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SUPPORTING INFORMATION

Title: The Formation of Cyclopropane Derivatives Bearing 1,2-Dicarbonyl Groups through Tandem Michael–Favorskii-Type Reactions with (*E*)-β-Styrylselenonium Triflate
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Ref. No.: O04756

General. Melting points were obtained with a Yanagimoto micro-melting-point apparatus and are uncorrected. IR spectra of solids (KBr) and liquids (NaCl) were recorded on a JASCO FT/IR-230 spectrophotometer. ^{1}HNMR spectra were recorded on a JEOL EX-400 (400 MHz) spectrometer with tetramethylsilane as an internal standard. ^{13}CNMR spectra were obtained on a JEOL EX-400 (100 MHz) spectrometer with chloroform as an internal standard. The *J* values are given in Hz. Mass spectra (MS and HRMS) were recorded on a JEOL JMS-SX102A spectrometer with an electron impact (EI, 70 eV) or fast atom bombardment (FAB, glycerol or 3-nitrobenzylalcohol) techniques. Elemental analyses of new compounds were performed by a Yanaco CHN Corder MT-5. All chromatographic isolations were accomplished with Kieselgel 60 PF_{254} containing gypsum (Merck) for preparative TLC. Organic solvents used were dried by standard methods. All active methylene compounds were purchased from commercial sources and were used without further purification.

1-[(1*R, 2*S**, 3*R**)-2-Benzoyl-3-phenylcyclopropyl]ethanone** (**2a**) [1]:

Pale yellow crystals, mp 98-99°C; IR (NaCl)/cm^{-1} 1704, 1680; ^{1}H NMR ($CDCl_3$) δ: 2.32 (s, 3 H, CH_3), 2.8 (dd, *J* = 6.0, 9.3, 1 H, CH), 3.2 (dd, *J* = 6.0, 9.3, 1 H, CH), 3.36 (t, *J* = 6.0, 1 H, CH), 7.22 (d, *J* = 8.0, 2 H, ArH), 7.27 (t, *J* = 8.0, 1 H, ArH), 7.36 (d, *J* = 8.0, 2 H, ArH), 7.46 (d, *J* = 8.0, 2 H, ArH), 7.56 (t, *J* = 8.0, 1 H, ArH), 7.98 (d, *J* = 8.0, 2 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 30.8, 31.0, 37.1, 39.5, 126.4, 127.1, 128.1, 128.6, 133.3, 136.9, 138.2, 194.1, 202.9; MS (FAB) *m/z* 265 $(M+H)^+$; Anal. Calcd for $C_{18}H_{16}O_2$: C, 81.79; H, 6.10. Found: C, 81.74; H, 6.21.

1-[(1*R, 2*R**, 3*S**)-2-Benzoyl-3-phenylcyclopropyl]ethanone** (**3a**) [1]:

Pale yellow crystals, mp 98-100°C; IR (NaCl)/cm^{-1} 1705, 1670; ^{1}H NMR ($CDCl_3$) δ: 2.19(s, 3 H, CH_3), 3.17(dd, *J* = 6, 9, 1 H, CH), 3.36 (dd, *J* = 6, 9, 1 H, CH), 4.00 (t, *J* = 6, 1 H, CH), 7.20 - 7.4

(m, 5 H, ArH), 7.52 (t, *J* = 7, 2 H, ArH), 7.63 (t, *J* = 7,1 H, ArH), 8.1 (d, *J* = 7, 2 H, ArH); MS (FAB) *m/z* 265 $(M+H)^+$; HRMS (FAB) Calcd for $C_{18}H_{17}O_2$ $(M+H)^+$ 265.1235. Found: 265.1235.

1-[(1*R, 2*S**, 3*s**)-2-Acetyl-3-phenylcyclopropyl]ethanone (2b)**:

Orange crystals, mp 44.5-45°C; IR (NaCl)/cm^{-1} 1715; ^1H NMR ($CDCl_3$) δ: 2.31 (s, 6 H, CH_3), 2.60, (d, *J* = 6, 2 H, CH), 3.18 (t, *J* = 6, 1 H, CH), 7.13 (d, *J* = 6.8, 2 H, ArH), 7.23 - 7.34 (m, 3 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 31.0, 31.8, 40.1, 126.5, 127.4, 129, 138.4, 203.4; MS (FAB) *m/z* 203 $(M+H)^+$; HRMS (FAB) Calcd for $C_{18}H_{17}O_2$ $([M+H]^+)$ 203.1072. Found: 203.1079.

1-[(1*R, 2*R**, 3*r**)-2-Acetyl-3-phenylcyclopropyl]ethanone (3b)** [2]:

Pale yellow oil; IR (NaCl)/cm^{-1} 1697; ^1H NMR ($CDCl_3$) δ: 2.1(s, 3 H, CH_3), 2.2(s, 3 H, CH_3), 2.96, (dd, *J* = 5, 10, 1 H, CH), 3.12 (dd, *J* = 5, 10, 1 H, CH), 3.28 (t, *J* = 5, 1 H, CH), 7.14 - 7.34 (m, 5 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 31.2, 31.3, 33.1, 36.8, 39.9, 127.3, 128.3, 128.6, 133.9, 201.4, 205.3; MS (FAB) *m/z* 203 $(M+H)^+$; HRMS (FAB) Calcd for $C_{18}H_{17}O_2$ $([M+H]^+)$ 203.1072. Found: 203.1078.

[(1*R, 2*S**, 3*s**)-2-Benzoyl-3-phenylcyclopropyl](phenyl)methanone (2c)** [3]:

Pale yellow crystals, mp 141.5-142.0°C; IR (NaCl)/cm^{-1} 1683; ^1H NMR ($CDCl_3$) δ: 3.39 (d, 2 H), 3.55 (t, 1 H), 7.3 - 7.46 (m, 9 H), 7.53 (t, 2 H), 7.99 (d, 4 H); ^{13}C NMR ($CDCl_3$) δ: 31.2, 36.9, 126.5, 127.2, 128.3, 128.6, 128.8, 133.1, 137.1, 138.5, 194.3; MS (EI) *m/z* 326 $(M)^+$; HRMS (EI) Calcd for $C_{23}H_{18}O_2$ (M^+) 326.1307. Found: 326.1303.

[(1*R, 2*R**, 3*r**)-2-Benzoyl-3-phenylcyclopropyl](phenyl)methanone (3c)**:

Pale yellow crystals, mp 102.5-103°C; IR (NaCl)/cm^{-1} 1664; ^1H NMR ($CDCl_3$) δ: 3.57 (dd, *J* =5, 10, 1 H, CH), 3.80 (dd, *J* = 5, 10, 1 H, CH), 4.24 (t, *J* =5, 1 H, CH), 7.1 - 7.3 (m, 6 H, ArH), 7.4 - 7.6 (m, 6 H, ArH), 7.62 (t, 1 H, ArH), 7.9 (d, 2 H, ArH), 8.16 (d, 2 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 29.8, 37.4, 38.0, 127.3, 128.26, 128.31, 128.4, 128.6, 128.7, 128.8, 133.2, 133.5, 134.3, 137.1, 137.5, 188.0, 193.7, 197.4; MS (EI) *m/z* 326 $(M)^+$; HRMS (EI) Calcd for $C_{23}H_{18}O_2$ (M^+) 326.1307. Found: 326.1310.

(1*R, 2*S**, 3*R**)-2-benzoyl-3-phenylcyclopropanecarbonitrile (2d)** [4]:

Pale yellow crystals, mp 125-126°C; IR (NaCl)/cm^{-1} 1672, 2236; ^1H NMR ($CDCl_3$) δ: 2.35 (dd, *J* = 6.35, 8.3, 1 H, CH), 3.40 (m, 2 H, CH), 7.19 (d, *J* = 6.83, 2 H, ArH), 7.34 (m, 3 H, ArH), 7.52 (t, *J*

= 7, 2 H, ArH), 7.63 (t, *J* = 7, 1 H, ArH), 8.06 (d, *J* = 7, 2 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 15.8, 30.9, 32.2, 116., 126.5, 128.8, 129, 133.9, 135.8, 136.5, 192.7; MS (FAB) *m/z* 248 $(M+H)^+$; Anal. Calcd for $C_{17}H_{14}NO$: C, 82.57; H, 5.30; N, 5.66. Found: C, 82.52; H, 5.31; N, 5.61.

(1*R, 2*R**, 3*R**)-2-benzoyl-3-phenylcyclopropanecarbonitrile (3d)** [5]:

Pale yellow crystals, mp 101-102°C; IR (NaCl)/cm^{-1} 1672, 2242; ^{1}H NMR ($CDCl_3$) δ: 2.73 (dd, *J* = 5, 9, 1 H, CH), 3.07 (dd, *J* = 5, 9, 1 H, CH), 3.63 (t, *J* = 5, 1 H, CH), 7.4 (m, 5 H, ArH), 7.55 (t, *J* = 7, 2 H, ArH), 7.65 (t, *J* = 7, 1 H, ArH), 8.03 (d, *J* = 7, 2 H, ArH); MS (FAB) *m/z* 248 $(M+H)^+$; HRMS (FAB) Calcd for $C_{17}H_{14}NO$ ($[M+H]^+$) 248.1075. Found: 248.1078.

Benzyl (1*R, 2*S**, 3*S**)-2-acetyl-3-phenylcyclopropanecarboxylate (2e)**:

White crystals, mp 45-45.5°C; IR (NaCl)/cm-1 1604, 1715; ^{1}H NMR ($CDCl_3$) δ: 2.28 (s, 3 H, CH_3), 2.47 - 2.58 (m, 2 H, CH), 3.22 (t, *J* =6, 1 H, CH), 5.15 (s, 2 H, $PhCH_2$), 7.11 (d, *J* = 7.3, 2 H, CH), 7.23 - 7.37 (m, 8 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 30.2, 30.8, 31.8, 37.8, 67.1, 126.4, 127.1, 128.3, 128.4, 128.5, 128.6, 135.6,137.7, 168.8, 202.4; MS (EI) *m/z* 294 $(M)^+$; HRMS (EI) Calcd for $C_{19}H_{18}O_3$ (M^+) 294.1256. Found: 294.1254.

Ethyl (1*R, 2*S**, 3*S**)-2-benzoyl-3-phenylcyclopropanecarboxylate (2f)** [5]:

Pale yellow crystals, mp 98.5-100.5°C; IR (NaCl)/cm^{-1} 1682, 1731; ^{1}H NMR ($CDCl_3$) δ: 1.14 (t, *J* = 7.2, 3 H, CH_3), 2.64 (dd, *J* = 6.3, 10, 1 H, CH), 3.09 (dd, *J* = 6.3, 10, 1 H, CH), 3.37 (t, *J* = 6.3, 1 H, CH), 4.09 (q, *J* = 7.2, 2 H, CH_2), 7.2 –7.28 (m, 3 H, ArH), 7.34 (t, *J* = 7, 2 H, ArH), 7.46 (t, *J* = 7, 2 H, ArH), 7.55 (d, *J* = 7, 1 H, ArH), 8.02 (d, *J* = 7, 2 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 14.0, 29.7, 31.6, 35.1, 61.1, 126.6, 127.1, 128.6, 128.7, 133.3, 136.9, 138.1, 169.1, 193.7; MS (EI) *m/z* 294 $(M)^+$; HRMS (EI) Calcd for $C_{19}H_{18}O_3$ $(M)^+$ 294.1256. Found: 294.1248.

Diethyl 2-phenylcyclopropane-1,1-dicarboxylate (4a) [6]:

Yellow oil; IR (NaCl)/cm^{-1} 1280, 1325, 1720, 1731; ^{1}H NMR ($CDCl_3$) δ: 0.86 (t, *J* = 7, 3 H, CH_3), 1.29 (t, *J* = 7, 3 H, CH_3), 1.70 (dd, *J* = 5, 8, 1 H, CH), 2.17 (dd, *J* = 5, 8, 1 H, CH), 3.21 (t, *J* = 8, 1 H, CH), 3.84 (dd, *J* = 7, 14, 2 H, CH_2), 4.16 - 4.32 (m, 2 H, CH_2), 7.1 (m, 5 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 13.6, 14.1, 18.7, 32.1, 37.4, 61.1, 61.6, 127.3, 128.1, 128.5, 134.6, 166.6, 169.8; MS (EI) *m/z* 262 $(M)^+$; HRMS (EI) Calcd for $C_{15}H_{18}O_4$ (M^+) 262.1205. Found: 262.1216.

Dibenzyl 2-phenylcyclopropane-1,1-dicarboxylate (4b) :

Pale yellow crystals, mp 67-69°C; IR (NaCl)/cm^{-1} 1275, 1323, 1730, 1740; ^{1}H NMR ($CDCl_3$) δ: 1.78 (dd, *J* = 5, 8.5, 1 H, CH), 2.25 (dd, *J* = 5, 8.5, 1 H, CH), 3.30 (t, *J* = 8.5, 1 H, CH), 4.78 (s, 2 H, $PhCH_2$), 5.17 (d, *J* = 12, 1 H, CH), 5.28 (d, *J* = 12, 1 H, CH), 6.95 (d, *J* = 7, 2 H, ArH), 7.18-7.28 (m, 8 H, ArH), 7.33 (s, 5 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 19.1, 32.6, 37.4, 67.1, 67.3, 127.4, 127.88, 127.94, 128.1, 128.16, 128.25, 128.47, 128.50, 134.4, 135.2, 135.4, 166.4, 169.5; MS (FAB) *m/z* 387 $(M+H)^+$; Anal. Calcd for $C_{25}H_{22}O_4$: C, 77.70; H, 5.74. Found: C, 77.30; H, 5.78.

(1*r, 1a*S**, 7a*R**)-1-Phenyl-1a,7a-dihydro-1*H*-cyclopropa[*b*]naphthalene-2,7-dione (8a)**:
Pale yellow crystals, mp 149-150°C; IR (NaCl)/cm^{-1} 1677; ^{1}H NMR ($CDCl_3$) δ: 3.0 - 3.1 (m, 3 H, CH), 7.13 (d, *J* = 7.33, 2 H, ArH), 7.2 - 7.4 (m, 3 H, ArH), 7.7 - 7.8 (m, 2 H, ArH), 8.0 - 8.1 (m, 2 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 37.0, 37.6, 126.3, 127.1, 127.8, 128.8, 132.6, 134.3, 136.5, 191,4; MS (EI) *m/z* 248 $(M)^+$; HRMS (EI) Calcd for $C_{17}H_{12}O_2$ (M^+) 248.0837. Found: 248.0833.

(1*R, 7*S**, 8*s**)-8-Phenylbicyclo[5.1.0]octane-2,6-dione (8b)**:
White crystals, mp 83-83.5°C; IR (NaCl)/cm^{-1} 1680; ^{1}H NMR ($CDCl_3$) δ: 1.69 (q, *J* = 13.8, 1 H, CH), 2.03 (m, 1 H, CH), 2.59 (d, *J* = 6.84, 2 H, CH), 2.70 (m, 2 H, CH), 2.81 (m, 2 H, CH), 3.44 (t, *J* = 6.5, 1 H, CH), 7.14 (d, *J* = 6.84, 2 H, ArH), 7.27 - 7.35 (m, 3 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 22.1, 34.0, 39.7, 41.6, 126.5, 127.7, 128.9, 136.6, 205.9; MS (FAB) *m/z* 215 $(M+H)^+$; HRMS (FAB) Calcd for $C_{14}H_{15}O_2$ $([M+H]^+)$ 215.1072. Found: 215.1084.

(1*R, 7*S**, 8*s**)-4,4-Dimethyl-8-phenylbicyclo[5.1.0]octane-2,6-dione (8c)**:
Pale yellow crystals, mp 125-126.5°C; IR (NaCl)/cm^{-1} 1666; ^{1}H NMR ($CDCl_3$) δ: 0.92 (s, 3 H, CH_3), 1.14 (s, 3 H, CH_3), 2.41 (d, *J* = 12.2, 2 H, CH), 2.61 (d, *J* = 6.35, 2 H, CH), 2.92 (d, *J* = 12.2, 2 H, CH), 3.46 (t, *J* = 6.35, 1 H, CH), 7.14 (d, *J* = 8.31, 2 H, ArH), 7.26 - 7.34 (m, 3 H, ArH); ^{13}C NMR ($CDCl_3$) δ: 24.8, 33.0, 34.2, 34.6, 40.7, 54.6, 126.5, 127.7, 128.9, 136.6, 204,6; MS (EI) *m/z* 242 $(M)^+$; HRMS (EI) Calcd for $C_{16}H_{18}O_2$ (M^+) 242.1307. Found: 242.1297.

[1] Y. Huang, Y. Xu, Z. Li, *Org. Prep. Proced. Int.* **1982**, *14*, 373.
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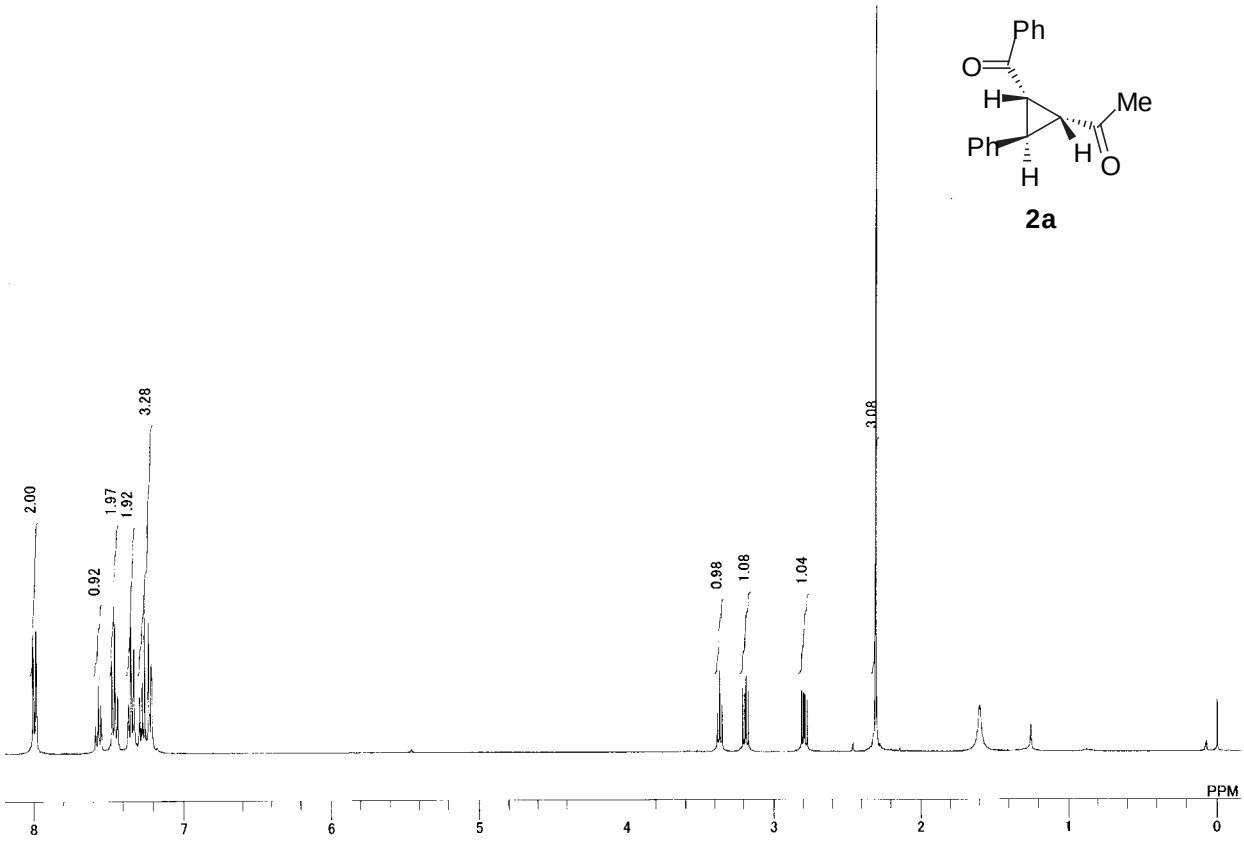
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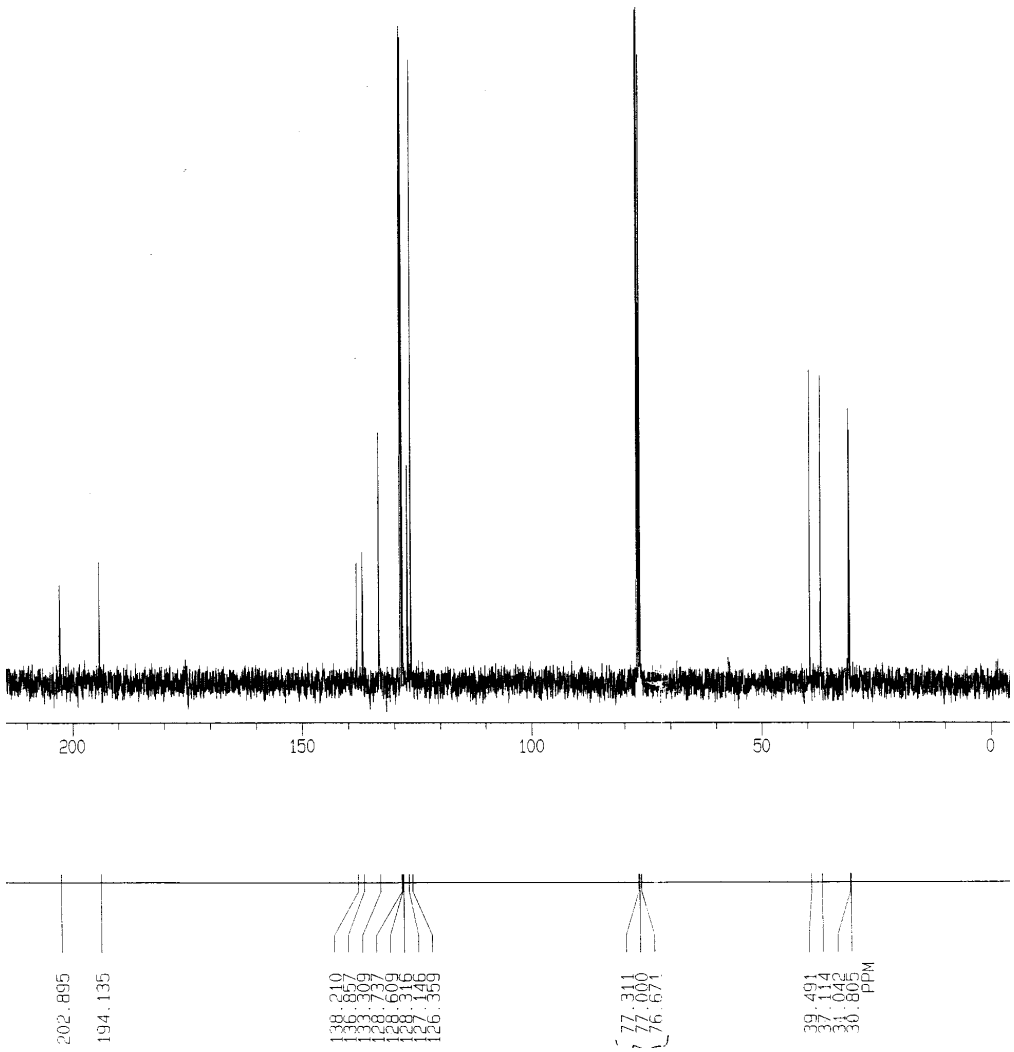
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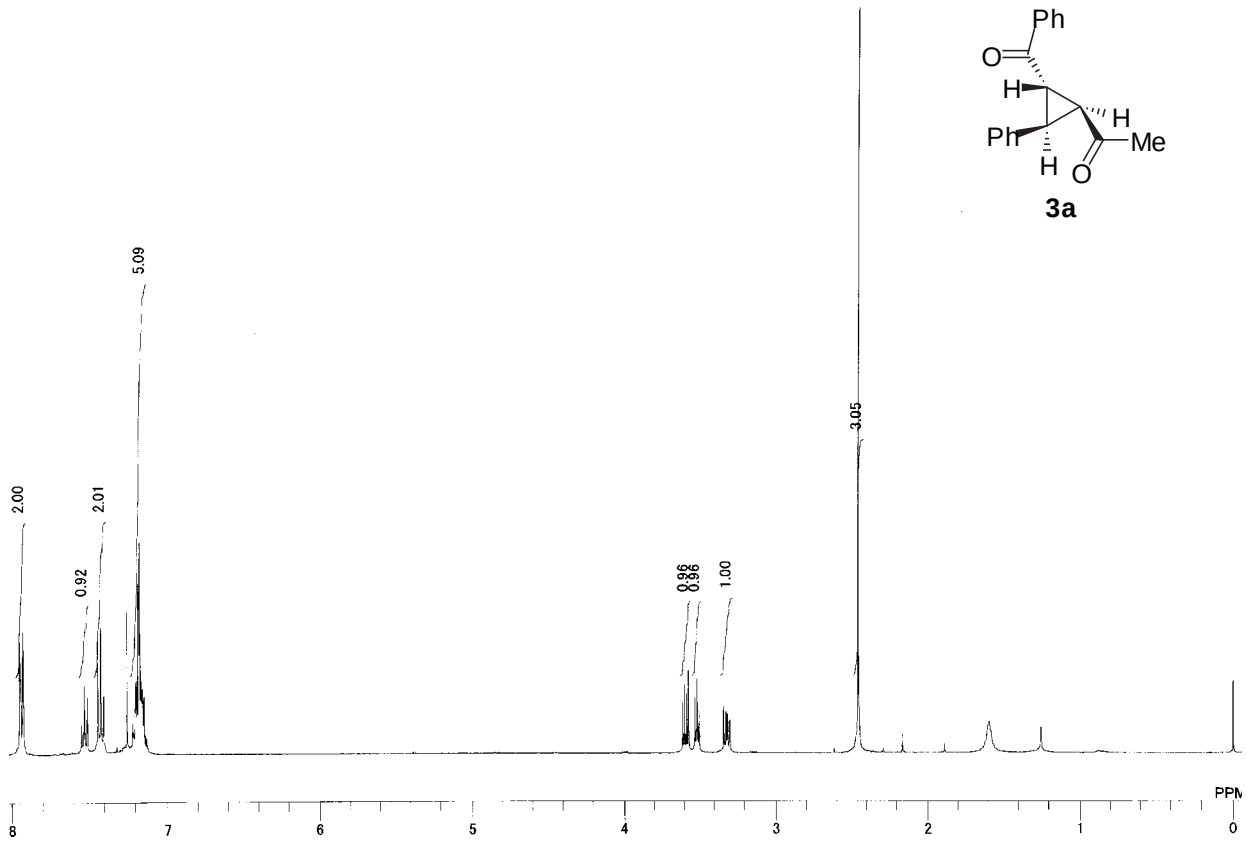

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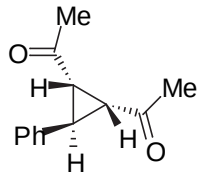
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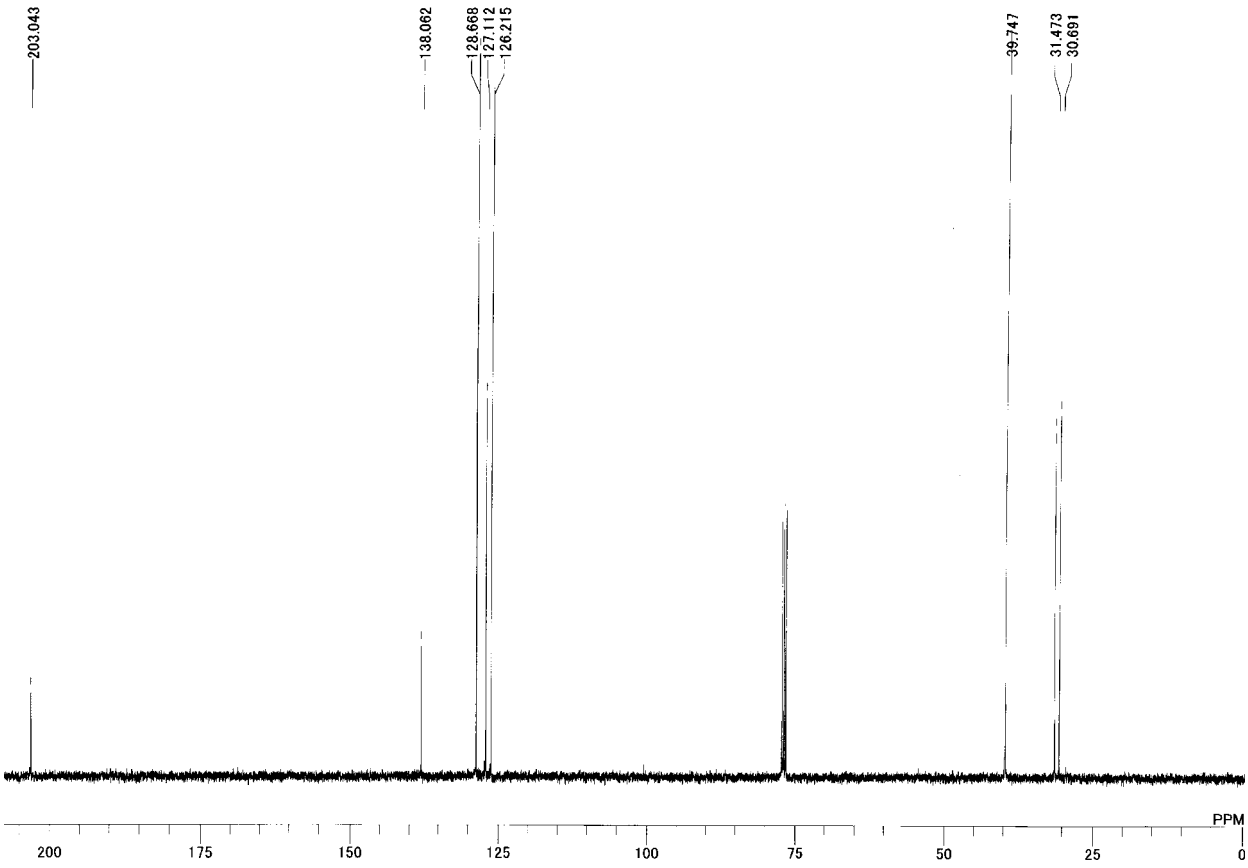
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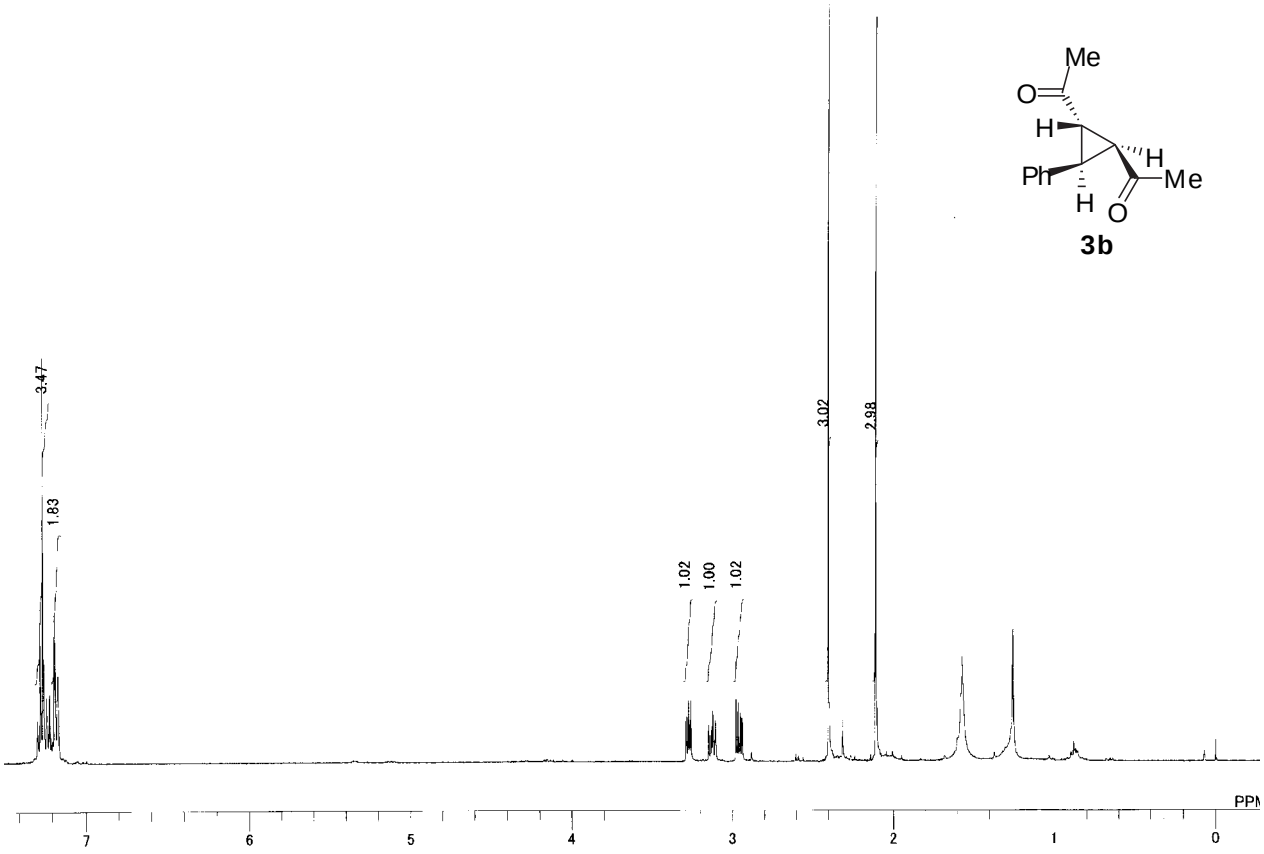
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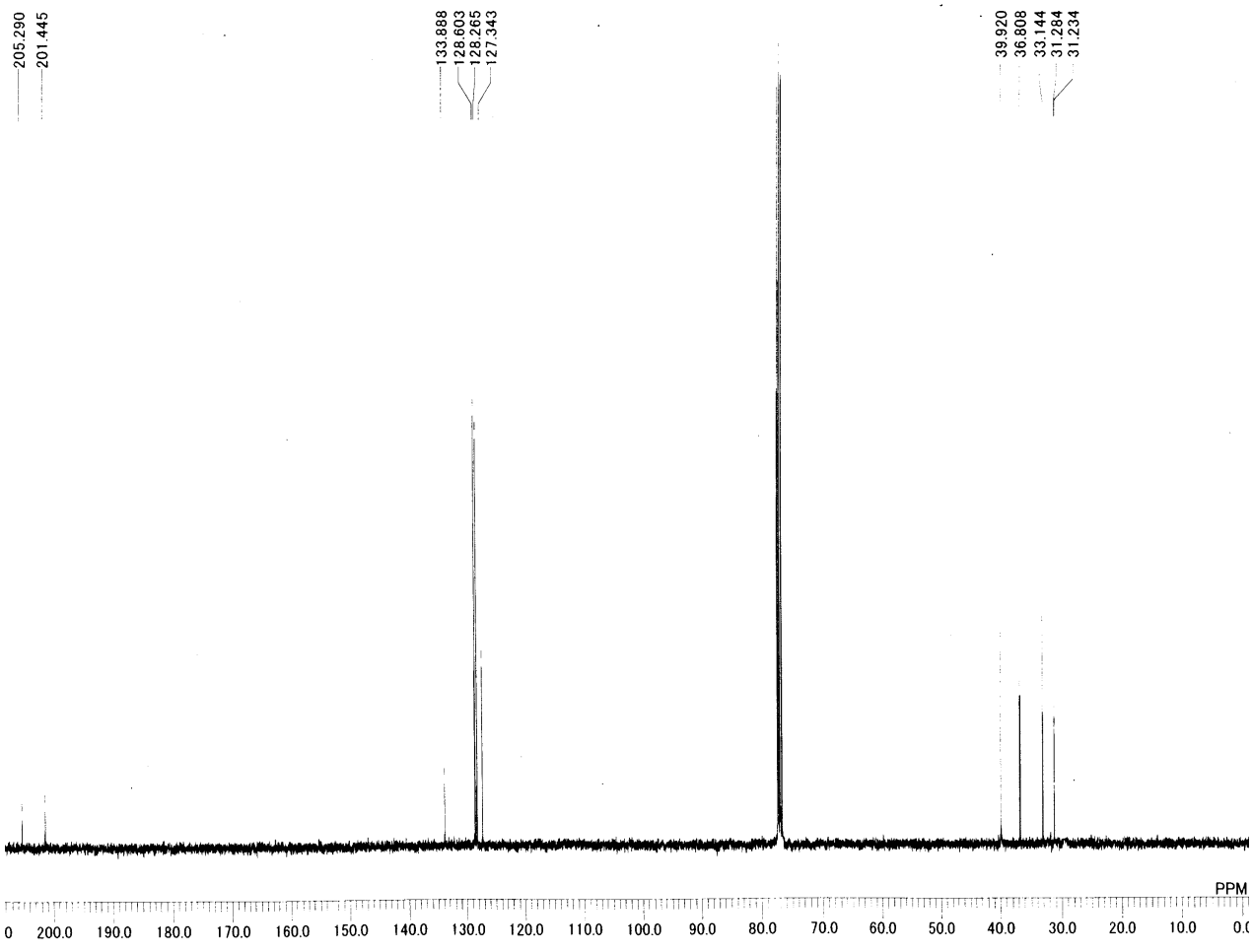
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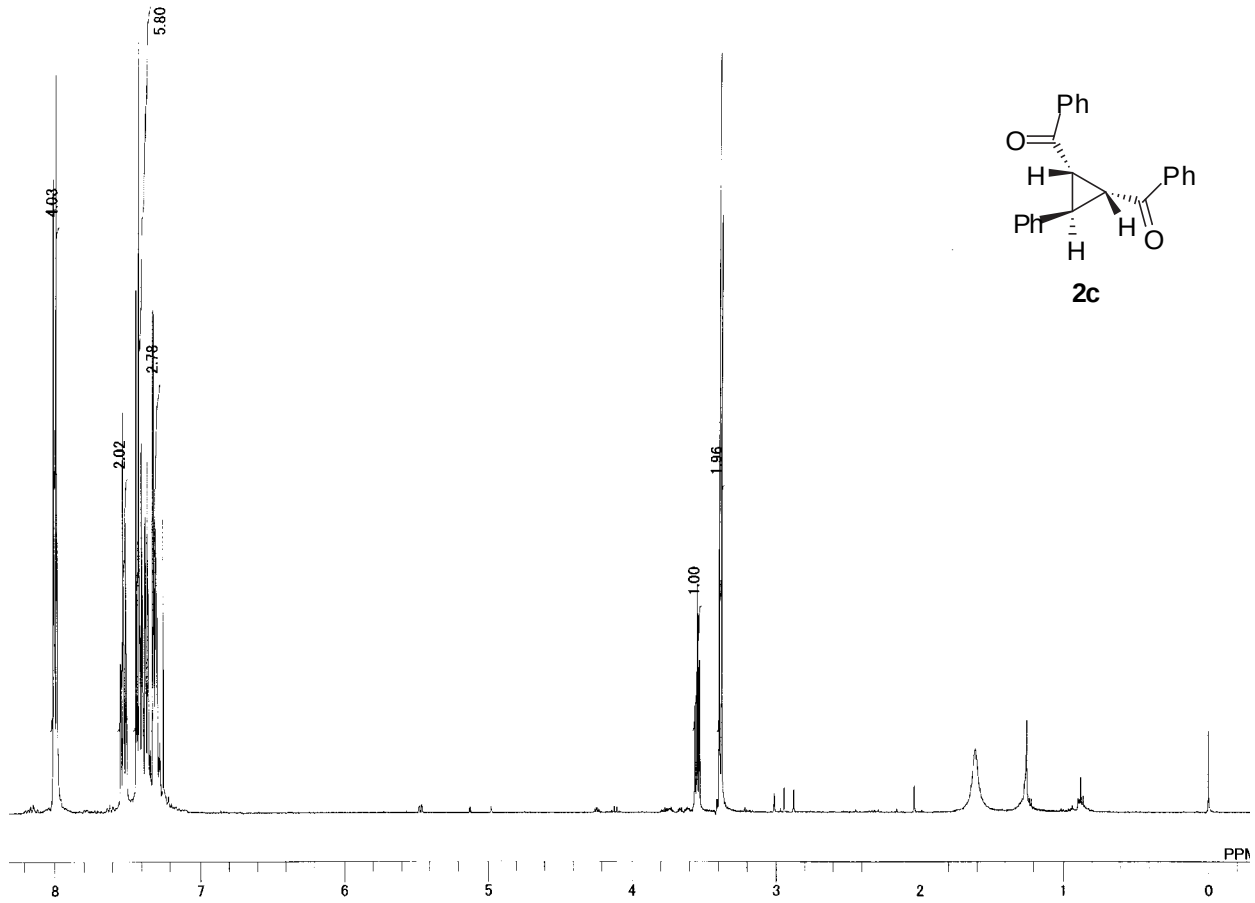
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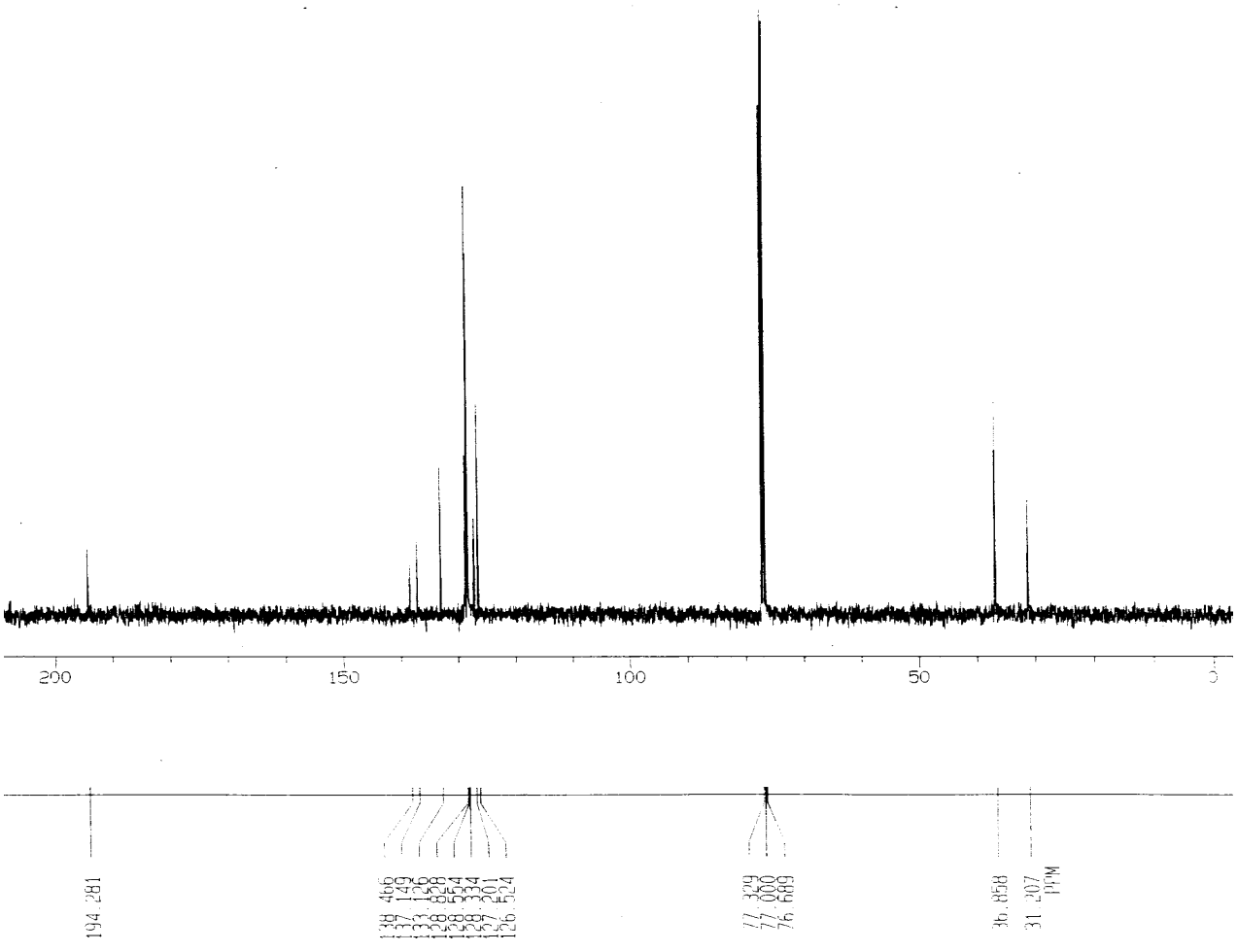
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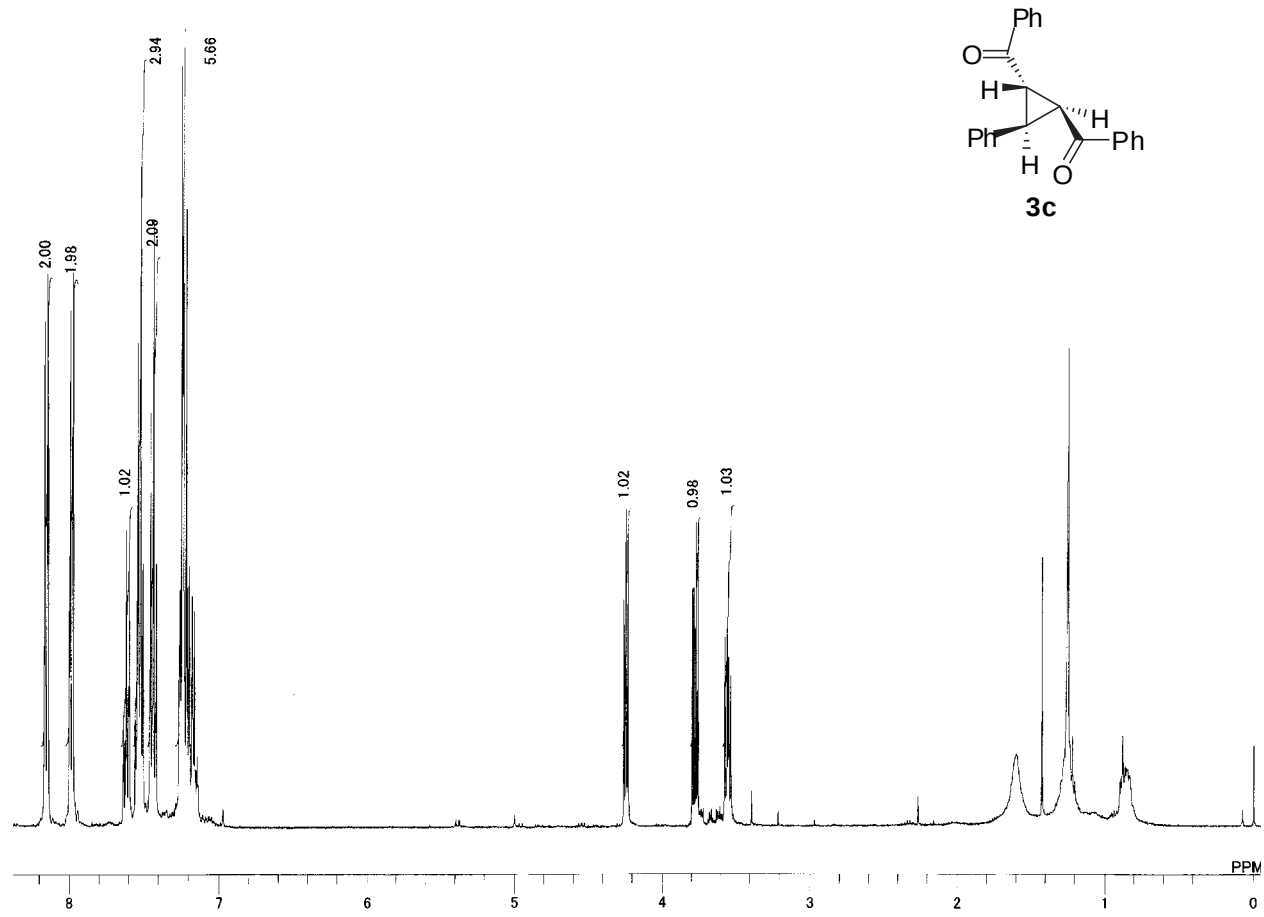
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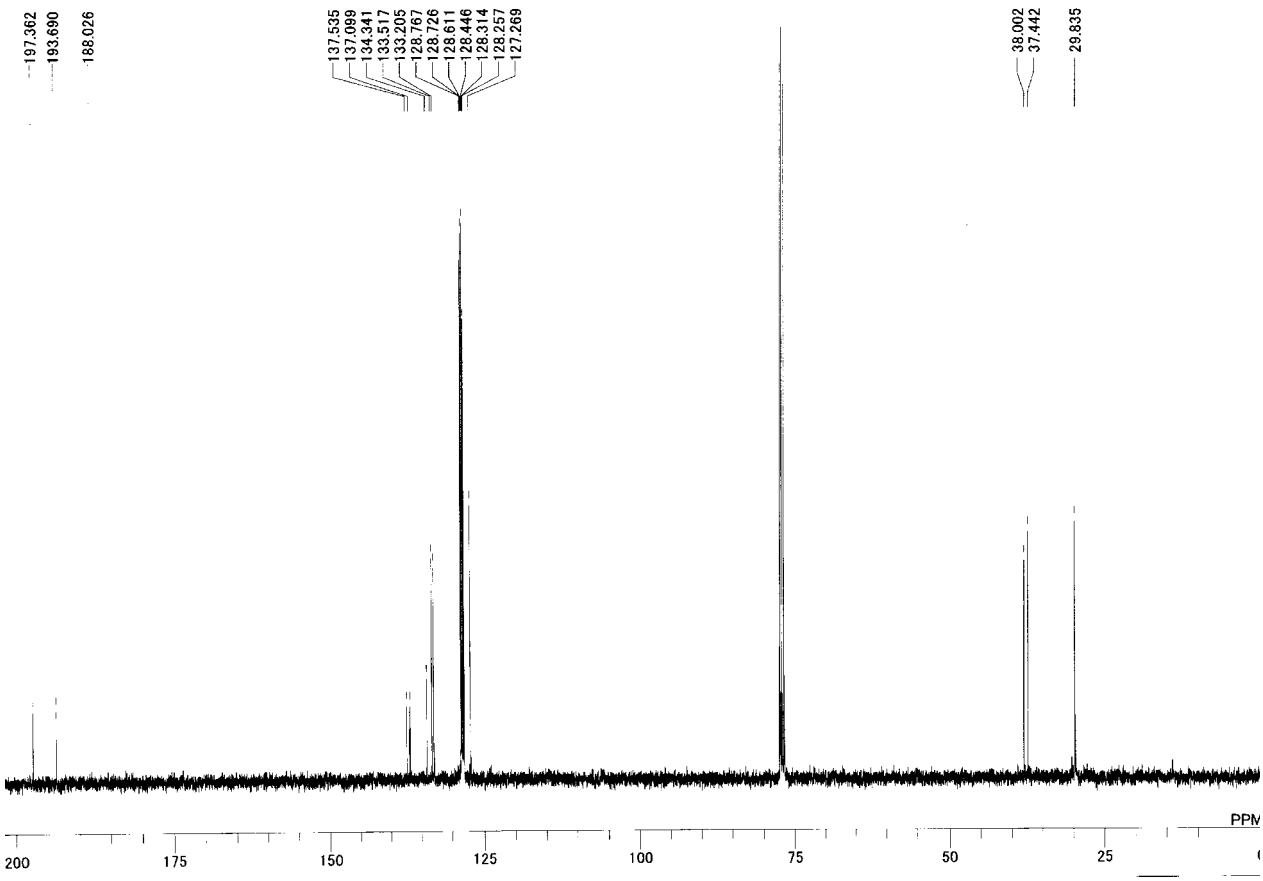
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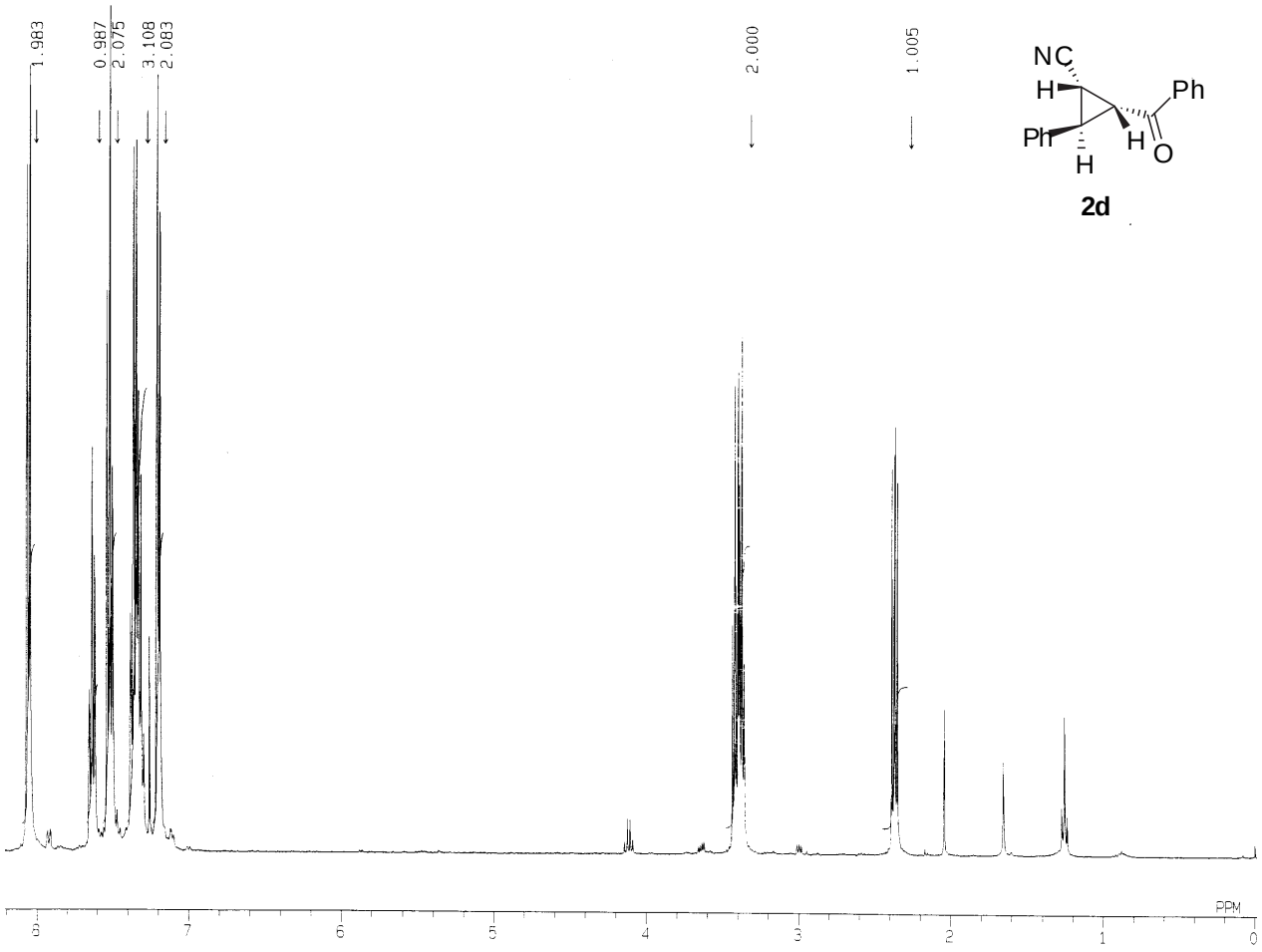
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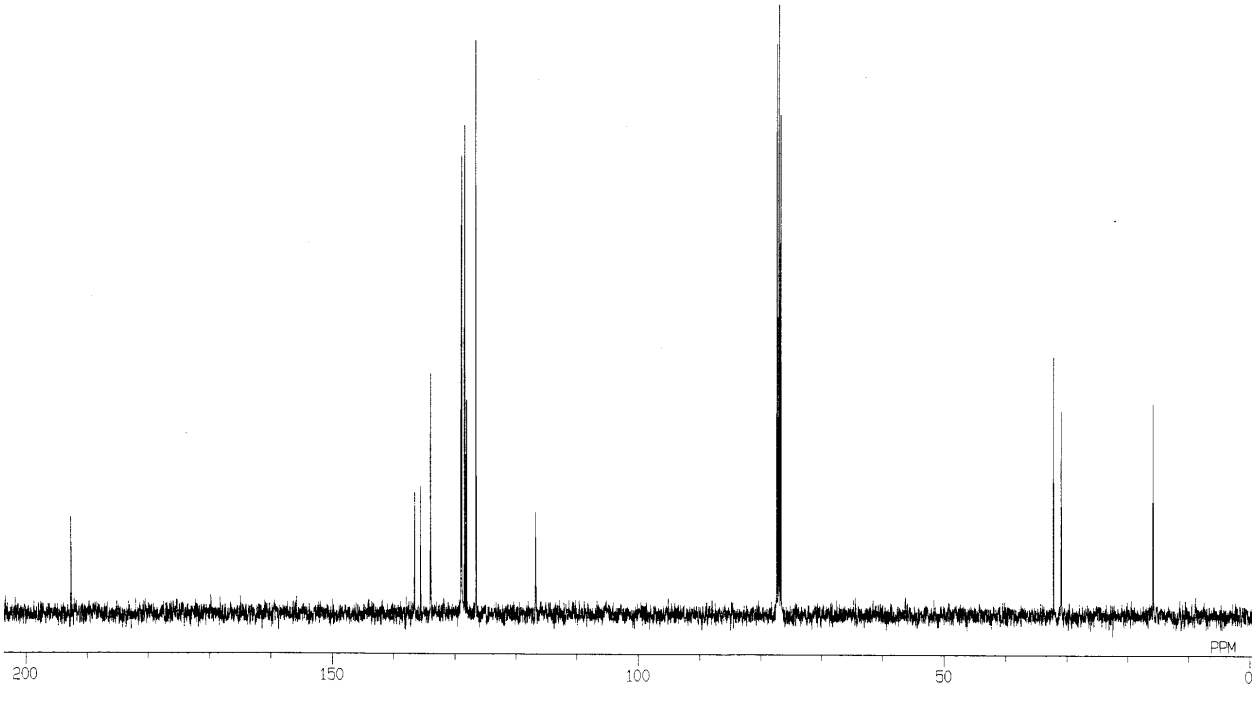
2d


PPM
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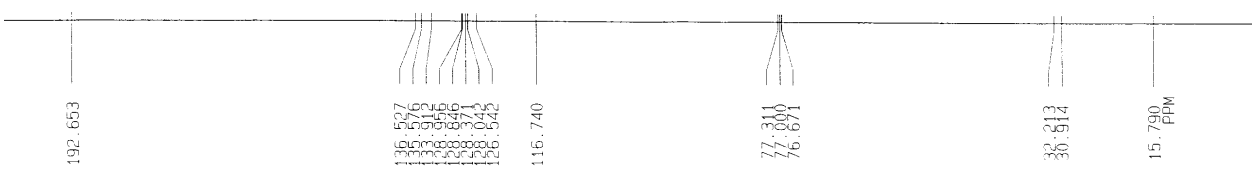
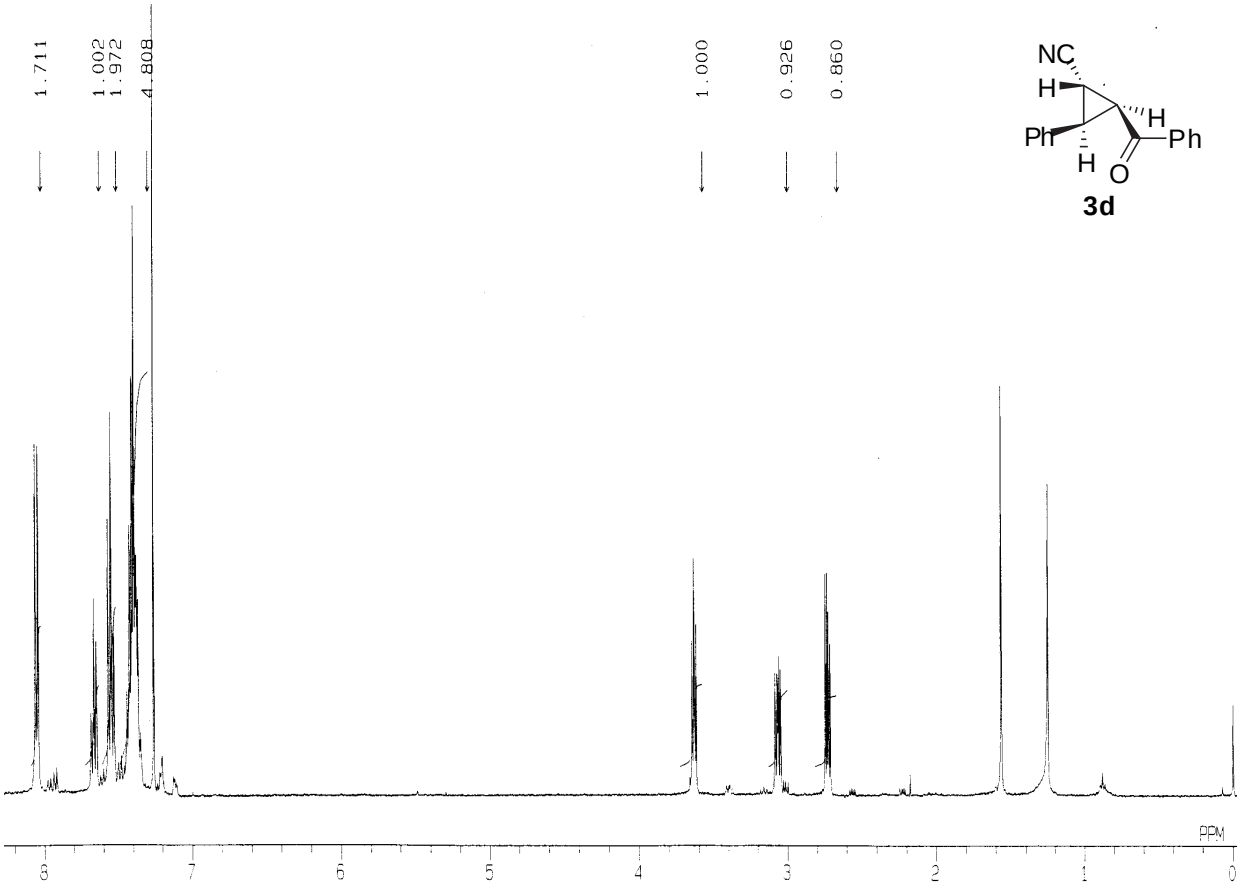
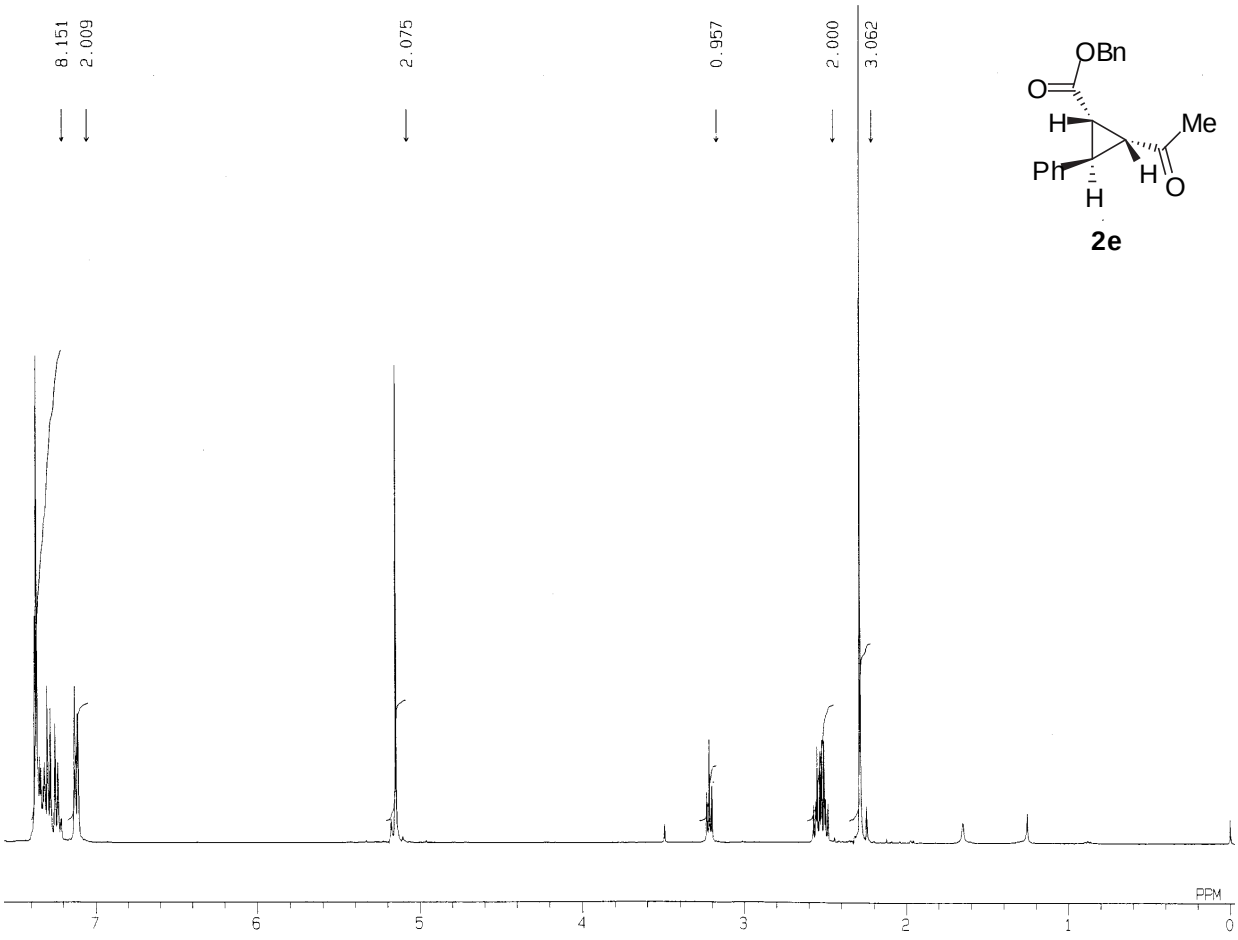
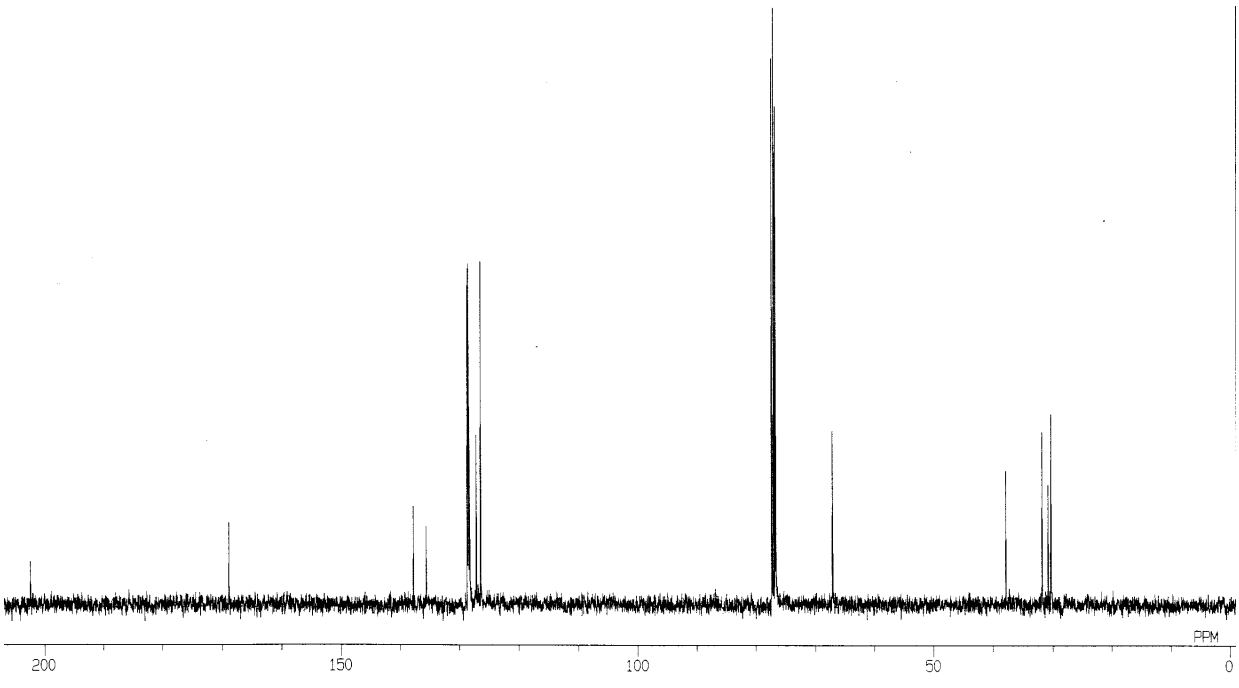

192.653
136.527
135.576
133.912
128.956
128.846
128.371
128.045
126.542
116.740
77.311
77.000
76.671
32.213
30.914
15.790
PPM


1.711
1.002
1.972
4.808
1.000
0.926
0.860
NC
H
Ph
H
H
Ph
O
3d
PPM
8
7
6
5
4
3
2
1
0


8.151
2.009
2.075
0.957
2.000
3.062
PPM
7
6
5
4
3
2
1
0

OBn
O
H
Me
Ph
H
H
O

2e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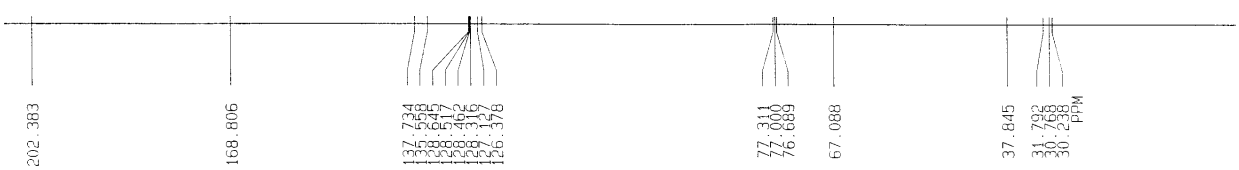
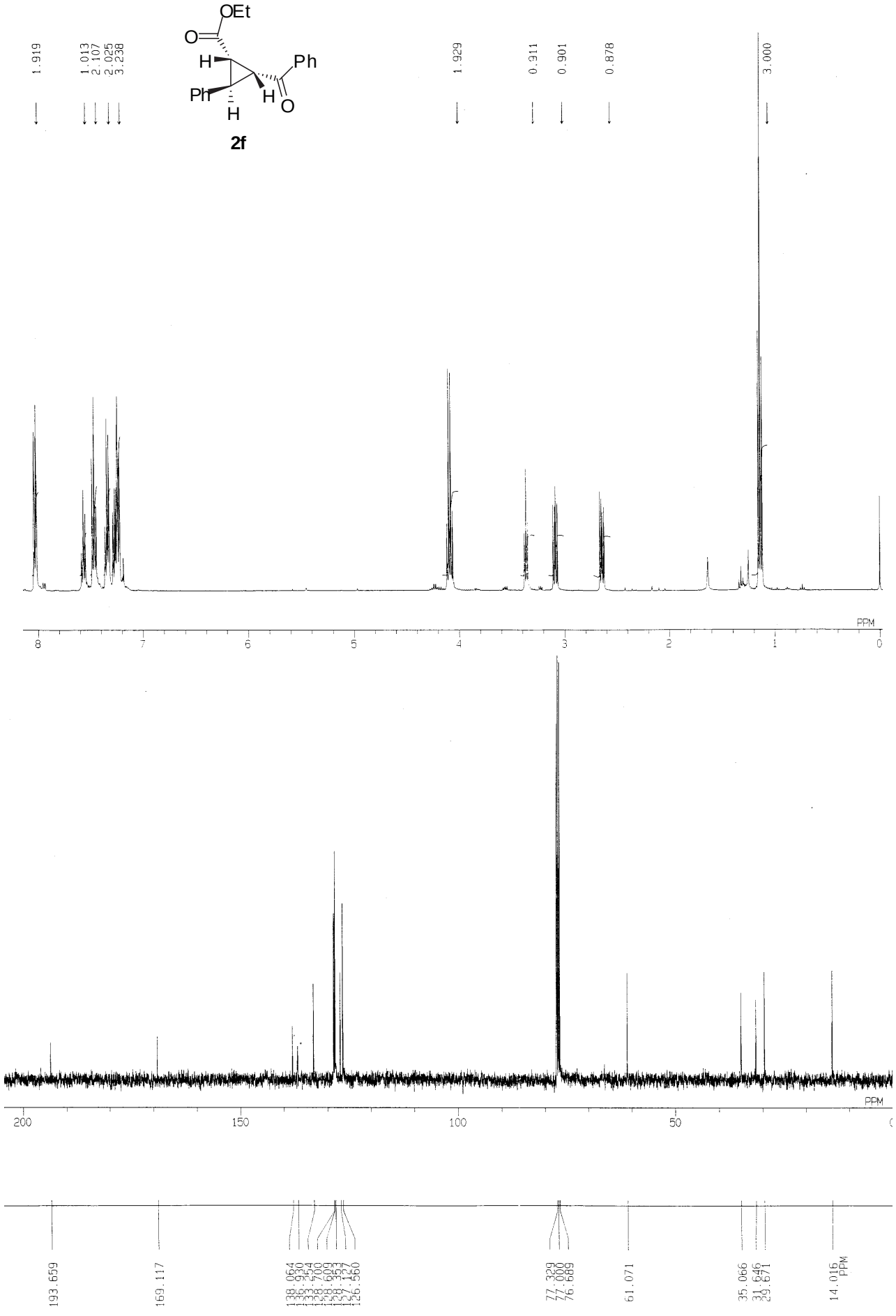
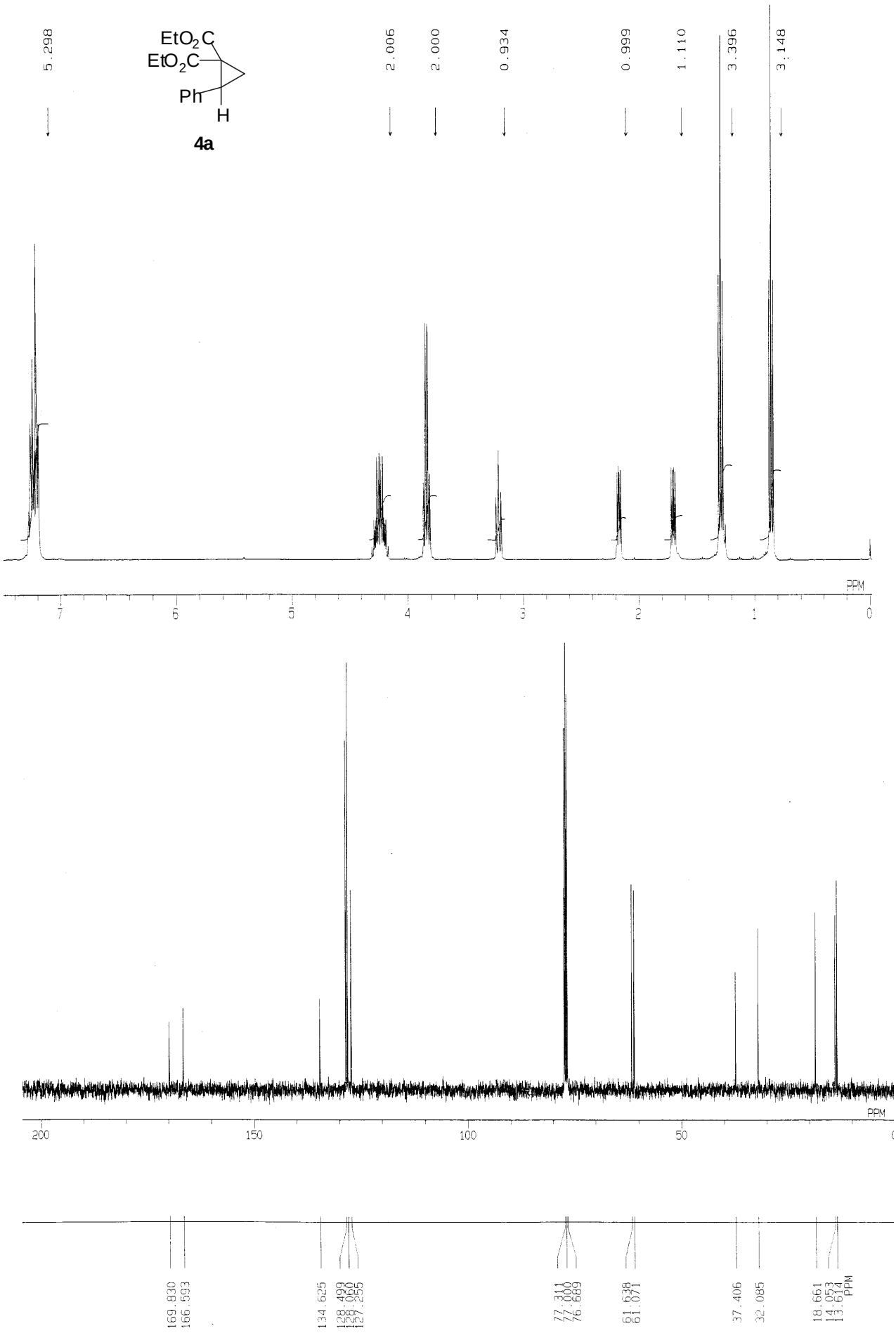
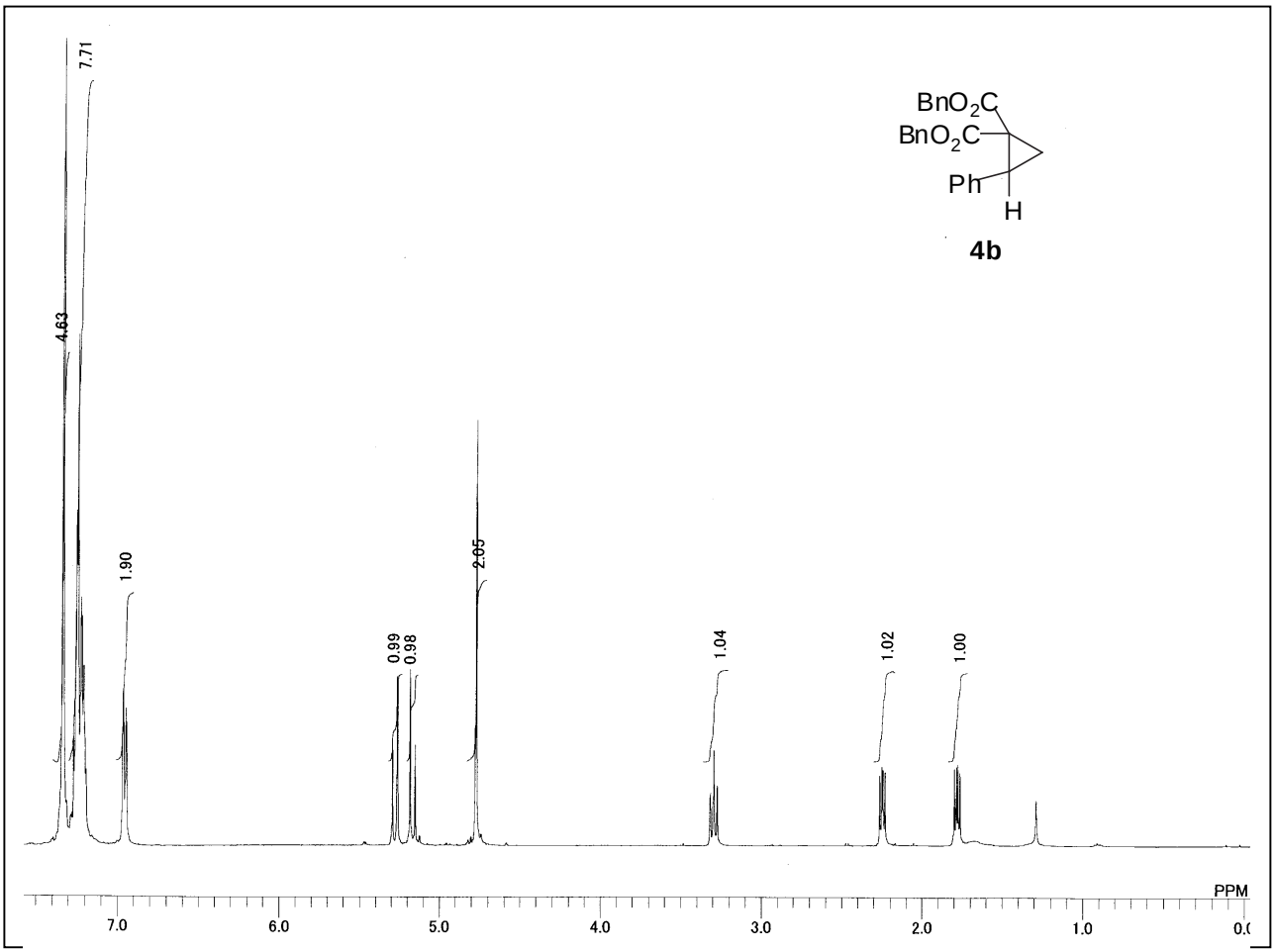
100
50
0

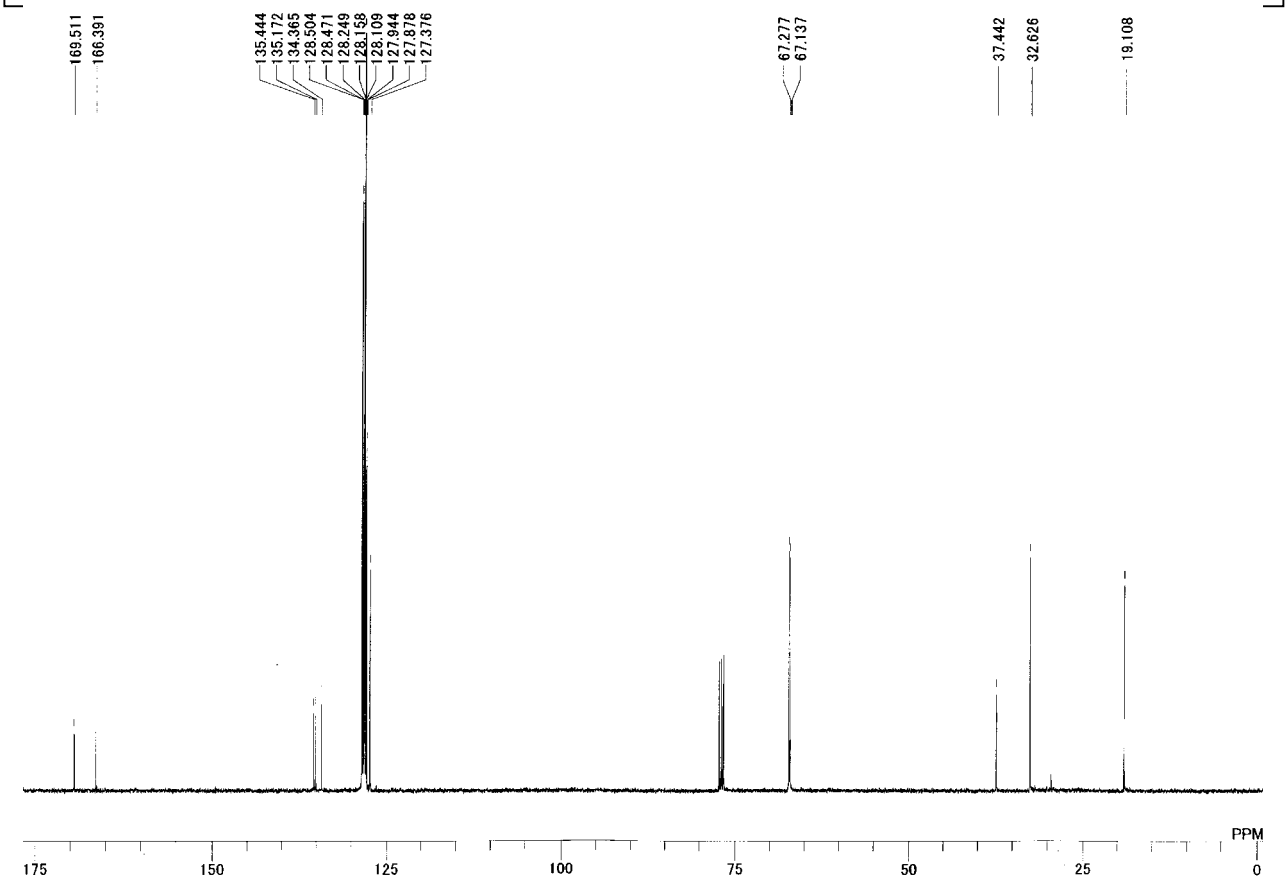

202.383
168.806
137.734
135.558
128.645
128.517
128.462
128.316
127.127
126.378
77.311
77.000
76.689
67.088
37.845
31.792
30.768
30.238
PPM


OEt
O
H
Ph
Ph
H
H
O
1.919
1.013
2.107
2.025
3.238
1.929
0.911
0.901
0.878
3.000
PPM
8
7
6
5
4
3
2
1
0
200
150
100
50
193.659
169.117
138.064
136.930
133.454
128.700
128.609
128.553
127.427
126.960
77.239
77.000
76.689
61.071
35.066
31.646
29.671
14.016
PPM

2f


EtO2C
EtO2C
Ph
H
4a
5.298
2.006
2.000
0.934
0.999
1.110
3.396
3.148
PPM
7
6
5
4
3
2
1
0
200
150
100
50
169.830
166.593
134.625
128.499
128.060
127.255
77.311
77.000
76.689
61.638
61.071
37.406
32.085
18.661
14.053
13.614
PPM


BnO2C
BnO2C
Ph
H
4b
7.71
4.63
1.90
0.99
0.98
2.05
1.04
1.02
1.00
PPM
7.0
6.0
5.0
4.0
3.0
2.0
1.0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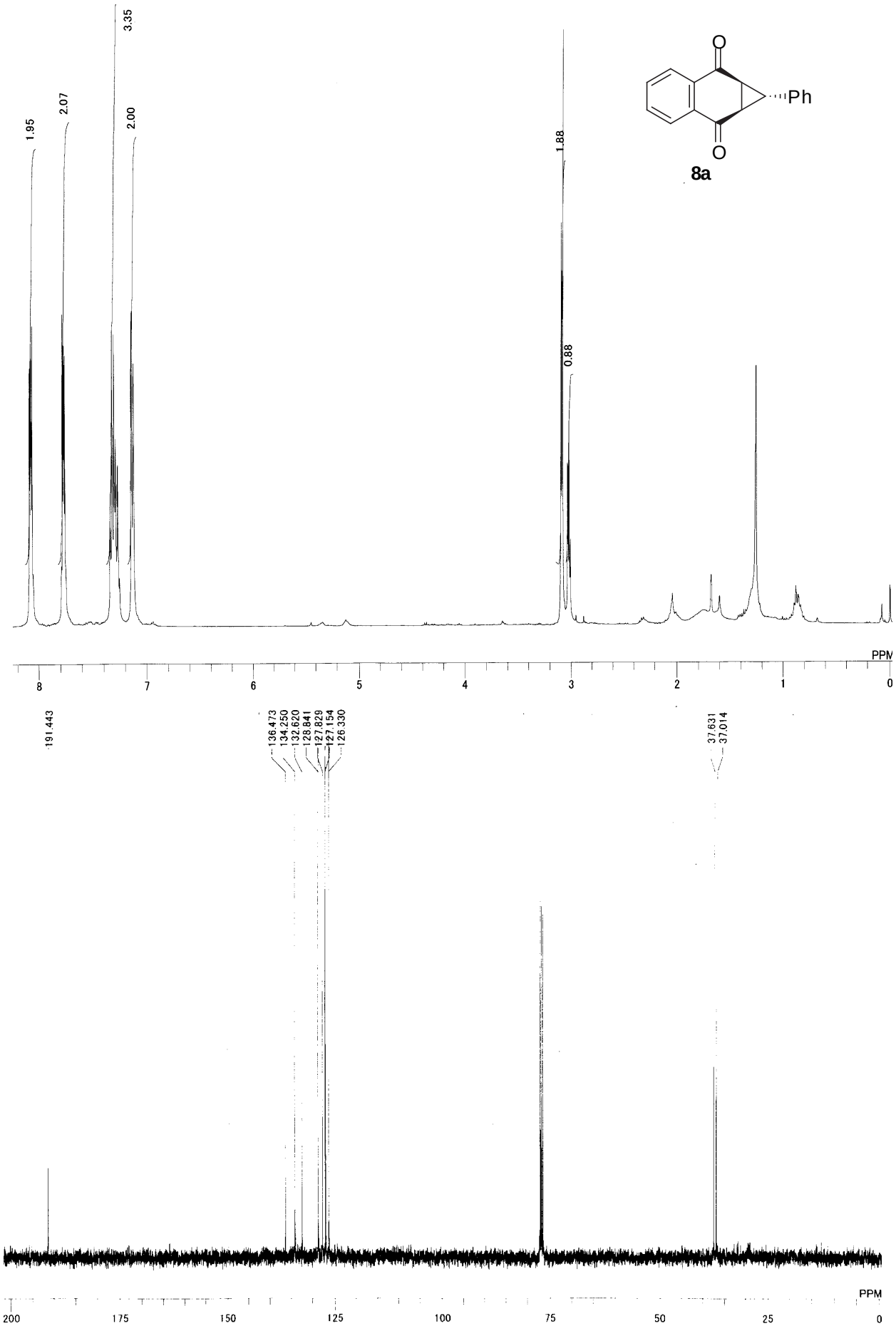
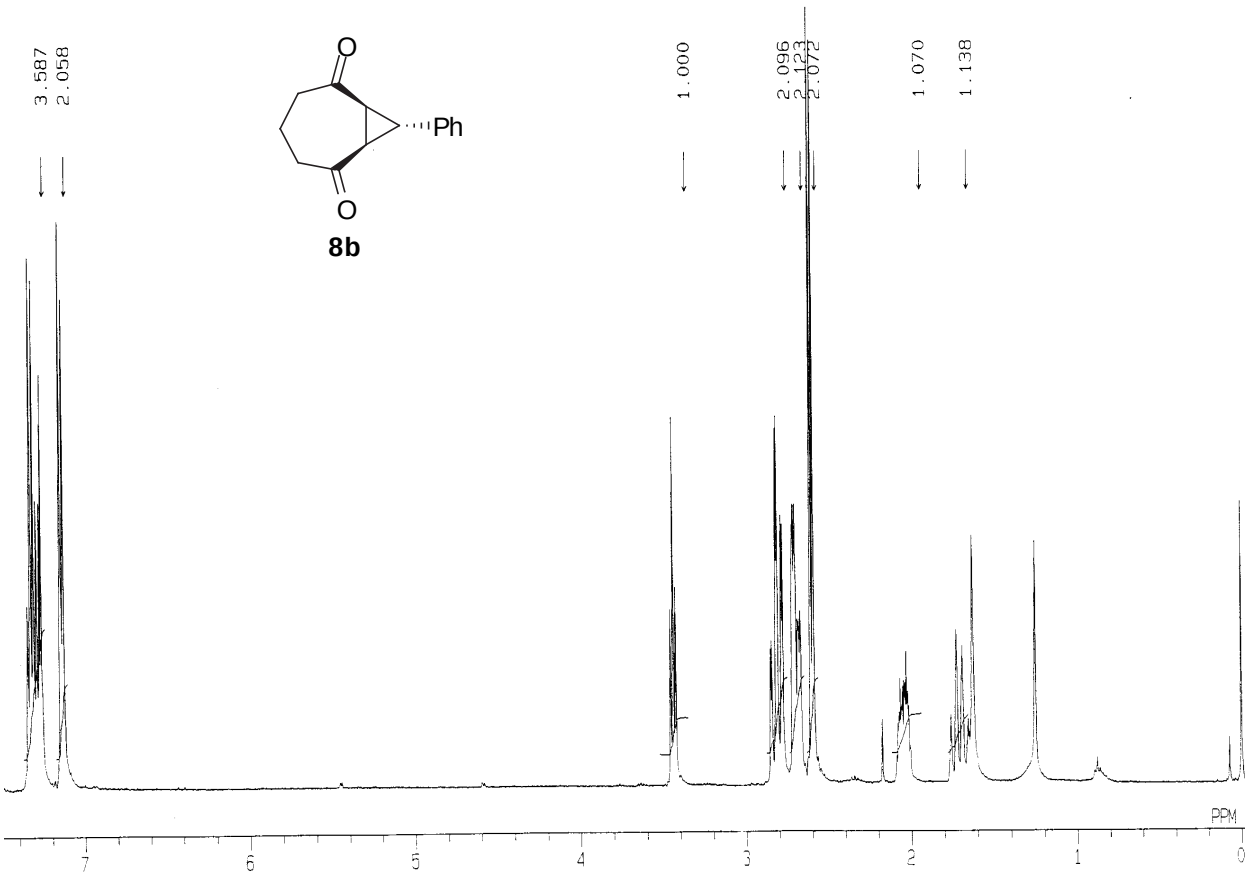
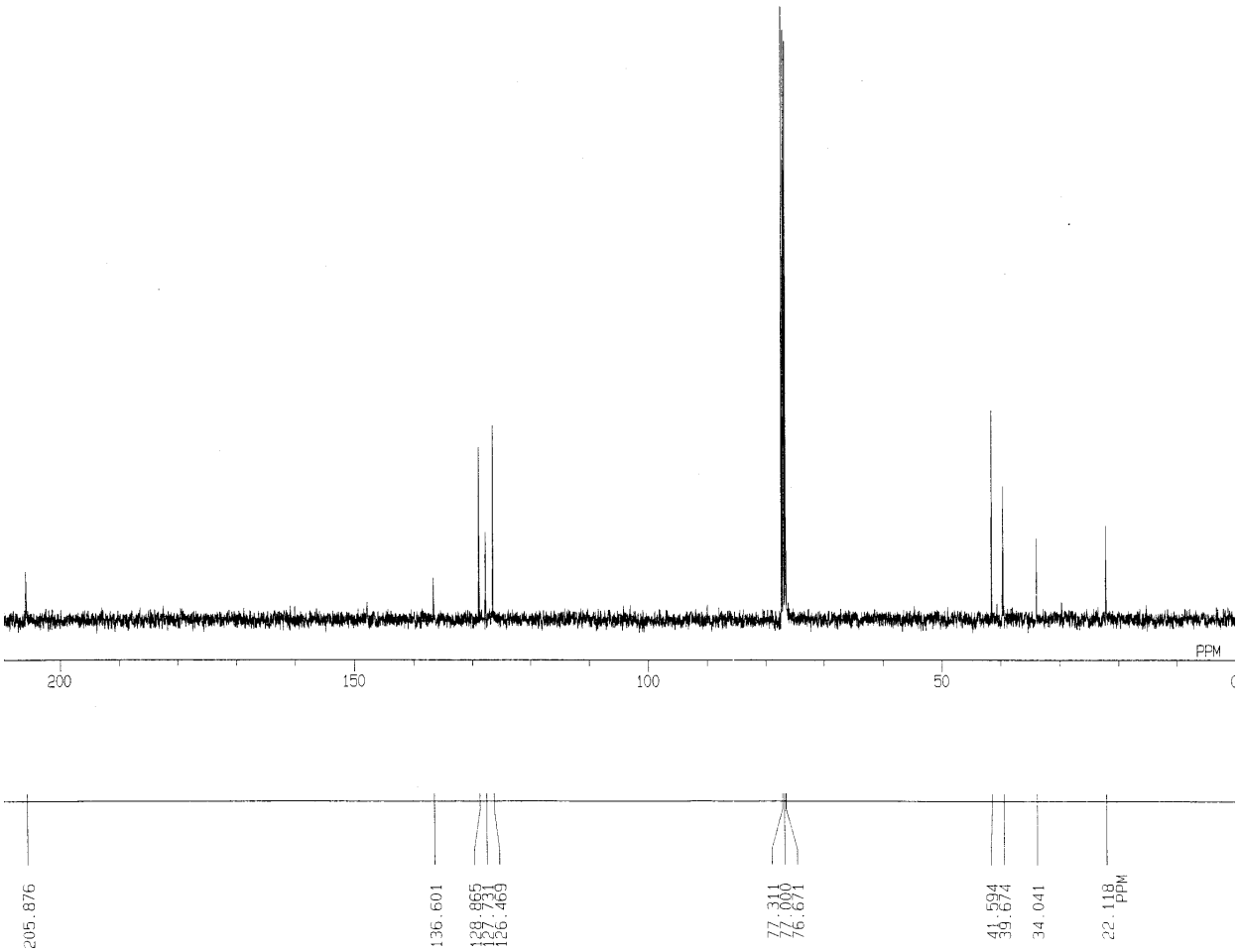
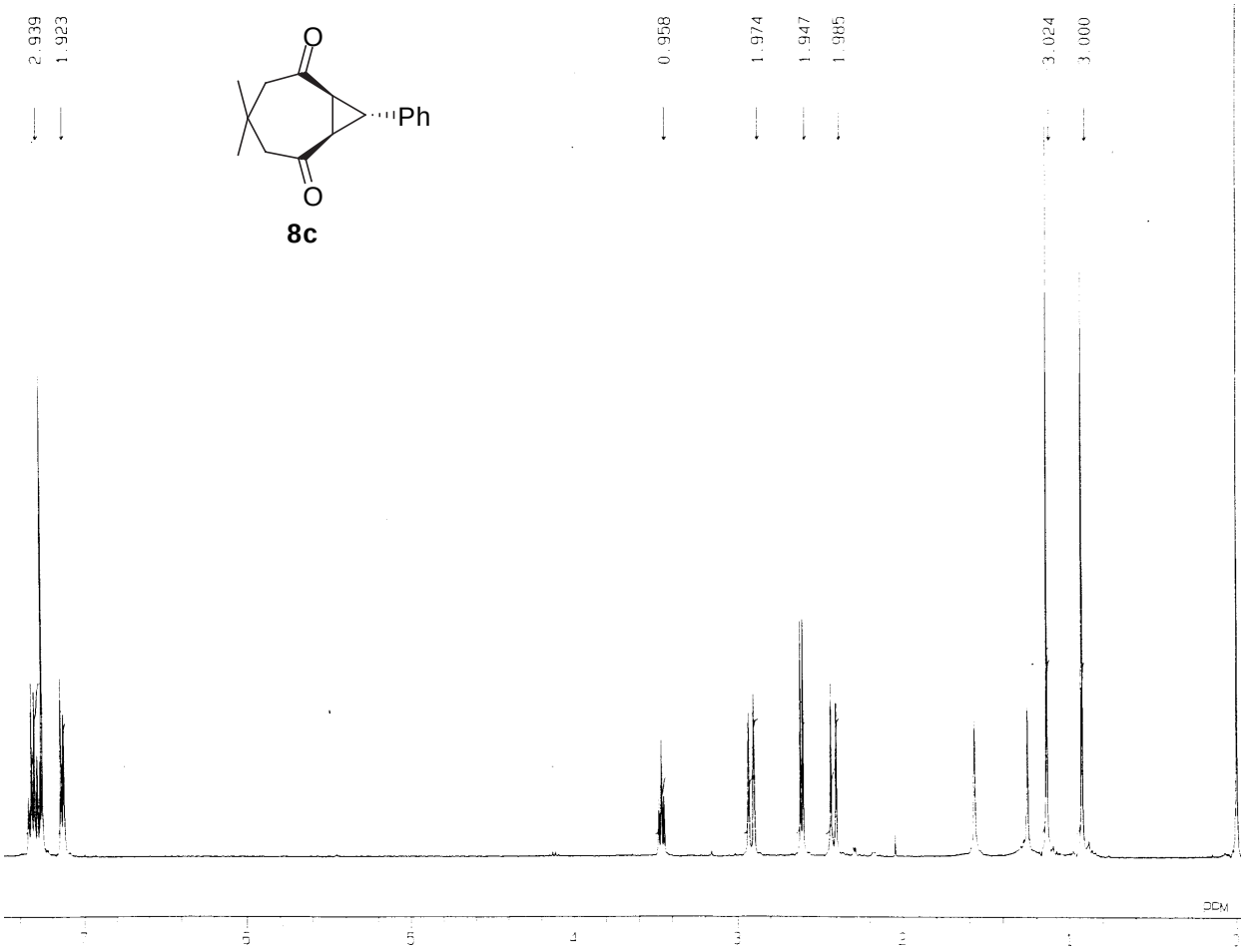
166.391
135.444
135.172
134.365
128.504
128.471
128.249
128.158
128.109
127.944
127.878
127.376
67.277
67.137
37.442
32.626
19.108
PPM
175
150
125
100
75
50
25
0


1.95
2.07
3.35
2.00
1.88
0.88
O
O
Ph
8a
PPM
8
7
6
5
4
3
2
1
0
191.443
136.473
134.250
132.620
128.841
127.829
127.154
126.330
37.631
37.014
PPM
200
175
150
125
100
75
50
25
0

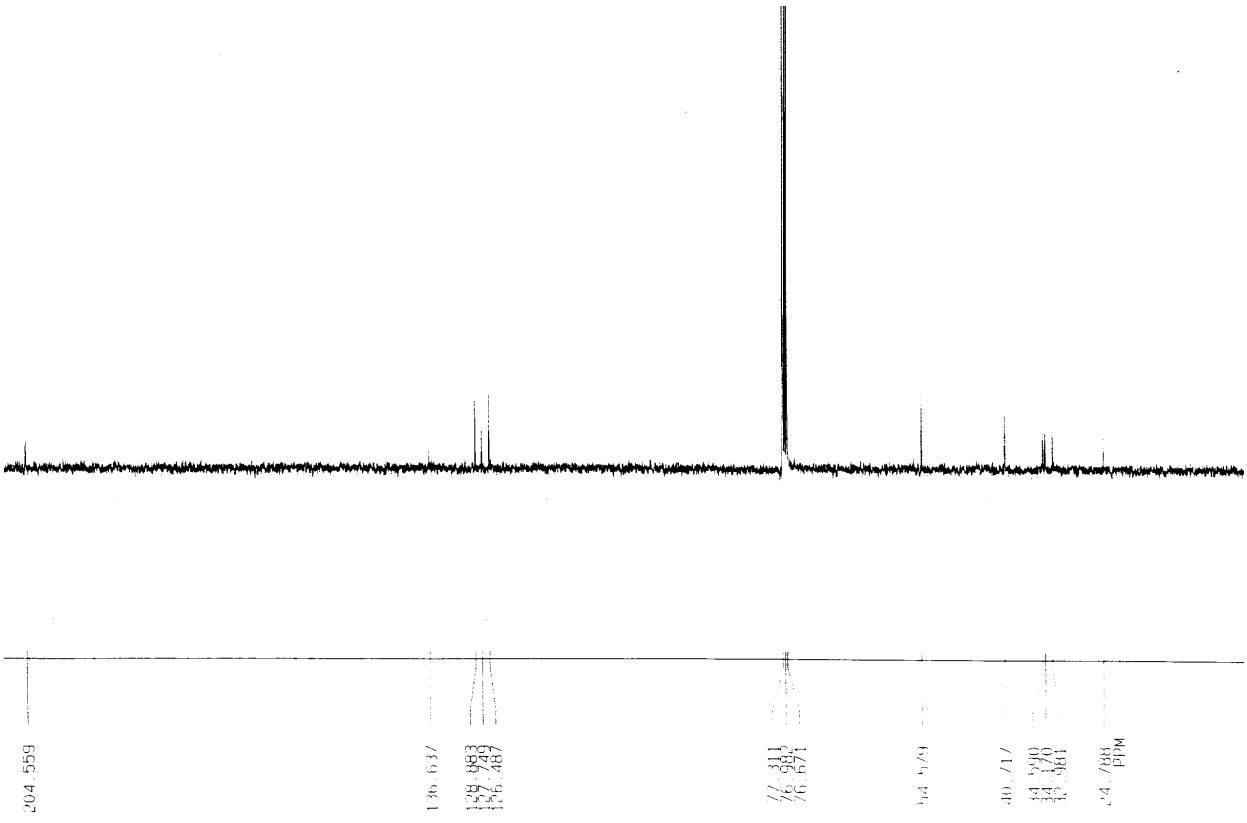

3.587
2.058
1.000
2.096
2.123
2.072
1.070
1.138
O
Ph
O
PPM
7
6
5
4
3
2
1
0

8b


PPM
200
150
100
50
205.876
136.601
128.865
127.921
127.469
126.469
77.311
77.000
76.671
41.594
39.674
34.041
22.118
PPM


2.939
1.923
0.958
1.974
1.947
1.985
3.024
3.000
Ph
O
O
PPM

8c


204.559
136.637
128.883
127.749
126.487
77.411
77.094
76.671
64.579
40.717
34.520
34.170
33.981
24.788
PPM