Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Nickel-Catalyzed Direct C3-Acylation of 2*H*-Indazoles with Aldehydes

*Yan-Ling Liu, You-Lu Pan, Gang-Jian Li, Hai-Feng Xu, Jian-Zhong Chen**

College of Pharmaceutical Sciences, Zhejiang University, 866 Yuhangtang Rd., Hangzhou, 310058, China

Supporting Information

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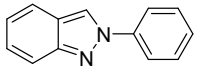
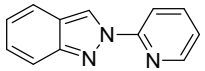
General procedure for the preparation of 2*H*-indazoles.[1]

NaN3 (1.19 g, 18.26 mmol), CuI (173.90 mg, 0.913 mmol), 2-bromobenzaldehyde (1.07 mL, 9.13 mmol), TMEDA (137.00 μL, 9.13 mmol) and anilines (10.96 mmol) were reacted in 20.00 mL of DMSO in pressure tubes. The reaction mixture was heated to 120 ℃ for 12 h. After cooling, the mixture was poured into the EtOAc (50.0mL) and washed with water (3 × 25.0 mL), brine (3 × 25.0 mL), then dried over MgSO4 and was passed through a Celite. Evaporation of the solvent under reduced pressure provided the crude product, which was purified by column chromatography (Petroleum ether : EtOAc = 15:1) to afford the final product.

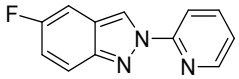
Characterization of 2*H*-indazoles.



2-Phenyl-2*H*-indazole (1a). General procedure. Yellow solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2] 1H NMR (500 MHz, CDCl3): δ 8.38 (s, 1H), 7.89 (d, *J* = 7.64 Hz, 1H), 7.79 (d, *J* = 8.74 Hz, 1H), 7.69 (d, *J* = 8.46 Hz, 1H), 7.50 (t, *J* = 7.91 Hz, 2H), 7.38 (t, *J* = 7.42 Hz, 1H), 7.31 (dd, *J* = 8.15, 7.19 Hz, 1H), 7.10 (dd, *J* = 8.06, 7.00 Hz, 1H). 13C NMR (126 MHz, CDCl3): δ 149.86, 140.61, 129.57, 127.90, 126.83, 122.48, 121.03, 120.40, 118.01, 77.30, 77.04, 76.79.

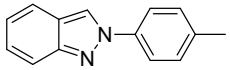


2-(Pyridin-2-yl)-2*H*-indazole (1b1). General procedure. Pale yellow solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2] 1H NMR (500 MHz, CDCl3): δ 9.10 (d, *J* = 0.94 Hz, 1H), 8.50 (dd, *J* = 4.80, 1.03 Hz, 1H), 8.28 (d, *J* = 8.24 Hz, 1H), 7.89 (dt, *J* = 8.13, 7.86, 1.81 Hz, 1H), 7.79-7.70 (m, 2H), 7.35-7.30 (m, 1H), 7.29 (dd, *J* = 7.37, 4.83 Hz, 1H), 7.10 (ddd, *J* = 8.43, 6.56, 0.75 Hz, 1H). 13C NMR (126 MHz, CDCl3): δ 151.93, 150.36, 148.32, 138.83, 127.57, 122.74, 122.70, 121.21, 120.61, 118.09, 114.12, 77.30, 77.05, 76.80.

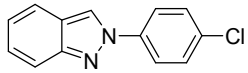


5-Fluoro-2-(pyridin-2-*yl*)-2*H*-indazole (1b2). General procedure. Yellow solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2] 1H NMR (500 MHz, CDCl3): δ 8.97 (d, *J* = 0.79 Hz, 1H), 8.41 (ddd, *J* = 4.79, 1.74, 0.73 Hz, 1H), 7.80 (ddd, *J* = 8.22, 7.45, 1.84 Hz, 1H), 7.66-7.62 (m, 1H), 7.20 (ddt, *J* = 8.91, 5.98, 2.82 Hz, 2H), 7.05 (dt, *J* = 9.25, 9.23, 2.43 Hz, 1H). 13C NMR (126 MHz, CDCl3): δ 158.70, 156.78, 150.64, 147.31,

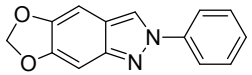
146.72, 137.88, 121.88, 119.69, 119.62, 119.20, 119.12, 118.55, 118.31, 112.90, 102.34, 102.14, 76.26, 76.01, 75.75.



2-(*p*-Tolyl)-2*H*-indazole (1b3). General procedure 1. Brown solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2].1H NMR (500 MHz, CDCl3): δ 8.34 (d, *J* = 0.81 Hz, 1H), 7.81-7.73 (m, 3H), 7.68 (td, *J* = 8.36, 0.83 Hz, 1H), 7.36-7.27 (m, 3H), 7.09 (ddd, *J* = 8.37, 6.61, 0.69 Hz, 1H), 2.41 (s, 3H). 13C NMR (126 MHz, CDCl3): δ 149.70, 138.34, 137.90, 130.09, 126.65, 122.75, 122.32, 120.88, 120.33, 120.27, 117.92, 77.29, 77.04, 76.79.



2-(4-Chlorophenyl)-2*H*-indazole (1b4). General procedure 1. Brown solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2] 1H NMR (500 MHz, CDCl3): δ 8.35 (d, *J* = 0.77 Hz, 1H), 7.85-7.81 (m, 2H), 7.77 (dd, *J* = 8.81, 0.83 Hz, 1H), 7.68 (d, *J* = 8.48 Hz, 1H), 7.49-7.46 (m, 2H), 7.32 (ddd, *J* = 8.77, 6.59, 0.99 Hz, 1H), 7.11 (ddd, *J* = 8.39, 6.62, 0.65 Hz, 1H). 13C NMR (126 MHz, CDCl3): δ 149.93, 139.05, 133.59, 129.71, 127.16, 122.76, 122.03, 120.40, 120.32, 117.94, 77.32, 77.07, 76.81.



2-Phenyl-2*H*-[1,3]dioxolo[4,5-*f*]indazole (1b5). General procedure 1. Yellow solid. ^{1}H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.[2] 1H NMR (500 MHz, CDCl3): δ 8.17 (d, *J* = 0.68 Hz, 1H), 7.82-7.79 (m, 2H), 7.48 (dd, *J* = 10.75, 5.23 Hz, 2H), 7.33 (t, *J* = 7.42 Hz, 1H), 7.03 (s, 1H), 6.88 (s, 1H), 5.96 (s, 2H). 13C NMR (126 MHz, CDCl3): δ 149.73, 147.44, 146.11, 140.51, 129.52, 127.13, 120.06, 119.68, 118.59, 101.01, 94.88, 94.20, 77.32, 77.06, 76.81.

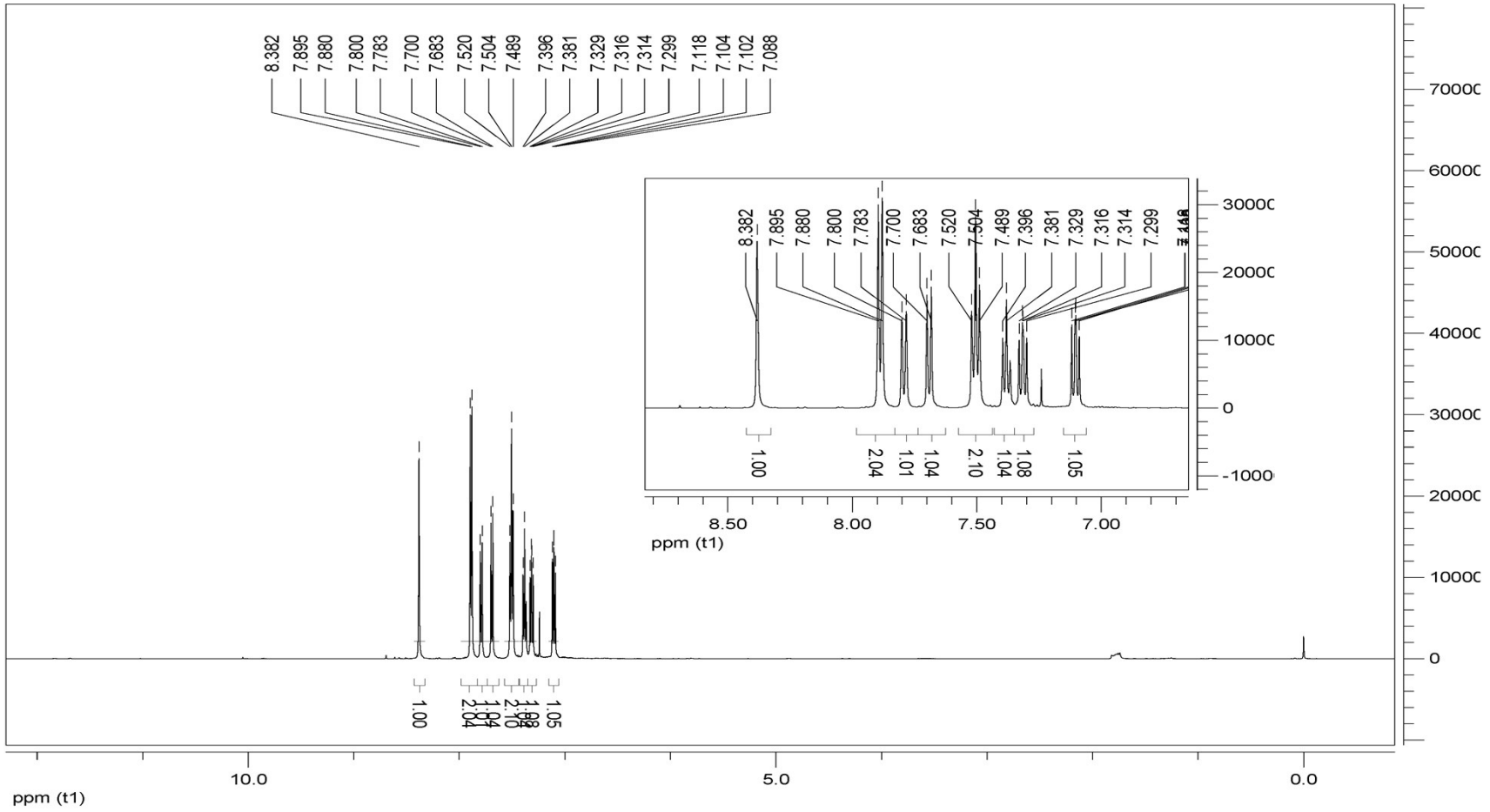
references

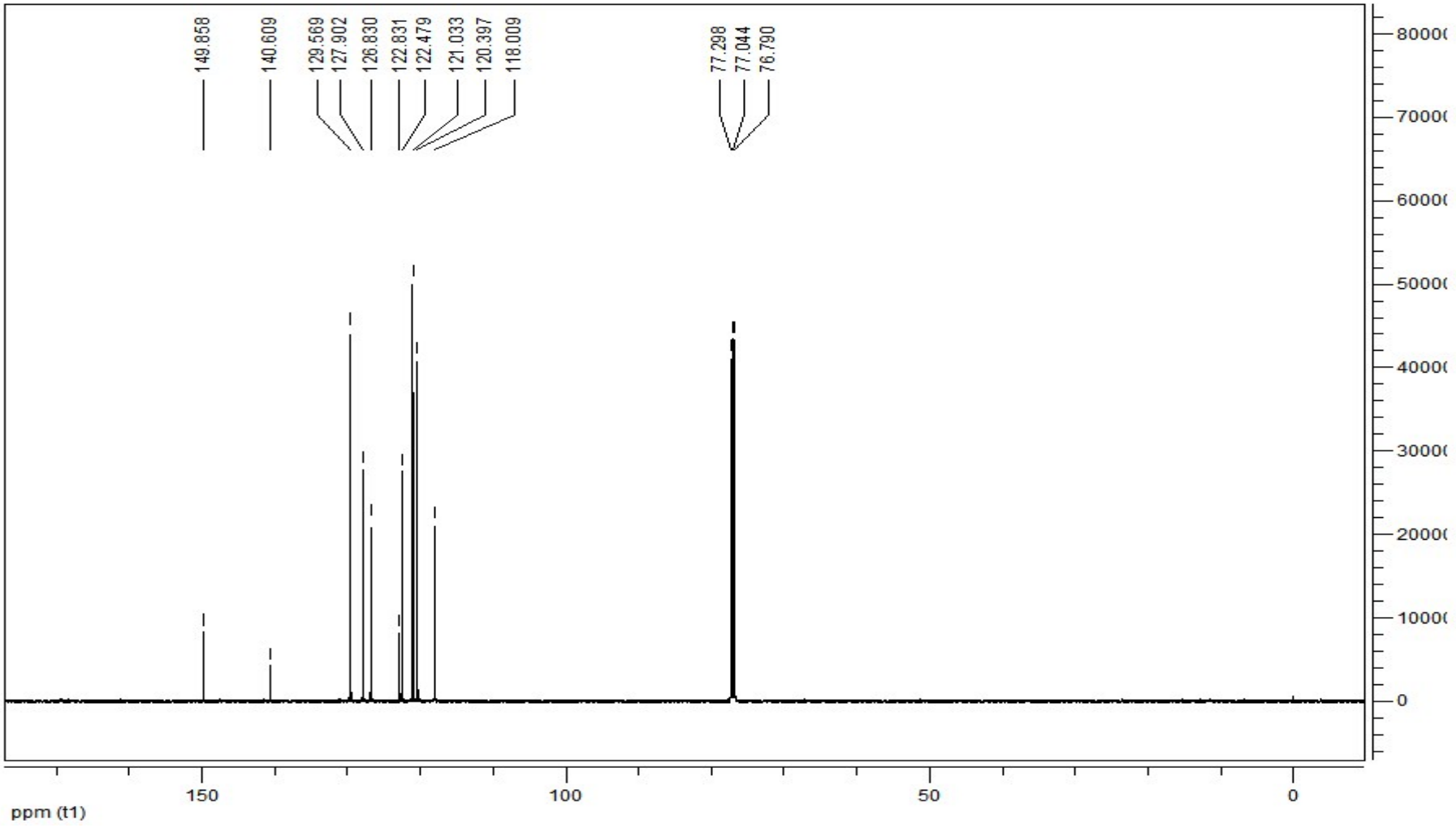
[1] M. R. Kumar, A. Park, N. Park and S. Lee, *Organic Letters*, 2011, **13**, 3542-3545.

[2] G. Bogonda, H. Y. Kim and K. Oh, *Organic Letters*, 2018, 2711-2715.

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

1a

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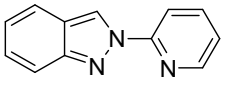
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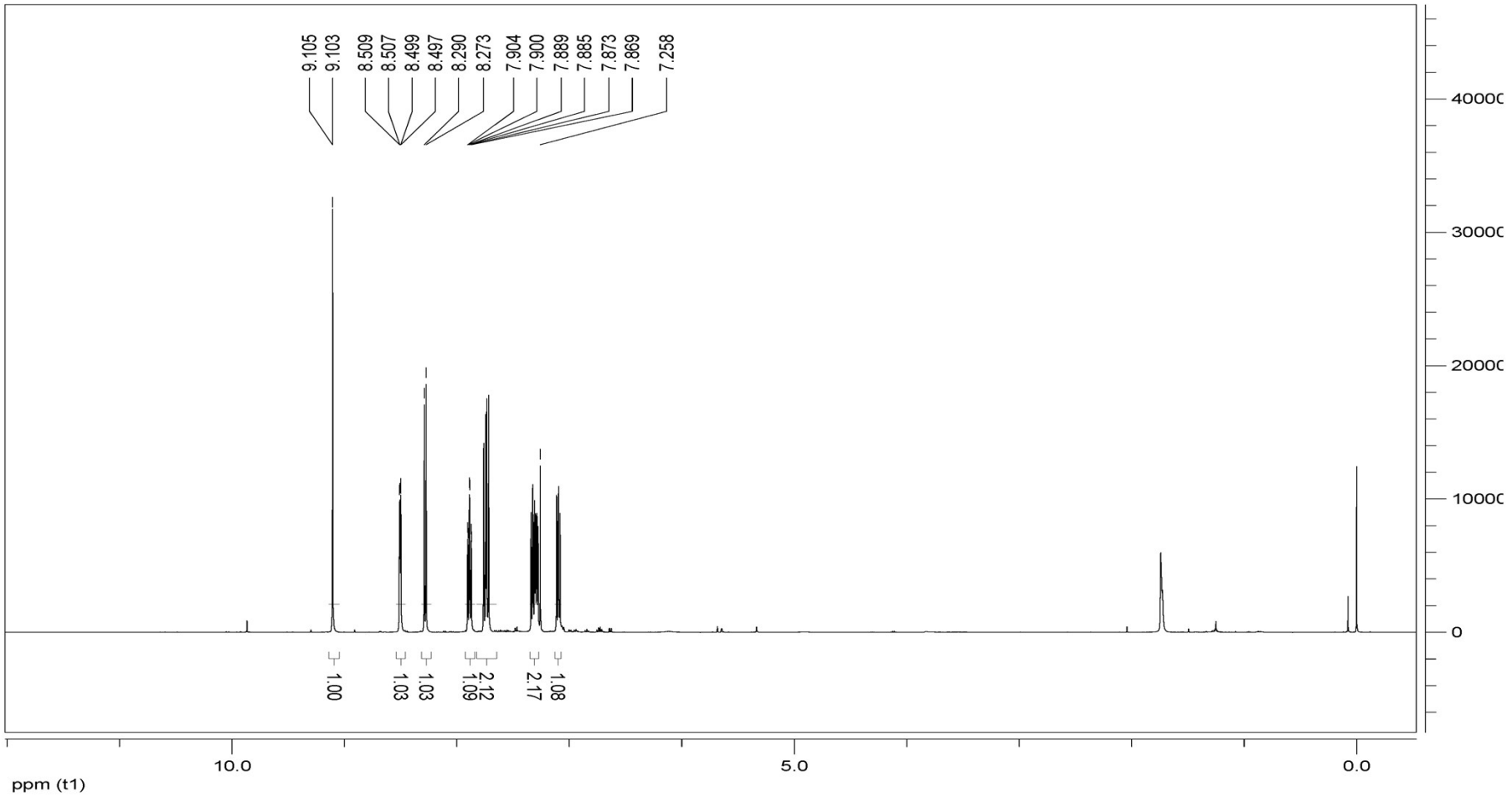
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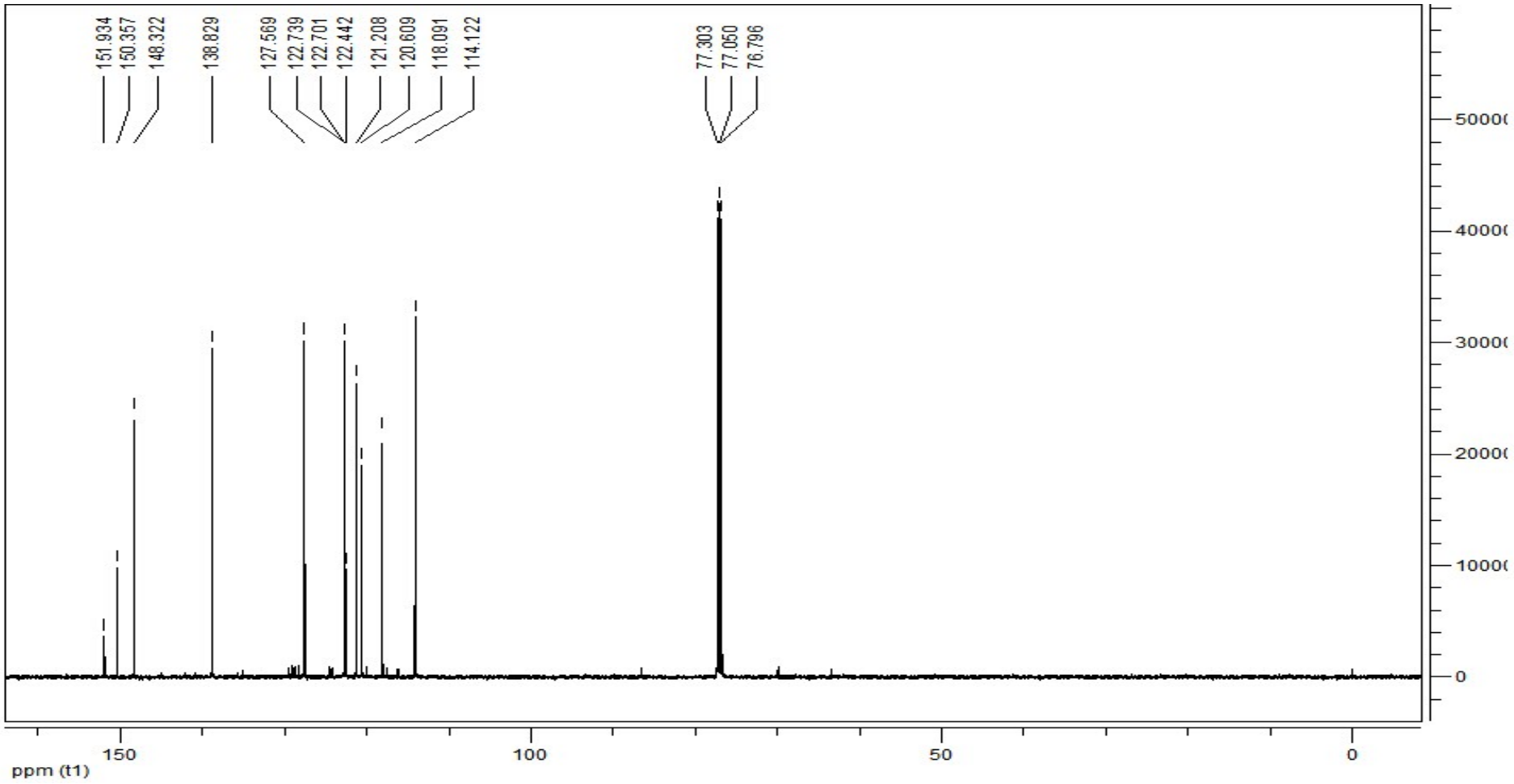
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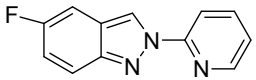
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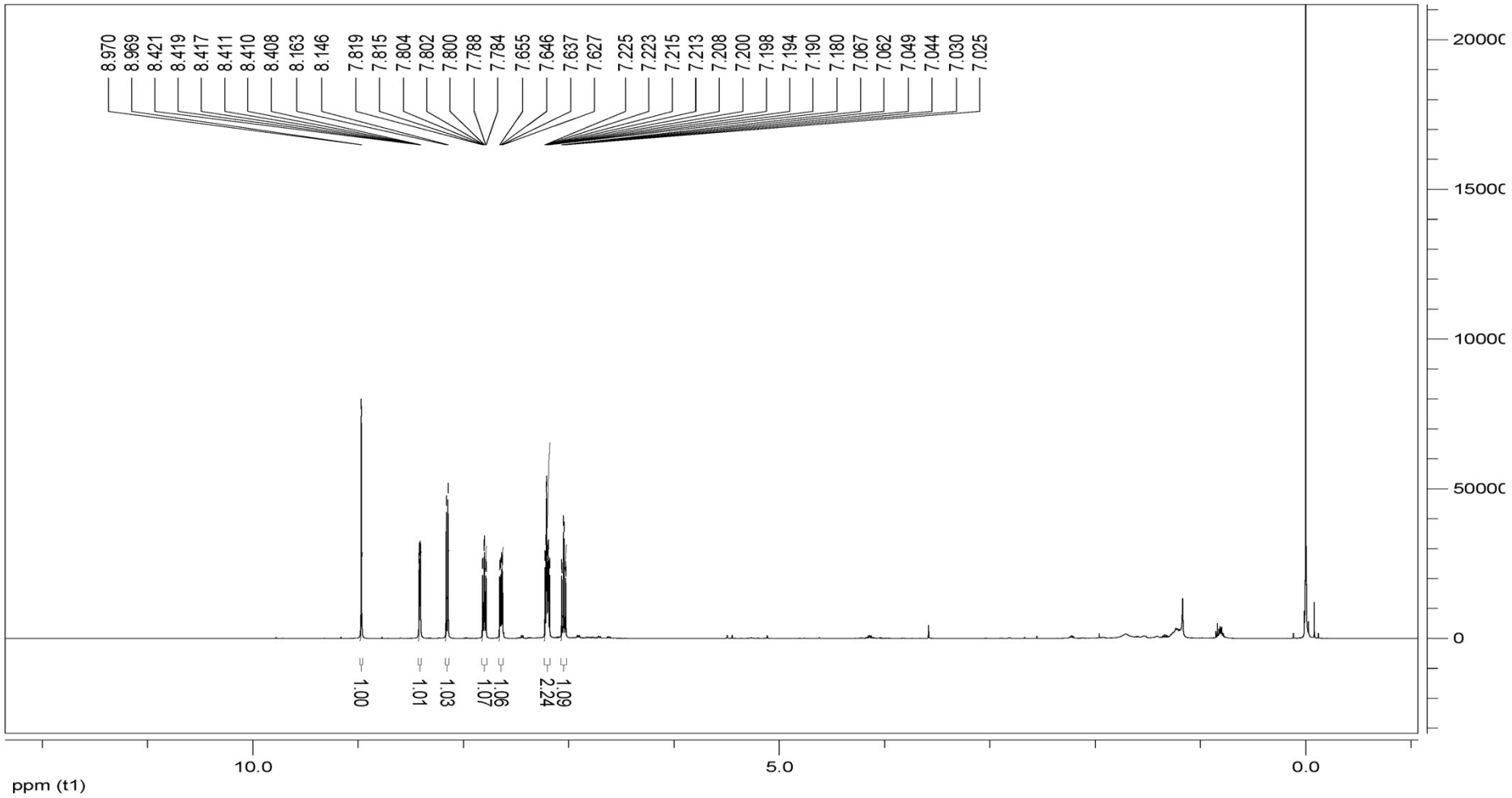
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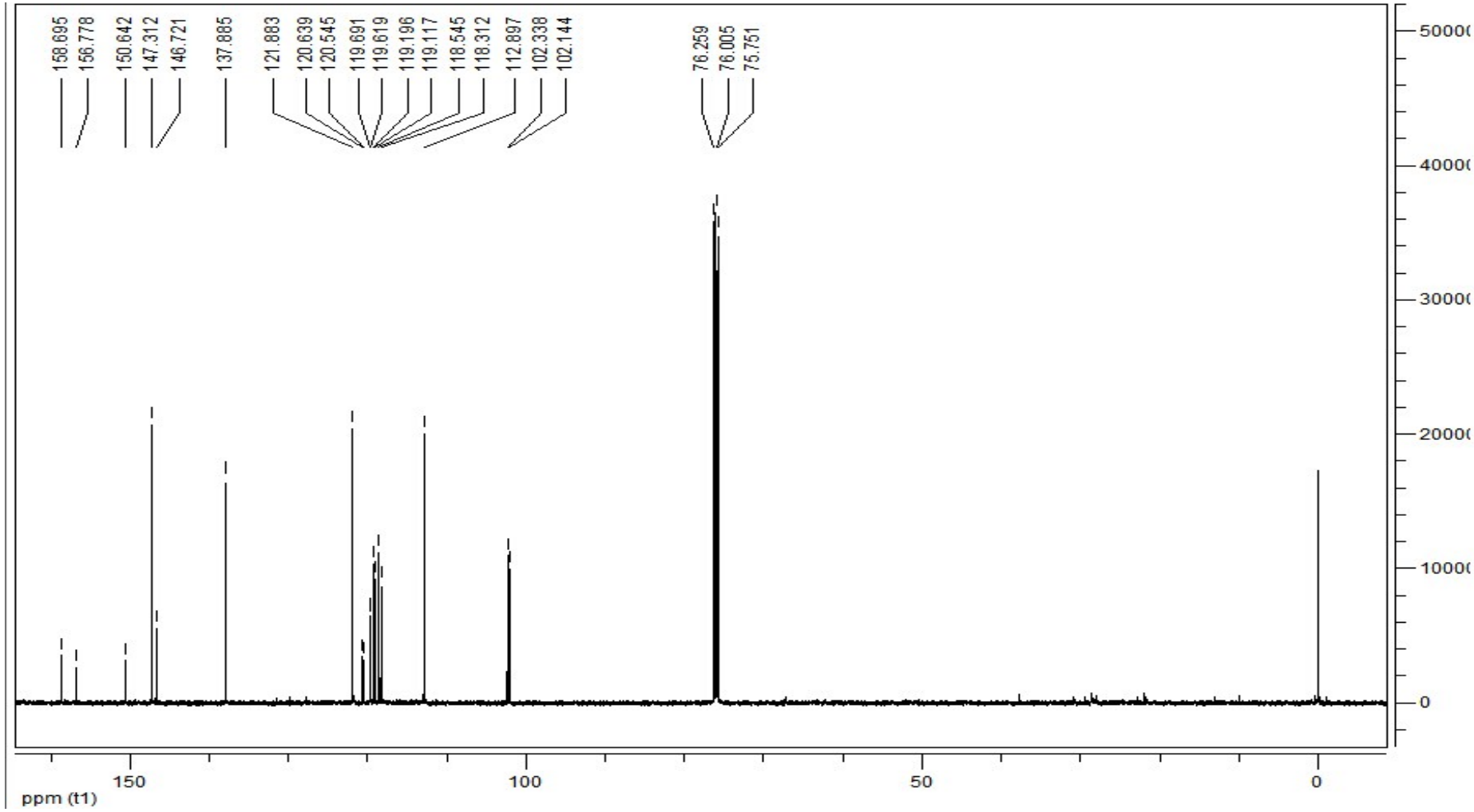
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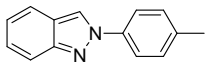

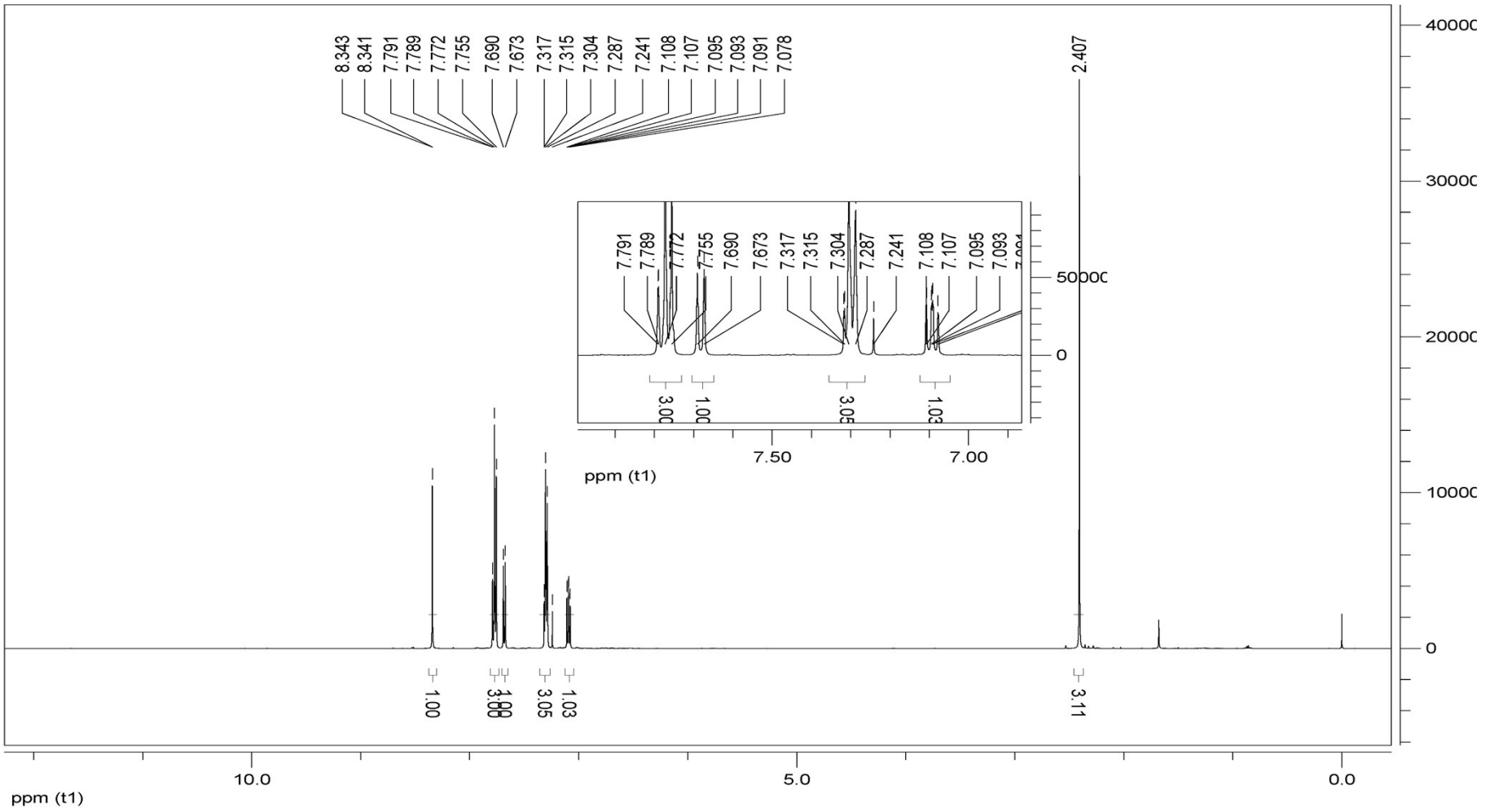
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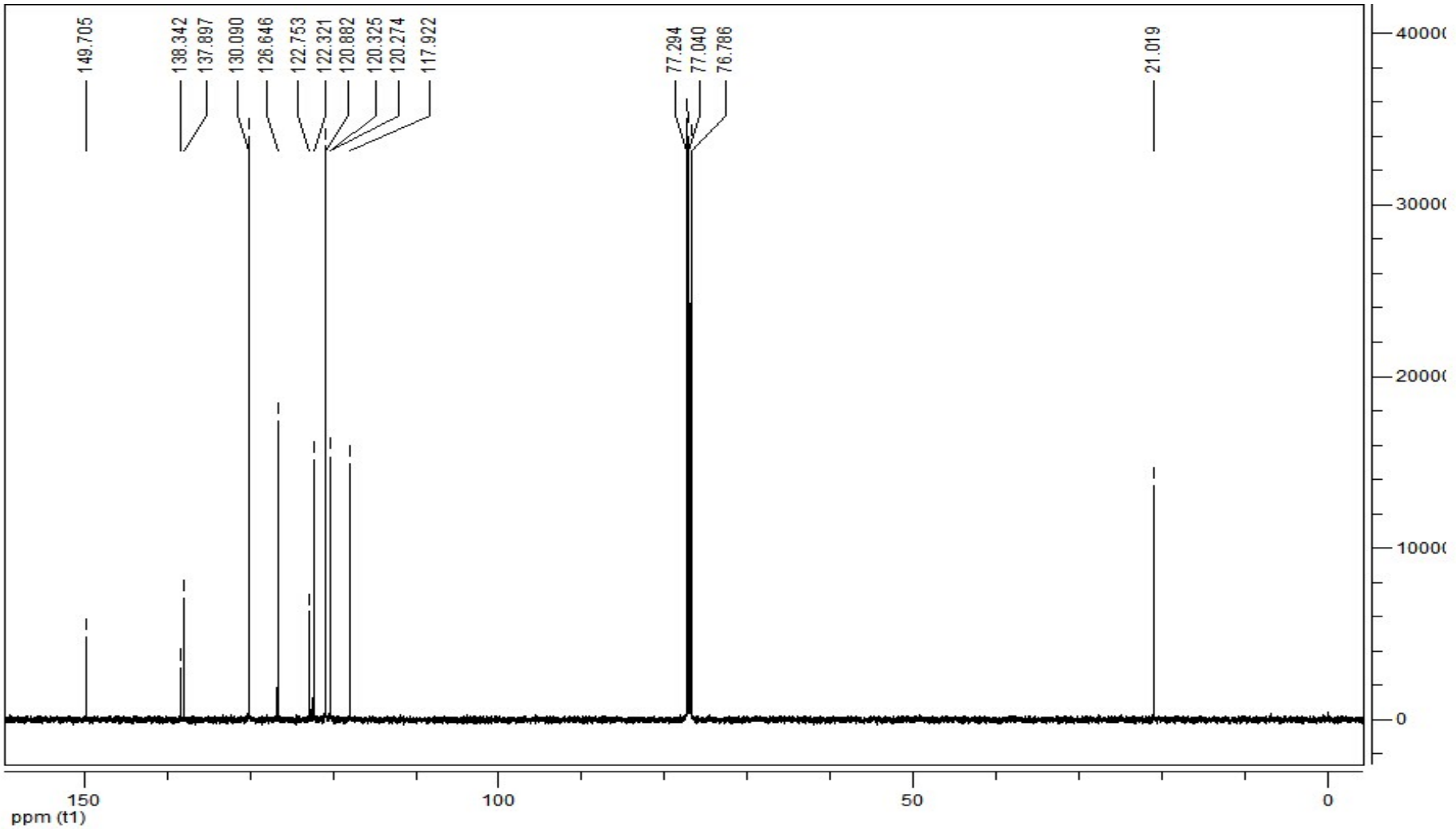
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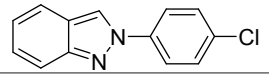
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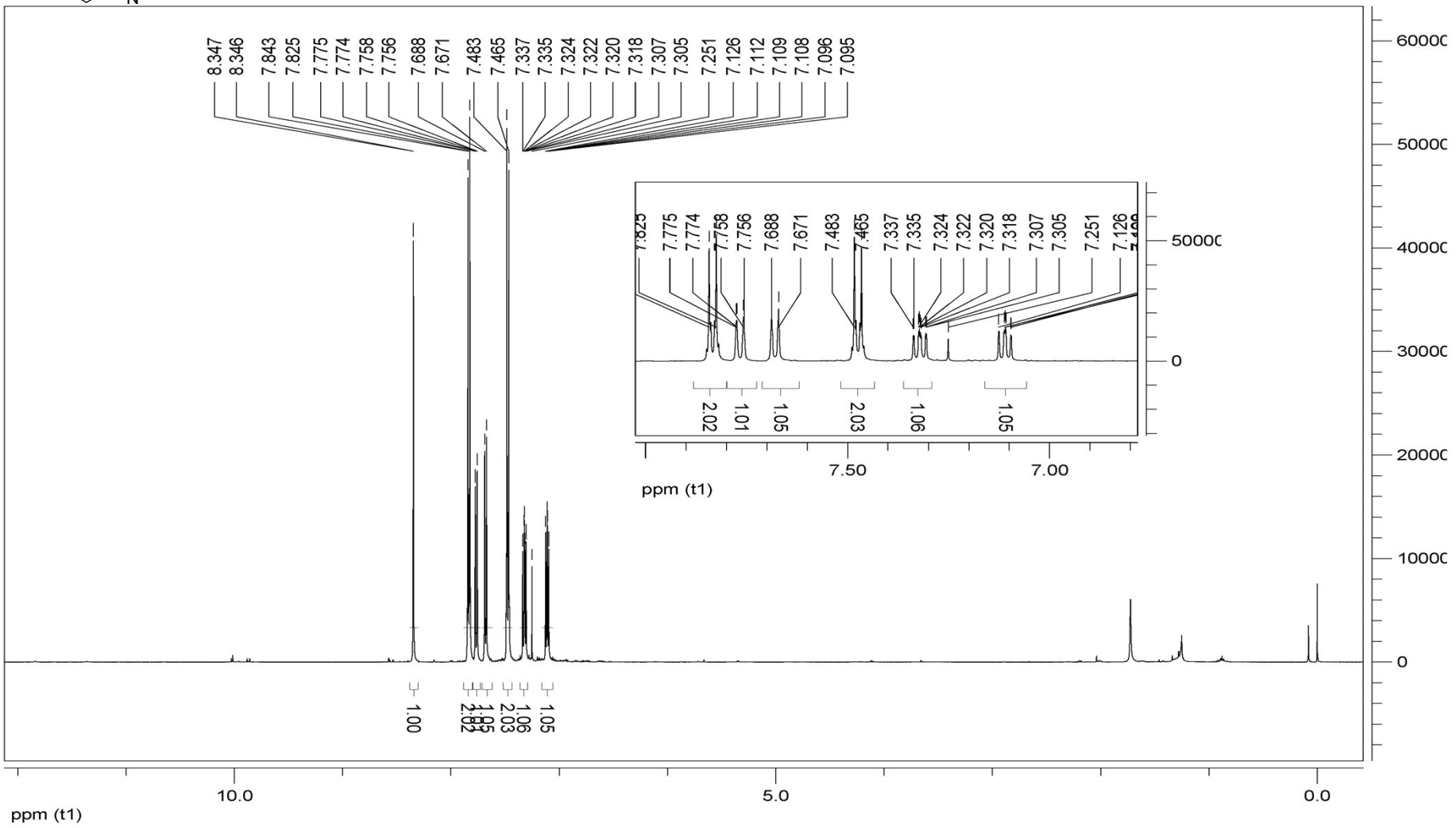
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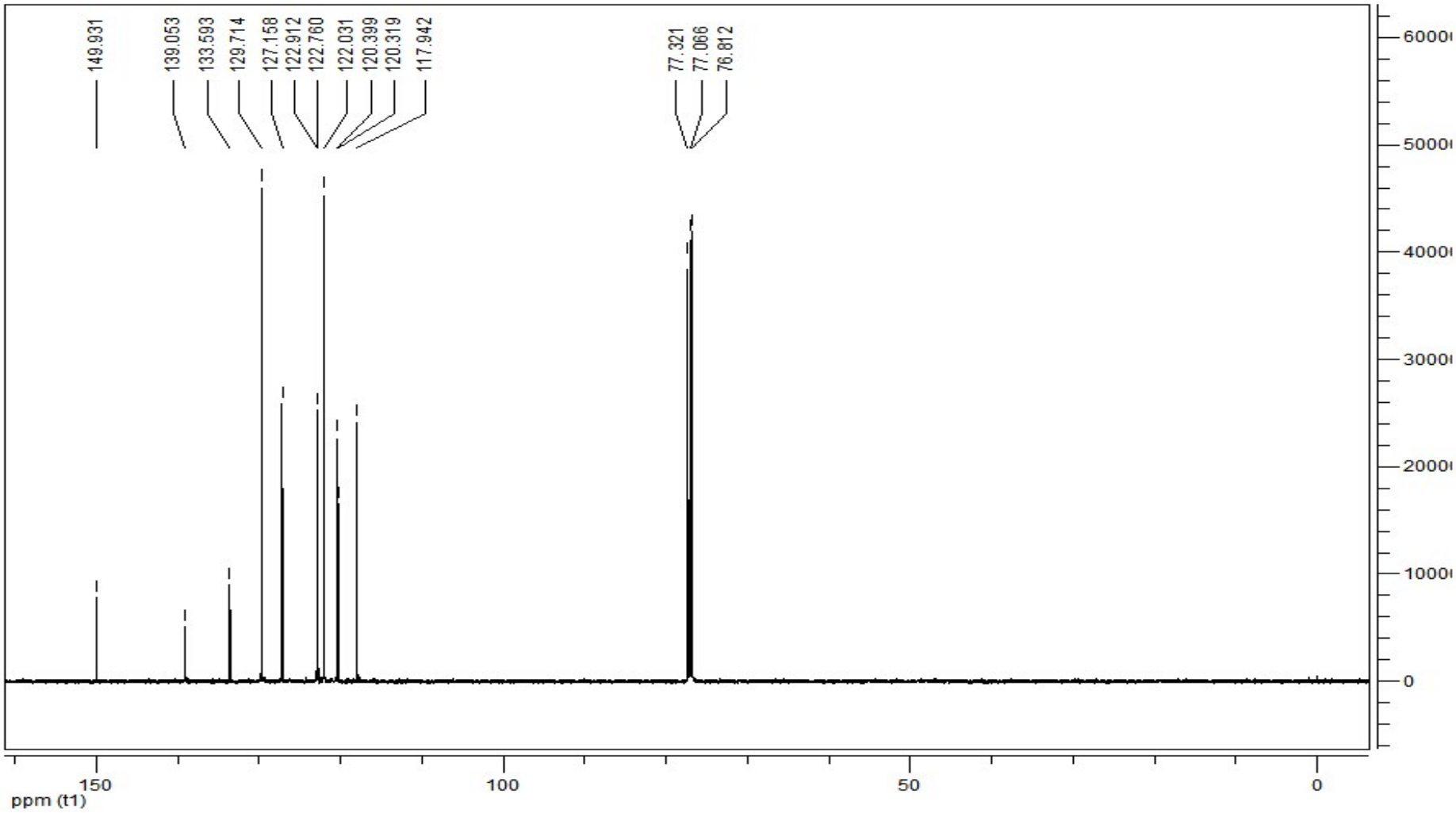
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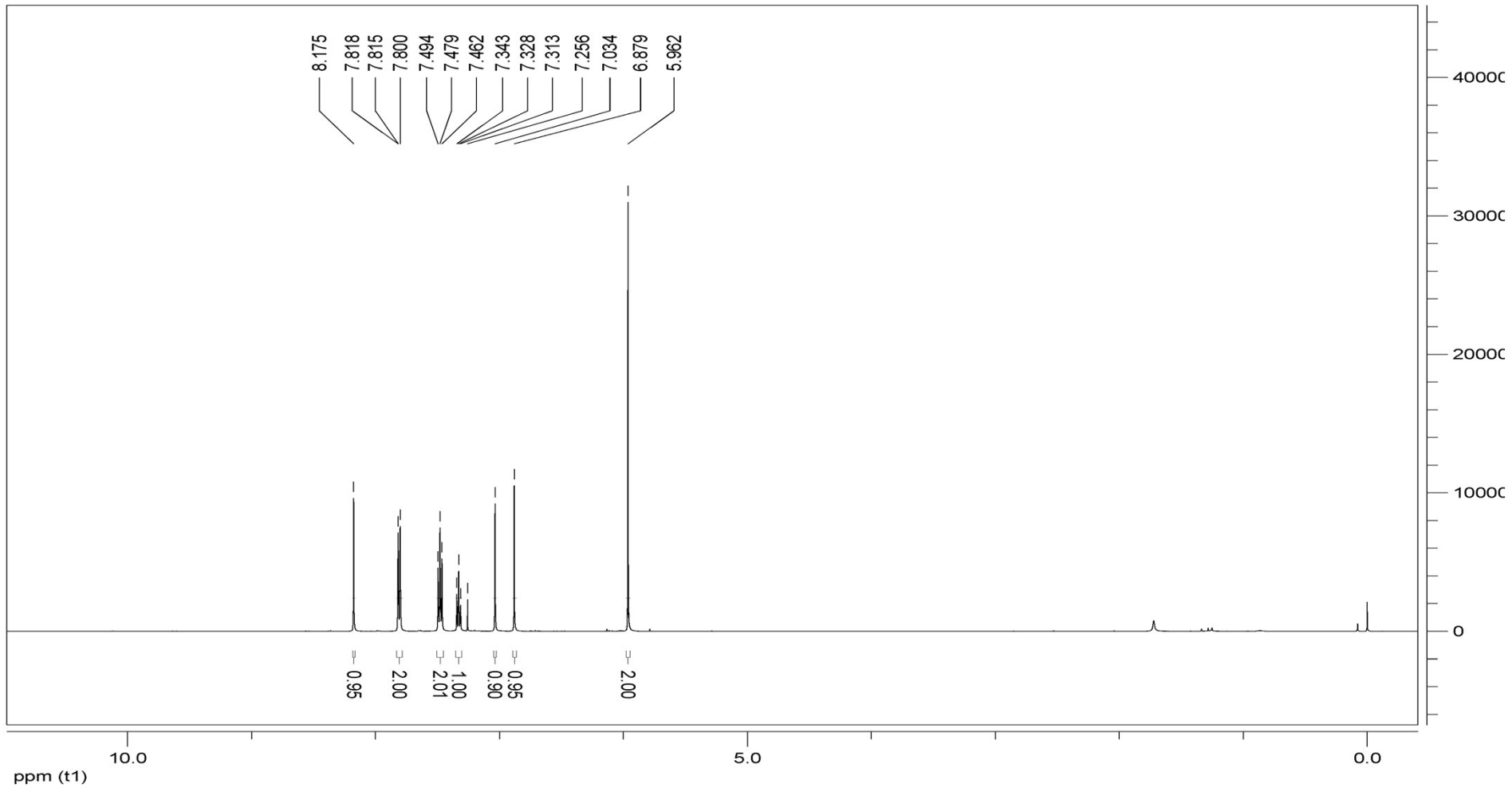
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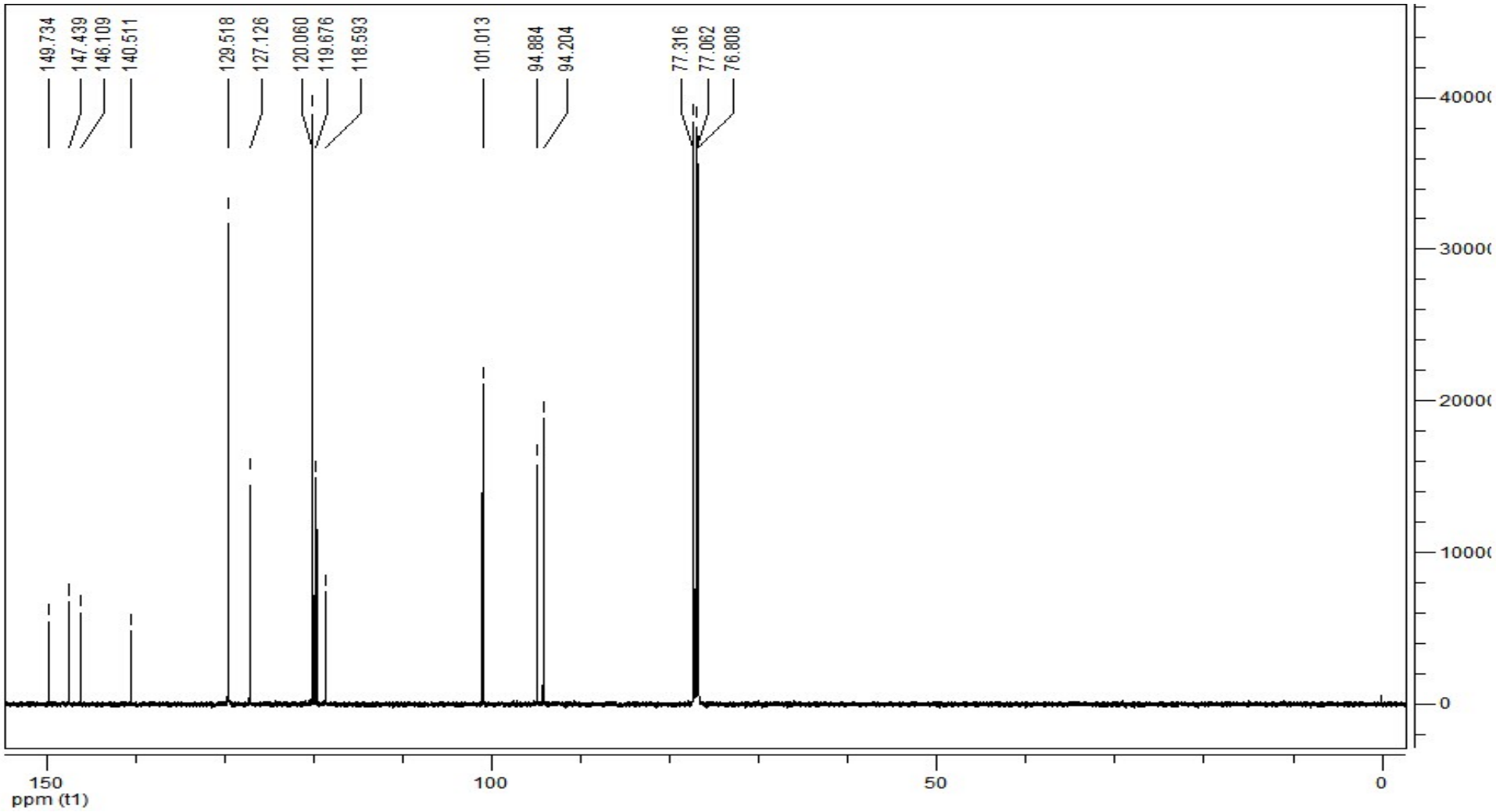
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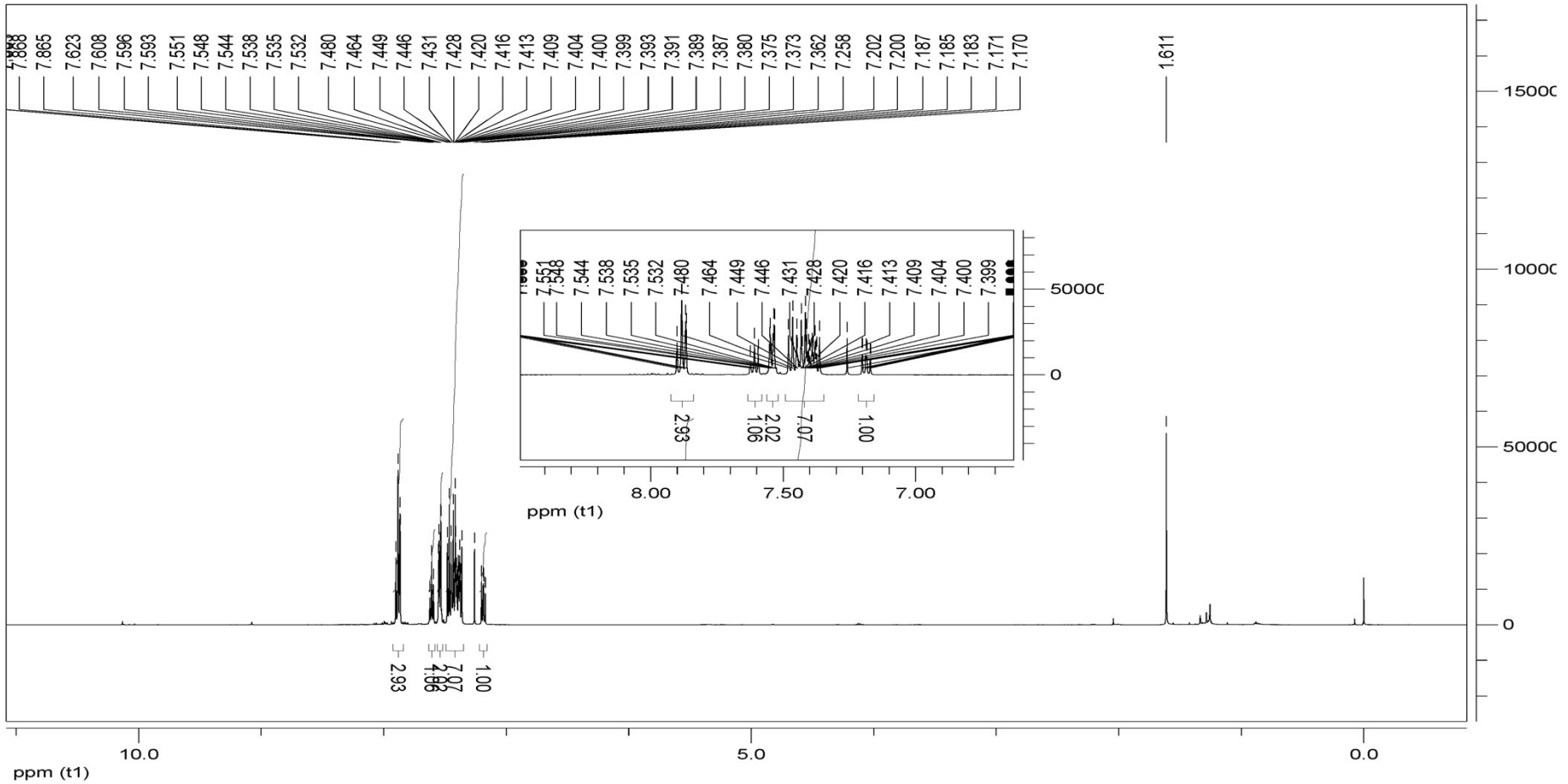
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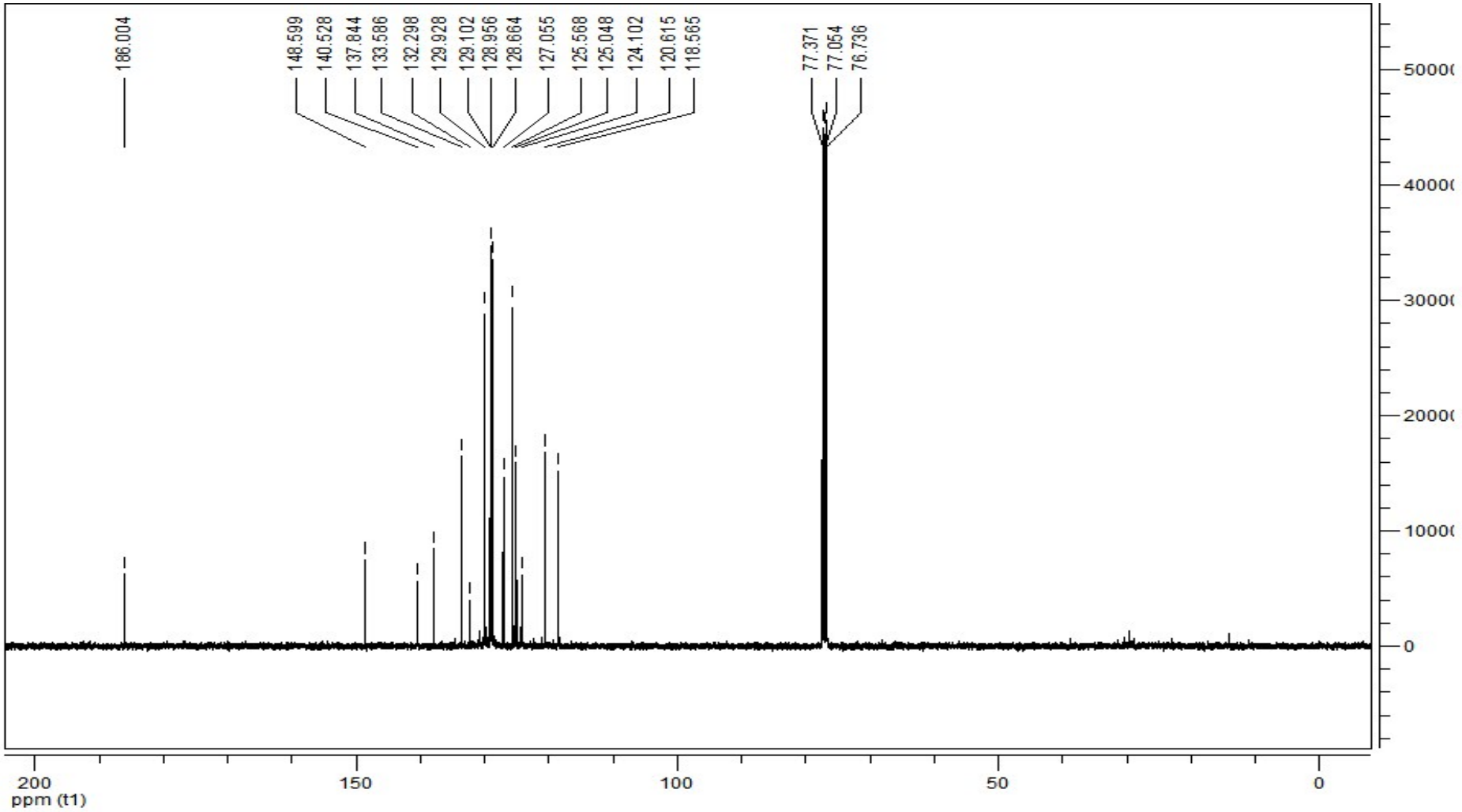
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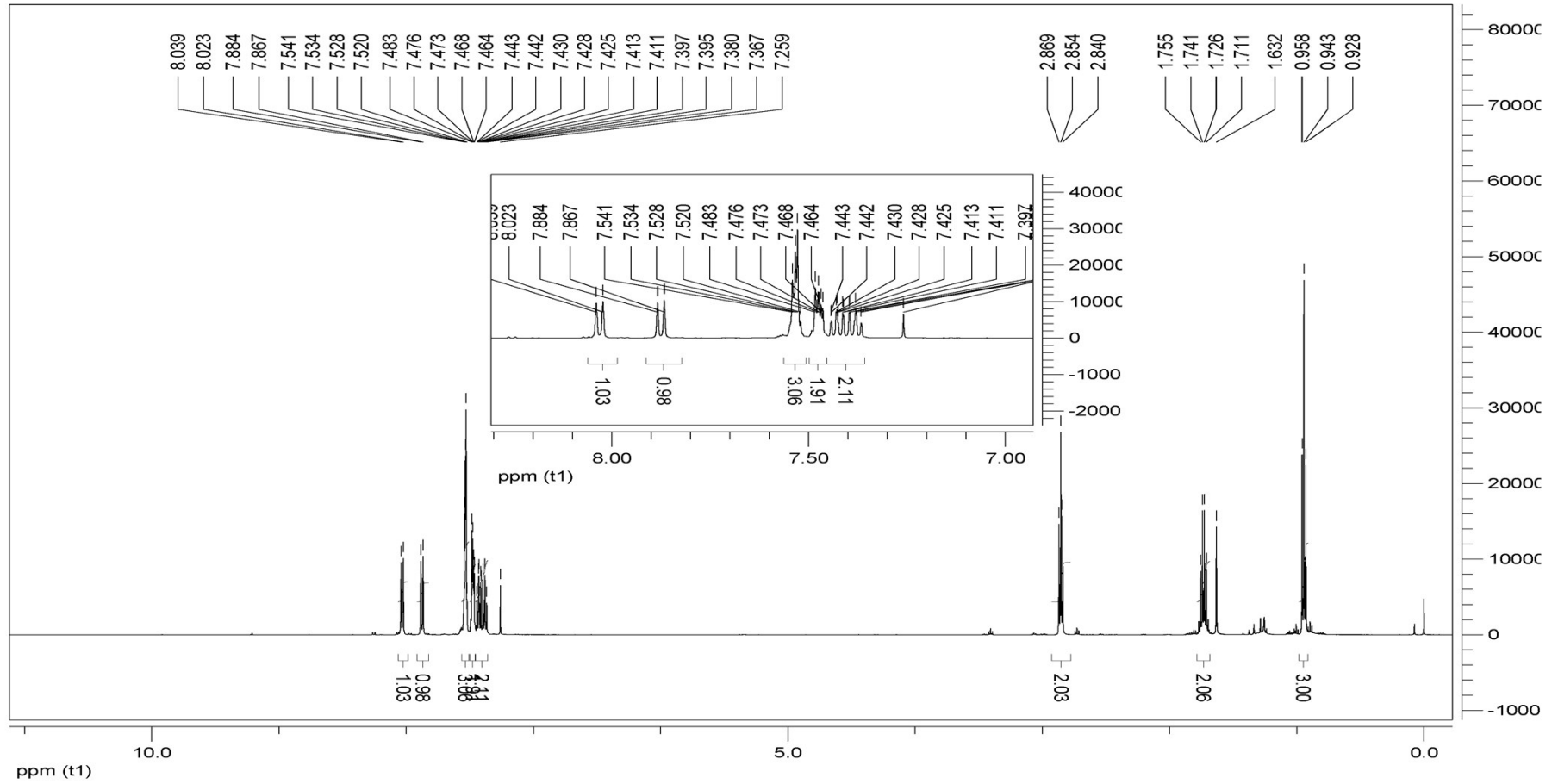
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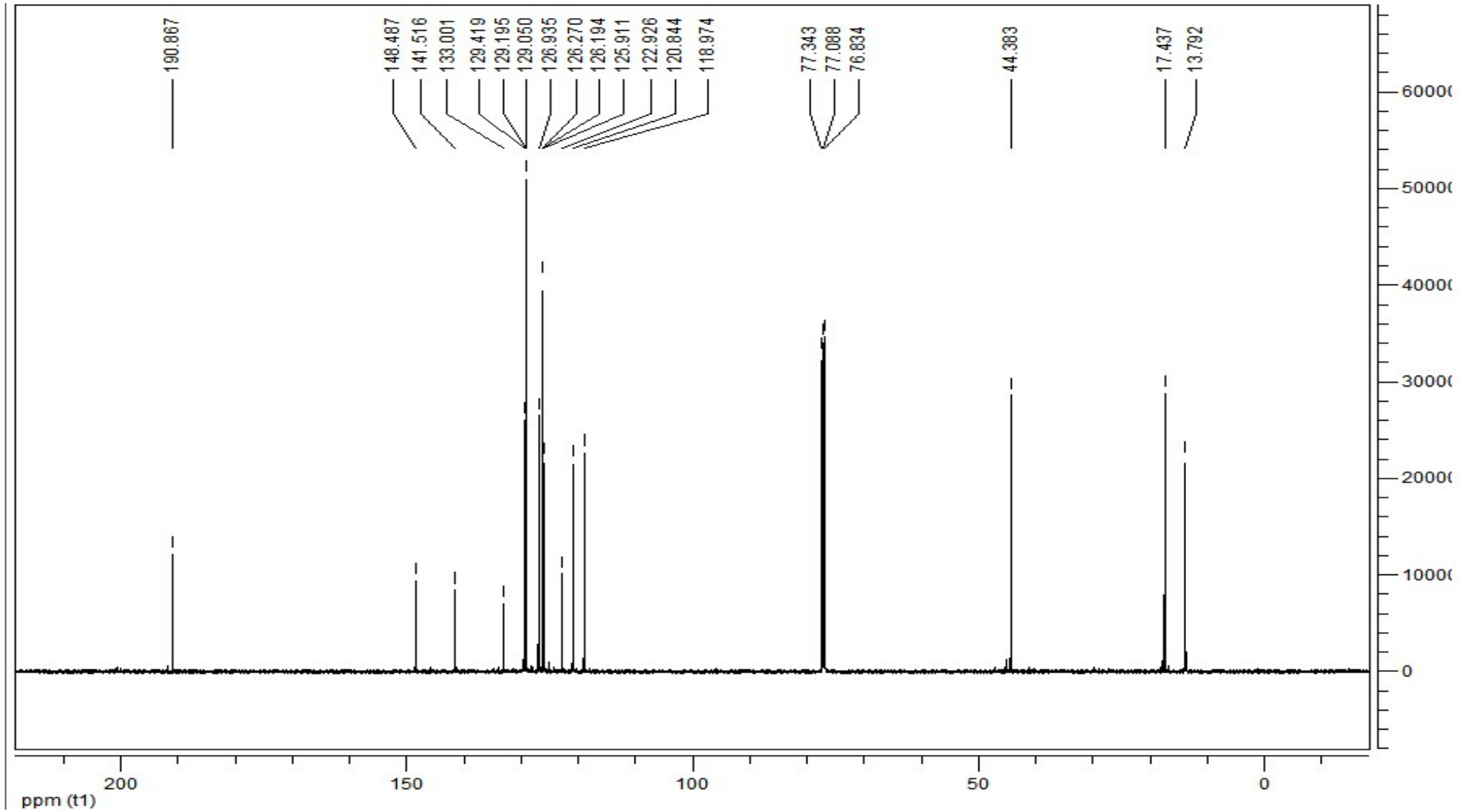
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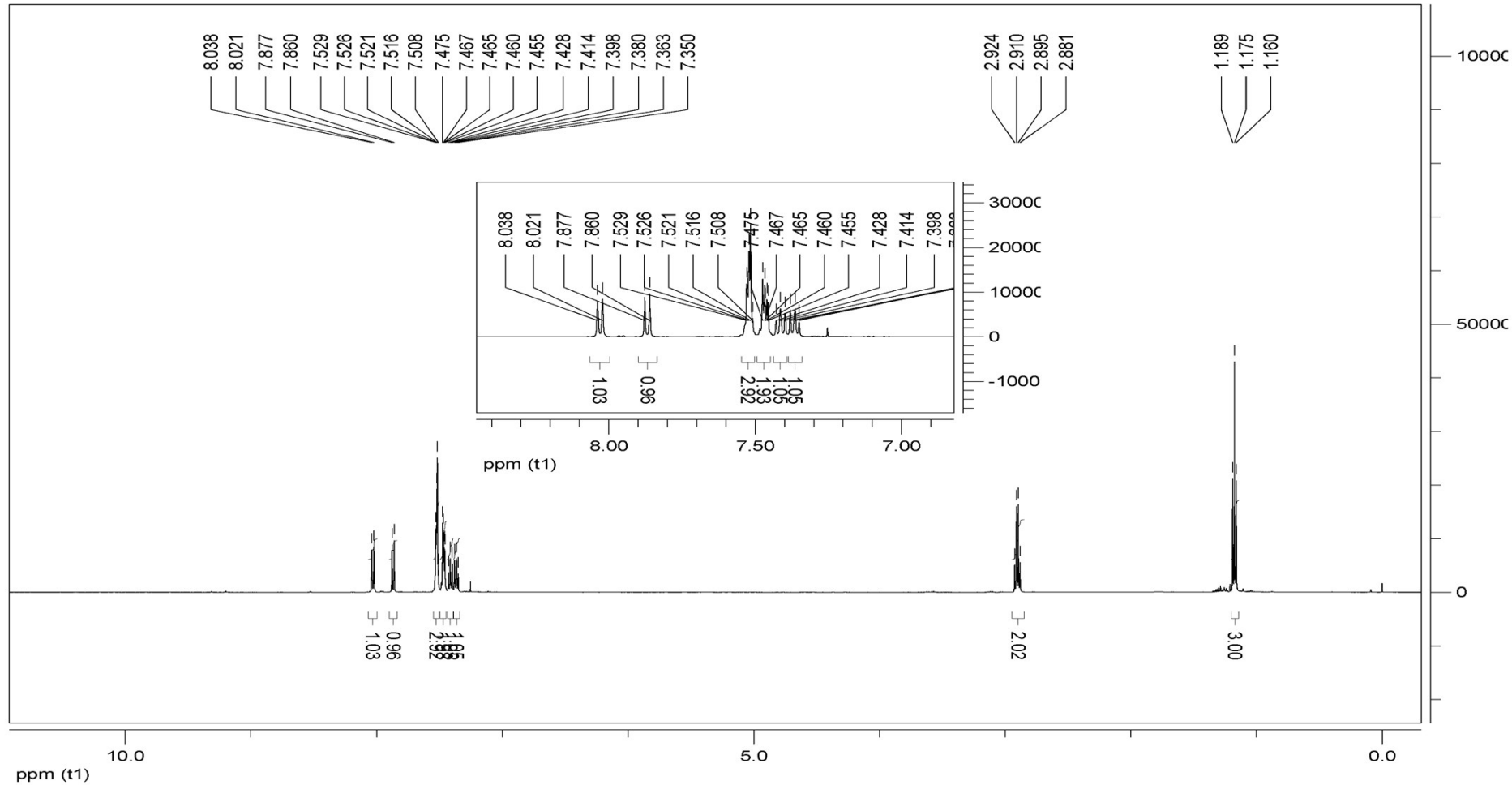
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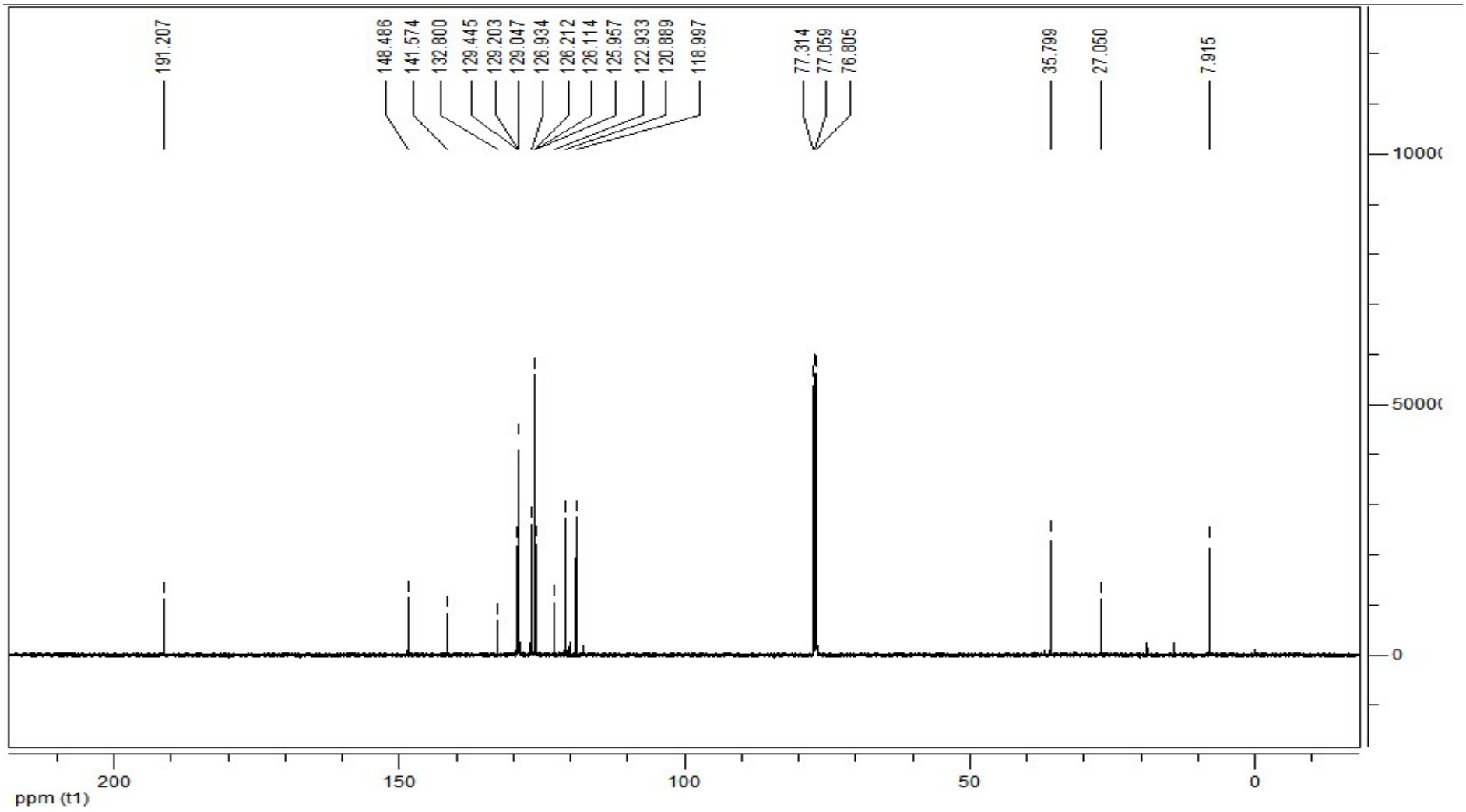
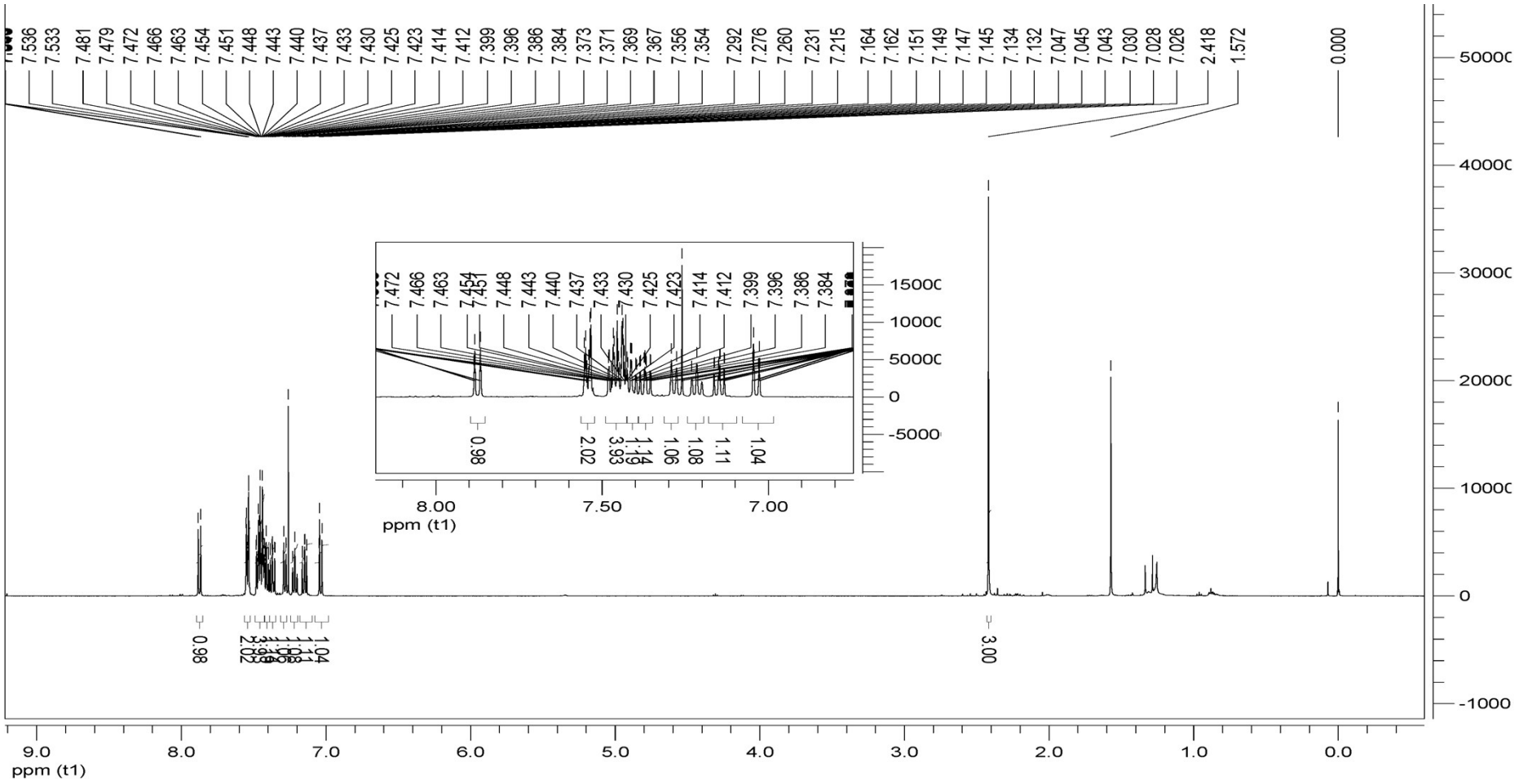
7.521
7.516
7.508
7.475
7.467
7.465
7.460
7.455
7.428
7.414
7.398
7.380
7.363
7.350
2.924
2.910
2.895
2.881
1.189
1.175
1.160
1.03
0.96
2.92
2.02
3.00
ppm (t1)
10.0
5.0
0.0


191.207
148.486
141.574
132.800
129.445
129.203
129.047
126.934
126.212
126.114
125.957
122.933
120.889
118.997
77.314
77.059
76.805
35.799
27.050
7.915
10000
50000
0
200
150
100
50
0
ppm (t1)

3d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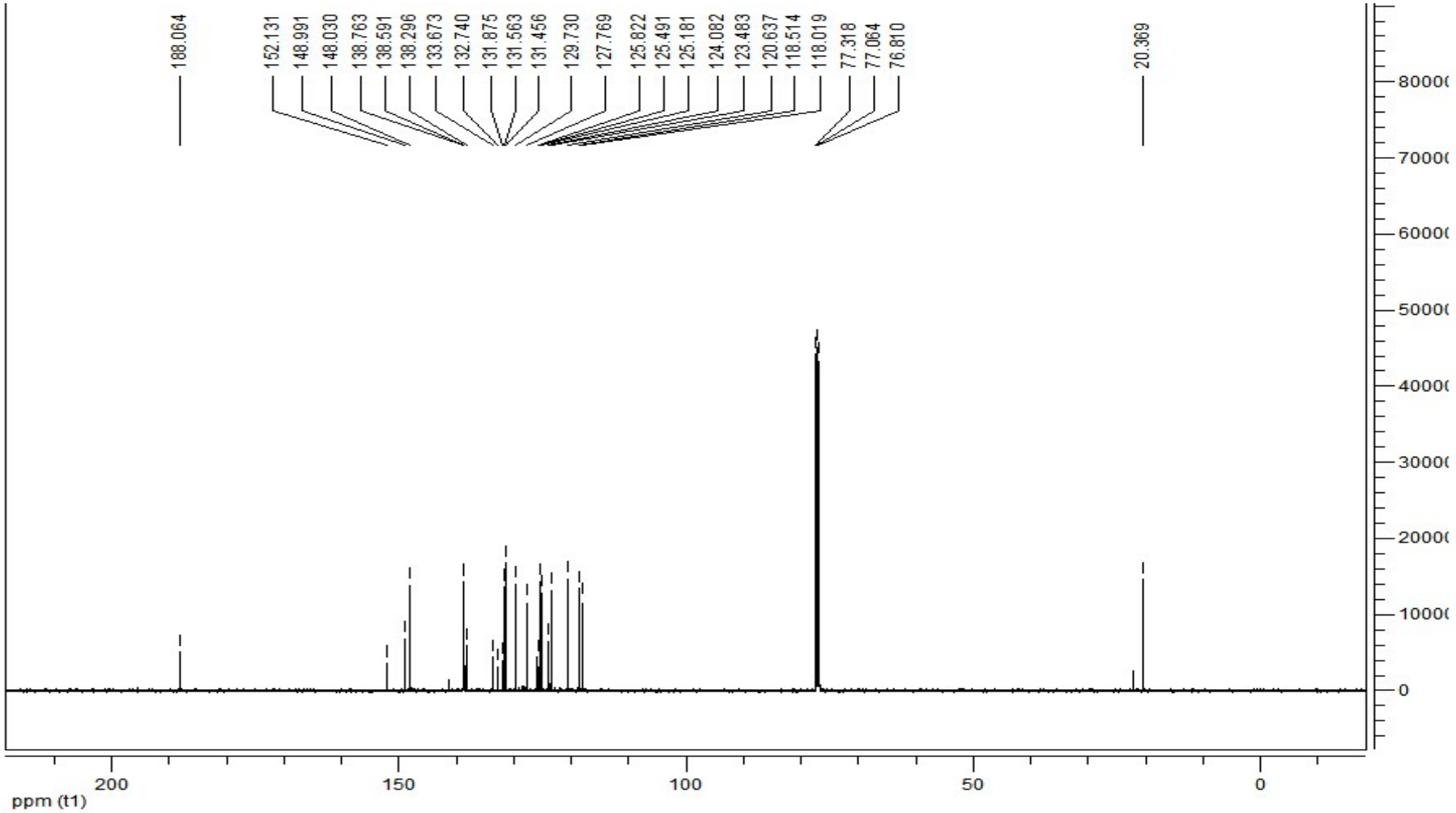
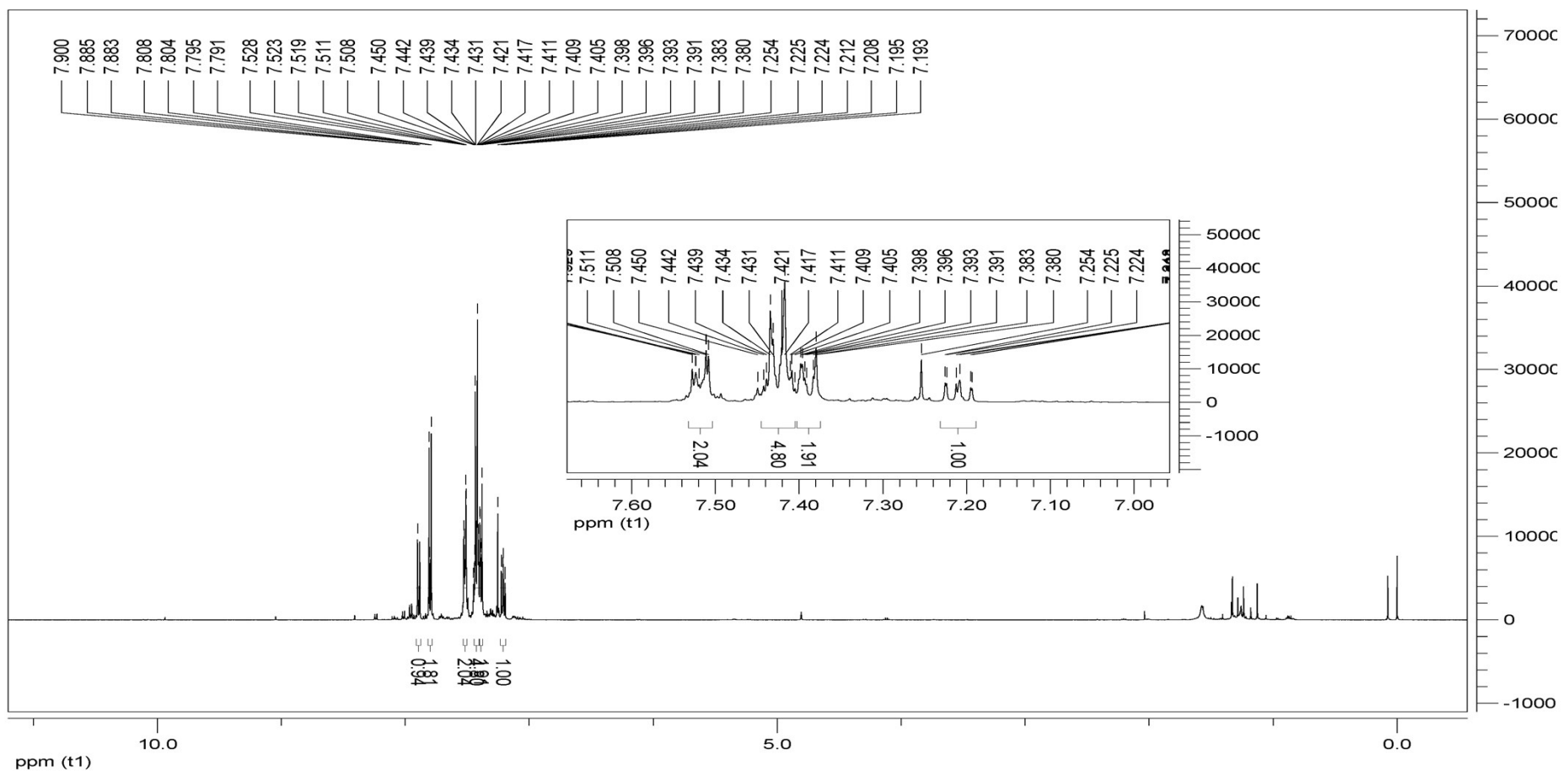
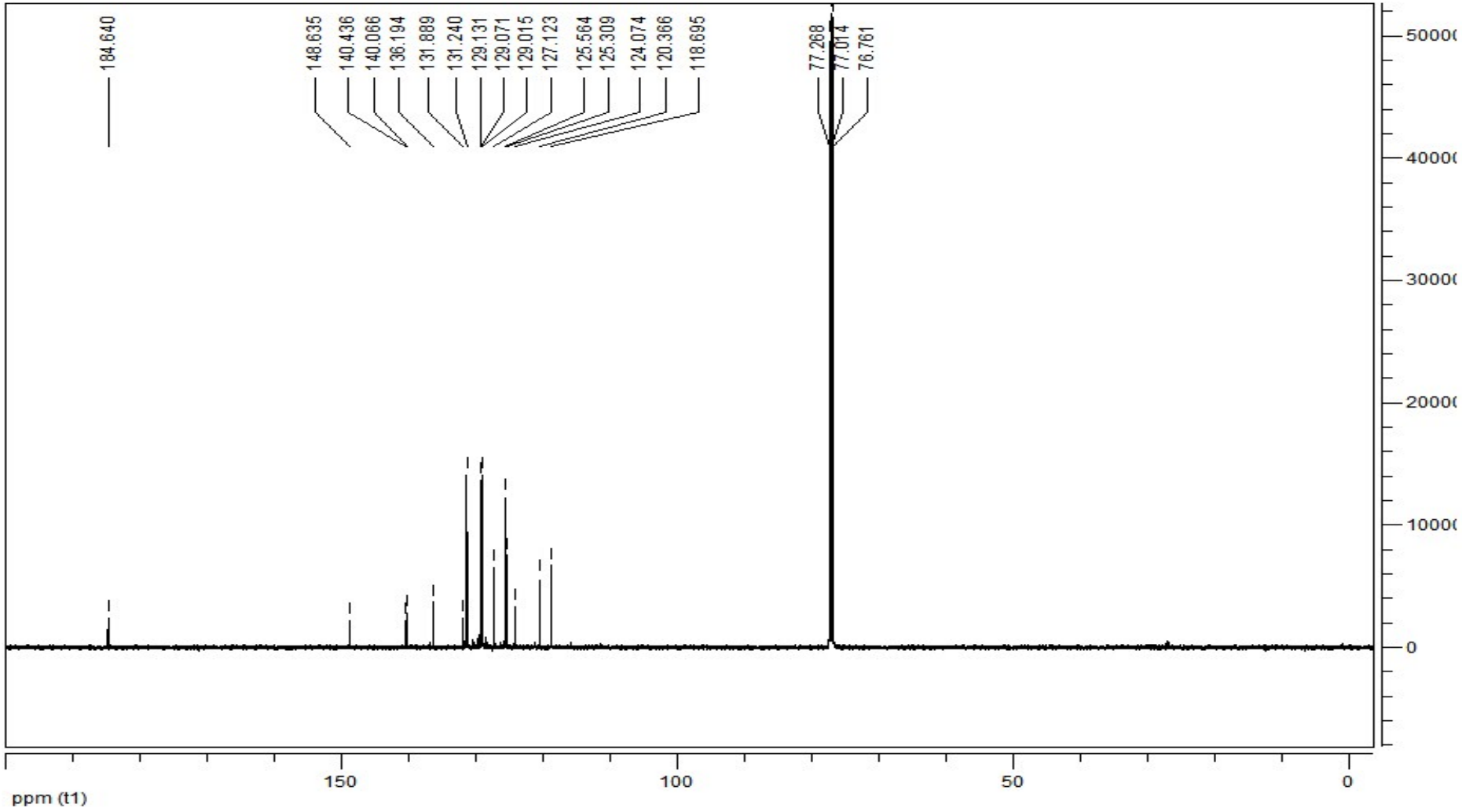
7.533
7.481
7.479
7.472
7.466
7.463
7.454
7.451
7.448
7.443
7.440
7.437
7.433
7.430
7.425
7.423
7.414
7.412
7.399
7.396
7.386
7.384
7.373
7.371
7.369
7.367
7.356
7.354
7.292
7.276
7.260
7.231
7.215
7.164
7.162
7.151
7.149
7.147
7.145
7.134
7.132
7.047
7.045
7.043
7.030
7.028
7.026
2.418
1.572
0.000
0.98
2.02
3.93
1.14
1.06
1.08
1.11
1.04
3.00
ppm (t1)

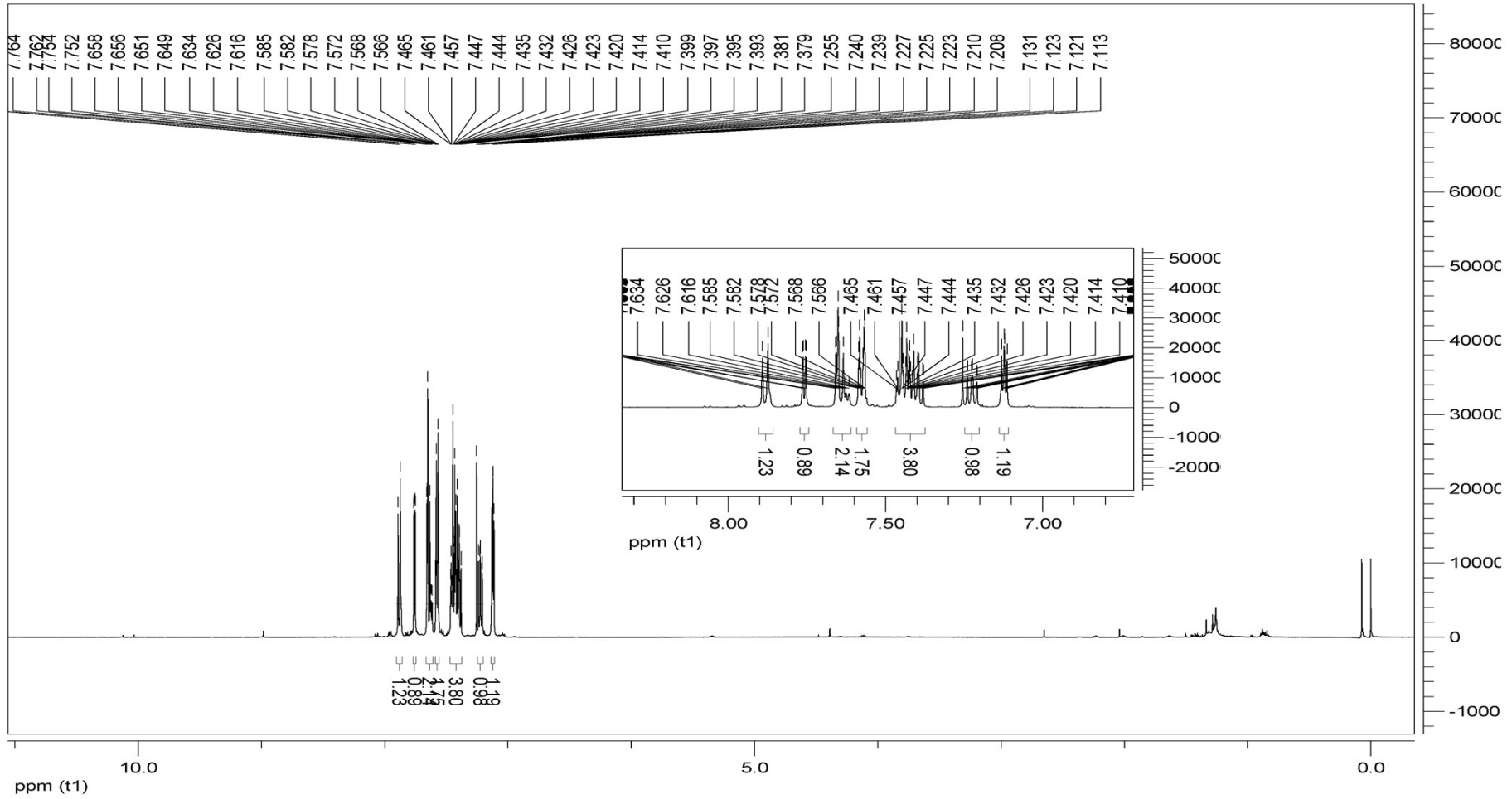

188.064
152.131
148.991
148.030
138.763
138.591
138.296
133.673
132.740
131.875
131.563
131.456
129.730
127.769
125.822
125.491
125.181
124.082
123.483
120.637
118.514
118.019
77.318
77.064
76.810
20.369
80000
70000
60000
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

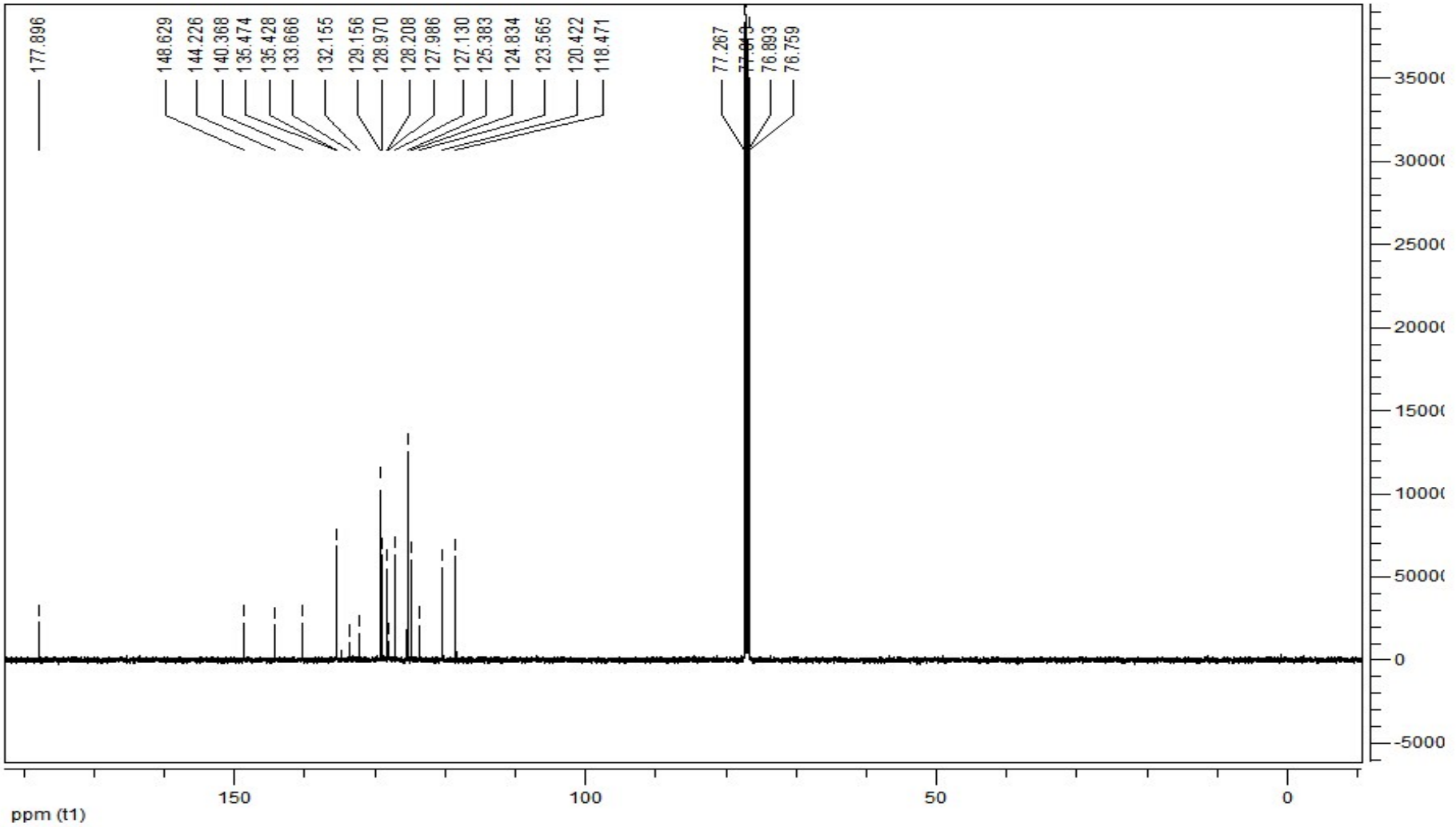
3e


7.900
7.885
7.883
7.808
7.804
7.795
7.791
7.528
7.523
7.519
7.511
7.508
7.450
7.442
7.439
7.434
7.431
7.421
7.417
7.411
7.409
7.405
7.398
7.396
7.393
7.391
7.383
7.380
7.254
7.225
7.224
7.212
7.208
7.195
7.193
2.04
4.80
1.91
1.00
ppm (t1)
0.84
1.81
2.04
1.00
10.0
5.0
0.0
ppm (t1)

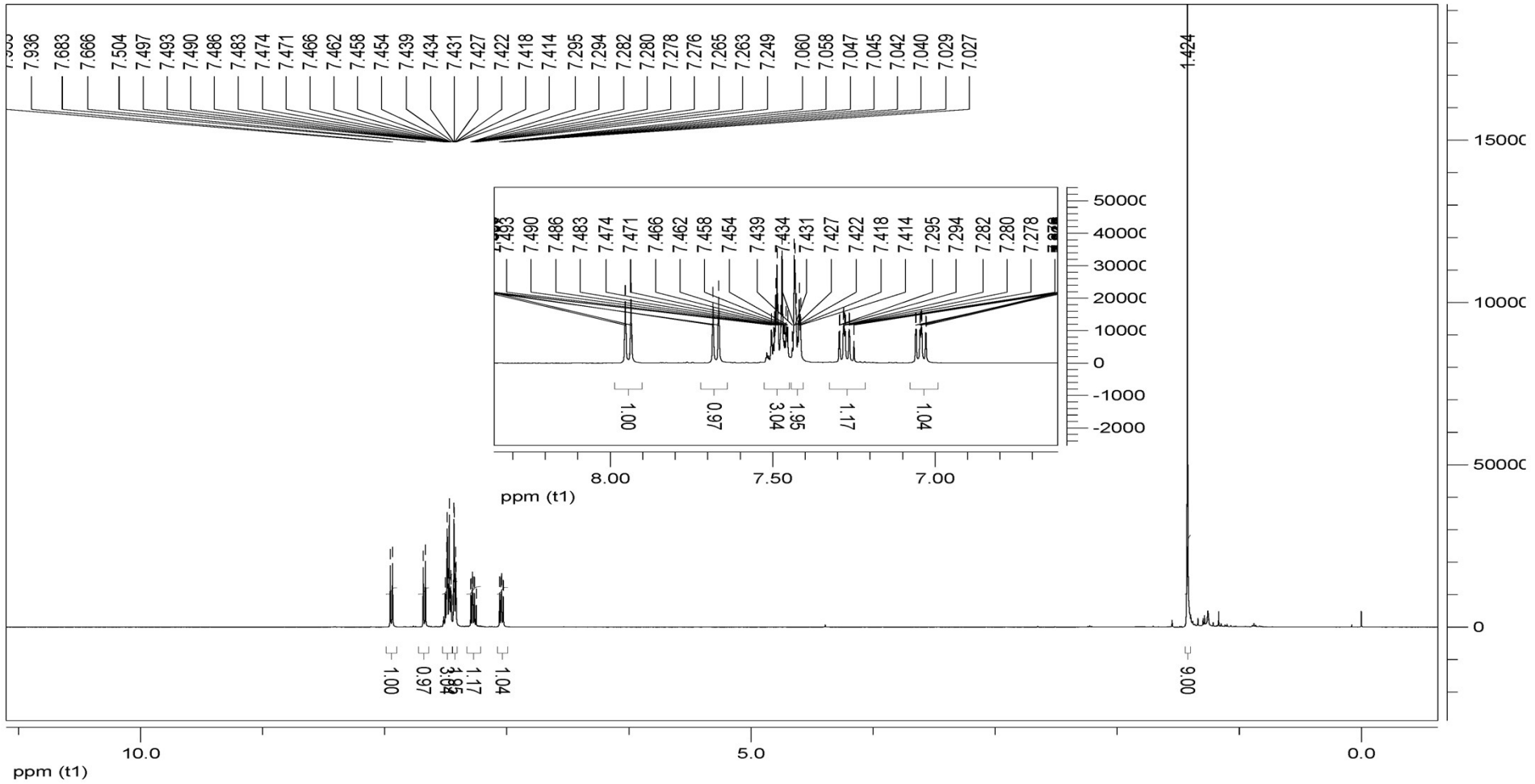

184.640
148.635
140.436
140.066
136.194
131.889
131.240
129.131
129.071
129.015
127.123
125.564
125.309
124.074
120.366
118.695
77.268
77.014
76.761
5000
4000
3000
2000
1000
0
150
100
50
0
ppm (t1)

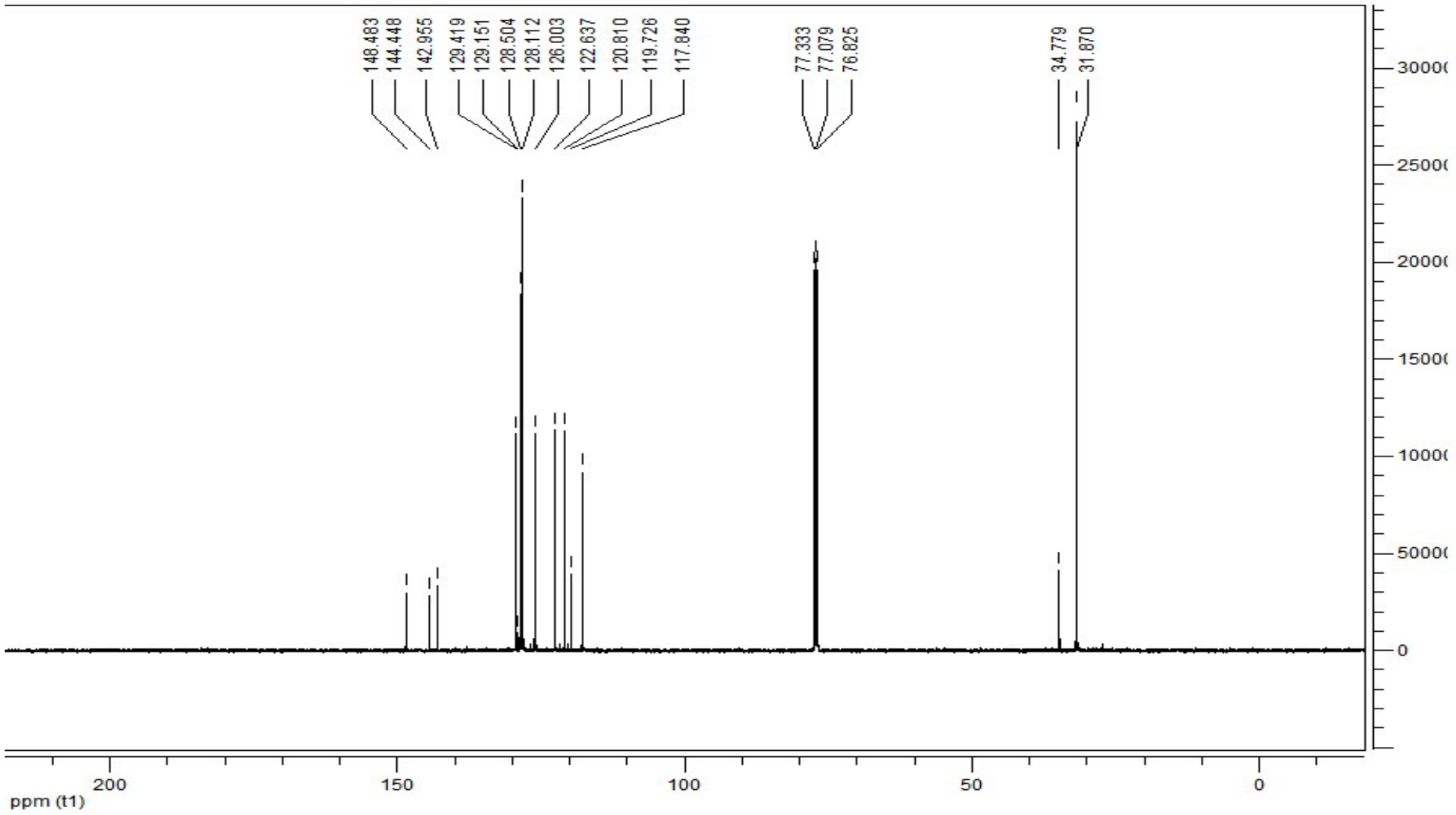
3f


7.764
7.762
7.754
7.752
7.658
7.656
7.651
7.649
7.634
7.626
7.616
7.585
7.582
7.578
7.572
7.568
7.566
7.465
7.461
7.457
7.447
7.444
7.435
7.432
7.426
7.423
7.420
7.414
7.410
7.399
7.397
7.395
7.393
7.381
7.379
7.255
7.240
7.239
7.227
7.225
7.223
7.210
7.208
7.131
7.123
7.121
7.113
1.23
0.89
2.14
1.75
3.80
0.98
1.19
ppm (t1)
10.0
5.0
0.0

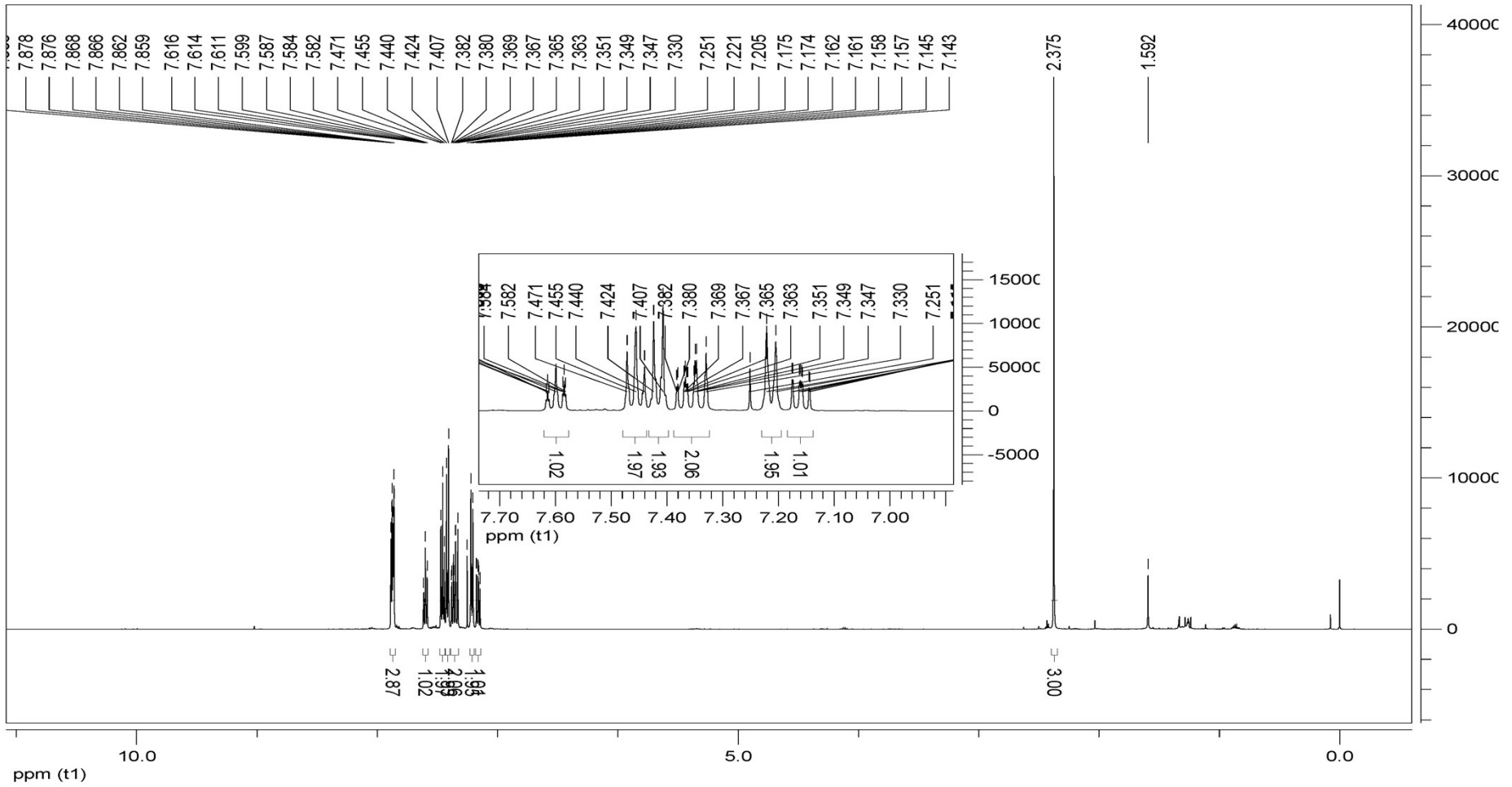

177.896
148.629
144.226
140.368
135.474
135.428
133.666
132.155
129.156
128.970
128.208
127.986
127.130
125.383
124.834
123.565
120.422
118.471
77.267
76.893
76.759
3500
3000
2500
2000
1500
1000
5000
0
-5000
150
100
50
0
ppm (t1)

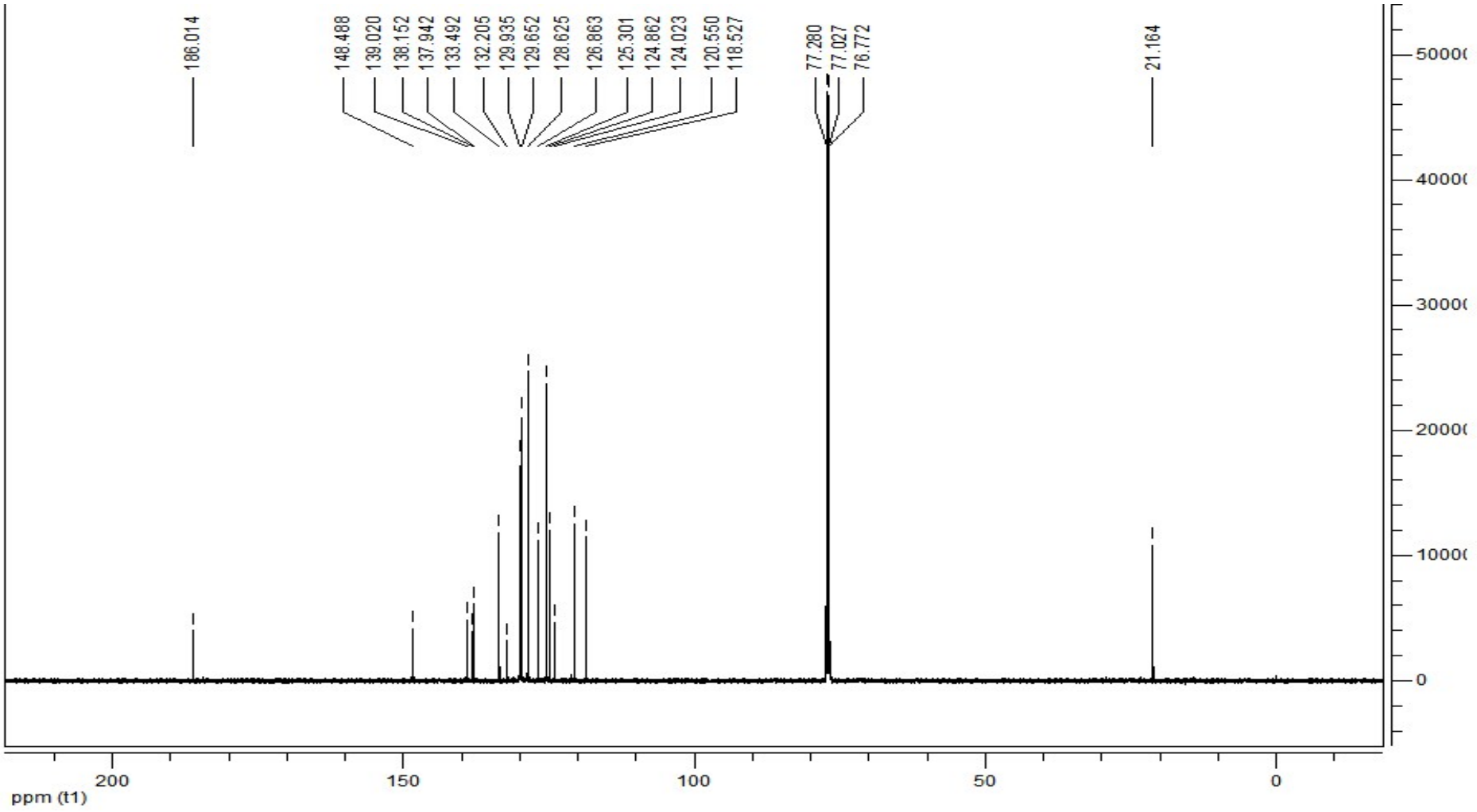
3g


7.936
7.683
7.666
7.504
7.497
7.493
7.490
7.486
7.483
7.474
7.471
7.466
7.462
7.458
7.454
7.439
7.434
7.431
7.427
7.422
7.418
7.414
7.295
7.294
7.282
7.280
7.278
7.276
7.265
7.263
7.249
7.060
7.058
7.047
7.045
7.042
7.040
7.029
7.027
1.424
1.00
0.97
3.04
1.96
1.17
1.04
9.00
ppm (t1)
10.0
5.0
0.0
8.00
7.50
7.00

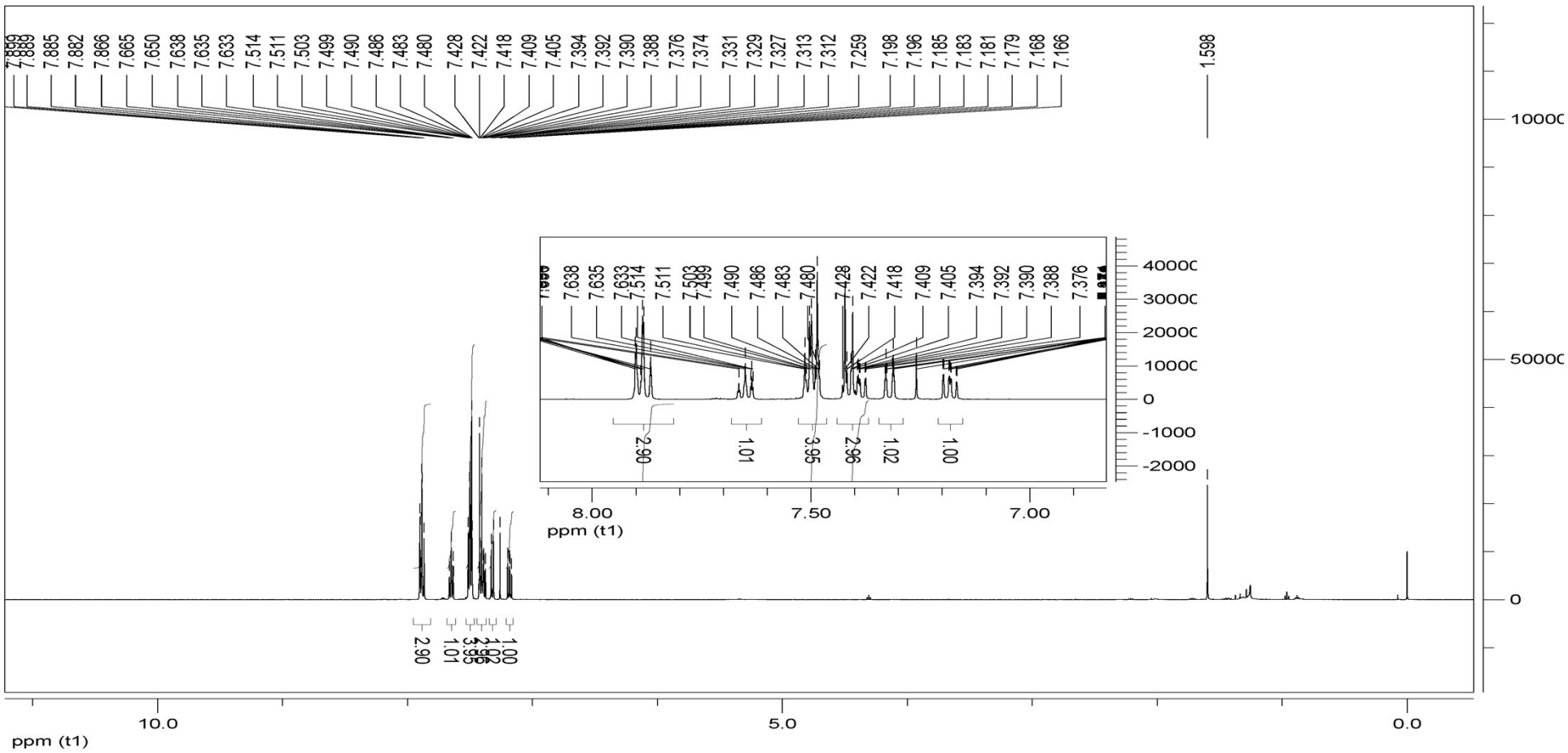

148.483
144.448
142.955
129.419
129.151
128.504
128.112
126.003
122.637
120.810
119.726
117.840
77.333
77.079
76.825
34.779
31.870
30000
25000
20000
15000
10000
5000
0
200
150
100
50
0
ppm (t1)

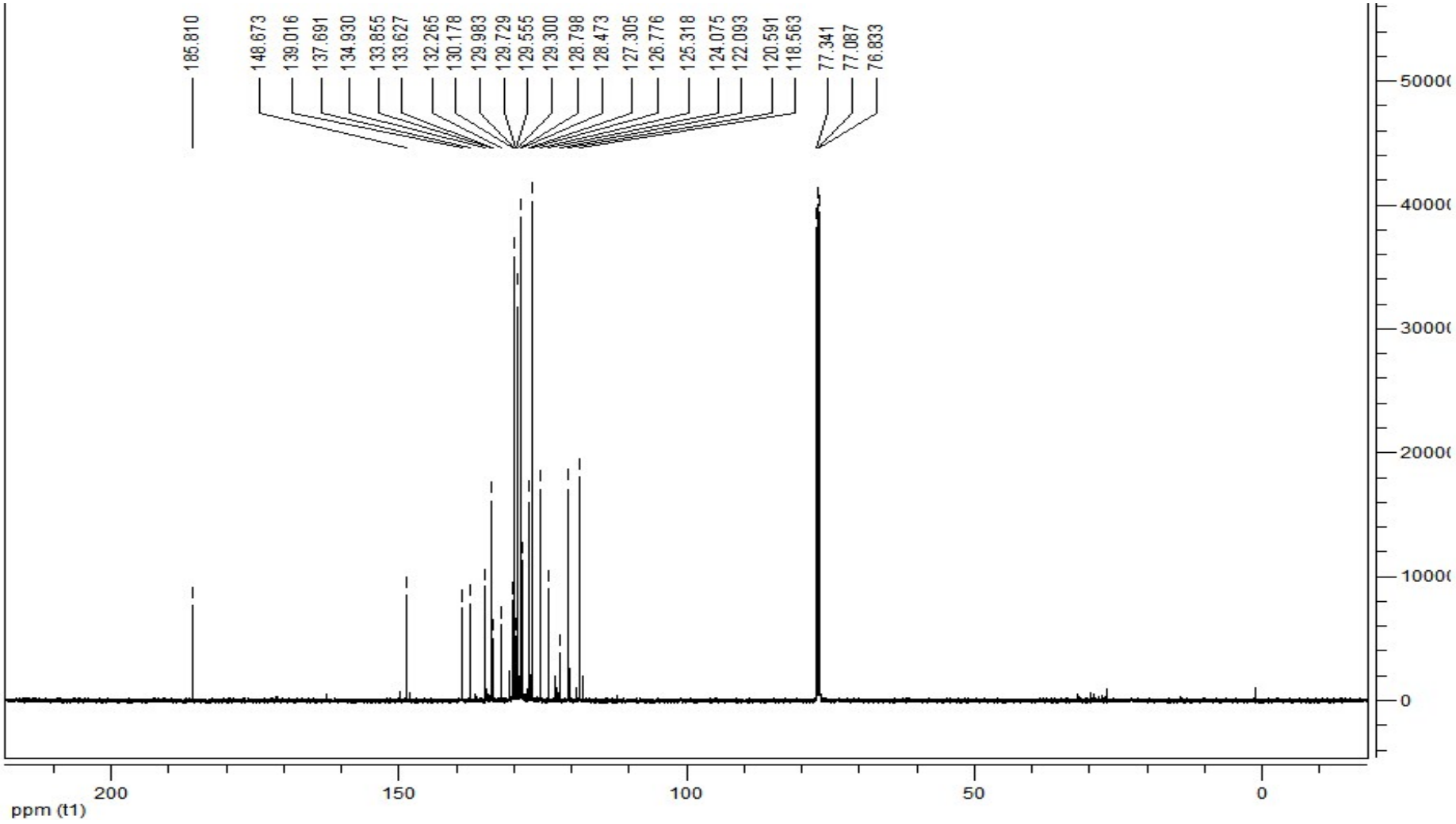
4a

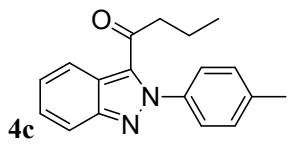

7.878
7.876
7.868
7.866
7.862
7.859
7.616
7.614
7.611
7.599
7.587
7.584
7.582
7.471
7.455
7.440
7.424
7.407
7.382
7.380
7.369
7.367
7.365
7.363
7.351
7.349
7.347
7.330
7.251
7.221
7.205
7.175
7.174
7.162
7.161
7.158
7.157
7.145
7.143
2.375
1.592
1.02
1.97
1.93
2.06
1.96
1.01
7.70 7.60 7.50 7.40 7.30 7.20 7.10 7.00
ppm (t1)
2.87
1.02
3.00
10.0
5.0
0.0
ppm (t1)


186.014
148.488
139.020
138.152
137.942
133.492
132.205
129.935
129.652
128.625
126.863
125.301
124.862
124.023
120.550
118.527
77.280
77.027
76.772
21.164
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

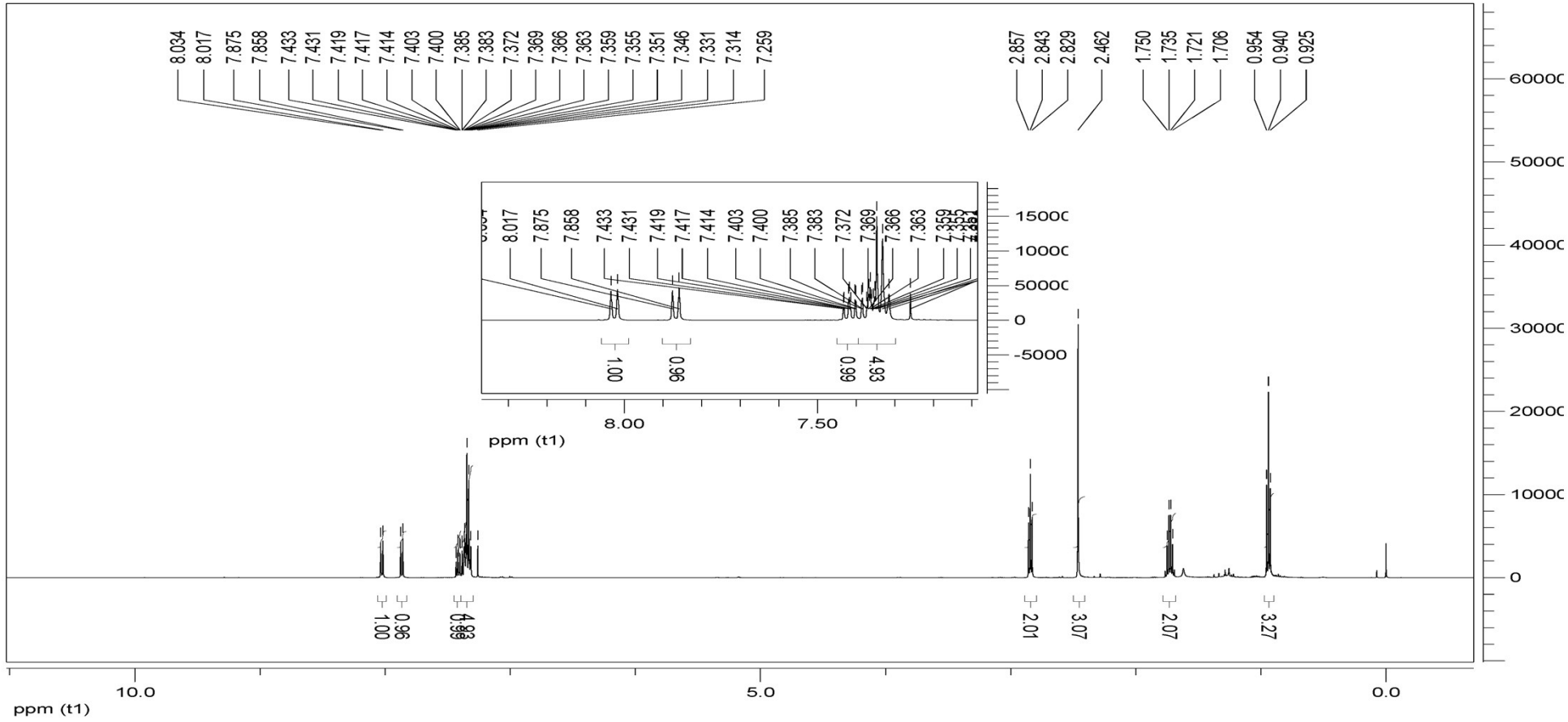
4b

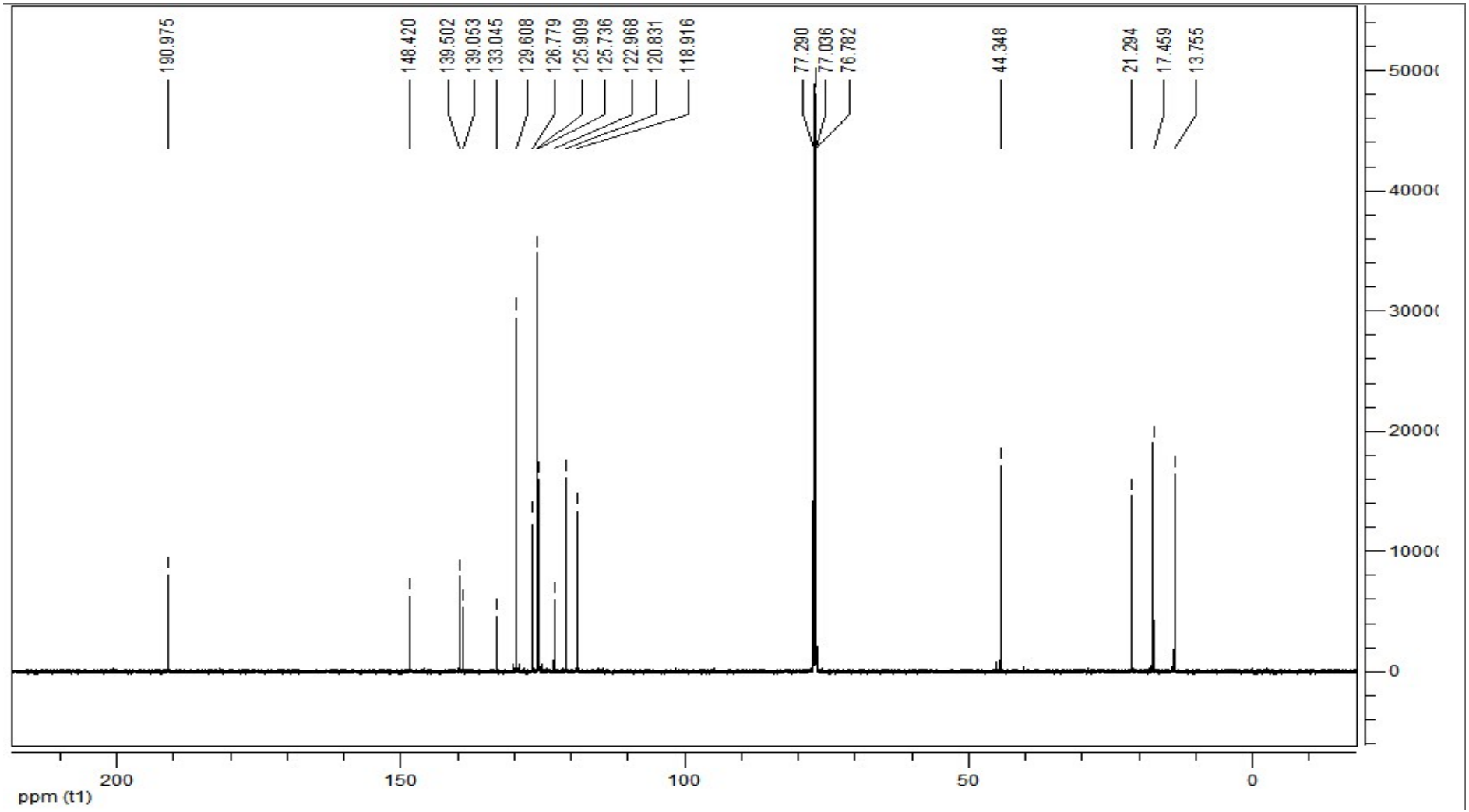

7.889
7.885
7.882
7.866
7.665
7.650
7.638
7.635
7.633
7.514
7.511
7.503
7.499
7.490
7.486
7.483
7.480
7.428
7.422
7.418
7.409
7.405
7.394
7.392
7.390
7.388
7.376
7.374
7.331
7.329
7.327
7.313
7.312
7.259
7.198
7.196
7.185
7.183
7.181
7.179
7.168
7.166
1.598
2.90
1.01
3.95
2.96
1.02
1.00
ppm (t1)
10.0
5.0
0.0
8.00
7.50
7.00


185.810
148.673
139.016
137.691
134.930
133.855
133.627
132.265
130.178
129.983
129.729
129.555
129.300
128.798
128.473
127.305
126.776
125.318
124.075
122.093
120.591
118.563
77.341
77.087
76.833
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

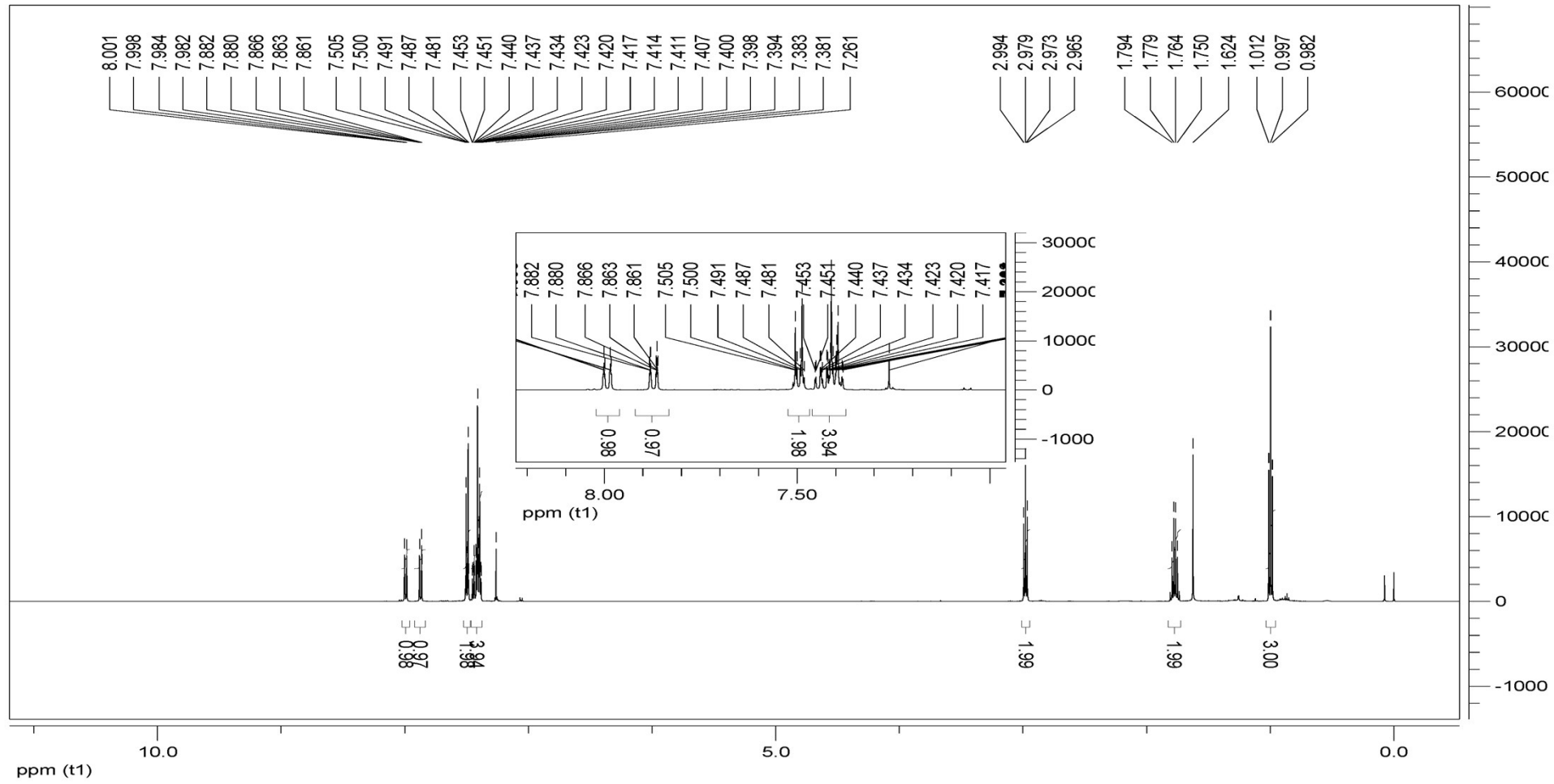

O
N
N

4c


8.034
8.017
7.875
7.858
7.433
7.431
7.419
7.417
7.414
7.403
7.400
7.385
7.383
7.372
7.369
7.366
7.363
7.359
7.355
7.351
7.346
7.331
7.314
7.259
2.857
2.843
2.829
2.462
1.750
1.735
1.721
1.706
0.954
0.940
0.925
1.00
0.96
0.99
4.33
2.01
3.07
2.07
3.27
ppm (t1)
10.0
5.0
0.0
8.00
7.50


190.975
148.420
139.502
139.053
133.045
129.608
126.779
125.909
125.736
122.968
120.831
118.916
77.290
77.036
76.782
44.348
21.294
17.459
13.755
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

4d


8.001
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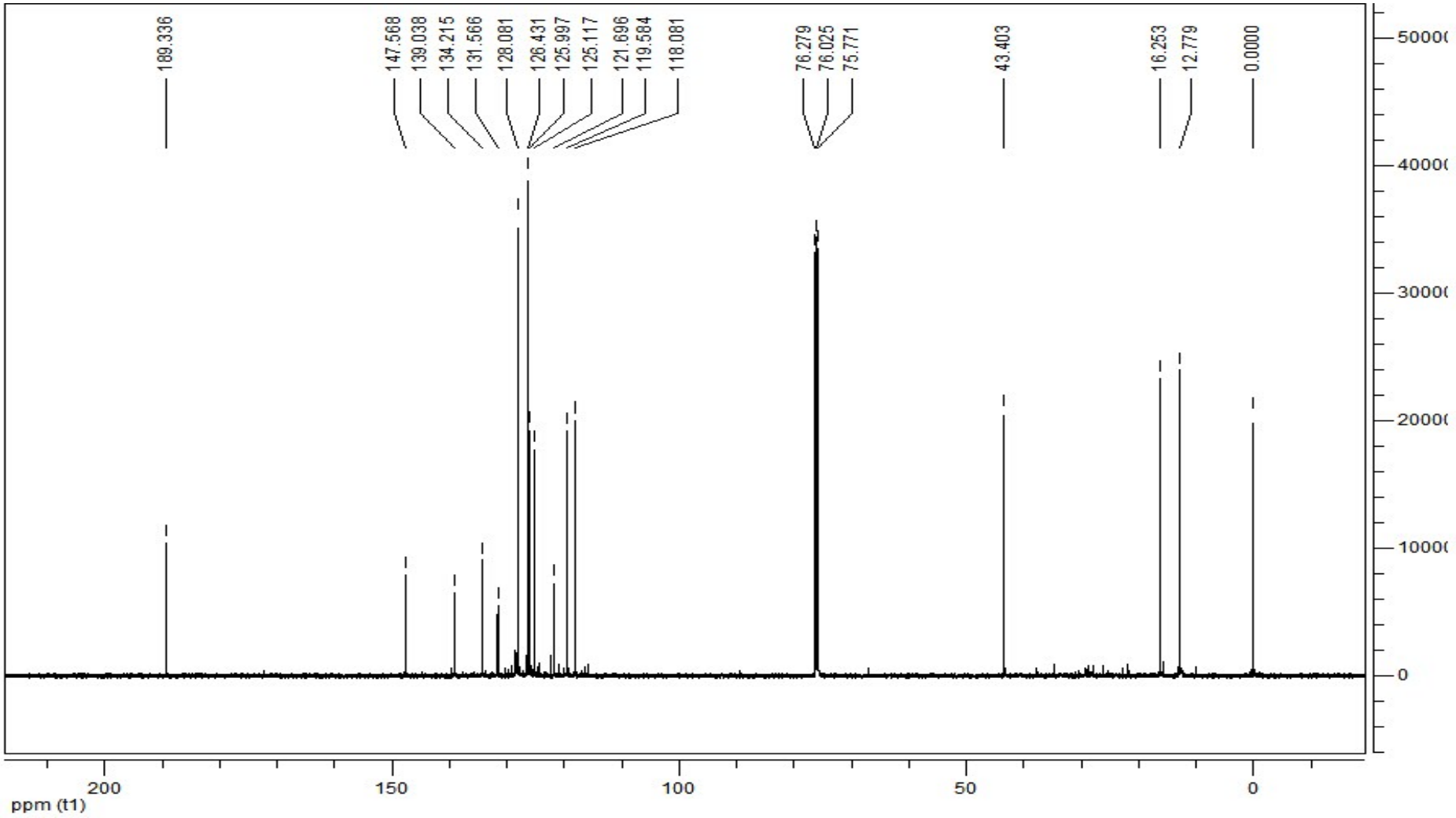
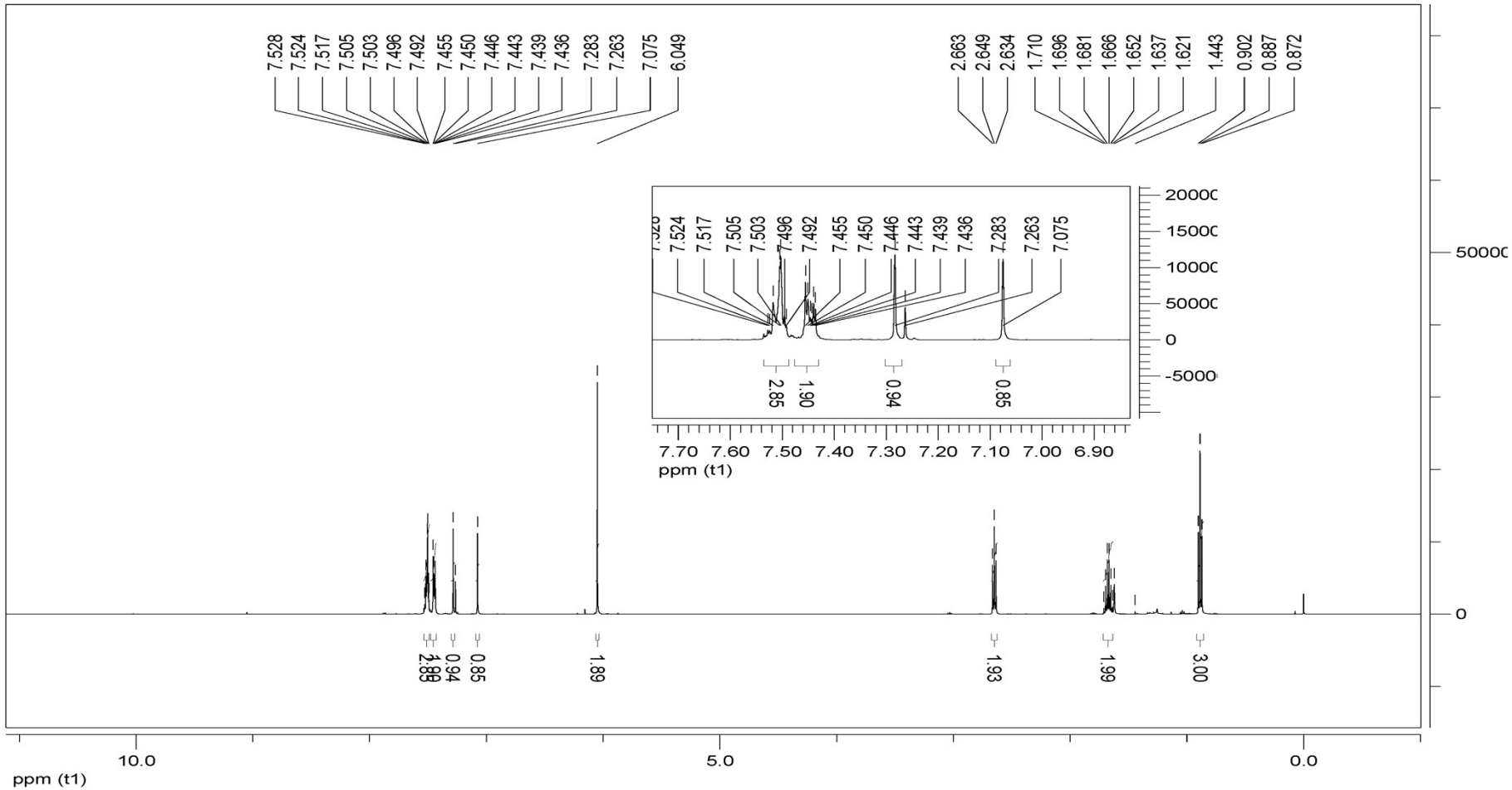
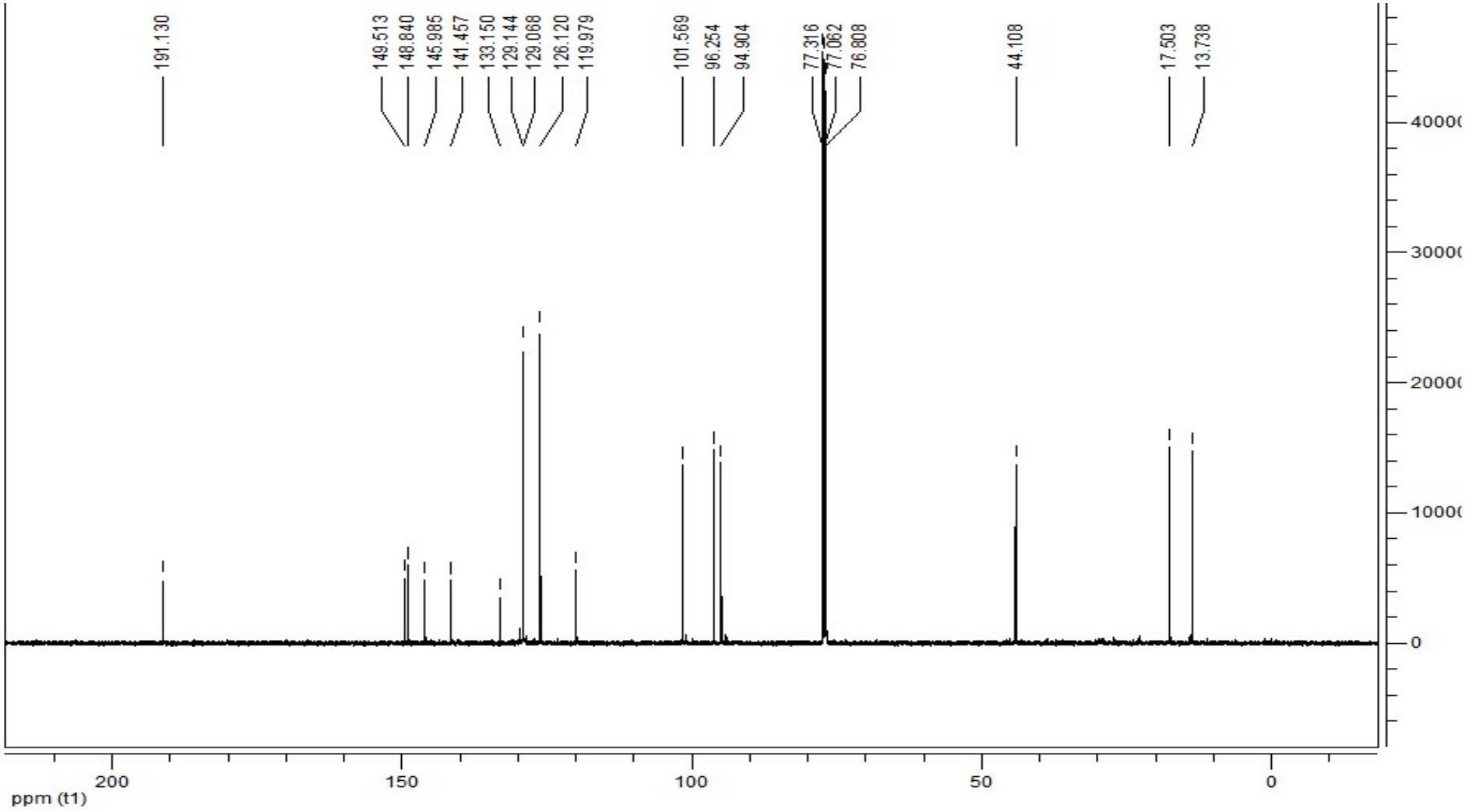
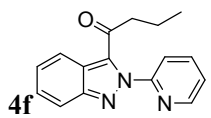
7.982
7.882
7.880
7.866
7.863
7.861
7.505
7.500
7.491
7.487
7.481
7.453
7.451
7.440
7.437
7.434
7.423
7.420
7.417
7.414
7.411
7.407
7.400
7.398
7.394
7.383
7.381
7.261
2.994
2.979
2.973
2.965
1.794
1.779
1.764
1.750
1.624
1.012
0.997
0.982
0.98
0.97
1.98
3.94
8.00
7.50
ppm (t1)
0.98
0.97
1.98
3.94
1.99
1.99
3.00
10.0
5.0
0.0
ppm (t1)


189.336
147.568
139.038
134.215
131.566
128.081
126.431
125.997
125.117
121.696
119.584
118.081
76.279
76.025
75.771
43.403
16.253
12.779
0.0000
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

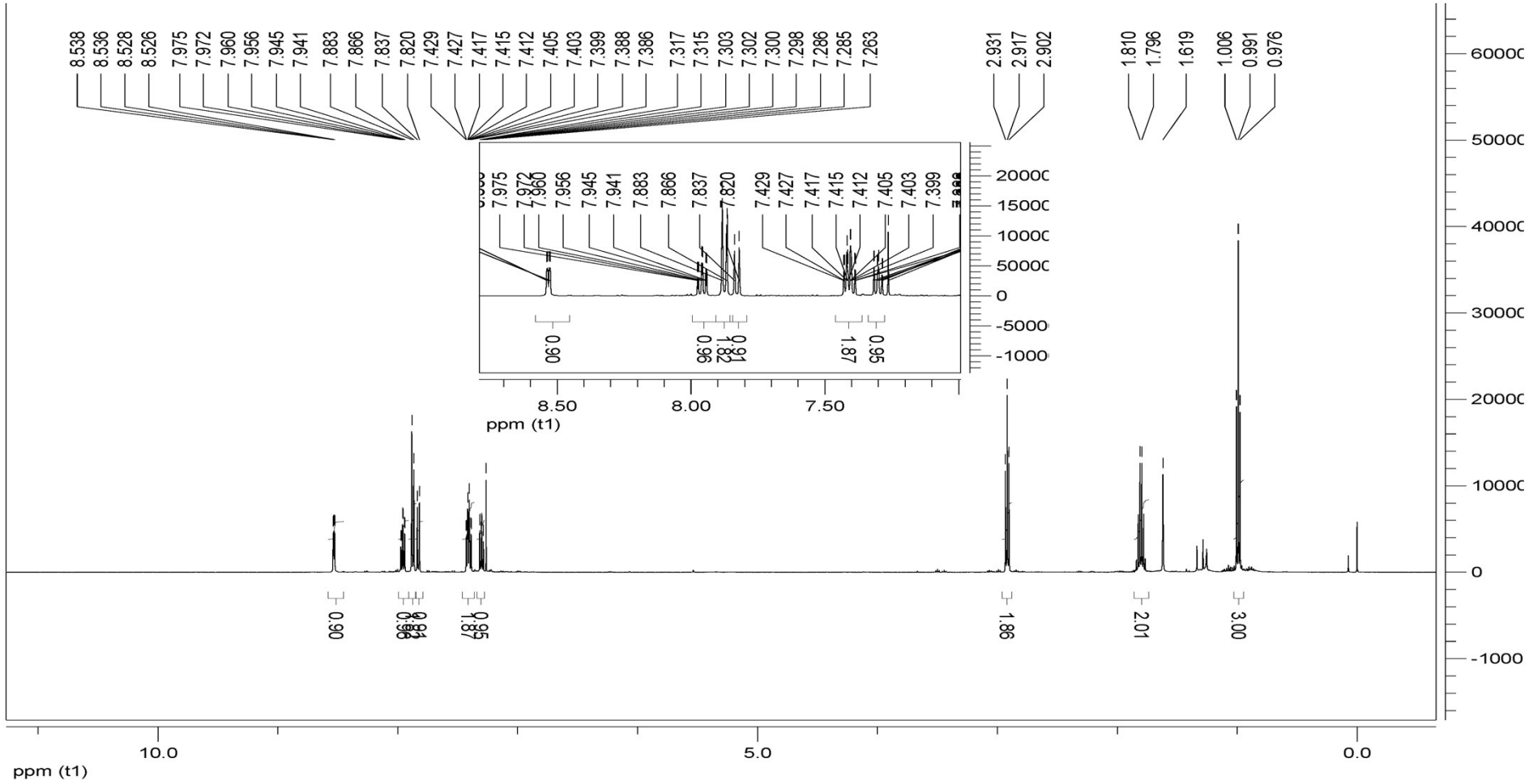
4e

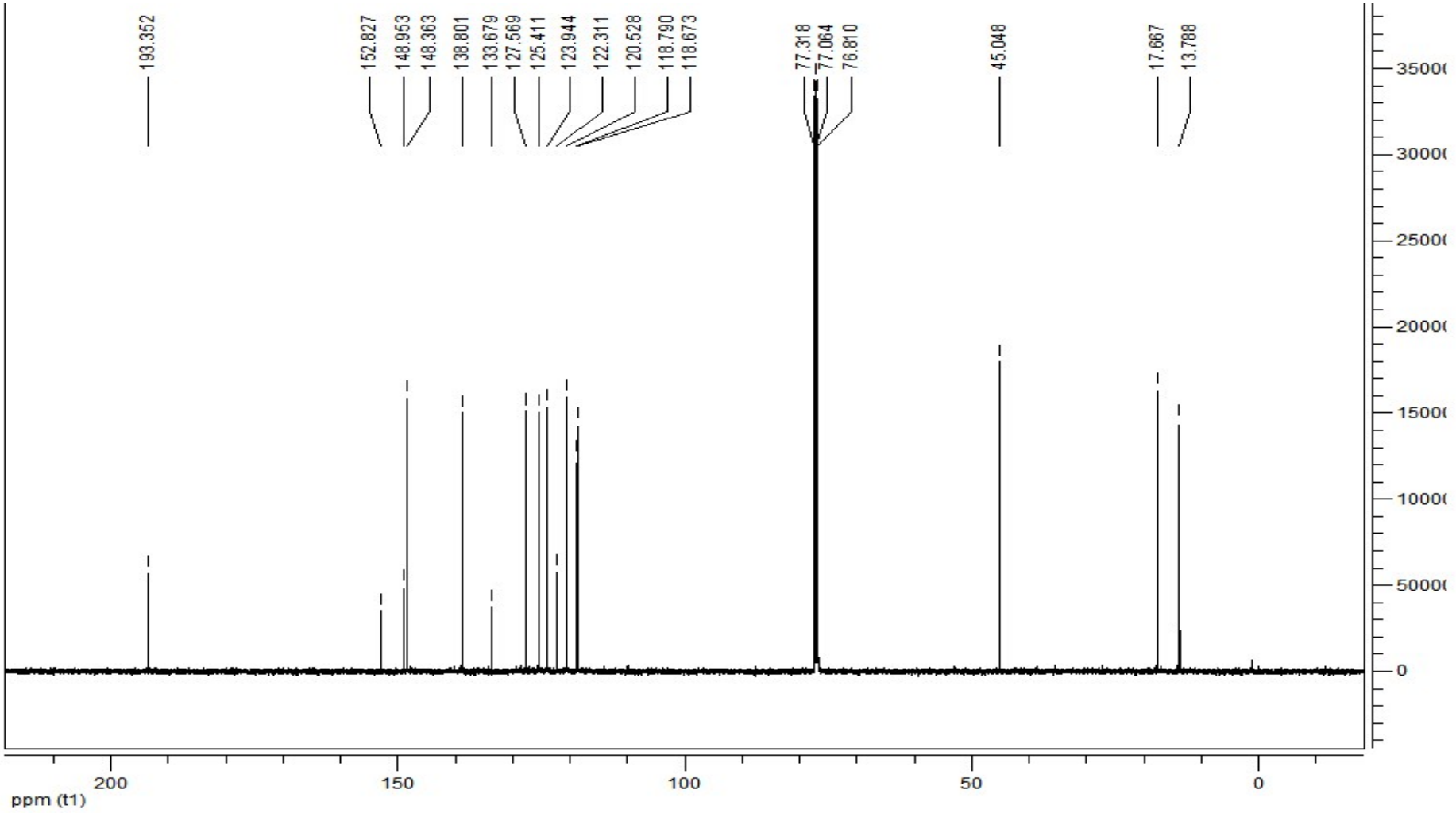

7.528
7.524
7.517
7.505
7.503
7.496
7.492
7.455
7.450
7.446
7.443
7.439
7.436
7.283
7.263
7.075
6.049
2.663
2.649
2.634
1.710
1.696
1.681
1.666
1.652
1.637
1.621
1.443
0.902
0.887
0.872
2.85
1.00
0.94
0.85
1.89
1.93
1.99
3.00
10.0
5.0
0.0
ppm (t1)
7.70 7.60 7.50 7.40 7.30 7.20 7.10 7.00 6.90
ppm (t1)


191.130
149.513
148.840
145.985
141.457
133.150
129.144
129.068
126.120
119.979
101.569
96.254
94.904
77.316
77.062
76.808
44.108
17.503
13.738
4000
3000
2000
1000
0
200
150
100
50
0
ppm (t1)

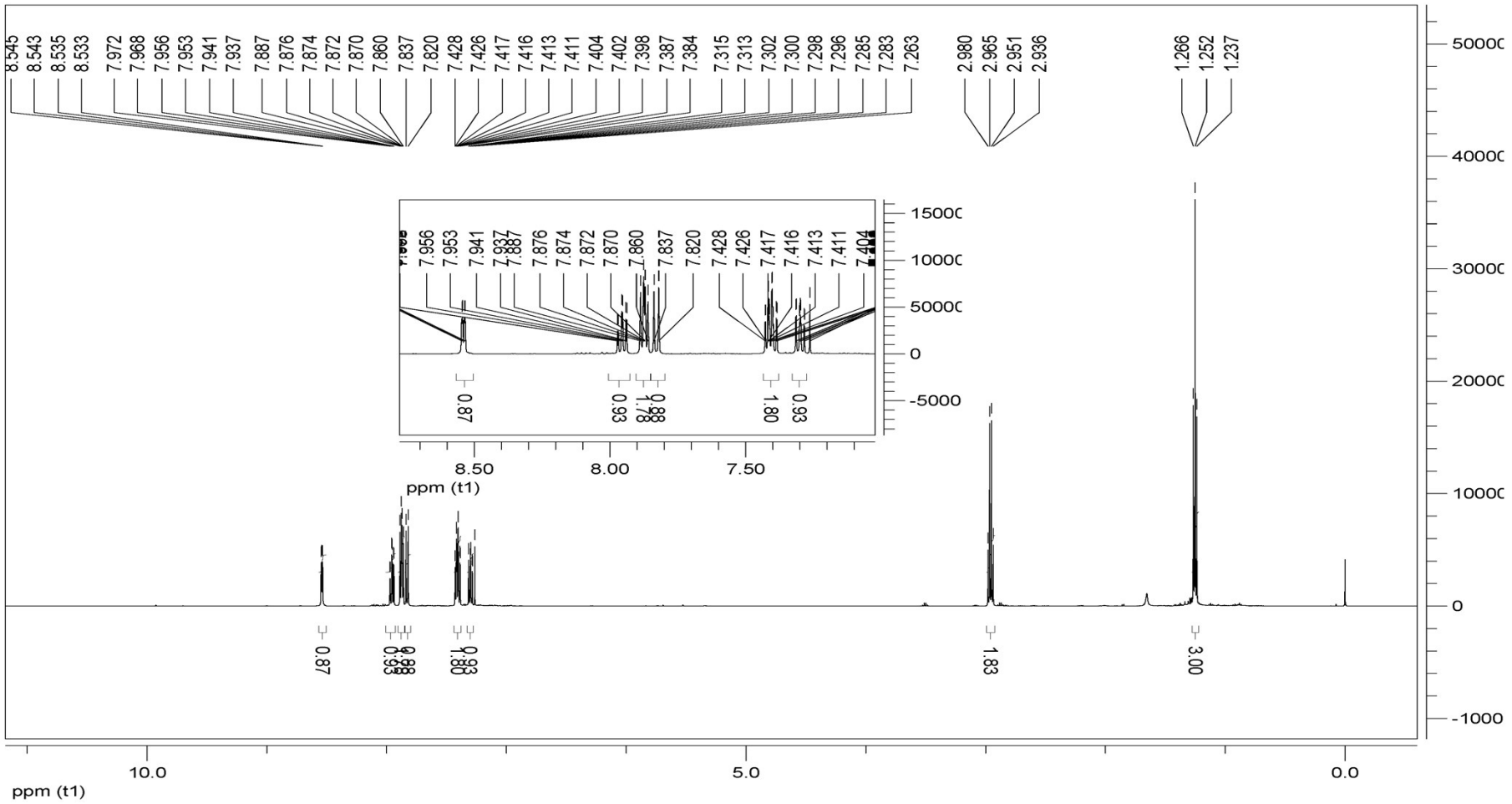

O
N
N
N

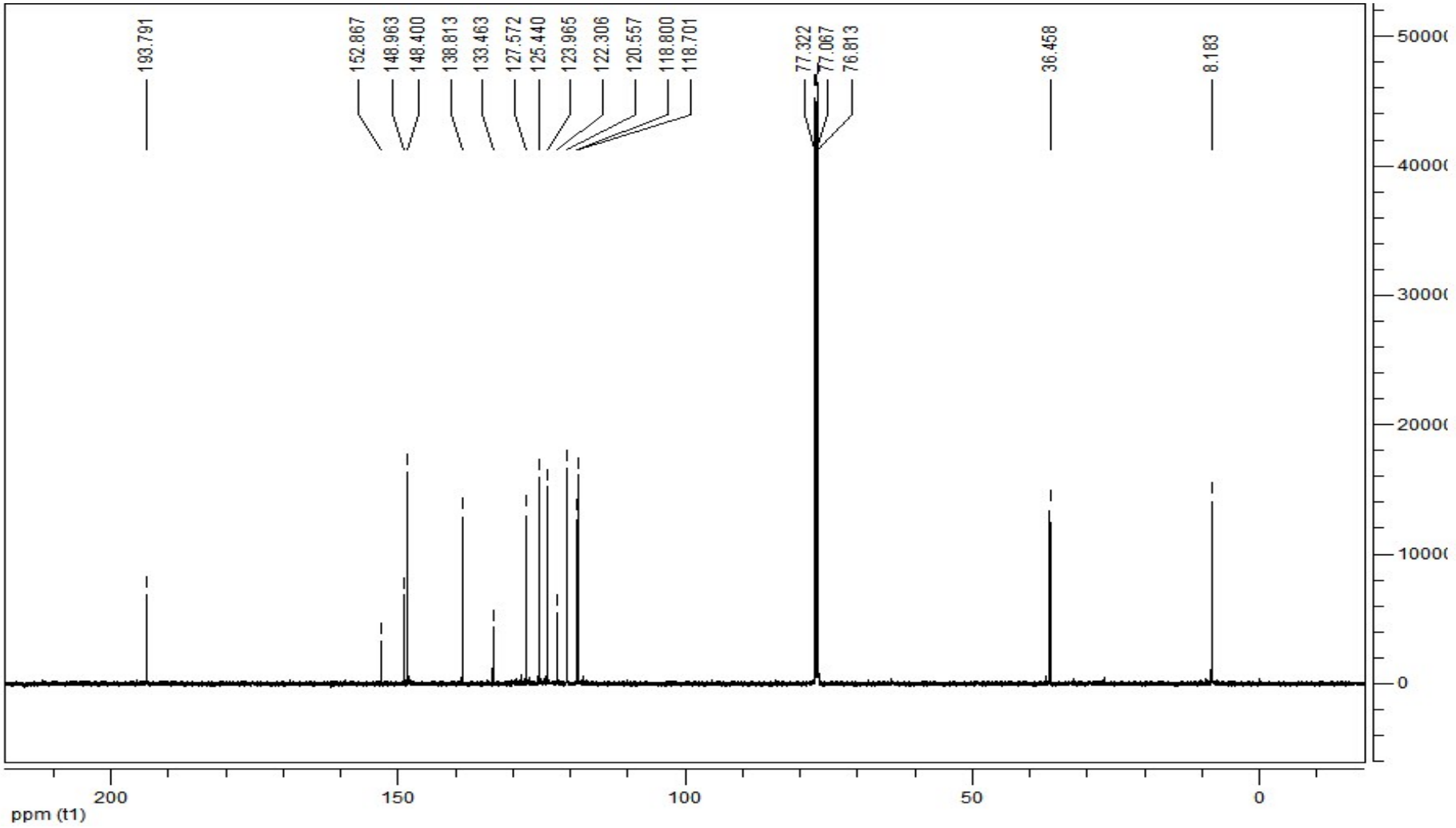
4f


8.538
8.536
8.528
8.526
7.975
7.972
7.960
7.956
7.945
7.941
7.883
7.866
7.837
7.820
7.429
7.427
7.417
7.415
7.412
7.405
7.403
7.399
7.388
7.386
7.317
7.315
7.303
7.302
7.300
7.298
7.286
7.285
7.263
2.931
2.917
2.902
1.810
1.796
1.619
1.006
0.991
0.976
0.90
1.82
1.87
0.96
1.86
2.01
3.00
8.50
8.00
7.50
ppm (t1)
10.0
5.0
0.0
ppm (t1)


193.352
152.827
148.953
148.363
138.801
133.679
127.569
125.411
123.944
122.311
120.528
118.790
118.673
77.318
77.064
76.810
45.048
17.667
13.788
3500
3000
2500
2000
1500
1000
5000
0
200
150
100
50
0
ppm (t1)

4g


8.545
8.543
8.535
8.533
7.972
7.968
7.956
7.953
7.941
7.937
7.887
7.876
7.874
7.872
7.870
7.860
7.837
7.820
7.428
7.426
7.417
7.416
7.413
7.411
7.404
7.402
7.398
7.387
7.384
7.315
7.313
7.302
7.300
7.298
7.296
7.285
7.283
7.263
2.980
2.965
2.951
2.936
1.266
1.252
1.237
0.87
0.93
1.78
1.80
0.93
1.83
3.00
ppm (t1)
10.0
5.0
0.0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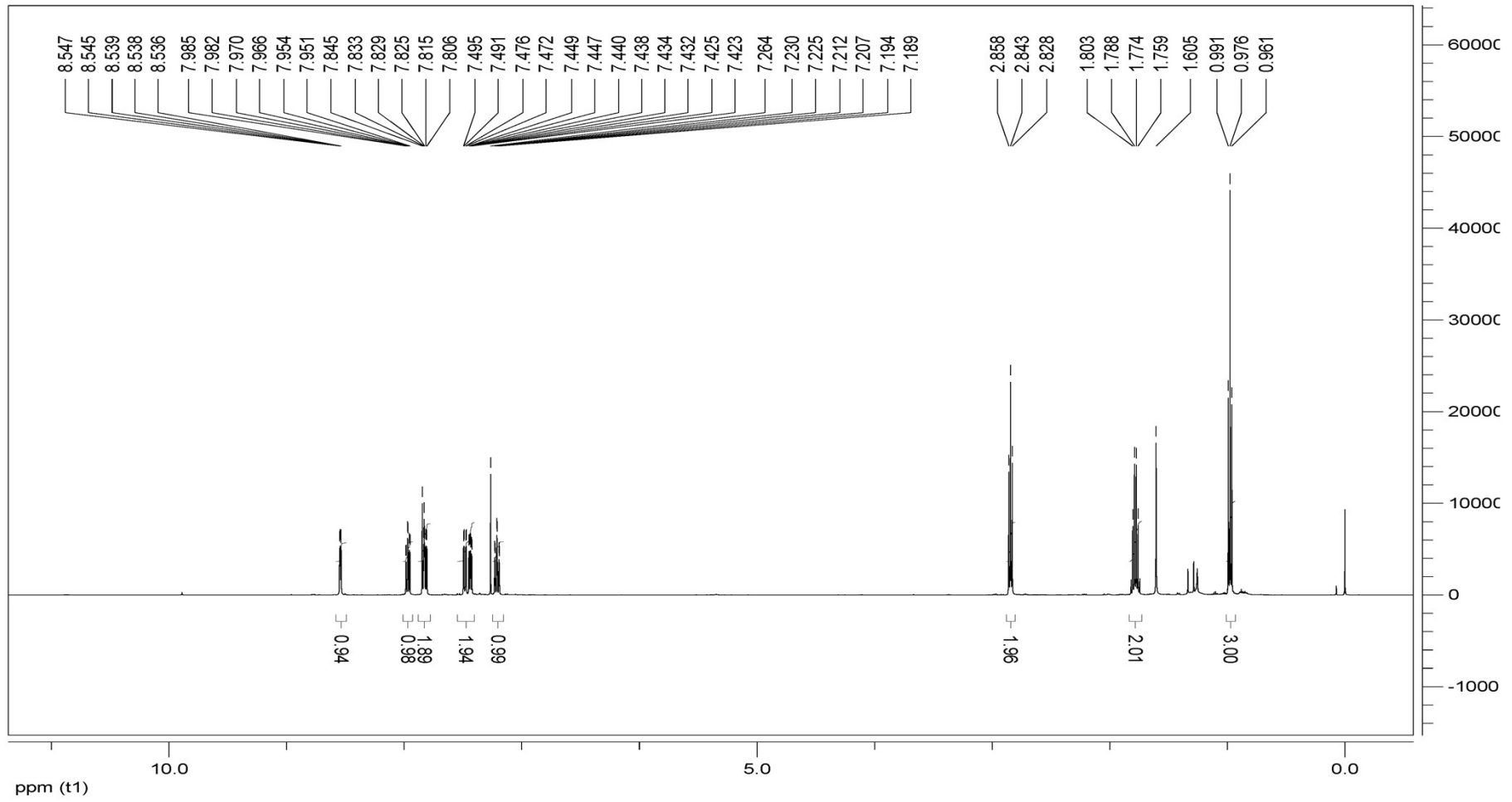
152.867
148.963
148.400
138.813
133.463
127.572
125.440
123.965
122.306
120.557
118.800
118.701
77.322
77.067
76.813
36.458
8.183
5000(
4000(
3000(
2000(
1000(
0
200
150
100
50
0
ppm (t1)

4h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8.545
8.539
8.538
8.536
7.985
7.982
7.970
7.966
7.954
7.951
7.845
7.833
7.829
7.825
7.815
7.806
7.495
7.491
7.476
7.472
7.449
7.447
7.440
7.438
7.434
7.432
7.425
7.423
7.264
7.230
7.225
7.212
7.207
7.194
7.189
2.858
2.843
2.828
1.803
1.788
1.774
1.759
1.605
0.991
0.976
0.961
0.94
0.98
1.89
1.94
0.99
1.96
2.01
3.00
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50000
40000
30000
20000
10000
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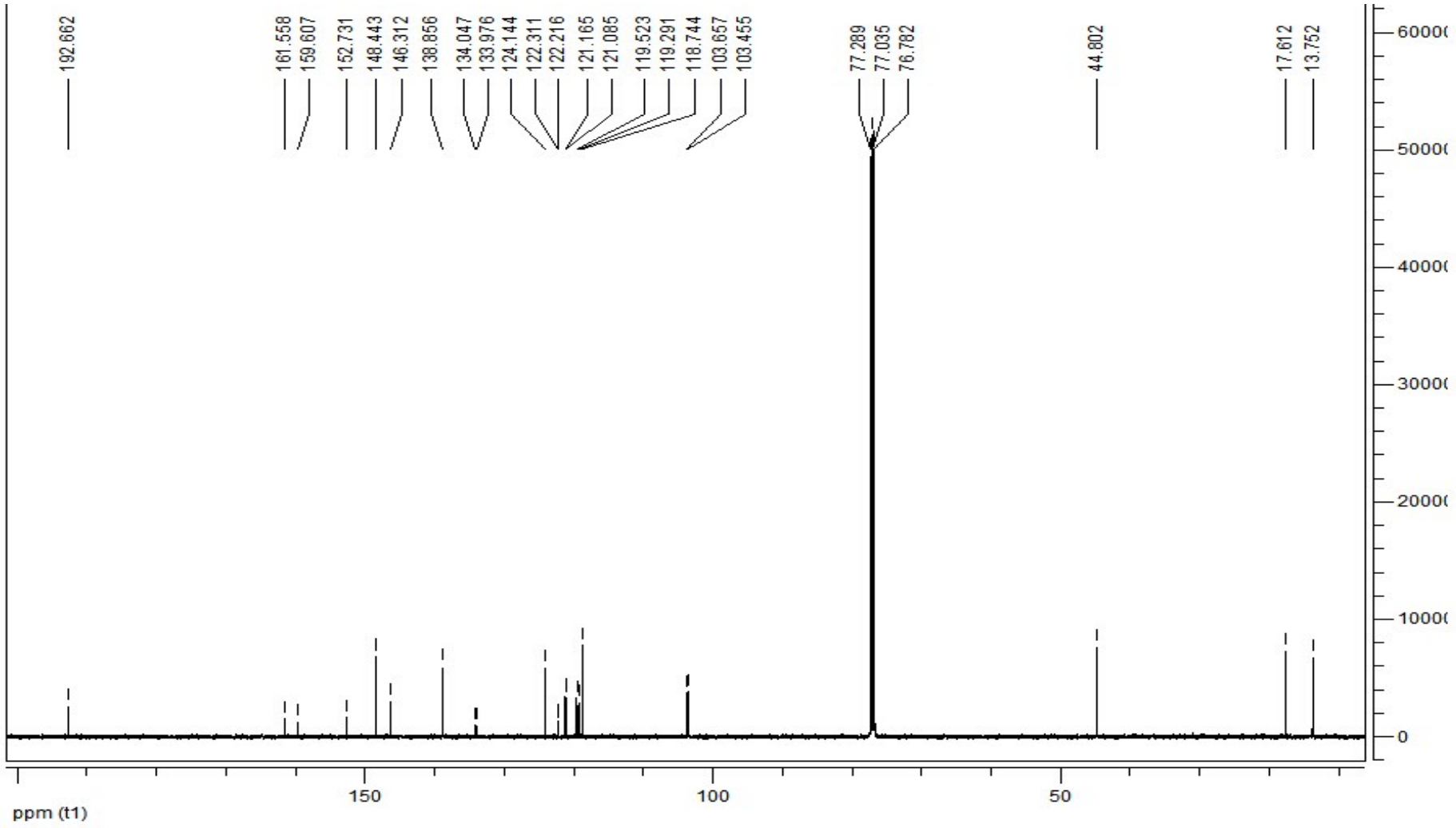
-1000
10.0
5.0
0.0
ppm (t1)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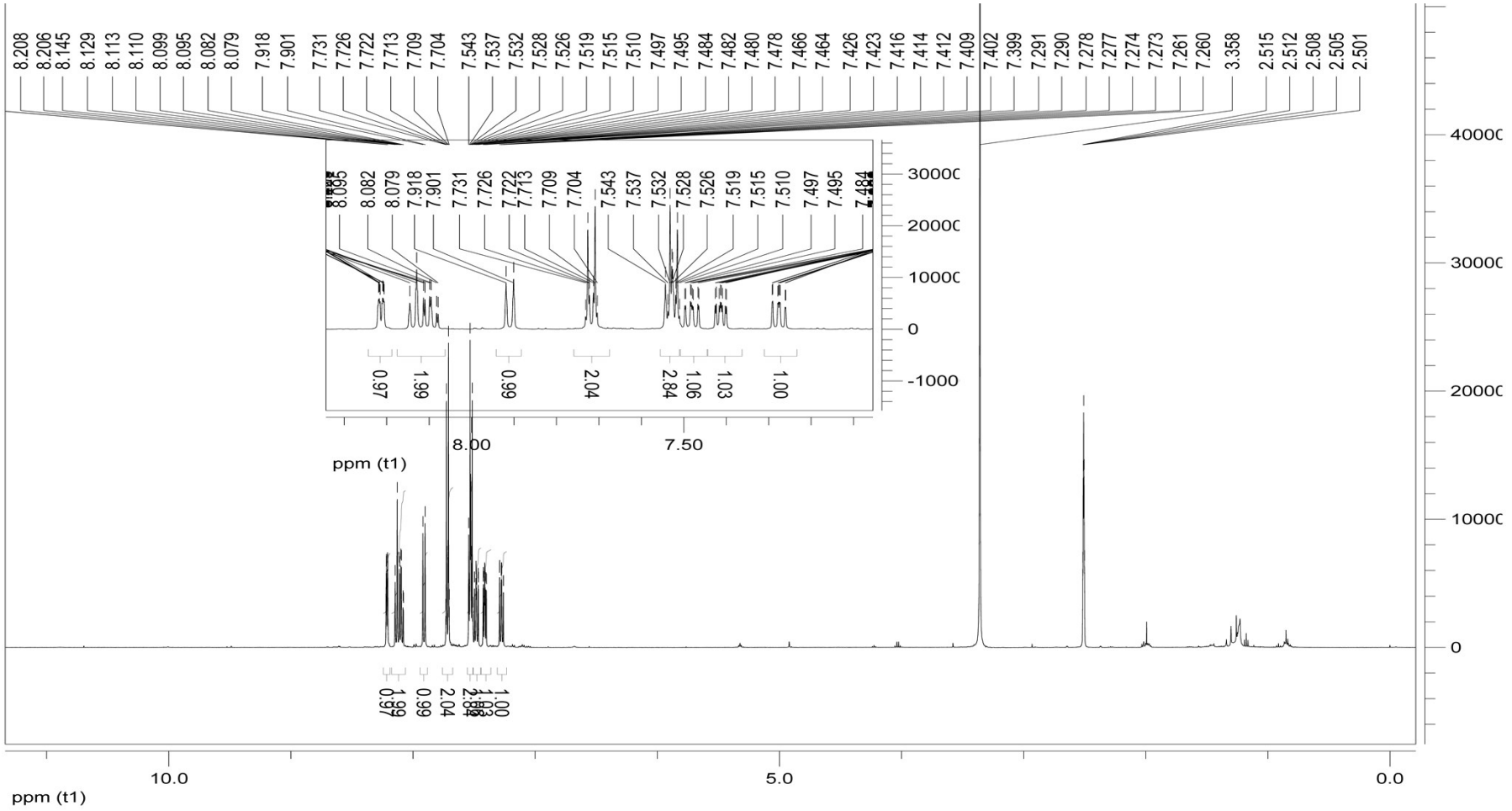
161.558
159.607
152.731
148.443
146.312
138.856
134.047
133.976
124.144
122.311
122.216
121.165
121.085
119.523
119.291
118.744
103.657
103.455
77.289
77.035
76.782
44.802
17.612
13.752
6000
5000
4000
3000
2000
1000
0
150
100
50
ppm (t1)

4i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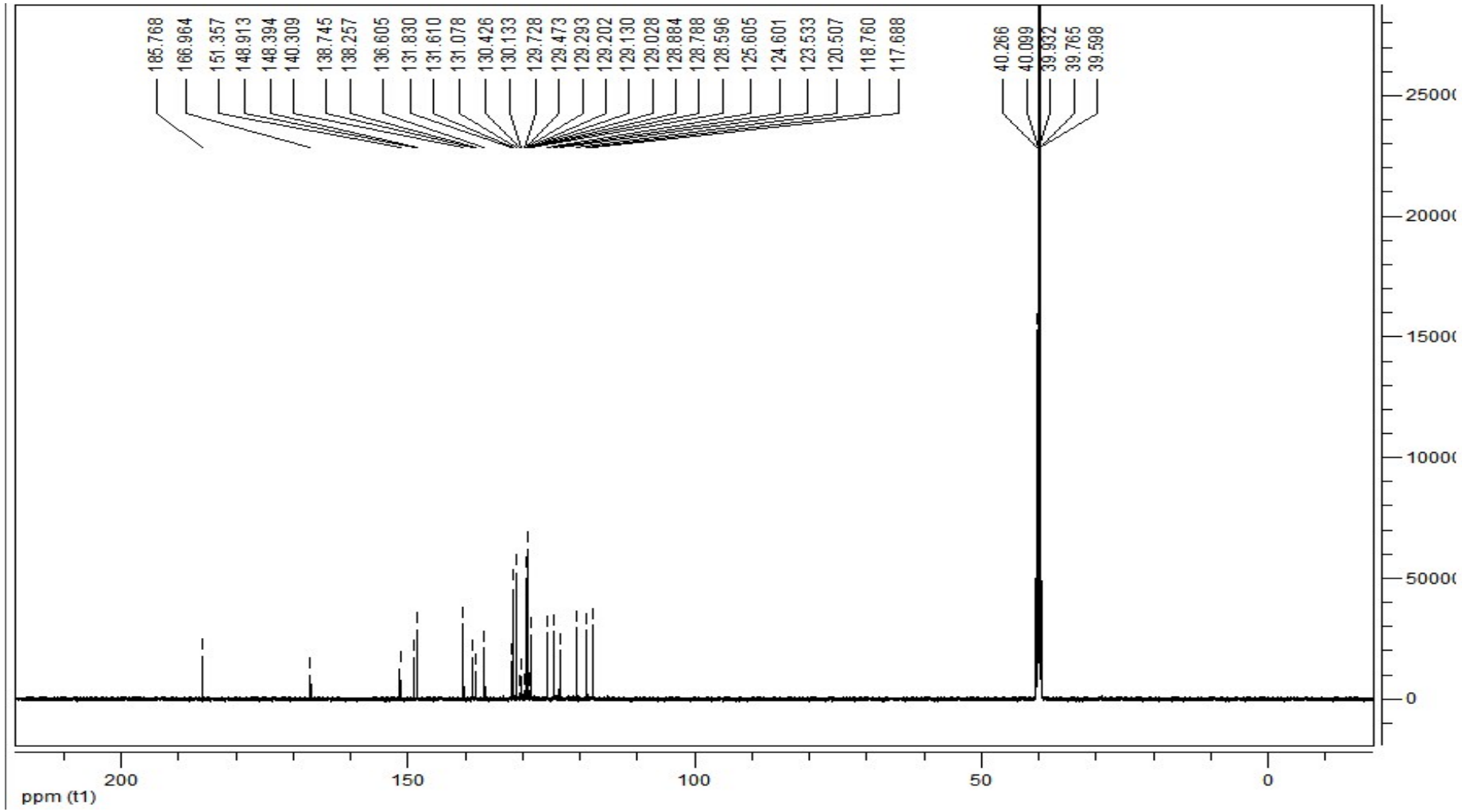
8.206
8.145
8.129
8.113
8.110
8.099
8.095
8.082
8.079
7.918
7.901
7.731
7.726
7.722
7.713
7.709
7.704
7.543
7.537
7.532
7.528
7.526
7.519
7.515
7.510
7.497
7.495
7.484
7.482
7.480
7.478
7.466
7.464
7.426
7.423
7.416
7.414
7.412
7.409
7.402
7.399
7.291
7.290
7.278
7.277
7.274
7.273
7.261
7.260
3.358
2.515
2.512
2.508
2.505
2.501
0.97
1.99
0.99
2.04
2.84
1.06
1.03
1.00
8.00
7.50
ppm (t1)
10.0
5.0
0.0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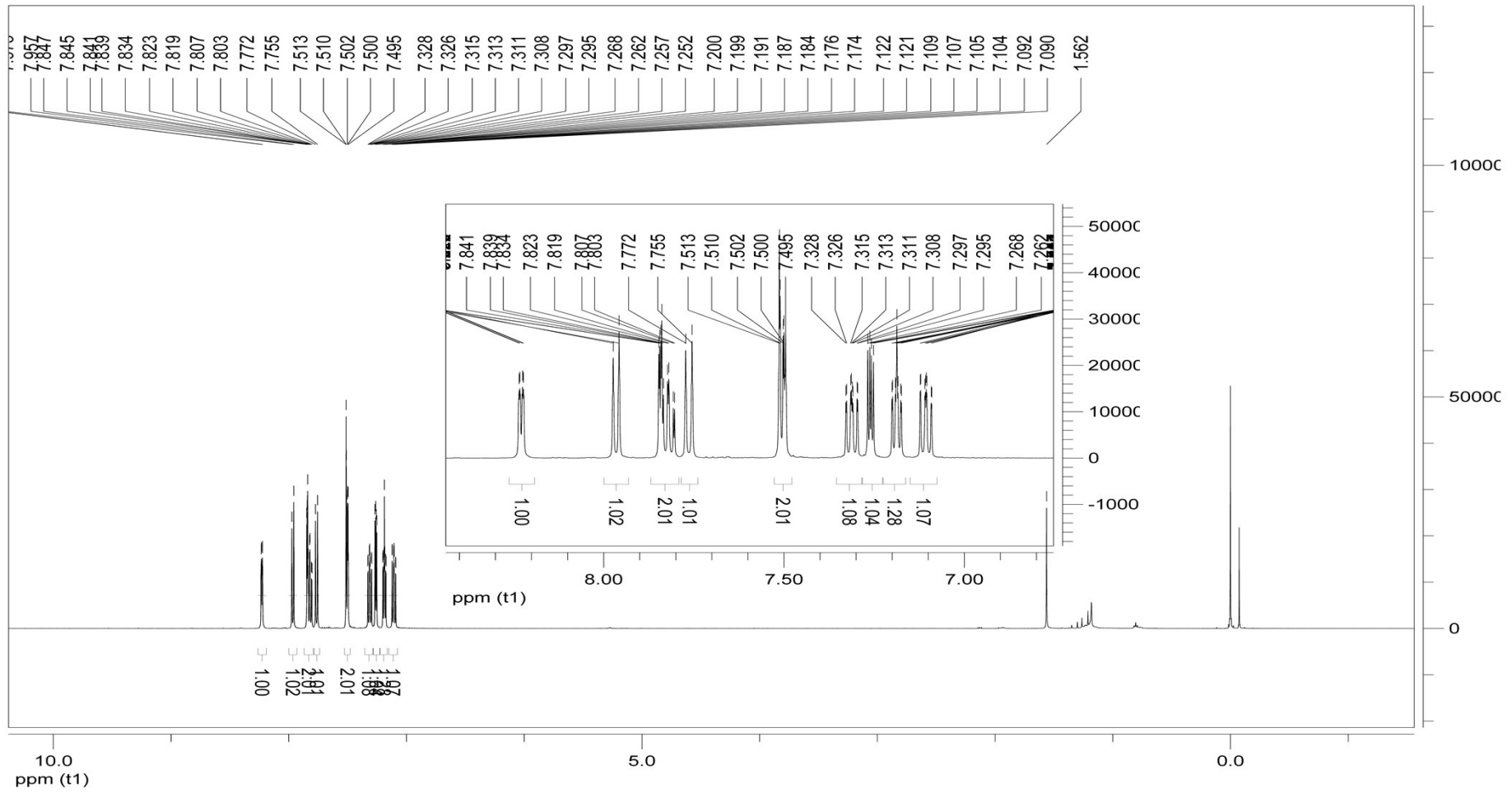
166.964
151.357
148.913
148.394
140.309
138.745
138.257
136.605
131.830
131.610
131.078
130.426
130.133
129.728
129.473
129.293
129.202
129.130
129.028
128.884
128.788
128.596
125.605
124.601
123.533
120.507
118.760
117.688
40.266
40.099
39.932
39.765
39.598
25000
20000
15000
10000
5000
0
200
150
100
50
0
ppm (t1)

4j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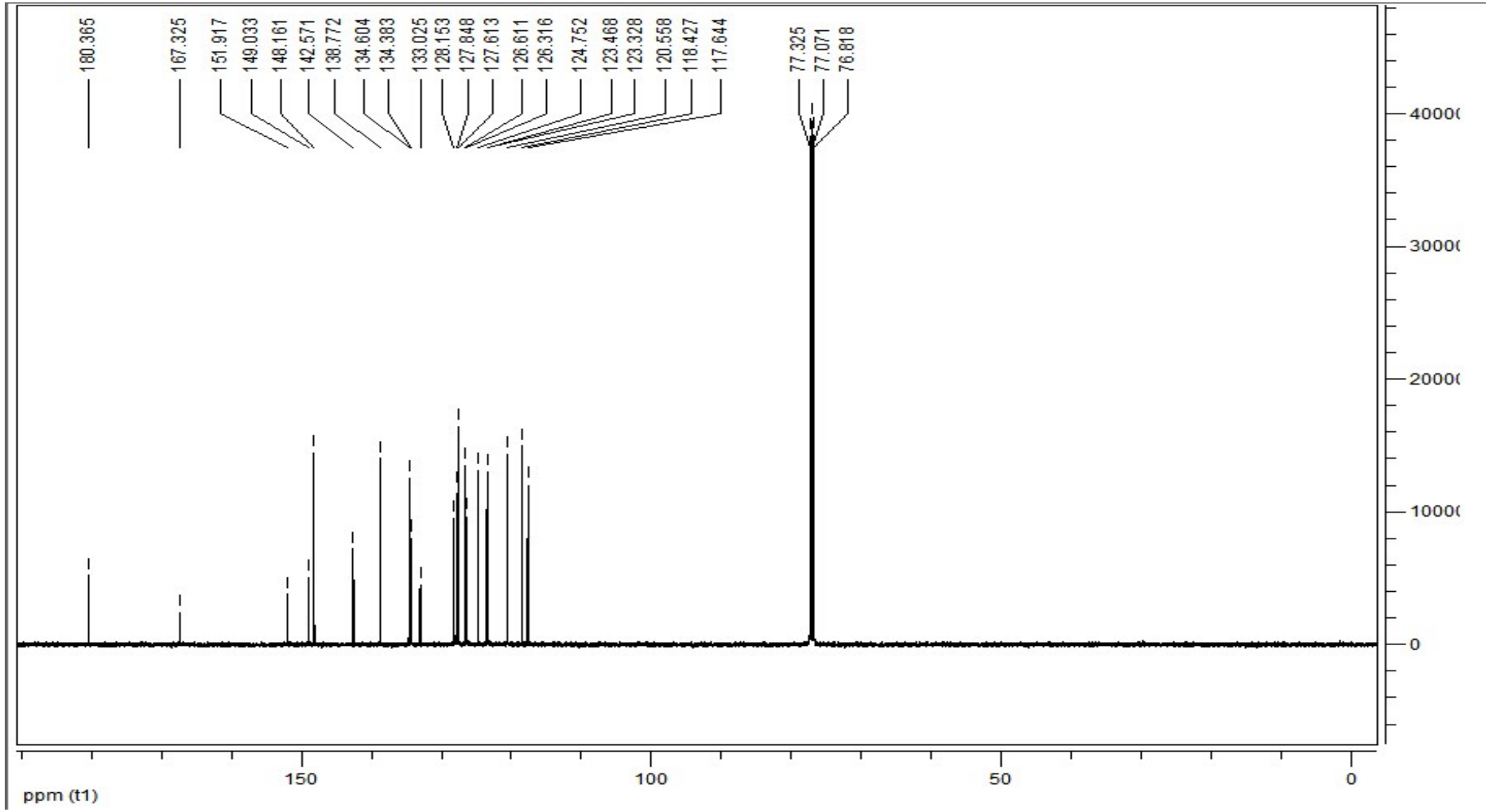
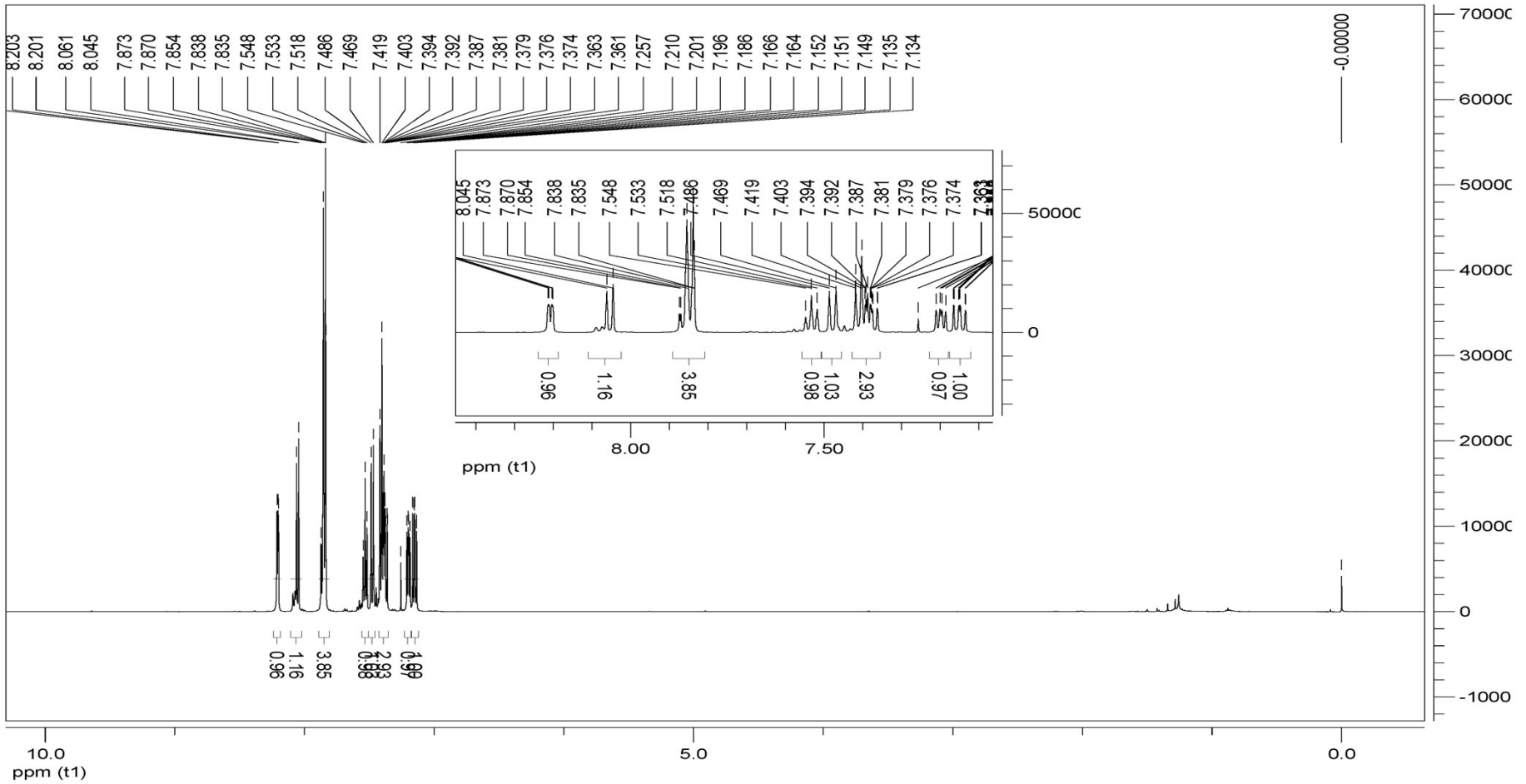
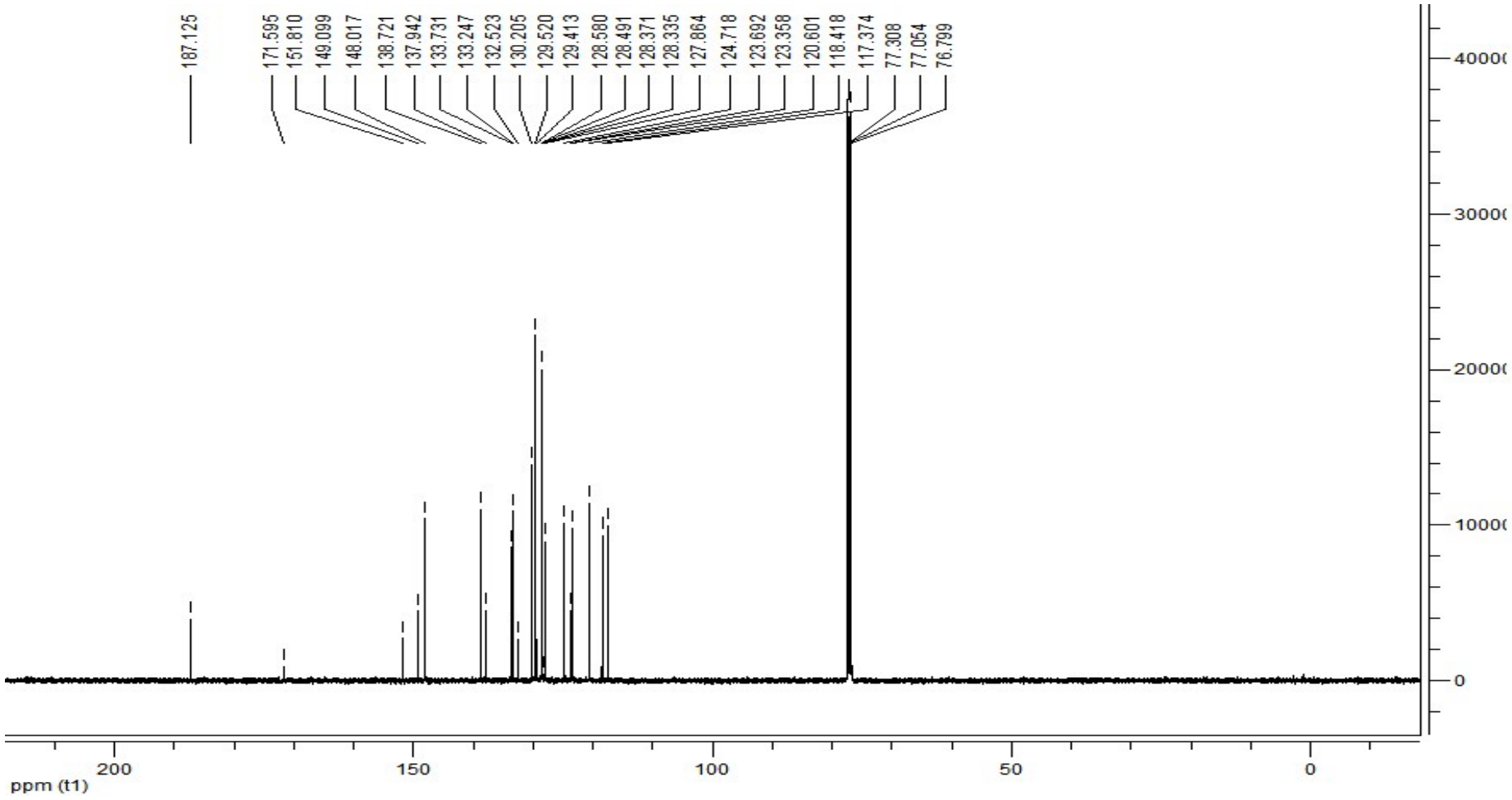
7.847
7.845
7.841
7.839
7.834
7.823
7.819
7.807
7.803
7.772
7.755
7.513
7.510
7.502
7.500
7.495
7.328
7.326
7.315
7.313
7.311
7.308
7.297
7.295
7.268
7.262
7.257
7.252
7.200
7.199
7.191
7.187
7.184
7.176
7.174
7.122
7.121
7.109
7.107
7.105
7.104
7.092
7.090
1.562
1.00
1.02
2.01
1.01
2.01
1.08
1.04
1.28
1.07
8.00
7.50
7.00
ppm (t1)
10.0
5.0
0.0
ppm (t1)

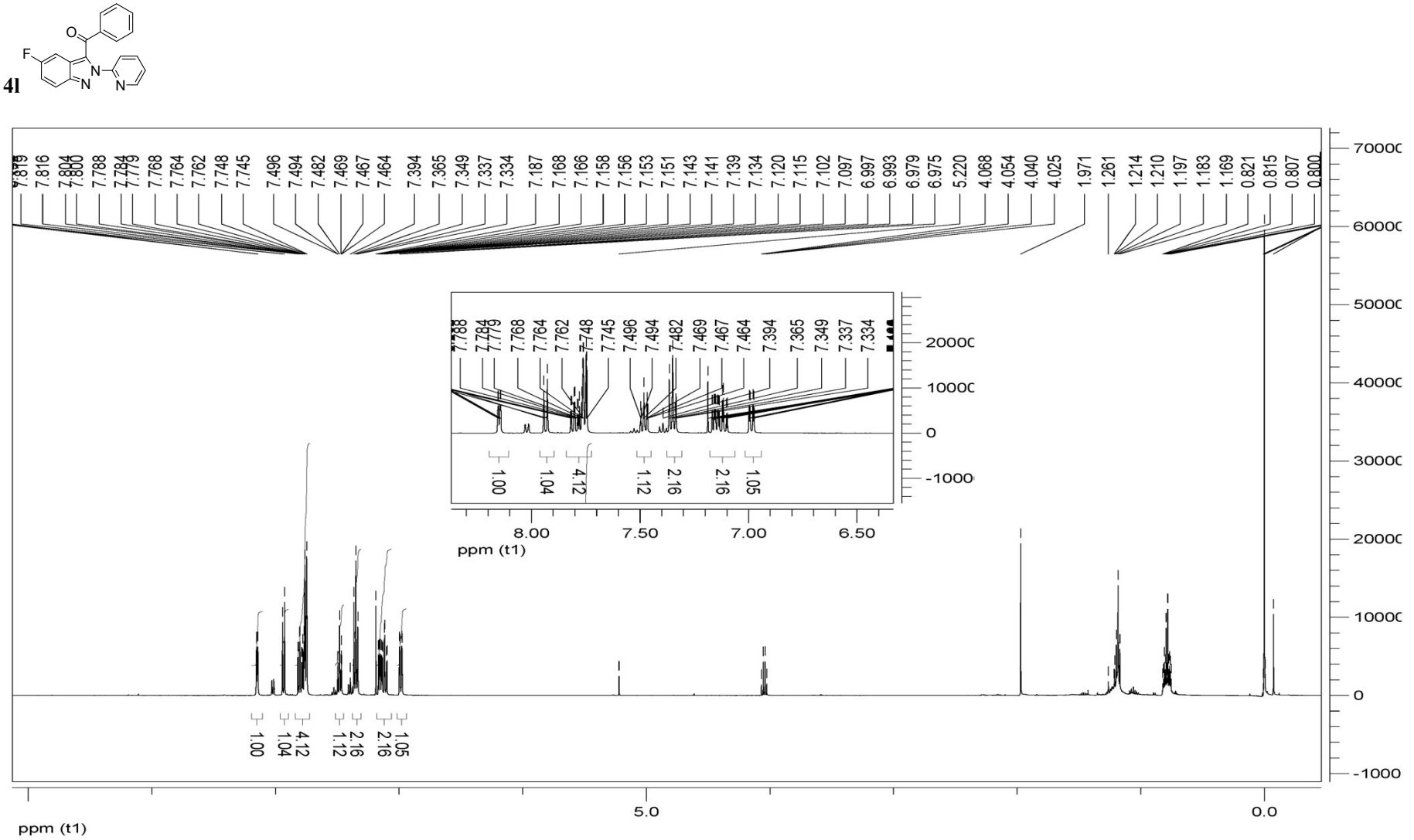

180.365
167.325
151.917
149.033
148.161
142.571
138.772
134.604
134.383
133.025
128.153
127.848
127.613
126.611
126.316
124.752
123.468
123.328
120.558
118.427
117.644
77.325
77.071
76.818
40000
30000
20000
10000
0
150
100
50
0
ppm (t1)

4k


8.203
8.201
8.061
8.045
7.873
7.870
7.854
7.838
7.835
7.548
7.533
7.518
7.486
7.469
7.419
7.403
7.394
7.392
7.387
7.381
7.379
7.376
7.374
7.363
7.361
7.257
7.210
7.201
7.196
7.186
7.166
7.164
7.152
7.151
7.149
7.135
7.134
-0.00000
0.96
1.16
3.85
0.98
1.03
2.93
0.97
1.00
8.00
7.50
ppm (t1)
10.0
5.0
0.0
ppm (t1)


187.125
171.595
151.810
149.099
148.017
138.721
137.942
133.731
133.247
132.523
130.205
129.520
129.413
128.580
128.491
128.371
128.335
127.864
124.718
123.692
123.358
120.601
118.418
117.374
77.308
77.054
76.799
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)

4l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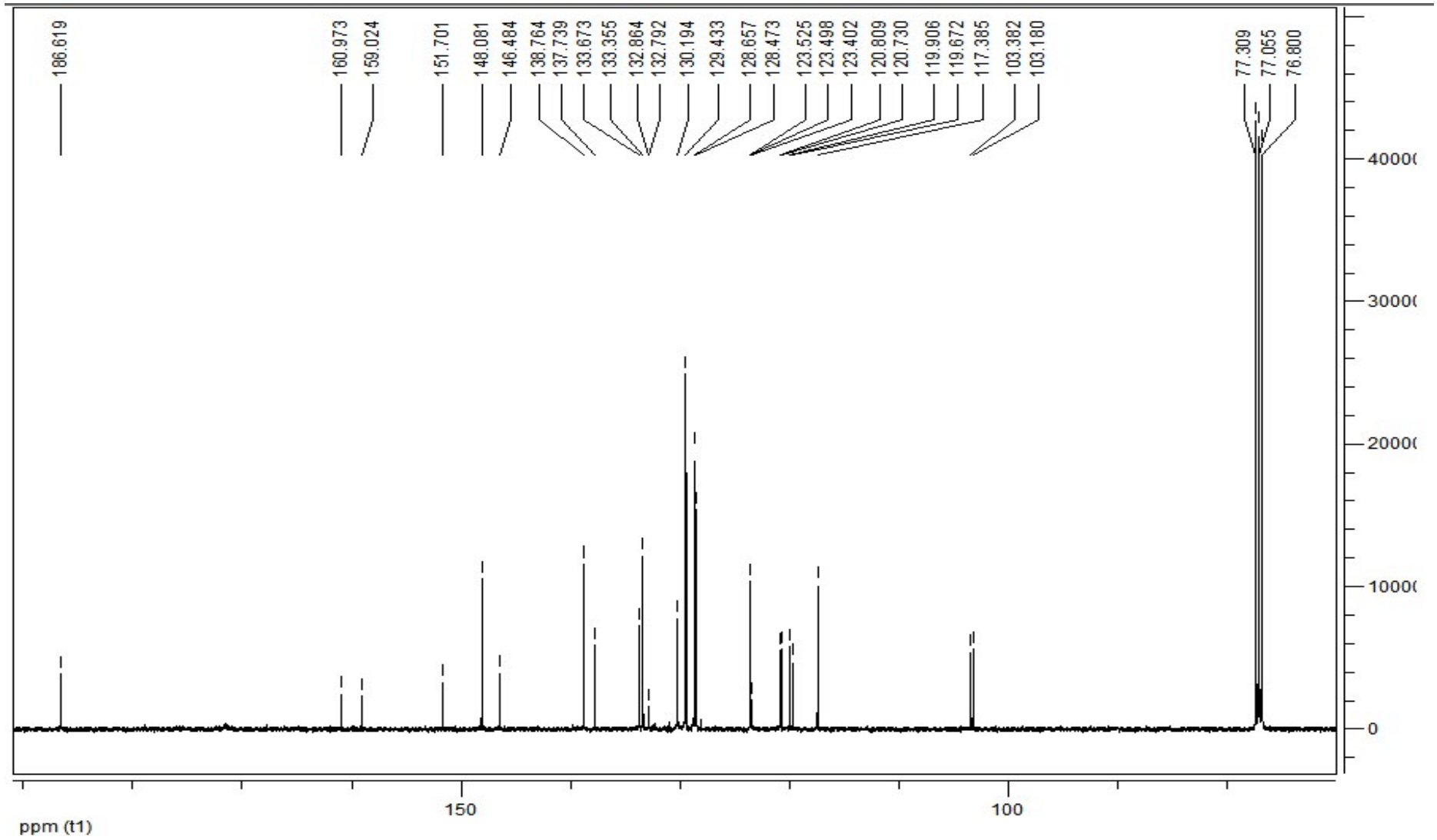
7.804
7.800
7.788
7.784
7.779
7.768
7.764
7.762
7.748
7.745
7.496
7.494
7.482
7.469
7.467
7.464
7.394
7.365
7.349
7.337
7.334
7.187
7.168
7.166
7.158
7.156
7.153
7.151
7.143
7.141
7.139
7.134
7.120
7.115
7.102
7.097
6.997
6.993
6.979
6.975
5.220
4.068
4.054
4.040
4.025
1.971
1.261
1.214
1.210
1.197
1.183
1.169
0.821
0.815
0.807
0.800
1.00
1.04
4.12
1.12
2.16
2.16
1.05
ppm (t1)
8.00
7.50
7.00
6.50
5.0
0.0
70000
60000
50000
40000
30000
20000
10000
0
-10000
20000
10000
0
-10000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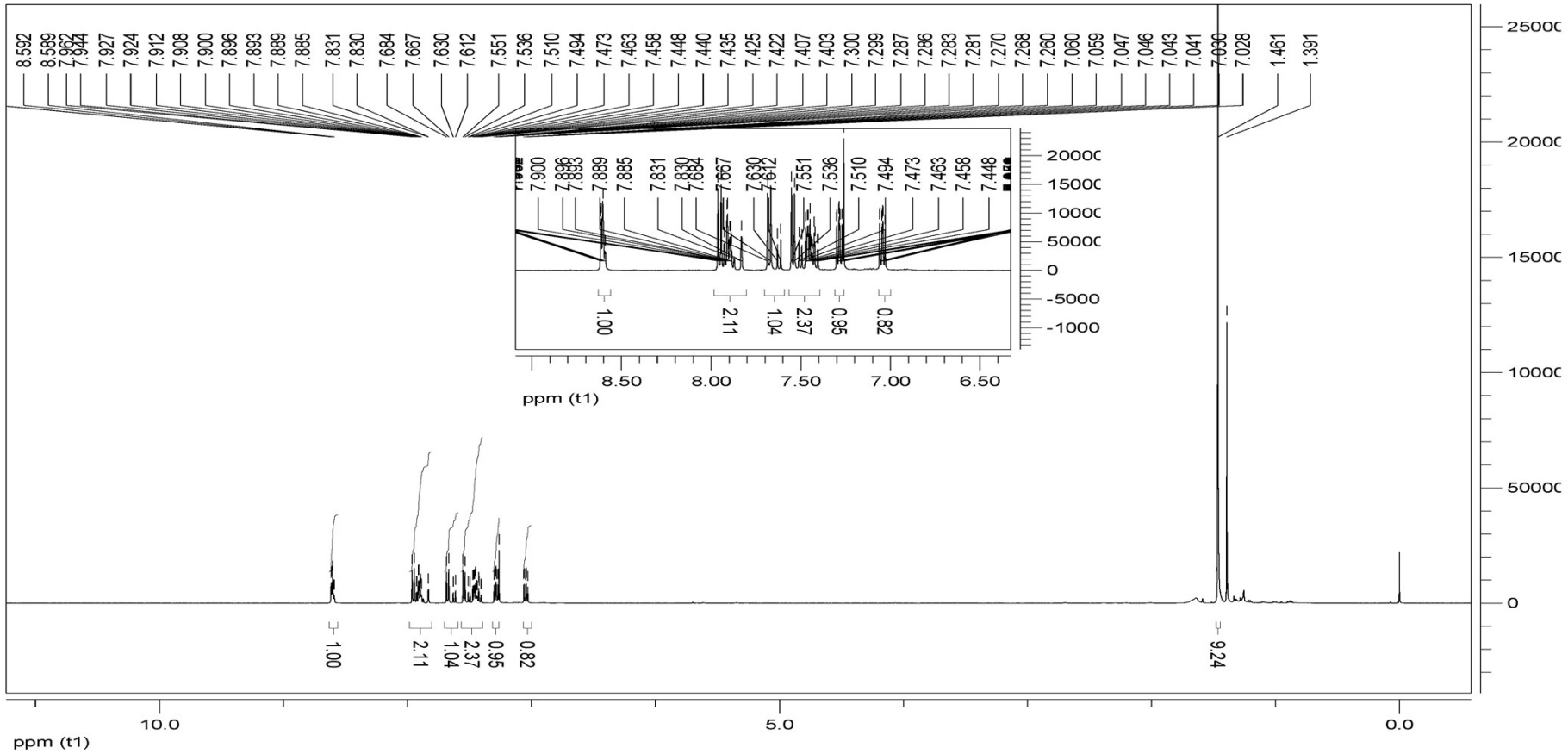
159.024
151.701
148.081
146.484
138.764
137.739
133.673
133.355
132.864
132.792
130.194
129.433
128.657
128.473
123.525
123.498
123.402
120.809
120.730
119.906
119.672
117.385
103.382
103.180
77.309
77.055
76.800
40000
30000
20000
10000
0
150
100
ppm (t1)

4m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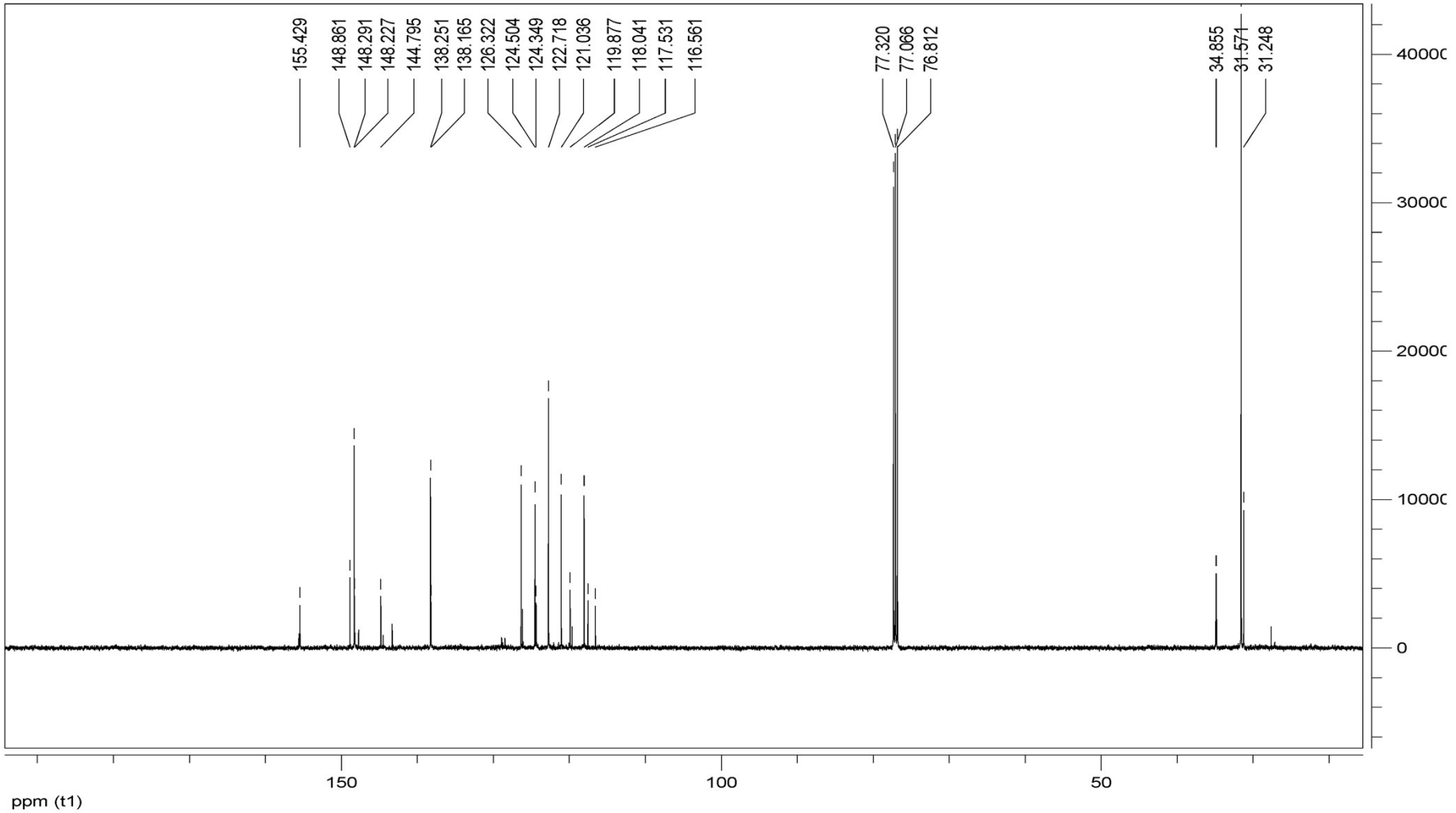
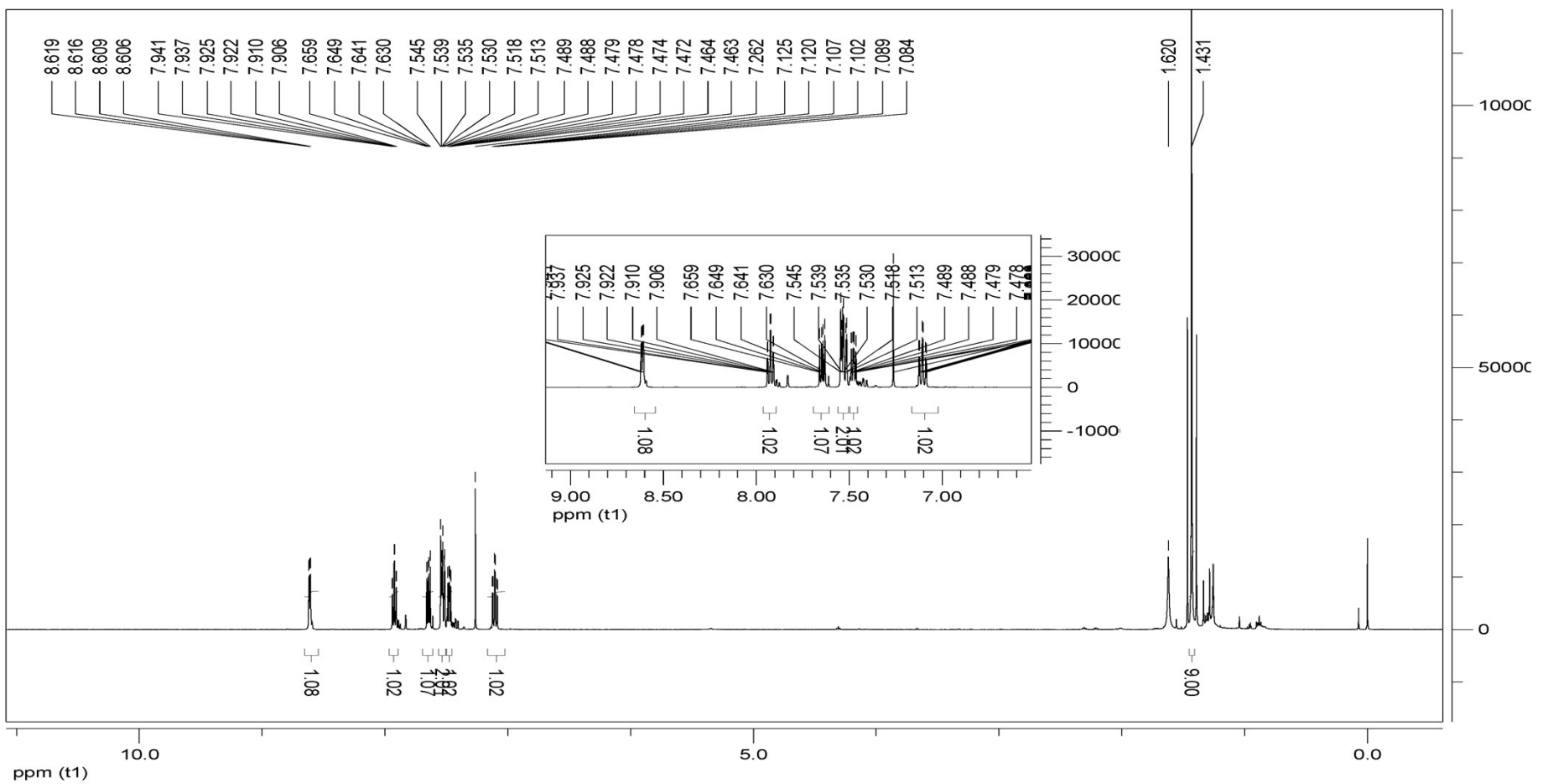
8.589
7.962
7.944
7.927
7.924
7.912
7.908
7.900
7.896
7.893
7.889
7.885
7.831
7.830
7.684
7.667
7.630
7.612
7.551
7.536
7.510
7.494
7.473
7.463
7.458
7.448
7.440
7.435
7.425
7.422
7.407
7.403
7.300
7.299
7.287
7.286
7.283
7.281
7.270
7.268
7.260
7.060
7.059
7.047
7.046
7.043
7.041
7.030
7.028
1.461
1.391
1.00
2.11
1.04
2.37
0.96
0.82
9.24
ppm (t1)
10.0
5.0
0.0
8.50
8.00
7.50
7.00
6.50


155.429
148.861
148.291
148.227
144.795
138.251
138.165
126.322
124.504
124.349
122.718
121.036
119.877
118.041
117.531
116.561
77.320
77.066
76.812
34.855
31.571
31.248
40000
30000
20000
10000
0
150
100
50
ppm (t1)

4n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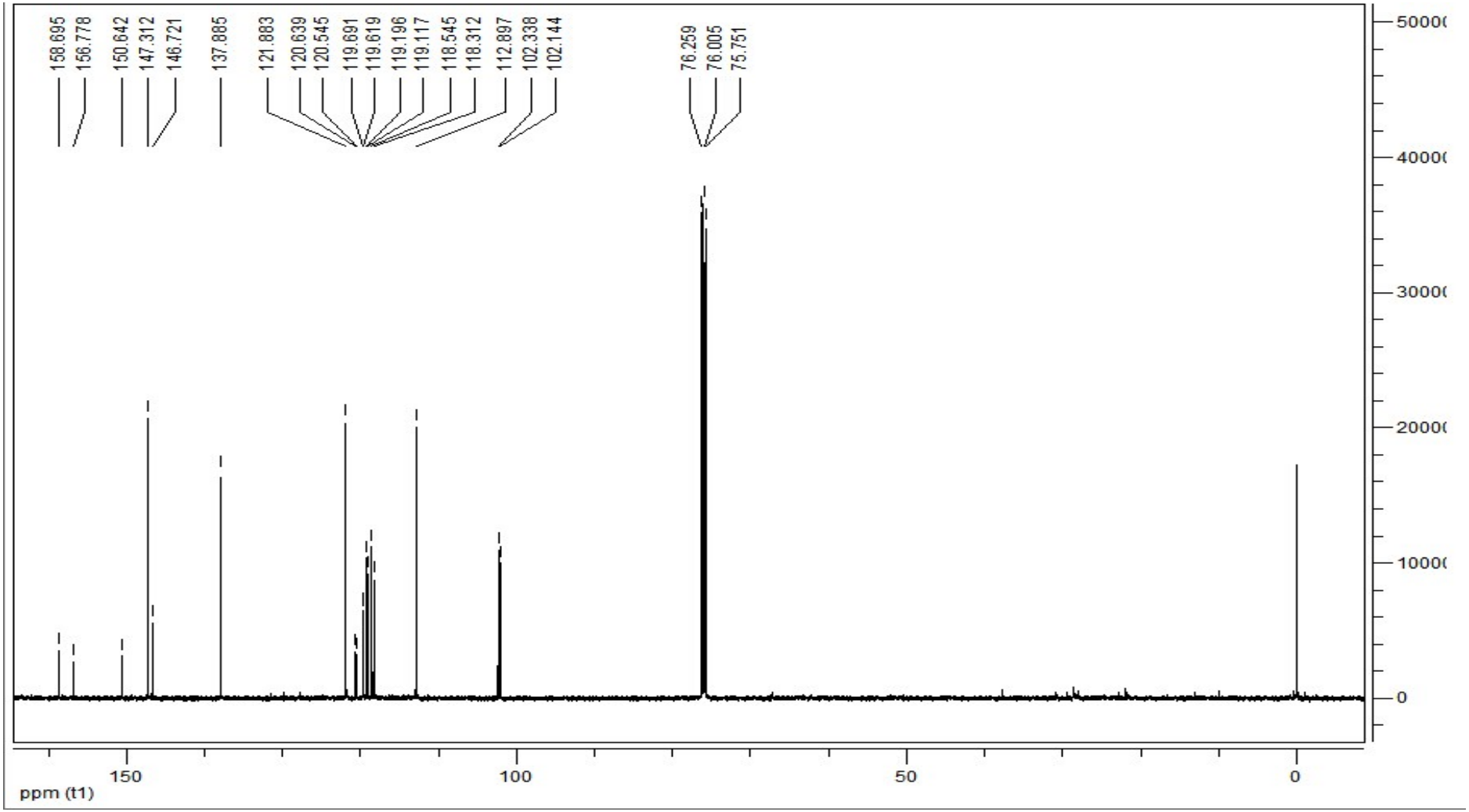
8.609
8.606
7.941
7.937
7.925
7.922
7.910
7.906
7.659
7.649
7.641
7.630
7.545
7.539
7.535
7.530
7.518
7.513
7.489
7.488
7.479
7.478
7.474
7.472
7.464
7.463
7.262
7.125
7.120
7.107
7.102
7.089
7.084
1.620
1.431
1.08
1.02
1.07
1.02
9.00
10.0
5.0
0.0
ppm (t1)
9.00
8.50
8.00
7.50
7.00
ppm (t1)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156.778
150.642
147.312
146.721
137.885
121.883
120.639
120.545
119.691
119.619
119.196
119.117
118.545
118.312
112.897
102.338
102.144
76.259
76.005
75.751
50000
40000
30000
20000
10000
0
150
100
50
0
ppm (t1)