Metal-Free Triple Annulation of Ene–Yne–Ketones with Isocyanides: Domino Access to Furan Fused Heterocycles via Furoketenimine

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1. General Information

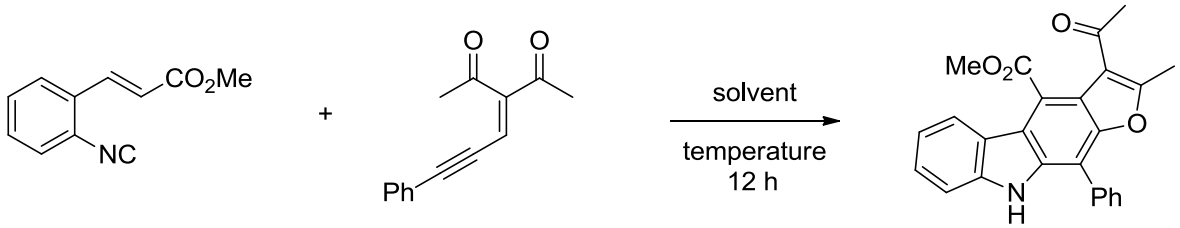
All reagents were purchased from commercial sources and used without further purification, unless otherwise indicated. All reactions were carried out without any particular precautions to extrude moisture or oxygen, unless otherwise indicated. All reactions were monitored by TLC, which was performed on precoated aluminum sheets of silica gel 60 (F254). The products were purified by flash column chromatography on silica gel (300−400 mesh). NMR spectra were obtained on a Bruker 400 spectrometer, with $CDCl_3$ or DMSO-d_6 as solvents. All chemical shifts are given in ppm. High-resolution mass spectra (HRMS) were recorded on a Bruker micro TOF IV focus spectromet0er.

2. Experimental Procedures

2.1 Synthesis of starting materials.

Isocyanides **2** were synthesized according to known literature procedure.[1,2,3] Ene-yne-ketones **1** were synthesized according to known literature procedure.[4,5]

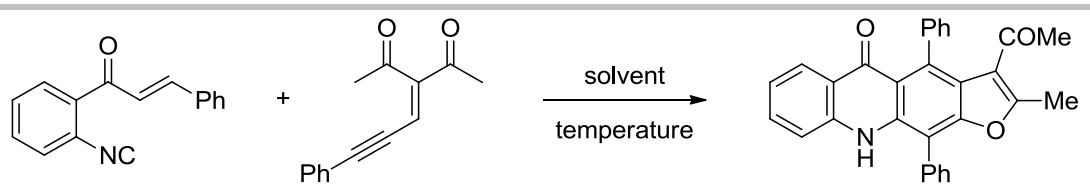
2.2 Optimization of reaction conditions



2a **1a** **3a**

Entry	Solvent	Temp. (℃)	Yield of **5a** (%)[a,b]
1	EtOH	100	34
2	DCE	100	58
3	DMF	100	63
4	***CH_3CN***	***100***	***83***
5	1,4-dioxane	100	80
6	THF	100	60
7	Toluene	100	68
8	DCM	100	50
9	CH_3CN	120	79
10	CH_3CN	80	51

[a] Reaction conditions: **2a** (0.25 mmol), **1a** (0.375 mmol), solvent (2 mL). [b] Yield of isolated products.



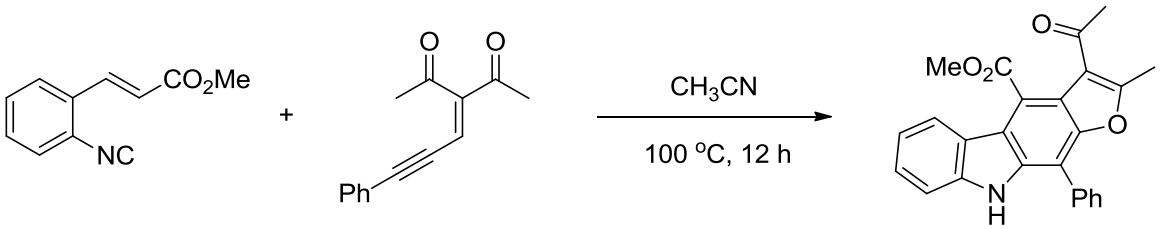
8a **1a** **9a**

Entry	Solvent	Temp. (℃)	Time (h)	Yield of **9a** (%)[a,b]
1	CH_3CN	100	48	37
2	1,4-dioxane	100	48	48
3	***1,4-dioxane***	***130***	***36***	***62***

[a] Reaction conditions: **8a** (0.25 mmol), **1a** (0.375 mmol), solvent (2 mL). [b] Yield of isolated products.

2.3 Synthesis of products

General synthetic procedures of **3** and **4** (taking **3a** for example)



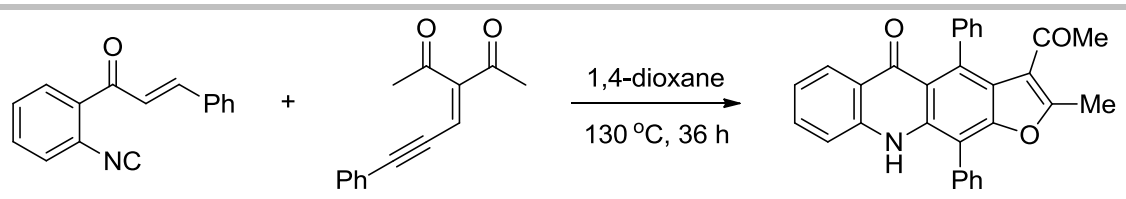
2a (0.25 mmol) **1a** (0.375 mmol) **3a** (83%)

Isocyanide **2a** (46.8 mg, 0.25 mmol) and ene-yne-ketone **1a** (79.5 mg, 0.375 mmol) were dissolved in CH_3CN (2 mL) in a sealed tube, the reaction mixture was set in a pre-heated (100 ^oC) metal block and kept stirring until Isocyanide **2a** was completely consumed as indicated by TLC. Cooled to room temperature, the reaction mixture was concentrated in vacuo and purified by flash column chromatography (silica gel; petroleum: ethyl acetate = 15:1-10:1) to give furocarbazole **3a** (82.4 mg, 83% yield) as a white solid.

Gram Scale Synthesis of **3a**

Isocyanide **2a** (0.935 g, 5 mmol) and ene-yne-ketone **1a** (1.591 g, 7.5 mmol) were dissolved in CH_3CN (15 mL) in a sealed tube, the reaction mixture was set in a pre-heated (100 ^oC) metal block and kept stirring until Isocyanide **2a** was completely consumed as indicated by TLC. Cooled to room temperature, the reaction mixture was concentrated in vacuo and purified by flash column chromatography (silica gel; petroleum: ethyl acetate = 15:1-10:1) to give furocarbazole **3a** (1.389 g, 70% yield) as a white solid.

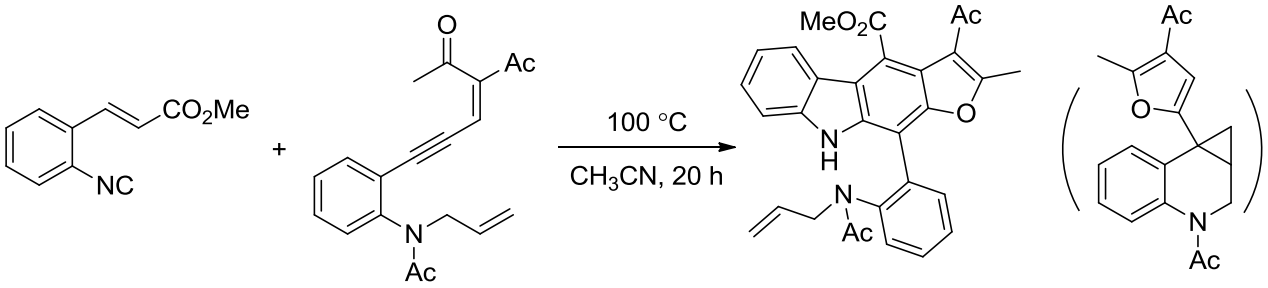
General synthetic procedures of **9** (taking **9a** for example)



8a (0.25 mmol) **1a** (0.375 mmol) **9a** (62%)

Isocyanide **8a** (58.2 mg, 0.25 mmol) and ene-yne-ketone **1a** (79.5 mg, 0.375 mmol) were dissolved in 1,4-dioxane (2 mL) in a sealed tube, the reaction mixture was set in a pre-heated (130 ^{o}C) metal block and kept stirring until Isocyanide **8a** was completely consumed as indicated by TLC. Cooled to room temperature, the reaction mixture was concentrated in vacuo and purified by flash column chromatography (silica gel; petroleum: ethyl acetate = 15:1-10:1) to give furocarbazole **9a** (68.6 mg, 62% yield) as a white solid.

From **2a** and **5** to **6**



2a (0.25 mmol) **5** (0.375 mmol) **6** (68%) **7** (Not detected)

Isocyanide **2a** (46.8 mg, 0.25 mmol) and ene-yne-ketone **5** (115.9 mg, 0.375 mmol) were dissolved in CH_3CN (2 mL) in a sealed tube, the reaction mixture was set in a pre-heated (100 ^{o}C) metal block and kept stirring until ene-yne-ketone **5** was completely consumed as indicated by TLC. Cooled to room temperature, the reaction mixture was concentrated in vacuo and purified by flash column chromatography (silica gel; petroleum: ethyl acetate = 15:1-10:1) to give furocarbazole **6** (84 mg, 68% yield) as a white solid.

References:

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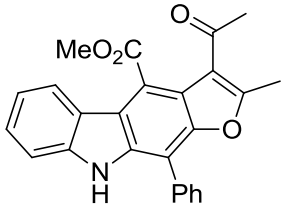
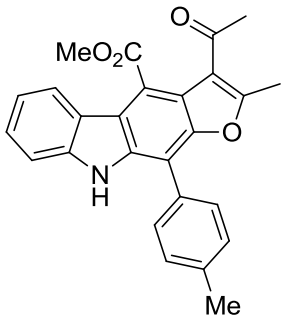
[5] Zhu, D.; Ma, J.; Luo, K.; Fu, H. G.; Zhang, L.; Zhu, S. F. Enantioselective Intramolecular C-H Insertion of Donor and Donor/Donor Carbenes by a Nondiazo Approach. *Angew. Chem. Int. Ed.* **2016**, *55*, 8452-8456.

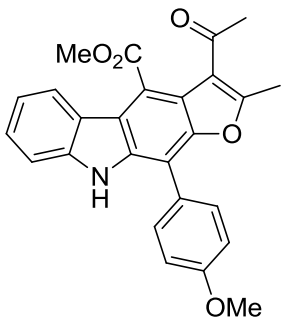
3. Analytical data of compounds 3, 4, 6, 9



3a, Methyl 3-acetyl-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 83% yield, 82.4 mg, m.p. 216-218 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.57 (s, 3H), 2.72 (s, 3H), 4.16 (s, 3H), 7.21-7.26 (m, 1H), 7.36-7.44 ((m, 2H), 7.50-7.54 (m, 1H), 7.63 (t, J = 8.0 Hz, 2H), 7.75-7.77 (m, 2H), 8.19 (d, J = 8.0 Hz, 1H), 8.30 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.5, 30.6, 52.1, 109.3, 110.4, 117.5, 118.3, 118.8, 119.4, 119.9, 121.8, 122.5, 126.3, 128.5, 129.3, 129.5, 132.4, 136.3, 140.6, 149.5, 160.0, 168.7, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{19}NNaO_4^+$ ($[M+Na]^+$) 420.1206, found 420.1210. **IR**: 706, 742, 765, 957, 1016, 1138, 1221, 1234, 1250, 1401, 1436, 1459, 1578, 1599, 1656, 1725, 2952, 3058, 3370, 3409.

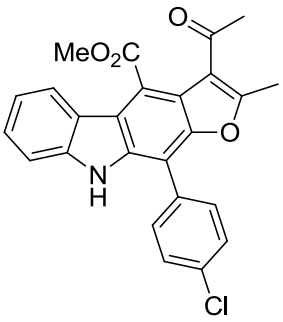


3b, Methyl 3-acetyl-2-methyl-10-(*p*-tolyl)-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 72% yield, 73.9 mg, m.p. 248-249 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.45 (s, 3H), 2.56 (s, 3H), 2.74 (s, 3H), 4.01 (s, 3H), 7.14-7.18 (m, 1H), 7.38-7.42 (m, 1H), 7.44 (d, J = 7.6 Hz, 2H), 7.52 (d, J = 8.0 Hz, 1H), 7.64 (d, J = 8.0 Hz, 2H), 7.95 (d, J = 8.0 Hz, 1H), 11.22 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.9, 21.4, 31.0, 52.3, 109.4, 112.0, 116.6, 118.1, 118.2, 118.8, 119.4, 121.0, 121.7, 126.4, 129.4, 130.1, 130.2, 136.5, 138.2, 142.0, 149.4, 161.7, 168.4, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{21}NNaO_4^+$ ($[M+Na]^+$) 434.1363, found 434.1373. **IR**: 702, 746, 790, 941, 1047, 1120, 1215, 1238, 1282, 1317, 1327, 1388, 1456, 1491, 1593, 1669, 1905, 2919, 3030, 3303.

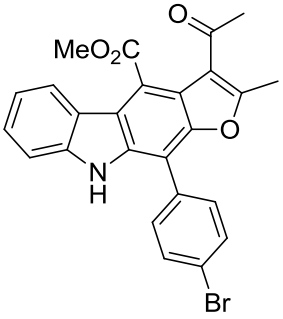


3c, Methyl 3-acetyl-10-(4-methoxyphenyl)-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 70% yield, 74.7 mg, m.p. 251-253 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.56 (s, 3H), 2.71 (s, 3H), 3.92 (s, 3H), 4.15 (s, 3H), 7.13-7.16 (m, 2H), 7.21-7.25 (m, 1H), 7.36-7.44 (m, 2H), 7.66-7.70 (m, 2H),

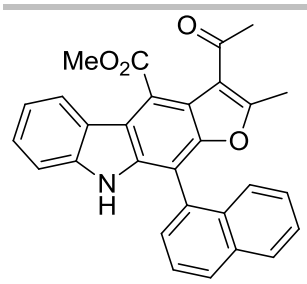
8.19 (d, *J* = 8.0 Hz, 1H), 8.28 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.4, 30.6, 52.1, 55.4, 109.1, 110.4, 114.8, 117.6, 117.8, 118.7, 119.4, 119.8, 121.9, 122.6, 124.4, 126.3, 130.7, 136.4, 140.6, 149.6, 159.6, 159.9, 168.7, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{21}NNaO_5^+$ ($[M+Na]^+$) 450.1312, found 450.1324. **IR**: 760, 1034, 1054, 1138, 1175, 1219, 1239, 1401, 1433, 1462, 1515, 1588, 1608, 1652, 1714, 2835, 2947, 3298.



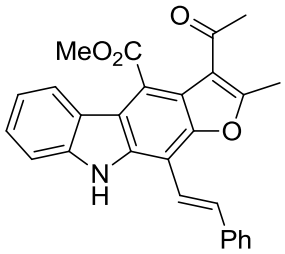
3d, Methyl 3-acetyl-10-(4-chlorophenyl)-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 76% yield, 81.9 mg, m.p. 271-272 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.56 (s, 3H), 2.74 (s, 3H), 4.02 (s, 3H), 7.18 (t, *J* = 7.2 Hz, 1H), 7.40 (t, *J* = 7.2 Hz, 1H), 7.51 (d, *J* = 8.0 Hz, 1H), 7.69 (d, *J* = 8.4 Hz, 2H), 7.77 (d, *J* = 8.4 Hz, 2H), 7.95 (d, *J* = 8.0 Hz, 1H), 11.3 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.9, 31.0, 52.4, 108.1, 112.0, 116.6, 118.2, 118.8, 118.8, 119.6, 121.0, 121.8, 126.6, 129.6, 131.3, 132.2, 133.5, 136.4, 142.0, 149.3, 161.9, 168.3, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{19}ClNO_4^+$ ($[M+H]^+$) 432.0997, found 432.1005. **IR**: 755, 827, 836, 955, 1015, 1089, 1139, 1221, 1247, 1325, 1336, 1399, 1431, 1461, 1589, 1651, 1719, 2951, 3289.



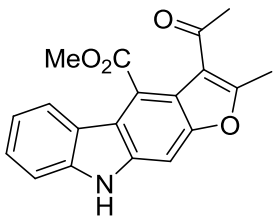
3e, Methyl 3-acetyl-10-(4-bromophenyl)-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 68% yield, 80.7 mg, m.p. 289-290 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.56 (s, 3H), 2.74 (s, 3H), 4.02 (s, 3H), 7.17 (td, *J* = 8.0 Hz, *J* = 0.8 Hz 1H), 7.41 (td, *J* = 8.0 Hz, *J* = 0.8 Hz 1H), 7.51 (d, *J* = 8.4 Hz, 1H), 7.70 (d, *J* = 8.4 Hz, 2H), 7.83 (d, *J* = 8.4 Hz, 2H), 7.94 (d, *J* = 8.0 Hz, 1H), 11.3 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.9, 31.0, 52.3, 108.1, 112.0, 116.6, 118.2, 118.8, 118.8, 119.6, 121.0, 121.8, 122.1, 126.6, 131.6, 132.5, 132.5, 142.0, 149.2, 161.9, 168.3, 194.2. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{18}BrNNaO_4^+$ ($[M+Na]^+$) 498.0311, found 498.0318. **IR**: 586, 756, 828, 956, 1056, 1140, 1221, 1247, 1325, 1337, 1399, 1431, 1462, 1510, 1586, 1652, 1720, 2950, 3287.



3f, Methyl 3-acetyl-2-methyl-10-(naphthalen-1-yl)-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 72% yield, 80.4 mg, m.p. 270-271 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.57 (s, 3H), 2.63 (s, 3H), 4.05 (s, 3H), 7.14-7.18 (m, 1H), 7.27 (d, J = 8.0 Hz, 1H), 7.36-7.40 (m, 3H), 7.56-7.60 (m, 1H), 7.71-7.78 (m, 2H), 7.98 (d, J = 8.0 Hz, 1H), 8.11 (d, J = 8.0 Hz, 1H), 8.16 (d, J = 8.0 Hz, 1H), 10.94 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.9, 31.0, 52.3, 107.6, 111.8, 116.3, 117.9, 118.8, 118.9, 119.5, 121.0, 121.8, 125.6, 126.5, 126.7, 127.2, 129.0, 129.3, 129.5, 129.8, 131.9, 134.1, 137.7, 141.9, 150.3, 161.8, 168.5, 194.4. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{21}NNaO_4^+$ ([M+Na]$^+$) 470.1363, found 470.1370. **IR**: 744, 778, 802, 956, 1017, 1069, 1142, 1201, 1249, 1324, 1407, 1430, 1462, 1506, 1515, 1584, 1657, 1722, 2947, 2995, 3060, 3364.

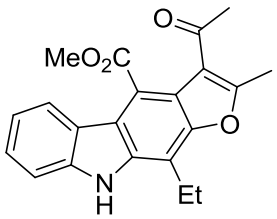


3g, (*E*)-methyl 3-acetyl-2-methyl-10-styryl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 52% yield, 55 mg, m.p. 261-262 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.59 (s, 3H), 2.92 (s, 3H), 3.99 (s, 3H), 7.17 (t, J = 7.6 Hz, 1H), 7.37 (t, J = 7.6 Hz, 1H), 7.45-7.51 (m, 3H), 7.58 (d, J = 8.0 Hz, 1H), 7.83 (d, J = 7.6 Hz, 2H), 7.92 (s, 2H), 7.94 (d, J = 8.0 Hz, 1H), 11.9 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 16.1, 31.1, 52.3, 105.9, 111.5, 117.0, 118.1, 118.3, 118.6, 119.2, 119.7, 121.0, 122.0, 126.8, 127.3, 128.7, 129.3, 134.2, 137.2, 137.9, 141.5, 149.2, 161.6, 168.3, 194.5. **HRMS** (ESI-TOF) m/z calculated for $C_{27}H_{21}NNaO_4^+$ ([M+Na]$^+$) 446.1363, found 446.1371.

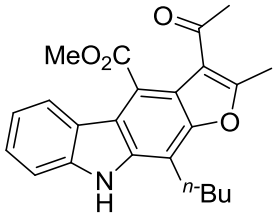


3h, Methyl 3-acetyl-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 72% yield, 57.8 mg, m.p. 277-278 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.56 (s, 3H), 2.81 (s, 3H), 3.99 (s, 3H), 7.13-7.17 (m, 1H), 7.39- 7.43 (m, 1H), 7.50 (d, J = 8.0 Hz, 1H), 7.74 (s, 1H), 7.90 (d, J = 7.6 Hz, 1H), 11.5 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.9, 30.9, 52.3, 94.5, 11.4, 116.2, 117.5, 118.7, 119.3, 120.8, 121.7, 126.5, 138.7, 141.5, 152.3, 161.7, 168.4, 194.2. **HRMS** (ESI-TOF) m/z calculated for $C_{19}H_{15}NNaO_4^+$ ([M+Na]$^+$) 344.0893, found 344.0894. **IR**: 577, 711, 739, 837, 956, 1015, 1069, 1140,

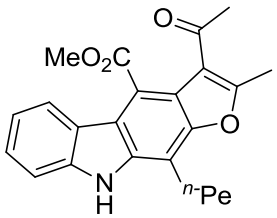
1140, 1201, 1251, 1324, 1333, 1397, 1432, 1459, 1513, 1573, 1610, 1629, 1644, 1720, 2947, 2992, 3100, 3231.



3i, Methyl 3-acetyl-10-ethyl-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 81% yield, 70.7 mg, m.p. 273-274 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 1.34 (t, J = 7.6 Hz, 3H), 2.54 (s, 3H), 2.80 (s, 3H), 3.19 (q, J = 7.6 Hz, 2H), 3.96 (s, 3H), 7.14 (t, J = 7.6 Hz, 1H), 7.41 (t, J = 7.6 Hz, 1H), 7.52 (d, J = 8.0 Hz, 1H), 7.93 (d, J = 8.0 Hz, 1H), 11.5 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 14.3, 15.9, 18.6, 31.0, 52.1, 110.8, 111.4, 116.4, 116.7, 117.6, 119.0, 119.2, 121.3, 121.9, 126.3, 137.1, 141.6, 150.2, 161.2, 168.6, 194.4. **HRMS** (ESI-TOF) m/z calculated for $C_{21}H_{19}NNaO_4^+$ ([M+Na]$^+$) 372.1206, found 372.1210.

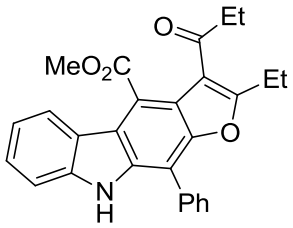


3j, Methyl 3-acetyl-2-methyl-10-propyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 83% yield, 78.2 mg, m.p. 256-257 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 0.99 (t, J = 7.2 Hz, 3H), 1.77 (q, J = 7.2 Hz, 2H), 2.54 (s, 3H), 2.79 (s, 3H), 3.16 (t, J = 7.6 Hz, 2H), 3.97 (s, 3H), 7.12 (t, J = 7.6 Hz, 1H), 7.41 (t, J = 7.6 Hz, 1H), 7.52 (d, J = 8.0 Hz, 1H), 7.93 (d, J = 8.0 Hz, 1H), 11.5 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 14.3, 15.9, 22.5, 27.1, 31.0, 52.1, 109.2, 111.4, 116.3, 116.8, 117.5, 119.0, 119.2, 121.3, 121.9, 126.3, 137.5, 141.6, 150.5, 161.2, 168.6, 194.4. **HRMS** (ESI-TOF) m/z calculated for $C_{22}H_{22}NNaO_4^+$ ([M+Na]$^+$) 386.1363, found 386.1370. **IR**: 581, 712, 736, 954, 1093, 1162, 1206, 1243, 1323, 1345, 1404, 1430, 1461, 1515, 1568, 1604, 1645, 1737, 2873, 2958, 3068, 3264.

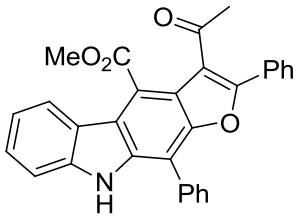


3k, Methyl 3-acetyl-2-methyl-10-pentyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 87% yield, 85.0 mg, m.p. 156-158 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 0.86-0.90 (m, 3H), 1.36-1.39 (m, 4H), 1.74-1.81 (m, 2H), 2.53 (s, 3H), 2.74 (s, 3H), 3.19 (t, J = 7.6 Hz, 2H), 4.13 (s, 3H), 7.18-7.22 (m, 1H), 7.37-7.43 (m, 2H), 8.12 (s, 1H), 8.16 (d, J = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.9, 15.4, 22.5, 25.3, 28.7, 30.5, 31.7, 52.0, 109.2, 110.3, 116.5, 117.1, 118.4, 119.5, 119.7, 122.1, 122.5, 126.0, 137.0, 140.6, 150.8, 159.5, 169.0, 194.5. **HRMS** (ESI-TOF) m/z calculated for $C_{24}H_{25}NNaO_4^+$

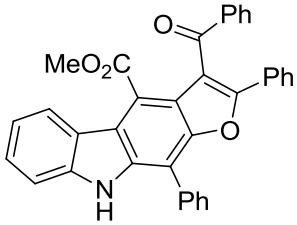
([M+Na]$^+$) 414.1676, found 414.1680.



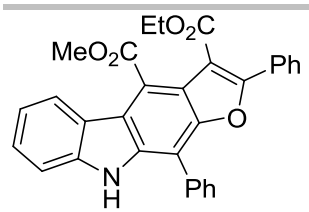
3l, Methyl 2-ethyl-10-phenyl-3-propionyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 81% yield, 86.1 mg, m.p. 175-176 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.26 (t, J = 7.6 Hz, 3H), 1.37 (t, J = 7.6 Hz, 3H), 2.85 (q, J = 7.6 Hz, 2H), 3.00 (q, J = 7.6 Hz, 2H), 4.10 (s, 3H), 7.21-7.26 (m, 1H), 7.37-7.44 (m, 2H), 7.52 (t, J = 7.6 Hz, 1H), 7.63 (t, J = 7.6 Hz, 2H), 7.77 (d, J = 7.6 Hz , 2H), 8.28-8.30 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 8.52, 12.7, 22.1, 36.3, 52.0, 109.6, 110.3, 117.7, 118.2, 118.5, 118.9, 119.8, 121.9, 123.0, 126.3, 128.4, 129.3, 129.5, 132.6, 136.3, 140.7, 149.6, 162.7, 168.4, 198.9. **HRMS** (ESI-TOF) m/z calculated for $C_{27}H_{24}NO_4^+$ ([M+H]$^+$) 426.1700, found 426.1705.



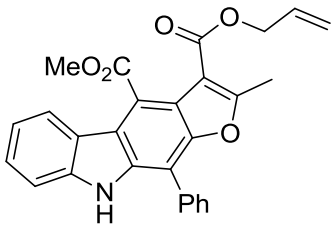
3m, Methyl 3-acetyl-2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 80% yield, 91.8 mg, m.p. 244-246 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.43 (s, 3H), 4.13 (s, 3H), 7.23-7.27 (m, 1H), 7.38-7.51 (m, 6H), 7.63 (t, J = 7.6 Hz, 2H), 7.67-7.70 (m, 2H), 7.83 (d, J = 7.2 Hz, 2H), 8.28 (d, J = 8.4 Hz, 1H), 8.39 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 31.2, 51.8, 109.9, 110.4, 117.5, 118.9, 119.1, 119.3, 119.9, 121.8, 123.0, 126.5, 128.5, 128.5, 128.7, 129.4, 129.4, 129.7, 129.9, 132.4, 136.8, 140.8, 149.9, 156.2, 167.9, 198.2. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{22}NO_4^+$ ([M+H]$^+$) 460.1543, found 460.1550.



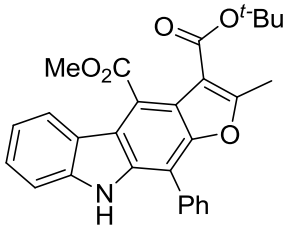
3n, Methyl 3-benzoyl-2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 82% yield, 106.8 mg, m.p. 209-210 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.52 (s, 3H), 7.15-7.19 (m, 1H), 7.23-7.26 (m, 3H), 7.34-7.40 (m, 4H), 7.51 (t, J = 8.0 Hz, 2H), 7.61-7.66 (m, 4H), 7.89 (d, J = 7.2 Hz, 2H), 7.99 (d, J = 7.2 Hz, 2H), 8.31 (d, J = 8.0 Hz, 1H), 8.44 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 51.1, 110.4, 110.5, 116.3, 116.7, 119.7, 119.8, 121.6, 121.7, 123.6, 126.6, 127.5, 128.4, 128.5, 128.6, 129.2, 129.3, 129.4, 129.5, 129.6, 132.4, 133.6, 136.9, 137.1, 140.9, 149.7, 154.8, 167.3, 192.4. **HRMS** (ESI-TOF) m/z calculated for $C_{35}H_{24}NO_4^+$ ([M+H]$^+$) 522.1700, found 522.1709.



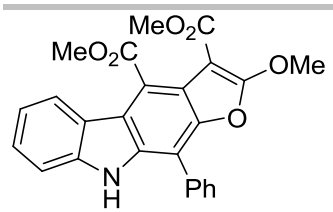
3o, 3-Ethyl 4-methyl 2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-3,4-dicarboxylate. White solid in 74% yield, 90.4 mg, m.p. 181-182 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.33 (t, J = 7.2 Hz, 3H), 4.12 (s, 3H), 4.39 (q, J = 7.2 Hz, 2H), 7.24-7.27 (m, 1H), 7.39-7.46 (m, 5H), 7.53 (t, J = 7.2 Hz, 1H), 7.64 (t, J = 7.6 Hz, 2H), 7.83 (d, J = 7.2 Hz, 2H), 7.88-7.90 (m, 2H), 8.33 (d, J = 8.4 Hz, 1H), 8.36 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.9, 52.1, 61.3, 109.9, 110.4, 110.4, 117.6, 119.3, 119.4, 119.9, 121.8, 123.1, 126.6, 128.2, 128.5, 128.7, 129.4, 129.5, 129.6, 129.8, 132.4, 136.8, 140.8, 149.7, 157.6, 164.6, 168.1. **HRMS** (ESI-TOF) m/z calculated for $C_{31}H_{24}NO_5^+$ ($[M+H]^+$) 490.1649, found 490.1652.



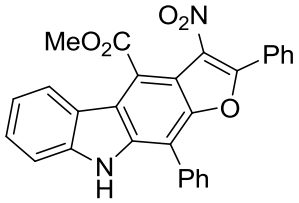
3p, 3-Allyl 4-methyl 2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-3,4-dicarboxylate. White solid in 83% yield, 91.1 mg, m.p. 186-188 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.72 (s, 3H), 4.11 (s, 3H), 4.85 (d, J = 5.2 Hz, 2H), 5.29 (d, J = 10.4 Hz, 1H), 5.39 (d, J = 17.2 Hz, 1H), 6.02-6.11 (m, 1H), 7.20-7.25 (m, 1H), 7.36-7.42 (m, 2H), 7.50 (t, J = 7.6 Hz, 1H), 7.61 (t, J = 7.6 Hz, 2H), 7.74 (d, J = 7.6 Hz, 2H), 8.15 (d, J = 8.0 Hz, 1H), 8.31 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.0, 52.3, 65.4, 109.2, 109.4, 110.4, 117.3, 117.9, 118.4, 118.4, 119.8, 121.7, 122.2, 126.2, 128.4, 129.3, 129.5, 132.2, 132.3, 136.0, 140.5, 149.6, 162.7, 163.6, 168.8. **HRMS** (ESI-TOF) m/z calculated for $C_{27}H_{22}NO_5^+$ ($[M+H]^+$) 440.1492, found 440.1500. **IR**: 590, 694, 739, 938, 992, 1079, 1144, 1228, 1238, 1268, 1321, 1402, 1517, 1588, 1601, 1703, 1722, 2948, 3067, 3374.



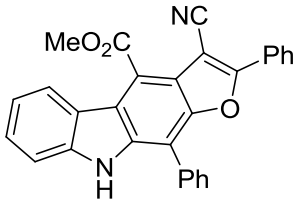
3q, 3-*tert*-Butyl 4-methyl 2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-3,4-dicarboxylate. White solid in 79% yield, 89.8 mg, m.p. 179-180 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.65 (s, 9H), 2.69 (s, 3H), 4.13 (s, 3H), 7.21-7.26 (m, 1H), 7.34-7.40 (m, 2H), 7.50 (t, J = 7.6 Hz, 1H), 7.61 (t, J = 7.6 Hz, 2H), 7.75-7.77 (m, 2H), 8.21 (d, J = 8.0 Hz, 1H), 8.31 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 14.9, 28.4, 52.2, 81.2, 109.0, 110.3, 111.1, 117.9, 118.0, 118.3, 119.7, 121.8, 122.4, 126.1, 128.3, 129.2, 129.4, 132.5, 136.0, 140.5, 149.6, 161.1, 163.1, 168.7. **HRMS** (ESI-TOF) m/z calculated for $C_{28}H_{26}NO_5^+$ ($[M+H]^+$) 456.1805, found 456.1809.



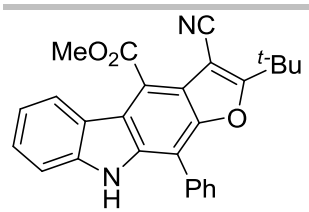
3r, Dimethyl 2-methoxy-10-phenyl-9*H*-furo[2,3-*b*]carbazole-3,4-dicarboxylate. White solid in 76% yield, 81.5 mg, m.p. 97-98 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 3.78 (s, 3H), 4.01 (s, 3H), 4.17 (s, 3H), 7.17 (t, J = 7.6 Hz, 1H), 7.41 (t, J = 7.6 Hz, 1H), 7.55 (t, J = 7.6 Hz, 2H), 7.66 (t, J = 7.6 Hz, 2H), 7.86 (d, J = 7.2 Hz, 1H), 7.91 (d, J = 8.0 Hz, 1H), 11.32 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 51.6, 52.4, 59.1, 86.2, 109.8, 112.1, 116.9, 117.4, 117.8, 119.4, 120.8, 121.4, 126.3, 128.8, 129.6, 131.2, 132.1, 134.8, 141.6, 143.5, 163.2, 164.9, 168.6. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{20}NO_6^+$ ($[M+H]^+$) 430.1285, found 430.1287.



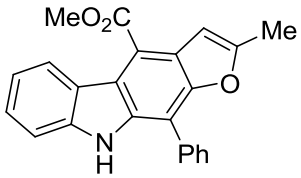
3s, Methyl 3-nitro-2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 76% yield, 87.8 mg, m.p. 255-257 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 4.04 (s, 3H), 7.24 (t, J = 7.6 Hz, 1H), 7.49 (t, J = 7.6 Hz, 1H), 7.56-7.63 (m, 5H), 7.68 (t, J = 7.6 Hz, 2H), 7.88-7.91 (m, 4H), 8.11 (d, J = 8.0 Hz, 1H), 11.61 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 52.6, 110.6, 111.7, 112.3, 116.6, 119.8, 120.0, 120.5, 122.4, 127.3, 127.5, 129.1, 129.6, 130.4, 130.6, 131.3, 132.0, 137.6, 142.6, 148.1, 155.5, 167.4. **HRMS** (ESI-TOF) m/z calculated for $C_{28}H_{18}N_2NaO_5^+$ ($[M+Na]^+$) 485.1108, found 485.1110. **IR**: 442, 685, 699, 746, 769, 841, 1128, 1148, 1170, 1225, 1247, 1263, 1338, 1433, 1459, 1516, 1599, 1721, 2952, 3053, 3447.



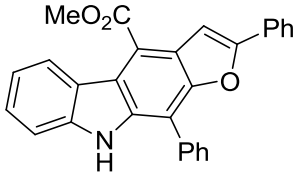
3t, Methyl 3-cyano-2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 84% yield, 92.8 mg, m.p. 257-259 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 4.14 (s, 3H), 7.22 (t, J = 7.6 Hz, 1H), 7.47 (t, J = 7.6 Hz, 1H), 7.59-7.65 (m, 5H), 7.71 (t, J = 7.6 Hz, 2H), 7.90 (d, J = 7.2 Hz, 2H), 8.03 (d, J = 7.2 Hz, 2H), 8.17 (d, J = 8.0 Hz, 1H), 11.55 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 52.4, 87.8, 111.2, 112.3, 114.9, 116.1, 117.7, 119.7, 119.8, 120.4, 122.8, 126.8, 127.4, 127.7, 129.2, 129.7, 129.9, 130.3, 131.6, 132.0, 137.6, 142.5, 149.2, 162.7, 167.0. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{19}N_2O_3^+$ ($[M+H]^+$) 443.1390, found 443.1391. **IR**: 688, 749, 1150, 1173, 1222, 1265, 1332, 1436, 1458, 1560, 1600, 1723, 2222, 2945, 3059, 3461.



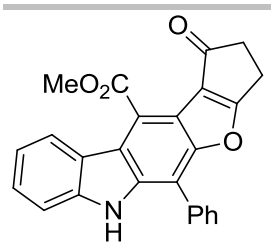
3u, Methyl 2-(*tert*-butyl)-3-cyano-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 85% yield, 89.7 mg, m.p. 214-215 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.55 (s, 9H), 4.21 (s, 3H), 7.24-7.28 (m, 1H), 7.39 (d, J = 8.0 Hz, 1H), 7.44-7.48 (m, 1H), 7.52-7.56 (m, 1H), 7.64 (t, J = 8.0 Hz, 2H), 7.77-7.79 (m, 2H), 8.35 (d, J = 8.0 Hz, 1H), 8.39 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 28.7, 35.5, 52.0, 88.0, 110.5, 114.4, 116.5, 118.6, 119.7, 120.1, 121.4, 123.4, 126.9, 128.7, 129.2, 129.4, 131.9, 136.6, 140.8, 148.5, 167.0, 175.3. **HRMS** (ESI-TOF) m/z calculated for $C_{27}H_{23}N_2O_3^+$ ($[M+H]^+$) 423.1703, found 423.1702.



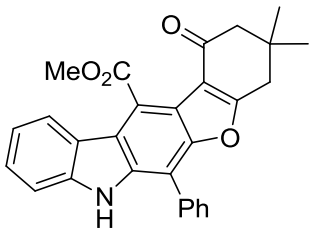
3v, Methyl 2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 76% yield, 67.4 mg, m.p. 181-182 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.48 (d, J = 1.2 Hz, 3H), 4.16 (s, 3H), 6.94 (d, J = 1.2 Hz, 1H), 7.22-7.27 (m, 1H), 7.37-7.42 (m, 2H), 7.50-7.52 (m, 1H), 7.63 (t, J = 7.6 Hz, 2H), 7.81-7.83 (m, 2H), 8.31 (s, 1H), 8.74 (d, J = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 14.3, 51.9, 104.2, 110.2, 111.6, 114.3, 119.4, 119.6, 122.3, 124.9, 125.3, 126.1, 128.5, 129.3, 129.6, 132.8, 136.0, 140.7, 150.6, 156.4, 168.1. **HRMS** (ESI-TOF) m/z calculated for $C_{23}H_{18}NO_3^+$ ($[M+H]^+$) 356.1281, found 356.1282.



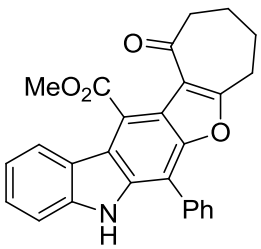
3w, Methyl 2,10-diphenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 74% yield, 77.1 mg, m.p. 196-198 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 4.21 (s, 3H), 7.24-7.28 (m, 1H), 7.34 (t, J = 7.6 Hz, 1H), 7.38-7.45 (m, 4H), 7.56 (t, J = 7.6 Hz, 1H), 7.60 (s, 1H), 7.67 (t, J = 7.6 Hz, 2H), 7.85 (d, J = 7.2 Hz, 2H), 7.89 (d, J = 7.2 Hz, 2H), 8.39 (s, 1H), 8.75 (d, J = 8.4 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 52.0, 102.9, 110.3, 111.7, 115.0, 119.6, 120.4, 122.2, 124.9, 125.1, 125.3, 126.4, 128.5, 128.5, 128.7, 129.3, 129.6, 130.2, 132.7, 136.7, 140.9, 150.6, 156.3, 168.0. **HRMS** (ESI-TOF) m/z calculated for $C_{28}H_{20}NO_3^+$ ($[M+H]^+$) 418.1438, found 418.1440.



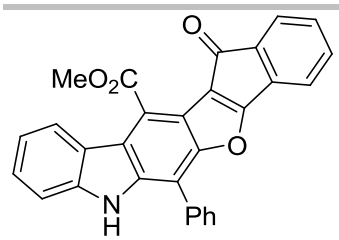
3x, Methyl 1-oxo-5-phenyl-1,2,3,6-tetrahydrocyclopenta[4,5]furo[2,3-*b*]carbazole-11-carboxylate. White solid in 51% yield, 50.3 mg, m.p. 293-294 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.98-2.99 (m, 2H), 3.15-3.17 (m, 2H), 4.08 (s, 3H), 7.19 (t, J = 7.6 Hz, 1H), 7.44 (t, J = 7.6 Hz, 1H), 7.56-7.61 (m, 2H), 7.68 (t, J = 7.6 Hz, 2H), 7.80 (d, J = 7.2 Hz, 2H), 8.09 (d, J = 8.0 Hz, 1H), 11.45 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 22.8, 41.5, 53.2, 111.9, 112.2, 113.8, 117.5, 117.9, 119.6, 120.7, 122.3, 123.0, 126.8, 129.1, 129.6, 130.3, 131.9, 136.6, 142.0, 156.4, 168.4, 188.0, 193.8. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{18}NO_4^+$ ([M+H]$^+$) 396.1230, found 396.1236.



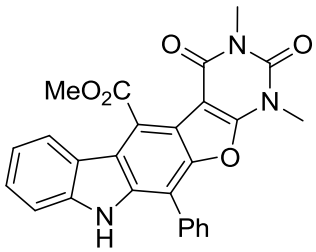
3y, Methyl 3,3-dimethyl-1-oxo-6-phenyl-2,3,4,7-tetrahydro-1*H*-benzofuro[2,3-*b*]carbazole-12-carboxylate. White solid in 83% yield, 90.7 mg, m.p. 264-265 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.20 (s, 6H), 2.50 (s, 2H), 2.91 (s, 2H), 4.25 (s, 3H), 7.22-7.26 (m, 1H), 7.37-7.44 (m, 2H), 7.52 (t, J = 7.6 Hz, 1H), 7.63 (t, J = 7.6 Hz, 2H), 7.76-7.78 (m, 2H), 8.03 (d, J = 8.0 Hz, 1H), 8.33 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 28.6, 35.1, 38.0, 52.3, 52.7, 109.4, 110.5, 114.3, 115.3, 118.2, 118.8, 120.0, 121.6, 121.8, 126.3, 128.5, 129.4, 129.5, 132.3, 136.2, 140.4, 150.8, 169.1, 170.2, 192.9. **HRMS** (ESI-TOF) m/z calculated for $C_{28}H_{24}NO_4^+$ ([M+H]$^+$) 438.1700, found 438.1708. **IR**: 698, 738, 1049, 1161, 1219, 1243, 1326, 1417, 1435, 1460, 1514, 1586, 1670, 1724, 2870, 2954, 3053, 3381, 3473.



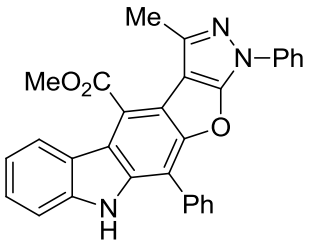
3z, Methyl 12-oxo-6-phenyl-5,8,9,10,11,12-hexahydrocyclohepta[4,5]furo[2,3-*b*]carbazole-13-carboxylate. White solid in 53% yield, 56 mg, m.p. 246-248 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.96-2.06 (m, 4H), 2.84 (t, J = 7.6 Hz, 2H), 3.15 (t, J = 7.6 Hz, 2H), 4.21 (s, 3H), 7.22 (t, J = 7.2 Hz, 1H), 7.34-7.41 (m, 2H), 7.49 (t, J = 7.2 Hz, 1H), 7.60 (t, J = 7.6 Hz, 2H), 7.74 (d, J = 7.2 Hz, 2H), 8.06 (d, J = 8.0 Hz, 1H), 8.37 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 22.4, 24.2, 29.4, 44.1, 52.3, 108.7, 110.4, 116.8, 118.4, 118.8, 119.0, 119.8, 121.7, 121.9, 126.1, 128.3, 129.3, 129.4, 132.4, 136.2, 140.4, 149.8, 166.2, 168.8, 196.8. **HRMS** (ESI-TOF) m/z calculated for $C_{27}H_{22}NO_4^+$ ([M+H]$^+$) 424.1543, found 424.1549.



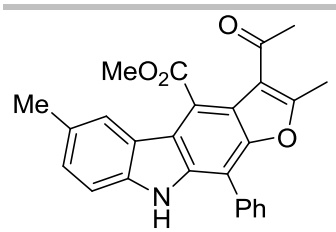
3aa, Methyl 13-oxo-6-phenyl-7,13-dihydroindeno[2',1':4,5]furo[2,3-*b*]carbazole-12-carboxylate. Red solid in 68% yield, 75.3 mg, m.p. >300 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 4.12 (s, 3H), 7.17 (t, J = 7.6 Hz, 1H), 7.21-7.29 (m, 3H), 7.36 (d, J = 6.4 Hz, 1H), 7.42 (t, J = 7.6 Hz, 1H), 7.54 (d, J = 8.0 Hz, 1H), 7.61 (t, J = 7.6 Hz, 1H), 7.69 (t, J = 7.6 Hz, 2H), 7.82 (d, J = 6.4 Hz, 2H), 8.18 (d, J = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 53.4, 112.2, 112.7, 114.9, 116.7, 117.4, 119.1, 119.2, 119.7, 120.7, 122.9, 123.7, 127.1, 129.2, 129.7, 130.5, 131.3, 131.8, 132.9, 133.9, 137.0, 138.1, 142.3, 156.2, 168.2, 178.6, 183.7. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{17}NNaO_4^+$ ([M+Na]$^+$) 466.1050, found 466.1057.



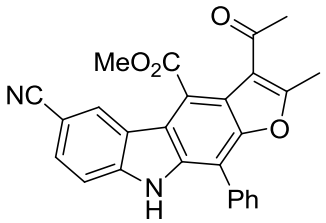
3ab, Methyl 1,3-dimethyl-2,4-dioxo-11-phenyl-2,3,4,10-tetrahydro-1*H*-pyrimido[5',4':4,5]furo[2,3-*b*]carbazole-5-carboxylate. White solid in 71% yield, 80.4 mg, m.p. >300 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 3.28 (s, 3H), 3.45 (s, 3H), 4.09 (s, 3H), 7.20 (t, J = 7.6 Hz, 1H), 7.43 (t, J = 7.6 Hz, 1H), 7.56-7.59 (m, 2H), 7.67 (t, J = 7.6 Hz, 2H), 7.84 (d, J = 7.2 Hz, 2H), 11.45 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 28.5, 30.2, 52.9, 91.6, 110.4, 112.3, 114.1, 117.4, 117.5, 119.8, 120.6, 121.1, 126.6, 129.1, 129.7, 130.2, 131.7, 135.4, 141.7, 147.4, 150.6, 157.8, 159.1, 168.5. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{20}N_3O_5^+$ ([M+H]$^+$) 454.1397, found 454.1400.



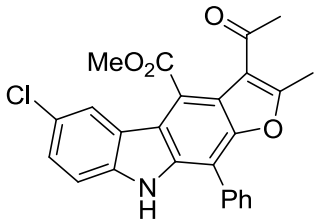
3ac, **Methyl 3-methyl-1,10-diphenyl-1,9-dihydropyrazolo[4',3':4,5]furo[2,3-*b*]carbazole-4-carboxylate.** White solid in 78% yield, 91.8 mg, m.p. 267-268 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.56 (s, 3H), 4.18 (s, 3H), 7.17-7.25 (m, 2H), 7.36-7.42 (m, 4H), 7.51 (t, J = 7.4 Hz, 1H), 7.61 (t, J = 7.6 Hz, 2H), 7.78-7.83 (m, 4H), 8.19 (d, J = 8.0 Hz, 1H), 8.45 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.7, 52.5, 107.2, 110.6, 112.3, 115.9, 116.0, 117.5, 117.6, 119.7, 121.7, 122.7, 125.4, 126.1, 128.6, 129.3, 129.3, 129.4, 132.0, 135.2, 137.6, 140.3, 142.2, 154.9, 156.5, 168.8. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{21}N_3NaO_3^+$ ([M+Na]$^+$) 494.1475, found 494.1478.



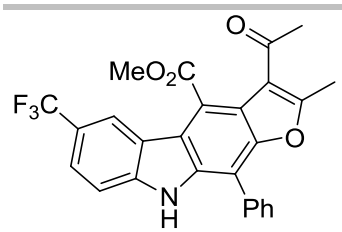
4b, Methyl 3-acetyl-2,6-dimethyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 85% yield, 87.3 mg, m.p. 215-217 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.51 (s, 3H), 2.56 (s, 3H), 2.71 (s, 3H), 4.17 (s, 3H), 7.22-7.27 (m, 2H), 7.51 (t, J = 7.6 Hz, 1H), 7.61 (t, J = 7.6 Hz, 2H), 7.74 (d, J = 7.2 Hz, 2H), 7.95 (s, 1H), 8.21 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.5, 21.6, 30.6, 52.1, 109.1, 110.1, 117.3, 118.2, 119.4, 122.0, 122.4, 127.6, 128.4, 129.1, 129.3, 129.5, 132.5, 136.6, 138.8, 149.5, 159.9, 168.7, 194.2. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{22}NO_4^+$ ($[M+H]^+$) 412.1543, found 412.1550.



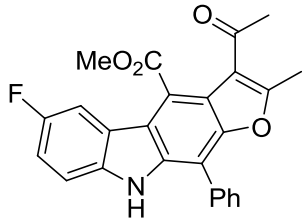
4c, Methyl 3-acetyl-6-cyano-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 73% yield, 77 mg, m.p. 269-270 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.58 (s, 3H), 2.75 (s, 3H), 4.00 (s, 3H), 7.56-7.60 (m, 1H), 7.65-7.69 (m, 3H), 7.76-7.81 (m, 3H), 8.38 (d, J = 1.6 Hz, 1H), 11.86 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.7, 31.0, 52.4, 101.2, 110.7, 113.2, 117.2, 118.4, 118.5, 119.0, 120.9, 121.1, 126.9, 129.1, 129.6, 129.6, 130.4, 131.8, 136.9, 144.1, 150.0, 162.1, 167.9, 194.7. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{18}N_2NaO_4^+$ ($[M+Na]^+$) 445.1159, found 445.1160. **IR**: 463, 776, 810, 948, 966, 1032, 1066, 1145, 1202, 1252, 1303, 1401, 1431, 1516, 1575, 1596, 1654, 1728, 2217, 2944, 3233.



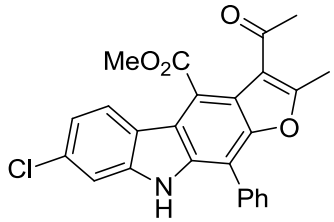
4d, Methyl 3-acetyl-6-chloro-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 60% yield, 64.6 mg, m.p. 239-240 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.55 (s, 3H), 2.71 (s, 3H), 4.15 (s, 3H), 7.26 (d, J = 8.0 Hz, 1H), 7.33 (dd, J = 8.8 Hz, J = 2.0 Hz, 1H), 7.50-7.54 (m, 1H), 7.62 (t, J = 7.6 Hz, 2H), 7.72 (d, J = 7.2 Hz, 2H), 8.15 (d, J = 2.0 Hz, 1H), 8.35 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.4, 30.5, 52.2, 109.6, 111.3, 117.9, 118.1, 118.3, 119.4, 122.3, 122.9, 125.2, 126.4, 128.6, 129.4, 129.4, 132.0, 136.7, 138.9, 149.8, 160.2, 168.3, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{19}ClNO_4^+$ ($[M+H]^+$) 432.0997, found 432.0997.



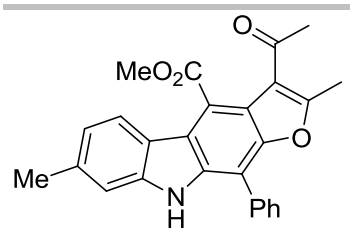
4e, Methyl 3-acetyl-2-methyl-10-phenyl-6-(trifluoromethyl)-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 76% yield, 88.3 mg, m.p. 210-211 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.54 (s, 3H), 2.71 (s, 3H), 4.16 (s, 3H), 7.41 (d, J = 8.4 Hz, 1H), 7.53 (t, J = 7.6 Hz, 1H), 7.62 (t, J = 7.6 Hz, 2H), 7.72 (d, J = 7.2 Hz, 2H), 8.49 (s, 1H), 8.56 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.3, 30.5, 52.2, 109.9, 110.6, 118.3, 118.5, 118.5, 119.4, 120.2 (q, J = 4.2 Hz), 121.4, 121.8 (q, J = 31.8 Hz), 123.1 (q, J = 3.4 Hz), 123.7 (q, J = 269.8 Hz), 128.7, 129.4, 129.4, 131.9, 136.6, 142.0, 149.8, 160.4, 168.2, 194.2. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{19}F_3NO_4^+$ ($[M+H]^+$) 466.1261, found 466.1264. **IR**: 592, 646, 694, 826, 960, 1061, 1112, 1157, 1283, 1311, 1325, 1404, 1435, 1520, 1581, 1600, 1659, 1713, 1721, 2945, 3055, 3314.



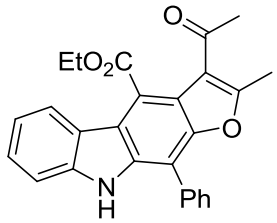
4f, Methyl 3-acetyl-6-fluoro-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 79% yield, 81.9 mg, m.p. 219-220 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.54 (s, 3H), 2.70 (s, 3H), 4.14 (s, 3H), 7.10-7.16 (m, 1H), 7.26 (dd, J = 8.8 Hz, J = 4.4 Hz, 1H), 7.59-7.63 (m, 2H), 7.72-7.75 (m, 2H), 7.87 (dd, J = 10.0 Hz, J = 2.4 Hz, 1H), 8.30 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.3, 30.5, 52.1, 108.4 (d, J = 25.2 Hz), 109.6, 110.8 (d, J = 9.1 Hz), 114.0 (d, J = 25.5 Hz), 117.9, 118.3, 118.5 (d, J = 4.1 Hz), 119.4, 122.2 (d, J = 9.9 Hz), 128.6, 129.3, 129.4, 132.2, 136.9, 137.3, 149.7, 156.1 (d, J = 233.8 Hz), 160.1, 168.3, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{18}FNNaO_4^+$ ($[M+Na]^+$) 438.1112, found 438.1116.



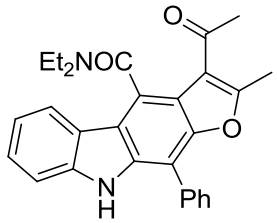
4g, Methyl 3-acetyl-7-chloro-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 78% yield, 84 mg, m.p. 245-247 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.56 (s, 3H), 2.72 (s, 3H), 4.11 (s, 3H), 7.16 (dd, J = 8.8 Hz, J = 2.0 Hz, 1H), 7.32 (d, J = 2.0 Hz, 1H), 7.51-7.55 (m, 1H), 7.63 (t, J = 7.6 Hz, 2H), 7.73-7.75 (m,2H), 8.08 (d, J = 8.8 Hz, 1H), 8.32 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.4, 30.6, 52.1, 109.6, 110.4, 118.0, 118.1, 118.3, 119.4, 120.4, 120.5, 123.5, 128.6, 129.4, 129.5, 132.0, 132.1, 136.4, 141.1, 149.6, 160.2, 168.4, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{25}H_{19}ClNO_4^+$ ($[M+H]^+$) 432.0997, found 432.1000.



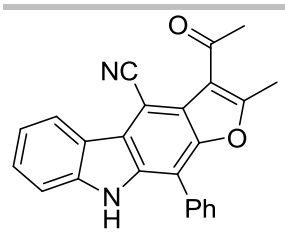
4h, Methyl 3-acetyl-2,7-dimethyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 73% yield, 75 mg, m.p. 266-267 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.49 (s, 3H), 2.56 (s, 3H), 2.71 (s, 3H), 4.14 (s, 3H), 7.04 (dd, J = 8.4 Hz, J = 0.8 Hz, 1H), 7.16 (s, 1H), 7.50-7.54 (m, 1H), 7.62 (t, J = 8.0 Hz, 2H), 7.74-7.76 (m, 2H), 8.07 (d, J = 8.4 Hz, 1H), 8.18 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.4, 21.9, 30.6, 52.1, 109.3, 110.5, 117.5, 117.7, 119.0, 119.5, 119.5, 121.4, 122.3, 128.4, 129.3, 129.5, 132.5, 136.3, 136.7, 141.1, 149.3, 159.7, 168.7, 194.4. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{22}NO_4^+$ ($[M+H]^+$) 412.1543, found 412.1545.



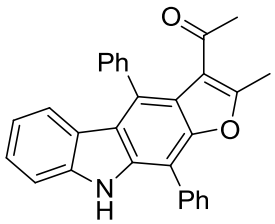
4i, Ethyl 3-acetyl-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. White solid in 76% yield, 78.1 mg, m.p. 203-205 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.46 (t, J = 7.2 Hz, 3H), 2.58 (s, 3H), 2.72 (s, 3H), 4.66 (q, J = 7.2 Hz, 2H), 7.21-7.23 (m, 1H), 7.37-7.44 (m, 2H), 7.52 (t, J = 7.6 Hz, 1H), 7.63 (t, J = 7.6 Hz, 2H), 7.74-7.76 (m, 2H), 8.23 (d, J = 8.0 Hz, 1H), 8.29 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 14.2, 15.4, 61.4, 109.2, 110.4, 117.5, 118.7, 118.7, 119.5, 119.8, 121.9, 122.7, 126.3, 128.5, 129.3, 129.5, 132.4, 136.3, 140.6, 149.6, 159.9, 168.3, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{26}H_{21}NNaO_4^+$ ($[M+Na]^+$) 434.1363, found 434.1363.



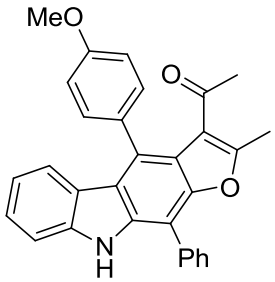
4j, 3-Acetyl-*N*,*N*-diethyl-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carboxamide. White solid in 78% yield, 85.4 mg, m.p. 216-218 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 0.77 (t, J = 6.8 Hz, 3H), 1.42 (t, J = 6.8 Hz, 3H), 2.54 (s, 3H), 2.72 (s, 3H), 3.05-3.19 (m, 2H), 3.72 (q, J = 6.8 Hz, 2H), 7.13 (t, J = 7.2 Hz, 1H), 7.36 (t, J = 7.2 Hz, 1H), 7.53 (t, J = 7.2 Hz, 2H), 7.65 (t, J = 7.2 Hz, 2H), 7.79 (d, J = 7.2 Hz, 2H), 7.89 (d, J = 7.6 Hz, 1H), 11.89 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 13.1, 13.7, 15.9, 31.4, 43.1, 107.7, 111.9, 115.8, 117.7, 119.2, 121.7, 121.8, 123.0, 126.0, 128.5, 129.5, 130.3, 132.8, 136.4, 141.8, 149.6, 160.8, 168.2, 194.0. **HRMS** (ESI-TOF) m/z calculated for $C_{28}H_{27}N_2O_3^+$ ($[M+H]^+$) 439.2016, found 439.2014. **IR**: 583, 691, 745, 953, 1062, 1126, 1229, 1298, 1318, 1391, 1457, 1518, 1576, 1594, 1615, 1670, 2927, 2974, 3264.



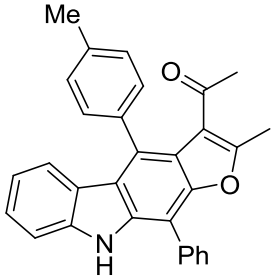
4k, 3-Acetyl-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazole-4-carbonitrile. White solid in 75% yield, 68.2 mg, m.p. >300 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.66 (s, 3H), 2.75 (s, 3H), 7.28-7.32 (m, 1H), 7.50-7.54 (m, 1H), 7.58-7.62 (m, 2H), 7.68 (t, J = 8.0 Hz, 2H), 7.79-7.81 (m, 2H), 8.64 (d, J = 8.0 Hz, 1H), 11.54 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.7, 31.5, 92.8, 112.4, 113.6, 117.8, 118.8, 120.0, 120.7, 121.3, 123.1, 127.6, 129.4, 129.6, 130.3, 131.6, 136.0, 142.4, 149.2, 162.7, 194.0. **HRMS** (ESI-TOF) m/z calculated for $C_{24}H_{16}N_2NaO_2^+$ ([M+Na]$^+$) 387.1104, found 387.1104.



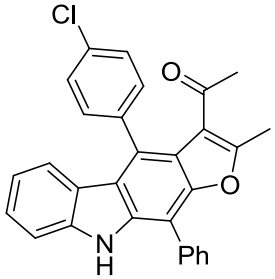
4l, 1-(2-Methyl-4,10-diphenyl-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 70% yield, 72.6 mg, m.p. 243-244 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.58 (s, 3H), 2.48 (s, 3H), 6.93-6.97 (m, 1H), 7.28-7.37 (m, 3H), 7.52-7.67 (m, 8H), 7.84-7.86 (m, 2H), 8.33 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.4, 30.4, 106.9, 110.2, 119.1, 119.7, 120.7, 122.2, 123.3, 125.4, 127.8, 128.1, 128.3, 129.1, 129.3, 129.5, 130.0, 133.1, 136.3, 139.2, 140.5, 149.8, 156.6, 199.0. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{22}NO_2^+$ ([M+H]$^+$) 416.1645, found 416.1644.



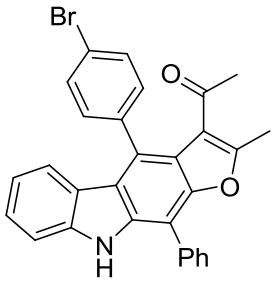
4m, 1-(4-(4-Methoxyphenyl)-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 72% yield, 80.1 mg, m.p. 245-247 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.63 (s, 3H), 2.47 (s, 3H), 3.95 (s, 3H), 6.94-6.98 (m, 1H), 7.10-7.13 (m, 2H), 7.29-7.33 (m, 1H), 7.35 (d, J = 8.8 Hz, 2H), 7.49-7.54 (m, 3H), 7.64 (t, J = 7.6 Hz, 2H), 7.83-7.85 (m, 2H), 8.32 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.4, 30.7, 55.3, 106.7, 110.2, 114.5, 119.1, 119.4, 120.0, 120.7, 122.2, 123.5, 125.3, 127.6, 128.0, 129.3, 129.5, 131.1, 131.5, 133.2, 136.3, 140.4, 149.8, 156.4, 159.6, 199.3. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{24}NO_3^+$ ([M+H]$^+$) 446.1751, found 446.1750.



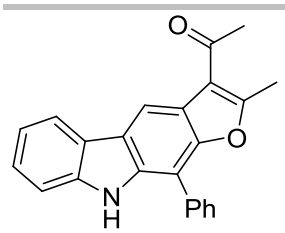
4n, 1-(2-Methyl-10-phenyl-4-(*p*-tolyl)-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 74% yield, 79.3 mg, m.p. 285-286 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.57 (s, 3H), 2.47 (s, 3H), 2.51 (s, 3H), 6.93-6.97 (m, 1H), 7.29-7.40 (m, 5H), 7.50-7.53 (m, 3H), 7.62-7.66 (m, 3H), 7.83-7.85 (m, 2H), 8.30 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.4, 21.4, 30.6, 106.7, 110.2, 119.1, 119.1, 119.8, 120.7, 122.2, 123.4, 125.3, 128.0, 128.1, 129.3, 129.5, 129.8, 133.2, 136.2, 136.3, 138.1, 140.4, 149.8, 156.5, 199.3. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{24}NO_2^+$ ($[M+H]^+$) 430.1802, found 430.1801.



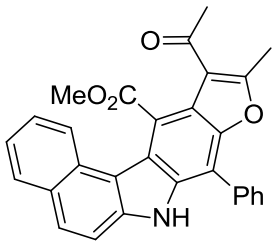
4o, 1-(4-(4-Chlorophenyl)-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 77% yield, 86.4 mg, m.p. 284-285 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.69 (s, 3H), 2.49 (s, 3H), 6.96-7.00 (m, 1H), 7.26 (d, J = 8.0 Hz, 1H), 7.31-7.38 (m, 2H), 7.51-7.59 (m, 5H), 7.65 (t, J = 7.6 Hz, 2H), 7.83-7.85 (m. 2H), 8.32 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.5, 30.8, 107.2, 110.4, 119.1, 119.3, 119.6, 120.4, 122.0, 123.1, 125.6, 126.3, 128.2, 129.4, 129.5, 131.4, 133.0, 134.3, 136.3, 137.7, 140.5, 149.8, 156.8, 198.6. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{21}ClNO_2^+$ ($[M+H]^+$) 450.1255, found 450.1256.



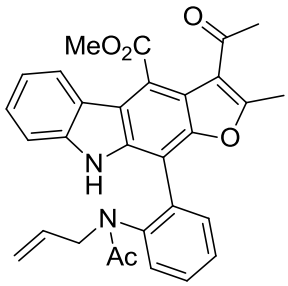
4p, 1-(4-(4-Bromophenyl)-2-methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 75% yield, 92.4 mg, m.p. 296-297 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 1.73 (s, 3H), 2.44 (s, 3H), 6.90 (t, J = 7.2 Hz, 1H), 7.01 (d, J = 8.0 Hz, 1H), 7.27-7.30 (m, 1H), 7.47-7.56 (m, 4H), 7.66 (t, J = 8.0 Hz, 2H), 7.80 (d, J = 8.4 Hz, 4H), 11.1 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 13.9, 31.2, 107.5, 111.9, 118.8, 118.9, 119.1, 120.3, 121.4, 122.0, 122.4, 125.8, 126.2, 128.5, 129.6, 130.3, 132.3, 132.4, 133.1, 136.5, 138.6, 141.9, 149.7, 156.6, 197.4. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{21}BrNO_2^+$ ($[M+H]^+$) 494.0750, found 494.0750.



4q, 1-(2-Methyl-10-phenyl-9*H*-furo[2,3-*b*]carbazol-3-yl)ethanone. White solid in 58% yield, 49.1 mg, m.p. 214-216 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.73 (s, 3H), 2.79 (s, 3H), 7.25-7.29 (m, 1H), 7.38-7.43 (m, 2H), 7.50 (t, J = 7.2 Hz, 1H), 7.62 (t, J = 8.0 Hz, 2H), 7.80 (d, J = 7.2 Hz, 1H), 8.17 (d, J = 8.0 Hz, 1H), 8.24 (s, 1H), 8.63 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 15.7, 31.2, 107.5, 110.4, 111.5, 117.9, 119.5, 120.3, 120.3, 121.9, 123.6, 125.7, 128.0, 129.2, 129.4, 133.1, 135.9, 140.2, 149.9, 162.1, 194.4. **HRMS** (ESI-TOF) m/z calculated for $C_{23}H_{17}NNaO_2^+$ ([M+Na]$^+$) 362.1151, found 362.1151.

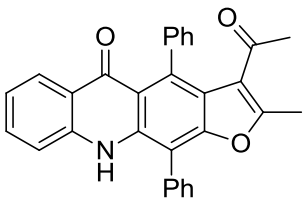


4r, Methyl 11-acetyl-10-methyl-8-phenyl-7*H*-benzo[*g*]furo[2,3-*b*]carbazole-12-carboxylate. White solid in 69% yield, 77.1 mg, m.p. 261-262 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.59 (s, 3H), 2.67 (s, 3H), 4.01 (s, 3H), 7.44 (t, J = 7.6 Hz, 1H), 7.56-7.70 (m, 4H), 7.80-7.83 (m, 3H), 7.93 (d, J = 8.8 Hz, 1H), 8.02-8.05 (m, 2H), 11.76 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.1, 31.7, 52.3, 110.1, 113.7, 114.2, 117.8, 118.0, 118.7, 119.4, 123.0, 124.4, 126.4, 128.6, 128.9, 129.2, 129.4, 129.6, 129.6, 130.5, 132.4, 135.7, 140.6, 148.4, 159.2, 169.8, 196.0. **HRMS** (ESI-TOF) m/z calculated for $C_{29}H_{21}NNaO_4^+$ ([M+Na]$^+$) 470.1363, found 470.1369.

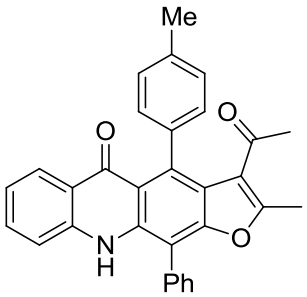


6, Methyl 3-acetyl-10-(2-(*N*-allylacetamido)phenyl)-2-methyl-9*H*-furo[2,3-*b*]carbazole-4-carboxylate. Mixture of two regioisomers, White solid in 68% yield, 84 mg, m.p. 220-222 ^{o}C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 2.09 (s, 3H), 2.56 (s, 4H), 2.68 (s, 3H), 2.73-2.79 (m, 2.23H), 3.50-3.56 (m, 0.88H), 1.02-4.06 (m, 5H), 4.43 (d, J = 13.6 Hz, 0.36H), 4.73 (d, J = 17.2 Hz, 1H), 4.82 (d, J = 17.2 Hz, 1H), 5.06-5.11 (m, 0.7H), 5.42-5.52 (m, 1H), 5.77-5.87 (m, 0.41H), 7.17 (t, J = 7.6 Hz, 1.34H), 7.40 (t, J = 7.6 Hz, 1.34H), 7.45-7.58 (m, 3H), 7.65-7.66 (m, 4H), 7.92-7.95 (m, 1.36H), 11.15 (s, 0.31H), 11.19 (s, 1H). **^{13}C NMR** (100 MHz, DMSO-d_6) δ 15.6, 15.8, 22.2, 23.5, 31.0, 50.1, 52.3, 106.4, 106.4, 111.9, 112.0, 114.3, 116.0, 116.1, 117.4, 117.5, 118.0, 118.1, 118.7, 118.8, 119.2, 119.2, 119.6, 121.0, 121.7, 126.6, 127.9, 129.1, 129.2, 129.6, 130.2, 130.4, 130.6, 130.9, 131.5, 133.0, 133.1, 133.3, 134.7,

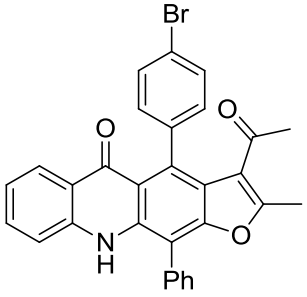
137.2, 137.3, 141.9, 141.9, 142.4, 143.1, 143.2, 149.4, 149.5, 156.7, 161.5, 161.7, 168.3, 169.2, 169.8, 194.2, 194.3. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{27}N_2O_5^+$ ($[M+H]^+$) 495.1914, found 495.1914.



9a, 3-Acetyl-2-methyl-4,11-diphenylfuro[3,2-*b*]acridin-5(10*H*)-one. White solid in 62% yield, 68.6 mg, m.p. 250-252 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.46 (s, 3H), 2.35 (s, 3H), 7.12 (d, J = 8.0 Hz, 1H), 7.12-7.16 (m, 1H), 7.39-7.49 (m, 5H), 7.51-7.55 (m, 1H), 7.60-7.64 (m, 3H), 7.68-7.72 (m, 2H), 8.05 (s, 1H), 8.28 (dd, J = 8.0 Hz, J = 1.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.0, 30.3, 110.6, 115.6, 116.0, 121.1, 121.3, 121.5, 122.7, 127.5, 127.6, 128.0, 129.1, 129.3, 129.9, 130.6, 130.7, 133.0, 136.0, 137.1, 139.4, 141.0, 153.0, 157.0, 178.6, 199.1 **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{21}NNaO_3^+$ ($[M+Na]^+$) 466.1414, found 466.1414.

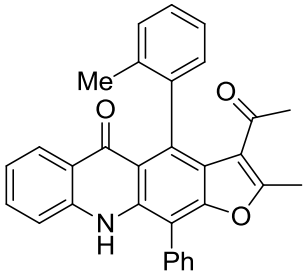


9b, 3-Acetyl-2-methyl-11-phenyl-4-(*p*-tolyl)furo[3,2-*b*]acridin-5(10*H*)-one. White solid in 65% yield, 74.2 mg, m.p. 264-265 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.45 (s, 3H), 2.35 (s, 3H), 2.45 (s, 3H), 7.03 (d, J = 8.0 Hz, 1H), 7.14 (t, J = 8.0 Hz, 1H), 7.26-7.31 (m, 4H), 7.50-7.55 (m, 1H), 7.60-7.64 (m, 3H), 7.68-7.72 (m, 2H), 8.02 (s, 1H), 8.29 (d, J = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.0, 21.4, 30.4, 110.4, 115.6, 116.1, 121.2, 121.3, 121.6, 122.8, 127.6, 128.8, 129.1, 129.3, 129.9, 130.6, 130.7, 133.0, 136.3, 137.1, 137.1, 138.0, 139.4, 153.0, 156.9, 178.7, 199.3. **HRMS** (ESI-TOF) m/z calculated for $C_{31}H_{23}NNaO_3^+$ ($[M+Na]^+$) 480.1570, found 480.1570. **IR**: 688, 787, 936, 1127, 1195, 1212, 1269, 1309, 1395, 1483, 1511, 1531, 1589, 1615, 1634, 1685, 2921, 3026, 3180.

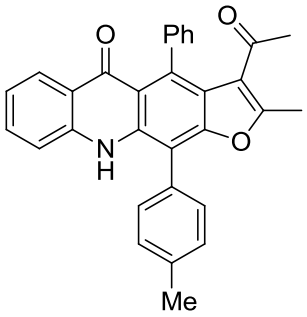


9c, 3-Acetyl-4-(4-bromophenyl)-2-methyl-11-phenylfuro[3,2-*b*]acridin-5(10*H*)-one. White solid in 60% yield, 78.1 mg, m.p. 269-270 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.57 (s, 3H), 2.36 (s, 3H), 7.05 (d, J = 8.0 Hz, 1H), 7.14-7.18 (m, 1H), 7.27-7.31 (m, 2H), 7.53-7.65 (m, 6H), 7.68-7.72 (m, 2H), 8.07 (s,

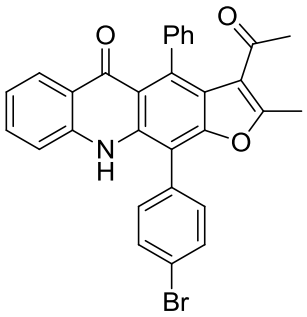
1H), 8.27 (dd, *J* = 8.0 Hz, *J* = 1.2 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.1, 30.6, 111.0, 115.7, 115.9, 120.8, 121.4, 121.5, 121.6, 122.5, 127.4, 129.4, 129.9, 130.5, 130.5, 130.8, 131.2, 133.2, 134.5, 137.1, 139.4, 139.9, 153.0, 157.3, 178.6, 198.7. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{20}BrNNaO_3^+$ ($[M+Na]^+$) 544.0519, found 544.0520. **IR**: 694, 756, 789, 1011, 1127, 1213, 1270, 1309, 1395, 1483, 1530, 1583, 1616, 1686, 3025, 3130, 3181, 3253.



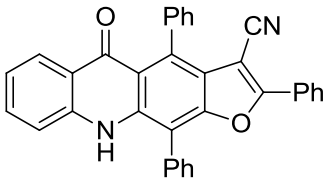
9d, 3-Acetyl-2-methyl-11-phenyl-4-(*o*-tolyl)furo[3,2-*b*]acridin-5(10*H*)-one. White solid in 58% yield, 66.2 mg, m.p. 220-221 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.52 (s, 3H), 2.13 (s, 3H), 2.35 (s, 3H), 7.04 (d, *J* = 8.0 Hz, 1H), 7.12-7.18 (m, 2H), 7.25-7.36 (m, 3H), 7.50-7.55 (m, 1H), 7.60-7.72 (m, 5H), 8.05 (s, 1H), 8.28 (dd, *J* = 8.0 Hz, *J* = 1.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.1, 20.0, 30.1, 110.4, 115.6, 116.5, 121.2, 121.3, 121.4, 122.2, 125.7, 127.6, 127.7, 128.4, 129.2, 129.6, 129.9, 130.6, 130.7, 133.0, 135.4, 136.1, 136.9, 139.5, 140.7, 153.1, 156.7, 178.5, 198.9. **HRMS** (ESI-TOF) m/z calculated for $C_{31}H_{23}NNaO_3^+$ ($[M+Na]^+$) 480.1570, found 480.1571.



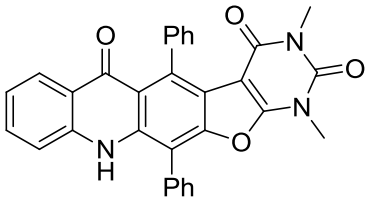
9e, 3-Acetyl-2-methyl-4-phenyl-11-(*p*-tolyl)furo[3,2-*b*]acridin-5(10*H*)-one. White solid in 63% yield, 72 mg, m.p. 238-240 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.45 (s, 3H), 2.35 (s, 3H), 2.53 (s, 3H), 7.05 (d, *J* = 8.4 Hz, 1H), 7.11-7.15 (m, 1H), 7.39-7.54 (m, 10H), 8.12 (s, 1H), 8.27 (d, *J* = 7.2 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.0, 21.4, 30.3, 110.6, 115.6, 115.9, 121.1, 121.2, 121.5, 122.6, 127.4, 127.5, 127.5, 128.0, 129.1, 130.3, 130.6, 133.0, 135.7, 137.2, 139.3, 139.4, 141.1, 153.1, 156.9, 178.6, 199.1. **HRMS** (ESI-TOF) m/z calculated for $C_{31}H_{23}NNaO_3^+$ ($[M+Na]^+$) 480.1570, found 480.1574.



9f, 3-Acetyl-11-(4-bromophenyl)-2-methyl-4-phenylfuro[3,2-*b*]acridin-5(10*H*)-one. White solid in 66% yield, 85.9 mg, m.p. 263-265 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.45 (s, 3H), 2.35 (s, 3H), 7.08 (d, J = 8.4 Hz, 1H), 7.13-7.17 (m, 1H), 7.37-7.41 (m, 2H), 7.42-7.48 (m, 3H), 7.49-7.57 (m, 3H), 7.80-7.83 (m, 2H), 7.96 (s, 1H), 7.26 (dd, J = 8.0 Hz, J = 1.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 13.0, 30.3, 109.3, 115.7, 116.0, 121.1, 121.5, 121.6, 122.7, 123.7, 127.6, 128.1, 129.1, 129.6, 132.3, 133.2, 136.5, 136.9, 139.4, 140.9, 152.9, 156.9, 178.5, 199.0. **HRMS** (ESI-TOF) m/z calculated for $C_{30}H_{20}BrNNaO_3^+$ ($[M+Na]^+$) 544.0519, found 544.0519.



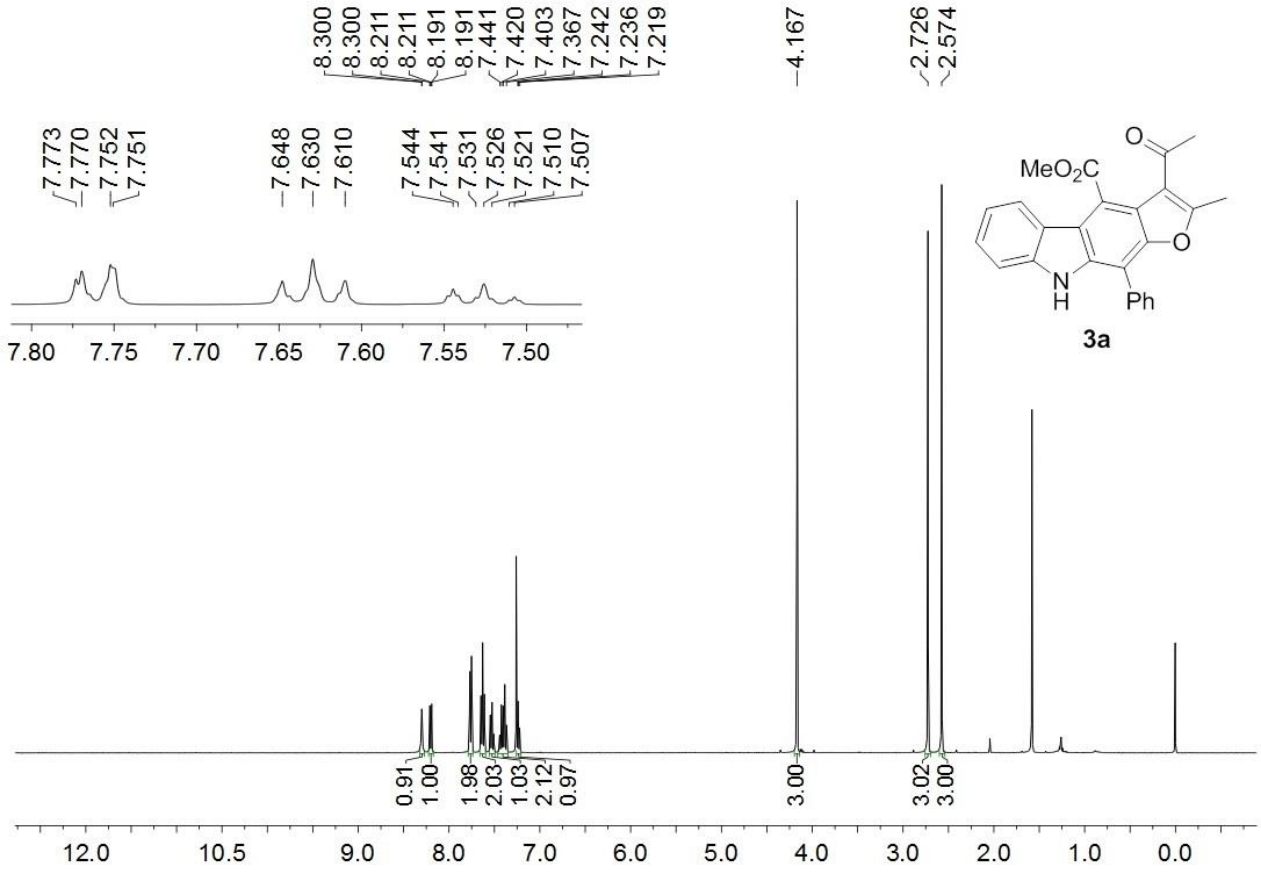
9g, 5-Oxo-2,4,11-triphenyl-5,10-dihydrofuro[3,2-*b*]acridine-3-carbonitrile. White solid in 65% yield, 79.3 mg, m.p. 246-248 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.07 (d, J = 8.4 Hz, 1H), 7.15-7.19 (m, 1H), 7.43-7.47 (m, 5H), 7.54-7.58 (m, 4H), 7.65-7.77 (m, 5H), 8.01-8.03 (m, 2H), 8.15 (s, 1H), 8.30 (dd, J = 8.0 Hz, J = 1.2 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 89.1, 111.0, 112.6, 115.8, 117.2, 121.6, 121.8, 122.3, 126.6, 127.4, 127.7, 127.8, 127.9, 128.3, 129.0, 129.6, 130.0, 130.1, 130.4, 131.3, 133.4, 137.6, 137.8, 138.5, 139.5, 152.2, 163.3, 178.4. **HRMS** (ESI-TOF) m/z calculated for $C_{34}H_{20}N_2NaO_2^+$ ($[M+Na]^+$) 511.1417, found 511.1419. **IR**: 687, 701, 757, 1158, 1306, 1393, 1484, 1533, 1589, 1615, 2225, 3056, 3133, 3190, 3260, 3452, 3638.



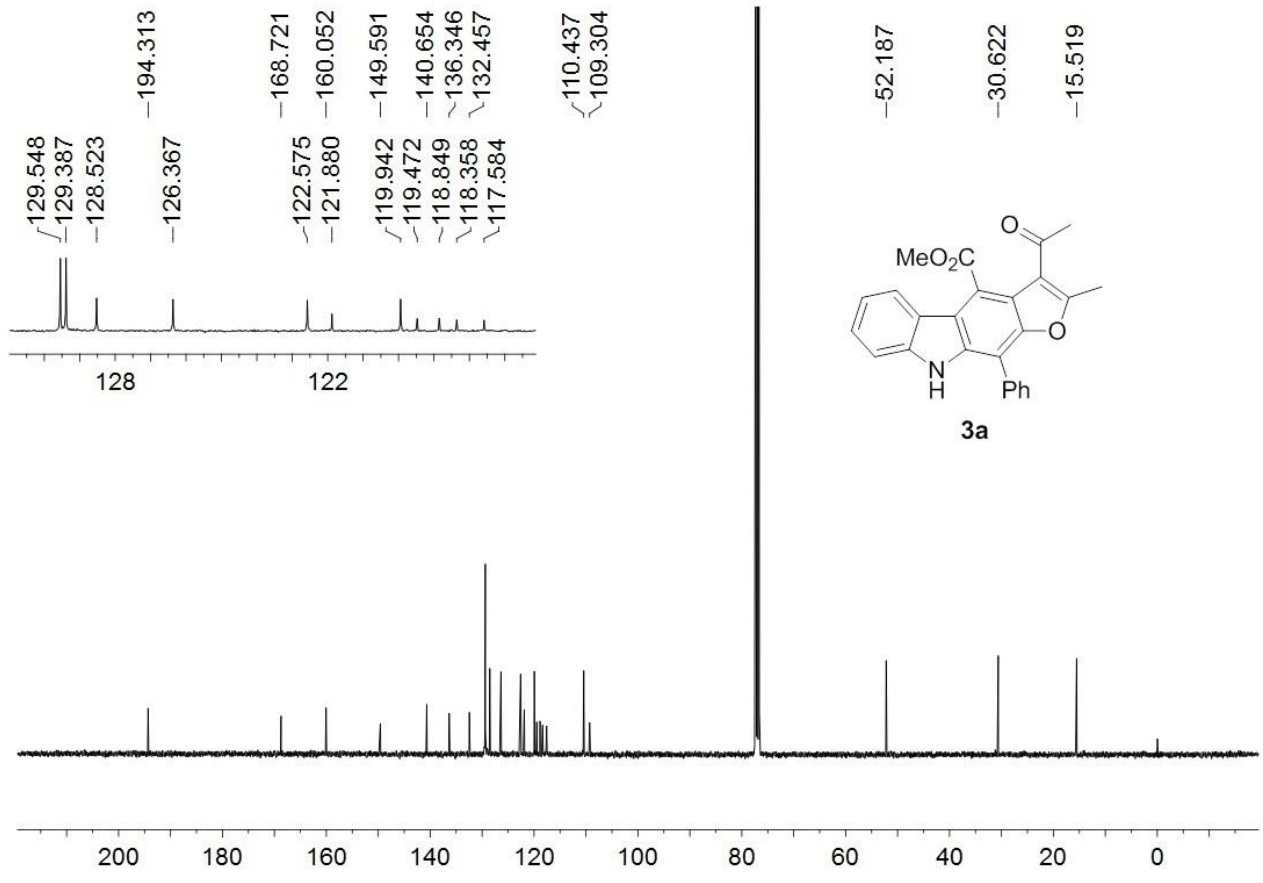
9h, 1,3-dimethyl-5,12-diphenylpyrimido[5',4':4,5]furo[3,2-*b*]acridine-2,4,6(1*H*,3*H*,11*H*)-trione. White solid in 45% yield, 56.1 mg, m.p. 269-270 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.75 (s, 3H), 3.49 (s, 3H), 7.20-7.24 (m, 1H), 7.33-7.37 (m, 3H), 7.46-7.51 (m, 6H), 7.64-7.68 (m, 1H), 7.79-7.81 (m, 2H), 8.21 (d, J = 6.8 Hz, 1H). 9.19 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 28.8, 39.3, 83.4, 105.8, 110.6, 116.2, 121.7, 122.0, 122.1, 122.4, 122.6, 127.7, 127.9, 128.8, 129.7, 130.4, 131.9, 131.9, 134.0, 135.0, 138.1, 138.2, 139.0, 152.5, 160.6, 178.3. **HRMS** (ESI-TOF) m/z calculated for $C_{31}H_{21}N_3NaO_4^+$ ($[M+Na]^+$) 522.1424, found 522.1426.

4. Copies of ^{1}H NMR and ^{13}C NMR spectra of compounds 3, 4, 6, 9

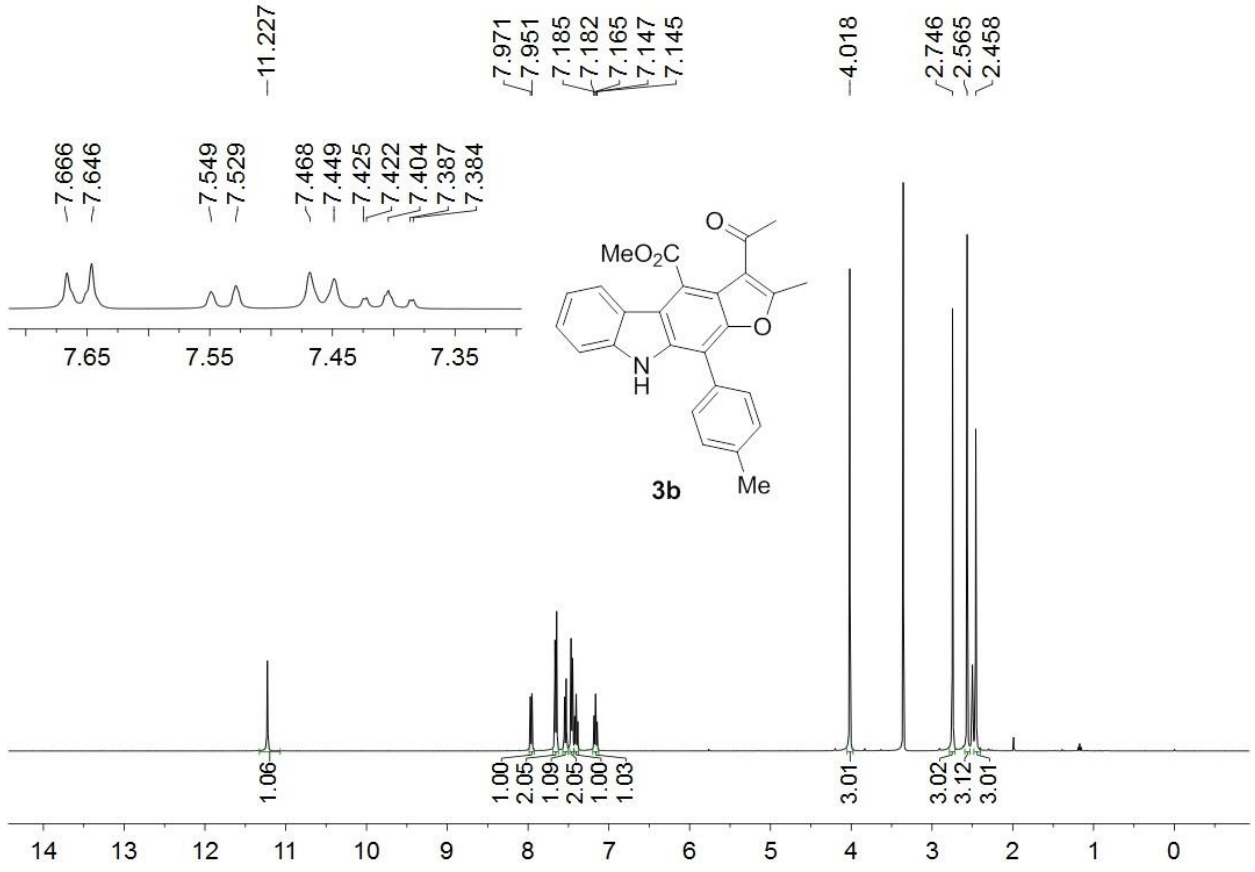
^{1}H NMR (400 MHz, $CDCl_3$) for **3a**



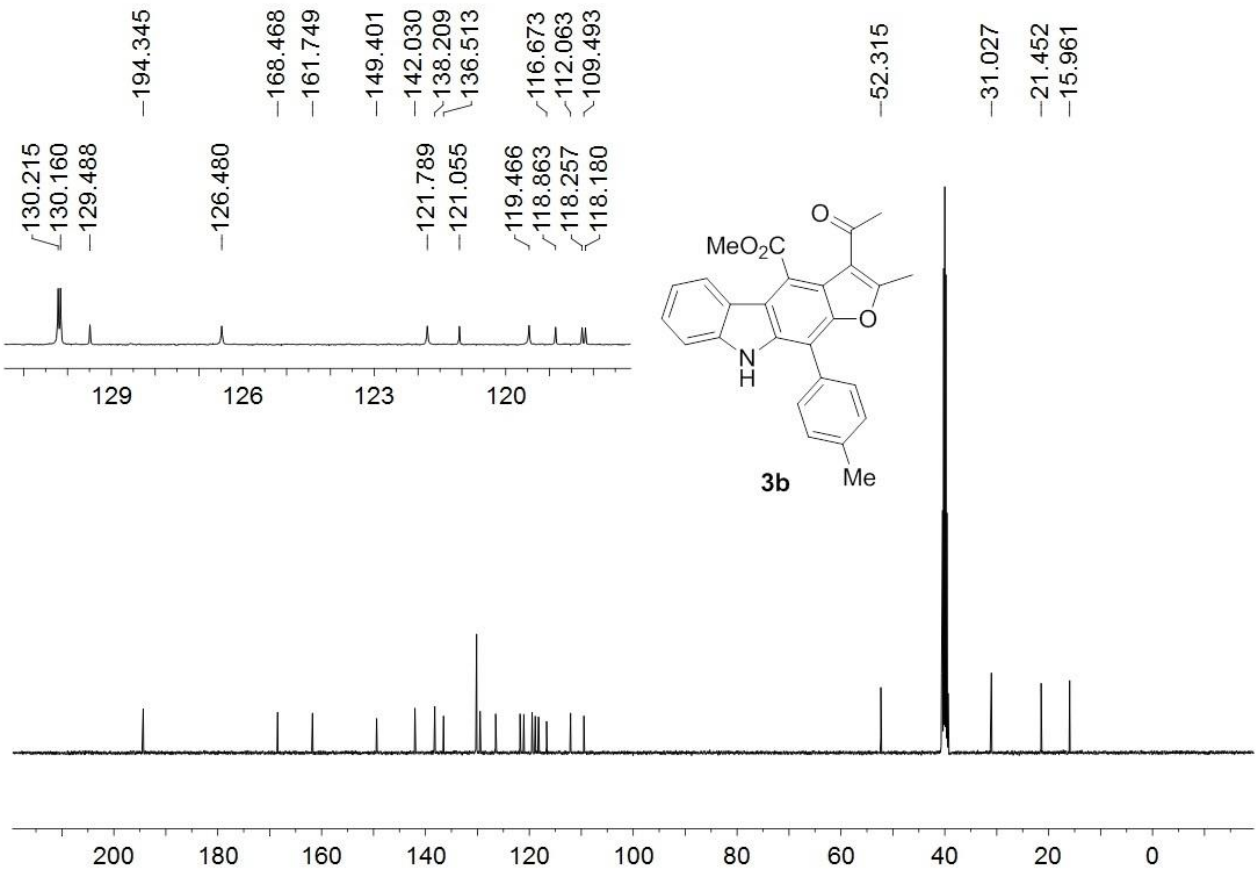
^{13}C NMR (100 MHz, $CDCl_3$) for **3a**



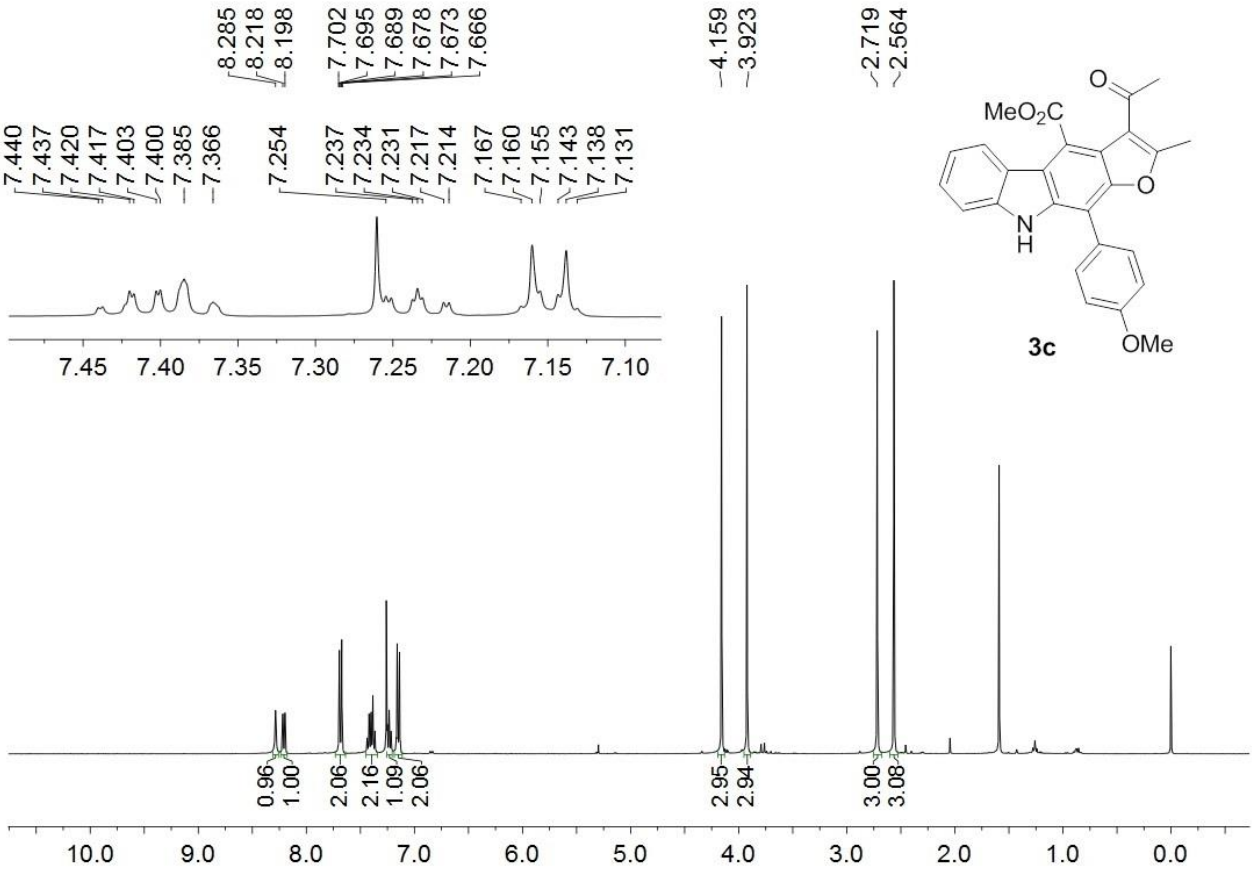
^{1}H NMR (400 MHz, DMSO-d_6) for **3b**



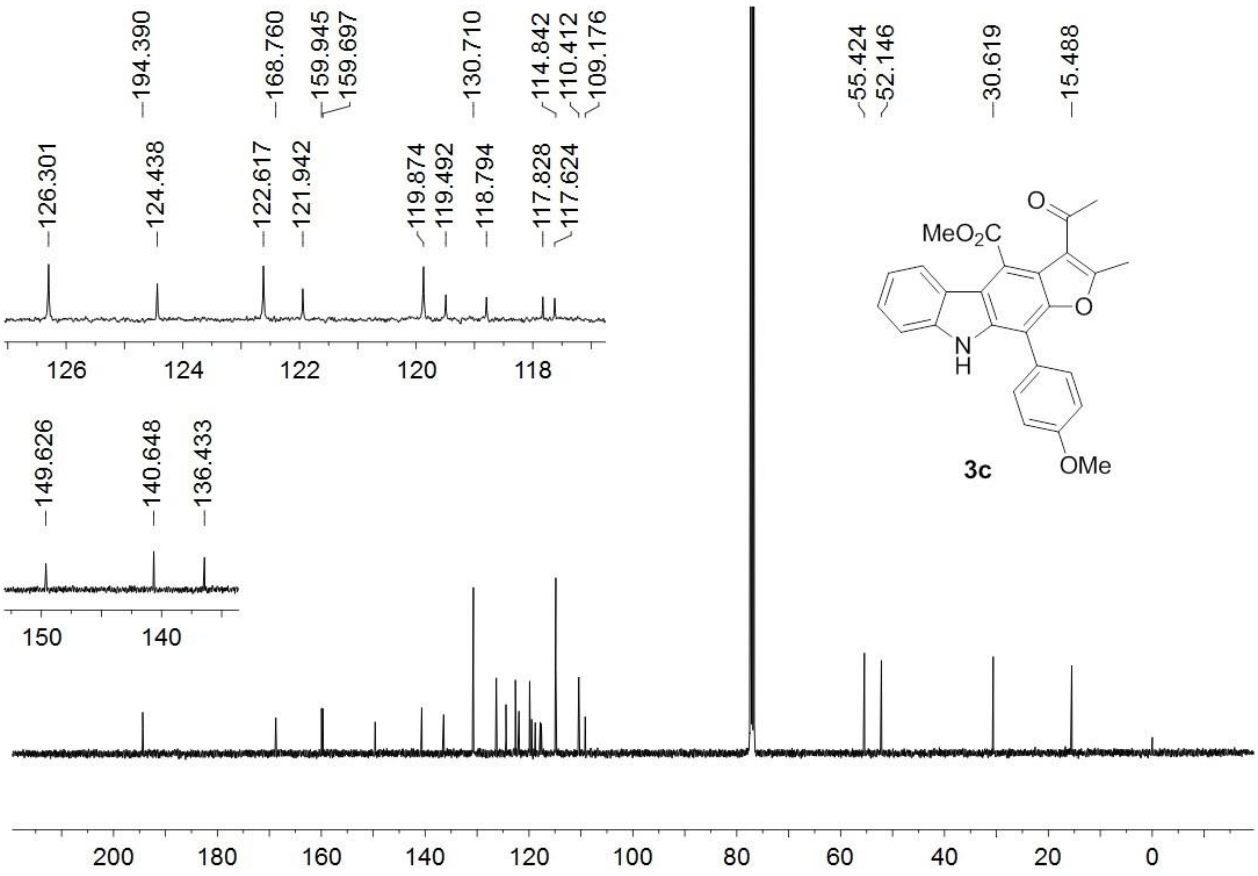
^{13}C NMR (100 MHz, DMSO-d_6) for **3b**



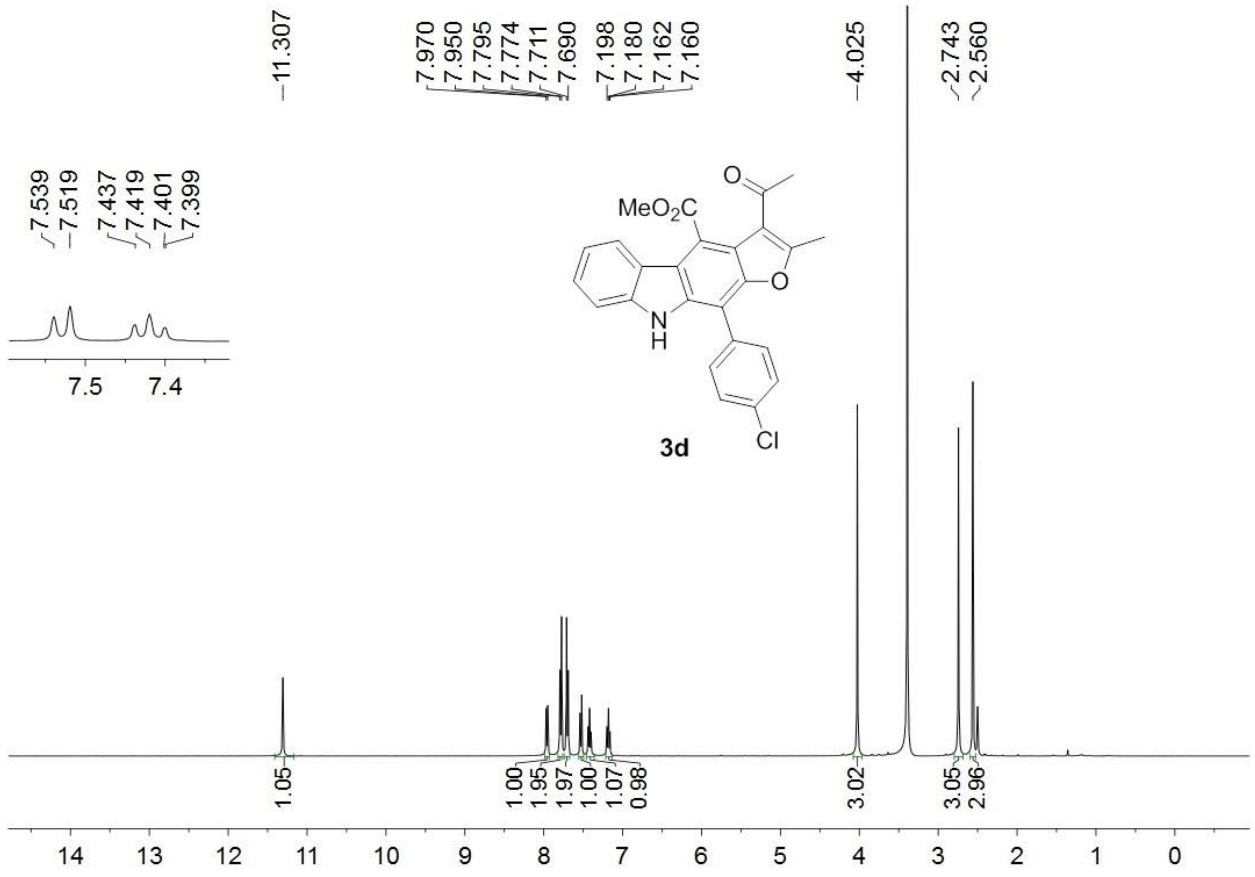
^{1}H NMR (400 MHz, $CDCl_3$) for **3c**



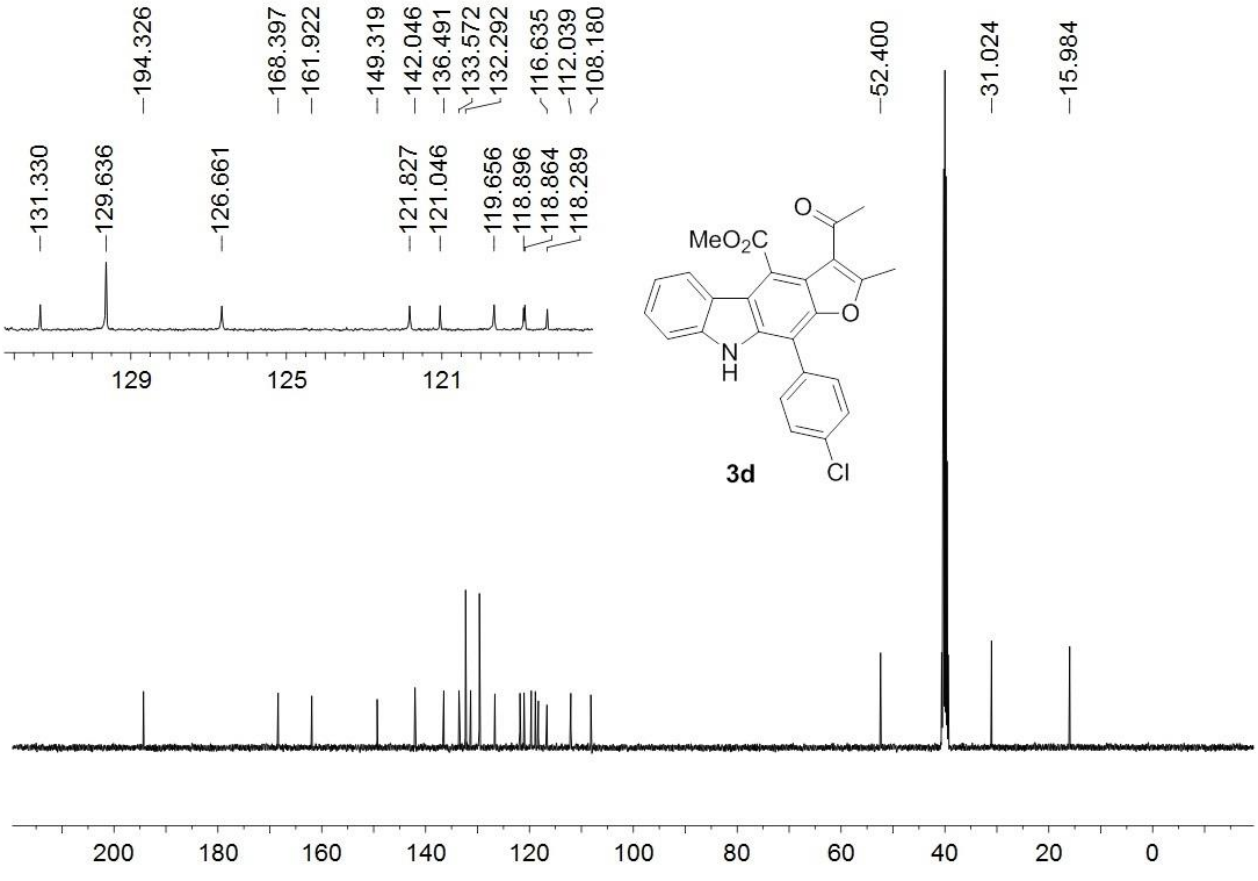
^{13}C NMR (100 MHz, $CDCl_3$) for **3c**



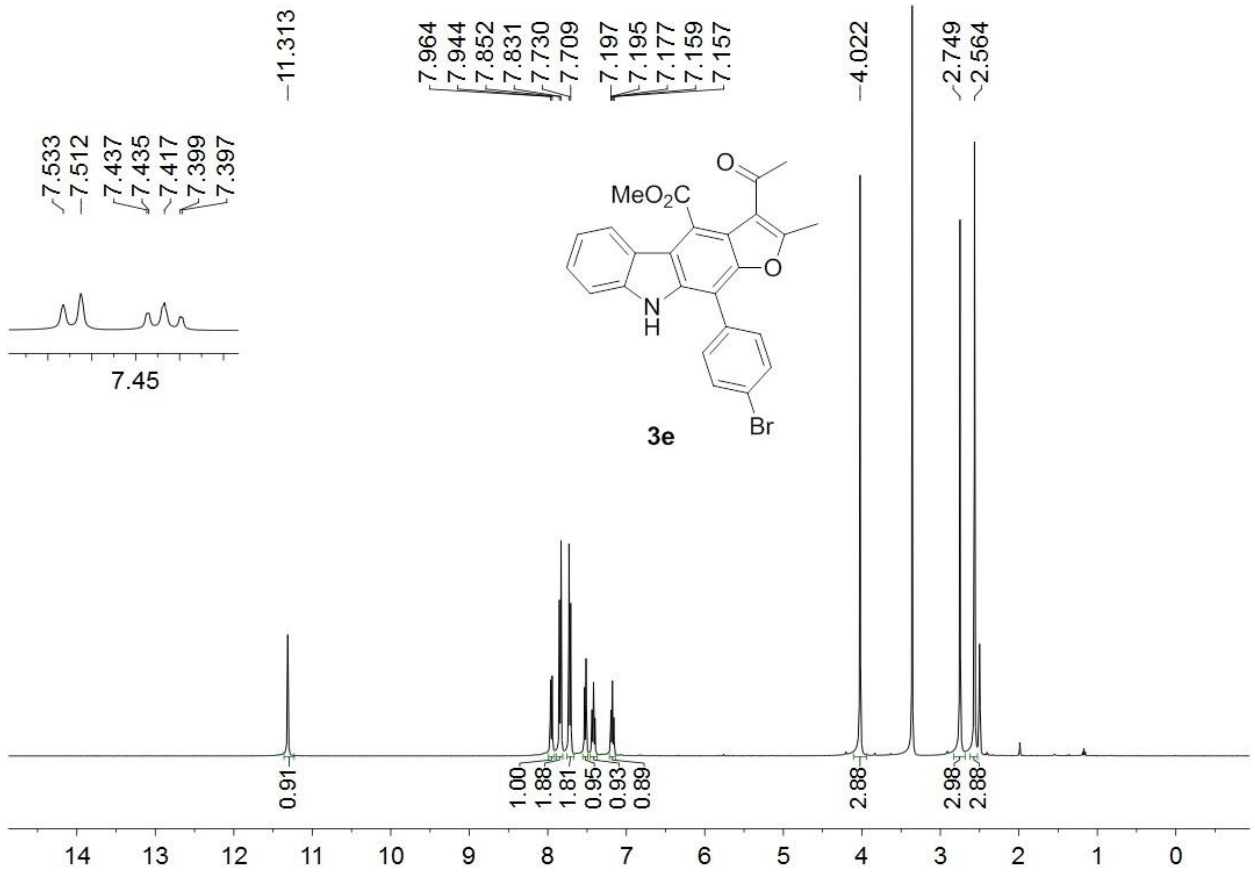
^{1}H NMR (400 MHz, DMSO-d_6) for **3d**



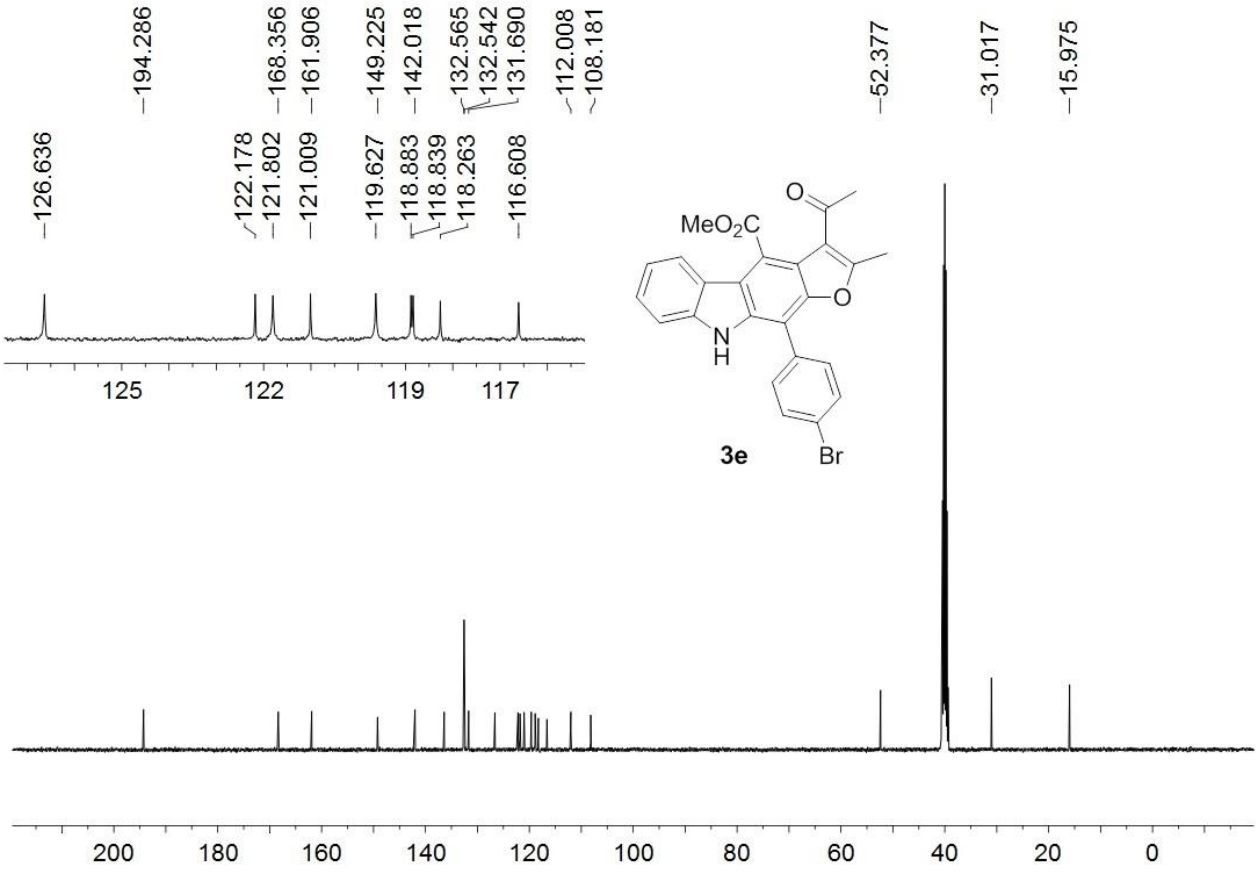
^{13}C NMR (100 MHz, DMSO-d_6) for **3d**



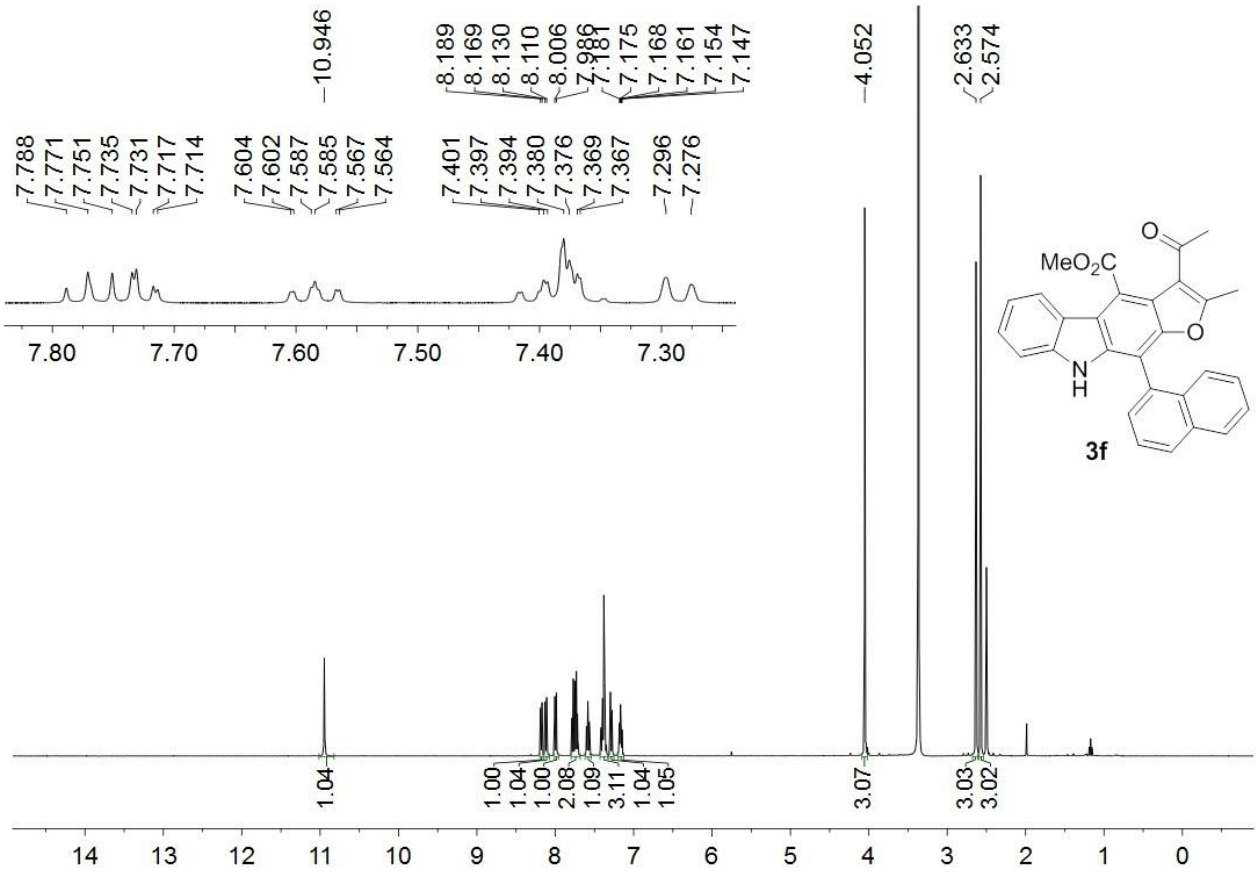
^{1}H NMR (400 MHz, DMSO-d_6) for **3e**



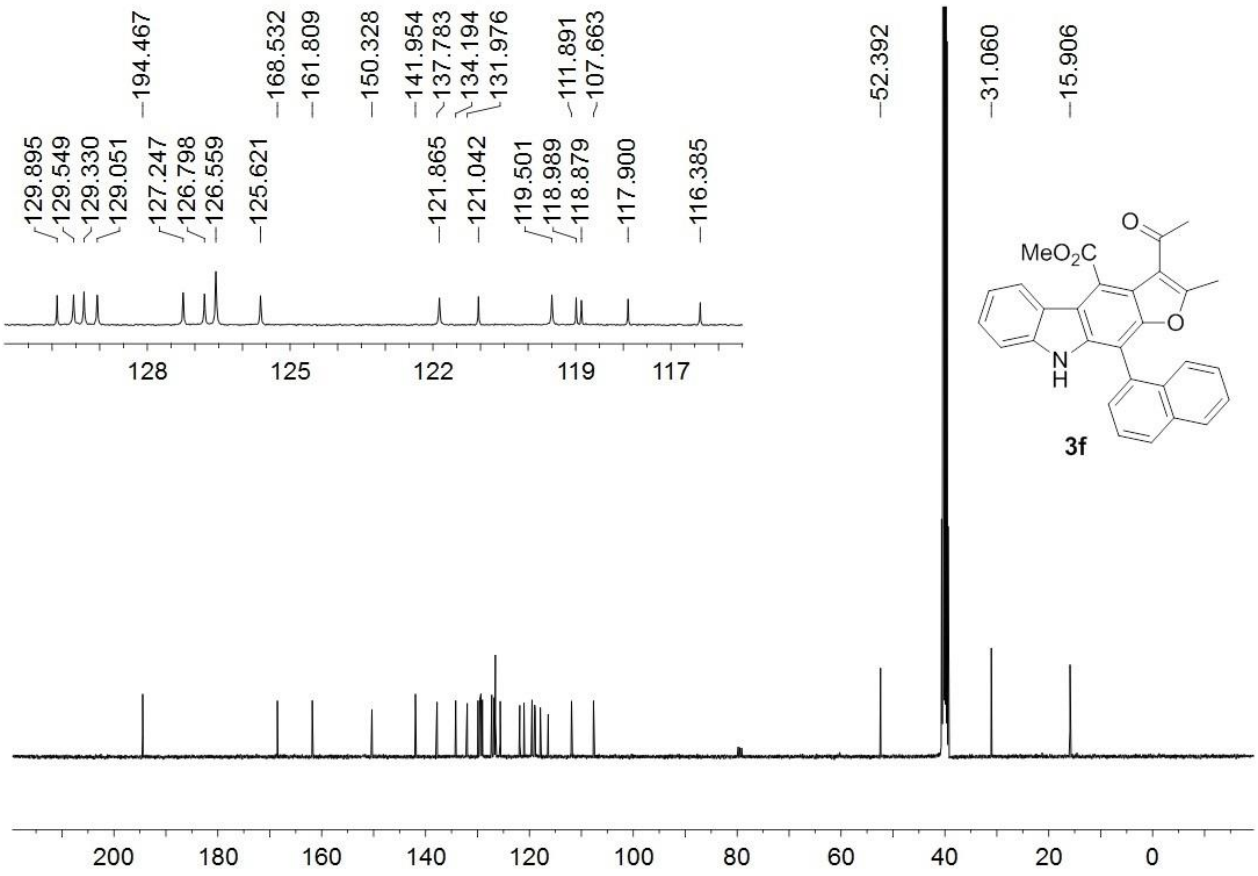
^{13}C NMR (100 MHz, DMSO-d_6) for **3e**



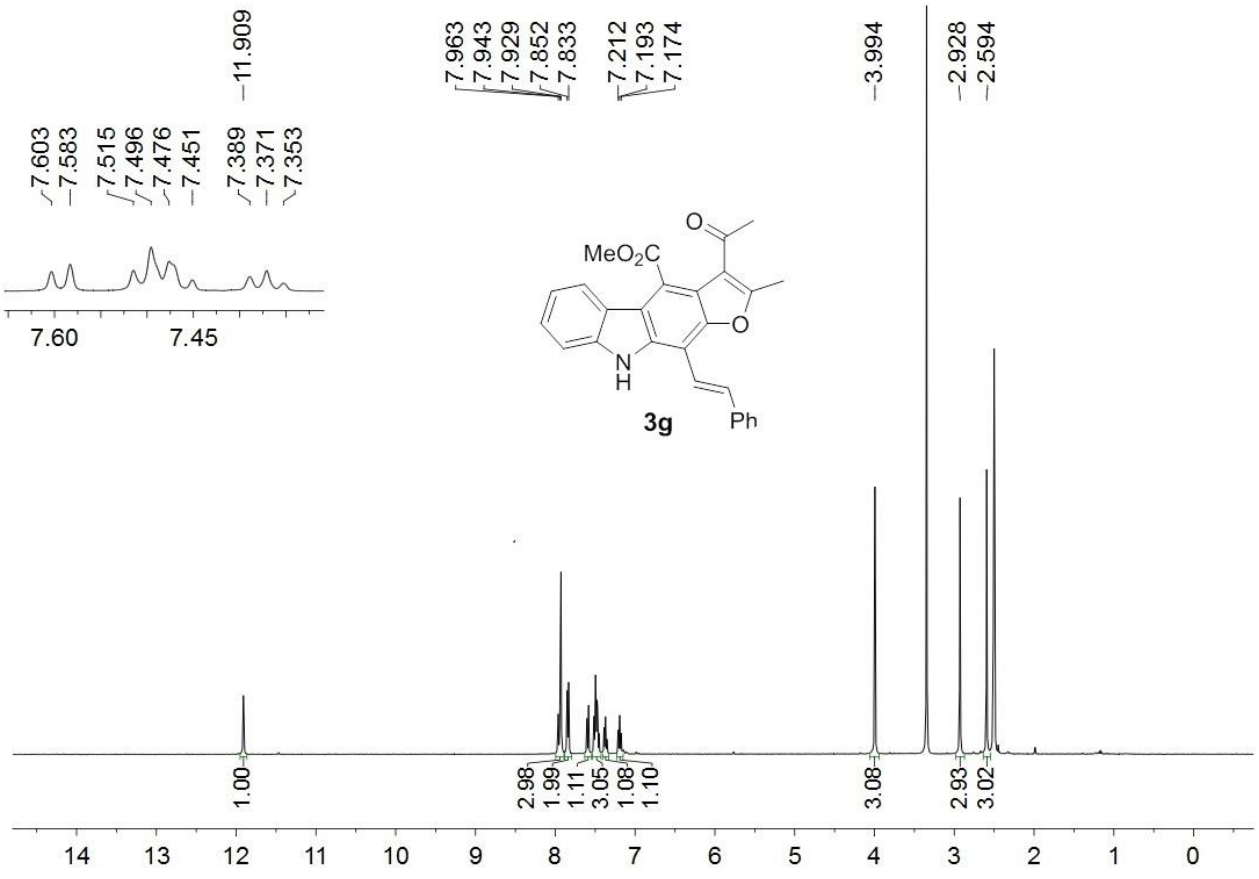
^{1}H NMR (400 MHz, DMSO-d_6) for **3f**



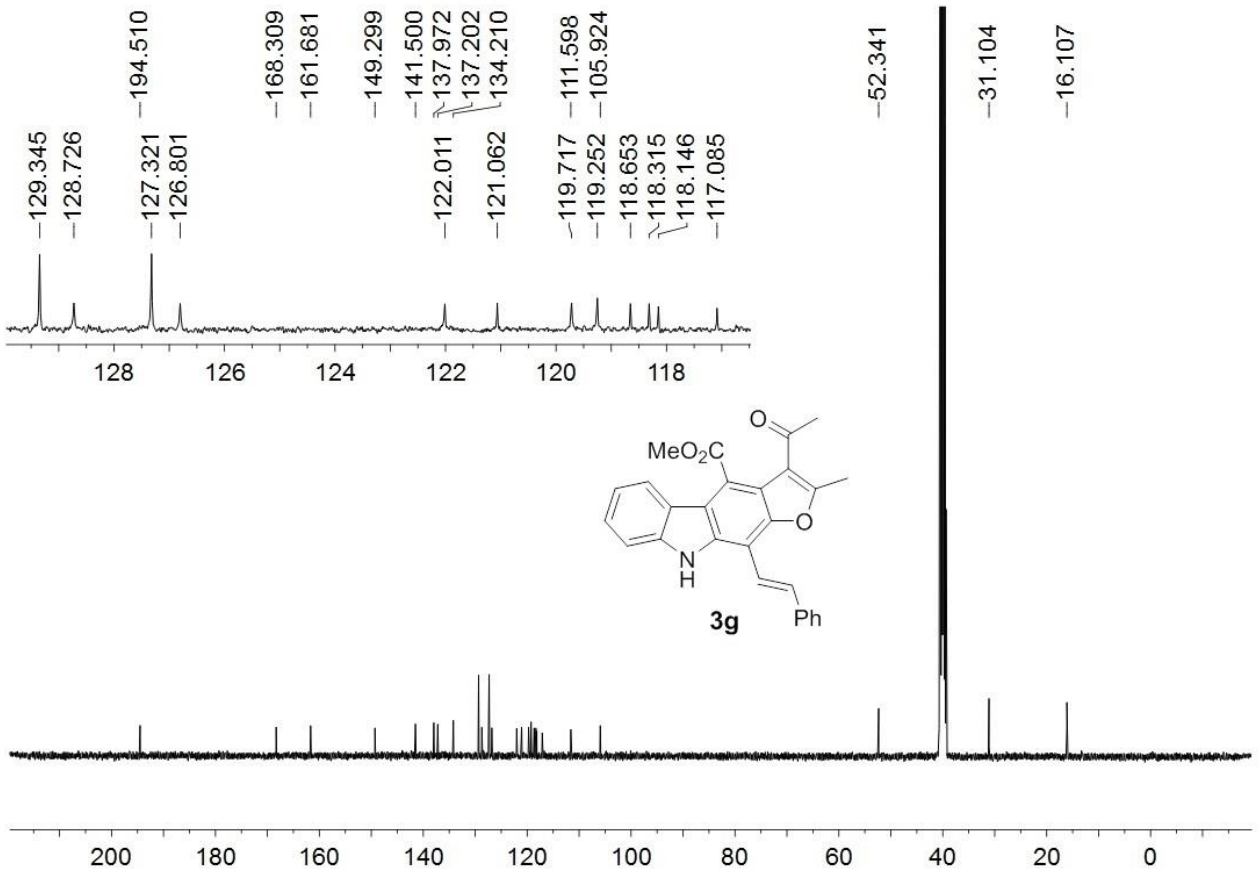
^{13}C NMR (100 MHz, DMSO-d_6) for **3f**



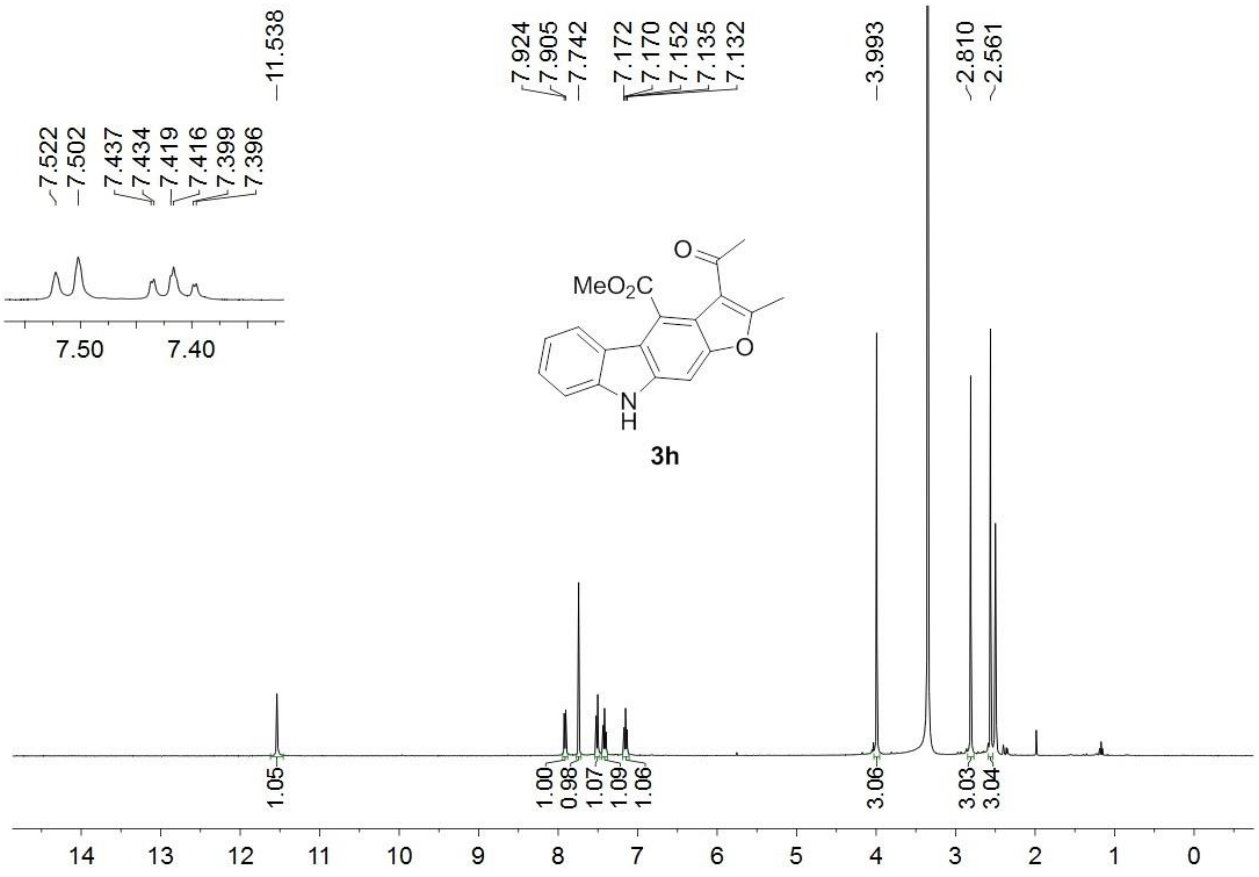
^{1}H NMR (400 MHz, DMSO-d_6) for **3g**



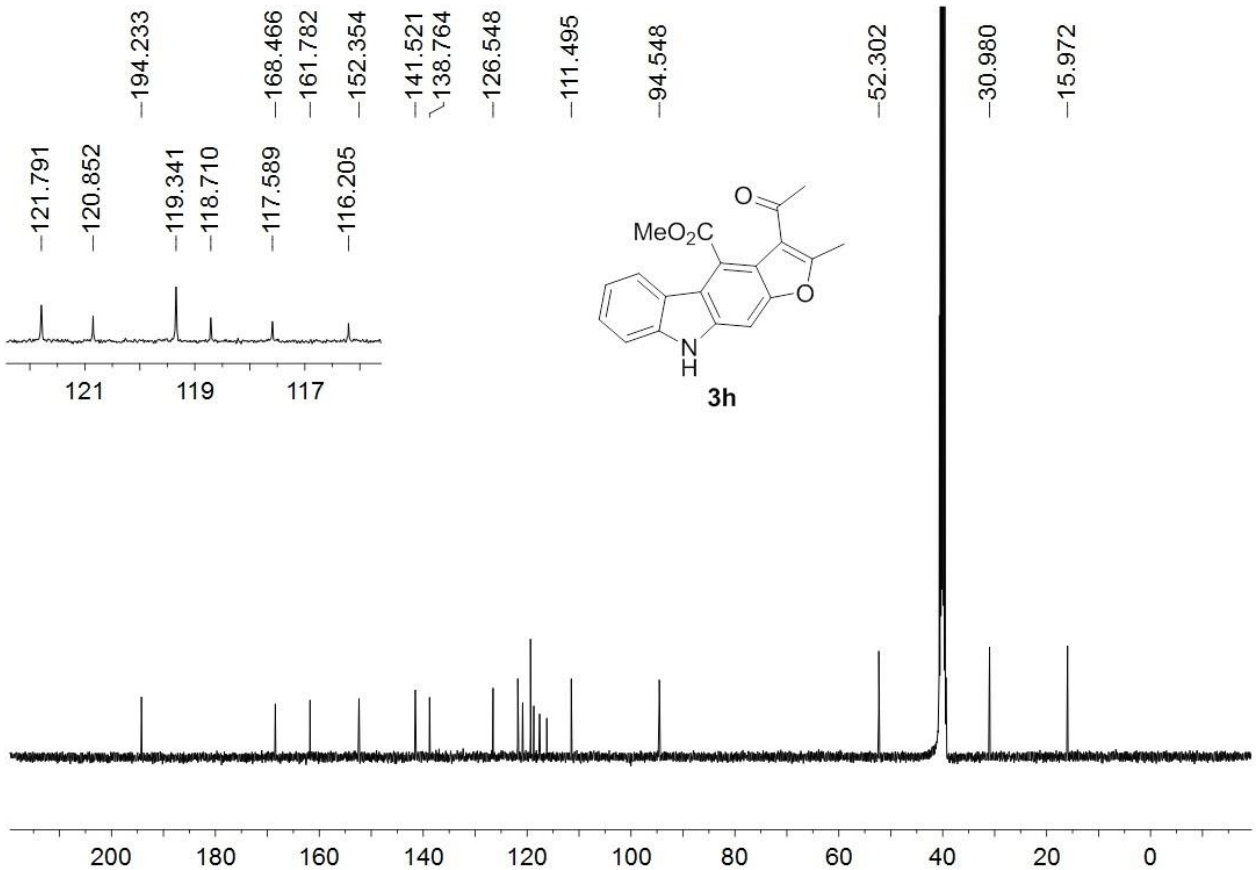
^{13}C NMR (100 MHz, DMSO-d_6) for **3g**



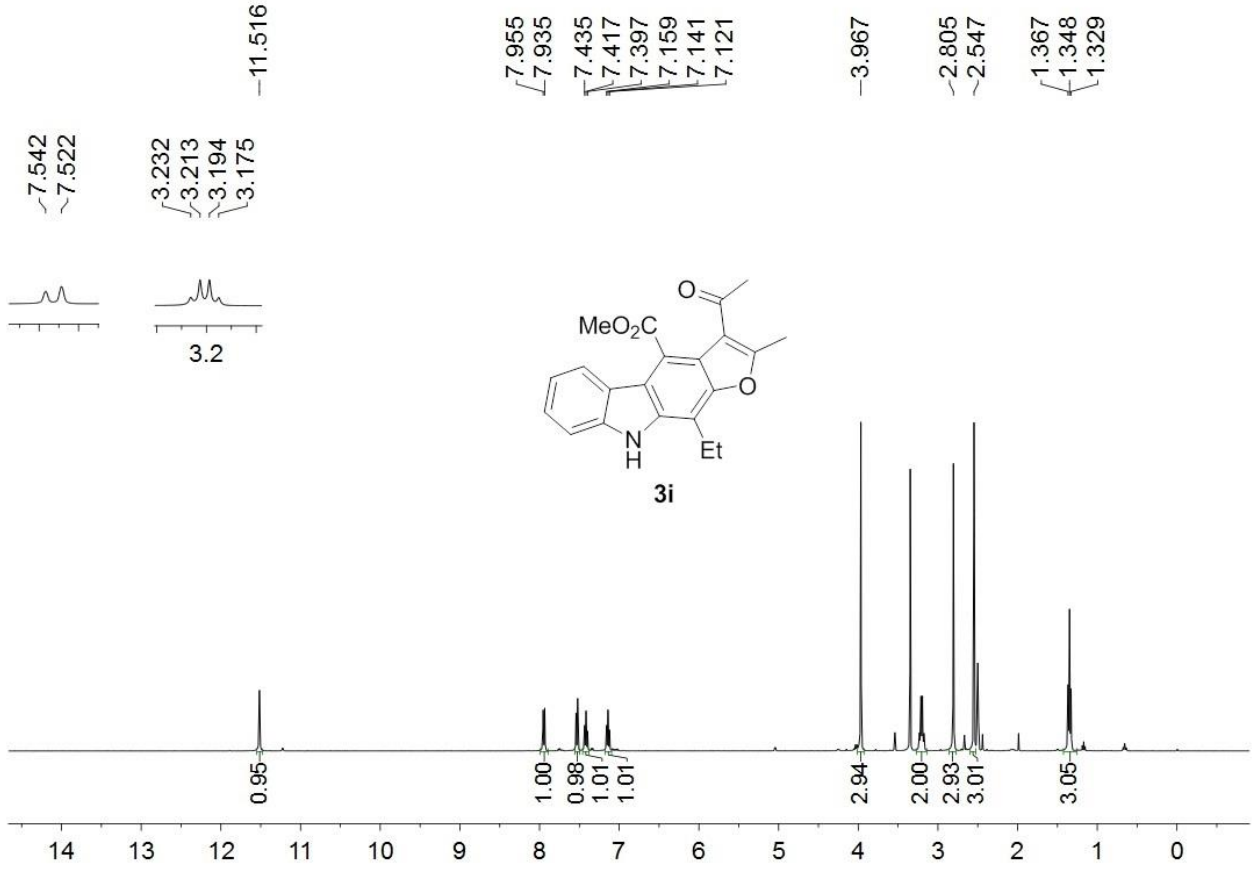
^{1}H NMR (400 MHz, DMSO-d_6) for **3h**



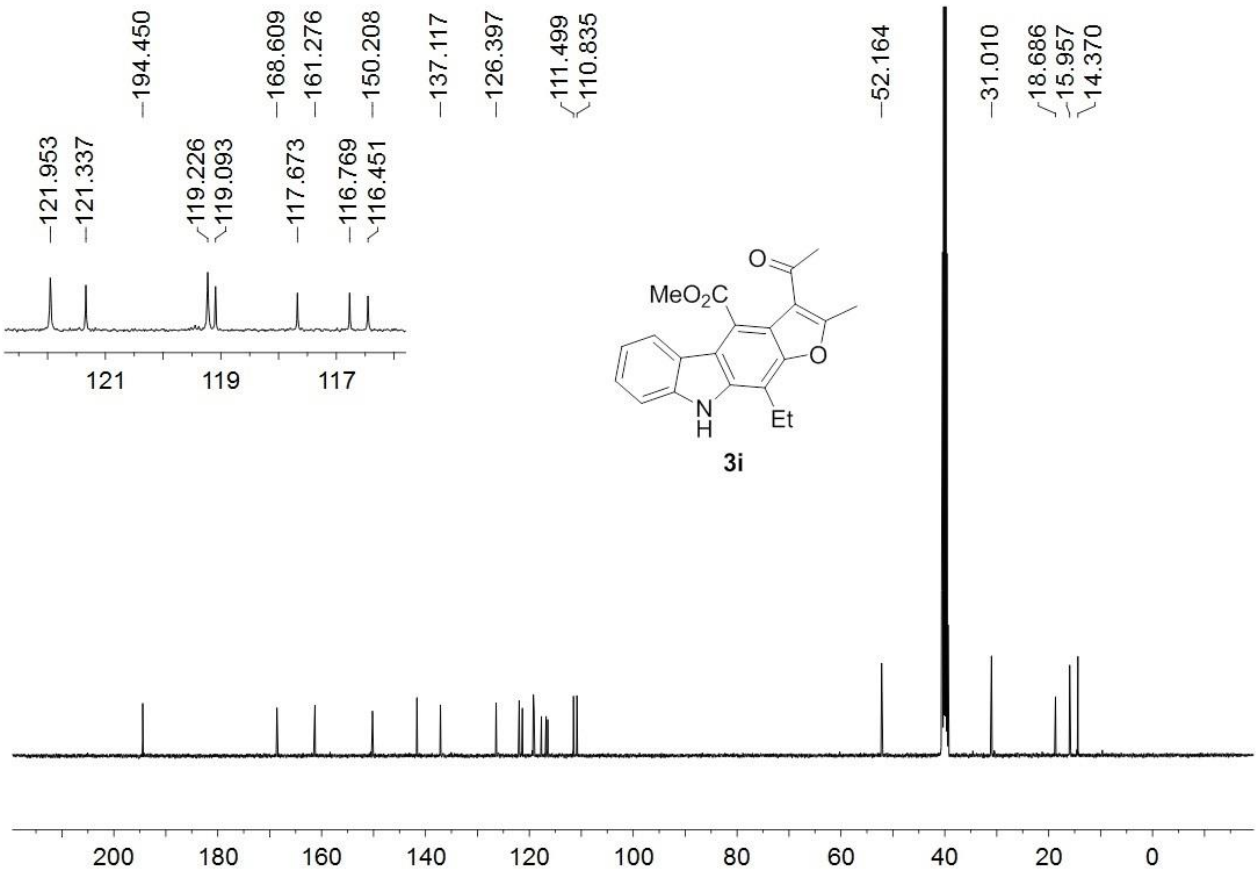
^{13}C NMR (100 MHz, DMSO-d_6) for **3h**



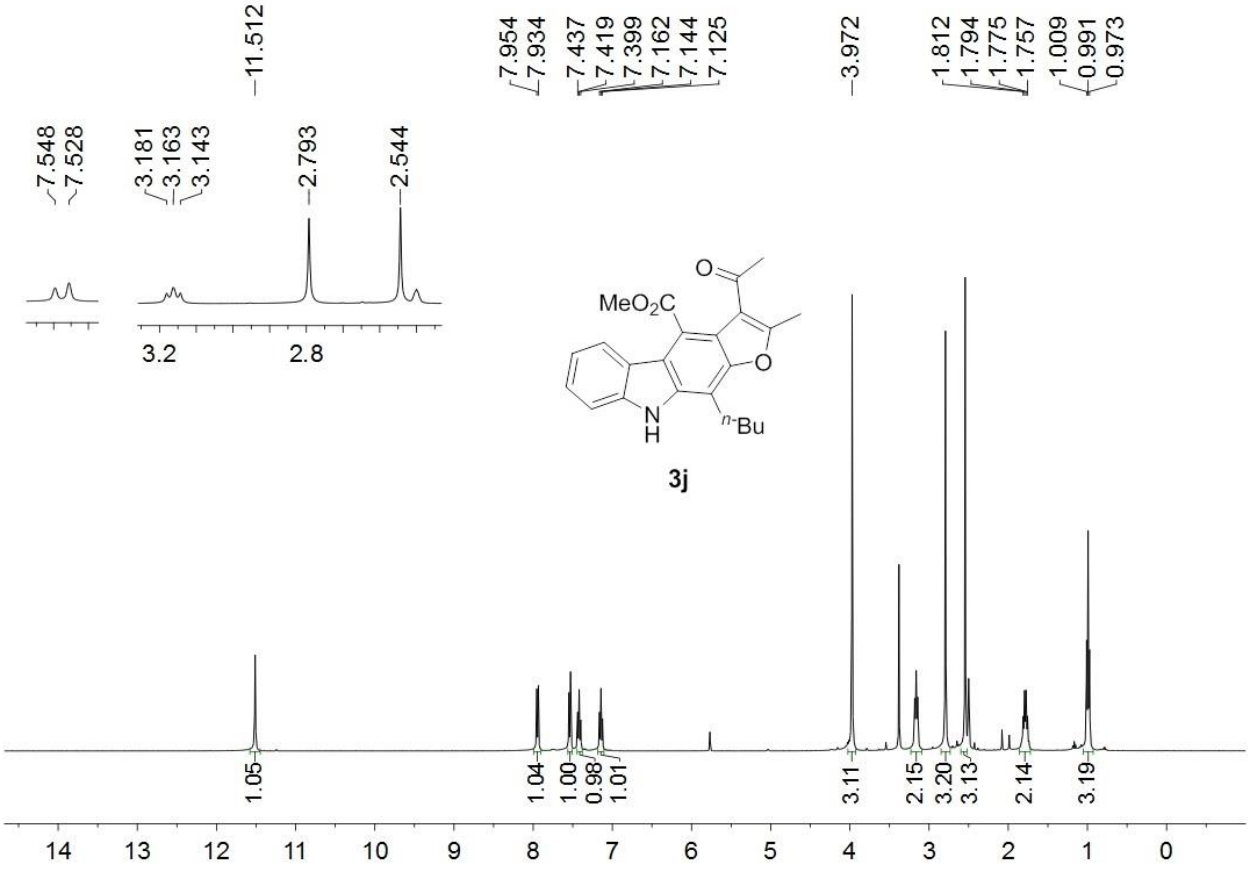
^{1}H NMR (400 MHz, DMSO-d_6) for **3i**



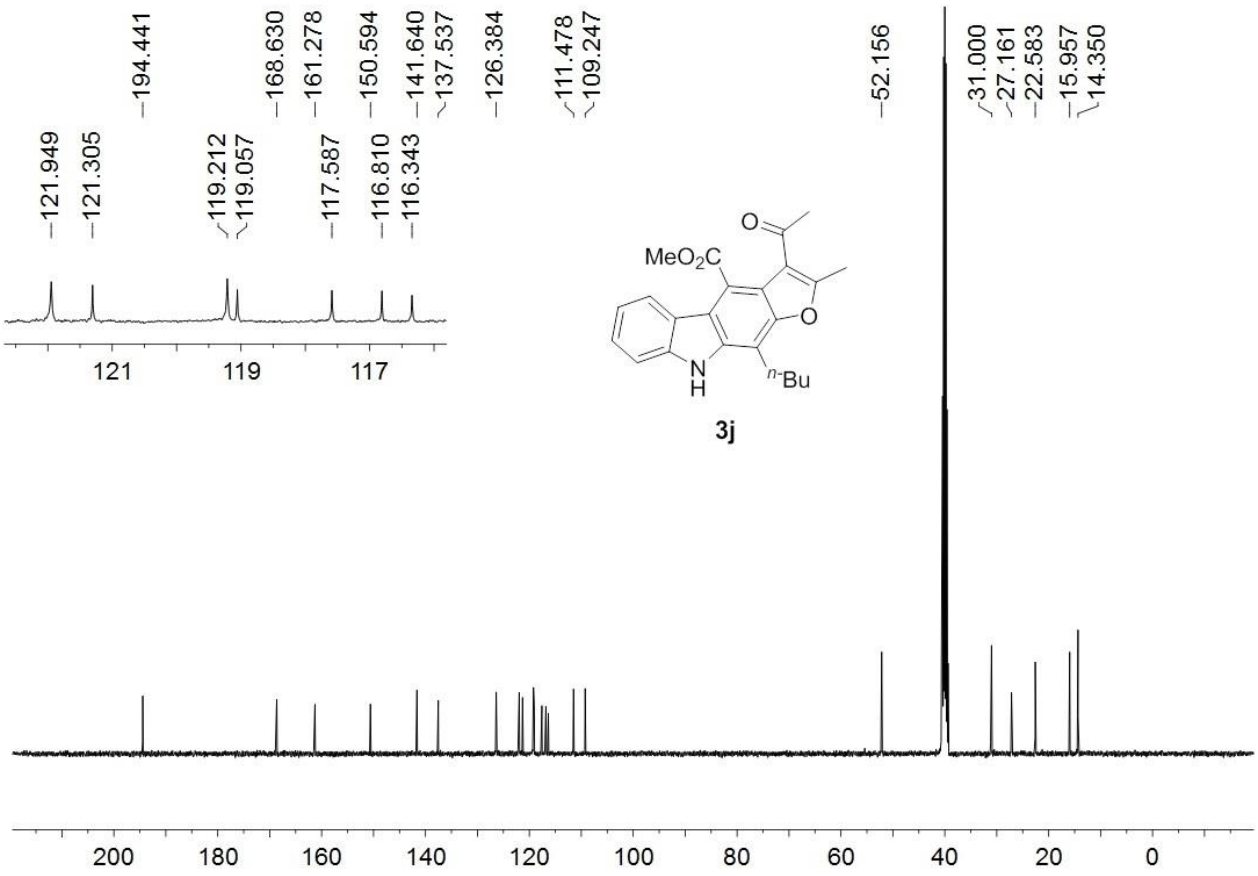
^{13}C NMR (100 MHz, DMSO-d_6) for **3i**



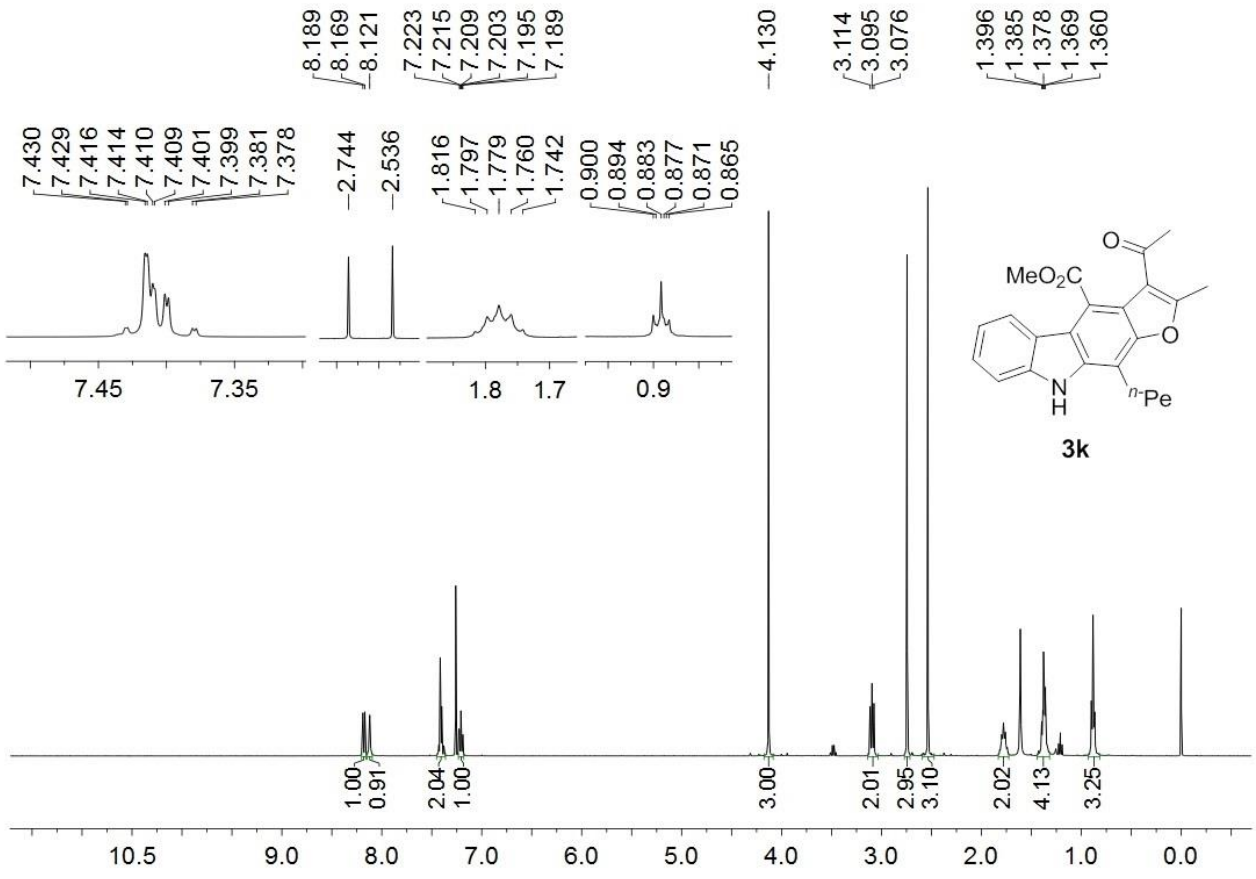
^{1}H NMR (400 MHz, DMSO-d_6) for **3j**



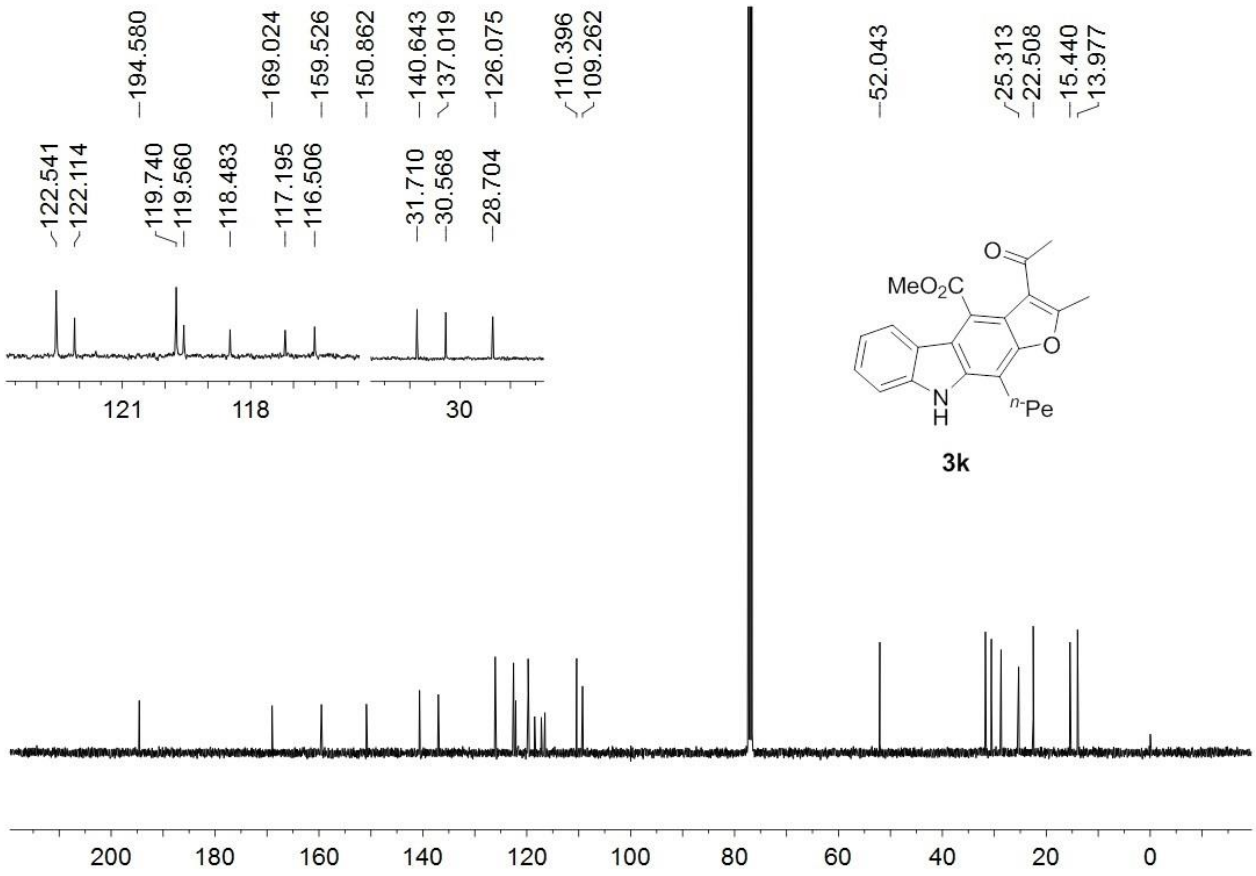
^{13}C NMR (100 MHz, DMSO-d_6) for **3j**



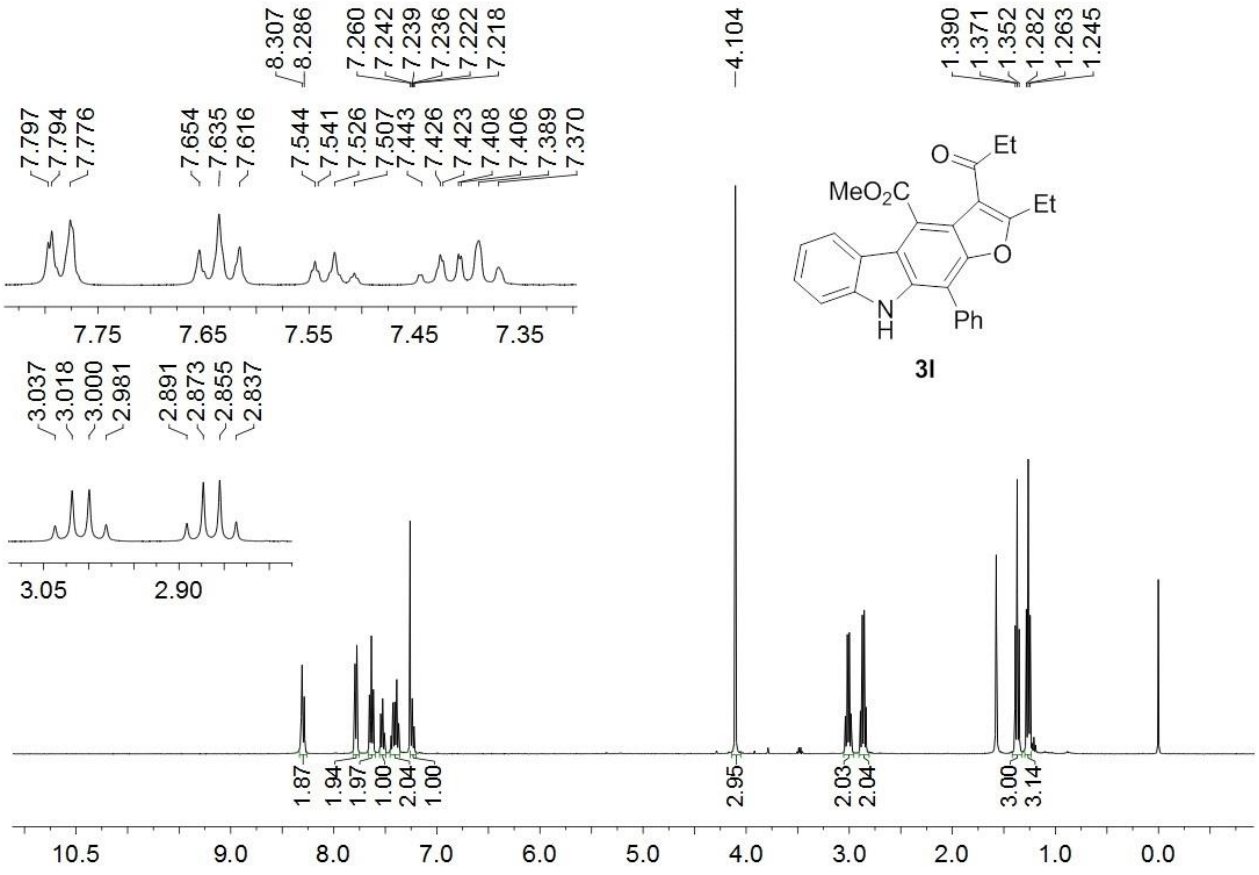
^{1}H NMR (400 MHz, $CDCl_3$) for **3k**



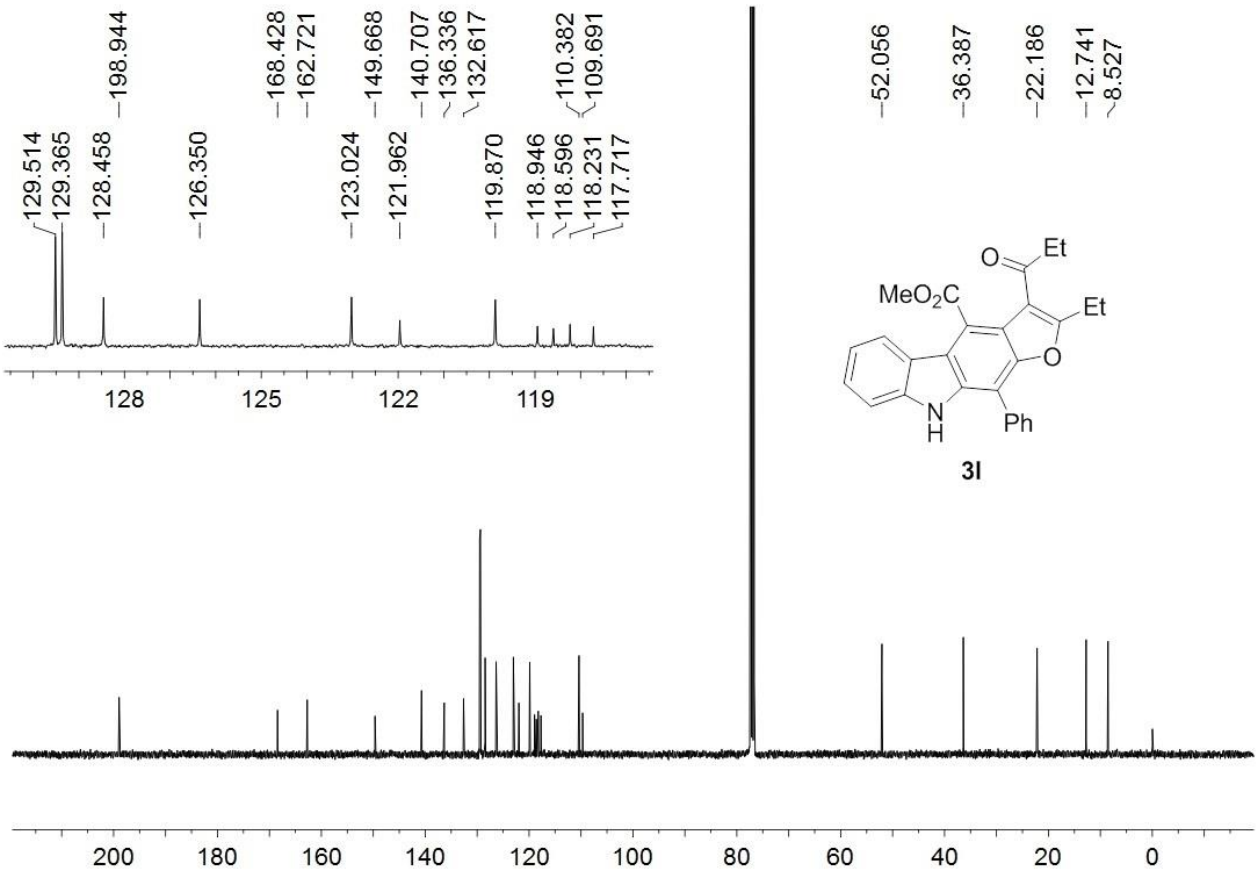
^{13}C NMR (100 MHz, $CDCl_3$) for **3k**



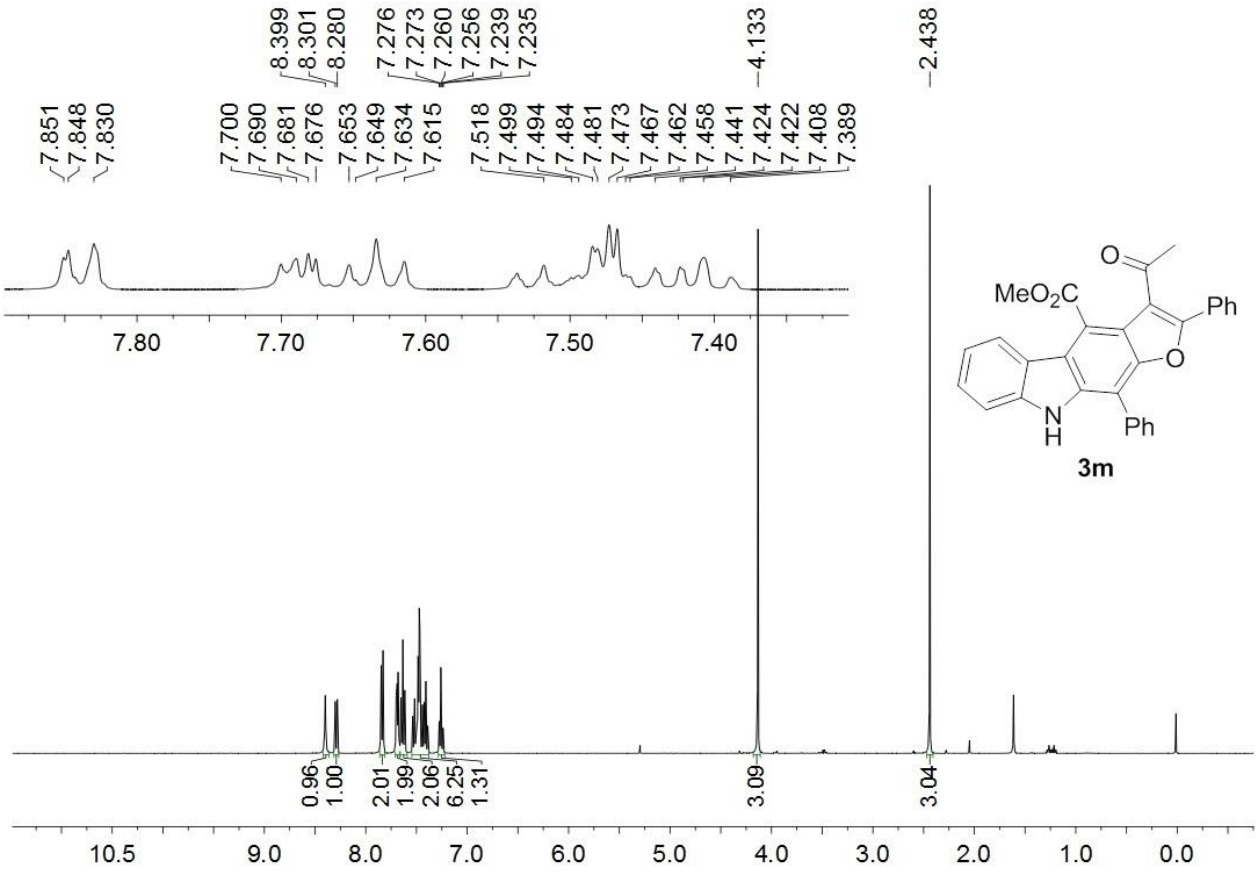
^{1}H NMR (400 MHz, $CDCl_3$) for **3l**



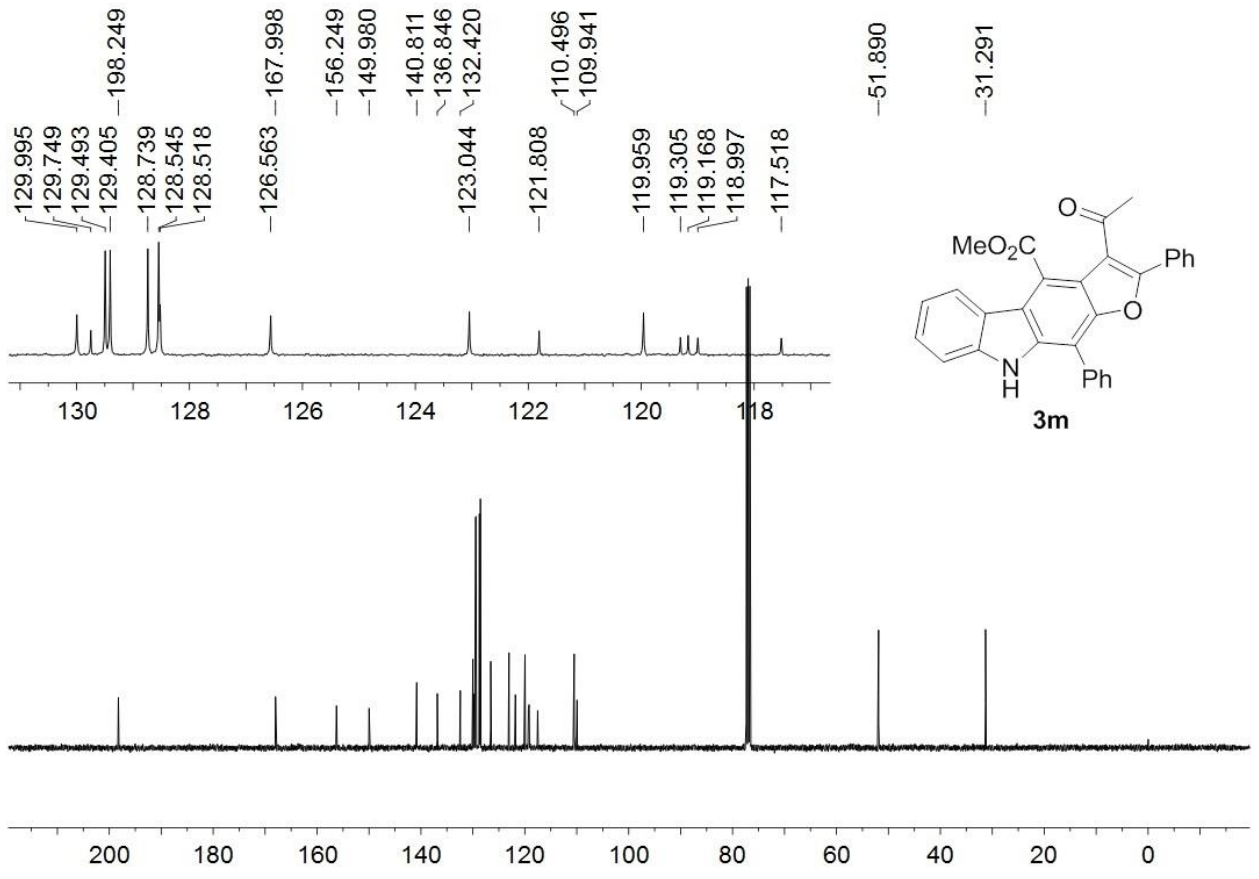
^{13}C NMR (100 MHz, $CDCl_3$) for **3l**



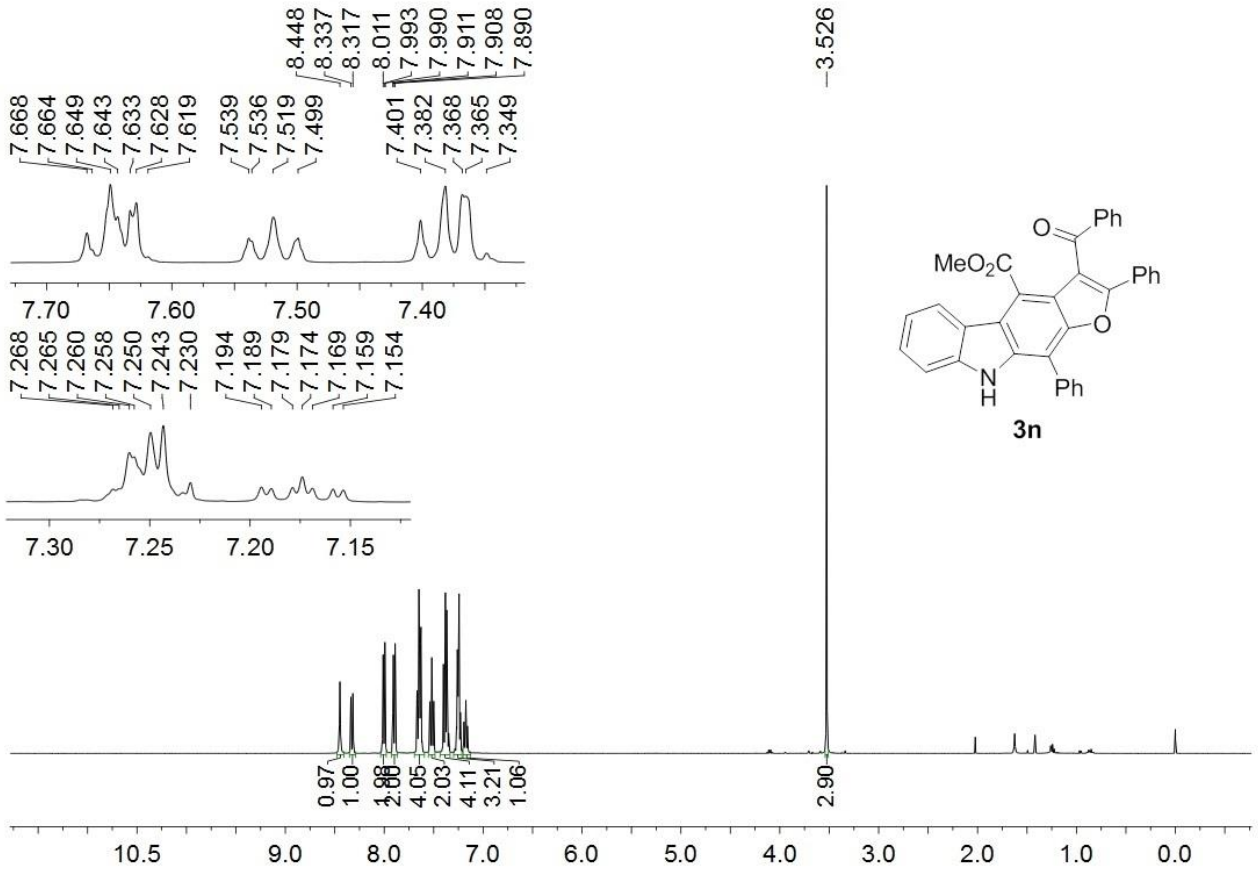
^{1}H NMR (400 MHz, $CDCl_3$) for **3m**



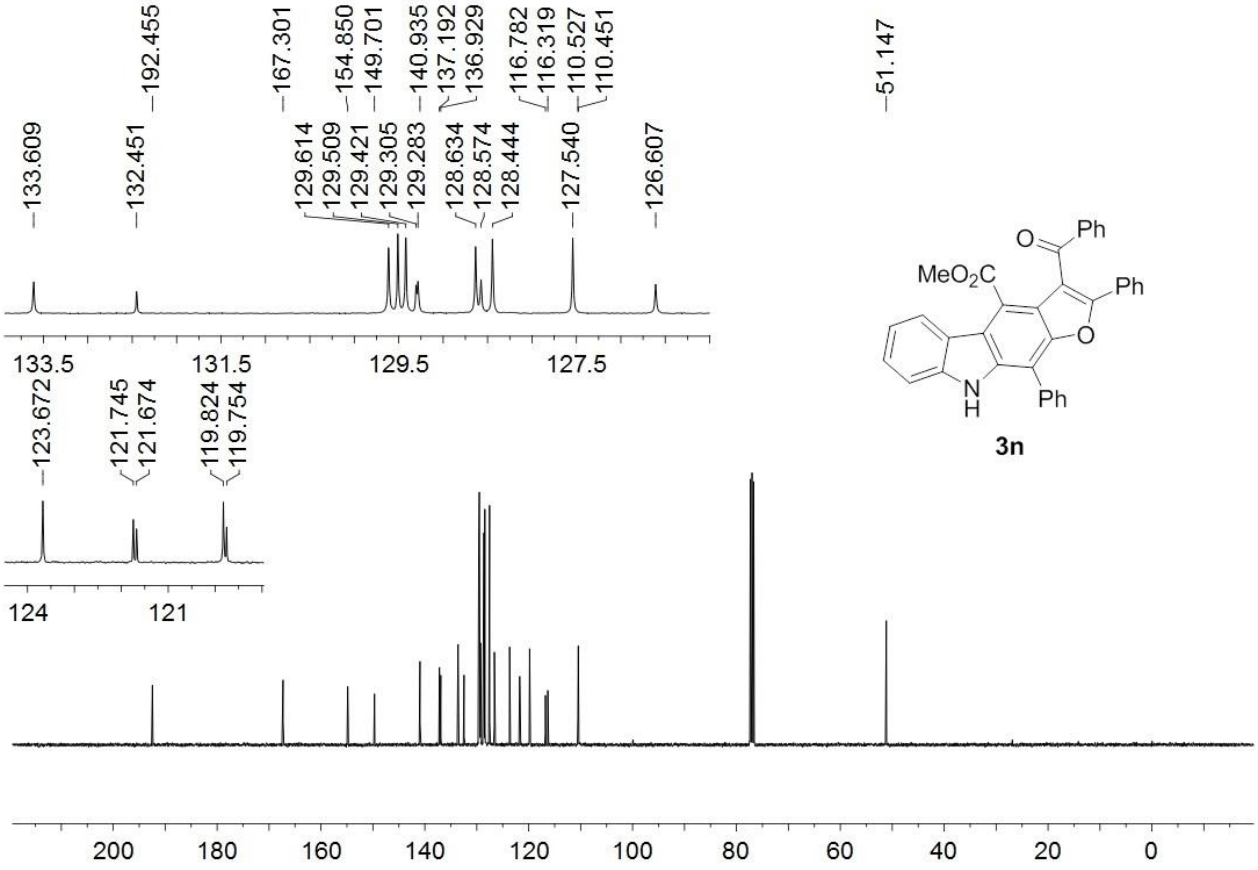
^{13}C NMR (100 MHz, $CDCl_3$) for **3m**



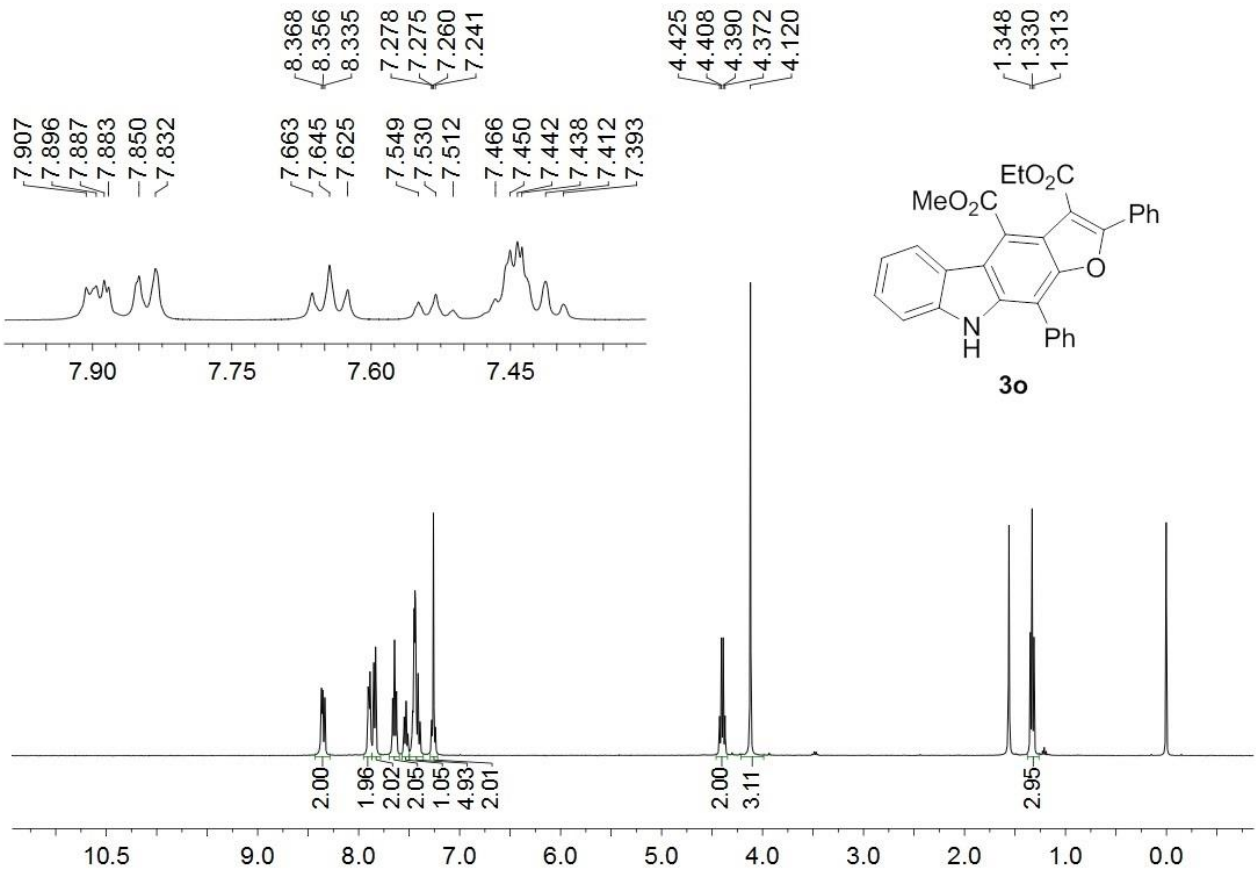
^{1}H NMR (400 MHz, $CDCl_3$) for **3n**



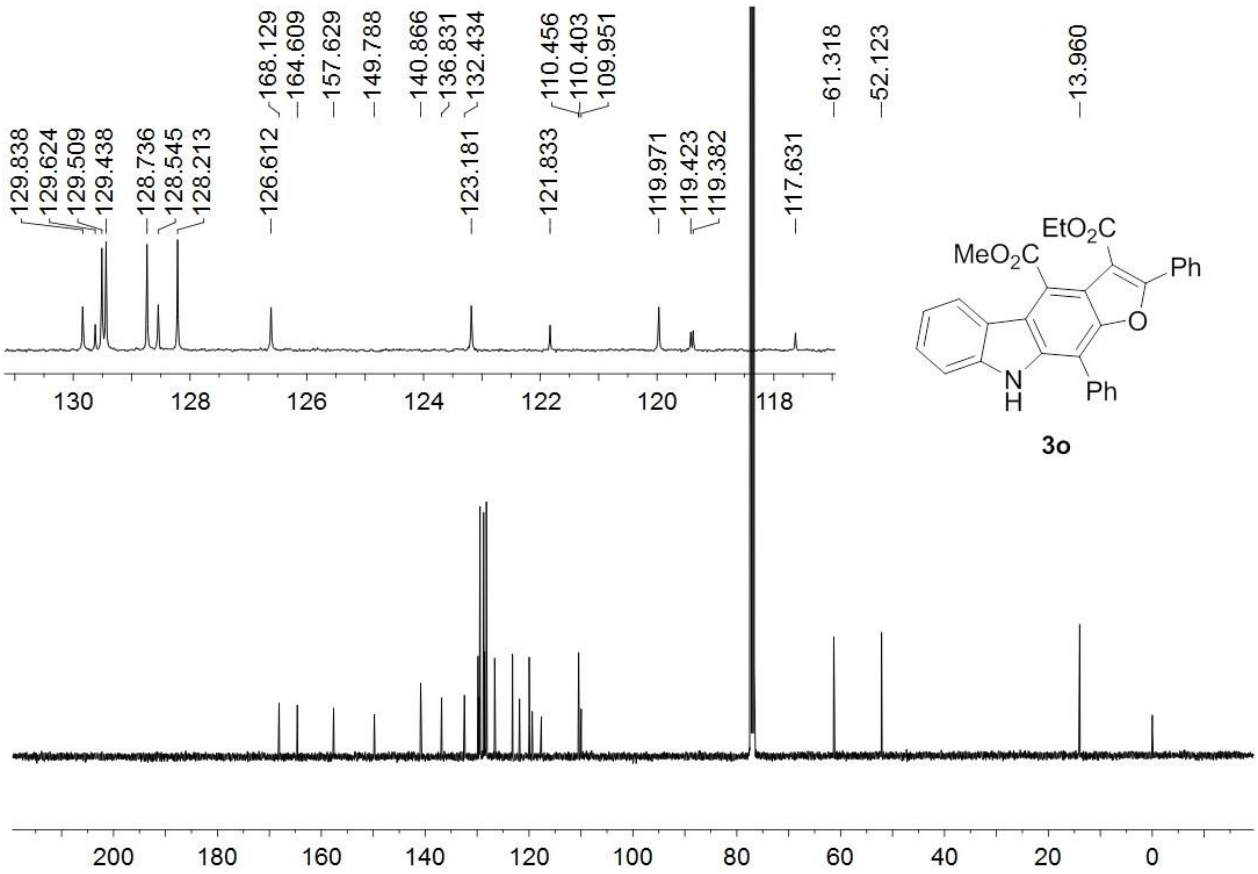
^{13}C NMR (100 MHz, $CDCl_3$) for **3n**



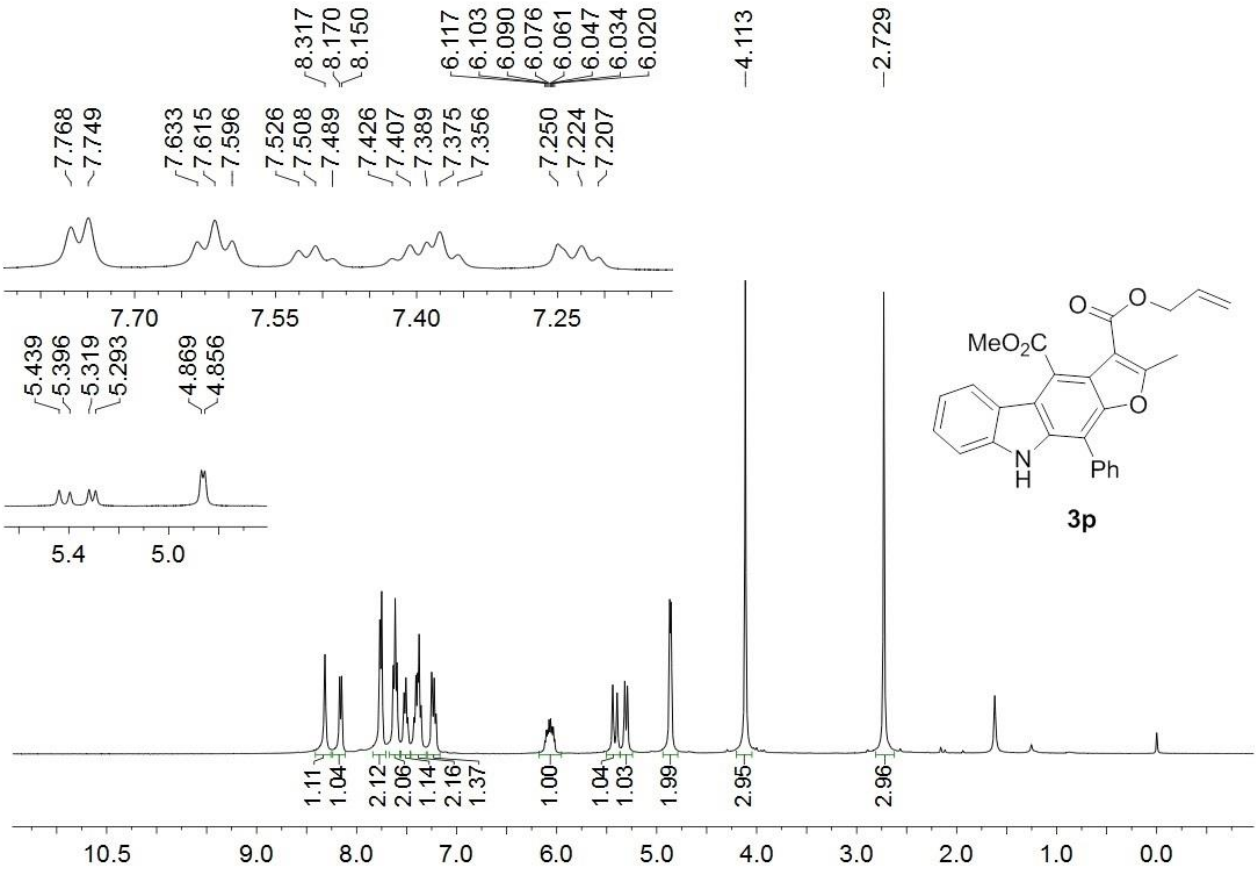
^{1}H NMR (400 MHz, $CDCl_3$) for **3o**



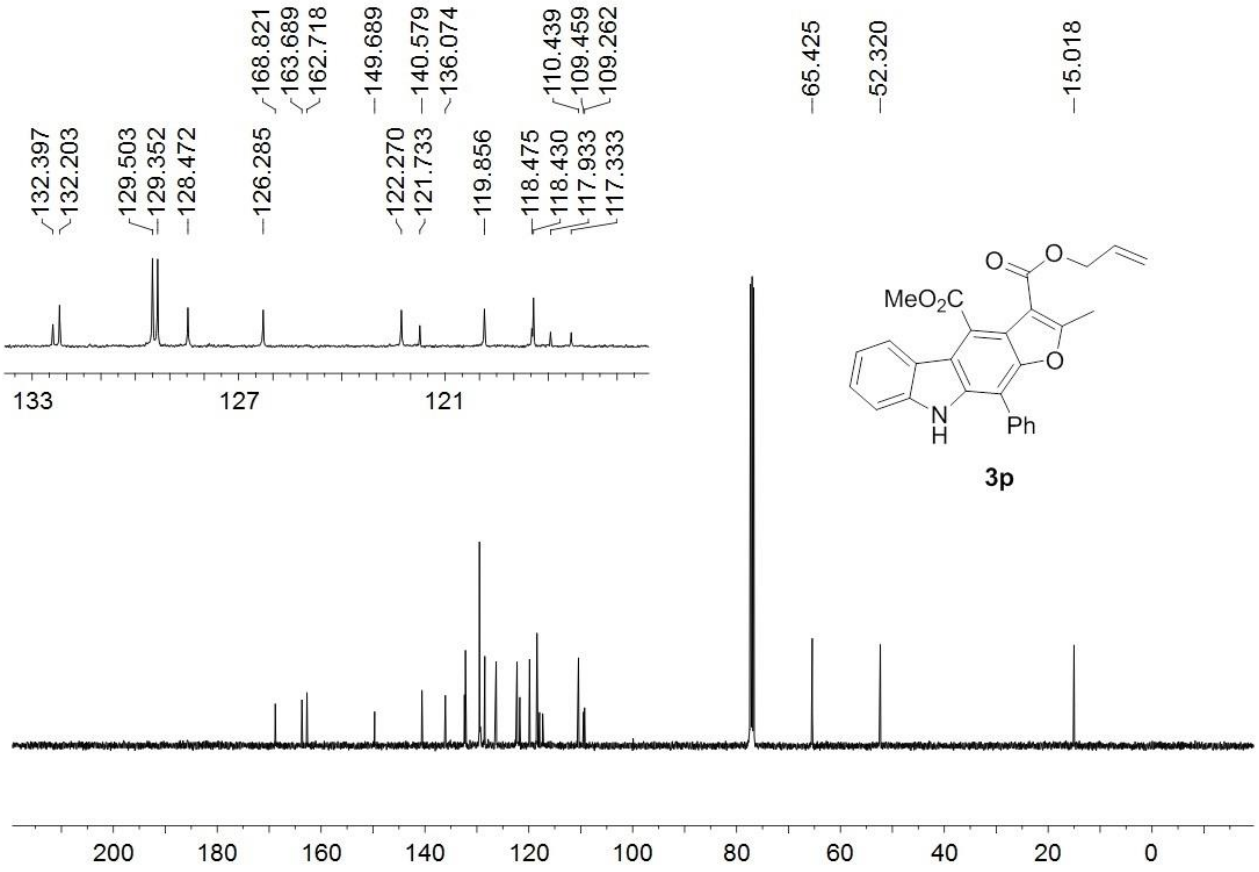
^{13}C NMR (100 MHz, $CDCl_3$) for **3o**



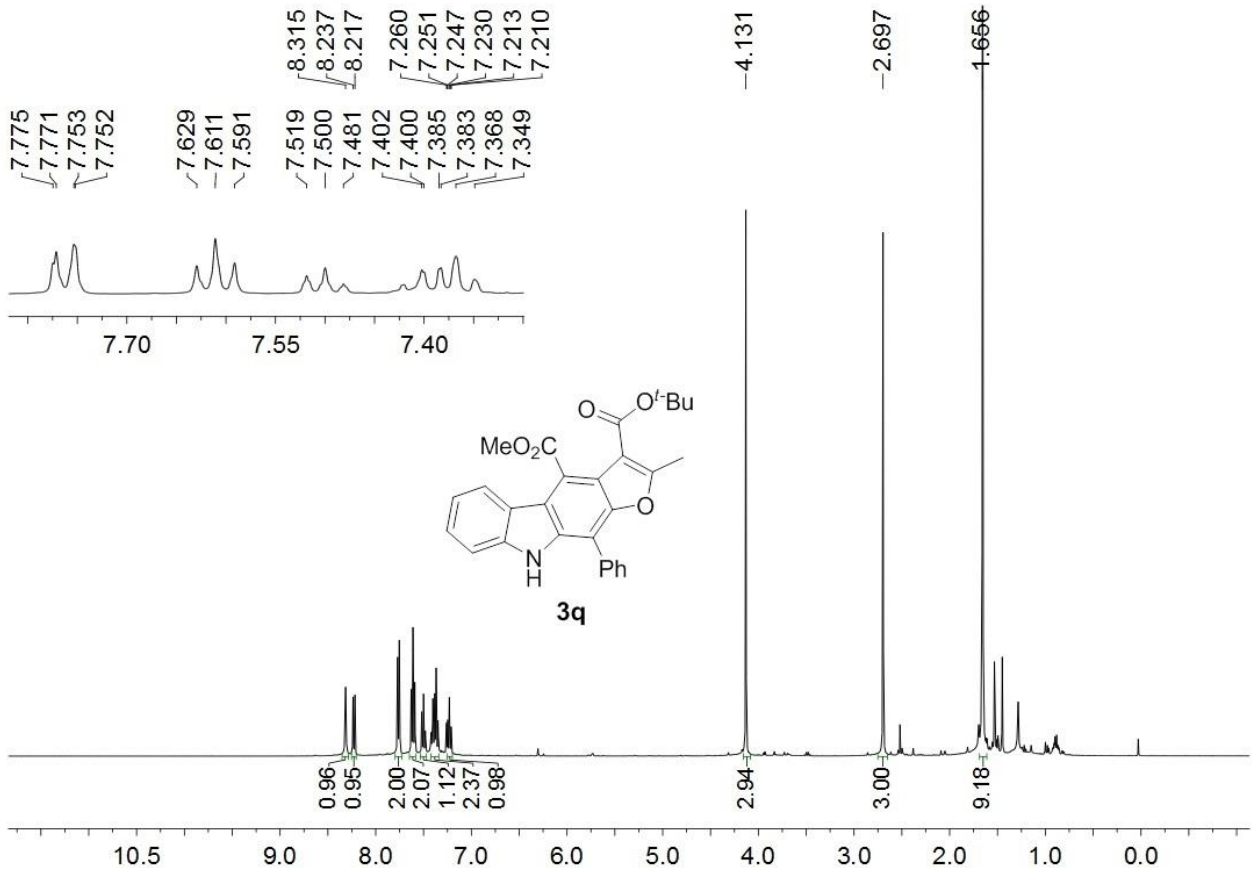
^{1}H NMR (400 MHz, $CDCl_3$) for **3p**



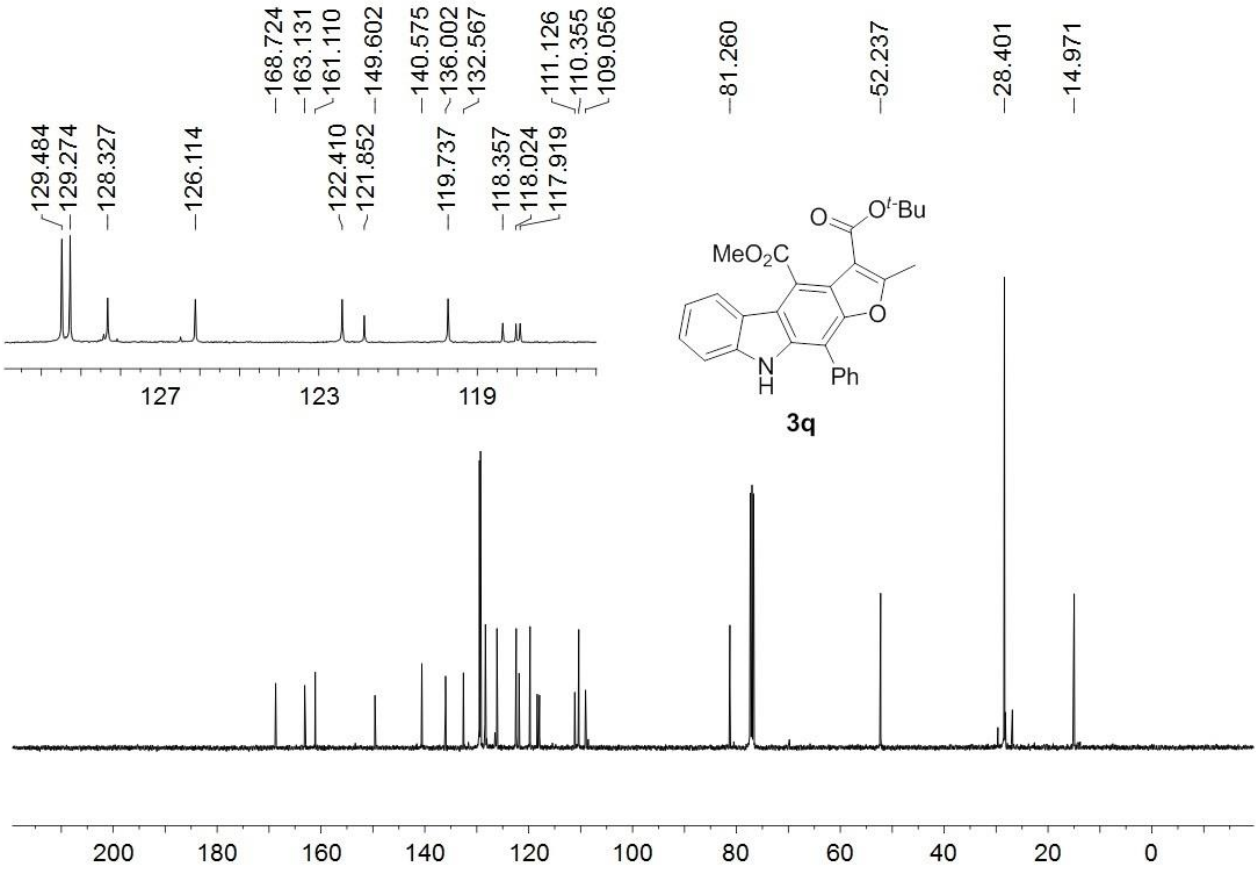
^{13}C NMR (100 MHz, $CDCl_3$) for **3p**



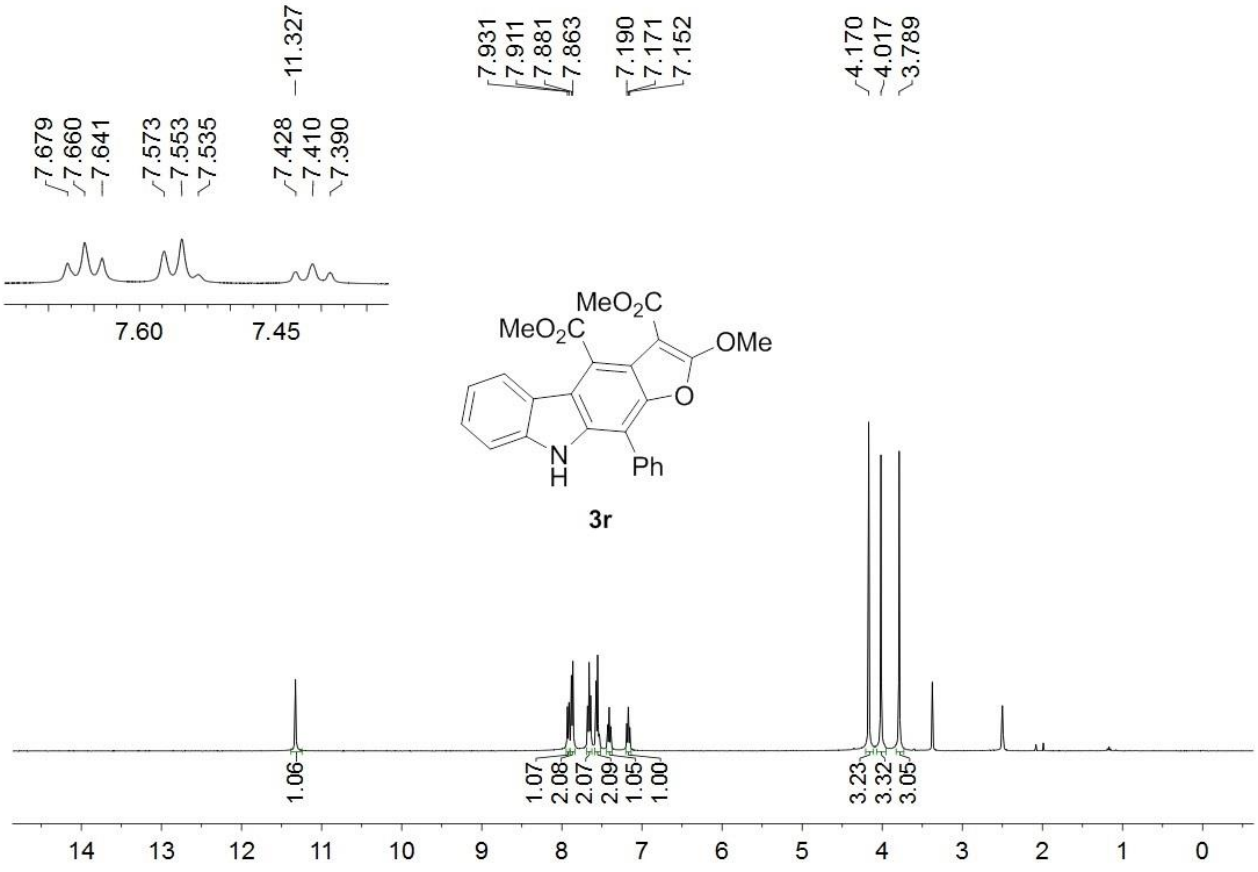
^{1}H NMR (400 MHz, $CDCl_3$) for **3q**



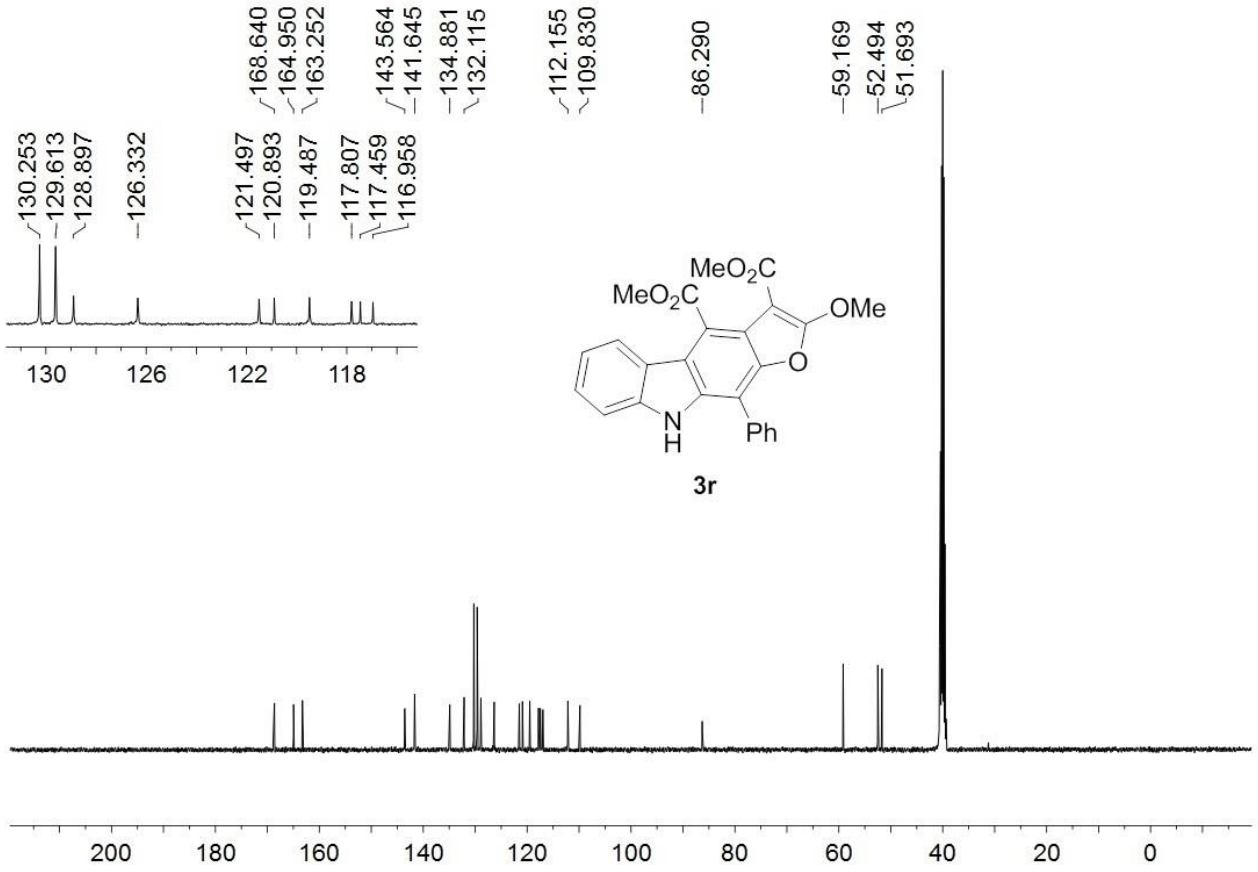
^{13}C NMR (100 MHz, $CDCl_3$) for **3q**



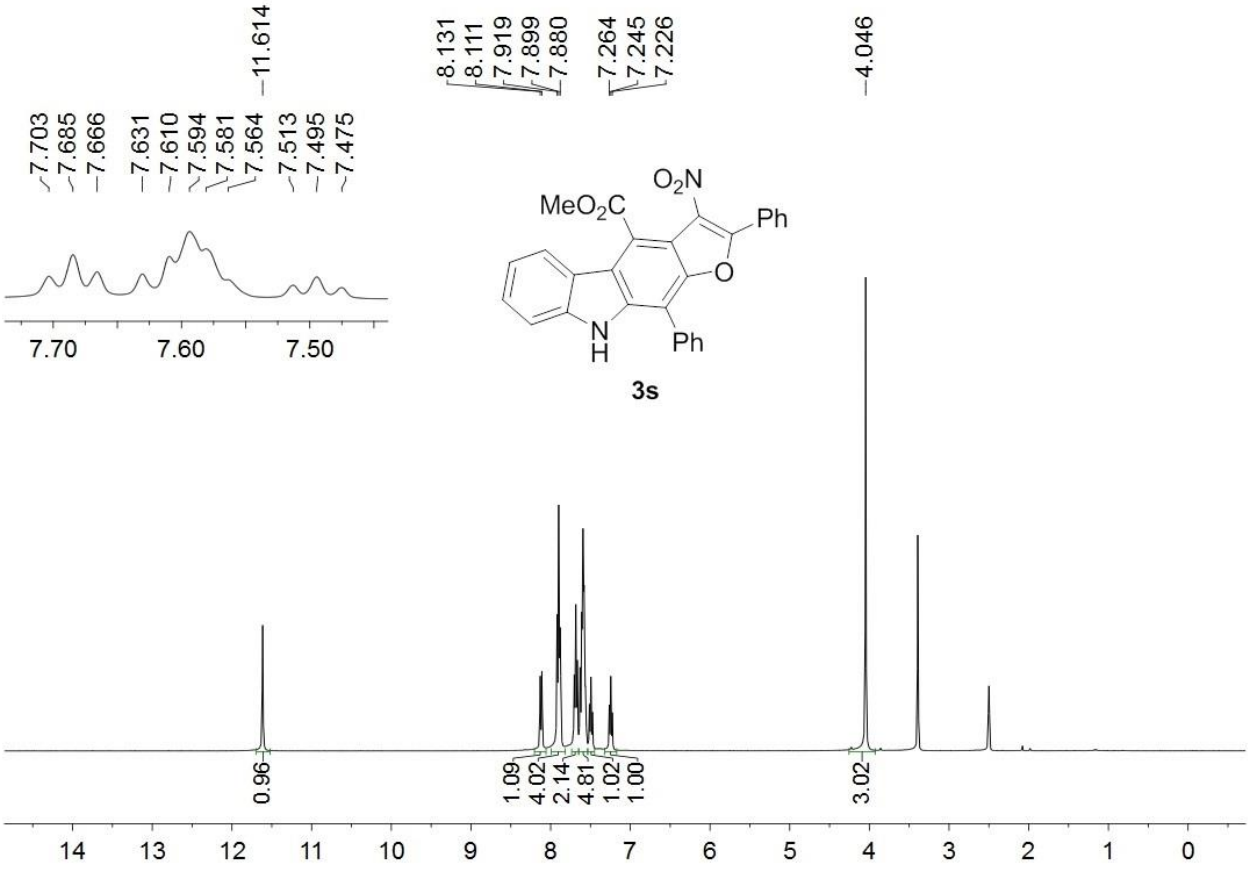
^{1}H NMR (400 MHz, DMSO-d_6) for **3r**



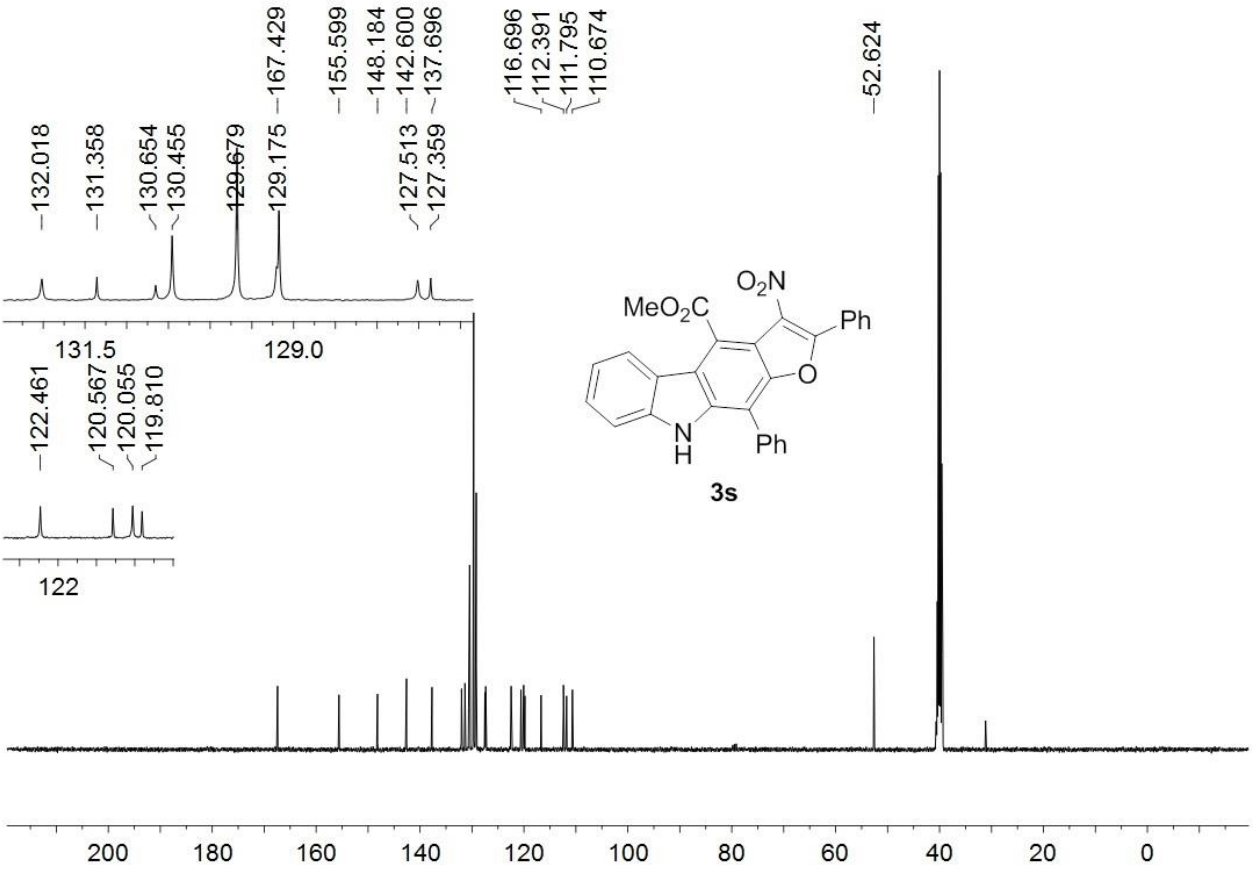
^{13}C NMR (100 MHz, DMSO-d_6) for **3r**



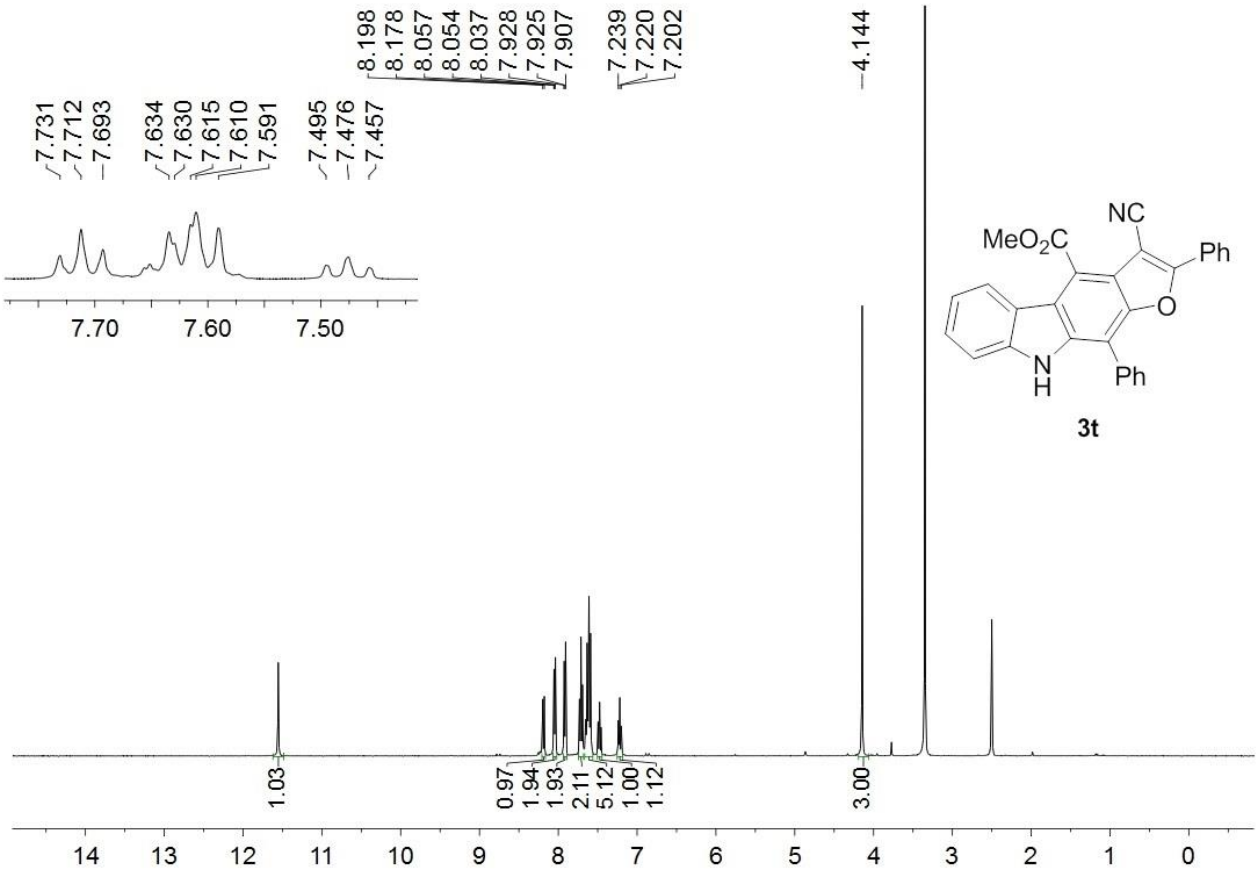
^{1}H NMR (400 MHz, DMSO-d_6) for **3s**



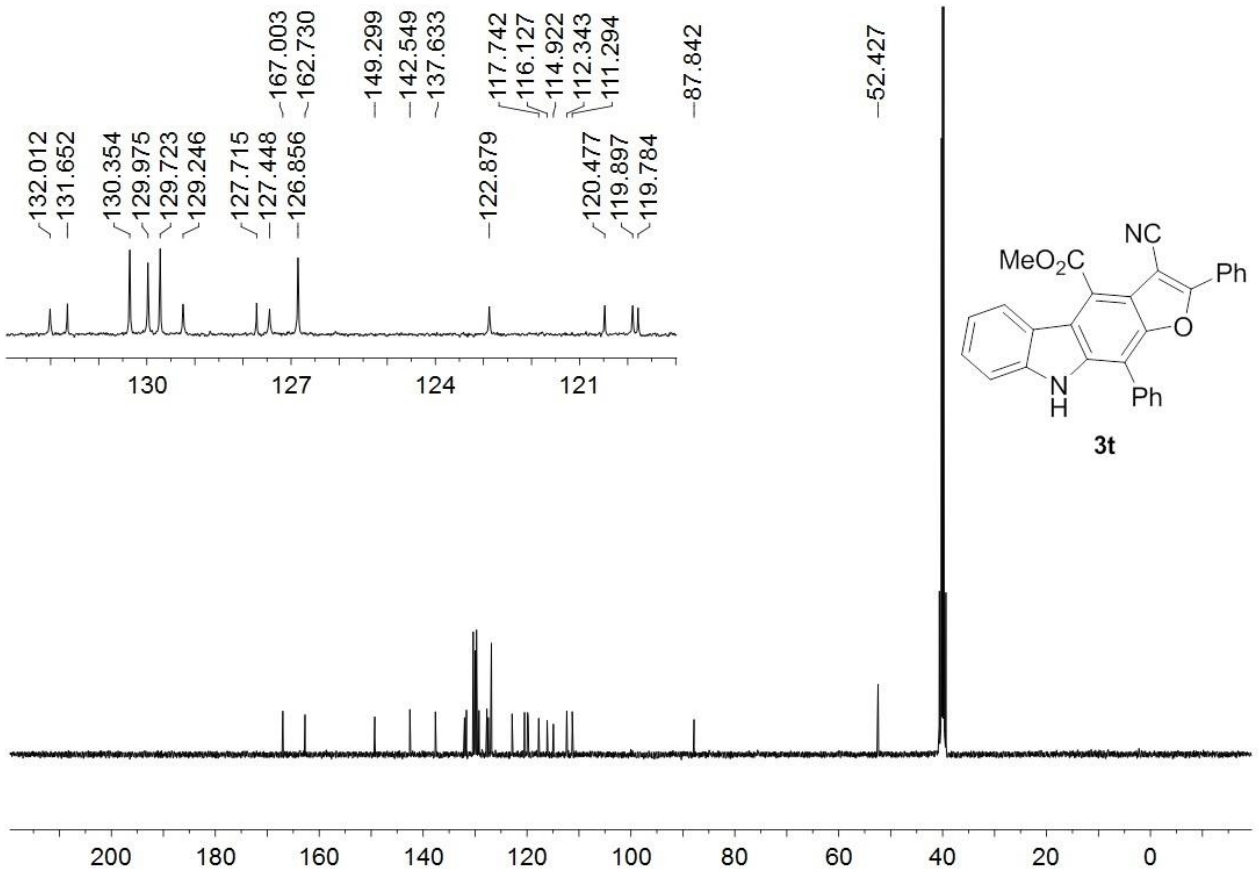
^{13}C NMR (100 MHz, DMSO-d_6) for **3s**



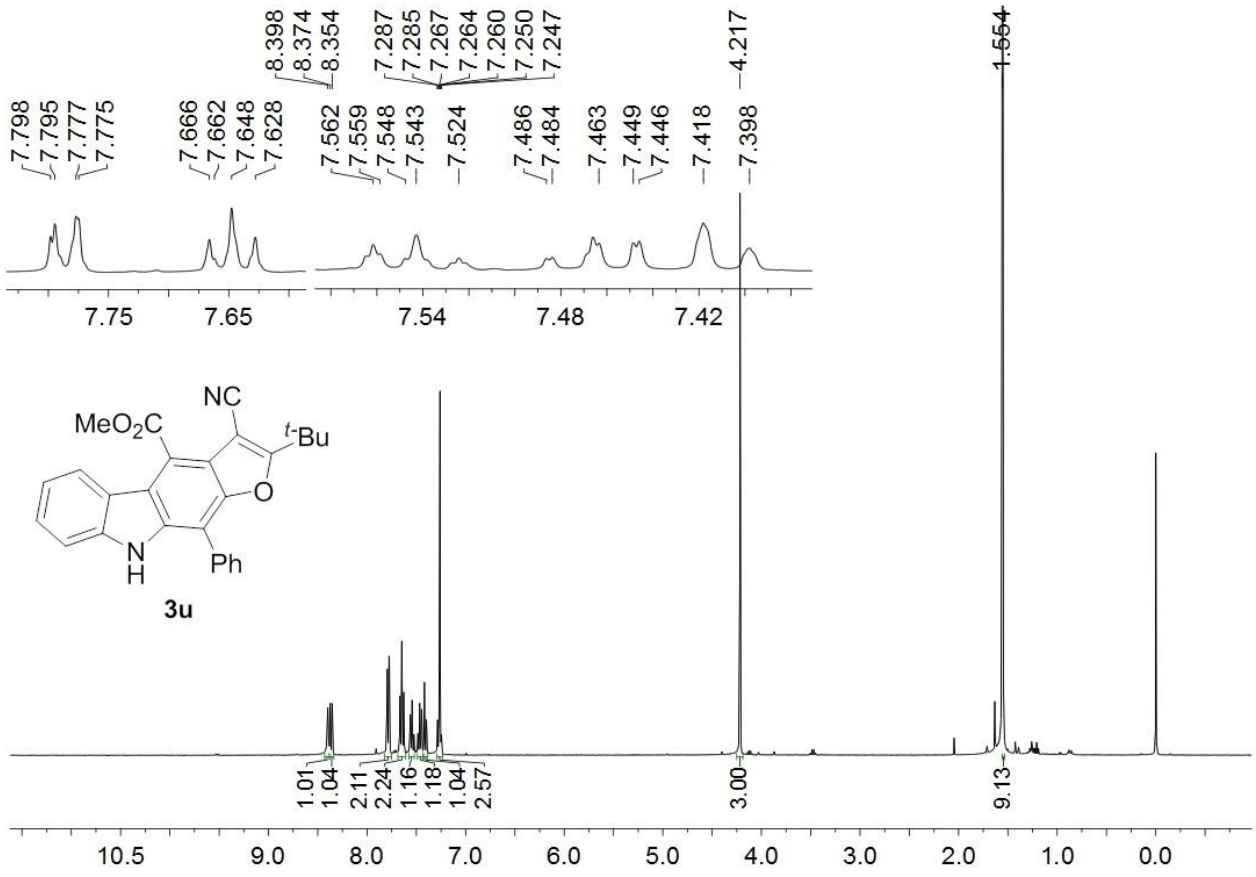
^{1}H NMR (400 MHz, DMSO-d_6) for **3t**



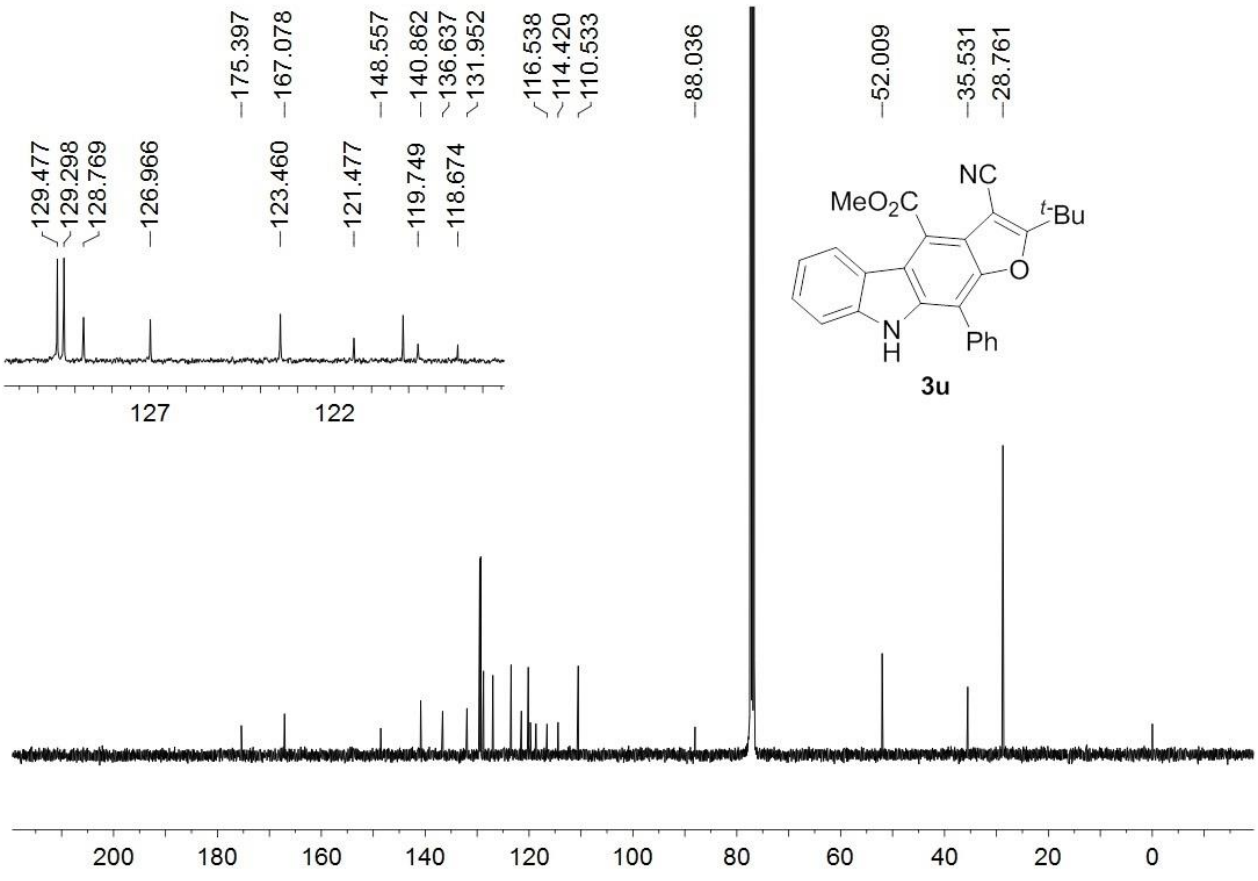
^{13}C NMR (100 MHz, DMSO-d_6) for **3t**



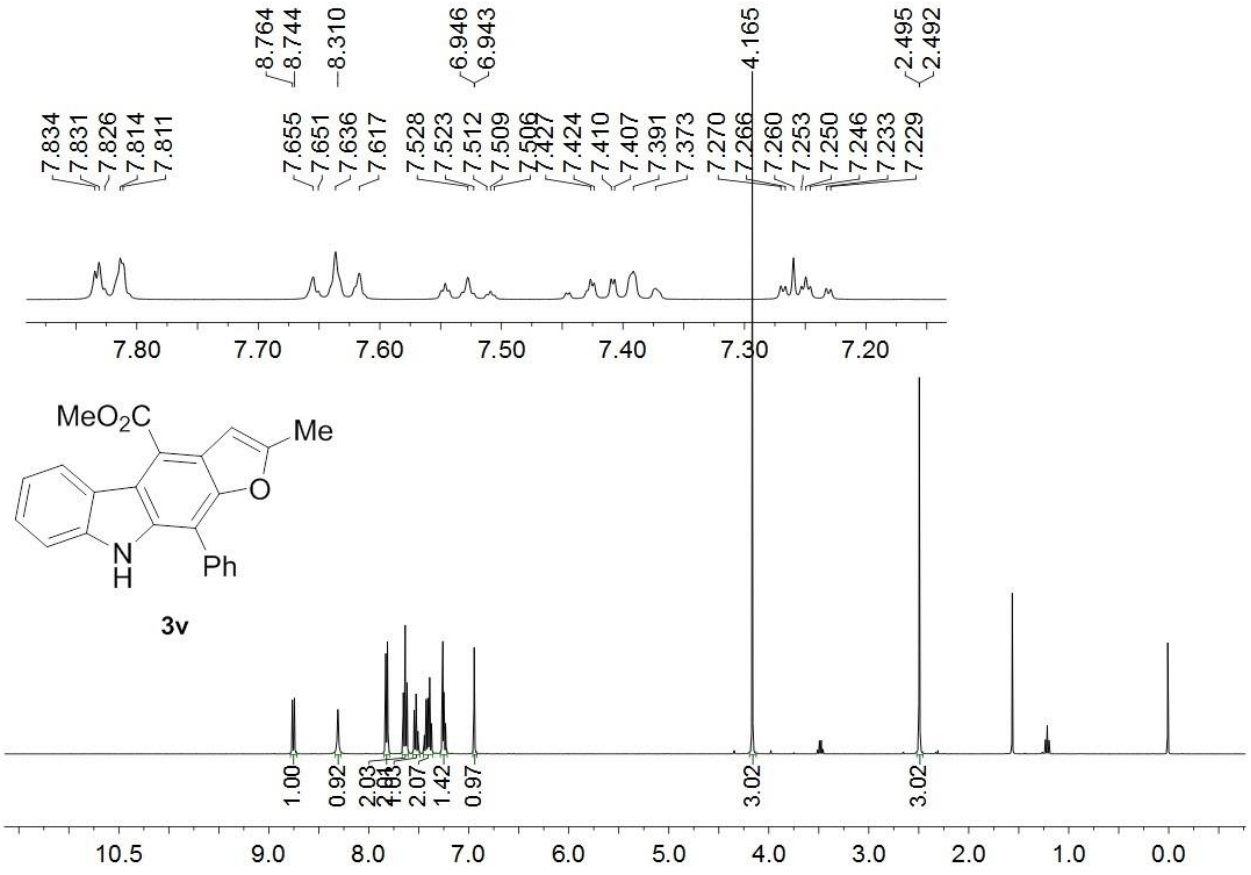
^{1}H NMR (400 MHz, $CDCl_3$) for **3u**



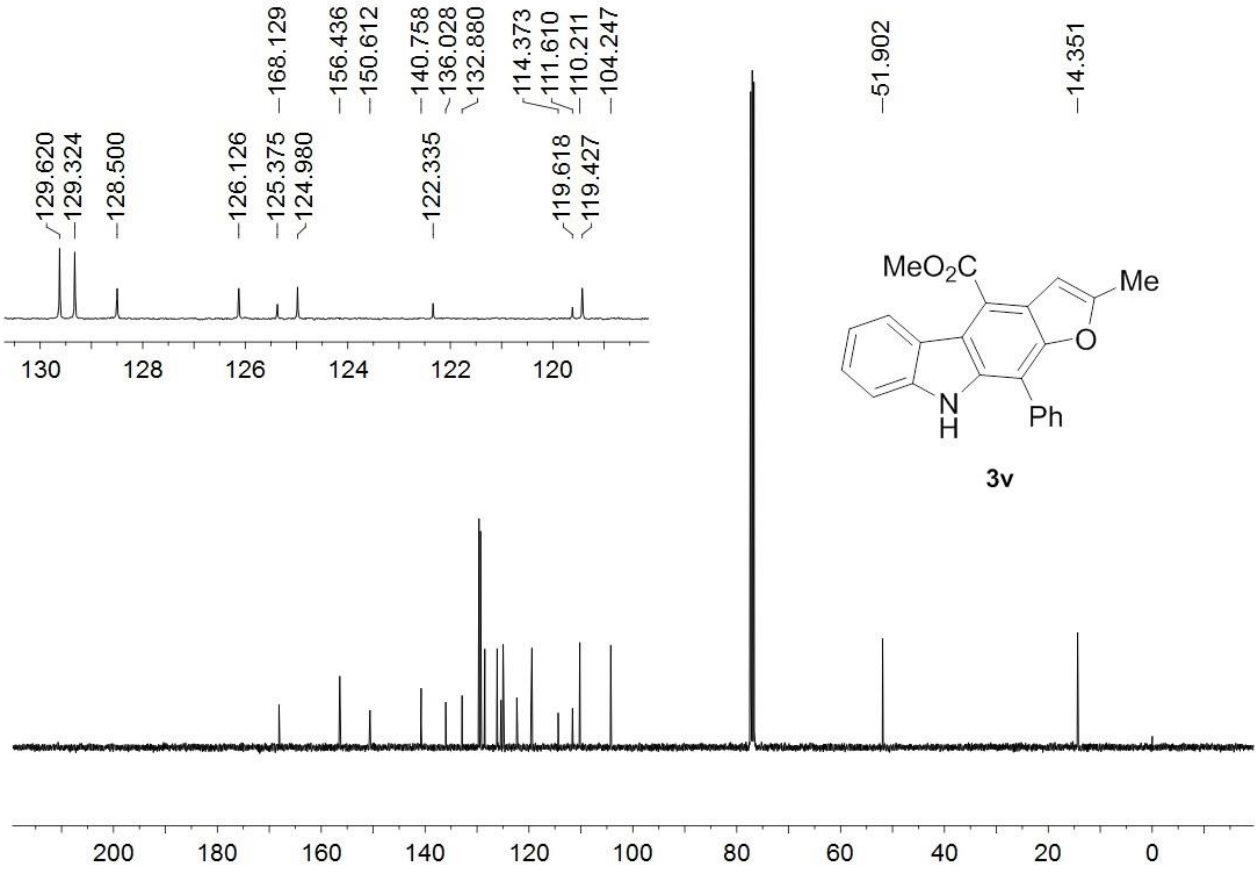
^{13}C NMR (100 MHz, $CDCl_3$) for **3u**



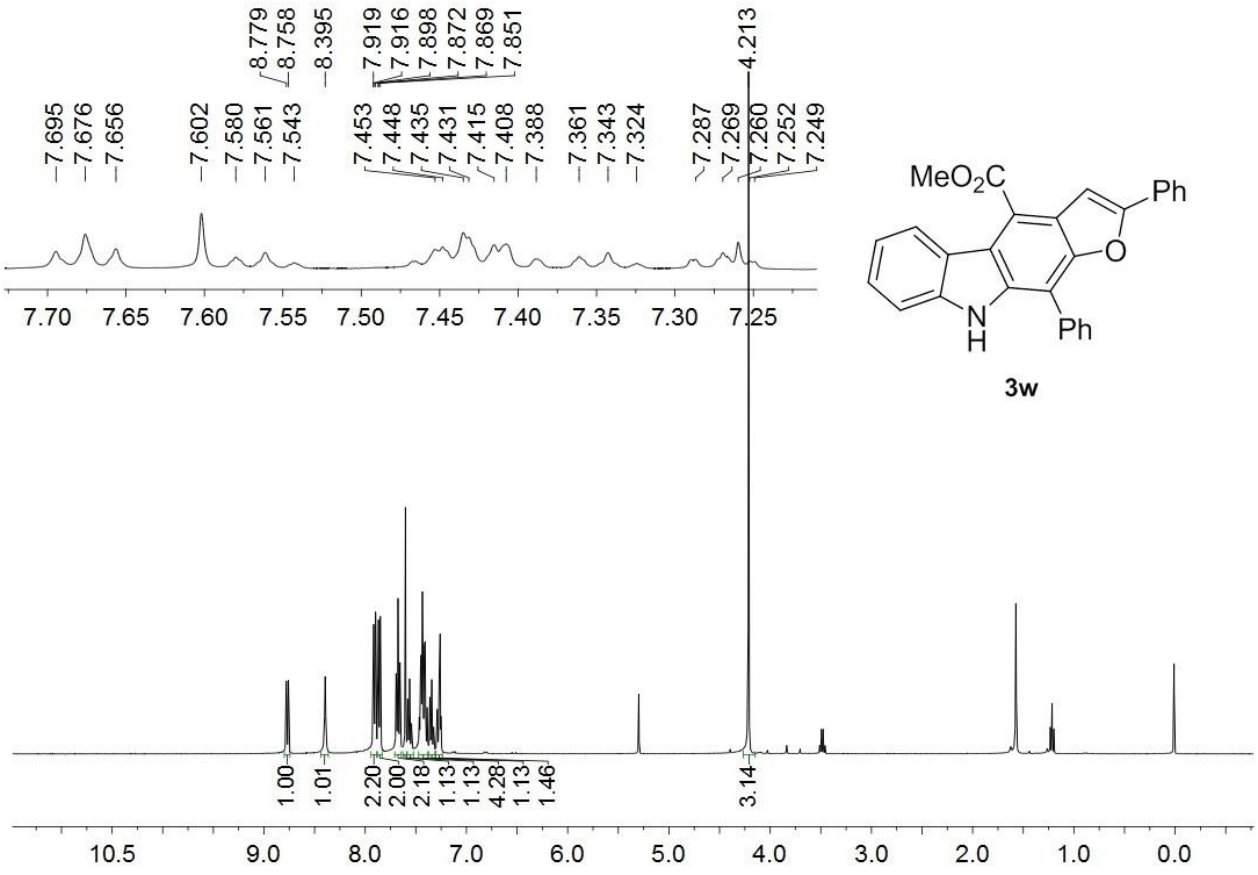
^{1}H NMR (400 MHz, $CDCl_3$) for **3v**



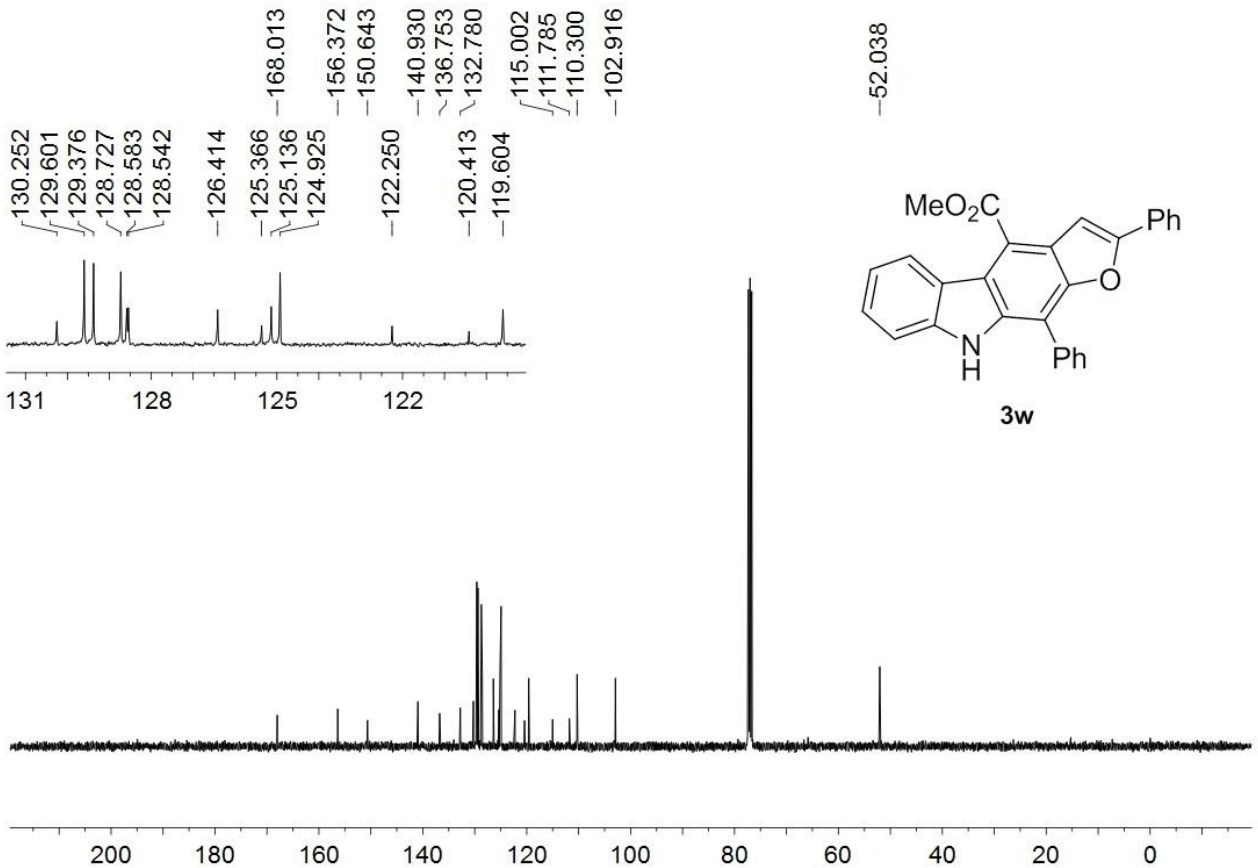
^{13}C NMR (100 MHz, $CDCl_3$) for **3v**



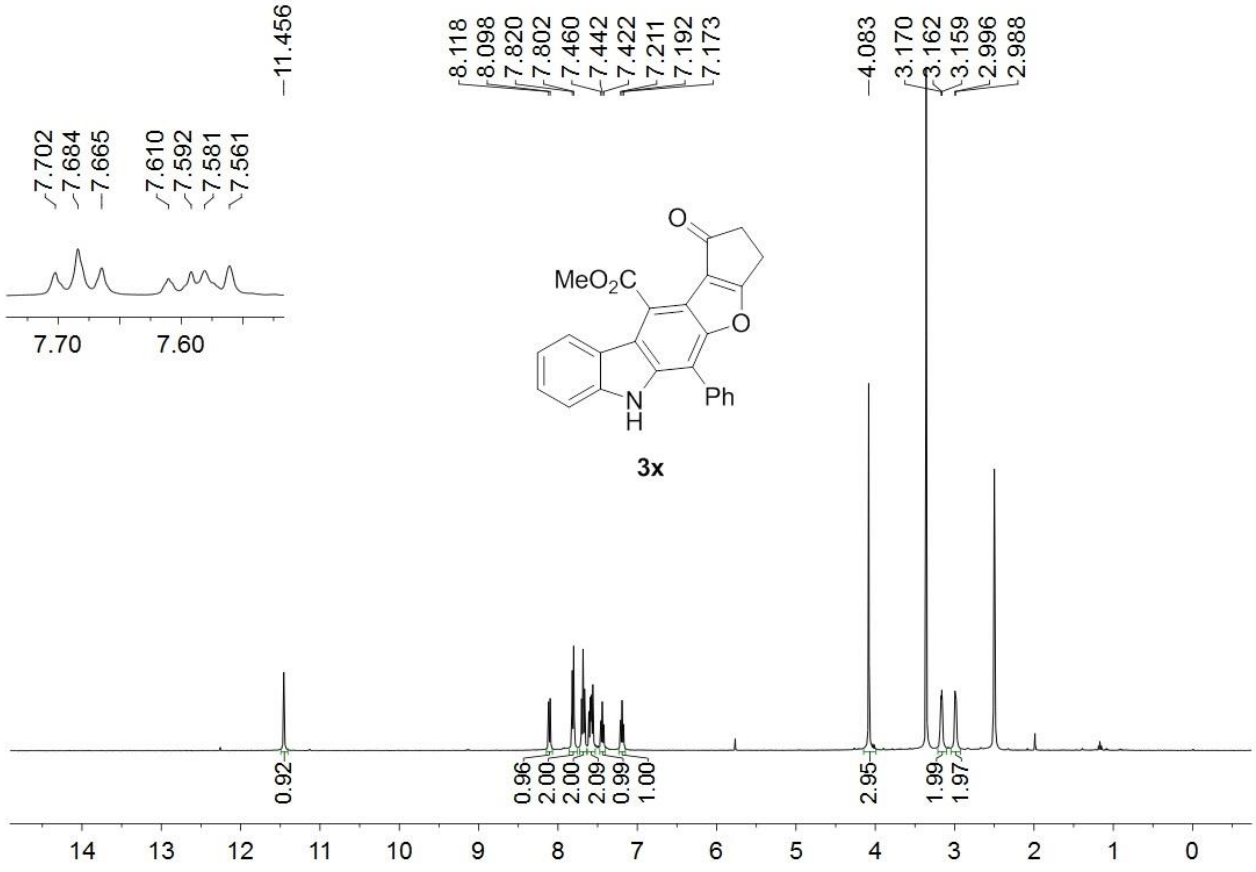
^{1}H NMR (400 MHz, $CDCl_3$) for **3w**



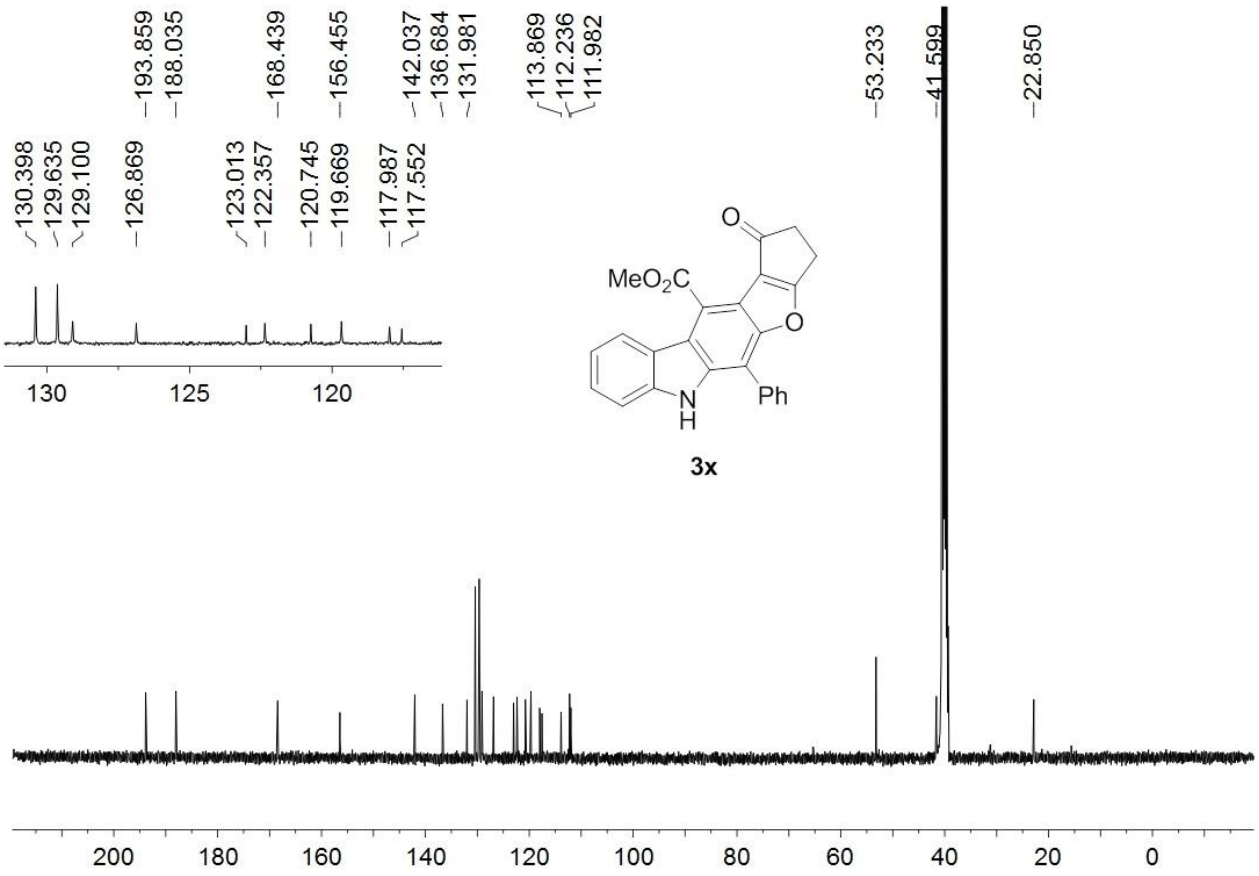
^{13}C NMR (100 MHz, $CDCl_3$) for **3w**



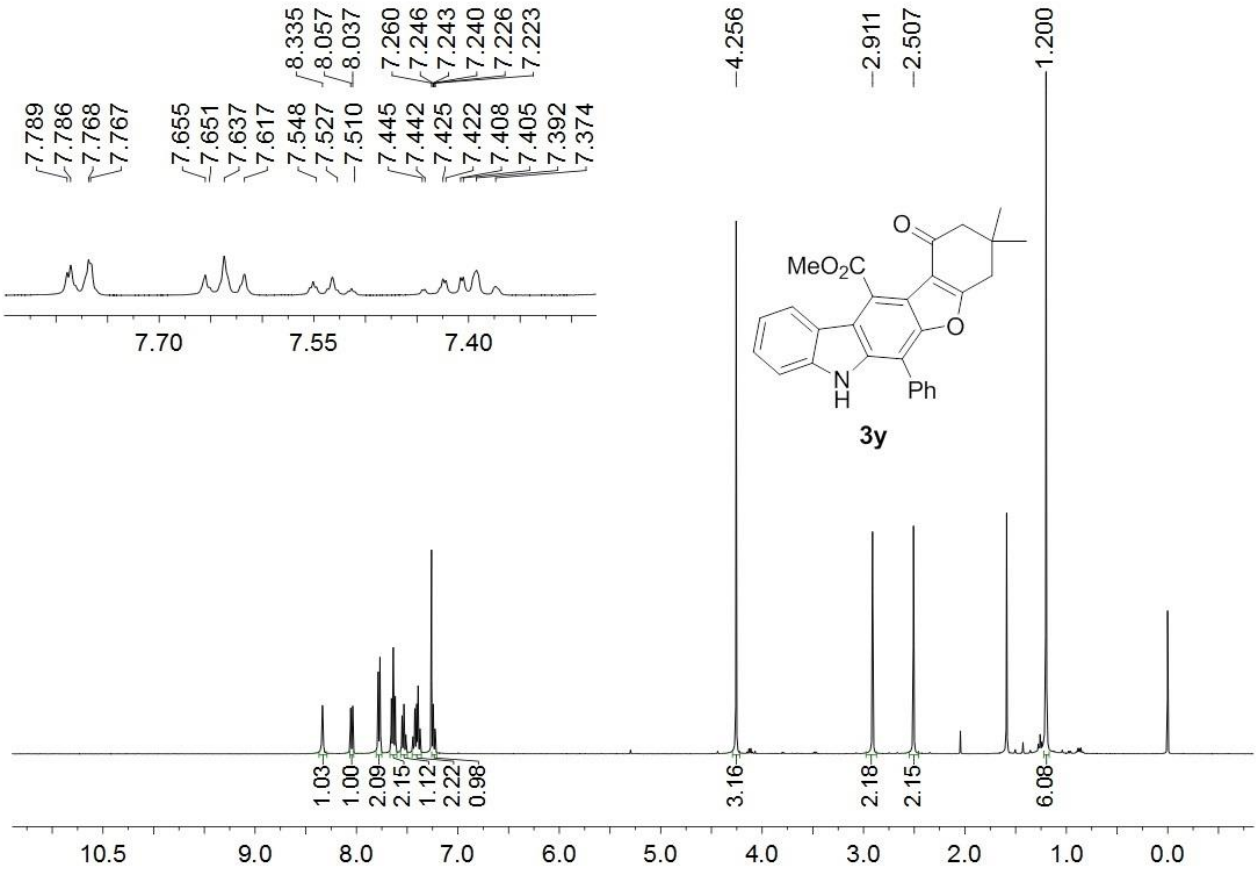
^{1}H NMR (400 MHz, DMSO-d_6) for **3x**



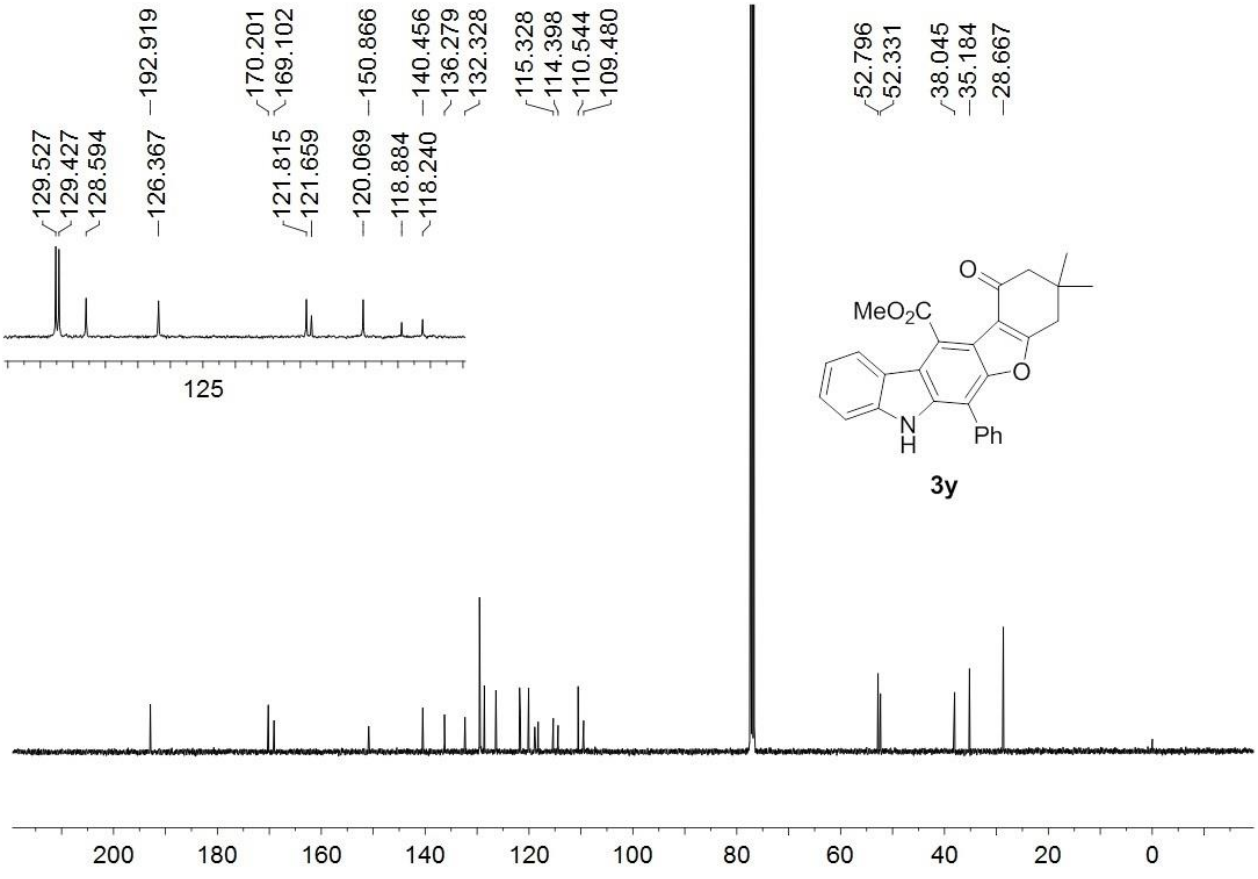
^{13}C NMR (100 MHz, DMSO-d_6) for **3x**



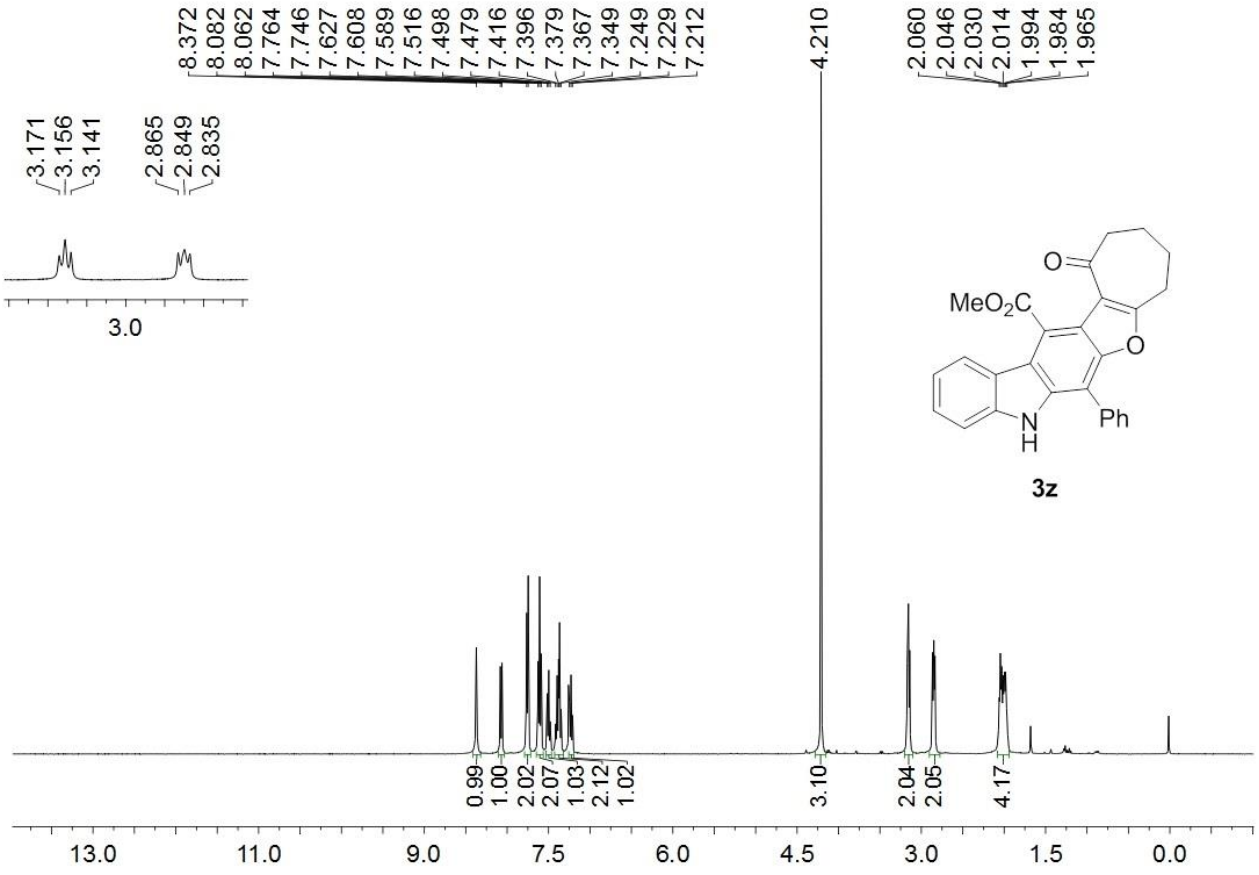
^{1}H NMR (400 MHz, DMSO-d_6) for **3y**



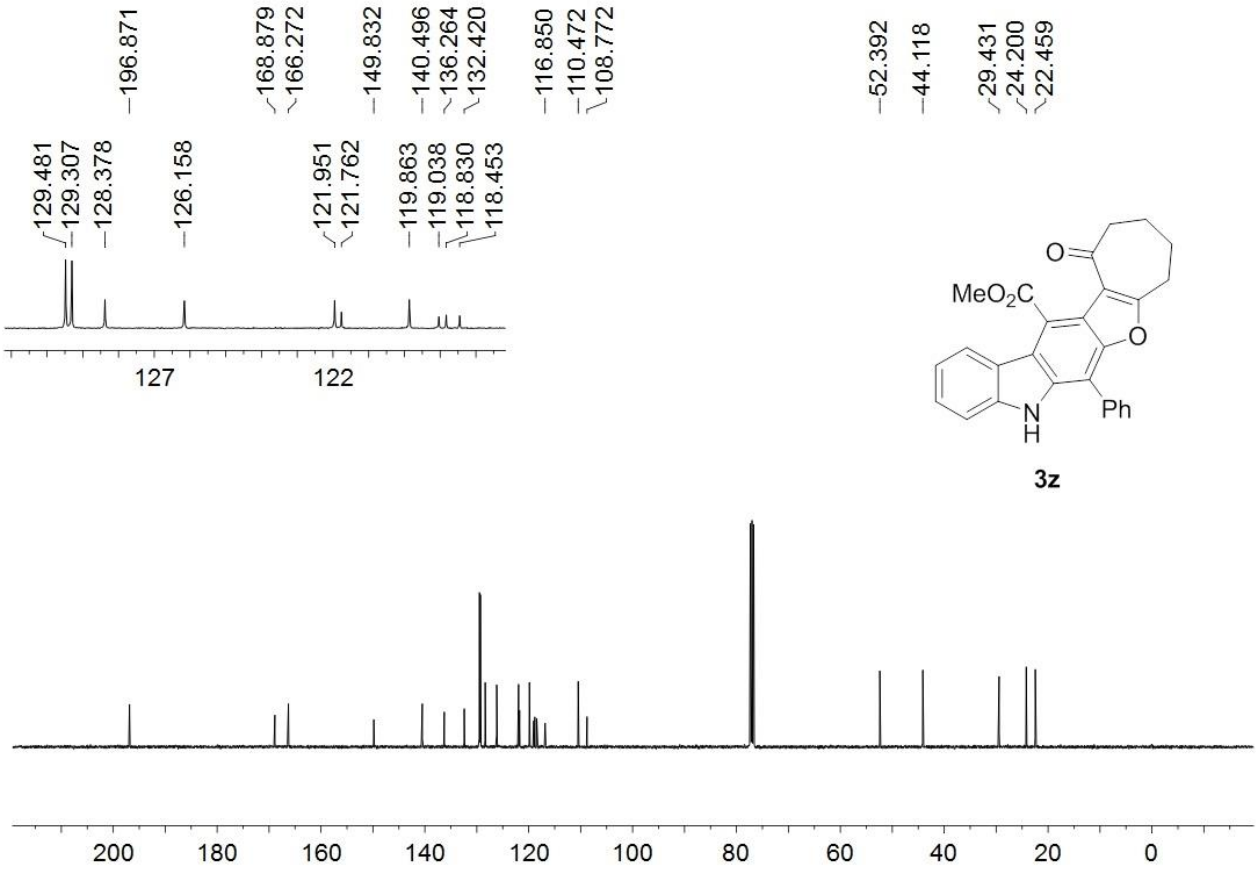
^{13}C NMR (100 MHz, DMSO-d_6) for **3y**



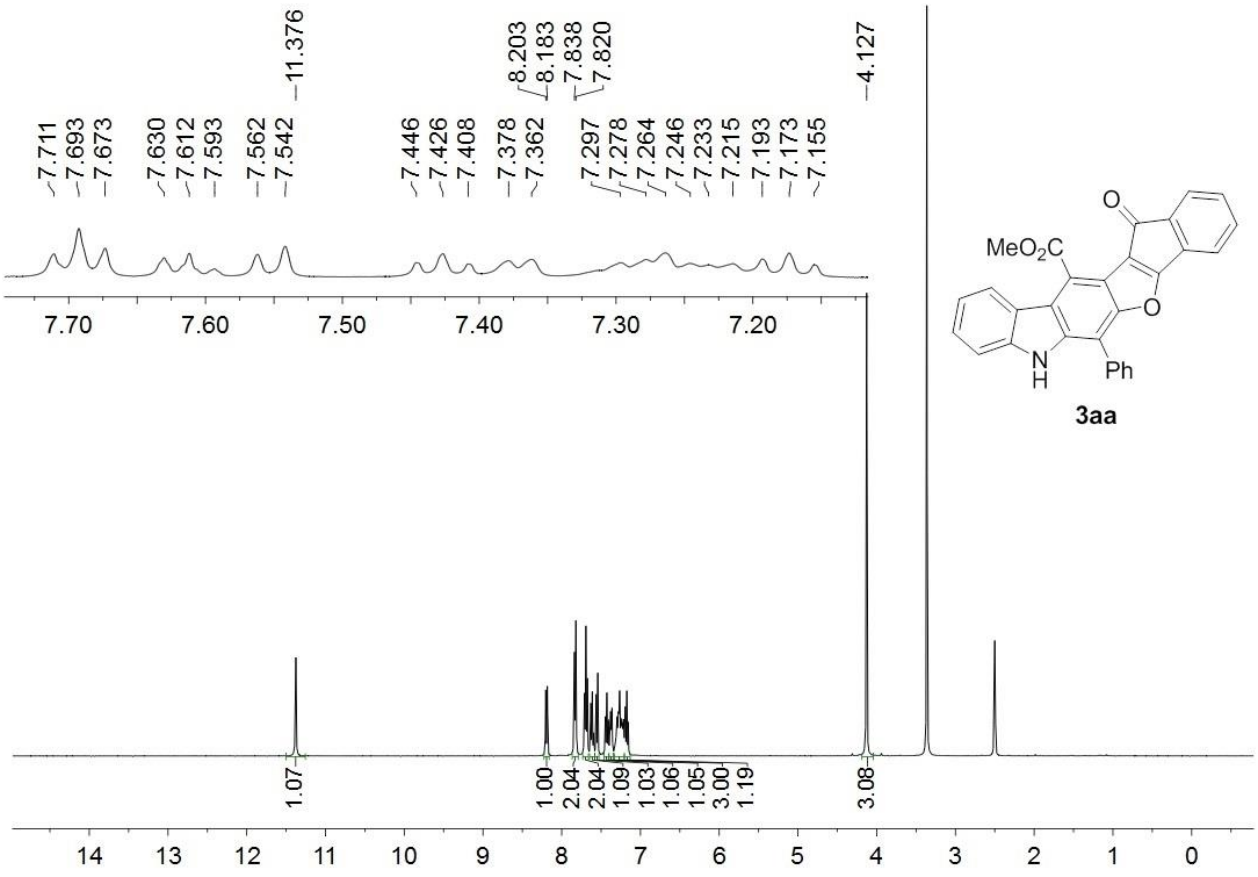
^{1}H NMR (400 MHz, $CDCl_3$) for **3z**



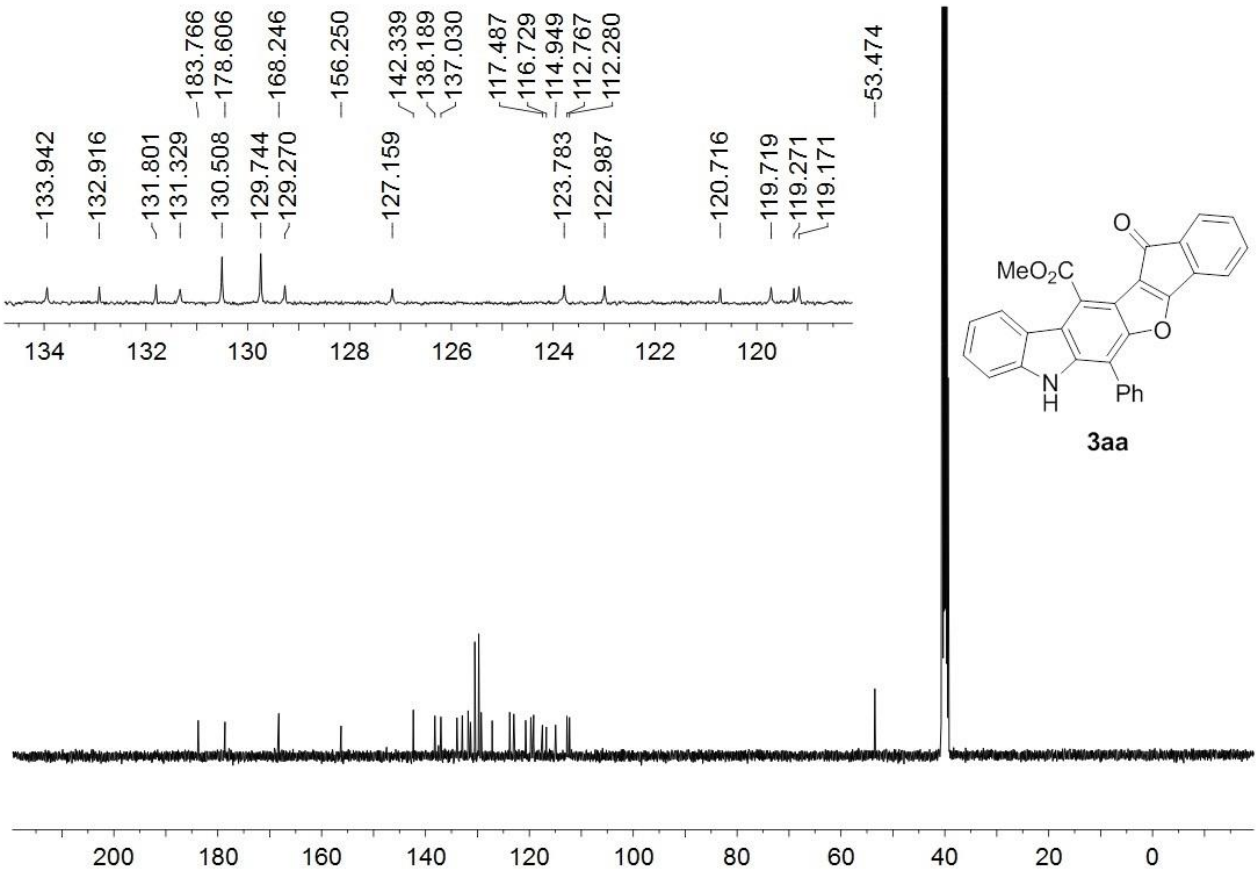
^{13}C NMR (100 MHz, $CDCl_3$) for **3z**



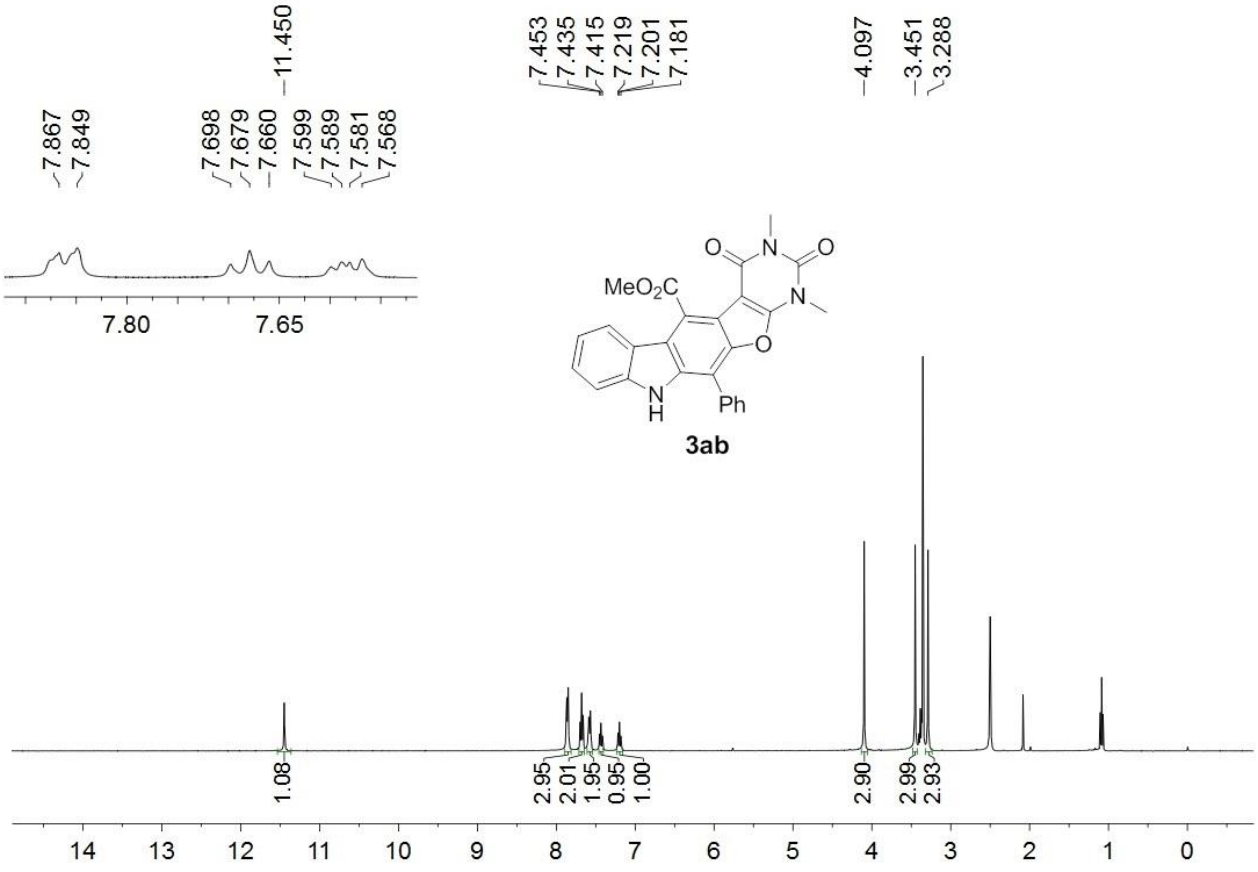
^{1}H NMR (400 MHz, DMSO-d_6) for **3aa**



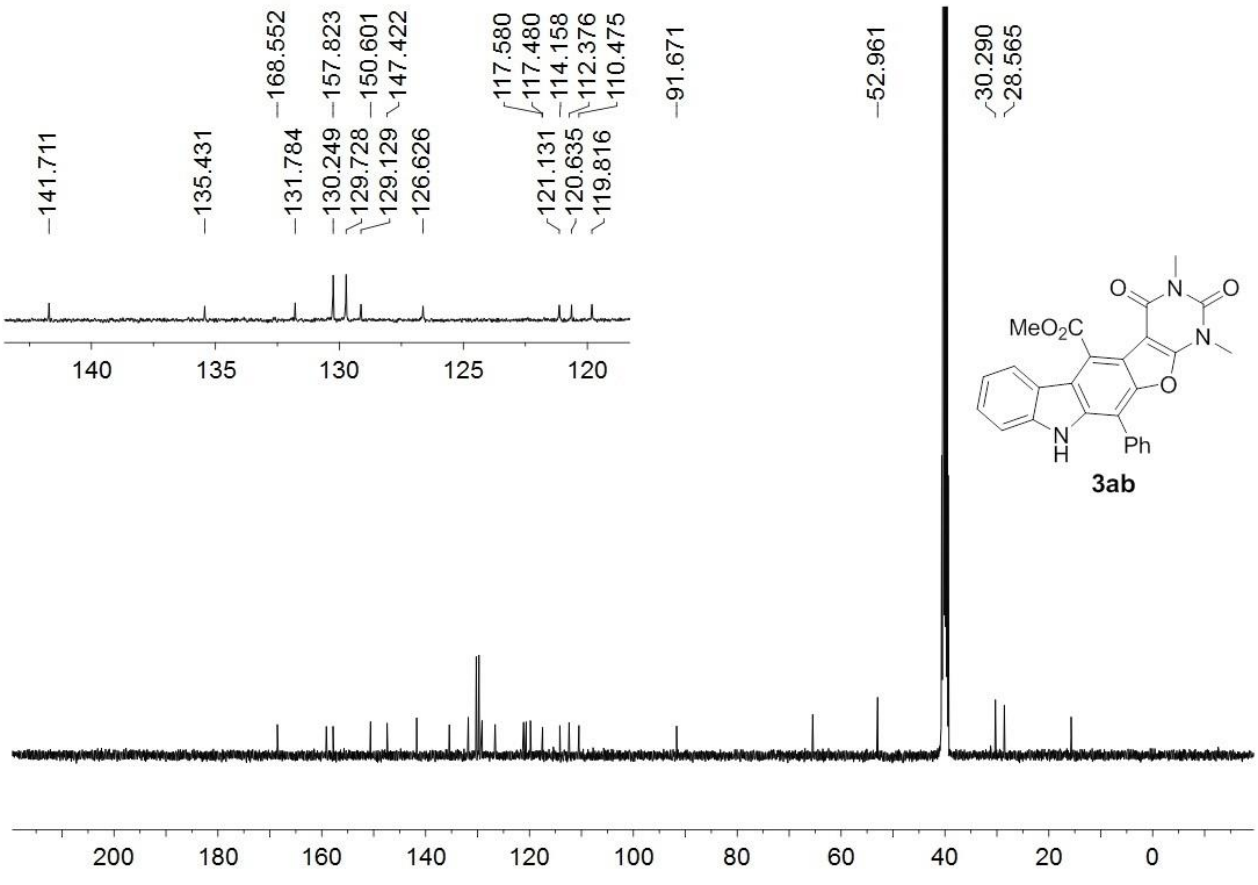
^{13}C NMR (100 MHz, DMSO-d_6) for **3aa**



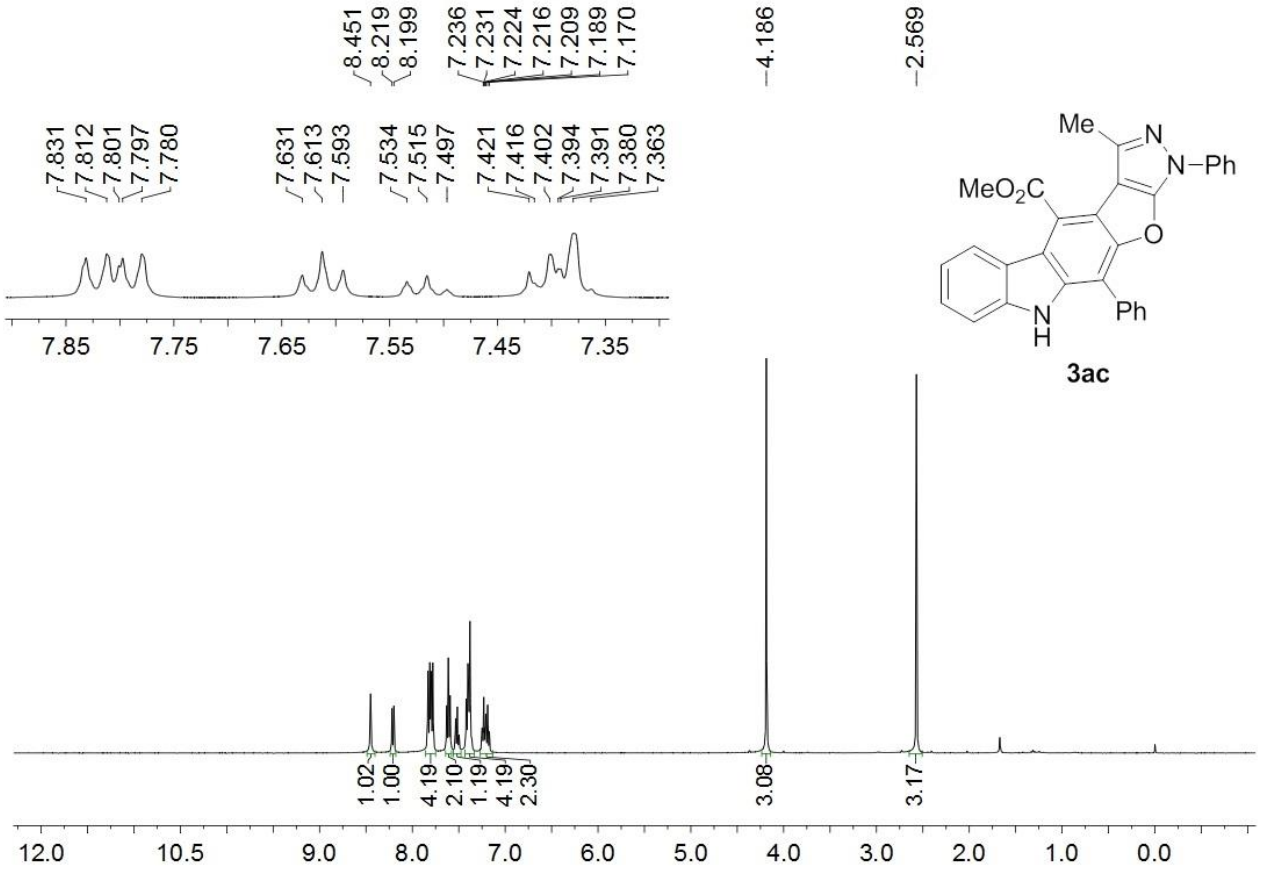
^{1}H NMR (400 MHz, DMSO-d_6) for **3ab**



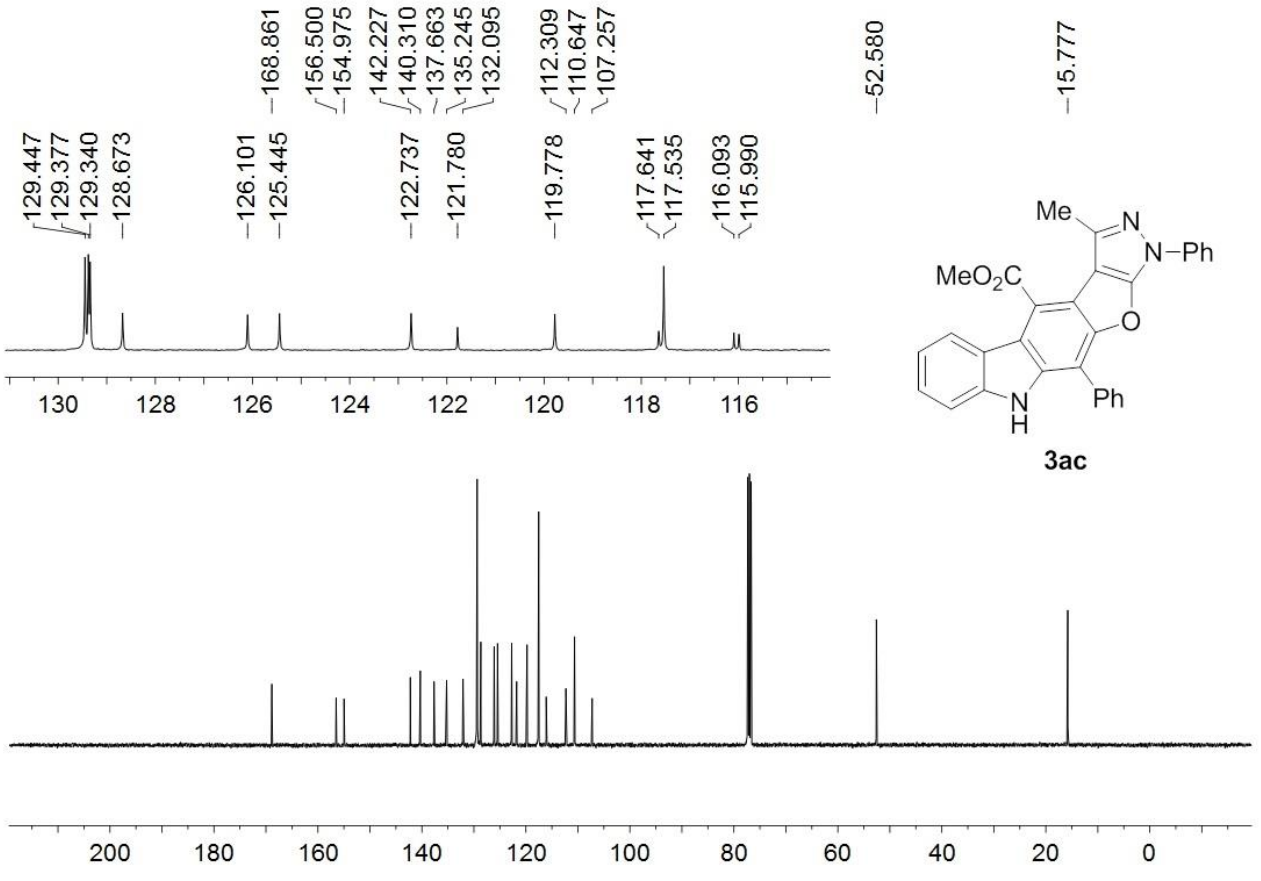
^{13}C NMR (100 MHz, DMSO-d_6) for **3ab**



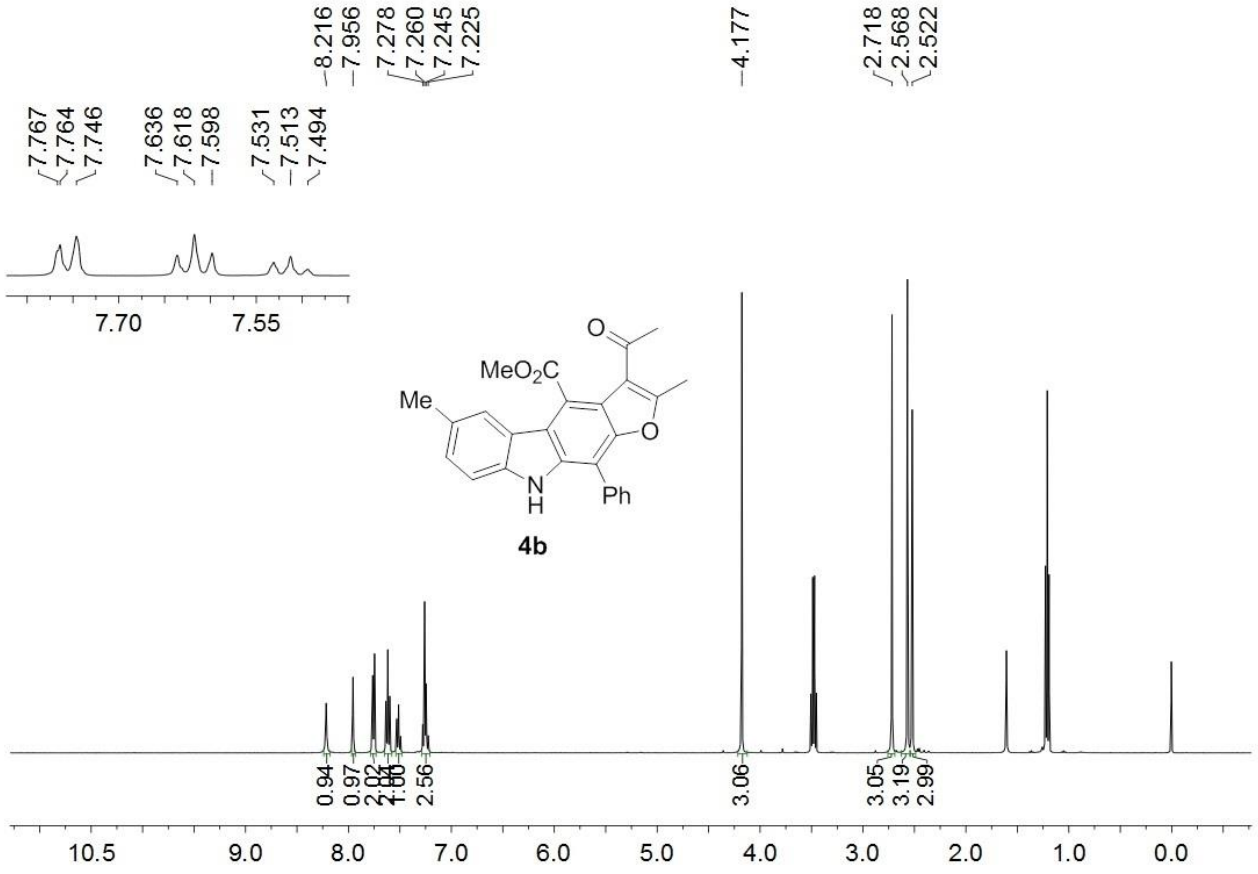
^{1}H NMR (400 MHz, $CDCl_3$) for **3ac**



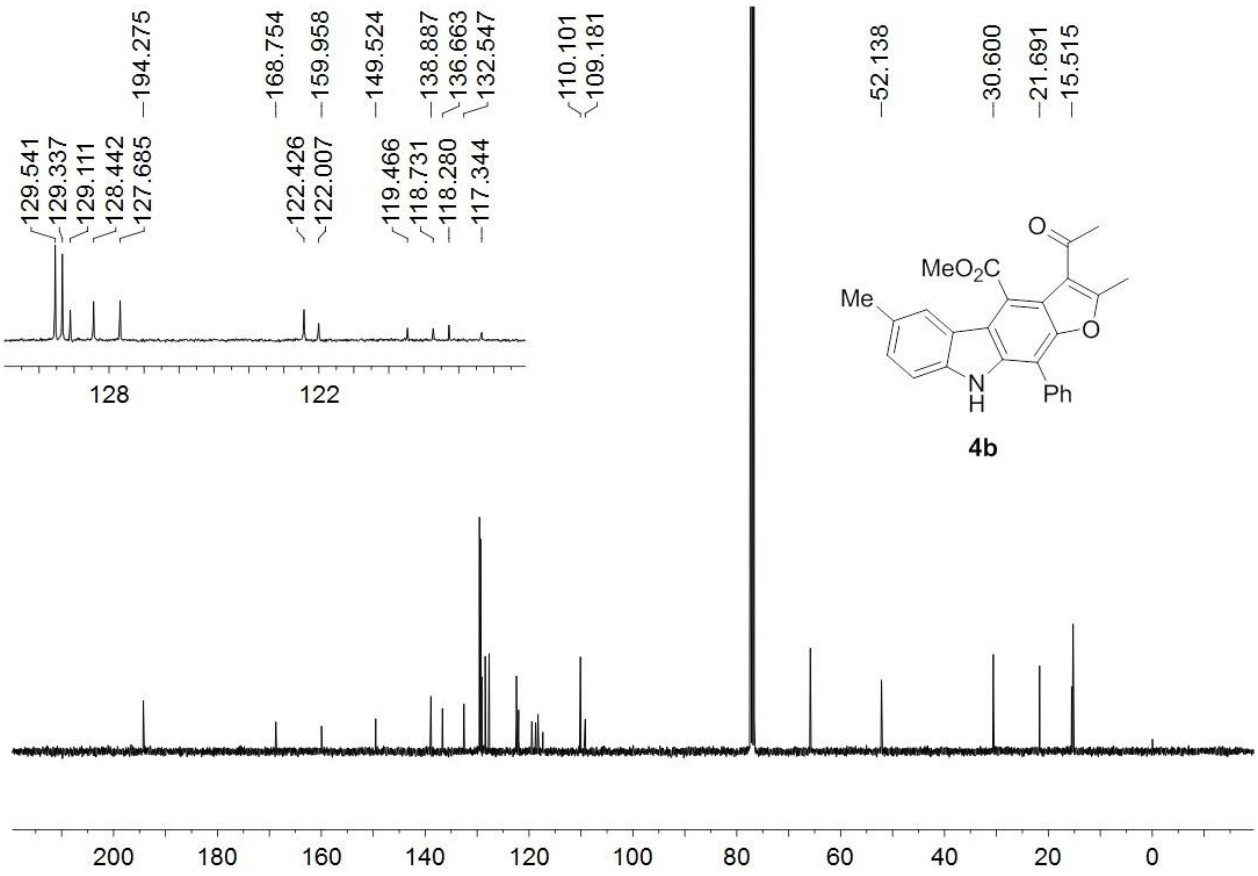
^{13}C NMR (100 MHz, $CDCl_3$) for **3ac**



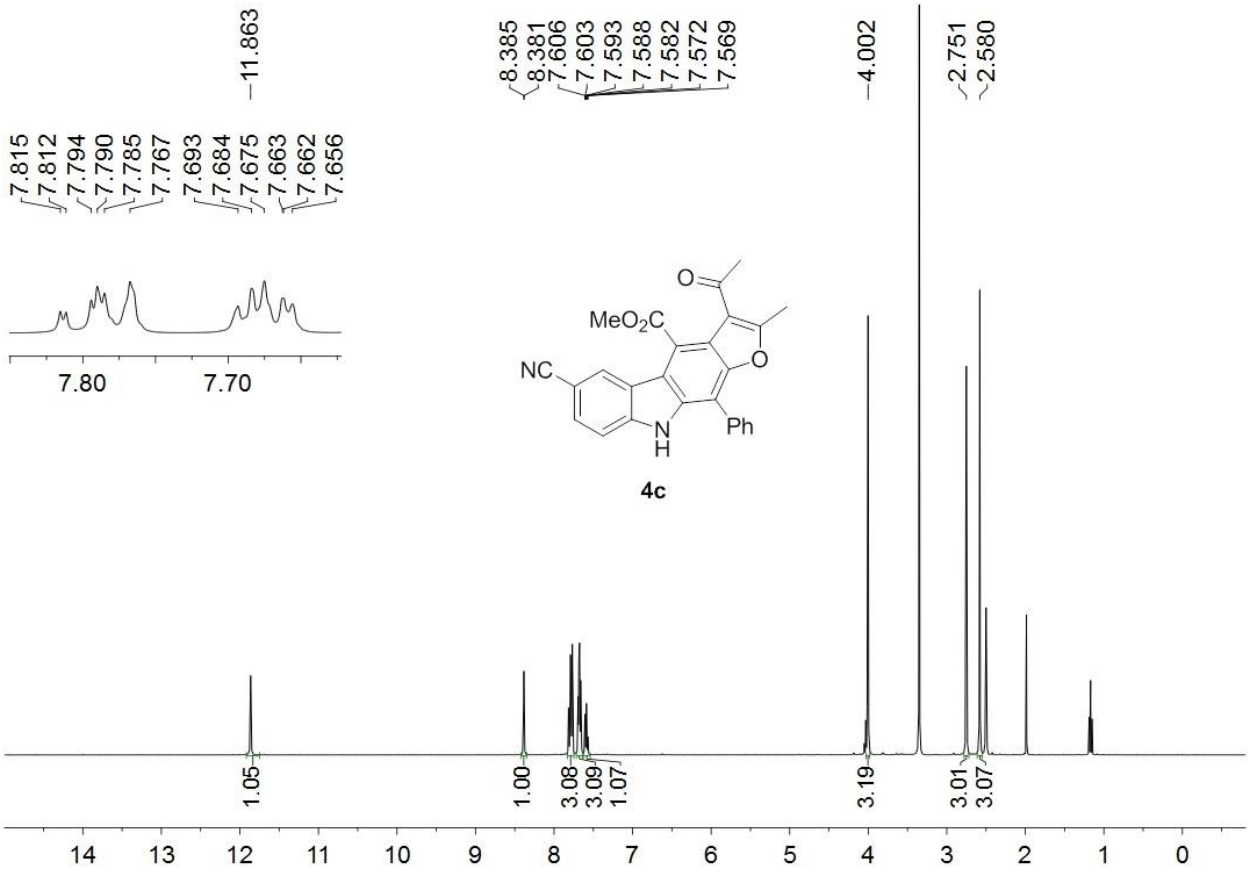
^{1}H NMR (400 MHz, $CDCl_3$) for **4b**



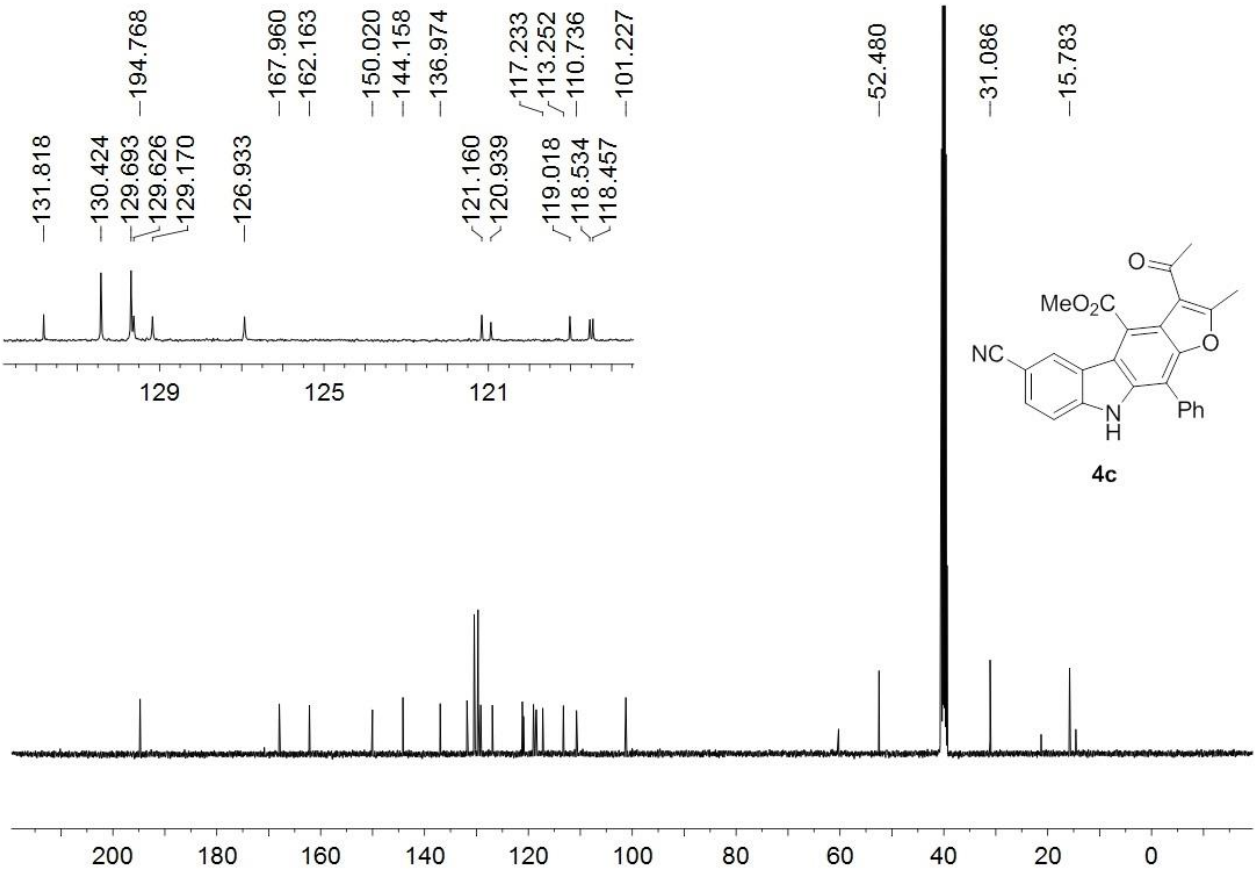
^{13}C NMR (100 MHz, $CDCl_3$) for **4b**



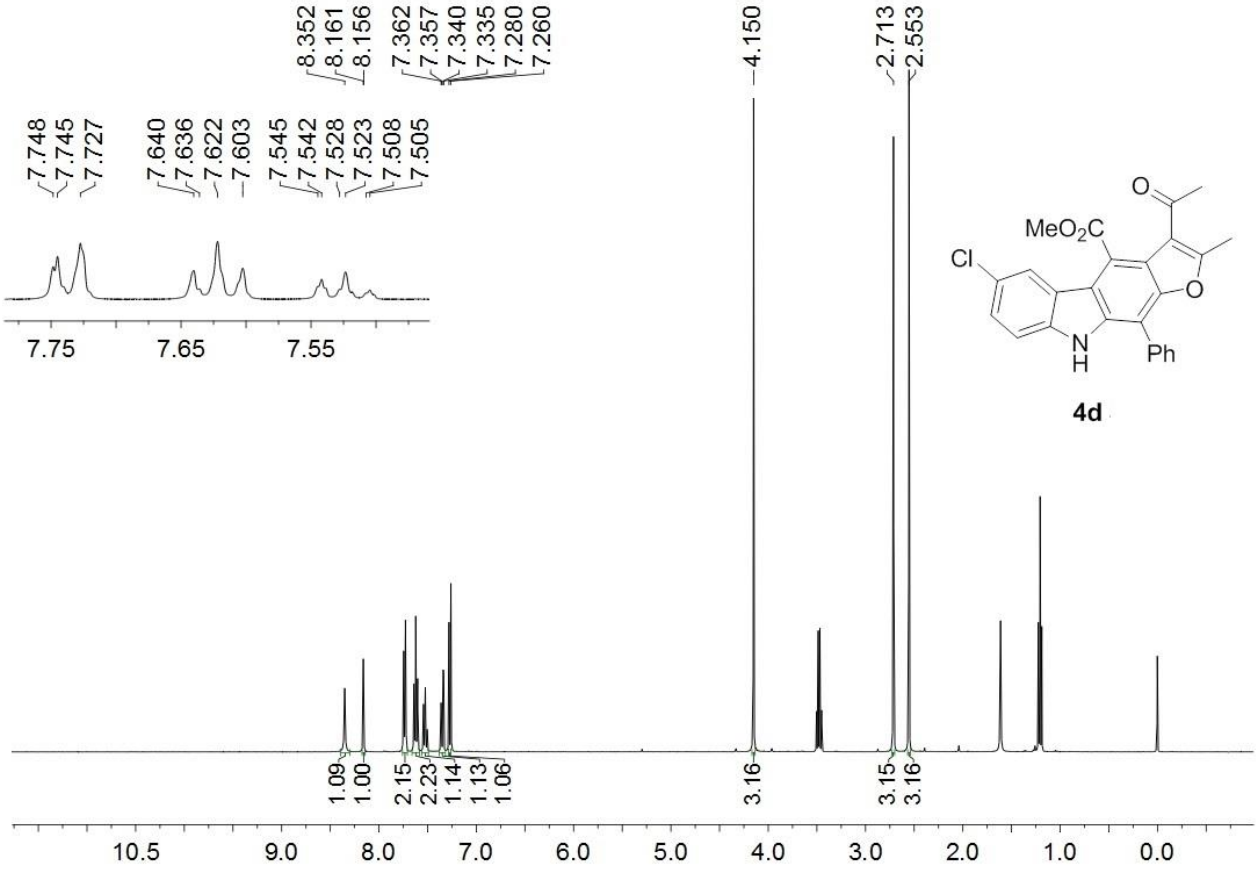
^{1}H NMR (400 MHz, DMSO-d_6) for **4c**



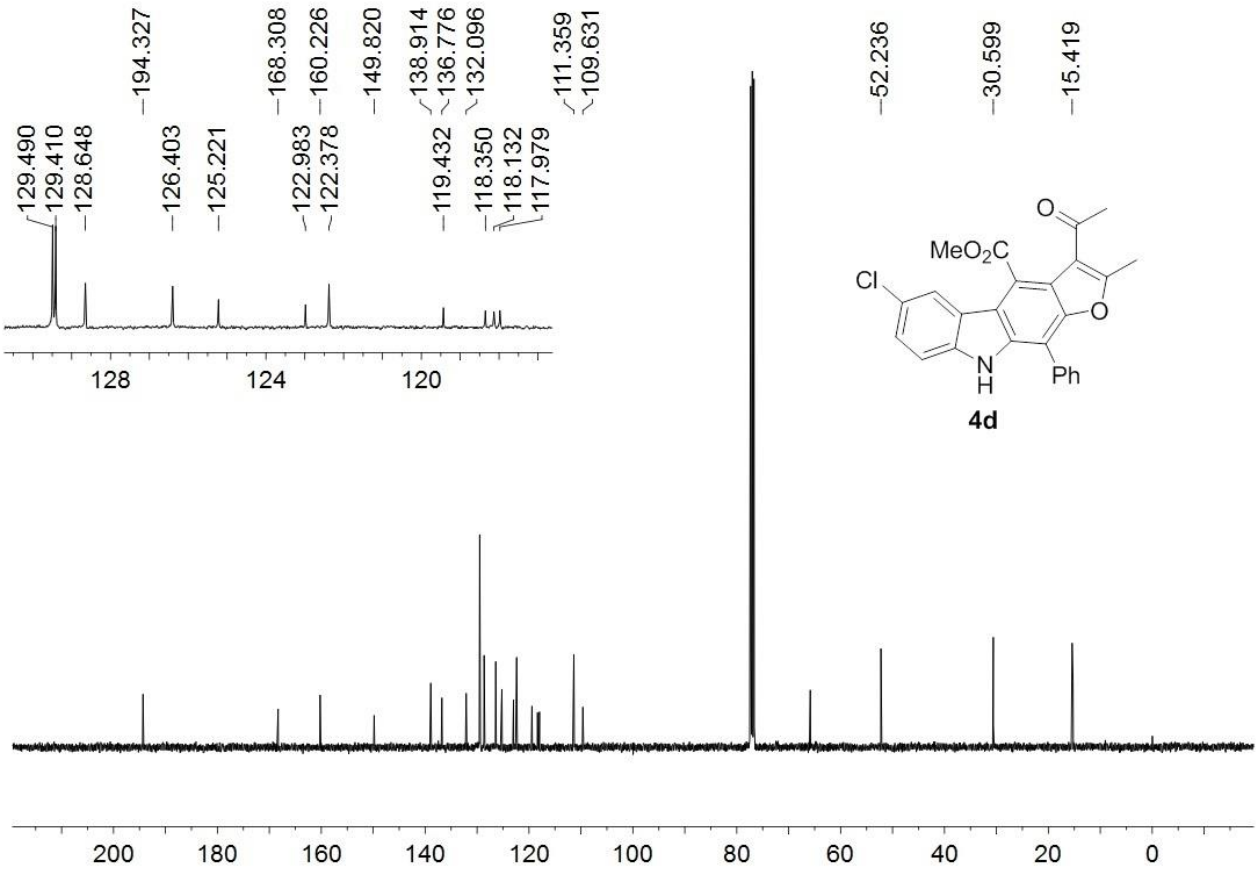
^{13}C NMR (100 MHz, DMSO-d_6) for **4c**



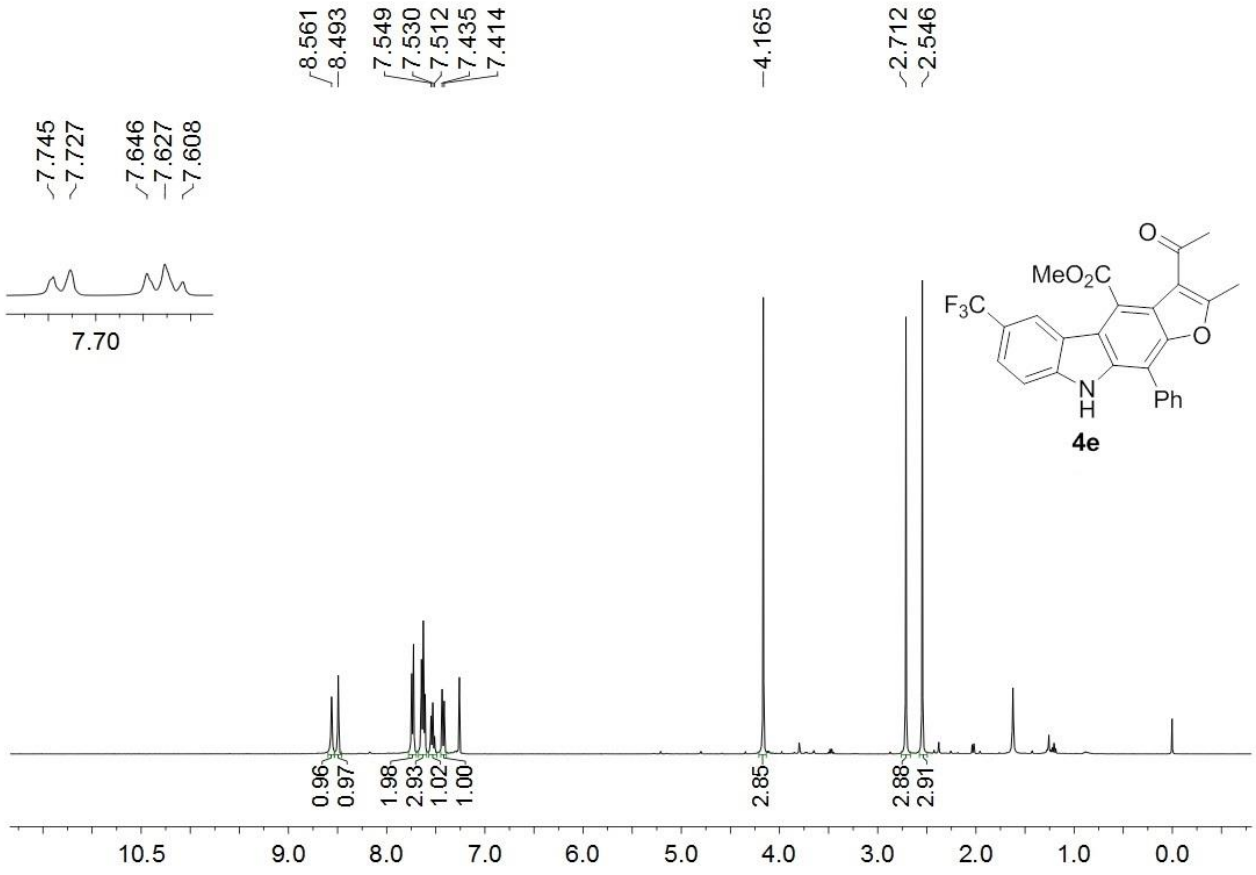
^{1}H NMR (400 MHz, $CDCl_3$) for **4d**



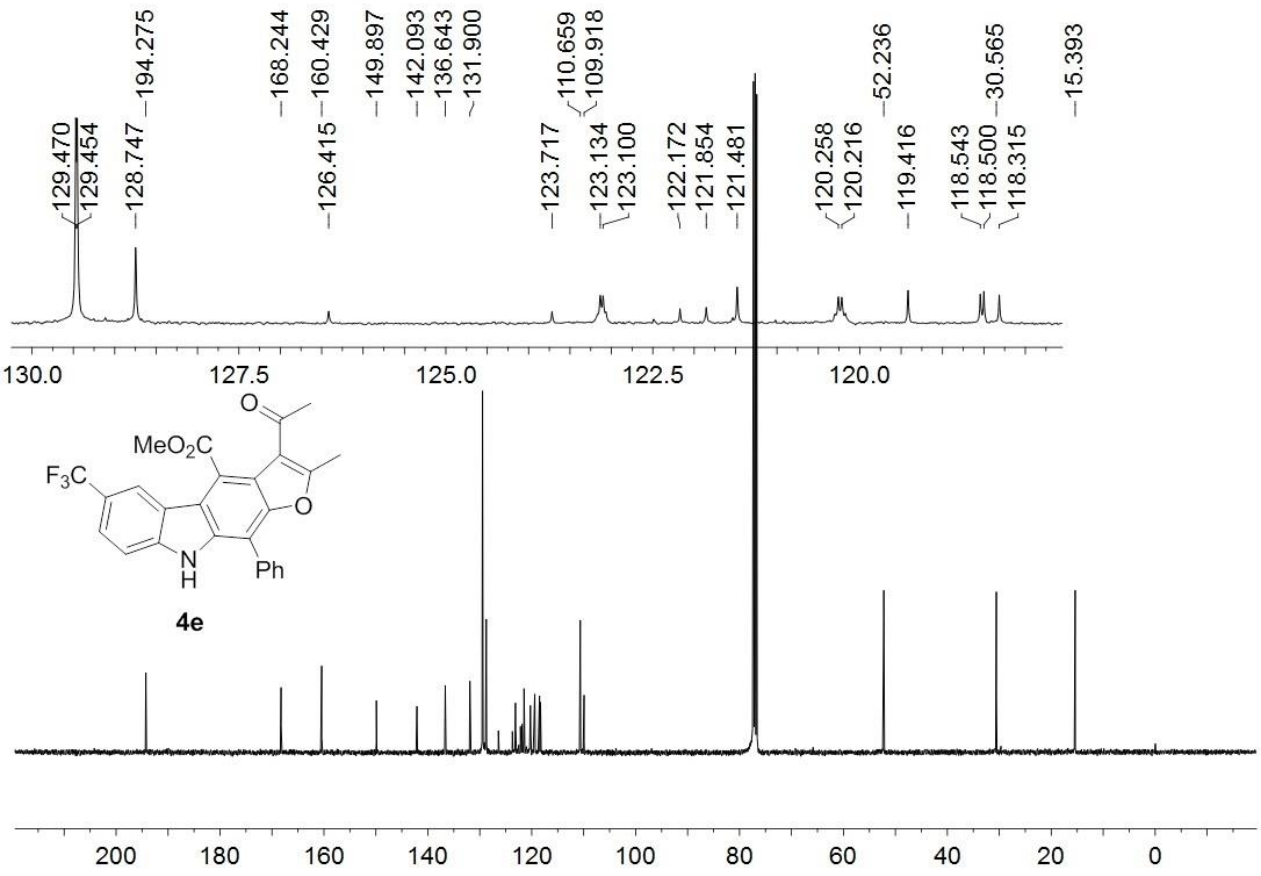
^{13}C NMR (100 MHz, $CDCl_3$) for **4d**



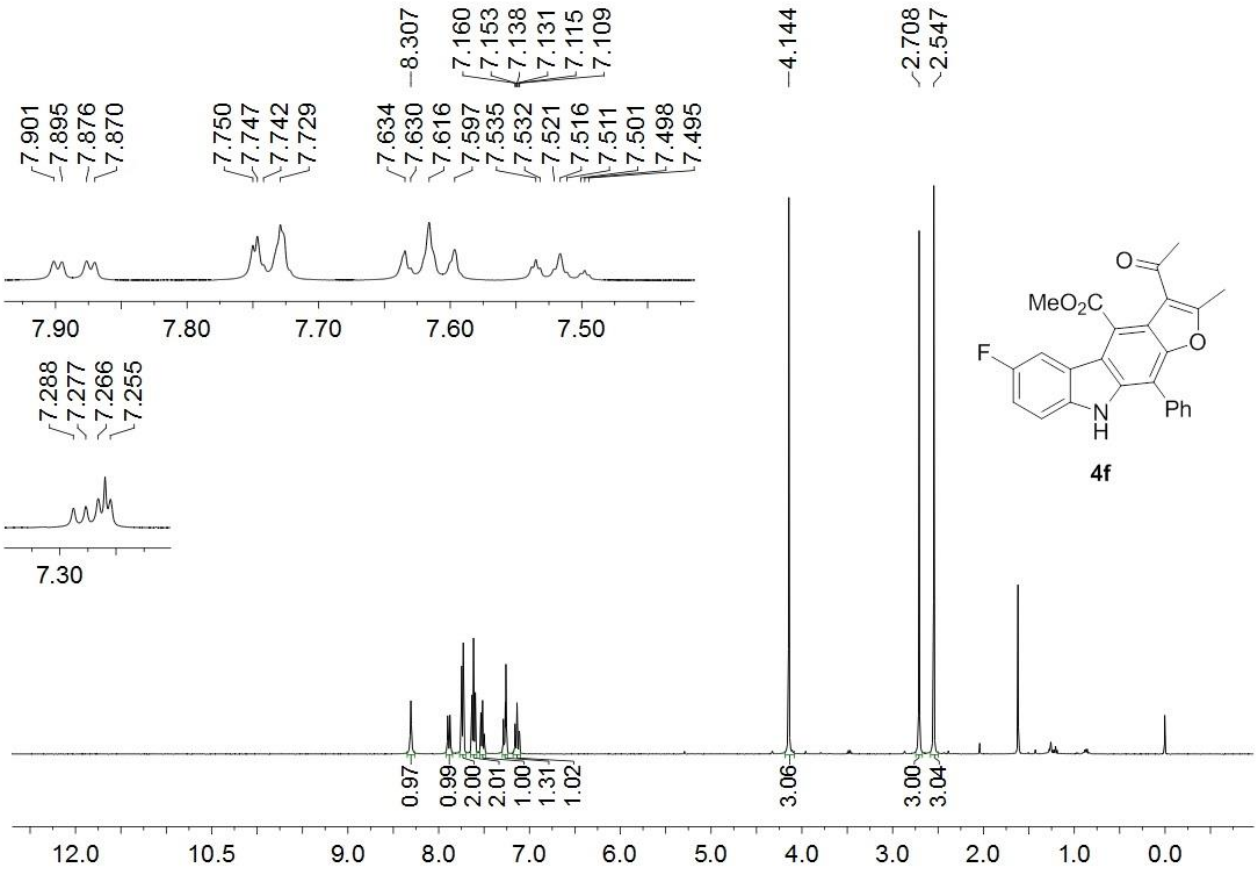
^{1}H NMR (400 MHz, $CDCl_3$) for **4e**



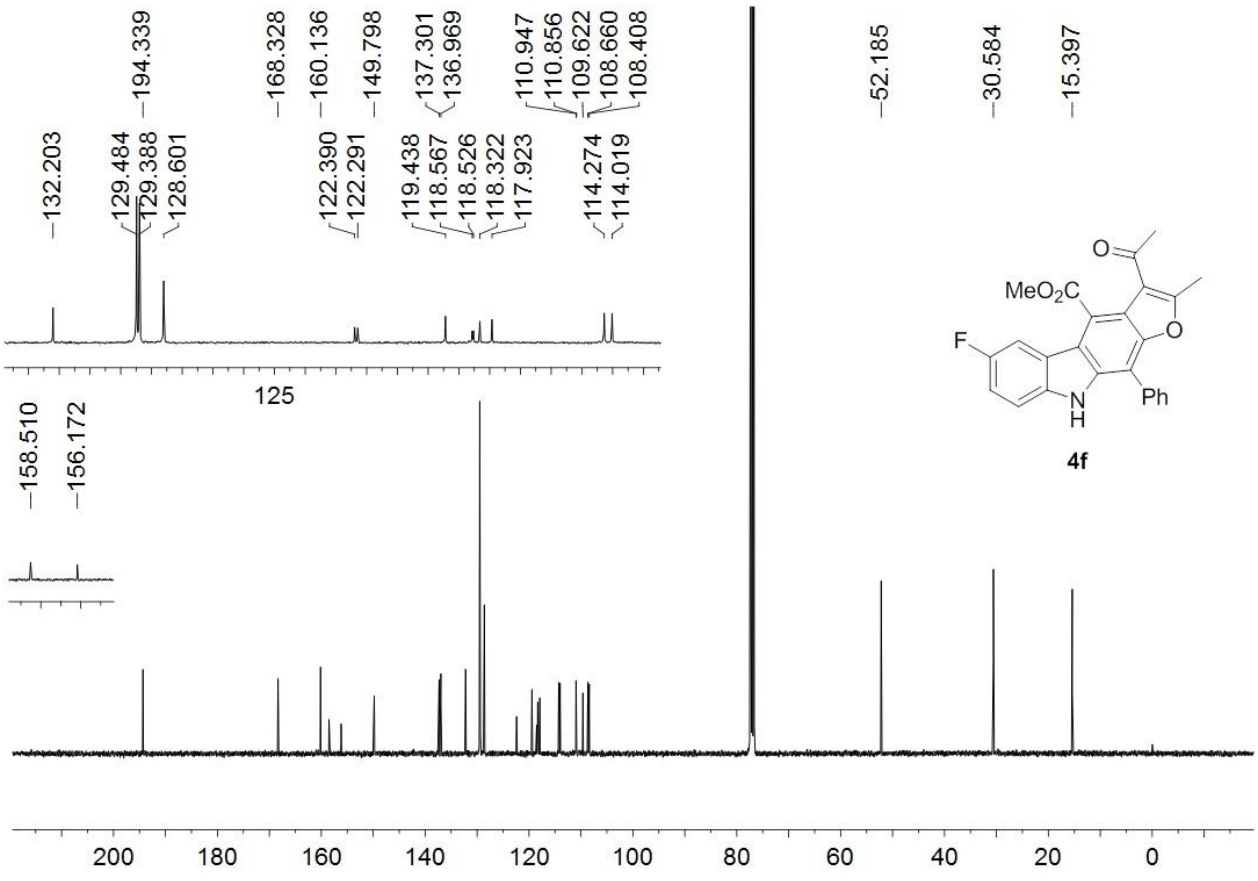
^{13}C NMR (100 MHz, $CDCl_3$) for **4e**



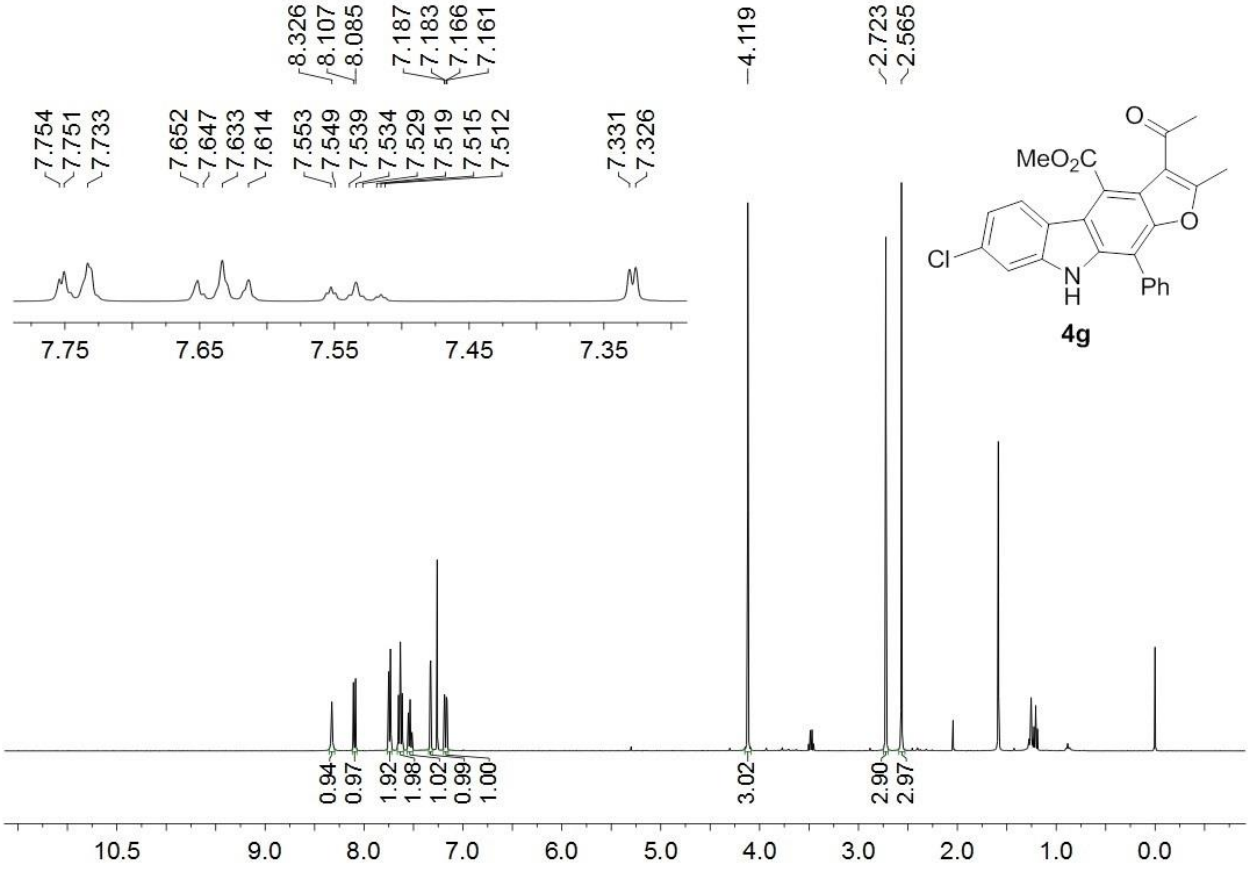
^{1}H NMR (400 MHz, $CDCl_3$) for **4f**



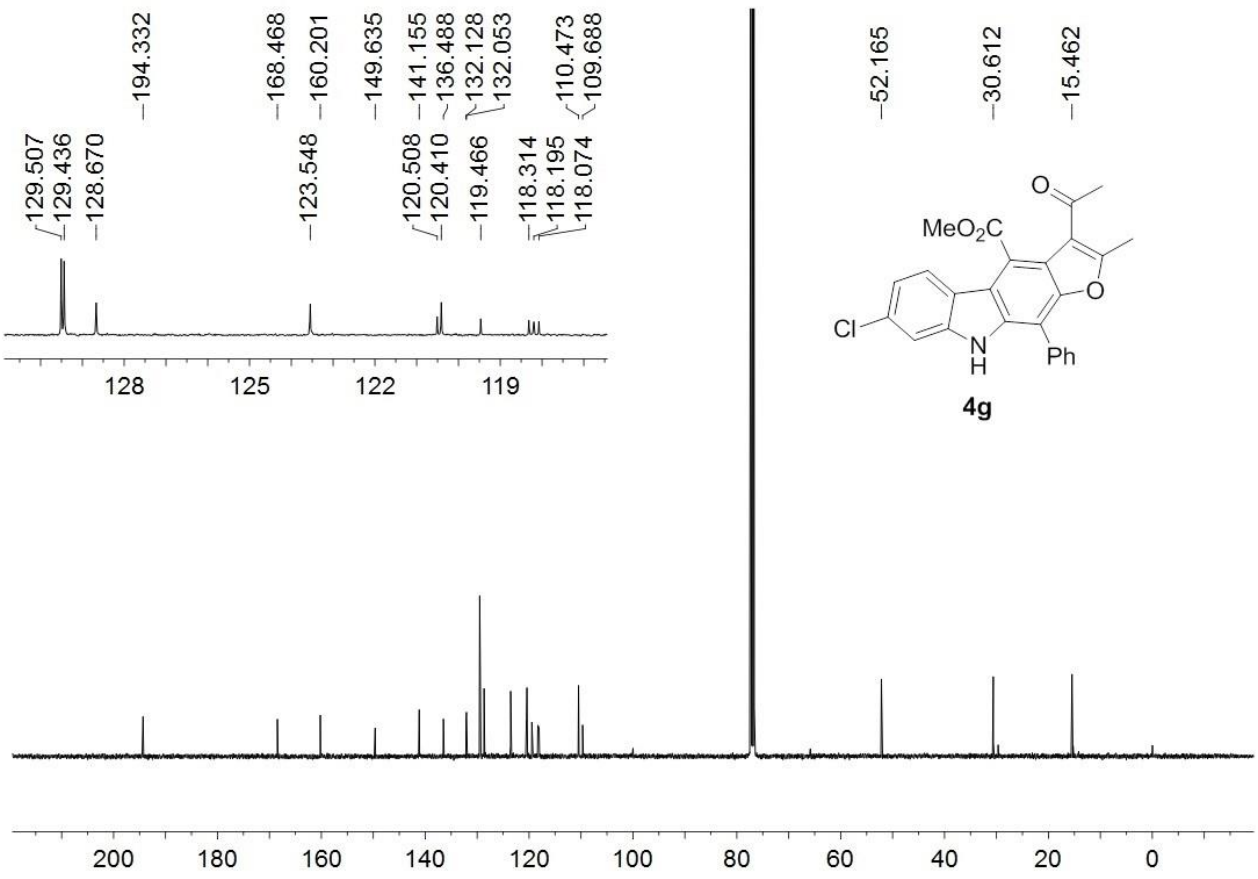
^{13}C NMR (100 MHz, $CDCl_3$) for **4f**



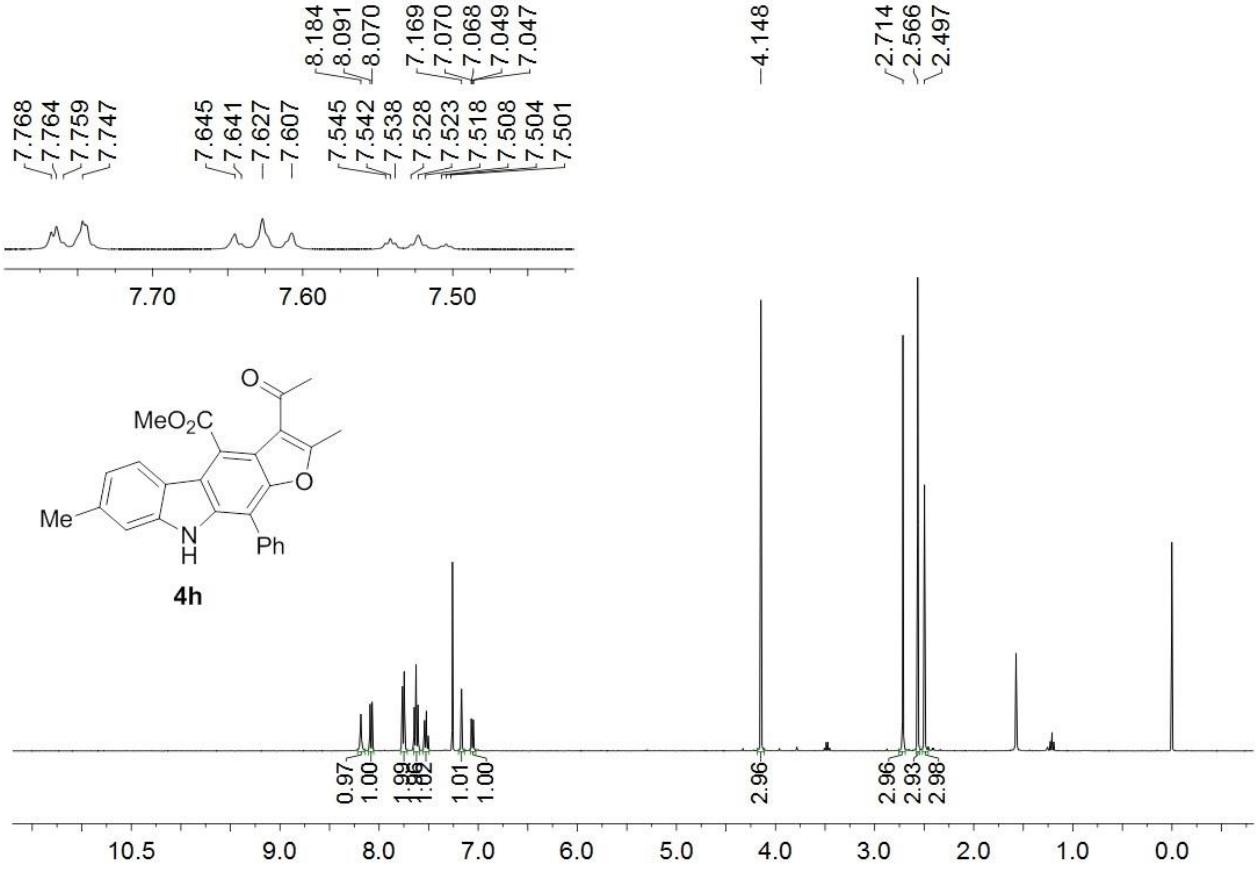
^{1}H NMR (400 MHz, $CDCl_3$) for **4g**



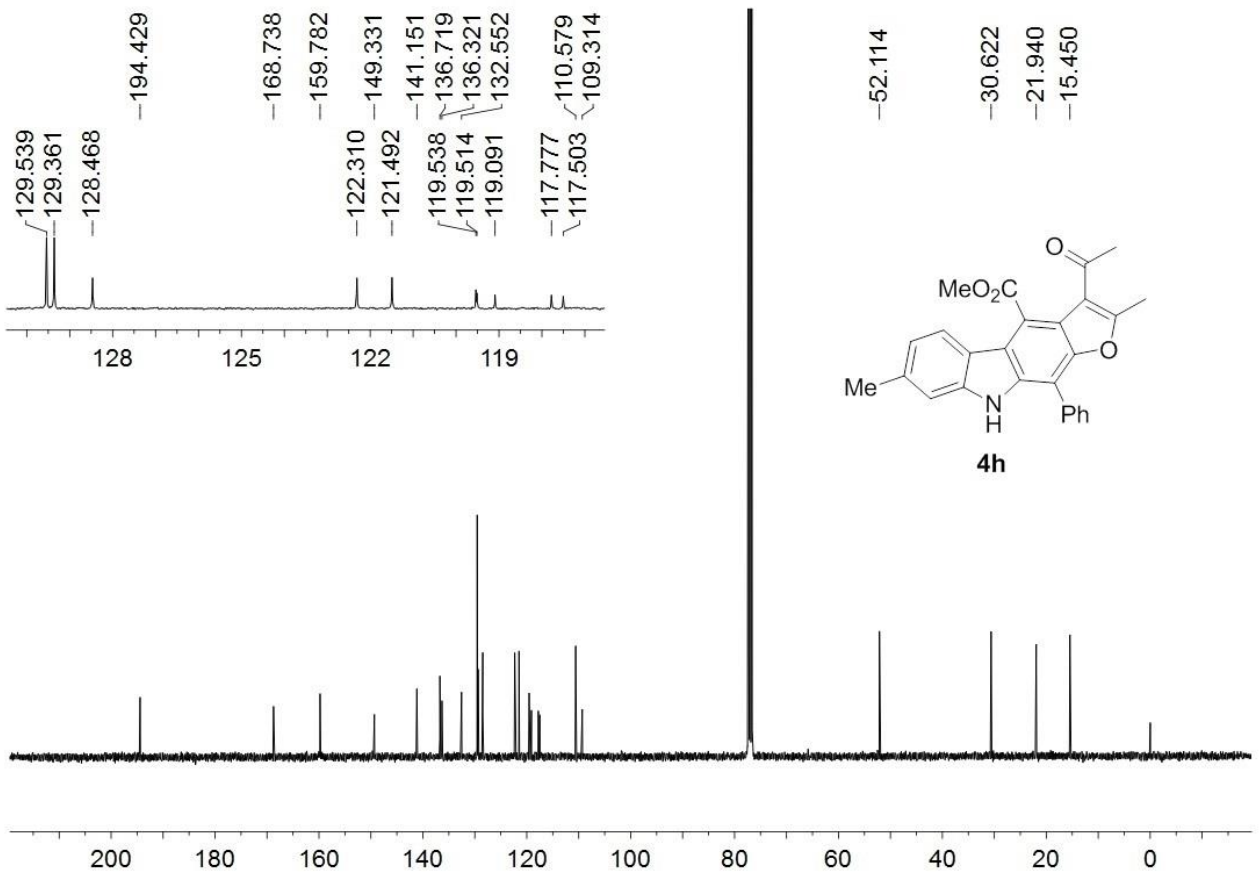
^{13}C NMR (100 MHz, $CDCl_3$) for **4g**



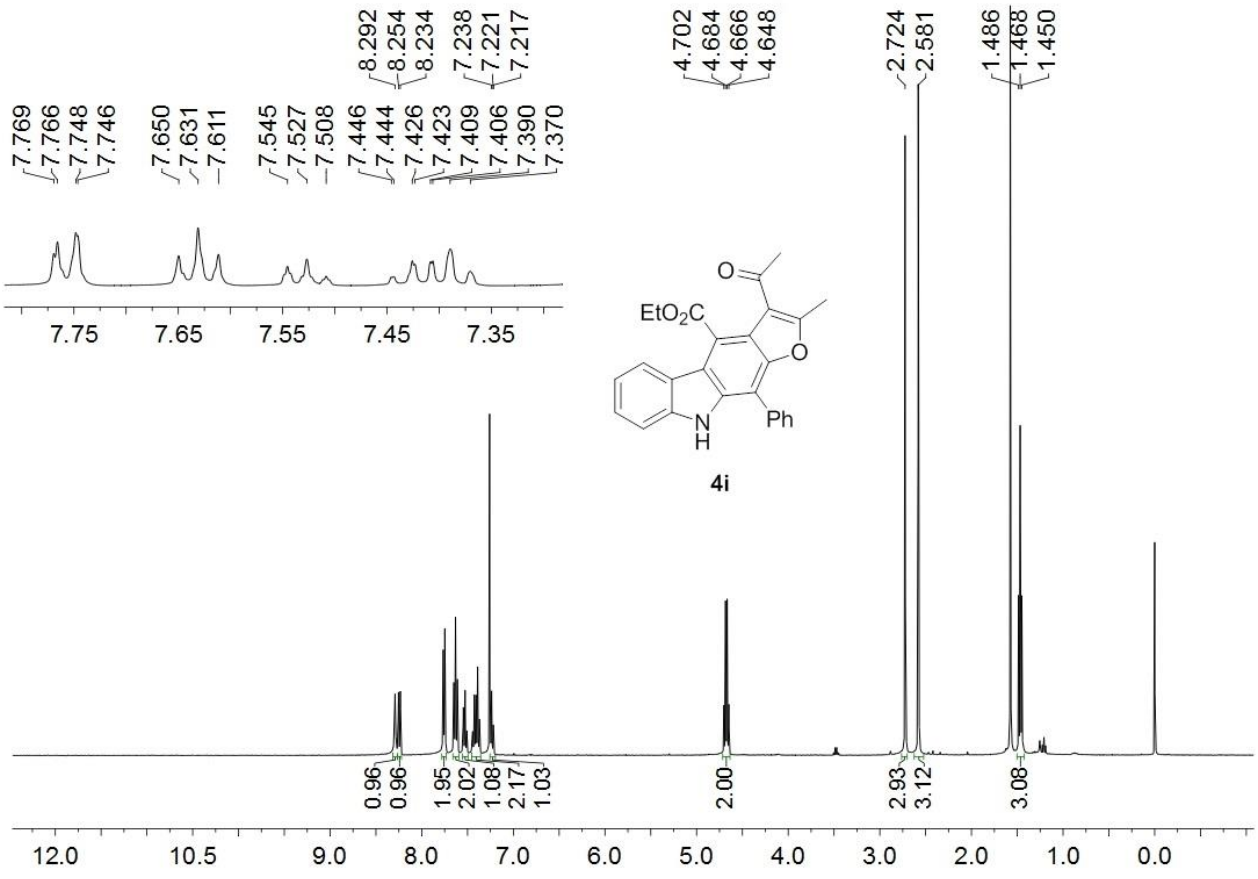
^{1}H NMR (400 MHz, $CDCl_3$) for **4h**



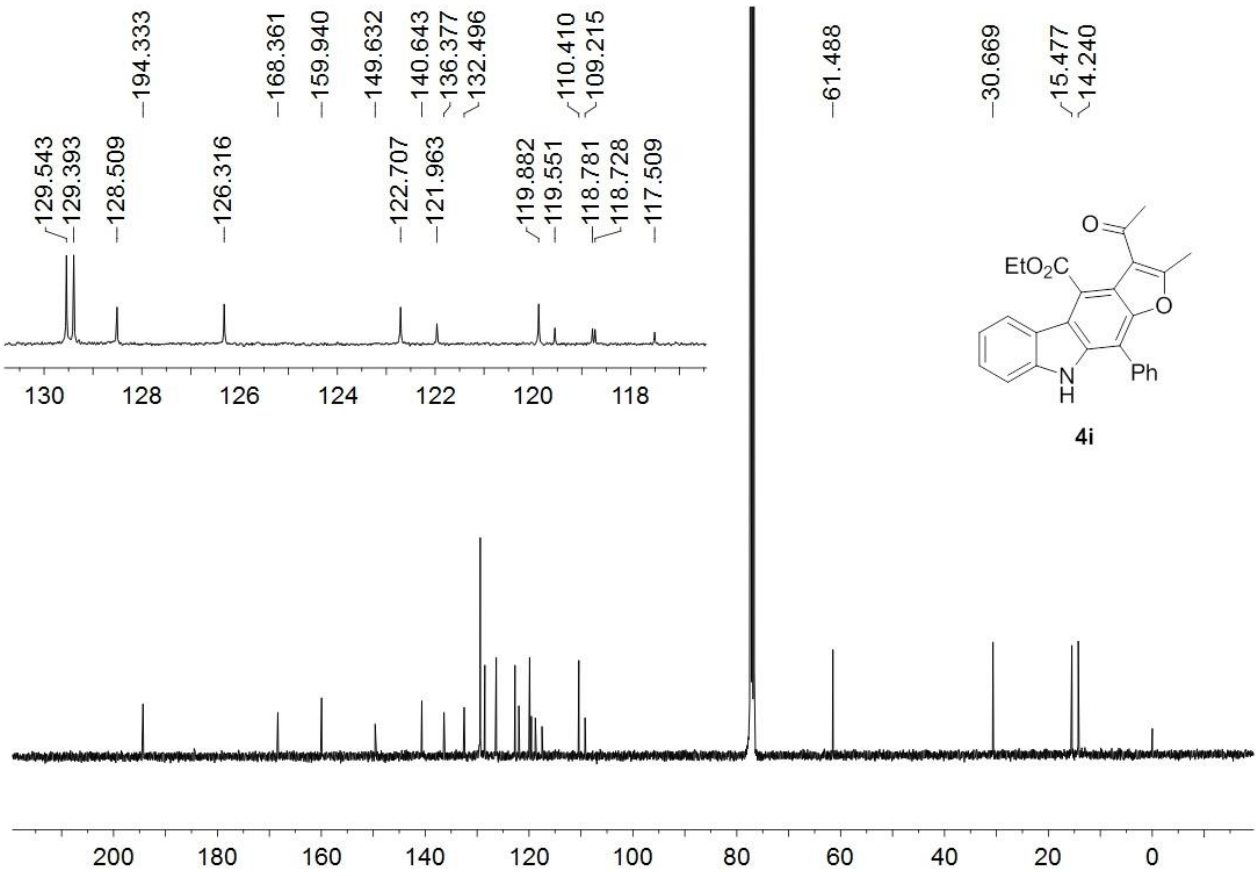
^{13}C NMR (100 MHz, $CDCl_3$) for **4h**



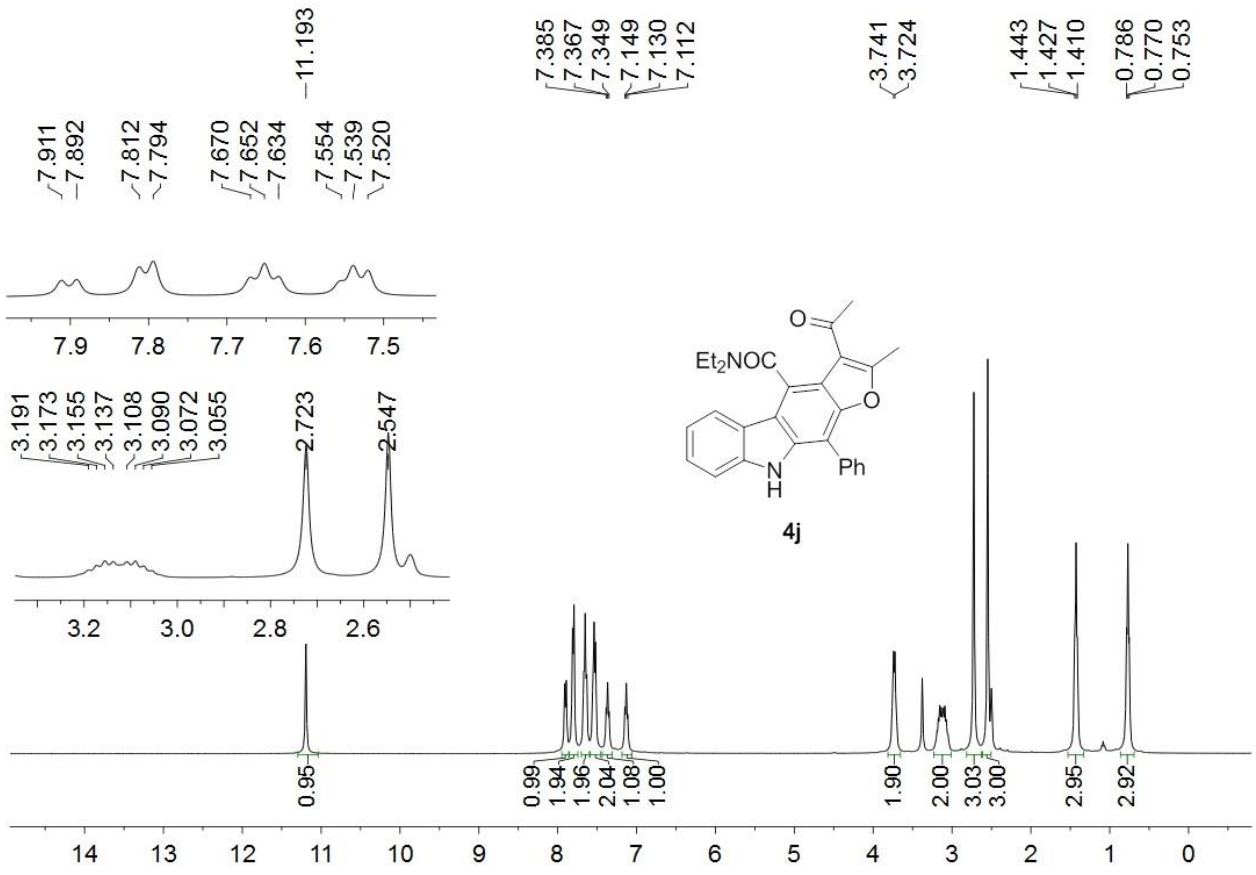
^{1}H NMR (400 MHz, $CDCl_3$) for **4i**



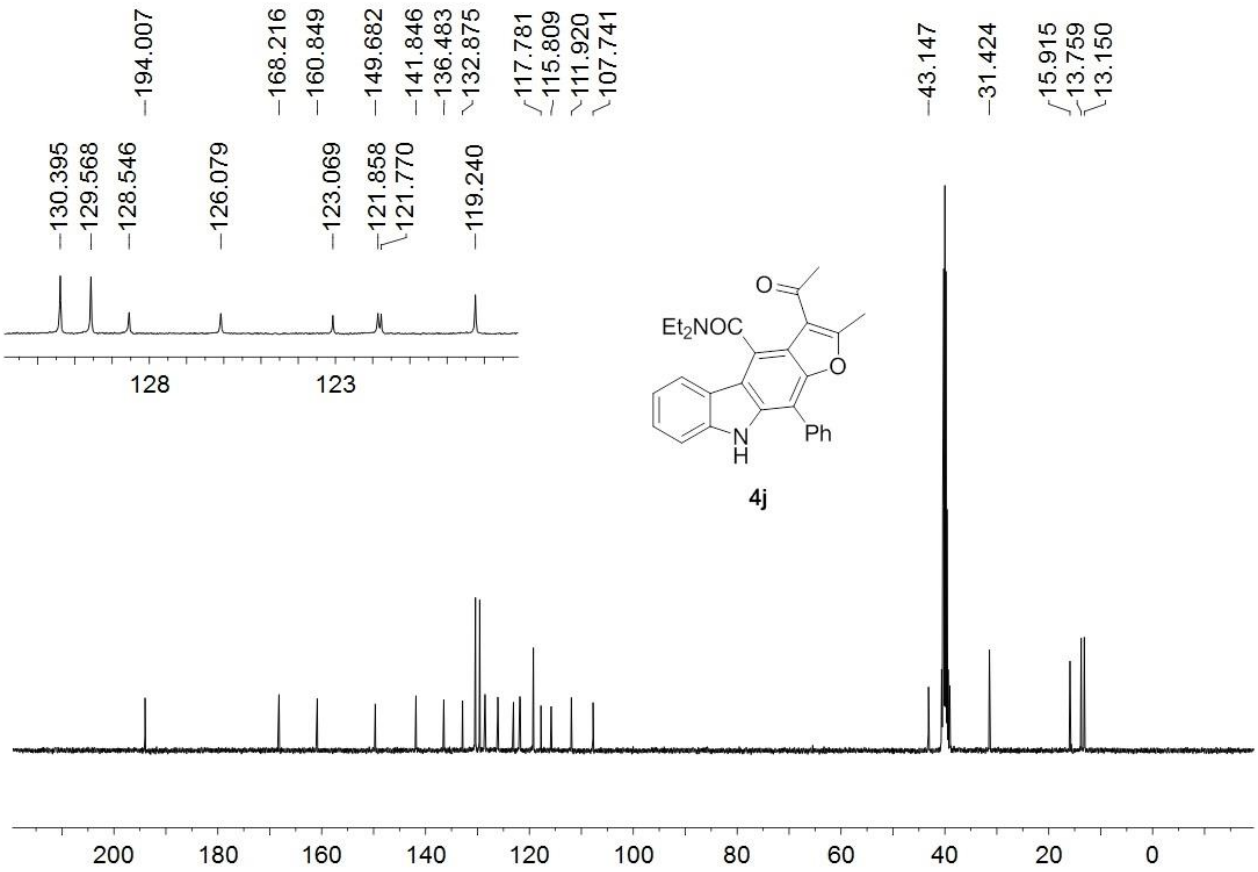
^{13}C NMR (100 MHz, $CDCl_3$) for **4i**



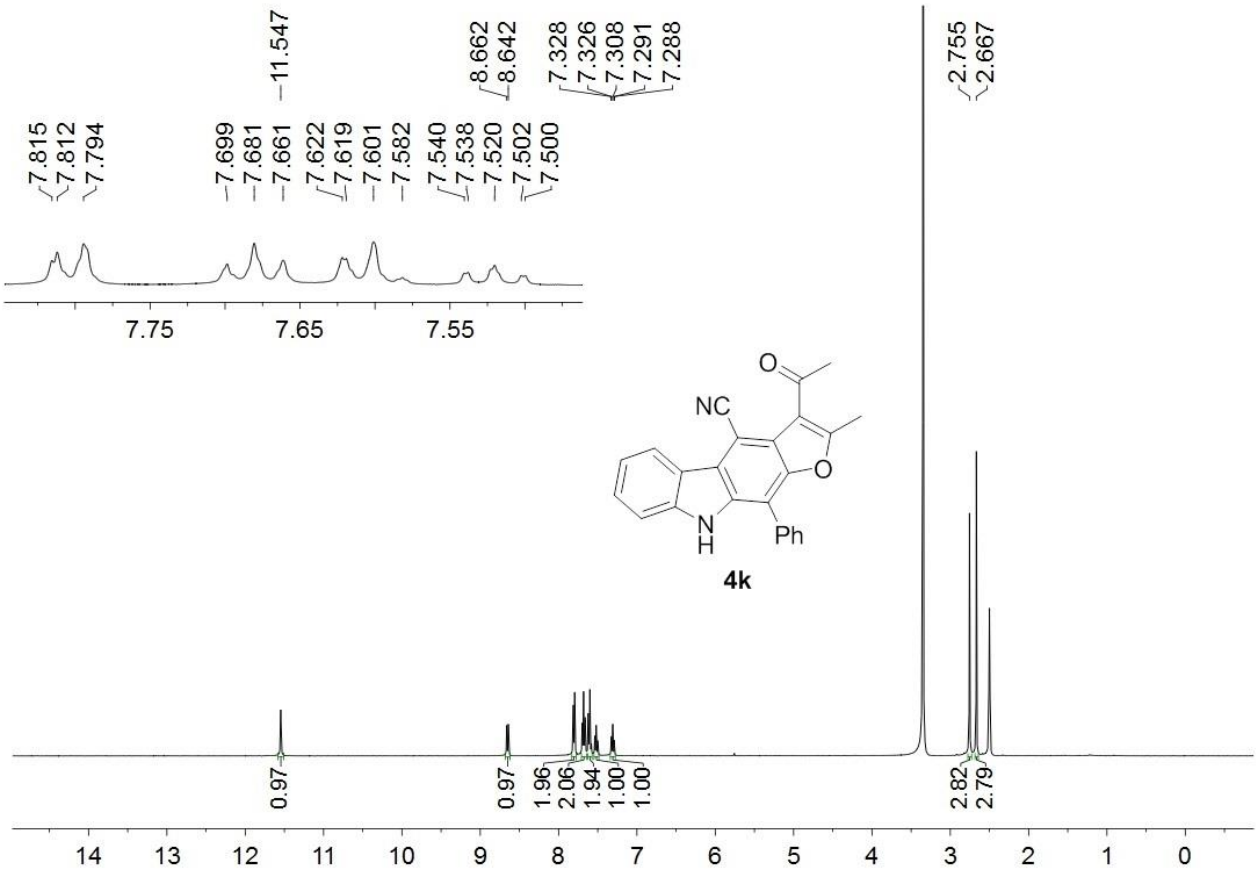
^{1}H NMR (400 MHz, DMSO-d_6) for **4j**



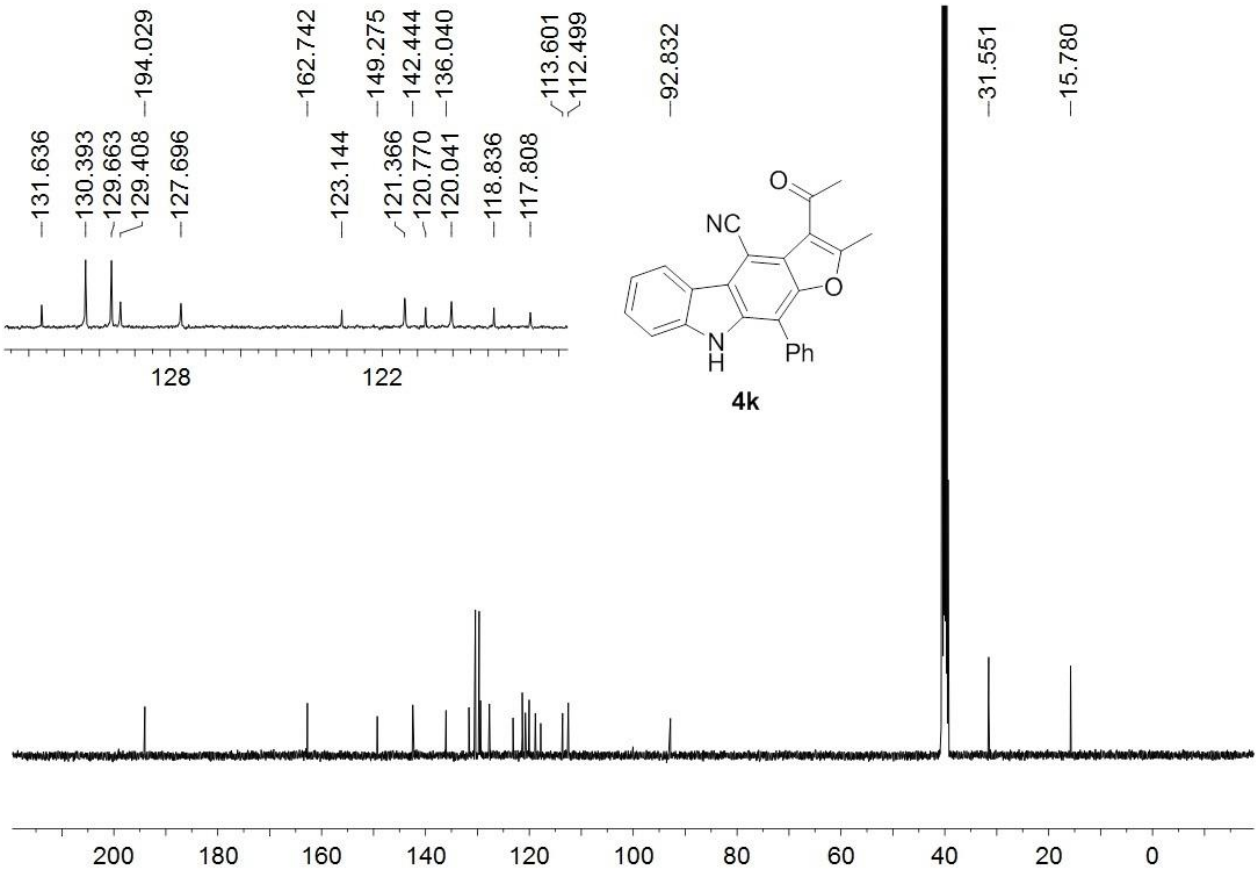
^{13}C NMR (100 MHz, DMSO-d_6) for **4j**



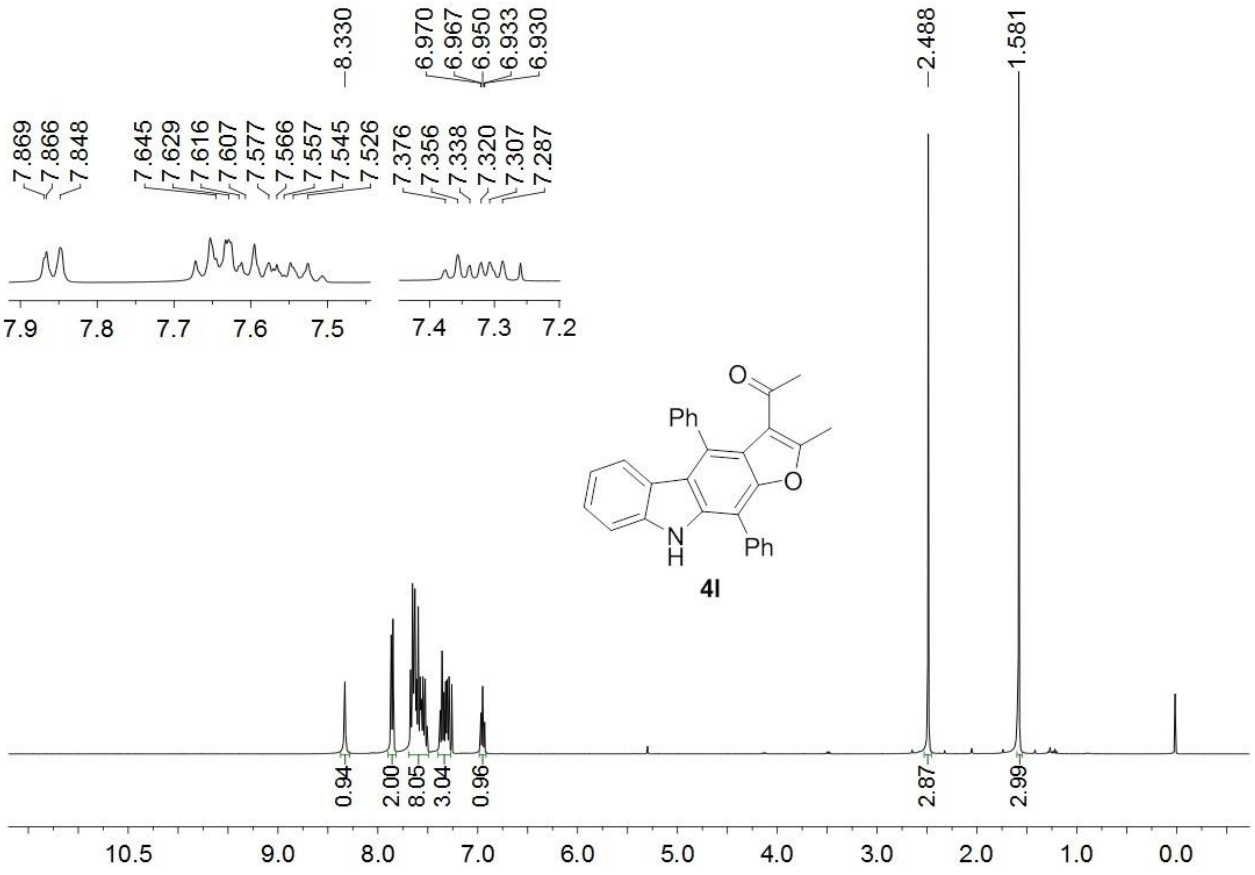
^{1}H NMR (400 MHz, DMSO-d_6) for **4k**



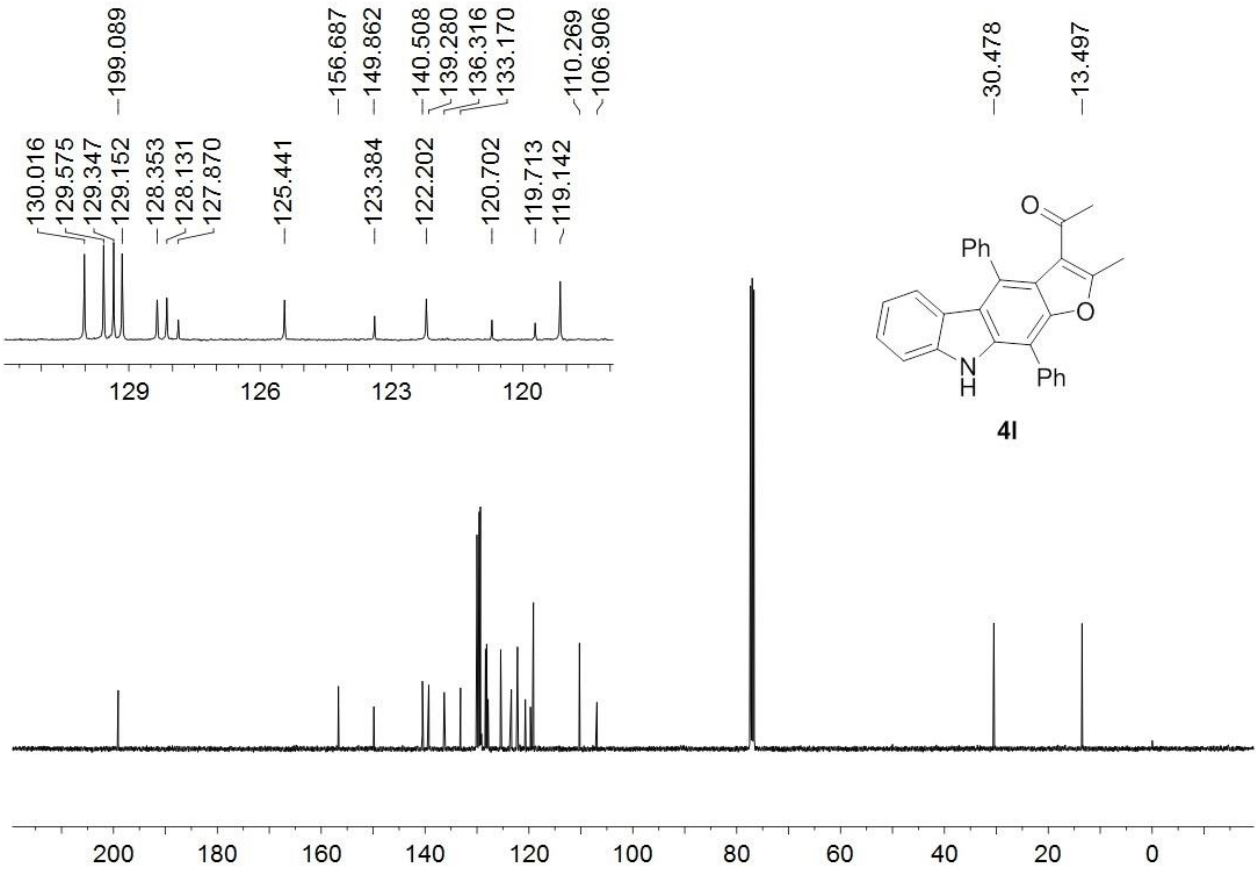
^{13}C NMR (100 MHz, DMSO-d_6) for **4k**



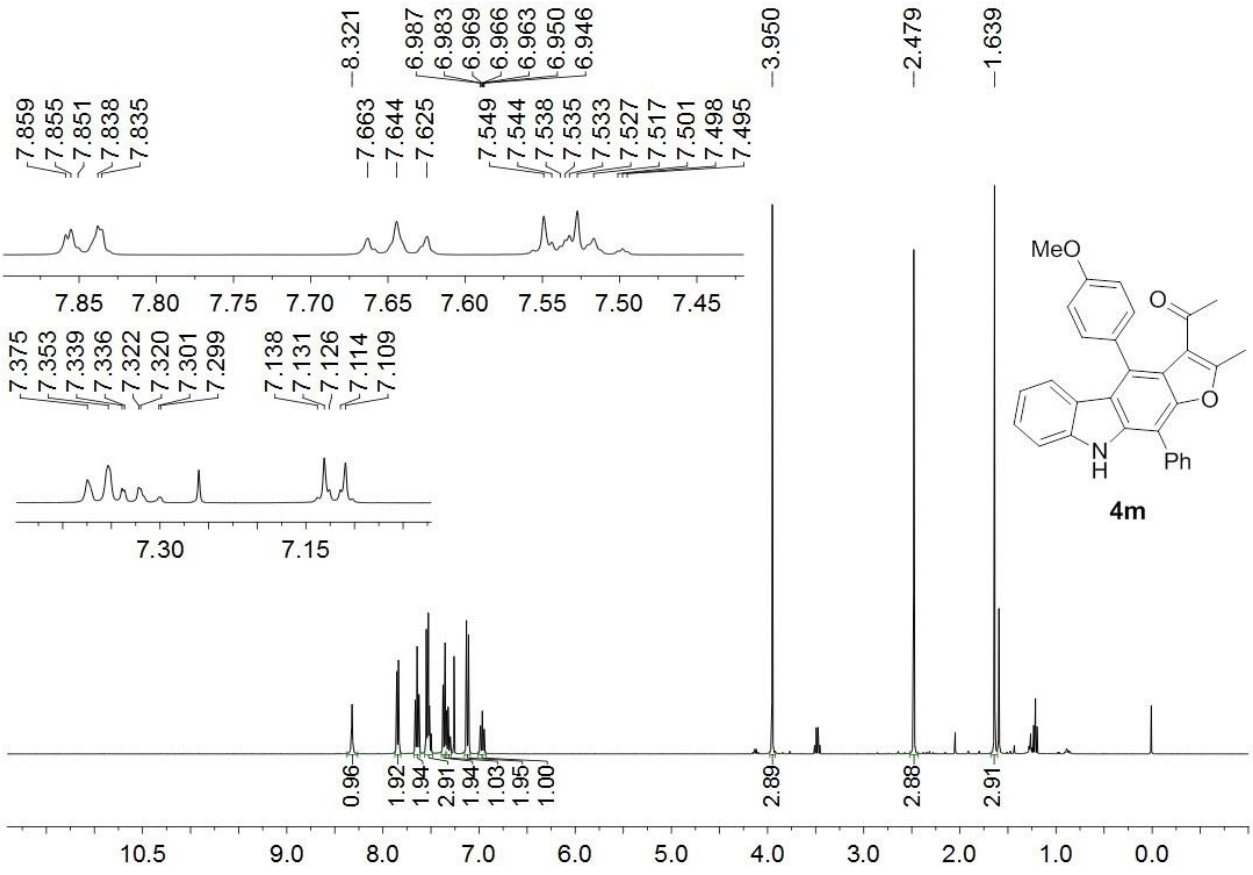
^{1}H NMR (400 MHz, $CDCl_3$) for **4l**



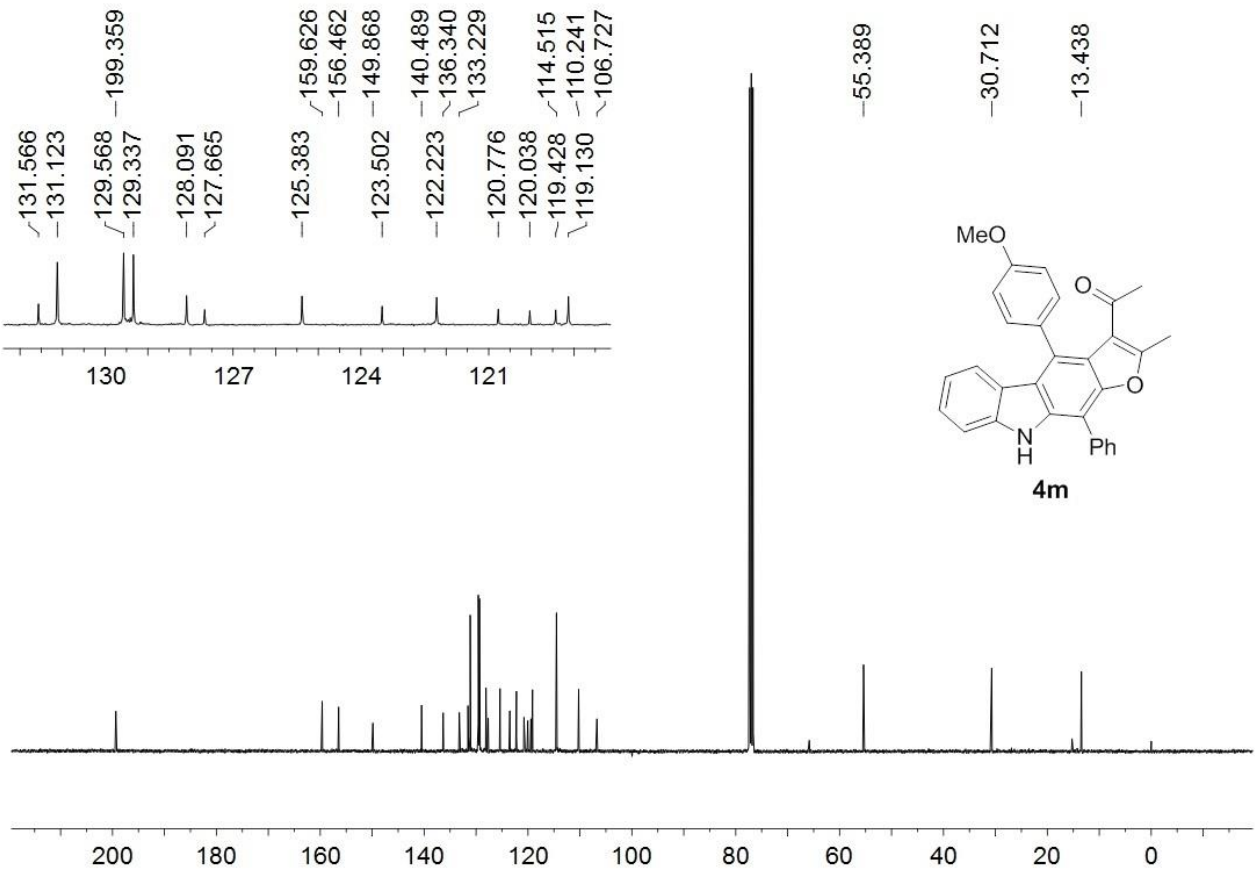
^{13}C NMR (100 MHz, $CDCl_3$) for **4l**



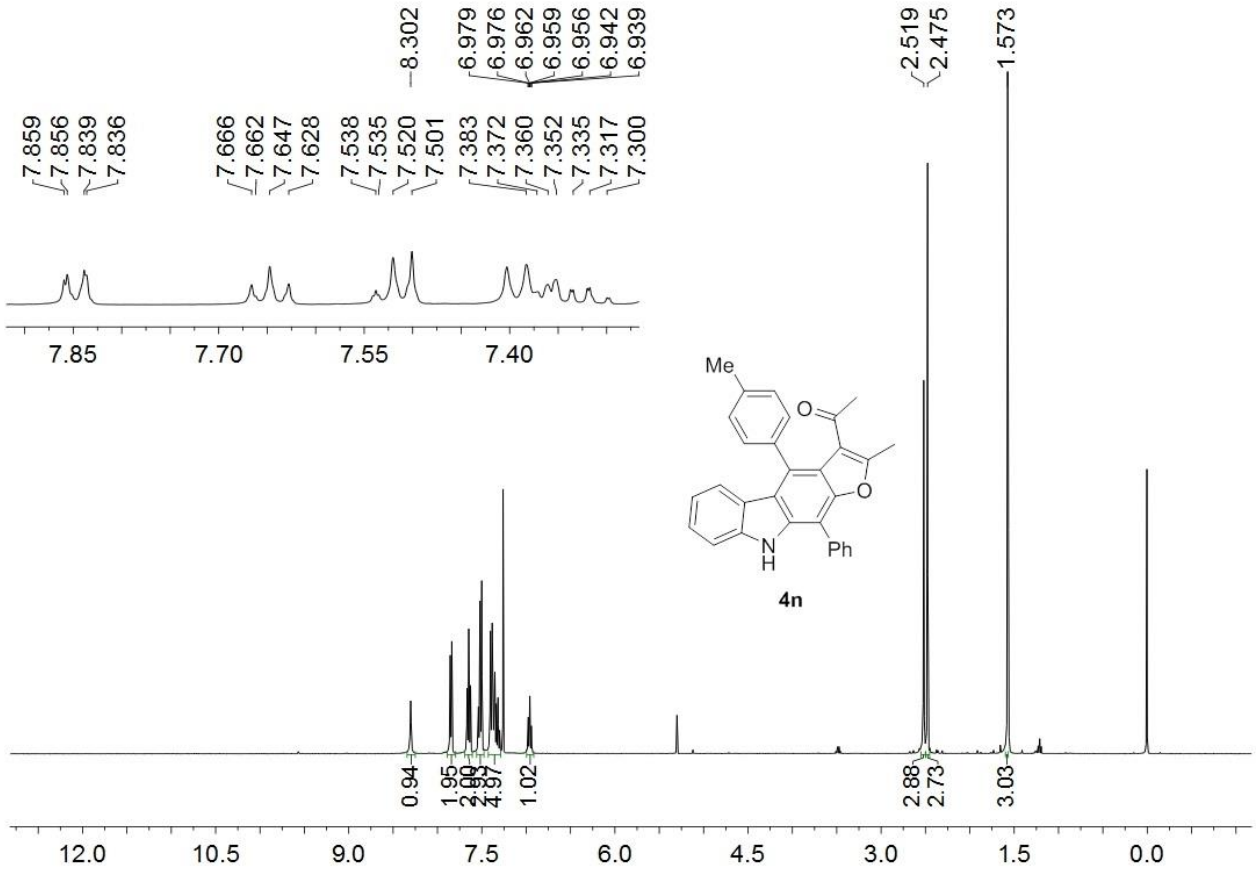
^{1}H NMR (400 MHz, $CDCl_3$) for **4m**



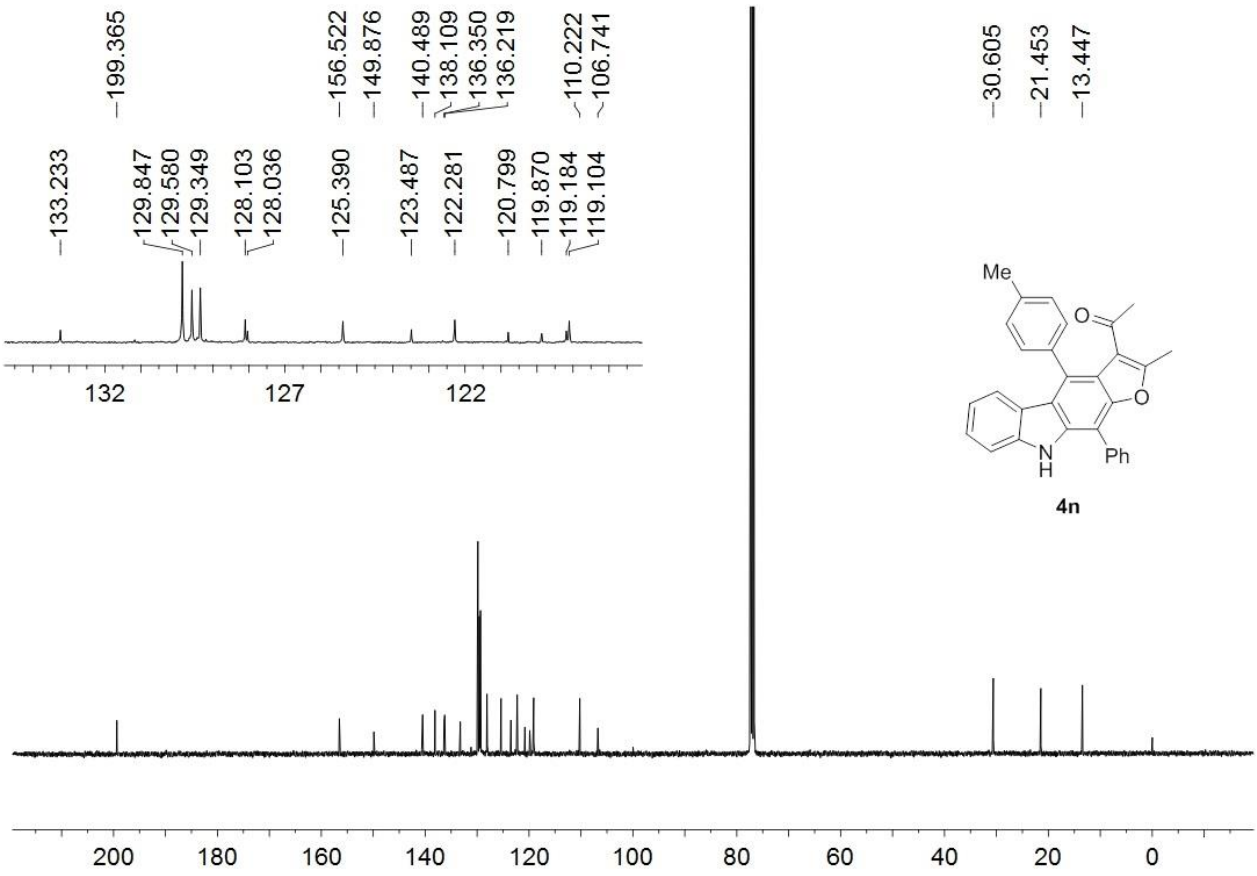
^{13}C NMR (100 MHz, $CDCl_3$) for **4m**



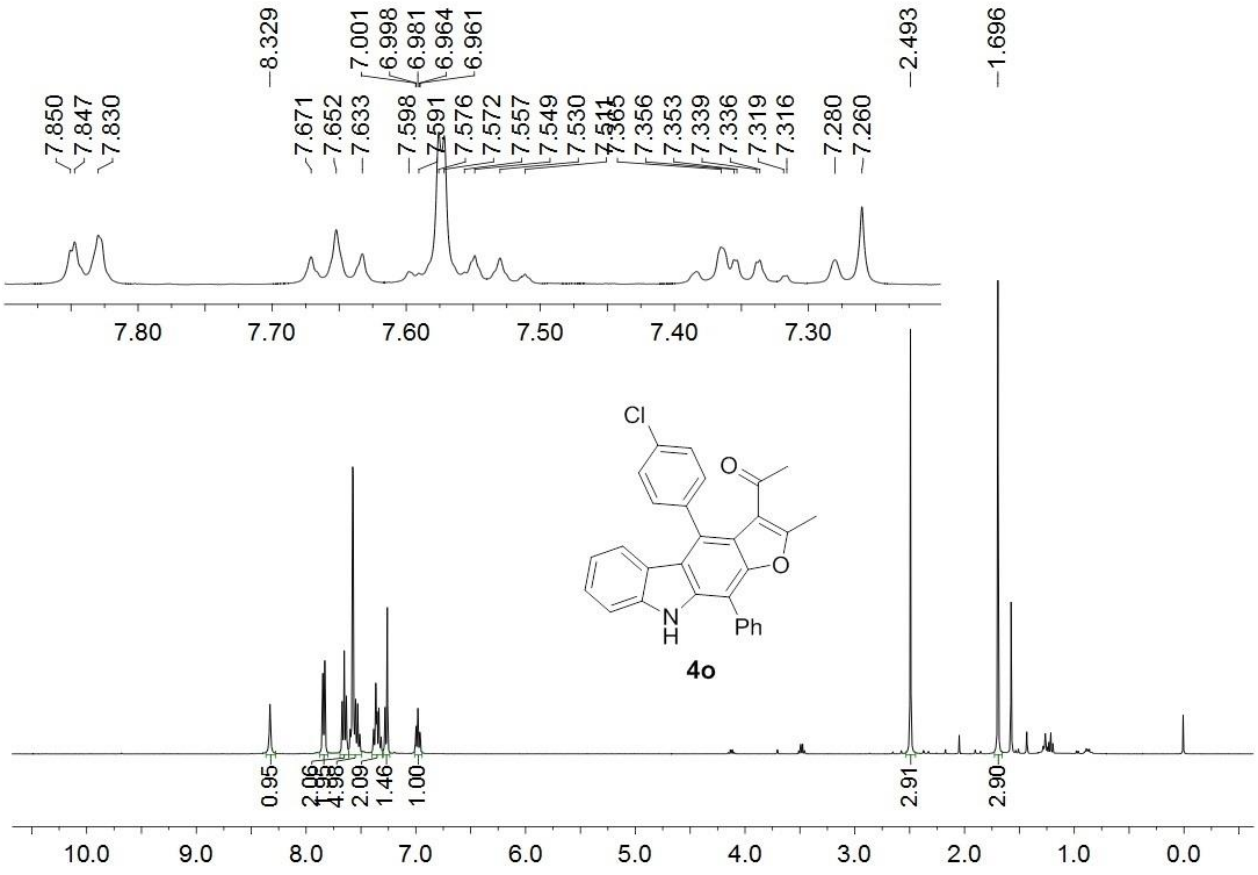
^{1}H NMR (400 MHz, $CDCl_3$) for **4n**



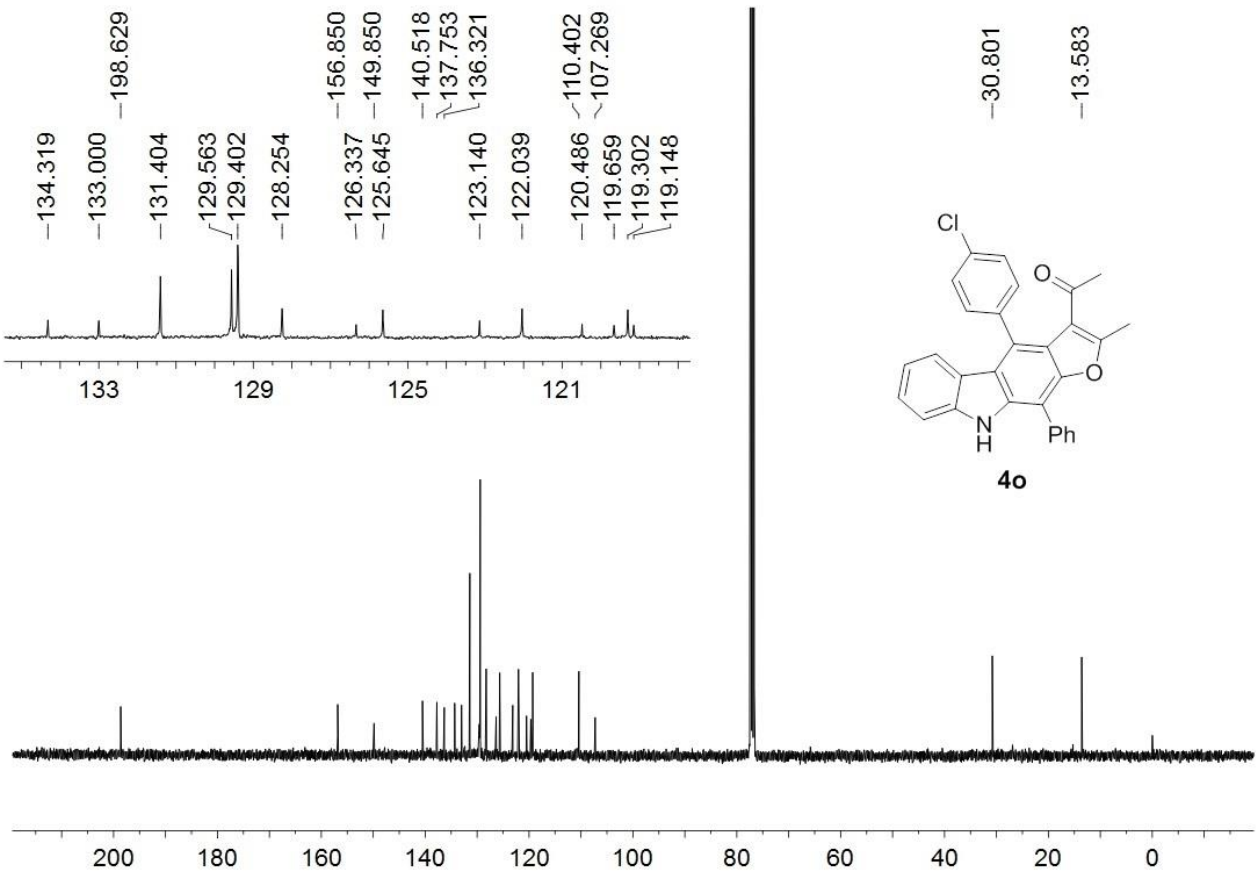
^{13}C NMR (100 MHz, $CDCl_3$) for **4n**



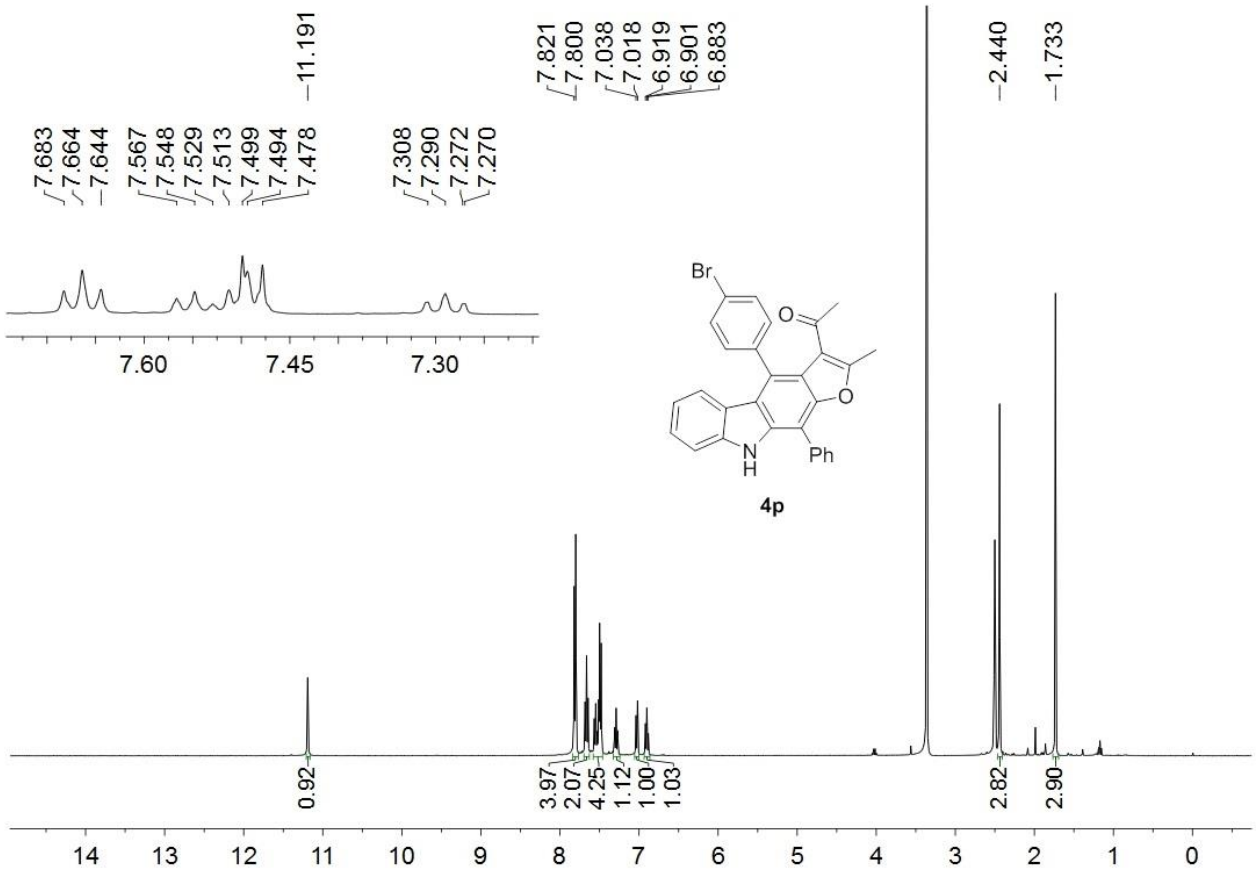
^{1}H NMR (400 MHz, $CDCl_3$) for **4o**



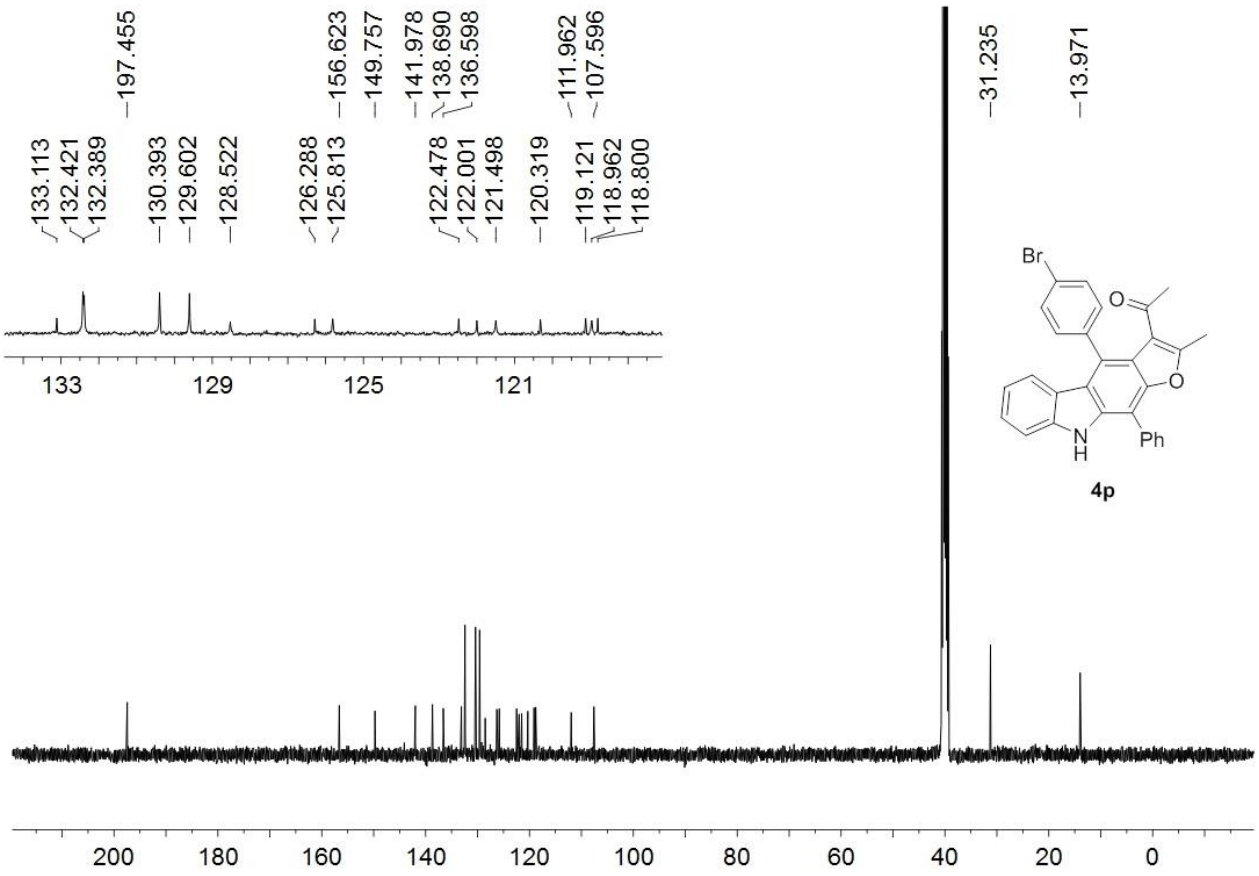
^{13}C NMR (100 MHz, $CDCl_3$) for **4o**



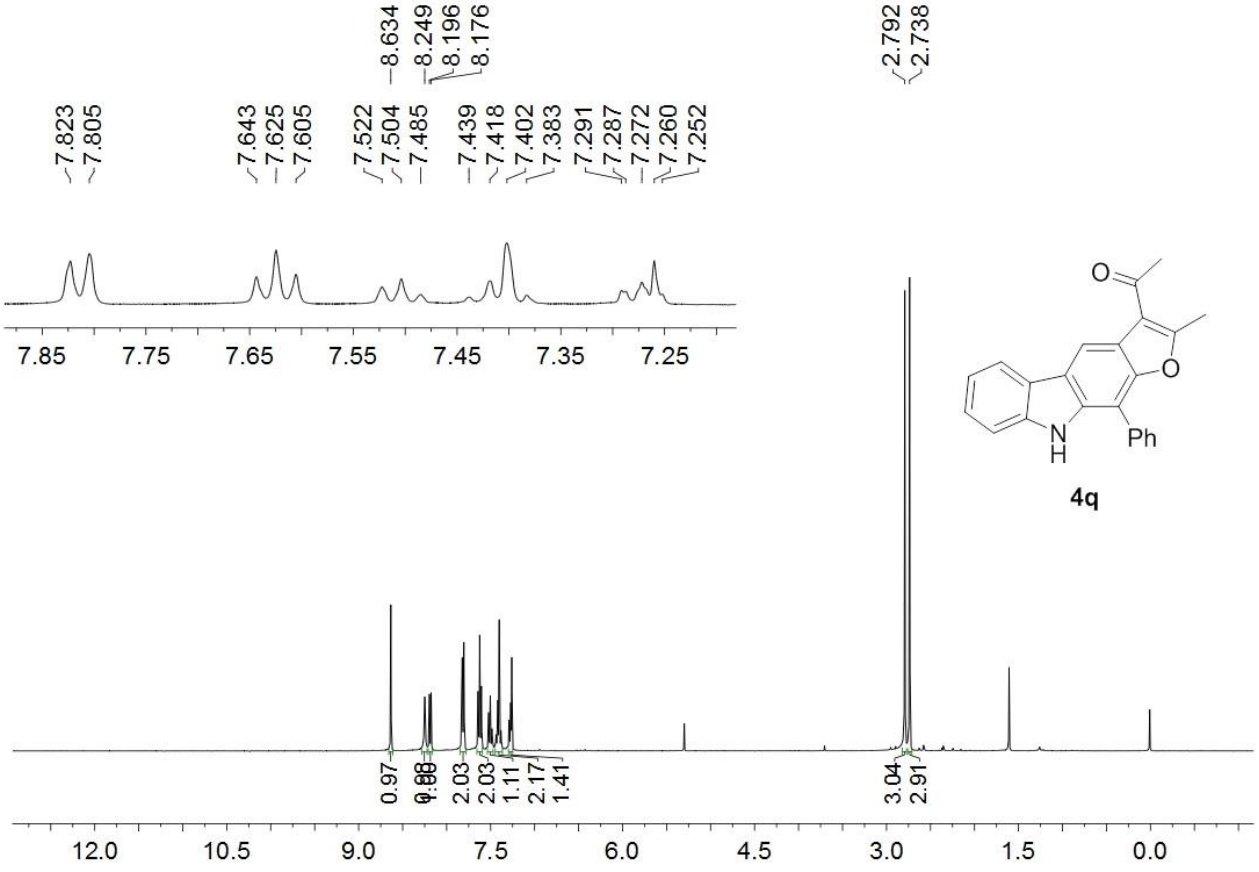
^{1}H NMR (400 MHz, DMSO-d_6) for **4p**



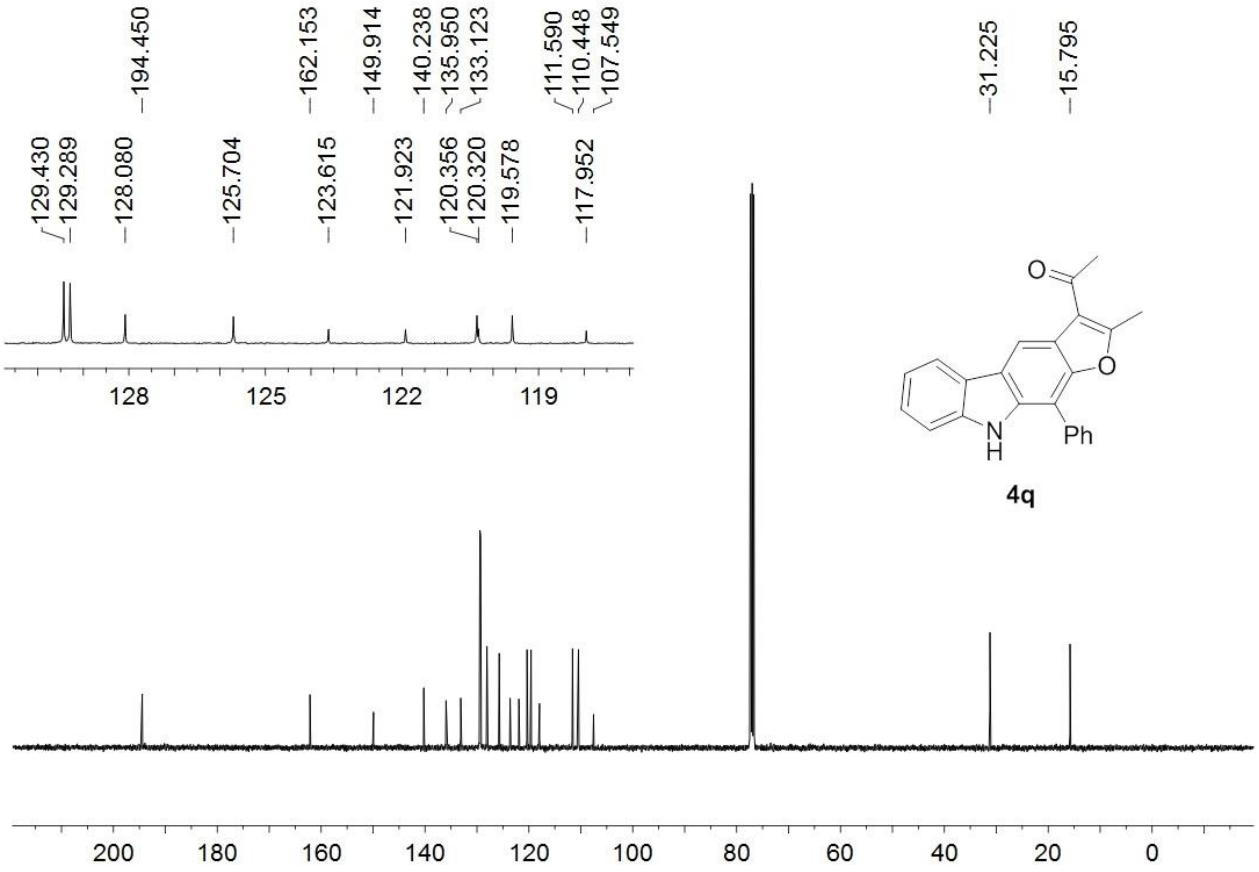
^{13}C NMR (100 MHz, DMSO-d_6) for **4p**



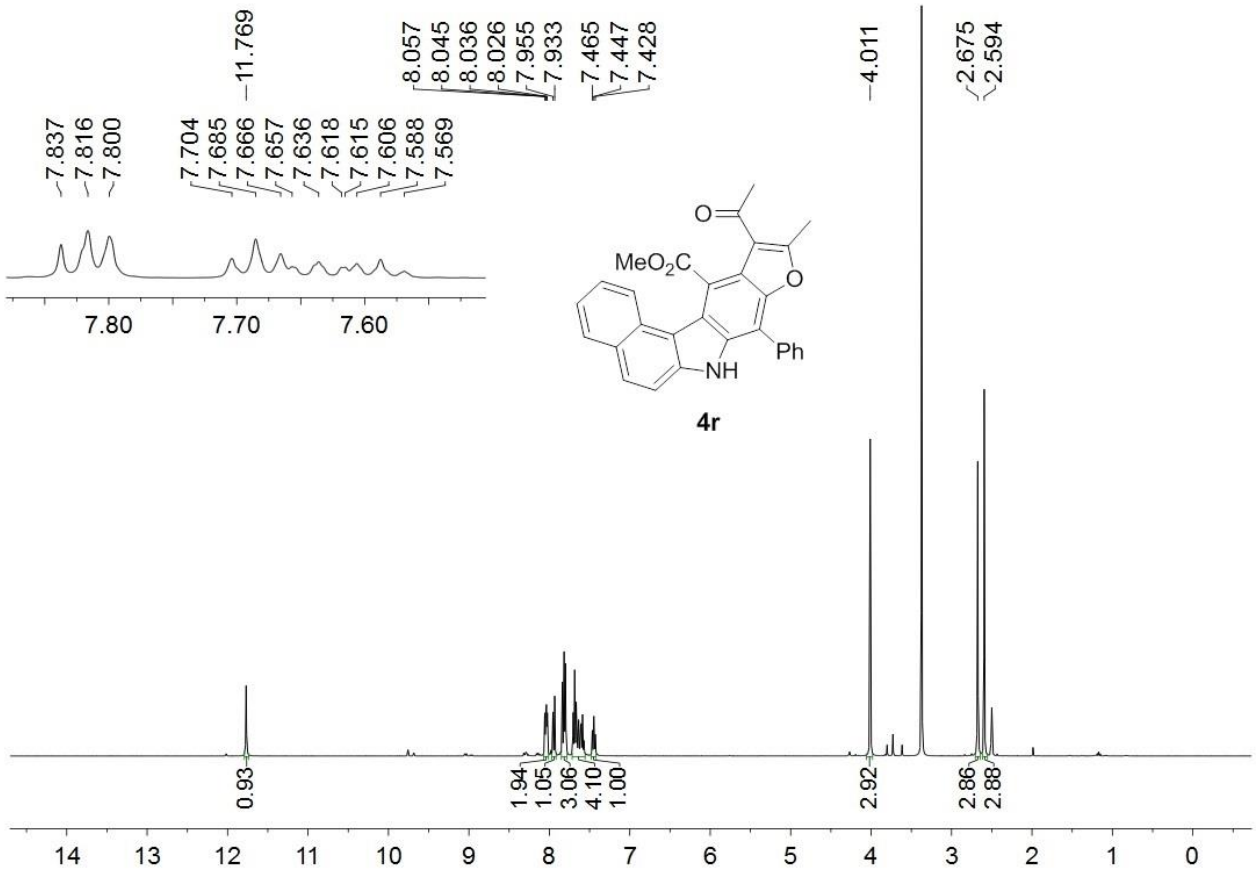
^{1}H NMR (400 MHz, $CDCl_3$) for **4q**



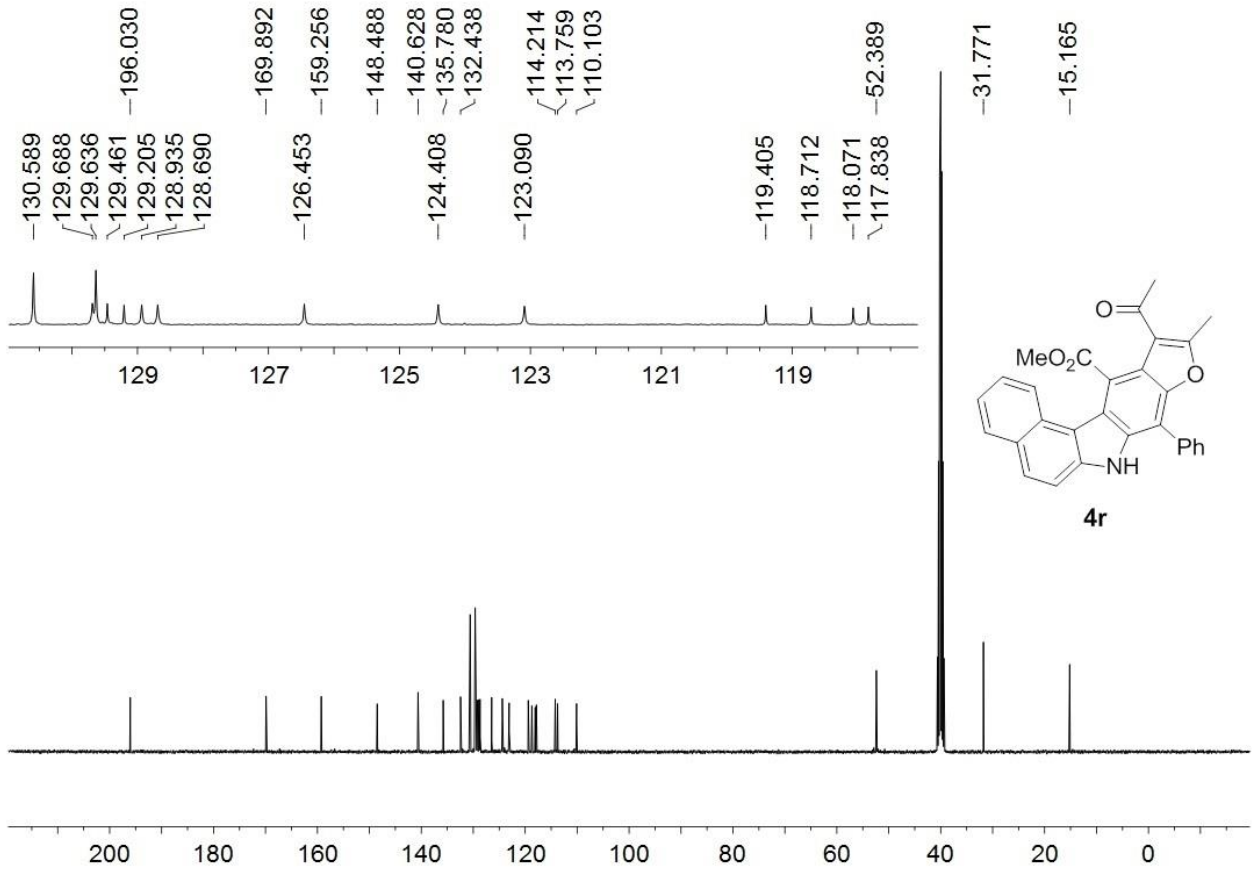
^{13}C NMR (100 MHz, $CDCl_3$) for **4q**



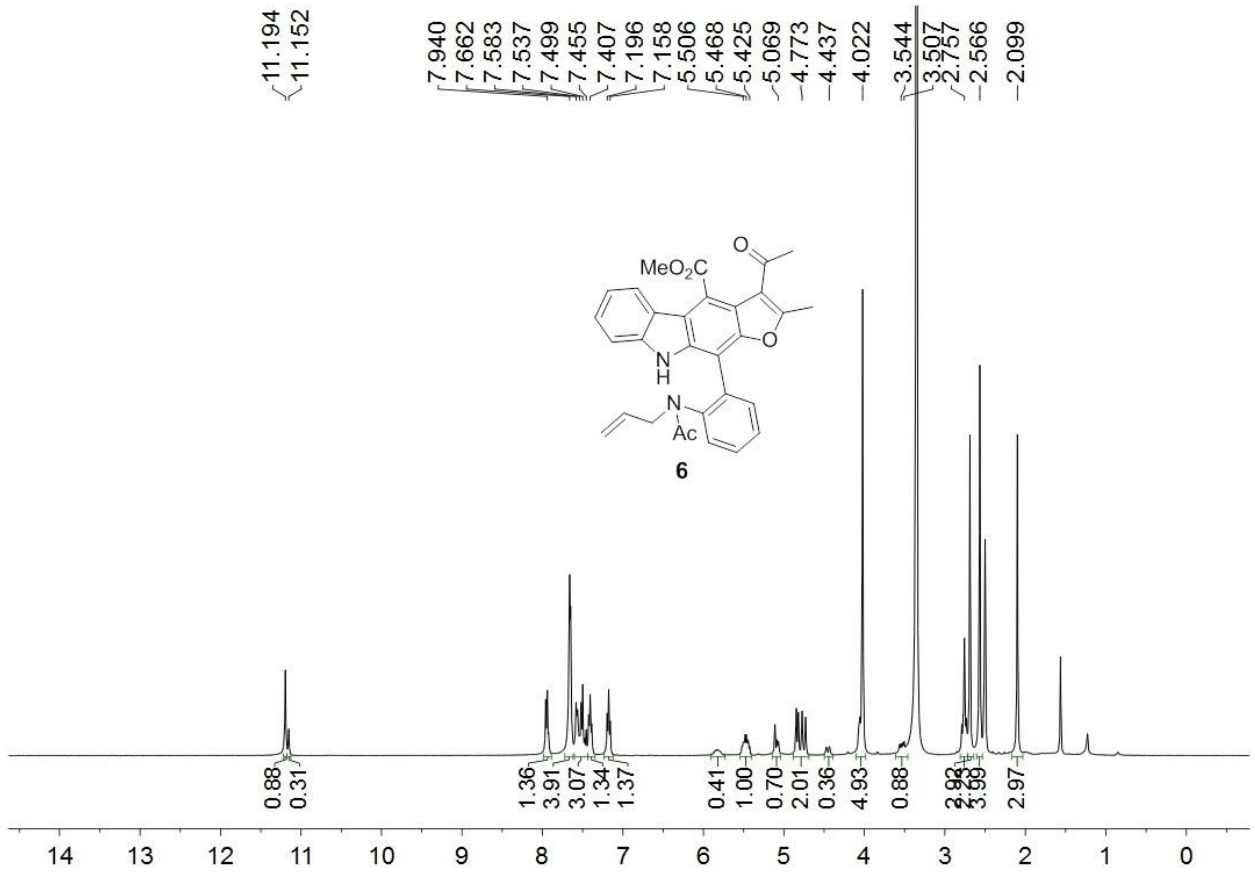
^{1}H NMR (400 MHz, DMSO-d_6) for **4r**



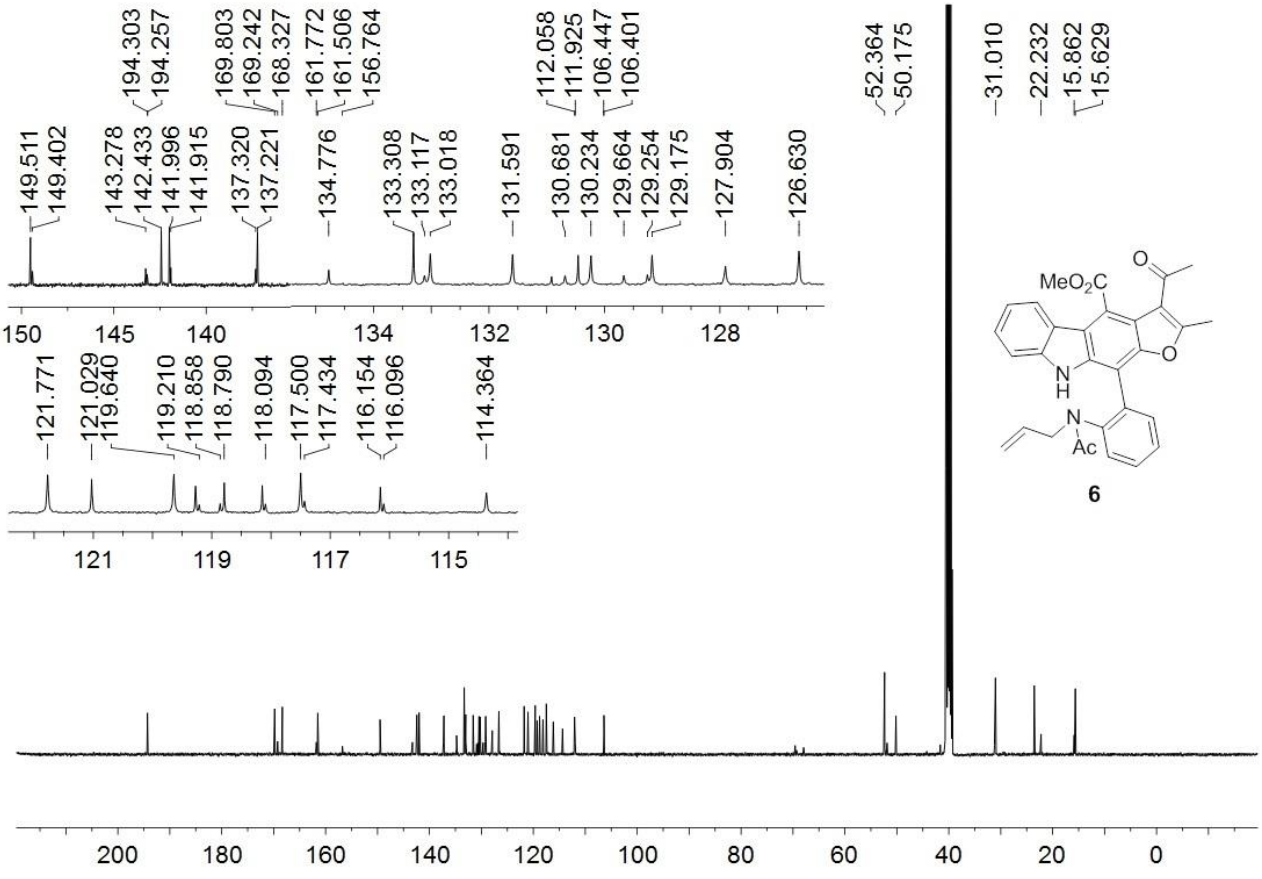
^{13}C NMR (100 MHz, DMSO-d_6) for **4r**



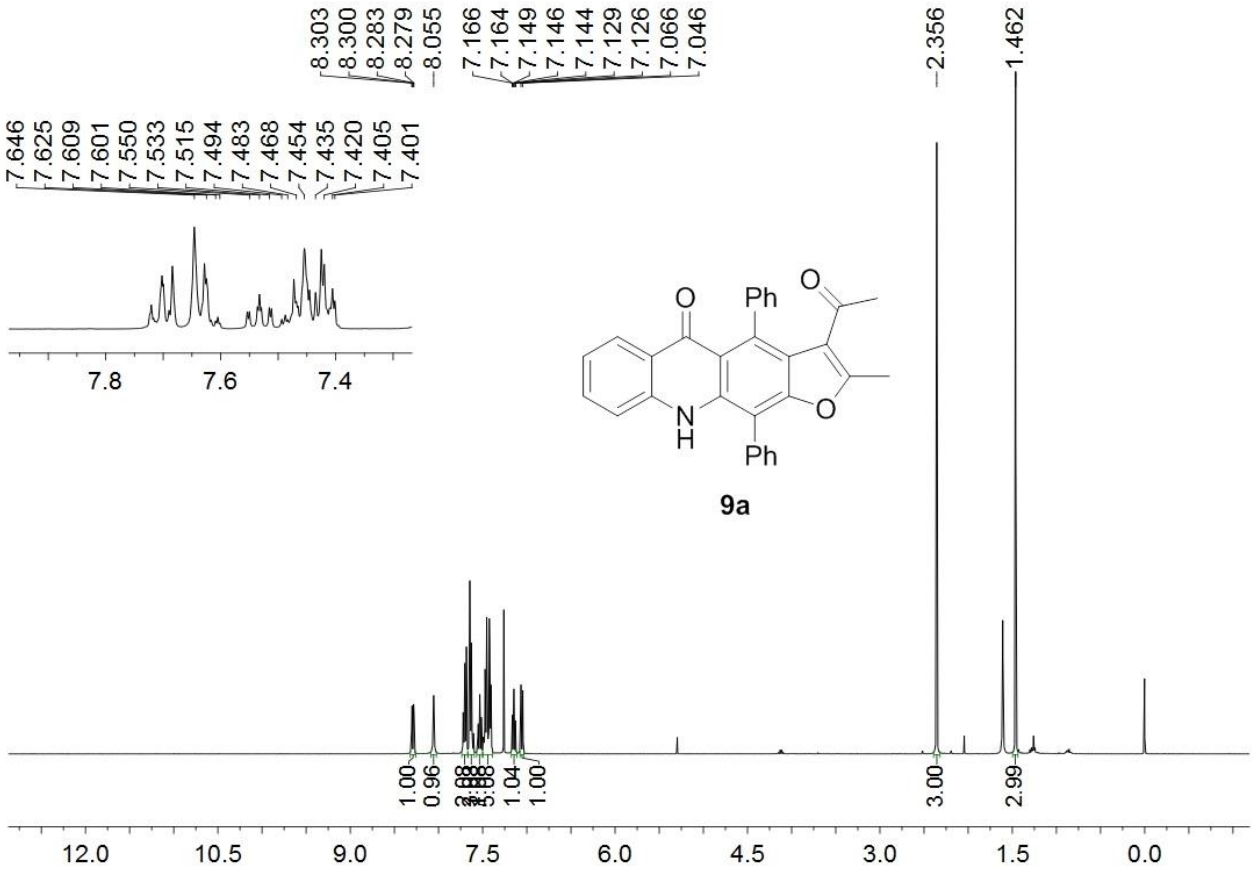
^{1}H NMR (400 MHz, DMSO-d_6) for **6**



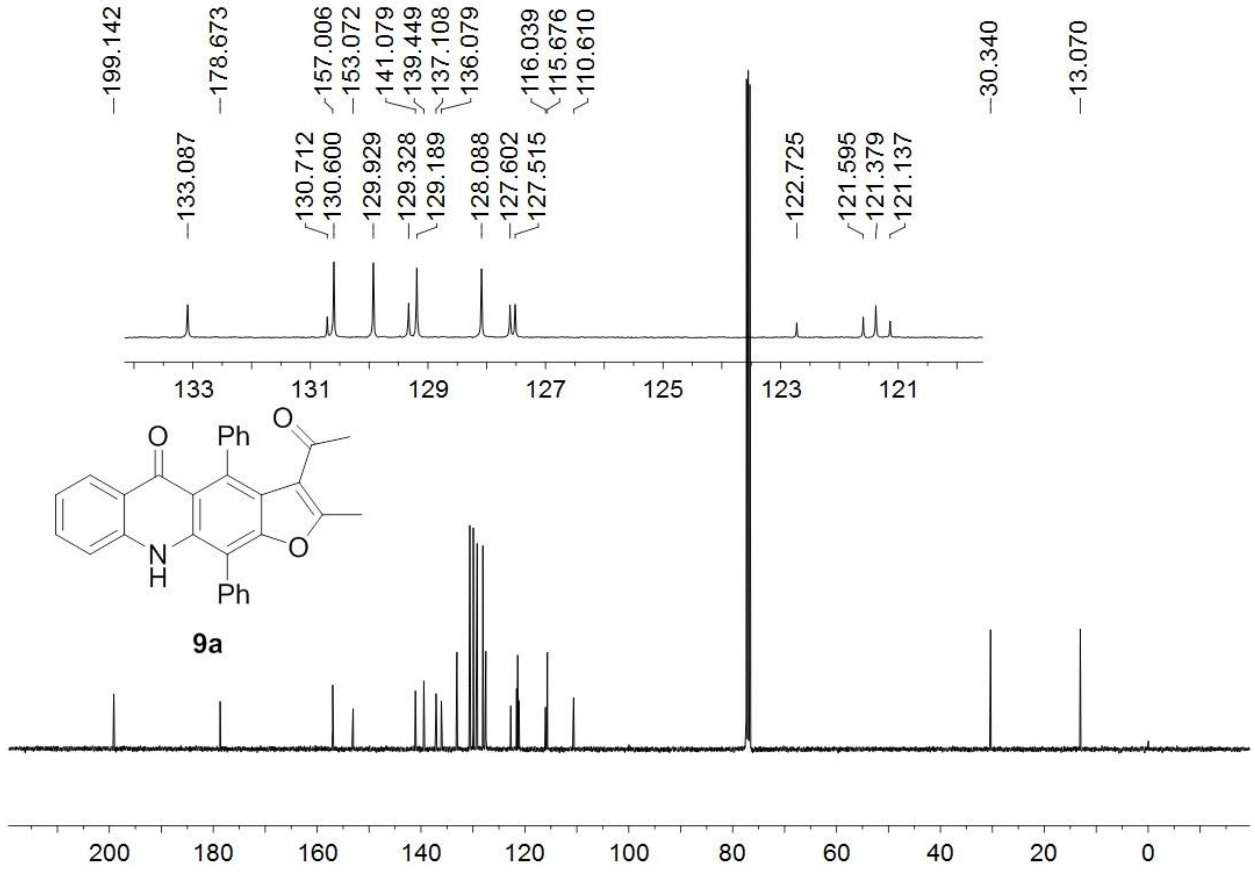
^{13}C NMR (100 MHz, DMSO-d_6) for **6**



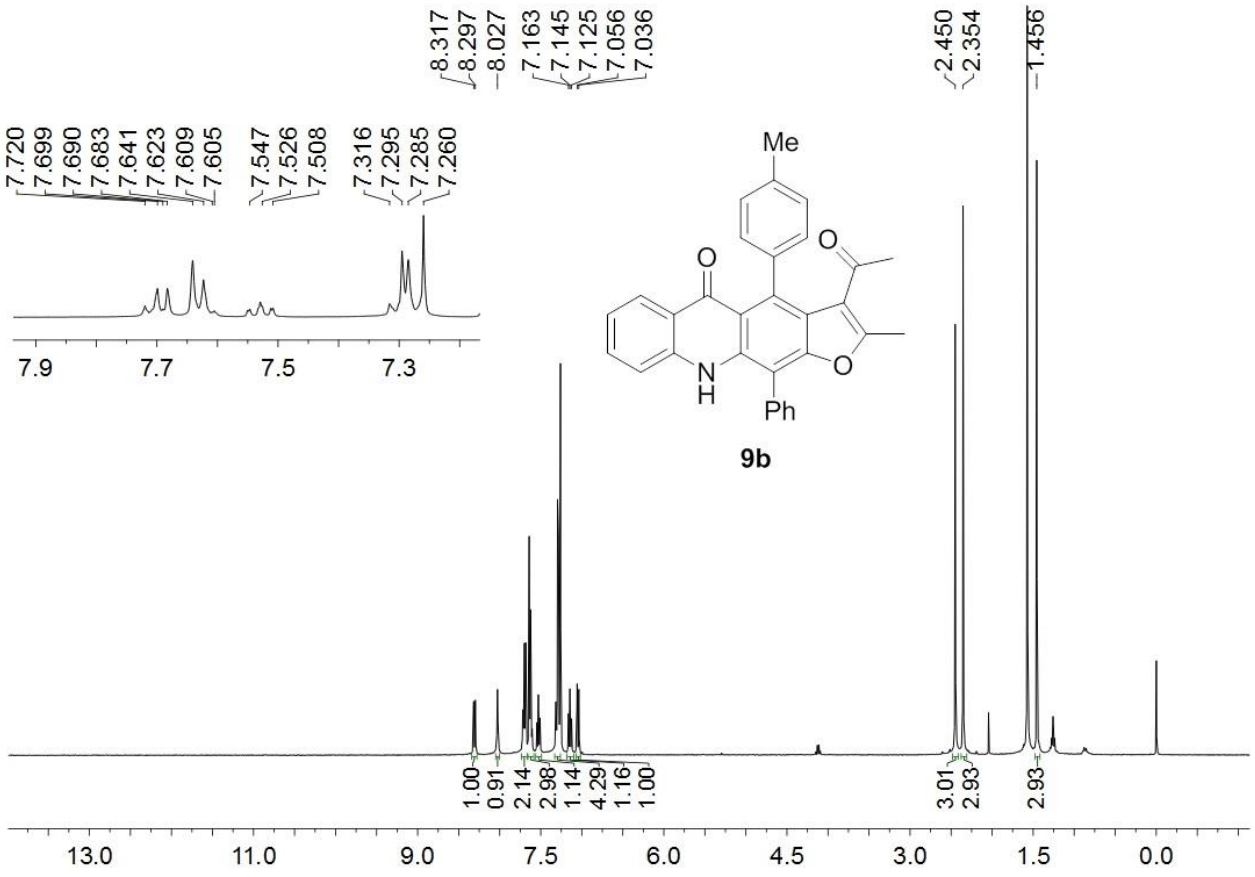
^{1}H NMR (400 MHz, $CDCl_3$) for **9a**



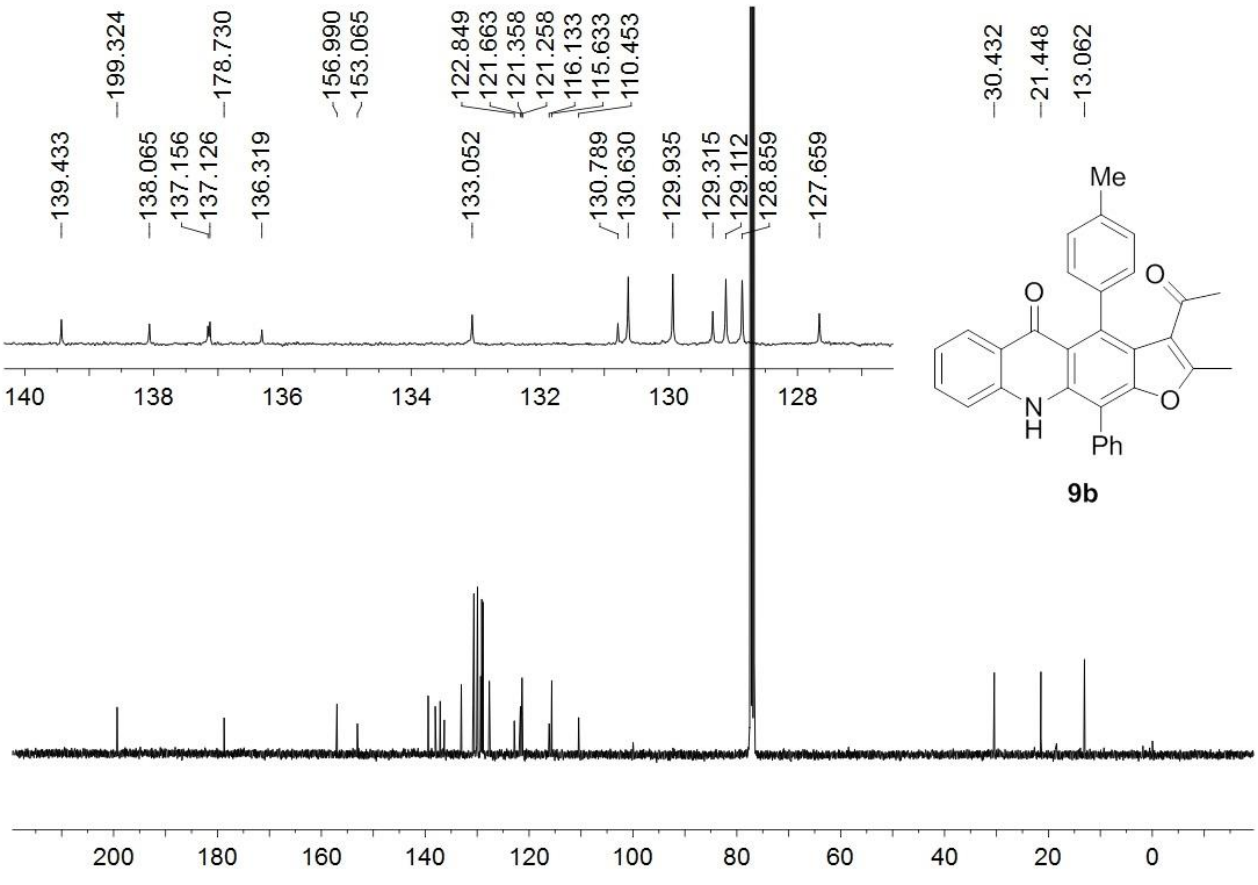
^{13}C NMR (100 MHz, $CDCl_3$) for **9a**



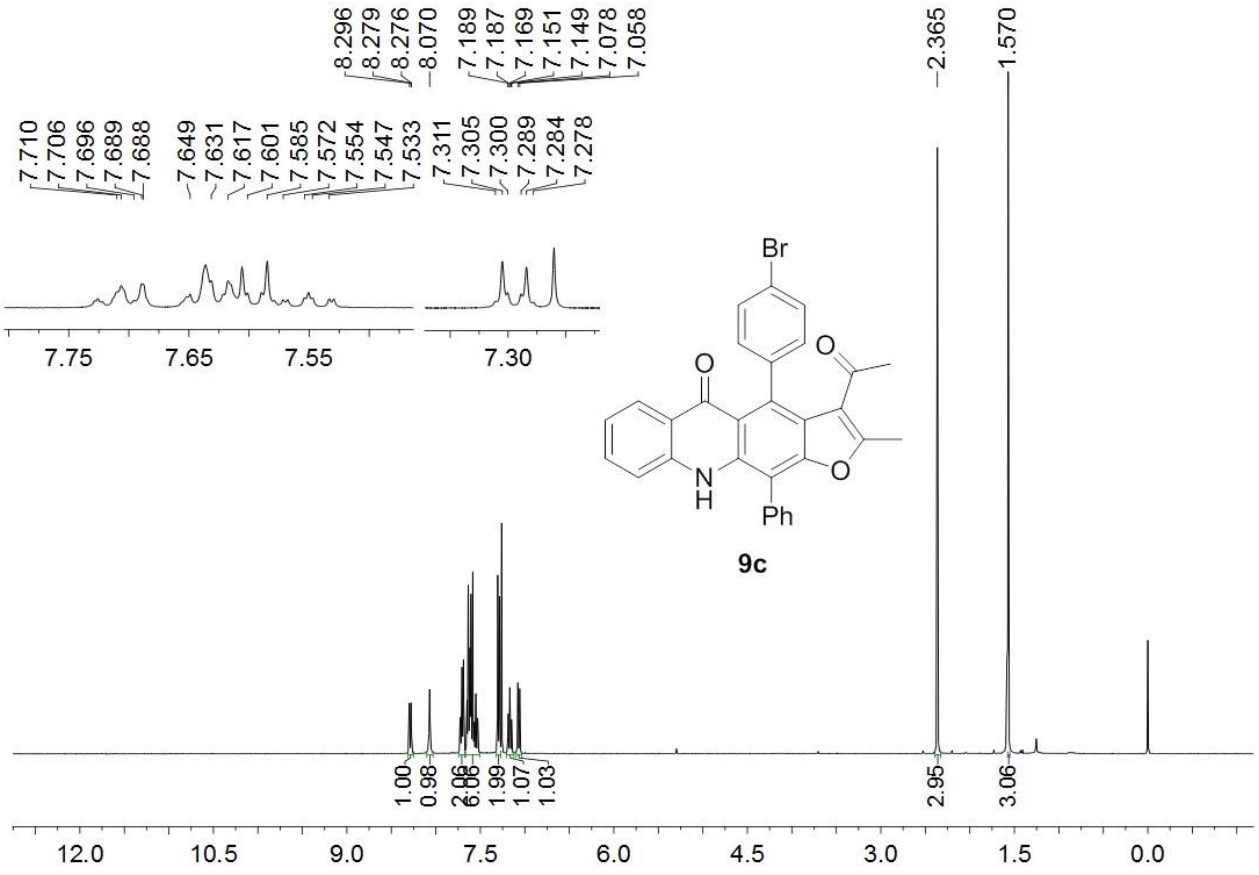
^{1}H NMR (400 MHz, $CDCl_3$) for **9b**



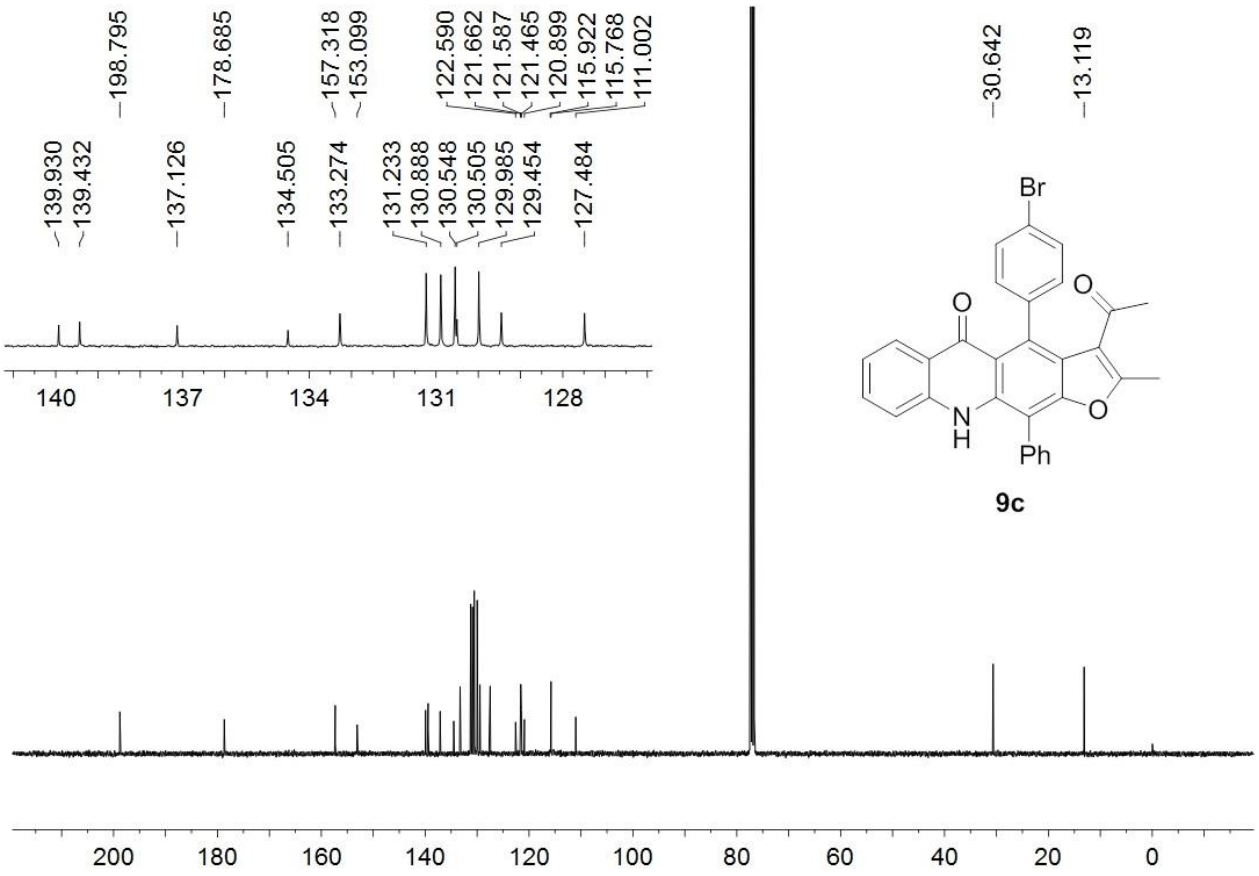
^{13}C NMR (100 MHz, $CDCl_3$) for **9b**



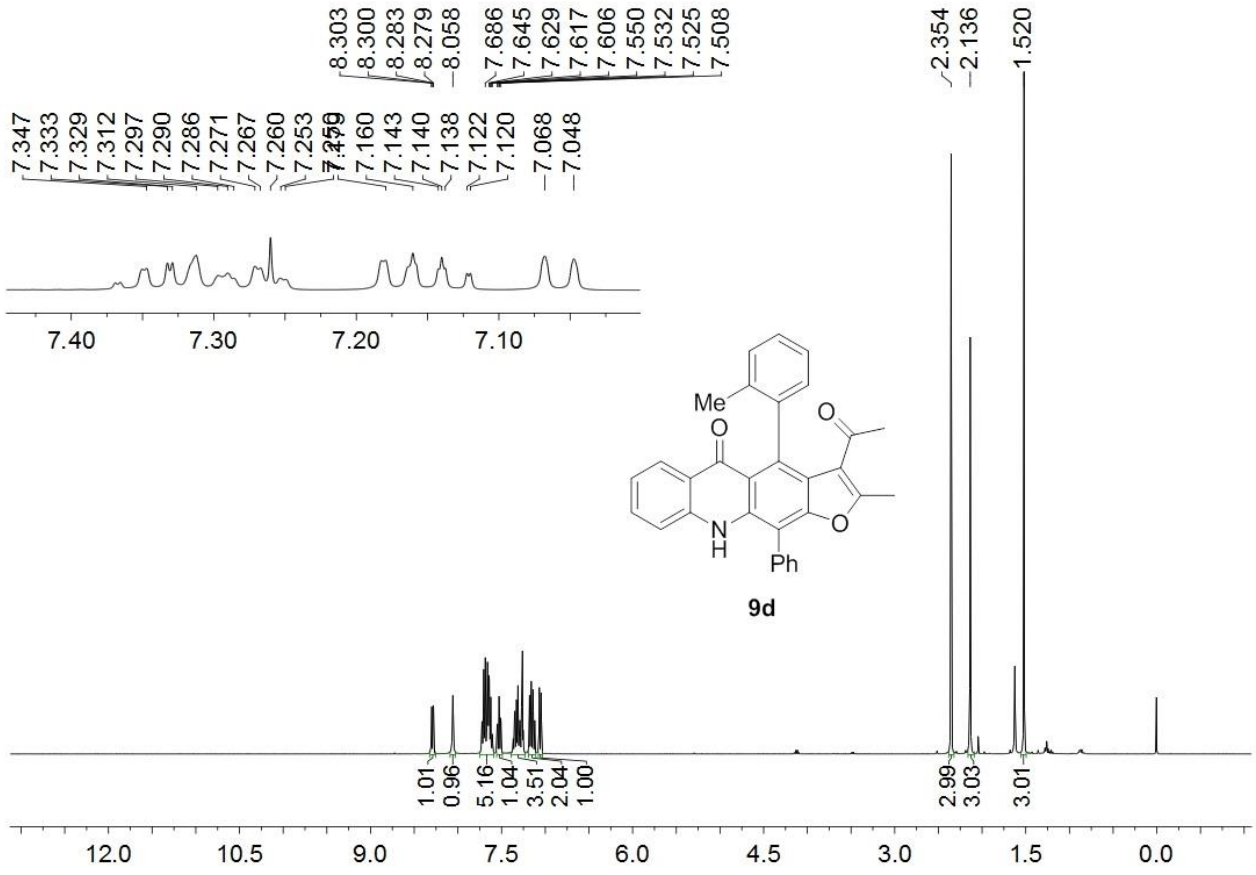
^{1}H NMR (400 MHz, $CDCl_3$) for **9c**



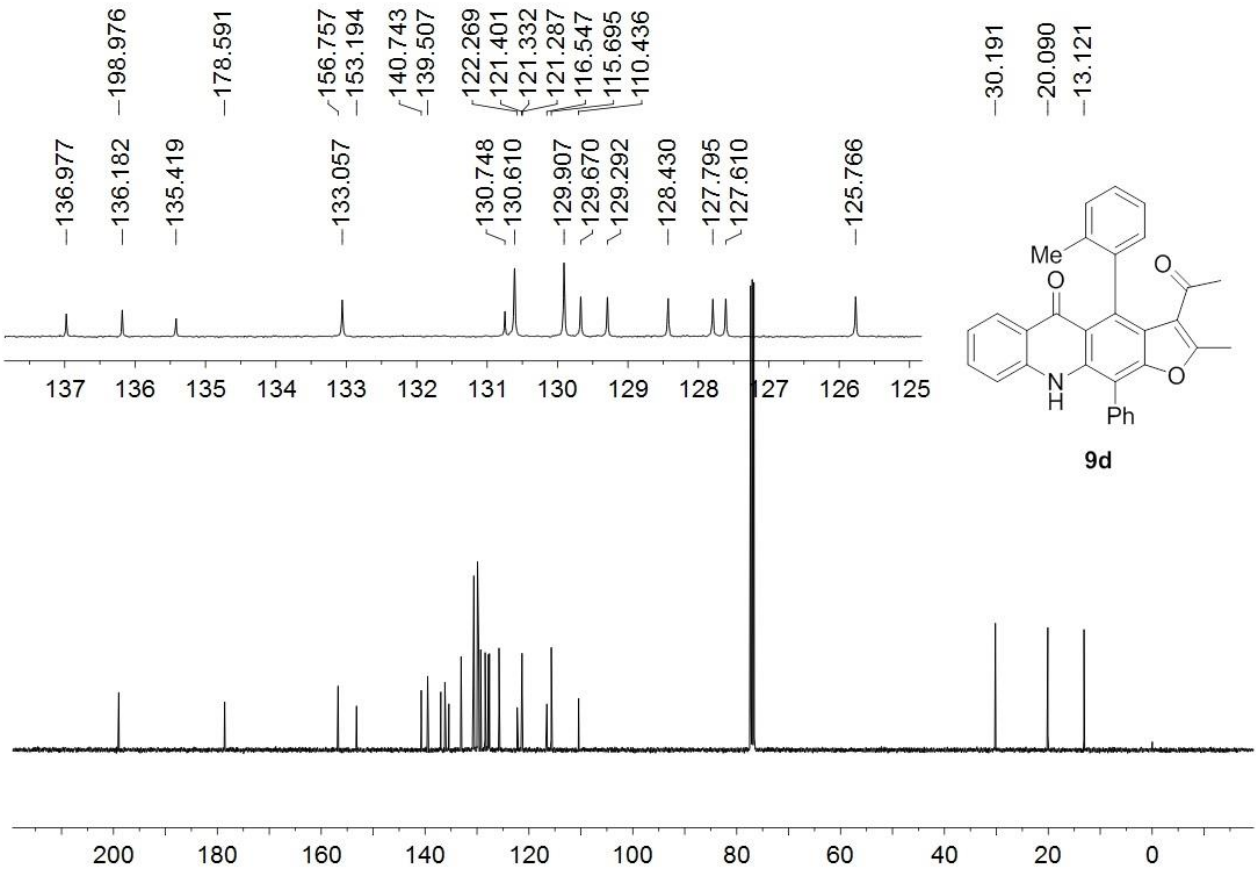
^{13}C NMR (100 MHz, $CDCl_3$) for **9c**



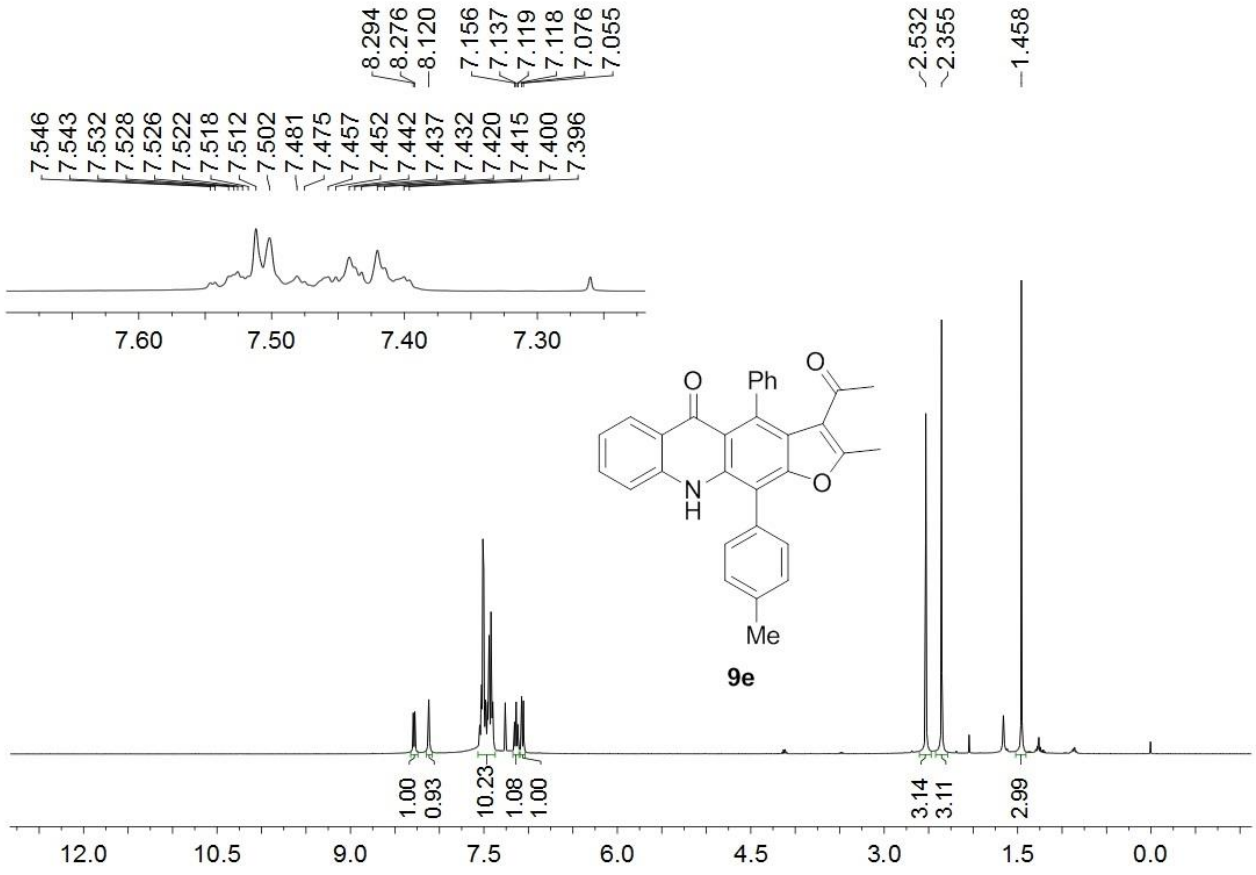
^{1}H NMR (400 MHz, $CDCl_3$) for **9d**



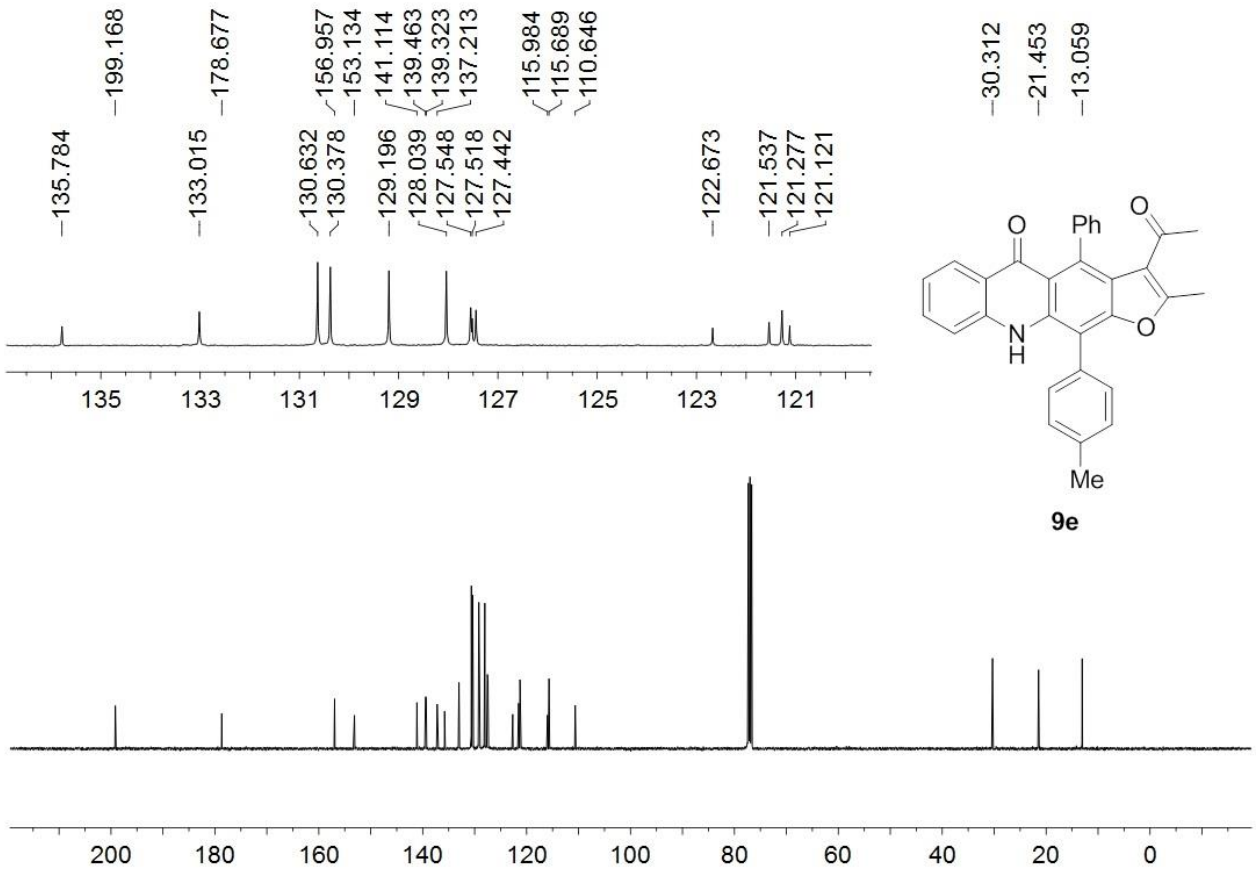
^{13}C NMR (100 MHz, $CDCl_3$) for **9d**



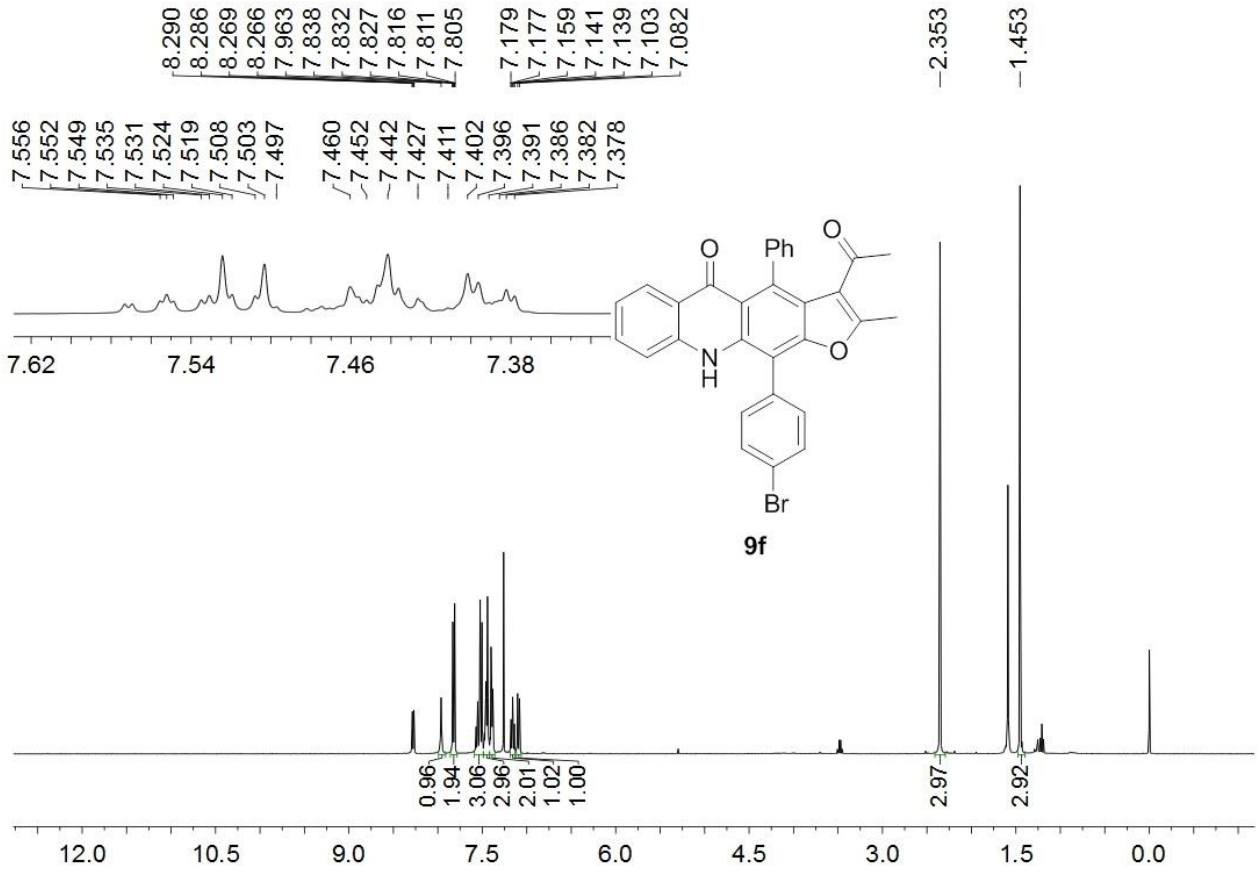
^{1}H NMR (400 MHz, $CDCl_3$) for **9e**



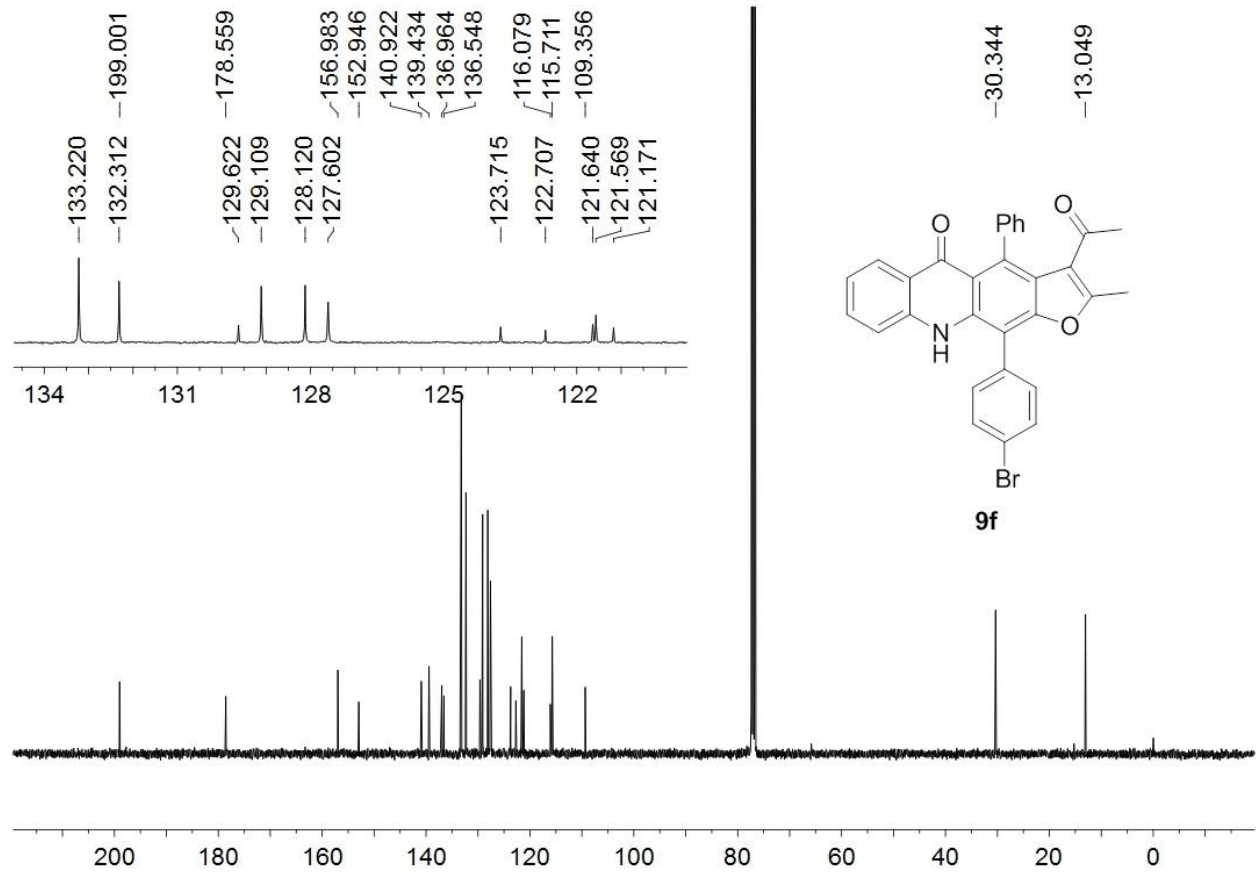
^{13}C NMR (100 MHz, $CDCl_3$) for **9e**



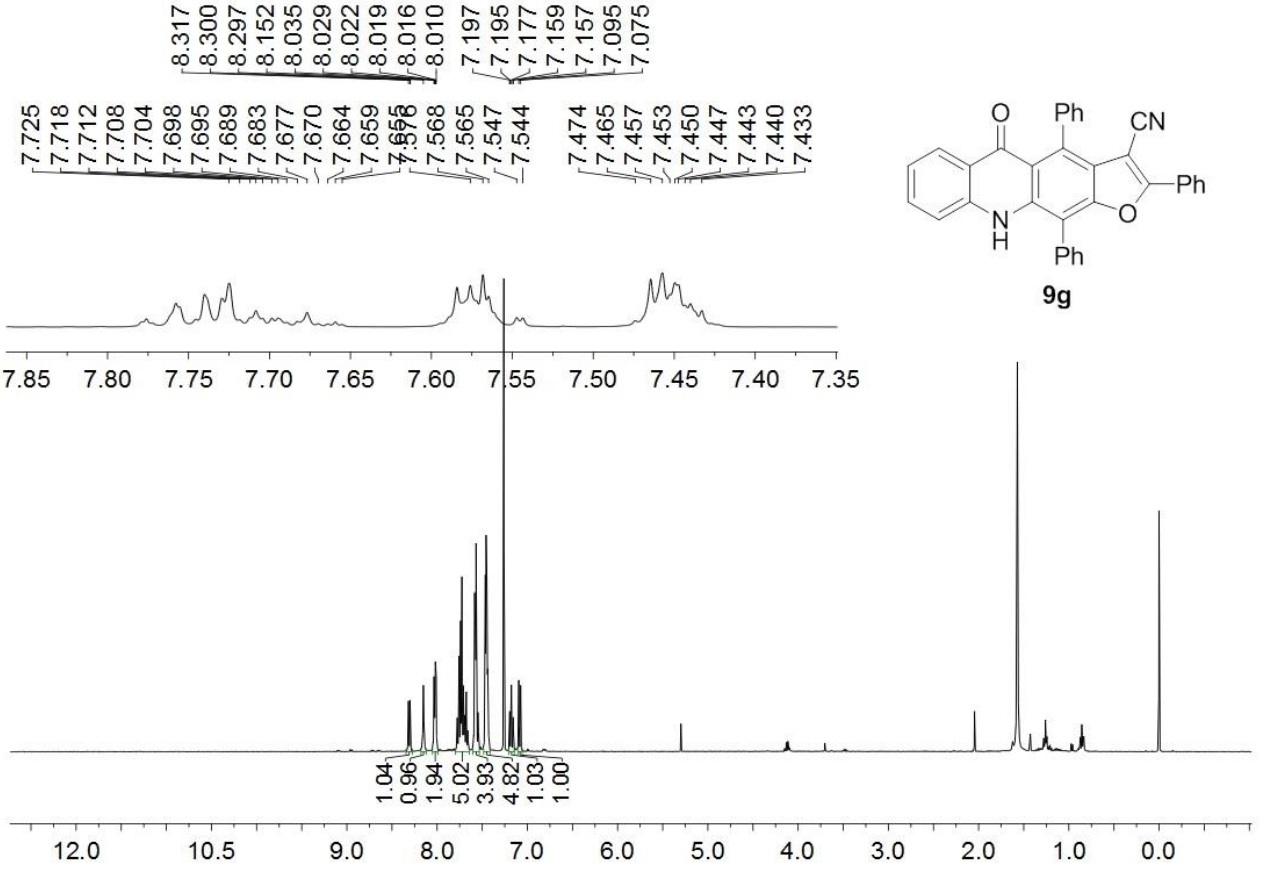
^{1}H NMR (400 MHz, $CDCl_3$) for **9f**



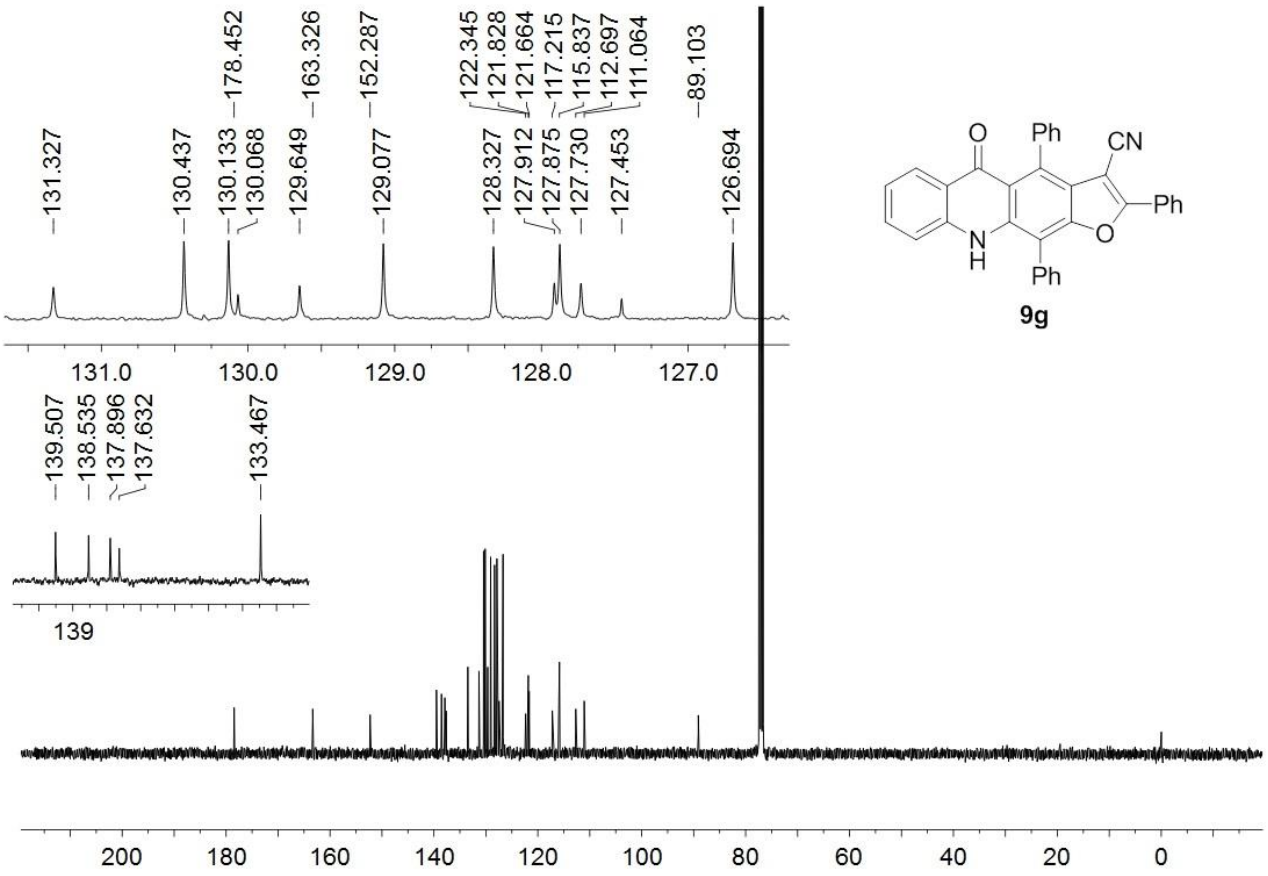
^{13}C NMR (100 MHz, $CDCl_3$) for **9f**



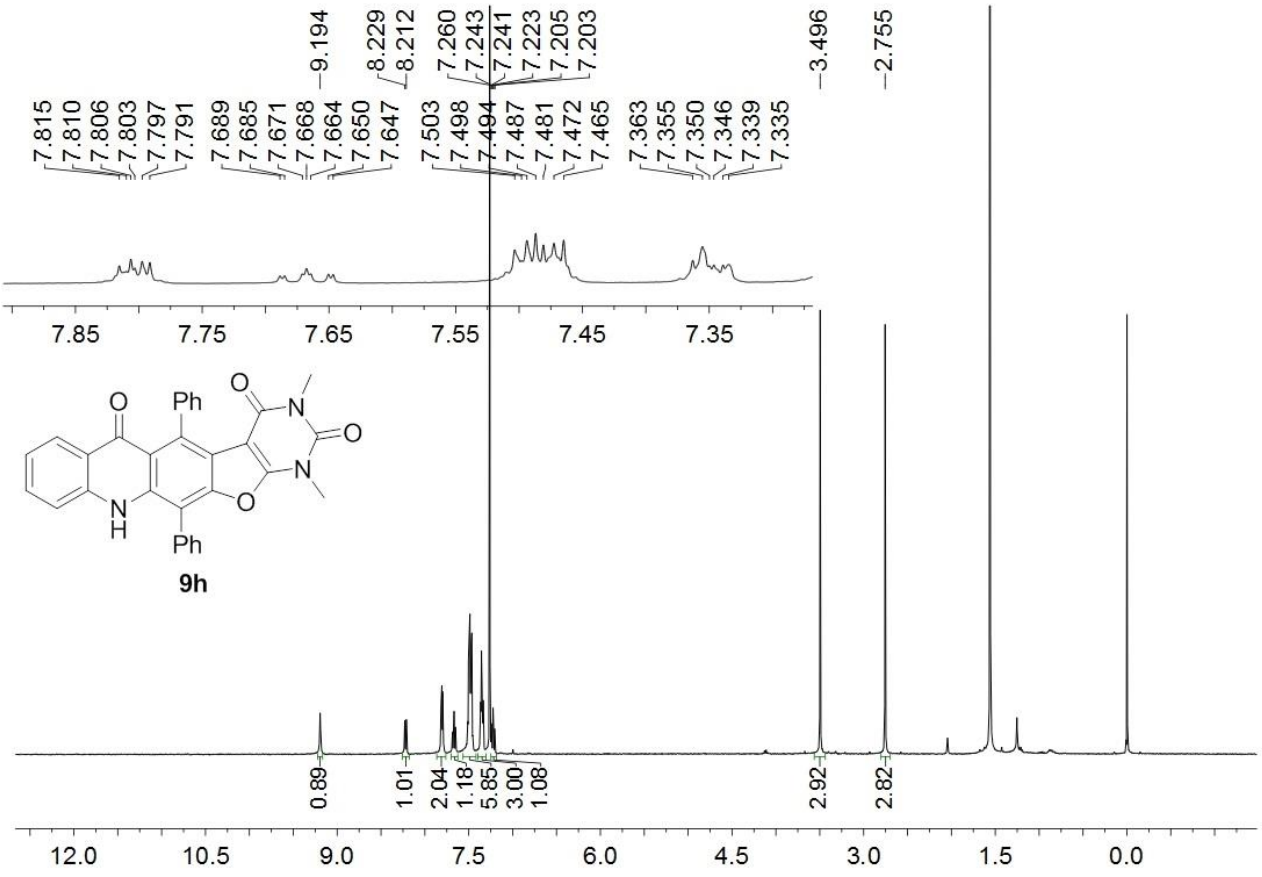
^{1}H NMR (400 MHz, $CDCl_3$) for **9g**



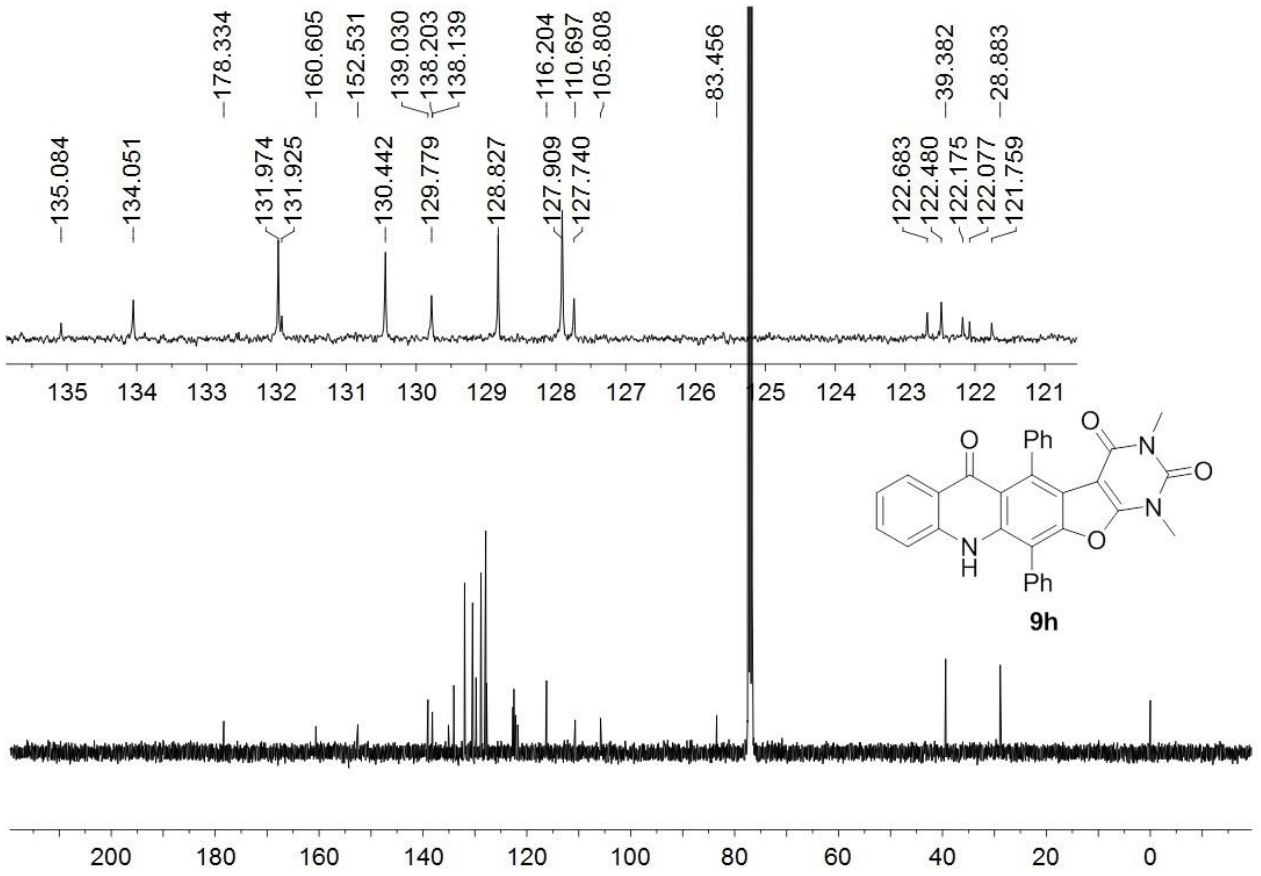
^{13}C NMR (100 MHz, $CDCl_3$) for **9g**



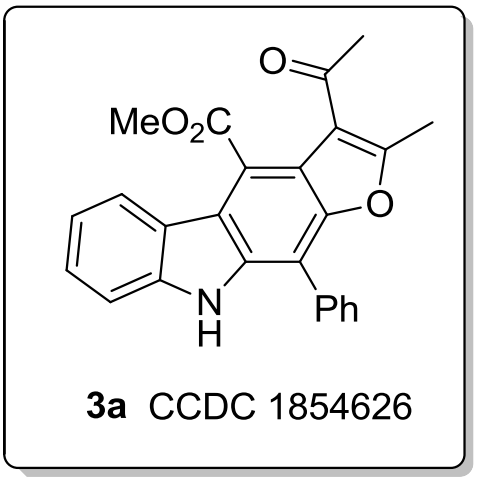
^{1}H NMR (400 MHz, $CDCl_3$) for **9h**

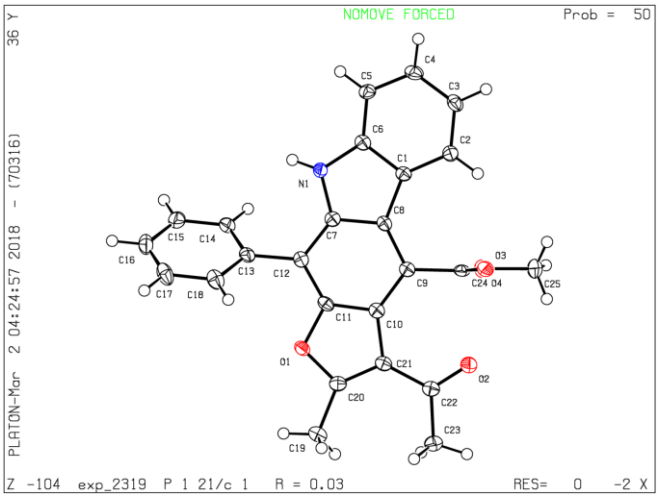


^{13}C NMR (100 MHz, $CDCl_3$) for **9h**



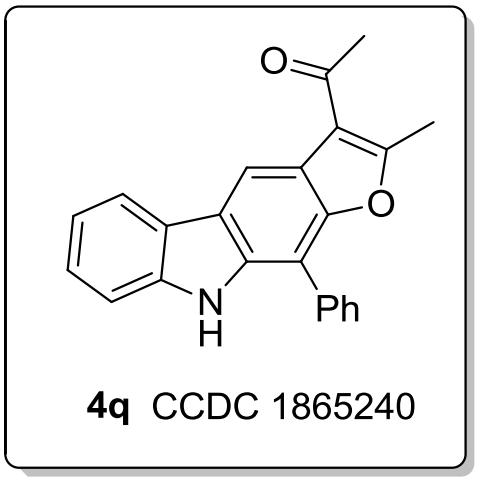
5. X-ray Crystallographic Data of compound 3a and 4q



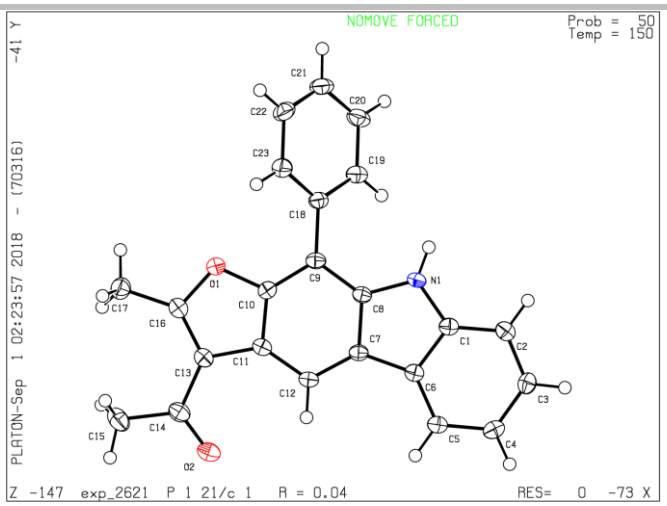


Crystal data:

Empirical formula	$C_{25}H_{19}NO_4$
Formula weight	397.41
Temperature/K	133(40)
Crystal system	monoclinic
Space group	P 1 21/c 1
a/Å	12.6115(4)
b/Å	12.5397(4)
c/Å	13.3771(5)
α/°	90.00
β/°	115.085(4)
γ/°	90.00
Volume/Å^3	1915.97(11)
Z	4
Mu (mm-1)	0.762
ρ_{calc}g/cm^3	1.378
F(000)	832
Crystal size/mm^3	0.23 × 0.13 × 0.06
Radiation	CuK\a
Index ranges	$-15 \le h \le 9$, $-12 \le k \le 14$, $-15 \le l \le 15$
Reflections collected	7030
Independent reflections	3410 [R_{int} = 0.0168, R_{sigma} = 0.0207]
Data/restraints/parameters	2319/0/274
Goodness-of-fit on F^2	1.043
Final R indexes [*I*>=2σ (*I*)]	R_1 = 0.0369, wR_2 = 0.0880
Final R indexes [all data]	R_1 = 0.0369, wR_2 = 0.0906



4q CCDC 1865240



Crystal data:

Empirical formula	$C_{23}H_{17}NO_2$
Formula weight	339.38
Temperature/K	150(10)
Crystal system	monoclinic
Space group	P 1 21/c 1
a/Å	10.3613(2)
b/Å	9.12439(18)
c/Å	17.7316(3)
α/°	90.00
β/°	103.3377(19)
γ/°	90.00
Volume/Å^3	1631.14(6)
Z	4
Mu (mm-1)	0.701
ρ_{calc}g/cm^3	1.382
F(000)	712
Crystal size/mm^3	0.3 × 0.21 × 0.04
Radiation	CuK\a
Index ranges	-11 ≤ h ≤ 12, -10 ≤ k ≤ 10, -21 ≤ l ≤ 18
Reflections collected	5864
Independent reflections	2907 [R_{int} = 0.0145, R_{sigma} = 0.0180]
Data/restraints/parameters	2621/0/237
Goodness-of-fit on F^2	1.058
Final R indexes [I>=2σ (I)]	R_1 = 0.0386, wR_2 = 0.0989
Final R indexes [all data]	R_1 = 0.0418, wR_2 = 0.1021