Supporting Information

Highly Efficient and Enantioselective Synthesis of β-Heteroaryl Amino Alcohols via Ru-Catalyzed Asymmetric Hydrogenation

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Content

1. General Information

Unless otherwise mentioned, all experiments were carried out under an atmosphere of argon in a glovebox or using standard Schlenk techniques. Solvents were dried with standard procedures and degassed with Ar_2. Flash column chromatography was performed using Tsingdao silica gel (60, particle size 300-400 mesh). NMR spectra were recorded on a Bruker DPX 400 spectrometer at 400 MHz for ^{1}H NMR, 101 MHz for ^{13}C NMR and 162 MHz for ^{31}P NMR or a Bruker DPX 600 spectrometer at 600 MHz for ^{1}H NMR, 150 MHz for ^{13}C NMR in $CDCl_3$, DMSO-*d6* and CD_3OD with tetramethylsilane (TMS) as internal standard. Chemical shifts are reported in ppm and coupling constants are given in Hz.

2. Experimental Details

2.1 General Procedure for the Synthesis of Substrate

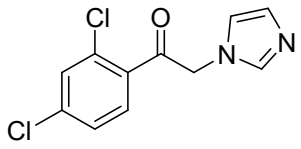
Procedure A：Preparation of ketones 1a~1q, 1t.[1]

To a solution of substituted α-bromo aryl ketone (10 mmol, 1.0 eq) in dichloromethane (10 mL), was added slowly to a suspension of imidazole (24.5 g, 0.36 mol) in dichloromethane (10 mL), and the mixture was heated to 40 °C for 2 h and then overnight at room temperature. The reaction mixture was washed with water and brine (100 mL) and dried (Na_2SO_4), and solvent was removed under vacuum to give a red oil. The desired product was purified by silica gel column chromatography with a mixture of petroleum ether and ethyl acetate as eluent.

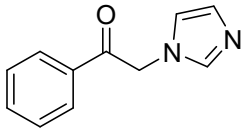
Procedure B：Preparation of ketones 1r, 1s, 1u.[2]

Potassium carbonate (1.5 mmol), nitrogen heterocyclic (1.2 mmol) and α-bromo aryl ketone (1.0 mmol) were heated at 80 ℃ in acetonitrile (10 mL) for 10 hours. After solvents evaporation under vacuum, water was added to the reaction mixture followed by extraction with DCM. The combined organic phases were dried over Na_2SO_4, filtered, and concentrated in vacuo. The desired product was purified by silica gel column chromatography.

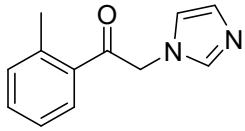
2.2 Characterization Data of 1



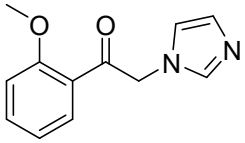
1-(2,4-dichlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1a)[1]： white solid; 83% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.3 Hz, 1H), 7.54 – 7.49 (m, 2H), 7.38 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.12 (s, 1H), 6.94 (s, 1H), 5.33 (s, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 193.68, 139.27, 138.03, 134.10, 132.49, 131.14, 130.79, 129.83, 127.99, 119.99, 55.51.



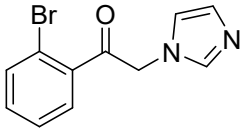
2-(1H-imidazol-1-yl)-1-phenylethan-1-one (1b)[1]：white solid; 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.93 (m, 2H), 7.71 – 7.62 (m, 1H), 7.58 – 7.48 (m, 3H), 7.12 (s, 1H), 6.94 (d, *J* = 1.4 Hz, 1H), 5.40 (d, *J* = 2.1 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.73, 138.17, 134.40, 134.18, 129.55, 129.13, 127.98, 120.34, 52.48.



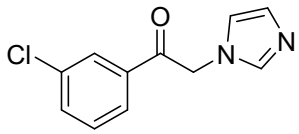
2-(1H-imidazol-1-yl)-1-(o-tolyl)ethan-1-one (1c)[3]： white solid; 79% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.8 Hz, 1H), 7.52 – 7.45 (m, 2H), 7.33 (t, *J* = 7.8 Hz, 2H), 7.13 (s, 1H), 6.94 (s, 1H), 5.30 (s, 2H), 2.53 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 194.37, 139.95, 138.13, 133.95, 132.85, 132.76, 129.67, 128.30, 126.07, 120.21, 54.05, 21.70.



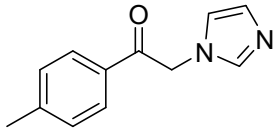
2-(1H-imidazol-1-yl)-1-(2-methoxyphenyl)ethan-1-one (1d)[4]： white solid; 81% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (dd, *J* = 7.8, 1.8 Hz, 1H), 7.56 (ddd, *J* = 8.4, 7.3, 1.9 Hz, 1H), 7.47 (s, 1H), 7.10 (t, *J* = 1.1 Hz, 1H), 7.09 – 7.01 (m, 2H), 6.91 (s, 1H), 5.32 (s, 2H), 4.00 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.15, 159.34, 138.22, 135.32, 131.28, 129.27, 124.54, 121.29, 120.30, 111.66, 56.90, 55.70.



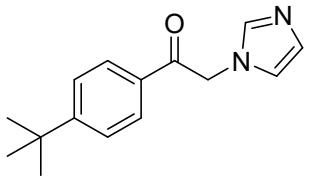
1-(2-bromophenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1e)： white solid; 61% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 7.1 Hz, 1H), 7.52 (s, 1H), 7.43 – 7.34 (m, 3H), 7.10 (s, 1H), 6.96 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 196.18, 138.49, 137.96, 133.88, 132.85, 129.78, 128.98, 127.88, 119.95, 118.91, 55.01. HRMS (ESI) calcd. for $C_{11}H_9BrN_2O$ $[M+H]^+$: 264.9898, Found: 264.9970.



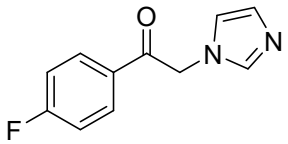
1-(3-chlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1f)[5]： white solid; 84% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (t, *J* = 1.9 Hz, 1H), 7.84 (dt, *J* = 7.8, 1.3 Hz, 1H), 7.63 (ddd, *J* = 8.0, 2.1, 1.0 Hz, 1H), 7.54 – 7.43 (m, 2H), 7.13 (s, 1H), 6.93 (s, 1H), 5.38 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 190.56, 138.10, 135.64, 135.57, 134.36, 130.50, 129.70, 128.14, 126.01, 120.26, 52.52.



2-(1H-imidazol-1-yl)-1-(*p*-tolyl)ethan-1-one (1g)[3]： white solid; 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.2 Hz, 2H), 7.49 (s, 1H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.12 (s, 1H), 6.93 (s, 1H), 5.35 (s, 2H), 2.43 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.20, 145.48, 138.16, 131.71, 129.78, 129.57, 128.07, 120.29, 52.33, 21.79.

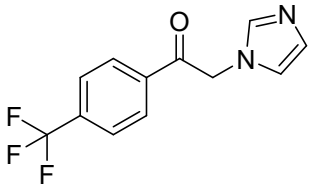


1-(4-(tert-butyl)phenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1h): white solid, 86% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 – 7.86 (m, 2H), 7.58 – 7.46 (m, 3H), 7.13 (d, *J* = 1.3 Hz, 1H), 6.94 (q, *J* = 1.3 Hz, 1H), 5.38 (s, 2H), 1.36 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.19, 158.45, 138.15, 131.63, 129.56, 127.99, 126.09, 120.29, 52.38, 35.33, 31.02. HRMS (ESI) calcd. for $C_{15}H_{18}N_2O$ $[M+H]^+$: 242.1419, Found: 243.1492.

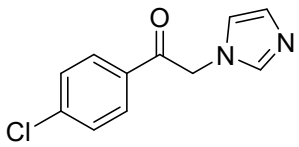


1-(4-fluorophenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1i)[5]： white solid; 80% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 – 7.96 (m, 2H), 7.50 (s, 1H), 7.24 – 7.15 (m, 2H), 7.13 (s, 1H), 6.93 (t, *J* = 1.3 Hz, 1H), 5.37 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ

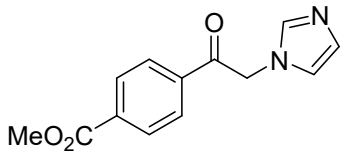
190.09, 167.69, 165.14, 138.13, 130.80, 130.71, 130.67, 130.64, 129.75, 120.24, 116.54, 116.32, 52.35. ^{19}F NMR (376 MHz, $CDCl_3$) δ -102.27.



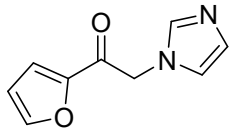
2-(1H-imidazol-1-yl)-1-(4-(trifluoromethyl)phenyl)ethan-1-one (1j): white solid; 80% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.0 Hz, 2H), 7.81 (d, *J* = 8.8 Hz, 2H), 7.56 (s, 1H), 7.15 (s, 1H), 6.96 (s, 1H), 5.46 (s, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 191.14, 138.11, 136.78, 135.53 (q, *J* = 33.1 Hz), 129.43, 128.43, 126.17 (q, *J* = 3.7 Hz), 123.31 (q, *J* = 272.9 Hz), 120.36, 52.76. ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.31. HRMS (ESI) calcd. for $C_{12}H_9F_3N_2O$ $[M+H]^+$: 254.0667, Found: 255.0739.



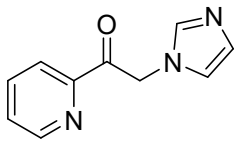
1-(4-chlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-one (1k)[3]： white solid; 83% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.6 Hz, 2H), 7.56 – 7.47 (m, 3H), 7.14 (s, 1H), 6.94 (s, 1H), 5.37 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 190.49, 141.05, 138.12, 132.49, 129.81, 129.53, 129.37, 120.21, 52.41.



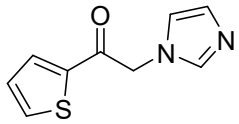
methyl 4-(2-(1H-imidazol-1-yl)acetyl)benzoate (1l): white solid, 87% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 – 8.16 (m, 2H), 8.06 – 8.01 (m, 2H), 7.53 (s, 1H), 7.15 (s, 1H), 6.96 (s, 1H), 5.44 (s, 2H), 3.97 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.28, 165.83, 138.11, 137.26, 135.07, 130.27, 129.78, 127.94, 120.23, 52.73, 52.68. HRMS (ESI) calcd. for $C_{13}H_{12}N_2O_3$ $[M+H]^+$: 244.0848, Found: 245.0921.



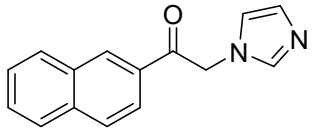
1-(furan-2-yl)-2-(1H-imidazol-1-yl)ethan-1-one (1m)[6]： white solid; 51% yield. ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.10 (s, 1H), 7.59 (s, 2H), 7.12 (d, J = 2.6 Hz, 1H), 6.91 (d, J = 2.5 Hz, 1H), 6.80 (s, 1H), 5.50 (s, 2H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 182.64, 150.39, 148.88, 138.82, 128.44, 121.31, 119.72, 113.23, 52.07.



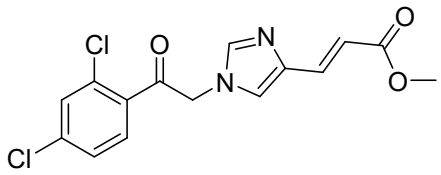
2-(1H-imidazol-1-yl)-1-(pyridin-2-yl)ethan-1-one (1n)[6]： white solid; 57% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.06 (d, J = 6.7 Hz, 1H), 7.89 (t, J = 7.8 Hz, 1H), 7.54 (d, J = 19.7 Hz, 2H), 7.12 (s, 1H), 6.96 (s, 1H), 5.65 (s, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 193.48, 151.33, 149.24, 138.27, 137.37, 129.50, 128.29, 122.38, 120.29, 52.28.



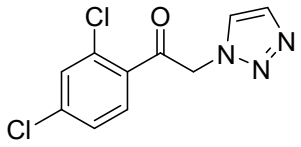
2-(1H-imidazol-1-yl)-1-(thiophen-2-yl)ethan-1-one (1o)[7]： white solid; 73% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (ddd, J = 7.8, 4.4, 1.1 Hz, 2H), 7.54 (s, 1H), 7.20 (dd, J = 4.9, 3.8 Hz, 1H), 7.13 (s, 1H), 6.97 (d, J = 1.4 Hz, 1H), 5.29 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.73, 140.59, 138.11, 135.36, 132.52, 129.74, 128.65, 120.24, 52.57.



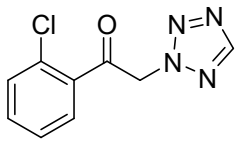
2-(1H-imidazol-1-yl)-1-(naphthalen-2-yl)ethan-1-one (1p)[7]： white solid; 85% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (d, J = 1.7 Hz, 1H), 8.03 – 7.88 (m, 4H), 7.72 – 7.51 (m, 3H), 7.16 (d, J = 1.1 Hz, 1H), 6.99 (s, 1H), 5.53 (s, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 193.99, 138.86, 135.78, 132.58, 132.24, 130.50, 130.07, 129.46, 129.03, 128.39, 128.27, 127.68, 123.81, 121.43, 53.10.



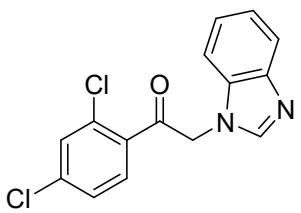
Methyl (*E*)-3-(1-(2-(2,4-dichlorophenyl)-2-oxoethyl)-1H-imidazol-4-yl)acrylate (1q): white solid, 79% yield. ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.98 (d, J = 8.4 Hz, 1H), 7.83 (d, J = 2.0 Hz, 1H), 7.71 (s, 1H), 7.67 (dd, J = 8.4, 2.0 Hz, 1H), 7.59 – 7.53 (m, 2H), 6.37 (d, J = 15.5 Hz, 1H), 5.64 (s, 2H), 3.69 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 194.01, 167.09, 140.26, 137.36, 137.30, 136.67, 133.62, 132.05, 131.49, 130.54, 127.71, 124.78, 113.61, 54.99, 51.19. HRMS (ESI) calcd. for $C_{15}H_{12}Cl_2N_2O_3$ $[M+H]^+$: 338.0225, Found: 339.0299.



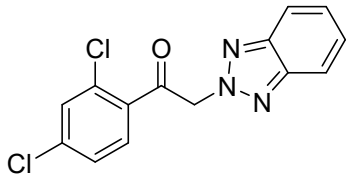
1-(2,4-dichlorophenyl)-2-(1H-1,2,3-triazol-1-yl)ethan-1-one (1r)[8]：white solid; 69% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (s, 2H), 7.62 (d, J = 8.4 Hz, 1H), 7.49 (d, J = 2.0 Hz, 1H), 7.35 (dd, J = 8.4, 2.0 Hz, 1H), 5.88 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.52, 139.16, 135.37, 133.80, 132.92, 131.38, 130.78, 127.73, 62.91.



1-(2-chlorophenyl)-2-(2H-tetrazol-2-yl)ethan-1-one (1s)[9]：white solid; 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.63 (s, 1H), 7.77 – 7.72 (m, 1H), 7.54 (dd, J = 6.2, 1.7 Hz, 2H), 7.44 (ddd, J = 7.8, 6.2, 2.3 Hz, 1H), 6.17 (s, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 190.99, 153.34, 134.73, 133.94, 132.11, 131.11, 130.67, 127.52, 77.31, 77.10, 76.88, 60.78, 25.37.



2-(1H-benzo[d]imidazol-1-yl)-1-(2,4-dichlorophenyl)ethan-1-one (1t)[10]： white solid; 80% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 – 8.00 (m, 2H), 7.93 (s, 1H), 7.88 – 7.82 (m, 1H), 7.72 – 7.66 (m, 1H), 7.56 (dd, *J* = 8.5, 7.1 Hz, 2H), 7.33 – 7.26 (m, 2H), 7.25 – 7.21 (m, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.24, 143.77, 143.63, 134.50, 134.25, 129.20, 128.07, 123.30, 122.37, 120.62, 109.23, 77.36, 77.04, 76.73, 50.39.

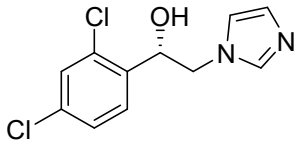


2-(2H-benzo[d][1,2,3]triazol-2-yl)-1-(2,4-dichlorophenyl)ethan-1-one (1u)： white solid; 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.4 Hz, 1H), 7.67 (d, *J* = 8.4 Hz, 1H), 7.55 – 7.49 (m, 2H), 7.47 – 7.35 (m, 3H), 6.06 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.06, 146.06, 139.50, 133.69, 133.63, 132.87, 131.41, 130.92, 128.03, 127.99, 124.17, 120.31, 109.29, 77.35, 77.04, 76.72, 56.63. HRMS (ESI) calcd. for $C_{14}H_9Cl_2N_3O$ $[M+H]^+$: 306.0123, Found: 306.0200.

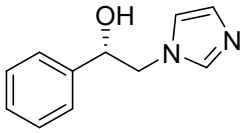
3. General procedure for the asymmetric hydrogenation

3.1 General procedure for the asymmetric hydrogenation conducted with S/C = 100

To a 4.0 mL vial was added the catalyst (2×10^{-2} mmol, 24 mg) and anhydrous THF (2.0 mL) under argon atmosphere. The mixture was stirred in the argon-filled glovebox. The resulting solution (200 μL) and KOH (0.1 mg) were transferred by syringe into a 5.0 mL vial charged with substrate (0.2 mmol) in 0.5 mL anhydrous THF. The vials were transferred to an autoclave, which was then charged with 50 atm of H_2 and stirred at room temperature for 24 h. The hydrogen gas was released slowly in a well-ventilated hood and the solution was concentrated and passed through a short column of silica gel to remove the metal complex.

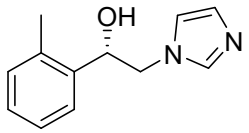


(*S*)-1-(2,4-dichlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2a)[1]： white solid; 99% yield, >99% ee, $[\alpha]^{25}_D$ = +85 (*c* 1.0, MeOH) (lit.[1] $[\alpha]^{25}_D$ = +83.8 (*c* 0.998, MeOH), 91% ee, *S*); ^{1}H NMR (600 MHz, DMSO-d_6) δ 7.59 (d, *J* = 3.3 Hz, 1H), 7.45 (dt, *J* = 23.0, 5.4 Hz, 3H), 7.05 (s, 1H), 6.84 (s, 1H), 6.06 (s, 1H), 5.13 – 5.04 (m, 1H), 4.17 (dd, *J* = 14.1, 2.9 Hz, 1H), 4.05 (ddd, *J* = 14.3, 6.8, 3.3 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 139.12, 138.21, 133.22, 132.28, 129.85, 128.88, 128.42, 127.93, 120.50, 69.16, 52.08. The enantiomeric excess of **2a** was determined by HPLC analysis on Chiralpak AS-H column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 10.4 min (major), 13.1 min (minor).

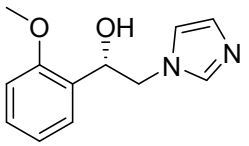


(*S*)-2-(1H-imidazol-1-yl)-1-phenylethan-1-ol (2b)[1]： white solid; 97% yield, >99% ee, $[\alpha]^{25}_D$ = +81 (*c* 0.5, MeOH) (lit.[1] $[\alpha]^{25}_D$ = +46.1 (*c* 0.98, EtOH), 97% ee, *S*); ^{1}H

NMR (600 MHz, DMSO-d_6) δ 7.49 (d, J = 8.5 Hz, 1H), 7.35 (d, J = 6.9 Hz, 4H), 7.30 – 7.24 (m, 1H), 7.11 (d, J = 8.3 Hz, 1H), 6.83 (d, J = 8.4 Hz, 1H), 5.72 (s, 1H), 4.82 (td, J = 8.5, 4.0 Hz, 1H), 4.14 (tt, J = 9.2, 4.3 Hz, 1H), 4.04 (dt, J = 13.7, 8.3 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 143.12, 138.18, 128.54, 128.19, 127.80, 126.49, 120.50, 72.55, 54.01. The enantiomeric excess of **2b** was determined by HPLC analysis on Chiralpak AS-H column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 10.4 min (major), 13.1 min (minor).

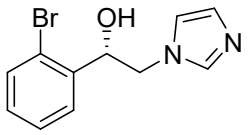


(*S*)-2-(1H-imidazol-1-yl)-1-(o-tolyl)ethan-1-ol (2c)： white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +67 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.50 (s, 1H), 7.41 – 7.38 (m, 1H), 7.18 – 7.12 (m, 3H), 7.04 (s, 1H), 6.90 (s, 1H), 5.16 – 5.11 (m, 1H), 4.21 – 4.14 (m, 2H), 2.28 (s, 3H). ^{13}C NMR (151 MHz, CD_3OD) δ 139.53, 137.61, 134.55, 129.92, 127.33, 126.98, 125.87, 125.43, 120.16, 69.34, 52.86, 17.62. HRMS (ESI) calcd. for $C_{12}H_{14}N_2O$ $[M+H]^+$: 203.1106, Found: 203.1177. The enantiomeric excess of **2c** was determined by HPLC analysis on Chiralpak IB column. Conditions: hexane/isopropanol = 80/20, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 11.4 min (minor), 23.6 min (major).

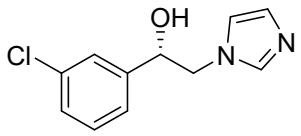


(*S*)-2-(1H-imidazol-1-yl)-1-(2-methoxyphenyl)ethan-1-ol (2d)： white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +80 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.50 (s, 1H), 7.38 – 7.34 (m, 1H), 7.28 (td, J = 7.8, 1.7 Hz, 1H), 7.03 (s, 1H), 6.99 (d, J = 7.3 Hz, 1H), 6.94 (t, J = 7.5 Hz, 1H), 6.90 (s, 1H), 5.25 (dd, J = 7.1, 3.4 Hz, 1H), 4.26 (dd, J = 14.1, 3.4 Hz, 1H), 4.12 (dd, J = 14.0, 7.1 Hz, 1H), 3.88 (s, 3H). ^{13}C NMR (151 MHz, CD_3OD) δ 155.97, 137.56, 129.29, 128.49, 126.84, 126.09, 120.22, 120.12, 109.88, 67.70, 54.47, 52.57. HRMS (ESI) calcd. for $C_{12}H_{14}N_2O_2$ $[M+H]^+$: 219.1055,

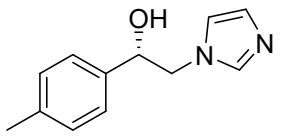
Found: 219.1126. The enantiomeric excess of **2d** was determined by HPLC analysis on Chiralpak AS-H column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 16.3 min (major), 22.2 min (minor).



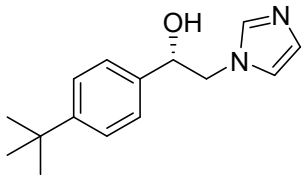
(*S*)-1-(2-bromophenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2e)：white solid; 97% yield, >99% ee, $[\alpha]^{25}_D$ = +65 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.57 (d, *J* = 7.5 Hz, 2H), 7.49 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.20 (td, *J* = 7.7, 1.8 Hz, 1H), 7.07 (s, 1H), 6.92 (s, 1H), 5.25 (dd, *J* = 7.3, 3.0 Hz, 1H), 4.30 (dd, *J* = 14.3, 3.1 Hz, 1H), 4.13 (dd, *J* = 14.3, 7.3 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 140.38, 137.58, 132.27, 129.21, 127.66, 127.52, 126.86, 121.26, 120.17, 71.69, 52.38. HRMS (ESI) calcd. for $C_{11}H_{11}BrN_2O$ $[M+H]^+$: 267.0055, Found: 267.0124. The enantiomeric excess of **2e** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 3.0 min (major), 3.6 min (minor).



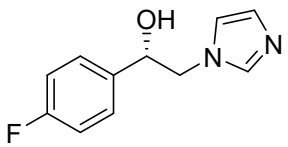
(*S*)-1-(3-chlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2f)：white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +23 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.71 (s, 1H), 7.35 (s, 1H), 7.33 – 7.24 (m, 3H), 7.15 (s, 1H), 7.00 (s, 1H), 4.95 (dd, *J* = 7.3, 4.1 Hz, 1H), 4.28 (dd, *J* = 14.1, 4.0 Hz, 1H), 4.19 (dd, *J* = 14.1, 7.3 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 143.93, 137.37, 134.04, 129.61, 127.53, 125.79, 125.74, 124.07, 120.61, 53.99. HRMS (ESI) calcd. for $C_{11}H_{11}ClN_2O$ $[M+H]^+$: 223.0560, Found: 223.0641. The enantiomeric excess of **2f** was determined by HPLC analysis on Chiralpak IB column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 18.3 min (major), 23.9 min (minor).



(*S*)-2-(1H-imidazol-1-yl)-1-(p-tolyl)ethan-1-ol (2g)： white solid; 99% yield, >99% ee, $[\alpha]^{25}_{D}$ = +35 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, DMSO-d_6) δ 7.49 (s, 1H), 7.22 (d, *J* = 7.9 Hz, 2H), 7.13 (d, *J* = 7.8 Hz, 2H), 7.10 (s, 1H), 5.63 (s, 1H), 4.77 (dd, *J* = 7.9, 4.1 Hz, 1H), 4.10 (dd, *J* = 13.9, 4.2 Hz, 1H), 4.01 (dd, *J* = 13.9, 7.9 Hz, 1H), 2.28 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 140.11, 138.15, 136.83, 129.09, 128.09, 126.41, 120.51, 72.37, 54.05, 21.18. HRMS (ESI) calcd. for $C_{12}H_{14}N_2O$ $[M+H]^+$: 203.1106, Found: 203.1177. The enantiomeric excess of **2g** was determined by HPLC analysis on Chiralpak AS-H column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 210 nm, t_R = 21.8 min (major), 24.3 min (minor).

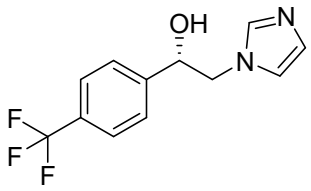


(*S*)-1-(4-(tert-butyl)phenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2h): white solid, 98% yield, >99% ee, $[\alpha]^{25}_{D}$ = +33 (*c* 0.1, MeOH). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (s, 1H), 7.38 (dt, *J* = 8.4, 2.0 Hz, 2H), 7.25 (dt, *J* = 8.5, 2.1 Hz, 2H), 7.08 (t, *J* = 1.3 Hz, 1H), 6.91 (s, 1H), 4.86 (d, *J* = 2.3 Hz, 1H), 4.25 – 4.11 (m, 2H), 1.31 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.58, 142.51, 141.56, 130.90, 129.40, 128.88, 124.03, 76.64, 57.84, 37.91, 34.33. HRMS (ESI) calcd. for $C_{15}H_{20}N_2O$ $[M+H]^+$: 244.1576, Found: 245.1649. The enantiomeric excess of **2h** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 75/25, flow rate = 0.5 mL/min, uv-vis detection at λ = 220 nm, t_R = 3.40 min (major), 3.91 min (minor).

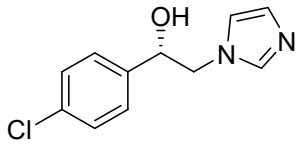


(*S*)-1-(4-fluorophenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2i)： white solid; 98% yield, >99% ee, $[\alpha]^{25}_{D}$ = +41 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.48 (s, 1H), 7.32 (dd, *J* = 8.4, 5.4 Hz, 2H), 7.07 – 7.01 (m, 3H), 6.89 (s, 1H), 4.92 (dd, *J* = 7.2, 4.5 Hz, 1H), 4.20 (dd, *J* = 14.1, 4.4 Hz, 1H), 4.15 (dd, *J* = 14.1, 7.1 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 163.22, 161.60, 137.64, 127.63, 127.57, 127.02, 120.13,

114.74, 114.60, 72.11, 53.82. ^{19}F NMR (377 MHz, CD_3OD) δ -116.94. HRMS (ESI) calcd. for $C_{11}H_{11}FN_2O$ $[M+H]^+$: 207.0855, Found: 207.0924. The enantiomeric excess of **2i** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 230 nm, t_R = 3.2 min (major), 3.7 min (minor).

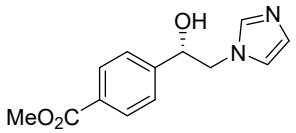


(*S*)-2-(1H-imidazol-1-yl)-1-(4-(trifluoromethyl)phenyl)ethan-1-ol (2j): white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +30 (*c* 0.1, MeOH).. ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.70 (d, *J* = 8.1 Hz, 2H), 7.56 (d, *J* = 8.0 Hz, 2H), 7.48 (s, 1H), 7.12 (s, 1H), 6.83 (s, 1H), 5.92 (d, *J* = 4.6 Hz, 1H), 4.95 (dt, *J* = 8.2, 4.4 Hz, 1H), 4.19 (dd, *J* = 14.0, 4.1 Hz, 1H), 4.07 (dd, *J* = 13.9, 7.6 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 147.78, 138.22, 128.42 (q, *J* = 31.6 Hz), 128.27, 127.29, 125.40 (q, *J* = 3.8 Hz), 124.79 (q, *J* = 271.9, 270.7 Hz), 120.54, 71.90, 53.63. ^{19}F NMR (376 MHz, DMSO-d_6) δ -59.99. HRMS (ESI) calcd. for $C_{12}H_{11}F_3N_2O$ $[M+H]^+$: 256.0823, Found: 257.0895. The enantiomeric excess of **2j** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 75/25, flow rate = 0.5 mL/min, uv-vis detection at λ = 220 nm, t_R = 2.38 min (major), 2.84 min (minor).

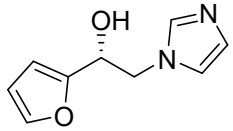


(*S*)-1-(4-chlorophenyl)-2-(1H-imidazol-1-yl)ethan-1-ol (2k)：white solid; 97% yield, >99% ee, $[\alpha]^{25}_D$ = +86 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.48 (s, 1H), 7.30 (q, J = 8.5 Hz, 4H), 7.05 (s, 1H), 6.89 (s, 1H), 4.92 (dd, J = 7.1, 4.3 Hz, 1H), 4.22 (dd, J = 14.1, 4.4 Hz, 1H), 4.16 (dd, J = 14.1, 7.1 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 140.47, 137.66, 133.16, 128.08, 127.34, 127.04, 120.14, 72.05, 53.68. HRMS (ESI) calcd. for $C_{11}H_{11}ClN_2O$ $[M+H]^+$: 223.0560, Found: 223.0641. The enantiomeric excess of **2k** was determined by HPLC analysis on Chiralpak IB column.

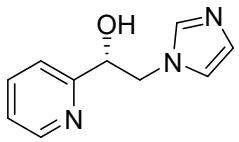
Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 20.3 min (major), 23.5 min (minor).



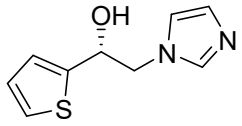
methyl (S)-4-(1-hydroxy-2-(1H-imidazol-1-yl)ethyl)benzoate (2l): white solid, 99% yield, >99% ee, $[\alpha]^{25}_D$ = +120 (*c* 0.1, MeOH). **^{1}H NMR** (400 MHz, CD_3OD) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.49 (s, 1H), 7.44 (d, *J* = 8.3 Hz, 2H), 7.06 (s, 1H), 6.90 (s, 1H), 5.01 (dd, *J* = 7.0, 4.2 Hz, 1H), 4.27 (dd, *J* = 14.1, 4.3 Hz, 1H), 4.19 (dd, *J* = 14.1, 7.0 Hz, 1H), 3.89 (s, 3H). **^{13}C NMR** (101 MHz, CD_3OD) δ 166.91, 147.14, 137.68, 129.40, 129.22, 127.06, 128.89, 120.19, 72.29, 53.62, 51.26. HRMS (ESI) calcd. for $C_{13}H_{14}N_2O_3$ $[M+H]^+$: 246.1004, Found: 247.1077. The enantiomeric excess of **2l** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 75/25, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 4.53 min (major), 5.33 min (minor).



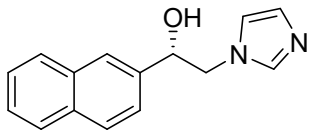
(*R*)-1-(furan-2-yl)-2-(1H-imidazol-1-yl)ethan-1-ol (2m)：white solid; 96% yield, >99% ee, $[\alpha]^{25}_D$ = +34 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.41 (d, *J* = 1.8 Hz, 1H), 7.31 (s, 1H), 6.84 – 6.80 (m, 2H), 6.35 (dd, *J* = 3.3, 1.8 Hz, 1H), 6.29 (d, *J* = 3.3 Hz, 1H), 5.05 (s, 1H), 4.92 (dd, *J* = 7.7, 3.9 Hz, 1H), 4.27 (dd, *J* = 14.1, 4.0 Hz, 1H), 4.20 (dd, *J* = 14.1, 7.7 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 153.78, 142.24, 137.61, 128.42, 119.61, 110.55, 107.18, 67.32, 52.07. HRMS (ESI) calcd. for $C_9H_{10}N_2O_2$ $[M+H]^+$: 179.0742, Found: 179.0813. The enantiomeric excess of **2m** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 1.9 min (major), 2.5 min (minor).



(*R*)-2-(1H-imidazol-1-yl)-1-(pyridin-2-yl)ethan-1-ol (2n): white solid; 97% yield, >99% ee, $[\alpha]^{25}_{D}$ = +18 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 8.53 (s, 1H), 7.80 (t, *J* = 7.8 Hz, 1H), 7.54 – 7.45 (m, 2H), 7.35 – 7.29 (m, 1H), 7.03 (s, 1H), 6.88 (s, 1H), 5.01 – 4.95 (m, 1H), 4.42 (dt, *J* = 14.3, 3.3 Hz, 1H), 4.32 – 4.21 (m, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 160.42, 148.23, 137.68, 137.39, 127.04, 122.86, 120.92, 120.10, 73.07, 52.66. HRMS (ESI) calcd. for $C_{10}H_{11}N_3O$ $[M+H]^+$: 190.0902, Found: 190.0973. The enantiomeric excess of **2n** was determined by UPLC analysis on Chiralpak IG-3 column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 5.3 min (major), 5.7 min (minor).

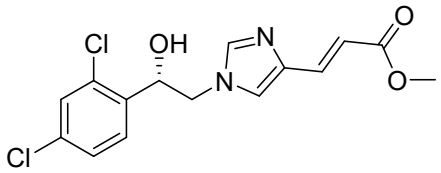


(*R*)-2-(1H-imidazol-1-yl)-1-(thiophen-2-yl)ethan-1-ol (2o): yellow solid; 96% yield, >99% ee, $[\alpha]^{25}_{D}$ = +10 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.54 (s, 1H), 7.33 (dd, *J* = 4.9, 1.3 Hz, 1H), 7.10 (s, 1H), 6.96 (dt, *J* = 7.4, 3.5 Hz, 2H), 6.91 (s, 1H), 5.17 (dd, *J* = 7.4, 4.5 Hz, 1H), 4.30 (dd, *J* = 14.0, 4.5 Hz, 1H), 4.23 (dd, *J* = 14.1, 7.4 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 145.30, 137.66, 127.06, 126.37, 124.47, 123.77, 120.08, 69.05, 53.99. HRMS (ESI) calcd. for $C_9H_1N_2S$ $[M+H]^+$: 195.0514, Found: 195.0585. The enantiomeric excess of **2o** was determined by UPLC analysis on Chiralpak AS-H column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 210 nm, t_R = 2.4 min (major), 2.9 min (minor).

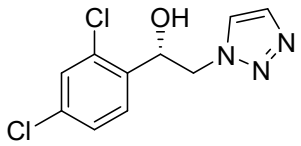


(*S*)-2-(1H-imidazol-1-yl)-1-(naphthalen-2-yl)ethan-1-ol (2p): white solid; 99% yield, >99% ee, $[\alpha]^{25}_{D}$ = +43 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.67 (s, 2H), 7.58 (d, *J* = 8.4 Hz, 1H), 7.43 (d, *J* = 2.1 Hz, 1H), 7.35 (d, *J* = 8.6 Hz, 1H), 5.57 (dd, *J* = 8.1, 3.9 Hz, 1H), 4.65 (dd, *J* = 13.8, 3.9 Hz, 1H), 4.57 (dd, *J* = 13.8, 8.0 Hz,

1H). ^{13}C NMR (151 MHz, CD_3OD) δ 137.83, 134.08, 133.84, 132.43, 128.85, 128.54, 127.25, 68.55, 59.31. HRMS (ESI) calcd. for $C_{15}H_{14}N_2O$ $[M+H]^+$: 239.1106, Found: 239.1177. The enantiomeric excess of **2p** was determined by HPLC analysis on Chiralpak IB column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 26.6 min (major), 30.9 min (minor).

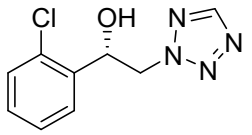


methyl (*S*, *E*)-3-(1-(2-(2,4-dichlorophenyl)-2-hydroxyethyl)-1H-imidazol-4-yl) acrylate (2q): white solid, 98% yield, >99% ee, $[\alpha]^{25}_D$ = +21 (*c* 0.1, MeOH). ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.62 (t, *J* = 1.2 Hz, 1H), 7.59 – 7.58 (m, 1H), 7.55 (s, 1H), 7.50 (d, *J* = 15.6 Hz, 1H), 7.45 (d, *J* = 1.5 Hz, 2H), 6.33 (d, *J* = 15.6 Hz, 1H), 6.08 (d, *J* = 4.6 Hz, 1H), 5.08 (ddd, *J* = 7.7, 4.7, 3.3 Hz, 1H), 4.20 (dd, *J* = 14.1, 3.3 Hz, 1H), 4.05 (dd, *J* = 14.1, 7.3 Hz, 1H), 3.68 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 167.59, 140.30, 138.83, 137.88, 137.06, 133.34, 132.26, 129.82, 128.97, 128.01, 124.73, 113.81, 68.93, 52.31, 51.63. HRMS (ESI) calcd. for $C_{15}H_{14}Cl_2N_2O_3$ $[M+H]^+$: 340.0381, Found: 341.0455. The enantiomeric excess of **2q** was determined by UPLC analysis on Chiralpak IA-U column. Conditions: hexane/isopropanol = 75/25, flow rate = 0.5 mL/min, uv-vis detection at λ = 280 nm, t_R = 1.92 min (major), 3.02 min (minor).

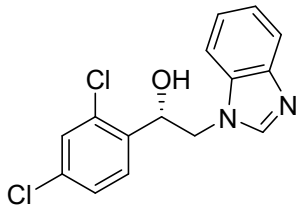


(*S*)-1-(2,4-dichlorophenyl)-2-(1H-1,2,3-triazol-1-yl)ethan-1-ol (2r): white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +22 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.67 (s, 2H), 7.58 (d, *J* = 8.4 Hz, 1H), 7.43 (d, *J* = 2.1 Hz, 1H), 7.35 (d, *J* = 8.6 Hz, 1H), 5.57 (dd, *J* = 8.1, 3.9 Hz, 1H), 4.65 (dd, *J* = 13.8, 3.9 Hz, 1H), 4.57 (dd, *J* = 13.8, 8.0 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 137.83, 134.08, 133.84, 132.43, 128.85, 128.54, 127.25, 68.55, 59.31. HRMS (ESI) calcd. for $C_{10}H_9Cl_2N_3O$ $[M+H]^+$: 258.0123, Found: 258.0194. The enantiomeric excess of **2r** was determined by HPLC analysis on

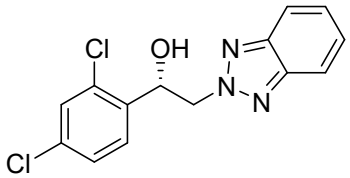
Chiralpak IB column. Conditions: hexane/isopropanol = 90/10, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 11.6 min (major), 12.2 min (minor).



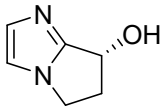
(*S*)-1-(2-chlorophenyl)-2-(2H-tetrazol-2-yl)ethan-1-ol (2s): white solid; 98% yield, 98.5% ee, $[\alpha]^{25}_D$ = +66 (c 0.25, MeOH). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.54 (s, 1H), 7.63 (dd, *J* = 7.7, 1.8 Hz, 1H), 7.40 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.32 (dtd, *J* = 22.8, 7.5, 1.6 Hz, 2H), 5.73 (dt, *J* = 8.5, 3.3 Hz, 1H), 4.99 (dd, *J* = 13.9, 2.7 Hz, 1H), 4.79 (dd, *J* = 13.9, 8.7 Hz, 1H), 3.26 (d, *J* = 4.2 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 152.91, 136.63, 131.78, 129.79, 129.71, 127.51, 127.37, 69.25, 58.00. HRMS (ESI) calcd. for $C_9H_9ClN_4O$ $[M+H]^+$: 224.0456, Found: 224.0527. The enantiomeric excess of **2s** was determined by HPLC analysis on Chiralpak IC column. Conditions: hexane/isopropanol = 75/25, flow rate = 1.0 mL/min, uv-vis detection at λ = 208 nm, t_R = 6.8 min (major), 7.6 min (minor).



(*S*)-2-(1H-benzo[d]imidazol-1-yl)-1-(2,4-dichlorophenyl)ethan-1-ol (2t): white solid; 98% yield, >99% ee, $[\alpha]^{25}_D$ = +10 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.99 (s, 1H), 7.65 (dd, *J* = 7.2, 1.5 Hz, 1H), 7.51 (dd, *J* = 7.4, 1.5 Hz, 1H), 7.36 – 7.31 (m, 4H), 7.30 – 7.24 (m, 3H), 5.07 (dd, *J* = 7.2, 4.8 Hz, 1H), 4.51 – 4.43 (m, 2H). ^{13}C NMR (151 MHz, CD_3OD) δ 144.01, 142.32, 141.65, 133.91, 128.10, 127.57, 125.71, 122.71, 121.91, 118.51, 110.23, 71.83, 51.89. HRMS (ESI) calcd. for $C_{15}H_{12}Cl_2N_2O$ $[M+H]^+$: 307.0329, Found: 307.0400. The enantiomeric excess of **2t** was determined by HPLC analysis on Chiralpak IB column. Conditions: hexane/isopropanol = 80/20, flow rate = 1.0 mL/min, uv-vis detection at λ = 210 nm, t_R = 14.2 min (major), 17.2 min (minor).



(*S*)-2-(2H-benzo[d][1,2,3]triazol-2-yl)-1-(2,4-dichlorophenyl)ethan-1-ol (2u): white solid; 98% yield, 97% ee, $[\alpha]^{25}_{D}$ = +34 (*c* 0.5, MeOH). ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.02 (d, *J* = 8.3 Hz, 1H), 7.80 (d, *J* = 8.3 Hz, 1H), 7.61 (d, *J* = 2.1 Hz, 1H), 7.58 – 7.51 (m, 2H), 7.45 (dd, *J* = 8.4, 2.1 Hz, 1H), 7.42 – 7.36 (m, 1H), 6.08 (s, 1H), 5.40 (dd, *J* = 7.6, 3.8 Hz, 1H), 4.88 (dd, *J* = 14.4, 3.8 Hz, 1H), 4.82 (dd, *J* = 14.4, 7.6 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 145.10, 137.87, 133.94, 132.26, 128.83, 128.55, 127.26, 127.16, 124.10, 118.28, 110.68, 68.72, 53.35. HRMS (ESI) calcd. for $C_{14}H_{11}Cl_2N_3O$ $[M+H]^+$: 308.0279, Found: 308.0350. The enantiomeric excess of **2u** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 2.9 min (minor), 3.2 min (major).



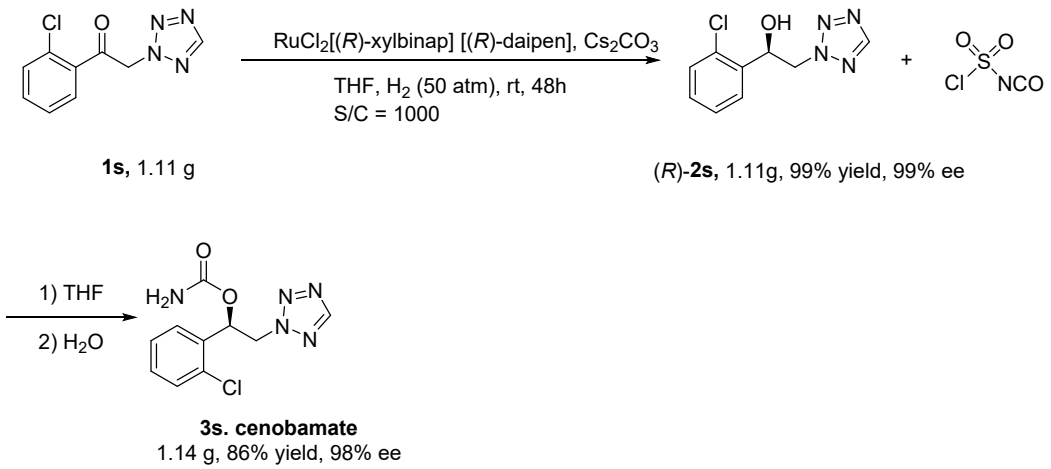
(*R*)-6,7-dihydro-5H-pyrrolo[1,2-a]imidazol-7-ol (2v)[11]: white solid; 65% yield, >99% ee, $[\alpha]^{25}_{D}$ = +35.4 (*c* 0.125, MeOH) (lit.[11] $[\alpha]^{24}_{D}$ = +11 (*c* 0.48, MeOH), 99% ee, *R*). ^{1}H NMR (600 MHz, CD_3OD) δ 7.04 (s, 2H), 5.04 – 5.00 (m, 1H), 4.16 (ddt, *J* = 10.2, 7.6, 3.6 Hz, 1H), 3.96 (td, *J* = 8.4, 4.2 Hz, 1H), 2.93 (dq, *J* = 14.4, 7.4 Hz, 1H), 2.42 (ddd, *J* = 13.8, 7.4, 3.6 Hz, 1H). ^{13}C NMR (151 MHz, CD_3OD) δ 154.36, 131.51, 114.44, 64.12, 42.05, 36.45. HRMS (ESI) calcd. for $C_6H_8N_2O$ $[M+H]^+$: 125.0637, Found: 125.0708. The enantiomeric excess of **2v** was determined by UPLC analysis on Chiralpak OD column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 210 nm, t_R = 1.9 min (major), 3.4 min (minor).

3.2 General procedure for the asymmetric hydrogenation conducted with S/C =

4000

$RuCl_2$[(*R*)-xylbinap] [(*R*)-daipen] (1.25×10^{-4} mmol) and KOH (0.1 mg) transferred by syringe into a 10 mL vial charged with substrate (1.27 g, 5 mmol) in 2.0 mL anhydrous THF. The vial was transferred to an autoclave, which was then charged with 50 atm of H_2 and stirred at room temperature for 48 h. The hydrogen gas was released slowly in a well-ventilated hood and the solution was concentrated and passed through a short column of silica gel to remove the metal complex.

4. Synthetic Applications



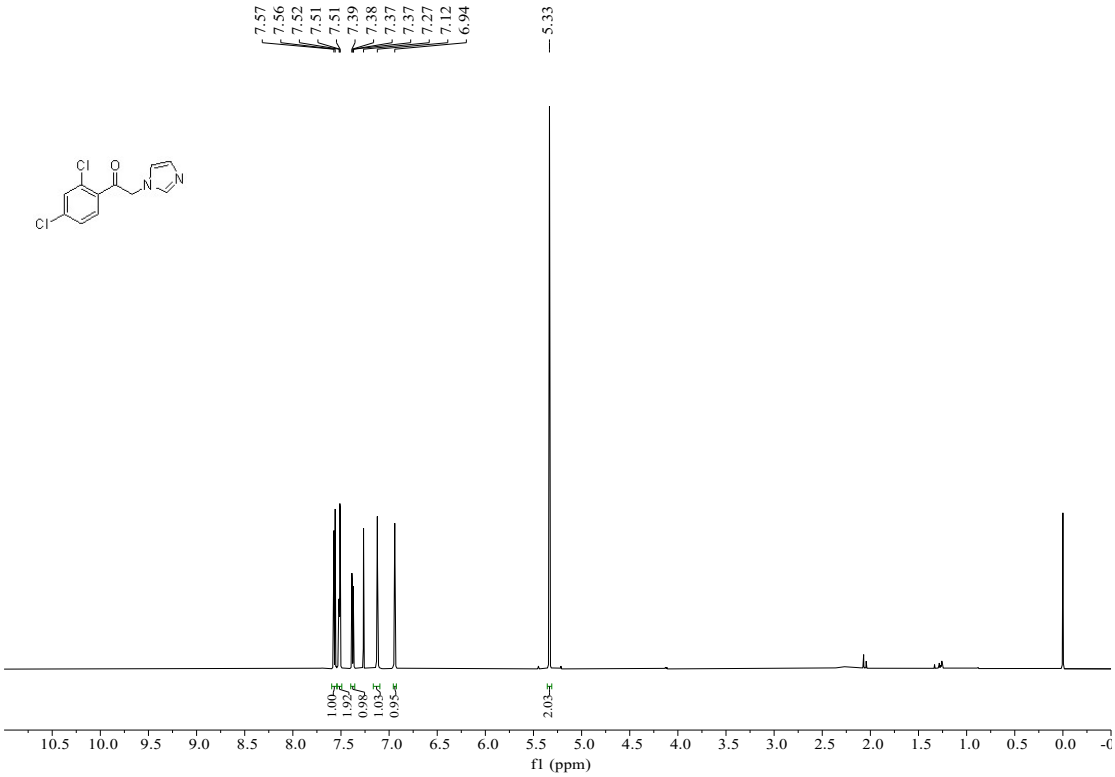
Step 1: I $RuCl_2$[(*R*)-xylbinap] [(*R*)-daipen] (5×10^{-4} mmol) and Cs_2CO_3 (0.3 mg) transferred by syringe into a 10 mL vial charged with substrate (1.11 g, 5 mmol) in 2.0 mL anhydrous THF. The vial was transferred to an autoclave, which was then charged with 50 atm of H_2 and stirred at room temperature for 48 h. The hydrogen gas was released slowly in a well-ventilated hood and the solution was concentrated and passed through a short column of silica gel to remove the metal complex.

Step 2[12]: Chlorosulfonylisocyanate (1.5 equiv) was dissolved in dry THF (0.1-0.15 M) and placed in an ice bath. The (*R*)-**2s** (1 equiv) dissolved in dry THF (0.3 M) was added slowly to the reaction. The ice bath was removed and stirred until consumption of alcohol was apparent by TLC. The reaction was placed back in an ice bath and water was added. The reaction flask was fitted with a reflux condenser and refluxed

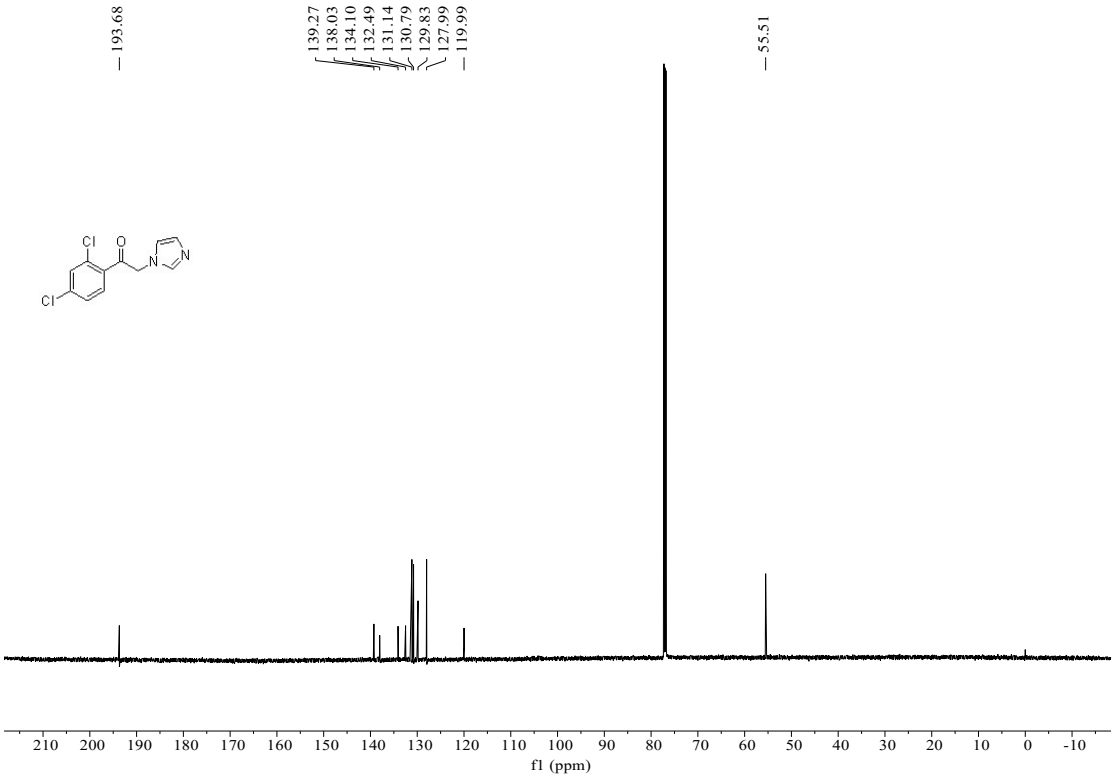
until TLC indicated complete conversion of the starting material. Water was added and the organic phase separated collected. The aqueous layer was extracted with 3 portions of ethyl acetate, the organics combined, dried over anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified by silica gel chromatography. The products **3s**[13] were obtained as oil (1.14 g, 86% yield, 98% ee). $[\alpha]^{25}_{D}$ = 3.4 (c 0.5, MeOH).^{1}H NMR (400 MHz, CD_3OD) δ 8.70 (s, 1H), 7.45 (ddd, *J* = 9.5, 5.5, 3.5 Hz, 2H), 7.39 – 7.27 (m, 2H), 6.54 (dd, *J* = 8.1, 3.6 Hz, 1H), 5.10 (dd, *J* = 14.2, 8.2 Hz, 1H), 5.03 (dd, *J* = 14.3, 3.6 Hz, 1H), 4.85 (s, 2H). ^{13}C NMR (151 MHz, CD_3OD) δ 156.19, 152.77, 134.57, 131.75, 129.84, 129.46, 127.31, 127.08, 70.46, 55.34. The enantiomeric excess of **3s** was determined by UPLC analysis on Chiralpak IB-U column. Conditions: hexane/isopropanol = 80/20, flow rate = 0.5 mL/min, uv-vis detection at λ = 230 nm, t_R = 2.8 min (minor), 3.9 min (major).

5. Spectroscopic data

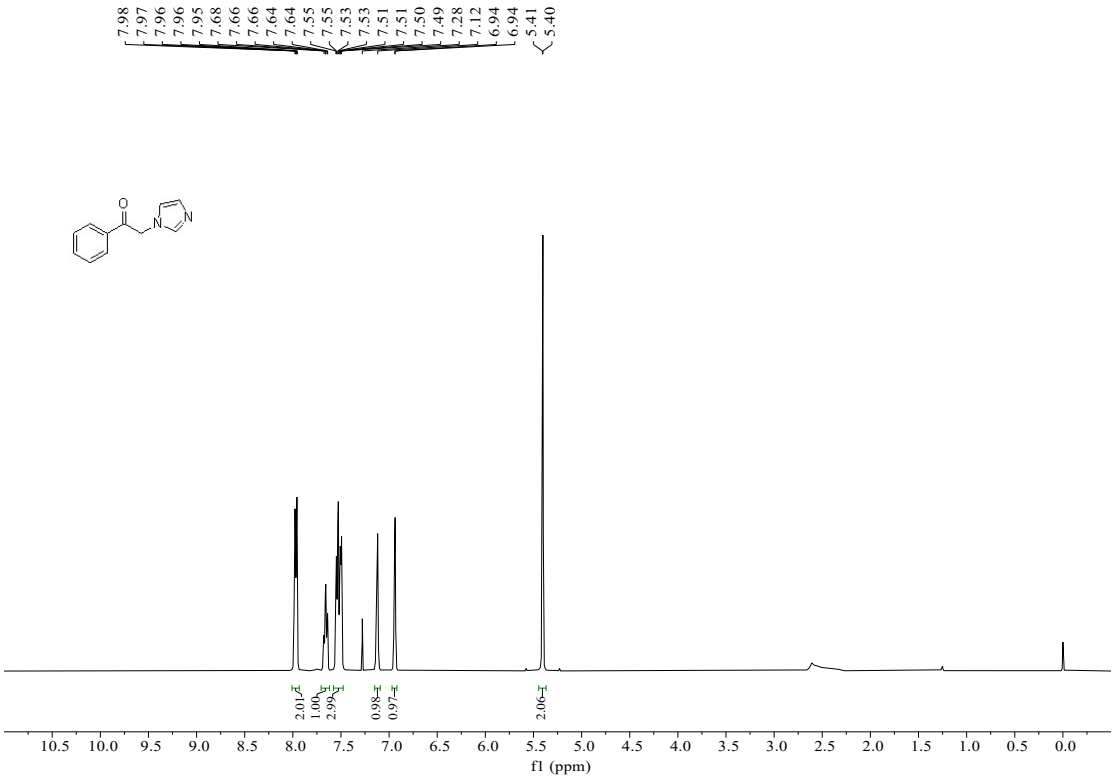
^{1}H NMR (600 MHz, $CDCl_3$) of **1a**:



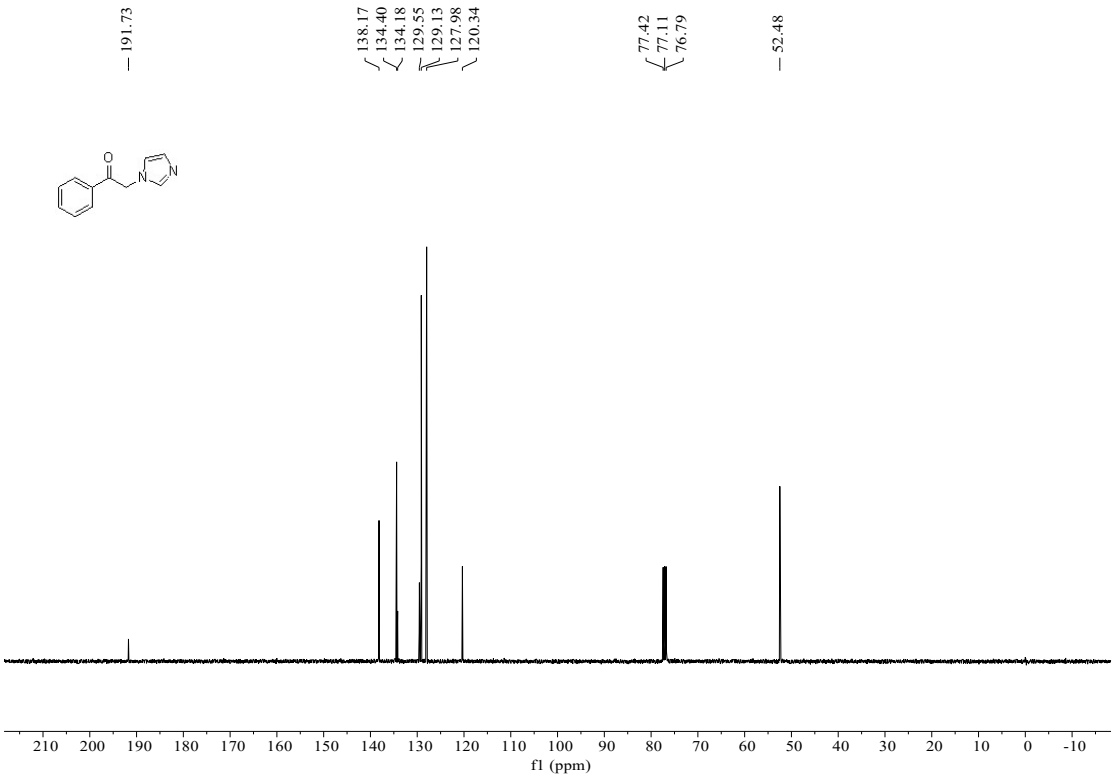
^{13}C NMR (151 MHz, $CDCl_3$) of **1a**:



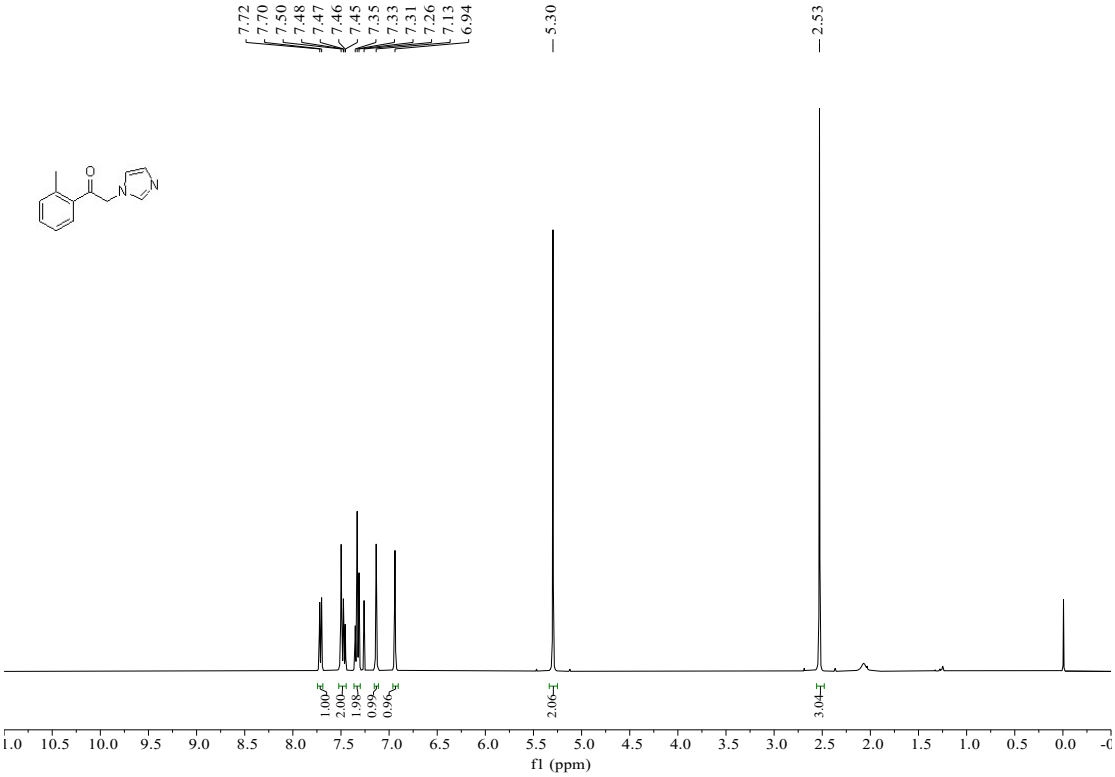
^{1}H NMR (400 MHz, $CDCl_3$) of **1b**:



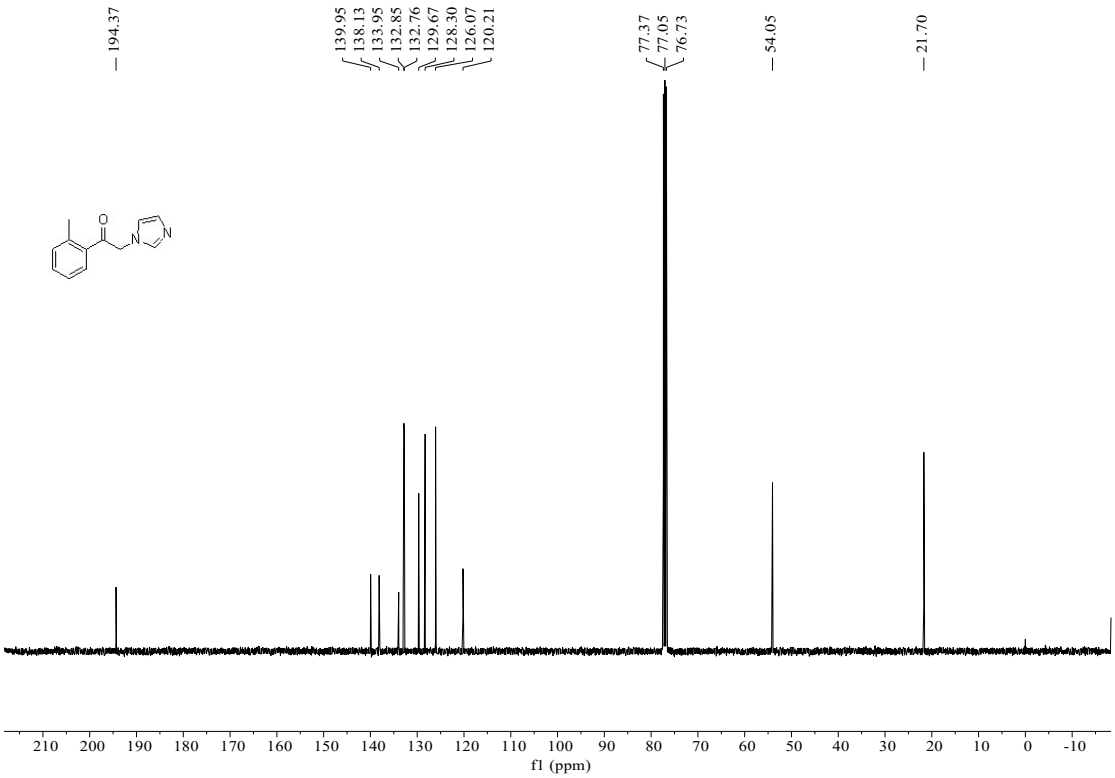
^{13}C NMR (101 MHz, $CDCl_3$) of **1b**:



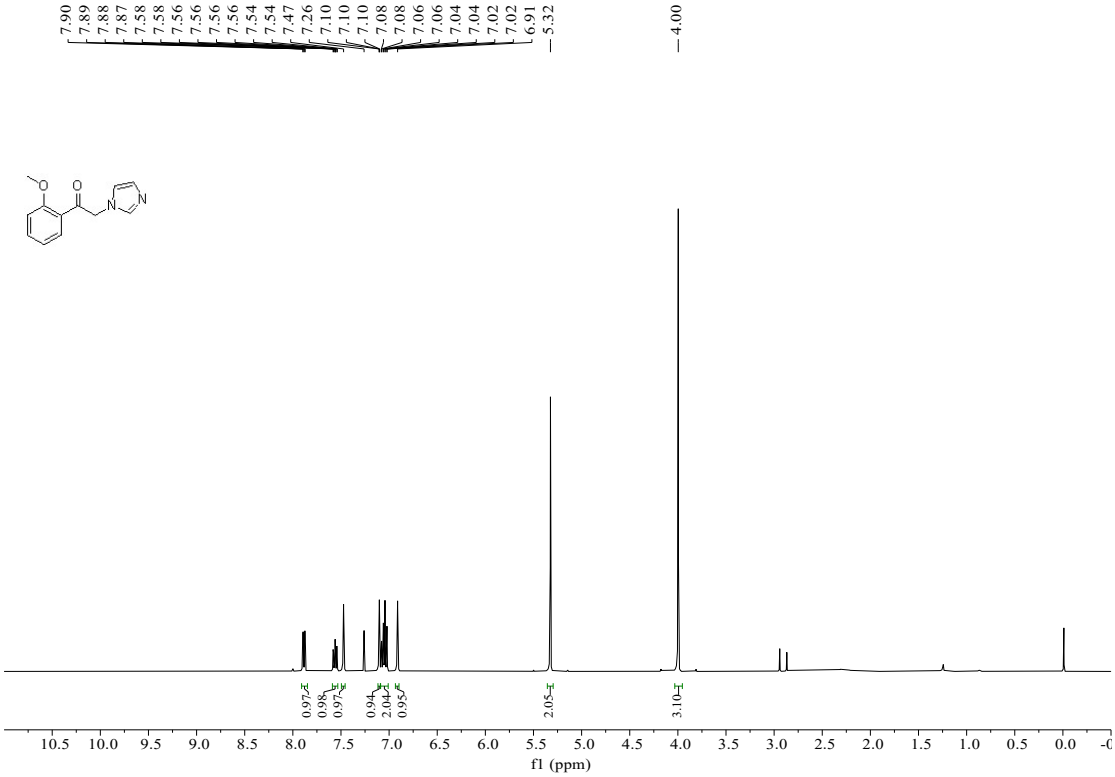
^{1}H NMR (400 MHz, $CDCl_3$) of **1c**:



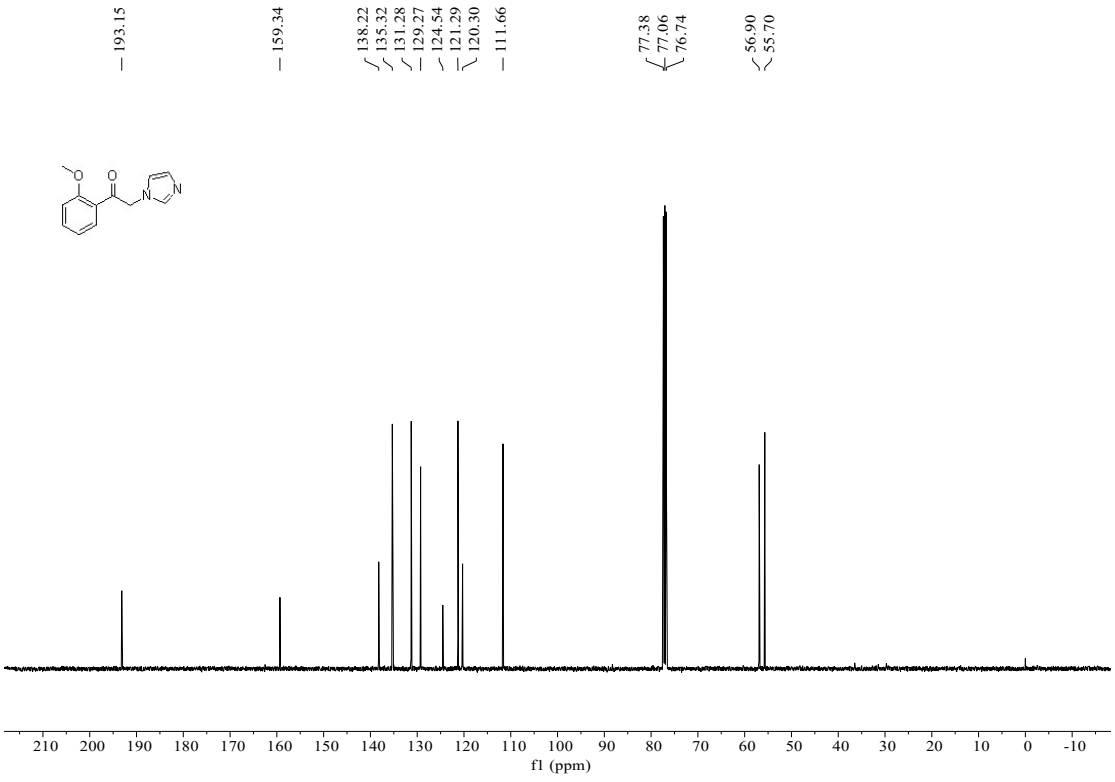
^{13}C NMR (101 MHz, $CDCl_3$) of **1c**:



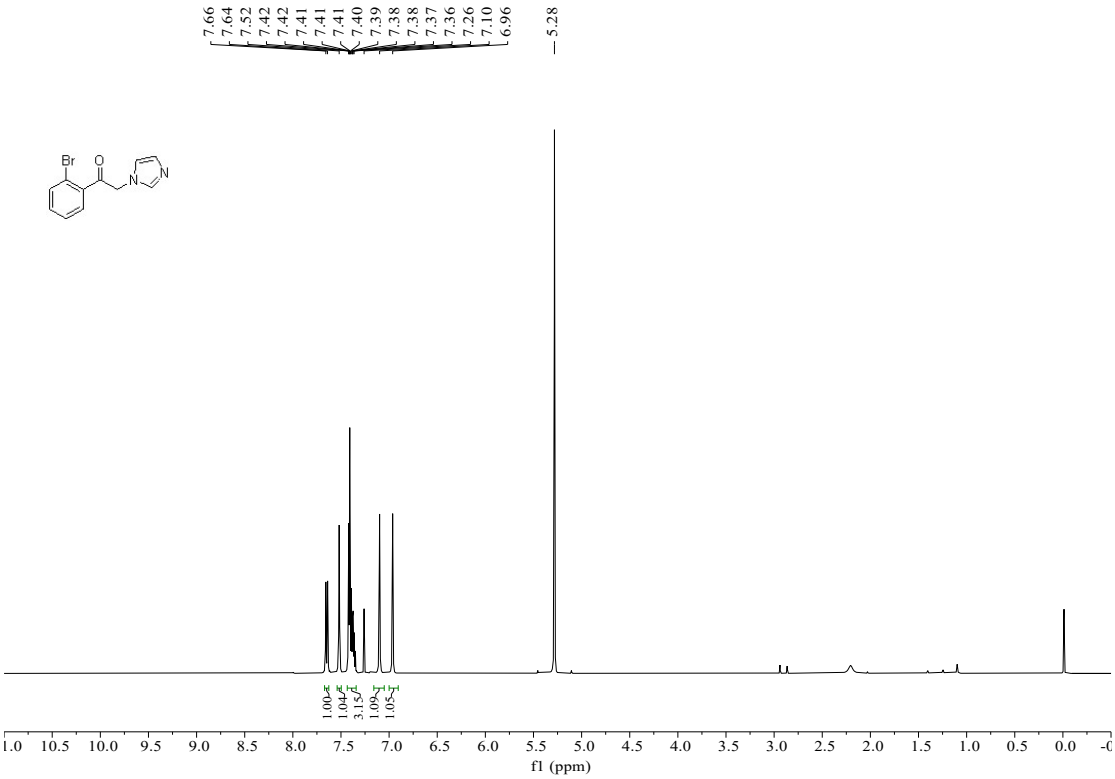
^{1}H NMR (400 MHz, $CDCl_3$) of **1d**:



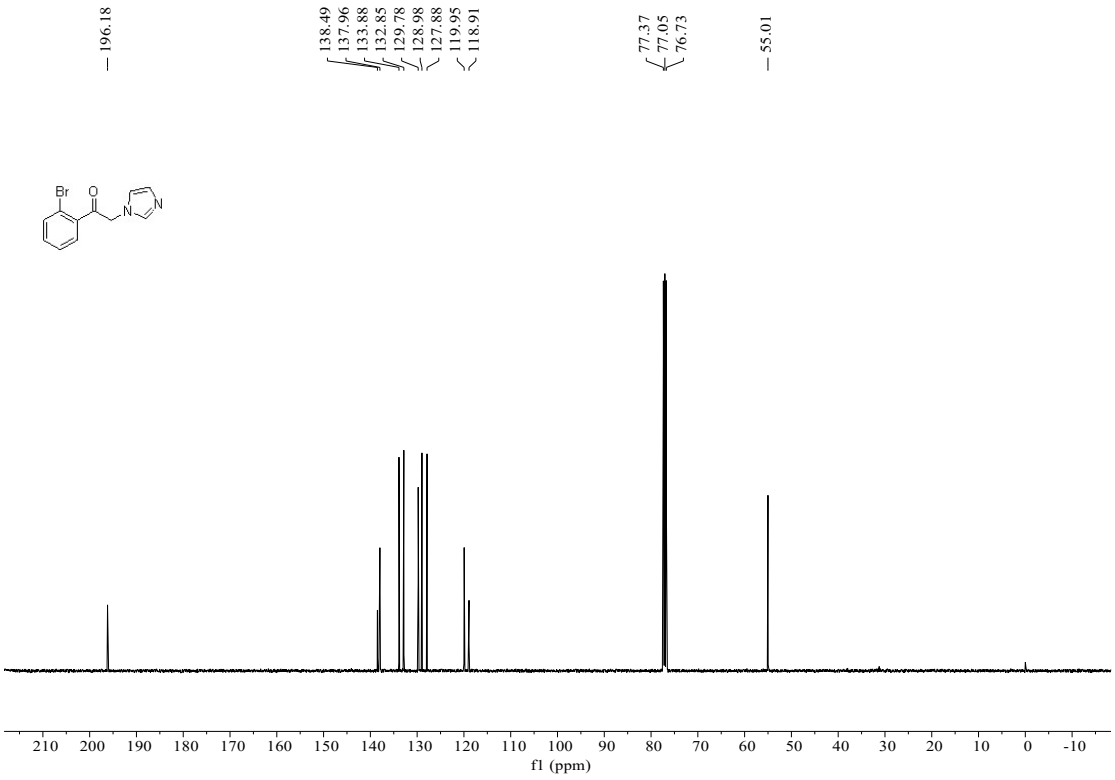
^{13}C NMR (101 MHz, $CDCl_3$) of **1d**:



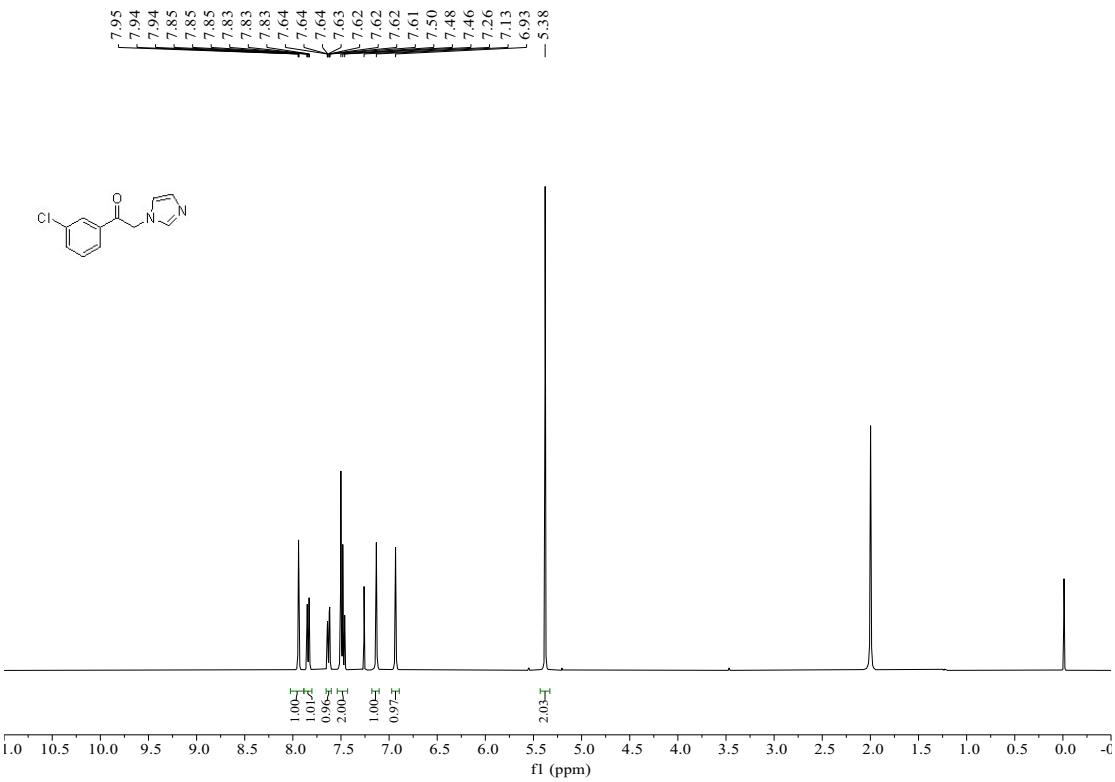
^{1}H NMR (400 MHz, $CDCl_3$) of **1e**:



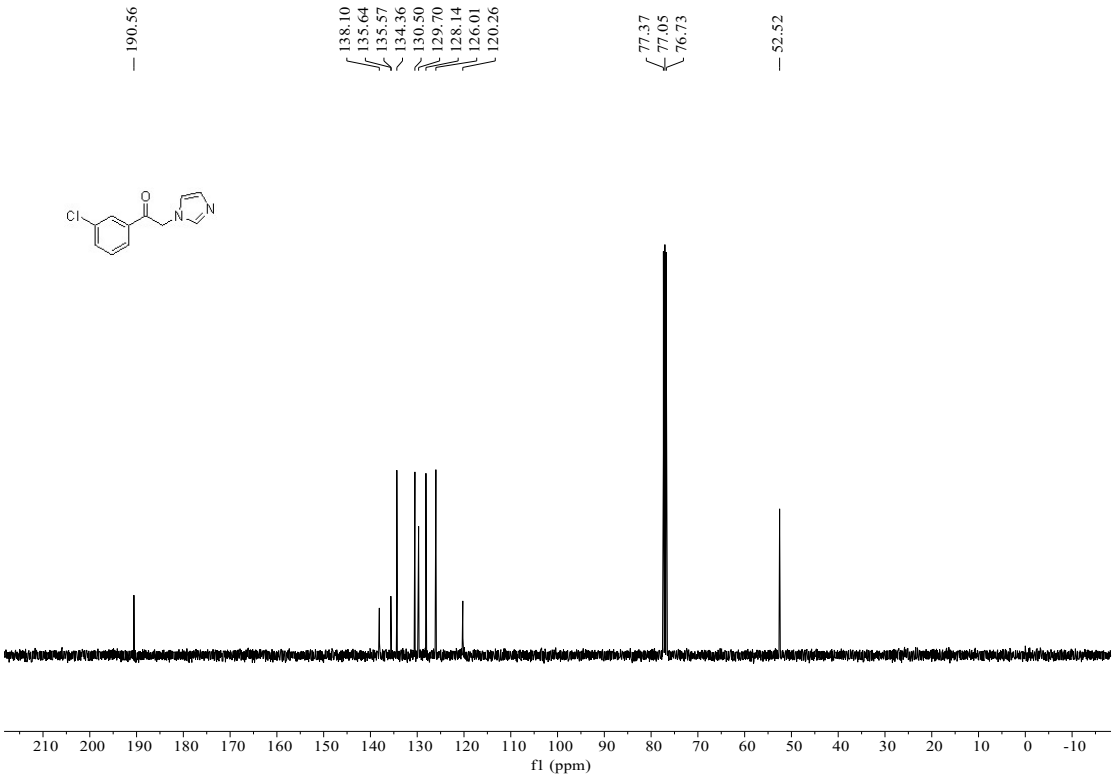
^{13}C NMR (101 MHz, $CDCl_3$) of **1e**:



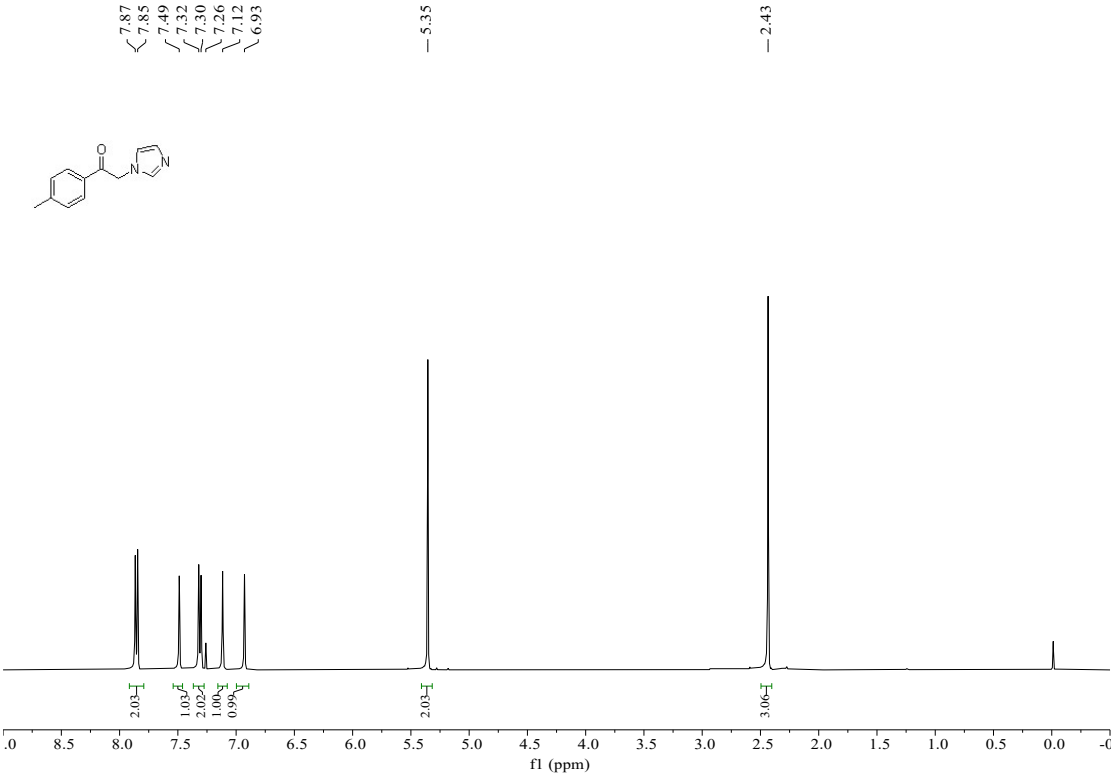
^{1}H NMR (400 MHz, $CDCl_3$) of **1f**:



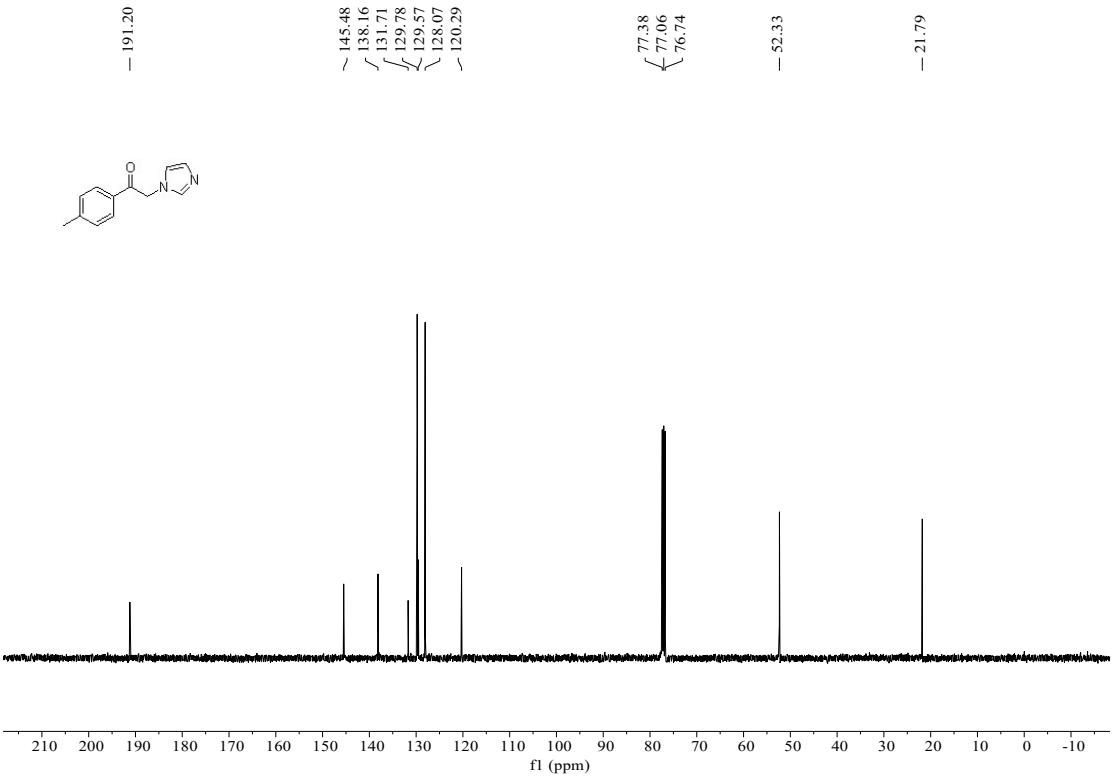
^{13}C NMR (101 MHz, $CDCl_3$) of **1f**:



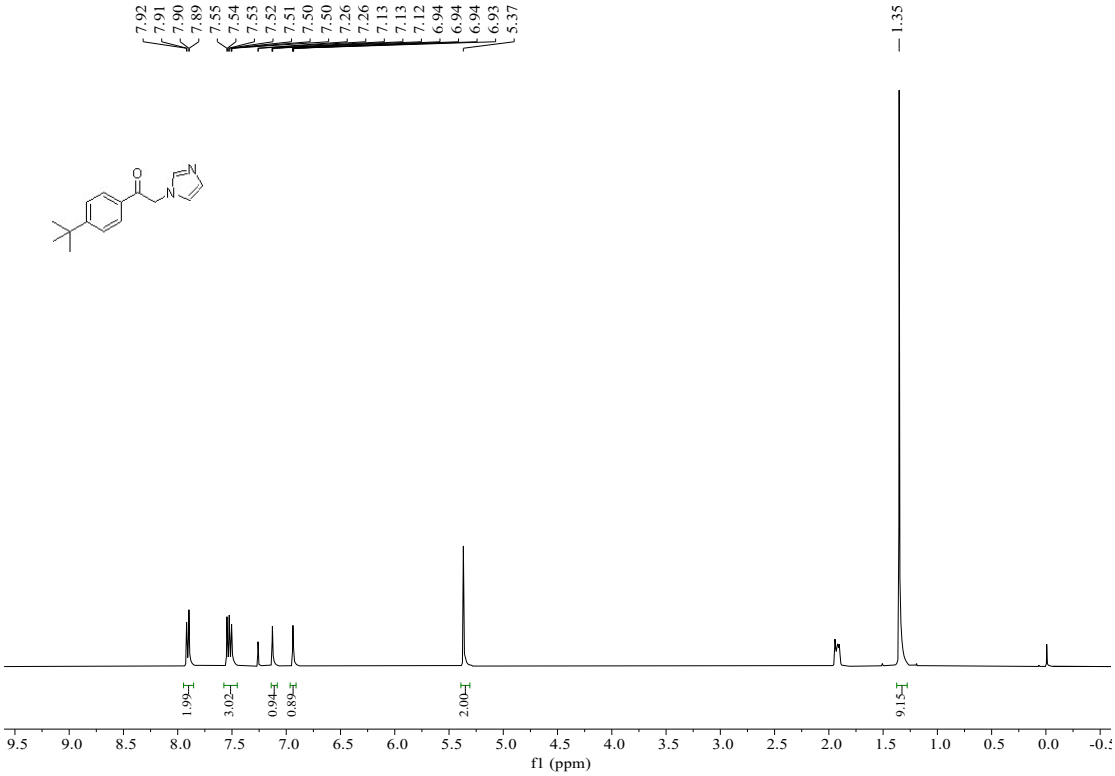
^{1}H NMR (400 MHz, $CDCl_3$) of **1g**:



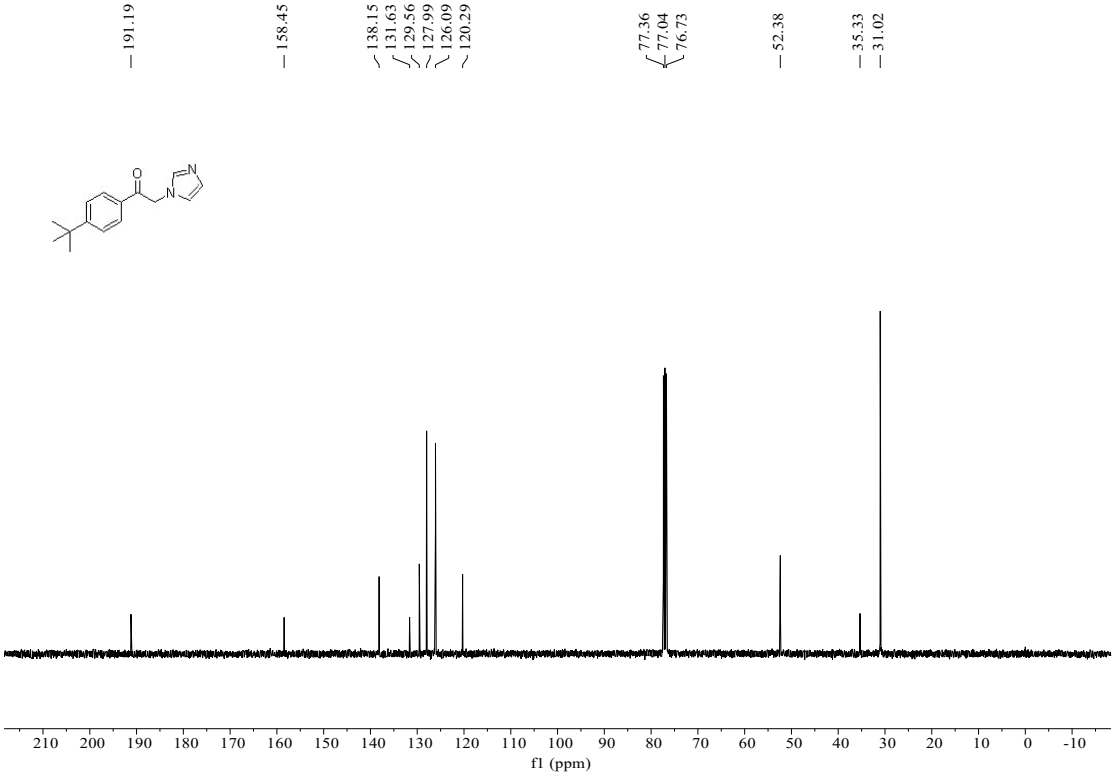
^{13}C NMR (101 MHz, $CDCl_3$) of **1g**:



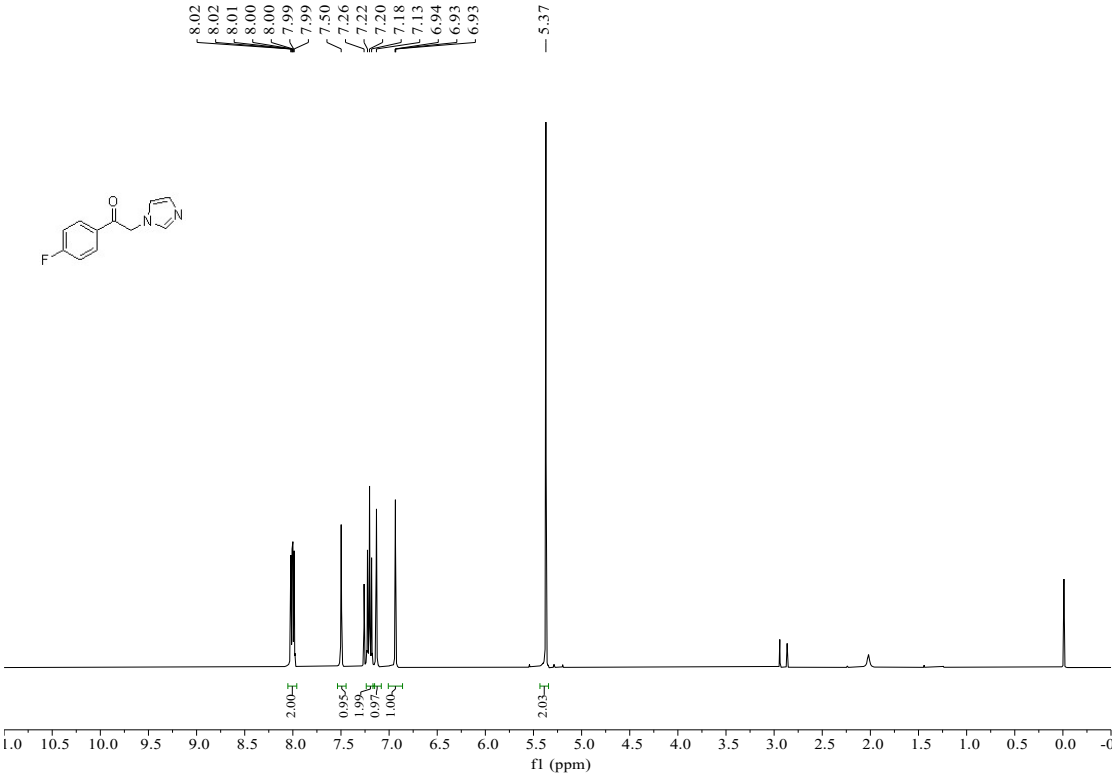
^{1}H NMR (400 MHz, $CDCl_3$) of **1h**:



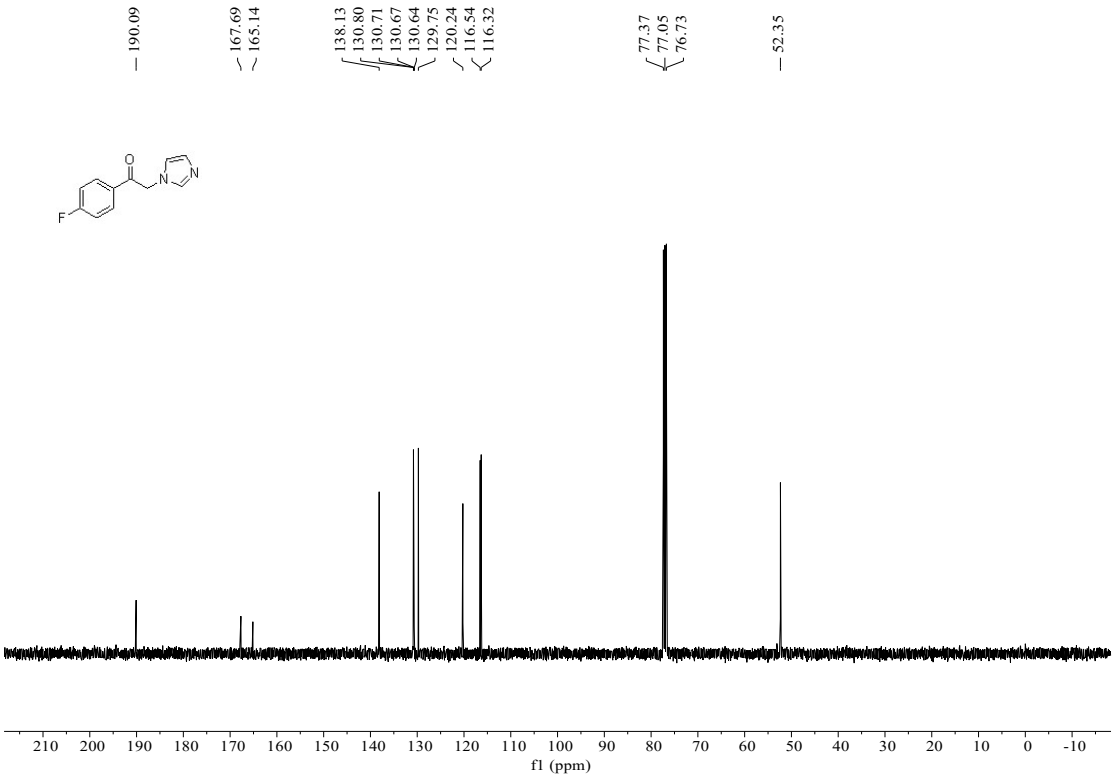
^{13}C NMR (101 MHz, $CDCl_3$) of **1h**:



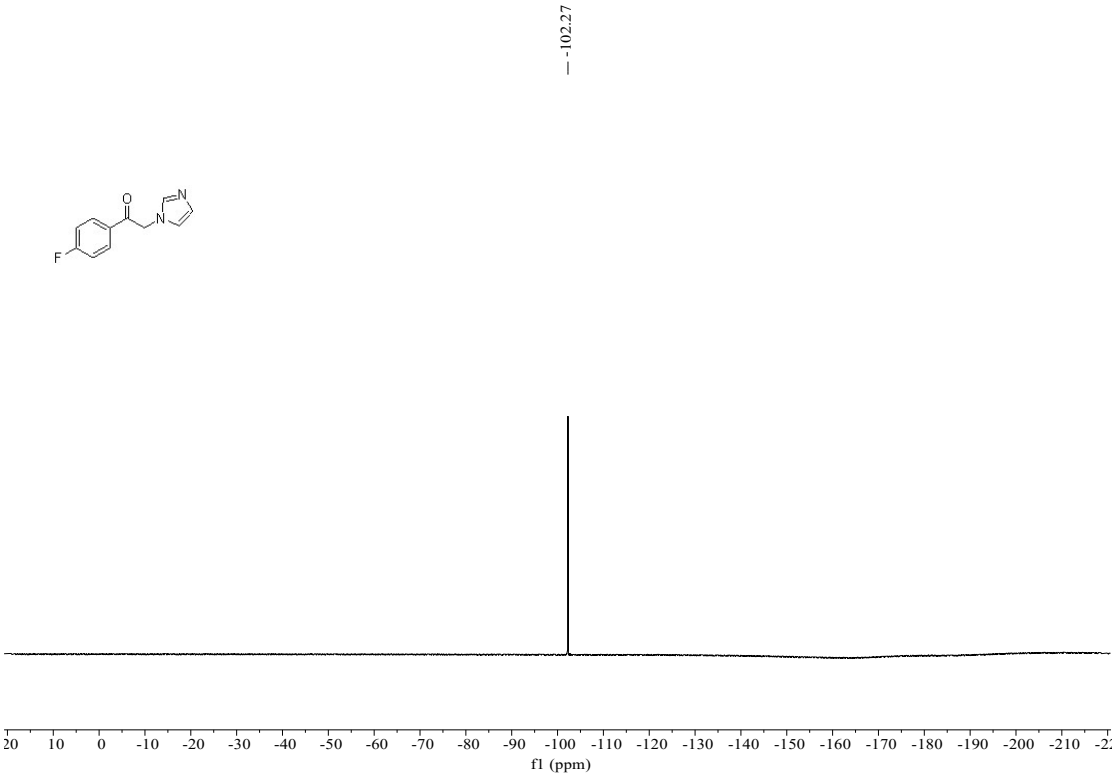
^{1}H NMR (400 MHz, $CDCl_3$) of **1i**:



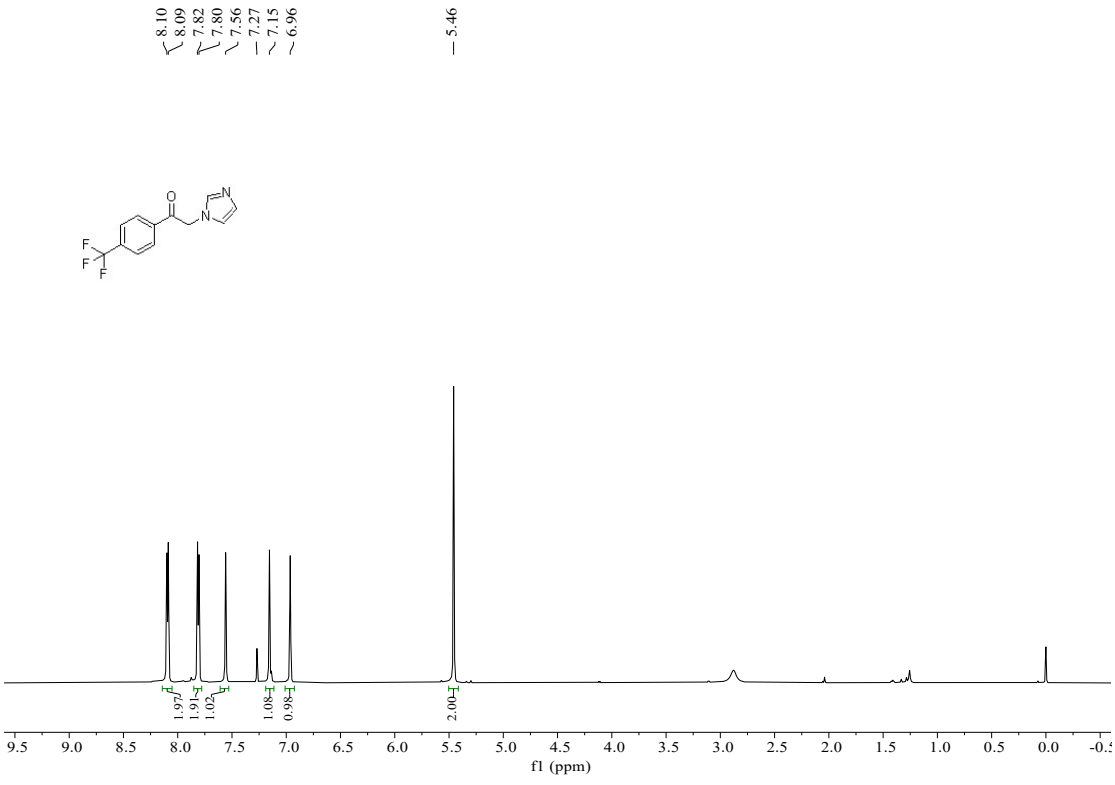
^{13}C NMR (101 MHz, $CDCl_3$) of **1i**:



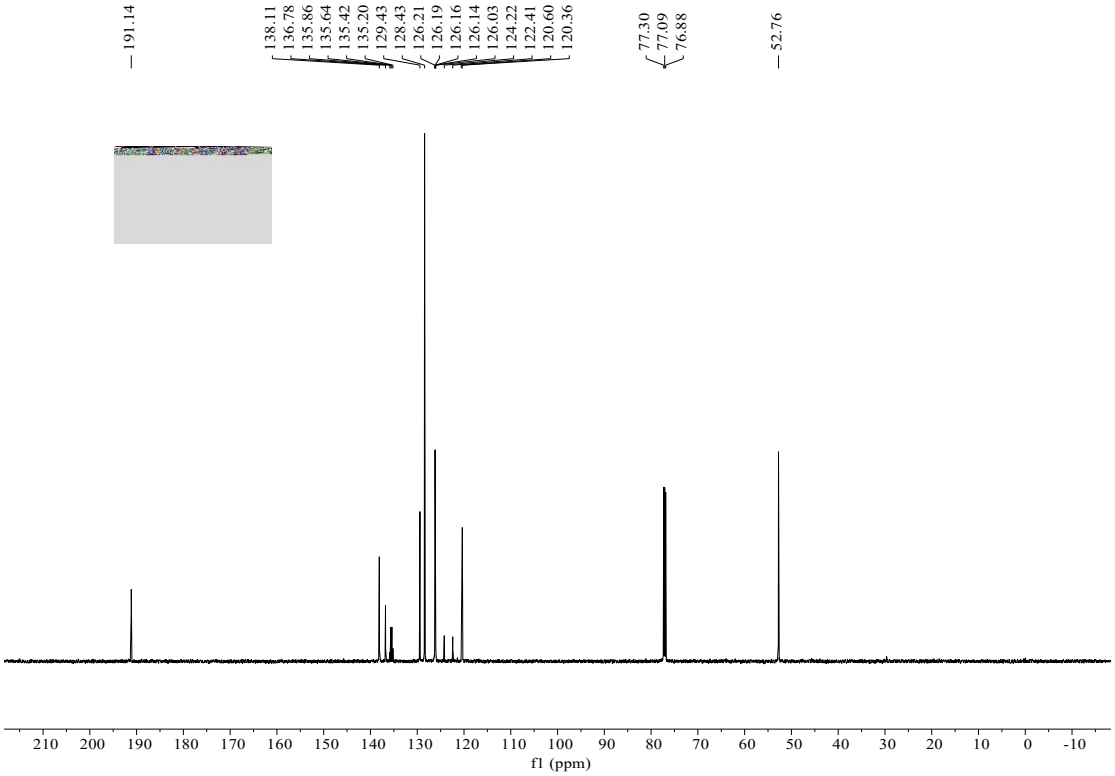
^{19}F NMR (376 MHz, $CDCl_3$) of **1i**:



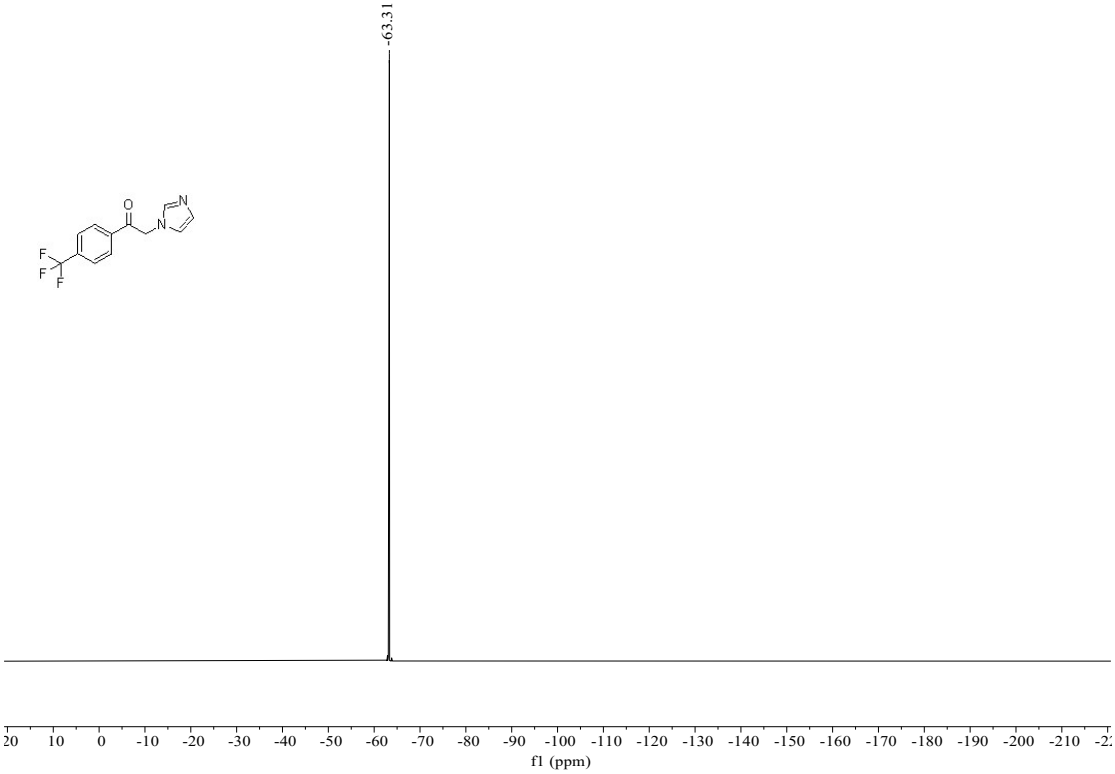
^{1}H NMR (600 MHz, $CDCl_3$) of **1j**:



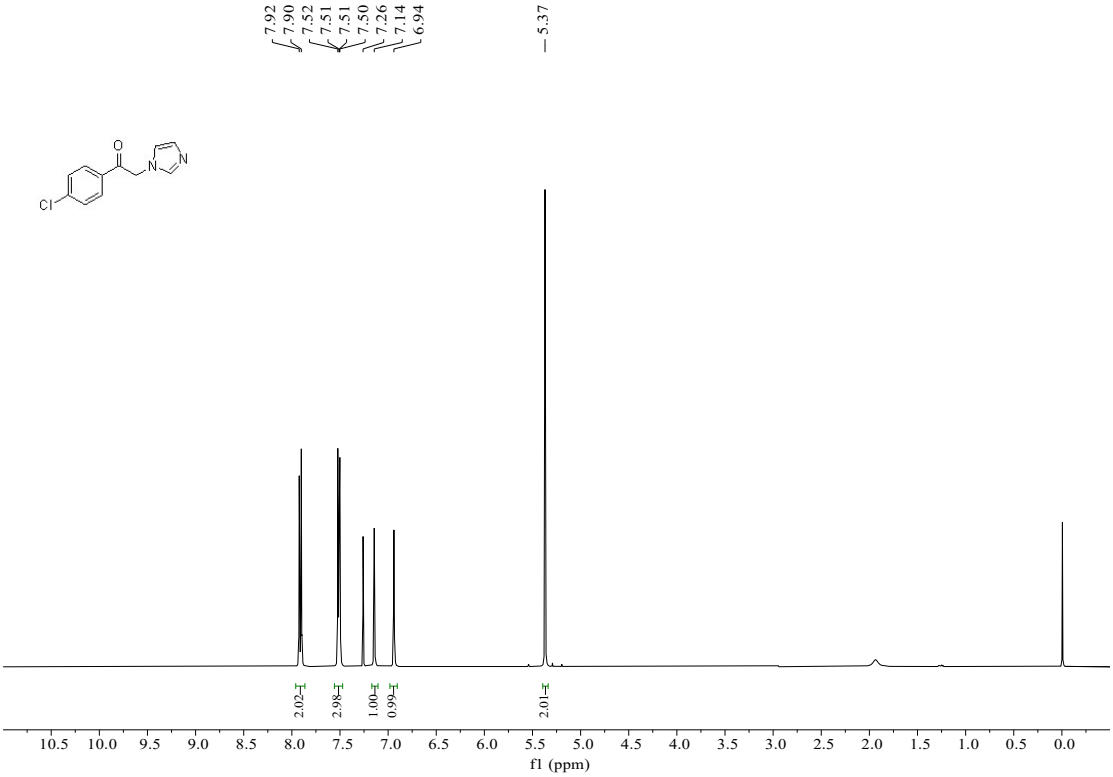
^{13}C NMR (151 MHz, $CDCl_3$) of **1j**:



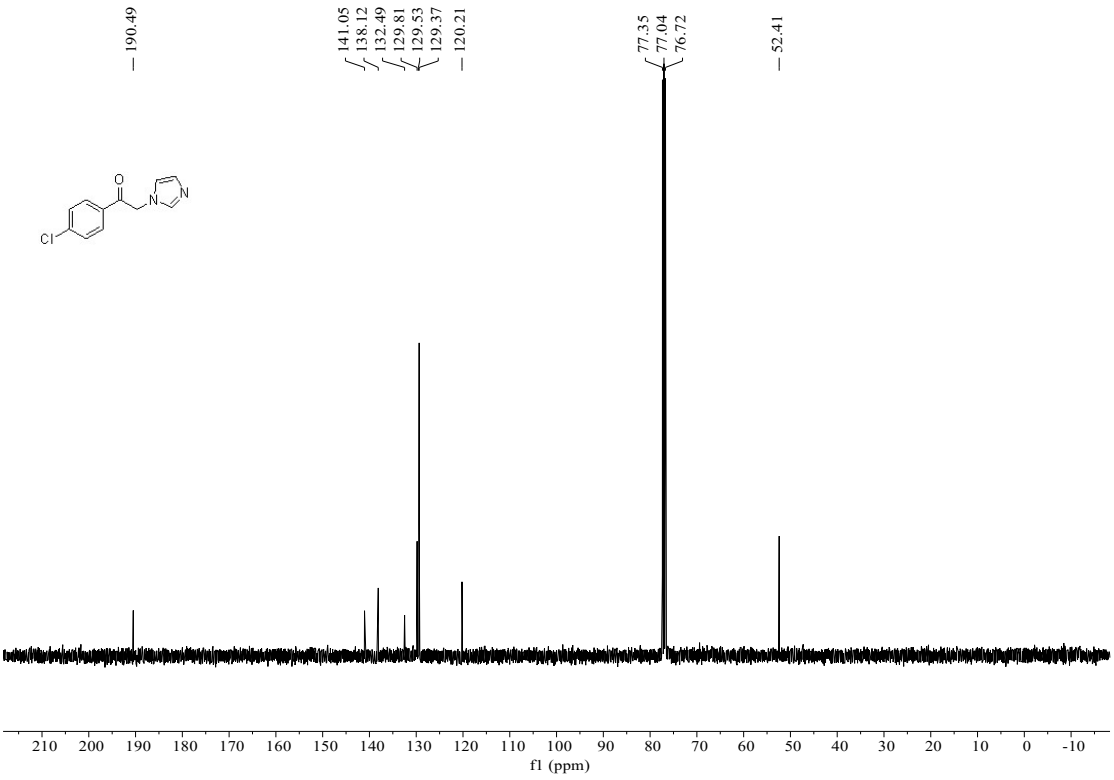
^{19}F NMR (376 MHz, $CDCl_3$) of **1j**:



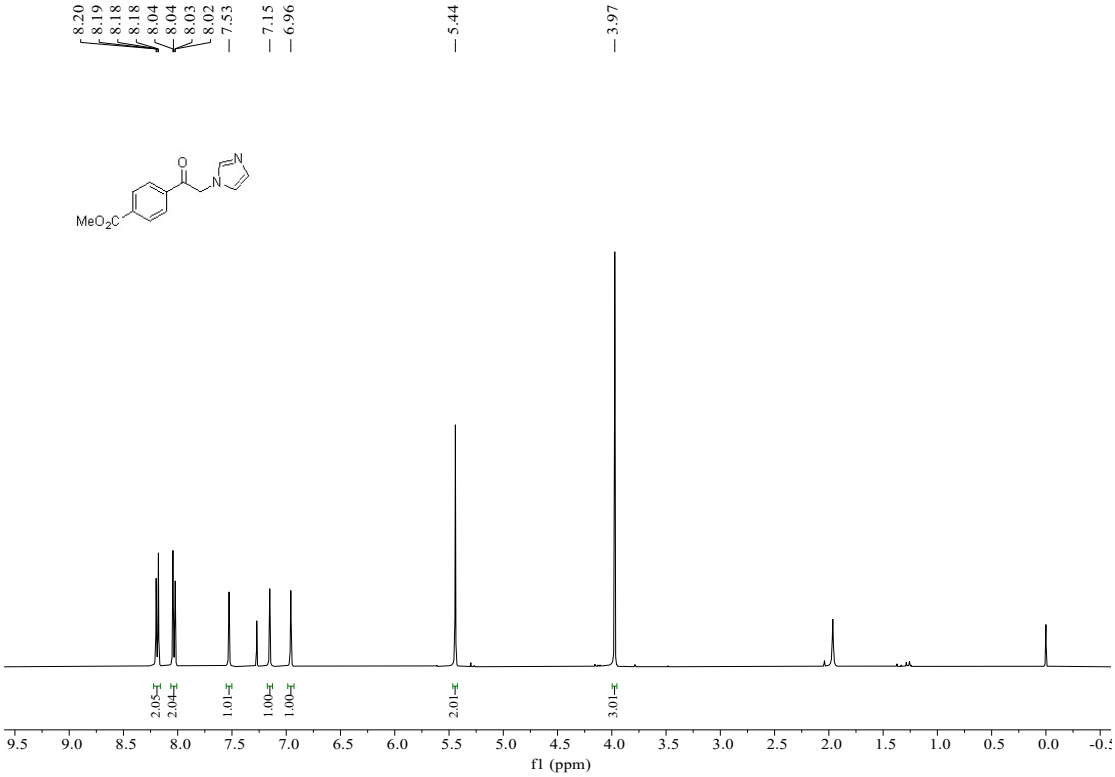
^{1}H NMR (400 MHz, $CDCl_3$) of **1k**:



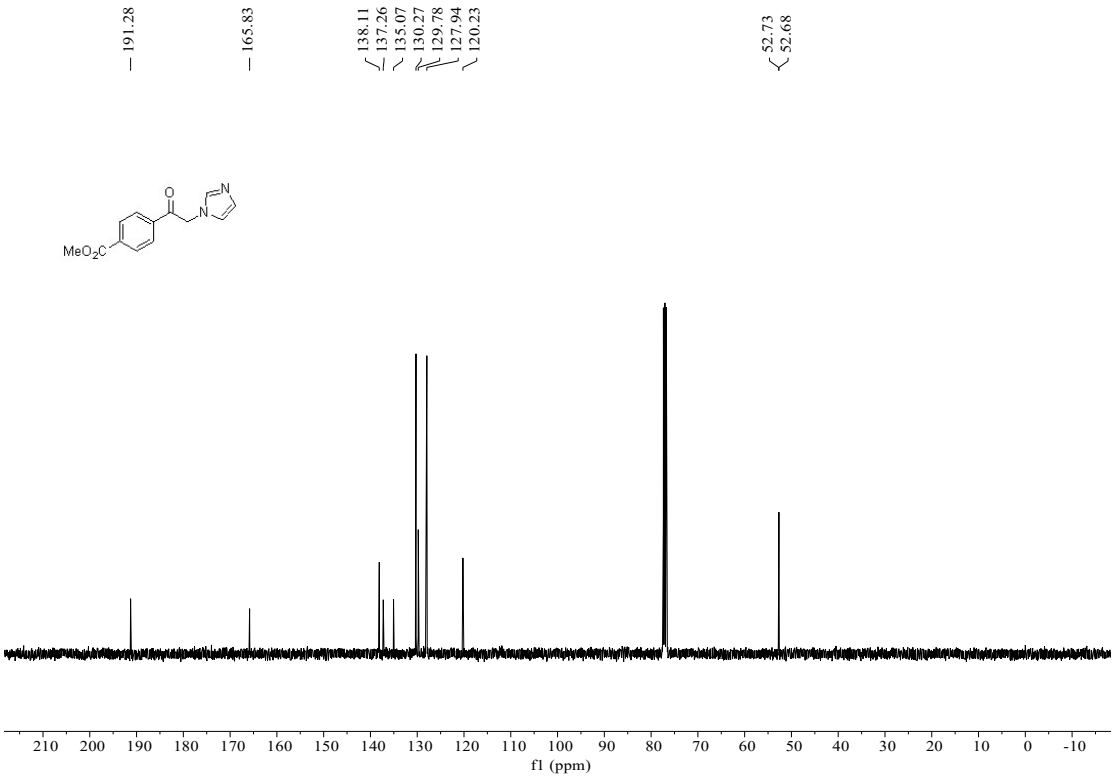
^{13}C NMR (101 MHz, $CDCl_3$) of **1k**:



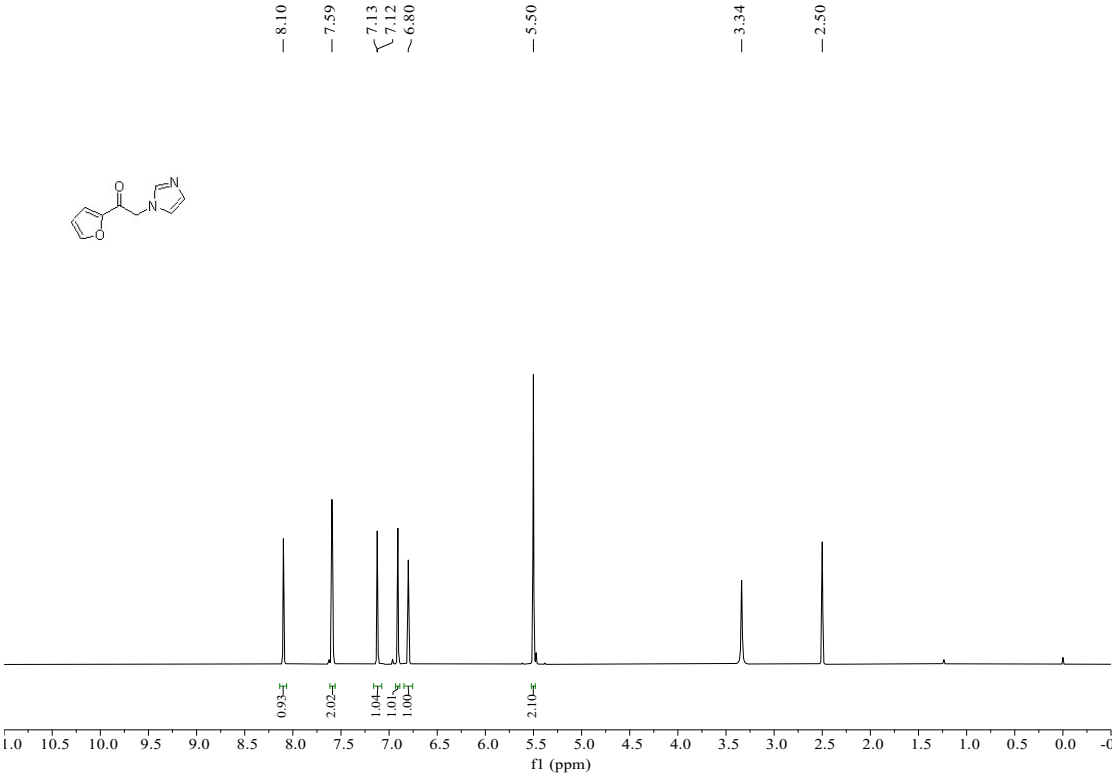
^{1}H NMR (400 MHz, $CDCl_3$) of **1l**:



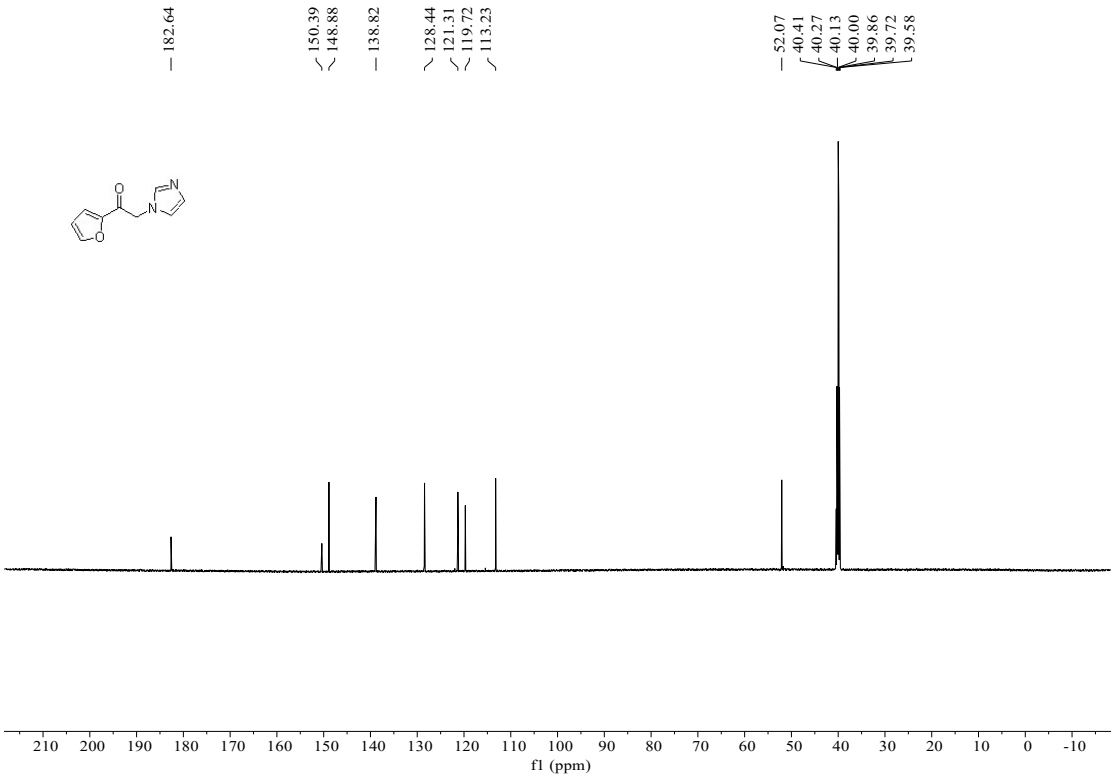
^{13}C NMR (101 MHz, $CDCl_3$) of **1l**:



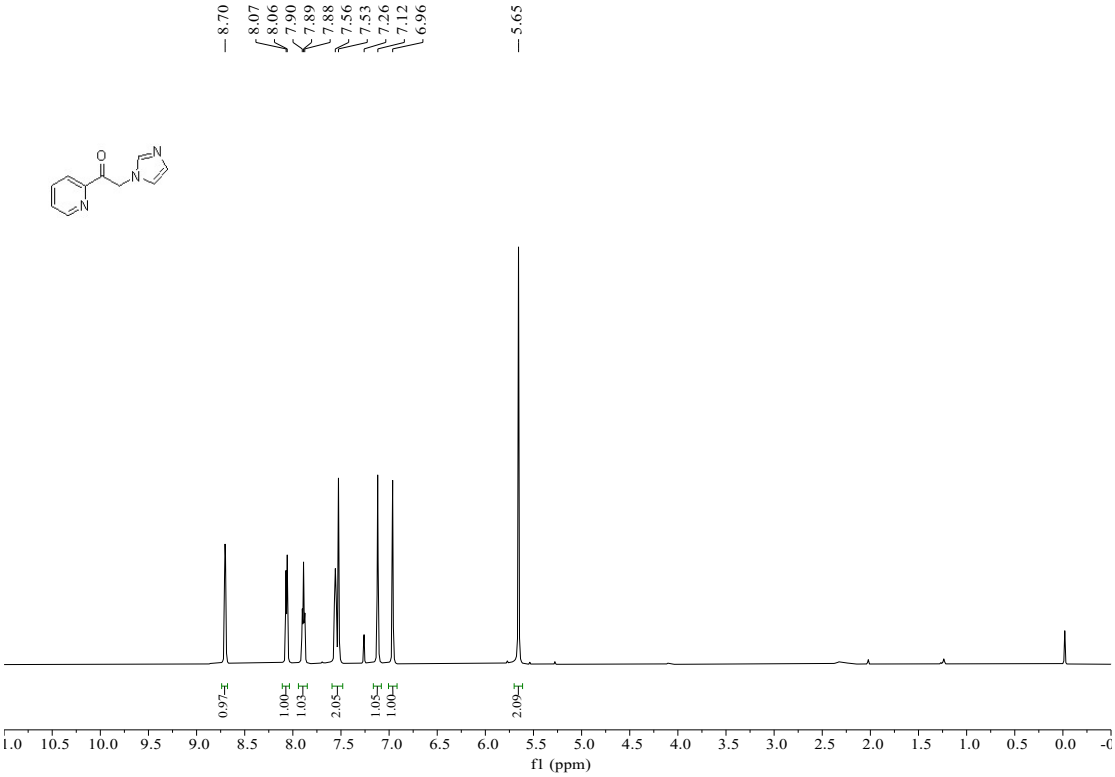
^{1}H NMR (600 MHz, DMSO-d_6) of **1m**:



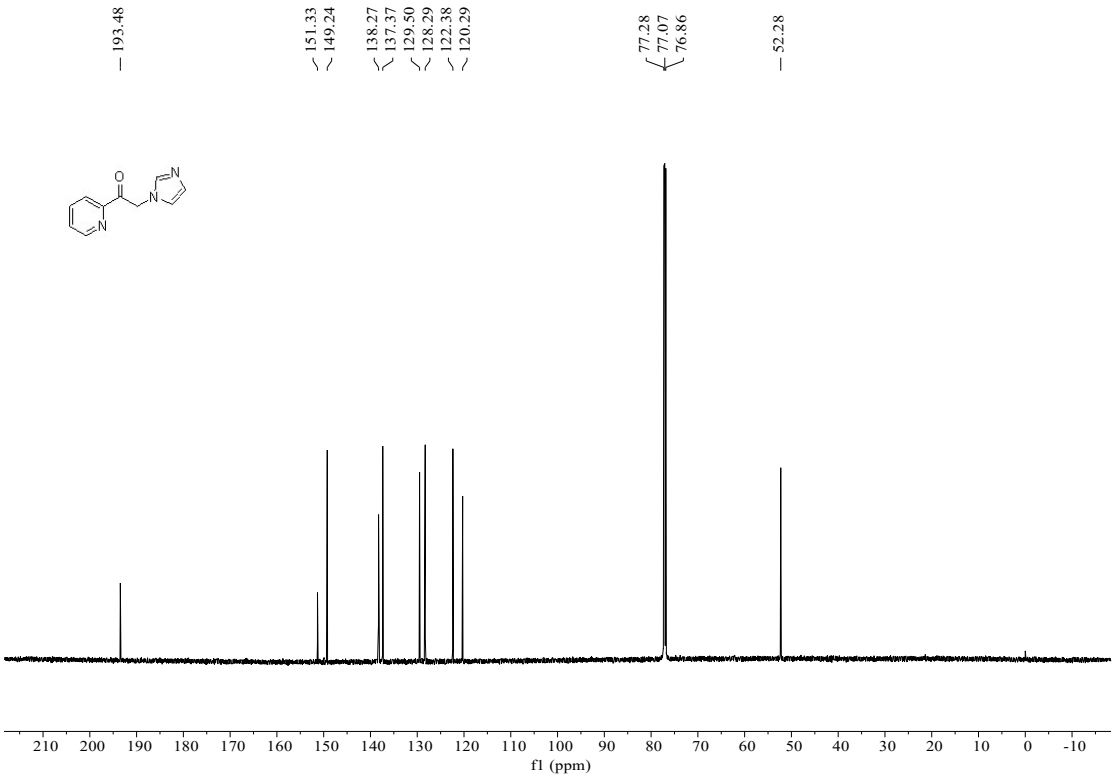
^{13}C NMR (151 MHz, DMSO-d_6) of **1m**:



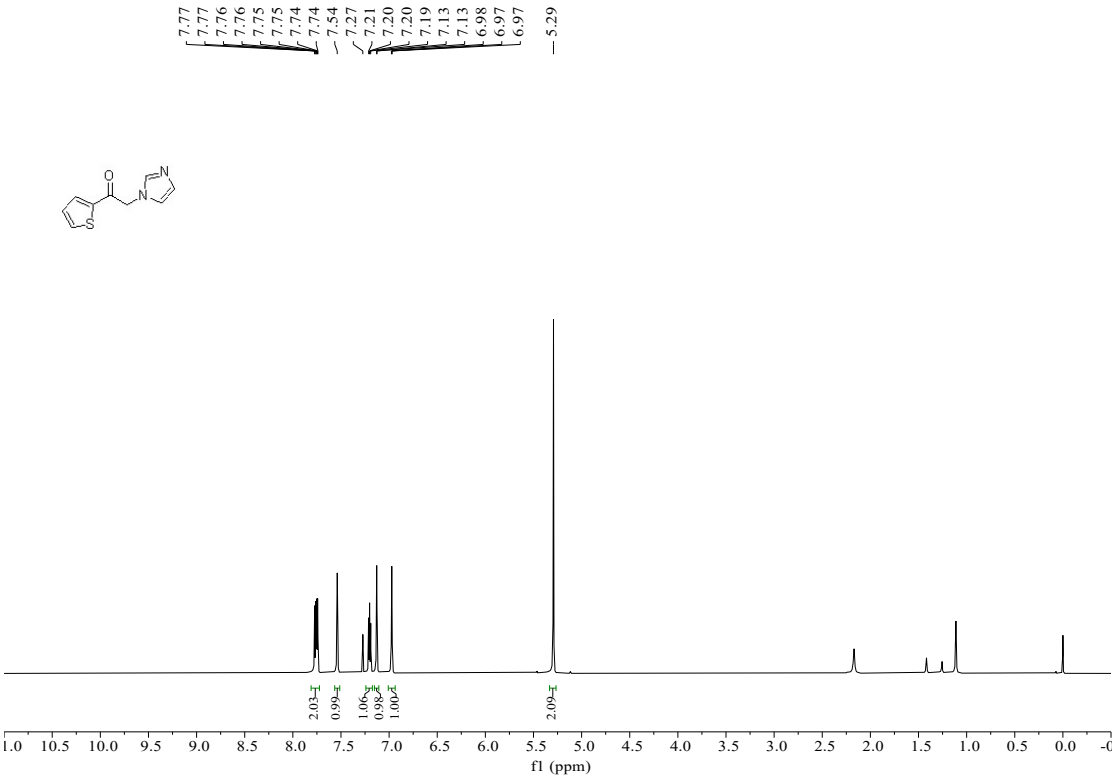
^{1}H NMR (600 MHz, $CDCl_3$) of **1n**:



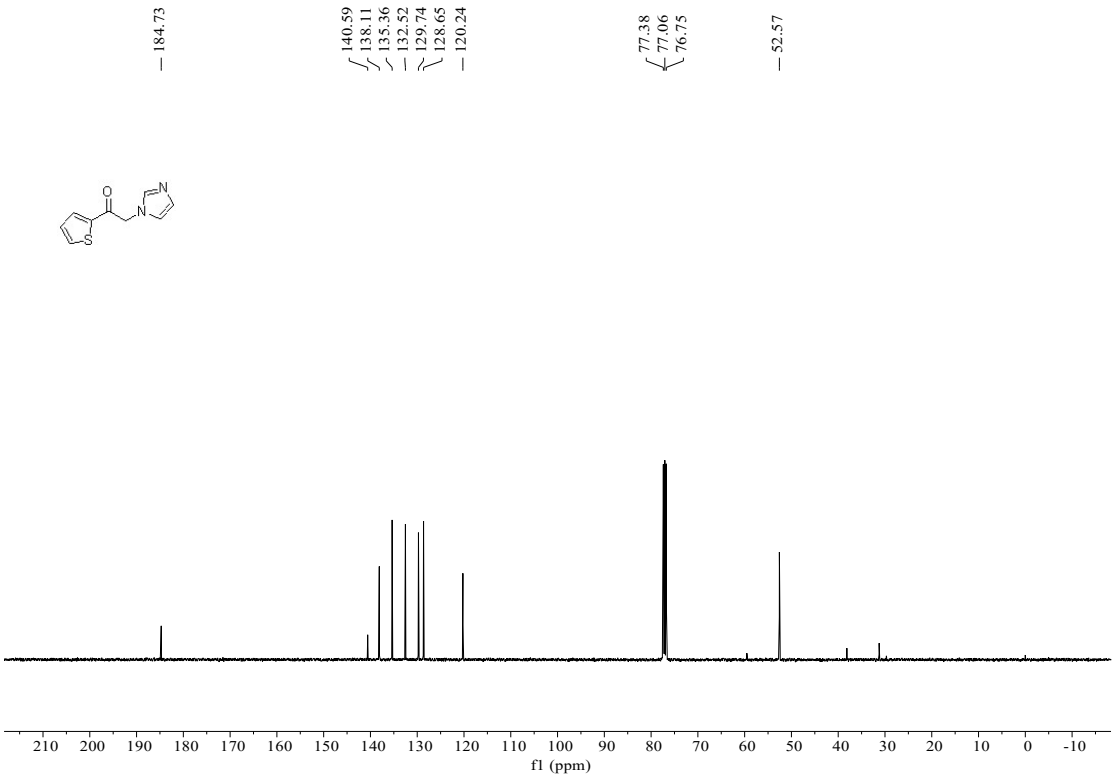
^{13}C NMR (151 MHz, $CDCl_3$) of **1n**:



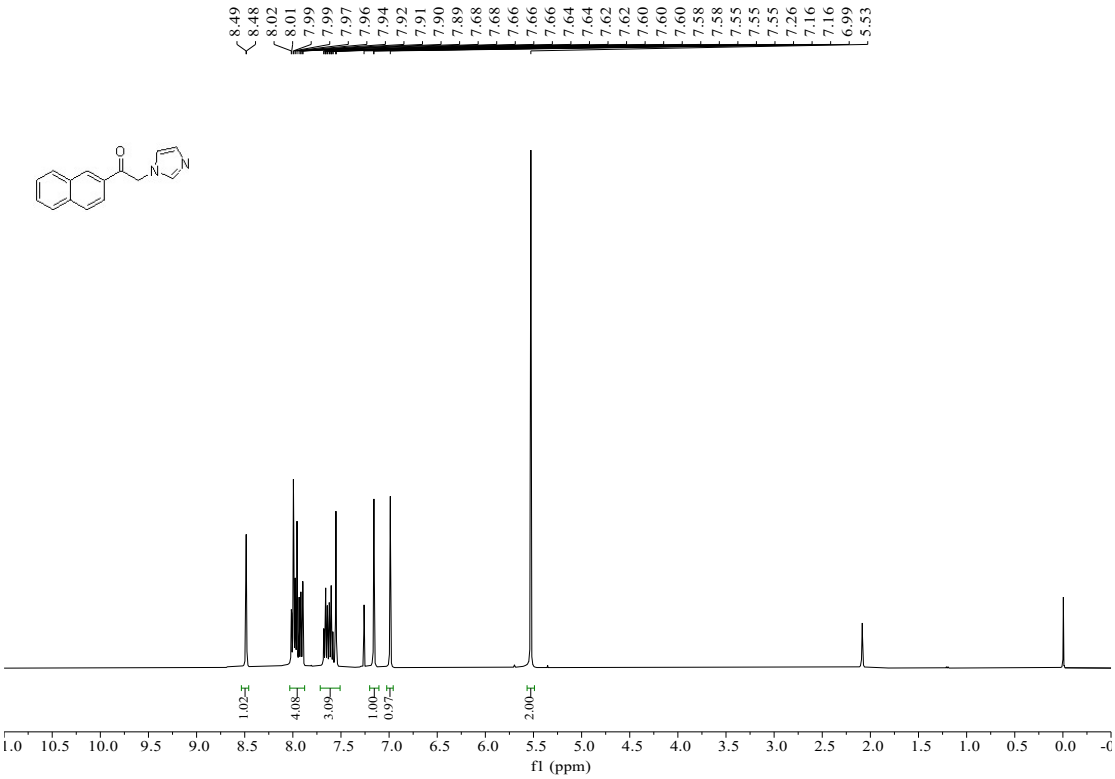
^{1}H NMR (400 MHz, $CDCl_3$) of **1o**:



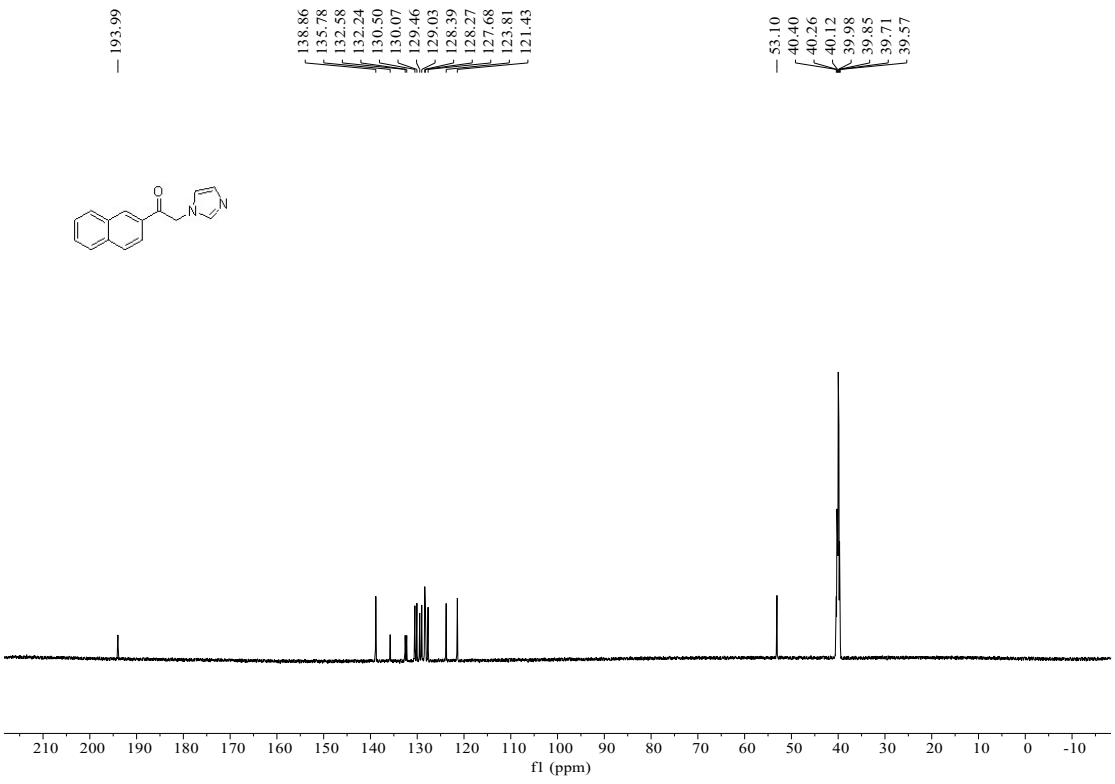
^{13}C NMR (101 MHz, $CDCl_3$) of **1o**:



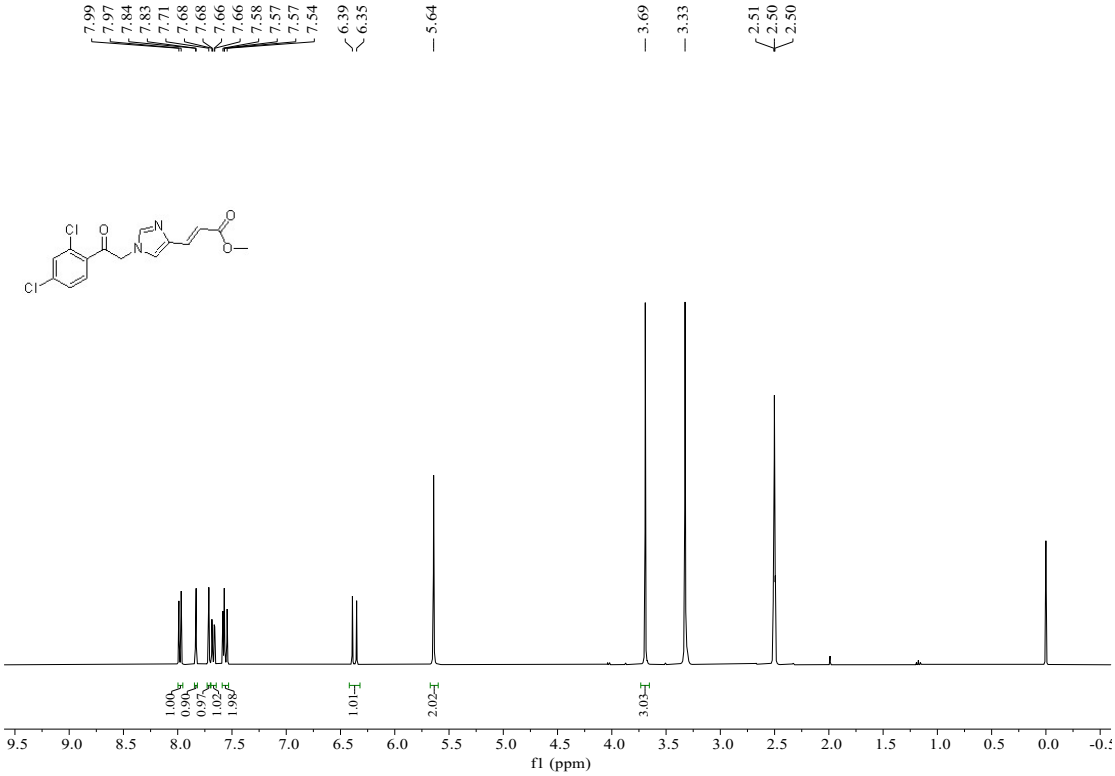
^{1}H NMR (400 MHz, $CDCl_3$) of **1p**:



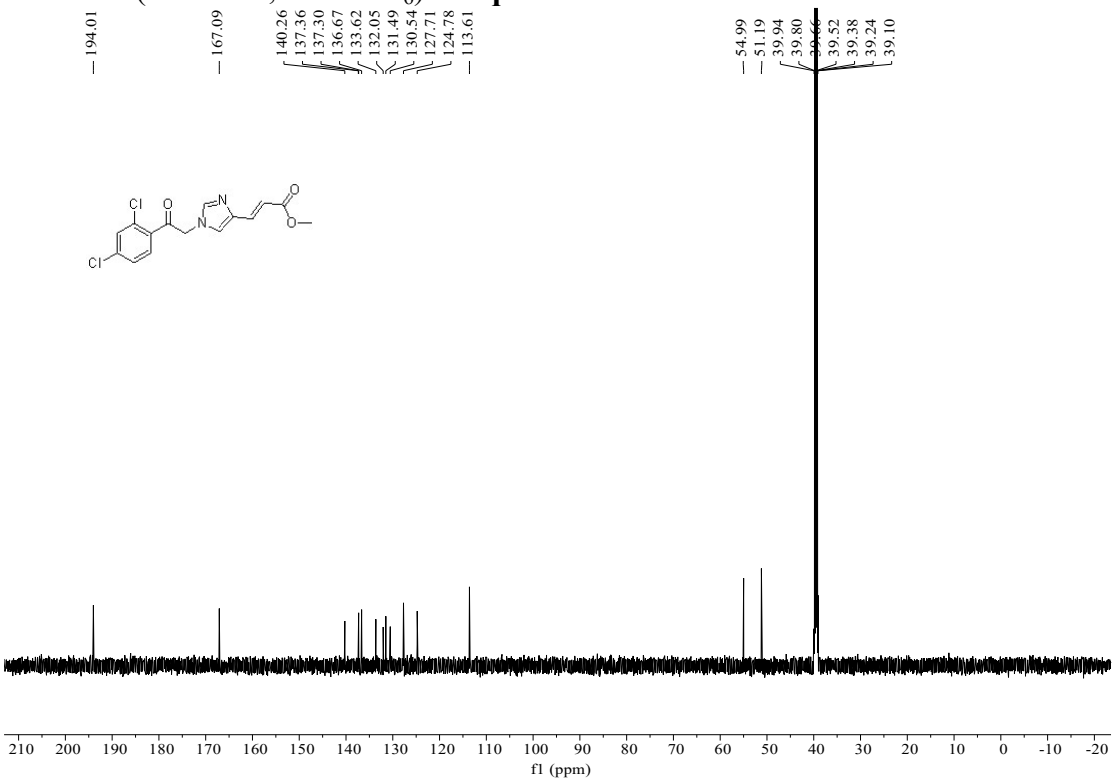
^{13}C NMR (101 MHz, $CDCl_3$) of **1p**:



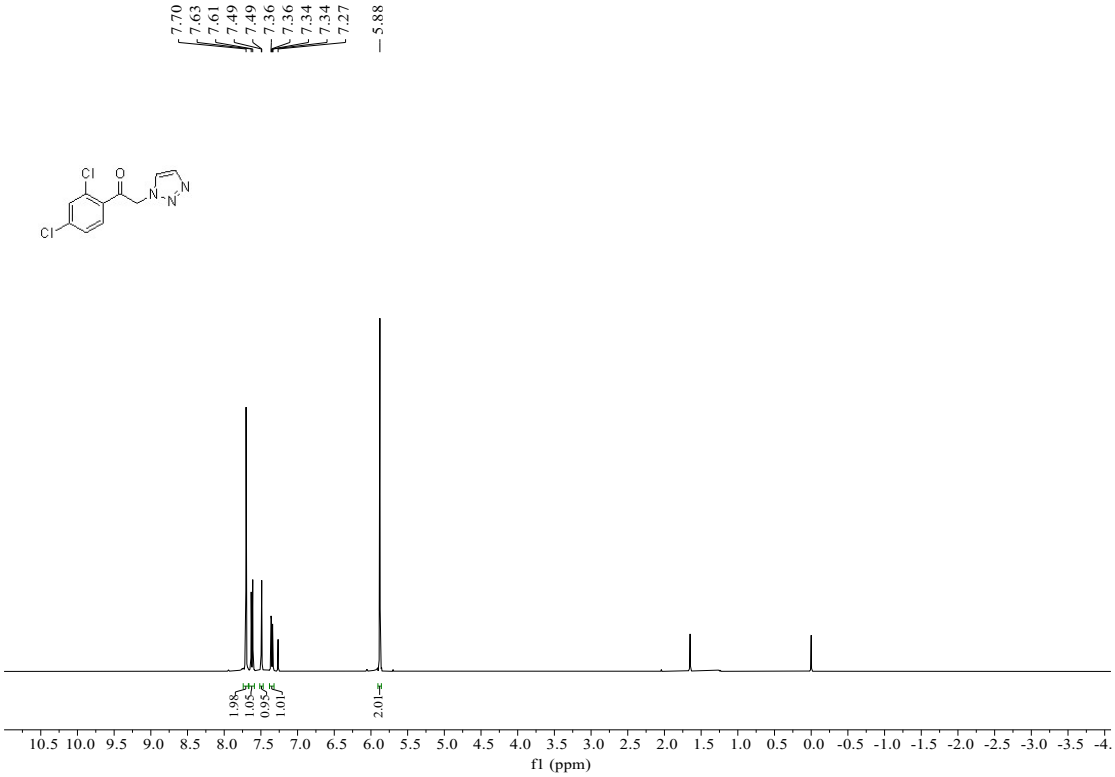
^{1}H NMR (400 MHz, DMSO-d_6) of **1q**:



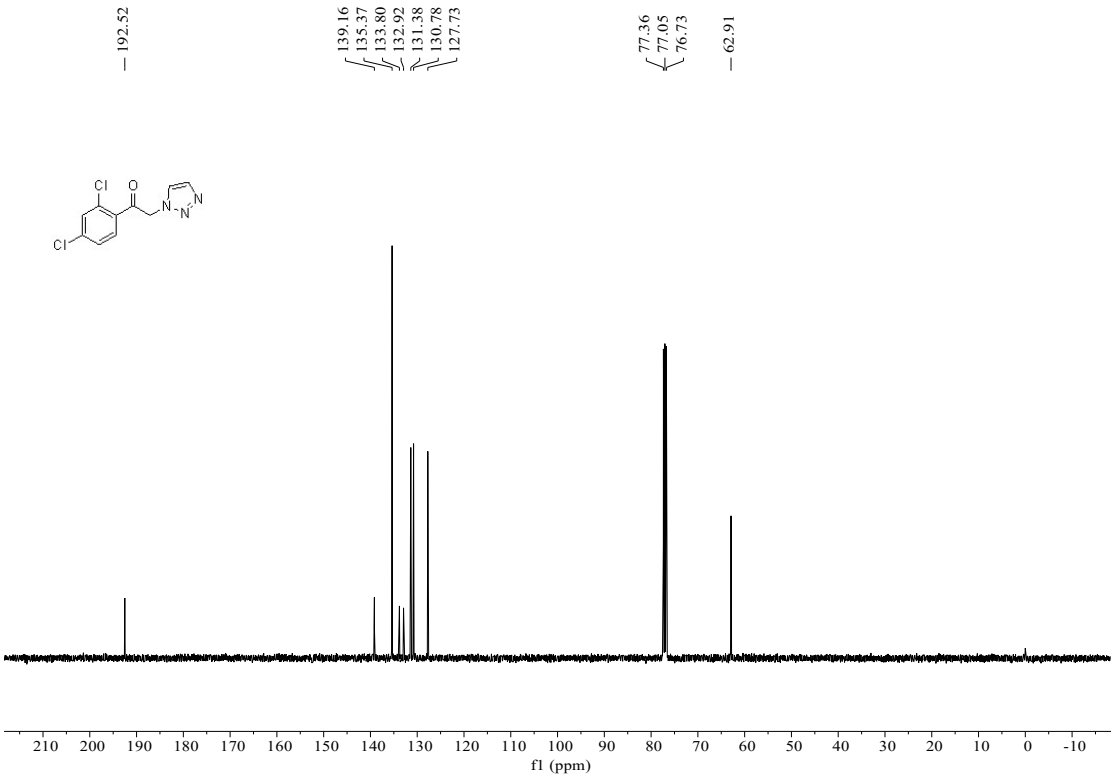
^{13}C NMR (151 MHz, DMSO-d_6) of **1q**:



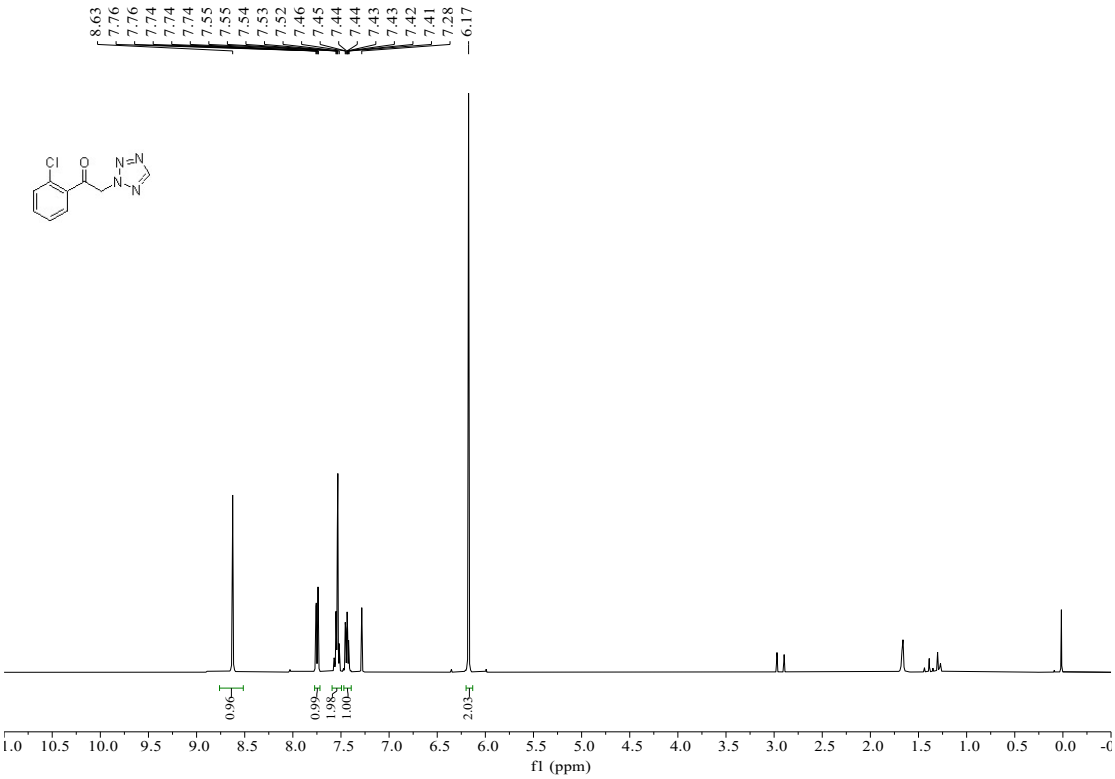
^{1}H NMR (400 MHz, $CDCl_3$) of **1r**:



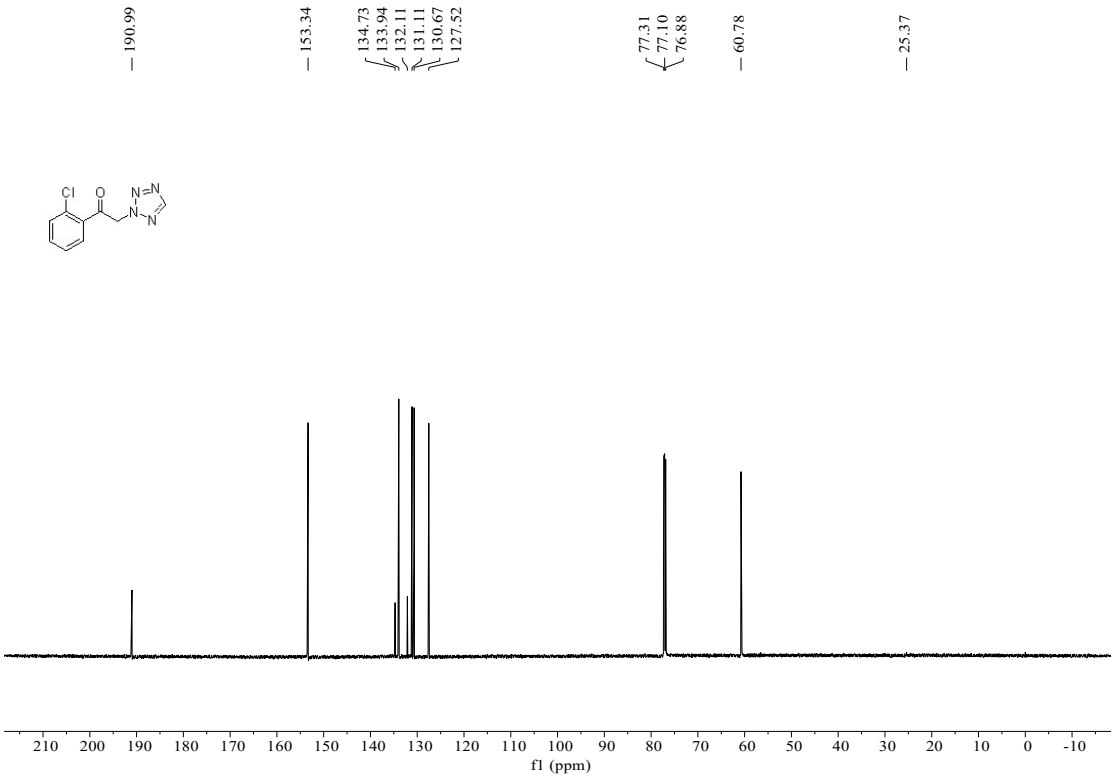
^{13}C NMR (101 MHz, $CDCl_3$) of **1r**:



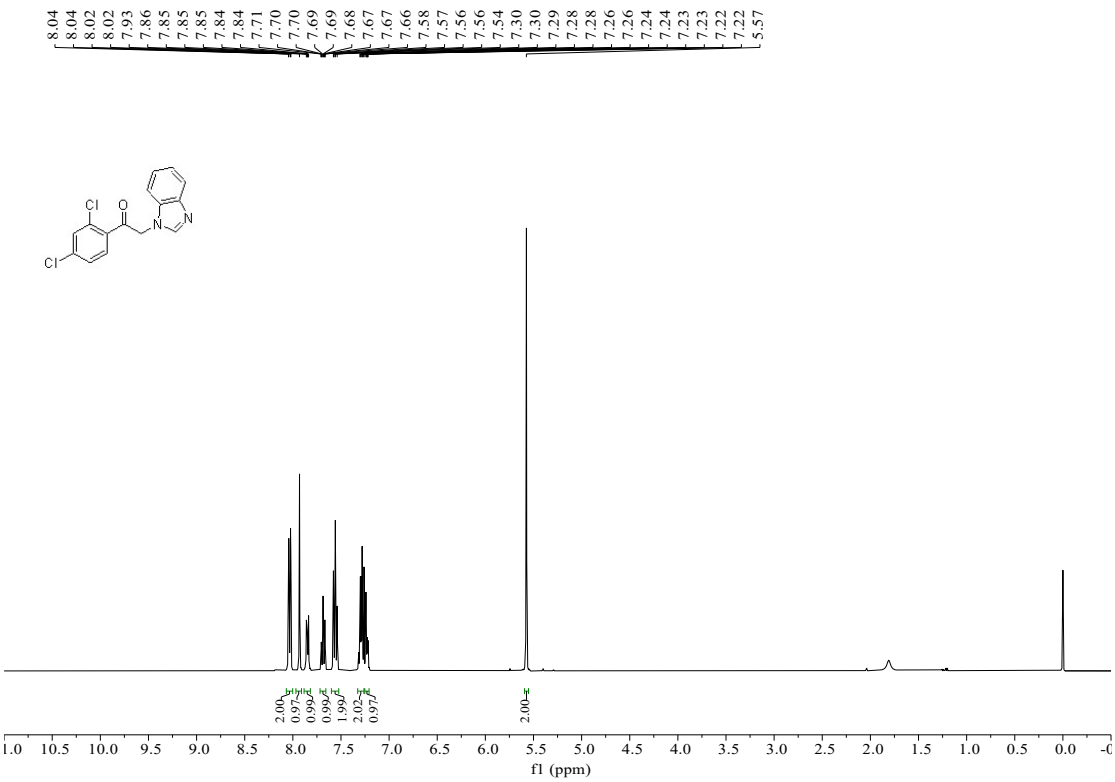
^{1}H NMR (400 MHz, $CDCl_3$) of **1s**:



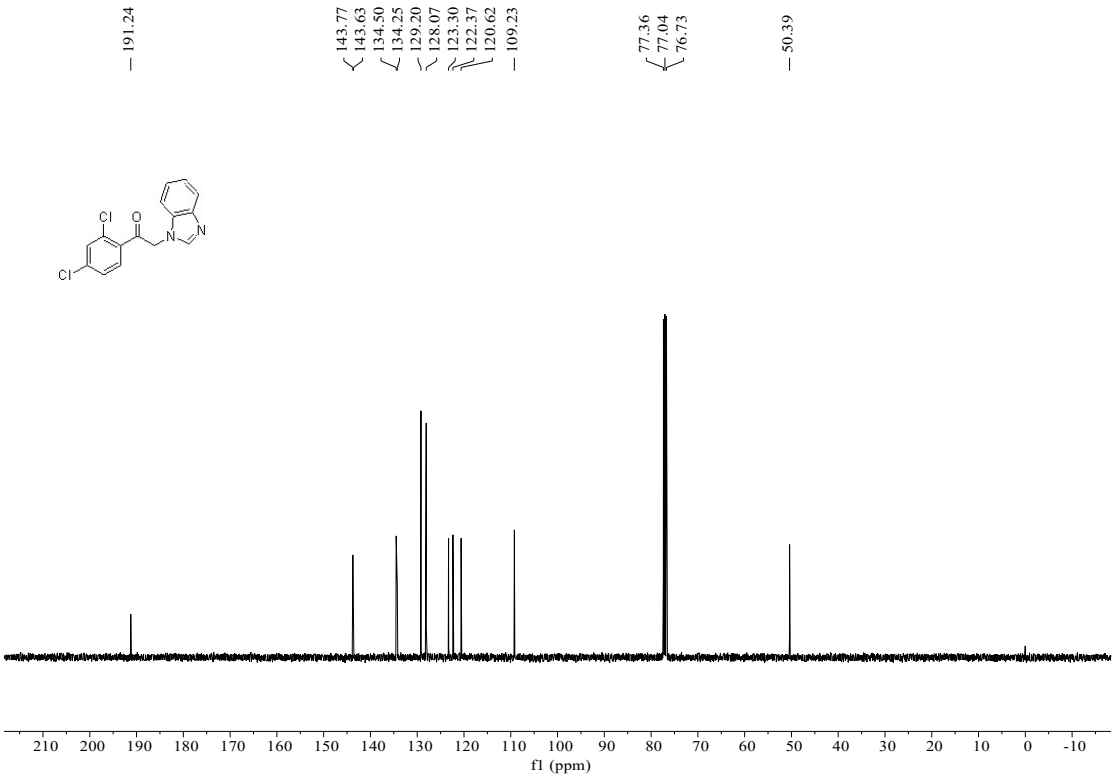
^{13}C NMR (151 MHz, $CDCl_3$) of **1s**:



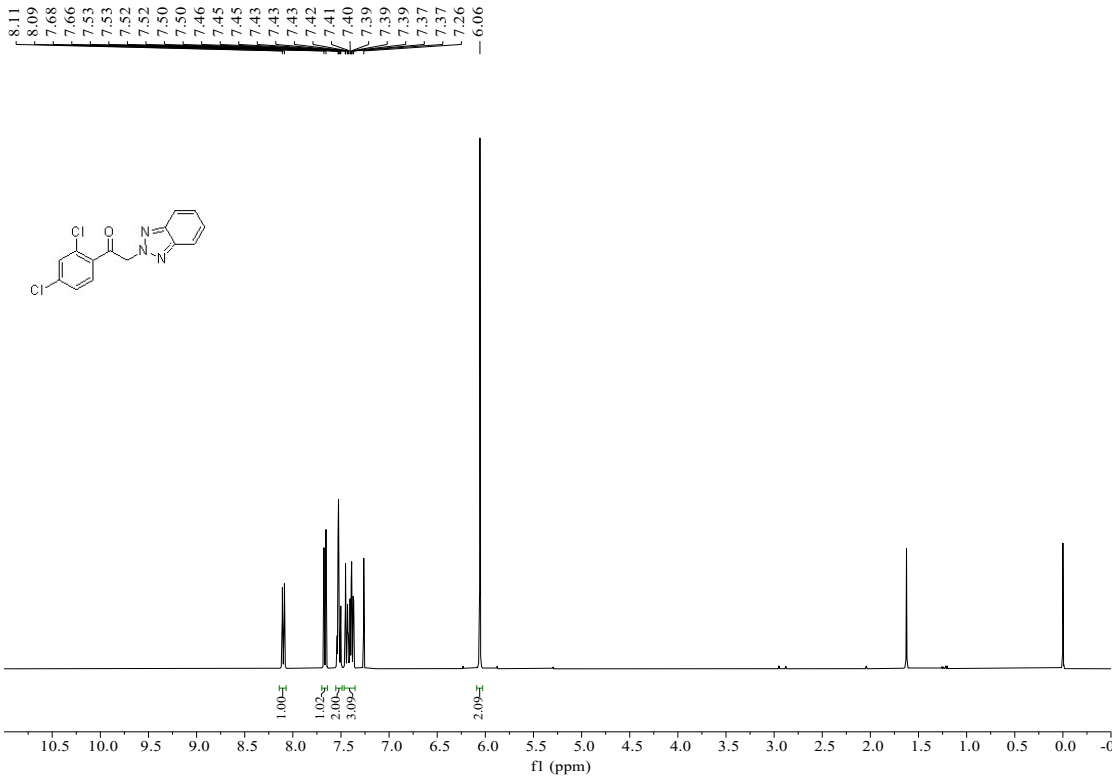
^{1}H NMR (400 MHz, $CDCl_3$) of **1t**:



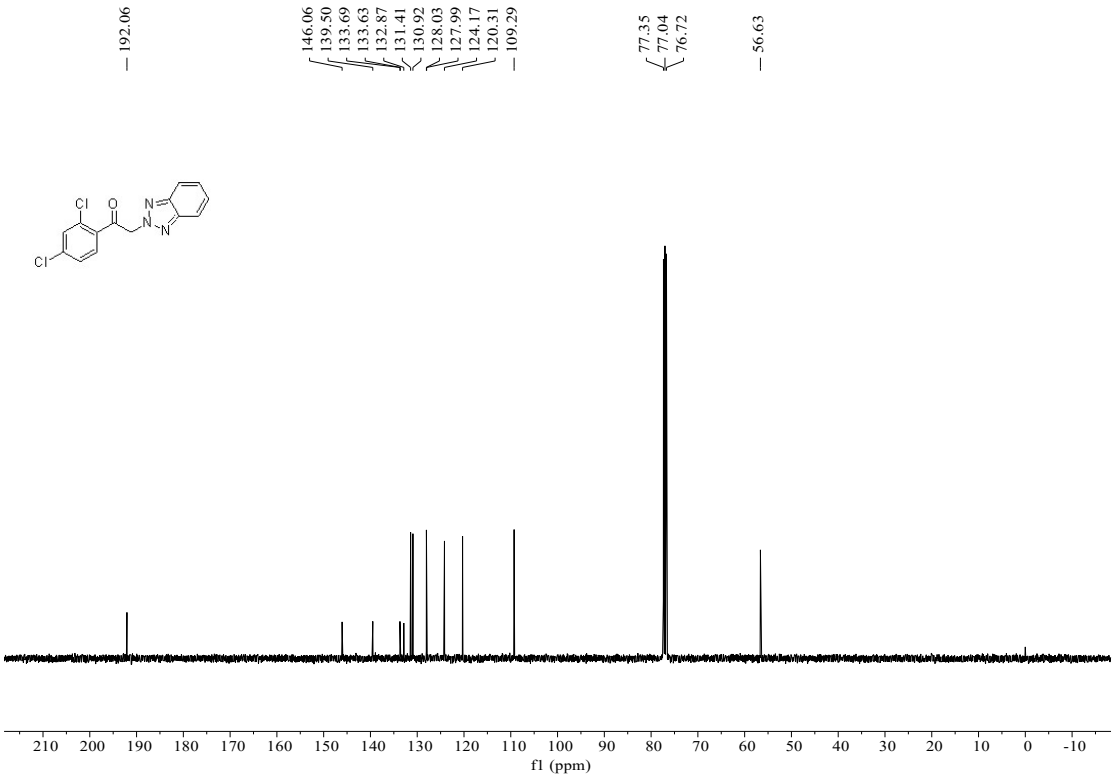
^{13}C NMR (101 MHz, $CDCl_3$) of **1t**:



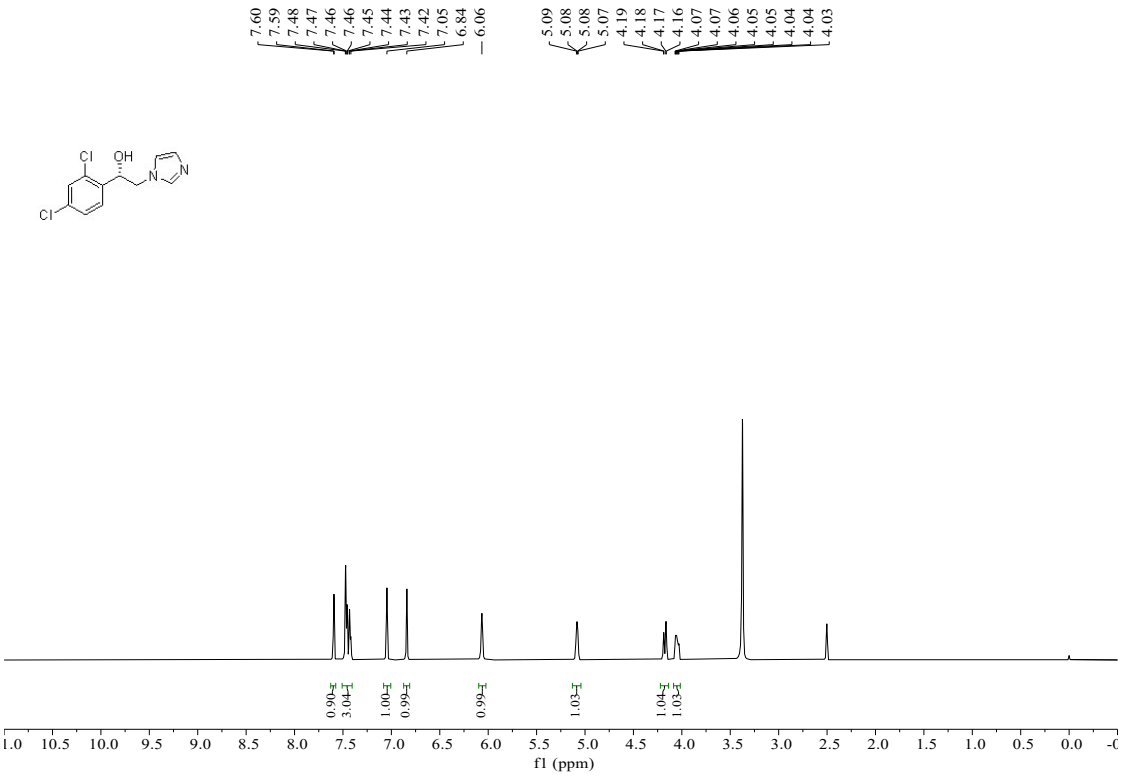
^{1}H NMR (400 MHz, $CDCl_3$) of **1u**:



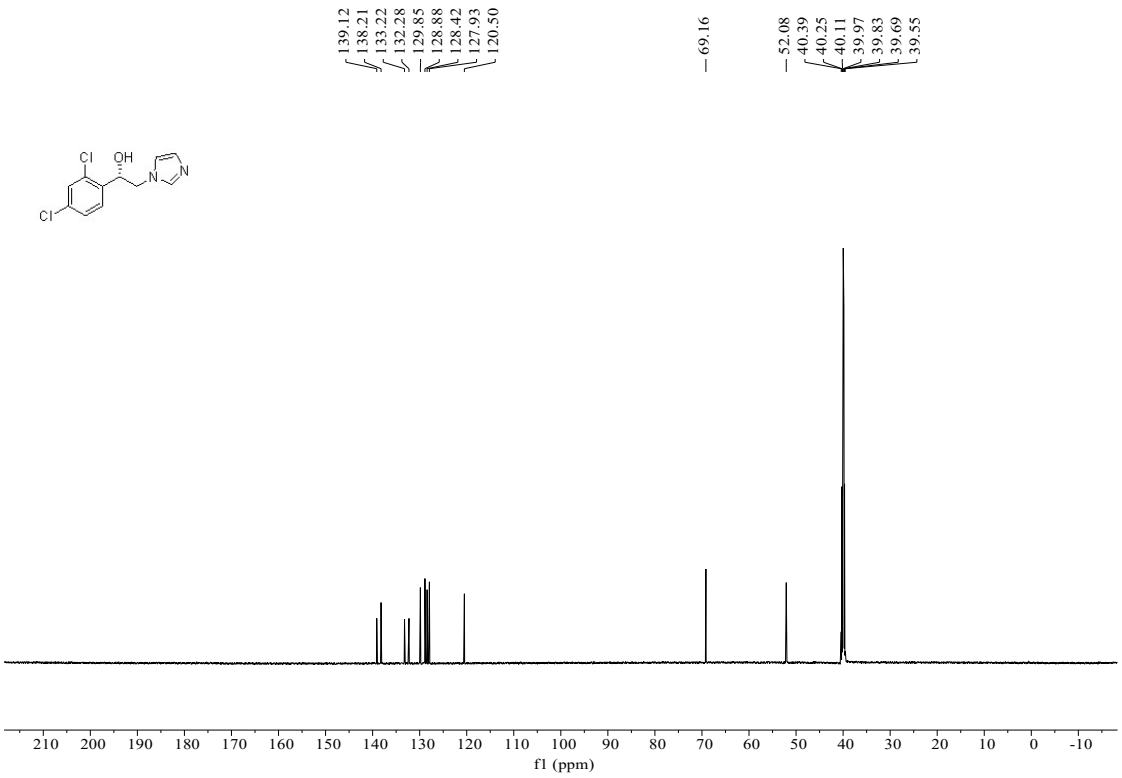
^{13}C NMR (101 MHz, $CDCl_3$) of **1u**:



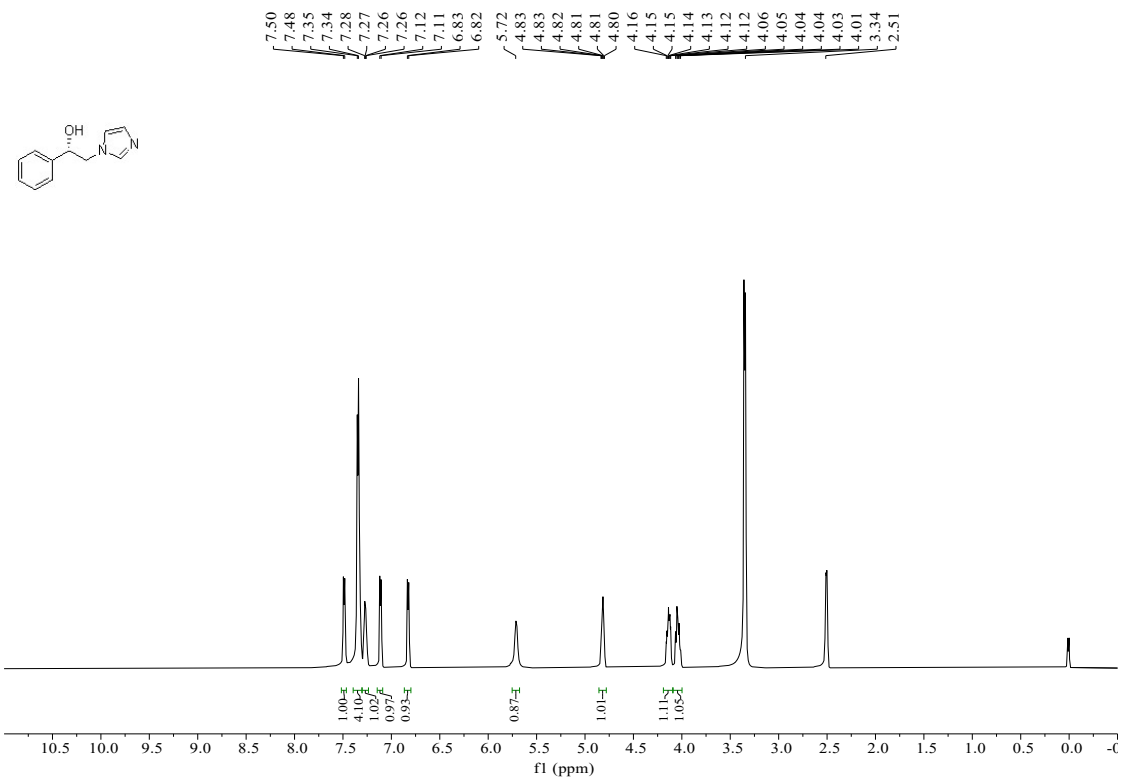
^{1}H NMR (600 MHz, DMSO-d_6) of **2a**:



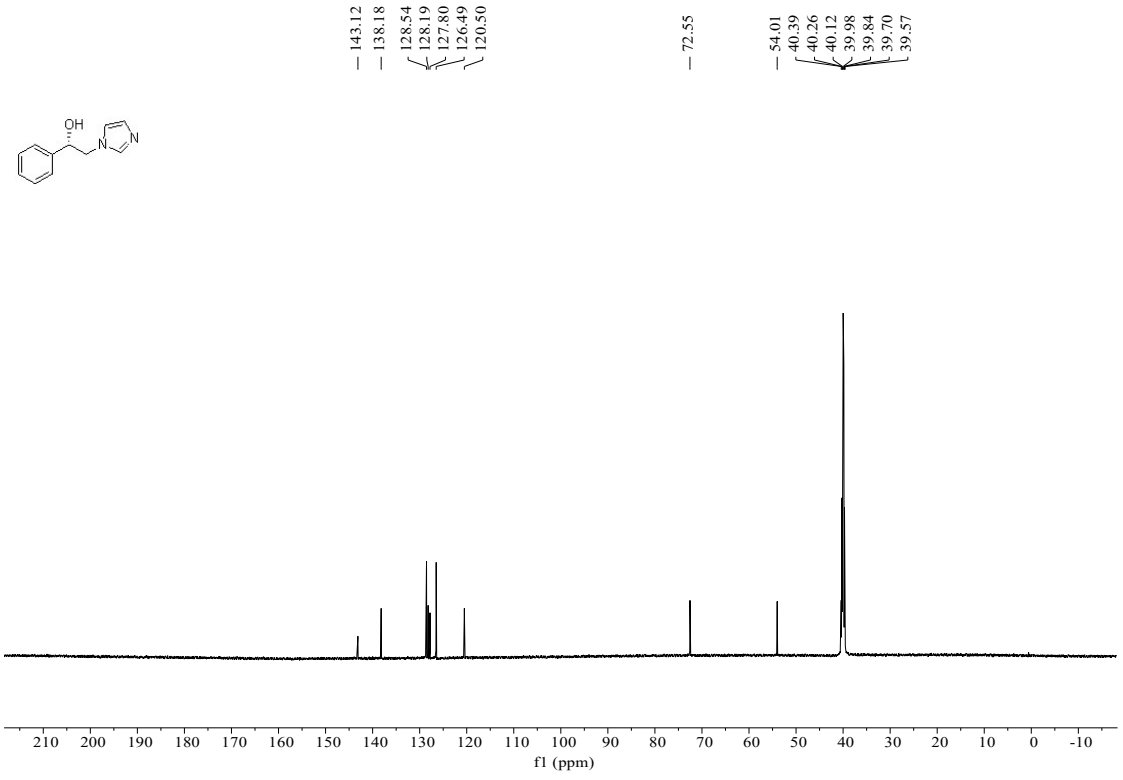
^{13}C NMR (151 MHz, DMSO-d_6) of **2a**:



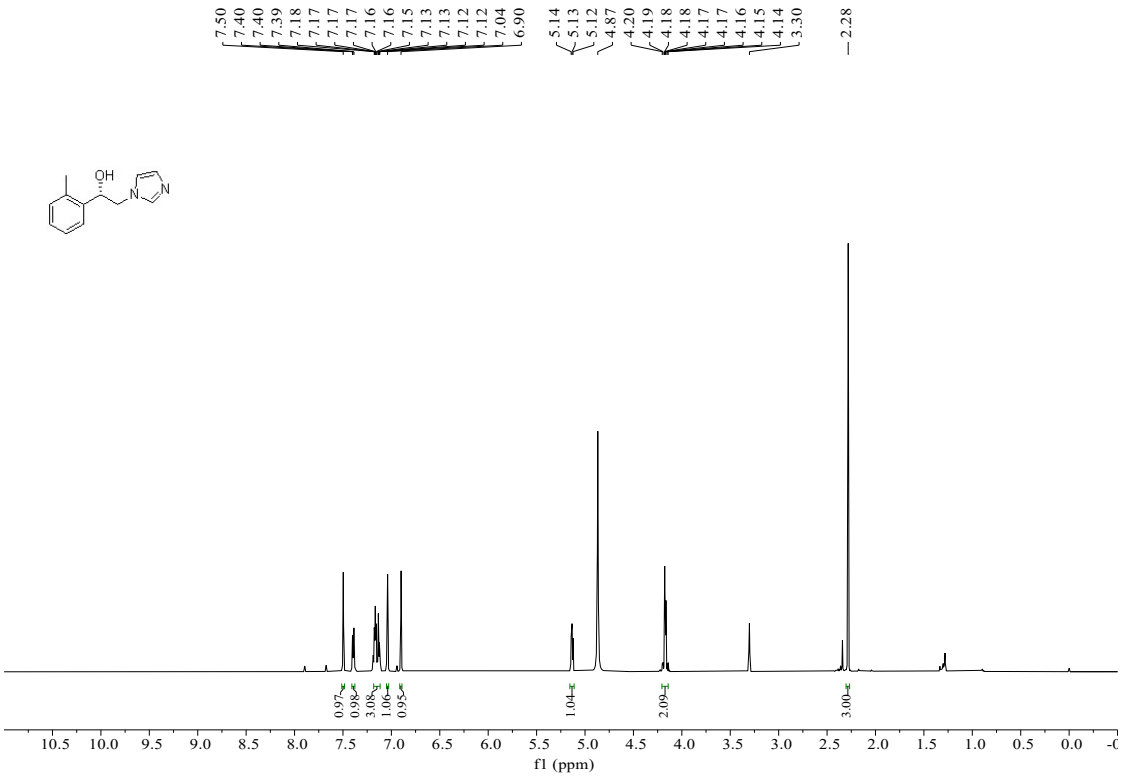
^{1}H NMR (600 MHz, DMSO-d_6) of **2b**:



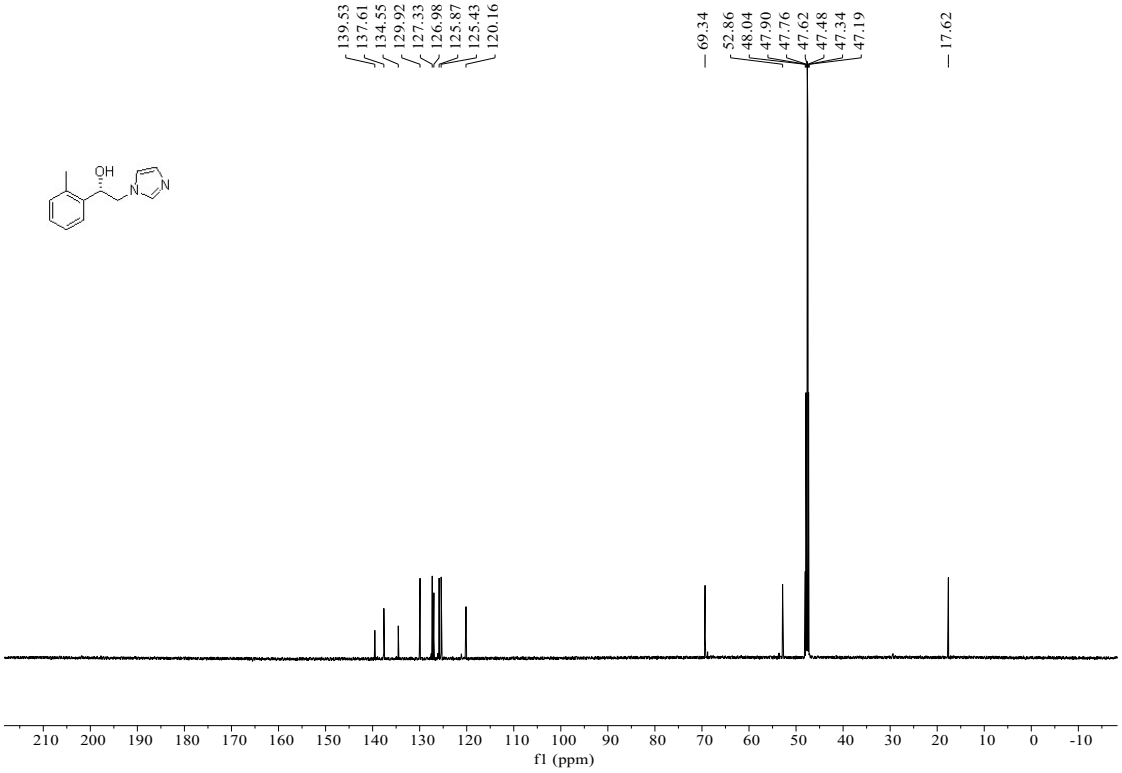
^{13}C NMR (151 MHz, DMSO-d_6) of **2b**:



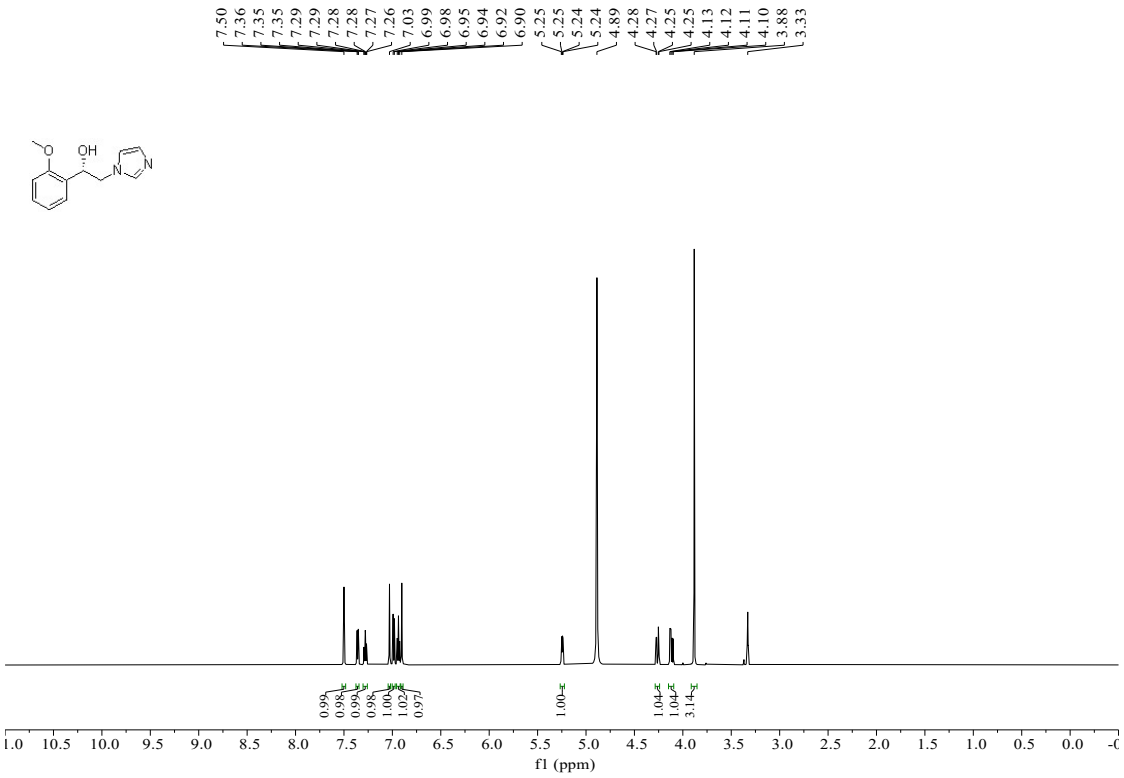
^{1}H NMR (600 MHz, CD_3OD) of **2c**:



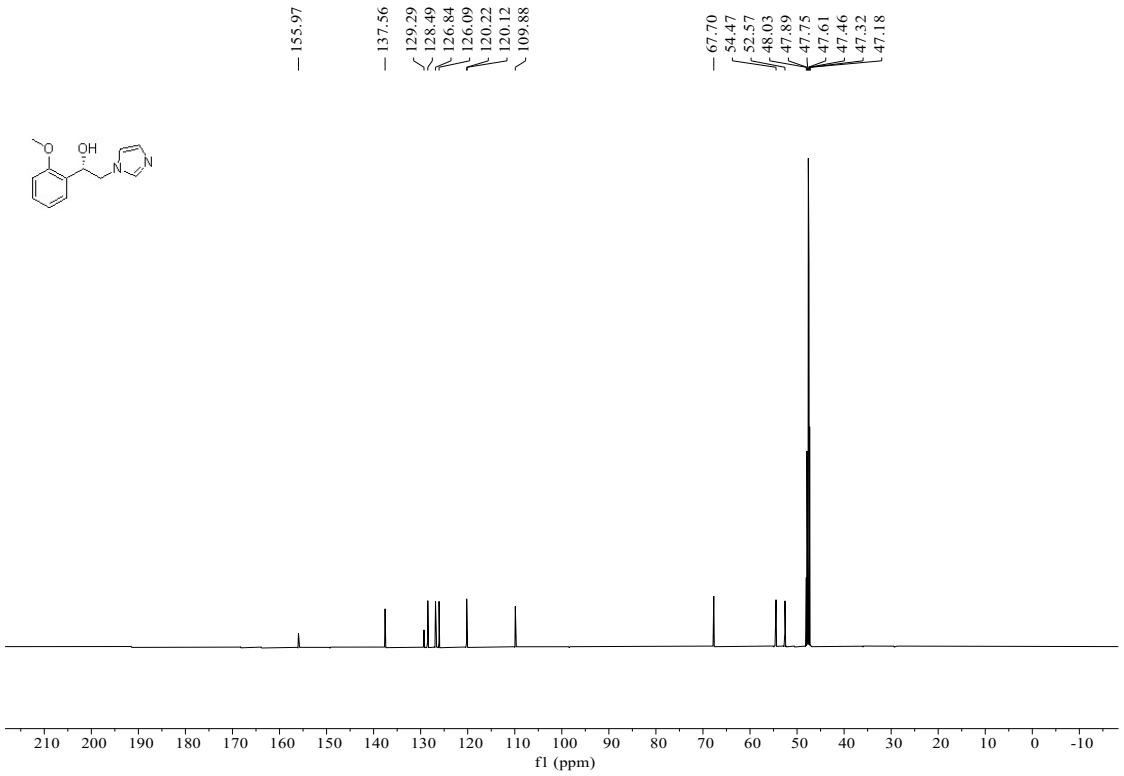
^{13}C NMR (151 MHz, CD_3OD) of **2c**:



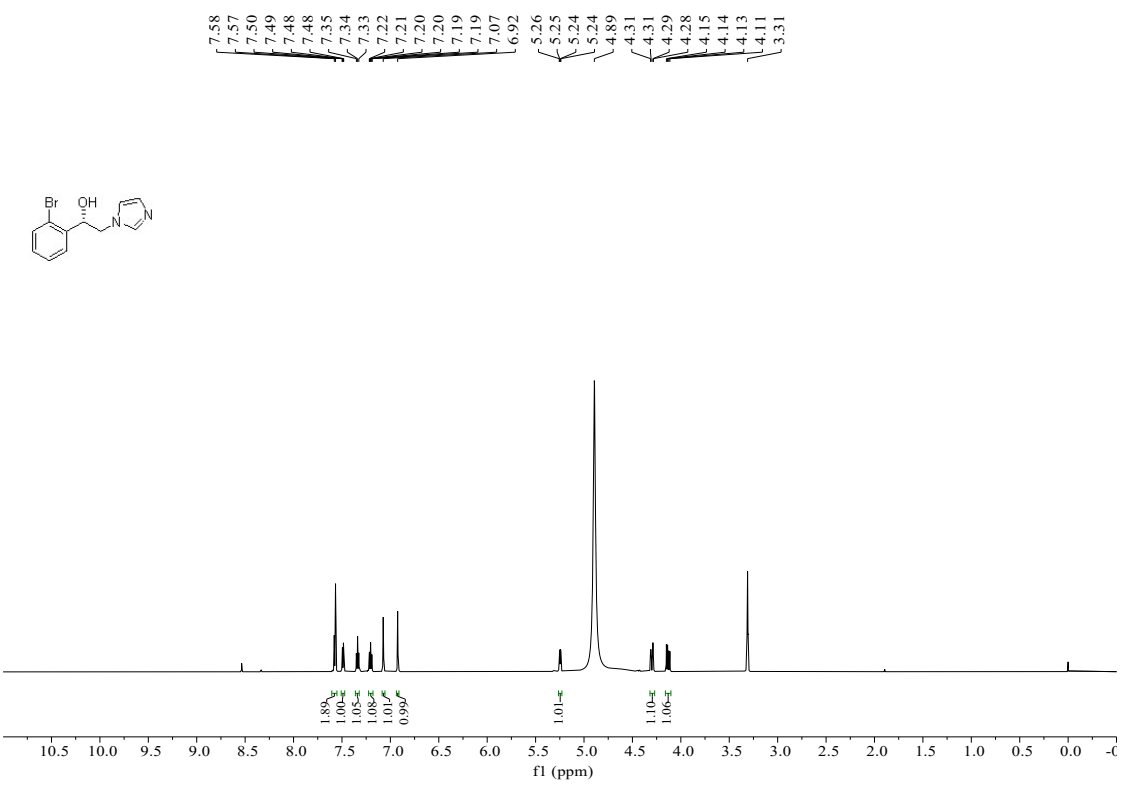
^{1}H NMR (600 MHz, CD_3OD) of **2d**:



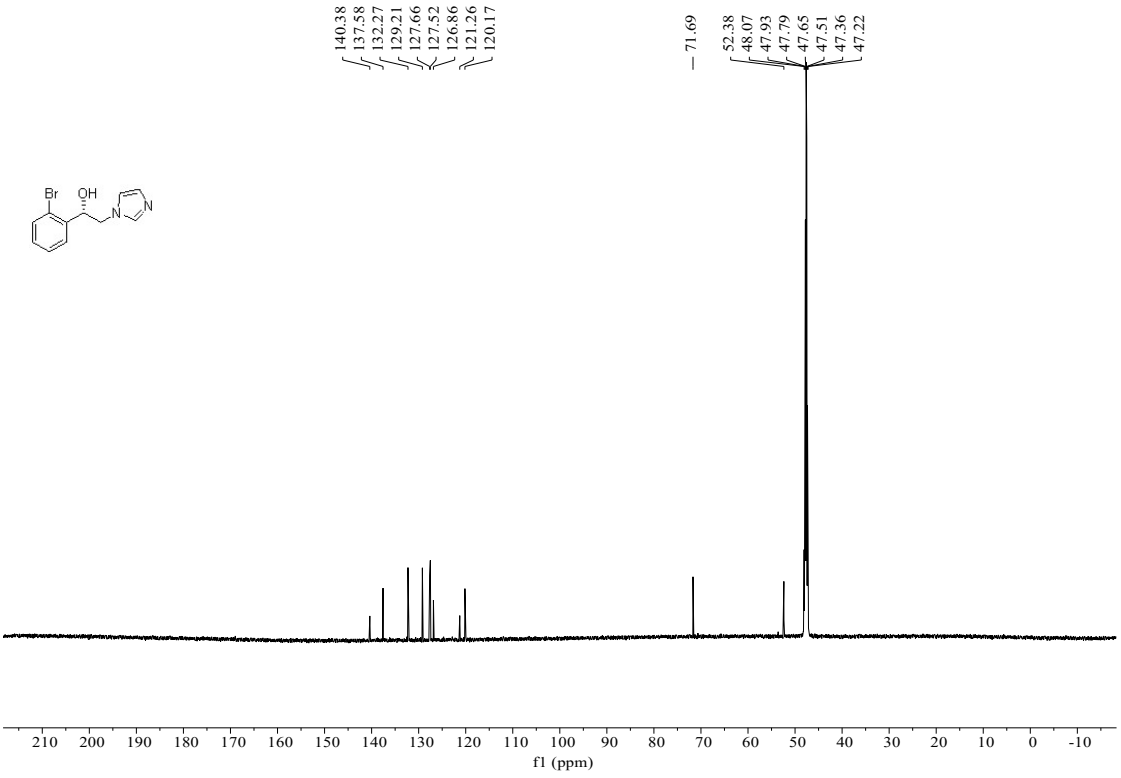
^{13}C NMR (151 MHz, CD_3OD) of **2d**:



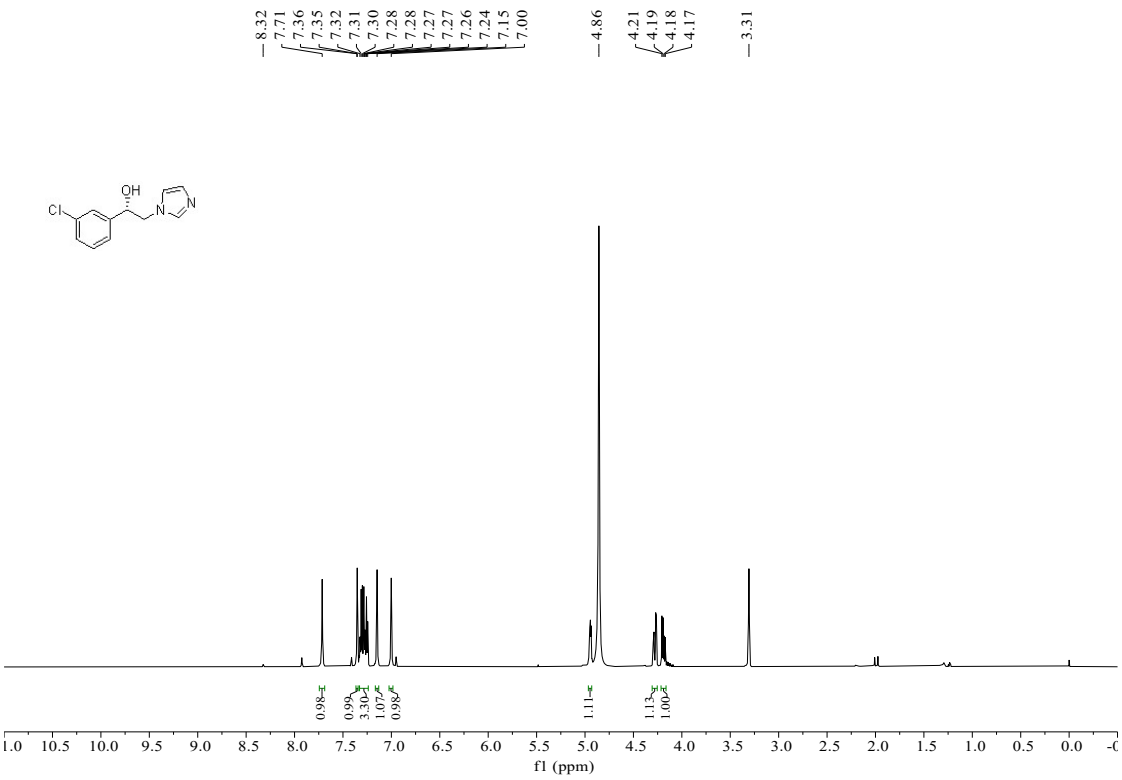
^{1}H NMR (600 MHz, CD_3OD) of **2e**:



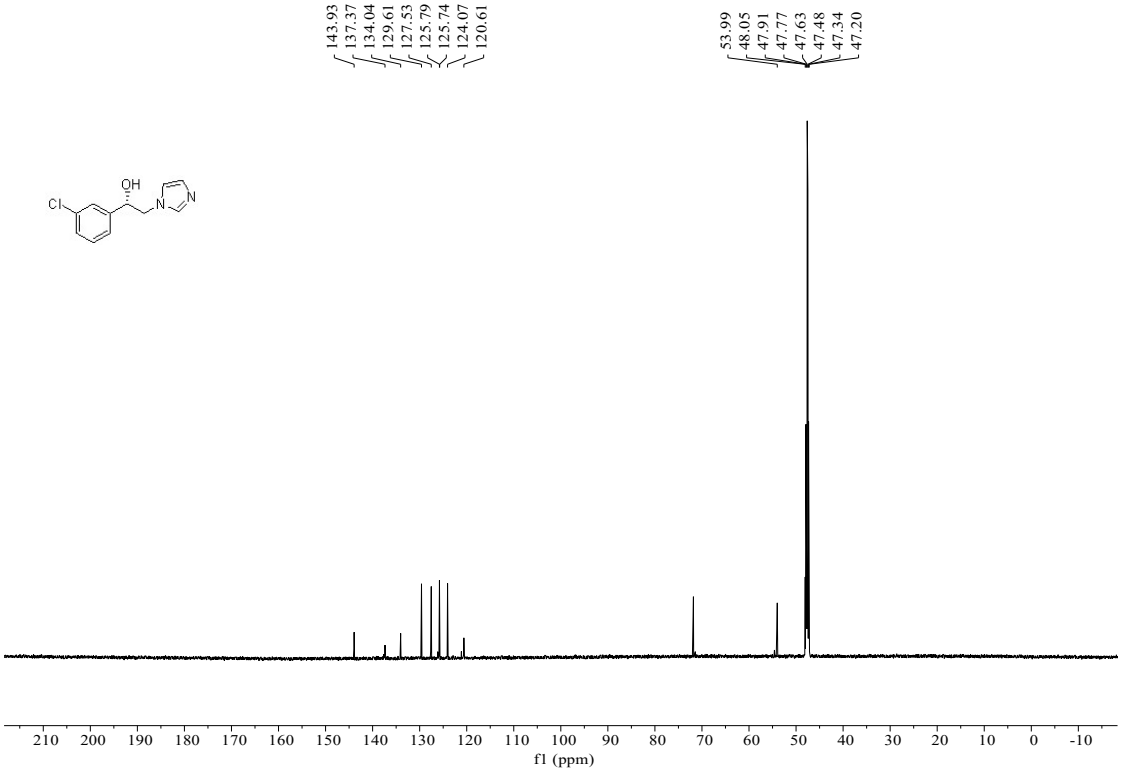
^{13}C NMR (151 MHz, CD_3OD) of **2e**:



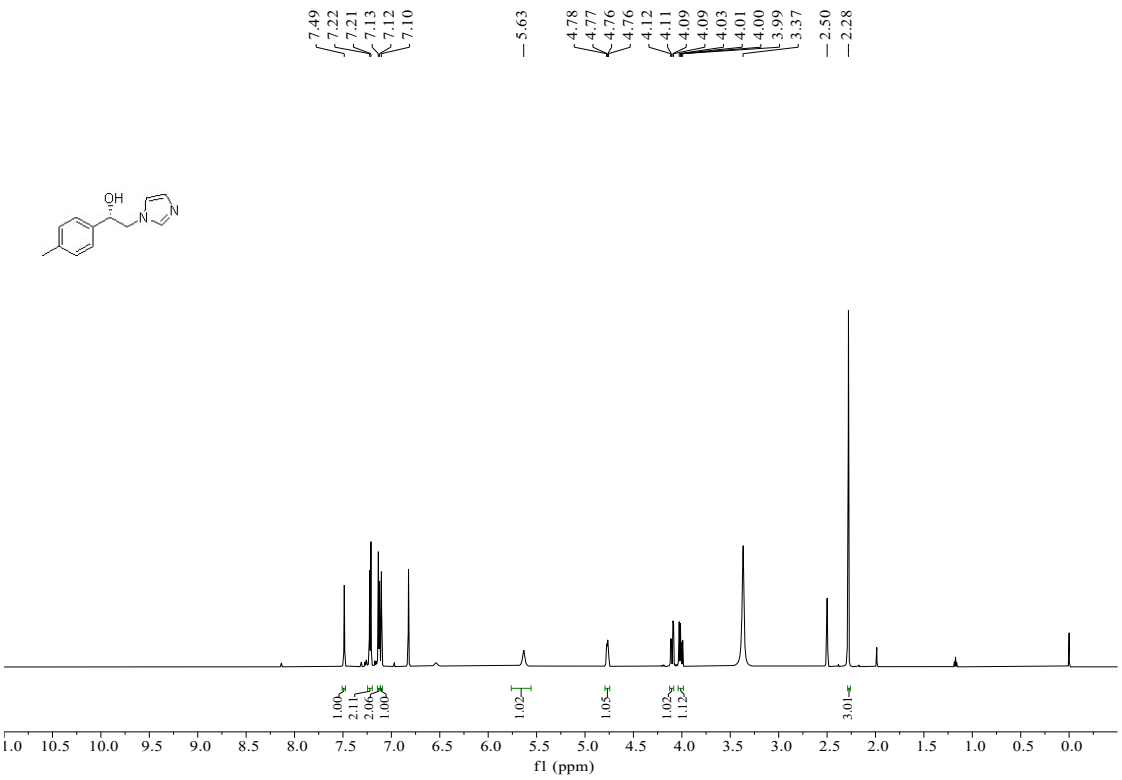
^{1}H NMR (600 MHz, CD_3OD) of **2f**:



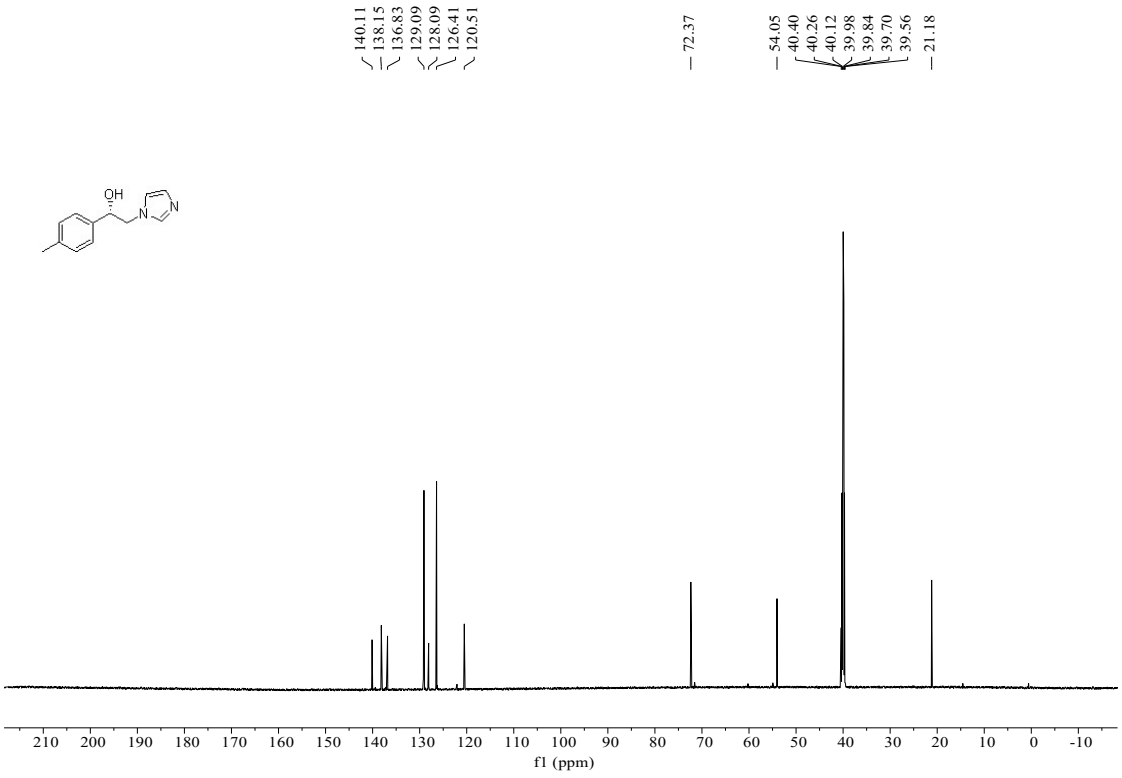
^{13}C NMR (151 MHz, CD_3OD) of **2f**:



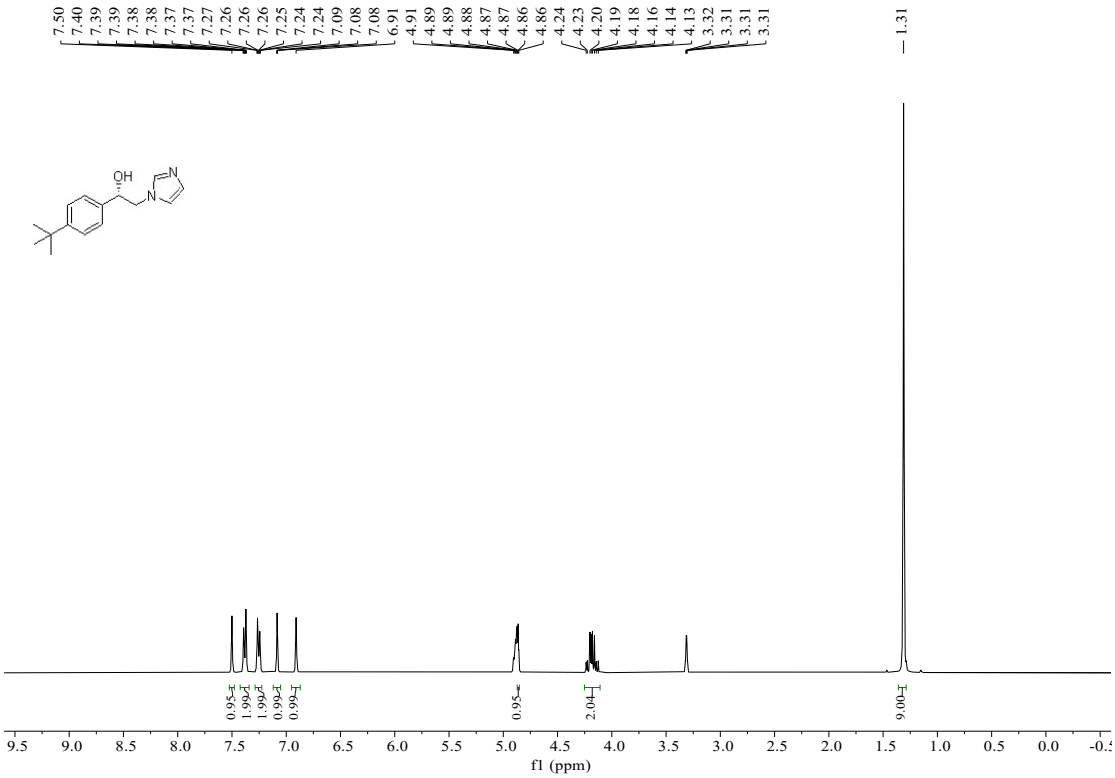
^{1}H NMR (600 MHz, DMSO-d_6) of **2g**:



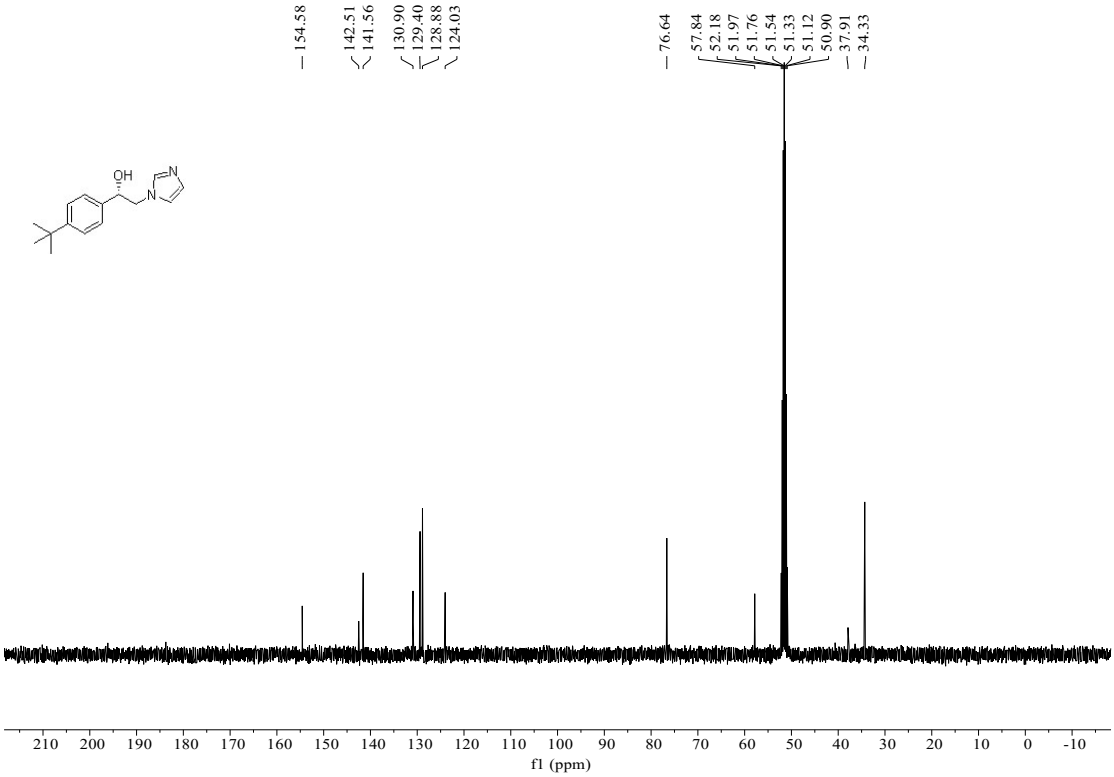
^{13}C NMR (151 MHz, DMSO-d_6) of **2g**:



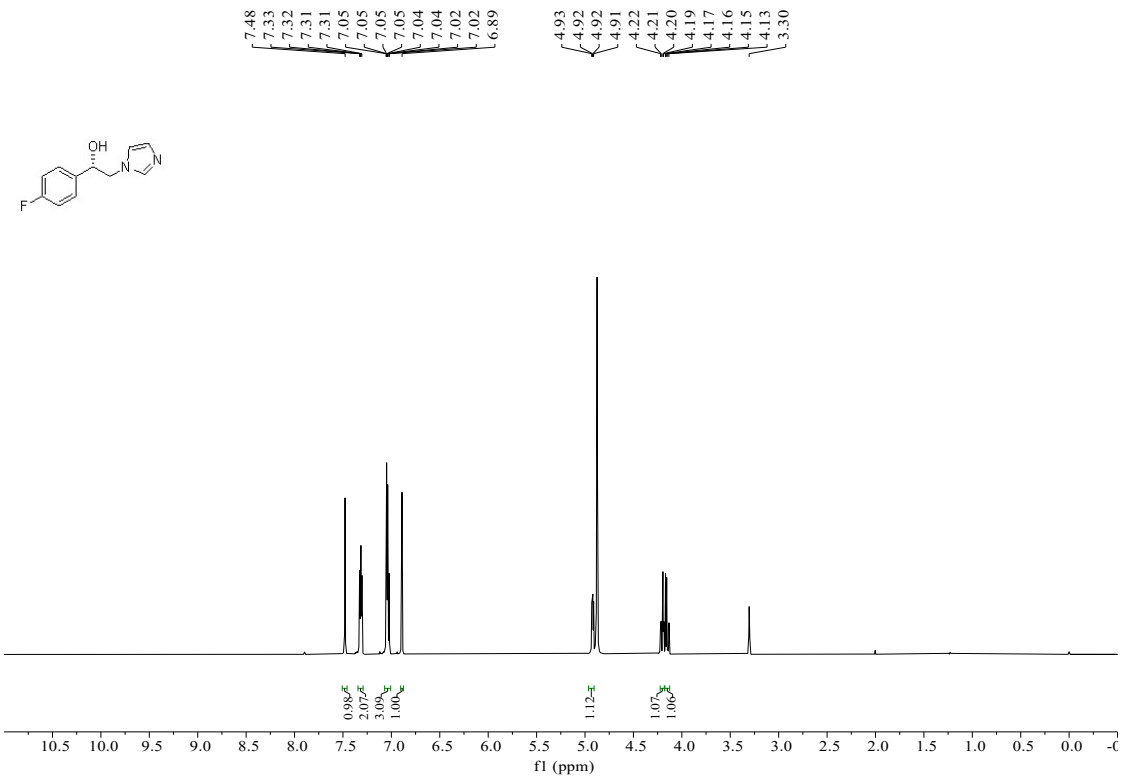
^{1}H NMR (400 MHz, CD_3OD) of **2h**:



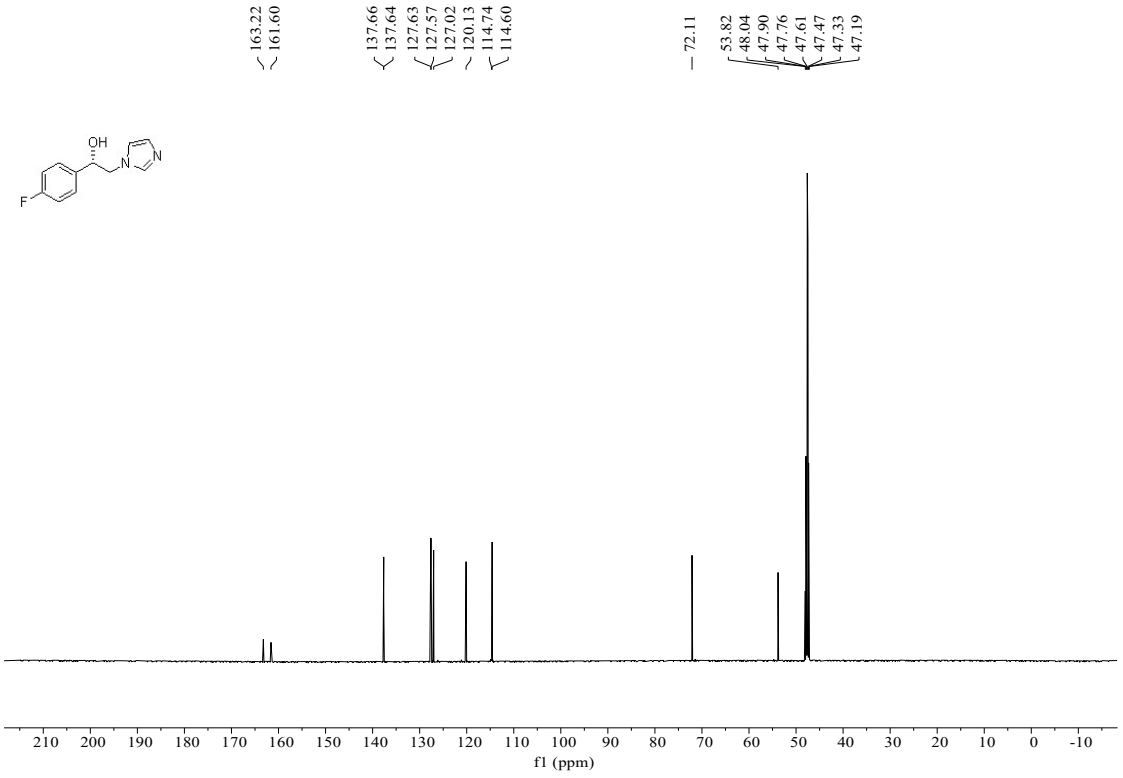
^{13}C NMR (101 MHz, CD_3OD) of **2h**:



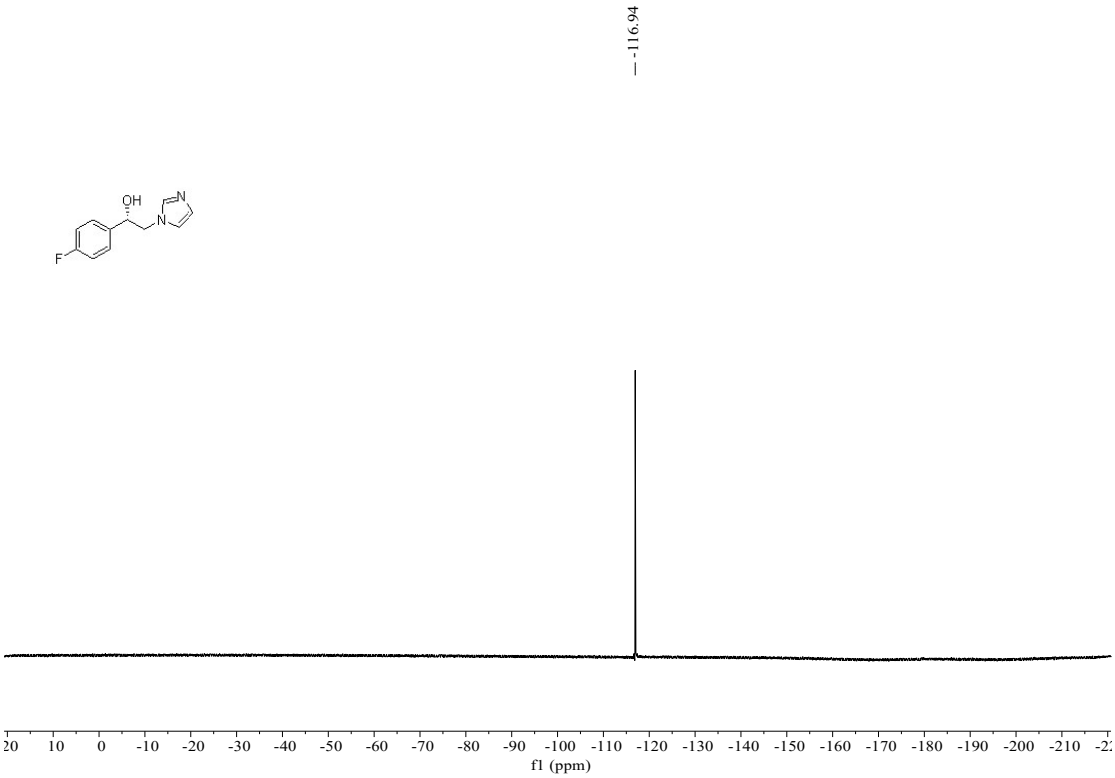
^{1}H NMR (600 MHz, CD_3OD) of **2i**:



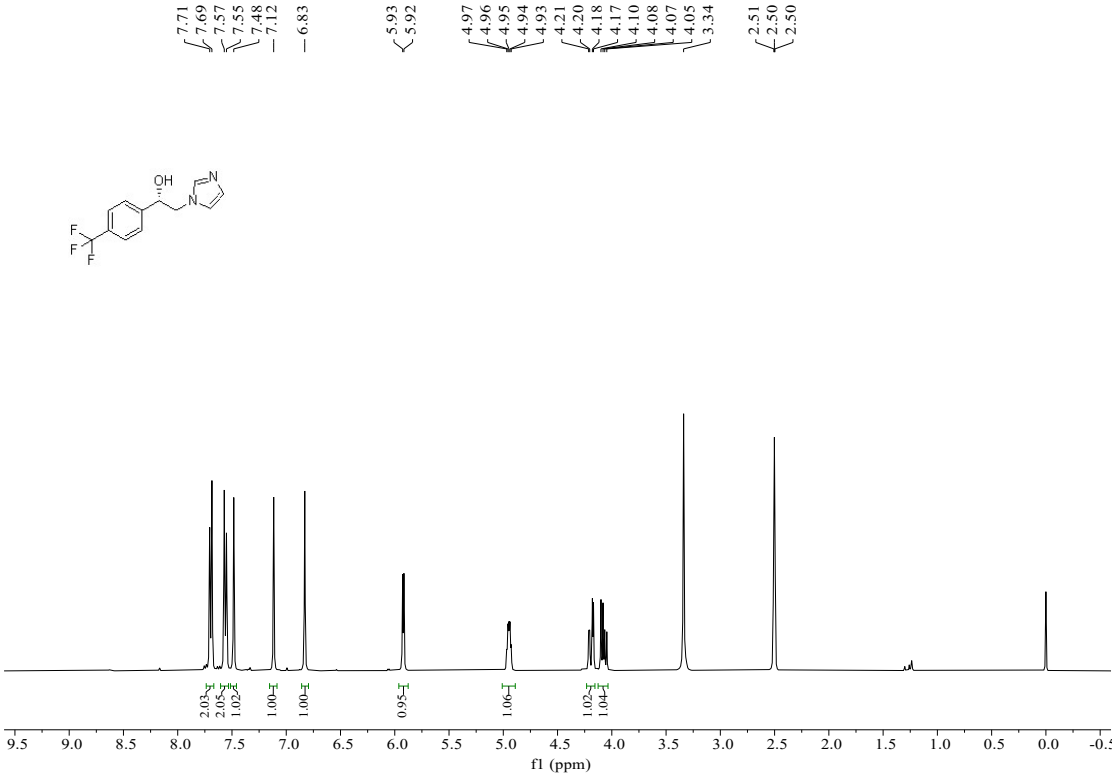
^{13}C NMR (151 MHz, CD_3OD) of **2i**:



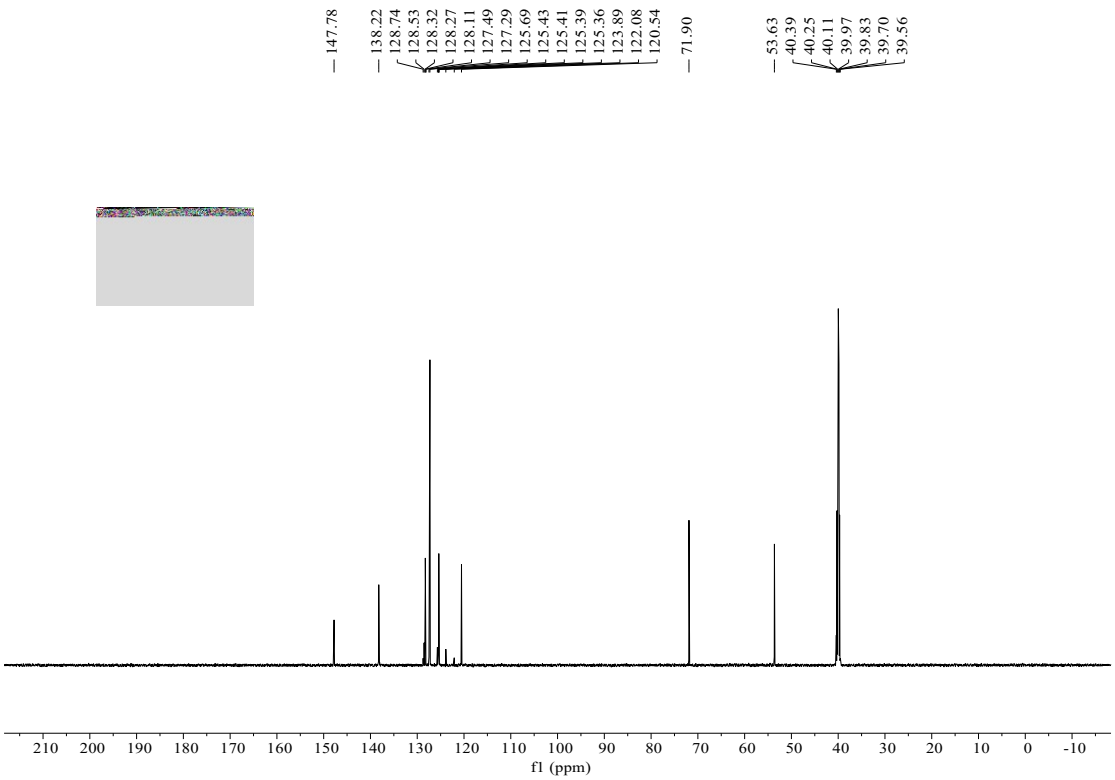
^{19}F NMR (377 MHz, CD_3OD) of **2i**:



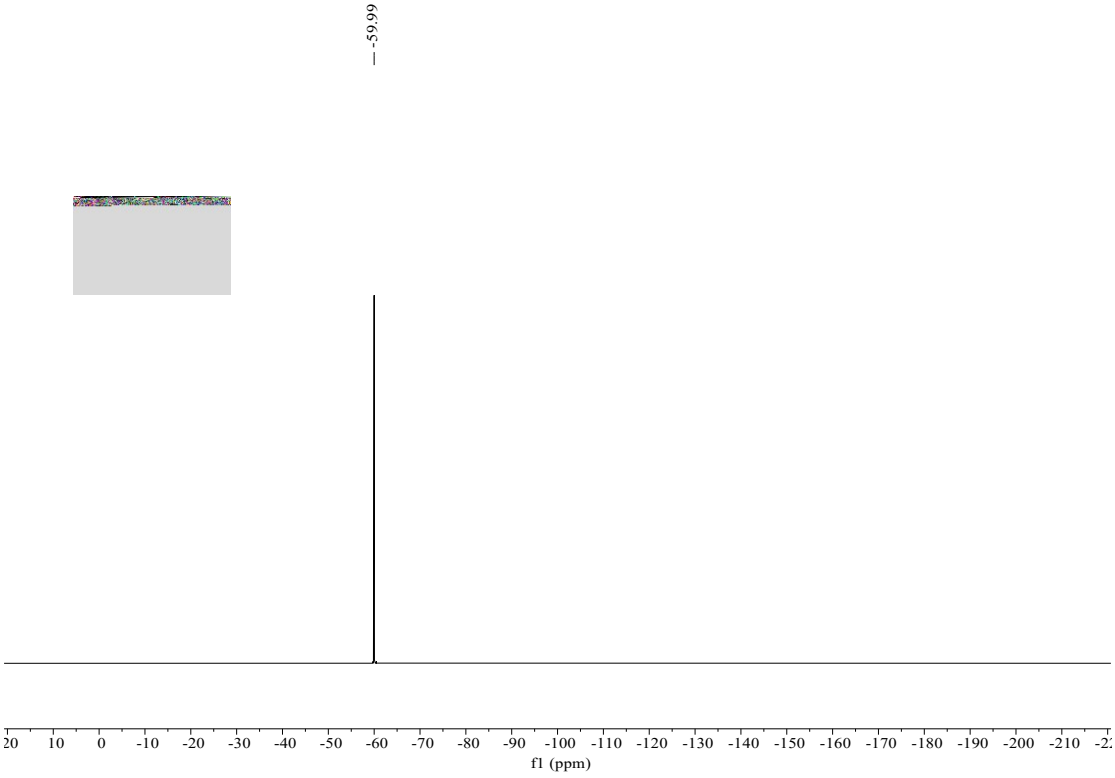
^{1}H NMR (400 MHz, DMSO-d_6) of **2j**:



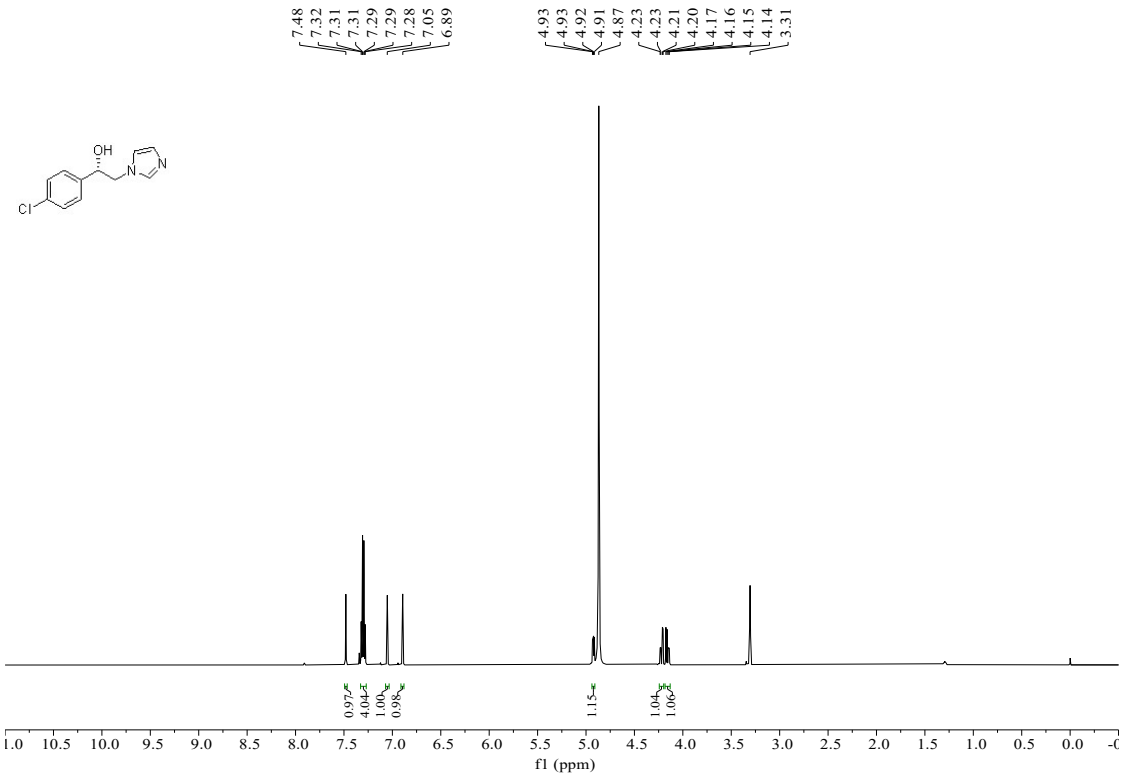
^{13}C NMR (151 MHz, DMSO-d_6) of **2j**:



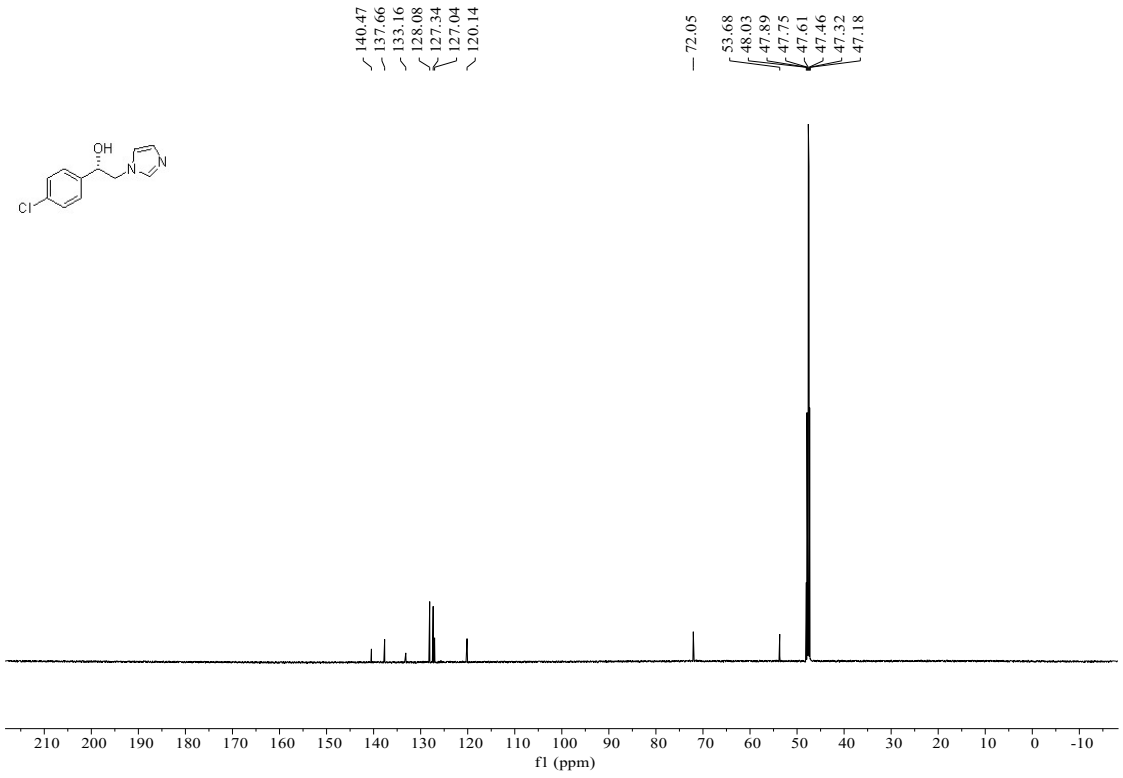
^{19}F NMR (376 MHz, DMSO-d_6) of **2j**:



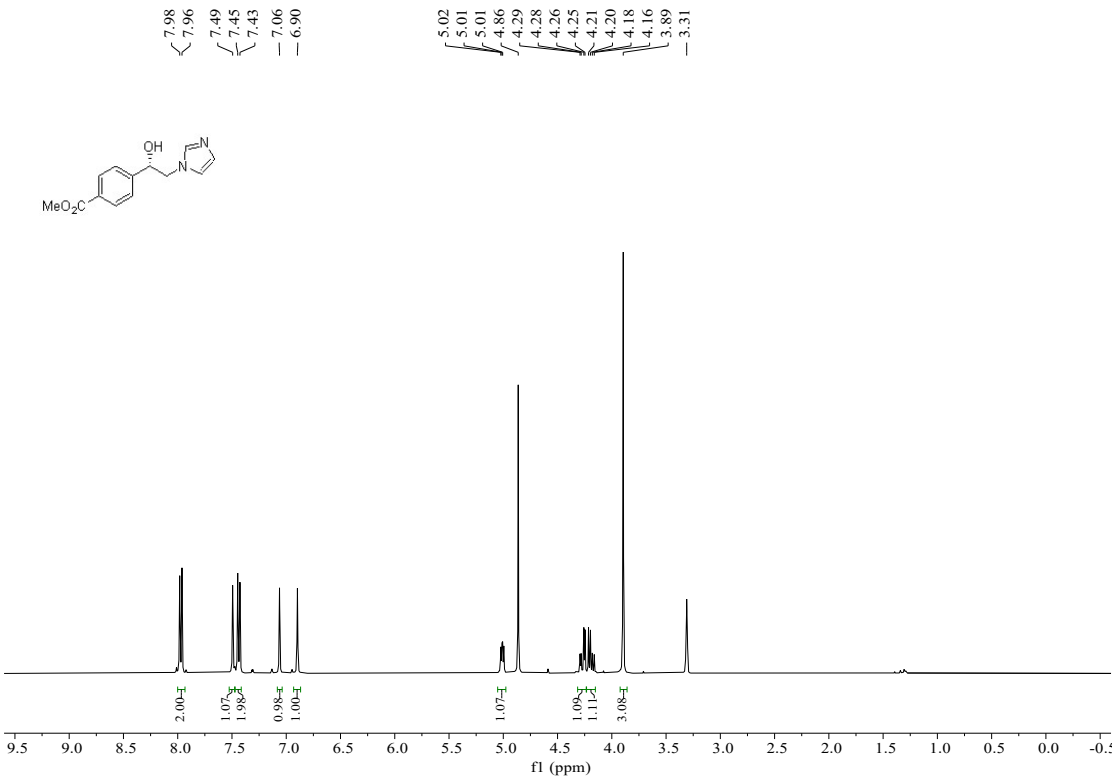
^{1}H NMR (600 MHz, CD_3OD) of **2k**:



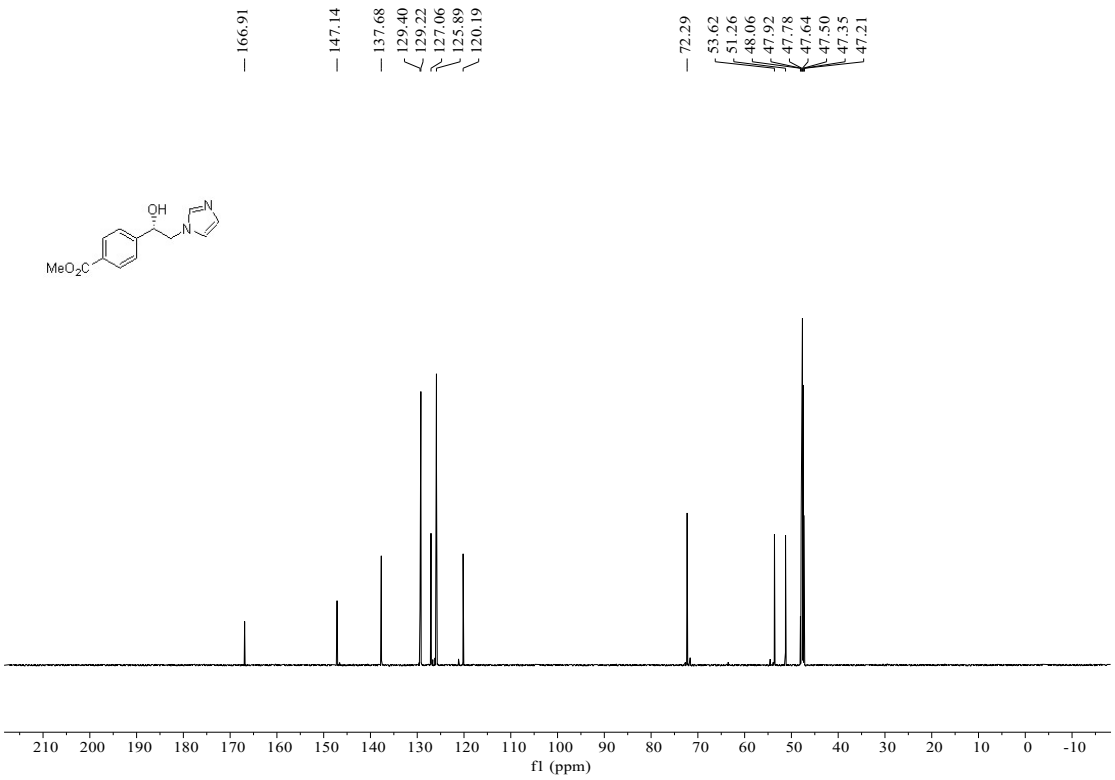
^{13}C NMR (151 MHz, CD_3OD) of **2k**:



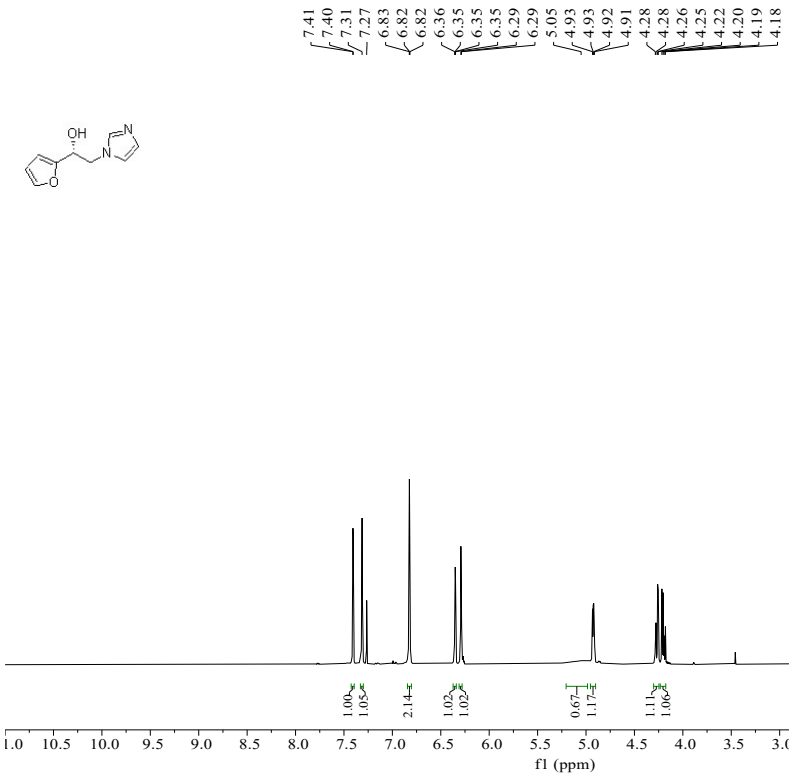
^{1}H NMR (400 MHz, CD_3OD) of **2l**:



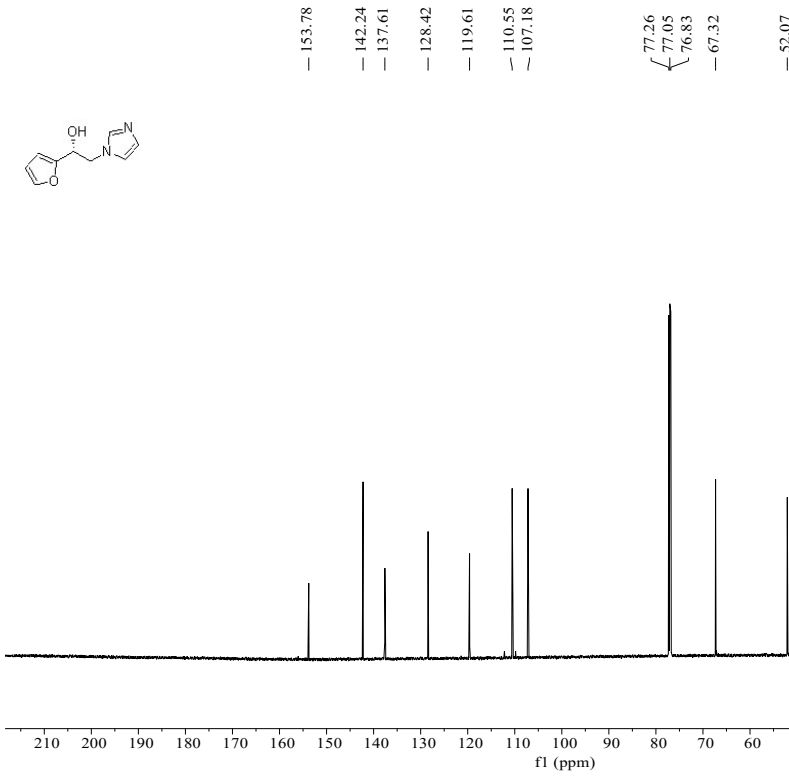
^{13}C NMR (101 MHz, CD_3OD) of **2l**:



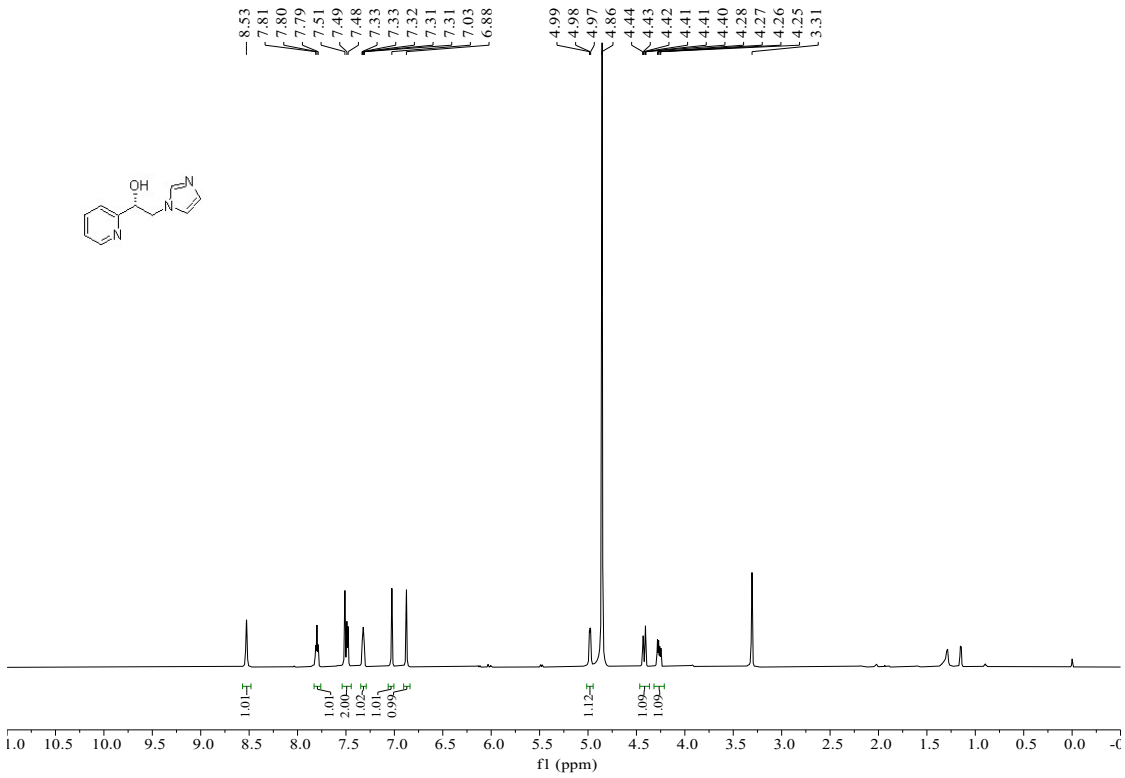
^{1}H NMR (600 MHz, $CDCl_3$) of **2m**:



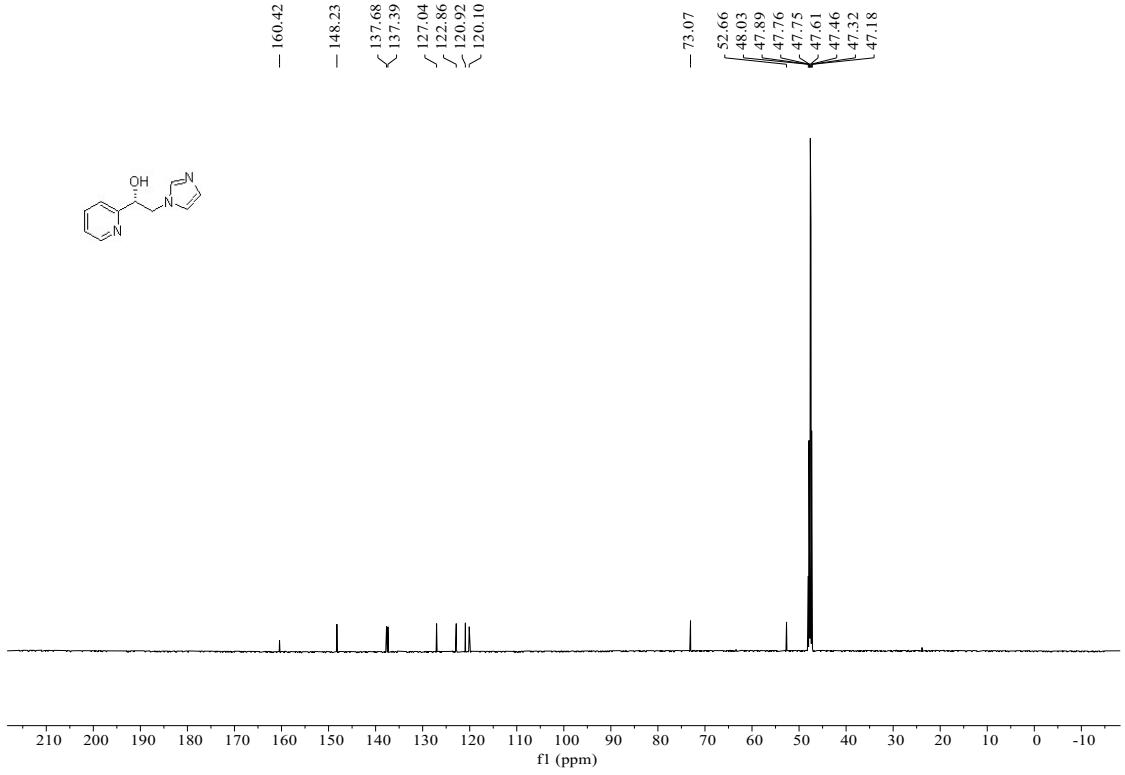
^{13}C NMR (151 MHz, $CDCl_3$) of **2m**:



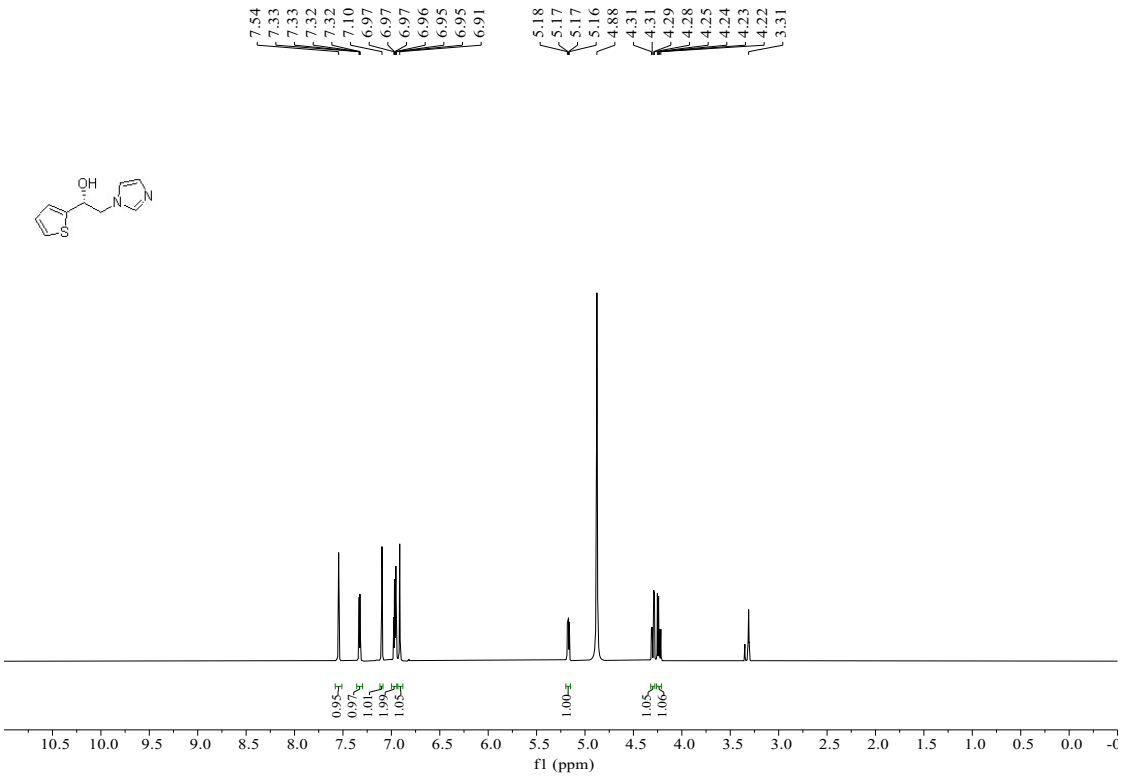
^{1}H NMR (600 MHz, CD_3OD) of **2n**:



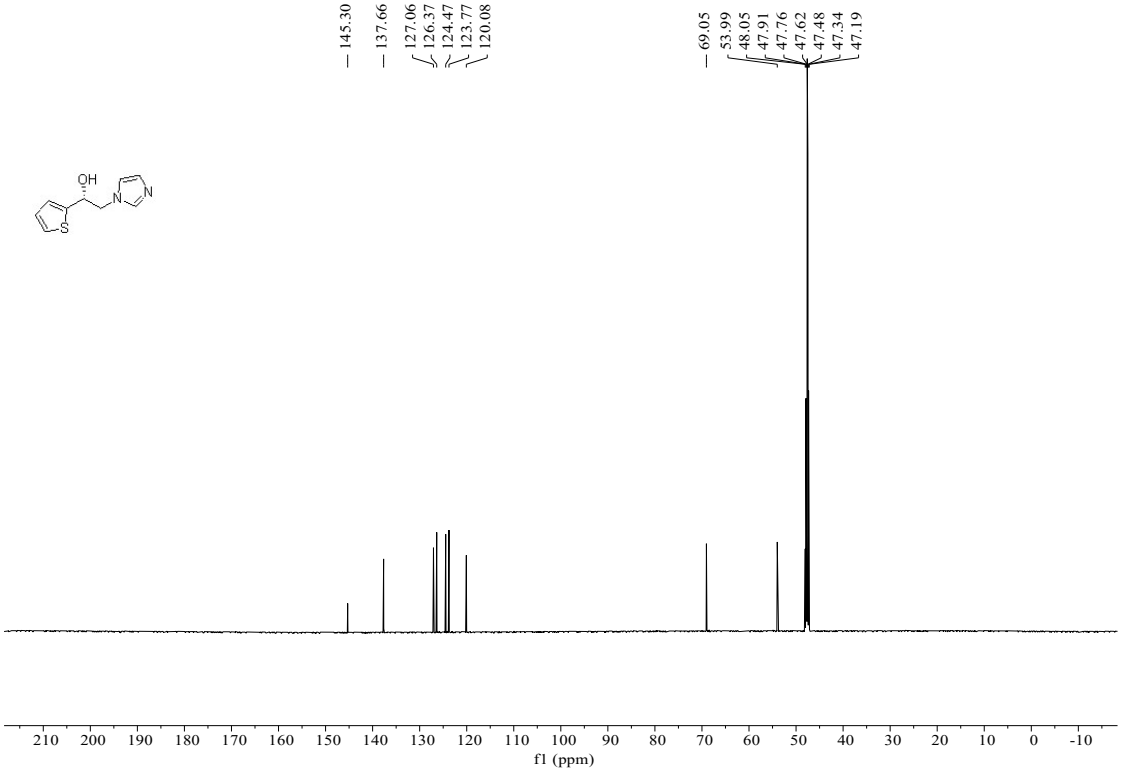
^{13}C NMR (151 MHz, CD_3OD) of **2n**:



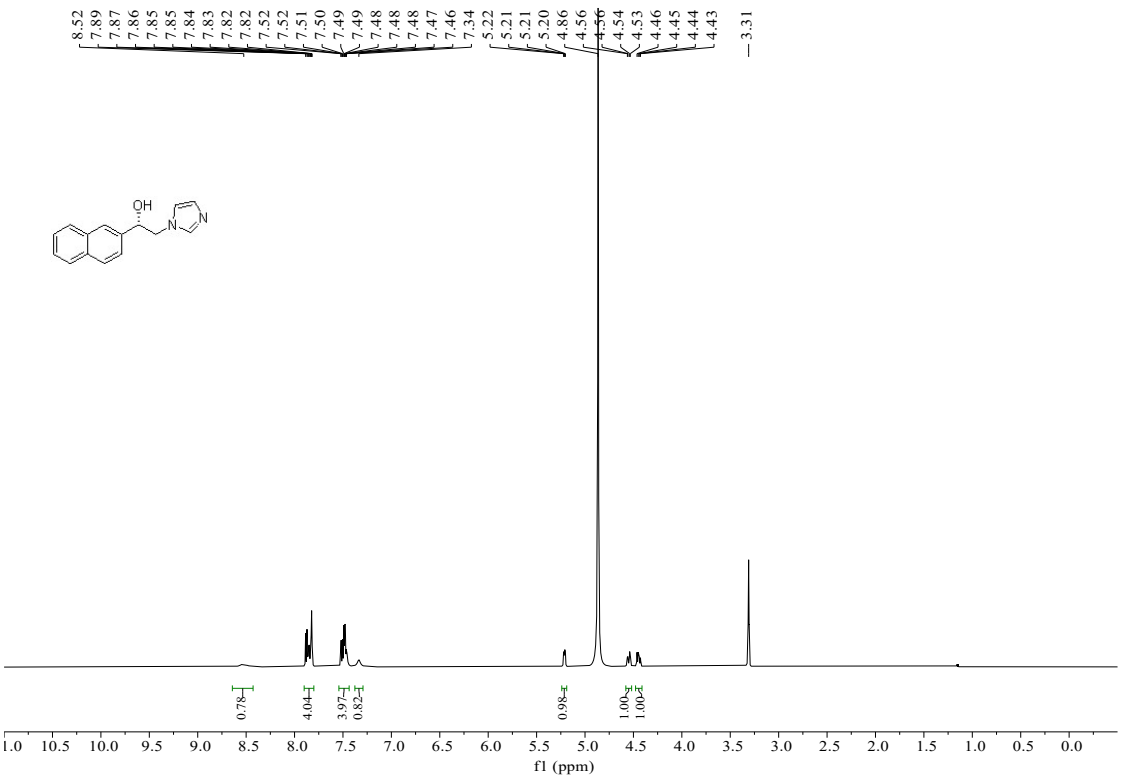
^{1}H NMR (600 MHz, CD_3OD) of **2o**:



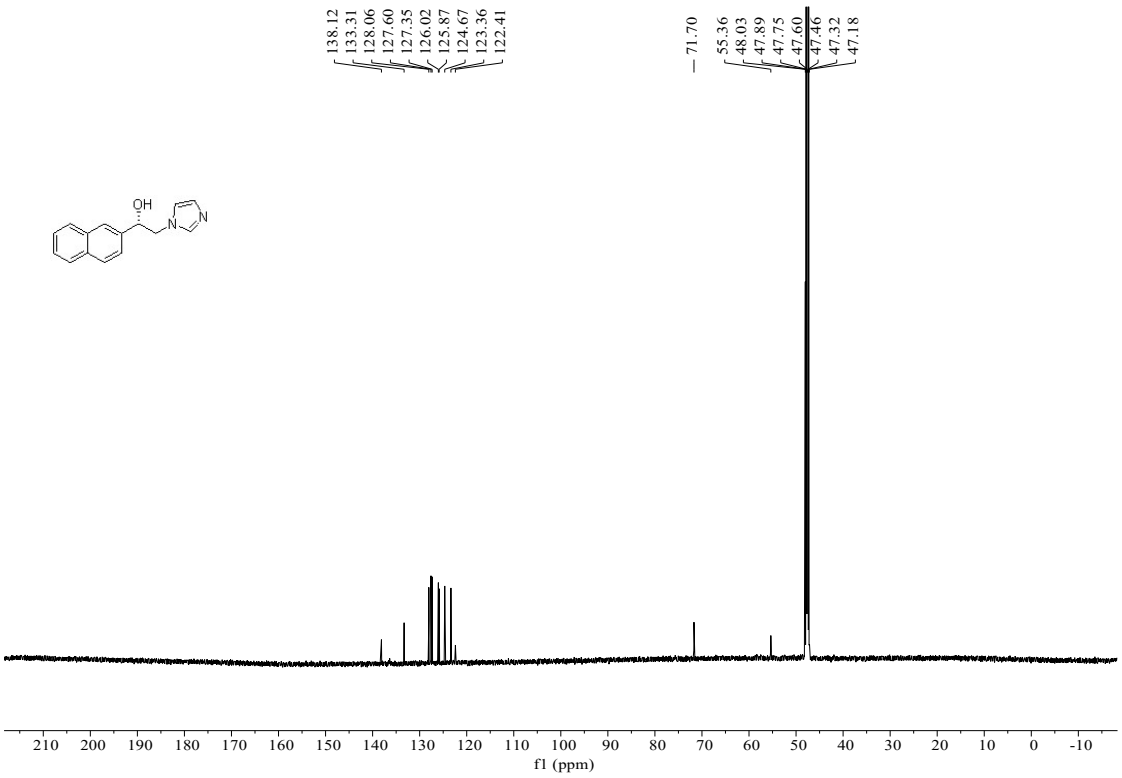
^{13}C NMR (151 MHz, CD_3OD) of **2o**:



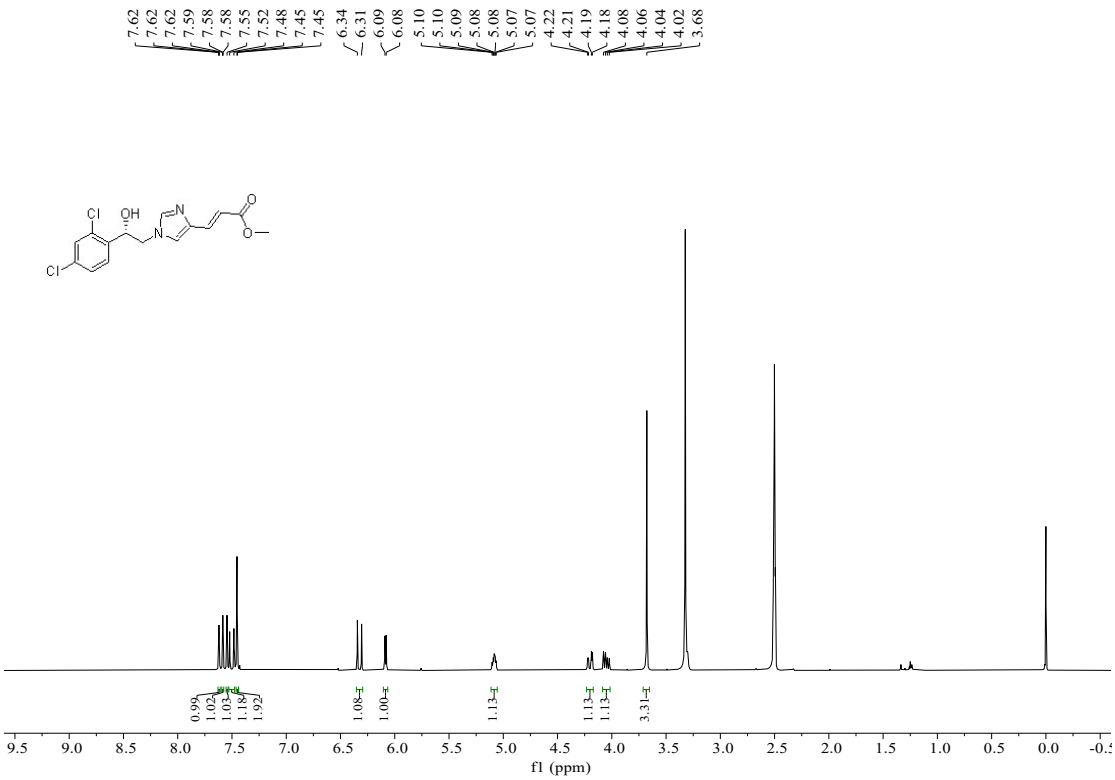
^{1}H NMR (600 MHz, CD_3OD) of **2p**:



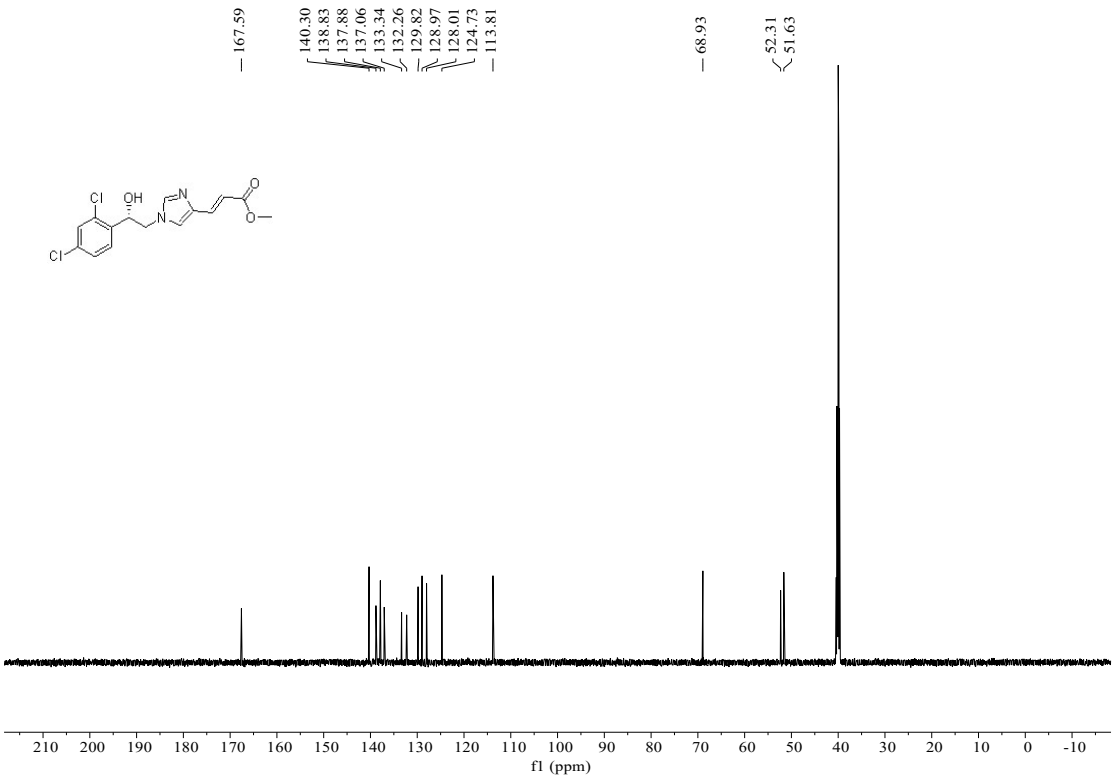
^{13}C NMR (151 MHz, CD_3OD) of **2p**:



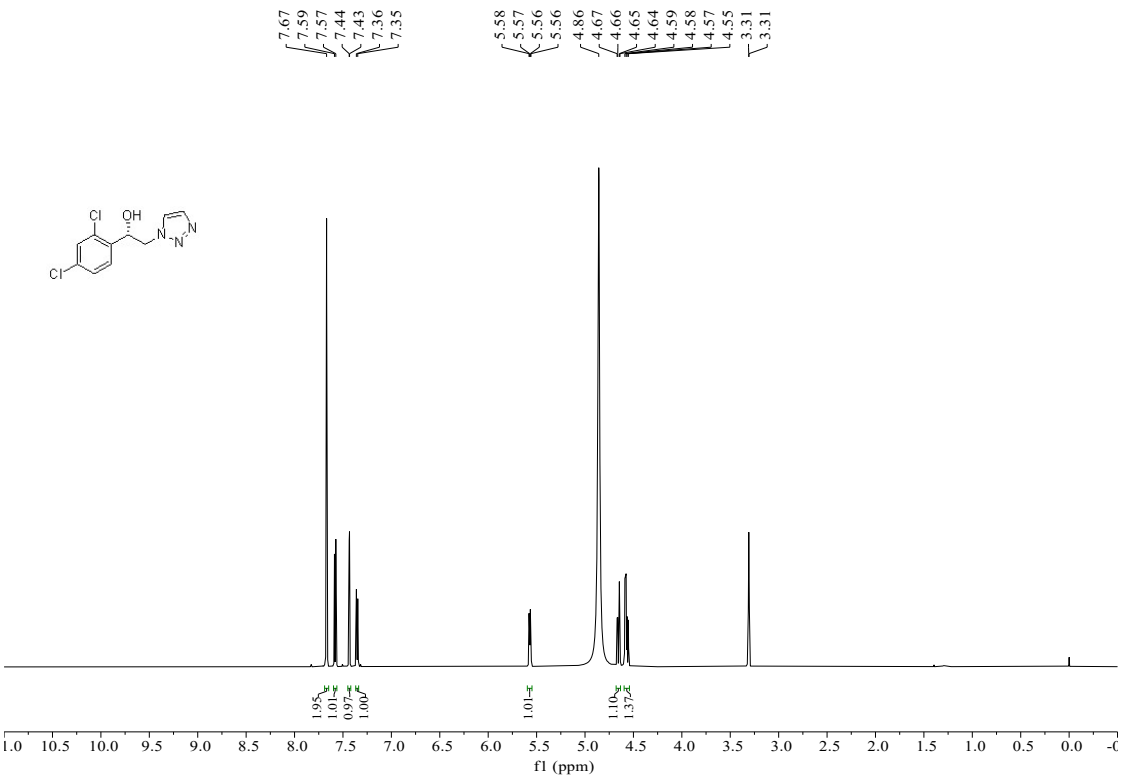
^{1}H NMR (400 MHz, DMSO-d_6) of **2q**:



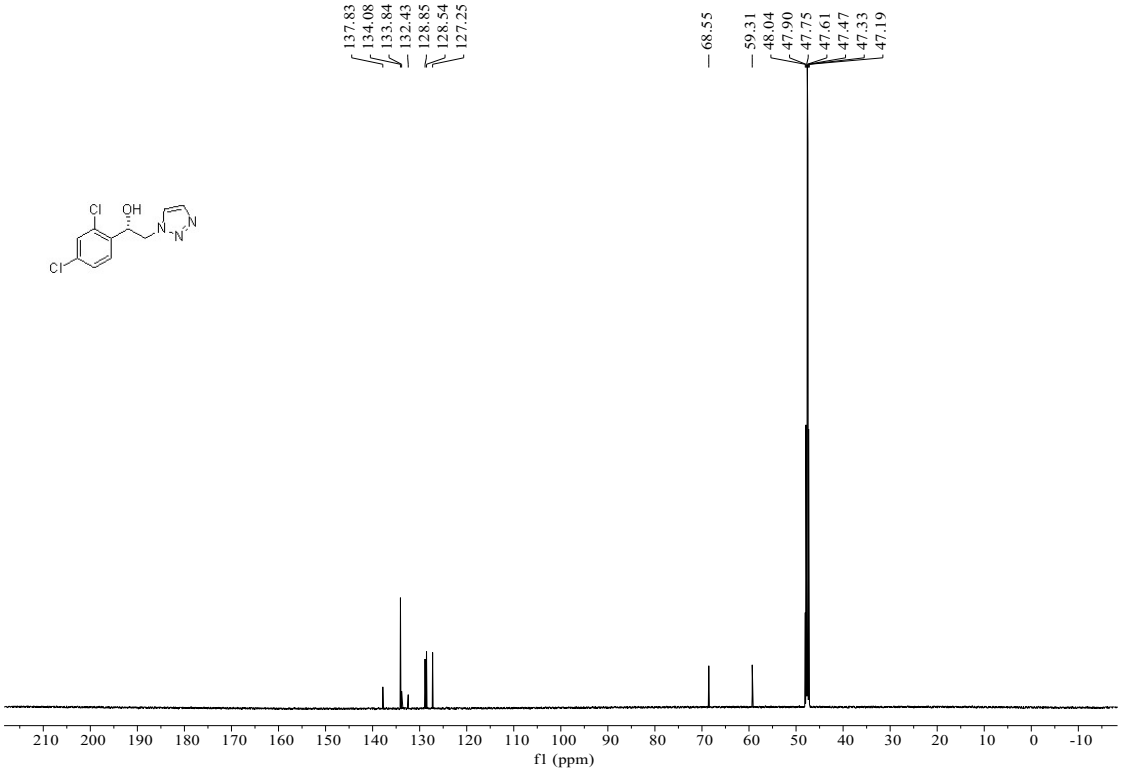
^{13}C NMR (151 MHz, DMSO-d_6) of **2q**:



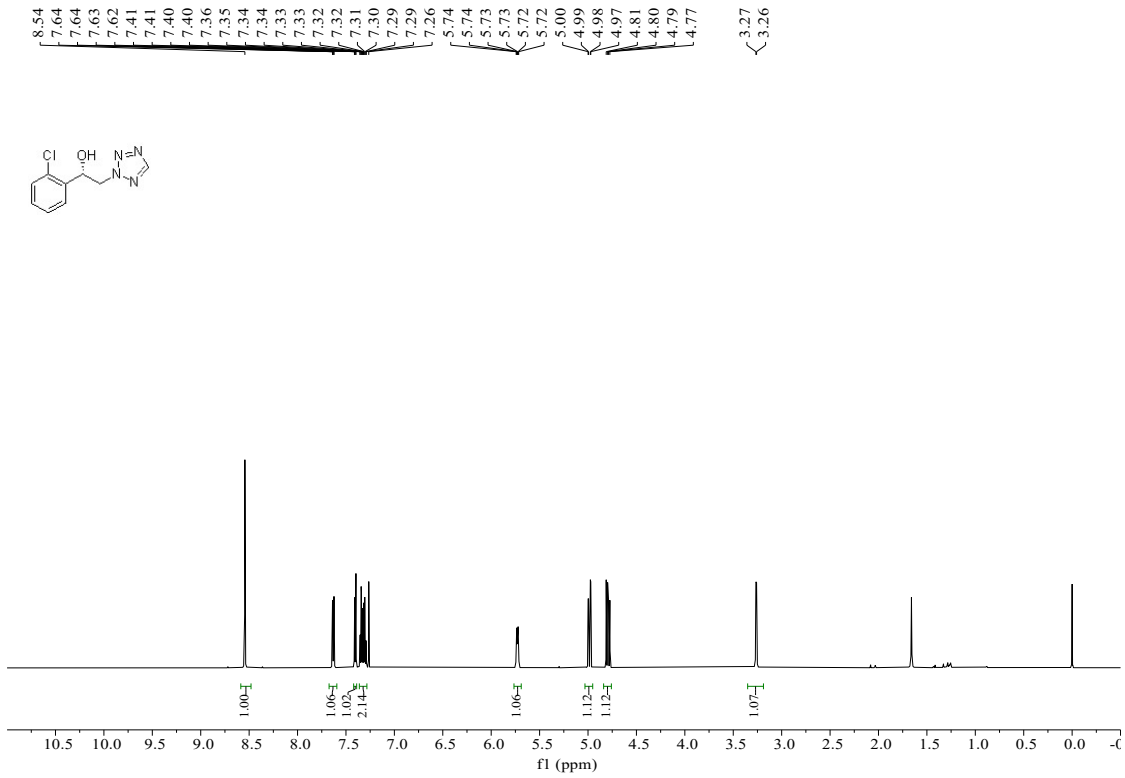
^{1}H NMR (600 MHz, CD_3OD) of **2r**:



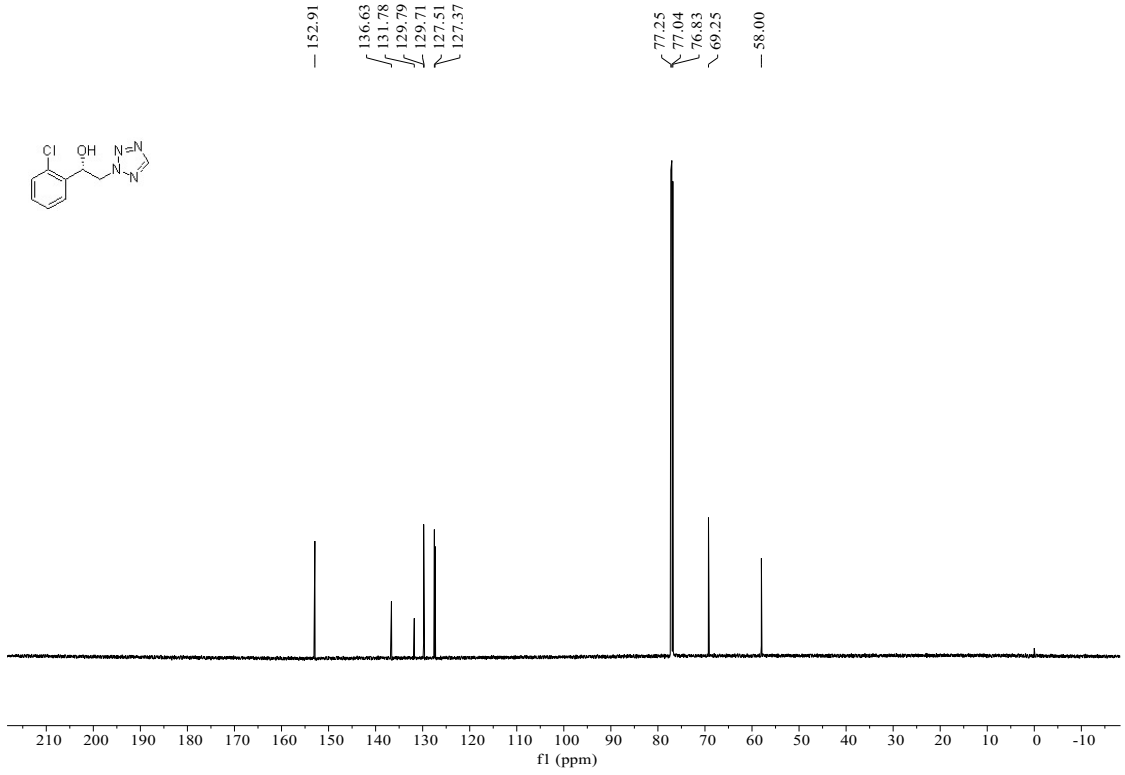
^{13}C NMR (151 MHz, CD_3OD) of **2r**:



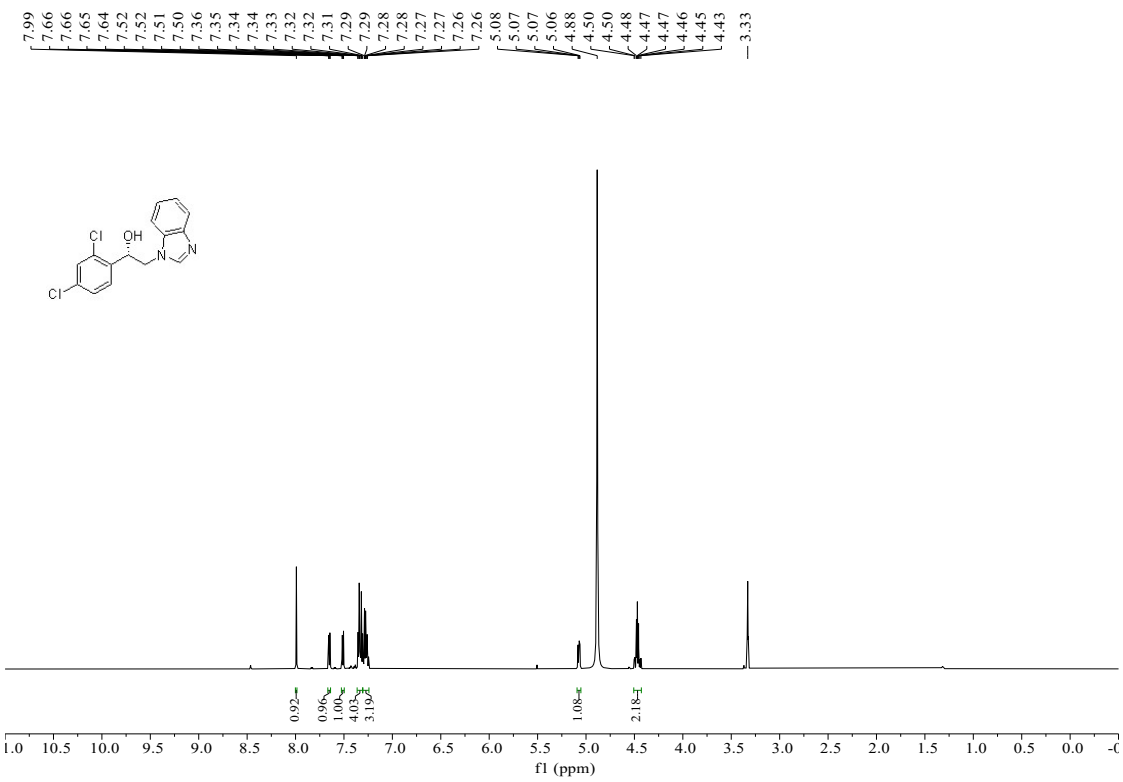
^{1}H NMR (600 MHz, $CDCl_3$) of **2s**:



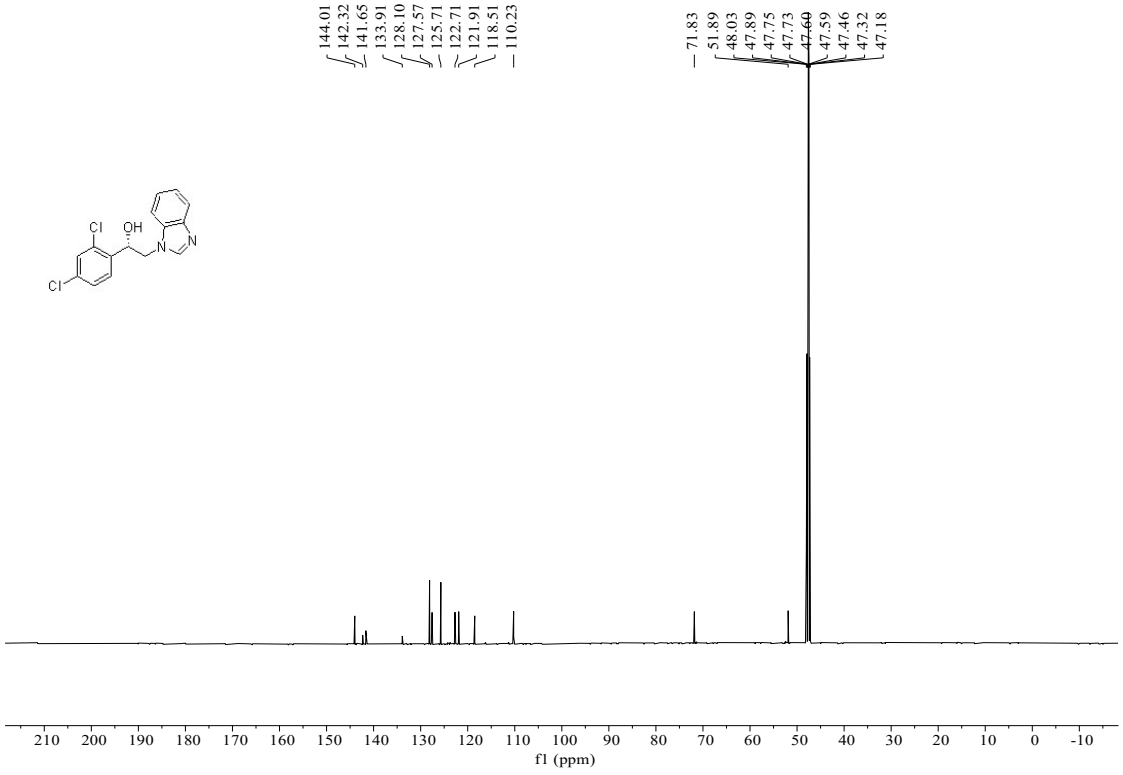
^{13}C NMR (151 MHz, $CDCl_3$) of **2s**:



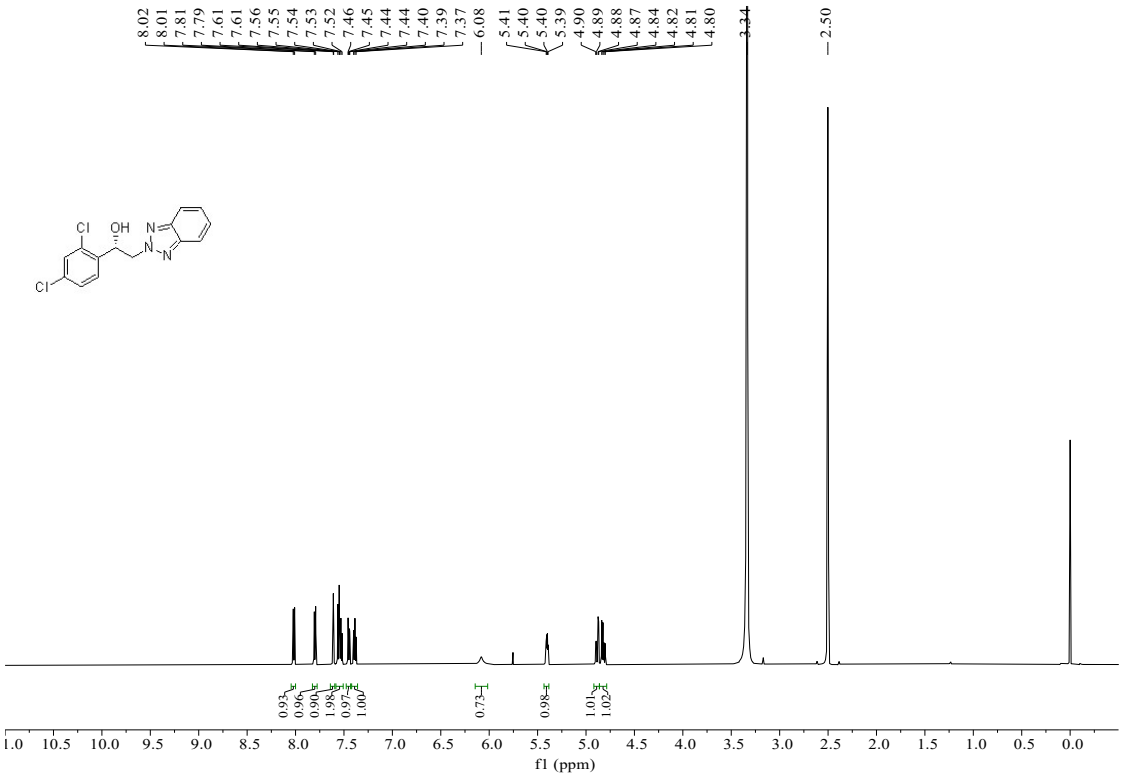
^{1}H NMR (600 MHz, CD_3OD) of **2t**:



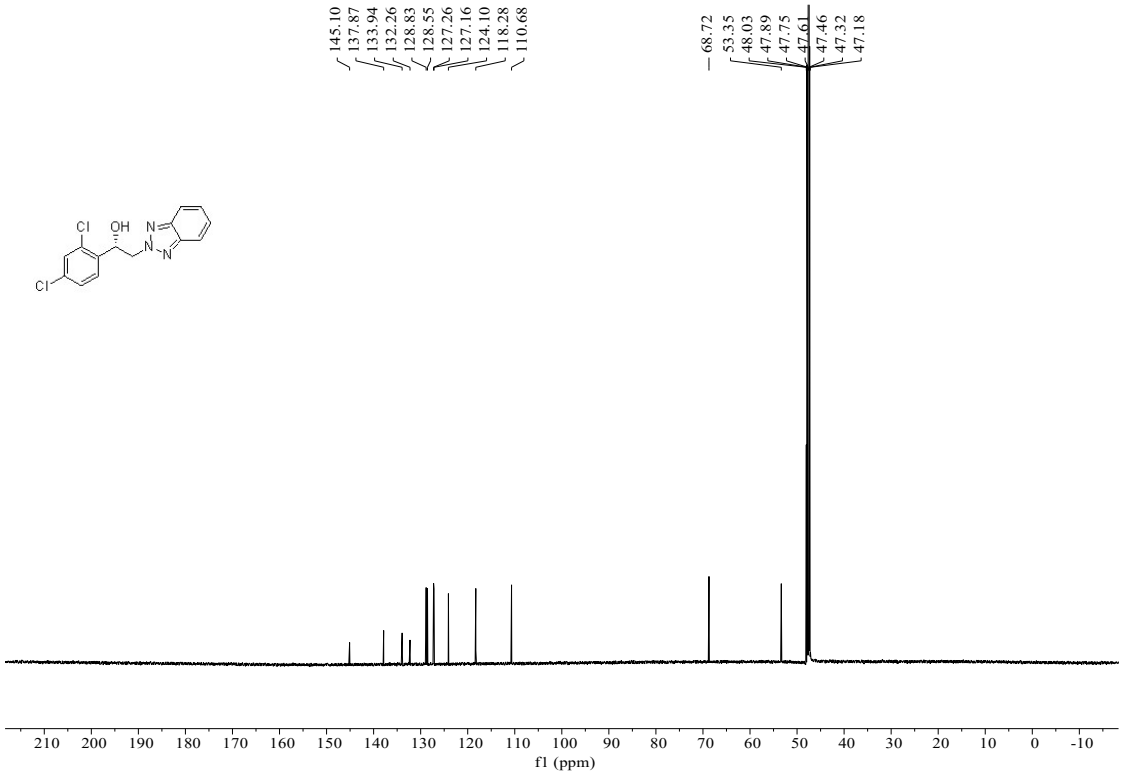
^{13}C NMR (151 MHz, CD_3OD) of **2t**:



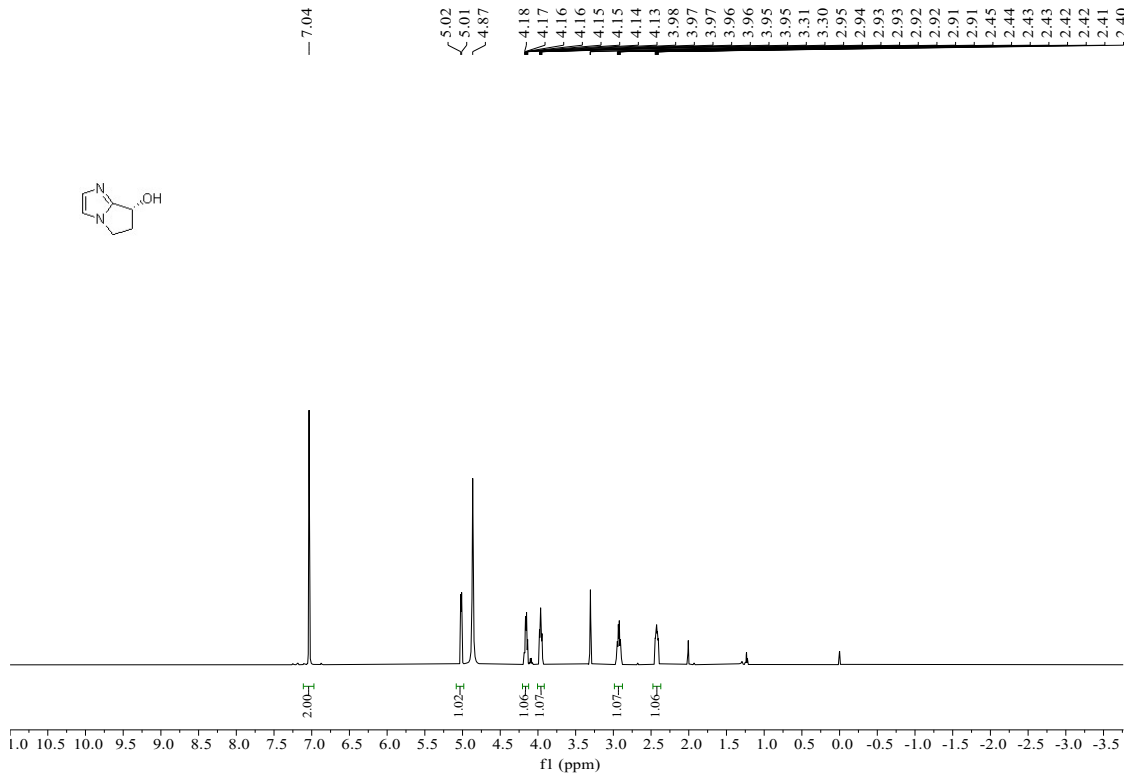
^{1}H NMR (600 MHz, DMSO-d_6) of **2u**:



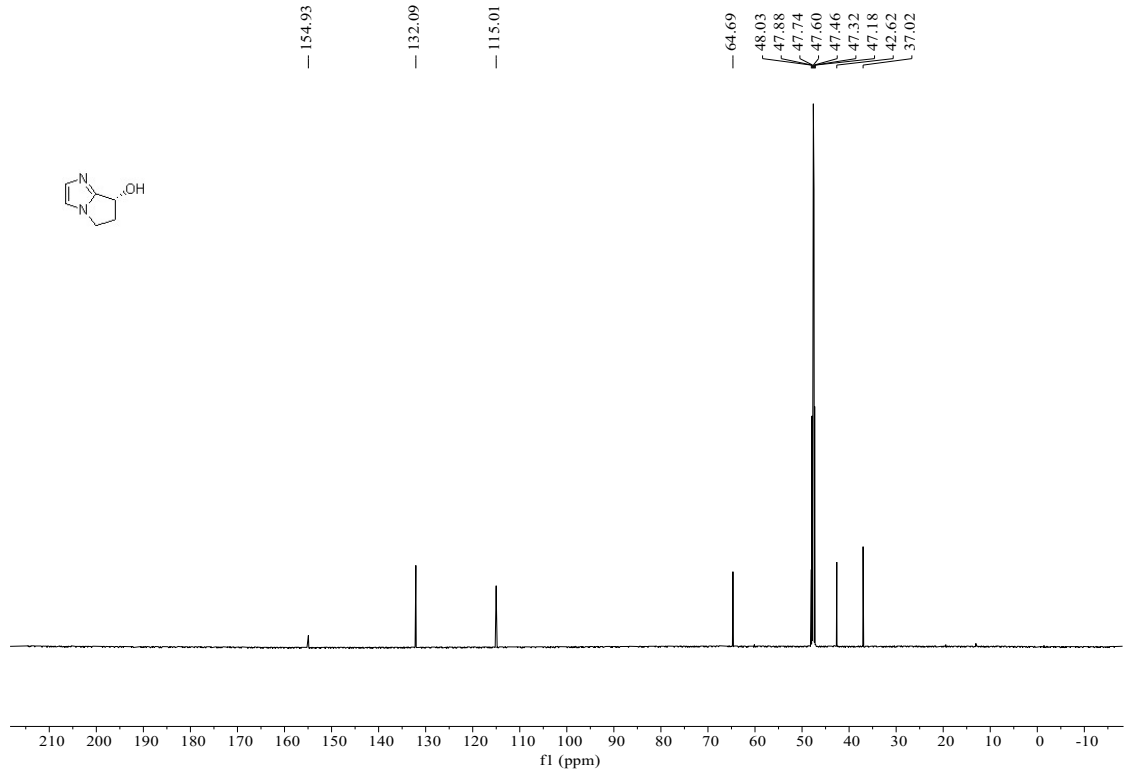
^{13}C NMR (151 MHz, CD_3OD) of **2u**:



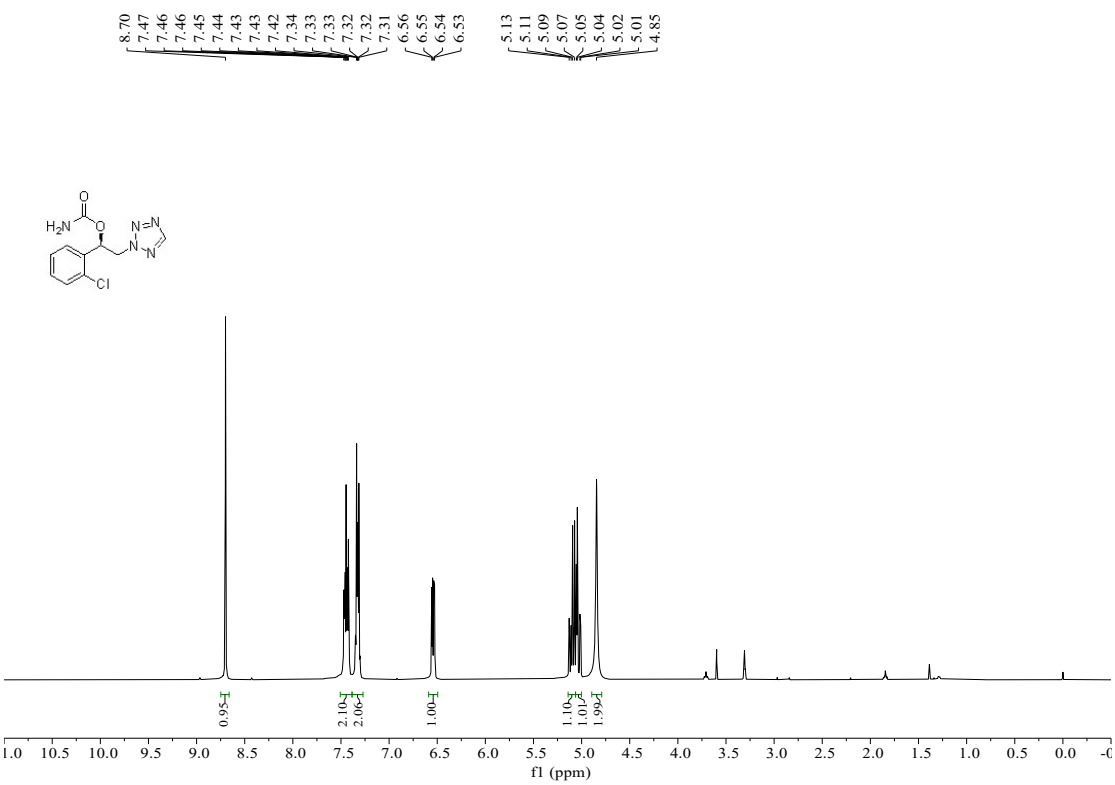
^{1}H NMR (600 MHz, CD_3OD) of **2v**:



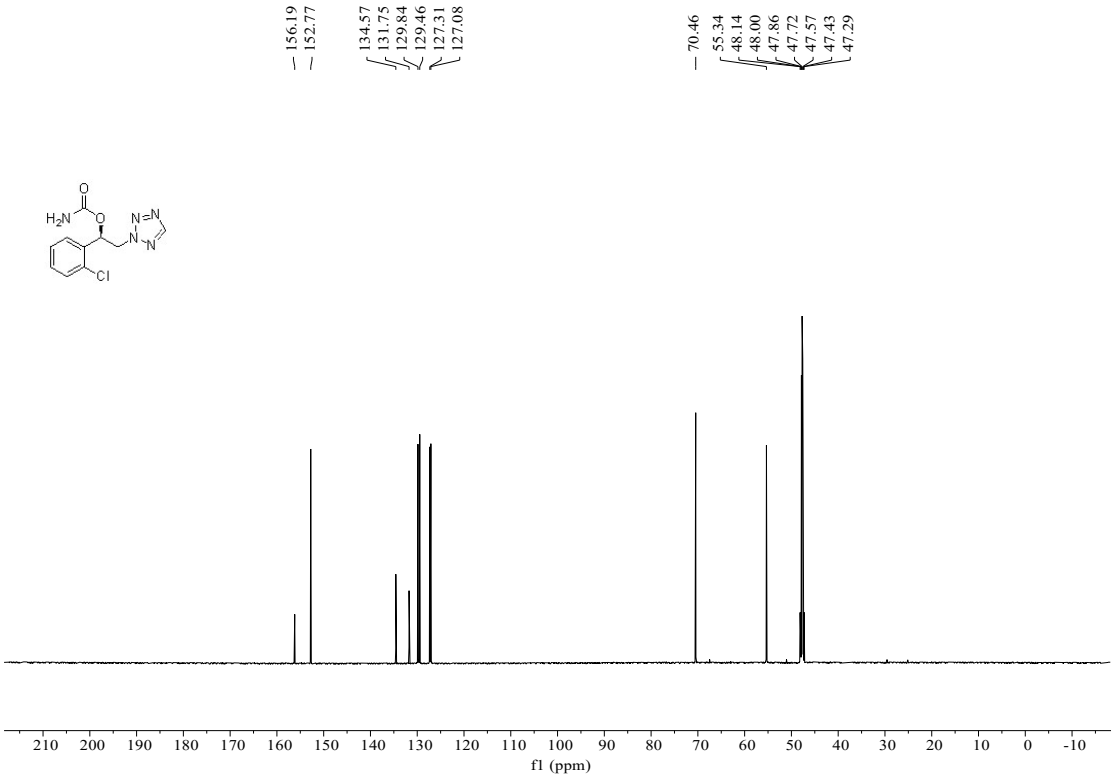
^{13}C NMR (151 MHz, CD_3OD) of **2v**:



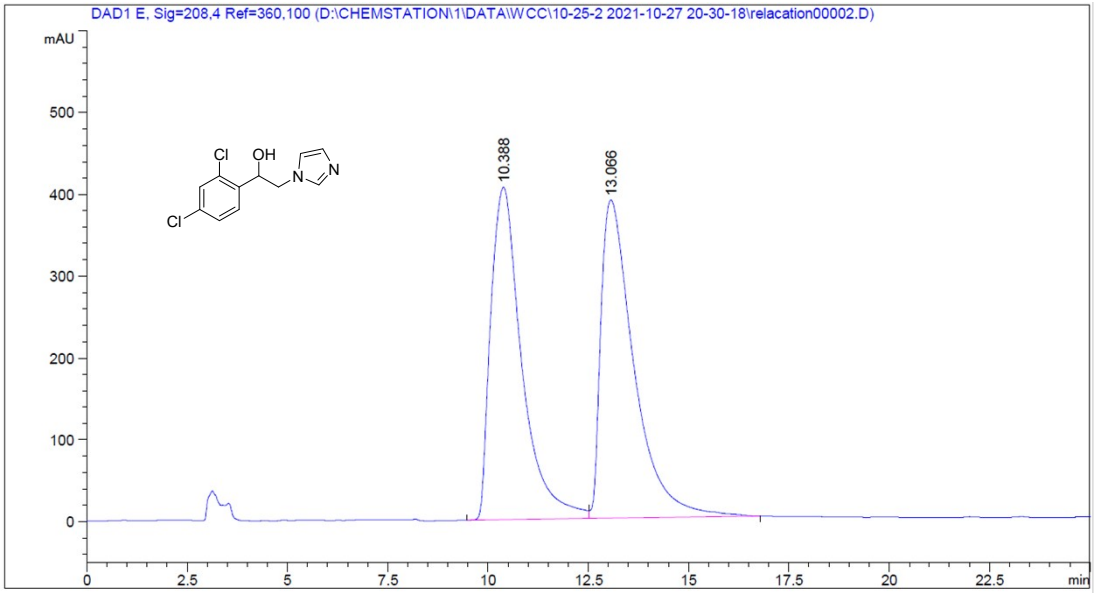
^{1}H NMR (400 MHz, CD_3OD) of **3s**:



^{13}C NMR (101 MHz, CD_3OD) of **3s**:

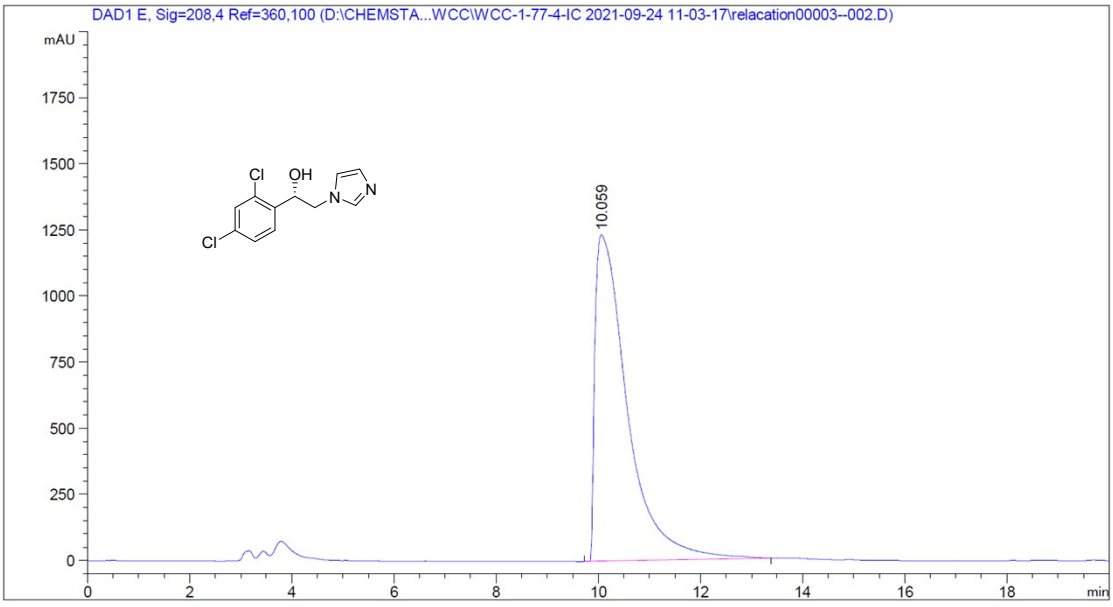


6. HPLC spectra



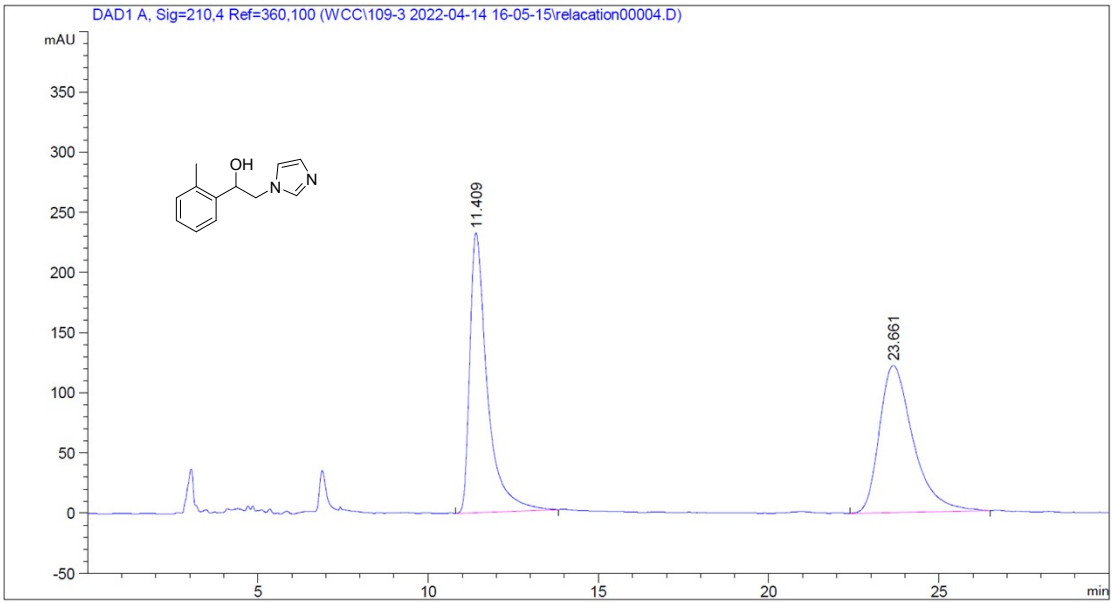
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.388	BV	0.8300	2.18737e4	406.34833	49.4832
2	13.066	VB	0.8675	2.23306e4	389.11380	50.5168
Totals :				4.42043e4	795.46213	



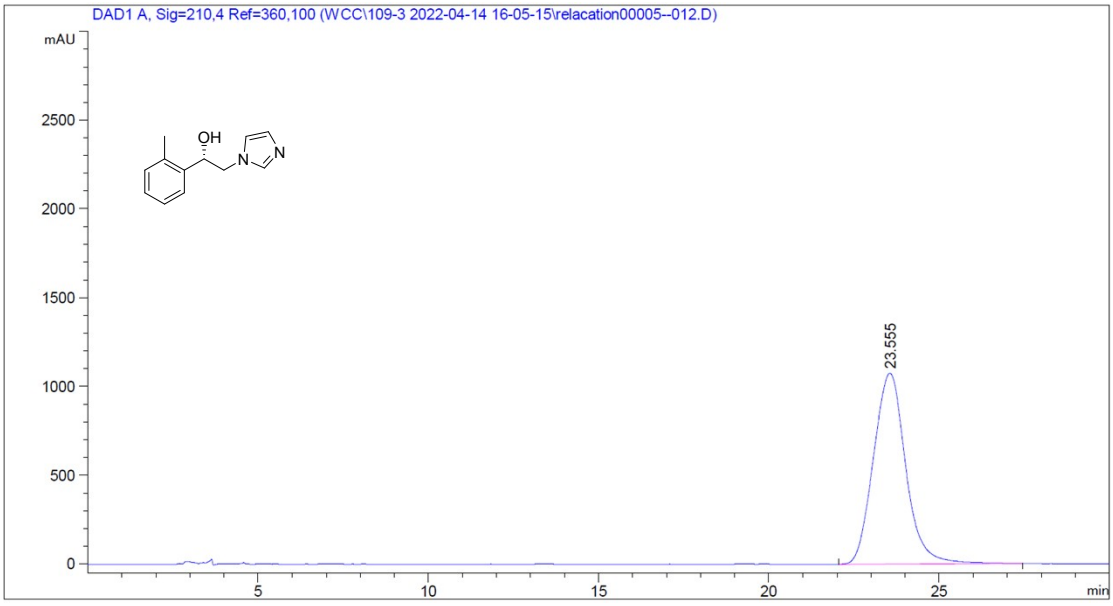
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.059	BB	0.6726	5.42146e4	1233.79675	100.0000



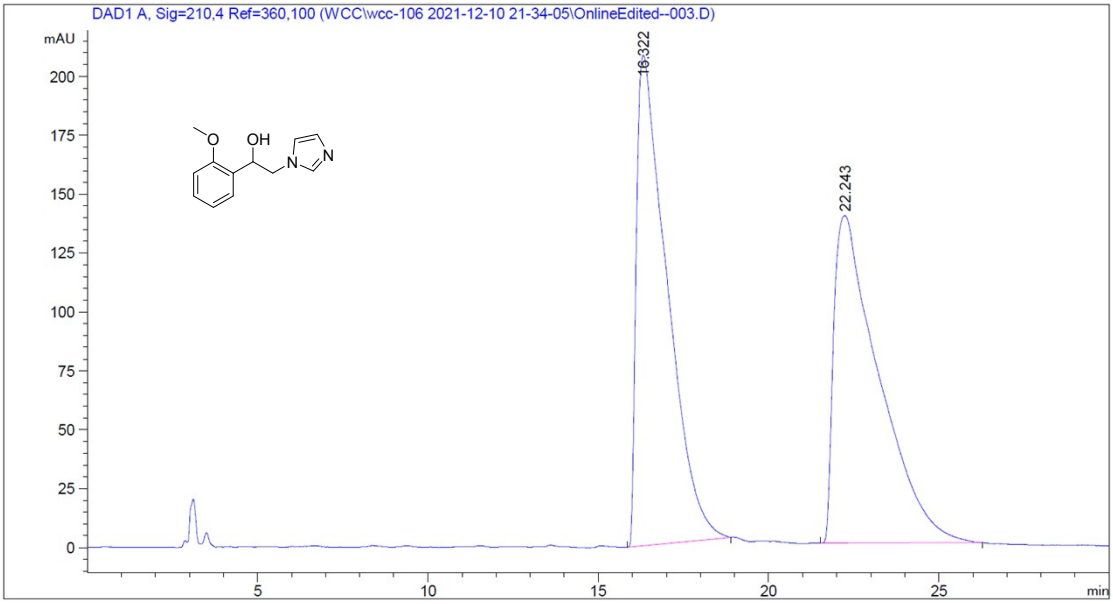
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.409	BB	0.5263	8291.38867	232.36989	49.6316
2	23.661	BB	1.0394	8414.48047	122.18788	50.3684
Totals :				1.67059e4	354.55777	



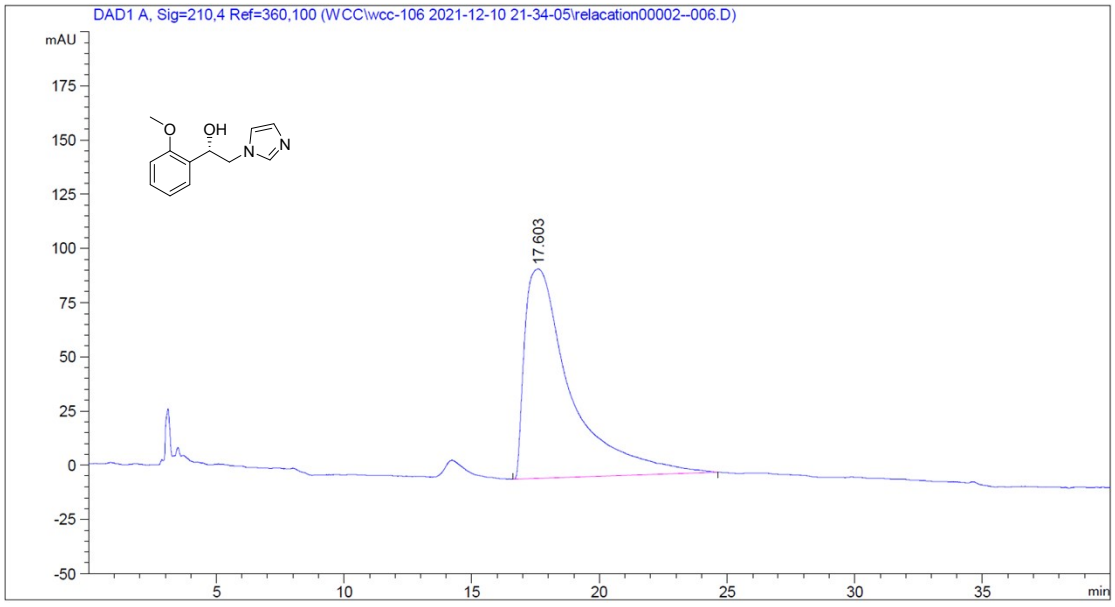
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.555	BB	1.0231	7.08493e4	1074.67920	100.0000
Totals :				7.08493e4	1074.67920	



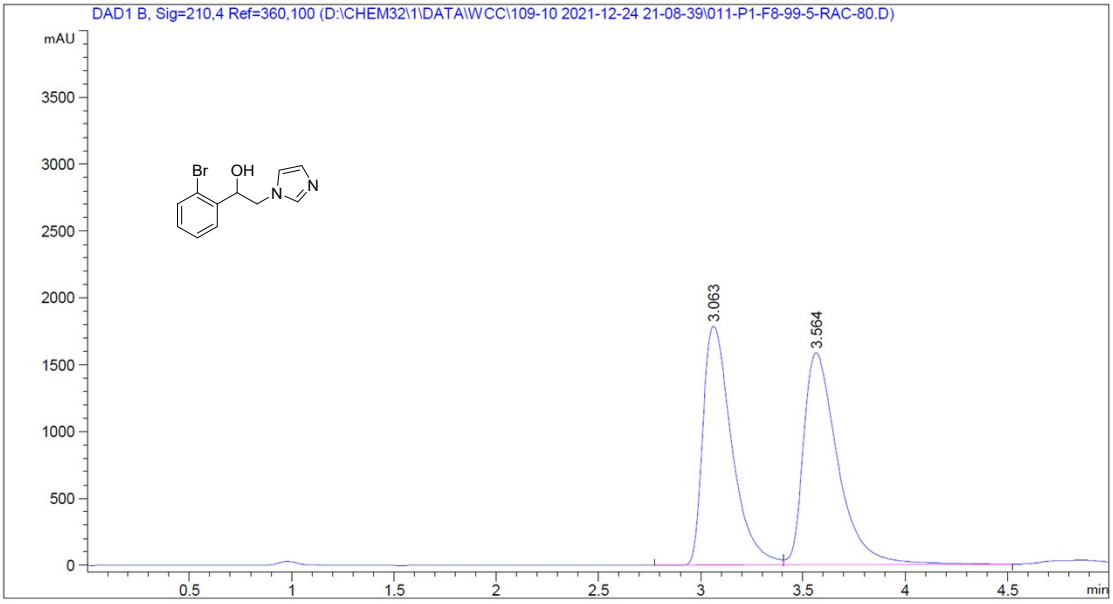
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.322	BB	0.8488	1.30053e4	208.18881	50.4193
2	22.243	BB	1.1455	1.27890e4	138.99339	49.5807



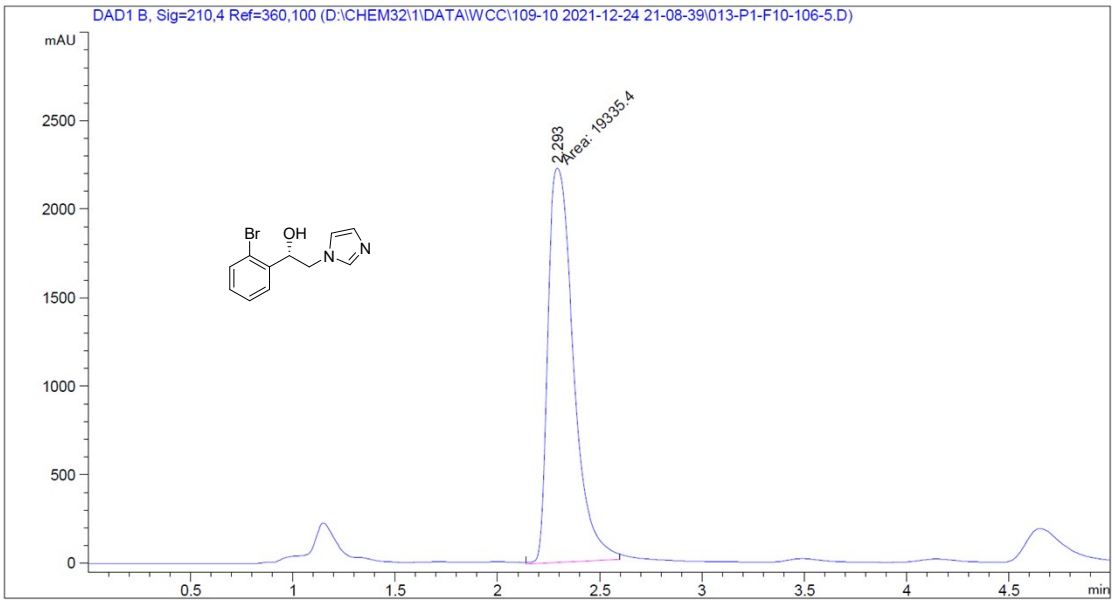
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.603	BB	1.5081	1.22038e4	96.58673	100.0000
Totals :				1.22038e4	96.58673	



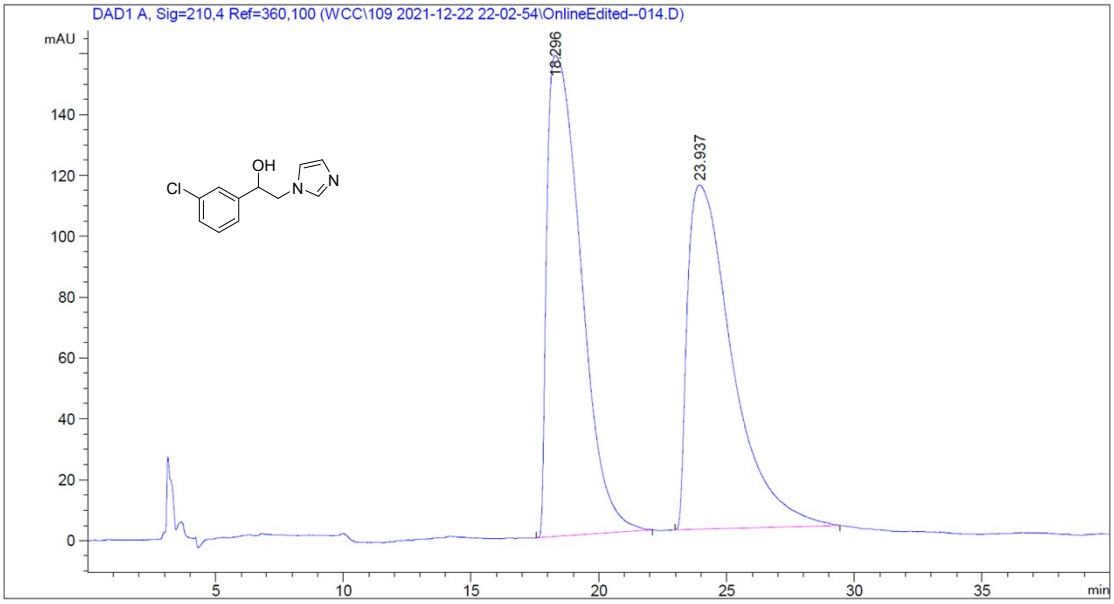
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.063	BV	0.1508	1.76086e4	1789.19788	48.7634
2	3.564	VB	0.1781	1.85017e4	1586.24841	51.2366
Totals :				3.61102e4	3375.44629	



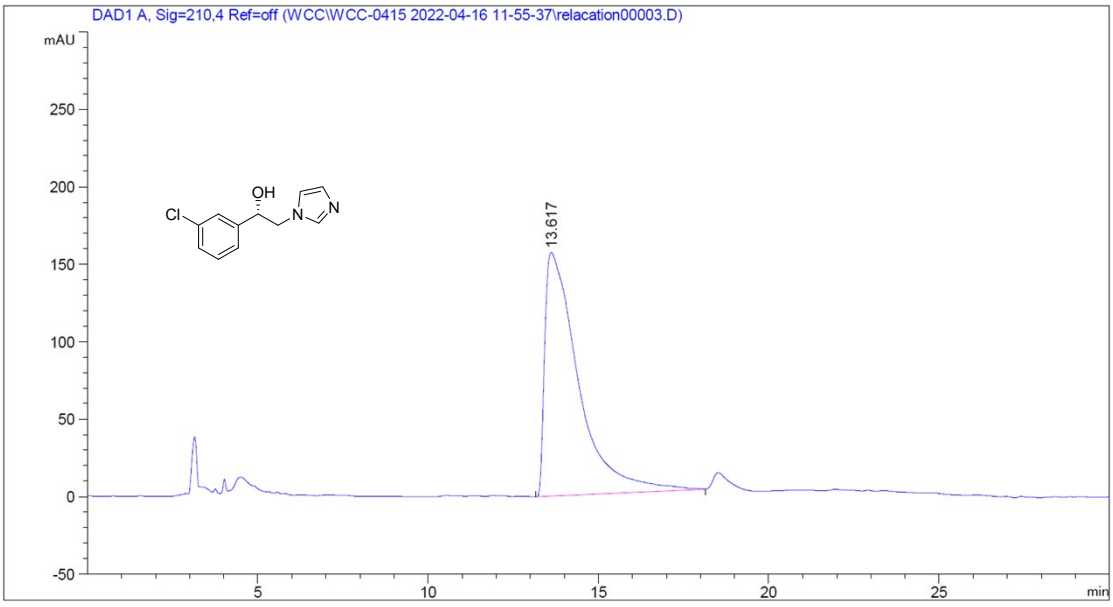
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.293	MM	0.1446	1.93354e4	2229.32056	100.0000
Totals :				1.93354e4	2229.32056	



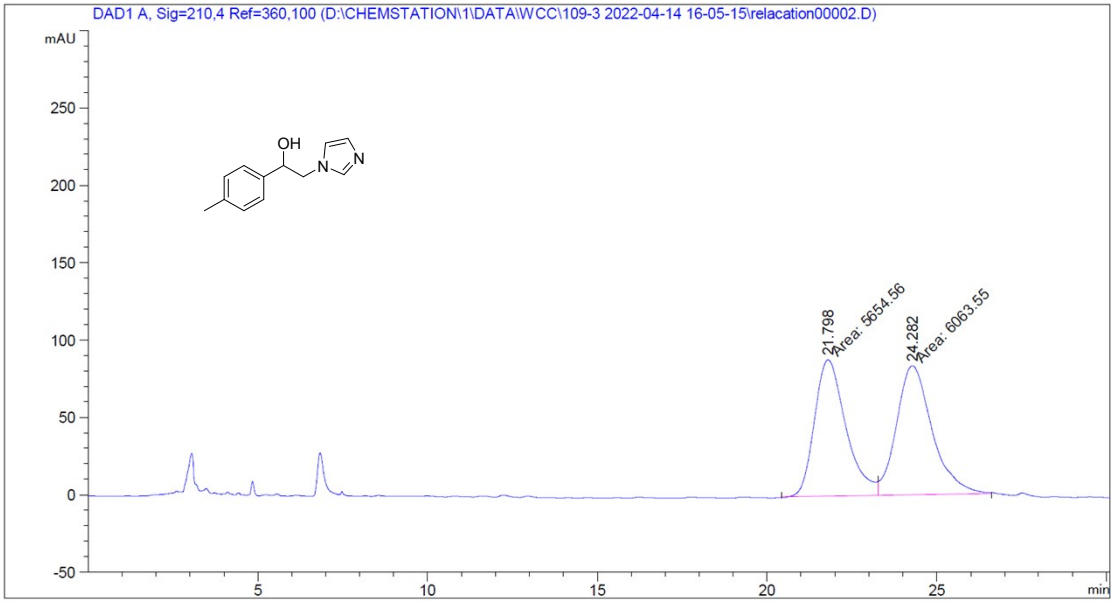
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.296	BB	1.2264	1.45578e4	158.08727	51.3504
2	23.937	BB	1.5067	1.37921e4	113.10023	48.6496
Totals :				2.83499e4	271.18750	



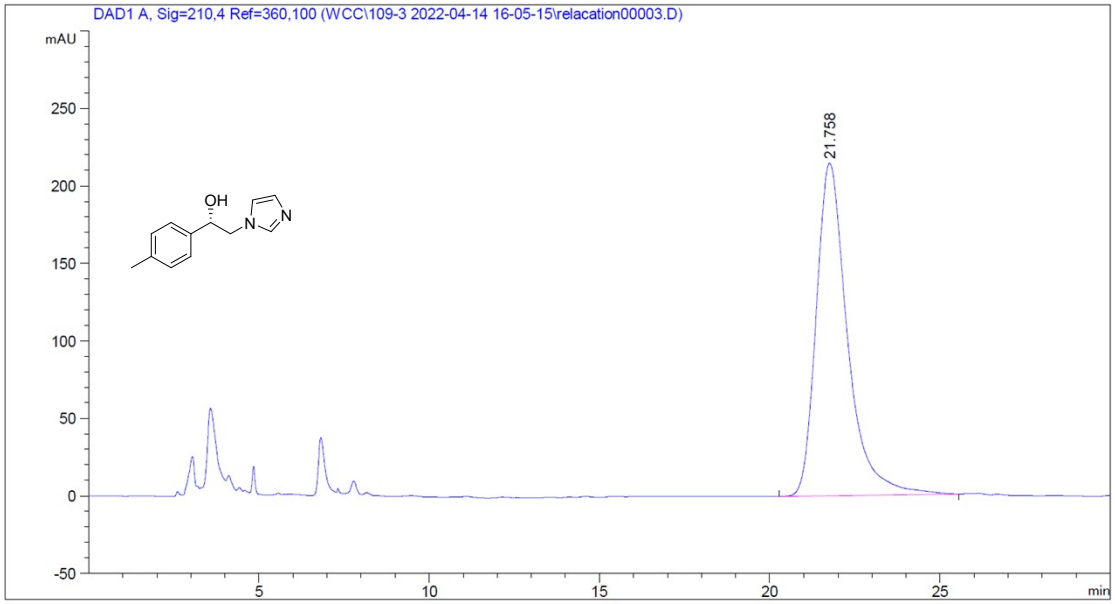
Signal 1: DAD1 A, Sig=210,4 Ref=off

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.617	BB	0.9095	1.08159e4	157.44118	100.0000
Totals :				1.08159e4	157.44118	



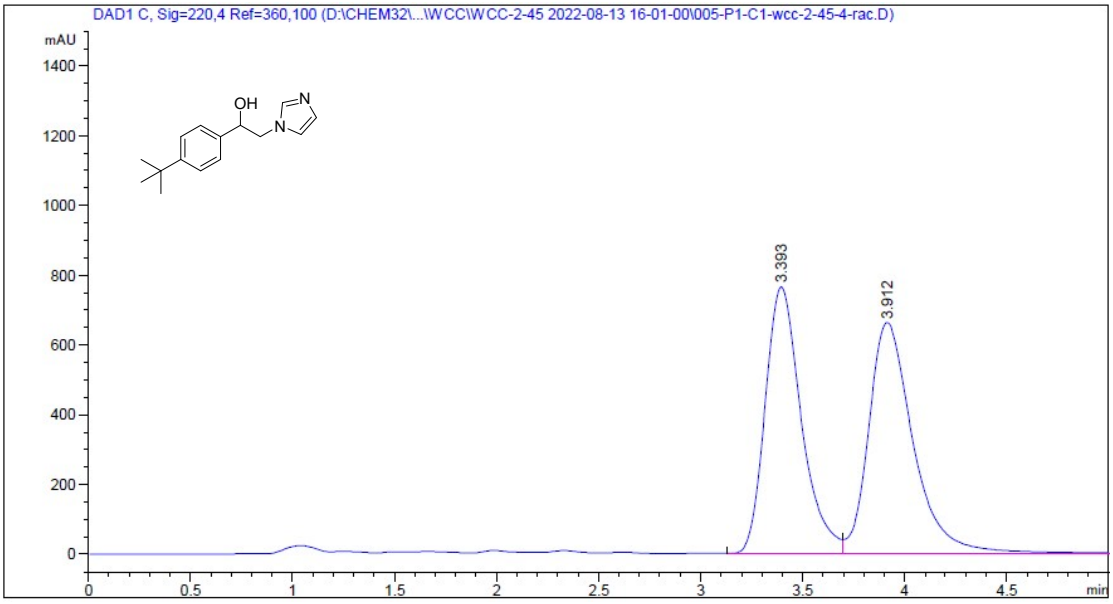
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.798	MF	1.0716	5654.55566	87.94574	48.2549
2	24.282	FM	1.2136	6063.55273	83.26916	51.7451



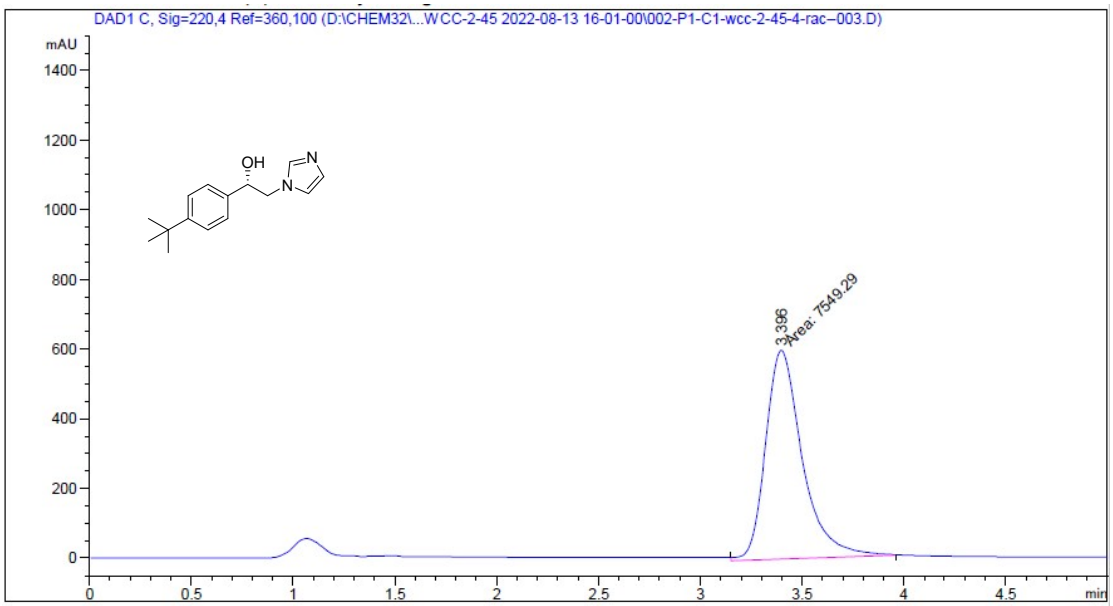
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.758	BB	0.9529	1.37448e4	214.70074	100.0000
Totals :				1.37448e4	214.70074	



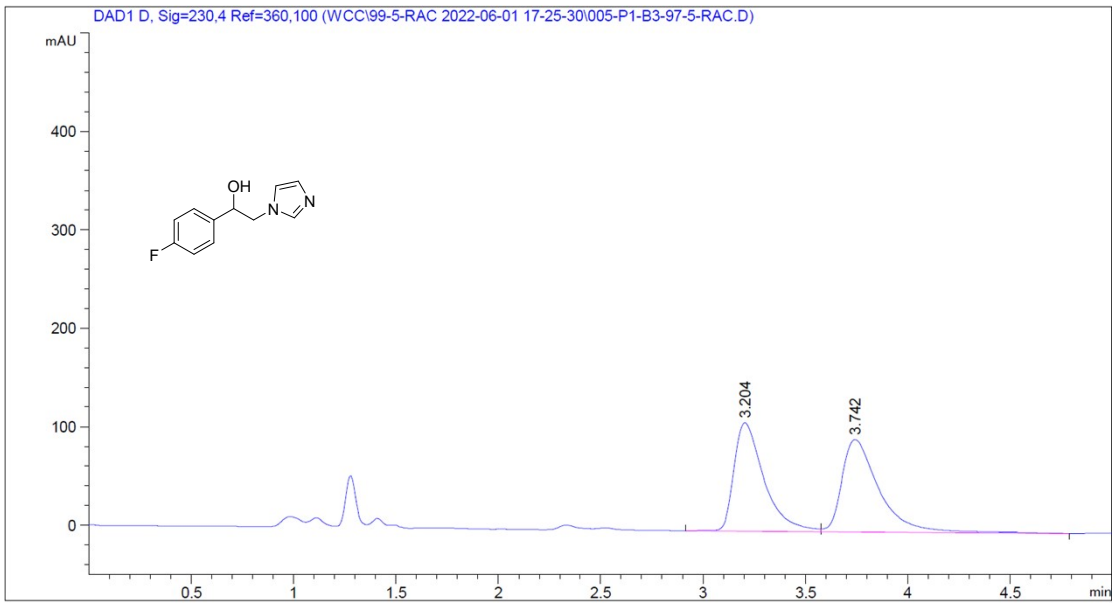
Signal 1: DAD1 C, Sig=220,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.393	BV	0.1870	9383.28320	765.69318	48.2830
2	3.912	VB	0.2289	1.00507e4	662.71301	51.7170
Totals :				1.94339e4	1428.40619	



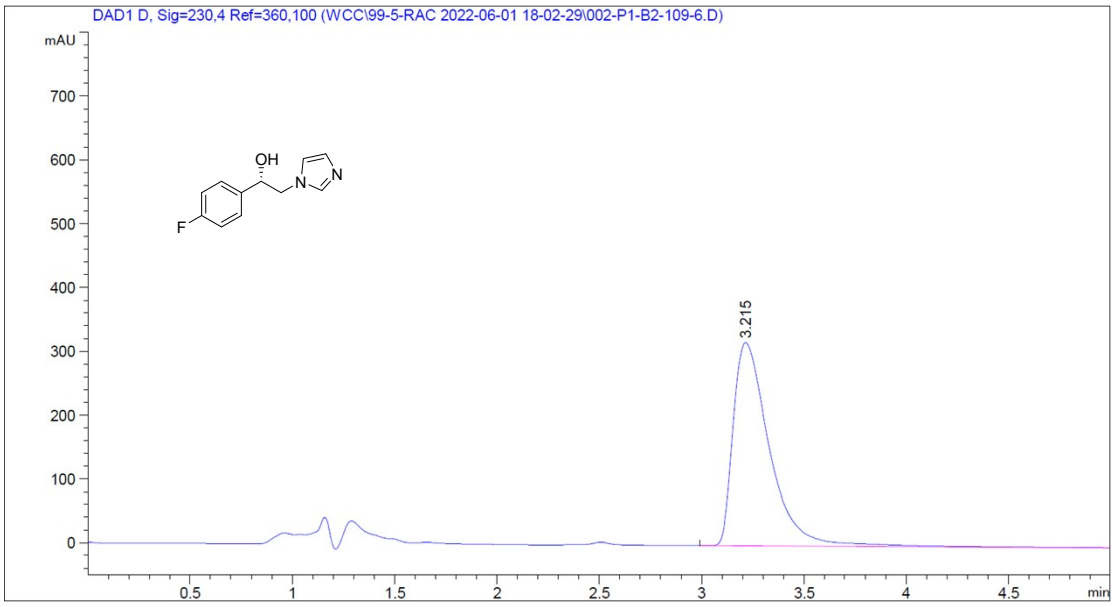
Signal 1: DAD1 C, Sig=220,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.396	MM	0.2094	7549.28662	600.90680	100.0000
Totals :				7549.28662	600.90680	



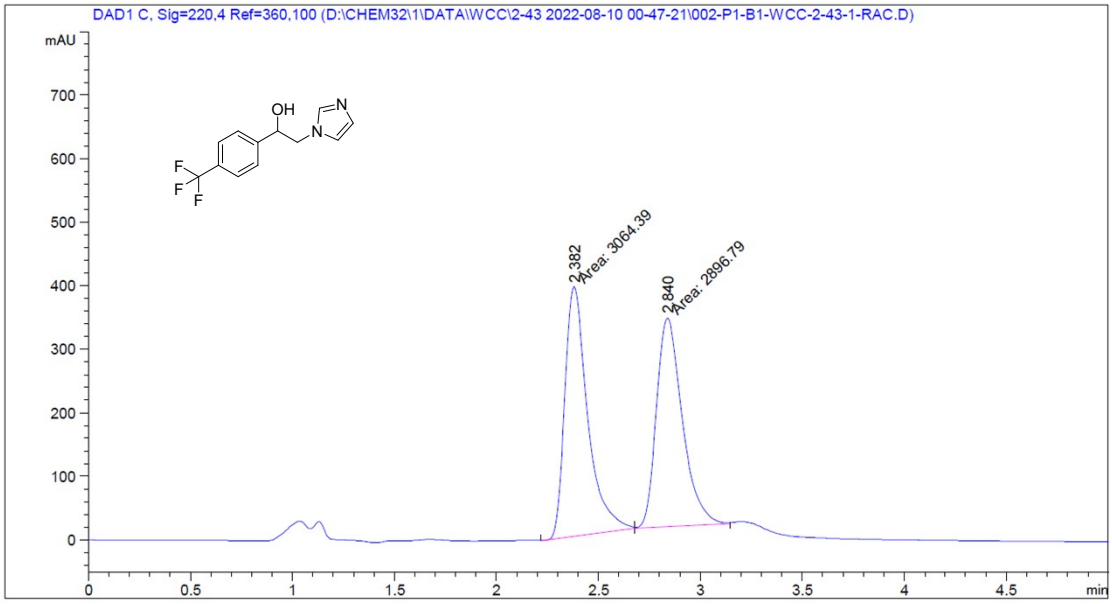
Signal 1: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.204	BV	0.1529	1124.43457	110.36457	48.6112
2	3.742	VB	0.1876	1188.68591	93.93526	51.3888
Totals :				2313.12048	204.29984	



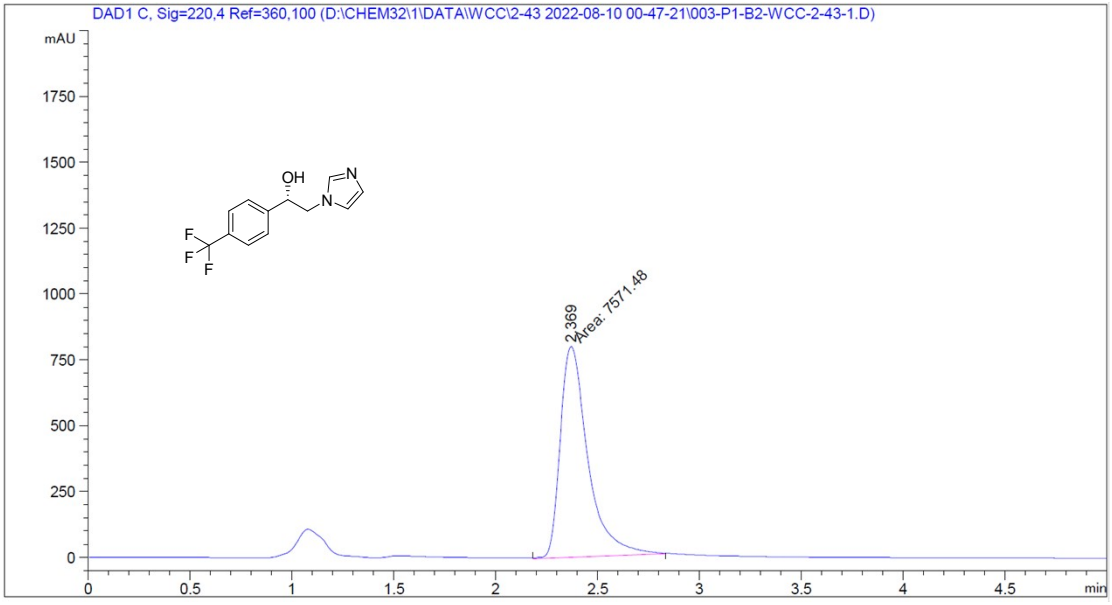
Signal 1: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.215	BBA	0.1909	3958.71265	318.76175	100.0000
Totals :				3958.71265	318.76175	



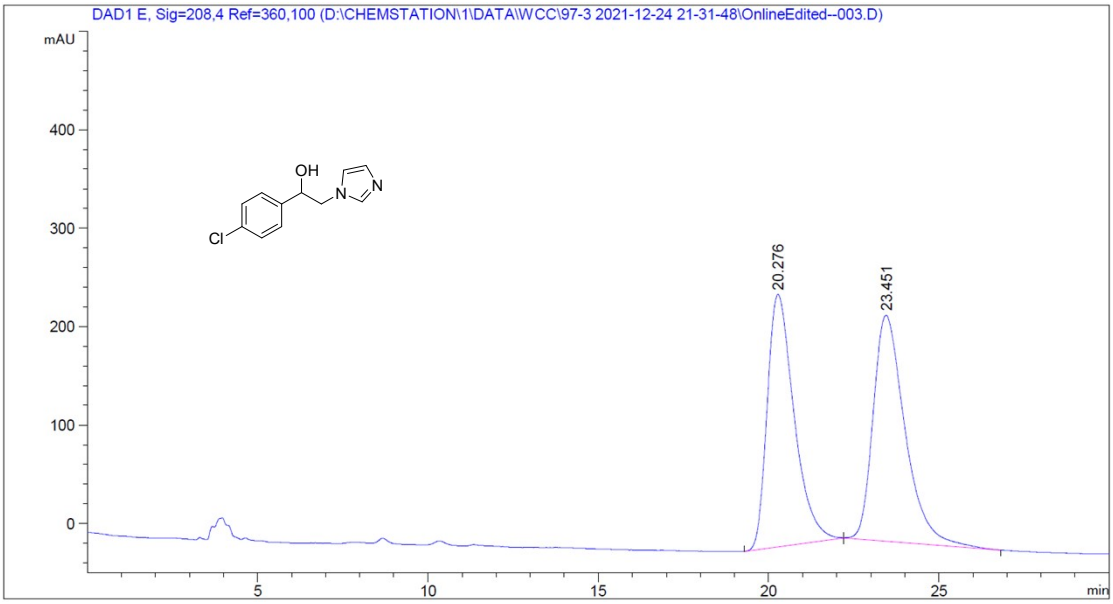
Signal 1: DAD1 C, Sig=220,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.382	MM	0.1297	3064.38647	393.64590	51.4058
2	2.840	MM	0.1469	2896.78735	328.66504	48.5942
Totals :				5961.17383	722.31094	



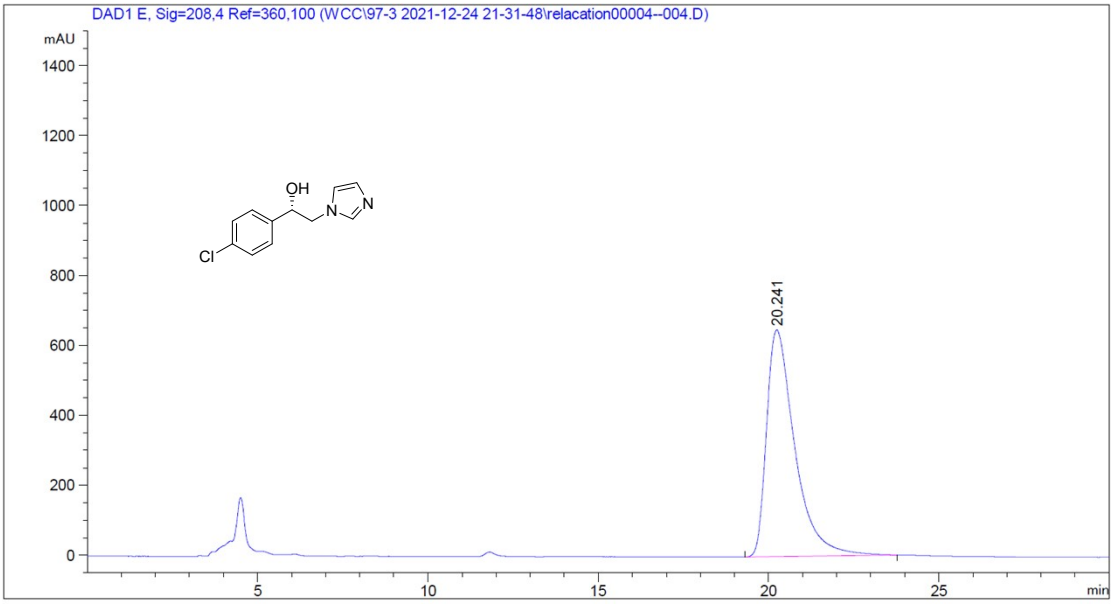
Signal 1: DAD1 C, Sig=220,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.369	MM	0.1575	7571.47803	801.30267	100.0000
Totals :				7571.47803	801.30267	



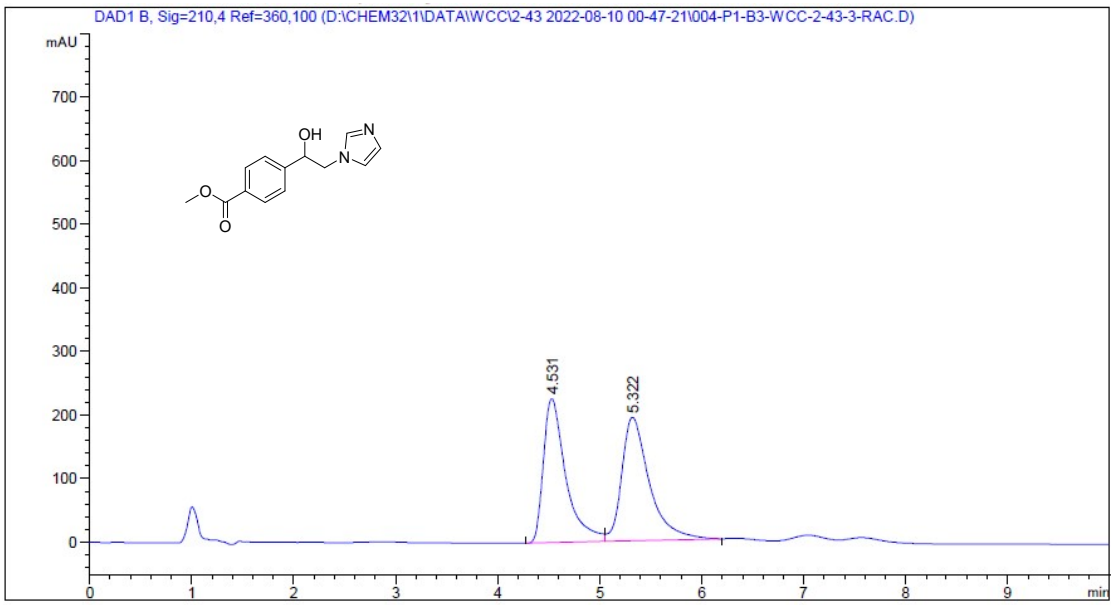
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.276	BB	0.8227	1.40428e4	256.52542	48.4773
2	23.451	BB	0.9292	1.49249e4	229.36137	51.5227



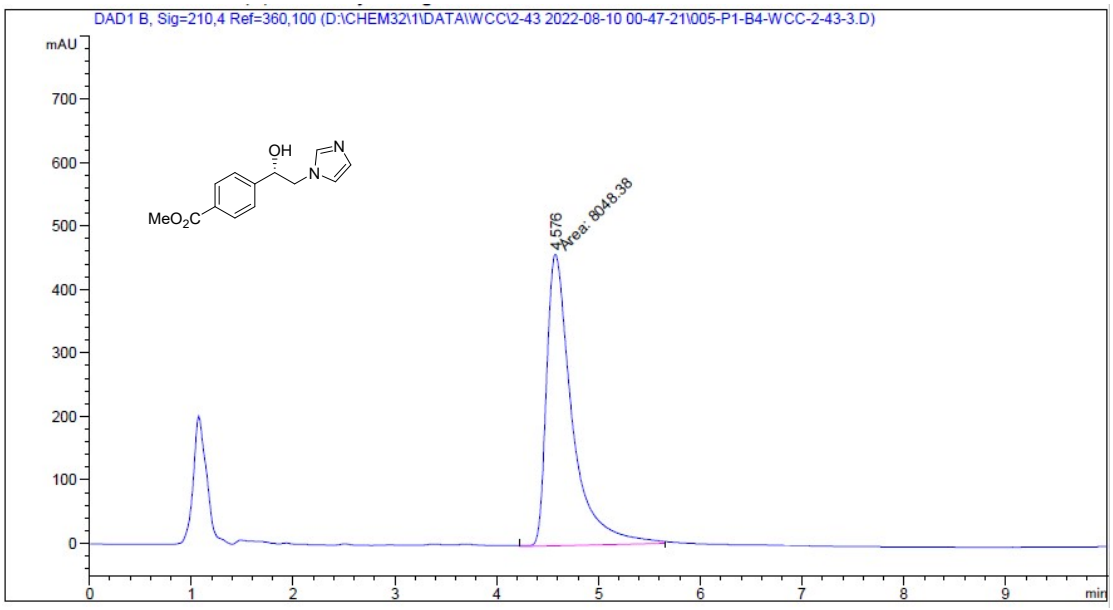
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.241	BB	0.8369	3.74351e4	649.05475	100.0000
Totals :				3.74351e4	649.05475	



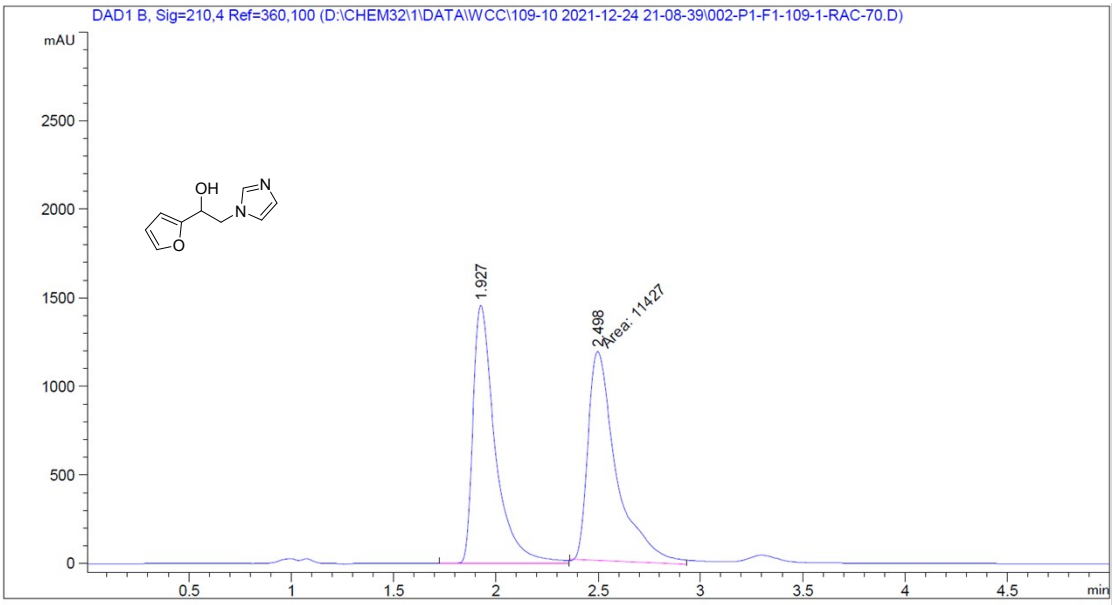
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.531	BV	0.2286	3468.59229	226.54500	48.6715
2	5.322	VB	0.2817	3657.94824	194.20930	51.3285
Totals :				7126.54053	420.75430	

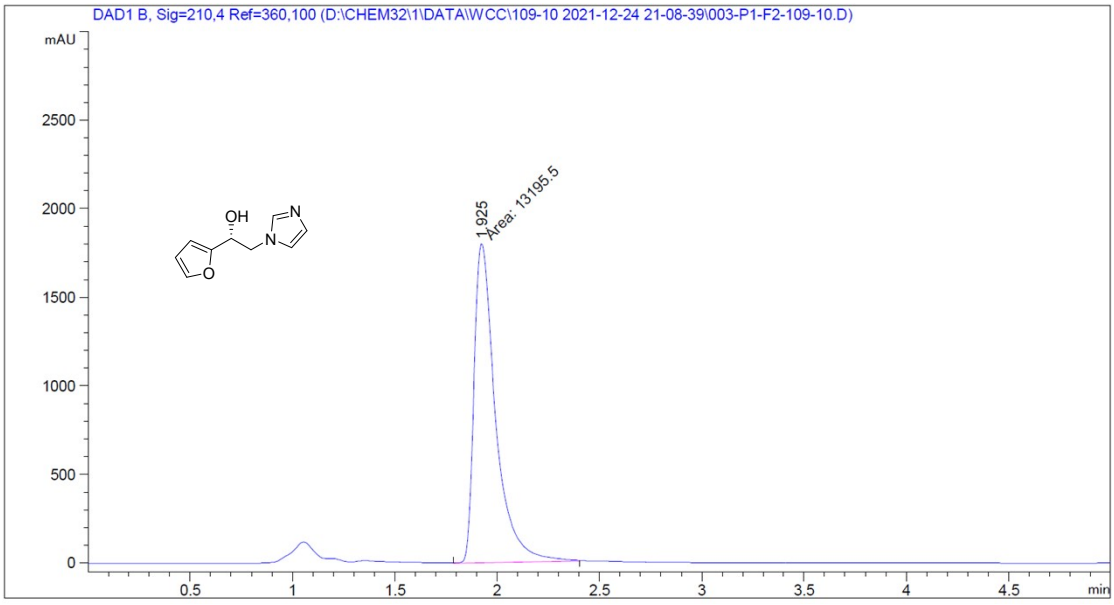


Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.576	MM	0.2918	8048.38037	459.70197	100.0000
Totals :				8048.38037	459.70197	

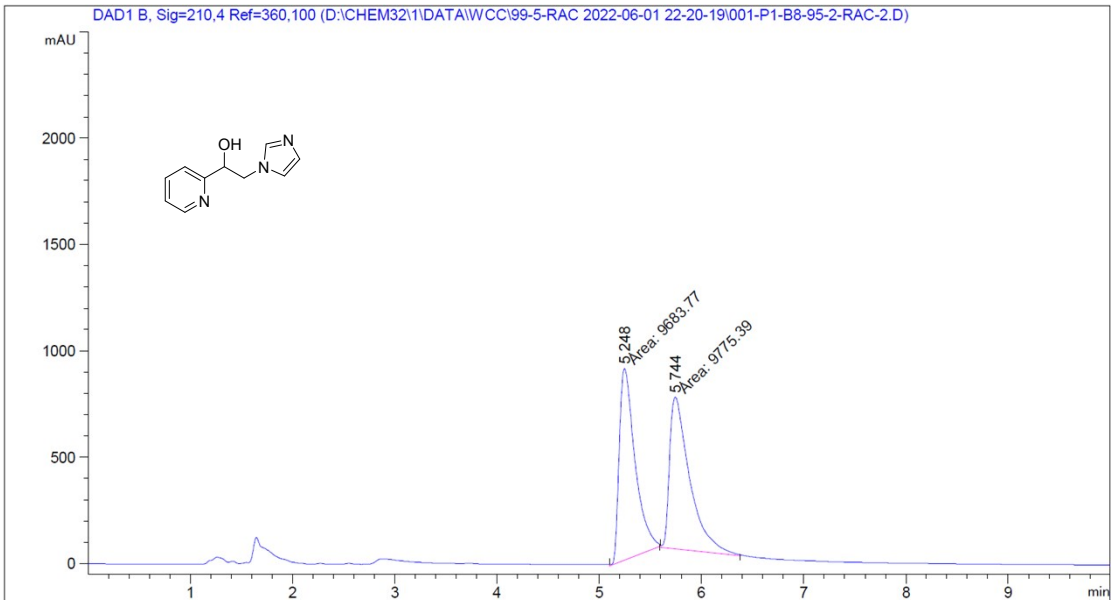


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.927	BV	0.1119	1.09902e4	1459.46130	49.0258
2	2.498	MM	0.1612	1.14270e4	1181.69531	50.9742
Totals :				2.24172e4	2641.15662	



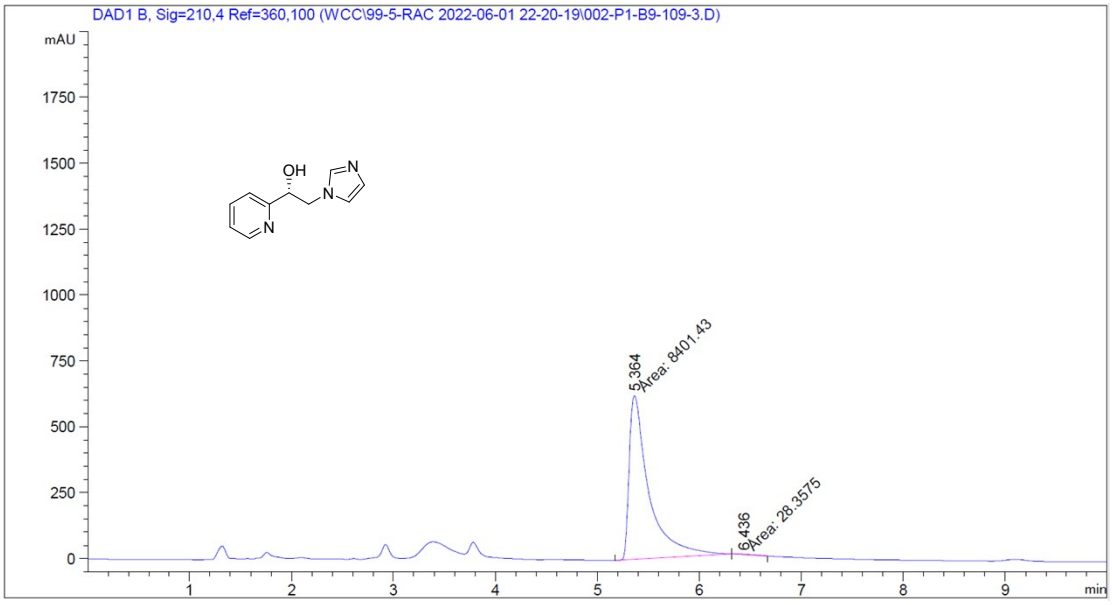
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.925	MM	0.1218	1.31955e4	1806.21582	100.0000
Totals :				1.31955e4	1806.21582	



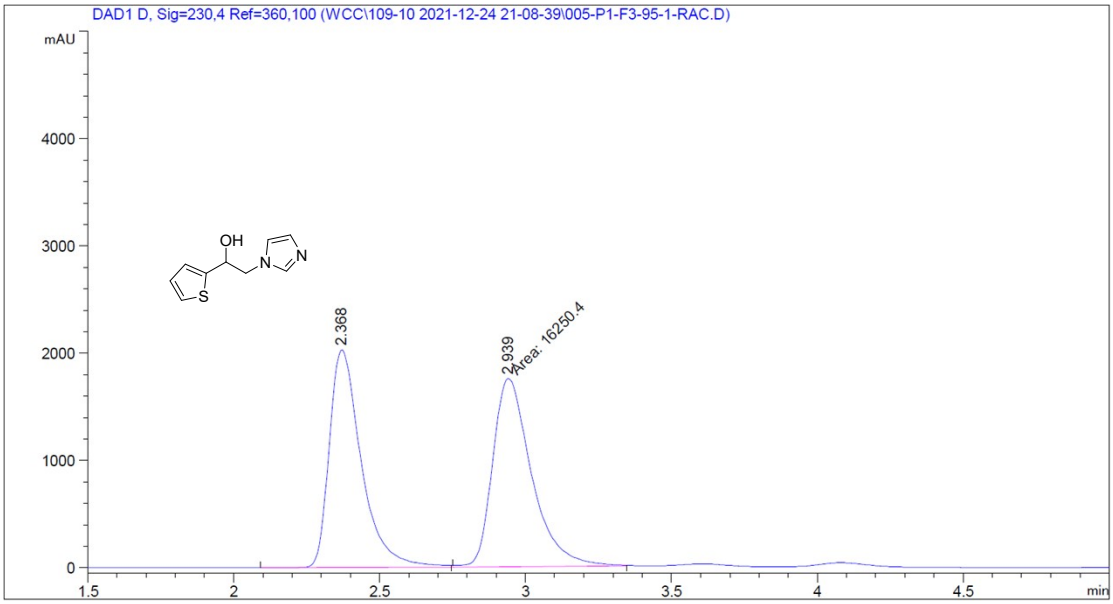
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.248	MM	0.1789	9683.76953	902.33600	49.7646
2	5.744	MM	0.2279	9775.38867	714.77600	50.2354
Totals :				1.94592e4	1617.11200	



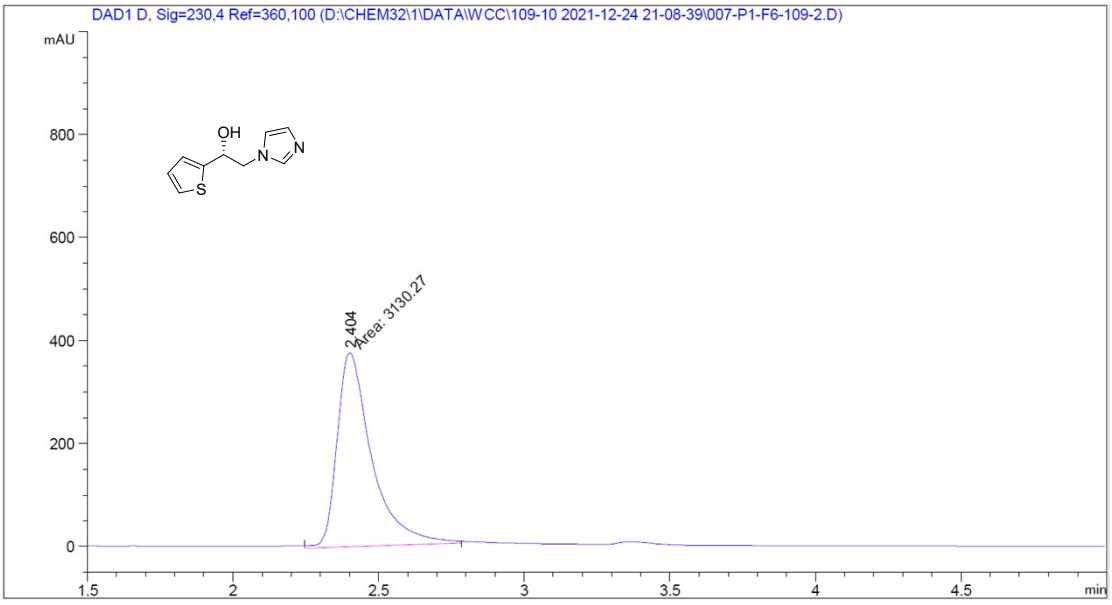
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.364	MM	0.2250	8401.42773	622.21075	99.6636
2	6.436	MM	0.2456	28.35750	1.92461	0.3364
Totals :				8429.78523	624.13537	



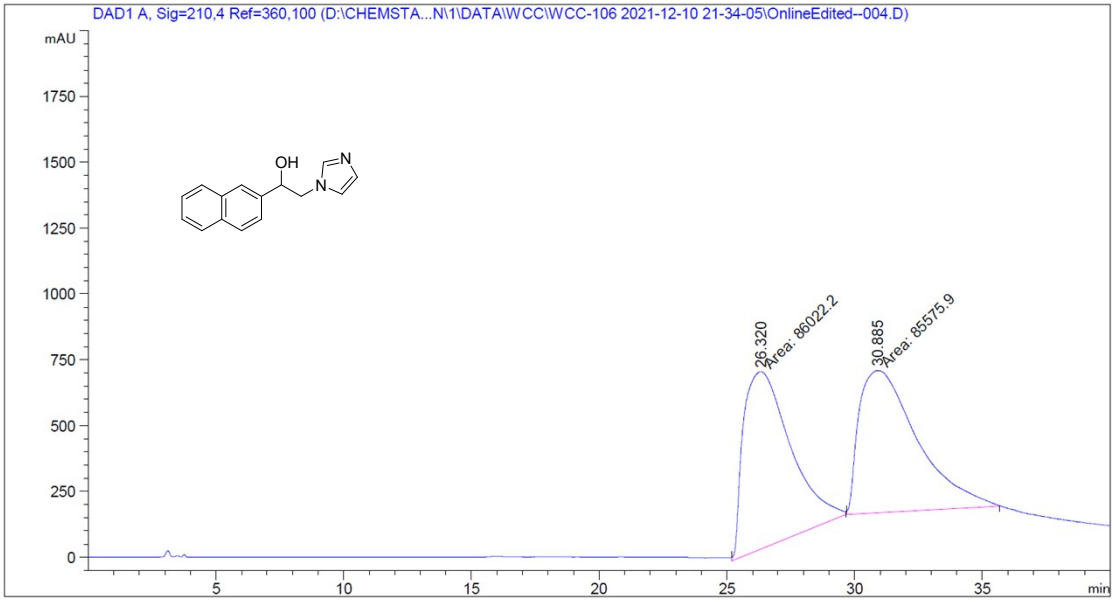
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.368	MM	0.1273	1.09782e4	1437.71606	49.0736
2	2.939	MM	0.1525	1.13927e4	1245.04895	50.9264
Totals :				2.23708e4	2682.76501	



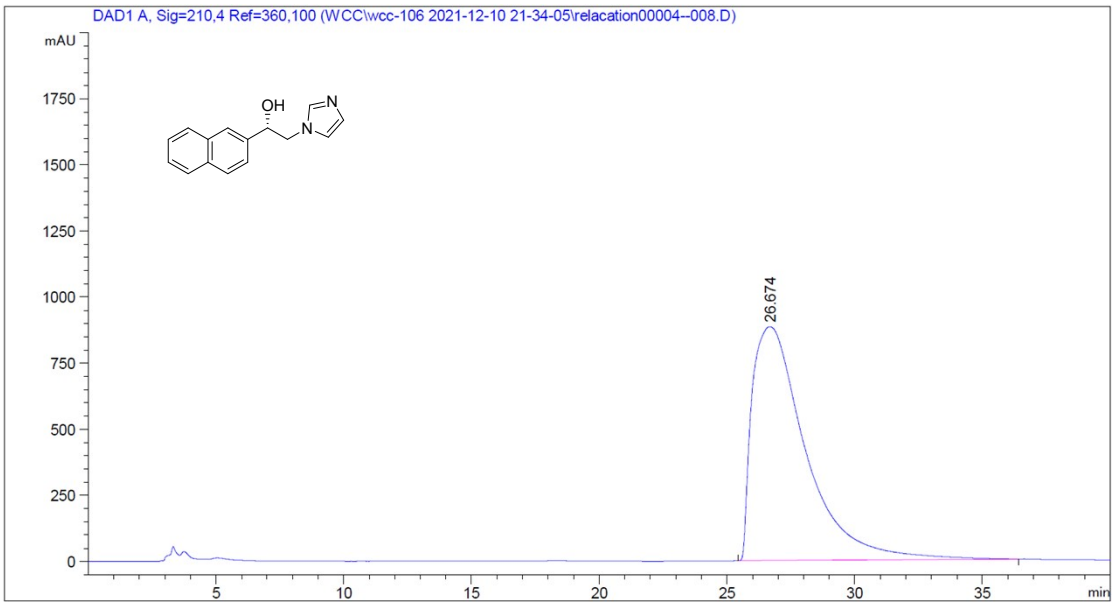
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.404	MM	0.1413	2323.25635	273.98352	100.0000
Totals :				2323.25635	273.98352	



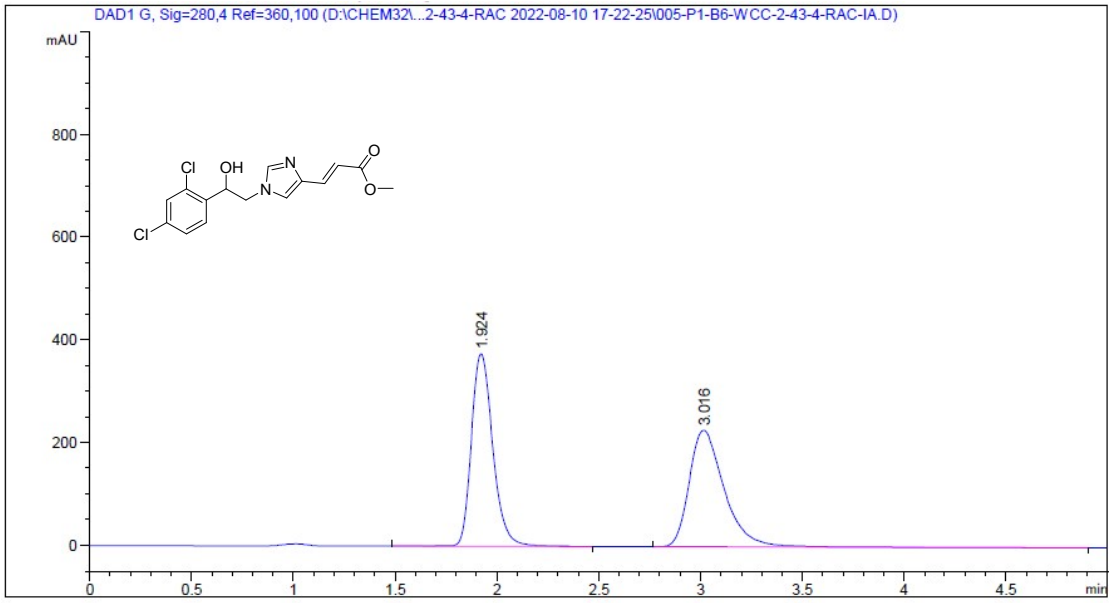
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.320	MM	2.1267	8.60222e4	674.15271	50.1301
2	30.885	MM	2.6425	8.55759e4	539.73499	49.8699



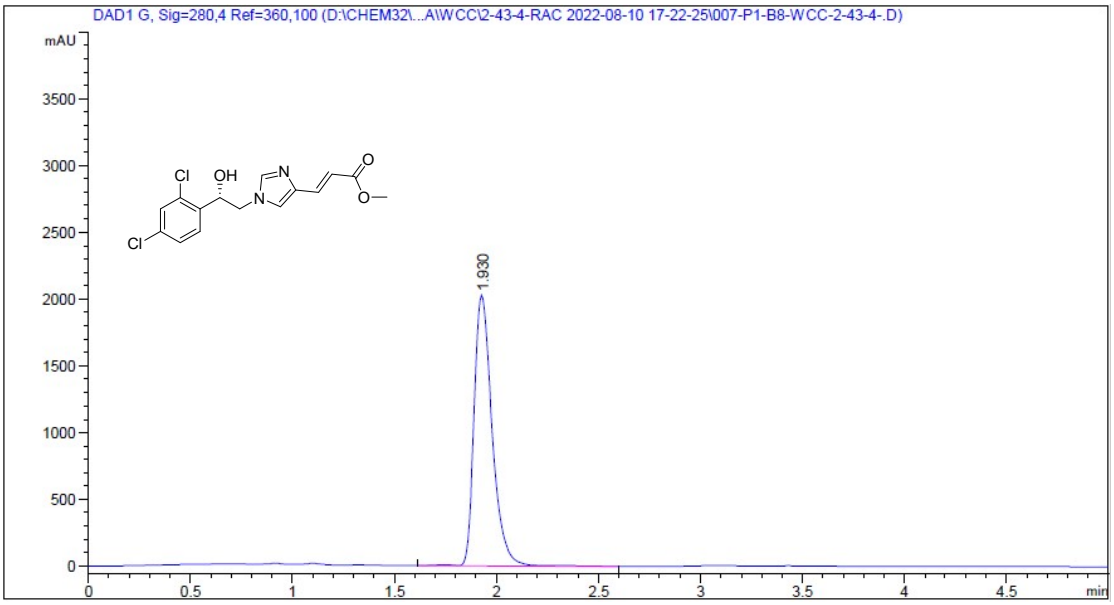
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.674	BB	1.7352	1.29459e5	884.68591	100.0000
Totals :				1.29459e5	884.68591	



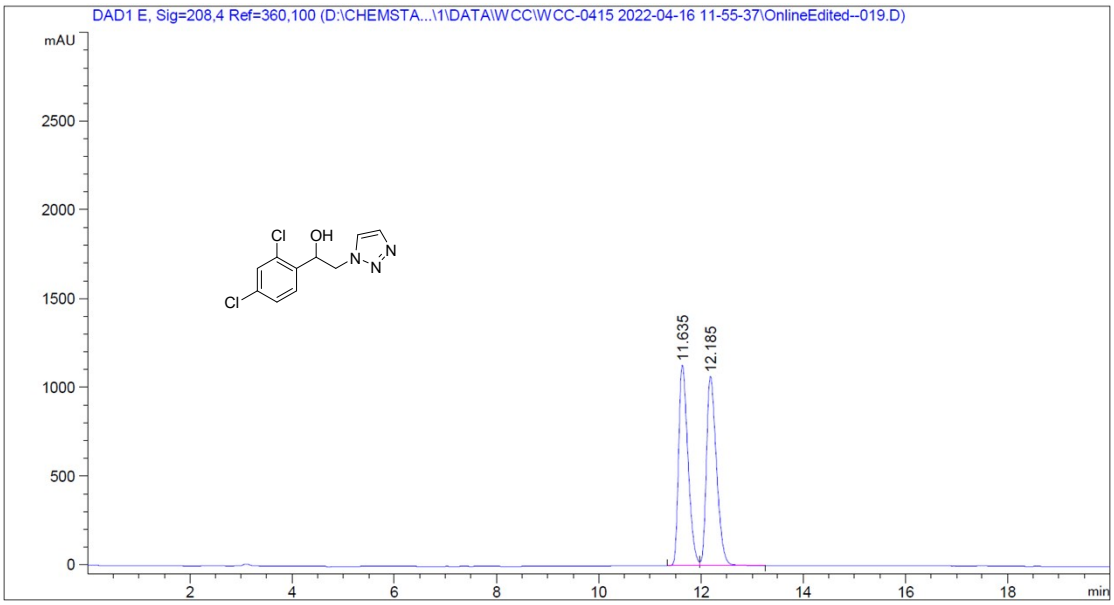
Signal 1: DAD1 G, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.924	BB	0.1133	2742.44360	375.06287	50.2110
2	3.016	BBA	0.1817	2719.38965	227.06509	49.7890
Totals :				5461.83325	602.12796	



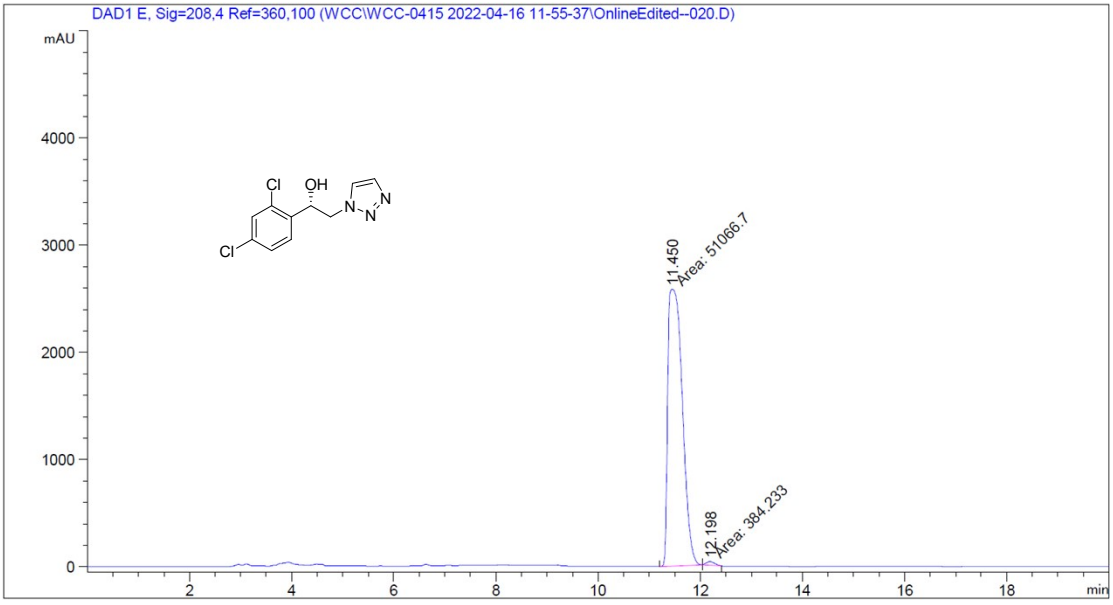
Signal 1: DAD1 G, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.930	VV R	0.0931	1.24510e4	2026.74792	100.0000
Totals :				1.24510e4	2026.74792	



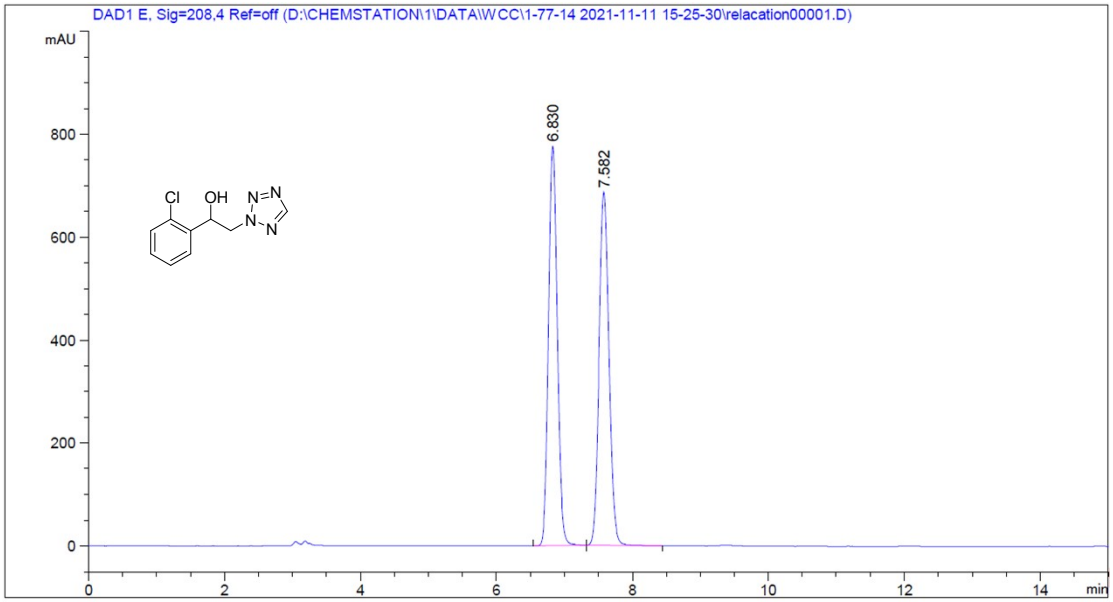
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.635	BV	0.1962	1.43582e4	1130.05945	49.6172
2	12.185	VB	0.2094	1.45798e4	1066.79895	50.3828



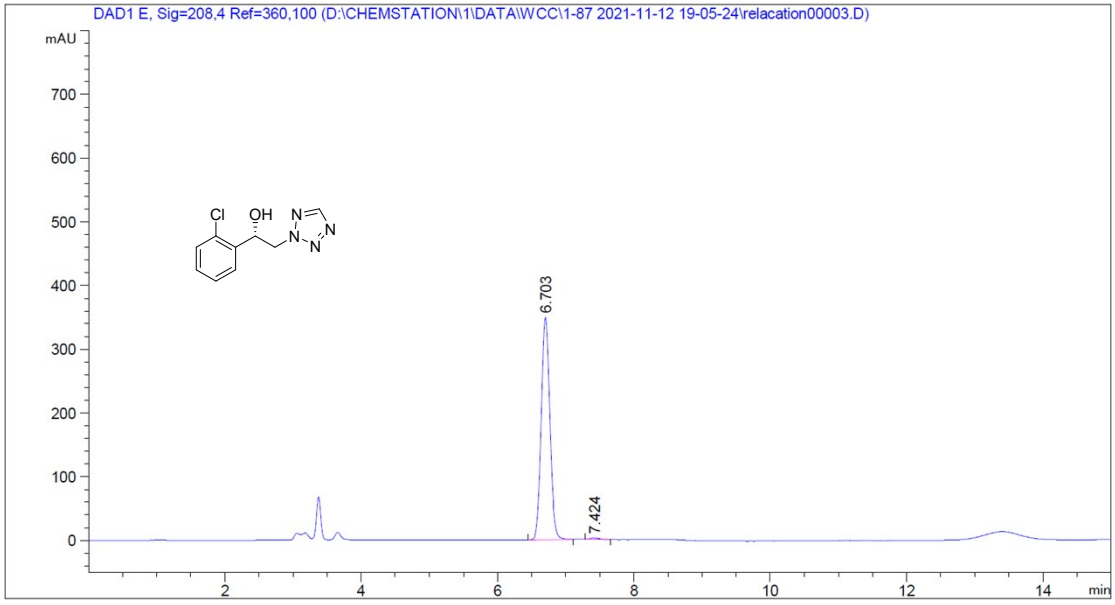
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.450	MM	0.3296	5.10667e4	2582.09473	99.2532
2	12.198	MM	0.1935	384.23291	33.09596	0.7468



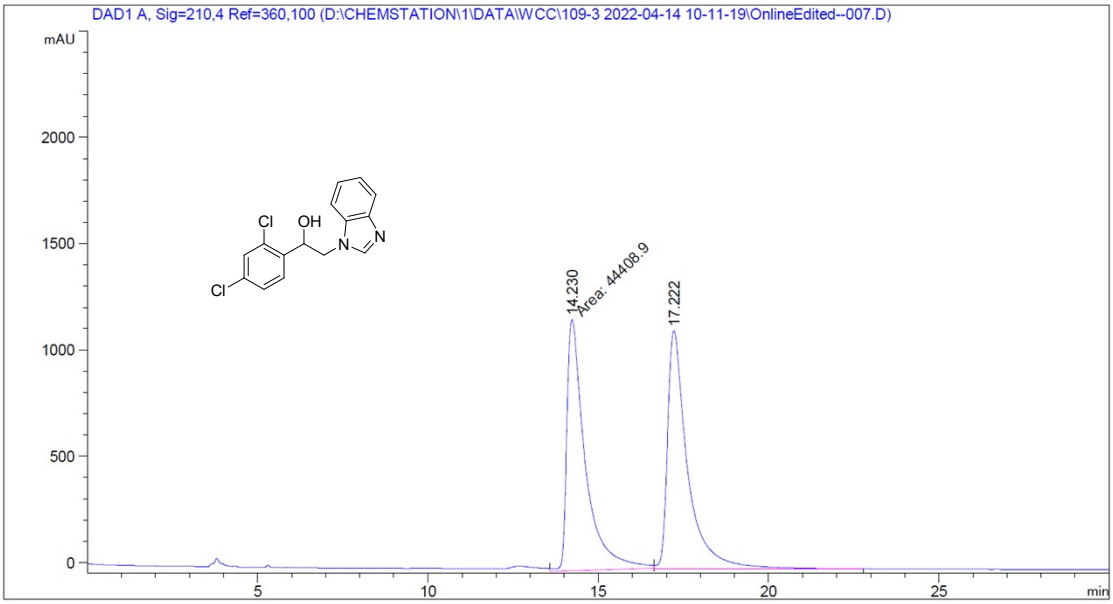
Signal 1: DAD1 E, Sig=208,4 Ref=off

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.830	BB	0.1376	6897.81592	777.13690	49.9374
2	7.582	BB	0.1555	6915.10107	686.80951	50.0626
Totals :				1.38129e4	1463.94641	



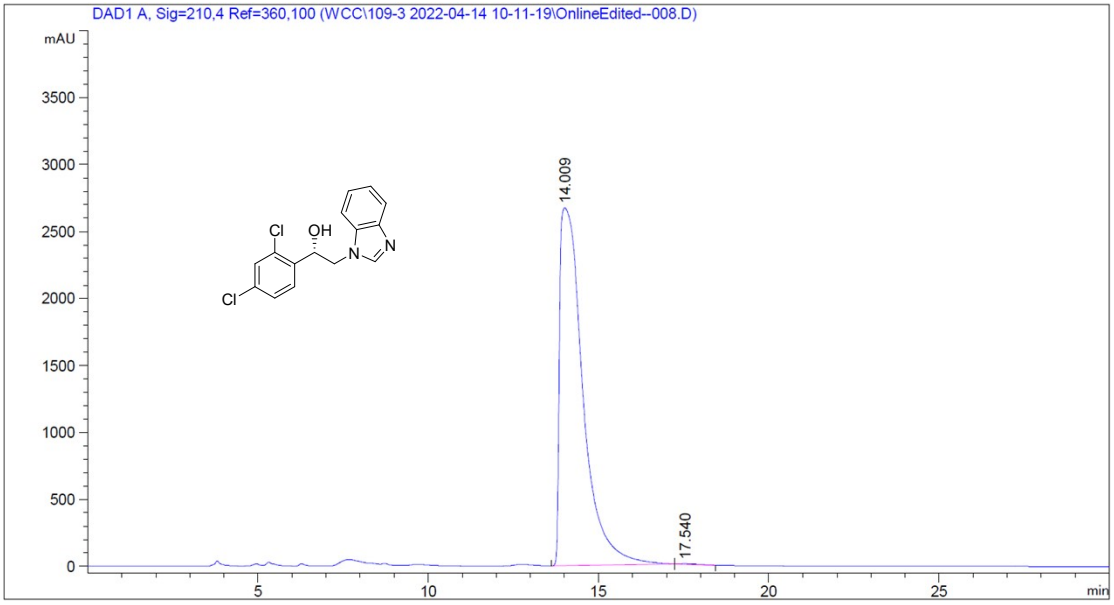
Signal 1: DAD1 E, Sig=208,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.703	BB	0.1354	3028.35278	348.45911	99.3265
2	7.424	BB	0.1353	20.53299	2.31836	0.6735
Totals :				3048.88577	350.77747	



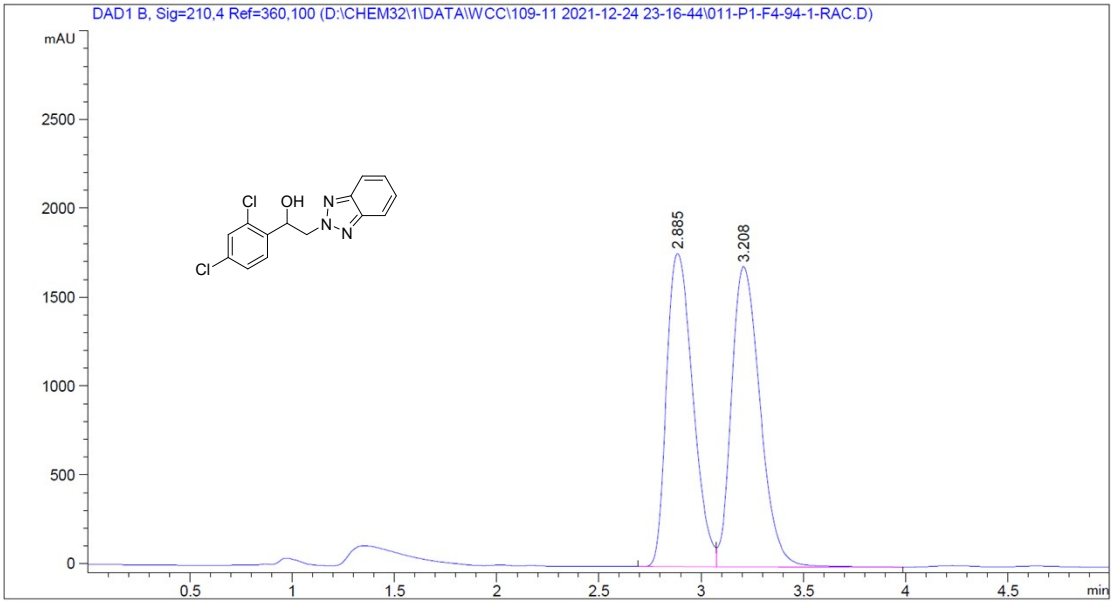
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.230	MM	0.6264	4.44089e4	1181.56445	49.1842
2	17.222	VB	0.5917	4.58820e4	1120.52917	50.8158



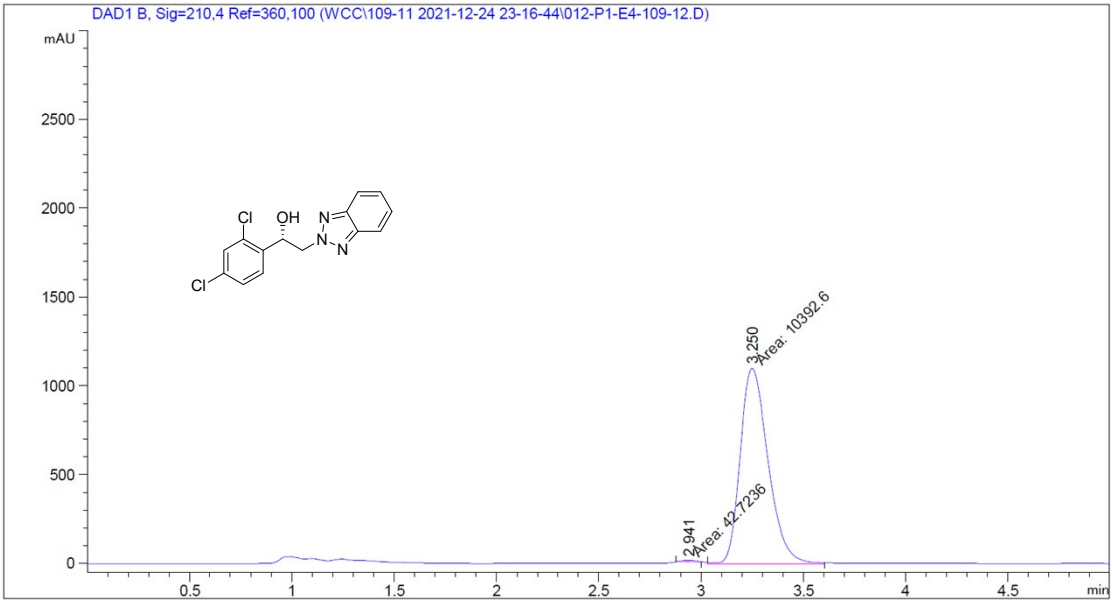
Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.009	BB	0.6099	1.26449e5	2673.07446	99.8887
2	17.540	BB	0.5189	140.83405	3.69280	0.1113



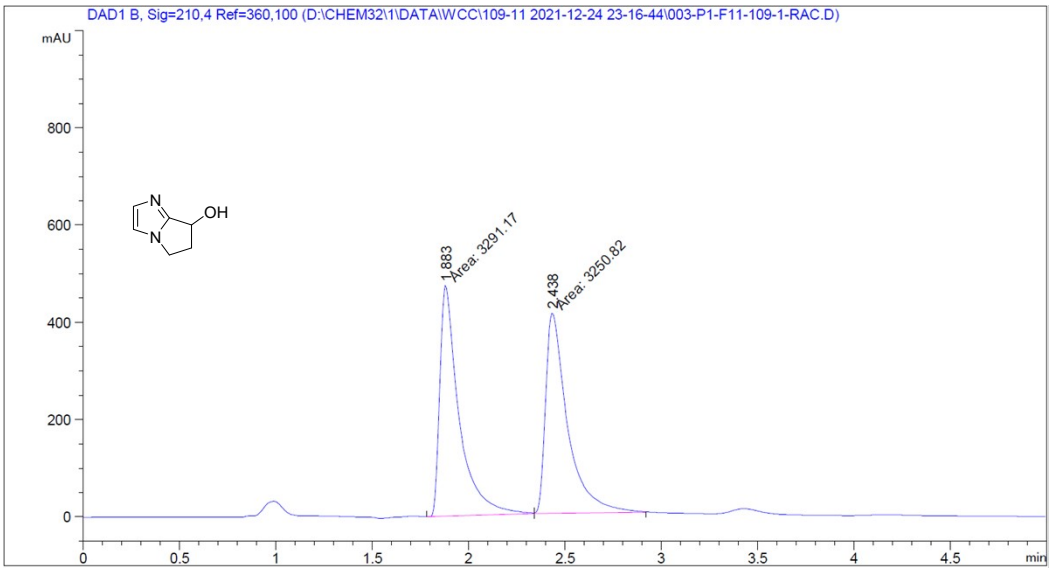
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.885	BV	0.1421	1.57373e4	1763.17883	48.8532
2	3.208	VB	0.1537	1.64761e4	1690.78552	51.1468
Totals :				3.22134e4	3453.96436	



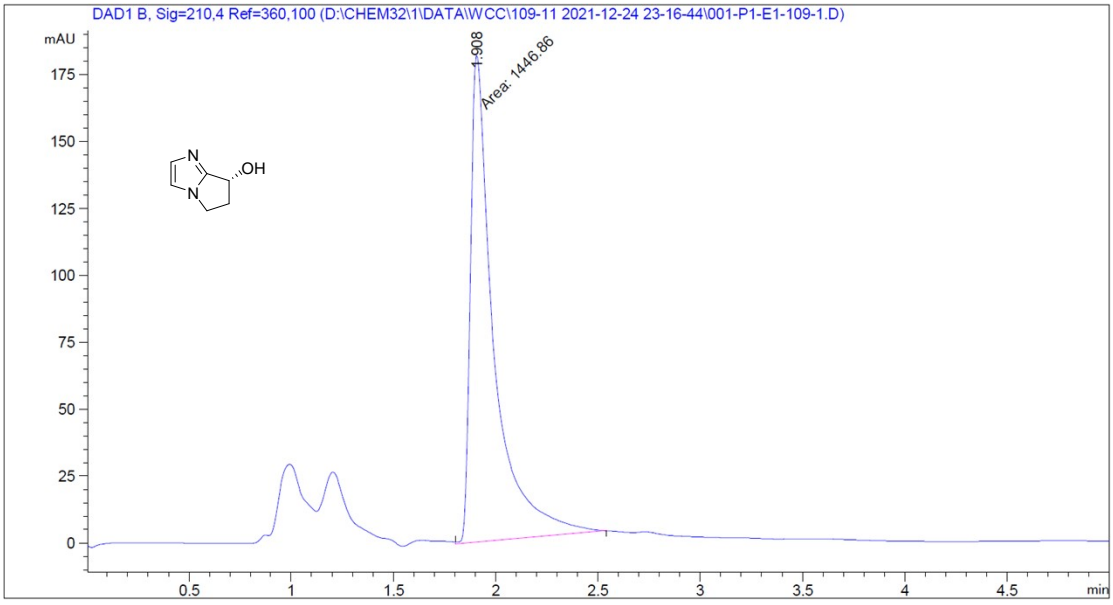
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.941	MM	0.0816	42.72357	8.72127	0.4094
2	3.250	MM	0.1576	1.03926e4	1099.19788	99.5906
Totals :				1.04353e4	1107.91914	



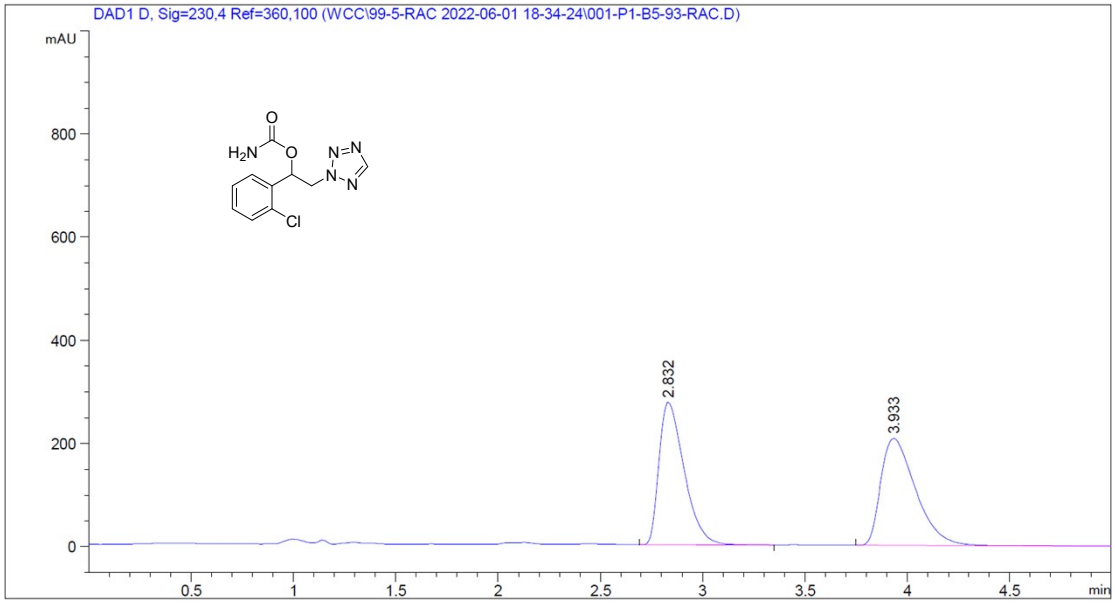
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.883	MM	0.1153	3291.16821	475.60983	50.3084
2	2.438	MM	0.1314	3250.82227	412.33521	49.6916
Totals :				6541.99048	887.94504	



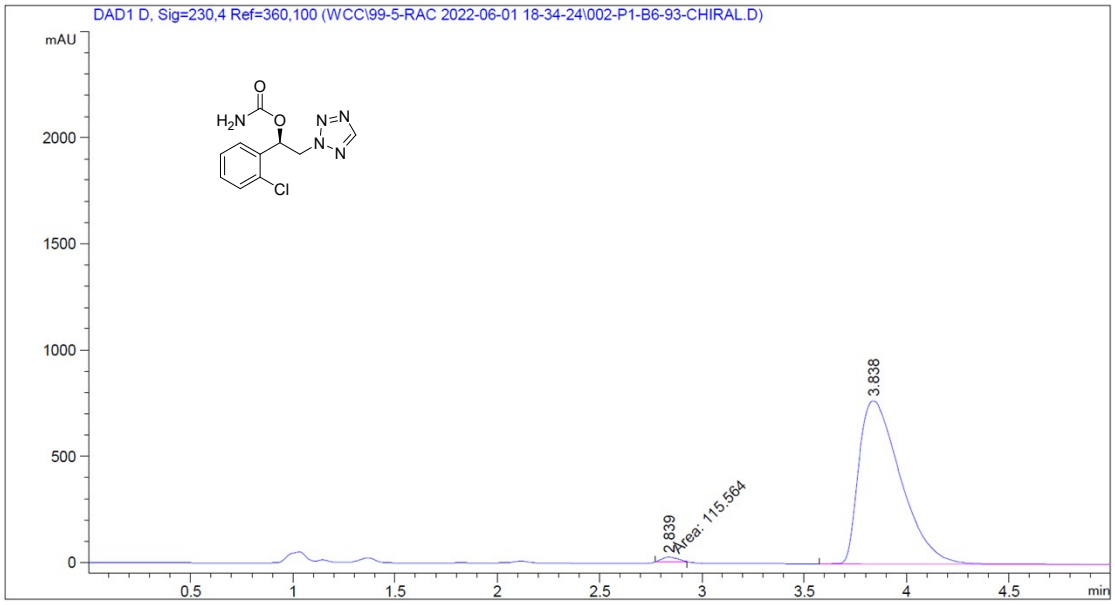
Signal 1: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	1.908	MM	0.1322	1446.86353	182.44945	100.0000
Totals :				1446.86353	182.44945	



Signal 1: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.832	BB	0.1314	2351.97925	276.13885	48.9468
2	3.933	BBA	0.1819	2453.19067	207.51233	51.0532
Totals :				4805.16992	483.65118	



Signal 1: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	2.839	MM	0.0885	115.56354	21.75784	1.0502
2	3.838	BBA	0.2212	1.08883e4	769.11243	98.9498
Totals :				1.10038e4	790.87026	

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