Supporting Information

Dinuclear zinc-catalyzed asymmetric Friedel–Crafts alkylation/cyclization of 3-aminophenols with α,α-dicyanoolefins

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General Information

All reactions were carried out under an atmosphere of argon using oven-dried glassware. Super dry solvents, metal catalysts, were purchased from chemical companies and used without further treatment. Flash column chromatography was performed using silica gel (300-400 mesh). ^{1}H NMR ,^{13}C NMR, ^{19}F NMR spectra were recorded in $CDCl_3$ or DMSO-d6 on a 400 MHz spectrometer; chemical shifts are reported in ppm with the solvent signals as reference, and coupling constants (*J*) are given in Hertz. The peak information is described as: s = singlet, d = doublet, t = triplet, q = quartet, m= multiplet. High-resolution mass spectra (HRMS) were recorded on a commercial apparatus (ESI Source).

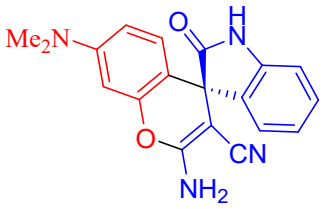
General Procedure for optimization of the reaction conditions.

Under a nitrogen atmosphere, a solution of diethylzinc (40 μL, 1.0 M in hexane, 0.04 mmol) was added dropwise to a solution of **L** (0.02 mmol) in solvent (2 mL). After the mixture was stirred for 30 min at room temperature, then, 3-aminophenol **1** (0.2 mmol) and isatylidene malononitrile **2a** (0.2 mmol) were added. The reaction mixture was stirred for corresponding time at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with EA (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product **3a**.

Synthesis of chiral 2-amino-4*H*-chromenes.

Under a nitrogen atmosphere, a solution of diethylzinc (40 μL, 1.0 M in hexane, 0.04 mmol) was added dropwise to a solution of **L1d** (0.02 mmol) in MeCN (2 mL). After the mixture was stirred for 30 min at room temperature, the temperature of the mixture was lowered to 10 °C. Then, 3-aminophenol **1** (0.2 mmol) and isatylidene malononitriles **2** (0.2 mmol) or benzylidene malononitriles **4** (0.2 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with CH_2Cl_2 (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (5/1) to afford the desired product **3** or **5**.

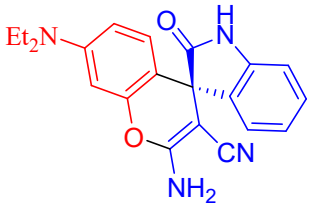
(*R*)-2-amino-7-(dimethylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3a):



3a

white solid (36.5 mg) in 55% isolated yield; $[\alpha]_D^{20}$ = + 86 (c = 1.0, THF, 10% ee); **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.46 (s, 1H), 7.29 – 7.21 (m, 1H), 7.10 (s, 2H), 7.05 – 6.97 (m, 2H), 6.92 (d, *J* = 7.7 Hz, 1H), 6.46 – 6.39 (m, 1H), 6.32 – 6.23 (m, 2H), 2.87 (s, 6H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.8, 162.0, 151.3, 150.0, 142.4, 135.4, 129.2, 127.4, 125.2, 123.0, 119.3, 110.2, 110.1, 107.9, 99.1, 54.8, 50.3, 40.4; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{19}H_{17}N_4O_2]^+$: 333.1346, found: 333.1346; **IR**: 3463, 3189, 2202, 1716, 1401, 1119, 750, 618 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.97 min and t_{minor} = 18.97 min.

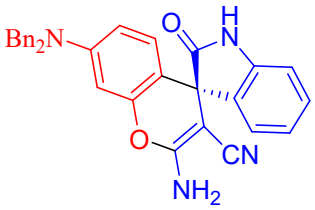
(*R*)-2-amino-7-(diethylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3b)



3b

yellow solid (43.9 mg) in 61% isolated yield; $[\alpha]_D^{20}$ = + 112 (c = 1.0, THF, 72% ee); **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.46 (s, 1H), 7.28 – 7.20 (m, 1H), 7.09 (s, 2H), 7.04 – 6.94 (m, 2H), 6.92 (d, *J* = 7.7 Hz, 1H), 6.38 – 6.32 (m, 1H), 6.26 – 6.18 (m, 2H), 3.31 – 3.23 (m, 4H), 1.05 (t, *J* = 7.0 Hz, 6H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.9, 162.1, 150.3, 148.3, 142.4, 135.4, 129.2, 127.6, 125.2, 123.0, 119.4, 110.2, 109.2, 106.8, 98.0, 54.8, 50.3, 44.2, 12.8; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{21}H_{21}N_4O_2]^+$: 361.1659, found: 361.1657; **IR**: 3446, 3329, 2972, 2194, 1703, 1401, 1121, 760, 614 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.81 min and t_{minor} = 35.91 min.

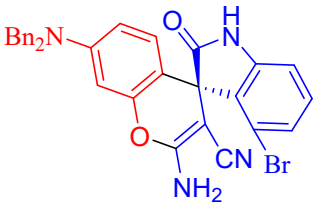
(*R*)-2-amino-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3c)



3c

white solid (61.0 mg) in 63% isolated yield; $[\alpha]_D^{20}$ = + 19 (c = 1.0, THF, 99% ee); **m.p.** = 257.3-258.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.46 (s, 1H), 7.39–7.28 (m, 4H), 7.29–7.15 (m, 7H), 7.08 (s, 2H), 7.01–6.92 (m, 2H), 6.92–6.85 (m, 1H), 6.39 (d, *J* = 8.7 Hz, 1H), 6.20 (d, *J* = 8.8 Hz, 1H), 6.15 (d, *J* = 2.5 Hz, 1H), 4.69 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.8, 162.0, 149.9, 149.2, 142.4, 138.8, 135.2, 129.2, 129.1, 127.4, 127.3, 126.8, 125.2, 123.0, 119.3, 110.2, 110.2, 110.0, 108.1, 99.3, 54.7, 54.7, 50.3; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{25}N_4O_2]^+$: 485.1972, found: 485.1976; **IR**: 3462, 3173, 3032, 2922, 2192, 1691, 1647, 1520, 1518, 1407, 1290, 1195, 1124, 793, 728, 695 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.36 min and t_{minor} = 23.16 min.

(*R*)-2-amino-4'-bromo-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3f)

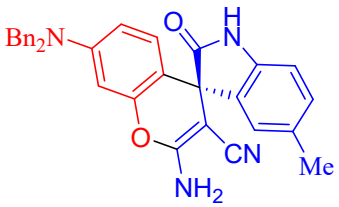


3f

white solid (62.9 mg) in 56% isolated yield; $[\alpha]_D^{20}$ = + 350 (c = 1.0, THF, >99% ee); **m.p.** = 274.6-276.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.74 (s, 1H), 7.36–7.29 (m, 4H), 7.27–7.21 (m, 6H), 7.18–7.14 (m, 1H), 7.14–7.07 (m, 3H), 6.92 (d, *J* = 7.6 Hz, 1H), 6.42 (m, 1H), 6.28 (d, *J* = 8.7 Hz, 1H), 6.17 (d, *J* = 2.0 Hz, 1H), 4.69 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 178.9, 162.2, 150.4, 149.5,

144.4, 138.9, 132.3, 131.2, 129.1, 127.3, 127.0, 126.9, 126.3, 119.9, 119.1, 110.0, 109.8, 105.5, 99.2, 54.7, 52.6, 52.1; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{31}H_{24}BrN_4O_2$]$^+$: 563.1077, found: 563.1074; **IR:** 3440, 3304, 3183, 3064, 2189, 1700, 1653, 1520, 1415, 1194, 839, 730, 693 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.79 min.

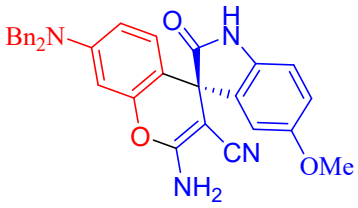
(*R*)-2-amino-7-(dibenzylamino)-5'-methyl-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3g)



3g

white solid (86.7 mg) in 87% isolated yield; [α]$_D^{20}$ = - 34 (c = 1.0, THF, 99% ee); **m.p.** = 293.6-294.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.35 (s, 1H), 7.43–7.29 (m, 4H), 7.28–7.17 (m, 6H), 7.05 (s, 2H), 7.01 (d, *J* = 7.9 Hz, 1H), 6.86–6.69 (m, 2H), 6.39 (d, *J* = 8.4 Hz, 1H), 6.26–6.10 (m, 2H), 4.69 (s, 4H), 2.18 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.8, 161.8, 149.8, 149.2, 139.9, 138.9, 135.4, 131.9, 129.6, 129.1, 127.6, 127.3, 126.8, 125.6, 119.4, 110.0, 108.1, 99.2, 54.8, 50.3, 21.0; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{32}H_{27}N_4O_2$]$^+$: 499.2129, found: 499.2128; **IR:** 3476, 3301, 3151, 3034, 2919, 2189, 1692, 1647, 1519, 1490, 1407, 1196, 1129, 813, 731, 694 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.61 min and t_{minor} = 22.52 min.

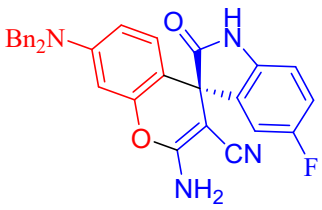
(*R*)-2-amino-7-(dibenzylamino)-5'-methoxy-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3h)



3h

white solid (90.5 mg) in 88% isolated yield; [α]$_D^{20}$ = - 67 (c = 1.0, THF, 98% ee); **m.p.** = 285.3-286.9 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.28 (s, 1H), 7.37–7.28 (m, 4H), 7.28–7.20 (m, 6H), 7.08 (s, 2H), 6.87–6.77 (m, 2H), 6.59 (d, *J* = 1.5 Hz, 1H), 6.41 (m, 1H), 6.21 (d, *J* = 8.8 Hz, 1H), 6.16 (d, *J* = 2.2 Hz, 1H), 4.69 (s, 4H), 3.64 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.7, 161.9, 155.9, 149.8, 149.2, 138.8, 136.4, 135.7, 129.1, 127.5, 127.3, 126.8, 119.4, 114.2, 111.6, 110.7, 109.9, 108.1, 99.3, 55.9, 54.7, 54.6, 50.8; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{32}H_{27}N_4O_3$]$^+$: 515.2078, found: 515.2077; **IR:** 3459, 3287, 3151, 3034, 2189, 1690, 1548, 1519, 1492, 1402, 1298, 1193, 1124, 813, 697 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.68 min and t_{minor} = 25.30 min.

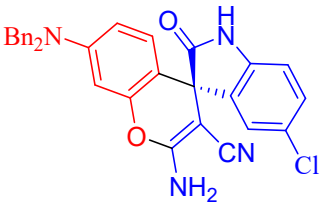
(*R*)-2-amino-7-(dibenzylamino)-5'-fluoro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3i)



3i

white solid (84.3 mg) in 84% isolated yield; $[\alpha]_D^{20}$ = + 46 (c = 1.0, THF, 98% ee); **m.p.** = 276.7-278.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.49 (s, 1H), 7.39–7.29 (m, 4H), 7.28–7.19 (m, 6H), 7.13 (s, 2H), 7.10–7.03 (m, 1H), 6.94 (d, *J* = 7.8 Hz, 1H), 6.91-6.88 (m, 1H), 6.41 (d, *J* = 7.9 Hz, 1H), 6.23 (d, *J* = 8.7 Hz, 1H), 6.16 (s, 1H), 4.70 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.8, 162.0, 160.2, 159.0 (d, *J* = 238.0 Hz), 149.8, 149.3, 138.8, 138.6, 136.8, 136.8, 129.1, 127.4, 127.3, 126.8, 119.2, 115.9, 115.7, 113.0, 112.8, 111.2, 111.1, 110.0, 107.4, 99.4, 54.8, 54.1, 50.8; **^{19}F NMR** (376 MHz, DMSO-d6) δ -120.8; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{24}FN_4O_2]^+$: 503.1878, found: 503.1880; **IR:** 3500, 3342, 3163, 3063, 2187, 1698, 1644, 1520, 1489, 1414, 1185, 1123, 826, 732, 696 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 24.97 min and t_{minor} = 18.52 min.

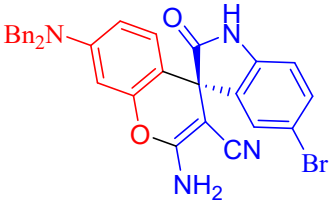
(*R*)-2-amino-5'-chloro-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3j)



3j

white solid (100.5 mg) in 97% isolated yield; $[\alpha]_D^{20}$ = - 32 (c = 1.0, THF, >99% ee); **m.p.** = 271.4-273.0 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.59 (s, 1H), 7.42–7.30 (m, 4H), 7.30–7.18 (m, 7H), 7.14 (s, 2H), 7.07 (s, 1H), 6.91 (d, *J* = 7.6 Hz, 1H), 6.41 (d, *J* = 7.3 Hz, 1H), 6.31–6.04 (m, 2H), 4.70 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.5, 162.0, 149.8, 149.4, 141.4, 138.8, 137.2, 129.3, 129.1, 127.4, 127.3, 126.9, 126.8, 125.2, 119.2, 111.8, 110.0, 107.2, 99.4, 54.7, 54.0, 50.6; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{24}ClN_4O_2]^+$: 519.1582, found: 519.1584; **IR:** 3471, 3280, 3174, 3030, 2190, 1696, 1644, 1510, 1402, 1188, 821, 748, 693 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.62 min.

(*R*)-2-amino-5'-bromo-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3k)

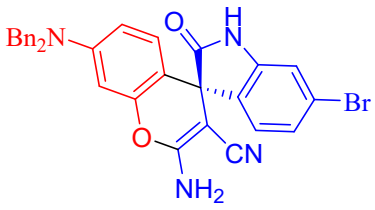


3k

white solid (101.2 mg) in 90% isolated yield; $[\alpha]_D^{20}$ = + 115 (c = 1.0, THF, 98% ee); **m.p.** = 264.3-265.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.60 (s, 1H), 7.42-7.40 (m, 1H), 7.36–7.29 (m, 4H), 7.28–7.20 (m, 6H), 7.18 (d, *J* = 1.7 Hz, 1H), 7.13 (s, 2H), 6.86 (d, *J* = 8.3 Hz, 1H), 6.44-6.41 (m, 1H),

6.24 (d, *J* = 8.8 Hz, 1H), 6.16 (d, *J* = 2.3 Hz, 1H), 4.71 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.4, 161.9, 149.8, 149.4, 141.8, 138.8, 137.6, 132.2, 129.1, 127.9, 127.3, 126.8, 119.2, 114.6, 112.3, 110.1, 107.2, 99.4, 54.8, 54.0, 50.6; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{24}BrN_4O_2]^+$: 563.1077, found: 563.1080; **IR:** 3468, 3280, 3152, 3030, 2192, 1696, 1644, 1510, 1401, 1188, 820, 748, 693 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.71 min and t_{minor} = 13.16 min.

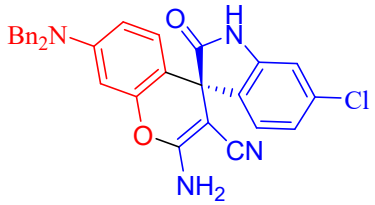
(*R*)-2-amino-6'-bromo-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3l)



3l

white solid (101.2 mg) in 90% isolated yield; $[\alpha]_D^{20}$ = + 58 (c = 1.0, THF, 98% ee); **m.p.** = 278.8-281.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.64 (s, 1H), 7.36–7.31 (m, 4H), 7.26–7.21 (m, 7H), 7.17–7.14 (m, 2H), 7.13 (d, *J* = 1.8 Hz, 1H), 7.07 (d, *J* = 1.5 Hz, 1H), 6.96 (d, *J* = 7.9 Hz, 1H), 6.41-6.39 (m, 1H), 6.24 (d, *J* = 8.8 Hz, 1H), 6.17 (d, *J* = 2.4 Hz, 1H), 4.70 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 149.8, 149.3, 144.1, 138.8, 134.4, 129.1, 128.9, 127.5, 127.4, 127.1, 126.8, 125.6, 121.8, 119.2, 113.1, 110.0, 107.2, 99.4, 54.8, 54.0, 50.1; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{24}BrN_4O_2]^+$: 563.1077, found: 563.1074; **IR:** 3479, 3314, 3181, 3033, 2192, 1699, 1647, 1518, 1407, 1126, 856, 733, 698 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.46 min and t_{minor} = 18.11 min.

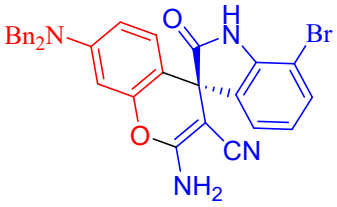
(*R*)-2-amino-6'-chloro-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3m)



3m

white solid (63.2 mg) in 61% isolated yield; $[\alpha]_D^{20}$ = + 49 (c = 1.0, THF, 97% ee); **m.p.** = 268.9-271.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.39–7.30 (m, 4H), 7.26–7.19 (m, 6H), 7.12 (s, 2H), 7.07–6.96 (m, 2H), 6.91 (d, *J* = 1.3 Hz, 1H), 6.41-6.39 (m, 1H), 6.24 (d, *J* = 8.8 Hz, 1H), 6.16 (d, *J* = 2.2 Hz, 1H), 4.70 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.7, 162.0, 149.8, 149.4, 144.0, 138.8, 134.0, 133.4, 129.1, 127.5 127.3, 126.8, 122.7, 119.1, 110.3, 110.0, 107.4, 99.4, 54.8, 54.1, 50.0; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{24}ClN_4O_2]^+$: 519.1582, found: 519.1587; **IR:** 3482, 3322, 3191, 3030, 2193, 1717, 1643, 1614, 1516, 1399, 1125, 915, 731, 695 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.80 min and t_{minor} = 19.18 min.

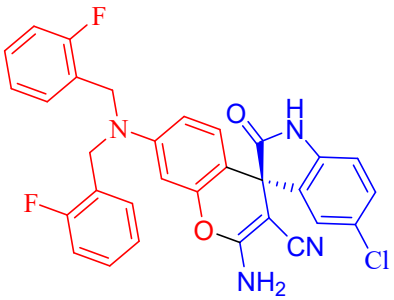
(*R*)-2-amino-7'-bromo-7-(dibenzylamino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3n)



3n

white solid (65.2 mg) in 58% isolated yield; $[\alpha]_D^{20}$ = + 159 (c = 1.0, THF, 99% ee); **m.p.** = 272.2-274.6 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.80 (s, 1H), 7.42 (d, *J* = 7.8 Hz, 1H), 7.36–7.28 (m, 4H), 7.27–7.21 (m, 6H), 7.17 (s, 2H), 7.04–6.97 (m, 1H), 6.95–6.87 (m, 1H), 6.42-6.40 (m, 1H), 6.23 (d, *J* = 8.8 Hz, 1H), 6.17 (d, *J* = 2.3 Hz, 1H), 4.69 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.7, 161.9, 149.7, 149.4, 141.9, 138.8, 137.0, 132.2, 129.1, 127.4, 127.3, 126.8, 124.7, 124.4, 119.2, 110.1, 107.4, 102.7, 99.4, 54.8, 54.2, 51.5; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{24}BrN_4O_2]^+$: 563.1077, found: 563.1077; **IR:** 3465, 3304, 3182, 3064, 2193, 1701, 1647, 1517, 1408, 1130, 825, 746, 696 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 17.53 min and t_{minor} = 24.29 min.

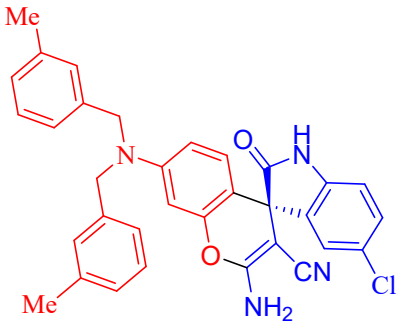
(*R*)-2-amino-7-(bis(2-fluorobenzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3o)



3o

white solid (80.9 mg) in 73% isolated yield; $[\alpha]_D^{20}$ = + 29 (c = 1.0, THF, 99% ee); **m.p.** = 283.2-286.5 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.63 (s, 1H), 7.35–7.26 (m, 3H), 7.25–7.11 (m, 8H), 7.08 (d, *J* = 1.7 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.42-6.40 (m, 1H), 6.28 (d, *J* = 8.8 Hz, 1H), 6.20 (d, *J* = 2.1 Hz, 1H), 4.76 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.5, 161.9 (d, *J* = 5.0 Hz), 159.5, 149.9, 148.9, 141.4, 137.2, 129.4, 129.4, 128.7, 128.6, 127.6, 126.9, 125.2, 125.1, 125.0, 125.0, 119.2, 116.0, 115.8, 111.8, 110.0, 107.8, 99.4, 54.0, 50.6, 48.8; **^{19}F NMR** (376 MHz, DMSO-d6) δ -117.9; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{22}ClF_2N_4O_2]^+$: 555.1394, found: 555.1396; **IR:** 3462, 3300, 3179, 3047, 2192, 1697, 1644, 1512, 1401, 1192, 822, 751, 631 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 8.16 min and t_{minor} = 11.10 min.

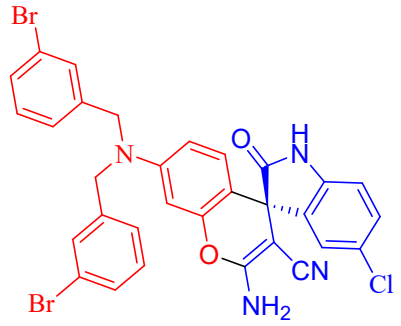
(*R*)-2-amino-7-(bis(3-methylbenzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3p)



3p

white solid (84.1 mg) in 77% isolated yield; $[\alpha]_D^{20}$ = + 23 (c = 1.0, THF, 98% ee); **m.p.** = 247.5-249.6 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.29-7.27 (m, 1H), 7.24–7.18 (m, 2H), 7.16 (s, 2H), 7.09–6.96 (m, 7H), 6.92 (d, *J* = 8.3 Hz, 1H), 6.40-6.38 (m, 1H), 6.23 (d, *J* = 8.8 Hz, 1H), 6.16 (d, *J* = 2.1 Hz, 1H), 4.65 (s, 4H), 2.27 (s, 6H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.5, 162.0, 149.8, 149.5, 141.4, 138.8, 138.2, 137.2, 129.3, 129.0, 128.0, 127.4, 127.3, 126.9, 125.2, 123.9, 119.2, 111.8, 110.0, 107.1, 99.3, 54.8, 54.0, 50.6, 21.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{33}H_{28}ClN_4O_2]^+$: 547.1895, found: 547.1895; **IR:** 3462, 3323, 3187, 3023, 2192, 1714, 1643, 1516, 1398, 1185, 817, 776, 692 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.05 min and t_{minor} = 17.18 min.

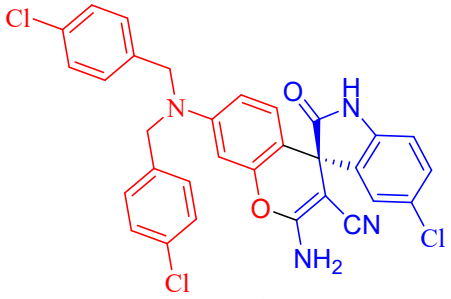
(*R*)-2-amino-7-(bis(3-bromobenzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3q)



3q

white solid (84.9 mg) in 63% isolated yield; $[\alpha]_D^{20}$ = - 48 (c = 1.0, THF, 99% ee); **m.p.** = 237.2-239.7 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.62 (s, 1H), 7.49–7.38 (m, 4H), 7.35–7.26 (m, 3H), 7.26–7.15 (m, 4H), 7.10 (d, *J* = 1.9 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.41-6.39 (m, 1H), 6.27 (d, *J* = 8.8 Hz, 1H), 6.16 (d, *J* = 2.2 Hz, 1H), 4.74 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.4, 161.9, 149.8, 148.9, 141.9, 141.4, 137.2, 131.3, 130.3, 129.5, 129.3, 127.6, 126.9, 125.8, 125.3, 122.5, 119.2, 111.8, 110.1, 107.7, 99.5, 54.2, 54.0, 50.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{22}Br_2ClN_4O_2]^+$: 674.9793, found: 674.9798; **IR:** 3475, 3287, 3179, 3061, 2195, 1705, 1645, 1515, 1406, 1196, 824, 775, 682 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 19.24 min and t_{minor} = 22.12 min.

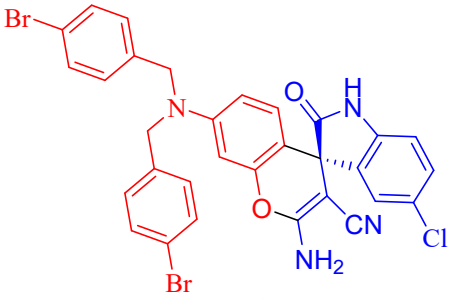
(*R*)-2-amino-7-(bis(4-chlorobenzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3r)



3r

white solid (92.6 mg) in 79% isolated yield; $[\alpha]_D^{20}$ = - 8 (c = 1.0, THF, 97% ee); **m.p.** = 166.6-168.1 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.63 (s, 1H), 7.47–7.33 (m, 4H), 7.32–7.20 (m, 5H), 7.17 (s, 2H), 7.07 (s, 1H), 6.92 (d, *J* = 7.1 Hz, 1H), 6.38 (d, *J* = 5.9 Hz, 1H), 6.25 (d, *J* = 7.5 Hz, 1H), 6.14 (s, 1H), 4.69 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.5, 161.9, 149.8, 149.0, 141.3, 137.8, 137.2, 131.9, 129.3, 129.1, 128.7, 127.6, 126.9, 125.2, 119.2, 111.8, 110.1, 107.6, 99.4, 54.0, 54.0, 50.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{22}Cl_3N_4O_2]^+$: 587.0803, found: 587.0808; **IR:** 3472, 3318, 3187, 3050, 2194, 1718, 1646, 1516, 1402, 1196, 812, 772, 725 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.14 min and t_{minor} = 13.16 min.

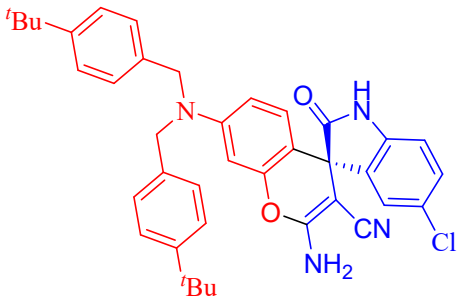
(*R*)-2-amino-7-(bis(4-bromobenzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3s)



3s

white solid (101.1 mg) in 75% isolated yield; $[\alpha]_D^{20}$ = + 17 (c = 1.0, THF, 98% ee); **m.p.** = 196.2-199.7 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.64 (s, 1H), 7.51 (d, *J* = 7.1 Hz, 4H), 7.31–7.26 (m, 1H), 7.22–7.11 (m, 6H), 7.08–7.01 (m, 1H), 6.99–6.91 (m, 1H), 6.33 (d, *J* = 8.8 Hz, 1H), 6.21 (d, *J* = 8.8 Hz, 1H), 6.18–6.12 (m, 1H), 4.66 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.4, 161.9, 149.8, 149.0, 141.3, 138.3, 137.2, 132.0, 129.3, 129.1, 127.6, 126.9, 125.2, 120.3, 119.2, 111.8, 110.1, 107.6, 99.4, 54.1, 54.0, 50.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{22}Br_2ClN_4O_2]^+$: 674.9793, found: 674.9791; **IR:** 3448, 3324, 3199, 3081, 2204, 1711, 1655, 1517, 1399, 1009, 794, 733 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.89 min and t_{minor} = 14.42 min.

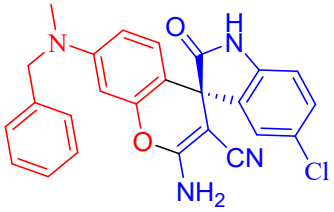
(*R*)-2-amino-7-(bis(4-(tert-butyl)benzyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3t)



3t

white solid (109.6 mg) in 87% isolated yield; $[\alpha]_D^{20}$ = + 17 (c = 1.0, THF, 99% ee); **m.p.** = 230.2 - 232.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.43–7.31 (m, 4H), 7.30-7.27 (m, 1H), 7.22–7.07 (m, 6H), 7.05 (d, *J* = 1.9 Hz, 1H), 6.92 (d, *J* = 8.3 Hz, 1H), 6.39-6.37 (m, 1H), 6.21 (d, *J* = 8.8 Hz, 1H), 6.18 (d, *J* = 2.1 Hz, 1H), 4.62 (s, 4H), 1.25 (s, 18H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.5, 162.0, 149.8, 149.6, 149.5, 141.4, 137.2, 135.6, 129.3, 127.5, 126.9, 126.4, 125.9, 125.2, 119.2, 111.8, 109.9, 107.0, 99.1, 54.2, 54.0, 50.6, 34.6, 31.6; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{39}H_{40}ClN_4O_2]^+$: 631.2834, found: 631.2838; **IR:** 3465, 3324, 3157, 2961, 2194, 1701, 1648, 1518, 1403, 1128, 816, 796, 645 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 8.90 min and t_{minor} = 11.45 min.

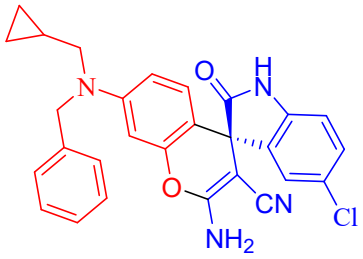
(*R*)-2-amino-7-(benzyl(methyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3u)



3u

yellow solid (85.7 mg) in 97% isolated yield; $[\alpha]_D^{20}$ = - 32 (c = 1.0, THF, 98% ee); **m.p.** = 287.4-290.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.64 (s, 1H), 7.36–7.27 (m, 3H), 7.29–7.13 (m, 5H), 7.07 (s, 1H), 6.95 (d, *J* = 8.2 Hz, 1H), 6.45 (d, *J* = 8.2 Hz, 1H), 6.29 (d, *J* = 8.7 Hz, 1H), 6.24 (s, 1H), 4.56 (s, 2H), 3.03 (s, 3H).; **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 150.1, 149.9, 141.4, 139.0, 137.4, 129.3, 129.0, 127.4, 127.3, 126.9, 125.2, 119.3, 111.8, 109.8, 106.9, 98.9, 55.6, 54.0, 50.6, 31.2; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{25}H_{20}ClN_4O_2]^+$: 443.1269, found: 443.1271; **IR:** 3459, 3271, 3173, 3064, 2189, 1698, 1641, 1517, 1403, 1102, 825, 730, 696 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.43 min and t_{minor} = 13.79 min.

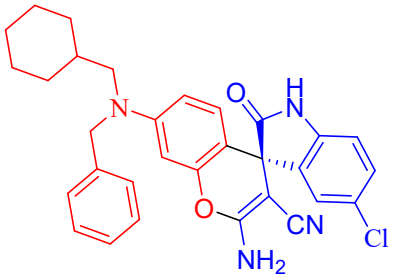
(*R*)-2-amino-7-(benzyl(cyclopropylmethyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3v)



3v

white solid (90.6 mg) in 94% isolated yield; $[\alpha]_D^{20}$ = - 9 (c = 1.0, THF, 99% ee); **m.p.** = 267.4-270.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.35 – 7.26 (m, 3H), 7.25 – 7.18 (m, 3H), 7.16 (s, 2H), 7.08 (s, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.50 – 6.42 (m, 1H), 6.27 (d, *J* = 8.8 Hz, 1H), 6.20 – 6.15 (m, 1H), 4.59 (s, 1H), 3.32 (d, *J* = 6.3 Hz, 2H), 1.12 – 1.00 (m, 1H), 0.51 – 0.32 (m, 2H), 0.29 – 0.11 (m, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 149.9, 149.4, 141.4, 139.1, 137.3, 129.3, 129.0, 127.4, 127.1, 126.9, 126.6, 125.2, 119.2, 111.8, 109.8, 106.7, 99.0, 55.4, 54.3, 54.0, 50.6, 9.8, 3.9; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{28}H_{24}ClN_4O_2]^+$: 483.1582, found: 483.1587; **IR:** 3472, 3280, 3179, 3064, 2188, 1697, 1643, 1517, 1403, 1216, 1129, 822, 713, 694 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 8.33 min and t_{minor} = 10.88 min.

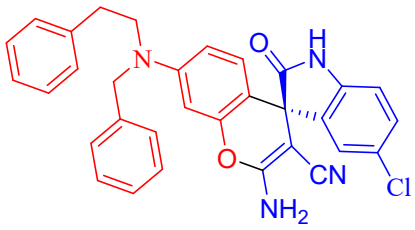
(*R*)-2-amino-7-(benzyl(cyclohexylmethyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3w)



3w

white solid (82.8 mg) in 79% isolated yield; $[\alpha]_D^{20}$ = - 27 (c = 1.0, THF, 96% ee); **m.p.** = 292.4-295.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.34–7.26 (m, 3H), 7.23–7.11 (m, 5H), 7.08 (d, *J* = 2.0 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.38-6.36 (m, 1H), 6.24 (d, *J* = 8.8 Hz, 1H), 6.13 (d, *J* = 2.1 Hz, 1H), 4.58 (s, 2H), 3.28 (d, *J* = 6.1 Hz, 2H), 1.75–1.57 (m, 6H), 1.24–1.07 (m, 3H), 0.99-0..-97 (m, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ179.6, 162.0, 149.8, 149.2, 141.4, 138.8, 137.3, 129.3, 129.1, 127.3, 127.2, 126.9, 126.6, 125.2, 119.2, 111.8, 109.8, 106.4, 98.9, 58.2, 55.1, 54.0, 50.6, 36.7, 30.9, 26.5, 25.9; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{31}H_{30}ClN_4O_2]^+$: 525.2052, found: 525.2056; **IR:** 3465, 3288, 3180, 2928, 2197, 1698, 1644, 1516, 1403, 1125, 819, 727, 693 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.78 min and t_{minor} = 14.61 min.

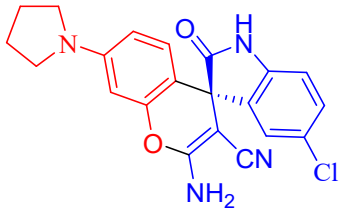
(*R*)-2-amino-7-(benzyl(phenethyl)amino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3x)



3x

white solid (78.7 mg) in 74% isolated yield; $[\alpha]_D^{20}$ = - 18 (c = 1.0, THF, 95% ee); **m.p.** = 244.3-247.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.65 (s, 1H), 7.36 – 7.26 (m, 7H), 7.25 – 7.16 (m, 6H), 7.10 (d, *J* = 1.4 Hz, 1H), 6.95 (d, *J* = 8.3 Hz, 1H), 6.52-6.50 (m, 1H), 6.32 (d, *J* = 8.8 Hz, 1H), 6.20 (d, *J* = 2.1 Hz, 1H), 4.52 (s, 2H), 3.66 – 3.54 (m, 2H), 2.93 – 2.78 (m, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 150.0, 148.9, 141.4, 139.5, 138.9, 137.3, 129.3, 129.2, 129.1, 128.9, 127.6, 127.3, 126.9, 126.7, 125.3, 119.2, 111.8, 109.7, 106.9, 99.0, 54.0, 54.0, 53.3, 50.6, 33.2; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{32}H_{26}ClN_4O_2]^+$: 533.1739, found: 533.1743; **IR:** 3472, 3280, 3177, 3026, 2192, 1697, 1643, 1517, 1404, 1164, 1125, 821, 736, 695 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.90 min and t_{minor} = 19.31 min.

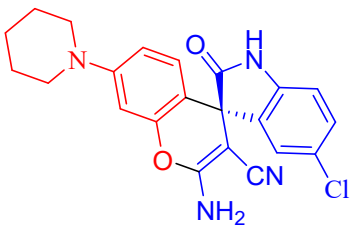
(*R*)-2-amino-5'-chloro-2'-oxo-7-(pyrrolidin-1-yl)spiro[chromene-4,3'-indoline]-3-carbonitrile (3y)



3y

white solid (68.2 mg) in 87% isolated yield; $[\alpha]_D^{20}$ = - 56 (c = 1.0, THF, 97% ee); **m.p.** = 280.3-282.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.62 (s, 1H), 7.30 (d, *J* = 6.3 Hz, 1H), 7.20 (s, 2H), 7.04 (s, 1H), 6.95 (d, *J* = 6.9 Hz, 1H), 6.27 (d, *J* = 10.5 Hz, 2H), 6.12 (s, 1H), 3.18 (s, 4H), 1.92 (s, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 149.9, 148.6, 141.3, 137.6, 129.2, 127.4, 126.9, 125.1, 119.3, 111.8, 109.8, 106.2, 98.4, 54.1, 50.7, 47.8, 31.2, 25.4. **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{21}H_{18}ClN_4O_2]^+$: 393.1113, found: 393.1119; **IR:** 3438, 3319, 3192, 2827, 2199, 1713, 1651, 1522, 1415, 1202, 811, 790, 634 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.11 min and t_{minor} = 18.07 min.

(*R*)-2-amino-5'-chloro-2'-oxo-7-(piperidin-1-yl)spiro[chromene-4,3'-indoline]-3-carbonitrile (3z)

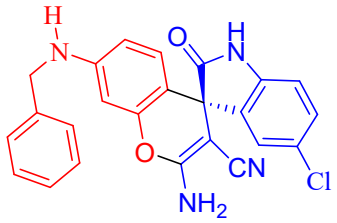


3z

white solid (75.5 mg) in 93% isolated yield; $[\alpha]_D^{20}$ = - 12 (c = 1.0, THF, 98% ee); **m.p.** = 295.5-300.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.66 (s, 1H), 7.32-7.30 (m, 1H), 7.22 (s, 2H), 7.09 (d, *J* = 1.9 Hz, 1H), 6.95 (d, *J* = 8.3 Hz, 1H), 6.64-6.62 (m, 1H), 6.49 (d, *J* = 2.2 Hz, 1H), 6.32 (d, *J* = 8.7 Hz, 1H),

3.13 (s, 4H), 1.54 (s, 6H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.4, 162.0, 152.4, 149.9, 141.4, 137.2, 129.4, 127.3, 127.0, 125.2, 119.2, 113.2, 111.8, 108.9, 102.2, 54.0, 50.7, 49.2, 25.4, 24.3; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{22}H_{20}ClN_4O_2$]$^+$: 407.1269, found: 407.1270; **IR:** 3376, 3278, 3172, 2916, 2880, 2188, 1703, 1617, 1505, 1403, 1187, 1112, 1019, 827, 644 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.42 min and t_{minor} = 11.64 min.

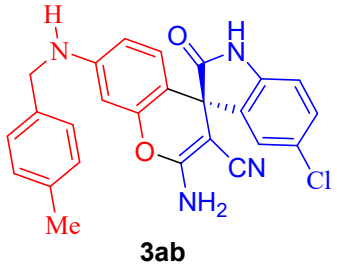
(*R*)-2-amino-7-(benzylamino)-5'-chloro-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3aa)



3aa

white solid (83.9 mg) in 98% isolated yield; [α]$_D^{20}$ = + 15 (c = 1.0, THF, 98% ee); **m.p.** = 167.5-170.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.60 (s, 1H), 7.43–7.27 (m, 5H), 7.24-7.22 (m, 1H), 7.15 (s, 2H), 7.10–7.02 (m, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.70 (t, *J* = 5.5 Hz, 1H), 6.35-6.33 (m, 1H), 6.20 (d, *J* = 8.6 Hz, 1H), 6.17–6.08 (m, 1H), 4.25 (d, *J* = 5.4 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 150.0, 149.9, 141.4, 140.1, 137.4, 129.2, 128.9, 127.4, 127.2, 126.9, 125.2, 119.3, 111.8, 110.9, 106.6, 98.6, 54.0, 50.7, 46.7; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{24}H_{18}ClN_4O_2$]$^+$: 429.1113, found: 429.1117; **IR:** 3465, 3375, 3319, 3198, 2196, 1700, 1648, 1521, 1402, 1165, 825, 731, 695 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.07 min and t_{minor} = 21.34 min.

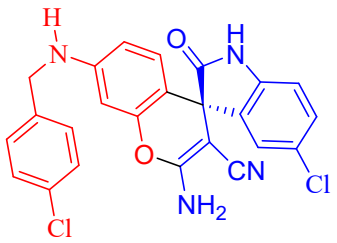
(*R*)-2-amino-5'-chloro-7-((4-methylbenzyl)amino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3ab)



3ab

white solid (86.6 mg) in 98% isolated yield; [α]$_D^{20}$ = - 4 (c = 1.0, THF, 96% ee); **m.p.** = 243.7-246.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.60 (s, 1H), 7.29 (d, *J* = 8.1 Hz, 1H), 7.24–7.18 (m, 2H), 7.19–7.09 (m, 4H), 7.06 (s, 1H), 6.93 (d, *J* = 8.2 Hz, 1H), 6.72–6.59 (m, 1H), 6.33 (d, *J* = 8.4 Hz, 1H), 6.19 (d, *J* = 8.5 Hz, 1H), 6.11 (s, 1H), 4.20 (s, 2H), 2.26 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 150.0, 149.9, 141.4, 137.4, 137.0, 136.3, 129.4, 129.2, 127.4, 127.2, 126.9, 125.2, 119.3, 111.8, 110.9, 106.57, 98.6, 54.0, 50.7, 46.4, 21.1; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{25}H_{20}ClN_4O_2$]$^+$: 443.1269, found: 443.1274; **IR:** 3462, 3428, 3287, 3164, 2188, 1699, 1642, 1528, 1399, 1190, 1124, 826, 803, 645 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.41 min and t_{minor} = 21.43 min.

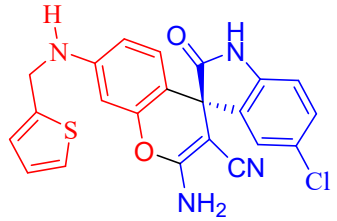
(*R*)-2-amino-5'-chloro-7-((4-chlorobenzyl)amino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3ac)



3ac

white solid (85.9 mg) in 93% isolated yield; $[\alpha]_D^{20}$ = - 11 (c = 1.0, THF, 97% ee); **m.p.** = 247.3-249.6 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.62 (s, 1H), 7.37-7.35 (m, 4H), 7.30-7.28 (m, 1H), 7.16 (s, 2H), 7.07 (d, *J* = 2.1 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.34-6.32 (m, 1H), 6.21 (d, *J* = 8.6 Hz, 1H), 6.11 (d, *J* = 2.2 Hz, 1H), 4.25 (s, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 161.9, 149.9, 149.8, 141.3, 139.2, 137.4, 131.7, 129.2, 128.8, 127.3, 126.9, 125.2, 119.3, 111.8, 110.9, 106.8, 98.6, 54.0, 50.7, 45.9; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{31}H_{22}Cl_3N_4O_2]^+$: 463.0723, found: 463.0729; **IR:** 3407, 3348, 3205, 2975, 2188, 1698, 1644, 1578, 1407, 1244, 1201, 1136, 832, 692 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 8.69 min and t_{minor} = 19.74 min.

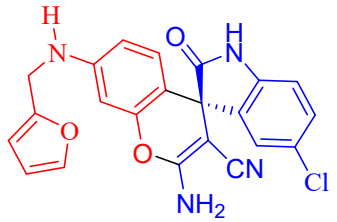
(*R*)-2-amino-5'-chloro-2'-oxo-7-((thiophen-2-ylmethyl)amino)spiro[chromene-4,3'-indoline]-3-carbonitrile (3ad)



3ad

white solid (84.2 mg) in 97% isolated yield; $[\alpha]_D^{20}$ = - 43 (c = 1.0, THF, 97% ee); **m.p.** = 147.3-149.9 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.60 (s, 1H), 7.37 (d, *J* = 4.9 Hz, 1H), 7.30-7.28 (m, 1H), 7.17 (s, 2H), 7.07 (d, *J* = 1.9 Hz, 1H), 7.02 (d, *J* = 2.7 Hz, 1H), 6.99–6.95 (m, 1H), 6.92 (d, *J* = 8.3 Hz, 1H), 6.71 (t, *J* = 5.7 Hz, 1H), 6.37-6.35 (m, 1H), 6.28–6.12 (m, 2H), 4.43 (d, *J* = 5.6 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 149.9, 149.7, 144.3, 141.4, 137.4, 129.3, 127.3, 127.3, 126.9, 125.2, 125.1, 119.3, 111.8, 111.0, 107.1, 98.8, 54.0, 50.7, 42.2; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{22}H_{16}ClN_4O_2S]^+$: 435.0677, found: 435.0684; **IR:** 3462, 3366, 3230, 3126, 2221, 2199, 1719, 1699, 1644, 1575, 1398, 1129, 814, 695, 642 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 19.10 min and t_{minor} = 24.01 min.

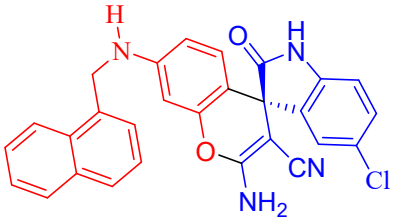
(*R*)-2-amino-5'-chloro-7-((furan-2-ylmethyl)amino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3ae)



3ae

white solid (76.1 mg) in 91% isolated yield; $[\alpha]_D^{20}$ = - 37 (c = 1.0, THF, 96% ee); **m.p.** = 272.4-275.4 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.57 (d, *J* = 0.9 Hz, 1H), 7.31-7.29 (m, 1H), 7.19 (s, 2H), 7.08 (d, *J* = 2.1 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.53 (t, *J* = 5.9 Hz, 1H), 6.41–6.33 (m, 2H), 6.32–6.24 (m, 2H), 6.22 (d, *J* = 8.5 Hz, 1H), 4.23 (d, *J* = 5.8 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.2, 161.6, 152.8, 149.5, 149.3, 142.2, 140.9, 137.0, 128.8, 126.8, 126.5, 124.8, 118.9, 111.4, 110.4, 110.3, 107.0, 106.6, 98.3, 53.6, 50.3, 39.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{22}H_{16}ClN_4O_3]^+$: 419.0905, found: 419.0916; **IR:** 3383, 3321, 3201, 2192, 1699, 1656, 1512, 1404, 1187, 1132, 826, 739 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 19.15 min and t_{minor} = 23.68 min.

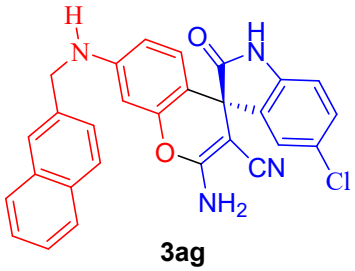
(*R*)-2-amino-5'-chloro-7-((naphthalen-1-ylmethyl)amino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3af)



3af

white solid (75.5 mg) in 79% isolated yield; $[\alpha]_D^{20}$ = + 13 (c = 1.0, THF, 97% ee); **m.p.** = 302.3 -306.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.63 (s, 1H), 8.13 (d, *J* = 7.8 Hz, 1H), 8.00–7.94 (m, 1H), 7.86-7.84 (m, 1H), 7.59–7.53 (m, 2H), 7.51–7.45 (m, 2H), 7.32-7.30 (m, 1H), 7.15 (s, 2H), 7.09 (d, *J* = 1.8 Hz, 1H), 6.94 (d, *J* = 8.3 Hz, 1H), 6.71 (t, *J* = 5.3 Hz, 1H), 6.44-6.42 (m, 1H), 6.25-6.23 (m, 1H), 6.19 (s, 1H), 4.70 (d, *J* = 5.2 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ179.6, 162.0, 150.2, 150.0, 141.4, 137.5, 134.7, 133.9, 131.4, 129.2, 129.0, 127.9, 127.3, 126.9, 126.6, 126.3, 126.0, 125.2, 124.0, 119.3, 111.8, 110.8, 106.7, 98.6, 54.0, 50.7, 44.9; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{28}H_{20}ClN_4O_2]^+$: 479.1269, found: 479.1271; **IR:** 3434, 3399, 3161, 2921, 2197, 1711, 1641, 1516, 1394, 1190, 1129, 831, 798, 777 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.66 min and t_{minor} = 18.99 min.

(*R*)-2-amino-5'-chloro-7-((naphthalen-2-ylmethyl)amino)-2'-oxospiro[chromene-4,3'-indoline]-3-carbonitrile (3ag)

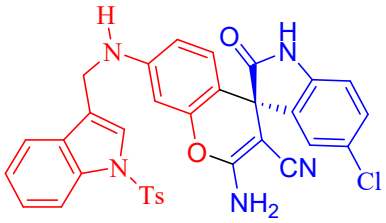


3ag

white solid (88.0 mg) in 92% isolated yield; $[\alpha]_D^{20}$ = + 5 (c = 1.0, THF, >99% ee); **m.p.** = 174.2-177.8 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.61 (s, 1H), 7.91–7.80 (m, 4H), 7.54–7.44 (m, 3H), 7.30-7.28 (m, 1H), 7.14 (s, 2H), 7.07 (d, *J* = 2.1 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.82 (t, *J* = 5.7 Hz, 1H), 6.41-6.39 (m, 1H), 6.23 (d, *J* = 8.6 Hz, 1H), 6.17 (d, *J* = 2.2 Hz, 1H), 4.44 (d, *J* = 5.5 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 150.1, 149.9, 141.3, 137.8, 137.4, 133.4, 132.7, 129.2, 128.5, 128.0, 128.0, 127.3, 126.9, 126.7, 126.1, 126.0, 125.4, 125.2, 119.3, 111.8, 111.0, 106.8, 98.6,

54.0, 50.7, 47.0; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{28}H_{20}ClN_4O_2$]$^+$: 479.1269, found: 479.1278; **IR:** 3322, 3194, 3057, 2975, 2199, 1704, 1644, 1623, 1519, 1403, 1188, 1130, 815, 726, 647 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 25.61 min.

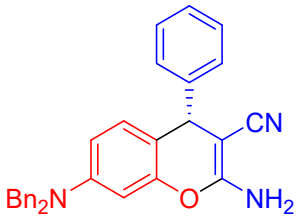
(*R*)-2-amino-5'-chloro-2'-oxo-7-(((1-tosyl-1*H*-indol-3-yl)methyl)amino)spiro[chromene-4,3'-indoline]-3-carbonitrile (3ah)



3ah

white solid (121.7 mg) in 98% isolated yield; $[\alpha]_D^{20}$ = + 15 (c = 1.0, THF, 98% ee); **m.p.** = 151.4-153.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.63 (s, 1H), 7.91 (d, *J* = 8.3 Hz, 1H), 7.76–7.65 (m, 4H), 7.38–7.24 (m, 5H), 7.22 (s, 2H), 7.06 (d, *J* = 1.9 Hz, 1H), 6.95 (d, *J* = 8.3 Hz, 1H), 6.63 (t, *J* = 5.5 Hz, 1H), 6.40-6.38 (m, 1H), 6.28–6.20 (m, 2H), 4.38 (d, *J* = 5.1 Hz, 2H), 2.30 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.6, 162.0, 149.9, 149.7, 145.9, 141.4, 137.5, 135.3, 134.3, 130.6, 130.2, 129.3, 127.2, 127.0, 126.9, 125.4, 125.2, 124.9, 123.8, 121.1, 120.8, 119.3, 113.8, 111.8, 111.0, 106.8, 98.7, 54.1, 50.7, 38.4, 21.5; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{33}H_{25}ClN_5O_4S$]$^+$: 622.1310, found: 622.1319; **IR:** 3441, 3366, 3331, 3208, 2204, 1700, 1649, 1392, 1367, 1260, 1175, 816, 743, 666 cm^{-1}; **HPLC**: Daicel Chiralpak IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.63 min and t_{minor} = 36.10 min.

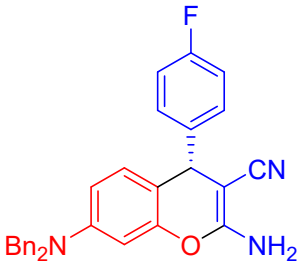
(*S*)-2-amino-7-(dibenzylamino)-4-phenyl-4*H*-chromene-3-carbonitrile (5a)



5a

yellow solid (46.1 mg) in 52% isolated yield; $[\alpha]_D^{20}$ = + 238 (c = 1.0, THF, 94% ee); **m.p.** = 127.1-129.2 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.36–7.30 (m, 4H), 7.29–7.19 (m, 8H), 7.19–7.11 (m, 3H), 6.84–6.67 (m, 3H), 6.42 (d, *J* = 8.7 Hz, 1H), 6.12 (s, 1H), 4.69 (s, 4H), 4.55 (s, 1H). **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.3, 148.6, 146.9, 139.1, 130.0, 129.1, 129.0, 127.8, 127.3, 127.0, 126.8, 121.2, 111.1, 109.85, 99.2, 56.5, 54.8, 40.3; **HRMS** (ESI): m/z [M + H]$^+$ calcd for [$C_{30}H_{26}N_3O$]$^+$: 444.2070, found: 444.2073; **IR:** 3448, 3320, 2190, 1657, 1514, 1410, 726, 423 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.70 min and t_{minor} = 10.73 min.

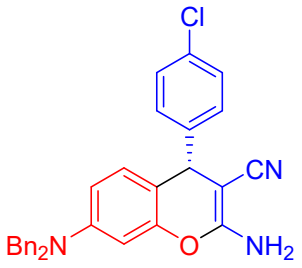
(*S*)-2-amino-7-(dibenzylamino)-4-(4-fluorophenyl)-4*H*-chromene-3-carbonitrile (5b)



5b

yellow solid (59.0 mg) in 64% isolated yield; $[\alpha]_D^{20}$ = + 51 (c = 1.0, THF, 96% ee); **m.p.** = 196.1-199.3 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.39–7.30 (m, 4H), 7.28–7.21 (m, 6H), 7.21–7.16 (m, 2H), 7.12-7.10 (m, 2H), 6.80 (s, 2H), 6.71 (d, *J* = 8.7 Hz, 1H), 6.45-6.43 (m, 1H), 6.14 (d, *J* = 2.3 Hz, 1H), 4.69 (s, 4H), 4.60 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 162.6, 161.4 (d, *J* = 242.4Hz), 160.8, 149.2, 148.6, 143.0, 143.0, 139.0, 130.0, 129.8, 129.7, 129.1, 127.3, 126.9, 121.1, 115.8, 115.6, 110.9, 109.8, 99.2, 56.5, 54.8, 39.5; **^{19}F NMR** (376 MHz, DMSO-d6) δ -116.4; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{30}H_{25}FN_3O]^+$: 462.1976, found: 462.1974; **IR:** 3448, 3325, 2197, 1657, 1395, 720, 473 cm^{-1}; **HPLC**: Daicel Chiralpak IF, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 17.99 min and t_{minor} = 14.78 min.

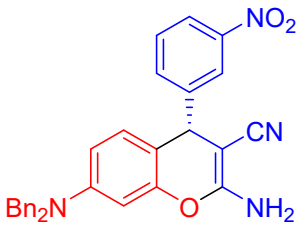
(*S*)-2-amino-4-(4-chlorophenyl)-7-(dibenzylamino)-4*H*-chromene-3-carbonitrile (5c)



5c

yellow solid (66.8 mg) in 70% isolated yield; $[\alpha]_D^{20}$ = + 153 (c = 1.0, THF, 95% ee); **m.p.** = 209.4-211.1 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37–7.30 (m, 4H), 7.29–7.26 (m, 4H), 7.23–7.17 (m, 4H), 7.16–7.09 (m, 2H), 6.67 (d, *J* = 8.7 Hz, 1H), 6.44-6.42 (m, 1H), 6.29 (d, *J* = 2.4 Hz, 1H), 4.62 (s, 4H), 4.59 (s, 1H), 4.50 (s, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.3, 149.4, 149.3, 143.6, 137.8, 132.8, 129.9, 129.3, 128.9, 128.8, 127.2, 126.5, 110.0, 109.9, 99.3, 60.7, 54.3, 39.8; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{30}H_{25}ClN_3O]^+$: 478.1681, found: 478.1678; **IR:** 3449, 3327, 2194, 1656, 1516, 1401, 723, 457 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 11.23 min and t_{minor} = 10.15 min.

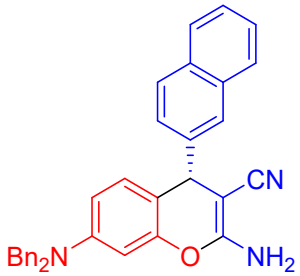
(*S*)-2-amino-7-(dibenzylamino)-4-(3-nitrophenyl)-4*H*-chromene-3-carbonitrile (5d)



5d

yellow solid (71.2 mg) in 73% isolated yield; $[\alpha]_D^{20}$ = + 22 (c = 1.0, THF, 96% ee); **m.p.** = 149.2-151.8 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.1 Hz, 1H), 8.01 (s, 1H), 7.55 (d, *J* = 7.5 Hz, 1H), 7.47 – 7.39 (m, 1H), 7.37 – 7.29 (m, 4H), 7.28 – 7.23 (m, 2H), 7.23 – 7.12 (m, 4H), 6.63 (d, *J* = 8.6 Hz, 1H), 6.43-6.41 (m, 1H), 6.32 (d, *J* = 1.8 Hz, 1H), 4.71 (s, 1H), 4.68 (s, 2H), 4.62 (s, 4H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.8, 149.6, 149.3, 148.6, 147.4, 137.7, 134.3, 129.9, 129.7, 129.2, 128.9, 127.2, 126.5, 123.0, 122.3, 119.9, 110.0, 109.0, 99.5, 59.4, 54.4, 40.2; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{30}H_{25}N_4O_3]^+$: 489.1921, found: 489.1919; **IR:** 3451, 3329, 2192, 1654, 1514, 1403, 725, 455 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 24.03 min and t_{minor} = 21.36 min.

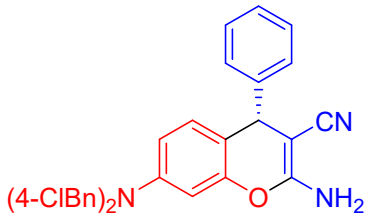
(*S*)-2-amino-7-(dibenzylamino)-4-(naphthalen-2-yl)-4*H*-chromene-3-carbonitrile (5e)



5e

yellow solid (61.1 mg) in 62% isolated yield; $[\alpha]_D^{20}$ = + 61 (c = 1.0, THF, 97% ee); **m.p.** = 227.3-229.6 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.92–7.78 (m, 3H), 7.73 (s, 1H), 7.53–7.41 (m, 2H), 7.39–7.28 (m, 4H), 7.26–7.11 (m, 7H), 6.83 (s, 2H), 6.73 (d, *J* = 8.7 Hz, 1H), 6.43-6.41 (m, 1H), 6.16 (d, *J* = 2.2 Hz, 1H), 4.73 (s, 1H), 4.67 (s, 4H) **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.3, 148.7, 144.0, 139.0, 133.3, 132.5, 130.2, 129.1, 129.0, 128.1, 128.0, 127.3, 126.9, 126.8, 126.4, 126.2, 126.0, 121.2, 110.8, 109.8, 99.2, 56.5, 54.8, 40.6; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{34}H_{28}N_3O]^+$: 494.2227, found: 494.2225; **IR:** 3422, 3315, 2194, 1654, 1516, 1403, 725, 482 cm^{-1}; **HPLC**: Daicel Chiralpak ID, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 12.78 min and t_{minor} = 11.18 min.

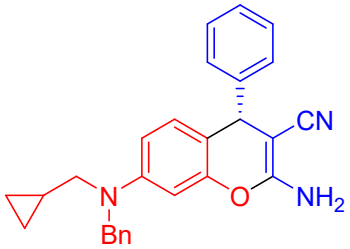
(*S*)-2-amino-7-(bis(4-chlorobenzyl)amino)-4-phenyl-4*H*-chromene-3-carbonitrile (5f)



5f

yellow solid (61.3 mg) in 60% isolated yield; $[\alpha]_D^{20}$ = + 37 (c = 1.0, THF, 96% ee); **m.p.** = 131.2-133.5 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.41–7.35 (m, 4H), 7.31–7.21 (m, 6H), 7.21–7.12 (m, 3H), 6.83–6.66 (m, 3H), 6.41 (d, *J* = 8.3 Hz, 1H), 6.11 (s, 1H), 4.67 (s, 4H), 4.56 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.3, 148.2, 146.8, 138.1, 131.8, 130.1, 129.0, 128.8, 127.8, 127.1, 121.2, 111.6, 109.8, 99.4, 56.6, 54.1, 40.3; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{30}H_{24}Cl_2N_3O]^+$: 512.1291, found: 512.1275; **IR:** 3455, 3193, 2198, 1656, 1484, 1403, 812, 698 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 14.72 min and t_{minor} = 13.73 min.

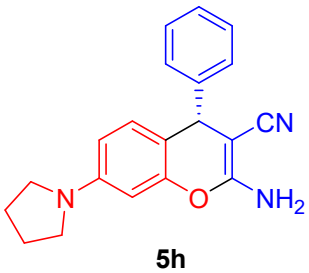
(*S*)-2-amino-7-(benzyl(cyclopropylmethyl)amino)-4-phenyl-4*H*-chromene-3-carbonitrile (5g)



5g

yellow solid (46.4 mg) in 57% isolated yield; $[\alpha]_D^{20}$ = + 78 (c = 1.0, THF, 95% ee); **m.p.** = 141.3-142.8 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.34–7.25 (m, 4H), 7.24–7.13 (m, 6H), 6.85–6.67 (m, 3H), 6.47 (d, *J* = 7.2 Hz, 1H), 6.16 (s, 1H), 4.59 (s, 2H), 4.56 (s, 1H), 3.30 (d, *J* = 4.3 Hz, 2H), 1.12–0.94 (m, 1H), 0.52–0.36 (m, 2H), 0.30–0.14 (m, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.9, 149.4, 148.7, 147.0, 139.4, 130.0, 129.0, 128.9, 127.9, 127.1, 127.0, 126.7, 121.3, 110.7, 109.6, 98.9, 56.7, 55.5, 54.3, 9.8, 3.9, 3.8; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{27}H_{26}N_3O]^+$: 408.2070, found: 408.2070; **IR:** 3463, 3321, 2198, 1662, 1516, 1401, 723, 700 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.98 min and t_{minor} = 9.36 min.

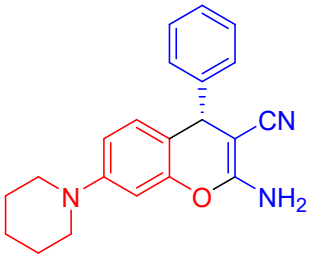
(*S*)-2-amino-4-phenyl-7-(pyrrolidin-1-yl)-4*H*-chromene-3-carbonitrile (5h)



5h

yellow solid (45.6 mg) in 72% isolated yield; $[\alpha]_D^{20}$ = + 165 (c = 1.0, THF, 89% ee); **m.p.** = 197.5-199.1 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.35–7.26 (m, 2H), 7.20 (d, *J* = 7.3 Hz, 1H), 7.16 (d, *J* = 7.1 Hz, 2H), 6.85–6.72 (m, 3H), 6.28-6.26 (m, 1H), 6.08 (d, *J* = 2.2 Hz, 1H), 4.58 (s, 1H), 3.22–3.10 (m, 4H), 1.96–1.87 (m, 4H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.5, 147.9, 147.3, 130.0, 129.0, 127.8, 127.0, 121.3, 110.0, 109.4, 98.2, 56.9, 47.8, 40.5, 25.4; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{20}H_{20}N_3O]^+$: 318.1601, found: 318.1600; **IR:** 3445, 3321, 2188, 1642, 1520, 1405, 1164, 696 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 13.17 min and t_{minor} = 11.46 min.

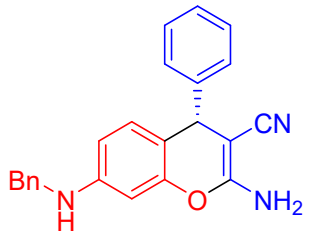
(*S*)-2-amino-4-phenyl-7-(piperidin-1-yl)-4*H*-chromene-3-carbonitrile (5i)



5i

yellow solid (41.7 mg) in 63% isolated yield; $[\alpha]_D^{20}$ = + 296 (c = 1.0, THF, 94% ee); **m.p.** = 224.2-225.9 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.34–7.27 (m, 2H), 7.23–7.15 (m, 3H), 6.86–6.77 (m, 3H), 6.67-6.65 (m, 1H), 6.44 (d, *J* = 2.4 Hz, 1H), 4.61 (s, 1H), 3.16–3.04 (m, 4H), 1.62–1.48 (m, 6H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.9, 151.8, 149.4, 146.9, 129.9, 129.0, 128.8, 127.9, 127.1, 121.2, 113.1, 113.0, 102.1, 56.7, 49.5, 40.6, 25.5, 24.3; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{21}H_{22}N_3O]^+$: 332.1757, found: 332.1759; **IR:** 3426, 3321, 2189, 1646, 1506, 1409, 1112, 696 cm^{-1};**HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 10.65 min and t_{minor} = 9.51 min.

(*S*)-2-amino-7-(benzylamino)-4-phenyl-4*H*-chromene-3-carbonitrile (5j)

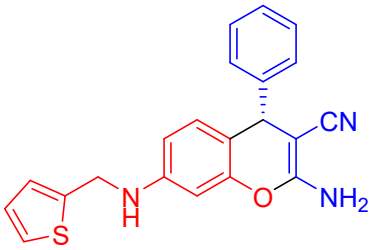


5j

yellow solid (36.7 mg) in 52% isolated yield; $[\alpha]_D^{20}$ = + 136 (c = 1.0, THF, 89% ee); **m.p.** = 185.3-187.6 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.34–7.30 (m, 4H), 7.27 (d, *J* = 7.6 Hz, 2H), 7.24–7.17 (m, 2H), 7.16–7.12 (m, 2H), 6.78 (s, 2H), 6.66 (d, *J* = 8.5 Hz, 1H), 6.51 (t, *J* = 5.9 Hz, 1H), 6.36-6.34 (m, 1H), 6.09 (d, *J* = 2.2 Hz, 1H), 4.52 (s, 1H), 4.23 (d, *J* = 5.9 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.4, 149.2, 147.1, 140.3, 129.8, 129.0, 128.8, 127.8, 127.5, 127.2, 127.0, 121.3, 110.6, 110.5, 98.4, 56.7, 46.8, 40.5; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{23}H_{20}N_3O]^+$: 354.1601, found: 354.1603;

IR: 3422, 3306, 2200, 1629, 1522, 1395, 731, 698, 400 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 15.07 min and t_{minor} = 14.22 min.

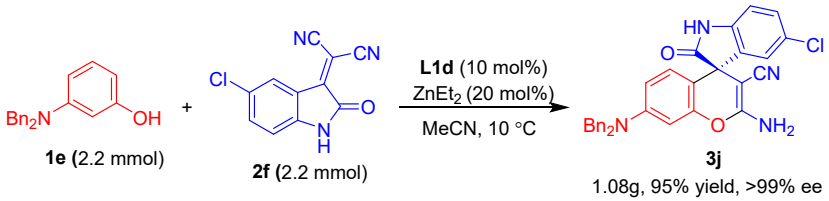
(*S*)-2-amino-4-phenyl-7-((thiophen-2-ylmethyl)amino)-4*H*-chromene-3-carbonitrile (5k)



5k

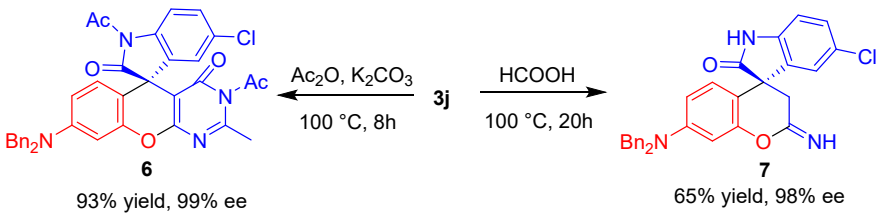
yellow solid (35.9 mg) in 50% isolated yield; $[\alpha]_D^{20}$ = + 85 (c = 1.0, THF, 87% ee); **m.p.** = 203.5-205.7 °C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 7.37-7.35 (m, 1H), 7.31-7.28 (m, 2H), 7.22–7.13 (m, 3H), 7.04–6.99 (m, 1H), 6.99–6.95 (m, 1H), 6.79 (s, 2H), 6.69 (d, *J* = 8.5 Hz, 1H), 6.49 (t, *J* = 5.7 Hz, 1H), 6.40-6.38 (m, 1H), 6.20 (d, *J* = 2.0 Hz, 1H), 4.54 (s, 1H), 4.42 (d, *J* = 5.6 Hz, 2H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 160.8, 149.4, 148.8, 147.1, 144.5, 129.8, 129.0, 127.8, 127.3, 127.0, 125.1, 125.0, 121.3, 111.1, 110.6, 98.7, 56.8, 42.4, 40.5; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{21}H_{17}N_3OS]^+$: 360.1165, found: 360.1164; **IR:** 3430, 3405, 3175, 2202, 1630, 1524, 1399, 1187, 710 cm^{-1}; **HPLC**: Daicel Chiralpak IE, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 16.93 min and t_{minor} = 15.94 min.

Gram-scale reaction



Under a nitrogen atmosphere, a solution of diethylzinc (440 μL, 1.0 M in hexane, 0.44 mmol) was added dropwise to a solution of **L1d** (0.22 mmol) in MeCN (10 mL). After the mixture was stirred for 30 min at room temperature, the temperature of the mixture was lowered to 10 °C. Then, 3-aminophenol **1e** (2.2 mmol) and isatylidene malononitriles **2f** (2.2 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with EA (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product 1.08g of **3j**.

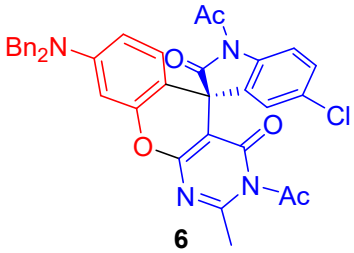
Derivatization



Synthesis of **6**[1]: Compound **3j** (52.0 mg, 0.1 mmol) and K_2CO_3 (27.5 mg, 0.2 mmol) were added to Ac_2O (1 mL), and the mixture was stirred at 100 °C for 8 h. The reaction was quenched with water, and extracted with DCM (5 mL×5). The organic layers were dried over Na_2SO_4 and concentrated. Then, the solvent was removed under reduced pressure. The residue was purified by flash chromatography on silica gel (petroleum ether/ EtOAc = 10/1) to give the product **6** as a white solid.

Synthesis of **7**[2]: Compound **3j** (52.0 mg, 0.1 mmol) was added to a solution of HCOOH (1.0 mL), and the mixture was stirred at 100 °C for 20 h. The reaction was quenched with $NaHCO_3$ (aq.), and extracted with DCM (5 mL×5). The organic layers were dried over Na_2SO_4 and concentrated. The residue was purified by flash chromatography on silica gel (petroleum ether/ EtOAc = 10/1) to give the product **7** as a white solid.

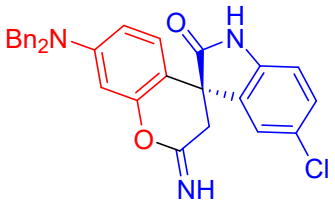
(*R*)-1',3-diacetyl-5'-chloro-8-(dibenzylamino)-2-methylspiro[chromeno[2,3-d]pyrimidine-5,3'-indoline]-2',4(3*H*)-dione (6)



6

white solid (60.1 mg) in 93% isolated yield; $[\alpha]_D^{20}$ = - 25 (c = 1.0, THF, 99% ee); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.26 (d, *J* = 8.8 Hz, 1H), 7.40-7.38 (m, 1H), 7.37–7.31 (m, 4H), 7.30–7.25 (m, 3H), 7.19 (d, *J* = 7.1 Hz, 4H), 6.49–6.40 (m, 2H), 6.36–6.25 (m, 1H), 4.63 (s, 4H), 2.64 (s, 3H), 2.53 (s, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 175.9, 170.3, 155.8, 151.0, 150.0, 138.5, 137.0, 132.3, 131.8, 130.7, 129.0, 127.4, 126.3, 125.5, 118.2, 113.1, 111.4, 104.9, 100.1, 89.5, 54.3, 52.6, 26.5; **HRMS** (ESI): m/z [M + H]$^+$ calcd for $[C_{37}H_{30}ClN_4O_5]^+$: 645.1899, found: 645.1898; **IR**: 1732, 1718, 1520, 1318, 1281, 1199, 1158, 612 cm^{-1}; **HPLC**: Daicel Chiralpak IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 9.73 min and t_{minor} = 12.21 min.

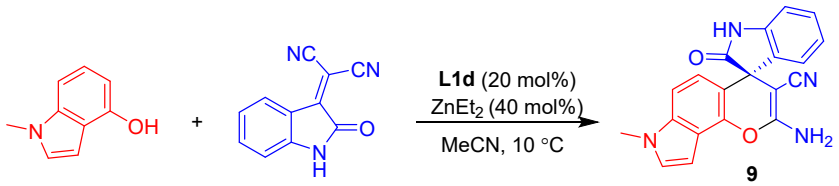
(*R*)-5'-chloro-7-(dibenzylamino)-2-iminospiro[chromane-4,3'-indolin]-2'-one (7)



7

yellow solid (32.1 mg) in 65% isolated yield; $[\alpha]_D^{20}$ = - 42 (c = 1.0, THF, 98% ee); **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.70 (s, 1H), 7.36–7.32 (m, 6H), 7.27–7.23 (m, 6H), 6.94 (d, *J* = 8.8 Hz, 1H), 6.42–6.33 (m, 2H), 6.22 (d, *J* = 8.2 Hz, 1H), 4.77 (s, 1H), 4.72 (s, 4H), 3.53 (d, *J* = 15.9 Hz, 1H), 2.79 (d, *J* = 15.9 Hz, 1H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 178.7, 166.7, 153.3, 149.8, 142.0, 138.9, 132.6, 129.5, 129.1, 127.3, 127.1, 127.0, 126.7, 125.2, 112.0, 109.7, 108.9, 100.8, 54.7, 49.8, 36.0; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{30}H_{25}ClN_3O_2]^+$: 494.1630, found: 494.1632; **IR**: 3230, 1710, 1623, 1518, 1164, 976, 731, 694 cm^{-1}; **HPLC**: Daicel Chiralpak IC, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 28.39 min and t_{minor} = 46.63 min.

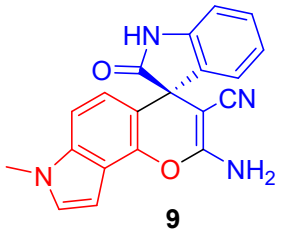
Tandem reaction of 4-hydroxyindole with isatylidene malononitrile



8 + **2a** → **9**, 70% yield, 92% ee

Under a nitrogen atmosphere, a solution of diethylzinc (80 μL, 1.0 M in hexane, 0.08 mmol) was added dropwise to a solution of **L1d** (0.04 mmol) in MeCN (2 mL). After the mixture was stirred for 30 min at room temperature, the temperature of the mixture was lowered to 10 °C. Then, 3-hydroxyindole **8** (0.2 mmol) and isatylidene malononitriles **2a** (0.2 mmol) were added. The reaction mixture was stirred for 24 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with CH_2Cl_2 (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1) to afford the desired product **9**.

(*R*)-2'-amino-7'-methyl-2-oxo-7'*H*-spiro[indoline-3,4'-pyrano[2,3-e]indole]-3'-carbonitrile (9)

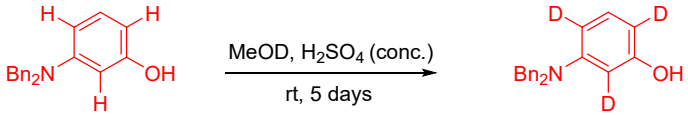


9

white solid (47.9 mg) in 70% isolated yield; $[\alpha]_D^{20}$ = + 77 (c = 1.0, THF, 92% ee); **^{1}H NMR** (400 MHz, DMSO-d6) δ 10.51 (s, 1H), 7.38 (d, *J* = 3.0 Hz, 1H), 7.30–7.23 (m, 1H), 7.21 (s, 2H), 7.10 (d, *J* = 8.6 Hz, 1H), 7.04–6.93 (m, 3H), 6.48 (d, *J* = 2.9 Hz, 1H), 6.22 (d, *J* = 8.5 Hz, 1H), 3.74 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 179.9, 161.8, 142.3, 141.9, 137.5, 136.0, 130.7, 129.3, 125.3, 123.0, 119.4, 117.2, 110.3, 109.7, 107.8, 97.2, 55.1, 50.9, 33.2; **HRMS** (ESI): m/z $[M + H]^+$ calcd for $[C_{20}H_{15}N_4O_2]^+$: 343.1190, found: 343.1189; **IR**: 3448, 3320, 2190, 1657, 1514, 1410, 726, 423 cm^{-1}; **HPLC**: Daicel

Chiralpak IF, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1 mL/min, λ = 254 nm, t_{major} = 23.83 min and t_{minor} = 17.14 min.

Intermolecular Kinetic Isotope Effect



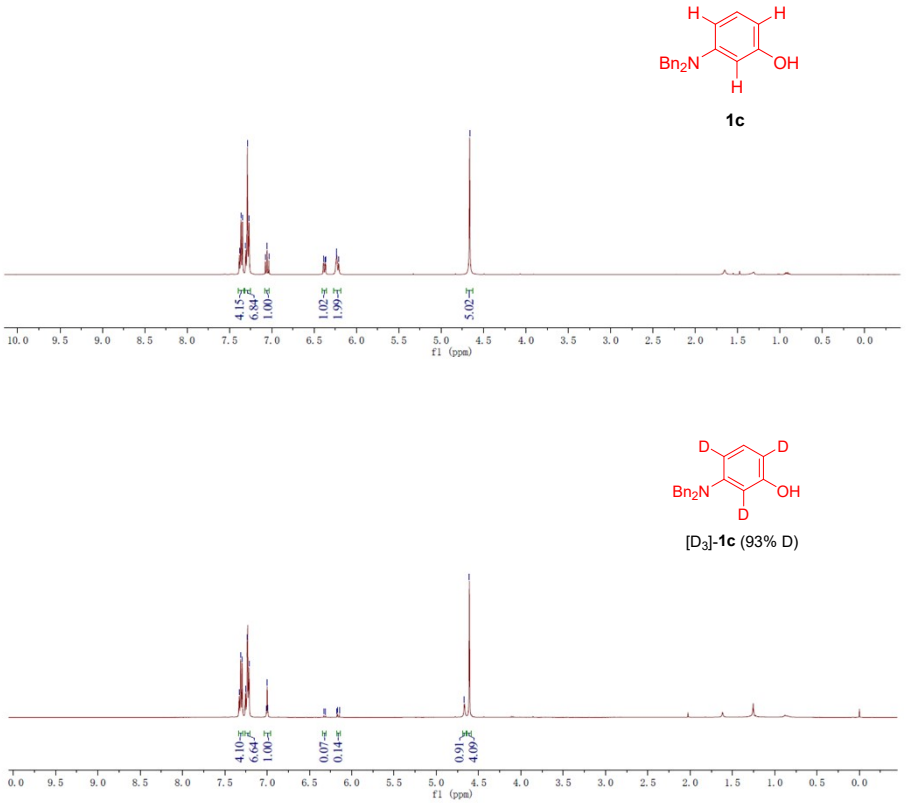
1c [D$_3$]-**1c** (93% D)

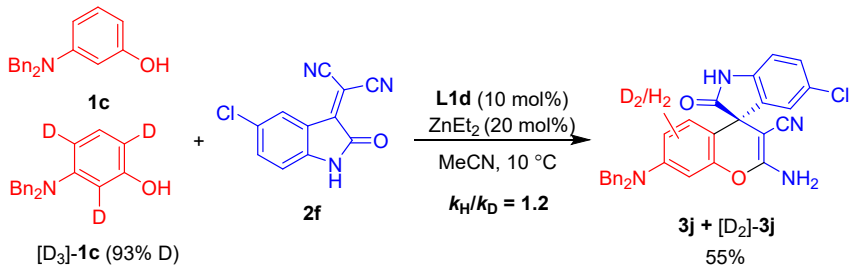
The substrate **1c** (1 mmol) was dissolved in MeOD-d1 (10 mL). A solution of H_2SO_4 (98%, 5.5 μL) was added and the mixture was stirred at the room temperature under argon for 5 days.[3]

3-(dibenzylamino)phen-2,4,6-d3-ol

[D$_3$]-**1c** (93% D)

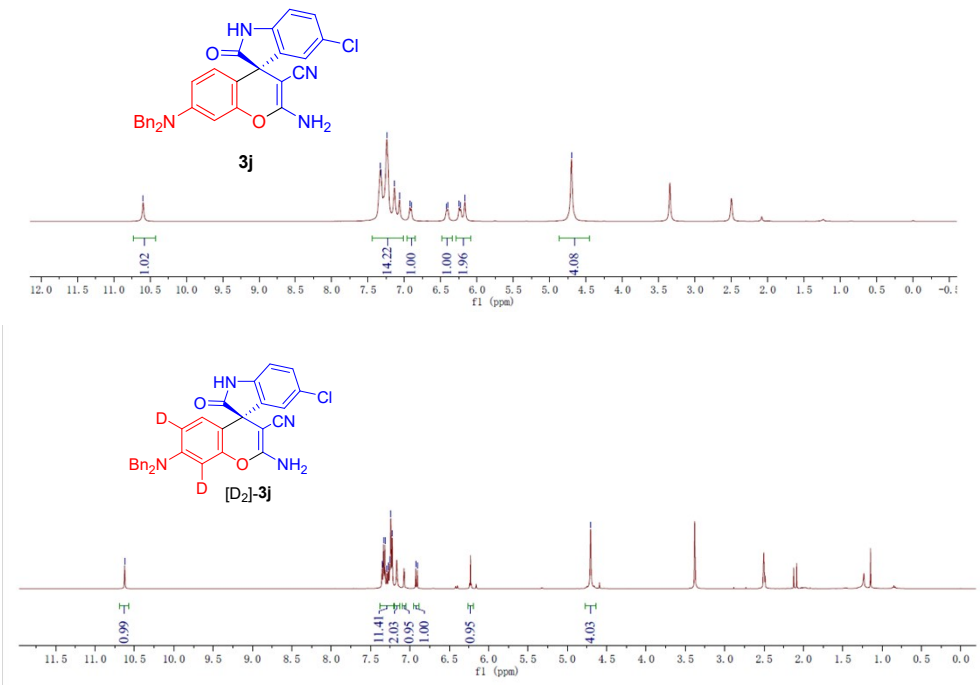
White solid in 93% deuterium incorporation. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.31 (t, *J* = 7.2 Hz, 4H), 7.26–7.20 (m, 6H), 7.03–6.96 (m, 1H), 6.32 (d, *J* = 8.4 Hz, 0.07 H), 6.18–6.14 (m, 0.14 H), 4.67 (s, 1H), 4.61 (s, 4H).

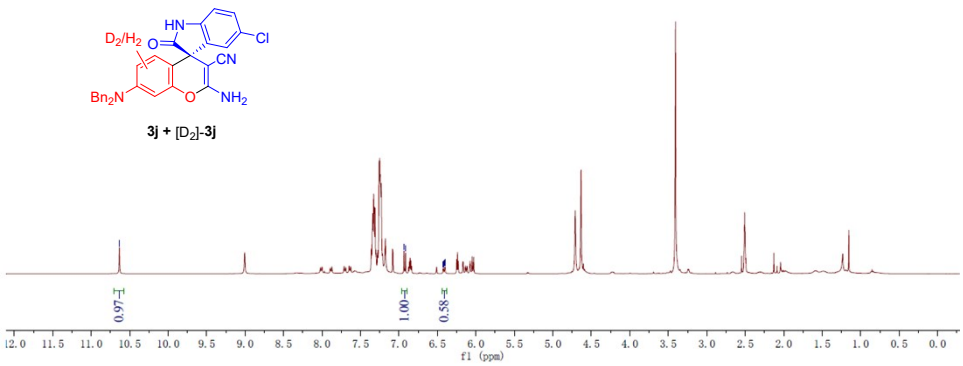




Under a nitrogen atmosphere, a solution of diethylzinc (40 μL, 1.0 M in hexane, 0.04 mmol) was added dropwise to a solution of **L1d** (0.02 mmol) in MeCN (2 mL). After the mixture was stirred for 30 min at room temperature, the temperature of the mixture was lowered to 10 °C. Then, 3-aminophenol **1c** (0.2 mmol), 3-aminophenol [D_3]-**1c**-93% deuterium incorporation (0.2 mmol) and isatylidene malononitriles **2f** (0.2 mmol) were added. The reaction mixture was stirred for 8 h at the same temperature. The reaction was quenched with HCl solution (1 M, 2 mL), and the organic layer was extracted with EA (3 × 5 mL). The combined organic layer was washed with brine and dried over Na_2SO_4. The solvent was removed under reduced pressure by using a rotary evaporator. The residue was purified by flash chromatography with petroleum ether/ethyl acetate (4/1), and the KIE value was determined by crude H-NMR.

$$KIE = k_H/k_D = [0.58/(1+0.07)]/[0.42/0.93] = 1.22$$





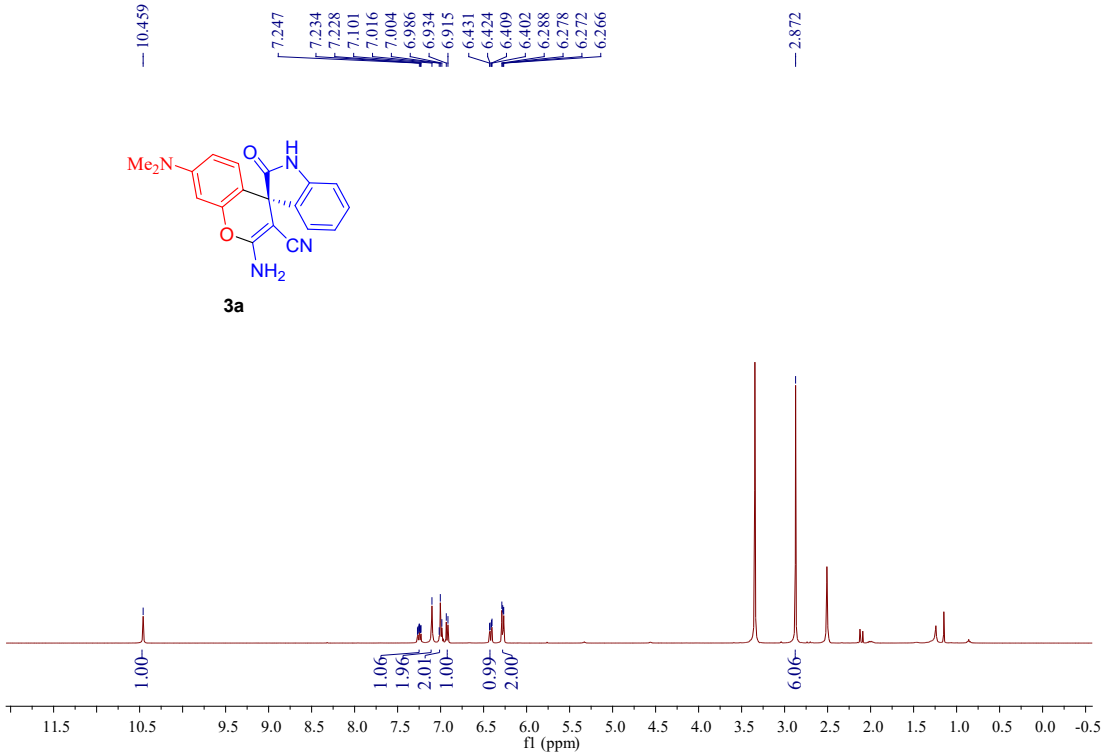
References

1 X. Jiang, Y. Sun, J. Yao, Y. Cao, M. Kai, N. He, X. Zhang, Y. Wang and R. Wang, *Adv. Synth. Catal.,* 2012, **354**, 917−925.

2 Q. He, Z.-H. Yang, J. Yang, W. Du and Y.-C. Chen, *Adv. Synth. Catal.,* 2020, **362**, 4438–4443.

3 O. Fischer, A. Hubert and M. R. Heinrich, *J. Org. Chem,.* 2020, **85**, 11856−11866.

NMR Spectra of compounds



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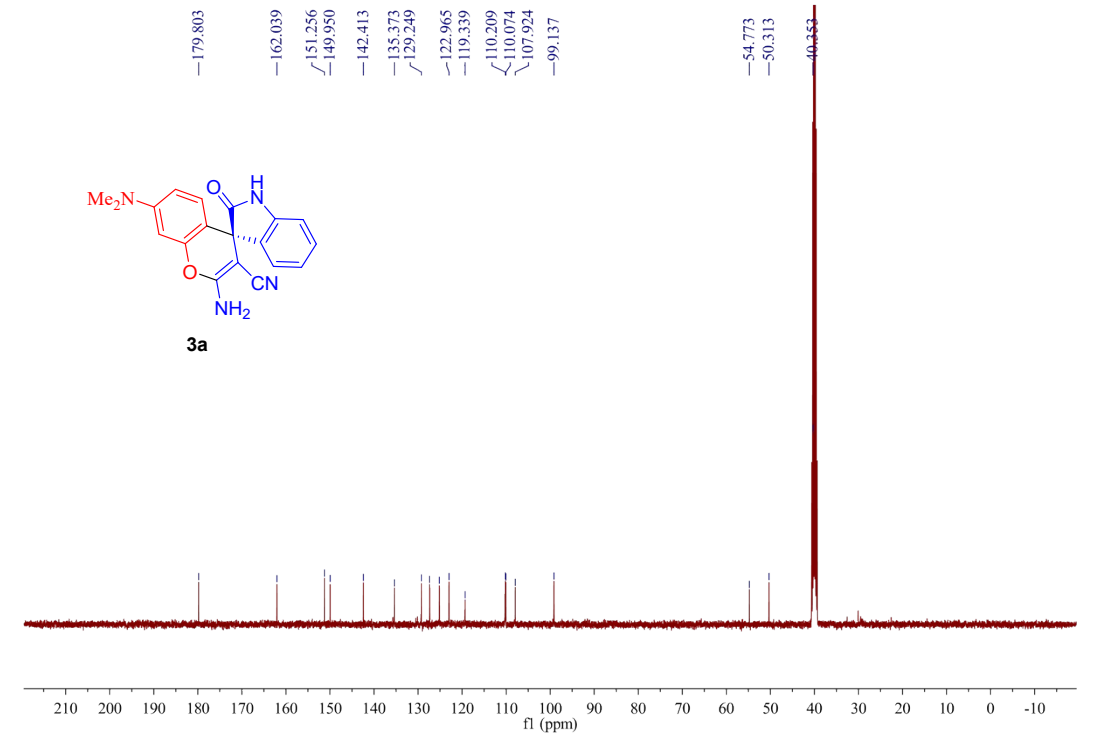

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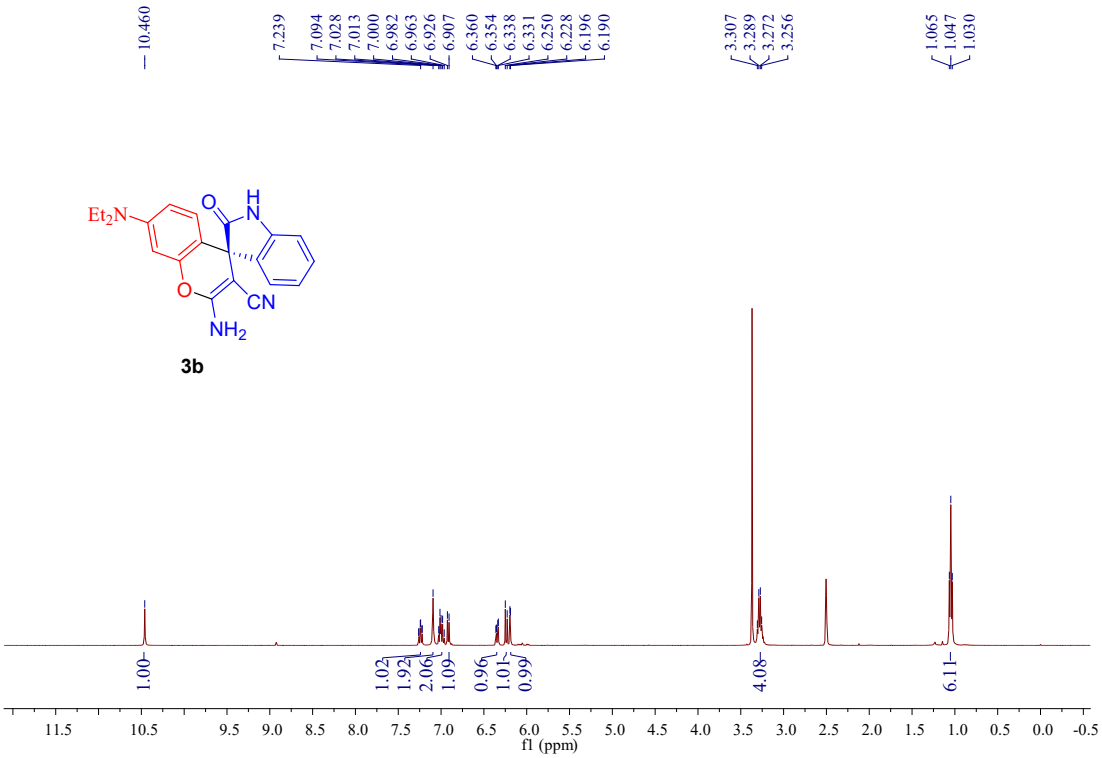
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6.963
6.926
6.907
6.360
6.354
6.338
6.331
6.250
6.228
6.196
6.190
3.307
3.289
3.272
3.256
1.065
1.047
1.030
Et2N
O
H
N
O
CN
NH2
3b
1.00
1.02
1.92
2.06
1.09
0.96
1.01
0.99
4.08
6.11
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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2.0
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0.5
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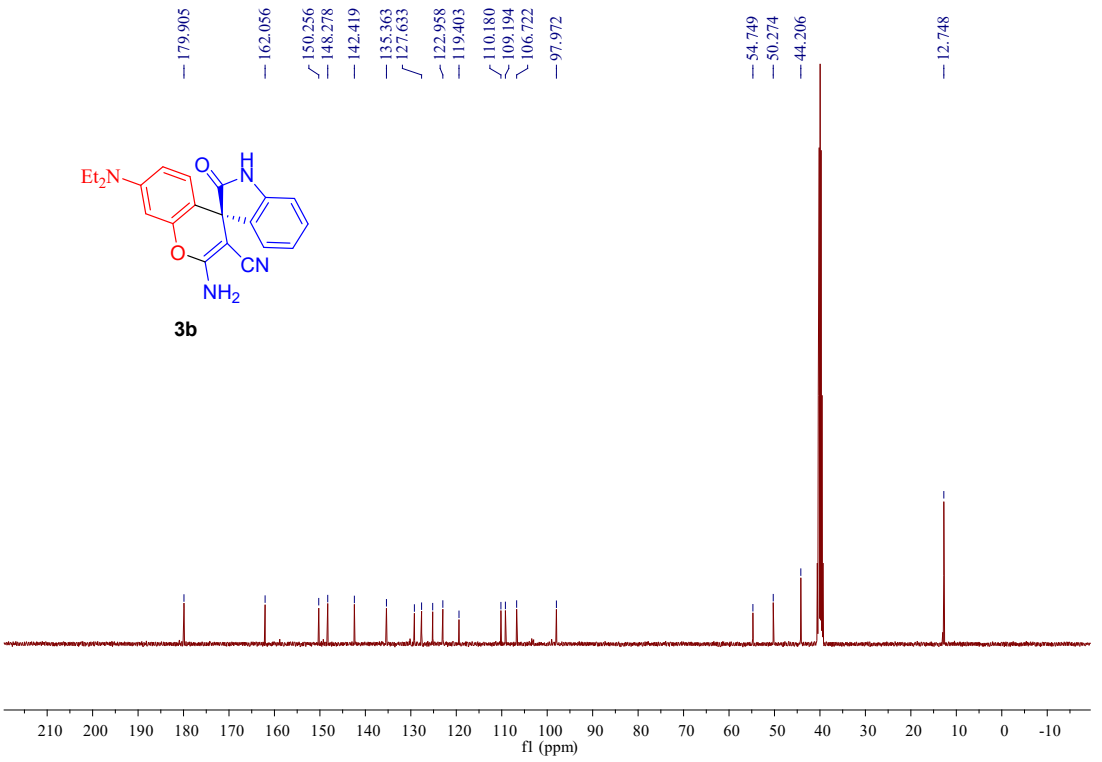
-0.5
f1 (ppm)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97.972
54.749
50.274
44.206
12.748
Et2N
O
H
N
O
CN
NH2
3b
210
200
190
180
170
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120
110
100
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80
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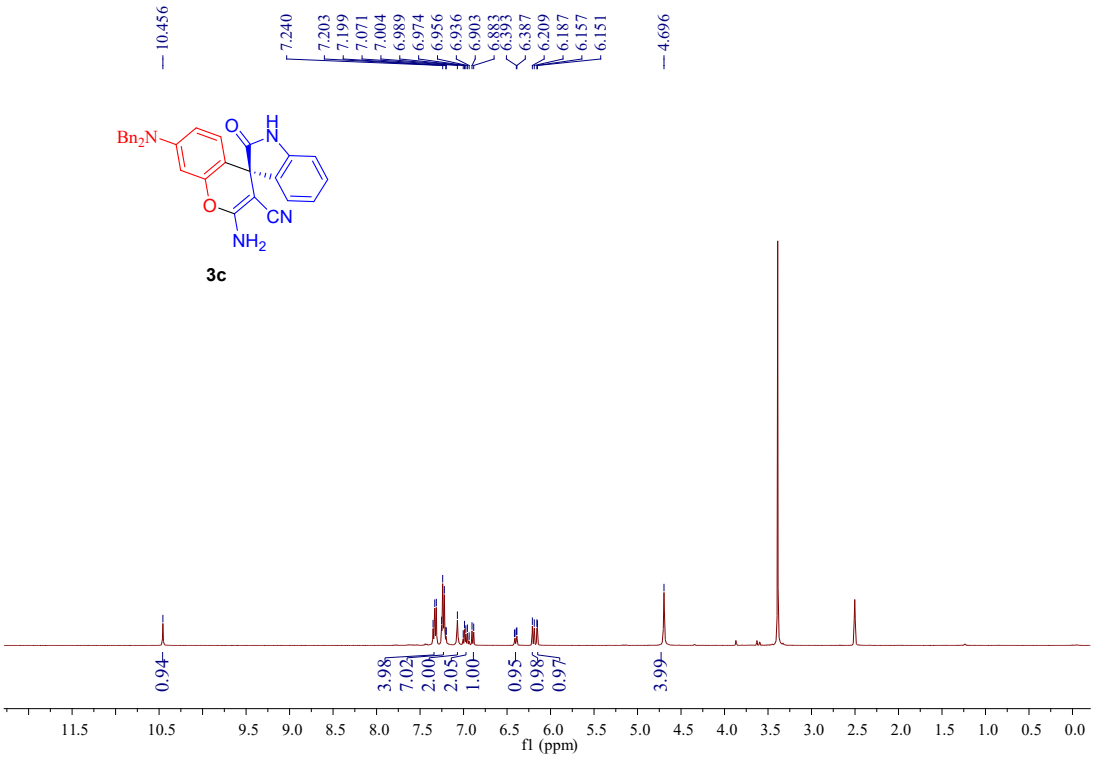
60
50
40
30
20
10
0
-10
f1 (ppm)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6.974
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6.393
6.387
6.209
6.187
6.157
6.151
4.696
Bn2N
O
H
N
CN
NH2
3c
0.94
3.98
7.02
2.00
2.05
1.00
0.95
0.98
0.97
3.99
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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2.0
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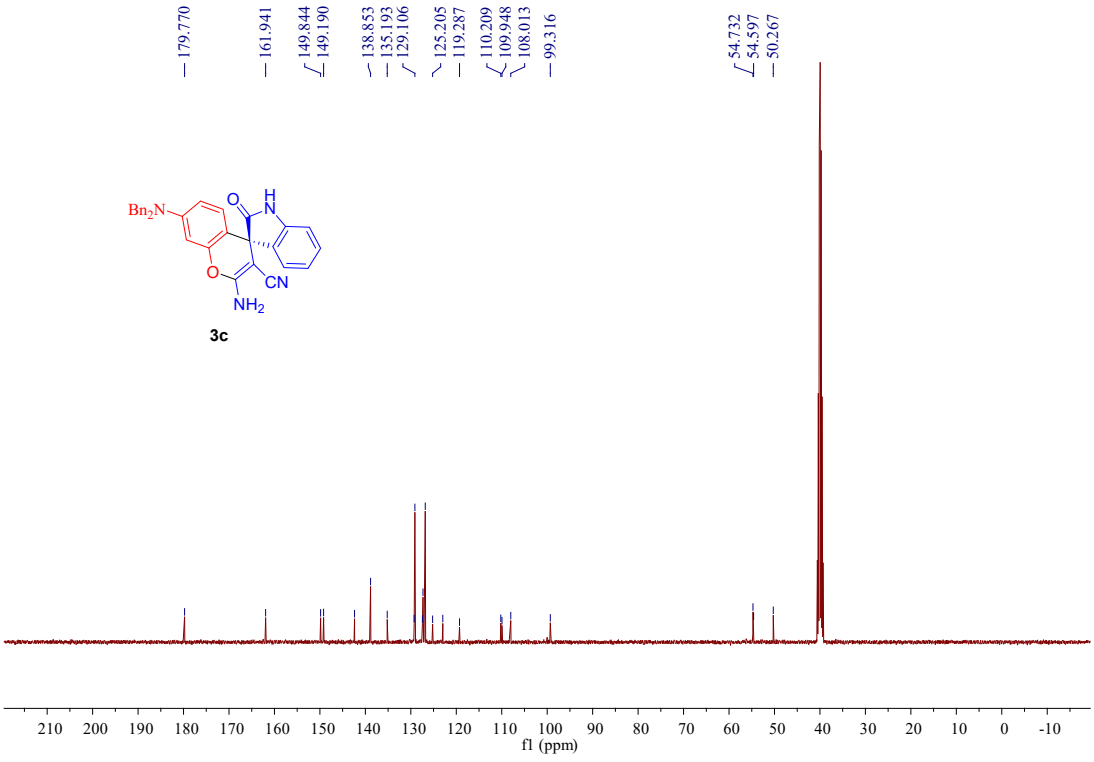
0.0
f1 (ppm)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H
N
CN
NH2
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200
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80
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40
30
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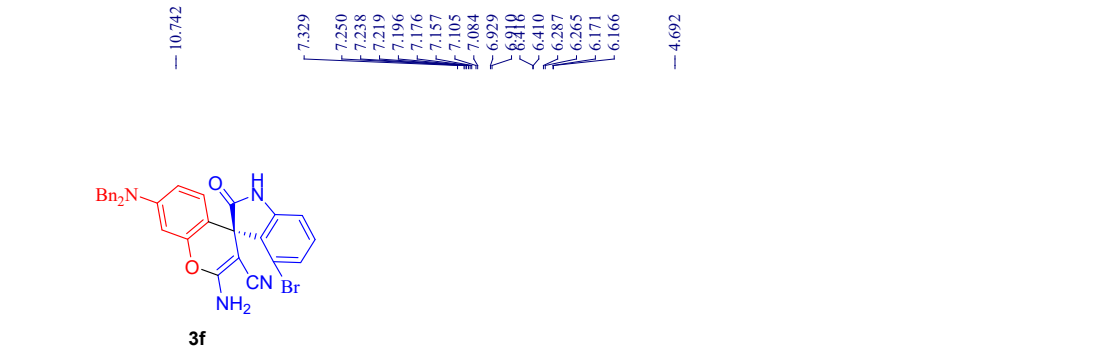
f1 (ppm)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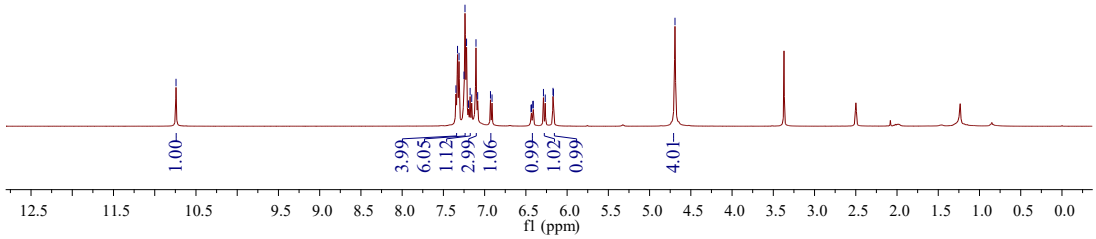
H
N
O
CN
Br
NH2

3f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8.5
8.0
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6.5
6.0
5.5
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3.0
2.5
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1.0
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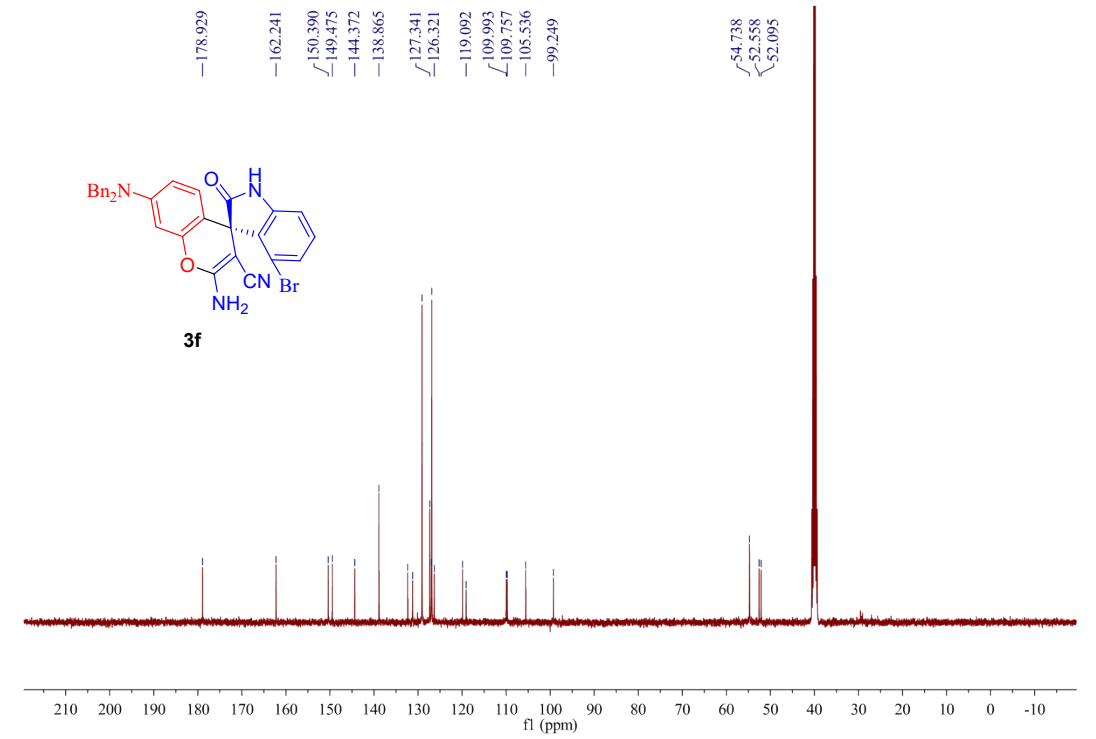
0.0
f1 (ppm)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54.738
52.558
52.095
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H
N
O
CN
Br
NH2
210
200
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180
170
160
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20
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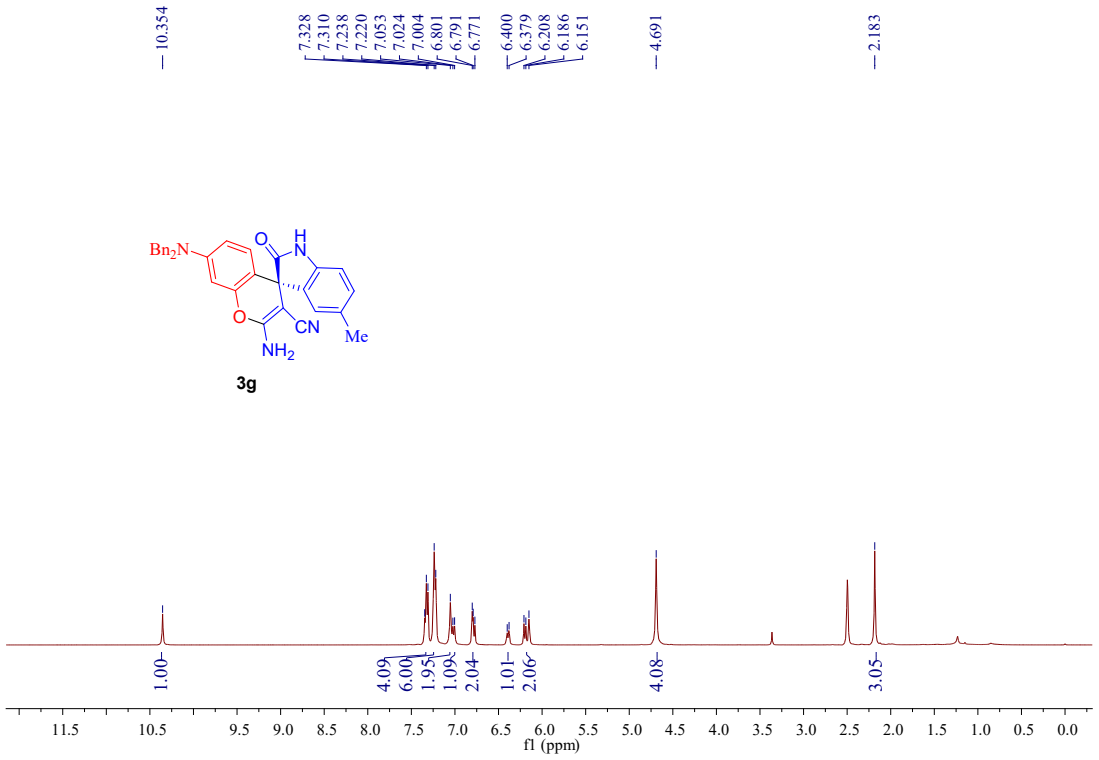
f1 (ppm)

3f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6.208
6.186
6.151
4.691
2.183
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O
H
N
CN
Me
NH2
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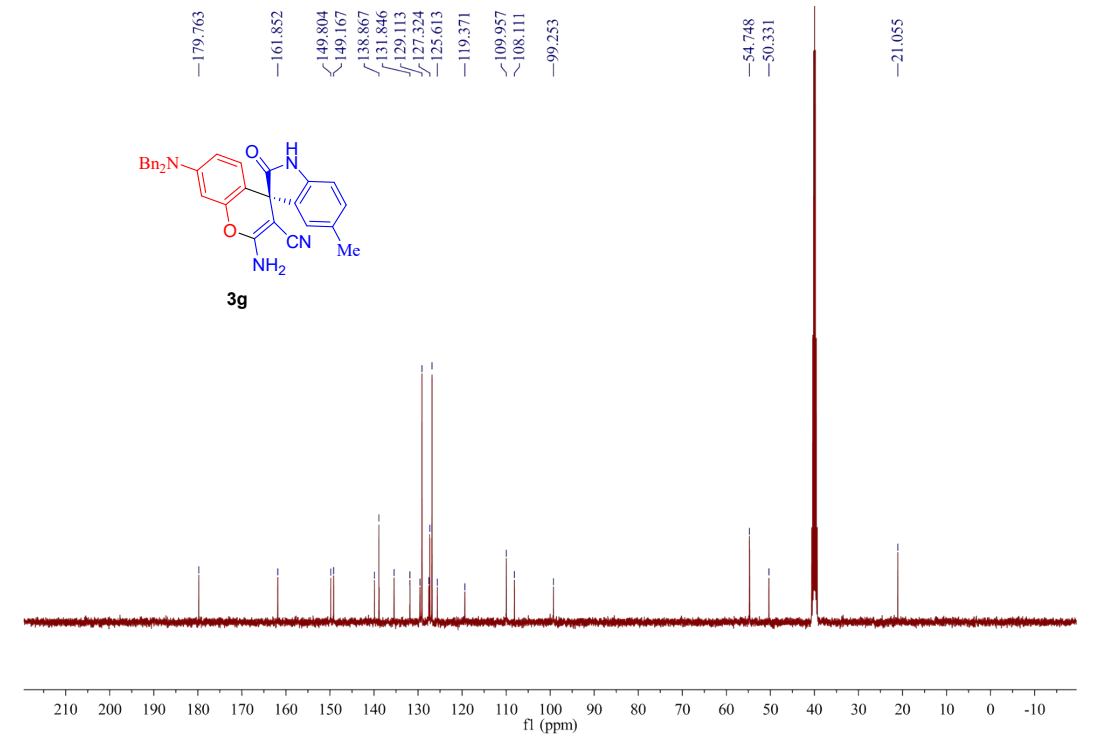
f1 (ppm)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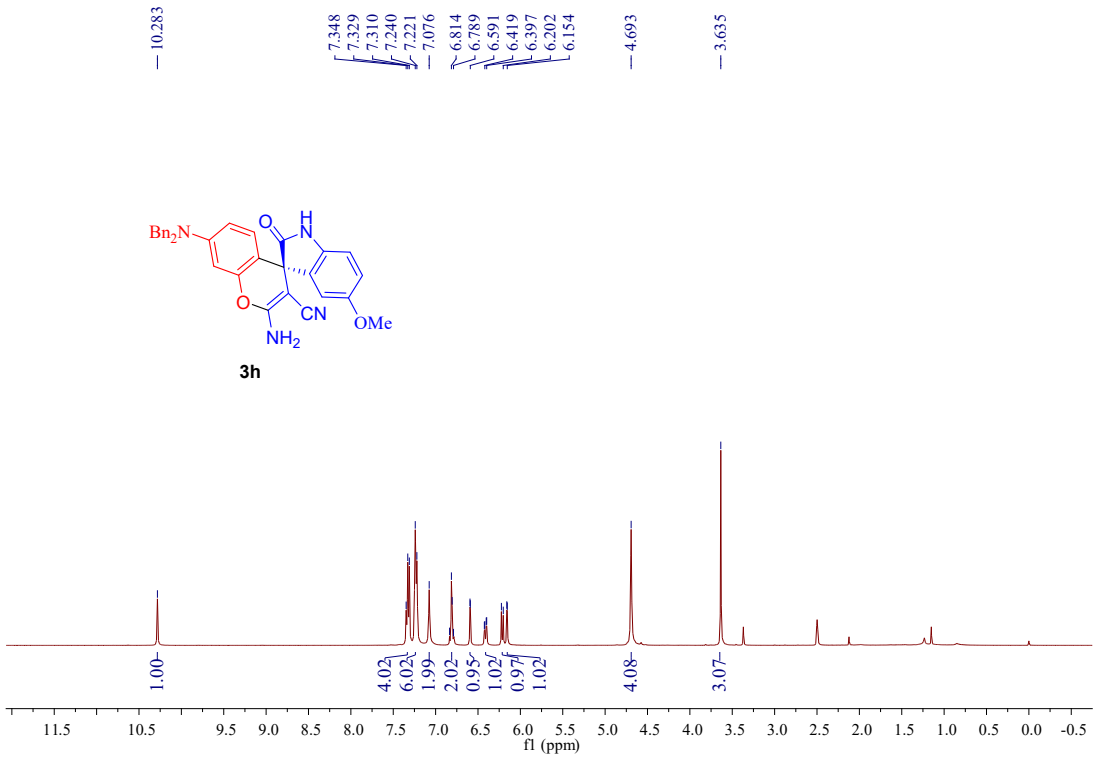
H
N
CN
Me
NH2
3g
f1 (ppm)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6.154
4.693
3.635
Bn2N
O
H
N
O
CN
OMe
NH2
3h
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4.02
6.02
1.99
2.02
0.95
1.02
0.97
1.02
4.08
3.07
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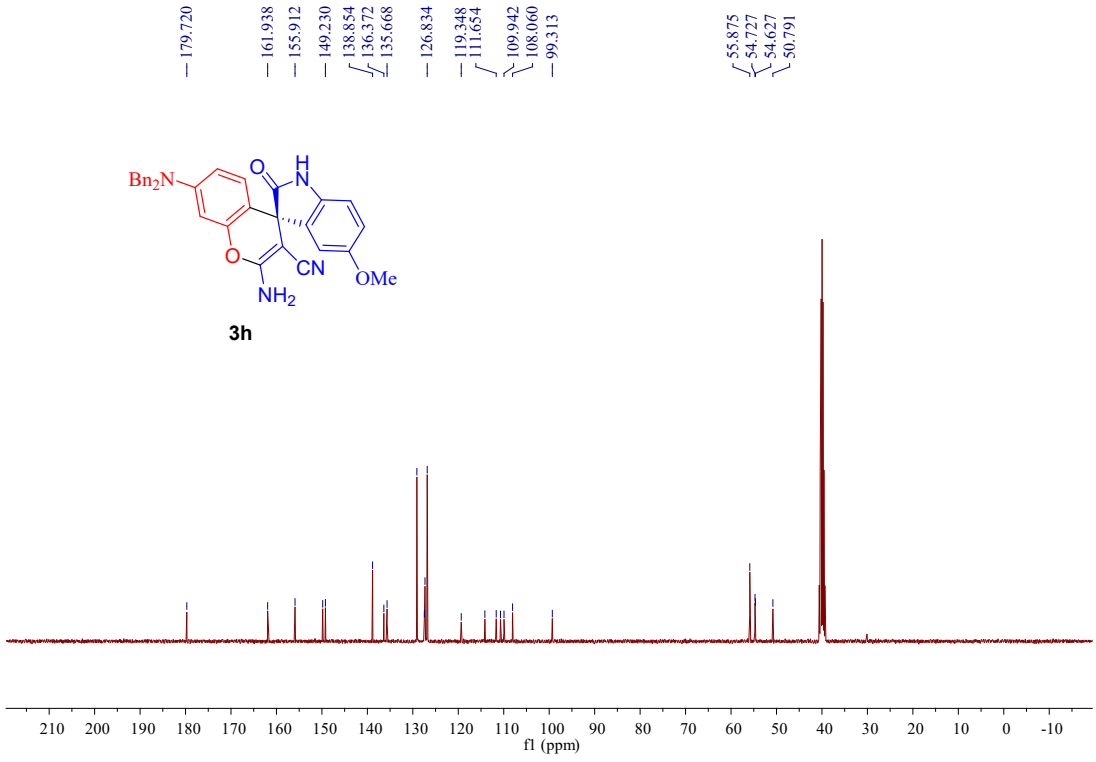
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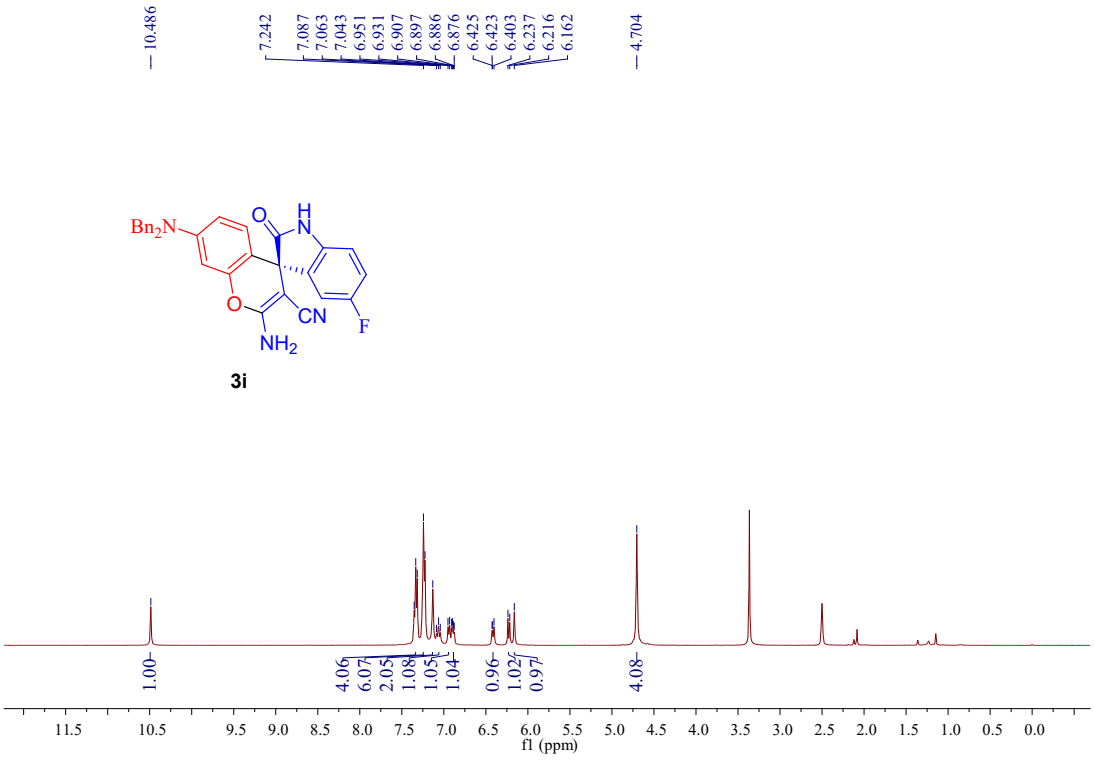
f1 (ppm)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1.04
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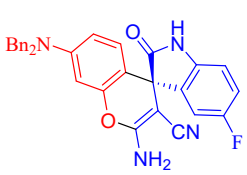
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3i

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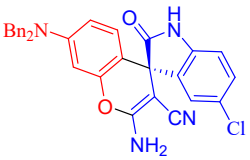
f1 (ppm)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3j

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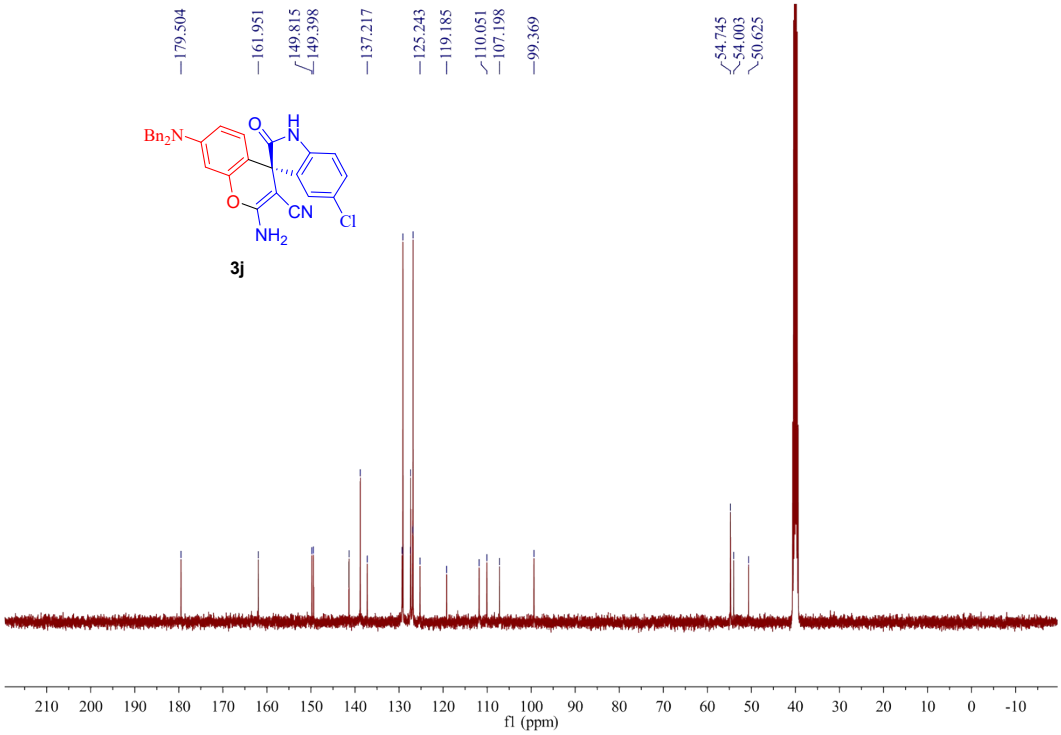
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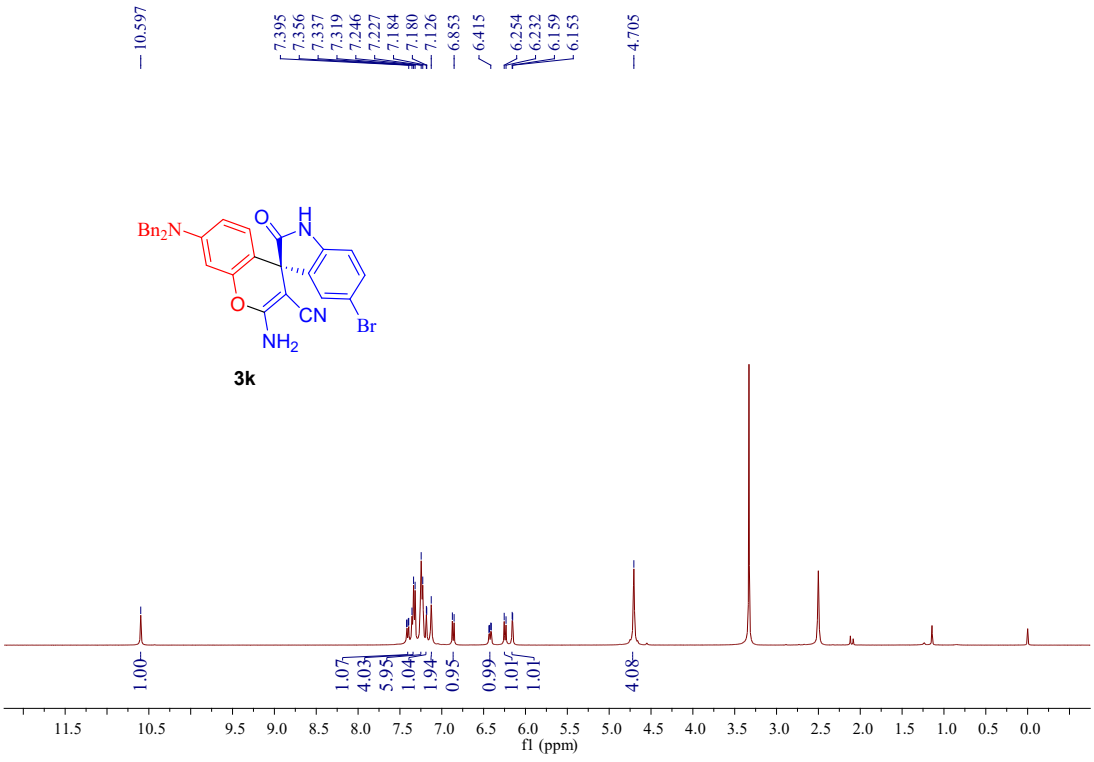
f1 (ppm)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CN
Br
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4.03
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1.04
1.94
0.95
0.99
1.01
1.01
4.08
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
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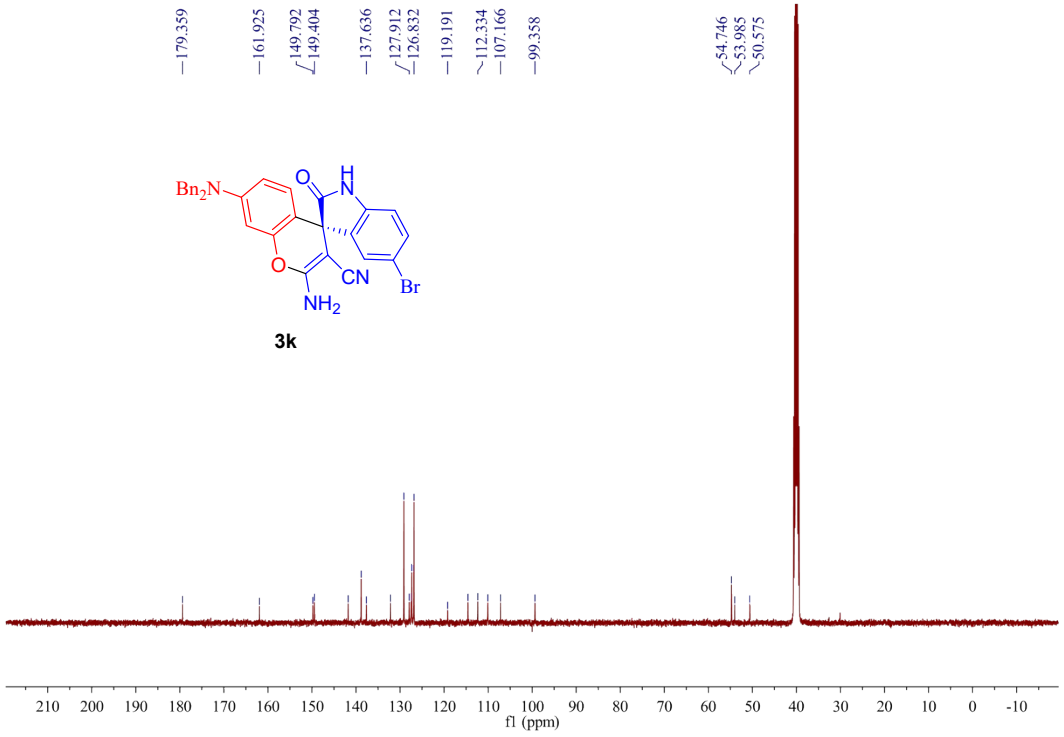
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50.575
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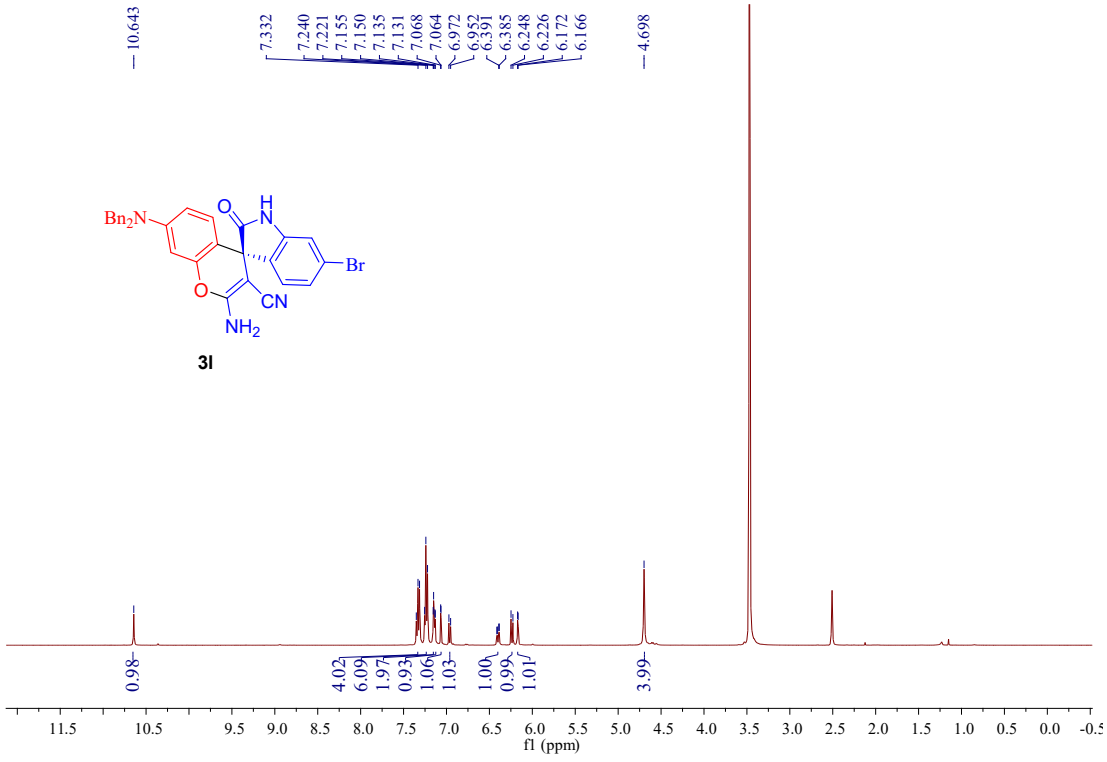
O
CN
Br
NH2
3k
f1 (ppm)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3l
0.98
4.02
6.09
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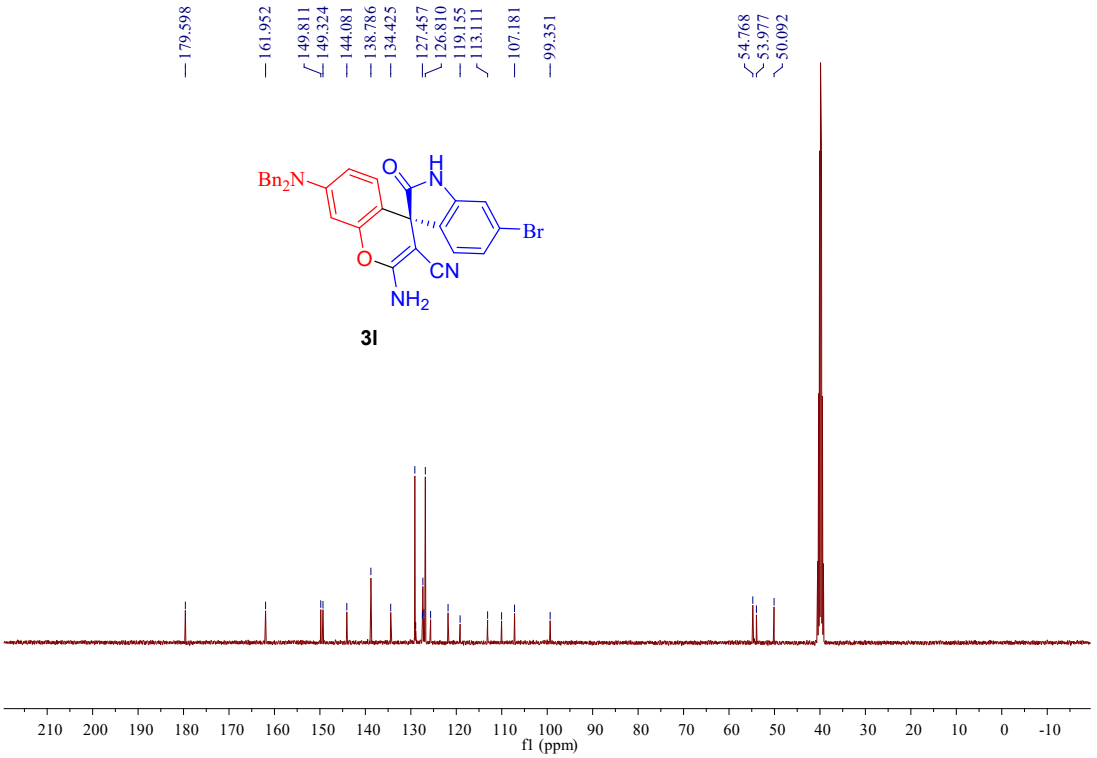
0.93
1.06
1.03
1.00
0.99
1.01
3.99
f1 (ppm)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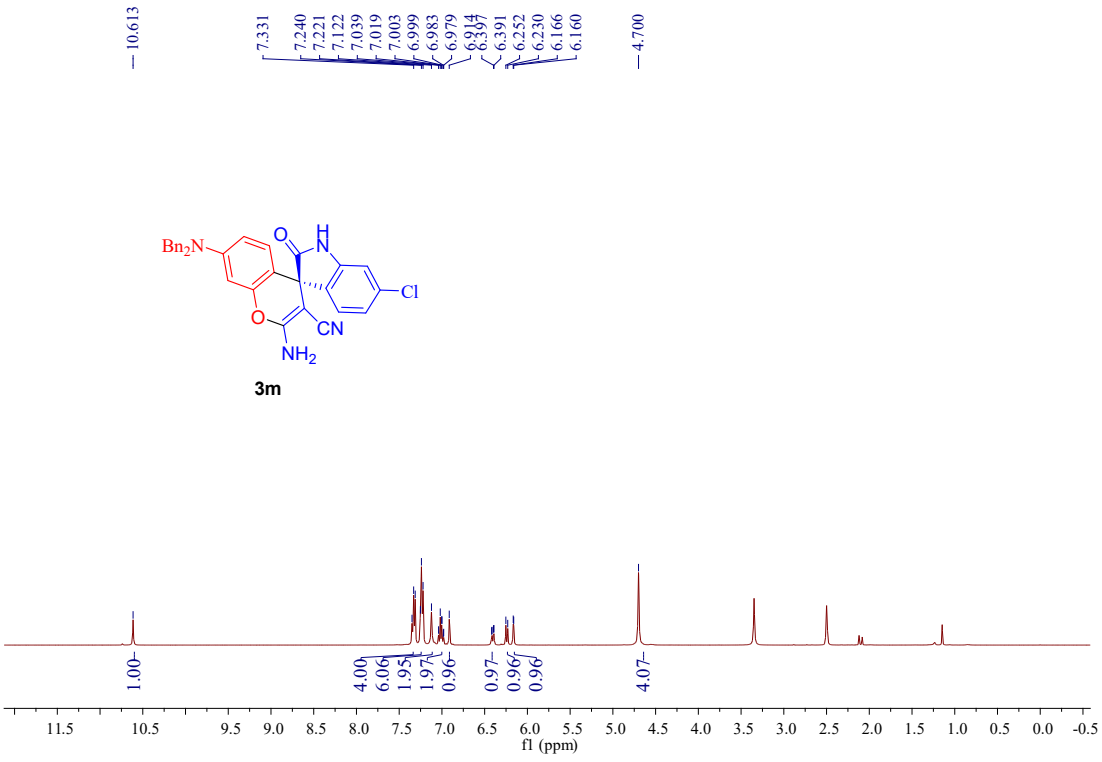
161.952
149.811
149.324
144.081
138.786
134.425
127.457
126.810
119.155
113.111
107.181
99.351
54.768
53.977
50.092
Bn2N
O
H
N
Br
O
CN
NH2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

3l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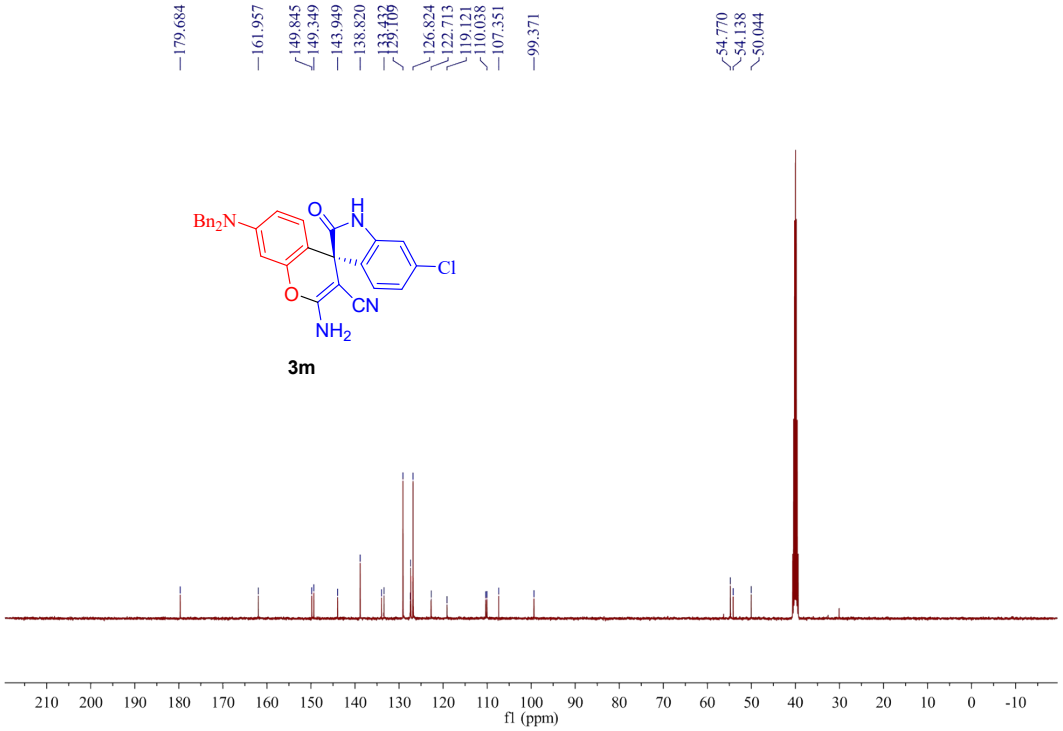
7.331
7.240
7.221
7.122
7.039
7.019
7.003
6.999
6.983
6.979
6.814
6.397
6.391
6.252
6.230
6.166
6.160
4.700
Bn2N
O
H
N
Cl
O
CN
NH2
1.00
4.00
6.06
1.95
1.97
0.96
0.97
0.96
0.96
4.07
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

3m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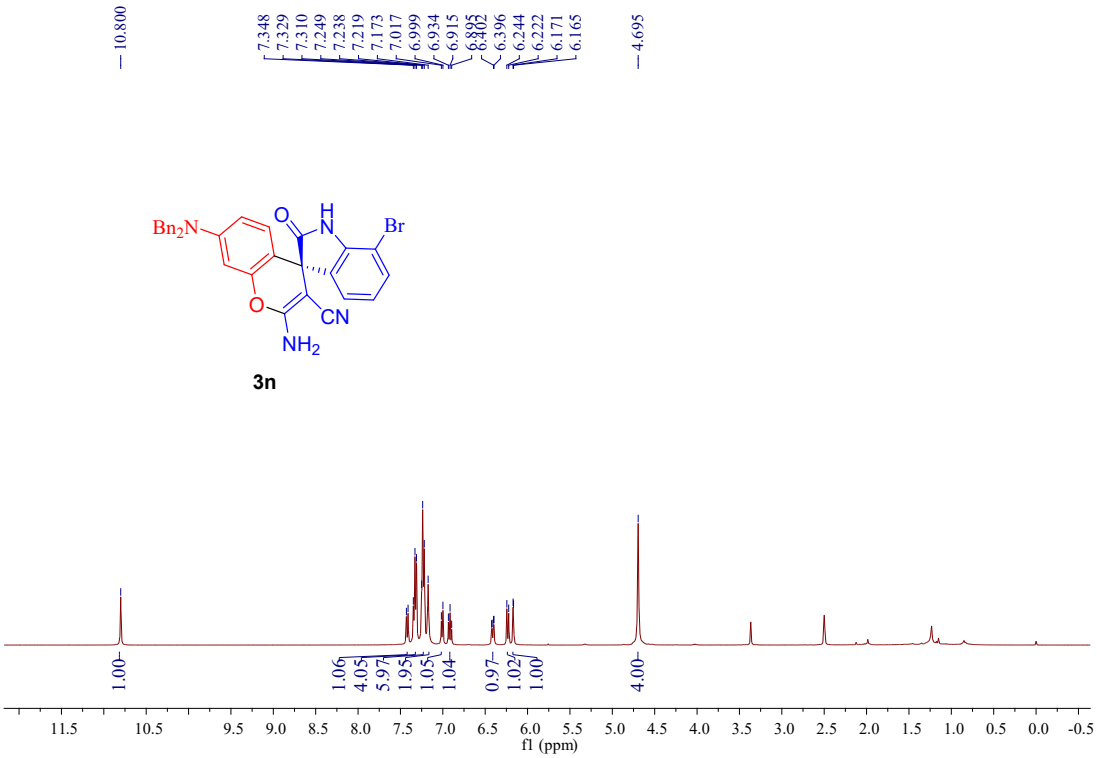
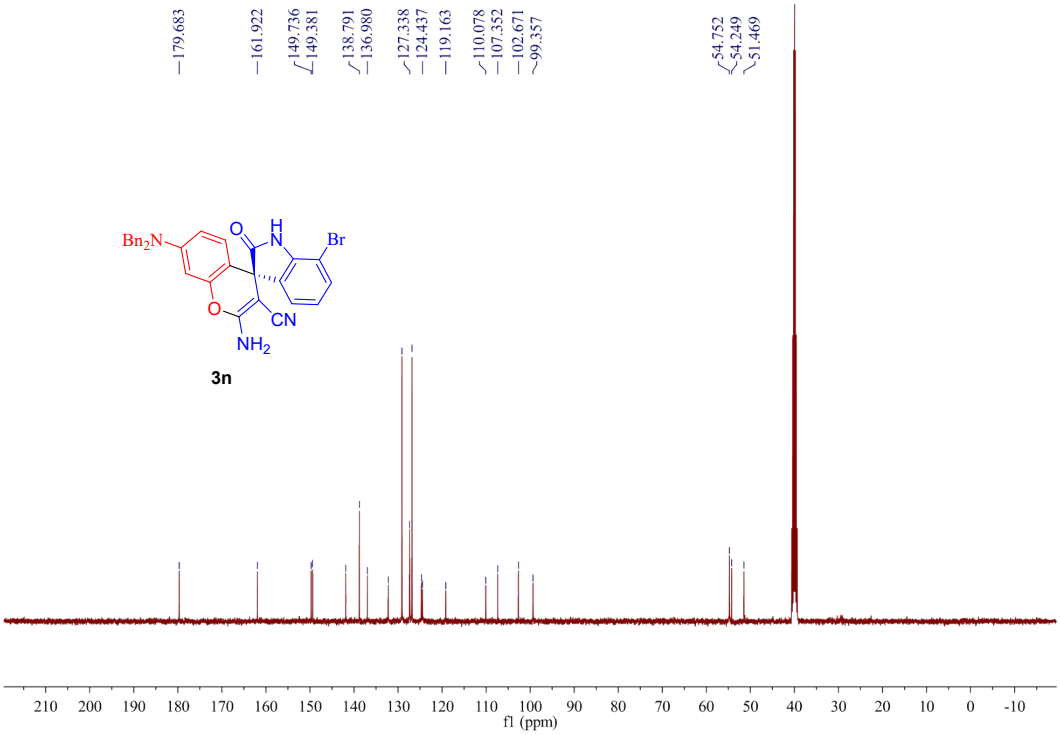
149.845
149.349
143.949
138.820
133.432
129.109
126.824
122.713
119.121
110.038
107.351
99.371
54.770
54.138
50.044
Bn2N
O
H
N
Cl
O
CN
NH2
3m
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


10.800
7.348
7.329
7.310
7.249
7.238
7.219
7.173
7.017
6.999
6.934
6.915
6.805
6.402
6.396
6.244
6.222
6.171
6.165
4.695
Bn2N
O
H
N
Br
O
CN
NH2
3n
1.00
1.06
4.05
5.97
1.95
1.05
1.04
0.97
1.02
1.00
4.00
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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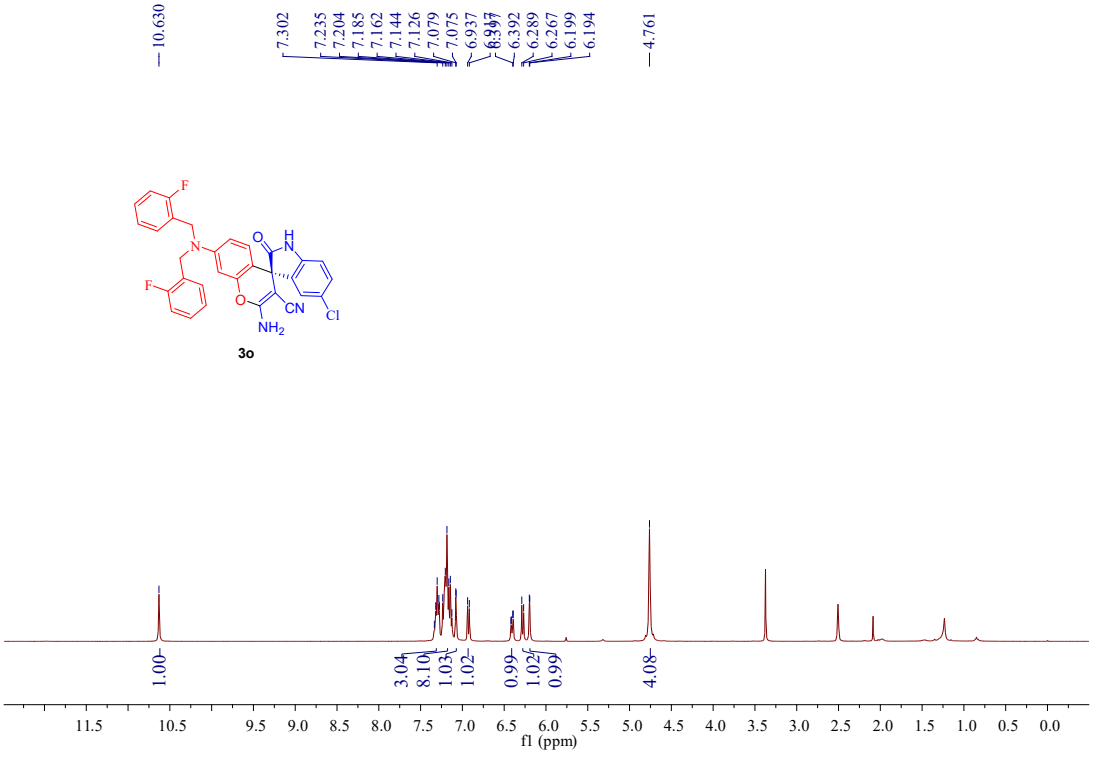
161.922
149.736
149.381
138.791
136.980
127.338
124.437
119.163
110.078
107.352
102.671
99.357
54.752
54.249
51.469
Bn2N
O
H
N
Br
O
CN
NH2
3n
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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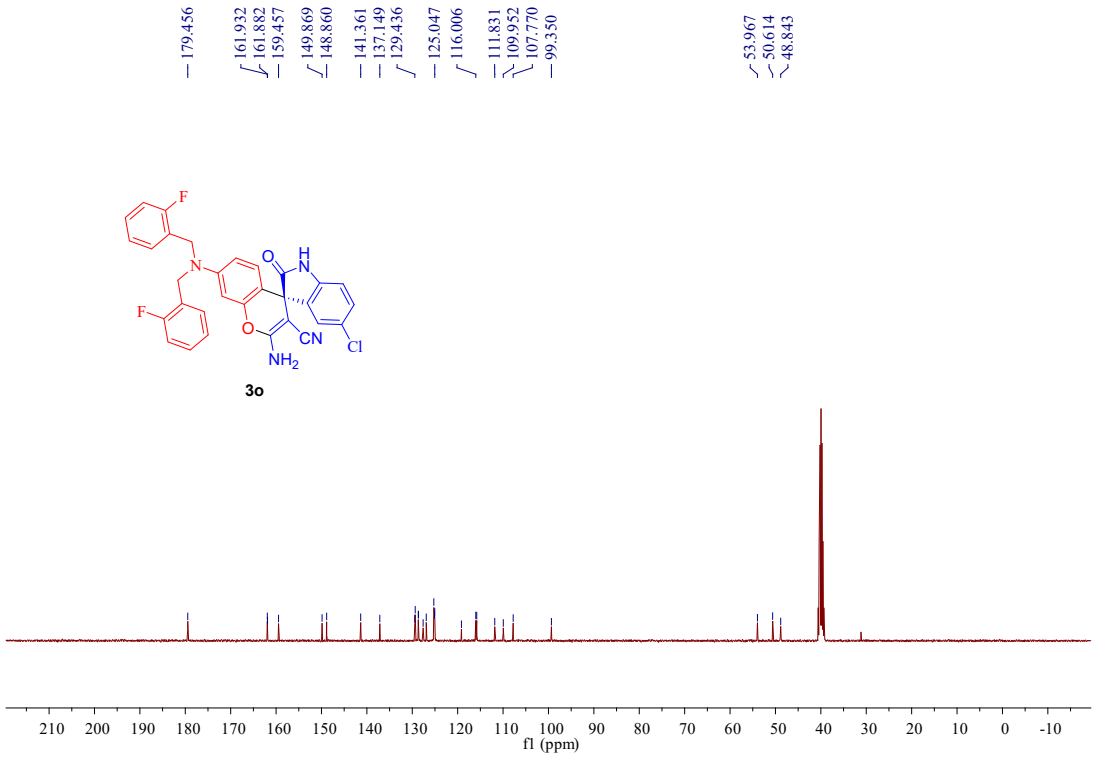
7.302
7.235
7.204
7.185
7.162
7.144
7.126
7.079
7.075
6.937
6.392
6.289
6.267
6.199
6.194
4.761
F
N
F
O
H
N
CN
Cl
NH2
3o
1.00
3.04
8.10
1.03
1.02
0.99
1.02
0.99
4.08
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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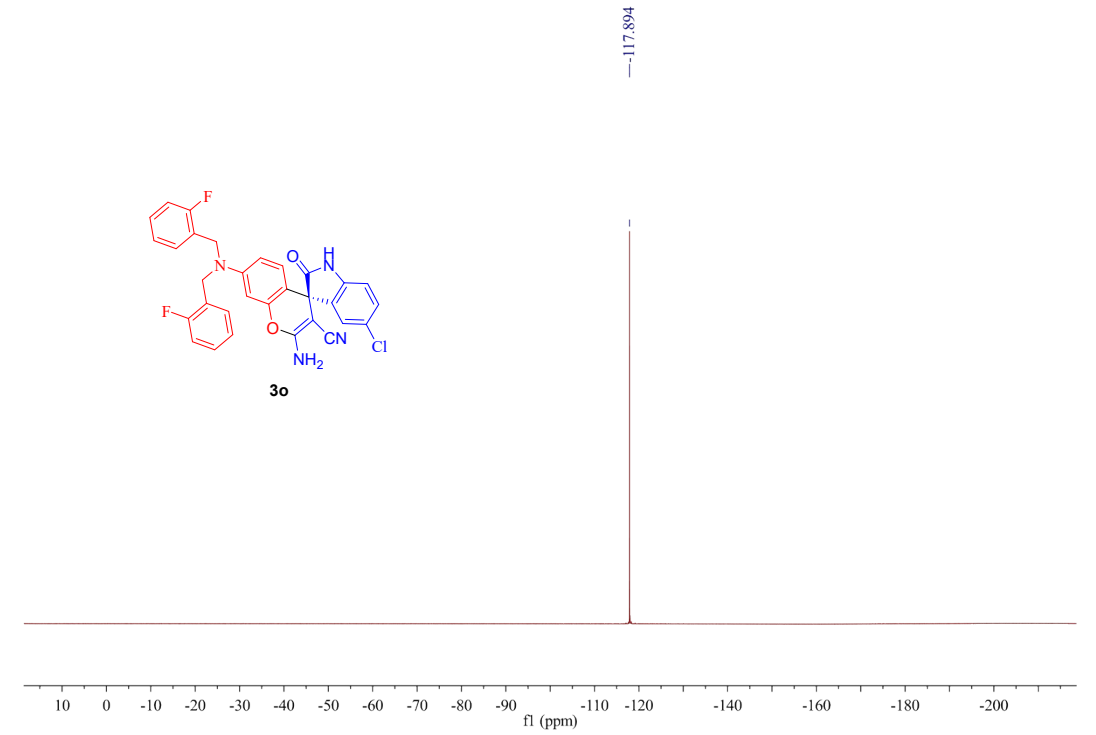
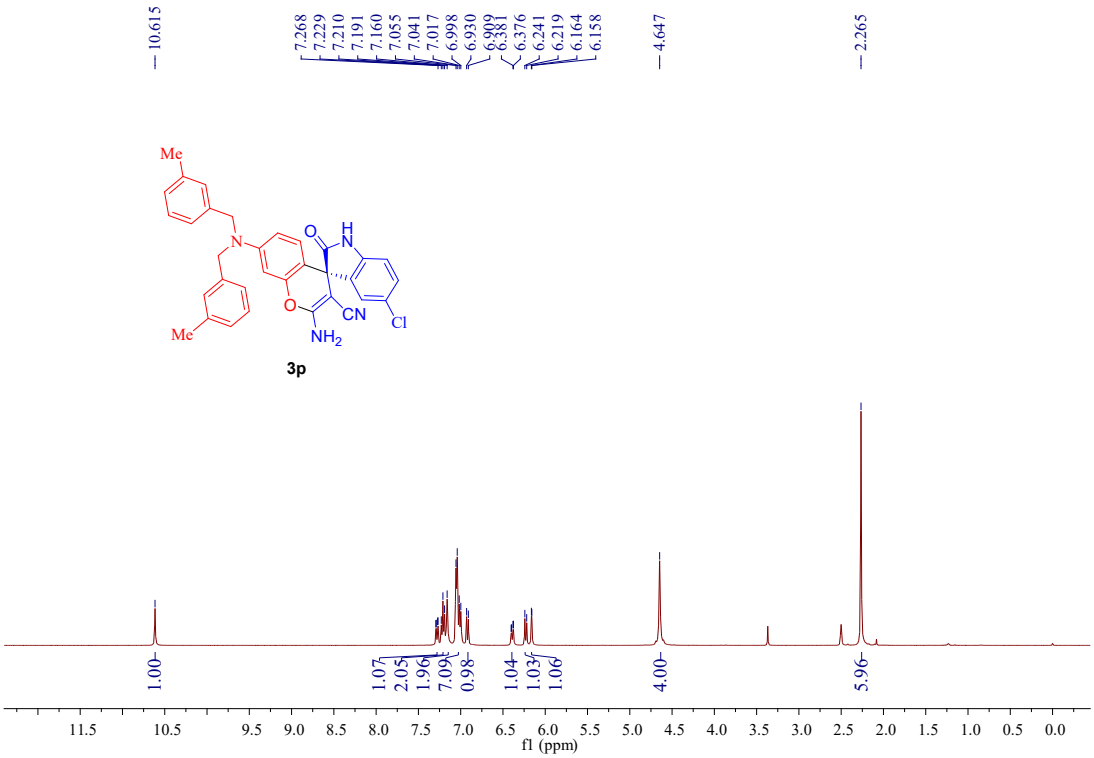
161.932
161.882
159.457
149.869
148.860
141.361
137.149
129.436
125.047
116.006
111.831
109.952
107.770
99.350
53.967
50.614
48.843
F
N
O
H
N
F
O
CN
Cl
NH2
3o
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-117.894
F
N
O
H
N
F
O
CN
Cl
NH2
3o
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -110 -120 -140 -160 -180 -200
f1 (ppm)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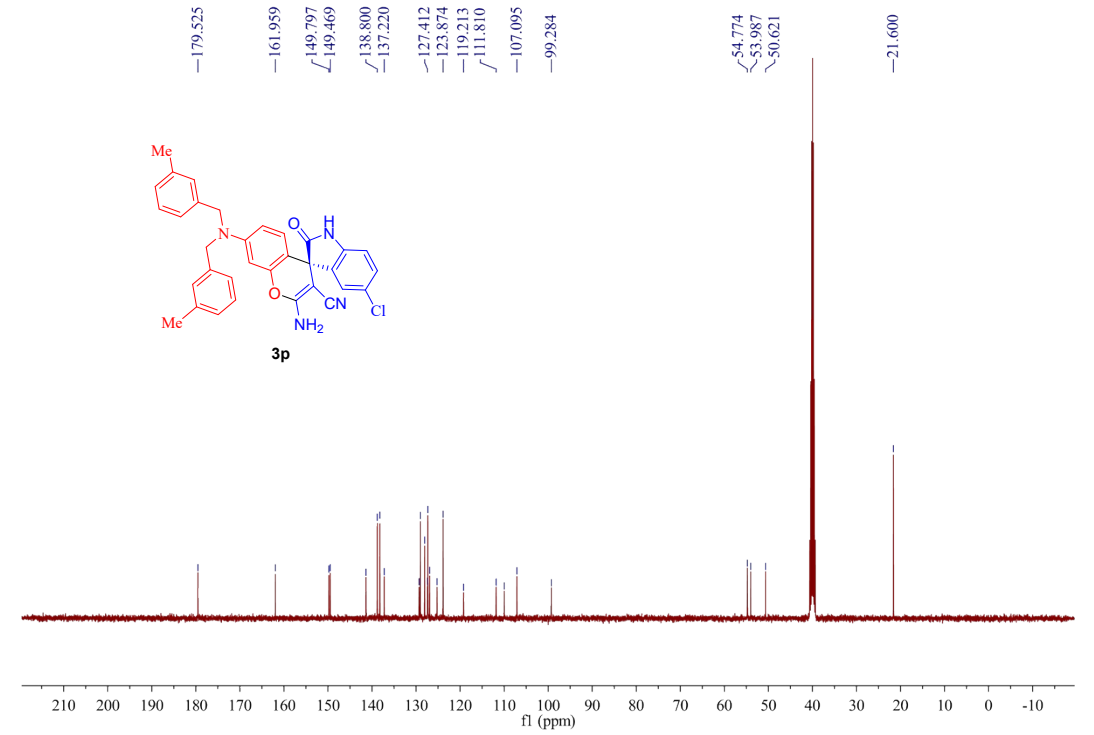
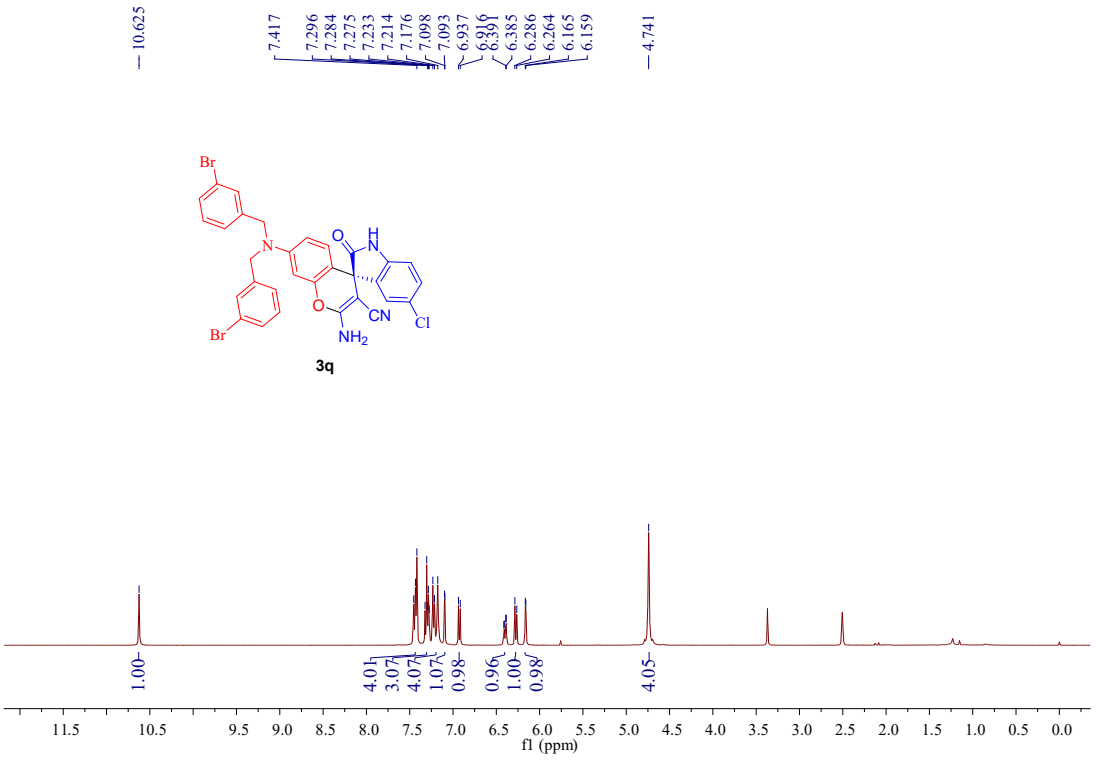
7.268
7.229
7.210
7.191
7.160
7.055
7.041
7.017
6.998
6.930
6.909
6.381
6.376
6.241
6.219
6.164
6.158
4.647
2.265
Me
O
H
N
N
CN
Cl
O
Me
NH2
1.00
1.07
2.05
1.96
7.09
0.98
1.04
1.03
1.06
4.00
5.96
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3p


179.525
161.959
149.797
149.469
138.800
137.220
127.412
123.874
119.213
111.810
107.095
99.284
54.774
53.987
50.621
21.600
Me
O
H
N
N
CN
Cl
O
Me
NH2
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3p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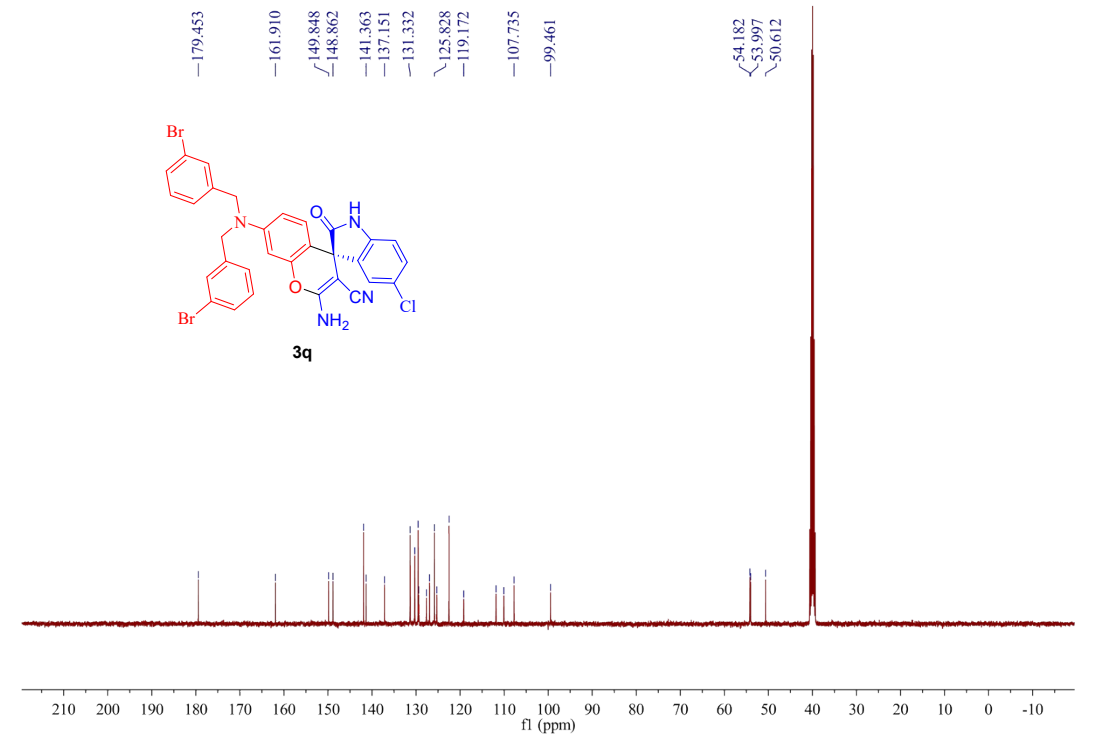
7.417
7.296
7.284
7.275
7.233
7.214
7.176
7.098
7.093
6.937
6.916
6.391
6.385
6.286
6.264
6.165
6.159
4.741
Br
N
O
H
N
O
CN
Cl
Br
NH2
3q
1.00
4.01
3.07
4.07
1.07
0.98
0.96
1.00
0.98
4.05
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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137.151
131.332
125.828
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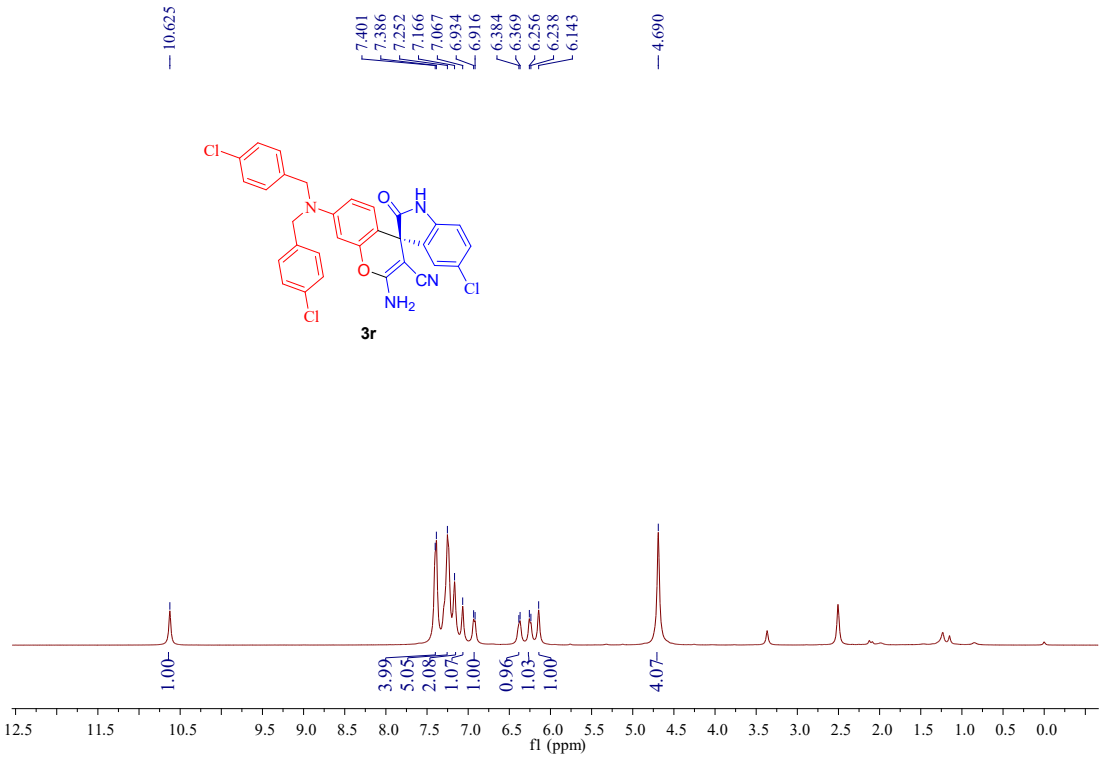
107.735
99.461
54.182
53.997
50.612
Br
N
O
H
N
O
CN
Cl
Br
NH2
3q
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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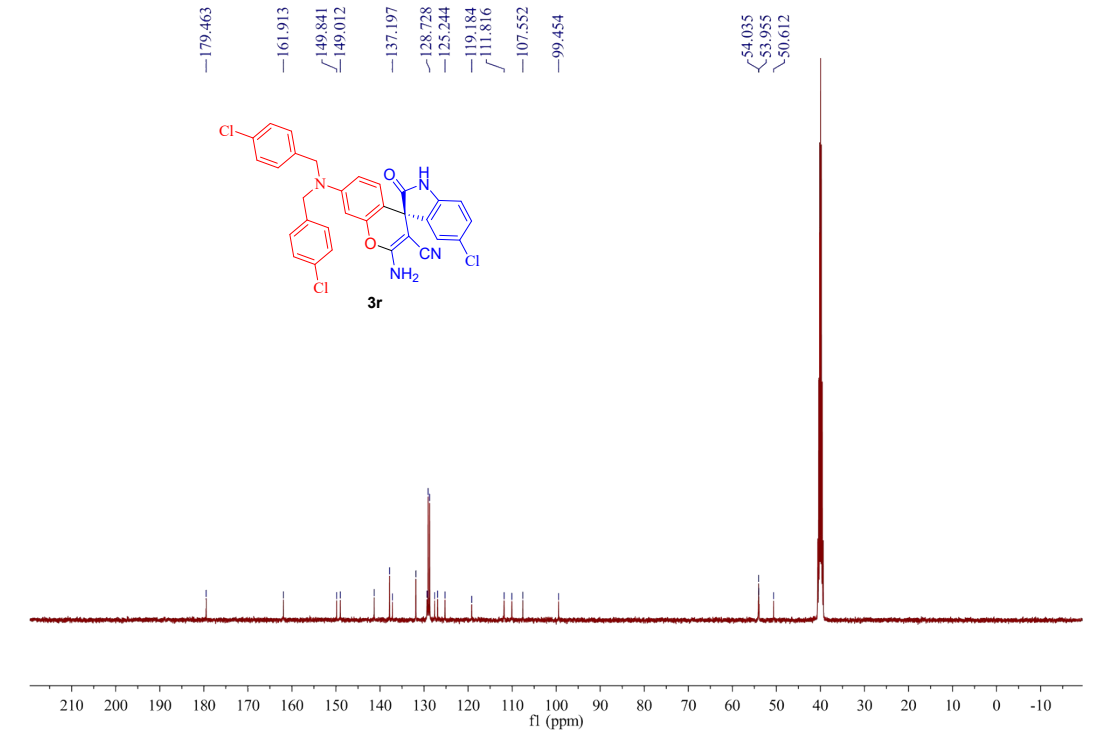
7.252
7.166
7.067
6.934
6.916
6.384
6.369
6.256
6.238
6.143
4.690
Cl
N
O
H
N
O
CN
Cl
NH2
Cl
3r
1.00
3.99
5.05
2.08
1.07
1.00
0.96
1.03
1.00
4.07
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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149.841
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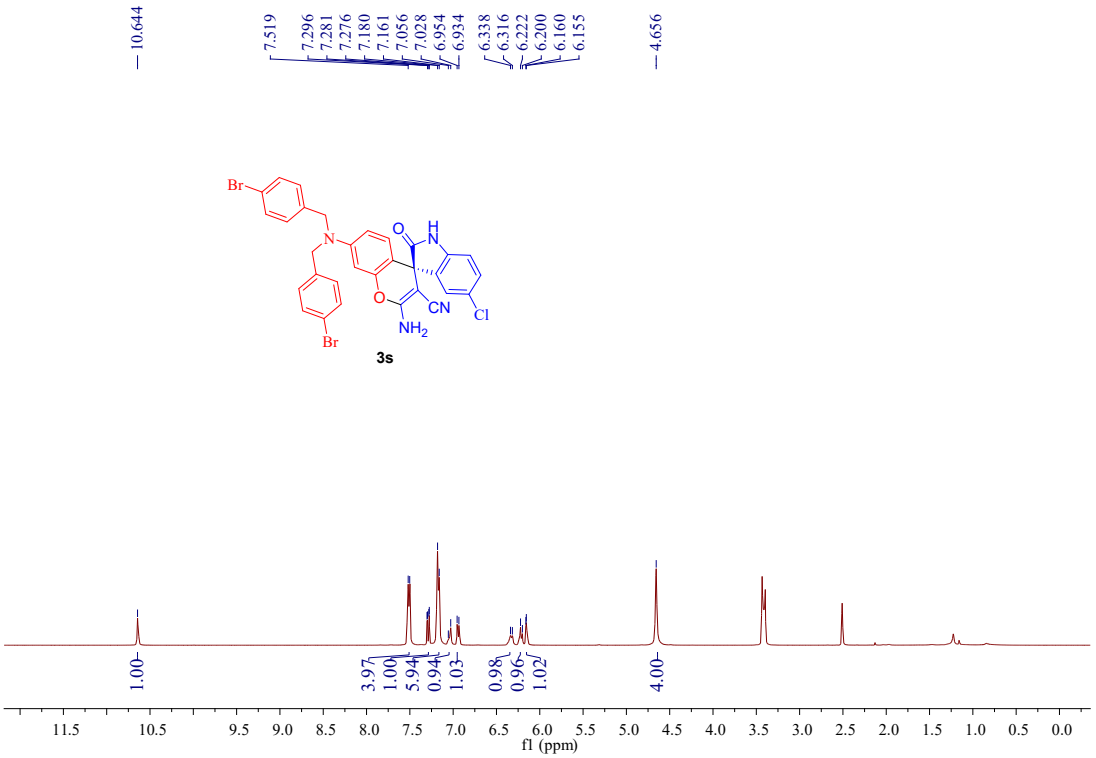
119.184
111.816
107.552
99.454
54.035
53.955
50.612
Cl
N
O
H
N
O
CN
Cl
NH2
Cl
3r
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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7.056
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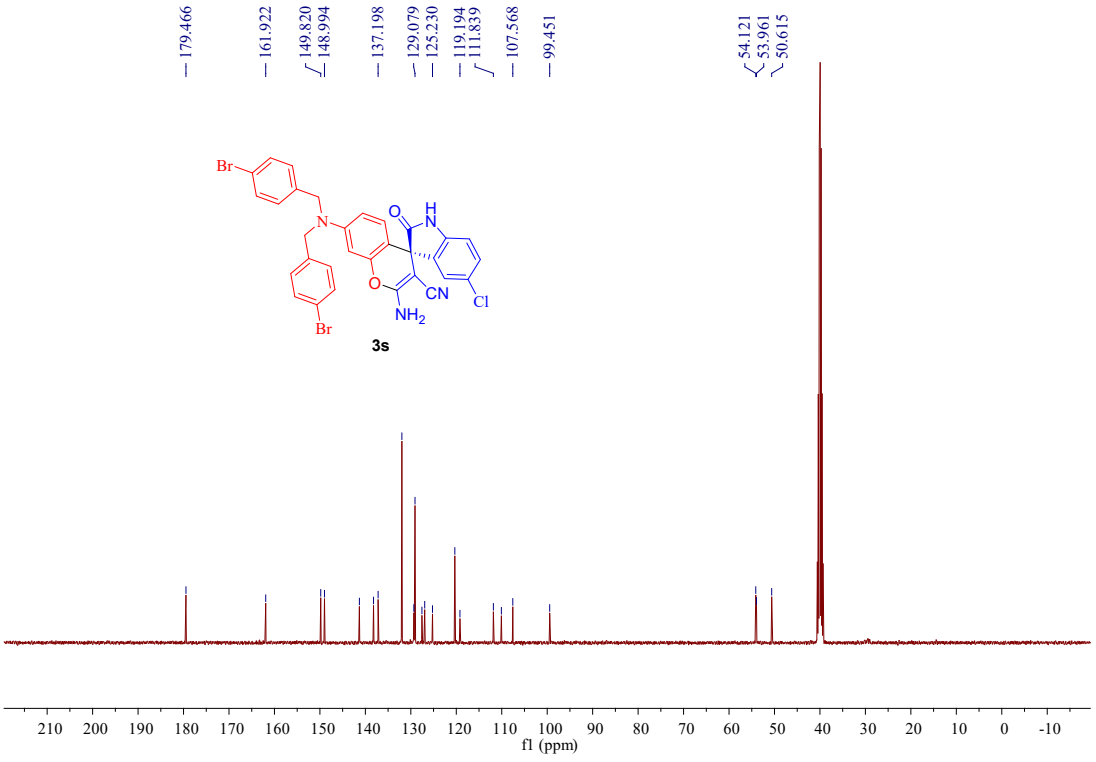
6.934
6.338
6.316
6.222
6.200
6.160
6.155
4.656
Br
N
O
H
N
CN
Cl
NH2
Br
3s
1.00
3.97
1.00
5.94
0.94
1.03
0.98
0.96
1.02
4.00
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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119.194
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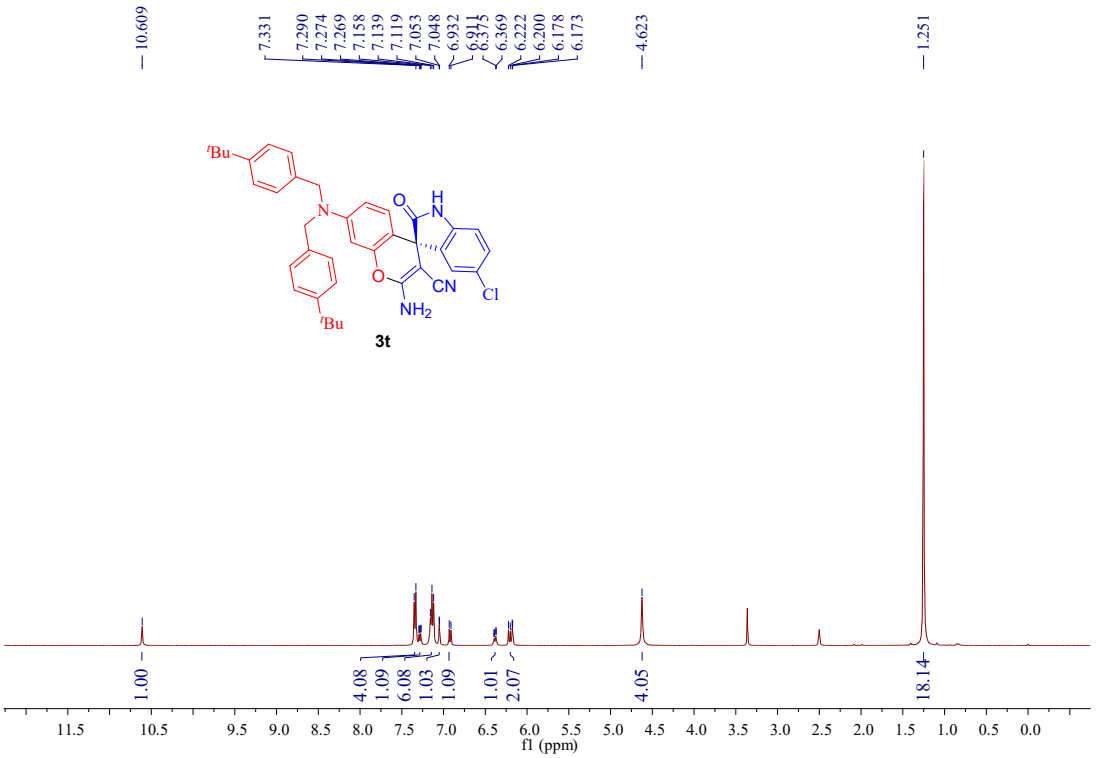
99.451
54.121
53.961
50.615
Br
N
O
H
N
CN
Cl
NH2
Br
3s
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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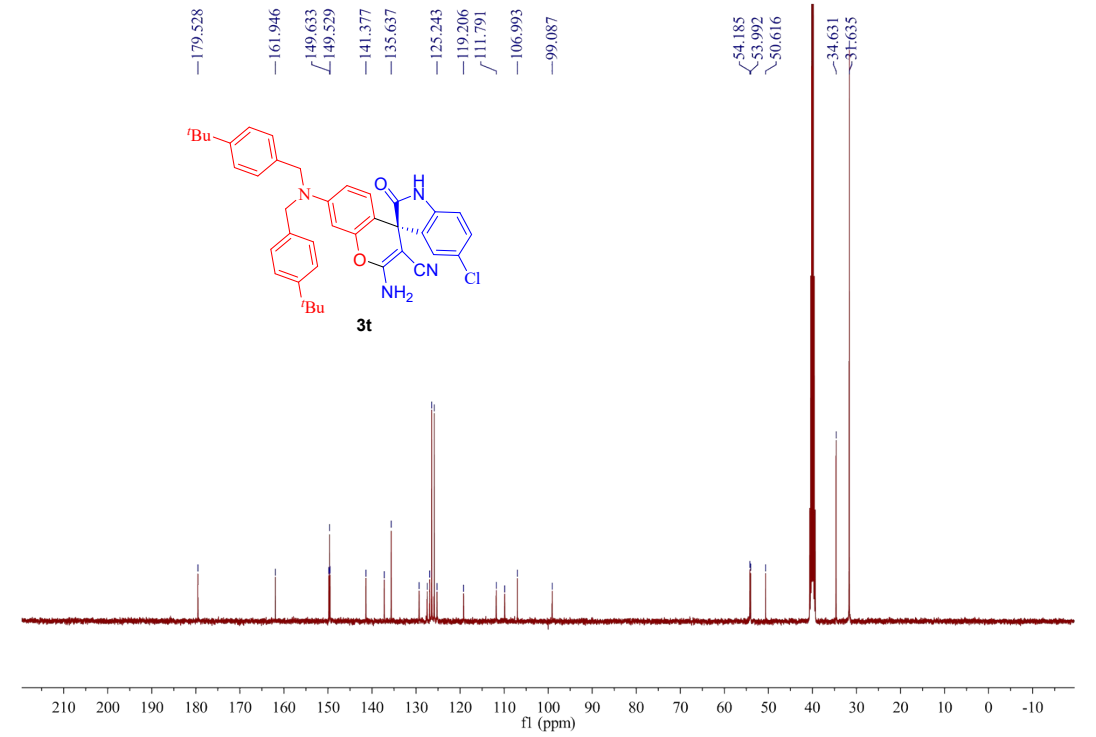
7.119
7.053
7.048
6.932
6.375
6.369
6.222
6.200
6.178
6.173
4.623
1.251
tBu
N
O
H
N
CN
Cl
NH2
O
tBu
3t
1.00
4.08
1.09
6.08
1.03
1.09
1.01
2.07
4.05
18.14
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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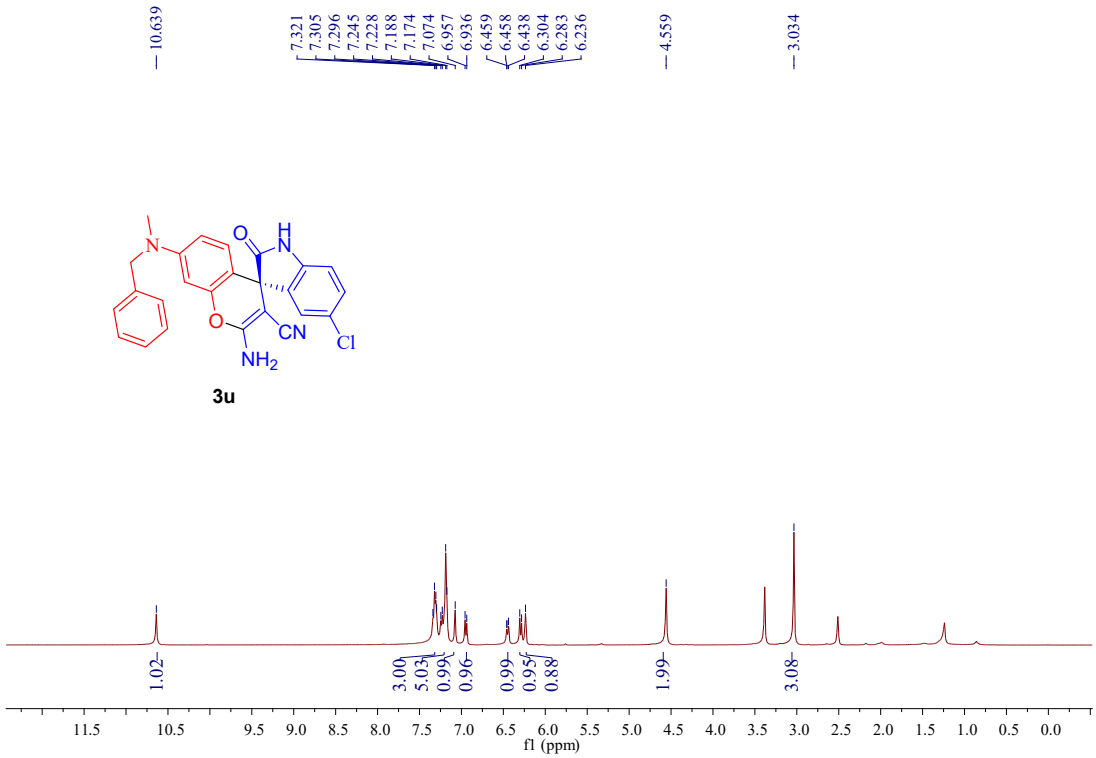
161.946
149.633
149.529
141.377
135.637
125.243
119.206
111.791
106.993
99.087
54.185
53.992
50.616
34.631
31.635
tBu
N
O
H
N
CN
Cl
NH2
O
tBu
3t
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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7.174
7.074
6.957
6.936
6.459
6.458
6.438
6.304
6.283
6.236
4.559
3.034
O
H
N
N
O
CN
Cl
NH2
1.02
3.00
5.03
0.99
0.96
0.99
0.95
0.88
1.99
3.08
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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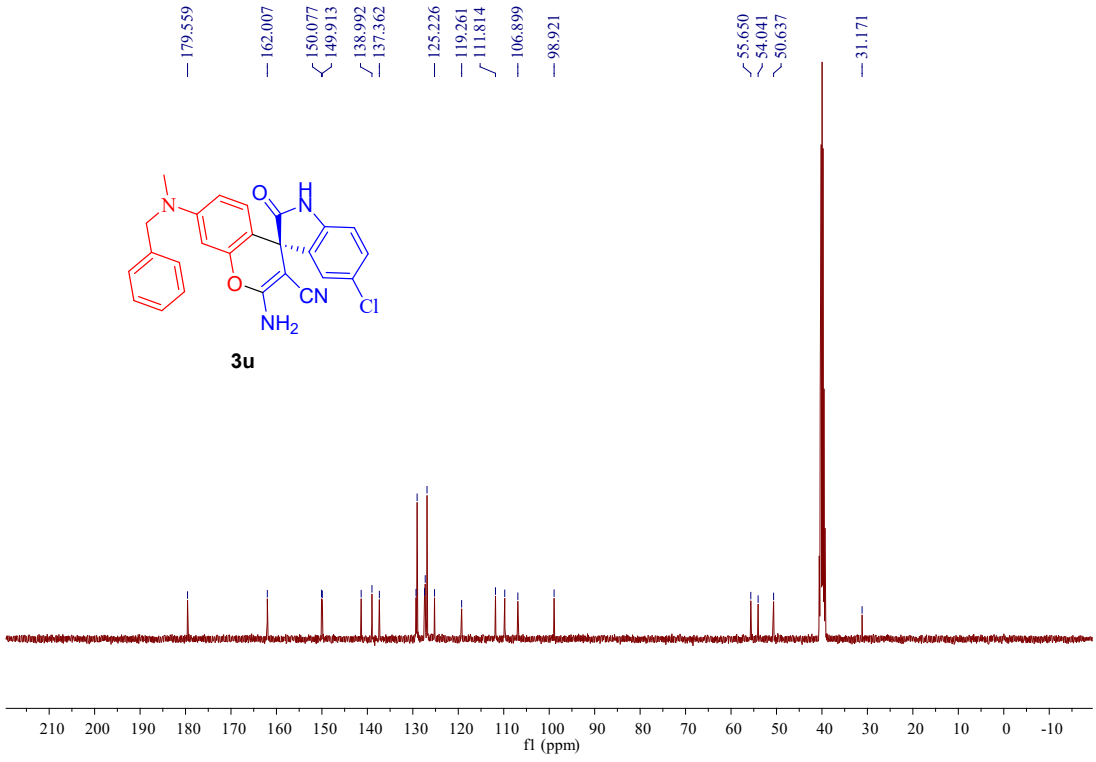
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3u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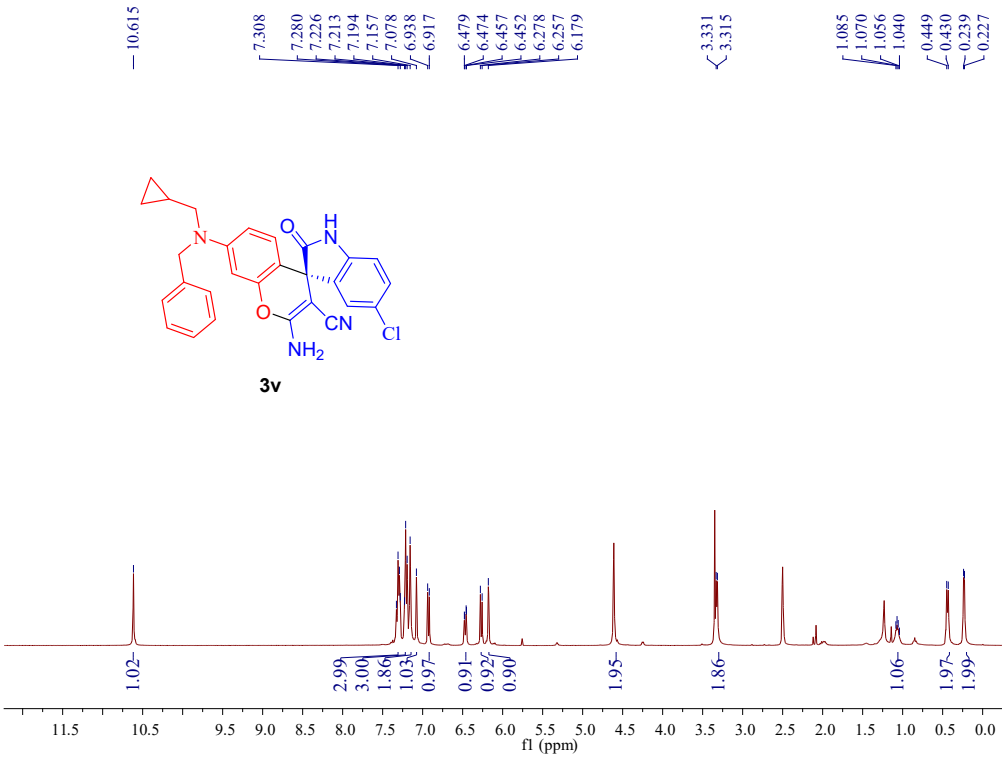
55.650
54.041
50.637
31.171
O
H
N
N
O
CN
Cl
NH2
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3u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7.280
7.226
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7.194
7.157
7.078
6.938
6.917
6.479
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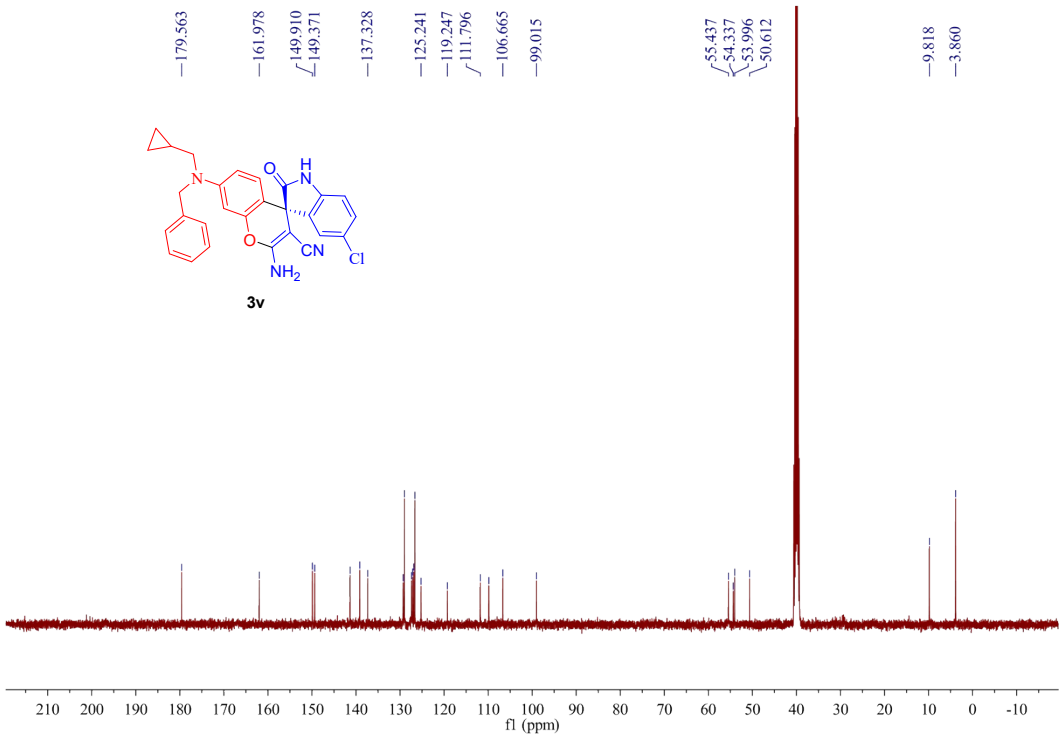
6.452
6.278
6.257
6.179
3.331
3.315
1.085
1.070
1.056
1.040
0.449
0.430
0.239
0.227
O
H
N
N
O
CN
Cl
NH2
3v
1.02
2.99
3.00
1.86
1.03
0.97
0.91
0.92
0.90
1.95
1.86
1.06
1.97
1.99
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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161.978
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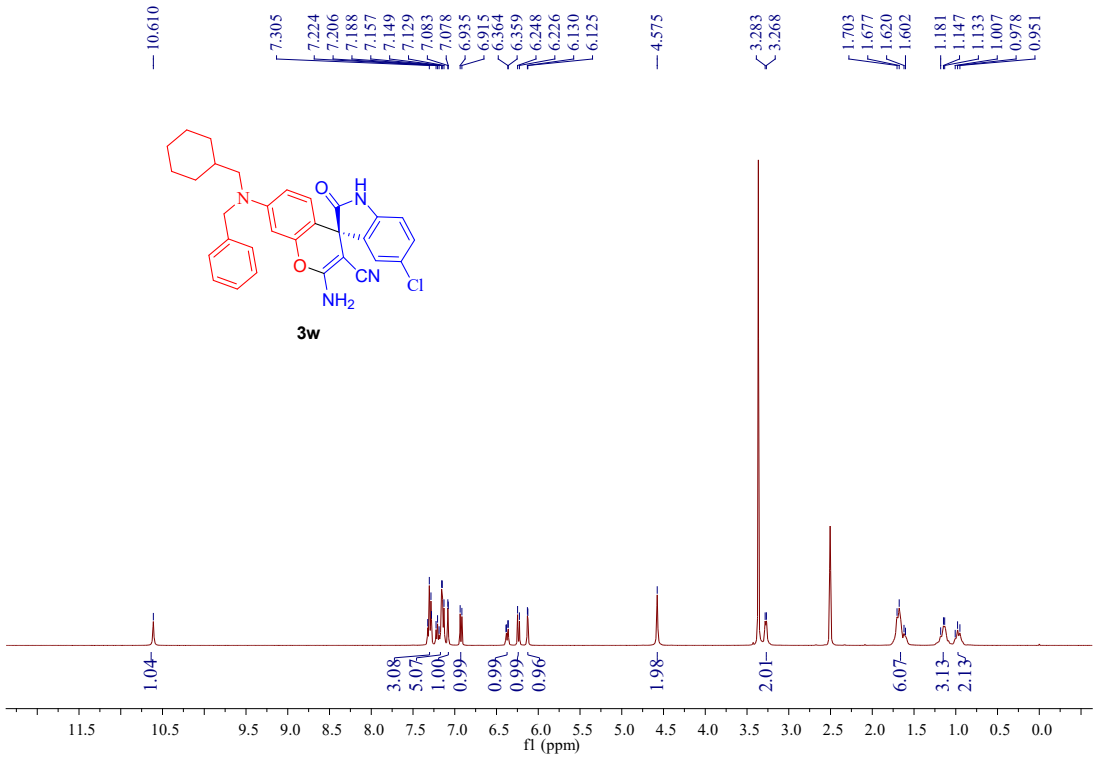
125.241
119.247
111.796
106.665
99.015
55.437
54.337
53.996
50.612
9.818
3.860
O
H
N
N
O
CN
Cl
NH2
3v
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


10.610
7.305
7.224
7.206
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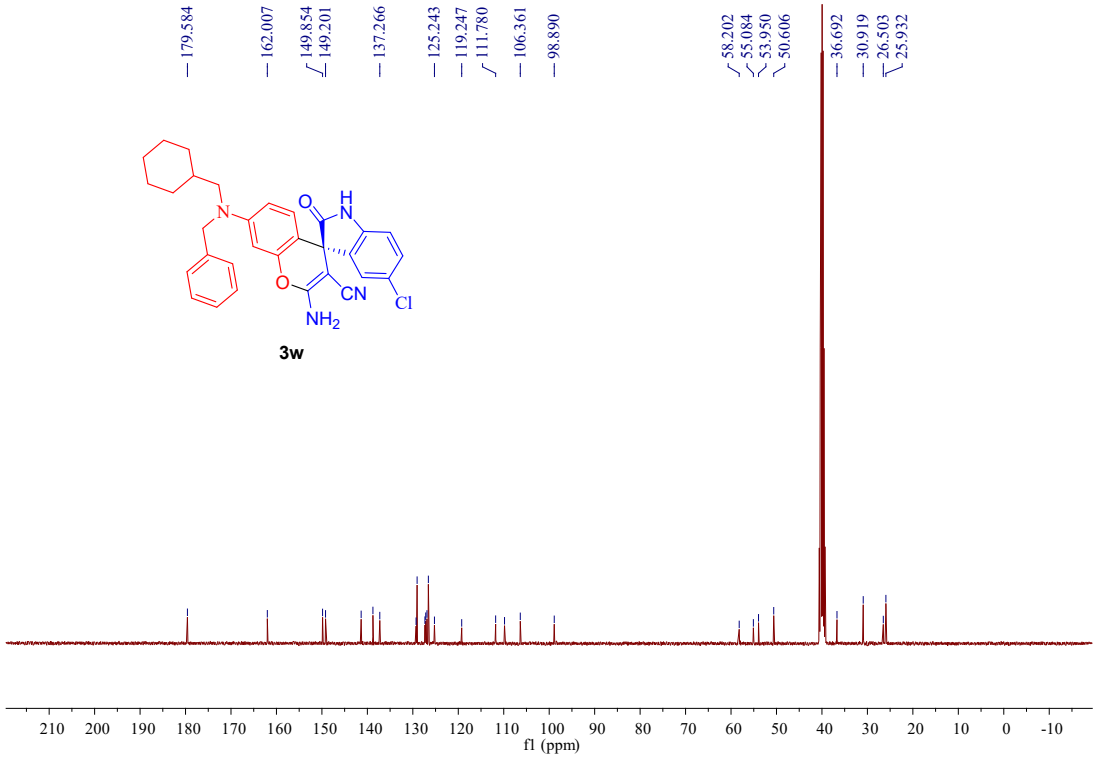
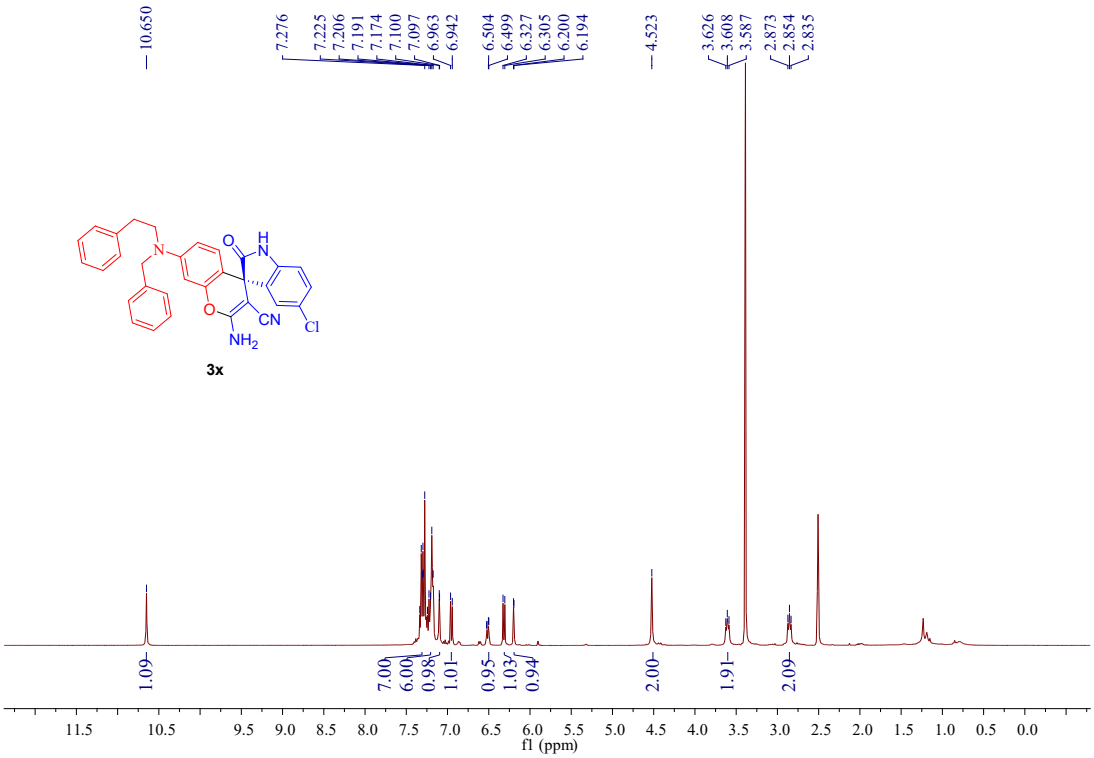
7.157
7.149
7.129
7.083
7.078
6.935
6.915
6.364
6.359
6.248
6.226
6.130
6.125
4.575
3.283
3.268
1.703
1.677
1.620
1.602
1.181
1.147
1.133
1.007
0.978
0.951
O
H
N
N
O
CN
Cl
NH2
3w
1.04
3.08
5.07
1.00
0.99
0.99
0.99
0.96
1.98
2.01
6.07
3.13
2.13
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


179.584
162.007
149.854
149.201
137.266
125.243
119.247
111.780
106.361
98.890
58.202
55.084
53.950
50.606
36.692
30.919
26.503
25.932
O
H
N
N
O
CN
Cl
NH2
3w
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


10.650
7.276
7.225
7.206
7.191
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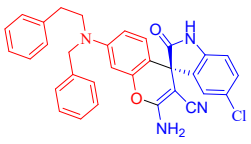
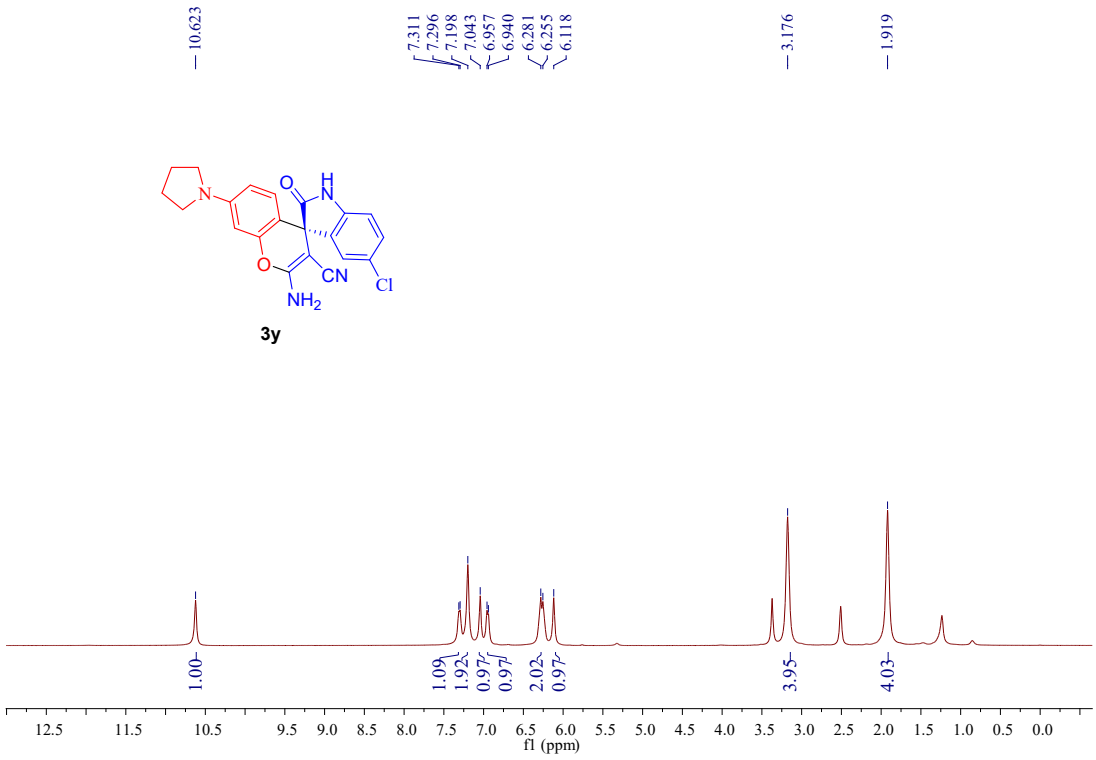
7.100
7.097
6.963
6.942
6.504
6.499
6.327
6.305
6.200
6.194
4.523
3.626
3.608
3.587
2.873
2.854
2.835
1.09
7.00
6.00
0.98
1.01
0.95
1.03
0.94
2.00
1.91
2.09
f1 (ppm)



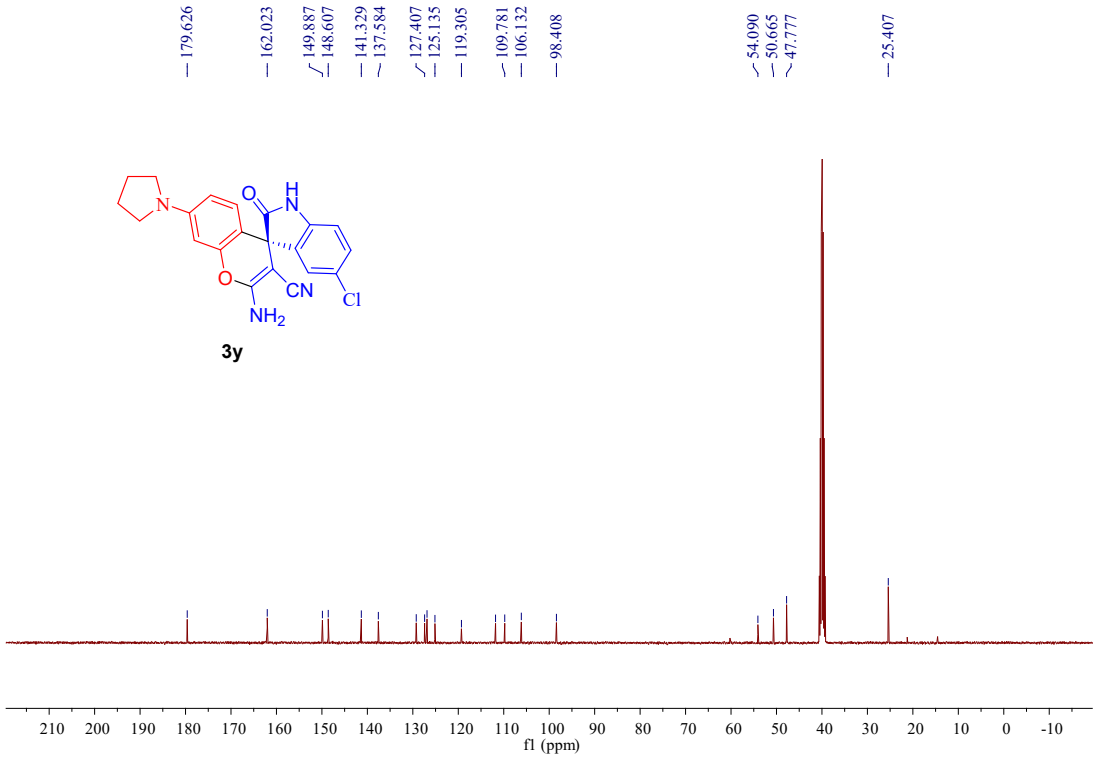
3x

179.573
162.017
149.985
148.876
137.301
125.261
119.254
111.816
106.859
98.948
54.018
53.974
53.337
50.640
33.233
f1 (ppm)

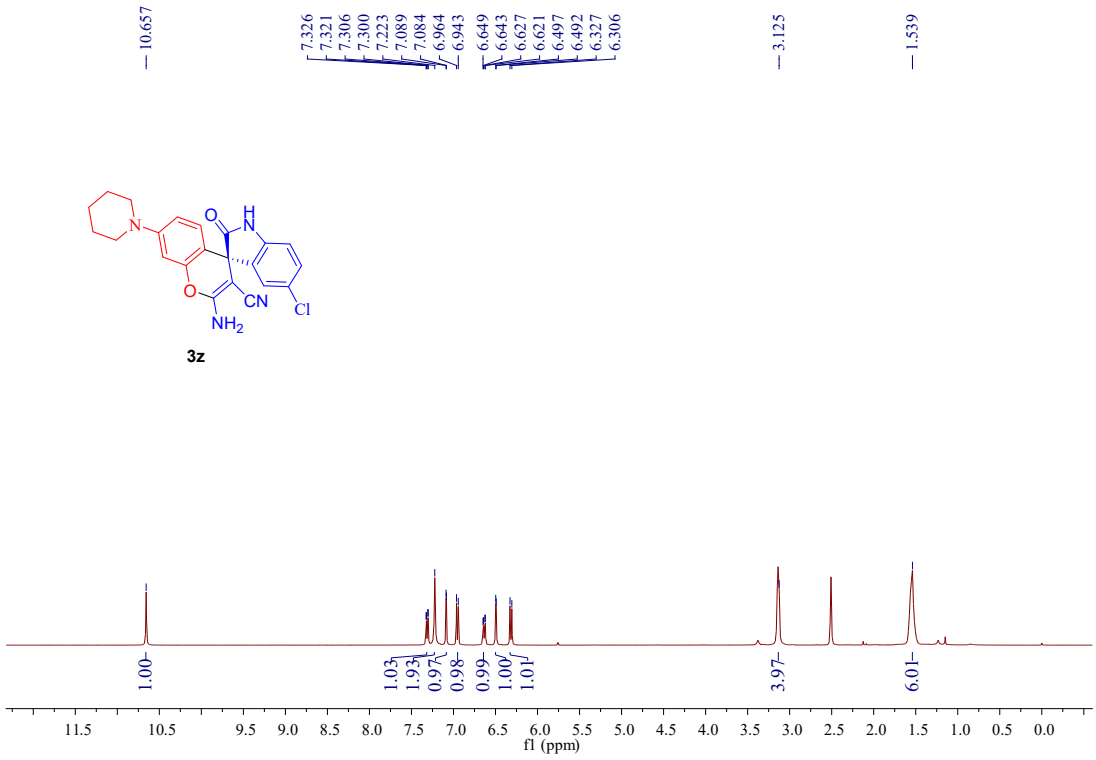
3x

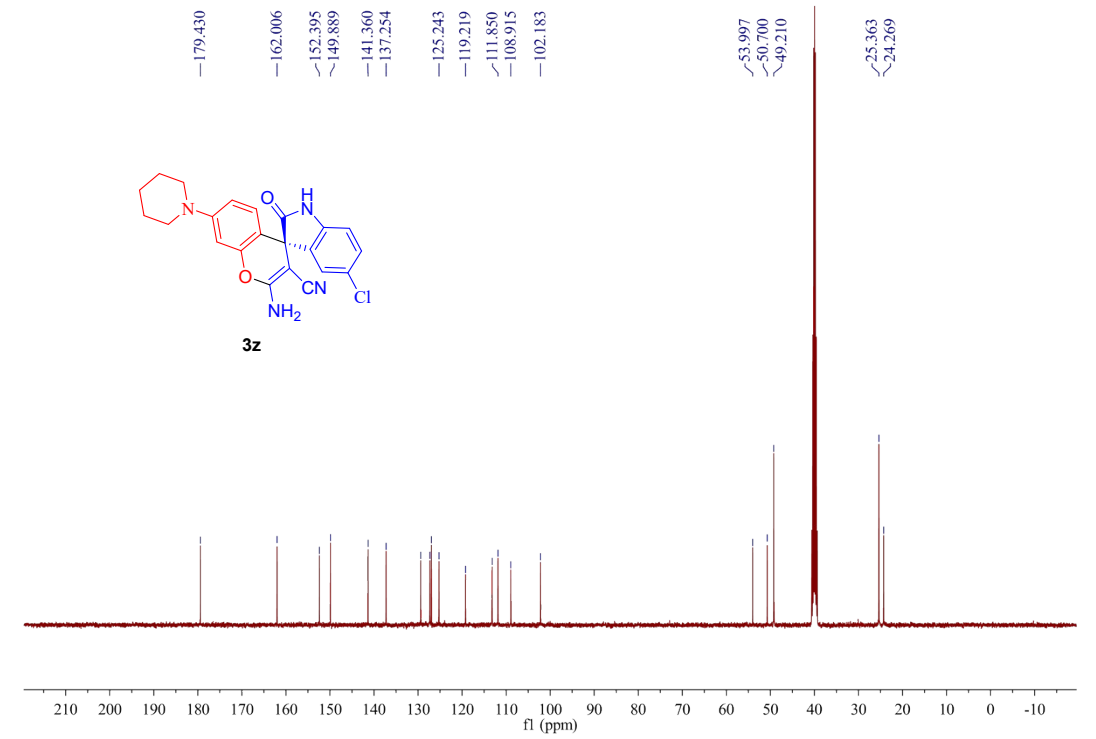

10.623
7.311
7.296
7.198
7.043
6.957
6.940
6.281
6.255
6.118
3.176
1.919
O
H
N
N
O
CN
Cl
NH2
1.00
1.09
1.92
0.97
0.97
2.02
0.97
3.95
4.03
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3y


179.626
162.023
149.887
148.607
141.329
137.584
127.407
125.135
119.305
109.781
106.132
98.408
54.090
50.665
47.777
25.407
O
H
N
N
O
CN
Cl
NH2
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

3y


10.657
7.326
7.321
7.306
7.300
7.223
7.089
7.084
6.964
6.943
6.649
6.643
6.627
6.621
6.497
6.492
6.327
6.306
3.125
1.539
O
H
N
N
O
CN
Cl
NH2
3z
1.00
1.03
1.93
0.97
0.98
0.99
1.00
1.01
3.97
6.01
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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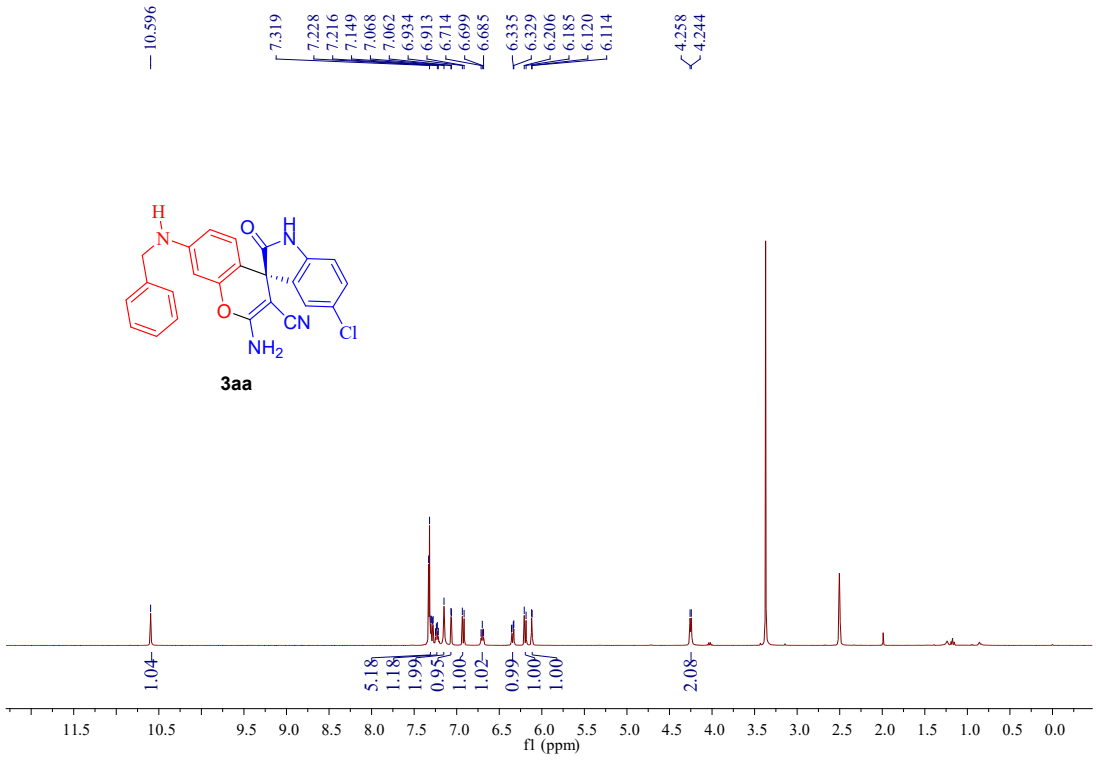
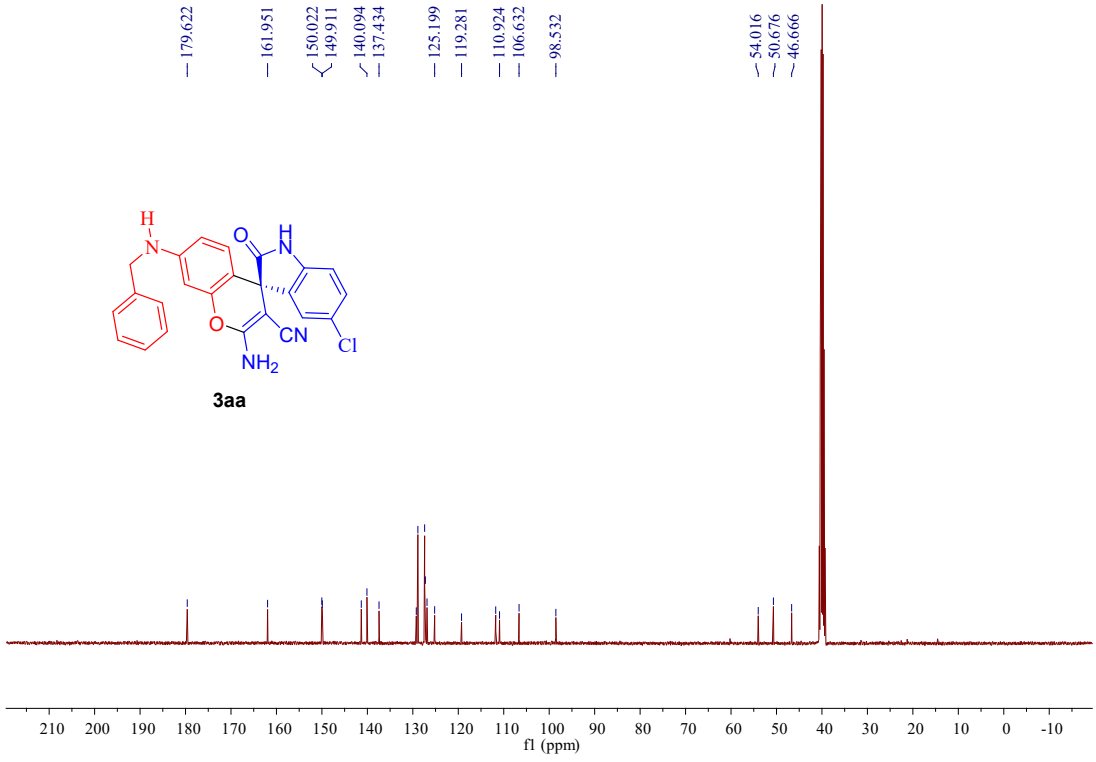
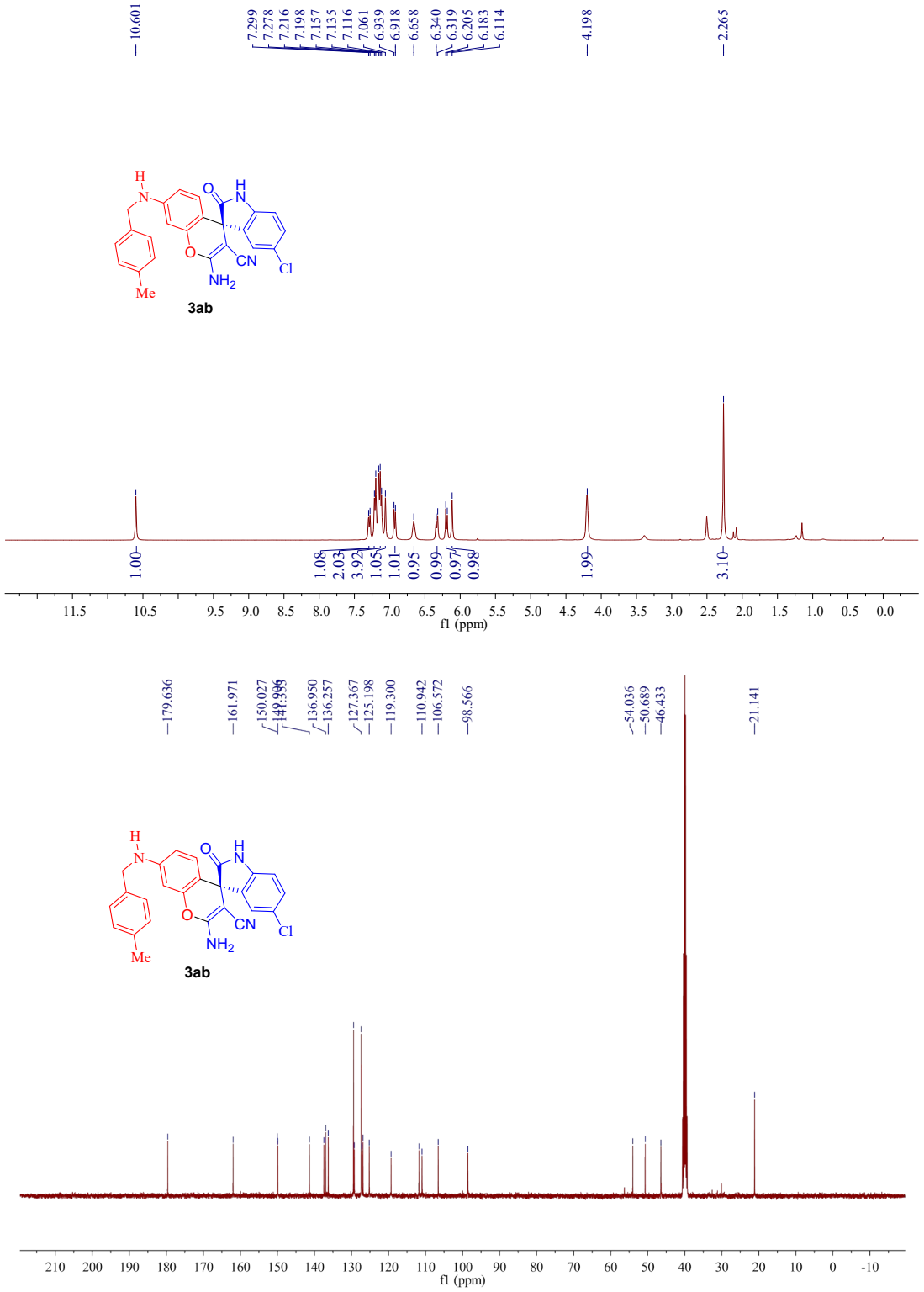
162.006
152.395
149.889
141.360
137.254
125.243
119.219
111.850
108.915
102.183
53.997
50.700
49.210
25.363
24.269
O
H
N
N
O
CN
Cl
NH2
3z
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

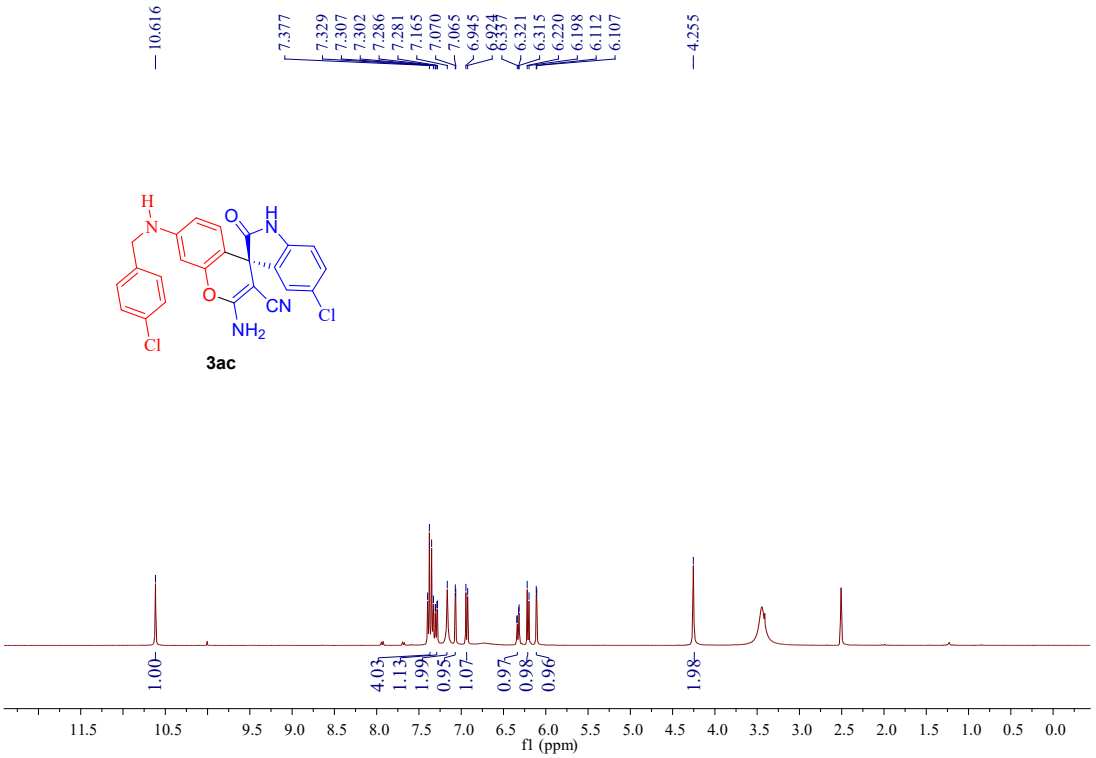

10.596
7.319
7.228
7.216
7.149
7.068
7.062
6.934
6.913
6.714
6.699
6.685
6.335
6.329
6.206
6.185
6.120
6.114
4.258
4.244
1.04
5.18
1.18
1.99
0.95
1.00
1.02
0.99
1.00
1.00
2.08
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

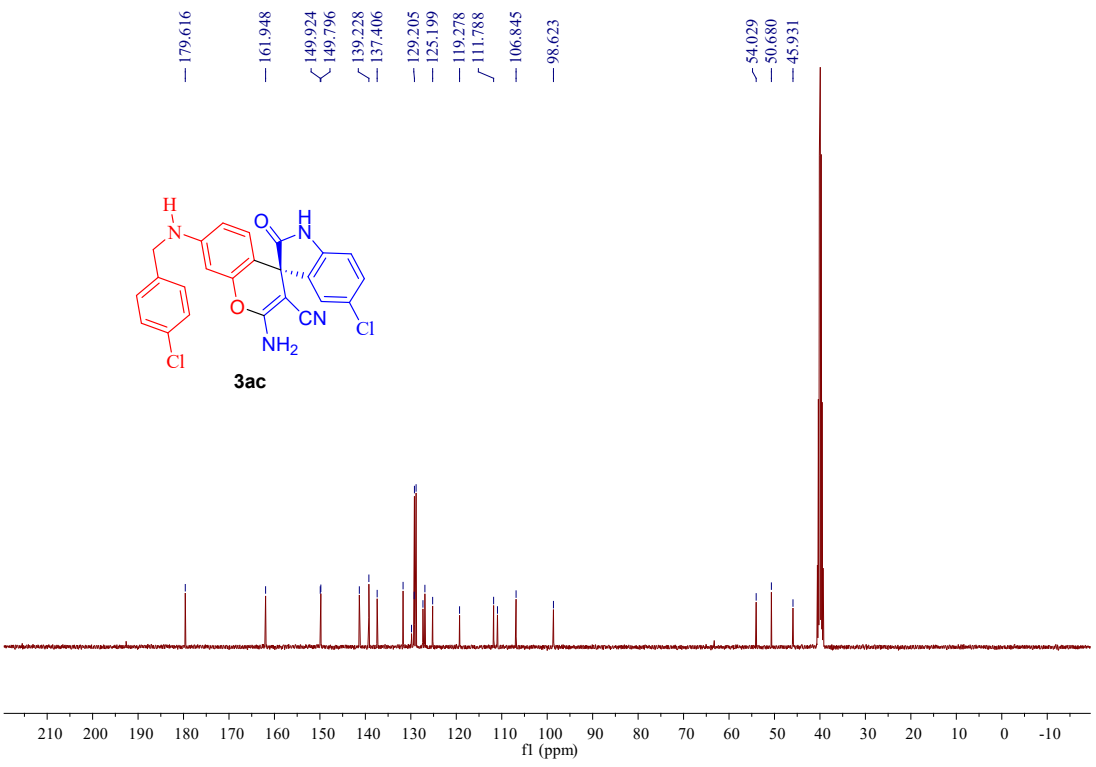
3aa

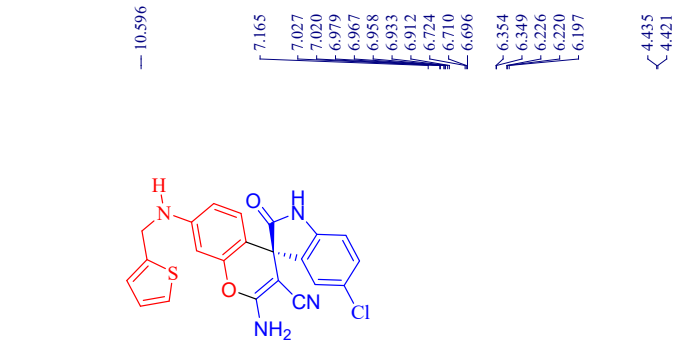

179.622
161.951
150.022
149.911
140.094
137.434
125.199
119.281
110.924
106.632
98.532
54.016
50.676
46.666
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3aa

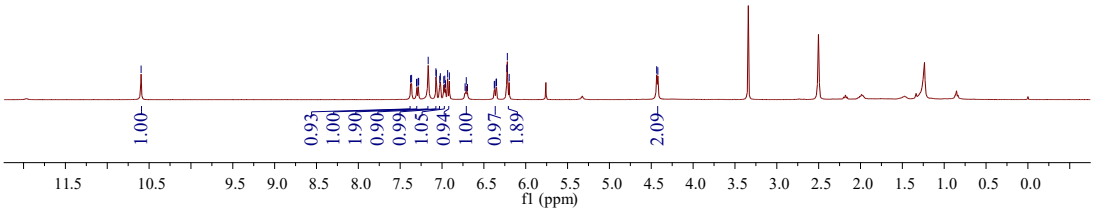

10.601
7.299
7.278
7.216
7.198
7.157
7.135
7.116
7.061
6.939
6.918
6.658
6.340
6.319
6.205
6.183
6.114
4.198
2.265
3ab
1.00
1.08
2.03
3.92
1.05
1.01
0.95
0.99
0.97
0.98
1.99
3.10
f1 (ppm)
179.636
161.971
150.027
136.950
136.257
127.367
125.198
119.300
110.942
106.572
98.566
54.036
50.689
46.433
21.141
3ab
f1 (ppm)

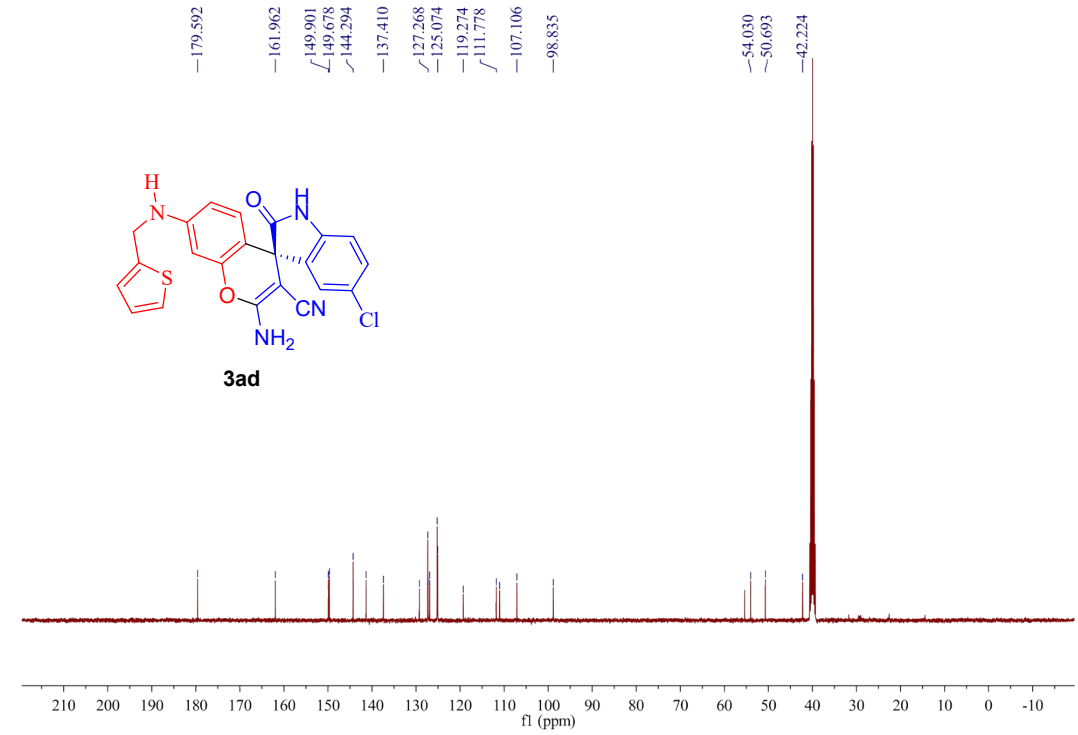

10.616
7.377
7.329
7.307
7.302
7.286
7.281
7.165
7.070
7.065
6.945
6.924
6.337
6.321
6.315
6.220
6.198
6.112
6.107
4.255
3ac
1.00
4.03
1.13
1.99
0.95
1.07
0.97
0.98
0.96
1.98
f1 (ppm)


179.616
161.948
149.924
149.796
139.228
137.406
129.205
125.199
119.278
111.788
106.845
98.623
54.029
50.680
45.931
3ac
f1 (ppm)

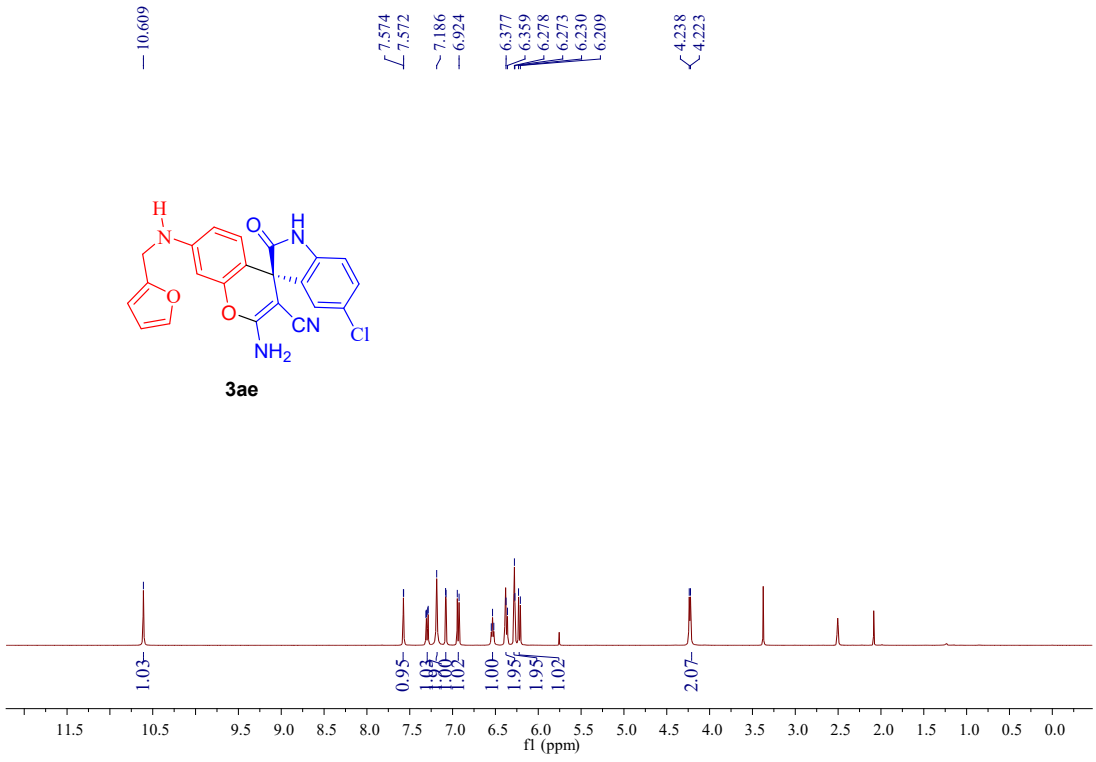

10.596
7.165
7.027
7.020
6.979
6.967
6.958
6.933
6.912
6.724
6.710
6.696
6.354
6.349
6.226
6.220
6.197
4.435
4.421
H
N
O
H
N
S
O
CN
Cl
NH2

3ad


1.00
0.93
1.00
1.90
0.90
0.99
1.05
0.94
1.00
0.97
1.89
2.09
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


179.592
161.962
149.901
149.678
144.294
137.410
127.268
125.074
119.274
111.778
107.106
98.835
54.030
50.693
42.224
H
N
O
H
N
S
O
CN
Cl
NH2
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

3ad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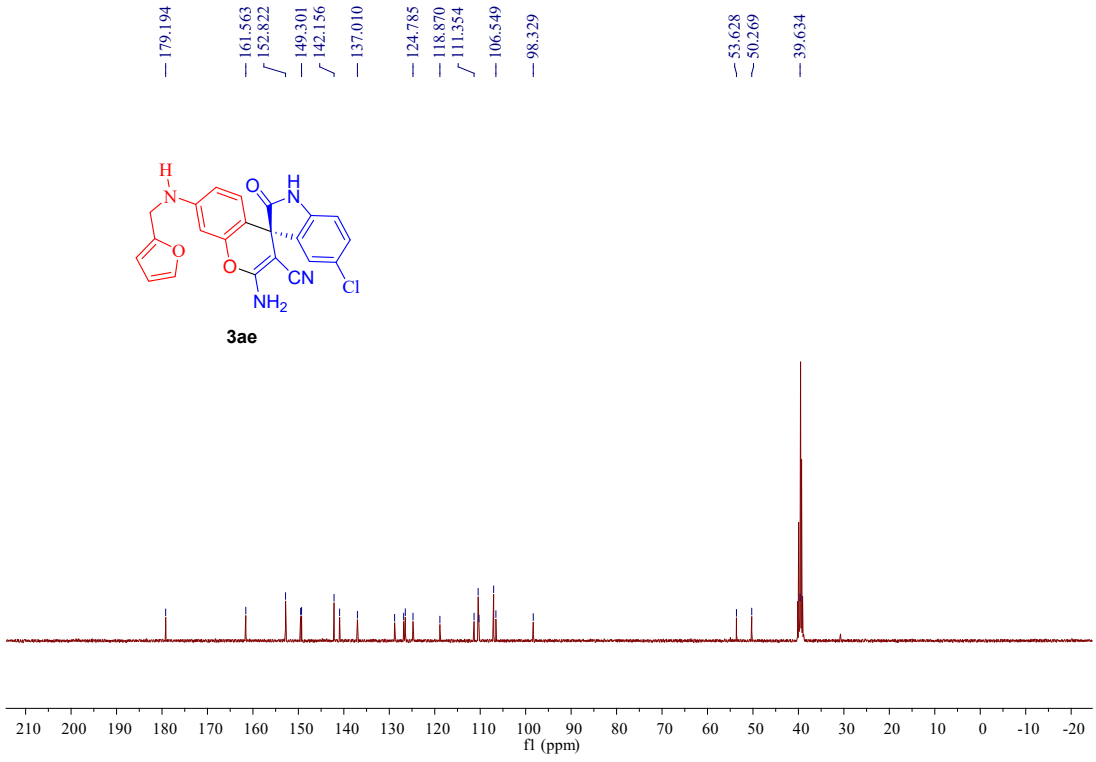
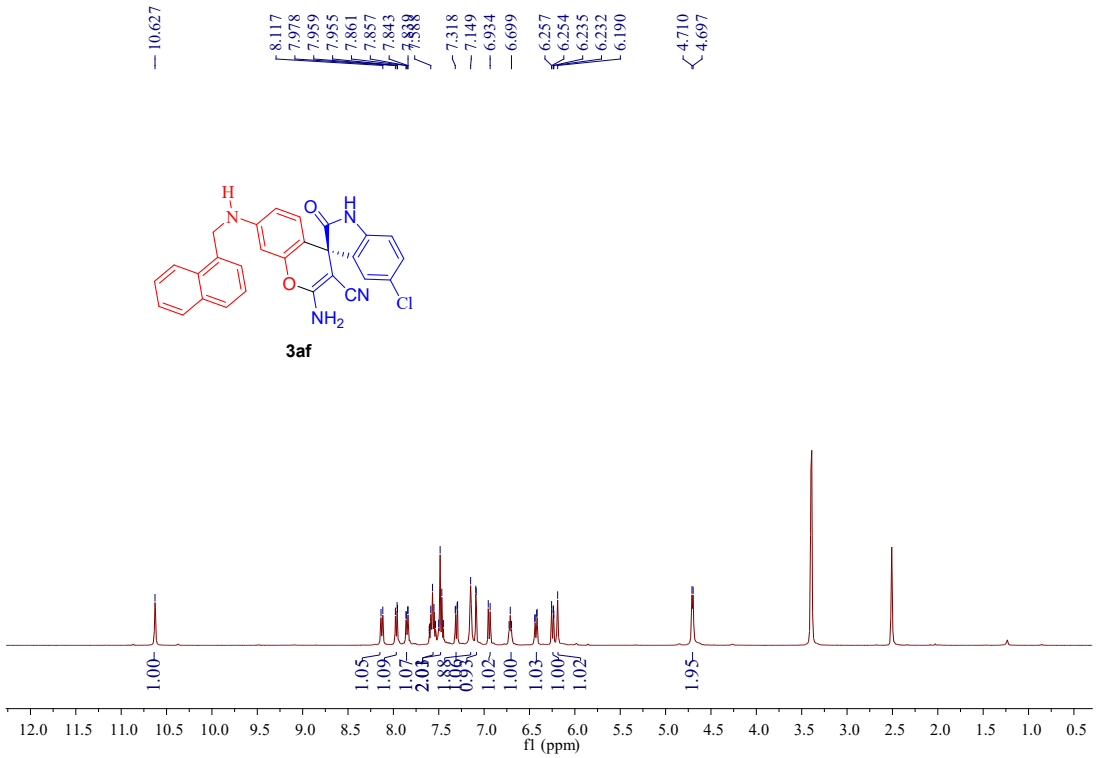
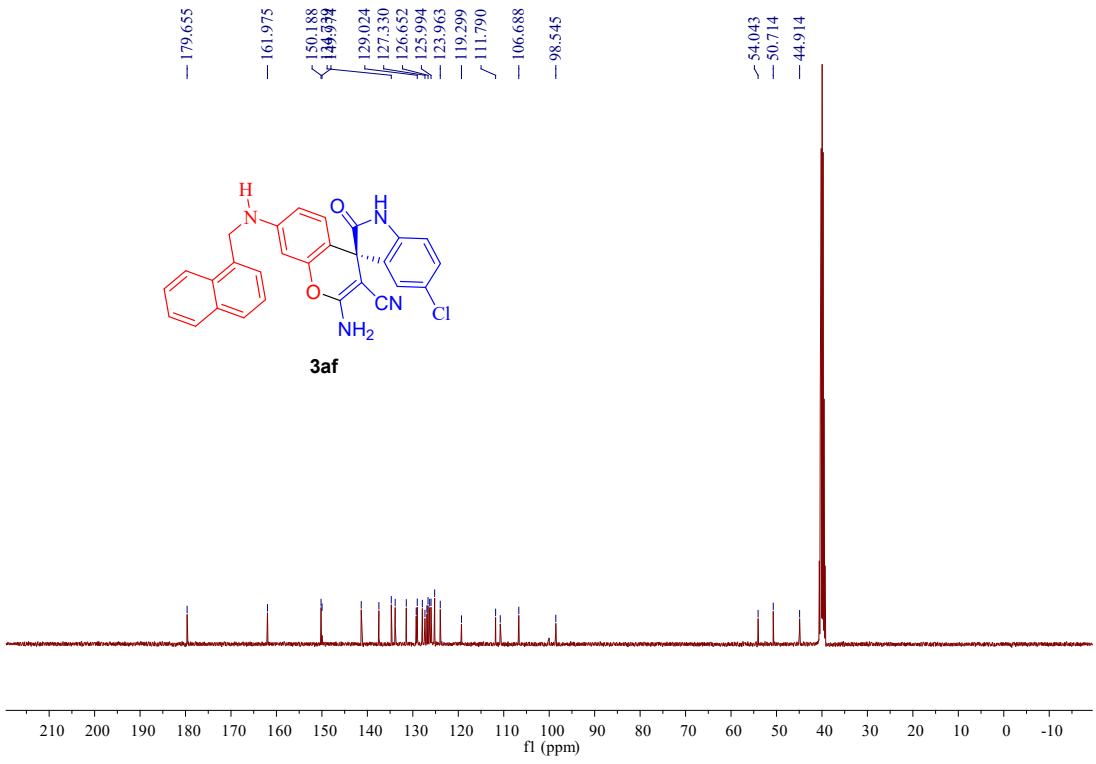
7.574
7.572
7.186
6.924
6.377
6.359
6.278
6.273
6.230
6.209
4.238
4.223
1.03
0.95
1.03
1.00
1.02
1.00
1.95
1.95
1.02
2.07
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3ae


179.194
161.563
152.822
149.301
142.156
137.010
124.785
118.870
111.354
106.549
98.329
53.628
50.269
39.634
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

3ae


10.627
8.117
7.978
7.959
7.955
7.861
7.857
7.843
7.318
7.149
6.934
6.699
6.257
6.254
6.235
6.232
6.190
4.710
4.697
3af
1.00
1.05
1.09
1.07
2.01
1.88
0.95
1.02
1.00
1.03
1.00
1.02
1.95
f1 (ppm)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150.188
129.024
127.330
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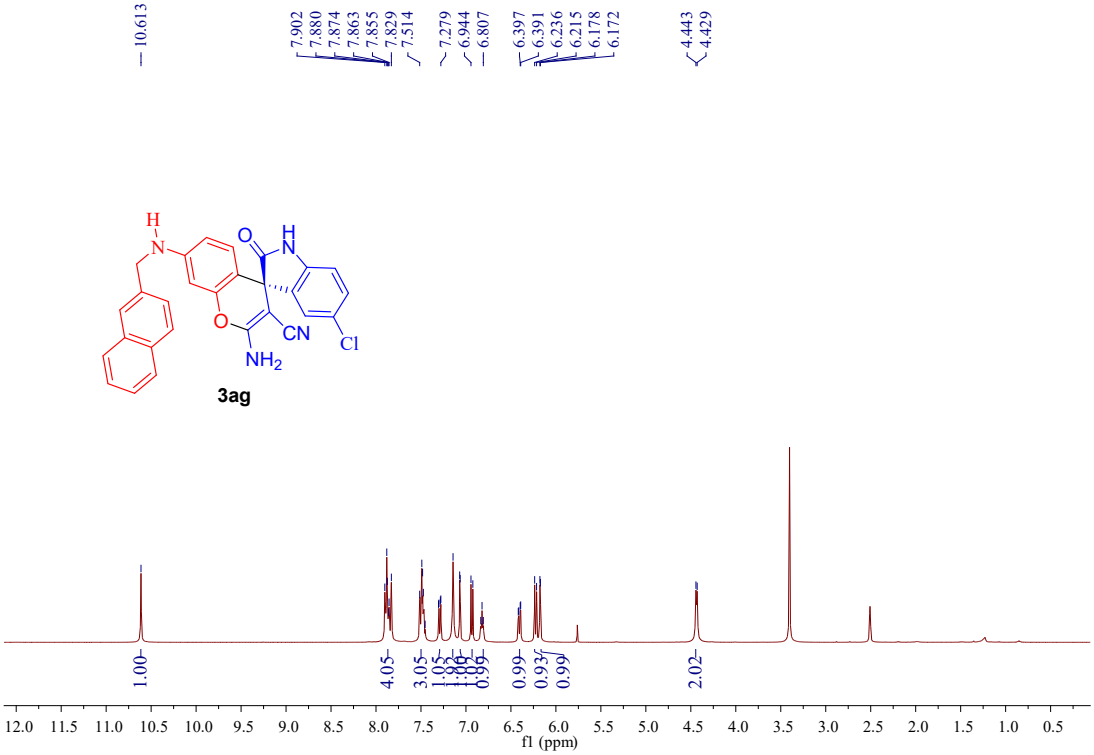
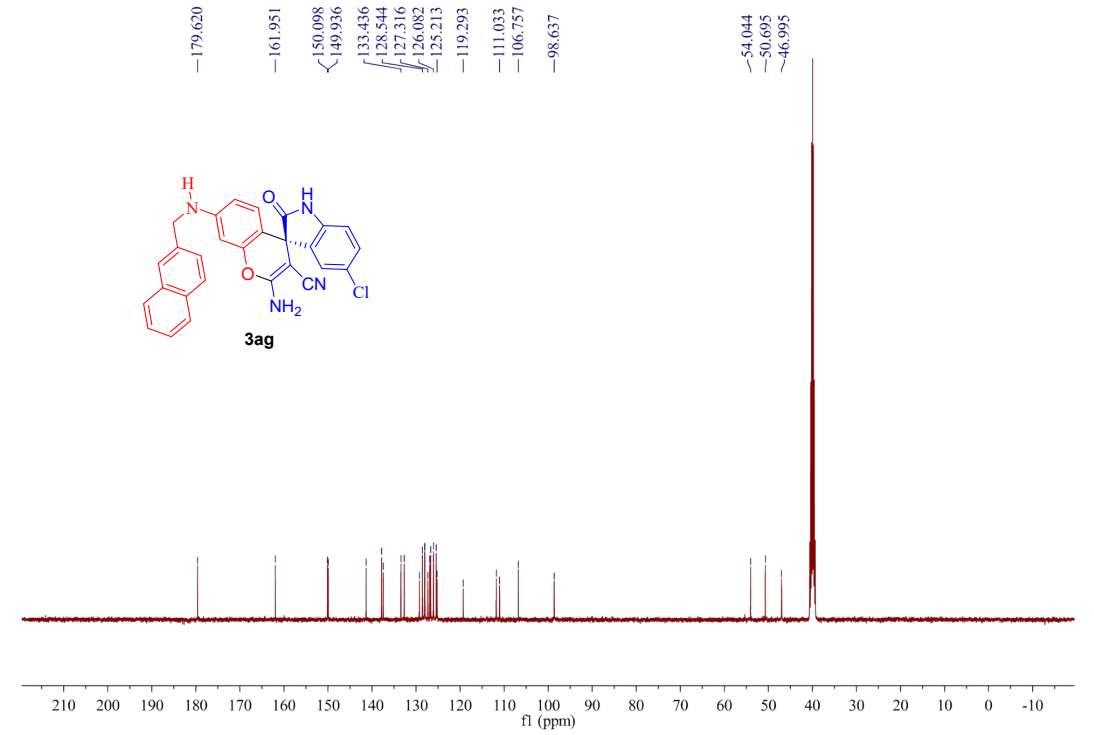
119.299
111.790
106.688
98.545
54.043
50.714
44.914
3af
f1 (ppm)


10.613
7.902
7.880
7.874
7.863
7.855
7.829
7.514
7.279
6.944
6.807
6.397
6.391
6.236
6.215
6.178
6.172
4.443
4.429
3ag
1.00
4.05
3.05
2.02
fl (ppm)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150.098
149.936
133.436
128.544
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126.082
125.213
119.293
111.033
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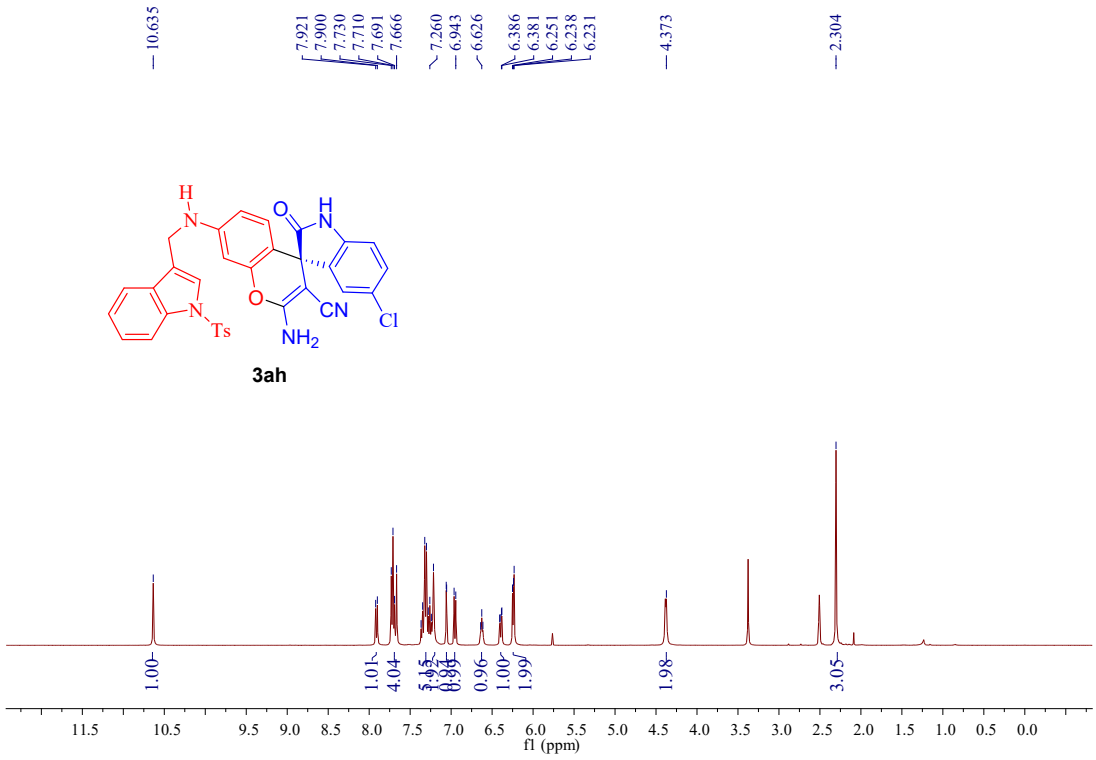
98.637
54.044
50.695
46.995
3ag
fl (ppm)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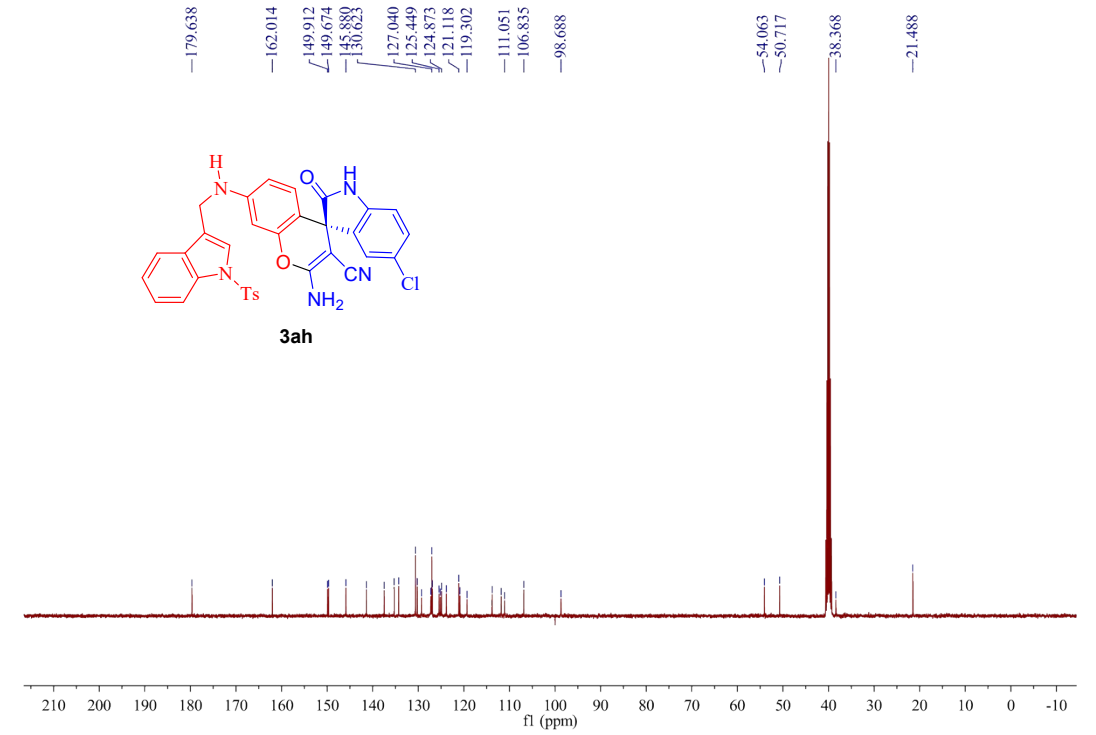
7.900
7.730
7.710
7.691
7.666
7.260
6.943
6.626
6.386
6.381
6.251
6.238
6.231
4.373
2.304
H
N
O
H
N
CN
Cl
O
N
Ts
NH2
3ah
1.00
1.01
4.04
0.96
1.00
1.99
1.98
3.05
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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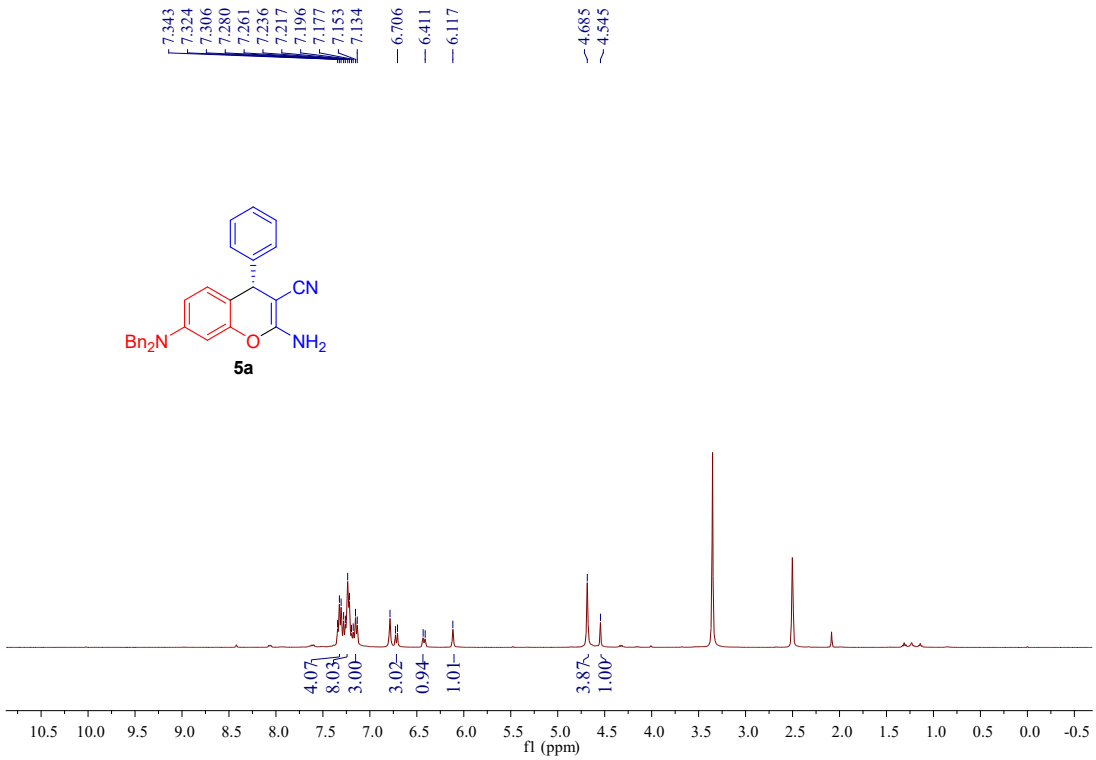
145.880
130.623
127.040
125.449
124.873
121.118
119.302
111.051
106.835
98.688
54.063
50.717
38.368
21.488
H
N
O
H
N
CN
Cl
O
N
Ts
NH2
3ah
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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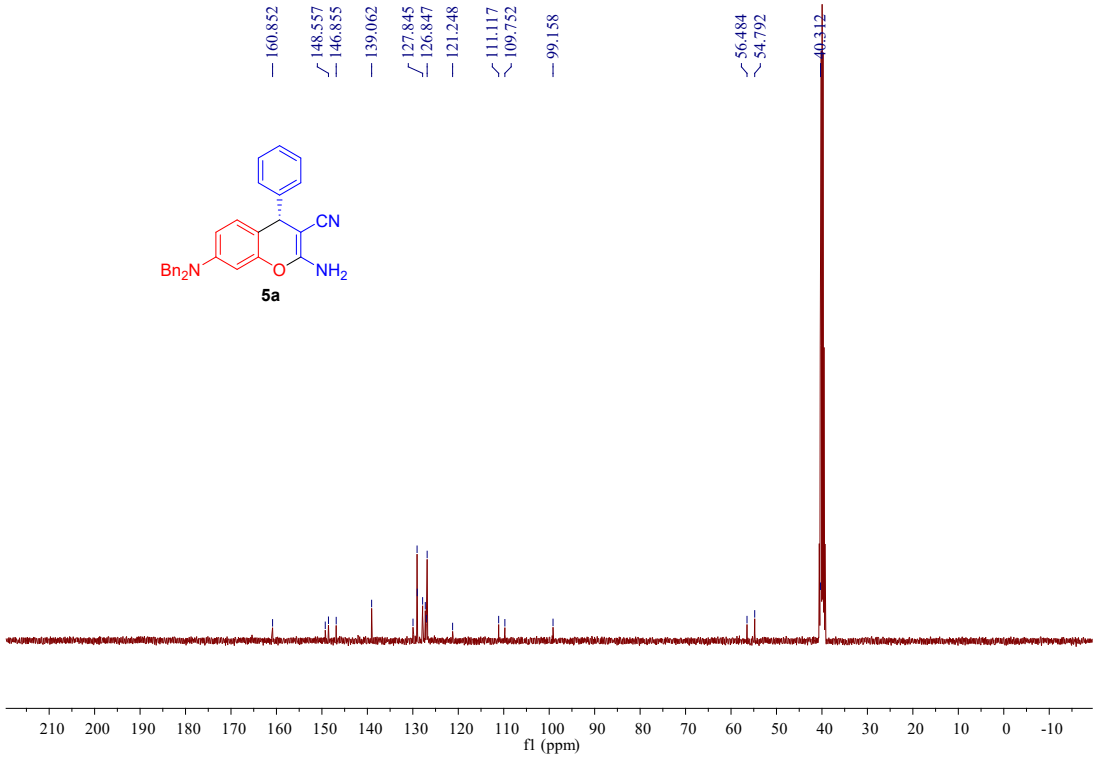
7.261
7.236
7.217
7.196
7.177
7.153
7.134
6.706
6.411
6.117
4.685
4.545
CN
Bn2N
O
NH2
5a
4.07
8.03
3.00
3.02
0.94
1.01
3.87
1.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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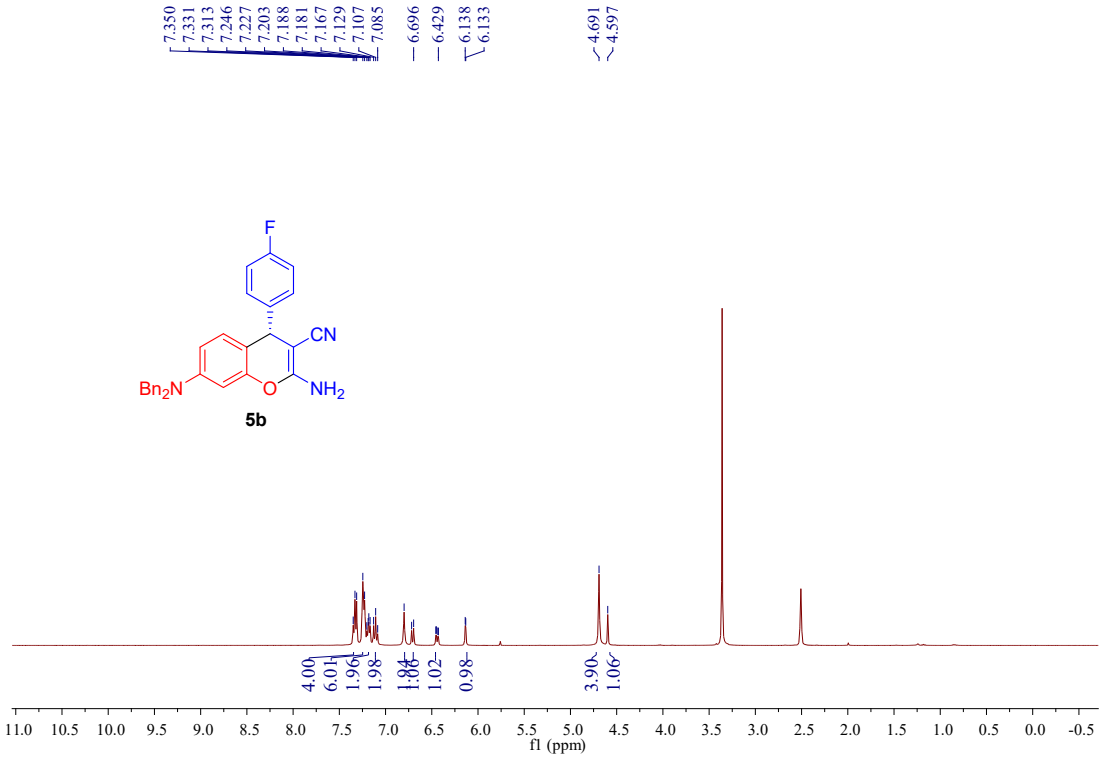
148.557
146.855
139.062
127.845
126.847
121.248
111.117
109.752
99.158
56.484
54.792
40.312
CN
Bn2N
O
NH2
5a
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.331
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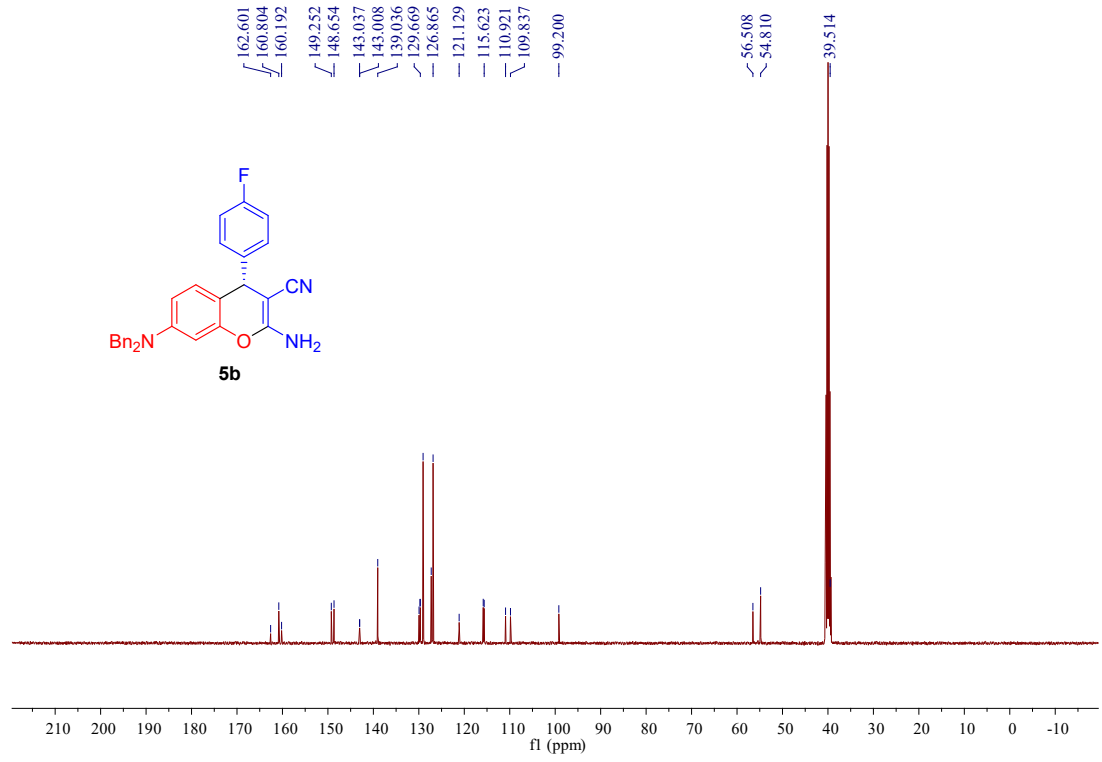
7.246
7.227
7.203
7.188
7.181
7.167
7.129
7.107
7.085
6.696
6.429
6.138
6.133
4.691
4.597
F
CN
Bn2N
O
NH2
5b
4.00
6.01
1.96
1.98
1.02
0.98
3.90
1.06
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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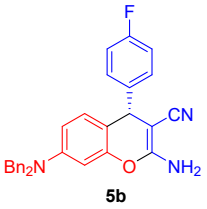
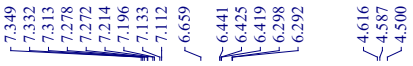
160.804
160.192
149.252
148.654
143.037
143.008
139.036
129.669
126.865
121.129
115.623
110.921
109.837
99.200
56.508
54.810
39.514
F
CN
Bn2N
O
NH2
5b
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


F
CN
Bn_2N
O
NH_2

5b

-116.405
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -110 -120 -140 -160 -180 -200
f1 (ppm)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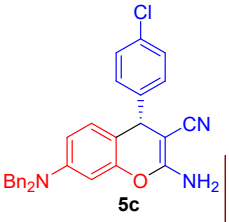
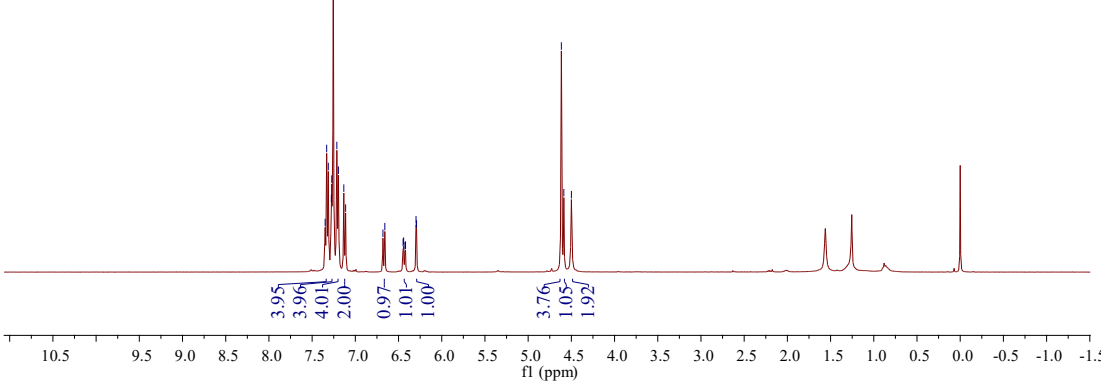
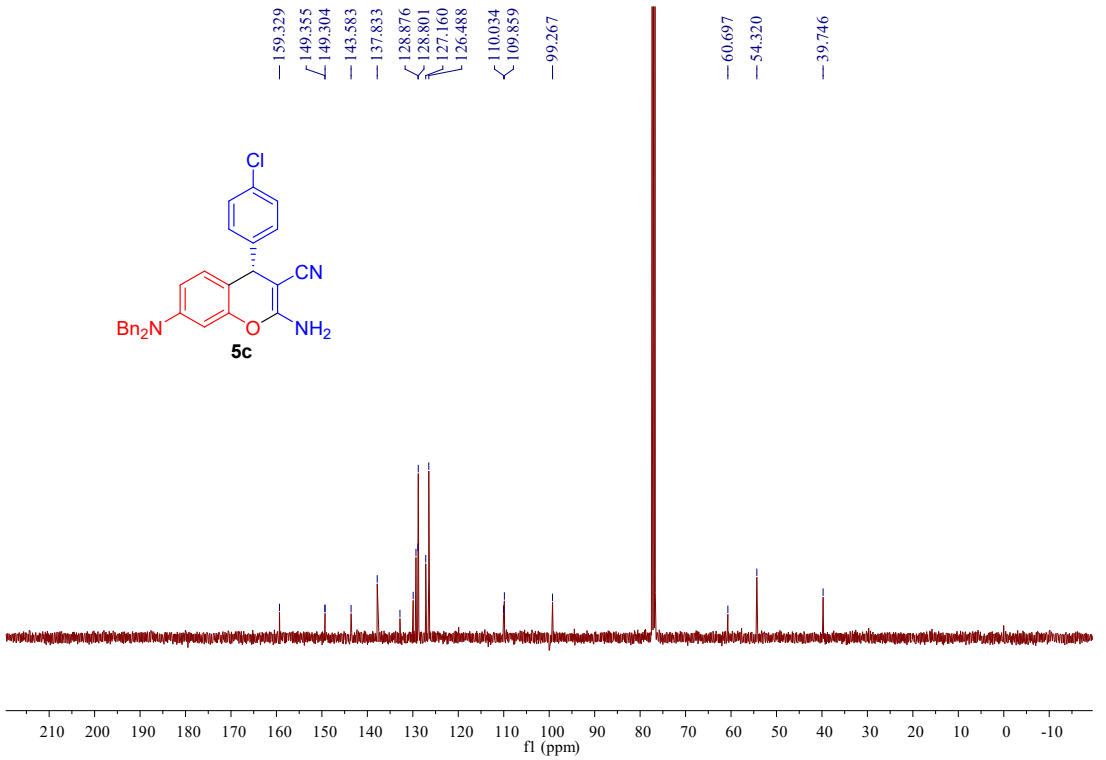
7.332
7.313
7.278
7.272
7.214
7.196
7.133
7.112
6.659
6.441
6.425
6.419
6.298
6.292
4.616
4.587
4.500


Cl
CN
Bn_2N
O
NH_2

5c


3.95
3.96
4.01
2.00
0.97
1.01
1.00
3.76
1.05
1.92
10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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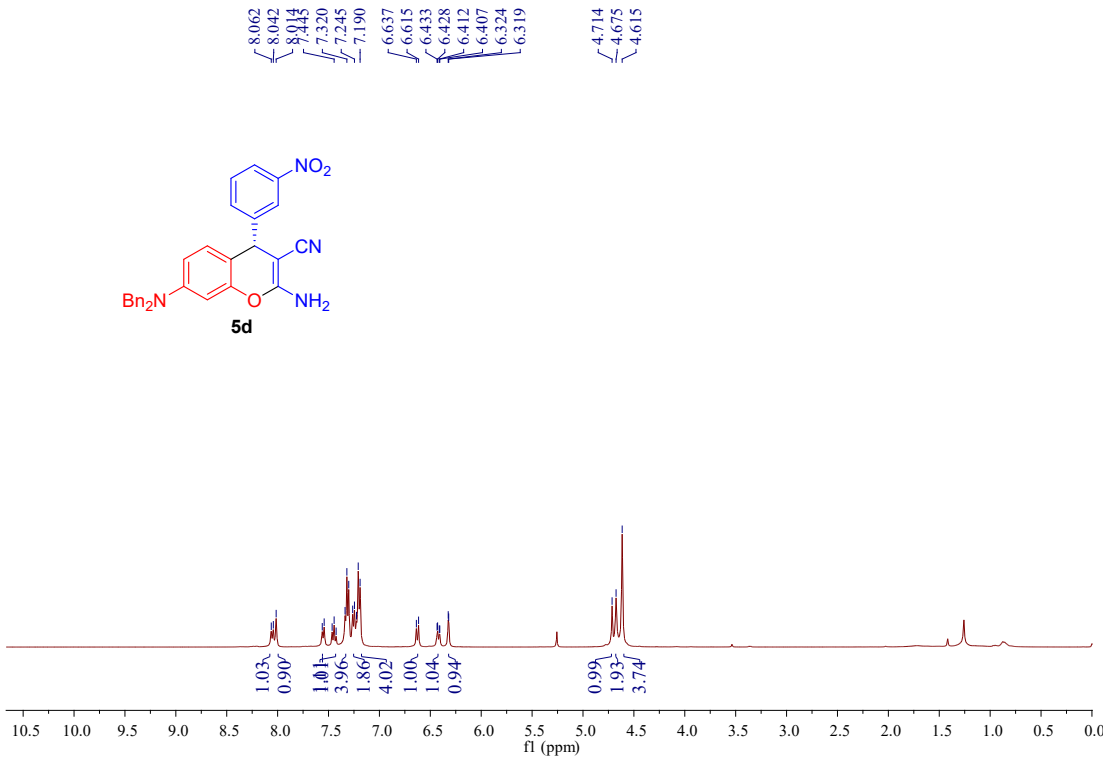
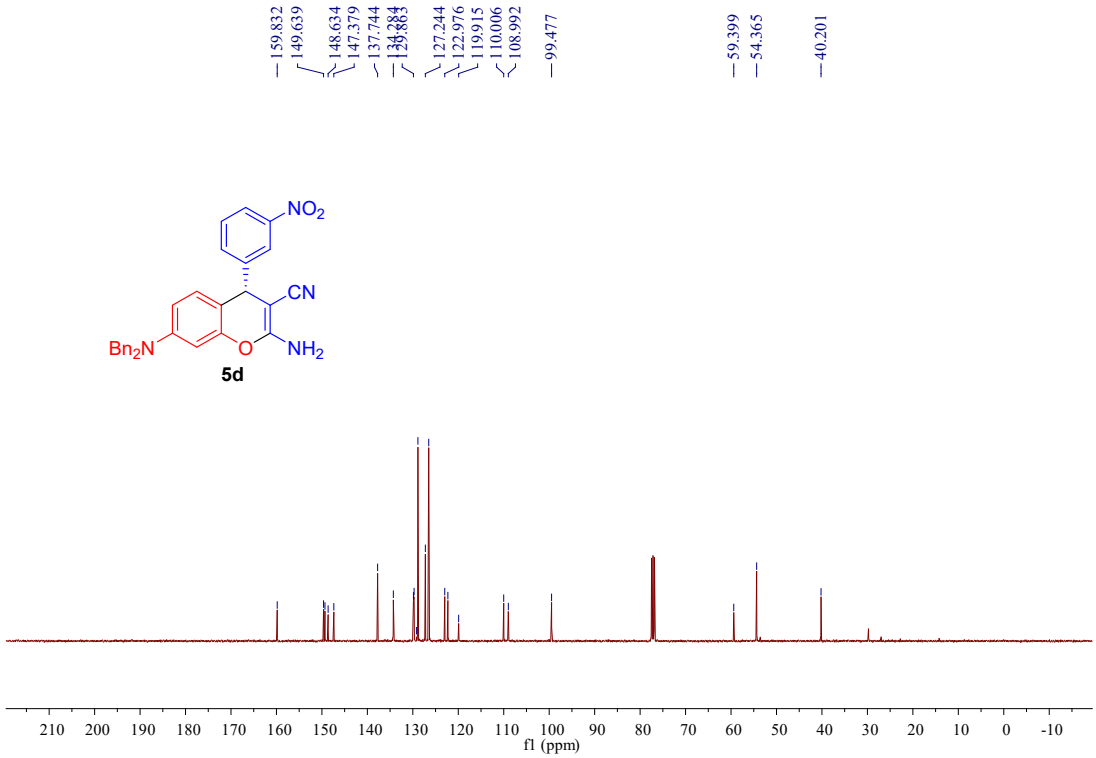
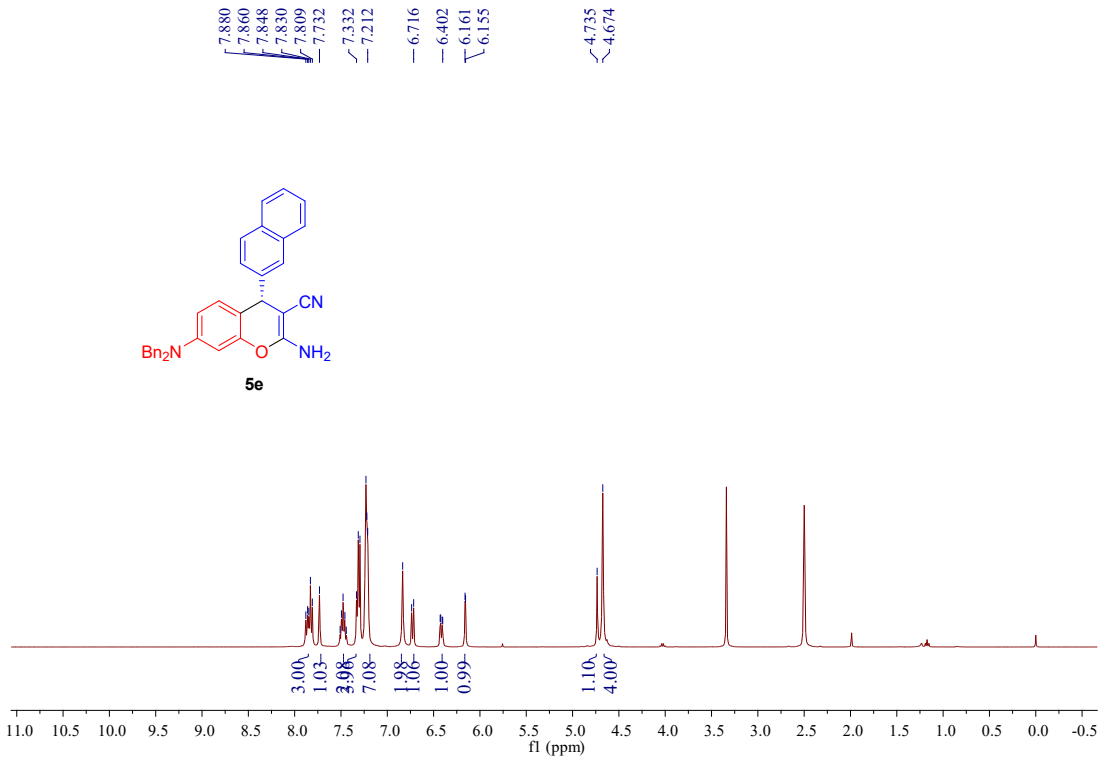
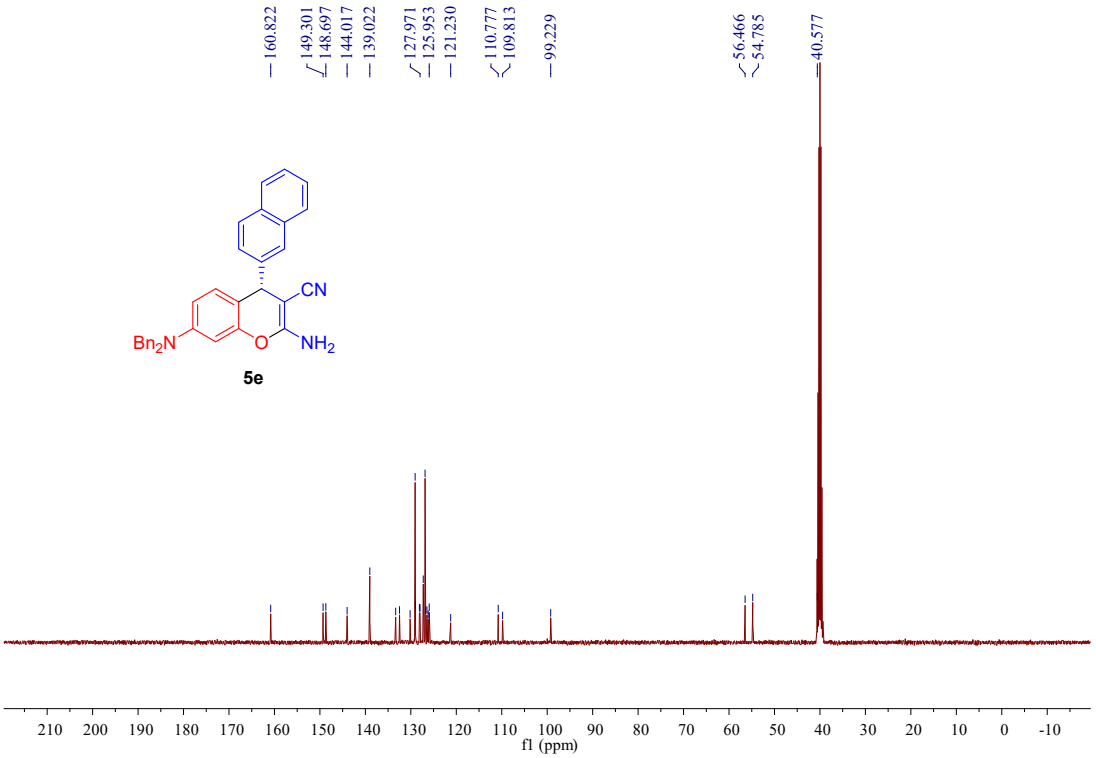
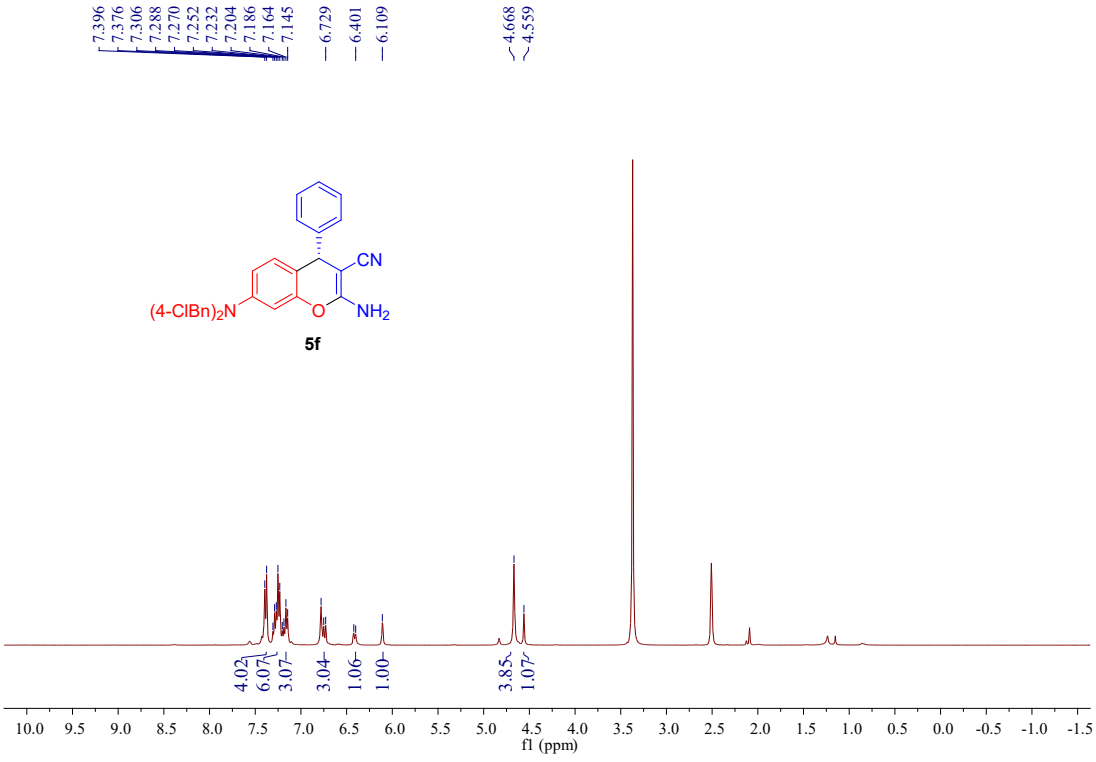
149.355
149.304
143.583
137.833
128.876
128.801
127.160
126.488
110.034
109.859
99.267
60.697
54.320
39.746
Cl
CN
Bn2N
O
NH2
5c
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

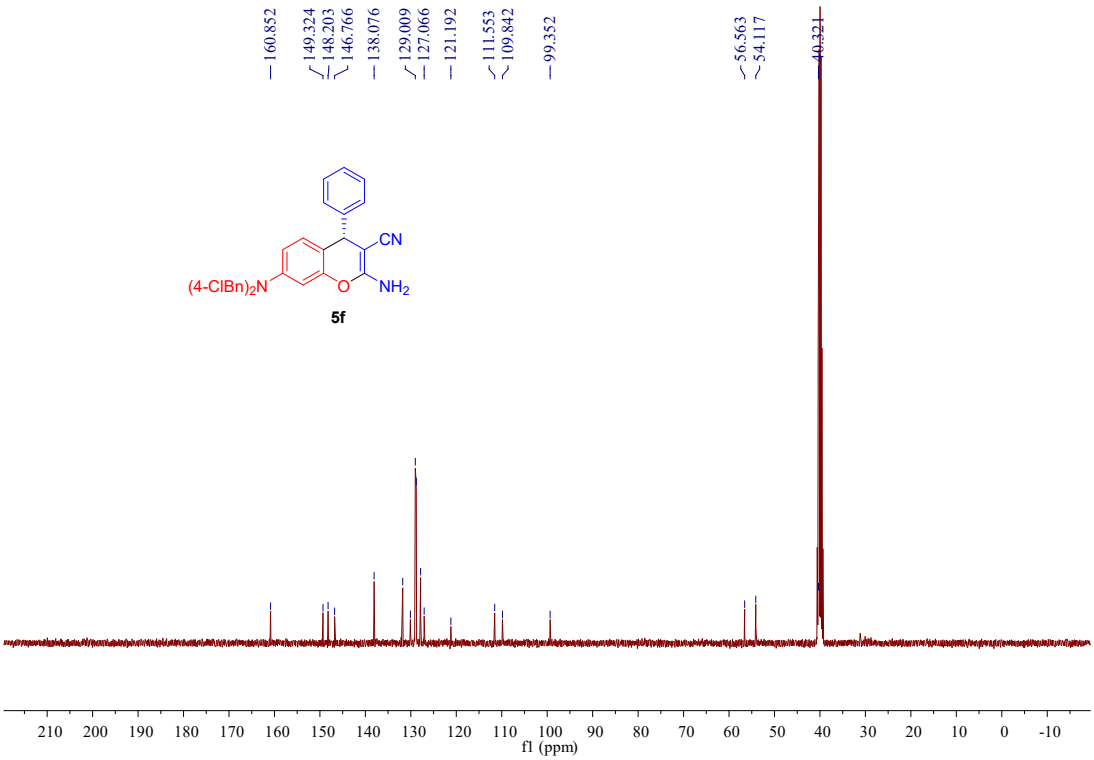

8.062
8.042
8.014
7.445
7.320
7.245
7.190
6.637
6.615
6.433
6.428
6.412
6.407
6.324
6.319
4.714
4.675
4.615
NO2
CN
Bn2N
O
NH2
5d
1.03
0.90
1.01
3.96
1.86
4.02
1.00
1.04
0.94
0.99
1.93
3.74
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

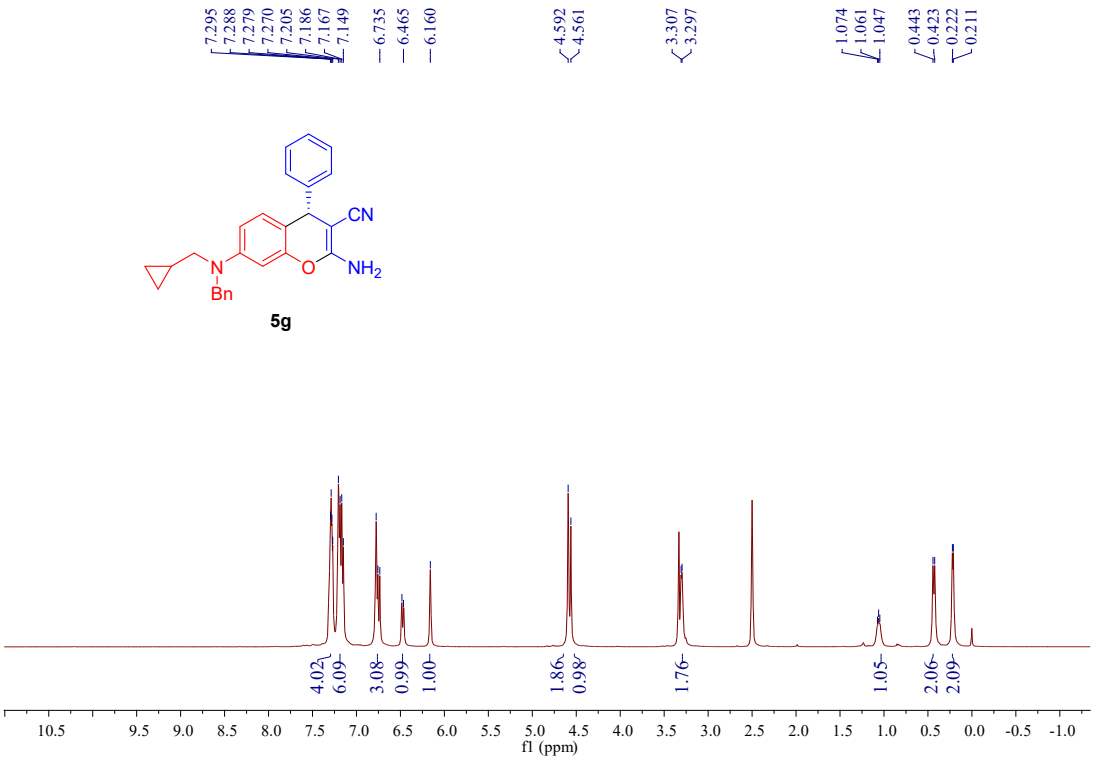

159.832
149.639
148.634
147.379
137.744
127.244
122.976
119.915
110.006
108.992
99.477
59.399
54.365
40.201
NO2
CN
Bn2N
O
NH2
5d
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

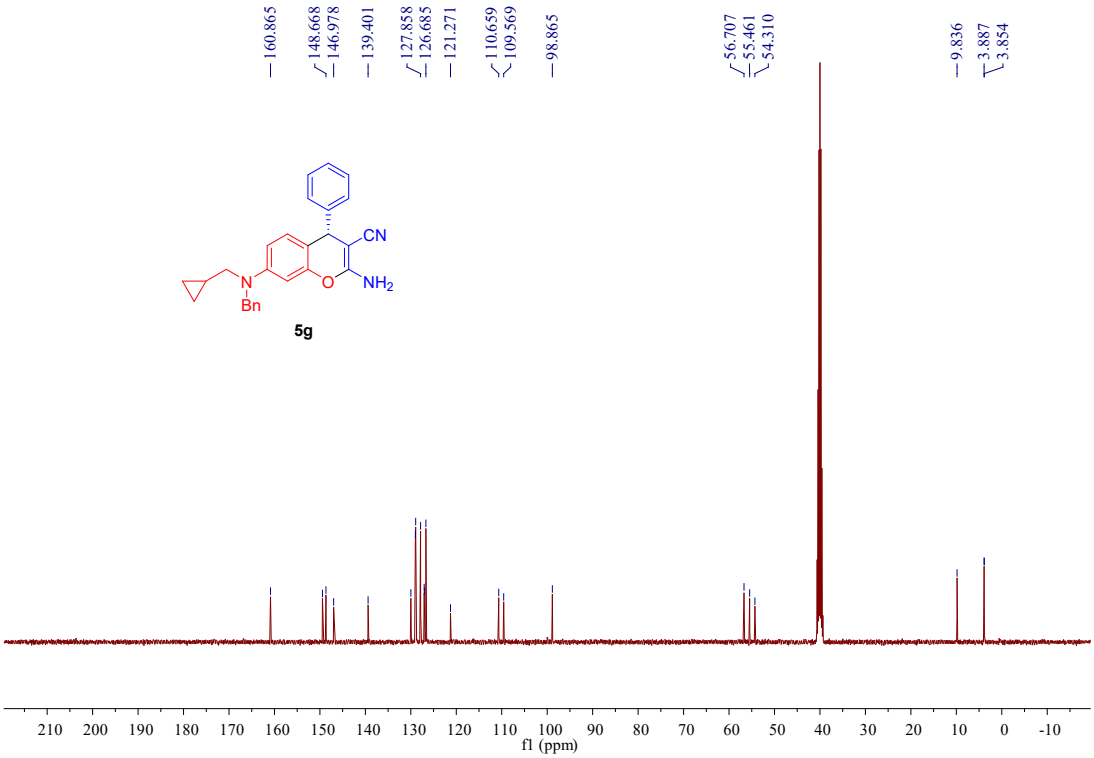

7.880
7.860
7.848
7.830
7.809
7.732
7.332
7.212
6.716
6.402
6.161
6.155
4.735
4.674
CN
Bn2N
O
NH2
5e
3.00
1.03
7.08
1.98
1.02
1.00
0.99
1.10
4.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

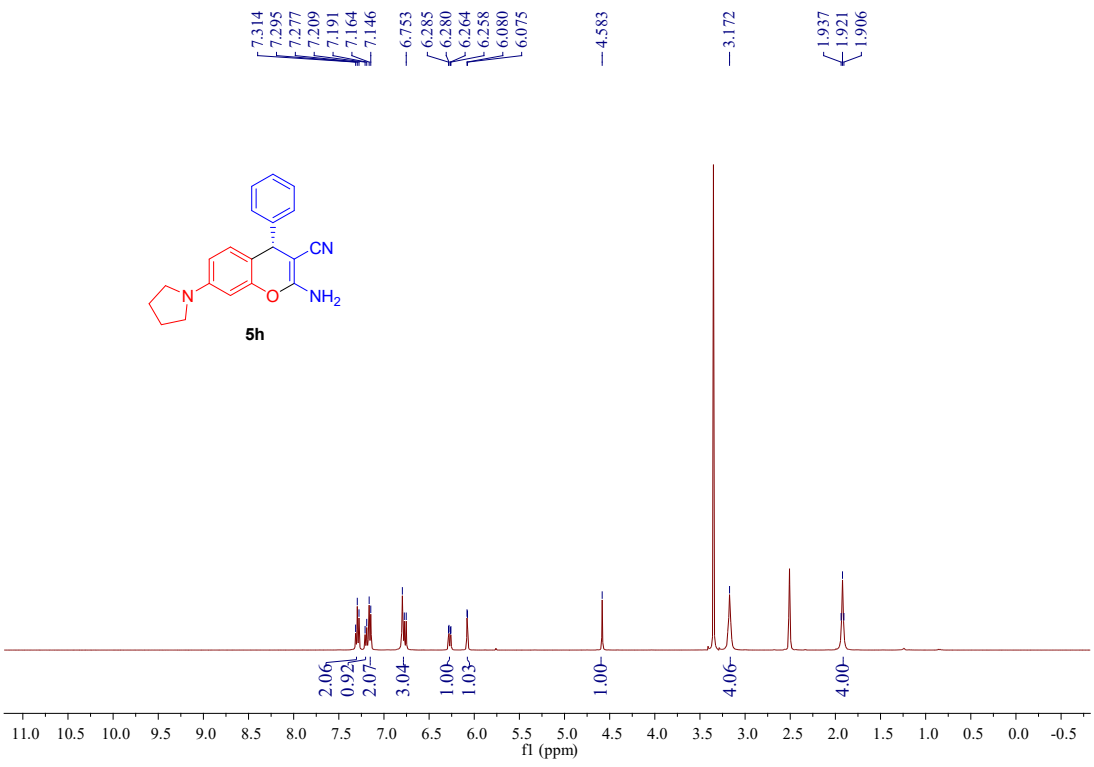

160.822
149.301
148.697
144.017
139.022
127.971
125.953
121.230
110.777
109.813
99.229
56.466
54.785
40.577
CN
Bn2N
O
NH2
5e
f1 (ppm)

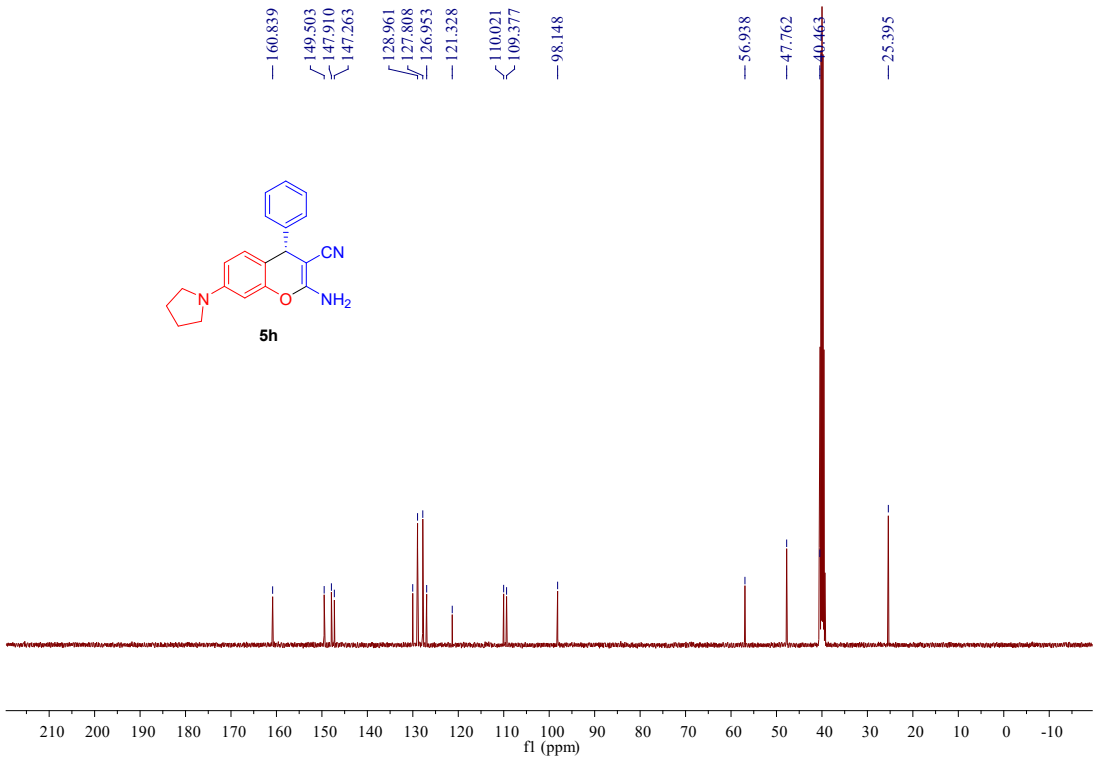

7.396
7.376
7.306
7.288
7.270
7.252
7.232
7.204
7.186
7.164
7.145
6.729
6.401
6.109
4.668
4.559
CN
(4-ClBn)2N
O
NH2
5f
4.02
6.07
3.07
3.04
1.06
1.00
3.85
1.07
f1 (ppm)

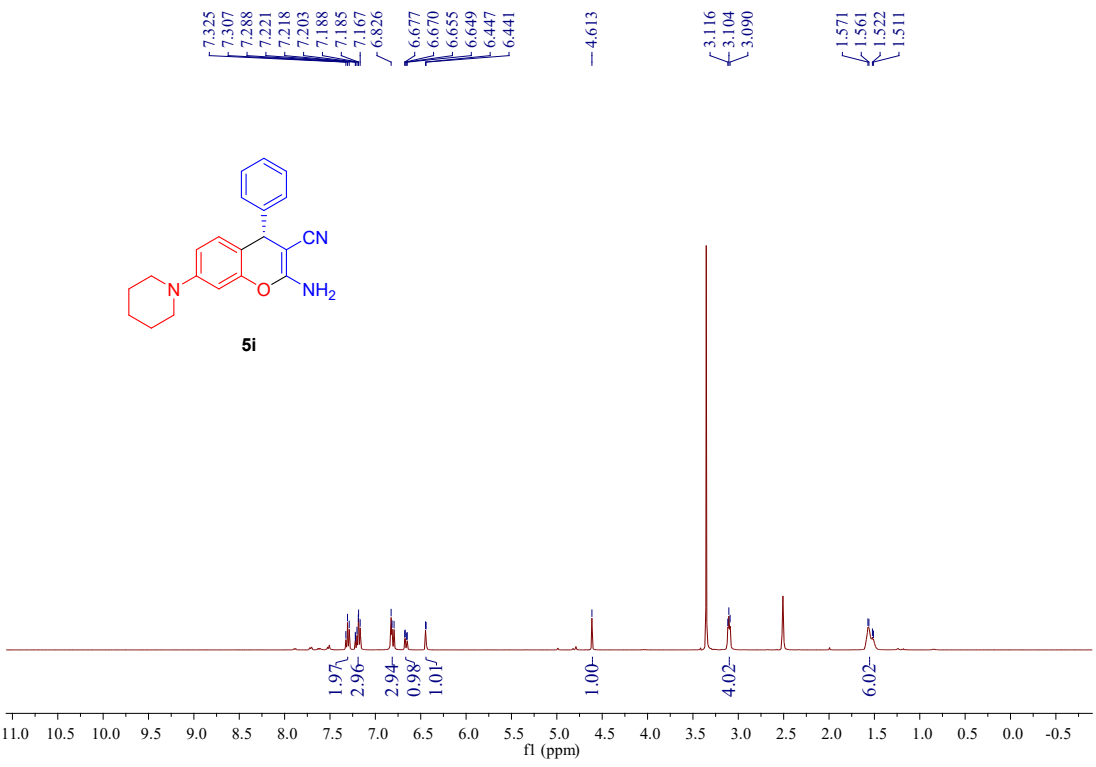

160.852
149.324
148.203
146.766
138.076
129.009
127.066
121.192
111.553
109.842
99.352
56.563
54.117
40.321
CN
(4-ClBn)2N
O
NH2
5f
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

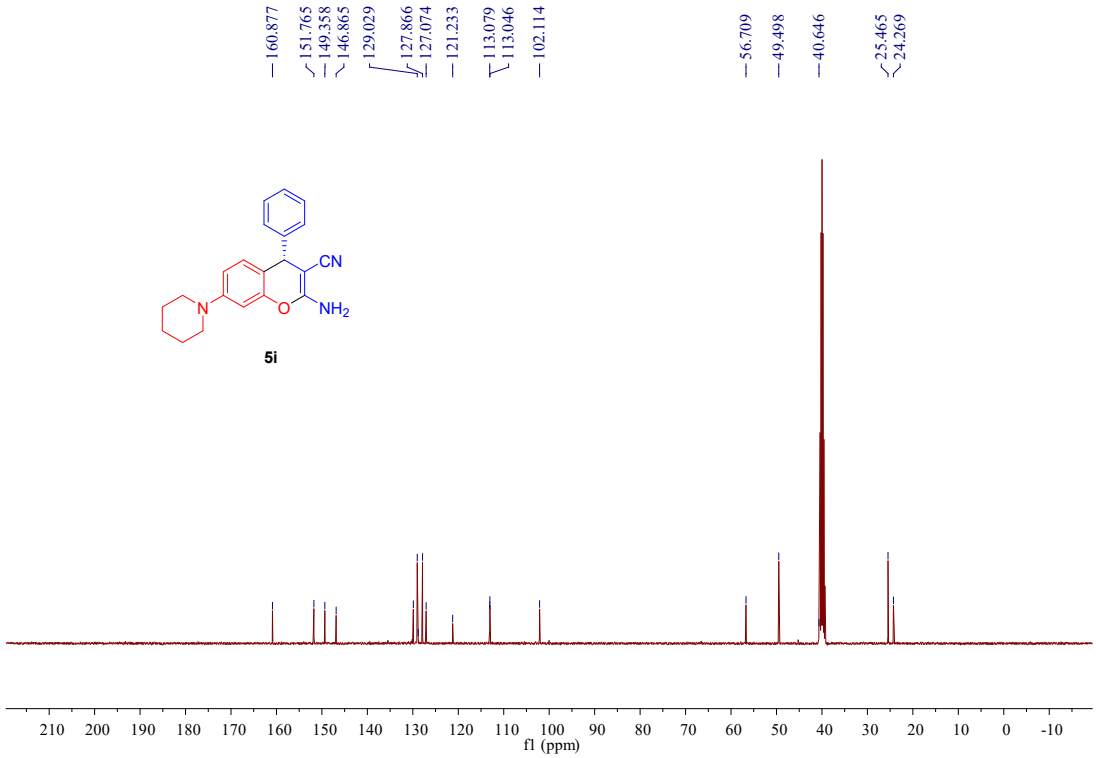

7.295
7.288
7.279
7.270
7.205
7.186
7.167
7.149
6.735
6.465
6.160
4.592
4.561
3.307
3.297
1.074
1.061
1.047
0.443
0.423
0.222
0.211
CN
N
Bn
O
NH2
5g
4.02
6.09
3.08
0.99
1.00
1.86
0.98
1.76
1.05
2.06
2.09
10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


160.865
148.668
146.978
139.401
127.858
126.685
121.271
110.659
109.569
98.865
56.707
55.461
54.310
9.836
3.887
3.854
CN
NH2
N
O
Bn
5g
fl (ppm)


7.314
7.295
7.277
7.209
7.191
7.164
7.146
6.753
6.285
6.280
6.264
6.258
6.080
6.075
4.583
3.172
1.937
1.921
1.906
CN
NH2
N
O
5h
2.06
0.92
2.07
3.04
1.00
1.03
1.00
4.06
4.00
fl (ppm)


160.839
149.503
147.910
147.263
128.961
127.808
126.953
121.328
110.021
109.377
98.148
56.938
47.762
40.463
25.395
CN
NH2
N
O
5h
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.325
7.307
7.288
7.221
7.218
7.203
7.188
7.185
7.167
6.826
6.677
6.670
6.655
6.649
6.447
6.441
4.613
3.116
3.104
3.090
1.571
1.561
1.522
1.511
CN
NH2
N
O
5i
1.97
2.96
2.94
0.98
1.01
1.00
4.02
6.02
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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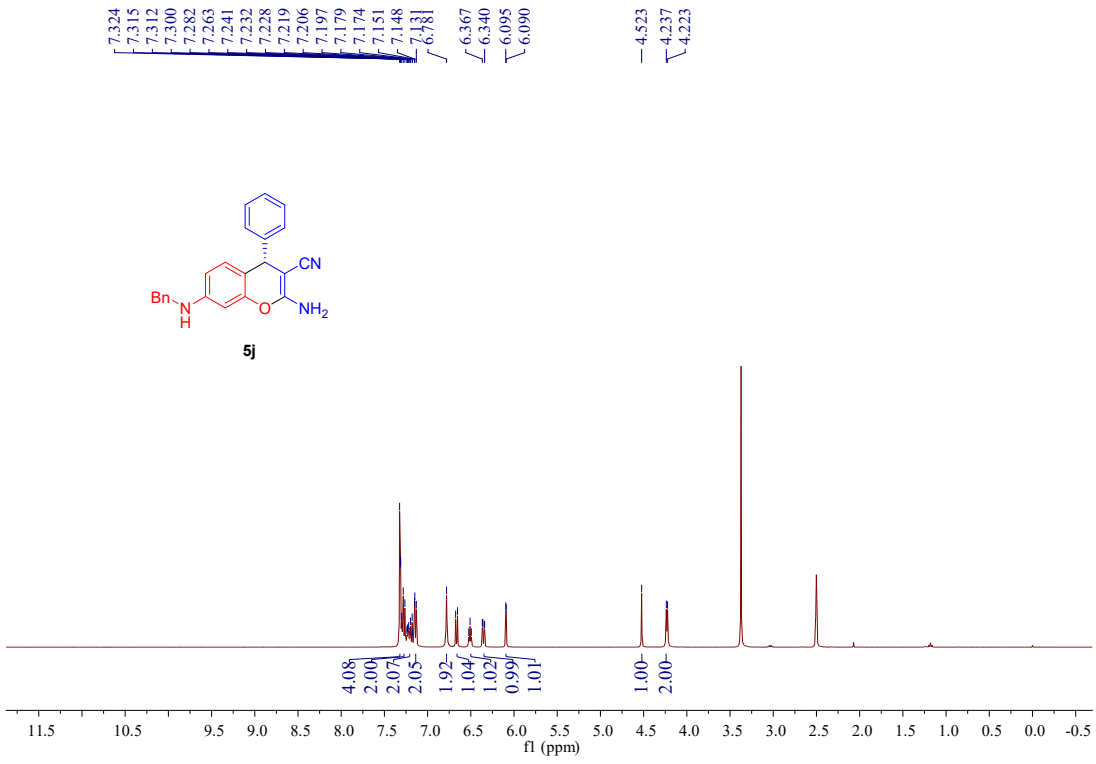
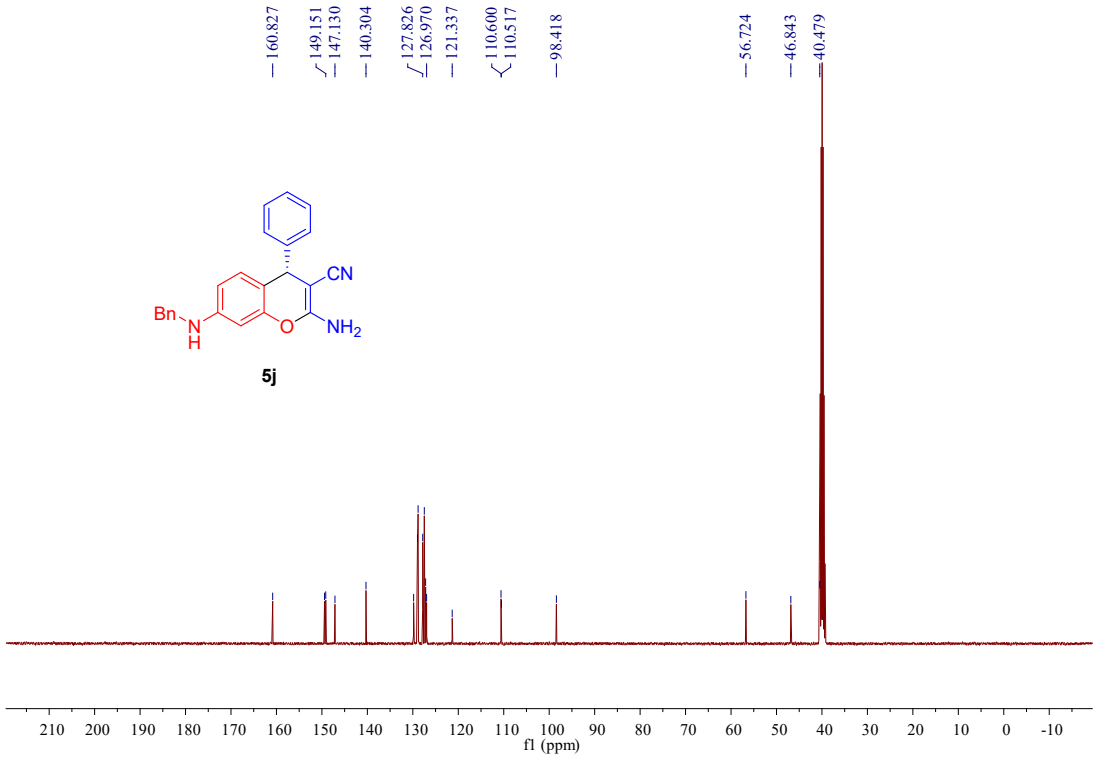
146.865
129.029
127.866
127.074
121.233
113.079
113.046
102.114
56.709
49.498
40.646
25.465
24.269
CN
NH2
N
O
5i
f1 (ppm)


7.324
7.315
7.312
7.300
7.282
7.263
7.241
7.232
7.228
7.219
7.206
7.197
7.179
7.174
7.151
7.148
7.131
6.781
6.367
6.340
6.095
6.090
4.523
4.237
4.223
CN
NH2
Bn
N
H
O
5j
4.08
2.00
2.07
2.05
1.92
1.04
1.02
0.99
1.01
1.00
2.00
f1 (ppm)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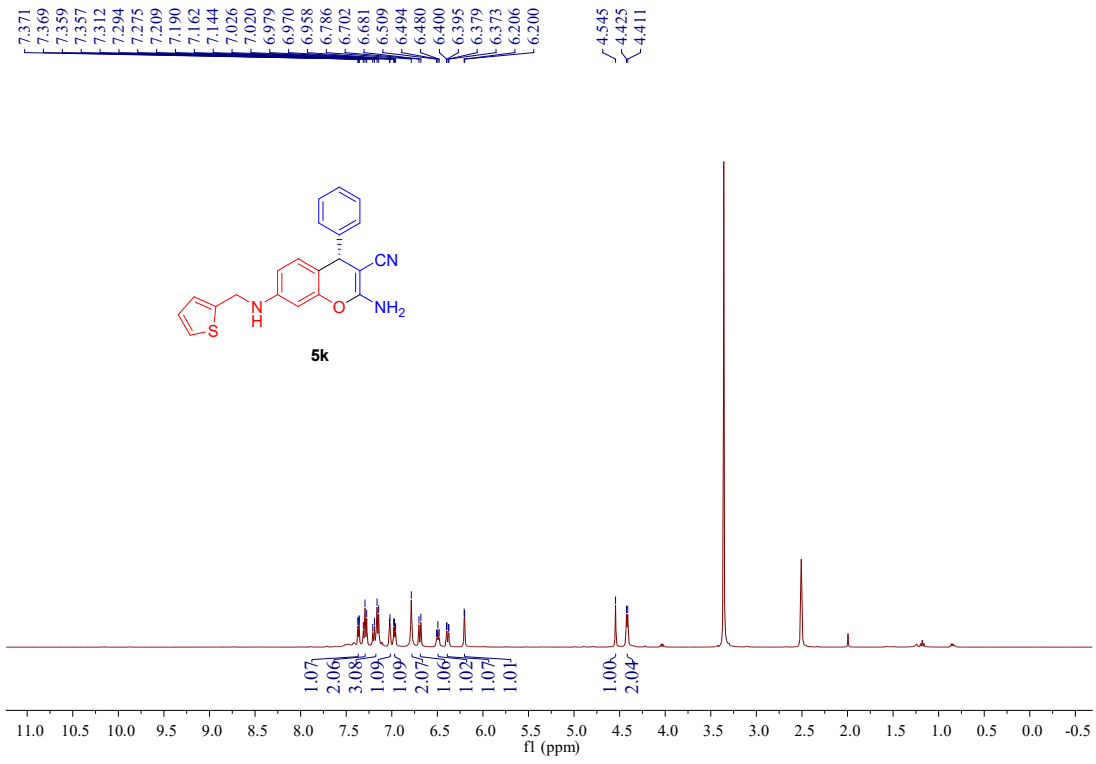
147.130
140.304
127.826
126.970
121.337
110.600
110.517
98.418
56.724
46.843
40.479
CN
Bn
N
H
O
NH2
5j
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.357
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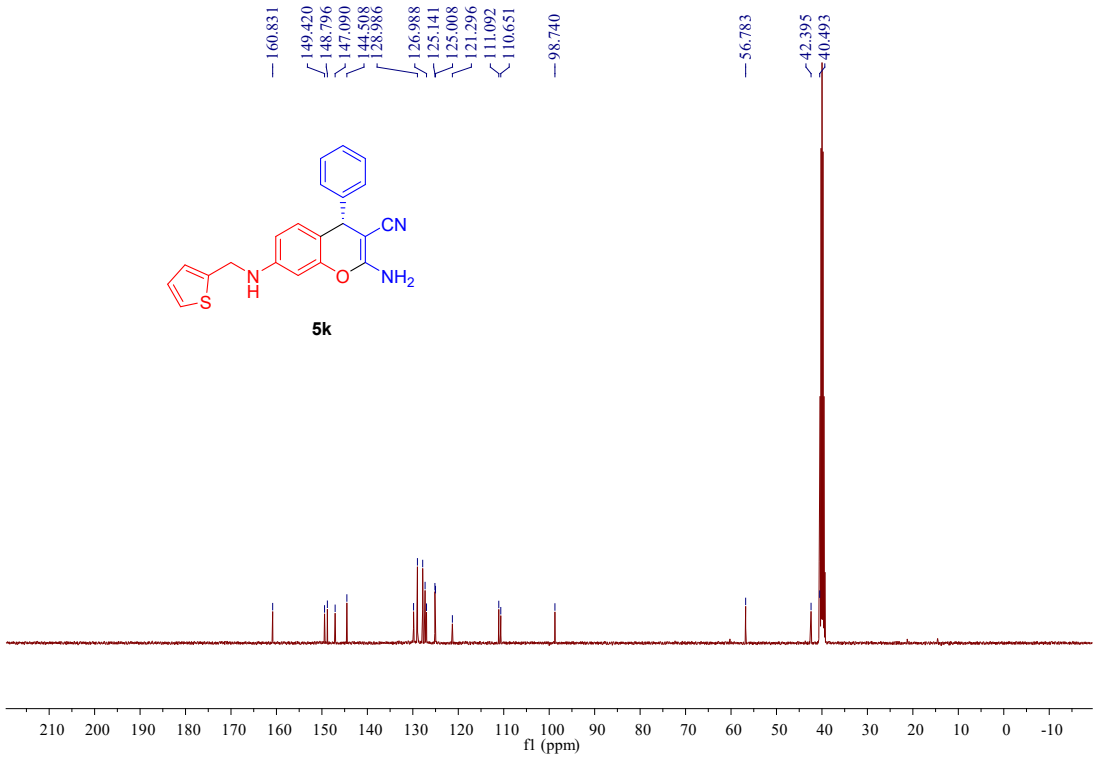
7.294
7.275
7.209
7.190
7.162
7.144
7.026
7.020
6.979
6.970
6.958
6.786
6.702
6.681
6.509
6.494
6.480
6.400
6.395
6.379
6.373
6.206
6.200
4.545
4.425
4.411
CN
N
H
O
NH2
S
5k
1.07
2.06
3.08
1.09
1.09
2.07
1.06
1.02
1.07
1.01
1.00
2.04
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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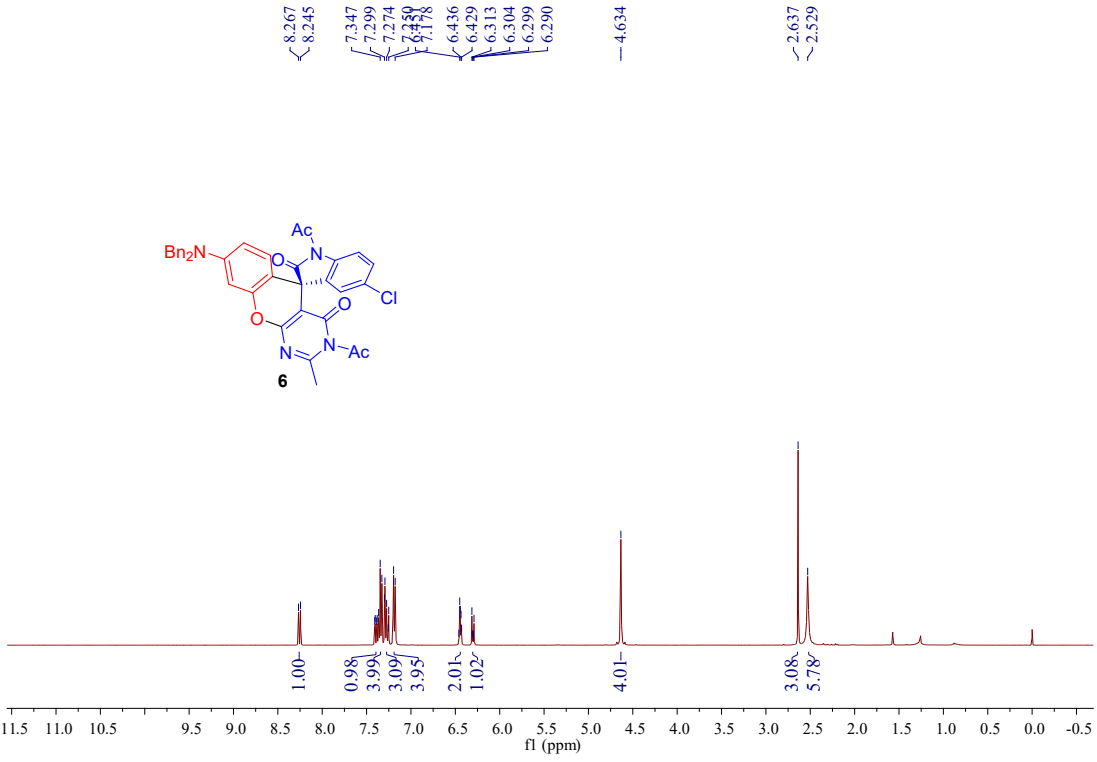
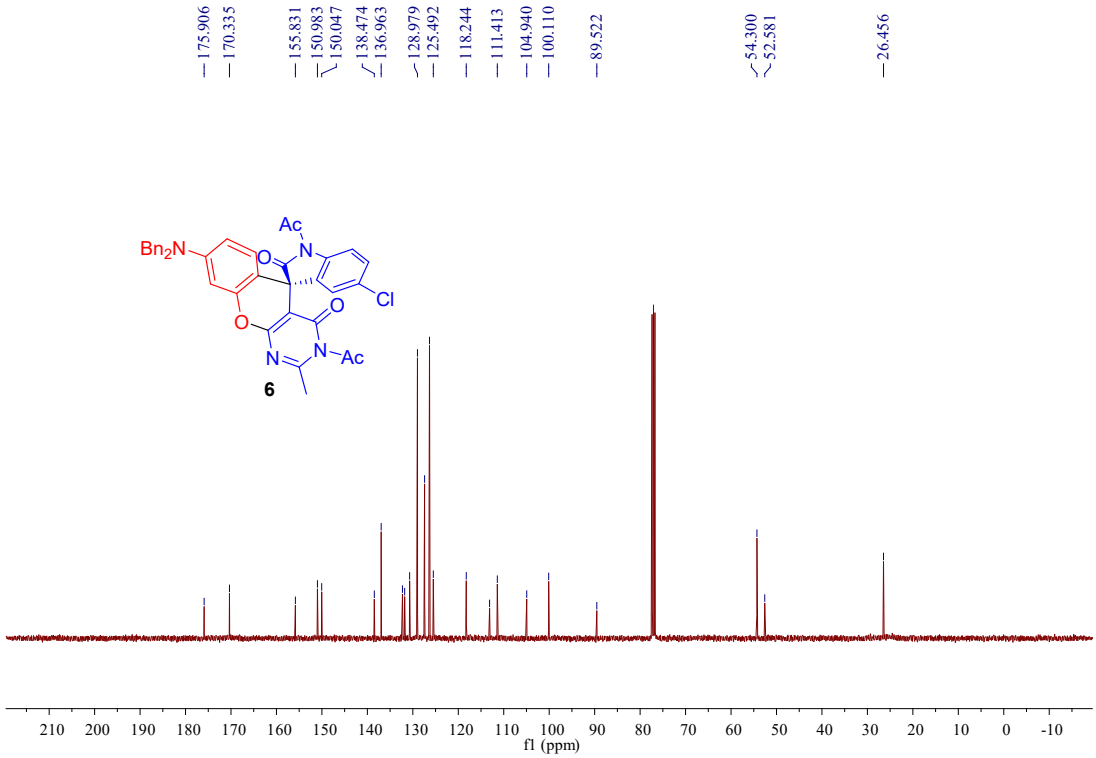
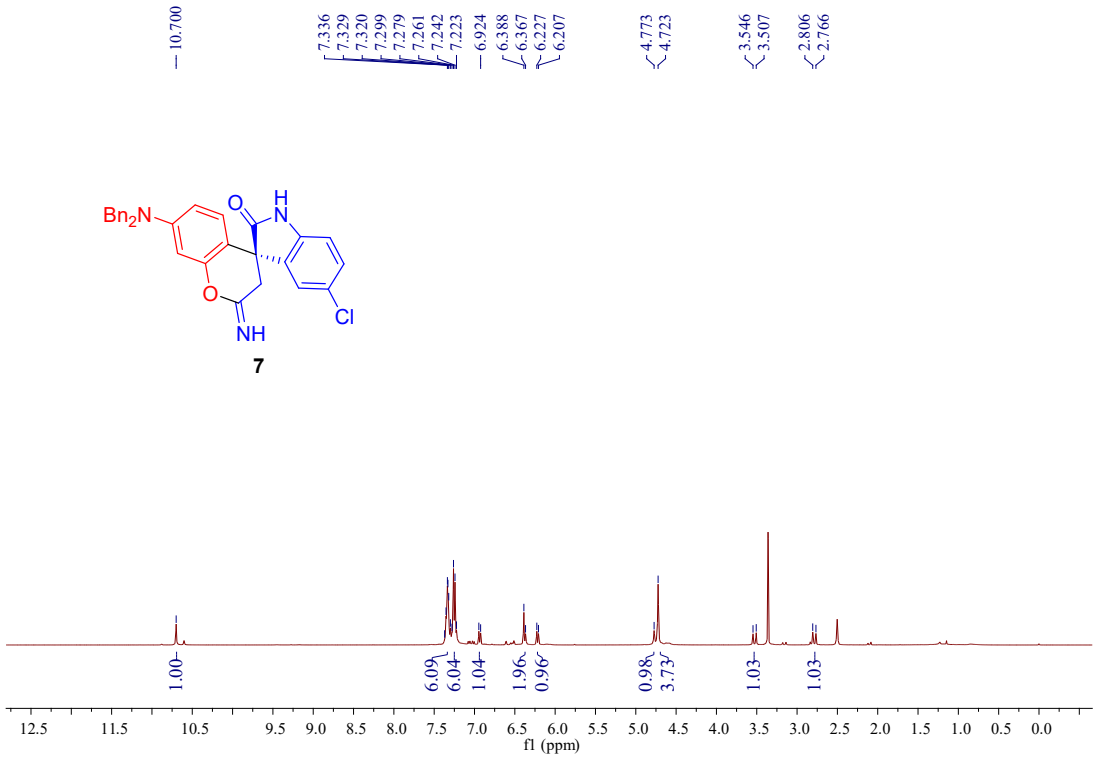
148.796
147.090
144.508
128.986
126.988
125.141
125.008
121.296
111.092
110.651
98.740
56.783
42.395
40.493
CN
NH2
N
H
O
S
5k
fl (ppm)


8.267
8.245
7.347
7.299
7.274
7.178
6.436
6.429
6.313
6.304
6.299
6.290
4.634
2.637
2.529
Ac
Bn2N
O
N
Cl
O
O
N
N
Ac
6
1.00
0.98
3.99
3.09
3.95
2.01
1.02
4.01
3.08
5.78
fl (ppm)


175.906
170.335
155.831
150.983
150.047
138.474
136.963
128.979
125.492
118.244
111.413
104.940
100.110
89.522
54.300
52.581
26.456
Ac
Bn2N
O
N
Cl
O
O
N
N
Ac
6
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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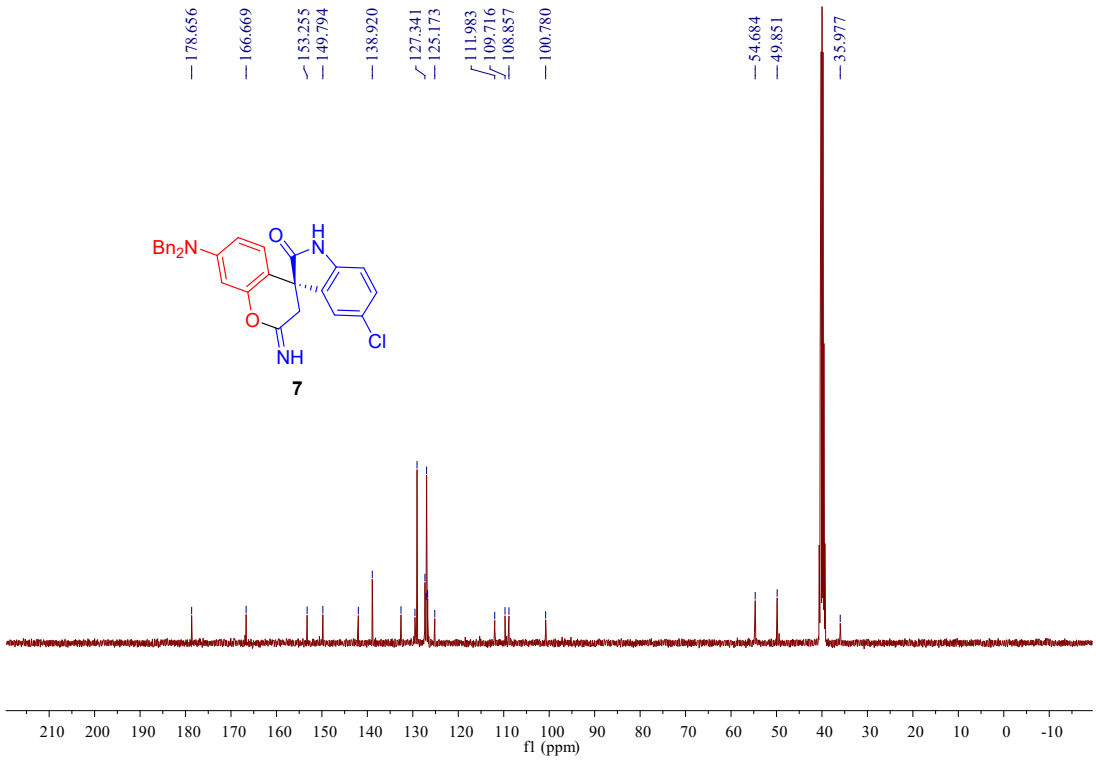
7.279
7.261
7.242
7.223
6.924
6.388
6.367
6.227
6.207
4.773
4.723
3.546
3.507
2.806
2.766
Bn2N
O
H
N
O
Cl
NH
7
1.00
6.09
6.04
1.04
1.96
0.96
0.98
3.73
1.03
1.03
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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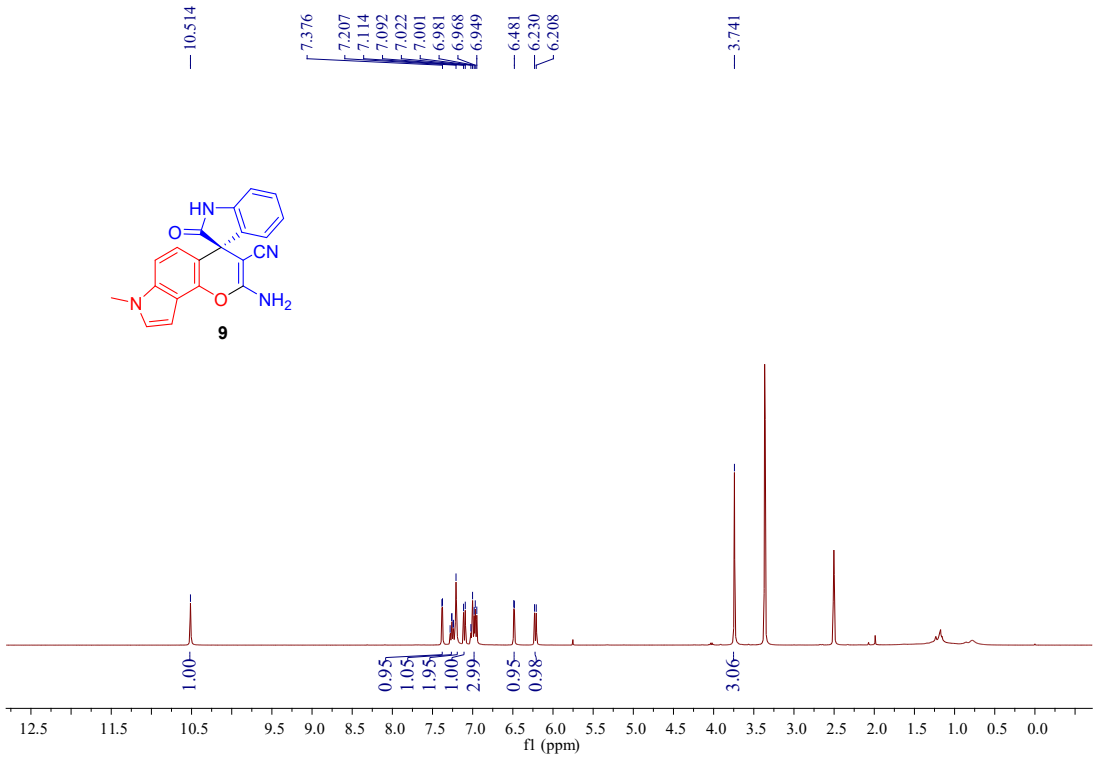
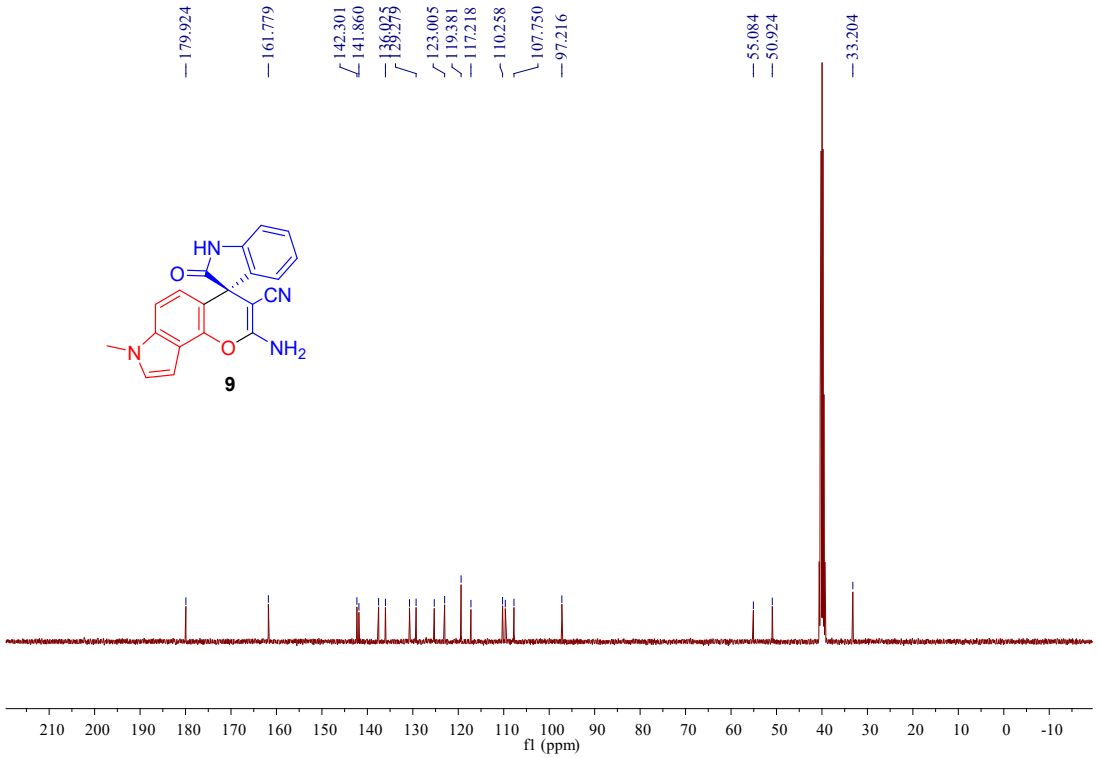
166.669
153.255
149.794
138.920
127.341
125.173
111.983
109.716
108.857
100.780
54.684
49.851
35.977
Bn2N
O
H
N
O
NH
Cl
7
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


10.514
7.376
7.207
7.114
7.092
7.022
7.001
6.981
6.968
6.949
6.481
6.230
6.208
3.741
HN
O
CN
N
O
NH2
9
1.00
0.95
1.05
1.95
1.00
2.99
0.95
0.98
3.06
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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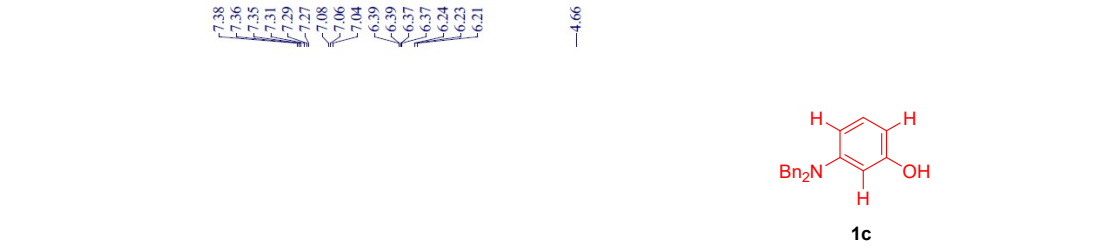
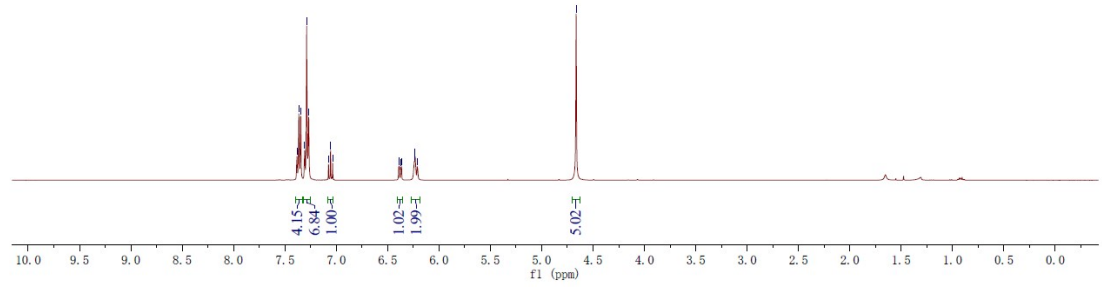
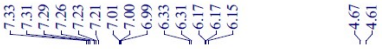
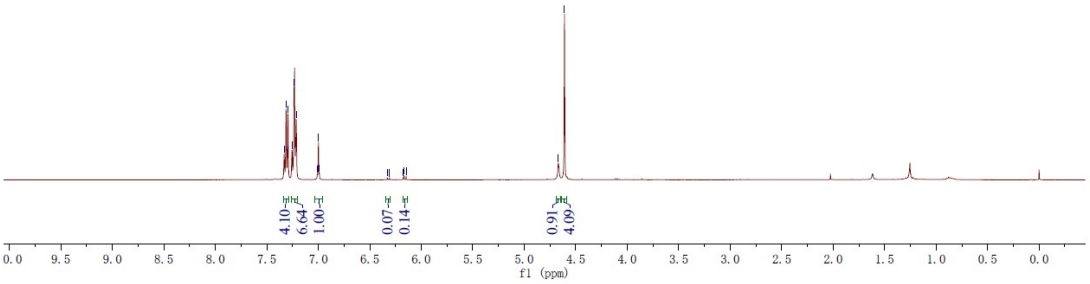
161.779
142.301
141.860
136.025
128.279
123.005
119.381
117.218
110.258
107.750
97.216
55.084
50.924
33.204
HN
O
CN
N
O
NH2
9
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

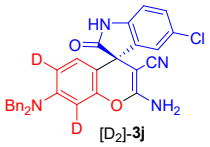

7.38
7.36
7.35
7.31
7.29
7.27
7.08
7.06
7.04
6.39
6.37
6.37
6.24
6.23
6.21
4.66
H
H
Bn2N
OH
H
1c


4.15
6.84
1.00
1.02
1.99
5.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

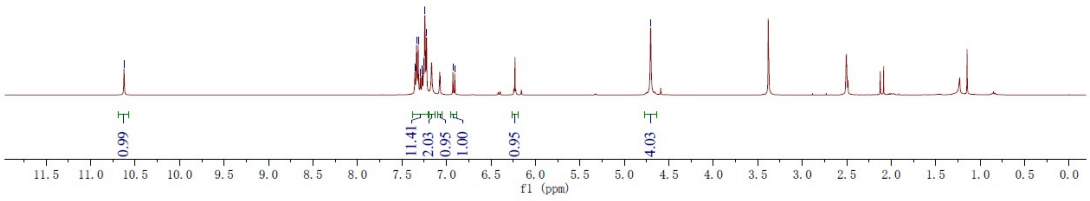


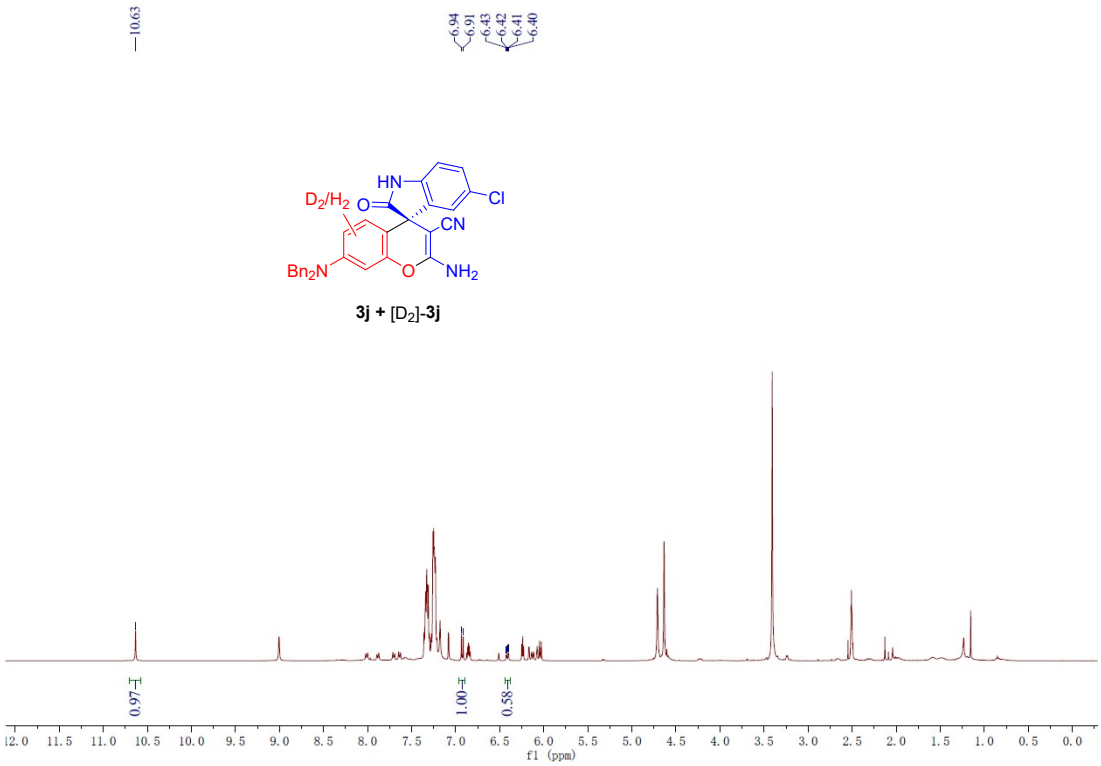
[D_3]-**1c** (93% D)





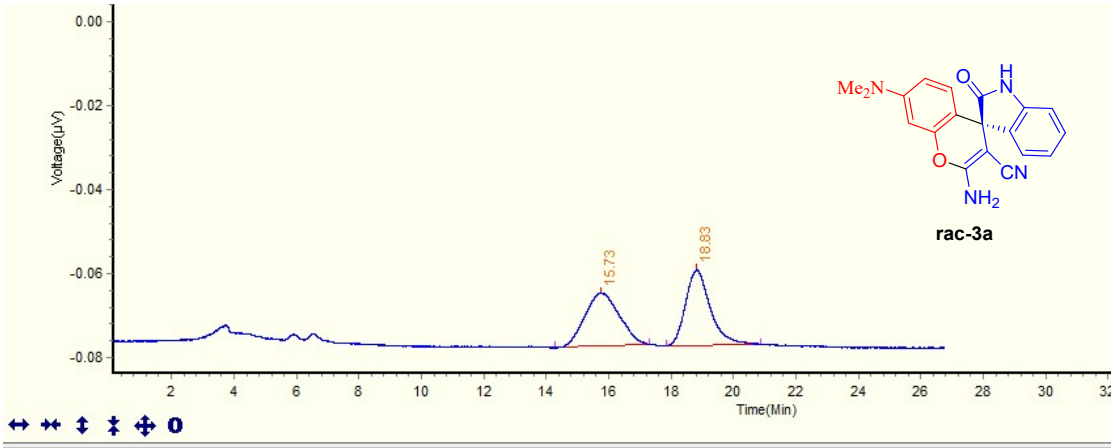
[D_2]-**3j**





3j + [D_2]-**3j**

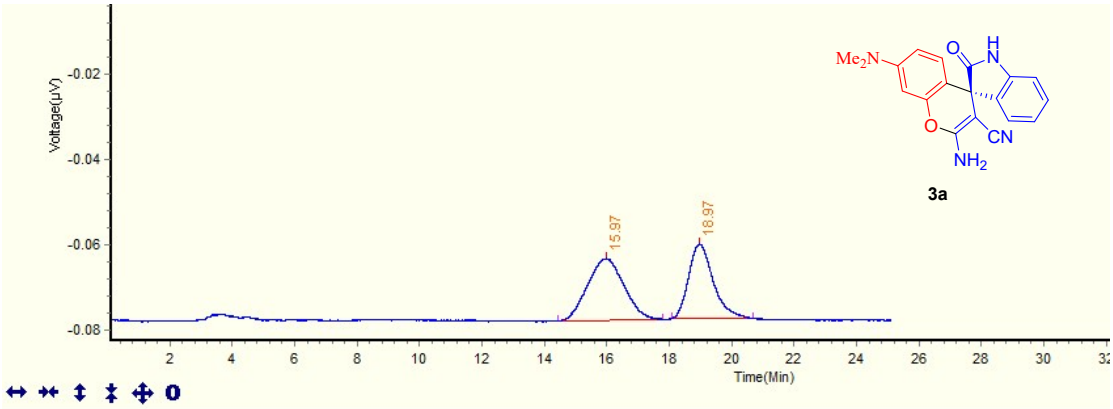
HPLC spectra of compounds



rac-3a

Integration Result | Calculation Result | TimeTable

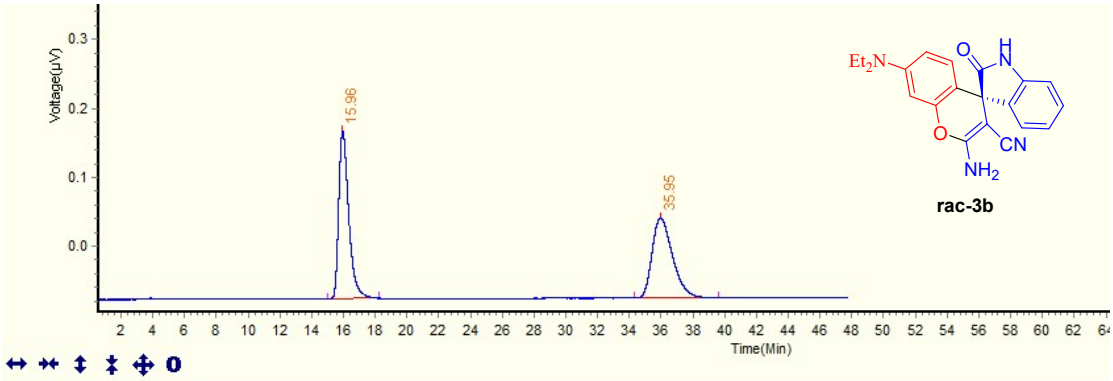
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.73	481801	6324	49.66%	3.021	BB
2	18.83	488425	8919	50.34%	3.053	BB
Total		970,226	15,243	100.00%		



3a

Integration Result | Calculation Result | TimeTable

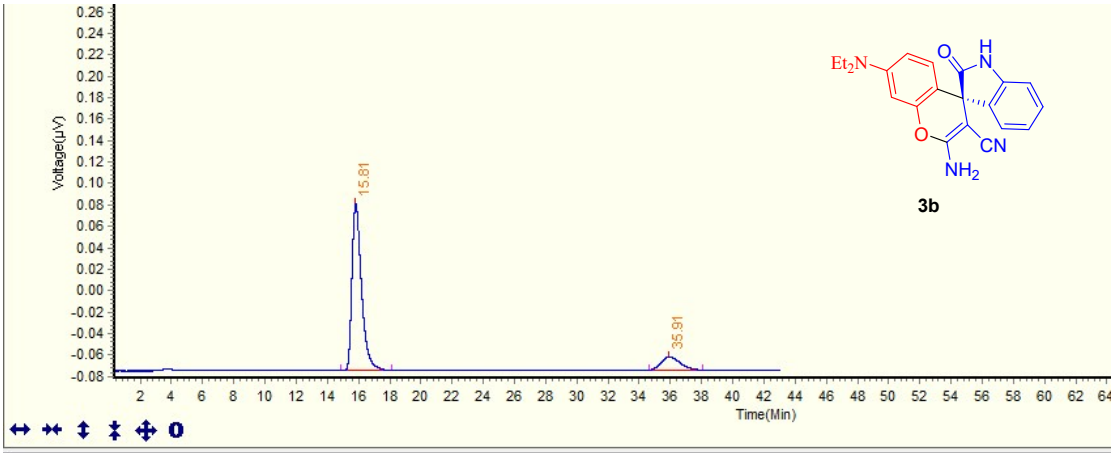
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.97	586710	7251	55.05%	3.348	BB
2	18.97	479045	8751	44.95%	2.594	BB
Total		1,065,755	16,002	100.00%		



rac-3b

Integration Result | Calculation Result | TimeTable

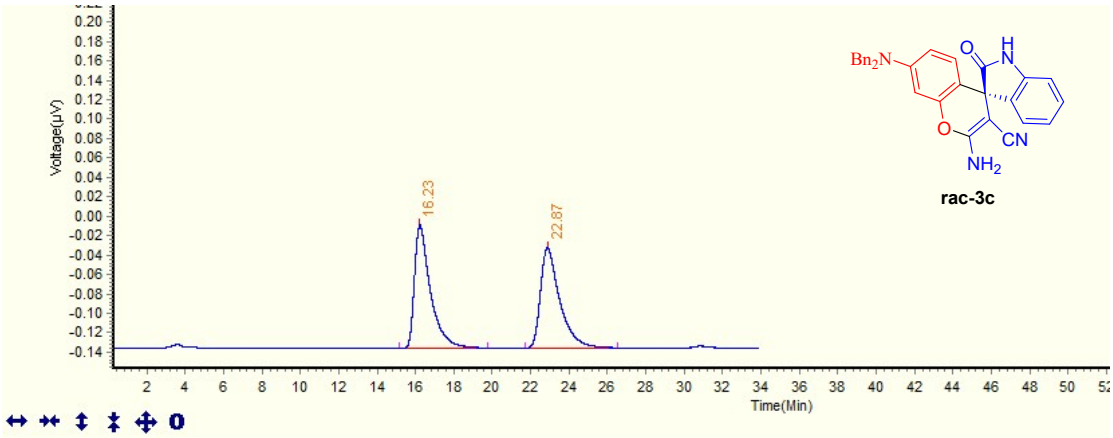
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.96	5315717	121286	50.57%	3.158	BB
2	35.95	5195961	58093	49.43%	5.342	BB
Total		10,511,678	179,379	100.00%		



3b

Integration Result | Calculation Result | TimeTable

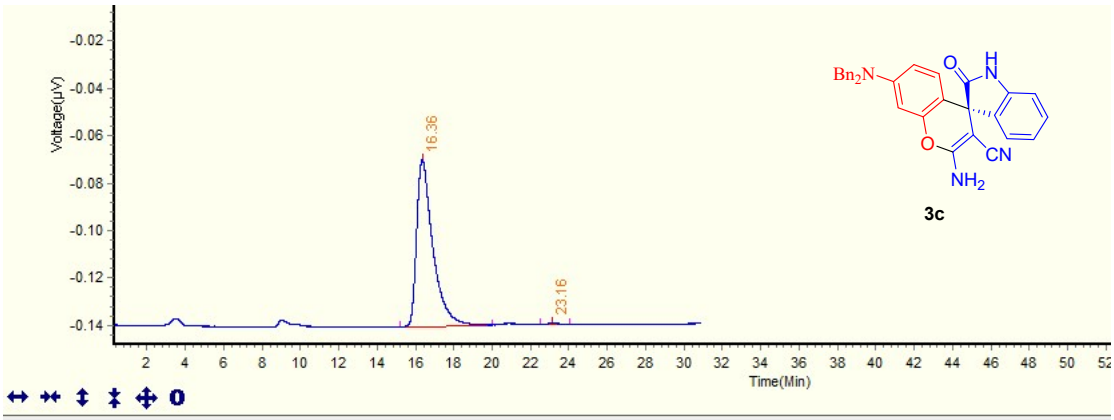
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.81	3301745	77624	86.14%	3.264	BB
2	35.91	531197	6220	13.86%	3.368	BB
Total		3,832,942	83,844	100.00%		



rac-3c

Integration Result | Calculation Result | TimeTable

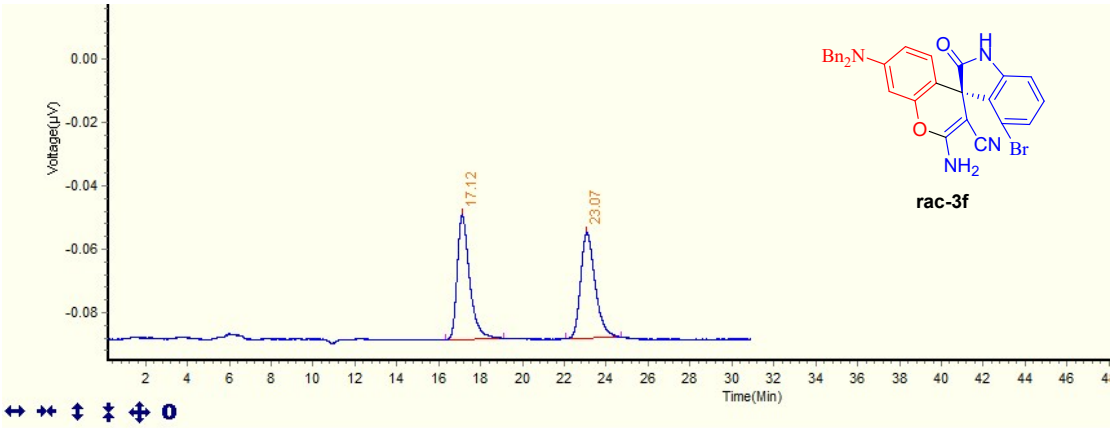
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.23	3679975	63395	50.50%	4.607	BB
2	22.87	3606628	51650	49.50%	4.81	BB
Total		7,286,603	115,045	100.00%		



3c

Integration Result | Calculation Result | TimeTable

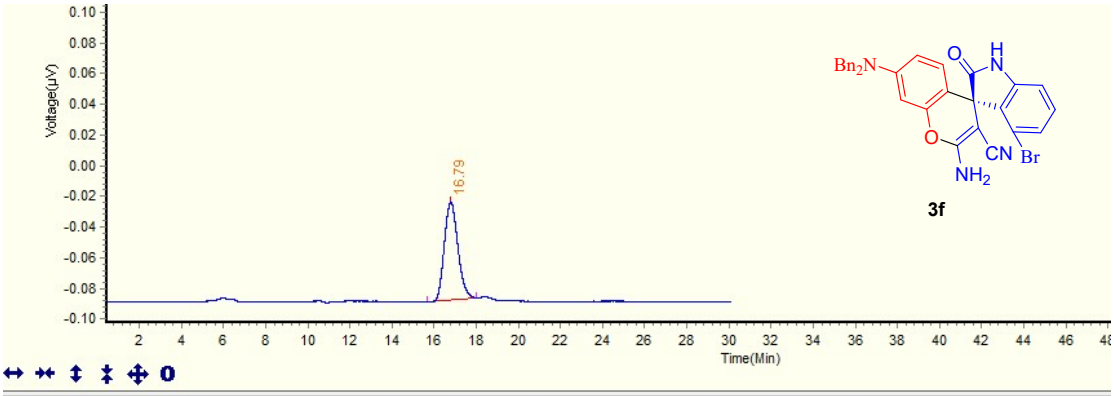
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.36	2065301	35214	99.49%	4.789	BB
2	23.16	10631	251	0.51%	1.523	BB
Total		2,075,932	35,465	100.00%		



rac-3f

Integration Result | Calculation Result | TimeTable

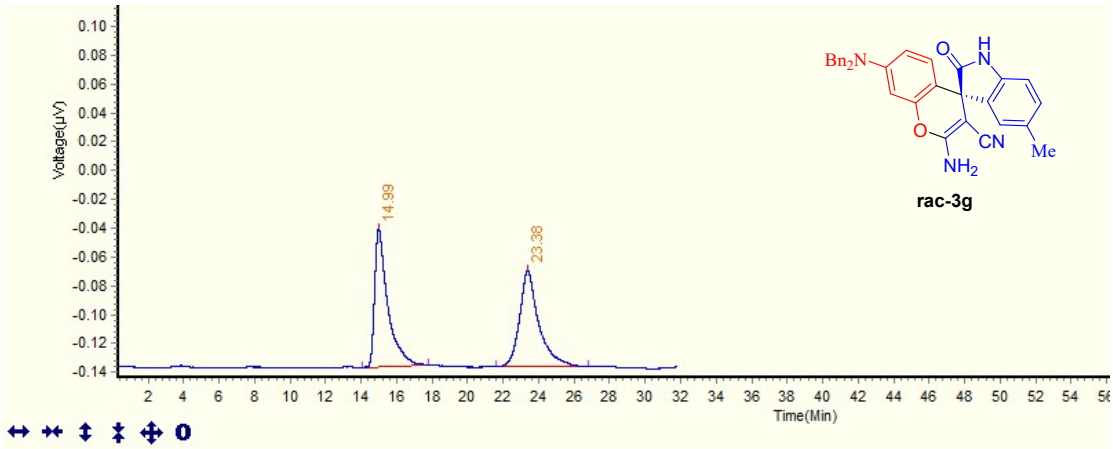
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	17.12	802374	19626	49.89%	2.823	BB
2	23.07	806057	16658	50.11%	2.637	BB
Total		1,608,431	36,284	100.00%		



3f

Integration Result | Calculation Result | TimeTable

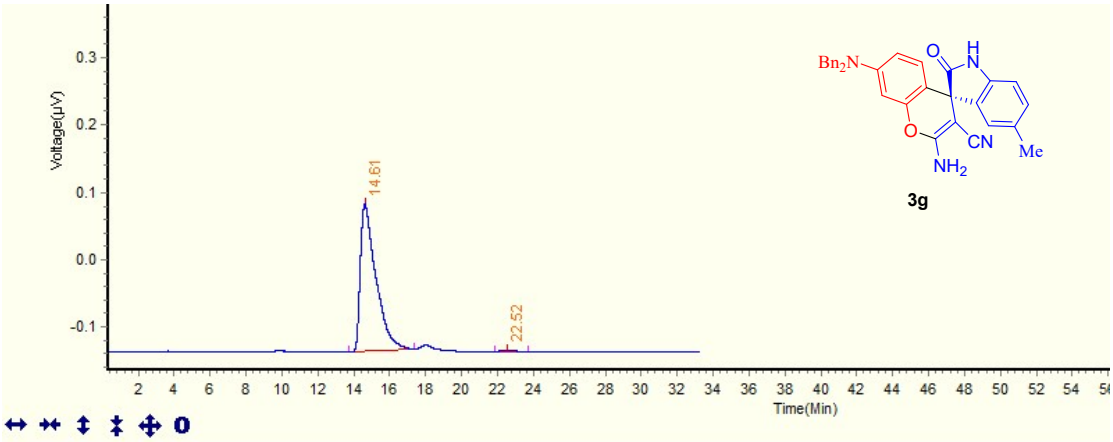
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.79	1424008	31840	100.00%	2.365	BB
Total		1,424,008	31,840	100.00%		



rac-3g

Integration Result | Calculation Result | TimeTable

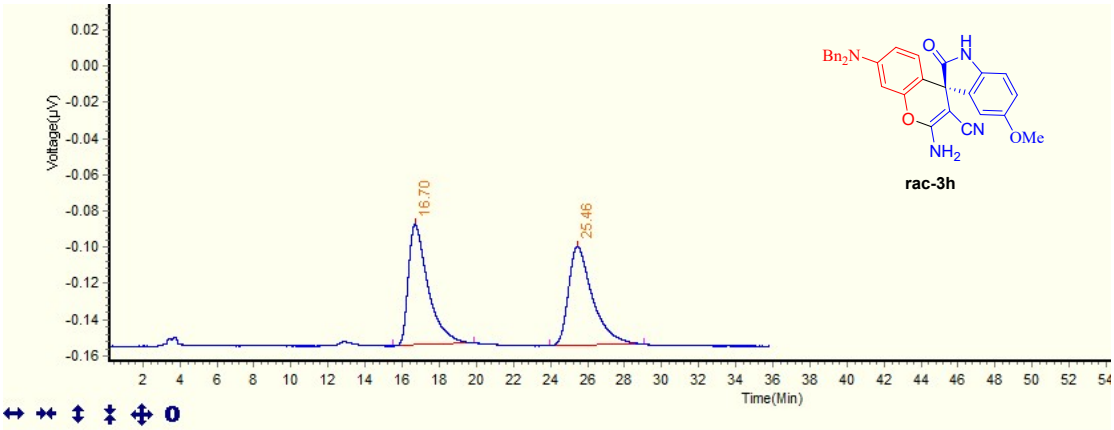
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.99	2442699	47787	49.44%	3.715	BB
2	23.38	2498351	33294	50.56%	5.246	BB
Total		4,941,050	81,081	100.00%		



3g

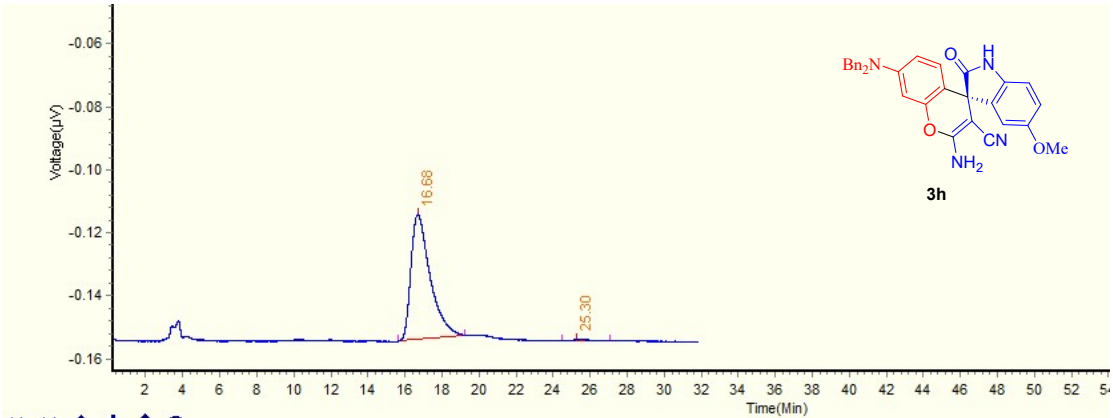
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.61	6554042	108600	99.42%	3.638	BB
2	22.52	37981	748	0.58%	1.839	BB
Total		6,592,023	109,348	100.00%		



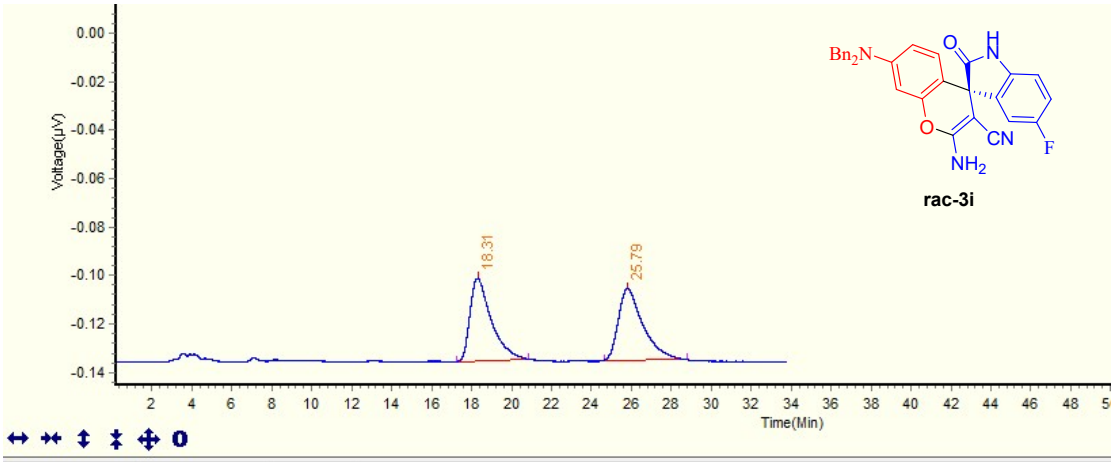
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.70	2465701	33220	50.04%	4.348	BB
2	25.46	2461370	27255	49.96%	5.079	BB
Total		4,927,071	60,475	100.00%		



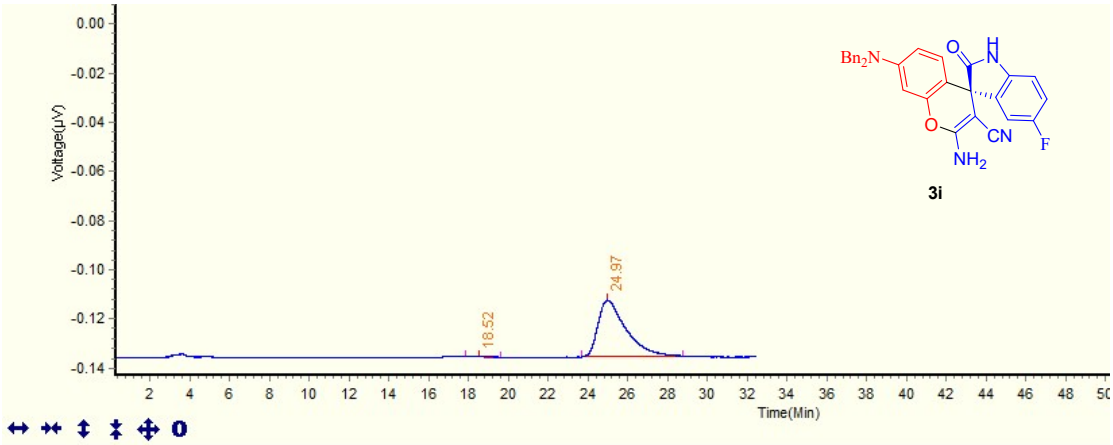
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.68	1432679	19852	98.91%	3.597	BB
2	25.30	15757	202	1.09%	2.604	BB
Total		1,448,436	20,054	100.00%		



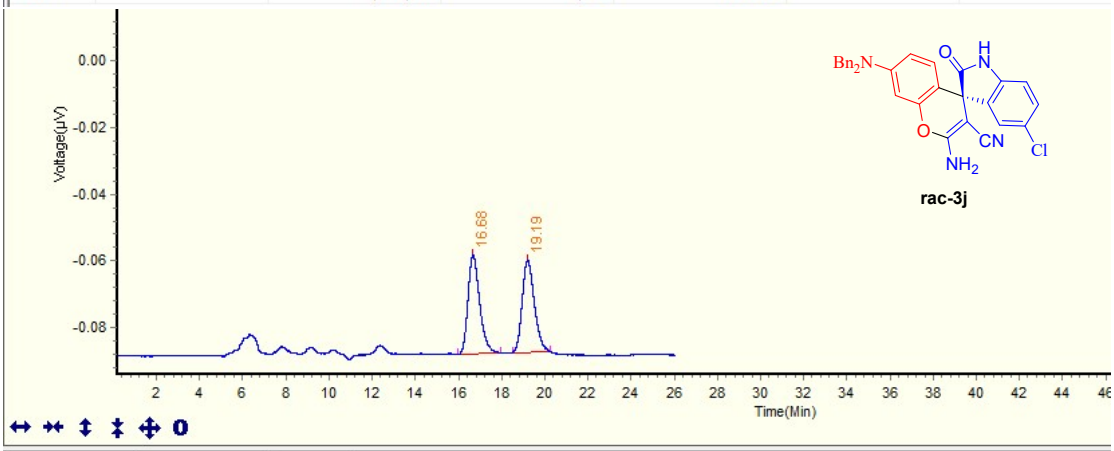
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	18.31	1258321	17025	49.91%	3.612	BB
2	25.79	1262730	14707	50.09%	4.14	BB
Total		2,521,051	31,732	100.00%		



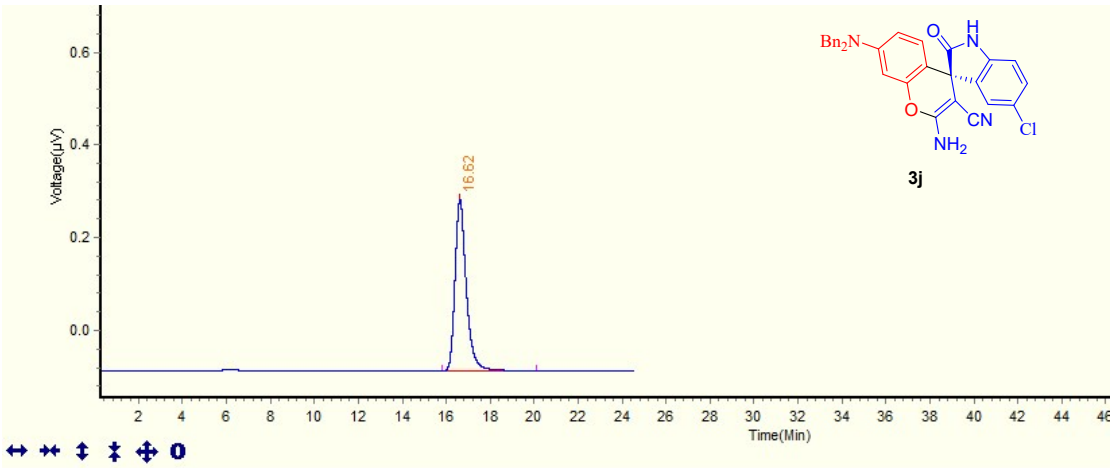
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	18.52	10186	219	0.91%	1.794	BB
2	24.97	1114452	11509	99.09%	5.07	BB
Total		1,124,638	11,728	100.00%		



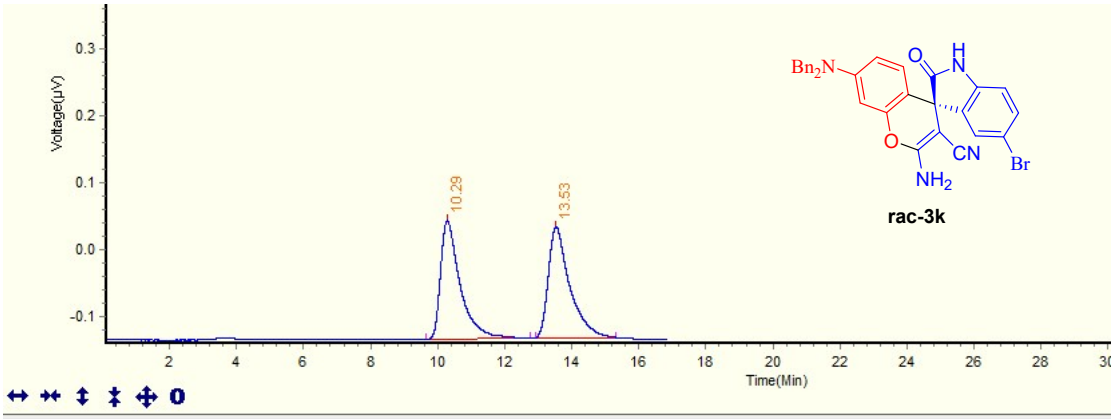
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.68	555260	14892	50.54%	1.94	BB
2	19.19	543307	13815	49.46%	1.783	BB
Total		1,098,567	28,707	100.00%		



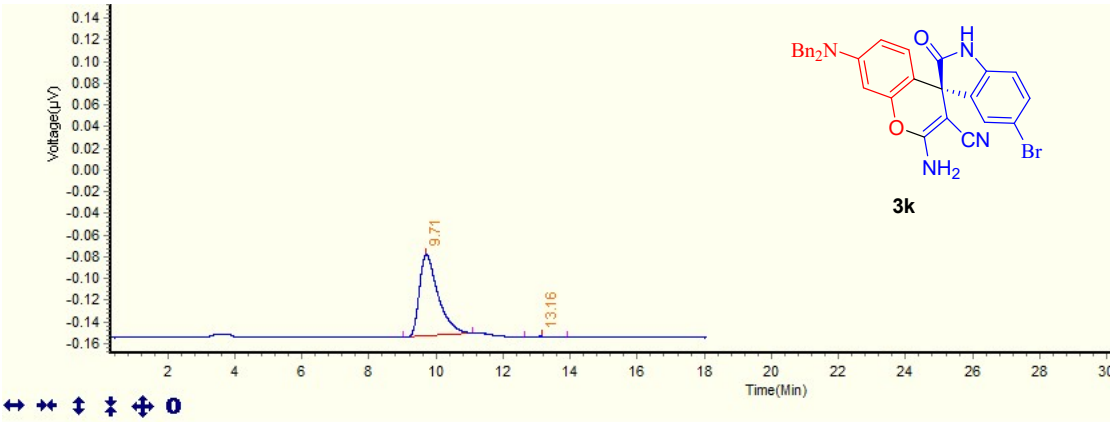
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.62	6605400	185654	100.00%	4.338	BB
Total		6,605,400	185,654	100.00%		



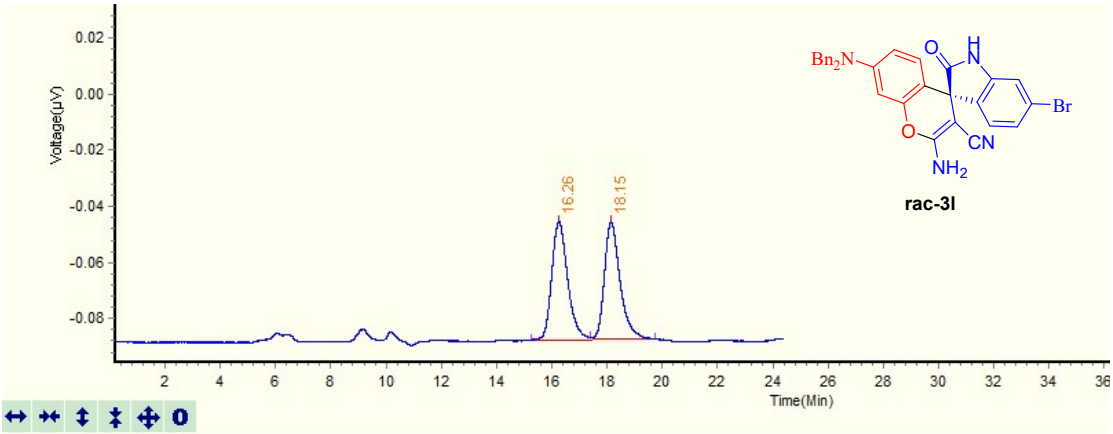
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.29	3602636	88301	49.60%	3.081	BB
2	13.53	3660346	83208	50.40%	2.412	BB
Total		7,262,982	171,509	100.00%		



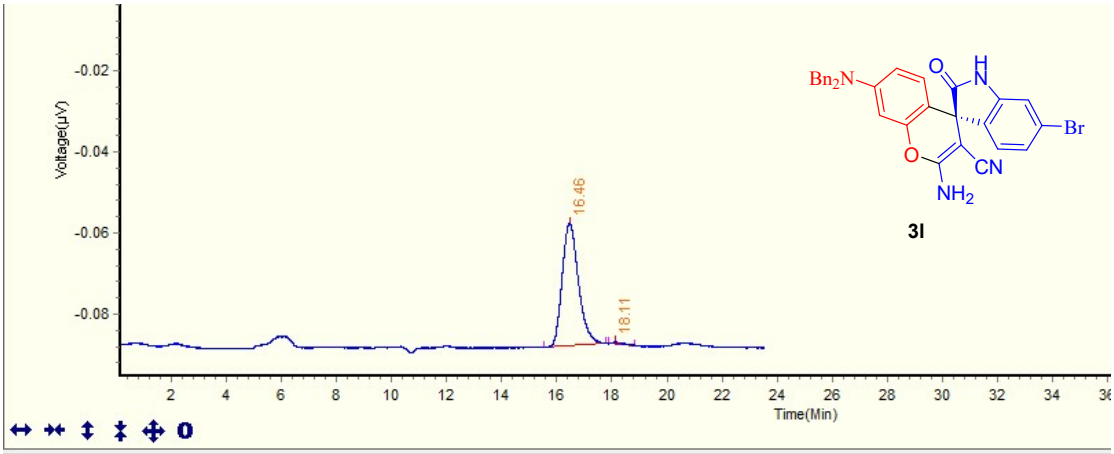
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.71	1453515	37466	99.13%	2.064	BB
2	13.16	12761	322	0.87%	1.268	BB
Total		1,466,276	37,788	100.00%		



Integration Result | Calculation Result | TimeTable

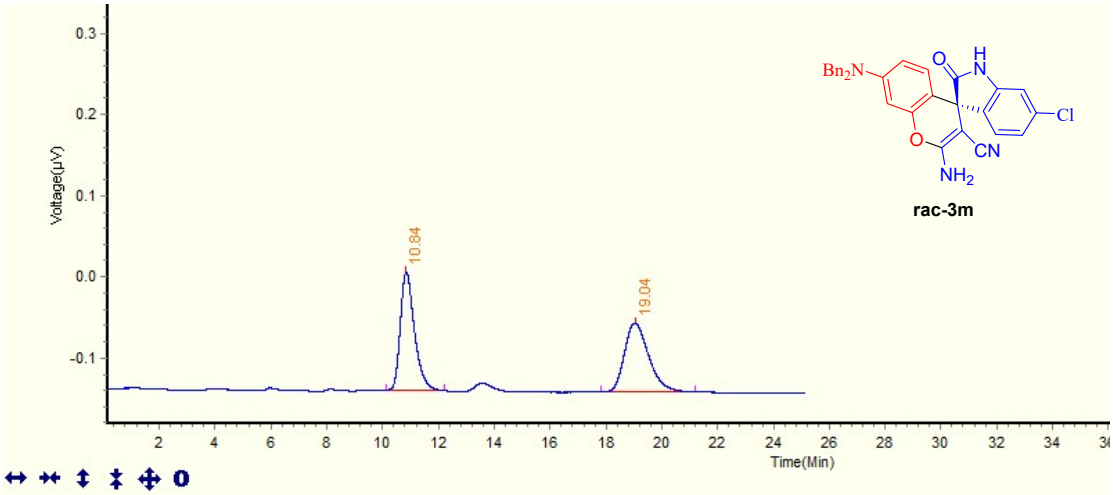
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.26	842008	21052	50.50%	2.139	BV
2	18.15	825261	20901	49.50%	2.314	VB
Total		1,667,269	41,953	100.00%		



3l

Integration Result | Calculation Result | TimeTable

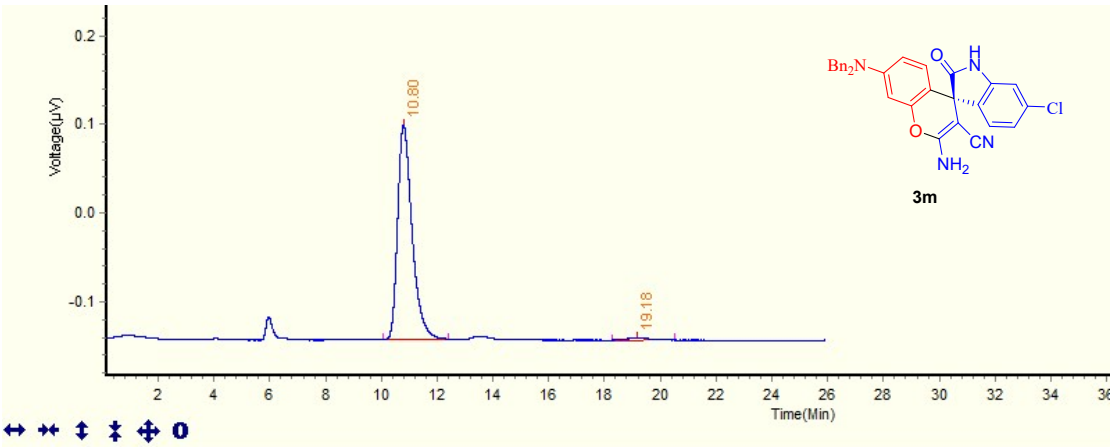
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.46	612431	14992	99.05%	2.236	BB
2	18.11	5892	243	0.95%	0.958	BB
Total		618,323	15,235	100.00%		



rac-3m

Integration Result | Calculation Result | TimeTable

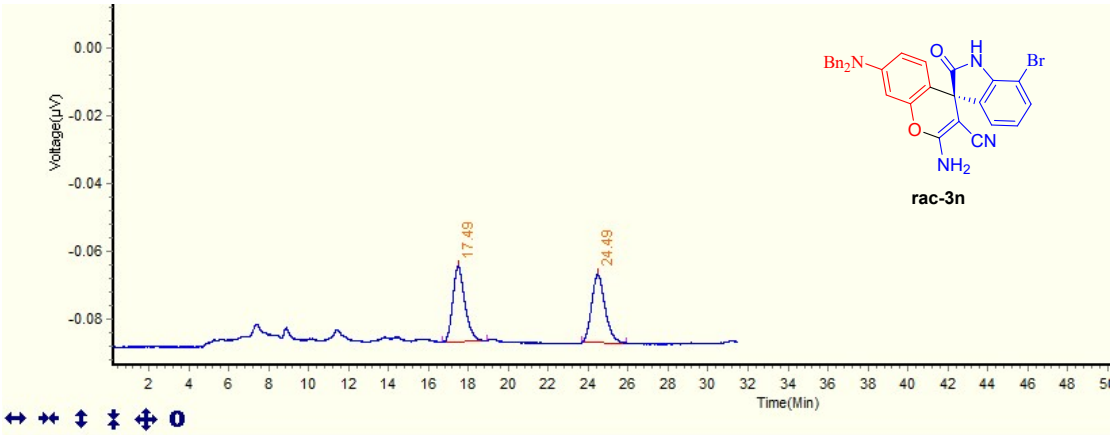
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.84	2576867	73113	50.07%	2.054	BB
2	19.04	2569436	42595	49.93%	3.383	BB
Total		5,146,303	115,708	100.00%		



3m

Integration Result | Calculation Result | TimeTable

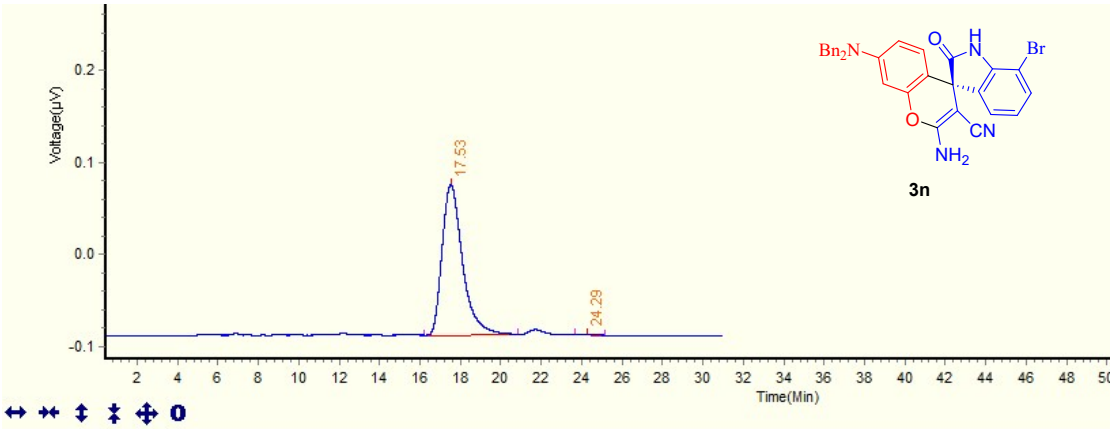
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.80	4351890	121091	98.44%	2.367	BB
2	19.18	68814	1213	1.56%	2.211	BB
Total		4,420,704	122,304	100.00%		



rac-3n

Integration Result | Calculation Result | TimeTable

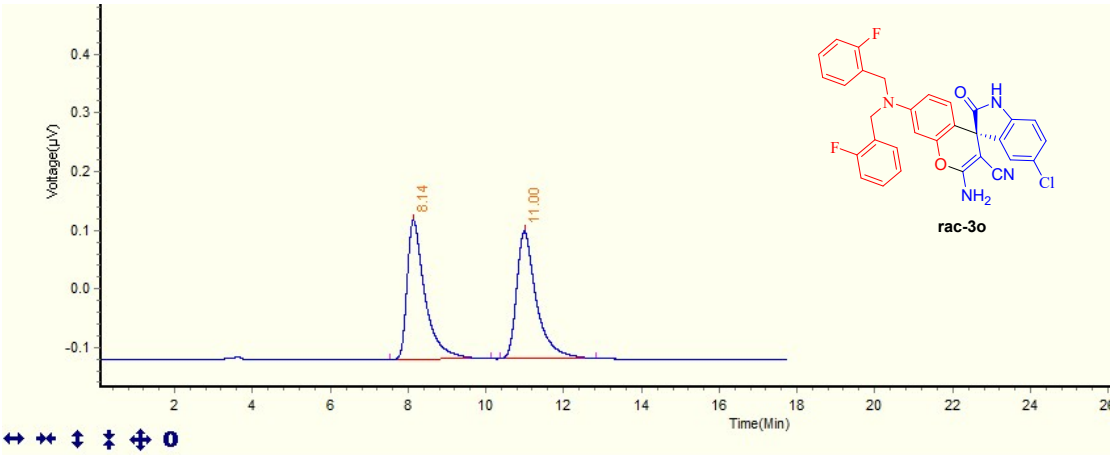
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	17.49	462013	11059	49.55%	2.273	BB
2	24.49	470483	10054	50.45%	2.198	BB
Total		932,496	21,113	100.00%		



3n

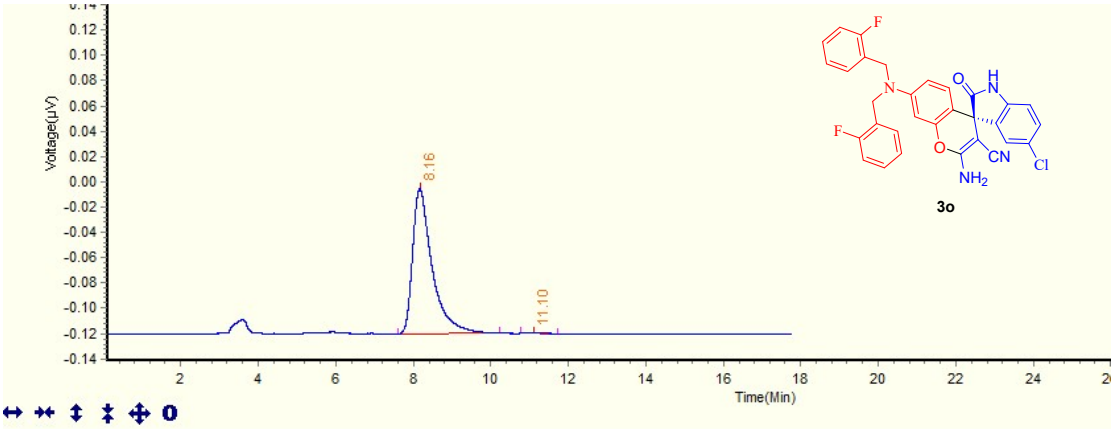
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	17.53	5693825	81431	99.62%	4.697	BB
2	24.29	21850	526	0.38%	1.454	BB
Total		5,715,675	81,957	100.00%		



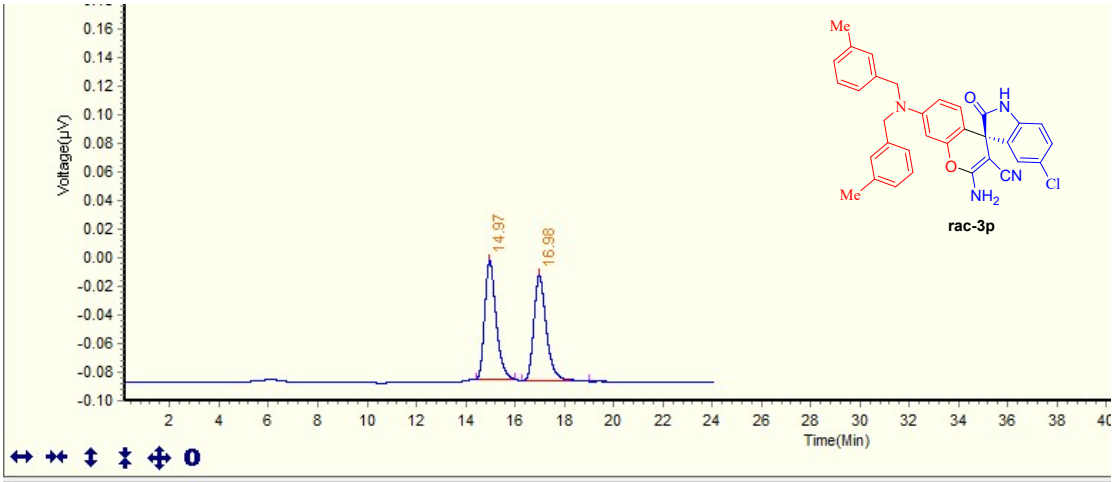
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.14	3789247	118688	49.74%	2.583	BB
2	11.00	3829274	108626	50.26%	2.476	BB
Total		7,618,521	227,314	100.00%		



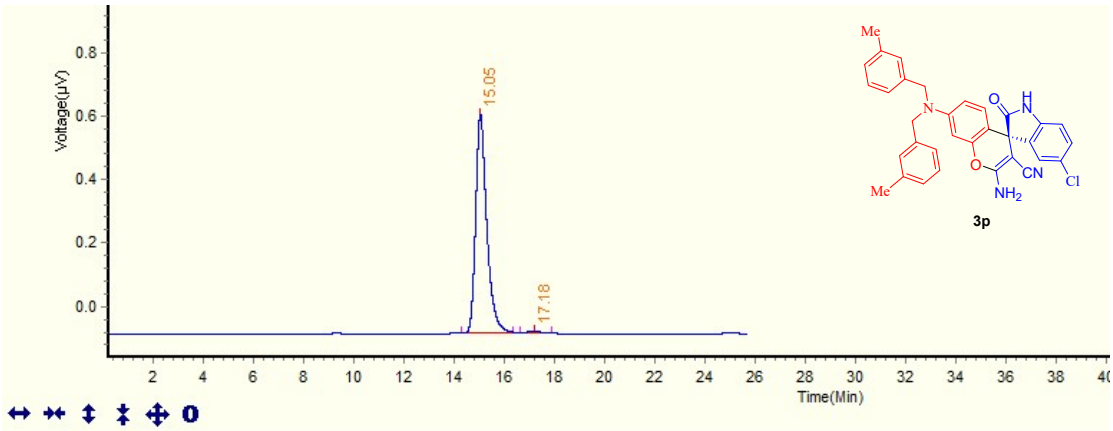
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.16	2012927	57248	99.43%	2.629	BB
2	11.10	11558	452	0.57%	0.94	BB
Total		2,024,485	57,700	100.00%		



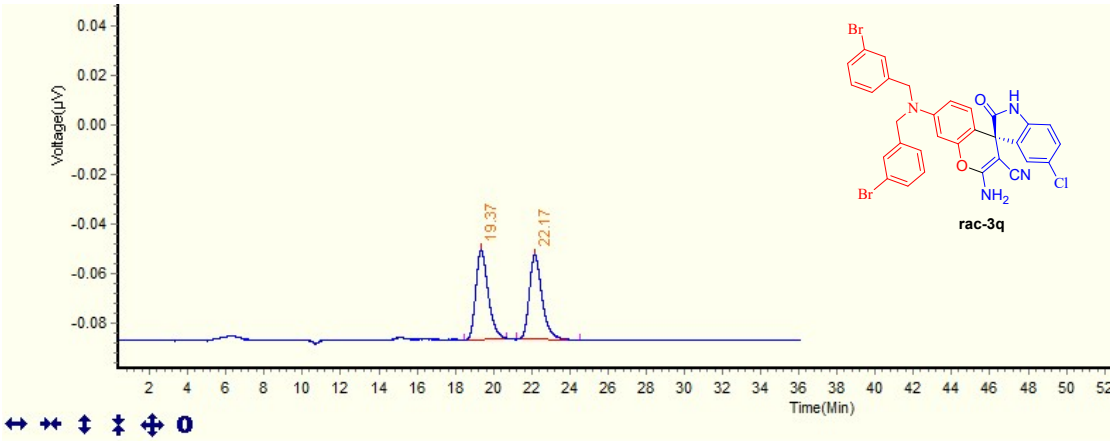
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.97	1326433	41450	50.38%	1.563	BB
2	16.98	1306544	36883	49.62%	2.692	BB
Total		2,632,977	78,333	100.00%		



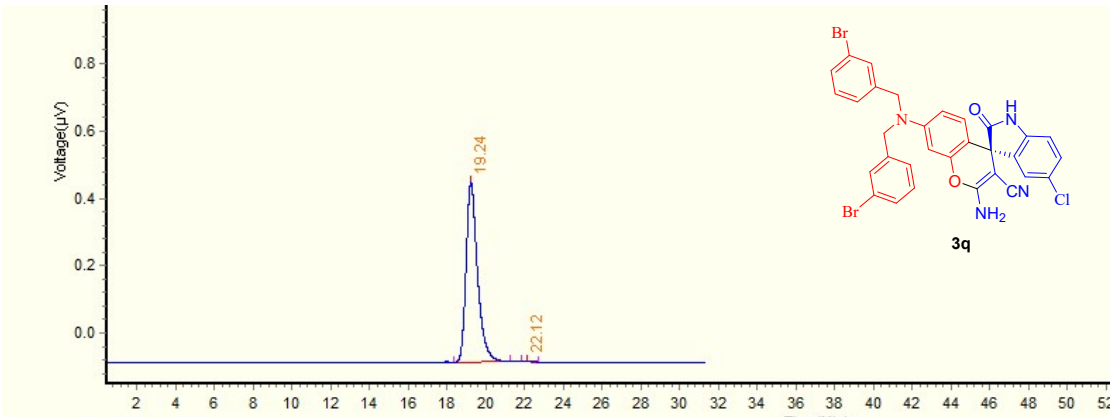
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.05	10481276	344271	99.10%	2.088	BB
2	17.18	95271	3000	0.90%	1.227	BB
Total		10,576,547	347,271	100.00%		



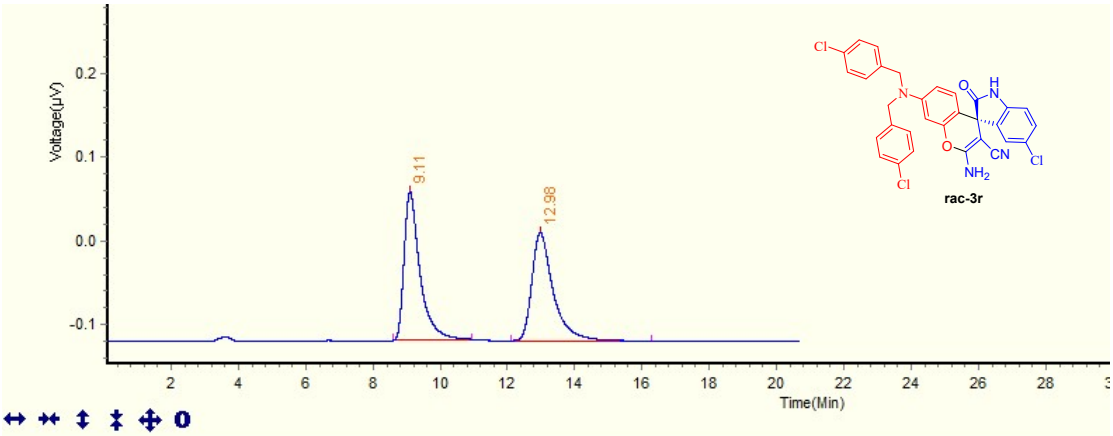
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.37	807913	18065	50.40%	2.213	BB
2	22.17	795183	17058	49.60%	3.297	BB
Total		1,603,096	35,123	100.00%		



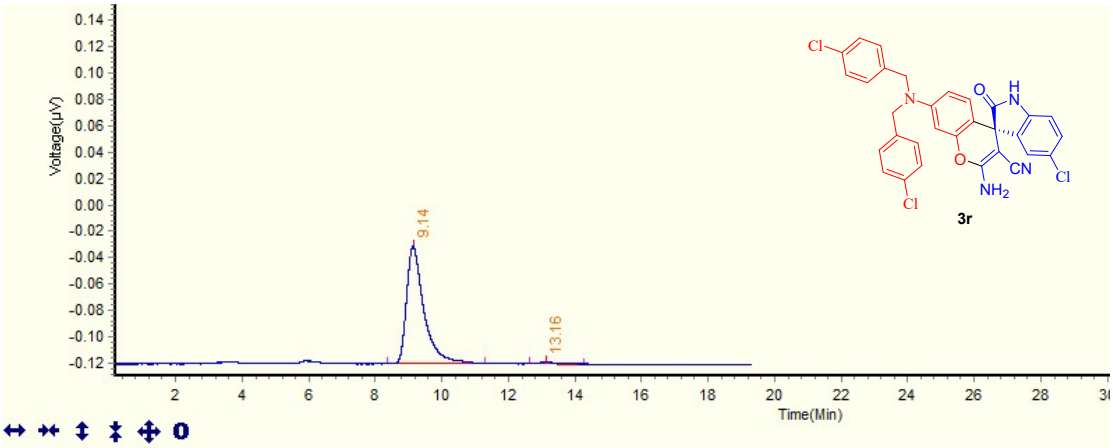
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.24	10914557	266675	99.67%	2.899	BB
2	22.12	36092	1207	0.33%	0.93	BB
Total		10,950,649	267,882	100.00%		



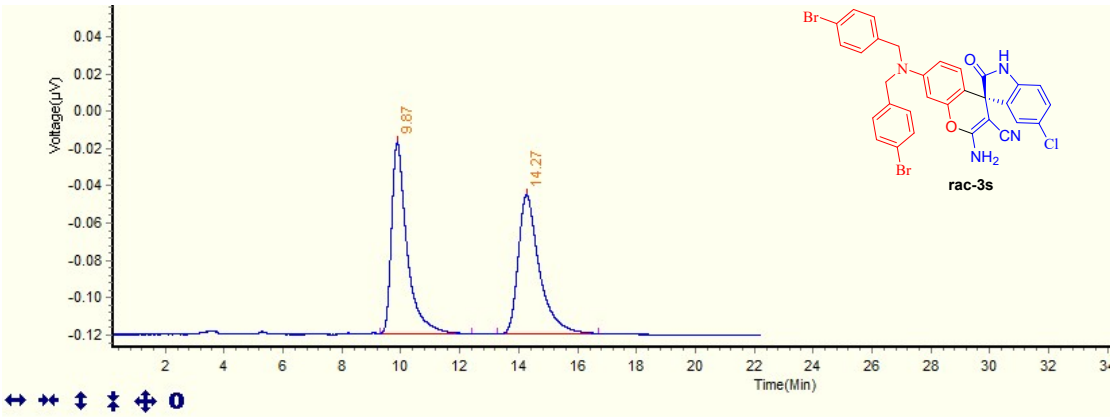
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.11	2899569	88614	50.43%	2.316	BB
2	12.98	2850564	64611	49.57%	4.182	BB
Total		5,750,133	153,225	100.00%		



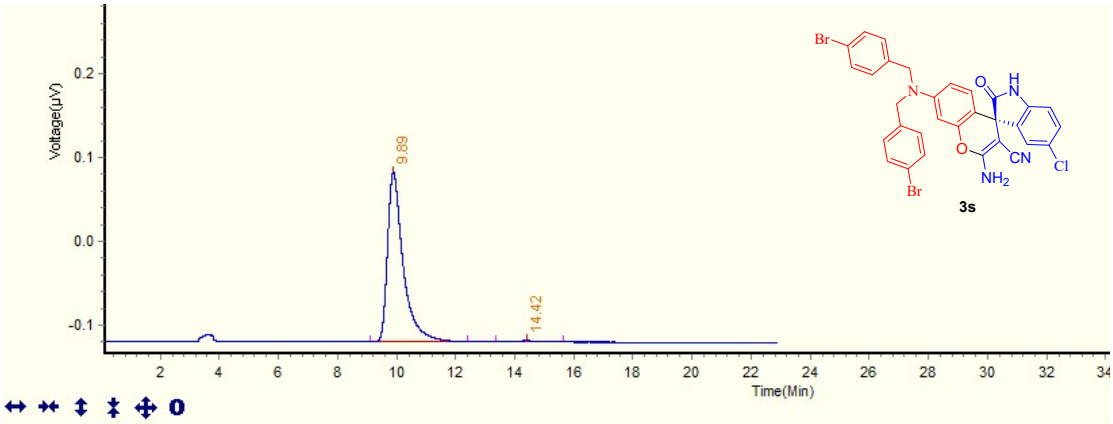
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.14	1618817	44635	98.53%	2.93	BB
2	13.16	24150	605	1.47%	1.628	BB
Total		1,642,967	45,240	100.00%		



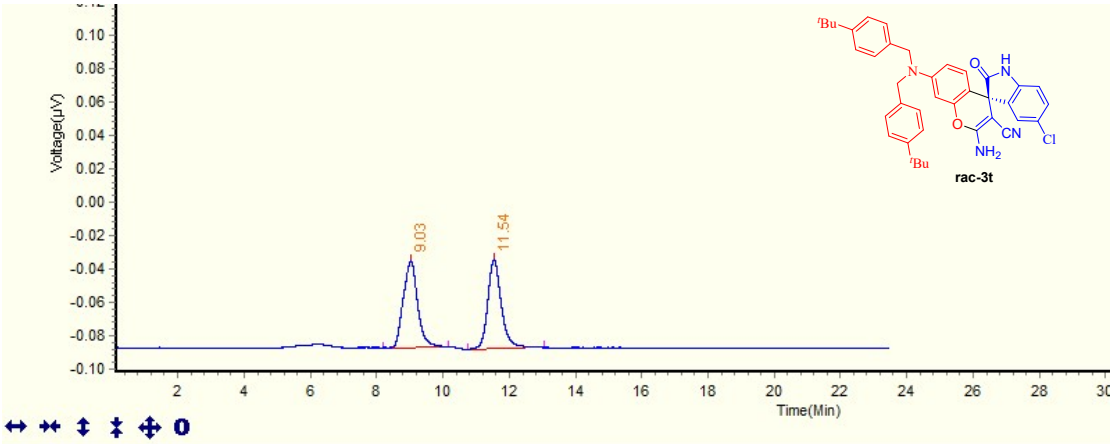
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.87	1868644	51314	50.10%	3.125	BB
2	14.27	1861407	37324	49.90%	3.419	BB
Total		3,730,051	88,638	100.00%		



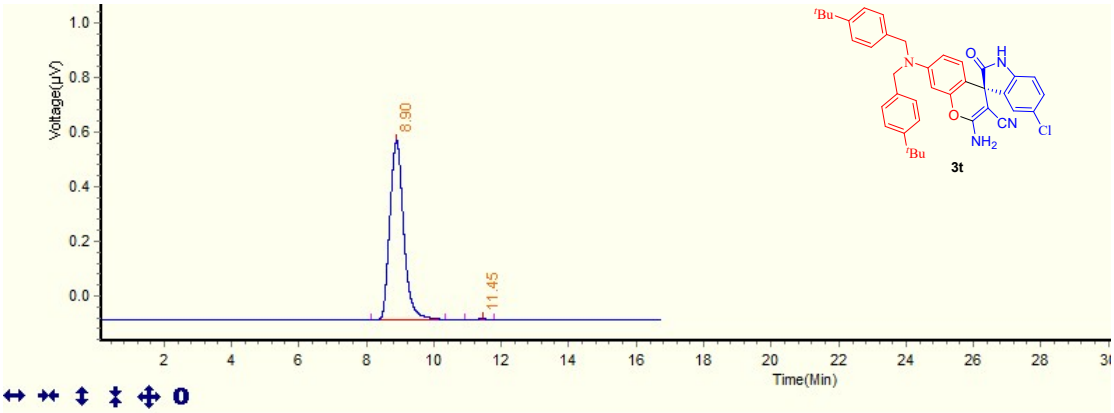
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.89	3725931	101321	99.07%	3.276	BB
2	14.42	35120	781	0.93%	2.258	BB
Total		3,761,051	102,102	100.00%		



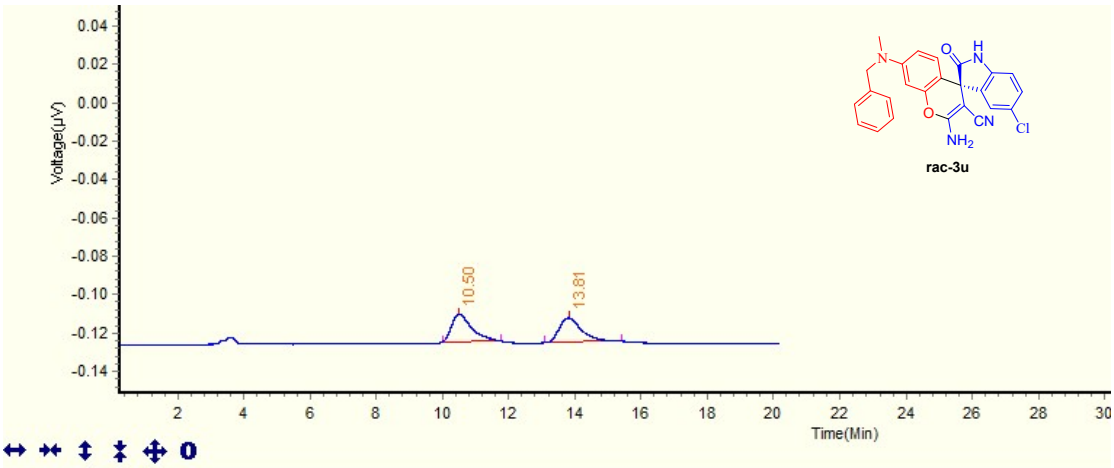
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.03	768791	25842	50.13%	1.947	BB
2	11.54	764924	26614	49.87%	2.313	BB
Total		1,533,715	52,456	100.00%		



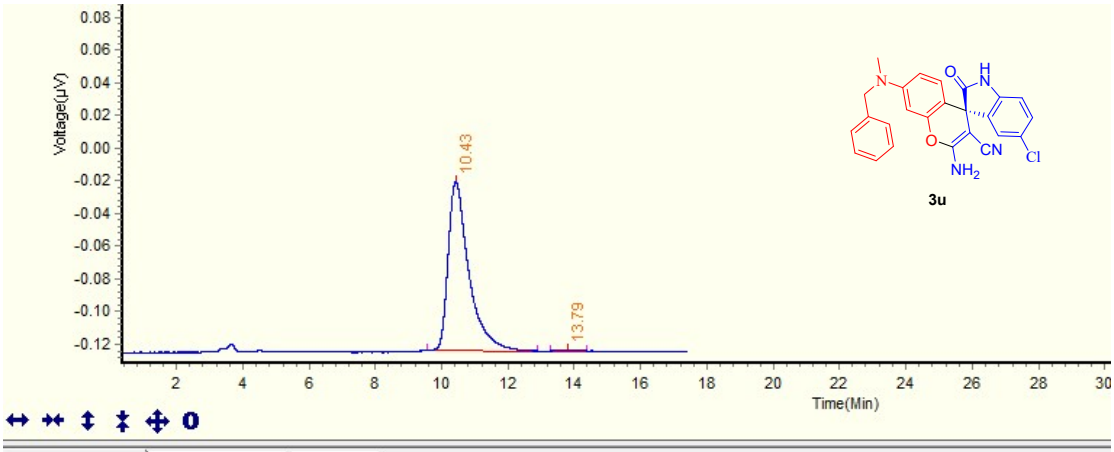
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.90	9331843	328048	99.58%	2.191	BB
2	11.45	39295	1757	0.42%	0.865	BB
Total		9,371,138	329,805	100.00%		



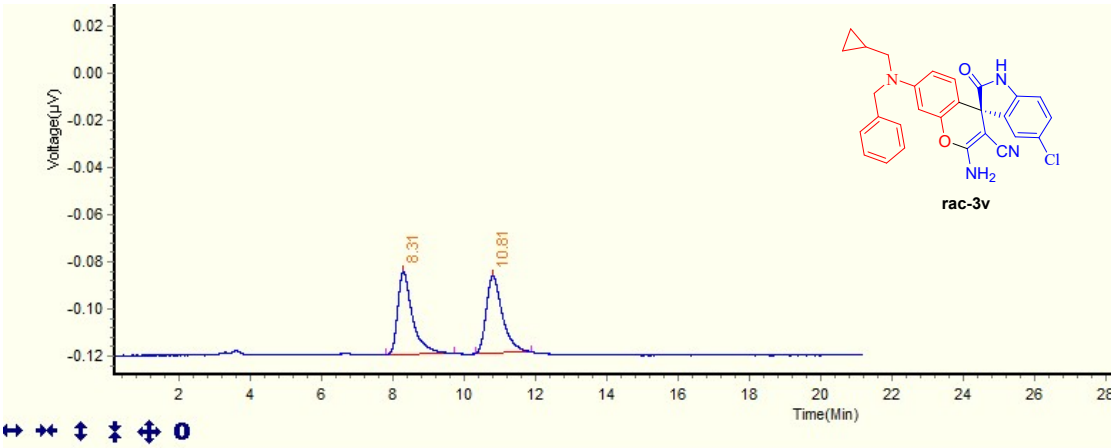
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.50	299858	7086	50.07%	1.746	BB
2	13.81	299018	6331	49.93%	2.328	BB
Total		598,876	13,417	100.00%		



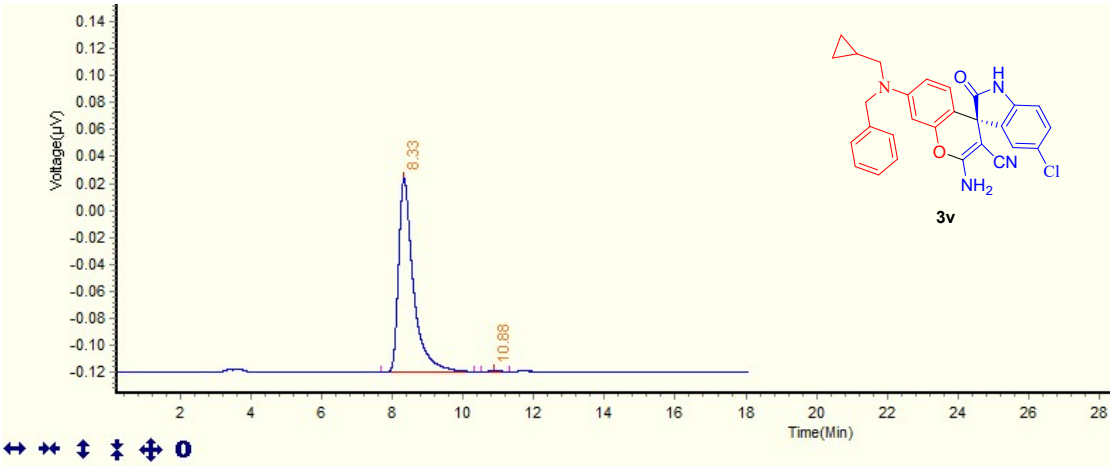
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.43	2249780	51884	99.28%	3.333	BB
2	13.79	16267	469	0.72%	1.09	BB
Total		2,266,047	52,353	100.00%		



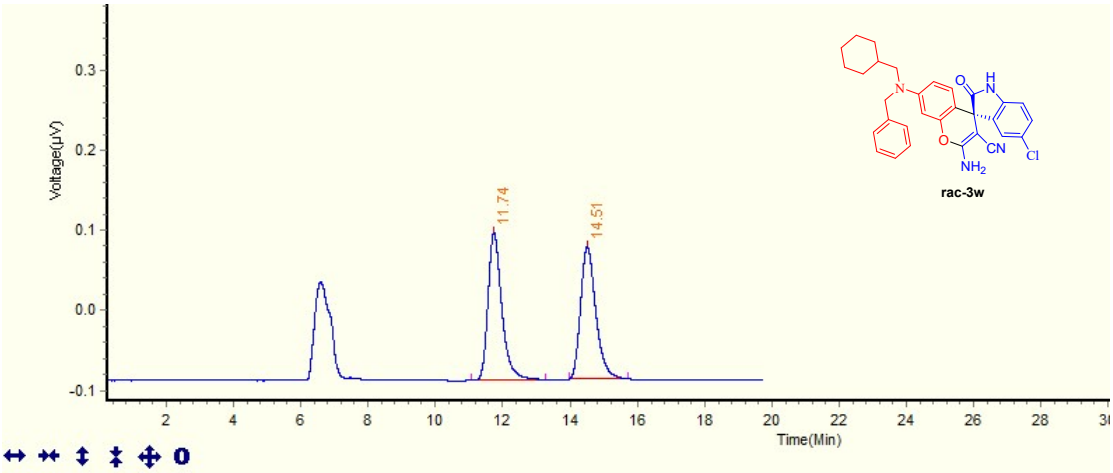
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.31	504571	17597	49.51%	1.908	BB
2	10.81	514565	16451	50.49%	1.577	BB
Total		1,019,136	34,048	100.00%		



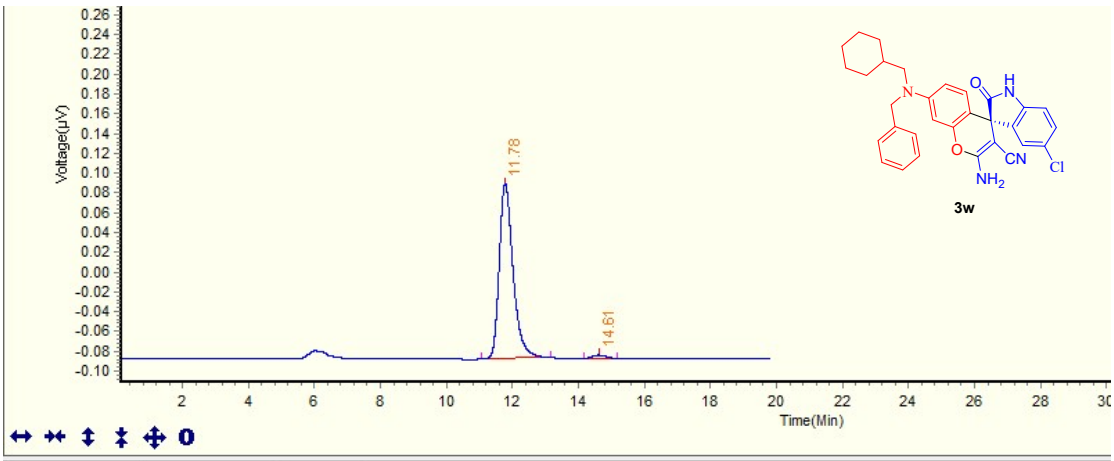
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.33	2093673	71768	99.59%	2.609	BB
2	10.88	8581	401	0.41%	0.805	BB
Total		2,102,254	72,169	100.00%		



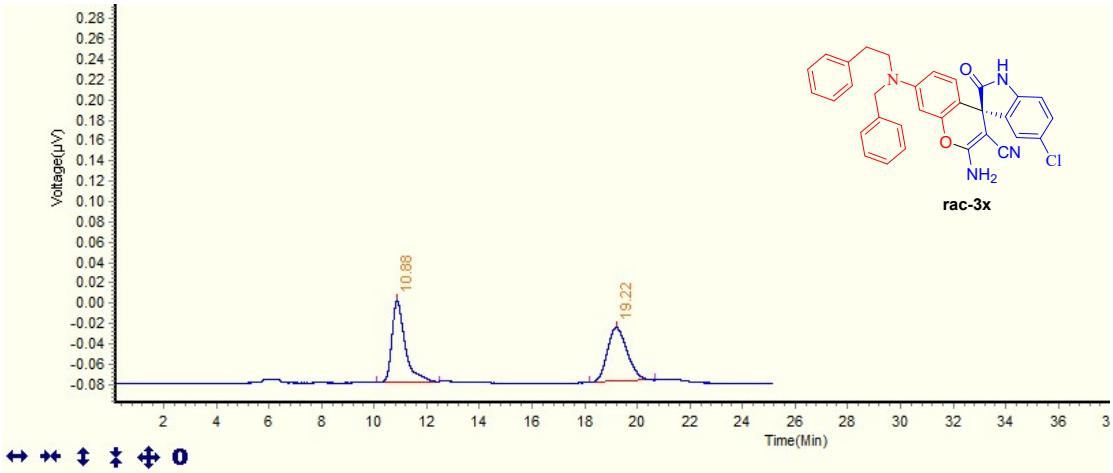
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.74	2628534	92263	50.13%	2.207	BB
2	14.51	2614448	82767	49.87%	1.756	BB
Total		5,242,982	175,030	100.00%		



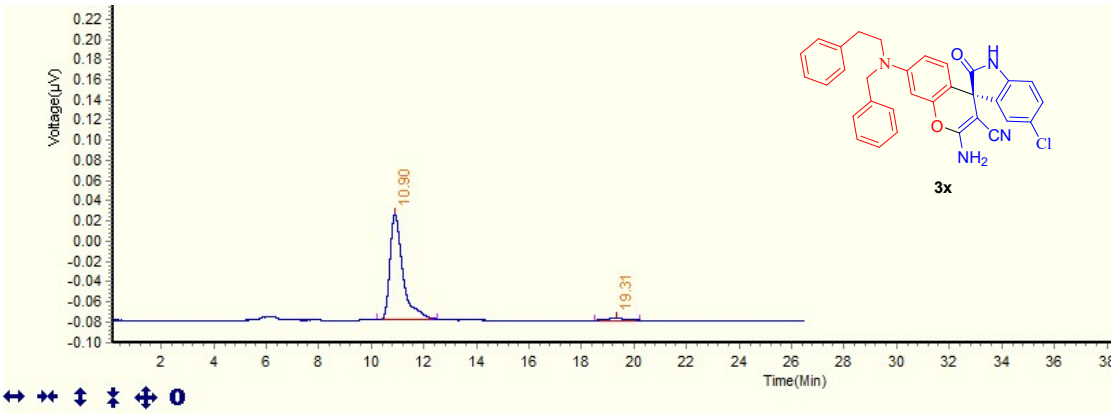
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.78	2575436	88279	98.18%	2.096	BB
2	14.61	47647	1712	1.82%	1.0	BB
Total		2,623,083	89,991	100.00%		



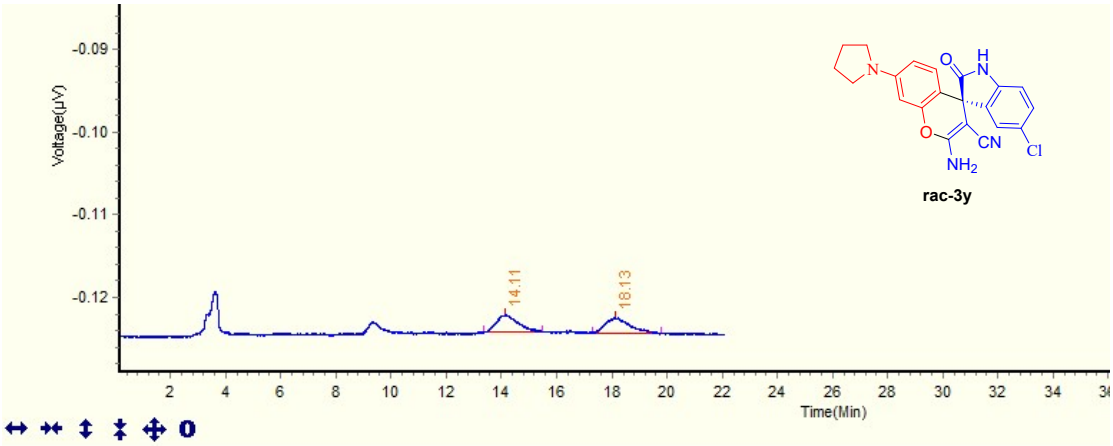
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.88	1385264	40107	49.84%	2.42	BB
2	19.22	1394025	26445	50.16%	2.48	BB
Total		2,779,289	66,552	100.00%		



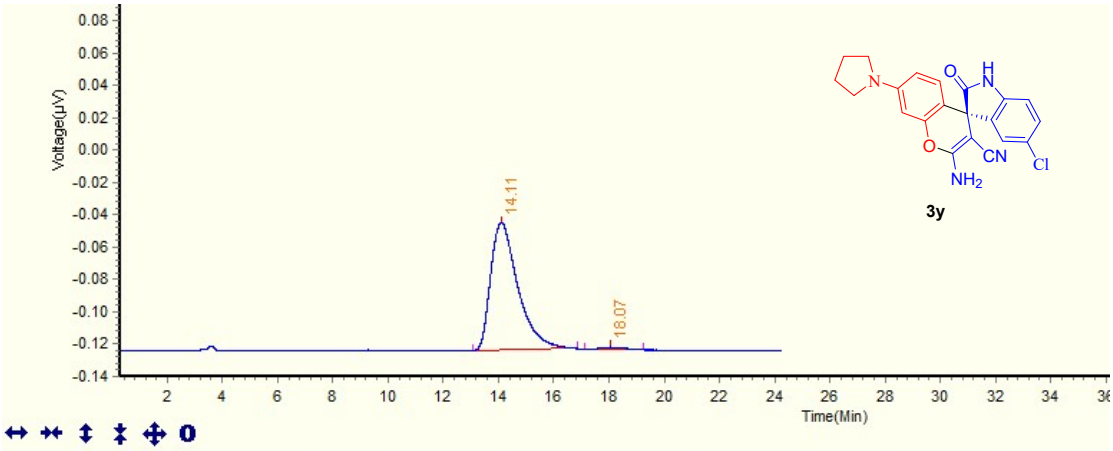
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.90	1776752	52042	97.38%	2.294	BB
2	19.31	47784	962	2.62%	1.721	BB
Total		1,824,536	53,004	100.00%		



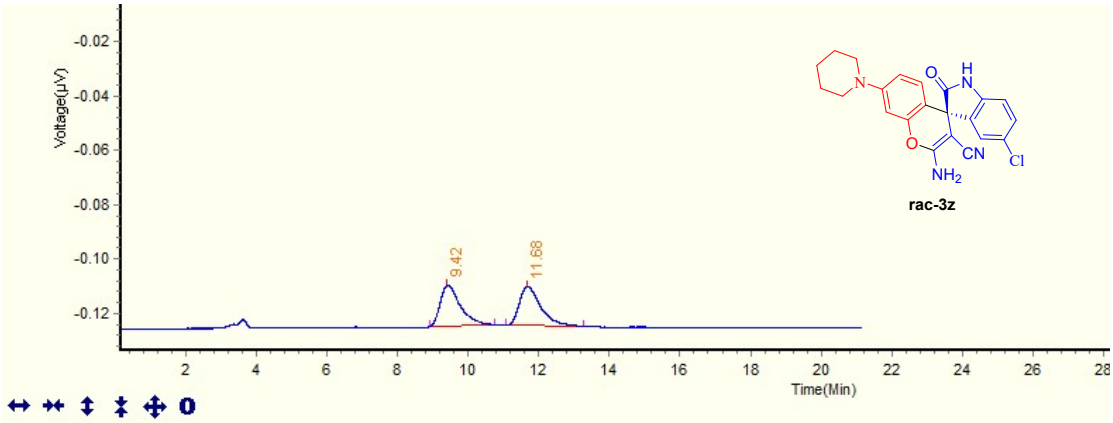
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.11	56369	1035	50.15%	2.119	BB
2	18.13	56023	915	49.85%	2.516	BB
Total		112,392	1,950	100.00%		



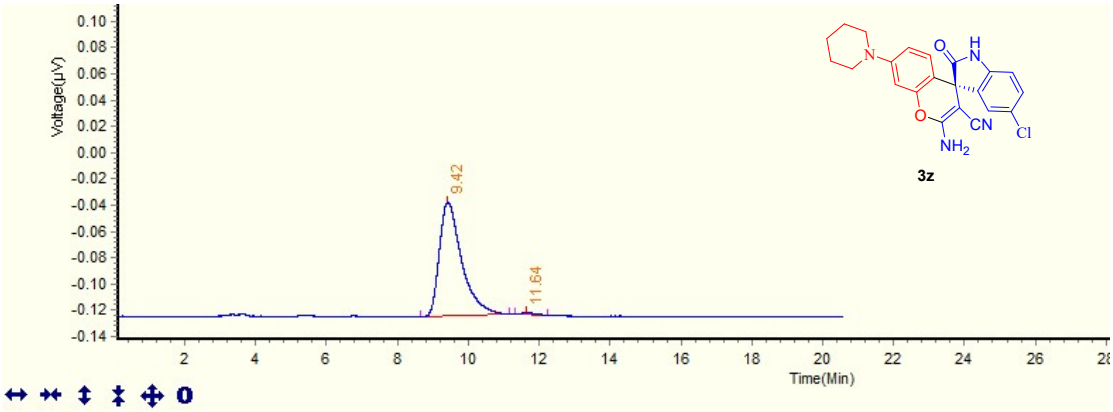
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.11	2716071	39481	98.60%	3.818	BB
2	18.07	38619	710	1.40%	2.128	BB
Total		2,754,690	40,191	100.00%		



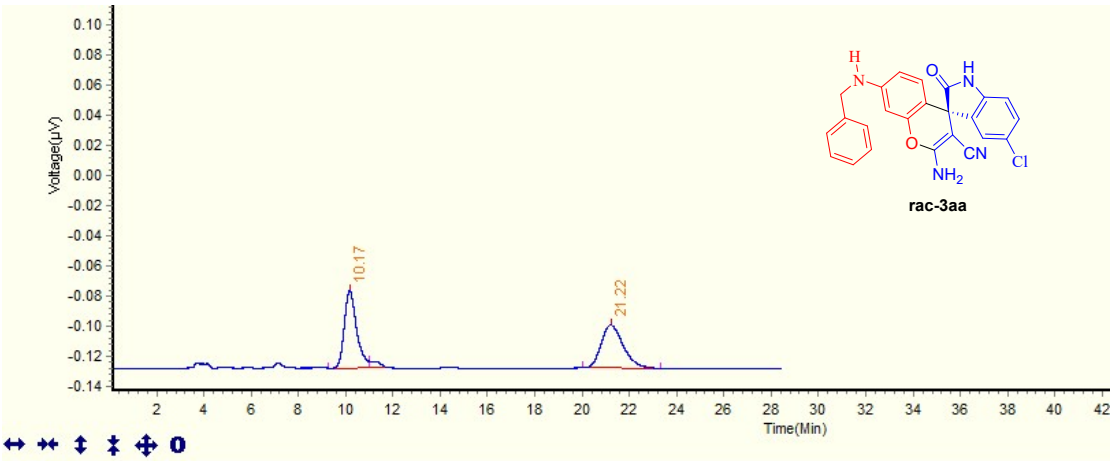
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.42	299053	7551	49.85%	1.858	BB
2	11.68	300814	7258	50.15%	2.188	BB
Total		599,867	14,809	100.00%		



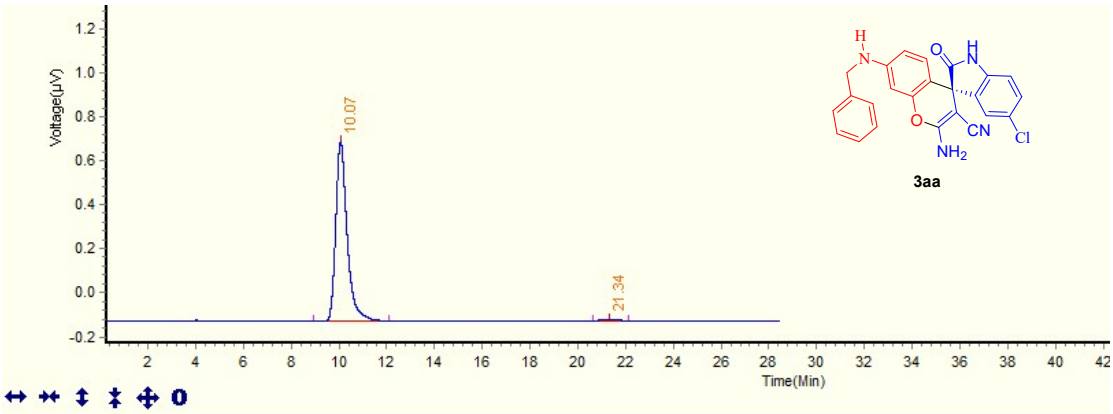
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.42	1892849	43393	99.05%	2.522	BB
2	11.64	18185	658	0.95%	0.915	BB
Total		1,911,034	44,051	100.00%		



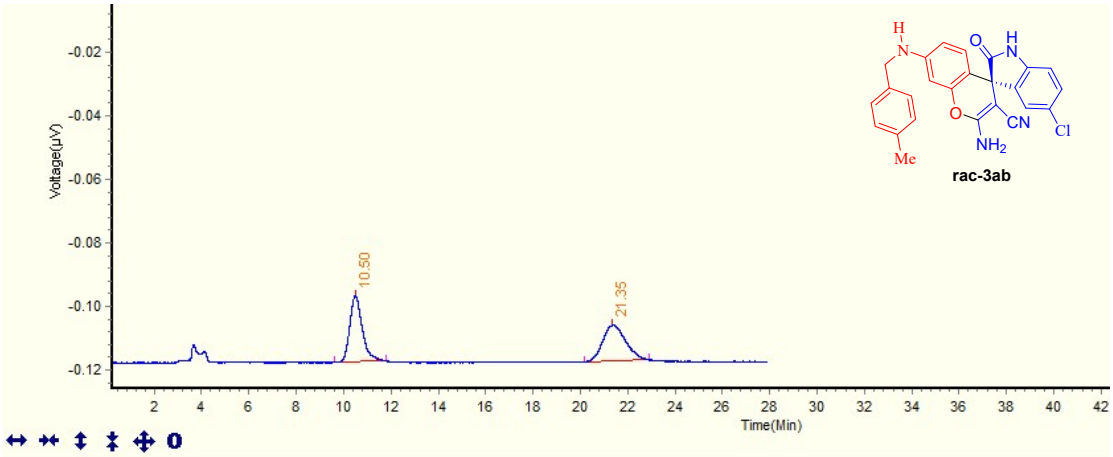
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.17	926342	25508	49.86%	1.743	BV
2	21.22	931403	14243	50.14%	3.314	BB
Total		1,857,745	39,751	100.00%		



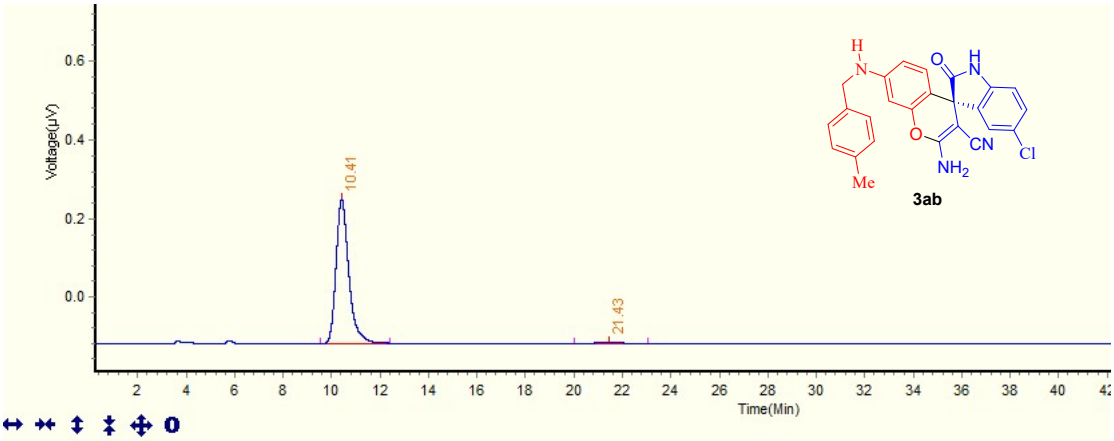
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.07	13421198	407037	98.99%	3.13	BB
2	21.34	137506	2744	1.01%	1.531	BB
Total		13,558,704	409,781	100.00%		



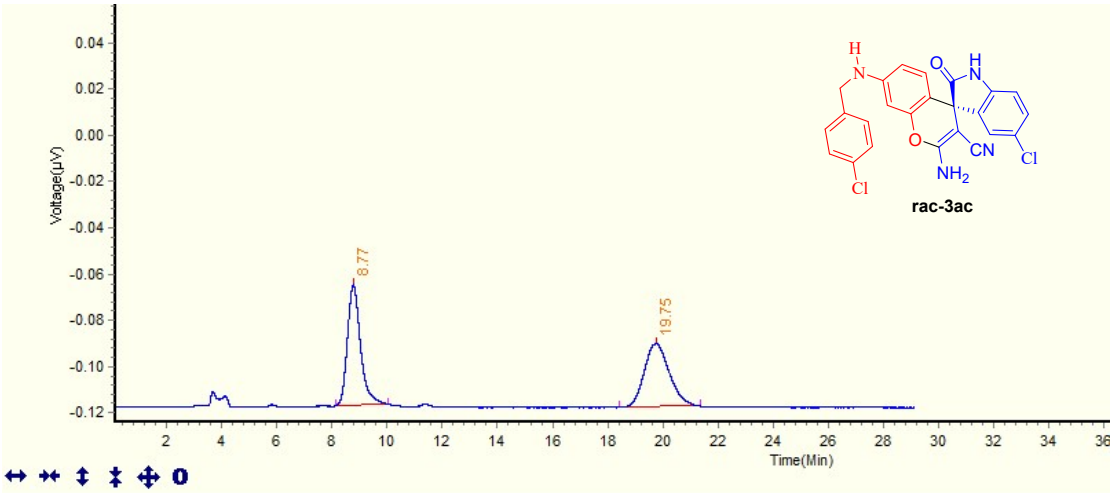
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.50	385133	10352	50.53%	2.213	BB
2	21.35	377083	5628	49.47%	2.716	BB
Total		762,216	15,980	100.00%		



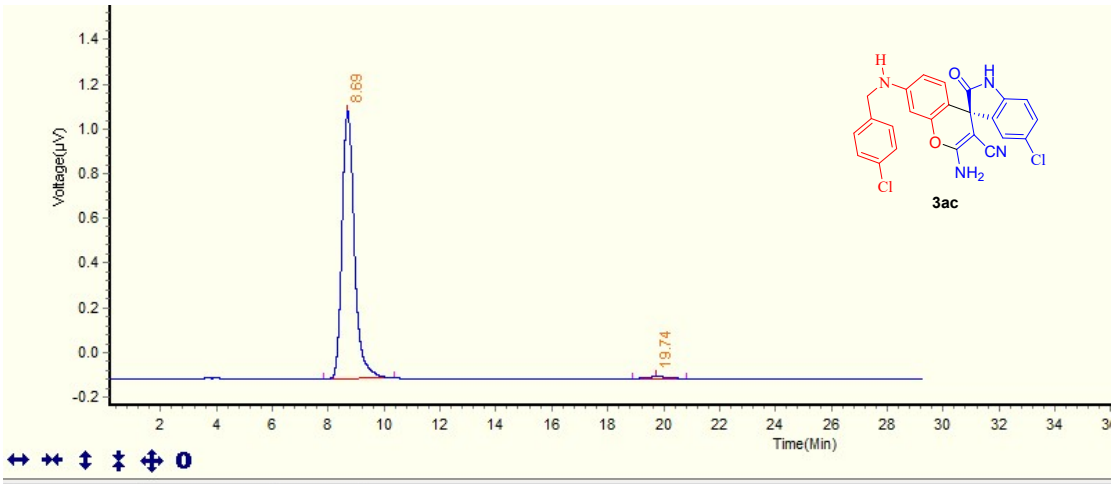
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.41	6692405	183195	97.91%	2.827	BB
2	21.43	142702	2123	2.09%	3.029	BB
Total		6,835,107	185,318	100.00%		



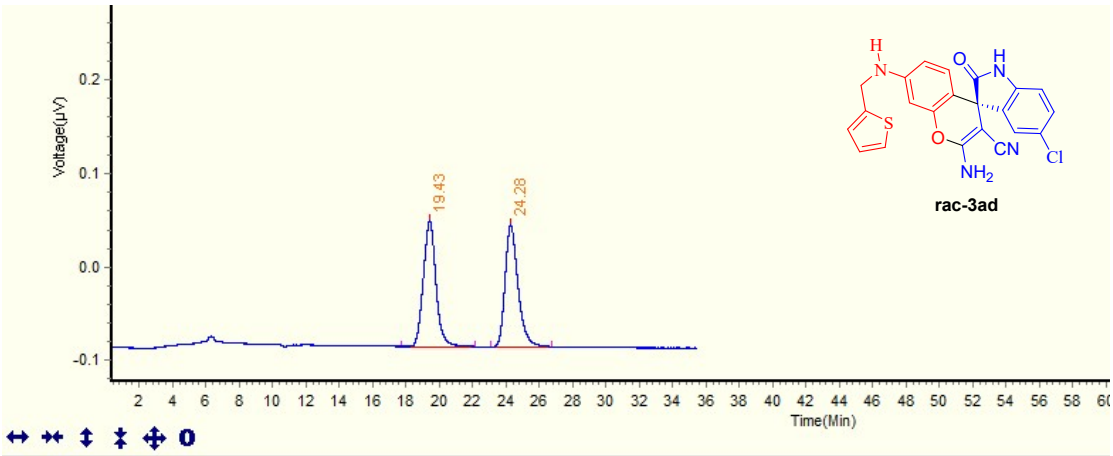
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.77	860076	26042	49.91%	1.925	BB
2	19.75	863203	13680	50.09%	2.942	BB
Total		1,723,279	39,722	100.00%		



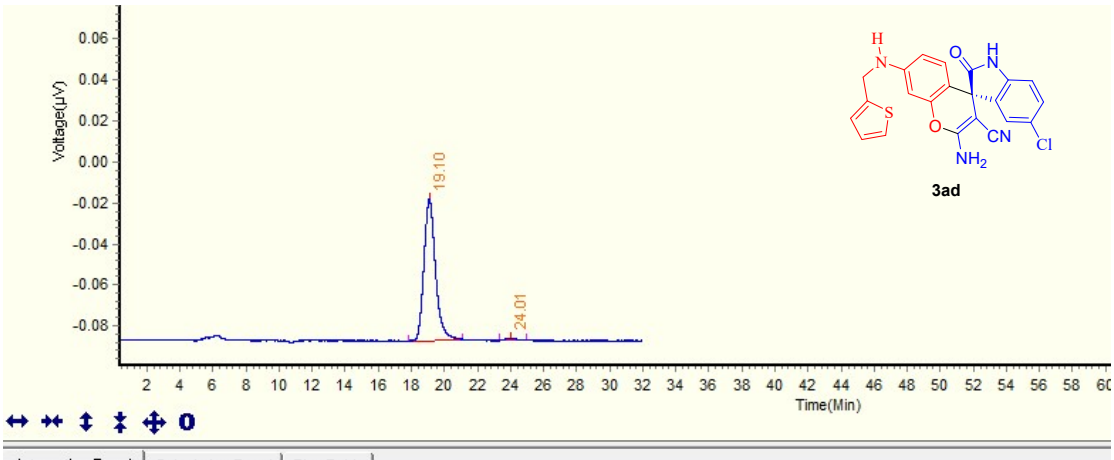
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	8.69	18394867	598881	98.59%	2.543	BB
2	19.74	262141	4693	1.41%	1.916	BB
Total		18,657,008	603,574	100.00%		



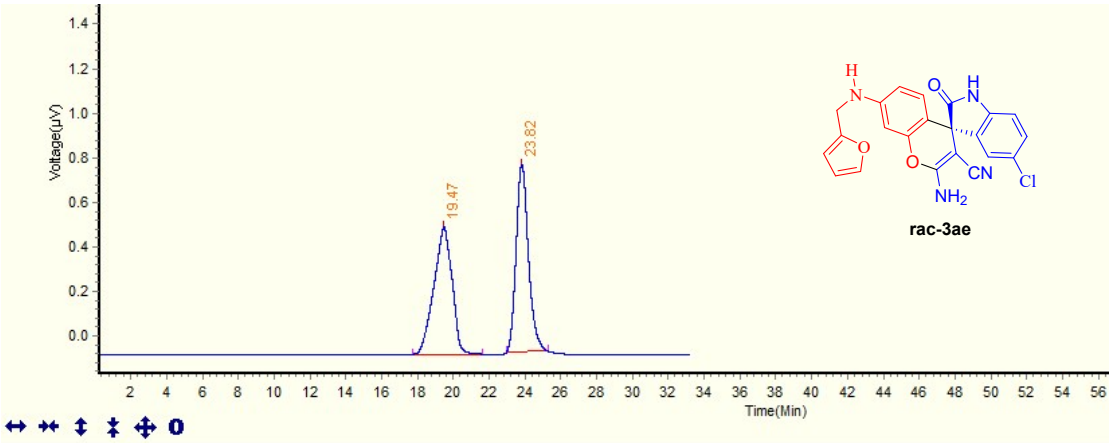
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.43	3535984	67120	50.24%	4.437	BB
2	24.28	3502624	64919	49.76%	3.584	BB
Total		7,038,608	132,039	100.00%		



Integration Result | Calculation Result | TimeTable

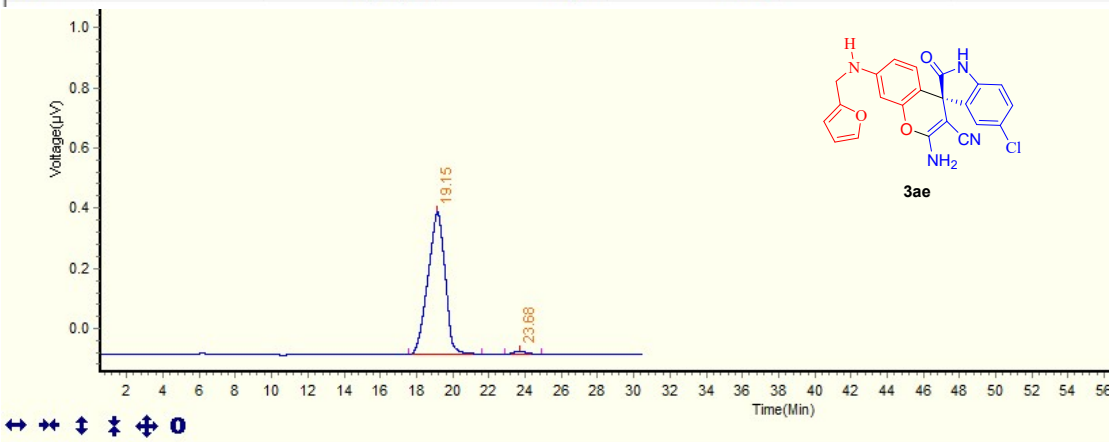
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.10	1661364	34219	98.48%	3.266	BB
2	24.01	25606	552	1.52%	1.652	BB
Total		1,686,970	34,771	100.00%		



rac-3ae

Integration Result | Calculation Result | TimeTable

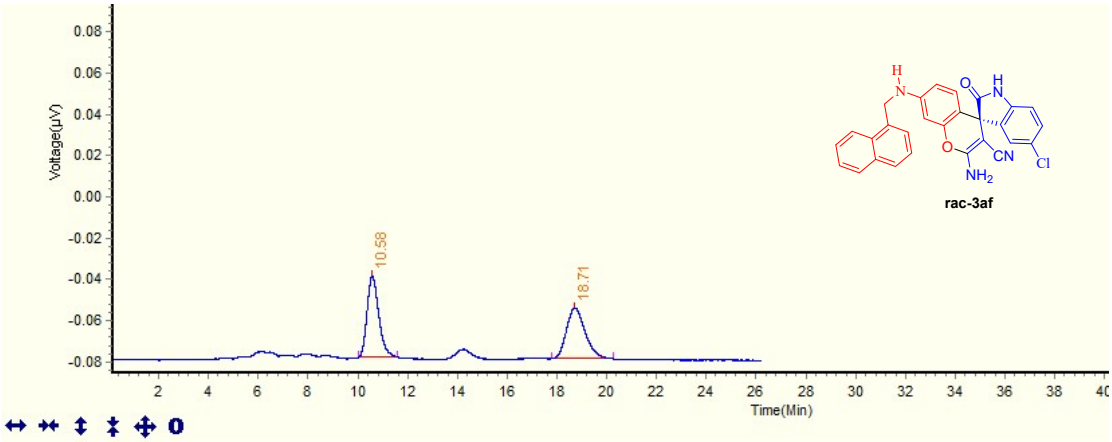
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.47	20132448	286283	49.93%	3.973	BB
2	23.82	20191664	421028	50.07%	2.344	BB
Total		40,324,112	707,311	100.00%		



3ae

Integration Result | Calculation Result | TimeTable

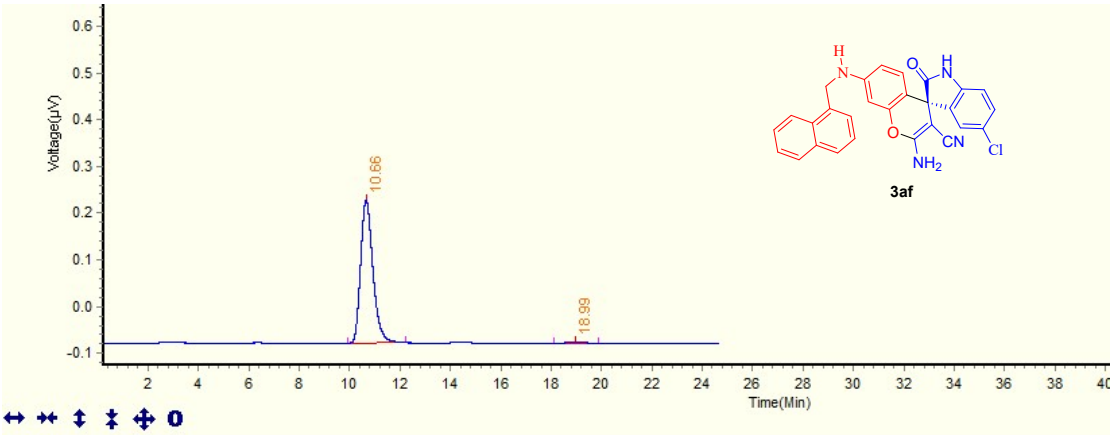
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	19.15	15429170	235903	98.13%	4.034	BB
2	23.68	293486	5628	1.87%	2.017	BB
Total		15,722,656	241,531	100.00%		



rac-3af

Integration Result | Calculation Result | TimeTable

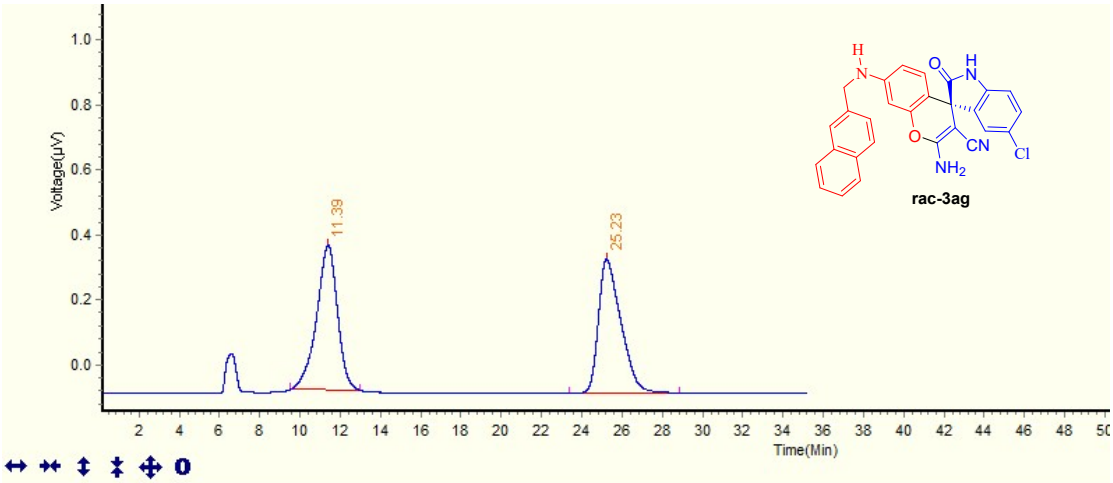
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.58	641783	19613	50.08%	1.545	BB
2	18.71	639685	12330	49.92%	2.492	BB
Total		1,281,468	31,943	100.00%		



3af

Integration Result | Calculation Result | TimeTable

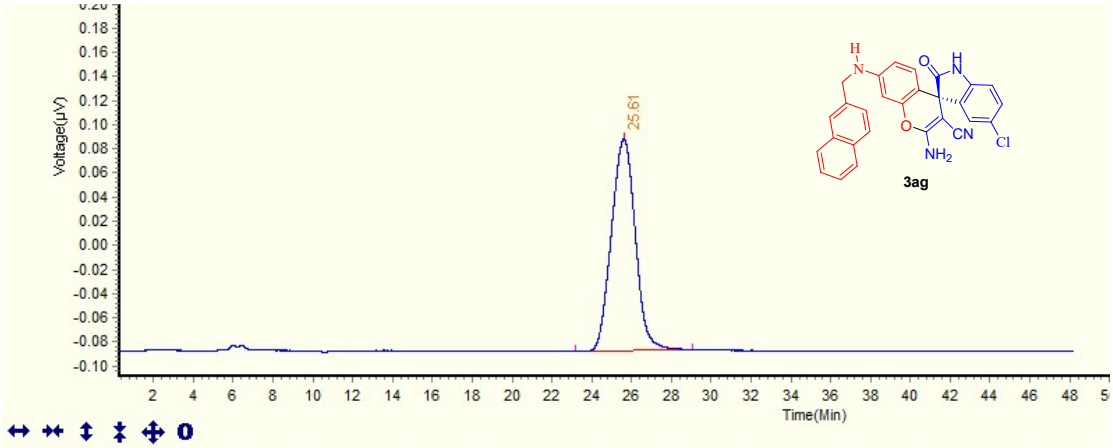
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.66	5199916	152524	98.63%	2.343	BB
2	18.99	72042	1451	1.37%	1.809	BB
Total		5,271,958	153,975	100.00%		



rac-3ag

Integration Result | Calculation Result | TimeTable

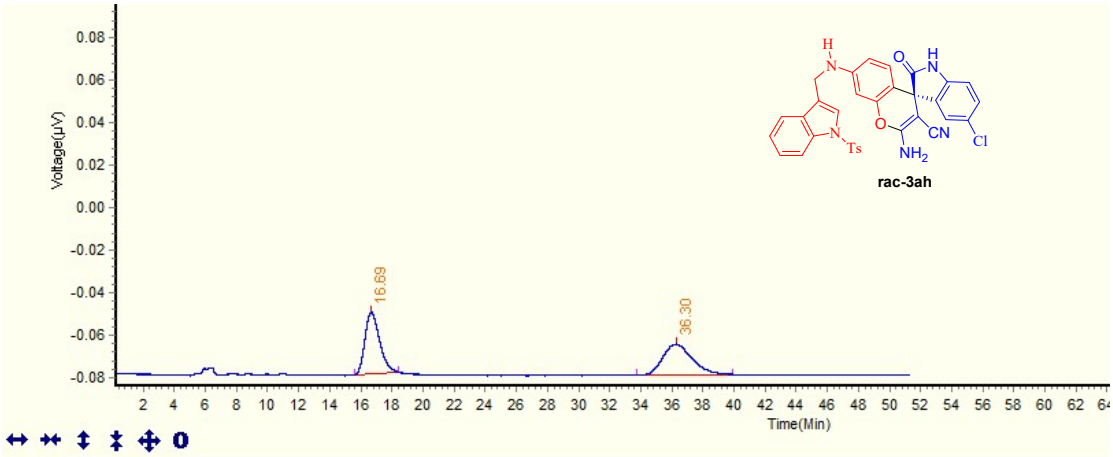
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.39	15981931	222229	50.07%	3.447	BB
2	25.23	15939494	206759	49.93%	5.464	BB
Total		31,921,425	428,988	100.00%		



3ag

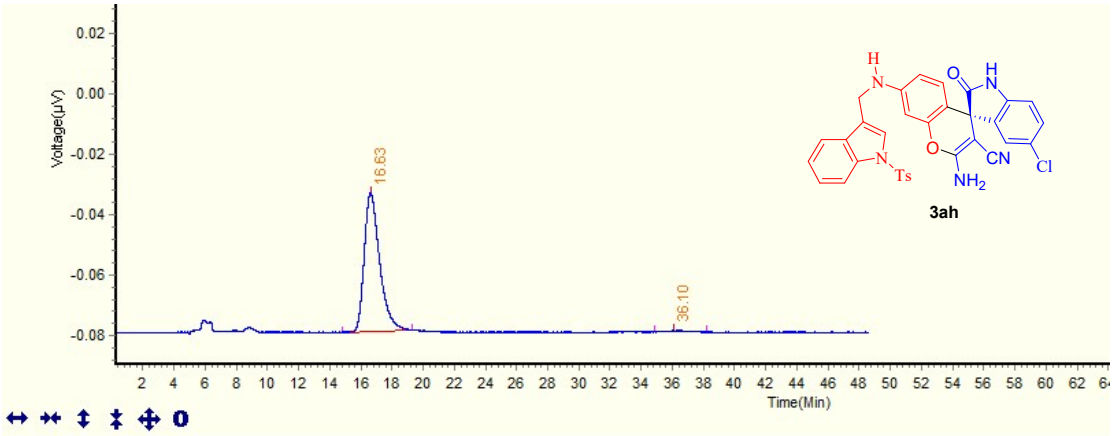
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	25.61	7294754	87764	100.00%	5.854	BB
Total		7,294,754	87,764	100.00%		



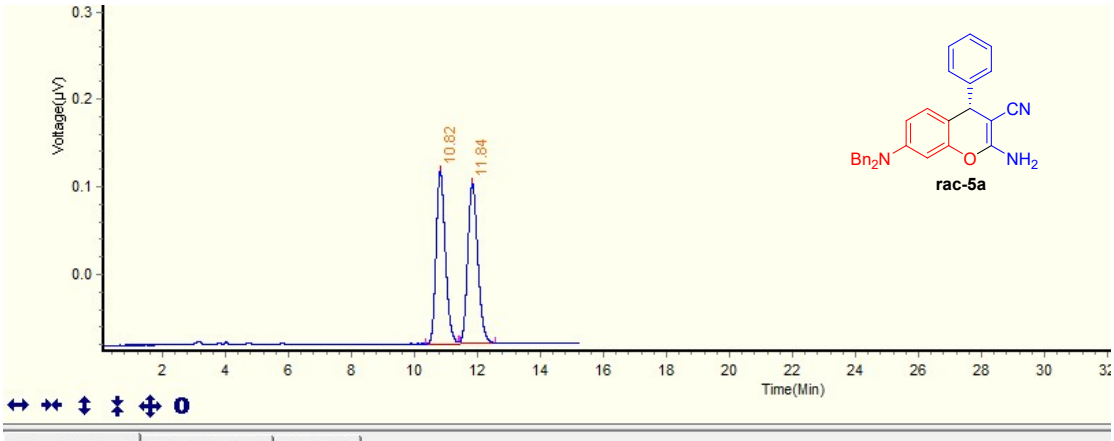
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.69	954698	14525	50.44%	2.901	BB
2	36.30	938008	7244	49.56%	6.111	BB
Total		1,892,706	21,769	100.00%		



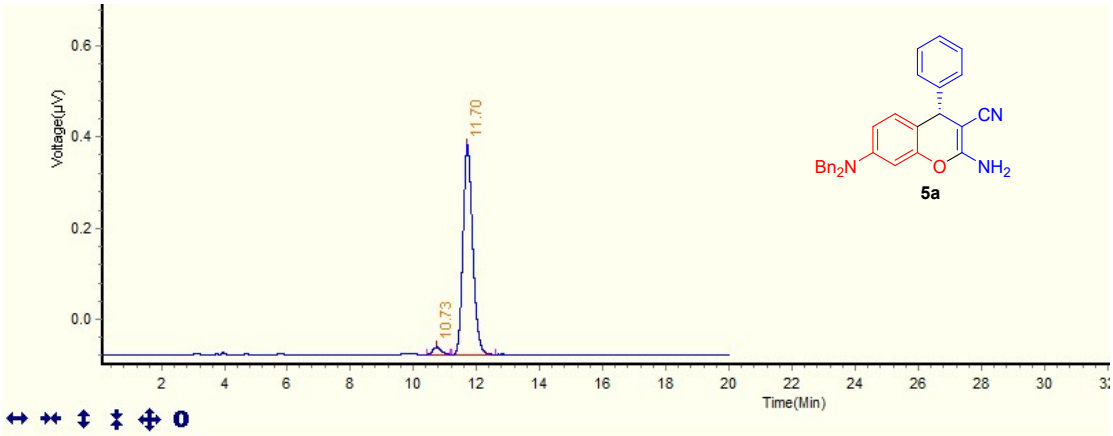
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.63	1567045	22914	98.92%	4.499	BB
2	36.10	17103	228	1.08%	3.351	BB
Total		1,584,148	23,142	100.00%		



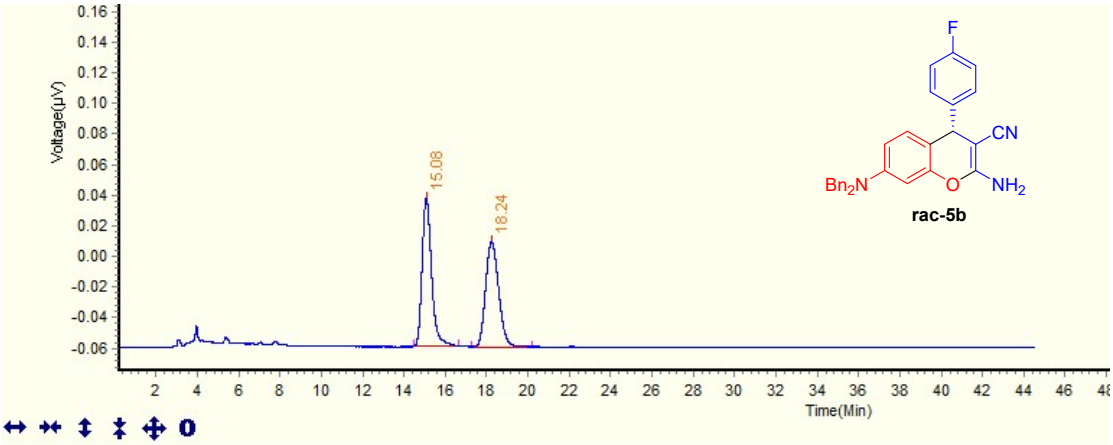
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.82	2000415	98801	49.65%	1.064	BV
2	11.84	2028836	91465	50.35%	1.156	VB
Total		4,029,251	190,266	100.00%		



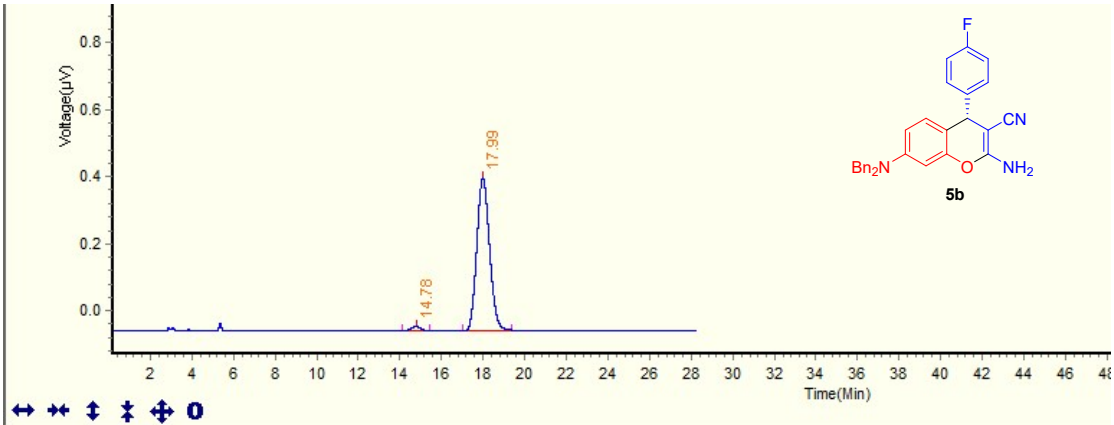
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.73	153888	7987	3.06%	0.739	BB
2	11.70	4874308	229486	96.94%	1.373	BB
Total		5,028,196	237,473	100.00%		



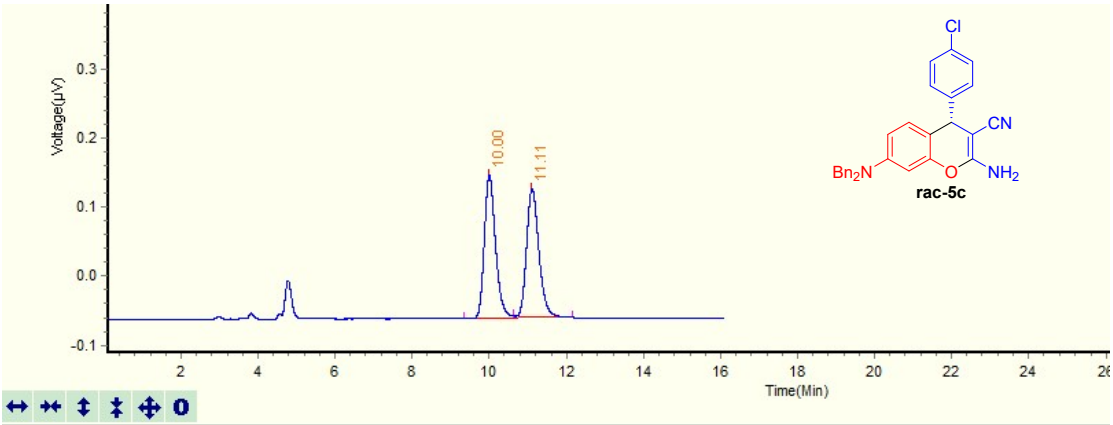
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.08	1539511	48443	50.53%	2.142	BB
2	18.24	1506944	34453	49.47%	2.944	BB
Total		3,046,455	82,896	100.00%		



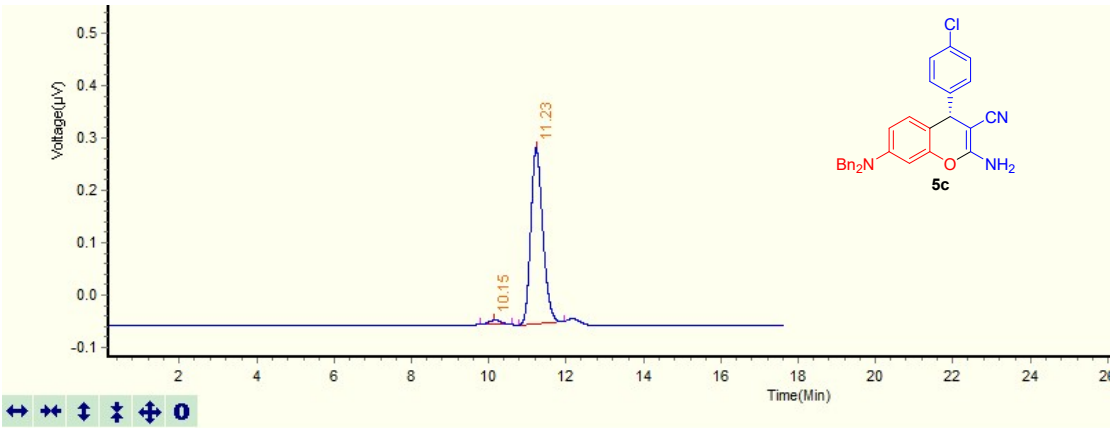
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.78	194929	6196	1.98%	1.313	BB
2	17.99	9671099	226732	98.02%	2.357	BB
Total		9,866,028	232,928	100.00%		



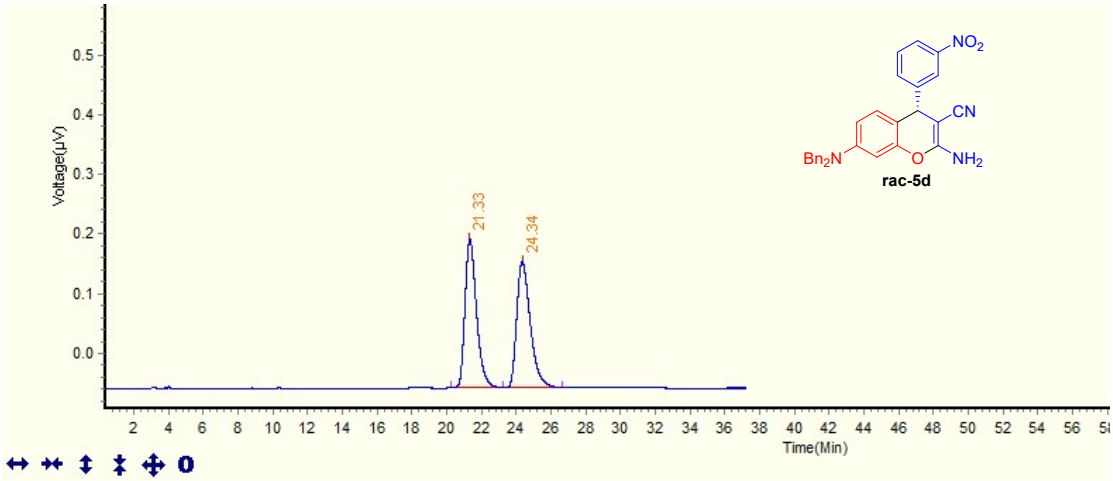
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.00	2083870	103433	49.80%	1.277	BV
2	11.11	2100309	93515	50.20%	1.508	VB
Total		4,184,179	196,948	100.00%		



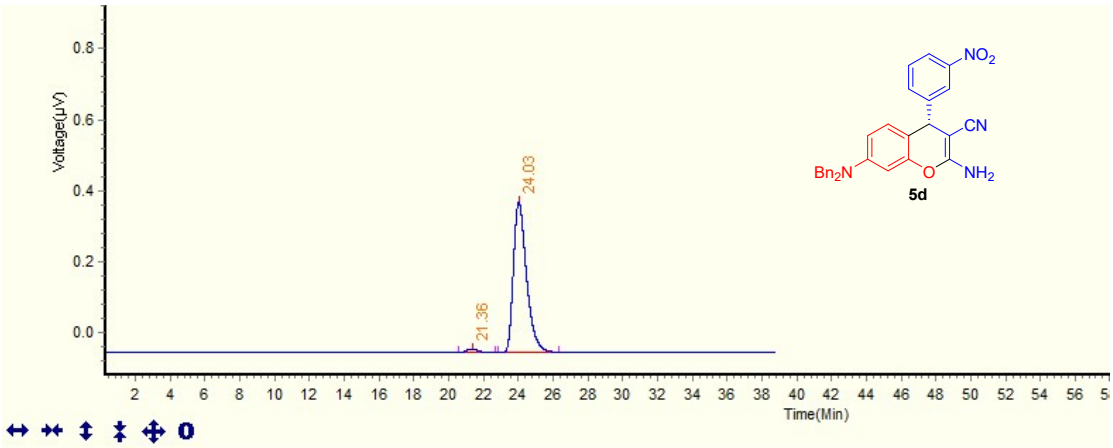
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.15	86992	4144	2.35%	0.785	BB
2	11.23	3607302	167465	97.65%	1.166	BB
Total		3,694,294	171,609	100.00%		



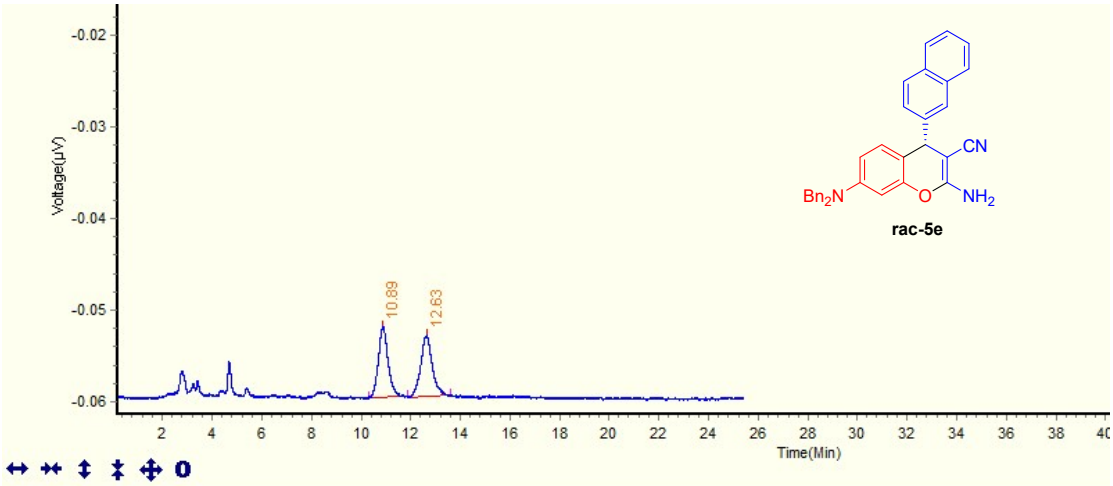
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	21.33	5691895	124249	49.85%	2.997	BV
2	24.34	5725557	105326	50.15%	3.398	VB
Total		11,417,452	229,575	100.00%		



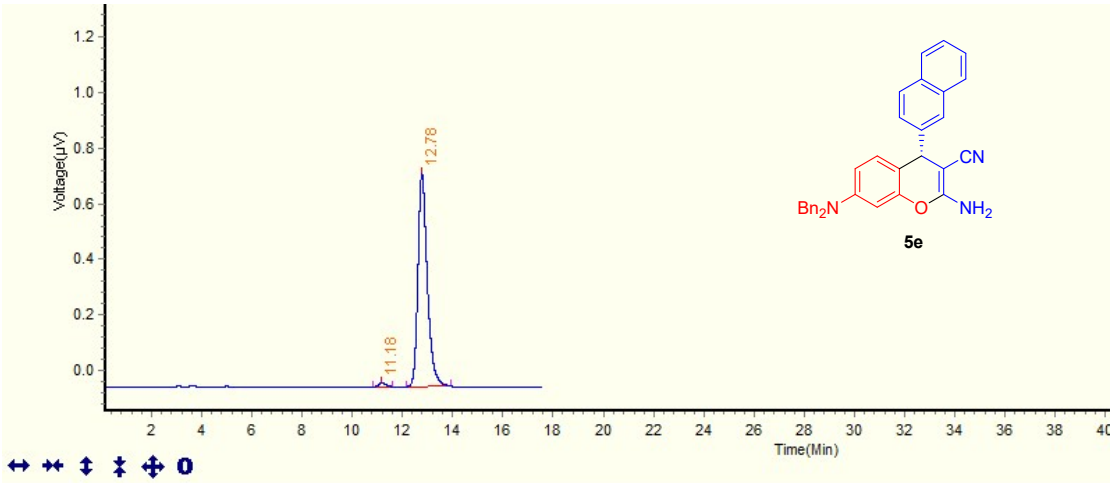
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	21.36	222198	4892	1.96%	2.098	BB
2	24.03	11089060	212196	98.04%	3.543	BB
Total		11,311,258	217,088	100.00%		



Integration Result | Calculation Result | TimeTable

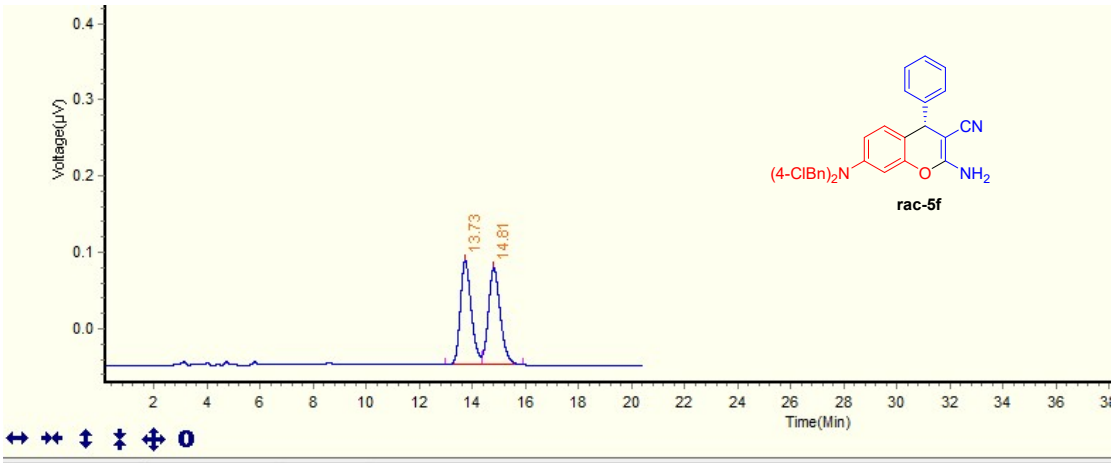
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	10.89	105329	3880	49.61%	1.527	BB
2	12.63	106978	3306	50.39%	1.74	BB
Total		212,307	7,186	100.00%		



5e

Integration Result | Calculation Result | TimeTable

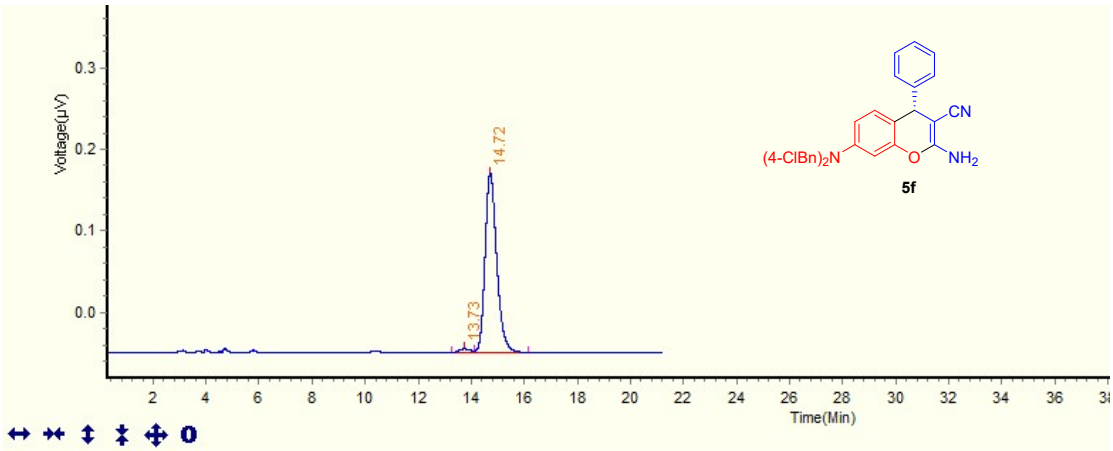
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.18	132241	6196	1.32%	0.773	BB
2	12.78	9898194	382548	98.68%	1.735	BB
Total		10,030,435	388,744	100.00%		



rac-5f

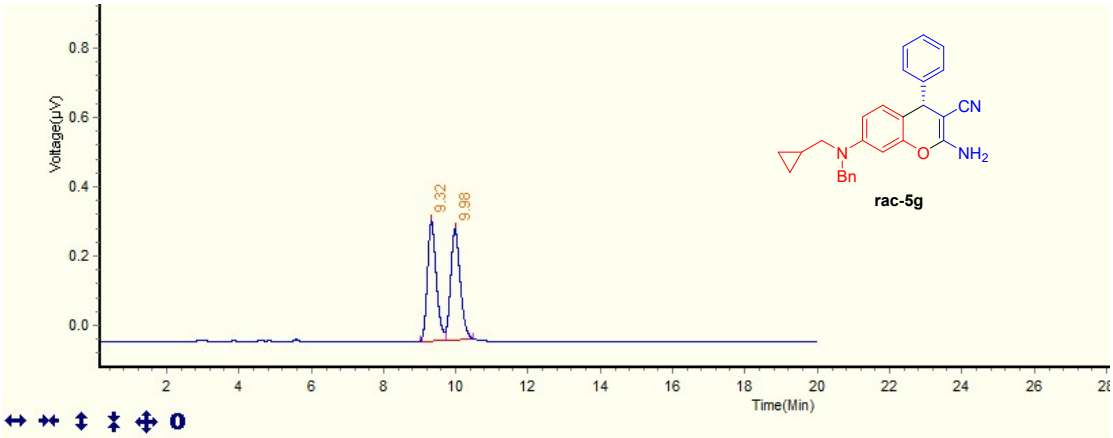
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	13.73	1962004	68219	49.60%	1.385	BV
2	14.81	1993423	63325	50.40%	1.532	VB
Total		3,955,427	131,544	100.00%		



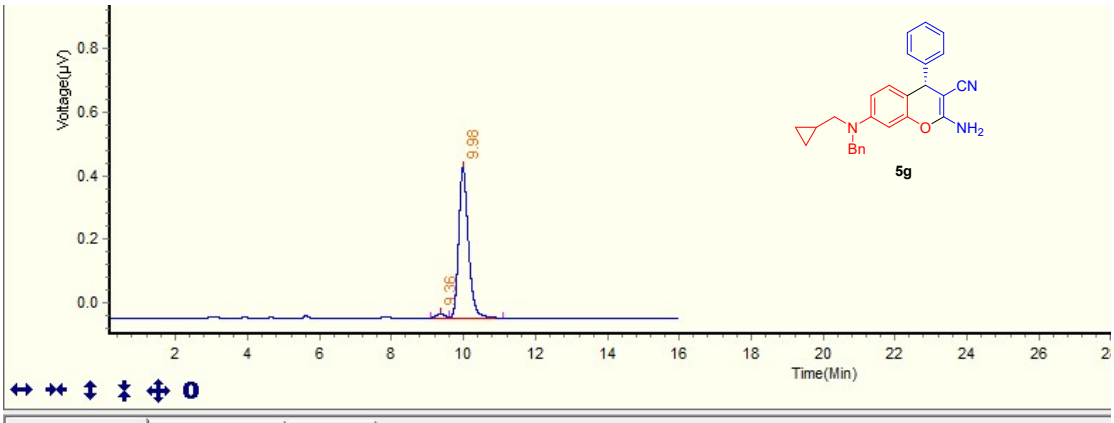
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	13.73	61381	2180	1.80%	0.841	BV
2	14.72	3350306	110062	98.20%	2.042	VB
Total		3,411,687	112,242	100.00%		



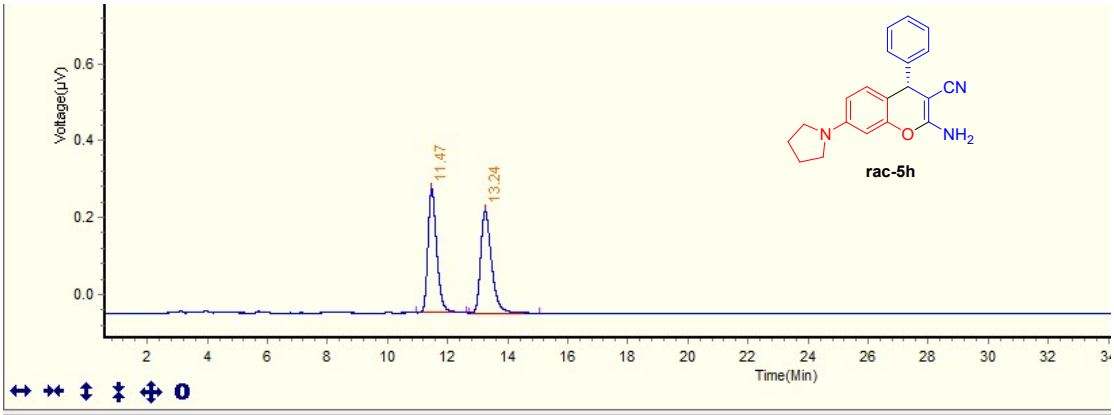
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.32	2941448	172370	50.19%	0.714	BV
2	9.98	2919043	159234	49.81%	0.762	VB
Total		5,860,491	331,604	100.00%		



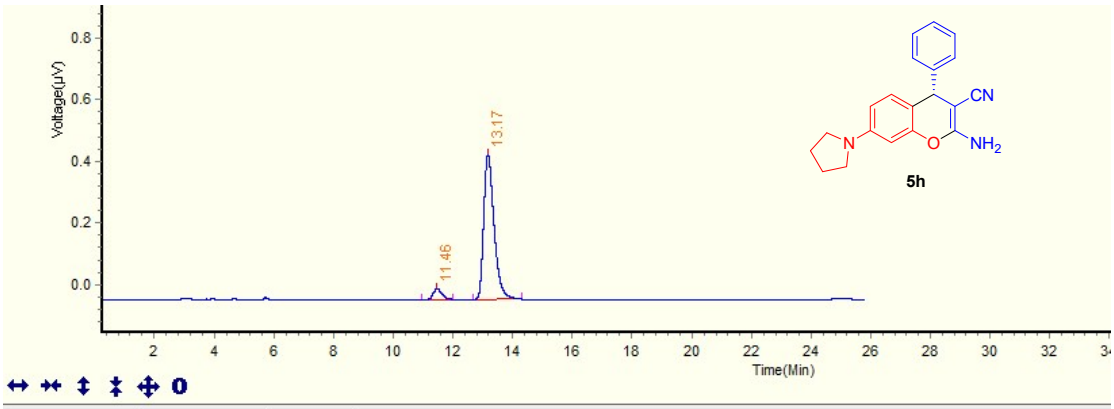
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.36	113538	6861	2.51%	0.532	BV
2	9.98	4413023	236997	97.49%	1.503	VB
Total		4,526,561	243,858	100.00%		



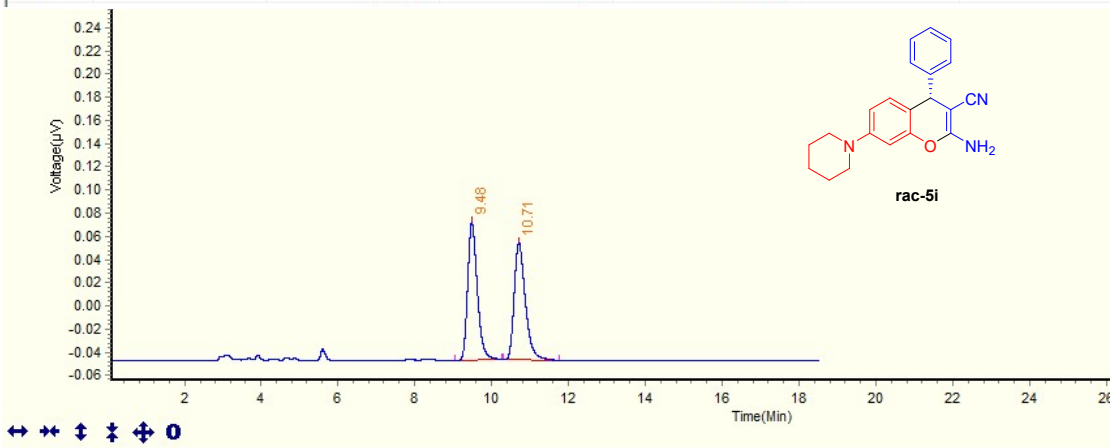
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.47	3296870	161444	49.90%	1.648	BB
2	13.24	3309557	132934	50.10%	2.355	BB
Total		6,606,427	294,378	100.00%		



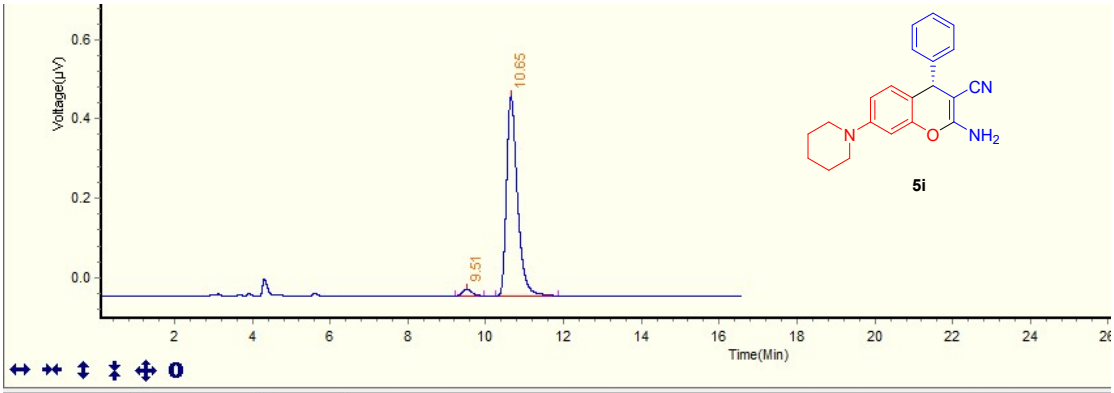
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	11.46	340079	17163	5.66%	1.045	BB
2	13.17	5669107	235136	94.34%	1.628	BB
Total		6,009,186	252,299	100.00%		



Integration Result | Calculation Result | TimeTable

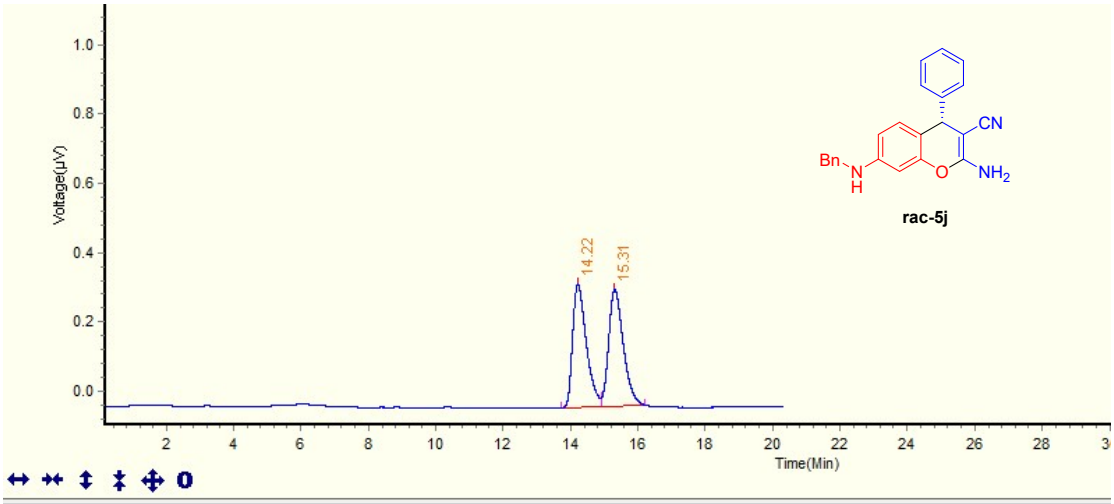
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.48	1036289	59406	50.51%	1.225	BB
2	10.71	1015467	50422	49.49%	1.447	BB
Total		2,051,756	109,828	100.00%		



5i

Integration Result | Calculation Result | TimeTable

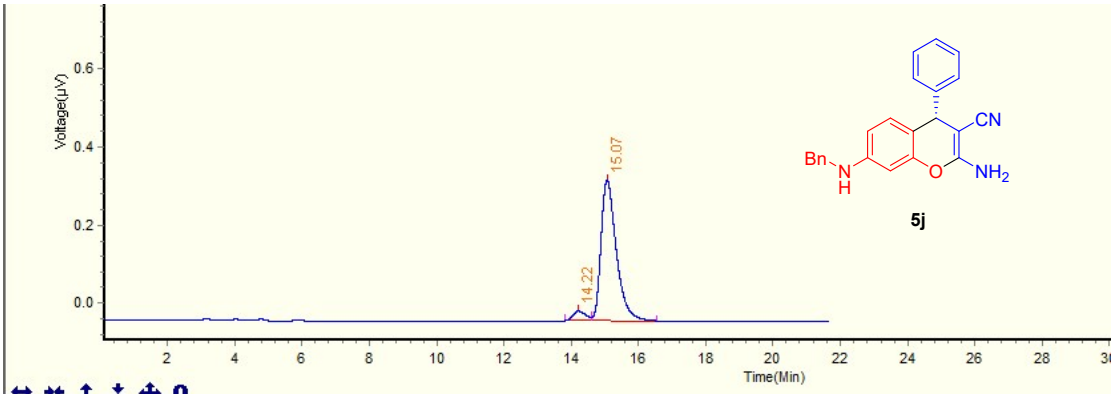
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.51	147466	8707	2.92%	0.75	BB
2	10.65	4907235	251284	97.08%	1.618	BB
Total		5,054,701	259,991	100.00%		



rac-5j

Integration Result | Calculation Result | TimeTable

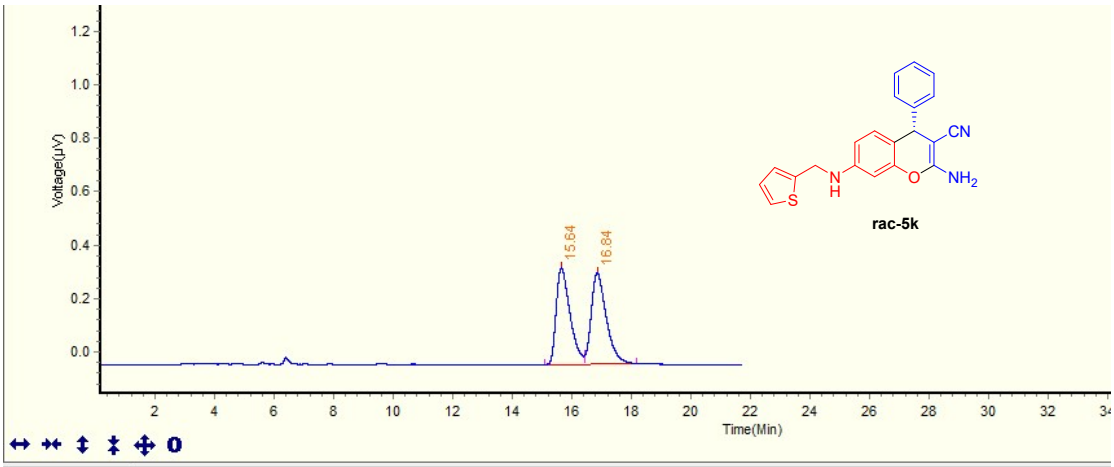
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.22	4990563	176831	49.72%	1.185	BV
2	15.31	5046858	168200	50.28%	1.281	VB
Total		10,037,421	345,031	100.00%		



5j

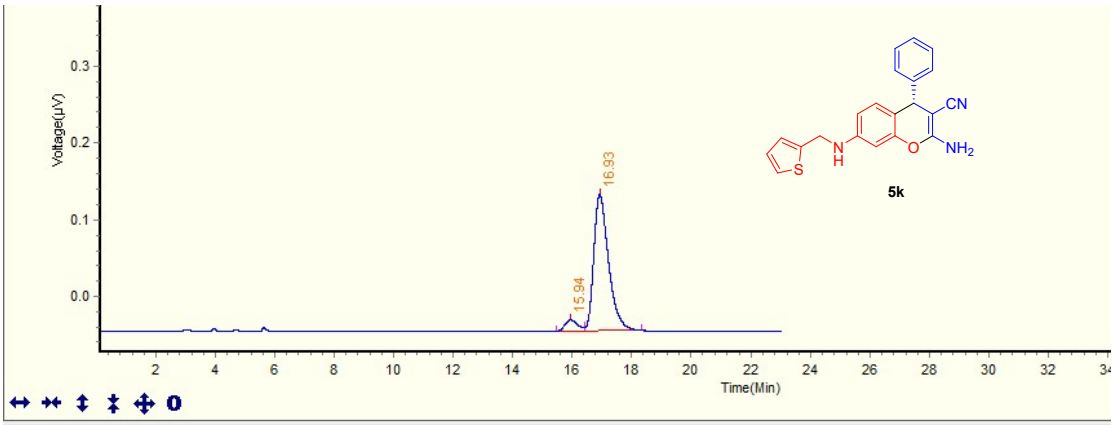
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	14.22	328573	12220	5.47%	0.78	BV
2	15.07	5675852	179747	94.53%	1.952	VB
Total		6,004,425	191,967	100.00%		



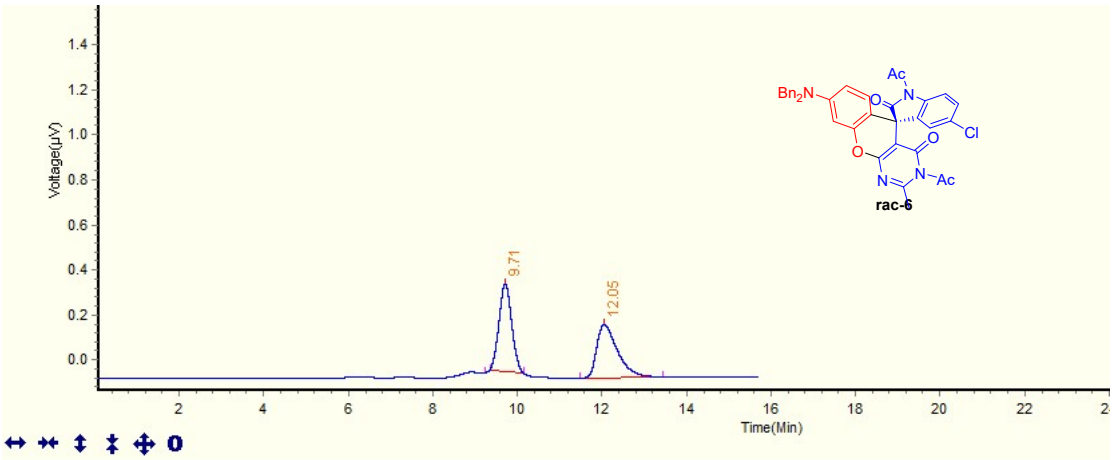
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.64	5796905	179754	49.34%	1.345	BV
2	16.84	5952852	169554	50.66%	1.733	VB
Total		11,749,757	349,308	100.00%		



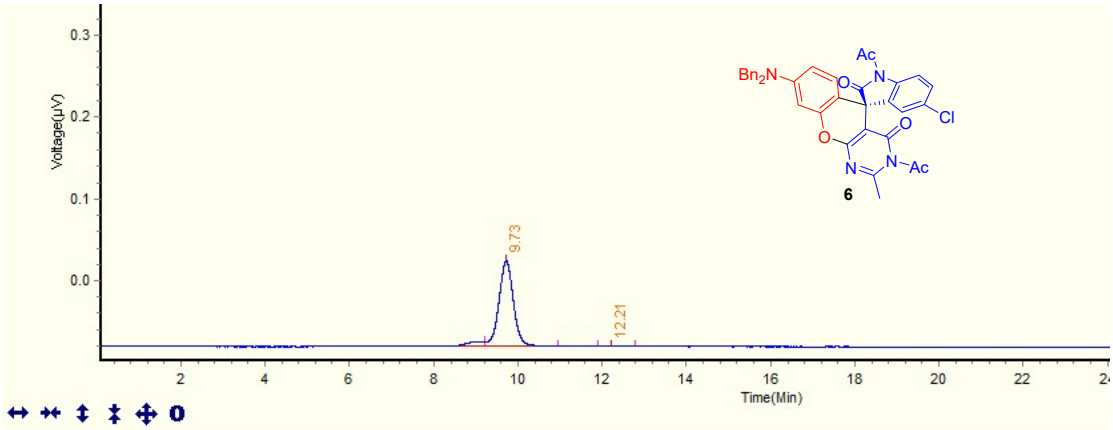
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	15.94	219225	7217	6.64%	0.941	BV
2	16.93	3083400	89395	93.36%	1.912	VB
Total		3,302,625	96,612	100.00%		



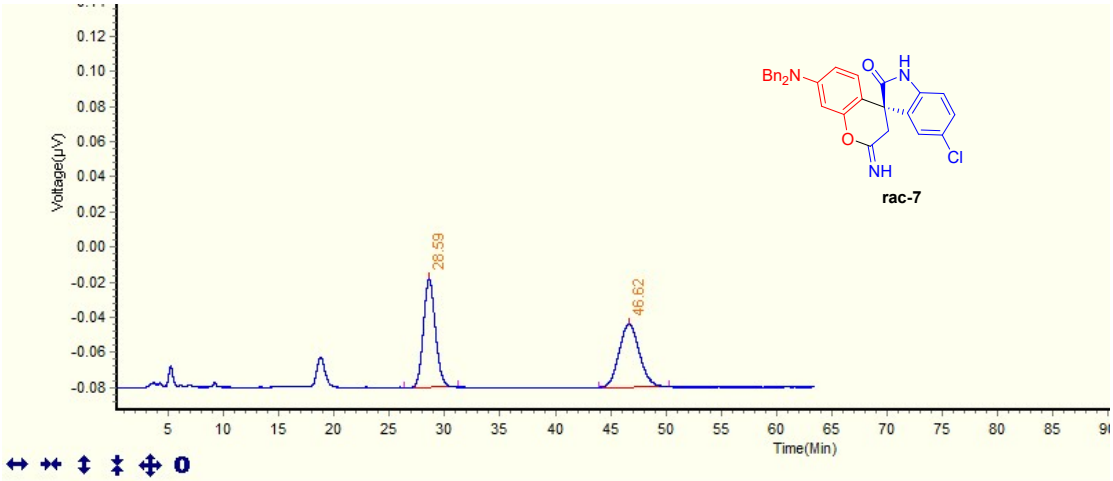
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	-23.42	0	-40303	0.00%	0.0	TBB
2	9.71	4042144	193948	50.31%	0.794	BB
3	12.05	3991643	117274	49.69%	1.984	BB
Total		8,033,787	270,919	100.00%		



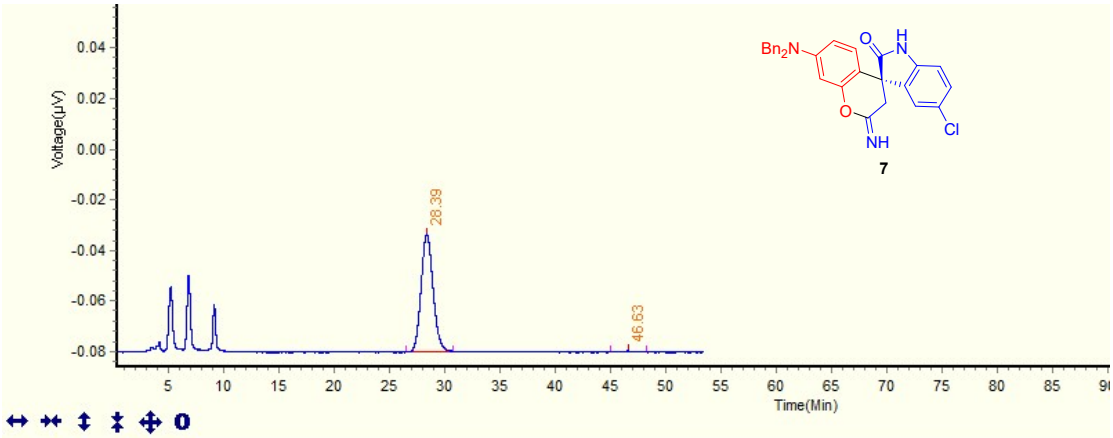
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	9.73	1253104	52377	99.40%	1.718	VB
2	12.21	7614	323	0.60%	0.891	BB
Total		1.260.718	52.700	100.00%		



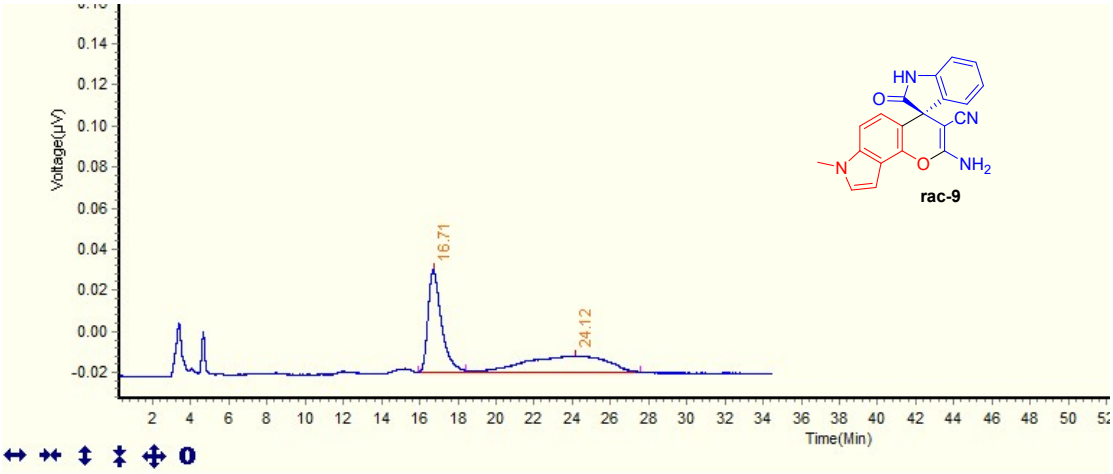
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	28.59	2317443	30848	50.23%	4.802	BB
2	46.62	2296450	18043	49.77%	6.327	BB
Total		4,613,893	48,891	100.00%		



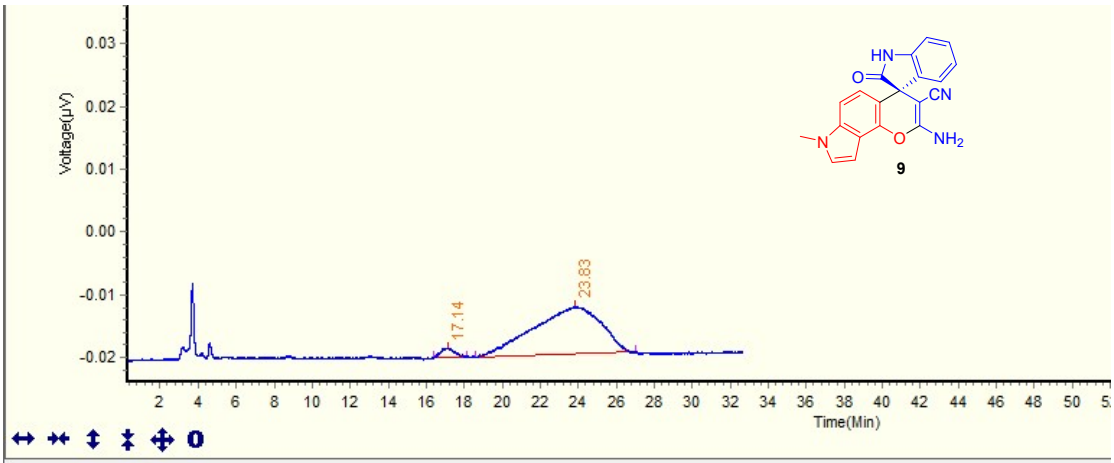
Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	28.39	1750761	23209	99.05%	4.247	BB
2	46.63	16740	221	0.95%	3.346	BB
Total		1,767,501	23,430	100.00%		



Integration Result | Calculation Result | TimeTable

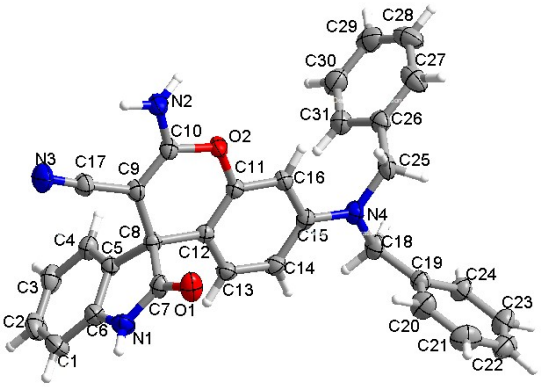
No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	16.71	1221462	24852	51.23%	2.532	BV
2	24.12	1162796	3913	48.77%	9.171	VB
Total		2,384,258	28,765	100.00%		



Integration Result | Calculation Result | TimeTable

No.	Retention Time	Peak Area	Peak Height	Peak Area(%)	Peak Width	
1	17.14	36772	721	3.79%	1.765	BB
2	23.83	934570	3779	96.21%	8.433	BB
Total		971,342	4,500	100.00%		

Single-crystal X-ray diffraction of 3c (CCDC 2056878)



Structure factors have been supplied for datablock(s) 202010225

THIS REPORT IS FOR GUIDANCE ONLY. IF USED AS PART OF A REVIEW PROCEDURE FOR PUBLICATION, IT SHOULD NOT REPLACE THE EXPERTISE OF AN EXPERIENCED CRYSTALLOGRAPHIC REFEREE.

No syntax errors found. CIF dictionary Interpreting this report

Datablock: 202010225

Bond precision: C-C = 0.0045 A Wavelength=1.54184

Cell: a=9.4348(4) b=10.8834(5) c=24.5503(9)
alpha=90 beta=90 gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	2520.89(18)	2520.89(18)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C31 H24 N4 O2	C31 H24 N4 O2
Sum formula	C31 H24 N4 O2	C31 H24 N4 O2
Mr	484.54	484.54
Dx,g cm-3	1.277	1.277
Z	4	4
Mu (mm-1)	0.651	0.651
F000	1016.0	1016.0
F000'	1018.94	
h,k,lmax	11,13,29	11,13,29
Nref	4490[2568]	4490
Tmin,Tmax	0.911,0.937	0.294,1.000
Tmin'	0.907	

Correction method= # Reported T Limits: Tmin=0.294 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.75/1.00 Theta(max)= 67.077

R(reflections)= 0.0404(3996) wR2(reflections)= 0.1049(4490)

S = 1.053 Npar= 346

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level C

PLAT340_ALERT_3_C	Low Bond Precision on C-C Bonds			0.00453	Ang.
PLAT410_ALERT_2_C	Short Intra H...H Contact	H14	..H18B .	1.96	Ang.
			x,y,z =	1_555	Check
PLAT420_ALERT_2_C	D-H Without Acceptor	N1	--H1 .	Please	Check
PLAT420_ALERT_2_C	D-H Without Acceptor	N2	--H2B .	Please	Check
PLAT480_ALERT_4_C	Long H...A H-Bond Reported	H2B	..N3 .	2.78	Ang.

Alert level G

PLAT002_ALERT_2_G	Number of Distance or Angle Restraints on AtSite	2	Note
PLAT172_ALERT_4_G	The CIF-Embedded .res File Contains DFIX Records	1	Report
PLAT199_ALERT_1_G	Reported _cell_measurement_temperature ..... (K)	293	Check
PLAT200_ALERT_1_G	Reported _diffrn_ambient_temperature ..... (K)	293	Check
PLAT791_ALERT_4_G	Model has Chirality at C8 (Sohnke SpGr)	R	Verify
PLAT860_ALERT_3_G	Number of Least-Squares Restraints	1	Note
PLAT909_ALERT_3_G	Percentage of I>2sig(I) Data at Theta(Max) Still	78%	Note
PLAT954_ALERT_1_G	Reported (CIF) and Actual (FCF) Kmax Differ by .	1	Units
PLAT978_ALERT_2_G	Number C-C Bonds with Positive Residual Density.	0	Info

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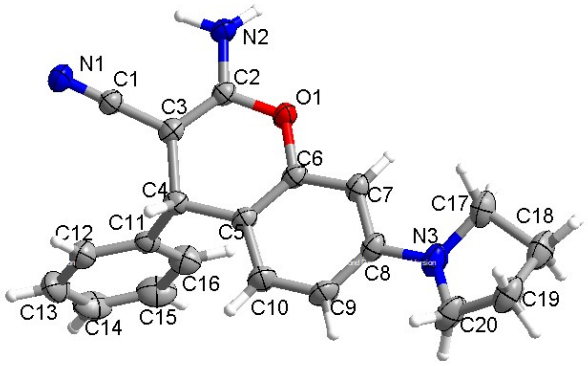
Single-crystal X-ray diffraction of 5h (CCDC 2084637)



checkCIF/PLATON report

Structure factors have been supplied for datablock(s) 202105125a

THIS REPORT IS FOR GUIDANCE ONLY. IF USED AS PART OF A REVIEW PROCEDURE FOR PUBLICATION, IT SHOULD NOT REPLACE THE EXPERTISE OF AN EXPERIENCED CRYSTALLOGRAPHIC REFEREE.

No syntax errors found. CIF dictionary Interpreting this report

Datablock: 202105125a

Bond precision: C-C = 0.0081 A Wavelength=1.54184

Cell: a=6.16719(18) b=9.1665(3) c=29.5744(9)
alpha=90 beta=90 gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	1671.89(9)	1671.88(9)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C20 H19 N3 O	C20 H19 N3 O
Sum formula	C20 H19 N3 O	C20 H19 N3 O
Mr	317.38	317.38
Dx,g cm-3	1.261	1.261
Z	4	4
Mu (mm-1)	0.630	0.630
F000	672.0	672.0
F000'	673.88	
h,k,lmax	7,10,35	7,10,35
Nref	2983[1764]	2971
Tmin,Tmax	0.927,0.945	0.569,1.000
Tmin'	0.893	

Correction method= # Reported T Limits: Tmin=0.569 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.68/1.00 Theta(max)= 67.054

R(reflections)= 0.0729(2650) wR2(reflections)= 0.2254(2971)

S = 1.053 Npar= 232

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level C

STRVA01_ALERT_4_C	Flack parameter is too small	
	From the CIF: _refine_ls_abs_structure_Flack -0.300	
	From the CIF: _refine_ls_abs_structure_Flack_su 0.400	
PLAT234_ALERT_4_C	Large Hirshfeld Difference C18 --C19 .	0.21 Ang.
PLAT340_ALERT_3_C	Low Bond Precision on C-C Bonds	0.00812 Ang.
PLAT480_ALERT_4_C	Long H...A H-Bond Reported H2A ..N1 .	2.86 Ang.
PLAT911_ALERT_3_C	Missing FCF Refl Between Thmin & STh/L= 0.597	4 Report

Alert level G

PLAT002_ALERT_2_G	Number of Distance or Angle Restraints on AtSite	6 Note
PLAT003_ALERT_2_G	Number of Uiso or Uij Restrained non-H Atoms ...	2 Report
PLAT012_ALERT_1_G	No _shelx_res_checksum Found in CIF	Please Check
PLAT032_ALERT_4_G	Std. Uncertainty on Flack Parameter Value High .	0.400 Report
PLAT072_ALERT_2_G	SHELXL First Parameter in WGHT Unusually Large	0.15 Report
PLAT171_ALERT_4_G	The CIF-Embedded .res File Contains EADP Records	2 Report
PLAT172_ALERT_4_G	The CIF-Embedded .res File Contains DFIX Records	3 Report
PLAT186_ALERT_4_G	The CIF-Embedded .res File Contains ISOR Records	1 Report
PLAT199_ALERT_1_G	Reported _cell_measurement_temperature ..... (K)	293 Check
PLAT200_ALERT_1_G	Reported _diffrn_ambient_temperature ..... (K)	293 Check
PLAT301_ALERT_3_G	Main Residue Disorder .....(Resd 1)	8% Note
PLAT791_ALERT_4_G	Model has Chirality at C4 (Sohnke SpGr)	S Verify
PLAT860_ALERT_3_G	Number of Least-Squares Restraints	15 Note
PLAT909_ALERT_3_G	Percentage of I>2sig(I) Data at Theta(Max) Still	76% Note
PLAT910_ALERT_3_G	Missing # of FCF Reflection(s) Below Theta(Min).	1 Note
PLAT933_ALERT_2_G	Number of OMIT Records in Embedded .res File ...	9 Note
PLAT978_ALERT_2_G	Number C-C Bonds with Positive Residual Density.	1 Info

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