Supplementary Information

Organocatalytic Asymmetric Addition of Alcohols to Cyclic Trifluoromethyl Ketimines: Highly Enantioselective Synthesis of Chiral N, O-Ketals

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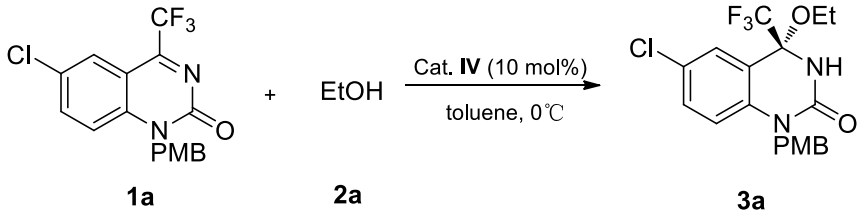
General Information

Unless otherwise noted, all reagents were obtained commercially and used without further purification. Unless otherwise specified, all other reagents were purchased from Acros, Aldrich, Fisher, Adamas-beta Co. Ltd. or TCI and used without further purification. ^{1}H, ^{13}C were recorded at 400 or 500 MHz (^{1}H NMR), 100 or 125 MHz (^{13}C NMR). Chemical shifts were reported in ppm from the solvent resonance as the internal standard (*d*$_6$–DMSO: δH=2.50 ppm, δC=39.52 ppm; $CDCl_3$, δH=7.26 ppm, δC=77.00 ppm). Chemical shifts were reported in parts per million (ppm, δ) downfield from tetramethylsilane (δ=0.00ppm). Proton coupling patterns are described as singlet (s), doublet (d), triplet (t), quartet (q), multiplet (m), and broad (br).

Materials: Toluene and CH_2Cl_2 were distilled from CaH_2. All purchased reagents were used without further purification. Analytical thin layer chromatography was performed on 0.20 mm Qingdao Haiyang silica gel plates. Silica gel (200–300 mesh) (from Qingdao Haiyang Chem. Company, Ltd.) was used for flash chromatography. Standard reagents and solvents were purified according to known procedures. Catalysts **I-V** were prepared from quinine[1] Catalyst **VI** was synthetized according to literatures.[2] The ketimines were synthesized according to literatures.[1,3, 4]

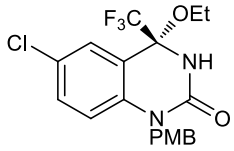
General Procedure for Synthesis of Compounds 3



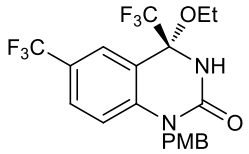
1a **2a** **3a**

PMB=*p*-methoxybenzyl

The mixture of cyclic ketimine **1a** (0.054 mmol, 20.0 mg), bifunctional catalyst **IV** (3.2 mg, 10 mol%) and alcohol **2a** (0.272 mmol, 15.9 uL) in toluene (0.5 mL) was added into a 10 mL schlenk flask equipped with a stirring bar under Ar atmosphere. The reaction was then stirred at rt. After completion of the reaction (monitored by TLC), the residue was purified by column chromatography on silica gel (eluting with petroleum ether/ethyl acetate) to give the product **3a** in 90% yield.

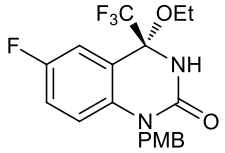


(*R*)-6-chloro-4-ethoxy-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3a). The title compound was prepared according to the general procedure (reaction time: 1 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 54.7 mg (90%). $[\alpha]_D^{25}$ = –26.4º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (s, 1H), 7.34 – 7.23 (m, 1H), 7.15 (d, *J* = 8.4 Hz, 2H), 6.95 – 6.78 (m, 3H), 6.36 (br, 1H), 5.27 (d, *J* = 16.2 Hz, 1H), 5.02 (d, *J* = 16.3 Hz, 1H), 3.79 (s, 3H), 3.66 (dq, *J* = 14.2, 7.0 Hz, 1H), 3.31 (dq, *J* = 14.1, 7.0 Hz, 1H), 1.27 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.96, 151.90, 137.25, 131.63, 128.13, 127.78, 127.53, 127.23, 116.19, 115.53, 114.37, 85.35(q, *J* = 32.1 Hz), 59.14, 55.27, 45.42, 14.98. HRMS (ESI) m/z calcd for $C_{19}H_{19}ClF_3N_2O_3$ $(M+1)^+$ 415.1036, found 415.1023. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.273 min, t_{major} = 3.301 min, ee = 94%.

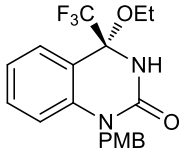


(*R*)-4-ethoxy-1-(4-methoxybenzyl)-4,6-bis(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3b). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 26.3 mg (91%). $[\alpha]_D^{25}$ = –10.6º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.79 (s, 1H), 7.58 (d, *J* = 8.7 Hz, 1H), 7.17 (d, *J* = 8.6 Hz, 2H), 7.04 (d, *J* = 8.8 Hz, 1H), 6.88 (d, *J* = 8.7 Hz, 2H), 6.44 (s, 1H), 5.32

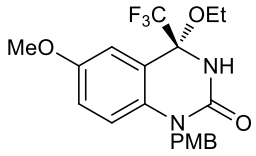
(d, *J* = 16.2 Hz, 1H), 5.08 (d, *J* = 16.4 Hz, 1H), 3.79 (s, 3H), 3.67 (dq, *J* = 14.1, 7.0 Hz, 1H), 3.29 (dq, *J* = 14.1, 7.0 Hz, 1H), 1.27 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.05, 151.83, 141.38, 128.68, 128.65, 127.56, 127.46, 124.88, 123.11 (q, *J* = 139.2 Hz), 115.08, 114.44, 85.43 (q, *J* = 32.2 Hz), 59.33, 55.27, 45.54, 14.95. HRMS (ESI) m/z calcd for $C_{20}H_{19}F_6N_2O_3$ $(M+1)^+$ 449.1300, found 449.1285. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 3.310 min, t_{major} = 2.906 min, ee = 92%.



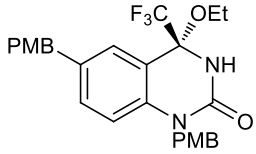
(*R*)-4-ethoxy-6-fluoro-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3c). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 30.5 mg (92%). $[\alpha]_D^{25}$ = –6.2° (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.27 (d, *J* = 11.4 Hz, 1H), 7.17 (d, *J* = 8.2 Hz, 2H), 7.05 (t, *J* = 7.0 Hz, 1H), 6.98 – 6.74 (m, 3H), 6.25 (br, 1H), 5.27 (d, *J* = 16.1 Hz, 1H), 5.03 (d, *J* = 16.2 Hz, 1H), 3.79 (s, 3H), 3.72 – 3.61 (m, 1H), 3.40 – 3.19 (m, 1H), 1.26 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.48, 156.73, 134.50, 127.53, 127.10, 118.22 (d, *J* = 21.3 Hz), 115.83 (d, *J* = 7.5 Hz), 115.07 (d, *J* = 7.5 Hz), 113.90, 113.70 (d, *J* = 23.8 Hz), 84.93 (q, *J* = 31.7 Hz), 58.63, 54.81, 45.07, 14.51. HRMS (ESI) m/z calcd for $C_{19}H_{19}F_4N_2O_3$ $(M+1)^+$ 399.1332, found 399.1320. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 3.835 min, t_{major} = 3.063 min, ee = 95%.



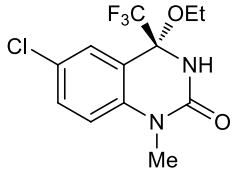
(*R*)-4-ethoxy-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3d). The title compound was prepared according to the general procedure (reaction time: 7 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 22.1 mg (95%). $[\alpha]_D^{25}$ = –2.0° (c 0.25, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53 (d, *J* = 7.8 Hz, 1H), 7.31 (t, *J* = 7.2 Hz, 1H), 7.17 (d, *J* = 8.6 Hz, 2H), 7.08 (t, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.85 (d, *J* = 8.6 Hz, 2H), 6.10 (s, 1H), 5.26 (d, *J* = 16.3 Hz, 1H), 5.04 (d, *J* = 16.3 Hz, 1H), 3.77 (s, 3H), 3.62 (dq, *J* = 14.1, 7.1 Hz, 1H), 3.28 (dq, *J* = 14.2, 7.1 Hz, 1H), 1.23 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.83, 152.10, 138.60, 131.53, 128.32, 127.57, 127.51, 122.86 (q, *J* = 285.4 Hz), 122.56, 114.71, 114.27, 113.78, 85.76 (q, *J* = 32.1 Hz), 58.90, 55.26, 45.26, 15.00. HRMS (ESI) m/z calcd for $C_{19}H_{20}F_3N_2O_3$ $(M+1)^+$ 381.1426, found 381.1413. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.208 min, t_{major} = 3.183 min, ee = 94%.



(*R*)-4-ethoxy-6-methoxy-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3e). The title compound was prepared according to the general procedure (reaction time: 22 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford 34.0 mg (99%). $[\alpha]_D^{25}$ = –21.0º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.17 (d, *J* = 8.6 Hz, 2H), 7.07 (s, 1H), 6.94 – 6.82 (m, 4H), 6.06 (br, 1H), 5.26 (d, *J* = 16.2 Hz, 1H), 5.02 (d, *J* = 16.3 Hz, 1H), 3.78 (s, 6H), 3.66 (dq, *J* = 8.9, 7.0 Hz, 1H), 3.32 (dq, *J* = 9.0, 7.0 Hz, 1H), 1.25 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.80, 155.07, 152.02, 132.20, 128.44, 127.55, 117.47, 115.93, 114.84, 114.25, 112.14, 85.71 (q, *J* = 31.7 Hz), 58.91, 55.64, 55.25, 45.30, 15.05. HRMS (ESI) m/z calcd for $C_{20}H_{22}F_3N_2O_4$ $(M+1)^+$ 411.1532, found 411.1520. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.044 min, t_{major} = 3.133 min, ee = 95%.

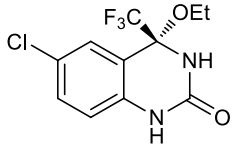


(*R*)-4-ethoxy-1,6-bis(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3f). The title compound was prepared according to the general procedure (reaction time: 22 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford 33.0 mg (98%). $[\alpha]_D^{25}$ = –11.8º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (s, 1H), 7.17 (d, *J* = 8.6 Hz, 2H), 7.11 (d, *J* = 8.5 Hz, 1H), 7.07 (d, *J* = 8.5 Hz, 2H), 6.85 (t, *J* = 8.6 Hz, 5H), 6.11 (br, 1H), 5.24 (d, *J* = 16.1 Hz, 1H), 5.02 (d, *J* = 16.2 Hz, 1H), 3.89 (s, 2H), 3.80 (t, *J* = 8.2 Hz, 6H), 3.62 (dq, *J* = 14.2, 7.1 Hz, 1H), 3.25 (dq, *J* = 14.2, 7.1 Hz, 1H), 1.19 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.36, 157.70, 151.70, 136.29, 135.72, 132.03, 131.42, 129.29, 127.99, 127.16, 127.04, 114.38, 113.81, 113.56, 113.25, 85.34 (q, *J* = 31.7 Hz), 58.49, 54.82, 54.80, 44.84, 39.60, 14.52. HRMS (ESI) m/z calcd for $C_{27}H_{28}F_3N_2O_4$ $(M+1)^+$ 501.2001, found 501.1986. (Chiralpak OD-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.808 min, t_{major} = 3.389 min, ee = 94%.

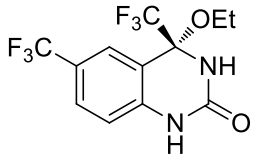


(*R*)-6-chloro-4-ethoxy-1-methyl-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3g). The title compound was prepared according to the general procedure (reaction time: 4.5 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford 19.4 mg (83%). $[\alpha]_D^{25}$ = 4.0º (c 0.1, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (s, 1H), 7.44 (d, *J* = 8.8 Hz, 1H), 6.95 (d, *J* = 8.8 Hz,

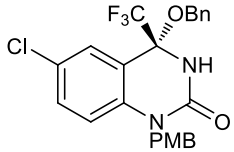
1H), 6.10 (s, 1H), 3.59 (dq, *J* = 14.2, 7.1 Hz, 1H), 3.38 (s, 3H), 3.24 (dq, *J* = 14.2, 7.1 Hz, 1H), 1.23 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.90, 137.73, 131.30, 127.62, 126.79, 114.79, 114.58, 84.84 (q, *J* = 32.5 Hz), 58.60, 29.22, 14.50. HRMS (ESI) m/z calcd for $C_{12}H_{13}ClF_3N_2O_2$ $(M+1)^+$ 309.0618, found 309.0608. (Chiralpak OD-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 5.714 min, t_{major} = 4.839 min, ee = 95%.



(*R*)-6-chloro-4-ethoxy-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3h). The title compound was prepared according to the general procedure (reaction time: 7 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford 23.1 mg (97%). $[\alpha]_D^{25}$ = –7.0° (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.60 (s, 1H), 7.48 (s, 1H), 7.34 (d, *J* = 8.6 Hz, 1H), 6.87 (d, *J* = 8.6 Hz, 1H), 6.44 (s, 1H), 3.60 (dq, *J* = 14.2, 7.1 Hz, 1H), 3.27 (dq, *J* = 14.3, 7.0 Hz, 1H), 1.23 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 152.31, 135.35, 131.44, 127.90, 126.59, 122.06 (q, ^1J = 285 Hz), 116.04, 112.93, 85.98 (q, ^2J = 32.5 Hz), 58.88, 14.48. HRMS (ESI) m/z calcd for $C_{11}H_{11}ClF_3N_2O_2$ $(M+1)^+$ 295.0461, found 295.0452. (Chiralpak AS-3R, CH_3CN/H_2O = 40/60, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 8.662 min, t_{major} = 10.050 min, ee = 82%.

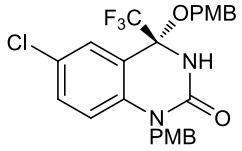


(*R*)-4-ethoxy-4,6-bis(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3i). The title compound was prepared according to the general procedure (reaction time: 5 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford 34.6 mg (96%). $[\alpha]_D^{25}$ = 8.7° (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, DMSO) δ 10.36 (s, 1H), 8.73 (s, 1H), 7.75 (d, *J* = 7.6 Hz, 1H), 7.54 (s, 1H), 7.11 (d, *J* = 8.5 Hz, 1H), 3.53 (dq, *J* = 14.2, 7.0 Hz, 1H), 3.12 (dq, *J* = 14.1, 7.0 Hz, 1H), 1.12 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, DMSO) δ 151.09, 142.51, 129.18, 125.56, 124.05, 115.91, 112.27, 86.22 (q, *J* = 31.2 Hz), 59.03, 15.23. HRMS (ESI) m/z calcd for $C_{12}H_{11}F_6N_2O_2$ $(M+1)^+$ 329.0725, found 329.0715. (Chiralpak AS-3R, CH_3CN/H_2O = 40/60, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 7.278 min, t_{major} = 8.158 min, ee = 70%.

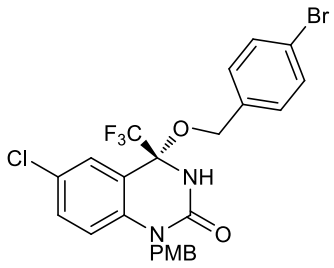


(*R*)-4-(benzyloxy)-6-chloro-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydro

quinazolin-2(1*H*)-one (3j). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 24.9 mg (97%). $[\alpha]_D^{25}$ = –10.4º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59 (s, 1H), 7.46 – 7.24 (m, 6H), 7.19 (d, *J* = 8.3 Hz, 2H), 6.99 – 6.80 (m, 3H), 6.70 (s, 1H), 5.31 (d, *J* = 15.8 Hz, 1H), 5.05 (d, *J* = 16.0 Hz, 1H), 4.68 (d, *J* = 11.2 Hz, 1H), 4.34 (d, *J* = 11.2 Hz, 1H), 3.80 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.01, 151.89, 137.31, 136.18, 131.86, 128.58, 128.30, 128.13, 127.73, 127.64, 127.59, 127.44, 116.30, 115.21, 114.41, 85.62 (q, *J* = 32.5 Hz), 65.35, 55.29, 45.50. HRMS (ESI) m/z calcd for $C_{24}H_{21}ClF_3N_2O_3$ $(M+1)^+$ 477.1193, found 477.1178. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} =7.718 min, t_{major} = 5.270 min, ee = 90%.

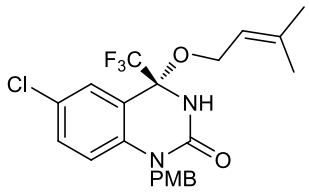


(*R*)-6-chloro-1-(4-methoxybenzyl)-4-((4-methoxybenzyl)oxy)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3k). The title compound was prepared according to the general procedure (reaction time: 2 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to afford 33.1 mg (81%). $[\alpha]_D^{25}$ = –14.8º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (s, 1H), 7.31 (d, *J* = 8.9 Hz, 1H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 6.96 – 6.78 (m, 6H), 5.29 (d, *J* = 16.1 Hz, 1H), 5.07 (d, *J* = 16.4 Hz, 1H), 4.61 (d, *J* = 10.8 Hz, 1H), 4.27 (d, *J* = 10.8 Hz, 1H), 3.84 – 3.75 (m, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.10, 158.55, 151.60, 136.84, 131.33, 129.04, 127.81, 127.75, 127.32, 127.14, 127.06, 115.83, 114.96, 113.97, 113.54, 85.06 (q, *J* = 32.1 Hz), 64.76, 54.84, 45.06. HRMS (ESI) m/z calcd for $C_{25}H_{23}ClF_3N_2O_4$ $(M+1)^+$ 507.1298, found 507.1285. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} =6.843 min, t_{major} = 5.231 min, ee = 94%.

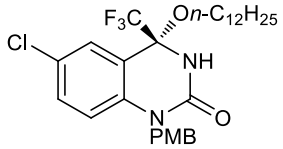


(*R*)-4-((4-bromobenzyl)oxy)-6-chloro-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3l). The title compound was prepared according to the general procedure (reaction time: 13 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 35.4 mg (80%). $[\alpha]_D^{25}$ = –11.6º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.41 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.9 Hz, 1H), 7.21 – 7.14 (m, 4H), 7.07 (s, 1H), 6.92 – 6.85 (m,

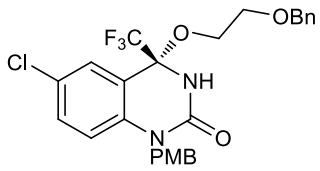
3H), 5.26 (d, *J* = 16.0 Hz, 1H), 5.06 (d, *J* = 15.9 Hz, 1H), 4.62 (d, *J* = 11.4 Hz, 1H), 4.27 (d, *J* = 11.4 Hz, 1H), 3.79 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.60, 151.63, 136.81, 134.77, 131.49, 131.22, 128.87, 127.92, 127.18, 127.11, 126.91, 121.63, 115.92, 114.62, 113.99, 85.17 (q, *J* = 32.5 Hz), 64.15, 54.85, 45.08. HRMS (ESI) m/z calcd for $C_{24}H_{20}BrClF_3N_2O_3$ $(M+1)^+$ 555.0298, found 555.0284. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} =9.430 min, t_{major} = 7.478 min, ee = 89%.



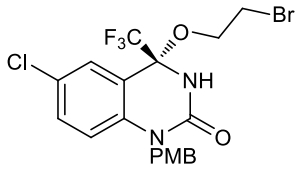
(*R*)-6-chloro-1-(4-methoxybenzyl)-4-((3-methylbut-2-en-1-yl)oxy)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3m). The title compound was prepared according to the general procedure (reaction time: 5 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 30.4 mg (80%). $[\alpha]_D^{25}$ = –31.2º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.32 – 7.26 (m, 1H), 7.17 (d, *J* = 8.6 Hz, 2H), 6.87 (d, *J* = 8.5 Hz, 3H), 6.35 (s, 1H), 5.44 – 5.21 (m, 2H), 5.01 (d, *J* = 16.3 Hz, 1H), 4.12 (dd, *J* = 11.0, 7.1 Hz, 1H), 3.89 – 3.65 (m, 4H), 1.75 (s, 3H), 1.58 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.96, 151.81, 138.65, 137.29, 131.66, 128.13, 127.78, 127.56, 127.48, 119.07, 116.16, 115.57, 114.37, 85.36 (q, *J* = 32.1 Hz), 60.41, 55.27, 45.44, 25.81, 17.97. HRMS (ESI) m/z calcd for $C_{22}H_{23}ClF_3N_2O_3$ $(M+1)^+$ 455.1349, found 455.1335. (Chiralpak OD-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 7.083 min, t_{major} = 5.077 min, ee = 90%.



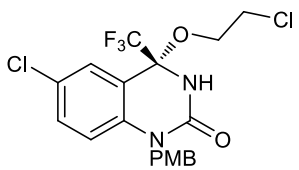
(*R*)-6-chloro-4-(dodecyloxy)-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3n). The title compound was prepared according to the general procedure (reaction time: 4 h) and purified by column chromatography on silica gel (petroleum ether/ dichloromethane = 2:1) to afford 36.0 mg (79%). $[\alpha]_D^{25}$ = –22.2º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.50 (s, 1H), 7.35 – 7.22 (m, 1H), 7.16 (d, *J* = 8.6 Hz, 2H), 6.92 – 6.78 (m, 3H), 6.34 (br, 1H), 5.29 (d, *J* = 16.3 Hz, 1H), 5.01 (d, *J* = 16.3 Hz, 1H), 3.79 (s, 3H), 3.64 – 3.52 (m, 1H), 3.30 – 3.12 (m, 1H), 1.67 – 1.56 (m, 2H), 1.38 – 1.22 (m, 19H), 0.90 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.51, 151.48, 136.80, 131.14, 127.65, 127.35, 127.10, 126.89, 115.71, 115.08, 113.91, 84.79 (q, *J* = 32.1 Hz), 62.90, 54.81, 44.96, 31.49, 29.22, 29.20, 29.15, 29.09, 28.92, 28.89, 28.85, 25.56, 22.26, 13.69. HRMS (ESI) m/z calcd for $C_{29}H_{39}ClF_3N_2O_3$ $(M+1)^+$555.2601, found 555.2590. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 11.027 min, t_{major} = 7.896 min, ee = 94%.



(*R*)-4-(2-(benzyloxy)ethoxy)-6-chloro-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3, 4-dihydroquinazolin-2(1*H*)-one (3o). The title compound was prepared according to the general procedure (reaction time: 5.5 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford 33.9 mg (80%). $[\alpha]_D^{25}$ = –22.4º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (s, 1H), 7.42 – 7.34 (m, 4H), 7.35 – 7.23 (m, 2H), 7.15 (d, *J* = 7.8 Hz, 2H), 6.98 – 6.76 (m, 3H), 6.56 (br, 1H), 5.28 (d, *J* = 16.2 Hz, 1H), 4.99 (d, *J* = 16.3 Hz, 1H), 4.60 (s, 2H), 3.79 (s, 4H), 3.67 (s, 2H), 3.56 – 3.44 (m, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.50, 151.31, 151.20, 137.45, 136.84, 131.29, 128.04, 127.71, 127.36, 127.32, 127.21, 127.11, 115.69, 115.00, 113.92, 84.94 (q, *J* = 32.1 Hz), 72.85, 67.84, 62.54, 54.82, 44.96. HRMS (ESI) m/z calcd for $C_{26}H_{25}ClF_3N_2O_4$ $(M+1)^+$ 521.1455, found 521.1442. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} =6.387 min, t_{major} = 4.924 min, ee = 92%.

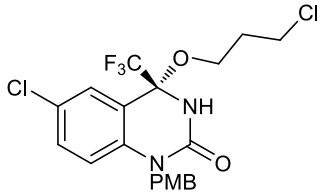


(*R*)-4-(2-bromoethoxy)-6-chloro-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dih ydroquinazolin-2(1*H*)-one (3p). The title compound was prepared according to the general procedure (reaction time: 4 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to afford 27.9 mg (93%). $[\alpha]_D^{25}$ = –24.8º (c 0.5, MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (s, 1H), 7.31 (d, *J* = 8.9 Hz, 1H), 7.15 (d, *J* = 8.6 Hz, 2H), 6.93 – 6.80 (m, 3H), 6.61 (s, 1H), 5.28 (d, *J* = 16.2 Hz, 1H), 5.02 (d, *J* = 16.3 Hz, 1H), 3.96 – 3.88 (m, 1H), 3.64 – 3.55 (m, 1H), 3.54 – 3.46 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.01, 151.68, 137.15, 132.02, 128.38, 127.58, 127.55, 127.45, 116.33, 114.74, 114.42, 85.36 (q, *J* = 32.5 Hz), 63.24, 55.29, 45.47, 29.28. HRMS (ESI) m/z calcd for $C_{19}H_{17}BrClF_3N_2NaO_3$ $(M+Na)^+$ 514.9961, found 514.9984. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.049 min, t_{major} = 3.405 min, ee = 70%.

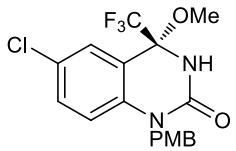


(*R*)-6-chloro-4-(2-chloroethoxy)-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dih

ydroquinazolin-2(1*H*)-one (3q). The title compound was prepared according to the general procedure (reaction time: 4 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to afford 29.1 mg (93%). $[\alpha]_D^{25}$ = –31.3º (c 0.4, MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.55 (s, 1H), 7.29 (d, *J* = 8.9 Hz, 1H), 7.14 (d, *J* = 8.6 Hz, 2H), 6.95 – 6.84 (m, 3H), 6.78 (br, 1H), 5.26 (d, *J* = 16.2 Hz, 1H), 5.00 (d, *J* = 16.3 Hz, 1H), 3.90 – 3.81 (m, 1H), 3.77 (s, 3H), 3.65 (t, *J* = 5.7 Hz, 2H), 3.57 – 3.47 (m, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.56, 151.37, 136.73, 131.54, 127.93, 127.18, 127.12, 127.01, 115.87, 114.36, 113.97, 84.94 (q, *J* = 32.9 Hz), 63.00, 54.84, 45.02, 41.58. HRMS (ESI) m/z calcd for $C_{19}H_{18}Cl_2F_3N_2NaO_3$ $(M+Na)^+$ 471.0466, found 471.0450. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 3.827 min, t_{major} = 3.250 min, ee = 87%.

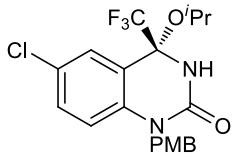


(*R*)-6-chloro-4-(3-chloropropoxy)-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-di hydroquinazolin-2(1*H*)-one (3r). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 31.9 mg (92%). $[\alpha]_D^{25}$ = –35.8º (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (s, 1H), 7.30 (d, *J* = 8.9 Hz, 2H), 7.16 (d, *J* = 8.5 Hz, 2H), 6.95 (s, 1H), 6.88 (d, *J* = 8.7 Hz, 3H), 5.29 (d, *J* = 16.1 Hz, 1H), 5.03 (d, *J* = 16.3 Hz, 1H), 3.84 – 3.74 (m, 4H), 3.68 (t, *J* = 6.2 Hz, 2H), 3.39 (dt, *J* = 9.4, 5.7 Hz, 1H), 2.13 – 2.02 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.97, 152.06, 137.21, 131.77, 128.24, 127.75, 127.55, 127.32, 116.26, 115.00, 114.38, 85.24(q, *J* = 32.5 Hz), 59.32, 55.28, 45.40, 41.28, 31.90.HRMS (ESI) m/z calcd for $C_{20}H_{20}Cl_2F_3N_2O_3$ $(M+1)^+$ 463.0803, found 463.0788. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 10.531 min, t_{major} = 7.821 min, ee = 95%.



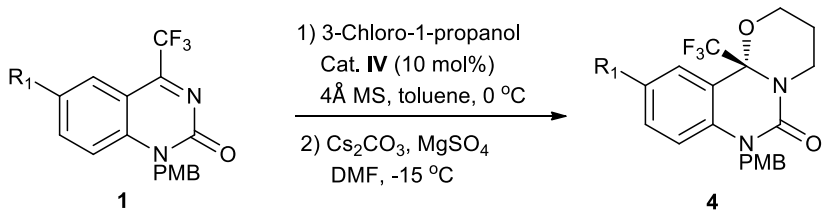
(*R*)-6-chloro-4-methoxy-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroqui nazolin-2(1*H*)-one (3s). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 37.2 mg (98%) $[\alpha]_D^{25}$ = –21.5º (c 0.5, CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.48 (s, 1H), 7.27 (d, *J* = 8.9 Hz, 1H), 7.14 (d, *J* = 8.6 Hz, 2H), 6.88 – 6.82 (m, 3H), 6.42 (s, 1H), 5.26 (d, *J* = 16.3 Hz, 1H), 5.01 (d, *J* = 16.3 Hz, 1H), 3.77 (s, 3H), 3.26 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.52, 151.52, 137.00, 131.34, 127.79, 127.27, 127.09, 126.88, 115.82, 114.23, 113.93, 85.25 (q, *J* = 32.1Hz), 54.82, 49.95, 44.98. HRMS (ESI) m/z calcd for $C_{18}H_{17}ClF_3N_2O_3$ $(M+1)^+$ 401.0880, found 401.0868. (Chiralpak AS-3R, CH_3CN/H_2O

= 60/40, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} =8.101 min, t_{major} = 5.700 min, ee = 92%.



(*R*)-6-chloro-4-isopropoxy-1-(4-methoxybenzyl)-4-(trifluoromethyl)-3,4-dihydroquinazolin-2(1*H*)-one (3t). The title compound was prepared according to the general procedure (reaction time: 21 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 15.4 mg (67%). $[\alpha]_D^{25}$ = –38.0° (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.31 – 7.22 (m, 2H), 7.14 (d, *J* = 8.6 Hz, 2H), 6.92 – 6.80 (m, 3H), 6.35 (s, 1H), 5.27 (d, *J* = 16.3 Hz, 1H), 5.00 (d, *J* = 16.3 Hz, 1H), 3.93 – 3.85 (m, 1H), 3.77 (s, 3H), 1.28 (d, *J* = 6.1 Hz, 3H), 1.09 (d, *J* = 6.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.97, 151.55, 137.08, 131.60, 127.92, 127.83, 127.78, 127.56, 116.43, 116.08, 114.37, 86.65 (q, *J* = 32.1 Hz), 67.83, 55.28, 45.42, 24.40, 23.69. HRMS (ESI) m/z calcd for $C_{20}H_{21}ClF_3N_2O_3$ $(M+1)^+$ 429.1193, found 429.1179. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 5.205 min, t_{major} = 4.467min, ee = 93%.

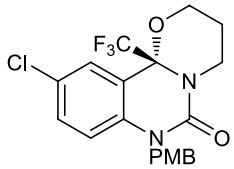
General Procedure for Synthesis of Compounds 4



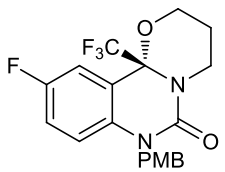
1 **4**

An oven-dried 10-mL round bottom flask was charged with ketimines **1** (0.081 mmol,), catalyst **IV** (10 mol%) and 4Å MS (100 mg). The flask was capped and backfilled with argon. Toluene was added via syringe. The mixture was cooled to 0 °C and then 3-chloro-1-propanol (0.122 mmol) was added. The reaction mixture was maintained at 0 °C until ketimines **1** had been completely consumed as determined by TLC. The reaction was purified via flash chromatography on silica gel (eluting with petroleum ether/ethyl acetate = 5:1) to give compound **1-1**.

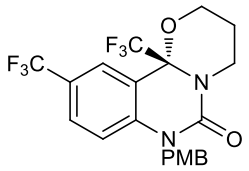
Compound **1-1**, $MgSO_4$ (100 mg) and DMF (0.5 mL) were loaded into a 10 mL flask. The reaction solution was cooled to -15 °C under argon. After being stirred for 1 h, Cs_2CO_3 (0.243 mmol) was added quickly. After completion of the reaction which was determined by TLC, the reaction was purified via flash chromatography on silica gel (eluting with petroleum ether/ethyl acetate = 5:1) to give compound **4.**



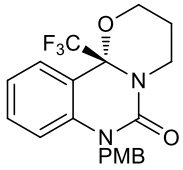
(*R*)-10-chloro-7-(4-methoxybenzyl)-11*b*-(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1, 3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4a). The title compound was prepared according to the general procedure and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 28.2 mg (96%). $[\alpha]_D^{25}$ = –15.8° (c 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (d, *J* = 1.7 Hz, 1H), 7.24 (dd, *J* = 8.8, 2.5 Hz, 1H), 7.16 (d, *J* = 8.6 Hz, 2H), 6.86 (d, *J* = 8.7 Hz, 2H), 6.79 (d, *J* = 8.8 Hz, 1H), 5.20 (d, *J* = 16.4 Hz, 1H), 5.04 (d, *J* = 16.4 Hz, 1H), 4.61 – 4.42 (m, 1H), 4.29 – 4.15 (m, 1H), 4.08 – 3.98 (m, 1H), 3.79 (s, 3H), 3.59 – 3.45 (m, 1H), 2.12 – 2.01 (m, 1H), 2.00 – 1.88 (m, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.84, 151.96, 136.01, 130.98, 128.32, 127.79, 127.67, 126.61, 118.85, 115.35, 114.23, 83.45 (q, *J* = 31.7 Hz), 61.79, 55.26, 46.62, 37.43, 23.35. HRMS (ESI) m/z calcd for $C_{20}H_{19}ClF_3N_2O_3$ $(M+1)^+$ 427.1036, found 427.1023. (Chiralpak AS-3R, CH_3CN/H_2O = 80/20, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 4.642 min, t_{major} = 3.821 min, ee = 94%.



(*R*)-10-fluoro-7-(4-methoxybenzyl)-11*b*-(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1,3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4b). The title compound was prepared according to the general procedure and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 36.0 mg (99%). $[\alpha]_D^{20}$ = -11.4º (c 0.5, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (dd, *J* = 8.6, 2.3 Hz, 1H), 7.15 (d, *J* = 8.5 Hz, 2H), 6.98 (td, *J* = 8.5, 2.9 Hz, 1H), 6.84 (d, *J* = 8.5 Hz, 2H), 6.78 (dd, *J* = 9.1, 4.3 Hz, 1H), 5.17 (d, *J* = 16.4 Hz, 1H), 5.03 (d, *J* = 16.4 Hz, 1H), 4.63 – 4.40 (m, 1H), 4.29 – 4.10 (m, 1H), 4.10 – 3.90 (m, 1H), 3.77 (s, 3H), 3.59 – 3.41 (m, 1H), 2.13 – 1.87 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.79, 152.09, 133.66 (d, *J* = 2.0 Hz), 128.51, 127.67, 124.45 (q, *J* = 295 Hz), 118.89 (d, *J* = 8.0 Hz), 118.91 (d, *J* = 22.0 Hz), 115.37 (d, *J* = 8.0 Hz), 114.21, 113.60 (d, *J* = 25.0 Hz), 83.42 (q, *J* = 31.2 Hz), 61.81, 55.26, 46.75, 37.39, 23.38. HRMS (ESI) m/z calcd for $C_{20}H_{19}F_4N_2O_3$ $(M+1)^+$ 411.1332, found 411.1326. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 5.862 min, t_{major} = 4.470 min, ee = 96%.

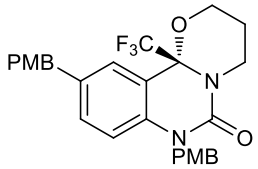


(*R*)-7-(4-methoxybenzyl)-10,11*b*-bis(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1,3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4c). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 32.4 mg (94%). $[\alpha]_D^{20}$ = 1.8º (c 0.5, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.52 (d, *J* = 8.6 Hz, 1H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.7 Hz, 1H), 6.85 (d, *J* = 8.5 Hz, 2H), 5.22 (d, *J* = 16.4 Hz, 1H), 5.08 (d, *J* = 16.4 Hz, 1H), 4.62 – 4.44 (m, 1H), 4.31 – 4.15 (m, 1H), 4.12 – 3.98 (m, 1H), 3.77 (s, 3H), 3.62 – 3.45 (m, 1H), 2.16 – 1.88 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.91, 151.83, 140.04, 128.13, 128.00, 127.68, 124.58 (q, *J* = 33.3 Hz), 124.23, 117.76, 114.29, 114.19, 83.31 (q, *J* = 31.1 Hz), 61.99, 55.27, 46.70, 37.64, 23.27. HRMS (ESI) m/z calcd for $C_{21}H_{19}F_6N_2O_3$ $(M+1)^+$ 461.1300, found 461.1292 (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 5.232 min, t_{major} = 4.420 min, ee = 94%.

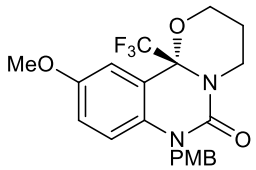


(*R*)-7-(4-methoxybenzyl)-11*b*-(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1,3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4d). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 35.0 mg (95%). $[\alpha]_D^{20}$ = –8.8º

(c 0.5, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 7.8 Hz, 1H), 7.32 – 7.23 (m, 1H), 7.17 (d, *J* = 8.5 Hz, 2H), 7.06 (t, *J* = 7.6 Hz, 1H), 6.91 – 6.70 (m, 3H), 5.18 (d, *J* = 16.4 Hz, 1H), 5.06 (d, *J* = 16.4 Hz, 1H), 4.62 – 4.39 (m, 1H), 4.28 – 4.12 (m, 1H), 4.08 – 3.91 (m, 1H), 3.76 (s, 3H), 3.60 – 3.44 (m, 1H), 2.14 – 1.86 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.70, 152.27, 137.37, 131.00, 128.85, 127.69, 126.61, 124.51 (q, *J* = 294.0 Hz), 122.35, 117.23, 114.14, 113.94, 83.90 (q, *J* = 31.0 Hz), 61.54, 55.25, 46.49, 37.26, 23.47. HRMS (ESI) m/z calcd for $C_{20}H_{20}F_3N_2O_3$ $(M+1)^+$ 393.1426, found 393.1420. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 6.149 min, t_{major} = 4.539 min, ee = 87%.



(*R*)-7,10-bis(4-methoxybenzyl)-11*b*-(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1,3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4e). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 33.9 mg (96%). $[\alpha]_D^{20}$ = –11.8º (c 0.5, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (s, 1H), 7.15 (d, *J* = 8.4 Hz, 2H), 7.09 – 6.96 (m, 3H), 6.89 – 6.78 (m, 4H), 6.74 (d, *J* = 8.5 Hz, 1H), 5.13 (d, *J* = 16.3 Hz, 1H), 5.03 (d, *J* = 16.3 Hz, 1H), 4.58 – 4.45 (m, 1H), 4.25 – 4.10 (m, 1H), 4.06 – 3.93 (m, 1H), 3.86 (s, 2H), 3.77 (s, 3H), 3.75 (s, 3H), 3.57 – 3.43 (m, 1H), 2.12 – 1.85 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.67, 158.03, 152.29, 135.75, 135.51, 132.70, 131.30, 129.80, 128.97, 127.71, 126.67, 117.11, 114.11, 114.08, 113.91, 83.86 (q, *J* = 31.0 Hz), 61.59, 55.26, 46.53, 40.16, 37.30, 23.47. HRMS (ESI) m/z calcd for $C_{28}H_{28}F_3N_2O_4$ $(M+1)^+$ 513.2001, found 513.1996. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 8.389 min, t_{major} = 5.812 min, ee = 87%.



(*R*)-10-methoxy-7-(4-methoxybenzyl)-11*b*-(trifluoromethyl)-3,4,7,11*b*-tetrahydro-[1,3]oxazino[3,2-*c*]quinazolin-6(2*H*)-one (4f). The title compound was prepared according to the general procedure (reaction time: 3 h) and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to afford 33.6 mg (94%). $[\alpha]_D^{20}$ = –16.4º (c 0.5, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.4 Hz, 2H), 7.10 (s, 1H), 6.83 (d, *J* = 8.5 Hz, 3H), 6.76 (d, *J* = 9.0 Hz, 1H), 5.16 (d, *J* = 16.4 Hz, 1H), 5.02 (d, *J* = 16.4 Hz, 1H), 4.58 – 4.46 (m, 1H), 4.24 – 4.13 (m, 1H), 4.06 – 3.95 (m, 1H), 3.76 (s, 6H), 3.57 – 3.44 (m, 1H), 2.10 – 1.87 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.68, 155.02, 152.28, 131.05, 128.98, 127.69, 124.50 (q, *J* =

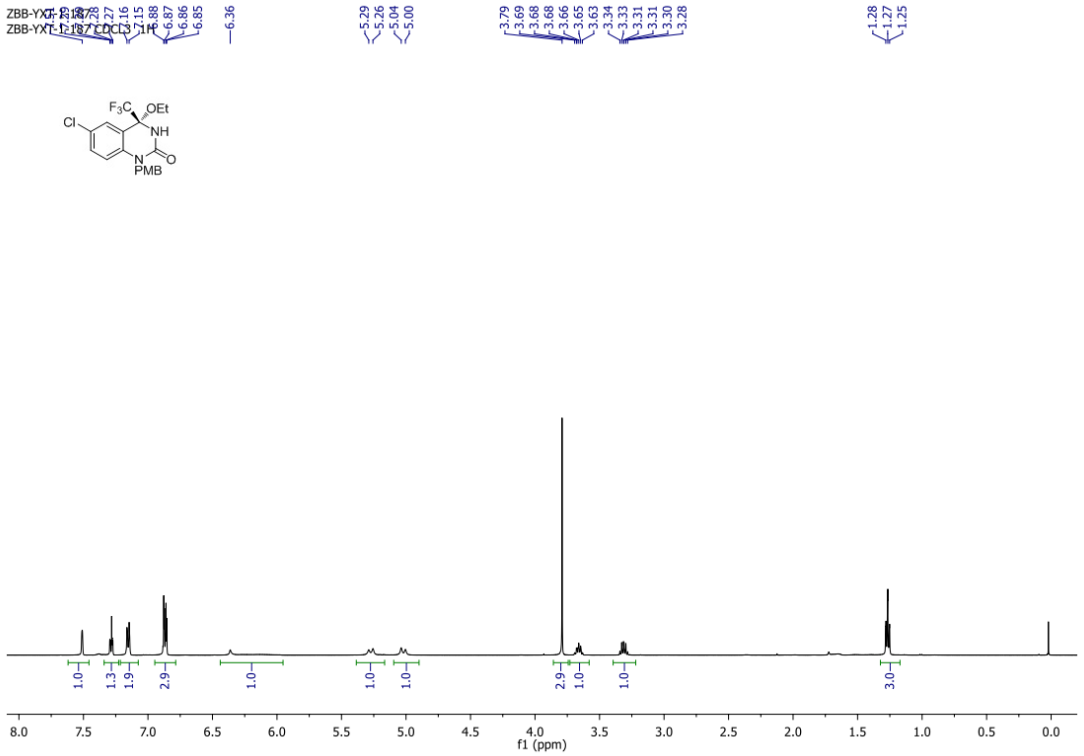
295.0 Hz), 118.26, 117.03, 115.16, 114.12, 111.34, 83.86 (q, *J* = 31.0 Hz), 61.59, 55.67, 55.25, 46.56, 37.23, 23.51. HRMS (ESI) m/z calcd for $C_{21}H_{22}F_3N_2O_4$ $(M+1)^+$ 423.1532, found 423.1526. (Chiralpak AS-3R, CH_3CN/H_2O = 70/30, flow rate = 0.8 mL/min, λ = 254 nm): t_{minor} = 5.910 min, t_{major} = 4.375 min, ee = 76%.

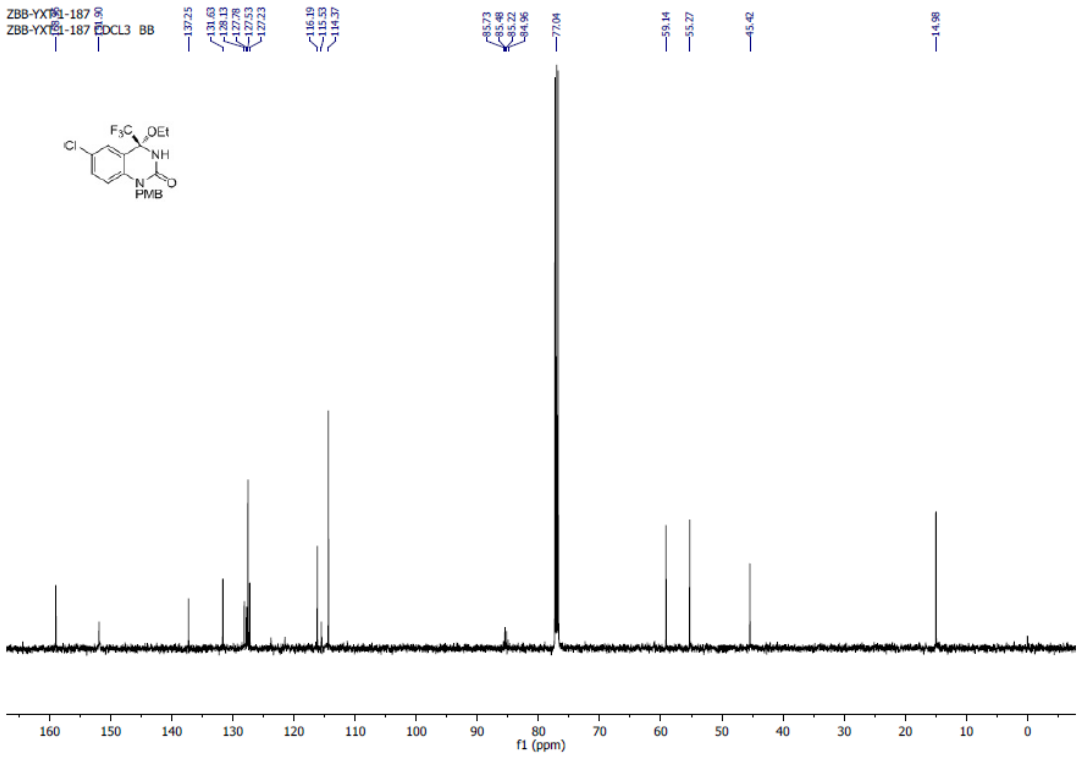
References

1. H. Xie, Y. Zhang, S. Zhang, X. Chen and W. Wang, *Angew. Chem., Int. Ed.*, 2011, **50**, 11773.
2. K. L. Kimmel, M. T. Robak and J. A. Ellman, *J. Am. Chem. Soc.*, 2009, **131**, 8754.
3. K. F. Zhang, J. Nie, R. Guo, Y. Zheng and J. A. Ma, *Adv. Synth. Catal.*, 2013, **355**, 3497.
4. H. Xie, A. Song, X. Zhang, X. Chen, H. Li, C. Sheng and W. Wang, *Chem. Commun.*, 2013, **49**, 928.

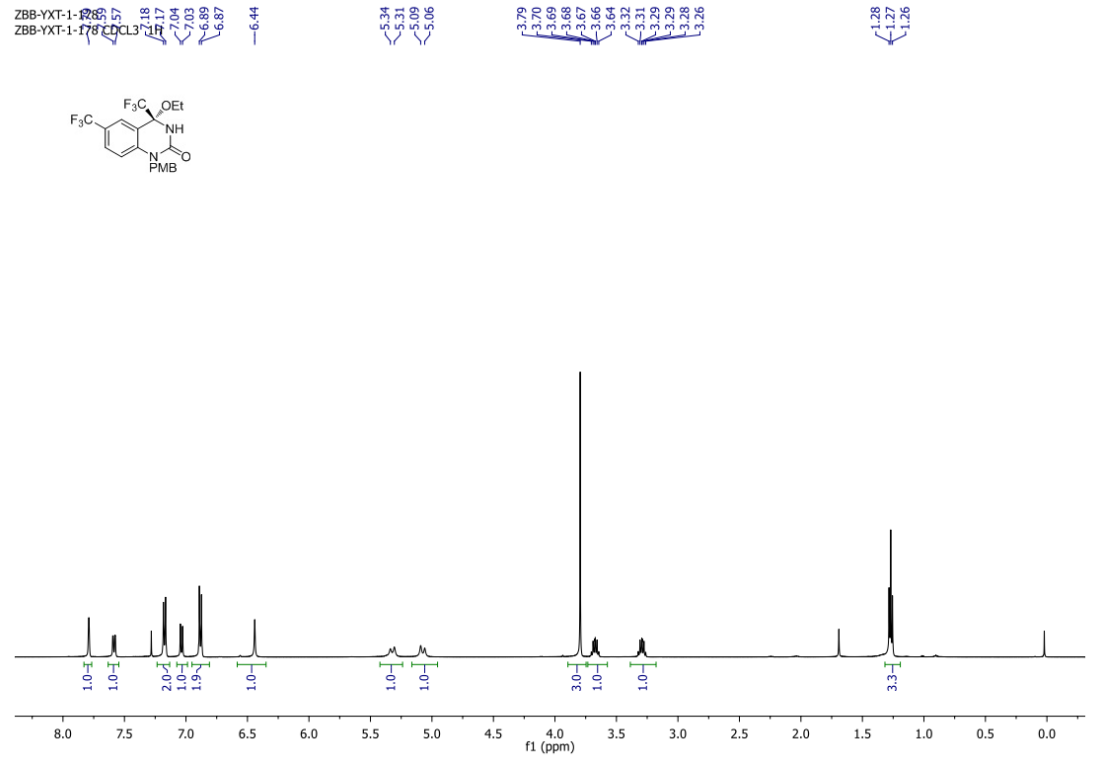
^{1}H and ^{13}C-NMR spectra

Compound 3a





Compound 3b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ZBB-YXT-1-178 CDCL3 1H
7.18
7.17
7.04
7.03
6.89
6.87
6.44
5.34
5.31
5.09
5.06
3.79
3.70
3.69
3.68
3.67
3.66
3.64
3.32
3.31
3.29
3.29
3.28
3.26
1.28
1.27
1.26
F3C
OEt
NH
N
O
PMB
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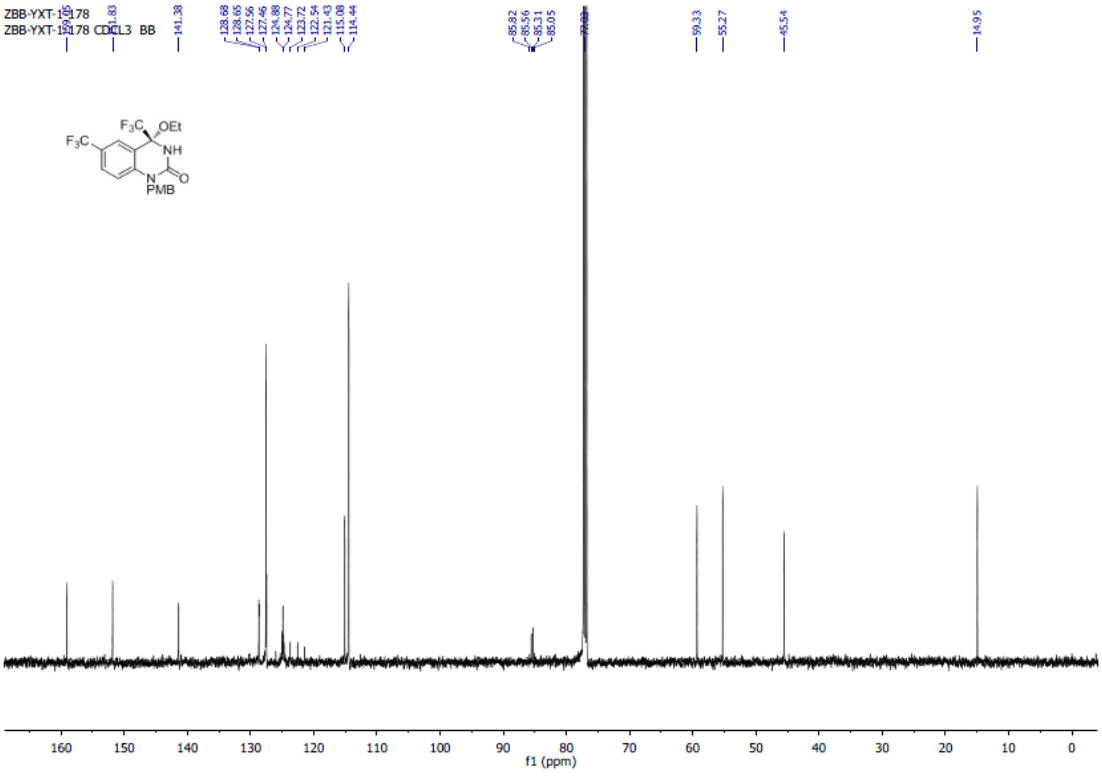
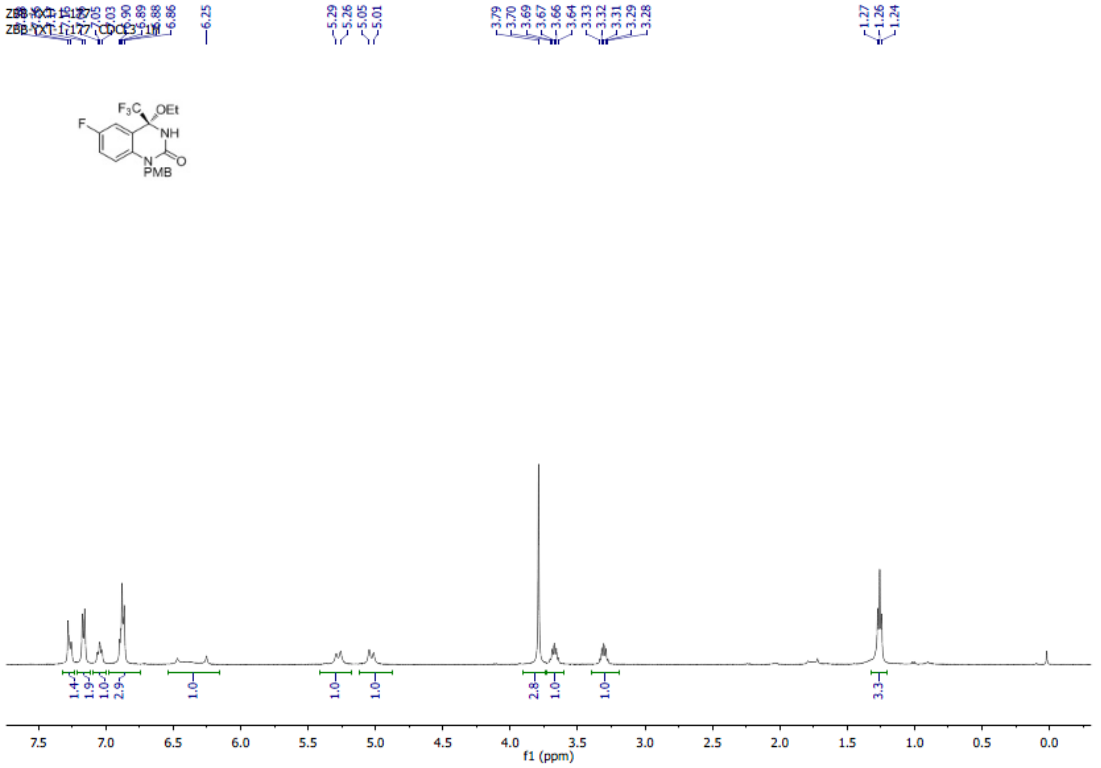
1.0
2.0
1.0
1.9
1.0
1.0
1.0
3.0
1.0
1.0
3.3
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


ZBB-YXT-1-178
ZBB-YXT-1-178 CDCL3 BB
159.45
151.83
141.38
128.68
128.65
127.56
127.46
124.88
124.77
123.72
122.54
121.43
115.08
114.44
85.82
85.56
85.31
85.05
77.00
59.33
55.27
45.54
14.95
F3C
OEt
NH
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 3c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6.25
5.29
5.26
5.05
5.01
3.79
3.70
3.69
3.67
3.66
3.64
3.33
3.32
3.31
3.29
3.28
1.27
1.26
1.24
F3C
OEt
NH
F
N
O
PMB
1.4
1.9
1.0
2.9
1.0
1.0
1.0
2.8
1.0
1.0
3.3
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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3.5
3.0
2.5
2.0
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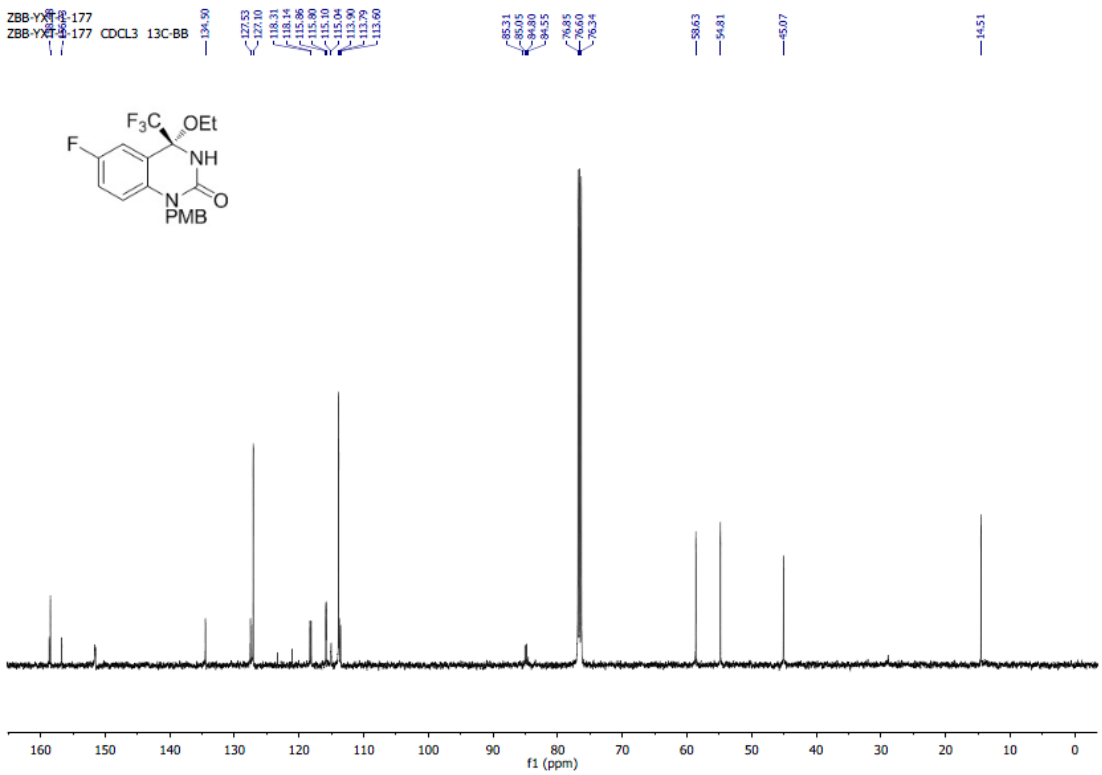
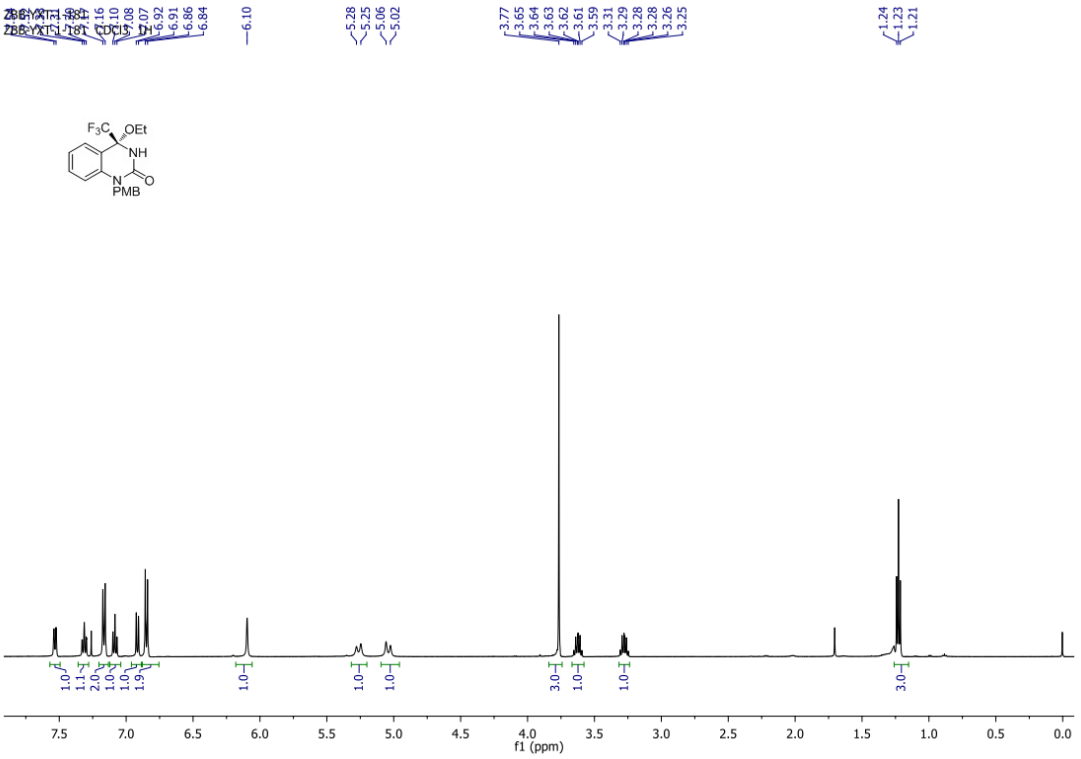
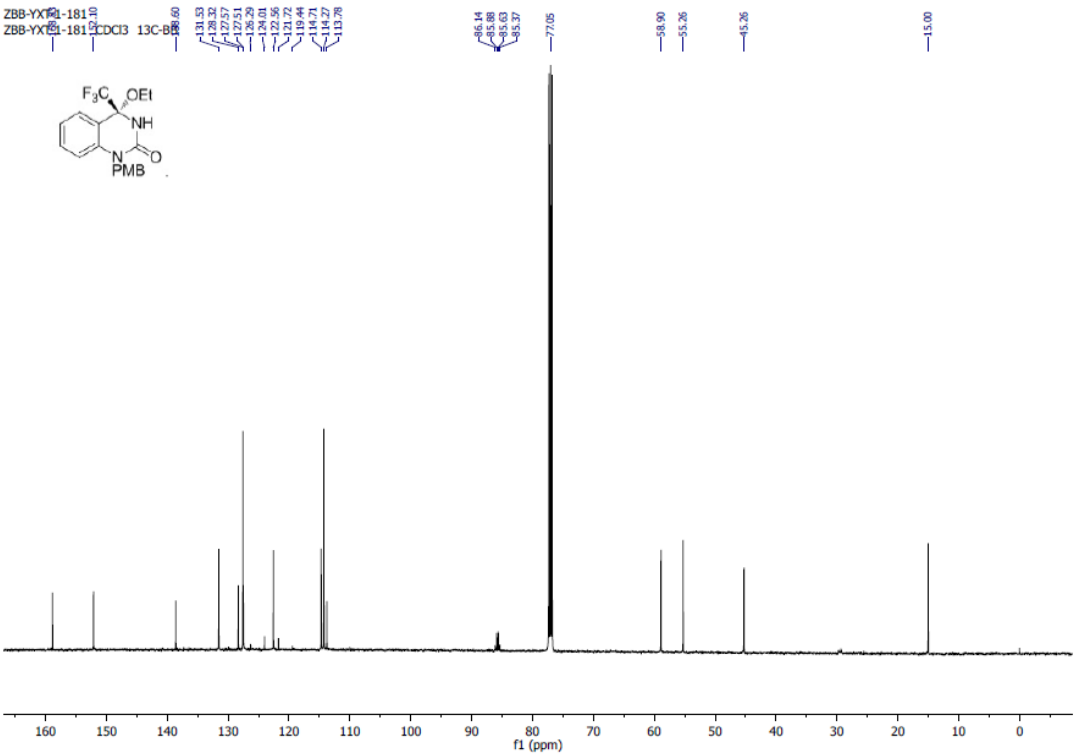
1.0
0.5
0.0
f1 (ppm)

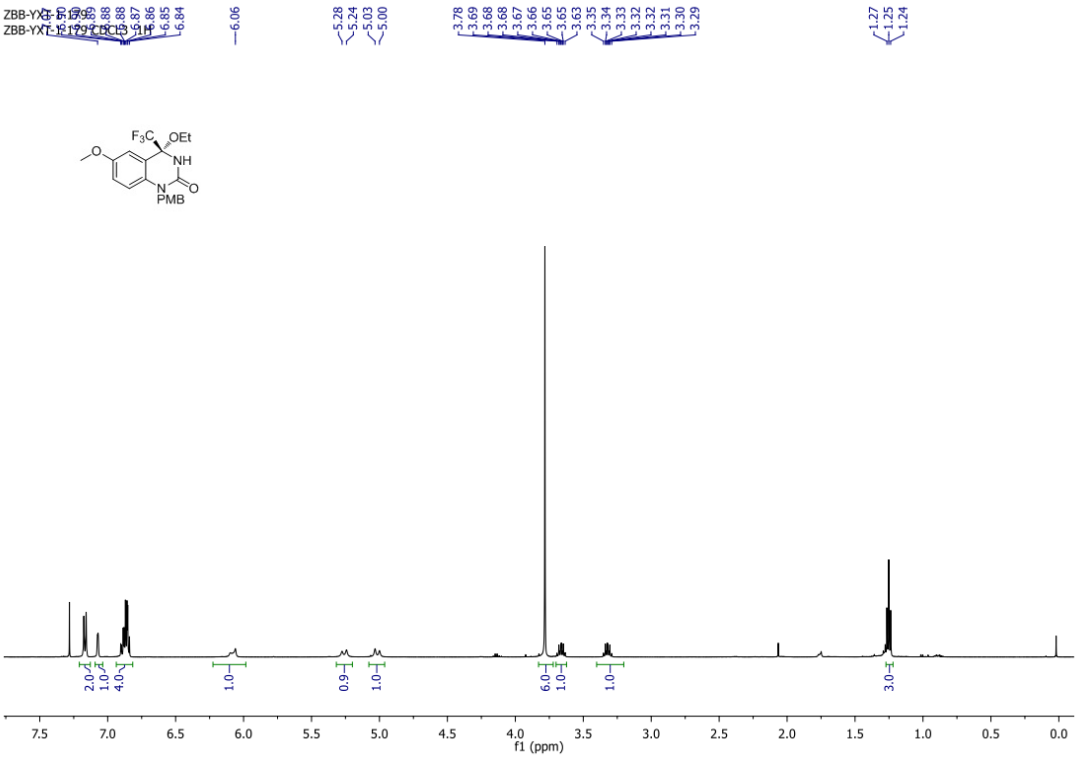

ZBB-YXT-177
ZBB-YXT-177 CDCL3 13C-BB
134.50
127.53
127.10
118.31
118.14
115.86
115.80
115.10
115.04
113.90
113.79
113.60
85.31
85.05
84.80
84.55
76.85
76.60
76.34
58.63
54.81
45.07
14.51
F3C
OEt
NH
F
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

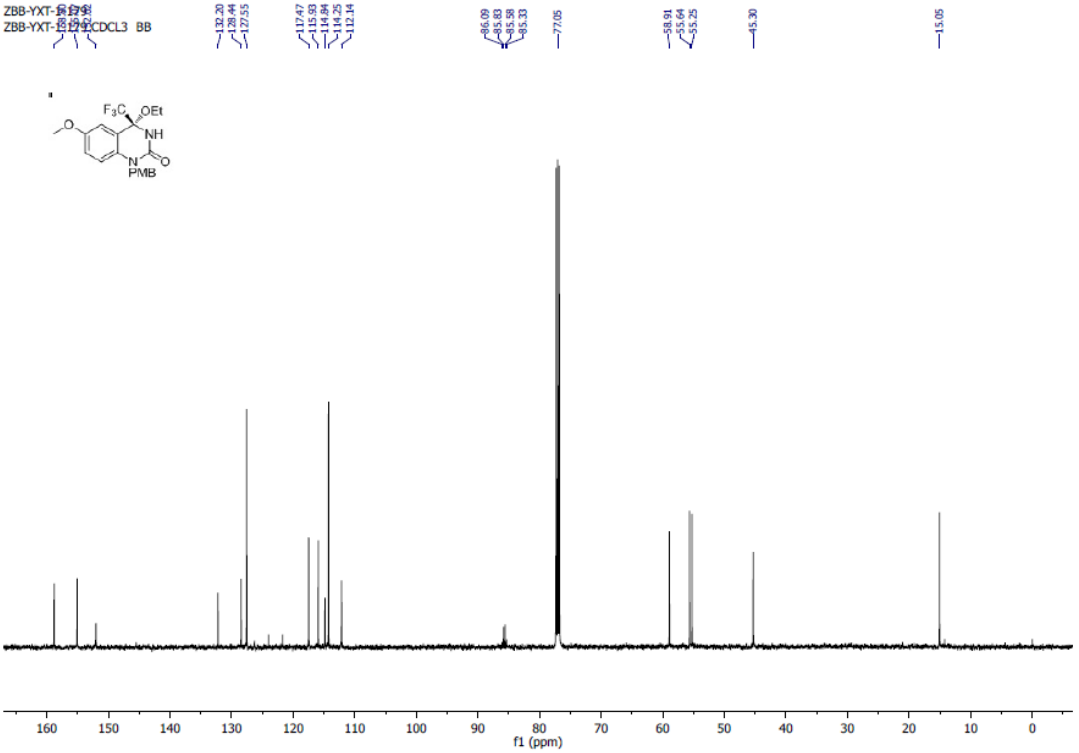
Compound 3d



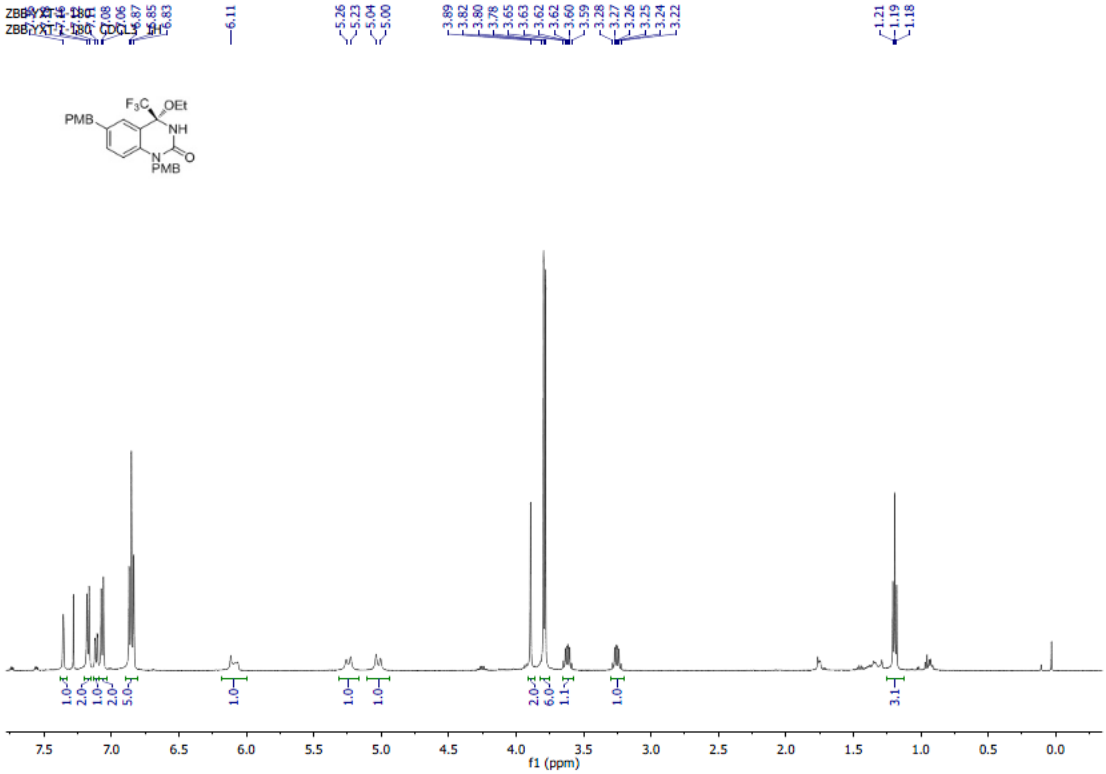


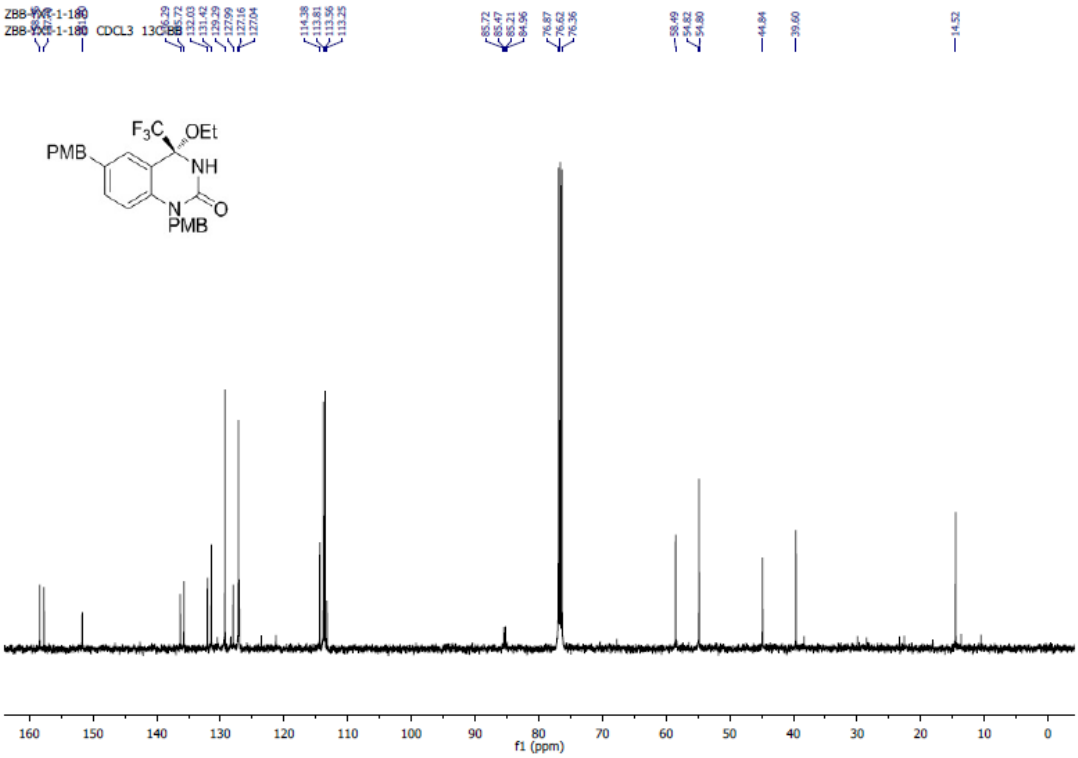
Compound 3e



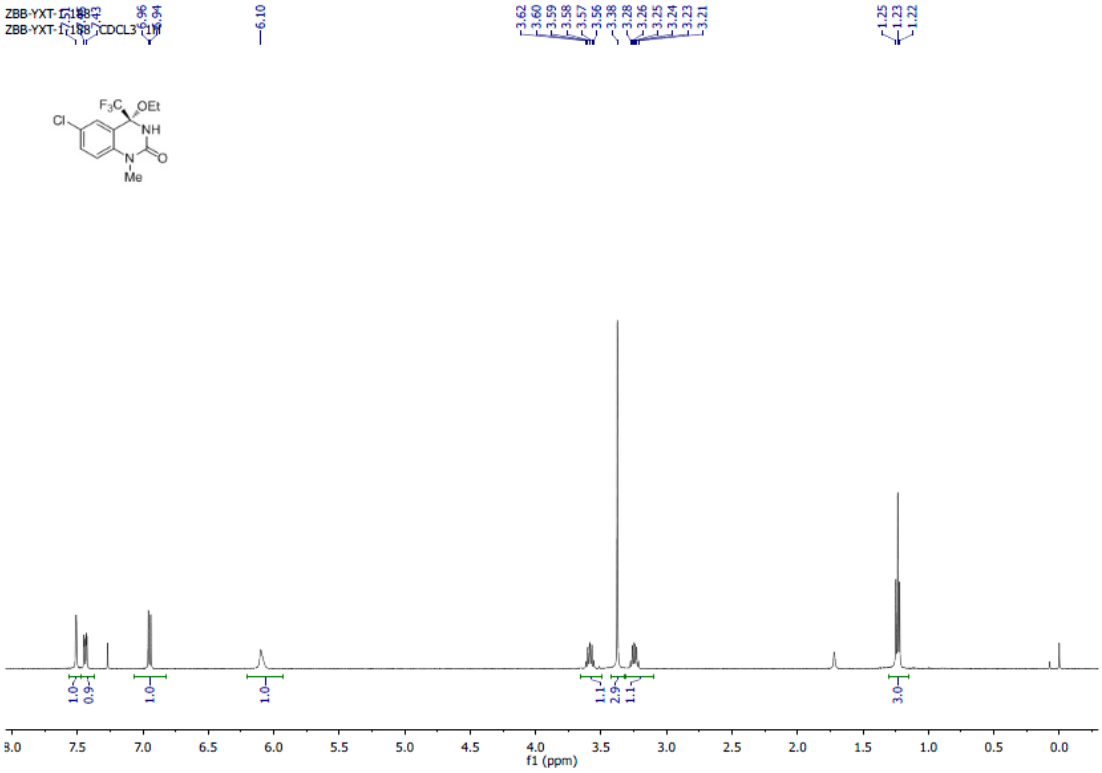


Compound 3f





Compound 3g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ZBB-YXT-1-188 CDCL3 1H
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3.62
3.60
3.59
3.58
3.57
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3.28
3.26
3.25
3.24
3.23
3.21
1.25
1.23
1.22
F3C
OEt
Cl
NH
N
O
Me
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1.0
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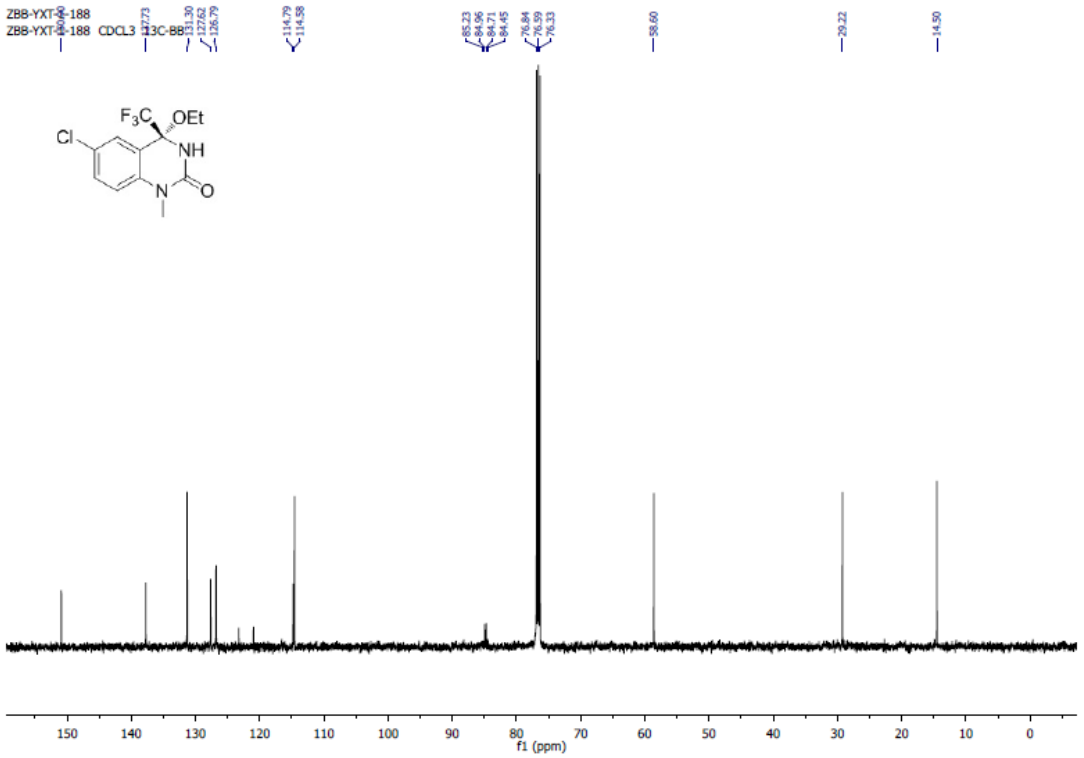
1.1
2.9
1.1
3.0
f1 (ppm)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ZBB-YXT-188 CDCL3 13C-BB
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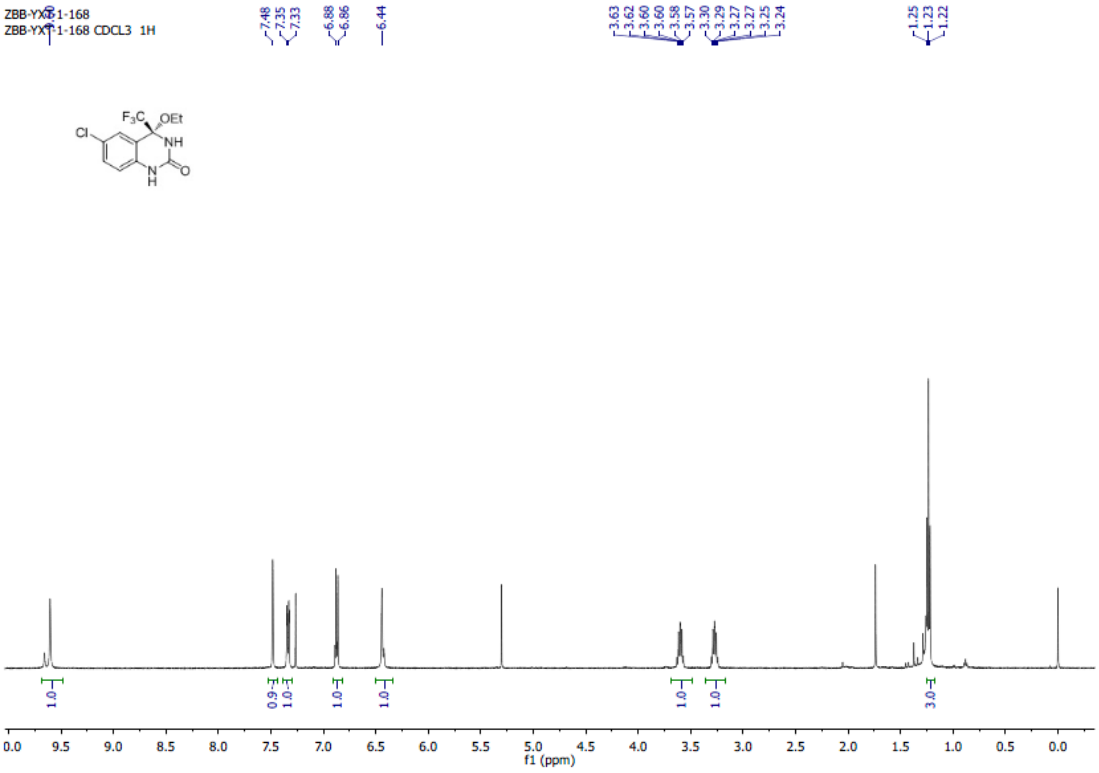
137.73
133.30
127.62
126.79
114.79
114.58
85.23
84.96
84.71
84.45
76.84
76.59
76.33
58.60
29.22
14.50
F3C
OEt
Cl
NH
N
O
f1 (ppm)

Compound 3h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ZBB-YXT1-168 CDCL3 1H
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7.33
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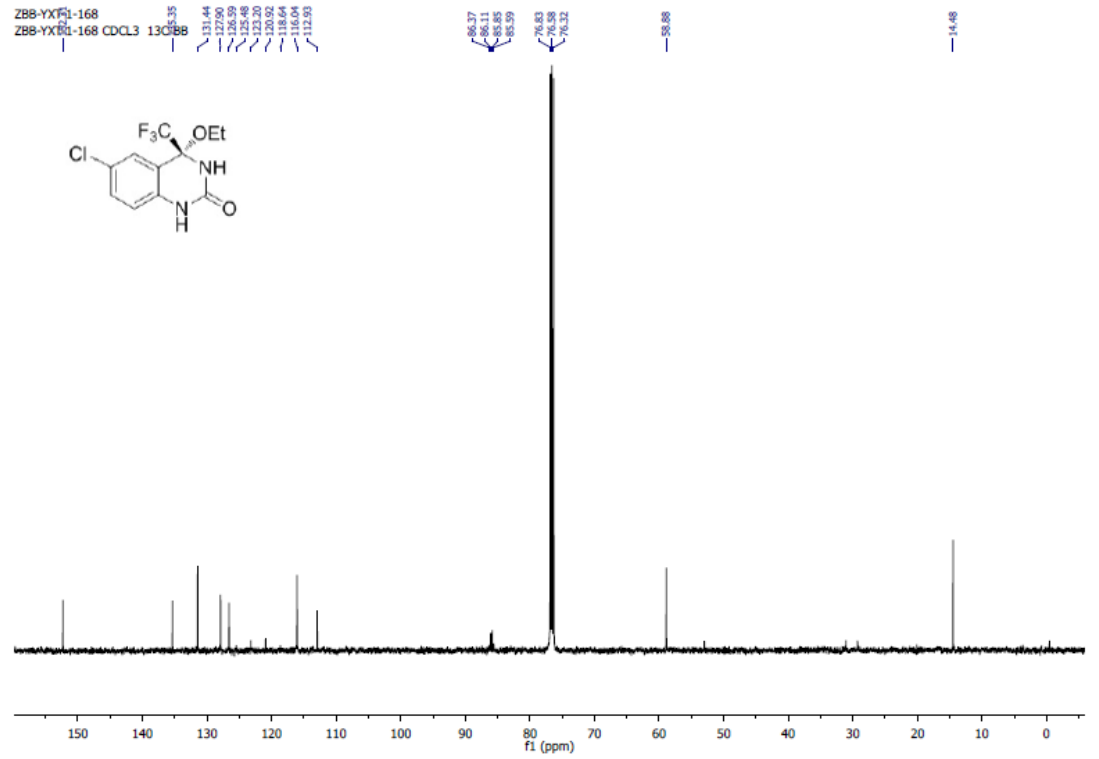
6.86
6.44
3.63
3.62
3.60
3.60
3.58
3.57
3.30
3.29
3.27
3.27
3.25
3.24
1.25
1.23
1.22
F3C
OEt
Cl
NH
N
H
O
1.0
0.9
1.0
1.0
1.0
1.0
1.0
3.0
0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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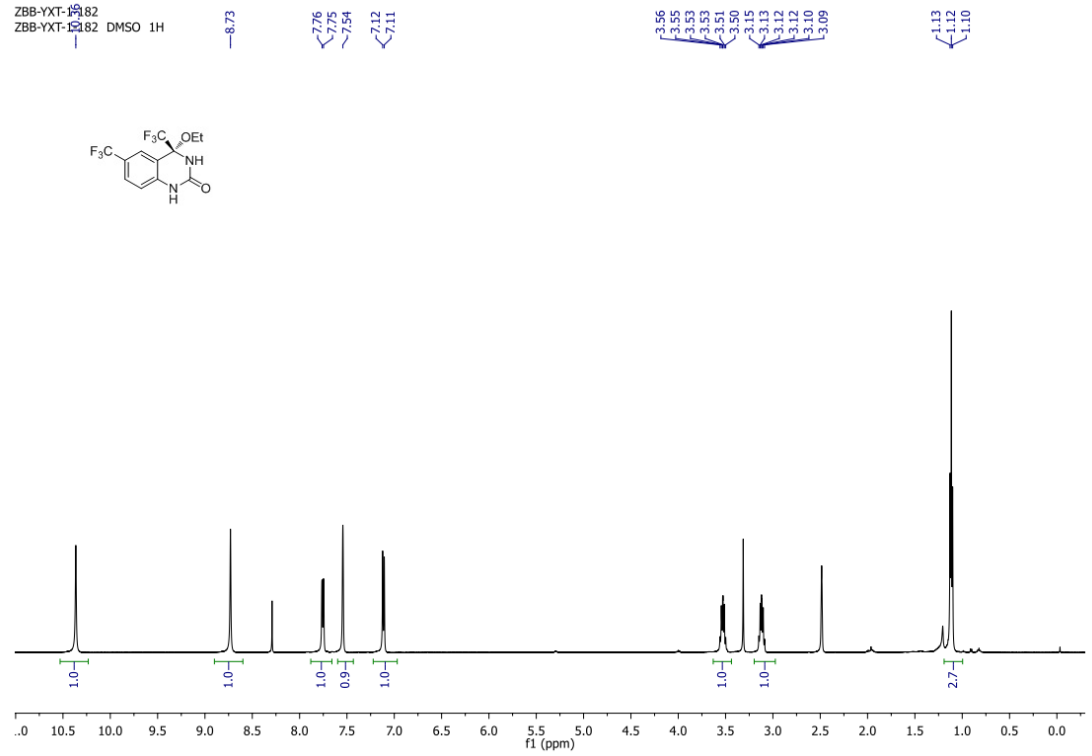
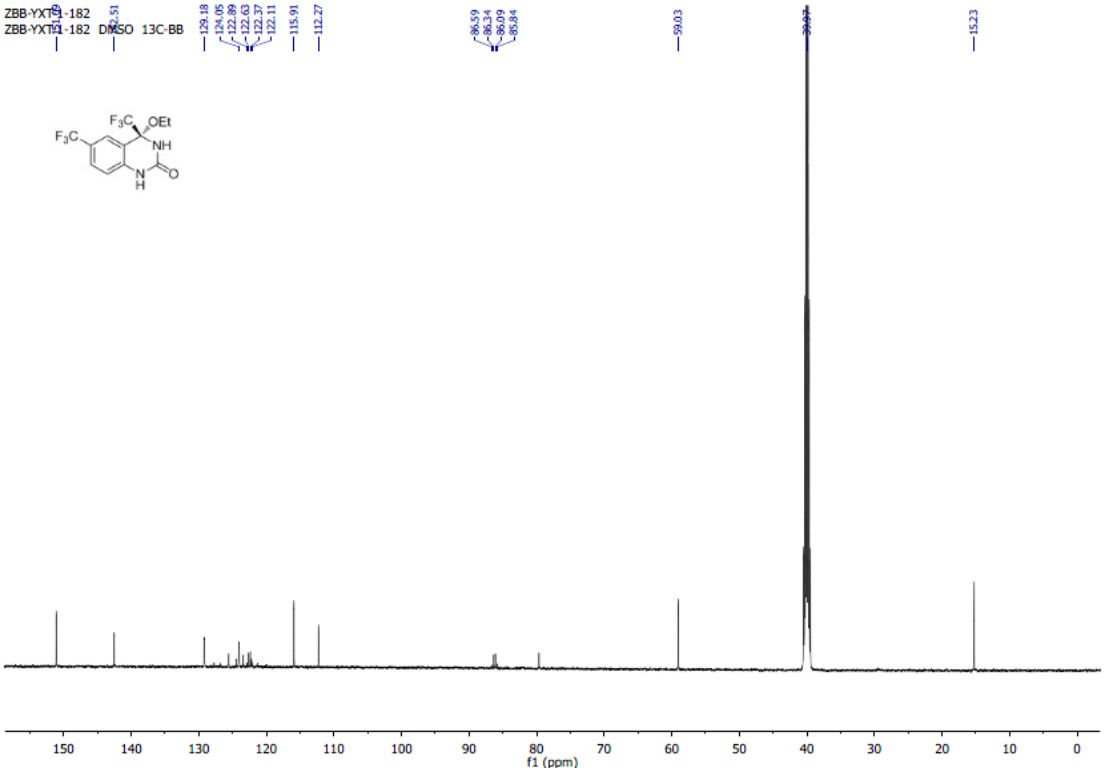
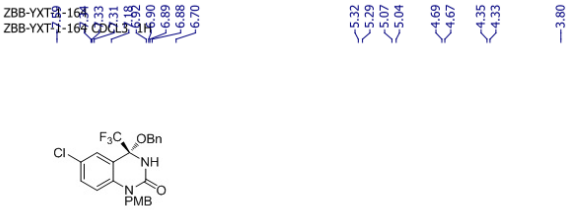
ZBB-YXT1-168 CDCL3 13CBB
135.35
131.44
127.90
126.59
125.48
123.20
120.92
118.64
116.04
112.93
86.37
86.11
85.85
85.59
76.83
76.58
76.32
58.88
14.48
F3C
OEt
Cl
NH
N
H
O
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

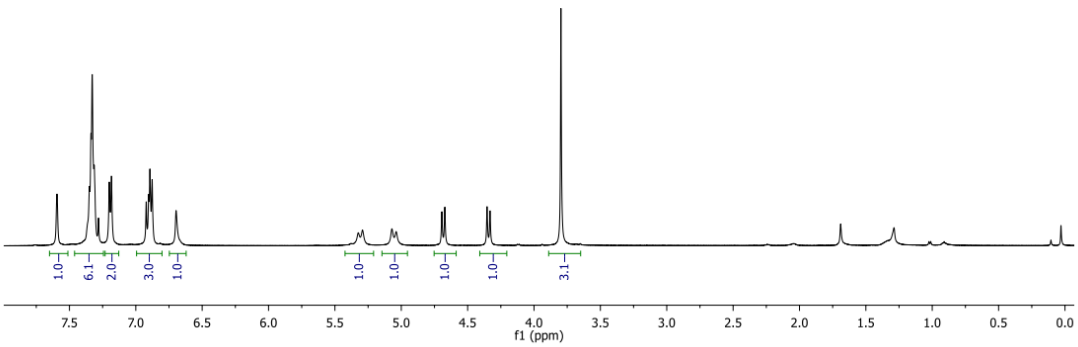
Compound 3i

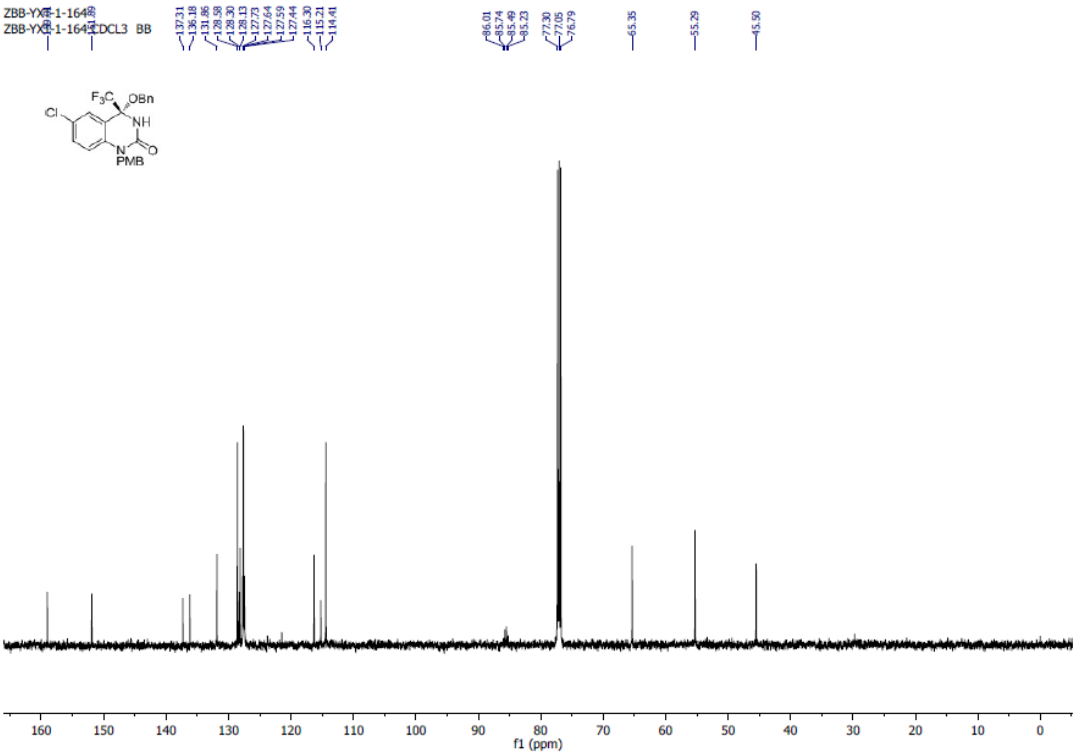

ZBB-YXT-182
ZBB-YXT-182 DMSO 1H
8.73
7.76
7.75
7.54
7.12
7.11
3.56
3.55
3.53
3.53
3.51
3.50
3.15
3.13
3.12
3.12
3.10
3.09
1.13
1.12
1.10
F3C
OEt
NH
F3C
N
H
O
1.0
1.0
1.0
0.9
1.0
1.0
1.0
2.7
f1 (ppm)


ZBB-YXT-182
ZBB-YXT-182 DMSO 13C-BB
129.18
124.05
122.89
122.63
122.37
122.11
115.91
112.27
86.59
86.34
86.09
85.84
59.03
39.07
15.23
F3C
OEt
NH
F3C
N
H
O
f1 (ppm)

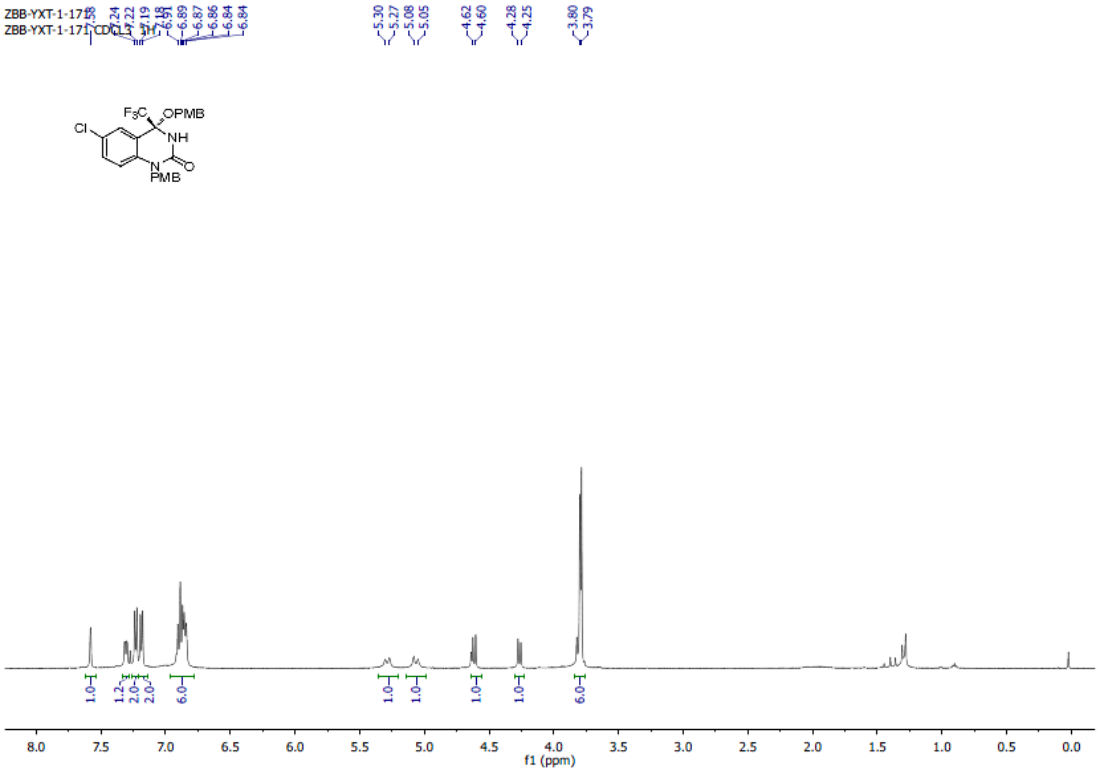
Compound 3j

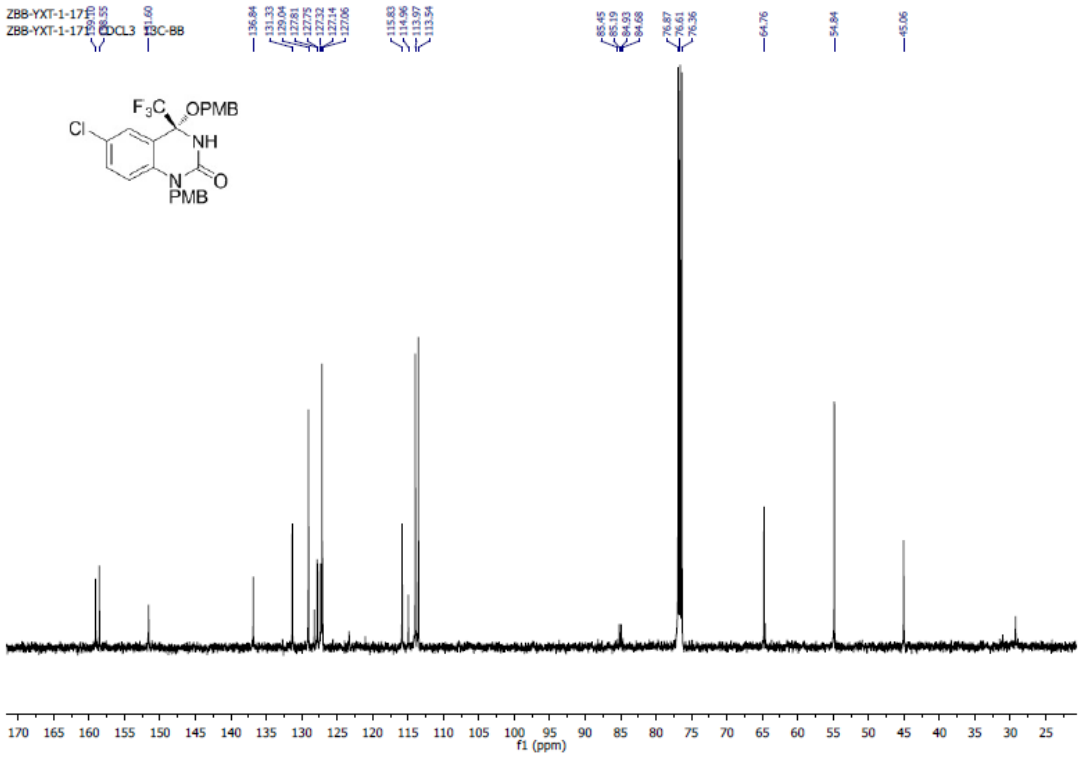




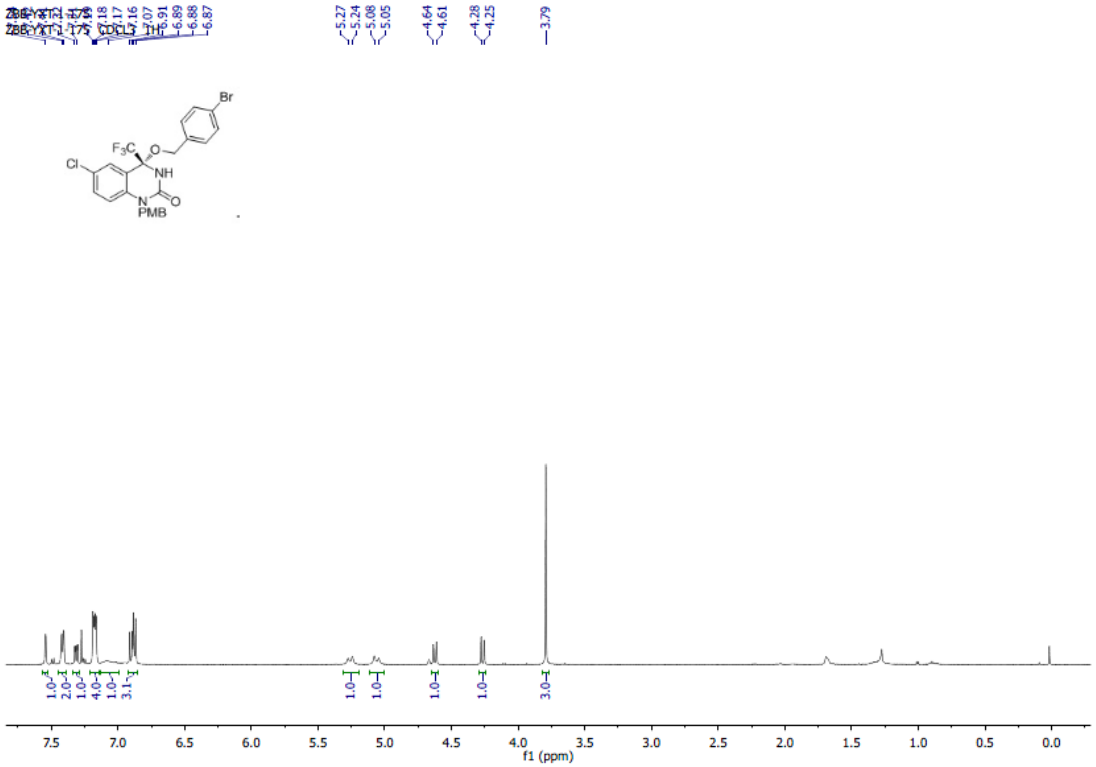


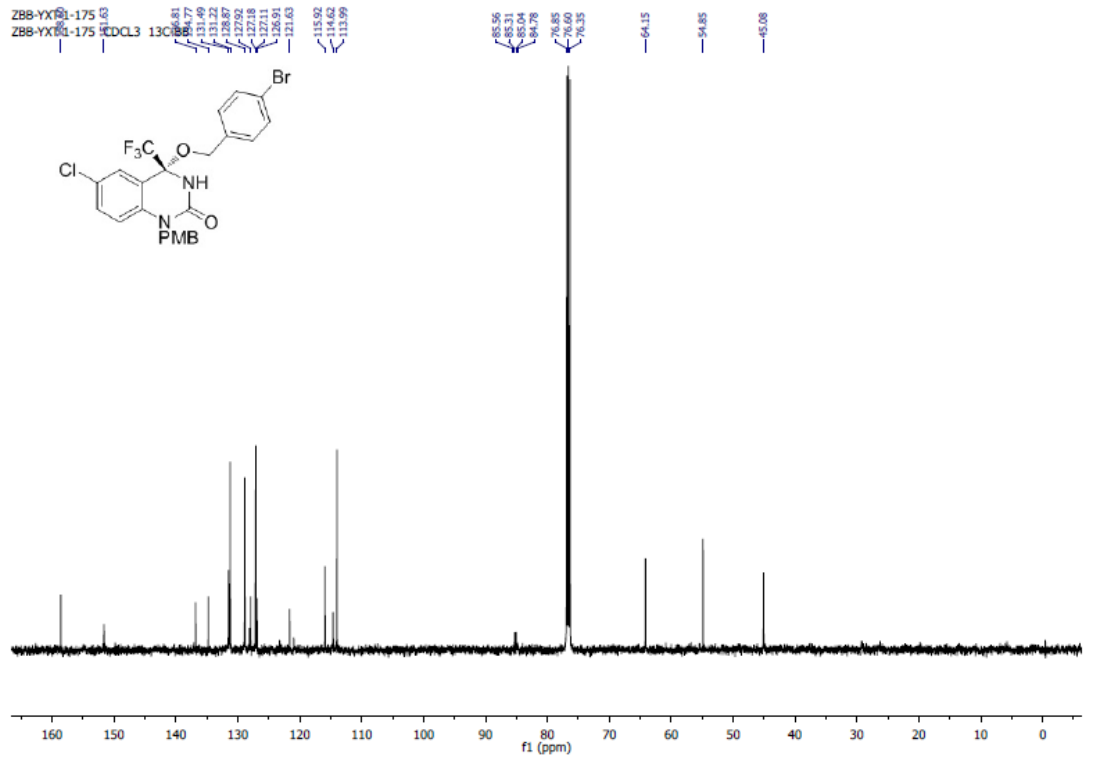
Compound 3k


ZBB-YXT-1-171
ZBB-YXT-1-171_CDCL3
7.24
7.22
7.19
7.18
6.91
6.89
6.87
6.86
6.84
6.84
5.30
5.27
5.08
5.05
4.62
4.60
4.28
4.25
3.80
3.79
F3C
OPMB
Cl
NH
N
O
PMB
1.0
1.2
2.0
2.0
6.0
1.0
1.0
1.0
1.0
6.0
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)

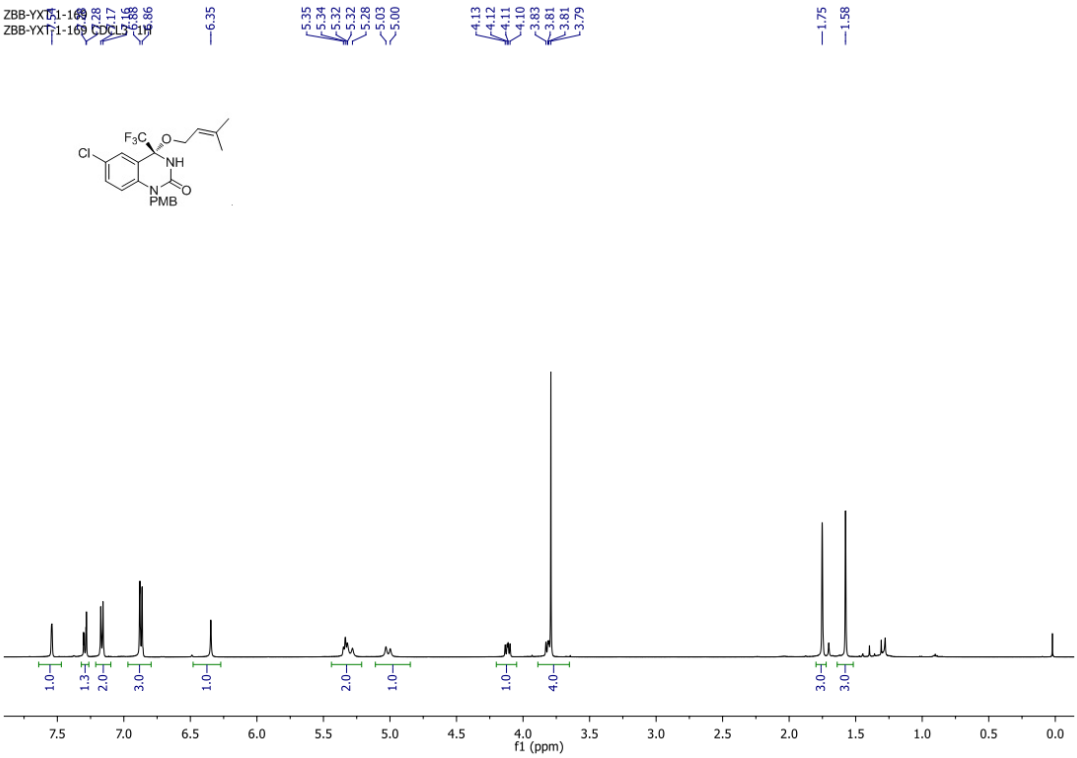

ZBB-YXT-1-171
ZBB-YXT-1-171_CDCL3_13C-BB
159.70
136.55
131.60
136.84
131.33
129.04
127.81
127.75
122.32
122.14
122.06
115.83
114.96
113.97
113.54
85.45
85.19
84.93
84.68
76.87
76.61
76.36
64.76
54.84
45.06
F3C
OPMB
Cl
NH
N
O
PMB
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
f1 (ppm)

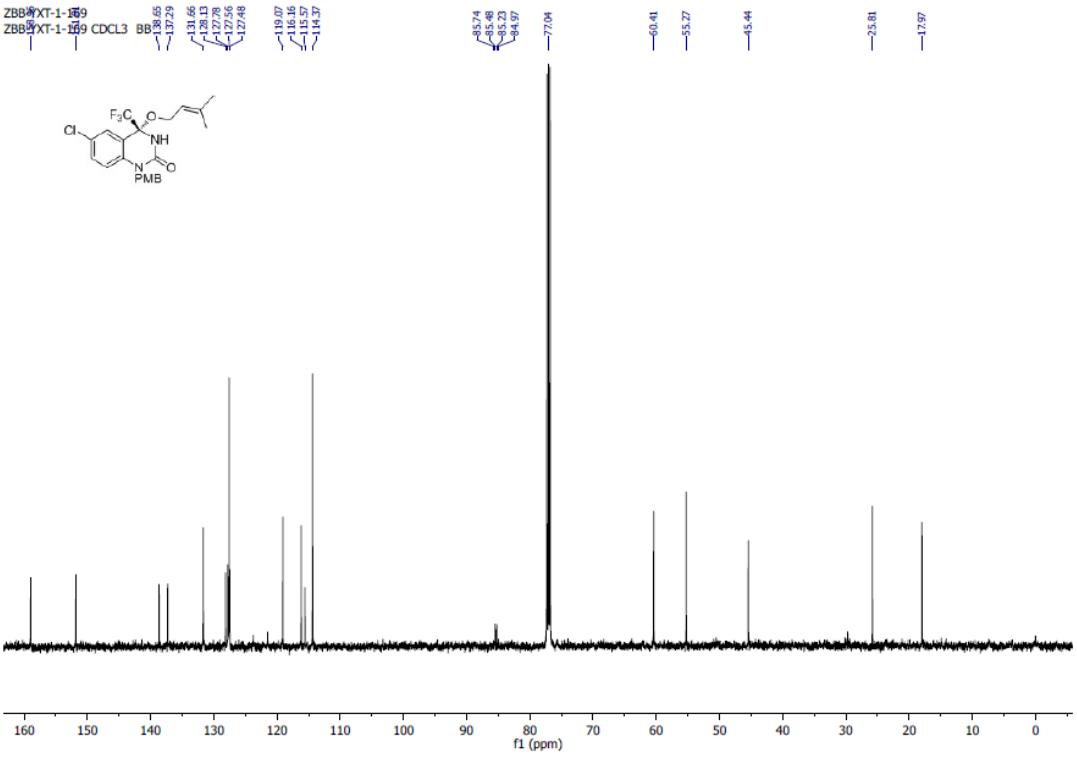
Compound 3l


5.27
5.24
5.08
5.05
4.64
4.61
4.28
4.25
3.79
Br
F3C
O
NH
Cl
N
O
PMB
f1 (ppm)

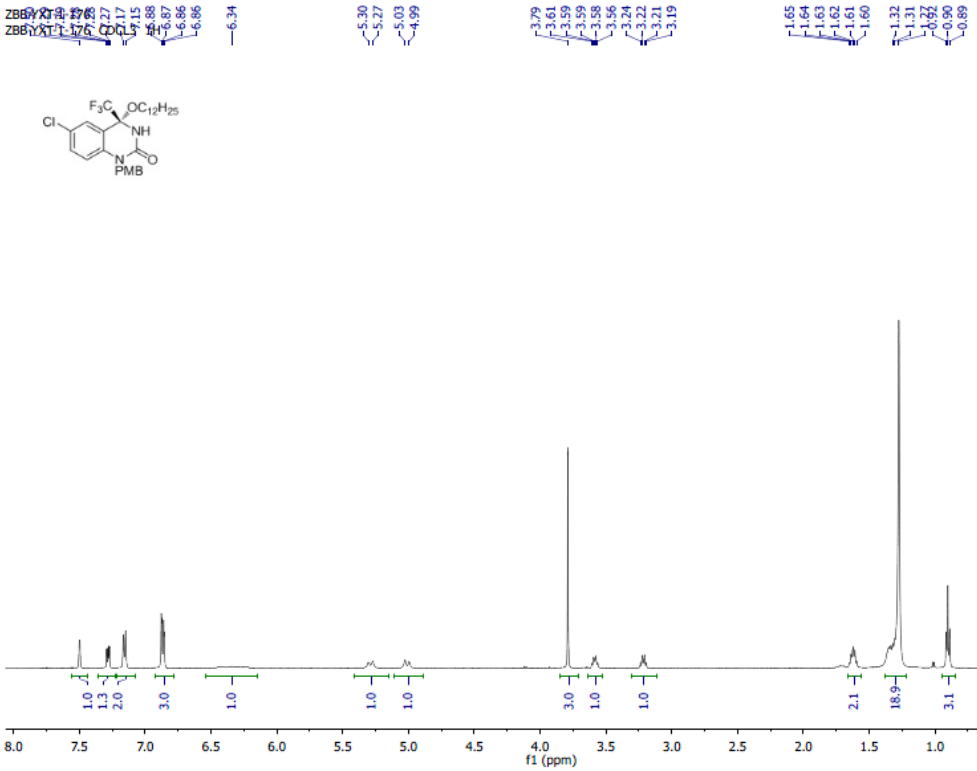

ZBB-YXH1-175
ZBB-YXH1-175 CDCL3 13CBB
64.15
54.85
45.08
Br
F3C
O
NH
Cl
N
O
PMB
f1 (ppm)

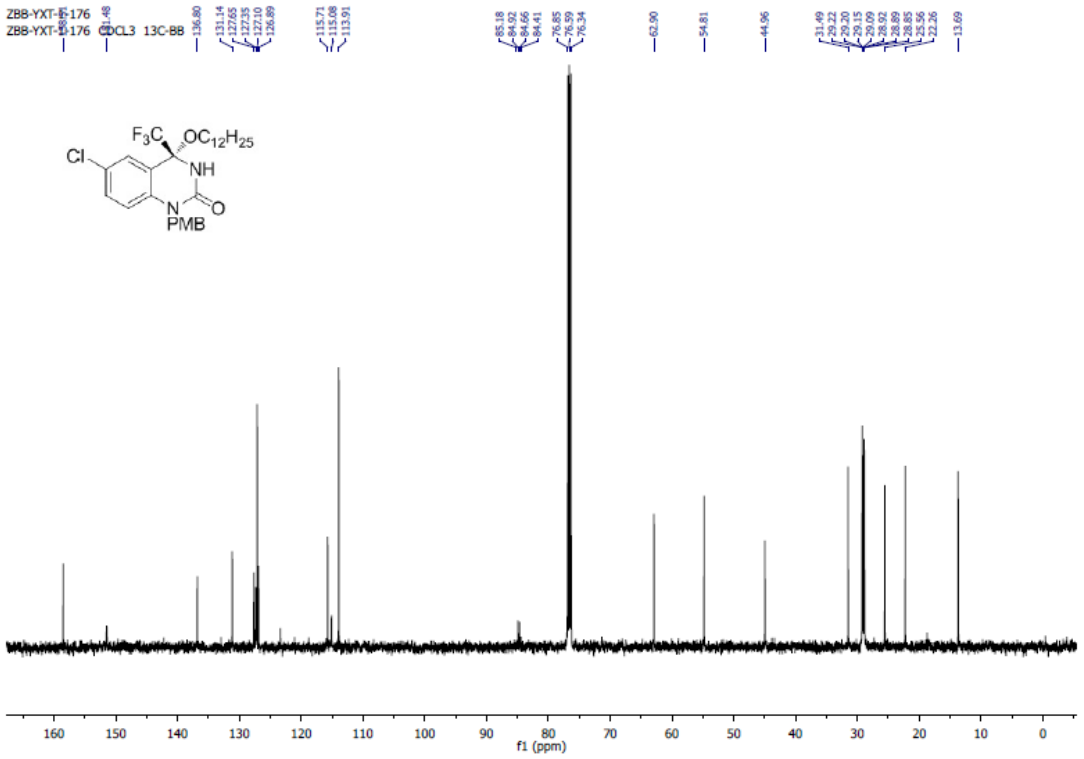
Compound 3m


ZBB-YXT-1-169
ZBB-YXT-1-169 CDCL3
6.35
5.35
5.34
5.32
5.32
5.28
5.03
5.00
4.13
4.12
4.11
4.10
3.83
3.81
3.81
3.79
1.75
1.58
F3C
O
Cl
NH
N
O
PMB
1.0
1.3
2.0
3.0
1.0
2.0
1.0
1.0
4.0
3.0
3.0
f1 (ppm)

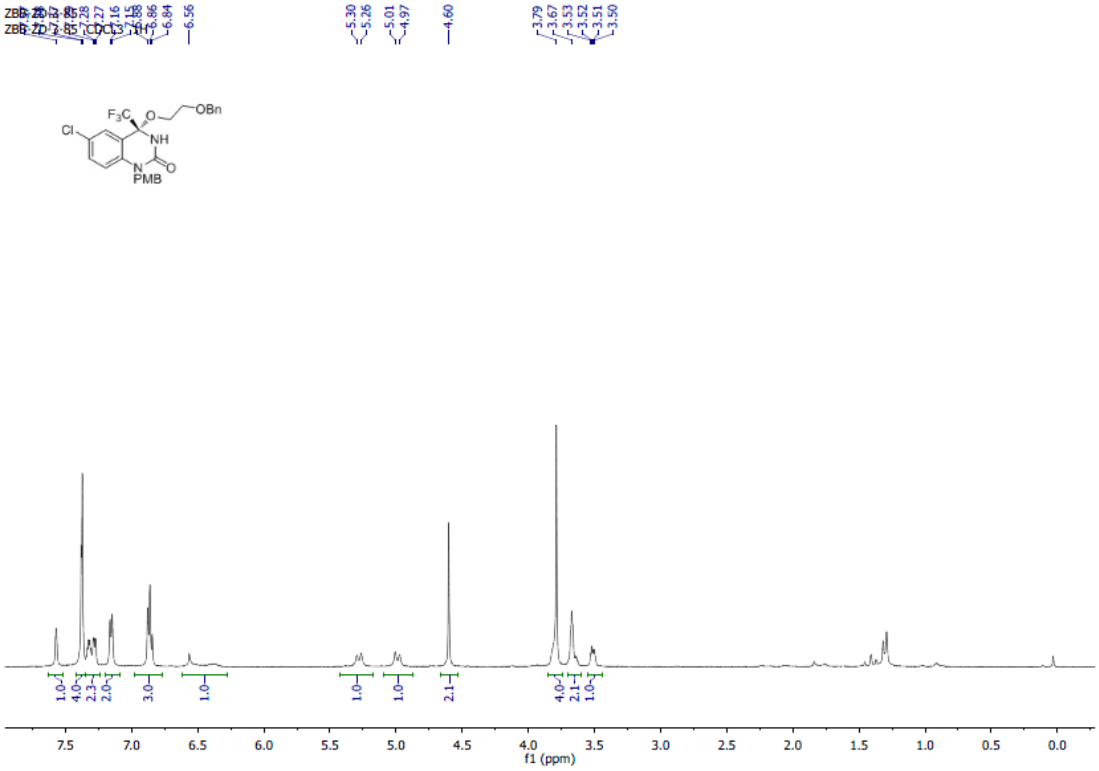

ZBB-YXT-1-169
ZBB-YXT-1-169 CDCL3
138.65
137.29
131.66
128.13
127.78
127.56
127.48
119.07
116.16
115.57
114.37
85.74
85.48
85.23
84.97
77.04
60.41
55.27
45.44
25.81
17.97
F3C
O
Cl
NH
N
O
PMB
f1 (ppm)

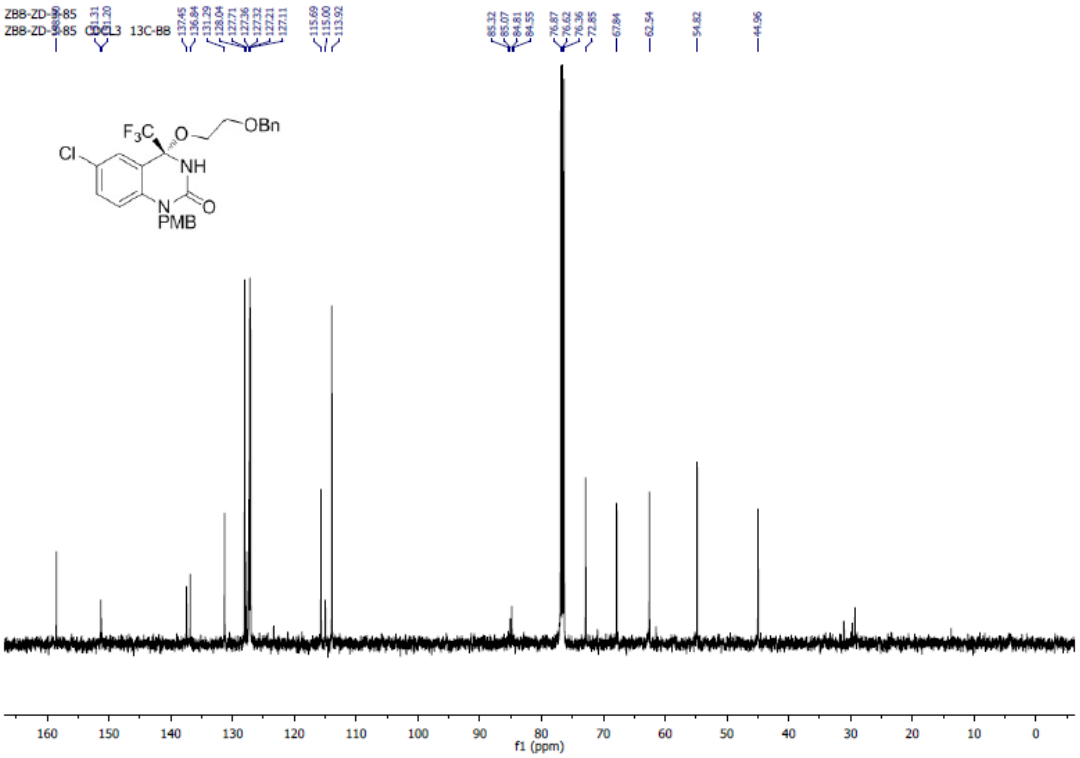
Compound 3n


ZBB-YXT-176
ZBB-YXT-176 CDCL3 1H
6.87
6.86
6.86
6.34
5.30
5.27
5.03
4.99
3.79
3.61
3.59
3.59
3.58
3.56
3.24
3.22
3.21
3.19
1.65
1.64
1.63
1.62
1.61
1.60
1.32
1.31
0.92
0.90
0.89
Cl
F3C
OC12H25
NH
N
O
PMB
1.0
1.3
2.0
3.0
1.0
1.0
1.0
3.0
1.0
1.0
2.1
18.9
3.1
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)

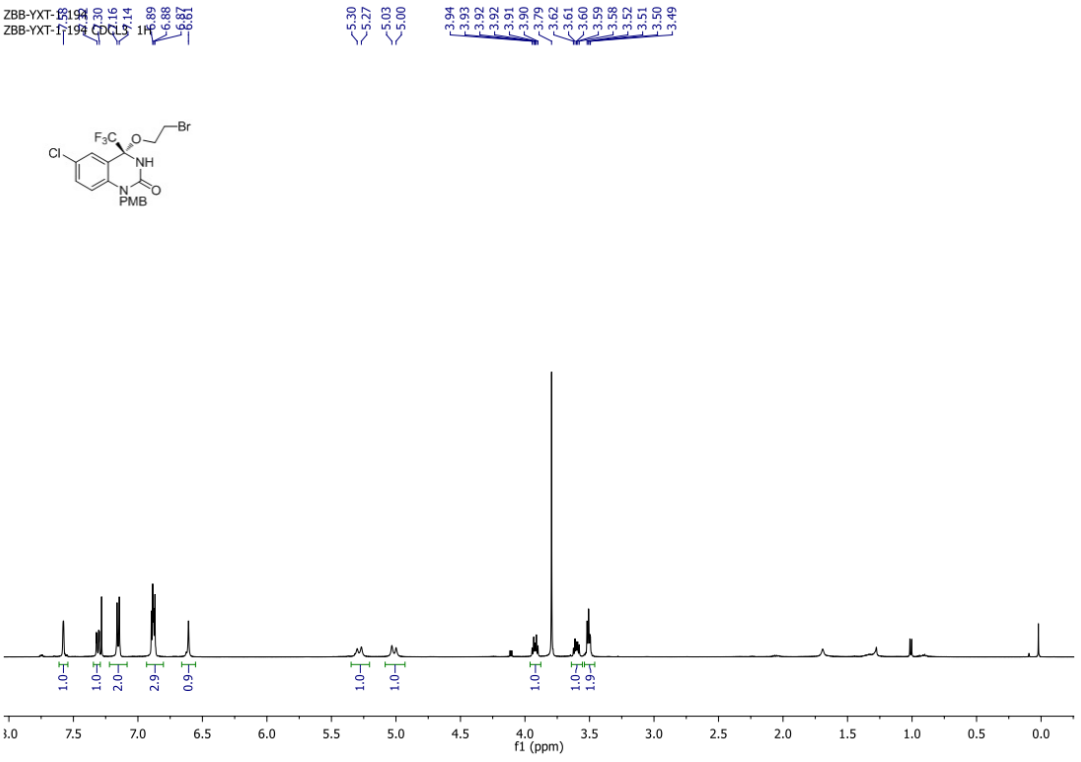

ZBB-YXT-176
ZBB-YXT-176 CDCL3 13C-BB
136.80
131.14
127.65
127.35
127.10
126.89
115.71
115.08
113.91
85.18
84.92
84.66
84.41
76.85
76.59
76.34
62.90
54.81
44.96
31.49
29.22
29.20
29.15
29.09
28.92
28.89
28.85
25.56
22.26
13.69
Cl
F3C
OC12H25
NH
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

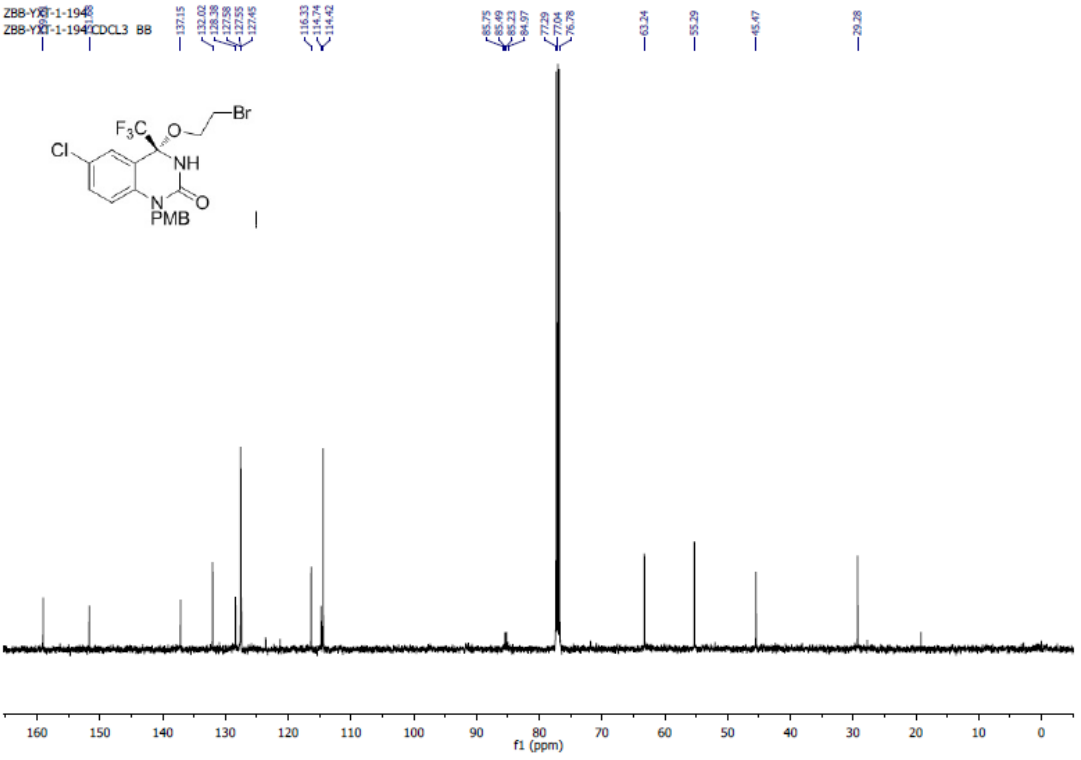
Compound 3o



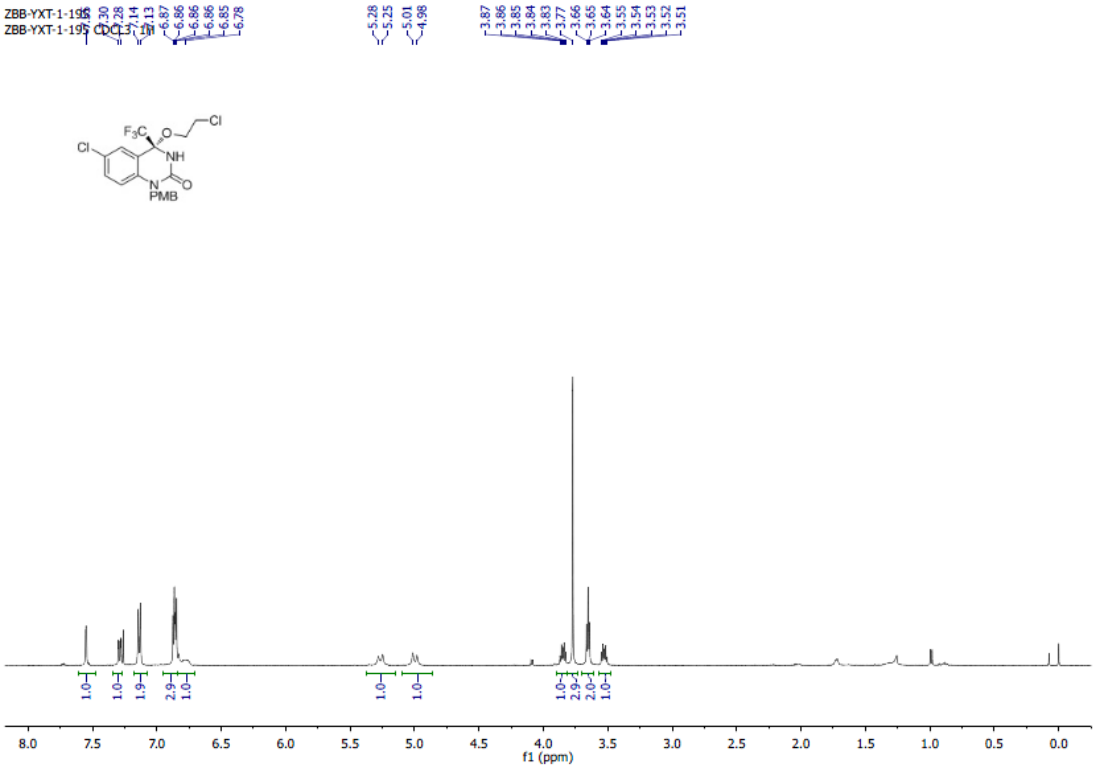


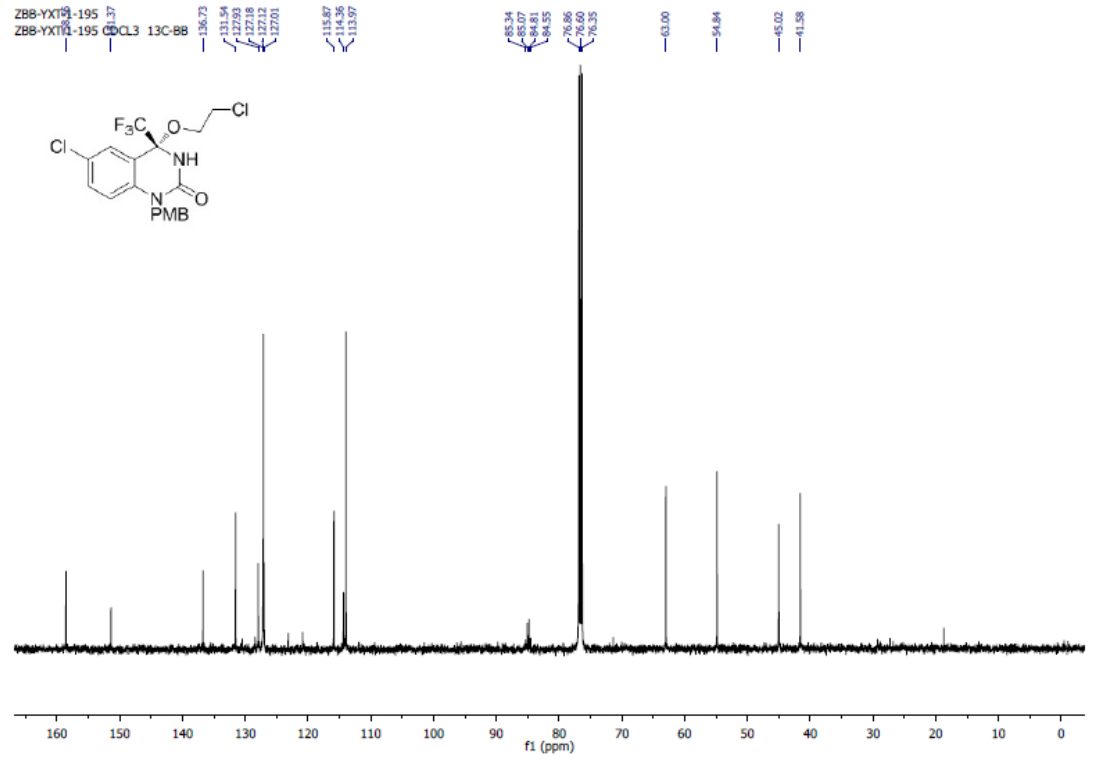
Compound 3p


ZBB-YXT-1-194
ZBB-YXT-1-194 CDCL3 1H
5.30
5.27
5.03
5.00
3.94
3.93
3.92
3.92
3.91
3.90
3.79
3.62
3.61
3.60
3.59
3.58
3.52
3.51
3.50
3.49
F3C
O
Br
Cl
NH
N
O
PMB
1.0
1.0
2.0
2.9
0.9
1.0
1.0
1.0
1.9
f1 (ppm)

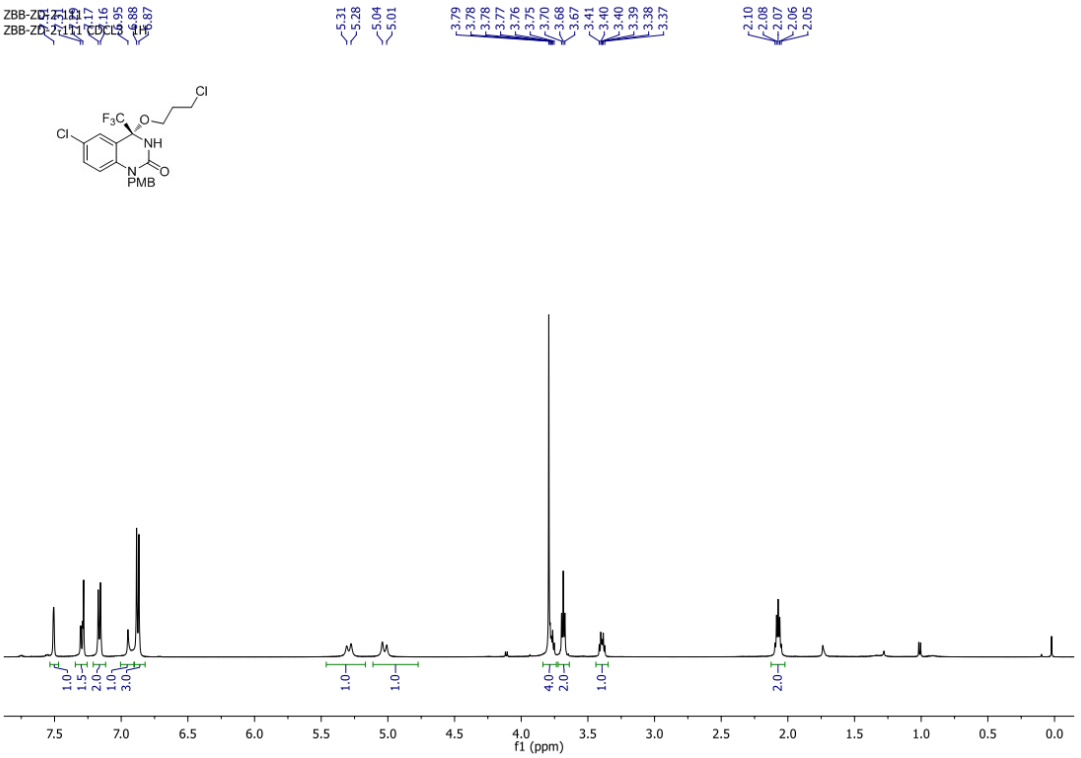

ZBB-YXT-1-194
ZBB-YXT-1-194 CDCL3 BB
137.15
132.02
128.38
127.58
127.55
127.45
116.33
114.74
114.42
85.75
85.49
85.23
84.97
77.29
77.04
76.78
63.24
55.29
45.47
29.28
F3C
O
Br
Cl
NH
N
O
PMB
f1 (ppm)

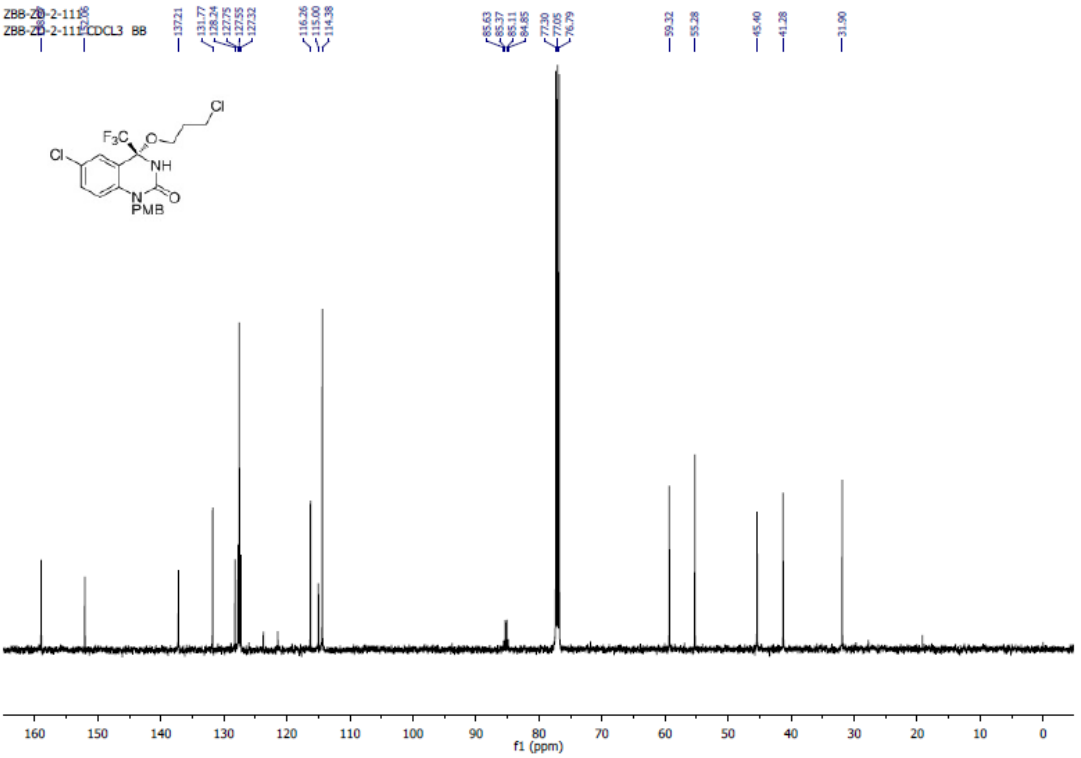
Compound 3q


ZBB-YXT-1-195
ZBB-YXT-1-195 CDCL3
7.30
7.28
7.14
7.13
6.87
6.86
6.86
6.86
6.85
6.78
5.28
5.25
5.01
4.98
3.87
3.86
3.85
3.84
3.83
3.77
3.66
3.65
3.64
3.55
3.54
3.53
3.52
3.51
F3C
O
Cl
NH
Cl
N
O
PMB
1.0
1.0
1.9
2.9
1.0
1.0
1.0
1.0
2.9
2.0
1.0
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)

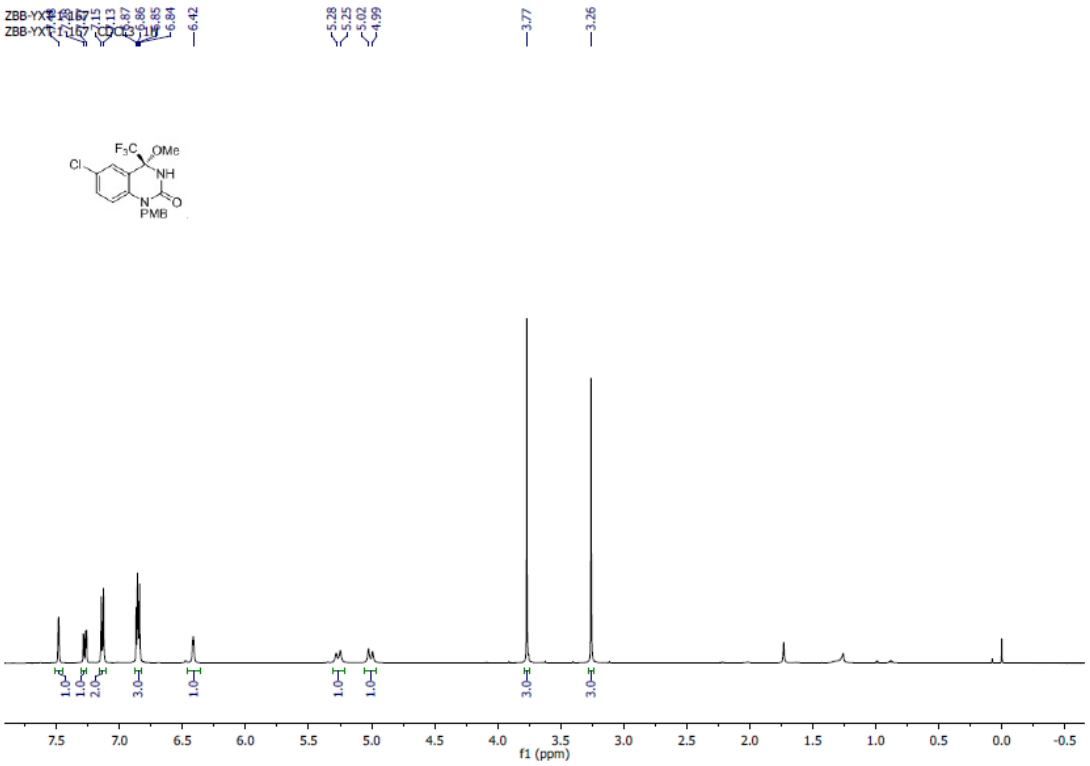

ZBB-YXT-1-195
ZBB-YXT-1-195 CDCL3 13C-BB
136.73
131.54
127.93
127.18
127.12
127.01
115.87
114.36
113.97
85.34
85.07
84.81
84.55
76.86
76.60
76.35
63.00
54.84
45.02
41.58
F3C
O
Cl
NH
Cl
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

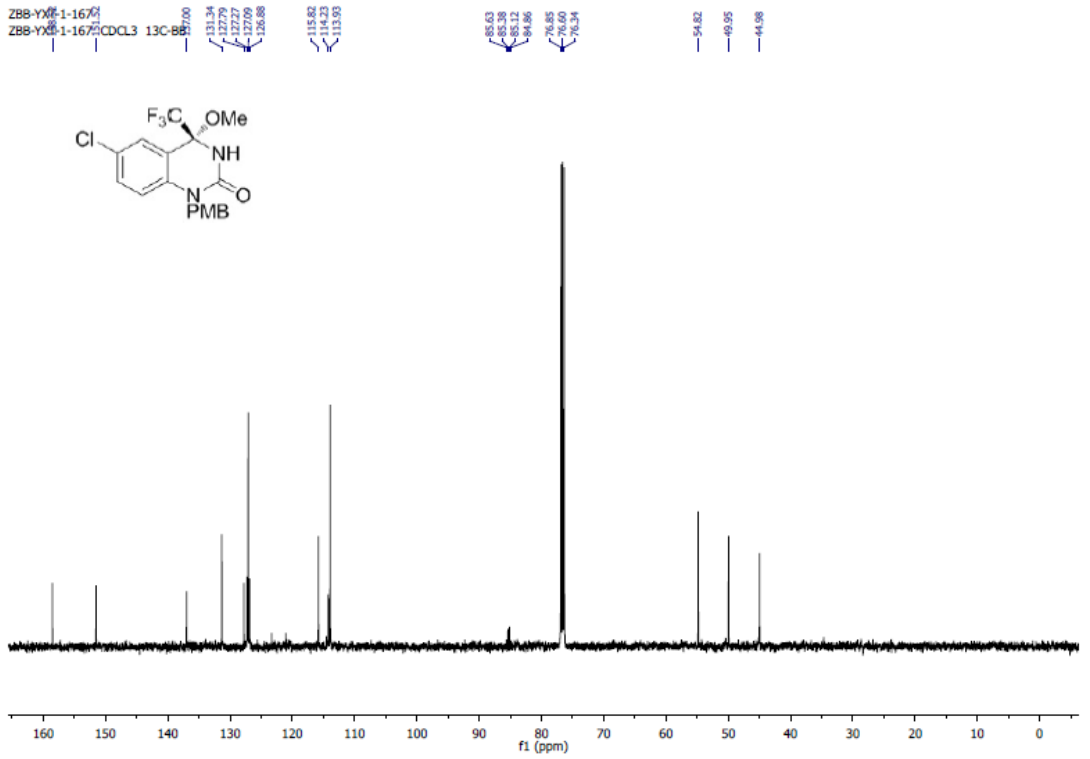
Compound 3r



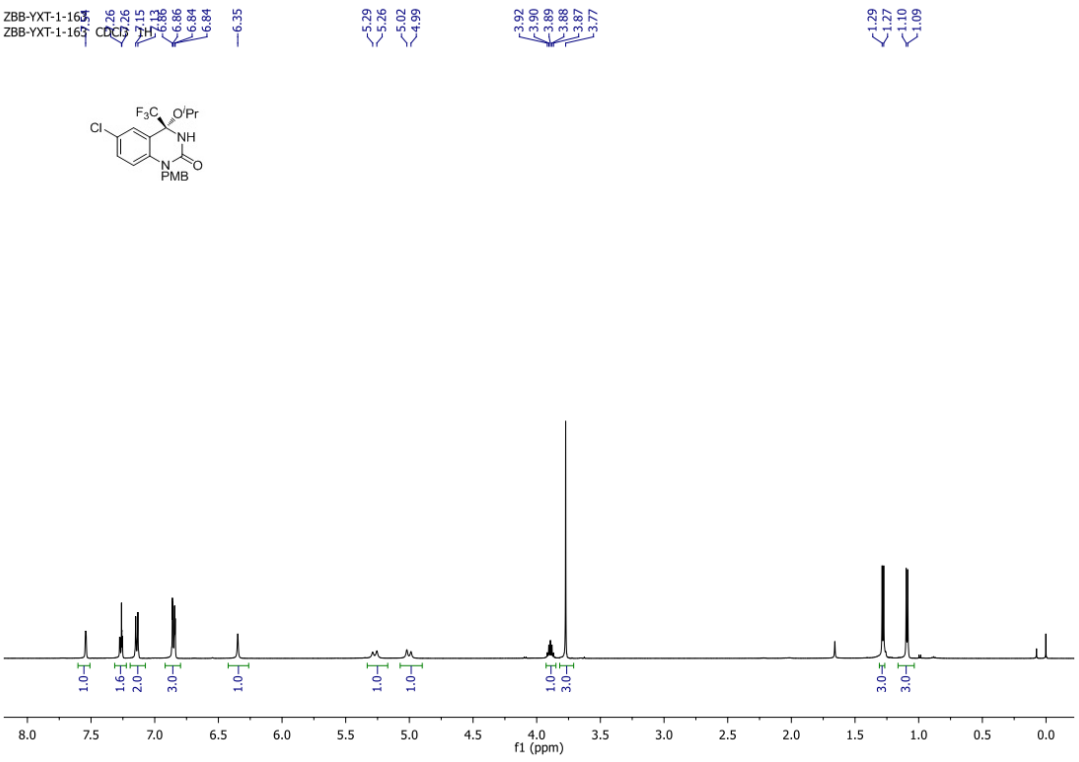


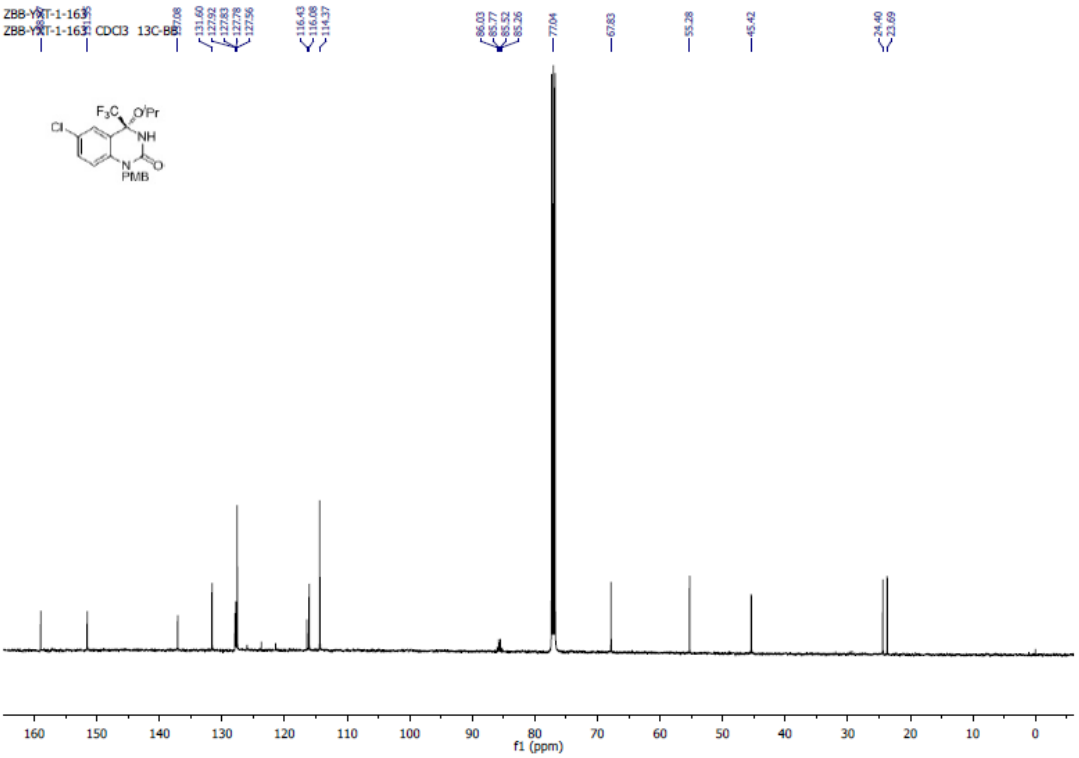
Compound 3s


ZBB-YXT-1167 CDCl3 1H
6.42
5.28
5.25
5.02
4.99
3.77
3.26
F3C
OMe
Cl
NH
N
O
PMB
1.0
1.0
2.0
3.0
1.0
1.0
1.0
3.0
3.0
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)

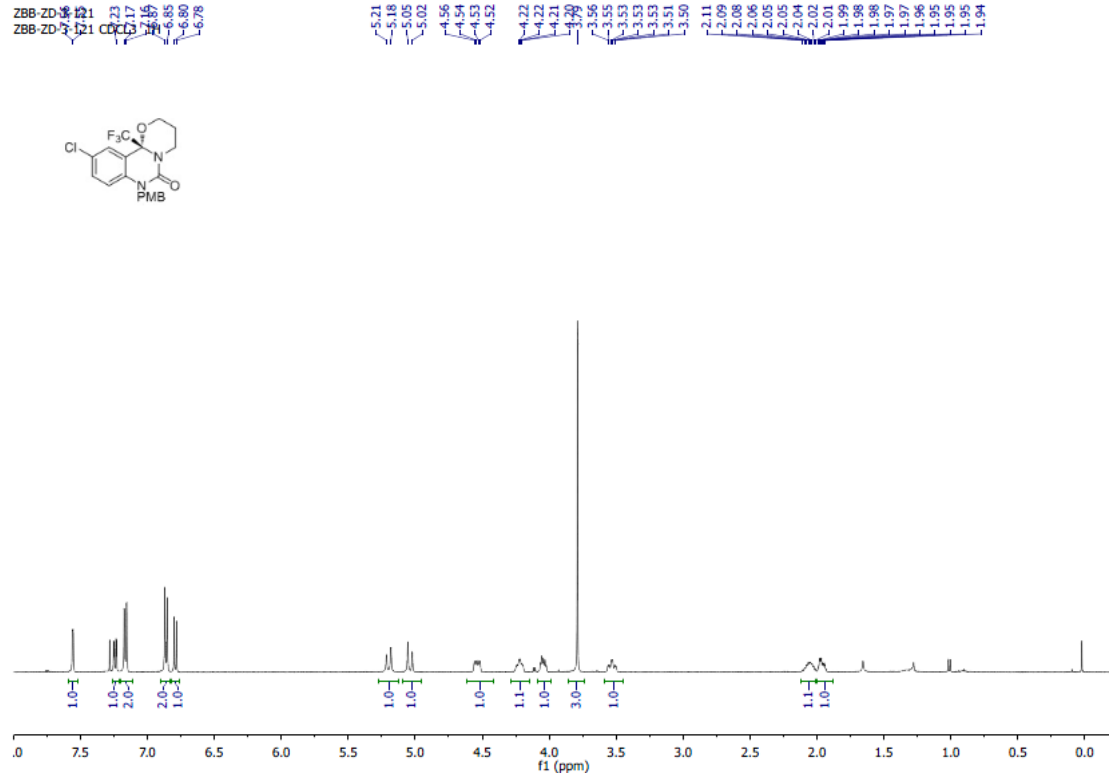

ZBB-YXT-1-167
ZBB-YXT-1-167 CDCl3 13C-BB
157.00
131.34
127.79
127.27
127.09
126.88
115.62
114.23
113.93
85.63
85.38
85.12
84.86
76.85
76.60
76.34
54.82
49.95
44.98
F3C
OMe
Cl
NH
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

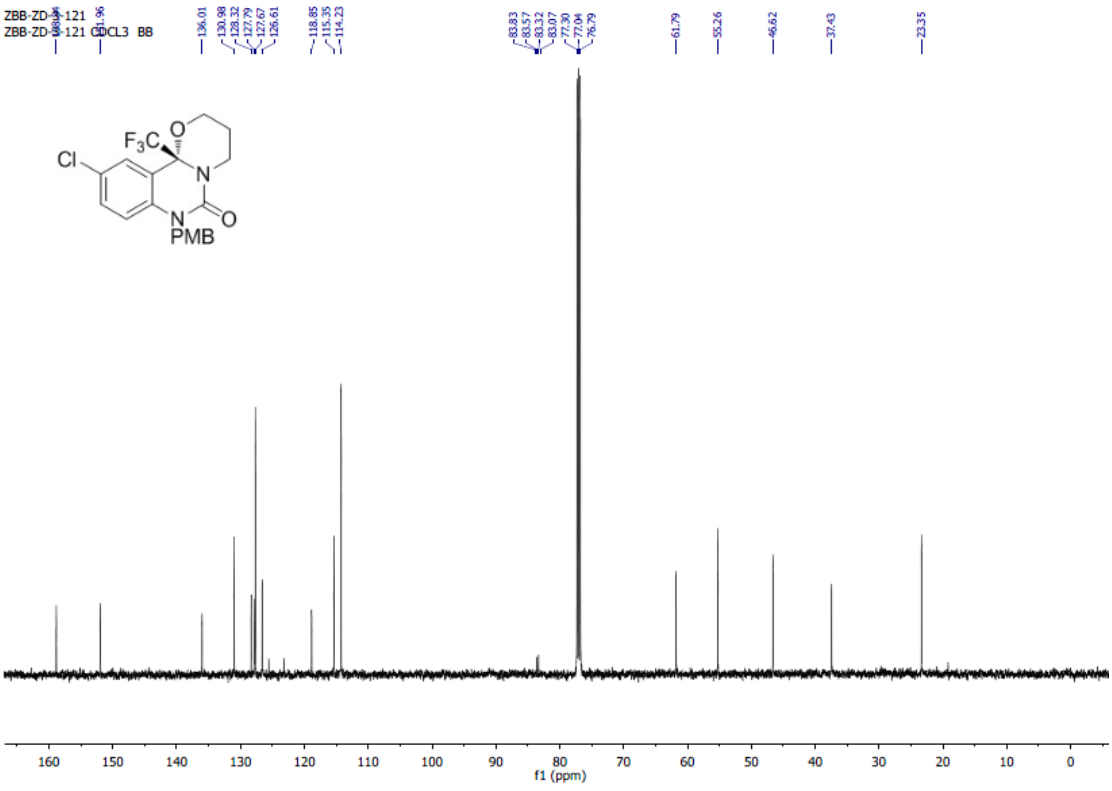
Compound 3t


ZBB-YXT-1-163
ZBB-YXT-1-163 CDCl3 1H
7.34
7.26
7.26
7.15
6.88
6.86
6.84
6.84
6.35
5.29
5.26
5.02
4.99
3.92
3.90
3.89
3.88
3.87
3.77
1.29
1.27
1.10
1.09
F3C
O'Pr
Cl
NH
N
O
PMB
1.0
1.6
2.0
3.0
1.0
1.0
1.0
1.0
3.0
3.0
3.0
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)

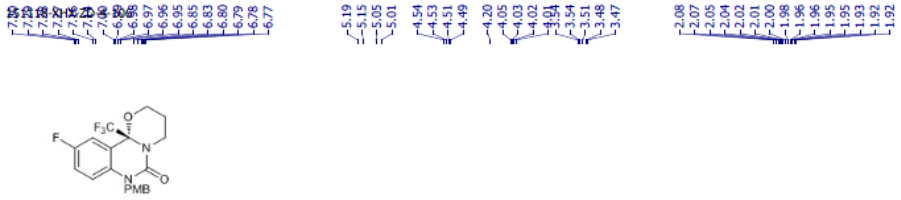

ZBB-YXT-1-163
ZBB-YXT-1-163 CDCl3 13C-BB
131.60
127.92
127.83
127.78
127.56
116.43
116.08
114.37
86.03
85.77
85.52
85.26
77.04
67.83
55.28
45.42
24.40
23.69
F3C
O'Pr
Cl
NH
N
O
PMB
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 4a

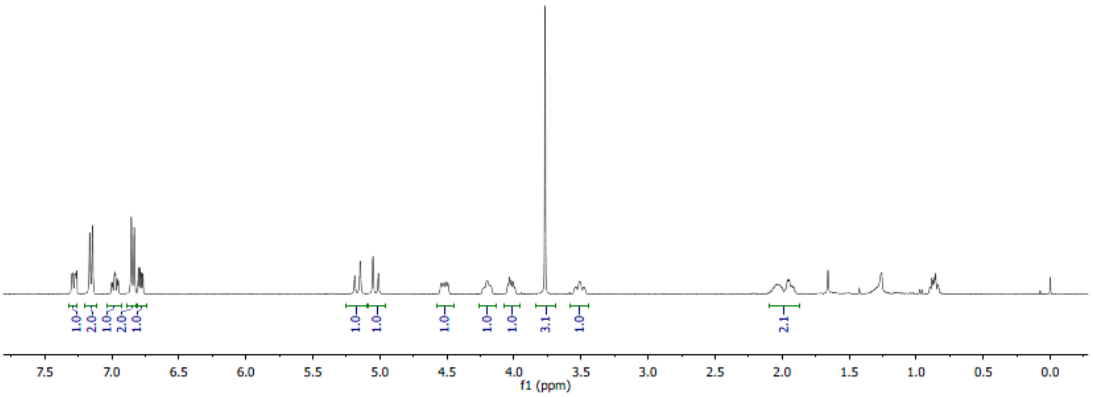

ZBB-ZD-121
ZBB-ZD-121 CDCL3 1H
F3C
O
N
Cl
N
PMB
O
f1 (ppm)

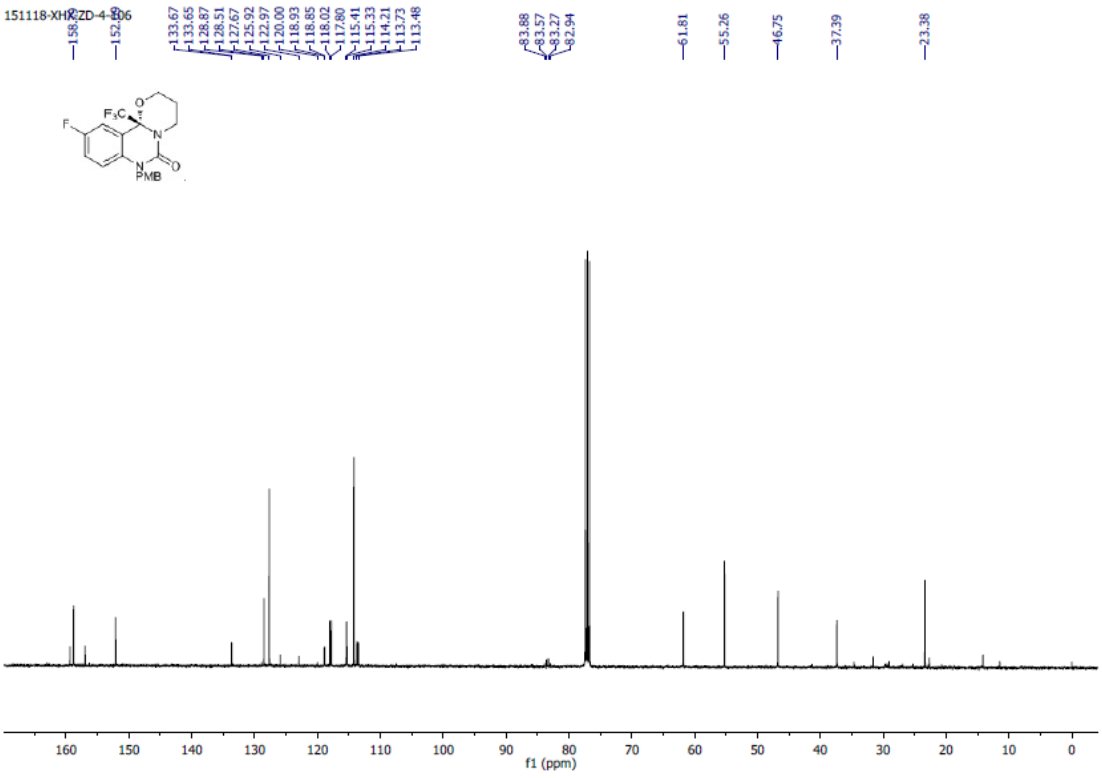

ZBB-ZD-121
ZBB-ZD-121 CDCL3 BB
F3C
O
N
Cl
N
PMB
O
f1 (ppm)

Compound 4b

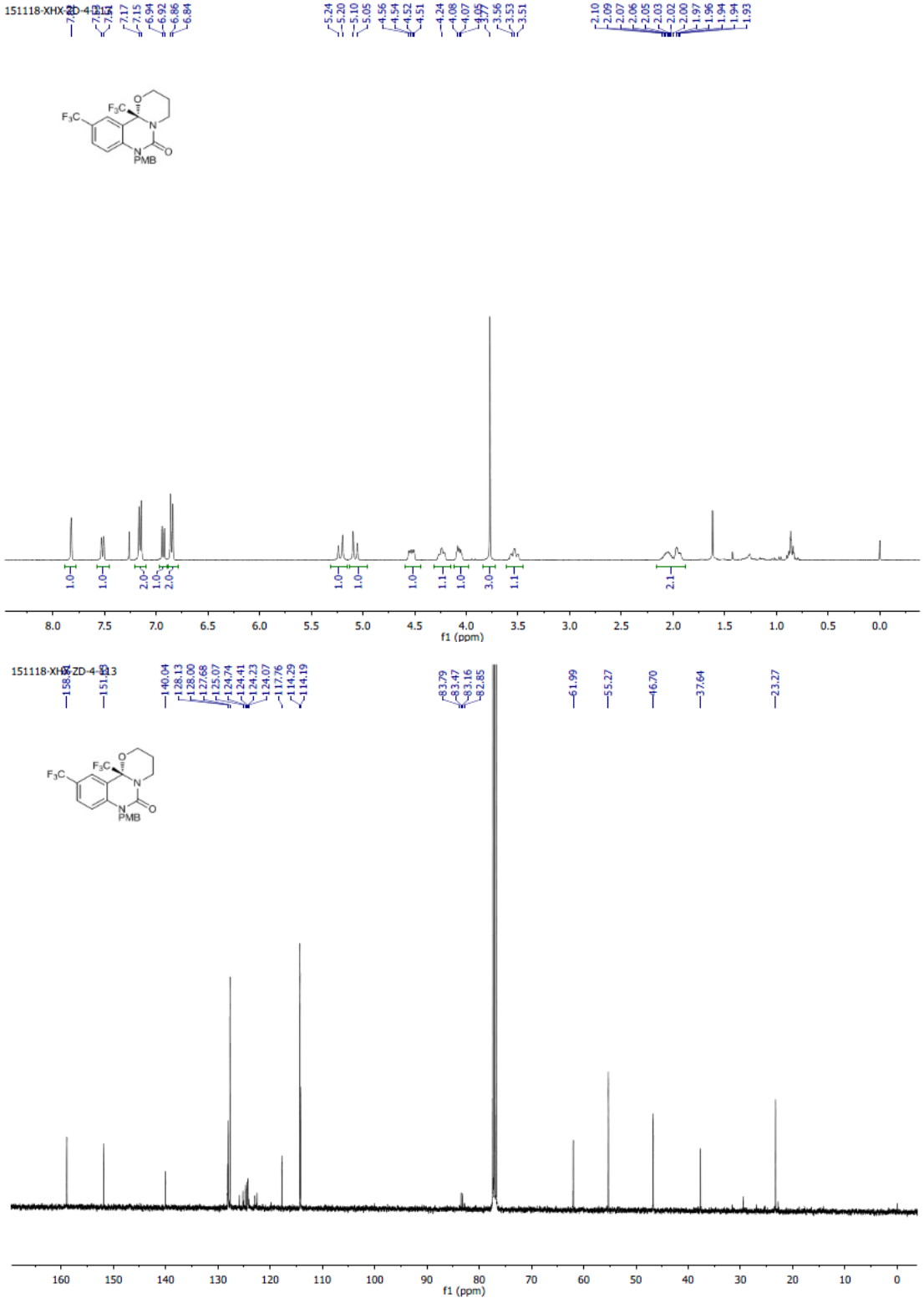


F
F3C
O
N
N
PMB
O

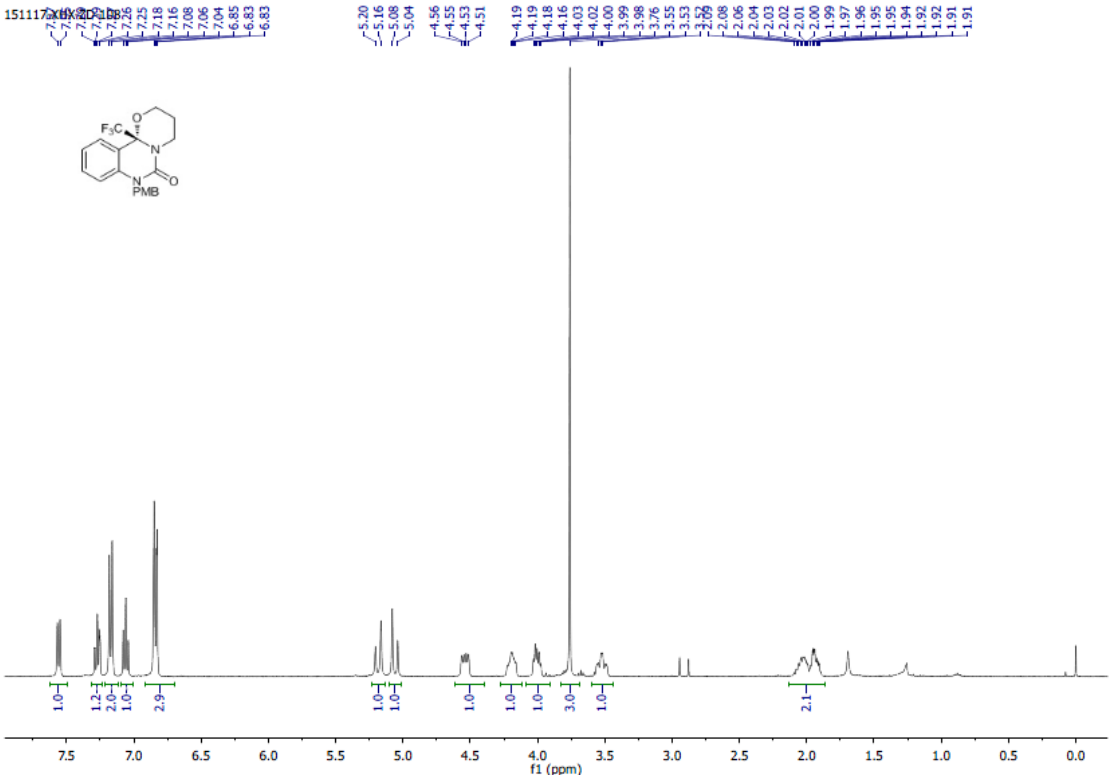

1.0
2.0
1.0
2.0
1.0
1.0
1.0
1.0
1.0
3.1
1.0
2.1
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

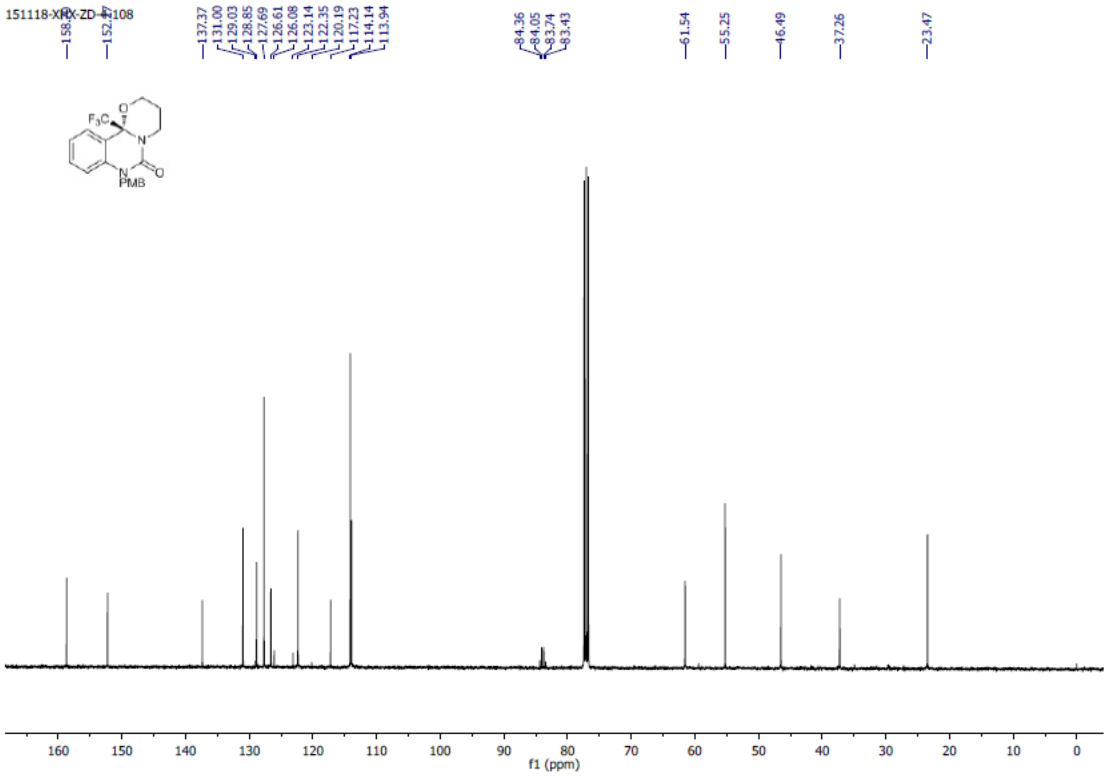

151118-XHXZD-4-206
158.
152.
133.67
133.65
128.87
128.51
127.67
125.92
122.97
120.00
118.93
118.85
118.02
117.80
115.41
115.33
114.21
113.73
113.48
83.88
83.57
83.27
82.94
61.81
55.26
46.75
37.39
23.38
F3C
O
N
N
PMB
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Compound 4c

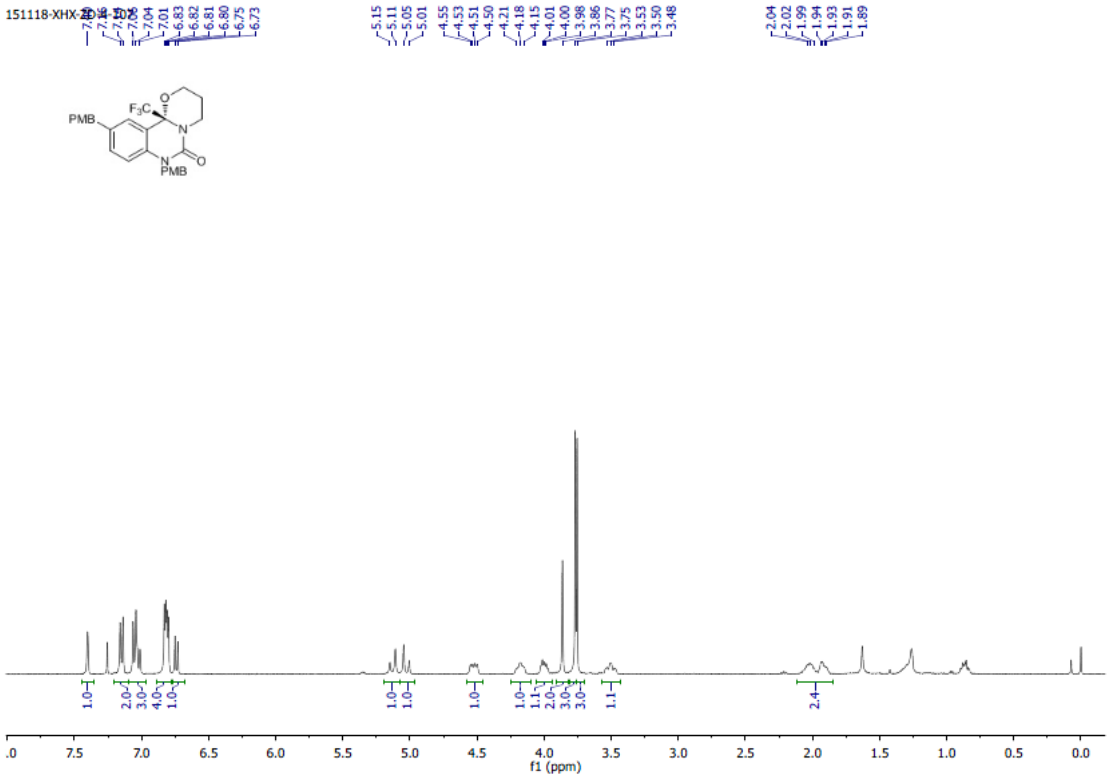

151118-XHX-ZD-4-13
7.17
7.15
6.94
6.92
6.86
6.84
5.24
5.20
5.10
5.05
4.56
4.54
4.52
4.51
4.24
4.08
4.07
3.56
3.53
3.51
2.10
2.09
2.07
2.06
2.05
2.03
2.02
2.00
1.97
1.96
1.94
1.94
1.93
F3C
O
N
N
PMB
O
1.0
1.0
2.0
1.0
2.0
1.0
1.0
1.0
1.1
1.0
3.0
1.1
2.1
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
151118-XHX-ZD-4-13
140.04
128.13
128.00
127.68
125.07
124.74
124.41
124.23
124.07
114.29
114.19
83.79
83.47
83.16
82.85
61.99
55.27
46.70
37.64
23.27
F3C
O
N
N
PMB
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

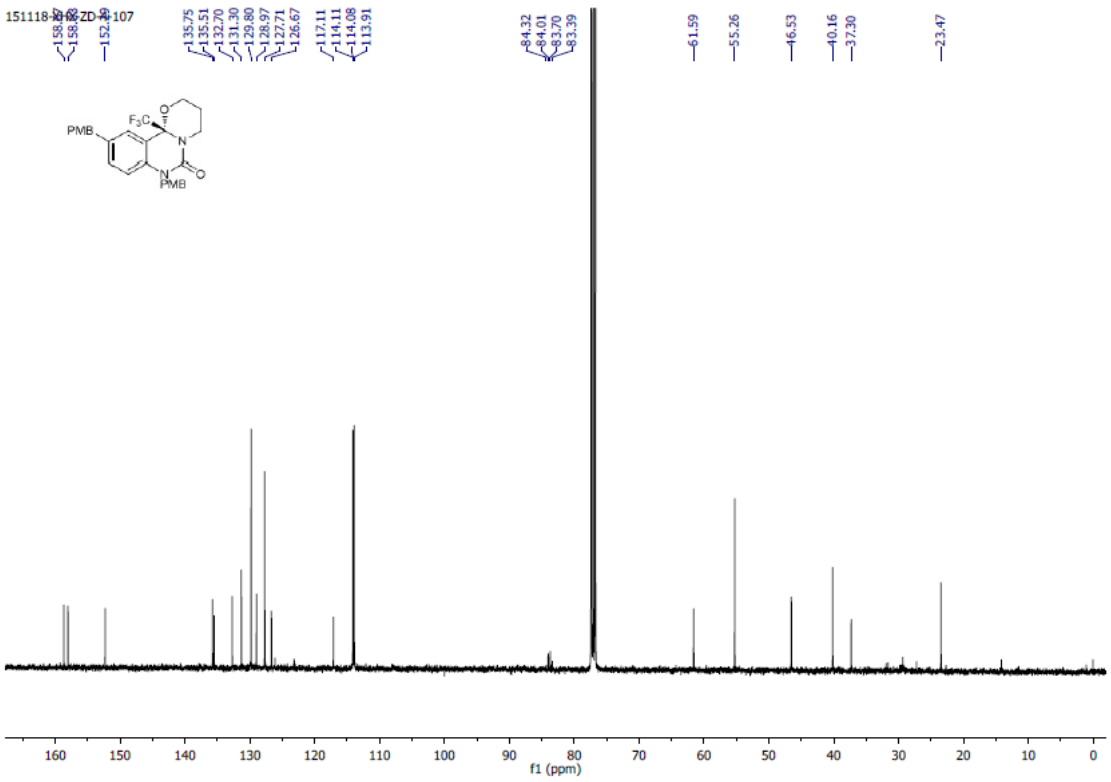
Compound 4d



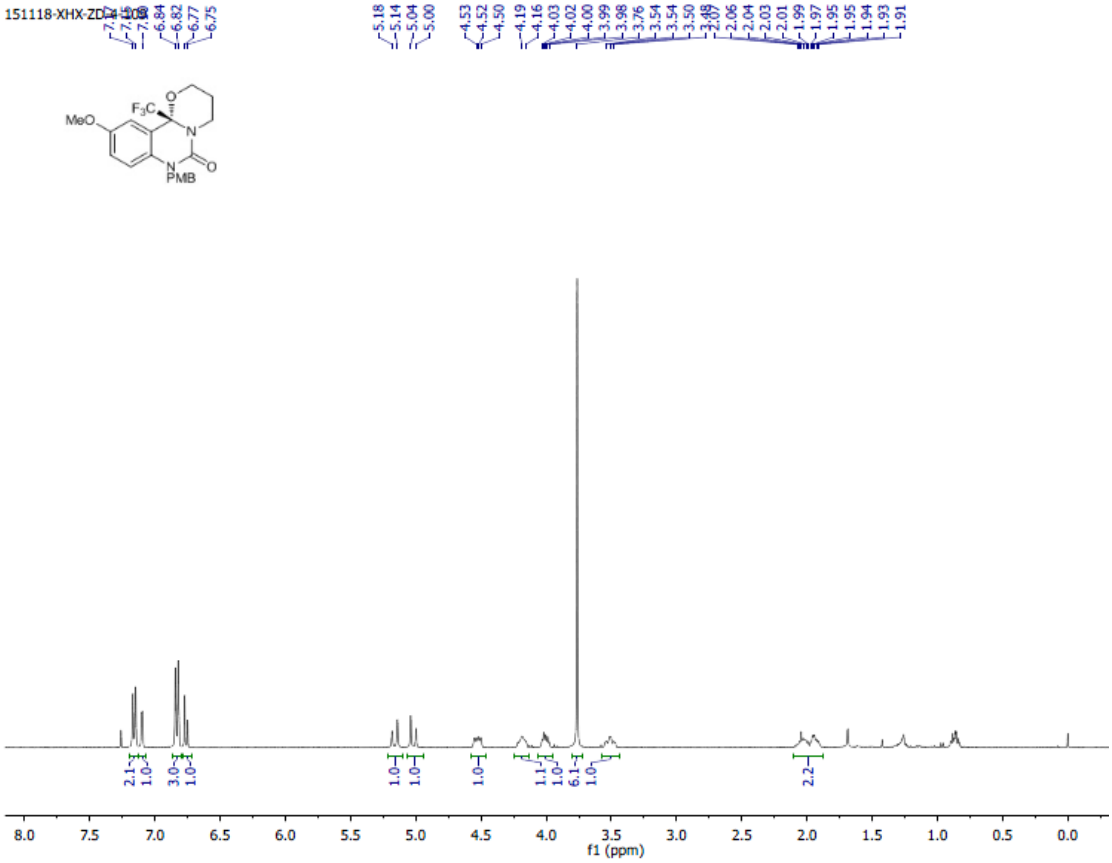


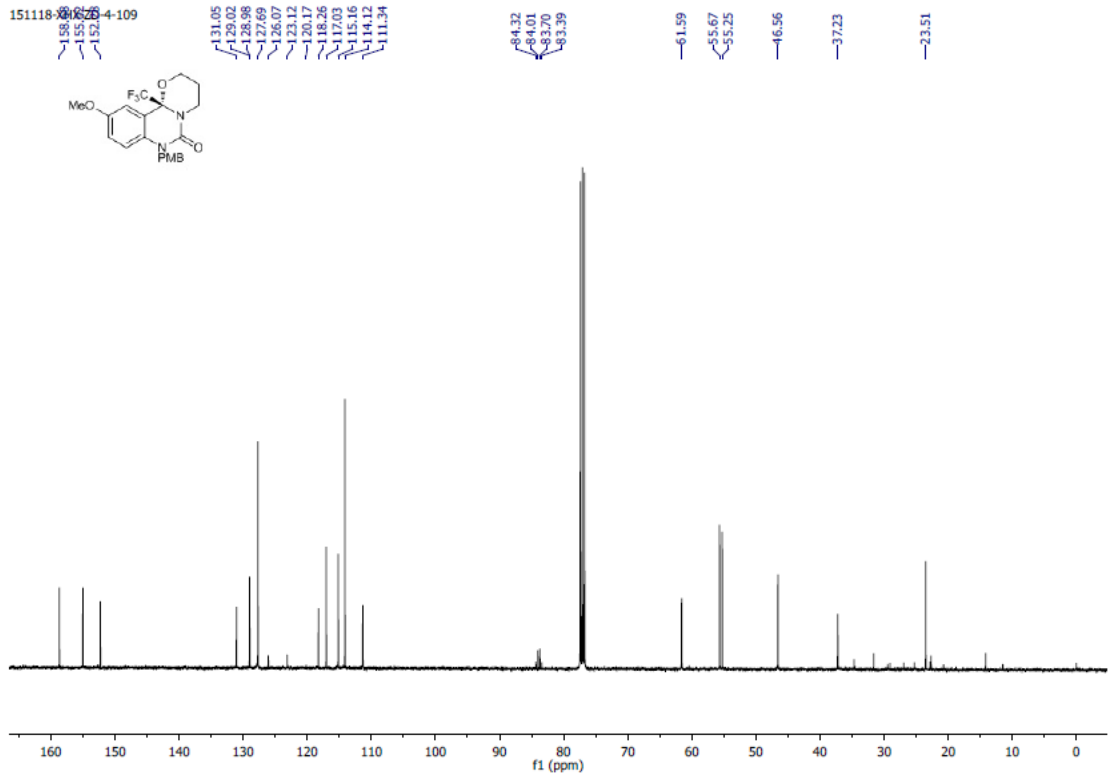
Compound 4e





Compounds 4f

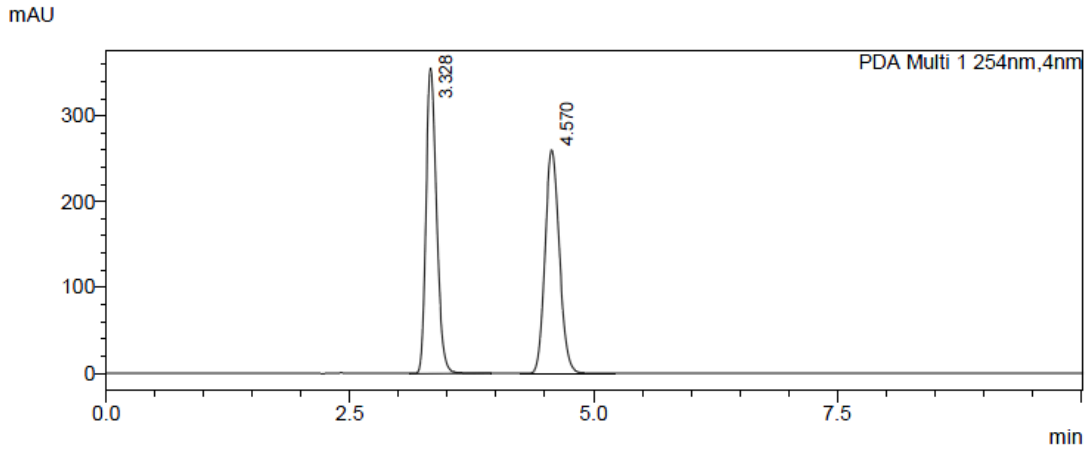




Chiral HPLC traces

Compound 3a

<Chromatogram>

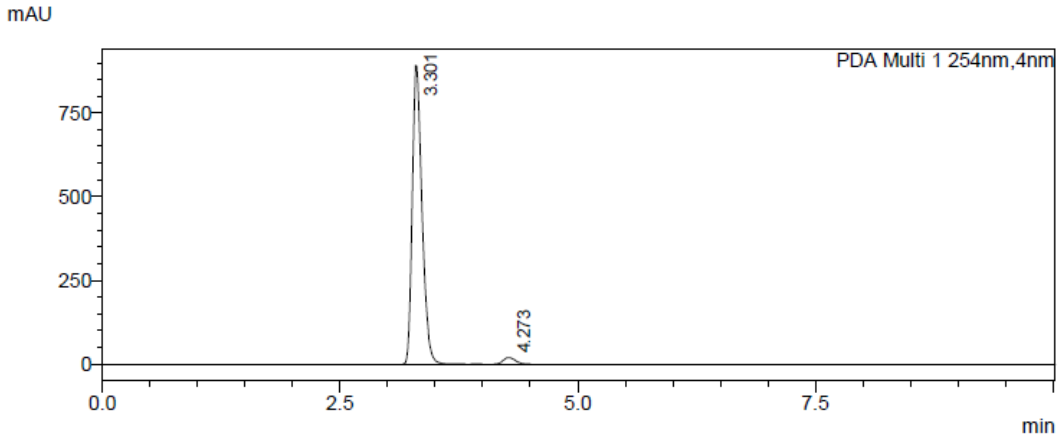


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.328	2679457	356870	50.104
2	4.570	2668297	260106	49.896
总计				100.000

<Chromatogram>



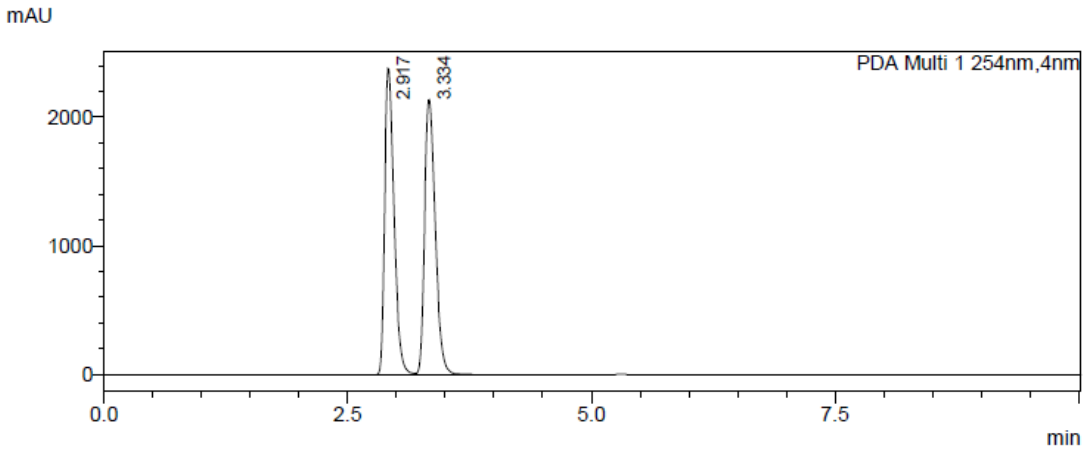
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.301	6424996	891479	97.168
2	4.273	187242	20543	2.832
总计				100.000

Compound 3b

<Chromatogram>

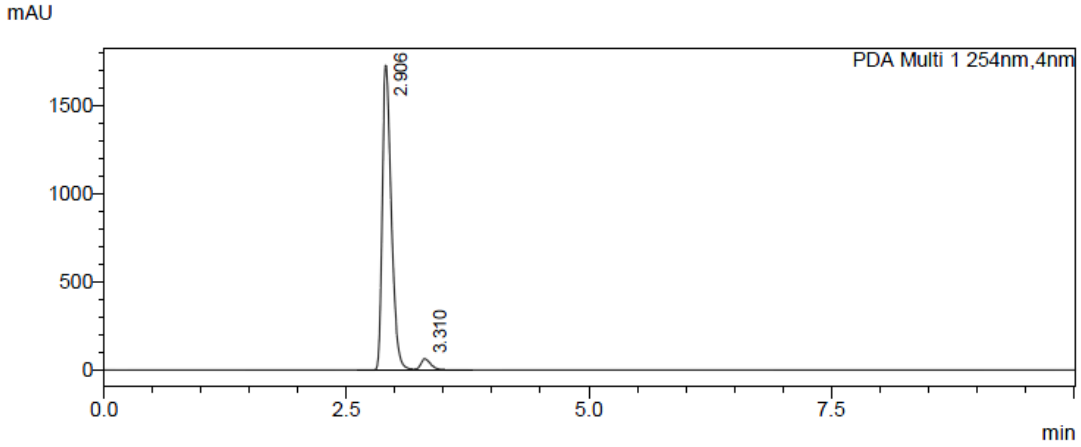


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	2.917	15945210	2376865	49.502
2	3.334	16265936	2133918	50.498
总计				100.000

<Chromatogram>



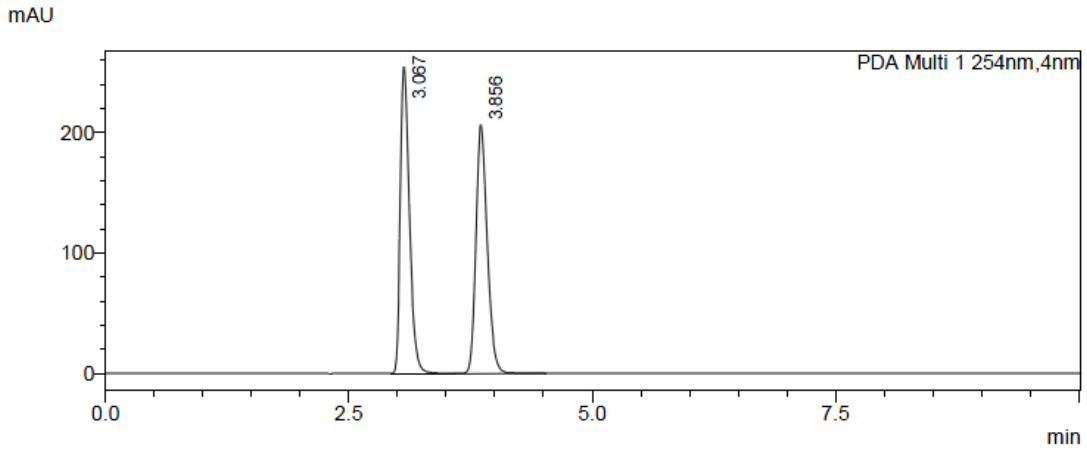
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	2.906	11279846	1728852	96.050
2	3.310	463907	62833	3.950
总计				100.000

Compound 3c

<Chromatogram>

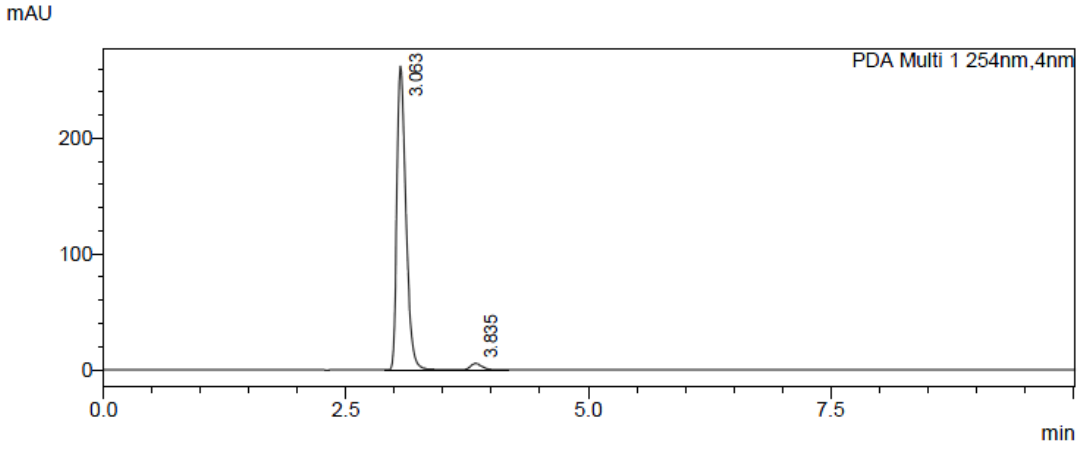


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.067	1667210	254067	49.861
2	3.856	1676518	206188	50.139
总计				100.000

<Chromatogram>



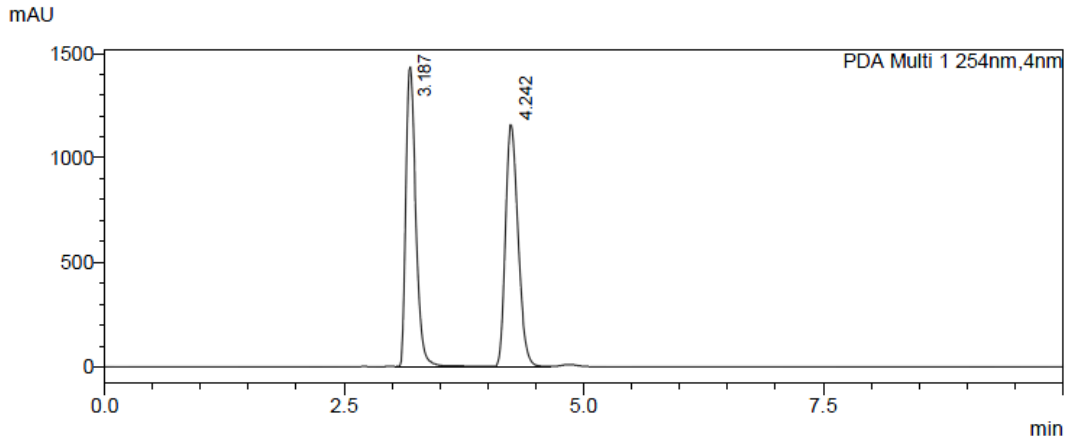
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.063	1697977	262948	97.472
2	3.835	44031	5596	2.528
总计				100.000

Compound 3d

<Chromatogram>

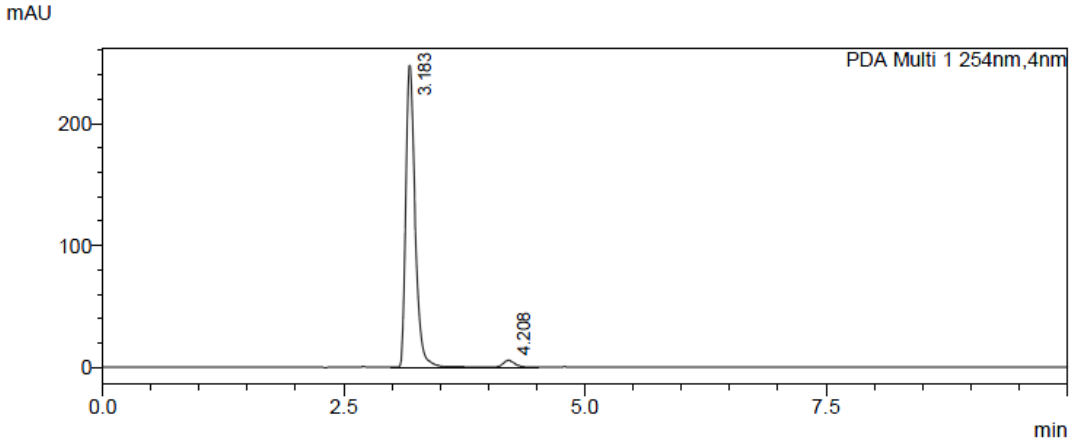


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.187	10370913	1438085	49.254
2	4.242	10685065	1160789	50.746
总计				100.000

<Chromatogram>



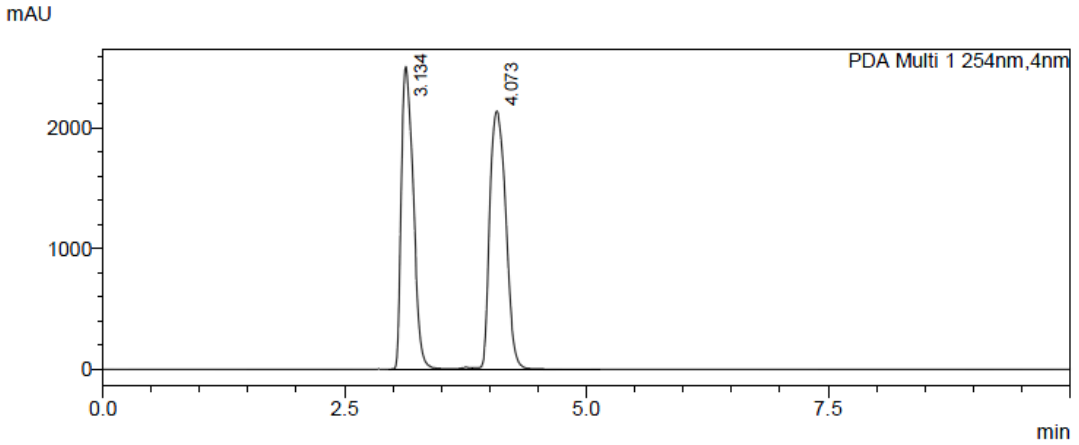
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.183	1654588	248106	97.232
2	4.208	47099	5593	2.768
总计				100.000

Compound 3e

<Chromatogram>

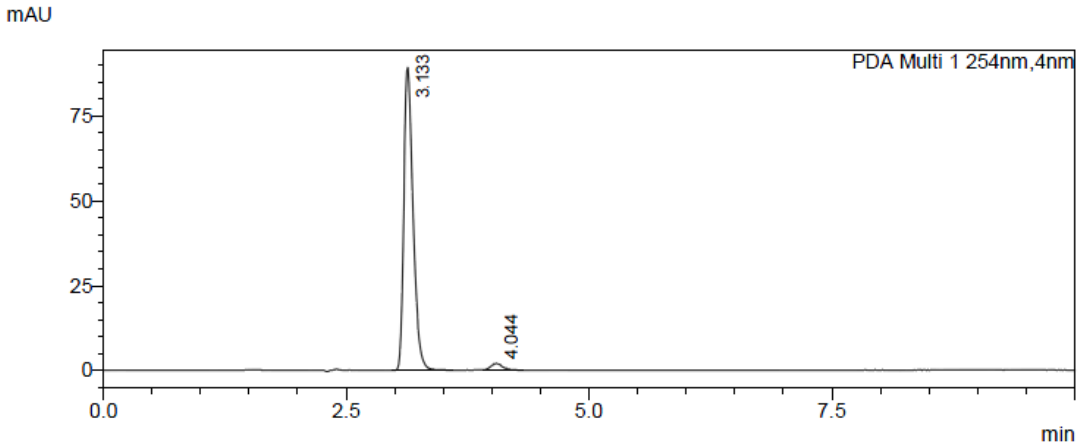


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.134	21982308	2518116	46.997
2	4.073	24791290	2143477	53.003
总计				100.000

<Chromatogram>



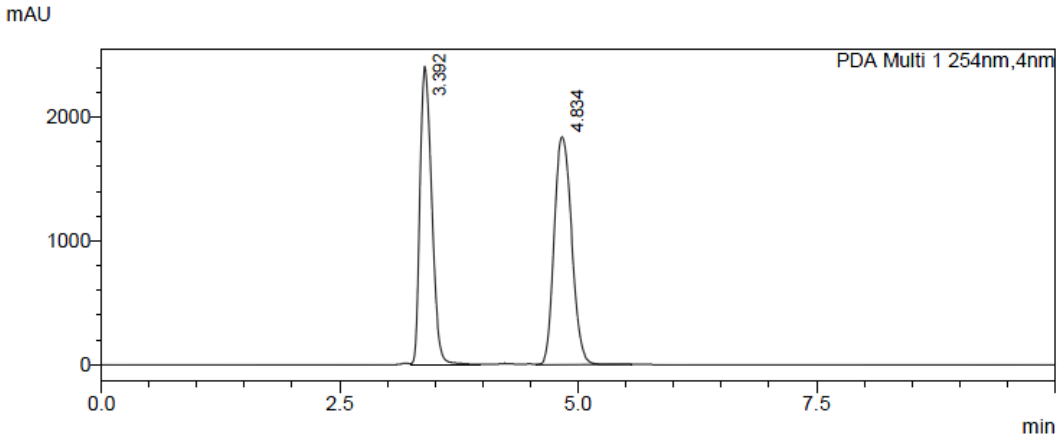
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.133	593700	89570	97.257
2	4.044	16744	1954	2.743
总计				100.000

Compound 3f

<Chromatogram>

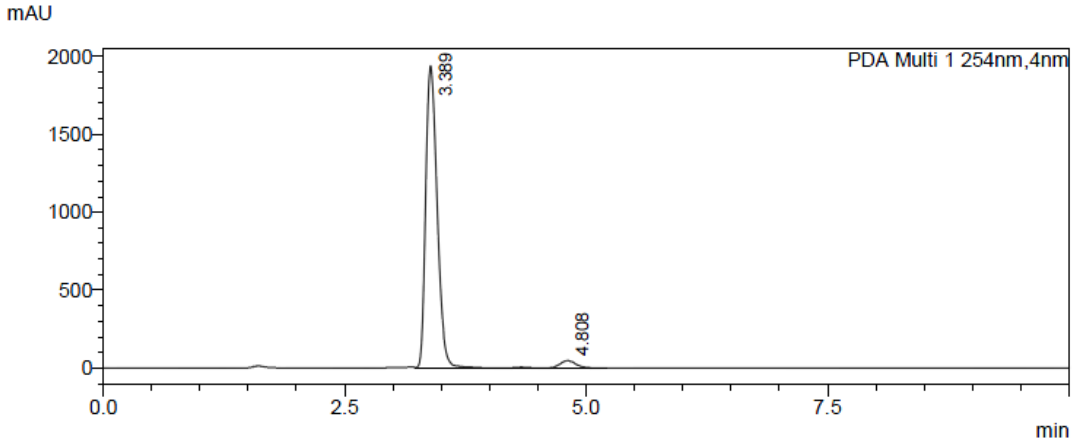


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.392	20852470	2415778	47.036
2	4.834	23480702	1839435	52.964
总计				100.000

<Chromatogram>



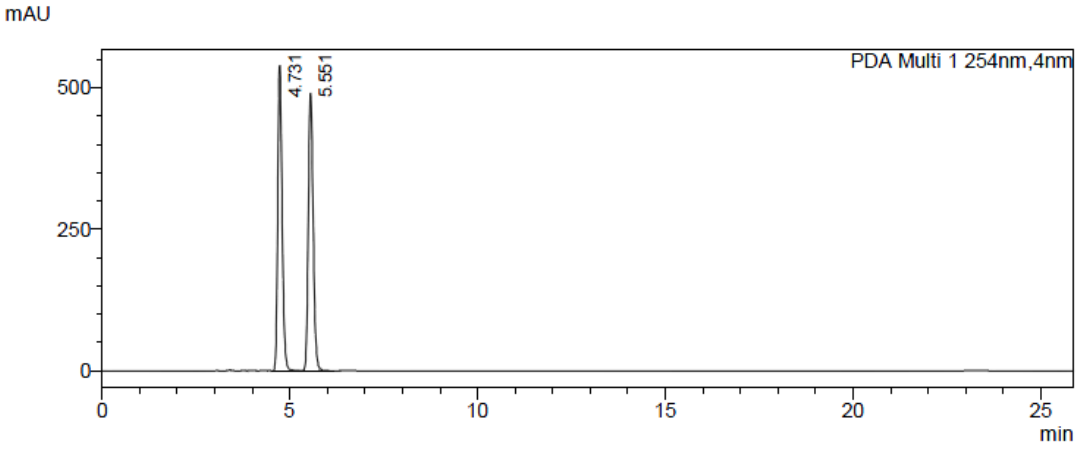
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.389	16155503	1944455	96.821
2	4.808	530383	47102	3.179
总计				100.000

Compound 3g

<Chromatogram>

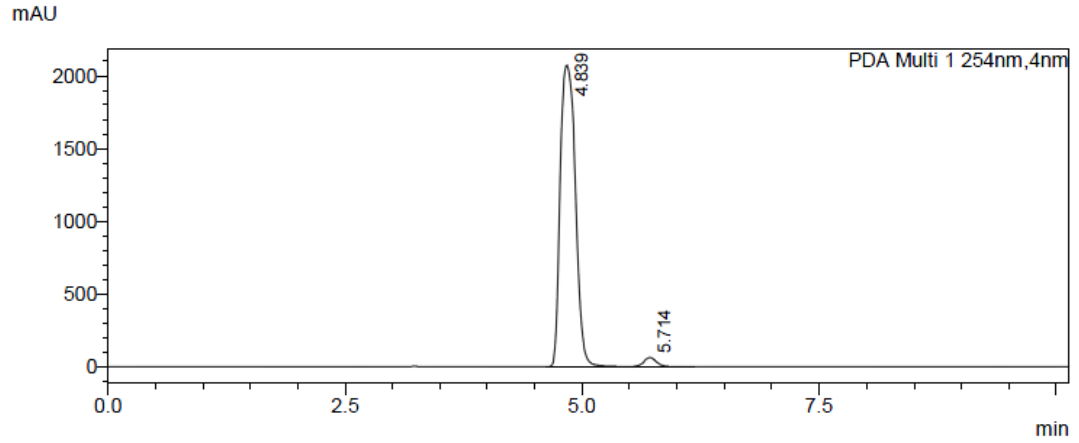


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.731	4428156	537494	50.013
2	5.551	4425913	490865	49.987
总计				100.000

<Chromatogram>



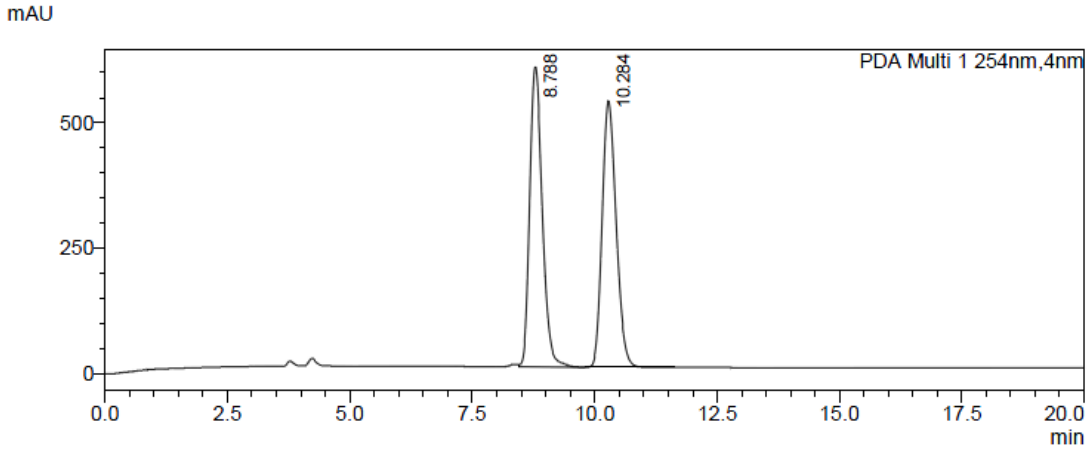
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.839	23244096	2072219	97.482
2	5.714	600394	62140	2.518
总计				100.000

Compound 3h

<Chromatogram>

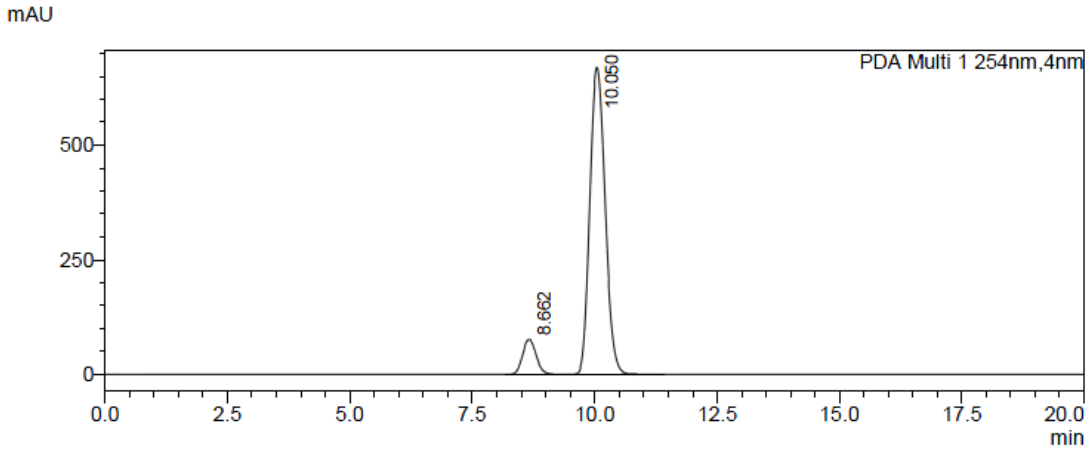


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	8.788	10684770	598606	50.205
2	10.284	10597427	532201	49.795
总计				100.000

<Chromatogram>



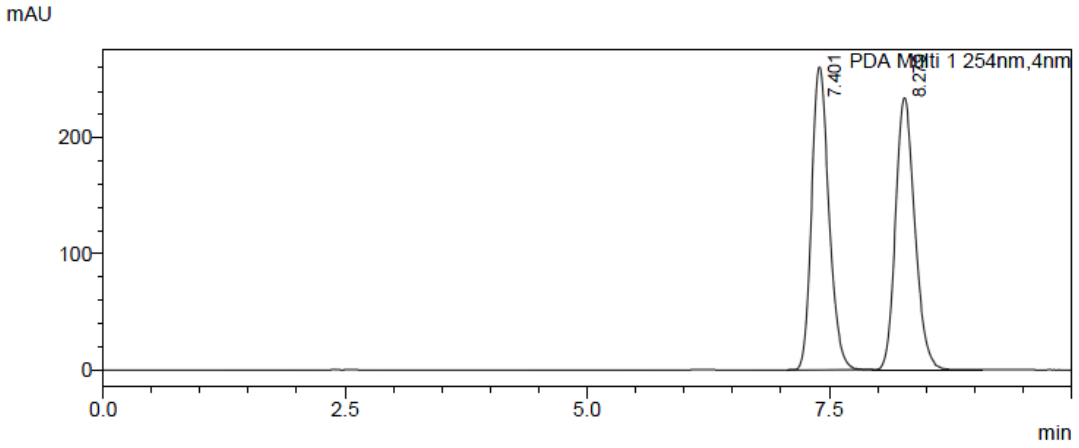
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	8.662	1461326	75962	9.116
2	10.050	14568950	669552	90.884
总计				100.000

Compound 3i

<Chromatogram>

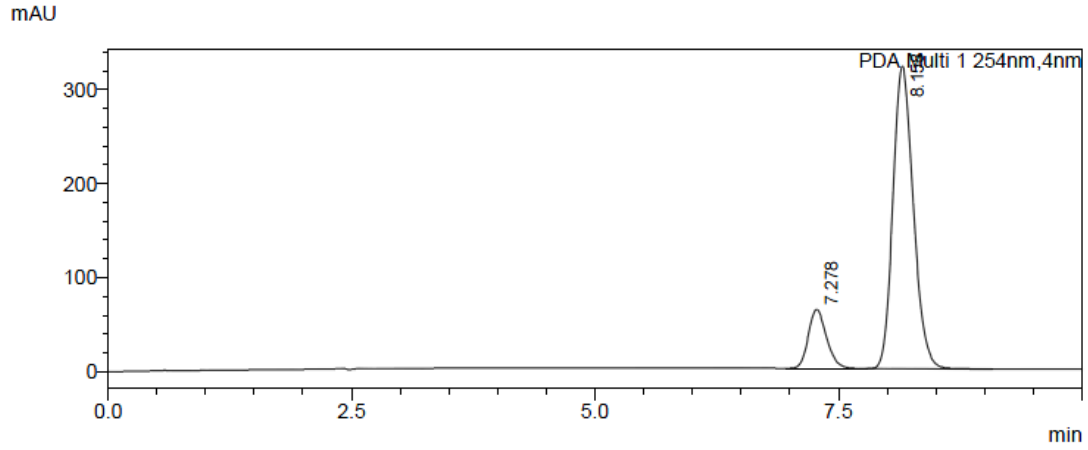


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.401	3248698	261437	49.956
2	8.279	3254389	234626	50.044
总计				100.000

<Chromatogram>



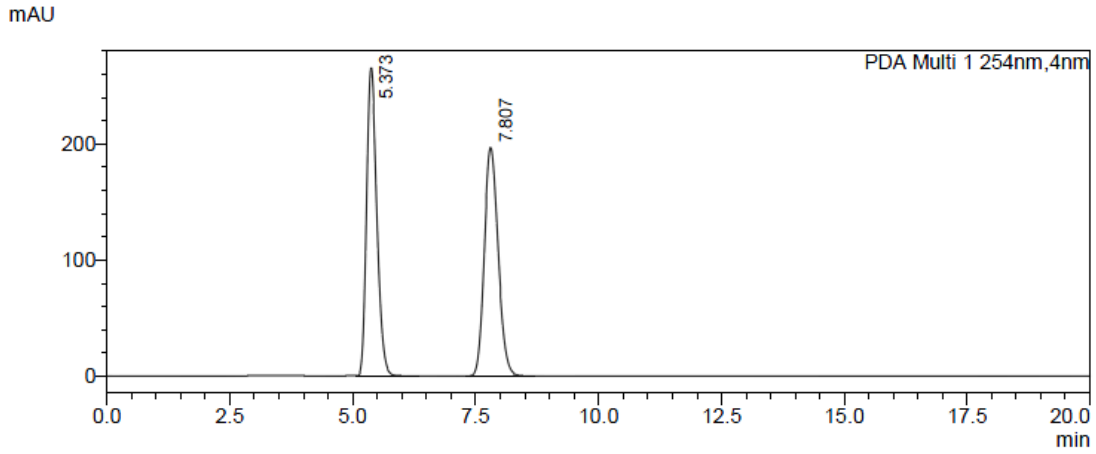
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.278	813074	62397	14.760
2	8.158	4695390	321704	85.240
总计				100.000

Compound 3j

<Chromatogram>

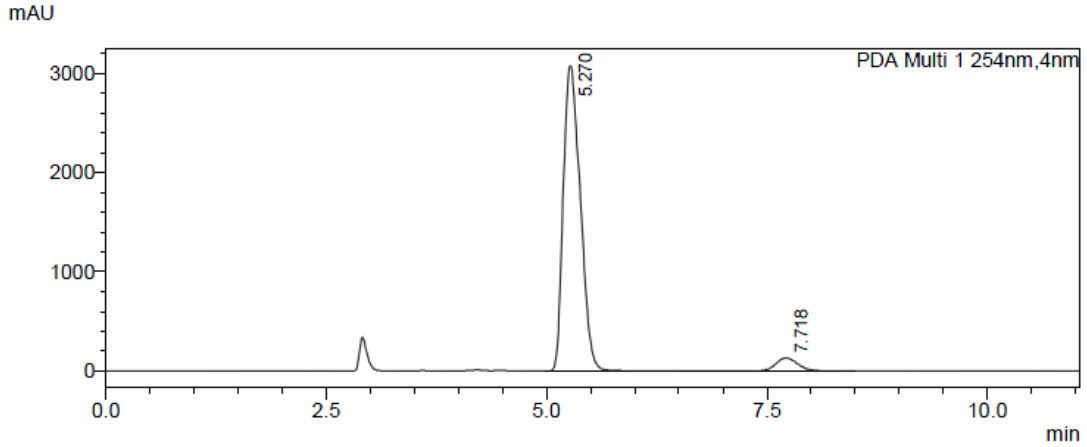


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.373	3851777	265524	49.968
2	7.807	3856675	196612	50.032
总计				100.000

<Chromatogram>



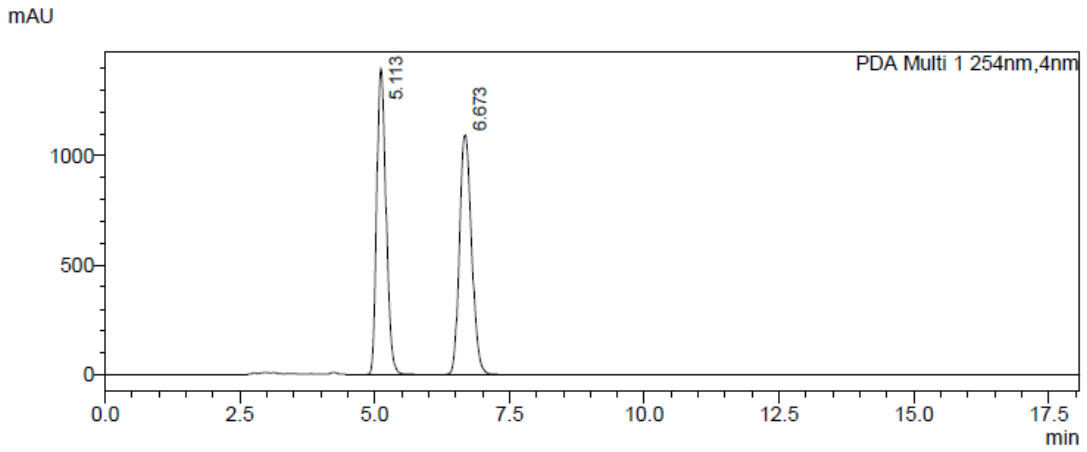
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.270	41374805	3078867	94.844
2	7.718	2249080	130768	5.156
总计				100.000

Compound 3k

<Chromatogram>

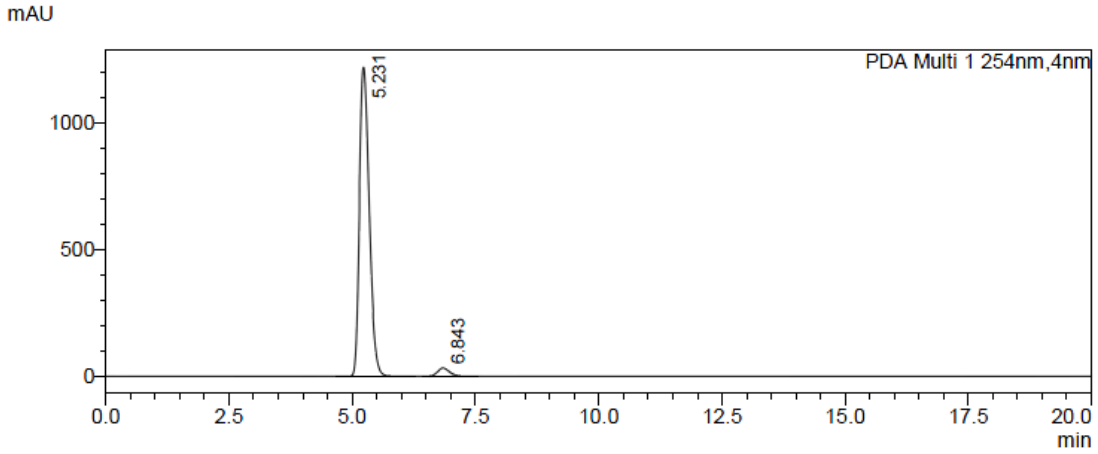


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.113	16913081	1398828	49.637
2	6.673	17160656	1094267	50.363
总计				100.000

<Chromatogram>



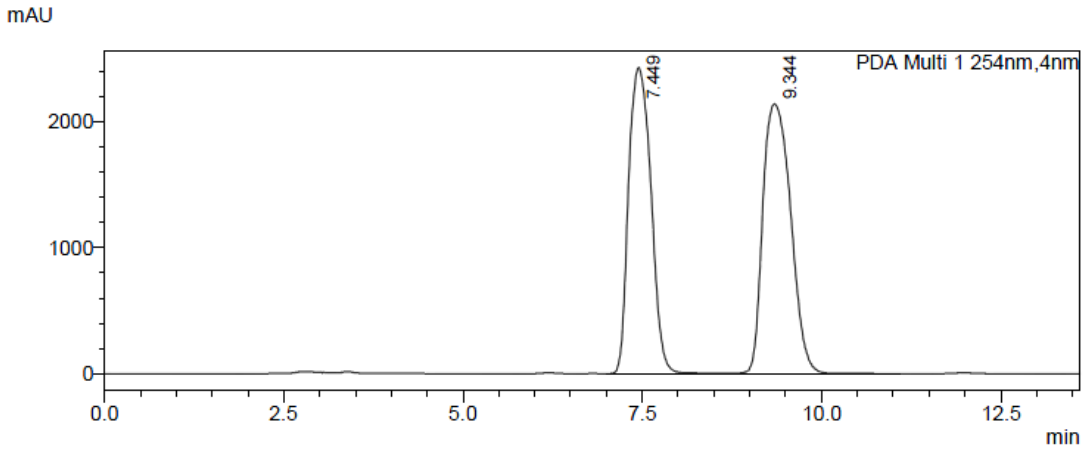
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.231	16861876	1220453	96.834
2	6.843	551253	32749	3.166
总计				100.000

Compound 3l

<Chromatogram>

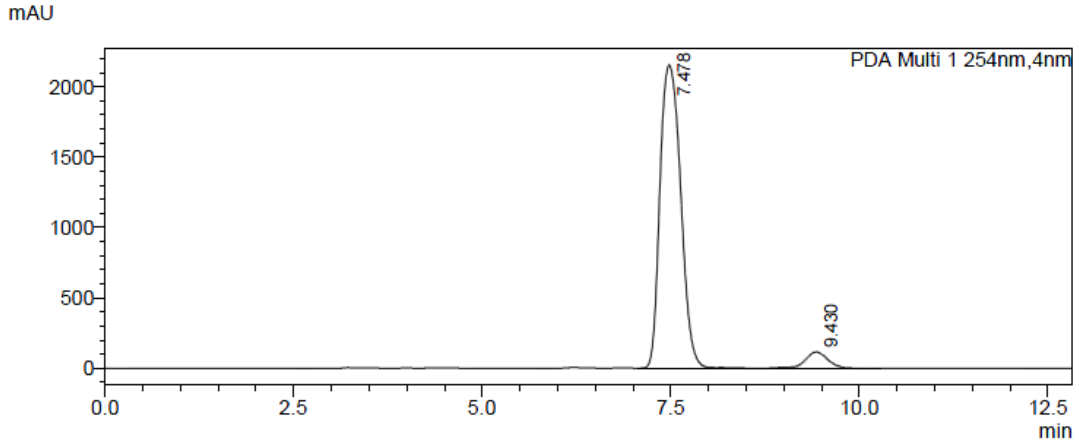


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.449	52964063	2427018	47.719
2	9.344	58026448	2139130	52.281
总计				100.000

<Chromatogram>



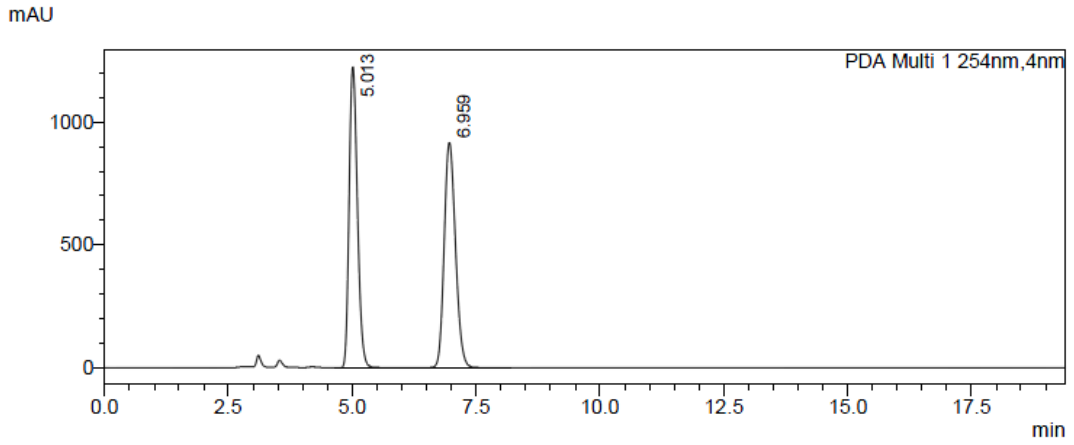
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.478	41297292	2154650	94.398
2	9.430	2450668	115902	5.602
总计				100.000

Compound 3m

<Chromatogram>

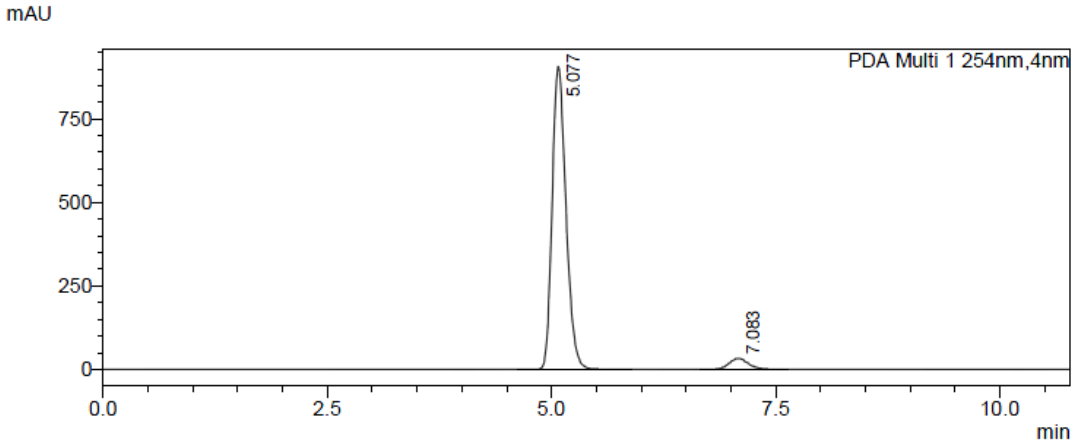


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.013	14204989	1227290	49.548
2	6.959	14464428	916759	50.452
总计				100.000

<Chromatogram>



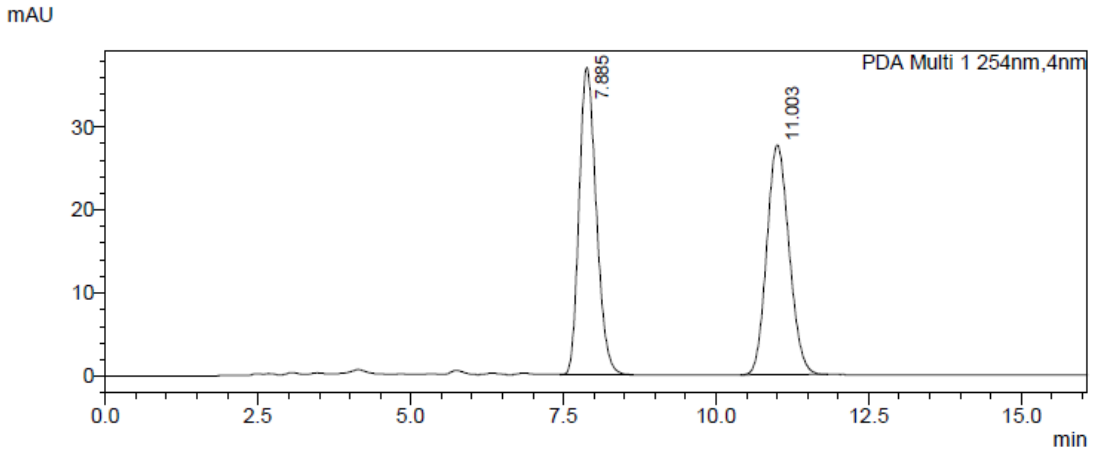
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.077	9708571	908832	95.220
2	7.083	487390	32698	4.780
总计				100.000

Compound 3n

<Chromatogram>

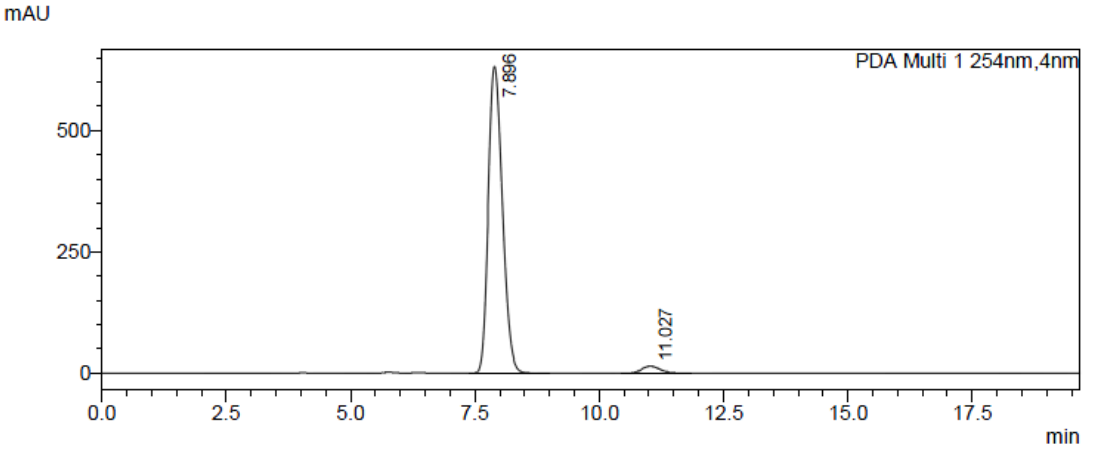


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.885	722862	36992	50.609
2	11.003	705475	27694	49.391
总计				100.000

<Chromatogram>



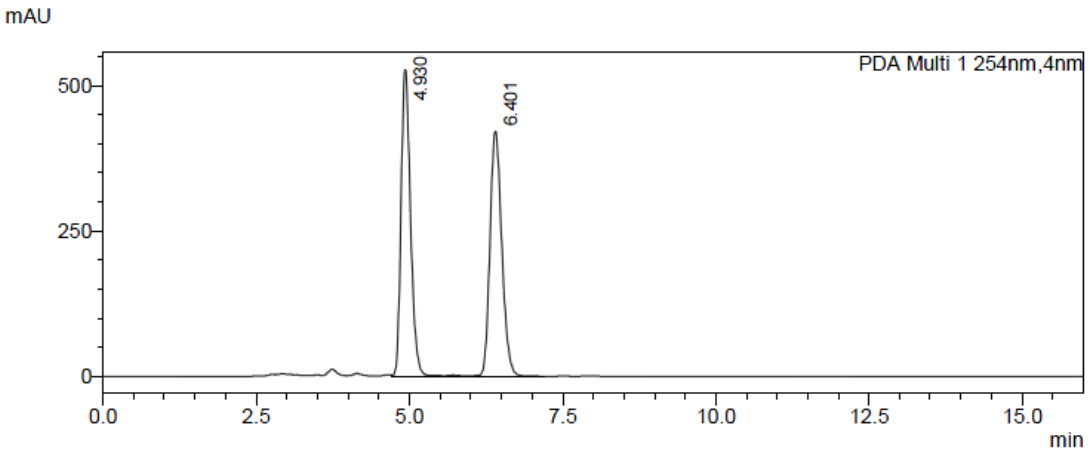
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.896	12474919	632592	97.108
2	11.027	371456	14542	2.892
总计				100.000

Compound 3o

<Chromatogram>

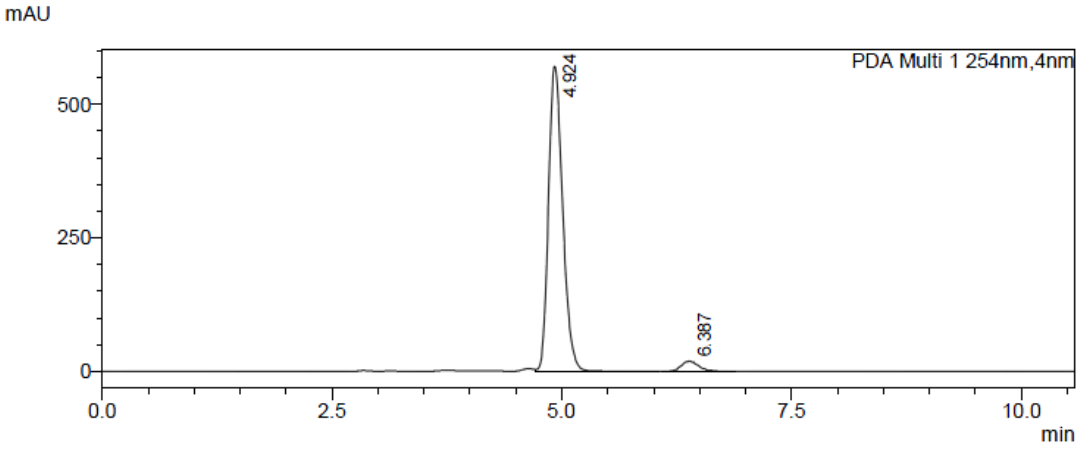


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.930	5692070	528914	50.271
2	6.401	5630706	421913	49.729
总计				100.000

<Chromatogram>



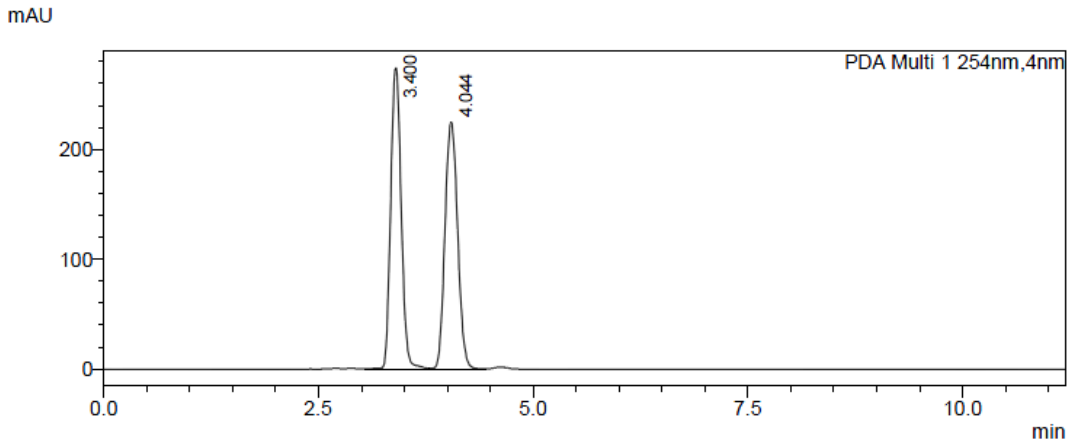
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.924	6114310	571648	96.099
2	6.387	248197	18831	3.901
总计				100.000

Compound 3p

<Chromatogram>

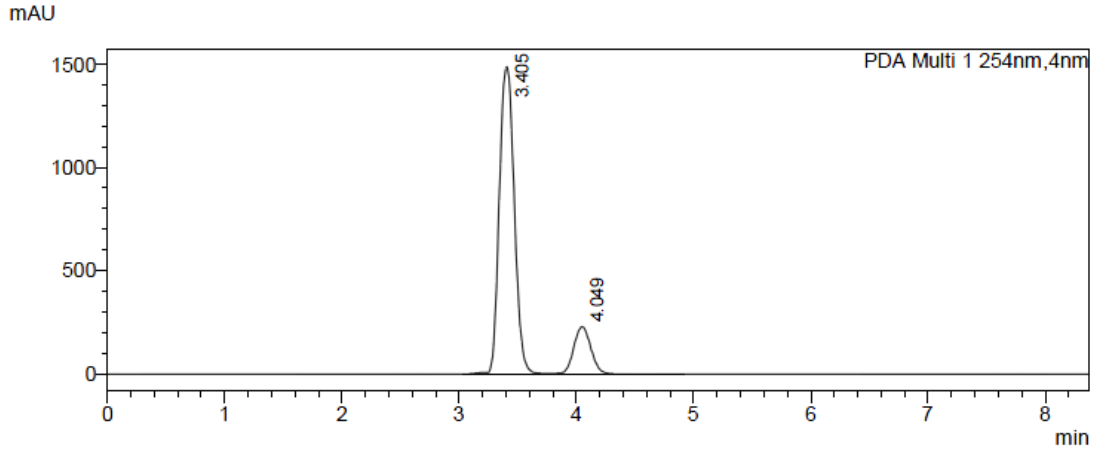


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.400	2348942	274808	50.293
2	4.044	2321609	225196	49.707
总计				100.000

<Chromatogram>



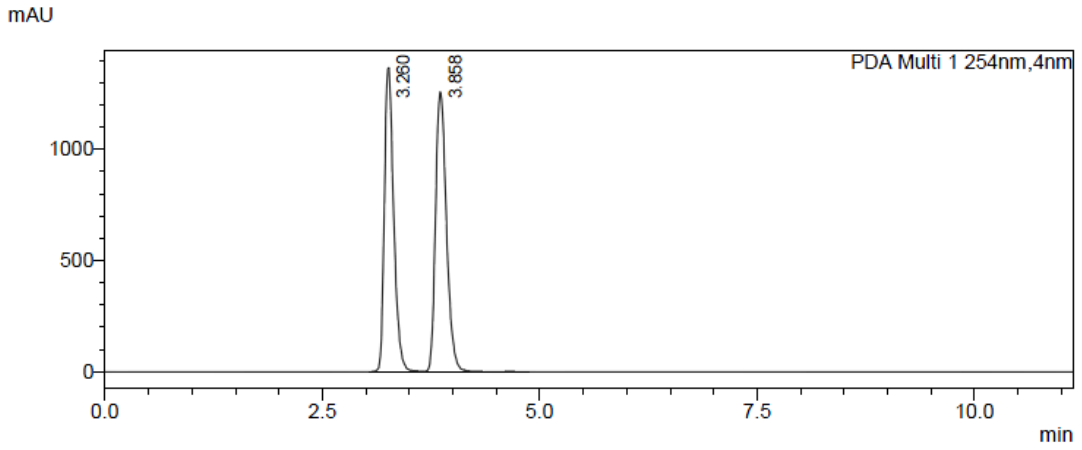
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.405	13292486	1491315	84.906
2	4.049	2362977	228863	15.094
总计				100.000

Compound 3q

<Chromatogram>

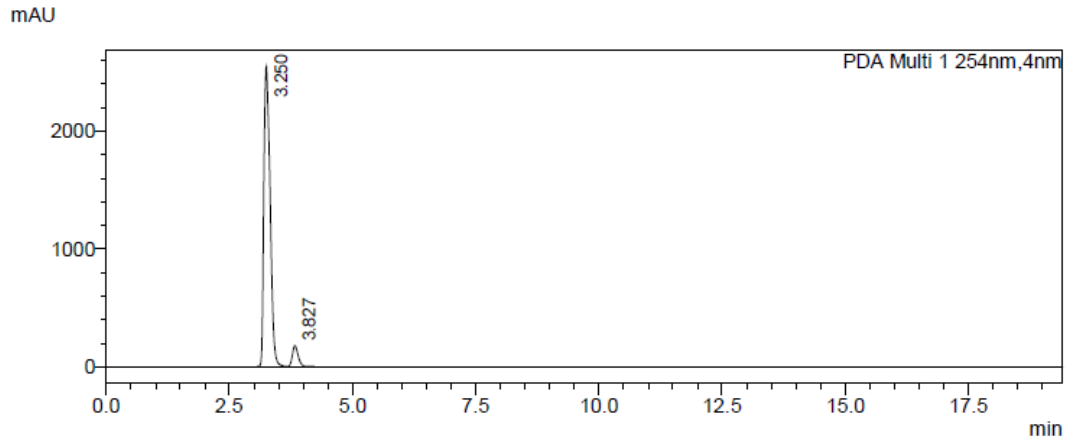


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.260	10214511	1368051	48.103
2	3.858	11020197	1258738	51.897
总计				100.000

<Chromatogram>



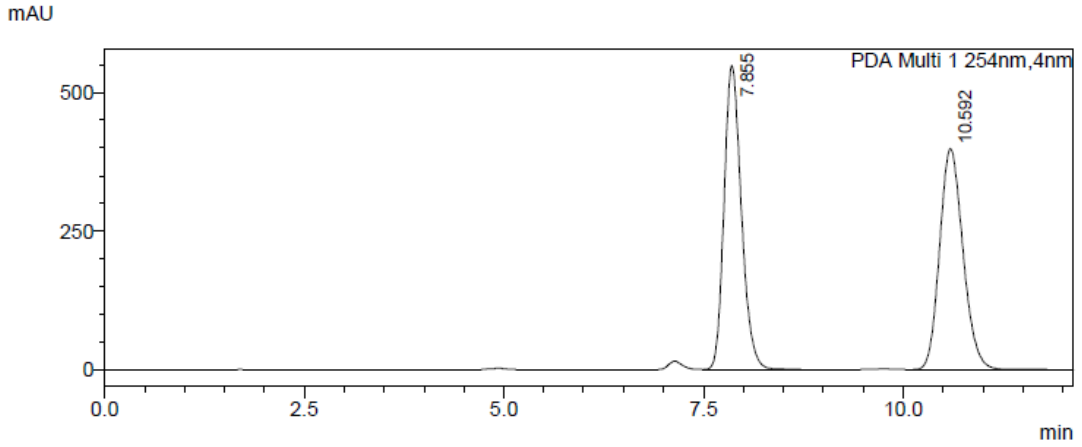
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.250	22447632	2549752	93.558
2	3.827	1545577	179958	6.442
总计				100.000

Compound 3r

<Chromatogram>

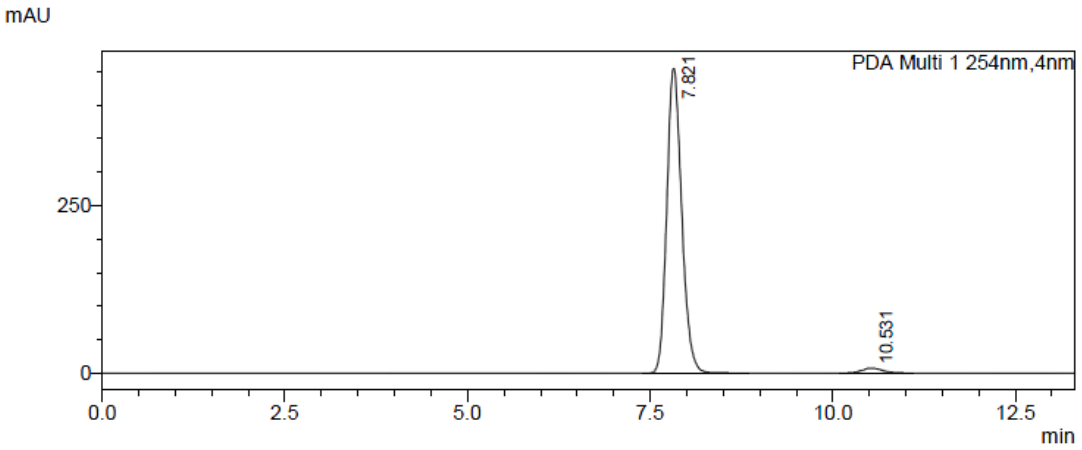


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.855	8284141	547975	50.450
2	10.592	8136219	398577	49.550
总计				100.000

<Chromatogram>



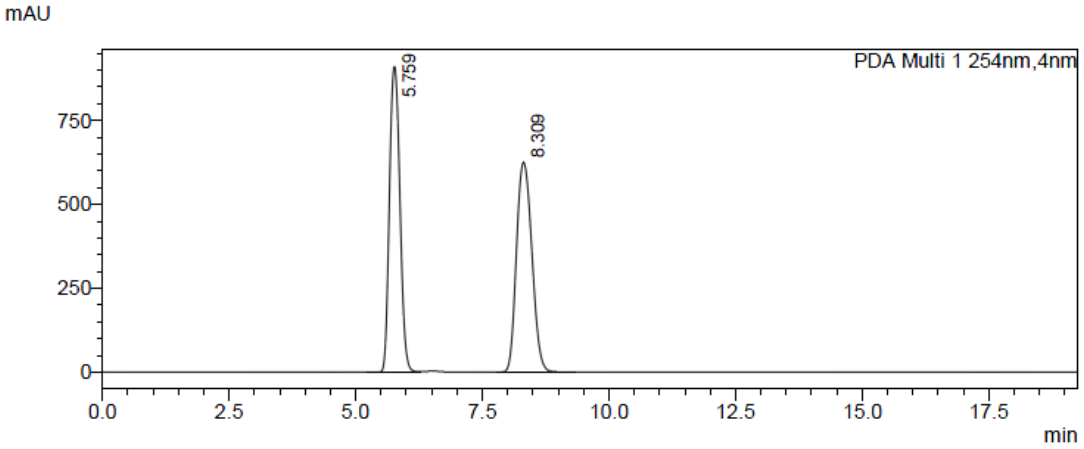
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	7.821	6482209	455852	97.823
2	10.531	144232	7383	2.177
总计				100.000

Compound 3s

<Chromatogram>

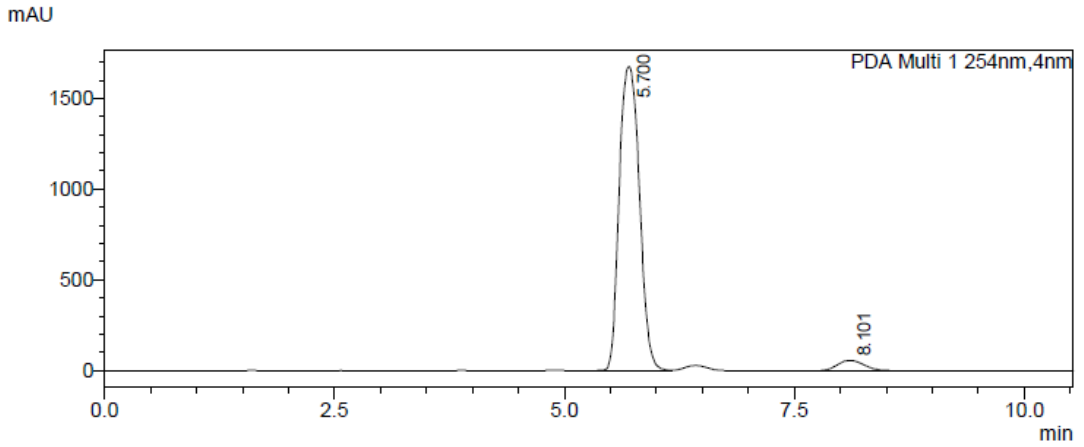


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.759	13083073	912008	49.698
2	8.309	13242070	624540	50.302
总计				100.000

<Chromatogram>



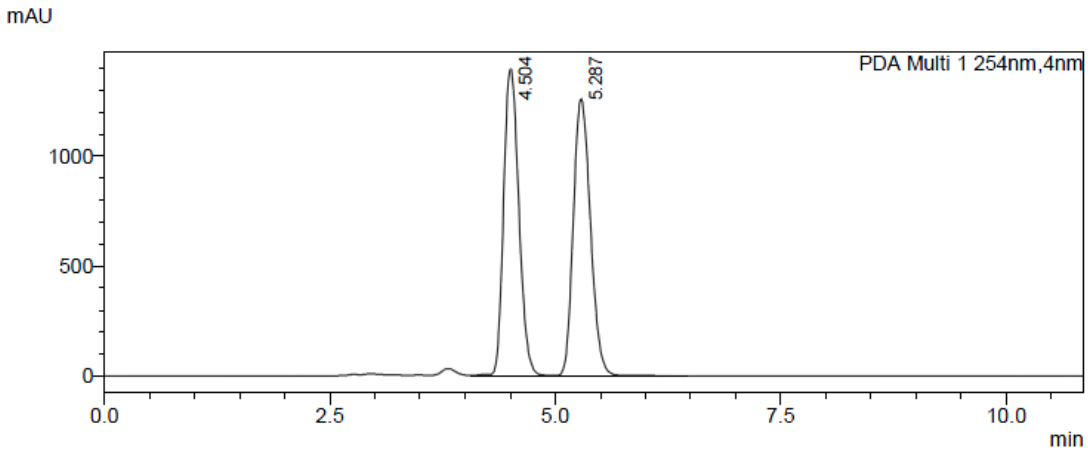
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.700	25617367	1675349	95.766
2	8.101	1132459	56117	4.234
总计				100.000

Compound 3t

<Chromatogram>

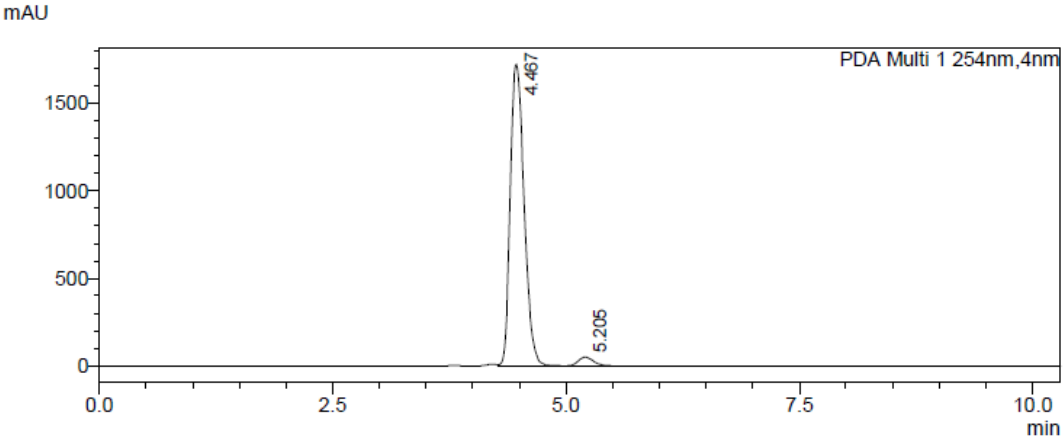


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.504	16486120	1398351	49.681
2	5.287	16697535	1259670	50.319
总计				100.000

<Chromatogram>



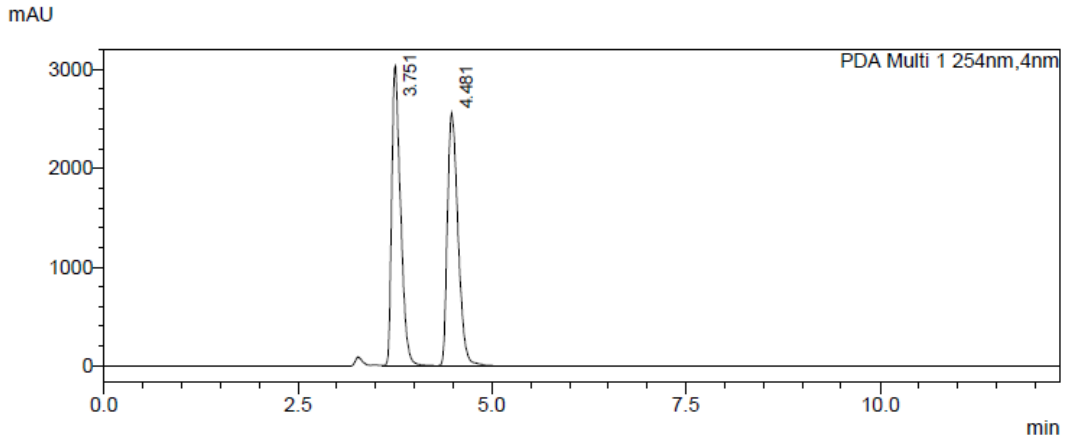
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.467	17834472	1721124	96.731
2	5.205	602623	51385	3.269
总计				100.000

Compound 4a

<Chromatogram>

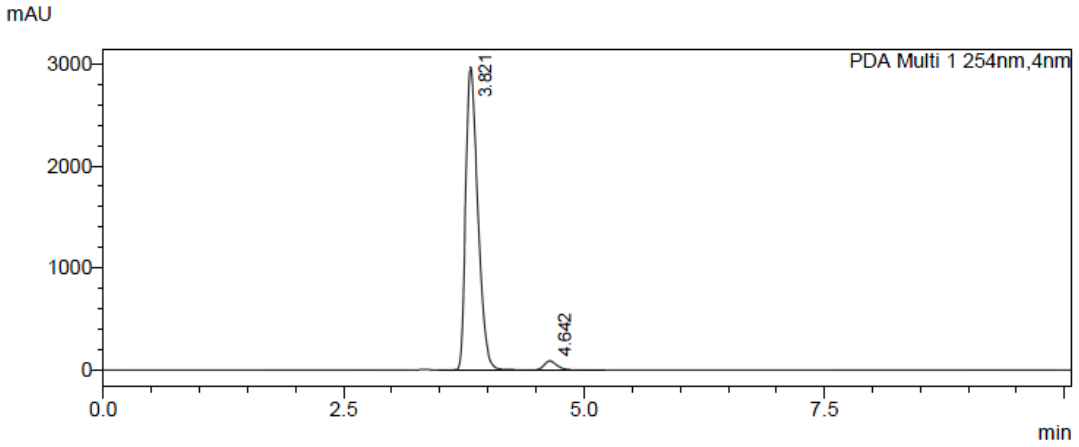


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.751	24002137	3036102	49.554
2	4.481	24434081	2556365	50.446
总计				100.000

<Chromatogram>



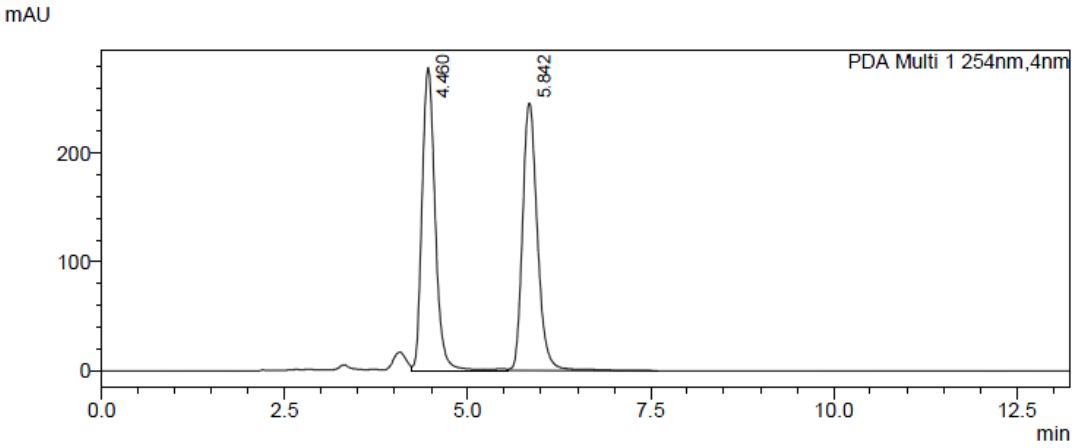
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	3.821	26166337	2978369	96.985
2	4.642	813424	87613	3.015
总计				100.000

Compound 4b

<Chromatogram>

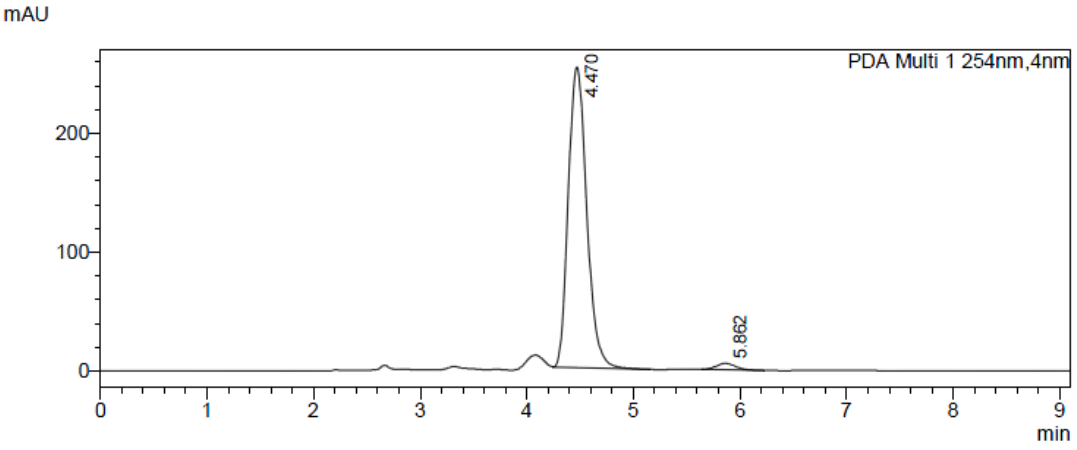


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.460	3474610	279075	49.918
2	5.842	3486064	246232	50.082
总计				100.000

<Chromatogram>



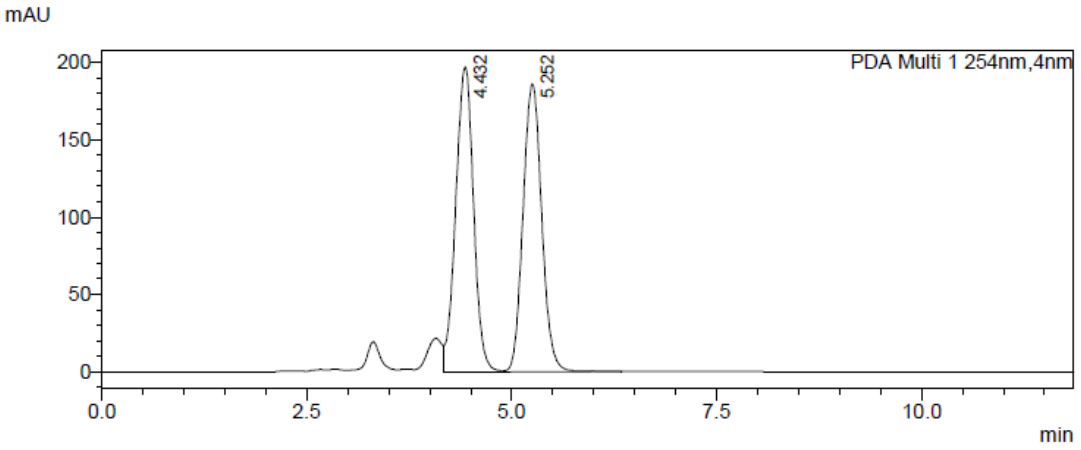
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.470	3051065	253900	97.833
2	5.862	67597	5299	2.167
总计				100.000

Compound 4c

<Chromatogram>

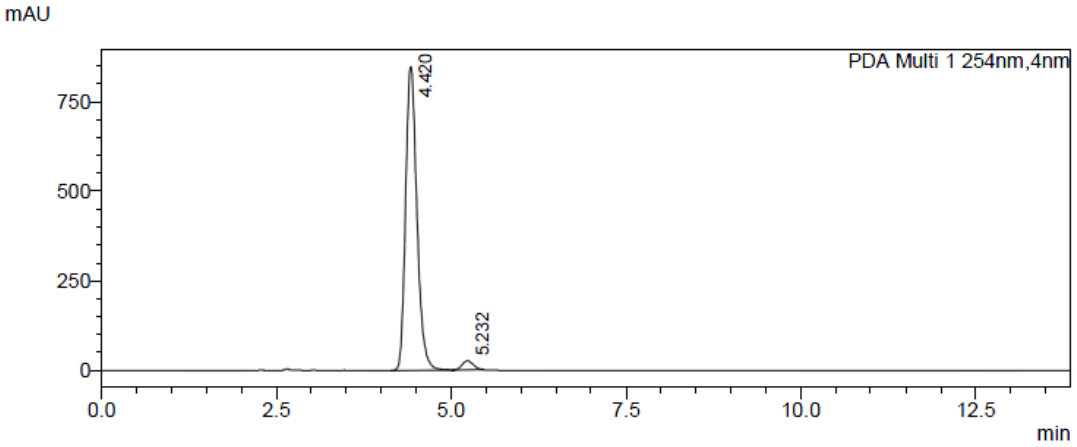


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.432	2980121	197015	50.233
2	5.252	2952495	186183	49.767
总计				100.000

<Chromatogram>



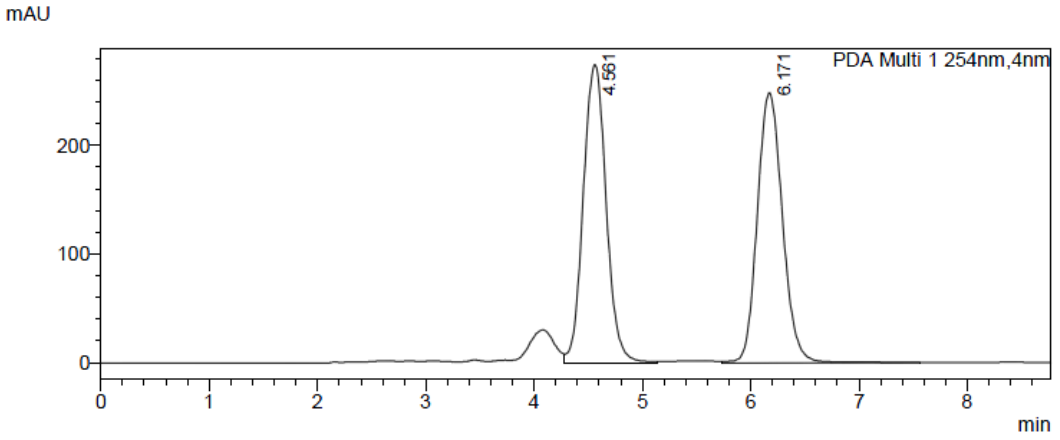
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.420	9531616	847833	97.172
2	5.232	277447	24526	2.828
总计				100.000

Compound 4d

<Chromatogram>

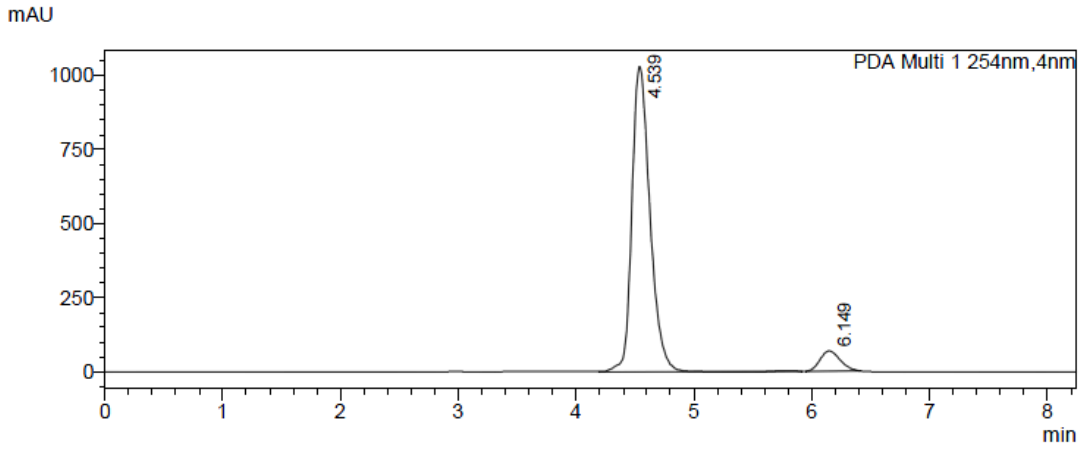


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.561	4039507	274057	50.121
2	6.171	4020059	248174	49.879
总计				100.000

<Chromatogram>



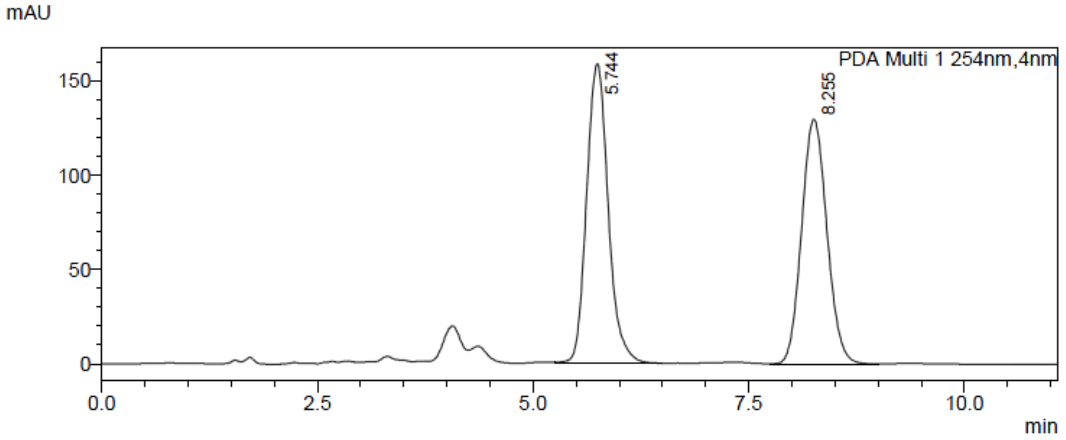
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.539	10921719	1027727	93.204
2	6.149	796317	67681	6.796
总计				100.000

Compound 4e

<Chromatogram>

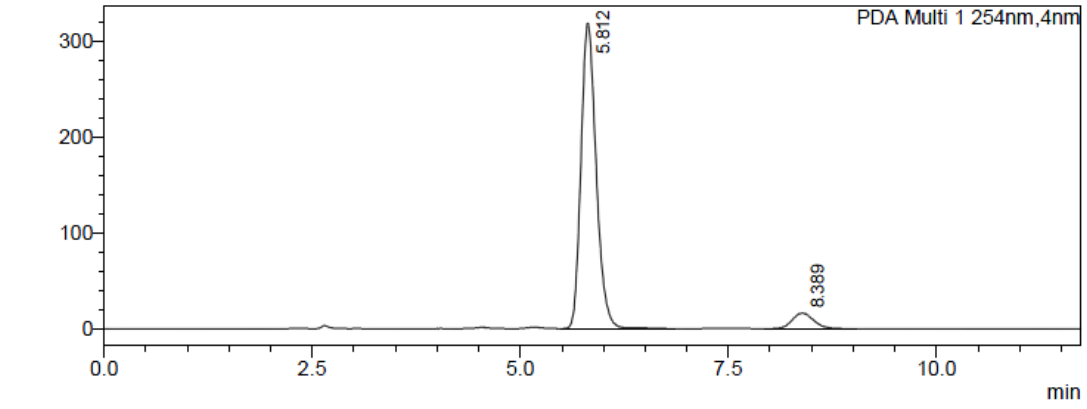


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.744	2782335	158938	51.259
2	8.255	2645666	129894	48.741
总计				100.000

<Chromatogram>



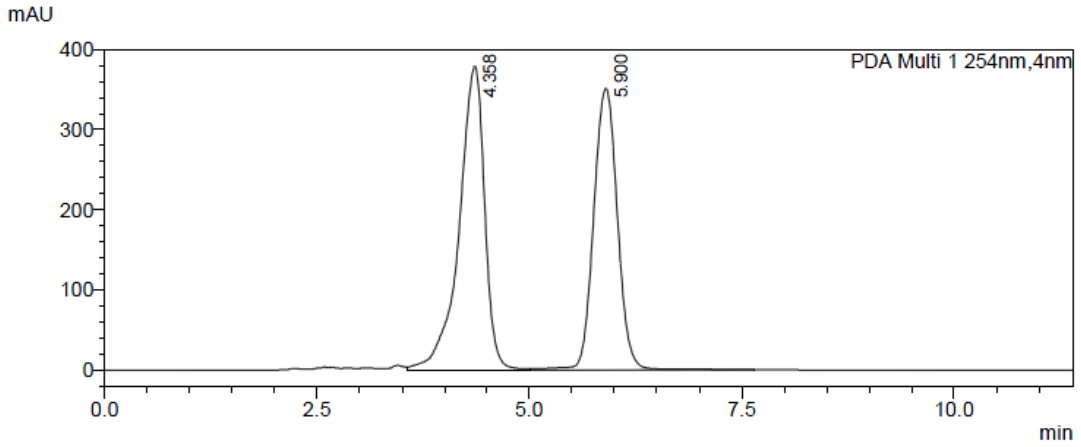
<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	5.812	4056358	319474	93.270
2	8.389	292674	16324	6.730
总计				100.000

Compound 4f

<Chromatogram>

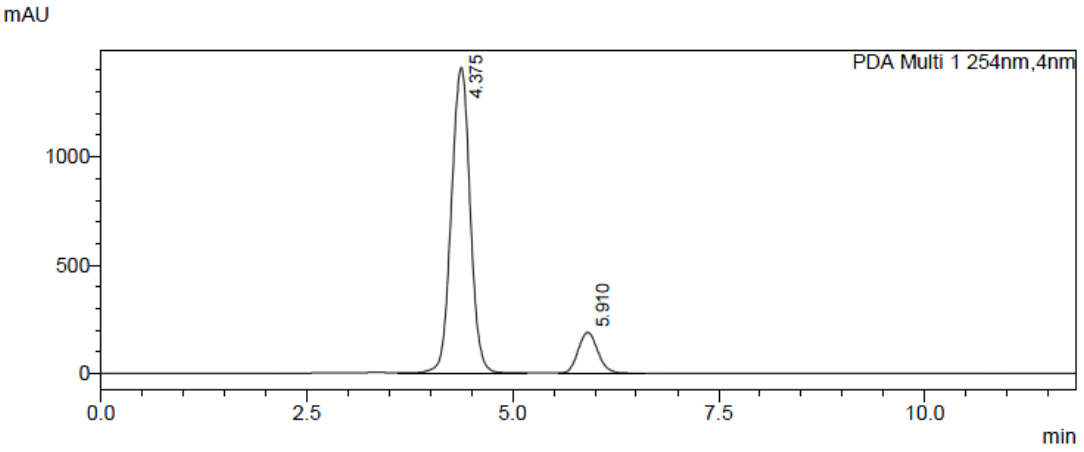


<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.358	7933863	378647	53.642
2	5.900	6856436	351271	46.358
总计				100.000

<Chromatogram>



<Peak Table>

PDA Ch1 254nm

Peak#	Ret. Time	Area	Height	Area%
1	4.375	22527570	1413138	87.843
2	5.910	3117764	188195	12.157
总计				100.000

1. H. Xie, Y. Zhang, S. Zhang, X. Chen and W. Wang, *Angewandte Chemie International Edition*, 2011, **50**, 11773-11776.
2. K. L. Kimmel, M. T. Robak and J. A. Ellman, *Journal of the American Chemical Society*, 2009, **131**, 8754-8755.
3. K.-F. Zhang, J. Nie, R. Guo, Y. Zheng and J.-A. Ma, *Advanced Synthesis & Catalysis*, 2013, **355**, 3497-3502.
4. H. Xie, A. Song, X. Zhang, X. Chen, H. Li, C. Sheng and W. Wang, *Chemical communications*, 2013, **49**, 928-930.