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

Selective construction of polycyclic spirooxindoles via $Cu(OTf)_2$/HOTf catalyzed domino reaction of *o*-arylalkynyl acetophenones and 3-phenacylideneoxindoles

Ren-Yin Yang, Jing Sun, Qiu Sun, Chao-Guo Yan

Content

General Information:

Unless otherwise noted, all reactants or reagents including dry solvents were obtained from commercial suppliers and used as received. Analytical thin-layer chromatography (TLC) was carried out using 0.25 mm commercial silica gel plates (Merck silica gel 60 F254). The developed chromatogram was analyzed by UV lamp (254 nm). ^{1}H NMR and ^{13}C NMR spectra were obtained on a Variance 400M. Chemical shifts (δ) are expressed in parts per million and are internally referenced. Infrared spectra were taken on a Perkin Elmer Spectrum 100 FTIR and are reported in reciprocal centimeters (cm^{-1}). High-resolution mass spectra (HRMS) were obtained on AB 5800 MALDI-TOF/TOF and are reported as m/z (relative intensity). X-ray crystallographic data were collected using SMART APEX II X-ray diffractometer. Melting points were measured on a Yanaco Micro Melting Point Apparatus and are uncorrected.

Experiment section:

General Procedure for the Preparation of **1a-1e.** To a solution of 12 mL THF were added $Pd(PPh_3)Cl_2$ (3 mol%), CuI (5 mol%), 2-bromoacetophenone (1.99 g, 10 mmol) phenylacetylene (1.53 g, 15 mmol) and Et_3N (20 mL) in a 100 mL Schleck tube with a magnetic stirrer under N_2 atmosphere. The mixture was heat under reflux or RT overnight. After removal of the solvent under reduce pressure, purification was performed by flash column chromatography on silica gel with light petroleum/ethyl acetate (gradient mixture ratio 50:1) as eluent to afford **1a.**

General Procedure for the Preparation of **1f**. To a solution of 10 mL THF were added $Pd(PPh_3)_2Cl_2$ (0.21 g, 3 mol%), CuI (0.095 g, 5 mol %), 2-iodoacetophenone (2.46 g, 10 mmol), phenylacetylene (2.20 g, 15 mmol) and Et_3N (20 mL) in a 100 mL Schleck tube with a magnetic stirrer under N_2 atmosphere. The mixture was stirred at room temperature overnight. After removal of the solvent under reduce pressure, purification was performed by flash column chromatography on silica gel with light petroleum/ethyl acetate (gradient mixture ratio 50:1) as eluent to afford **1f.**

General Procedure for the Preparation of 3 and 4:

To a solution of 10 mL DCE were added 3-phenacylideneoxindole (0.5 mmol), *o*-(alkynyl)arylketone (0.5 mmol), HOTf (20 mol%, 0.015 g) and $Cu(OTf)_2$ (5 mol%, 0.07 g) in a 50 mL flask with a magnetic stirrer. The reaction mixture was stirred under reflux for 15 h. After removal of the solvent under reduced pressure, purification was performed by flash column chromatography on silica gel with light petroleum/ethyl acetate (gradient mixture ratio is 20:1) or

light petroleum/CH_2Cl_2 (gradient mixture ratio is 2:1) as eluent to afford **3**-**4.**

Crystallographic Data for 3j, 3k, 3m, 4r, 4v and F1

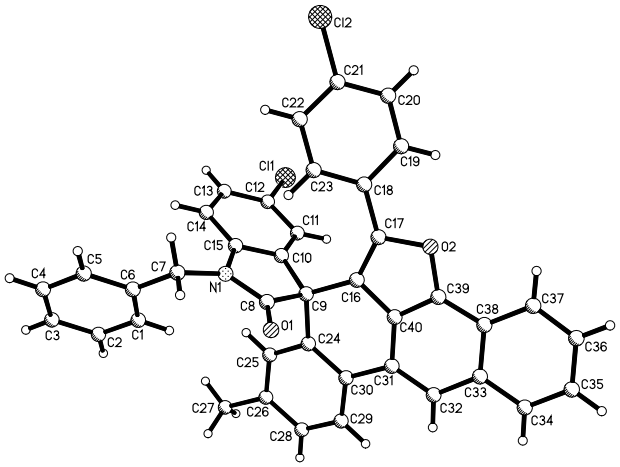


Fig. S1 molecular structure of compound **3j**

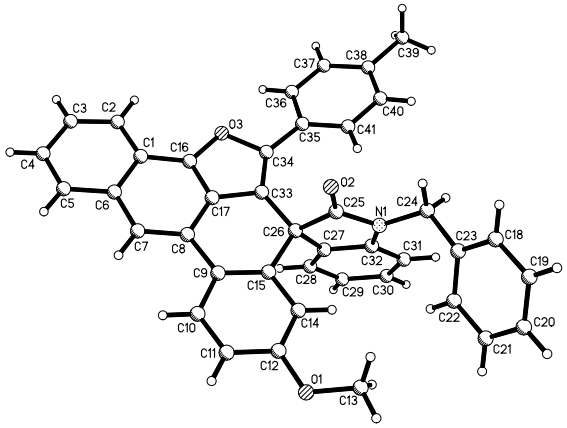


Fig. S2 molecular structure of compound **3k**

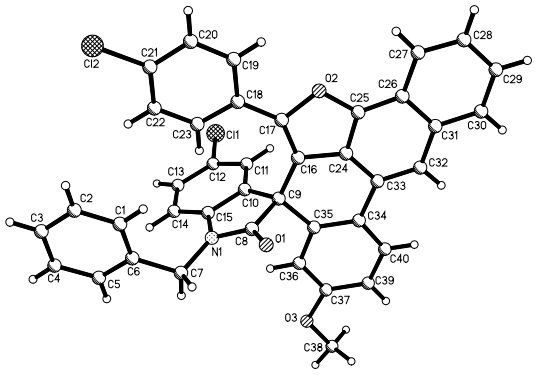


Fig. S3 molecular structure of compound **3m**

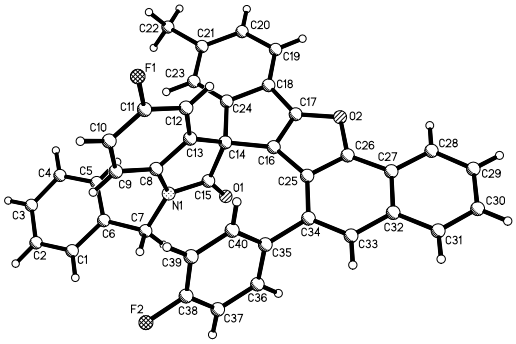


Fig. S4 molecular structure of compound **4r**

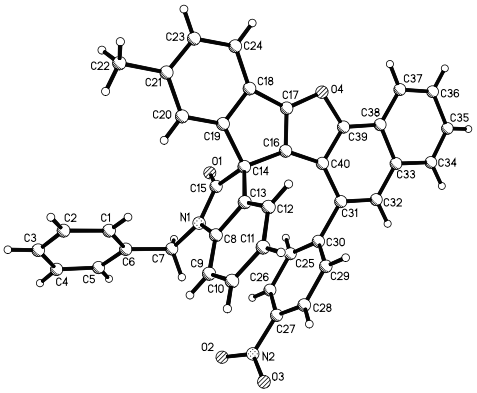


Fig. S5 molecular structure of compound **4v**

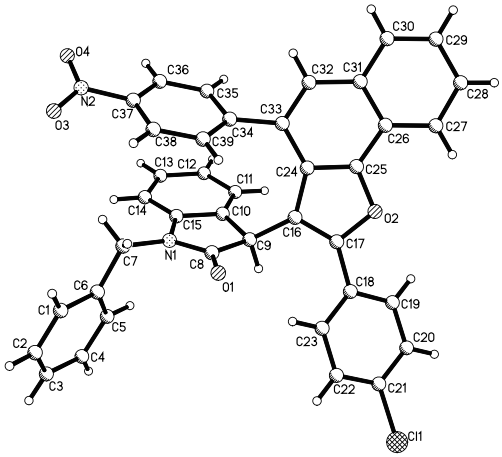
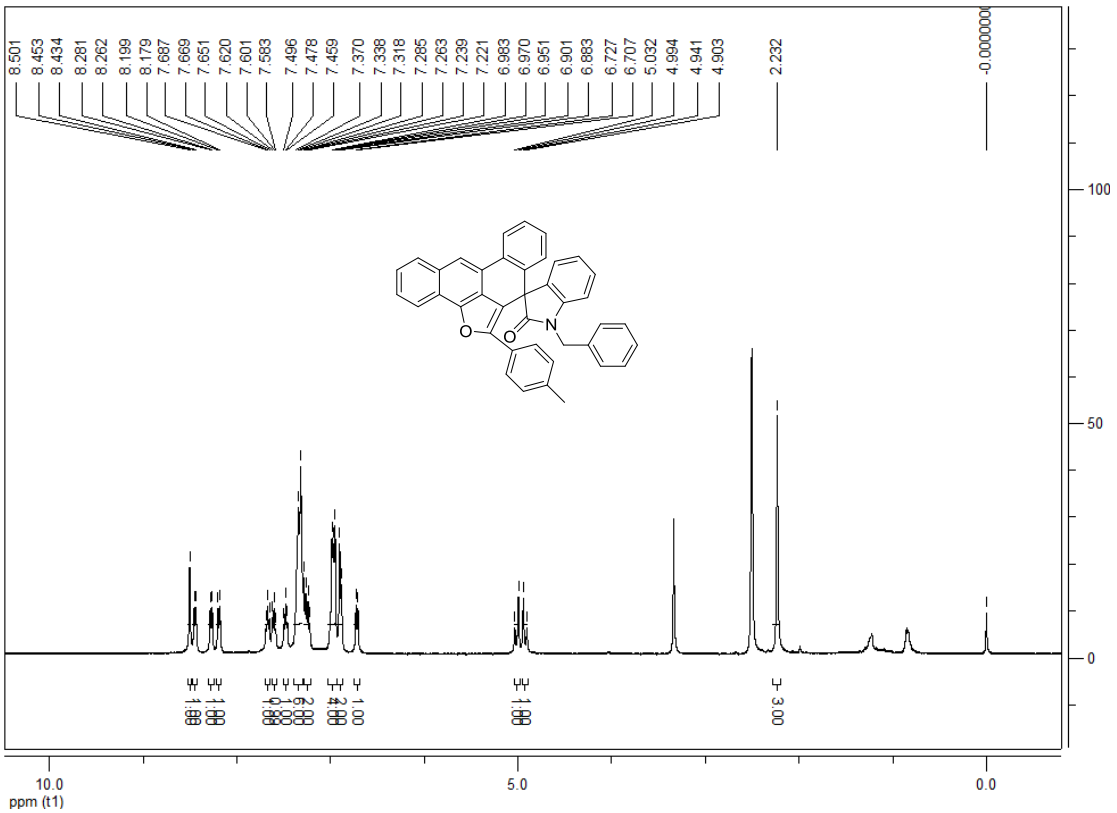
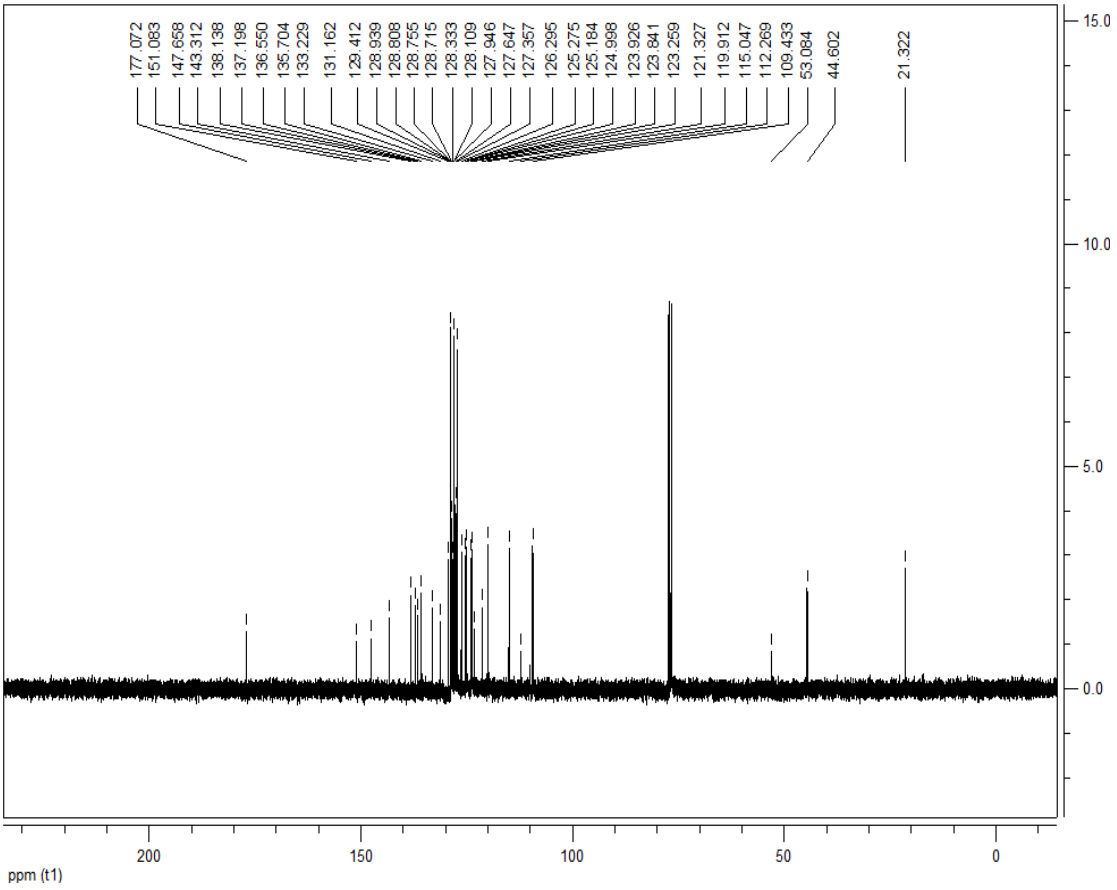


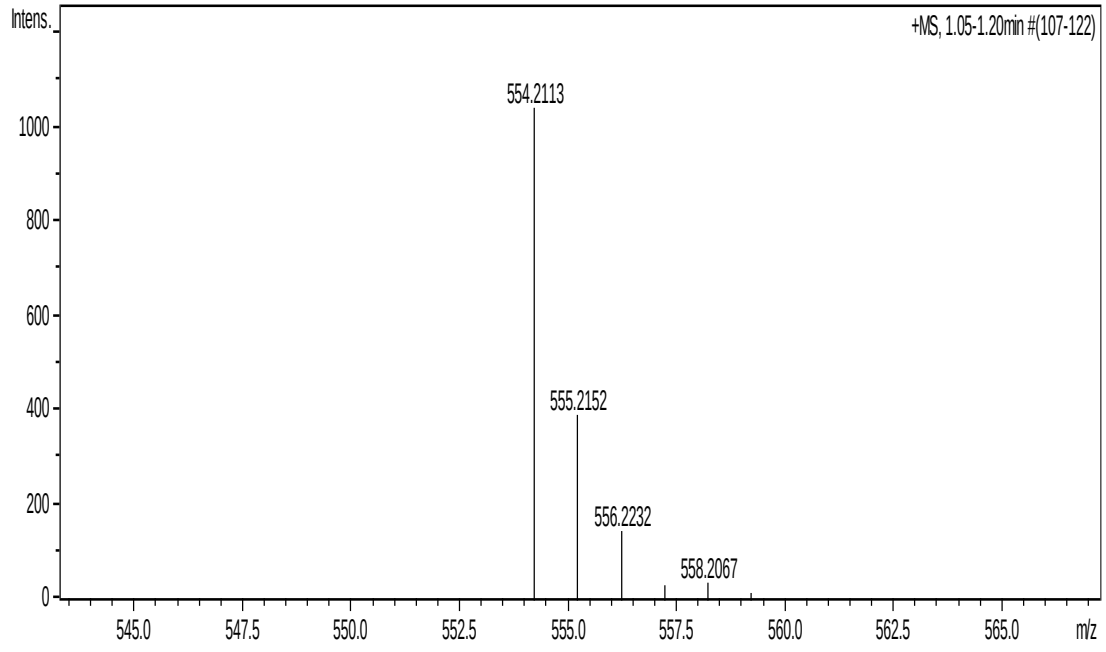
Fig. S6 molecular structure of intermediate **F1**

^{1}H NMR and ^{13}C NMR spectra for different products:

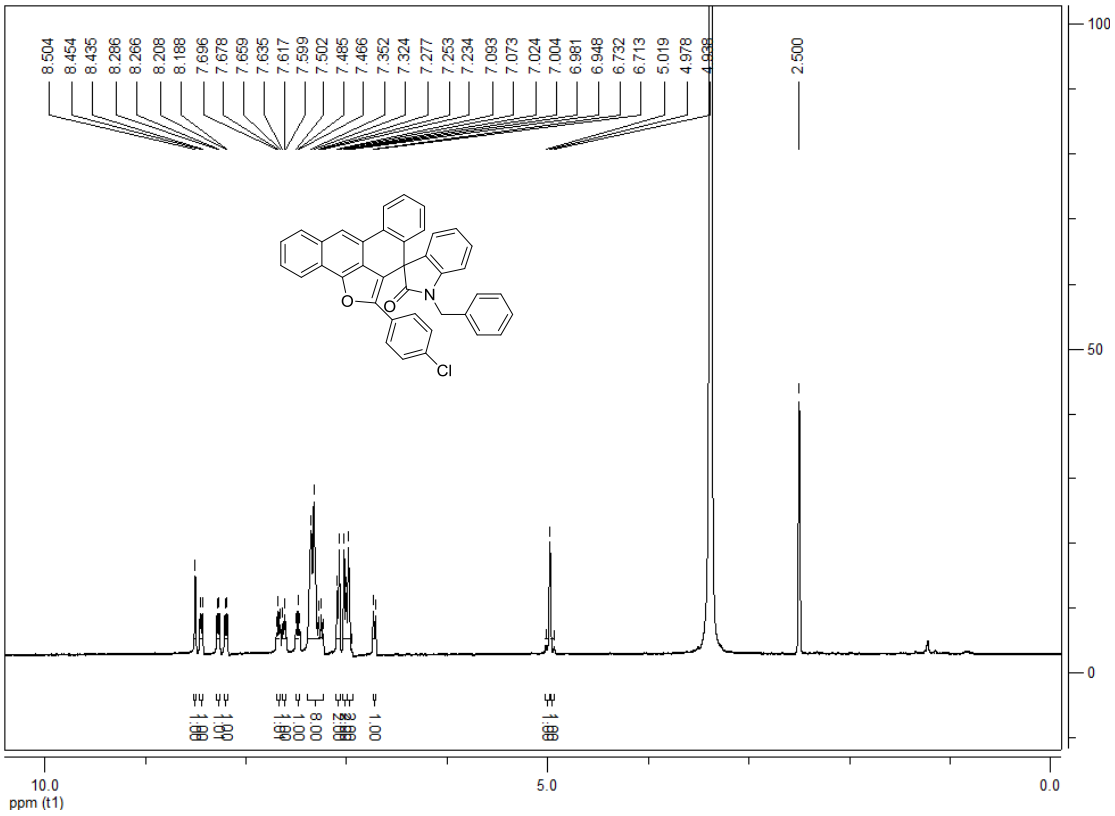
1-benzyl-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3a): Yellow solid, 81%, 0.224 g, m.p. 217-219℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.50 (s, 1H, ArH), 8.44 (d, *J* = 7.6 Hz, 1H, ArH), 8.27 (d, *J* = 7.6 Hz, 1H, ArH), 8.19 (d, *J* = 8.0 Hz, 1H, ArH), 7.67 (t, *J* = 7.2 Hz, 1H, ArH), 7.60 (t, *J* = 7.2 Hz, 1H, ArH), 7.48 (t, *J* = 7.2 Hz, 1H, ArH), 7.37-7.29 (m, 6H, ArH), 7.26-7.22 (m, 2H, ArH), 6.98-6.95 (m, 4H, ArH), 6.89 (d, *J* = 7.2 Hz, 2H, ArH), 6.72 (d, *J* = 8.0 Hz, 1H, ArH), 5.01 (d, *J* = 15.2 Hz, 1H, CH), 4.92 (d, *J* = 15.2 Hz, 1H, CH), 2.23 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 177.0, 151.0, 147.6, 143.3, 138.1, 137.1, 136.5, 135.7, 133.2, 131.1, 129.4, 128.9, 128.8, 128.7, 128.7, 128.3, 128.1, 127.9, 127.6, 127.3, 126.2, 125.2, 125.1, 124.9, 123.9, 123.8, 123.2, 121.3, 119.9, 115.0, 112.2, 109.4, 53.0, 44.6, 21.3; IR (KBr) υ: 3034, 2919, 1719, 1605, 1479, 1346, 1220, 1170, 1077, 1018, 932, 885, 820, 749 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{28}NO_2$ ([M+H]$^{+}$): 554.2115. Found: 554.2113.

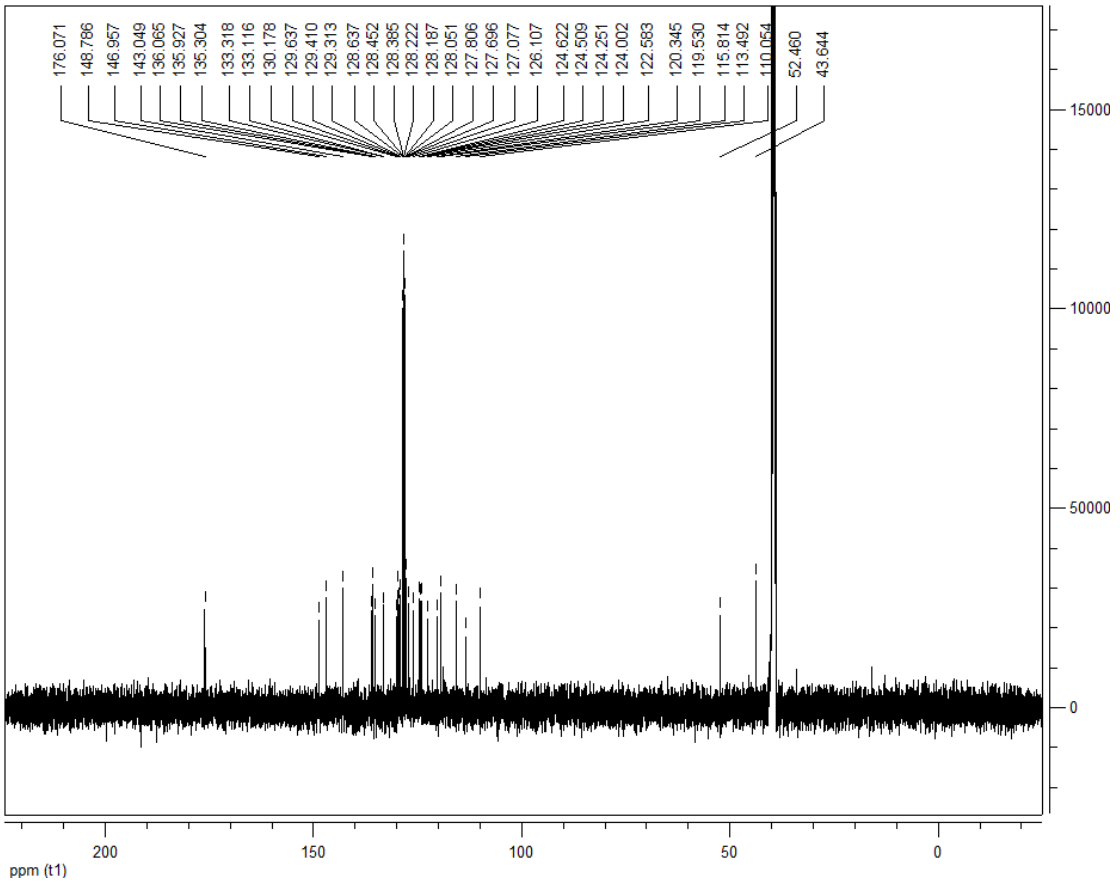


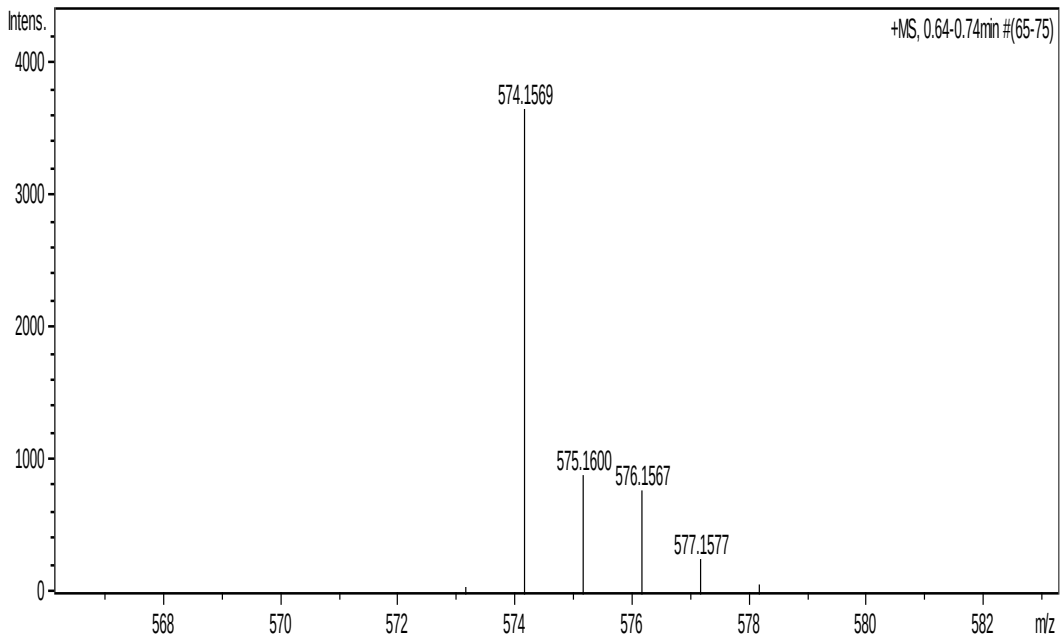

177.072
151.083
147.658
143.312
138.138
137.198
136.550
135.704
133.229
131.162
129.412
128.939
128.808
128.755
128.715
128.333
128.109
127.946
127.647
127.357
126.295
125.275
125.184
124.998
123.926
123.841
123.259
121.327
119.912
115.047
112.269
109.433
53.084
44.602
21.322
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 1.05-1.20min #(107-122)
554.2113
555.2152
556.2232
558.2067
1000
800
600
400
200
0
545.0
547.5
550.0
552.5
555.0
557.5
560.0
562.5
565.0
m/z

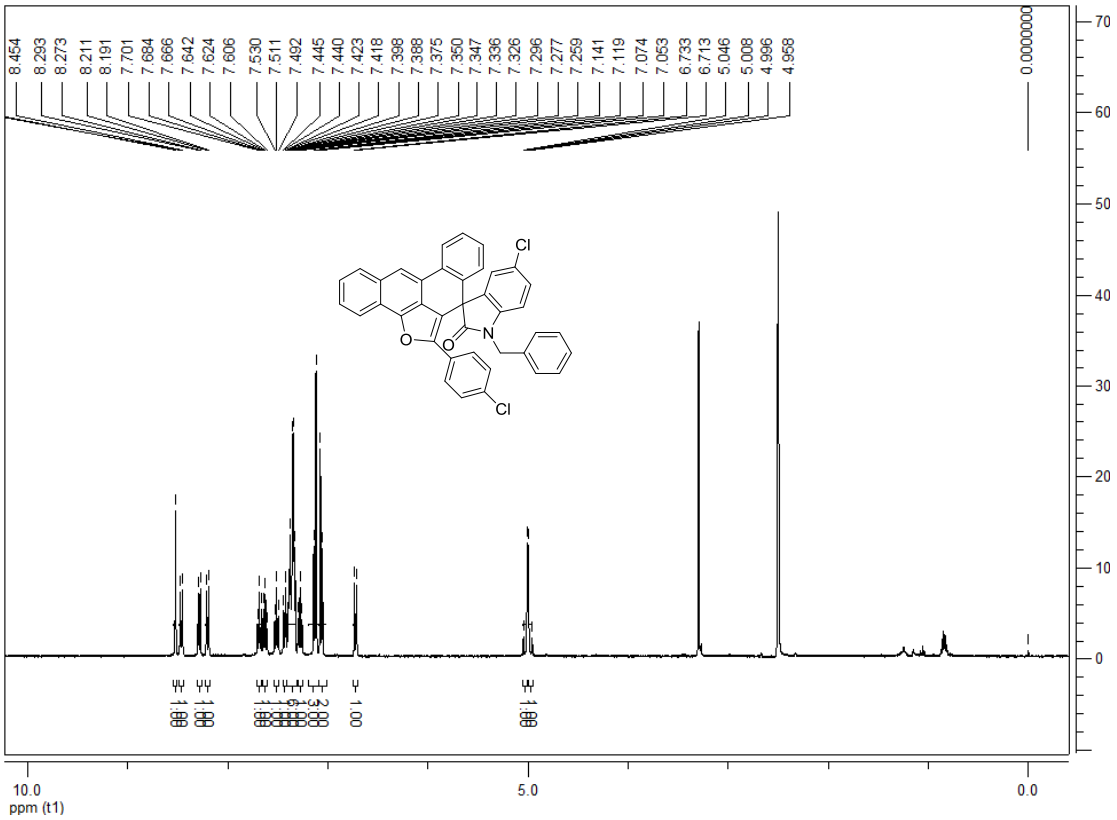
1-benzyl-6'-(4-chlorophenyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3b): Yellow solid, 84%, 0.240 g, m.p. 230-232℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.50 (s, 1H, ArH), 8.44 (d, *J* = 7.6 Hz, 1H, ArH), 8.28 (d, *J* = 8.0 Hz, 1H, ArH), 8.20 (d, *J* = 8.0 Hz, 1H, ArH), 7.68 (t, *J* = 7.2 Hz, 1H, ArH), 7.62 (t, *J* = 7.2 Hz, 1H, ArH), 7.49 (t, *J* = 7.2 Hz, 1H, ArH), 7.35-7.23 (m, 8H, ArH), 7.08 (d, *J* = 8.0 Hz, 2H, ArH), 7.01 (d, *J* = 8.0 Hz, 2H, ArH), 6.98-6.95 (m, 2H, ArH), 6.72 (d, *J* = 7.6 Hz, 1H, ArH), 5.00 (d, *J* = 16.4 Hz, 1H, CH), 4.96 (d, *J* = 16.0 Hz, 1H, CH); ^{13}C NMR (150 MHz, DMSO-d_6) δ: 176.0, 148.7, 146.9, 143.0, 136.0, 135.9, 135.3, 133.3, 133.1, 130.1, 129.6, 129.4, 129.3, 128.6, 128.4, 128.3, 128.2, 128.1, 128.0, 127.8, 127.6, 127.0, 126.1, 124.6, 124.5, 124.2, 124.0, 122.5, 120.3, 119.5, 115.8, 113.4, 110.0, 52.4, 43.6; IR (KBr) υ: 3060, 2893, 1717, 1602, 1479, 1343, 1223, 1170, 1083, 1011, 927, 885, 835, 750, 702 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for$C_{39}H_{25}ClNO_2$ ([M+H]$^+$): 574.1568. Found: 574.1569.

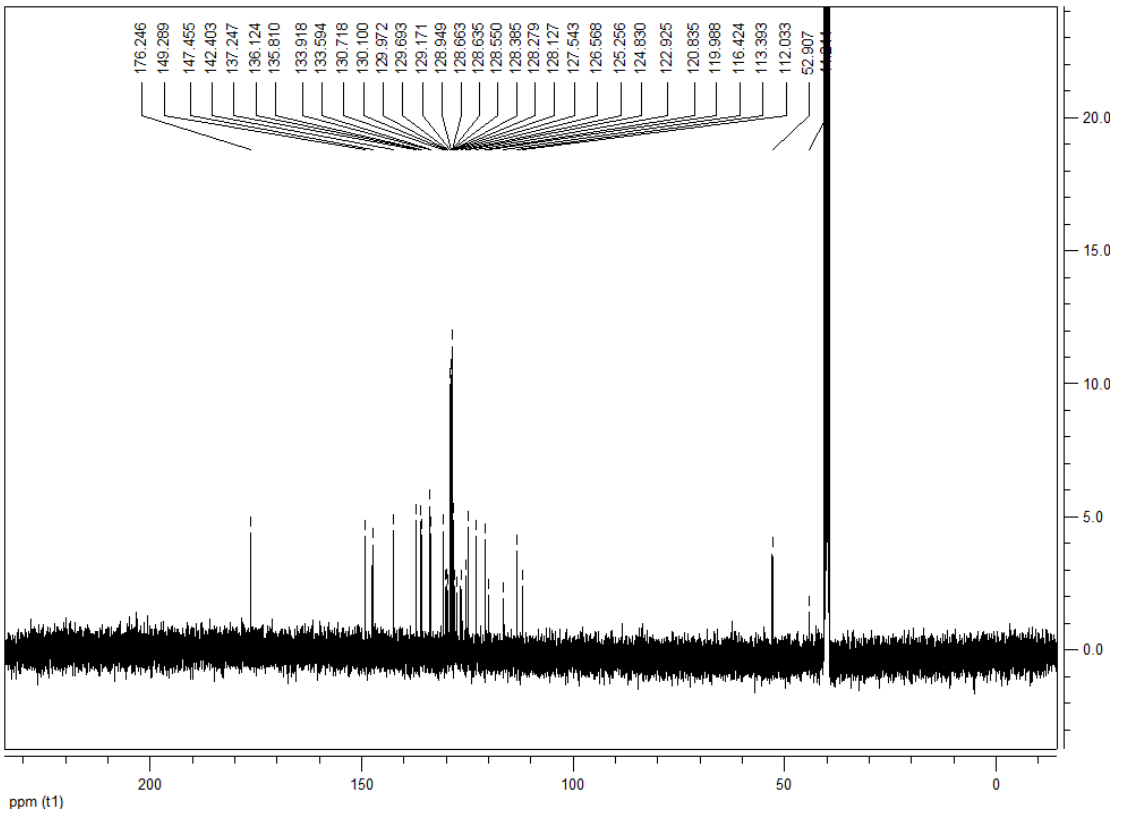


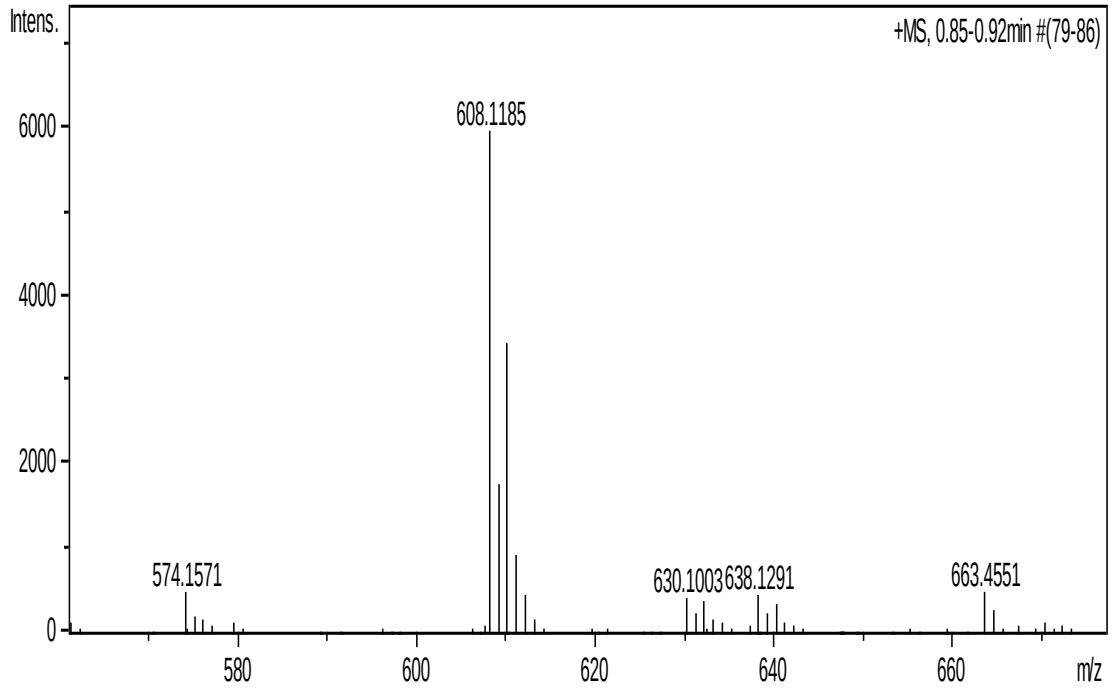

176.071
148.786
146.957
143.049
136.065
135.927
135.304
133.318
133.116
130.178
129.637
129.410
129.313
128.637
128.452
128.385
128.222
128.187
128.051
127.806
127.696
127.077
126.107
124.622
124.509
124.251
124.002
122.583
120.345
119.530
115.814
113.492
110.054
52.460
43.644
15000
10000
50000
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.64-0.74min #(65-75)
4000
3000
2000
1000
0
574.1569
575.1600
576.1567
577.1577
568
570
572
574
576
578
580
582
m/z

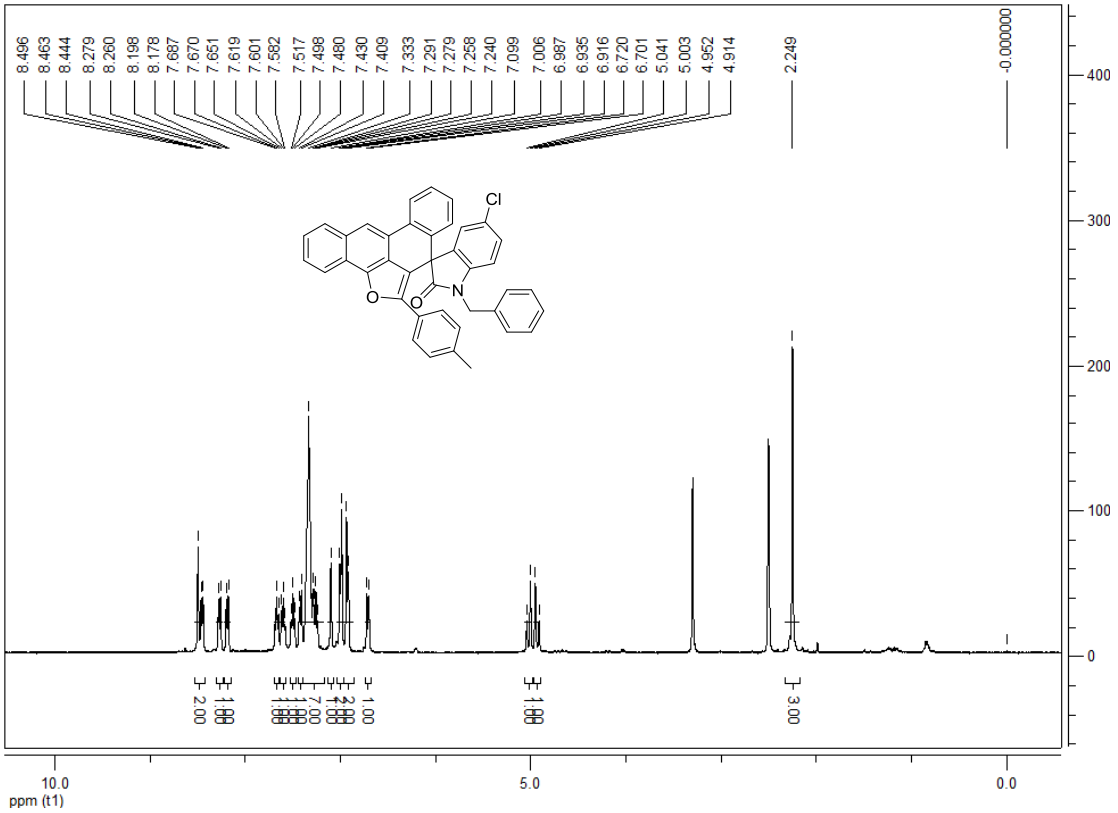
1-benzyl-5-chloro-6'-(4-chlorophenyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3c): Yellow solid, 80%, 0.243 g, m.p. 213-215℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.52 (s, 1H, ArH), 8.46 (d, *J* = 8.0 Hz, 1H, ArH), 8.28 (d, *J* = 8.0 Hz, 1H, ArH), 8.20 (d, *J* = 8.0 Hz, 1H, ArH), 7.68 (t, *J* = 7.2 Hz, 1H, ArH), 7.62 (t, *J* = 7.2 Hz, 1H, ArH), 7.51 (t, *J* = 7.6 Hz, 1H, ArH), 7.43 (dd, J_1 = 8.8 Hz, J_2= 2.0 Hz, 1H, ArH), 7.40-7.33 (m, 6H, ArH), 7.28 (t, *J* = 7.2 Hz, 1H, ArH), 7.14-7.12 (m, 3H, ArH), 7.06 (d, *J* = 8.4 Hz, 2H, ArH), 6.72 (d, *J* = 8.0 Hz, 1H, ArH), 5.03 (d, *J* = 15.2 Hz, 1H, CH), 4.98 (d, *J* = 15.2 Hz, 1H, CH); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 176.2, 149.2, 147.4, 142.4, 137.2, 136.1, 135.8, 133.9, 133.5, 130.7, 130.0, 129.9, 129.6, 129.1, 128.9, 128.7, 128.6, 128.5, 128.3, 128.2, 128.1, 127.5, 126.5, 125.2, 124.8, 122.9, 120.8, 119.9, 116.4, 113.3, 112.0, 52.9, 44.2; IR (KBr) υ: 3060, 2927, 1719, 1599, 1480, 1426, 1329, 1248, 1167, 1081, 1010, 863, 824, 750, 695 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{39}H_{24}Cl_2NO_2$ ([M+H]$^+$): 608.1179. Found: 608.1185.

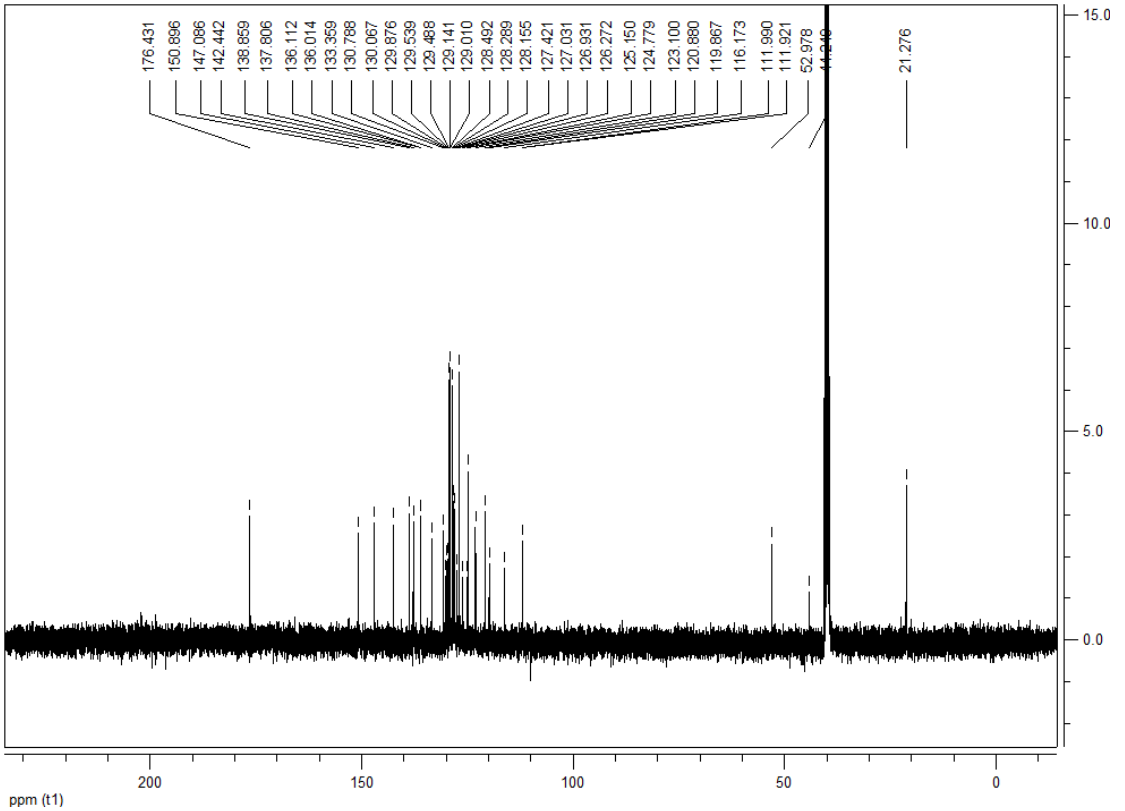


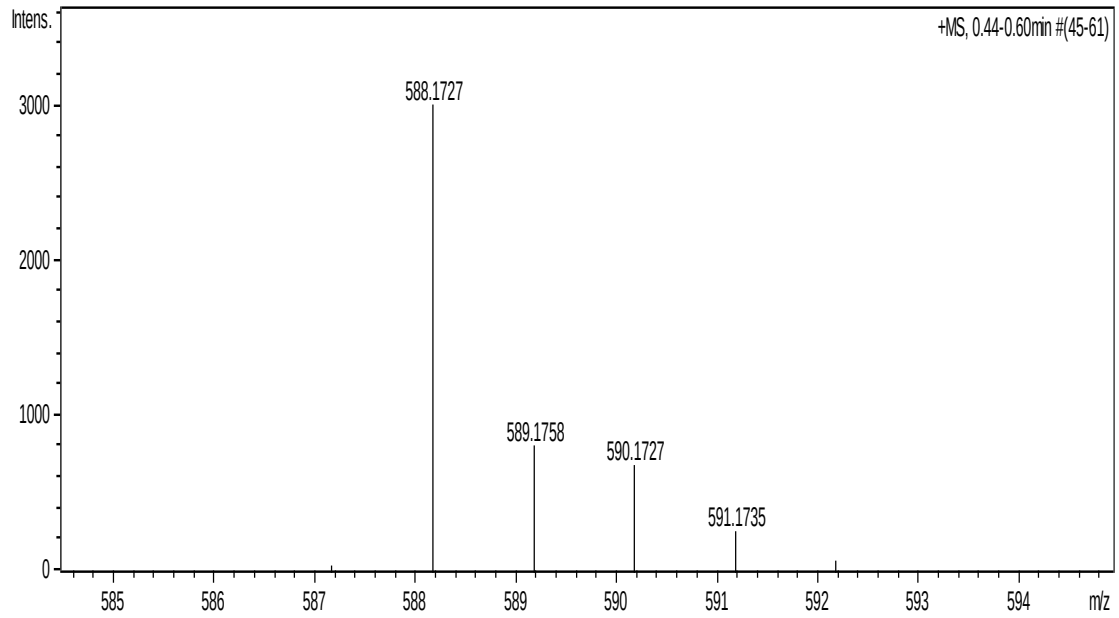

176.246
149.289
147.455
142.403
137.247
136.124
135.810
133.918
133.594
130.718
130.100
129.972
129.693
129.171
128.949
128.663
128.635
128.550
128.385
128.279
128.127
127.543
126.568
125.256
124.830
122.925
120.835
119.988
116.424
113.393
112.033
52.907
20.0
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.85-0.92min #(79-86)
608.1185
6000
4000
2000
0
574.1571
630.1003
638.1291
663.4551
580
600
620
640
660
m/z

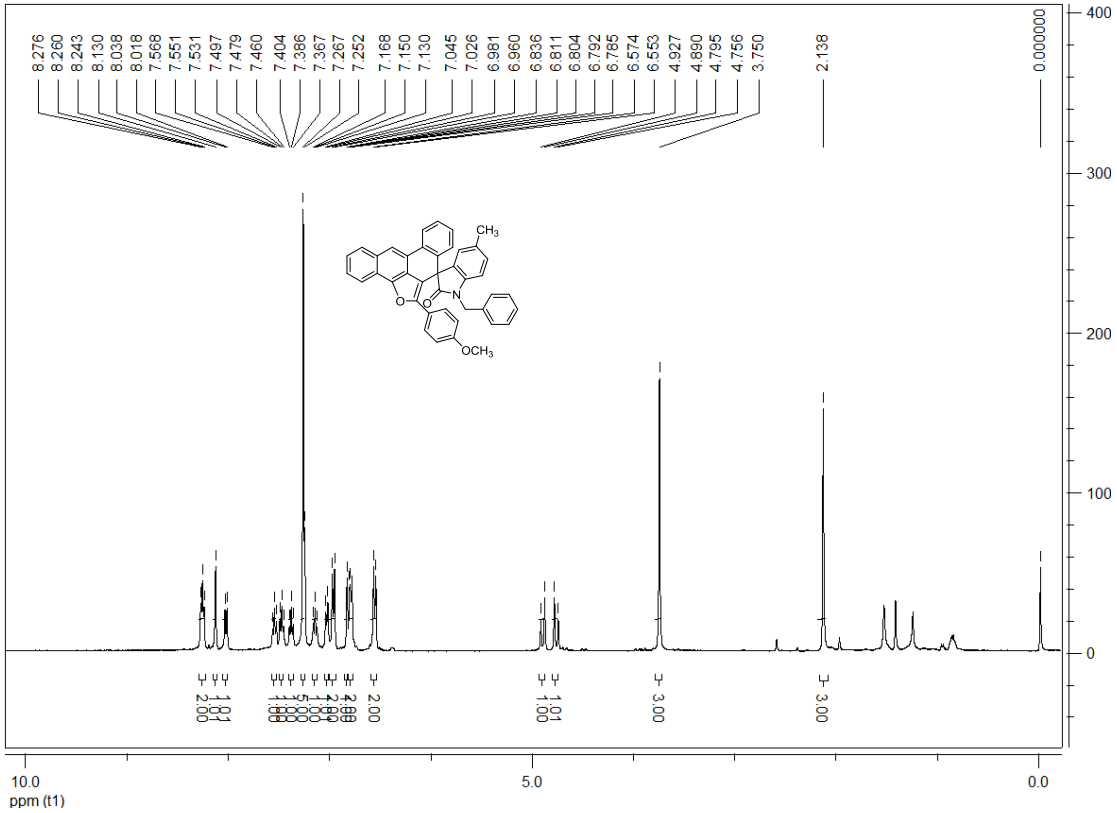
1-benzyl-5-chloro-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3d): Yellow solid, 76%, 0.223 g, m.p. 212-214℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.50 (s, 1H, ArH), 8.45 (d, *J* = 7.6 Hz, 1H, ArH), 8.27 (d, *J* = 7.6 Hz, 1H, ArH), 8.18 (d, *J* = 8.0 Hz, 1H, ArH), 7.67 (t, *J* = 7.2 Hz, 1H, ArH), 7.60 (t, *J* = 7.2 Hz, 1H, ArH), 7.50 (t, *J* = 7.2 Hz, 1H, ArH), 7.42 (d, *J* = 8.4 Hz, 1H, ArH), 7.33-7.24 (m, 7H, ArH), 7.10 (brs, 1H, ArH), 6.99 (d, *J* = 7.6 Hz, 2H, ArH), 6.93 (d, *J* = 7.6 Hz, 2H, ArH), 6.71 (d, *J* = 7.6 Hz, 1H, ArH), 5.02 (d, *J* = 15.6 Hz, 1H, CH), 4.93 (d, *J* = 15.2 Hz, 1H, CH), 2.25 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 176.4, 150.8, 147.0, 142.4, 138.8, 137.8, 136.1, 136.0, 133.3, 130.7, 130.0, 129.8, 129.5, 129.4, 129.1, 129.0, 128.4, 128.2, 128.1, 127.4, 127.0, 126.9, 126.2, 125.1, 124.7, 123.0, 120.8, 119.8, 116.1, 112.0, 111.9, 52.9, 44.2, 21.2; IR (KBr) υ: 3057, 2919, 1719, 1605, 1483, 1426, 1369, 1329, 1255, 1168, 1073, 1016, 865, 819, 751, 696 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for$C_{40}H_{27}ClNO_2$ ([M+H]$^+$): 588.1725. Found: 588.1727.

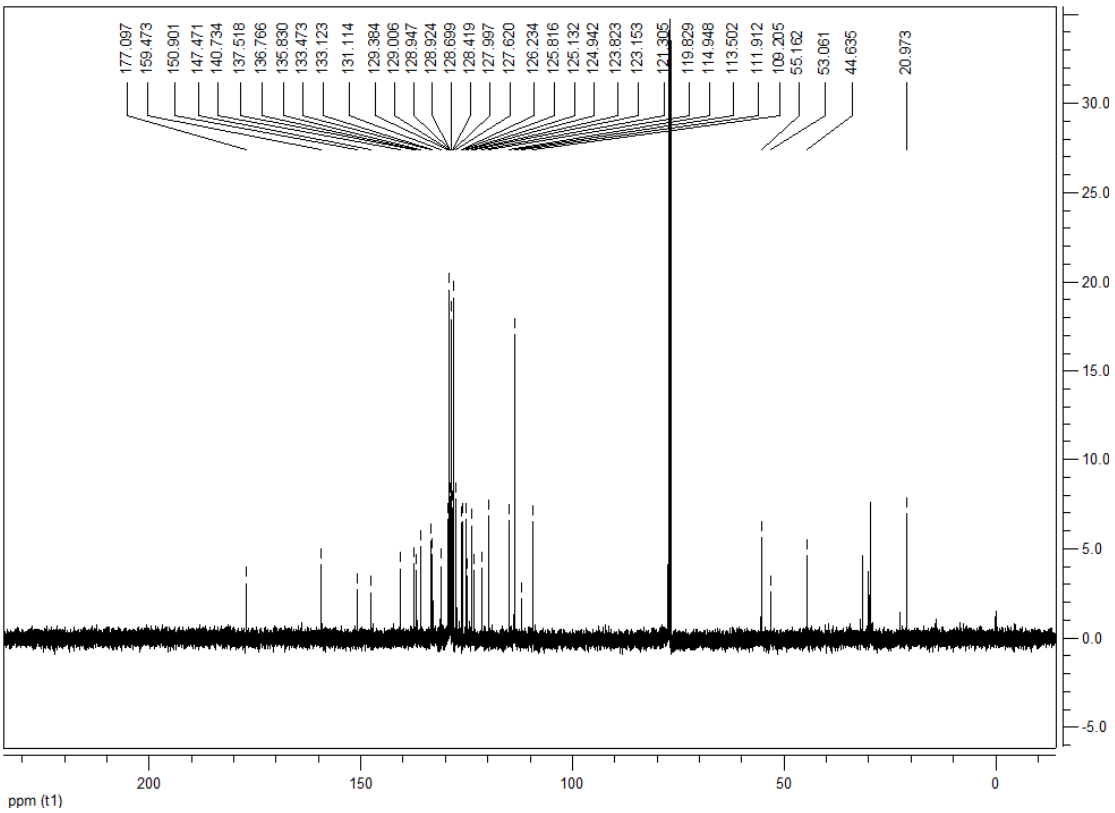


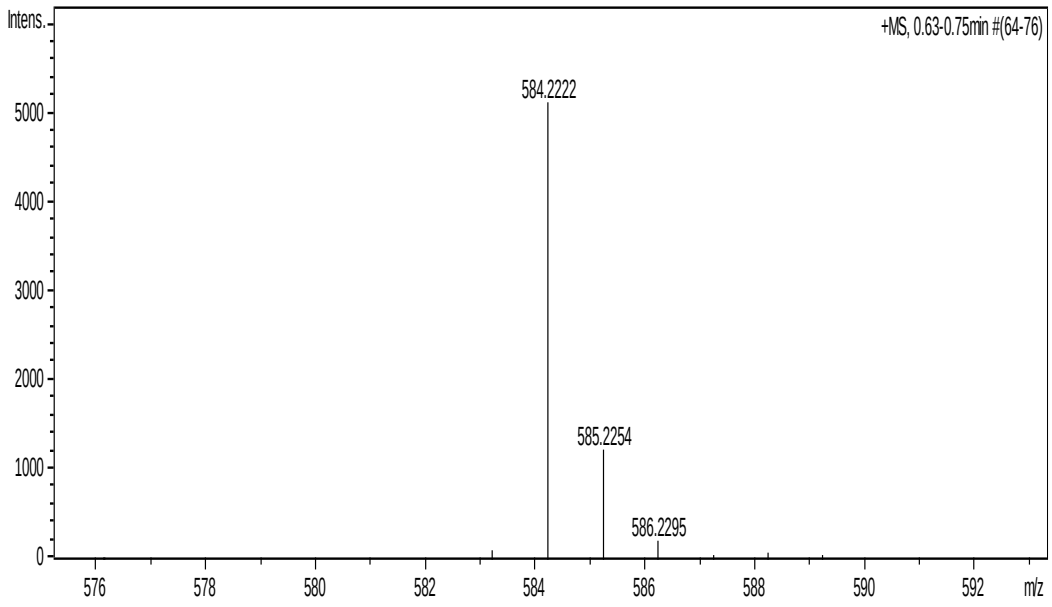

176.431
150.896
147.086
142.442
138.859
137.806
136.112
136.014
133.359
130.788
130.067
129.876
129.539
129.488
129.141
129.010
128.492
128.289
128.155
127.421
127.031
126.931
126.272
125.150
124.779
123.100
120.880
119.867
116.173
111.990
111.921
52.978
21.276
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.44-0.60min #(45-61)
588.1727
589.1758
590.1727
591.1735
3000
2000
1000
0
585
586
587
588
589
590
591
592
593
594
m/z

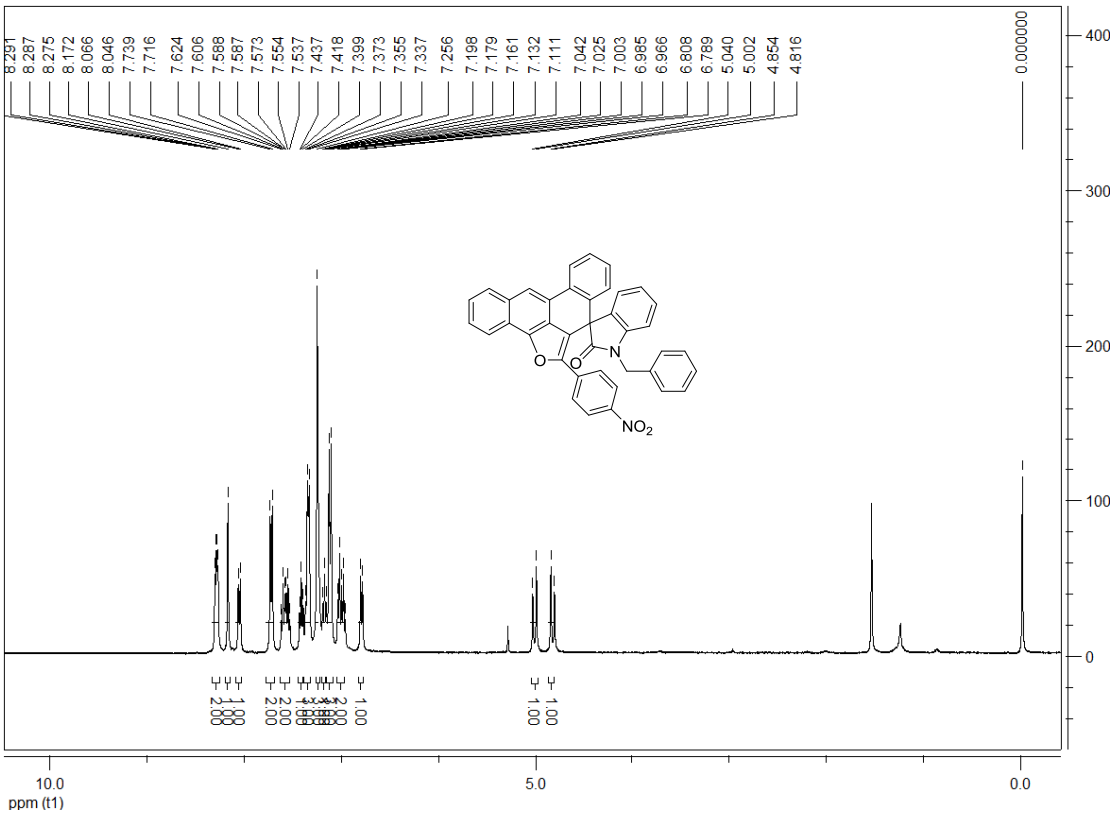
1-benzyl-6'-(4-methoxyphenyl)-5-methylspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3e): Yellow solid, 76%, 0.221 g, m.p. 223-225℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.28-8.24 (m, 2H, ArH), 8.13 (s, 1H, ArH), 8.03 (d, *J* = 8.0 Hz, 1H, ArH), 7.55 (t, *J* = 7.6 Hz, 1H, ArH), 7.45 (t, *J* = 7.6 Hz, 1H, ArH), 7.39 (t, *J* = 7.6 Hz, 1H, ArH), 7.27-7.25 (m, 5H, ArH), 7.15 (t, *J* = 7.6 Hz, 1H, ArH), 7.04 (d, *J* = 7.6 Hz, 1H, ArH), 6.97 (d, *J* = 7.6 Hz, 2H, ArH), 6.84 (s, 1H, ArH), 6.81-6.79 (m, 2H, ArH), 6.56 (d, *J* = 8.4 Hz, 2H, ArH), 4.91 (d, *J* = 14.8 Hz, 1H, CH), 4.78 (d, *J* = 15.6 Hz, 1H, CH), 3.75 (s, 3H, OCH_3), 2.14 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 177.0, 159.4, 150.9, 147.4, 140.7, 137.5, 136.7, 135.8, 133.4, 133.1, 131.1, 129.3, 129.0, 128.9, 128.9, 128.6, 128.4, 127.9, 127.6, 126.2, 125.8, 125.1, 124.9, 123.8, 123.1, 121.3, 119.8, 114.9, 113.5, 111.9, 109.2, 55.1, 53.0, 44.6, 20.9; IR (KBr) υ: 3057, 2922, 2853, 1718, 1605, 1497, 1448, 1371, 1333, 1250, 1177, 1076, 1027, 963, 884, 834, 753, 696 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. For $C_{41}H_{30}NO_3$ ($[M+H]^+$): 584.2226. Found: 584.2222.

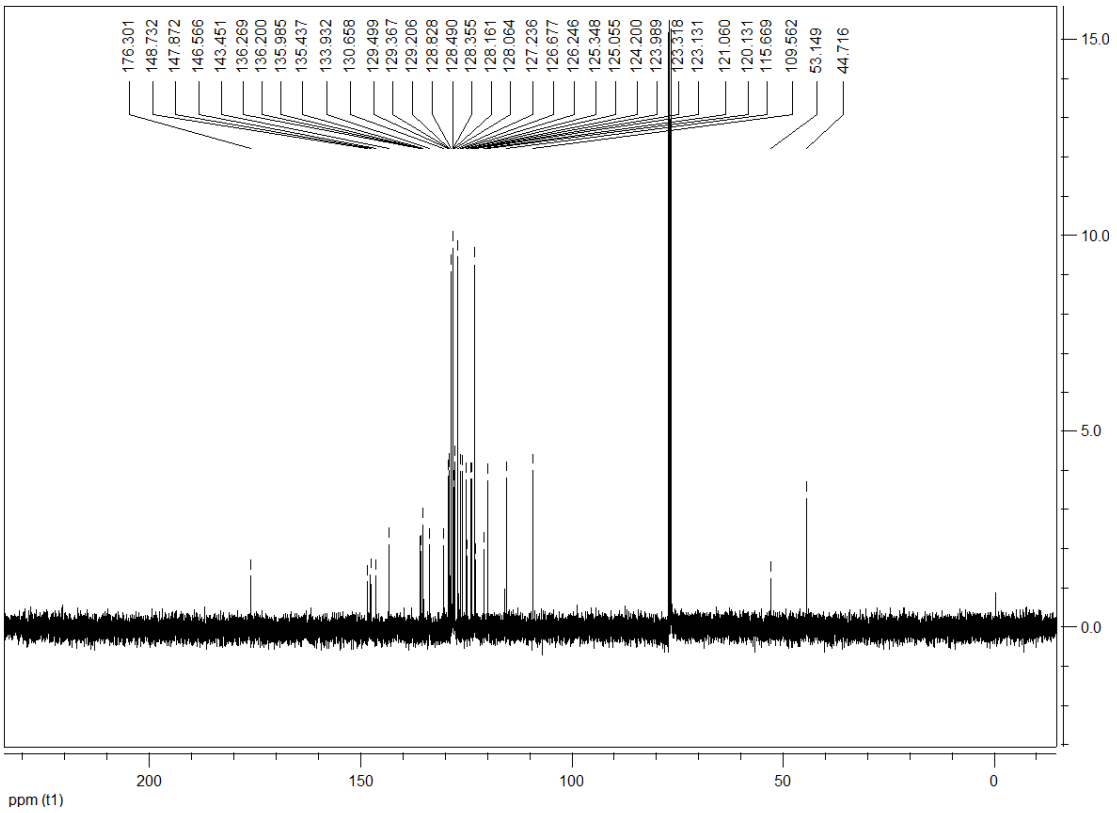


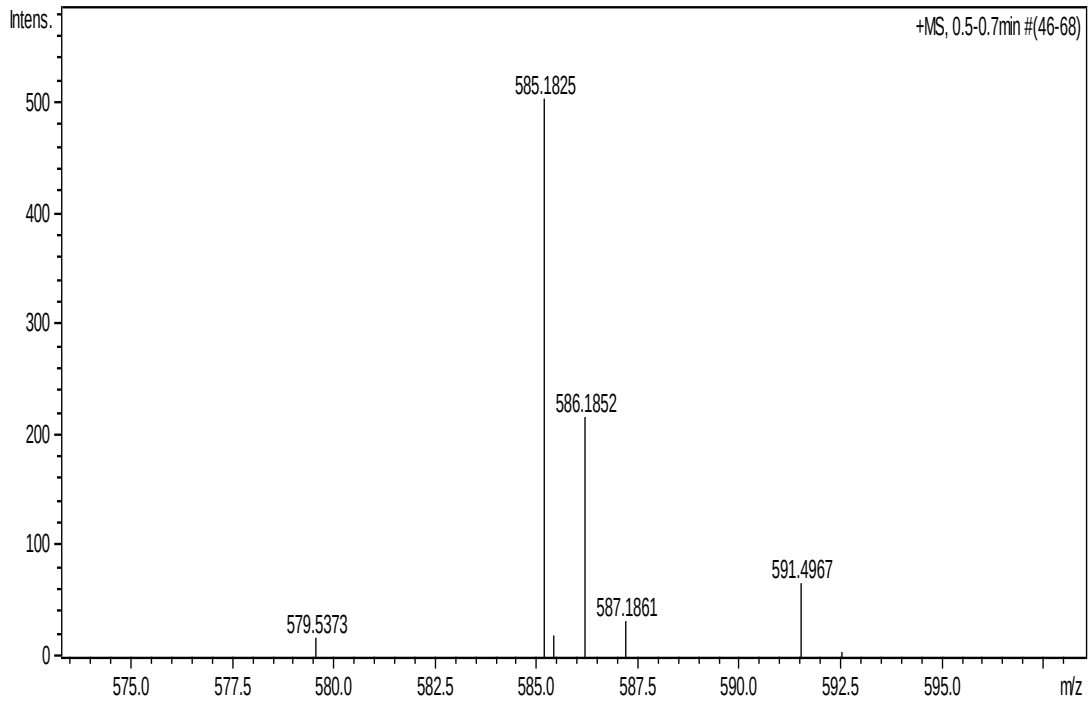

177.097
159.473
150.901
147.471
140.734
137.518
136.766
135.830
133.473
133.123
131.114
129.384
129.006
128.947
128.924
128.699
128.419
127.997
127.620
126.234
125.816
125.132
124.942
123.823
123.153
121.305
119.829
114.948
113.502
111.912
109.205
55.162
53.061
44.635
20.973
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.63-0.75min #(64-76)
584.2222
585.2254
586.2295
5000
4000
3000
2000
1000
0
576
578
580
582
584
586
588
590
592
m/z

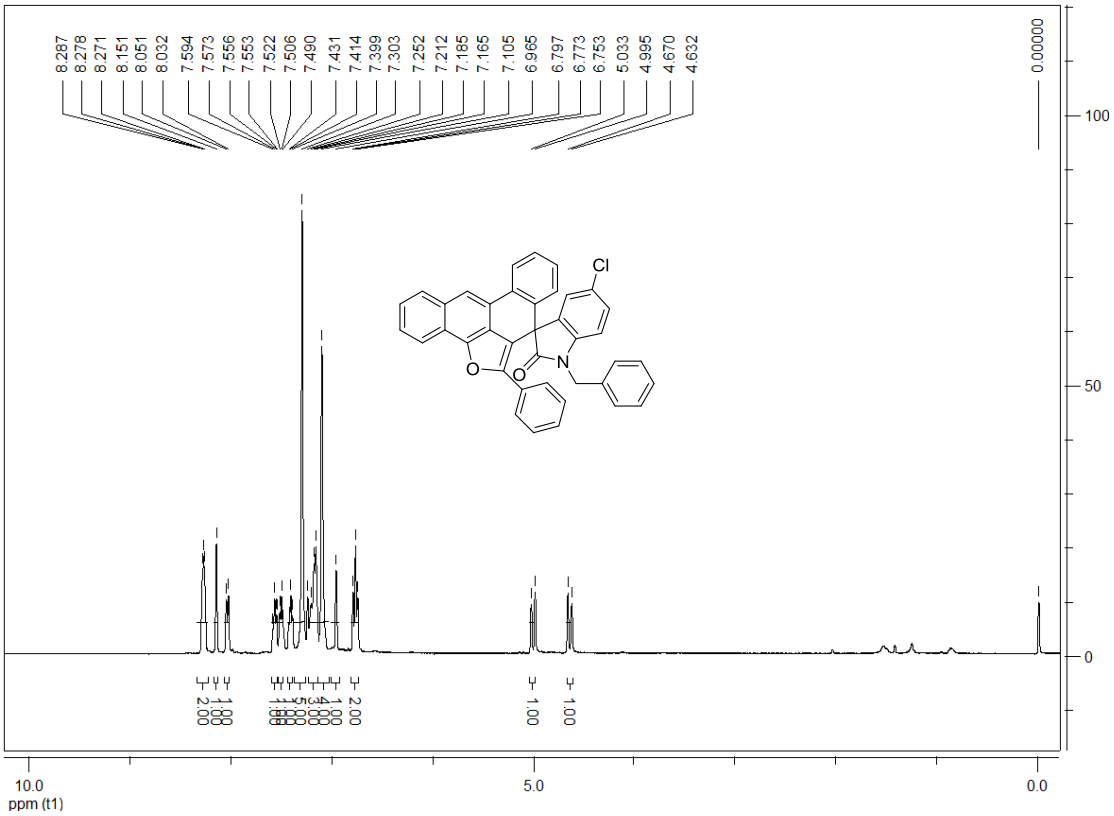
1-benzyl-6'-(4-nitrophenyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3f): light yellow solid, 90%, 0.262 g, m.p. over 300℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.30-8.28 (m, 2H, ArH), 8.17 (s, 1H, ArH), 8.06 (d, *J* = 8.0 Hz, 1H, ArH), 7.74-7.72 (m, 2H, ArH), 7.62-7.54 (m, 2H, ArH), 7.42 (t, *J* = 7.6 Hz, 1H, ArH), 7.37-7.34 (m, 3H, ArH), 7.26 (brs, 3H, ArH), 7.18 (t, *J* = 7.6 Hz, 1H, ArH), 7.13-7.11 (m, 3H, ArH), 7.04-6.97 (m, 2H, ArH), 6.80 (d, *J* = 7.6 Hz, 1H, ArH), 5.02 (d, *J* = 15.2 Hz, 1H, CH), 4.84 (d, *J* = 15.2 Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.3, 148.7, 147.8, 146.5, 143.4, 136.2, 136.1, 135.9, 135.4, 133.9, 130.6, 129.4, 129.3, 129.2, 128.8, 128.4, 128.3, 128.1, 128.0, 127.2, 126.6, 126.2, 125.3, 125.0, 124.1, 123.9, 123.3, 123.1, 121.0, 120.1, 115.6, 109.5, 53.1, 44.7; IR (KBr) υ: 3057, 3029, 2927, 1719, 1600, 1514, 1488, 1465, 1338, 1218, 1169, 1107, 1080, 924, 889, 852, 786, 749 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{39}H_{25}N_2O_4$ ([M+H]$^+$): 585.1814. Found: 585.1825.

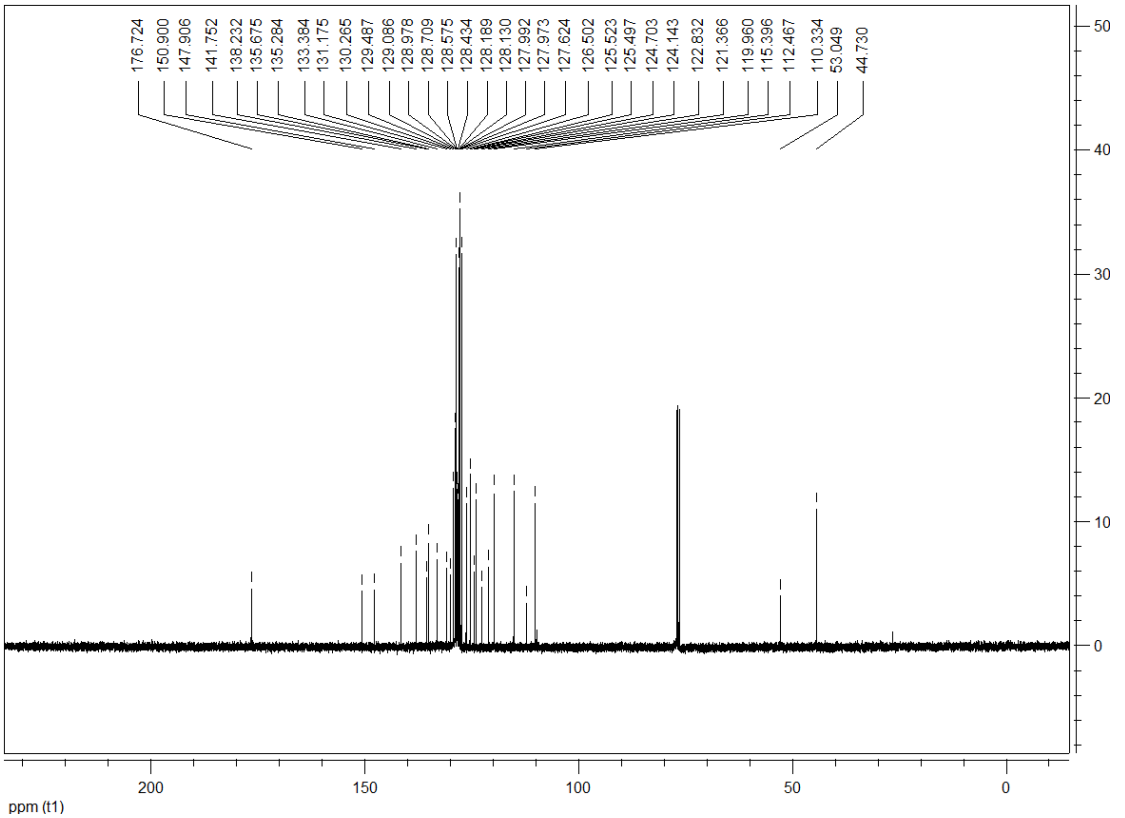


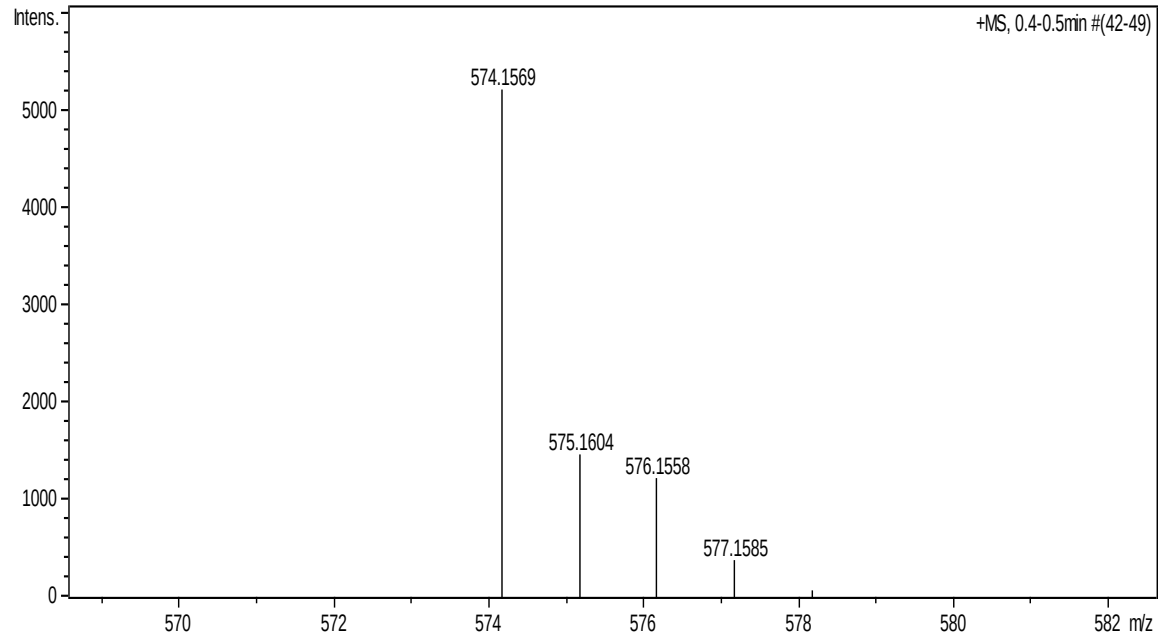

176.301
148.732
147.872
146.566
143.451
136.269
136.200
135.985
135.437
133.932
130.658
129.499
129.367
129.206
128.828
128.490
128.355
128.161
128.064
127.236
126.677
126.246
125.348
125.055
124.200
123.989
123.318
123.131
121.060
120.131
115.669
109.562
53.149
44.716
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.5-0.7min #(46-68)
585.1825
586.1852
591.4967
587.1861
579.5373
500
400
300
200
100
0
575.0
577.5
580.0
582.5
585.0
587.5
590.0
592.5
595.0
m/z

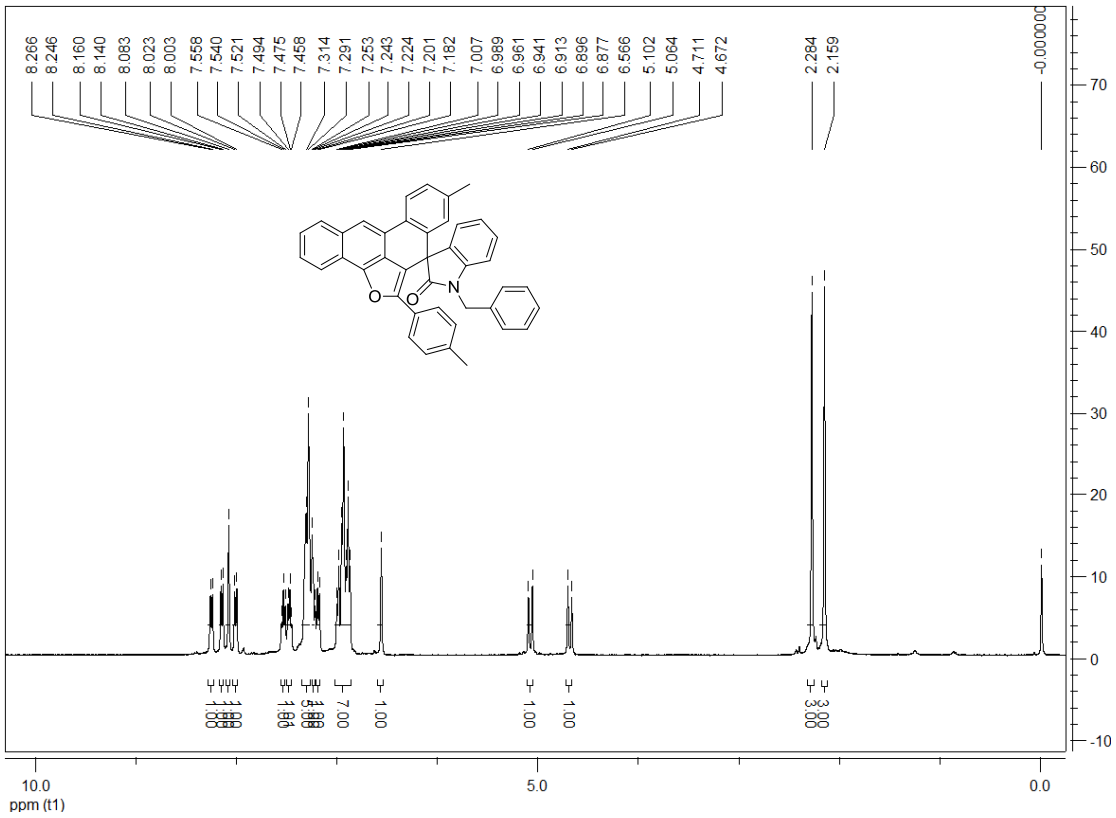
1-benzyl-5-chloro-6'-phenylspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3g): yellow solid, 91%, 0.260 g, m.p. 236-238℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.29-8.27 (m, 2H, ArH), 8.15 (s, 1H, ArH), 8.04 (d, *J* = 7.6 Hz, 1H, ArH), 7.59-7.57 (m, 1H, ArH), 7.52-7.49 (m, 1H, ArH), 7.43-7.40 (m, 1H, ArH), 7.30 (brs, 5H, ArH), 7.21-7.17 (m, 3H, ArH), 7.11 (brs, 4H, ArH), 6.97 (brs, 1H, ArH), 6.80-6.75 (m, 2H, ArH), 5.01 (d, *J* = 15.2 Hz, 1H, CH), 4.65 (d, *J* = 15.6 Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.7, 150.8, 147.9, 141.7, 138.2, 135.6, 135.2, 133.3, 131.1, 130.2, 129.4, 129.0, 128.9, 128.7, 128.5, 128.4, 128.2, 128.1, 128.0, 127.9, 127.6, 126.5, 125.5, 125.4, 124.7, 124.1, 122.8, 121.3, 119.9, 115.3, 112.4, 110.3, 53.0, 44.7; IR (KBr) υ: 3057, 3029, 2928, 1719, 1604, 1481, 1446, 1423, 1368, 1322, 1269, 1219, 1164, 1116, 1067, 1021, 964, 919, 898, 871, 848, 806, 784, 764, 745 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{39}H_{25}ClNO_2$ ($[M+H]^+$): 574.1574. Found: 574.1569.

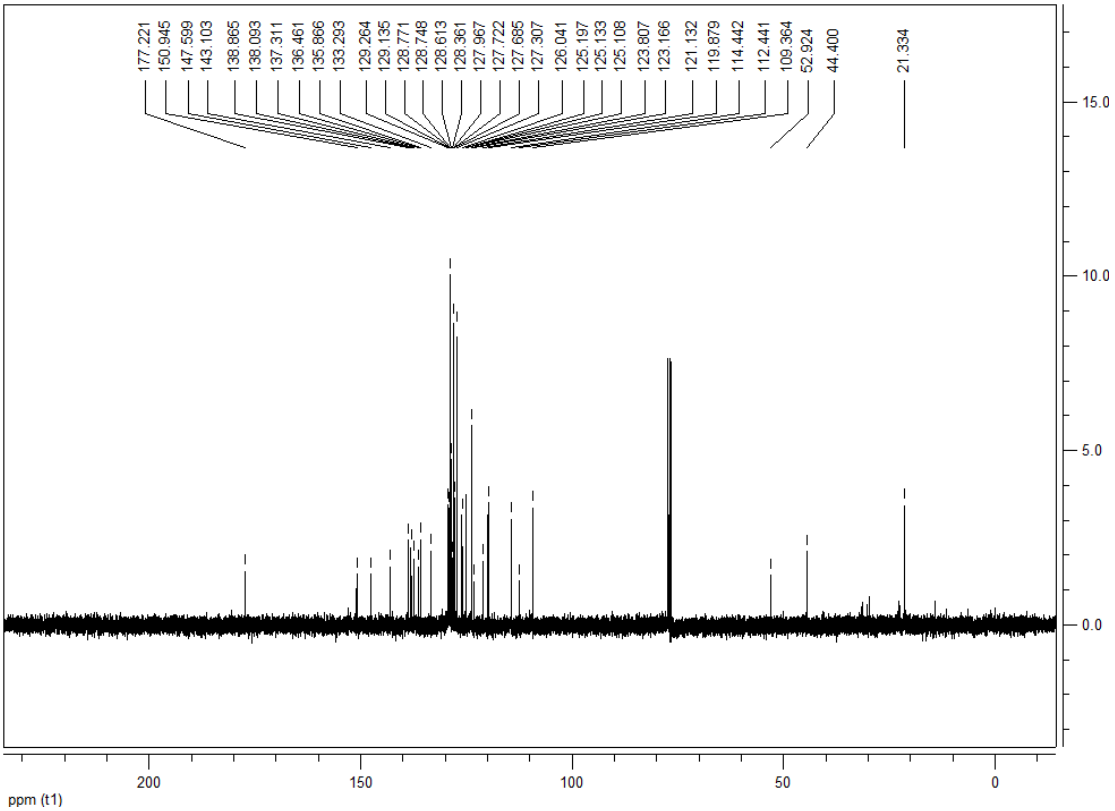


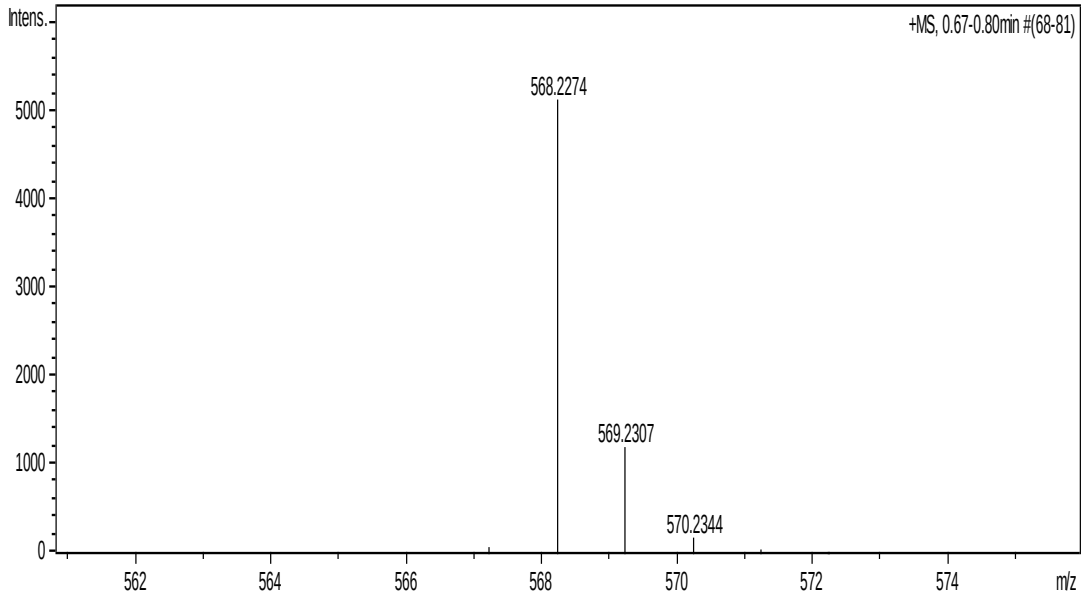

176.724
150.900
147.906
141.752
138.232
135.675
135.284
133.384
131.175
130.265
129.487
129.086
128.978
128.709
128.575
128.434
128.189
128.130
127.992
127.973
127.624
126.502
125.523
125.497
124.703
124.143
122.832
121.366
119.960
115.396
112.467
110.334
53.049
44.730
50
40
30
20
10
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.4-0.5min #(42-49)
574.1569
575.1604
576.1558
577.1585
5000
4000
3000
2000
1000
0
570
572
574
576
578
580
582 m/z

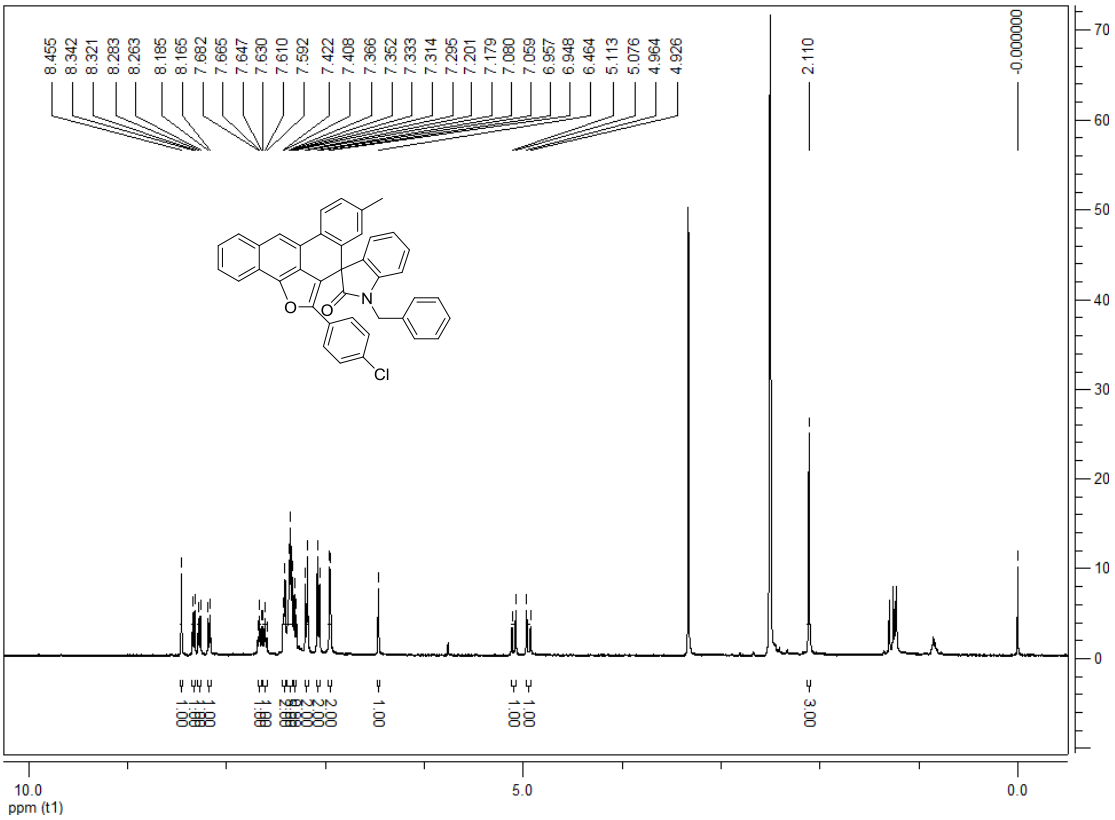
1-benzyl-9'-methyl-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3h): Yellow solid, 82%, 0.233 g, m.p. 216-218℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.26 (d, *J* = 8.0 Hz, 1H, ArH), 8.15 (d, *J* = 8.0 Hz, 1H, ArH), 8.08 (s, 1H, ArH), 8.01 (d, *J* = 8.0 Hz, 1H, ArH), 7.54 (t, *J* = 7.6 Hz, 1H, ArH), 7.48 (t, *J* = 7.6 Hz, 1H, ArH), 7.31-7.29 (m, 5H, ArH), 7.23 (d, *J* = 7.6 Hz, 1H, ArH), 7.19 (d, *J* = 7.6 Hz, 1H, ArH), 7.01-6.88 (m, 7H, ArH), 6.57 (s, 1H, ArH), 5.08 (d, *J* = 15.2 Hz, 1H, CH), 4.69 (d, *J* = 15.6 Hz, 1H, CH), 2.28 (s, 3H, CH_3), 2.16 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 177.2, 150.9, 147.5, 143.1, 138.8, 138.0, 137.3, 136.4, 135.8, 133.2, 129.2, 129.1, 128.8, 128.7, 128.6, 128.3, 127.9, 127.7, 127.6, 127.3, 126.0, 125.1, 125.1, 125.1, 123.8, 123.1, 121.1, 119.8, 114.4, 112.4, 109.3, 52.9, 44.4, 21.3; IR (KBr) υ: 3036, 2916, 1717, 1605, 1494, 1456, 1422, 1348, 1224, 1172, 1075, 1018, 961, 901, 820, 742, 694 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for$C_{41}H_{30}NO_2$ ($[M+H]^+$): 568.2271. Found: 568.2274.

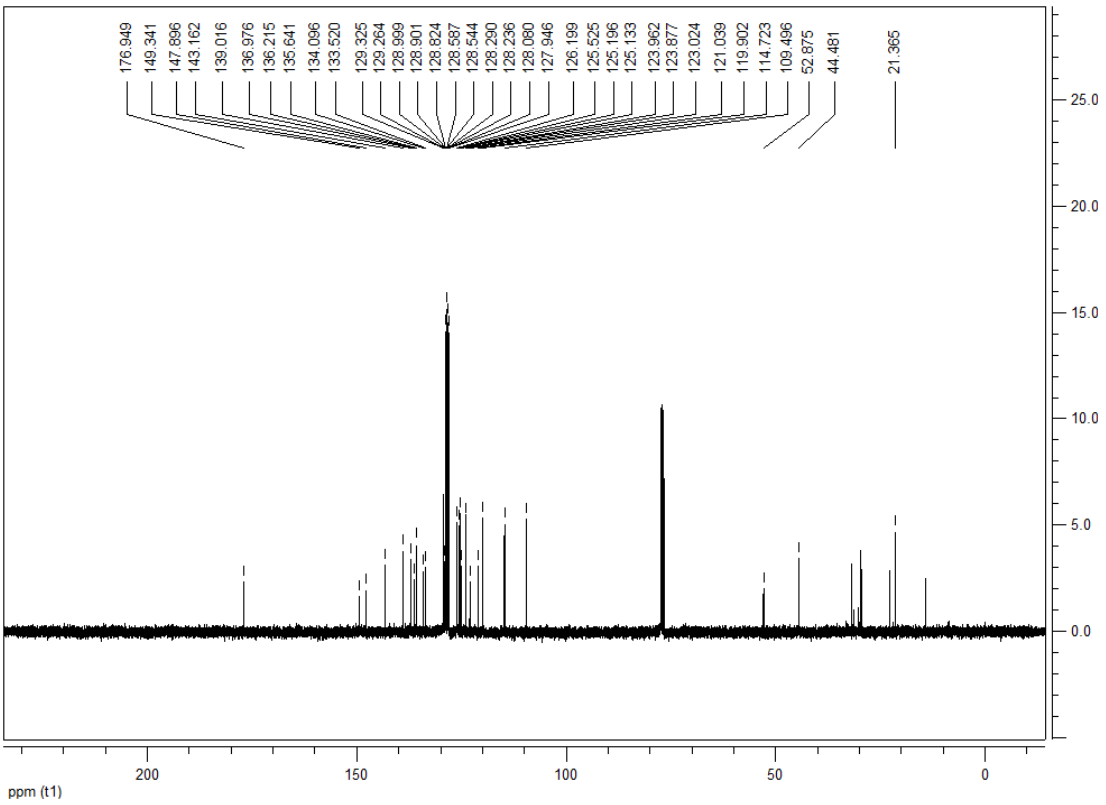


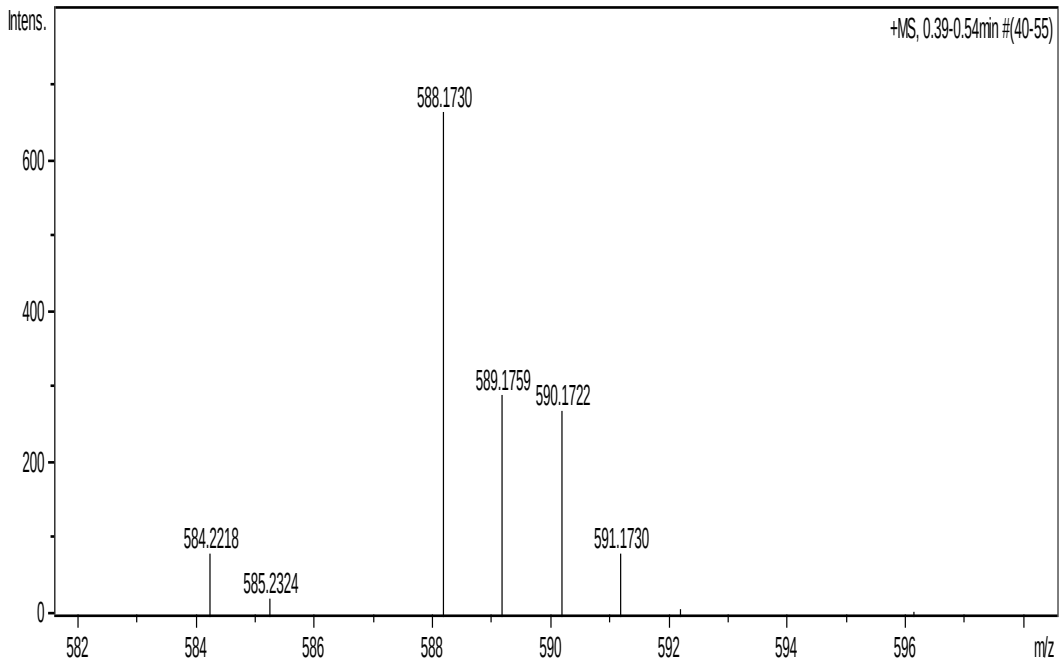

177.221
150.945
147.599
143.103
138.865
138.093
137.311
136.461
135.866
133.293
129.264
129.135
128.771
128.748
128.613
128.361
127.967
127.722
127.685
127.307
126.041
125.197
125.133
125.108
123.807
123.166
121.132
119.879
114.442
112.441
109.364
52.924
44.400
21.334
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.67-0.80min #(68-81)
568.2274
569.2307
570.2344
5000
4000
3000
2000
1000
0
562
564
566
568
570
572
574
m/z

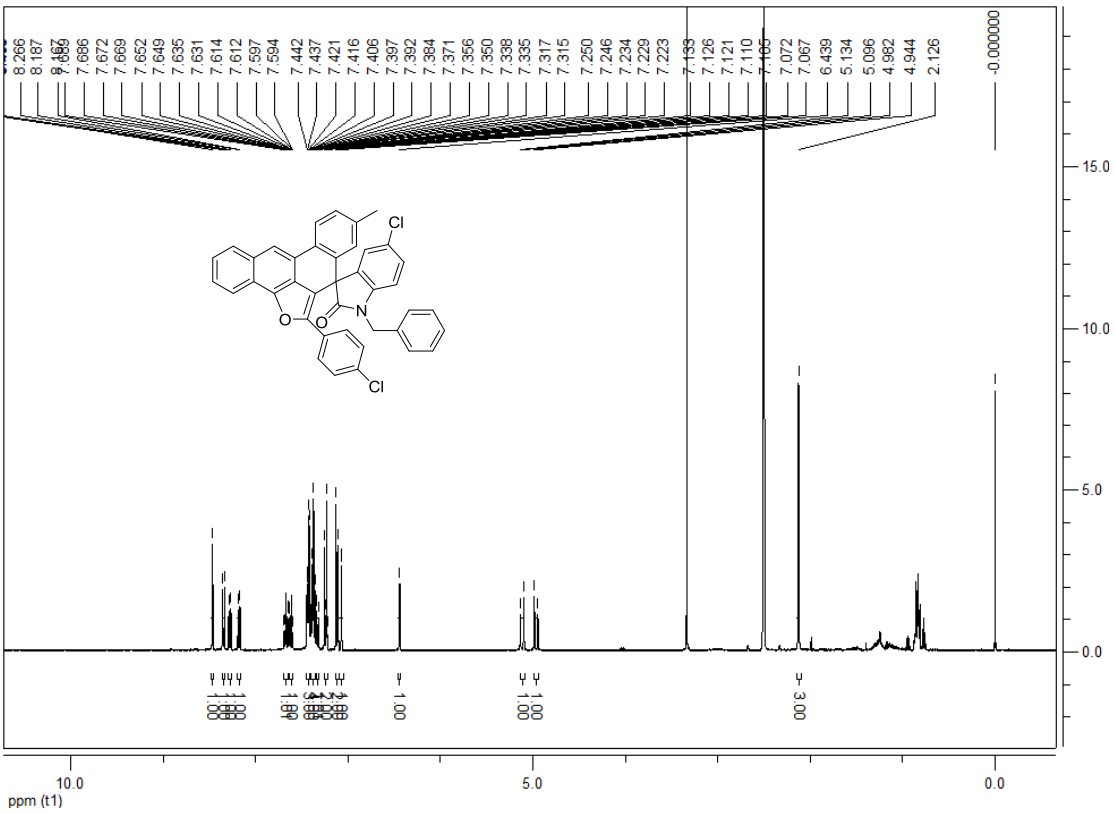
1-benzyl-6'-(4-chlorophenyl)-9'-methylspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3i): Yellow solid, 87%, 0.255 g, m.p. 268-270℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.46 (s, 1H, ArH), 8.33 (d, *J* = 8.4 Hz, 1H, ArH), 8.27 (d, *J* = 8.0 Hz, 1H, ArH), 8.18 (d, *J* = 8.0 Hz, 1H, ArH), 7.67 (t, *J* = 7.2 Hz, 1H, ArH), 7.61 (t, *J* = 7.6 Hz, 1H, ArH), 7.42-7.41 (m, 2H, ArH), 7.37-7.33 (m, 5H, ArH), 7.30 (d, *J* = 7.6 Hz, 1H, ArH), 7.19 (d, *J* = 8.8 Hz, 2H, ArH), 7.07 (d, *J* = 8.4 Hz, 2H, ArH), 6.95 (d, *J* = 3.6 Hz, 2H, ArH), 6.46 (brs, 1H, ArH), 5.09 (d, *J* = 14.8 Hz, 1H, CH), 4.94 (d, *J* = 15.2 Hz, 1H, CH), 2.11 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.9, 149.3, 147.8, 143.1, 139.0, 136.9, 136.2, 135.6, 134.0, 133.5, 129.3, 129.2, 128.9, 128.9, 128.8, 128.5, 128.5, 128.2, 128.2, 128.0, 127.9, 126.1, 125.5, 125.2, 125.1, 123.9, 123.8, 123.0, 121.0, 119.9, 114.7, 109.4, 52.8, 44.4, 21.3; IR (KBr) υ: 3029, 2919, 2852, 1717, 1605, 1477, 1369, 1342, 1221, 1166, 1083, 1014, 962, 909, 826, 749, 705 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for$C_{40}H_{27}ClNO_2$ ([M+H]$^+$): 588.1725. Found: 588.173.

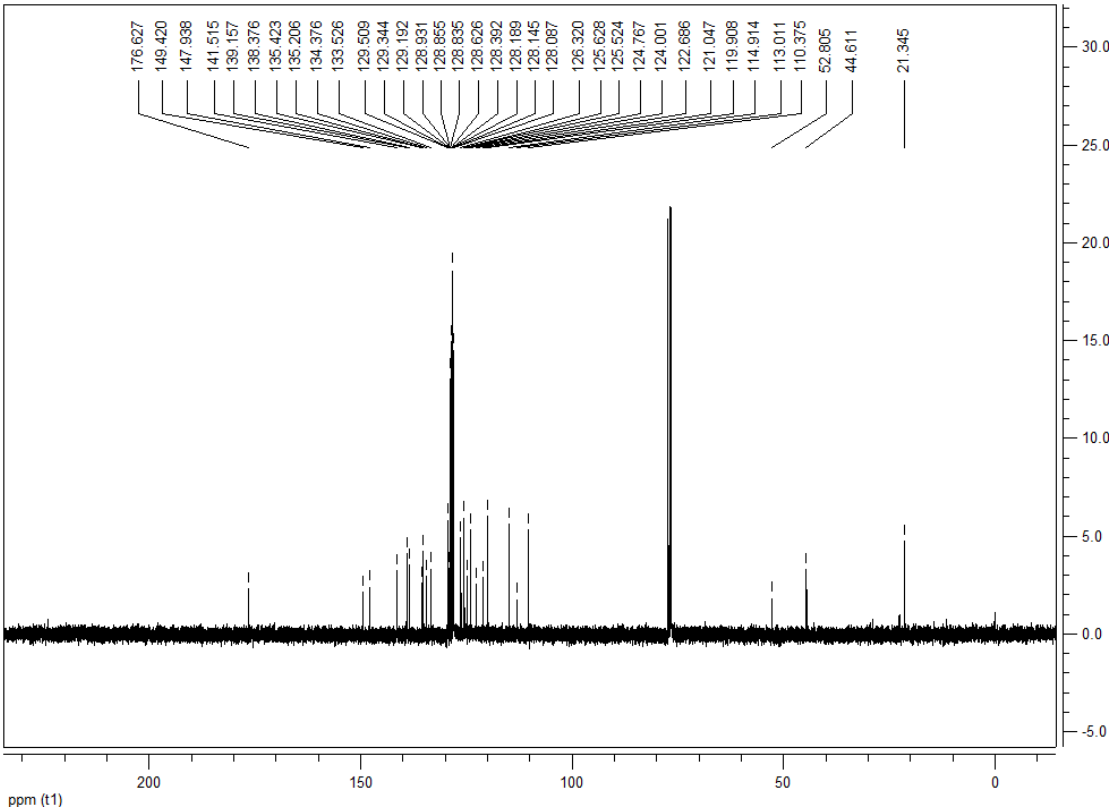


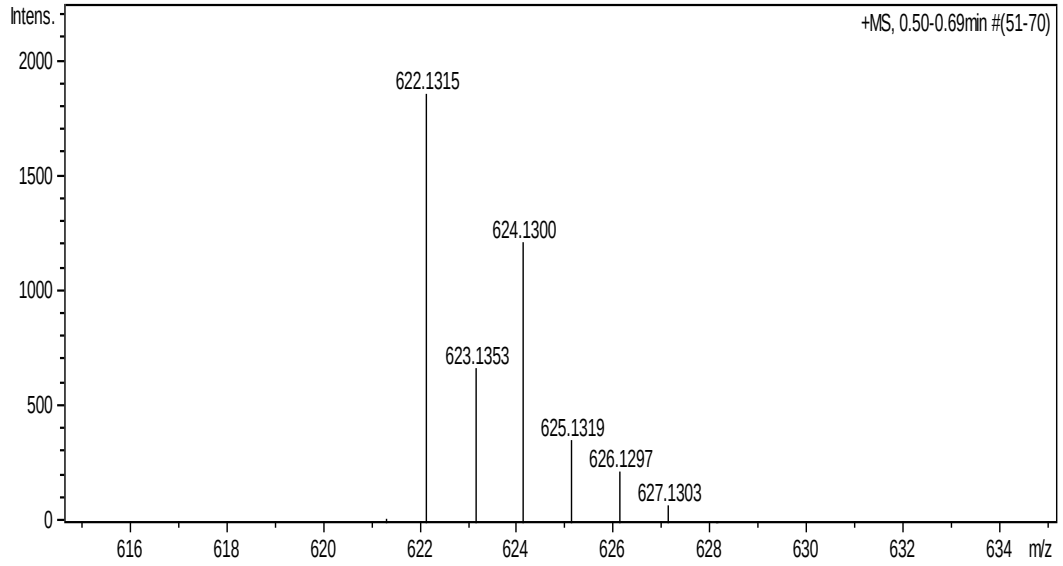

176.949
149.341
147.896
143.162
139.016
136.976
136.215
135.641
134.096
133.520
129.325
129.264
128.999
128.901
128.824
128.587
128.544
128.290
128.236
128.080
127.946
126.199
125.525
125.196
125.133
123.962
123.877
123.024
121.039
119.902
114.723
109.496
52.875
44.481
21.365
25.0
20.0
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.39-0.54min #(40-55)
588.1730
589.1759
590.1722
584.2218
585.2324
591.1730
600
400
200
0
582
584
586
588
590
592
594
596
m/z

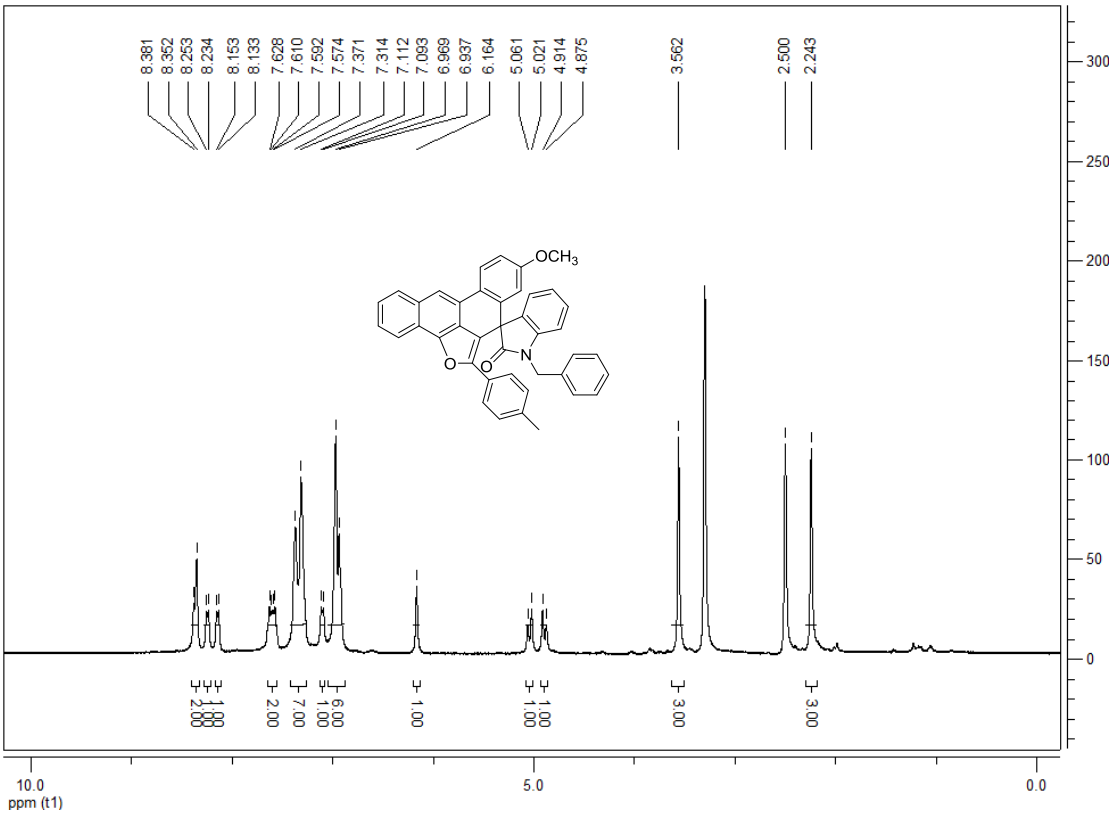
1-benzyl-5-chloro-6'-(4-chlorophenyl)-9'-methylspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3j): Yellow solid, 79%, 0.245 g, m.p. 236-238℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.46 (s, 1H, ArH), 8.35 (d, *J* = 8.4 Hz, 1H, ArH), 8.28 (d, *J* = 7.6 Hz, 1H, ArH), 8.18 (d, *J* = 7.6 Hz, 1H, ArH), 7.69-7.65 (m, 1H, ArH), 7.64-7.59 (m, 1H, ArH), 7.44-7.41 (m, 3H, ArH), 7.40-7.37 (m, 3H, ArH), 7.36-7.32 (m, 2H, ArH), 7.26-7.22 (m, 2H, ArH), 7.13-7.10 (m, 2H, ArH), 7.07 (d, *J* = 2.0 Hz, 1H, ArH), 6.44 (brs, 1H, ArH), 5.12 (d, *J* = 15.2 Hz, 1H, CH), 4.96 (d, *J* = 15.2 Hz, 1H, CH), 2.13 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.6, 149.4, 147.9, 141.5, 139.1, 138.3, 135.4, 135.2, 134.3, 133.5, 129.5, 129.3, 129.1, 128.9, 128.8, 128.8, 128.6, 128.3, 128.1, 128.1, 128.0, 126.3, 125.6, 125.5, 124.7, 124.0, 122.6, 121.0, 119.9, 114.9, 113.0, 110.3, 52.8, 44.6, 21.3; IR (KBr) υ: 3062, 2955, 1718, 1601, 1482, 1427, 1368, 1329, 1221, 1168, 1082, 1013, 887, 820, 749, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{26}Cl_2NO_2$ ($[M+H]^+$): 622.1335. Found: 622.1315.

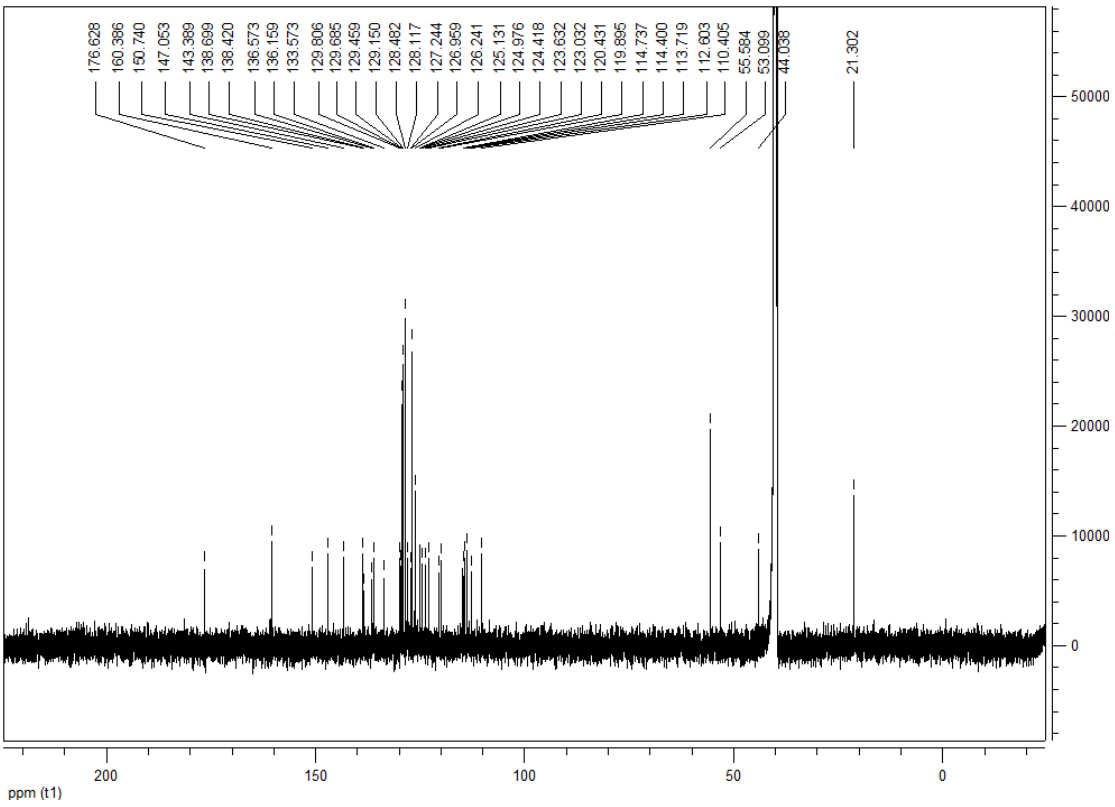


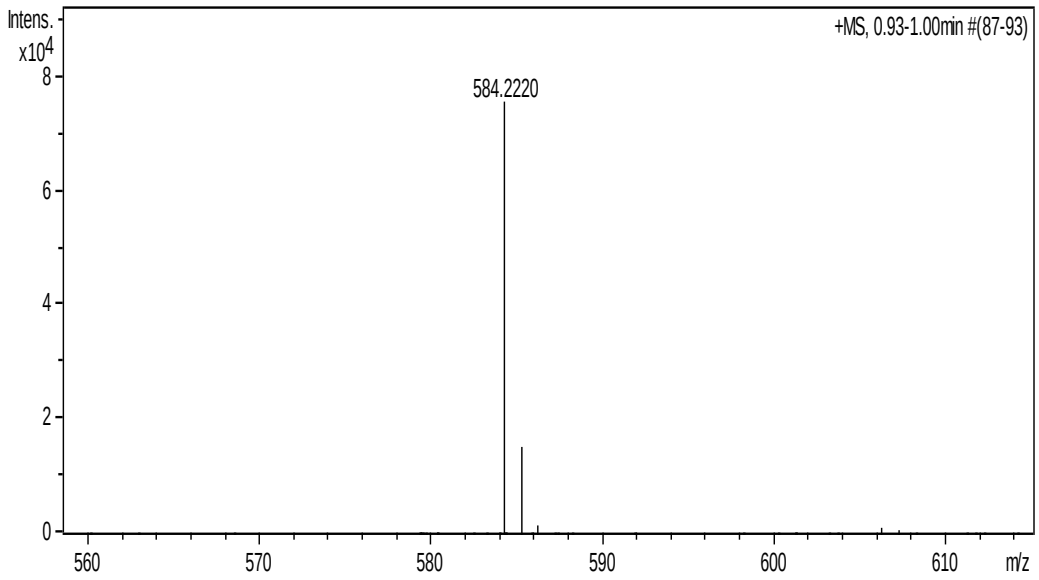

176.627
149.420
147.938
141.515
139.157
138.376
135.423
135.206
134.376
133.526
129.509
129.344
129.192
128.931
128.855
128.835
128.626
128.392
128.189
128.145
128.087
126.320
125.628
125.524
124.767
124.001
122.686
121.047
119.908
114.914
113.011
110.375
52.805
44.611
21.345
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.50-0.69min #(51-70)
2000
1500
1000
500
0
622.1315
624.1300
623.1353
625.1319
626.1297
627.1303
616
618
620
622
624
626
628
630
632
634
m/z

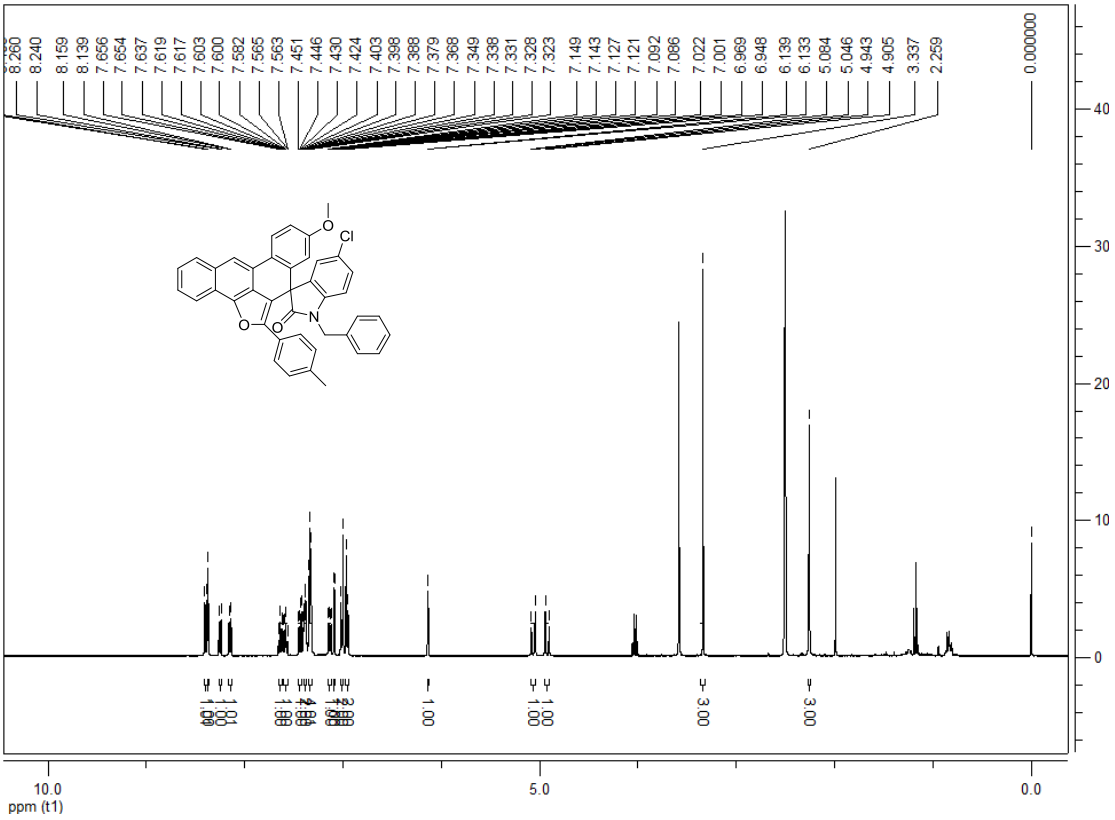
1-benzyl-9'-methoxy-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3k): Yellow solid, 83%, 0.242 g, m.p. 239-241℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.35 (m, 2H, ArH), 8.24 (d, *J* = 7.6 Hz, 1H, ArH), 8.14 (d, *J* = 8.0 Hz, 1H, ArH), 7.63-7.57 (m, 2H, ArH), 7.37-7.31 (m, 7H, ArH), 7.10 (d, *J* = 7.6 Hz, 1H, ArH), 6.97-6.94 (m, 6H, ArH), 6.16 (brs, 1H, ArH), 5.04 (d, *J* = 16.0 Hz, 1H, CH), 4.90 (d, *J* = 15.6 Hz, 1H, CH), 3.56 (s, 3H, OCH_3), 2.24 (s, 3H, CH_3); ^{13}C NMR (150 MHz, DMSO-d_6) δ: 176.6, 160.3, 150.7, 147.0, 143.3, 138.6, 138.4, 136.5, 136.1, 133.5, 129.8, 129.6, 129.4, 129.1, 128.4, 128.1, 127.2, 126.9, 126.2, 125.1, 124.9, 124.4, 123.6, 123.0, 120.4, 119.8, 114.7, 114.3, 113.7, 112.6, 110.4, 55.5, 53.0, 44.0, 21.3; IR (KBr) υ: 3035, 2922, 1722, 1605, 1496, 1469, 1345, 1290, 1246, 1172, 1080, 1036, 911, 825, 748, 698 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{41}H_{30}NO_3$ ([M+H]$^+$): 584.2220. Found: 584.2220.

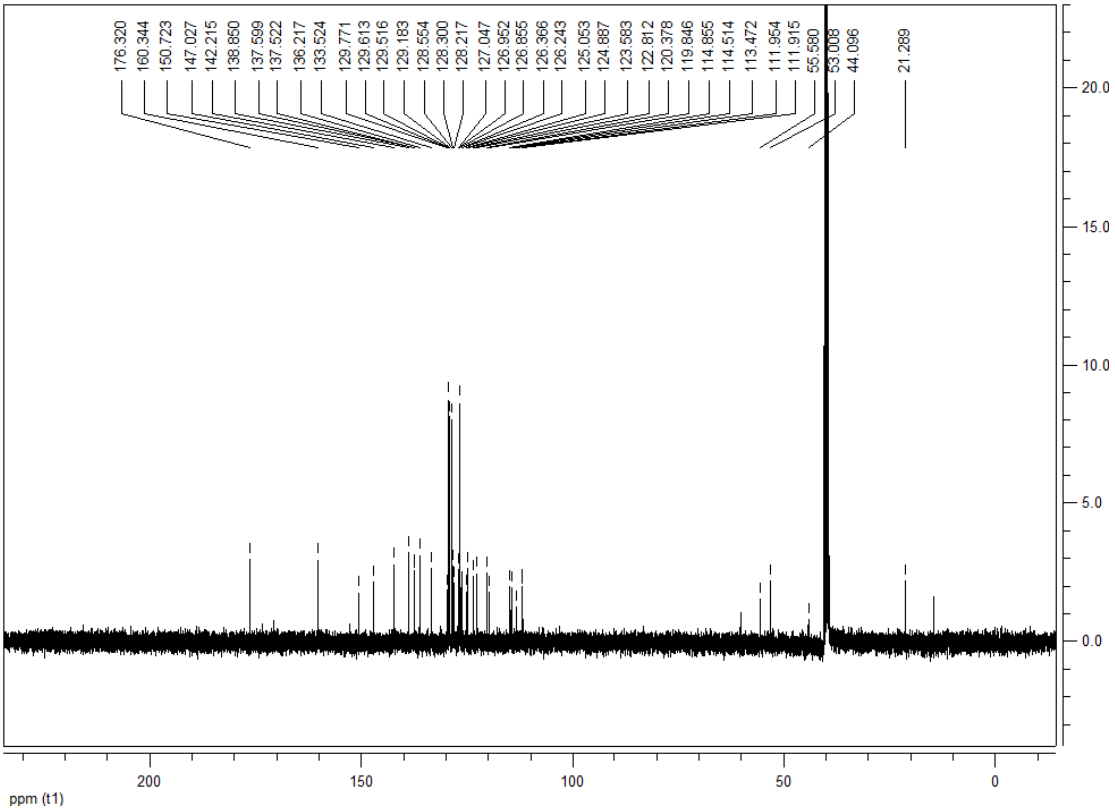


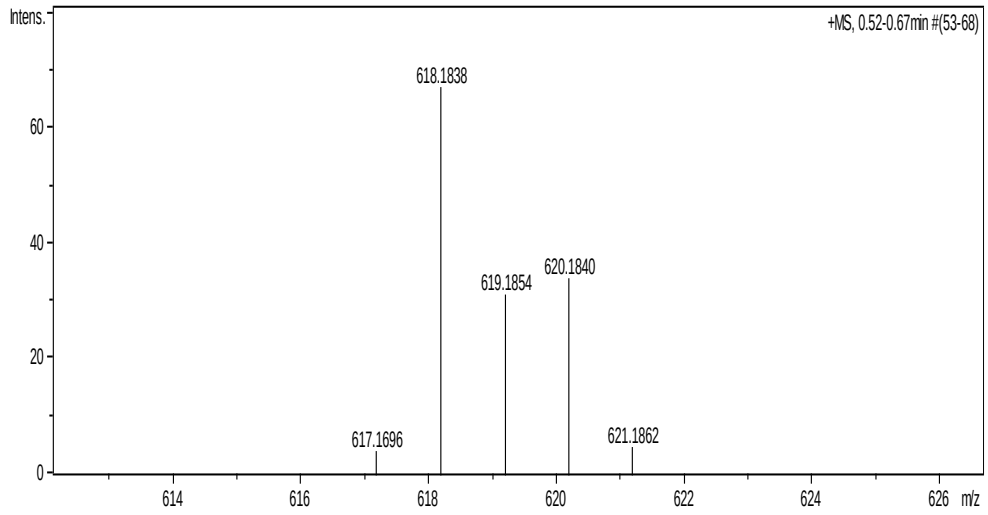

176.628
160.386
150.740
147.053
143.389
138.699
138.420
136.573
136.159
133.573
129.806
129.685
129.459
129.150
128.482
128.117
127.244
126.959
126.241
125.131
124.976
124.418
123.632
123.032
120.431
119.895
114.737
114.400
113.719
112.603
110.405
55.584
53.099
44.038
21.302
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)


Intens.
x10^4
8
6
4
2
0
+MS, 0.93-1.00min #(87-93)
584.2220
560
570
580
590
600
610
m/z

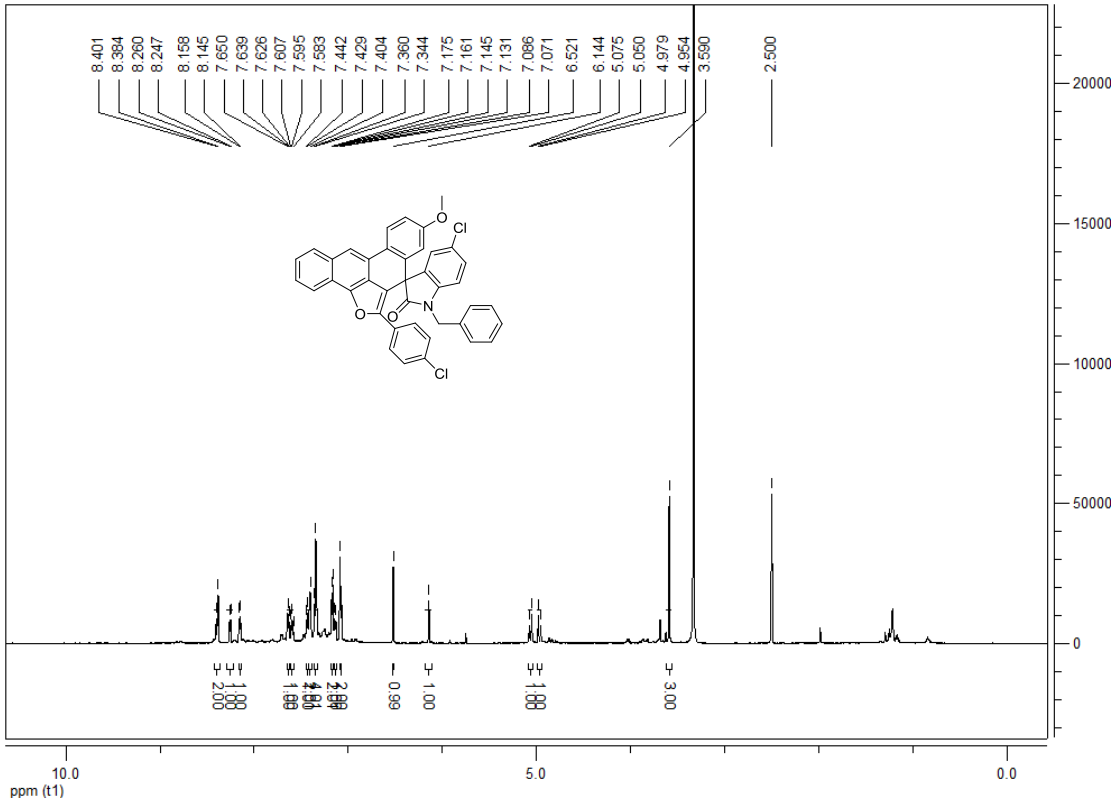
1-benzyl-5-chloro-9'-methoxy-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3l): Yellow solid, 64%, 0.197 g, m.p. 259-261℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.39 (d, J = 8.8 Hz, 1H, ArH), 8.37 (s, 1H, ArH), 8.25 (d, J = 8.0 Hz, 1H, ArH), 8.15 (d, J = 8.0 Hz, 1H, ArH), 7.66-7.62 (m, 1H, ArH), 7.60-7.56 (m, 1H, ArH), 7.44 (dd, J_1 = 8.8 Hz, J_1 = 2.4 Hz, 1H, ArH), 7.40-7.37 (m, 2H, ArH), 7.35-7.32 (m, 4H, ArH), 7.13 (dd, J_1 = 8.8 Hz, J_1 = 2.4 Hz, 1H, ArH), 7.09 (d, J = 2.4 Hz, 1H, ArH), 7.01 (d, J = 8.4 Hz, 2H, ArH), 6.96 (d, J = 8.4 Hz, 2H, ArH), 6.14 (d, J = 2.4 Hz, 1H, ArH), 5.06 (d, J = 15.2 Hz, 1H, CH), 4.93 (d, J = 15.2 Hz, 1H, CH), 3.34 (s, 3H, OCH_3), 2.26 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 176.3, 160.3, 150.7, 147.0, 142.2, 138.8, 137.5, 137.5, 136.2, 133.5, 129.7, 129.6, 129.5, 129.1, 128.5, 128.3, 128.2, 127.0, 126.9, 126.8, 126.3, 126.2, 125.0, 124.8, 123.5, 122.8, 120.3, 119.8, 114.8, 114.5, 113.4, 111.9, 111.9, 55.5, 53.0, 44.0, 21.2; IR (KBr) υ: 3037, 2918, 1724, 1604, 1568, 1478, 1425, 1367, 1323, 1244, 1166, 1080, 1042, 887, 814, 748, 700 cm^{-1}; MS (m/z): HRMS (ESI) Calcd. for $C_{41}H_{29}ClNO_3$ ([M+H]$^+$): 618.1830. Found: 618.1838.

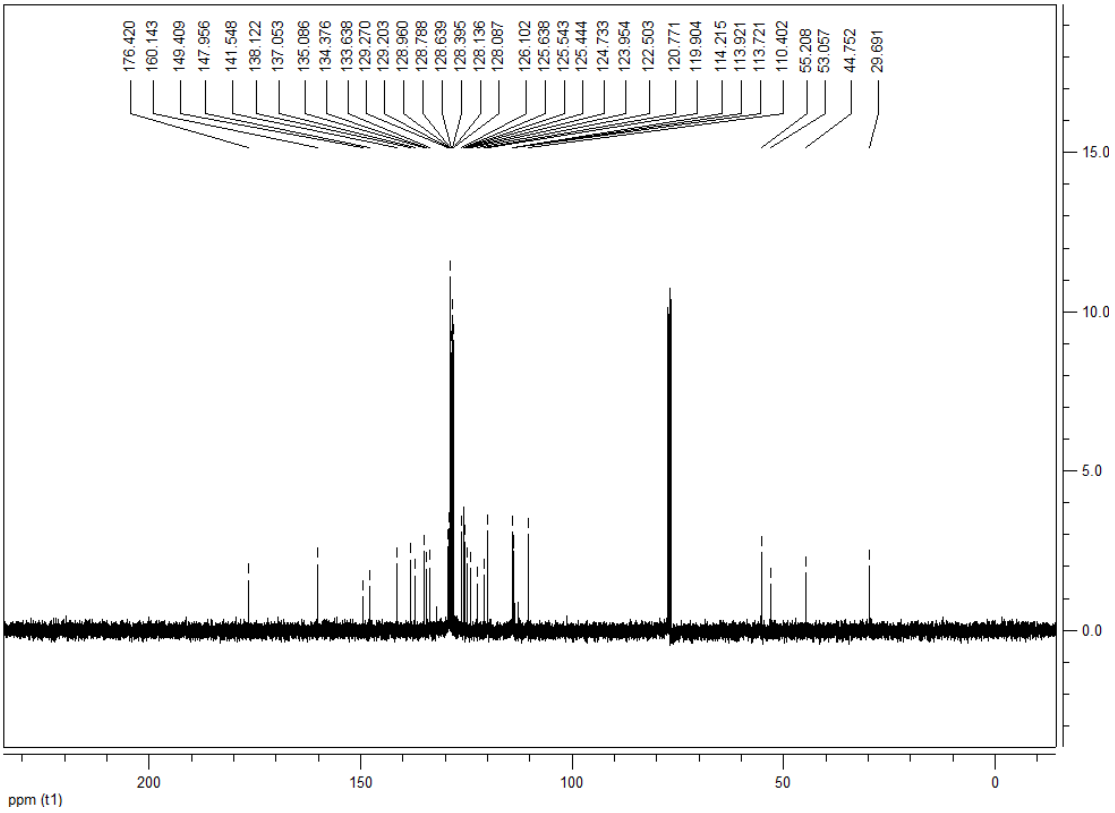


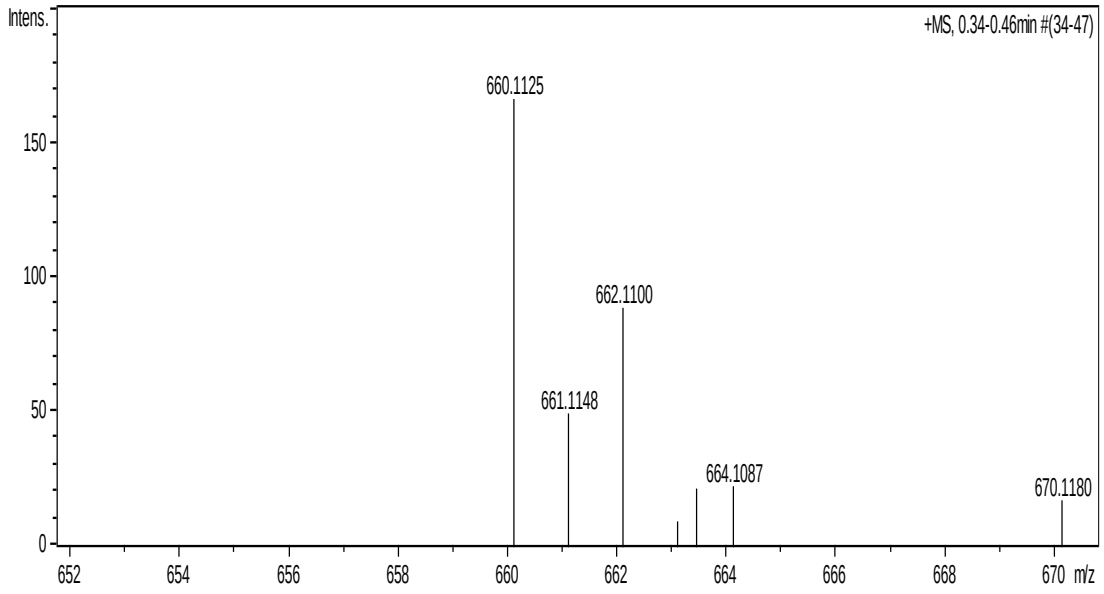

176.320
160.344
150.723
147.027
142.215
138.850
137.599
137.522
136.217
133.524
129.771
129.613
129.516
129.183
128.554
128.300
128.217
127.047
126.952
126.855
126.366
126.243
125.053
124.887
123.583
122.812
120.378
119.846
114.855
114.514
113.472
111.954
111.915
55.580
53.008
44.096
21.289
20.0
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.52-0.67min #(53-68)
618.1838
619.1854
620.1840
617.1696
621.1862
60
40
20
0
614
616
618
620
622
624
626
m/z

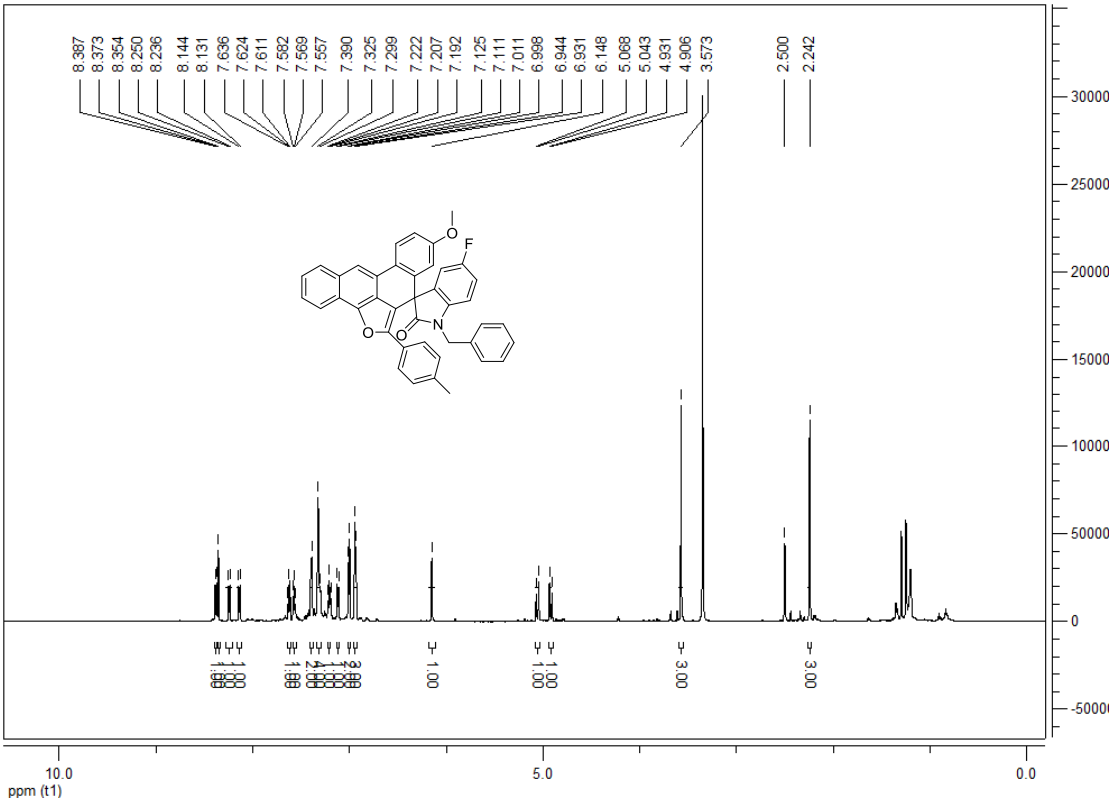
1-benzyl-5-chloro-6'-(4-chlorophenyl)-9'-methoxyspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3m): Yellow solid, 77%, 0.245 g, m.p. 246-248℃; ^{1}H NMR (600 MHz, DMSO-d_6) δ: 8.40-8.38 (m, 2H, ArH), 8.25 (d, *J* = 7.8 Hz, 1H, ArH), 8.15 (d, *J* = 7.8 Hz, 1H, ArH), 7.64 (t, *J* = 7.2 Hz, 1H, ArH), 7.60 (t, *J* = 7.8 Hz, 1H, ArH), 7.43 (d, *J* = 7.8 Hz, 1H, ArH), 7.40 (brs, 2H, ArH), 7.36-7.34 (m, 4H, ArH), 7.17 (d, *J* = 8.4 Hz, 2H, ArH), 7.14 (d, *J* = 8.4 Hz, 1H, ArH), 7.08 (d, *J* = 9.0 Hz, 2H, ArH), 6.52 (s, 1H, ArH), 6.14 (s, 1H, ArH), 5.06 (d, *J* = 15.0 Hz, 1H, CH), 4.96 (d, *J* = 15.0 Hz, 1H, CH), 3.59 (s, 3H, OCH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.4, 160.1, 149.4, 147.9, 141.5, 138.1, 137.0, 135.0, 134.3, 133.6, 129.2, 129.2, 128.9, 128.7, 128.6, 128.3, 128.1, 128.0, 126.1, 125.6, 125.5, 125.4, 124.7, 123.9, 122.5, 120.7, 119.9, 114.2, 113.9, 113.7, 110.4, 55.2, 53.0, 44.7, 29.6; IR (KBr) υ: 3062, 2925, 2845, 1724, 1605, 1483, 1431, 1330, 1288, 1249, 1169, 1085, 1042, 821, 748, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{25}Cl_2NNaO_3$ ([M+Na]$^+$): 660.1104. Found: 660.1125.

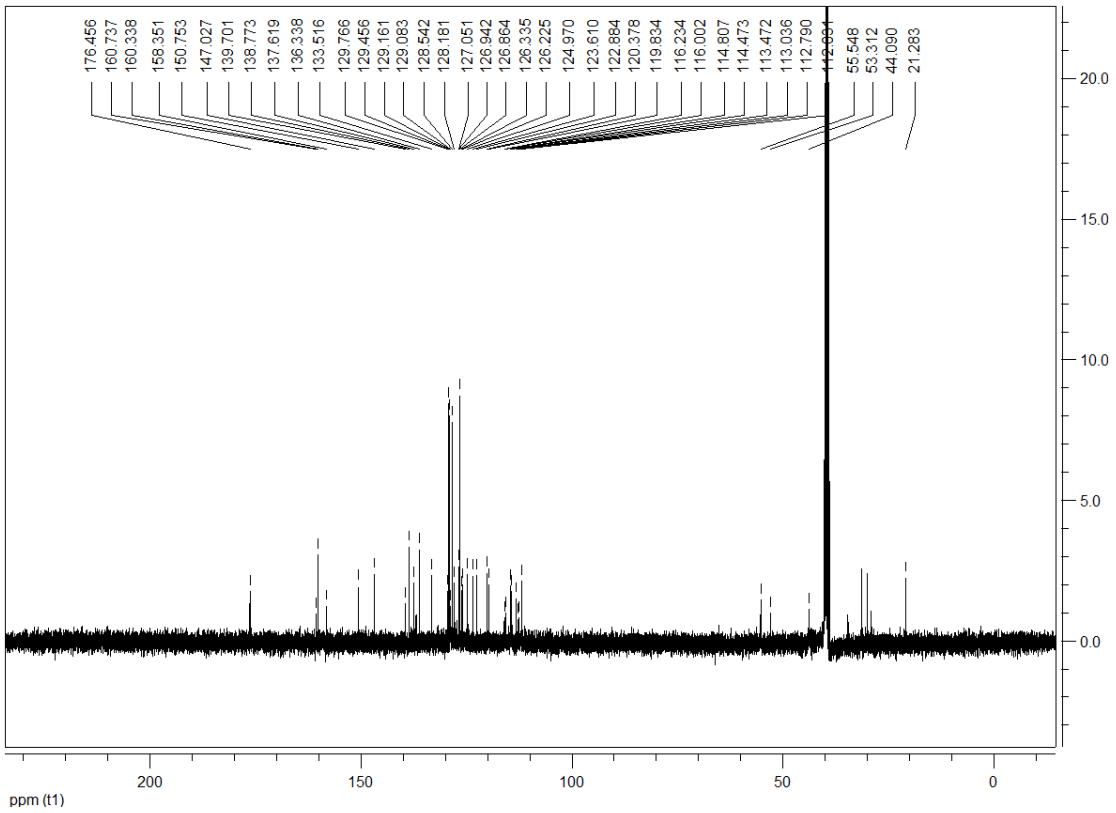


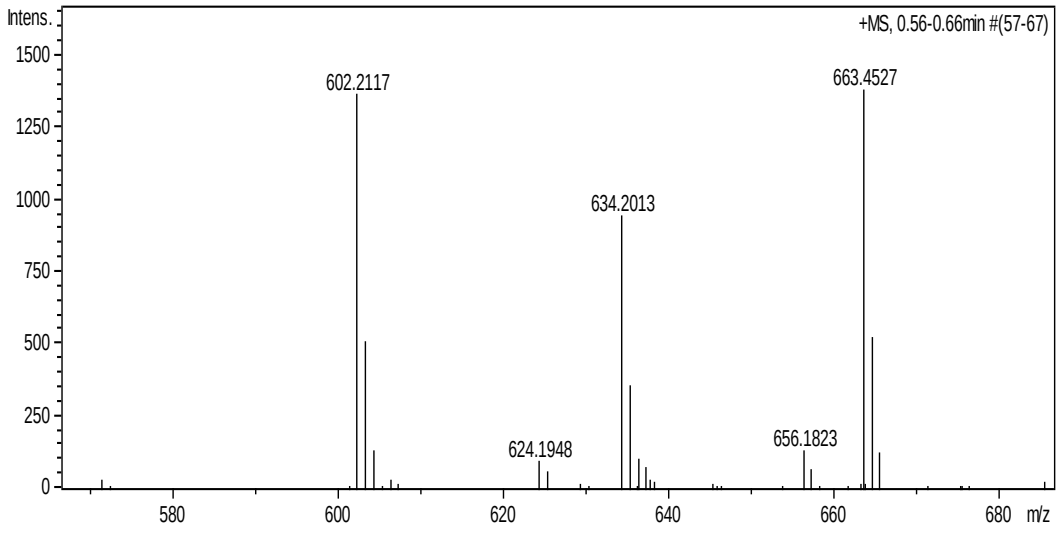

176.420
160.143
149.409
147.956
141.548
138.122
137.053
135.086
134.376
133.638
129.270
129.203
128.960
128.788
128.639
128.395
128.136
128.087
126.102
125.638
125.543
125.444
124.733
123.954
122.503
120.771
119.904
114.215
113.921
113.721
110.402
55.208
53.057
44.752
29.691
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.34-0.46min #(34-47)
660.1125
662.1100
661.1148
664.1087
670.1180
150
100
50
0
652
654
656
658
660
662
664
666
668
670 m/z

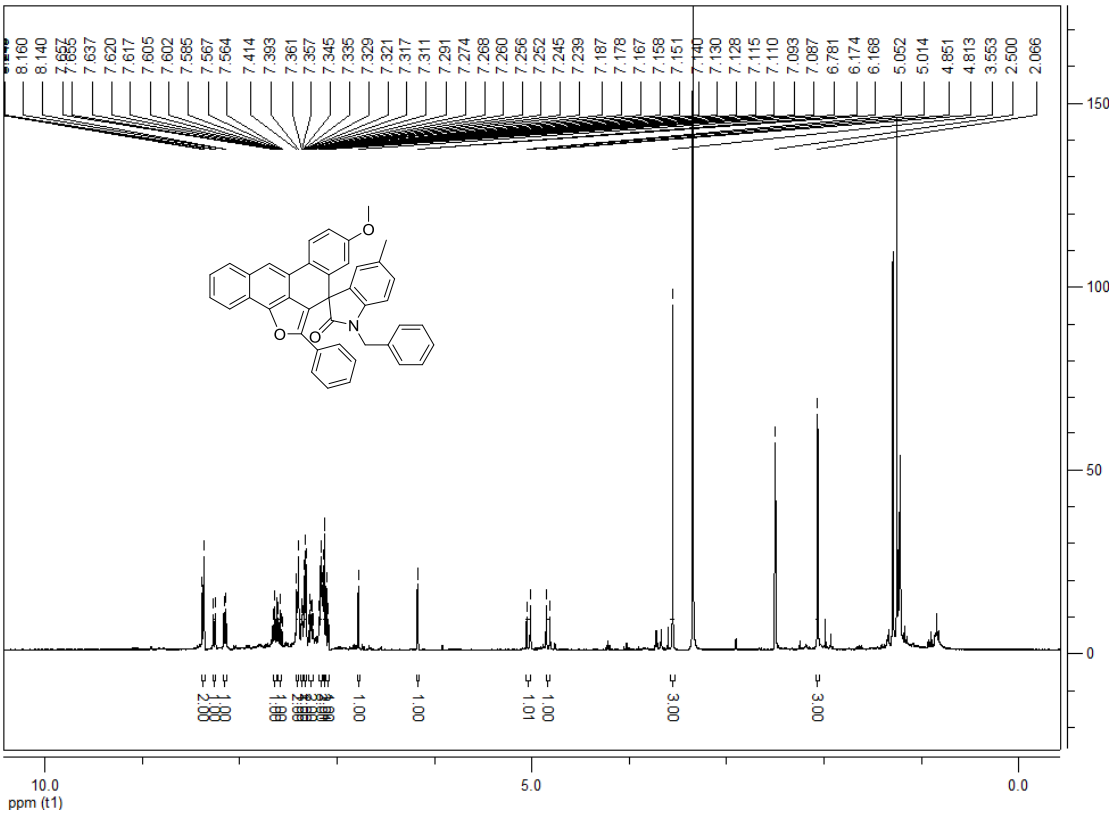
1-benzyl-5-fluoro-9'-methoxy-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3n): Yellow solid, 80%, 0.240 g, m.p. 241-243℃; ^{1}H NMR (600 MHz, DMSO-d_6) δ: 8.38 (d, *J* = 8.4 Hz, 1H, ArH), 8.35 (s, 1H, ArH), 8.24 (d, *J* = 8.4 Hz, 1H, ArH), 8.14 (d, *J* = 7.8 Hz, 1H, ArH), 7.62 (t, *J* = 7.8 Hz, 1H, ArH), 7.57 (t, *J* = 7.8 Hz, 1H, ArH), 7.39 (brs, 2H, ArH), 7.33-7.30 (m, 4H, ArH), 7.21 (t, *J* = 9.0 Hz, 1H, ArH), 7.12 (d, *J* = 8.4 Hz, 1H, ArH), 7.00 (d, *J* = 7.8 Hz, 2H, ArH), 6.94-6.93 (m, 3H, ArH), 6.15 (s, 1H, ArH), 5.06 (d, *J* = 15.0 Hz, 1H, CH), 4.92 (d, *J* = 15.0 Hz, 1H, CH), 3.57 (s, 3H, OCH_3), 2.24 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.4, 160.3, 159.5 (d, *J* = 238.6 Hz), 150.7, 147.0, 139.7, 138.7, 137.1 (d, *J* = 7.8 Hz), 133.5, 129.7, 129.4, 129.1, 129.0, 128.5, 128.1, 127.0, 126.9, 126.8, 126.3, 126.2, 124.9, 123.6, 122.8, 120.3, 119.8, 116.1 (d, *J* = 23.2 Hz), 114.8, 114.4, 113.4, 112.9 (d, *J* = 24.6 Hz), 112.0, 55.5, 53.3, 44.0, 21.2; IR (KBr) υ: 3060, 2922, 2853, 1724, 1607, 1491, 1447, 1332, 1252, 1170, 1081, 1032, 965, 819, 747, 698 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{41}H_{29}FNO_3$ ([M+H]$^+$): 602.2126. Found: 602.2117.

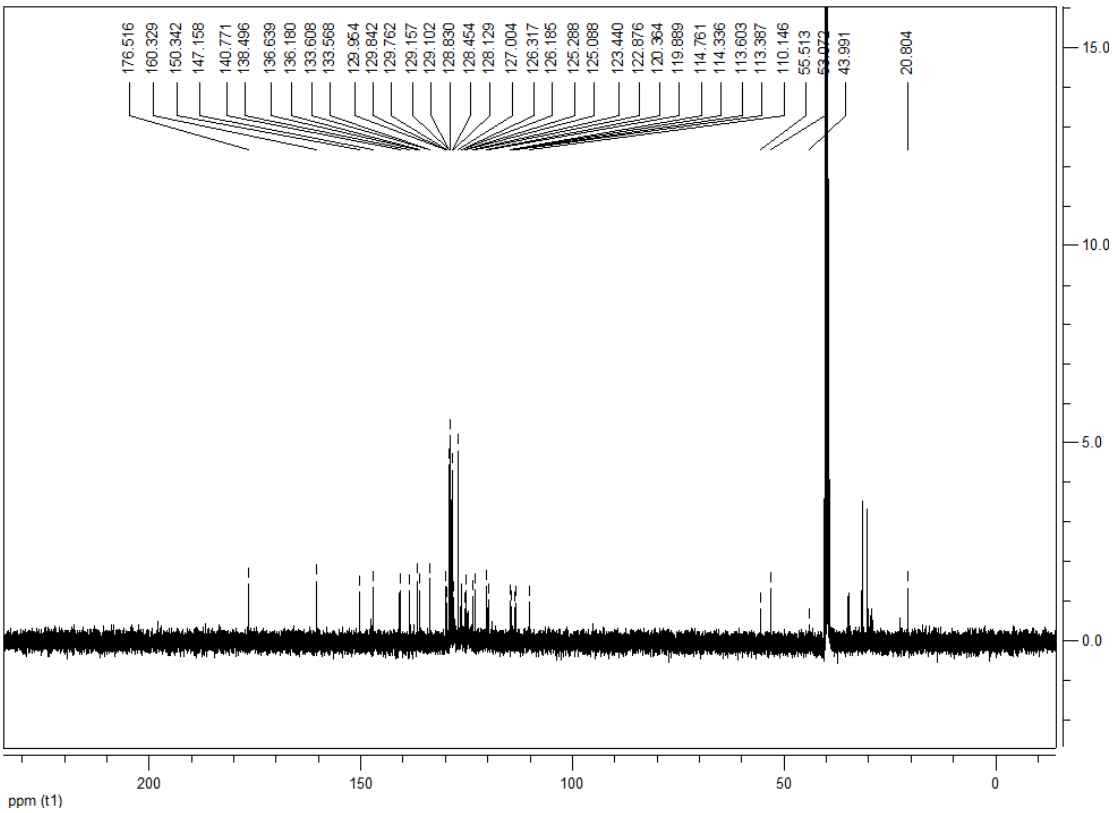


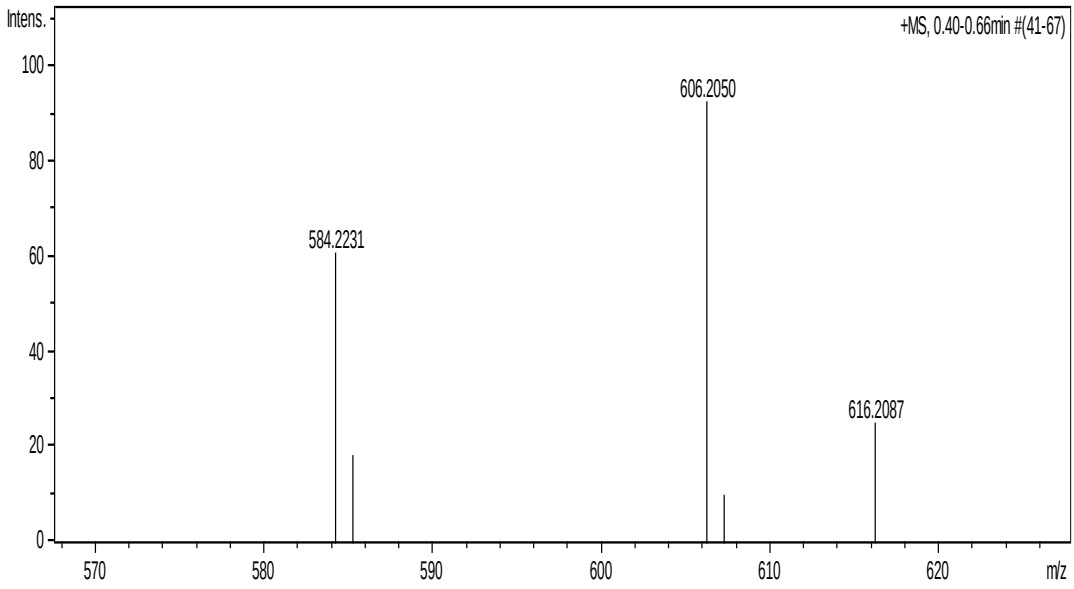

176.456
160.737
160.338
158.351
150.753
147.027
139.701
138.773
137.619
136.338
133.516
129.766
129.456
129.161
129.083
128.542
128.181
127.051
126.942
126.864
126.335
126.225
124.970
123.610
122.884
120.378
119.834
116.234
116.002
114.807
114.473
113.472
113.036
112.790
55.548
53.312
44.090
21.283
20.0
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.56-0.66min #(57-67)
1500
1250
1000
750
500
250
0
602.2117
663.4527
634.2013
624.1948
656.1823
580
600
620
640
660
680
m/z

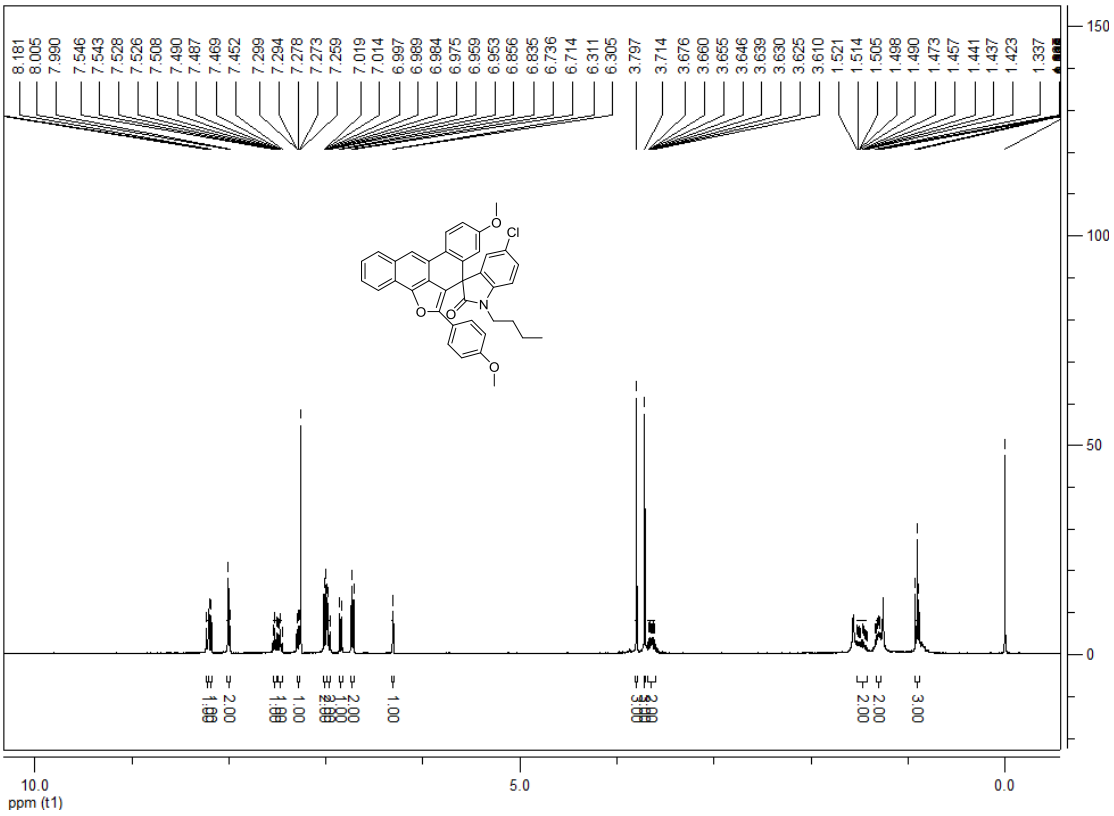
1-benzyl-9'-methoxy-5-methyl-6'-phenylspiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3o): Yellow solid, 74%, 0.216 g, m.p. 254-256℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.38-8.36 (m, 2H, ArH), 8.26 (d, *J* = 7.6 Hz, 1H, ArH), 8.15 (d, *J* = 8.0 Hz, 1H, ArH), 7.66-7.62 (m, 1H, ArH), 7.61-7.56 (m, 1H, ArH), 7.41-7.39 (m, 2H, ArH), 7.36-7.35 (m, 1H, ArH), 7.34-7.31 (m, 2H, ArH), 7.29-7.24 (m, 2H, ArH), 7.19-7.15 (m, 3H, ArH), 7.14-7.13 (m, 2H, ArH), 7.12-7.09 (m, 1H, ArH), 6.78 (brs, 1H, ArH), 6.17 (d, *J* = 2.4 Hz, 1H, ArH), 5.03 (d, *J* = 15.2 Hz, 1H, CH), 4.83 (d, *J* = 15.2 Hz, 1H, CH), 3.55 (s, 3H, OCH_3), 2.07 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 176.5, 160.3, 150.3, 147.1, 140.7, 138.4, 136.6, 136.1, 133.6, 133.5, 129.9, 129.8, 129.7, 129.2, 129.1, 128.8, 128.4, 128.1, 127.0, 126.3, 126.1, 125.2, 125.0, 123.4, 122.8, 120.3, 119.8, 114.7, 114.3, 113.6, 113.3, 110.1, 55.5, 53.0, 43.9, 20.8; IR (KBr) υ: 3058, 2923, 2856, 1715, 1604, 1494, 1455, 1368, 1331, 1285, 1242, 1183, 1079, 1033, 960, 817, 754, 696 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{41}H_{29}NNaO_3$ ([M+Na]$^+$): 606.2040. Found: 606.2050.

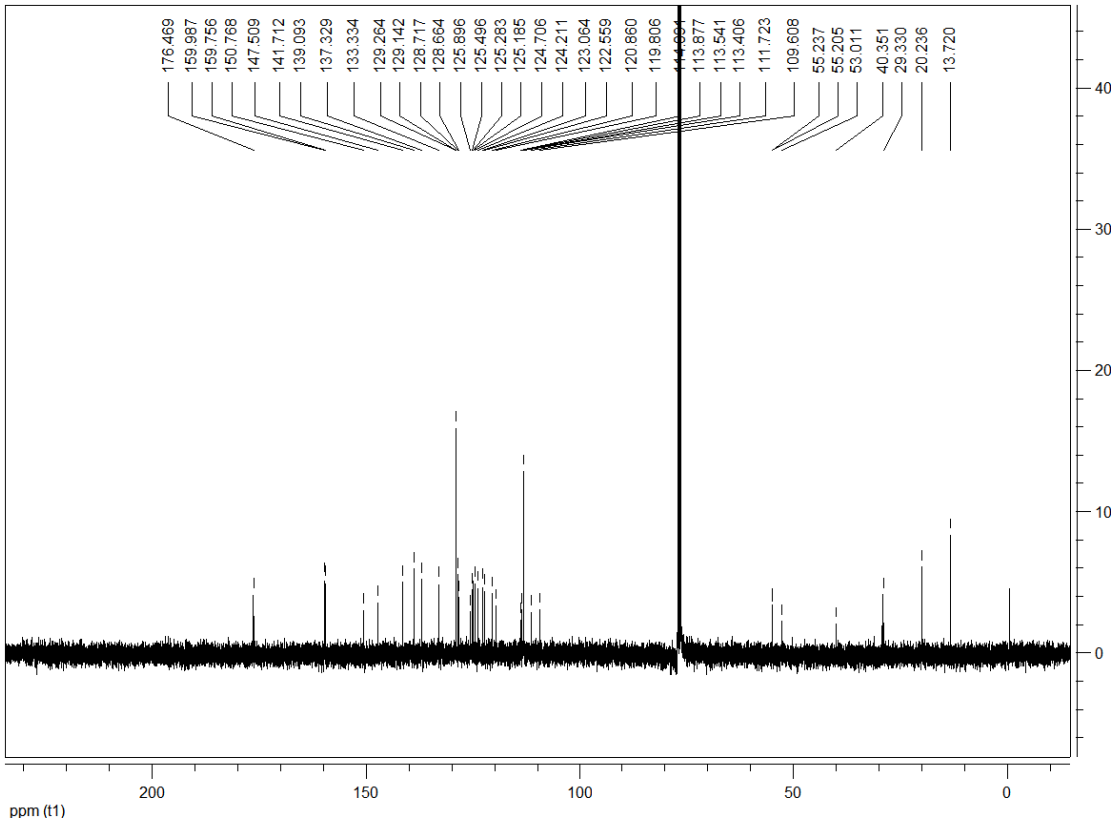


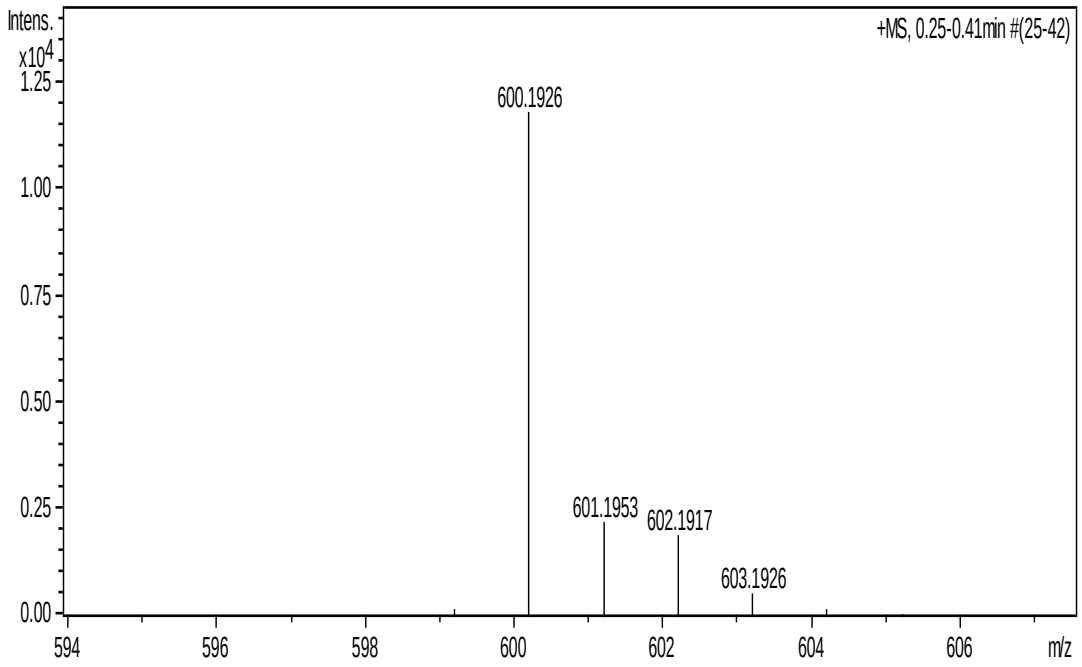

176.516
160.329
150.342
147.158
140.771
138.496
136.639
136.180
133.608
133.568
129.954
129.842
129.762
129.157
129.102
128.830
128.454
128.129
127.004
126.317
126.185
125.288
125.088
123.440
122.876
120.364
119.889
114.761
114.336
113.603
113.387
110.146
55.513
53.072
43.991
20.804
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.40-0.66min #(41-67)
606.2050
584.2231
616.2087
100
80
60
40
20
0
570
580
590
600
610
620
m/z

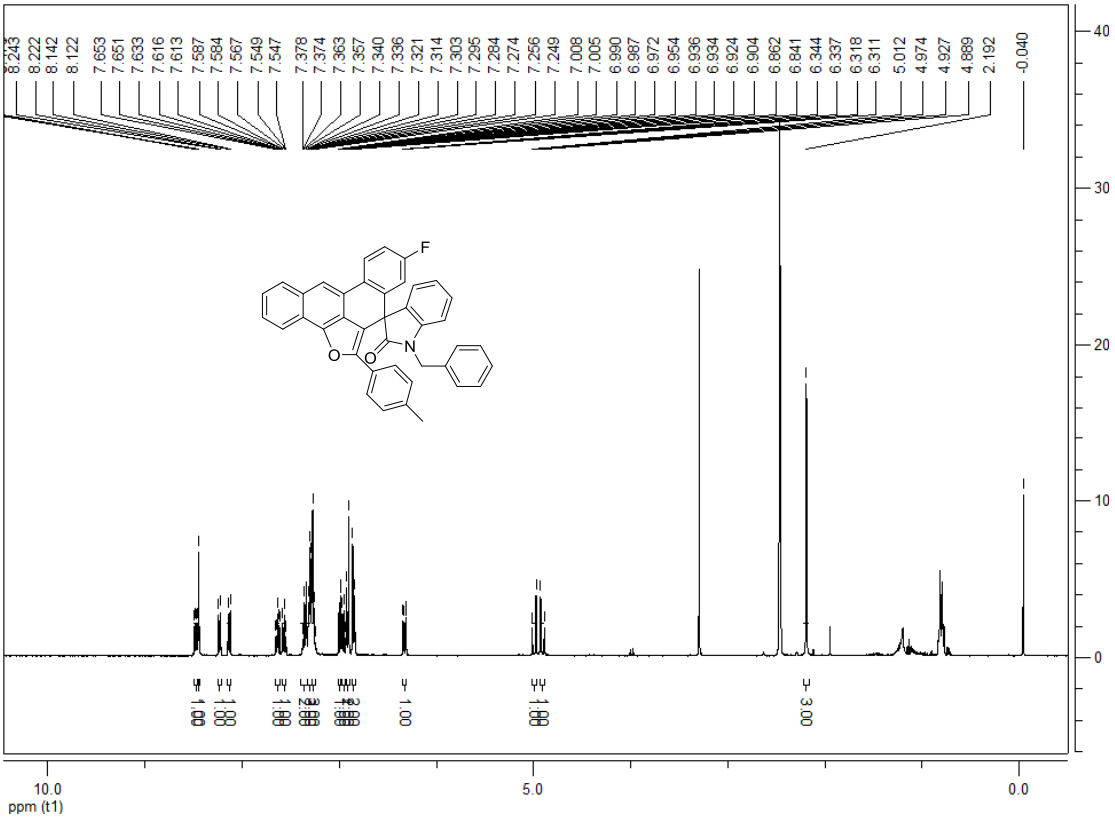
1-butyl-5-chloro-9'-methoxy-6'-(4-methoxyphenyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3p): Yellow solid, 61%, 0.182 g, m.p. 219-221℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.22 (d, *J* = 8.0 Hz, 1H, ArH), 8.19 (d, *J* = 8.8 Hz, 1H, ArH), 8.01-7.99 (m, 2H, ArH), 7.55-7.51 (m, 1H, ArH), 7.49-7.45 (m, 1H, ArH), 7.28 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.02-7.00 (m, 2H, ArH), 6.99-6.95 (m, 2H, ArH), 6.85 (d, *J* = 8.4 Hz, 1H, ArH), 6.74-6.71 (m, 2H, ArH), 6.31 (d, *J* = 2.4 Hz, 1H, ArH), 3.80 (s, 3H, OCH_3), 3.71 (s, 3H, OCH_3), 3.68-3.61 (m, 2H, CH), 1.52-1.42 (m, 2H, CH), 1.34-1.27 (m, 2H, CH), 0.91 (t, *J* = 7.6 Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.4, 159.9, 159.7, 150.7, 147.5, 141.7, 139.0, 137.3, 133.3, 129.2, 129.1, 128.7, 128.6, 125.8, 125.4, 125.2, 125.1, 124.7, 124.2, 123.0, 122.5, 120.8, 119.8, 114.0, 113.8, 113.5, 113.4, 111.7, 109.6, 55.2, 55.2, 53.0, 40.3, 29.3, 20.2, 13.7; IR (KBr) υ: 3068, 2943, 2869, 1717, 1597, 1521, 1481, 1432, 1344, 1277, 1228, 1184, 1112, 1073, 1024, 923, 853, 816, 748, 702 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{38}H_{31}ClNO_4$ ($[M+H]^+$): 600.1936. Found: 600.1926.

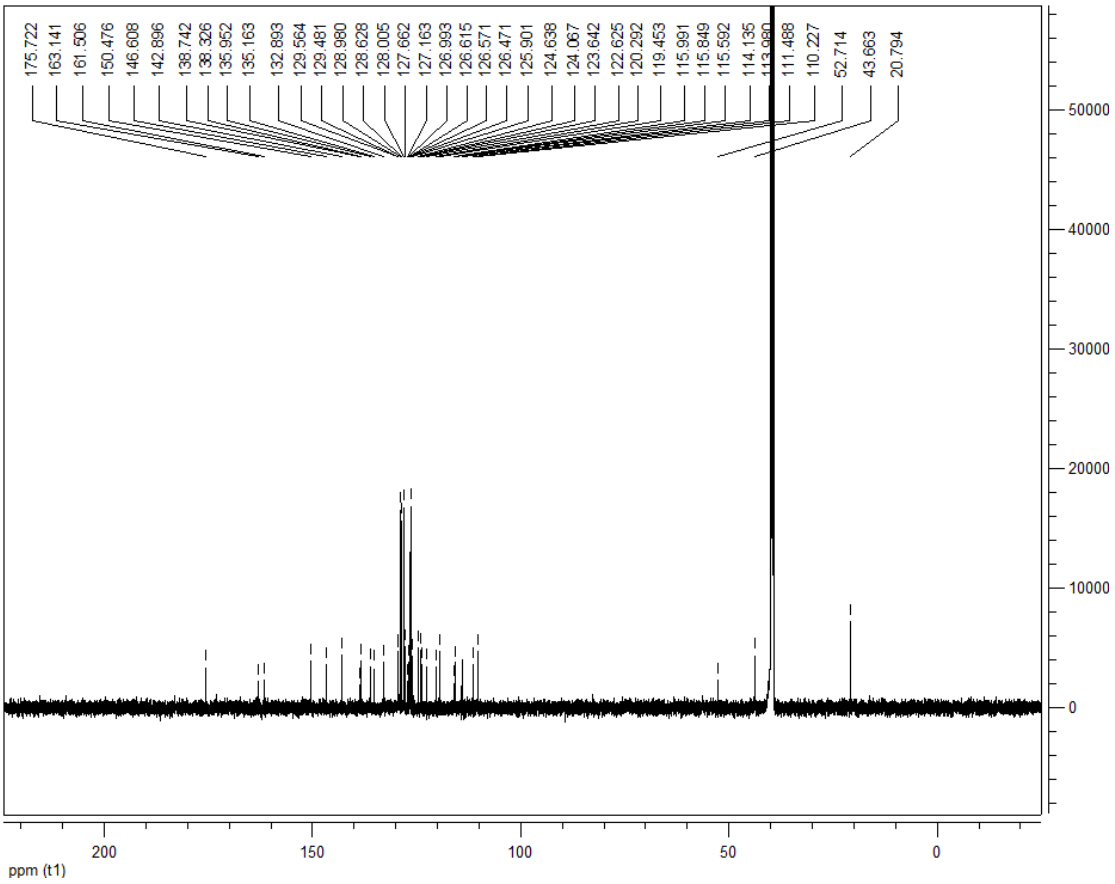


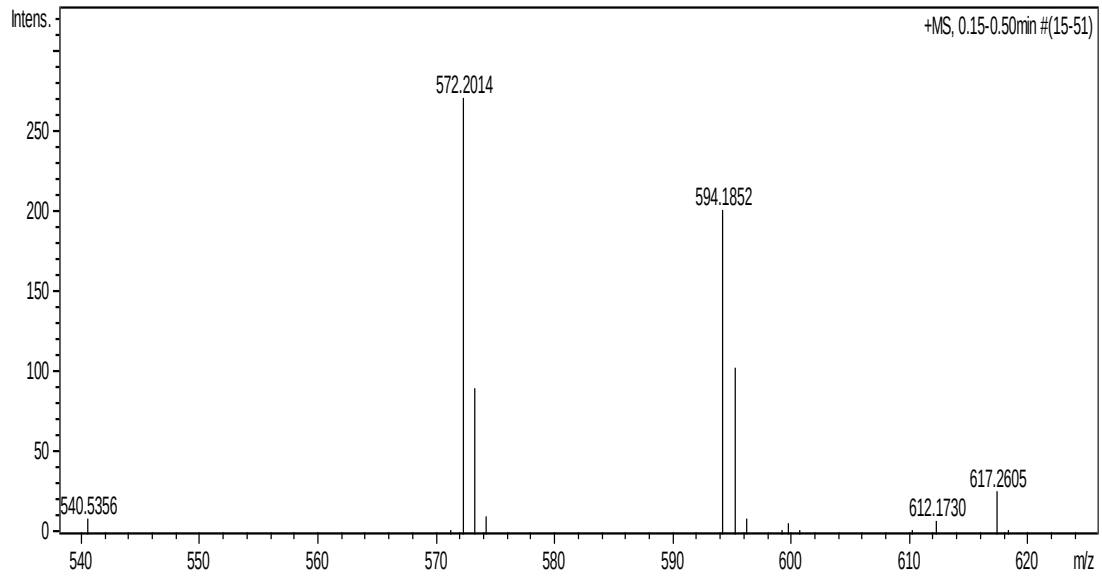

176.469
159.987
159.756
150.768
147.509
141.712
139.093
137.329
133.334
129.264
129.142
128.717
128.664
125.896
125.496
125.283
125.185
124.706
124.211
123.064
122.559
120.860
119.806
113.877
113.541
113.406
111.723
109.608
55.237
55.205
53.011
40.351
29.330
20.236
13.720
40
30
20
10
0
200
150
100
50
0
ppm (t1)


Intens.
x10^4
1.25
1.00
0.75
0.50
0.25
0.00
+MS, 0.25-0.41min #(25-42)
600.1926
601.1953
602.1917
603.1926
594
596
598
600
602
604
606
m/z

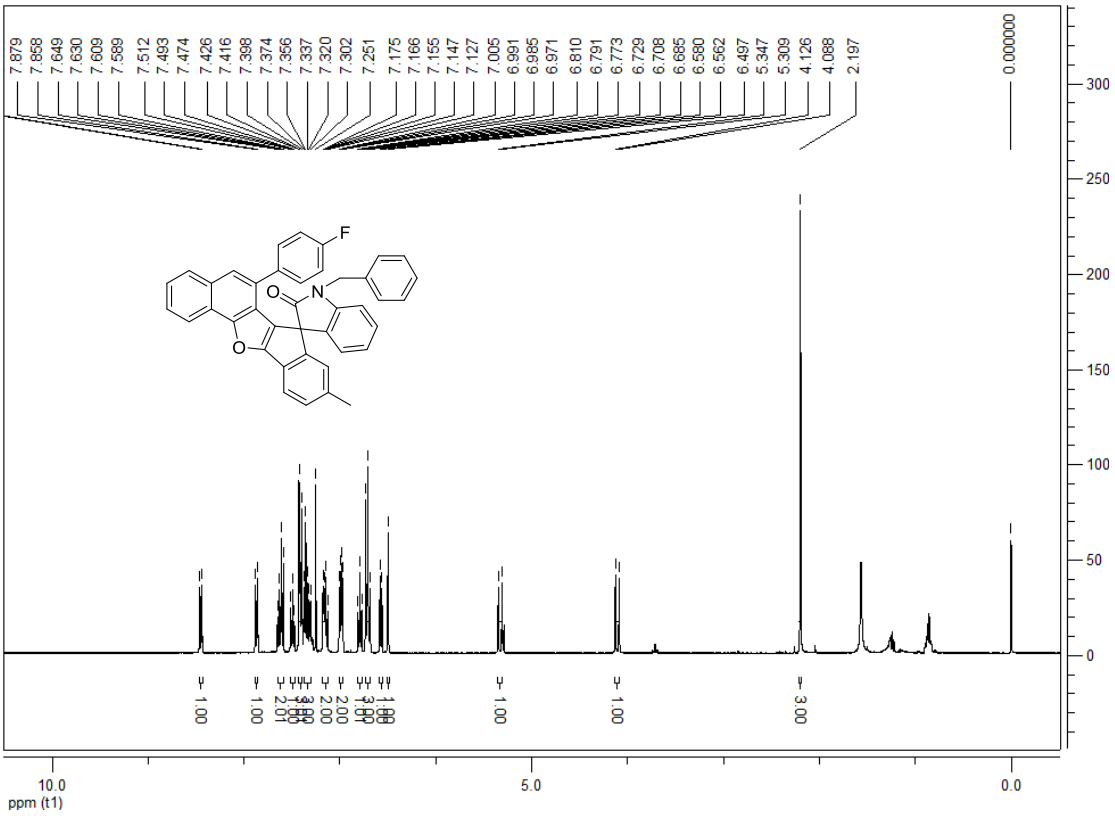
1-benzyl-9'-fluoro-6'-(*p*-tolyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3q): Yellow solid, 16%, 0.046 g, m.p. 247-249℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.49-8.46 (m, 1H, ArH), 8.45 (s, 1H, ArH), 8.23 (d, J = 8.4 Hz, 1H, ArH), 8.13 (d, J = 8.0 Hz, 1H, ArH), 7.65-7.61 (m, 1H, ArH), 7.59-7.55 (m, 1H, ArH), 7.38-7.34 (m, 2H, ArH), 7.32-7.30 (m, 3H, ArH), 7.28-7.25 (m, 3H, ArH), 7.00 (dd, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H, ArH), 6.97-6.93 (m, 1H, ArH), 6.91 (d, J = 8.0 Hz, 2H, ArH), 6.85 (d, J = 8.4 Hz, 2H, ArH), 6.33 (dd, J_1 = 10.4 Hz, J_2 = 2.8 Hz, 1H, ArH), 4.99 (d, J = 15.2 Hz, 1H, CH), 4.91 (d, J = 15.2 Hz, 1H, CH), 2.19 (s, 3H, CH_3); ^{13}C NMR (150 MHz, DMSO-d_6) δ: 175.7, 162.3 (d, J = 245.2 Hz), 150.4, 146.6, 142.8, 138.7, 138.3, 135.9, 135.1, 132.8, 129.5, 129.4, 128.9, 128.6, 128.0, 127.6, 127.1, 126.9, 126.6, 126.5, 126.4, 125.9, 124.6, 124.0, 123.6, 122.6, 120.2, 119.4, 115.9 (d, J = 21.3 Hz), 115.5, 114.0 (d, J = 23.3 Hz), 111.4, 110.2, 52.7, 43.6, 20.7; IR (KBr) υ: 3061, 2918, 1724, 1605, 1495, 1448, 1337, 1268, 1220, 1167, 1062, 1023, 957, 887, 818, 739, 696 cm^{-1}; HRMS (ESI) Calcd. for $C_{40}H_{27}FNO_3$ ([M+H]$^+$): 572.2020. Found: 572.2014.

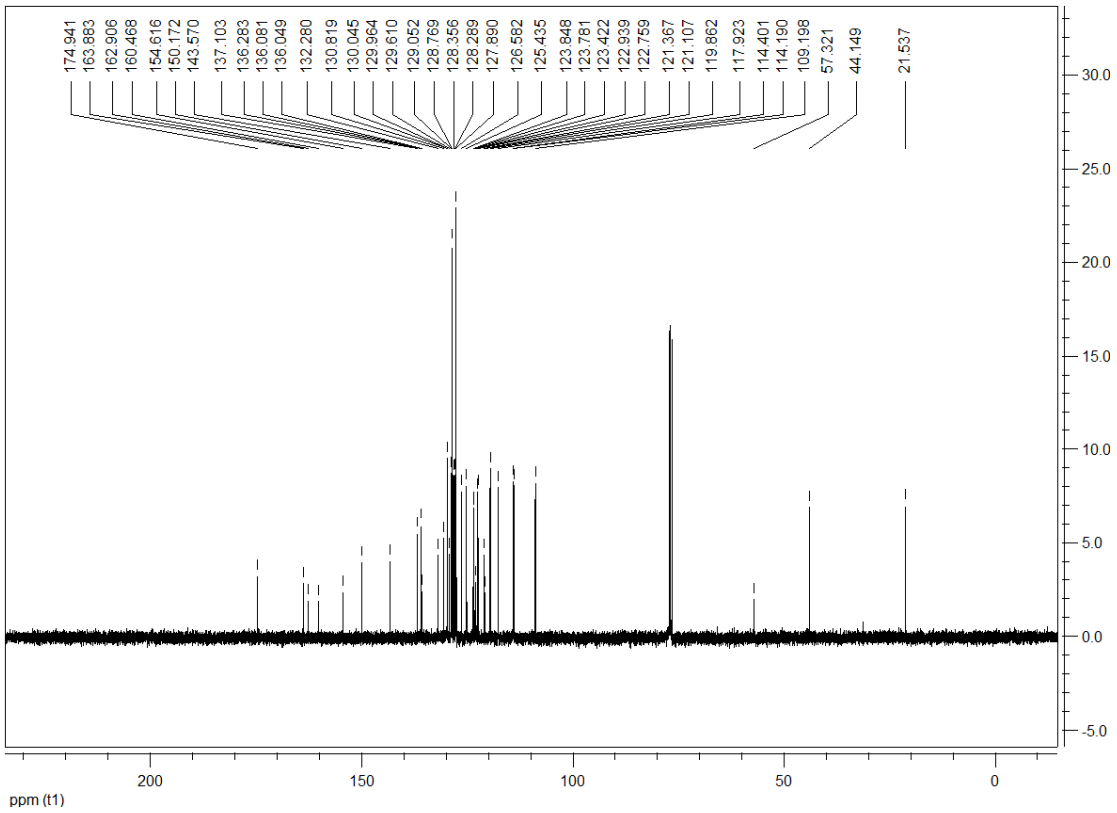


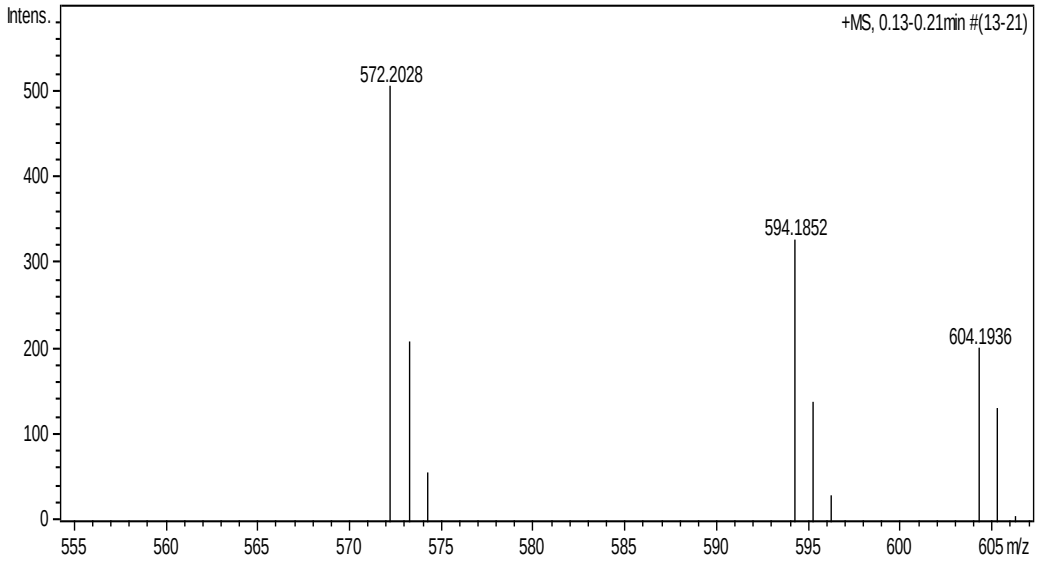

175.722
163.141
161.506
150.476
146.608
142.896
139.742
138.326
135.952
135.163
132.893
129.564
129.481
128.980
128.628
128.005
127.662
127.163
126.993
126.615
126.571
126.471
125.901
124.638
124.067
123.642
122.625
120.292
119.453
115.991
115.849
115.592
114.135
111.488
110.227
52.714
43.663
20.794
50000
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.15-0.50min #(15-51)
572.2014
594.1852
617.2605
612.1730
540.5356
250
200
150
100
50
0
540
550
560
570
580
590
600
610
620
m/z

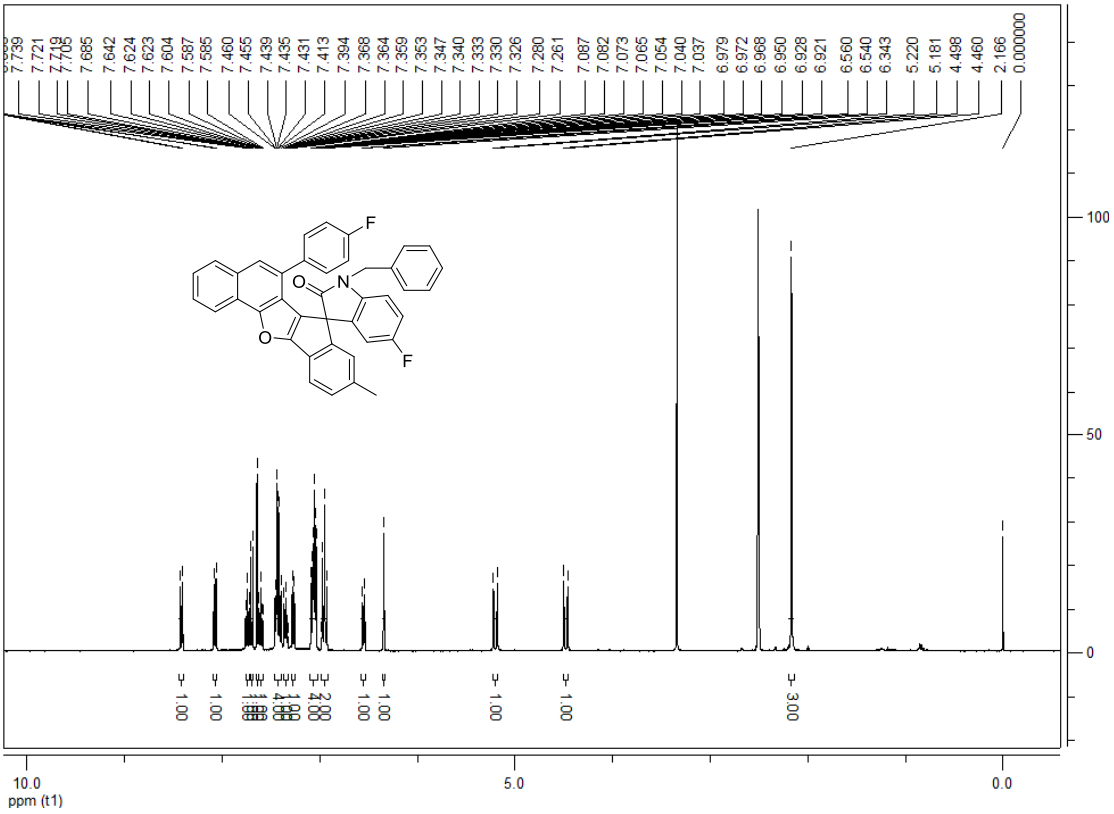
1'-benzyl-6-(4-fluorophenyl)-9-methylspiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4q): white solid, 36%, 0.102 g, m.p. 252-254℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.45 (d, *J* = 8.4 Hz, 1H, ArH), 7.87 (d, *J* = 8.4 Hz, 1H, ArH), 7.65-7.59 (m, 2H, ArH), 7.51-7.47 (m, 1H, ArH), 7.43-7.40 (m, 3H, ArH), 7.37-7.30 (m, 3H, ArH), 7.18-7.13 (m, 2H, ArH), 7.01-6.97 (m, 2H, ArH), 6.79 (t, *J* = 7.6 Hz, 1H, ArH), 6.73-6.69 (m, 3H, ArH), 6.57 (d, *J* = 7.2 Hz, 1H, ArH), 6.50 (s, 1H, ArH), 5.33 (d, *J* = 15.2 Hz, 1H, CH), 4.11 (d, *J* = 15.2 Hz, 1H, CH), 2.20 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.9, 163.8, 162.1.7 (d, *J* = 243.8 Hz), 154.6, 150.1, 143.5, 137.1, 136.2, 136.0, 136.0, 132.2, 130.8, 130.0 (d, *J* = 8.1 Hz), 129.6, 129.0, 128.7, 128.3 (d, *J* = 6.7 Hz), 127.8, 126.5, 125.4, 123.8, 123.7, 123.4, 122.9, 122.7, 121.3, 121.1, 119.8, 117.9, 114.3 (d, *J* = 21.1 Hz), 109.1, 57.3, 44.1, 21.5; IR (KBr) υ: 3057, 2946, 2833, 1714, 1595, 1534, 1492, 1441, 1337, 1279, 1228, 1181, 1085, 1021, 976, 918, 814, 744, 699 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{27}FNO_3$ ($[M+H]^+$): 572.2020. Found: 572.2028.

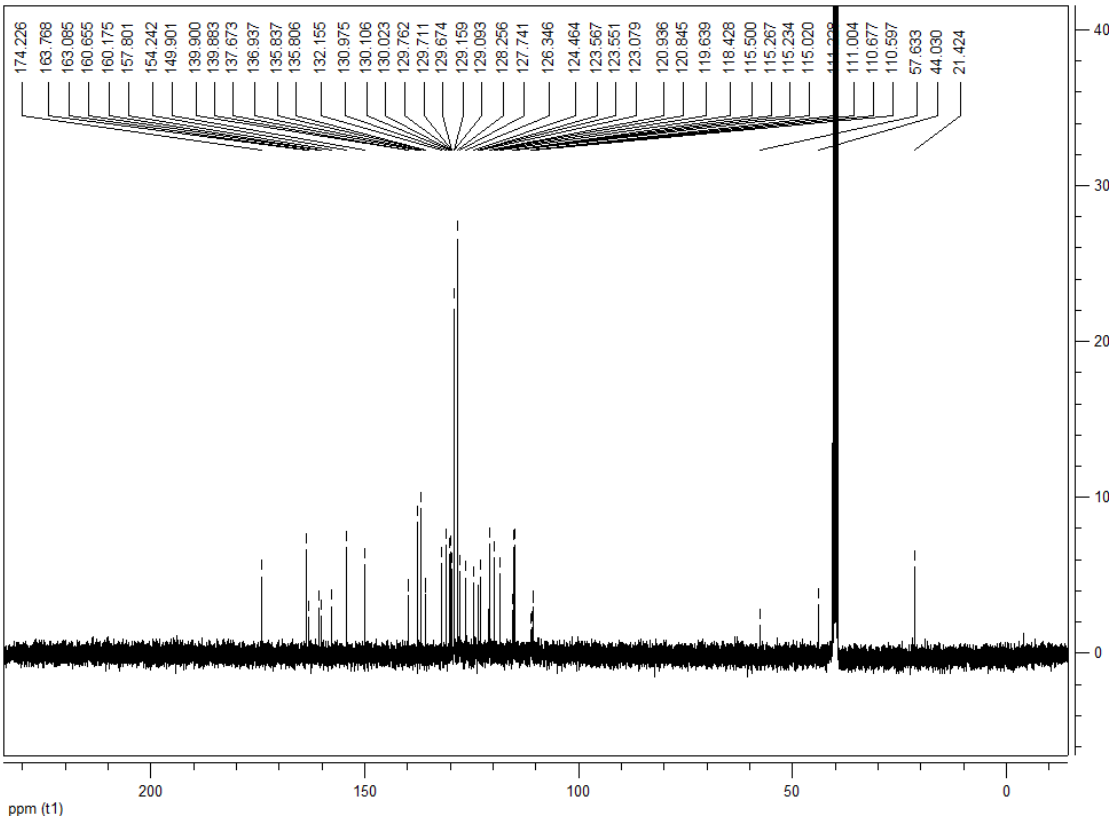


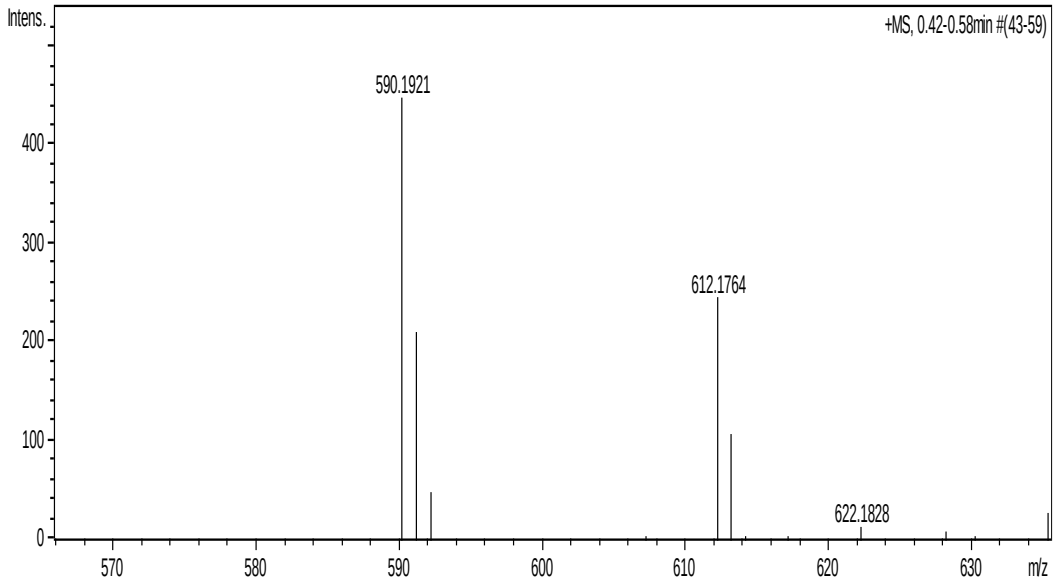

174.941
163.883
162.906
160.468
154.616
150.172
143.570
137.103
136.283
136.081
136.049
132.280
130.819
130.045
129.964
129.610
129.052
128.769
128.356
128.289
127.890
126.582
125.435
123.848
123.781
123.422
122.939
122.759
121.367
121.107
119.862
117.923
114.401
114.190
109.198
57.321
44.149
21.537
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.13-0.21min #(13-21)
572.2028
594.1852
604.1936
500
400
300
200
100
0
555
560
565
570
575
580
585
590
595
600
605 m/z

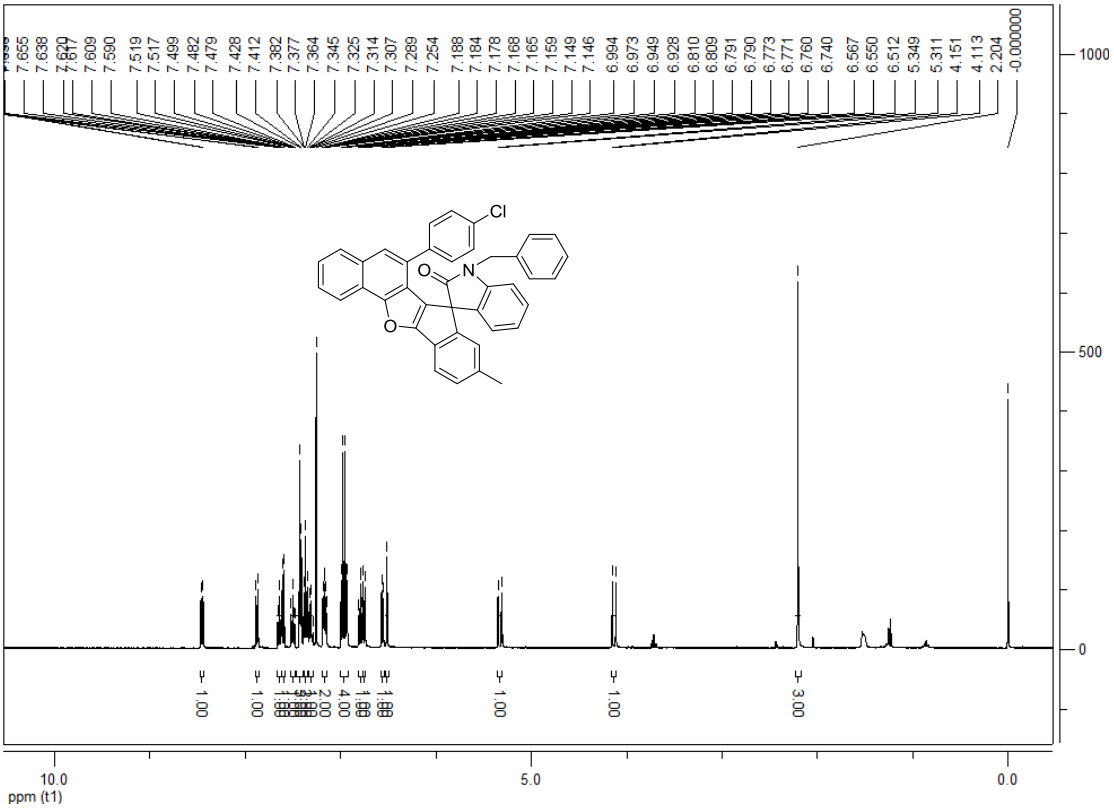
1'-benzyl-5'-fluoro-6-(4-fluorophenyl)-9-methylspiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4r): white solid, 43%, 0.126 g, m.p. 240-242℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.42 (d, *J* = 8.0 Hz, 1H, ArH), 8.07 (d, *J* = 8.4 Hz, 1H, ArH), 7.76-7.72 (m, 1H, ArH), 7.70 (d, *J* = 8.0 Hz, 1H, ArH), 7.64 (s, 1H, ArH), 7.62-7.59 (m, 1H, ArH), 7.46-7.39 (m, 4H, ArH), 7.37-7.33 (m, 1H, ArH), 7.27 (d, *J* = 7.6 Hz, 1H, ArH), 7.09-7.04 (m, 4H, ArH), 6.98-6.92 (m, 2H, ArH), 6.56-6.54 (m, 1H, ArH), 6.34 (s, 1H, ArH), 5.20 (d, *J* = 15.6 Hz, 1H, CH), 4.48 (d, *J* = 15.2 Hz, 1H, CH), 2.17 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 174.2, 163.7, 161.9 (d, *J* = 243.0 Hz), 160.0 (d, *J* = 237.4 Hz), 154.2, 149.9, 139.9 (d, *J* = 1.7 Hz), 137.6, 136.9, 135.8 (d, *J* = 3.1 Hz), 132.1, 130.9, 130.1, 130.0, 129.7, 129.7, 129.6, 129.1, 129.0, 128.2, 127.7, 126.3, 124.4, 123.5, 123.5, 123.0, 120.9, 120.8, 119.6, 118.4, 115.4 (d, *J* = 23.3 Hz), 115.1 (d, *J* = 21.4 Hz), 111.1 (d, *J* = 22.4 Hz), 110.6, 110.5, 57.6, 44.0, 21.4; IR (KBr) υ: 3040, 2955, 2915, 1717, 1606, 1495, 1348, 1232, 1171, 1072, 1018, 822, 745, 694 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{26}F_2NO_2$ ([M+H]$^+$): 590.1926. Found: 590.1921.

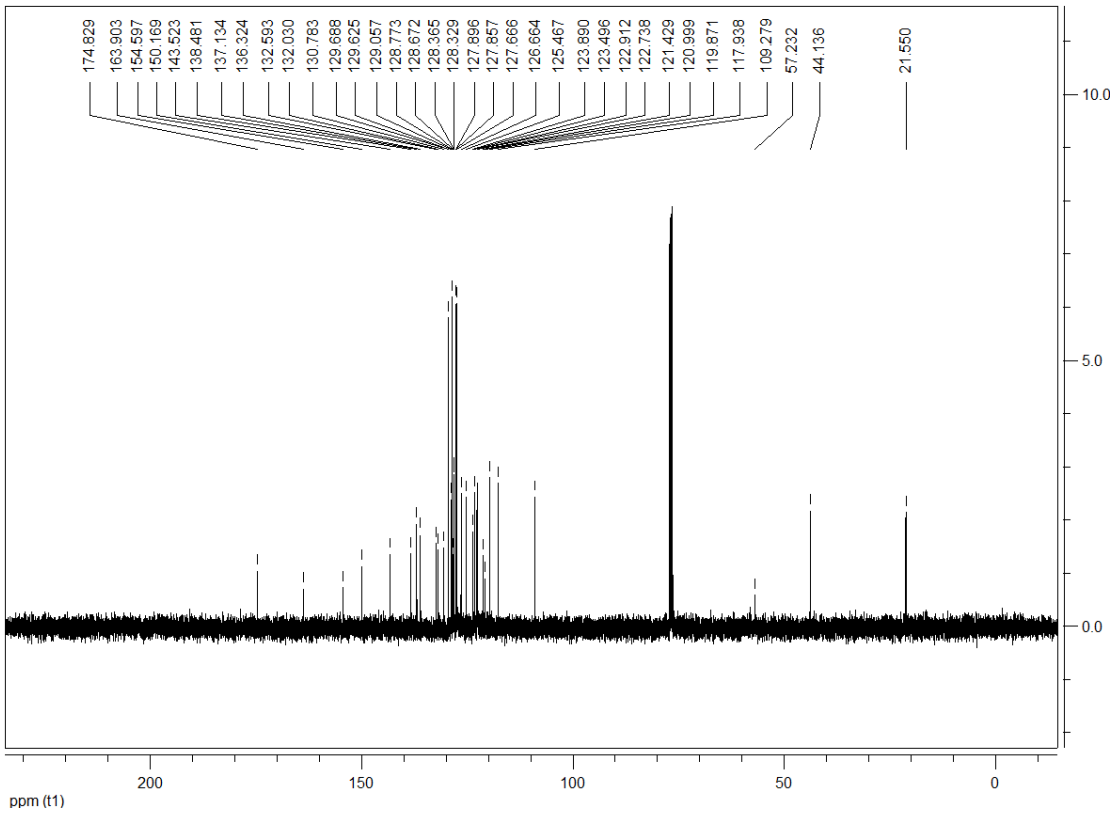


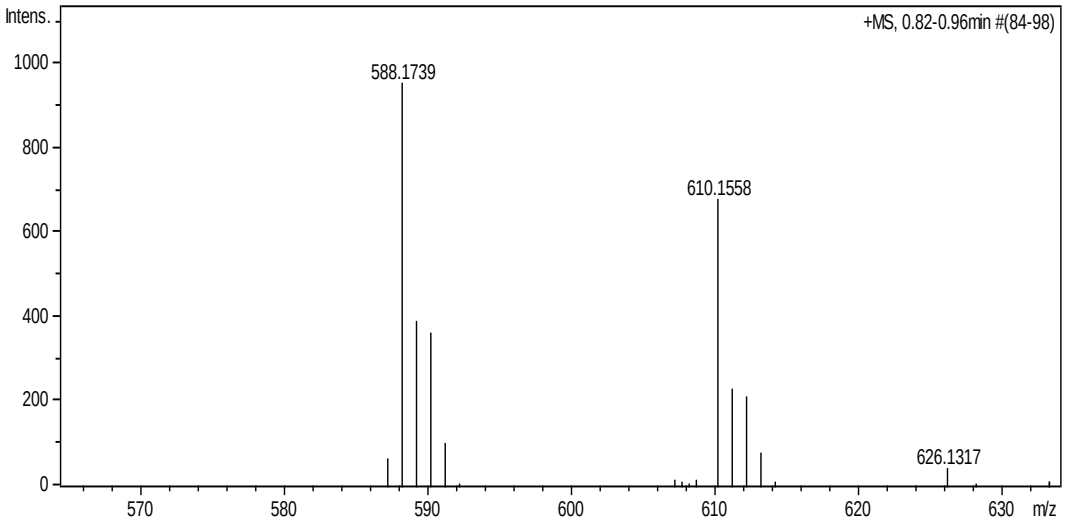

174.226
163.768
163.085
160.655
160.175
157.801
154.242
149.901
139.900
139.883
137.673
136.937
135.837
135.806
132.155
130.975
130.106
130.023
129.762
129.711
129.674
129.159
129.093
128.256
127.741
126.346
124.464
123.567
123.551
123.079
120.936
120.845
119.639
118.428
115.500
115.267
115.234
115.020
111.004
110.677
110.597
57.633
44.030
21.424
40
30
20
10
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.42-0.58min #(43-59)
590.1921
612.1764
622.1828
400
300
200
100
0
570
580
590
600
610
620
630
m/z

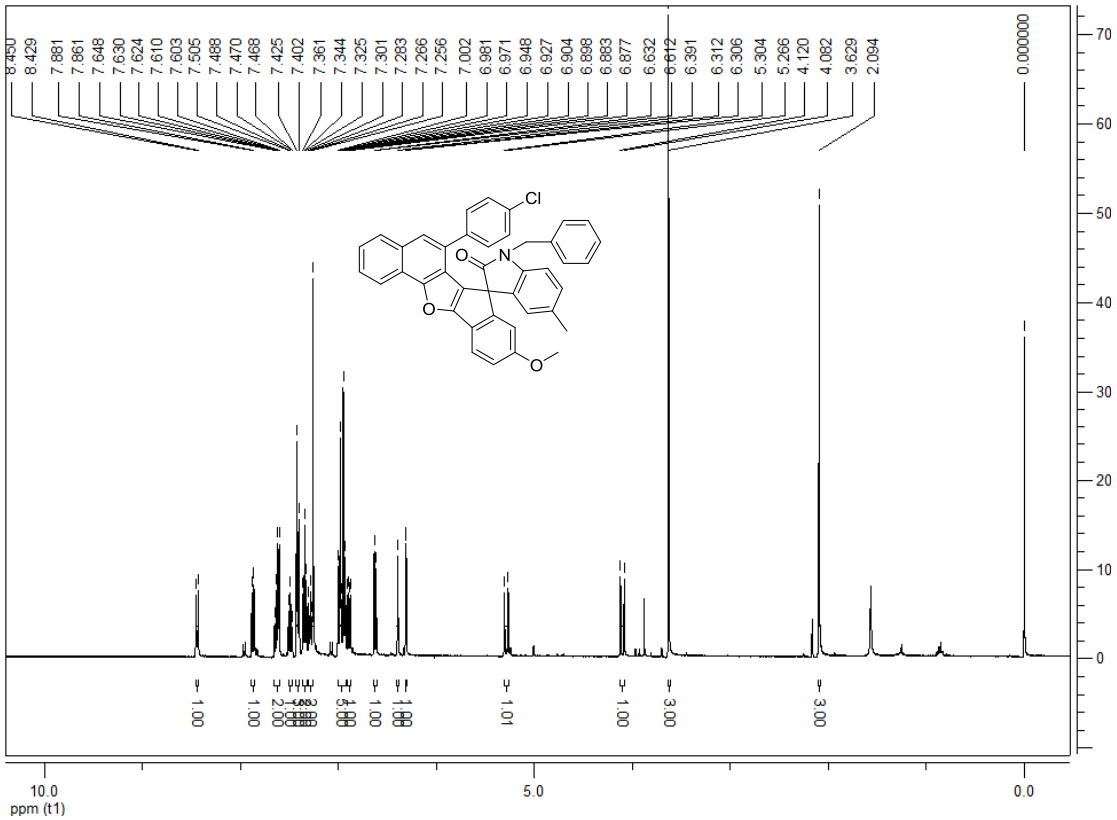
1'-benzyl-6-(4-chlorophenyl)-9-methylspiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4s): white solid, 51%, 0.150 g, m.p. 241-243℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.45 (d, *J* = 8.0 Hz, 1H, ArH), 7.87 (d, *J* = 8.4 Hz, 1H, ArH), 7.66-7.62 (m, 1H, ArH), 7.60 (d, *J* = 7.6 Hz, 1H, ArH), 7.52-7.48 (m, 1H, ArH), 7.43-7.41 (m, 3H, ArH), 7.38-7.35 (m, 2H, ArH), 7.33-7.29 (m, 1H, ArH), 7.19-7.15 (m, 2H, ArH), 6.99-6.93 (m, 4H, ArH), 6.81-6.77 (m, 1H, ArH), 6.75 (d, *J* = 8.0 Hz, 1H, ArH), 6.56 (d, *J* = 6.8 Hz, 1H, ArH), 6.51 (s, 1H, ArH), 5.33 (d, *J* = 15.2 Hz, 1H, CH), 4.13 (d, *J* = 15.2 Hz, 1H, CH), 2.20 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.8, 163.9, 154.5, 150.1, 143.5, 138.4, 137.1, 136.3, 132.5, 132.0, 130.7, 129.6, 129.6, 129.0, 128.7, 128.6, 128.3, 128.3, 127.8, 127.8, 127.6, 126.6, 125.4, 123.8, 123.4, 122.9, 122.7, 121.4, 120.9, 119.8, 117.9, 109.2, 57.2, 44.1, 21.6; IR (KBr) υ: 3055, 2945, 2834, 1714, 1598, 1535, 1491, 1441, 1338, 1279, 1229, 1181, 1125, 1082, 1023, 976, 919, 813, 744, 698 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{27}ClNO_3$ ([M+H]$^+$): 588.1725. Found: 588.1739.

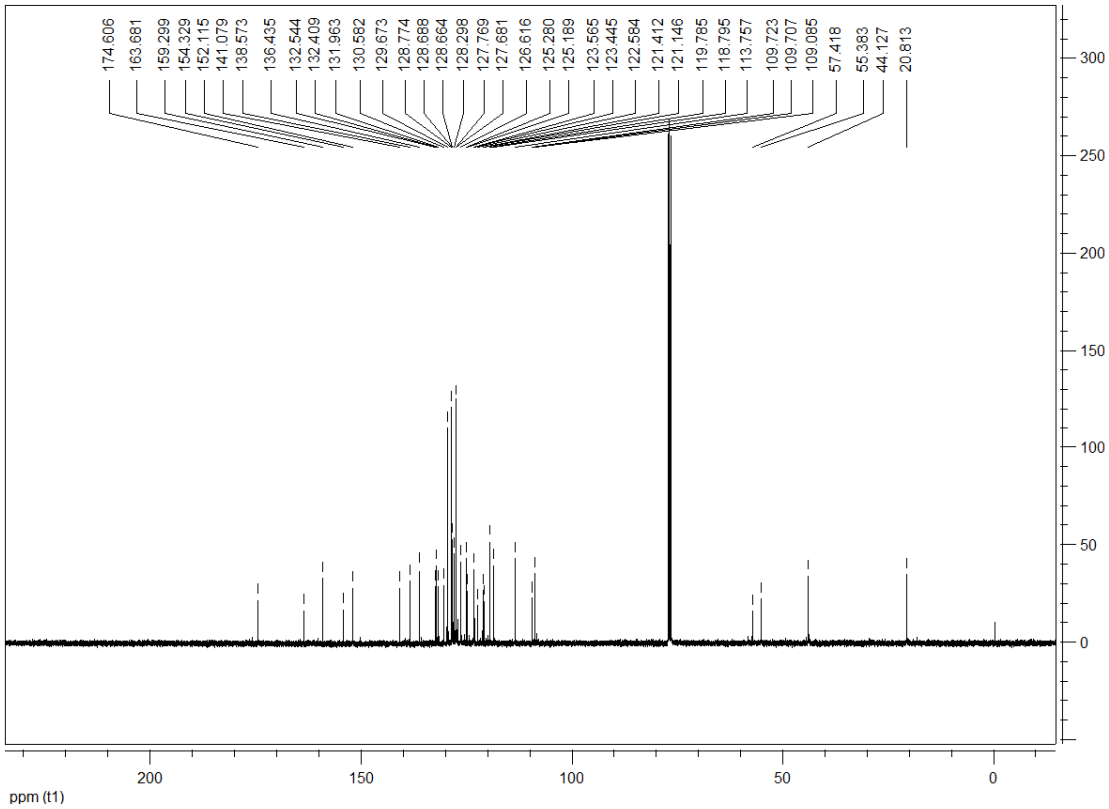


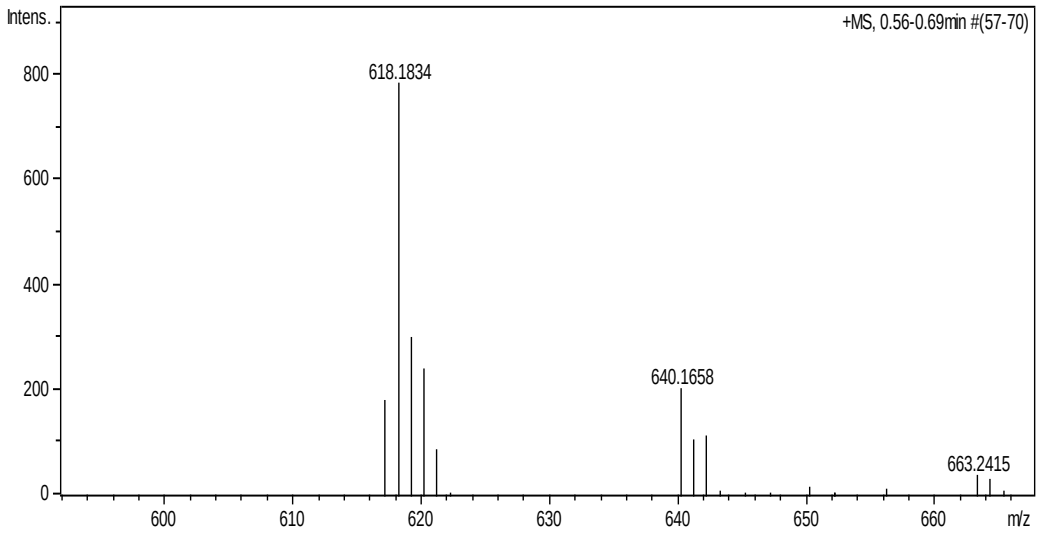

174.829
163.903
154.597
150.169
143.523
138.481
137.134
136.324
132.593
132.030
130.783
129.688
129.625
129.057
128.773
128.672
128.365
128.329
127.896
127.857
127.666
126.664
125.467
123.890
123.496
122.912
122.738
121.429
120.999
119.871
117.938
109.279
57.232
44.136
21.550
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.82-0.96min #(84-98)
1000
800
600
400
200
0
588.1739
610.1558
626.1317
570
580
590
600
610
620
630
m/z

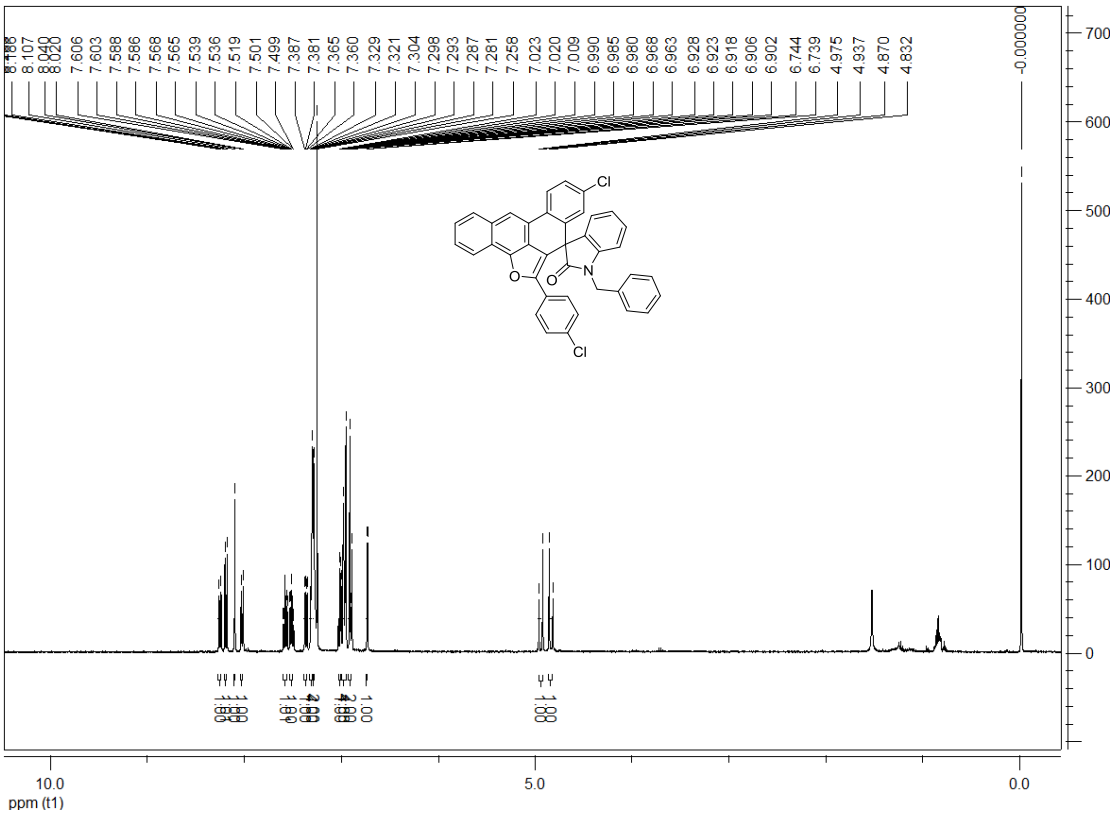
1'-benzyl-6-(4-chlorophenyl)-9-methoxy-5'-methylspiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4t): white solid, 62%, 0.191 g, m.p. 230-232℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.44 (d, *J* = 8.4 Hz, 1H, ArH), 7.87 (d, *J* = 8.0 Hz, 1H, ArH), 7.65-7.60 (m, 2H, ArH), 7.51-7.47 (m, 1H, ArH), 7.43-7.40 (m, 3H, ArH), 7.36-7.33 (m, 2H, ArH), 7.30-7.27 (m, 2H, ArH), 7.00-6.93 (m, 5H, ArH), 6.89 (dd, J_1 = 8.4 Hz, J_2 = 2.4 Hz, 1H, ArH), 6.62 (d, *J* = 8.0 Hz, 1H, ArH), 6.31 (d, *J* = 2.4 Hz, 1H, ArH), 5.29 (d, *J* = 15.2 Hz, 1H, CH), 4.10 (d, *J* = 15.2 Hz, 1H, CH), 3.63 (s, 3H, OCH_3), 2.09 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.6, 163.6, 159.2, 154.3, 152.1, 141.0, 138.5, 136.4, 132.5, 132.4, 131.9, 130.5, 129.6, 128.7, 128.6, 128.6, 128.2, 127.7, 127.6, 126.6, 125.2, 125.1, 123.5, 123.4, 122.5, 121.4, 121.1, 119.7, 118.7, 113.7, 109.7, 109.7, 109.0, 57.4, 55.3, 44.1, 20.8; IR (KBr) υ: 3057, 2946, 2832, 1715, 1596, 1534, 1492, 1440, 1338, 1278, 1229, 1180, 1126, 1084, 1021, 974, 917, 814, 745, 696 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{41}H_{29}ClNO_3$ ($[M+H]^+$): 618.1830. Found: 618.1834.

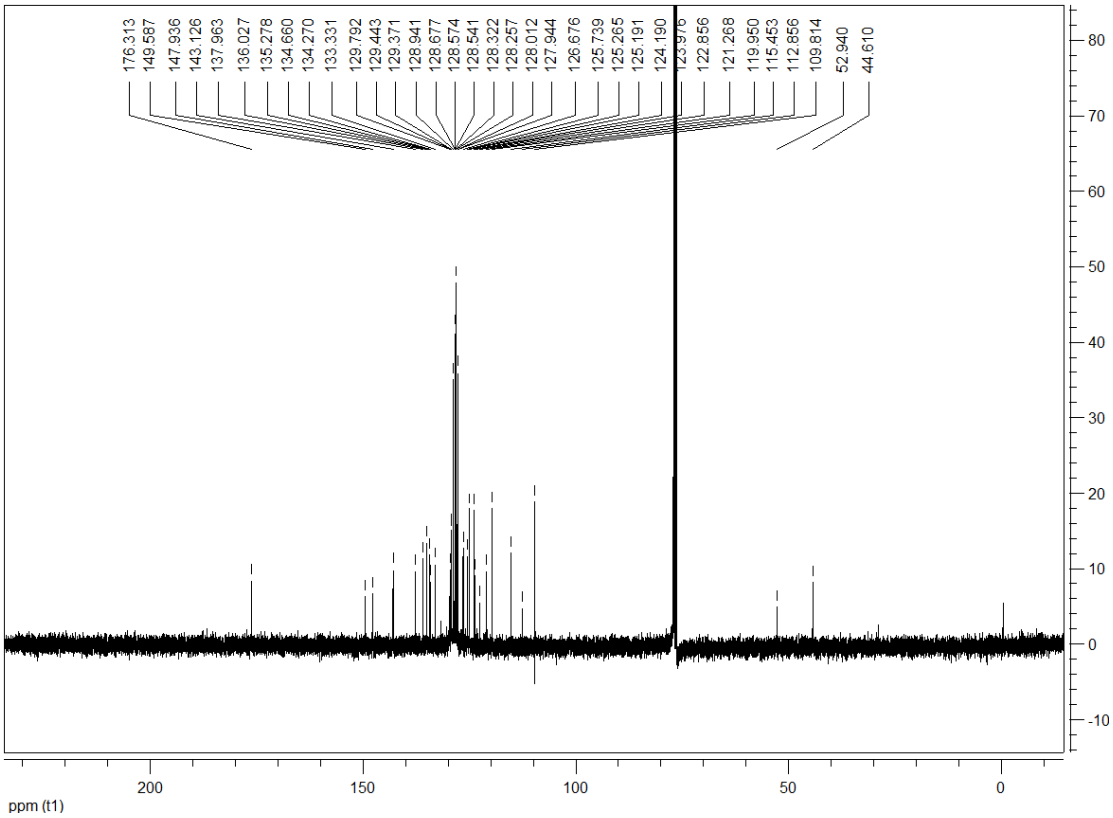


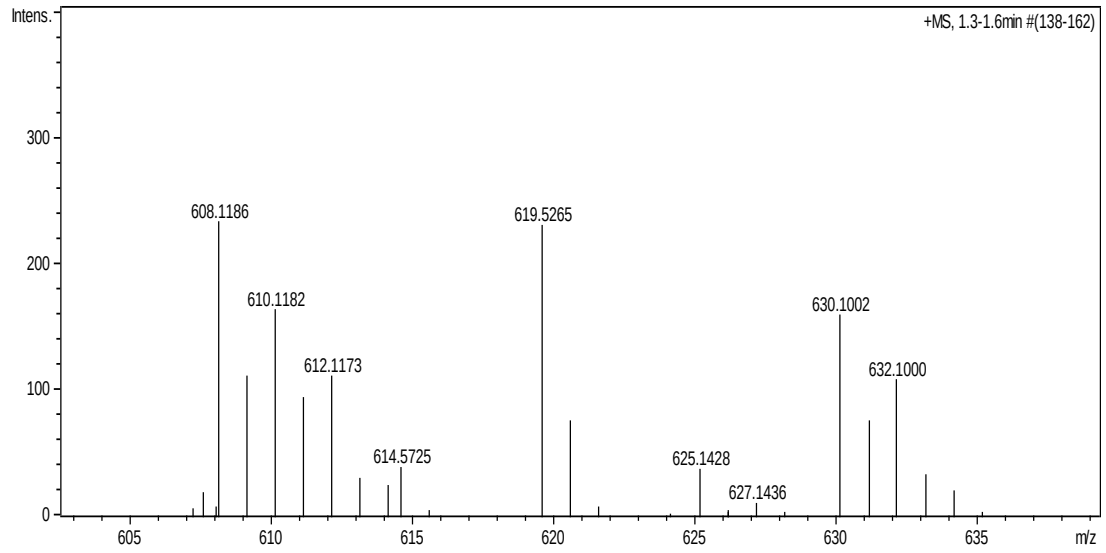

174.606
163.681
159.299
154.329
152.115
141.079
138.573
136.435
132.544
132.409
131.963
130.582
129.673
128.774
128.688
128.664
128.298
127.769
127.681
126.616
125.280
125.189
123.565
123.445
122.584
121.412
121.146
119.785
118.795
113.757
109.723
109.707
109.085
57.418
55.383
44.127
20.813
300
250
200
150
100
50
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.56-0.69min #(57-70)
618.1834
640.1658
663.2415
800
600
400
200
0
600
610
620
630
640
650
660
m/z

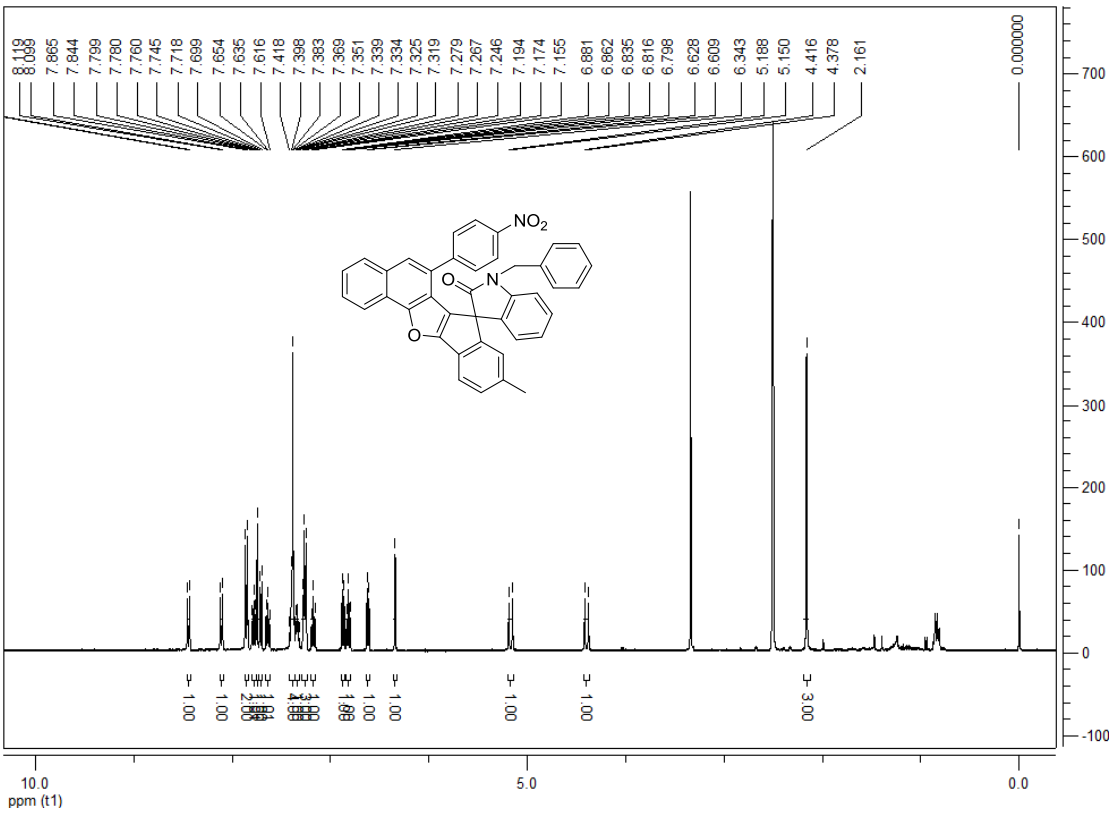
1-benzyl-9'-chloro-6'-(4-chlorophenyl)spiro[indoline-3,7'-tetrapheno[7,6-*bc*]furan]-2-one (3u): white solid, 5%, 0.121 g, m.p. 224-226℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.26 (d, *J* = 8.4 Hz, 1H, ArH), 8.20 (d, *J* = 8.4 Hz, 1H, ArH), 8.11 (s, 1H, ArH), 8.03 (d, *J* = 8.0 Hz, 1H, ArH), 7.61-7.59 (m, 1H, ArH), 7.54-7.50 (m, 1H, ArH), 7.37 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.33-7.30 (m, 4H, ArH), 7.29-7.28 (m, 2H, ArH), 7.02-7.01 (m, 1H, ArH), 6.99-6.96 (m, 4H, ArH), 6.93-6.90 (m, 2H, ArH), 6.74 (d, *J* = 2.0 Hz, 1H, ArH), 4.96 (d, *J* = 15.2 Hz, 1H, CH), 4.85 (d, *J* = 15.2 Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 176.3, 149.5, 147.9, 143.1, 137.9, 136.0, 135.2, 134.6, 134.2, 133.3, 129.7, 129.4, 129.3, 128.9, 128.7, 128.6, 128.5, 128.3, 128.2, 128.0, 127.9, 126.6, 125.7, 125.2, 125.1, 124.1, 123.9, 122.8, 121.2, 119.9, 115.4, 112.8, 109.8, 52.9, 44.6; IR (KBr) υ: 3060, 2921, 2850, 1717, 1603, 1482, 1342, 1263, 1221, 1166, 1084, 1011, 941, 909, 830, 746, 704 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{39}H_{24}Cl_2NO_2$ ($[M+H]^+$): 608.1106. Found: 608.1186.

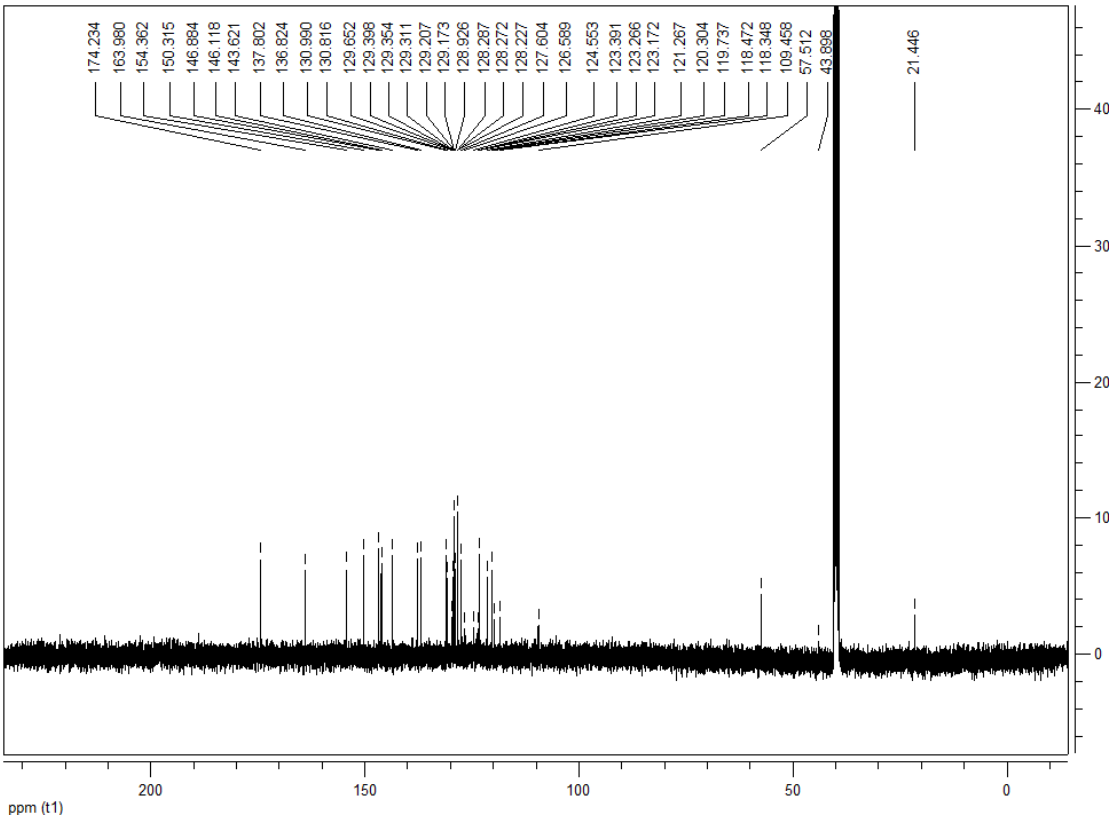


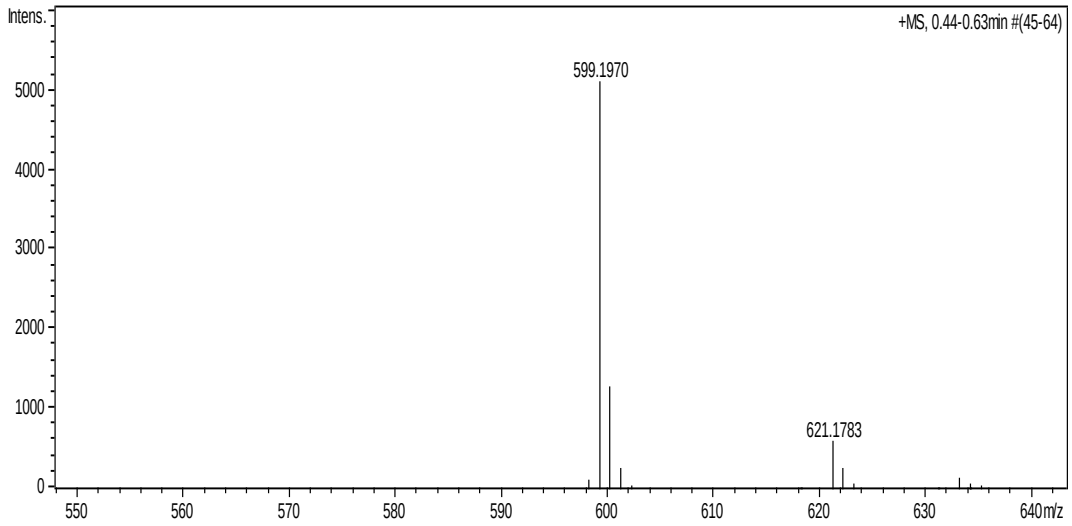

176.313
149.587
147.936
143.126
137.963
136.027
135.278
134.660
134.270
133.331
129.792
129.443
129.371
128.941
128.677
128.574
128.541
128.322
128.257
128.012
127.944
126.676
125.739
125.265
125.191
124.190
123.976
122.856
121.268
119.950
115.453
112.856
109.814
52.940
44.610
80
70
60
50
40
30
20
10
0
-10
200
150
100
50
0
ppm (t1)


Intens.
+MS, 1.3-1.6min #(138-162)
300
200
100
0
608.1186
610.1182
612.1173
614.5725
619.5265
625.1428
627.1436
630.1002
632.1000
605
610
615
620
625
630
635
m/z

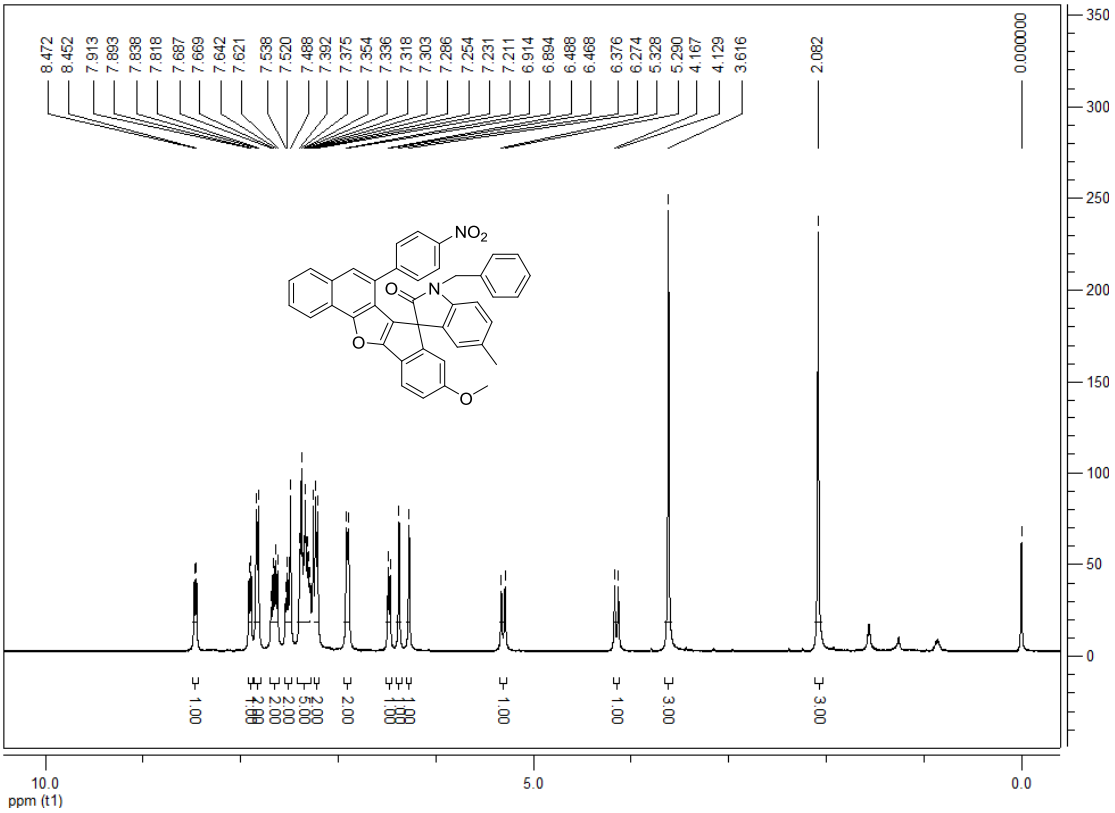
1'-benzyl-9-methyl-6-(4-nitrophenyl)spiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4v): Light yellow solid, 66%, 0.210 g, m.p. 226-228℃; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 8.44 (d, *J* = 8.0 Hz, 1H, ArH), 8.11 (d, *J* = 8.0 Hz, 1H, ArH), 7.85 (d, *J* = 8.4 Hz, 2H, ArH), 7.78 (t, *J* = 8.0 Hz, 1H, ArH), 7.75 (s, 1H, ArH), 7.71 (d, *J* = 7.6 Hz, 1H, ArH), 7.64 (d, *J* = 8.0 Hz, 1H, ArH), 7.42-7.37 (m, 4H, ArH), 7.35-7.32 (m, 1H, ArH), 7.28-7.25 (m, 3H, ArH), 7.17 (t, *J* = 8.0 Hz, 1H, ArH), 6.87 (d, *J* = 7.6 Hz, 1H, ArH), 6.82 (t, *J* = 7.6 Hz, 1H, ArH), 6.62 (d, *J* = 7.6 Hz, 1H, ArH), 6.34 (s, 1H, ArH), 5.17 (d, *J* = 15.2 Hz, 1H, CH), 4.40 (d, *J* = 15.2 Hz, 1H, CH), 2.16 (s, 3H, CH_3); ^{13}C NMR (100 MHz, DMSO-d_6) δ: 174.2, 163.9, 154.3, 150.3, 146.8, 146.1, 143.6, 137.8, 136.8, 130.9, 130.8, 129.6, 129.3, 129.3, 129.3, 129.2, 129.1, 128.9, 128.2, 128.2, 128.2, 127.6, 126.5, 124.5, 123.3, 123.2, 123.1, 121.2, 120.3, 119.7, 118.4, 118.3, 109.4, 57.5, 43.8, 21.4; IR (KBr) υ: 3056, 2950, 1717, 1602, 1518, 1481, 1343, 1171, 1106, 1068, 1018, 977, 911, 851, 749 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{40}H_{27}N_2O_4$ ([M+H]$^+$): 599.1965. Found: 599.1970.

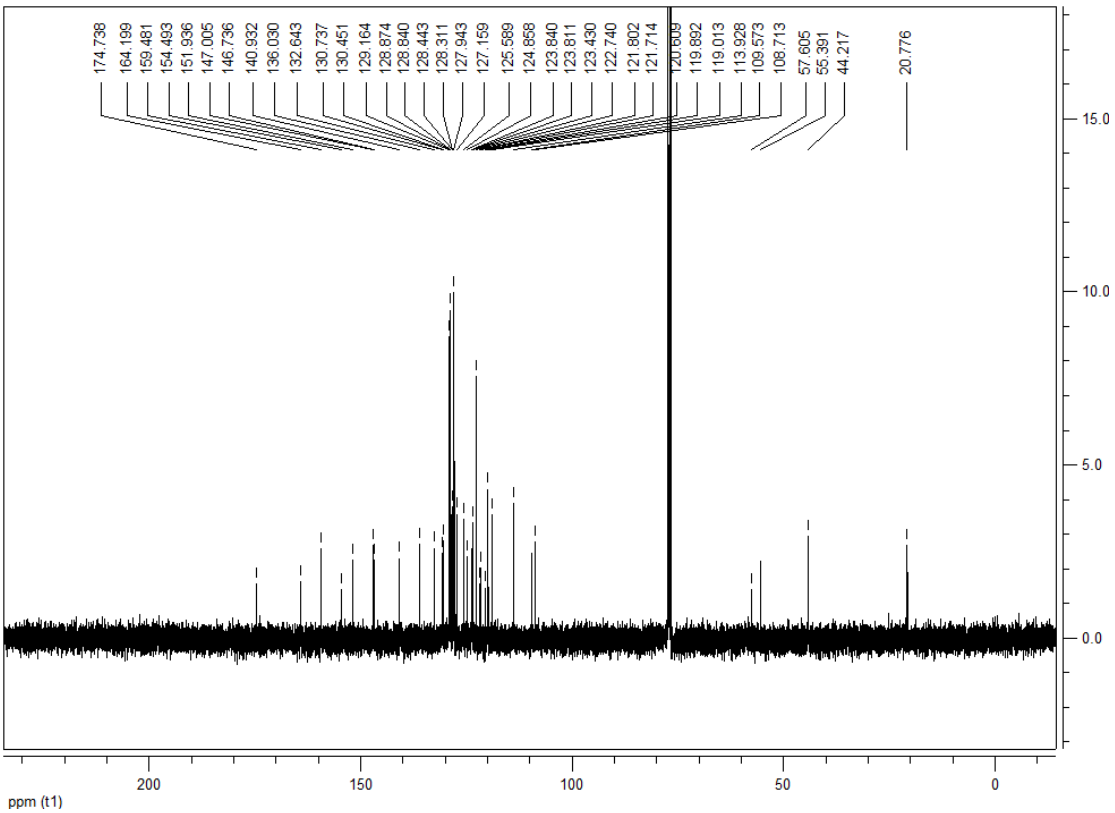


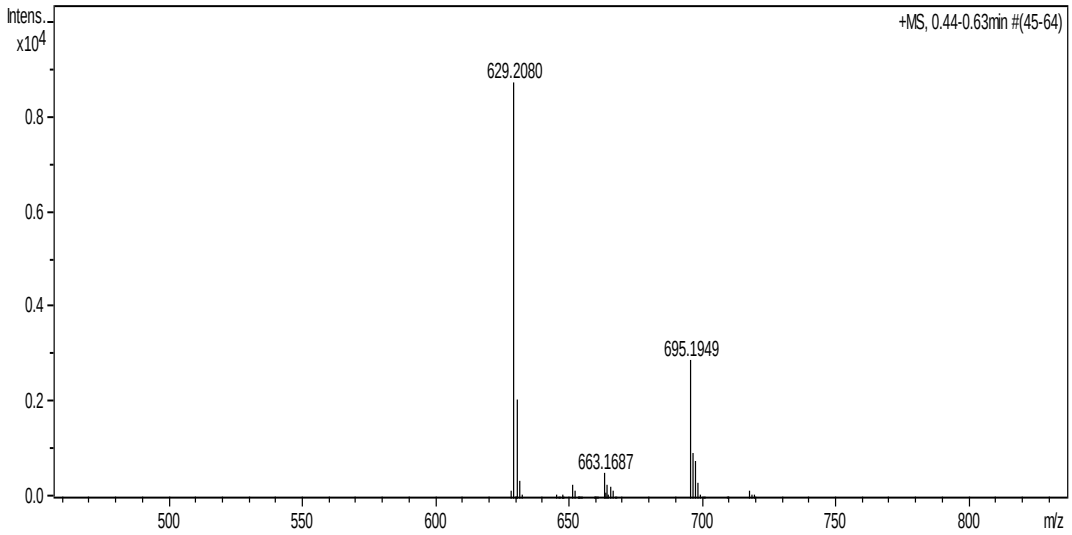

174.234
163.980
154.362
150.315
146.884
146.118
143.621
137.802
136.824
130.990
130.816
129.652
129.398
129.354
129.311
129.207
129.173
128.926
128.287
128.272
128.227
127.604
126.589
124.553
123.391
123.266
123.172
121.267
120.304
119.737
118.472
118.348
109.458
57.512
43.898
21.446
40
30
20
10
0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.44-0.63min #(45-64)
599.1970
621.1783
5000
4000
3000
2000
1000
0
550
560
570
580
590
600
610
620
630
640m/z

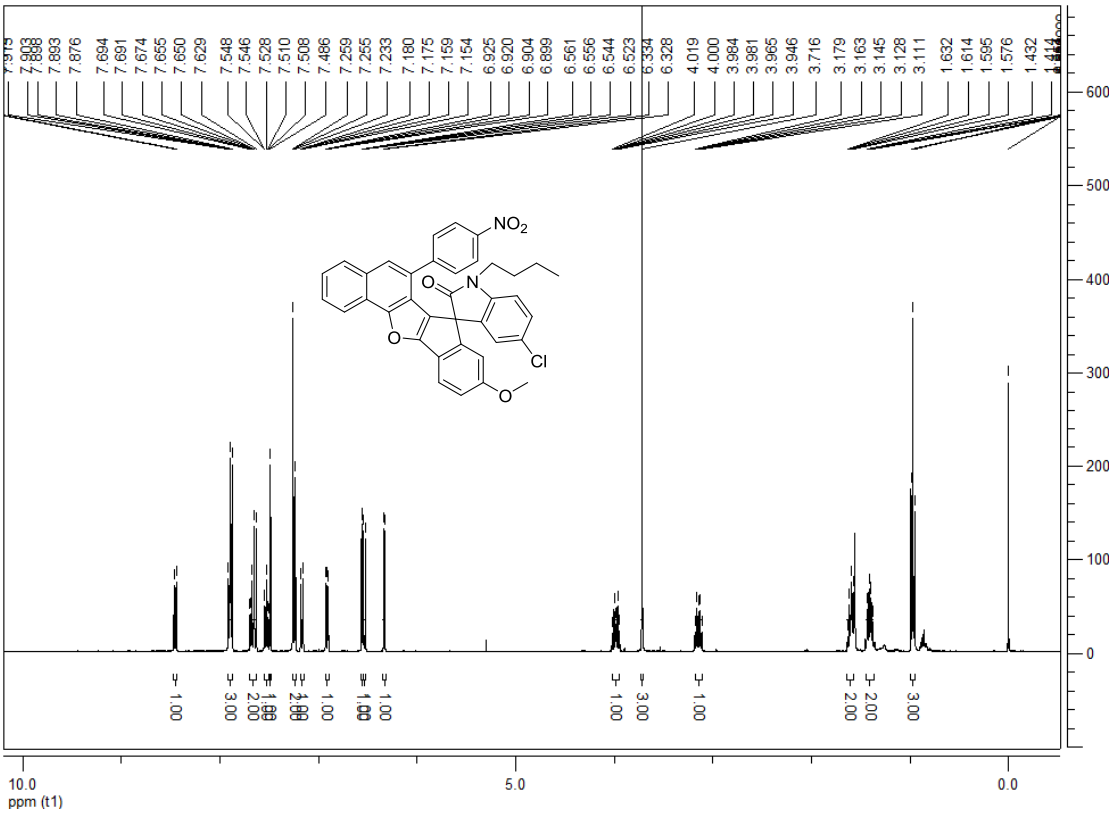
1'-benzyl-9-methoxy-5'-methyl-6-(4-nitrophenyl)spiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4w): Light yellow solid, 59%, 0.197 g, m.p. 239-241℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.46 (d, *J* = 8.0 Hz, 1H, ArH), 7.90 (d, *J* = 8.0 Hz, 1H, ArH), 7.83 (d, *J* = 8.0 Hz, 2H, ArH), 7.69-7.62 (m, 2H, ArH), 7.54-7.49 (m, 2H, ArH), 7.39-7.29 (m, 5H, ArH), 7.22 (d, *J* = 8.0 Hz, 2H, ArH), 6.90 (d, *J* = 8.0 Hz, 2H, ArH), 6.48 (d, *J* = 8.0 Hz, 1H, ArH), 6.38 (s, 1H, ArH), 6.27 (s, 1H, ArH), 5.31 (d, *J* = 15.2 Hz, 1H, CH), 4.15 (d, *J* = 15.2 Hz, 1H, CH), 3.62 (s, 3H, OCH_3), 2.08 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.7, 164.1, 159.4, 154.4, 151.9, 147.0, 146.7, 140.9, 136.0, 132.6, 130.7, 130.4, 129.1, 128.9, 128.8, 128.4, 128.3, 127.9, 127.1, 125.5, 124.8, 123.9, 123.8, 123.4, 122.7, 121.8, 121.7, 120.6, 119.8, 119.0, 113.9, 109.5, 108.7, 57.6, 55.3, 44.2, 20.7; IR (KBr) υ: 3069, 2943, 2869, 1717, 1597, 1521, 1481, 1432, 1344, 1276, 1228, 1185, 1112, 1071, 1025, 923, 852, 816, 747, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{41}H_{29}N_2O_5$ ($[M+H]^+$): 629.2071. Found: 629.2080.

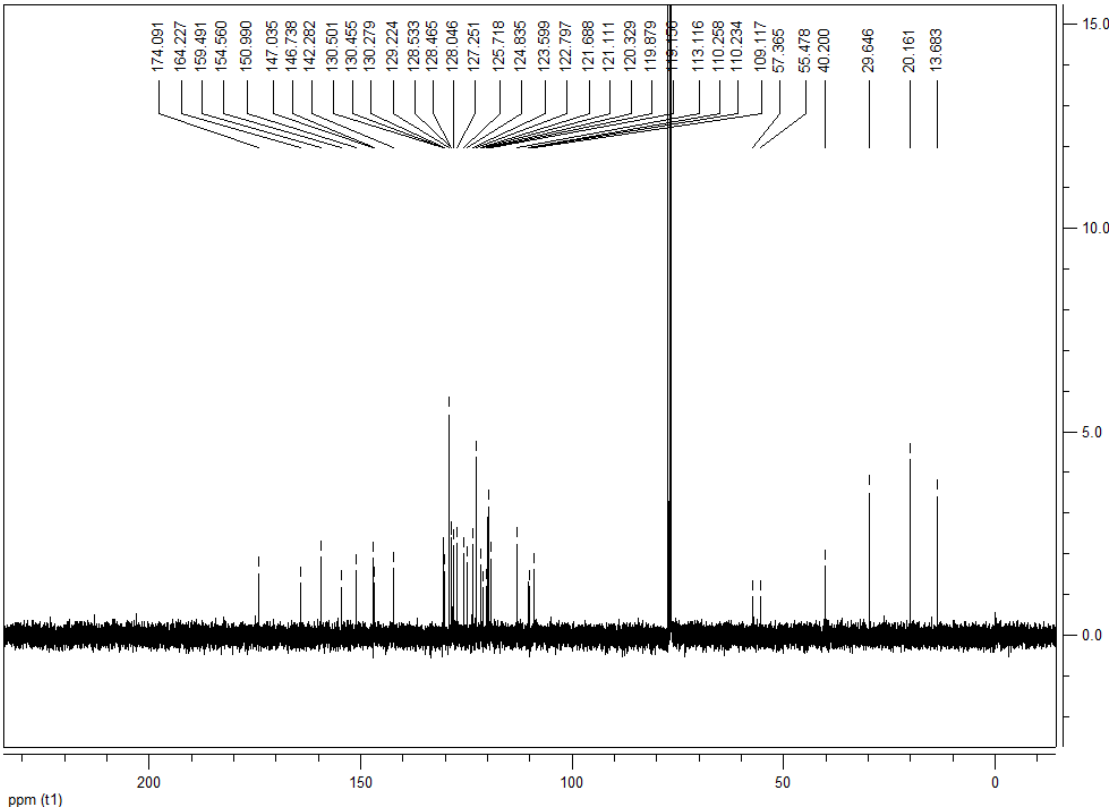


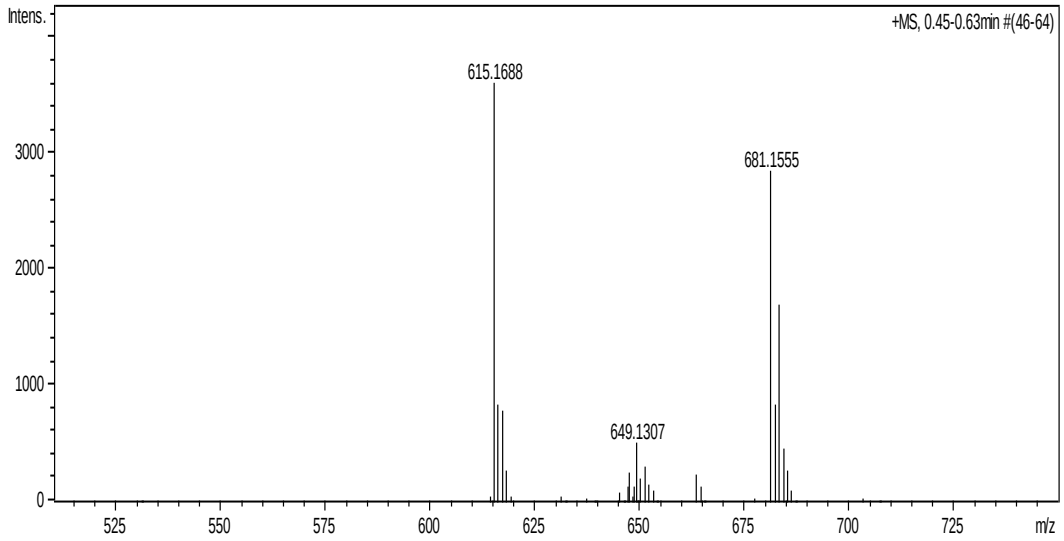

174.738
164.199
159.481
154.493
151.936
147.005
146.736
140.932
136.030
132.643
130.737
130.451
129.164
128.874
128.840
128.443
128.311
127.943
127.159
125.589
124.858
123.840
123.811
123.430
122.740
121.802
121.714
120.609
119.892
119.013
113.928
109.573
108.713
57.605
55.391
44.217
20.776
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
x10^4
+MS, 0.44-0.63min #(45-64)
629.2080
695.1949
663.1687
0.8
0.6
0.4
0.2
0.0
500
550
600
650
700
750
800
m/z

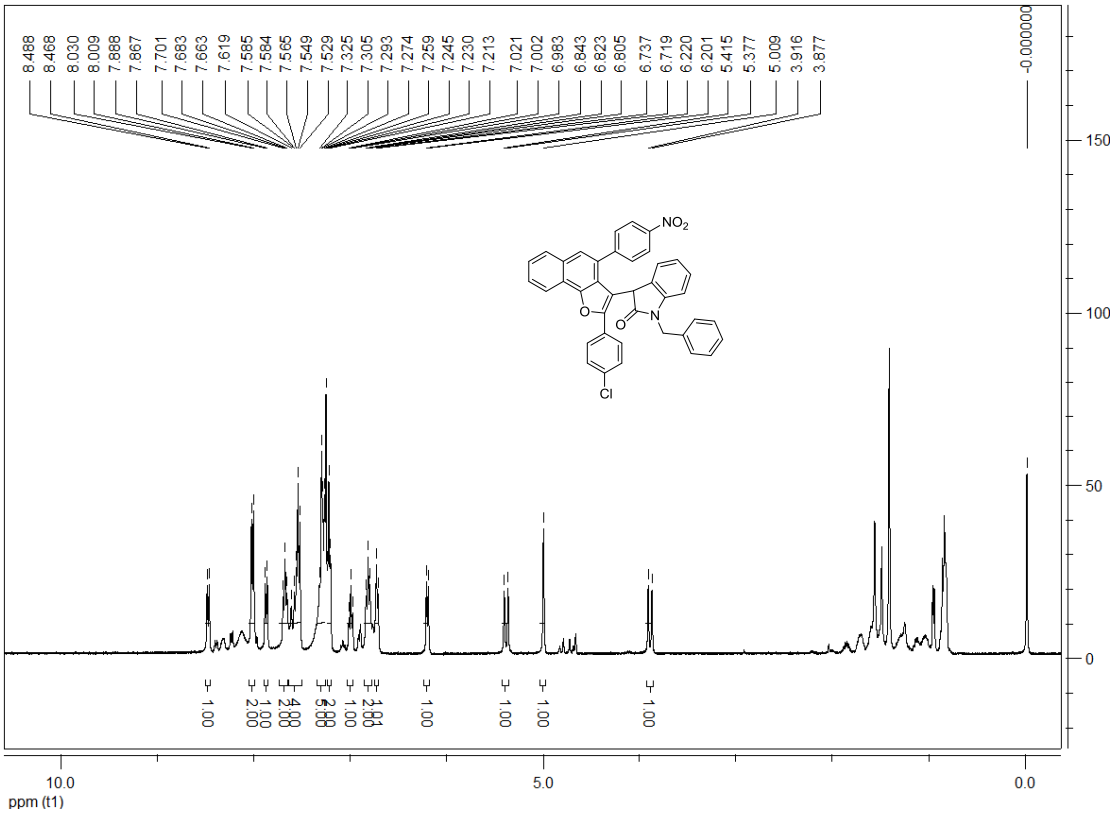
1'-butyl-5'-chloro-9-methoxy-6-(4-nitrophenyl)spiro[indeno[1,2-*b*]naphtho[2,1-*d*]furan-7,3'-indolin]-2'-one (4x): Light yellow solid, 55%, 0.179 g, m.p. 218-220℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.45 (d, *J* = 8.4 Hz, 1H, ArH), 7.91-7.88 (m, 3H, ArH), 7.69-7.63 (m, 2H, ArH), 7.55-7.51 (m, 1H, ArH), 7.49 (s, 1H, ArH), 7.25-7.23 (m, 2H, ArH), 7.17 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 1H, ArH), 6.91 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 1H, ArH), 6.56 (d, *J* = 2.0 Hz, 1H, ArH), 6.53 (d, *J* = 8.4 Hz, 1H, ArH), 6.33 (d, *J* = 2.4 Hz, 1H, ArH), 4.02-3.95 (m, 1H, CH), 3.72 (s, 3H, OCH_3), 3.18-3.11 (m, 1H, CH), 1.63-1.58 (m, 2H, CH), 1.43-1.37 (m, 2H, CH), 0.97 (t, *J* = 7.6 Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.0, 164.2, 159.4, 154.5, 150.9, 147.0, 146.7, 142.2, 130.5, 130.4, 130.2, 129.2, 128.5, 128.4, 128.0, 127.2, 125.7, 124.8, 123.5, 122.7, 121.6, 121.1, 120.3, 119.8, 119.1, 113.1, 110.2, 110.2, 109.1, 57.3, 55.4, 40.1, 29.6, 20.1, 13.6; IR (KBr) υ: 3069, 2943, 2869, 1717, 1597, 1521, 1481, 1432, 1344, 1276, 1228, 1185, 1112, 1071, 1025, 923, 852, 816, 747, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{37}H_{28}ClN_2O_5$ ($[M+H]^+$): 615.6181. Found: 615.6188.

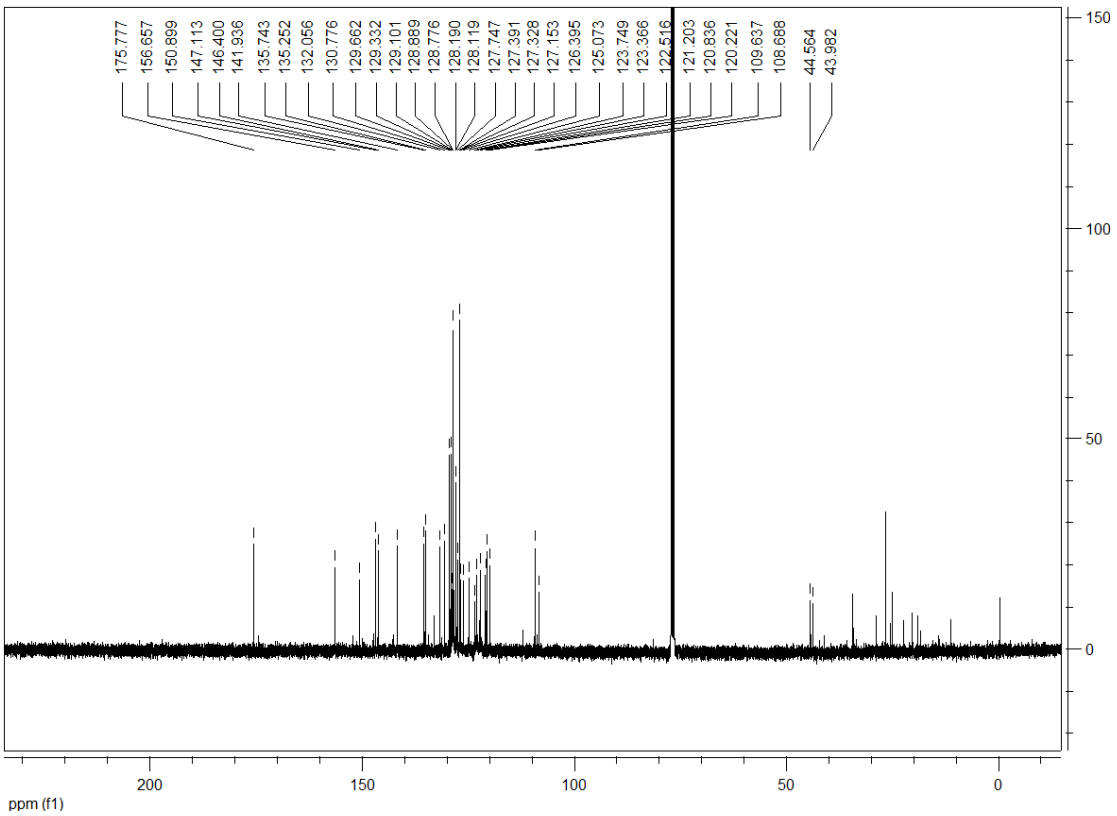


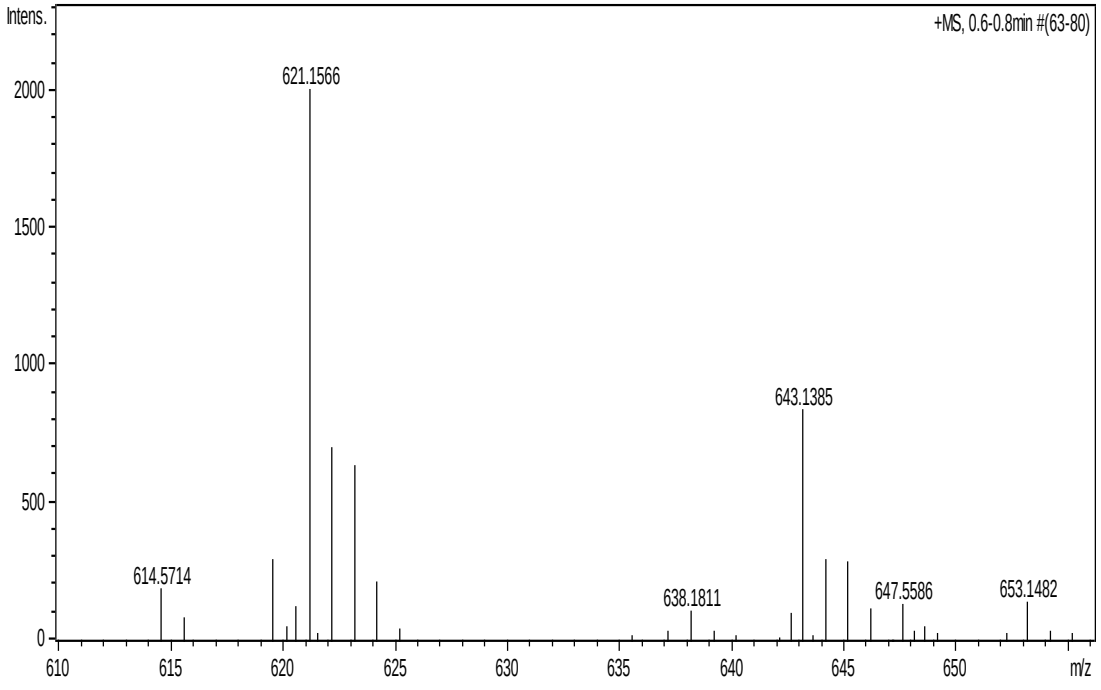

174.091
164.227
159.491
154.560
150.990
147.035
146.738
142.282
130.501
130.455
130.279
129.224
128.533
128.465
128.046
127.251
125.718
124.835
123.599
122.797
121.688
121.111
120.329
119.879
113.116
110.258
110.234
109.117
57.365
55.478
40.200
29.646
20.161
13.683
15.0
10.0
5.0
0.0
200
150
100
50
0
ppm (t1)


Intens.
+MS, 0.45-0.63min #(46-64)
615.1688
681.1555
649.1307
3000
2000
1000
0
525
550
575
600
625
650
675
700
725
m/z

1-benzyl-3-(2-(4-chlorophenyl)-4-(4-nitrophenyl)naphtho[1,2-*b*]furan-3-yl)indolin-2-one (G): orange solid, 6%, 0.149 g, m.p. 208-210℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.48 (d, *J* = 8.0 Hz, 1H, ArH), 8.02 (d, *J* = 8.4 Hz, 2H, ArH), 7.88 (d, *J* = 8.4 Hz, 1H, ArH), 7.68 (t, *J* = 7.6 Hz, 2H, ArH), 7.62-7.53 (m, 4H, ArH), 7.33-7.27 (m, 5H, ArH), 7.25-7.21 (m, 2H, ArH), 7.00 (t, *J* = 7.6 Hz, 1H, ArH), 6.82 (t, *J* = 7.6 Hz, 2H, ArH), 6.74-6.72 (m, 1H, ArH), 6.21 (d, *J* = 7.6 Hz, 1H, ArH), 5.40 (d, *J* = 15.2 Hz, 1H, CH), 5.01 (s, 1H, CH), 3.90 (d, *J* = 15.6 Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 175.8, 156.7, 150.9, 147.1, 146.4, 141.9, 135.7, 135.3, 132.1, 130.8, 129.7, 129.3, 129.1, 128.9, 128.8, 128.2, 128.1, 127.7, 127.4, 127.3, 127.1, 126.3, 125.0, 123.7, 123.3, 122.5, 121.2, 120.8, 120.2, 109.6, 108.7, 44.6, 44.0; IR (KBr) υ: 3059, 2922, 2850, 1718, 1602, 1518, 1482, 1343, 1171, 1106, 1069, 1018, 976, 912, 851, 751 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{39}H_{26}ClN_2O_4$ ($[M+H]^+$): 621.1503. Found: 621.1566.




175.777
156.657
150.899
147.113
146.400
141.936
135.743
135.252
132.056
130.776
129.662
129.332
129.101
128.889
128.776
128.190
128.119
127.747
127.391
127.328
127.153
126.395
125.073
123.749
123.366
122.516
121.203
120.836
120.221
109.637
108.688
44.564
43.982
150
100
50
0
200
150
100
50
0
ppm (f1)


Intens.
+MS, 0.6-0.8min #(63-80)
621.1566
643.1385
614.5714
638.1811
647.5586
653.1482
2000
1500
1000
500
0
610
615
620
625
630
635
640
645
650
m/z