SUPPORTING INFORMATION

An asymmetric oxidative cyclization/Mannich-type addition cascade reaction for direct access to chiral pyrrolidin-3-ones

Su Zhou, Xiongda Xie, Xinxin Xu, Shanliang Dong, Wenhao Hu, and Xinfang Xu*

Guangdong Provincial Key Laboratory of Chiral Molecule and Drug Discovery, School of Pharmaceutical Sciences, Sun Yat-sen University, Guangzhou 510006, China

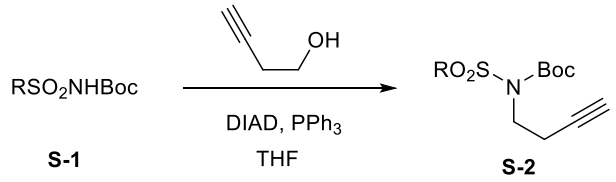
E-mail: xuxinfang@mail.sysu.edu.cn.

Table of Contents

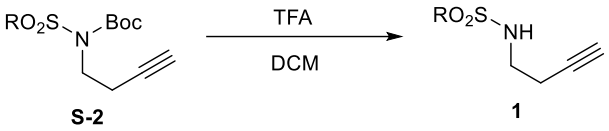
General Information

All reactions were carried out in oven-dried glassware. Solvents were dried and distilled followed the standard methods before using. Chiral phosphoric acids (CPAs), gold catalysts were purchased from chemical vendors and used directly without any treatment. Flash column chromatography was performed using silica gel (200-300 mesh). Analytical thin-layer chromatography was performed using glass plates pre-coated with 200-300 mesh silica gel impregnated with a fluorescent indicator (254 nm). ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ on a 400 or 500 MHz spectrometer; chemical shifts were reported in ppm with the solvent signal as reference, and coupling constants (*J*) were given in Hertz. The peak information was described as: br = broad, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, comp = composite. High-resolution mass spectra (HRMS) were recorded on a commercial apparatus (ESI or CI Source). Nitrones were prepared according to the known procedure and had physical and spectral properties identical to those earlier reported.[1]

General Procedure for the Preparation of Homopropargyl Amides 1.[2]



Synthesis of S-2:[2] To a 50-mL over-dried flask containing a magnetic stirring bar, **S-1** (8.0 mmol), propargyl alcohol (9.5 mmol, 1.2 equiv.), PPh_3 (9.5 mmol, 1.5 equiv.) and dry THF (15 mL) were added in sequence and cooling down to 0 ^{o}C, DIAD (9.5 mmol, 1.2 equiv.) was added slowly in 1 hour. The reaction mixture was stirred at room temperature overnight. Upon completion (monitored by TLC), the solvent was evaporated in *vacuo*. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc = 15:1) to give the products **S-2** as white solid in 70%-80% yields.

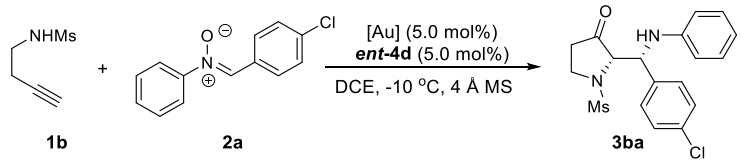


S-2 1

Synthesis of 1: To a 50-mL over-dried flask containing a magnetic stirring bar, **S-2** (6.0 mmol) and DCM (25 mL) were added in sequence and cooling down to 0 ^{o}C, TFA (30 mmol, 5.0 equiv.) were added dropwise and the reaction mixture was stirred at room temperature overnight. Upon completion (monitored by TLC), the crude reaction mixture was quenched with saturated aqueous sodium bicarbonate (20.0 mL), the combined organic layer was washed with brine and dried over anhydrous Na_2SO_4 and then evaporated *in vacuo*. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc : Dichloromethane = 5:1:1) to give the products **1** as white solid in >80% yields. The physical and spectral properties of these synthesized homopropargyl amides **1** are identical to those earlier reported.[2]

Condition Optimization

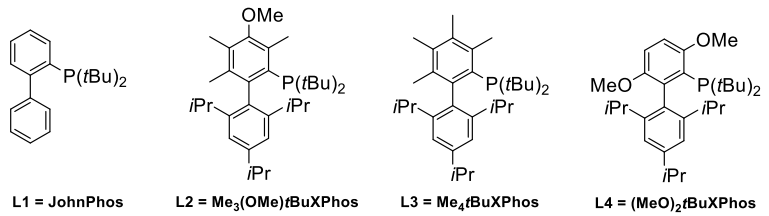
Table S1: Condition optimization for the synthesis of **3ba**[a]



1b 2a 3ba

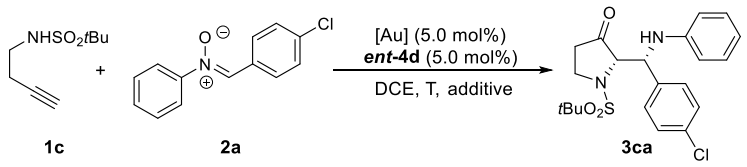
entry	[Au]	Yield (%)[b]	*dr*[c]	*ee* (%)[c]
1	**L3**AuNTf$_2$	72	>20:1	76
2[d]	**L3**AuNTf$_2$	74	>20:1	70
3[e]	**L3**AuNTf$_2$	82	>20:1	81
4[ef]	**L3**AuNTf$_2$	65	>20:1	79
5[eg]	**L3**AuNTf$_2$	76	>20:1	81
6[e]	PPh$_3$AuNTf$_2$	<5	-	-
7[e]	**L3**PhosAuCl+AgOTf	18	>20:1	63
8[e]	**L3**AuCl+AgSbF$_6$	45	>20:1	20
9[e]	**L3**AuCl+AgBF$_4$	<5	-	-
10[e]	**L3**AuCl+NaBarF	36	>20:1	61

[a]The reactions were conducted on a 0.1 mmol scale: **1b** (19.1 mg, 0.13 mmol), **2a** (23.1 mg, 0.1 mmol) in the presence of chiral phosphoric acid ***ent*-4d** (4.4 mg, 5.0 mol%), gold catalyst (5.0 mol%), and 4 Å molecular sieve (50 mg) in DCM (2.0 mL) under argon atmosphere at corresponding temperature. [b]Isolated yields of **3ba**. [c]The *dr* ratios were determined by ^{1}HNMR of crude reaction mixture and *ee* values were determined by chiral HPLC analysis. [d]The volume of DCE was 1.0 mL. [e]The volume of DCE was 4.0 mL. [f]The alkyne **1b** was adding in 1 hour by syringe pump. [g]The gold catalyst was adding in 1 hour by syringe pump.



L1 = JohnPhos | L2 = Me_3(OMe)*t*BuXPhos | L3 = Me_4*t*BuXPhos | L4 = $(MeO)_2$*t*BuXPhos

***Table S2*:** Condition optimization for the synthesis of **3ca**[a]

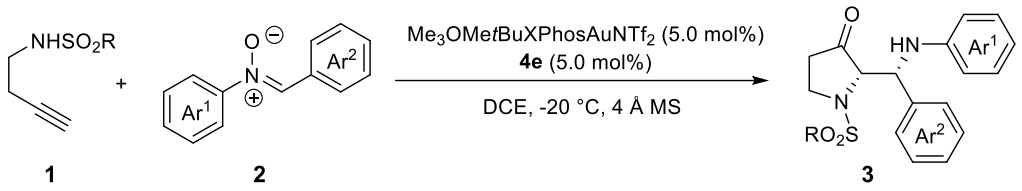


1c **2a** **3ca**

entry	[Au]	additive	T/°C	Yield (%)[b]	*dr*[c]	*ee* (%)[c]
1	**L3**AuNTf$_2$	4 Å MS	-10	84	>20:1	81
2	**L3**AuNTf$_2$	4 Å MS	-20	75	>20:1	84
3	**L3**AuNTf$_2$	4 Å MS	-30	66	>20:1	89
4[d]	**L3**AuNTf$_2$	4 Å MS	-20	79	>20:1	87
5[d]	**L3**AuNTf$_2$	5 Å MS	-20	79	>20:1	84
6[d]	**L3**AuNTf$_2$	3 Å MS	-20	75	>20:1	84
7[d]	**L2**AuNTf$_2$	4 Å MS	-20	77	>20:1	90
8[d]	**L4**AuNTf$_2$	4 Å MS	-20	65	>20:1	85

[a]The reactions were conducted on a 0.1 mmol scale: **1c** (24.6 mg, 0.13 mmol), **2a** (23.1 mg, 0.1 mmol) in the presence of chiral phosphoric acid ***ent*-4d** (4.4 mg, 5.0 mol%), gold catalyst (5.0 mol%), and powdered molecular sieve (50 mg) in DCM (2.0 mL) under argon atmosphere at corresponding temperature. [b]Isolated yields of **3a**. [c]The *dr* ratios were determined by ^{1}HNMR of crude reaction mixture and *ee* values were determined by chiral HPLC analysis. [d]The reaction was conducted in 4.0 mL DCE.

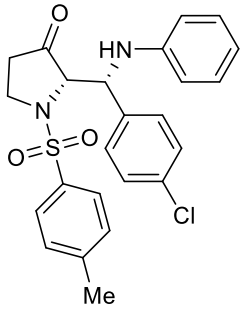
General Procedure for the Synthesis of 3:



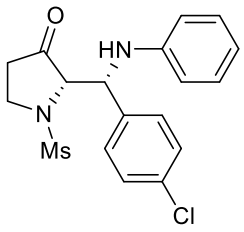
1 **2** **3**

To a 10-mL over-dried vial with a magnetic stirring bar, homopropargyl amides **1** (0.13 mmol), nitrone **2** (0.1 mmol), chiral phosphoric acid **4e** (4.4 mg, 5.0 mol%), 4 Å molecular sieves (50 mg), Me_3OM*e*t*t*BuXPhosAuNTf$_2$ (4.9 mg, 5.0 mol%), and anhydrous DCE (4.0 mL) were added in sequence under atmosphere of argon, and the reaction mixture was stirred at -20 °C for 24 hours. When the reaction was completed

(monitored by TLC), the solvent was evaporated in *vacuo* after filtration of the. The residue was purified by flash column chromatography on 200-300 mesh silica gel (Hexanes : EtOAc : Dichloromethane = 10:2:1) to give the pure products **3** in good to high yields with excellent stereoselectivity.

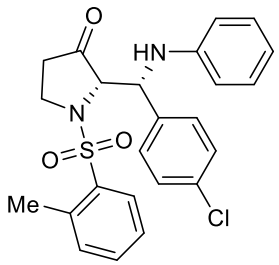


(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-tosylpyrrolidin-3-one (3aa). White solid, 32.7 mg, 72% yield, >95:5 *dr*, 78% *ee*, mp: 149 – 151 ^{o}C ; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.69 (d, *J* = 8.0 Hz, 2H), 7.38 – 7.24 (comp, 6H), 7.16 (t, *J* = 7.7 Hz, 2H), 6.73 (t, *J* = 7.3 Hz, 1H), 6.68 (d, *J* = 7.9 Hz, 2H), 5.28 (d, *J* = 3.0 Hz, 2H), 3.86 (s, 1H), 3.36 – 3.15 (m, 2H), 2.43 (s, 3H), 2.10 – 1.94 (m, 1H), 1.71 – 1.60 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.1, 145.7, 144.9, 136.1, 134.0, 132.7, 130.4, 129.52, 129.48, 128.8, 127.0, 118.6, 114.3, 65.5, 58.8, 44.5, 36.9, 21.7; HRMS (TOF MS ESI$^+$) calculated for $C_{24}H_{24}ClN_2O_3S$ $[M + H]^+$: 455.1191, found 455.1203; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 10.9 min, t_{minor} = 14.0 min.

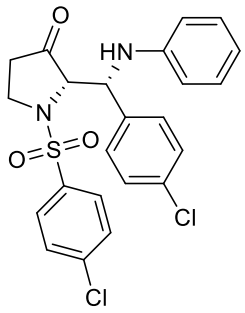


(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-(methylsulfonyl)pyrrolidin-3-one (3ba). Pale yellow oil, 28.7 mg, 76% yield, >95:5 *dr*, 83% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.27 (comp, 4H), 7.18 – 7.08 (comp, 2H), 6.70 (t, *J* = 7.3 Hz,

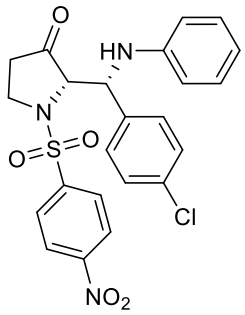
1H), 6.62 (d, *J* = 7.7 Hz, 2H), 5.27 (bs, 1H), 5.15 (d, *J* = 3.6 Hz, 1H), 4.13 (d, *J* = 4.6 Hz, 1H), 3.74 – 3.47 (m, 1H), 3.20– 3.13 (m, 1H), 2.90 (s, 3H), 2.47 – 2.38 (m, 1H), 1.89 – 1.80 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 211.8, 145.5, 136.0, 134.2, 129.5, 129.4, 129.0, 118.6, 114.0, 65.3, 58.8, 44.3, 37.2, 35.7; HRMS (TOF MS ESI$^+$) calculated for $C_{18}H_{20}ClN_2O_3S$ [M + H]$^+$: 379.0878, found 379.0876; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 240 nm, hexane : isopropanol = 92:8, flow rate =1.0 mL/min, t_{major} = 19.0 min, t_{minor} = 20.6 min.



(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-(*o*-tolylsulfonyl)pyrrolidin-3-one (3da). Colorless oil, 27.7 mg, 61% yield, >95:5 *dr*, 82% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.87 (d, *J* = 7.7 Hz, 1H), 7.50 (t, *J* = 7.5 Hz, 1H), 7.38 – 7.25 (comp, 6H), 7.11 (t, *J* = 7.9 Hz, 2H), 6.69 (t, *J* = 7.3 Hz, 1H), 6.58 (d, *J* = 7.9 Hz, 2H), 5.23 (s, 1H), 5.10 (s, 1H), 4.14 (d, *J* = 4.5 Hz, 1H), 3.61 – 3.49 (m, 1H), 3.11 – 3.04 (m, 1H), 2.65 (s, 3H), 2.34 – 2.26 (m, 1H), 1.85 – 1.77 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.4, 145.6, 137.9, 136.3, 135.7, 134.1, 133.7, 133.4, 130.2, 129.41, 129.35, 128.9, 126.9, 118.5, 114.0, 65.7, 58.5, 44.3, 37.1, 21.3; HRMS (TOF MS ESI$^+$) calculated for $C_{24}H_{24}ClN_2O_3S$ [M + H]$^+$: 455.1191, found 455.1196; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 11.0 min, t_{minor} = 12.5 min.

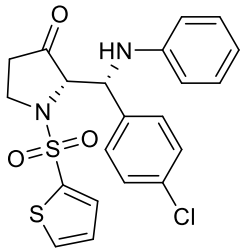


(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-((4-chlorophenyl)sulfonyl)pyrrolidin-3-one (3ea). Colorless oil, 31.3 mg, 66% yield, >95:5 *dr*, 78% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.75 (d, *J* = 8.5 Hz, 2H), 7.51 (d, *J* = 8.5 Hz, 2H), 7.35 – 7.30 (comp, 4H), 7.17 (t, *J* = 7.9 Hz, 2H), 6.75 (t, *J* = 7.3 Hz, 1H), 6.69 (d, *J* = 7.9 Hz, 2H), 5.29 – 5.24 (comp, 2H), 3.85 (d, *J* = 3.9 Hz, 1H), 3.33 – 3.22 (m, 2H), 2.12 – 2.06 (m, 1H), 1.73 – 1.64 (m, 1H);^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 211.4, 145.6, 140.6, 135.8, 134.2, 130.1, 129.54, 129.46, 129.2, 128.9, 118.8, 114.4, 65.4, 58.9, 44.6, 36.8; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{21}Cl_2N_2O_3S$ $[M + H]^+$: 475.0644, found 475.0644; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 12.7 min, t_{minor} = 16.3 min.

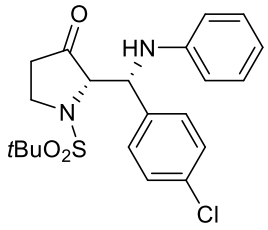


(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidin-3-one (3fa). Yellow solid, 29.1 mg, 60% yield, >95:5 *dr*, 78% *ee*, mp: 181 – 183 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 8.38 (d, *J* = 8.7 Hz, 2H), 8.00 (d, *J* = 8.7 Hz, 2H), 7.46 – 7.27 (comp, 4H), 7.19 (t, *J* = 7.9 Hz, 2H), 6.78 (t, *J* = 7.3 Hz, 1H), 6.71 (d, *J* = 7.9 Hz, 2H), 5.32 (d, *J* = 4.3 Hz, 1H), 5.22 (s, 1H), 3.88 (d, *J* = 4.0 Hz, 1H), 3.31 (t, *J* = 7.8 Hz, 2H), 2.16 – 2.08 (m, 1H), 1.78 – 1.68 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 210.6, 150.8, 145.5, 141.6, 135.5, 134.4, 129.6, 129.4, 129.10,

129.05, 125.0, 119.1, 114.5, 65.2, 59.1, 44.7, 36.7; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{21}ClN_3O_5S$ [M + H]$^+$: 486.0885, found 486.0890; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 33.2 min, t_{minor} = 54.3 min.

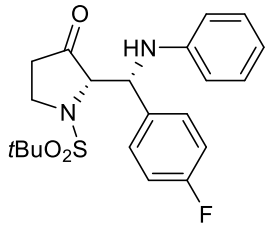


(*S*)-2-((*R*)-(4-Chlorophenyl)(phenylamino)methyl)-1-(thiophen-2-ylsulfonyl)pyrrolidin-3-one (3ga). Yellow oil, 33.9 mg, 76% yield, >95:5 *dr*, 75% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.65 (d, *J* = 4.9 Hz, 1H), 7.61 (d, *J* = 3.3 Hz, 1H), 7.35 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 8.2 Hz, 2H), 7.16 (t, *J* = 7.6 Hz, 3H), 6.73 (t, *J* = 7.3 Hz, 1H), 6.68 (d, *J* = 7.9 Hz, 2H), 5.28 (d, *J* = 12.5 Hz, 2H), 3.95 (s, 1H), 3.43 – 3.37 (m, 1H), 3.31 – 3.26 (m, 1H), 2.15 – 2.08 (m, 1H), 1.76 – 1.67 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 211.6, 145.6, 135.9, 135.6, 134.1, 133.6, 133.3, 129.51, 129.48, 128.9, 128.2, 118.7, 114.2, 65.5, 58.8, 44.6, 36.9; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{20}ClN_2O_3S_2$ [M + H]$^+$: 447.0598, found 447.0599; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 10.1 min, t_{minor} = 12.2 min.

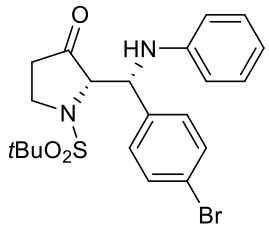


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(4-chlorophenyl)(phenylamino)methyl)pyrrolidin-3-one (3ca). Pale yellow oil, 33.2 mg, 79% yield, >95:5 *dr*, 93% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.37 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.11 (t, *J* = 7.7 Hz, 2H), 6.68 (t, *J* = 7.3 Hz, 1H), 6.60 (d, *J* = 8.0 Hz, 2H), 5.32 (d, *J* = 6.4 Hz,

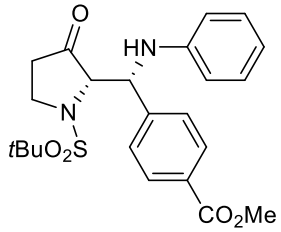
1H), 5.15 (bs, 1H), 4.47 (d, *J* = 4.7 Hz, 1H), 3.72 (t, *J* = 10.5 Hz, 1H), 2.65 – 2.58 (m, 1H), 2.54 – 2.43 (m, 1H), 2.01 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 213.5, 145.6, 136.9, 134.4, 129.4, 129.2, 118.3, 113.8, 66.4, 62.9, 58.9, 46.5, 37.8, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}ClN_2O_3S$ [M + H]$^+$: 421.1347, found 421.1346; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 245 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 9.5 min, t_{minor} = 14.4 min.



(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(4-fluorophenyl)(phenylamino)methyl)pyrrolidin-3-one (3cb). Pale yellow oil, 31.1 mg, 77% yield, >95:5 *dr*, 93% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.42 – 7.39 (comp, 2H), 7.11 (t, *J* = 7.8 Hz, 2H), 7.02 (t, *J* = 8.6 Hz, 2H), 6.68 (t, *J* = 7.3 Hz, 1H), 6.62 (d, *J* = 8.0 Hz, 2H), 5.34 (bs, 1H), 5.16 (d, *J* = 4.8 Hz, 1H), 4.46 (d, *J* = 4.5 Hz, 1H), 3.72 (t, *J* = 10.8 Hz, 1H), 2.62 – 2.43 (comp, 2H), 1.99 – 1.93 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.5, 162.8 (d, *J* = 247.4 Hz), 145.7, 134.0 (d, *J* = 3.2 Hz), 129.5 (d, *J* = 8.1 Hz), 129.4, 118.3, 116.0 (d, *J* = 21.4 Hz), 113.8, 66.4, 62.8, 58.8, 46.4, 37.8, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) -113.5; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}FN_2O_3S$ [M + H]$^+$: 405.1643, found 405.1648; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 240 nm, hexane : isopropanol = 85:15, flow rate =1.0 mL/min, t_{major} = 18.2 min, t_{minor} = 13.2 min.

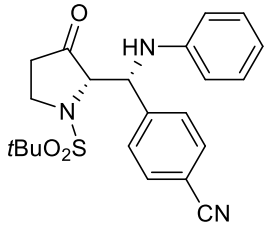


(*S*)-2-((*R*)-(4-Bromophenyl)(phenylamino)methyl)-1-((*tert*-butylthio)peroxy)pyrr olidin-3-one (3cc). Pale yellow oil, 33.9 mg, 73% yield, >95:5 *dr*, 92% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.46 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.3 Hz, 2H), 7.11 (t, *J* = 7.8 Hz, 2H), 6.68 (t, *J* = 7.3 Hz, 1H), 6.60 (d, *J* = 8.0 Hz, 2H), 5.32 (bs, 1H), 5.14 (d, *J* = 4.5 Hz, 1H), 4.46 (d, *J* = 4.7 Hz, 1H), 3.72 (t, *J* = 10.4 Hz, 1H), 2.65 – 2.57 (m, 1H), 2.54 – 2.44 (m, 1H), 2.02 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.4, 145.6, 137.5, 132.2, 129.6, 129.4, 122.5, 118.4, 113.8, 66.3, 62.9, 59.0, 46.5, 37.8, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}BrN_2O_3S$ [M + H]$^+$: 465.0842, found 465.0846; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 240 nm, hexane : isopropanol = 85:15, flow rate =1.0 mL/min, t_{major} = 21.4 min, t_{minor} = 14.6 min.

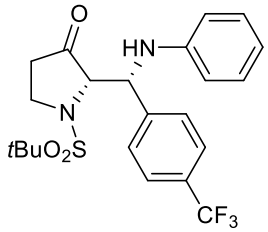


Methyl 4-((*R*)-((*S*)-1-((*tert*-butylthio)peroxy)-3-oxopyrrolidin-2-yl)(phenylamino) methyl)benzoate (3cd). Pale yellow oil, 32.0 mg, 72% yield, >95:5 *dr*, 90% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 8.00 (d, *J* = 8.1 Hz, 2H), 7.52(d, *J* = 8.1 Hz, 2H), 7.11 (t, *J* = 7.7 Hz, 2H), 6.68 (t, *J* = 7.3 Hz, 1H), 6.61 (d, *J* = 8.4 Hz, 2H), 5.37 (bs, 1H), 5.23 (d, *J* = 1.7 Hz, 1H), 4.52 (d, *J* = 4.8 Hz, 1H), 3.89 (s, 3H), 3.71 (t, *J* = 10.2 Hz, 1H), 2.56 – 2.43 (m, 2H), 2.98 – 1.92 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.3, 166.7, 145.6, 143.8, 130.3, 130.2, 129.4, 128.0, 118.4, 113.8, 66.3, 62.8, 59.4, 52.3, 46.5, 37.8, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{29}N_2O_5S$ [M + H]$^+$: 445.1792, found 445.1798; HPLC conditions for

determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 32.2 min, t_{minor} = 22.6 min.

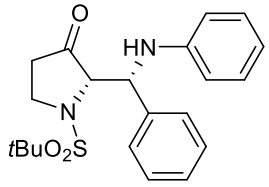


4-((*R*)-((*S*)-1-((*tert*-Butylthio)peroxy)-3-oxopyrrolidin-2-yl)(phenylamino)methyl) benzonitrile (3ce). White solid, 25.1 mg, 61% yield, >95:5 *dr*, 96% *ee*, mp: 168 – 160 ^{o}C ; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.64 – 7.57 (comp, 4H), 7.12 (t, *J* = 7.2 Hz, 2H), 6.70 (t, *J* = 7.3 Hz, 1H), 6.58 (d, *J* = 7.8 Hz, 2H), 5.37 (s, 1H), 5.28 (d, *J* = 7.3 Hz, 1H), 4.49 (d, *J* = 4.6 Hz, 1H), 3.75 (t, *J* = 10.5 Hz, 1H), 2.70 – 2.62 (m, 1H), 2.590 – 2.49 (m, 1H), 2.040 – 1.97 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.7, 145.2, 144.2, 132.7, 129.5, 128.7, 118.7, 118.5, 113.7, 112.4, 66.5, 63.1, 59.1, 46.4, 37.6, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{22}H_{26}N_3O_3S$ [M + H]$^+$: 412.1689, found 412.1705; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 48.3 min, t_{minor} = 53.1 min.

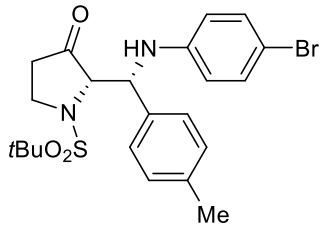


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(phenylamino)(4-(trifluoromethyl)phenyl)m ethyl)pyrrolidin-3-one (3cf). Colorless oil, 33.6 mg, 74% yield, >95:5 *dr*, 88% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.59 (q, *J* = 8.2 Hz, 4H), 7.12 (t, *J* = 7.6 Hz, 2H), 6.69 (t, *J* = 7.2 Hz, 1H), 6.61 (d, *J* = 7.9 Hz, 2H), 5.38 (s, 1H), 5.26 (s, 1H), 4.51 (d, *J* = 4.1 Hz, 1H), 3.73 (t, *J* = 10.5 Hz, 1H), 2.62 – 2.46 (m, 2H), 2.01 – 1.95 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.1, 145.5, 142.7, 130.7 (q, *J* = 36.0 Hz), 129.5, 128.4, 125.9 (q, *J* = 3.2 Hz), 124.0 (q, *J* = 272.0 Hz), 118.5,

113.8, 66.5, 63.0, 59.1, 46.5, 37.8, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) -62.6; HRMS (TOF MS ESI$^+$) calculated for $C_{22}H_{26}F_3N_2O_3S$ [M + H]$^+$: 455.1611, found 455.1623; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 6.8 min, t_{minor} = 9.7 min.

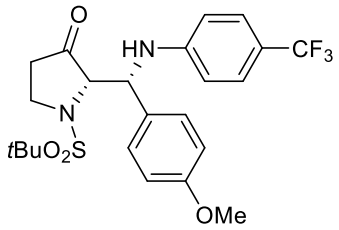


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-phenyl(phenylamino)methyl)pyrrolidin-3-one (3cg). Colorless oil, 23.9 mg, 62% yield, >95:5 *dr*, 92% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.42 (d, *J* = 7.6 Hz, 2H), 7.36 – 7.27 (comp, 3H), 7.11 (t, *J* = 7.6 Hz, 2H), 6.69 – 6.64 (comp, 3H), 5.33 (s, 1H), 5.14 (d, *J* = 4.1 Hz, 1H), 4.50 (d, *J* = 4.6 Hz, 1H), 3.69 (t, *J* = 10.2 Hz, 1H), 2.55 – 2.38 (m, 2H), 1.96 – 1.94 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.9, 145.9, 138.3, 129.4, 129.0, 128.5, 127.8, 118.1, 113.9, 66.4, 62.7, 59.6, 46.4, 38.0, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{27}N_2O_3S$ [M + H]$^+$: 387.1737, found 387.1746; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 95:5, flow rate =1.0 mL/min, t_{major} = 22.3 min, t_{minor} = 19.7 min.

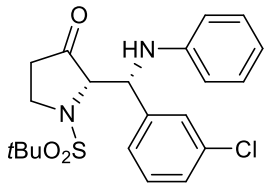


(*S*)-2-((*R*)-((4-Bromophenyl)amino)(*p*-tolyl)methyl)-1-((tert-Butylthio)peroxy)pyrrolidin-3-one (3ch). Colorless oil, 38.2 mg, 80% yield, >95:5 *dr*, 96% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.18 (d, *J* = 7.6 Hz, 2H), 7.10 (d, *J* = 8.6 Hz, 2H), 7.05 (d, *J* = 7.8 Hz, 2H), 6.43 (d, *J* = 8.6 Hz, 2H), 5.29 (s, 1H), 4.95 (s, 1H), 4.37 (d, *J* = 4.6 Hz, 1H), 3.65 – 3.57 (m, 1H), 2.44 – 2.34 (m, 2H), 2.23 (s, 3H), 1.91 – 1.84 (m, 1H), 1.38 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.0, 145.0, 138.4, 134.5, 132.0, 129.8,

127.6, 115.4, 109.7, 66.1, 62.6, 59.3, 46.4, 38.0, 25.0, 21.2; HRMS (TOF MS ESI$^+$) calculated for $C_{22}H_{28}BrN_2O_3S$ [M + H]$^+$: 479.0999, found 479.1004; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 260 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 20.8 min, t_{minor} = 19.4 min.

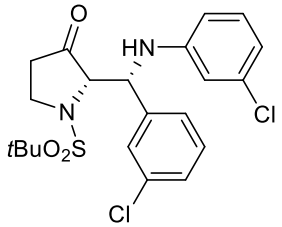


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(4-methoxyphenyl)((4-(trifluoromethyl)phenyl)amino)methyl)pyrrolidin-3-one (3ci). Colorless oil, 42.1 mg, 83% yield, >95:5 *dr*, 88% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.33 (t, *J* = 8.5 Hz, 4H), 6.87 (d, *J* = 8.3 Hz, 2H), 6.62 (d, *J* = 8.3 Hz, 2H), 5.68 (s, 1H), 5.09 (s, 1H), 4.43 (d, *J* = 4.4 Hz, 1H), 3.78 (s, 3H), 3.70 (t, *J* = 10.4 Hz, 1H), 2.57 – 2.46 (m, 2H), 2.00 – 1.95 (m, 1H), 1.47 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 214.1, 159.9, 148.5, 132.1, 129.1, 128.8, 126.7 (q, *J* = 3.7 Hz), 125.0 (q, *J* = 270.4 Hz), 119.5 (q, *J* = 32.7 Hz), 114.6, 113.0, 66.1, 62.8, 58.7, 55.4, 46.4, 38.0, 25.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.2; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{28}F_3N_2O_4S$ [M + H]$^+$: 507.1536, found 507.1554; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 9.2 min, t_{minor} = 14.2 min.

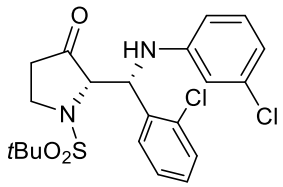


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(3-chlorophenyl)(phenylamino)methyl)pyrrolidin-3-one (3cj). Colorless oil, 35.3 mg, 84% yield, >95:5 *dr*, 95% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.41 (s, 1H), 7.36 – 7.32 (m, 1H), 7.27 (d, *J* = 4.7 Hz, 2H), 7.12 (t, *J* = 7.6 Hz, 2H), 6.69 (t, *J* = 7.2 Hz, 1H), 6.61 (d, *J* = 8.2 Hz, 2H), 5.35 (bs, 1H), 5.11 (d, *J* = 4.9 Hz, 1H), 4.49 (d, *J* = 4.8 Hz, 1H), 3.75 (t, *J* = 10.7 Hz, 1H), 2.62

– 2.45 (m, 2H), 2.05 – 1.96 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.3, 145.6, 140.7, 135.0, 130.3, 129.4, 128.7, 127.9, 126.2, 118.4, 113.8, 66.3, 62.8, 59.1, 46.5, 37.8, 25.0; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}ClN_2O_3S$ [M + H]$^+$: 421.1347, found 421.1357; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 10.0 min, t_{minor} = 20.4 min.

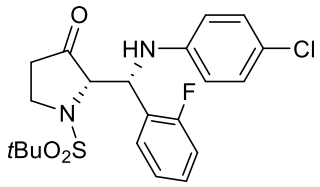


***(S)*-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(3-chlorophenyl)((3-chlorophenyl)amino)methyl)pyrrolidin-3-one (3ck).** Colorless oil, 38.6 mg, 85% yield, >95:5 *dr*, 97% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39 (s, 1H), 7.34 – 7.31 (m, 1H), 7.29 (d, *J* = 5.1 Hz, 2H), 7.02 (t, *J* = 8.0 Hz, 1H), 6.66 – 6.64 (m, 1H), 6.59 (t, *J* = 1.8 Hz, 1H), 6.48 – 6.46 (m, 1H), 5.47 (d, *J* = 8.9 Hz, 1H), 5.08 – 5.05 (m, 1H), 4.46 (d, *J* = 5.0 Hz, 1H), 3.77 – 3.72 (m, 1H), 2.61 – 2.46 (m, 2H), 2.04 – 1.97 (m, 1H), 1.47 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 213.3, 146.7, 140.1, 135.1, 130.4, 128.9, 127.7, 126.1, 118.3, 113.6, 111.8, 66.1, 62.9, 58.9, 46.5, 37.8, 25.0; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{25}Cl_2N_2O_3S$ [M + H]$^+$: 455.0957, found 455.0956; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 95:5, flow rate =1.0 mL/min, t_{major} = 18.2 min, t_{minor} = 17.0 min.

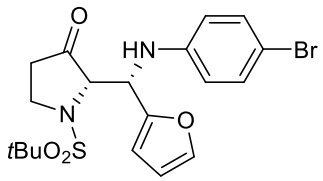


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(2-chlorophenyl)((3-chlorophenyl)amino)methyl)pyrrolidin-3-one (3cl). Colorless oil, 37.2 mg, 82% yield, 94:6 *dr*, 90%(54%) *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.43 – 7.33 (comp, 2H), 7.26 – 7.22 (comp, 2H),

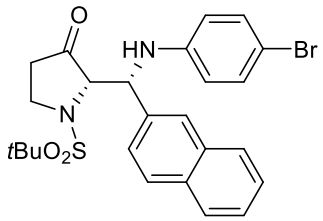
6.99 (t, *J* = 8.1 Hz, 1H), 6.64 – 2 (m, 1H), 6.53 (t, *J* = 2.0 Hz, 1H), 6.40 – 6.38 (m, 1H), 5.43 (s, 1H), 5.18 (d, *J* = 7.3 Hz, 1H), 4.38 (d, *J* = 7.0 Hz, 1H), 4.12 – 4.01 (m, 1H), 3.45 – 3.27 (m, 1H), 2.70 – 2.60 (m, 1H), 2.51 – 2.44 (m, 1H), 1.43 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 209.7, 147.1, 135.4, 135.1, 134.2, 130.4, 129.9, 129.8, 128.6, 127.8, 118.3, 113.6, 111.7, 67.3, 62.8, 55.1, 45.9, 37.6, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{25}Cl_2N_2O_3S$ [M + H]$^+$: 455.0957, found 455.0962; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 24.6 min, t_{minor} = 33.5 min.



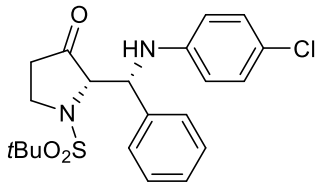
(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-((4-chlorophenyl)amino)(2-fluorophenyl)methyl)pyrrolidin-3-one (3cm). Pale yellow oil, 35.1 mg, 80% yield, >95:5 *dr*, 90% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.29 (t, *J* = 7.2 Hz, 2H), 7.12 – 7.04 (comp, 4H), 6.53 (d, *J* = 8.0 Hz, 2H), 5.34 (bs, 1H), 5.19 (d, *J* = 5.2 Hz, 1H), 4.54 (d, *J* = 12.3 Hz, 1H), 3.94 (t, *J* = 11.0 Hz, 1H), 2.87 – 2.81 (m, 1H), 2.65 – 2.51 (m, 1H), 2.23 – 2.19 (m, 1H), 1.44 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.7, 161.3 (d, *J* = 246.8 Hz), 144.3, 130.3 (d, *J* = 8.4 Hz), 129.3, 128.8 (d, *J* = 3.5 Hz), 125.2 (d, *J* = 12.2 Hz), 125.0 (d, *J* = 3.3 Hz), 123.0, 115.9 (d, *J* = 22.9 Hz), 114.8, 66.0, 62.4, 53.1, 46.4, 37.9, 24.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -116.2; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{25}ClFN_2O_3S$ [M + H]$^+$: 439.1253, found 439.1258; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 17.3 min, t_{minor} = 21.9 min.



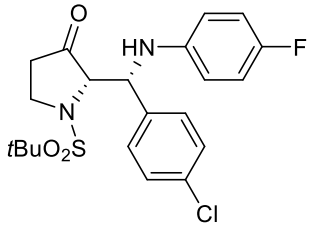
(*S*)-2-((*S*)-((4-Bromophenyl)amino)(furan-2-yl)methyl)-1-((*tert*-butylthio)peroxy) pyrrolidin-3-one (3cn). Yellow oil, 40.5 mg, 85% yield, >95:5 *dr*, 95% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.36 (s, 1H), 7.26 (d, *J* = 9.0 Hz, 2H), 6.60 (d, *J* = 8.7 Hz, 2H), 6.34 (d, *J* = 13.5 Hz, 2H), 5.07 (bs, 2H), 4.50 (s, 1H), 3.88 (t, *J* = 9.9 Hz, 1H), 2.77 – 2.67 (m, 1H), 2.64 – 2.54 (m, 1H), 2.324 – 2.26 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.7, 151.2, 144.7, 142.4, 132.2, 115.6, 111.3, 110.5, 109.4, 63.0, 62.0, 54.0, 46.1, 38.2, 24.7; HRMS (TOF MS ESI$^+$) calculated for $C_{19}H_{24}BrN_2O_4S$ [M + H]$^+$: 477.0454, found 477.0475; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 16.7 min, t_{minor} = 25.0 min.



(*S*)-2-((*R*)-((4-Bromophenyl)amino)(naphthalen-2-yl)methyl)-1-((*tert*-butylthio)peroxy)pyrrolidin-3-one (3co). White solid, 33.4 mg, 65% yield, >95:5 *dr*, 96% *ee*, mp: 162 – 164 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 – 7.79 (comp, 4H), 7.53 – 7.46 (comp, 3H), 7.16 (d, *J* = 8.8 Hz, 2H), 6.54 (d, *J* = 8.7 Hz, 2H), 5.54 (bs, 1H), 5.25 (d, *J* = 2.3 Hz, 1H), 4.53 (d, *J* = 4.7 Hz, 1H), 3.66 – 3.58 (m, 1H), 2.48 – 2.35 (m, 2H), 1.93 – 1.83 (m, 1H), 1.47 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 213.9, 144.9, 135.2, 133.33, 133.30, 132.1, 129.0, 128.2, 127.9, 127.2, 126.7, 126.6, 125.2, 115.5, 109.8, 66.4, 62.8, 59.7, 46.5, 37.9, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{25}H_{27}BrN_2O_3SNa$ [M + Na]$^+$: 537.0818, found 537.0819; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 23.5 min, t_{minor} = 26.7 min.

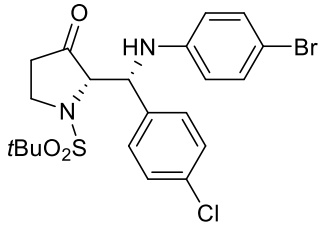


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-((4-chlorophenyl)amino)(phenyl)methyl)pyrrolidin-3-one (3cp). Yellow oil, 35.7 mg, 85% yield, >95:5 *dr*, 94% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.40 – 7.26 (comp, 5H), 7.05 (d, *J* = 8.4 Hz, 2H), 6.56 (d, *J* = 8.5 Hz, 2H), 5.38 (bs, 1H), 5.08 (d, *J* = 4.4 Hz, 1H), 4.46 (d, *J* = 4.7 Hz, 1H), 3.71 – 3.64 (m, 1H), 2.51 – 2.39 (m, 2H), 1.97 – 1.90 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.8, 144.5, 137.7, 129.2, 129.1, 128.6, 127.8, 122.7, 115.0, 66.2, 62.7, 59.7, 46.4, 37.9, 25.0; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}ClN_2O_3S$ [M + H]$^+$: 421.1347, found 421.1362; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 9.3 min, t_{minor} = 16.4 min.

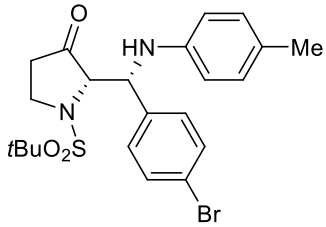


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-(4-chlorophenyl)((4-fluorophenyl)amino)methyl)pyrrolidin-3-one (3cq). Pale yellow oil, 30.7 mg, 70% yield, >95:5 *dr*, 93% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.39 – 7.27 (comp, 4H), 6.82 (t, *J* = 8.6 Hz, 2H), 6.56 – 6.52 (comp, 2H), 5.22 (bs, 1H), 5.10 (d, *J* = 4.4 Hz, 1H), 4.44 (d, *J* = 4.4 Hz, 1H), 3.72 (t, *J* = 9.9 Hz, 1H), 2.65 – 2.56 (m, 1H), 2.54 – 2.45 (m, 1H), 2.01 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.4, 156.2 (d, *J* = 236.1 Hz), 141.8 (d, *J* = 1.9 Hz), 136.6, 134.5, 129.3, 129.2, 115.9 (d, *J* = 21.4 Hz), 114.8 (d, *J* = 7.4 Hz), 66.3, 62.9, 59.5, 46.4, 37.8, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -126.9; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{25}ClFN_2O_3S$ [M + H]$^+$: 439.1253, found 439.1263; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ =

230 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 8.6 min, t_{minor} = 11.2 min.

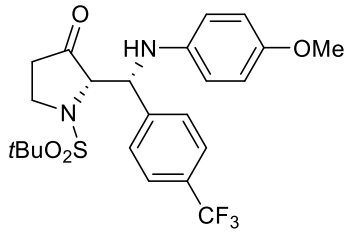


(*S*)-2-((*R*)-((4-Bromophenyl)amino)(4-chlorophenyl)methyl)-1-((*tert*-butylthio)peroxy)pyrrolidin-3-one (3cr). Pale yellow oil, 35.9 mg, 72% yield, >95:5 *dr*, 92% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.37 – 7.28 (comp, 4H), 7.18 (d, *J* = 8.8 Hz, 2H), 6.47 (d, *J* = 8.8 Hz, 2H), 5.39 (d, *J* = 7.1 Hz, 1H), 5.09 (bs, 1H), 4.43 (d, *J* = 5.0 Hz, 1H), 3.72 (t, *J* = 10.8 Hz, 1H), 2.63 – 2.44 (m, 2H), 2.03 – 1.95 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.4, 144.6, 136.3, 134.6, 132.1, 129.3, 129.2, 115.4, 110.1, 66.2, 63.0, 58.9, 46.4, 37.8, 25.1; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{25}ClBrN_2O_3S$ $[M + H]^+$: 499.0452, found 499.0453; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 8.6 min, t_{minor} = 11.4 min.

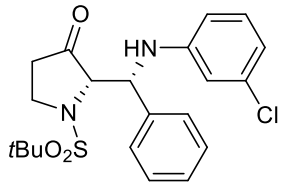


(*S*)-2-((*R*)-(4-Bromophenyl)(*p*-tolylamino)methyl)-1-((*tert*-butylthio)peroxy)pyrrolidin-3-one (3cs). Brown oil, 34.9 mg, 73% yield, >95:5 *dr*, 90% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.45 (d, *J* = 8.2 Hz, 2H), 7.29 (d, *J* = 8.2 Hz, 2H), 6.92 (d, *J* = 8.1 Hz, 2H), 6.52 (d, *J* = 8.1 Hz, 2H), 5.12 (d, *J* = 4.7 Hz, 2H), 4.46 (d, *J* = 4.2 Hz, 1H), 3.72 (t, *J* = 10.2 Hz, 1H), 2.66 – 2.58 (m, 1H), 2.53 – 2.43 (m, 1H), 2.18 (s, 3H), 2.01 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.4, 143.2, 137.6, 132.1, 129.9, 129.6, 127.6, 122.4, 114.0, 66.3, 62.8, 59.2, 46.5, 37.8, 25.1, 20.5; HRMS (TOF MS ESI$^+$) calculated for $C_{22}H_{28}BrN_2O_3S$ $[M + H]^+$: 479.0999, found

479.1025; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 230 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 10.0 min, t_{minor} = 19.1 min.

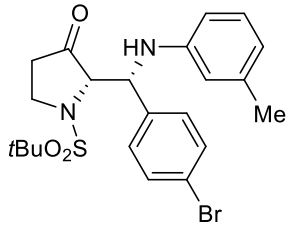


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-((4-methoxyphenyl)amino)(4-(trifluoromethyl)phenyl)methyl)pyrrolidin-3-one (3ct). Brown oil, 36.3 mg, 75% yield, >95:5 *dr*, 90% *ee*; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.60 – 7.54 (comp, 4H), 6.72 (d, *J* = 7.9 Hz, 2H), 6.59 (d, *J* = 7.9 Hz, 2H), 5.21 (s, 2H), 4.51 (s, 1H), 3.76 – 3.67 (comp, 4H), 2.63 – 2.58 (m, 1H), 2.54 – 2.46 (m, 1H), 2.00 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 213.1, 152.8, 142.8, 139.5, 130.6 (q, *J* = 32.7 Hz), 128.4, 125.9 (q, *J* = 3.6 Hz), 124.0 (d, *J* = 272.1 Hz), 115.2, 115.1, 66.4, 63.0, 60.0, 55.8, 46.5, 37.8, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.6; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{27}F_3N_2O_4SNa$ $[M + Na]^+$: 507.1536, found 507.1535; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 12.0 min, t_{minor} = 18.8 min.

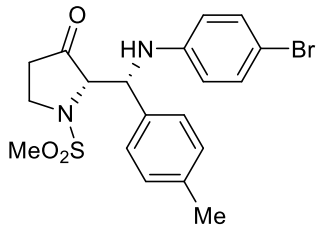


(*S*)-1-((*tert*-Butylthio)peroxy)-2-((*R*)-((3-chlorophenyl)amino)(phenyl)methyl)pyrrolidin-3-one (3cu). White solid, 34.5 mg, 82% yield, >95:5 *dr*, 96% *ee*, mp: 136 – 138 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.43 – 7.29 (comp, 5H), 7.01 (t, *J* = 8.3 Hz, 1H), 6.68 – 6.59 (comp, 2H), 6.50 (d, *J* = 8.3 Hz, 1H), 5.47 (bs, 1H), 5.09 (d, *J* = 4.4 Hz, 1H), 4.47 (d, *J* = 4.8 Hz, 1H), 3.74 – 3.63 (m, 1H), 2.52 – 2.40 (m, 2H), 1.98 – 1.88 (m, 1H), 1.46 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 213.8, 147.1,

137.6, 135.1, 130.4, 129.1, 128.7, 127.7, 118.0, 113.7, 111.9, 66.2, 62.7, 59.4, 46.4, 37.9, 25.0; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}ClN_2O_3S$ [M + H]$^+$: 421.1347, found 421.1351; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 8.8 min, t_{minor} = 13.8 min.

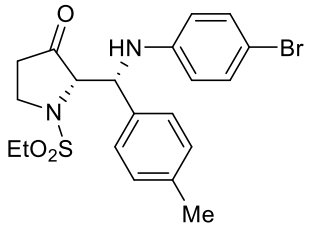


(*S*)-2-((*R*)-(4-Bromophenyl)(*m*-tolylamino)methyl)-1-((*tert*-butylthio)peroxy)pyrolidin-3-one (3cv). Brown oil, 34.4 mg, 72% yield, >95:5 *dr*, 94% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.46 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 6.99 (t, *J* = 7.8 Hz, 1H), 6.55 – 6.37 (comp, 3H), 5.25 (bs, 1H), 5.14 (d, *J* = 4.6 Hz, 1H), 4.46 (d, *J* = 4.5 Hz, 1H), 3.72 (t, *J* = 11.5 Hz, 1H), 2.66 – 2.58 (m, 1H), 2.54 – 2.43 (m, 1H), 2.22 (s, 3H), 2.02 – 1.95 (m, 1H), 1.45 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.4, 145.5, 139.2, 137.5, 132.1, 129.5, 129.3, 122.4, 119.3, 114.7, 110.8, 66.3, 62.9, 58.9, 46.5, 37.8, 25.1, 21.7; HRMS (TOF MS ESI$^+$) calculated for $C_{22}H_{28}BrN_2O_3S$ [M + H]$^+$: 479.0999, found 479.0996; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 230 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 9.4 min, t_{minor} = 16.1 min.

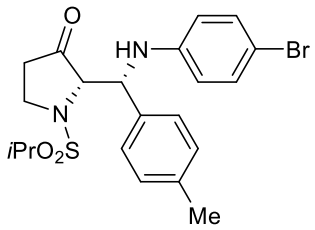


(*S*)-2-((*R*)-((4-Bromophenyl)amino)(*p*-tolyl)methyl)-1-((methylthio)peroxy)pyrrolidin-3-one (3bh). Yellow oil, 31.8 mg, 73% yield, >95:5 *dr*, 92% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.22 – 7.11 (comp, 6H), 6.52 (d, *J* = 8.6 Hz, 2H), 5.29 (bs, 1H), 5.02 (d, *J* = 4.1 Hz, 1H), 4.13 (d, *J* = 4.6 Hz, 1H), 3.54 – 3.47 (m, 1H), 3.09 – 2.99 (m,

1H), 2.89 (s, 3H), 2.44 – 2.34 (m, 1H), 2.30 (s, 3H), 1.86 – 1.77 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.2, 145.0, 138.2, 133.7, 132.1, 129.6, 127.8, 115.6, 110.0, 65.2, 59.3, 44.2, 37.3, 36.2, 21.2; HRMS (TOF MS ESI$^+$) calculated for $C_{19}H_{22}BrN_2O_3S$ [M + H]$^+$: 437.0529, found 437.0535; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 39.1 min, t_{minor} = 23.0 min.



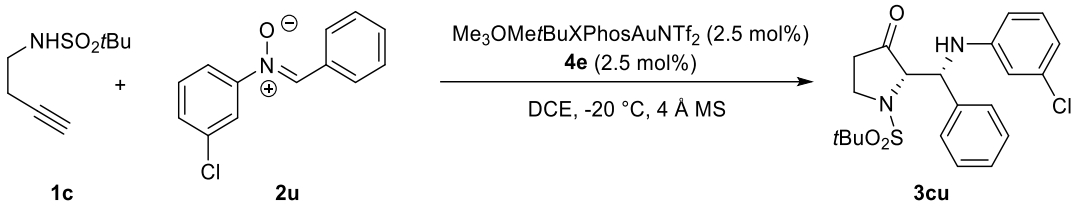
(*S*)-2-((*R*)-((4-Bromophenyl)amino)(*p*-tolyl)methyl)-1-((ethylthio)peroxy)pyrrolidin-3-one (3hh). Yellow oil, 34.2 mg, 76% yield, >95:5 *dr*, 92% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.25 – 7.10 (comp, 6H), 6.51 (d, *J* = 8.7 Hz, 2H), 5.28 (bs, 1H), 4.98 (d, *J* = 4.3 Hz, 1H), 4.25 (d, *J* = 4.7 Hz, 1H), 3.64 – 3.57 (m, 1H), 3.05 (q, *J* = 7.4 Hz, 2H), 2.91 – 2.84 (m, 1H), 2.46 – 2.37 (m, 1H), 2.30 (s, 3H),1.92 – 1.84 (m, 1H), 1.40 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 212.7, 145.0, 138.2, 133.9, 132.1, 129.6, 127.7, 115.6, 109.9, 65.2, 59.4, 45.1, 44.4, 37.5, 21.2, 8.1; HRMS (TOF MS ESI$^+$) calculated for $C_{20}H_{24}BrN_2O_3S$ [M + H]$^+$: 451.0686, found 451.0699; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 30.4 min, t_{minor} = 20.6 min.



(*S*)-2-((*R*)-((4-Bromophenyl)amino)(*p*-tolyl)methyl)-1-(isopropylsulfonyl)pyrrolidin-3-one (3ih). Yellow oil, 34.8 mg, 75% yield, >95:5 *dr*, 94% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.24 – 7.11 (comp, 6H), 6.50 (d, *J* = 8.7 Hz, 2H), 5.30 (d, *J* =

8.1 Hz, 1H), 4.96 (bs, 1H), 4.36 (d, J = 4.8 Hz, 1H), 3.70 – 3.67 (m, 1H), 3.31 – 3.24 (m, 1H), 2.76 – 2.69 (m, 1H), 2.50 – 2.41 (m, 1H), 2.30 (s, 3H), 1.97 – 1.90 (m, 1H), 1.40 – 1.38 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 213.2, 145.0, 138.3, 134.2, 132.1, 129.7, 127.7, 115.5, 109.9, 65.6, 59.6, 53.6, 45.0, 37.7, 21.3, 16.9, 16.8; HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{26}BrN_2O_3S$ $[M + H]^+$: 465.0842, found 465.0833; HPLC conditions for determination of enantiomeric excess: Chiral IA, λ = 254 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 27.2 min, t_{minor} = 18.7 min.

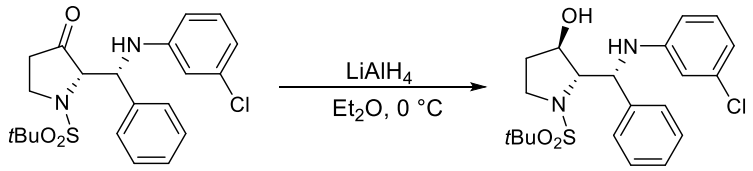
Procedure of the Scale Up



1c **2u** **3cu**

To a 250-mL over-dried vial with a magnetic stirring bar, homopropargyl amides **1c** (491.6 mg, 2.6 mmol), nitrone **2u** (462.1 mg, 2.0 mmol), chiral phosphoric acid **4e** (43.7 mg, 2.5 mol%), 4 Å molecular sieves (1.0 g), Me_3OMe*t*BuXPhosAuNTf$_2$ (48.8 mg, 2.5 mol%), and anhydrous DCE (80 mL) were added in sequence under atmosphere of argon, and the reaction mixture was stirred at -20 ^{o}C for 24 hours. When the reaction was completed (monitored by TLC), the solvent was evaporated in *vacuo* after filtration of molecular sieves. The residue was purified by flash column chromatography on 200-300 mesh silica gel (Hexanes : EtOAc : Dichloromethane = 10:2:1) to give 714.1 mg pure product **3cu** in 84% yield with >95:5 *dr* and 96% *ee*.

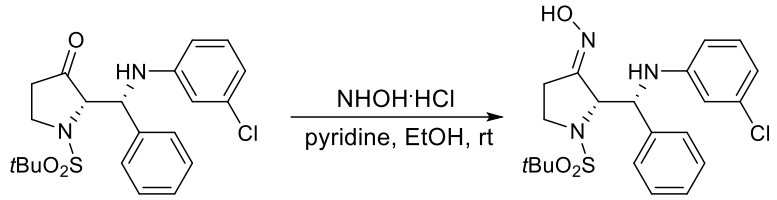
Synthetic Applications



3cu, 96% *ee*

5, 92% yield,
>20:1 *dr*, 96% *ee*

Synthesis of 5: To a 10-mL oven-dried round-bottom flask with a magnetic stirring bar, a solution of **3cu** (42.0 mg, 0.1 mmol) in Et_2O (2.0 mL), was added $LiAlH_4$ (3.8 mg, 0.1 mmol, 1.0 equiv) under stirring at 0 ^oC, and the reaction mixture was stirred for 30 minutes. When the reaction was completed (monitored by TLC), the crude reaction mixture was quenched with water (10 mL) and extracted with DCM (15 mL). The organic layer was washed with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated in *vacuo* after filtration. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc : DCM = 5:1:1) to give 38.7 mg of pure product **5** as colorless oil in 92% yield with >20:1 *dr*, 96% *ee*; ^1H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.53 (d, *J* = 7.4 Hz, 2H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.25 (d, *J* = 7.3 Hz, 1H), 6.93 (t, *J* = 8.0 Hz, 1H), 6.52 – 6.49 (comp, 2H), 6.40 (d, *J* = 9.7 Hz, 1H), 6.00 (d, *J* = 6.0 Hz, 1H), 4.72 – 4.66 (m, 1H), 4.57 – 4.54 (m, 1H), 4.13 (s, 1H), 3.75 – 3.67 (m, 1H), 3.47 – 4.41 (m, 1H), 1.89 – 1.82 (m, 1H), 1.78 (d, *J* = 2.2 Hz, 1H), 1.73 – 1.67 (m, 1H), 1.42 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 147.8, 141.8, 134.8, 130.1, 128.9, 128.0, 127.9, 116.5, 112.3, 111.2, 71.9, 67.9, 62.1, 58.0, 50.7, 35.5, 25.3; HRMS (TOF MS ESI+) calculated for $C_{21}H_{28}ClN_2O_3S$ $[M + H]^+$: 423.1504, found 423.1513; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 254 nm, hexane : isopropanol = 95:5, flow rate =1.0 mL/min, t_{major} = 11.0 min, t_{minor} = 22.1 min.



3cu, 96% *ee*

6, 67% yield,
>20:1 *dr*, 95% *ee*

Synthesis of 6: To a 10-mL oven-dried round-bottom flask with a magnetic stirring bar, and **3cu** (42.0 mg, 0.1 mmol) in EtOH (2.0 mL), was added NHOH·HCl (10.4 mg, 0.3 mmol, 3.0 equiv), and pydrine (12.0 mg, 0.3 mmol, 3.0 equiv.) under stirring at room temperature, and the reaction mixture was stirring for 12 h. When the reaction was completed (monitored by TLC), the crude reaction mixture was quenched with water (10 mL) and extracted with DCM (15 mL). The organic layer was washed with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated in *vacuo* after filtration. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc : DCM = 5:1:1) to give 29.2 mg of pure product **6** as colorless oil in 67% yield with >20:1 *dr*, 95% *ee*; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.85 (s, 1H), 7.40 (d, *J* = 7.3 Hz, 2H), 7.34 – 7.28 (comp, 3H), 6.98 (t, *J* = 8.2 Hz, 1H), 6.59 (d, *J* = 6.7 Hz, 2H), 6.46 (d, *J* = 7.7 Hz, 1H), 5.41 (s, 1H), 4.97 (s, 1H), 4.85 (d, *J* = 4.6 Hz, 1H), 3.51 (t, *J* = 10.0 Hz, 1H), 2.68 – 2.58 (m, 1H), 2.36 – 2.29 (m, 1H), 2.20 – 2.13 (m, 1H), 1.42 (d, *J* = 17.0 Hz, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) (δ, ppm) 161.8, 147.4, 138.3, 134.9, 130.3, 128.9, 128.4, 128.1, 117.6, 113.8, 111.8, 64.3, 62.8, 59.8, 47.9, 27.1, 25.1; HRMS (TOF MS ESI+) calculated for $C_{21}H_{27}ClN_3O_3S$ $[M + H]^+$: 434.1456, found 434.1469; HPLC conditions for determination of enantiomeric excess: Chiral IC, λ = 215 nm, hexane : isopropanol = 90:10, flow rate =1.0 mL/min, t_{major} = 13.2 min, t_{minor} = 9.2 min.

1D-NOE NMR Analysis of 5

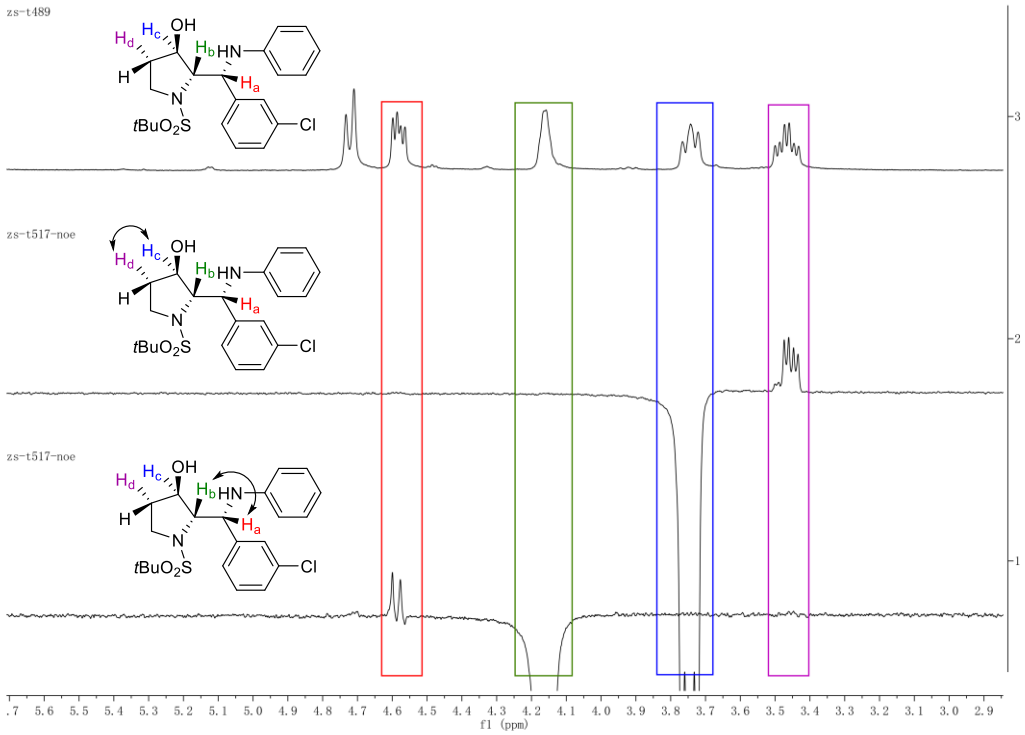


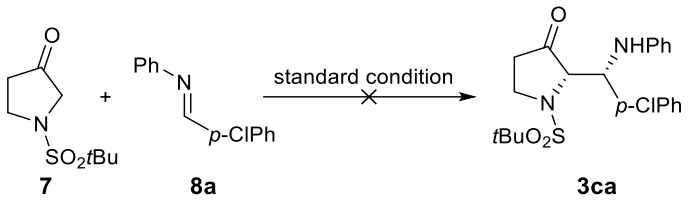
Figure S1. NOE NMR spectra of **5**.

Control Experiments

Compound **7** was prepared according to the reported synthetic method.[3]

1-(*tert*-Butylsulfonyl)pyrrolidin-3-one (7): colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.87 (t, *J* = 7.4 Hz, 2H), 3.82 (s, 2H), 2.60 (t, *J* = 7.5 Hz, 2H), 1.42 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 210.3, 61.7, 55.2, 46.7, 38.2, 24.5.

Control experimental with 7



To a 10-mL oven-dried vial with a magnetic stirring bar, **7** (20.5 mg, 0.1 mmol), imine **8a** (19.6 mg, 0.1 mmol), CPA **4e** (4.4 mg, 5 mol%), $Me_3OMe^tBuXPhosAuNTf_2$ (4.9 mg, 5.0 mol%), 4Å MS (50.0 mg), and anhydrous DCE (4.0 mL) were added in sequence under atmosphere of argon, and the reaction mixture was stirred at -20 °C for 24 hours. The reaction was monitored by ^{1}H NMR (see Figure S2). The imine decomposed while the N-H insertion product **7** remained intact.

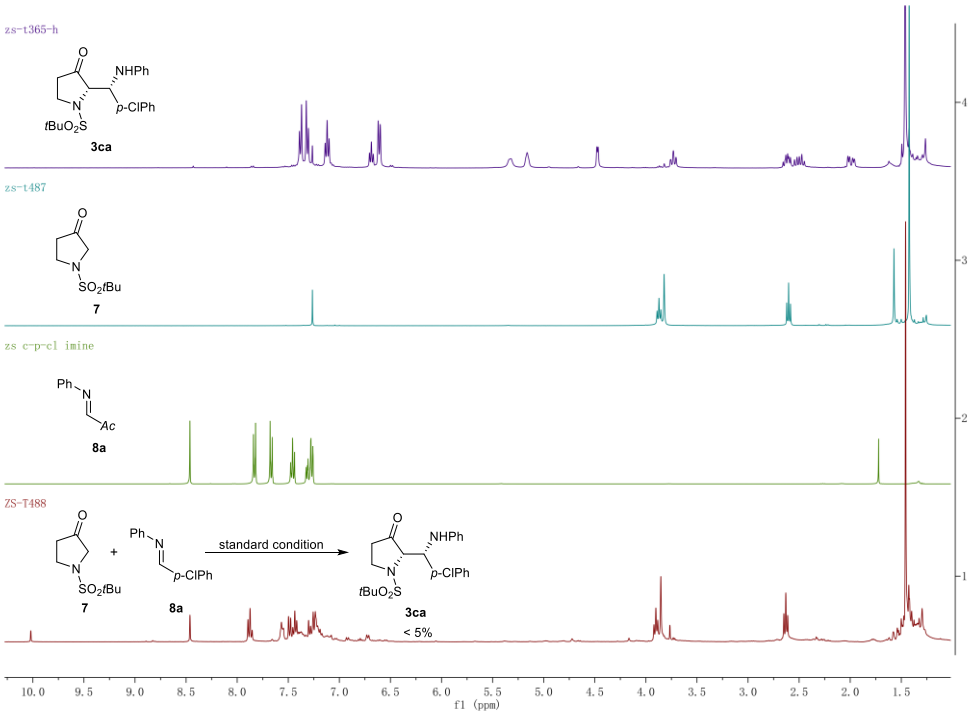
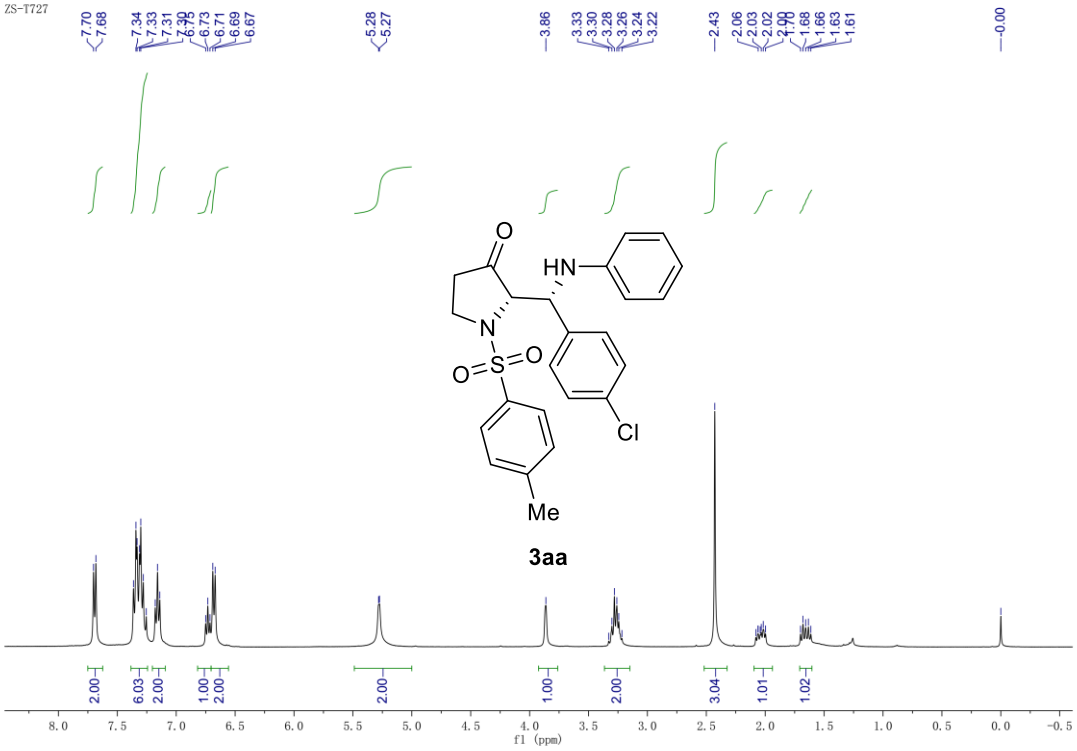
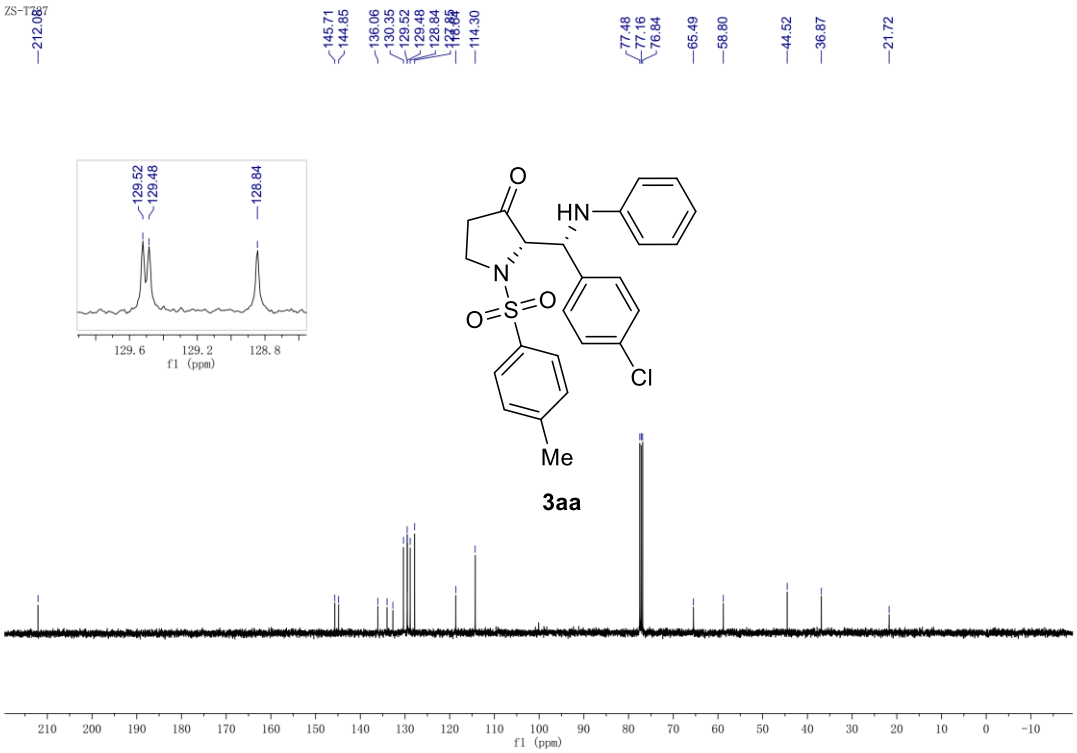
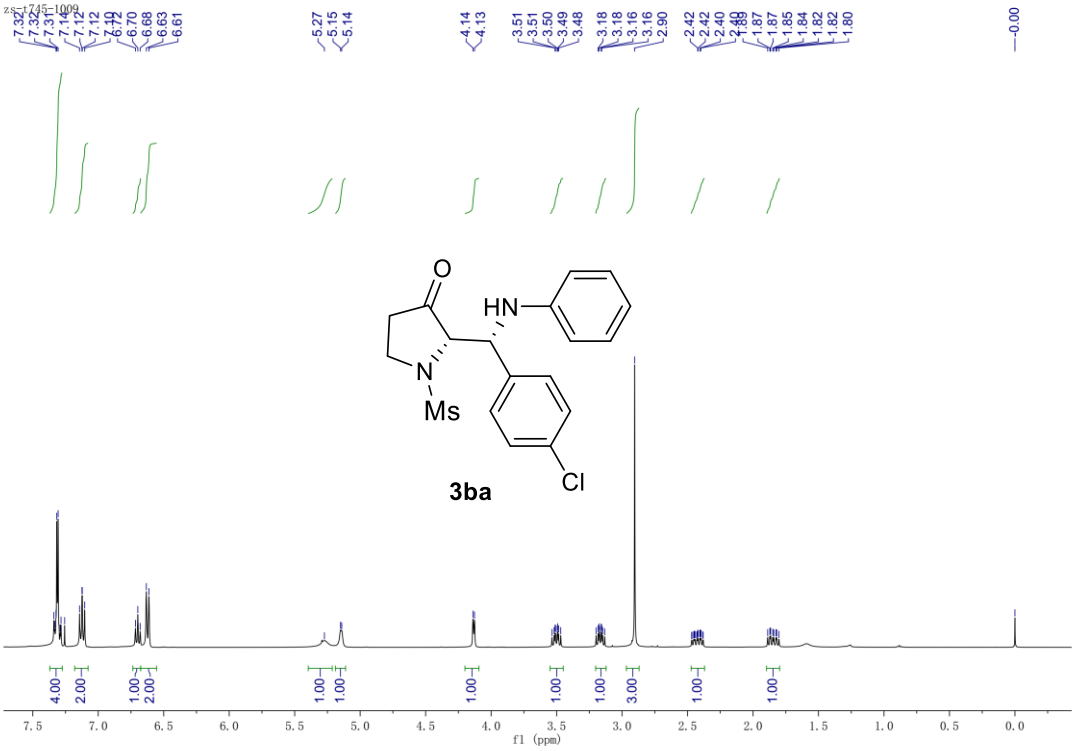
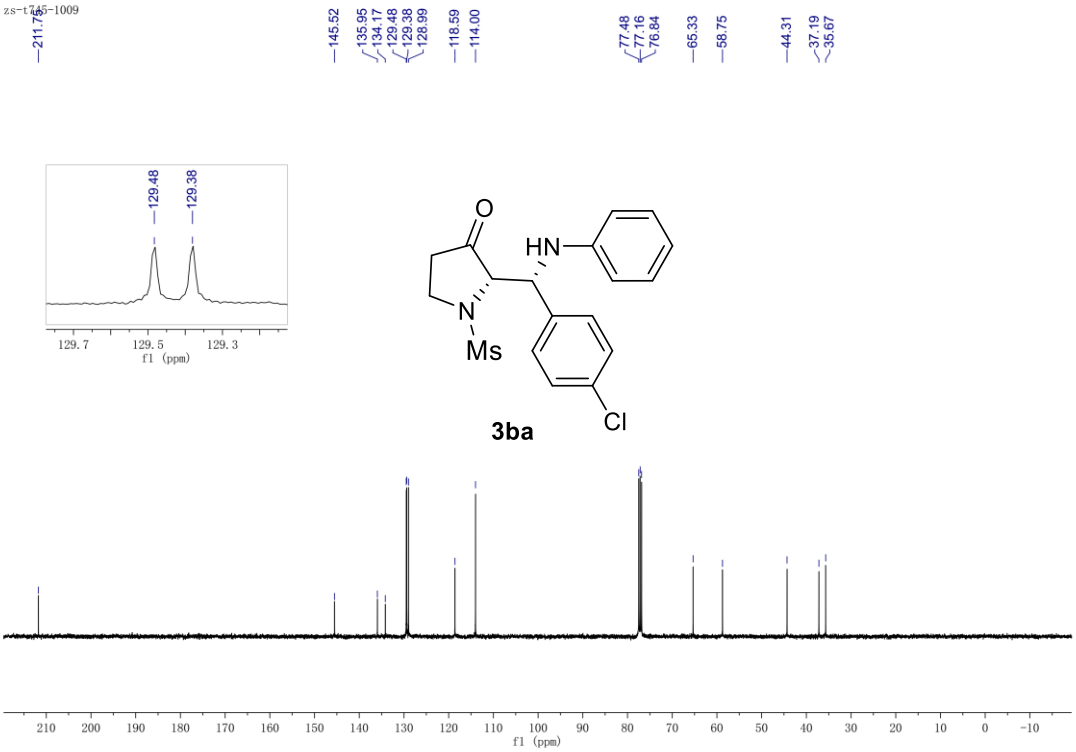


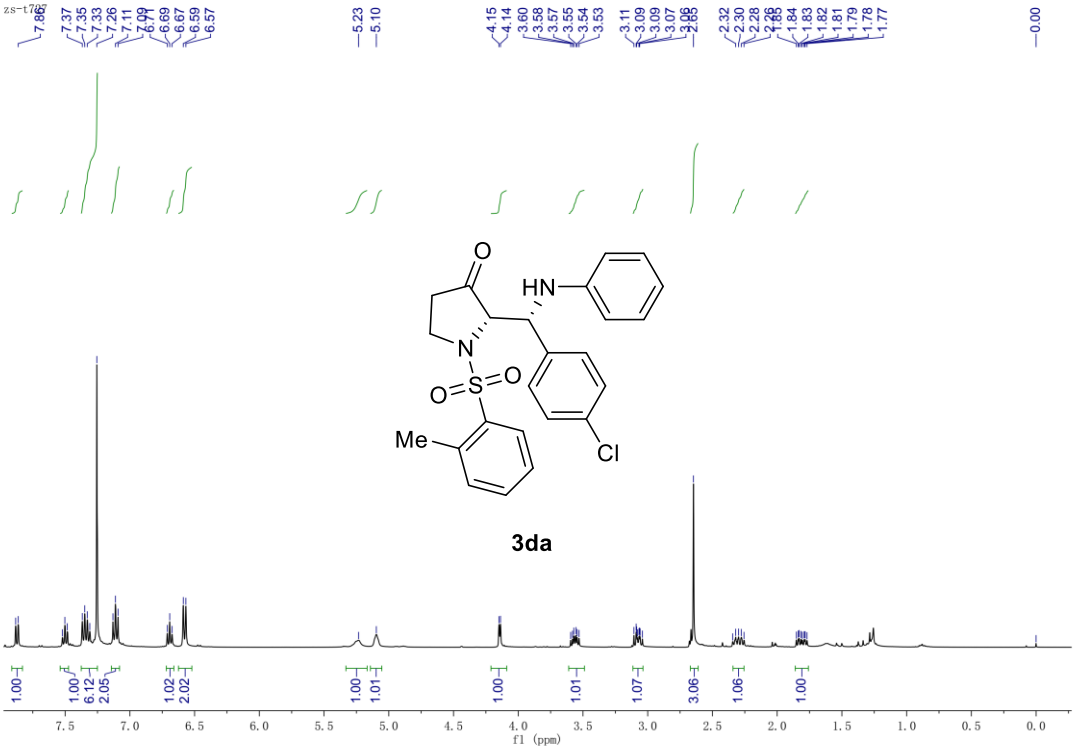
Figure S2. Control experimental of **7** with imine **8a**.


ZS-T727
7.70
7.68
7.34
7.33
7.31
6.73
6.71
6.69
6.67
5.28
5.27
3.86
3.33
3.30
3.28
3.26
3.24
3.22
2.43
2.06
2.03
2.02
1.68
1.66
1.63
1.61
0.00
O
HN
N
O=S=O
Cl
Me
3aa
2.00
6.03
2.00
1.00
2.00
2.00
1.00
2.00
3.04
1.01
1.02
f1 (ppm)

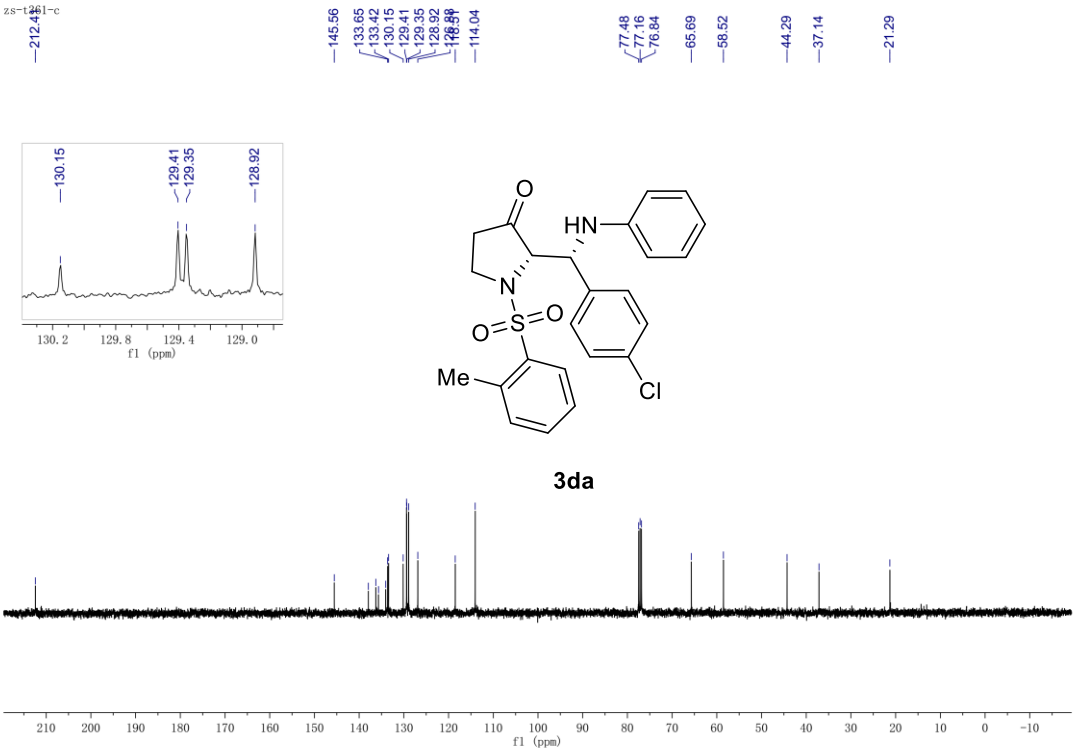

212.08
145.71
144.85
136.06
130.35
129.52
129.48
128.84
114.30
77.48
77.16
76.84
65.49
58.80
44.52
36.87
21.72
129.52
129.48
128.84
129.6
129.2
128.8
f1 (ppm)
O
HN
N
O=S=O
Cl
Me
3aa
f1 (ppm)


zs-t745-1009
7.32
7.31
7.14
7.12
6.70
6.68
6.63
6.61
5.27
5.15
5.14
4.14
4.13
3.51
3.50
3.49
3.48
3.18
3.16
2.90
2.42
2.40
1.87
1.85
1.84
1.82
1.80
0.00
O
HN
N
Ms
Cl
3ba
4.00
2.00
1.00
2.00
1.00
1.00
1.00
1.00
1.00
3.00
1.00
1.00
f1 (ppm)

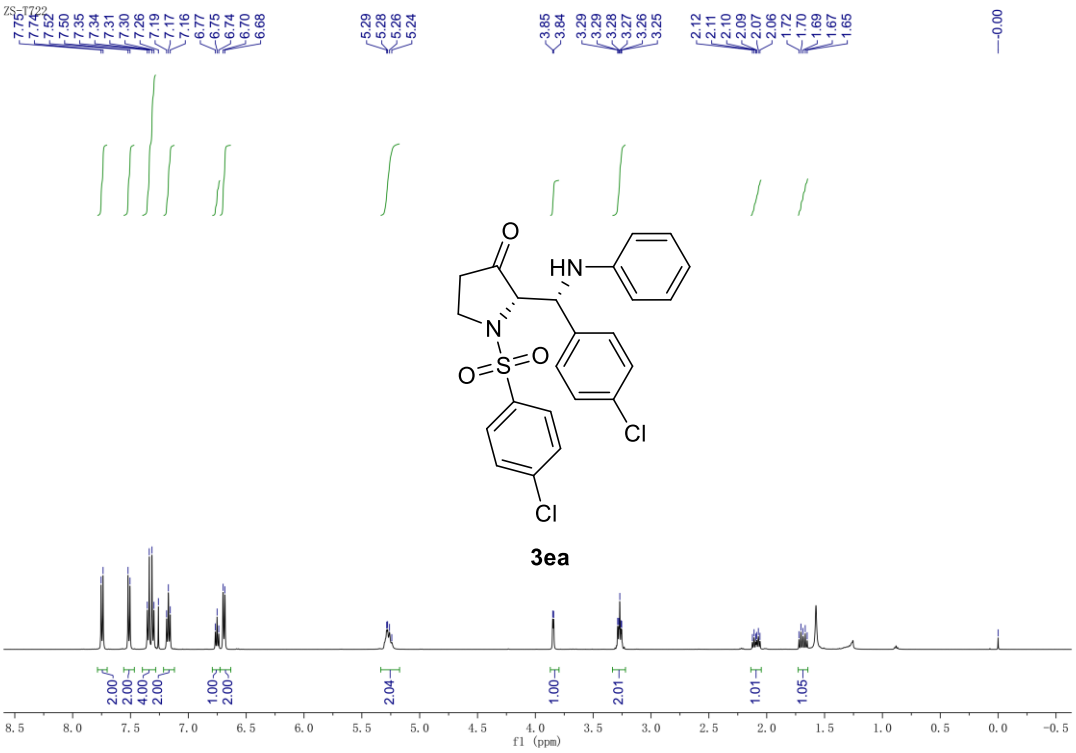

zs-t745-1009
211.77
145.52
135.95
134.17
129.48
129.38
128.99
118.59
114.00
77.48
77.16
76.84
65.33
58.75
44.31
37.19
35.67
129.48
129.38
129.7
129.5
129.3
f1 (ppm)
O
HN
N
Ms
Cl
3ba
f1 (ppm)


7.86
7.37
7.35
7.33
7.26
7.11
6.69
6.67
6.59
6.57
5.23
5.10
4.15
4.14
3.60
3.58
3.57
3.55
3.54
3.53
3.11
3.09
3.09
3.07
2.32
2.30
2.28
1.84
1.83
1.82
1.81
1.79
1.78
1.77
0.00
HN
N
O
O=S=O
Me
Cl
1.00
1.00
6.12
2.05
1.02
2.02
1.00
1.01
1.00
1.01
1.07
3.06
1.06
1.00
f1 (ppm)

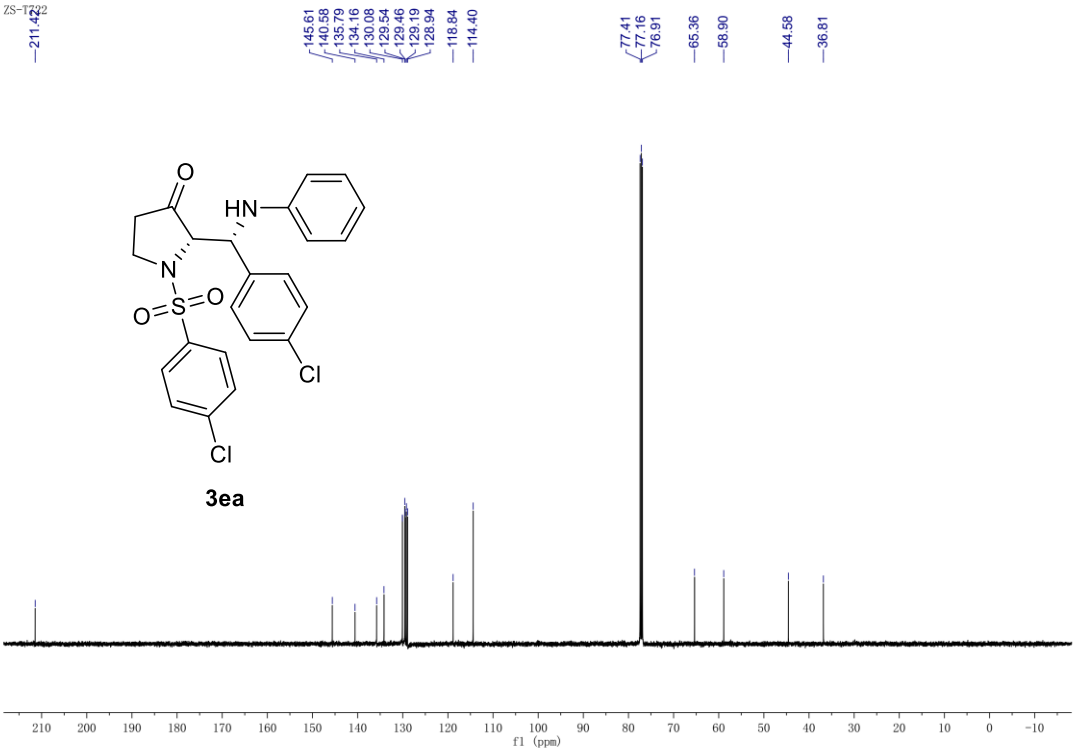
3da


212.43
145.56
133.65
133.42
130.15
129.41
129.35
128.92
114.04
77.48
77.16
76.84
65.69
58.52
44.29
37.14
21.29
130.15
129.41
129.35
128.92
f1 (ppm)
HN
N
O
O=S=O
Me
Cl
f1 (ppm)

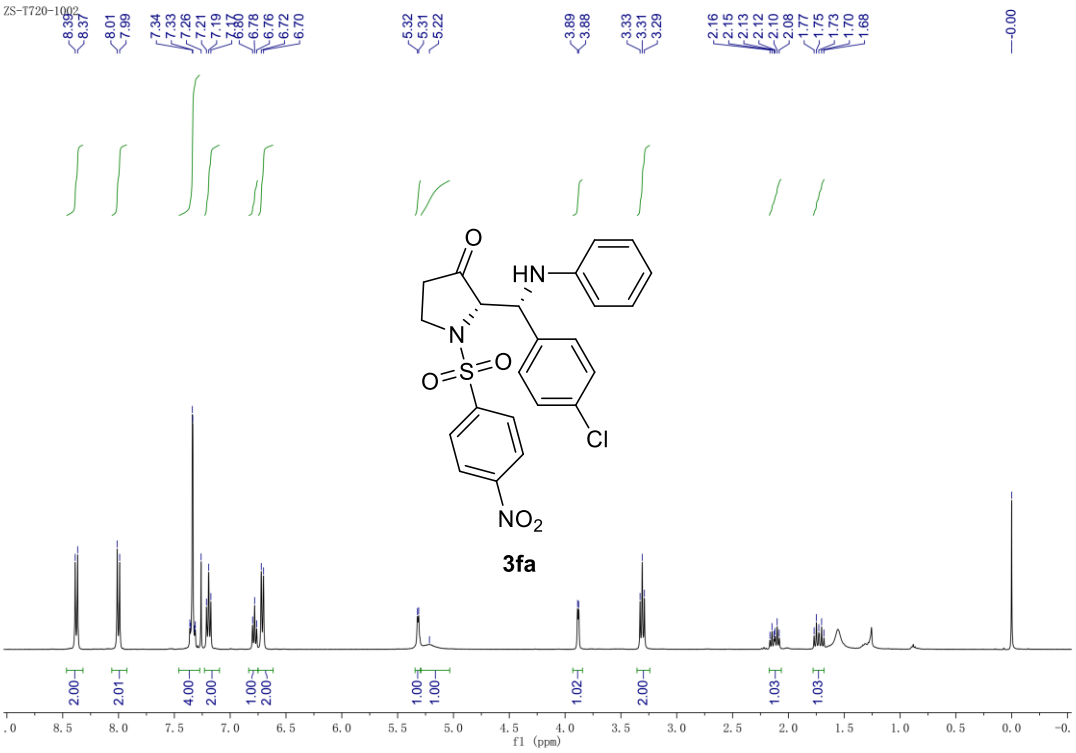
3da

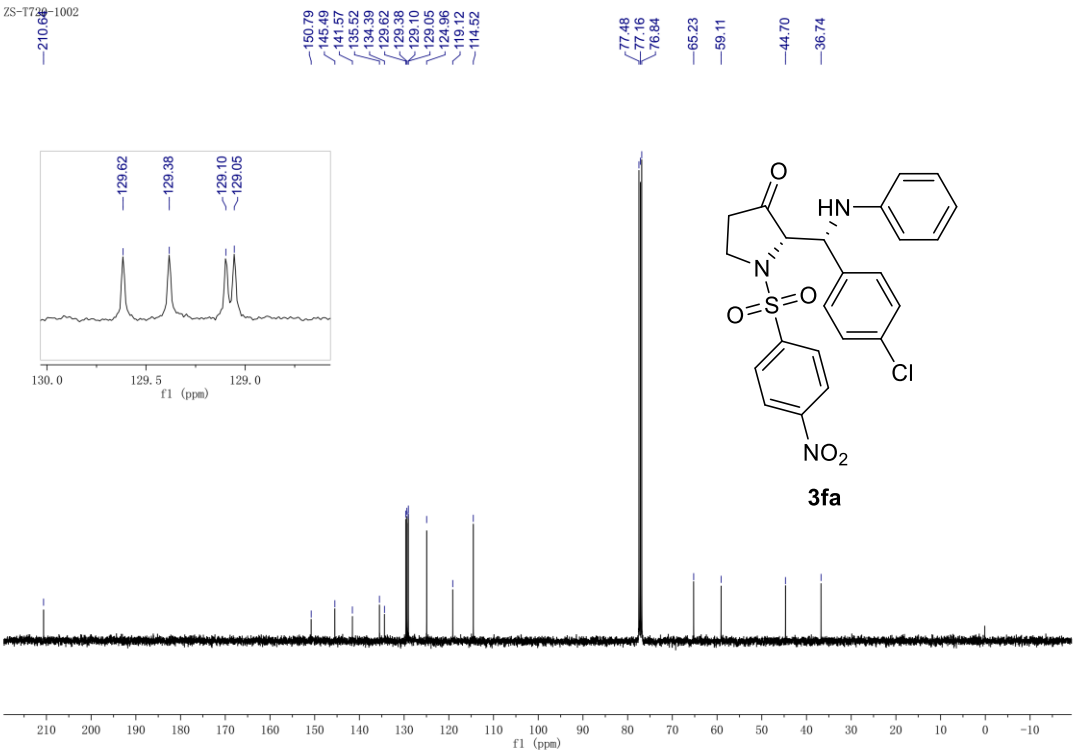

ZS-T722
7.75
7.74
7.52
7.50
7.35
7.34
7.31
7.30
7.26
7.19
7.17
7.16
6.77
6.75
6.74
6.70
6.68
5.29
5.28
5.26
5.24
3.85
3.84
3.29
3.29
3.28
3.27
3.26
3.25
2.12
2.11
2.10
2.09
2.07
2.06
1.72
1.70
1.69
1.67
1.65
0.00
O
HN
N
O=S=O
Cl
Cl
2.00
2.00
4.00
2.00
1.00
2.00
2.04
1.00
2.01
1.01
1.05
f1 (ppm)

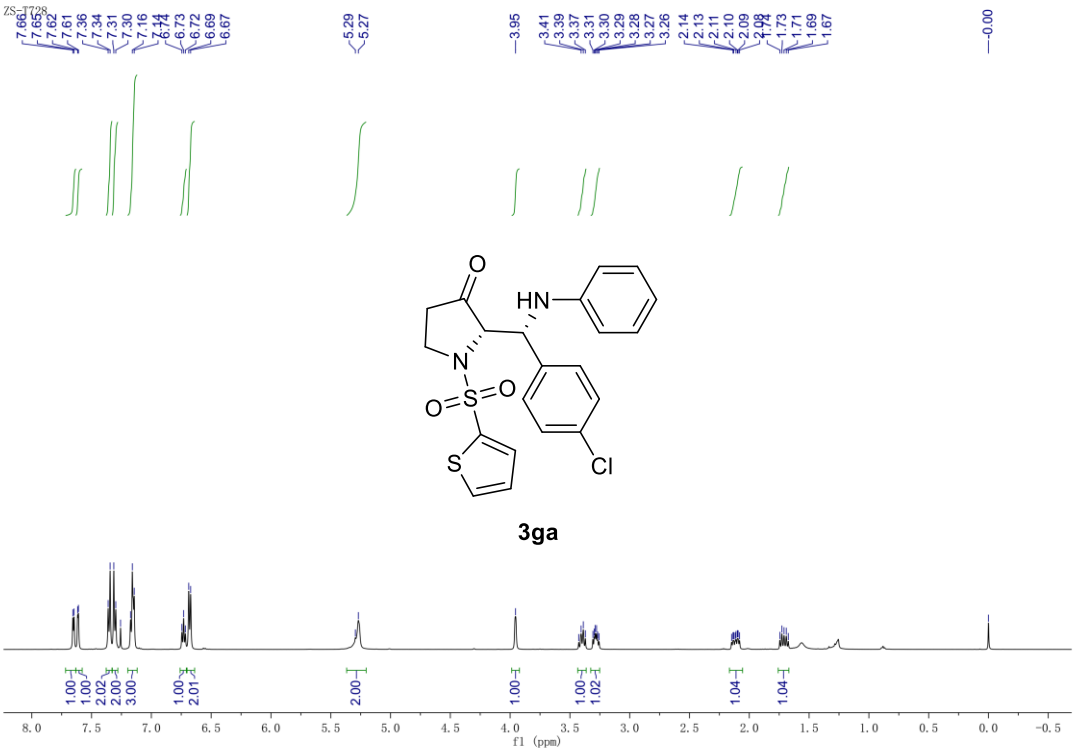
3ea


ZS-T722
211.42
145.61
140.58
135.79
134.16
130.08
129.54
129.46
129.19
128.94
118.84
114.40
77.41
77.16
76.91
65.36
58.90
44.58
36.81
O
HN
N
O=S=O
Cl
Cl
f1 (ppm)

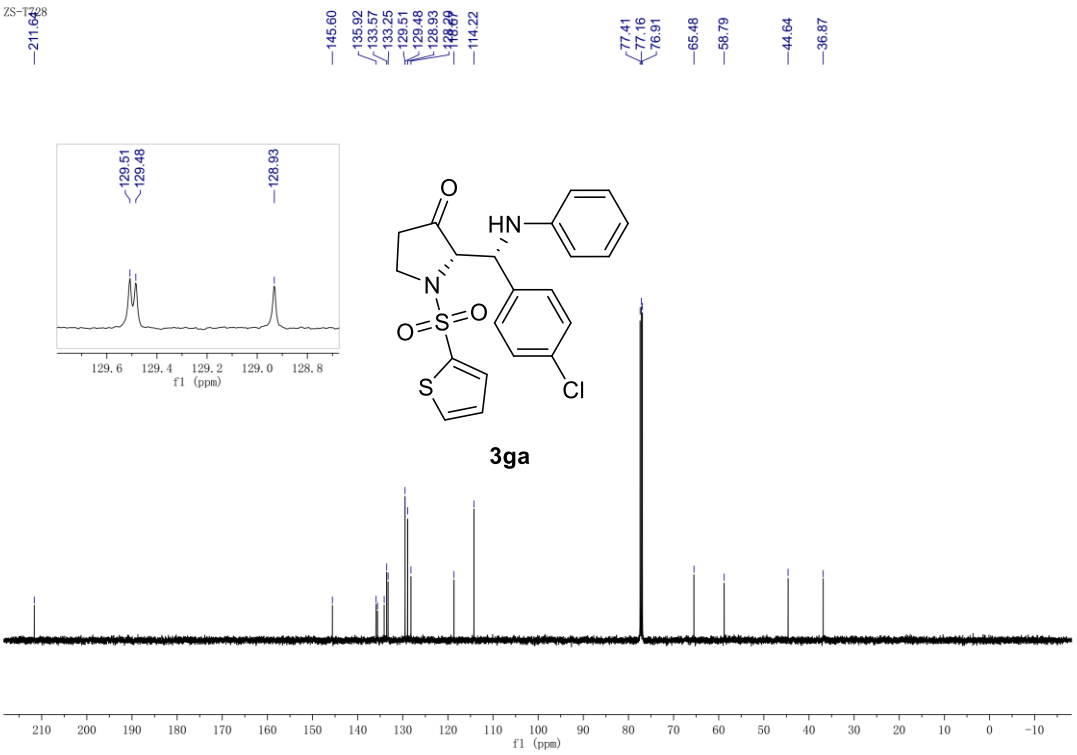
3ea


ZS-T720-1002
8.39
8.37
8.01
7.99
7.34
7.33
7.26
7.21
7.19
7.17
6.80
6.78
6.76
6.72
6.70
5.32
5.31
5.22
3.89
3.88
3.33
3.31
3.29
2.16
2.15
2.13
2.12
2.10
2.08
1.77
1.75
1.73
1.70
1.68
0.00
O
HN
N
O=S=O
Cl
NO2
3fa
2.00
2.01
4.00
2.00
1.00
2.00
1.00
1.00
1.02
2.00
1.03
1.03
f1 (ppm)

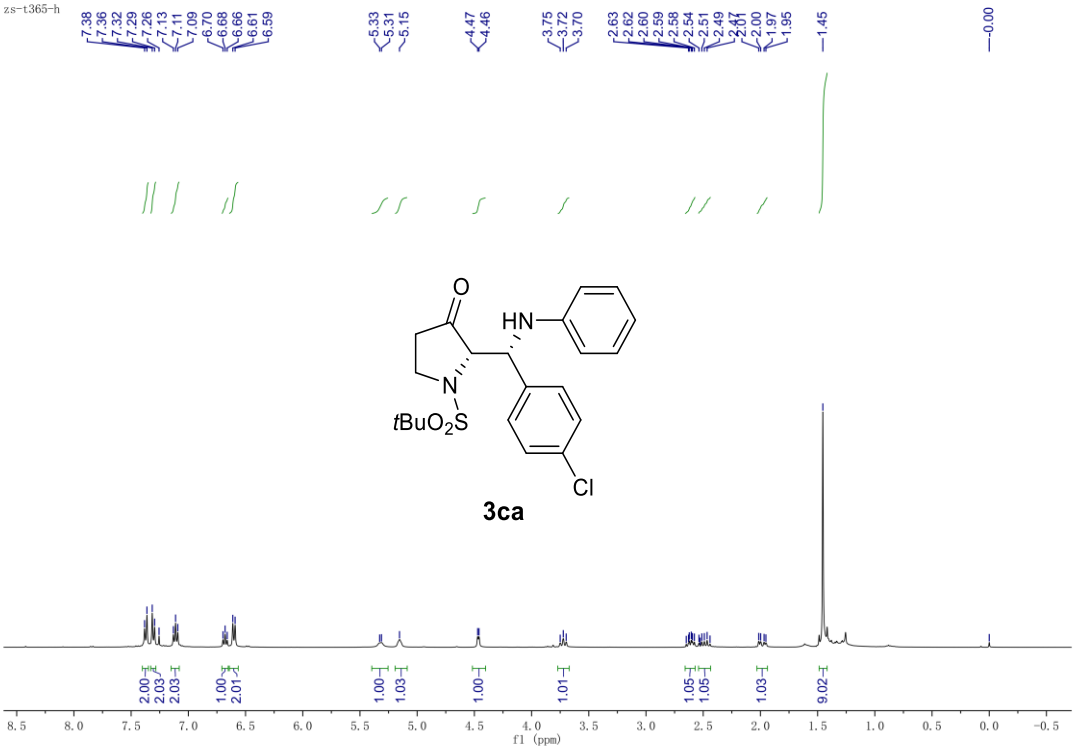

ZS-T720-1002
210.68
150.79
145.49
141.57
135.52
134.39
129.62
129.38
129.10
129.05
124.96
119.12
114.52
77.48
77.16
76.84
65.23
59.11
44.70
36.74
129.62
129.38
129.10
129.05
130.0
129.5
129.0
f1 (ppm)
O
HN
N
O=S=O
Cl
NO2
3fa
f1 (ppm)

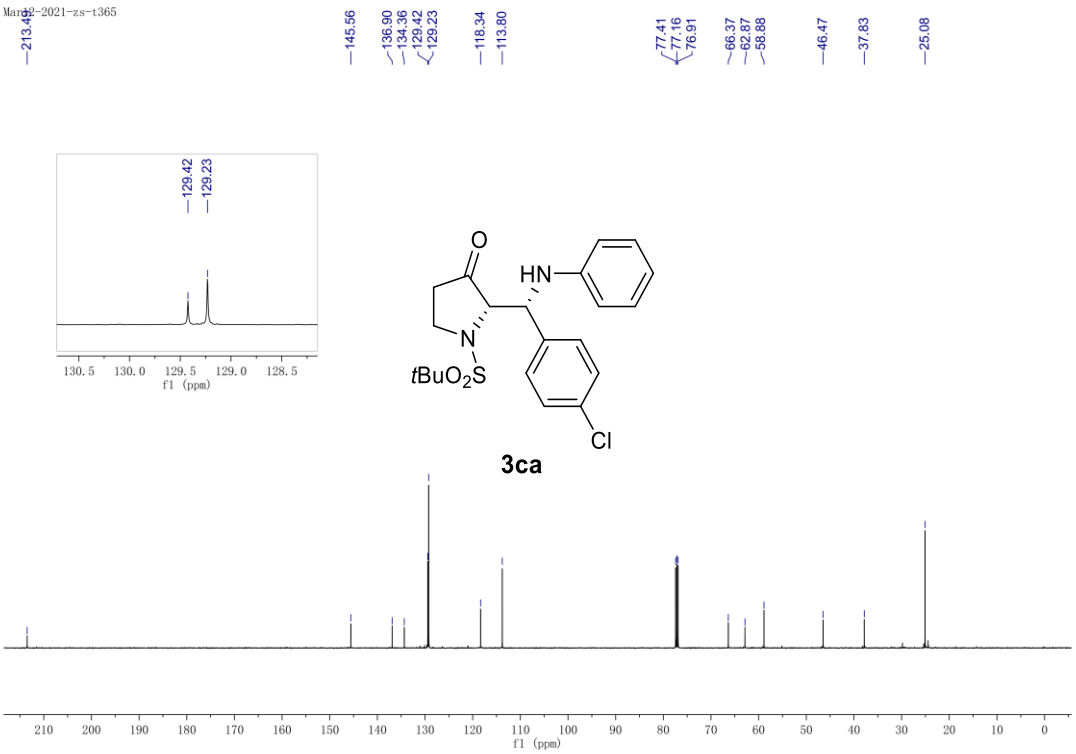

ZS-T728
7.66
7.65
7.62
7.61
7.36
7.34
7.31
7.30
7.16
6.73
6.72
6.69
6.67
5.29
5.27
3.95
3.41
3.39
3.37
3.31
3.30
3.29
3.28
3.27
3.26
2.14
2.13
2.11
2.10
2.09
1.73
1.71
1.69
1.67
0.00
O
HN
N
O=S=O
S
Cl
1.00
1.00
2.02
2.00
3.00
1.00
2.01
2.00
1.00
1.00
1.02
1.04
1.04
f1 (ppm)

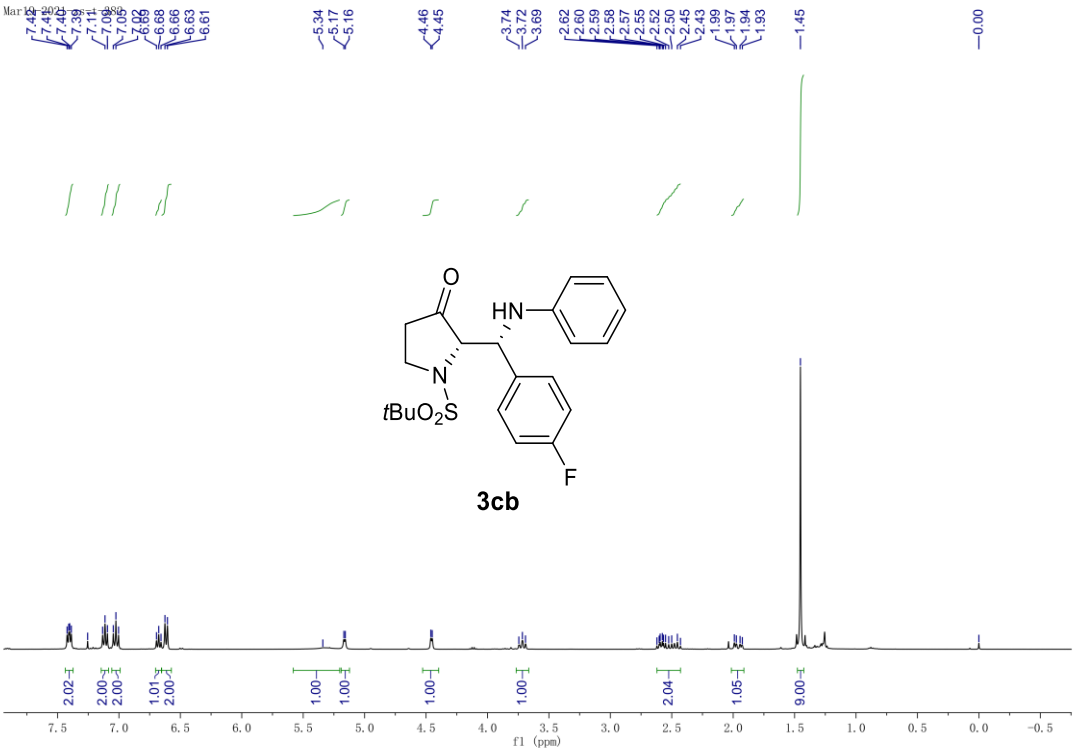
3ga

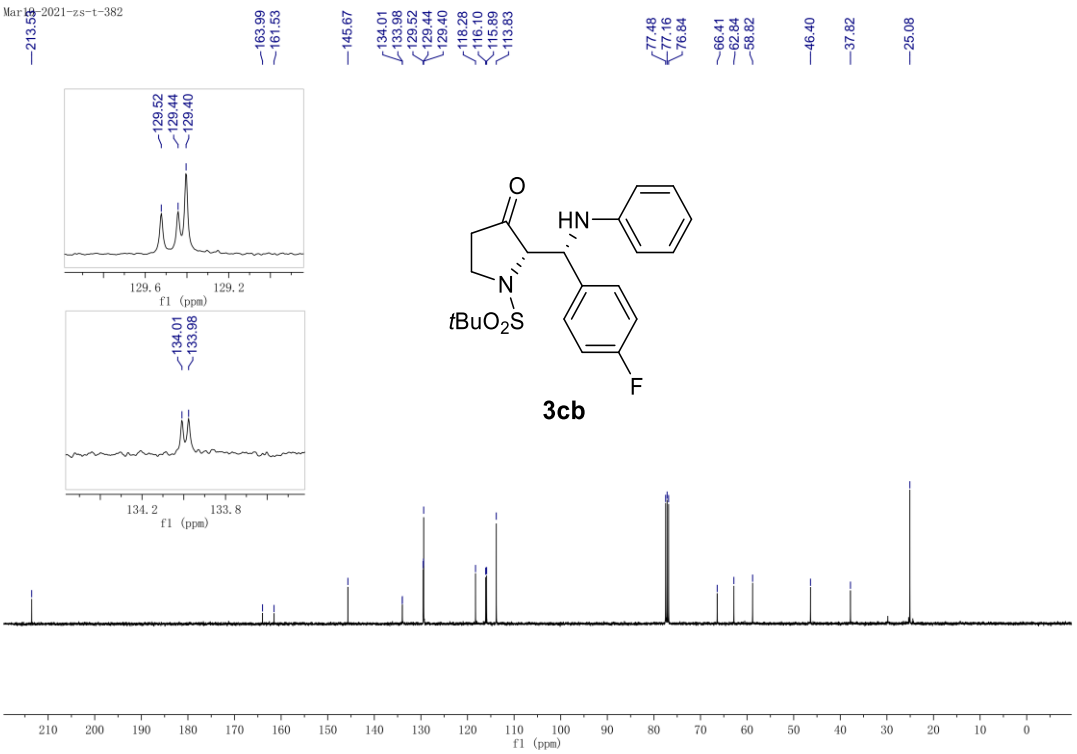

ZS-T728
211.64
145.60
135.92
133.57
133.25
129.51
129.48
128.93
114.22
77.41
77.16
76.91
65.48
58.79
44.64
36.87
129.51
129.48
128.93
f1 (ppm)
O
HN
N
O=S=O
S
Cl
f1 (ppm)

3ga

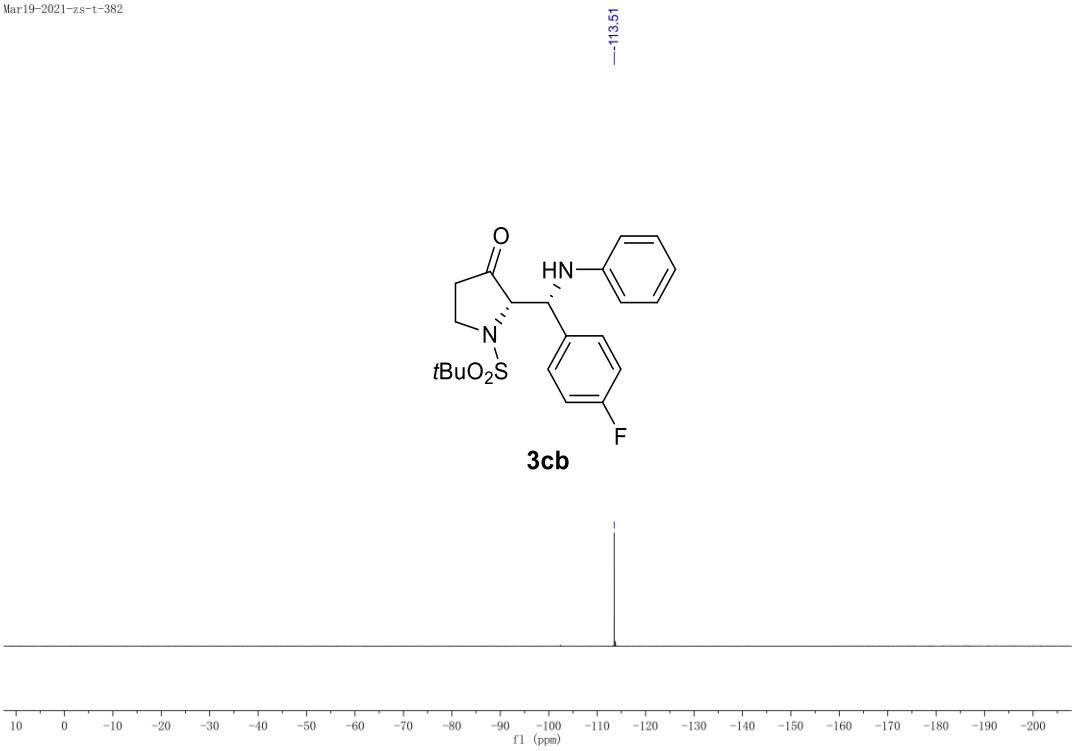

zs-t365-h
7.38
7.36
7.32
7.29
7.26
7.13
7.11
7.09
6.70
6.68
6.66
6.61
6.59
5.33
5.31
5.15
4.47
4.46
3.75
3.72
3.70
2.63
2.62
2.60
2.59
2.58
2.54
2.51
2.49
2.01
2.00
1.97
1.95
1.45
0.00
O
HN
N
tBuO2S
Cl
3ca
2.00
2.03
2.03
1.00
2.01
1.00
1.03
1.00
1.01
1.05
1.05
1.03
9.02
f1 (ppm)

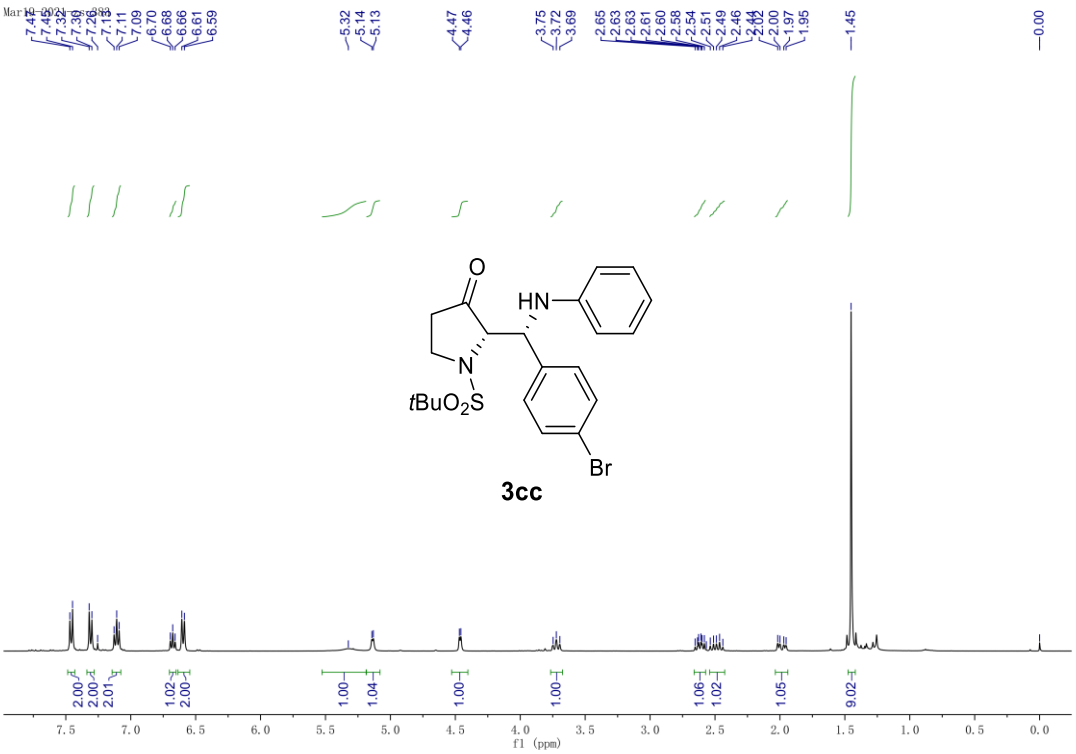

March2-2021-zs-t365
213.42
145.56
136.90
134.36
129.42
129.23
118.34
113.80
77.41
77.16
76.91
66.37
62.87
58.88
46.47
37.83
25.08
129.42
129.23
f1 (ppm)
O
HN
N
tBuO2S
Cl
3ca
f1 (ppm)

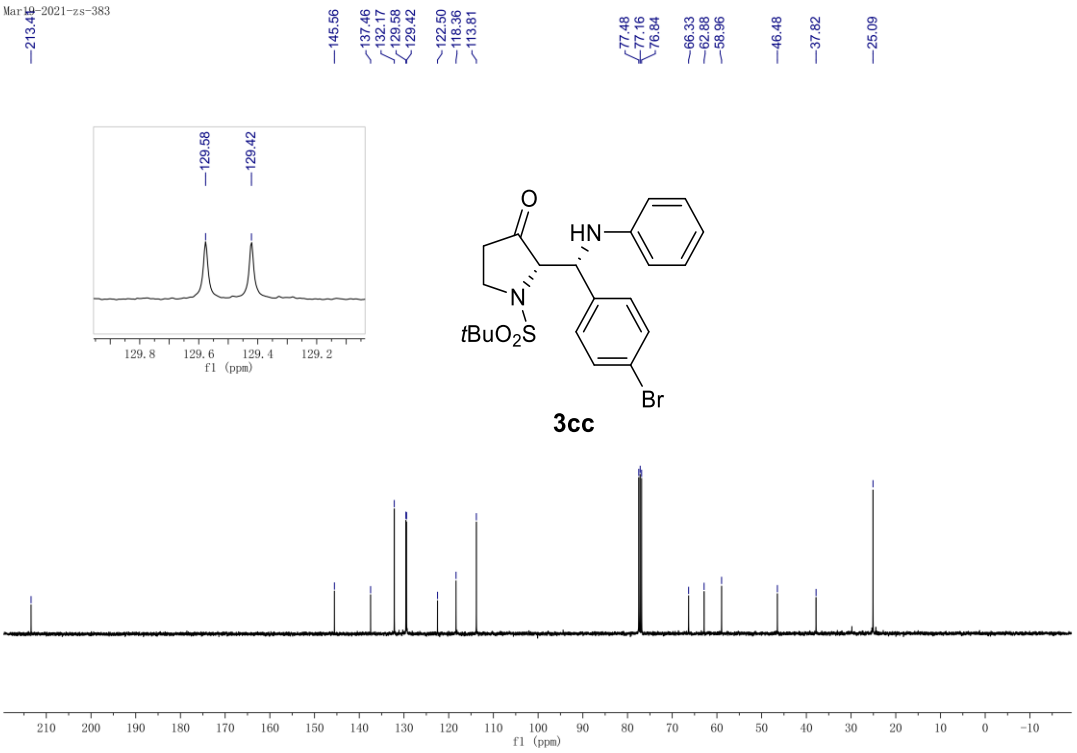

7.45
7.41
7.40
7.39
7.11
7.08
7.05
7.02
6.69
6.68
6.66
6.63
6.61
5.34
5.17
5.16
4.46
4.45
3.74
3.72
3.69
2.62
2.60
2.59
2.58
2.57
2.55
2.52
2.50
2.45
2.43
1.99
1.97
1.94
1.93
1.45
0.00
O
HN
N
tBuO2S
F
3cb
2.02
2.00
2.00
1.01
2.00
1.00
1.00
1.00
1.00
2.04
1.05
9.00
f1 (ppm)

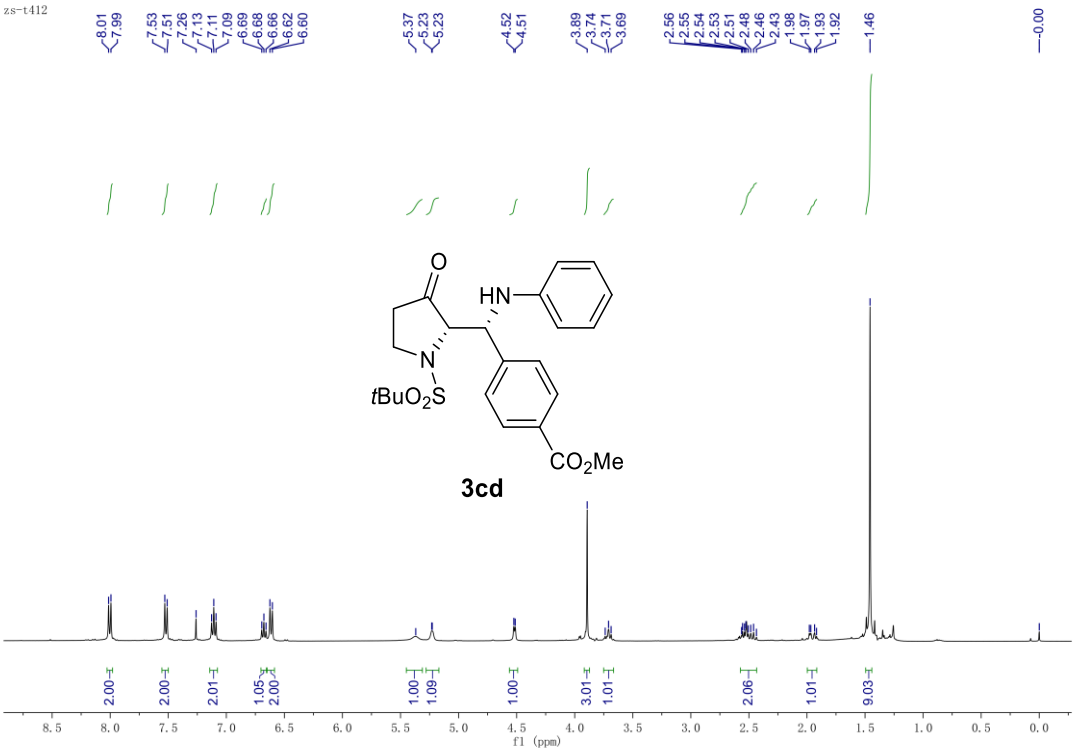

213.53
163.99
161.53
145.67
134.01
133.98
129.52
129.44
129.40
118.28
116.10
115.89
113.83
77.48
77.16
76.84
66.41
62.84
58.82
46.40
37.82
25.08
129.52
129.44
129.40
129.6
129.2
f1 (ppm)
134.01
133.98
134.2
133.8
f1 (ppm)
O
HN
N
tBuO2S
F
3cb
f1 (ppm)

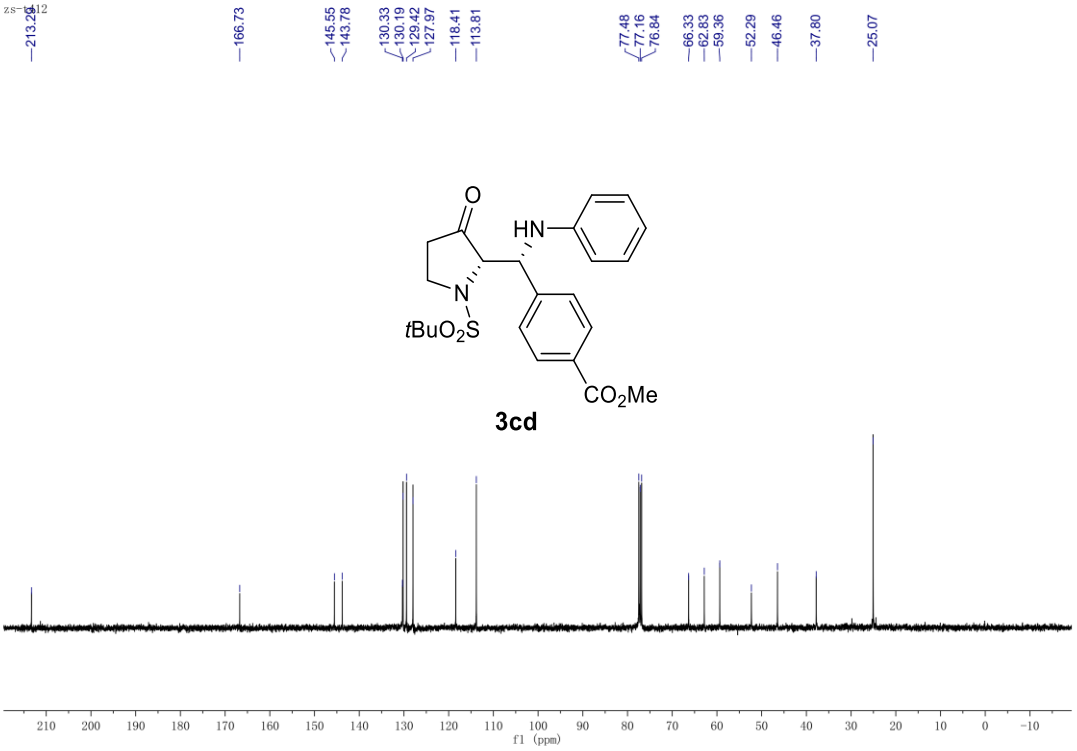
Mar19-2021-zs-t-382

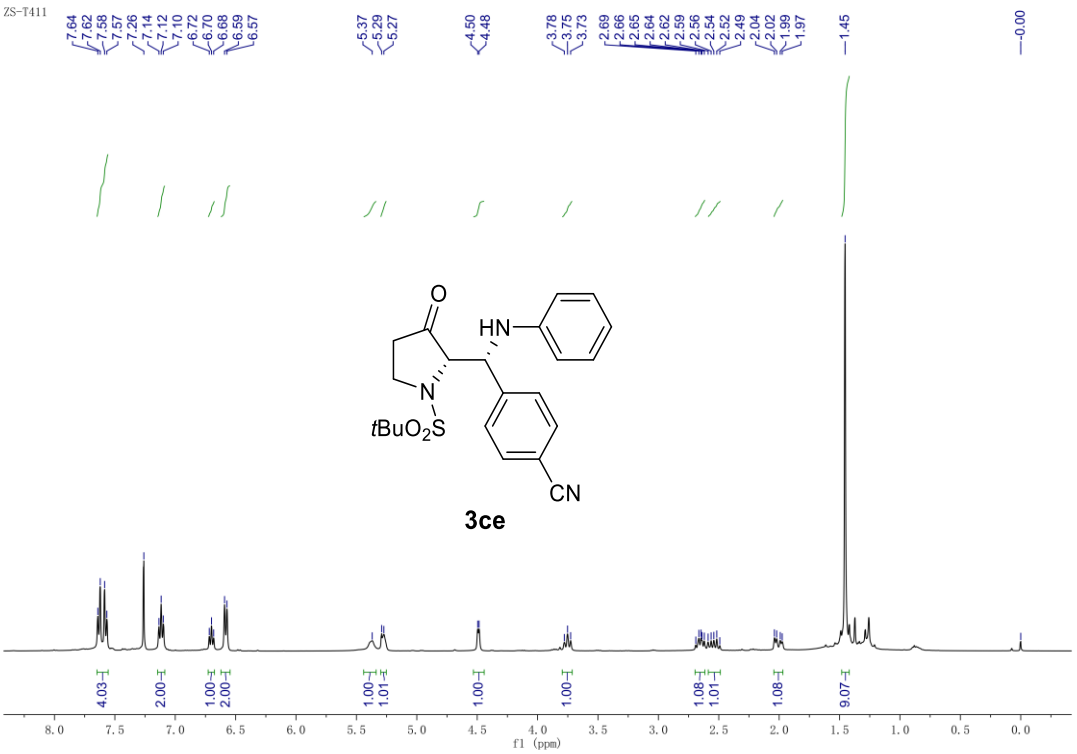


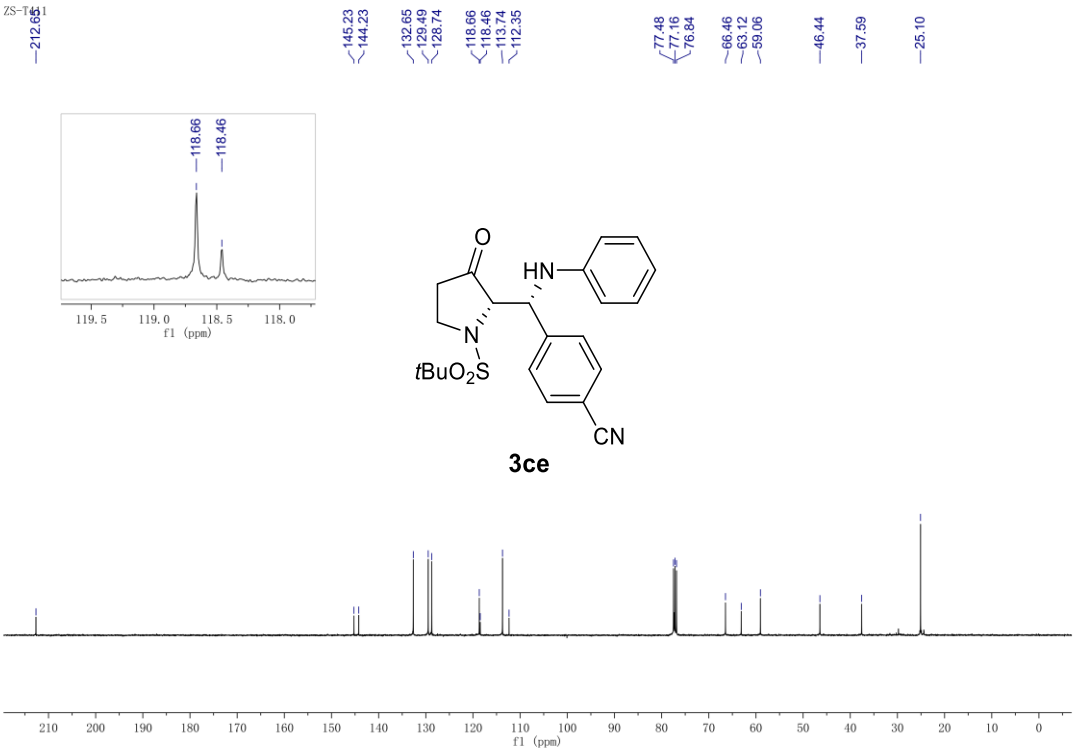


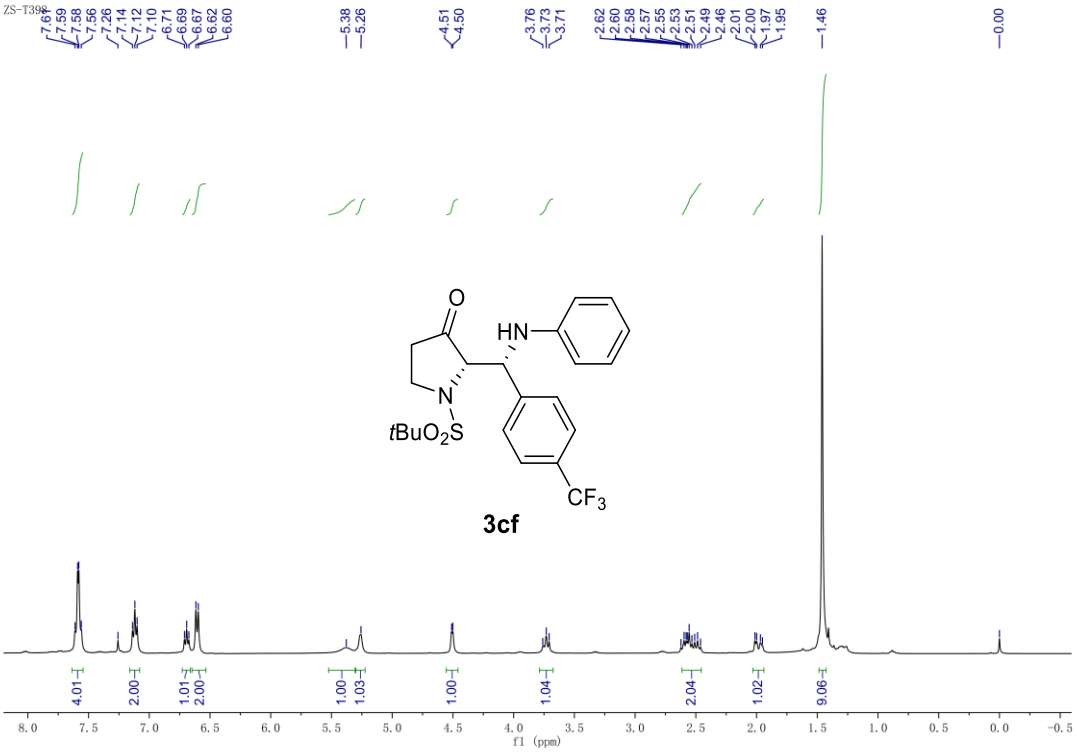

Mar19-2021-zs-383
213.45
145.56
137.46
132.17
129.58
129.42
122.50
118.36
113.81
77.48
77.16
76.84
66.33
62.88
58.96
46.48
37.82
25.09
129.58
129.42
129.8
129.6
129.4
129.2
f1 (ppm)
O
HN
N
tBuO2S
Br
3cc
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

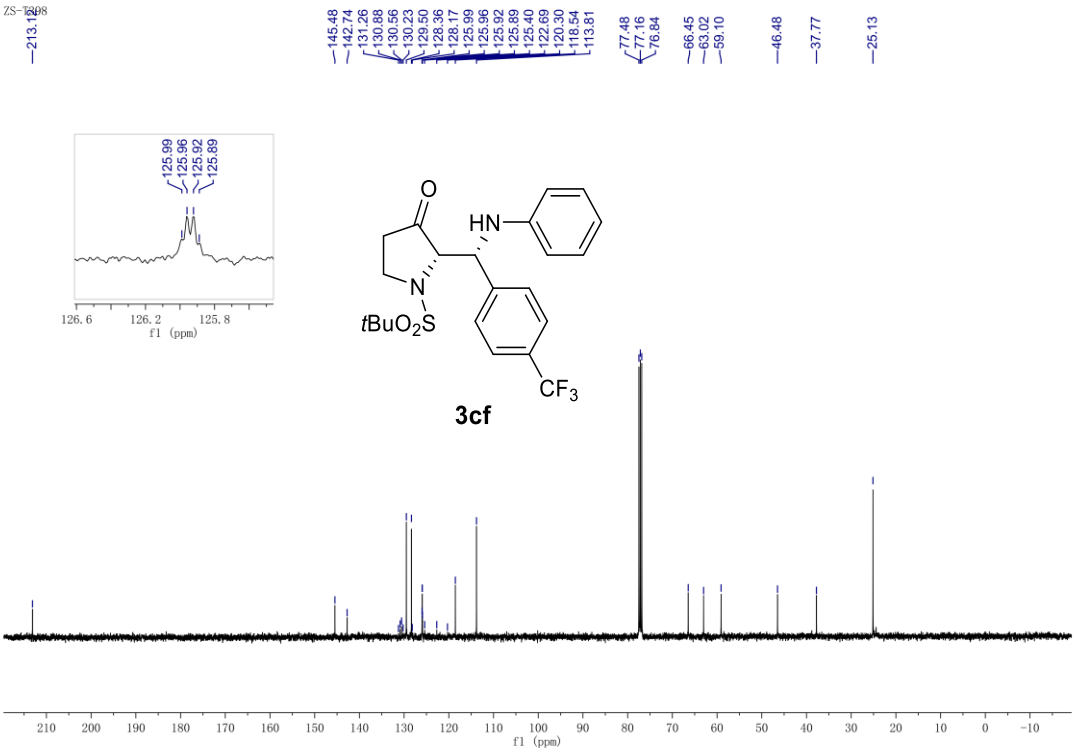

zs-t412
8.01
7.99
7.53
7.51
7.26
7.13
7.11
7.09
6.69
6.68
6.66
6.62
6.60
5.37
5.23
5.23
4.52
4.51
3.89
3.74
3.71
3.69
2.56
2.55
2.54
2.53
2.51
2.48
2.46
2.43
1.98
1.97
1.93
1.92
1.46
0.00
O
HN
N
tBuO2S
CO2Me
3cd
2.00
2.00
2.01
1.05
2.00
1.00
1.09
1.00
3.01
1.01
2.06
1.01
9.03
8.5
8.0
7.5
7.0
6.5
6.0
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)

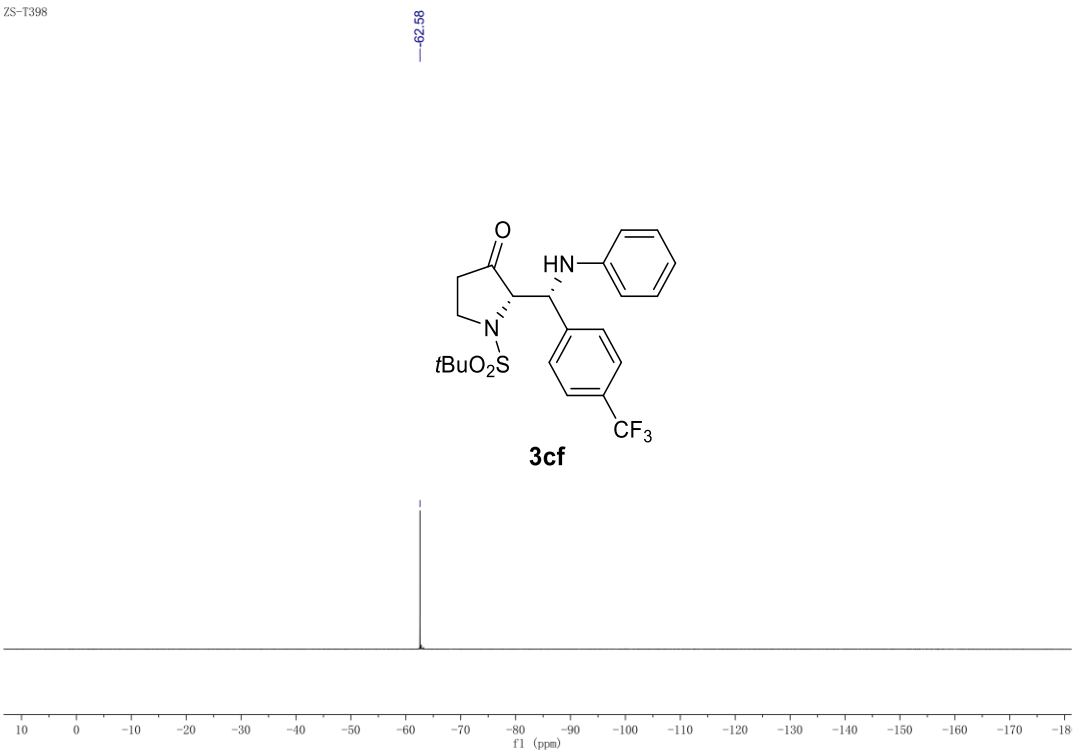

zs-412
213.26
166.73
145.55
143.78
130.33
130.19
129.42
127.97
118.41
113.81
77.48
77.16
76.84
66.33
62.83
59.36
52.29
46.46
37.80
25.07
O
HN
N
tBuO2S
CO2Me
3cd
f1 (ppm)

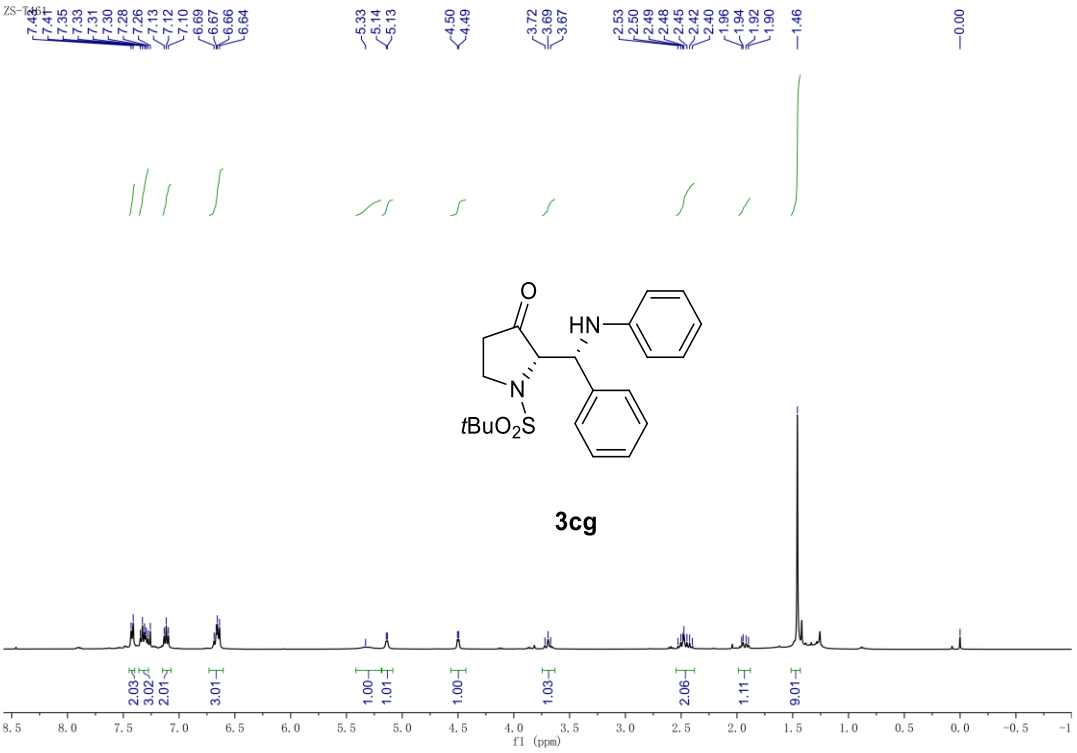

ZS-T411
7.64
7.62
7.58
7.57
7.26
7.14
7.12
7.10
6.72
6.70
6.68
6.59
6.57
5.37
5.29
5.27
4.50
4.48
3.78
3.75
3.73
2.69
2.66
2.65
2.64
2.62
2.59
2.56
2.54
2.52
2.49
2.04
2.02
1.99
1.97
1.45
0.00
O
HN
N
tBuO2S
CN
3ce
4.03
2.00
1.00
2.00
1.00
1.01
1.00
1.00
1.08
1.01
1.08
9.07
f1 (ppm)

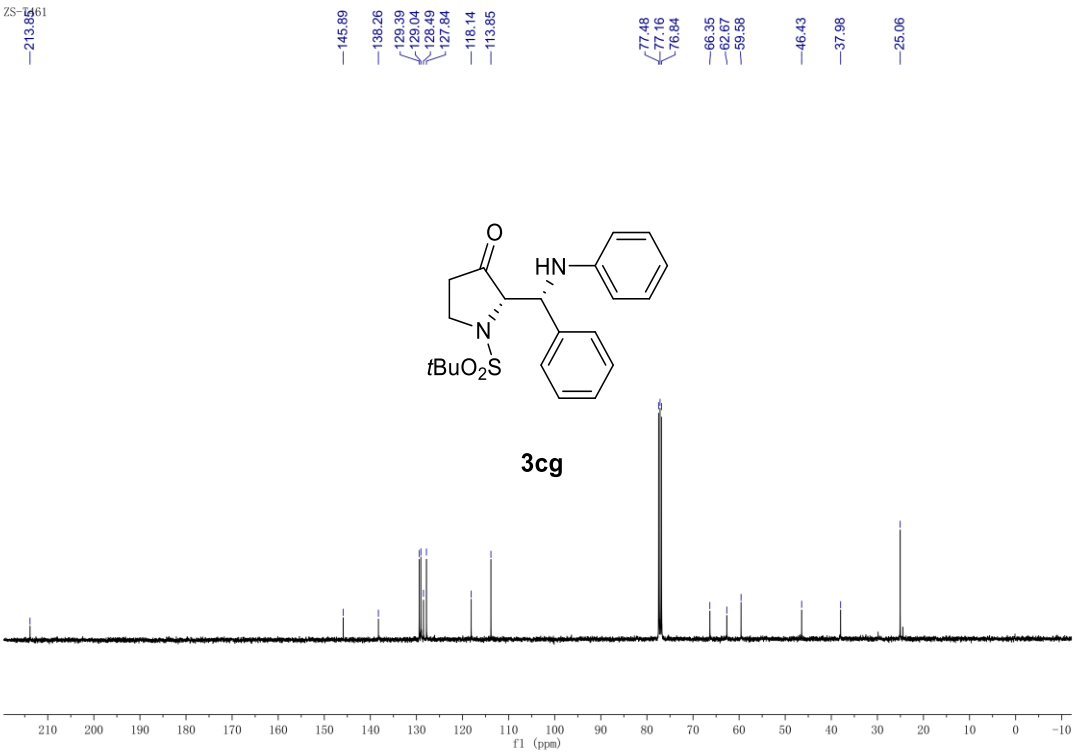

ZS-T441
212.65
145.23
144.23
132.65
129.49
128.74
118.66
118.46
113.74
112.35
77.48
77.16
76.84
66.46
63.12
59.06
46.44
37.59
25.10
118.66
118.46
119.5
119.0
118.5
118.0
f1 (ppm)
O
HN
N
tBuO2S
CN
3ce
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

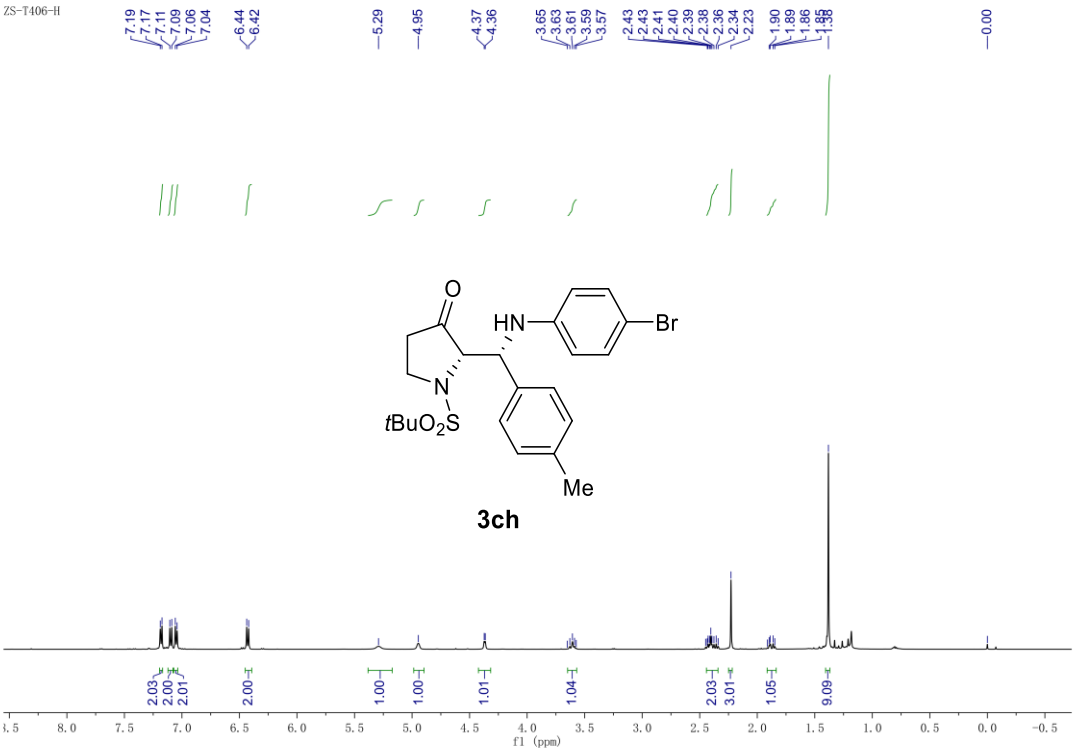

ZS-T398
7.61
7.59
7.58
7.56
7.26
7.14
7.12
7.10
6.71
6.69
6.67
6.62
6.60
5.38
5.26
4.51
4.50
3.76
3.73
3.71
2.62
2.60
2.58
2.57
2.55
2.53
2.51
2.49
2.46
2.01
2.00
1.97
1.95
1.46
0.00
O
HN
N
tBuO2S
CF3
3cf
4.01
2.00
1.01
2.00
1.00
1.03
1.00
1.04
2.04
1.02
9.06
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)


ZS-T398
213.12
145.48
142.74
131.26
130.88
130.56
130.23
129.50
128.36
128.17
125.99
125.96
125.92
125.88
125.40
122.69
120.30
118.54
113.81
77.48
77.16
76.84
66.45
63.02
59.10
46.48
37.77
25.13
125.99
125.96
125.92
125.89
126.6
126.2
125.8
f1 (ppm)
O
HN
N
tBuO2S
CF3
3cf
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

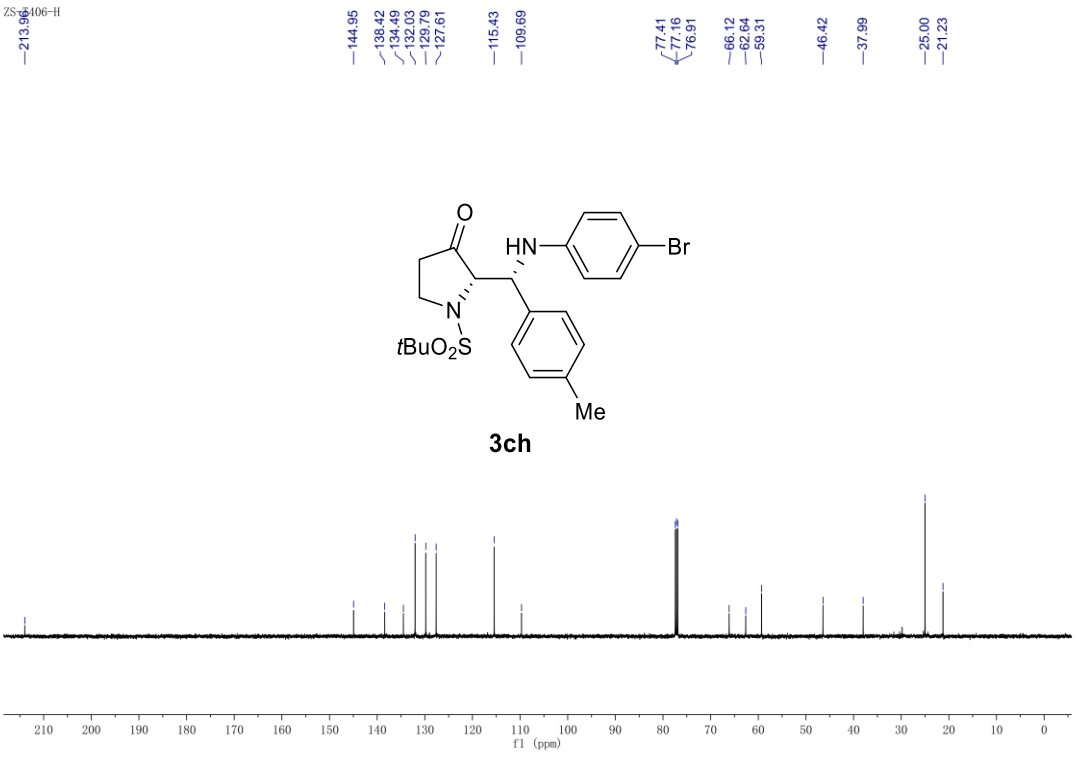

ZS-T398
62.58
O
HN
N
tBuO2S
CF3
3cf
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−18
f1 (ppm)


7.45
7.41
7.35
7.33
7.31
7.30
7.28
7.26
7.13
7.12
7.10
6.69
6.67
6.66
6.64
5.33
5.14
5.13
4.50
4.49
3.72
3.69
3.67
2.53
2.50
2.49
2.48
2.45
2.42
2.40
1.96
1.94
1.92
1.90
1.46
0.00
O
HN
N
tBuO2S
3cg
2.03
3.02
2.01
3.01
1.00
1.01
1.00
1.03
2.06
1.11
9.01
f1 (ppm)

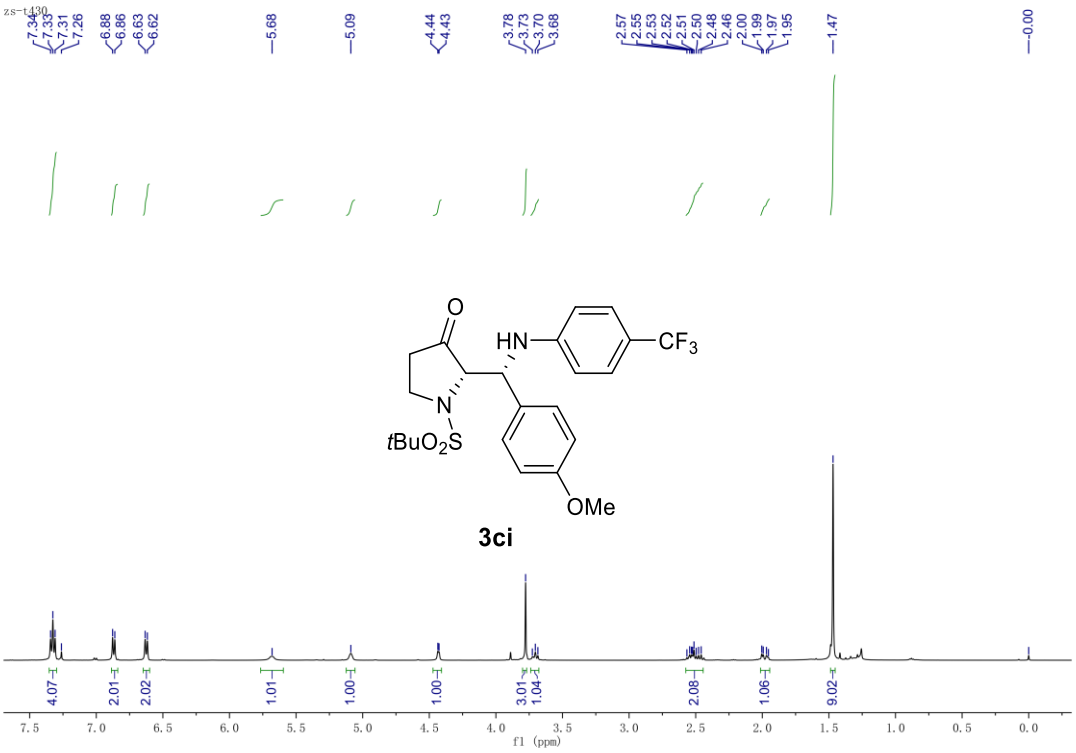

213.85
145.89
138.26
129.39
129.04
128.49
127.84
118.14
113.85
77.48
77.16
76.84
66.35
62.67
59.58
46.43
37.98
25.06
O
HN
N
tBuO2S
3cg
f1 (ppm)

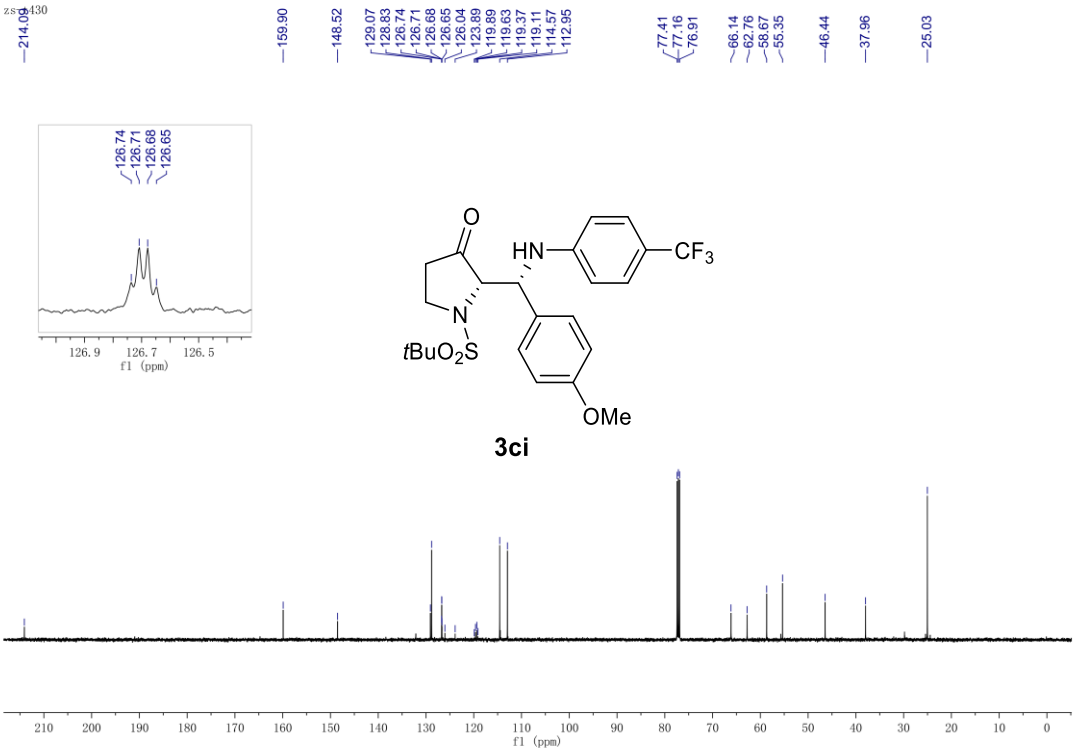

ZS-T406-H
7.19
7.17
7.11
7.09
7.06
7.04
6.44
6.42
5.29
4.95
4.37
4.36
3.65
3.63
3.61
3.59
3.57
2.43
2.43
2.41
2.40
2.39
2.38
2.36
2.34
2.23
1.90
1.89
1.86
1.85
1.38
0.00
O
HN
Br
N
tBuO2S
Me
2.03
2.00
2.01
2.00
1.00
1.00
1.01
1.04
2.03
3.01
1.05
9.09
f1 (ppm)

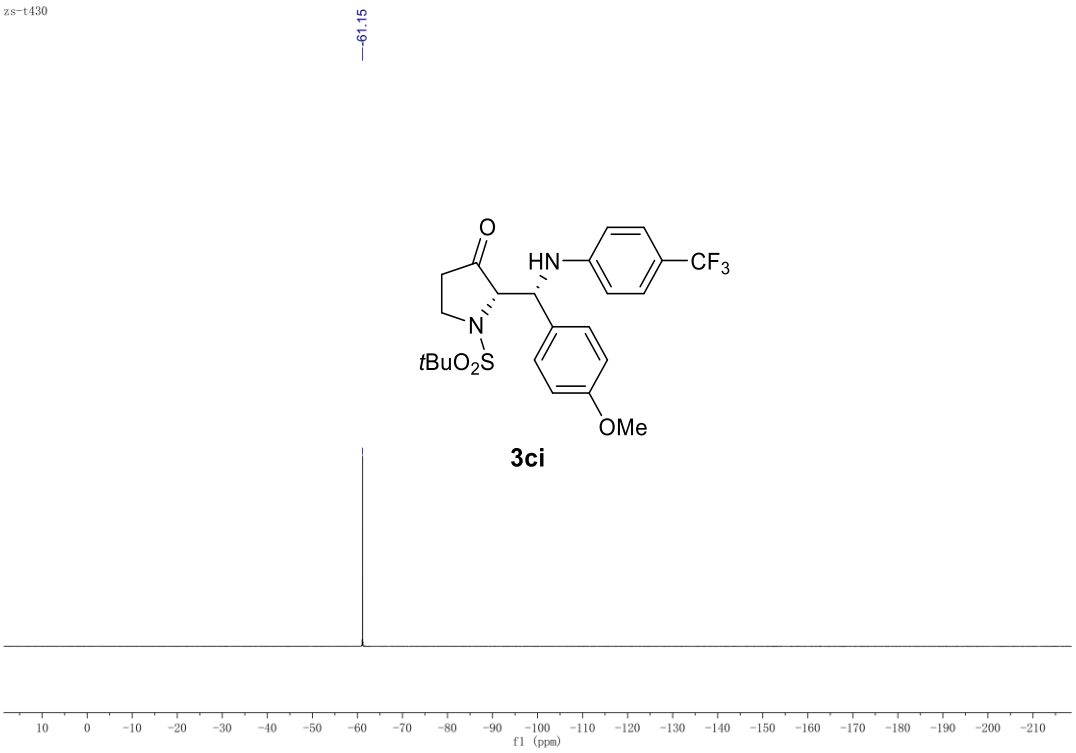
3ch

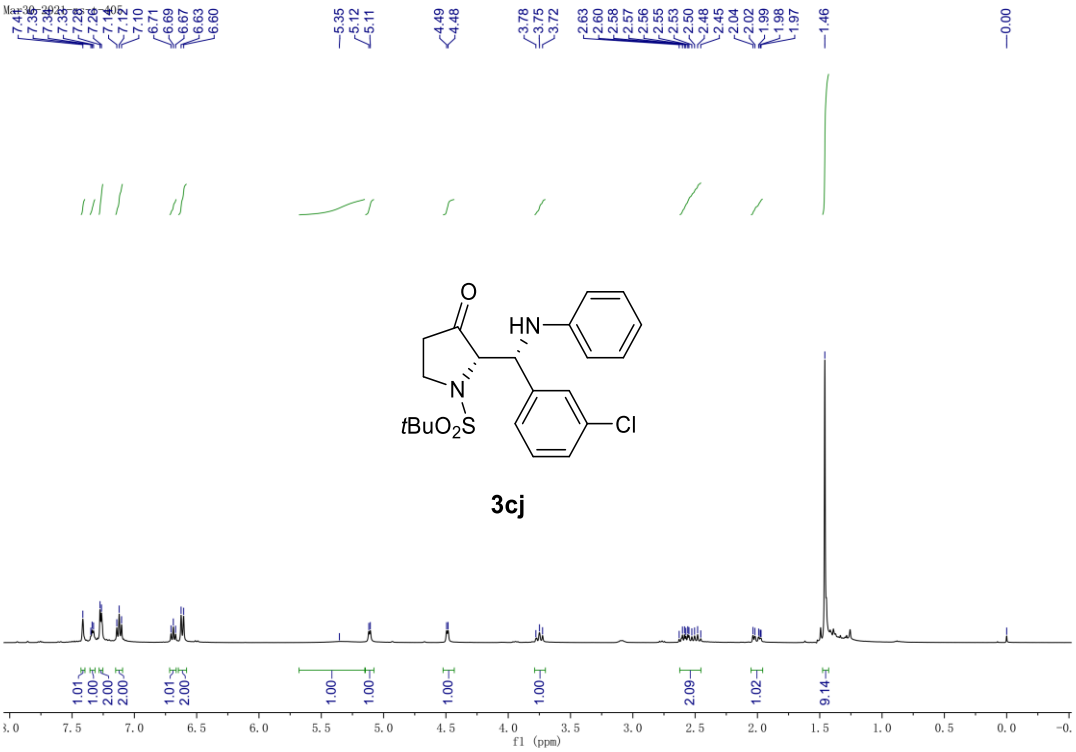

ZS-T406-H
213.66
144.95
138.42
134.49
132.03
129.79
127.61
115.43
109.69
77.41
77.16
76.91
66.12
62.64
59.31
46.42
37.99
25.00
21.23
O
HN
Br
N
tBuO2S
Me
f1 (ppm)

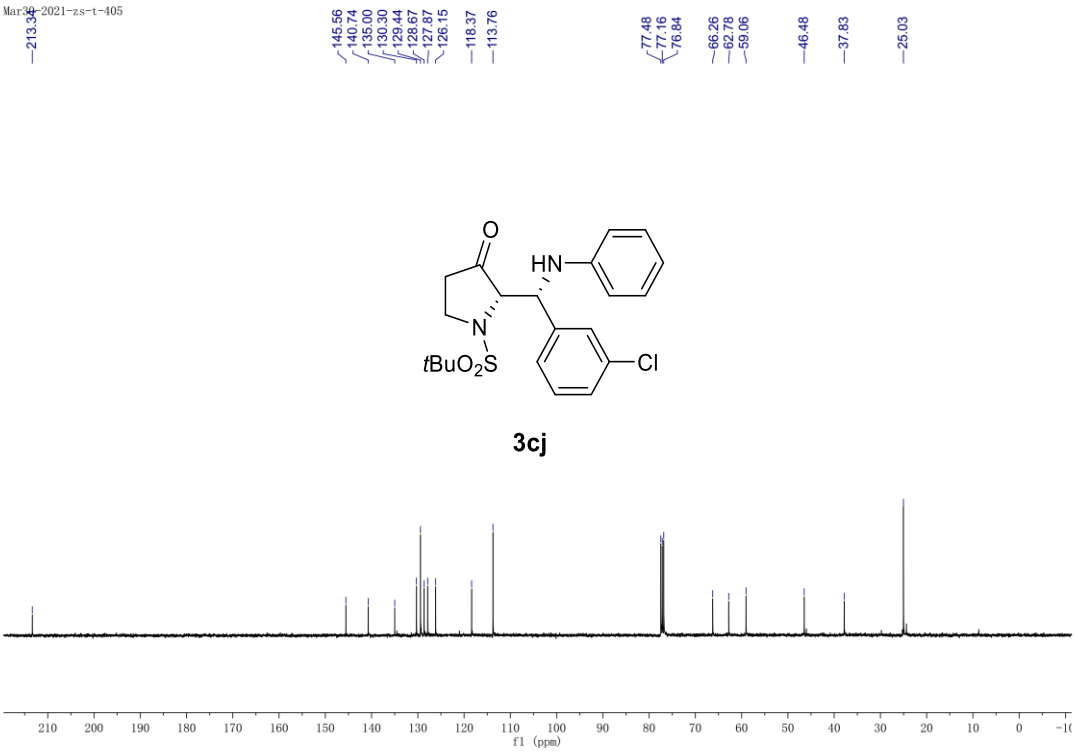
3ch


zs-t430
7.34
7.33
7.31
7.26
6.88
6.86
6.63
6.62
5.68
5.09
4.44
4.43
3.78
3.73
3.70
3.68
2.57
2.55
2.53
2.52
2.51
2.50
2.48
2.46
2.00
1.99
1.97
1.95
1.47
0.00
O
HN
CF3
N
tBuO2S
OMe
3ci
4.07
2.01
2.02
1.01
1.00
1.00
3.01
1.04
2.08
1.06
9.02
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)

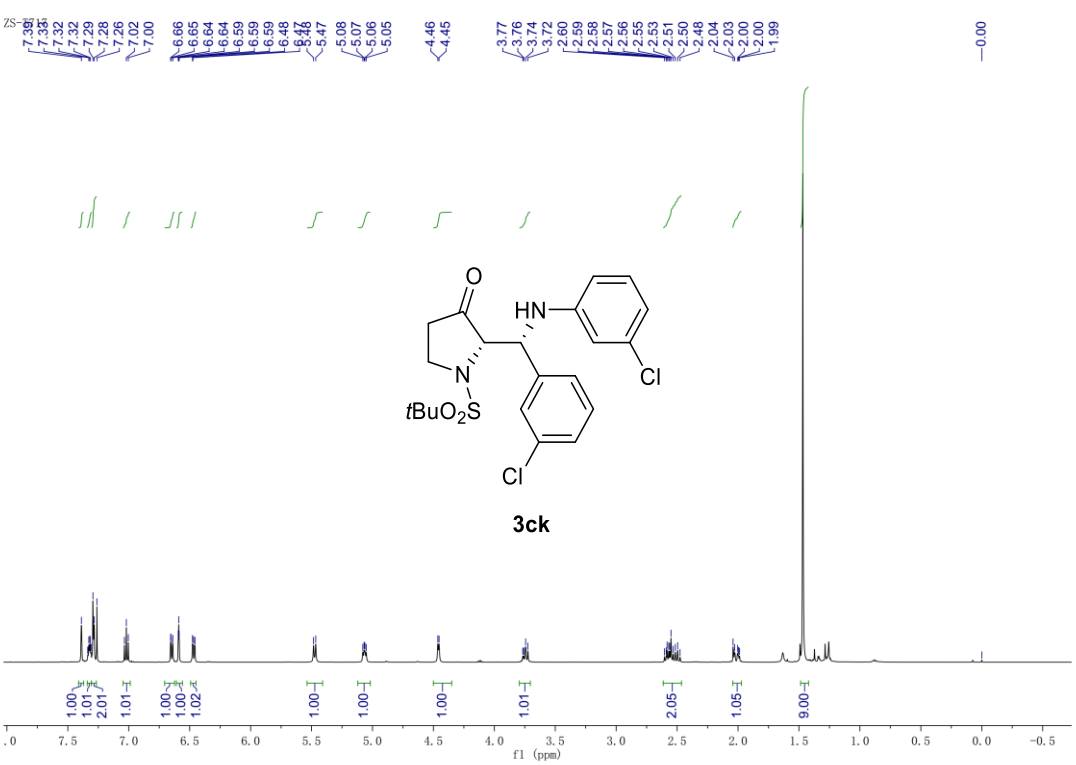

zs-t430
214.09
159.90
148.52
129.07
128.83
126.74
126.71
126.68
126.65
126.04
123.89
119.89
119.63
119.37
119.11
114.57
112.95
77.41
77.16
76.91
66.14
62.76
58.67
55.35
46.44
37.96
25.03
126.74
126.71
126.68
126.65
126.9
126.7
126.5
f1 (ppm)
O
HN
CF3
N
tBuO2S
OMe
3ci
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


zs-t430
-61.15
O
HN
CF3
N
tBuO2S
OMe
3ci
f1 (ppm)

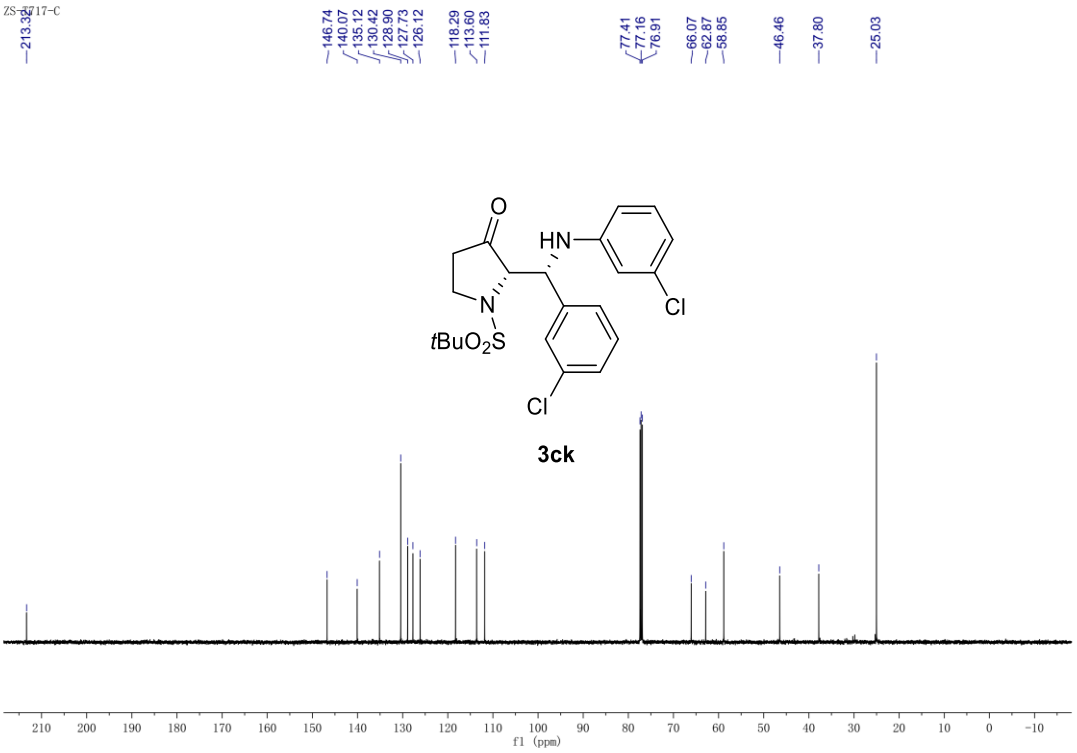

7.44
7.35
7.34
7.33
7.31
7.28
7.26
7.14
7.12
7.10
6.71
6.69
6.67
6.63
6.60
5.35
5.12
5.11
4.49
4.48
3.78
3.75
3.72
2.63
2.60
2.58
2.57
2.56
2.55
2.53
2.50
2.48
2.45
2.04
2.02
1.99
1.98
1.97
1.46
0.00
O
HN
N
tBuO2S
Cl
3cj
1.01
1.00
2.00
2.00
1.01
2.00
1.00
1.00
1.00
1.00
2.09
1.02
9.14
f1 (ppm)

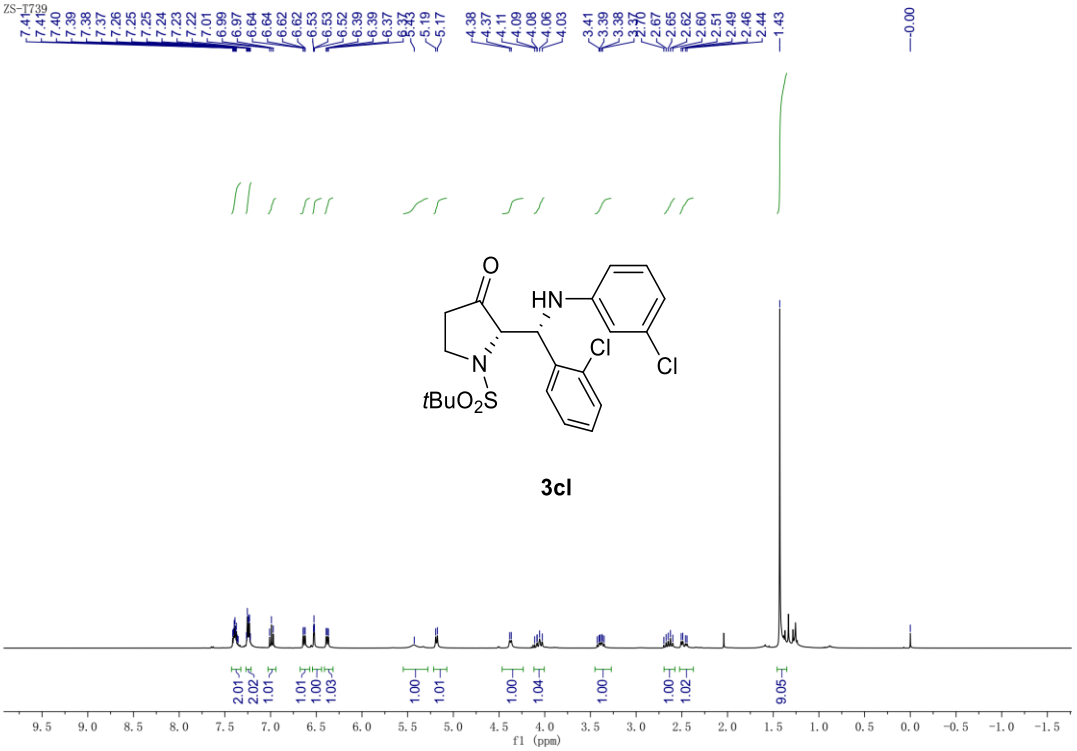

Mar30-2021-zs-t-405
213.34
145.56
140.74
135.00
130.30
129.44
128.67
127.87
126.15
118.37
113.76
77.48
77.16
76.84
66.26
62.78
59.06
46.48
37.83
25.03
O
HN
N
tBuO2S
Cl
f1 (ppm)

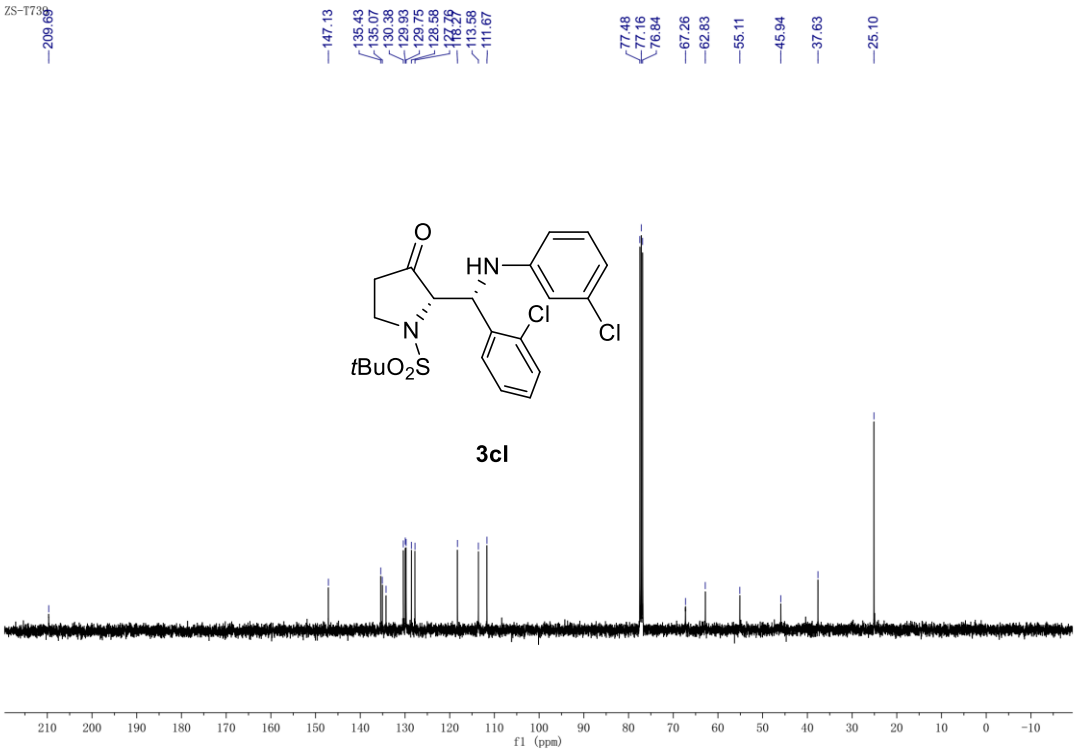
3cj

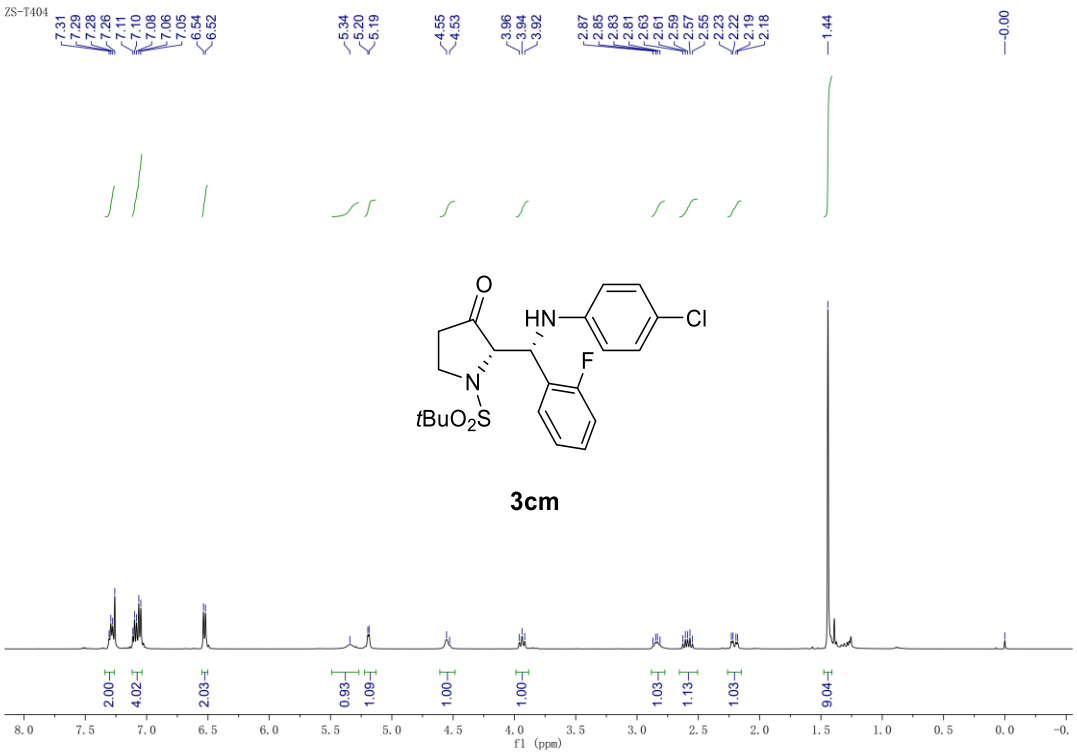

ZS-
7.39
7.35
7.32
7.32
7.29
7.28
7.26
7.02
7.00
6.66
6.65
6.64
6.64
6.59
6.59
6.59
6.48
6.47
5.48
5.47
5.08
5.07
5.06
5.05
4.46
4.45
3.77
3.76
3.74
3.72
2.60
2.59
2.58
2.57
2.56
2.55
2.53
2.51
2.50
2.48
2.04
2.03
2.00
2.00
1.99
0.00
O
HN
Cl
N
tBuO2S
Cl
1.00
1.01
2.01
1.01
1.00
1.00
1.02
1.00
1.00
1.00
1.01
2.05
1.05
9.00
f1 (ppm)

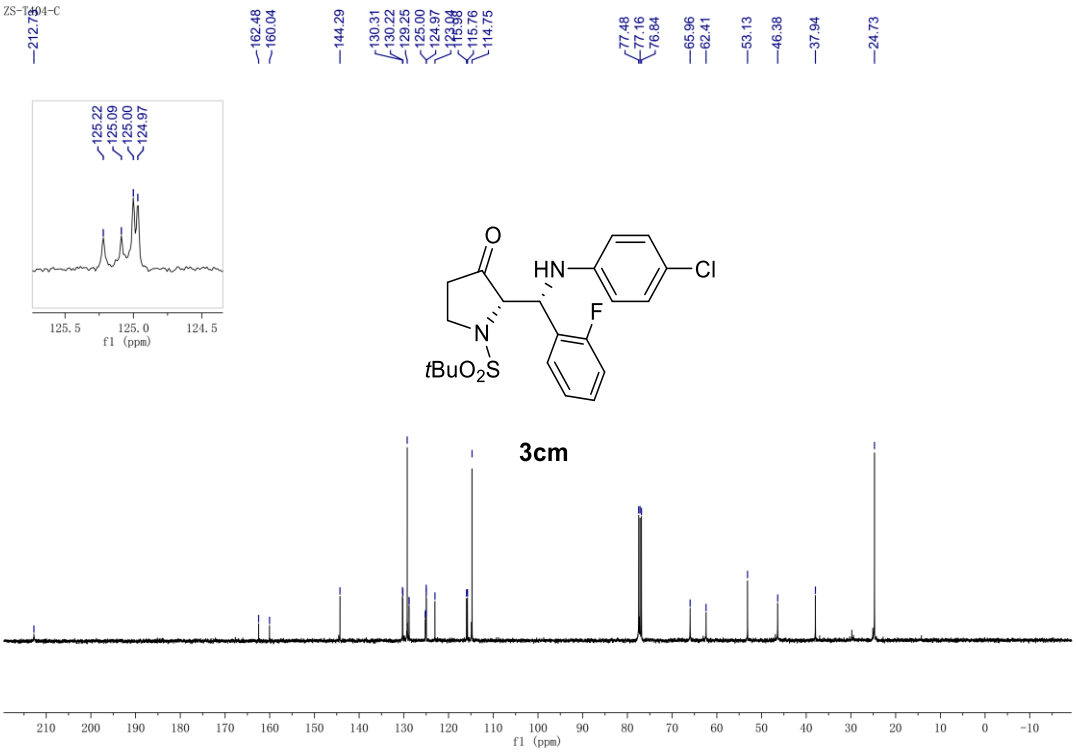
3ck

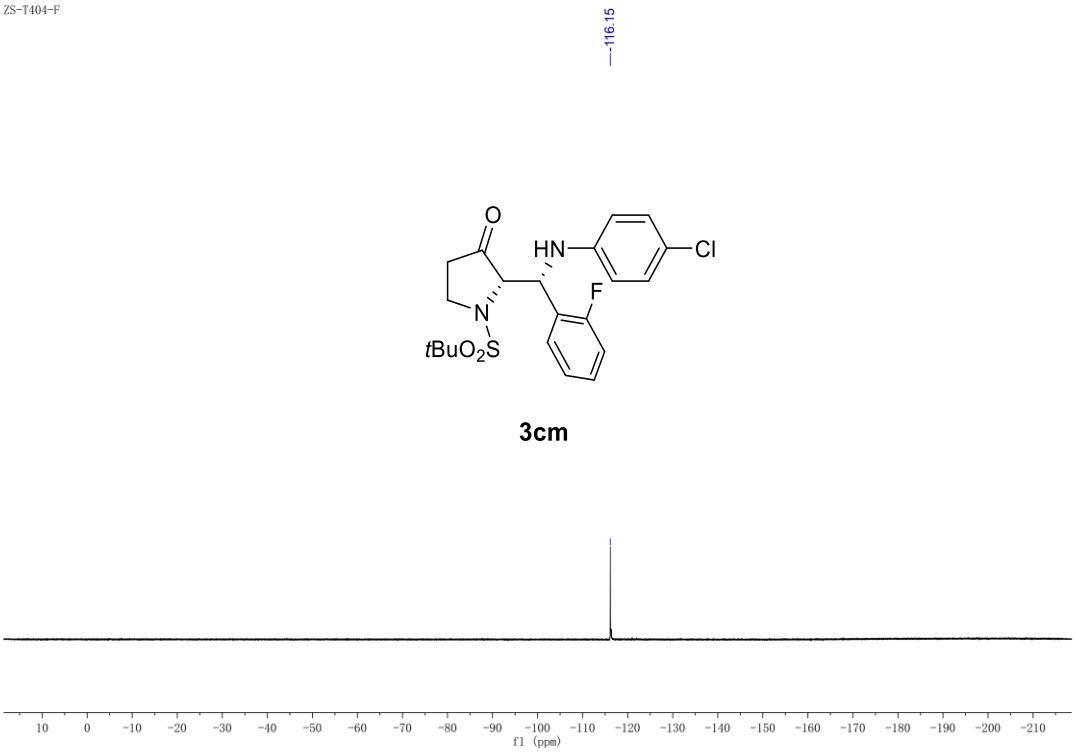

ZS-3717-C
213.32
146.74
140.07
135.12
130.42
128.90
127.73
126.12
118.29
113.60
111.83
77.41
77.16
76.91
66.07
62.87
58.85
46.46
37.80
25.03
O
HN
Cl
N
tBuO2S
Cl
3ck
f1 (ppm)

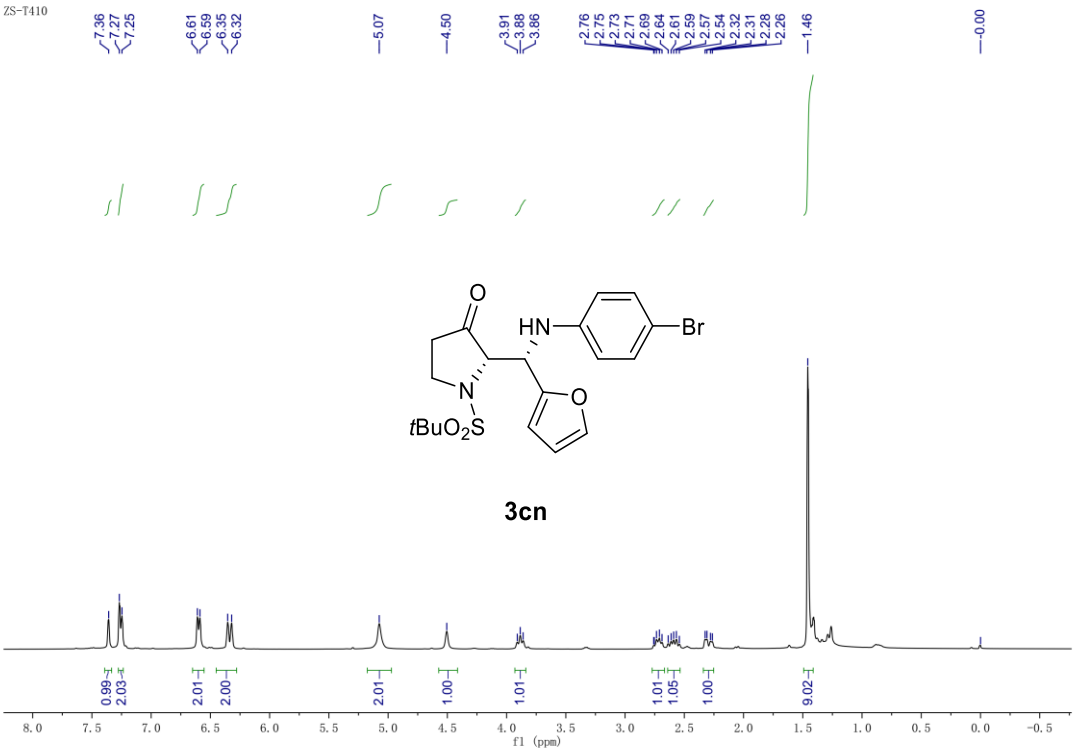

ZS-3739
7.41
7.40
7.39
7.38
7.37
7.26
7.25
7.24
7.23
7.22
7.01
6.99
6.97
6.64
6.64
6.62
6.62
6.53
6.53
6.52
6.39
6.39
6.37
5.43
5.19
5.17
4.38
4.37
4.11
4.09
4.08
4.06
4.03
3.41
3.39
3.38
3.37
3.20
2.67
2.65
2.62
2.60
2.51
2.49
2.46
2.44
1.43
0.00
O
HN
Cl
Cl
N
tBuO2S
3cl
2.01
2.02
1.01
1.01
1.00
1.03
1.00
1.01
1.00
1.04
1.00
1.00
1.02
9.05
f1 (ppm)


ZS-T736
209.69
147.13
135.43
135.07
130.38
129.93
129.75
128.58
113.58
111.67
77.48
77.16
76.84
67.26
62.83
55.11
45.94
37.63
25.10
O
HN
Cl
Cl
N
tBuO2S
3cl
f1 (ppm)

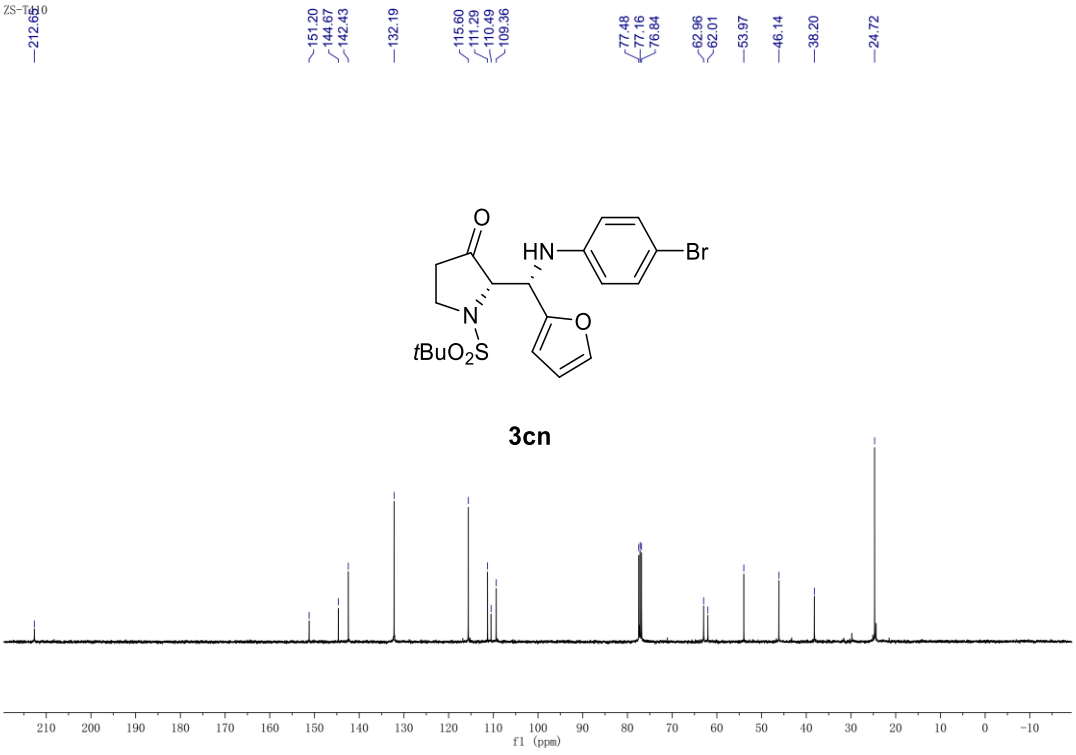

ZS-T404
7.31
7.29
7.28
7.26
7.11
7.10
7.08
7.06
7.05
6.54
6.52
5.34
5.20
5.19
4.55
4.53
3.96
3.94
3.92
2.87
2.85
2.83
2.81
2.63
2.61
2.59
2.57
2.55
2.23
2.22
2.19
2.18
1.44
0.00
O
HN
Cl
F
N
tBuO2S
3cm
2.00
4.02
2.03
0.93
1.09
1.00
1.00
1.03
1.13
1.03
9.04
f1 (ppm)


ZS-T404-C
212.75
162.48
160.04
144.29
130.31
130.22
129.25
125.00
124.97
115.76
114.75
77.48
77.16
76.84
65.96
62.41
53.13
46.38
37.94
24.73
125.22
125.09
125.00
124.97
125.5
125.0
124.5
f1 (ppm)
O
HN
Cl
F
N
tBuO2S
3cm
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

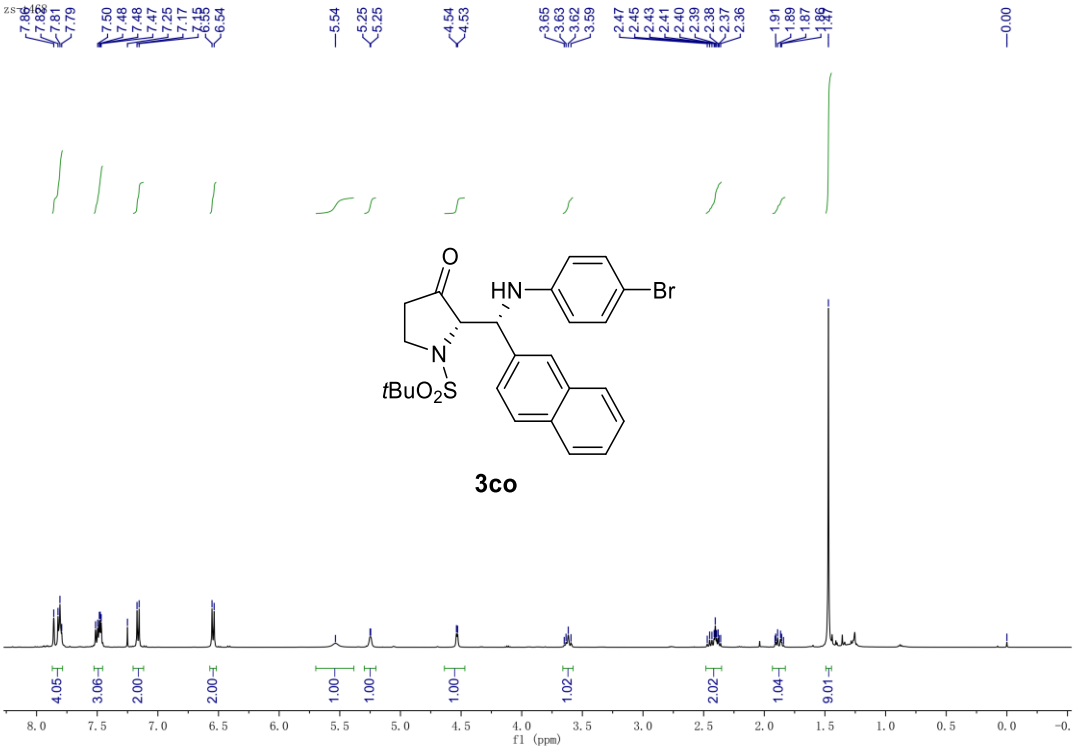

ZS-T404-F
-116.15
O
HN
Cl
F
N
tBuO2S
3cm
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

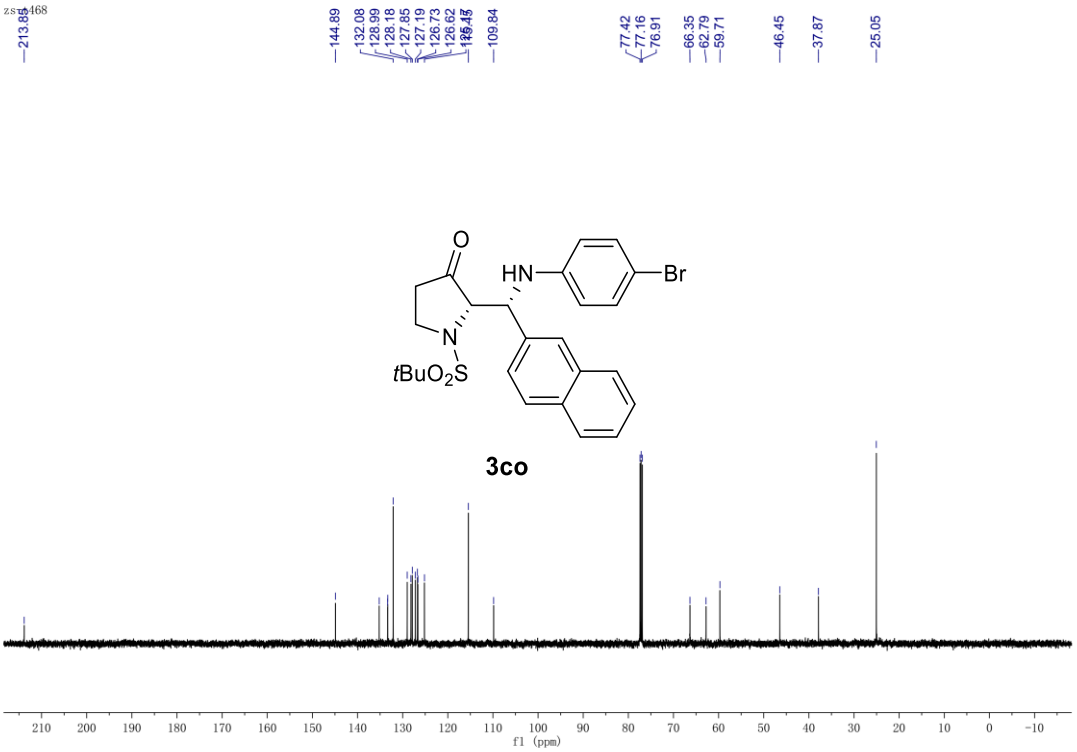

ZS-T410
7.36
7.27
7.25
6.61
6.59
6.35
6.32
5.07
4.50
3.91
3.88
3.86
2.76
2.75
2.73
2.71
2.69
2.64
2.61
2.59
2.57
2.54
2.32
2.31
2.28
2.26
1.46
0.00
O
HN
Br
N
O
tBuO2S
0.99
2.03
2.01
2.00
2.01
1.00
1.01
1.01
1.05
1.00
9.02
f1 (ppm)

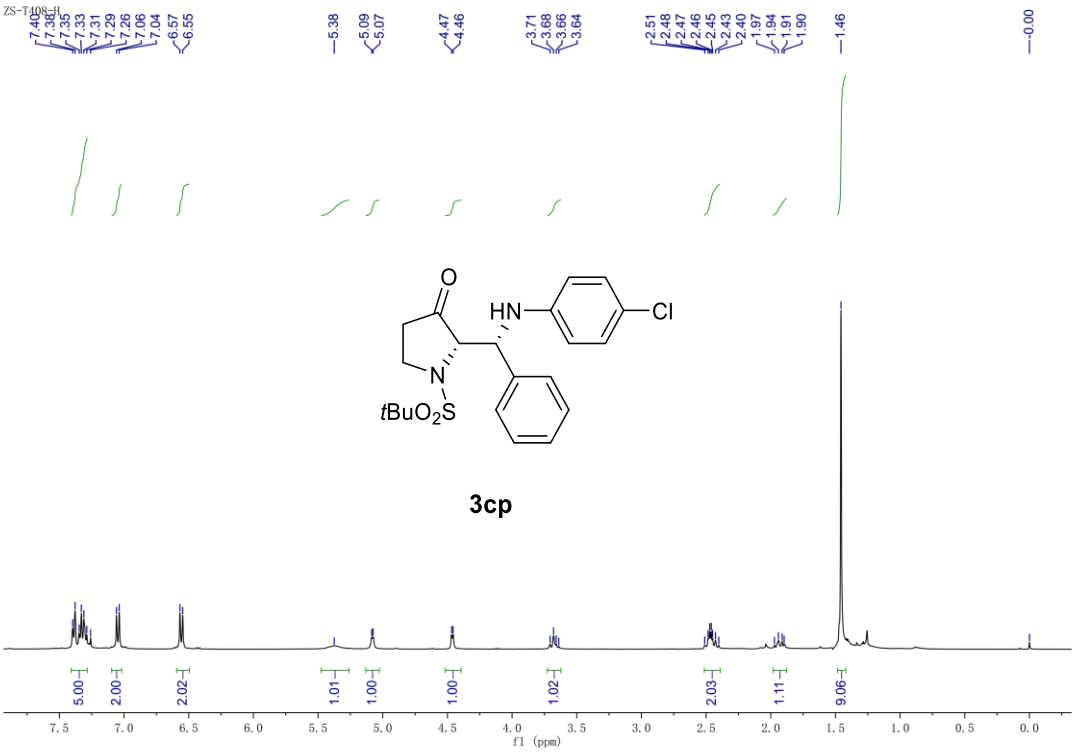
3cn

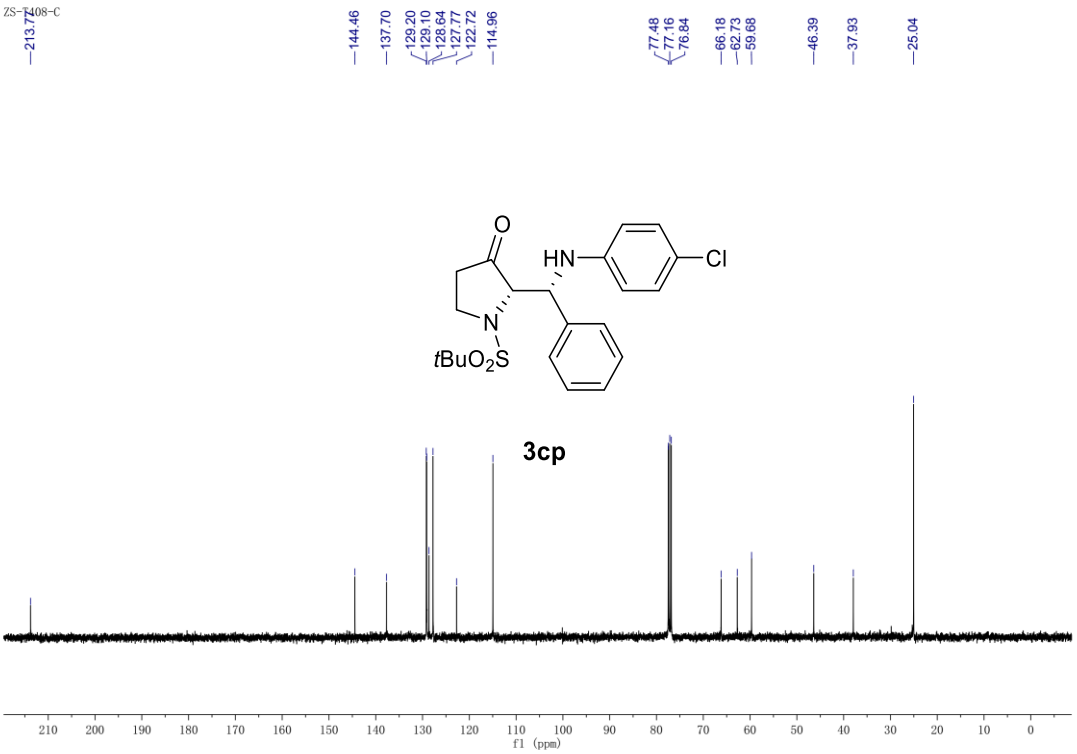

ZS-T410
212.66
151.20
144.67
142.43
132.19
115.60
111.29
110.49
109.36
77.48
77.16
76.84
62.96
62.01
53.97
46.14
38.20
24.72
O
HN
Br
N
O
tBuO2S
f1 (ppm)

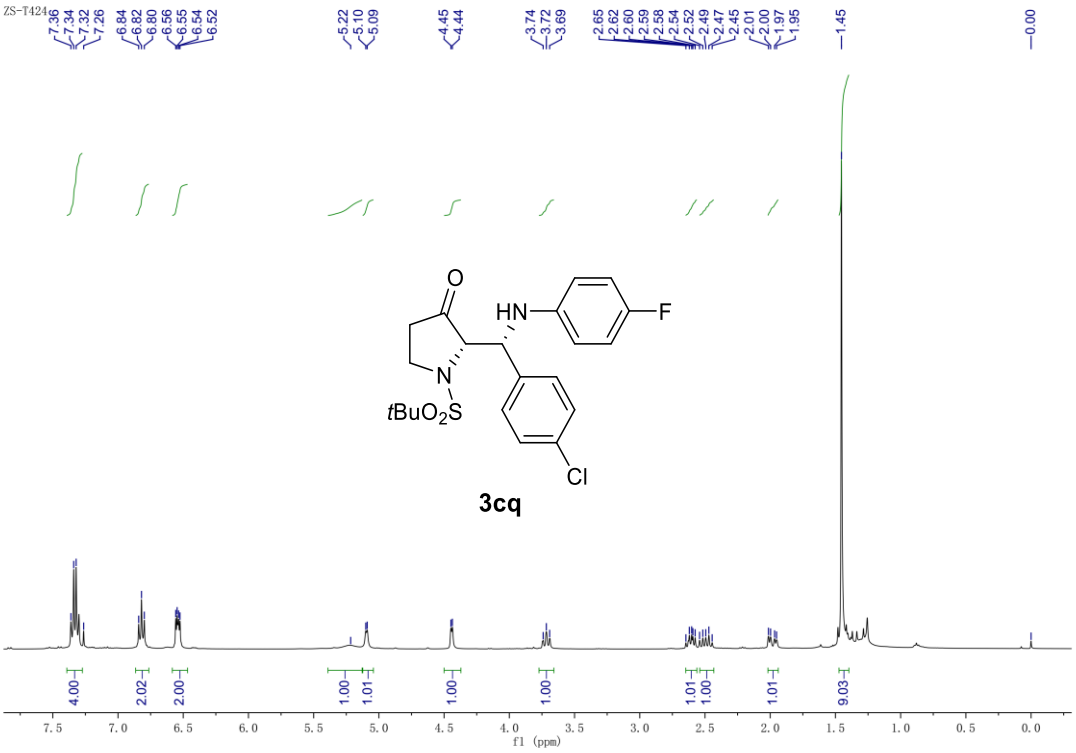
3cn

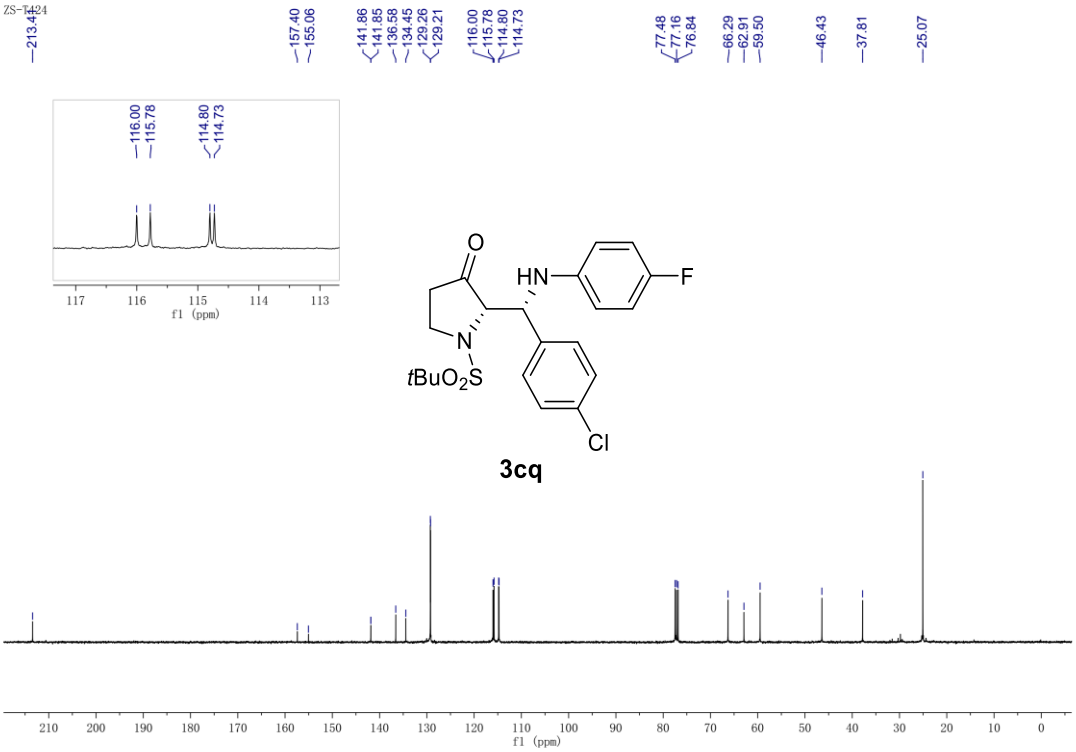

7.86
7.82
7.81
7.79
7.50
7.48
7.48
7.47
7.25
7.17
6.55
6.54
5.54
5.25
5.25
4.54
4.53
3.65
3.63
3.62
3.59
2.47
2.45
2.43
2.41
2.40
2.39
2.38
2.37
2.36
1.91
1.89
1.87
1.86
1.47
0.00
O
HN
Br
N
tBuO2S
3co
4.05
3.06
2.00
2.00
1.00
1.00
1.00
1.02
2.02
1.04
9.01
f1 (ppm)


213.85
144.89
132.08
128.99
128.18
127.85
127.19
126.73
126.62
109.84
77.42
77.16
76.91
66.35
62.79
59.71
46.45
37.87
25.05
O
HN
Br
N
tBuO2S
3co
f1 (ppm)

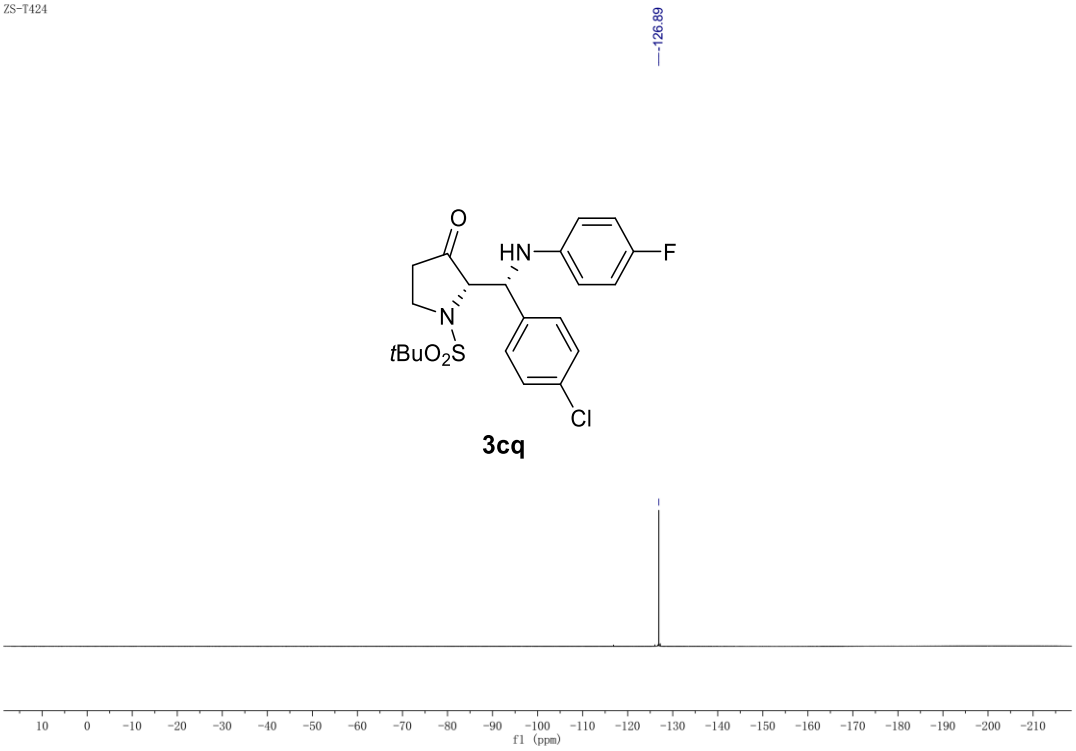

ZS-T408-H
7.40
7.38
7.35
7.33
7.31
7.29
7.26
7.06
7.04
6.57
6.55
5.38
5.09
5.07
4.47
4.46
3.71
3.68
3.66
3.64
2.51
2.48
2.47
2.46
2.45
2.43
2.40
1.97
1.94
1.91
1.90
1.46
0.00
O
HN
Cl
N
tBuO2S
3cp
5.00
2.00
2.02
1.01
1.00
1.00
1.02
2.03
1.11
9.06
f1 (ppm)


ZS-T408-C
213.72
144.46
137.70
129.20
129.10
128.64
127.77
122.72
114.96
77.48
77.16
76.84
66.18
62.73
59.68
46.39
37.93
25.04
O
HN
Cl
N
tBuO2S
3cp
f1 (ppm)

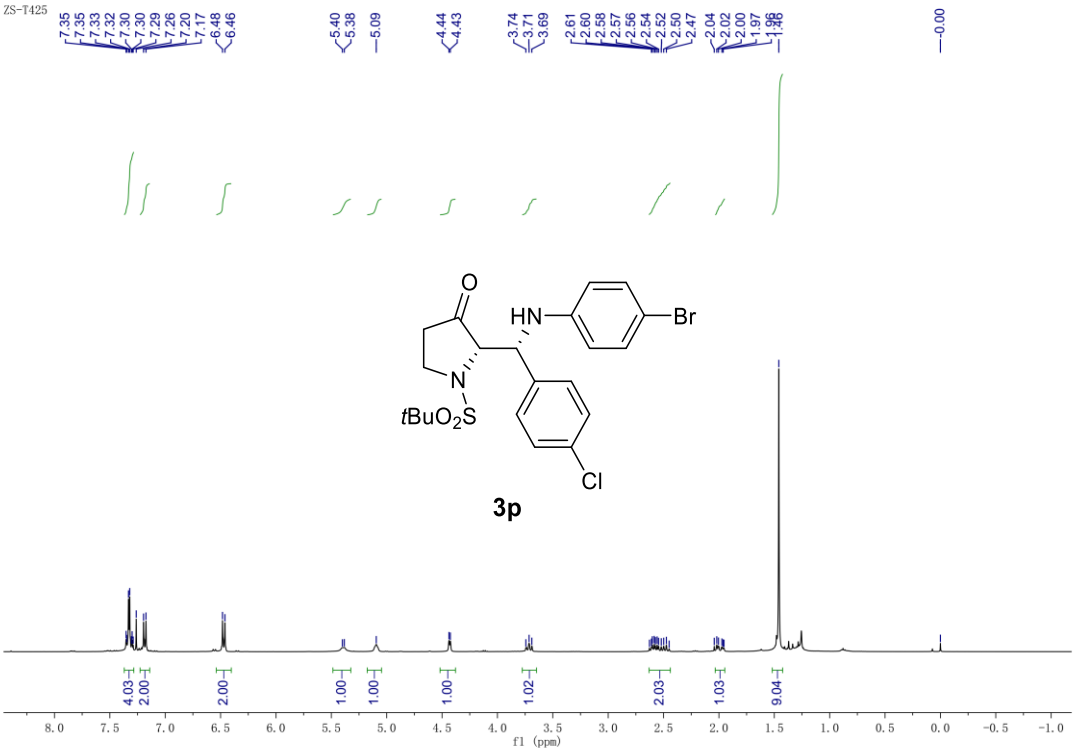

ZS-T424
7.36
7.34
7.32
7.26
6.84
6.82
6.80
6.56
6.55
6.54
6.52
5.22
5.10
5.09
4.45
4.44
3.74
3.72
3.69
2.65
2.62
2.60
2.59
2.58
2.54
2.52
2.49
2.47
2.45
2.01
2.00
1.97
1.95
1.45
0.00
O
HN
F
N
tBuO2S
Cl
3cq
4.00
2.02
2.00
1.00
1.01
1.00
1.00
1.01
1.00
1.01
9.03
f1 (ppm)

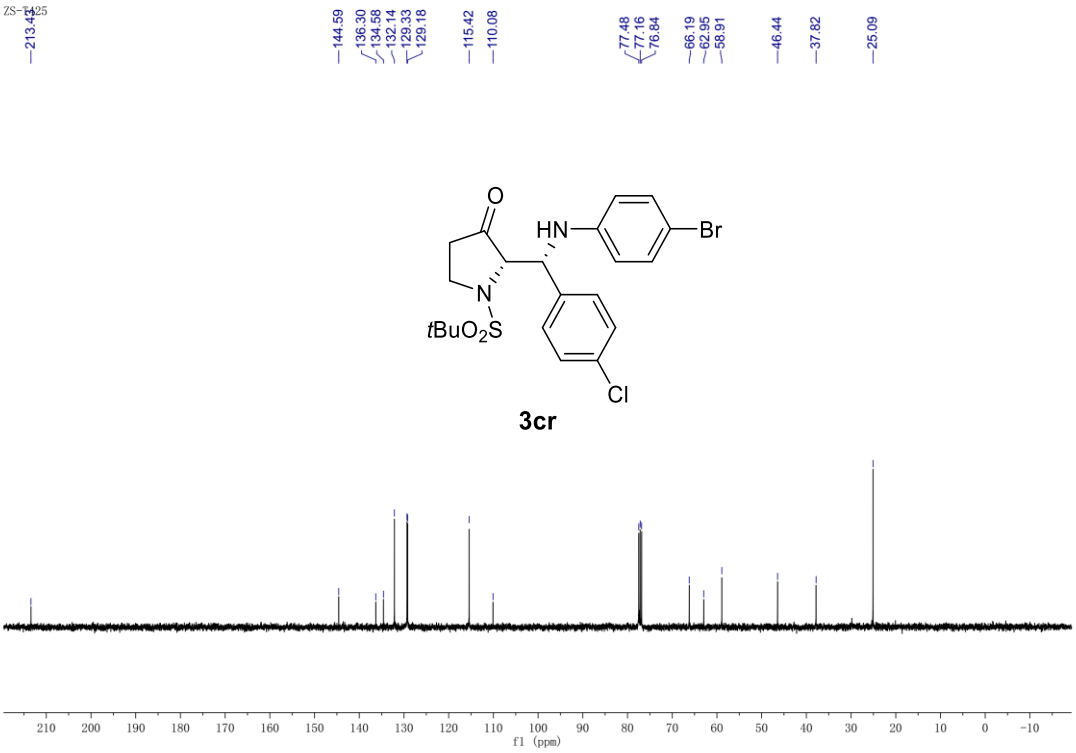

ZS-T424
213.43
157.40
155.06
141.86
141.85
136.58
134.45
129.26
129.21
116.00
115.78
114.80
114.73
77.48
77.16
76.84
66.29
62.91
59.50
46.43
37.81
25.07
116.00
115.78
114.80
114.73
f1 (ppm)
O
HN
F
N
tBuO2S
Cl
3cq
f1 (ppm)

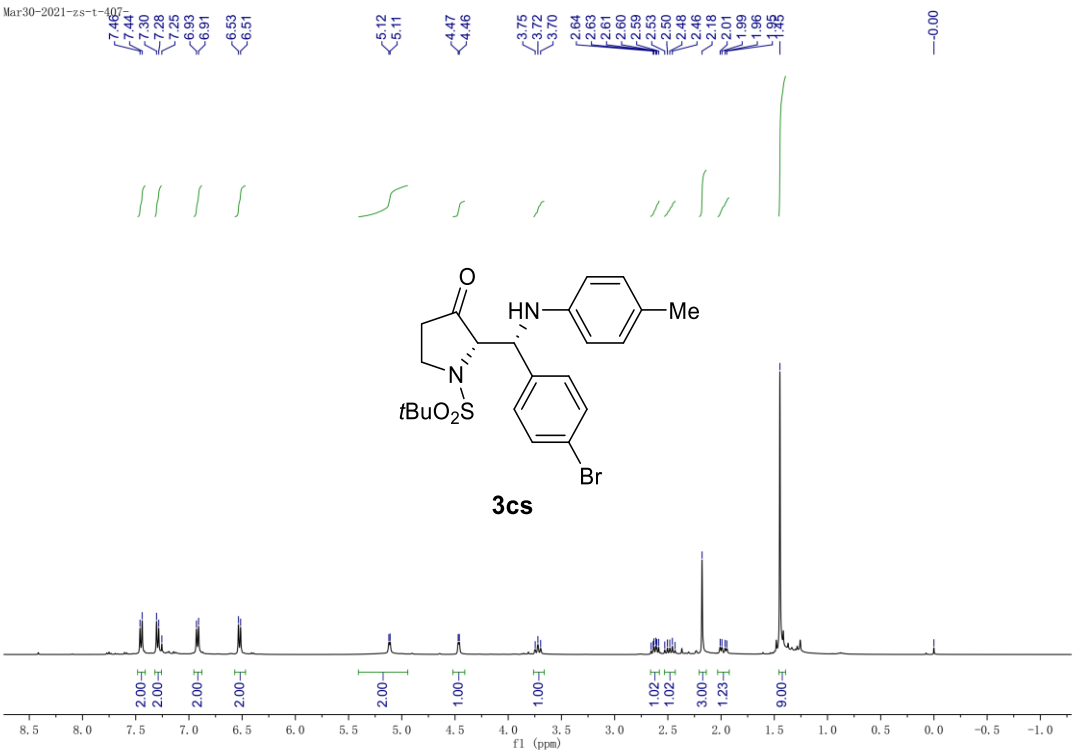
ZS-T424

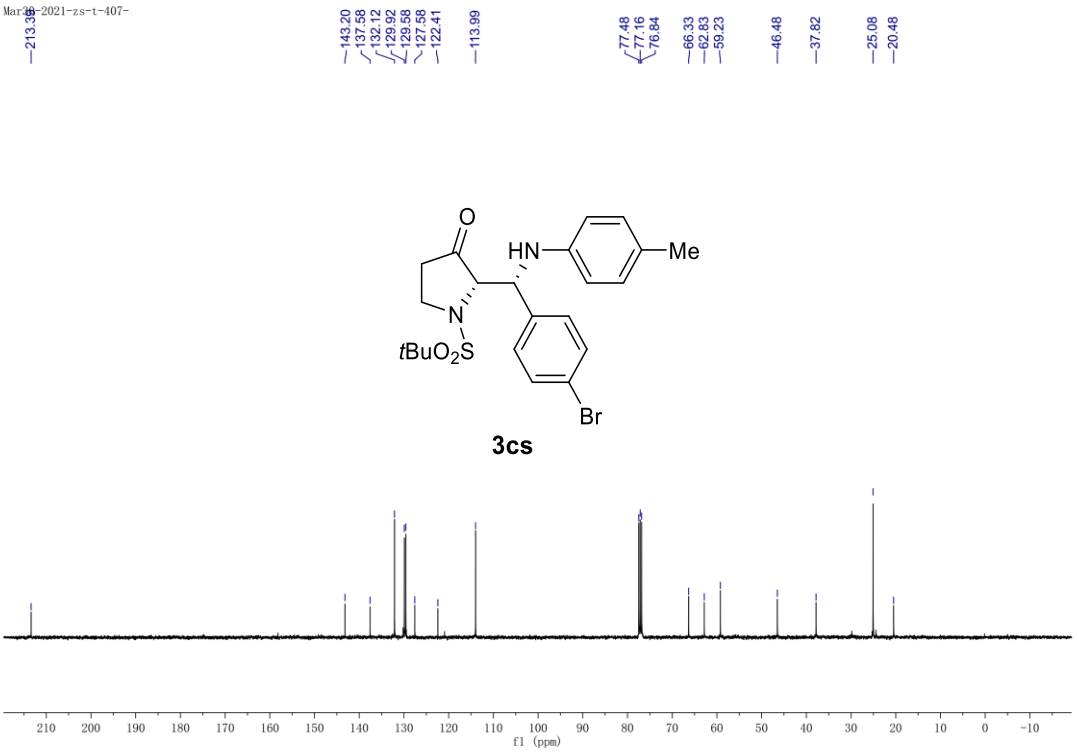


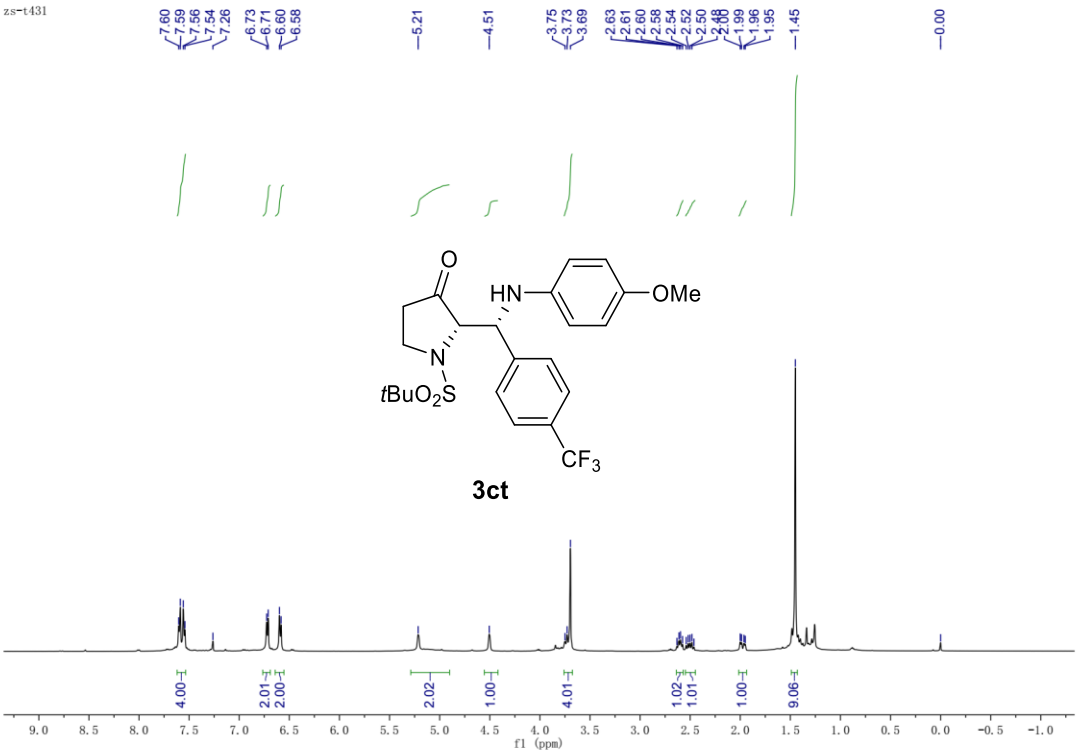
ZS-T425

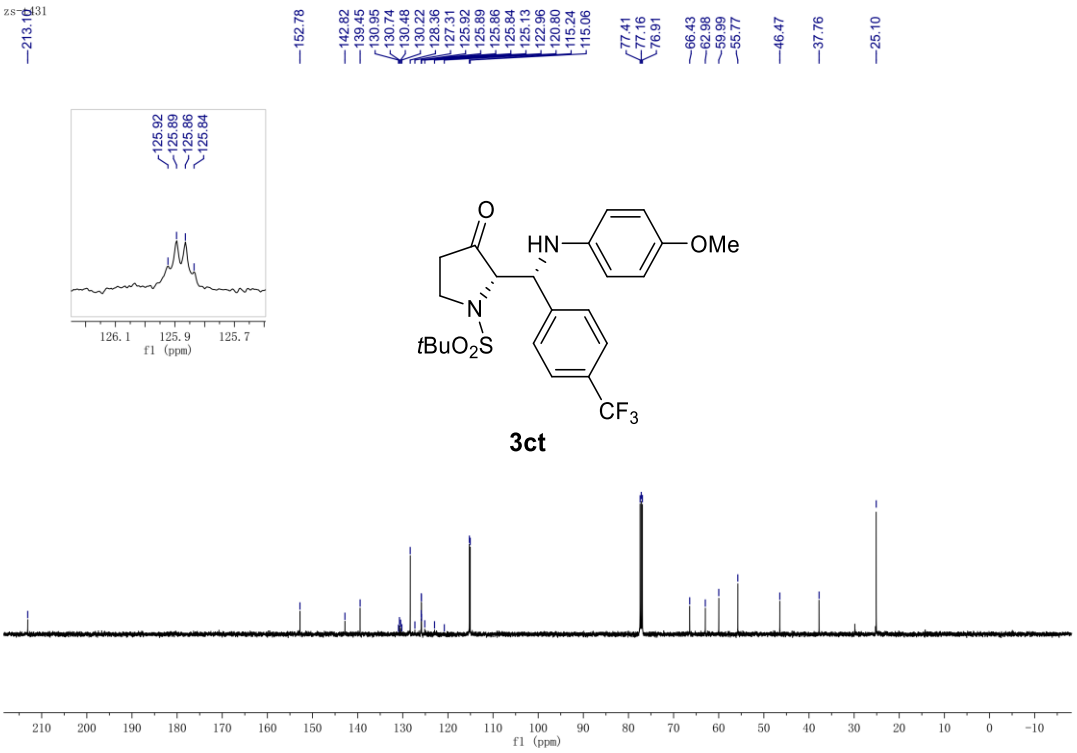


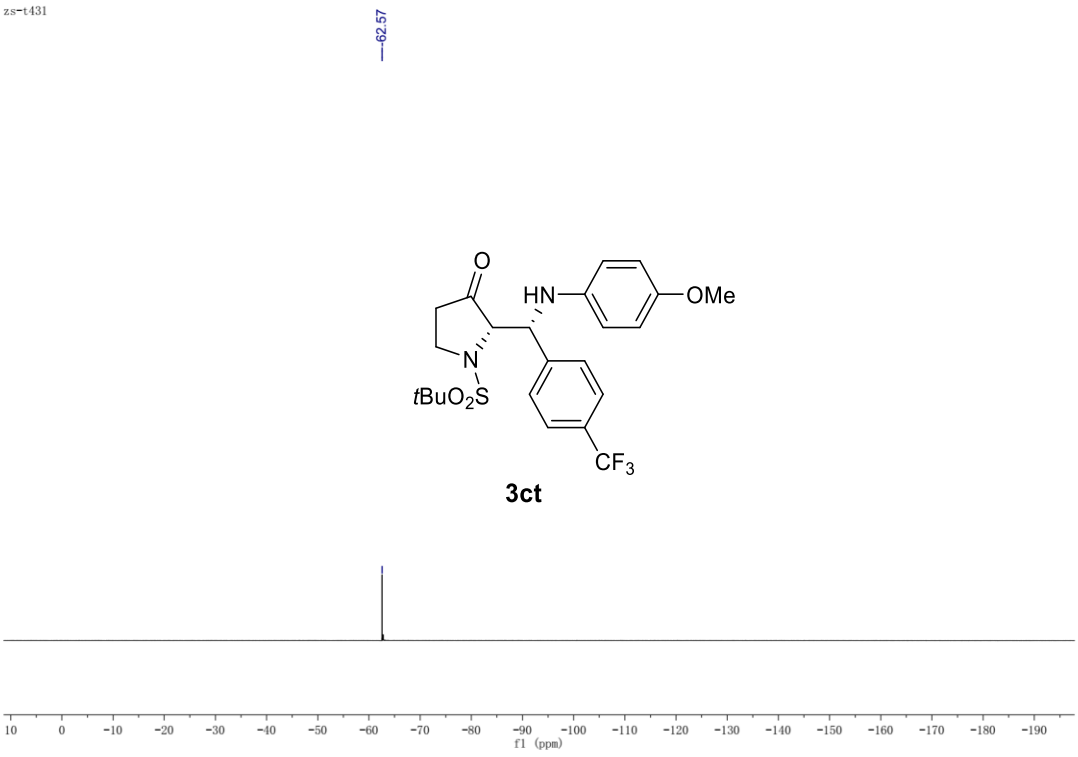

ZS-T425
213.42
144.59
136.30
134.58
132.14
129.33
129.18
115.42
110.08
77.48
77.16
76.84
66.19
62.95
58.91
46.44
37.82
25.09
O
HN
Br
N
tBuO2S
Cl
3cr
f1 (ppm)

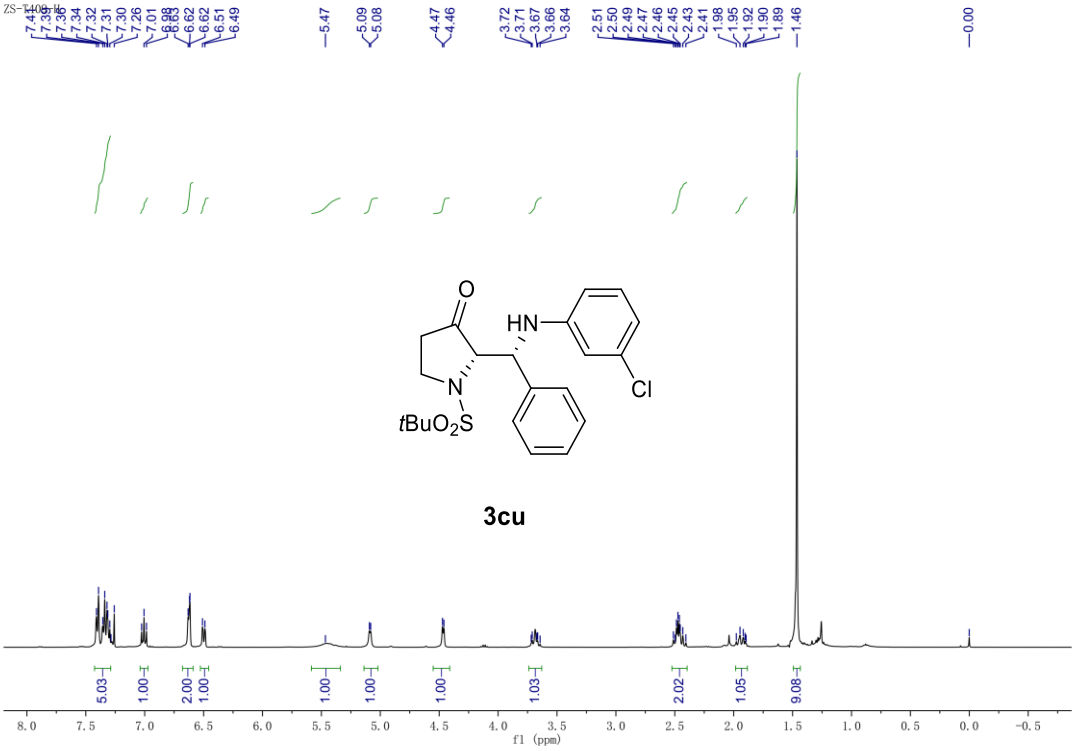

Mar30-2021-zs-t-407
7.46
7.44
7.30
7.28
7.25
6.93
6.91
6.53
6.51
5.12
5.11
4.47
4.46
3.75
3.72
3.70
2.64
2.63
2.61
2.60
2.59
2.53
2.50
2.48
2.46
2.18
2.01
1.99
1.96
1.25
1.23
0.00
O
HN
Me
N
tBuO2S
Br
3cs
2.00
2.00
2.00
2.00
2.00
1.00
1.00
1.02
1.02
3.00
1.23
9.00
f1 (ppm)


Mar30-2021-zs-t-407-
213.38
143.20
137.58
132.12
129.92
129.58
127.58
122.41
113.99
77.48
77.16
76.84
66.33
62.83
59.23
46.48
37.82
25.08
20.48
O
HN
Me
N
tBuO2S
Br
3cs
f1 (ppm)

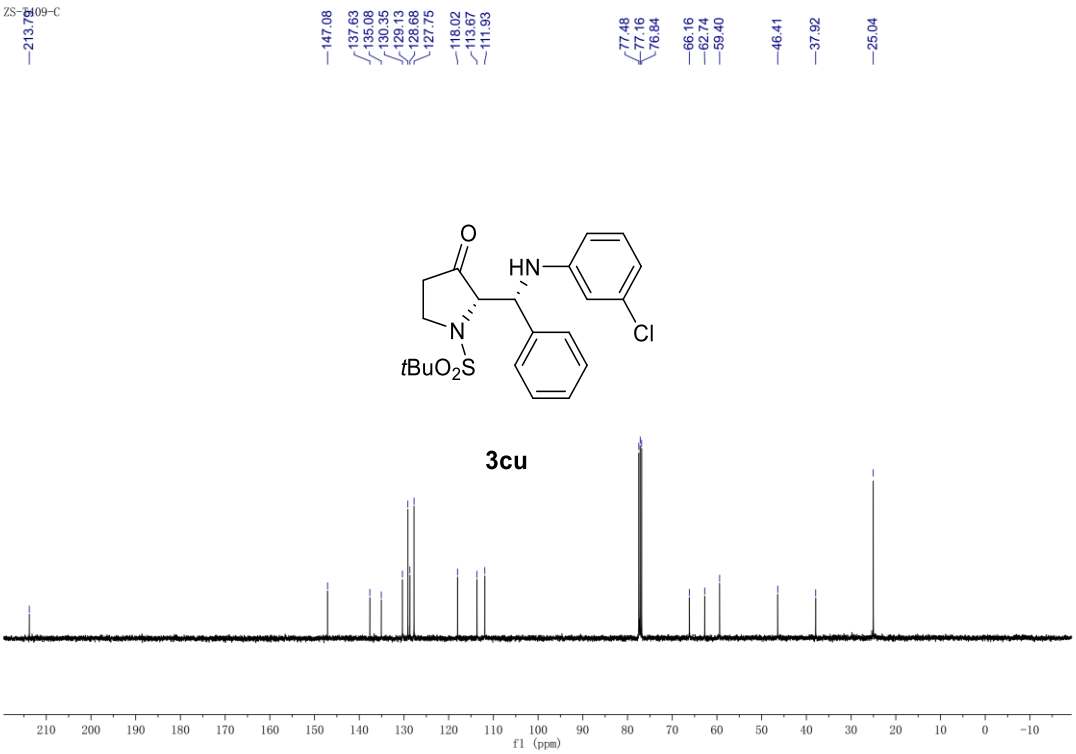

zs-t431
7.60
7.59
7.56
7.54
7.26
6.73
6.71
6.60
6.58
5.21
4.51
3.75
3.73
3.69
2.63
2.61
2.60
2.58
2.54
2.52
2.50
1.99
1.96
1.95
1.45
0.00
O
HN
OMe
N
tBuO2S
CF3
3ct
4.00
2.01
2.00
2.02
1.00
4.01
1.02
1.01
1.00
9.06
f1 (ppm)


zs-t431
213.16
152.78
142.82
139.45
130.95
130.74
130.48
130.22
128.36
127.31
125.92
125.89
125.86
125.84
125.13
122.96
120.80
115.24
115.06
77.41
77.16
76.91
66.43
62.98
59.99
55.77
46.47
37.76
25.10
125.92
125.89
125.86
125.84
126.1
125.9
125.7
f1 (ppm)
O
HN
OMe
N
tBuO2S
CF3
3ct
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

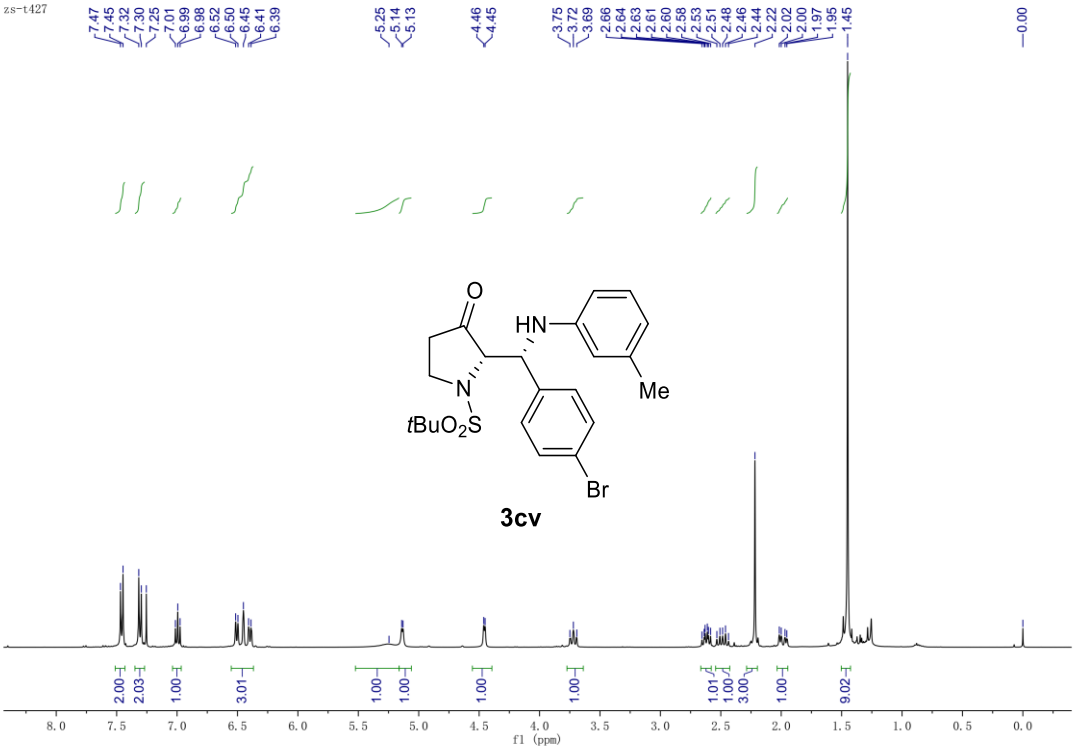

zs-t431
62.57
O
HN
OMe
N
tBuO2S
CF3
3ct
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

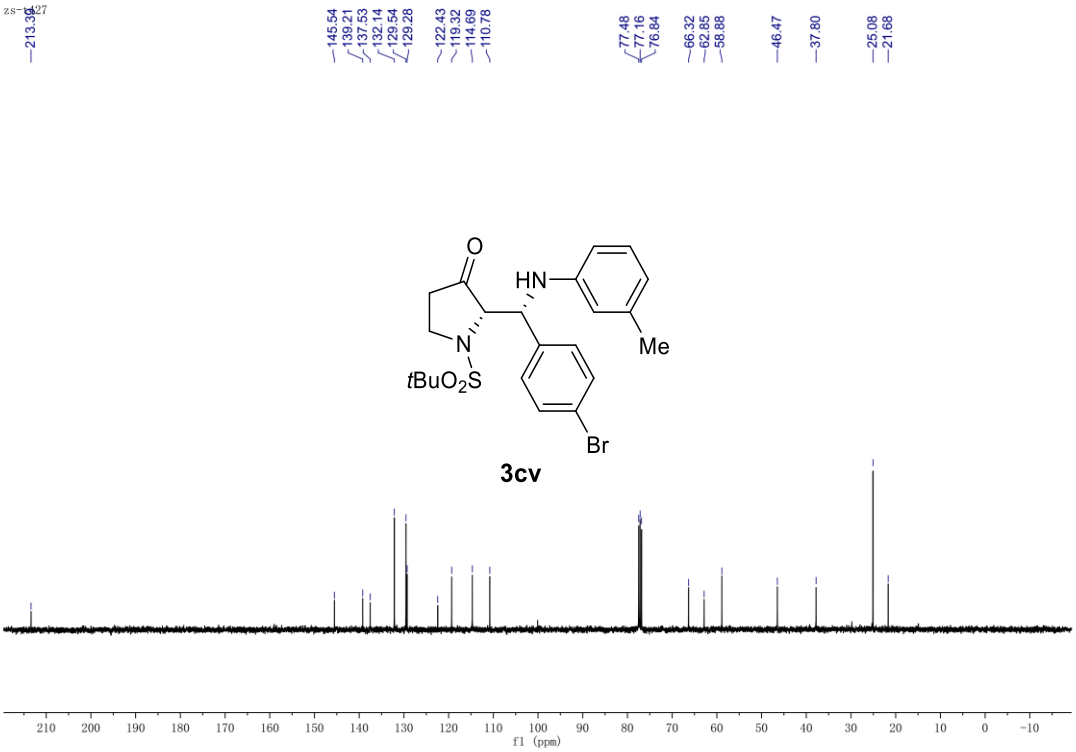

7.45
7.39
7.36
7.34
7.32
7.31
7.30
7.26
7.01
6.63
6.62
6.62
6.51
6.49
5.47
5.09
5.08
4.47
4.46
3.72
3.71
3.67
3.66
3.64
2.51
2.50
2.49
2.47
2.46
2.45
2.43
2.41
1.98
1.95
1.92
1.90
1.89
1.46
0.00
O
HN
N
Cl
tBuO2S
5.03
1.00
2.00
1.00
1.00
1.00
1.00
1.03
2.02
1.05
9.08
f1 (ppm)

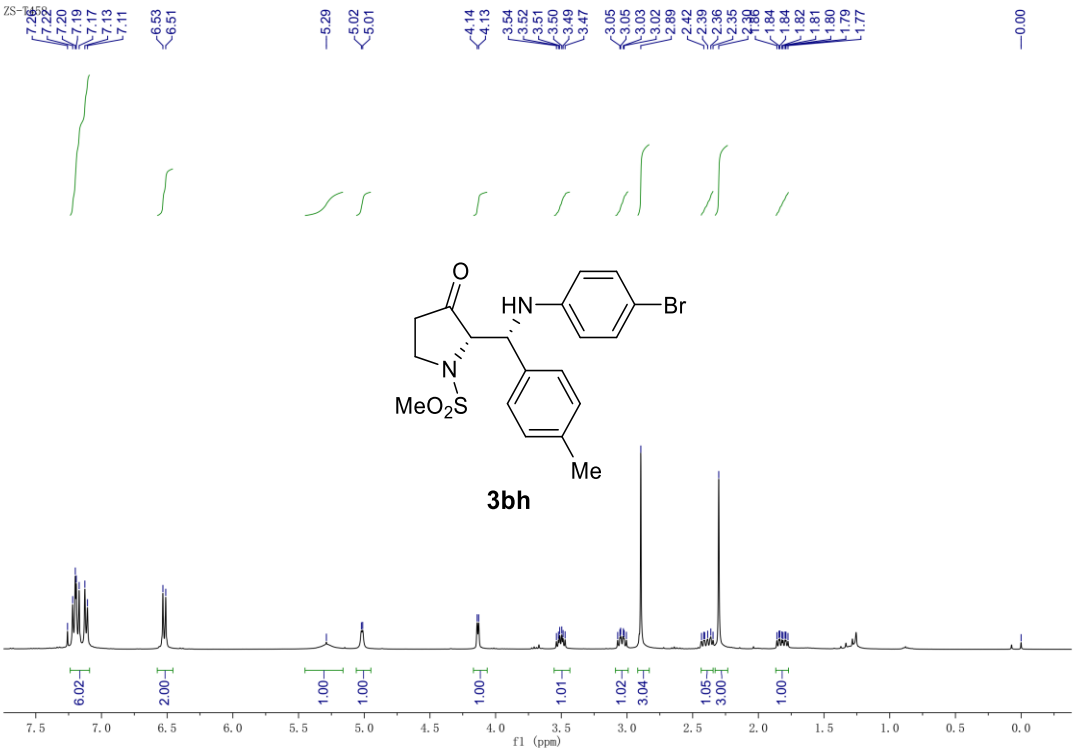
3cu

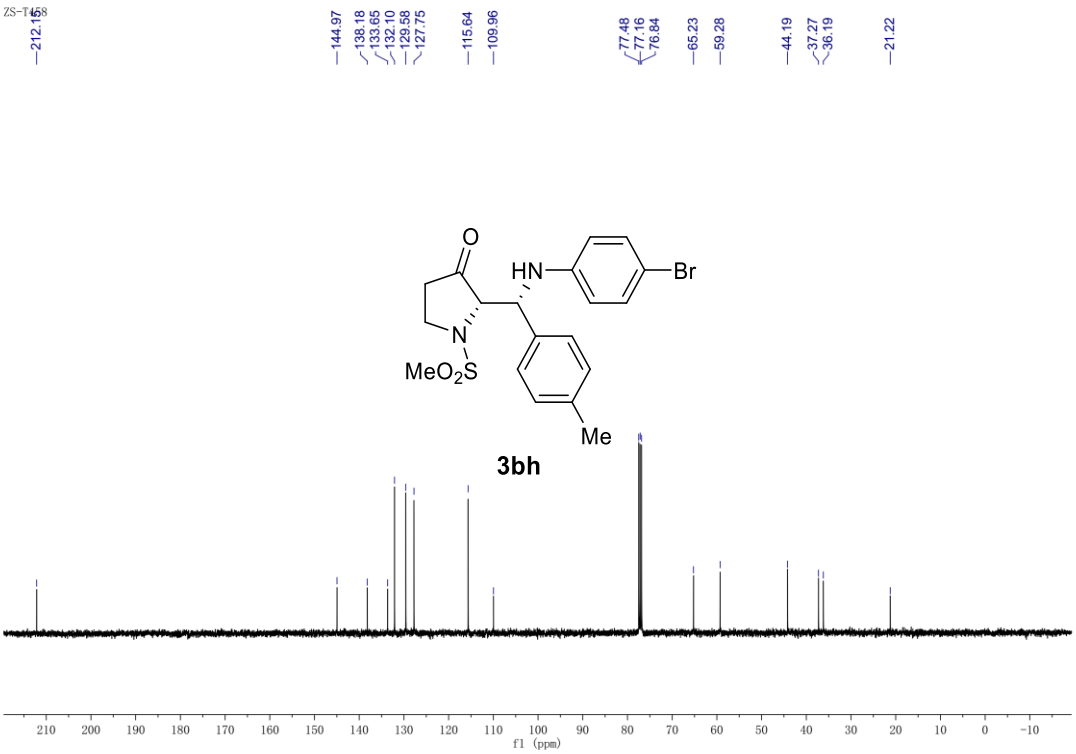

213.72
147.08
137.63
135.08
130.35
129.13
128.68
127.75
118.02
113.67
111.93
77.48
77.16
76.84
66.16
62.74
59.40
46.41
37.92
25.04
O
HN
N
Cl
tBuO2S
f1 (ppm)

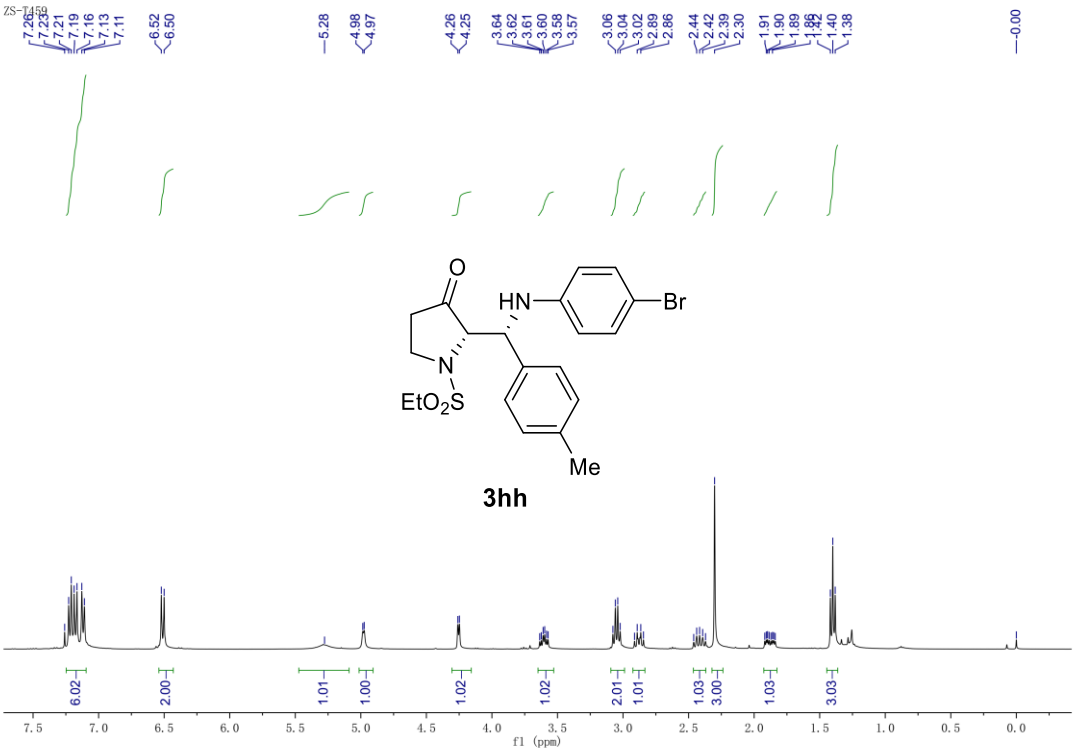
3cu


zs-t427
7.47
7.45
7.32
7.30
7.25
7.01
6.99
6.98
6.52
6.50
6.45
6.41
6.39
5.25
5.14
5.13
4.46
4.45
3.75
3.72
3.69
2.66
2.64
2.63
2.61
2.60
2.58
2.53
2.51
2.48
2.46
2.44
2.22
2.02
2.00
1.97
1.95
1.45
0.00
O
HN
N
Me
tBuO2S
Br
3cv
2.00
2.03
1.00
3.01
1.00
1.00
1.00
1.00
1.01
1.00
3.00
1.00
9.02
f1 (ppm)

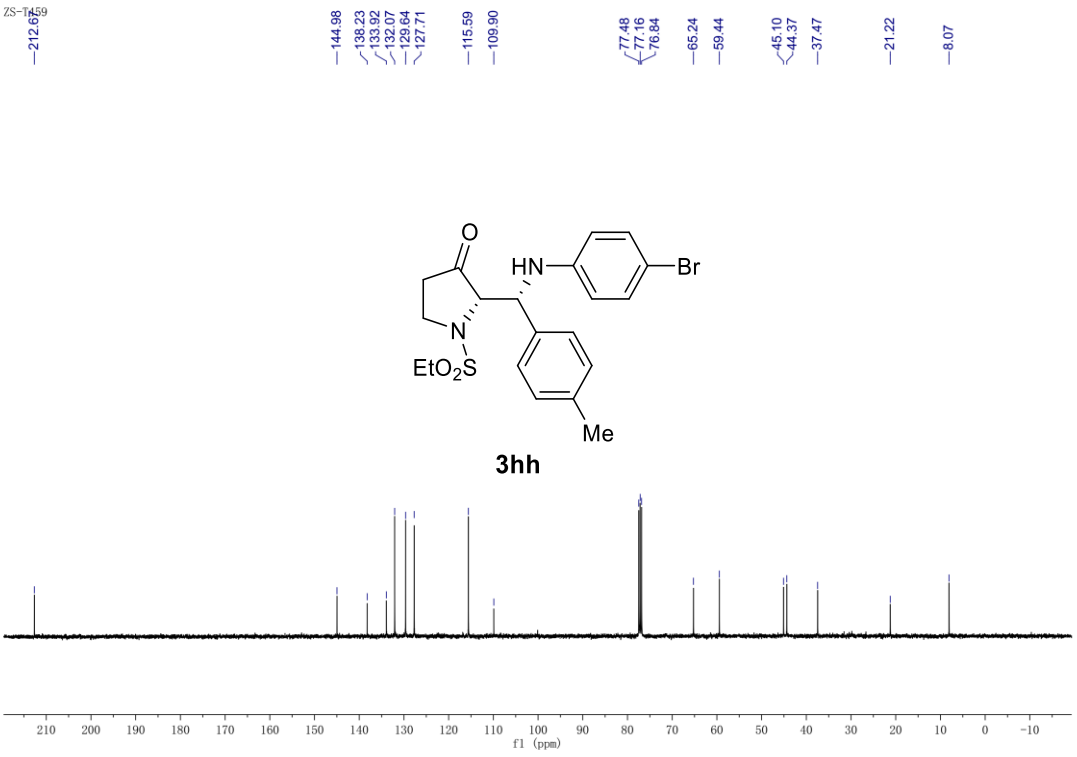

zs-t427
213.39
145.54
139.21
137.53
132.14
129.54
129.28
122.43
119.32
114.69
110.78
77.48
77.16
76.84
66.32
62.85
58.88
46.47
37.80
25.08
21.68
O
HN
N
Me
tBuO2S
Br
3cv
f1 (ppm)


ZS-T458
7.26
7.22
7.20
7.19
7.17
7.13
7.11
6.53
6.51
5.29
5.02
5.01
4.14
4.13
3.54
3.52
3.51
3.50
3.49
3.47
3.05
3.05
3.03
3.02
2.89
2.42
2.39
2.36
2.35
1.84
1.84
1.82
1.81
1.80
1.79
1.77
0.00
O
HN
Br
N
MeO2S
Me
3bh
6.02
2.00
1.00
1.00
1.00
1.01
1.02
3.04
1.05
3.00
1.00
f1 (ppm)

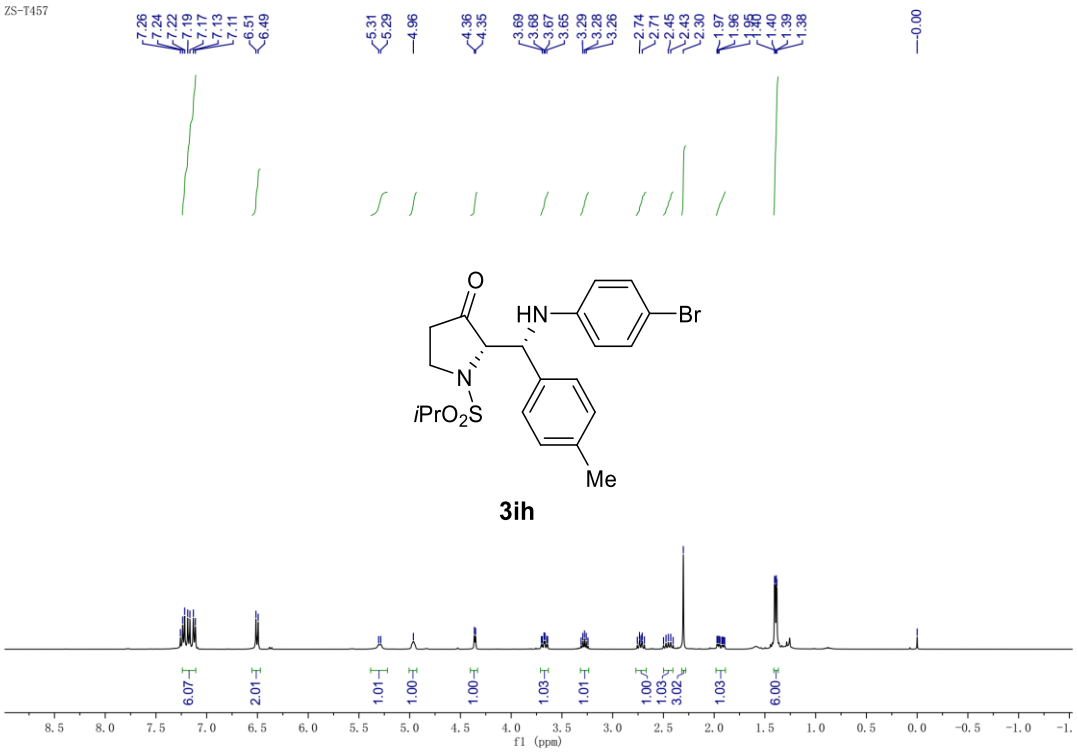

ZS-T458
212.15
144.97
138.18
133.65
132.10
129.58
127.75
115.64
109.96
77.48
77.16
76.84
65.23
59.28
44.19
37.27
36.19
21.22
O
HN
Br
N
MeO2S
Me
3bh
f1 (ppm)


ZS-T459
7.26
7.23
7.21
7.19
7.16
7.13
7.11
6.52
6.50
5.28
4.98
4.97
4.26
4.25
3.64
3.62
3.61
3.60
3.58
3.57
3.06
3.04
3.02
2.89
2.86
2.44
2.42
2.39
2.30
1.91
1.90
1.89
1.40
1.38
0.00
O
HN
Br
N
EtO2S
Me
6.02
2.00
1.01
1.00
1.02
1.02
2.01
1.01
1.03
3.00
1.03
3.03
f1 (ppm)

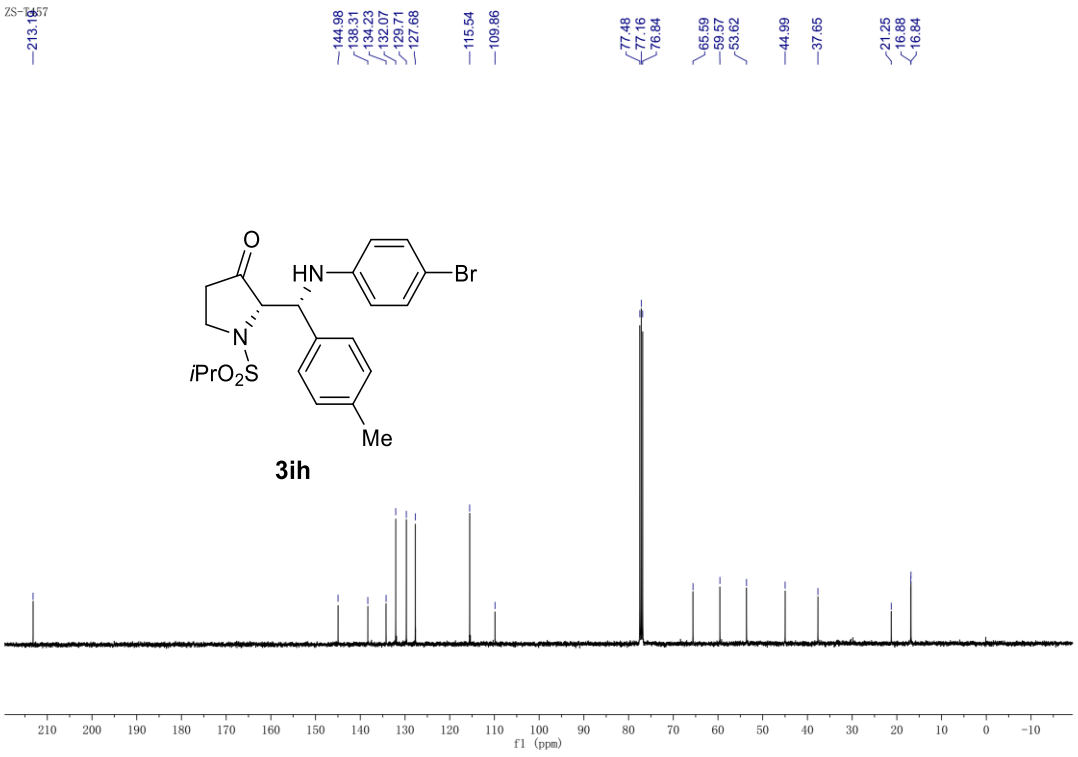
3hh


ZS-T459
212.67
144.98
138.23
133.92
132.07
129.64
127.71
115.59
109.90
77.48
77.16
76.84
65.24
59.44
45.10
44.37
37.47
21.22
8.07
O
HN
Br
N
EtO2S
Me
f1 (ppm)

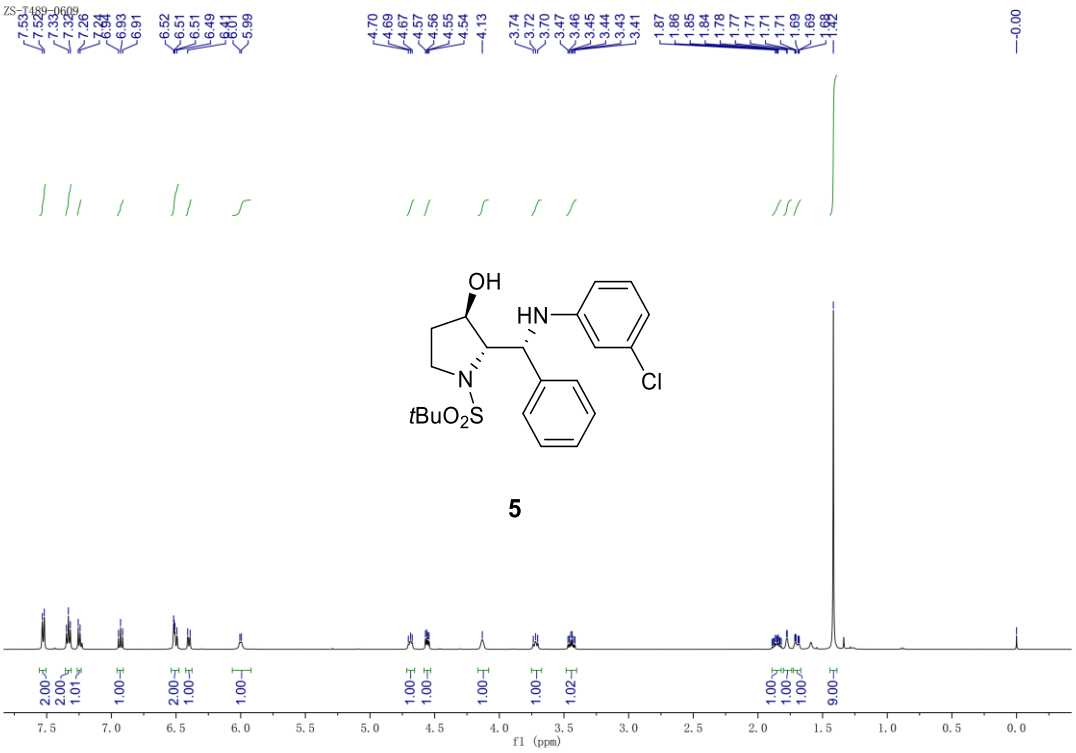
3hh

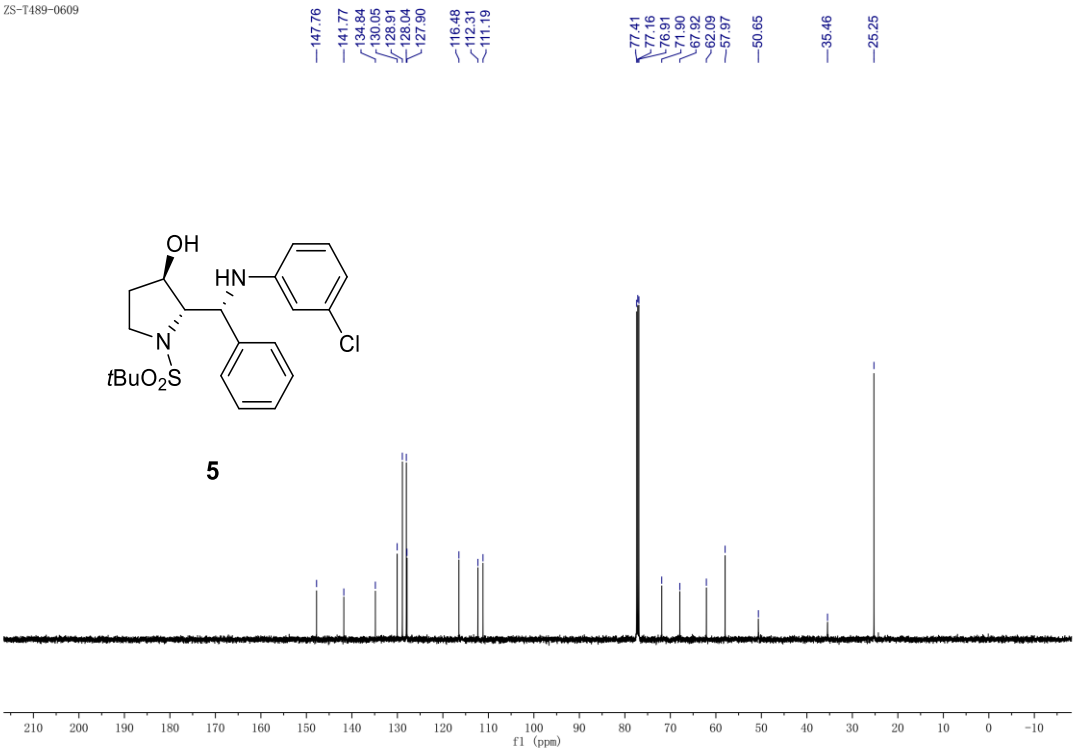

ZS-T457
7.26
7.24
7.22
7.19
7.17
7.13
7.11
6.51
6.49
5.31
5.29
4.96
4.36
4.35
3.69
3.68
3.67
3.65
3.29
3.28
3.26
2.74
2.71
2.45
2.43
2.30
1.97
1.96
1.95
1.40
1.39
1.38
0.00
O
HN
Br
N
iPrO2S
Me
6.07
2.01
1.01
1.00
1.00
1.03
1.01
1.00
1.03
3.02
1.03
6.00
f1 (ppm)

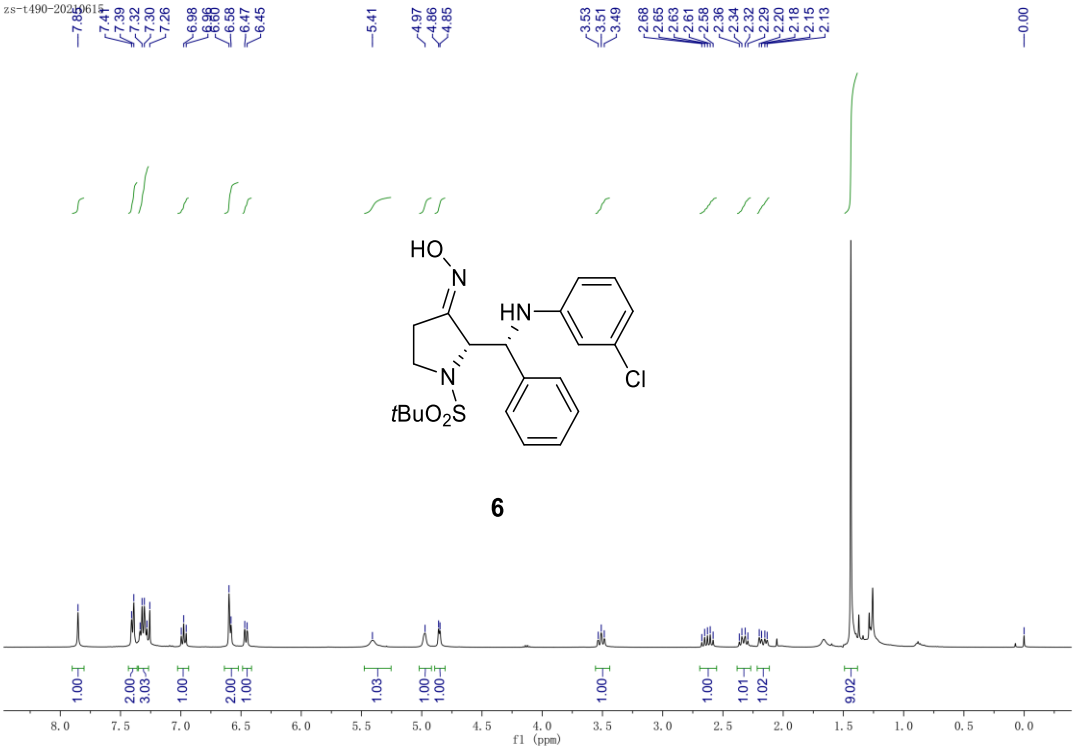
3ih

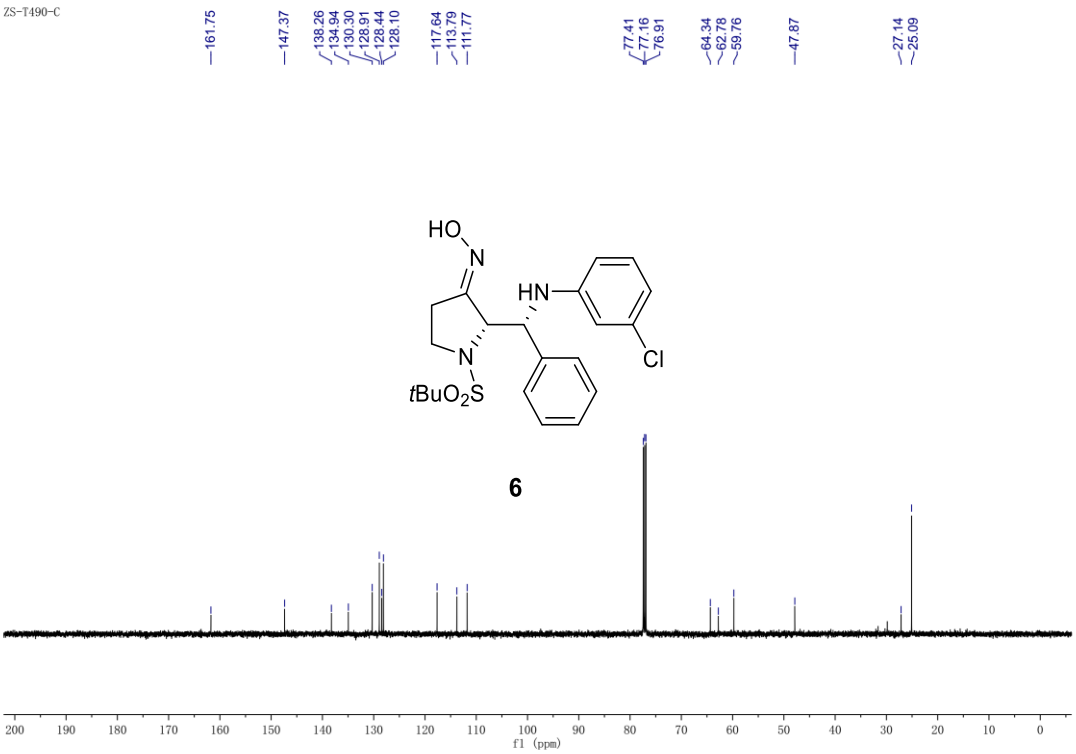

ZS-T457
213.19
144.98
138.31
134.23
132.07
129.71
127.68
115.54
109.86
77.48
77.16
76.84
65.59
59.57
53.62
44.99
37.65
21.25
16.88
16.84
O
HN
Br
N
iPrO2S
Me
f1 (ppm)

3ih


ZS-T489-0609
OH
HN
Cl
N
tBuO2S
5
f1 (ppm)

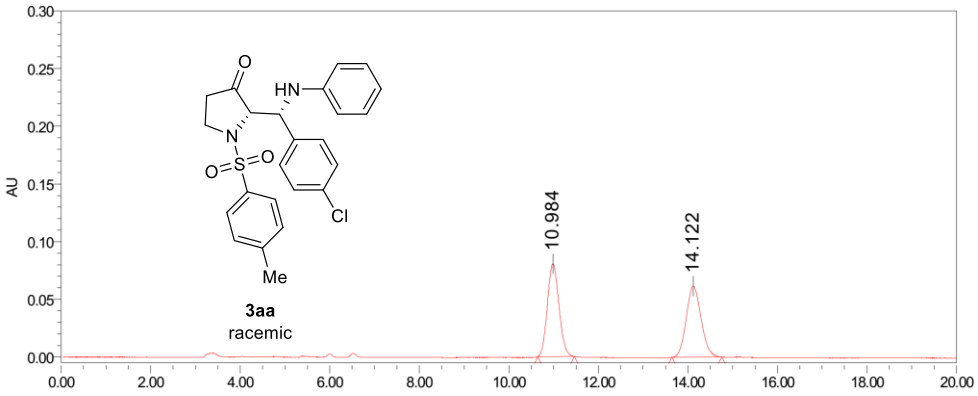

ZS-T489-0609
OH
HN
Cl
N
tBuO2S
5
f1 (ppm)


zs-t490-20200615
7.85
7.41
7.39
7.32
7.30
7.26
6.98
6.96
6.88
6.58
6.47
6.45
5.41
4.97
4.86
4.85
3.53
3.51
3.49
2.68
2.65
2.63
2.61
2.58
2.36
2.34
2.32
2.29
2.20
2.18
2.15
2.13
0.00
HO
N
HN
Cl
N
tBuO2S
6
1.00
2.00
3.03
1.00
2.00
1.00
1.03
1.00
1.00
1.00
1.00
1.01
1.02
9.02
f1 (ppm)

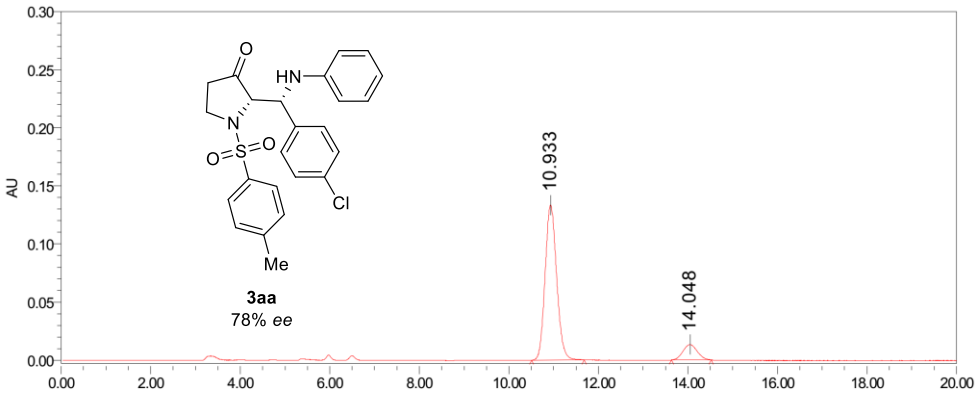

ZS-T490-C
161.75
147.37
138.26
134.94
130.30
128.91
128.44
128.10
117.64
113.79
111.77
77.41
77.16
76.91
64.34
62.78
59.76
47.87
27.14
25.09
HO
N
HN
Cl
N
tBuO2S
6
f1 (ppm)

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



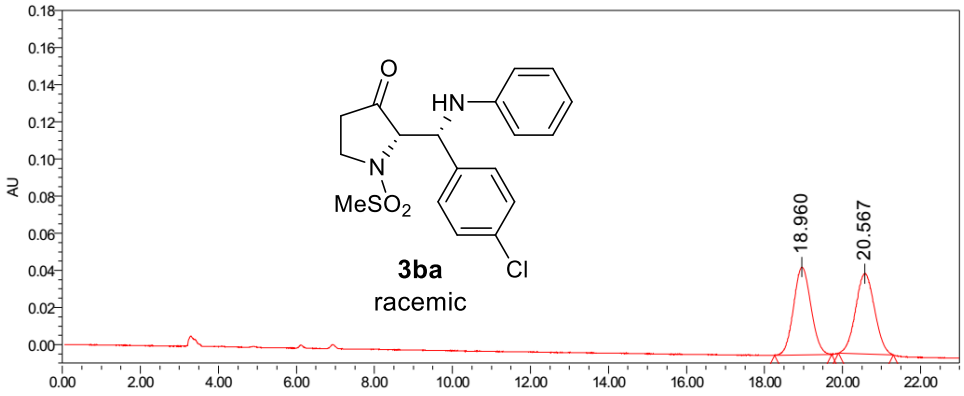
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.984	80381	1424004	50.01
2	14.122	61496	1423277	49.99



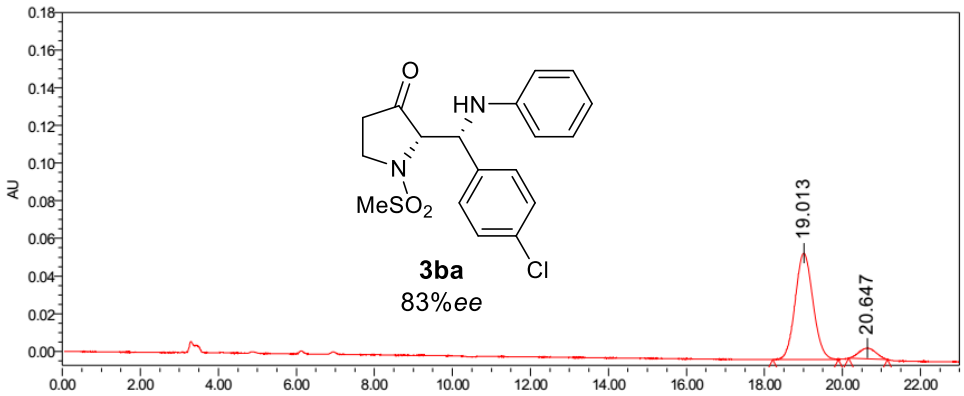
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.933	133424	2366955	88.85
2	14.048	13319	297111	11.15

Condition：Chrial IC, λ = 240 nm, hexane/isopropanol = 92:8

flow rate = 1.0 mL/min



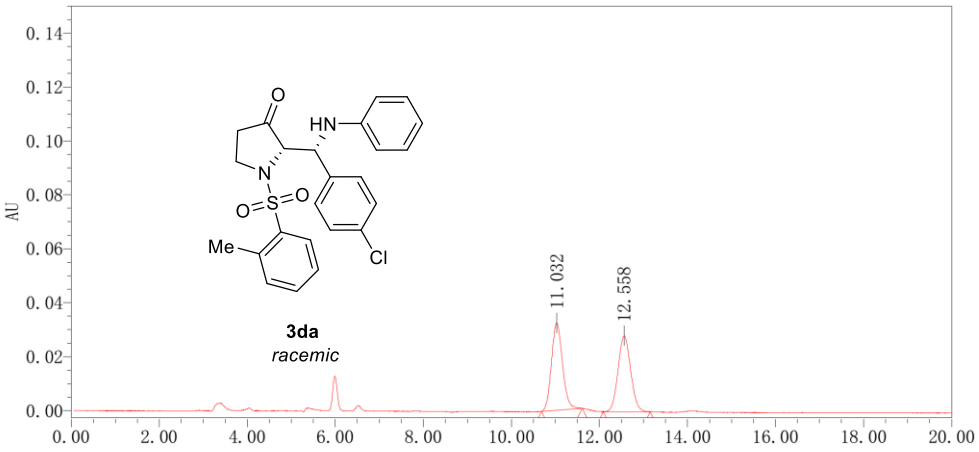
Entry	RT min	Height mV	Area mV.sec	% Area %
1	18.960	47161	1460603	50.04
2	20.567	43261	1458362	49.96



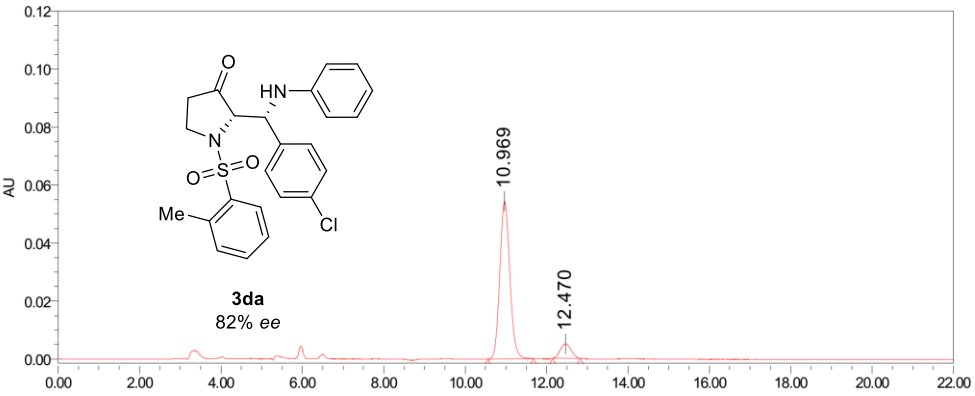
Entry	RT min	Height mV	Area mV.sec	% Area %
1	19.013	56423	1792318	91.24
2	20.647	5702	172103	8.76

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



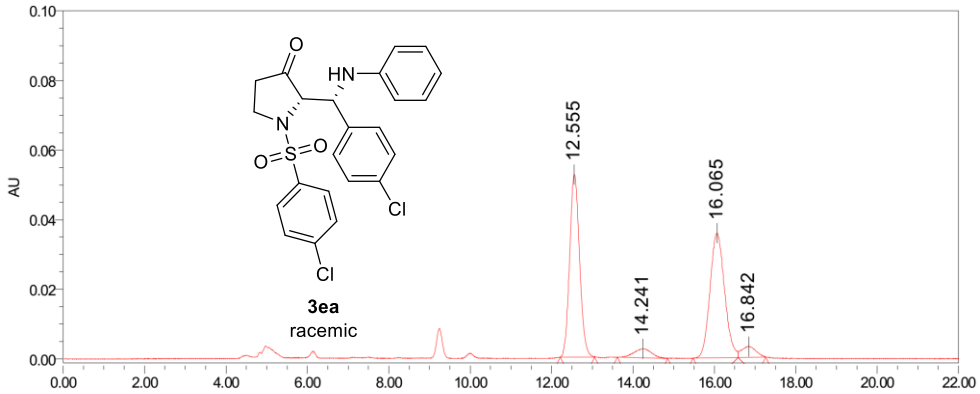
Entry	RT min	Height mV	Area mV.sec	% Area %
1	11.032	32317	562100	50.09
2	12.558	28172	560066	49.91



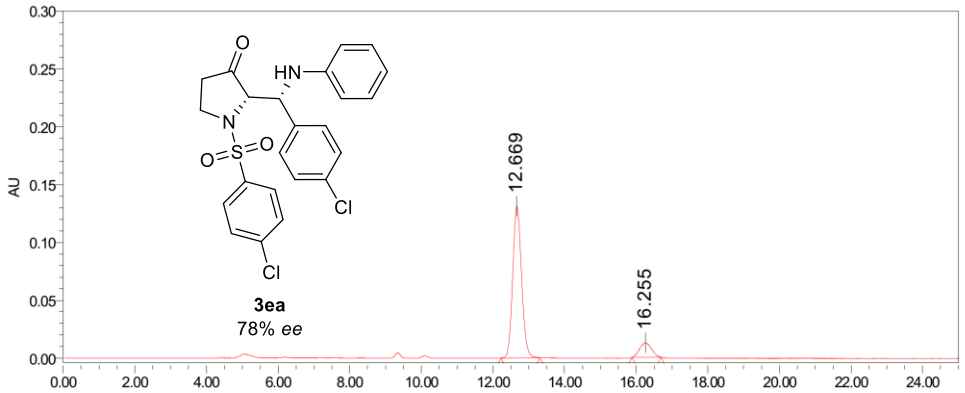
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.969	54344	937866	91.00
2	12.470	5063	92773	9.00

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



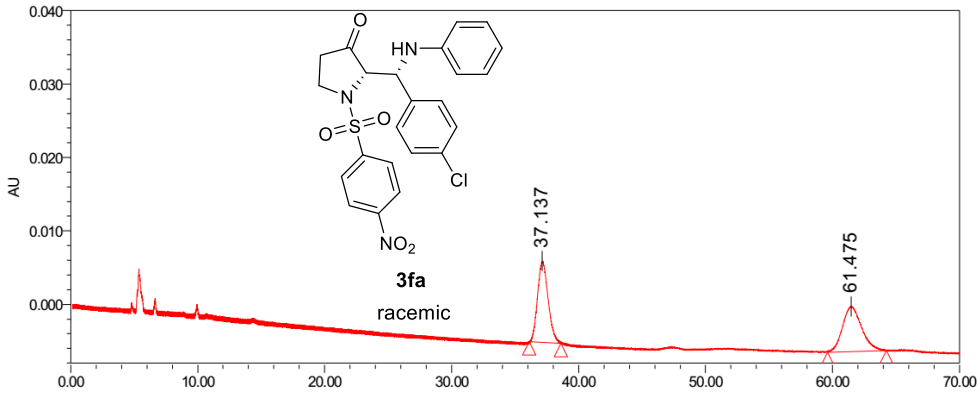
Entry	RT min	Height mV	Area mV.sec	% Area %
1	12.555	52427	883295	46.02
2	14.241	2538	75344	3.93
3	16.065	35778	883239	46.01
4	16.842	3137	77689	4.05



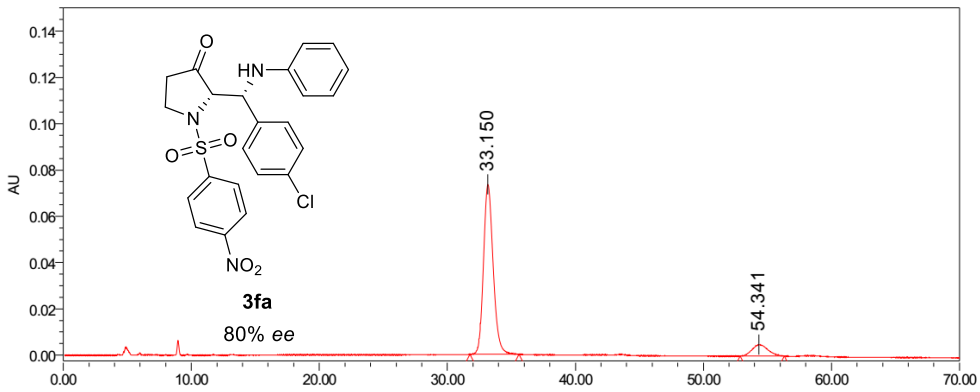
Entry	RT min	Height mV	Area mV.sec	% Area %
1	12.669	130824	2260060	88.76
2	16.255	12475	286232	11.24

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



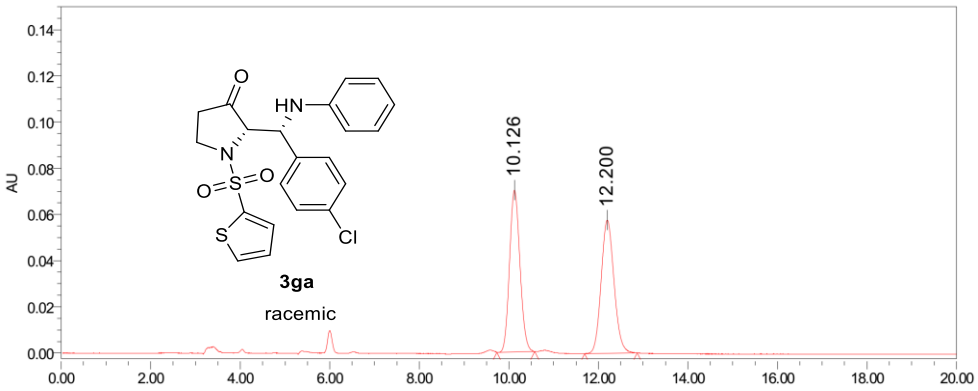
Entry	RT min	Height mV	Area mV.sec	% Area %
1	37.137	11103	645751	49.88
2	61.475	6161	648887	50.12



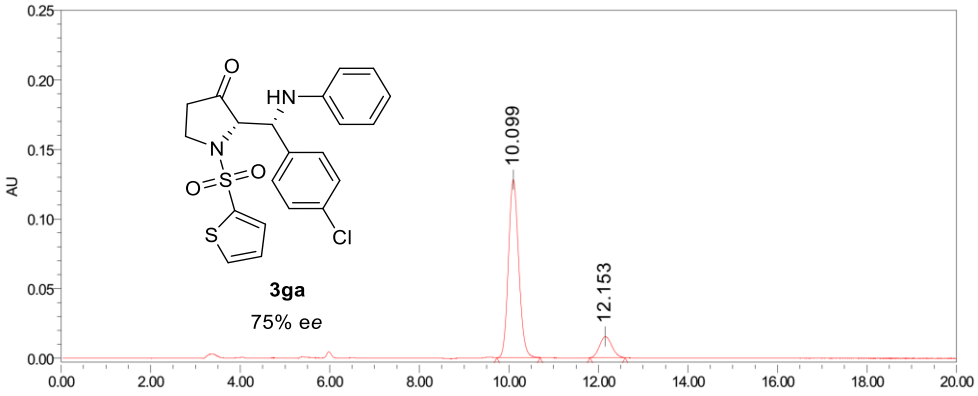
Entry	RT min	Height mV	Area mV.sec	% Area %
1	33.150	73347	3859564	90.10
2	54.341	4896	423925	9.90

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



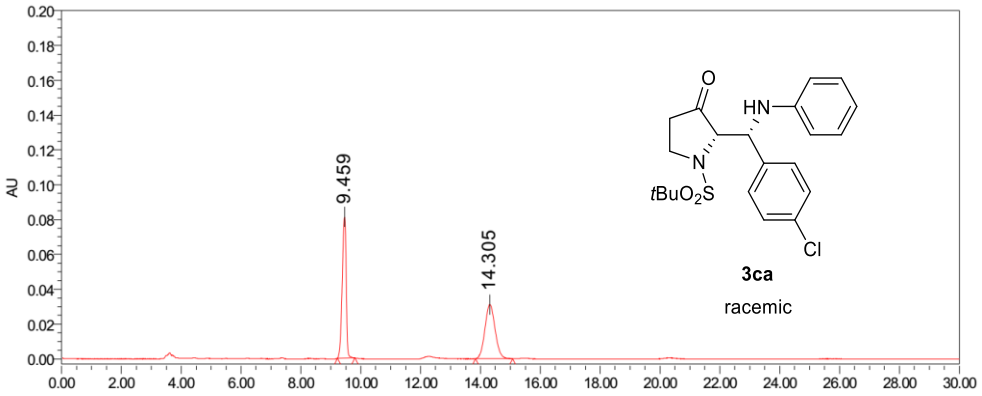
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.126	70007	1134922	49.47
2	12.200	57702	1159216	50.53



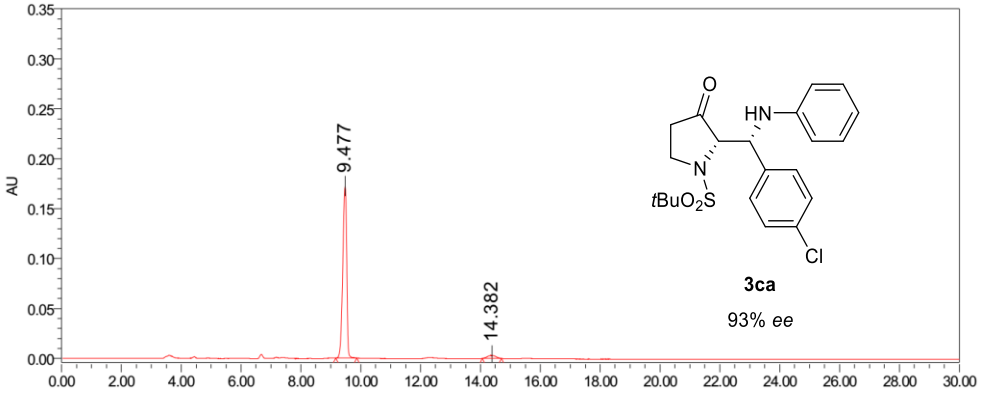
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.099	127937	2042893	87.56
2	12.153	15148	290160	12.44

Condition：Chrial IC, λ = 245 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



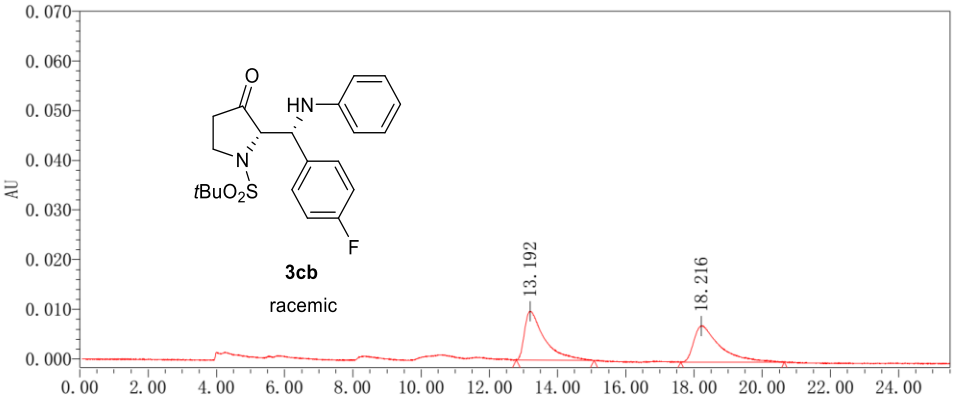
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.459	81048	748401	50.45
2	14.305	31138	734939	49.55



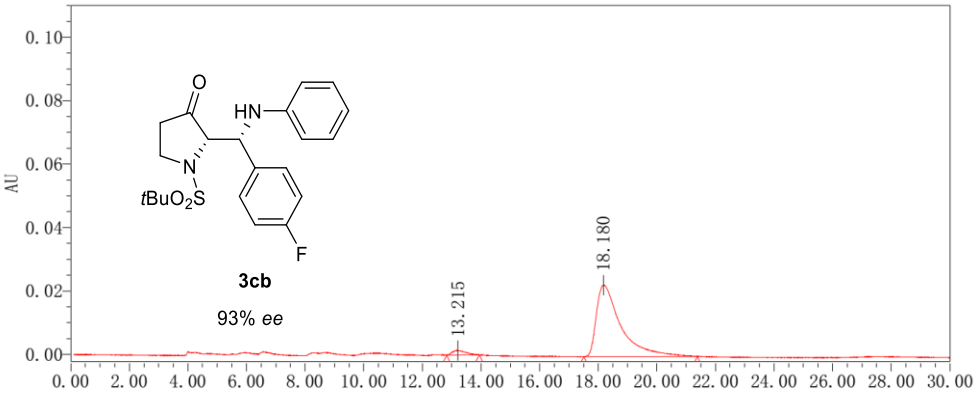
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.477	172268	1587493	96.25
2	14.382	3035	61875	3.75

Condition：Chrial IA, λ = 240 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



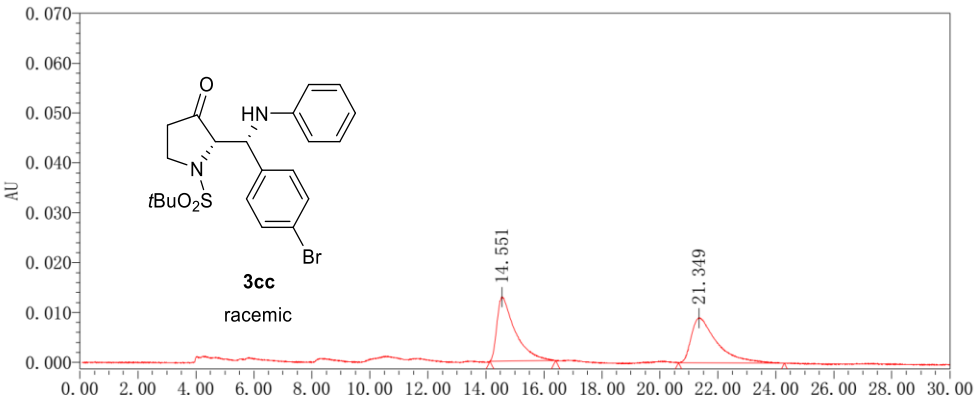
Entry	RT min	Height mV	Area mV.sec	% Area %
1	13.192	9828	392265	50.38
2	18.216	7302	386273	49.62



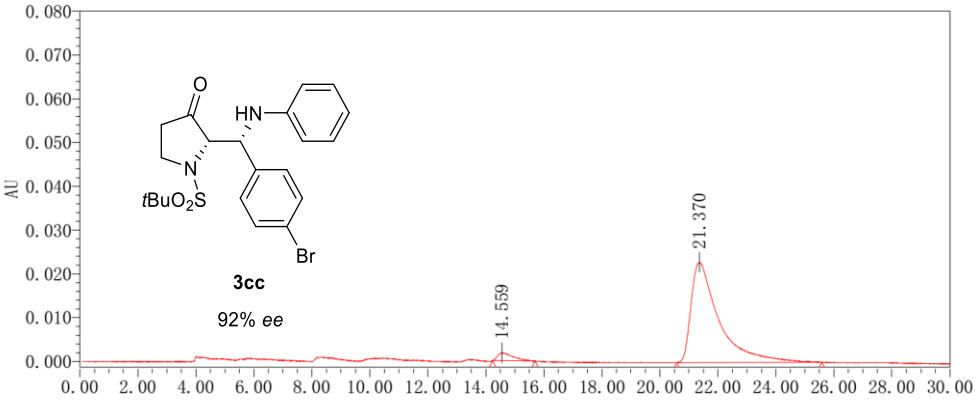
Entry	RT min	Height mV	Area mV.sec	% Area %
1	13.215	1460	47897	3.56
2	18.180	22588	1299168	96.44

Condition：Chrial IA, λ = 240 nm, hexane/isopropanol = 85:15

flow rate = 1.0 mL/min



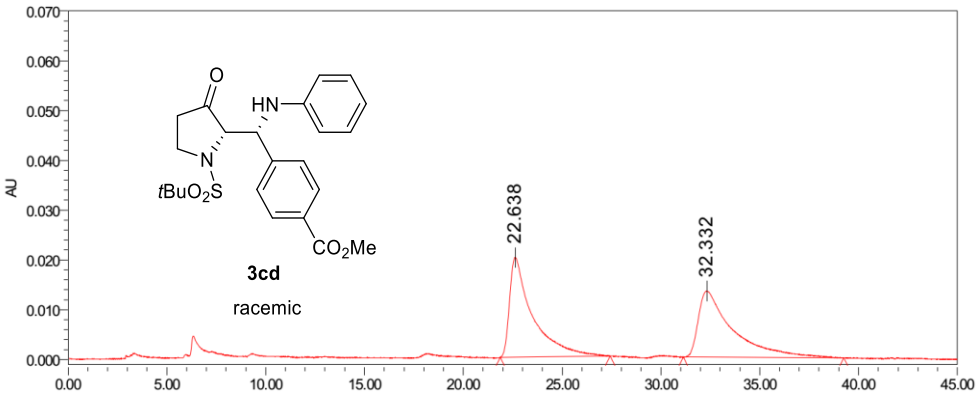
Entry	RT min	Height mV	Area mV.sec	% Area %
1	14.551	12855	557762	50.13
2	21.349	9000	554956	49.87



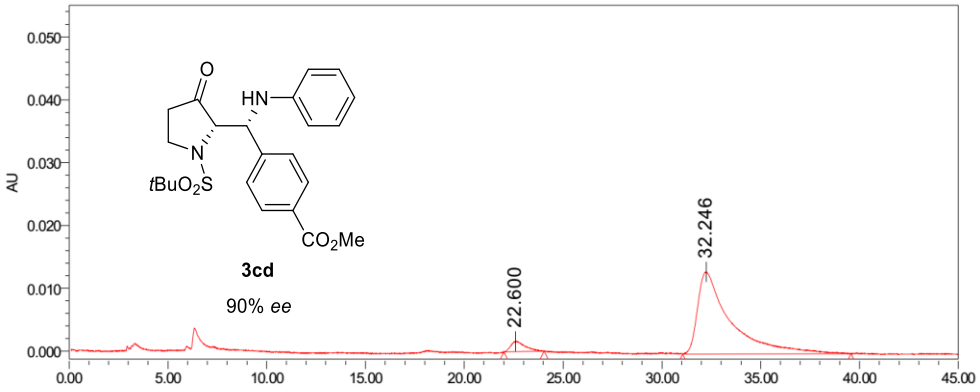
Entry	RT min	Height mV	Area mV.sec	% Area %
1	14.559	1804	66800	4.17
2	21.37	22938	1534154	95.83

Condition：Chrial IA, λ = 240 nm, hexane/isopropanol = 85:15

flow rate = 1.0 mL/min



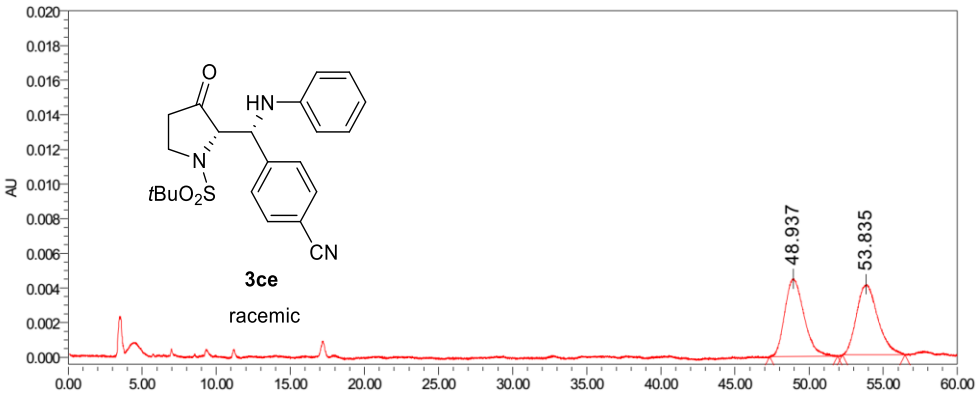
Entry	RT min	Height mV	Area mV.sec	% Area %
1	22.638	20029	1617940	50.25
2	32.332	13307	1601678	49.75



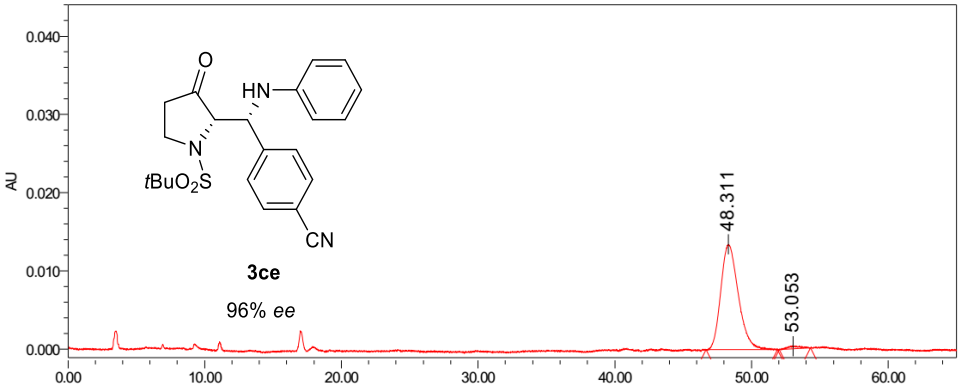
Entry	RT min	Height mV	Area mV.sec	% Area %
1	22.600	1655	82564	5.18
2	32.246	13084	1510239	94.82

Condition：Chrial IA, λ = 240 nm, hexane/isopropanol = 85:15

flow rate = 1.0 mL/min



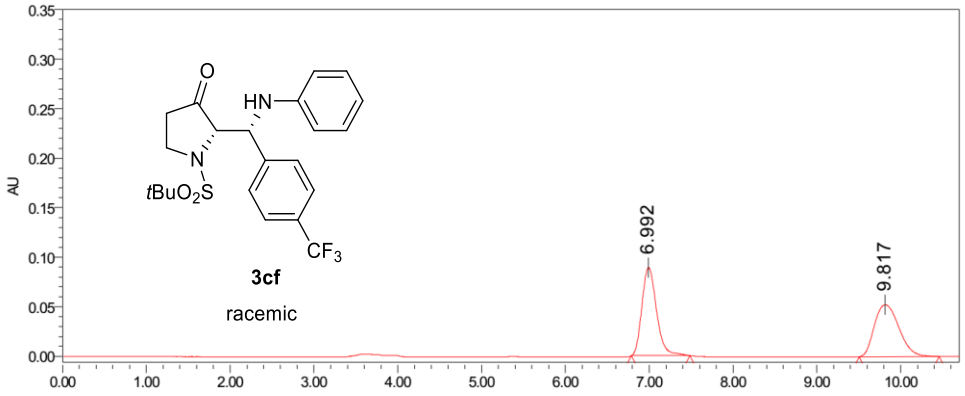
Entry	RT min	Height mV	Area mV.sec	% Area %
1	48.937	4495	405230	50.01
2	53.835	4067	405072	49.99



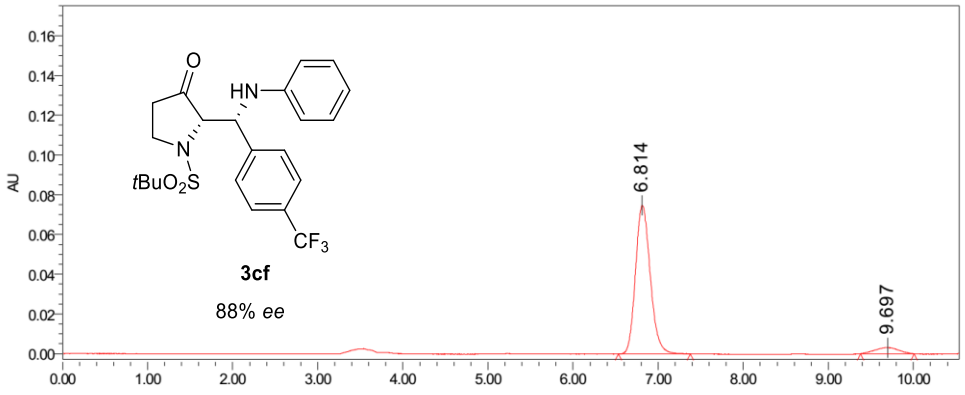
Entry	RT min	Height mV	Area mV.sec	% Area %
1	48.311	13468	1198746	98.04
2	53.053	361	23920	1.96

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



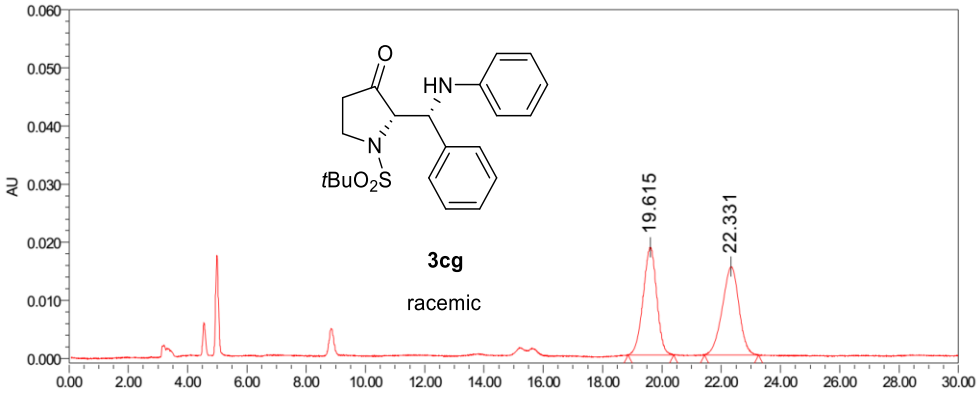
Entry	RT min	Height mV	Area mV.sec	% Area %
1	6.992	89026	1080369	50.22
2	9.817	52354	1070767	49.78



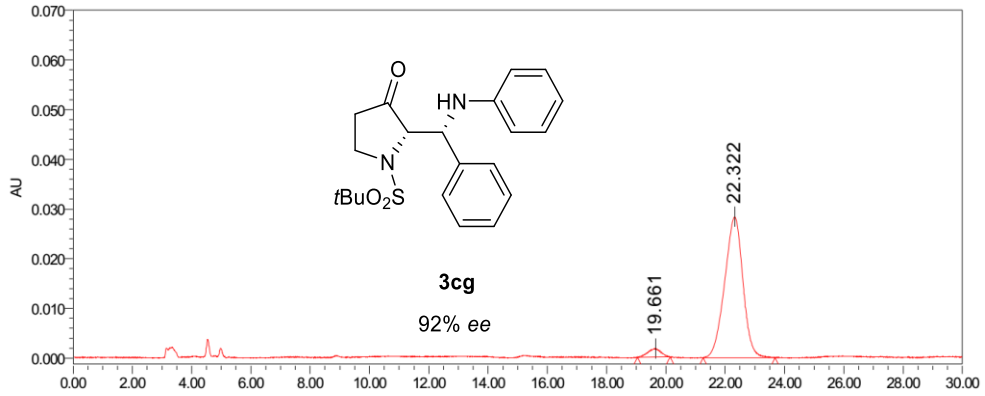
Entry	RT min	Height mV	Area mV.sec	% Area %
1	6.814	74766	900262	93.85
2	9.697	3054	59010	6.15

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



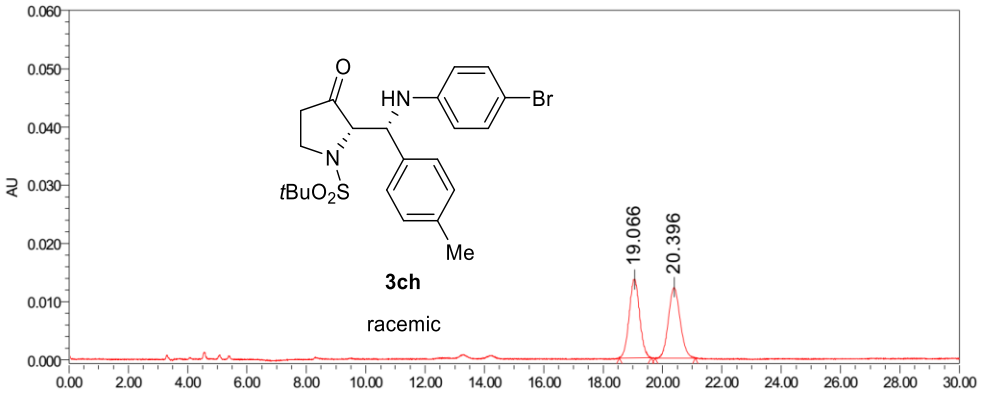
Entry	RT min	Height mV	Area mV.sec	% Area %
1	19.615	18526	592167	49.98
2	22.331	15202	592613	50.02



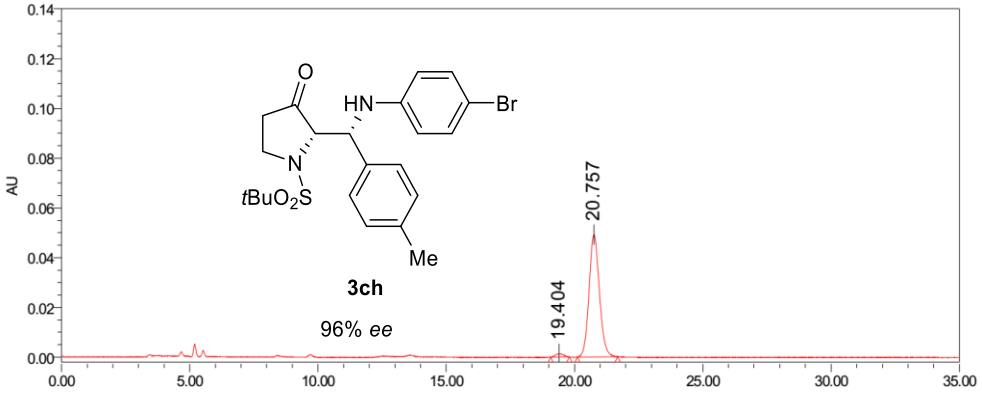
Entry	RT min	Height mV	Area mV.sec	% Area %
1	19.661	1702	52800	4.19
2	22.322	28322	1206569	95.81

Condition：Chrial IA, λ = 260 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



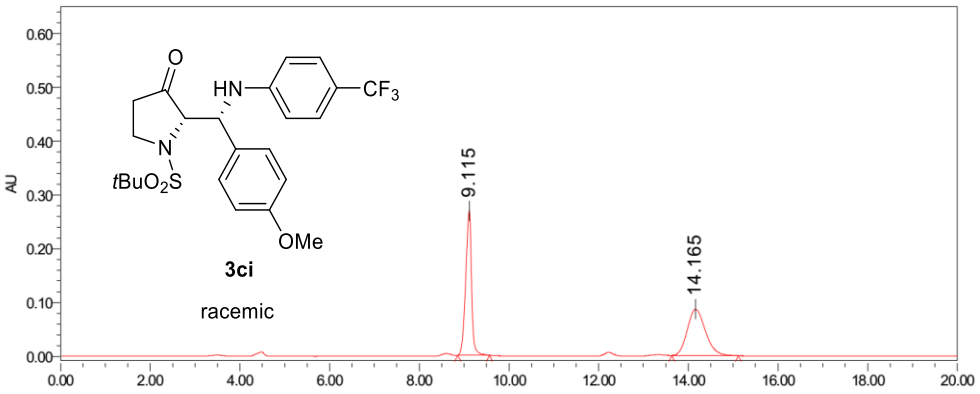
Entry	RT min	Height mV	Area mV.sec	% Area %
1	19.066	13477	332133	50.02
2	20.396	12158	331837	49.98



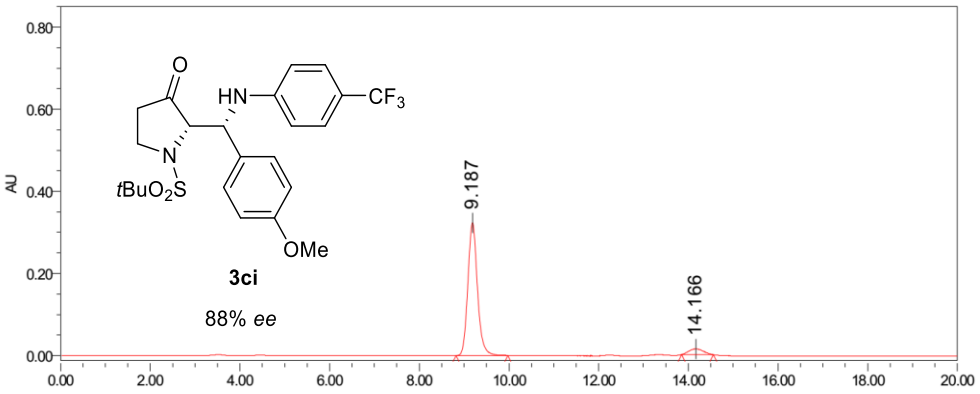
Entry	RT min	Height mV	Area mV.sec	% Area %
1	19.404	1365	28390	2.00
2	20.757	49139	1388457	98.00

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



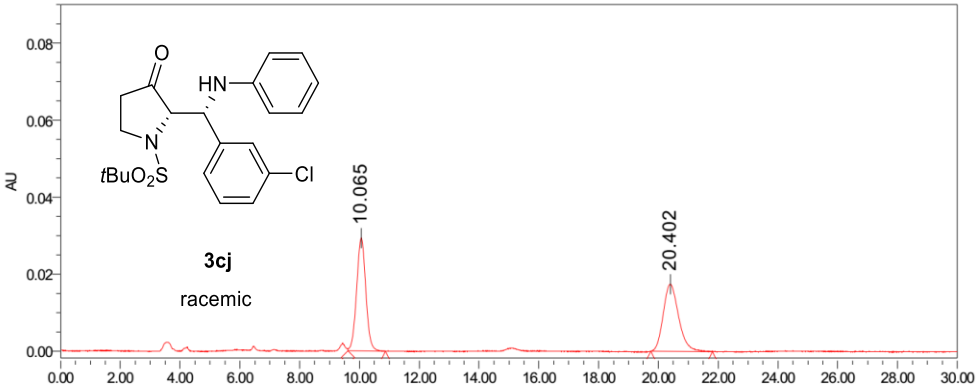
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.115	268863	2443231	50.22
2	14.165	86197	2422211	49.78



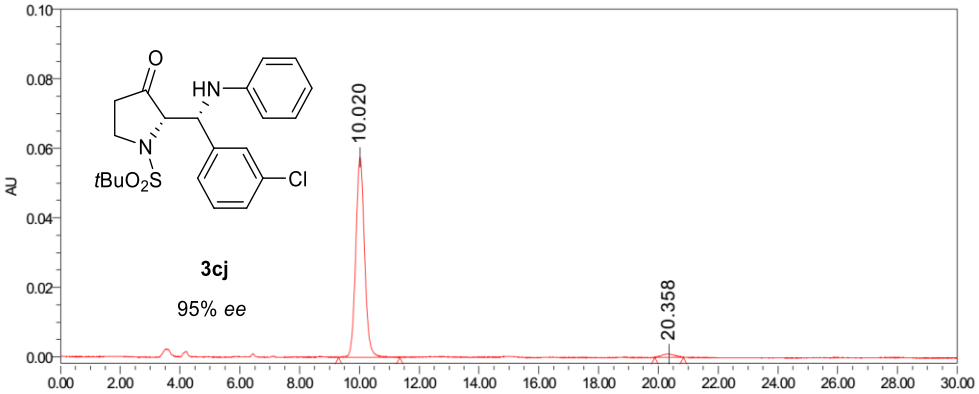
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.187	323105	4824059	93.81
2	14.166	14012	318542	6.19

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



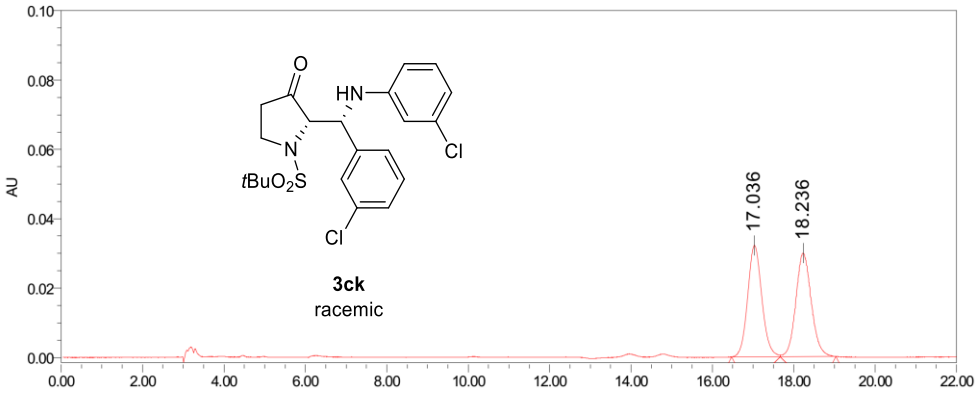
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.065	29292	628911	50.00
2	20.402	17471	628892	50.00



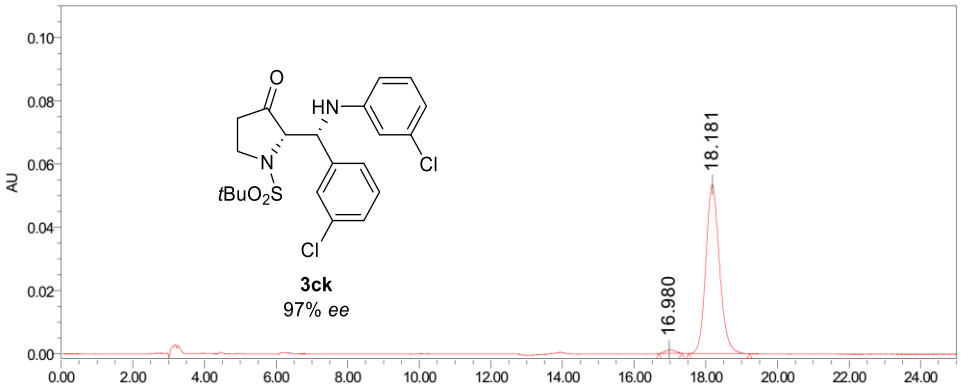
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.02	57411	1173937	97.65
2	20.358	940	28269	2.35

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 95:5

flow rate = 1.0 mL/min



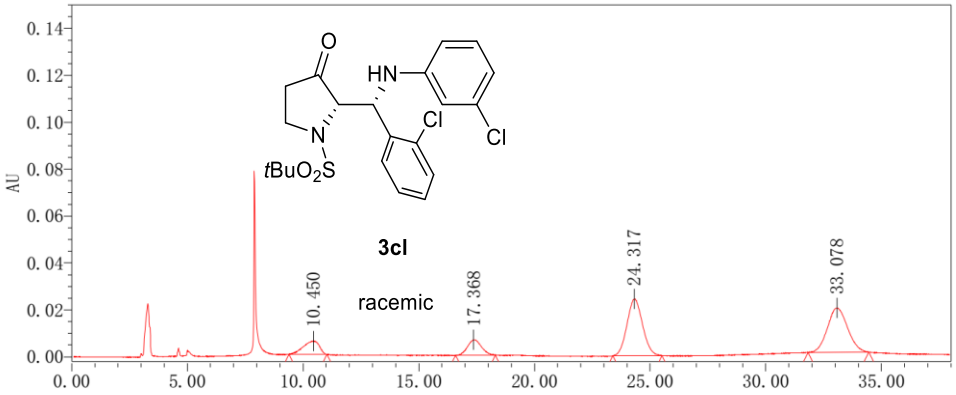
Entry	RT min	Height mV	Area mV.sec	% Area %
1	7.036	32115	780887	49.99
2	18.236	29853	781251	50.01



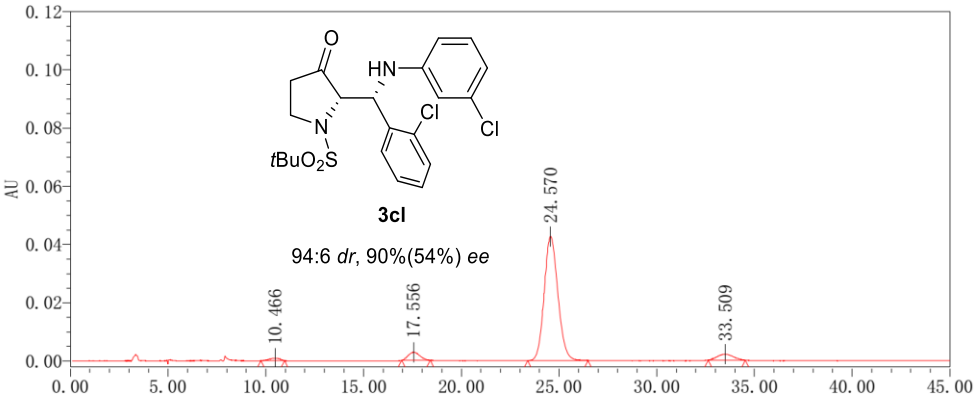
Entry	RT min	Height mV	Area mV.sec	% Area %
1	16.980	1165	22711	1.59
2	18.181	53340	1401234	98.41

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



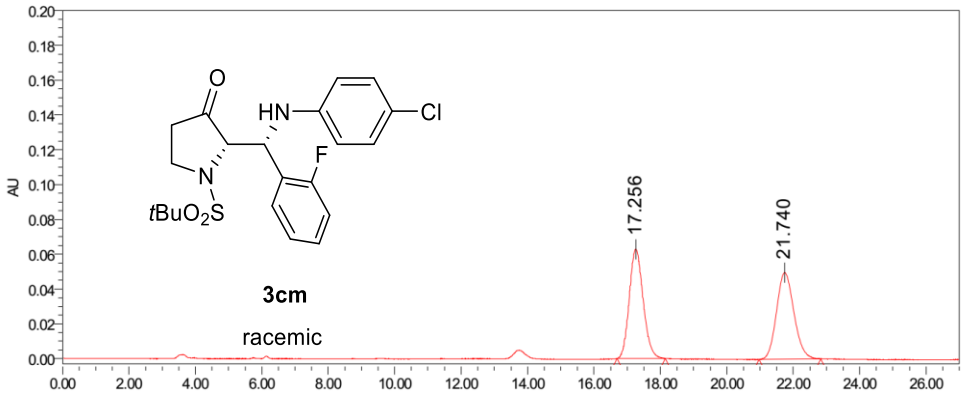
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.45	5654	267632	9.48
2	17.368	6525	269426	9.54
3	24.317	24217	1142111	40.45
4	33.078	18883	1144444	40.53



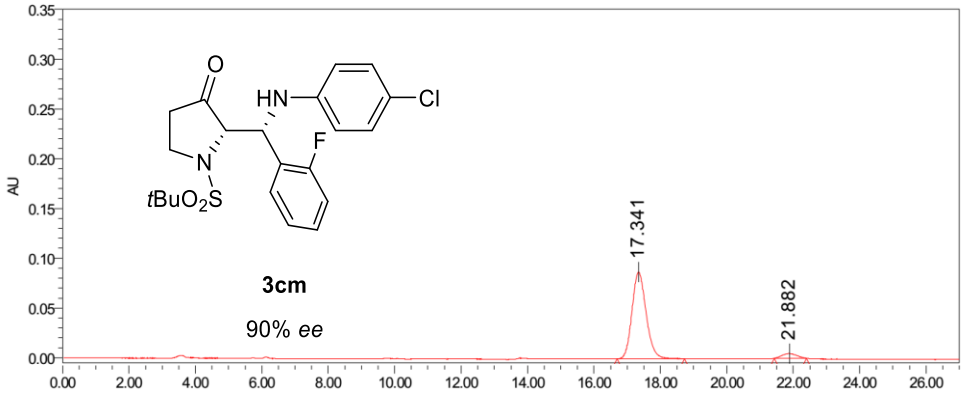
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.466	836	33221	1.41
2	17.556	2799	113732	4.84
3	24.57	42611	2088661	88.84
4	33.509	2065	115347	4.94

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



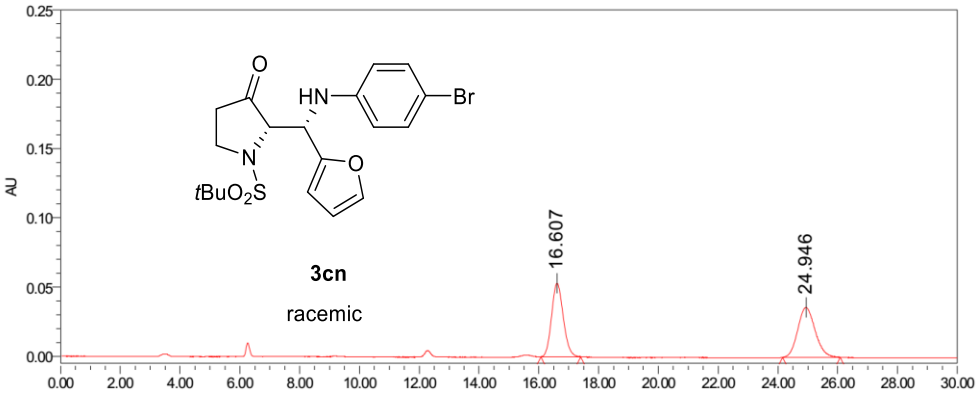
Entry	RT min	Height mV	Area mV.sec	% Area %
1	17.256	62727	1815902	50.00
2	21.74	49723	1815551	50.00



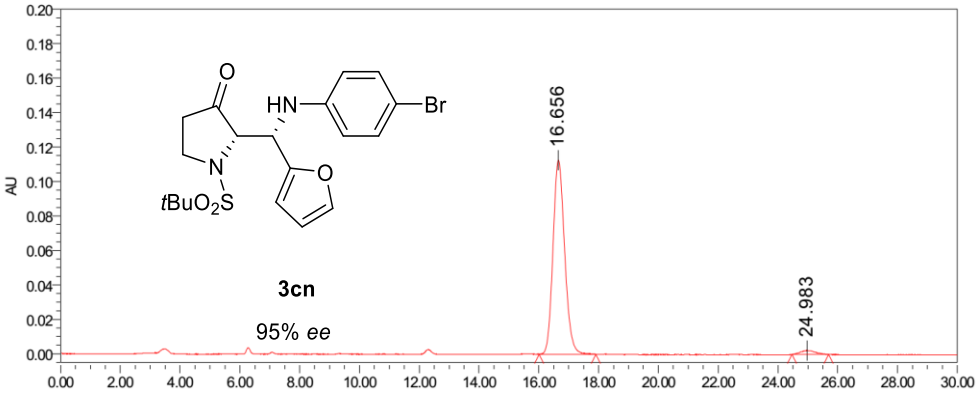
Entry	RT min	Height mV	Area mV.sec	% Area %
1	17.341	86973	2563948	94.75
2	21.882	4653	141959	5.25

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



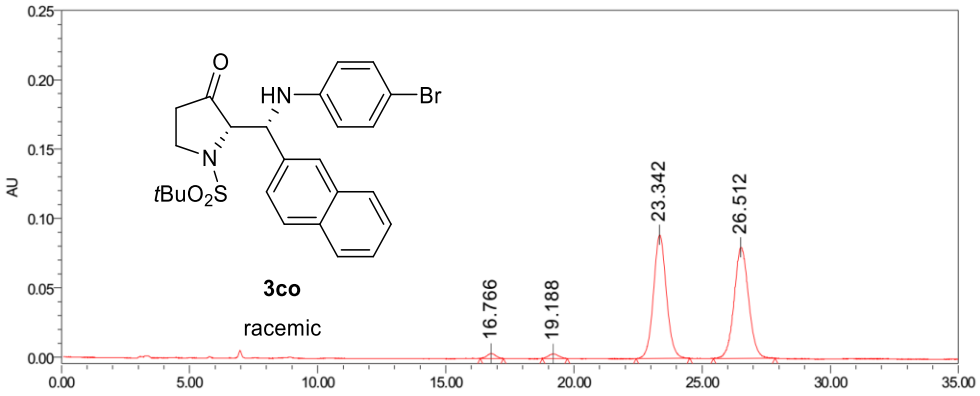
Entry	RT min	Height mV	Area mV.sec	% Area %
1	16.607	53059	1446432	50.00
2	24.946	35967	1446424	50.00



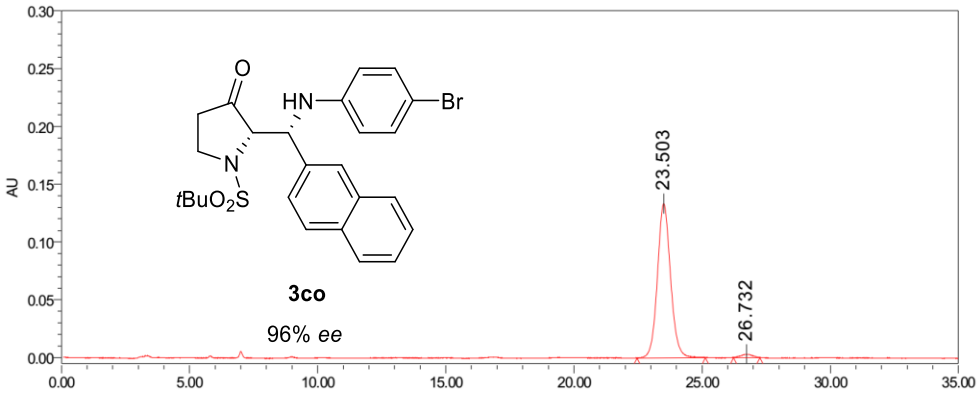
Entry	RT min	Height mV	Area mV.sec	% Area %
1	16.656	112576	3063888	97.50
2	24.983	2241	78517	2.50

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



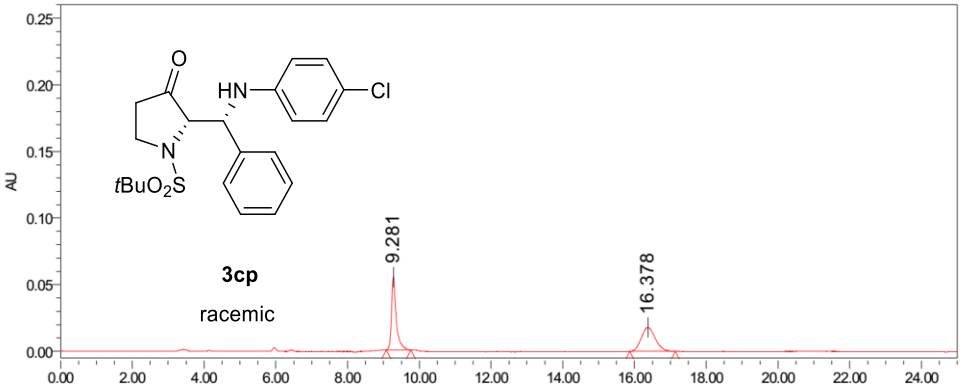
Entry	RT min	Height mV	Area mV.sec	% Area %
1	16.766	3539	83149	1.29
2	19.188	3195	84571	1.31
3	23.342	89065	3132530	48.66
4	26.512	79994	3137197	48.73



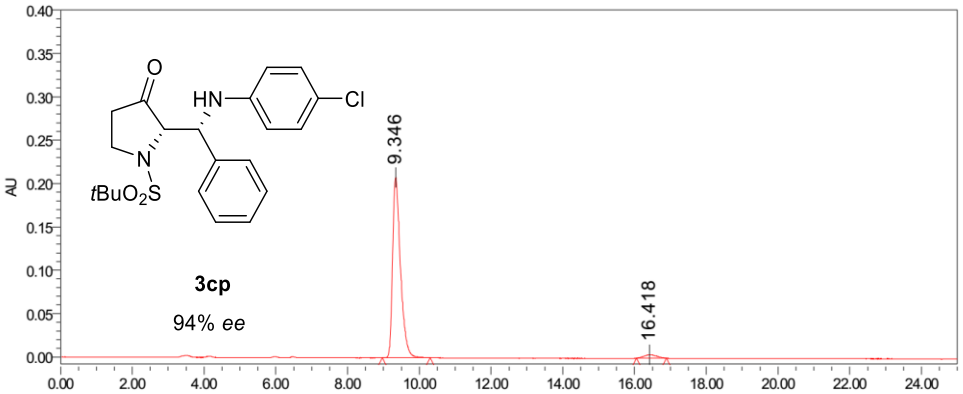
Entry	RT min	Height mV	Area mV.sec	% Area %
1	23.503	133417	4772498	98.16
2	26.732	2788	89323	1.84

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



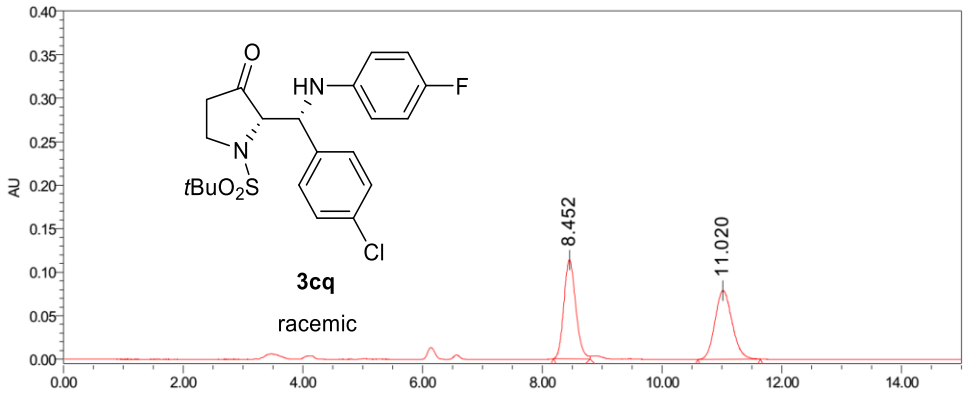
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.281	54593	492408	50.00
2	16.378	18044	492321	50.00



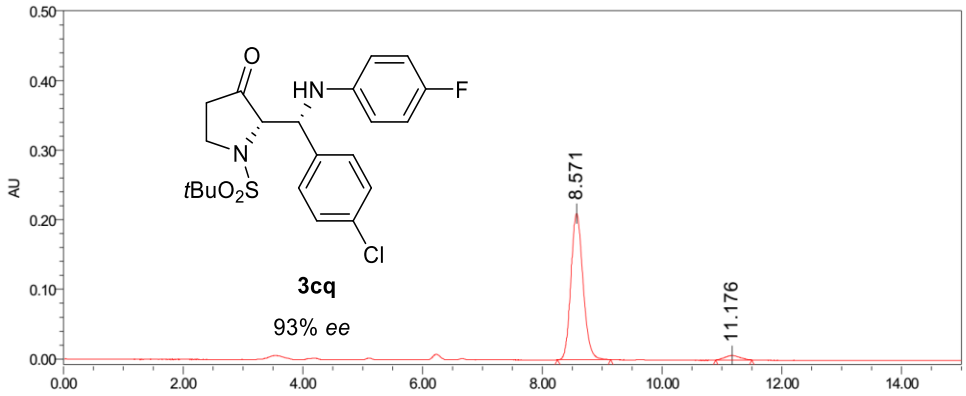
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.346	207884	3161231	97.10
2	16.418	3784	94383	2.90

Condition：Chrial IC, λ = 230 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



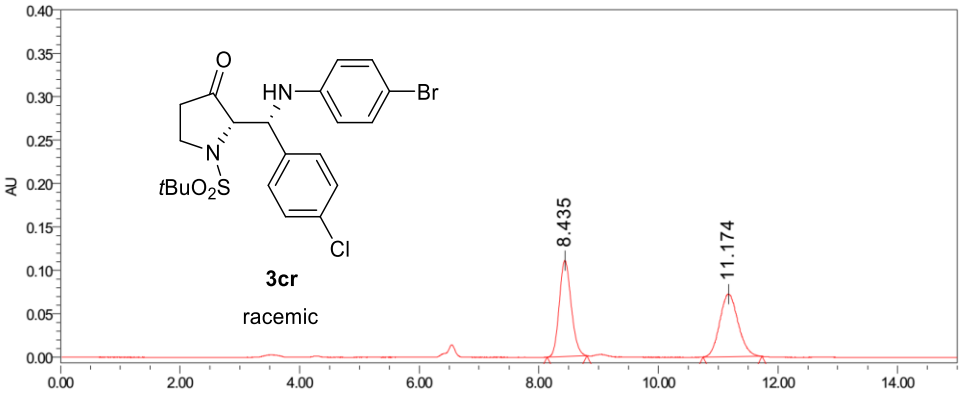
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.452	113746	1562199	50.03
2	11.02	78868	1560022	49.97



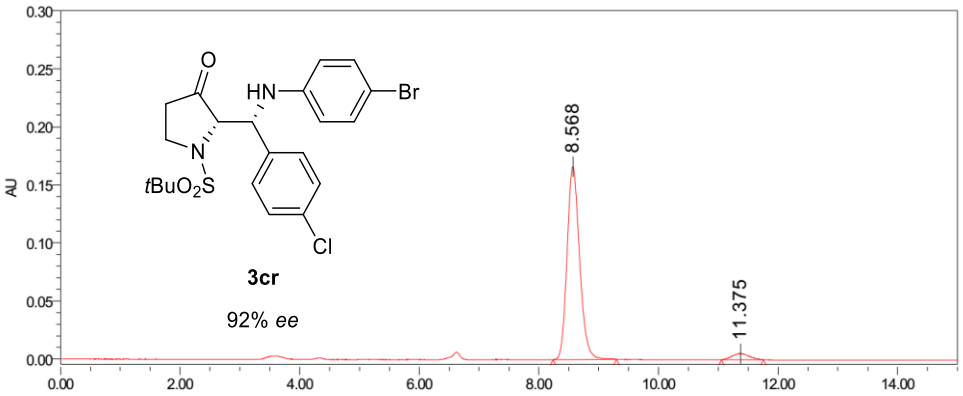
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.571	210092	2948328	96.50
2	11.176	6083	106893	3.50

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



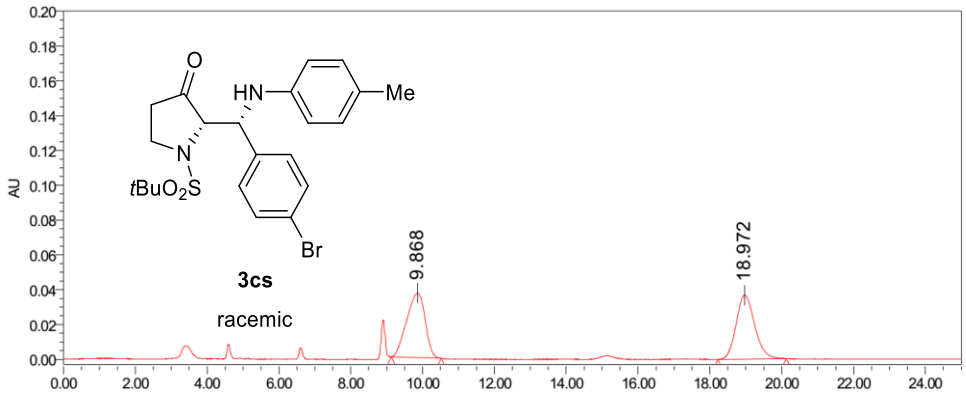
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.435	110590	1538935	50.00
2	11.174	72145	1539032	50.00



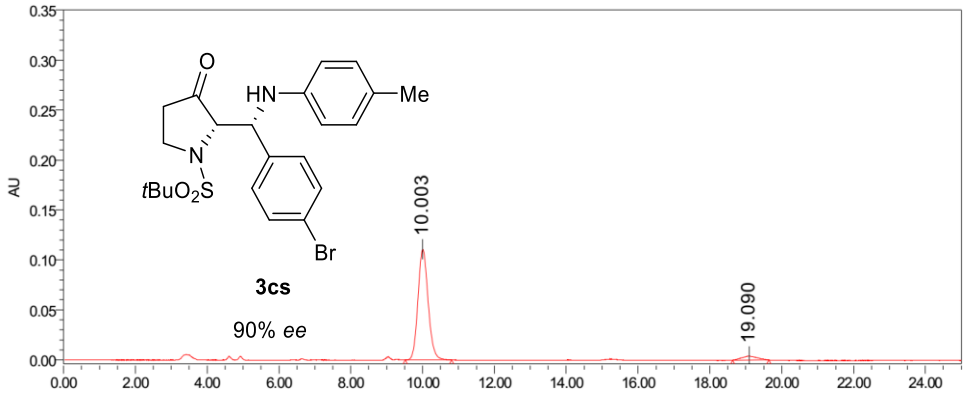
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.568	166017	2421221	96.02
2	11.375	5136	100397	3.98

Condition：Chrial IC, λ = 230 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



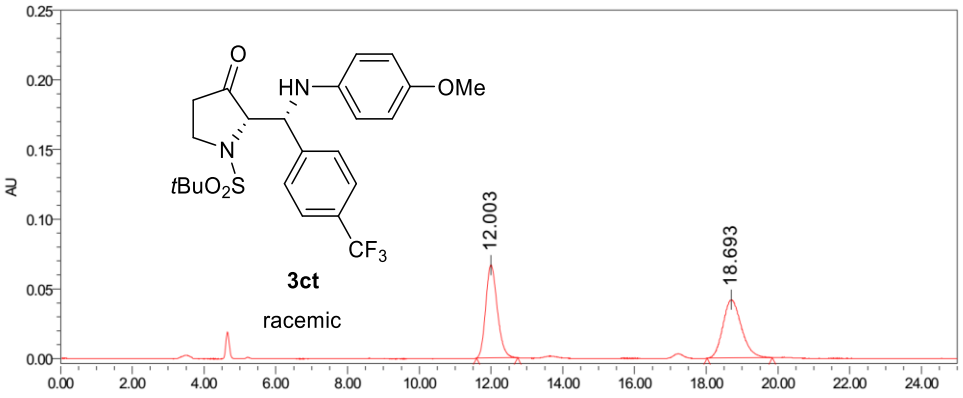
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.868	37022	1323124	50.05
2	18.972	36810	1320359	49.95



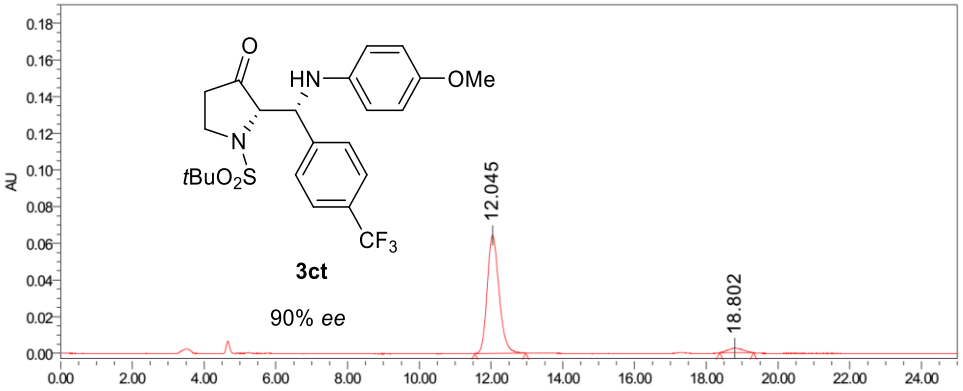
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.003	110829	2189041	95.13
2	19.09	3635	112148	4.87

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



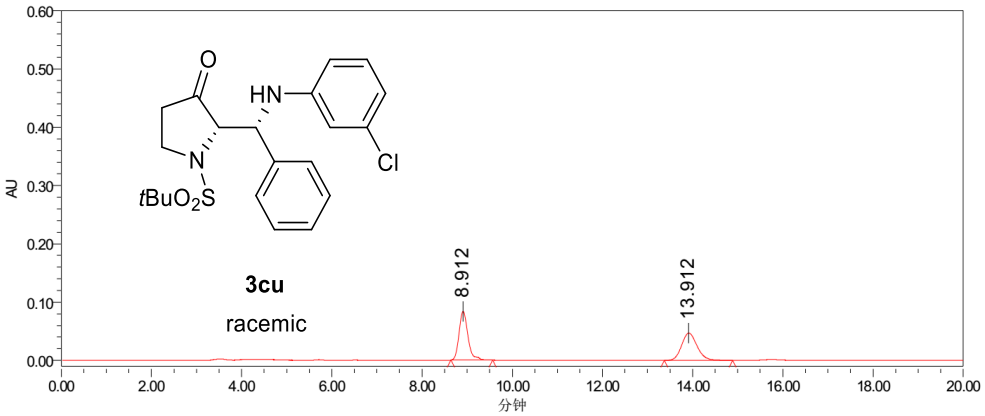
Entry	RT min	Height mV	Area mV.sec	% Area %
1	12.003	66643	1496839	50.00
2	18.693	41808	1497015	50.00



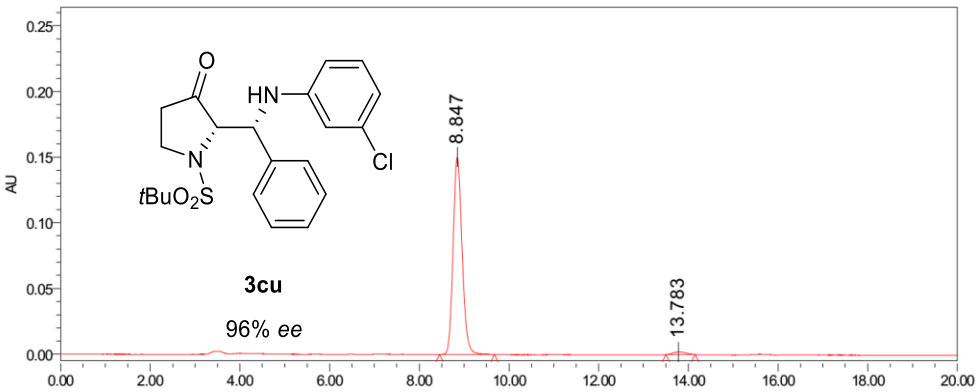
Entry	RT min	Height mV	Area mV.sec	% Area %
1	12.045	64358	1473230	95.08
2	18.802	2529	76201	4.98

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 90:10

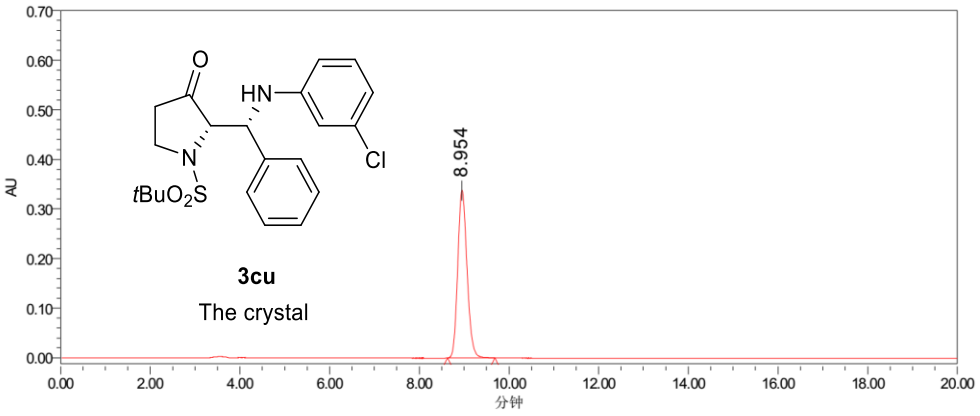
flow rate = 1.0 mL/min



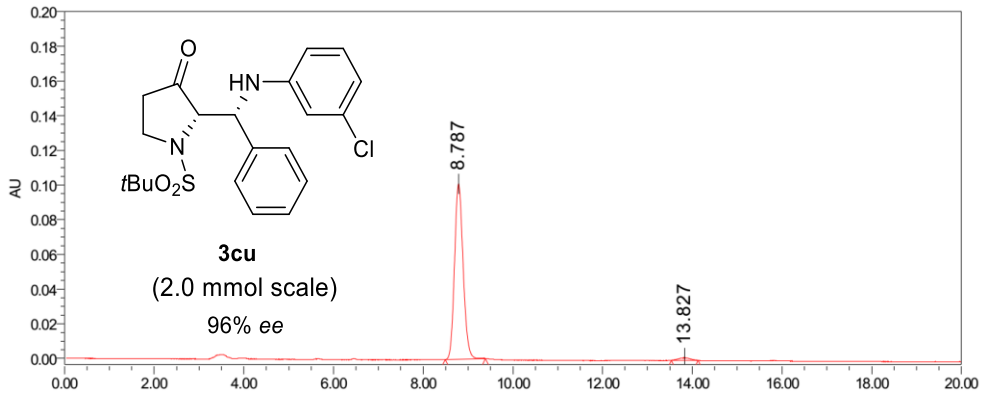
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.912	83697	1148118	50.89
2	13.912	46759	1107775	49.11



Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.847	150279	2098976	98.05
2	13.783	2087	41750	1.95



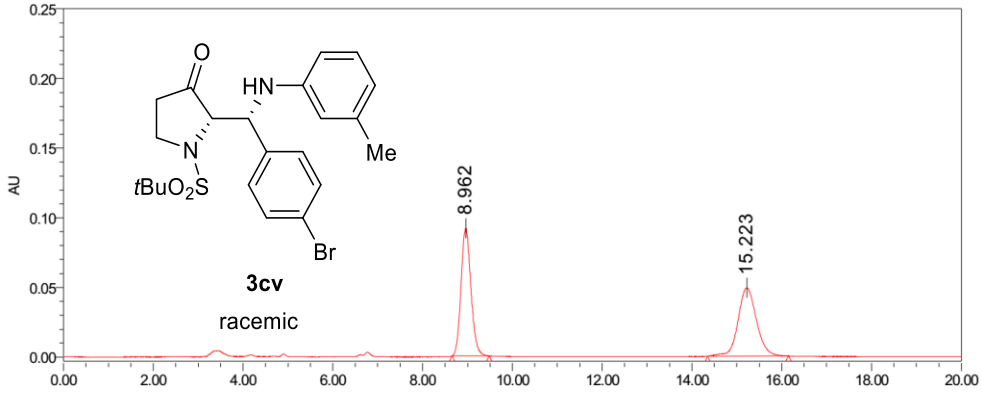
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.954	337866	4876742	100.00



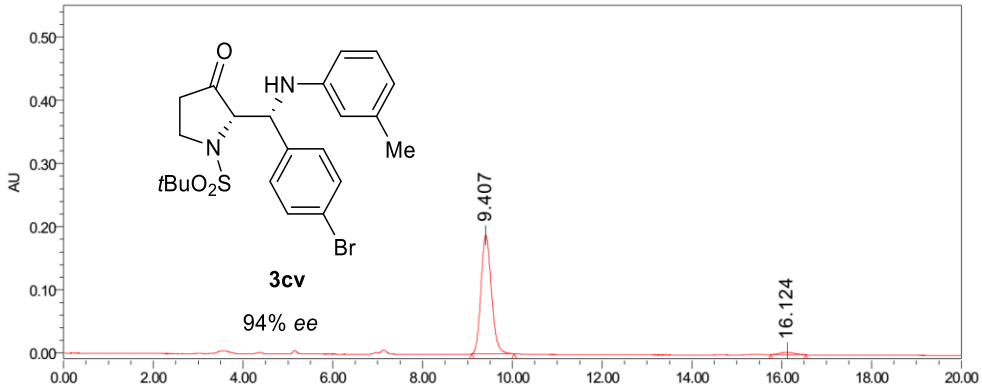
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.787	101140	1347772	97.96
2	13.827	1443	28014	2.04

Condition：Chrial IC, λ = 230 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



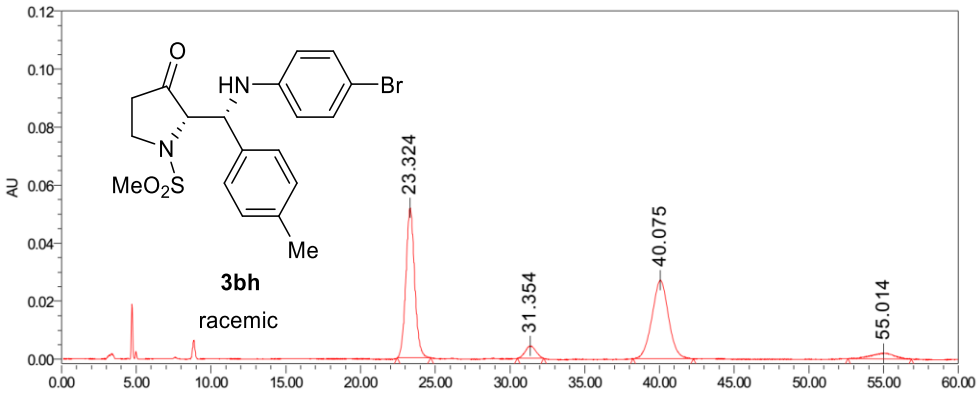
Entry	RT min	Height mV	Area mV.sec	% Area %
1	8.962	91617	1393294	50.03
2	15.223	49019	1391697	49.97



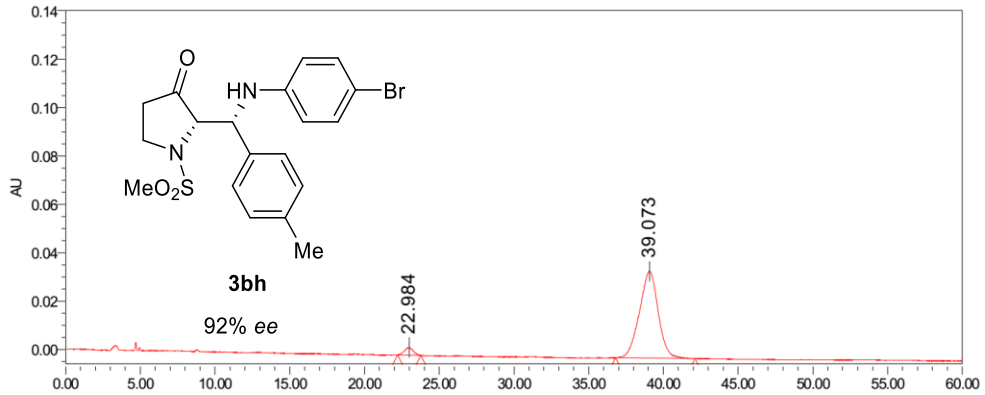
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.407	187847	3014210	97.17
2	16.124	3615	87715	2.83

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



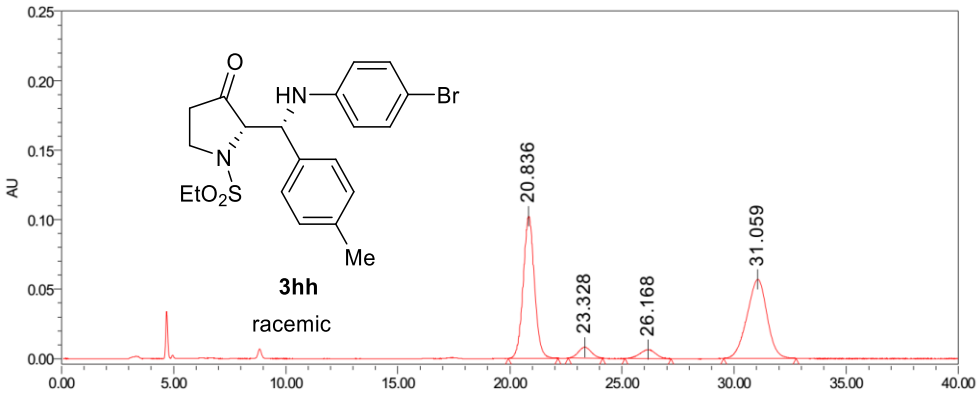
Entry	RT min	Height mV	Area mV.sec	% Area %
1	23.324	51743	2080316	45.51
2	31.354	4257	206893	4.53
3	40.075	27006	2080574	45.52
4	55.014	1920	203146	4.44



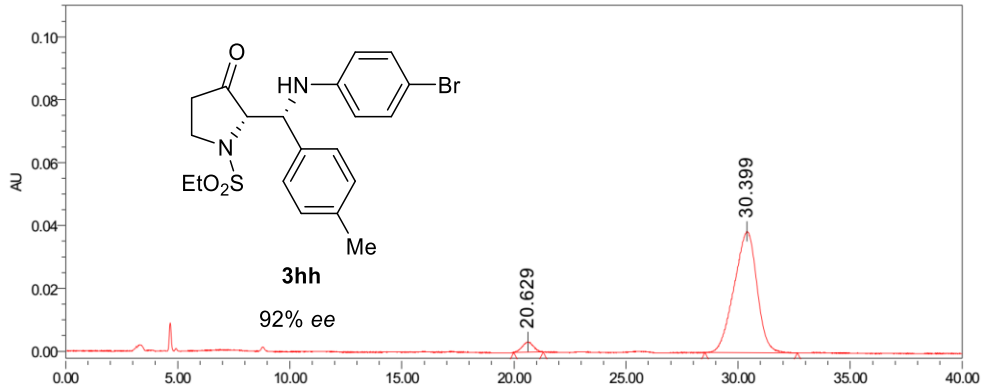
Entry	RT min	Height mV	Area mV.sec	% Area %
1	22.984	3096	125431	3.85
2	39.073	35922	3133917	96.15

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



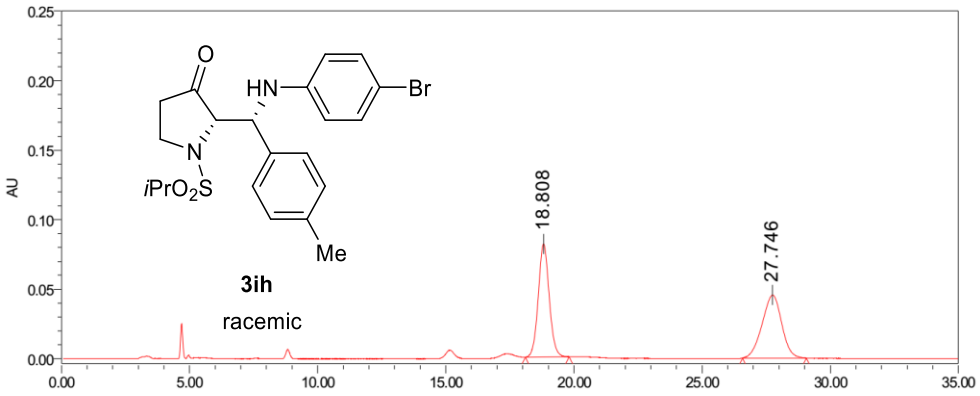
Entry	RT min	Height mV	Area mV.sec	% Area %
1	20.836	102208	3525184	45.90
2	23.328	7859	317120	4.13
3	26.168	6480	314756	4.10
4	31.059	56769	3523172	45.87



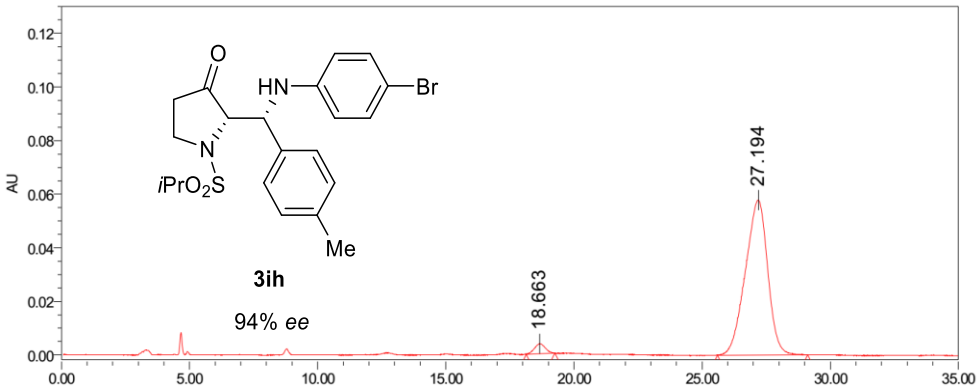
Entry	RT min	Height mV	Area mV.sec	% Area %
1	20.629	3209	109139	3.86
2	30.399	38459	2717833	96.14

Condition：Chrial IA, λ = 254 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min



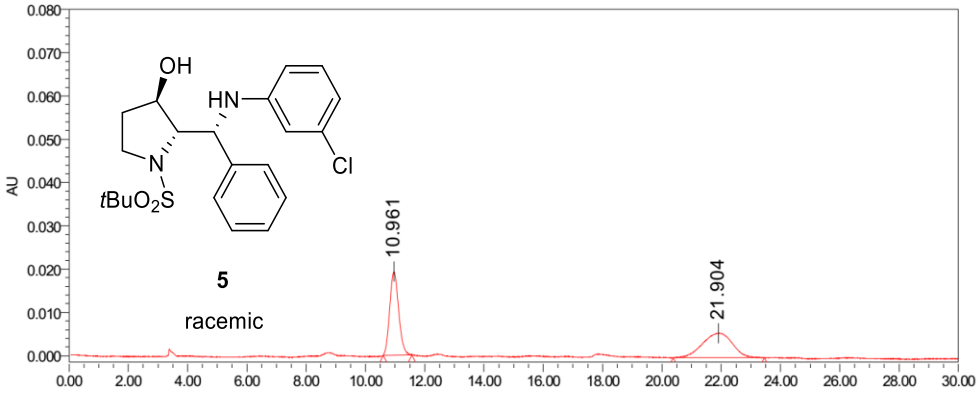
Entry	RT min	Height mV	Area mV.sec	% Area %
1	18.808	81279	2411977	50.05
2	27.746	45303	2406701	49.95



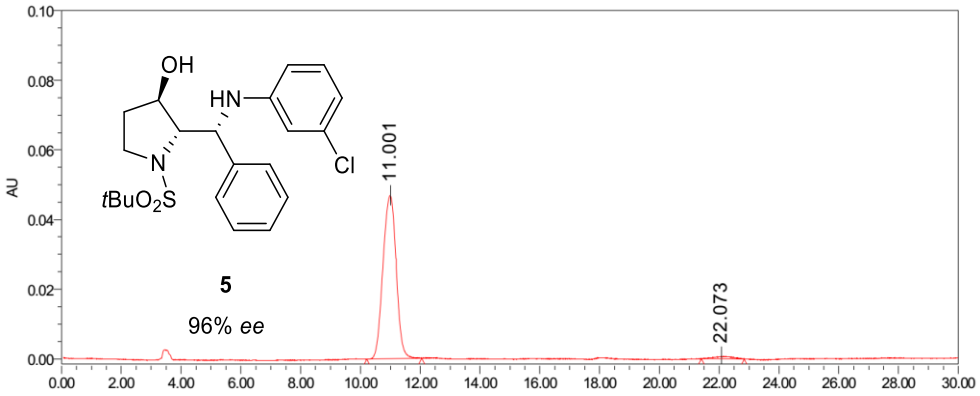
Entry	RT min	Height mV	Area mV.sec	% Area %
1	18.663	3686	108753	3.00
2	27.194	57863	3517867	97.00

Condition：Chrial IC, λ = 254 nm, hexane/isopropanol = 95:5

flow rate = 1.0 mL/min



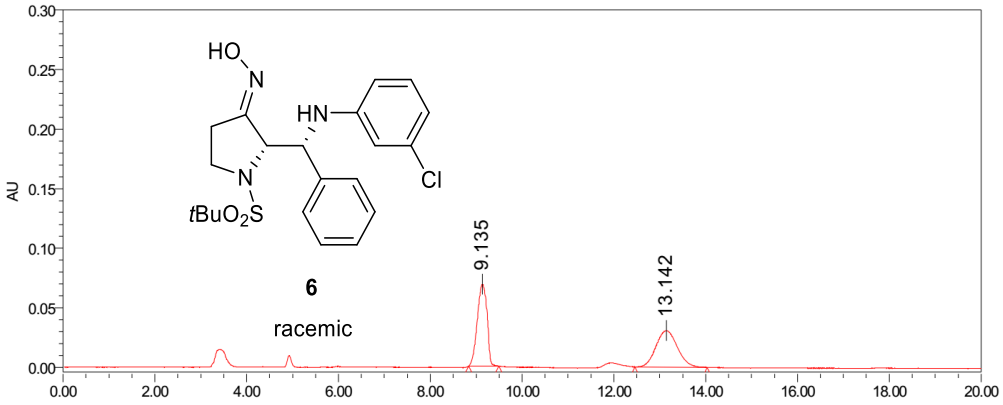
Entry	RT min	Height mV	Area mV.sec	% Area %
1	10.961	19259	401336	50.28
2	21.904	5676	396828	49.72



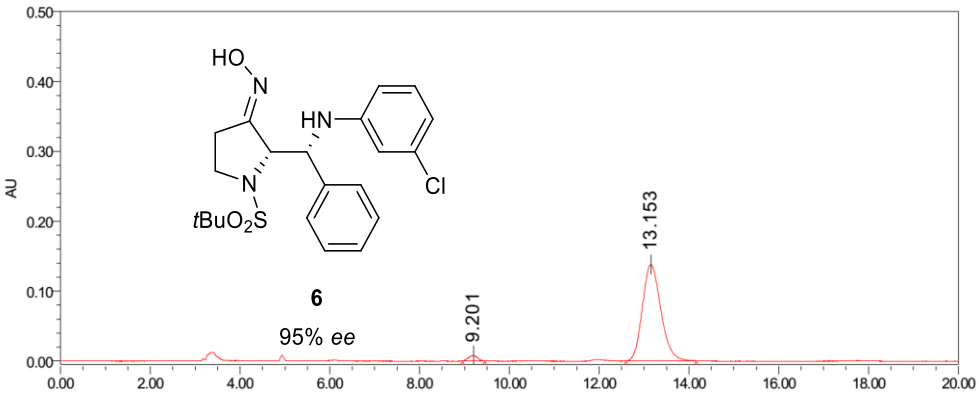
Entry	RT min	Height mV	Area mV.sec	% Area %
1	11.001	46914	1447389	97.87
2	22.073	657	31484	2.13

Condition：Chrial IC, λ = 215 nm, hexane/isopropanol = 90:10

flow rate = 1.0 mL/min

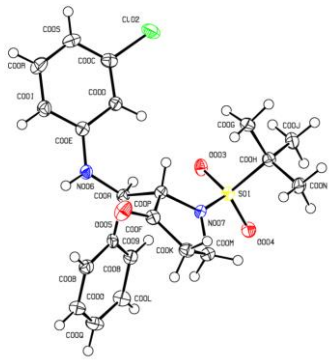


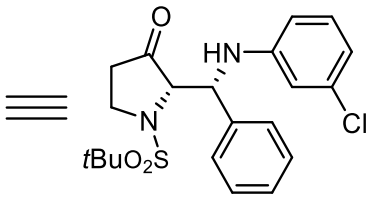
Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.135	68777	1005017	50.50
2	13.142	30603	985082	49.50



Entry	RT min	Height mV	Area mV.sec	% Area %
1	9.201	7401	100374	2.50
2	13.153	138019	3912578	97.50

Crystallographic Data for Compound 3cu





3cu
CCDC 2076641

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

Cell:            a=7.1972(2)     b=13.8507(2)         c=11.1349(2)
                 alpha=90        beta=108.671(2)      gamma=90
Temperature:     100 K

                 Calculated                Reported
Volume           1051.58(4)                1051.58(4)
Space group      P 21                      P 1 21 1
Hall group       P 2yb                     P 2yb
Moiety formula   C21 H25 Cl N2 O3 S        C21 H25 Cl N2 O3 S
Sum formula      C21 H25 Cl N2 O3 S        C21 H25 Cl N2 O3 S
Mr               420.94                    420.94
Dx,g cm-3        1.329                     1.329
Z                2                         2
Mu (mm-1)        2.733                     2.733
F000             444.0                     444.0
F000'            446.52
h,k,lmax         9,17,14                   8,17,13
Nref             4441[ 2317]               3557
Tmin,Tmax        0.799,0.872               0.601,1.000
Tmin'            0.725

Correction method= # Reported T Limits: Tmin=0.601 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.54/0.80      Theta(max)= 77.172

R(reflections)= 0.0318( 3323)     wR2(reflections)= 0.0786( 3557)

S = 1.068                 Npar= 256
```

References:

1 X. Wang, X. Xu, P. Y. Zavalij and M. P. Doyle, *J. Am. Chem. Soc.*, 2011, **133**, 16402.

2 H. Li, S. Ye, Y. Chen, W. Luo, P. Qian and L. Ye, *Chin. J. Chem*., 2020, **38**, 263.

3 C. Shu, L. Li, Y. Yu, S. Jiang and L. Ye, *Chem. Commun.*, 2014, **50**, 2522.