2.0
1.0
0
0.26
0.15
0.18
0.14
0.15
0.15
0.12
0.80
9.08m
26.49m
5.626
5.488
5.036
5.029
3.629
3.617
3.604
2.657
2.050
2.045
2.041
2.039
1.784
1.779
1.772
1.461
1.245
1.230
1.217
-0.015
X : parts per Million : Proton

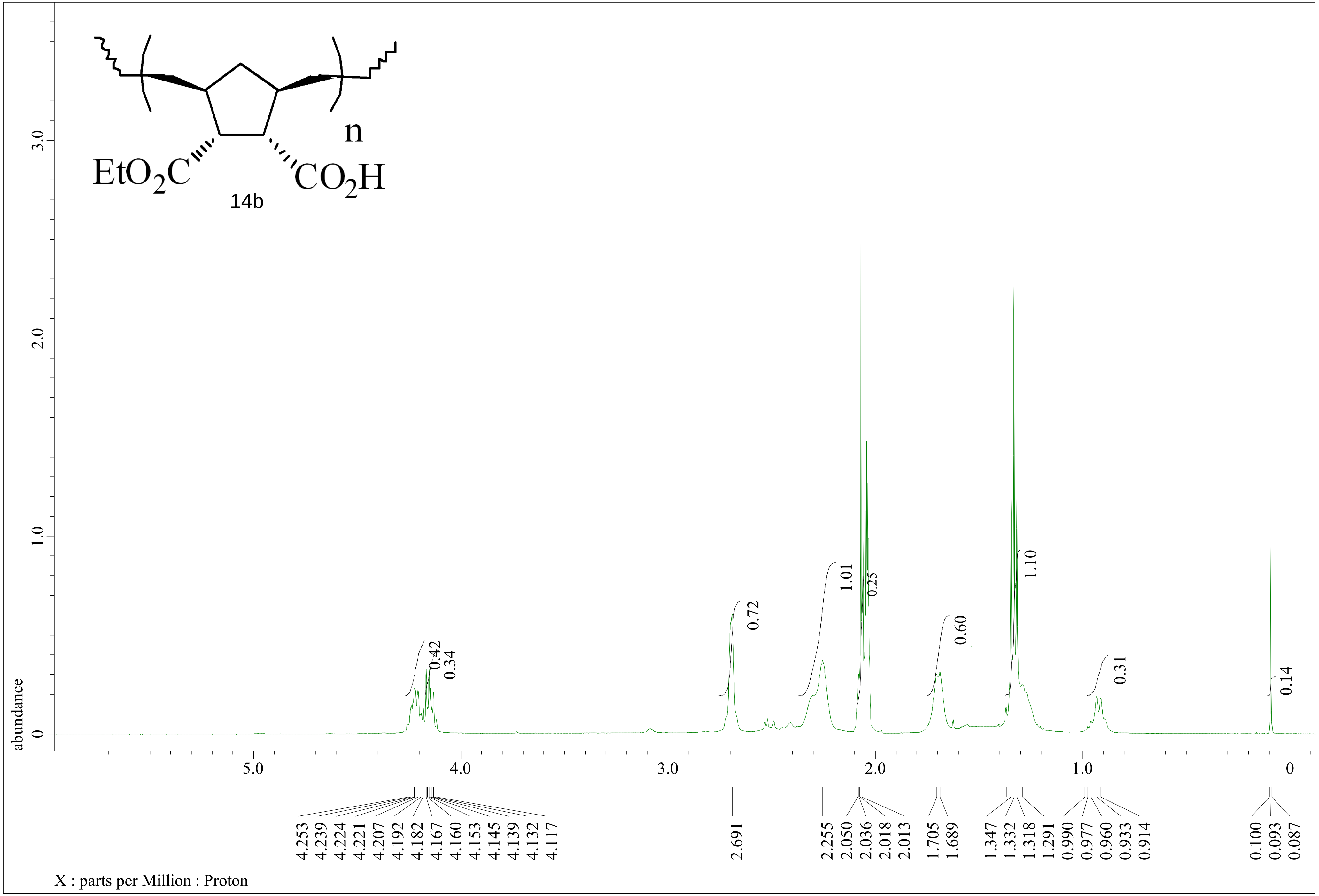


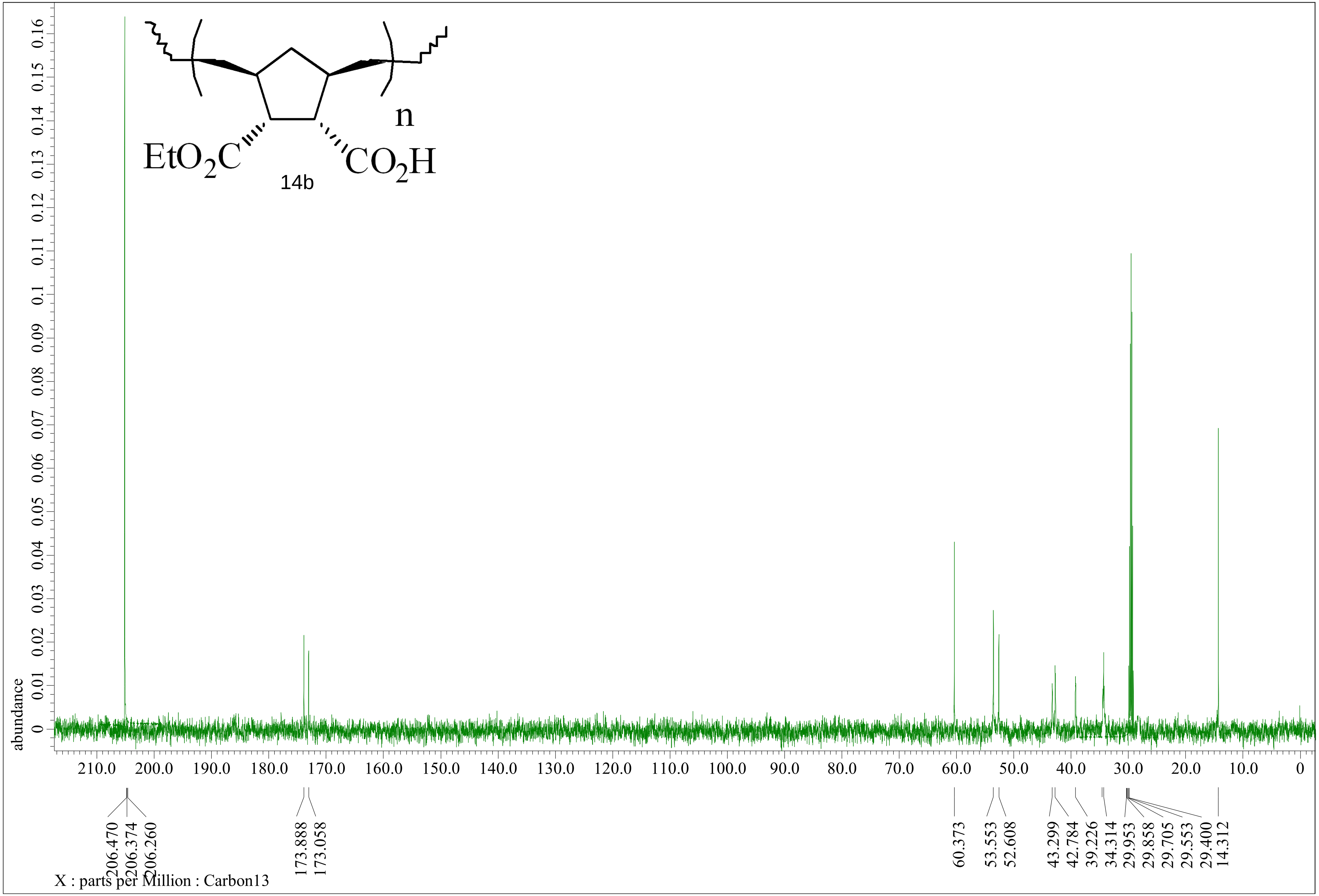
iPrO2C
CO2H
n
16a
abundance
X : parts per Million : Carbon13
173.558
173.110
80.493
67.778
53.461
52.756
43.246
43.103
39.364
34.766
34.499
28.299
22.033


MeO2C
CO2H
n
13b
abundance
X : parts per Million : Proton
0.23
0.14
0.23
0.15
0.15
0.17
76.98m
3.627
2.641
2.623
2.604
2.587
2.568
2.222
2.146
2.050
1.588
1.574
1.524
1.270
1.245
1.213
1.170
0.826
0.805
-0.009
-0.012

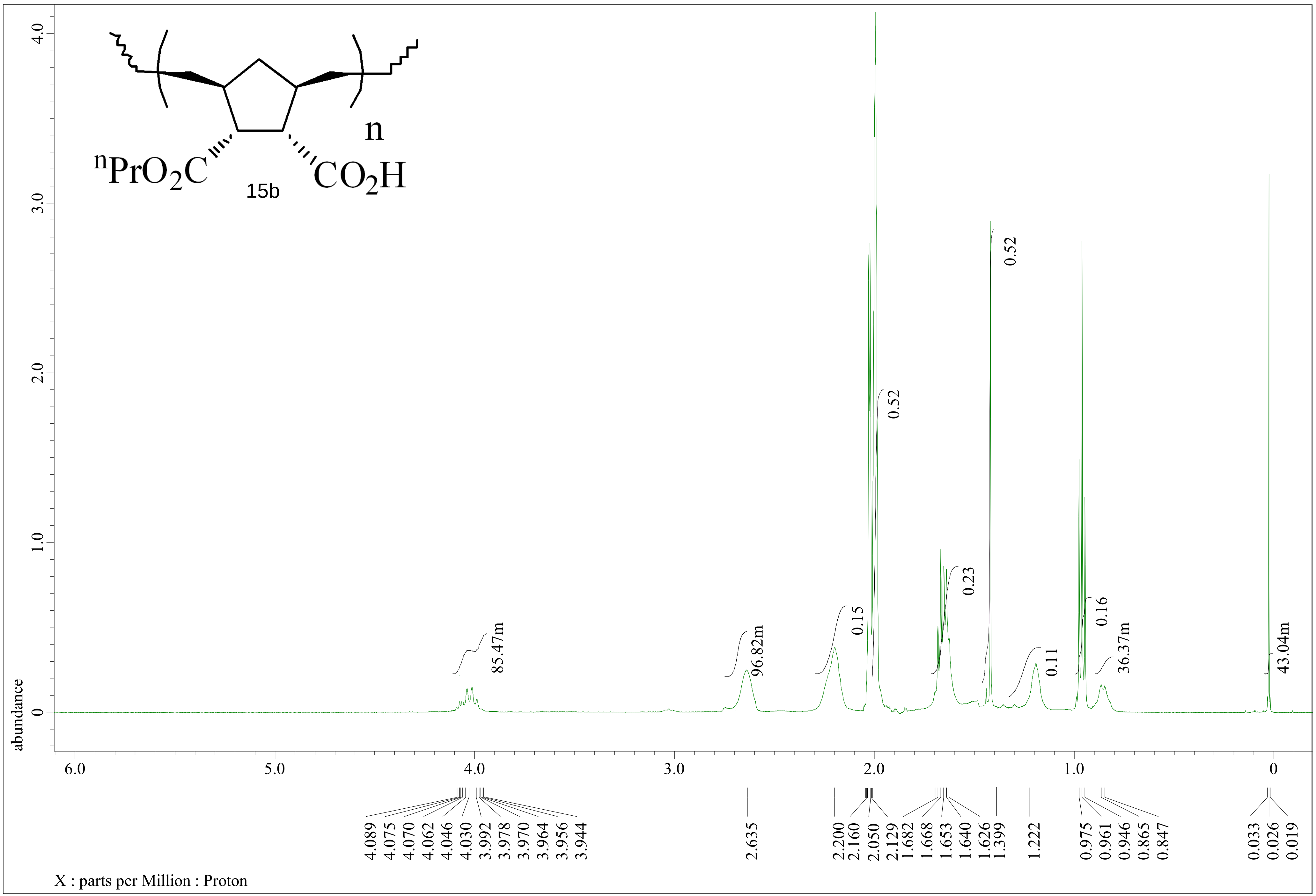


MeO2C
CO2H
n
13b
abundance
0.5
0.4
0.3
0.2
0.1
0
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
206.317
206.260
206.098
174.370
173.187
80.675
53.777
52.680
51.707
43.495
42.703
39.279
34.386
29.448
29.295
X : parts per Million : Carbon13

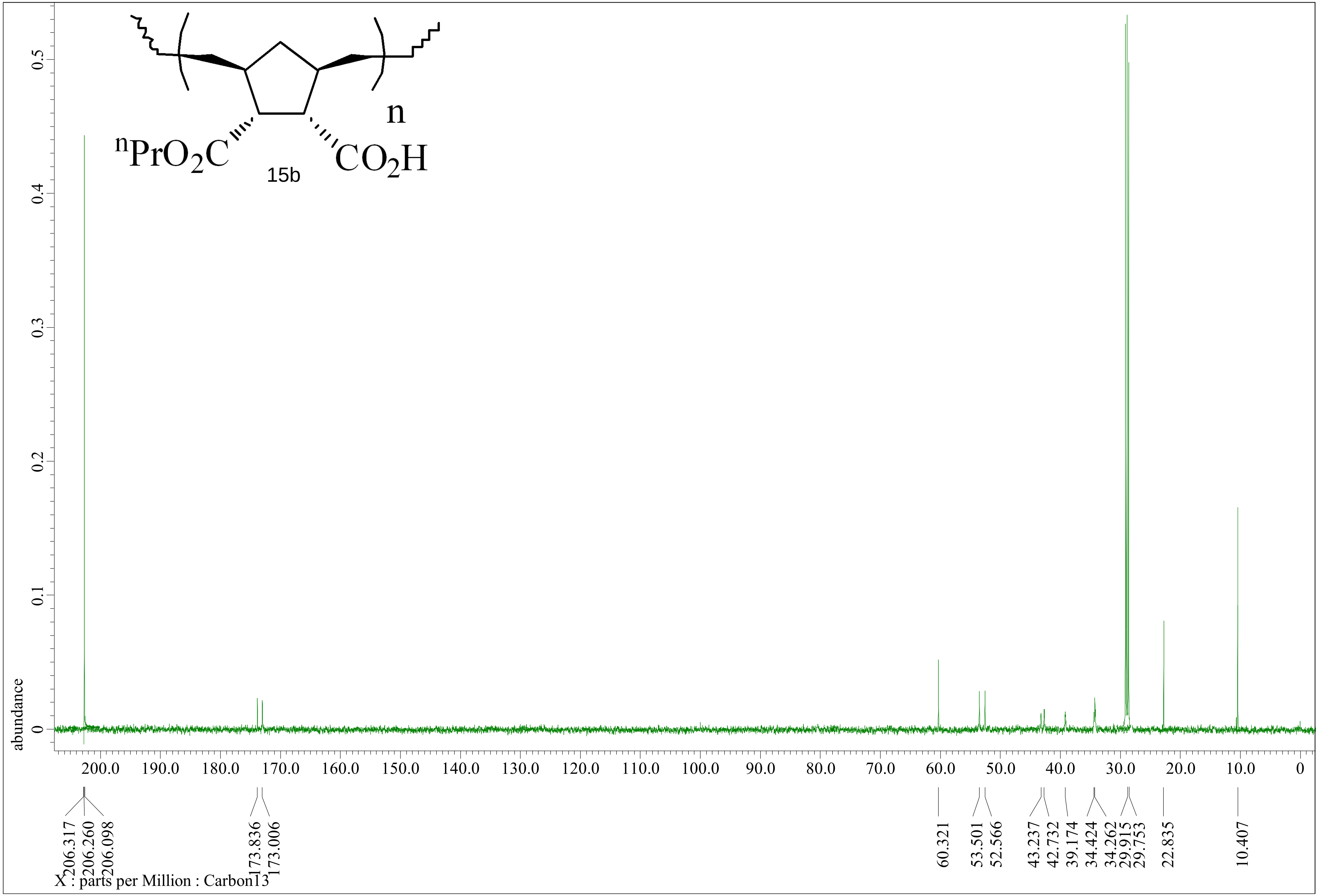

EtO2C
CO2H
n
14b
abundance
3.0
2.0
1.0
0
5.0
4.0
3.0
2.0
1.0
0
0.42
0.34
0.72
1.01
0.25
0.60
1.10
0.31
0.14
4.253
4.239
4.224
4.221
4.207
4.192
4.182
4.167
4.160
4.153
4.145
4.139
4.132
4.117
2.691
2.255
2.050
2.036
2.018
2.013
1.705
1.689
1.347
1.332
1.318
1.291
0.990
0.977
0.960
0.933
0.914
0.100
0.093
0.087
X : parts per Million : Proton



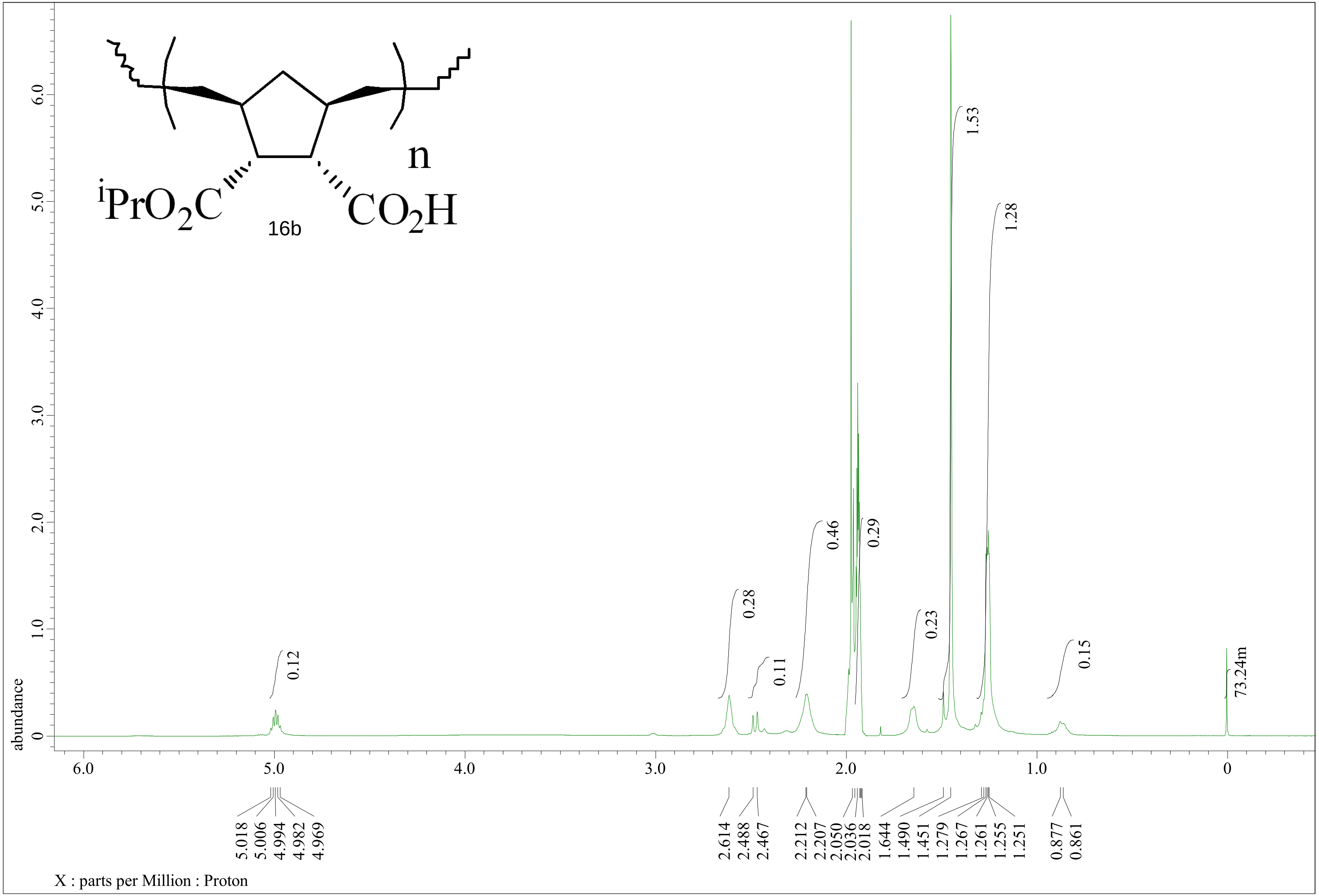
EtO2C
CO2H
n
14b
abundance
X : parts per Million : Carbon13
206.470
206.374
206.260
173.888
173.058
60.373
53.553
52.608
43.299
42.784
39.226
34.314
29.953
29.858
29.705
29.553
29.400
14.312



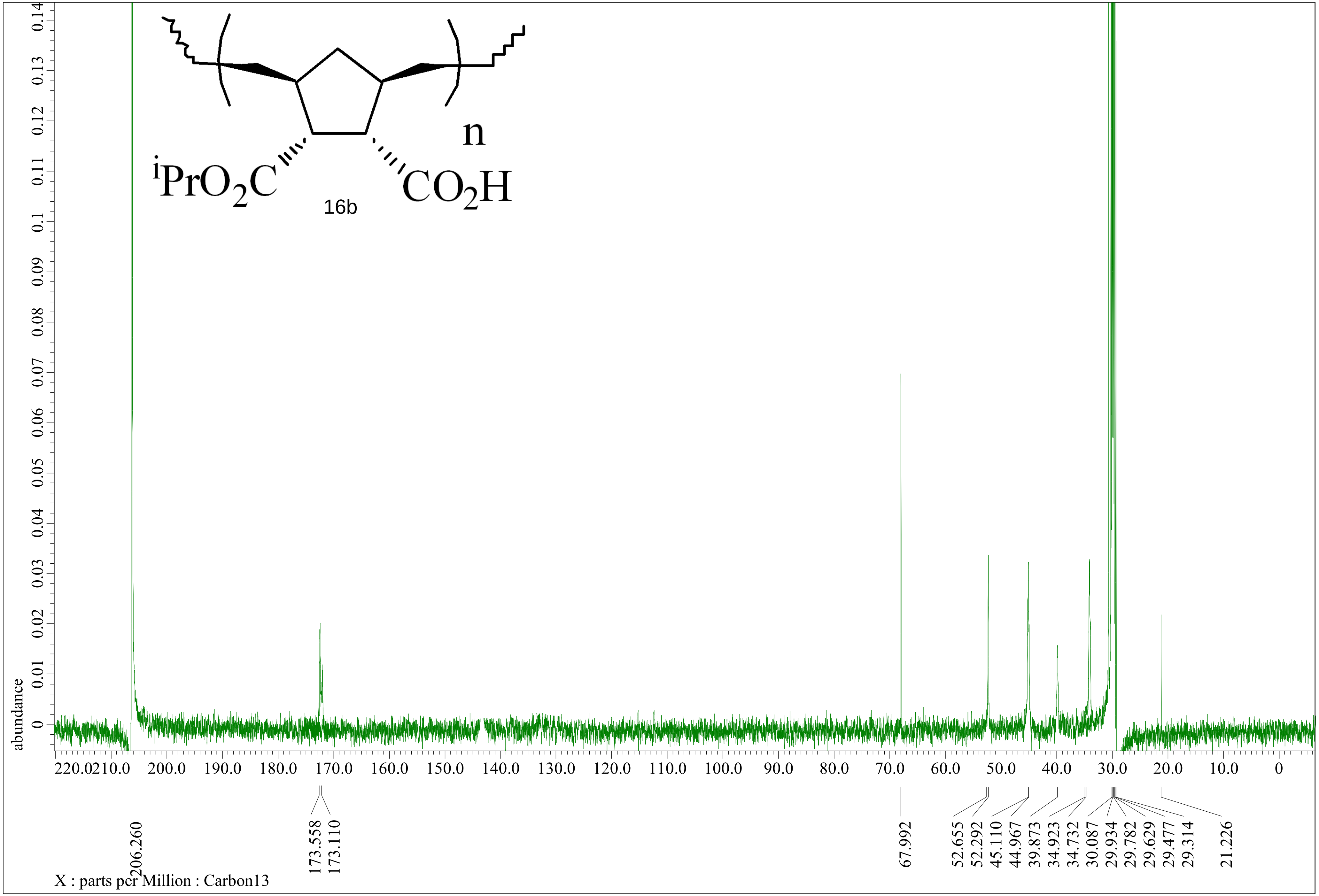
nPrO2C
CO2H
n
15b
abundance
X : parts per Million : Proton
6.0
5.0
4.0
3.0
2.0
1.0
0
85.47m
96.82m
0.15
0.52
0.23
0.52
0.11
0.16
36.37m
43.04m
4.089
4.075
4.070
4.062
4.046
4.030
3.992
3.978
3.970
3.964
3.956
3.944
2.635
2.200
2.160
2.050
2.129
1.682
1.668
1.653
1.640
1.626
1.399
1.222
0.975
0.961
0.946
0.865
0.847
0.033
0.026
0.019



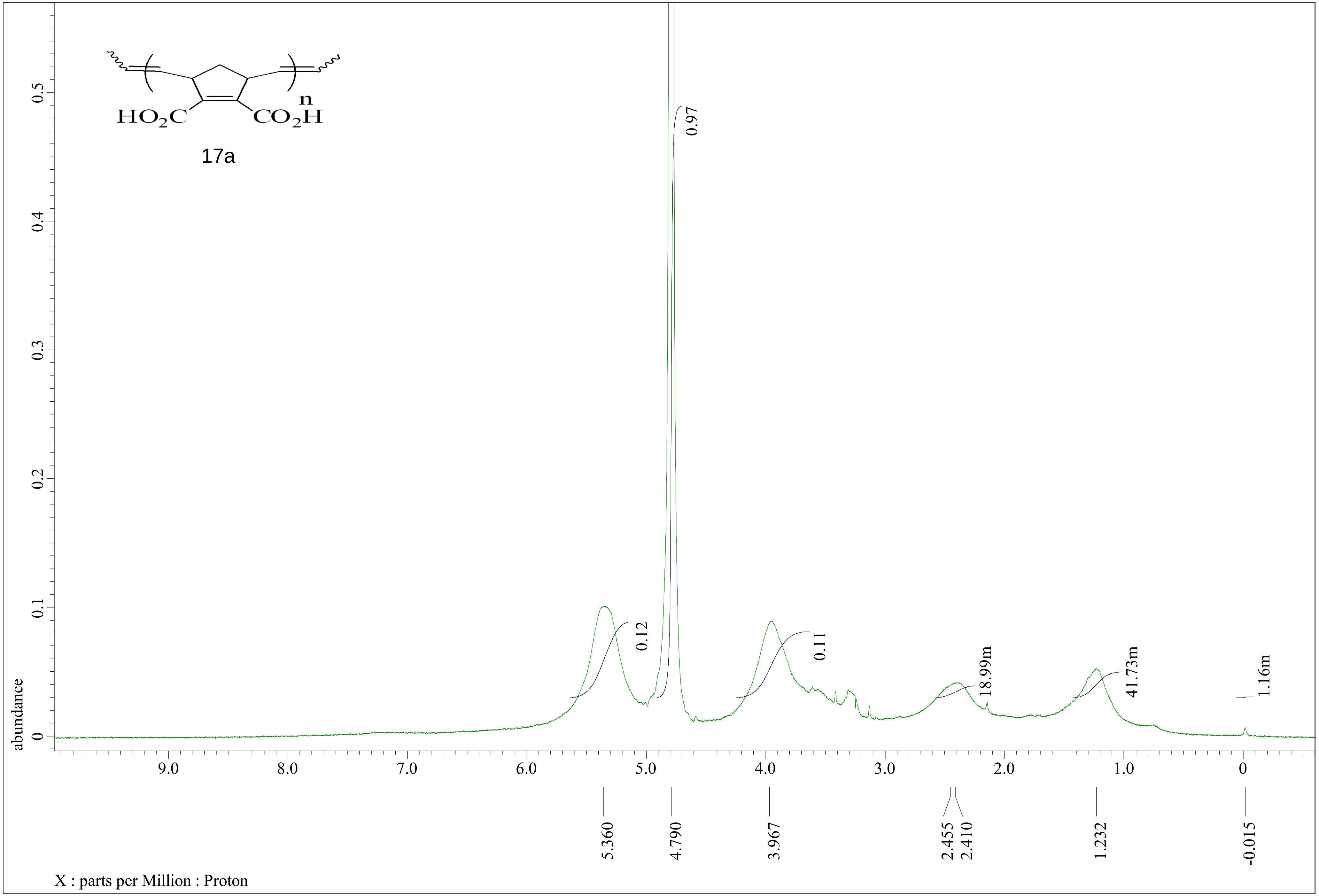
nPrO2C
CO2H
n
15b
abundance
0.5
0.4
0.3
0.2
0.1
0
200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
206.317
206.260
206.098
173.836
173.006
60.321
53.501
52.566
43.237
42.732
39.174
34.424
34.262
29.915
29.753
22.835
10.407
X : parts per Million : Carbon13

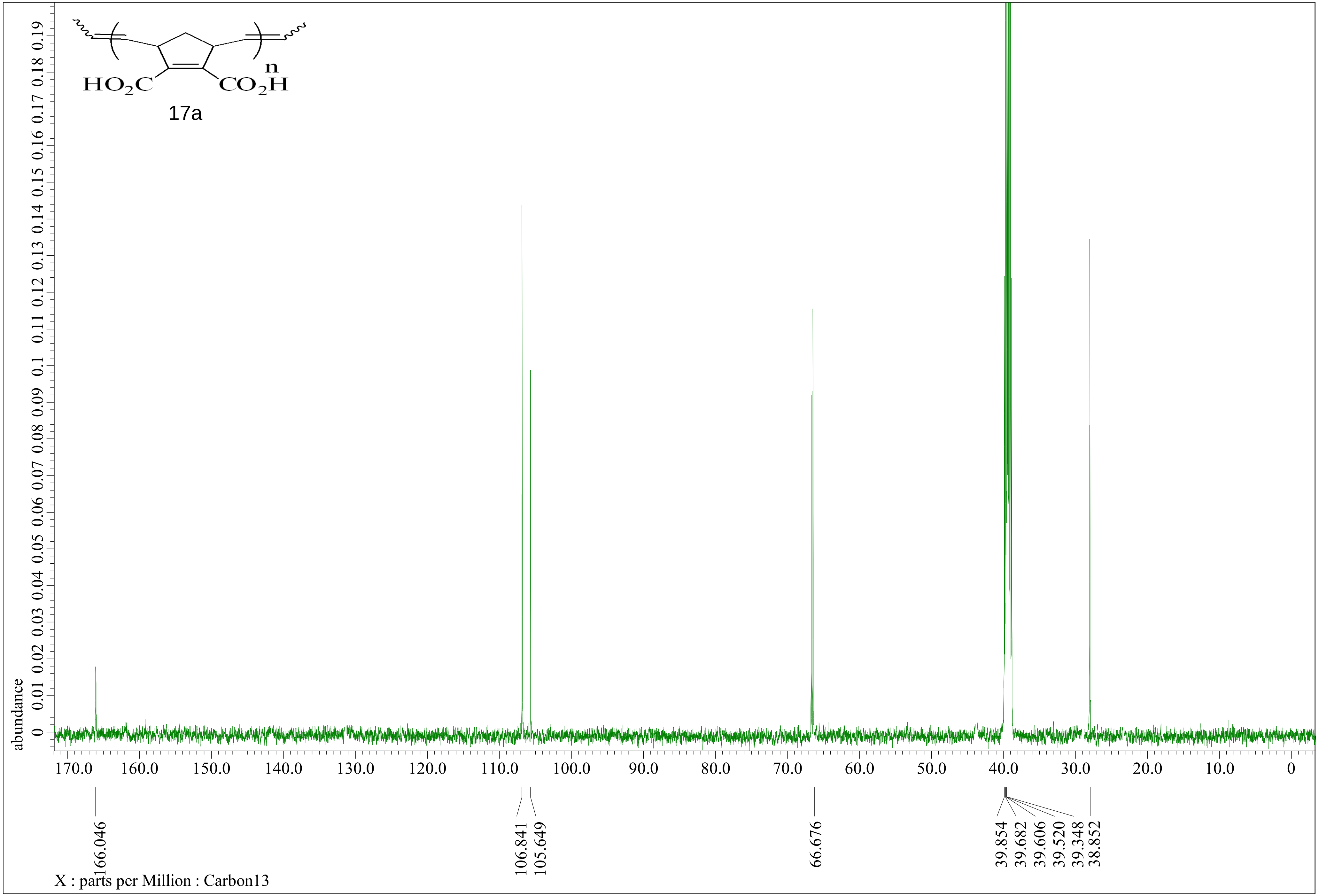


iPrO2C
CO2H
n
16b
abundance
X : parts per Million : Proton
0.12
0.28
0.11
0.46
0.29
1.53
0.23
1.28
0.15
73.24m
5.018
5.006
4.994
4.982
4.969
2.614
2.488
2.467
2.212
2.207
2.050
2.036
2.018
1.644
1.490
1.451
1.279
1.267
1.261
1.255
1.251
0.877
0.861

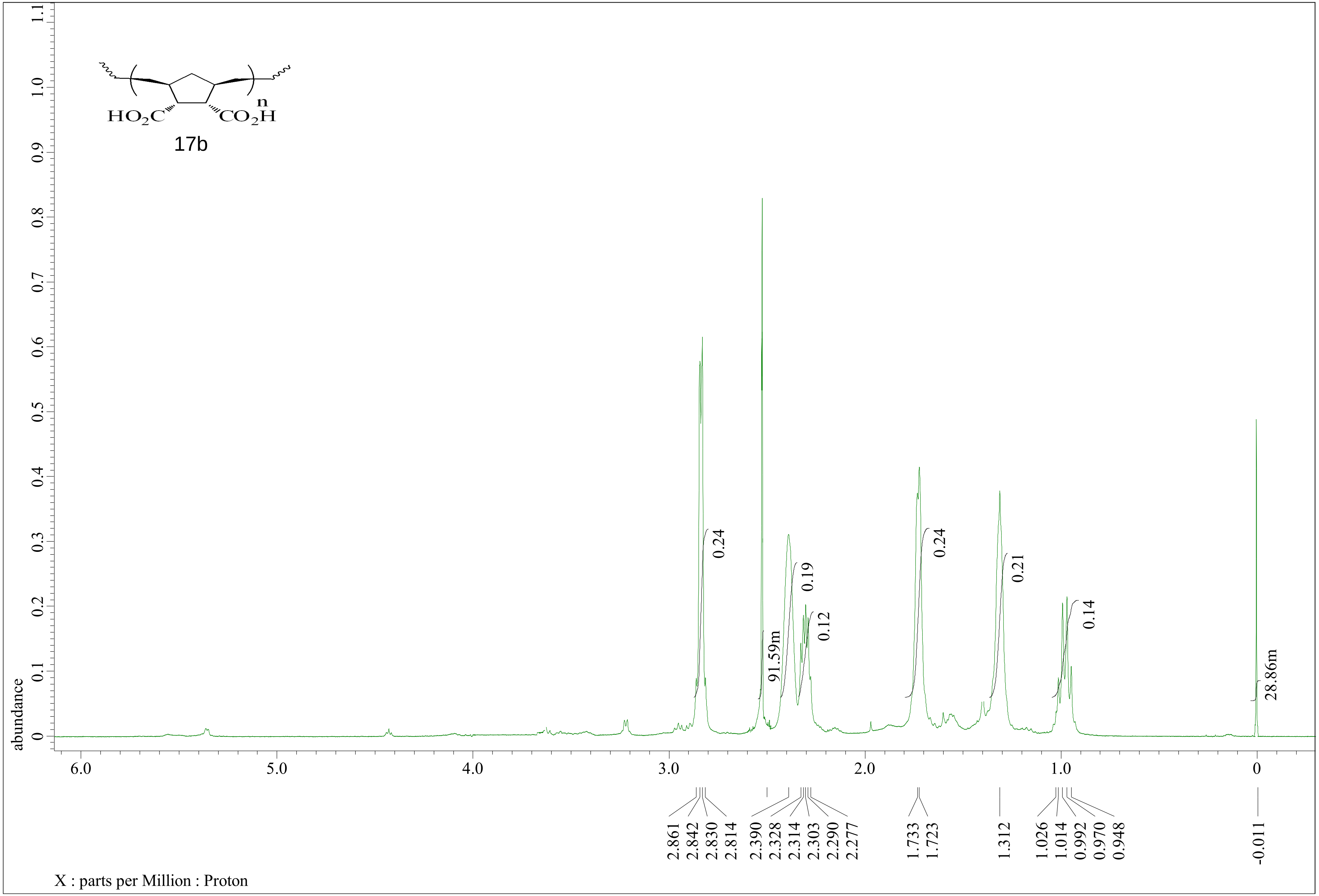


$^{i}PrO_2C$
CO_2H
n
16b
abundance
X : parts per Million : Carbon13
206.260
173.558
173.110
67.992
52.655
52.292
45.110
44.967
39.873
34.923
34.732
30.087
29.934
29.782
29.629
29.477
29.314
21.226

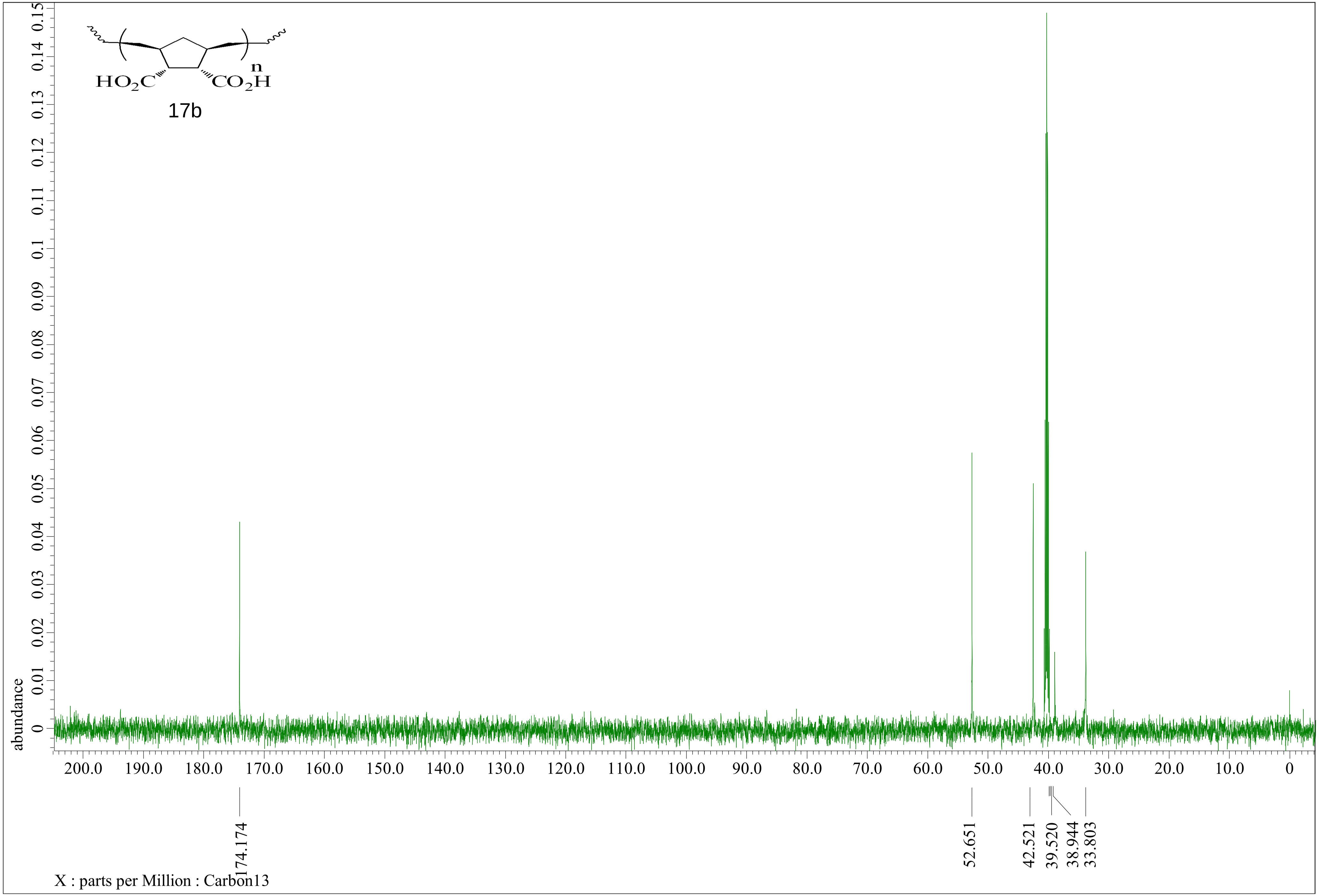

HO2C
CO2H
n
17a
0.97
0.12
0.11
18.99m
41.73m
1.16m
abundance
0
0.1
0.2
0.3
0.4
0.5
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
5.360
4.790
3.967
2.455
2.410
1.232
-0.015
X : parts per Million : Proton



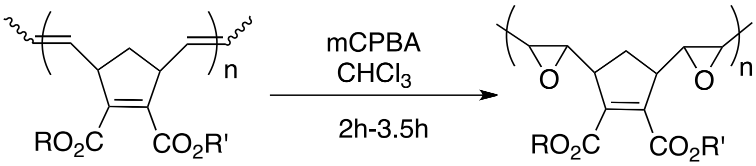
HO2C
CO2H
n
17a
abundance
X : parts per Million : Carbon13
166.046
106.841
105.649
66.676
39.854
39.682
39.606
39.520
39.348
38.852



HO2C
CO2H
n
17b
abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
6.0
5.0
4.0
3.0
2.0
1.0
0
0.24
91.59m
0.19
0.12
0.24
0.21
0.14
28.86m
2.861
2.842
2.830
2.814
2.390
2.328
2.314
2.303
2.290
2.277
1.733
1.723
1.312
1.026
1.014
0.992
0.970
0.948
-0.011
X : parts per Million : Proton


HO2C
CO2H
n
17b
abundance
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
174.174
52.651
42.521
39.520
38.944
33.803
X : parts per Million : Carbon13

Epoxidation of polymers

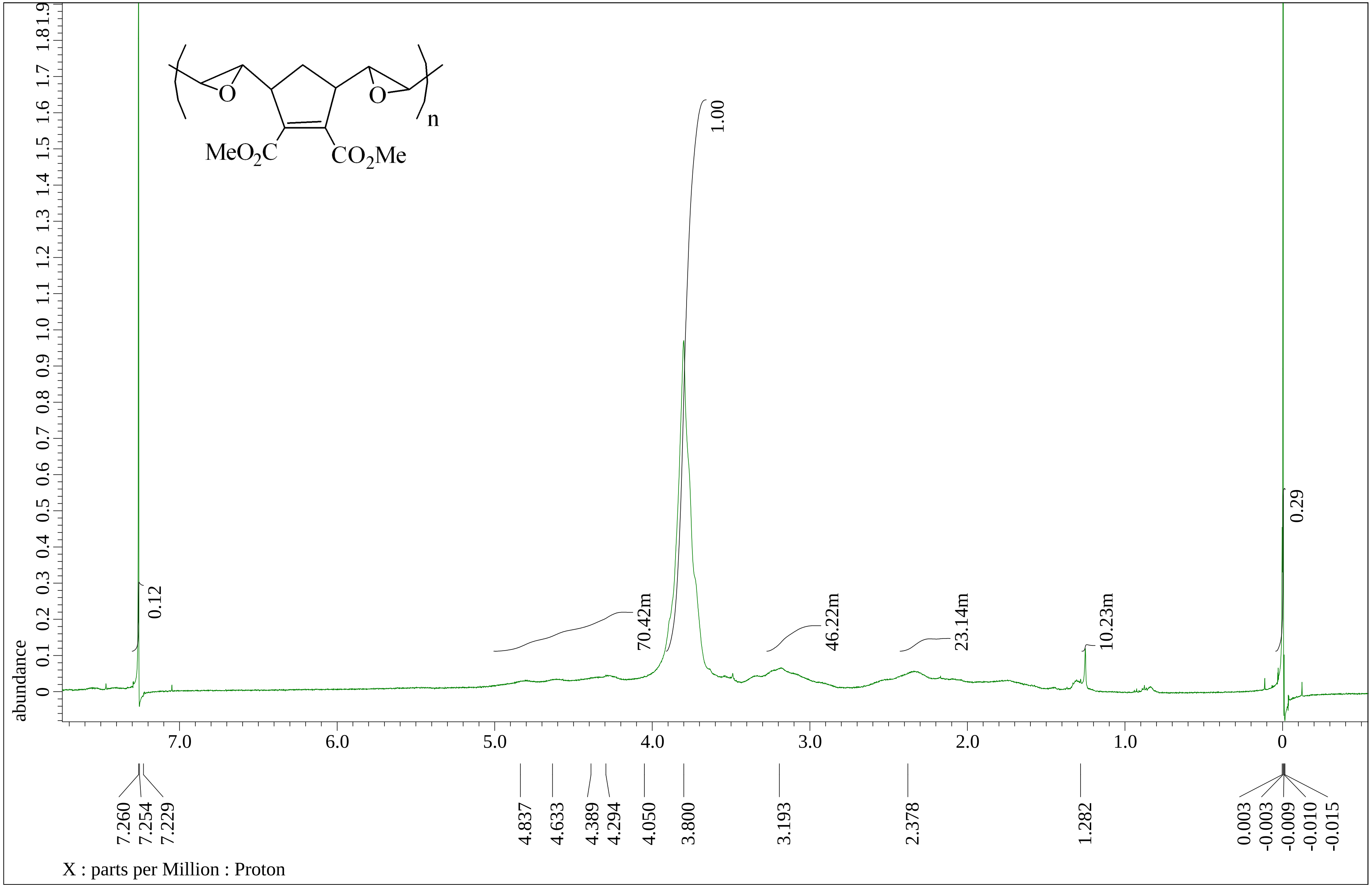


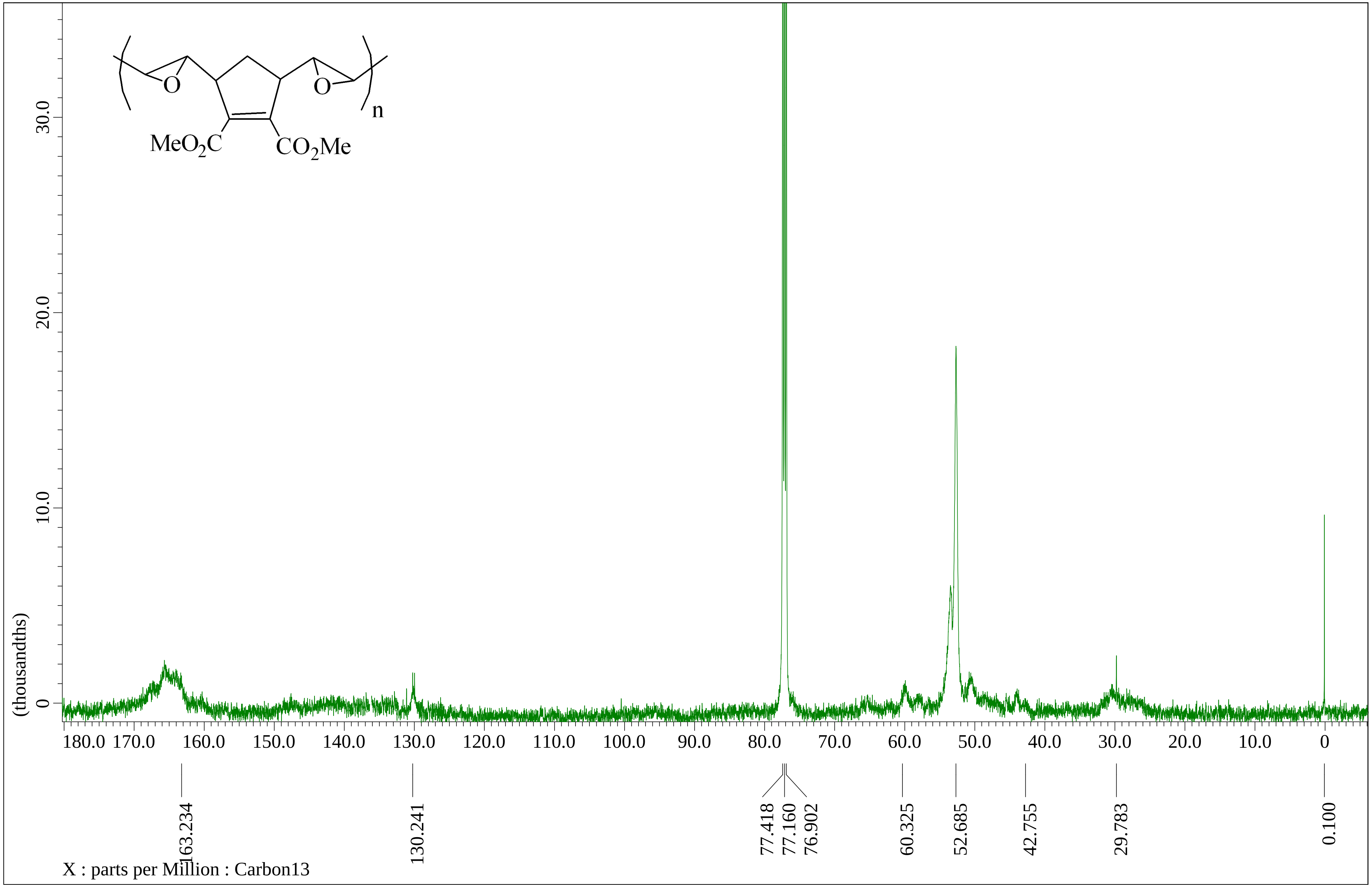
R and	R'[a]	Yield[b] (%)	M_n(GPC)[c] kDa	M_w/M_n[c]	T_g (°C)	T_d[5d] (°C)
Me	Me	>99	13.1	1.51	88	169
Et	Et	>99	14.6	1.69	71	174
^{n}P	^{n}P	>99	18.7	1.40	45	175
^{i}P	^{i}P	>99	17.3	1.39	86	197
^{t}Bu	^{t}Bu	>99	20.7	1.52	95	139
Bn	Bn	>99	45.1	1.40	60	197
Me	^{t}Bu	>99	21.2	1.51	89	161
Et	^{t}Bu	>99	24.9	1.42	76	155
^{n}P	^{t}Bu	>99	29.0	1.36	70	150
^{i}P	^{t}Bu	>99	28.6	1.55	34	156
Me	^{i}P	>99	19.7	1.73	84	202

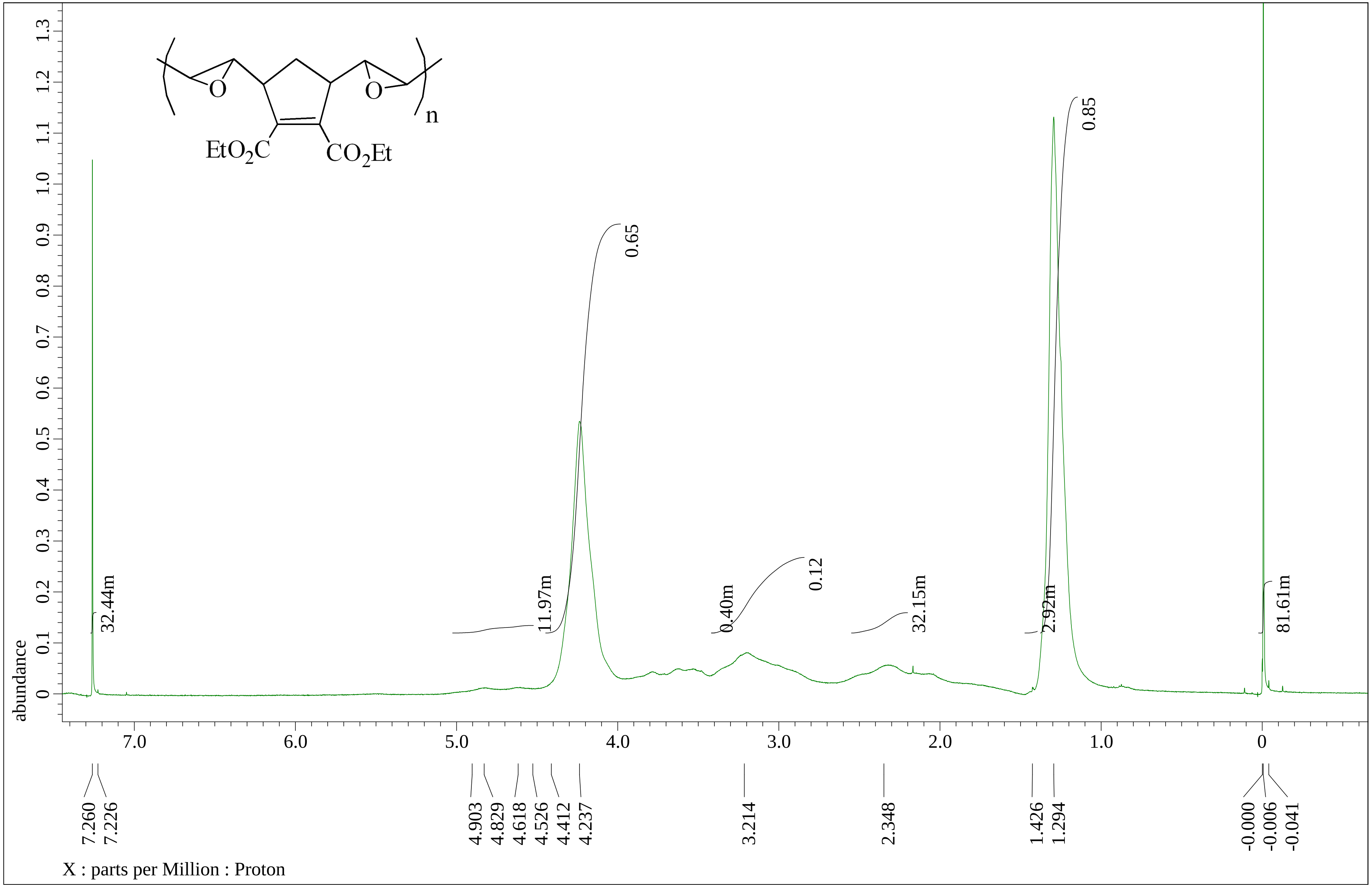
a: Interchangeable. b: Isolated yield after precipitation.

c: Determined by GPC with a polystyrene standard.

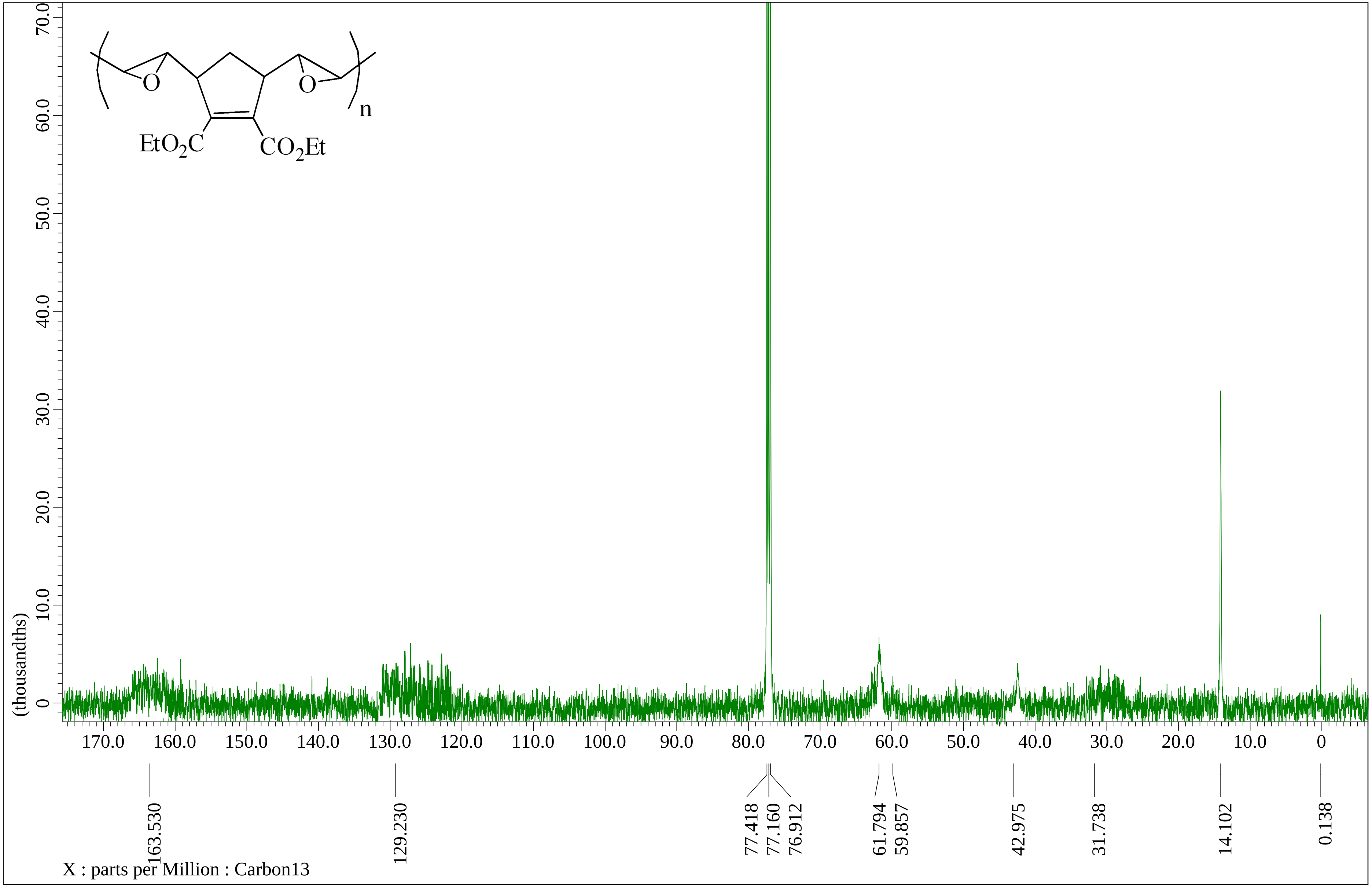
d: Temperature at 5% weight loss.


MeO2C
CO2Me
O
O
n
abundance
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.81.9
0.12
70.42m
1.00
46.22m
23.14m
10.23m
0.29
7.0 6.0 5.0 4.0 3.0 2.0 1.0 0
7.260 7.254 7.229
4.837 4.633 4.389 4.294 4.050 3.800 3.193 2.378 1.282
0.003 -0.003 -0.009 -0.010 -0.015
X : parts per Million : Proton

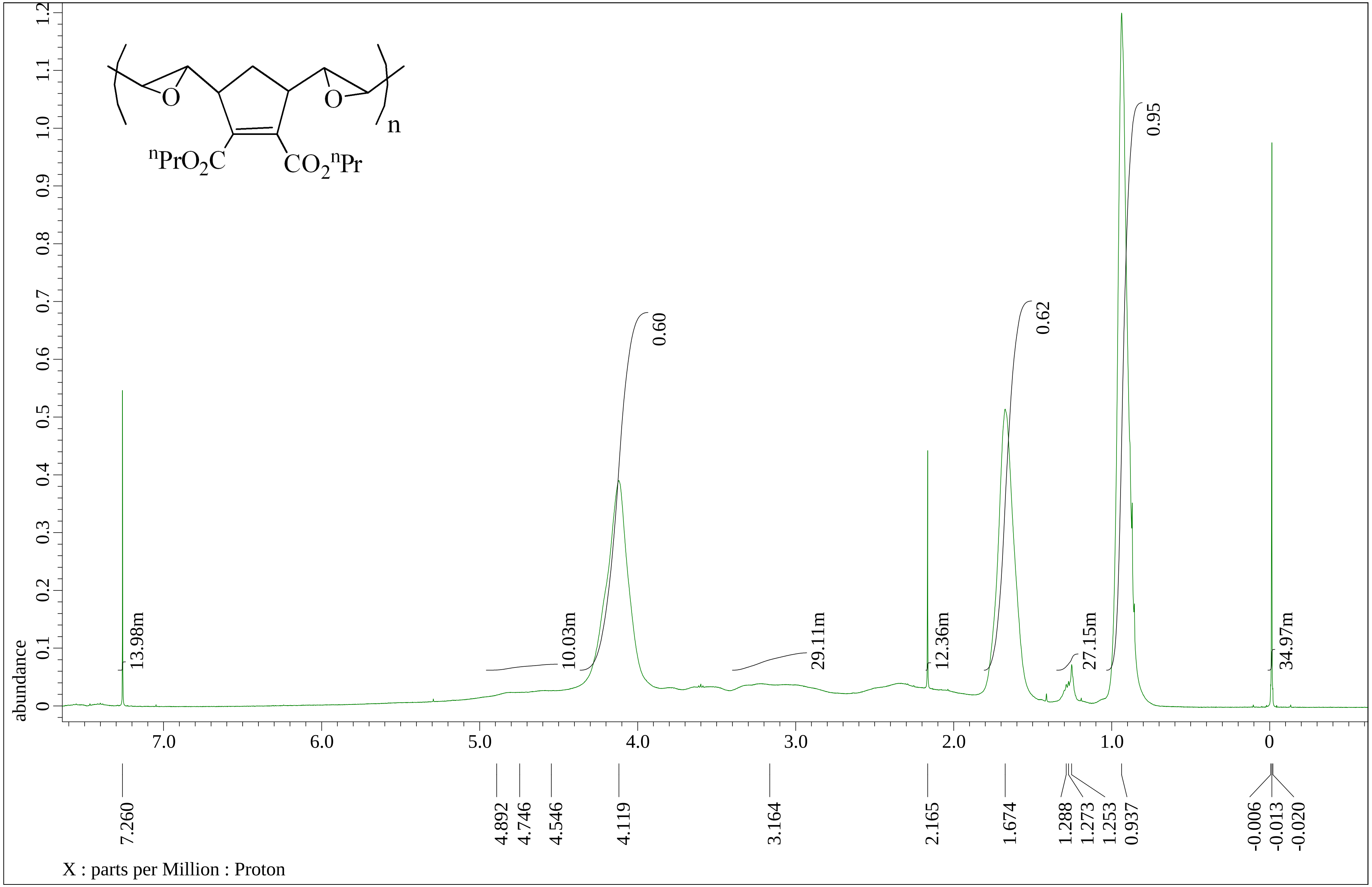

MeO2C
CO2Me
n
O
O
30.0
20.0
10.0
0
(thousandths)
180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
163.234
130.241
77.418
77.160
76.902
60.325
52.685
42.755
29.783
0.100
X : parts per Million : Carbon13



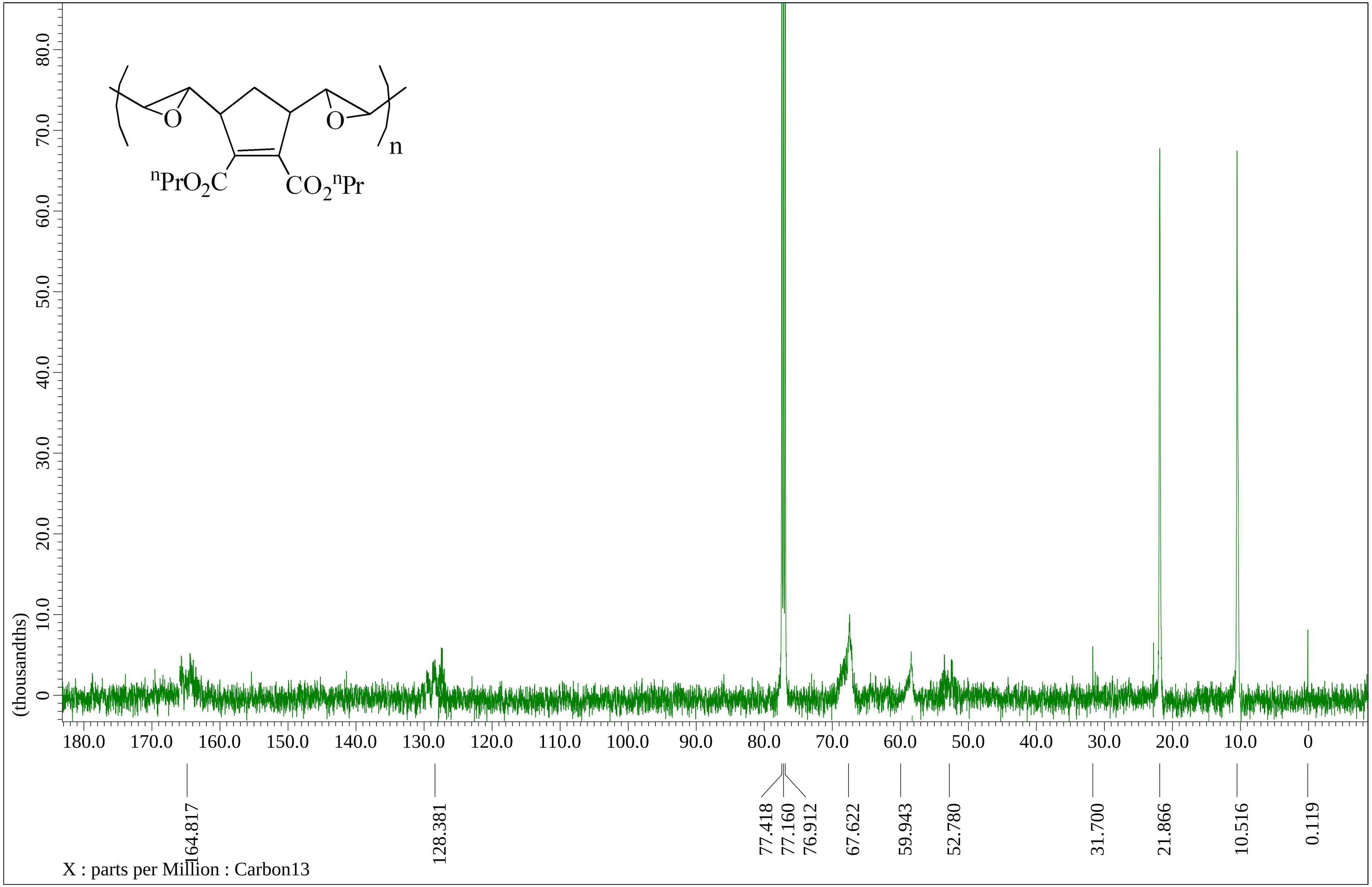
EtO2C
CO2Et
O
O
n
abundance
0.65
0.85
0.12
32.44m
11.97m
0.40m
32.15m
2.92m
81.61m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
7.226
4.903
4.829
4.618
4.526
4.412
4.237
3.214
2.348
1.426
1.294
-0.000
-0.006
-0.041
X : parts per Million : Proton



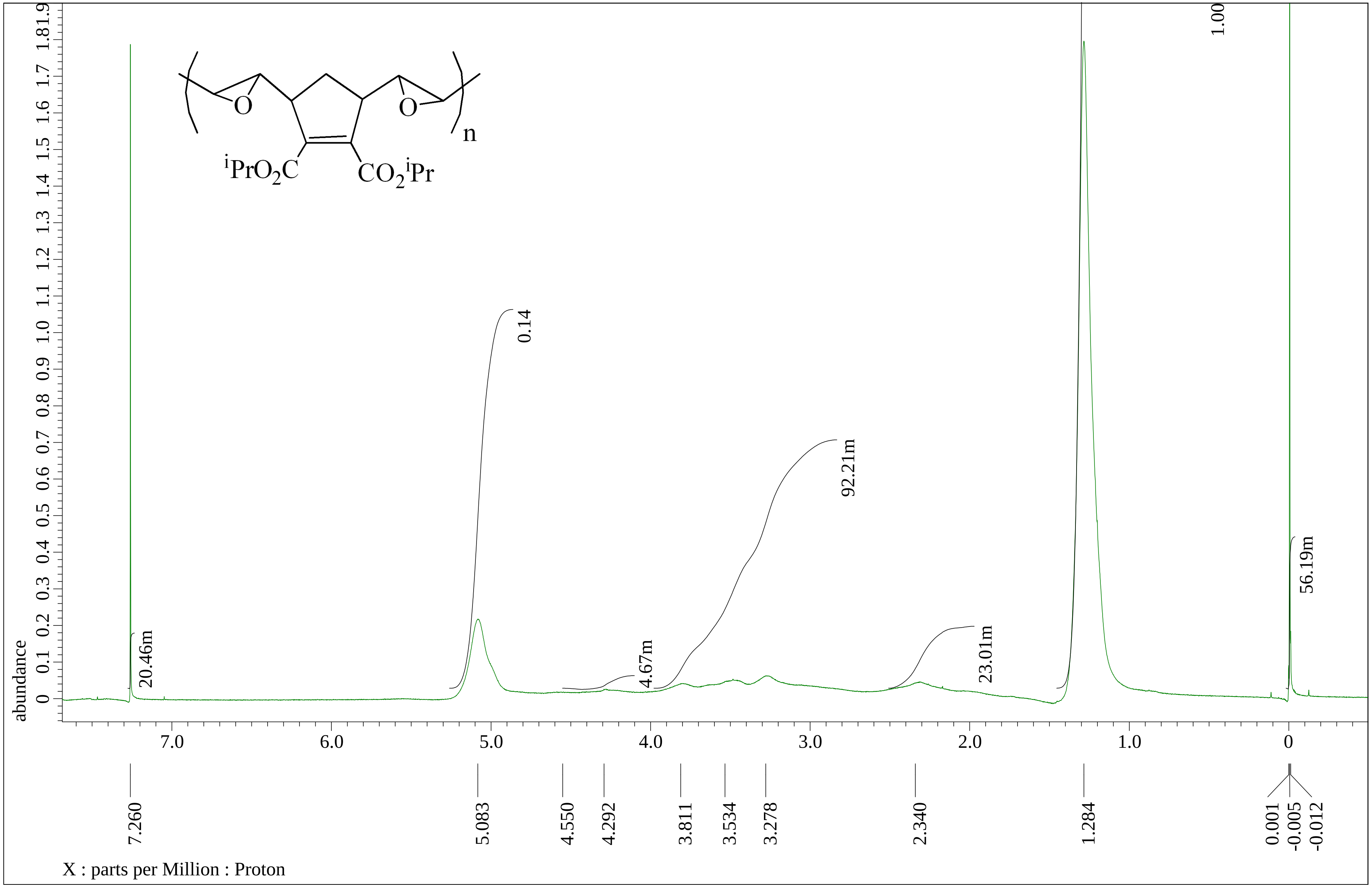
EtO2C
CO2Et
O
O
n
(thousandths)
0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
163.530
129.230
77.418
77.160
76.912
61.794
59.857
42.975
31.738
14.102
0.138
X : parts per Million : Carbon13

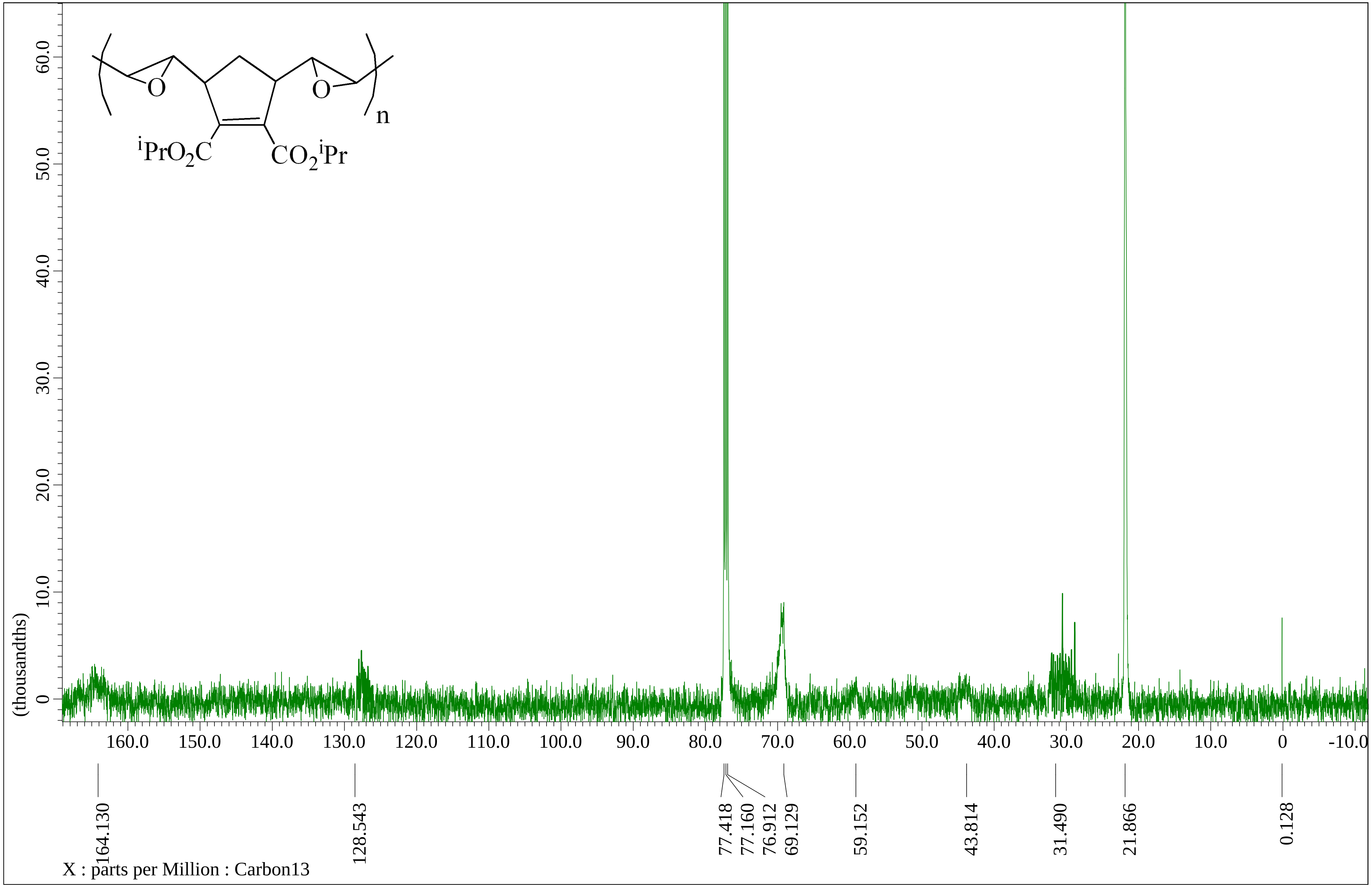


O
O
n
^{n}PrO$_2$C
CO$_2$^{n}Pr
abundance
X : parts per Million : Proton
13.98m
10.03m
0.60
29.11m
12.36m
0.62
27.15m
0.95
34.97m
7.260
4.892
4.746
4.546
4.119
3.164
2.165
1.674
1.288
1.273
1.253
0.937
-0.006
-0.013
-0.020

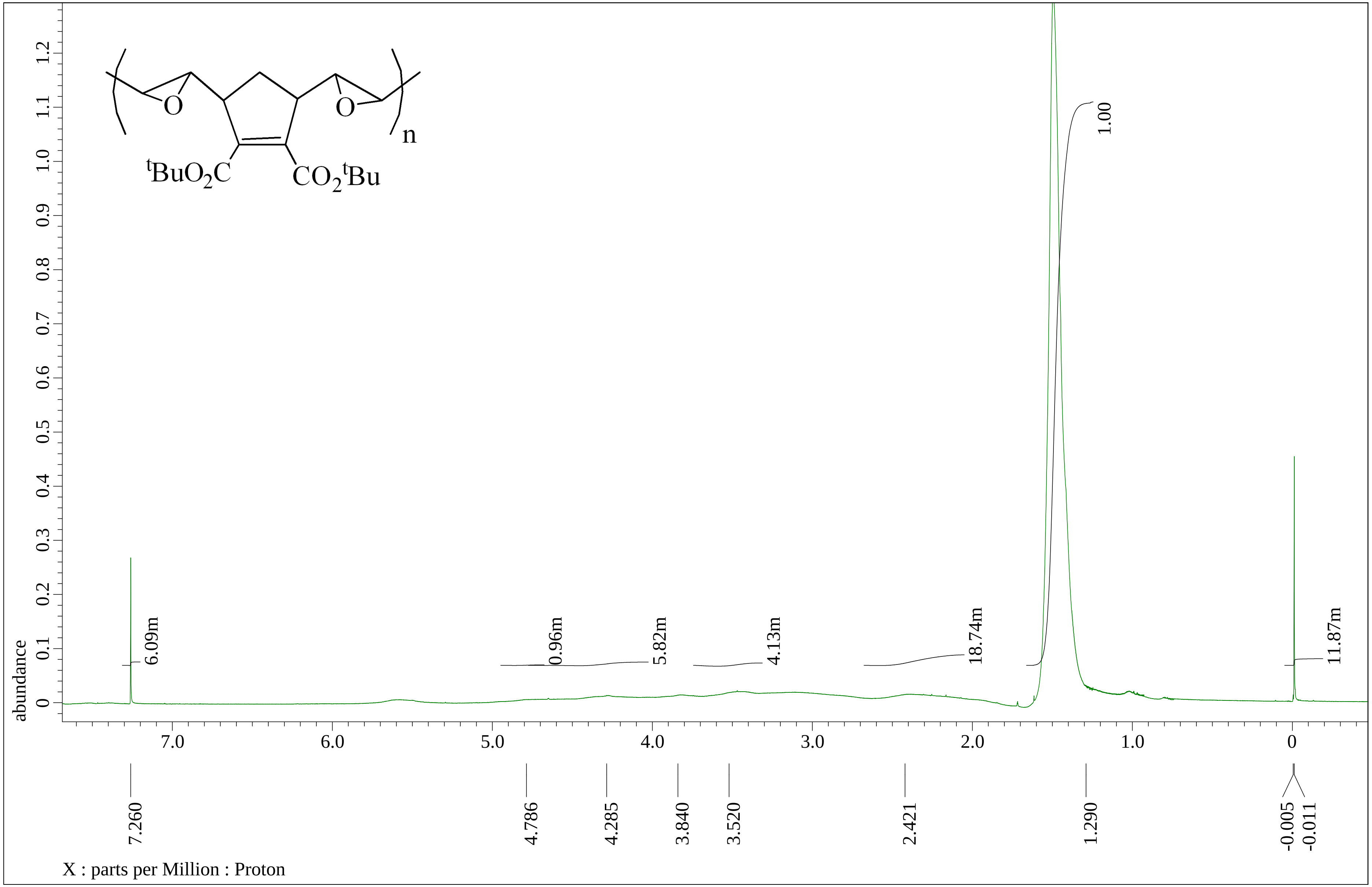


nPrO2C
CO2nPr
O
O
n
(thousandths)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.817
128.381
77.418
77.160
76.912
67.622
59.943
52.780
31.700
21.866
10.516
0.119
X : parts per Million : Carbon13

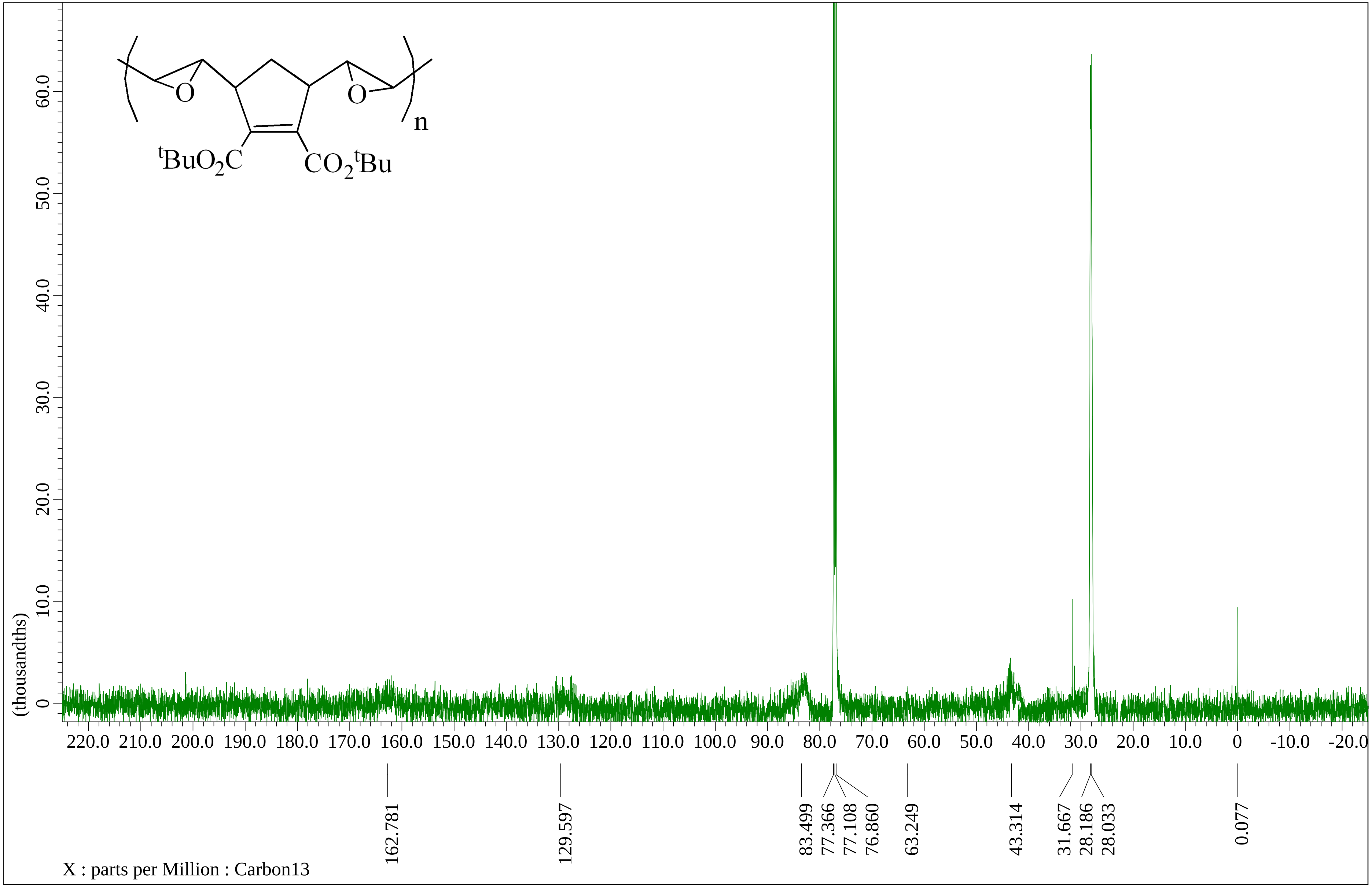

O
O
n
$^iPrO_2C$
$CO_2{}^iPr$
abundance
20.46m
0.14
4.67m
92.21m
23.01m
1.00
56.19m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.083
4.550
4.292
3.811
3.534
3.278
2.340
1.284
0.001
-0.005
-0.012
X : parts per Million : Proton



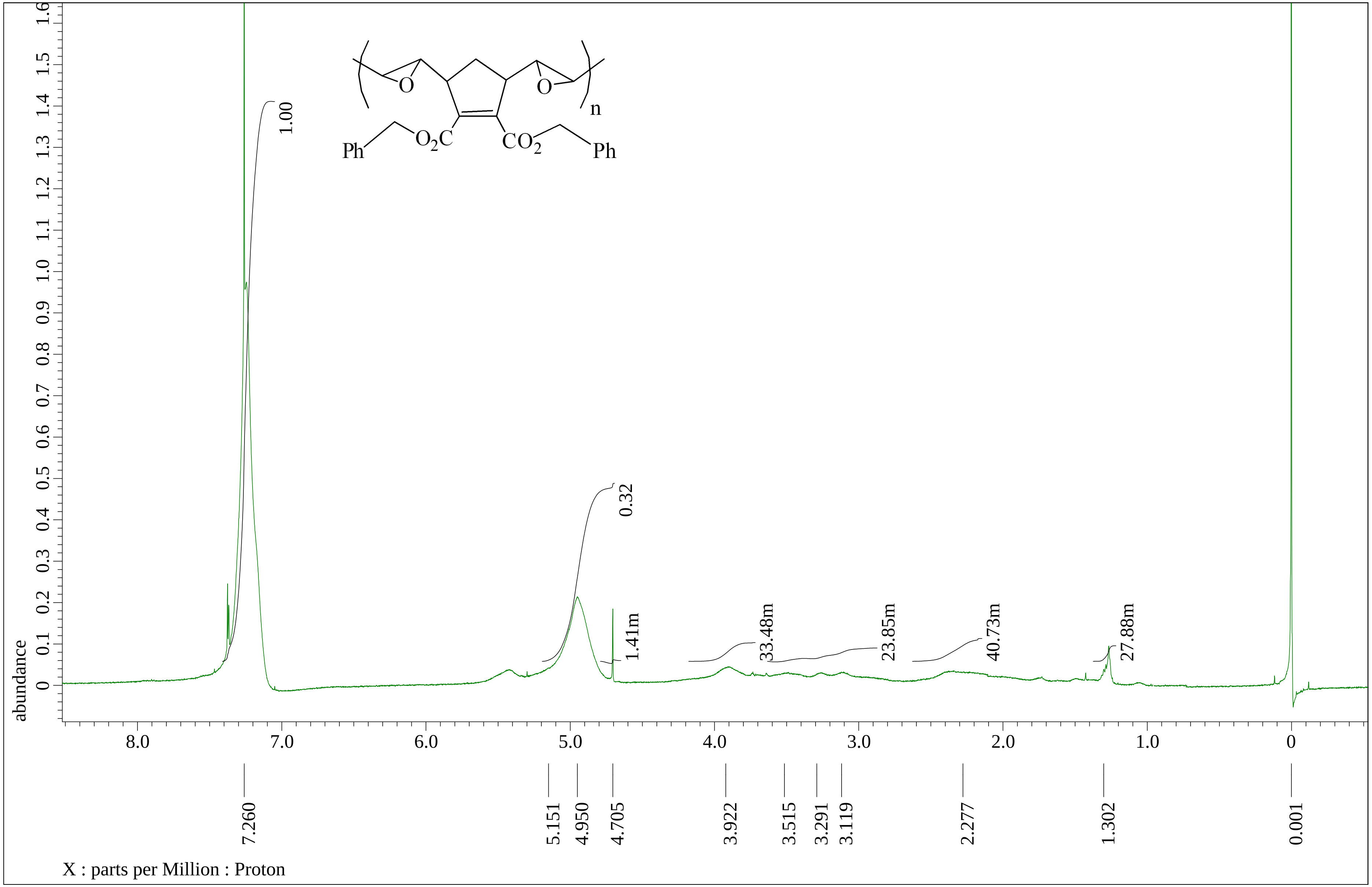
iPrO2C
CO2iPr
O
O
n
(thousandths)
60.0
50.0
40.0
30.0
20.0
10.0
0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
164.130
128.543
77.418
77.160
76.912
69.129
59.152
43.814
31.490
21.866
0.128
X : parts per Million : Carbon13



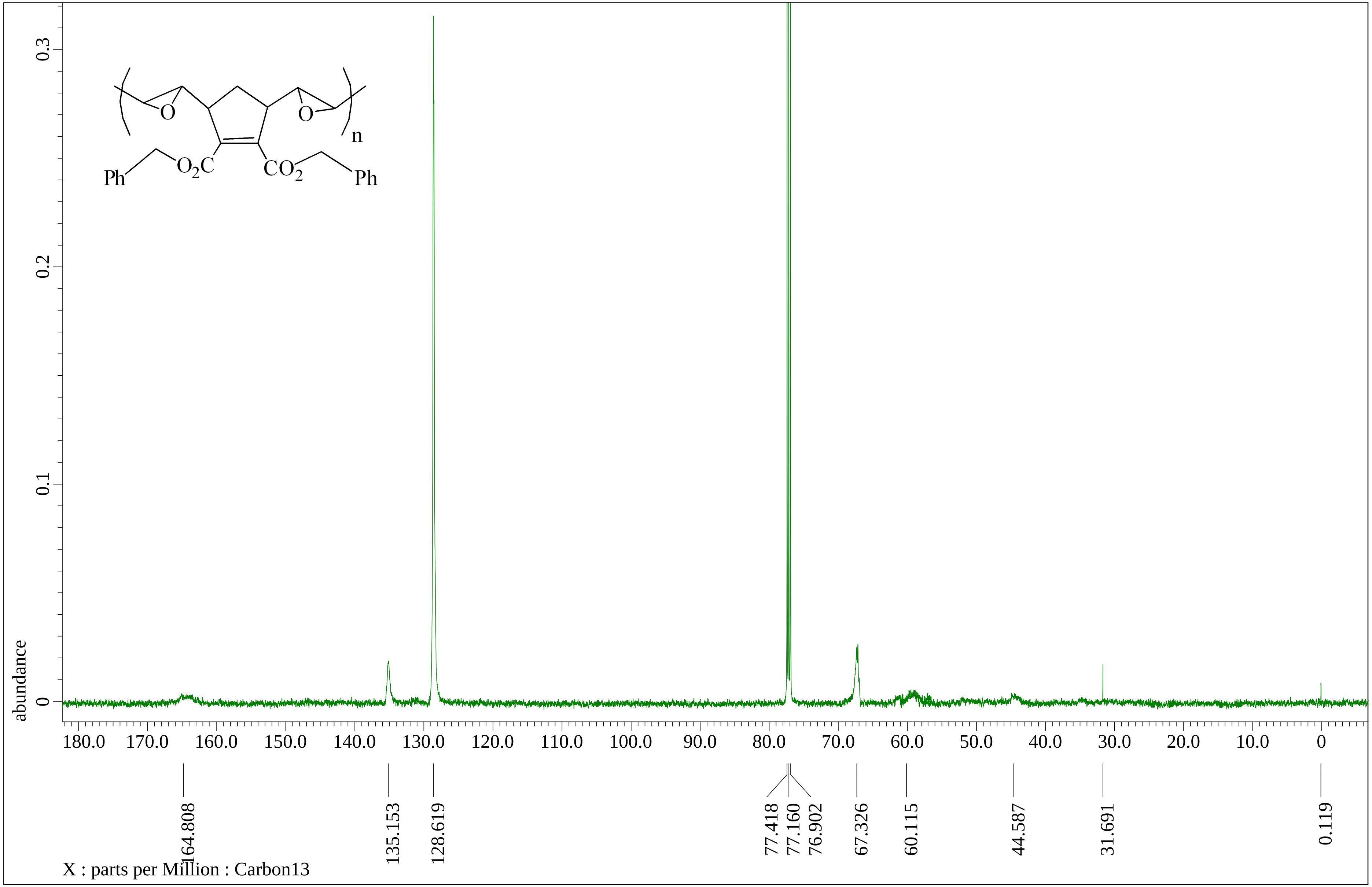
O
O
n
^{t}BuO$_2$C
CO$_2$^{t}Bu
abundance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6.09m
0.96m
5.82m
4.13m
18.74m
1.00
11.87m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
4.786
4.285
3.840
3.520
2.421
1.290
-0.005
-0.011
X : parts per Million : Proton

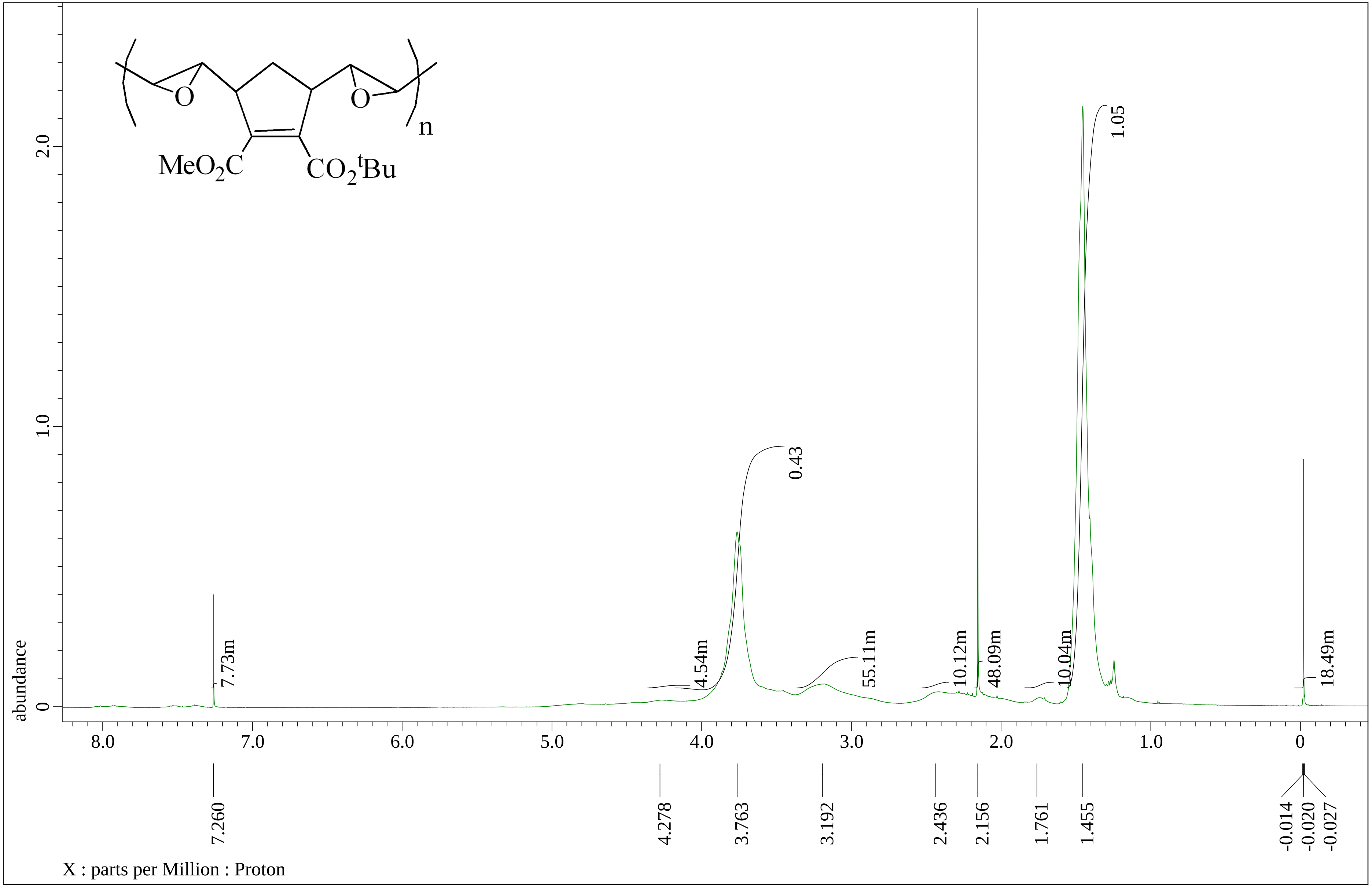


ᵗBuO₂C
CO₂ᵗBu
O
O
n
(thousandths)
0
10.0
20.0
30.0
40.0
50.0
60.0
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0 -20.0
162.781
129.597
83.499
77.366
77.108
76.860
63.249
43.314
31.667
28.186
28.033
0.077
X : parts per Million : Carbon13

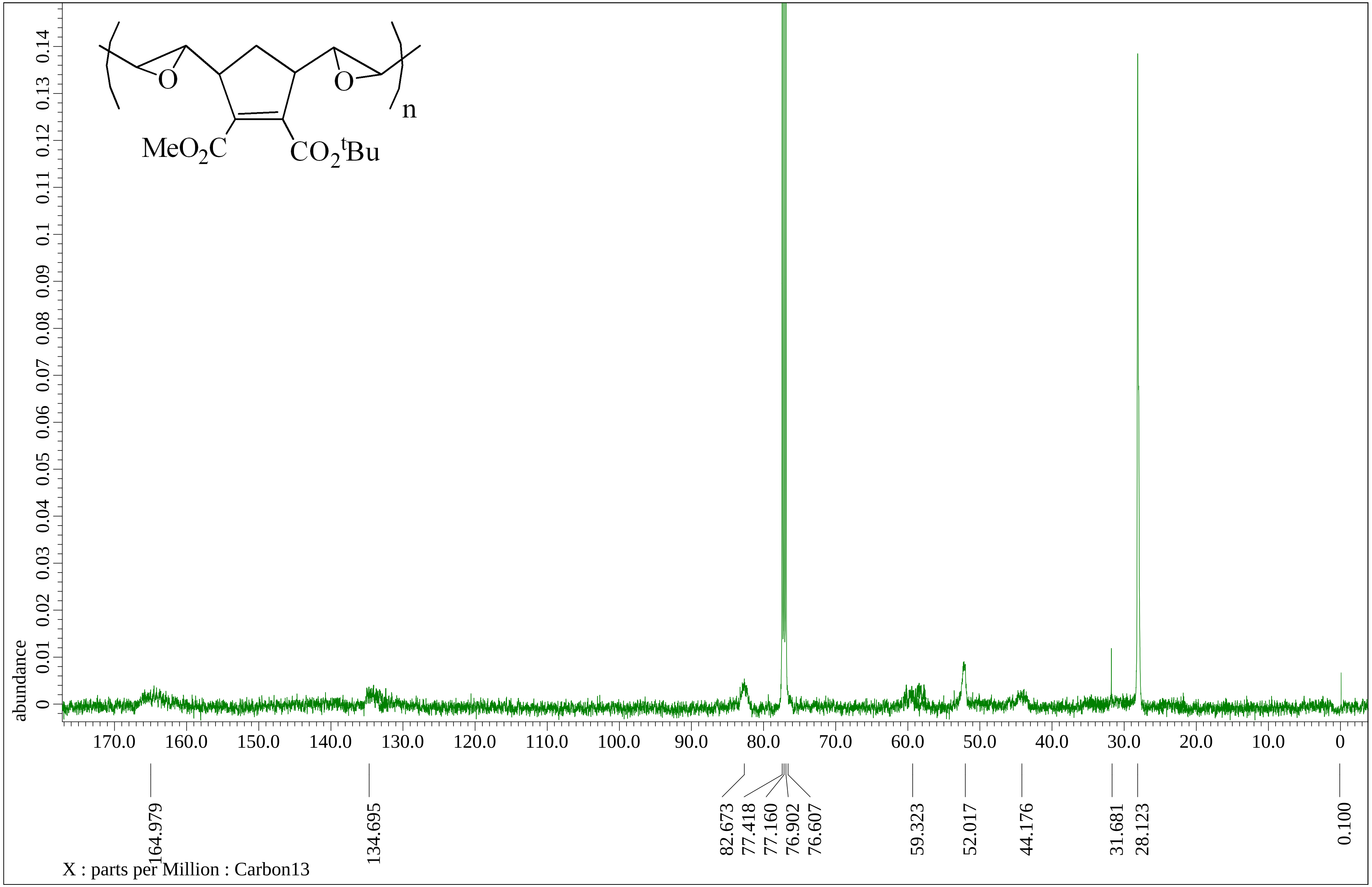


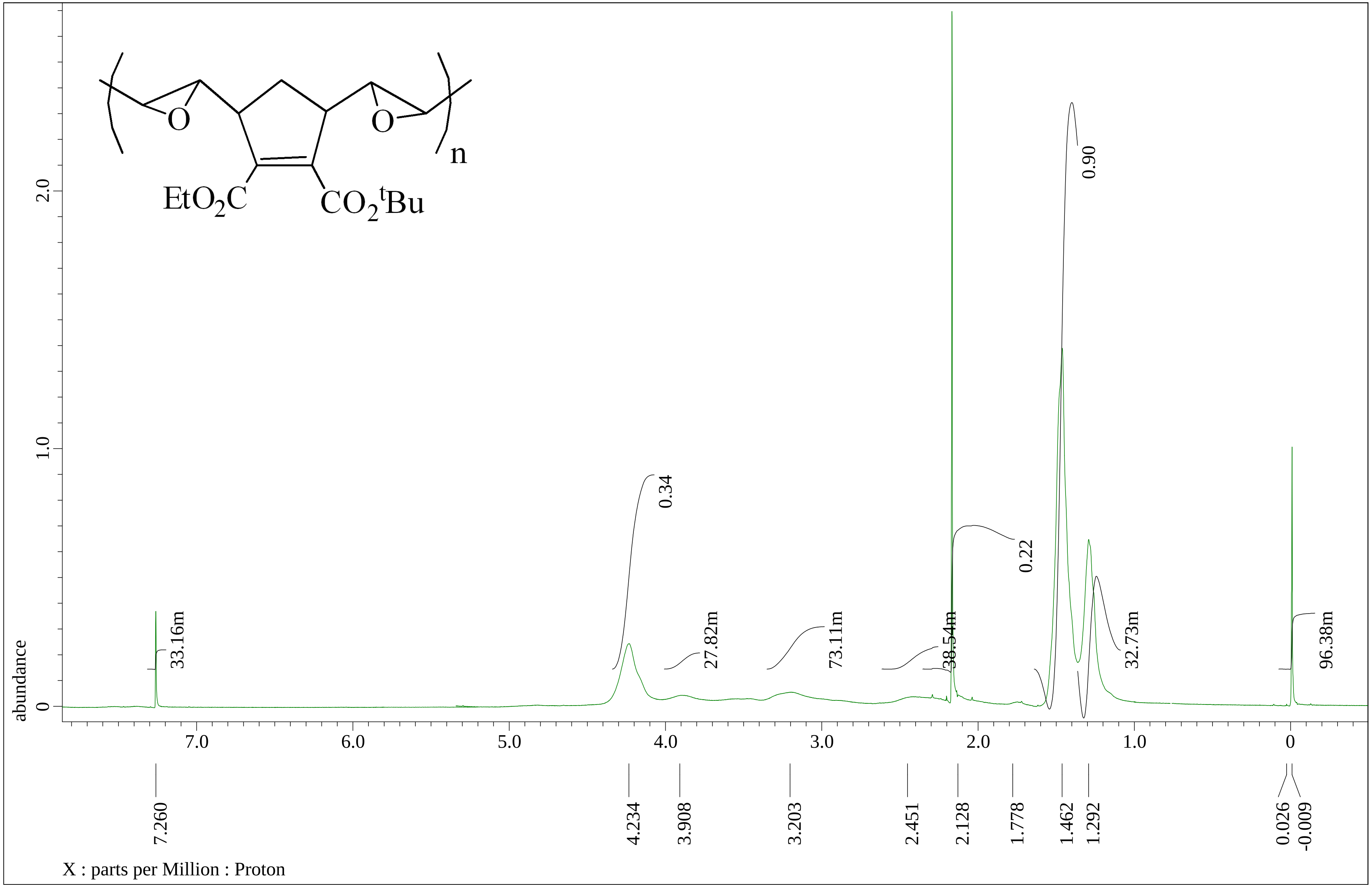
O
O
n
Ph
O2C
CO2
Ph
1.00
0.32
1.41m
33.48m
23.85m
40.73m
27.88m
abundance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.151
4.950
4.705
3.922
3.515
3.291
3.119
2.277
1.302
0.001
X : parts per Million : Proton

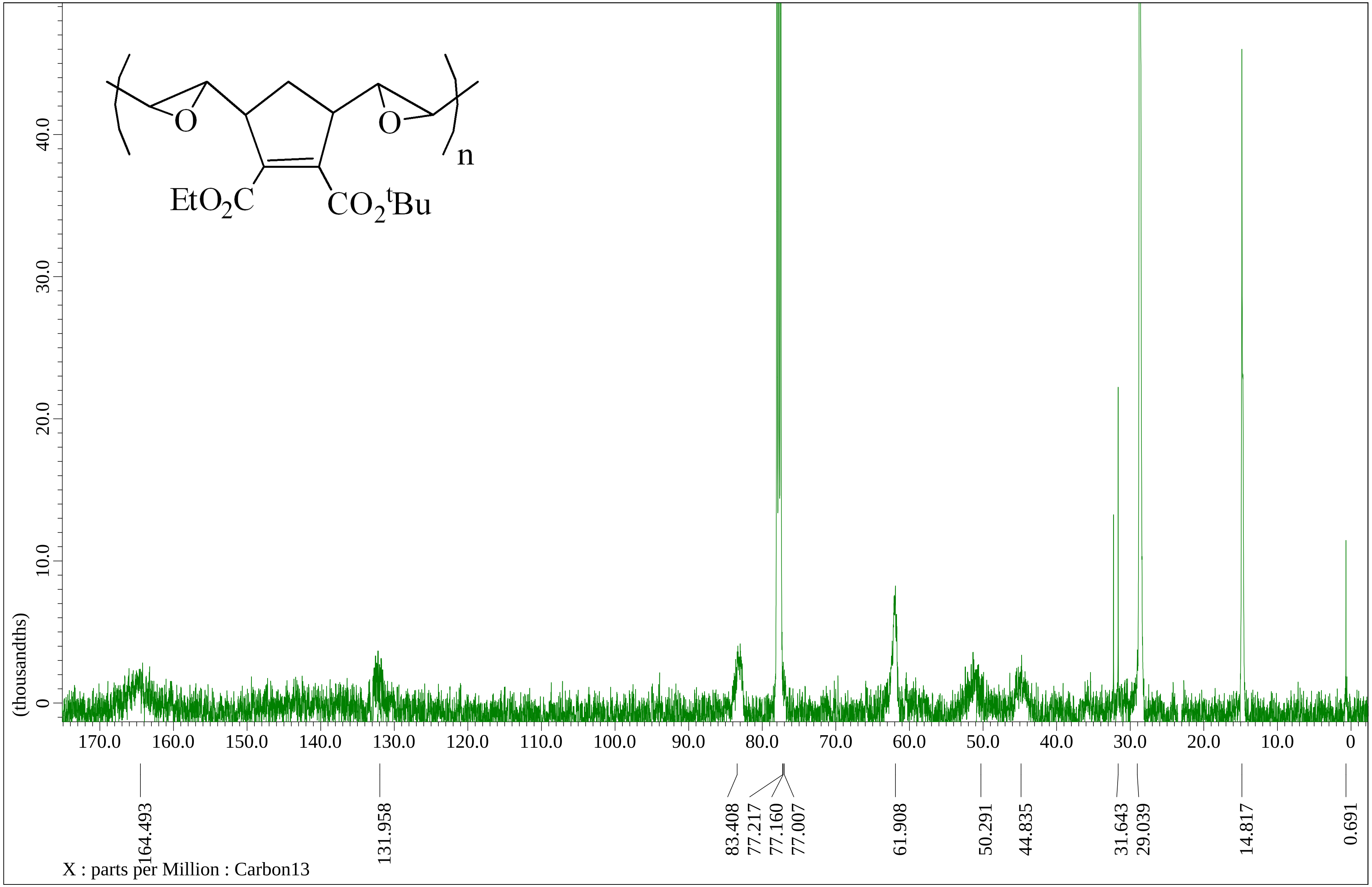

O
O
n
Ph
O_2C
CO_2
Ph
abundance
0.3
0.2
0.1
0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.808
135.153
128.619
77.418
77.160
76.902
67.326
60.115
44.587
31.691
0.119
X : parts per Million : Carbon13

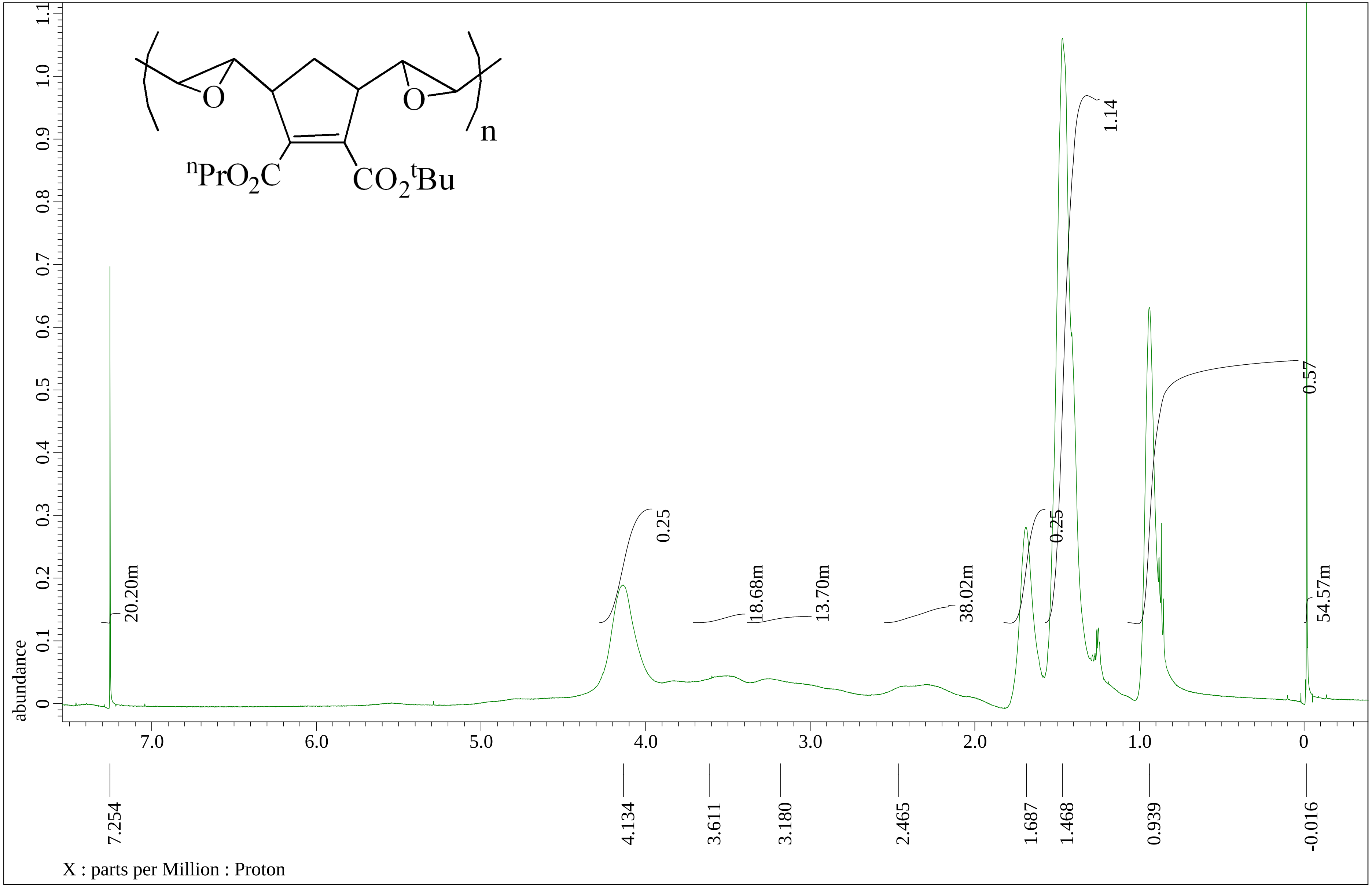


MeO2C
CO2tBu
n
O
O
abundance
0
1.0
2.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.73m
4.54m
0.43
55.11m
10.12m
48.09m
10.04m
1.05
18.49m
7.260
4.278
3.763
3.192
2.436
2.156
1.761
1.455
-0.014
-0.020
-0.027
X : parts per Million : Proton

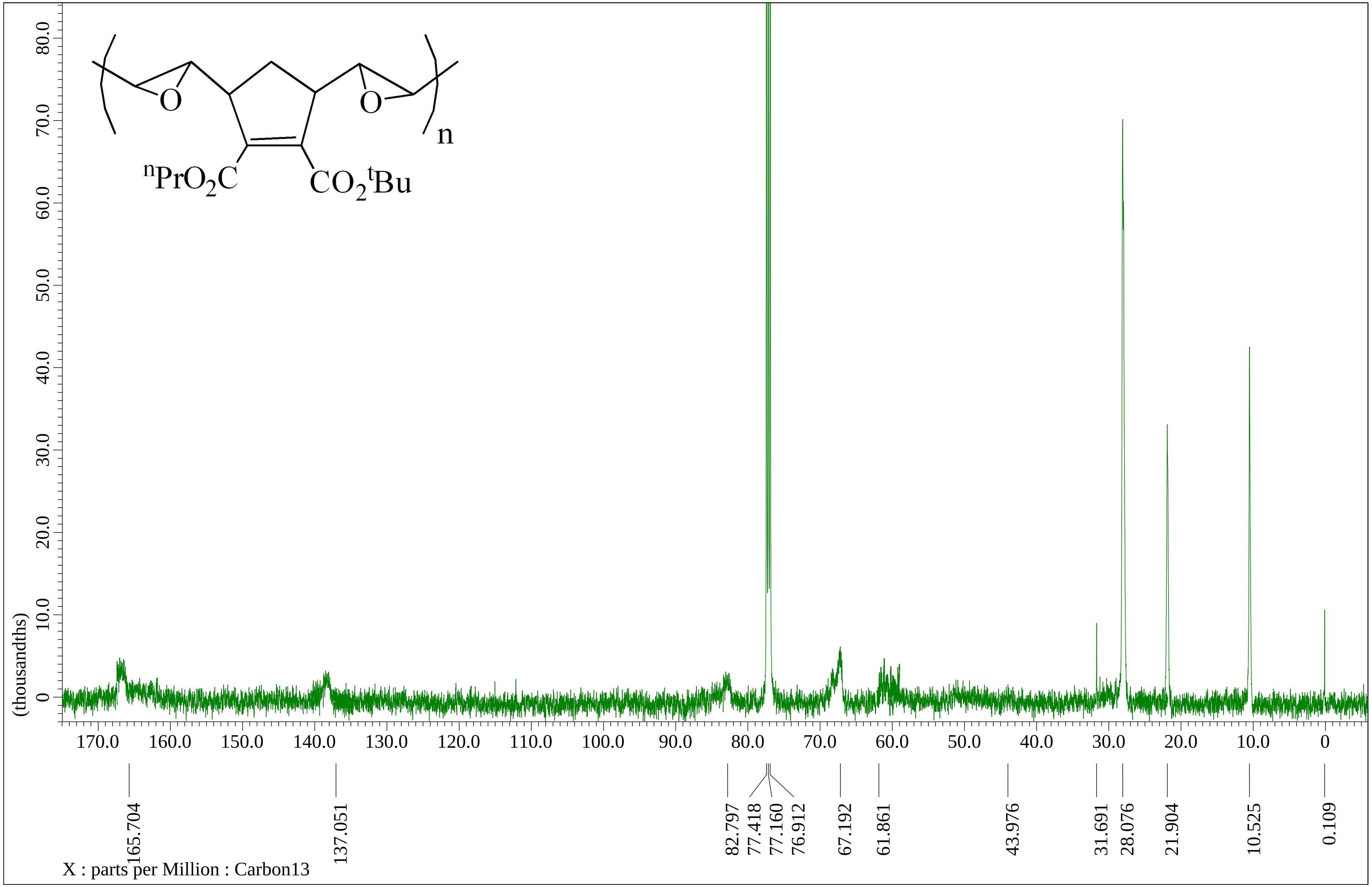

MeO2C
CO2tBu
n
abundance
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.979
134.695
82.673
77.418
77.160
76.902
76.607
59.323
52.017
44.176
31.681
28.123
0.100
X : parts per Million : Carbon13

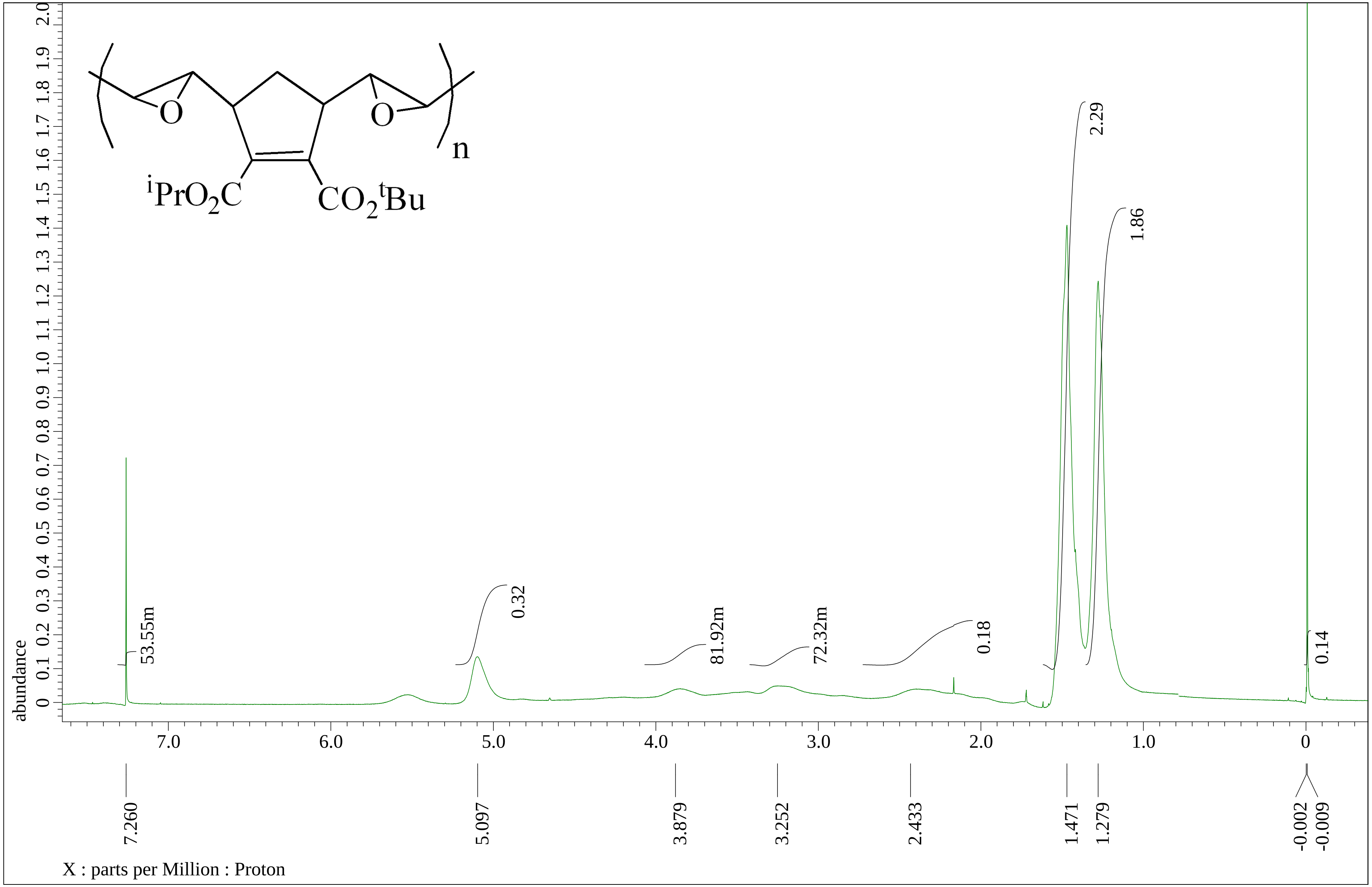

EtO2C
CO2tBu
n
O
O
2.0
1.0
0
abundance
33.16m
0.34
27.82m
73.11m
38.54m
0.22
0.90
32.73m
96.38m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
4.234
3.908
3.203
2.451
2.128
1.778
1.462
1.292
0.026
-0.009
X : parts per Million : Proton


EtO2C
CO2tBu
O
O
n
(thousandths)
0
10.0
20.0
30.0
40.0
170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
164.493
131.958
83.408
77.217
77.160
77.007
61.908
50.291
44.835
31.643
29.039
14.817
0.691
X : parts per Million : Carbon13

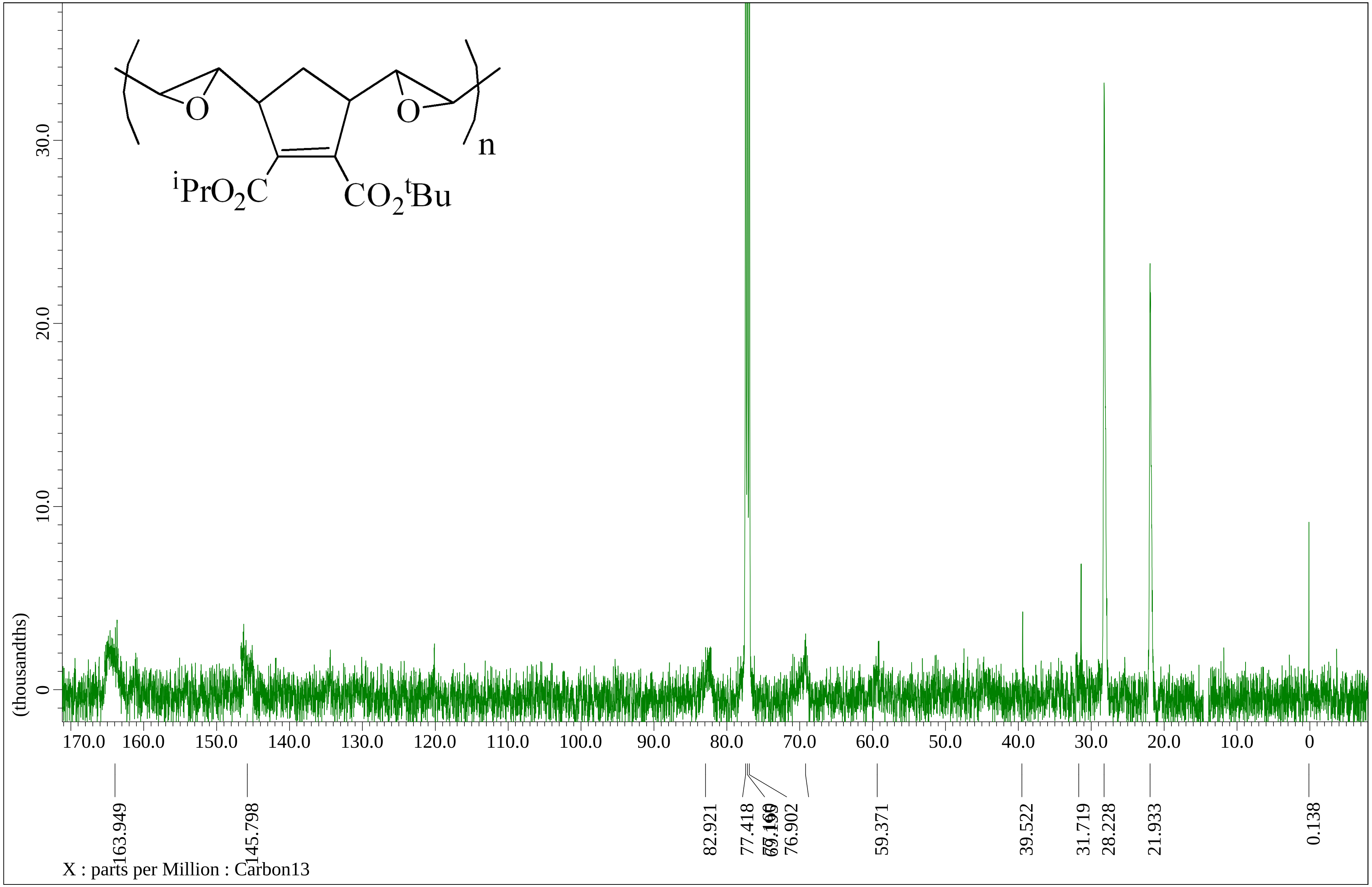


$^{n}PrO_2C$
$CO_2{}^{t}Bu$
n
O
O
abundance
X : parts per Million : Proton
7.254
4.134
3.611
3.180
2.465
1.687
1.468
0.939
-0.016
20.20m
0.25
18.68m
13.70m
38.02m
0.25
1.14
0.57
54.57m

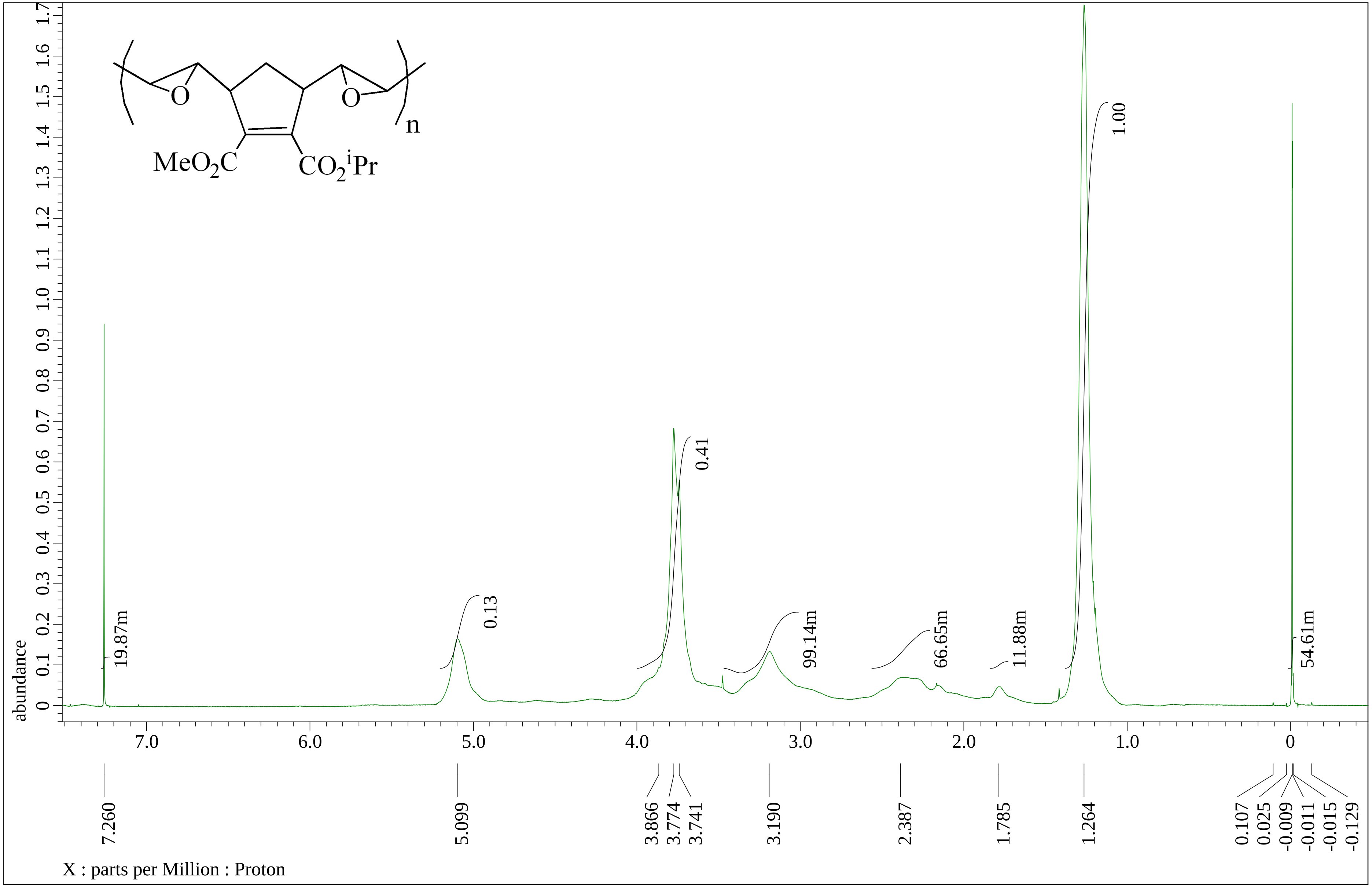

nPrO2C
CO2tBu
n
(thousandths)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.704
137.051
82.797
77.418
77.160
76.912
67.192
61.861
43.976
31.691
28.076
21.904
10.525
0.109
X : parts per Million : Carbon13



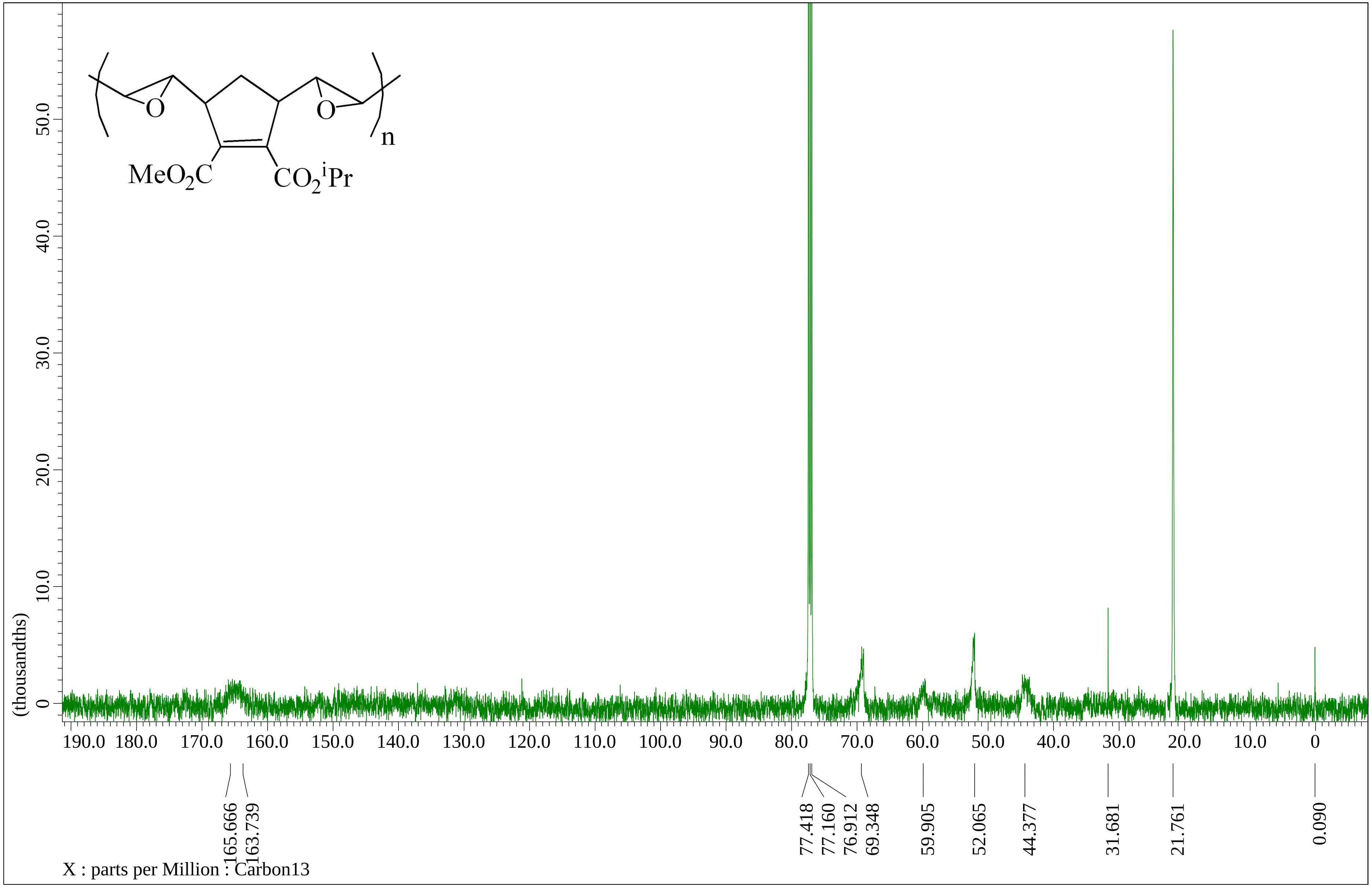
iPrO2C
CO2tBu
n
abundance
X : parts per Million : Proton
7.260
5.097
3.879
3.252
2.433
1.471
1.279
-0.002
-0.009
53.55m
0.32
81.92m
72.32m
0.18
2.29
1.86
0.14



O
O
n
ⁱPrO2C
CO2ᵗBu
(thousandths)
0
10.0
20.0
30.0
170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
163.949
145.798
82.921
77.418
76.902
59.371
39.522
31.719
28.228
21.933
0.138
X : parts per Million : Carbon13



MeO2C
CO2iPr
n
abundance
19.87m
0.13
0.41
99.14m
66.65m
11.88m
1.00
54.61m
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.260
5.099
3.866
3.774
3.741
3.190
2.387
1.785
1.264
0.107
0.025
-0.009
-0.011
-0.015
-0.129
X : parts per Million : Proton


MeO2C
CO2iPr
n
O
O
(thousandths)
0
10.0
20.0
30.0
40.0
50.0
190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
165.666
163.739
77.418
77.160
76.912
69.348
59.905
52.065
44.377
31.681
21.761
0.090
X : parts per Million : Carbon13