Supporting Information

Rapid construction of cyclopenta[*b*]naphthalene frameworks from propargylic alcohol tethered methylenecyclopropanes

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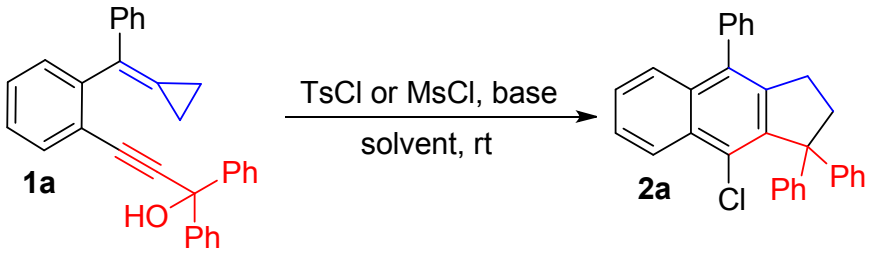
Content

1. General remarks

^{1}H NMR spectra were recorded on Varian Mercury-400 and Bruker-400 spectrometer for solution in $CDCl_3$ with tetramethylsilane (TMS) as an internal standard; coupling constants J are given in Hz. ^{13}C NMR spectra were recorded on a Varian Mercury-400 and Bruker-400 spectrophotometers with complete proton decoupling spectrophotometers ($CDCl_3$: 77.0 ppm). The reference of ^{19}F NMR (376 MHz) spectra is trichlorofluoromethane (δ ppm 0). Mass and HRMS spectra were recorded by DART or EI method. Organic solvents used were dried by standard methods when necessary. Infrared spectra were recorded on a Perkin-Elmer PE-983 spectrometer with absorption in cm^{-1}. Melting points were determined on a digital melting point apparatus and temperatures were uncorrected. Commercially obtained reagents were used without further purification. All these reactions were monitored by TLC with silica gel coated plates. Flash column chromatography was carried out using silica gel at increased pressure.

2. Optimization of reaction conditions

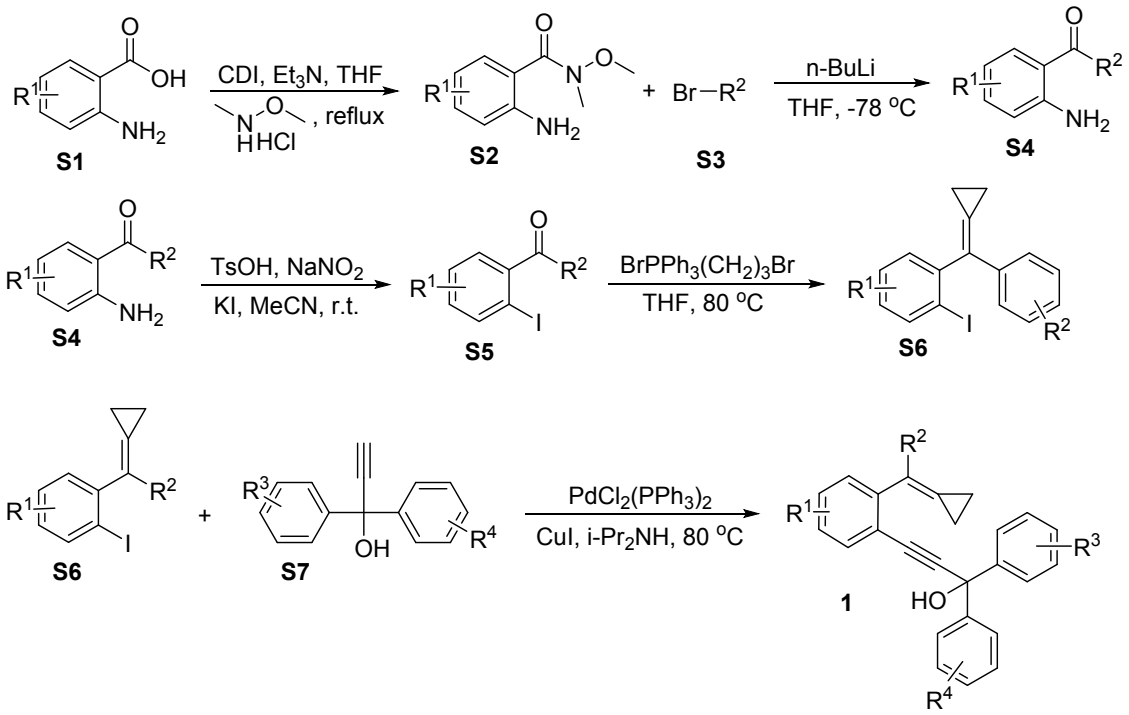
Table S1. Screening of reaction conditions



Entry	Reaction conditions[a]	Yield of **2a** [%][b]
1	TsCl (1.5 equiv), pyridine (1.6 equiv), DCM	NR
2	TsCl (1.5 equiv), Et_3N (1.6 equiv), DCM	NR
3	MsCl (1.5 equiv), Et_3N (1.6 equiv), DCM	79
4	MsCl (1.5 equiv), pyridine (1.6 equiv), DCM	NR
5	MsCl (1.5 equiv), K_2CO_3 (1.6 equiv), DCM	NR
6	MsCl (1.5 equiv), *i*-Pr_2NH (1.6 equiv), DCM	Trace
7	MsCl (1.5 equiv), Et_3N (1.6 equiv), DMSO	Trace
8	MsCl (1.5 equiv), Et_3N (1.6 equiv), MeCN	84
9	MsCl (1.5 equiv), Et_3N (1.6 equiv), THF	45
10	MsCl (1.5 equiv), Et_3N (1.6 equiv), Et_2O	Trace
11	MsCl (1.5 equiv), Et_3N (1.6 equiv), Dioxane	Trace
12	MsCl (1.5 equiv), Et_3N (1.6 equiv), DMF	Trace
13	MsCl (1.5 equiv), Et_3N (1.6 equiv), PhMe	34
14	MsCl (2.0 equiv), Et_3N (2.1 equiv), MeCN	86
15	MsCl (2.5 equiv), Et_3N (2.6 equiv), MeCN	90
16	MsCl (3.0 equiv), Et_3N (3.1 equiv), MeCN	85
17	MsCl (2.5 equiv), Et_3N (2.6 equiv), MeCN	81[c]

[a] Reaction conditions: **1a** (0.20 mmol, 1.0 equiv), MsCl or TsCl, base, solvent, rt, for 8 h. [b] ^1H NMR yield using 1,3,5-trimethoxybenzene as an internal standard. [c] Isolated yield.

3. Preparation of reactants

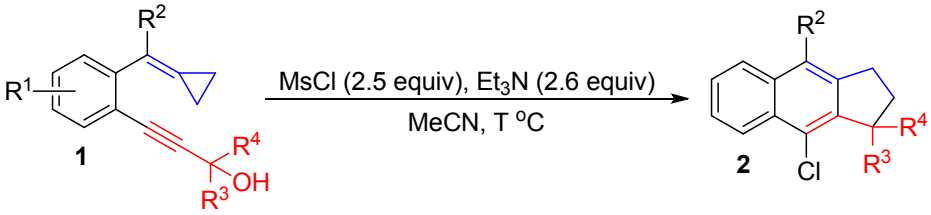


Propargylic alcohol-tethered methylenecyclopropanes were prepared according to the previous literature.[1]

1) Q. Li, L. Yu, Y. Wei and M. Shi, *J. Org. Chem.*, 2019, **84**, 9282–9296.

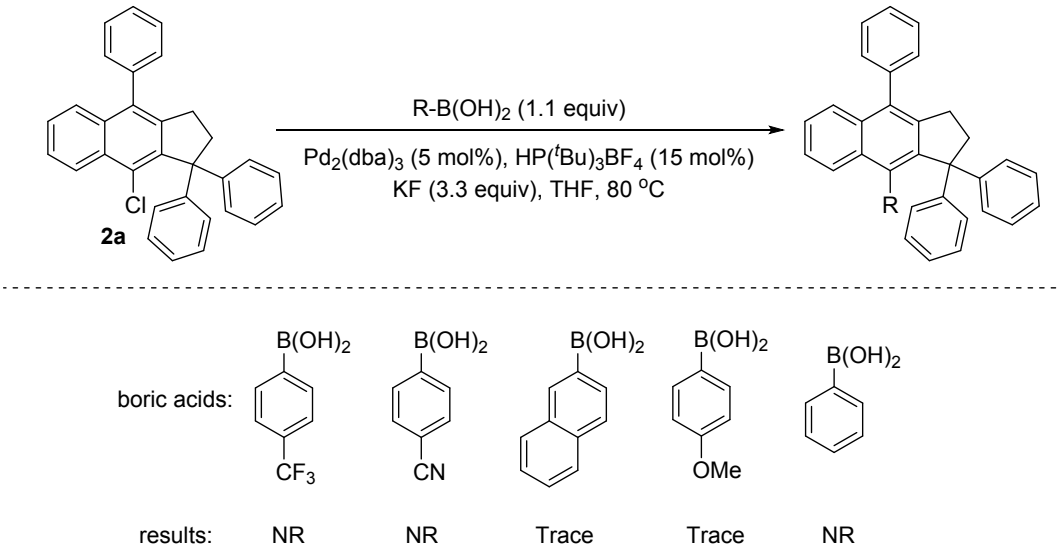
4. General procedures of cyclization reactions

General procedure for the preparation of compounds **2**:



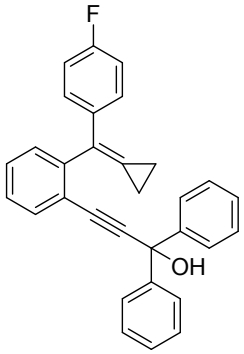
To a stirred solution of **1** (1.0 equiv) and Et_3N (2.6 equiv) in dry MeCN (2 mL) was added MsCl (2.5 equiv), and the resulting mixture was stirred at T °C for 8 h. After washing by water and removing the solvent under reduced pressure, the residue was purified by a column chromatography on silica gel with petroleum to afford the corresponding products **2**.

5. Unsuccessful coupling experiments

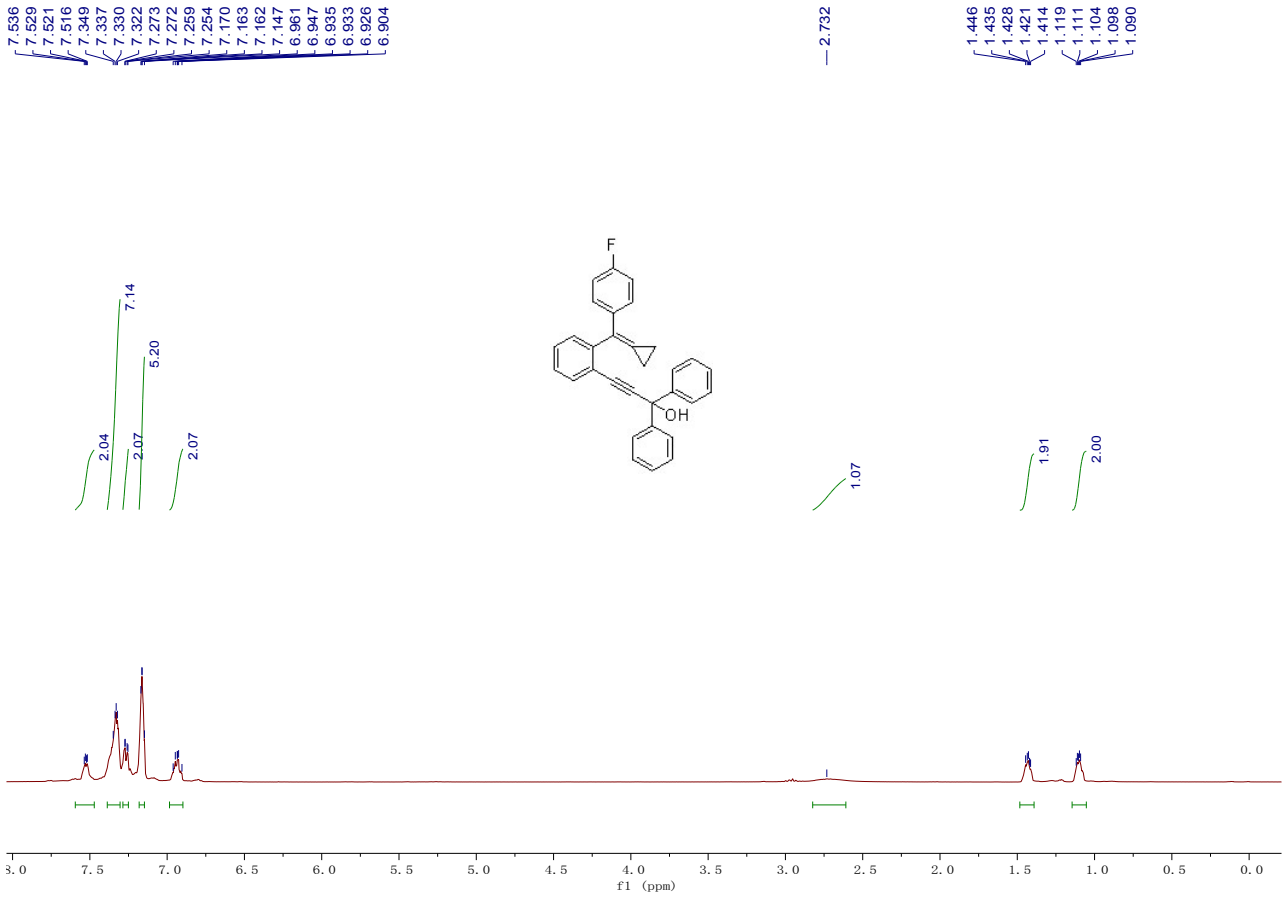


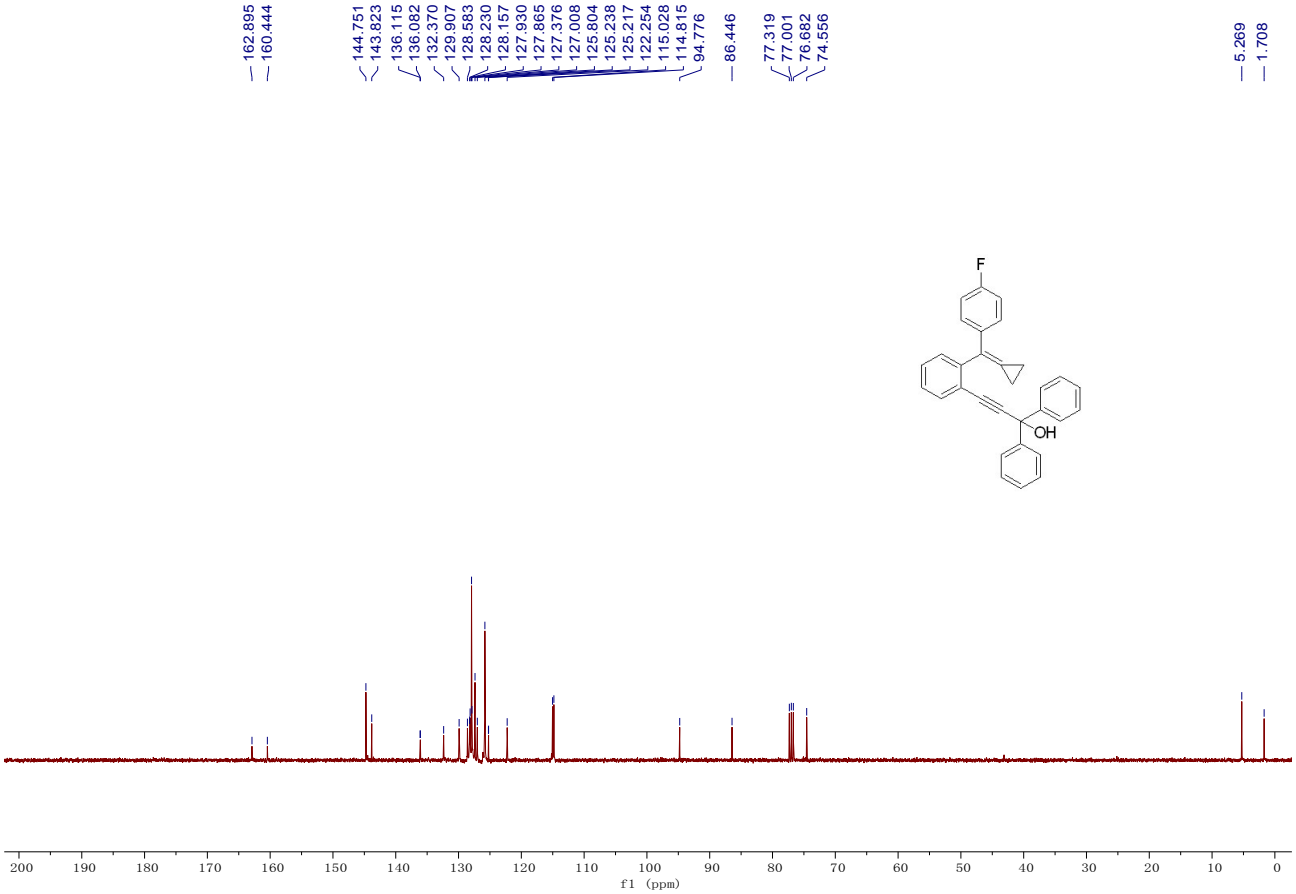
To a degassed solution of **2a** (1.0 equiv), KF (3.3 equiv) and boric acids (1.1 equiv) in dry THF (2 mL) was added $Pd_2(dba)_3$ (5 mol%) and $HP(^tBu)_3BF_4$ (15 mol%), and the resulting mixture was stirred at 80 °C for 8 h. After removing the solvent under reduced pressure, the crude ^1H NMR spectrum was determined.

6. Characterization and spectra charts



Compound 1f: Yield: 1.3 g, 80%; A white solid; Mp: 89 - 91 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.59 – 7.47 (m, 2H), 7.39 – 7.30 (m, 7H), 7.29 – 7.25 (m, 2H), 7.18 – 7.15 (m, 5H), 6.98 – 6.90 (m, 2H), 2.73 (s, 1H), 1.48 – 1.39 (m, 2H), 1.15 – 1.05 (m, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 161.7 (d, *J* = 246.3 Hz), 144.8, 143.8, 136.1, 136.1, 132.4, 129.9, 128.6, 128.2 (d, *J* = 7.4 Hz), 127.9, 127.4, 127.0, 125.8, 125.2 (d, *J* = 2.1 Hz), 122.3, 114.9 (d, *J* = 21.3 Hz), 94.8, 86.4, 74.6, 5.3, 1.7; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -115.25 – -115.42 (m); IR (neat): ν 2925, 2857, 1501, 1089, 834, 757 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{23}FO$ [M]$^{+}$: 430.1727, Found: 430.1737.

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132.370
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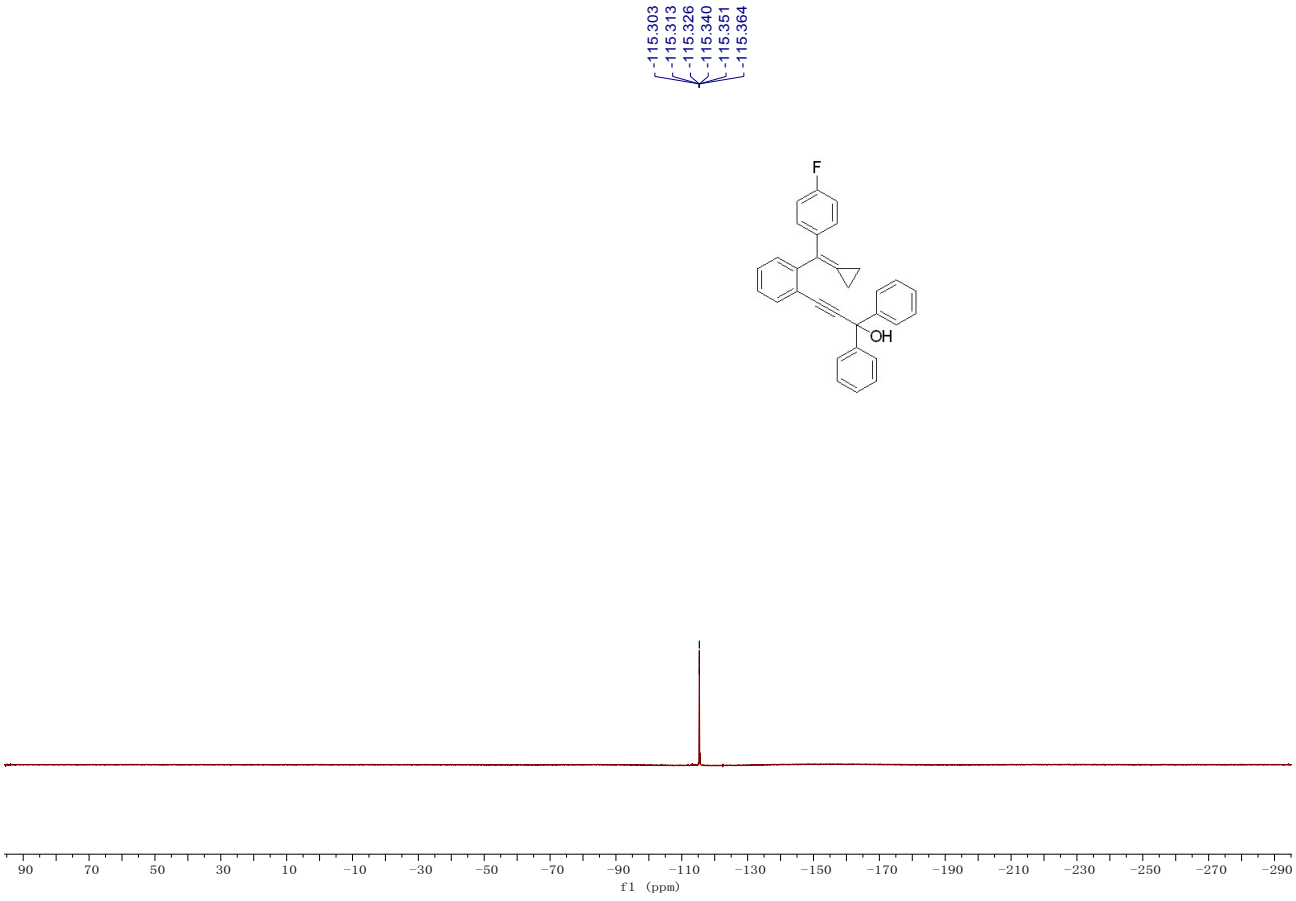
128.230
128.157
127.930
127.865
127.376
127.008
125.804
125.238
125.217
122.254
115.028
114.815
94.776
86.446
77.319
77.001
76.682
74.556
5.269
1.708
F
OH
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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-115.326
-115.340
-115.351
-115.364
F
OH
90
70
50
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10
-10
-30
-50
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-190
-210
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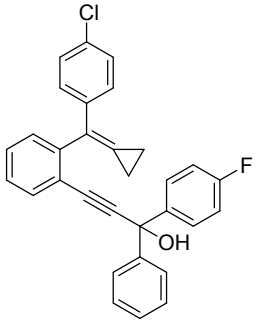
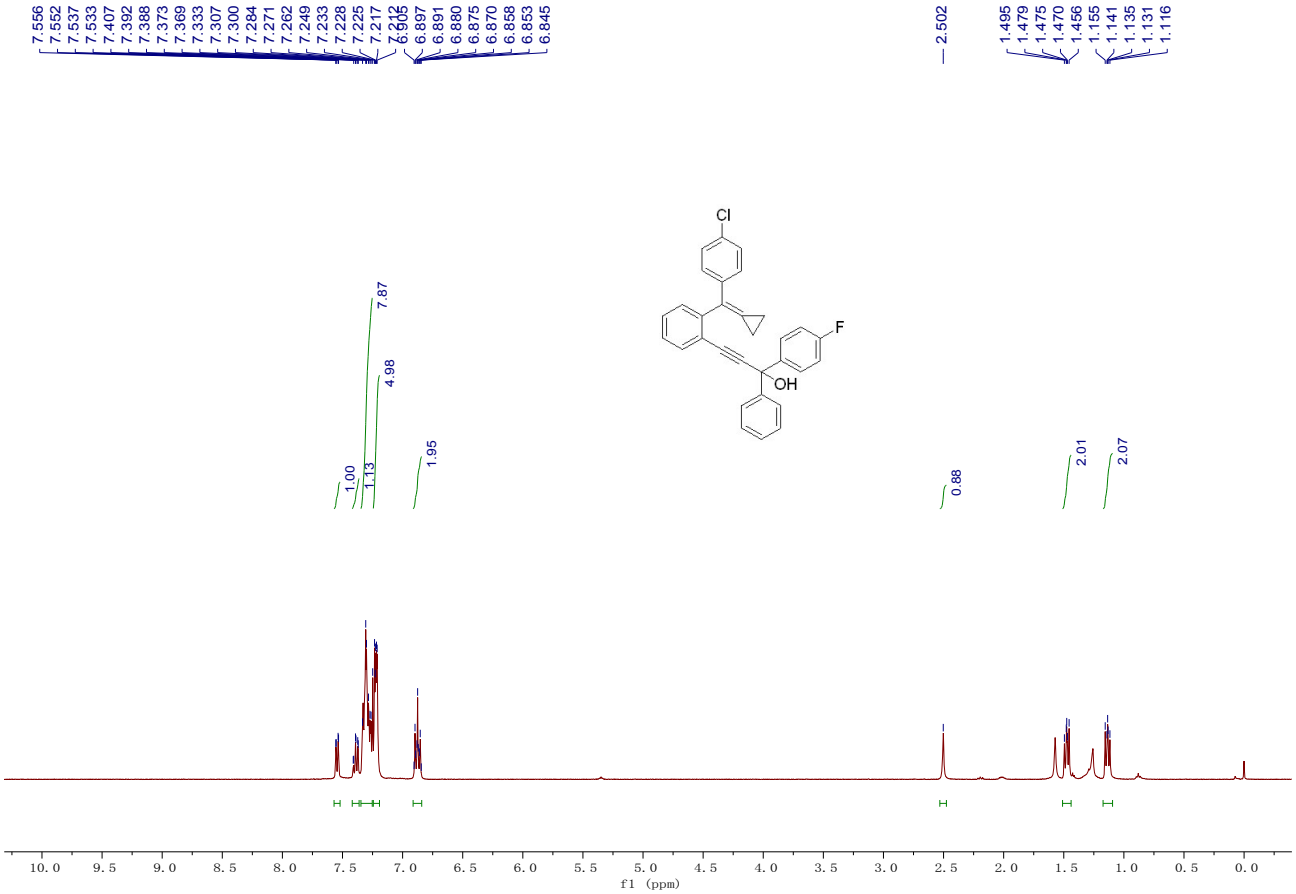
-250
-270
-290
f1 (ppm)



Compound 1k: Yield: 1.9 g, 85%; A white solid; Mp: 98 - 100 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.54 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.41 – 7.36 (m, 1H), 7.35 – 7.25 (m, 8H), 7.24 – 7.19 (m, 5H), 6.91 – 6.84 (m, 2H), 2.50 (s, 1H), 1.51 – 1.44 (m, 2H), 1.17 – 1.09 (m, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 162.0 (d, *J* = 246.6 Hz), 144.6, 143.5, 140.6, 138.4, 132.5, 132.4, 130.1, 128.8, 128.3, 128.1, 128.0, 127.9, 127.7, 127.6, 127.2, 126.4, 125.8, 122.1, 114.8 (d, *J* = 21.5 Hz), 94.7, 86.6, 74.2, 5.5, 1.8; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -115.05 – -115.13 (m); IR (neat): ν 2927, 1599, 1505, 1484, 1218, 1153, 754 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{22}ClFO$ $[M]^{+}$: 464.1338, Found: 464.1339.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7.271
7.262
7.249
7.233
7.228
7.225
7.217
6.897
6.891
6.880
6.875
6.870
6.858
6.853
6.845
2.502
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1.475
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1.155
1.141
1.135
1.131
1.116
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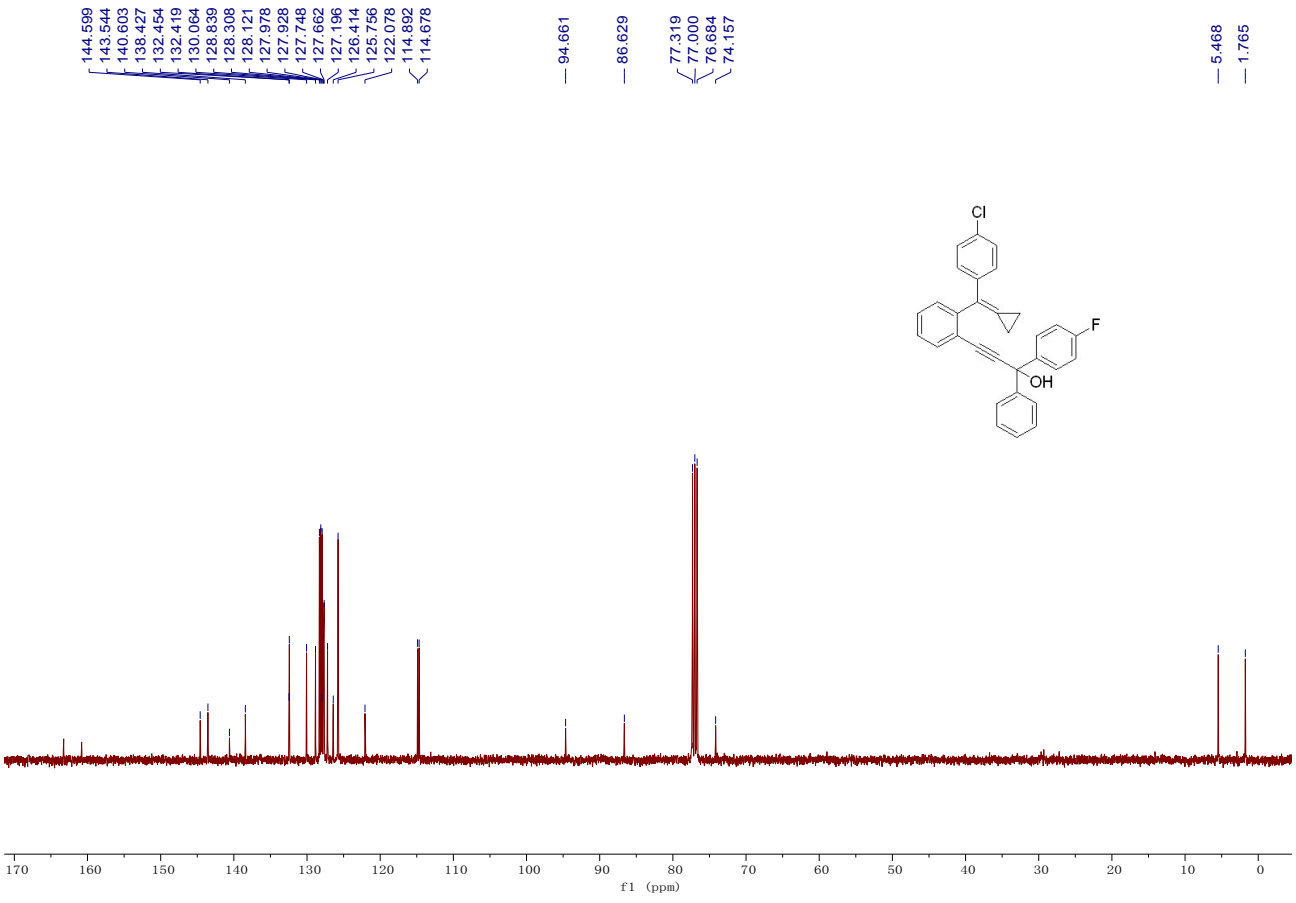
1.00
1.13
1.95
0.88
2.01
2.07
f1 (ppm)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127.196
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125.756
122.078
114.892
114.678
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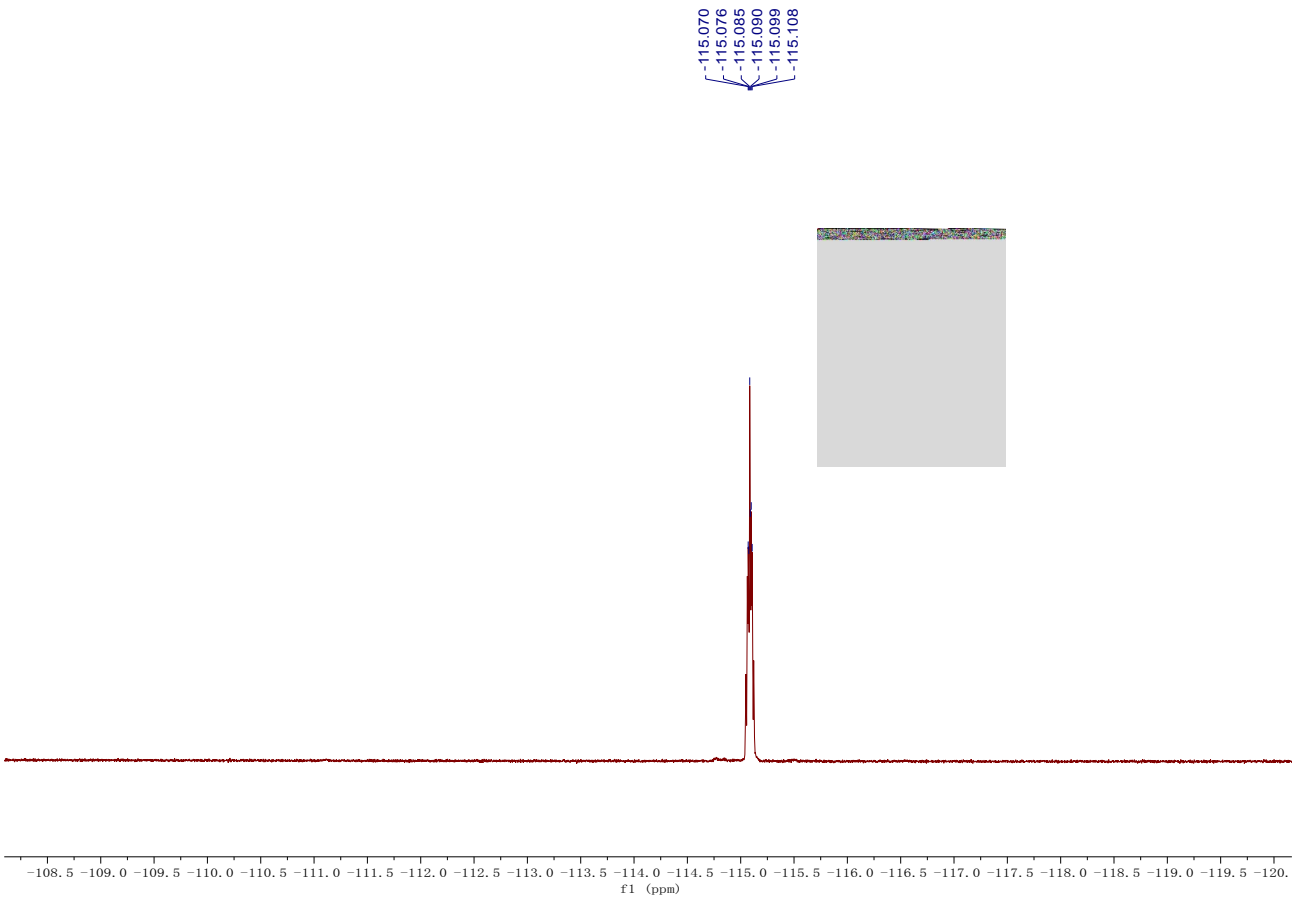
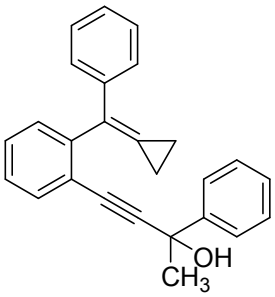
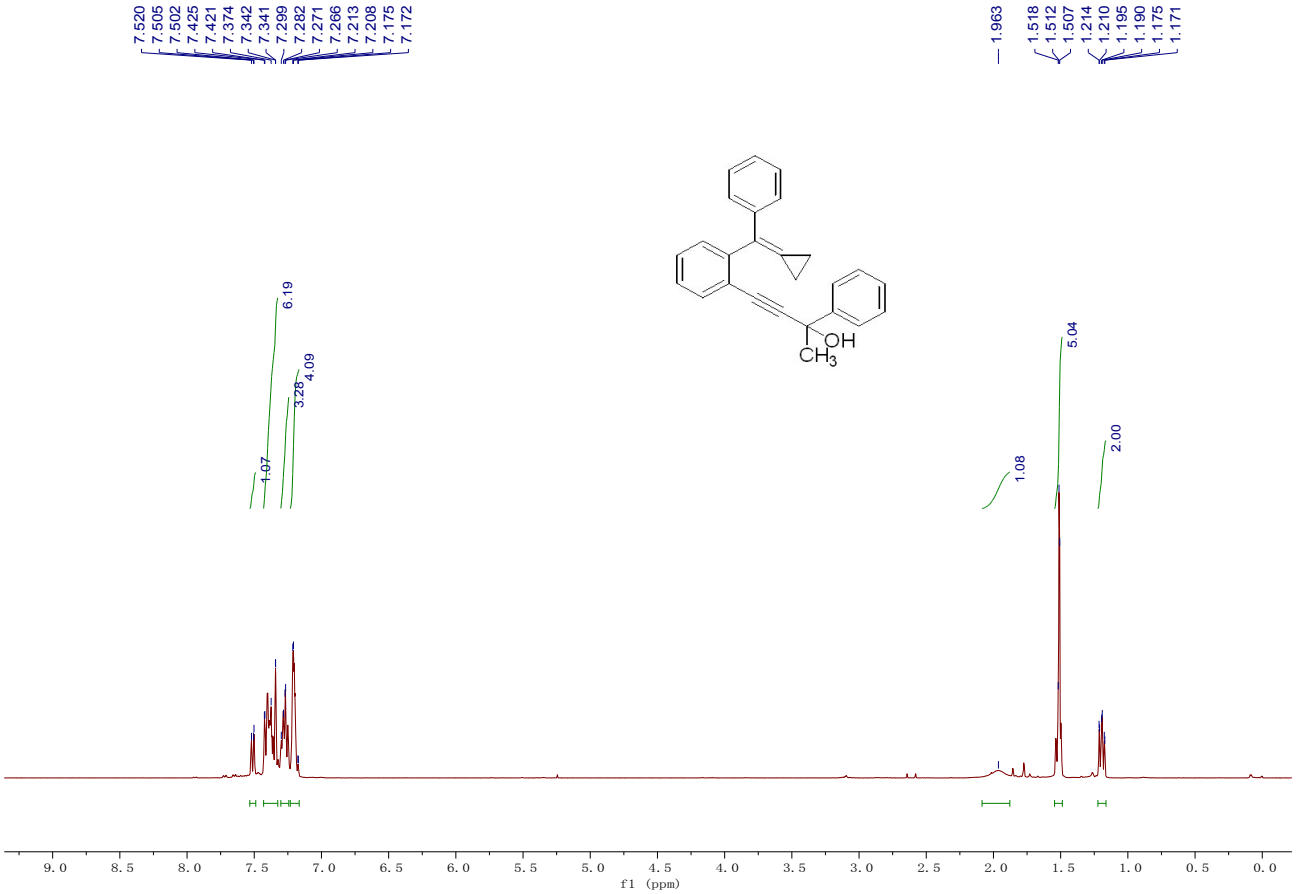
1.765
Cl
F
OH
f1 (ppm)





Compound 1o: Yield: 1.1 g, 70%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.53 – 7.49 (m, 1H), 7.43 – 7.32 (m, 6H), 7.30 – 7.24 (m, 3H), 7.23 – 7.17 (m, 4H), 1.96 (s, 1H), 1.55 – 1.49 (m, 5H), 1.22 – 1.16 (m, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.4, 144.0, 140.4, 132.3, 130.2, 129.1, 128.4, 128.1, 128.0, 127.3, 126.9, 126.6, 125.9, 124.8, 122.3, 95.9, 84.4, 70.0, 32.8, 5.3, 1.9; IR (neat): ν 3372, 2965, 1483, 1089, 1034, 759 cm^{-1}; HRMS (DART) Calcd. for $C_{26}H_{22}O$ $[M+NH_4]^+$: 368.2009, Found: 368.2006.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7.341
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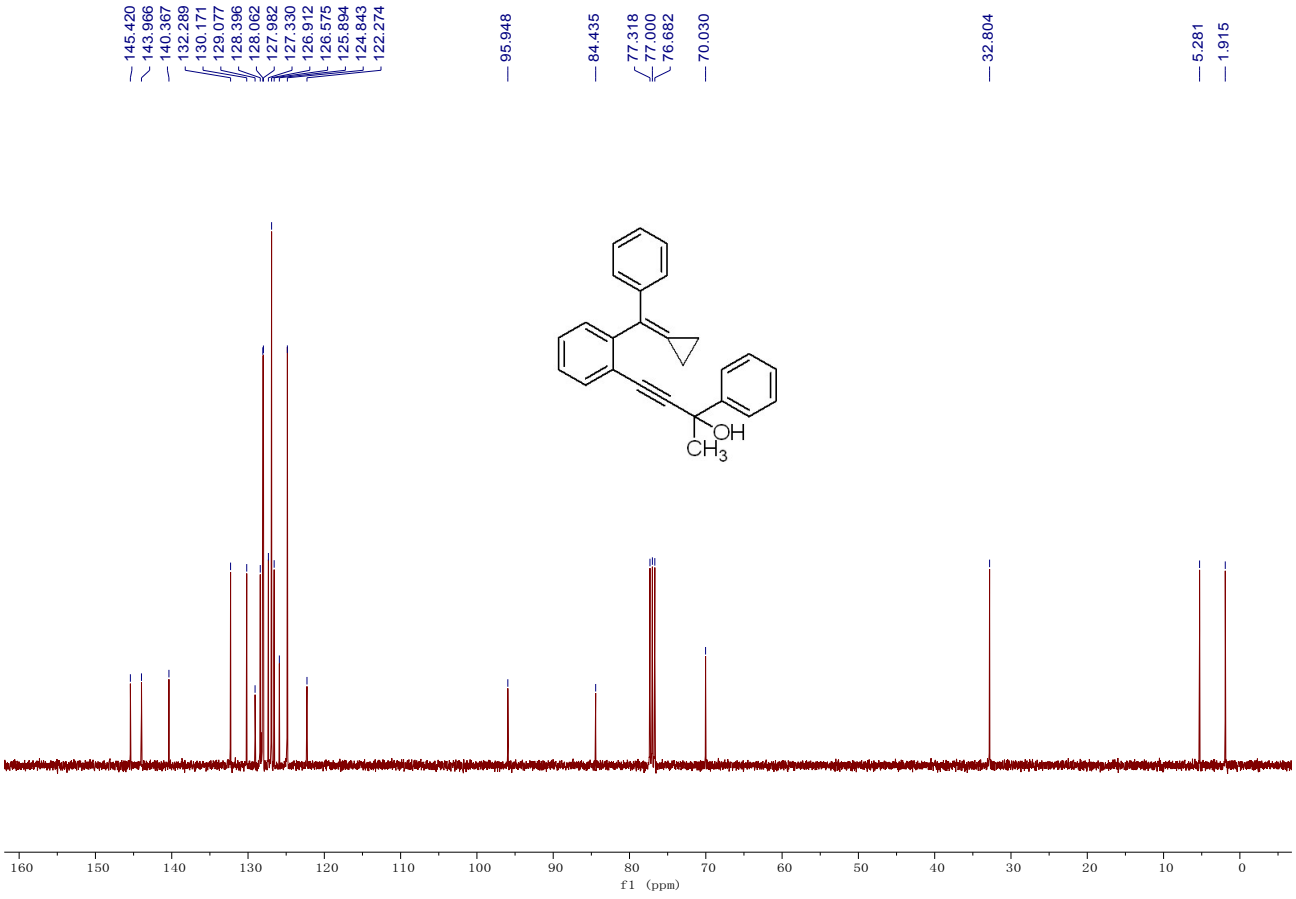
7.208
7.175
7.172
1.963
1.518
1.512
1.507
1.214
1.210
1.195
1.190
1.175
1.171
6.19
4.09
3.28
1.97
5.04
1.08
2.00
OH
CH3
f1 (ppm)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125.894
124.843
122.274
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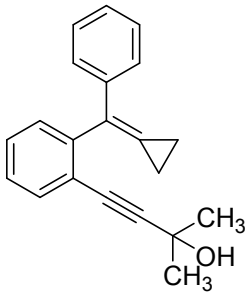
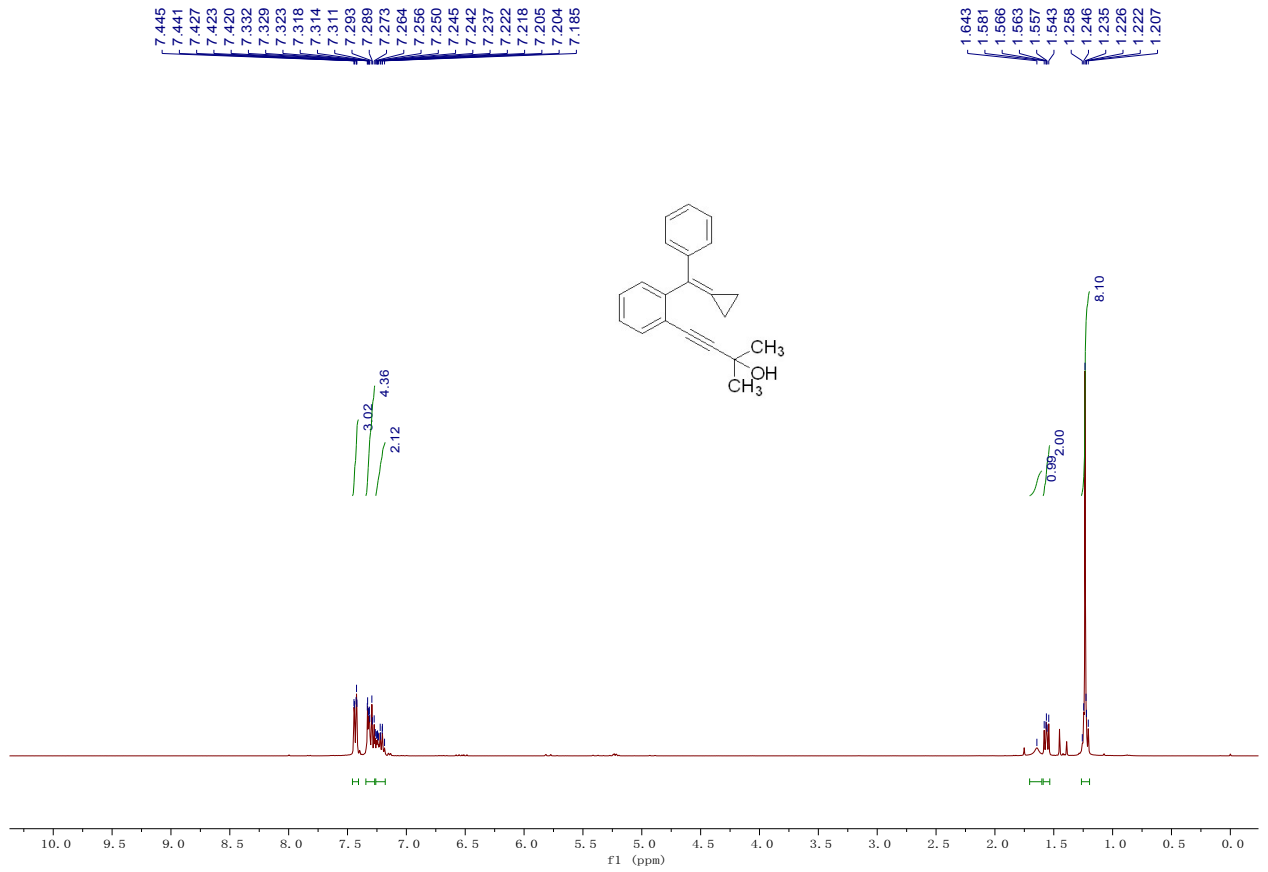
CH3
f1 (ppm)



Compound 1p: Yield: 0.8 g, 65%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.46 – 7.41 (m, 3H), 7.34 – 7.27 (m, 4H), 7.26 – 7.18 (m, 2H), 1.64 (s, 1H), 1.59 – 1.53 (m, 2H), 1.26 – 1.20 (m, 8H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 143.7, 140.7, 132.3, 130.3, 129.3, 128.2, 128.0, 127.1, 126.9, 126.5, 126.1, 122.3, 97.7, 81.8, 30.8, 5.2, 2.2; IR (neat): ν 2925, 2857, 1501, 1089, 834, 757 cm^{-1}; HRMS (EI) Calcd. for $C_{21}H_{20}O$ $[M]^{+}$: 288.1509, Found: 288.1507.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7.264
7.256
7.250
7.245
7.242
7.237
7.222
7.218
7.205
7.204
7.185
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1.246
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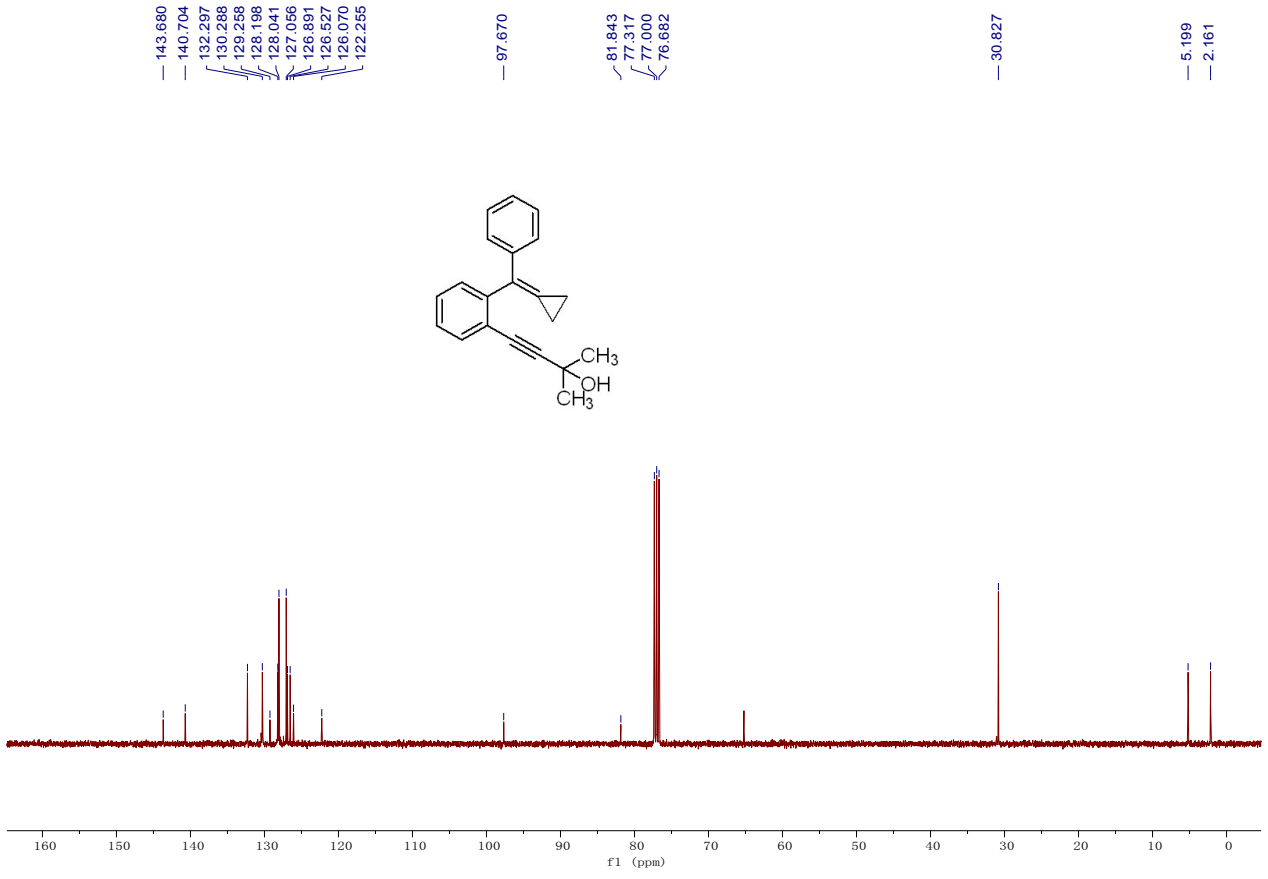
f1 (ppm)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126.070
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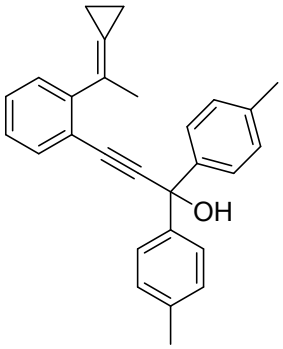
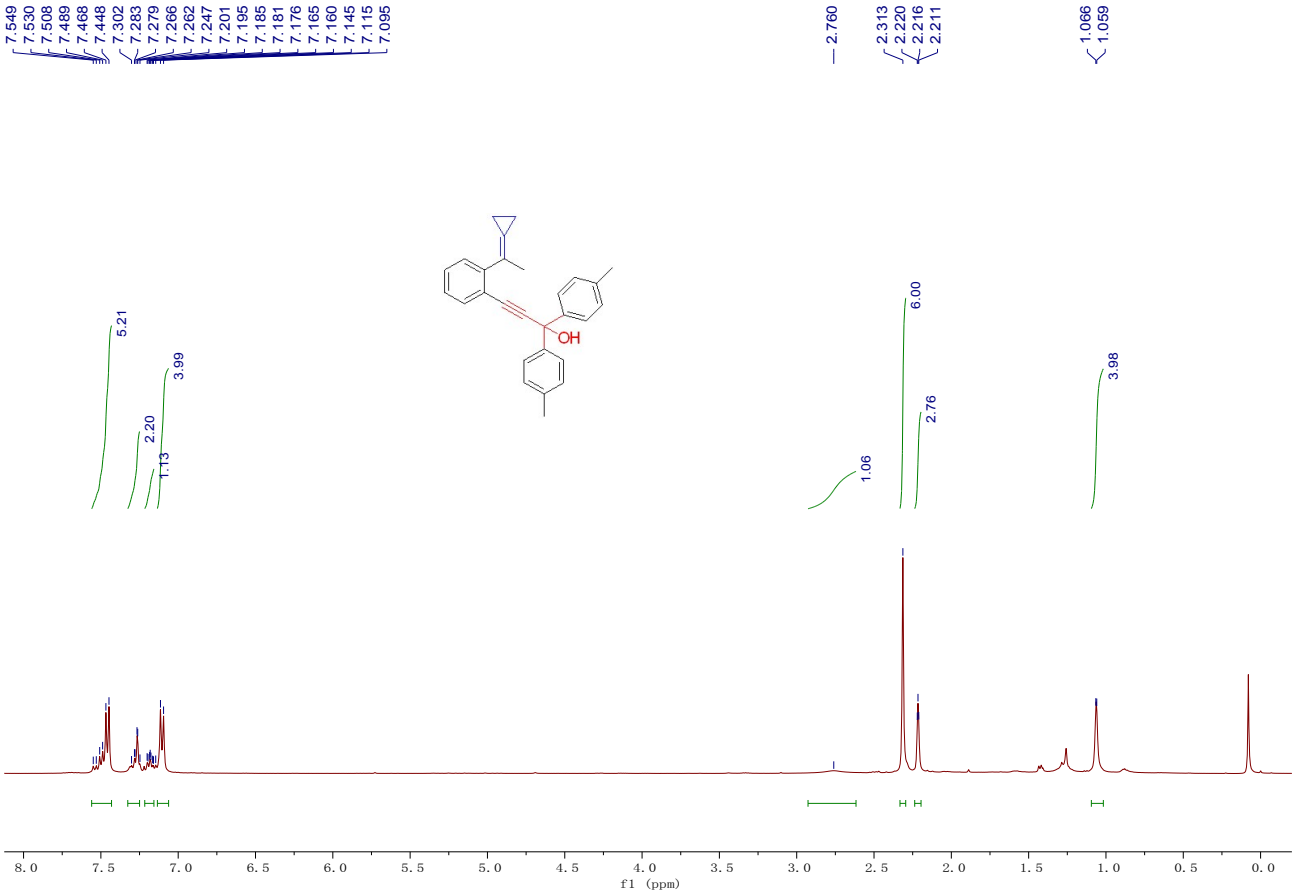
2.161
CH3
OH
CH3
f1 (ppm)



Compound 1r: Yield: 0.9 g, 48%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.56 – 7.43 (m, 5H), 7.33 – 7.25 (m, 2H), 7.22 – 7.16 (m, 1H), 7.10 (d, *J* = 8.0 Hz, 4H), 2.76 (s, 1H), 2.31 (s, 6H), 2.24 – 2.20 (m, 3H), 1.09 – 1.02 (m, 4H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.2, 142.3, 137.2, 132.8, 131.7, 128.9, 128.8, 128.5, 128.3, 128.0, 126.2, 126.0, 124.3, 122.8, 120.7, 94.1, 87.0, 74.6, 22.0, 21.0, 4.3, 2.2, 1.0; IR (neat): ν 3423, 2969, 2912, 1508, 989, 754, 754, 806 cm^{-1}; HRMS (EI) Calcd. for $C_{28}H_{26}O$ $[M]^{+}$: 378.1978, Found: 378.1979.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7.185
7.181
7.176
7.165
7.160
7.145
7.115
7.095
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2.313
2.220
2.216
2.211
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1.13
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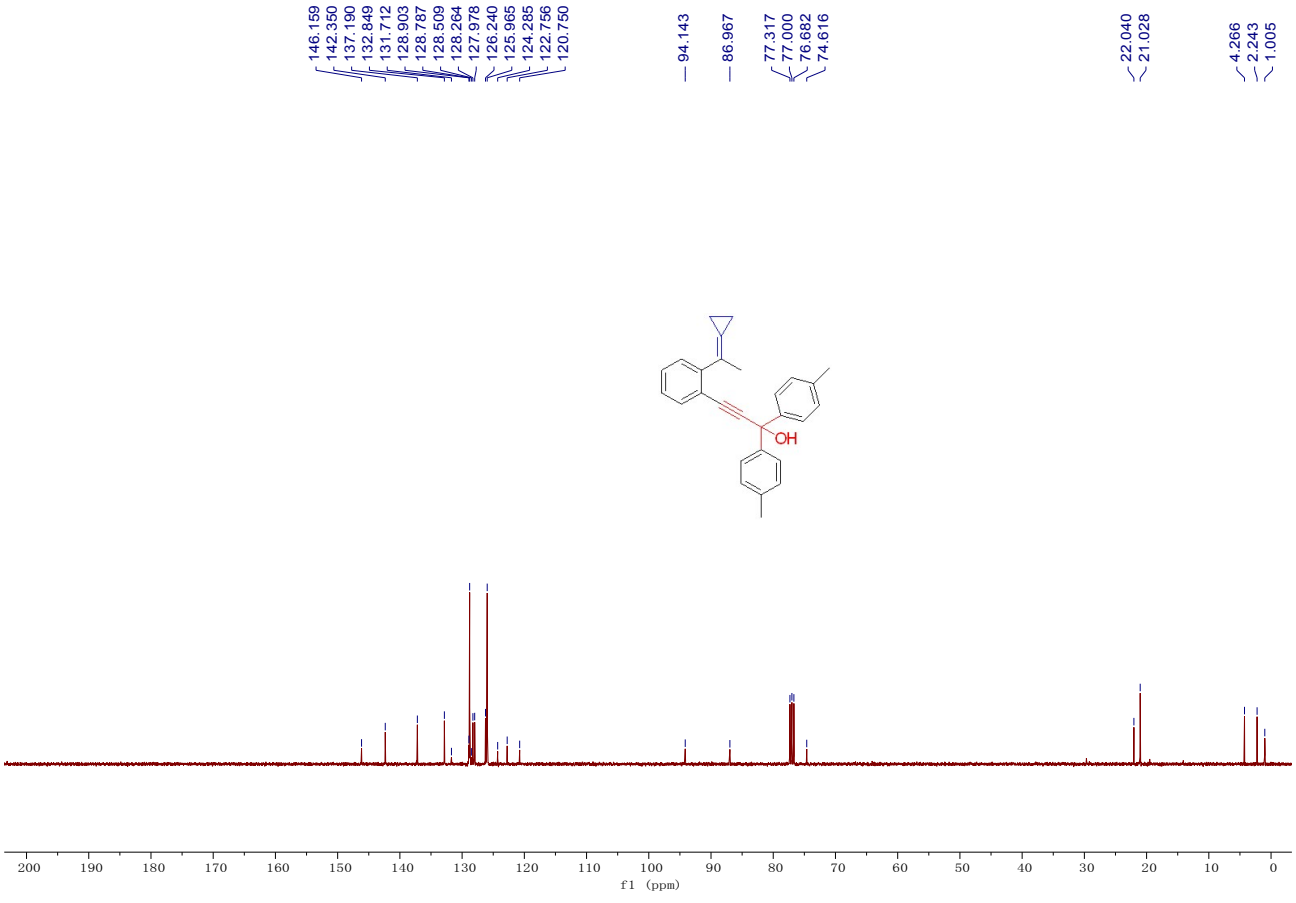
3.98
f1 (ppm)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124.285
122.756
120.750
94.143
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77.000
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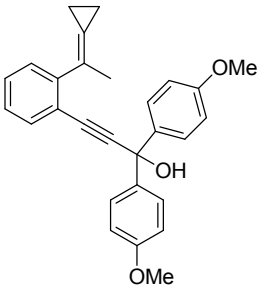
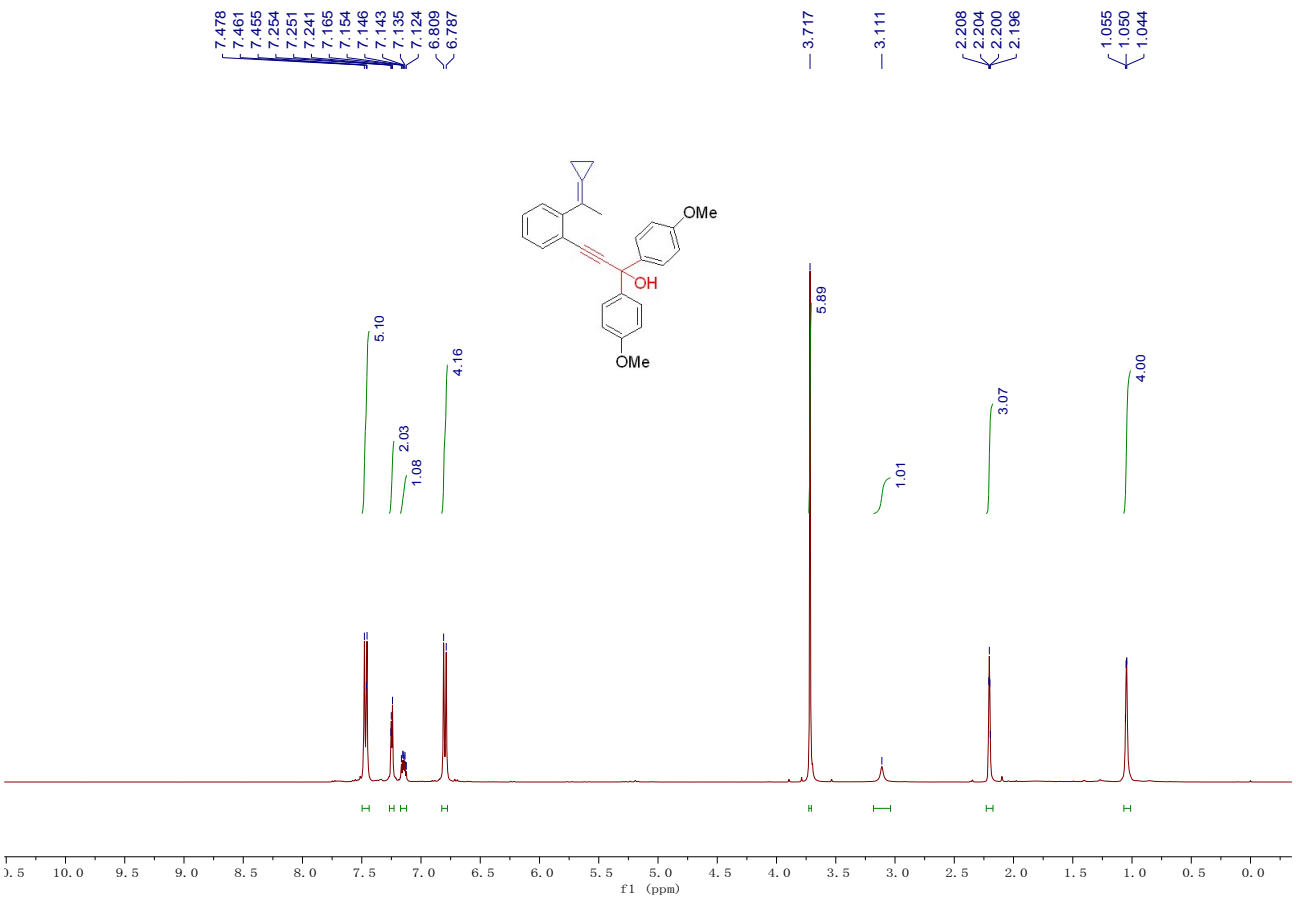
74.616
22.040
21.028
4.266
2.243
1.005
OH
f1 (ppm)



Compound 1s: Yield: 2.3 g, 69%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.50 – 7.43 (m, 5H), 7.28 – 7.22 (m, 2H), 7.19 – 7.10 (m, 1H), 6.83 – 6.76 (m, 4H), 3.72 (s, 6H), 2.23 – 2.17 (m, 3H), 1.05 (s, 4H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 158.7, 146.0, 137.6, 132.8, 128.2, 127.9, 127.3, 126.2, 124.2, 122.7, 120.7, 113.3, 94.3, 86.8, 74.1, 55.1, 21.9, 4.2, 2.2; IR (neat): ν 2831, 1604, 1505, 1247, 1163, 1030, 827, 756 cm^{-1}; HRMS (EI) Calcd. for $C_{28}H_{26}O_3$ $[M]^+$: 410.1876, Found: 410.1876.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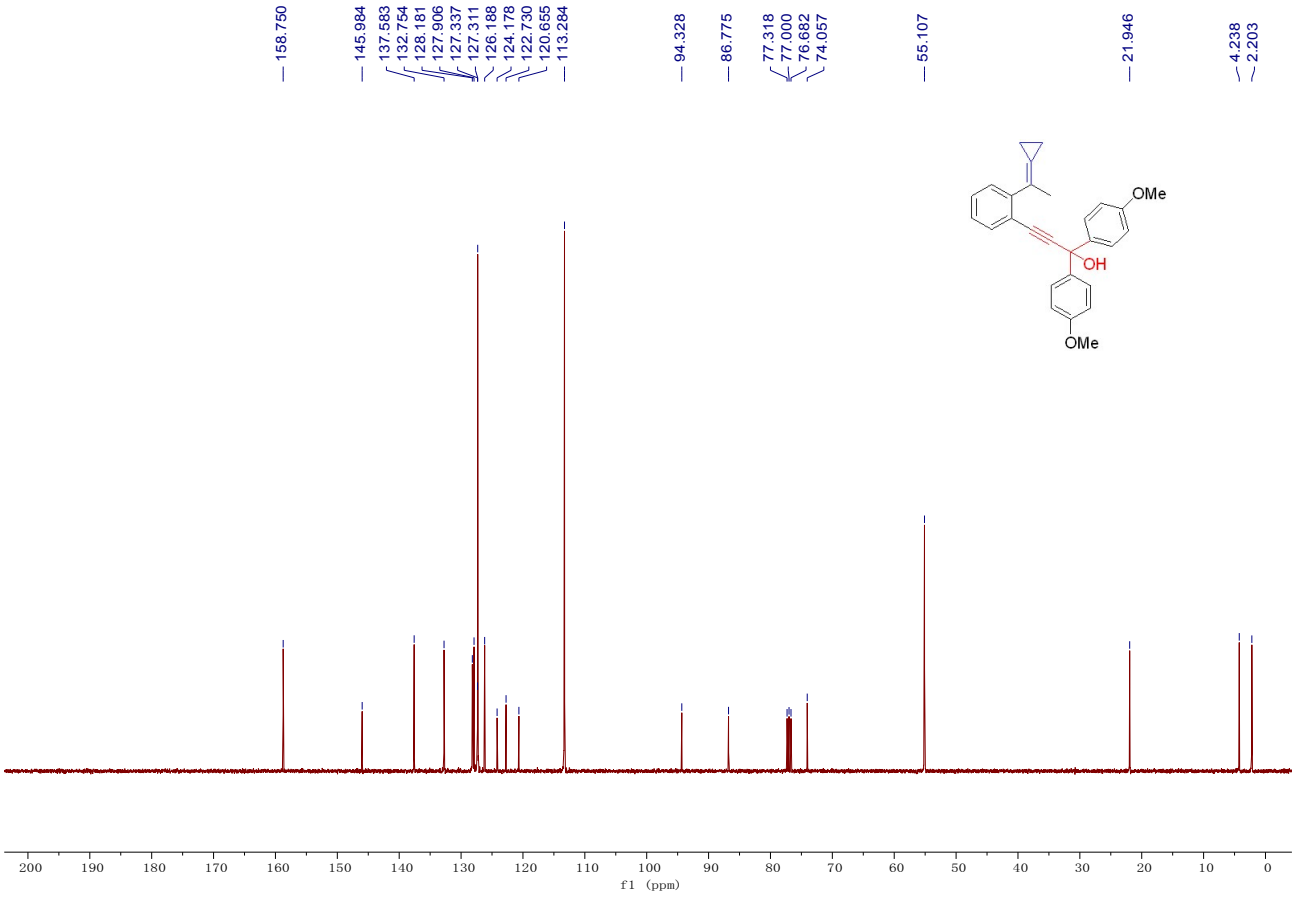
7.154
7.146
7.143
7.135
7.124
6.809
6.787
3.717
3.111
2.208
2.204
2.200
2.196
1.055
1.050
1.044
OMe
OH
OMe
5.10
2.03
1.08
4.16
5.89
1.01
3.07
4.00
f1 (ppm)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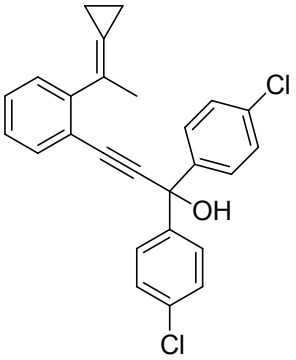
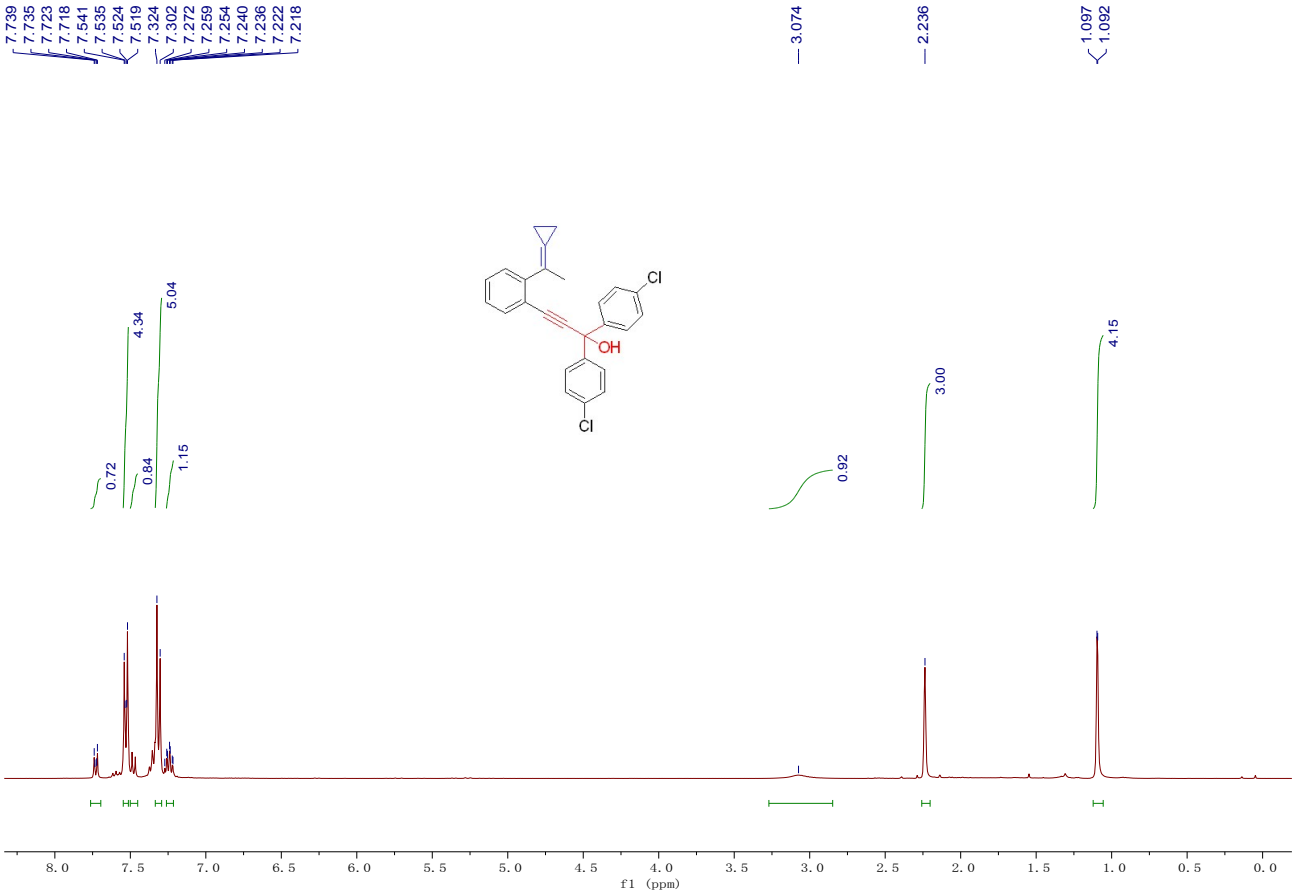
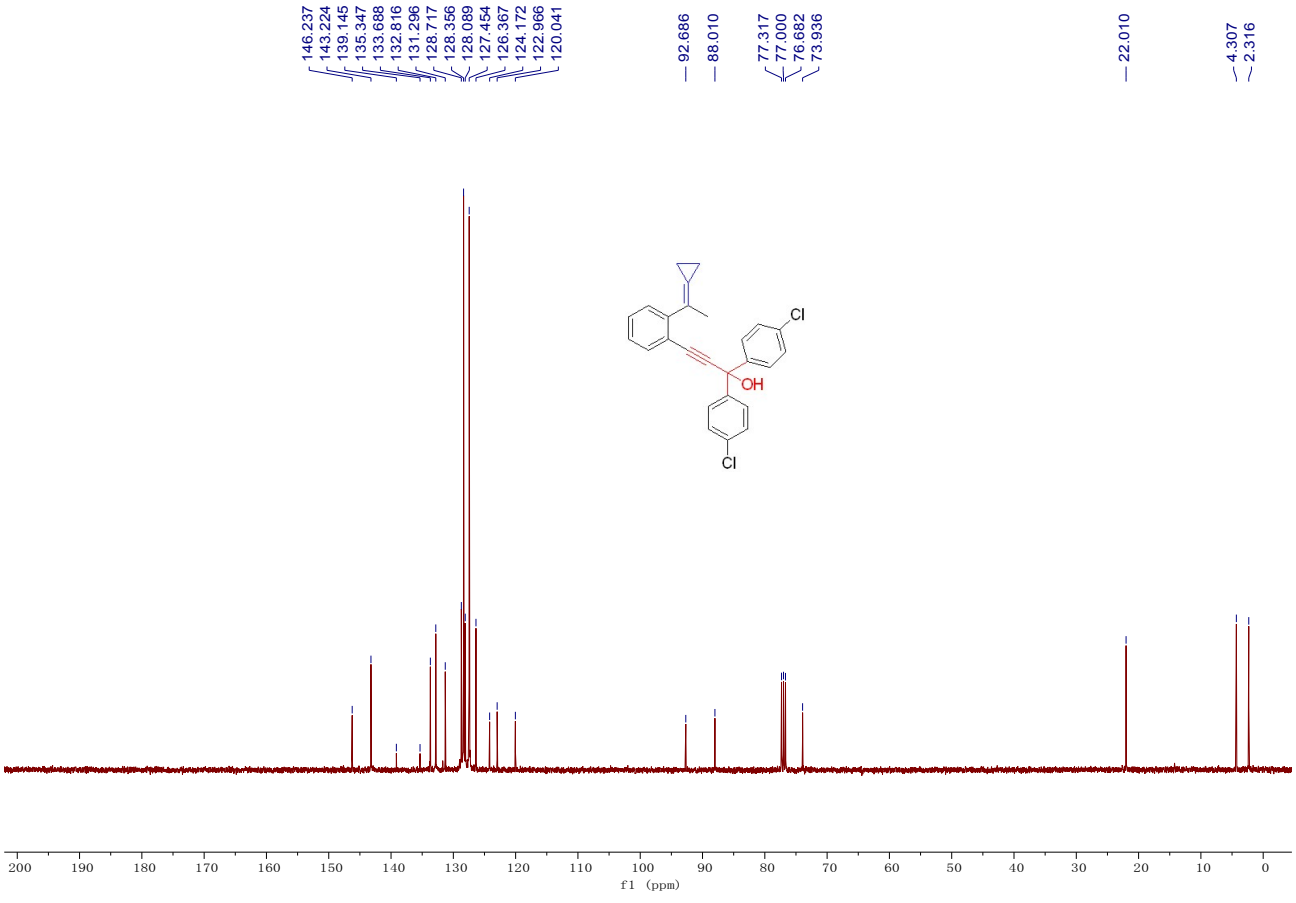
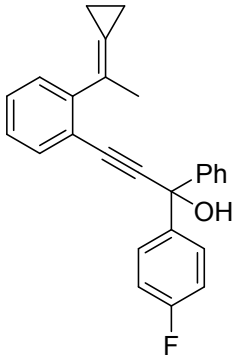
137.583
132.754
128.181
127.906
127.337
127.311
126.188
124.178
122.730
120.655
113.284
94.328
86.775
77.318
77.000
76.682
74.057
55.107
21.946
4.238
2.203
OMe
OH
OMe
f1 (ppm)



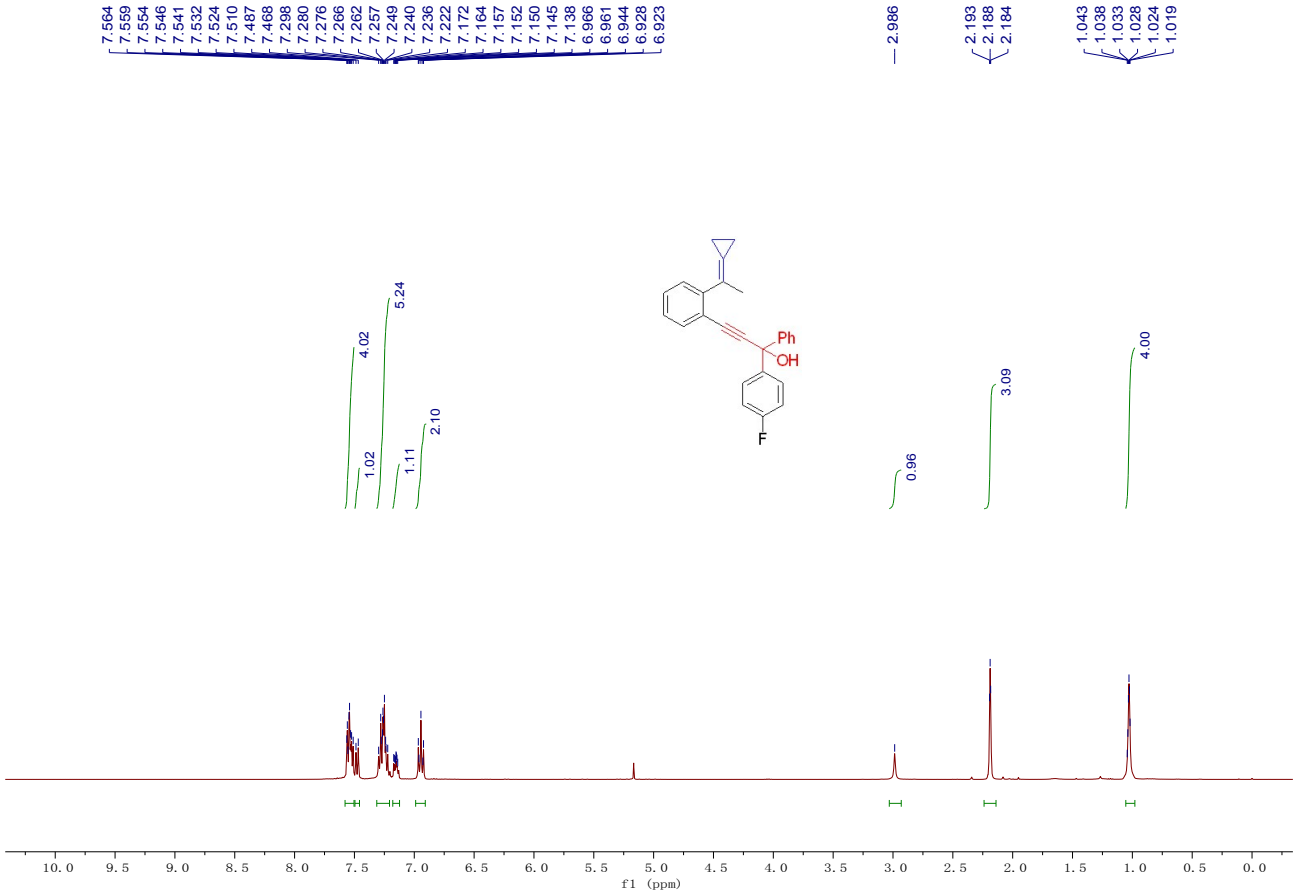
Compound 1t: Yield: 0.6 g, 53%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.76 – 7.70 (m, 1H), 7.55 – 7.51 (m, 4H), 7.50 – 7.45 (m, 1H), 7.33 – 7.29 (m, 5H), 7.26 – 7.21 (m, 1H), 3.02 (s, 1H), 2.26 – 2.20 (m, 3H), 1.12 – 1.06 (m, 4H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.2, 143.2, 139.1, 133.7, 132.8, 131.3, 128.7, 128.4, 128.1, 127.5, 126.4, 124.2, 123.0, 120.0, 92.7, 88.0, 73.9, 22.0, 4.3, 2.3; IR (neat): ν 3420, 2972, 1487, 1090, 1015, 816, 759 cm^{-1}; HRMS (EI) Calcd. for $C_{26}H_{20}Cl_2O$ $[M]^+$: 418.0886, Found: 418.0887.


7.739
7.735
7.723
7.718
7.541
7.535
7.524
7.519
7.324
7.302
7.272
7.259
7.254
7.240
7.236
7.222
7.218
3.074
2.236
1.097
1.092
Cl
OH
Cl
0.72
4.34
0.84
5.04
1.15
0.92
3.00
4.15
f1 (ppm)


146.237
143.224
139.145
135.347
133.688
132.816
131.296
128.717
128.356
128.089
127.454
126.367
124.172
122.966
120.041
92.686
88.010
77.317
77.000
76.682
73.936
22.010
4.307
2.316
Cl
OH
Cl
f1 (ppm)



Compound 1u: Yield: 1.2 g, 59%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.58 – 7.50 (m, 4H), 7.48 (d, *J* = 7.6 Hz, 1H), 7.31 – 7.21 (m, 5H), 7.18 – 7.12 (m, 1H), 6.99 – 6.91 (m, 2H), 2.99 (s, 1H), 2.24 – 2.14 (m, 3H), 1.05 – 0.98 (m, 4H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 162.1 (d, *J* = 246.5 Hz), 146.2, 144.8, 140.9 (d, *J* = 3.2 Hz), 132.8, 128.5, 128.2, 128.0, 127.9 (d, *J* = 8.2 Hz), 127.7, 126.3, 126.0, 124.2, 122.9, 120.4, 114.8 (d, *J* = 21.5 Hz), 93.5, 87.5, 74.4, 22.0, 4.3, 2.2; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -114.77 – -114.90 (m); IR (neat): ν 3380, 2989, 1496, 1040, 759, 696 cm^{-1}; HRMS (EI) Calcd. for $C_{26}H_{21}FO$ $[M]^{+}$: 368.1571, Found: 368.1574.


7.564
7.559
7.554
7.546
7.541
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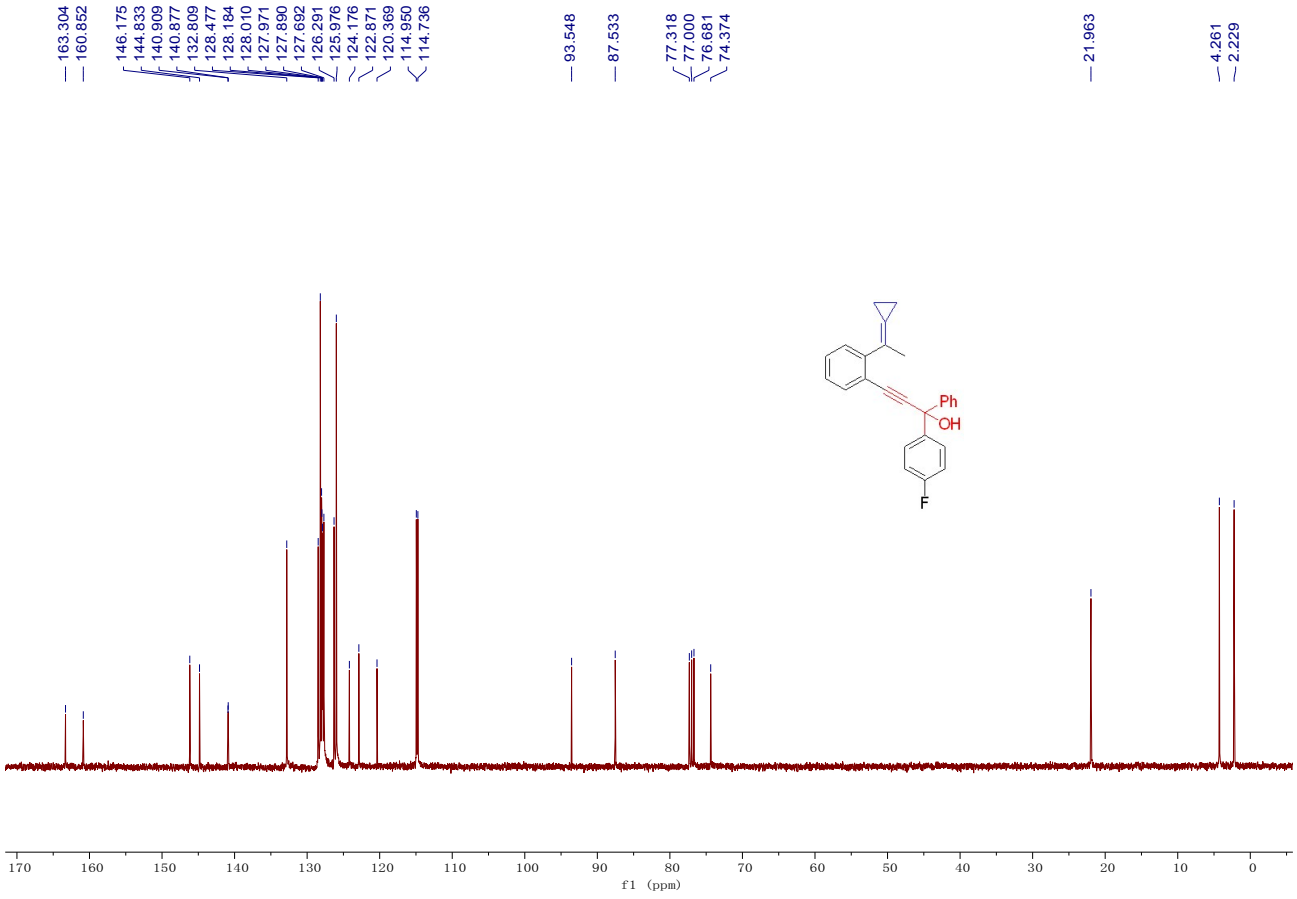
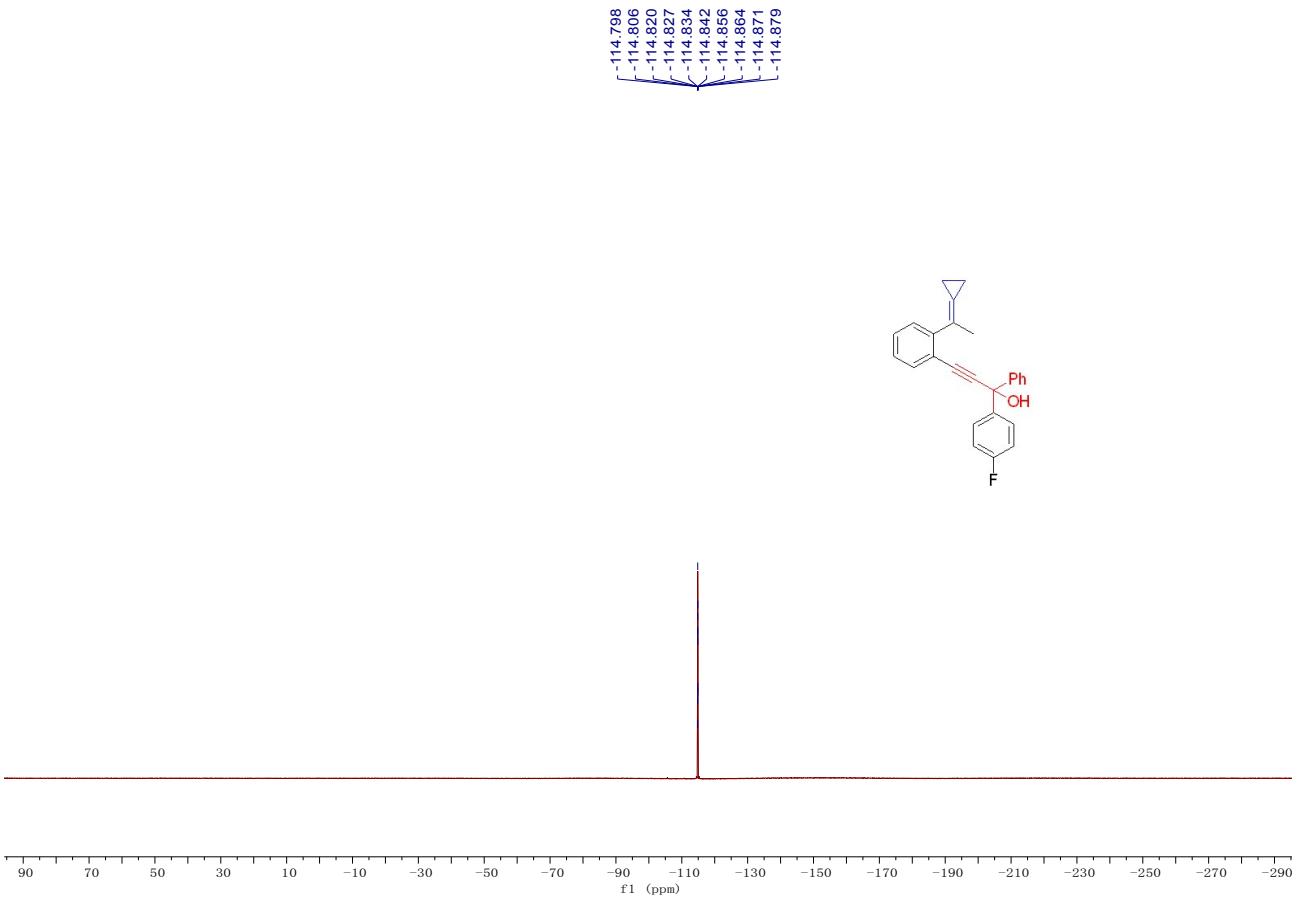
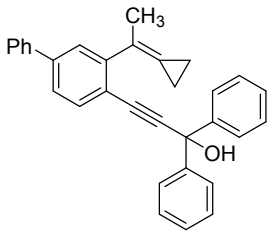
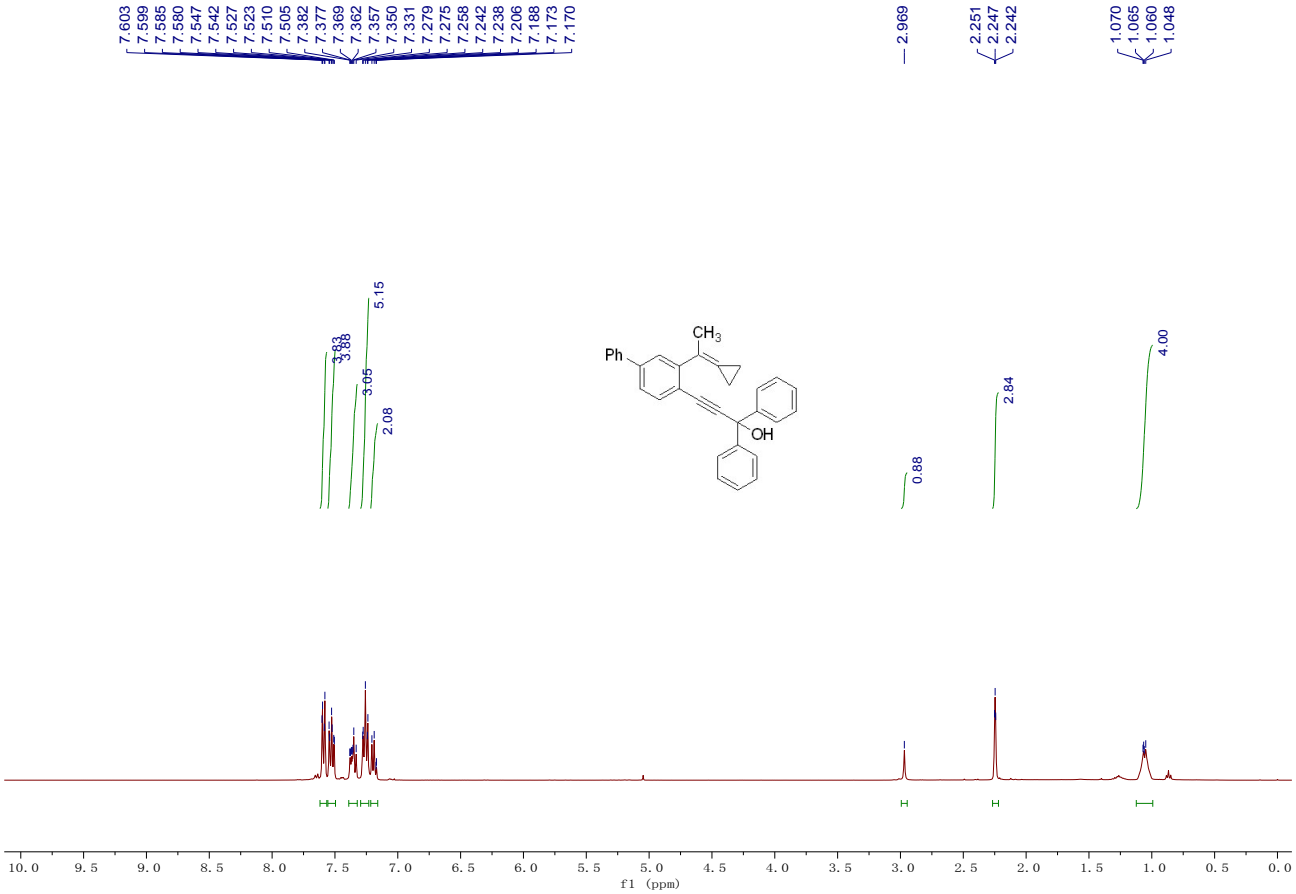
7.524
7.510
7.487
7.468
7.298
7.280
7.276
7.266
7.262
7.257
7.249
7.240
7.236
7.222
7.172
7.164
7.157
7.152
7.150
7.145
7.138
6.966
6.961
6.944
6.928
6.923
2.986
2.193
2.188
2.184
1.043
1.038
1.033
1.028
1.024
1.019
4.02
1.02
5.24
1.11
2.10
0.96
3.09
4.00
Ph
OH
F
f1 (ppm)


163.304
160.852
146.175
144.833
140.909
140.877
132.809
128.477
128.184
128.010
127.971
127.890
127.692
126.291
125.976
124.176
122.871
120.369
114.950
114.736
93.548
87.533
77.318
77.000
76.681
74.374
21.963
4.261
2.229
Ph
OH
F
f1 (ppm)





Compound 1v: Yield: 1.2 g, 89%; A faint yellow oil; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.62 – 7.56 (m, 4H), 7.56 – 7.50 (m, 4H), 7.39 – 7.32 (m, 3H), 7.30 – 7.23 (m, 5H), 7.22 – 7.16 (m, 2H), 2.97 (s, 1H), 2.27 – 2.22 (m, 3H), 1.12 – 0.99 (m, 4H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.6, 145.0, 141.0, 140.2, 133.3, 128.7, 128.1, 127.5, 126.9, 126.6, 126.0, 124.9, 124.2, 123.0, 119.5, 94.5, 87.2, 74.8, 22.0, 4.3, 2.3; IR (neat): ν 3371, 2966, 1482, 1445, 1033, 759, 696 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{26}O$ $[M]^{+}$: 426.1978, Found: 426.1980.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7.585
7.580
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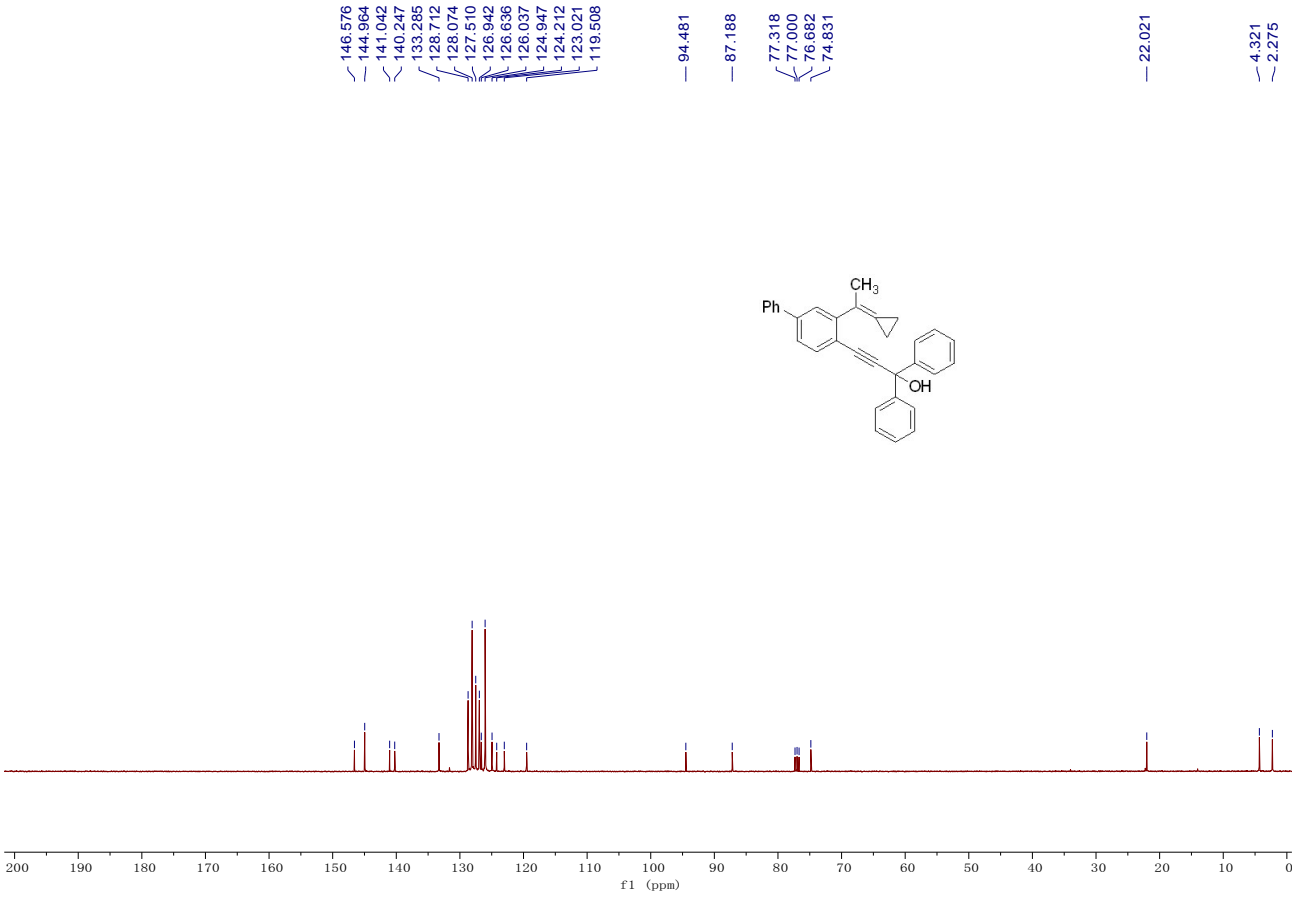
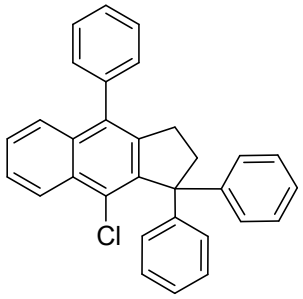
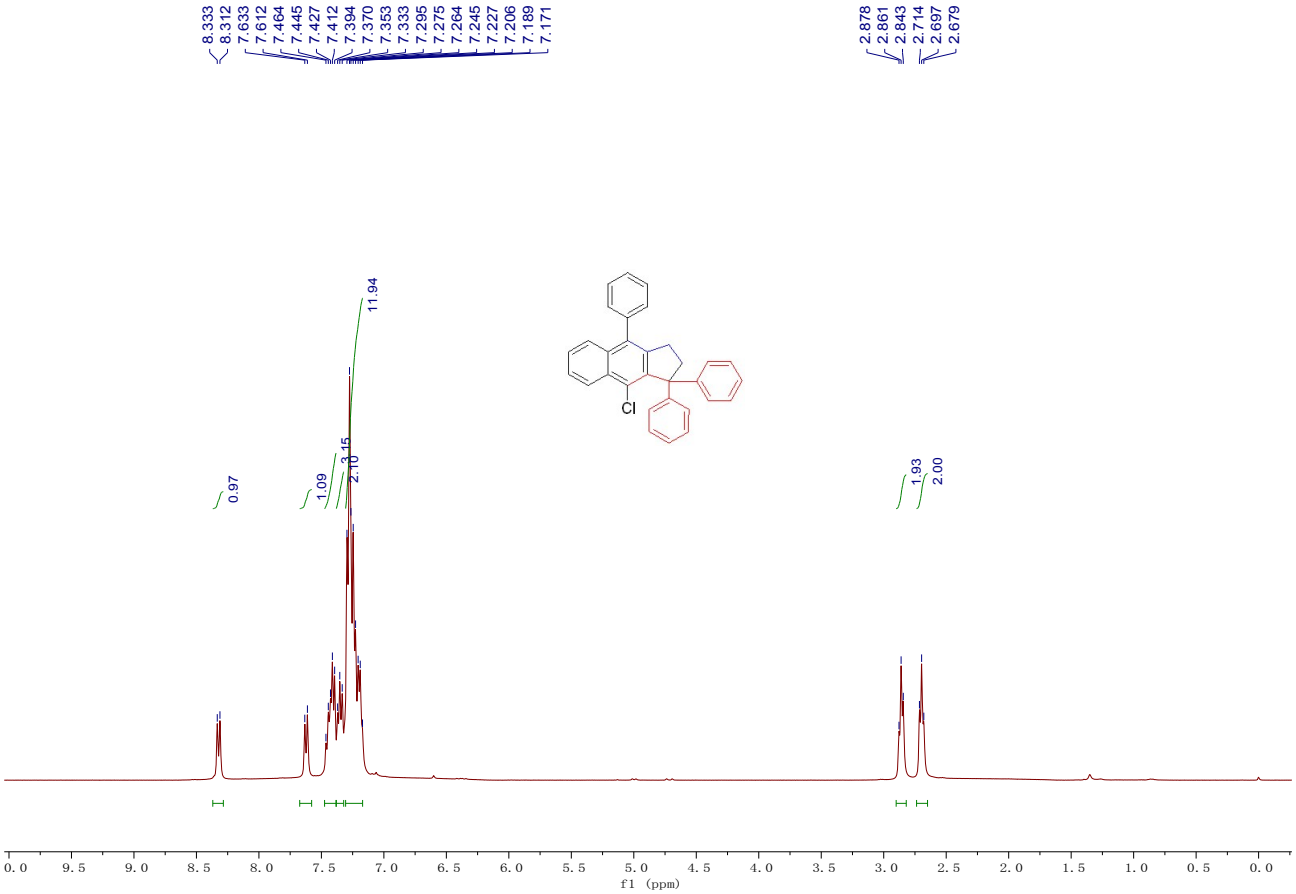
7.542
7.527
7.523
7.510
7.505
7.382
7.377
7.369
7.362
7.357
7.350
7.331
7.279
7.275
7.258
7.242
7.238
7.206
7.188
7.173
7.170
2.969
2.251
2.247
2.242
1.070
1.065
1.060
1.048
5.15
3.83
3.88
3.05
2.08
CH3
Ph
OH
0.88
2.84
4.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


146.576
144.964
141.042
140.247
133.285
128.712
128.074
127.510
126.942
126.636
126.037
124.947
124.212
123.021
119.508
94.481
87.188
77.318
77.000
76.682
74.831
22.021
4.321
2.275
CH3
Ph
OH
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



Compound 2a: Yield: 69 mg, 81%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.32 (d, *J* = 8.6 Hz, 1H), 7.62 (d, *J* = 8.6 Hz, 1H), 7.42 (dd, *J* = 13.2, 7.1 Hz, 3H), 7.38 – 7.32 (m, 2H), 7.31 – 7.17 (m, 12H), 2.86 (t, *J* = 7.0 Hz, 2H), 2.70 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.6, 144.5, 142.6, 138.4, 134.2, 133.4, 131.0, 130.0, 129.3, 129.1, 128.3, 127.9, 127.3, 126.28, 126.24, 126.1, 125.9, 124.4, 64.2, 47.7, 30.7; IR (neat): ν 2980, 1592, 1490, 1434, 1011, 765 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{23}Cl$ $[M]^{+}$: 430.1483, Found: 430.1486.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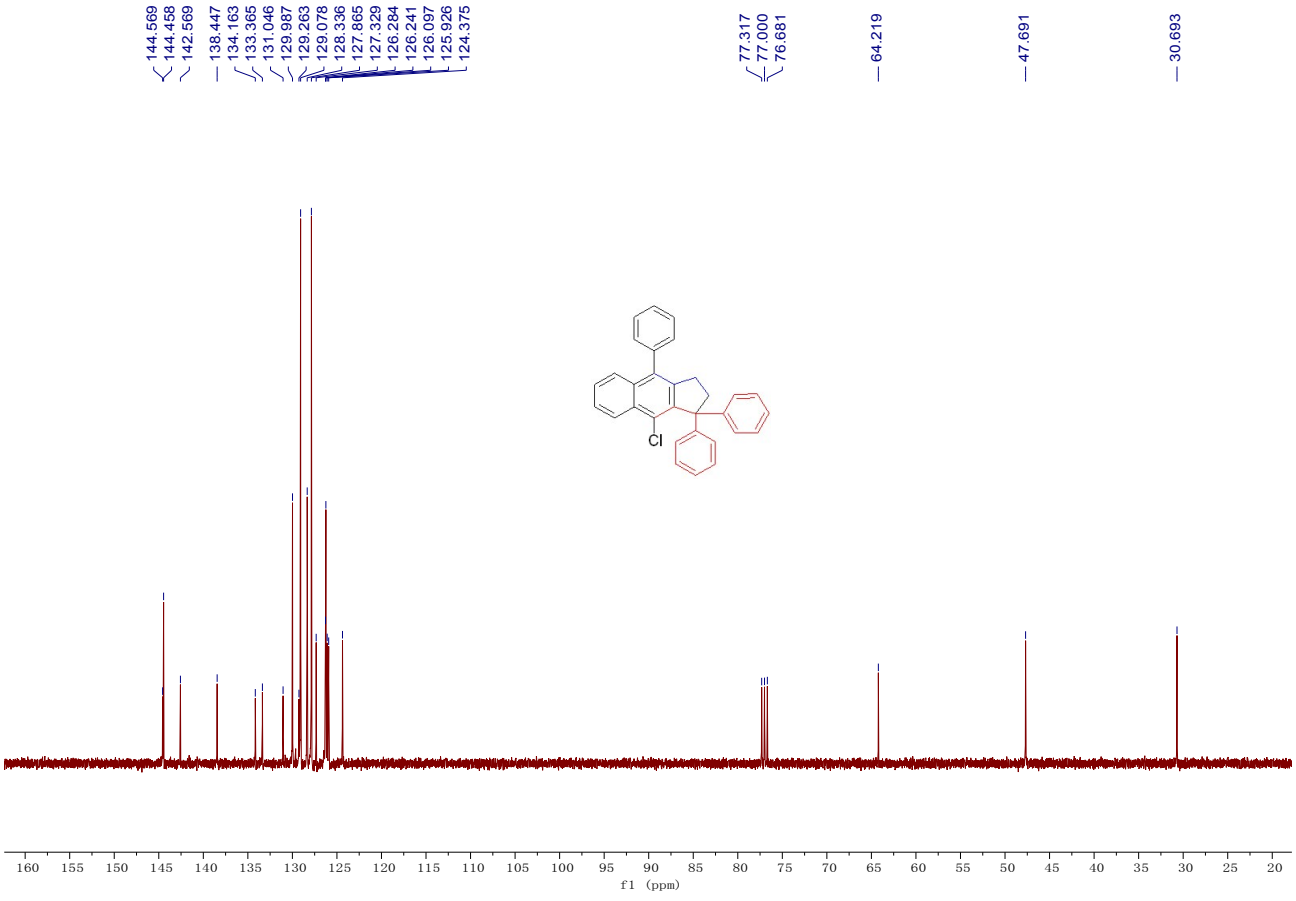
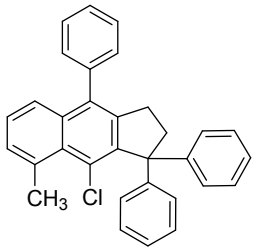
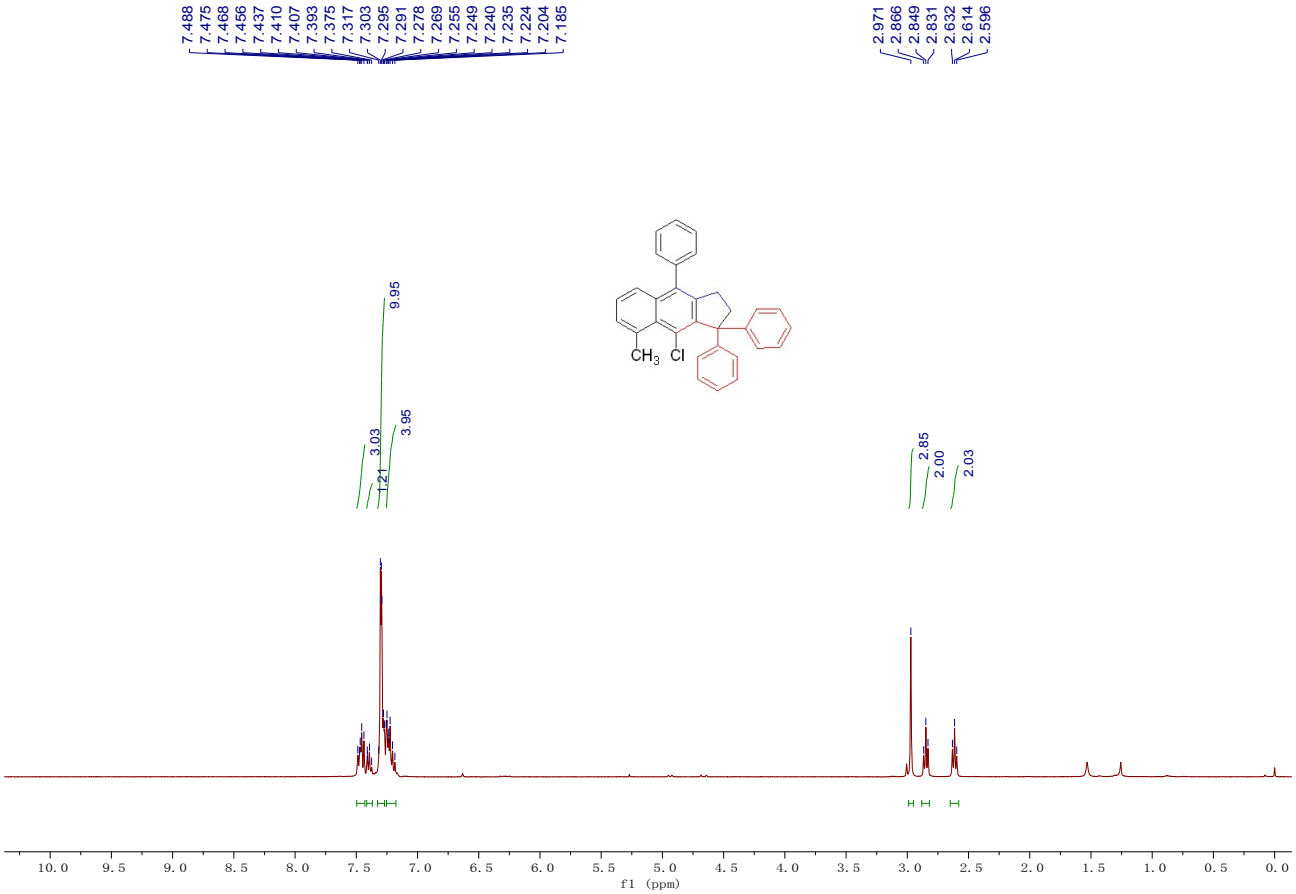
8.312
7.633
7.612
7.464
7.445
7.427
7.412
7.394
7.370
7.353
7.333
7.295
7.275
7.264
7.245
7.227
7.206
7.189
7.171
2.878
2.861
2.843
2.714
2.697
2.679
11.94
0.97
1.09
3.15
2.10
1.93
2.00
Cl
f1 (ppm)


144.569
144.458
142.569
138.447
134.163
133.365
131.046
129.987
129.263
129.078
128.336
127.865
127.329
126.284
126.241
126.097
125.926
124.375
77.317
77.000
76.681
64.219
47.691
30.693
Cl
f1 (ppm)



Compound 2b: Yield: 62 mg, 70%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 – 7.41 (m, 3H), 7.44 – 7.35 (m, 1H), 7.34 – 7.27 (m, 10H), 7.27 – 7.16 (m, 4H), 2.97 (s, 3H), 2.84 (t, *J* = 7.0 Hz, 2H), 2.61 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.4, 144.5, 142.3, 139.4, 135.7, 135.5, 134.9, 130.8, 130.4, 130.0, 129.9, 129.7, 129.3, 128.4, 128.0, 127.9, 127.8, 127.3, 126.1, 125.6, 125.5, 48.3, 30.5, 27.1; IR (neat): ν 2979, 1591, 1492, 1437, 1025, 767, 699 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{25}Cl$ $[M]^{+}$: 444.1639, Found: 444.1640.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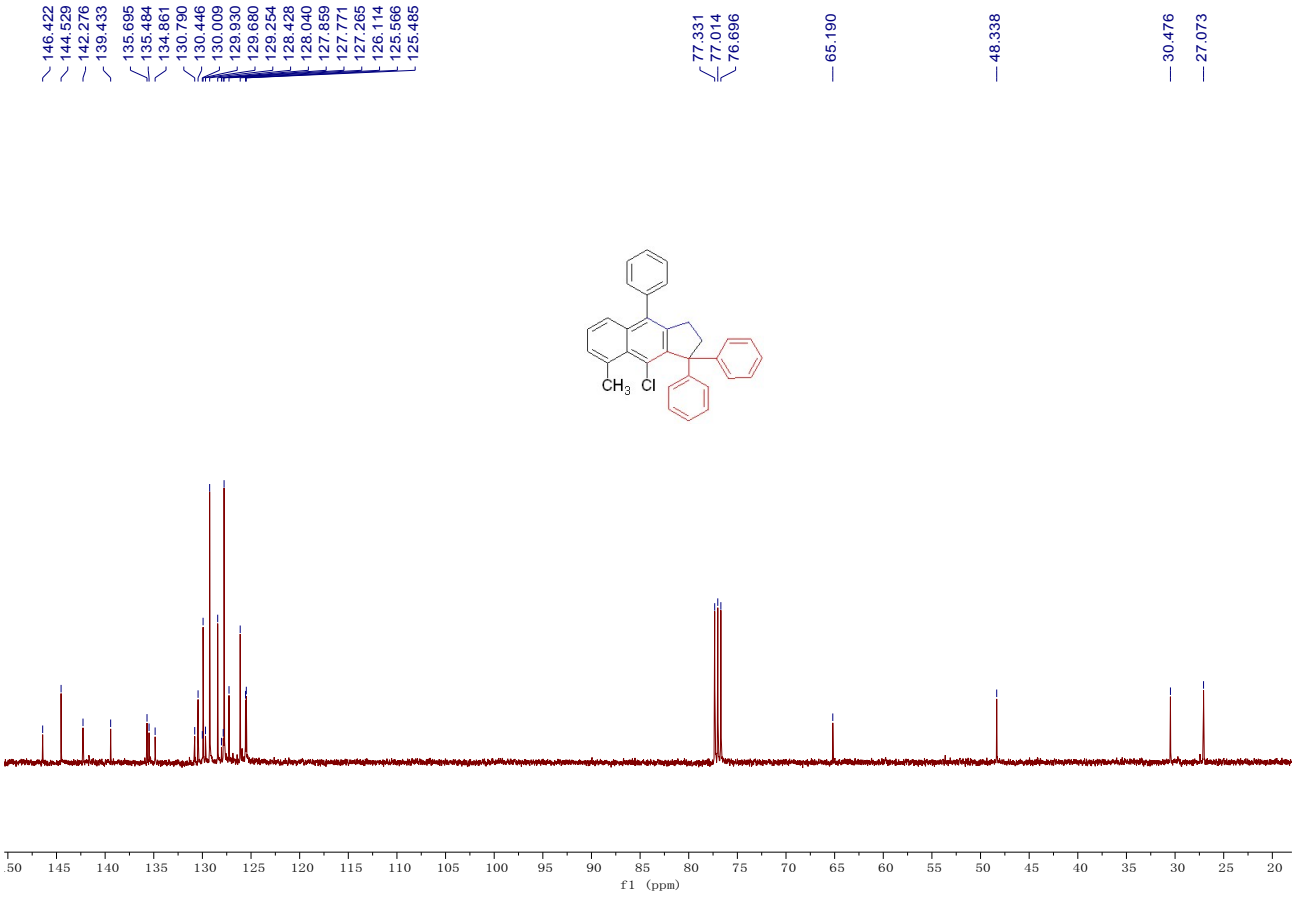
7.410
7.407
7.393
7.375
7.317
7.303
7.295
7.291
7.278
7.269
7.255
7.249
7.240
7.235
7.224
7.204
7.185
2.971
2.866
2.849
2.831
2.632
2.614
2.596
9.95
3.03
1.21
3.95
2.85
2.00
2.03
CH3 Cl
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


146.422
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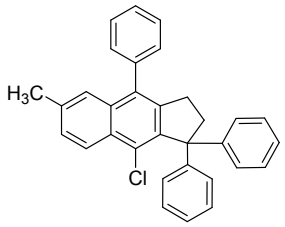
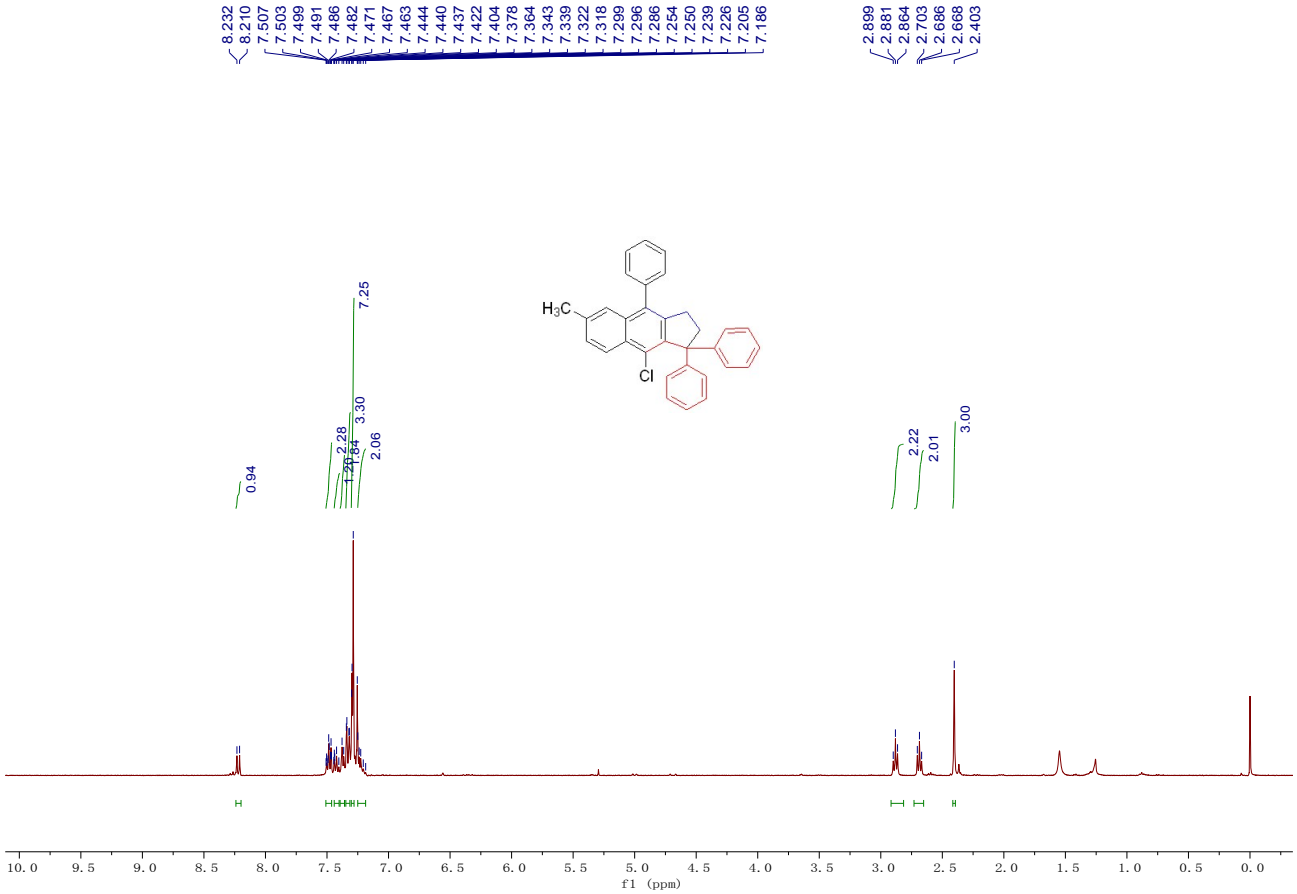
139.433
135.695
135.484
134.861
130.790
130.446
130.009
129.930
129.680
129.254
128.428
128.040
127.859
127.771
127.265
126.114
125.566
125.485
77.331
77.014
76.696
65.190
48.338
30.476
27.073
CH3 Cl
50 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
f1 (ppm)



Compound 2c: Yield: 60 mg, 68%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.22 (d, *J* = 8.6 Hz, 1H), 7.51 – 7.46 (m, 2H), 7.44 – 7.40 (m, 1H), 7.39 – 7.36 (m, 2H), 7.35 – 7.31 (m, 3H), 7.30 – 7.28 (m, 7H), 7.25 – 7.19 (m, 2H), 2.88 (t, *J* = 7.0 Hz, 2H), 2.69 (t, *J* = 7.0 Hz, 2H), 2.40 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.6, 143.6, 142.7, 138.7, 136.2, 133.6, 130.1, 129.7, 129.3, 129.1, 128.4, 128.1, 127.8, 127.3, 126.2, 125.1, 124.3, 64.1, 47.7, 30.7, 21.6; IR (neat): ν 2922, 1490, 1028, 816, 756, 699 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{25}Cl$ $[M]^{+}$: 444.1639, Found: 444.1645.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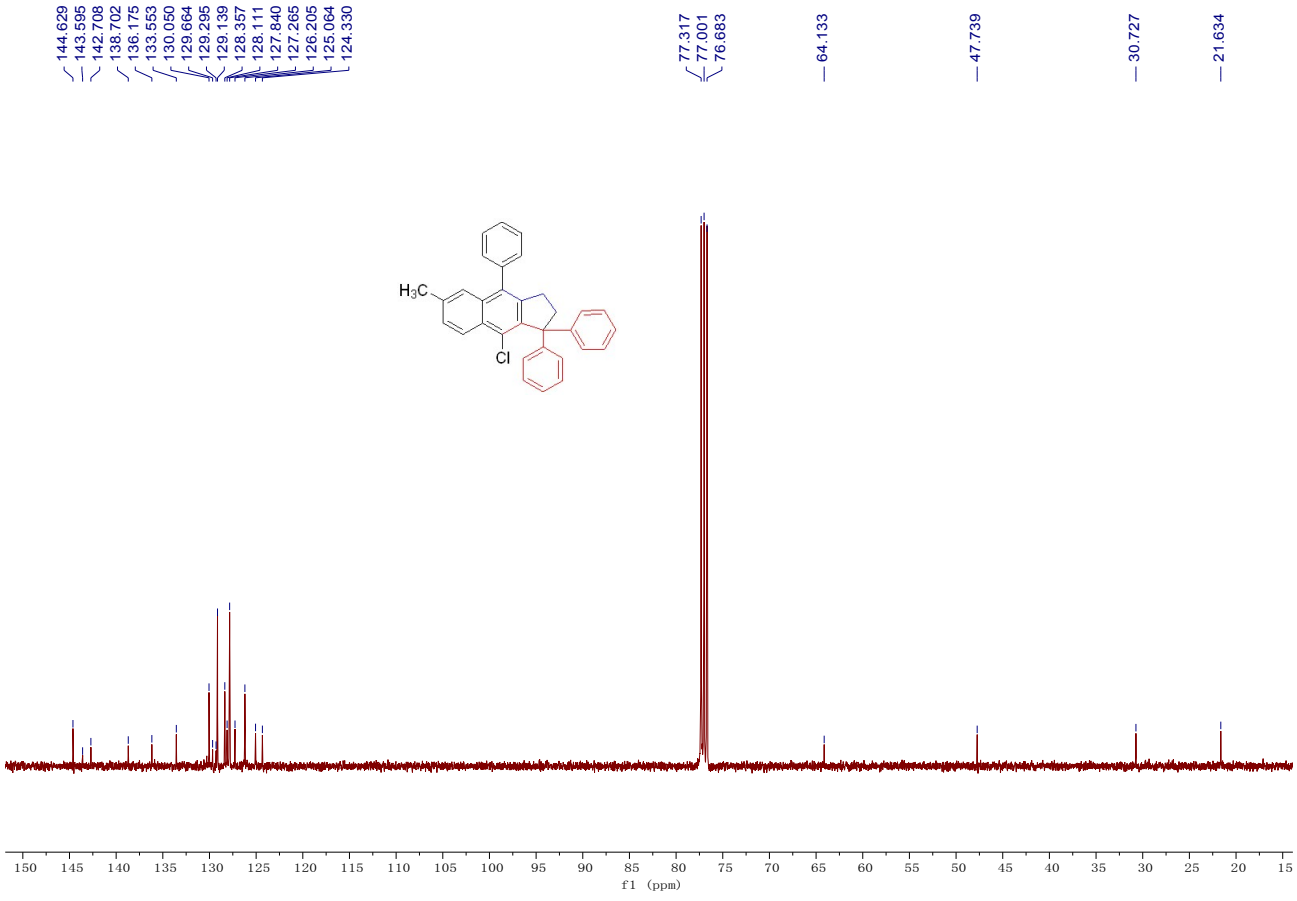
7.503
7.499
7.491
7.486
7.482
7.471
7.467
7.463
7.444
7.440
7.437
7.422
7.404
7.378
7.364
7.343
7.339
7.322
7.318
7.299
7.296
7.286
7.254
7.250
7.239
7.226
7.205
7.186
2.899
2.881
2.864
2.703
2.686
2.668
2.403
H3C
Cl
7.25
3.30
2.28
2.06
0.94
2.22
2.01
3.00
f1 (ppm)


144.629
143.595
142.708
138.702
136.175
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130.050
129.664
129.295
129.139
128.357
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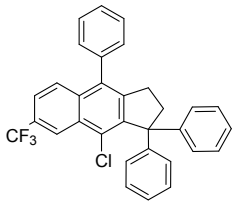
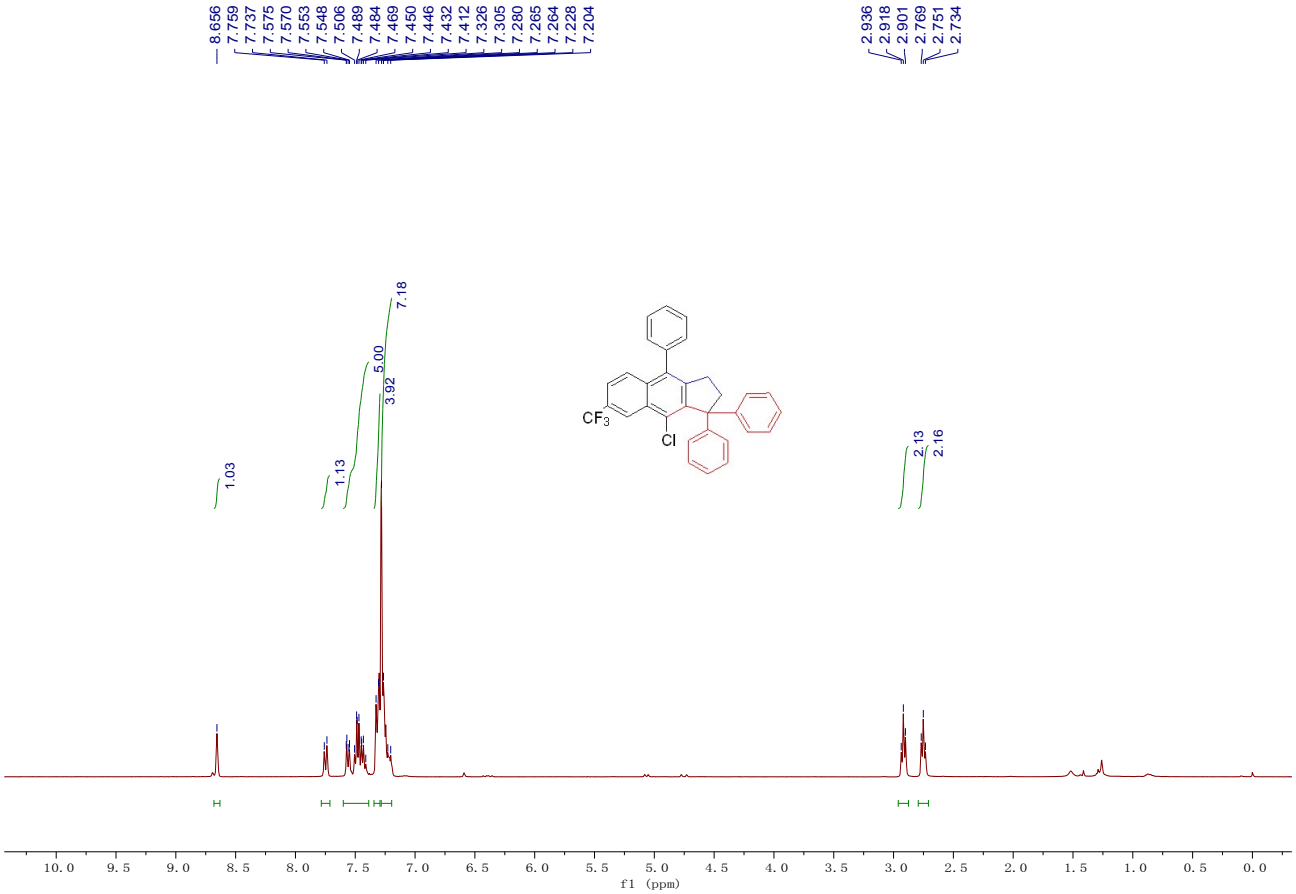
127.840
127.265
126.205
125.064
124.330
77.317
77.001
76.683
64.133
47.739
30.727
21.634
H3C
Cl
f1 (ppm)



Compound 2d: Yield: 79 mg, 80%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.66 (s, 1H), 7.75 (d, *J* = 8.9 Hz, 1H), 7.60 – 7.39 (m, 5H), 7.32 (d, *J* = 8.4 Hz, 4H), 7.28 – 7.20 (m, 7H), 2.92 (t, *J* = 7.0 Hz, 2H), 2.75 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.2, 145.2, 144.1, 141.2, 137.7, 134.8, 134.4, 130.8, 130.3, 130.1, 129.9, 129.6, 129.1, 128.6, 128.0, 127.8, 127.4, 126.9 (q, *J* = 270.4 Hz), 126.5, 122.4 (q, *J* = 4.7 Hz), 121.9 (q, *J* = 3.3 Hz), 64.4, 47.6, 30.9; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.15; IR (neat): ν 2980, 1346, 1289, 1167, 1116, 1078, 702 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{22}ClF_3$ $[M]^+$: 498.1357, Found: 498.1368.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7.506
7.489
7.484
7.469
7.450
7.446
7.432
7.412
7.326
7.305
7.280
7.265
7.264
7.228
7.204
2.936
2.918
2.901
2.769
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5.00
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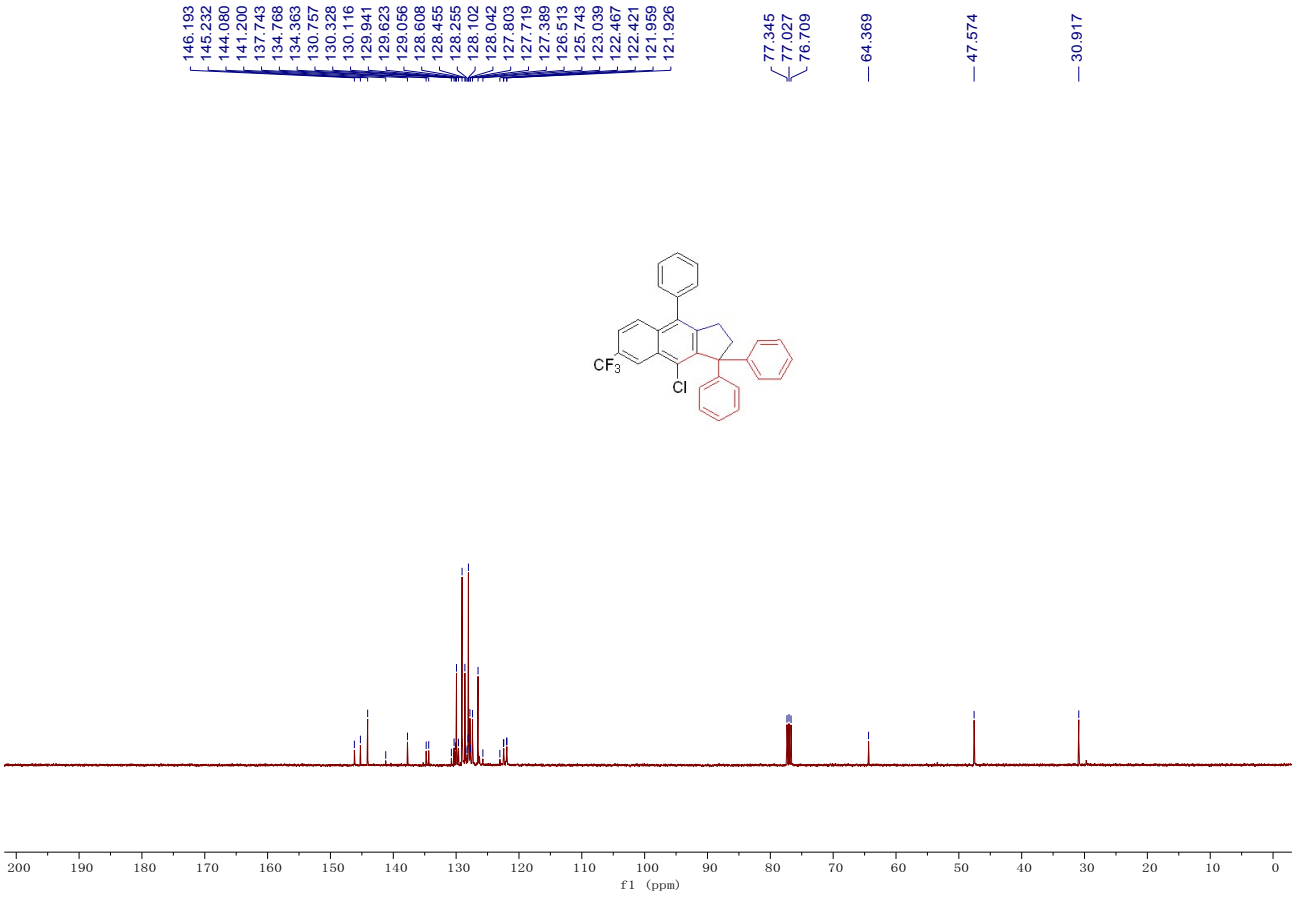
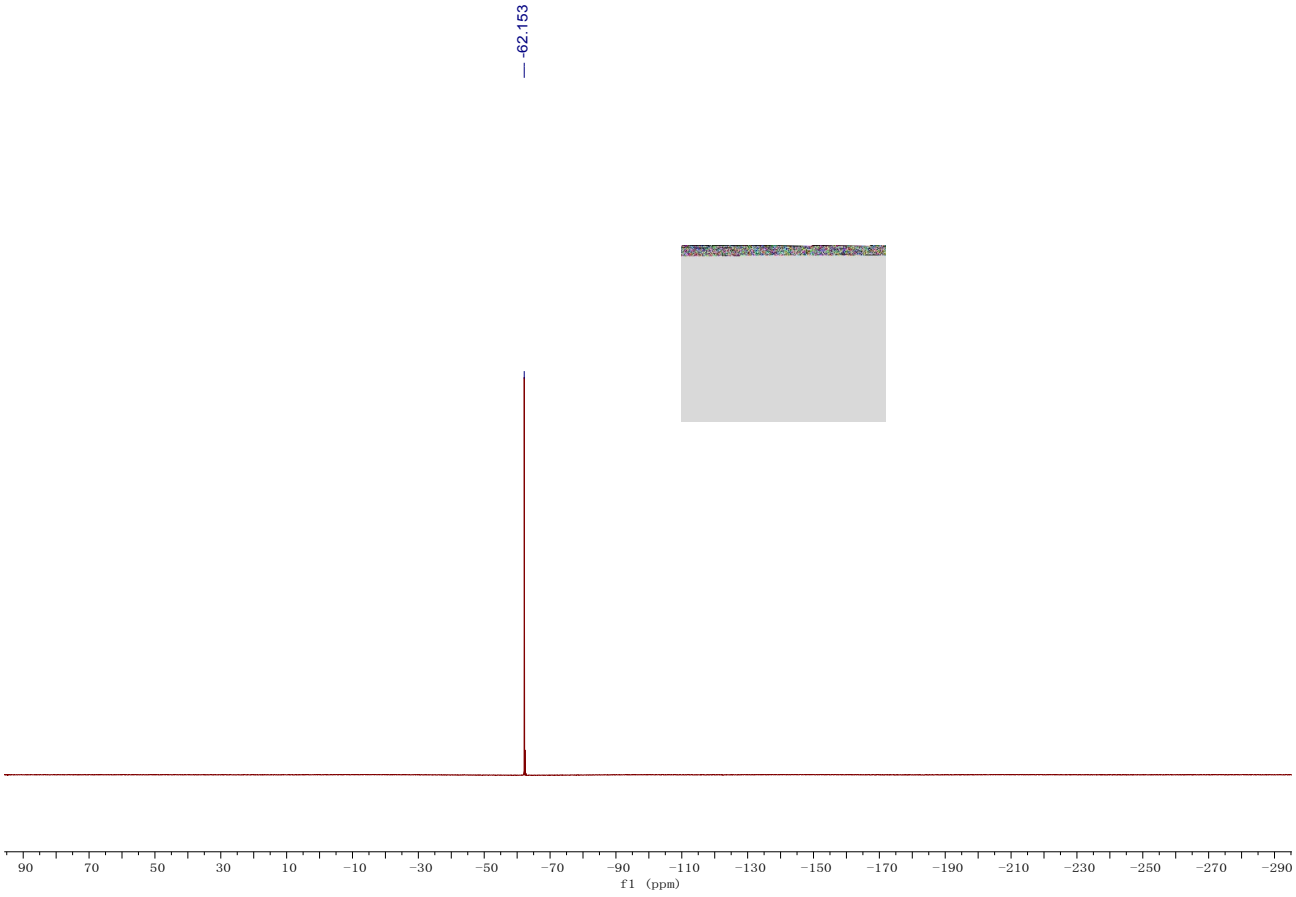
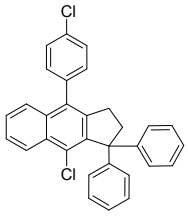
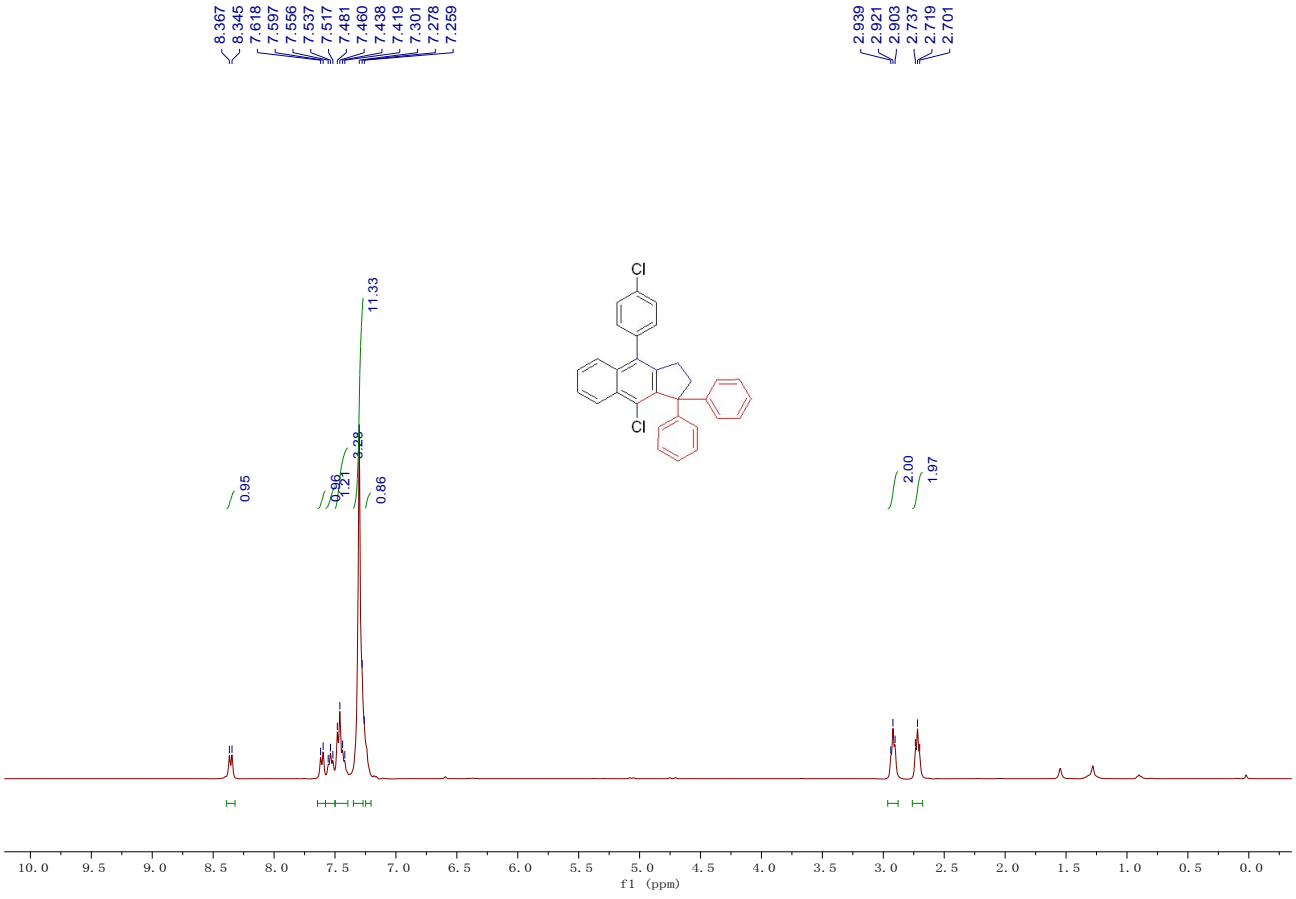
1.03
1.13
2.13
2.16
CF3
Cl
f1 (ppm)


146.193
145.232
144.080
141.200
137.743
134.768
134.363
130.757
130.328
130.116
129.941
129.623
129.056
128.608
128.455
128.255
128.102
128.042
127.803
127.719
127.389
126.513
125.743
123.039
122.467
122.421
121.959
121.926
77.345
77.027
76.709
64.369
47.574
30.917
CF3
Cl
f1 (ppm)





Compound 2e: Yield: 67 mg, 73%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.36 (d, *J* = 8.5 Hz, 1H), 7.61 (d, *J* = 8.5 Hz, 1H), 7.54 (t, *J* = 7.7 Hz, 1H), 7.50 – 7.39 (m, 3H), 7.35 – 7.27 (m, 11H), 7.25 – 7.20 (m, 1H), 2.91 (t, *J* = 7.1 Hz, 2H), 2.72 (t, *J* = 7.1 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.8, 144.5, 142.8, 137.1, 133.6, 133.3, 133.0, 131.6, 131.2, 129.8, 129.2, 128.8, 128.1, 126.7, 126.5, 126.2, 125.9, 124.7, 64.4, 47.8, 30.8; IR (neat): ν 2818, 1487, 1088, 1009, 822, 759, 696 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{22}Cl_2$ $[M]^+$: 464.1093, Found: 464.1092.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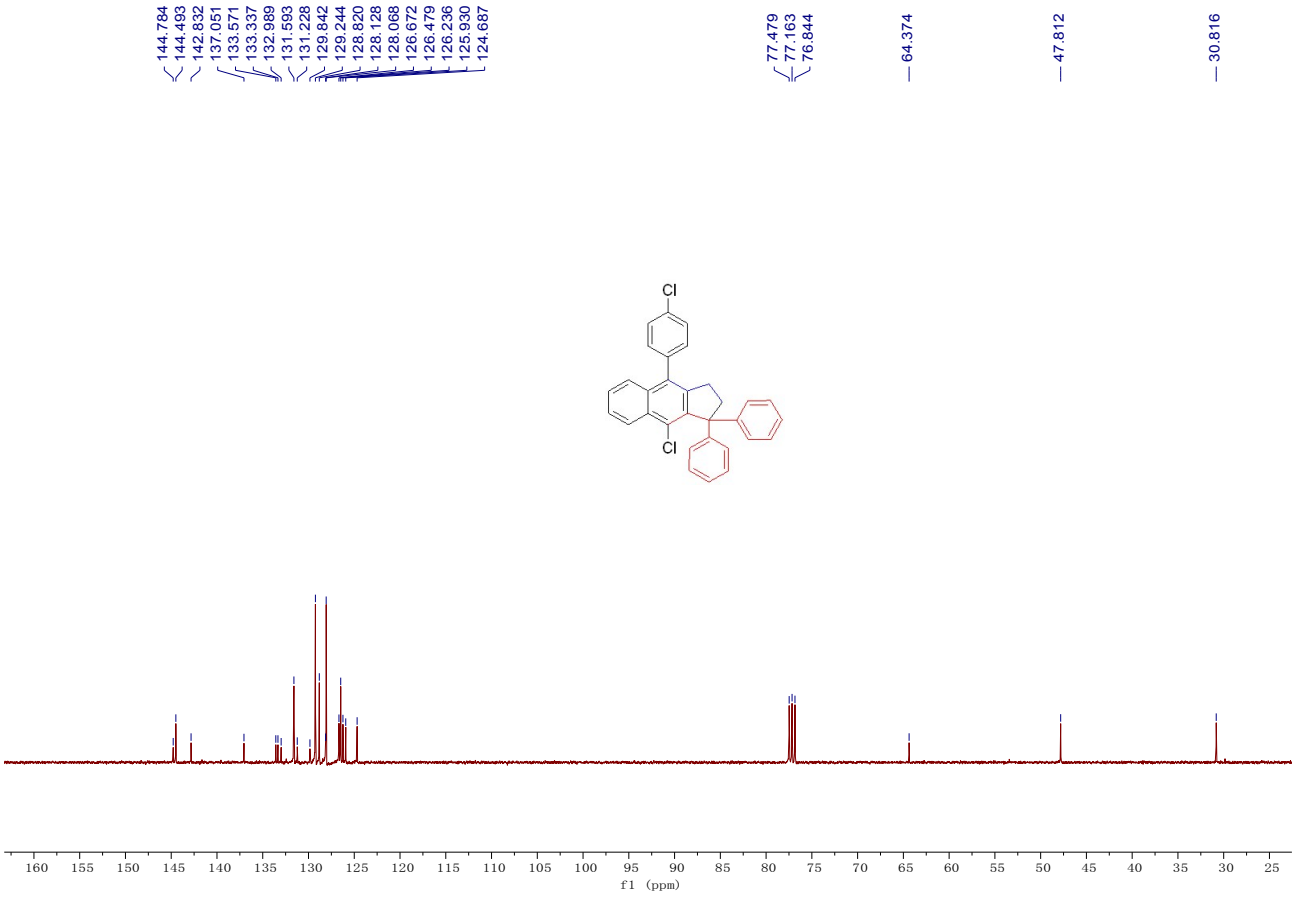
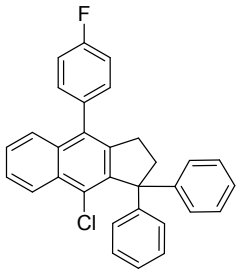
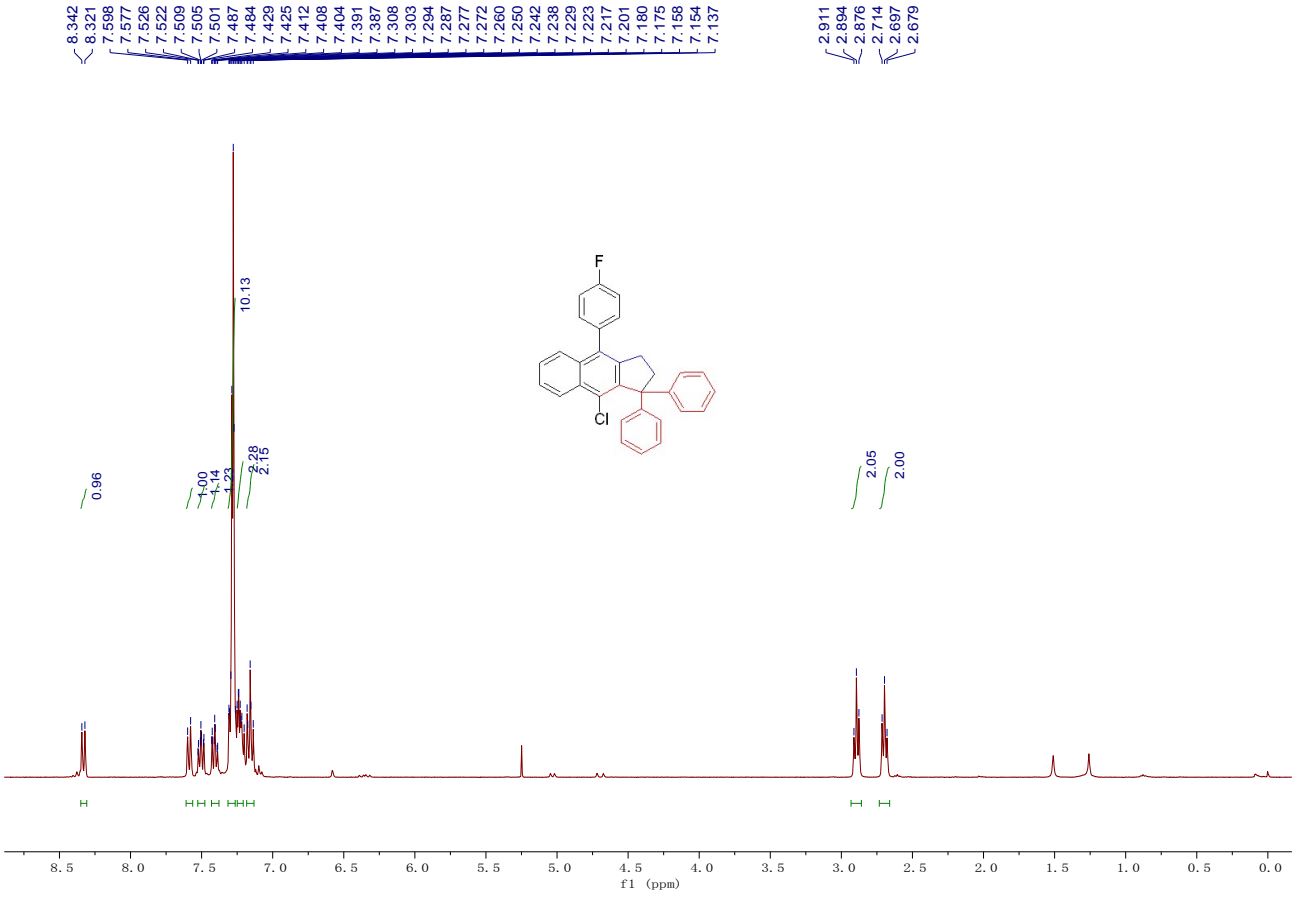
8.345
7.618
7.597
7.556
7.537
7.517
7.481
7.460
7.438
7.419
7.301
7.278
7.259
2.939
2.921
2.903
2.737
2.719
2.701
Cl
Cl
11.33
3.28
0.95
0.96
1.21
0.86
2.00
1.97
f1 (ppm)


144.784
144.493
142.832
137.051
133.571
133.337
132.989
131.593
131.228
129.842
129.244
128.820
128.128
128.068
126.672
126.479
126.236
125.930
124.687
77.479
77.163
76.844
64.374
47.812
30.816
Cl
Cl
f1 (ppm)



Compound 2f: Yield: 62 mg, 70%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.33 (d, *J* = 8.5 Hz, 1H), 7.59 (d, *J* = 8.5 Hz, 1H), 7.53 – 7.48 (m, 1H), 7.43 – 7.38 (m, 1H), 7.31 – 7.26 (m, 10H), 7.25 – 7.21 (m, 2H), 7.18 – 7.13 (m, 2H), 2.89 (t, *J* = 7.0 Hz, 2H), 2.70 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 162.3 (d, *J* = 246.4 Hz), 144.7, 144.5, 142.9, 134.4, 134.3, 133.5, 133.2, 131.8 (d, *J* = 8.0 Hz), 131.2, 129.7, 129.6, 129.2, 128.1, 128.0, 126.5, 126.4, 126.2, 126.1, 125.9, 124.6, 115.5 (d, *J* = 21.3 Hz), 64.4, 47.7, 30.8; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -114.74 – -114.81 (m); IR (neat): ν 2919, 2844, 1505, 1223, 1153, 832, 696 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{22}ClF$ $[M]^{+}$: 448.1389, Found: 448.1389.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8.321
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7.577
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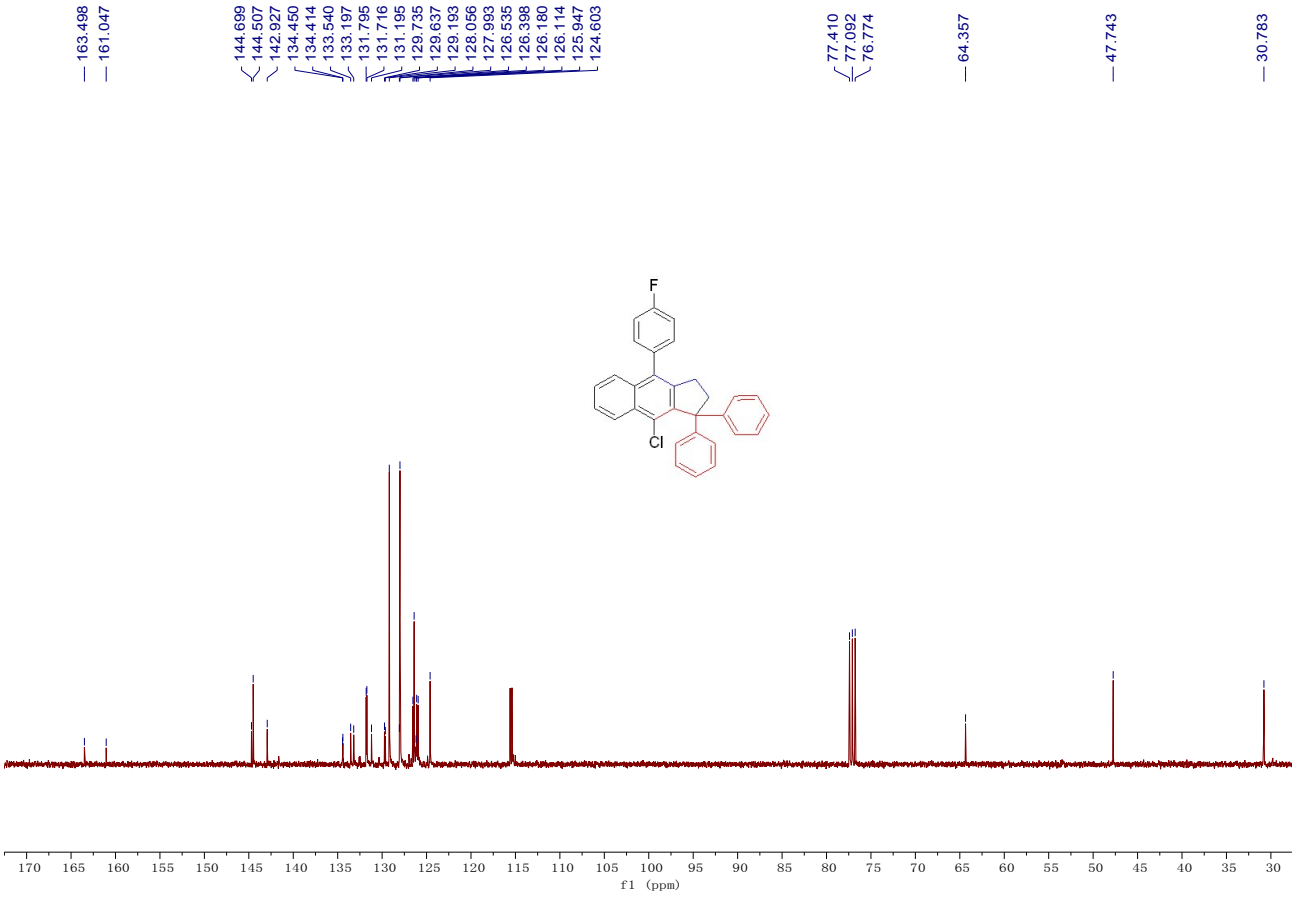
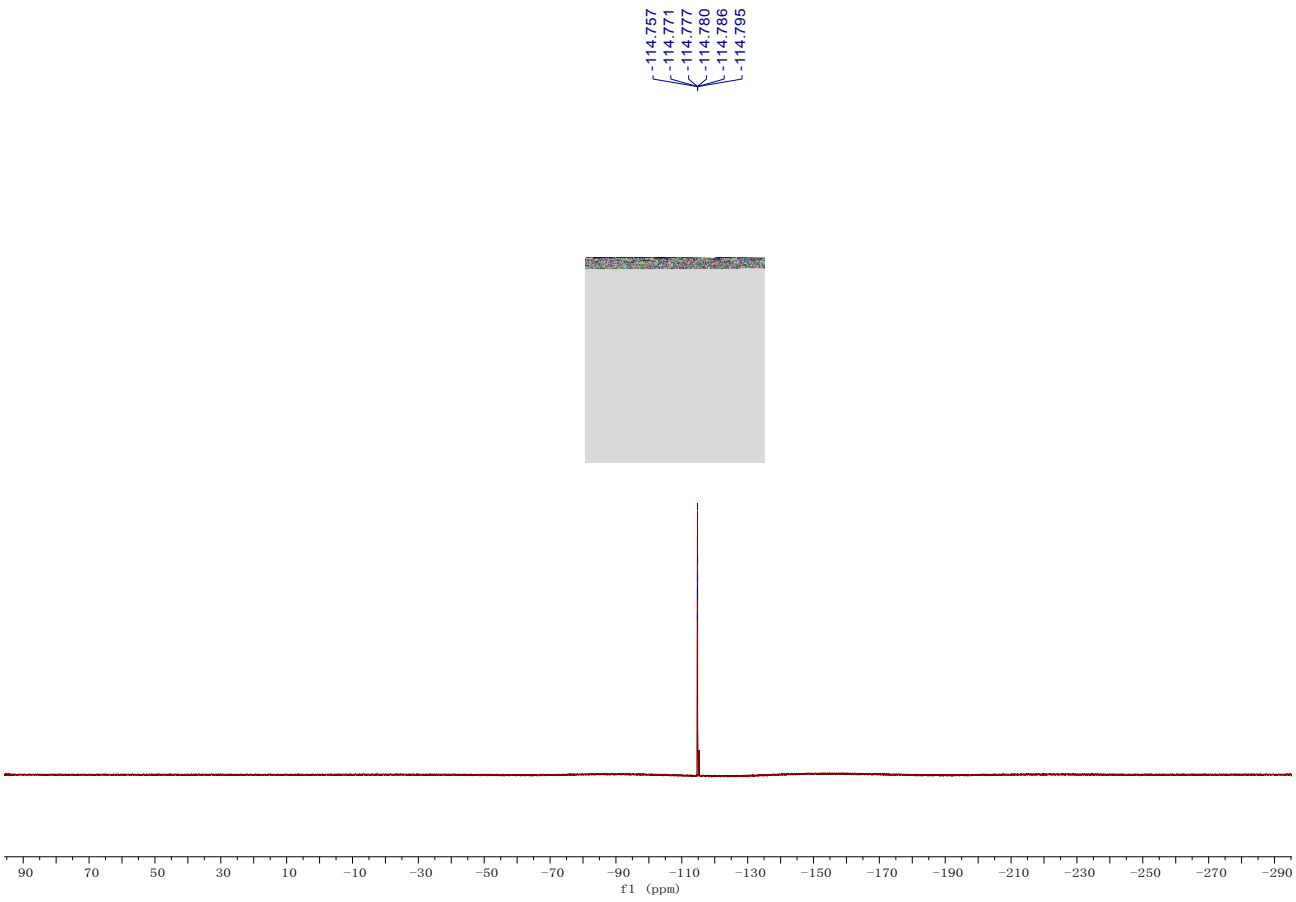
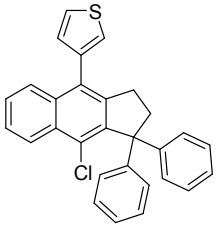
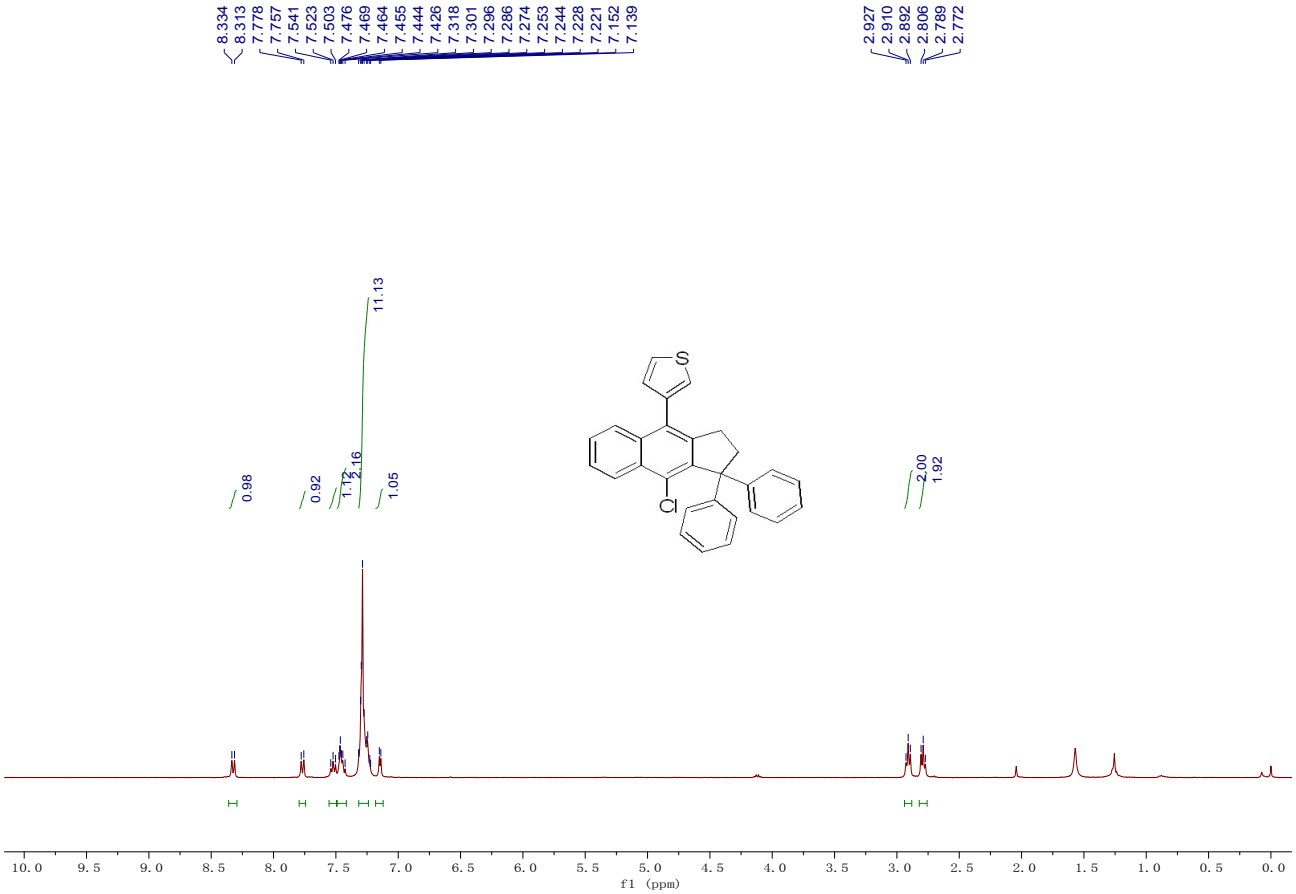
7.522
7.509
7.505
7.501
7.487
7.484
7.429
7.425
7.412
7.408
7.404
7.391
7.387
7.308
7.303
7.294
7.287
7.277
7.272
7.260
7.250
7.242
7.238
7.229
7.223
7.217
7.201
7.180
7.175
7.158
7.154
7.137
2.911
2.894
2.876
2.714
2.697
2.679
F
Cl
10.13
0.96
1.00
1.14
1.23
2.28
2.15
2.05
2.00
f1 (ppm)


163.498
161.047
144.699
144.507
142.927
134.450
134.414
133.540
133.197
131.795
131.716
131.195
129.735
129.637
129.193
128.056
127.993
126.535
126.398
126.180
126.114
125.947
124.603
77.410
77.092
76.774
64.357
47.743
30.783
F
Cl
f1 (ppm)





Compound 2j: Yield: 27 mg, 30%; A white solid; Mp: 162 - 164 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.32 (d, *J* = 8.5 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.52 (t, *J* = 7.7 Hz, 1H), 7.49 – 7.42 (m, 2H), 7.32 – 7.24 (m, 11H), 7.15 (d, *J* = 4.9 Hz, 1H), 2.91 (t, *J* = 6.9 Hz, 2H), 2.79 (t, *J* = 6.9 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.5 (d, *J* = 17.8 Hz), 143.3, 138.3, 133.7, 131.1, 129.6, 129.1, 127.9, 126.4, 126.3, 126.0, 126.0, 125.3, 124.4, 124.1, 47.7, 30.9; IR (neat): ν 2989, 2898, 1507, 1080, 1024, 837, 769, 701 cm^{-1}; HRMS (DART) Calcd. for $C_{29}H_{21}ClS$ $[M+NH_4]^+$: 454.1391, Found: 454.1386.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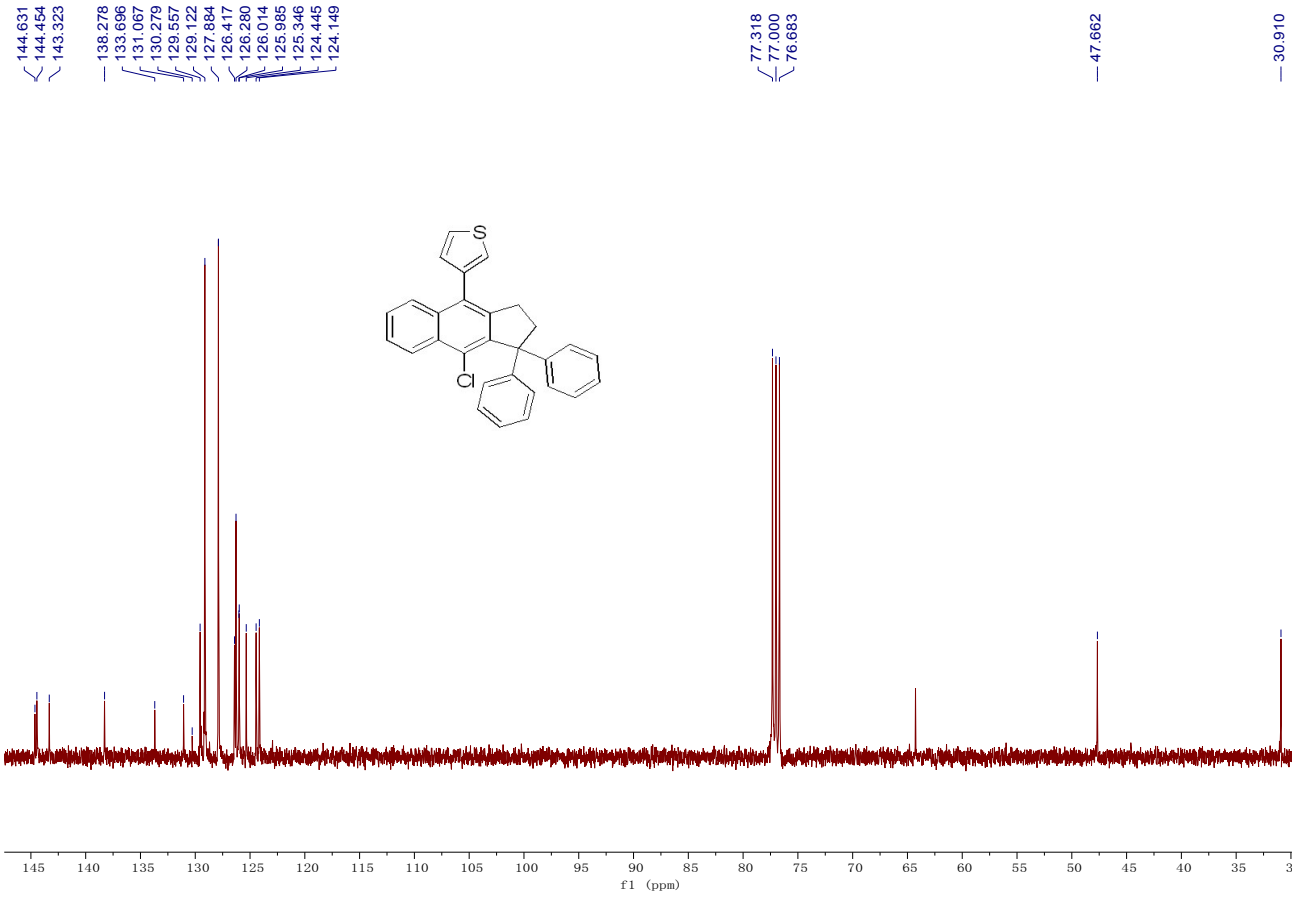
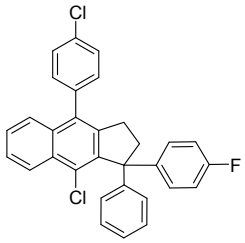
7.778
7.757
7.541
7.523
7.503
7.476
7.469
7.464
7.455
7.444
7.426
7.318
7.301
7.296
7.286
7.274
7.253
7.244
7.228
7.221
7.152
7.139
2.927
2.910
2.892
2.806
2.789
2.772
11.13
0.98
0.92
1.12
2.16
1.05
2.00
1.92
S
Cl
f1 (ppm)


144.631
144.454
143.323
138.278
133.696
131.067
130.279
129.557
129.122
127.884
126.417
126.280
126.014
125.985
125.346
124.445
124.149
77.318
77.000
76.683
47.662
30.910
S
Cl
f1 (ppm)



Compound 2k: Yield: 71 mg, 74%; A white solid; Mp: 169 - 171 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.33 (d, *J* = 8.5 Hz, 1H), 7.61 – 7.56 (m, 1H), 7.56 – 7.49 (m, 1H), 7.47 – 7.38 (m, 3H), 7.32 – 7.20 (m, 9H), 7.01 – 6.91 (m, 2H), 2.95 – 2.79 (m, 2H), 2.73 – 2.64 (m, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 161.5 (d, *J* = 245.6 Hz), 144.6, 144.2, 142.6, 140.5, 137.0, 133.7, 133.4, 133.1, 131.6, 131.3, 130.8 (d, *J* = 7.8 Hz), 129.8, 129.1, 128.9, 128.2, 126.8, 126.6, 126.3, 126.0, 124.7, 114.8 (d, *J* = 21.1 Hz), 63.9, 47.8, 30.7; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -116.80 – -116.90 (m); IR (neat): ν 3042, 2852, 1505, 1090, 1012, 827, 756, 702 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{21}Cl_2F$ $[M]^+$: 482.0999, Found: 482.1011.


8.342
8.321
7.597
7.591
7.576
7.570
7.545
7.542
7.529
7.525
7.520
7.507
7.503
7.469
7.464
7.460
7.453
7.447
7.443
7.438
7.430
7.426
7.422
7.405
7.301
7.296
7.291
7.283
7.277
7.267
7.261
7.253
7.246
7.228
7.224
7.214
7.208
6.987
6.982
6.966
6.960
6.944
2.904
2.899
2.887
2.881
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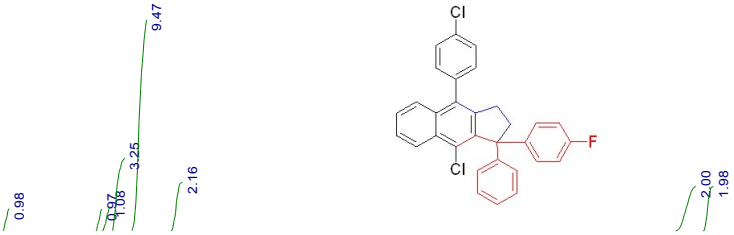
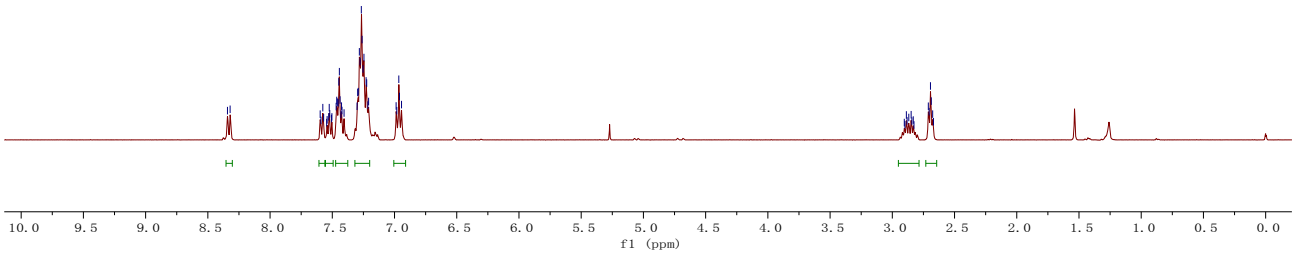
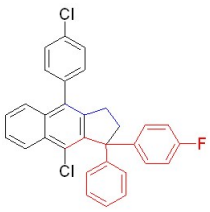
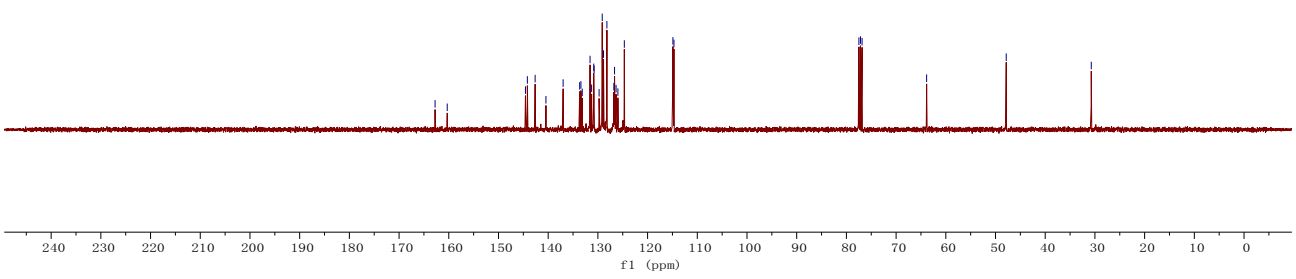
2.704
2.693
2.687
2.676
2.669

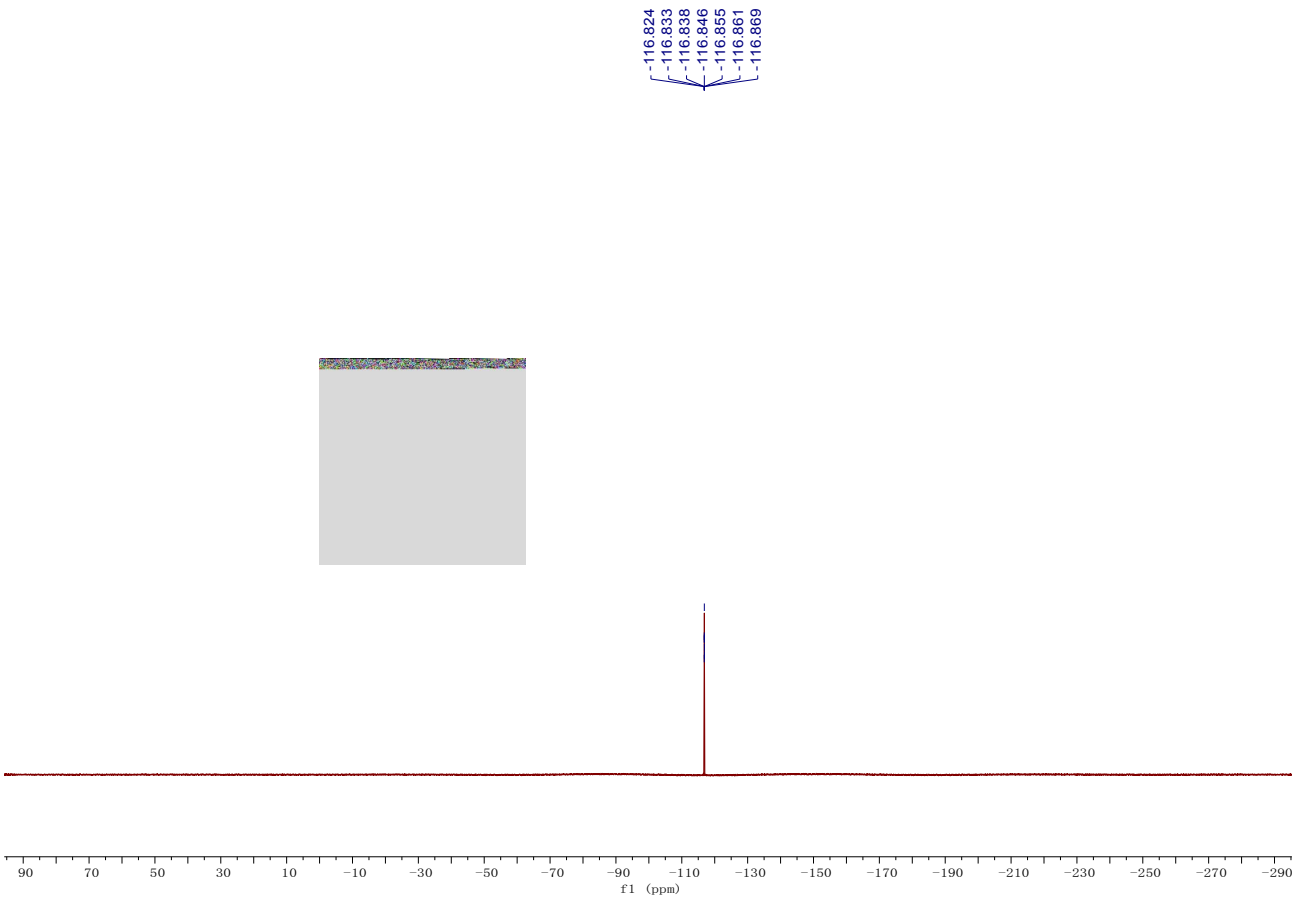

9.47
3.25
2.16
0.98
0.97
1.06
2.00
1.98
Cl
F
Cl

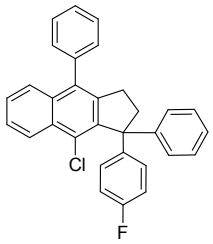

10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


162.755
160.311
144.572
144.190
142.626
140.450
136.994
133.663
133.412
133.143
131.575
131.263
130.833
130.755
129.756
129.124
128.865
128.185
126.785
126.648
126.341
125.972
124.681
114.906
114.697
77.484
77.167
76.848
63.859
47.844
30.736

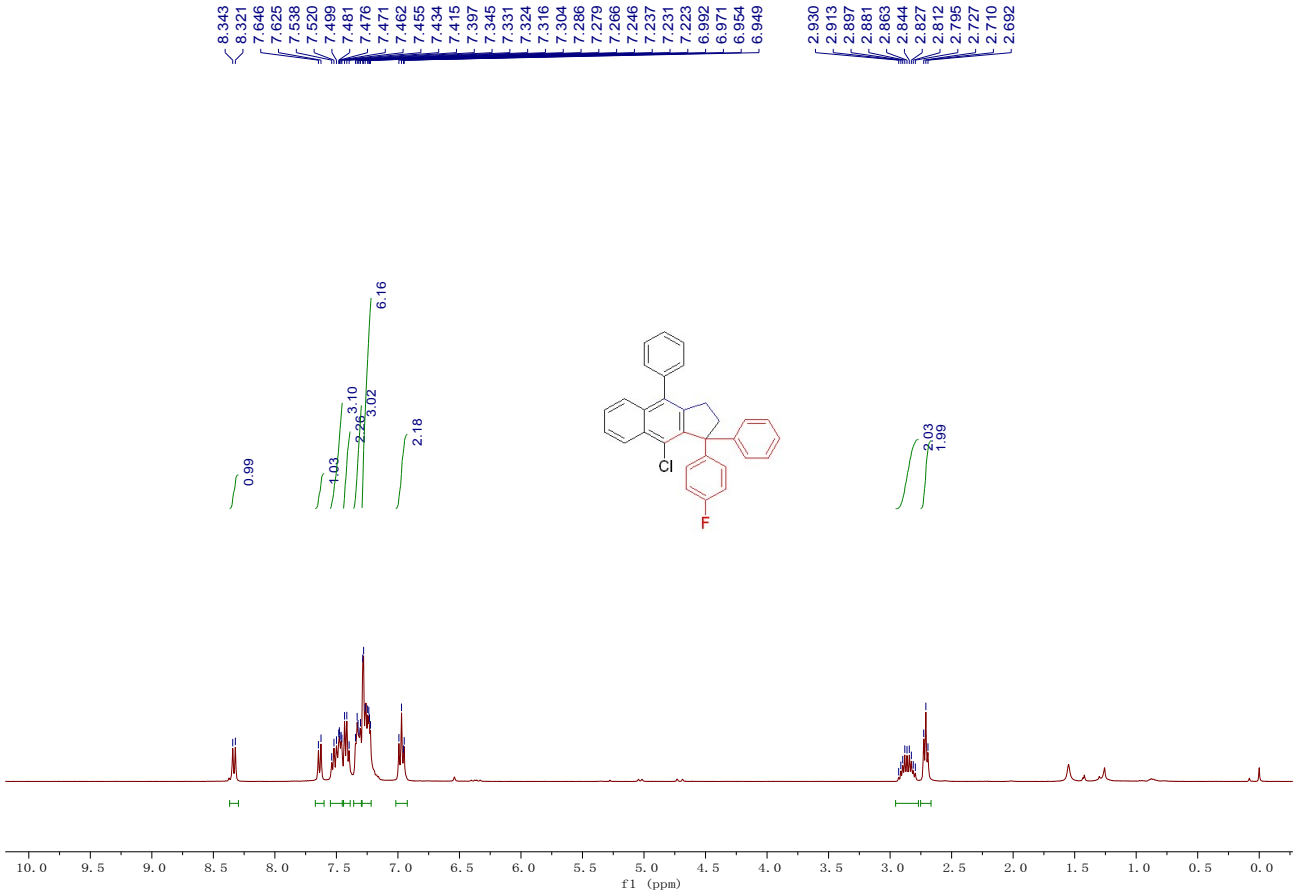

Cl
F
Cl


240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)





Compound 2l: Yield: 65 mg, 73%; A white solid; Mp: >200 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.33 (d, *J* = 8.5 Hz, 1H), 7.64 (d, *J* = 8.5 Hz, 1H), 7.55 – 7.45 (m, 3H), 7.44 – 7.39 (m, 2H), 7.36 – 7.30 (m, 3H), 7.29 – 7.22 (m, 6H), 7.02 – 6.92 (m, 2H), 2.96 – 2.77 (m, 2H), 2.71 (t, *J* = 6.9 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 161.4 (d, *J* = 245.3 Hz), 144.4, 144.2, 142.4, 140.4, 140.3, 138.4, 134.3, 133.4, 131.1, 130.7 (d, *J* = 7.8 Hz), 130.0, 129.9, 129.5, 129.2, 129.0, 128.4, 128.0, 127.4, 126.4, 126.3, 126.2, 126.0, 124.4, 114.6 (d, *J* = 21.1 Hz), 63.7, 47.8, 30.6; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -117.00 – -117.12 (m); IR (neat): ν 2919, 1594, 1484, 1437, 900, 728, 699 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{22}ClF$ $[M]^{+}$: 448.1389, Found: 448.1393.


8.343
8.321
7.646
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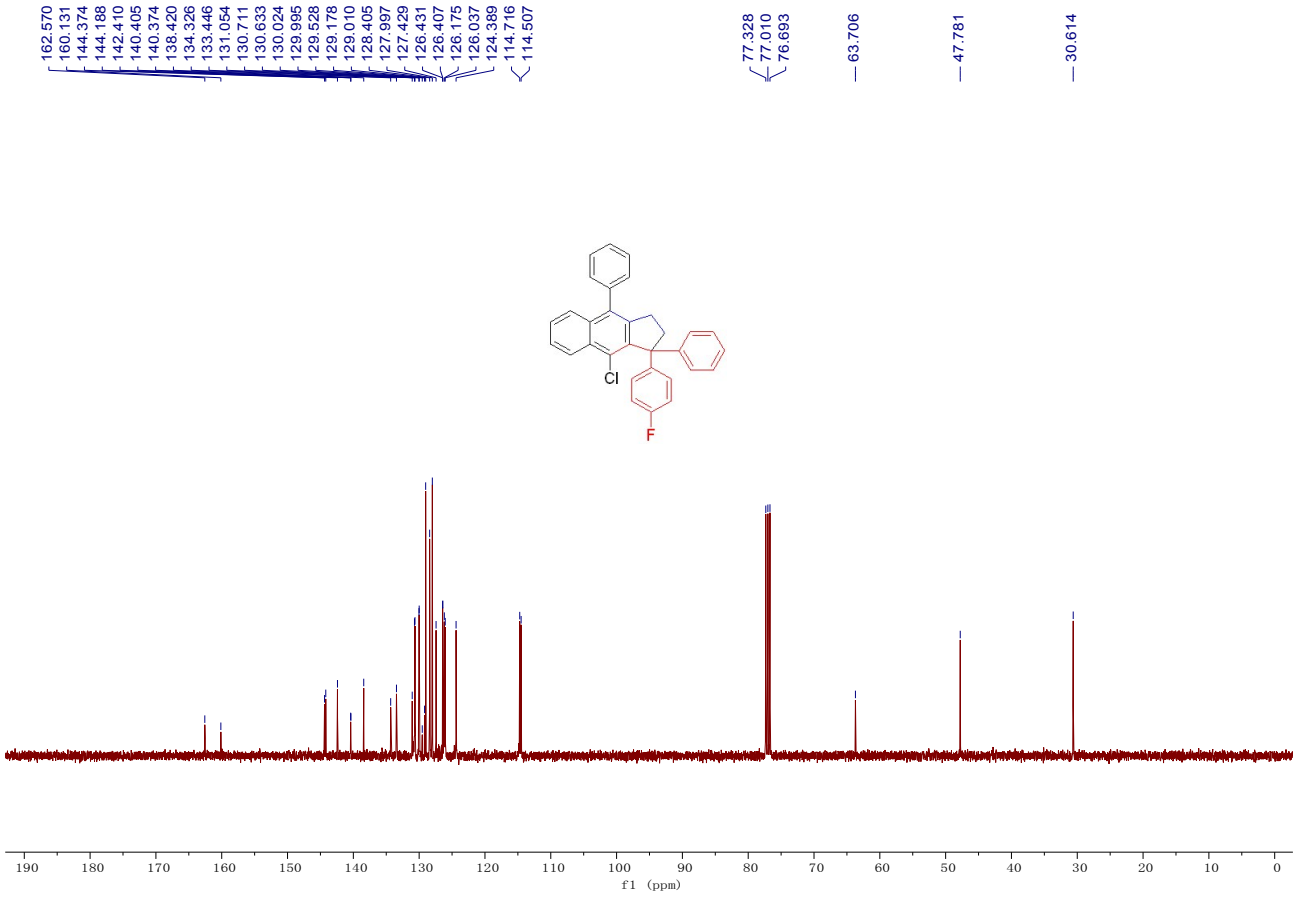
7.538
7.520
7.499
7.481
7.476
7.471
7.462
7.455
7.434
7.415
7.397
7.345
7.331
7.324
7.316
7.304
7.286
7.279
7.266
7.246
7.237
7.231
7.223
6.992
6.971
6.954
6.949
2.930
2.913
2.897
2.881
2.863
2.844
2.827
2.812
2.795
2.727
2.710
2.692
6.16
3.10
3.02
2.28
2.18
1.03
0.99
2.03
1.99
Cl
F
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


162.570
160.131
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144.188
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140.405
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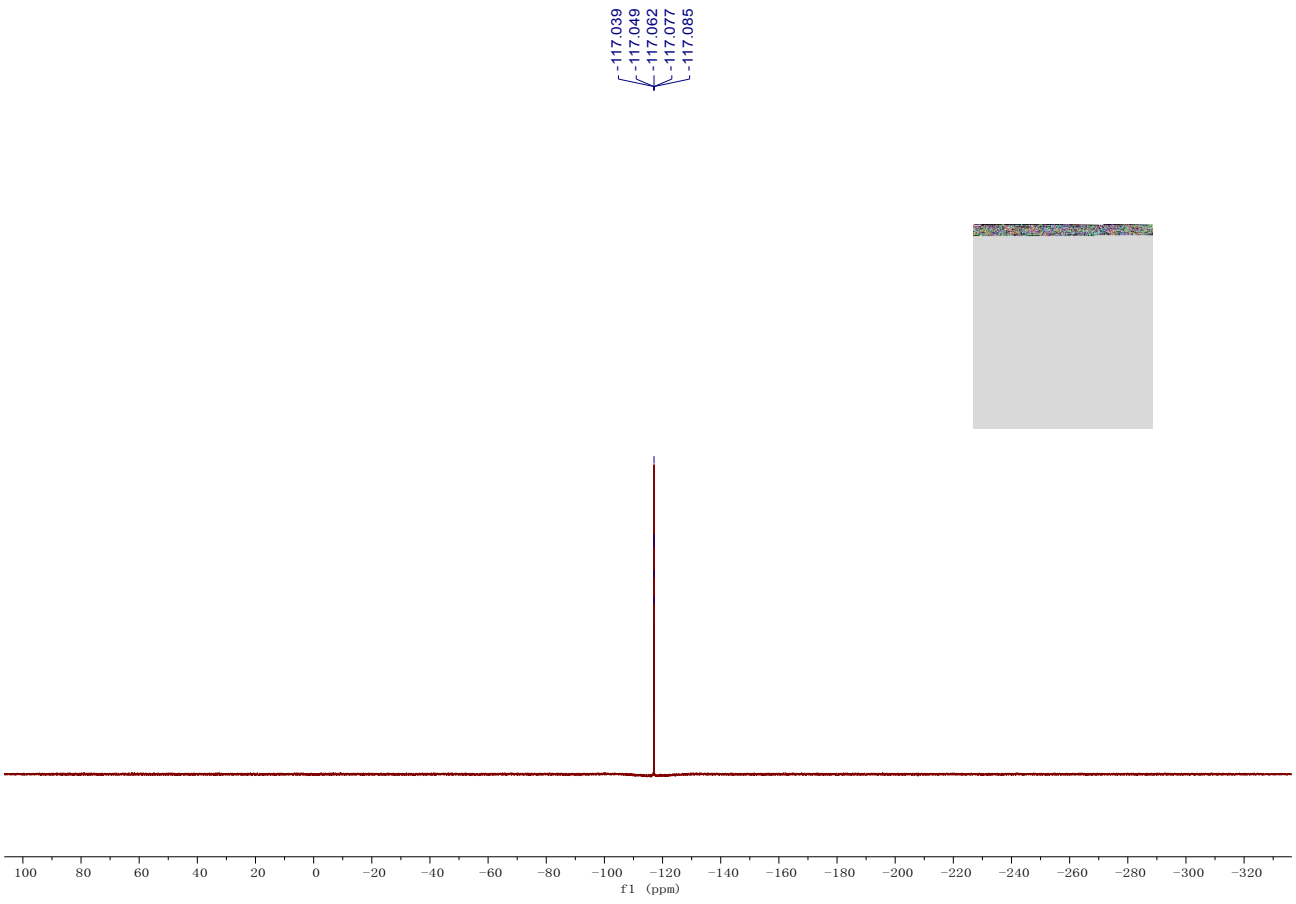
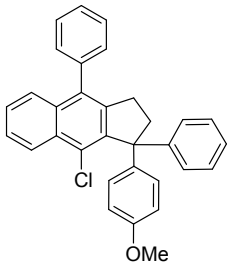
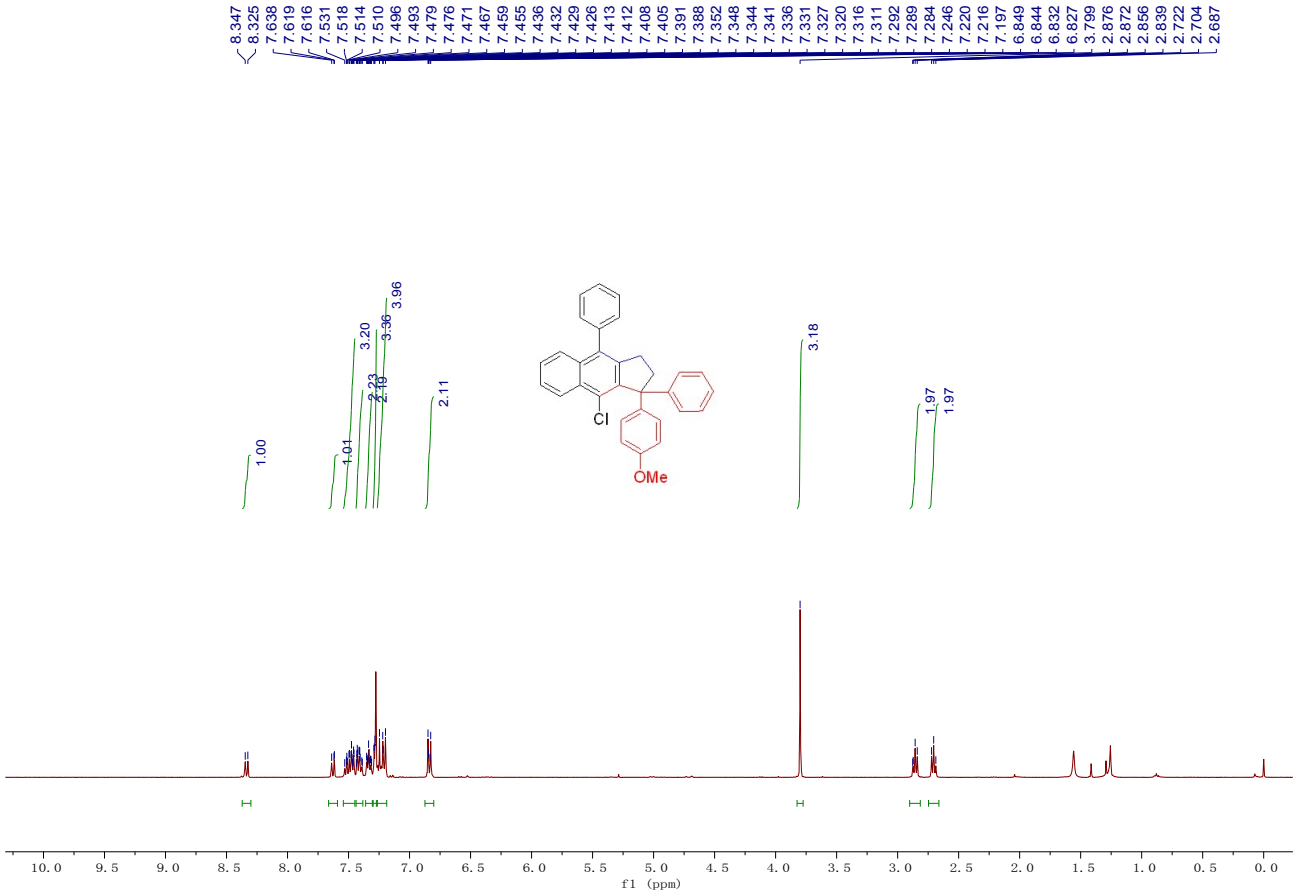
131.054
130.711
130.633
130.024
129.995
129.528
129.178
129.010
128.405
127.997
127.429
126.431
126.407
126.175
126.037
124.389
114.716
114.507
77.328
77.010
76.693
63.706
47.781
30.614
Cl
F
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)





Compound 2m: Yield: 27 mg, 30%; A white solid; Mp: 181 - 183 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.34 (d, *J* = 8.5 Hz, 1H), 7.66 – 7.59 (m, 1H), 7.54 – 7.45 (m, 3H), 7.44 – 7.38 (m, 2H), 7.36 – 7.31 (m, 2H), 7.30 – 7.27 (m, 3H), 7.26 – 7.19 (m, 4H), 6.87 – 6.80 (m, 2H), 3.80 (s, 3H), 2.86 (t, *J* = 6.8 Hz, 2H), 2.70 (t, *J* = 6.8 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 158.1, 145.2, 144.9, 142.7, 138.7, 136.3, 134.3, 133.5, 131.2, 130.3, 130.2, 129.3, 129.1, 128.5, 128.0, 127.5, 126.4, 126.3, 126.0, 124.5, 113.3, 63.7, 55.3, 47.7, 30.7; IR (neat): ν 2919, 2849, 1510, 1247, 1041, 759, 694 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{25}ClO$ $[M]^{+}$: 460.1588, Found: 460.1601.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7.476
7.471
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7.429
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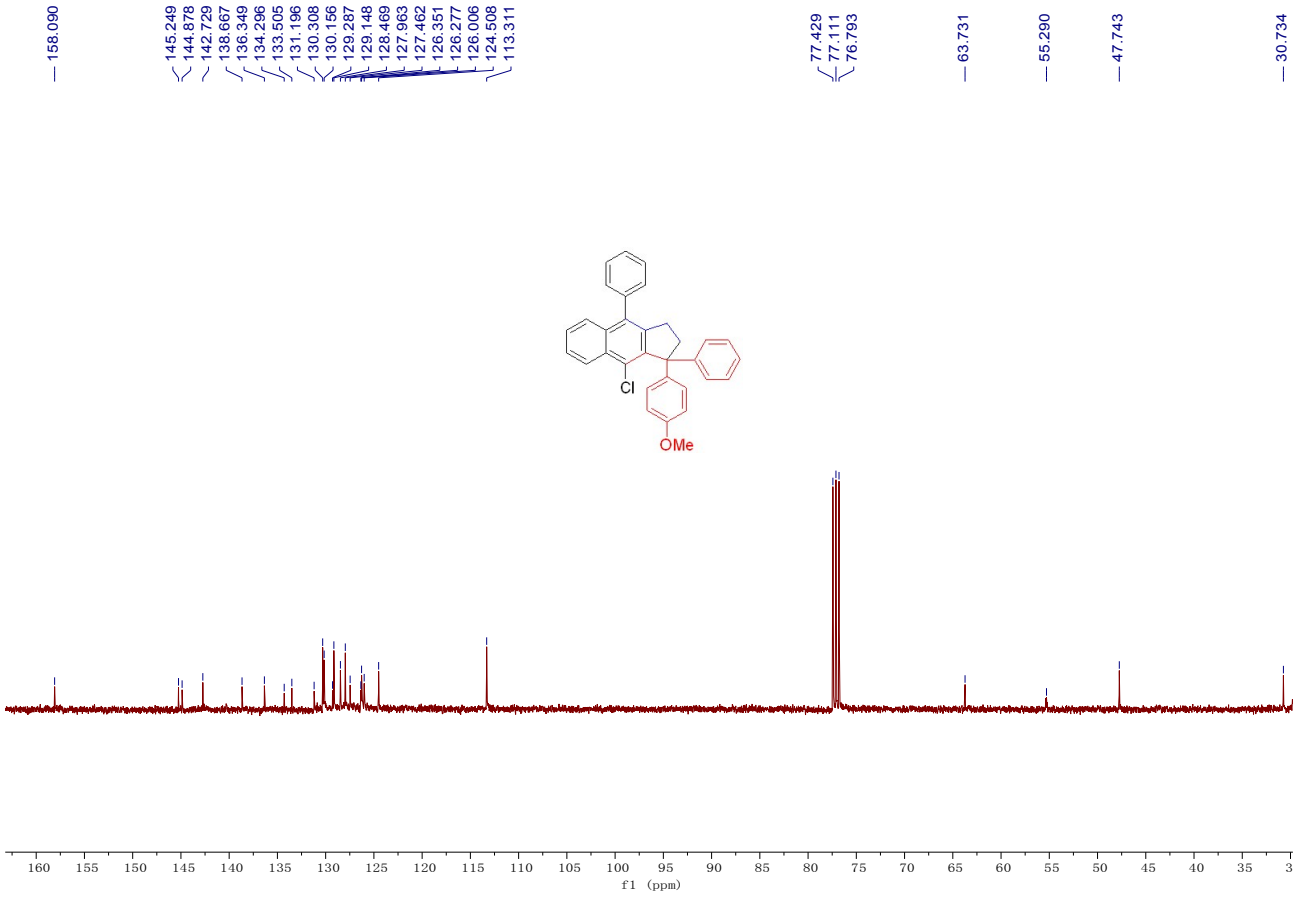
7.412
7.408
7.405
7.391
7.388
7.352
7.348
7.344
7.341
7.336
7.331
7.327
7.320
7.316
7.311
7.292
7.289
7.284
7.246
7.220
7.216
7.197
6.849
6.844
6.832
6.827
3.799
2.876
2.872
2.856
2.839
2.722
2.704
2.687
1.00
1.01
3.20
3.23
2.19
3.36
3.96
2.11
3.18
1.97
1.97
Cl
OMe
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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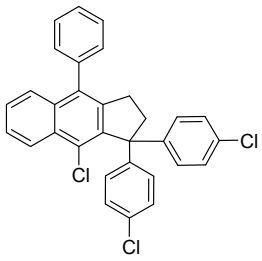
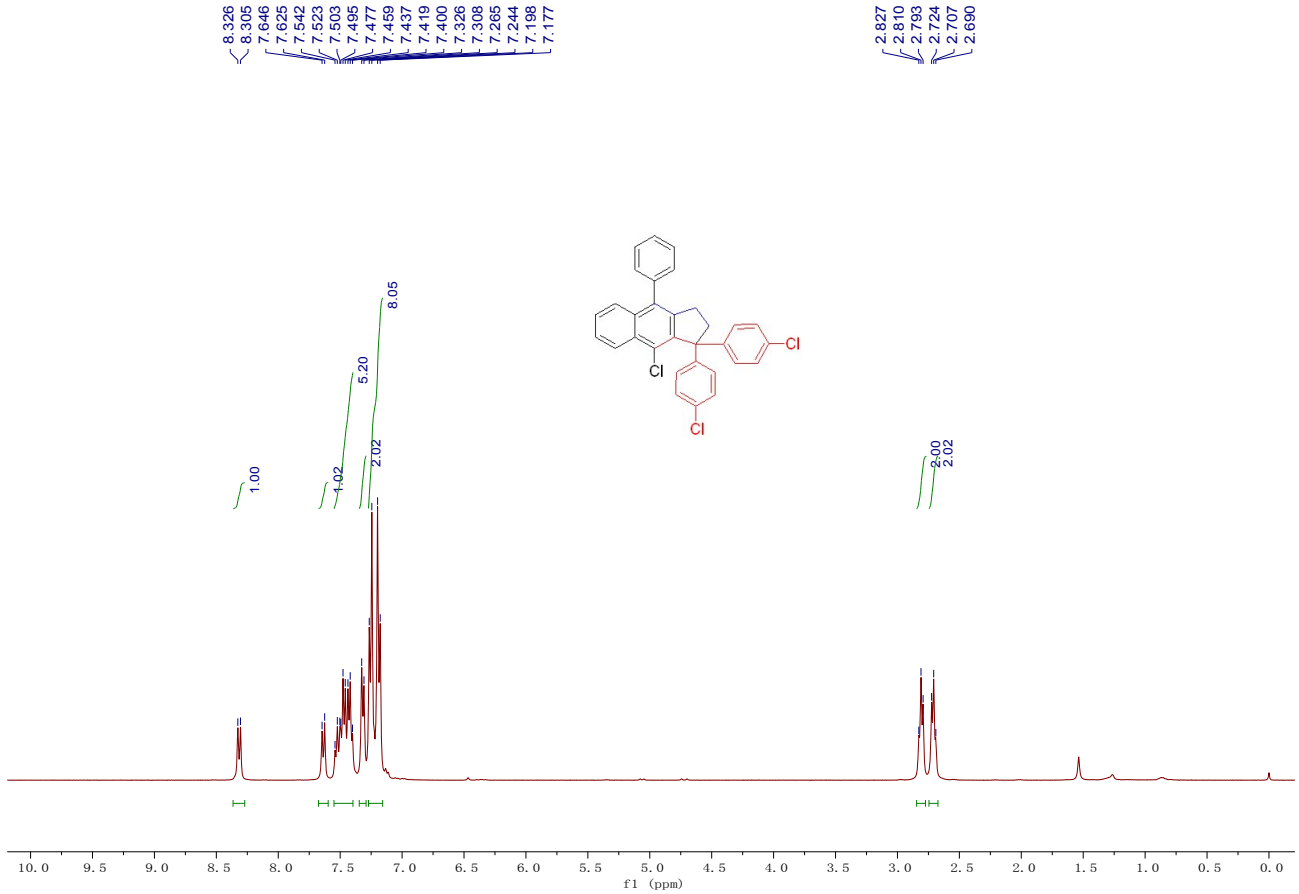
145.249
144.878
142.729
138.667
136.349
134.296
133.505
131.196
130.308
130.156
129.287
129.148
128.469
127.963
127.462
126.351
126.277
126.006
124.508
113.311
77.429
77.111
76.793
63.731
55.290
47.743
30.734
Cl
OMe
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
3
f1 (ppm)



Compound 2n: Yield: 74 mg, 75%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.32 (d, *J* = 8.5 Hz, 1H), 7.64 (d, *J* = 8.5 Hz, 1H), 7.55 – 7.40 (m, 5H), 7.32 (d, *J* = 7.3 Hz, 2H), 7.27 – 7.16 (m, 8H), 2.81 (t, *J* = 6.9 Hz, 2H), 2.71 (t, *J* = 6.9 Hz, 2H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 143.6, 142.7, 142.1, 138.3, 134.6, 133.5, 132.4, 131.0, 130.4, 130.0, 129.1, 128.5, 128.1, 127.5, 126.6, 126.2, 124.4, 63.4, 47.7, 30.6; IR (neat): ν 2919, 2849, 1488, 1092, 1013, 823, 757 cm^{-1}; HRMS (EI) Calcd. for $C_{31}H_{21}Cl_3$ $[M]^+$: 498.0703, Found: 498.0716.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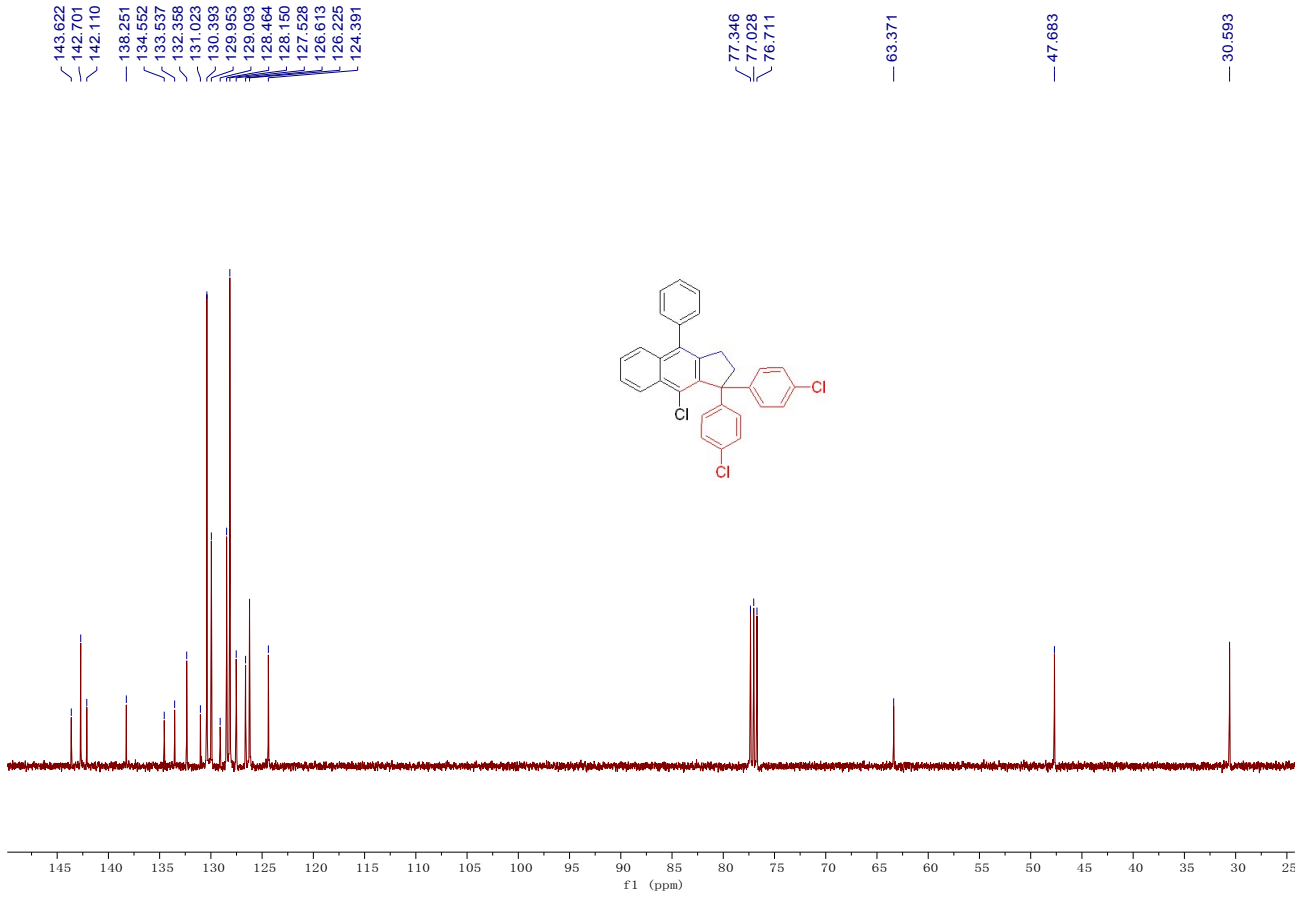
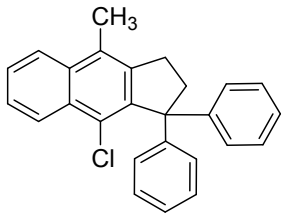
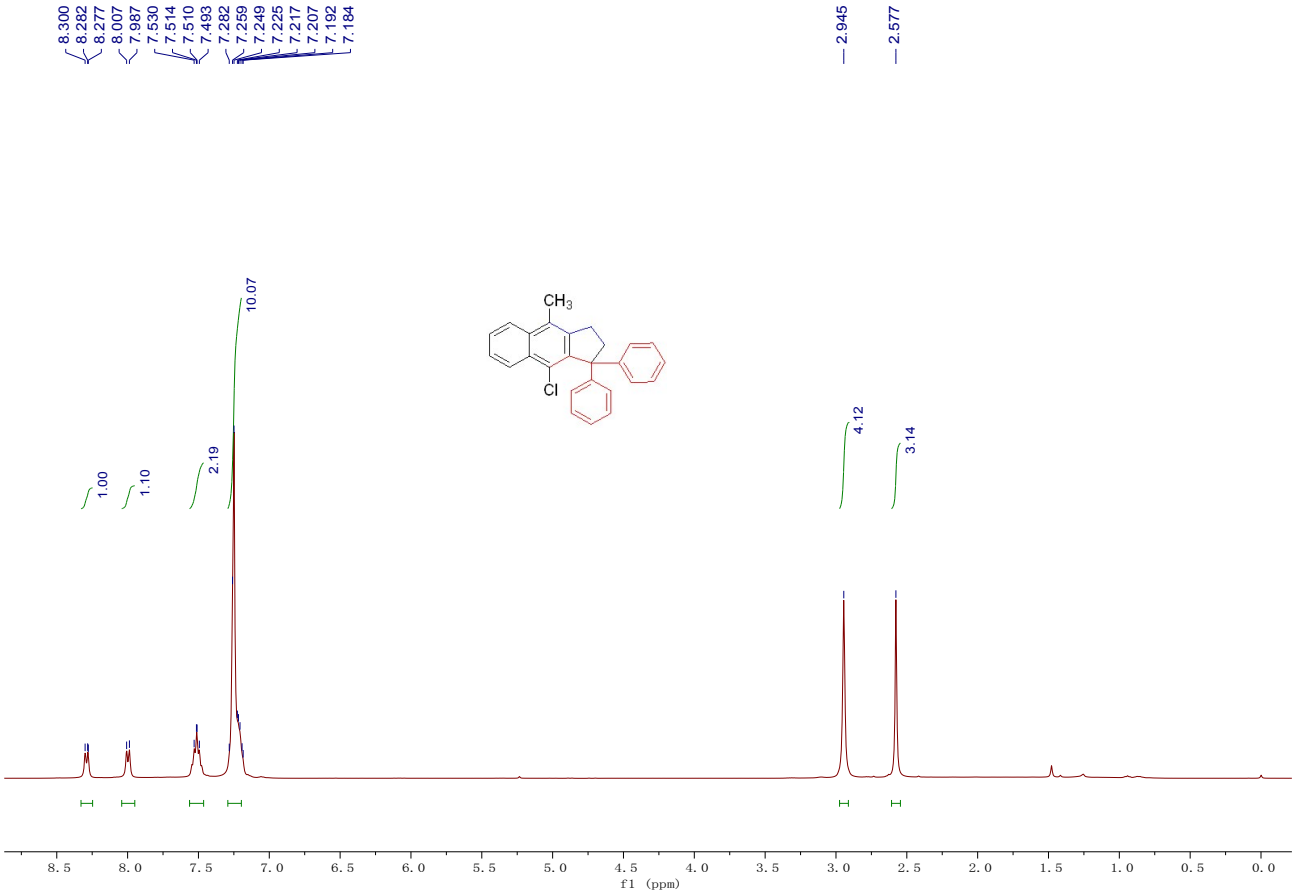
8.305
7.646
7.625
7.542
7.523
7.503
7.495
7.477
7.459
7.437
7.419
7.400
7.326
7.308
7.265
7.244
7.198
7.177
2.827
2.810
2.793
2.724
2.707
2.690
8.05
5.20
2.02
1.02
1.00
2.00
2.02
Cl
Cl
Cl
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


143.622
142.701
142.110
138.251
134.552
133.537
132.358
131.023
130.393
129.953
129.093
128.464
128.150
127.528
126.613
126.225
124.391
77.346
77.028
76.711
63.371
47.683
30.593
Cl
Cl
Cl
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
f1 (ppm)



Compound 2q: Yield: 36 mg, 50%; A white solid; Mp: >200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.29 (d, *J* = 7.4 Hz, 1H), 8.00 (d, *J* = 7.9 Hz, 1H), 7.56 – 7.46 (m, 2H), 7.28 – 7.18 (m, 10H), 2.95 - 2.87 (m, 4H), 2.58 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.6, 144.5, 142.4, 133.6, 131.0, 129.1, 127.8, 126.2, 126.1, 125.7, 124.8, 123.8, 64.1, 47.3, 30.1, 15.4; IR (neat): ν 2920, 1598, 1490, 1442, 1033, 911, 759, 727, 697 cm^{-1}; HRMS (EI) Calcd. for $C_{26}H_{21}Cl$ $[M]^{+}$: 368.1326, Found: 368.1344.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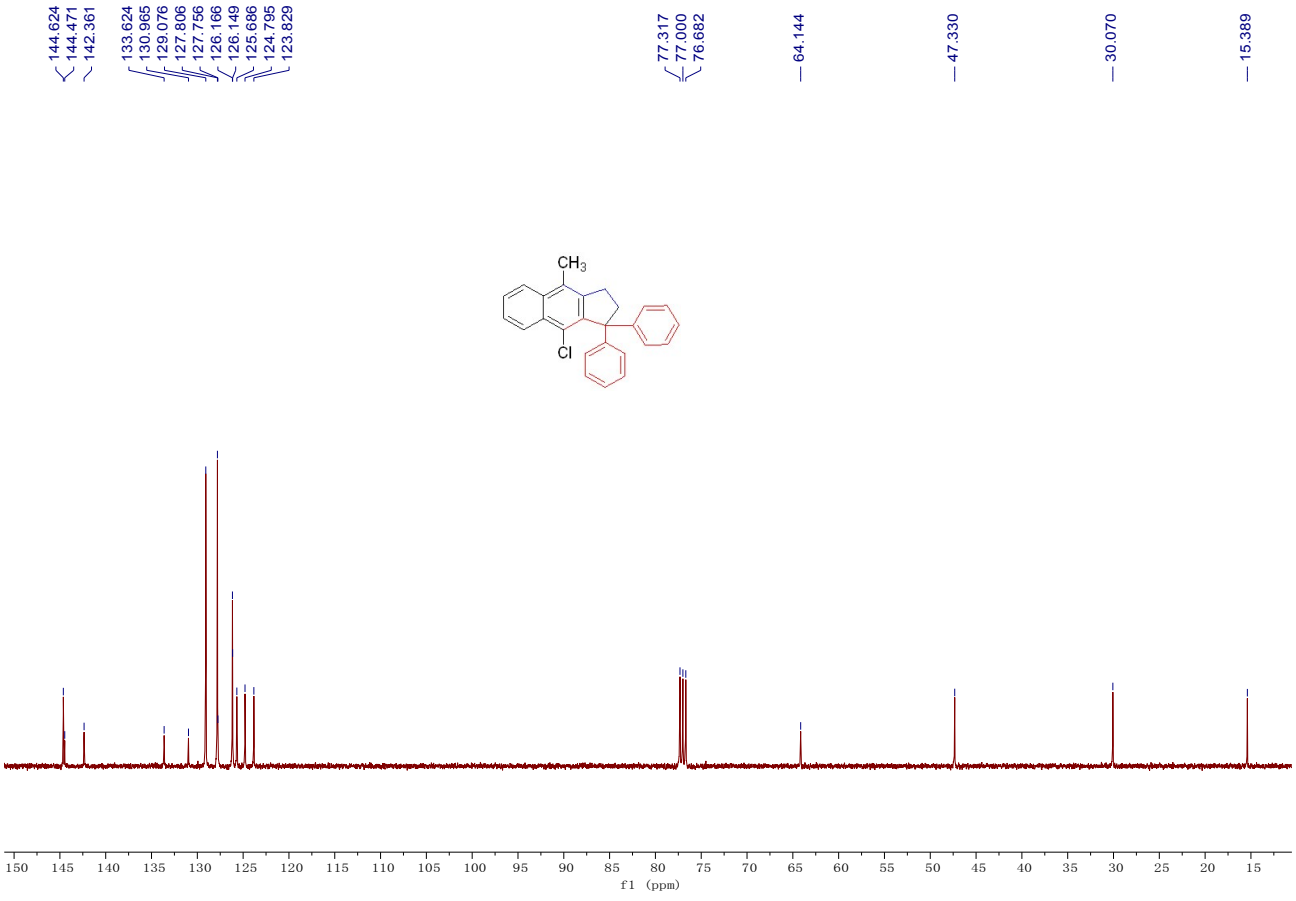
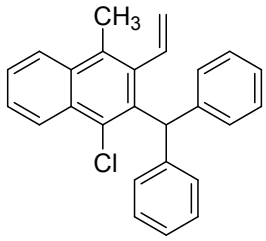
8.282
8.277
8.007
7.987
7.530
7.514
7.510
7.493
7.282
7.259
7.249
7.225
7.217
7.207
7.192
7.184
2.945
2.577
CH3
Cl
10.07
1.00
1.10
2.19
4.12
3.14
f1 (ppm)


144.624
144.471
142.361
133.624
130.965
129.076
127.806
127.756
126.166
126.149
125.686
124.795
123.829
77.317
77.000
76.682
64.144
47.330
30.070
15.389
CH3
Cl
f1 (ppm)



Compound 2q': Yield: 40 mg, 55%; A white solid; Mp: 139 - 141 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.38 – 8.32 (m, 1H), 8.10 – 8.03 (m, 1H), 7.60 – 7.51 (m, 2H), 7.27 – 7.22 (m, 4H), 7.22 – 7.16 (m, 6H), 6.62 (dd, *J* = 17.9, 11.3 Hz, 1H), 6.53 (s, 1H), 5.40 (dd, *J* = 11.3, 1.9 Hz, 1H), 5.01 (dd, *J* = 17.9, 1.9 Hz, 1H), 2.66 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 141.6, 138.6, 137.2, 136.4, 133.0, 131.1, 130.8, 129.6, 127.9, 126.5, 126.0, 125.3, 124.7, 121.3, 53.4, 17.1; IR (neat): ν 3055, 3024, 2922, 2846, 1492, 929, 749, 694 cm^{-1}; HRMS (EI) Calcd. for $C_{26}H_{21}Cl$ $[M]^{+}$: 368.1326, Found: 368.1329.


8.362
8.358
8.349
8.344
8.337
8.081
8.075
8.069
8.061
8.056
7.568
7.565
7.562
7.555
7.546
7.543
7.541
7.271
7.267
7.263
7.256
7.251
7.246
7.242
7.232
7.228
7.210
7.206
7.189
7.184
7.168
6.655
6.627
6.610
6.582
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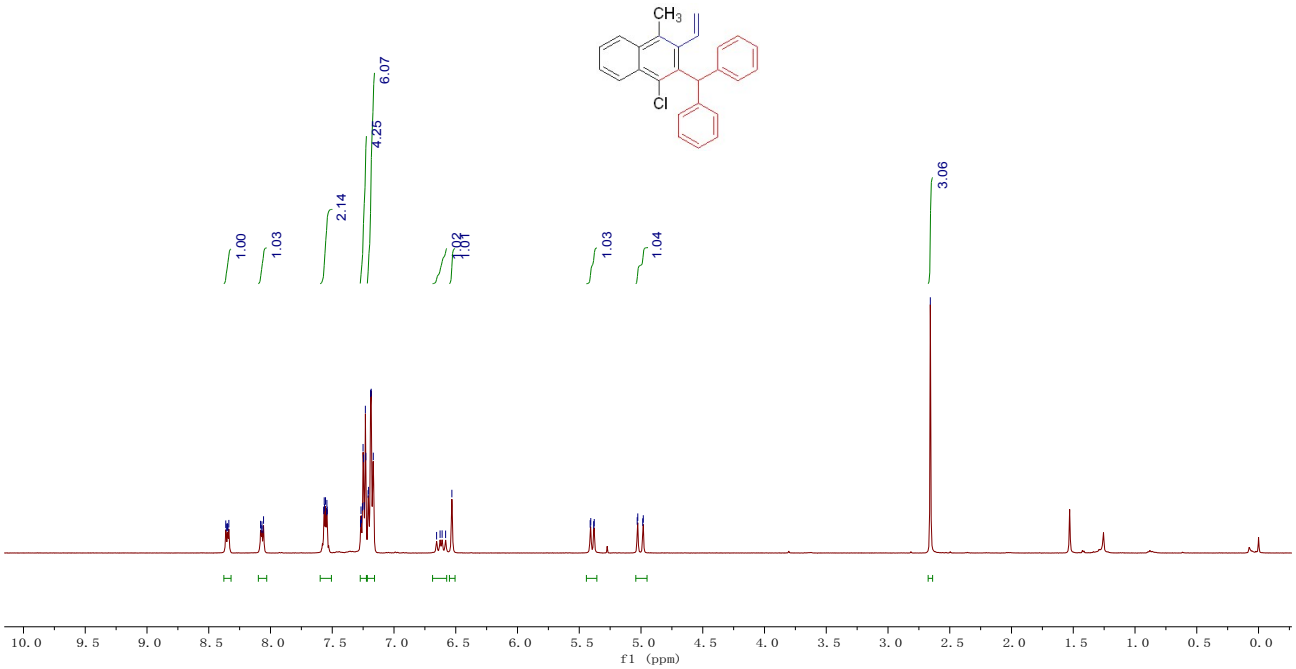
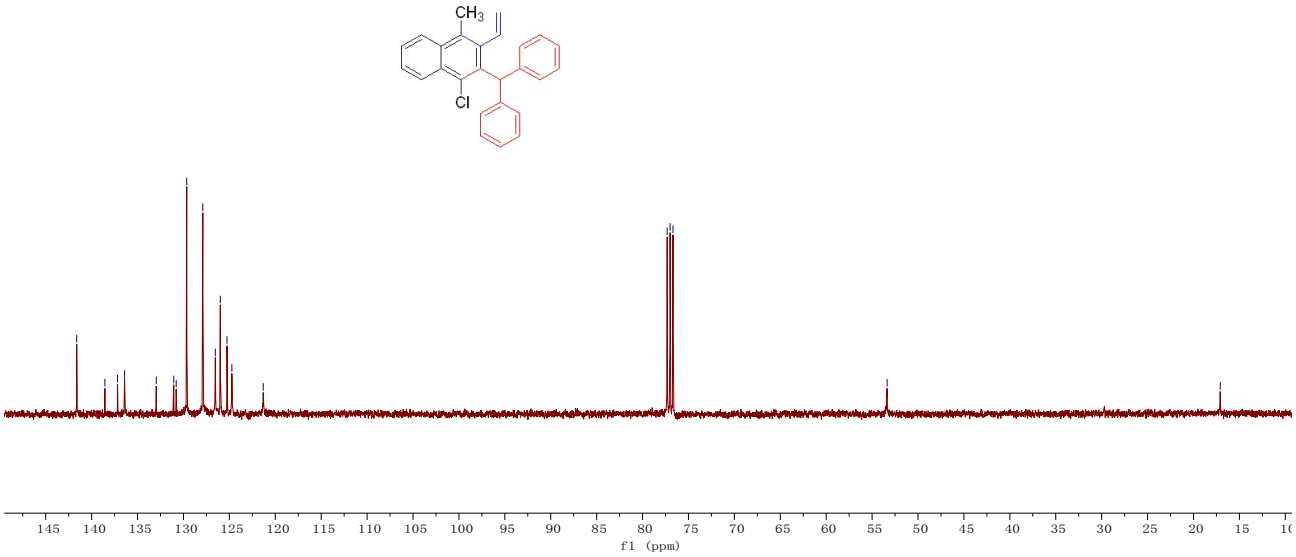
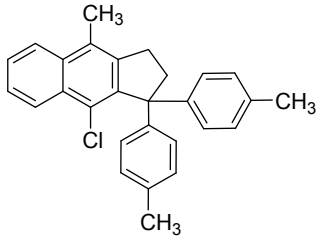
5.031
5.026
4.986
4.981
2.657

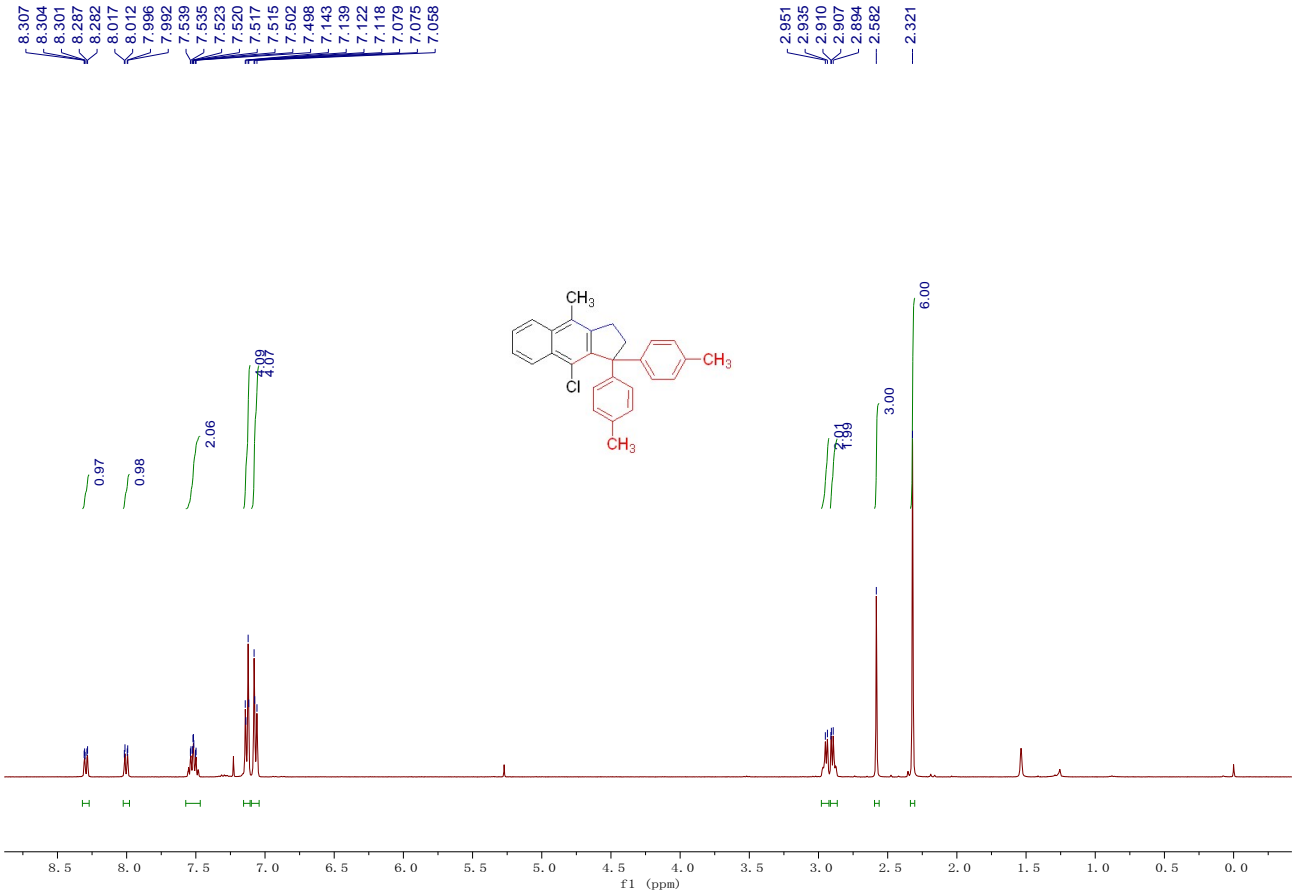

CH3
Cl
6.07
4.25
2.14
1.00
1.03
1.02
1.01
1.03
1.04
3.06
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


141.625
138.557
137.180
136.411
132.962
131.058
130.791
129.643
127.892
126.532
125.985
125.257
124.726
121.316
77.318
77.001
76.682
53.366
17.087


CH3
Cl
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
f1 (ppm)



Compound 2r: Yield: 43 mg, 55%; A white solid; Mp: 179 - 181 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.32 – 8.27 (m, 1H), 8.02 – 7.98 (m, 1H), 7.57 – 7.47 (m, 2H), 7.15 – 7.11 (m, 4H), 7.10 – 7.04 (m, 4H), 2.95 – 2.92 (m, 2H), 2.91 – 2.86 (m, 2H), 2.58 (s, 3H), 2.32 (s, 6H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.7, 142.5, 141.8, 135.6, 133.6, 131.0, 129.0, 128.5, 127.7, 127.6, 126.0, 125.6, 124.8, 123.8, 63.5, 47.3, 30.0, 21.0, 20.9, 15.3; IR (neat): ν 2925, 2852, 1508, 1450, 1187, 811, 754 cm^{-1}; HRMS (EI) Calcd. for $C_{28}H_{25}Cl$ $[M]^{+}$: 396.1639, Found: 396.1648.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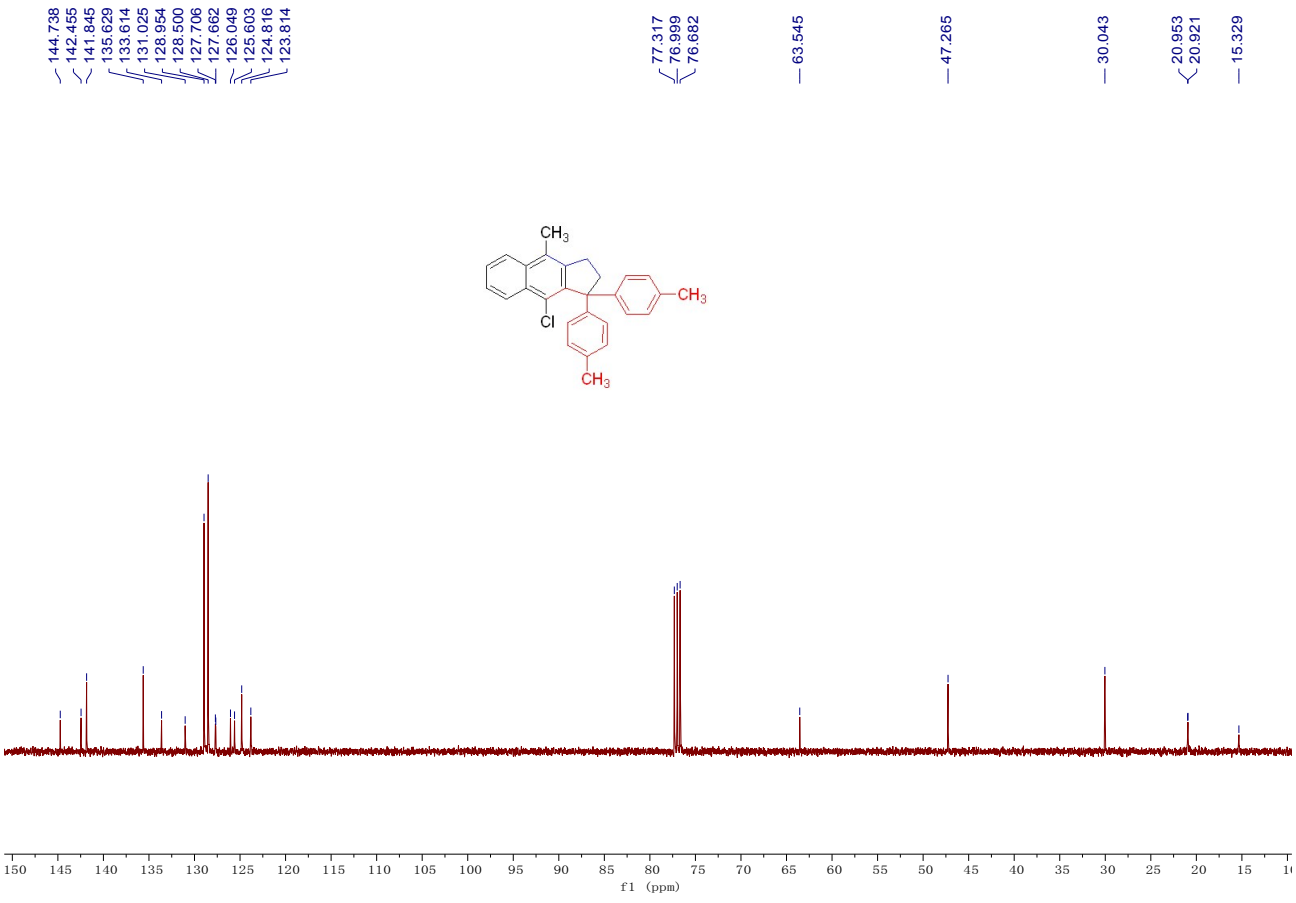
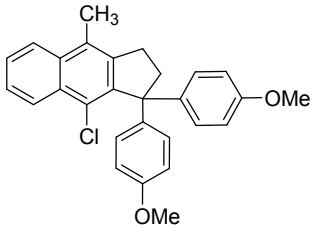
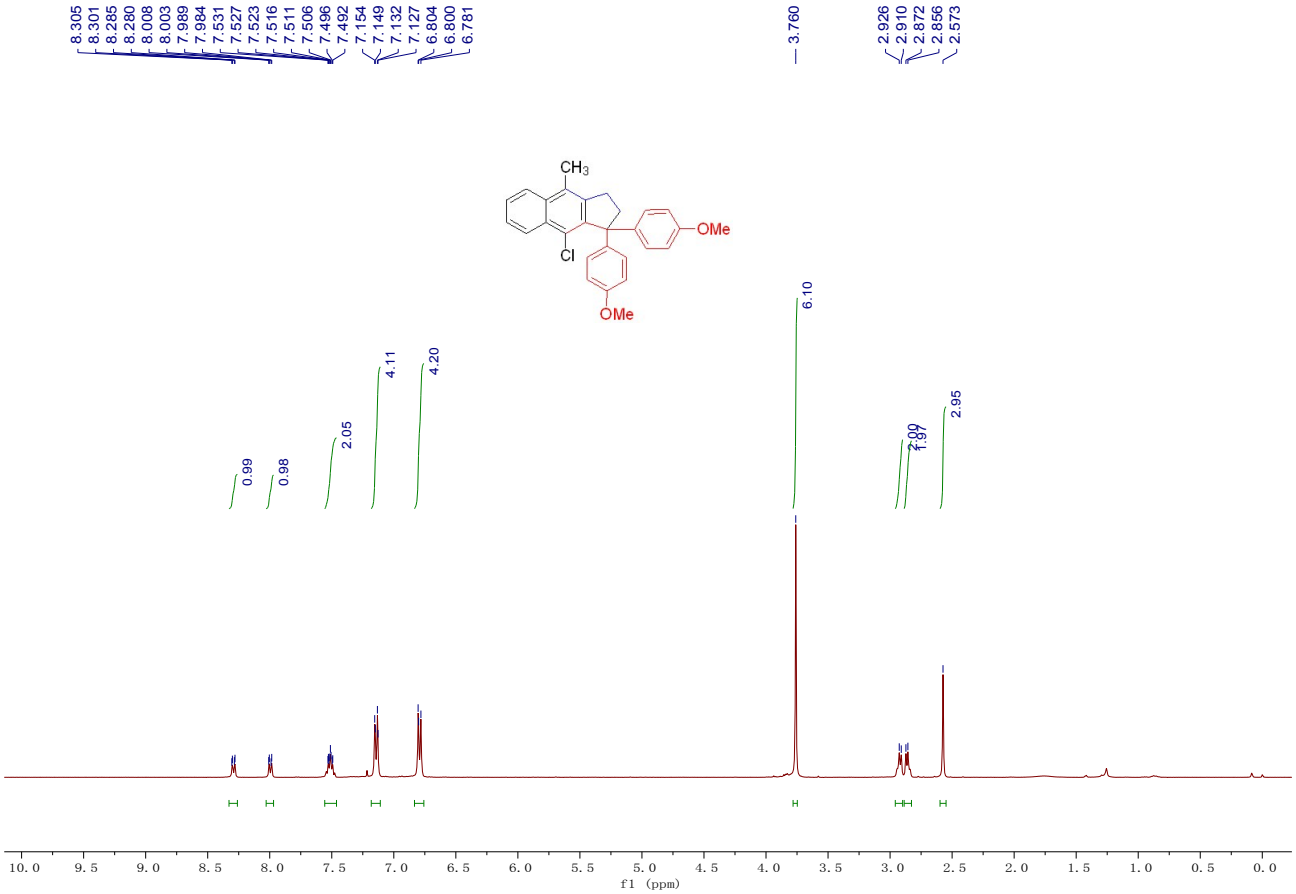
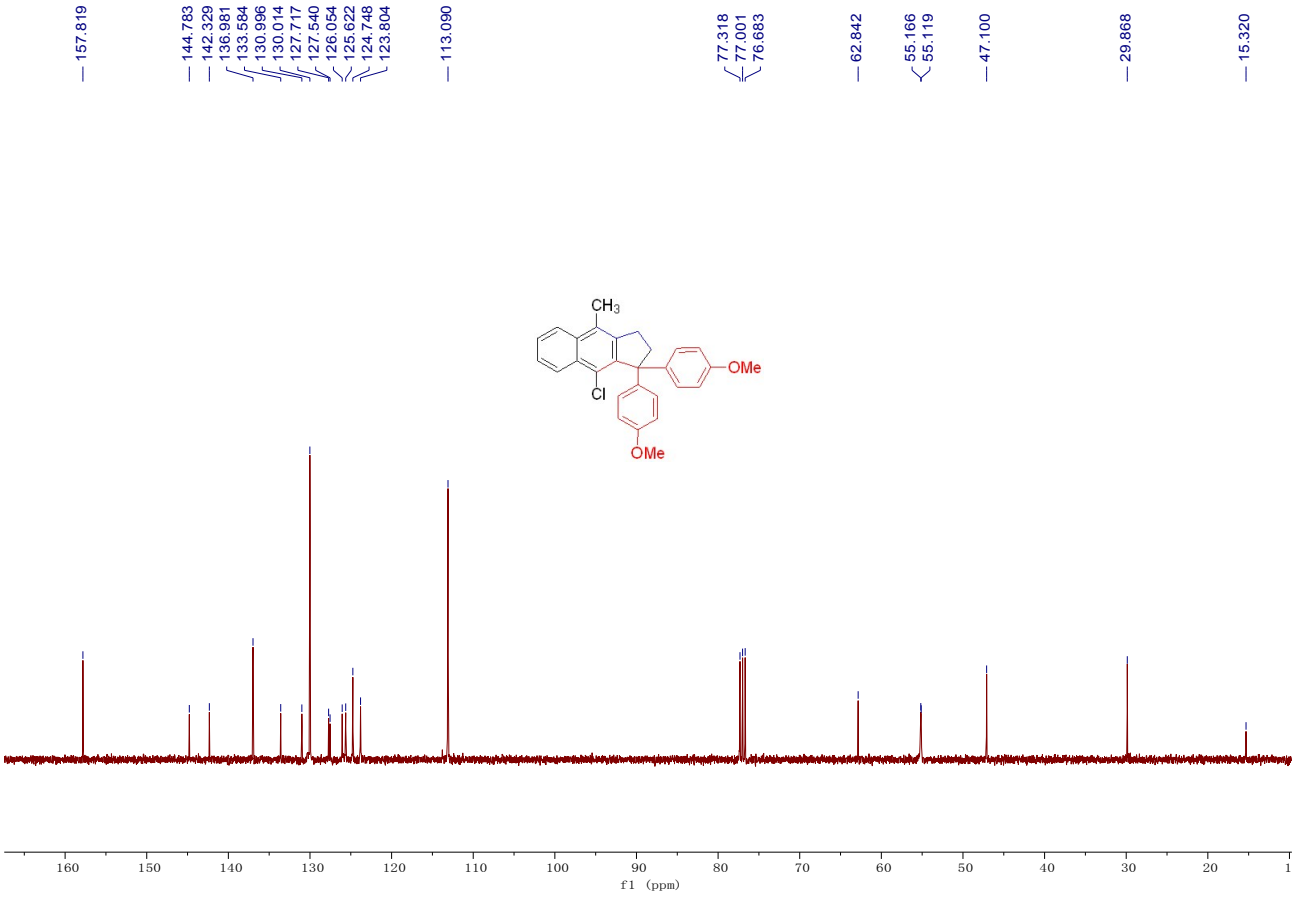
8.304
8.301
8.287
8.282
8.017
8.012
7.996
7.992
7.539
7.535
7.523
7.520
7.517
7.515
7.502
7.498
7.143
7.139
7.122
7.118
7.079
7.075
7.058
2.951
2.935
2.910
2.907
2.894
2.582
2.321
CH3
CH3
Cl
CH3
0.97
0.98
2.06
4.09
4.07
1.01
1.99
3.00
6.00
f1 (ppm)

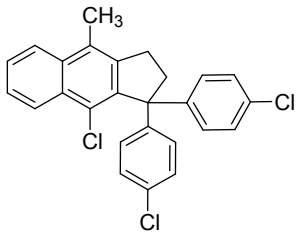

144.738
142.455
141.845
135.629
133.614
131.025
128.954
128.500
127.706
127.662
126.049
125.603
124.816
123.814
77.317
76.999
76.682
63.545
47.265
30.043
20.953
20.921
15.329
CH3
CH3
Cl
CH3
f1 (ppm)



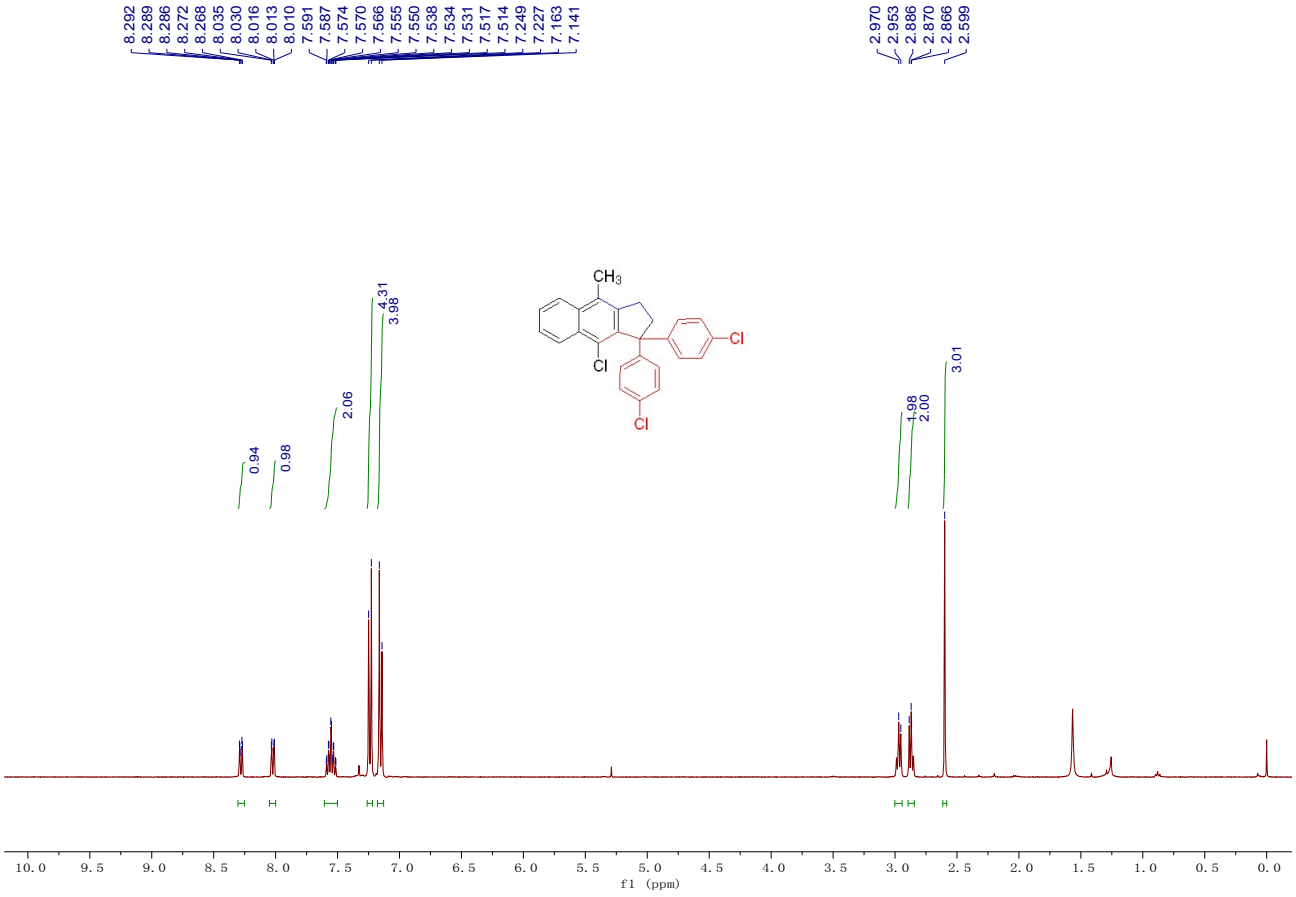
Compound 2s: Yield: 51 mg, 60%; A white solid; Mp: 76 - 78 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.33 – 8.26 (m, 1H), 8.00 (dd, *J* = 7.6, 2.0 Hz, 1H), 7.56 – 7.46 (m, 2H), 7.18 – 7.11 (m, 4H), 6.83 – 6.76 (m, 4H), 3.76 (s, 6H), 2.94 - 2.90 (m, 2H), 2.90 – 2.80 (m, 2H), 2.57 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 157.8, 144.8, 142.3, 137.0, 133.6, 131.0, 129.9, 127.7, 127.5, 126.1, 125.6, 124.7, 123.8, 113.1, 62.8, 55.2, 55.1, 47.1, 29.9, 15.3; IR (neat): ν 2951, 2828, 1604, 1508, 1247, 1179, 1033, 824 cm^{-1}; HRMS (EI) Calcd. for $C_{28}H_{25}ClO_2$ $[M]^+$: 428.1538, Found: 428.1539.


8.305
8.301
8.285
8.280
8.008
8.003
7.989
7.984
7.531
7.527
7.523
7.516
7.511
7.506
7.496
7.492
7.154
7.149
7.132
7.127
6.804
6.800
6.781
3.760
2.926
2.910
2.872
2.856
2.573
CH3
OMe
Cl
OMe
6.10
4.11
4.20
2.05
0.99
0.98
2.95
2.09
1.97
f1 (ppm)


157.819
144.783
142.329
136.981
133.584
130.996
130.014
127.717
127.540
126.054
125.622
124.748
123.804
113.090
77.318
77.001
76.683
62.842
55.166
55.119
47.100
29.868
15.320
CH3
OMe
Cl
OMe
f1 (ppm)



Compound 2t: Yield: 30 mg, 35%; A white solid; Mp: 198 - 200 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.30 – 8.25 (m, 1H), 8.05 – 8.00 (m, 1H), 7.61 – 7.50 (m, 2H), 7.26 – 7.22 (m, 4H), 7.18 – 7.13 (m, 4H), 3.00 – 2.94 (m, 2H), 2.89 – 2.84 (m, 2H), 2.60 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 143.5, 142.9, 141.9, 133.8, 132.3, 131.0, 130.4, 128.2, 128.1, 127.6, 126.5, 126.0, 124.8, 123.9, 63.3, 47.3, 30.0; IR (neat): ν 2980, 2870, 1511, 1448, 1180, 755 cm^{-1}; HRMS (EI) Calcd. for $C_{26}H_{19}Cl_3$ $[M]^+$: 436.0547, Found: 436.0555.


8.292
8.289
8.286
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8.030
8.016
8.013
8.010
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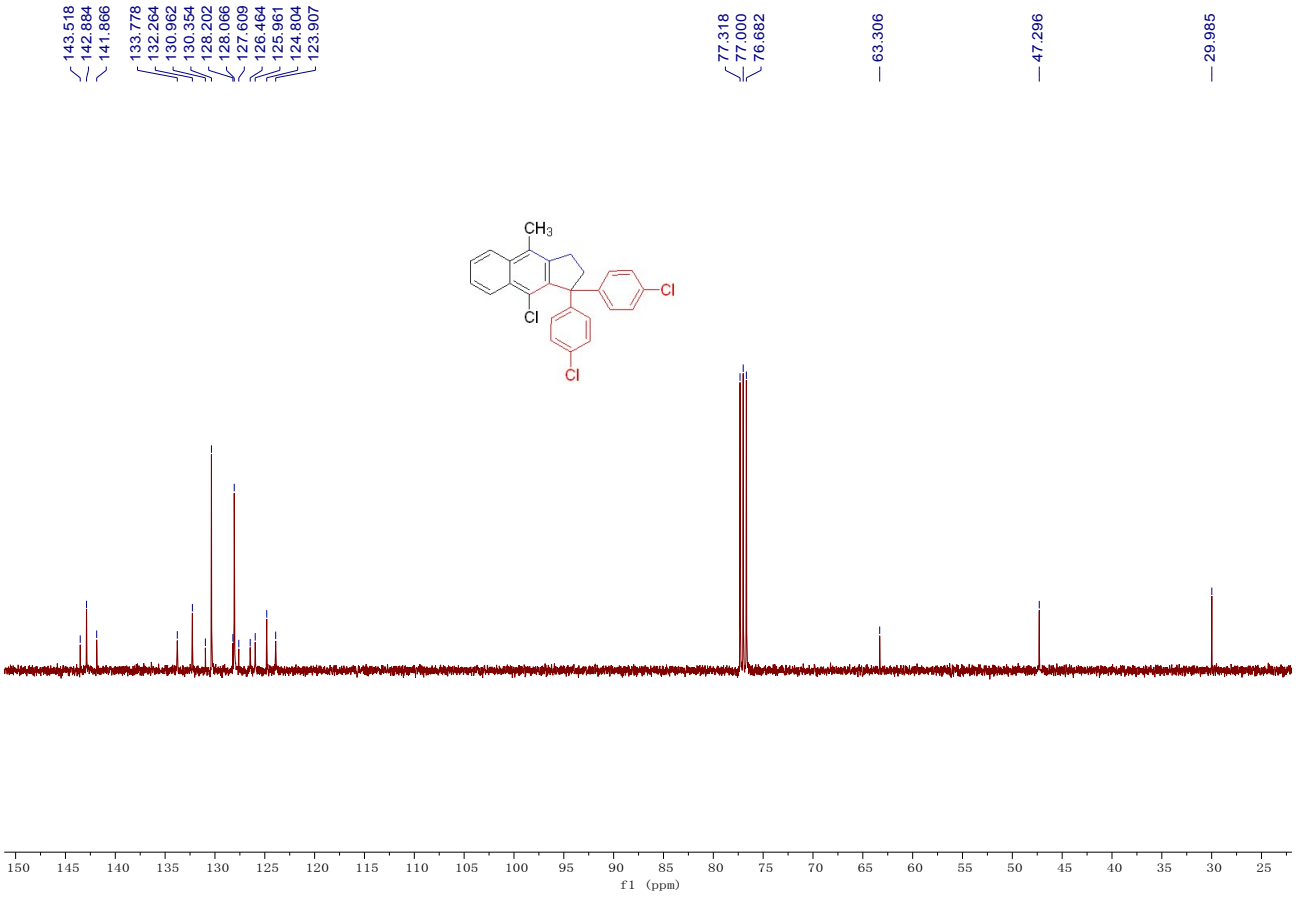
7.587
7.574
7.570
7.566
7.555
7.550
7.538
7.534
7.531
7.517
7.514
7.249
7.227
7.163
7.141
2.970
2.953
2.886
2.870
2.866
2.599
CH3
Cl
Cl
Cl
4.31
3.98
2.06
0.94
0.98
1.98
2.00
3.01
f1 (ppm)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132.264
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128.202
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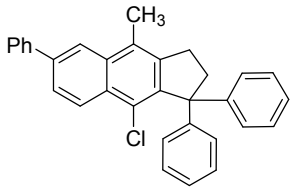
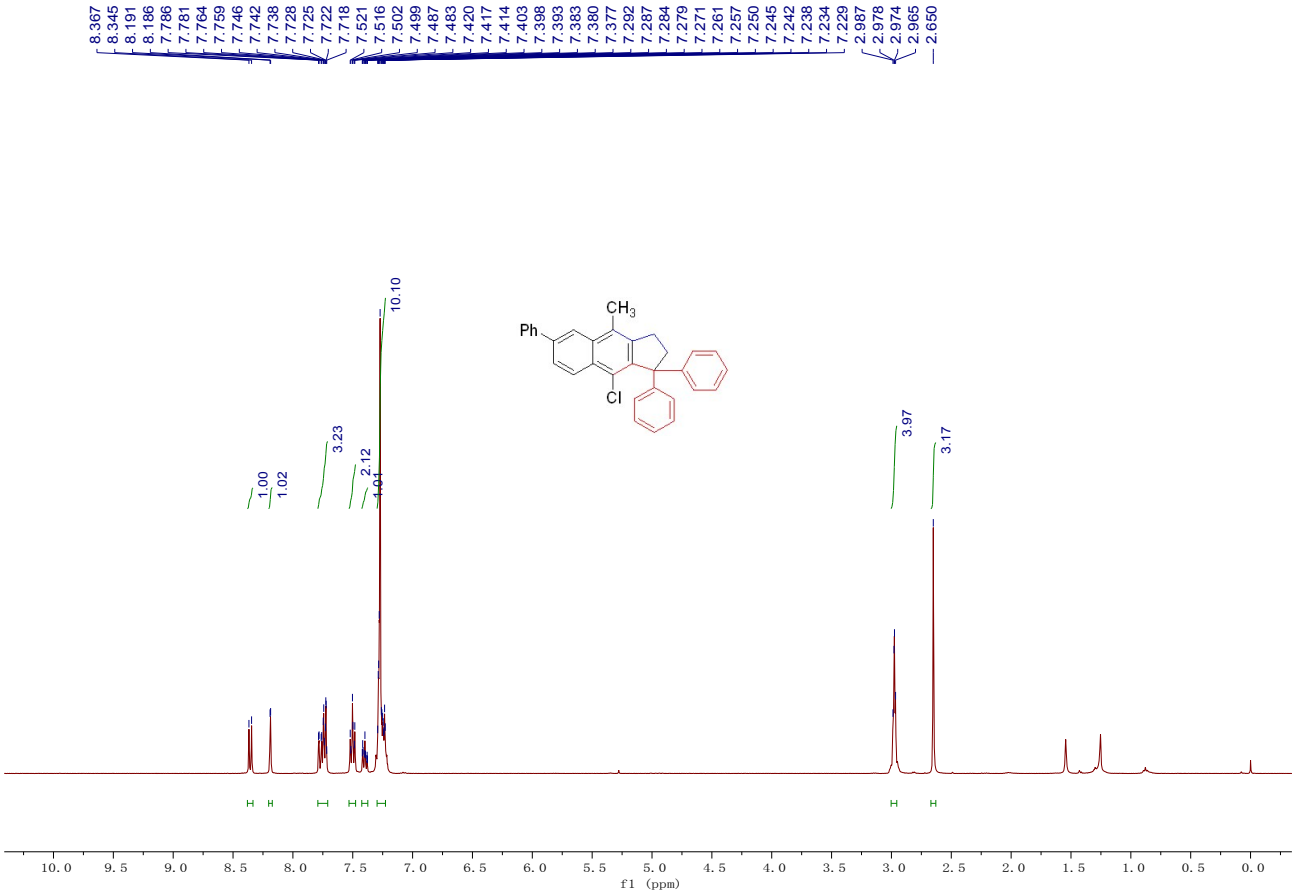
127.609
126.464
125.961
124.804
123.907
77.318
77.000
76.682
63.306
47.296
29.985
CH3
Cl
Cl
Cl
f1 (ppm)



Compound 2v: Yield: 26 mg, 30%; A white solid; Mp: 190 - 192 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.36 (d, *J* = 8.8 Hz, 1H), 8.19 (d, *J* = 1.8 Hz, 1H), 7.79 – 7.71 (m, 3H), 7.50 (dd, *J* = 8.4, 6.9 Hz, 2H), 7.42 – 7.37 (m, 1H), 7.30 – 7.23 (m, 10H), 3.00 – 2.90 (m, 4H), 2.65 (s, 3H); ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.6, 144.5, 142.9, 141.2, 139.0, 133.9, 130.2, 129.1, 128.9, 128.0, 127.8, 127.7, 127.54, 127.49, 126.2, 125.5, 125.4, 122.0, 64.2, 47.3, 30.1, 15.5; IR (neat): ν 2914, 2849, 1594, 1488, 1448, 1029, 933, 755 cm^{-1}; HRMS (EI) Calcd. for $C_{32}H_{25}Cl$ $[M]^{+}$: 444.4639, Found: 444.4642.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7.725
7.722
7.718
7.521
7.516
7.502
7.499
7.487
7.483
7.420
7.417
7.414
7.403
7.398
7.393
7.383
7.380
7.377
7.292
7.287
7.284
7.279
7.271
7.261
7.257
7.250
7.245
7.242
7.238
7.234
7.229
2.987
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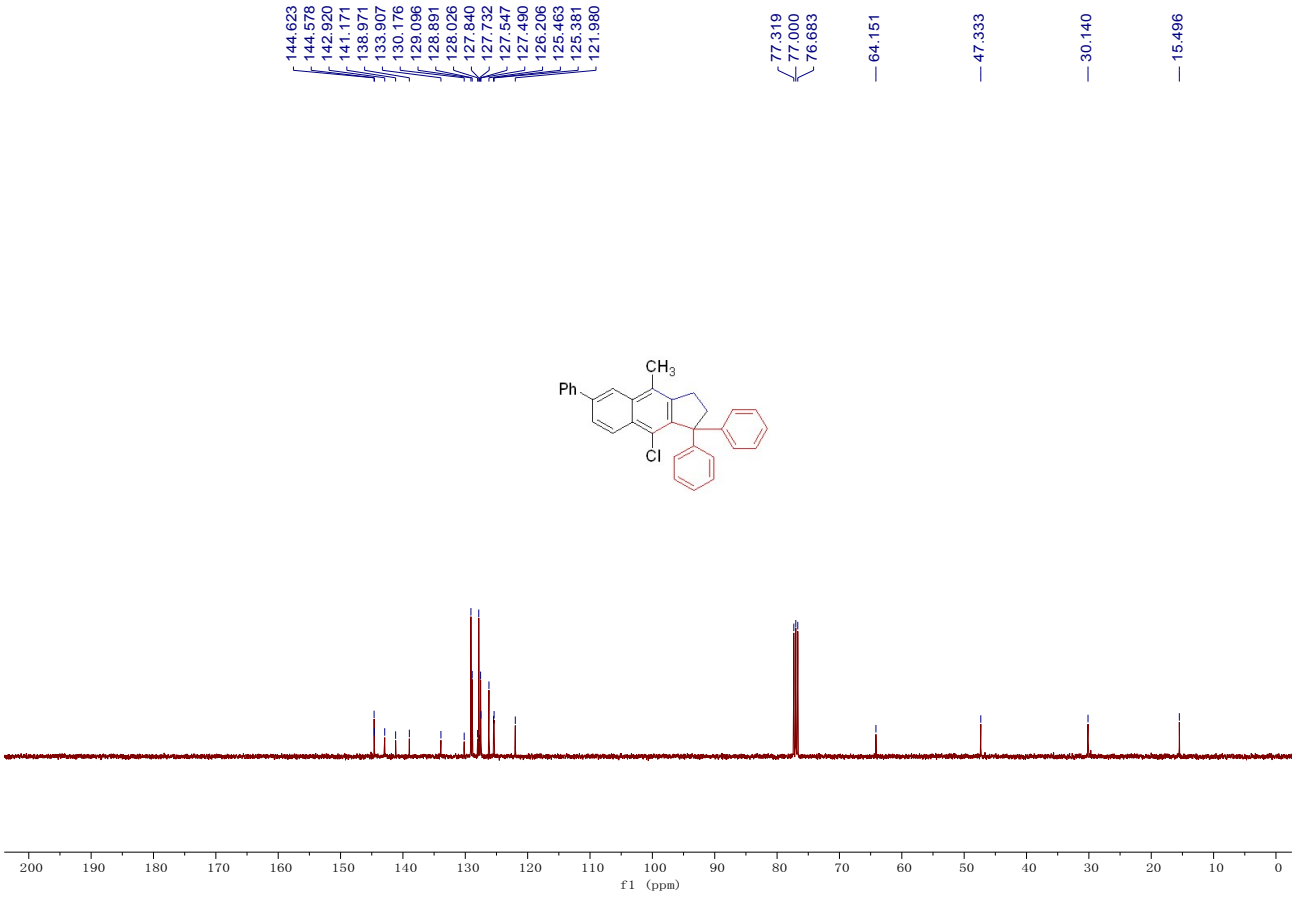
2.974
2.965
2.650
10.10
3.23
2.12
1.01
1.00
1.02
3.97
3.17
CH3
Ph
Cl
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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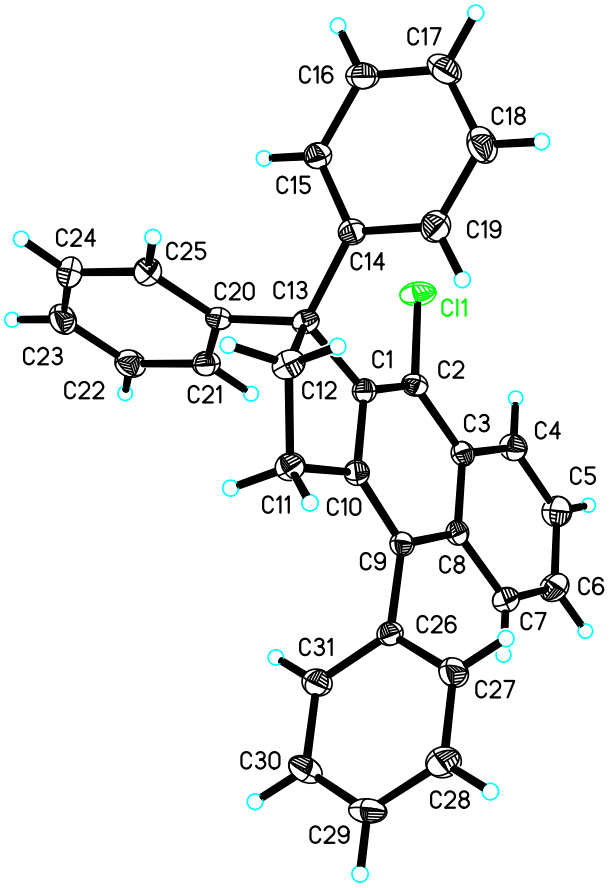
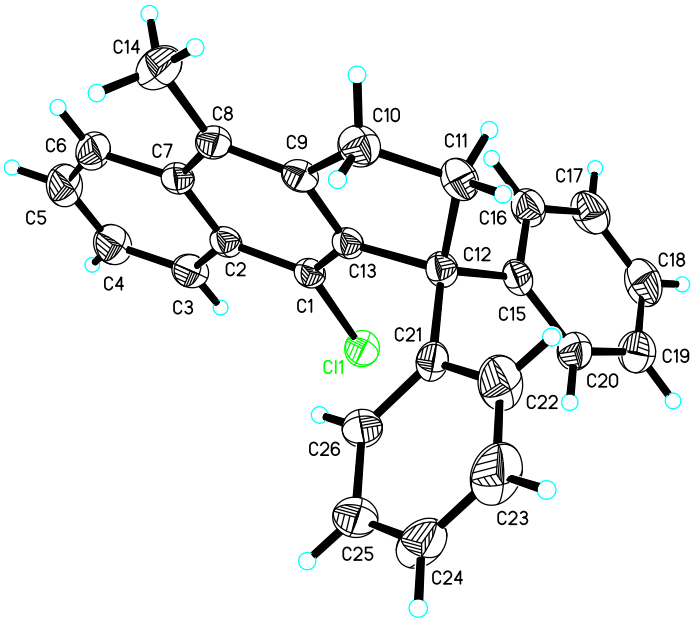
127.732
127.547
127.490
126.206
125.463
125.381
121.980
77.319
77.000
76.683
64.151
47.333
30.140
15.496
CH3
Ph
Cl
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

7. X-ray crystal data



The crystal data of **2a** have been deposited in CCDC with number 1949824. Empirical Formula: $C_{31}H_{23}Cl$; Formula Weight: 430.94; Crystal Color, Habit: colorless; Crystal Dimensions: 0.200 x 0.160 x 0.130 mm^3; Crystal System: Monoclinic; Lattice Parameters: a = 12.1573(13)Å, b = 12.3663(13)Å, c = 15.5243(14)Å, $\alpha = 90^o$, $\beta = 107.422(3)^o$, $\gamma = 90^o$, V = 2226.9(4)$Å^3$; Space group: P 21/n; Z = 4; D_{calc} = 1.285 g/cm^3; F_{000} = 904; Final R indices [I>2sigma(I)] R1 = 0.0350, wR2 = 0.0828.



The crystal data of **2q** have been deposited in CCDC with number 1975359. Empirical Formula: $C_{26}H_{21}Cl$; Formula Weight: 368.88; Crystal Color, Habit: colorless, Crystal Dimensions: 0.200 x 0.160 x 0.130 mm^3; Crystal System: Orthorhombic; Lattice Parameters: a = 20.7442(6) Å, b = 12.3960(3)Å, c = 7.5295(2) Å, $\alpha = 90^o$, $\beta = 90^o$, $\gamma = 90^o$, V = 1936.17(9) $Å^3$; Space group: P n a 21; Z = 4; D_{calc} = 1.265 g/cm^3; F_{000} = 776; Final R indices [I>2sigma(I)] R1 = 0.0318, wR2 = 0.0795.