

Photo-Induced Tandem Cyclizations of 3-Iodofalvones with Electron Rich Five-member Heteroarenes

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1. Spectroscopic Data of 1, 3, 5, 1aa and 1ab

3-Iodo-2-(4-methoxyphenyl)-6-methyl-4H-chromen-4-one (1b) ¹

Yield: 76%. Characteristic: a white powder. m.p. 151.4-152.0. IR(KBr):3452, 2388, 1616, 1348, 1254, 1074, 1020, 937, 802. ¹H NMR (400 MHz, CDCl₃) δ 8.04 (s, 1H), 7.81 – 7.79 (m, 1H), 7.79 – 7.77 (m, 1H), 7.51 (d, *J* = 2.1 Hz, 1H), 7.49 (d, *J* = 2.1 Hz, 1H), 7.37 (d, *J* = 8.5 Hz, 1H), 7.05 – 7.02 (m, 1H), 7.00 (d, *J* = 2.8 Hz, 1H), 3.90 (s, 3H), 2.47 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.8, 164.3, 161.7, 154.3, 135.9, 135.5, 131.5, 127.5, 126.1, 119.8, 117.43, 113.7, 87.6, 55.6, 21.1. HRMS (ESI): calc. for C₁₇H₁₃IO₃ [M + Na]⁺ 414.9807, found 414.9801.

6-Fluoro-3-iodo-2-(4-methoxyphenyl)-4H-chromen-4-one (1d) ¹

Yield: 63%. Characteristic: a brown powder. m.p. 299.4-302.0. IR(KBr):3452, 2641, 2359, 1932, 1638, 1385, 1277, 1211, 1026, 854, 822, 698. ¹H NMR (400 MHz, CDCl₃) δ 7.90 (d, *J* = 5.8 Hz, 1H), 7.79 (d, *J* = 8.3 Hz, 2H), 7.50 (dd, *J* = 8.5, 3.7 Hz, 1H), 7.42 (t, *J* = 6.7 Hz, 1H), 7.03 (d, *J* = 8.3 Hz, 2H), 3.90 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.1, 164.5, 161.8, 160.9, 158.5, 152.1, 131.4, 126.9, 122.5, 122.3, 121.0, 120.9, 119.8, 119.7, 113.6, 111.6, 111.4, 86.8, 55.6. HRMS (ESI) calc. for C₁₆H₁₀FIO₃ [M + Na]⁺ 418.9556, found 418.9558.

3-Iodo-6-methyl-2-p-tolyl-4H-chromen-4-one (1f) ¹

Yield: 37%. Characteristic: a white powder. m.p. 179.1-180.2. IR(KBr):3740, 3450, 2356, 1643, 1567, 1453, 1330, 1226, 1057, 967, 824, 754. ¹H NMR (400 MHz, CDCl₃) δ 8.05 (s, 1H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.51 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.37 (d, *J* = 8.6 Hz, 1H), 7.33 (d, *J* = 8.1 Hz, 2H), 2.48 (s, 3H), 2.46 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.7, 164.7, 154.3, 141.6, 135.9, 135.5, 132.5, 129.6, 129.0, 126.1, 119.8, 117.5, 88.0, 77.5, 77.2, 76.8, 21.7, 21.1. HRMS (ESI) calc. for C₁₇H₁₃IO₂ [M + Na]⁺ 398.9852, found 398.9851.

3-Iodo-7-methoxy-2-p-tolyl-4H-chromen-4-one (1g) ¹

Yield: 33%. Characteristic: a white powder. m.p. 193.3-194.1. IR(KBr):2941, 2357, 1796, 1693, 1560, 1500, 1442, 1364, 1329, 1057, 976, 860, 824. ¹H NMR (400 MHz, CDCl₃) δ 8.16 (d, *J* = 8.9 Hz, 1H), 7.68 (d, *J* = 8.1 Hz, 2H), 7.32 (d, *J* = 8.0 Hz, 2H), 6.99 (dd, *J* = 8.8, 2.3 Hz, 1H), 6.85 (d, *J* = 2.2 Hz, 1H), 3.89 (s, 3H), 2.45 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 173.8, 164.4, 164.2, 157.6, 141.4, 132.3, 129.4, 128.9, 128.1, 115.2, 113.9, 99.7, 88.3, 55.9, 21.6. HRMS (ESI) calc. for C₁₇H₁₃IO₃ [M + Na]⁺ 414.9807, found 414.9809.

6-Fluoro-3-iodo-2-p-tolyl-4H-chromen-4-one (1h) ¹

Yield: 32%. Characteristic: a white powder. m.p. 192.4-193.4. IR(KBr):3740, 3506, 3074, 2918, 2357, 1649, 1557, 1474, 1319, 1180, 1089, 1049, 823, 756. ¹H NMR (400 MHz, CDCl₃) δ 7.90 (dd, *J* = 8.1, 3.0 Hz, 1H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.50 (dd, *J* = 9.1, 4.2 Hz, 1H), 7.45 – 7.39 (m, 1H), 7.34 (d, *J* = 8.0 Hz, 2H), 2.47 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.1, 174.1, 165.1, 161.14, 158.7, 152.3, 141.9, 132.1, 129.5, 129.1, 122.7, 122.4, 121.2, 121.1, 120.0, 119.9, 111.7, 111.5, 87.3, 21.74. HRMS (ESI) calc. for C₁₆H₁₀FIO₂ [M + Na]⁺ 402.9602, found 402.9594.

2-(4-Fluorophenyl)-3-iodo-4H-chromen-4-one (1m) ¹

Yield: 16%. Characteristic: a white powder. m.p. 166.2-128.1. IR(KBr):3506,

3149, 2926, 2356, 1649, 1554, 1502, 1460, 1340, 1226, 1056, 912, 754, 682. ¹H NMR (400 MHz, CDCl₃) δ 8.28 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.84 – 7.79 (m, 2H), 7.75 – 7.69 (m, 1H), 7.47 (dd, *J* = 14.1, 7.6 Hz, 2H), 7.27 – 7.18 (m, 2H); ¹³C NMR (101 MHz, CDCl₃) δ 174.4, 165.3, 163.5, 162.8, 155.8, 134.3, 131.9, 131.8, 131.2, 131.1, 126.8, 125.9, 119.9, 117.6, 115.7, 115.4, 88.5. HRMS (ESI) calc. for C₁₅H₈FIO₂[M + Na]⁺ 388.9445, found 388.9450.

2-(4-Fluorophenyl)-3-iodo-6-methyl-4H-chromen-4-one (1n)¹

Yield: 17%. Characteristic: a yellow powder. m.p. 175.7-176.3. IR(KBr):3494, 3051, 2924, 2356, 1643, 1508, 1330, 1226, 1145, 1060, 922, 826, 657. ¹H NMR (400 MHz, CDCl₃) δ 8.05 (s), 7.84 – 7.76 (m, 1H), 7.53 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.38 (d, *J* = 8.6 Hz, 1H), 7.24 – 7.18 (m, 1H), 2.48 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.6, 165.4, 163.5, 162.9, 154.3, 136.2, 135.7, 132.0, 131.9, 131.4, 131.4, 126.1, 119.8, 117.5, 115.7, 115.5, 88.5, 21.14. HRMS (ESI) calc. for C₁₆H₁₀FIO₂[M + Na]⁺ 402.9602, found 402.9596.

2-(4-Fluorophenyl)-3-iodo-7-methoxy-4H-chromen-4-one (1o)¹

Yield: 14%. Characteristic: a white powder. m.p. 178.0-179.2. IR(KBr): 3740, 3505, 2989, 2356, 1628, 1506, 1433, 1332, 1244, 1056, 960, 837, 763. ¹H NMR (400 MHz, CDCl₃) δ 8.17 (d, *J* = 9.0 Hz, 1H), 7.79 (dd, *J* = 8.7, 5.2 Hz, 2H), 7.21 (t, *J* = 8.6 Hz, 2H), 7.01 (dd, *J* = 8.9, 2.3 Hz, 1H), 6.86 (d, *J* = 2.2 Hz, 1H), 3.90 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 173.8, 165.4, 164.7, 163.1, 162.9, 157.7, 132.0, 131.9, 131.4, 131.3, 128.4, 115.8, 115.5, 115.5, 114.0, 99.8, 89.0, 56.1. HRMS (ESI) calc. for C₁₆H₁₀FIO₃[M + Na]⁺ 418.9551, found 418.9557.

Ethyl 4-(3-iodo-4-oxo-4H-chromen-2-yl)benzoate (1p)¹

Yield: 8%. Characteristic: a white powder. m.p. 188.1-189.0. IR(KBr): 3740, 2920, 2356, 1719, 1658, 1610, 1462, 1276, 1107, 860, 756, 702. ¹H NMR (400 MHz, CDCl₃) δ 8.29 (dd, *J* = 7.9, 1.4 Hz, 1H), 8.20 (d, *J* = 8.3 Hz, 2H), 7.85 (d, *J* = 8.3 Hz, 2H), 7.73 (ddd, *J* = 8.6, 7.3, 1.6 Hz, 1H), 7.52 – 7.45 (m, 2H), 4.44 (q, *J* = 7.1 Hz, 2H), 1.43 (t, *J* = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.3, 165.6, 163.5, 155.9, 138.9, 134.4, 132.6, 129.5, 129.5, 126.8, 126.05, 120.0, 117.2, 88.9, 61.46, 14.32. HRMS (ESI) calc. for C₁₈H₁₃IO₄[M + Na]⁺ 442.9751, found 442.9751.

5-Methoxy-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3a)

Yield: 47%. Characteristic: a yellow powder. m.p.150.6-152.0. IR(KBr): 3609, 2949, 2357, 1622, 1468, 1431, 1388, 1223, 1028, 943, 788, 760. ¹H NMR (400 MHz, CDCl₃) δ 8.51 (d, *J* = 9.1 Hz, 1H), 8.34 (d, *J* = 7.9 Hz, 1H), 7.72 (t, *J* = 7.6 Hz, 1H), 7.62 (d, *J* = 8.3 Hz, 1H), 7.45 (d, *J* = 2.2 Hz, 1H), 7.42 (t, *J* = 7.5 Hz, 1H), 7.12 (dd, *J* = 11.2, 2.5 Hz, 2H), 6.94 (d, *J* = 2.9 Hz, 1H), 4.29 (s, 3H), 4.01 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 171.2, 156.4, 149.8, 148.4, 128.6, 125.6, 123.3, 121.5, 121.2, 119.2, 118.6, 116.7, 112.6, 110.7, 109.9, 104.2, 99.9, 97.9, 95.8, 50.6, 36.0. HRMS (ESI) calc. for C₂₁H₁₅NO₃[M + Na]⁺ 352.0944, found 352.0944.

5-Methoxy-1,11-dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3b)

Yield: 40%. Characteristic: a yellow powder. m.p.151.4-152.0. IR(KBr): 3688, 3413, 3233, 3024, 2920, 1618, 1493, 1454, 1381, 1267, 1217, 1026, 941, 748, 814. ¹H NMR (400 MHz, CDCl₃) δ 8.45 (d, *J* = 9.1 Hz, 1H), 8.09 (s, 1H), 7.51 – 7.45 (m, 2H), 7.41 (d, *J* = 2.3 Hz, 1H), 7.09 (dd, *J* = 9.1, 2.6 Hz, 2H), 6.91 (d, *J* = 3.0 Hz, 1H), 4.27

(s, 3H), 3.99 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 176.1, 161.2, 153.2, 152.9, 134.7, 133.8, 133.4, 130.3, 128.3, 126.0, 125.7, 123.1, 121.5, 117.2, 115.4, 114.9, 108.9, 102.8, 100.6, 55.54, 40.87, 21.08. HRMS (ESI) calc. for $\text{C}_{22}\text{H}_{17}\text{NO}_3[\text{M} + \text{Na}]^+$ 366.1101, found 366.1091.

11-Fluoro-5-methoxy-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3c)

Yield: 49%. Characteristic: a yellow powder. m.p.204.6-205.8. IR(KBr): 3742, 2926, 2357, 1680, 1622, 1487, 1382, 1217, 1084, 1018, 914, 813, 779. ^1H NMR (400 MHz, CDCl_3) δ 8.37 (d, $J = 9.1$ Hz, 1H), 7.91 (dd, $J = 8.4, 2.7$ Hz, 1H), 7.52 (dd, $J = 9.0, 4.1$ Hz, 1H), 7.40 (dd, $J = 7.9, 2.3$ Hz, 1H), 7.37 (s, 1H), 7.06 (d, $J = 3.2$ Hz, 2H), 6.88 (d, $J = 2.7$ Hz, 1H), 4.24 (s, 3H), 3.98 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 174.9, 161.2, 160.1, 157.7, 153.1, 150.6, 133.4, 130.4, 127.6, 125.8, 124.2, 124.1, 121.6, 121.5, 121.2, 119.2, 119.1, 115.5, 114.4, 111.1, 110.9, 108.1, 102.6, 100.5, 55.4, 40.8. HRMS (ESI) calc. for $\text{C}_{21}\text{H}_{14}\text{FNO}_3[\text{M} + \text{Na}]^+$ 370.0850, found 370.0858.

5,10-Dimethoxy-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3d)

Yield: 38%. Characteristic: a yellow powder. m.p.206.1-207.4. IR(KBr): 3740, 2924, 2357, 1620, 1448, 1383, 1221, 1096, 1024, 918, 824, 737. ^1H NMR (400 MHz, CDCl_3) δ 8.46 (d, $J = 9.1$ Hz, 1H), 8.21 (d, $J = 9.1$ Hz, 1H), 7.43 (d, $J = 2.4$ Hz, 1H), 7.12 – 7.08 (m, 2H), 6.99 – 6.94 (m, 2H), 6.93 (d, $J = 3.0$ Hz, 1H), 4.33 – 4.26 (m, 3H), 4.00 (s, 3H), 3.95 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 175.3, 164.0, 161.0, 156.2, 153.0, 133.0, 130.3, 128.2, 127.7, 125.7, 121.5, 117.2, 115.3, 114.7, 113.4, 108.9, 102.6, 100.4, 99.5, 55.79, 55.43, 40.85. HRMS (ESI) calc. for $\text{C}_{22}\text{H}_{17}\text{NO}_4[\text{M} + \text{Na}]^+$ 382.1050, found 382.1059.

1,5-Dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3e)

Yield: 50%. Characteristic: a yellow powder. m.p.177.8-179.0. IR(KBr): 3740, 3603, 3161, 2922, 2357, 1645, 1471, 1373, 1200, 1037, 873, 806, 746. ^1H NMR (400 MHz, CDCl_3) δ 8.47 (d, $J = 8.5$ Hz, 1H), 8.34 (dd, $J = 7.9, 1.6$ Hz, 1H), 7.93 (s, 1H), 7.75 – 7.70 (m, 1H), 7.63 (d, $J = 8.3$ Hz, 1H), 7.42 (t, $J = 7.2$ Hz, 1H), 7.32 (dd, $J = 8.5, 1.4$ Hz, 1H), 7.11 (d, $J = 3.0$ Hz, 1H), 6.97 (d, $J = 3.0$ Hz, 1H), 4.29 (s, 3H), 2.58 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 176.1, 154.5, 152.9, 140.2, 133.4, 131.6, 130.4, 127.6, 126.3, 126.1, 123.9, 123.8, 123.4, 122.4, 121.7, 118.2, 117.4, 109.9, 100.5, 40.7, 22.1. HRMS (ESI) calc. for $\text{C}_{21}\text{H}_{15}\text{NO}_2[\text{M} + \text{Na}]^+$ 336.0995, found 336.1003.

1,5,11-Trimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3f)

Yield: 46%. Characteristic: a yellow powder. m.p. 179.1-180.2. IR(KBr): 3672, 3412, 3109, 3065, 2918, 2388, 1634, 1454, 1373, 1281, 918, 813, 737. ^1H NMR (400 MHz, CDCl_3) δ 8.42 (d, $J = 8.5$ Hz, 1H), 8.09 (s, 1H), 7.90 (s, 1H), 7.52 – 7.44 (m, 2H), 7.33 – 7.23 (m, 1H), 7.08 (d, $J = 2.9$ Hz, 1H), 6.95 (d, $J = 2.9$ Hz, 1H), 4.27 (s, 3H), 2.56 (s, 3H), 2.48 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 176.1, 152.9, 152.7, 140.0, 134.6, 133.7, 131.5, 130.3, 127.7, 126.0, 125.6, 123.8, 123.0, 122.3, 121.6, 118.3, 117.1, 109.8, 100.5, 40.73, 22.10, 20.94. HRMS (ESI) calc. for $\text{C}_{22}\text{H}_{17}\text{NO}_2[\text{M} + \text{Na}]^+$ 350.1151, found 350.1150.

10-Methoxy-1,5-dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3g)

Yield: 42%. Characteristic: a white powder. m.p.198.2-199.8. IR(KBr): 3742, 3155, 2920, 2357, 1622, 1448, 1367, 1265, 1213, 1103, 1029, 912, 821, 742. ^1H NMR

(400 MHz, CDCl₃) δ 8.45 (d, J = 8.5 Hz, 1H), 8.23 (d, J = 8.8 Hz, 1H), 7.94 (s, 1H), 7.32 (dd, J = 8.5, 1.0 Hz, 1H), 7.11 (d, J = 3.0 Hz, 1H), 7.00 (d, J = 2.3 Hz, 1H), 6.97 (dd, J = 9.2, 2.6 Hz, 2H), 4.31 (s, 3H), 3.95 (s, 3H), 2.59 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 175.5, 164.1, 156.3, 152.8, 139.9, 131.3, 130.4, 127.8, 127.7, 126.0, 123.6, 122.3, 121.7, 118.2, 117.3, 113.4, 109.9, 100.4, 99.5, 55.78, 40.83, 22.09. HRMS (ESI) calc. for C₂₂H₁₇NO₃[M + Na]⁺ 366.1101, found 366.1104.

11-Fluoro-1,5-dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3h)

Yield: 56%. Characteristic: a yellow powder. m.p.192.4-193.4. IR(KBr): 3682, 3328, 2952, 2388, 1706, 1643, 1490, 1369, 1303, 972, 815, 769. ¹H NMR (400 MHz, CDCl₃) δ 8.36 (d, J = 8.5 Hz, 1H), 7.91 (dd, J = 8.4, 3.0 Hz, 1H), 7.88 (s, 1H), 7.54 (dd, J = 9.1, 4.2 Hz, 1H), 7.40 (ddd, J = 9.0, 7.9, 3.1 Hz, 1H), 7.28 (dd, J = 8.6, 0.8 Hz, 1H), 7.07 (d, J = 3.0 Hz, 1H), 6.93 (d, J = 3.0 Hz, 1H), 4.24 (s, 3H), 2.56 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 175.4, 160.4, 158.0, 153.2, 150.9, 140.6, 131.8, 130.8, 127.4, 126.3, 124.4, 124.4, 123.9, 122.6, 122.1, 121.8, 121.6, 119.5, 119.5, 118.2, 111.4, 111.1, 109.4, 100.8, 40.98, 22.35. HRMS (ESI) calc. for C₂₁H₁₄FNO₂[M + Na]⁺ 354.0901, found 354.0901.

1-Methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3i)

Yield: 61%. Characteristic: a yellow powder. m.p.202.2-203.1. IR(KBr): 3742, 3524, 3200, 2943, 2357, 1649, 1558, 1468, 1373, 1331, 1273, 1049, 972, 789, 750. ¹H NMR (400 MHz, CDCl₃) δ 8.61 (d, J = 8.3 Hz, 1H), 8.34 (dd, J = 7.9, 1.1 Hz, 1H), 8.17 (d, J = 8.2 Hz, 1H), 7.72 (ddd, J = 16.5, 11.9, 4.3 Hz, 2H), 7.65 (d, J = 8.3 Hz, 1H), 7.52 (t, J = 7.6 Hz, 1H), 7.42 (t, J = 7.4 Hz, 1H), 7.13 (d, J = 3.0 Hz, 1H), 7.01 (d, J = 3.0 Hz, 1H), 4.30 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 176.2, 154.6, 152.7, 133.6, 131.4, 130.7, 129.8, 127.4, 126.3, 124.1, 124.1, 123.9, 123.4, 122.9, 122.1, 120.2, 117.4, 110.6, 100.6, 40.78. HRMS (ESI) calc. for C₂₀H₁₃NO₂[M + Na]⁺ 322.0838, found 322.0846.

1,11-Dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3j)

Yield: 51%. Characteristic: a yellow powder. m.p. 208.7-210.4. IR(KBr): 3686, 3517, 3442, 3329, 2388, 1643, 1489, 1373, 1280, 1047, 912, 815, 725. ¹H NMR (400 MHz, CDCl₃) δ 8.61 (d, J = 8.4 Hz, 1H), 8.17 (d, J = 8.2 Hz, 1H), 8.11 (s, 1H), 7.69 (t, J = 7.4 Hz, 1H), 7.55 – 7.48 (m, 3H), 7.13 (d, J = 3.0 Hz, 1H), 7.01 (d, J = 2.9 Hz, 1H), 4.29 (s, 3H), 2.49 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 176.4, 153.0, 152.9, 135.0, 134.0, 131.5, 130.7, 129.8, 127.6, 125.8, 124.2, 124.1, 123.1, 123.0, 122.1, 120.5, 117.3, 110.6, 100.7, 40.88, 21.09. HRMS (ESI) calc. for C₂₁H₁₅NO₂[M + Na]⁺ 336.0995, found 336.0990.

10-Methoxy-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3k)

Yield: 45%. Characteristic: a grey powder. m.p.203.8-205.7. IR(KBr): 3742, 3614, 2922, 2357, 1620, 1445, 1368, 1271, 1150, 1093, 1022, 920, 820, 741. ¹H NMR (400 MHz, CDCl₃) δ 8.61 (d, J = 8.3 Hz, 1H), 8.24 (d, J = 8.9 Hz, 1H), 8.20 (d, J = 8.2 Hz, 1H), 7.73 – 7.66 (m, 1H), 7.55 – 7.49 (m, 1H), 7.14 (d, J = 3.0 Hz, 1H), 7.14 (d, J = 3.0 Hz, 1H), 7.04 (d, J = 2.4 Hz, 1H), 7.03 (d, J = 3.0 Hz, 1H), 6.99 (dd, J = 8.8, 2.4 Hz, 1H), 4.32 (s, 3H), 3.97 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 175.6, 164.2, 156.4, 152.6, 131.0, 130.7, 129.5, 127.8, 127.6, 124.0, 123.7, 122.9, 122.1, 120.3, 117.3, 113.6, 110.6, 100.5, 99.6, 55.84, 40.87. HRMS (ESI) calc. for C₂₁H₁₅NO₃[M +

Na]⁺ 352.0944, found 352.0951.

11-Fluoro-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3l)

Yield: 66%. Characteristic: a yellow powder. m.p.198.4-201.7. IR(KBr): 3740, 2924, 2357, 1711, 1643, 1481, 1373, 1267, 1034, 914, 818, 733. ¹H NMR (400 MHz, CDCl₃) δ 8.56 (d, *J* = 8.4 Hz, 1H), 8.16 (d, *J* = 8.2 Hz, 1H), 7.95 (dd, *J* = 8.4, 3.1 Hz, 1H), 7.73 – 7.67 (m, 1H), 7.61 (dd, *J* = 9.1, 4.1 Hz, 1H), 7.51 (t, *J* = 7.5 Hz, 1H), 7.44 (ddd, *J* = 9.1, 7.6, 3.1 Hz, 1H), 7.13 (d, *J* = 3.0 Hz, 1H), 7.00 (d, *J* = 3.0 Hz, 1H), 4.27 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 175.3, 160.2, 157.8, 152.8, 150.7, 131.5, 130.8, 130.0, 127.1, 124.2, 124.2, 123.9, 122.9, 122.2, 121.8, 121.6, 120.1, 119.4, 119.3, 111.2, 111.0, 109.9, 100.6, 40.77. HRMS (ESI) calc. for C₂₀H₁₂FNO₂[M + Na]⁺ 340.0744, found 340.0749.

5-Fluoro-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3m)

Yield: 68%. Characteristic: a yellow powder. m.p.226.8-228.1. IR(KBr):3740, 3523, 2959, 2357, 1649, 1470, 1377, 1323, 1261, 1186, 1084, 901, 806, 711. ¹H NMR (400 MHz, CDCl₃) δ 8.63 (dd, *J* = 9.2, 5.7 Hz, 1H), 8.34 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.77 (d, *J* = 2.1 Hz, 1H), 7.74 (dd, *J* = 5.4, 2.0 Hz, 1H), 7.65 (d, *J* = 8.3 Hz, 1H), 7.44 (t, *J* = 7.4 Hz, 1H), 7.29 – 7.22 (m, 2H) (containing the D of CDCl₃), 7.13 (d, *J* = 3.0 Hz, 1H), 6.94 (d, *J* = 3.0 Hz, 1H), 4.29 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 176.1, 165.0, 162.5, 154.5, 152.6, 133.7, 133.2, 133.1, 130.8, 128.0, 127.0, 126.9, 126.4, 124.2, 123.35, 121.6, 121.5, 117.4, 117.0, 113.7, 113.5, 110.0, 107.5, 107.3, 100.8, 40.81. HRMS (ESI) calc. for C₂₀H₁₂FNO₂[M + Na]⁺ 340.0744, found 340.0750.

5-Fluoro-1,11-dimethylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3n)

Yield: 54%. Characteristic: a yellow powder. m.p.189.8-190.8. IR(KBr): 3447, 3242, 2390, 2361, 2124, 1643, 1492, 1441, 1331, 1182, 943, 806, 646. ¹H NMR (400 MHz, CDCl₃) δ 8.62 (dd, *J* = 9.2, 5.7 Hz, 1H), 8.12 (s, 1H), 7.76 (dd, *J* = 9.9, 2.4 Hz, 1H), 7.59 – 7.49 (m, 2H), 7.25 (dt, *J* = 8.8, 3.7 Hz, 2H) (containing the D of CDCl₃), 7.13 (d, *J* = 3.0 Hz, 1H), 6.93 (d, *J* = 3.0 Hz, 1H), 4.29 (s, 3H), 2.51 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 176.1, 165.0, 162.5, 152.8, 152.6, 152.6, 134.9, 134.1, 133.1, 133.0, 130.7, 128.1, 127.0, 126.9, 125.7, 123.0, 121.4, 117.1, 117.1, 113.6, 113.4, 109.9, 107.5, 107.3, 100.8, 40.78, 20.96. HRMS (ESI) calc. for C₂₁H₁₄FNO₂[M + Na]⁺ 354.0901, found 354.0893.

5-Fluoro-10-methoxy-1-methylbenzo[e]chromeno[2,3-g]indol-13(1H)-one (3o)

Yield: 49%. Characteristic: a white powder. m.p.224.6-227.3. IR(KBr): 3663, 3566, 2962, 2361, 1616, 1578, 1450, 1381, 1263, 1099, 918, 813, 742. ¹H NMR (400 MHz, CDCl₃) δ 8.59 (dd, *J* = 9.0, 5.8 Hz, 1H), 8.23 (d, *J* = 8.6 Hz, 1H), 7.76 (d, *J* = 9.9 Hz, 1H), 7.23 (d, *J* = 8.7 Hz, 1H), 7.13 (d, *J* = 2.7 Hz, 1H), 7.00 (d, *J* = 11.2 Hz, 2H), 6.93 (d, *J* = 2.7 Hz, 1H), 4.30 (s, 3H), 3.97 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 175.4, 164.9, 164.3, 162.4, 156.3, 152.5, 132.9, 132.8, 130.8, 128.1, 127.8, 126.8, 126.7, 121.6, 121.5, 117.2, 117.0, 113.7, 113.6, 113.4, 110.0, 110.0, 107.4, 107.2, 100.7, 99.6, 55.86, 40.92. HRMS (ESI) calc. for C₂₁H₁₄FNO₃[M + Na]⁺ 370.0850, found 370.0860.

Ethyl-1-methyl-13-oxo-1,13-dihydrobenzo[e]chromeno[2,3-g]indole-5-carboxylate (3p)

Yield: 64%. Characteristic: a yellow powder. m.p.188.1-189.0. IR(KBr): 3688,

3440, 3300, 2387, 2304, 1708, 1658, 1585, 1463, 1236, 1035, 765, 729. ¹H NMR (400 MHz, CDCl₃) δ 8.79 (s, 1H), 8.54 (d, *J* = 8.7 Hz, 1H), 8.29 (d, *J* = 8.7 Hz, 1H), 8.03 (d, *J* = 8.6 Hz, 1H), 7.73 (t, *J* = 8.1 Hz, 1H), 7.60 (d, *J* = 8.3 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.11 (d, *J* = 2.9 Hz, 1H), 7.03 (d, *J* = 3.0 Hz, 1H), 4.49 (q, *J* = 7.1 Hz, 2H), 4.25 (s, 3H), 1.50 (t, *J* = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 176.3, 166.7, 154.7, 151.9, 133.9, 131.3, 130.9, 130.5, 127.6, 126.4, 125.3, 124.3, 124.1, 123.7, 123.4, 122.7, 122.6, 117.6, 111.8, 101.0, 61.48, 40.99, 14.58. HRMS (ESI) calc. for C₂₃H₁₇NO₄[M + Na]⁺ 394.1050, found 394.1046.

Benzo[e]chromeno[2,3-g]indol-13(1H)-one (3q)

Yield: 40%. Characteristic: a yellow powder. m.p. 237.8-238.5. IR(KBr): 3741, 3616, 3020, 2360, 1649, 1612, 1514, 1275, 1148, 1049, 866, 788, 750. ¹H NMR (400 MHz, DMSO) δ 11.94 (s, 1H), 8.73 (d, *J* = 8.3 Hz, 1H), 8.40 (d, *J* = 8.1 Hz, 1H), 8.35 (d, *J* = 7.5 Hz, 1H), 8.01 – 7.92 (m, 2H), 7.84 (t, *J* = 7.6 Hz, 1H), 7.65 (t, *J* = 7.5 Hz, 1H), 7.62 – 7.56 (m, 1H), 7.46 (t, *J* = 2.7 Hz, 1H), 7.25 – 7.18 (m, 1H); ¹³C NMR (101 MHz, DMSO) δ 176.7, 155.6, 151.0, 135.1, 131.6, 130.5, 126.2, 125.7, 125.2, 124.7, 124.6, 124.1, 123.9, 122.3, 119.7, 119.4, 119.0, 108.3, 101.5. HRMS (ESI) calc. for C₁₉H₁₁NO₂[M + Na]⁺ 308.0682, found 308.0684.

5-Methoxy-13H-benzo[c]furo[2,3-a]xanthen-13-one (3r)

Yield: 25%. Characteristic: a white powder. m.p. 248.2-249.1. IR(KBr): 3524, 3109, 2924, 2855, 2357, 1736, 1632, 1472, 1387, 1229, 1024, 824, 754. ¹H NMR (400 MHz, CDCl₃) δ 8.55 (d, *J* = 9.2 Hz, 1H), 8.45 (d, *J* = 7.2 Hz, 1H), 7.93 (d, *J* = 1.7 Hz, 1H), 7.76 (t, *J* = 7.1 Hz, 1H), 7.65 (d, *J* = 8.3 Hz, 1H), 7.45 (t, *J* = 7.4 Hz, 1H), 7.37 (d, *J* = 2.1 Hz, 1H), 7.22 (dd, *J* = 9.2, 2.3 Hz, 1H), 7.18 (d, *J* = 1.7 Hz, 1H), 4.01 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 174.9, 161.4, 155.2, 152.8, 148.1, 145.1, 134.0, 132.1, 126.5, 125.9, 124.4, 123.0, 118.8, 117.8, 116.8, 115.9, 107.3, 104.7, 103.6, 55.57. HRMS (ESI) calc. for C₂₀H₁₂O₄[M + Na]⁺ 339.0628, found 339.0638.

5-Methoxy-13H-benzo[c]thieno[2,3-a]xanthen-13-one (3s)

Yield: 18%. Characteristic: a white powder. m.p. 256.8-257.3. IR(KBr): 3724, 2924, 2855, 2357, 1680, 1622, 1472, 1387, 1220, 1024, 917, 754. ¹H NMR (600 MHz, CDCl₃) δ 8.61 (d, *J* = 9.1 Hz, 1H), 8.47 (dd, *J* = 7.9, 1.4 Hz, 1H), 7.92 (d, *J* = 5.4 Hz, 1H), 7.81 – 7.77 (m, 1H), 7.71 (dd, *J* = 7.0, 3.3 Hz, 2H), 7.65 (d, *J* = 2.3 Hz, 1H), 7.49 (t, *J* = 7.4 Hz, 1H), 7.28 (dd, *J* = 9.1, 2.4 Hz, 1H), 4.04 (s, 3H); ¹³C NMR (151 MHz, DMSO) δ 174.6, 161.9, 154.8, 152.2, 134.8, 133.7, 132.3, 128.7, 125.6, 125.5, 125.0, 121.7, 121.4, 118.5, 117.5, 116.1, 111.5, 105.1, 99.5, 55.9. HRMS (ESI) calc. for C₂₀H₁₂O₃S[M + Na]⁺ 355.0399, found 355.0405.

(3-Methyl-3H-benzo[e]indol-4-yl)(phenyl)methanone (5a)

Yield: 57%. Characteristic: a colorless liquid. IR(KBr): 3745, 3447, 3157, 2922, 2357, 1649, 1531, 1467, 1364, 1242, 1072, 943, 885, 777. ¹H NMR (400 MHz, CDCl₃) δ 8.28 (d, *J* = 8.2 Hz, 1H), 8.01 (d, *J* = 7.9 Hz, 2H), 7.86 (d, *J* = 8.1 Hz, 1H), 7.68 – 7.59 (m, 3H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.44 (t, *J* = 7.5 Hz, 1H), 7.15 (d, *J* = 2.9 Hz, 1H), 7.12 (d, *J* = 3.0 Hz, 1H), 3.71 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 196.4, 138.2, 133.5, 130.8, 129.9, 129.5, 129.5, 129.1, 128.6, 127.4, 127.3, 125.8, 125.4, 125.4, 124.0, 122.8, 100.5, 37.30. HRMS (ESI) calc. for C₂₀H₁₅NO [M + Na]⁺ 308.1046, found 308.1052.

(3H-Benzo[e]indol-4-yl)(phenyl)methanone (5b)

Yield: 42%. Characteristic: a yellow powder. m.p. 172.3-174.5 IR(KBr): 3347, 3053, 2922, 2356, 1699, 1622, 1446, 1298, 1095, 966, 881, 741. ¹H NMR (600 MHz, CDCl₃) δ 10.52 (s, 1H), 8.29 (d, *J* = 8.2 Hz, 1H), 8.04 (s, 1H), 7.92 (d, *J* = 8.1 Hz, 1H), 7.86 (d, *J* = 7.3 Hz, 2H), 7.68 (t, *J* = 7.5 Hz, 1H), 7.65 (t, *J* = 7.5 Hz, 1H), 7.57 (t, *J* = 7.6 Hz, 2H), 7.46 (d, *J* = 2.7 Hz, 1H), 7.44 (d, *J* = 8.6 Hz, 1H), 7.15 (t, *J* = 2.6 Hz, 1H); ¹³C NMR (151 MHz, CDCl₃) δ 198.2, 139.0, 131.8, 131.1, 130.9, 130.8, 130.5, 129.6, 128.9, 128.4, 127.8, 124.3, 124.0, 123.5, 123.1, 121.1, 101.4. HRMS (ESI) calc. for C₁₉H₁₃NO [M + Na]⁺ 294.0889, found 294.0900.

1-(3-Methyl-3H-benzo[e]indol-4-yl)ethan-1-one (5c)

Yield: 47%. Characteristic: a white crystal. m.p. 98.1-99.3 IR(KBr): 3445, 3130, 2357, 1674, 1441, 1356, 1244, 1155, 1085, 949, 851, 743. ¹H NMR (400 MHz, CDCl₃) δ 8.23 (d, *J* = 8.2 Hz, 1H), 7.93 (d, *J* = 7.8 Hz, 2H), 7.66 – 7.58 (m, 1H), 7.45 (ddd, *J* = 8.0, 7.0, 1.1 Hz, 1H), 7.14 (d, *J* = 3.0 Hz, 1H), 7.06 (d, *J* = 3.1 Hz, 1H), 3.85 (s, 3H), 2.84 (s, 3H); ¹³C NMR (151 MHz, CDCl₃) δ 195.3, 125.0, 124.8, 124.0, 123.5, 122.6, 122.2, 122.0, 121.1, 119.9, 118.7, 117.6, 95.1, 32.91, 24.22. HRMS (ESI) calc. for C₁₅H₁₃NO [M + Na]⁺ 246.0889, found 246.0895.

1-(3H-Benzo[e]indol-4-yl)ethan-1-one (5d)

Yield: 38%. Characteristic: a silver powder. m.p. 143.4-144.5 IR(KBr): 3742, 3371, 2922, 2359, 1751, 1647, 1366, 1292, 1213, 1082, 972, 889, 745. ¹H NMR (600 MHz, CDCl₃) δ 10.61 (s, 1H), 8.25 (d, *J* = 8.2 Hz, 1H), 8.22 (s, 1H), 8.00 (d, *J* = 8.1 Hz, 1H), 7.67 (t, *J* = 8.0 Hz, 1H), 7.47 (t, *J* = 7.5 Hz, 1H), 7.39 (t, *J* = 2.7 Hz, 1H), 7.09 (t, *J* = 2.7 Hz, 1H), 2.82 (s, 3H); ¹³C NMR (151 MHz, CDCl₃) δ 200.5, 131.1, 130.3, 130.0, 128.8, 128.0, 127.9, 124.2, 124.0, 123.5, 123.1, 121.9, 101.1, 26.48. HRMS (ESI) calc. for C₁₄H₁₁NO [M + Na]⁺ 232.0733, found 232.0737.

2-(4-Methoxyphenyl)-3-(1-methyl-1H-pyrrol-2-yl)-4H-chromen-4-one (1aa)

Yield: 25%. Characteristic: a white powder. m.p. 155.6-159.2. IR(KBr): 3447, 3118, 2922, 2356, 1638, 1462, 1369, 1253, 1175, 1028, 928, 878, 718. ¹H NMR (400 MHz, CDCl₃) δ 8.27 (dd, *J* = 7.9, 1.4 Hz, 1H), 7.70 (ddd, *J* = 8.7, 7.2, 1.6 Hz, 1H), 7.54 (d, *J* = 8.3 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.32 – 7.30 (m, 1H), 7.30 – 7.27 (m, 1H), 6.86 – 6.84 (m, 1H), 6.83 – 6.81 (m, 1H), 6.78 – 6.69 (m, 1H), 6.20 – 6.13 (m, 1H), 5.98 (dd, *J* = 3.6, 1.7 Hz, 1H), 3.82 (s, 3H), 3.38 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 177.8, 162.7, 161.23, 155.9, 133.6, 130.3, 126.3, 125.4, 125.1, 124.6, 123.2, 122.7, 117.8, 113.7, 110.8, 108.4, 55.32, 34.20. HRMS (ESI) calc. for C₂₁H₁₇NO₃ [M + Na]⁺ 354.1101, found 354.1107.

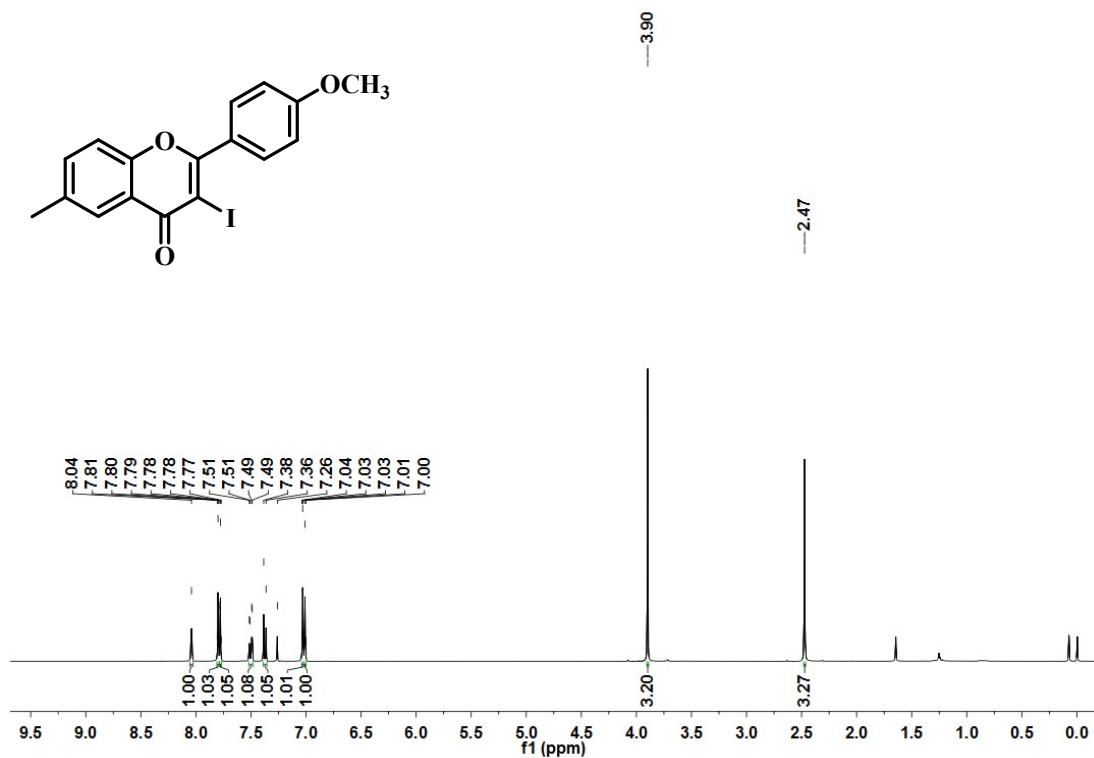
2-(2-(4-Methoxyphenyl)-4H-chromen-3-yl)-1-methyl-1H-pyrrole (1ab)^{2,3}

Yield: 60%. Characteristic: a pale yellow liquid. IR(KBr): 3690, 3443, 3123, 2384, 1719, 1578, 1506, 1246, 1121, 920, 843, 611. ¹H NMR (400 MHz, CDCl₃) δ 7.22 (d, *J* = 8.2 Hz, 1H), 7.19 (d, *J* = 8.7 Hz, 2H), 7.11 (d, *J* = 7.2 Hz, 1H), 7.07 (d, *J* = 4.1 Hz, 1H), 7.04 (t, *J* = 5.3 Hz, 1H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.49 (s, 1H), 6.18 (t, *J* = 3.0 Hz, 1H), 6.16 – 6.12 (m, 1H), 3.79 (s, 3H), 3.75 (s, 2H), 3.07 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 159.2, 151.6, 147.1, 131.7, 129.0, 128.4, 127.7, 127.4, 123.3, 121.2, 120.5, 116.1, 113.3, 107.9, 107.8, 100.6, 55.13, 33.82, 31.67. HRMS (ESI) calc. for C₂₁H₁₉NO₂ [M + Na]⁺ 340.1308, found 340.1306.

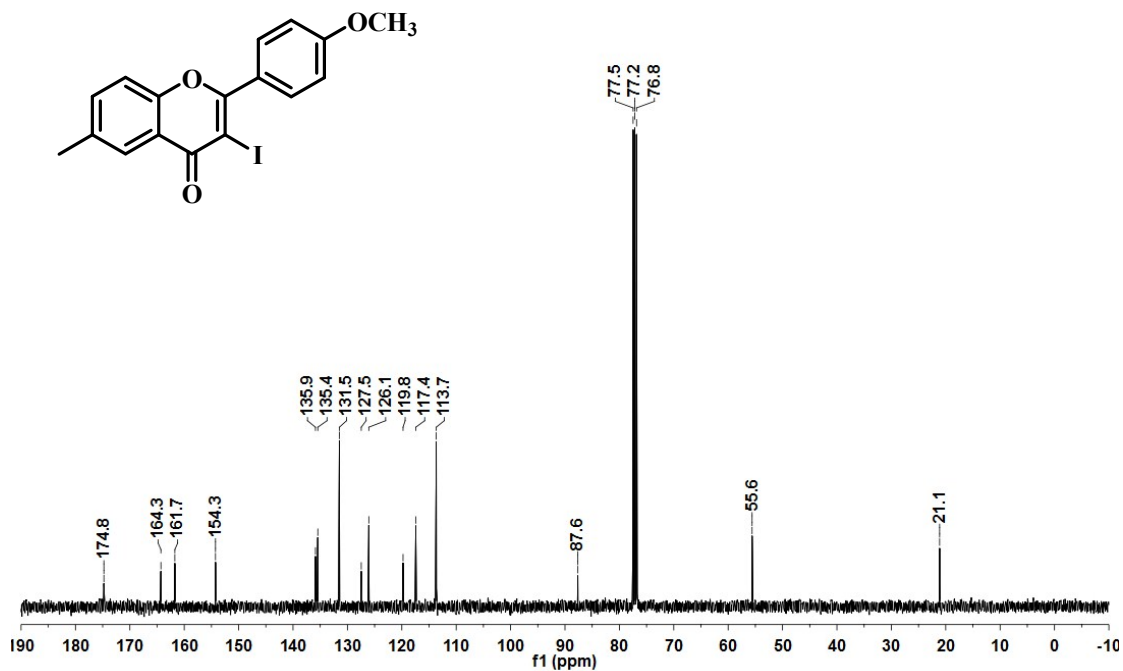
2. References:

1. F. J. Zhang and Y. L. Li, *Synthesis*, 1993, **1993**, 565-567.
2. C. Valla, A. Baeza, F. Menges and A. Pfaltz, *Synlett*, 2008, **2008**, 3167-3171.
3. T. G. C. Bird, B. R. Brown, I. A. Stuart and A. W. R. Tyrrell, *Journal of the Chemical Society, Perkin Transactions 1*, 1983, 1831-1846.

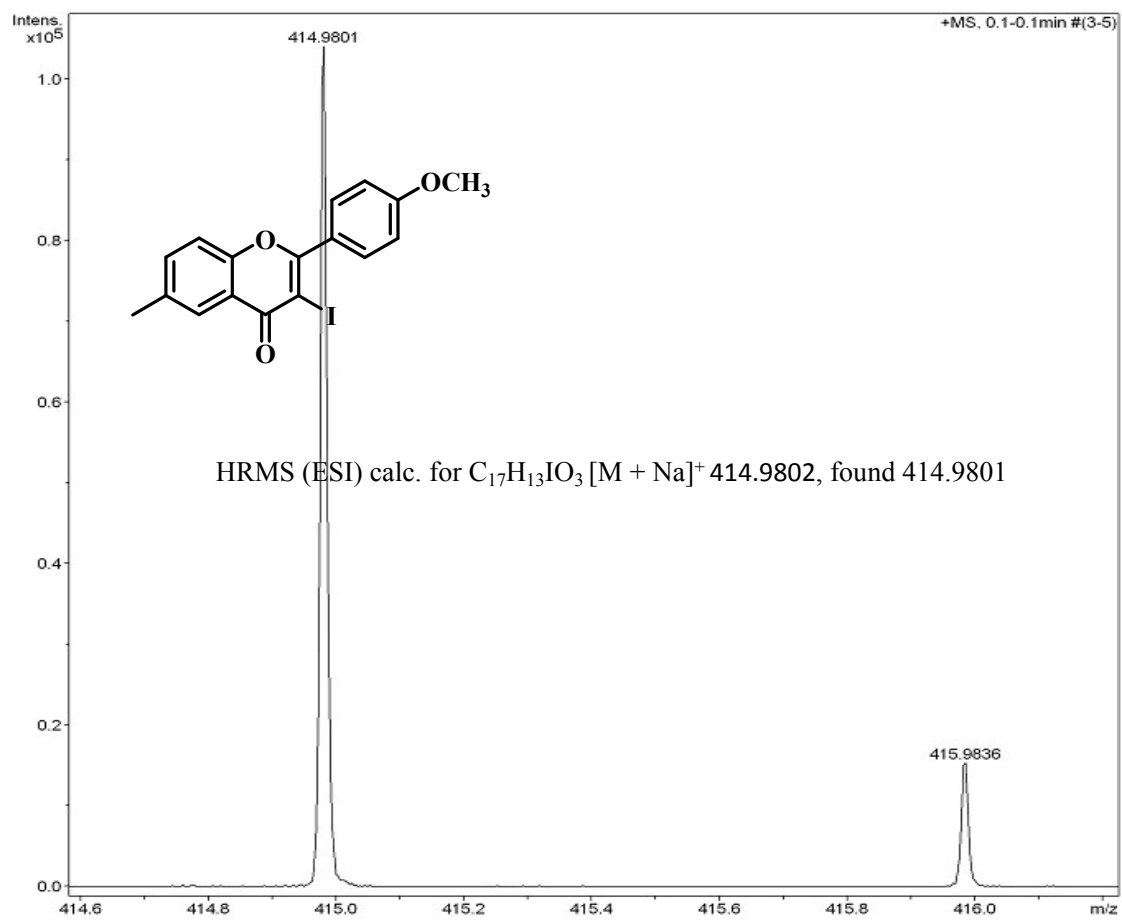
3. ^1H NMR ^{13}C NMR and HRMS Spectra of 1, 3, 5, 1aa and 1ab



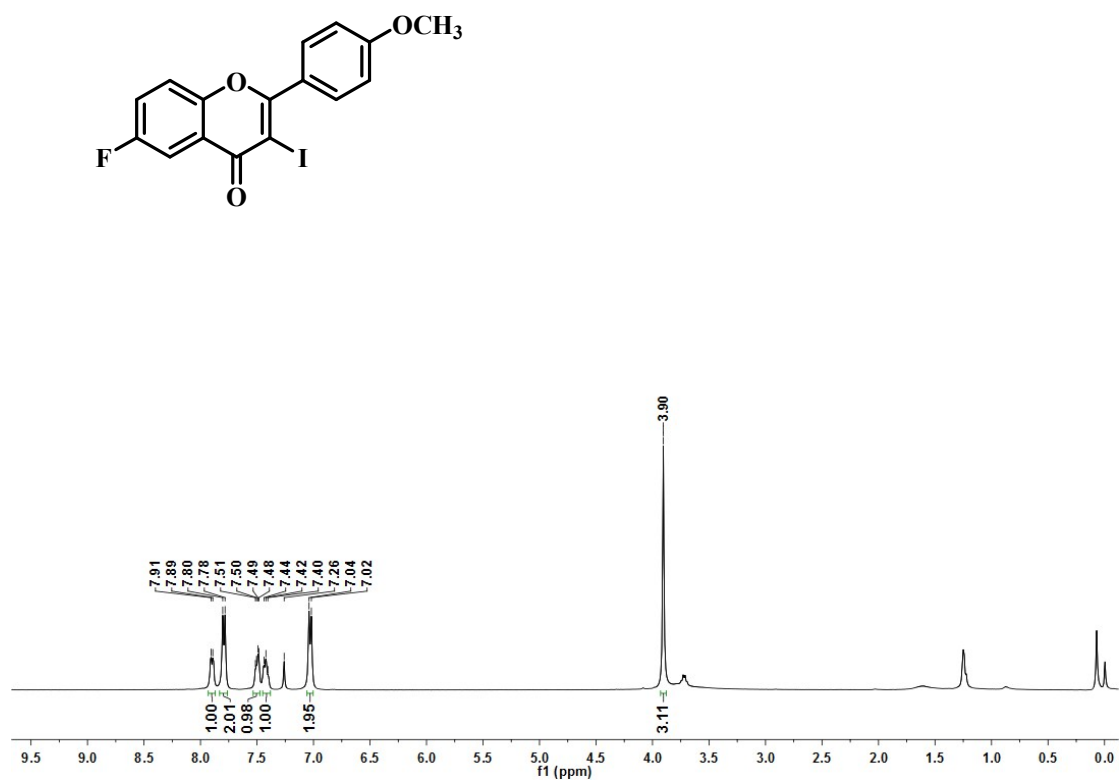
Compound 1b ^1H NMR(CDCl₃)



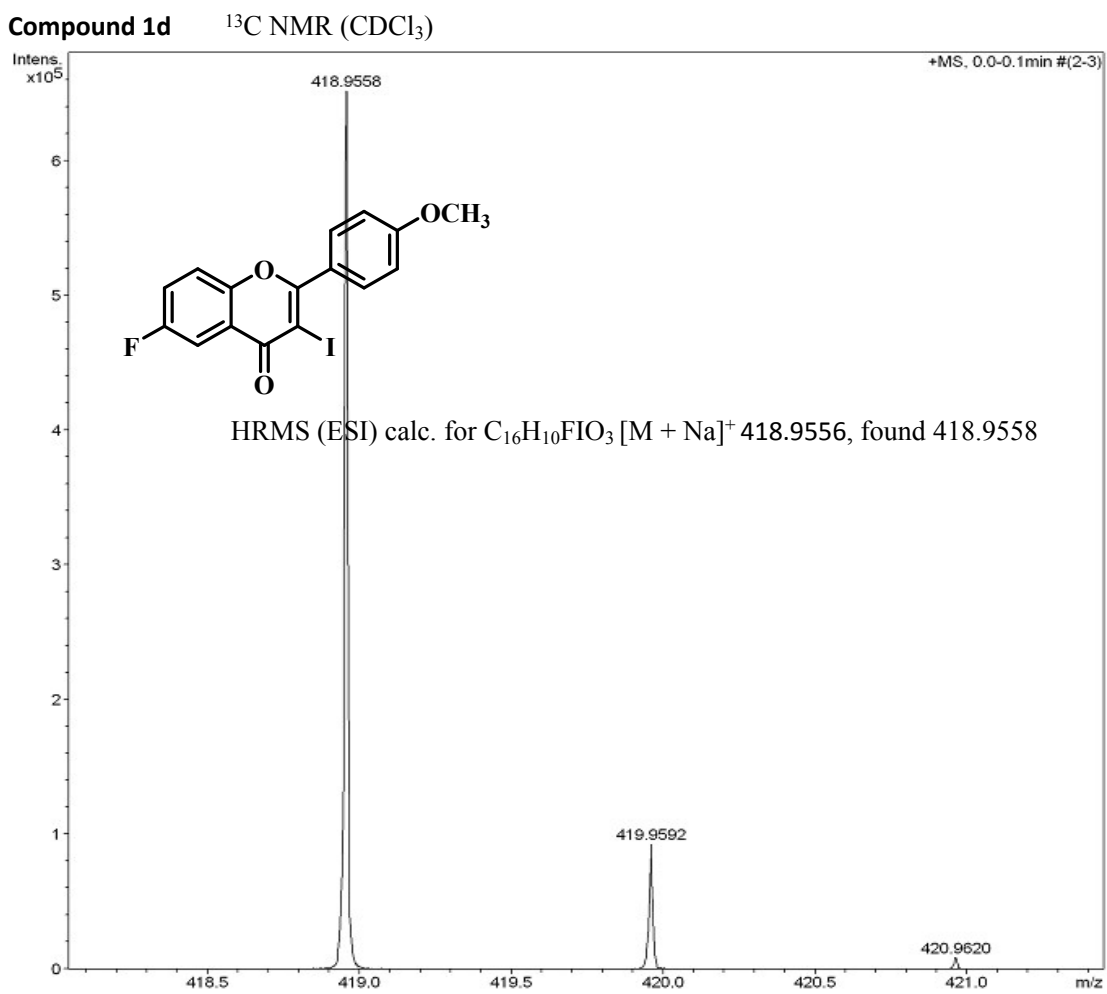
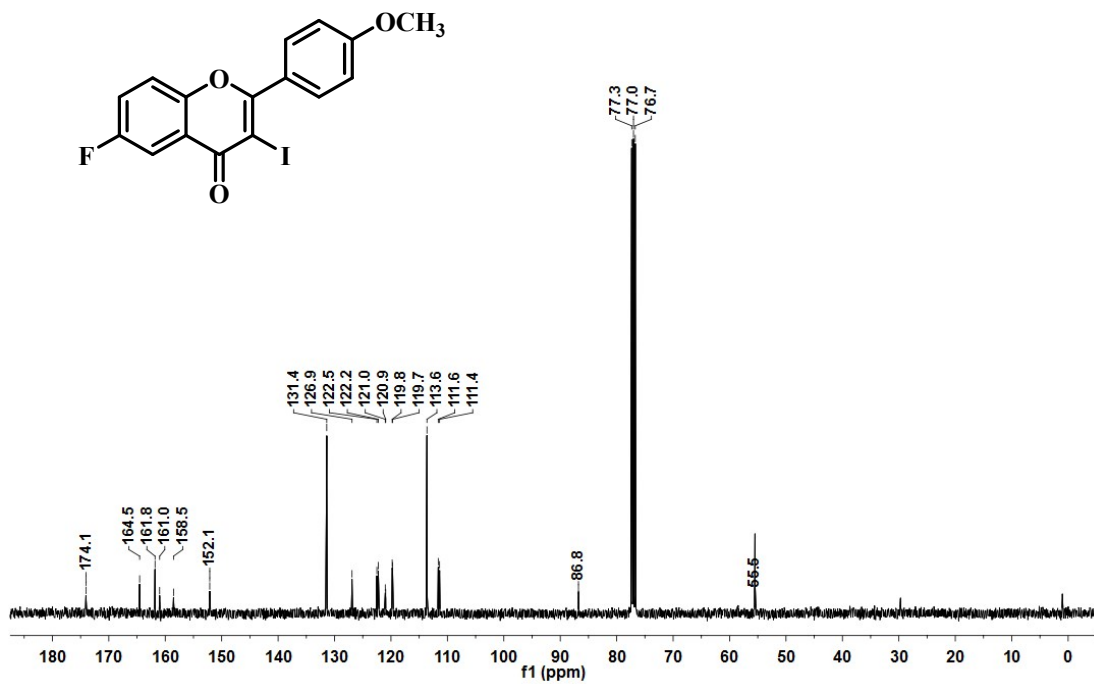
Compound 1b ^{13}C NMR (CDCl₃)



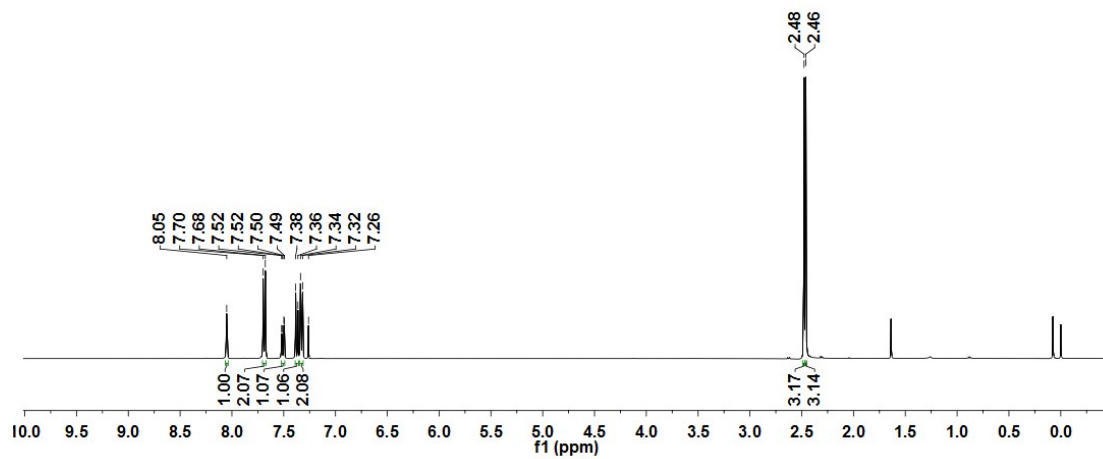
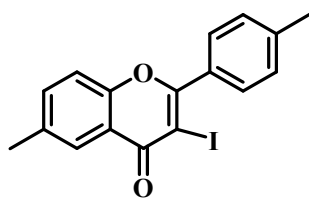
Compound 1b HRMS(MeOH)



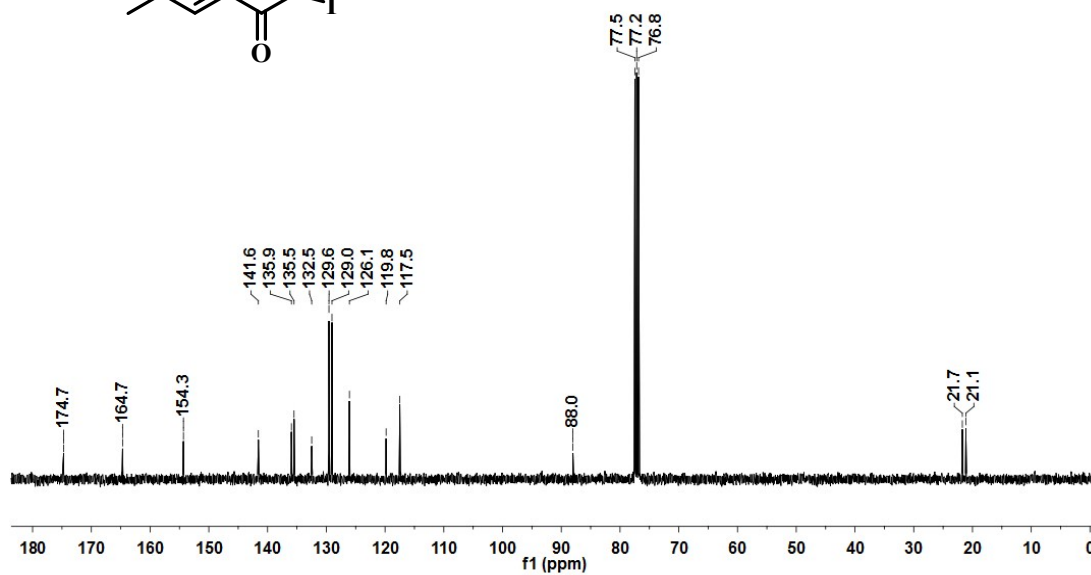
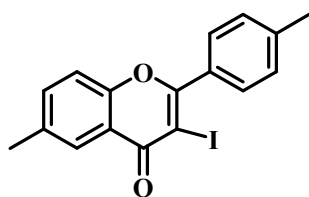
Compound 1d 1H NMR($CDCl_3$)



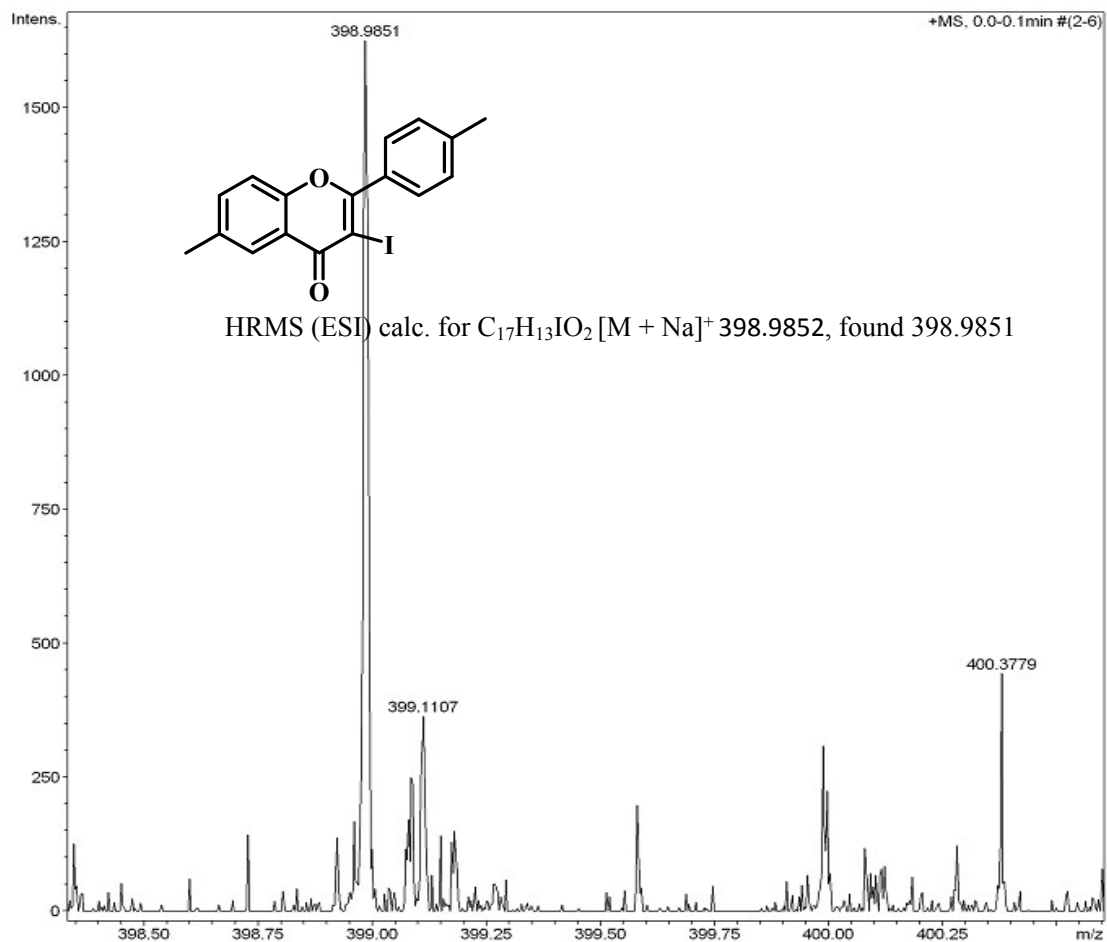
Compound 1d HRMS (MeOH)



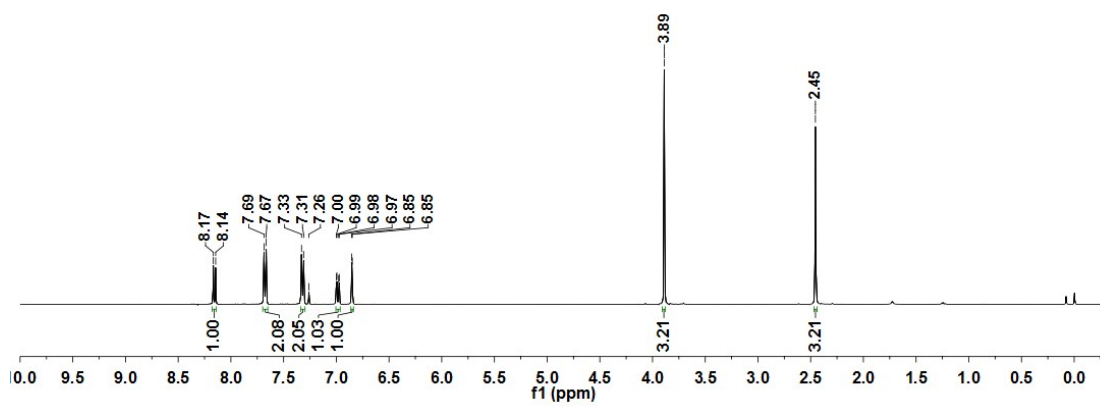
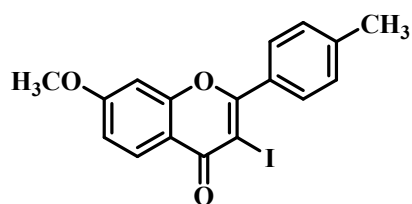
Compound 1f $^1\text{H NMR}(\text{CDCl}_3)$



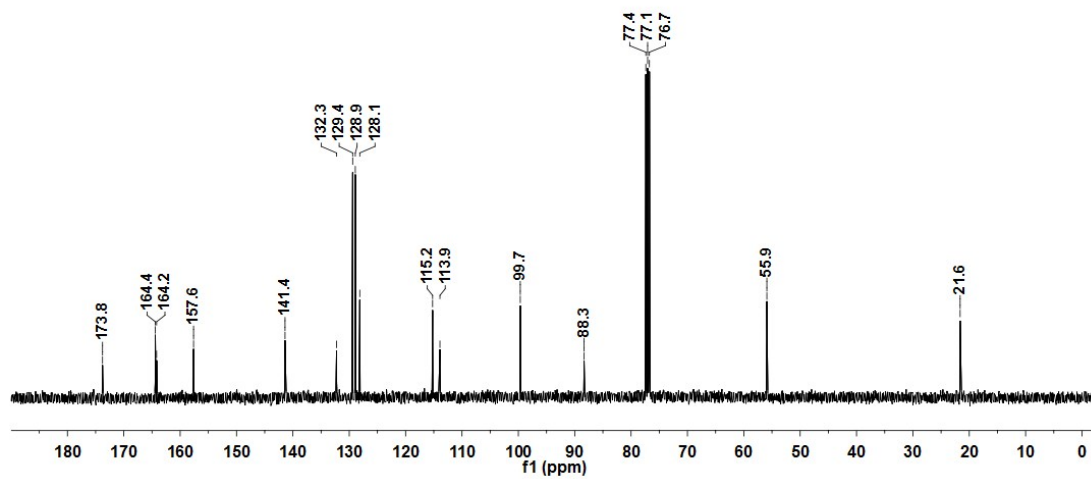
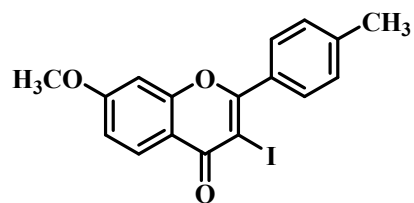
Compound 1f $^{13}\text{C NMR}(\text{CDCl}_3)$



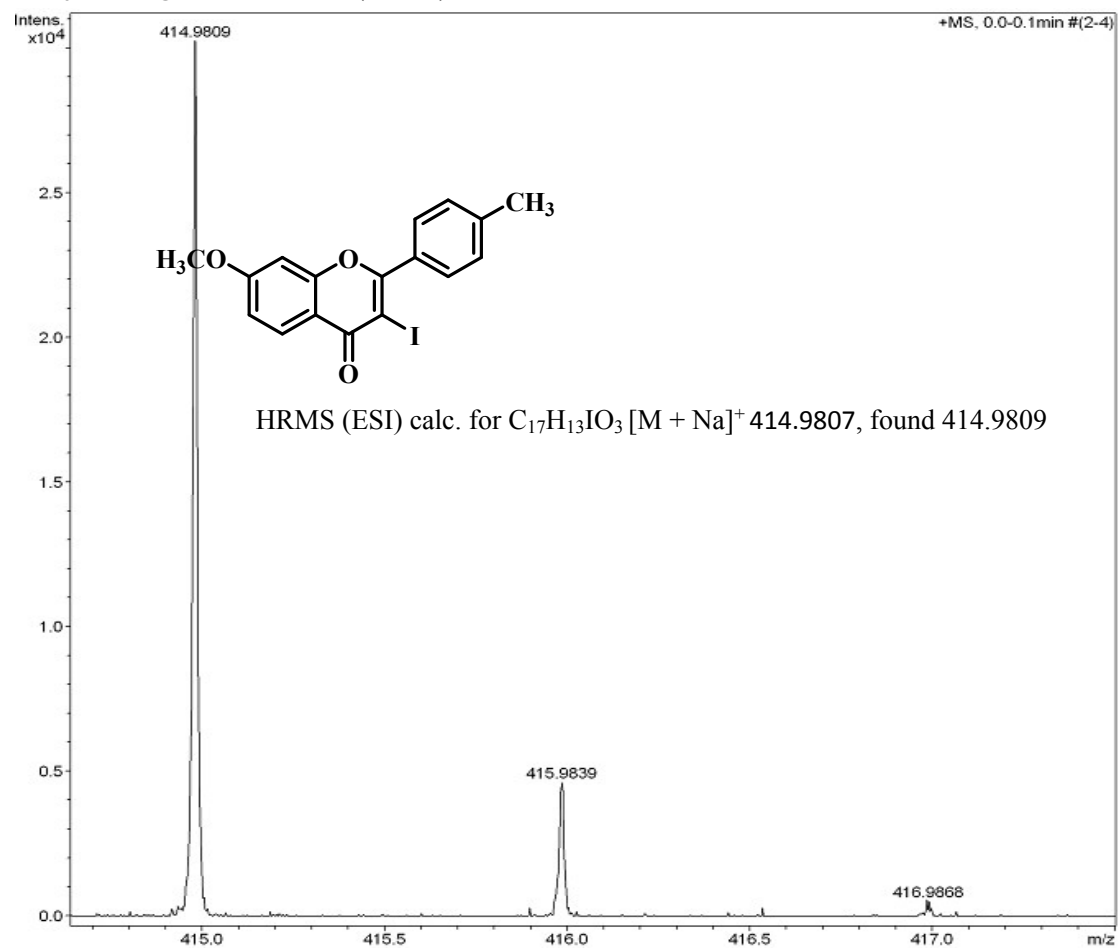
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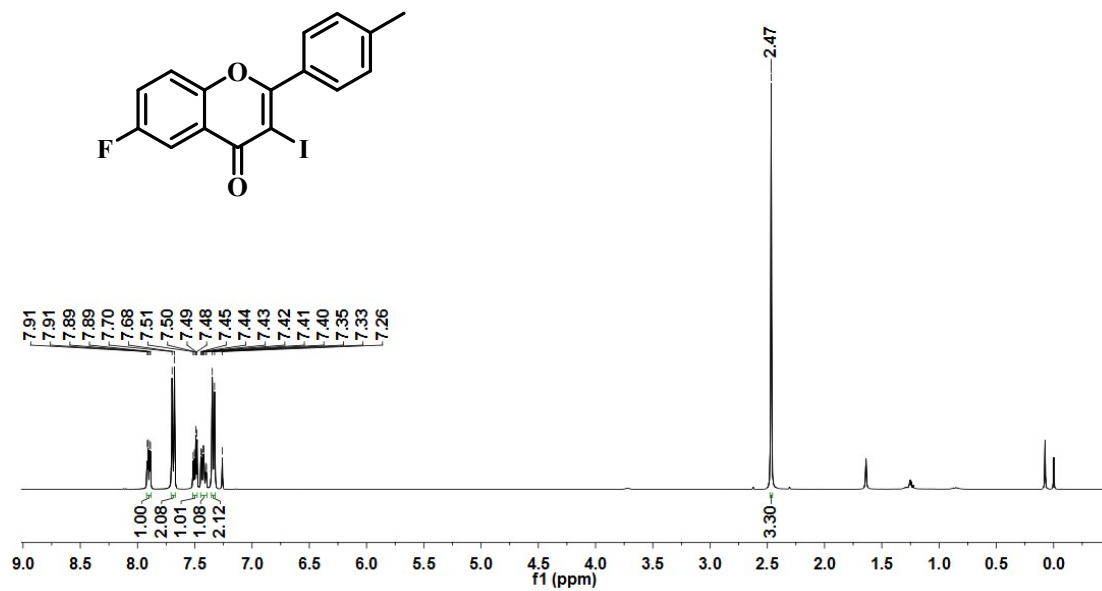
Compound 1g 1H NMR($CDCl_3$)



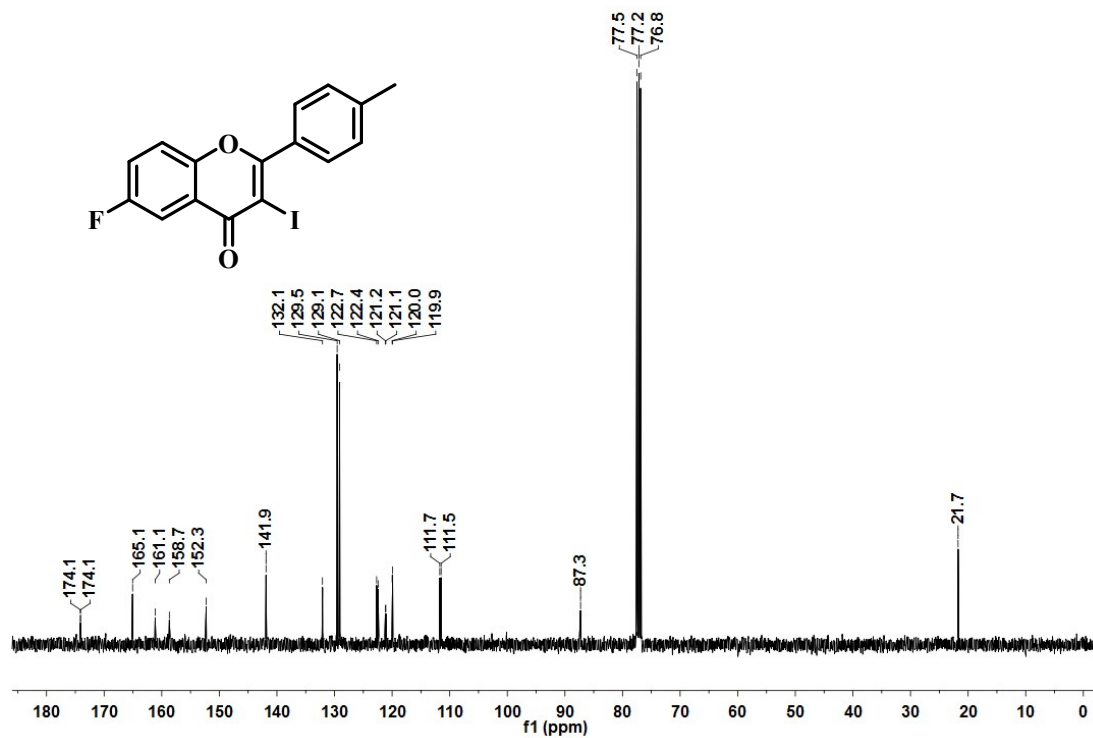
Compound 1g ^{13}C NMR (CDCl_3)



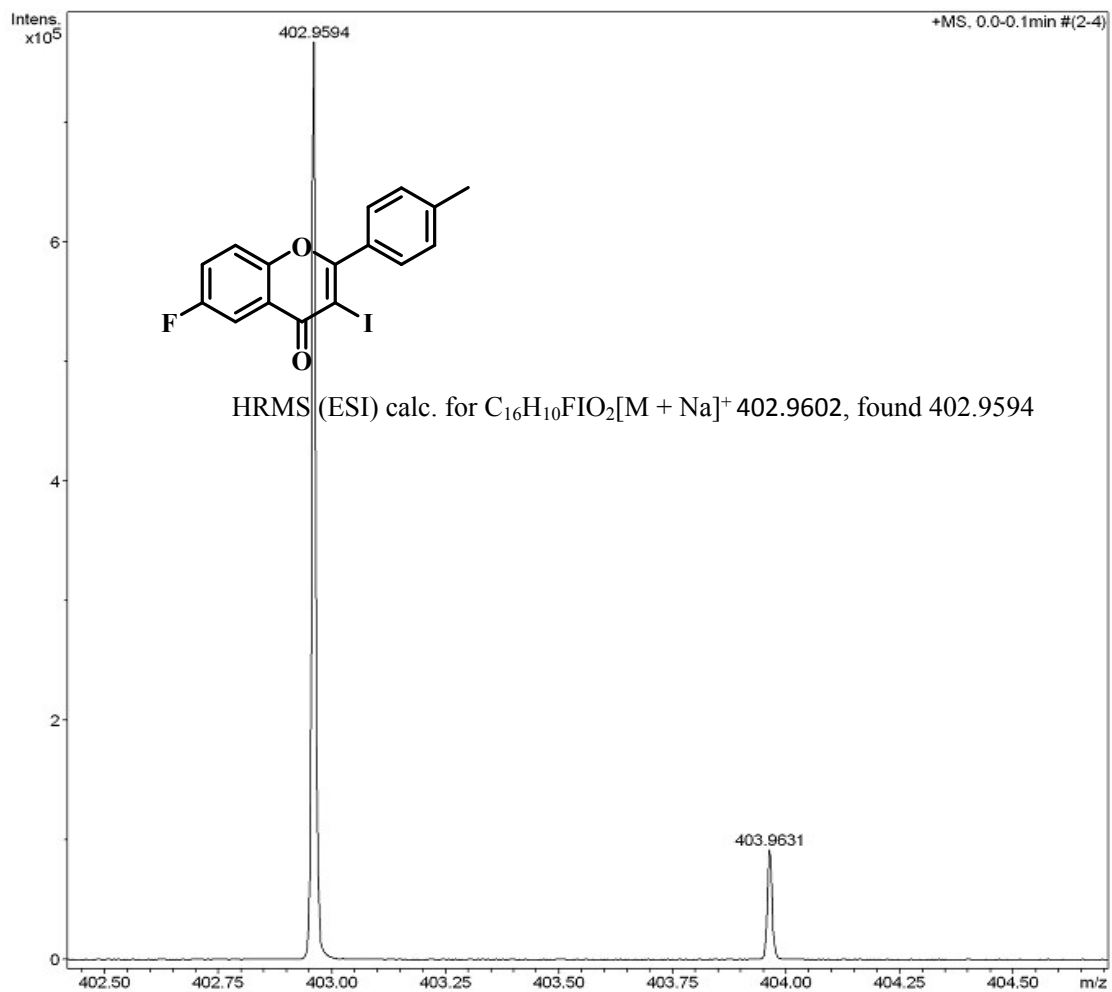
Compound 1g HRMS(MeOH)



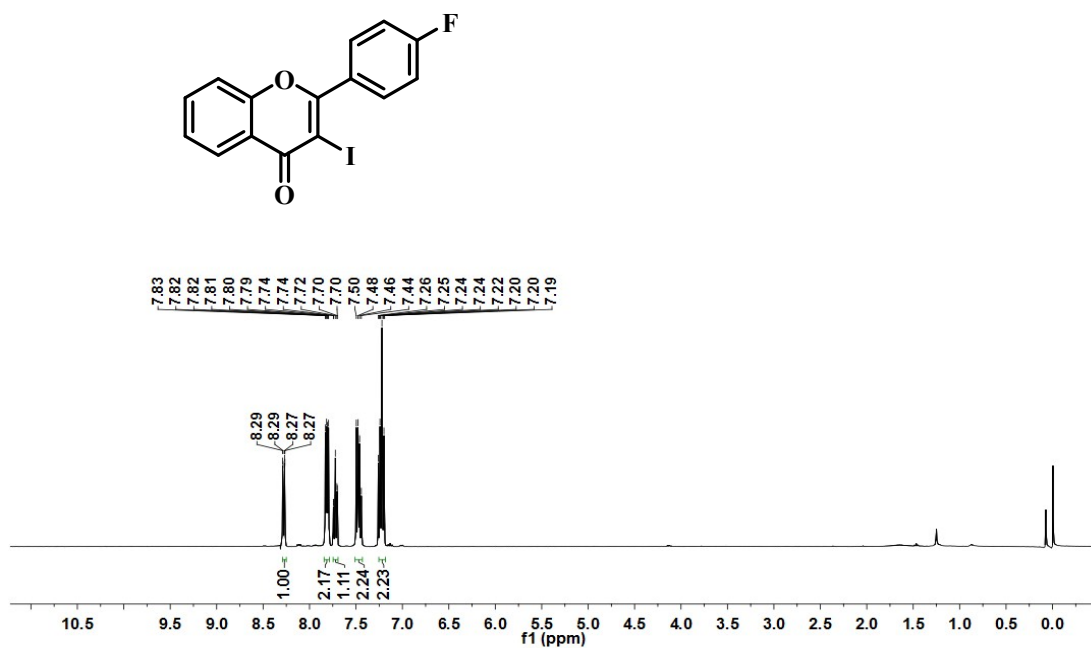
Compound 1h ¹H NMR(CDCl₃)



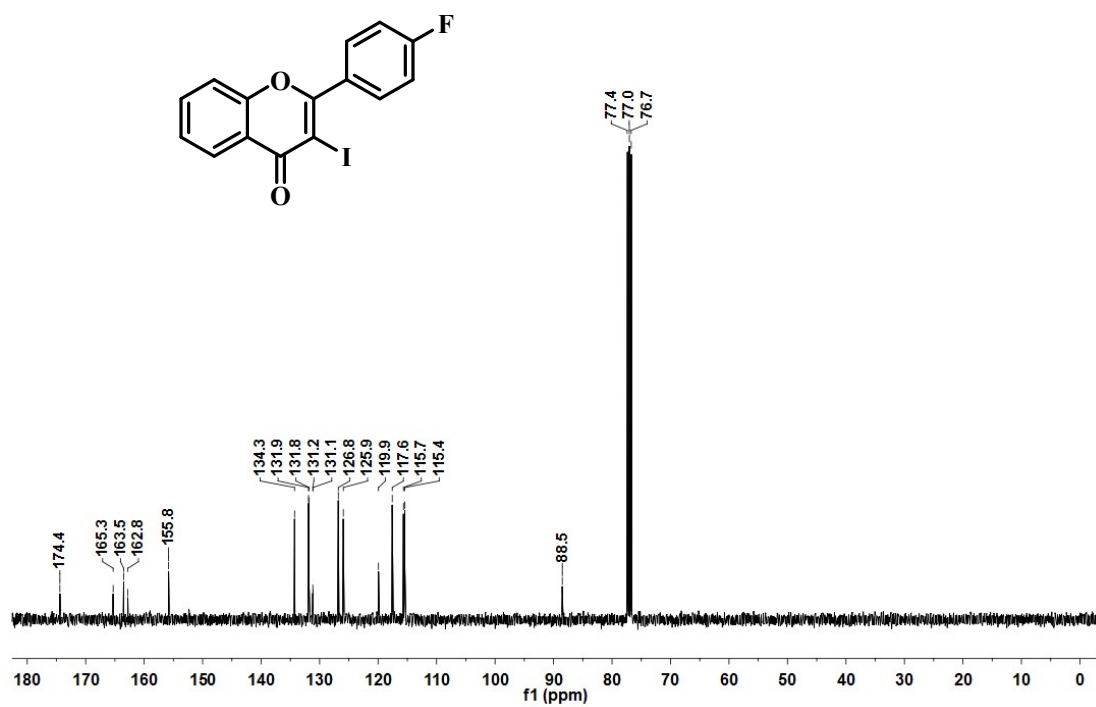
Compound 1h ¹³C NMR (CDCl₃)



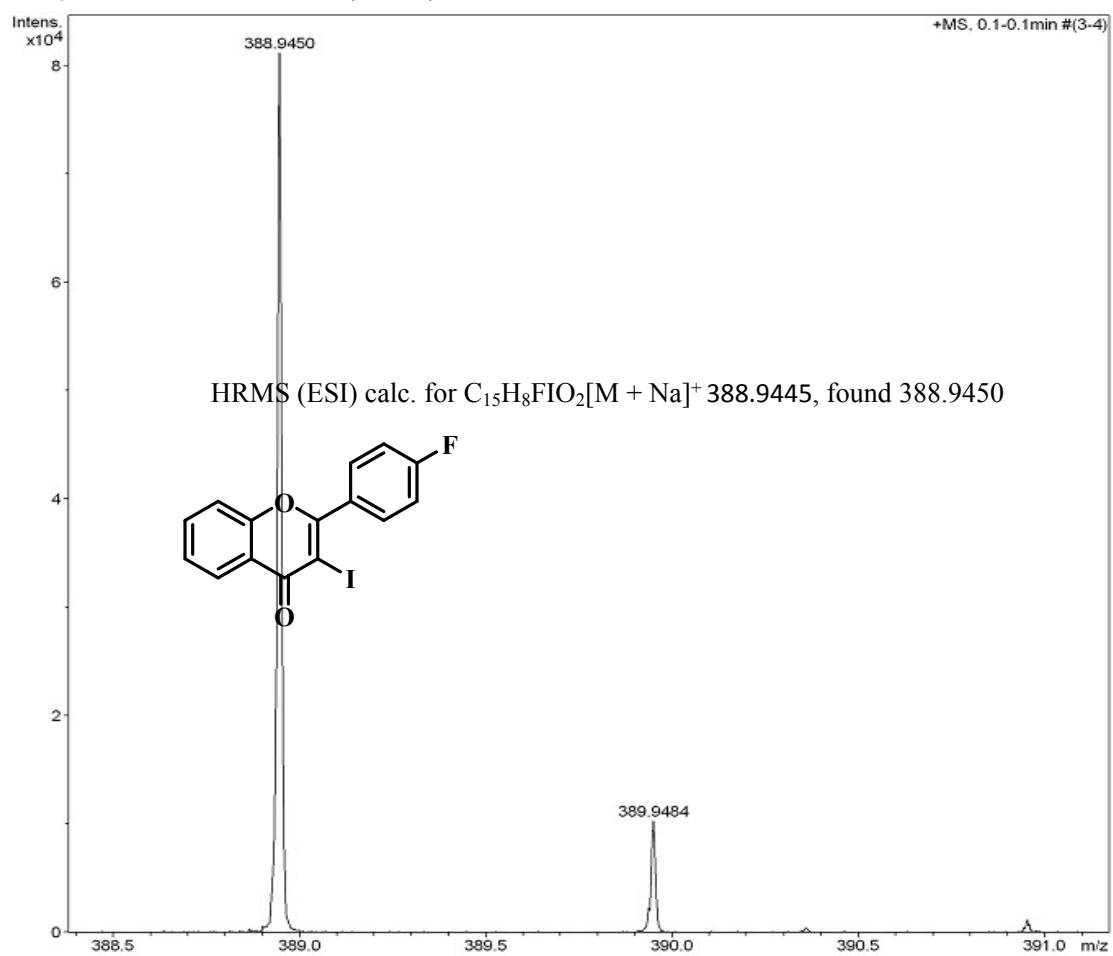
Compound 1h HRMS(MeOH)



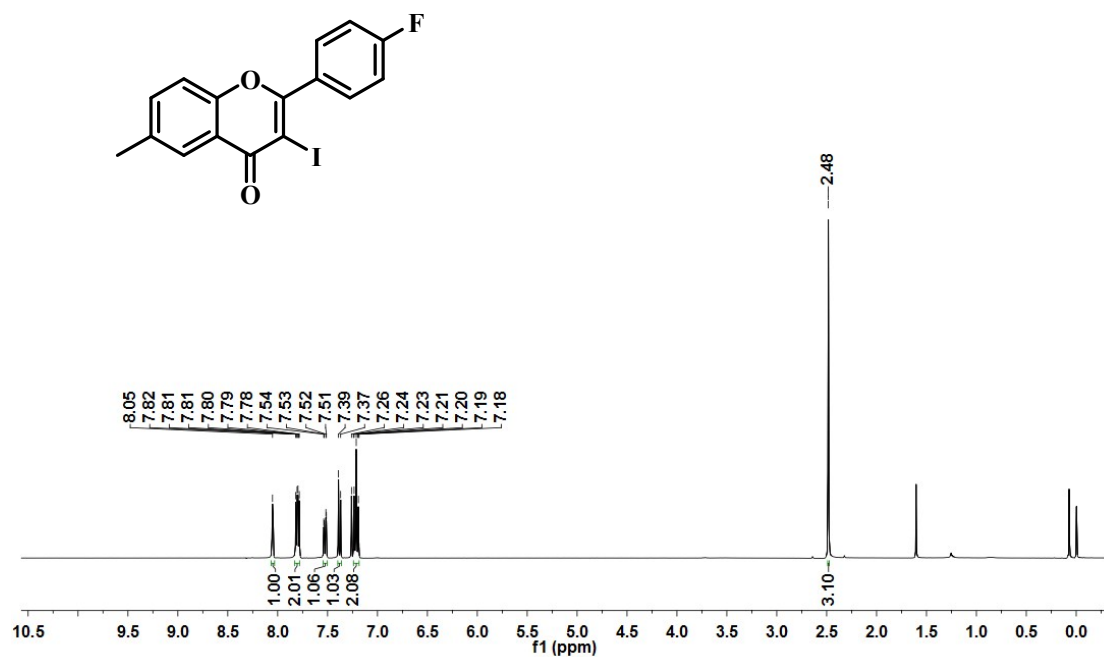
Compound 1m 1H NMR($CDCl_3$)



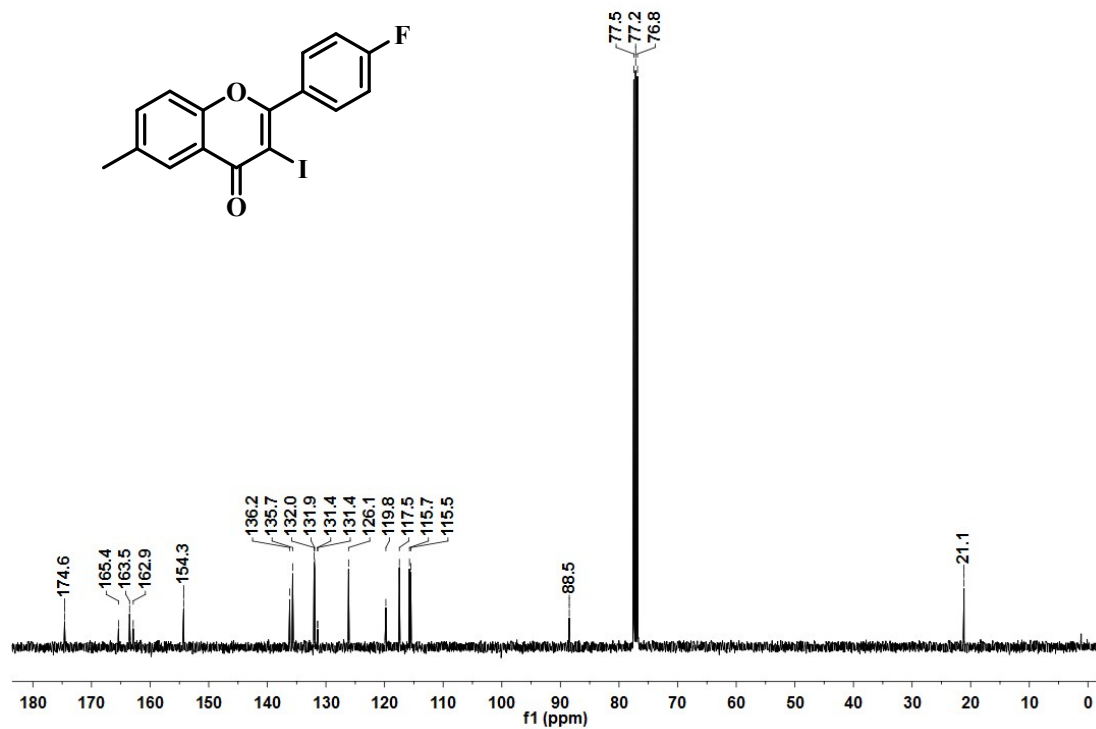
Compound 1m ¹³C NMR (CDCl₃)



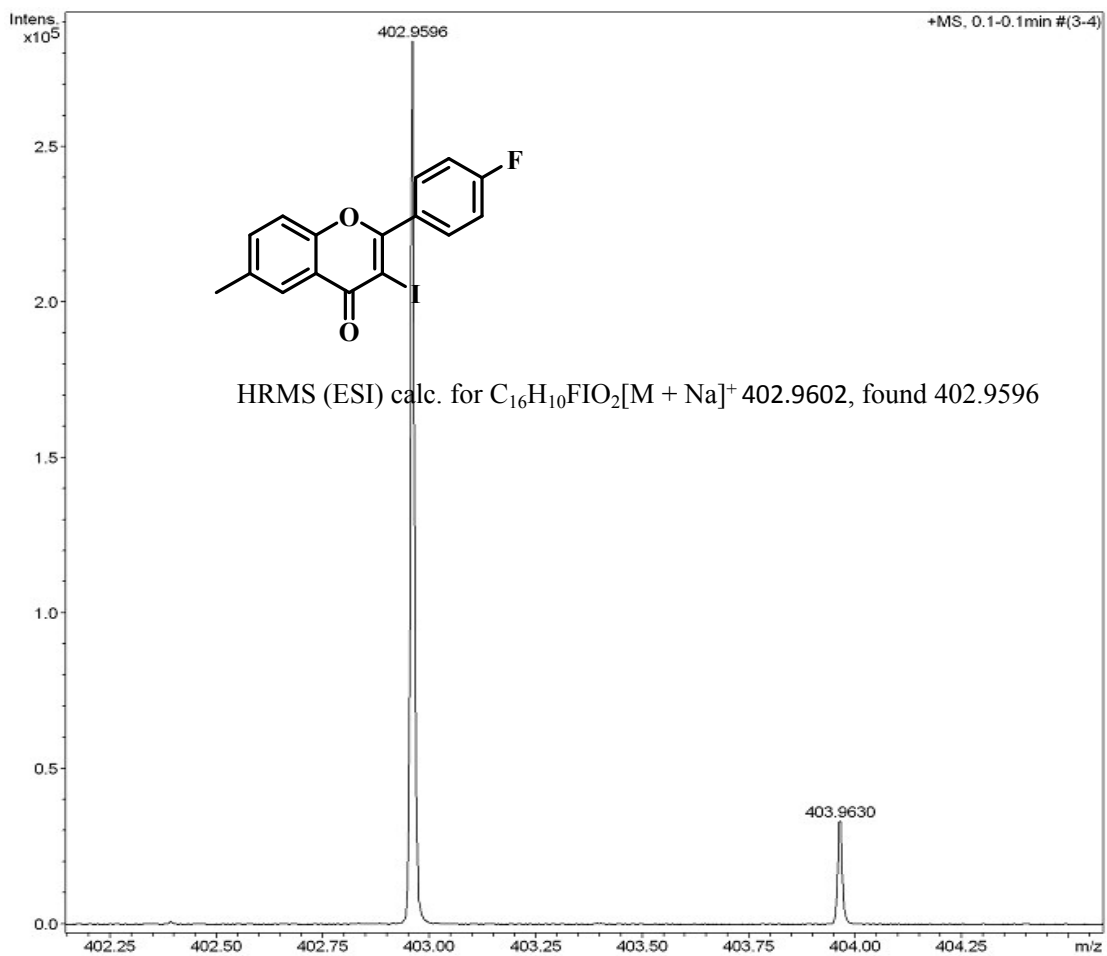
Compound 1m HRMS(MeOH)



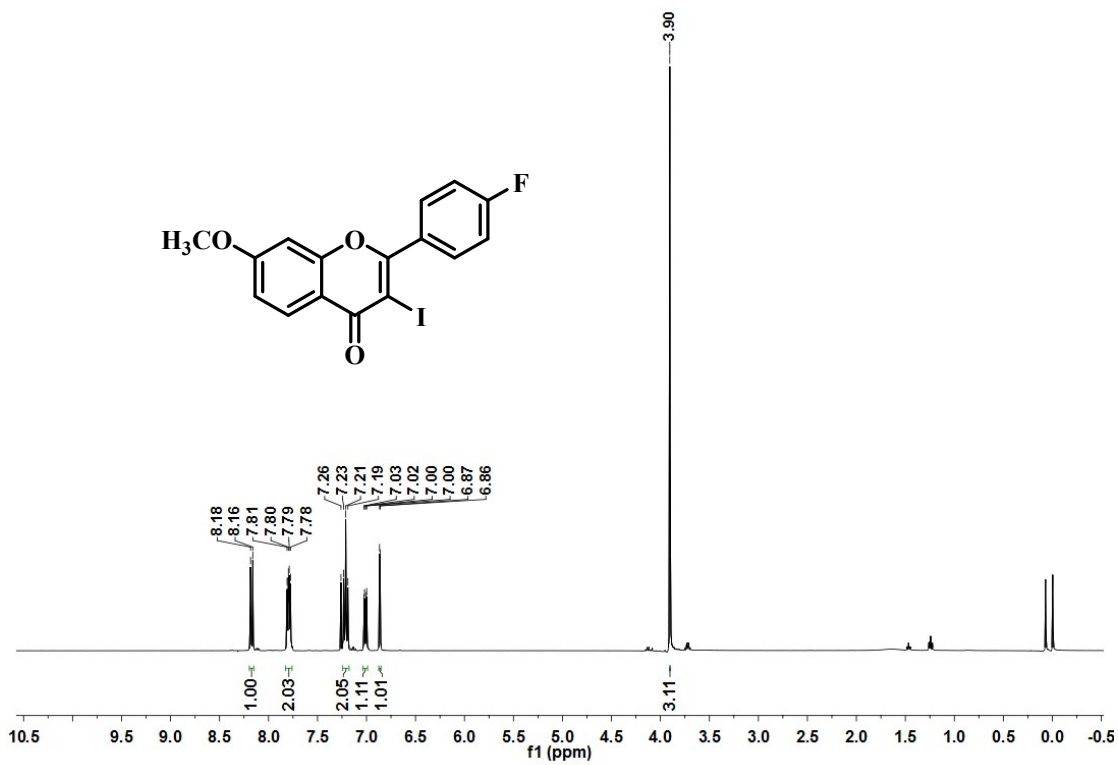
Compound 1n $^1\text{H NMR}$ (CDCl₃)



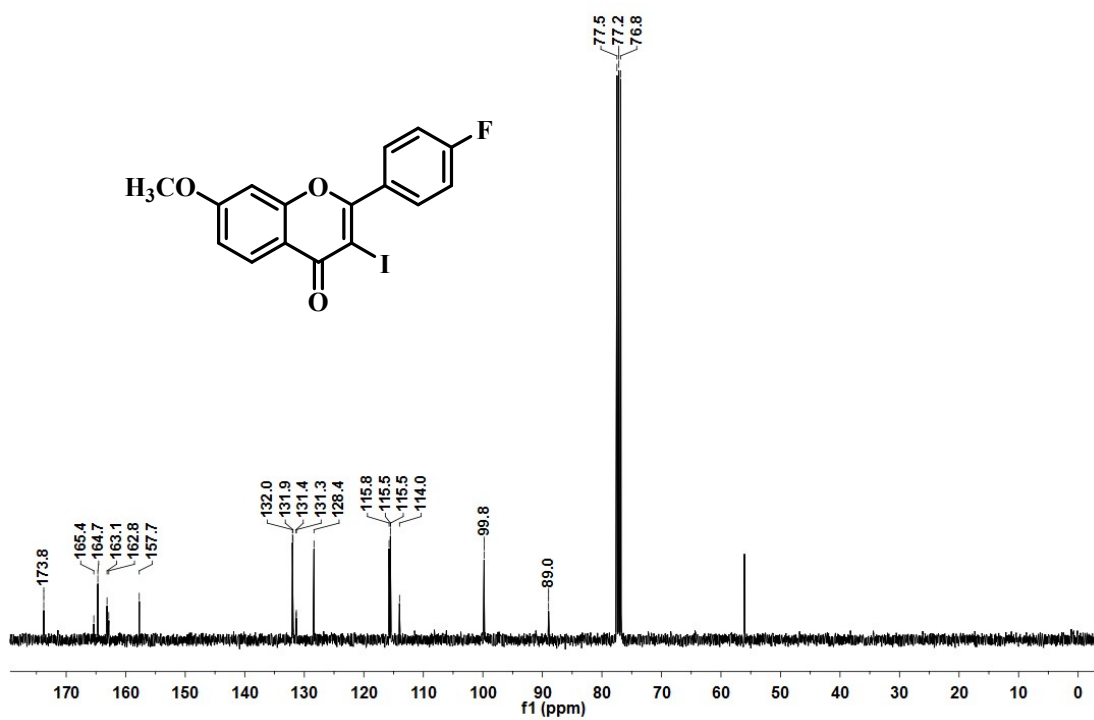
Compound 1n $^{13}\text{C NMR}$ (CDCl₃)



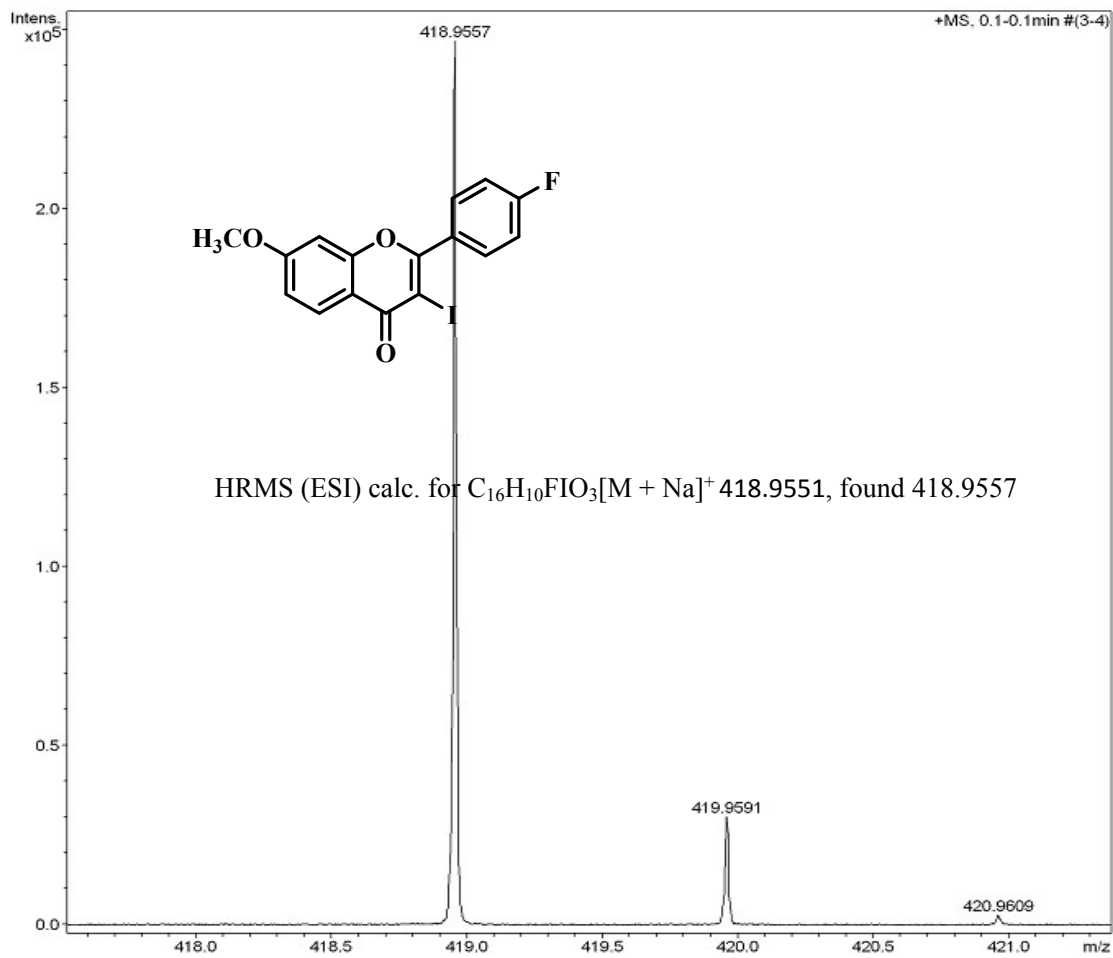
Compound 1n HRMS(MeOH)



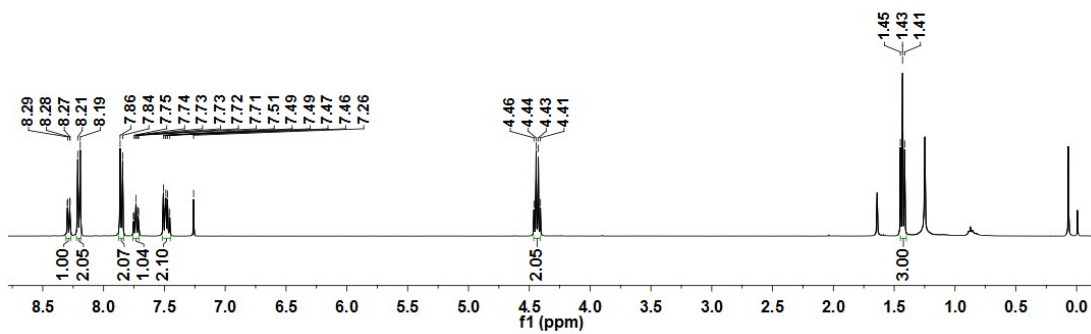
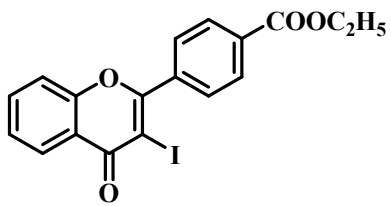
Compound 1o 1H NMR(CDCl₃)



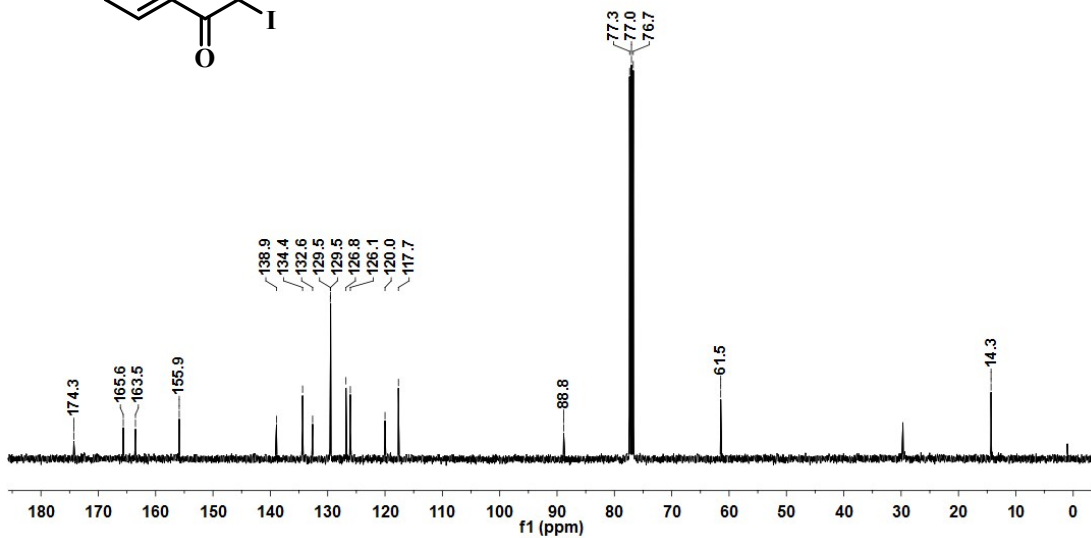
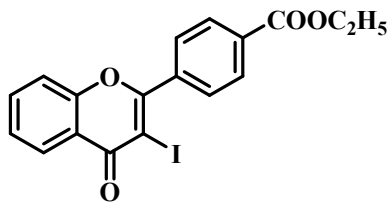
Compound 1o ^{13}C NMR (CDCl₃)



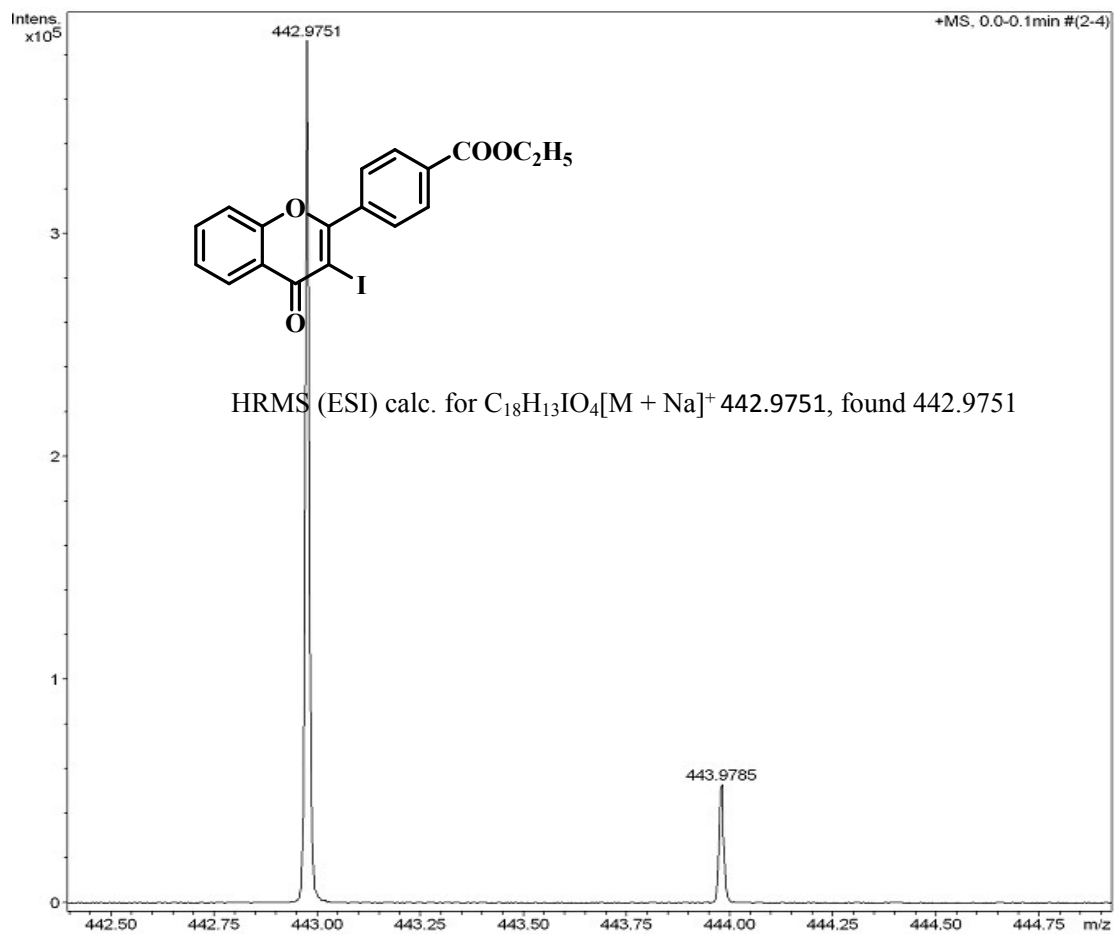
Compound 1o HRMS(MeOH)



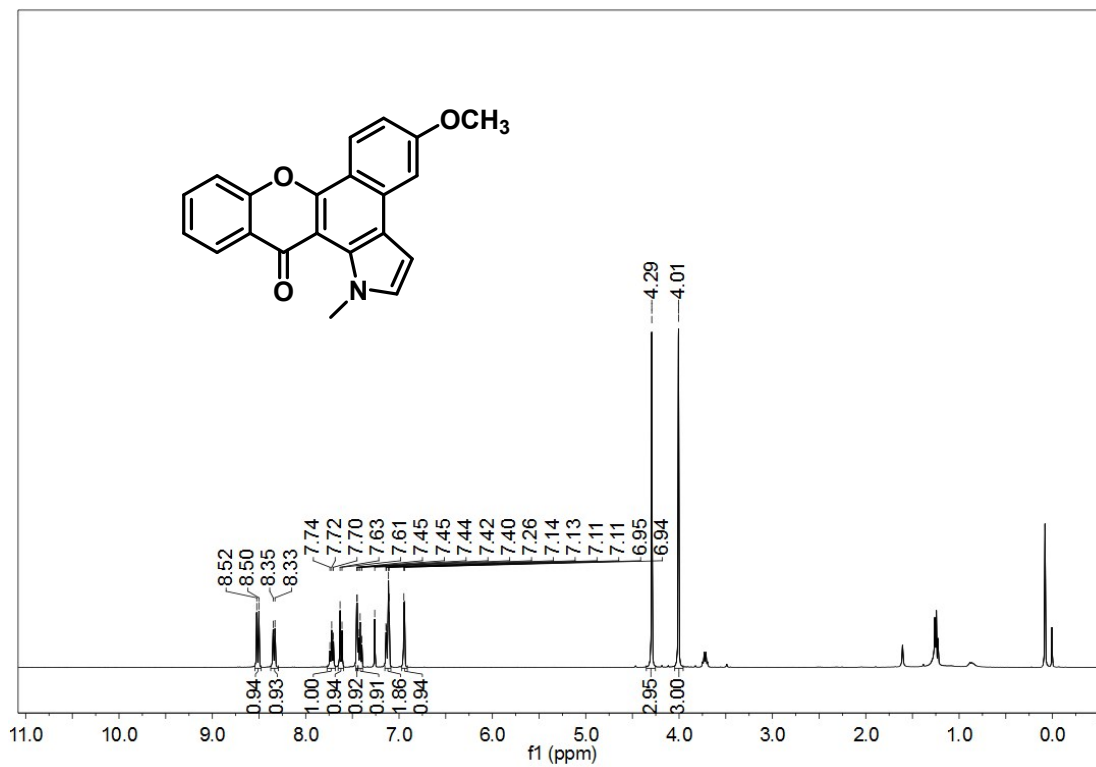
Compound 1p $^1\text{H NMR}(\text{CDCl}_3)$



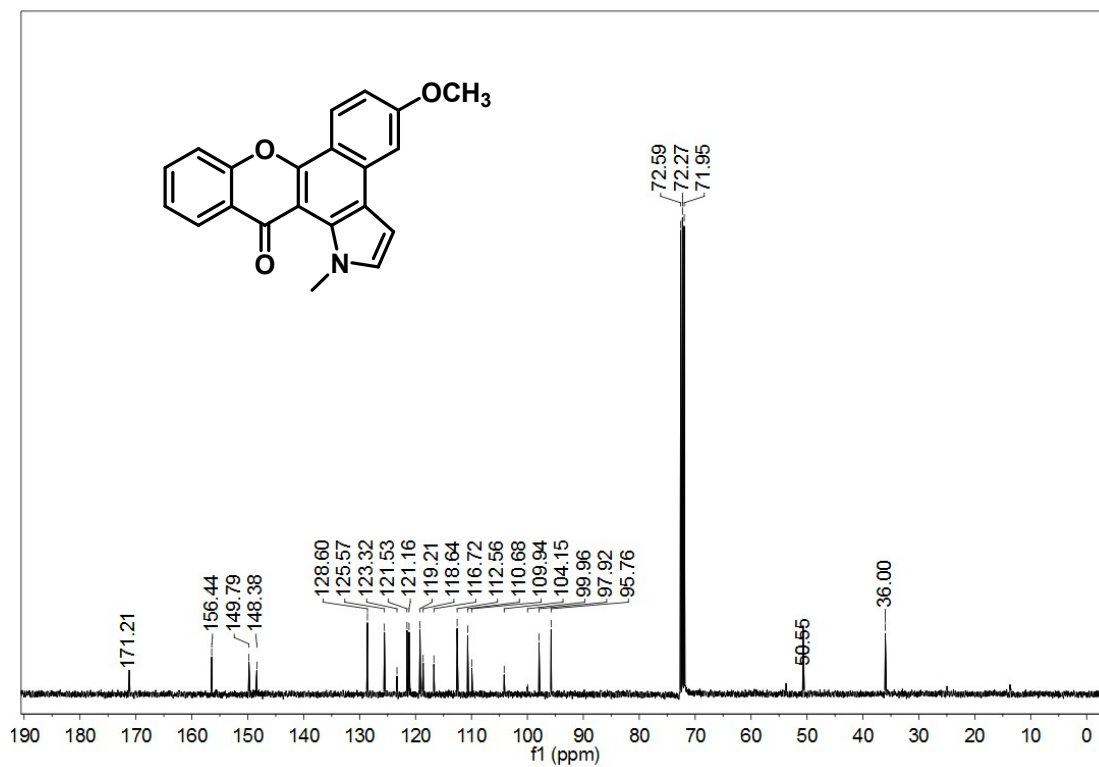
Compound 1p $^{13}\text{C NMR}(\text{CDCl}_3)$



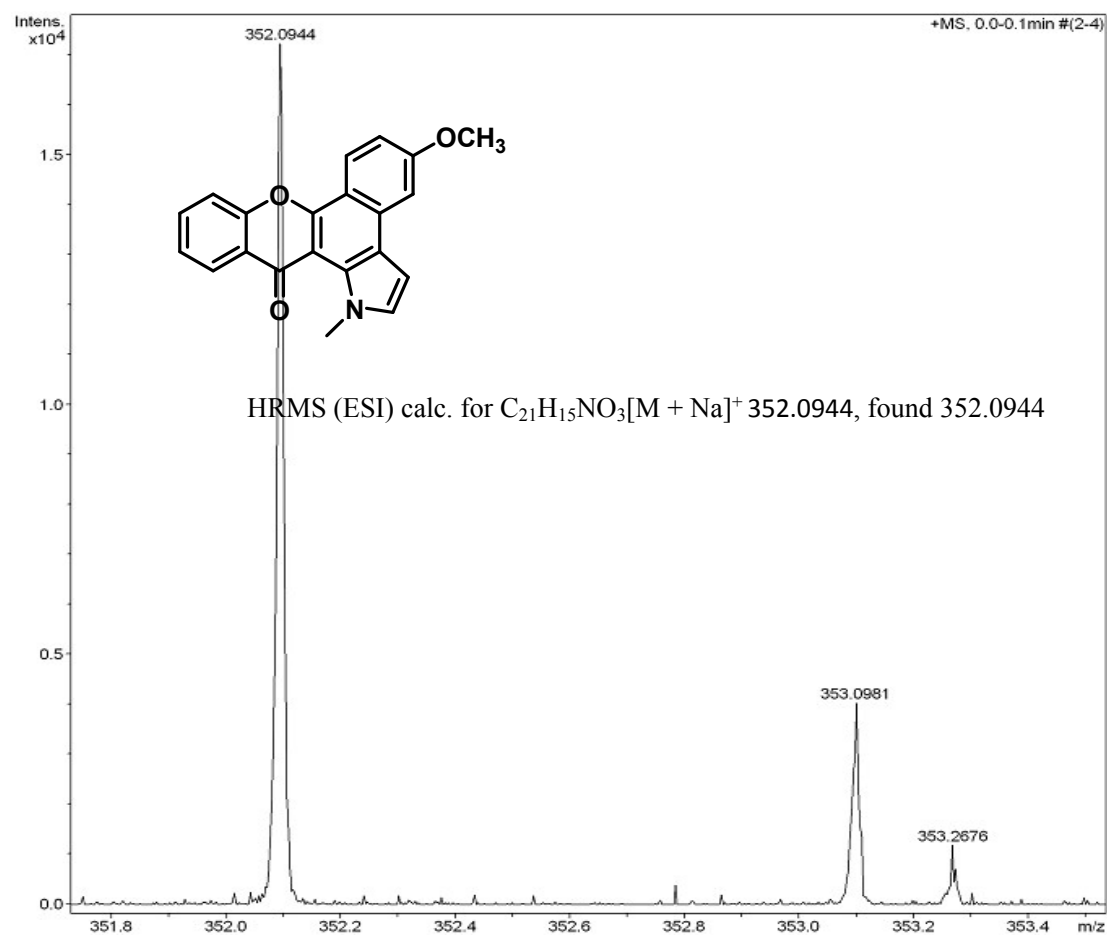
Compound 1p HRMS(MeOH)



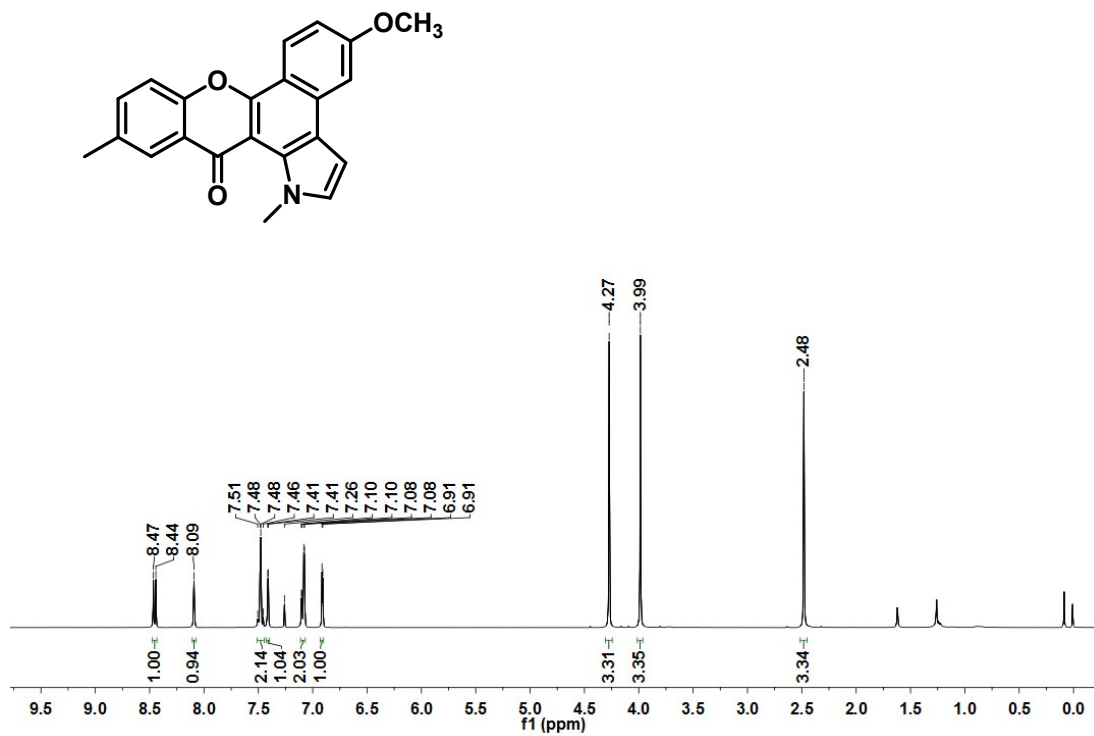
Compound 3a ¹H NMR(CDCl₃)



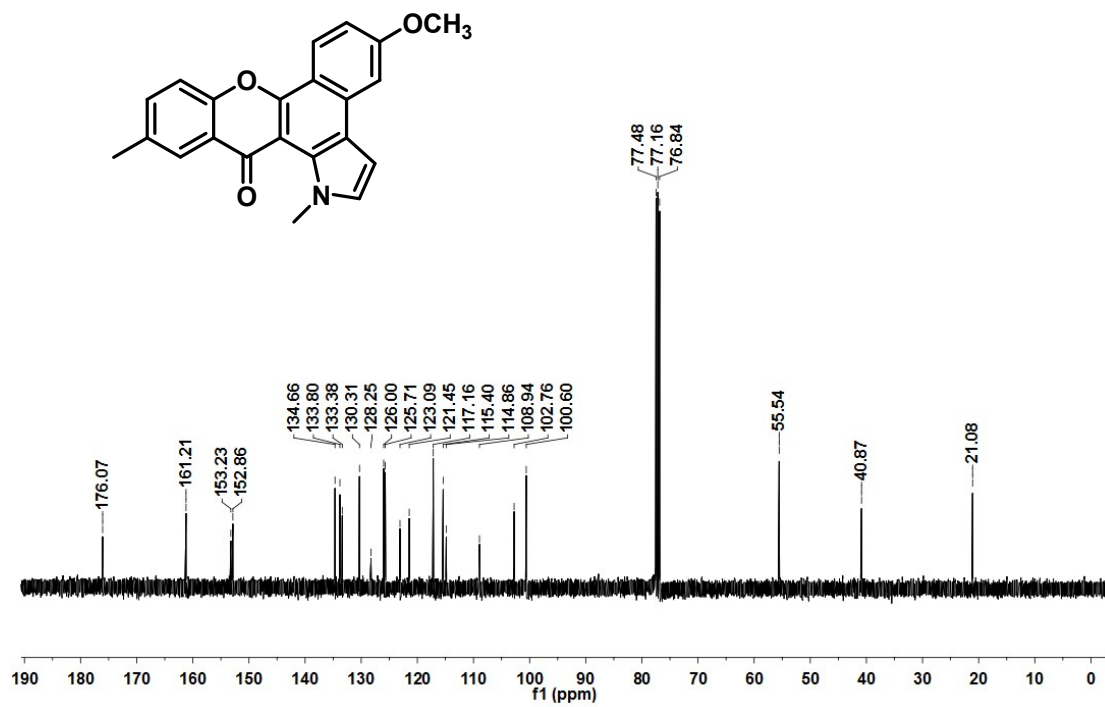
Compound 3a ¹³C NMR (CDCl₃)



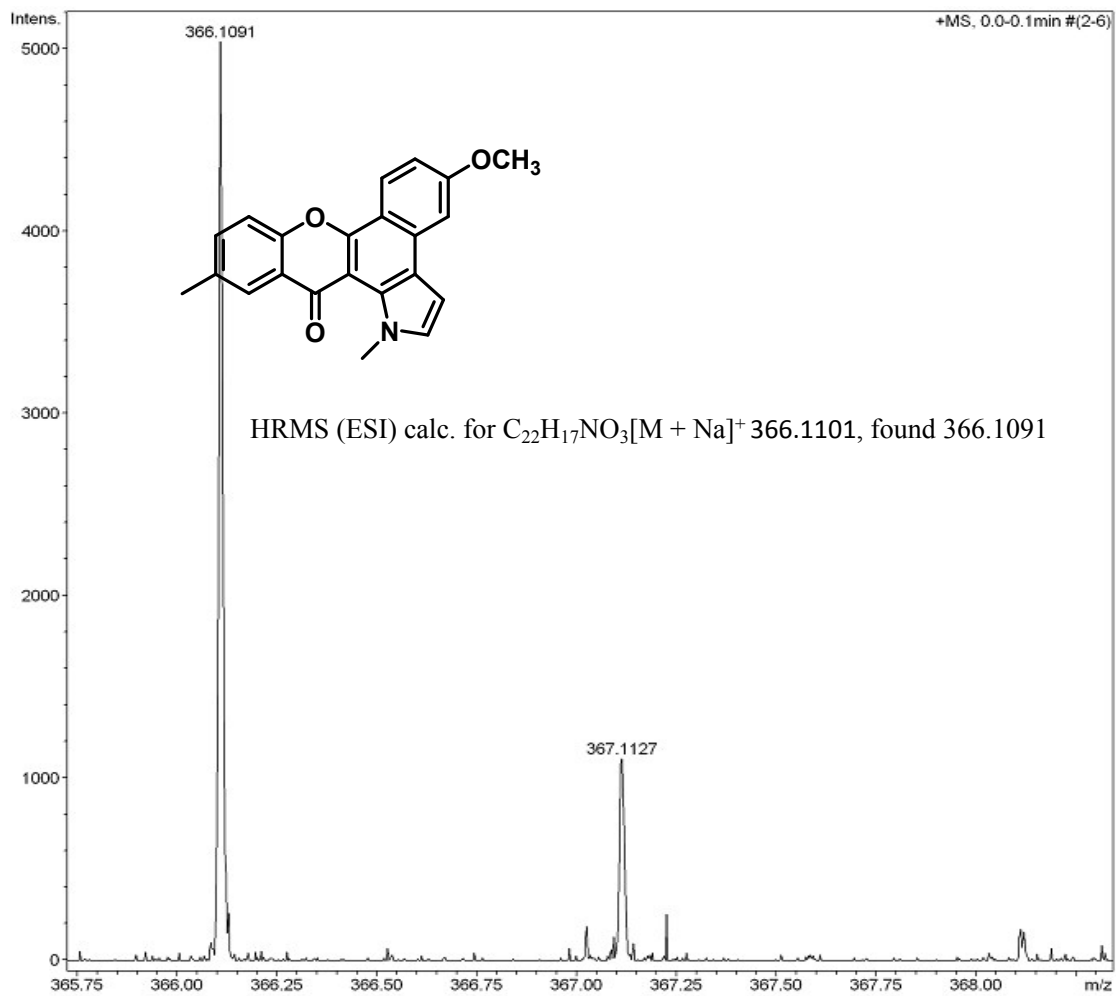
Compound 3a HRMS(MeOH)



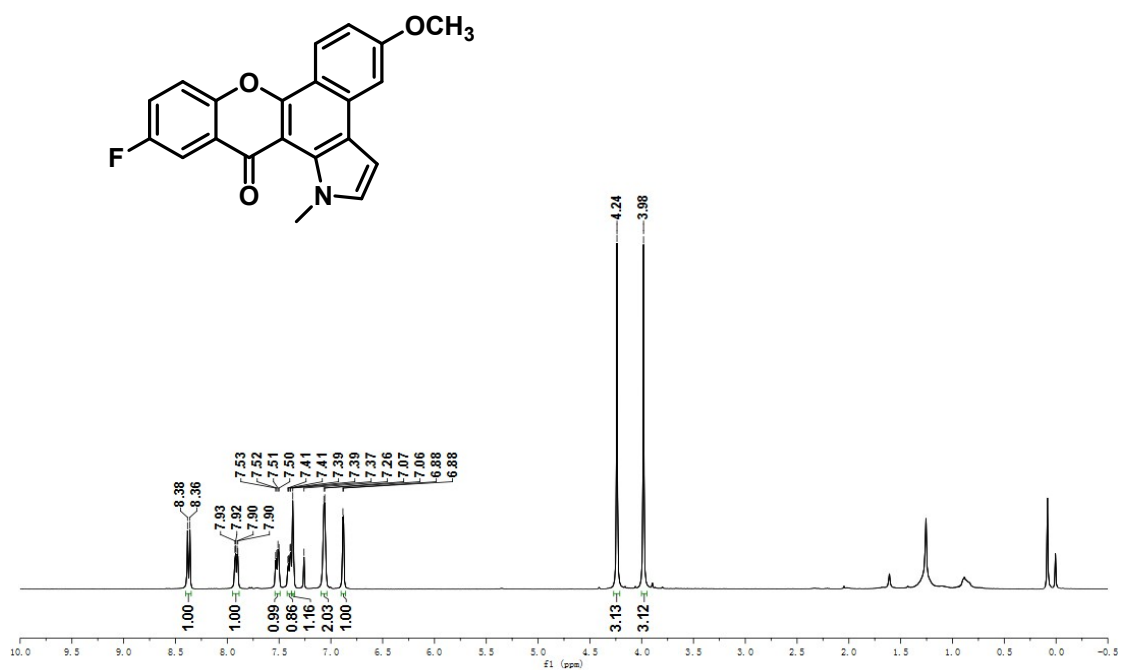
Compound 3b ¹H NMR(CDCl₃)



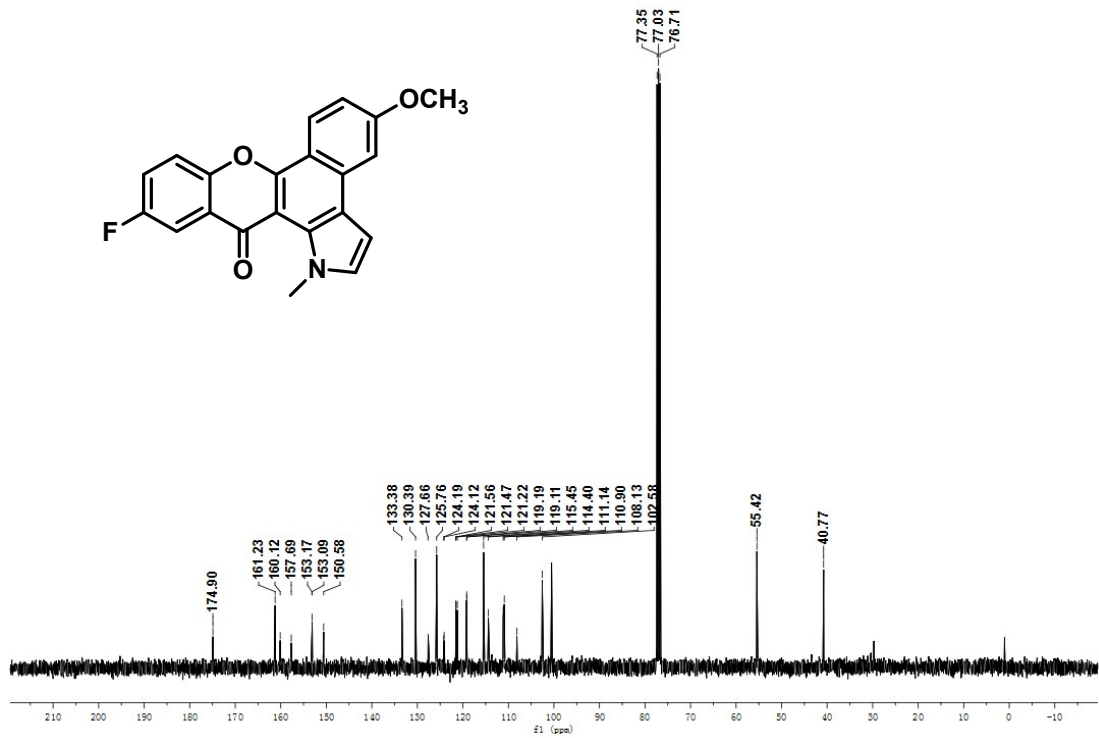
Compound 3b ¹³C NMR (CDCl₃)



Compound 3b HRMS(MeOH)

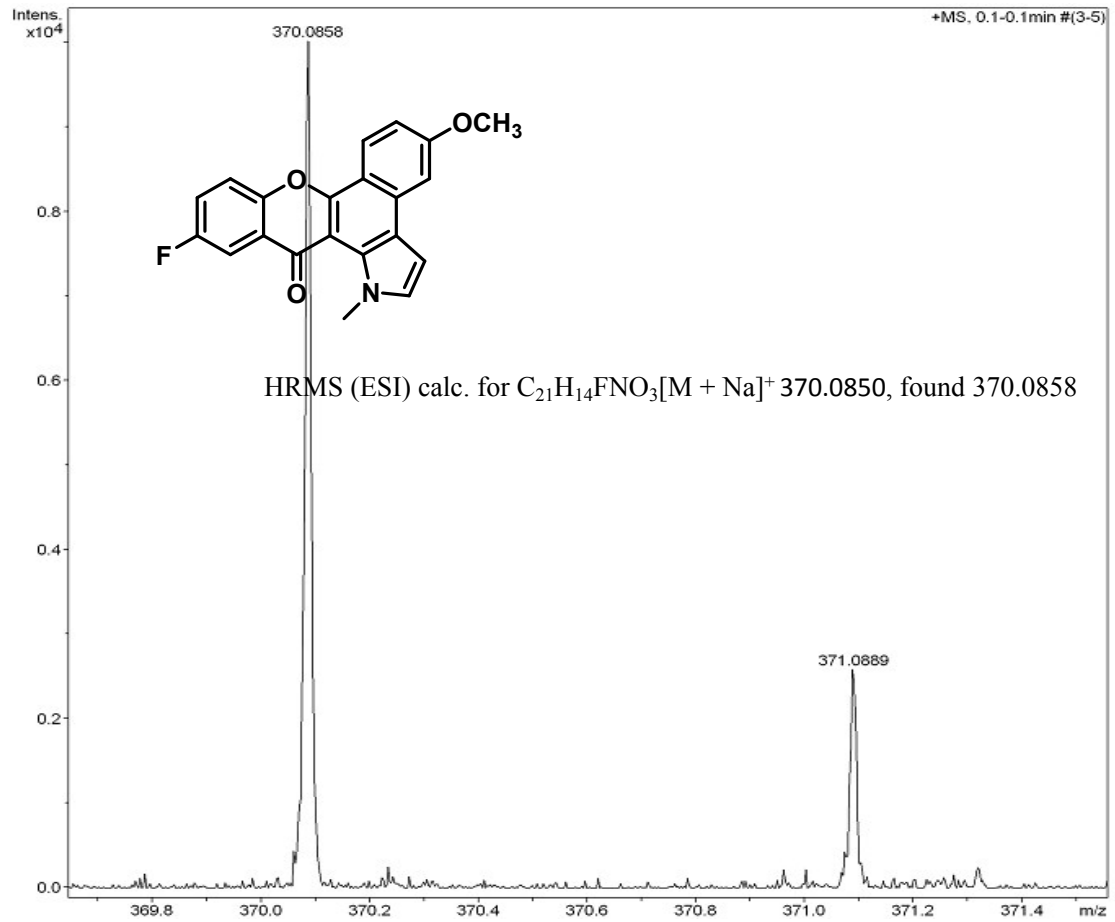


Compound 3c 1H NMR(CDCl₃)



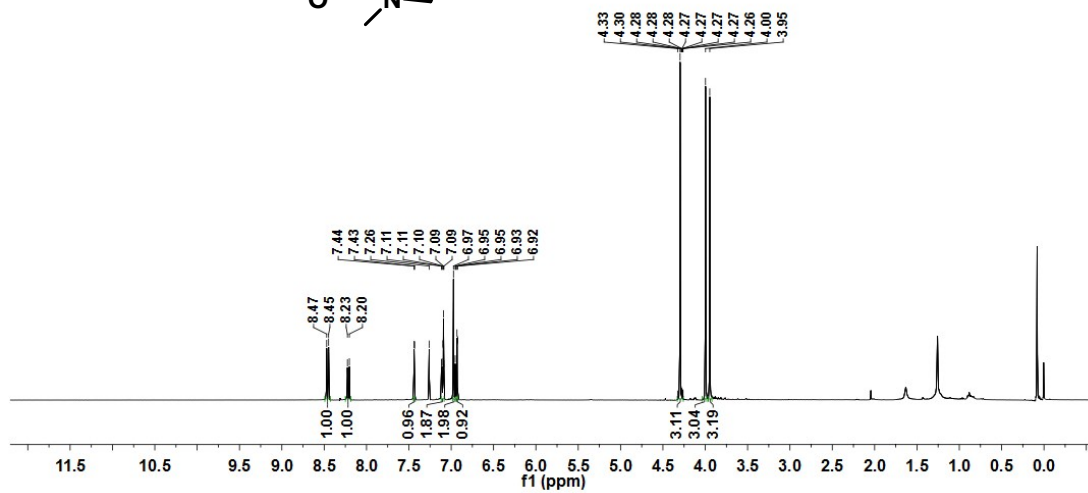
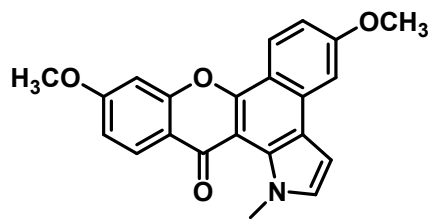
Compound 3c

¹³C NMR (CDCl₃)

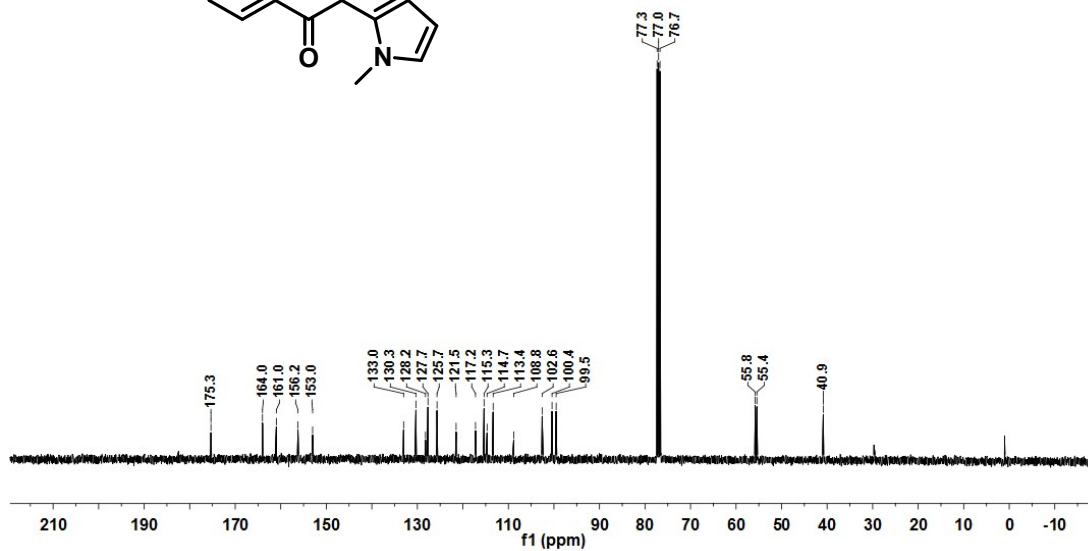
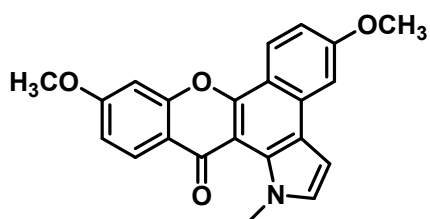


Compound 3c

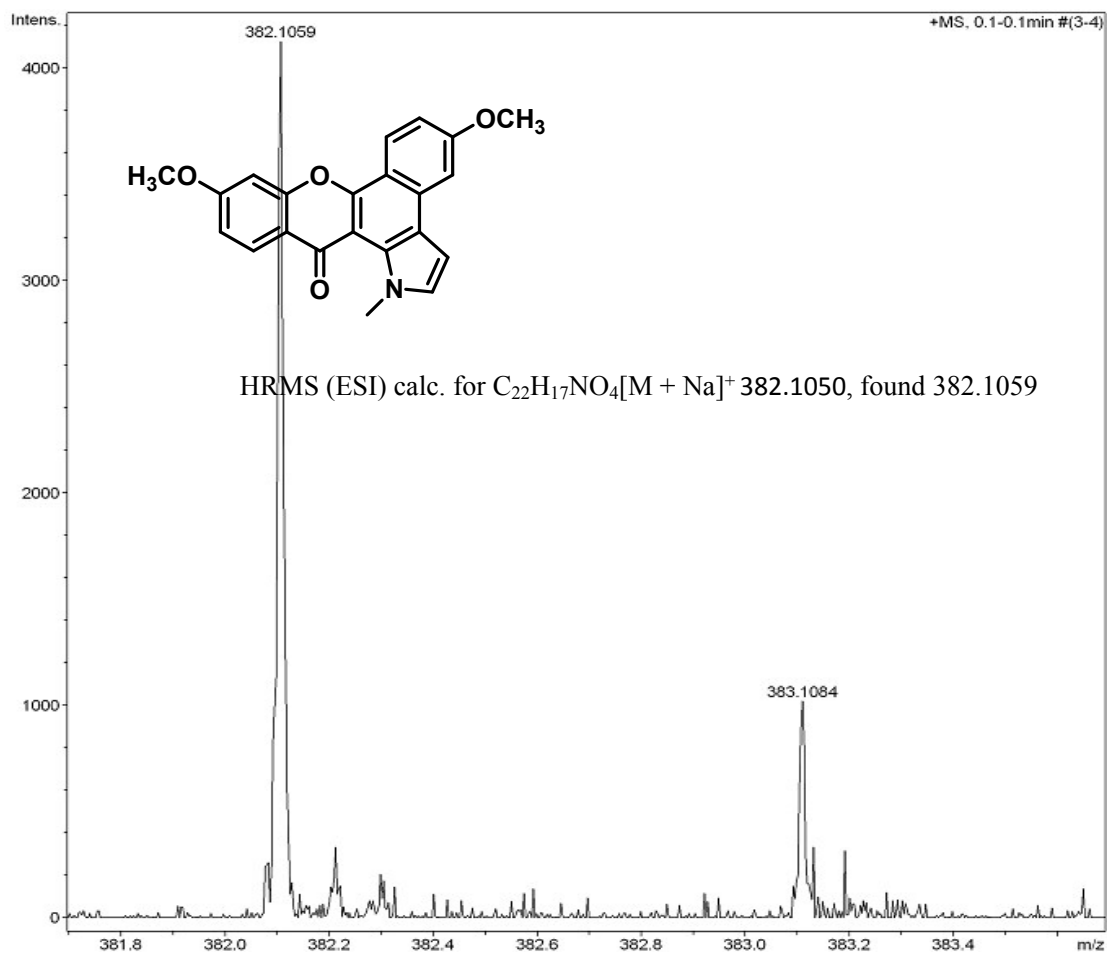
HRMS(MeOH)



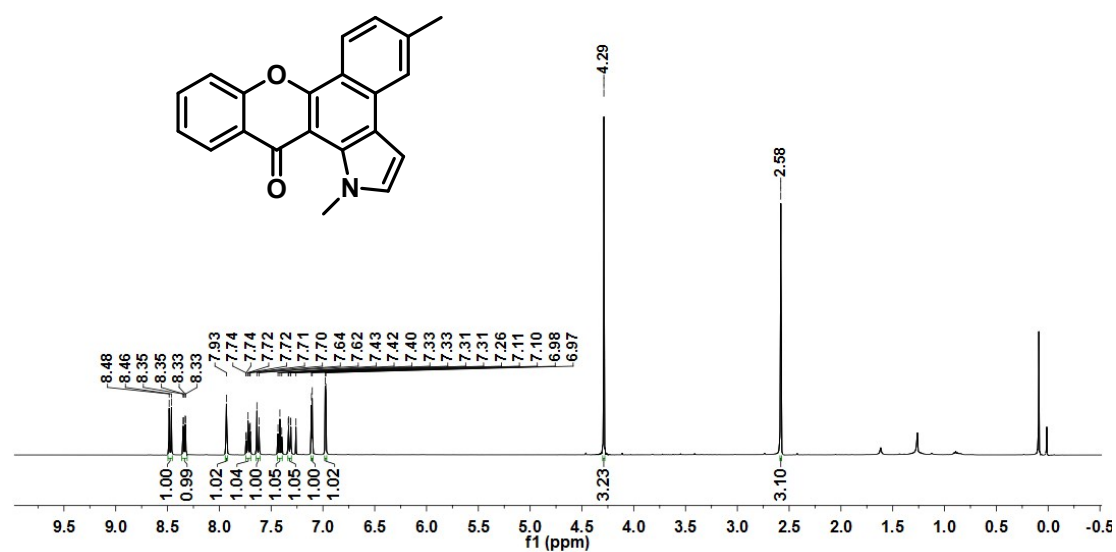
Compound 3d $^1\text{H NMR}(\text{CDCl}_3)$



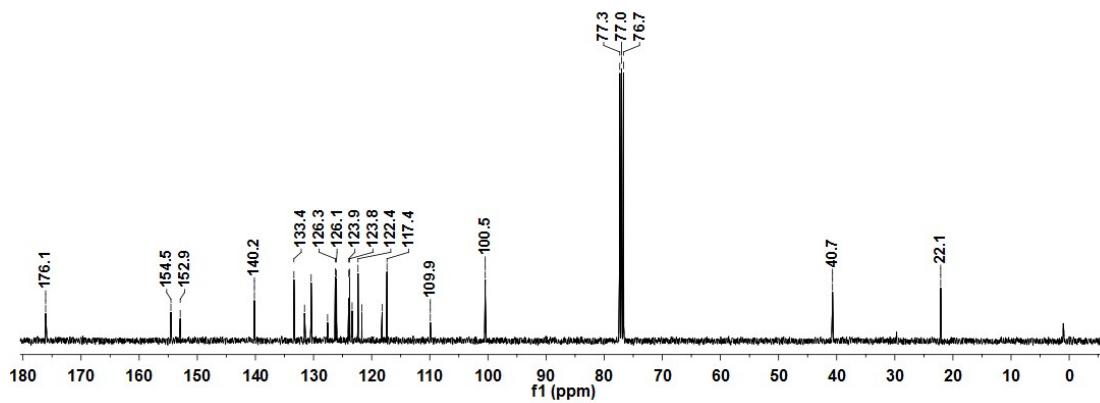
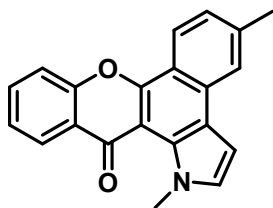
Compound 3d $^{13}\text{C NMR}(\text{CDCl}_3)$



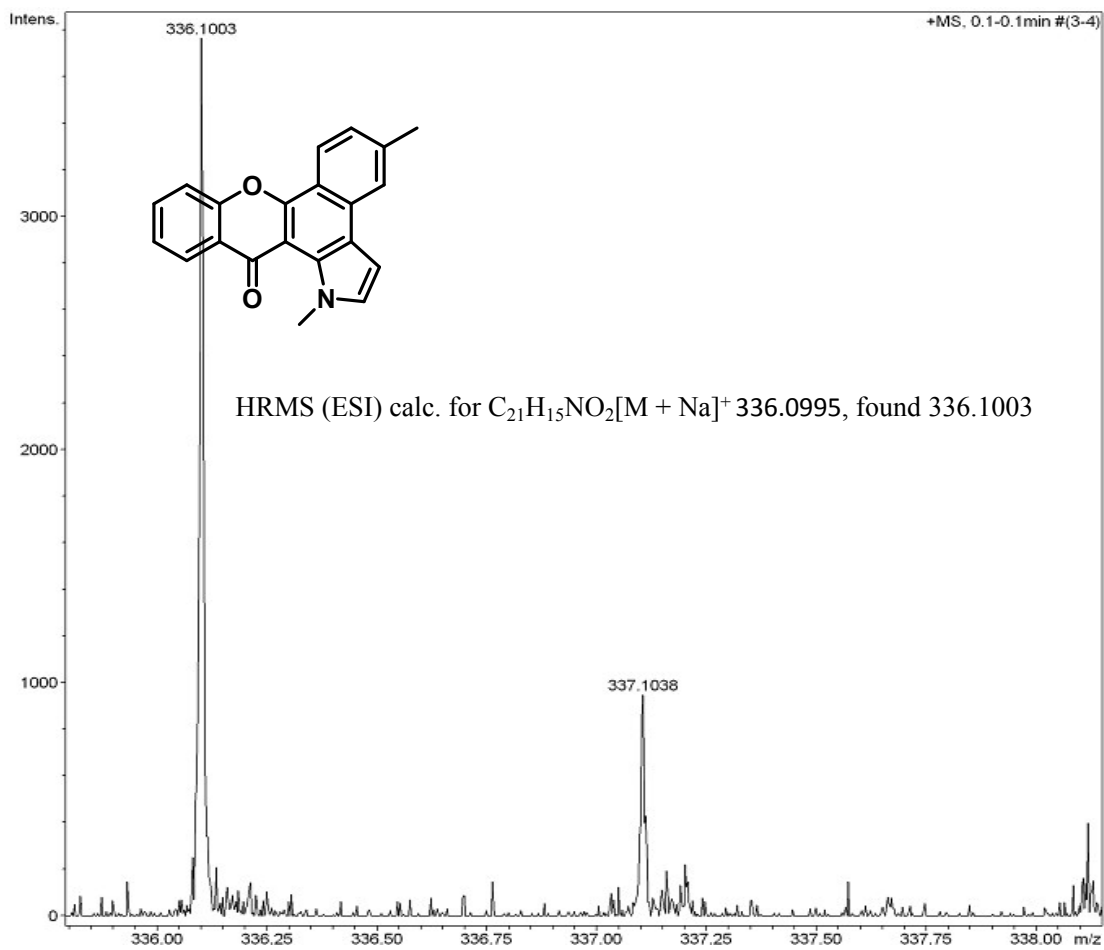
Compound 3d HRMS(MeOH)



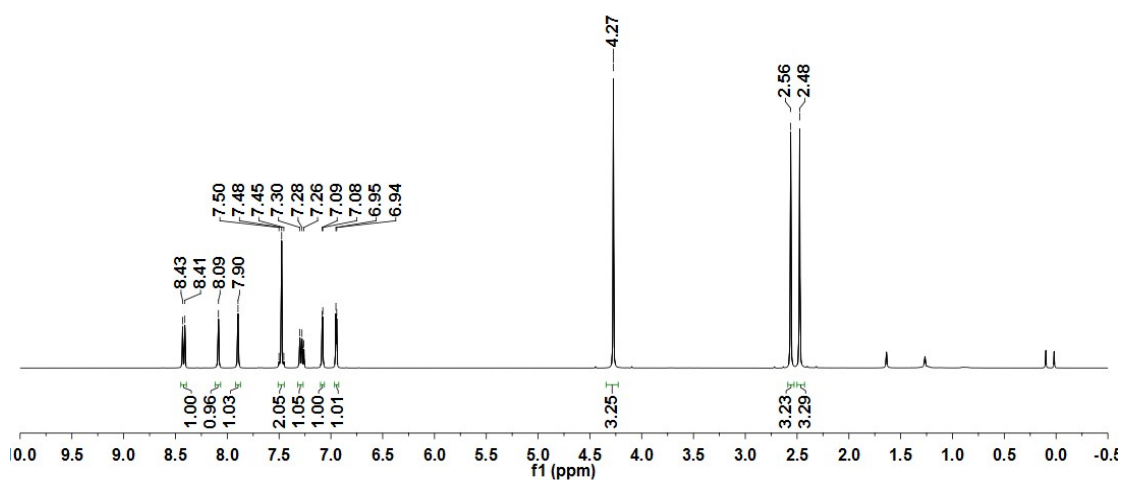
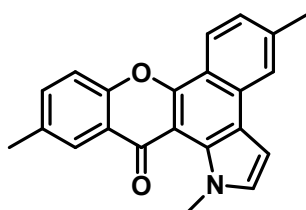
Compound 3e 1H NMR($CDCl_3$)



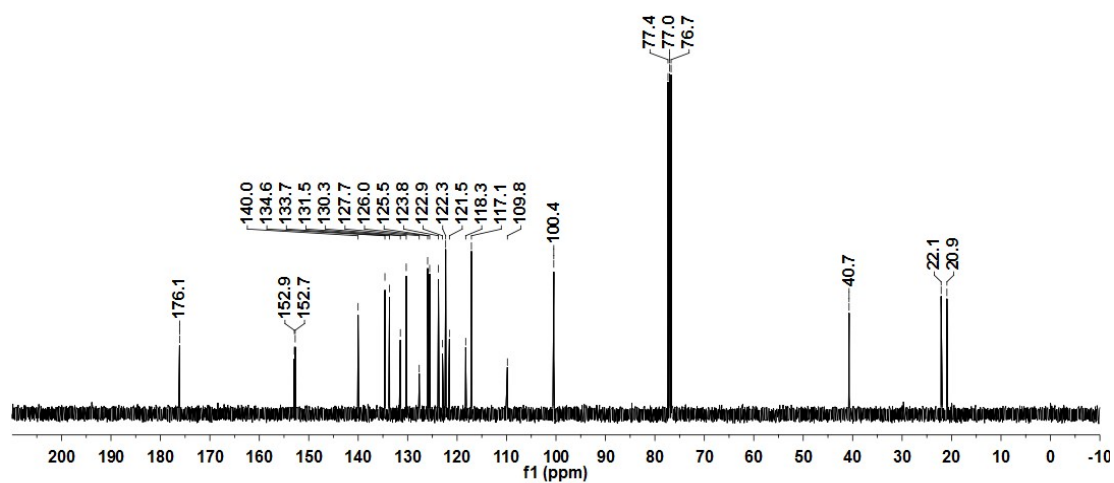
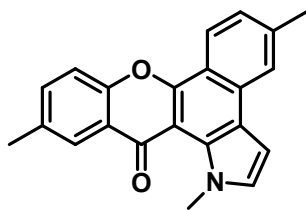
Compound 3e ^{13}C NMR (CDCl_3)



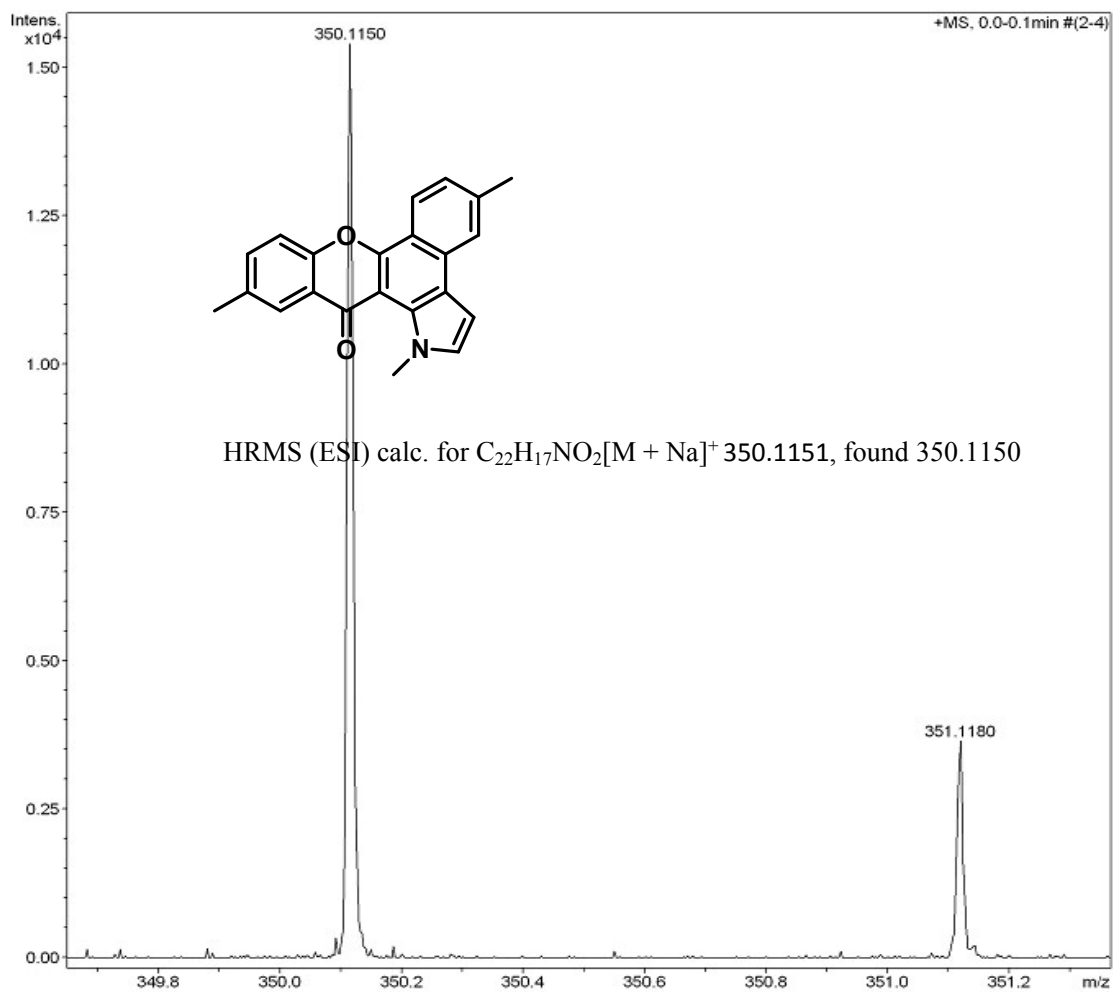
Compound 3e HRMS(MeOH)



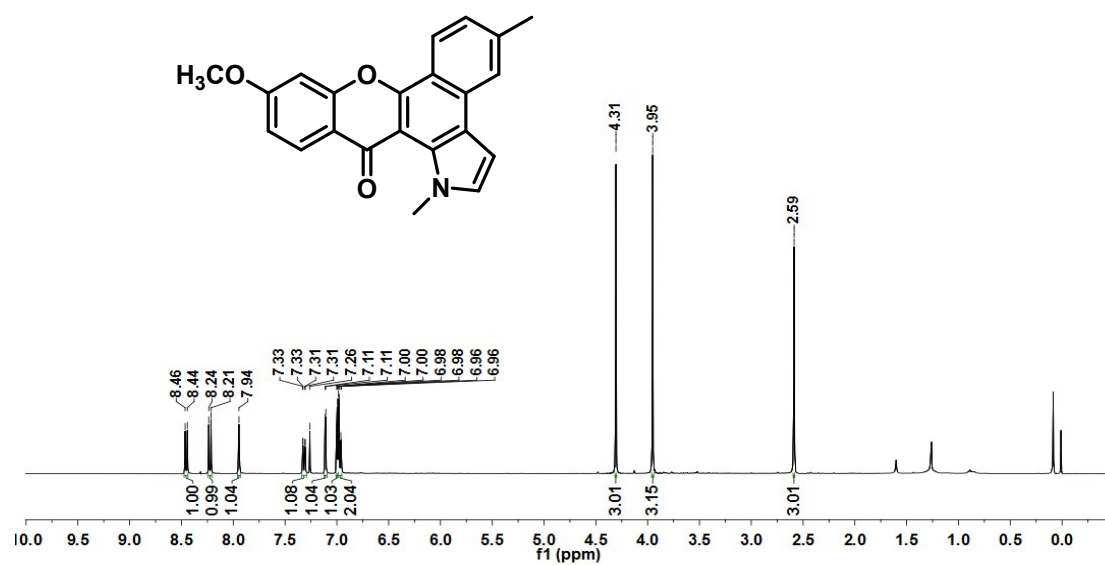
Compound 3f $^1\text{H NMR}(\text{CDCl}_3)$



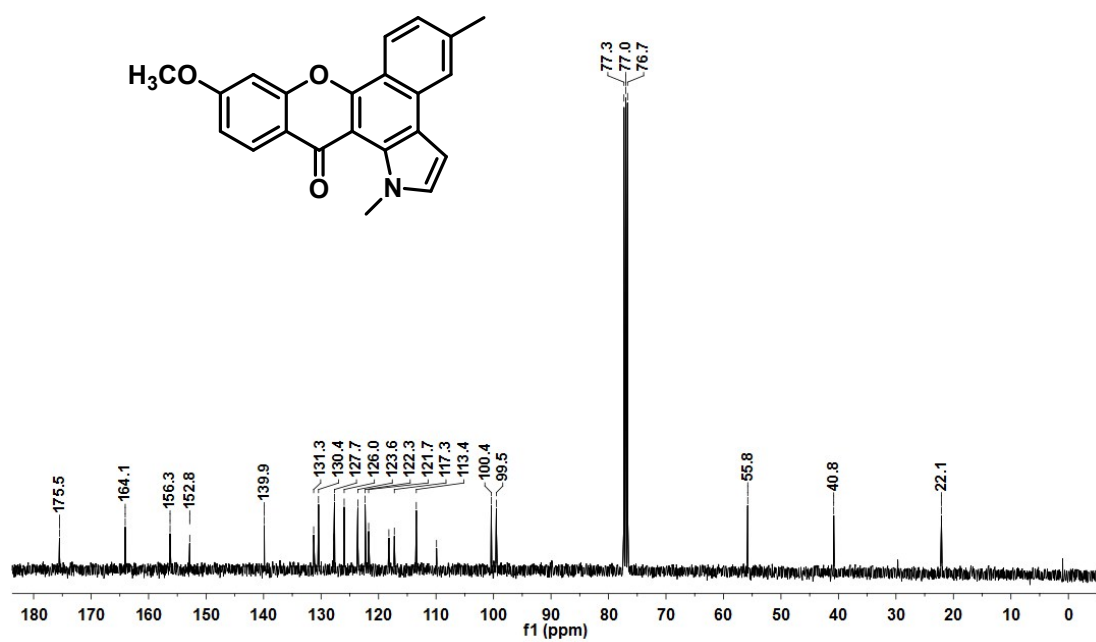
Compound 3f $^{13}\text{C NMR}(\text{CDCl}_3)$



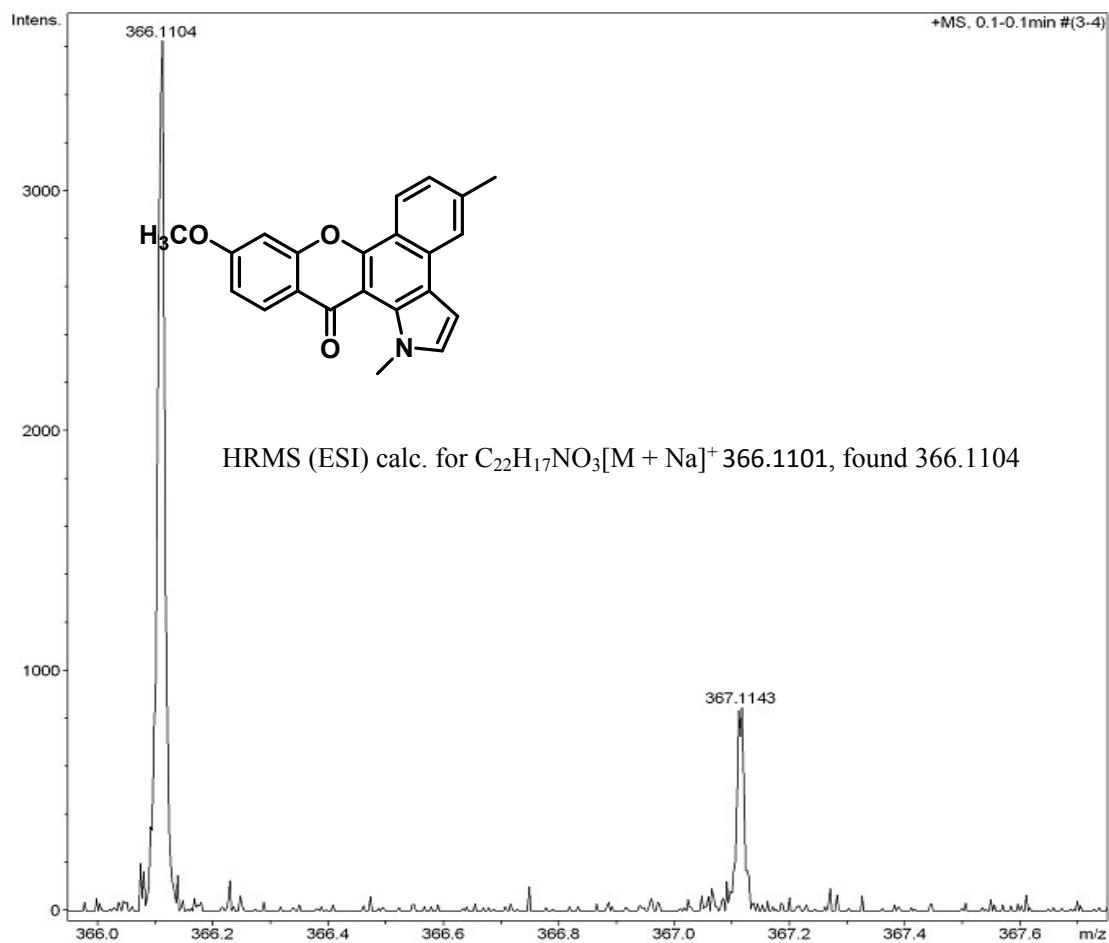
Compound 3f HRMS(MeOH)



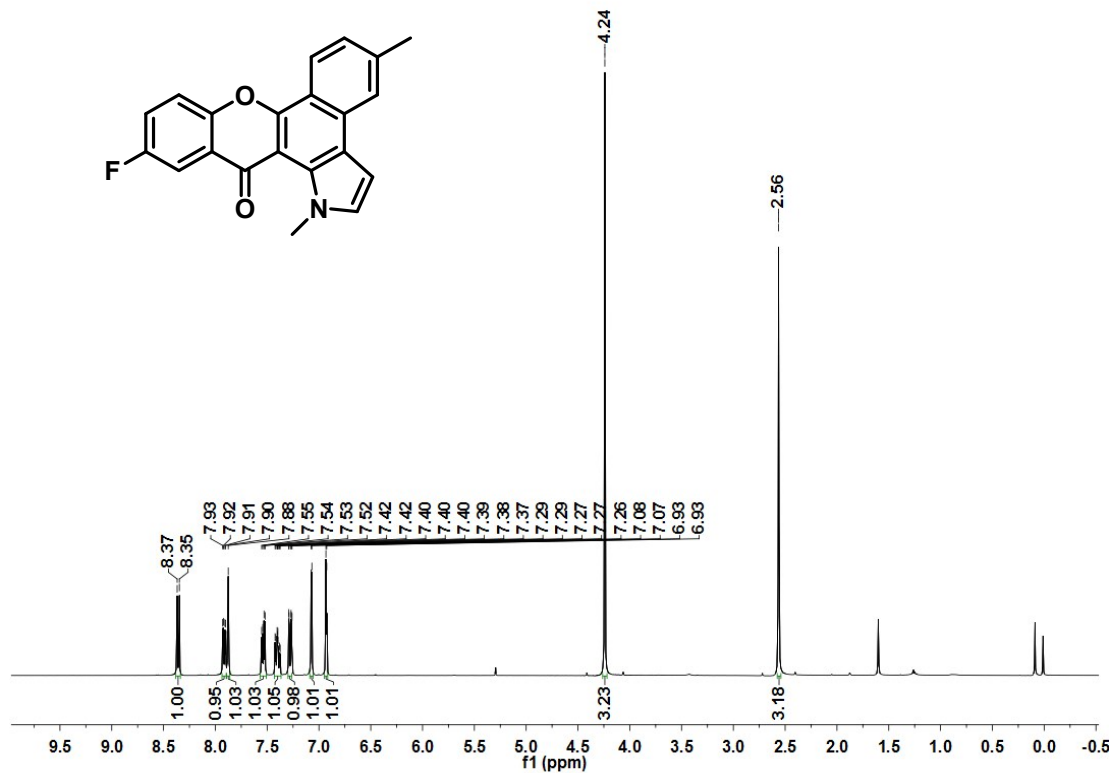
Compound 3g 1H NMR($CDCl_3$)



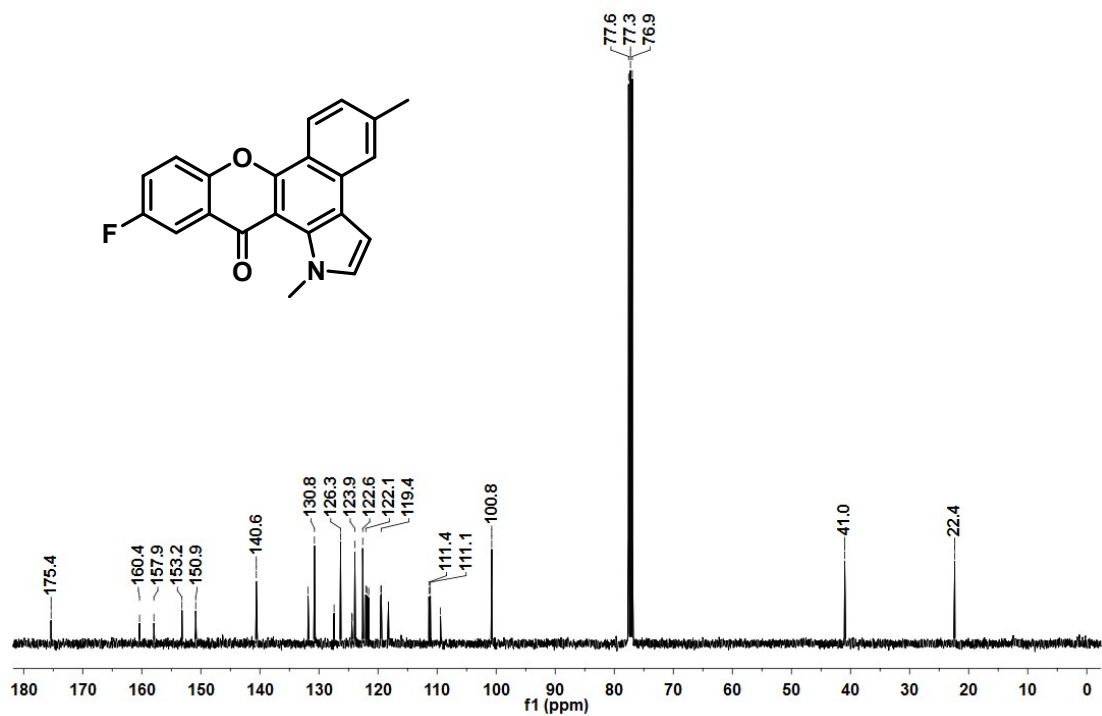
Compound 3g ¹³C NMR (CDCl₃)



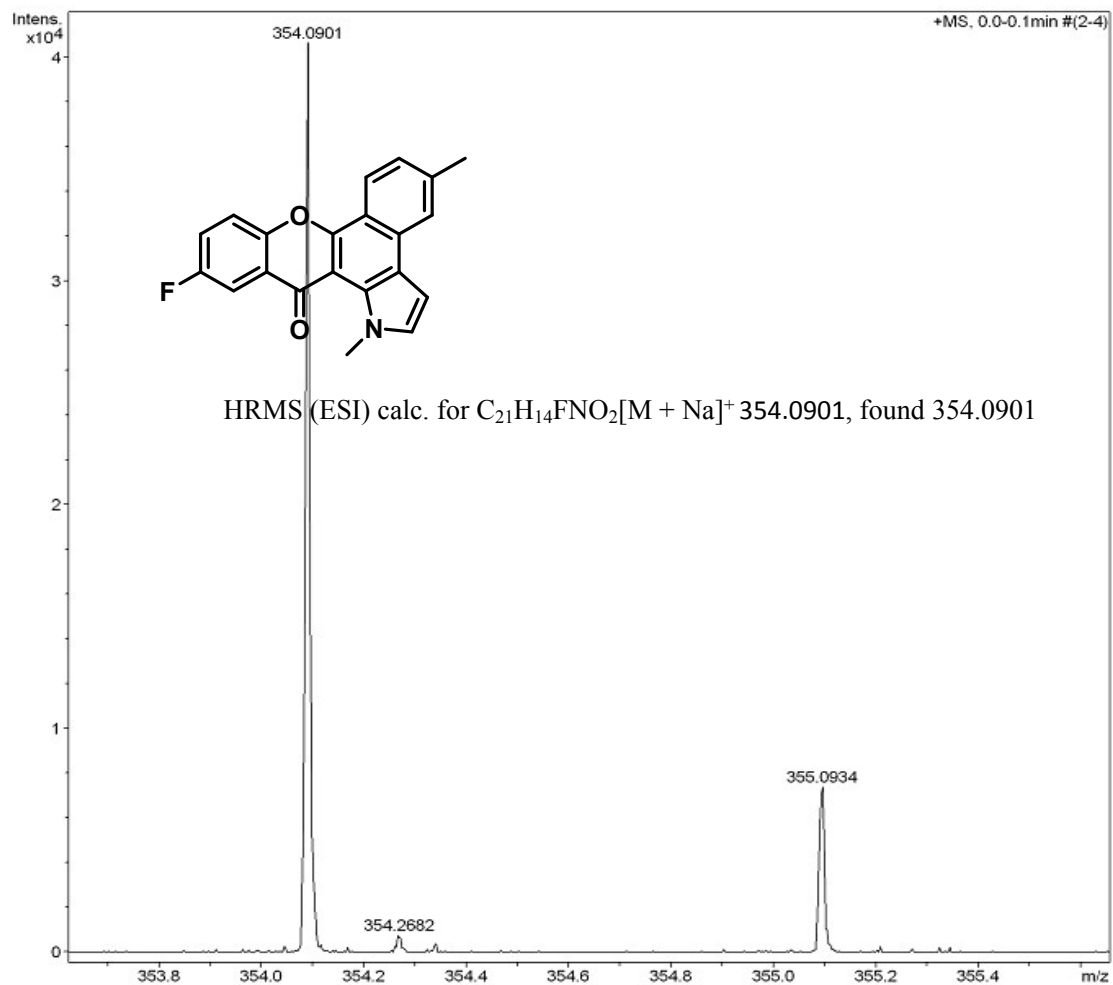
Compound 3g HRMS(MeOH)



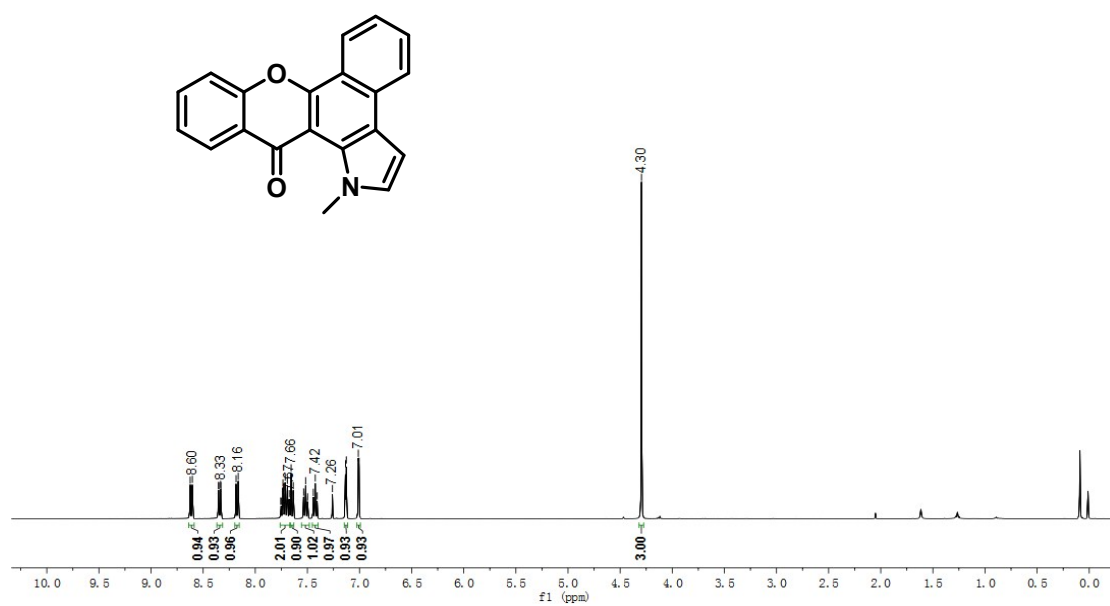
Compound 3h $^1\text{H NMR}(\text{CDCl}_3)$



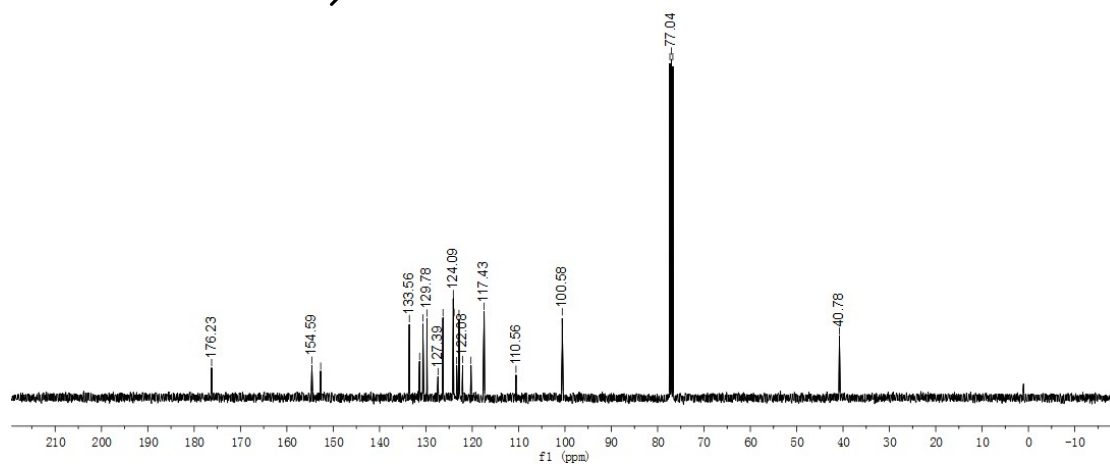
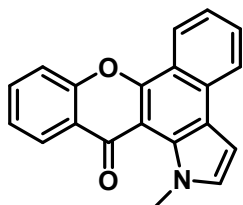
Compound 3h $^{13}\text{C NMR}(\text{CDCl}_3)$



Compound 3h HRMS(MeOH)

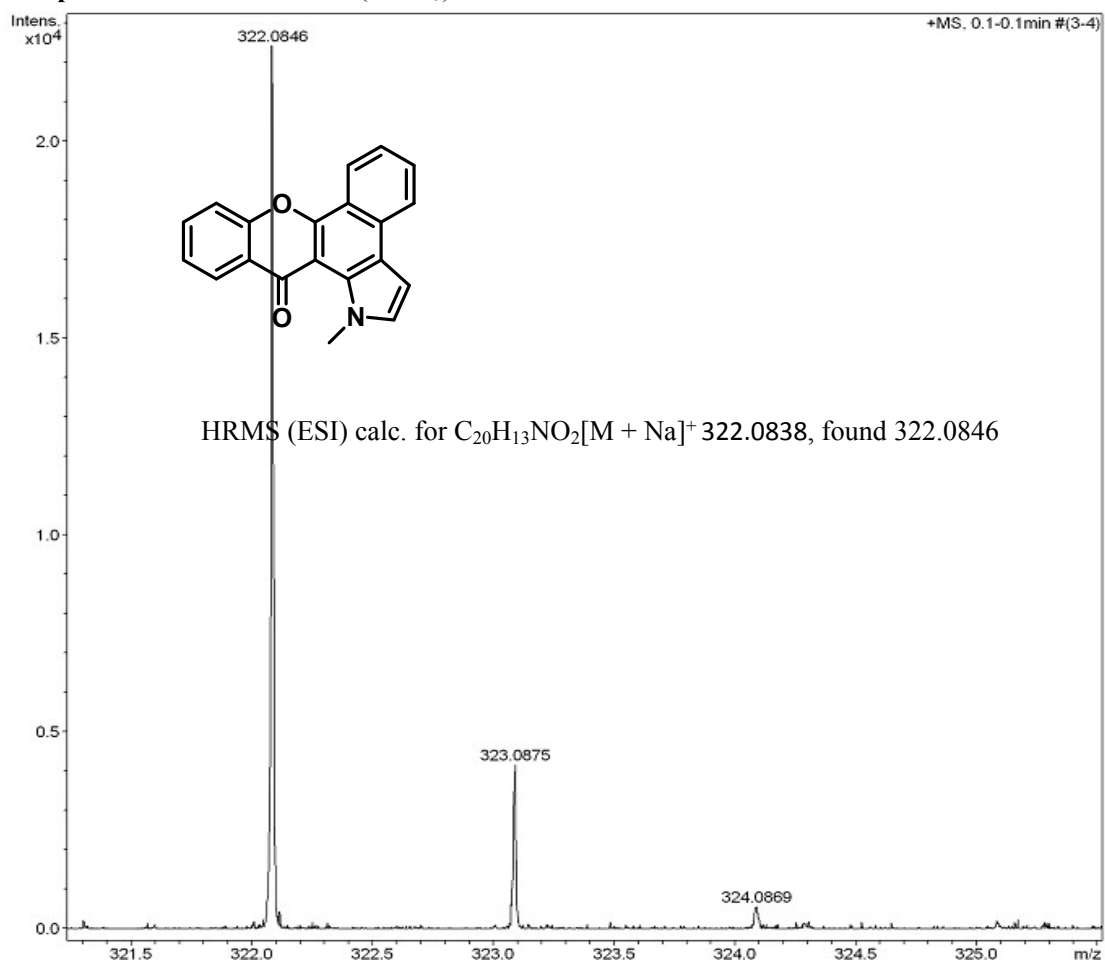


Compound 3i 1H NMR($CDCl_3$)



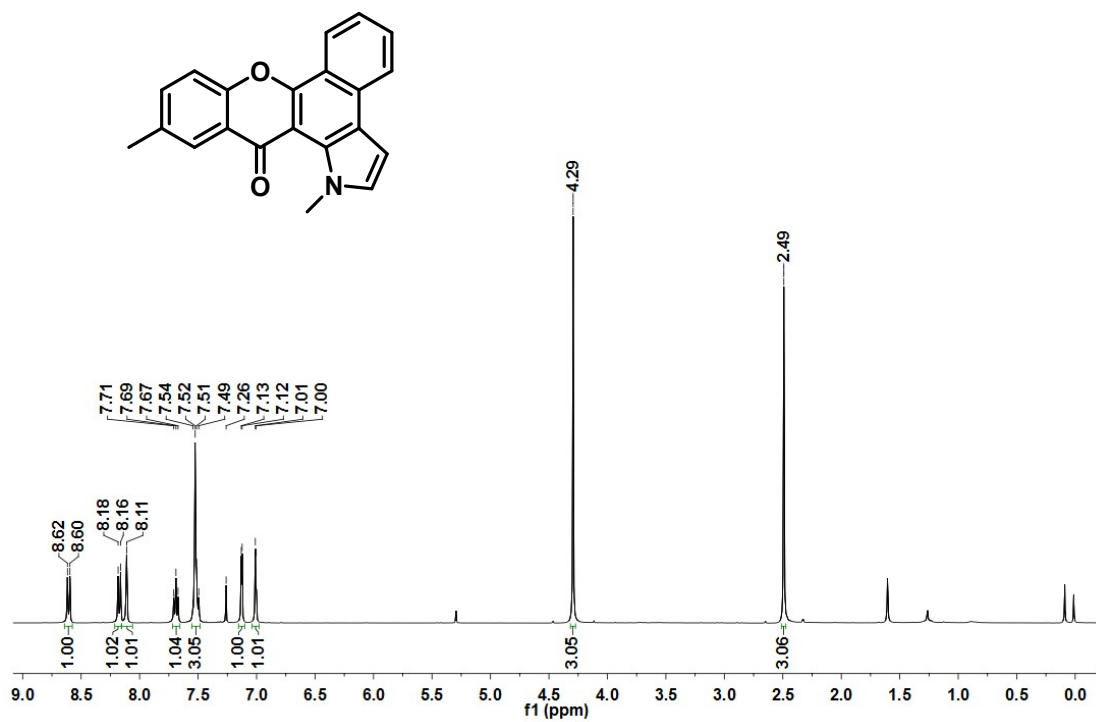
Compound 3i

^{13}C NMR (CDCl₃)

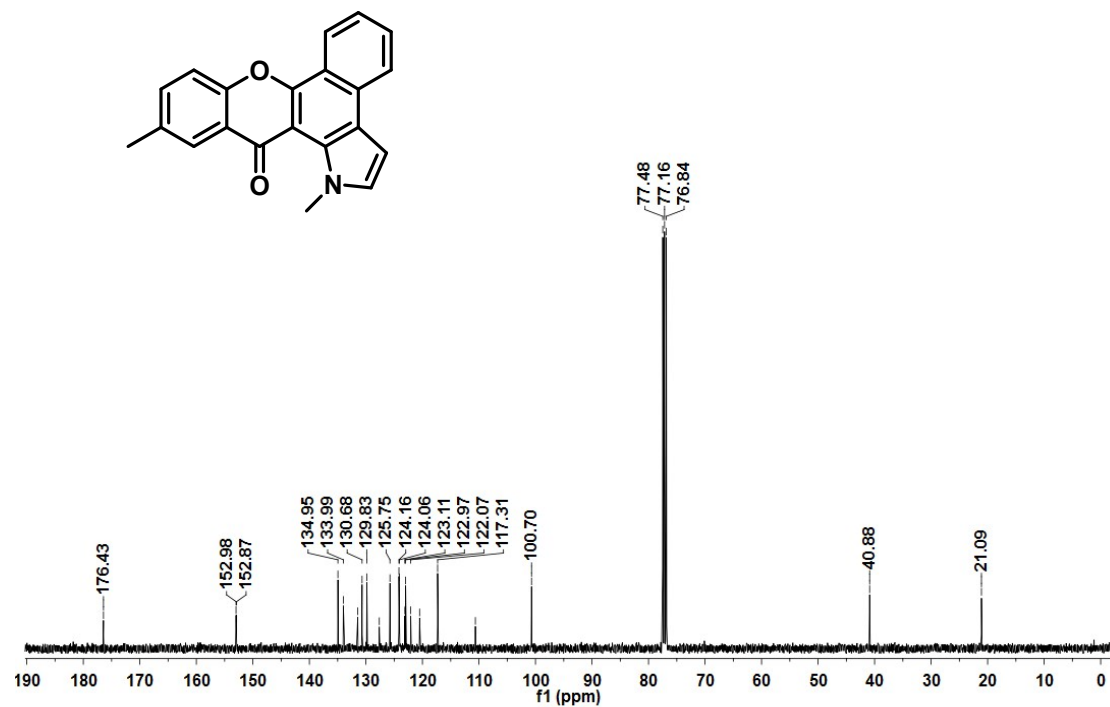


Compound 3i

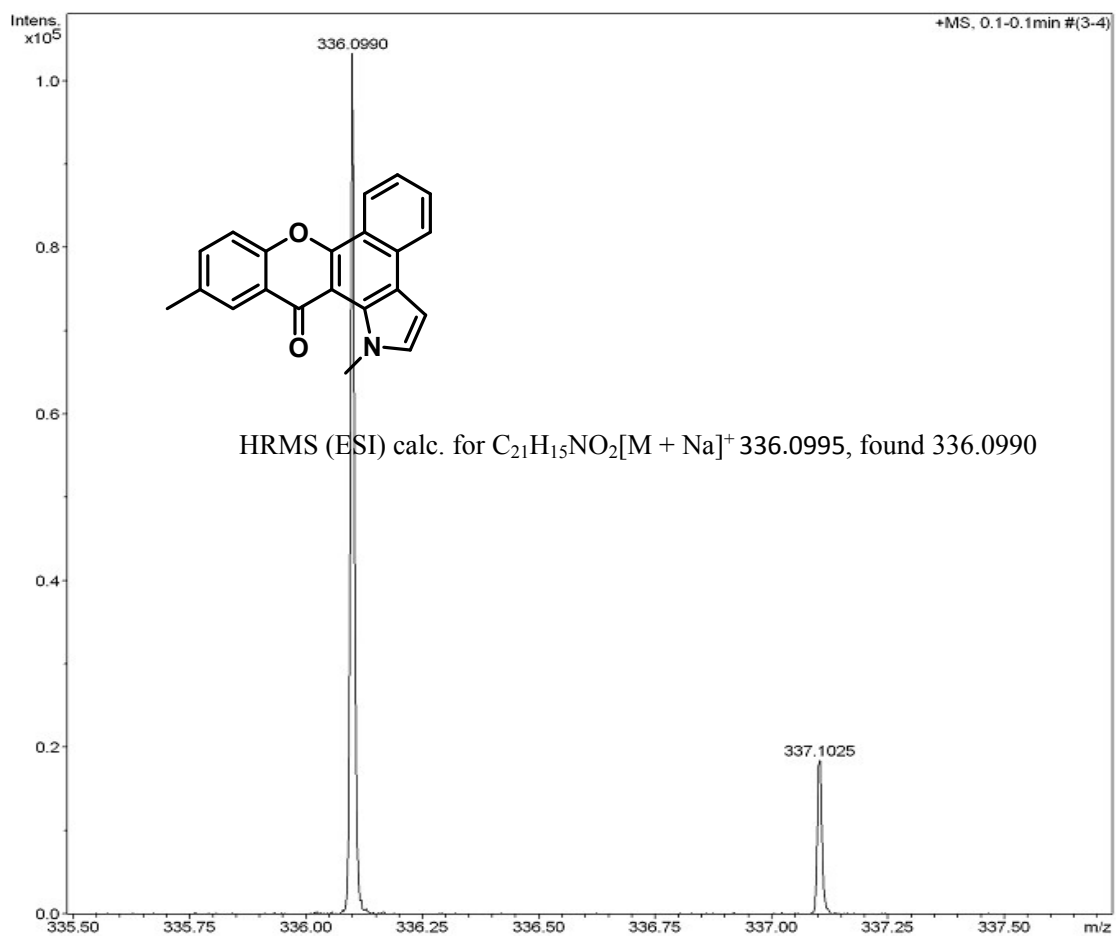
HRMS(MeOH)



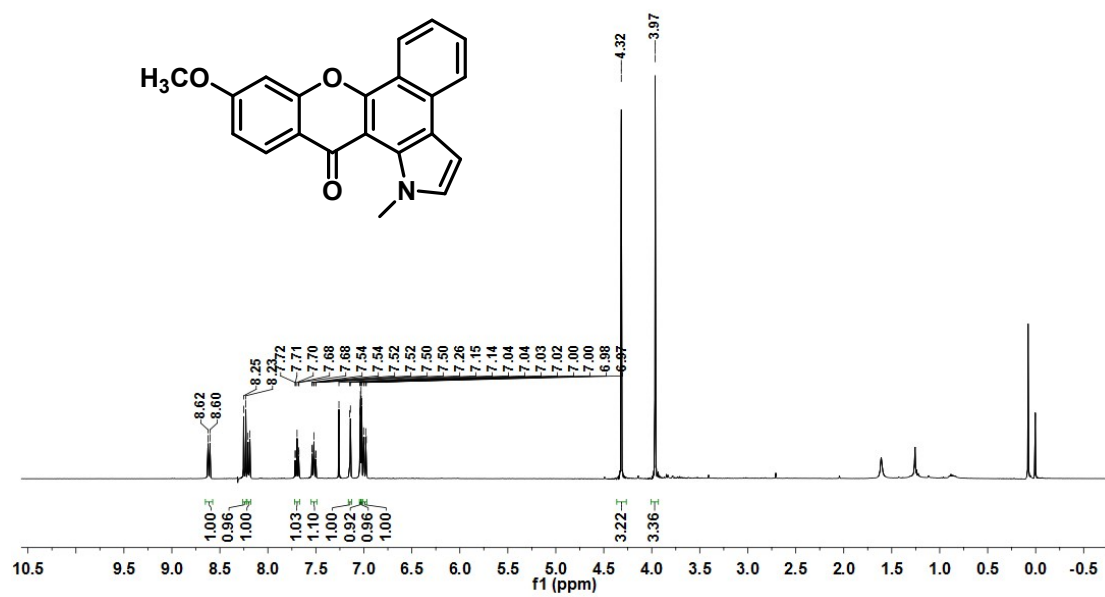
Compound 3j $^1\text{H NMR}(\text{CDCl}_3)$



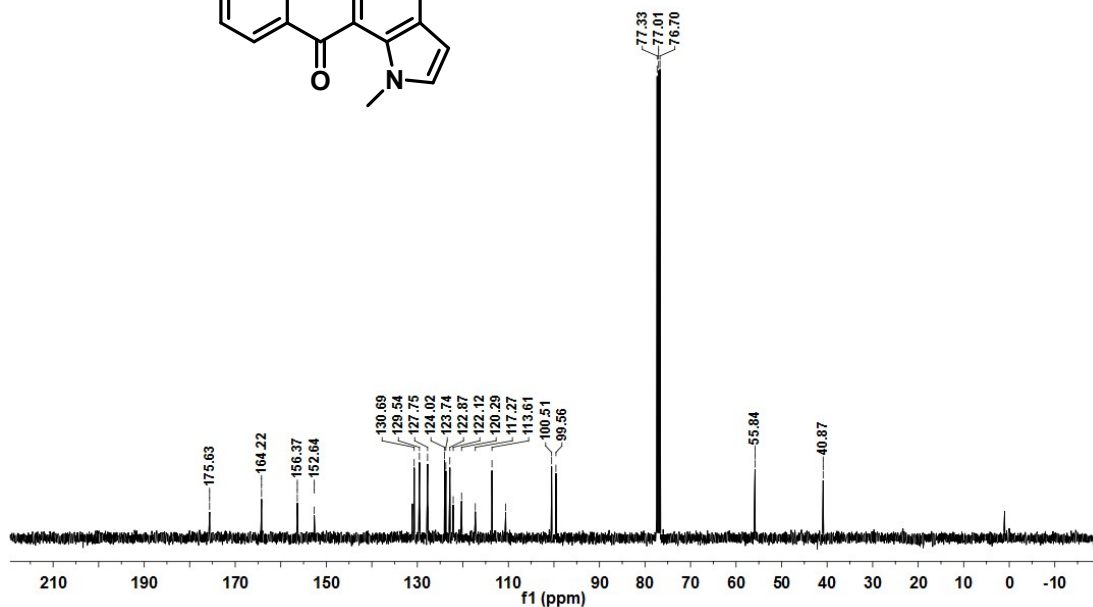
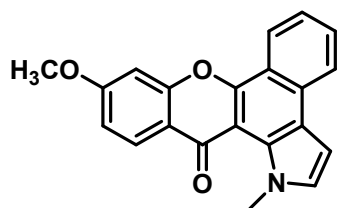
Compound 3j $^{13}\text{C NMR}(\text{CDCl}_3)$



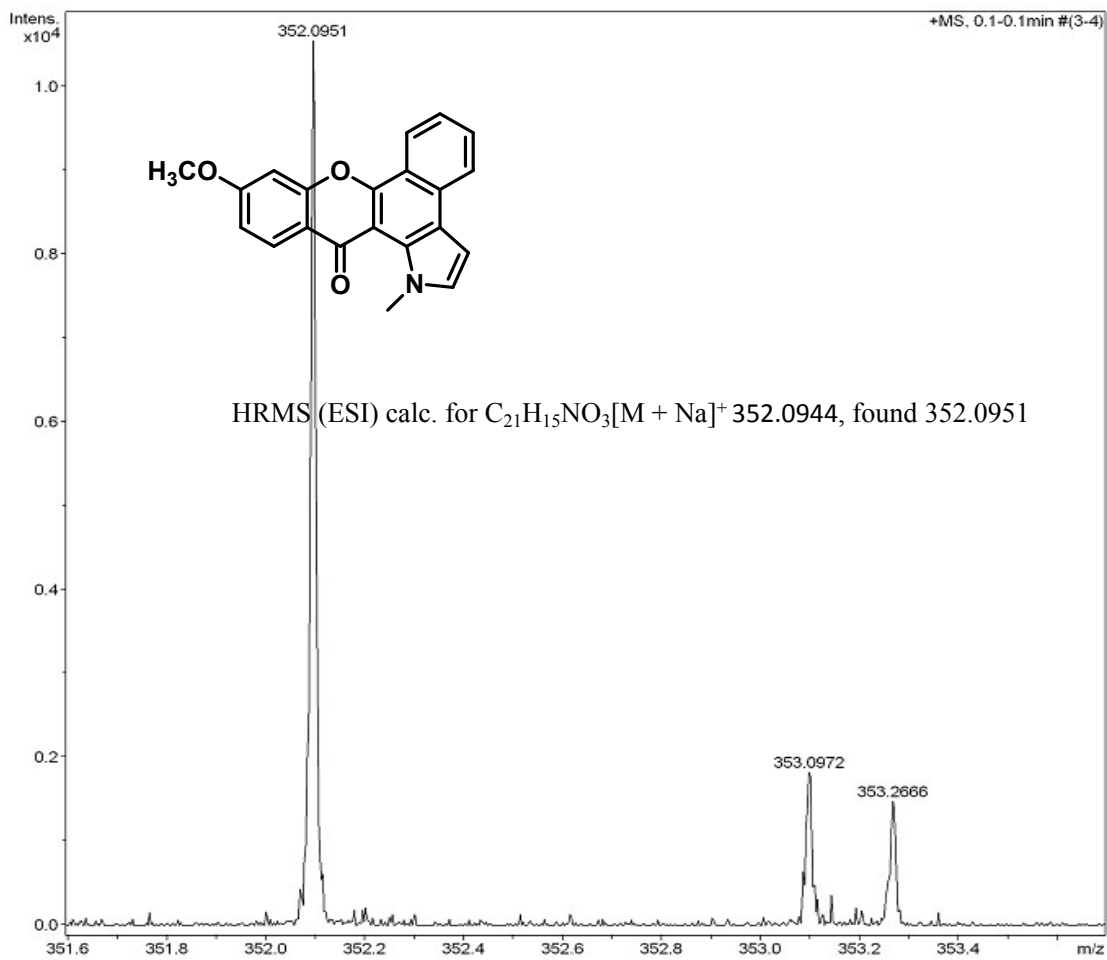
Compound 3j HRMS(MeOH)



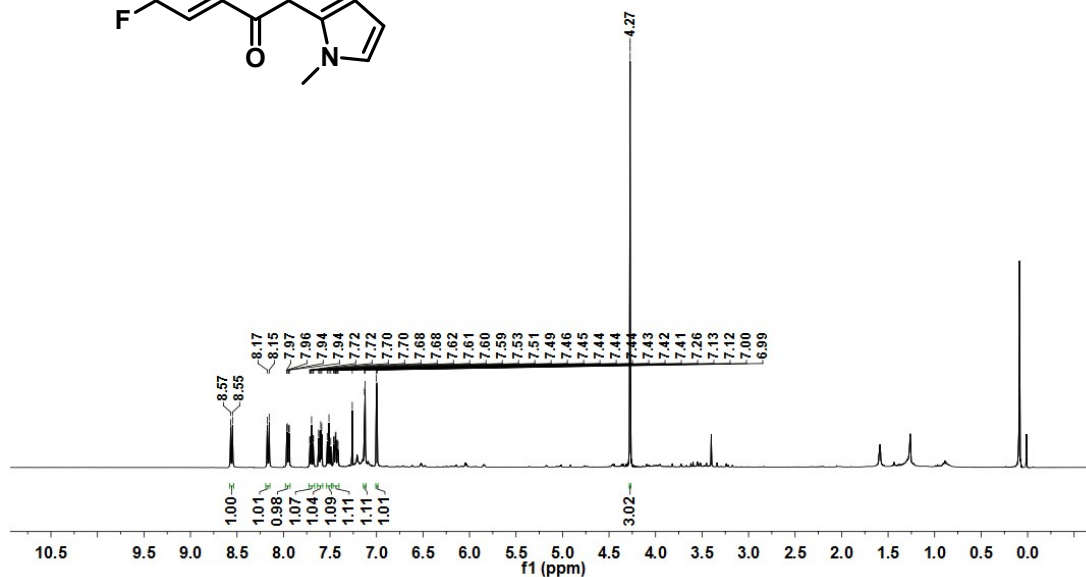
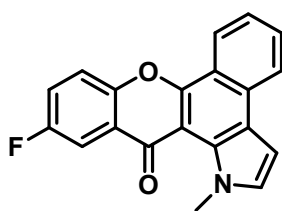
Compound 3k 1H NMR($CDCl_3$)



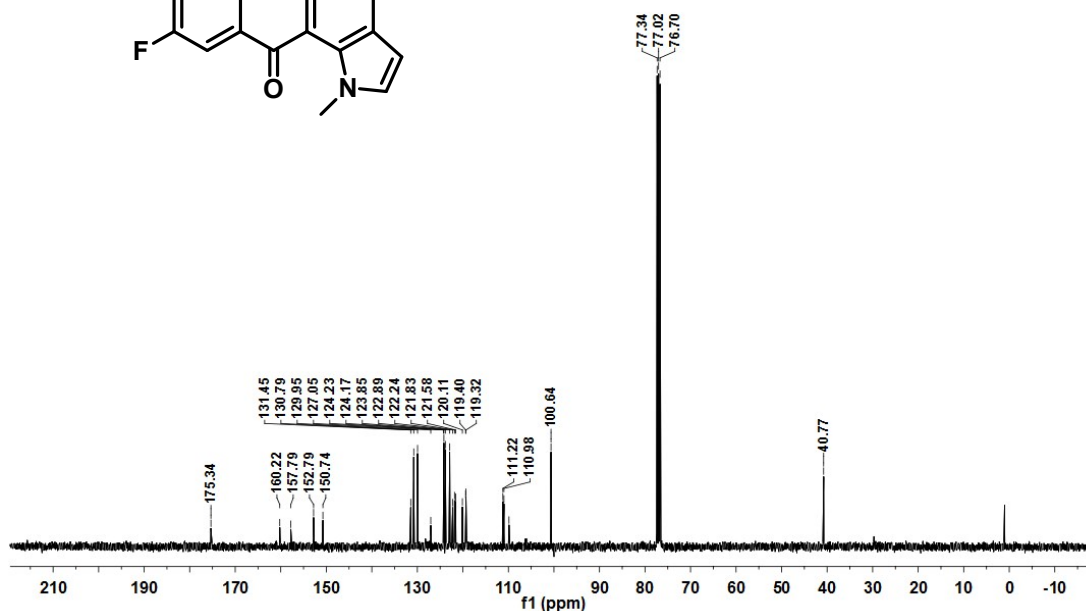
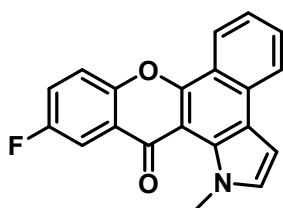
Compound 3k ^{13}C NMR (CDCl_3)



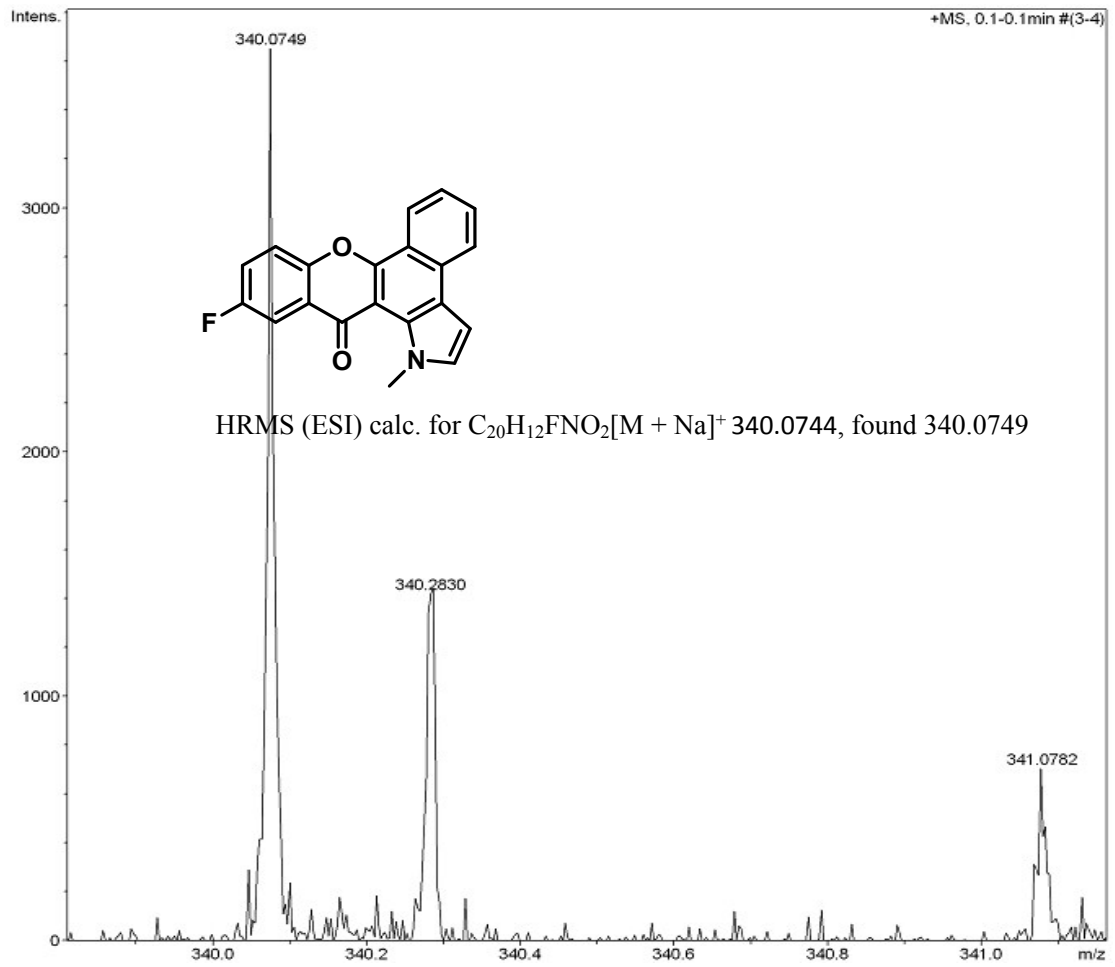
Compound 3k HRMS(MeOH)



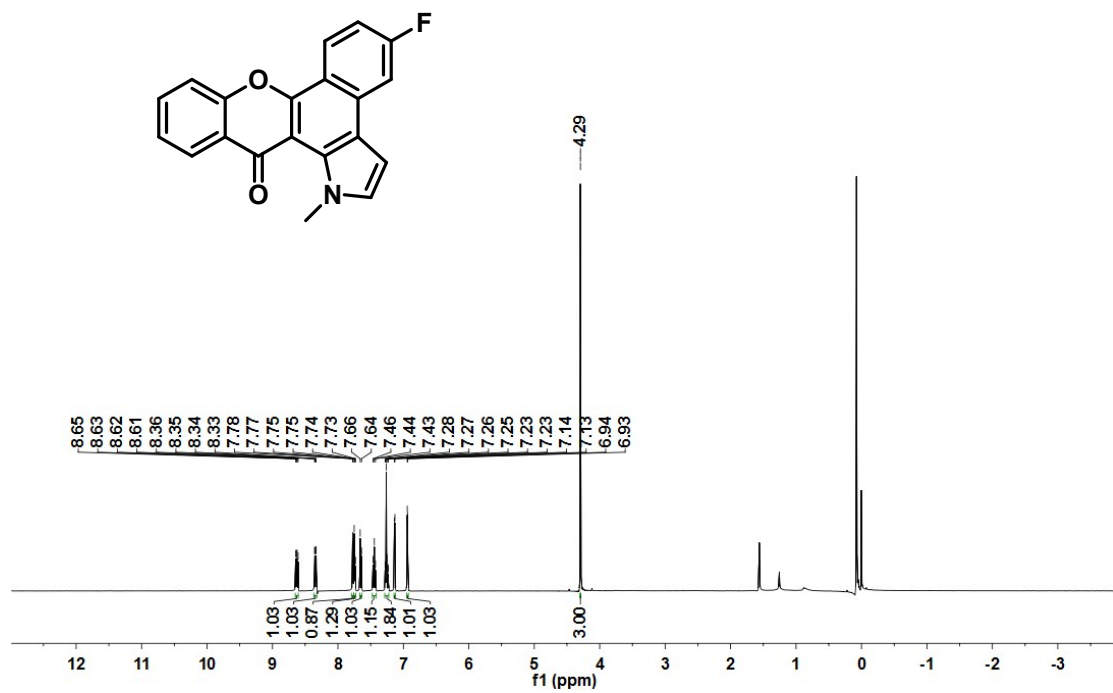
Compound 31 $^1\text{H NMR}(\text{CDCl}_3)$



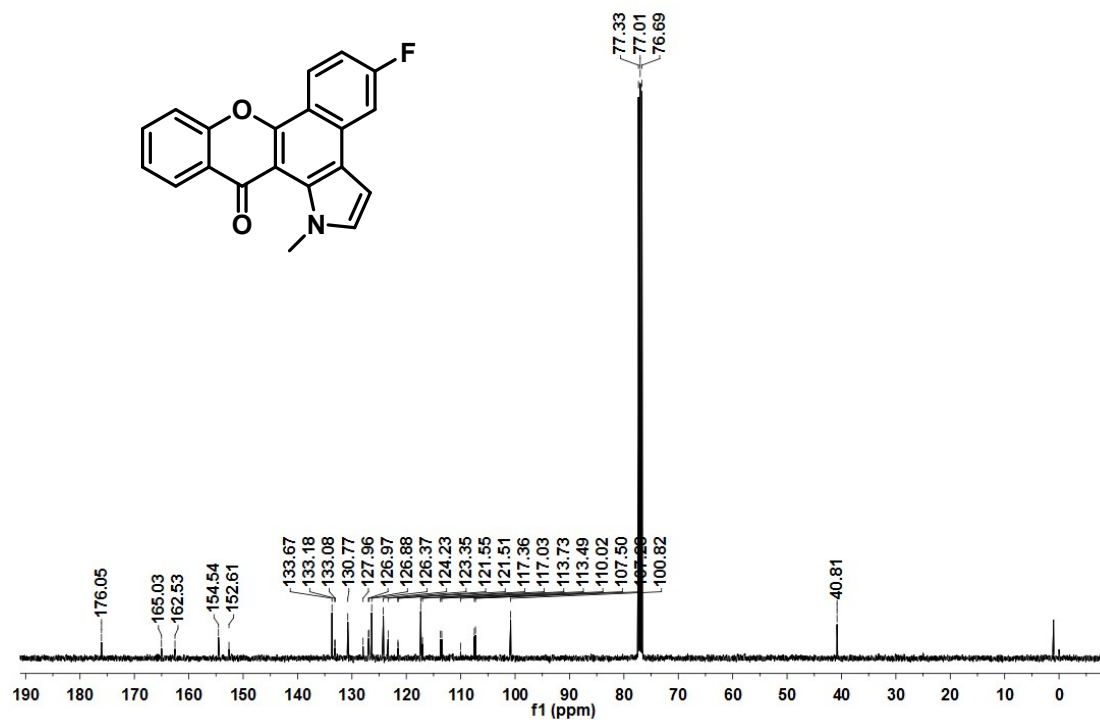
Compound 31 $^{13}\text{C NMR}(\text{CDCl}_3)$



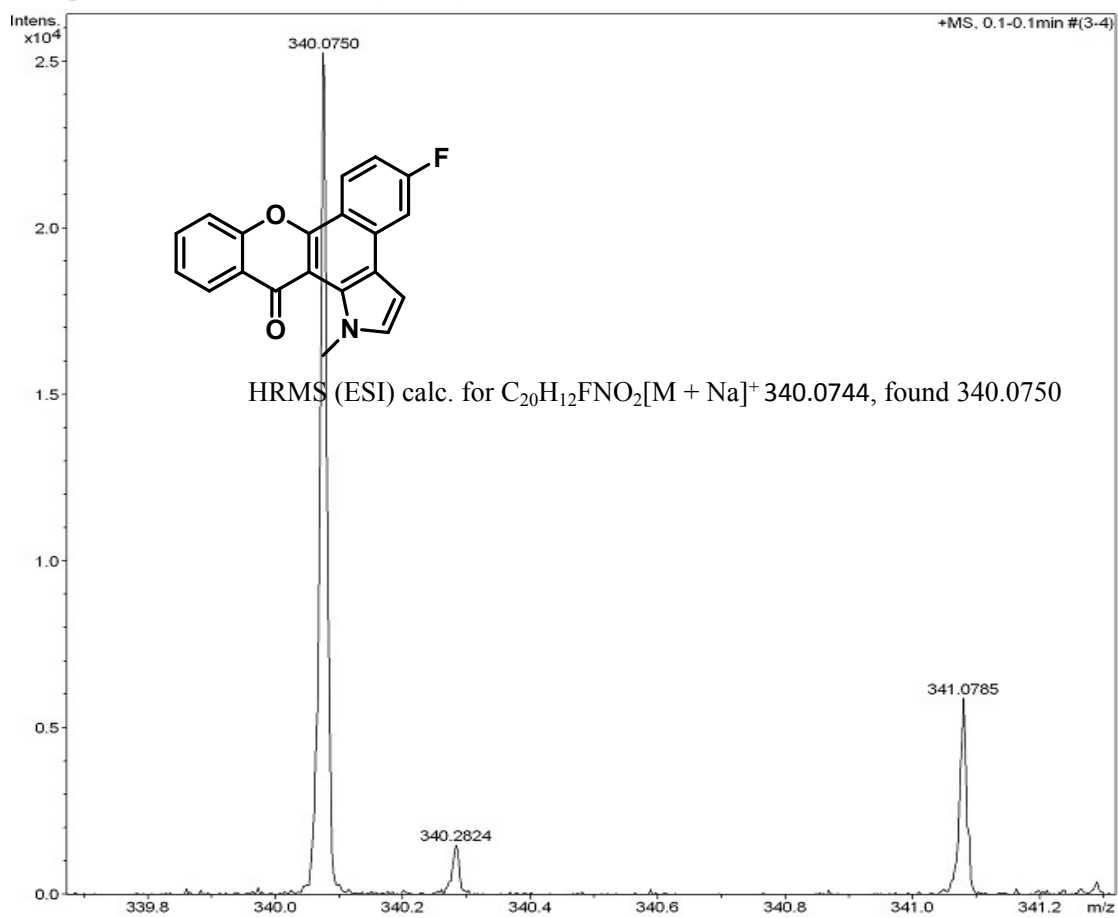
Compound 31 HRMS(MeOH)



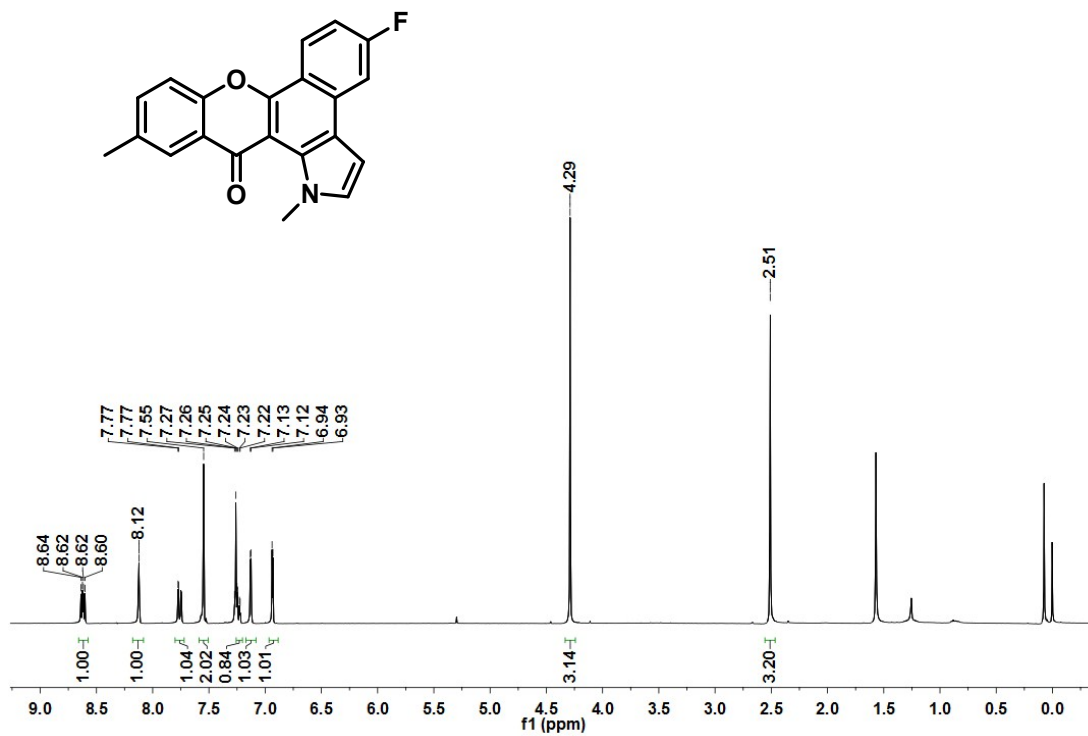
Compound 3m ¹H NMR(CDCl₃)



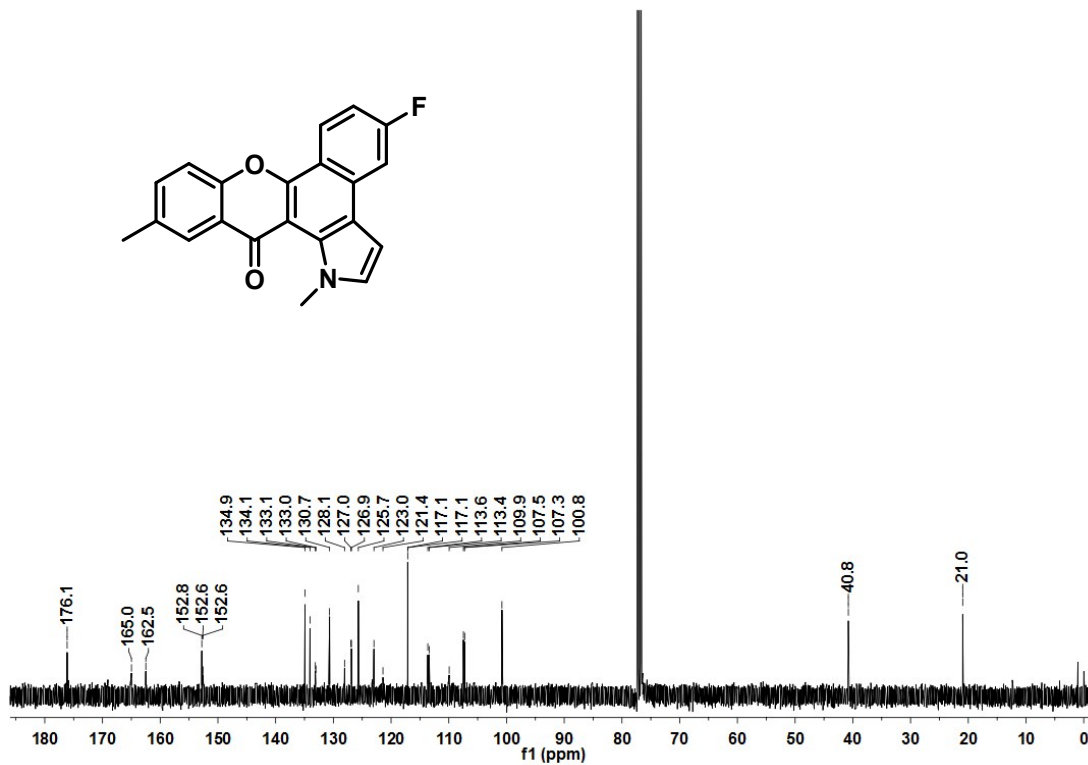
Compound 3m ¹³C NMR (CDCl₃)



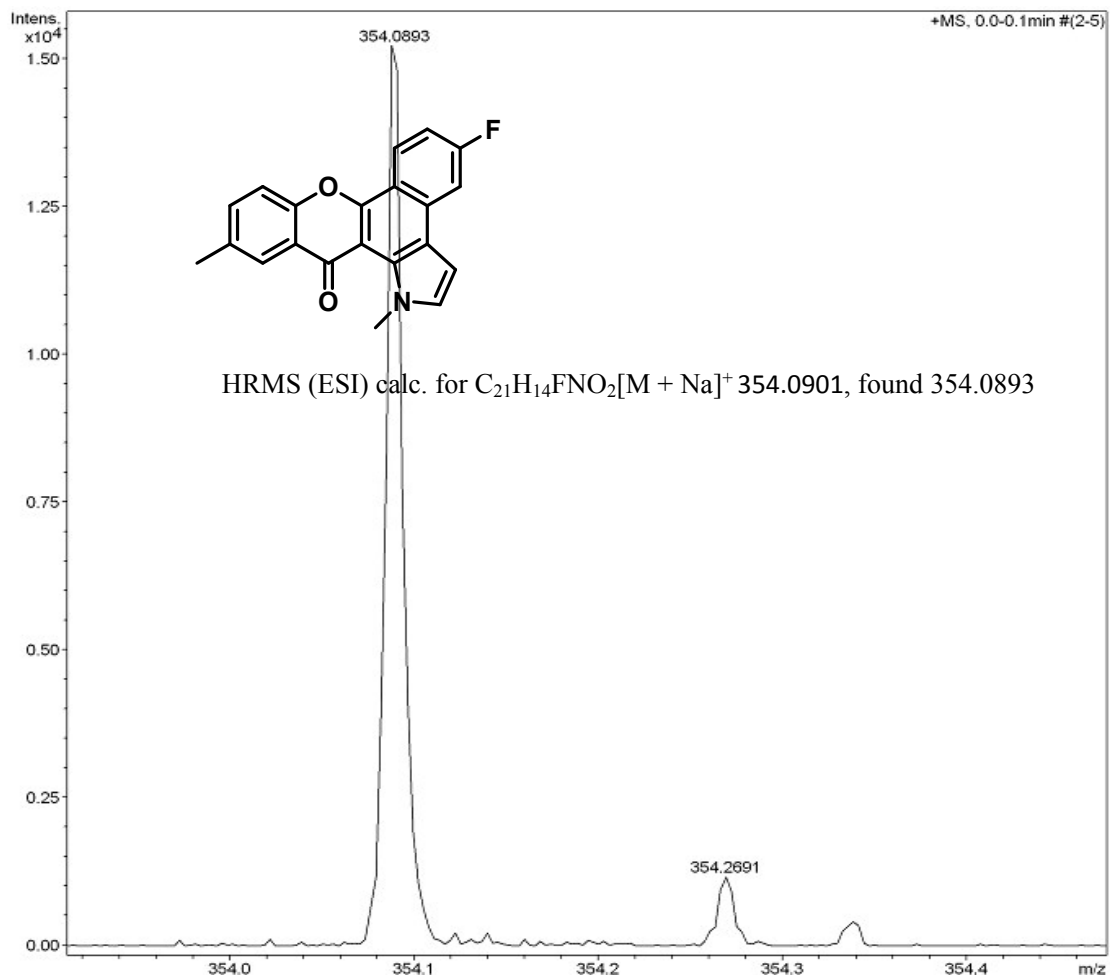
Compound 3m HRMS(MeOH)



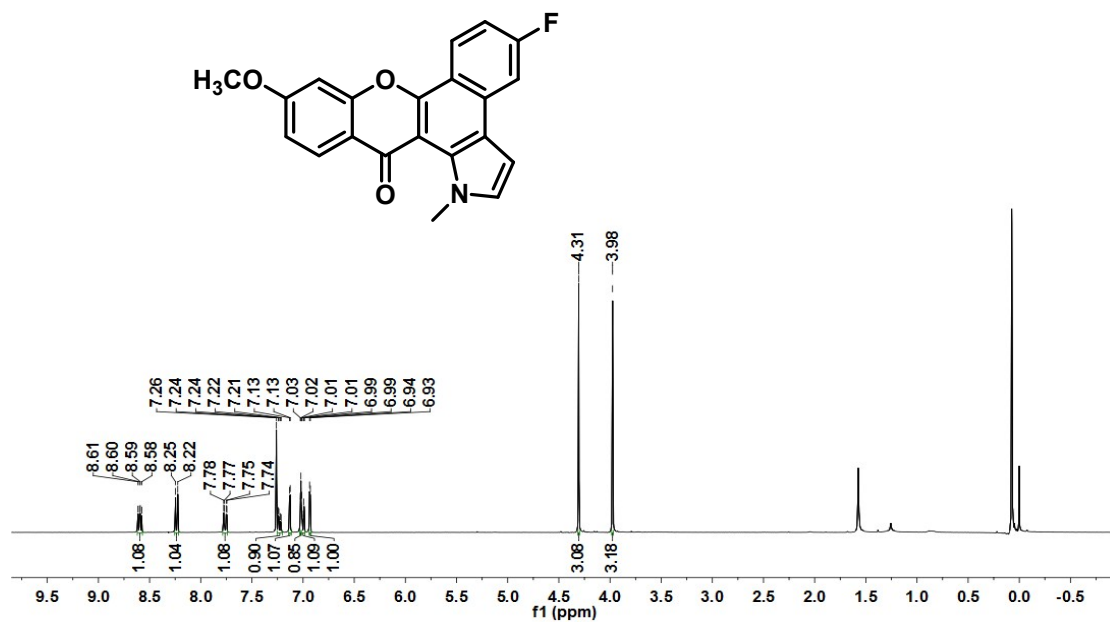
Compound 3n $^1\text{H NMR}(\text{CDCl}_3)$



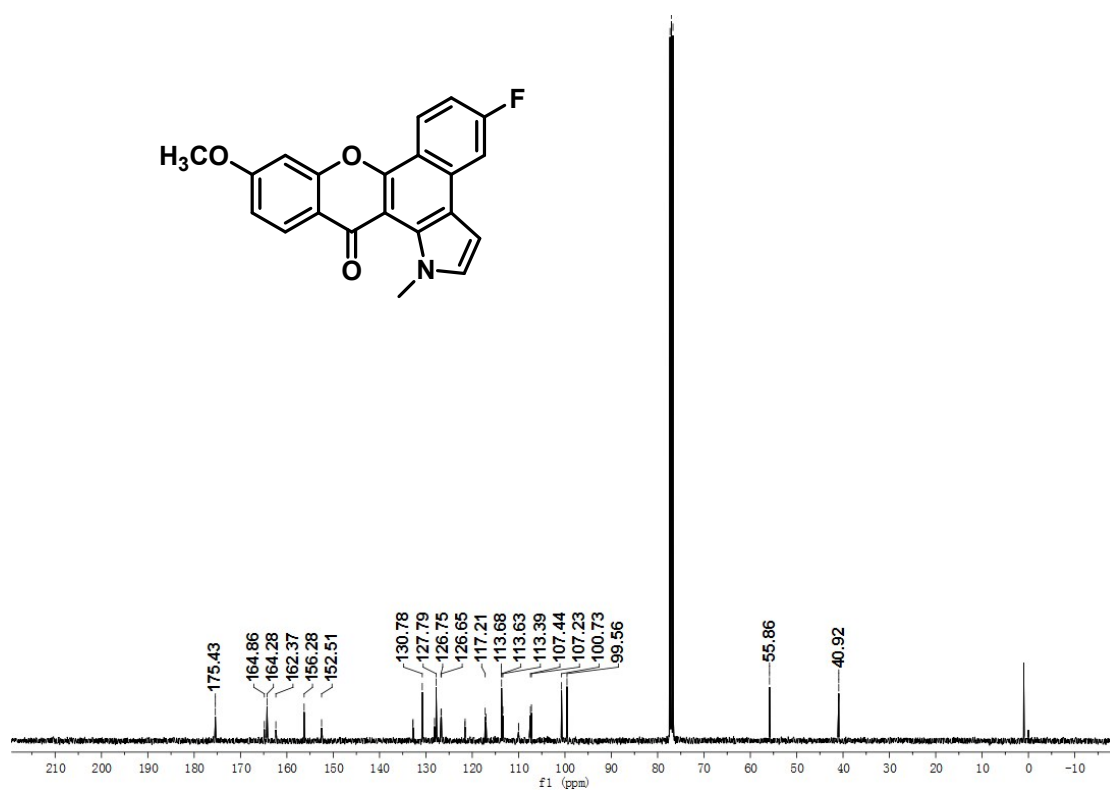
Compound 3n $^{13}\text{C NMR}(\text{CDCl}_3)$



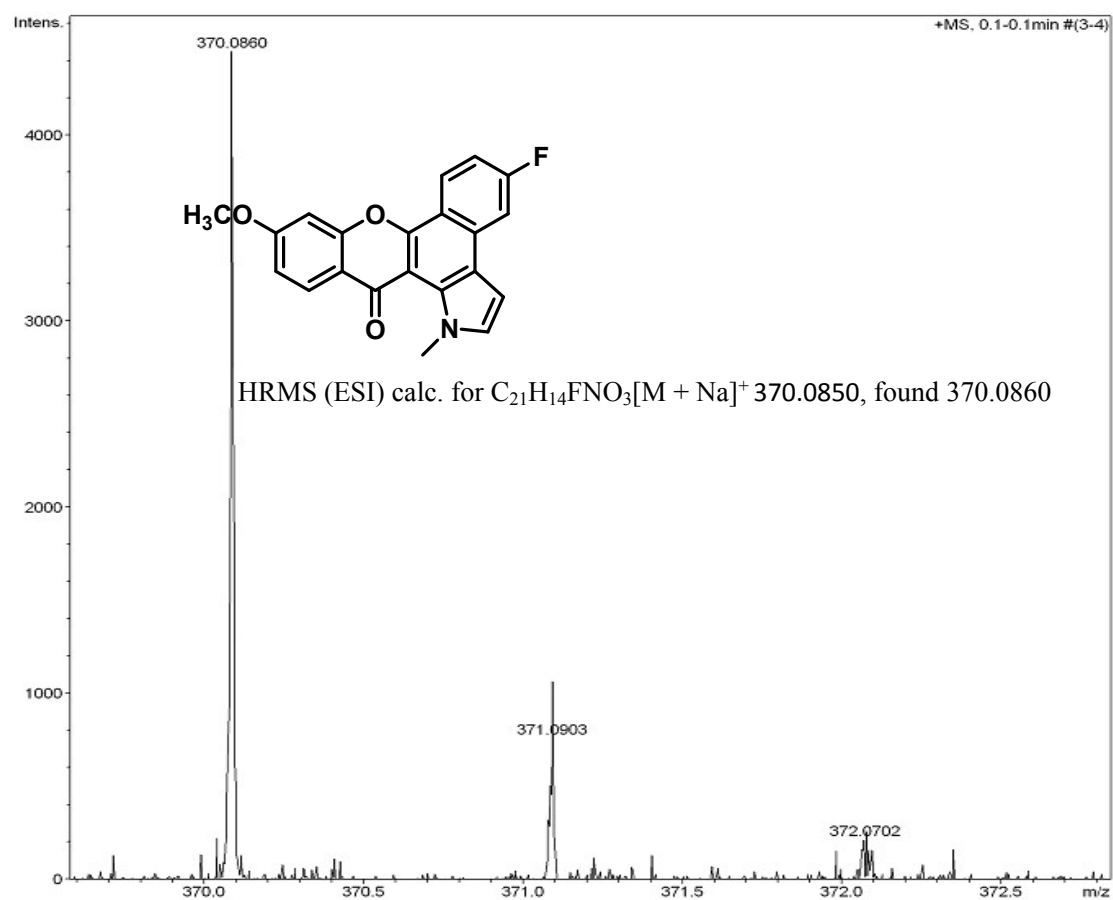
Compound 3n HRMS(MeOH)



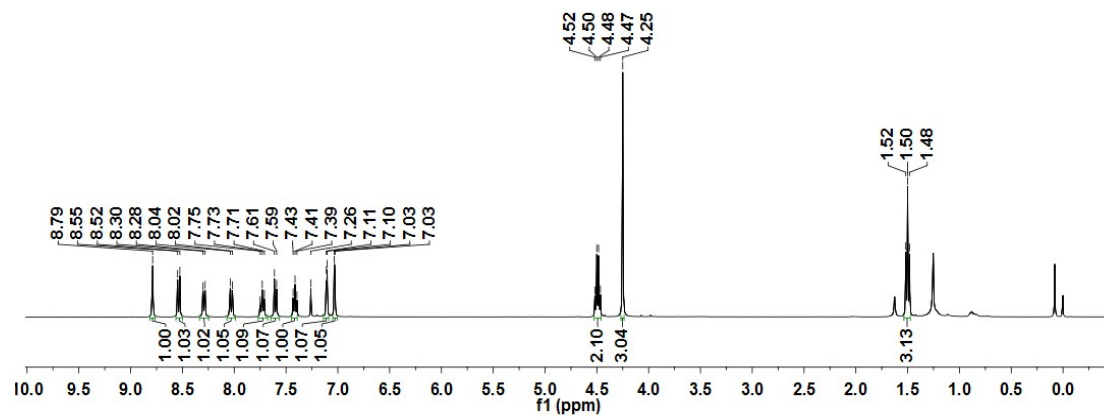
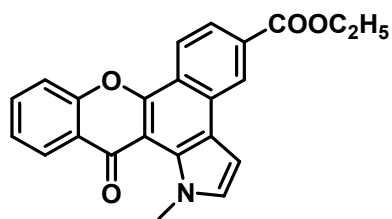
Compound 3o 1H NMR($CDCl_3$)



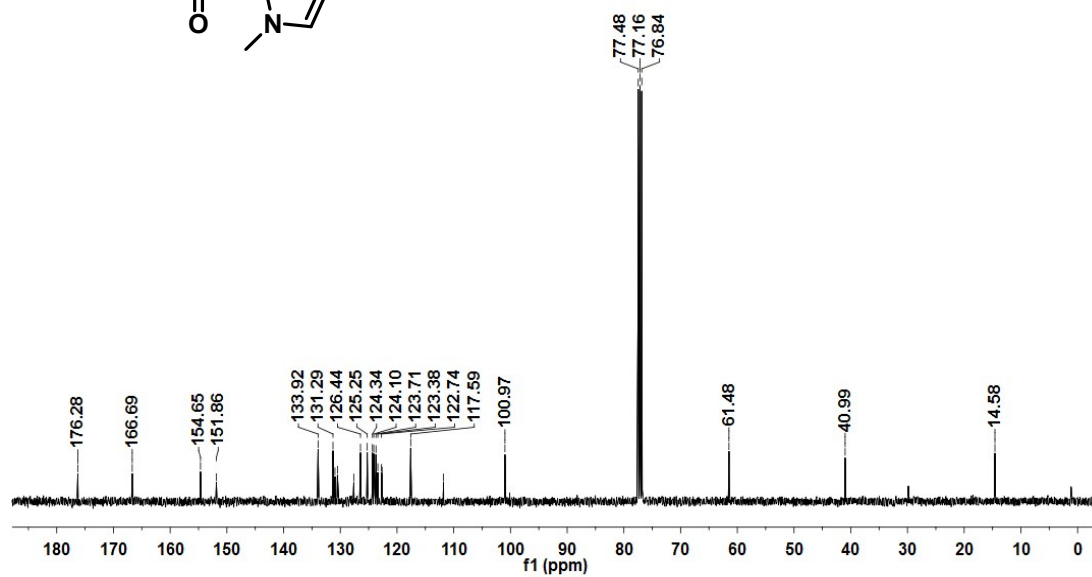
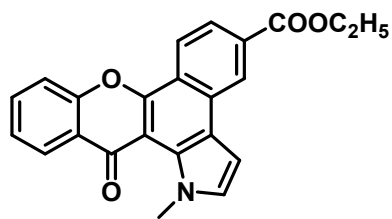
Compound 30 ^{13}C NMR (CDCl₃)



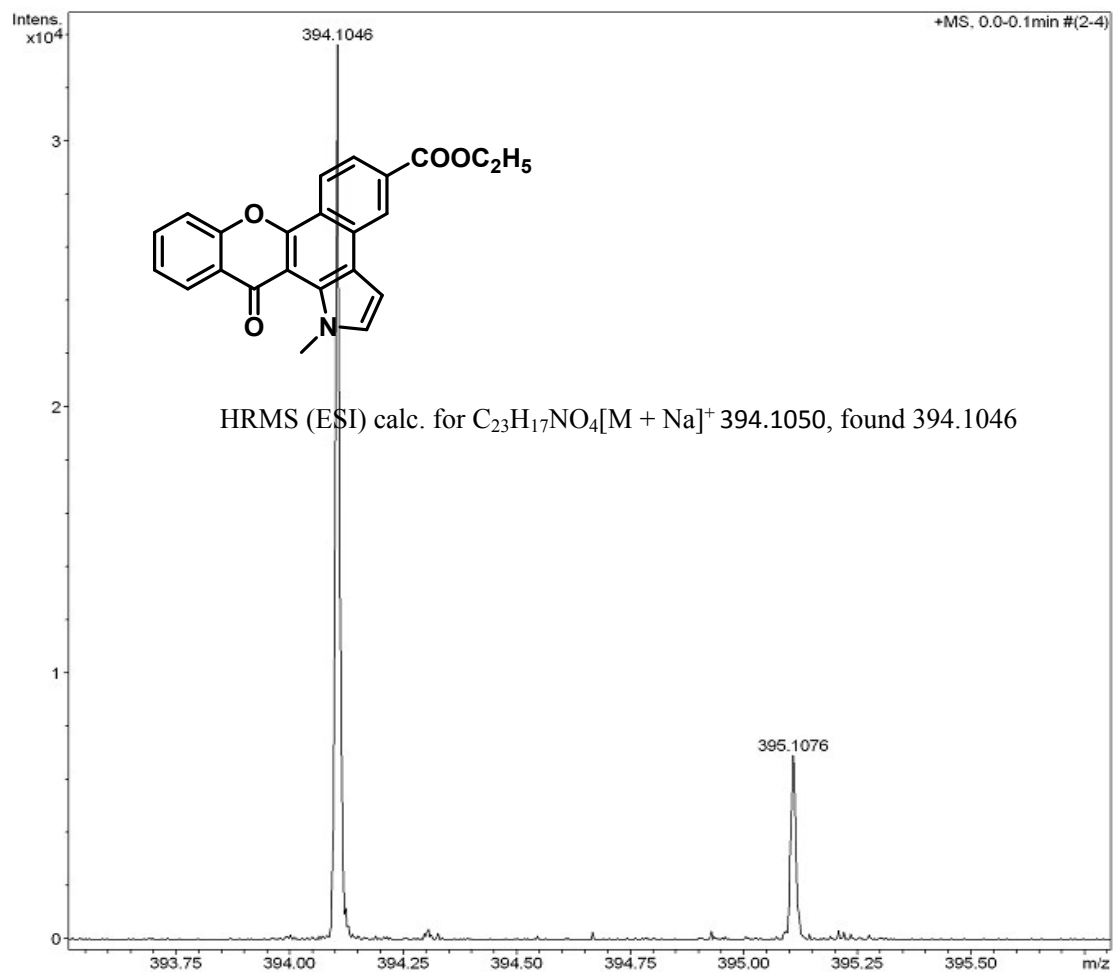
Compound 30 HRMS(MeOH)



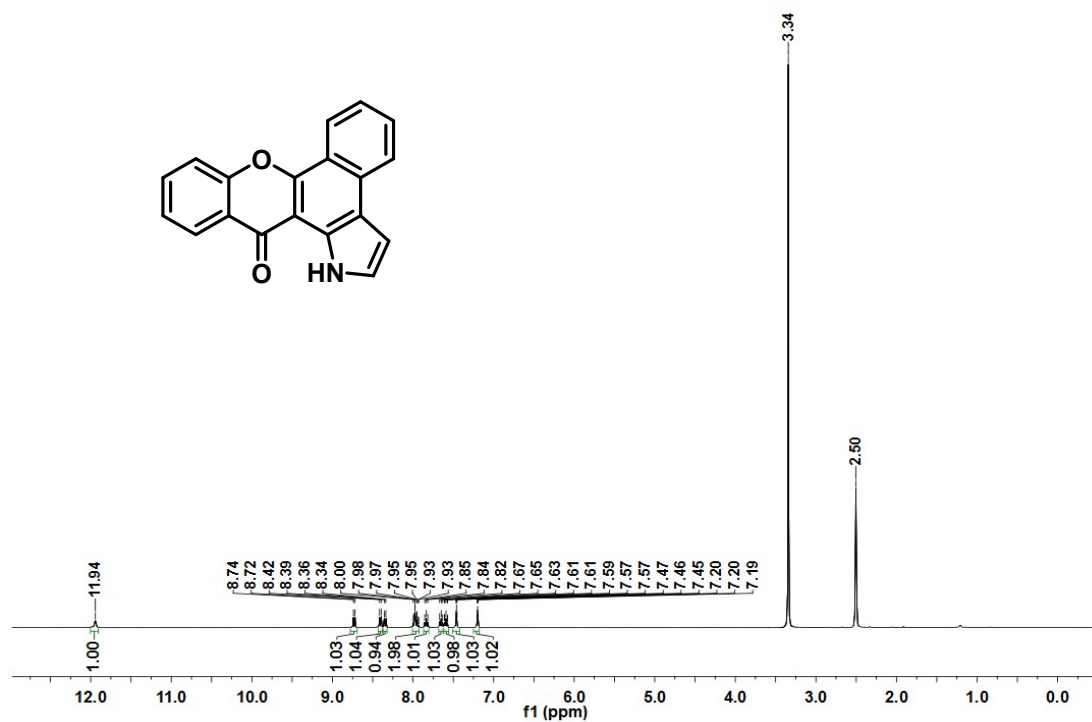
Compound 3p $^1\text{H NMR}(\text{CDCl}_3)$



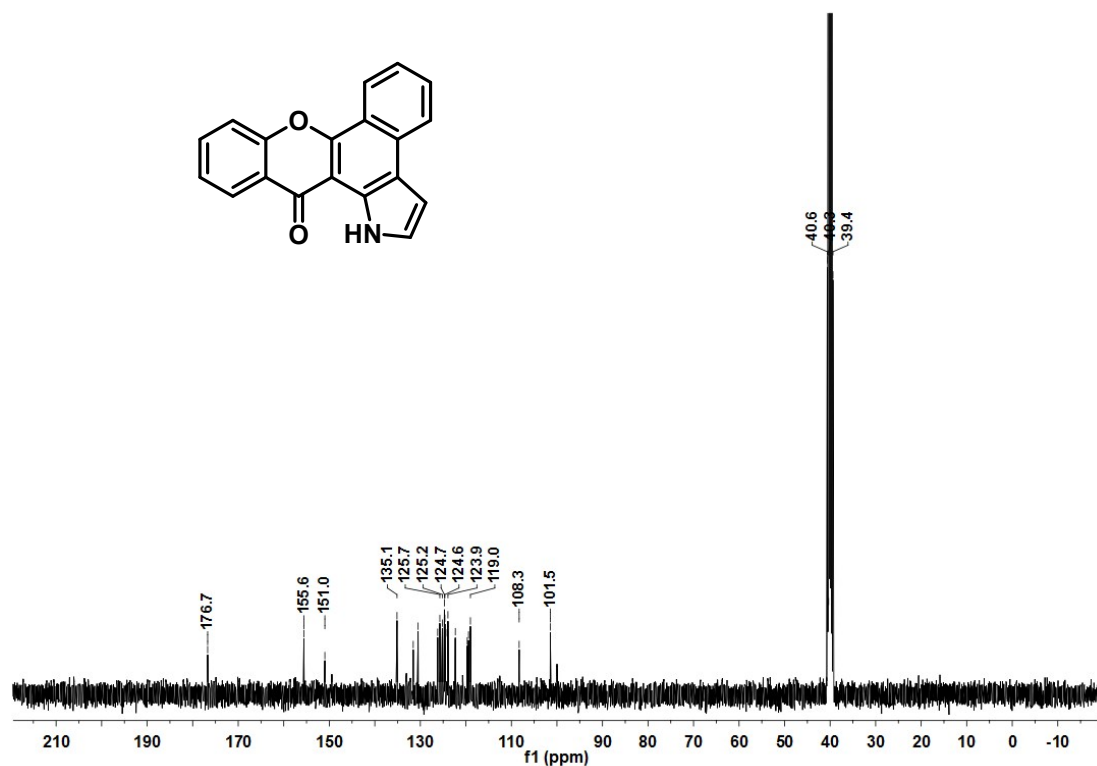
Compound 3p $^{13}\text{C NMR}(\text{CDCl}_3)$



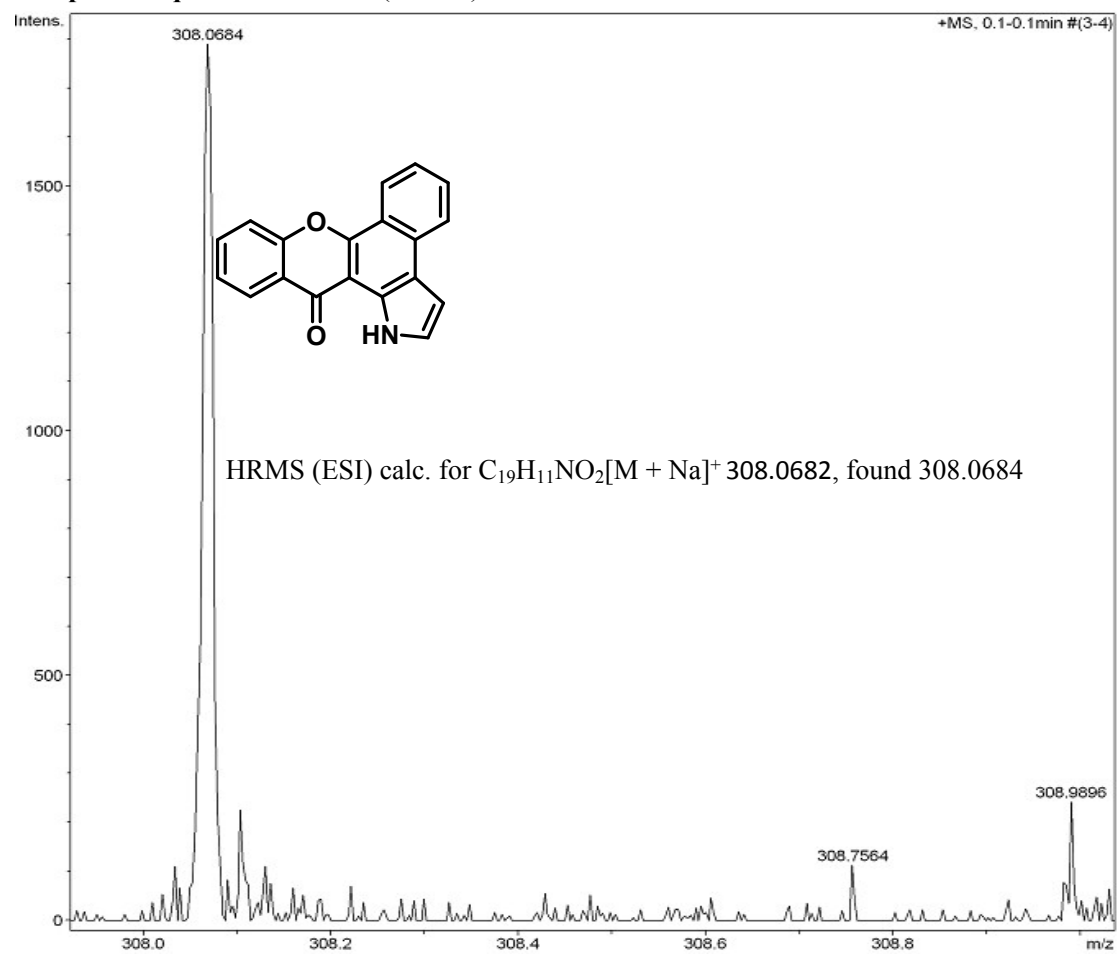
Compound 3p HRMS(MeOH)



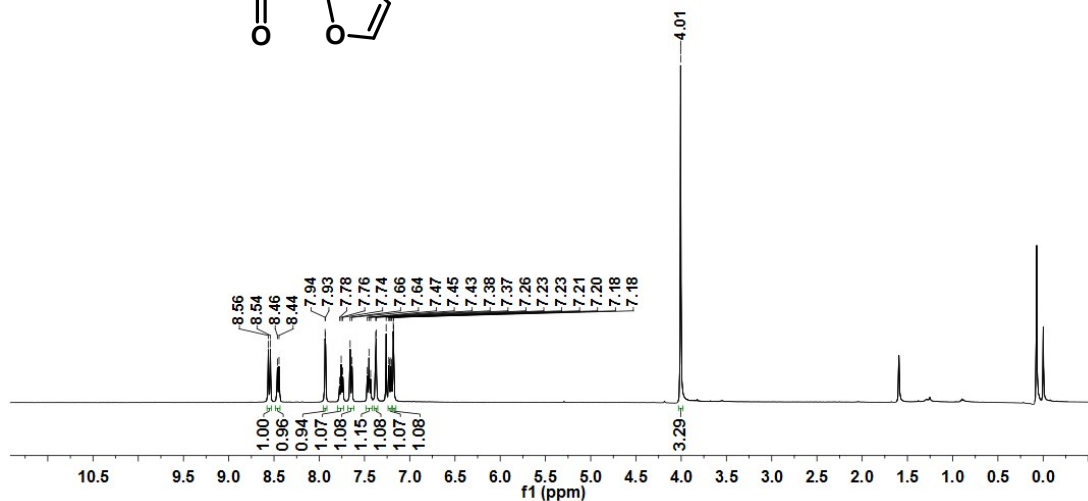
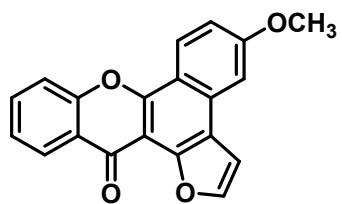
Compound 3q 1H NMR(DMSO)



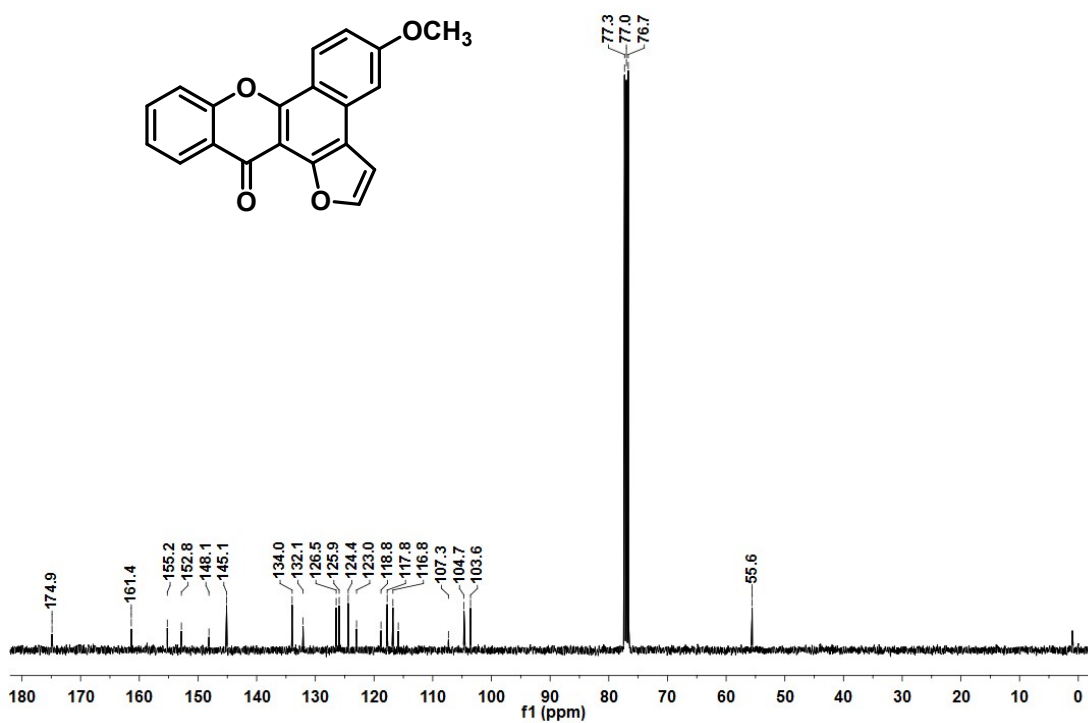
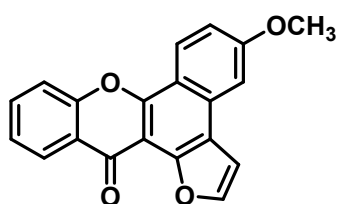
Compound 3q ¹³C NMR (DMSO)



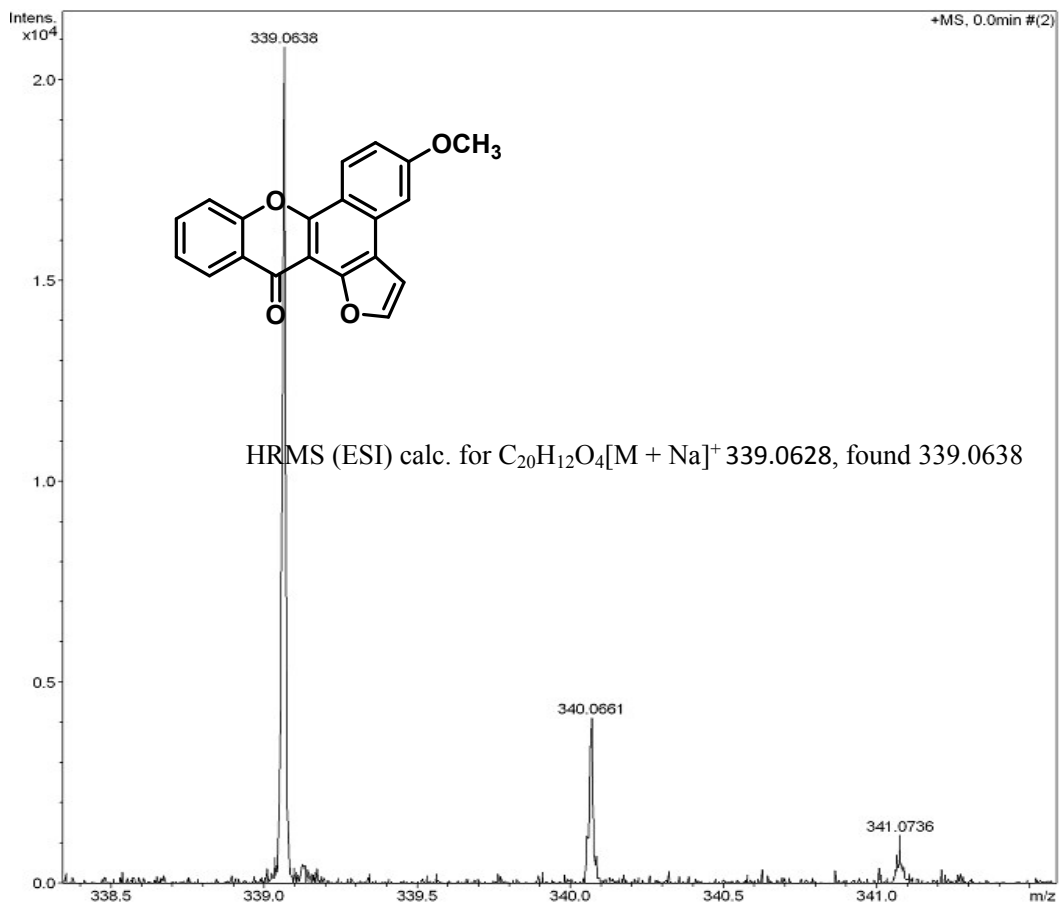
Compound 3q HRMS(MeOH)



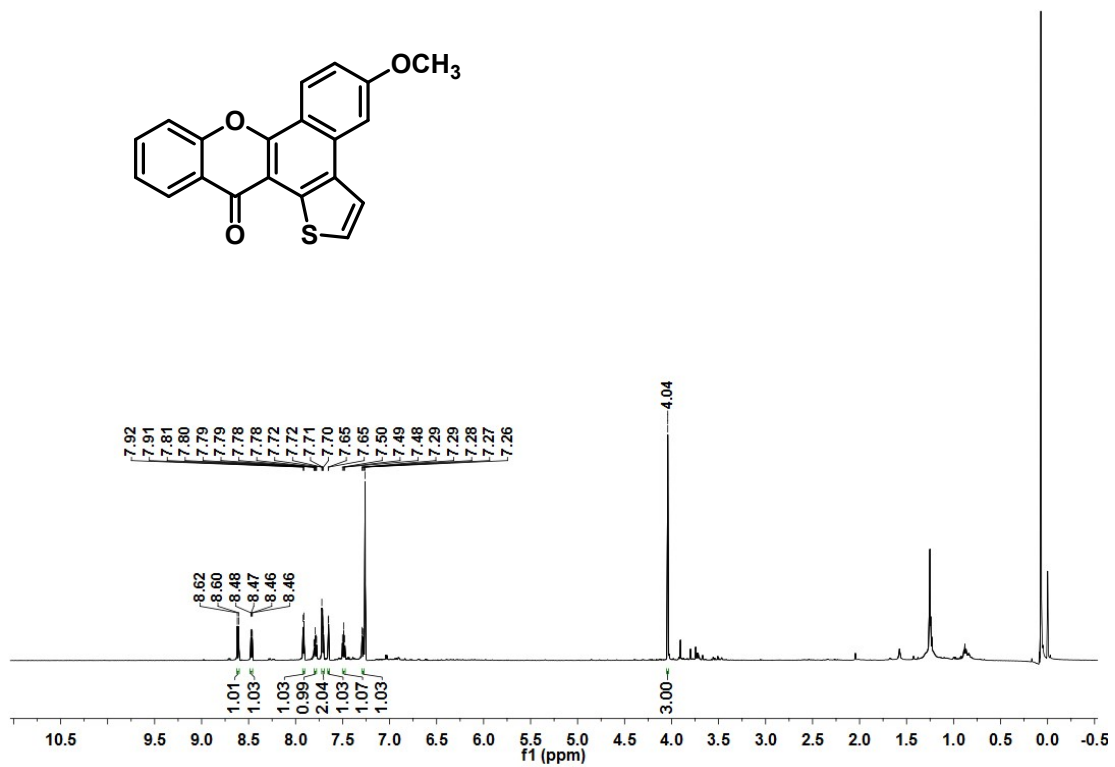
Compound 3r $^1\text{H NMR}(\text{CDCl}_3)$



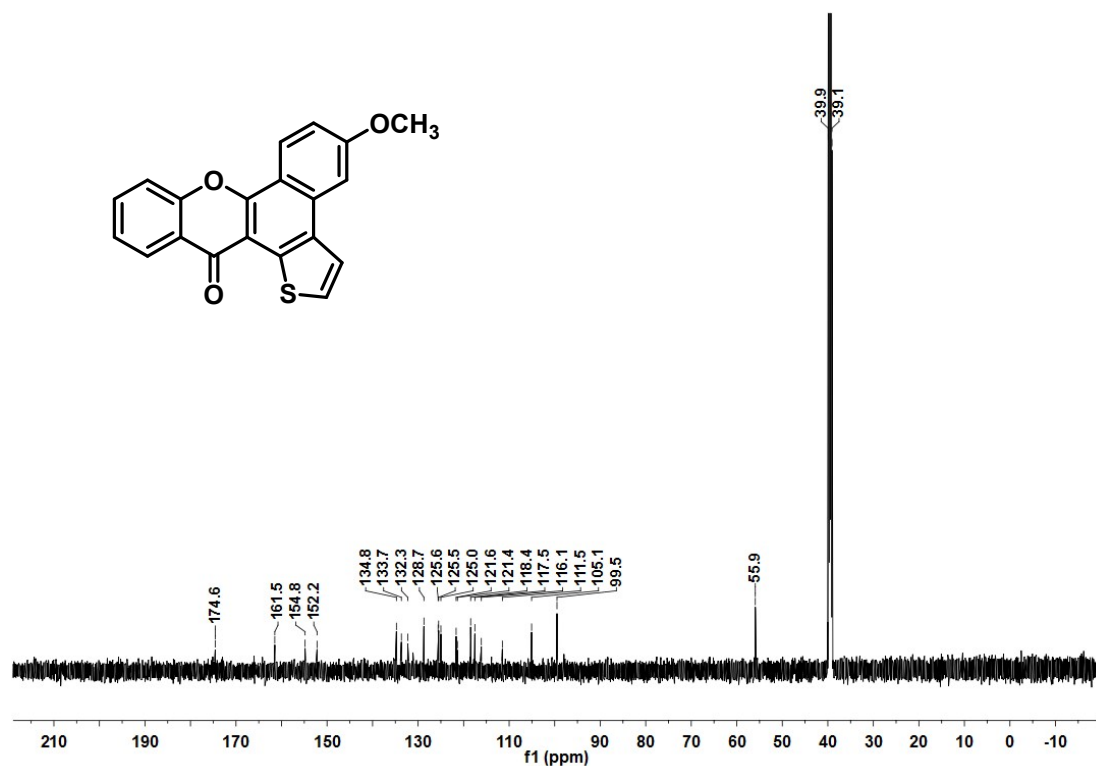
Compound 3r $^{13}\text{C NMR}(\text{CDCl}_3)$



Compound 3r HRMS(MeOH)

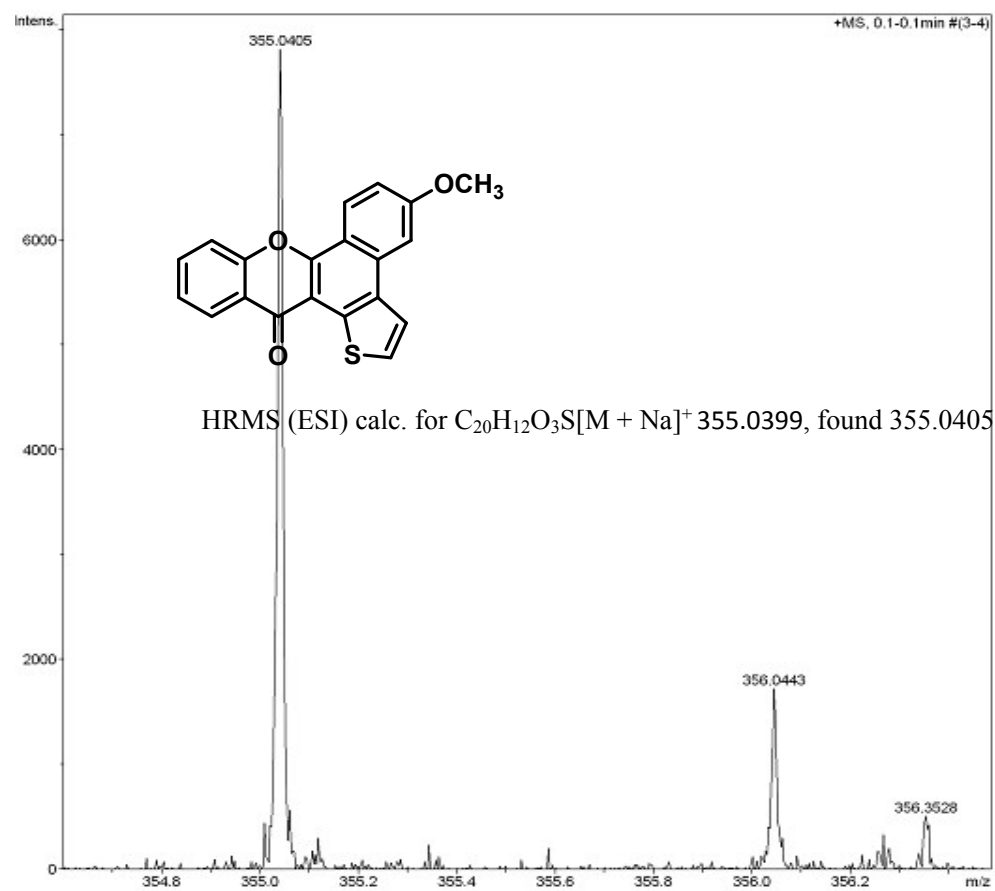


Compound 3s 1H NMR(CDCl₃)



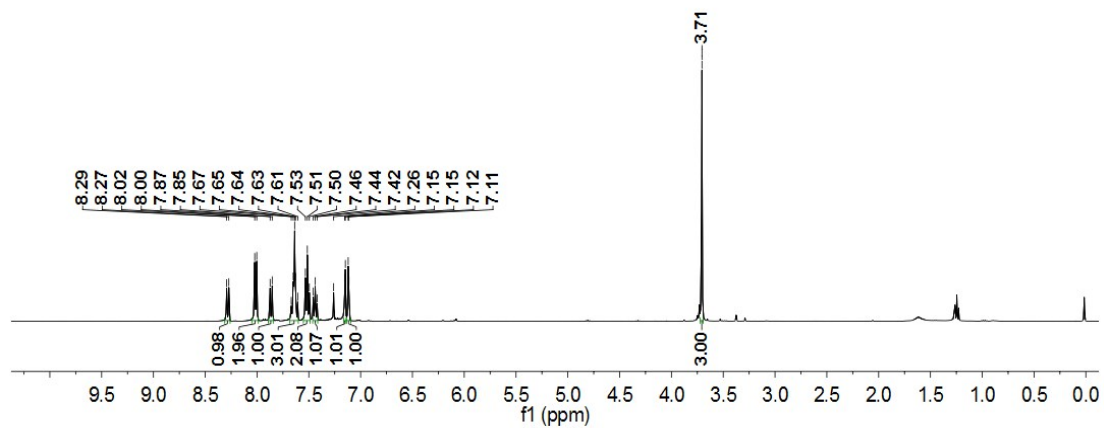
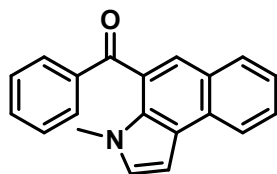
Compound 3s

^{13}C NMR (DMSO)

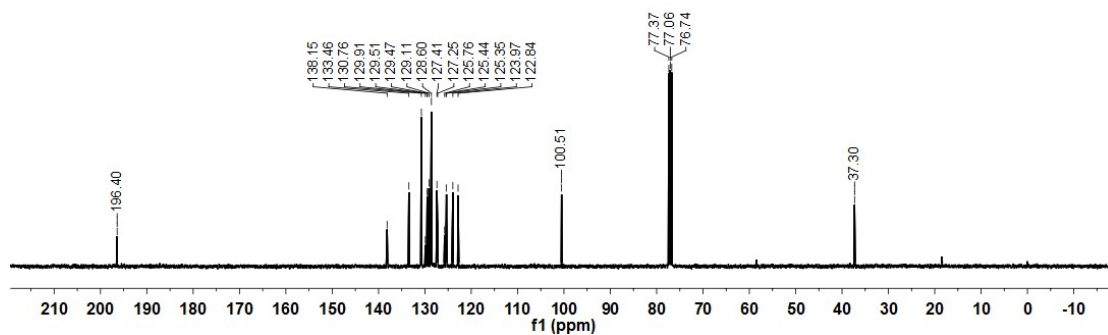
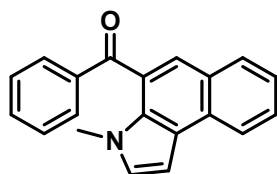


Compound 3s

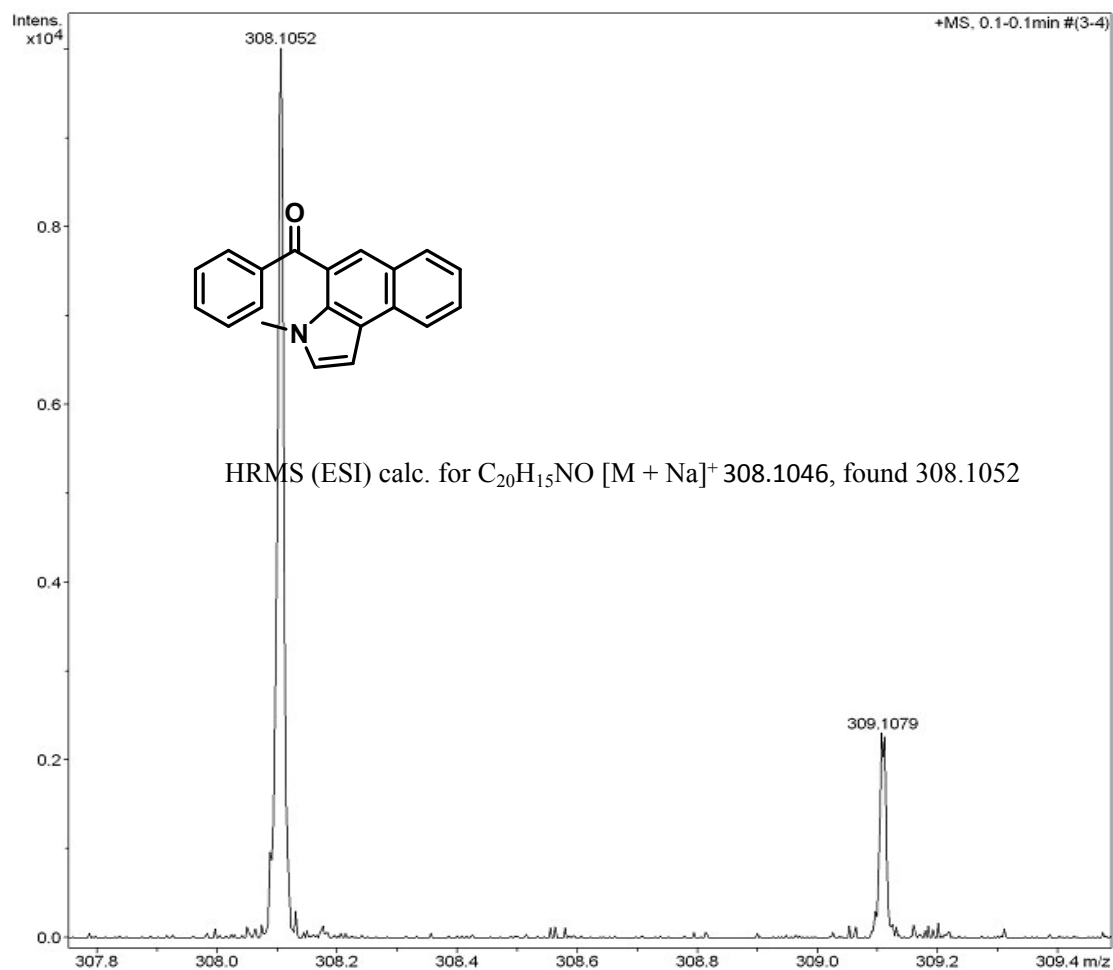
HRMS (MeOH)



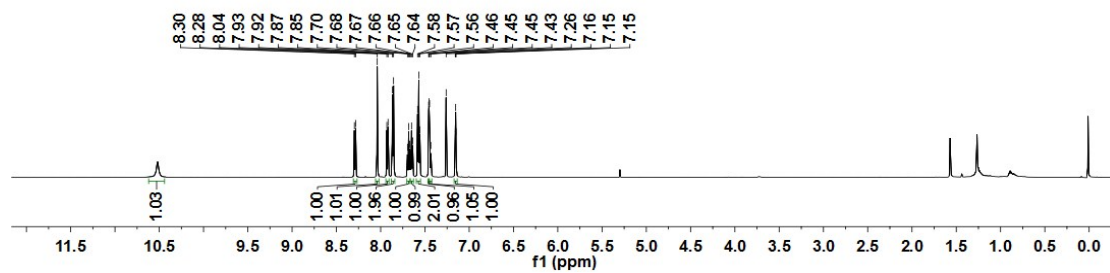
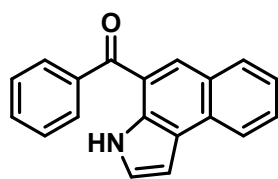
Compound 5a $^1\text{H NMR}(\text{CDCl}_3)$



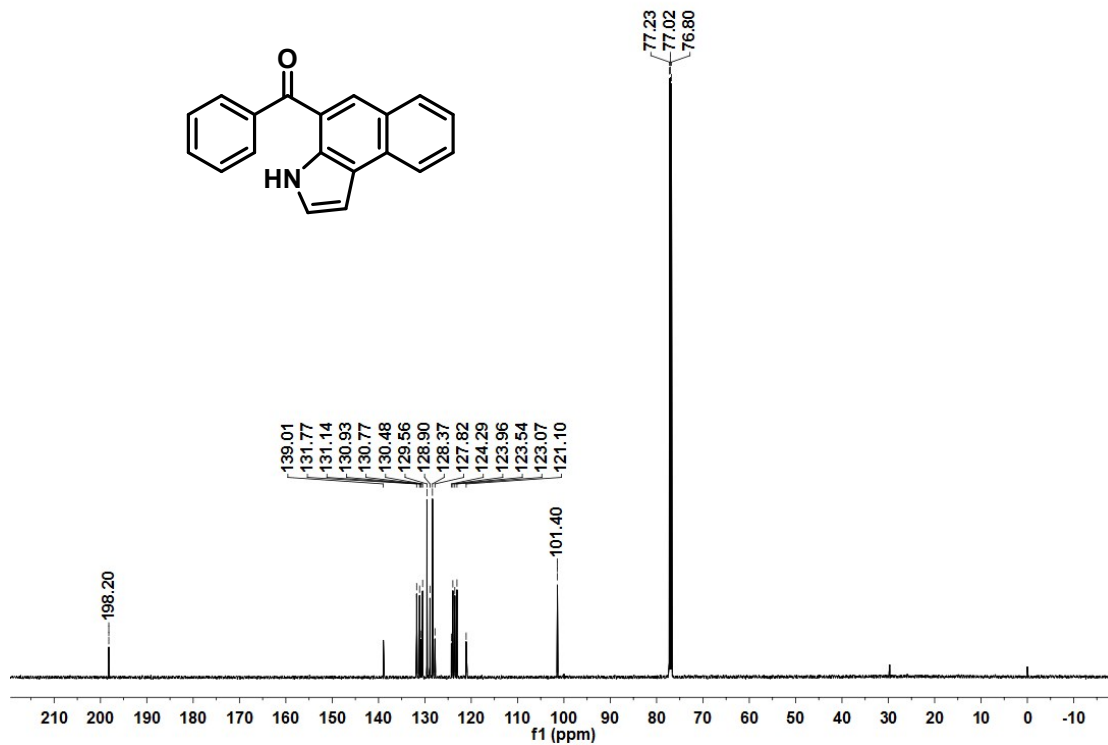
Compound 5a $^{13}\text{C NMR}(\text{CDCl}_3)$



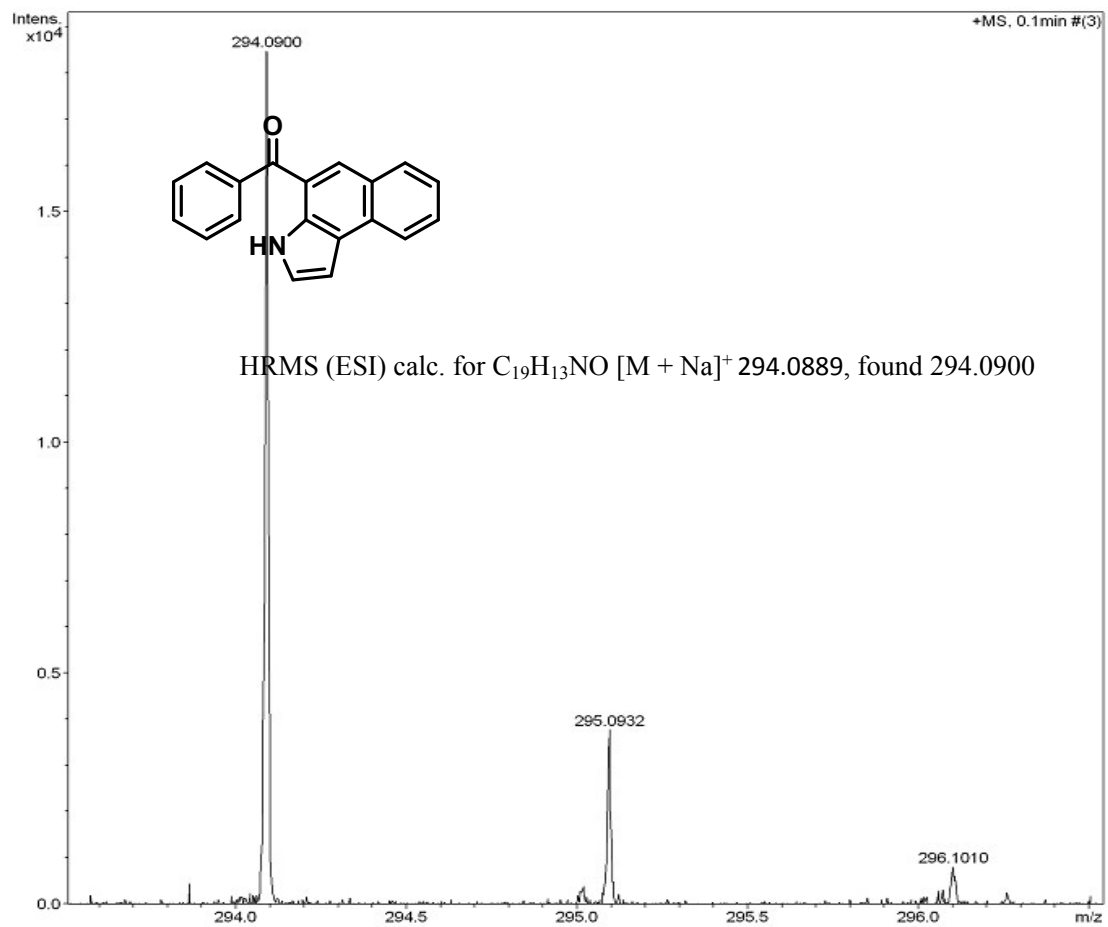
Compound 5a HRMS(MeOH)



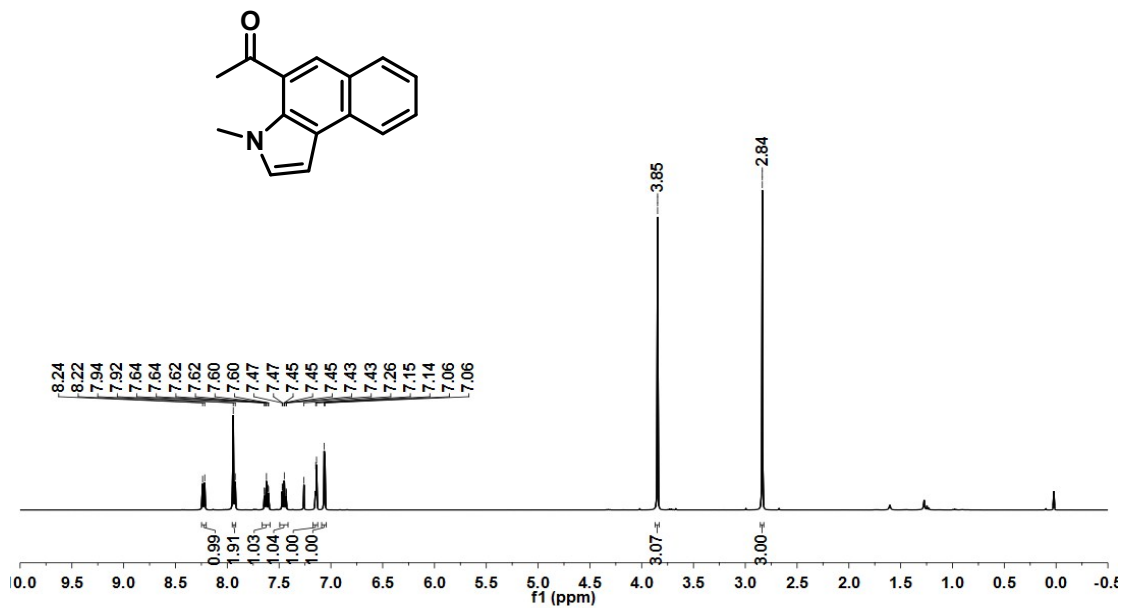
Compound 5b 1H NMR($CDCl_3$)



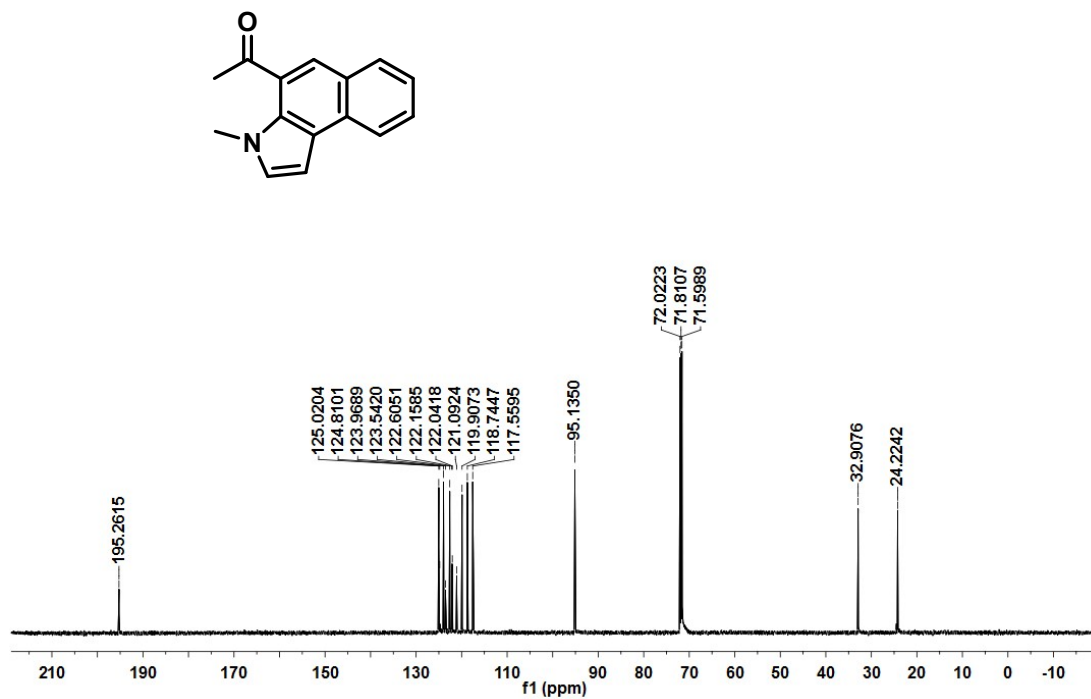
Compound 5b ^{13}C NMR (CDCl₃)



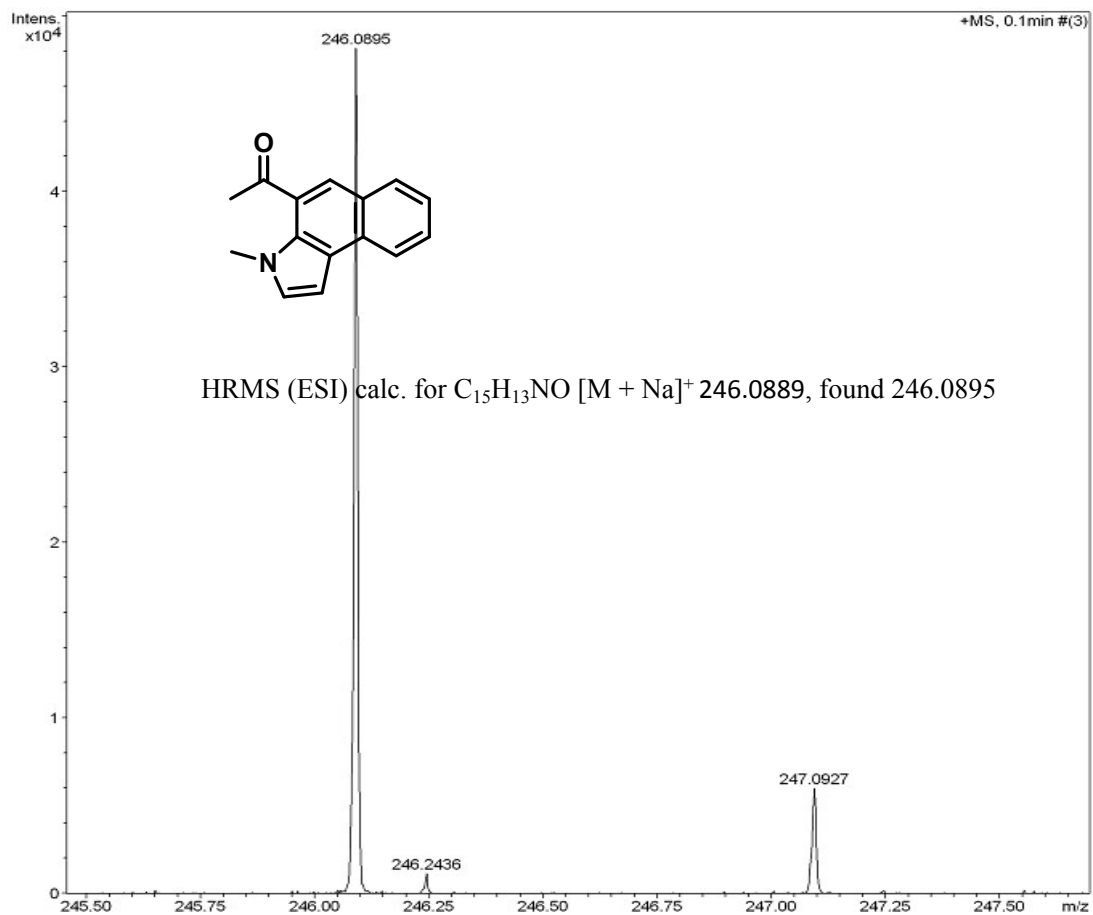
Compound 5b HRMS(MeOH)



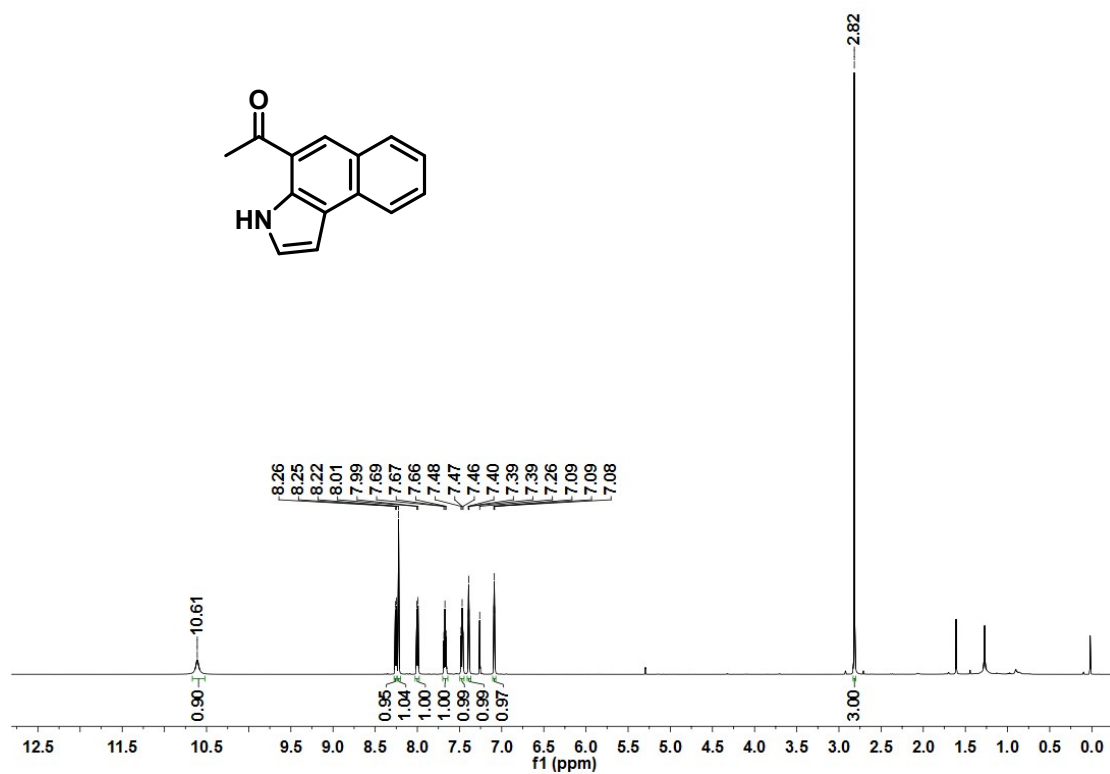
Compound 5c $^1\text{H NMR}(\text{CDCl}_3)$



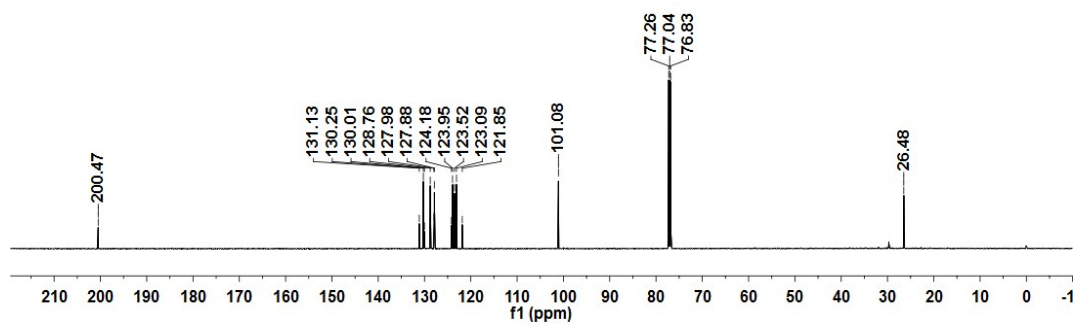
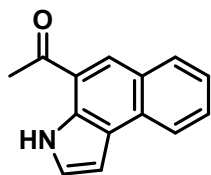
Compound 5c $^{13}\text{C NMR}(\text{CDCl}_3)$



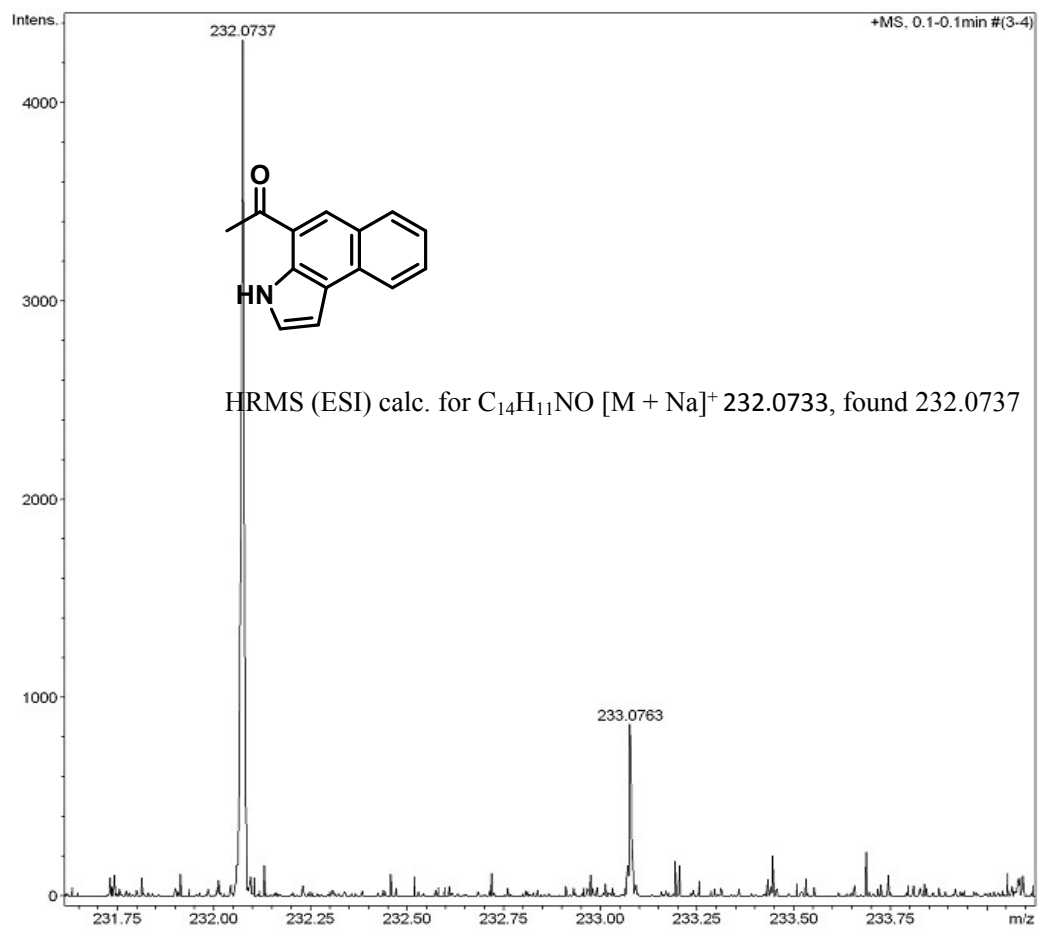
Compound 5c HRMS(MeOH)



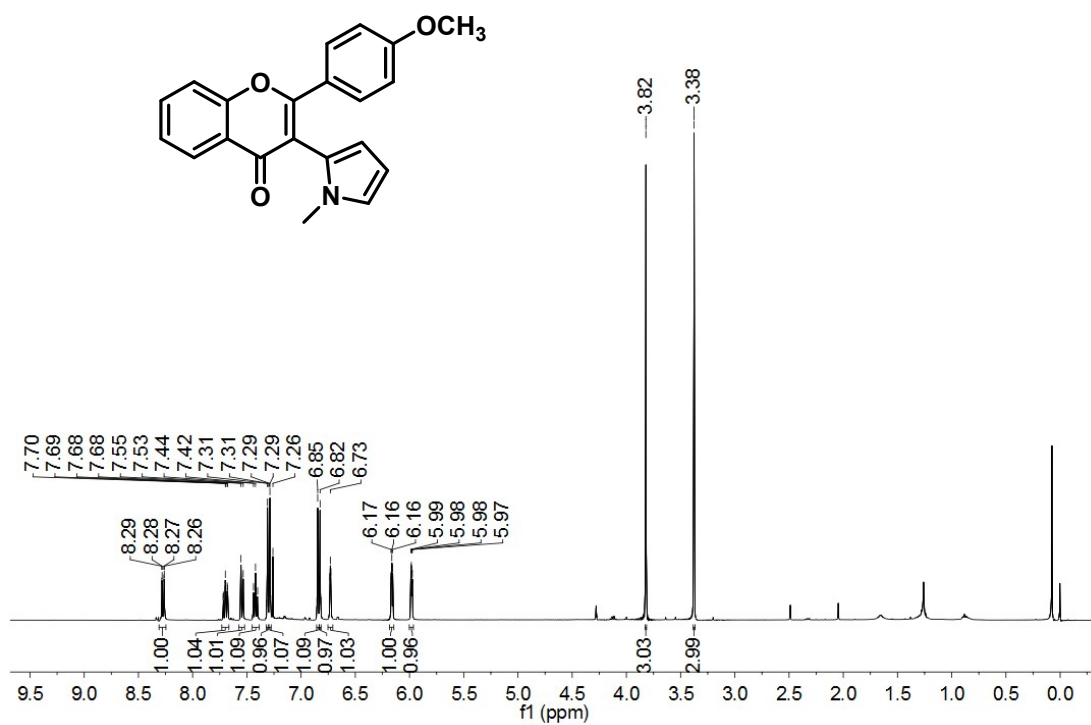
Compound 5d 1H NMR($CDCl_3$)



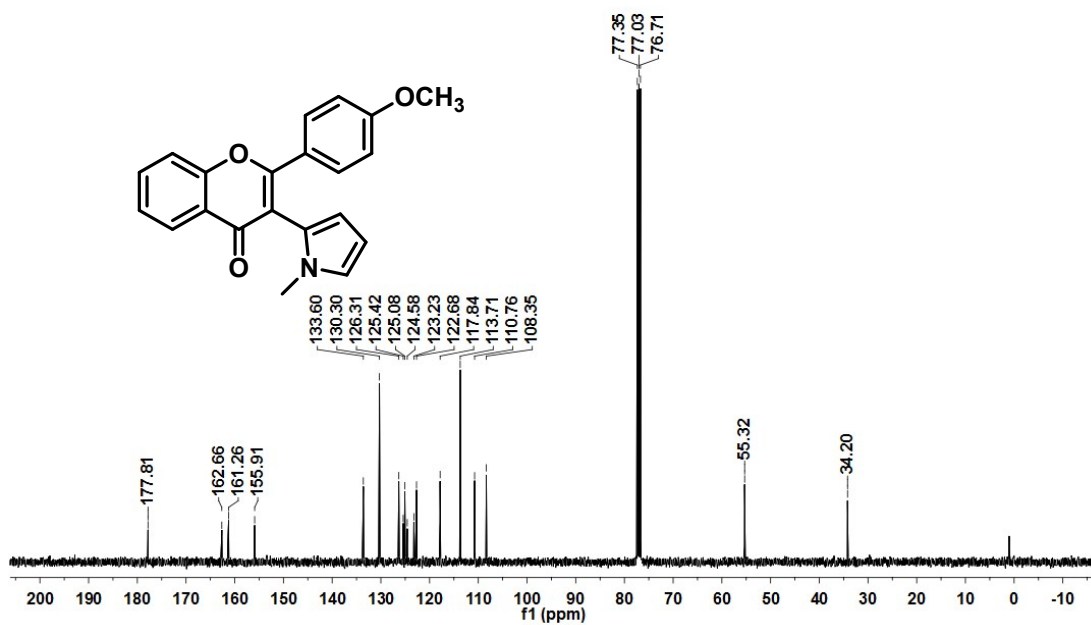
Compound 5d ^{13}C NMR (CDCl_3)



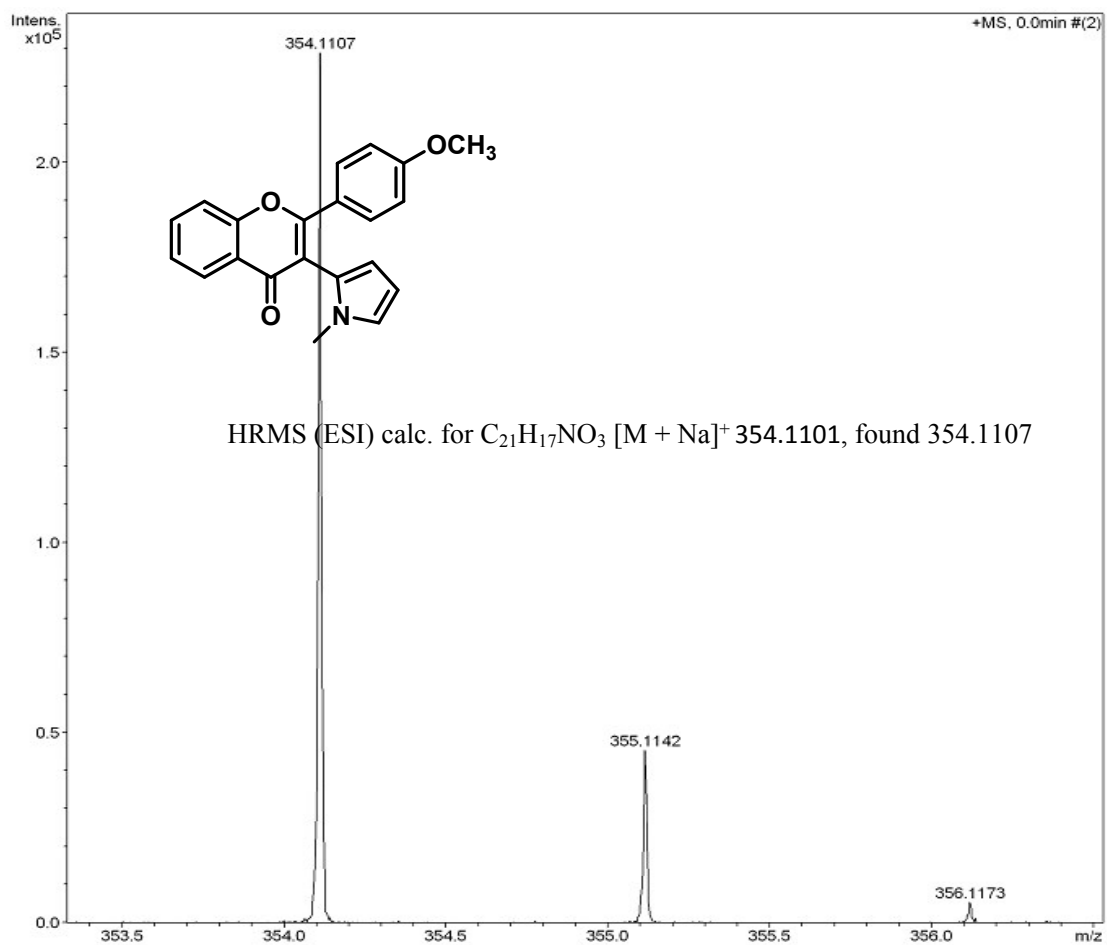
Compound 5d HRMS(MeOH)



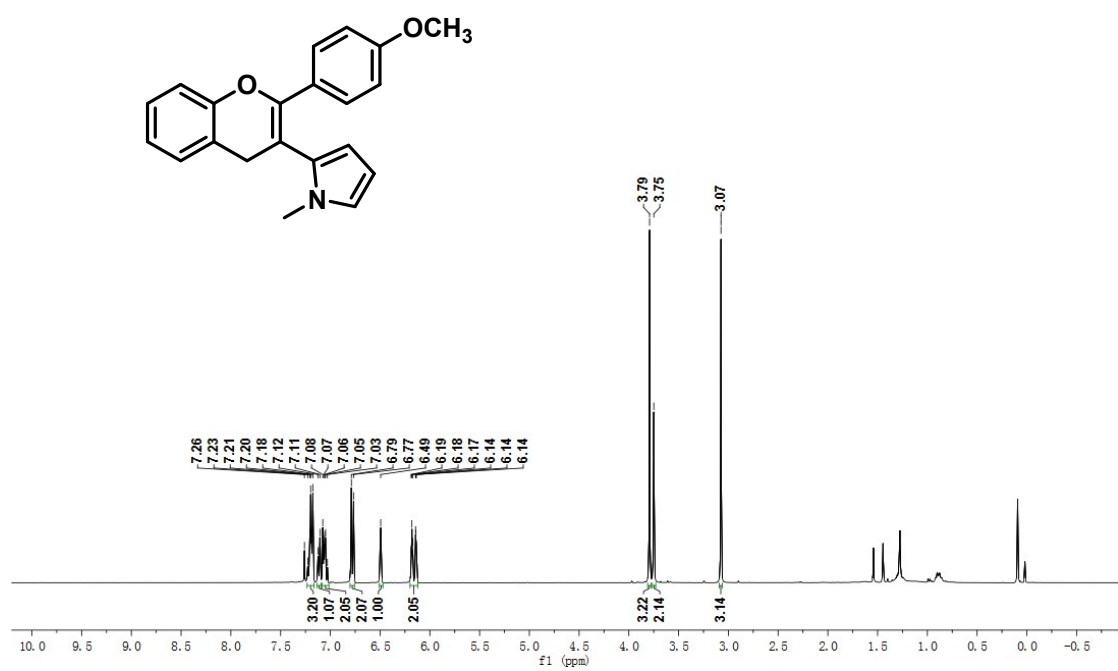
Compound 1aa $^1\text{H NMR}(\text{CDCl}_3)$



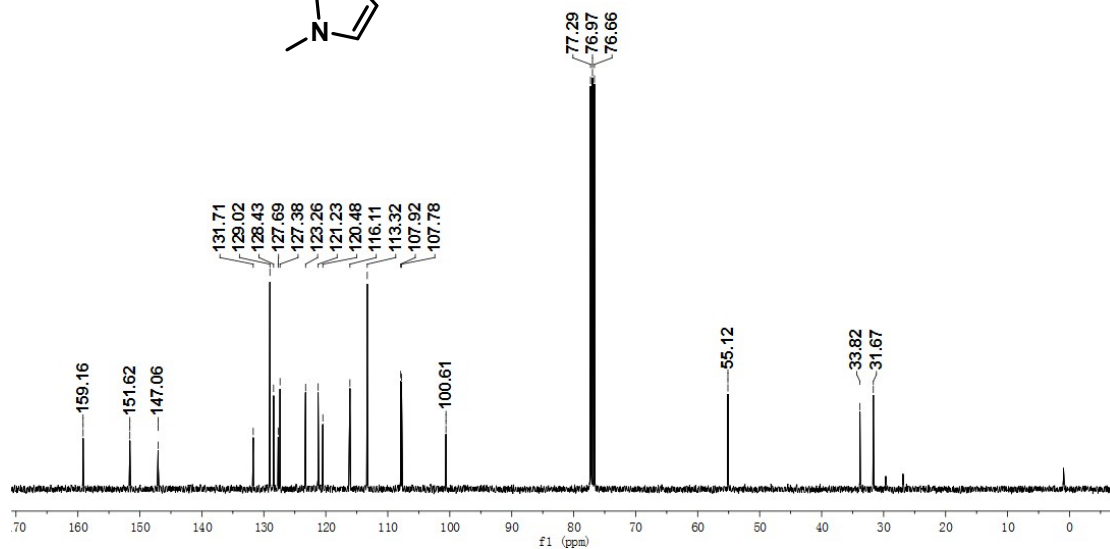
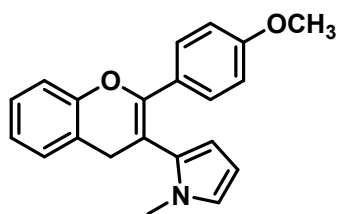
Compound 1aa $^{13}\text{C NMR}(\text{CDCl}_3)$



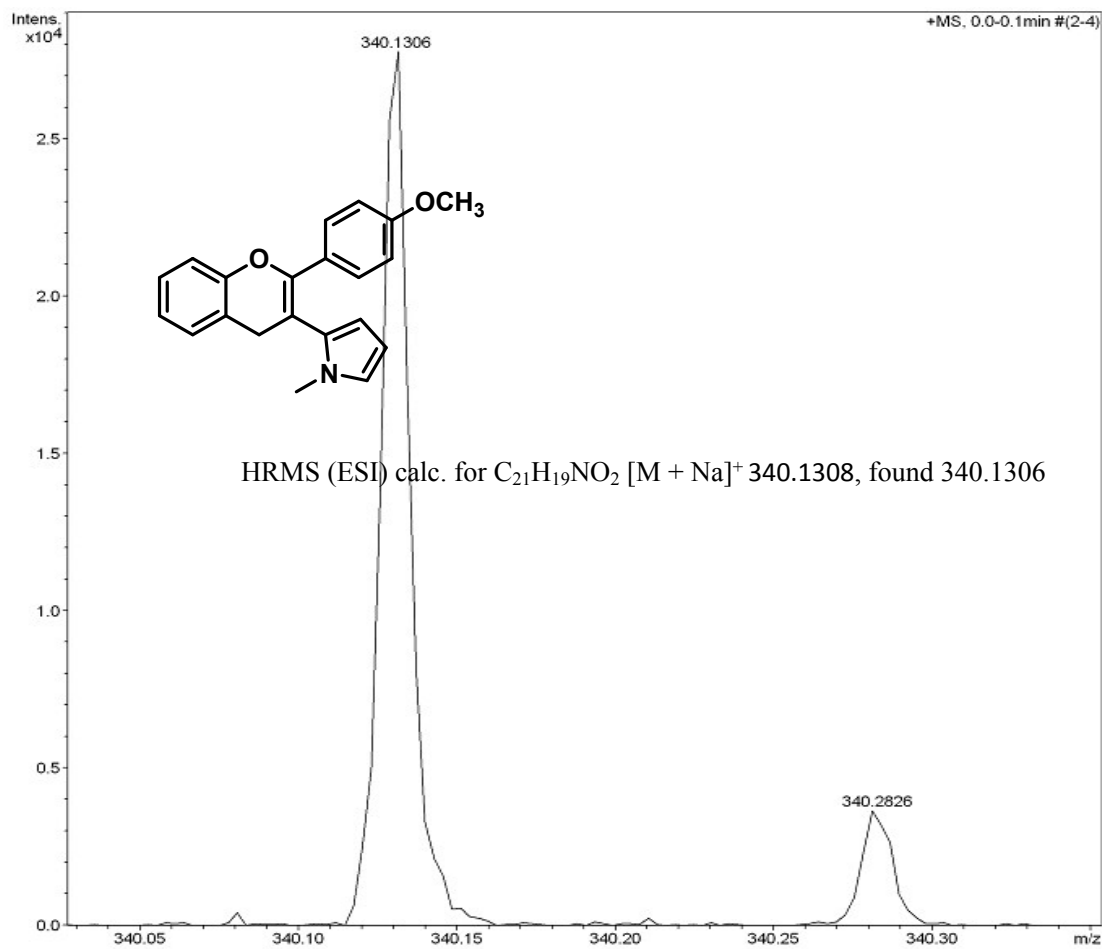
Compound 1aa HRMS(MeOH)



Compound 1ab 1H NMR(CDCl₃)



Compound 1ab ^{13}C NMR (CDCl_3)



Compound 1ab HRMS(MeOH)