Prochiral Alkyl-aminomethyl Ketones as Convenient Precursors for Efficient Synthesis of Chiral (2,3,5)- Tri-substitued Pyrrolidines *via* an Organo-Catalysed Tandem Reaction†

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Supporting information

Contents:

General.

The ^{1}H and ^{13}C NMR spectra were all recorded using a Bruker AV400 spectrometer (Ettlingen, Germany) operating at 400 MHz for ^{1}H and 100 MHz for ^{13}C. The chemical shifts (δ) for ^{1}H and ^{13}C are given in ppm relative to residual signals of the solvents ($CDCl_3$). Coupling constants are given in Hz. Carbon types were determined from DEPT ^{13}C NMR experiments. The following abbreviations are used to indicate the multiplicity: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; bs, broad signal. Purification of the reaction products was carried out by flash chromatography

(FC) on silica gel (200-300 mesh). High Resolution Mass spectra were obtained from the Dalian University of Technology. X-ray data were acquired on a Bruker APEX-2 diffractometer. All reactions were carried out in air and using distilled solvents, without any precautions to exclude moisture unless otherwise noted.

Materials.

Commercial grade reagents and solvents were used without further purification; otherwise, where necessary, they were purified as recommended.[1] Chiral and racemic amine catalysts 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine were prepared following the literature procedure.[2] Unsaturated aldehydes **1a-j** and were synthesized following the literature procedures.[3-6] Aminoketone **2a-g** were prepared following the literature procedure.[7-9]

Determination of Diastereomeric Ratios.

The diastereomeric ratio was determined by ^{1}H NMR analysis of the crude reaction mixture.

Determination of Enantiomeric Purity.

Chiral HPLC analysis was performed on an Agilent 1100-series instrument. Phenomenex Lux - Amylose 2 and Phenomenex Lux Cellulose 2 columns Daicel Chiralpak AD-H and Daicel Chiralcel OD-H with hexane/i-PrOH as the eluent were used. HPLC traces for compounds **3** and corresponding enantiomers, were compared to *quasi* racemic samples.

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1. W. L. F. Armarengo, D. D. Perrin, In *Purification of Laboratory Chemicals*, 4th ed.; Butterworth Heinemann: Oxford, 1996.
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Crystal Data for compound

Table S1. Crystallographic data for **3aa**

	3aa
Formula	$C_{19}H_{20}NO_4S$
Formula weight	358.42
Crystal dimensions (mm^3)	0.31 × 0.27× 0.23
Crystal system	Orthorhombic
Space group	P2(1)2(1)2(1)
a (Å)	7.3097(11)
b (Å)	10.0954(15)
c (Å)	24.274(4)
α (º)	90.00
β (º)	90.00
γ (º)	90.00
Volume ($Å^3$)	1791.2(5)
Z	4
T (K)	298(2)
D_{calcd} (g cm^{-3})	1.329
μ (mm^{-1})	0.204
F (000)	756
No. of rflns. collected	8108
No. of indep. rflns. /R_{int}	3156 / 0.0187
No. of obsd. rflns. [$I_0 > 2\sigma(I_0)$]	2972
Data / restraints / parameters	3156 / 0 / 226
R_1 / wR_2 [$I_0 > 2\sigma(I_0)$][a]	0.0323 / 0.0890
R_1 / wR_2 (all data)[a]	0.0353 / 0.0890
GOF (on F^2)[a]	1.041
Largest diff. peak and hole (e $Å^{-3}$)	0.228/ −0.245

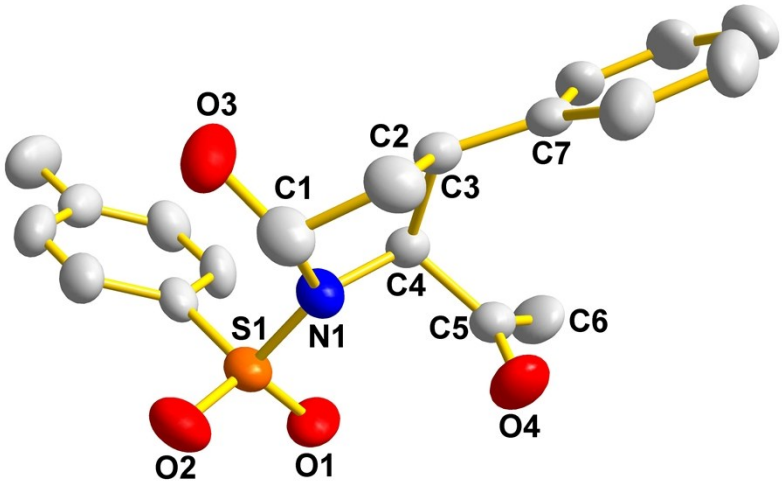


Table S2. Selected bond distances (Å) and bond angles (°) for **3aa**

Distances (Å)			
N1–C1	1.458(3)	O4–C5	1.203(2)
N1–C4	1.475(2)	C1–C2	1.507(3)
N1–S1	1.6186(16)	C2–C3	1.536(3)
S1–O1	1.4307(16)	C3–C7	1.508(3)
S1–O2	1.4378(15)	C3–C4	1.568(3)
S1–C13	1.753(2)	C4–C5	1.530(3)
O3–C1	1.422(3)	C5–C6	1.483(3)
Angles (°)			
O1–S1–O2	119.87(11)	N1–C1–C2	100.82(17)
O1–S1–N1	107.03(9)	C1–C2–C3	102.80(16)
O2–S1–N1	105.24(9)	C7–C3–C2	117.07(16)
O1–S1–C13	108.66(10)	C7–C3–C4	116.60(16)
O2–S1–C13	106.81(9)	C2–C3–C4	102.49(15)
N1–S1–C13	108.82(9)	N1–C4–C5	110.99(15)
C1–N1–C4	113.19(15)	N1–C4–C3	101.78(14)
C1–N1–S1	122.78(14)	C5–C4–C3	112.53(15)
C4–N1–S1	121.33(12)	O4–C5–C6	122.63(19)
O3–C1–N1	109.02(18)	O4–C5–C4	120.25(18)
O3–C1–C2	112.78(19)	C6–C5–C4	117.11(16)

Table S3. Crystallographic data for **3aa'**

	3j₂
Formula	$C_{19}H_{22.5}NO_{4.5}S$
Formula weight	368.94
Crystal dimensions (mm^3)	0.29 × 0.14 × 0.15
Crystal system	Orthorhombic
Space group	P2(1)2(1)2(1)
a (Å)	10.156(3)
b (Å)	17.874(5)
c (Å)	20.771(6)
α (º)	90.00
β (º)	90.00
γ (º)	90.00
Volume ($Å^3$)	3770.6(18)
Z	8
T (K)	298(2)
D_{calcd} (g cm^{-3})	1.300
μ (mm^{-1})	0.197
F (000)	1564
No. of rflns. collected	21290
No. of indep. rflns. /R_{int}	6643 / 0.0705
No. of obsd. rflns. [$I_0 > 2\sigma(I_0)$]	4203
Data / restraints / parameters	6643 / 0 / 451
R_1 / wR_2 [$I_0 > 2\sigma(I_0)$][a]	0.0585 / 0.1402
R_1 / wR_2 (all data)[a]	0.1043 / 0.1594
GOF (on F^2)[a]	1.006
Largest diff. peak and hole (e $Å^{-3}$)	0.194/ −0.384

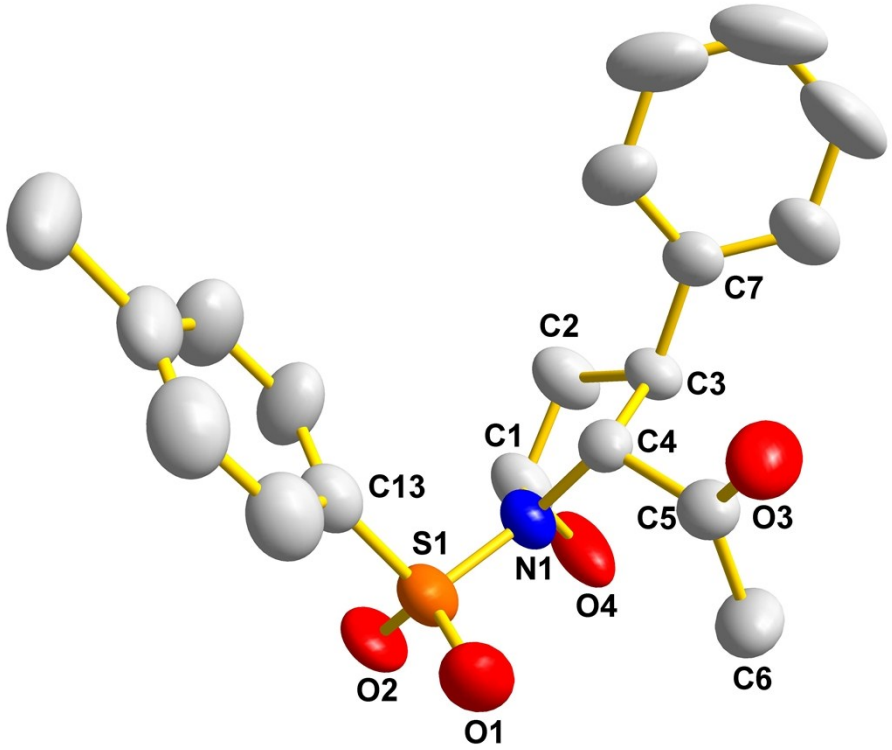


Table S4. Selected bond distances (Å) and bond angles (°) for **3aa'**

Distances (Å)			
S1–O1	1.427(3)	O4–C1	1.412(4)
S1–O2	1.428(3)	N1–C1	1.476(5)
S1–N1	1.612(2)	N1–C4	1.481(4)
S1–C13	1.744(5)	C3–C7	1.515(6)
O3–C5	1.207(5)		
Angles (°)			
O1–S1–O2	119.4(2)	N1–C1–C2	102.37(18)
O1–S1–N1	107.75(17)	C1–C2–C3	105.2(4)
O2–S1–N1	105.76(16)	C7–C3–C2	115.9(4)
O1–S1–C13	106.9(2)	C7–C3–C4	114.0(3)
O2–S1–C13	109.6(2)	C2–C3–C4	103.0(3)
N1–S1–C13	106.82(19)	N1–C4–C5	115.2(3)
C1–N1–C4	112.74(17)	N1–C4–C3	102.8(3)
C1–N1–S1	121.69(8)	C5–C4–C3	108.8(3)
C4–N1–S1	121.4(2)	O3–C5–C6	121.7(4)
O4–C1–N1	110.37(17)	O3–C5–C4	118.5(4)
O4–C1–C2	110.6(3)	C6–C5–C4	119.7(4)

General Procedure

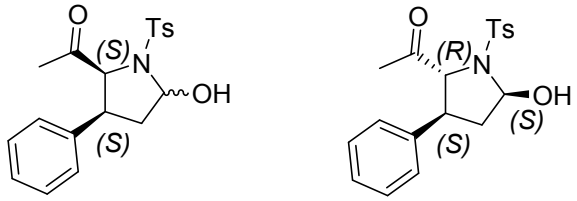
The preparation racemic products

(R,S)-2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.02 mmol, 13 mg, 10 mol%) was dissolved in 1 mL of CH_2Cl_2 and benzoic acid (0.04 mmol, 5 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then α,β-unsaturated aldehyde (0.2 mmol) and aminoketone (0.25mmol) were added. The vial was stirring continued at room temperature for 48 hours. The crude mixture was flushed through a short plug of silica.

General Procedure for chiral pyrrolidines synthesis

(R)-2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08 mmol, 26 mg, 20 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-Bromobenzene carboxylic acid (0.08 mmol, 16 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then α,β-unsaturated aldehyde (0.4 mmol) and aminoketone (0.5 mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo* and the diastereomeric ratio (dr) was determined by ^{1}H NMR analysis of the crude mixture. The desired compound was isolated by flash column chromatography.

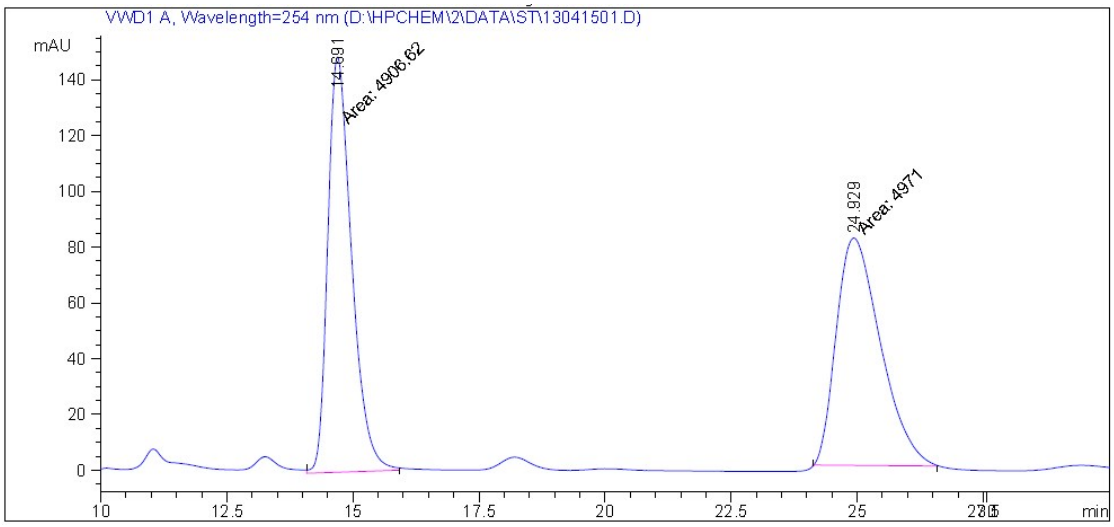
1-((2S,3S)-5-hydroxy-3-phenyl-1-tosylpyrrolidin-2-yl)ethanone (3aa) and 1-((2S,3R,5S) -5-hydroxy -3-phenyl -1-tosyl pyrrolidin -2-yl) ethanone (3aa')



3aa **3aa'**

Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol., 13 mg, 10 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar. The resulting solution was stirred at room temperature for 20 minutes, then cinnamaldehyde (0.4mmol) and 4-methyl-N-(2-oxopropyl)benzene-sulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo.* After flash column chromatography (hexane/ethyl acetate =4/1) 2,3-*cis* isomer **3aa**, (71.9 mg, 49 % yield, Mp. 135-136 ^{o}C, dr=5:4 and 99% ee (Fc-ester)) and 2,3-*trans* isomer **3aa'** (56.0 mg, 40% yield, Mp. 141-142 ^{o}C, 99% ee) were obtained as amorphous solids. The dr and ee of **3aa** were determined by ^{1}H NMR and HPLC analysis respectively. (Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 24.9 min; τ_{minor} = 14.7 min). ^{1}H NMR

(400 MHz, $CDCl_3$): 7.73-7.77 (t, J = 8.4 Hz, 2H), 7.28-7.32 (m, 5H), 7.14-7.16 (d, J = 7.4 Hz, 2H), 5.68-5.69, 5.74-5.76 (d, 1H), 4.68-4.70, 4.86-4.88 (d, 1H), 4.17-4.21, 3.51-3.58 (m, 1H), 3.90-3.92, 3.66 (m, 1H), 2.53,2.64 (m, 1H), 2.43 (d, 3H), 2.05-2.09 (m, 1H), 1.59-1.66 (s, 1H), 1.43 (s, 2H). ^{13}C NMR (400 MHz, $CDCl_3$): 208.3, 205.9, 144.0, 136.7, 136.6, 134.8, 134.7, 129.8, 129.6, 129.0, 128.9, 128.2, 128.1, 128.0, 127.9, 127.5, 127.4, 84.7, 83.1, 69.9, 69.5, 58.5, 47.2, 45.2, 38.0, 36.5, 29.8, 29.7, 21.6, 18.4. HRMS: ESI ORBITRAP (+) m/z: calculated for $C_{19}H_{21}NO_4S$ 359.1191, found $[M+Na]^+$ 382.1079.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
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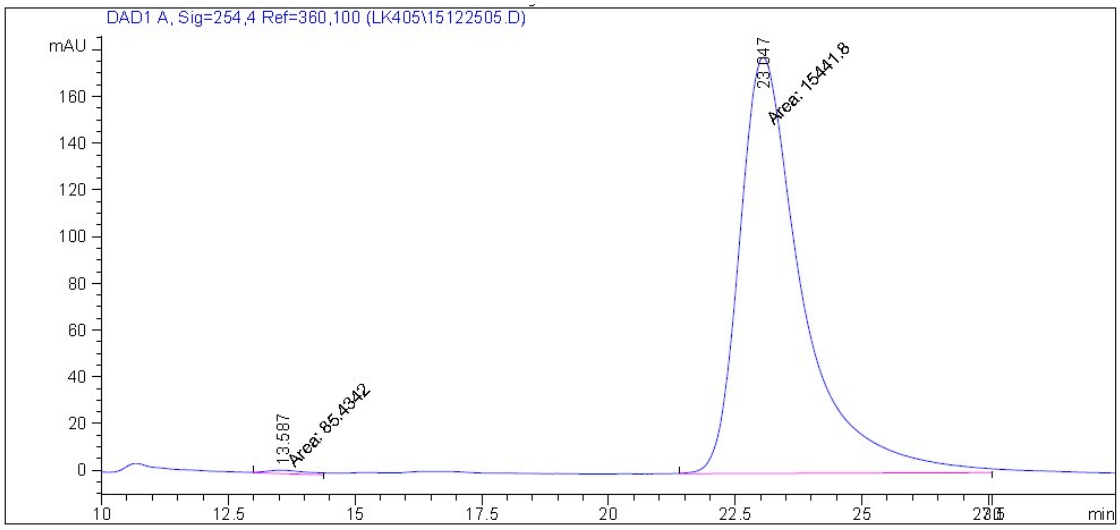
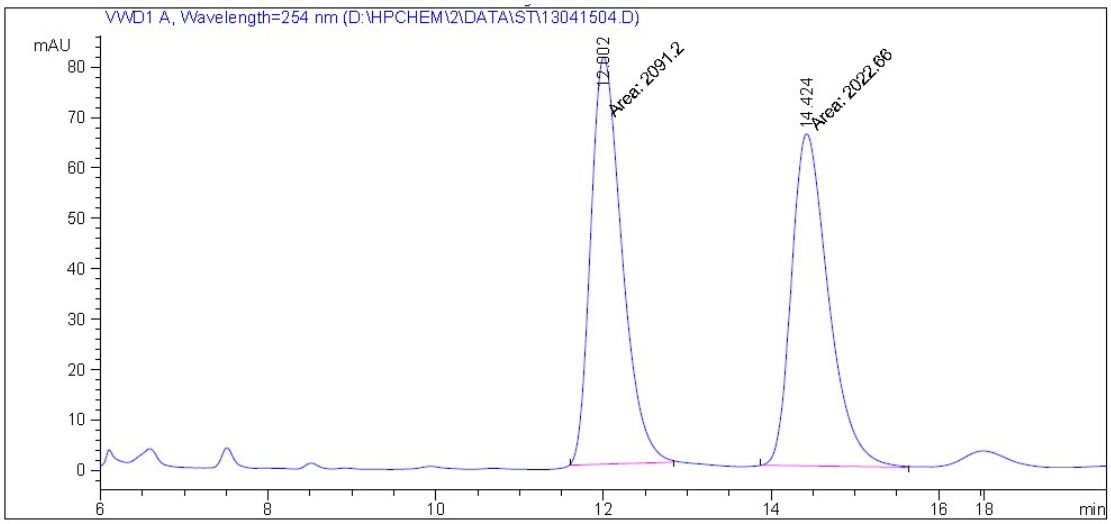
2	24.929	MM T	1.0163	4971.00098	81.52493	50.3259

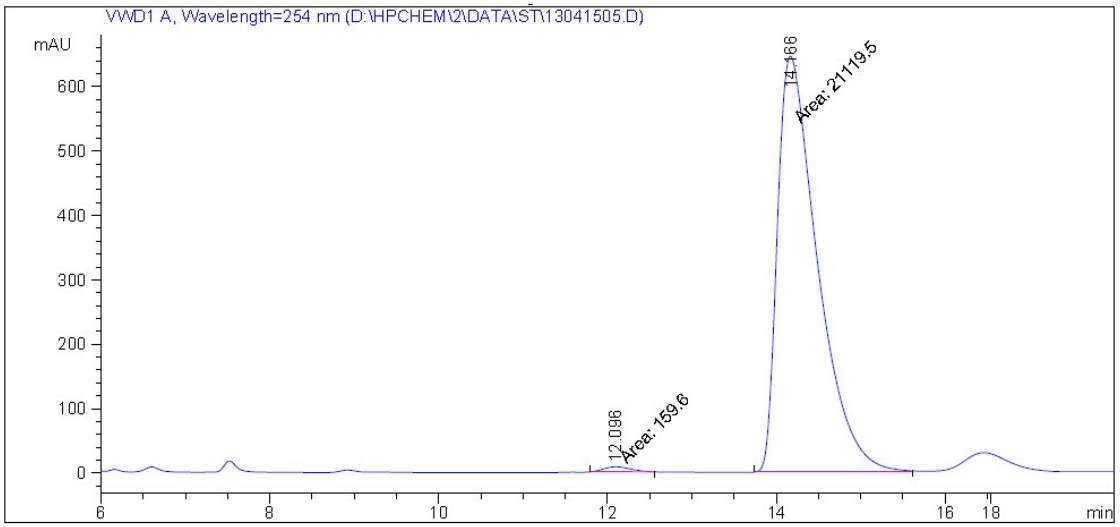


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.587	MM T	0.9380	85.43424	1.51808	0.5502
2	23.047	MM T	1.4458	1.54418e4	178.00536	99.4498

The ee of **3aa'** was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{minor} = 12.0 min τ_{major} = 14.4 min. ^{1}H NMR (400 MHz, $CDCl_3$) : 7.73 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 7.23 (td, *J* = 5.5, 2.7 Hz, 2H), 6.97 (dd, *J* = 7.4, 2.0 Hz, 2H), 5.61 (d, *J* = 5.4 Hz, 1H), 3.98 (d, *J* = 8.9 Hz, 1H), 3.66 (ddd, *J* = 11.3, 8.8, 6.7 Hz, 1H), 3.35 (s, 1H), 2.47 (s, 3H), 2.37 (s, 3H), 2.25 (dd, *J* = 13.2, 6.7 Hz, 1H), 1.83 (ddd, *J* = 13.1, 11.4, 5.6 Hz, 1H). ^{13}C NMR (400 MHz, $CDCl_3$): 206.9, 144.5, 138.0, 134.8, 130.1, 128.9, 127.7, 127.3, 127.2, 84.8, 77.4, 77.1, 76.7, 74.4, 46.6, 41.4, 25.5, 21.6. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{19}H_{21}NO_4S$ 359.1191, found $[M+Na]^+$ 382.1079.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.002	MM T	0.4311	2091.19702	80.84360	50.8329
2	14.424	MM T	0.5116	2022.66431	65.88905	49.1671



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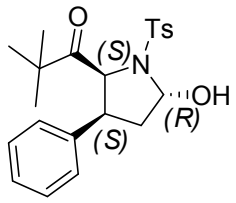
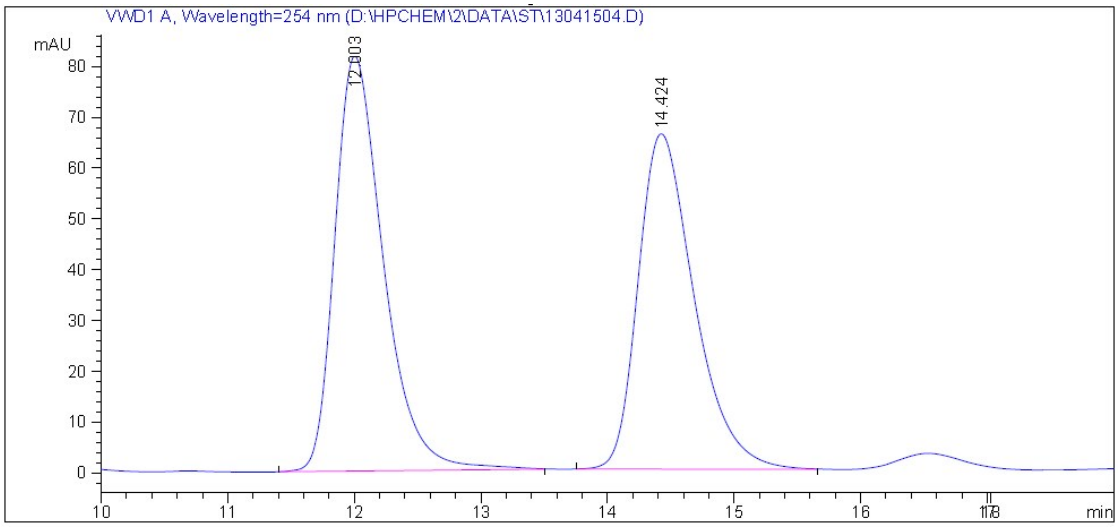
2	14.166	MM T	0.5459	2.11195e4	644.74634	99.2500

1-((2S,3S,5R)-5-hydroxy-3-phenyl-1-tosylpyrrolidin-2-yl)-2,2-dimethylpropan-1-one (3af)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then cinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-but yl)-4-methyl-benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3af** was obtained as amorphous solid (120.3mg, 75% yield, dr=8:1 and 98% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 70:30, flow rate 0.60 mL/min, λ = 254.0 nm: τ_{major} = 14.2 min, τ_{minor} = 12.0 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{22}H_{27}NO_4S$ 401.1661, found 424.1562 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.76 (d, *J* = 8.3 Hz, 2H), 7.32 – 7.27 (m, 4H), 7.08 (dd, *J* = 7.7, 1.5 Hz, 2H), 5.84 (s, 1H), 5.08 (d, *J* = 4.5 Hz, 1H), 4.23 (s, 1H), 3.30 (td, *J* = 7.7, 4.5 Hz, 1H), 2.44 (s, 3H), 2.35 (ddd, *J* = 13.6, 8.1, 2.1 Hz, 1H), 2.27 – 2.18 (m, 1H), 1.02 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 216.3, 143.8, 141.6, 137.1, 129.6, 129.1, 127.6, 127.4, 126.9, 85.2, 68.2, 49.3, 45.6, 43.6, 26.5, 21.6. Mp (°C): 178-179.



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1	12.003	BB	0.4099	2187.18628	81.70230	51.8396
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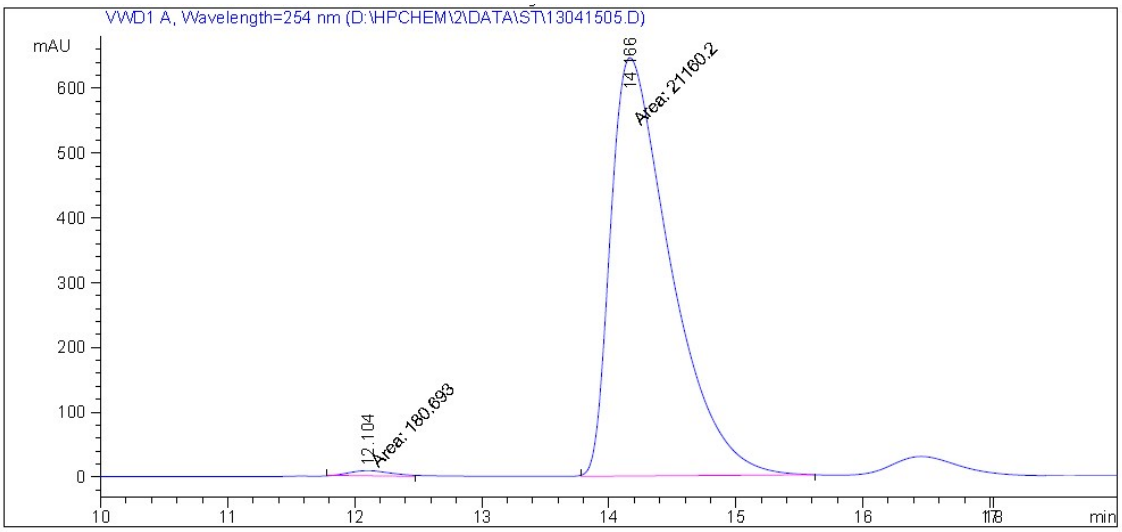
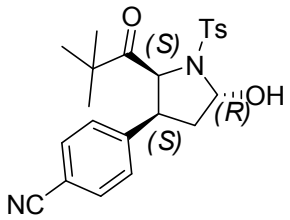
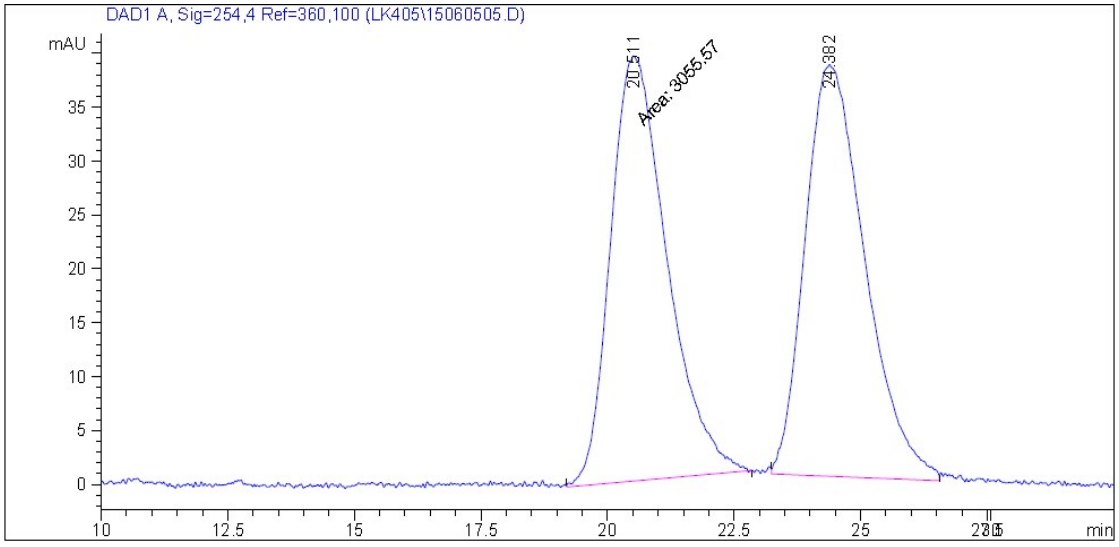


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.104	MM T	0.3750	180.69328	8.03170	0.8467
2	14.166	MM T	0.5461	2.11602e4	645.84796	99.1533

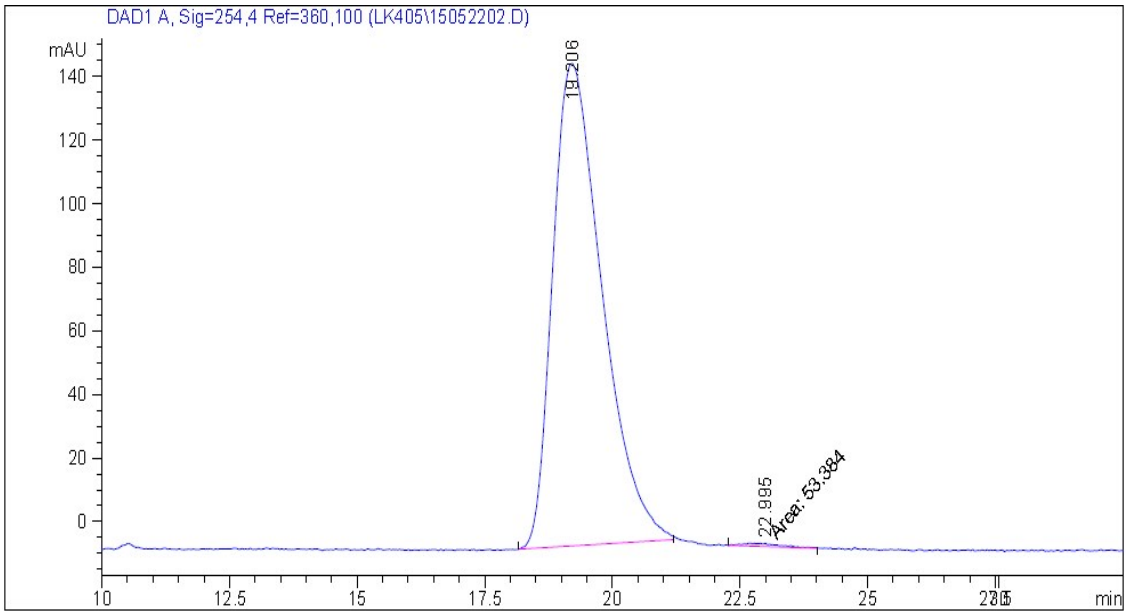
4-((2S,3S,5R)-5-hydroxy-2-pivaloyl-1-tosylpyrrolidin-3-yl)benzonitrile (3bf)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol, 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 4-cyanocinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3bf** was obtained an amorphous solid (135.2 mg, 79 % yield, dr = 15:1 and 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$): 7.74 (d, *J = 8.4* Hz, 2H), 7.61 (d, *J = 8.4* Hz, 2H), 7.30 (d, *J = 8.0* Hz, 2H), 7.24 (d, *J = 8.4* Hz, 2H), 5.87-5.91 (m, 1H), 5.07 (d, *J = 4.0* Hz, 1H), 4.28 (d, *J = 9.6* Hz, 1H), 3.32-3.37 (m, 1H), 2.45 (s, 3H), 2.38-2.42 (m, 1H), 2.23-2.30 (m, 1H), 1.03 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 215.3, 147.2, 144.1, 136.8, 133.0, 129.6, 127.7, 127.4, 118.3, 111.6, 85.1, 67.6, 48.9, 45.0, 43.7, 26.4, 21.6. Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 20.5 min, τ_{mminor} = 24.4 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{23}H_{26}N_2O_4S$ 426.1613, found $[M+Na]^+$ 449.1507. Mp. 147-148 ^{o}C.

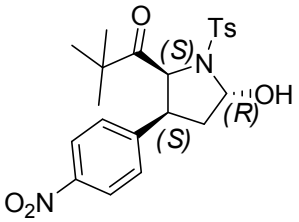


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.511	MM T	1.2914	3055.57275	39.43618	49.2649
2	24.382	VV	0.9730	3146.75830	38.20330	50.7351

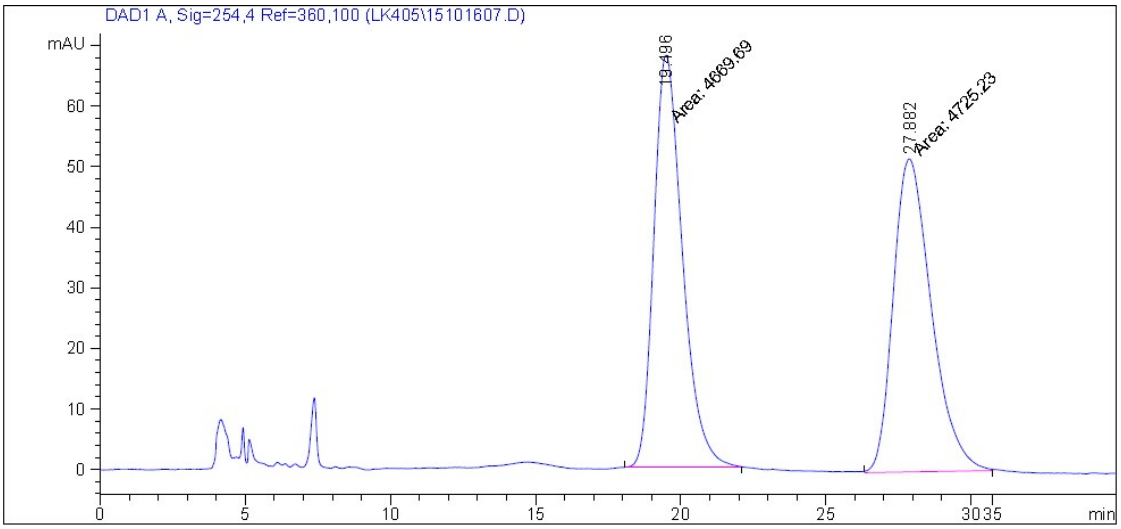


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.206	PB	0.8236	1.02075e4	151.58604	99.4797
2	22.995	MM T	0.8331	53.38404	1.06794	0.5203

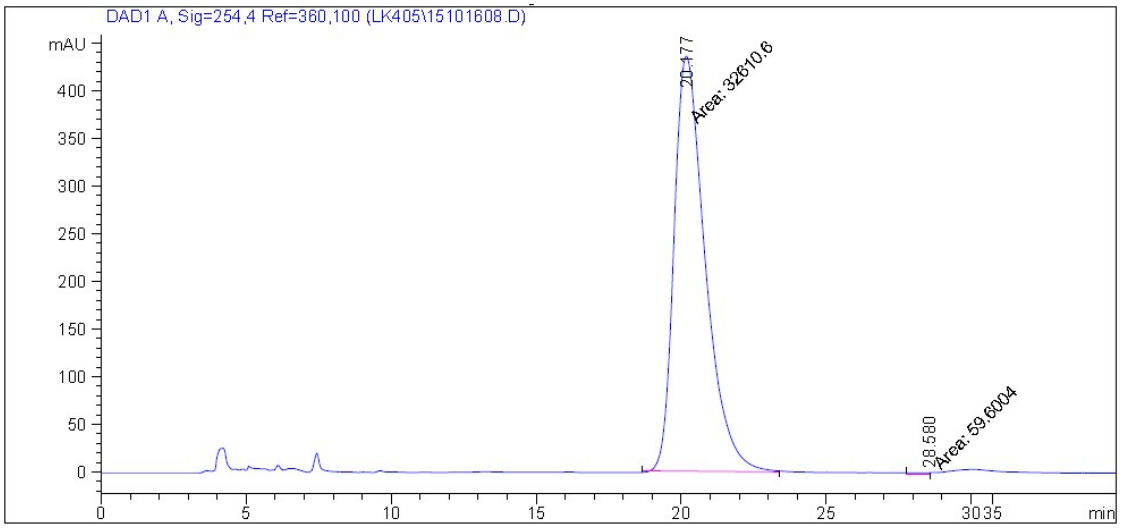
1-((2S,3S,5R)-5-hydroxy-3-(4-nitrophenyl)-1-tosylpyrrolidin-2-yl)-2,2-dimethylpropan-1-one (3cf)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol, 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 4-nitrocinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide(0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3cf** was obtained as amorphous solid (144.0 mg, 81% yield, dr=15:1 and >99% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 19.5 min, τ_{minor} = 27.9 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{23}H_{28}N_2O_6S$ 446.1512, found 469.1403 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.74 (d, *J = 8.0* Hz, 2H), 7.41 (d, *J = 8.4* Hz, 2H), 7.29 (d, *J = 8.0* Hz, 2H), 6.95 (d, *J = 8.8* Hz, 2H), 5.83-5.85 (m, 1H), 5.02 (d, *J = 4.4* Hz, 1H), 4.23 (s, 1H), 3.24-3.29 (m, 1H), 2.44 (s, 3H), 2.31-2.37 (m, 1H), 2.17-2.31 (m, 1H), 1.04 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 215.9, 143.9, 140.8, 137.0, 132.3, 129.6, 128.5, 127.4, 85.1, 68.0, 48.7, 45.3, 43.7, 26.5, 21.6. Mp (°C): 166-167.

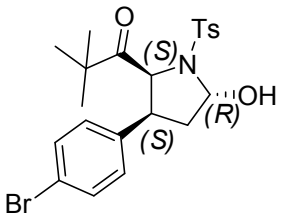


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.496	MM T	1.1443	4669.69434	68.01344	49.7044
2	27.882	MM T	1.5246	4725.23486	51.65618	50.2956



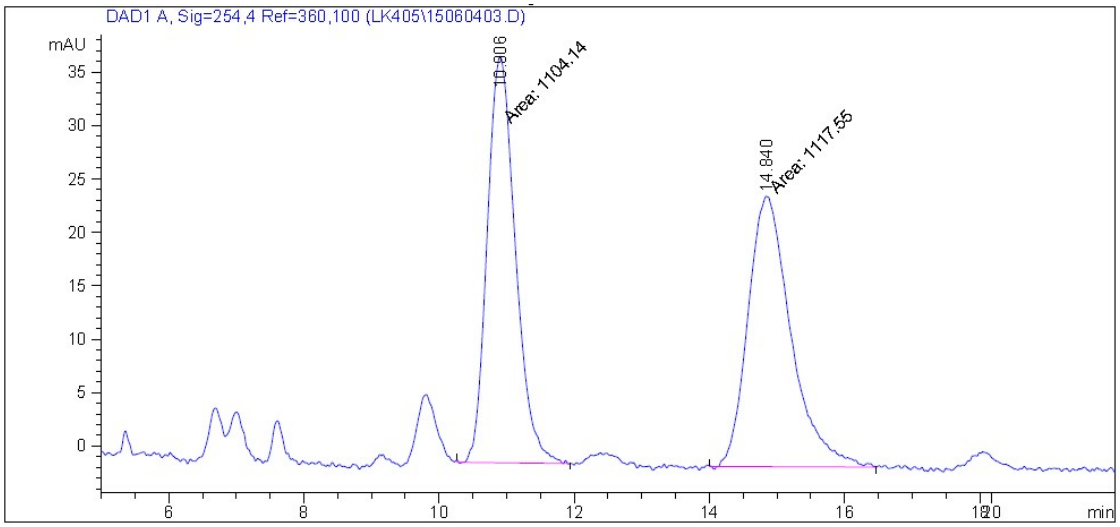
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.177	MM T	1.2484	3.26106e4	435.36523	99.8176
2	28.580	MM T	0.7161	59.60035	1.38708	0.1824

1-((2S,3S,5R)-3-(4-bromophenyl)-5-hydroxy-1-tosylpyrrolidin-2-yl)-2,2-dimethylpropan-1-one (3df)

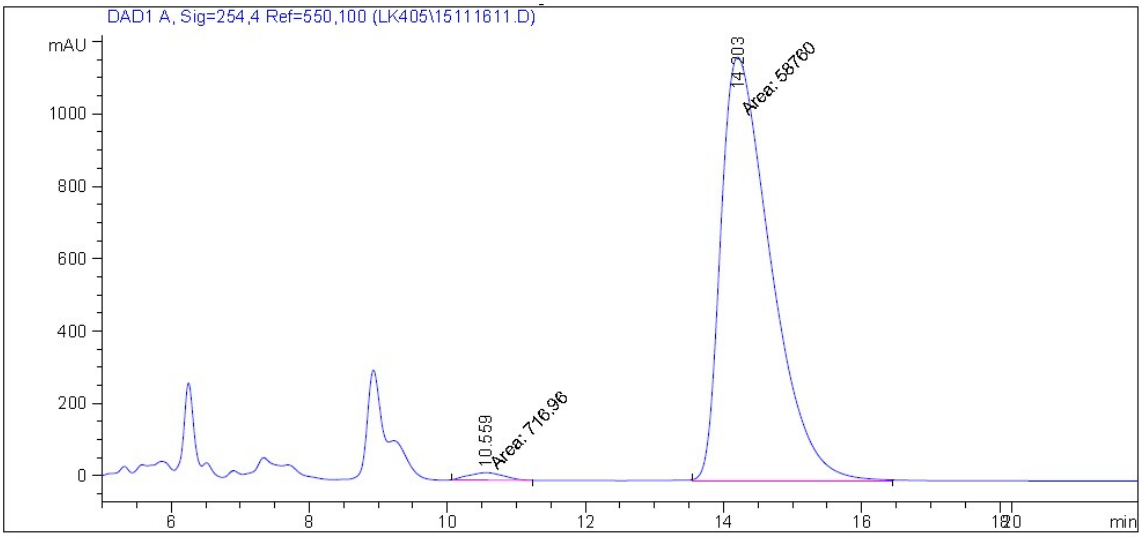


Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 4-bromocinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide(0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3df** was obtained as amorphous solid (121.7 mg, 64% yield, dr=6:1 and 98% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 14.2 min, τ_{minor} = 10.9 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{22}H_{26}BrNO_4S$ 479.0766, found 502.0660 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.17 (d, *J = 8.8* Hz, 2H), 7.75 (d, *J = 8.0* Hz, 2H), 7.30 (d, *J = 8.0* Hz, 2H), 7.27 (d, *J = 8.4* Hz, 2H), 5.88-5.93 (m, 1H), 5.08 (d, *J = 3.6* Hz, 1H), 4.29 (d, *J = 9.6* Hz, 1H), 3.39-3.43 (m, 1H), 2.45 (s, 3H), 2.38-2.42 (m, 1H), 2.25-2.32 (m, 1H), 1.04 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 215.3, 149.3, 147.3, 144.1, 136.9, 129.6, 127.8, 127.4, 124.4, 85.1, 67.6, 48.7, 45.1,

43.7, 26.4, 21.6. Mp (°C): 76-78.

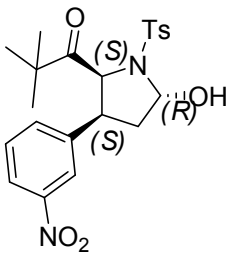


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.906	MM T	0.5402	1104.14197	38.05540	49.6983
2	14.840	MM T	0.7359	1117.54614	25.30936	50.3017

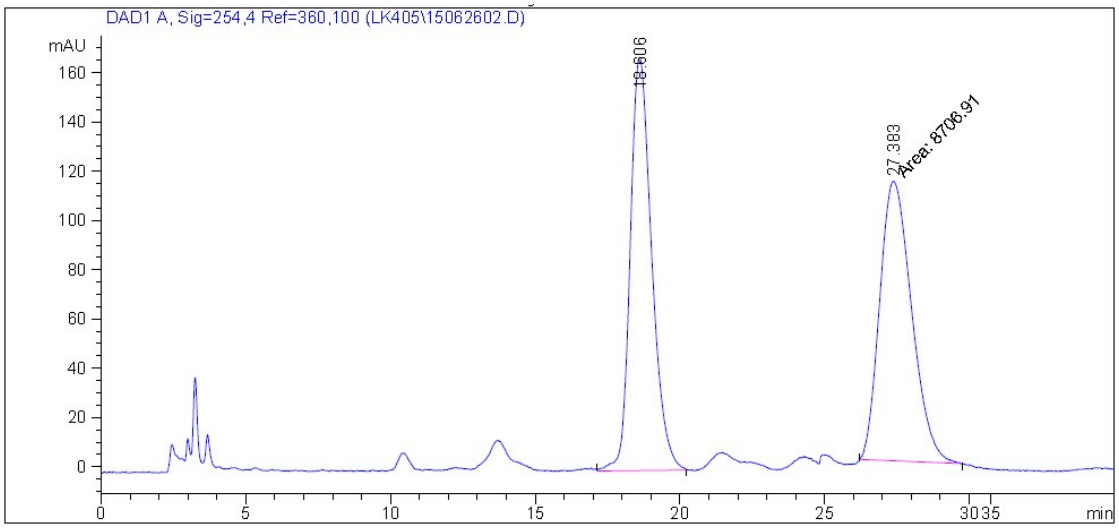


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.559	MM T	0.5811	716.96033	20.56492	1.2054
2	14.203	MM T	0.8364	5.87600e4	1170.84949	98.7946

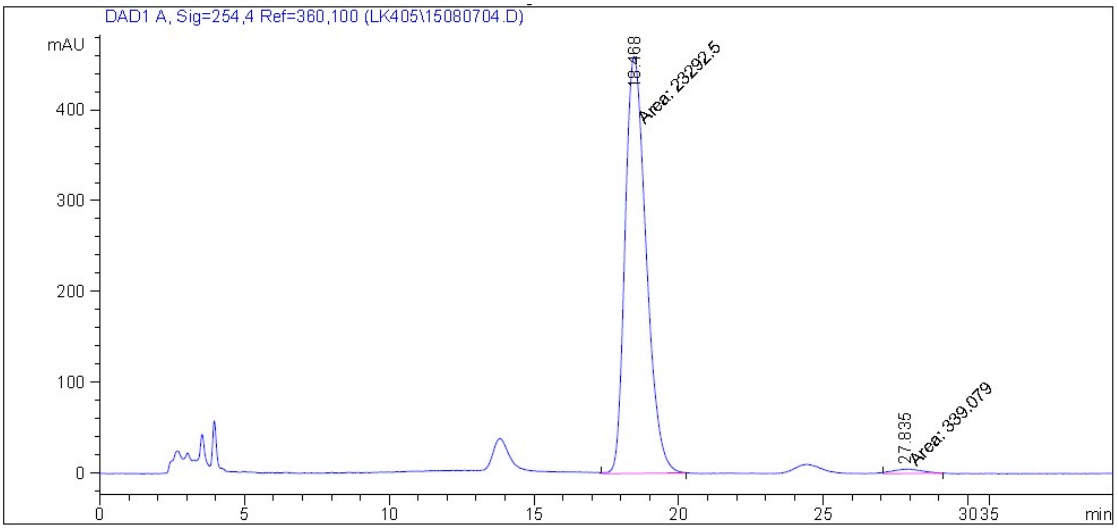
1-((2S,3S,5R)-5-hydroxy-3-(3-nitrophenyl)-1-tosylpyrrolidin-2-yl)-2,2-dimethylpropan-1-one (3ef)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 3-nitrocinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide(0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3ef** was obtained as amorphous solid (149.7 mg, 84% yield, dr=4:1 and 97% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 18.5 min, τ_{minor} = 27.4 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{22}H_{26}N_2O_6S_6$ 446.1512, found 469.1407 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.12-8.15 (m, 1H), 7.89 (s, 1H), 7.75 (d, *J = 8.0* Hz, 2H), 7.52-7.53 (m, 2H), 7.31 (d, *J = 8.4 Hz*, 1H), 5.88 (d, *J = 4.0* Hz, 1H), 5.06 (d, *J = 4.0 Hz*, 1H), 4.27 (s, 1H), 3.41-3.47 (m, 1H), 2.45 (s, 3H),2.38-2.42 (m, 1H), 2.21-2.70 (m, 1H), 1.06 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 215.3, 148.5, 144.2, 143.8, 136.7, 132.9, 130.4, 129.7, 127.3, 122.7, 121.8, 85.0, 67.7, 48.6, 45.0, 43.8, 26.5, 21.6. Mp (°C): 52-53.

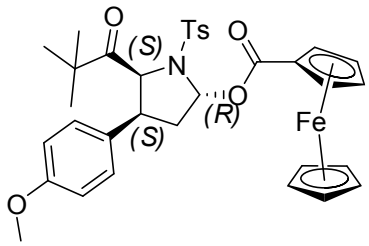


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.606	VB	0.7152	8646.22852	167.79413	49.8252
2	27.383	MM T	1.2775	8706.91016	113.58990	50.1748



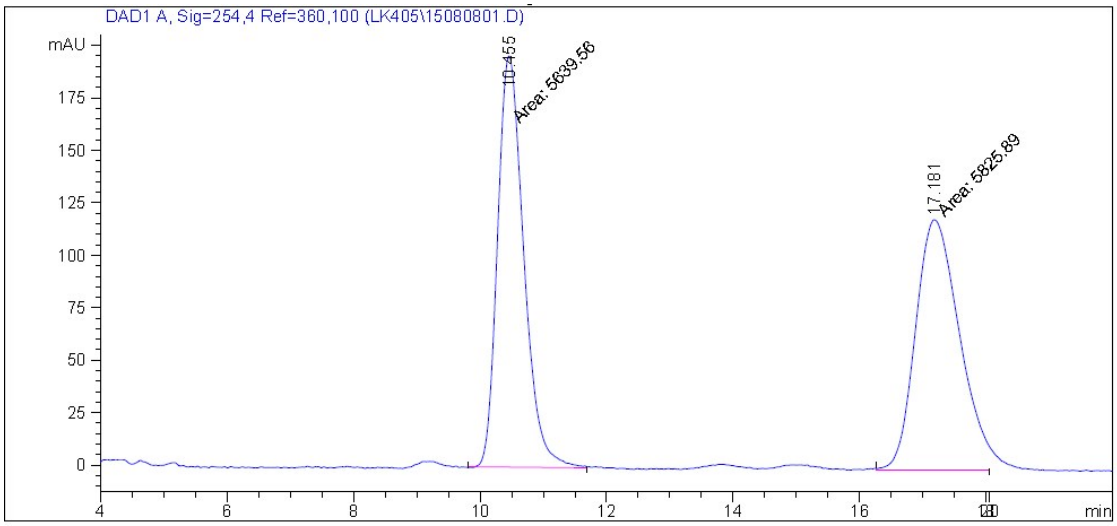
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.468	MM T	0.8451	2.32925e4	459.38281	98.5651
2	27.835	MM T	1.1692	339.07944	4.83335	1.4349

(2R,4S,5S)-4-(4-methoxyphenyl)-5-pivaloyl-1-tosylpyrrolidin-2-ferrocenyl-acetate (3ff)

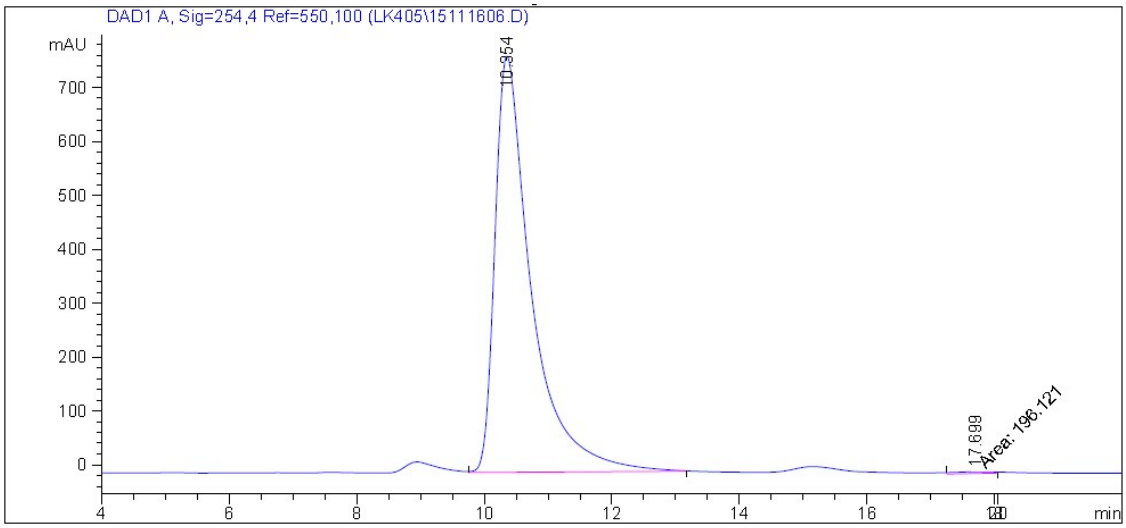


Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 4-methoxyphenylacrylaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamid e (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3ff** was obtained as amorphous solid (70.9 mg, 41% yield, dr=8:1 and 99% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 10.4 min, τ_{minor} = 17.2 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{34}H_{37}FeNO_6S$ 643.1691,

found 666.1578 $[M+Na]^+$. ^1H NMR (400 MHz, $CDCl_3$): 7.80 (d, J = 8.3 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 8.7 Hz, 2H), 6.85 (d, J = 8.7 Hz, 2H), 6.72 (d, J = 3.9 Hz, 1H), 5.05 (d, J = 8.0 Hz, 1H), 4.88 (dt, J = 2.5, 1.3 Hz, 1H), 4.76 (dt, J = 2.5, 1.3 Hz, 1H), 4.44 – 4.37 (m, 2H), 4.22 (s, 5H), 3.80 (s, 3H), 3.43 (dt, J = 10.6, 7.3 Hz, 1H), 2.40 (s, 3H), 0.97 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 213.8, 170.8, 159.2, 143.9, 136.6, 129.6, 128.6, 127.6, 114.5, 84.7, 71.5, 70.7, 69.9, 68.1, 60.9, 56.3, 55.3, 48.9, 43.8, 43.0, 27.0, 21.6. Mp (°C): 112-113.

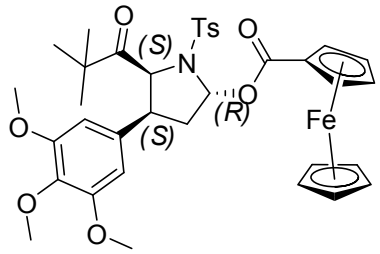


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.455	MM T	0.4797	5639.56445	195.92567	49.1874
2	17.181	MM T	0.8465	5825.89258	119.30319	50.8126

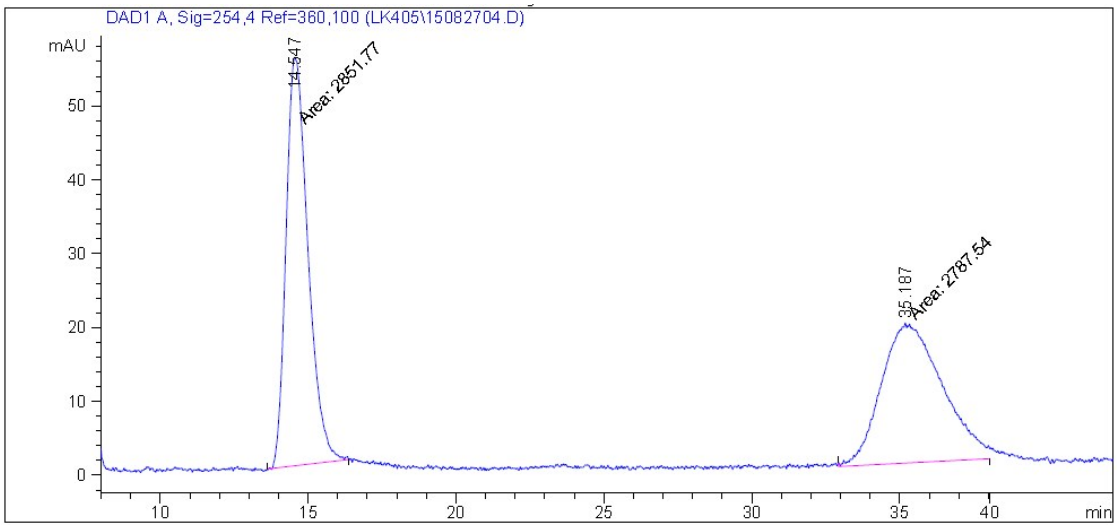


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.354	VB	0.5772	3.06417e4	771.74969	99.3640
2	17.699	MM T	0.8555	196.12123	3.82085	0.6360

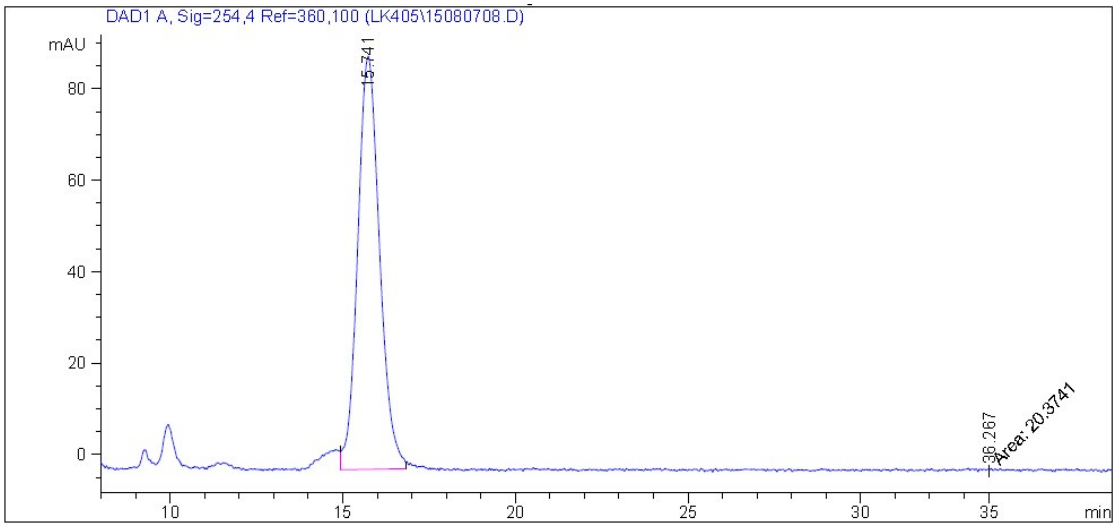
(2R,4S,5S)-4-(4-ethyl-3,5-dimethoxyphenyl)-5-pivaloyl-1-tosylpyrrolidin-2-ferrocenyl acetate (3gf)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol, 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 3,4,5-trimethoxyphenylacrylaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3gf** was obtained as amorphous solid (137.7 mg, 70% yield, dr=7:1 and 99% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 15.7 min, τ_{minor} = 35.2 min. HRMS ESI ORBITRAP (+) m/z: calculated for$C_{36}H_{41}FeNO_8S$ 703.1902, found 726.1791 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.82 (d, J = 8.3 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 6.78 (d, J = 3.0 Hz, 1H), 6.41 (s, 2H), 5.13 (d, J = 7.1 Hz, 1H), 4.87 (s, 1H), 4.74 (s, 1H), 4.45 – 4.36 (m, 2H), 4.21 (s, 5H), 3.83 (s, 9H), 3.38 (d, J = 9.2 Hz, 1H), 2.39 (s, 3H), 1.01 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 213.42, 170.71, 153.64, 143.89, 136.65, 134.54, 129.46, 127.62, 104.29, 84.91, 69.88, 67.62, 60.89, 56.22, 49.52, 43.76, 26.76, 21.51. Mp (°C): 128-129.

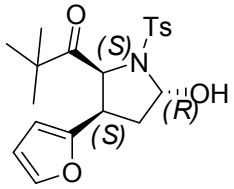


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.547	MM T	0.8834	2851.77319	55.30195	50.5695
2	35.187	MM T	2.4380	2787.53882	19.05618	49.4305



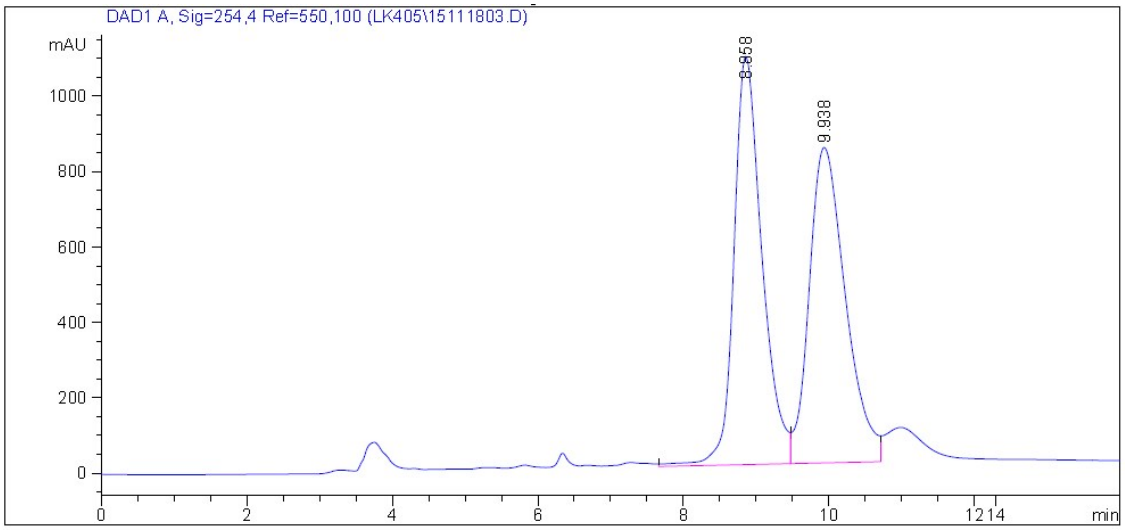
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.741	VV	0.5954	3993.48315	90.39220	99.4924
2	36.267	MM T	0.5607	20.37411	6.05576e-1	0.5076

1-((2S,3S,5R)-3-(furan-2-yl)-5-hydroxy-1-tosylpyrrolidin-2-yl)-2,2-dimethylpropan-1-one (3hf)

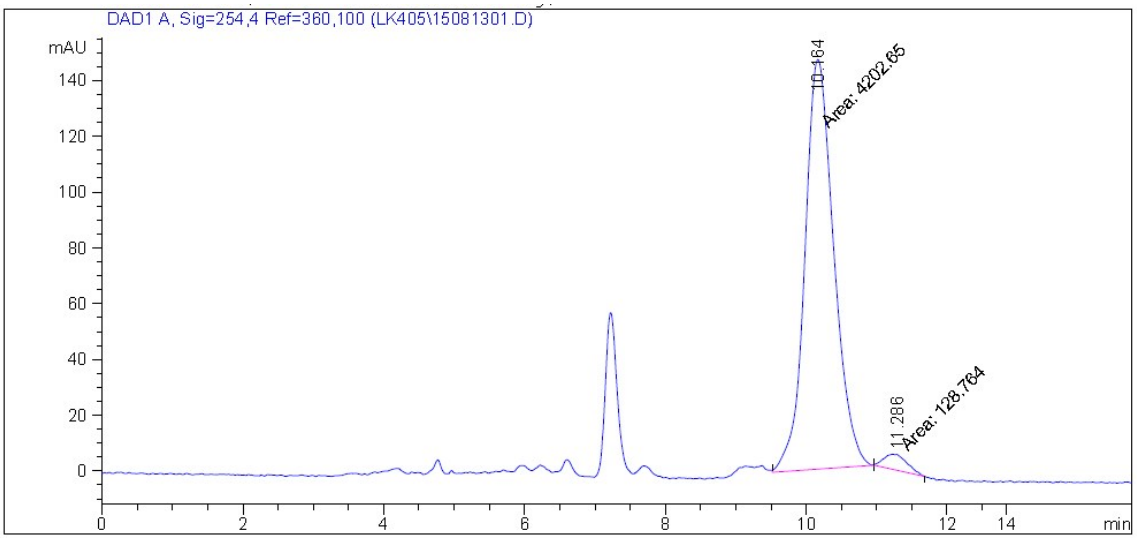


Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 2-furylcinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide(0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3hf** was obtained as amorphous solid (66.8 mg, 43% yield, dr=11:1 and 94% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralcel OD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 10.2 min, τ_{minor} = 11.3 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{20}H_{25}NO_5S$ 391.1453, found 414.1348 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.67 (d, *J = 8.0* Hz, 2H),

7.24 (d, *J* = *7.2* Hz, 3H), 6.21(m, 1H), 5.99 (d, *J* = *3.2* Hz, 1H), 5.69-5.70 (m, 1H), 5.12 (d, *J* = *3.6* Hz, 1H), 3.93 (s, 1H), 3.37-3.41 (m, 1H), 2.37-2.43 (m, 4H), 2.18-2.24 (m, 1H), 1.15 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 153.0, 143.6, 142.1, 136.8, 129.5, 127.3, 110.4, 106.5, 84.7, 65.6, 44.0, 42.0, 40.3, 26.4, 21.5. Mp (°C): 55-56.



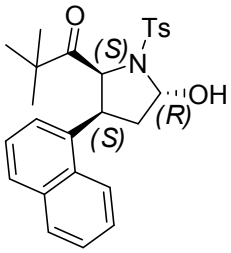
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.858	VV	0.4020	2.91397e4	1082.78638	50.0722
2	9.938	VV	0.5330	2.90557e4	837.03534	49.9278



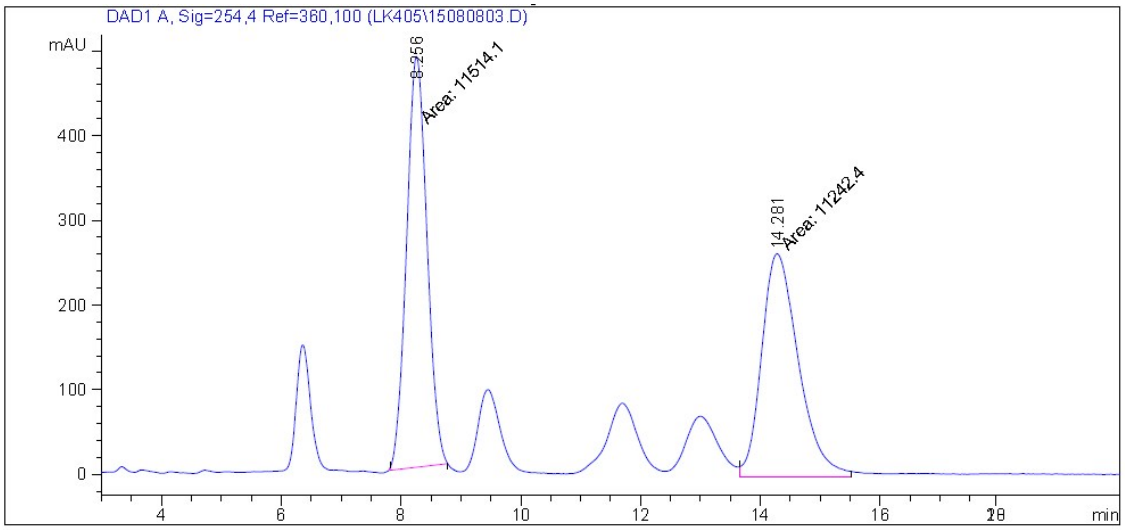
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.164	MM T	0.4767	4202.64600	146.93231	97.0272
2	11.286	MM T	0.3770	128.76361	5.69188	2.9728

1-((2S,3S,5R)-5-hydroxy-3-(naphthalen-1-yl)-1-tosylpyrrolidin-2-yl)-2,2-

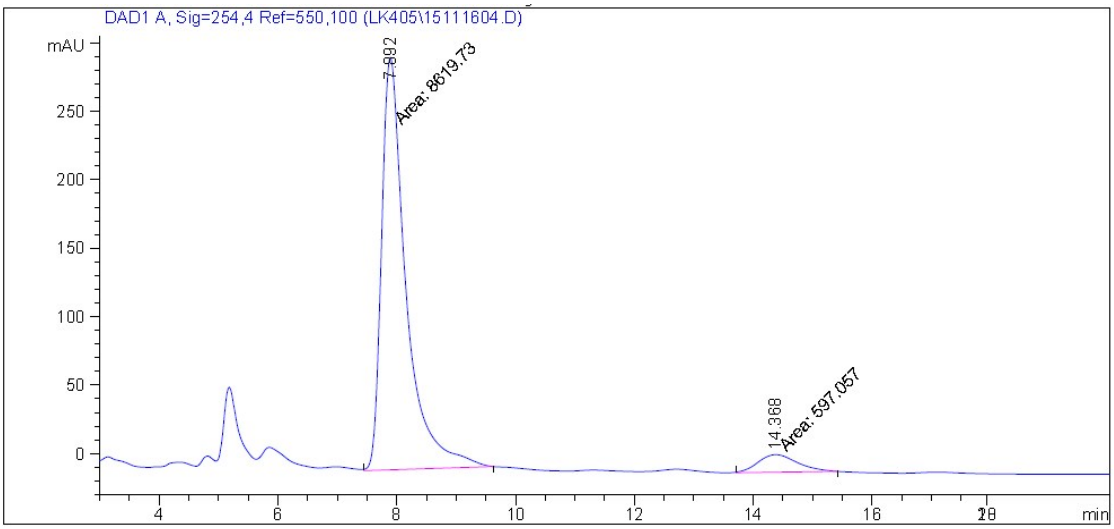
dimethylpropan-1-one (3if)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.08mmol., 26mg, 20mol%) was dissolved in 2.0 mL of CH_2Cl_2 and 4-bromobenzene carboxylic acid (0.08mmol., 16mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 1-naphthalenencinnamicaldehyde (0.4mmol) and N-(3,3-dimethyl-2-oxidanylidene-butyl)-4-methyl-benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) **3if** was obtained as amorphous solid (80.1 mg, 44% yield, dr=7:1 and 87% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 7.9 min, τ_{minor} = 14.4 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{26}H_{29}NO_4S$ 451.1817, found 474.1934 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.76-7.89 (m, 5H), 7.48-7.50 (m, 2H), 7.43 (d, *J = 5.2* Hz, 2H), 7.34 (d, *J = 8.0* Hz, 2H), 5.86 (s, 1H), 5.48 (d, *J = 4.4* Hz, 1H), 4.38 (s, 1H), 4.01 (s, 1H),, 2.50-2.56 (m, 1H), 2.46 (s, 3H),2.33 (s, 1H), 0.94 (s, 9H). ^{13}C NMR (400 MHz, $CDCl_3$): 216.6, 143.8, 137.3, 134.1, 130.8, 130.1, 129.6, 129.4, 128.20, 127.8, 127.6, 126.6, 125.9, 125.8, 122.3, 85.1, 67.0, 45.4, 43.7, 40.3, 26.9, 26.3, 21.6. Mp (°C): 160-162.

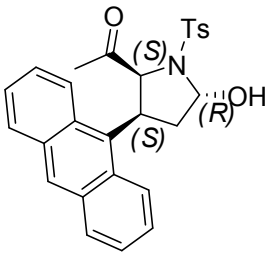


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.256	MM T	0.3956	1.15141e4	485.13367	50.5971
2	14.281	MM T	0.7114	1.12424e4	263.38504	49.4029



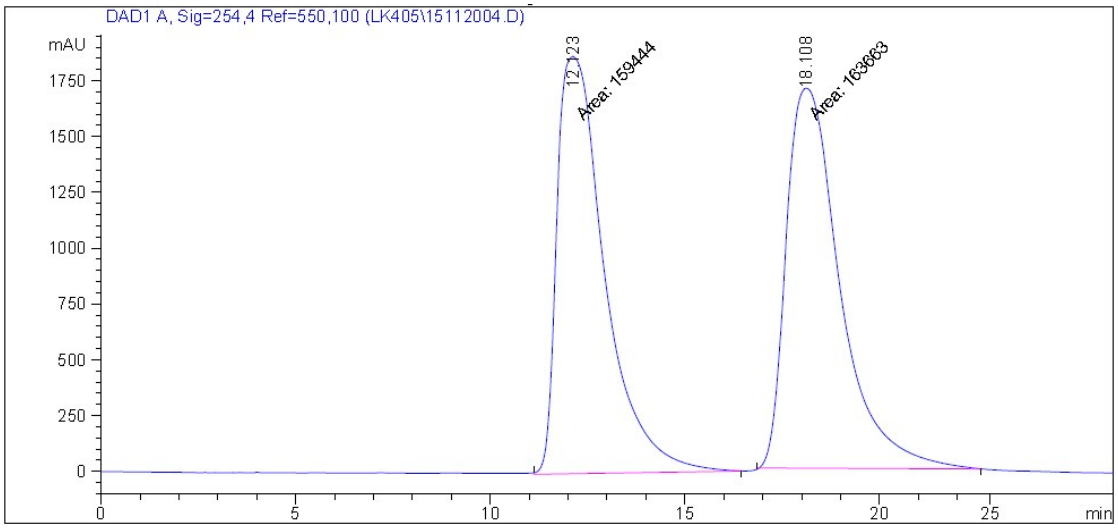
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.892	MM T	0.4768	8619.72949	301.31021	93.5221
2	14.368	MM T	0.7691	597.05701	12.93785	6.4779

1-((2S,3S,5R)-3-(anthracen-9-yl)-5-hydroxy-1-tosylpyrrolidin-2-yl)ethanone (3ja)

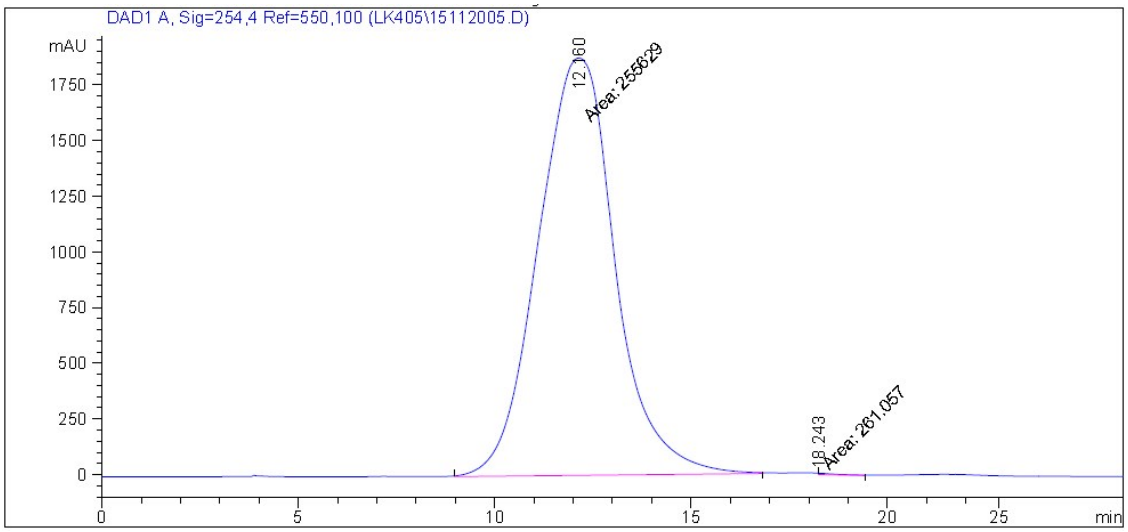


Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol , 13mg, 10 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 3-(anthracen-9-yl)acrylaldehyde (0.4mmol) and 4-methyl-N-(2-oxopropyl)benzene-su lfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo.* After flash column chromatography (hexane/ethyl acetate =6/1) **3ja** was obtained as amorphous solid (175.9mg, 96% yield, dr=25:1 and >99% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.60 mL/min, λ = 254.0 nm: τ_{major} = 12.2min, τ_{minor} = 18.1 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{27}H_{25}NO_4S$ 459.1504, found 482.1387 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.42 (s, 1H), 8.01 (d, *J = 8.4* Hz, 2H), 7.91 (d, *J = 8.4* Hz, 2H), 7.73 (s, 1H), 7.26-7.48 (m, 7H), 5.95 (d, *J =8.4* Hz, 1H), 5.12 (m, 1H), 5.07 (d, *J = 8.4* Hz, 1H), 3.68 (s, 1H), 2.79-2.87 (m, 1H), 2.57 (s, 3H), 2.39 (dd, *J = 13.6, 8.4* Hz, 1H), 2.21 (s, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 207.9, 144.4, 136.4, 131.8, 130.3, 130.2, 129.9, 128.9, 128.7, 127.4, 126.5, 124.8, 123.0, 85.1, 72.4, 41.5, 40.7, 26.3, 21.7. Mp. (°C):

183-184.

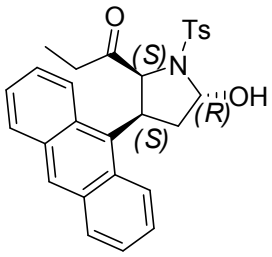


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.123	MM T	1.4212	1.59444e5	1869.81970	49.3471
2	18.108	MM T	1.6023	1.63663e5	1702.41016	50.6529

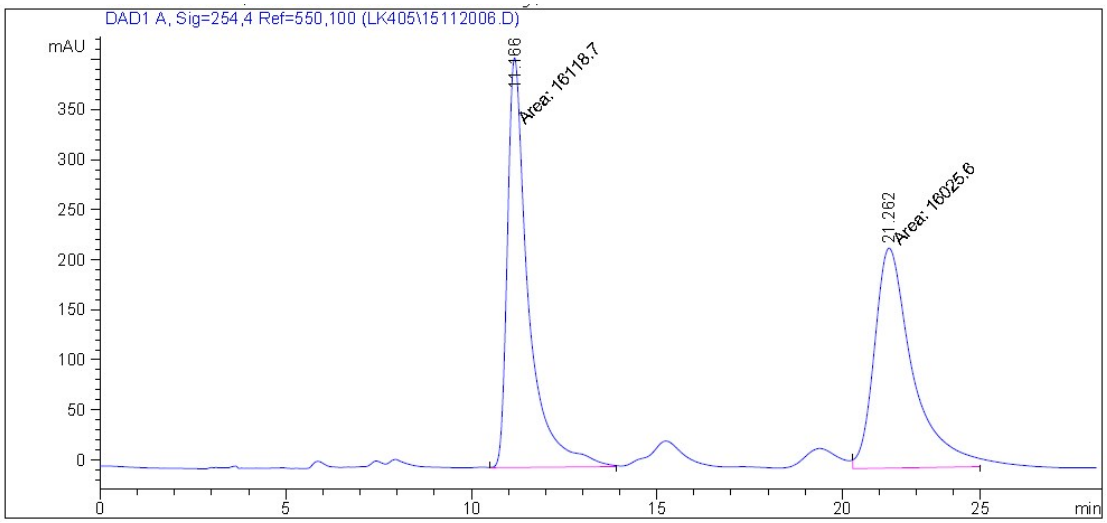


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.160	MM T	2.2712	2.55629e5	1875.87402	99.8980
2	18.243	MM T	0.4744	261.05725	6.53707	0.1020

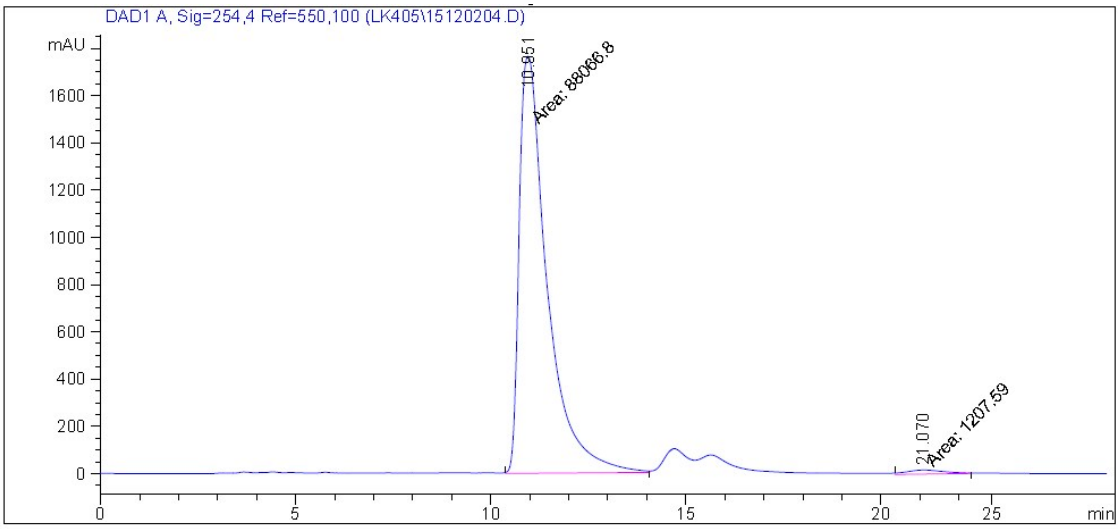
1-((2S,3S,5R)-3-(anthracen-9-yl)-5-hydroxy-1-tosylpyrrolidin-2-yl)propan-1-one (3jd)



Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol, 13mg, 10mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol, 10mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 3-(anthracen-9-yl)acrylaldehyde (0.4mmol) and 4-methyl-N-(2-oxobutyl)benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =6/1) **3jd** was obtained as amorphous solid 181.1mg, (96% yield, dr=10:1 and 97% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.60 mL/min, λ = 254.0 nm: τ_{major} = 11.0 min, τ_{minor} = 21.3 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{28}H_{27}NO_4S$ 473.1661, found 496.1546 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.43 (s, 1H), 8.03 (d, *J* = 8.5 Hz, 2H), 7.90 (d, *J* = 7.9 Hz, 2H), 7.73 (d, *J* = 7.8 Hz, 1H), 7.44 (t, *J* = 7.3 Hz, 4H), 7.30 (d, *J* = 7.7 Hz, 3H), 5.95 (d, *J* = 4.5 Hz, 1H), 5.16 (d, *J* = 8.2 Hz, 1H), 5.12 – 5.00 (m, 1H), 3.84 (d, *J* = 4.5 Hz, 1H), 2.90 – 2.78 (m, 1H), 2.56 (s, 3H), 2.38 (dd, *J* = 13.0, 7.9 Hz, 2H), 2.26 (dd, *J* = 18.6, 7.4 Hz, 1H), 0.92 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 210.77, 144.46, 143.66, 137.51, 136.12, 131.74, 129.94, 129.72, 129.03, 128.35, 127.54, 127.36, 124.98, 71.52, 70.34, 42.40, 41.07, 34.48 , 21.73, 7.12. Mp (°C): 163-164.

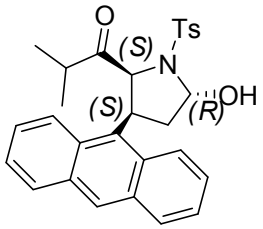


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.166	MM T	0.6563	1.61187e4	409.35056	50.1448
2	21.262	MM T	1.2142	1.60256e4	219.96652	49.8552



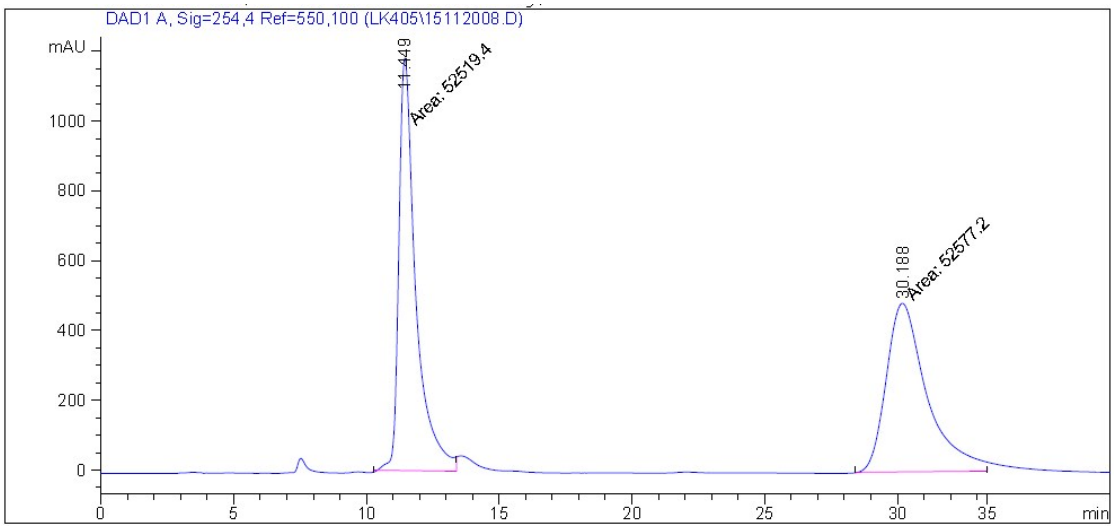
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.951	MM T	0.8313	8.80668e4	1765.66785	98.6473
2	21.070	MM T	1.1365	1207.59265	17.70903	1.3527

1-((2S,3S,5R)-3-(anthracen-9-yl)-5-hydroxy-1-tosylpyrrolidin-2-yl)-2-methylpropan-1-one (3je)

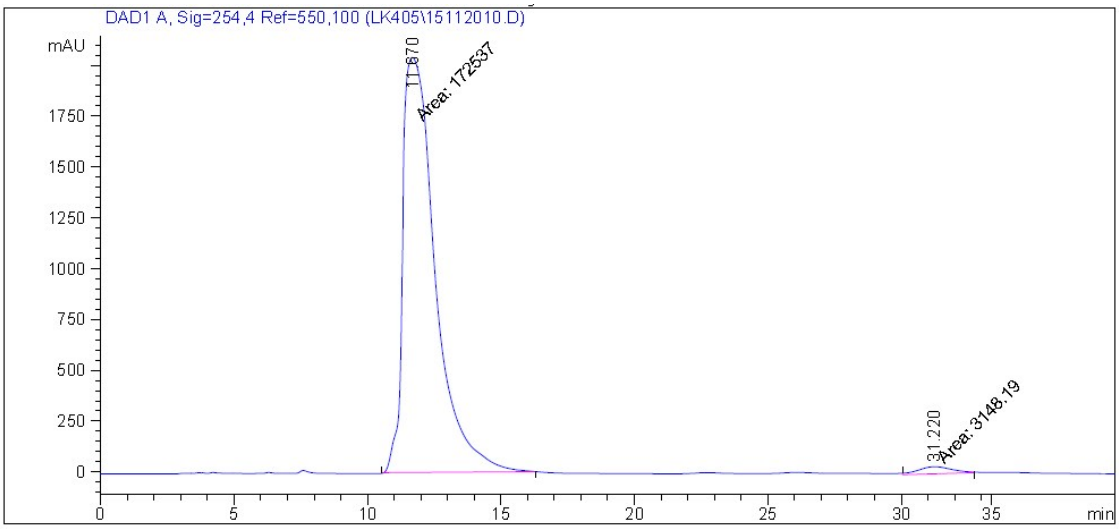


Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol., 13mg, 10mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10mg, 20mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 3-(anthracen-9-yl)acrylaldehyde (0.4mmol) and 4-methyl-N-(3-methyl-2-oxobutyl)-benzenesulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =6/1) **3je** was obtained as amorphous solid (178.9mg, 92% yield, dr=13:1 and 96% ee). The dr was determined by ^{1}H NMR and the ee was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 80:20, flow rate 0.60 mL/min, λ = 254.0 nm: τ_{major} = 11.7 min, τ_{minor} = 31.2 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{28}H_{27}NO_4S$ 487.1817, found 510.1703 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.44 (s, 1H), 8.04 (d, *J = 8.4* Hz, 3H), 7.88 (d, *J = 8.4* Hz, 3H), 7.40-7.49 (m, 6H), 6.00 (dd, *J = 6.4, 4.8* Hz, 1H), 5.43 (d, *J = 7.6* Hz, 1H), 4.96-5.03 (m, 1H), 4.18 (d, *J = 6.8* Hz, 1H), 2.83-2.91 (m, 1H), 2.52 (s, 3H), 2.43 (dd, J = *13.2, 8.4* Hz, 1H), 2.22-2.29 (m, 1H), 0.88 (d, *J = 6.8* Hz, 3H), 0.64 (d, *J = 6.8* Hz, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 215.4, 144.1, 137.3, 131.8, 129.9, 129.8, 128.8, 127.4,

127.2, 126.6, 125.0, 123.6, 84.9, 70.1, 43.1, 42.1, 39.6, 21.7, 18.1, 16.8. Mp (°C): 148-149.

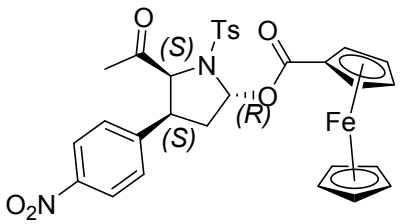


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.449	MM T	0.7412	5.25194e4	1180.91882	49.9725
2	30.188	MM T	1.8139	5.25772e4	483.08755	50.0275

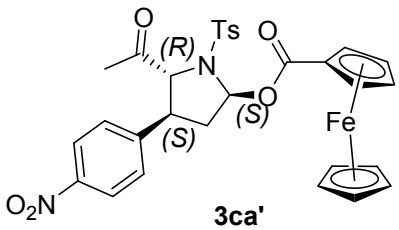


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.670	MM T	1.4086	1.72537e5	2041.40356	98.2081
2	31.220	MM T	1.4775	3148.18896	35.51200	1.7919

(2S,4S,5R)-5-acetyl-4-(4-nitrophenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3ca) and (2R,4S,5S)-5-acetyl-4-(4-nitrophenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3ca')

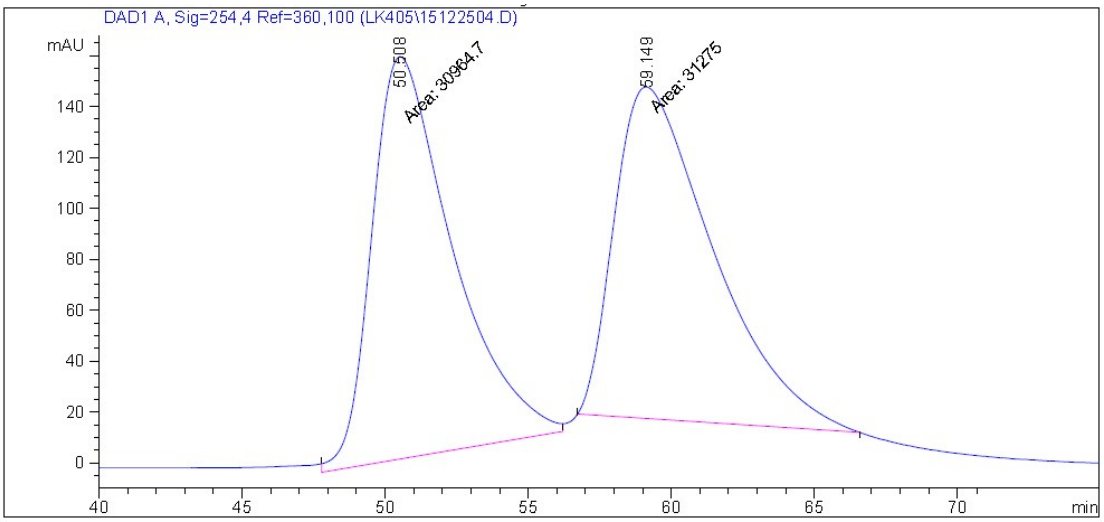


3ca

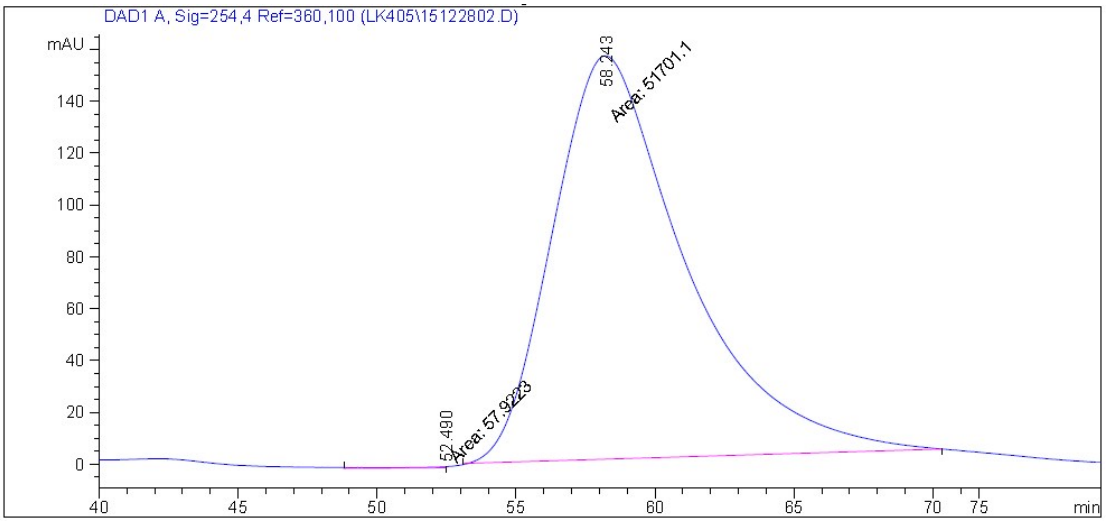


3ca'

Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol., 13 mg, 10 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar . The resulting solution was stirred at room temperature for 20 minutes, then 4-nitrocinnamicaldehyde (0.4mmol) and 4-methyl-N-(2-oxopropyl)benzene-sulfonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) reaction product was obtained as amorphous solid (158.7mg, 98% yield, dr=10:7, **3ca** >99% ee (Fc ester), **3ca'** >99% ee (Fc ester)). The dr was determined by ^{1}H NMR and the ee of **3ca** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 23.0 min, τ_{minor} = 52.0 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{30}H_{28}FeN_2O_7S$ 616.0967, found 639.0851 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 8.19 (d, J = 8.4 Hz, 2H), 7.83 (d, J = 8.2 Hz, 2H), 7.36 (dd, J = 14.9, 8.4 Hz, 4H), 6.81 (d, J = 4.6 Hz, 1H), 4.87 – 4.75 (m, 2H), 4.63 (s, 1H), 4.44 (d, J = 9.8 Hz, 2H), 4.25 (s, 5H), 4.20 – 4.06 (m, 1H), 2.96 – 2.85 (m, 1H), 2.46 (s, 3H), 2.26 (dd, J = 13.1, 5.6 Hz, 1H), 1.68 (s, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 205.45, 170.74, 147.68, 144.44, 141.91, 136.25, 129.76, 127.99, 124.03, 84.01, 77.39, 76.75, 71.60, 70.36, 70.07, 69.98, 69.24, 44.69, 36.15, 29.70, 21.67. mp (°C): 133-134.

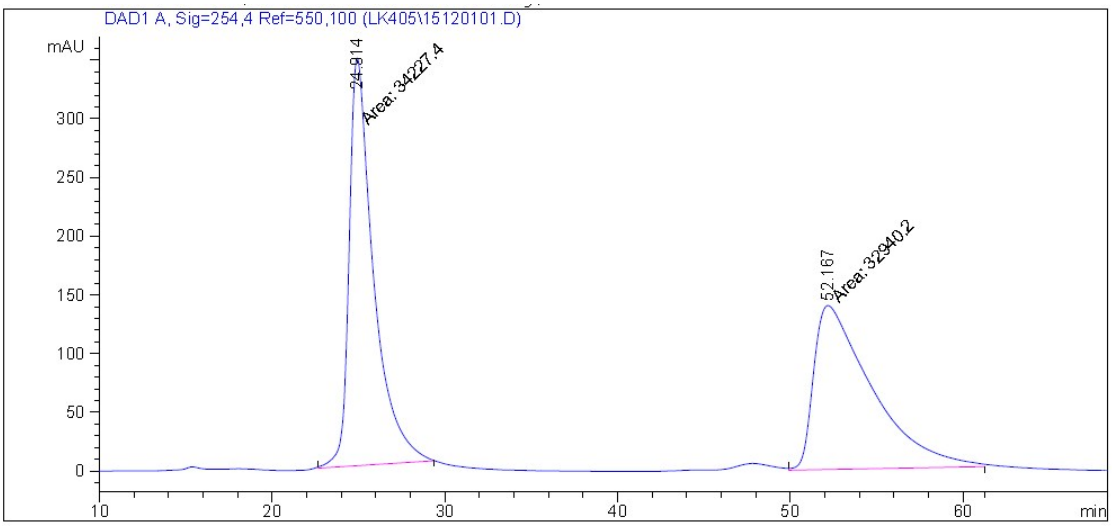


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	50.508	MM T	3.2665	3.09647e4	157.98924	49.7508
2	59.149	MM T	4.0043	3.12750e4	130.17268	50.2492

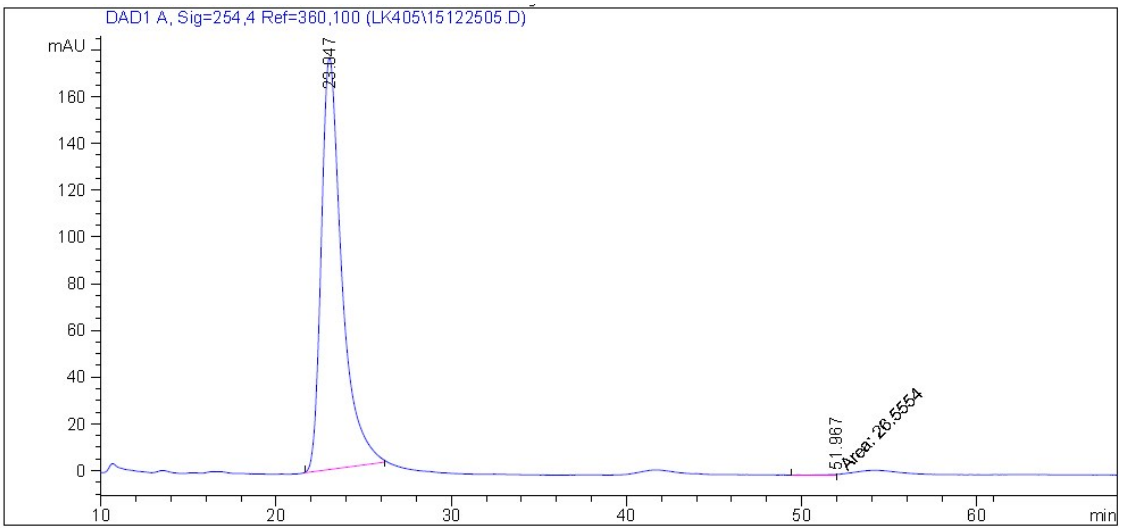


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	52.490	MM T	1.9250	57.92232	5.01500e-1	0.1119
2	58.243	MM T	5.5352	5.17011e4	155.67300	99.8881

The ee of **3ca'** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 58.2 min, τ_{minor} = 52.5 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{30}H_{28}FeN_2O_7S$ 616.0967, found 639.0851 $[M+Na]^+$. ^1H NMR (400 MHz, $CDCl_3$): 8.10 (d, *J* = 8.7 Hz, 2H), 7.84 – 7.76 (m, 2H), 7.38 (d, *J* = 8.1 Hz, 2H), 7.15 (d, *J* = 8.7 Hz, 2H), 6.74 (d, *J* = 5.0 Hz, 1H), 4.82 (d, *J* = 31.8 Hz, 2H), 4.47 (d, *J* = 7.7 Hz, 2H), 4.31 (s, 5H), 4.10 – 4.02 (m, 1H), 3.77 – 3.66 (m, 1H), 2.54 (s, 3H), 2.47 (s, 3H), 2.34 (dd, *J* = 13.5, 6.5 Hz, 1H), 2.01 – 1.91 (m, 1H). ^{13}C NMR (400 MHz, $CDCl_3$): 205.98, 170.40, 147.40, 145.07, 134.52, 130.31, 128.31, 127.49, 124.16, 84.59, 74.10, 72.01, 71.84, 70.50, 70.15, 69.94, 45.71, 40.76, 29.69, 25.34, 21.69. Mp (°C): 176-177.

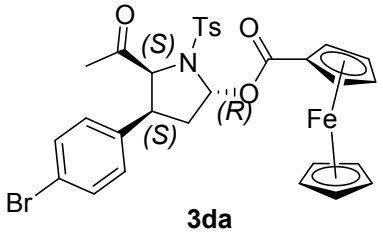


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.914	MM T	1.6431	3.42274e4	347.18488	50.9582
2	52.167	MM T	3.4728	3.29402e4	139.72362	49.0418

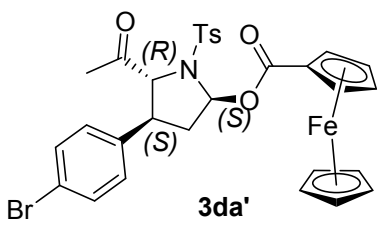


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.047	BB	1.2116	1.43729e4	176.20453	99.8156
2	51.967	MM T	1.0741	26.55542	4.12074e-1	0.1844

(2S,4S,5R)-5-acetyl-4-(4-bromophenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3da) and (2R,4S,5S)-5-acetyl-4-(4-bromophenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3da')



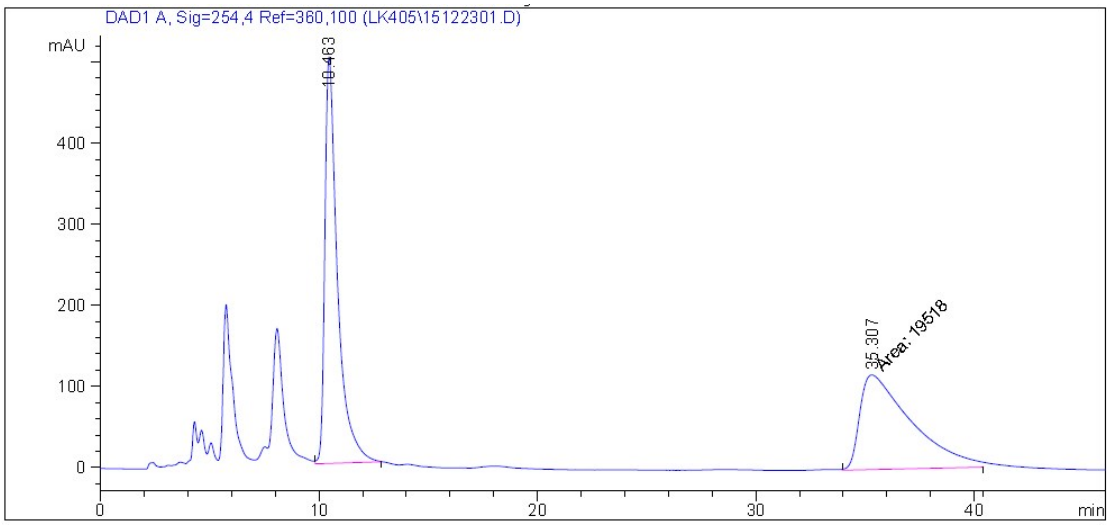
3da



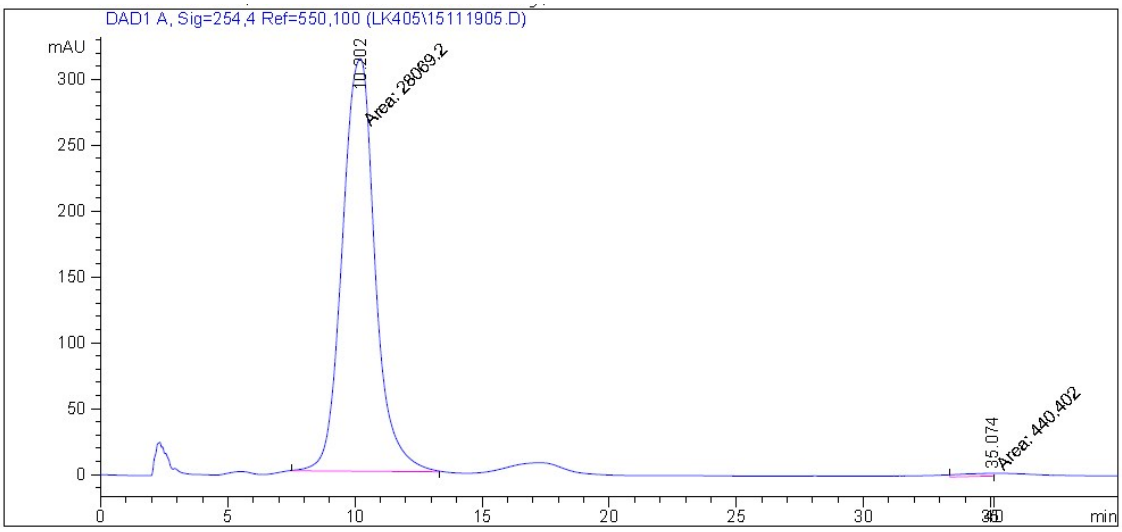
3da'

Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol., 13 mg, 10 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar .The resulting solution was stirred at room temperature for 20 minutes, then 4-

bromocinnamicaldehyde (0.4mmol) and 4-methyl-N-(2-oxopropyl)benzene-sulfona mide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) reaction product was obtained as amorphous solid (158.0mg, 90% yield, dr=10:6, **3da** 97% ee (Fc ester), **3da'** 99% ee (FC ester)). The dr was determined by ^{1}H NMR and the ee of **3da** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 10.2 minτ_{minor} = 35.1 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{30}H_{28}BrFeNO_5S$ 649.0221, found 672.0110 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.82 (t, *J* = 7.5 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 7.2 Hz, 2H), 7.06 (t, *J* = 7.5 Hz, 2H), 6.78 (s, 1H), 4.80 (d, *J* = 8.2 Hz, 2H), 4.61 (s, 1H), 4.41 (s, 2H), 4.23 (d, *J* = 7.2 Hz, 5H), 4.00 (d, *J* = 7.8 Hz, 1H), 2.90 – 2.75 (m, 1H), 2.45 (d, *J* = 7.1 Hz, 3H), 2.23 – 2.11 (m, 1H), 1.65 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 205.73, 170.73, 144.21, 136.48, 133.28, 132.11, 129.83, 129.63, 127.98, 122.26, 84.06, 71.55, 71.44, 70.34, 70.12, 70.07, 69.95, 69.38, 44.46, 36.13, 29.65, 21.65. Mp. (°C): 81-82.

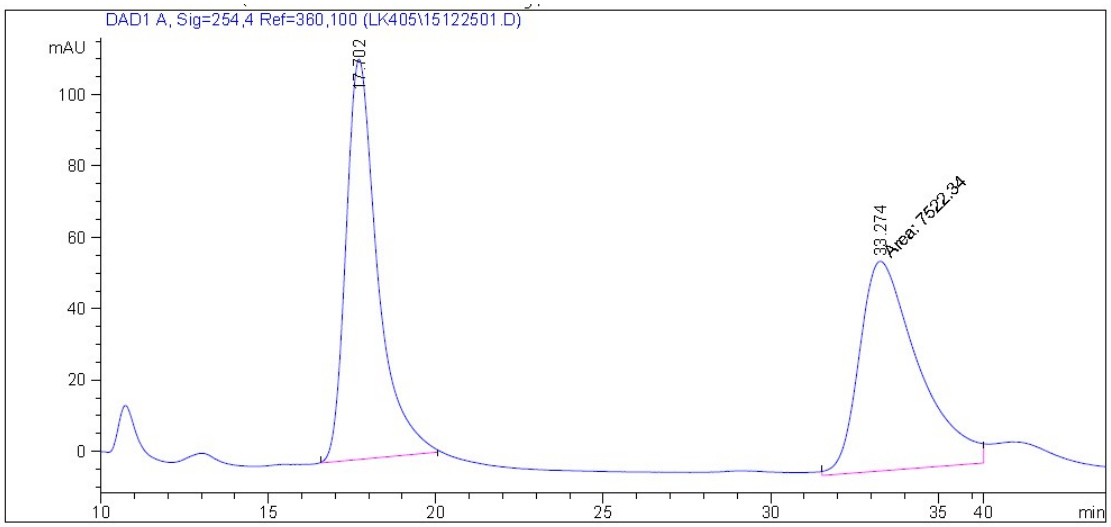


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.463	BB	0.5903	2.01965e4	501.05365	50.8543
2	35.307	MM T	2.7808	1.95180e4	116.98051	49.1457

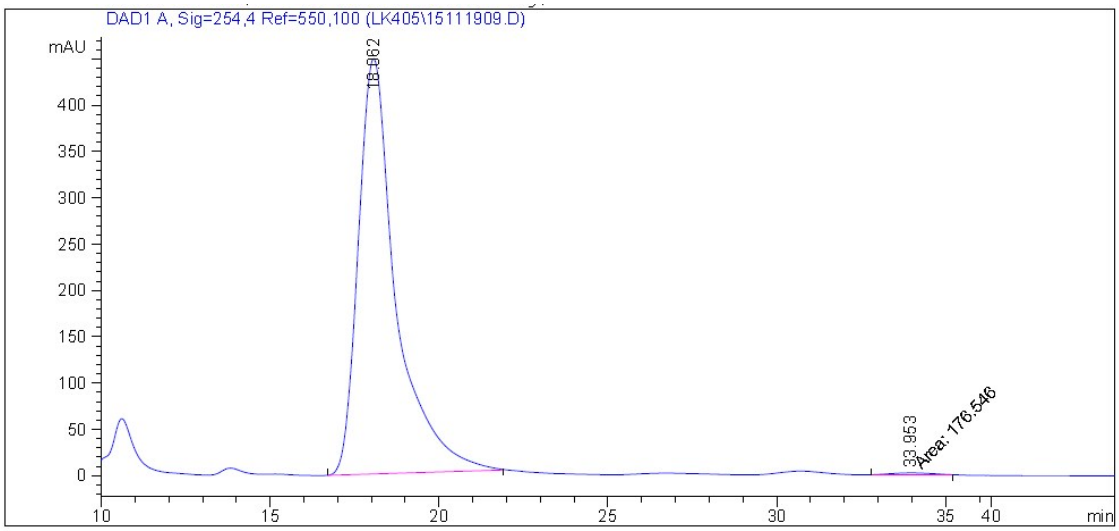


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.202	MM T	1.4941	2.80692e4	313.11780	98.4552
2	35.074	MM T	2.8738	440.40234	2.55410	1.5448

The ee of **3da'** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 18.1 min, τ_{minor} = 34.0 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{30}H_{28}BrFeNO_5S$ 649.0221, found 672.0110 $[M+Na]^+$. ^1H NMR (400 MHz, $CDCl_3$): 7.80 (d, *J* = 8.2 Hz, 2H), 7.38 (dd, *J* = 8.1, 4.0 Hz, 4H), 6.87 (d, *J* = 8.4 Hz, 2H), 6.71 (d, *J* = 5.0 Hz, 1H), 4.83 (d, *J* = 26.0 Hz, 2H), 4.51 – 4.43 (m, 2H), 4.31 (s, 5H), 4.02 (d, *J* = 9.2 Hz, 1H), 3.57 (dd, *J* = 17.3, 10.4 Hz, 1H), 2.51 (s, 3H), 2.48 (s, 3H), 2.30 (dd, *J* = 13.5, 6.4 Hz, 1H), 1.99 – 1.87 (m, 1H). ^{13}C NMR (400 MHz, $CDCl_3$): 206.00, 170.44, 144.85, 136.39, 134.66, 130.20, 128.93, 127.48, 121.79, 84.60, 74.35, 71.90, 71.75, 70.12, 69.96, 70.04, 45.67, 40.84, 29.70, 25.36, 21.69. Mp. (°C): 92-93.

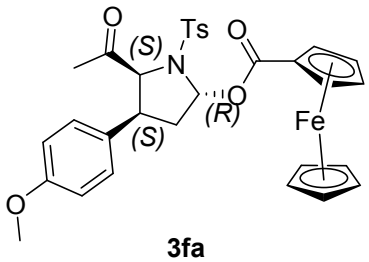


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.702	BB	0.9413	7362.47559	112.23239	49.4630
2	33.274	MM T	2.1257	7522.33936	58.97816	50.5370

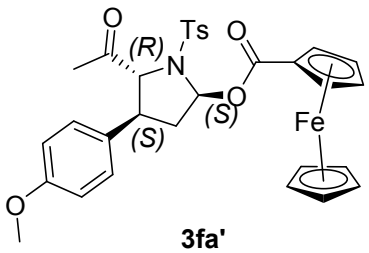


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.062	BB	1.1551	3.48755e4	448.52765	99.4963
2	33.953	MM T	1.4095	176.54646	2.08758	0.5037

(2S,4S,5R)-5-acetyl-4-(4-methoxyphenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3fa) and (2R,4S,5S)-5-acetyl-4-(4-methoxyphenyl)-1-tosylpyrrolidin-2-ferrocenyl acetate (3fa')



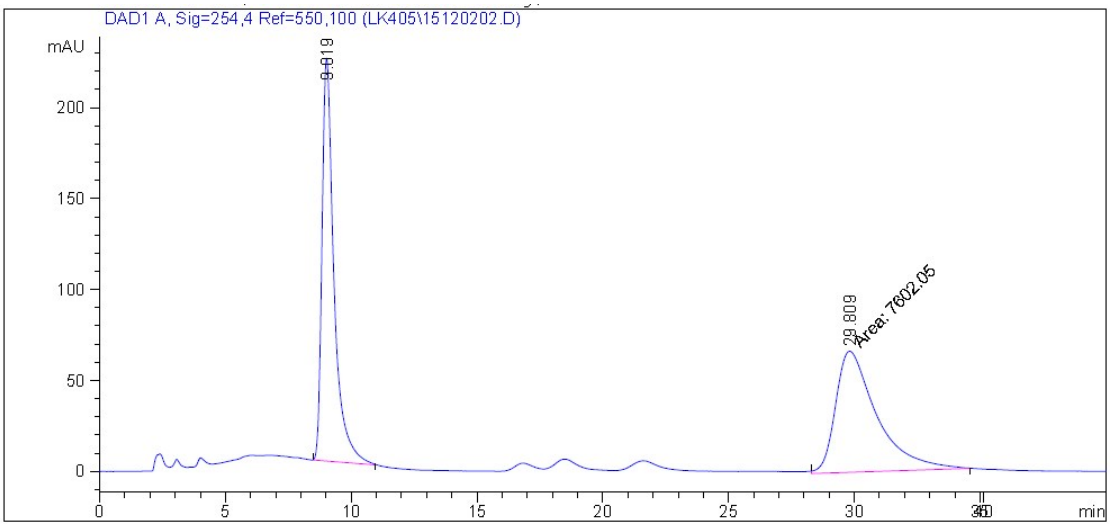
3fa



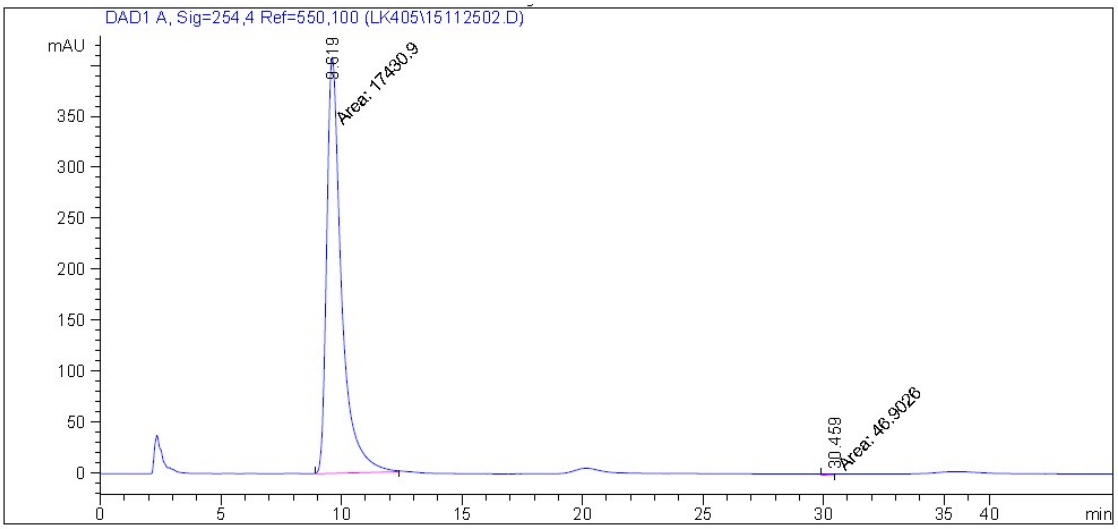
3fa'

Chiral amine catalyst 2-{diphenyl[(trimethylsilyl)oxy]methyl}pyrrolidine (0.04mmol., 13 mg, 10 mol%) was dissolved in 2.0 mL of CH_2Cl_2 and benzoic acid (0.08mmol., 10 mg, 20 mol%) was added in an ordinary vial equipped with a Teflon-coated stir bar .

The resulting solution was stirred at room temperature for 20 minutes, then 4-methoxyphenylacrylaldehyde (0.4mmol) and 4-methyl-N-(2-oxopropyl)benzene-sul fonamide (0.5mmol) was added. The vial was stirring continued at room temperature for 96 hours. The crude mixture was flushed through a short plug of silica. Solvent was removed in *vacuo*. After flash column chromatography (hexane/ethyl acetate =4/1) reaction product was obtained as amorphous solid (154.7mg, 99% yield, dr=10:6, **3fa** >99% ee (Fc Ester), **3fa'** 97% ee (Fc ester)). The dr was determined by ^{1}H NMR and the ee of **3fa** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 9.6 min, τ_{minor} = 30.4 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{31}H_{31}FeNO_6S$ 601.1222, found 624.1108 $[M+Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$): 7.82 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 8.7 Hz, 2H), 6.84 (d, *J* = 8.7 Hz, 2H), 6.77 (d, *J* = 4.6 Hz, 1H), 4.78 (d, *J* = 8.8 Hz, 2H), 4.60 – 4.57 (m, 1H), 4.43 – 4.37 (m, 2H), 4.23 (s, 5H), 4.01 (dd, *J* = 11.1, 5.7 Hz, 1H), 3.78 (s, 3H), 2.82 (td, *J* = 13.5, 4.8 Hz, 1H), 2.44 (s, 3H), 2.15 (dd, *J* = 13.2, 5.8 Hz, 1H), 1.61 (s, 3H). ^{13}C NMR (400 MHz, $CDCl_3$): 206.09 , 170.73 , 159.36 , 144.05 , 136.70 , 129.63 , 129.20 , 127.94 , 114.31 , 84.18 , 71.51, 71.38, 70.39, 70.31, 70.10, 69.92, 69.66 , 55.27 , 44.35 , 36.31 , 29.53, 21.64. Mp. (°C): 173-174.

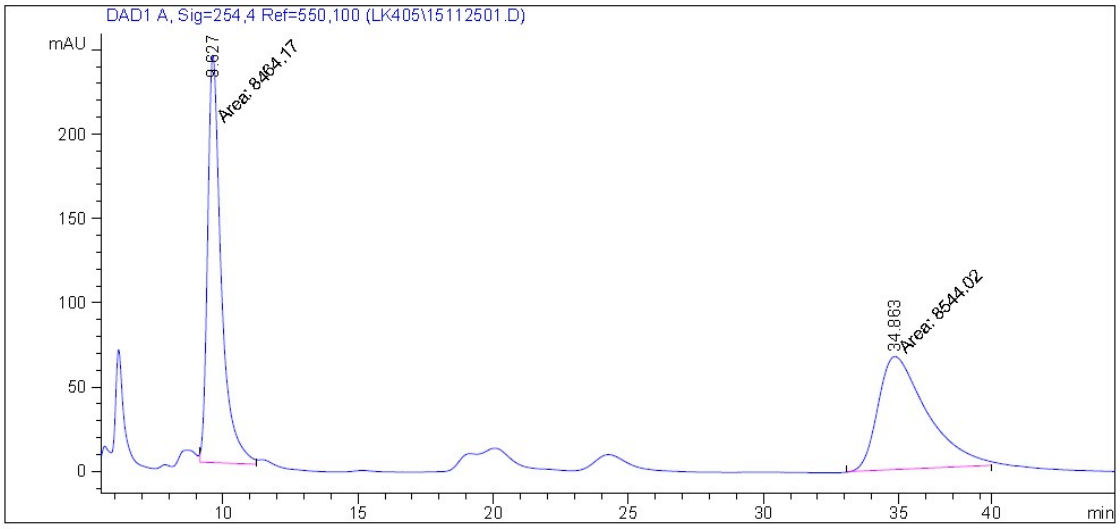


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.019	BB	0.4903	7335.48926	221.53583	49.1078
2	29.809	MM T	1.9015	7602.04785	66.63309	50.8922

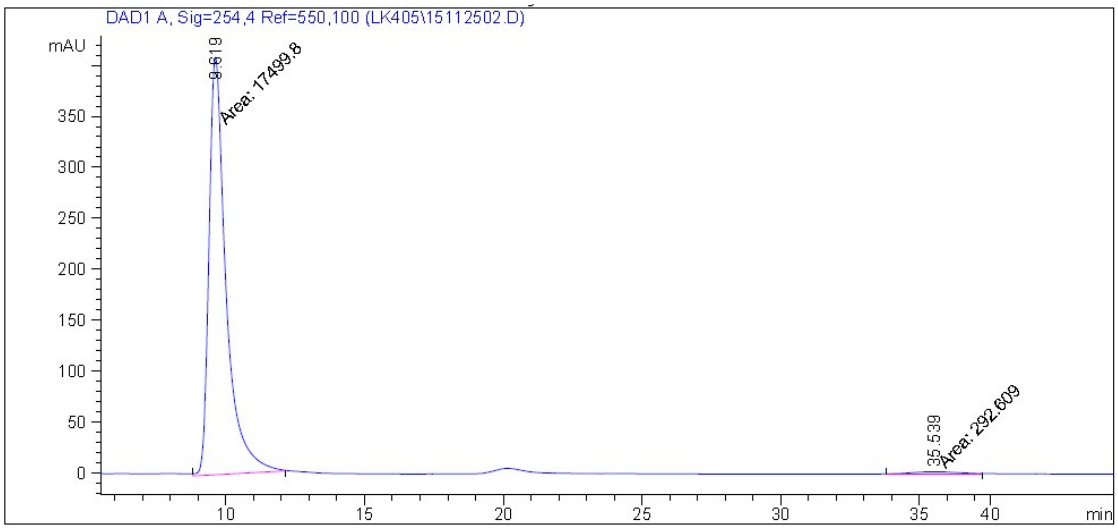


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.619	MM T	0.7120	1.74309e4	408.04706	99.7316
2	30.459	MM T	0.4930	46.90265	1.58558	0.2684

The ee of **3fc'** was determined by HPLC analysis on a Daicel Chiralpak AD-H column: hexane/*i*-PrOH 70:30, flow rate 0.80 mL/min, λ = 254.0 nm: τ_{major} = 9.6 min, τ_{minor} = 35.5 min. HRMS ESI ORBITRAP (+) m/z: calculated for $C_{31}H_{31}FeNO_6S$ 601.1222, found 624.1108 $[M+Na]^+$. ^1H NMR (400 MHz, $CDCl_3$): 7.82 (d, *J* = 8.2 Hz, 2H), 7.38 (d, *J* = 8.1 Hz, 2H), 6.93 (d, *J* = 8.6 Hz, 2H), 6.80 (d, *J* = 8.7 Hz, 2H), 6.69 (d, *J* = 5.0 Hz, 1H), 4.83 (d, *J* = 19.0 Hz, 2H), 4.46 (s, 2H), 4.31 (s, 5H), 4.01 (d, *J* = 9.6 Hz, 1H), 3.77 (s, 3H), 3.56 (ddd, *J* = 12.5, 9.8, 6.3 Hz, 1H), 2.47 (s, 3H), 2.46 (s, 3H), 2.28 (dd, *J* = 13.5, 6.3 Hz, 1H), 1.93 (td, *J* = 13.1, 5.1 Hz, 1H). ^{13}C NMR (400 MHz, $CDCl_3$): 205.99 , 170.47 , 159.19 , 144.65 , 134.84 , 130.13 , 128.28 , 127.54 , 114.41 , 84.64 , 74.60 , 71.81, 71.68, 70.47, 70.09, 69.98, 55.28 , 45.74 , 41.25 , 29.70 , 25.30 , 21.66 . Mp. (°C): 218-219.

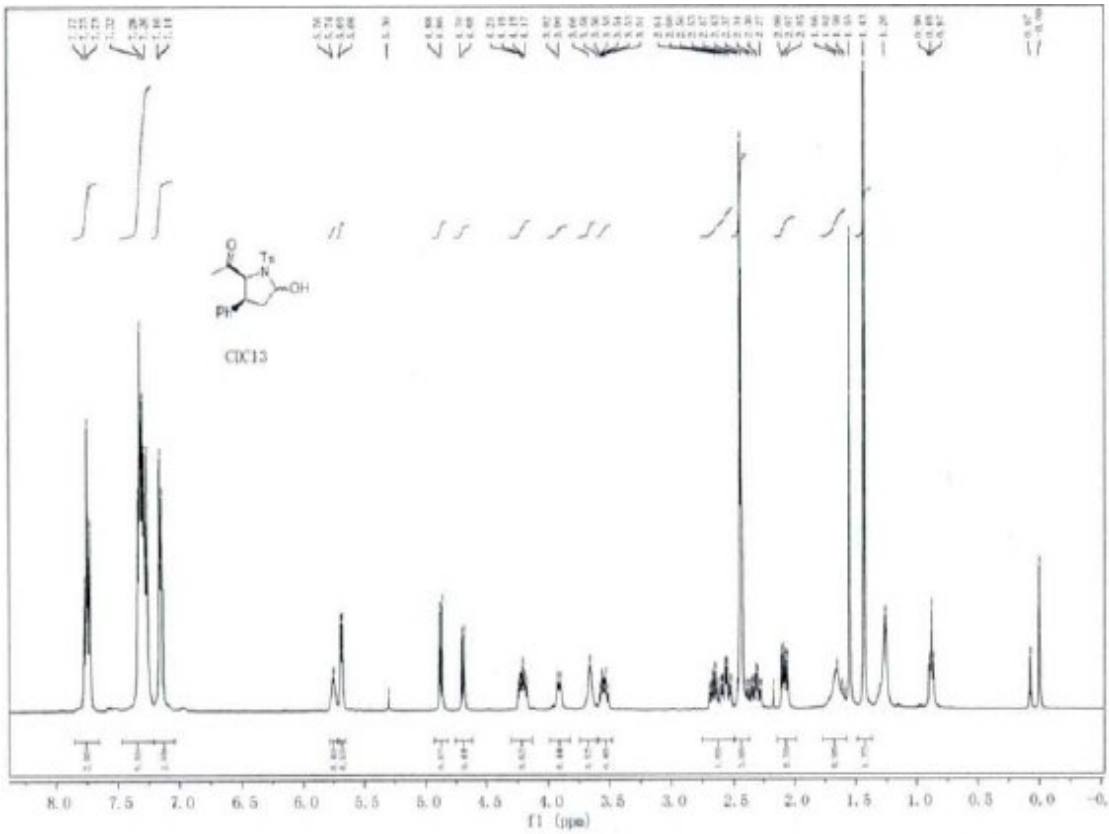


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.627	MM T	0.5841	8464.16504	241.49837	49.7652
2	34.863	MM T	2.1203	8544.01953	67.16100	50.2348

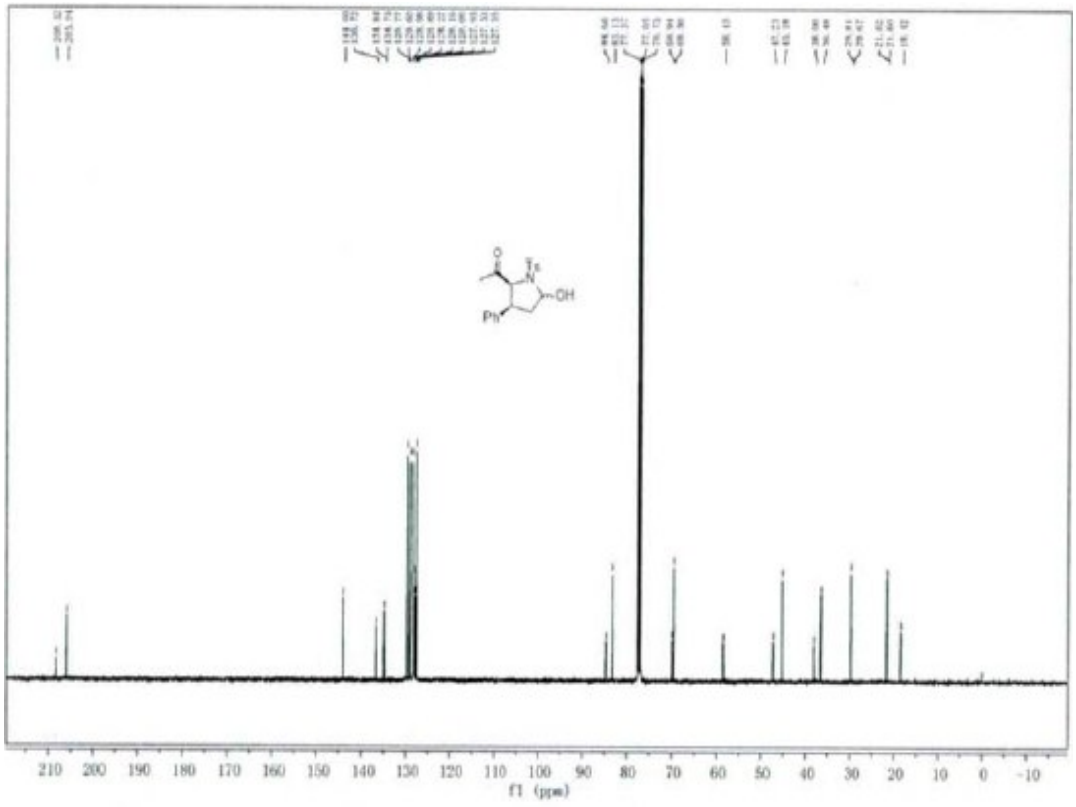


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.619	MM T	0.7127	1.74998e4	409.26483	98.3554
2	35.539	MM T	2.0838	292.60944	2.34040	1.6446

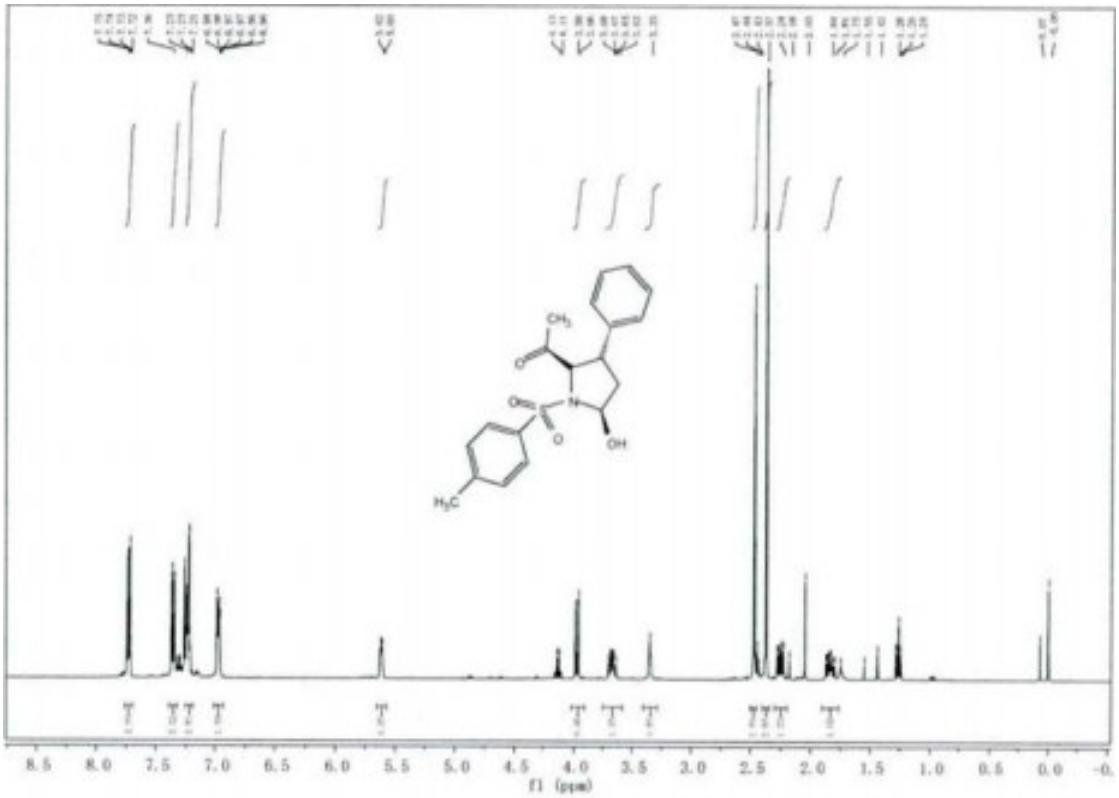
NMR spectra



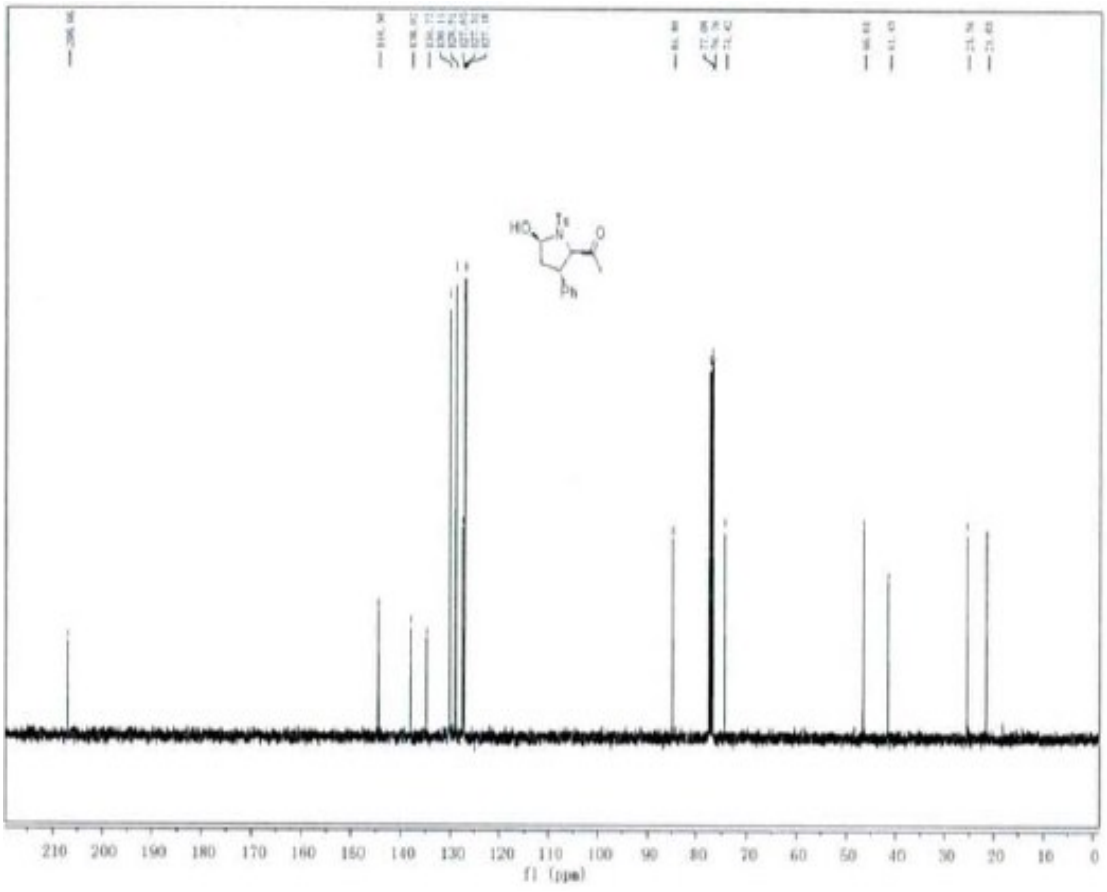
Compound **3aa** ^{1}H NMR



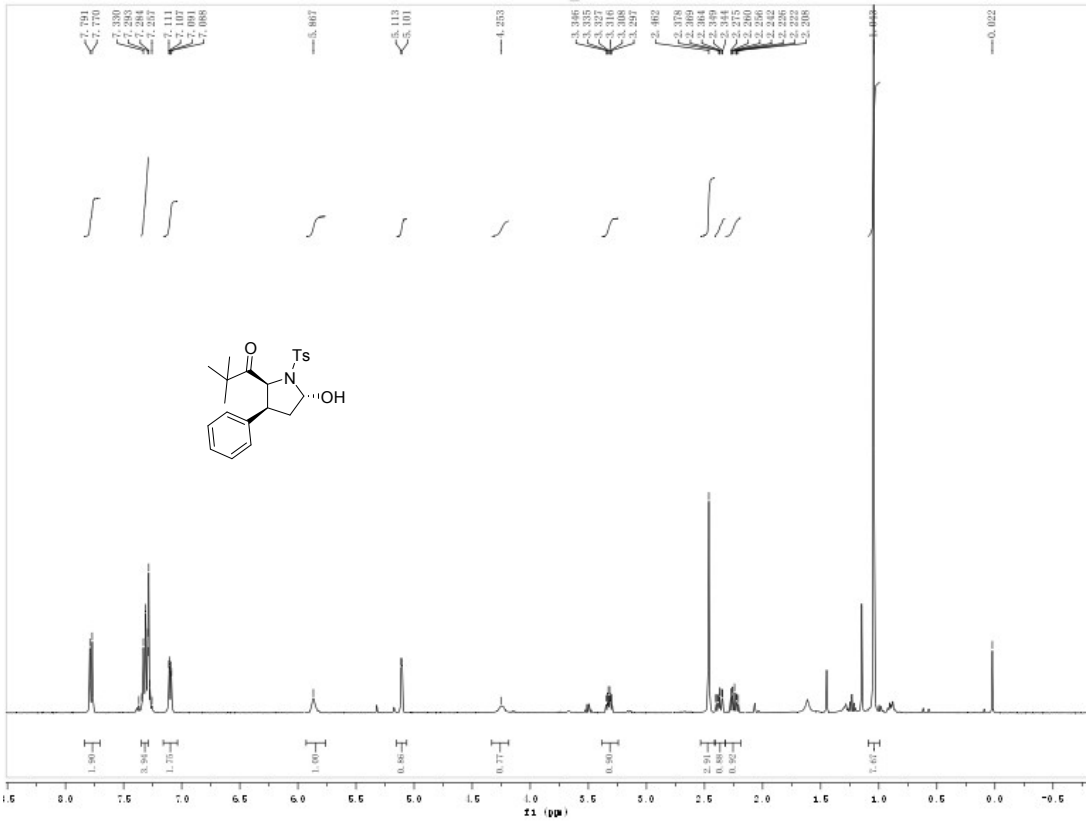
Compound **3aa** ^{13}C NMR



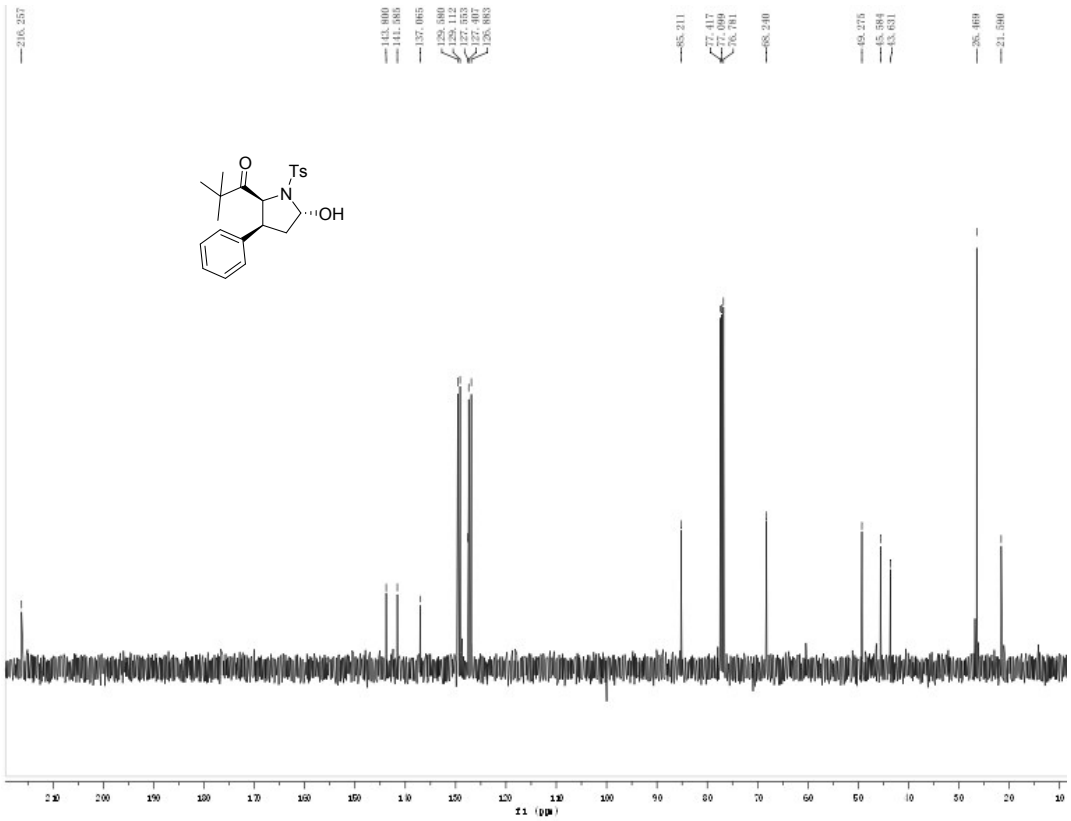
Compound **3aa'** ^{1}H NMR



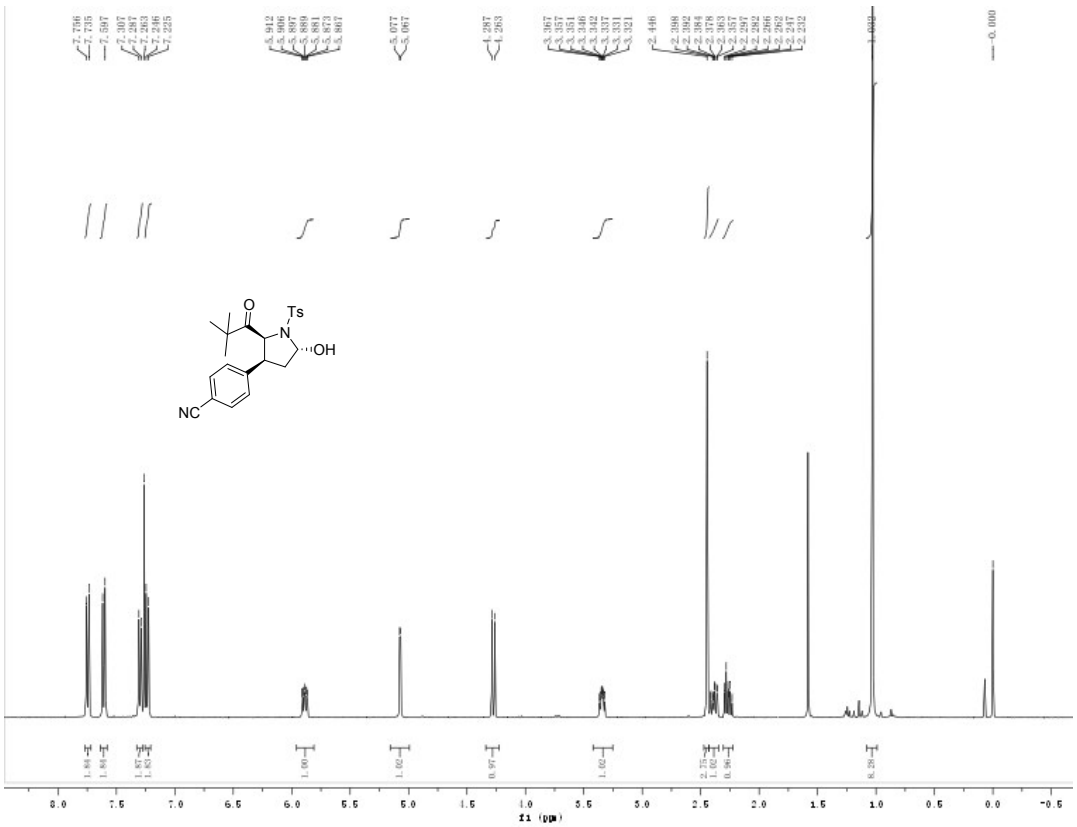
Compound **3aa'** ^{13}C NMR



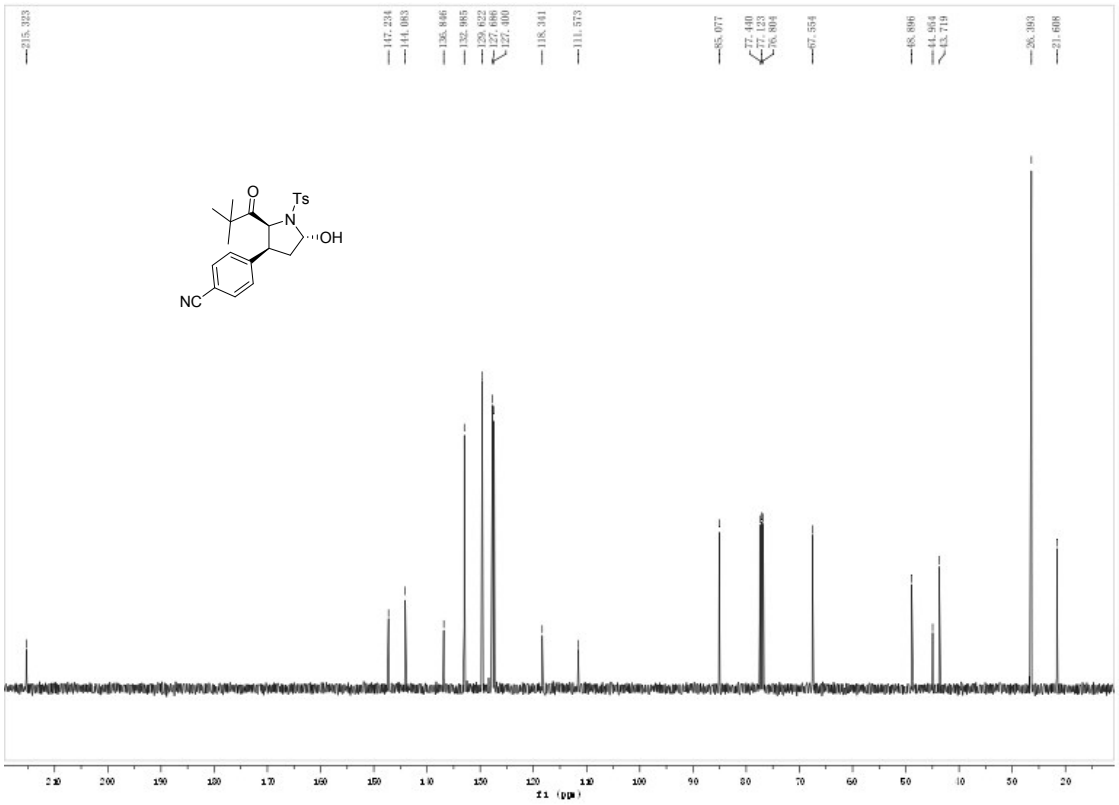
Compound **3af** ^{1}H NMR



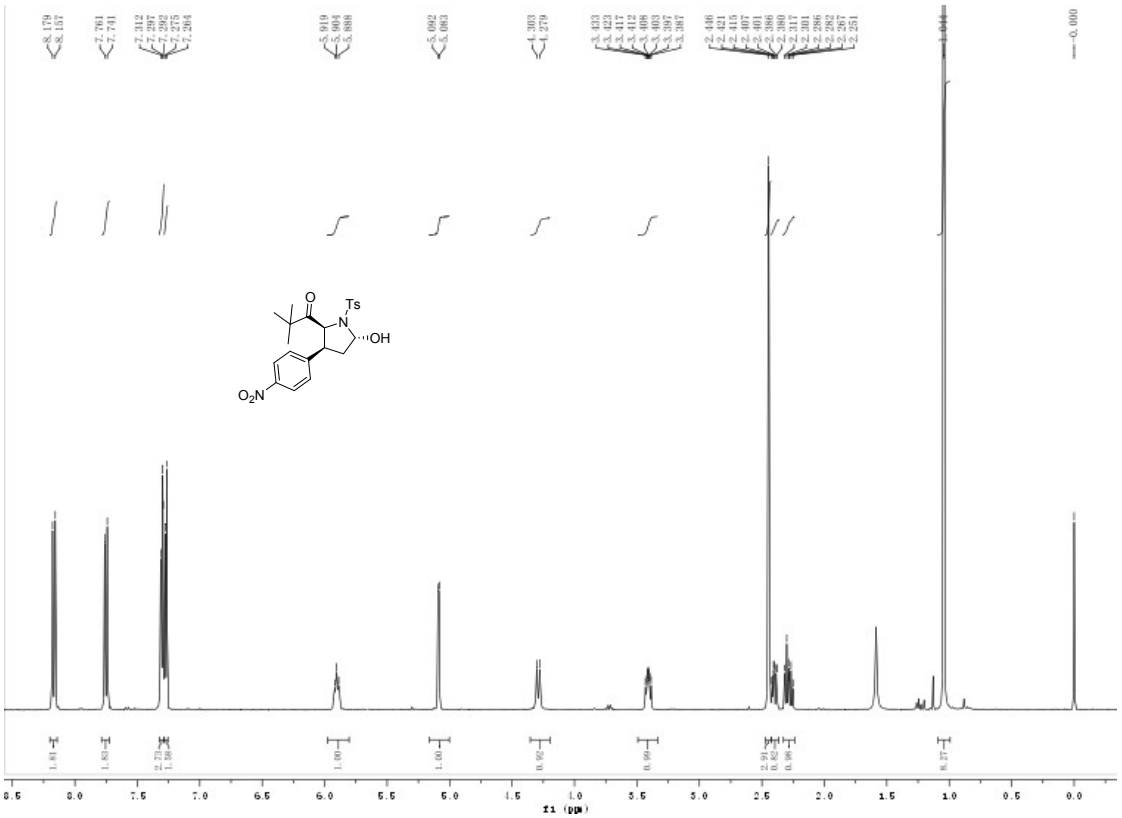
Compound **3af** ^{13}C NMR



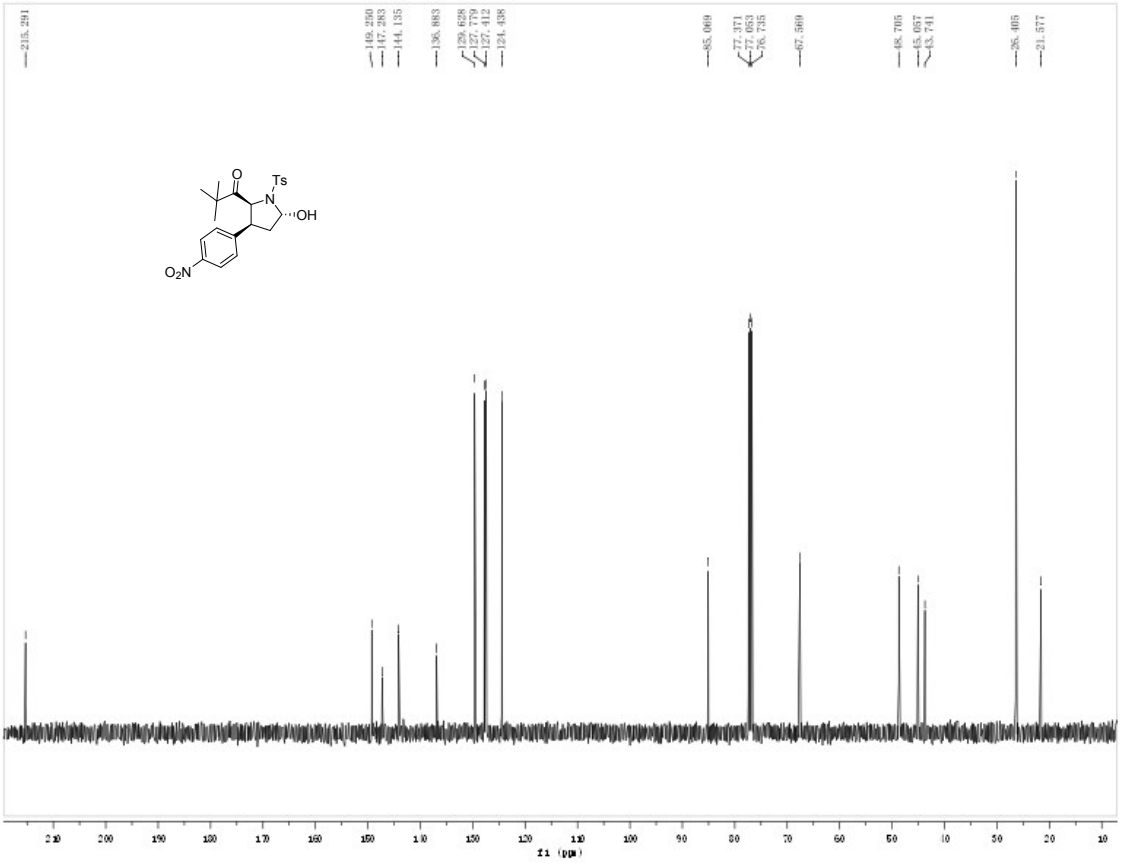
Compound **3bf** ^{1}H NMR



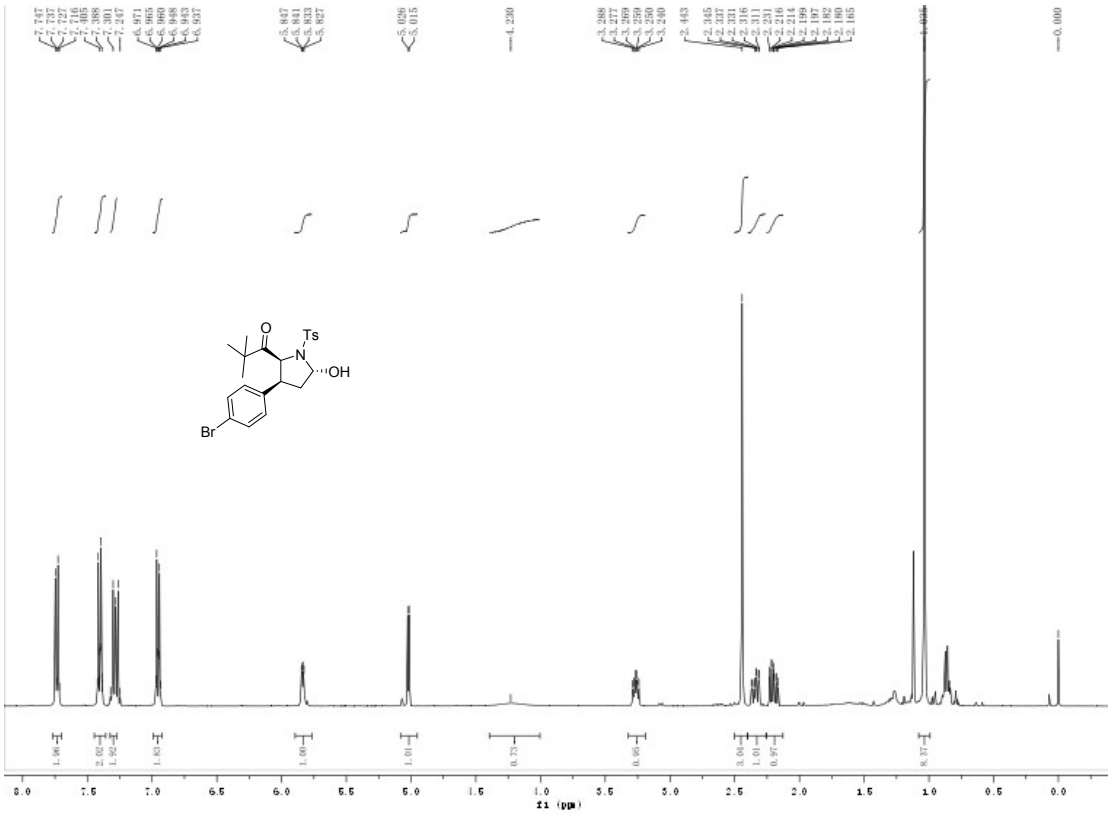
Compound **3bf** ^{13}C NMR



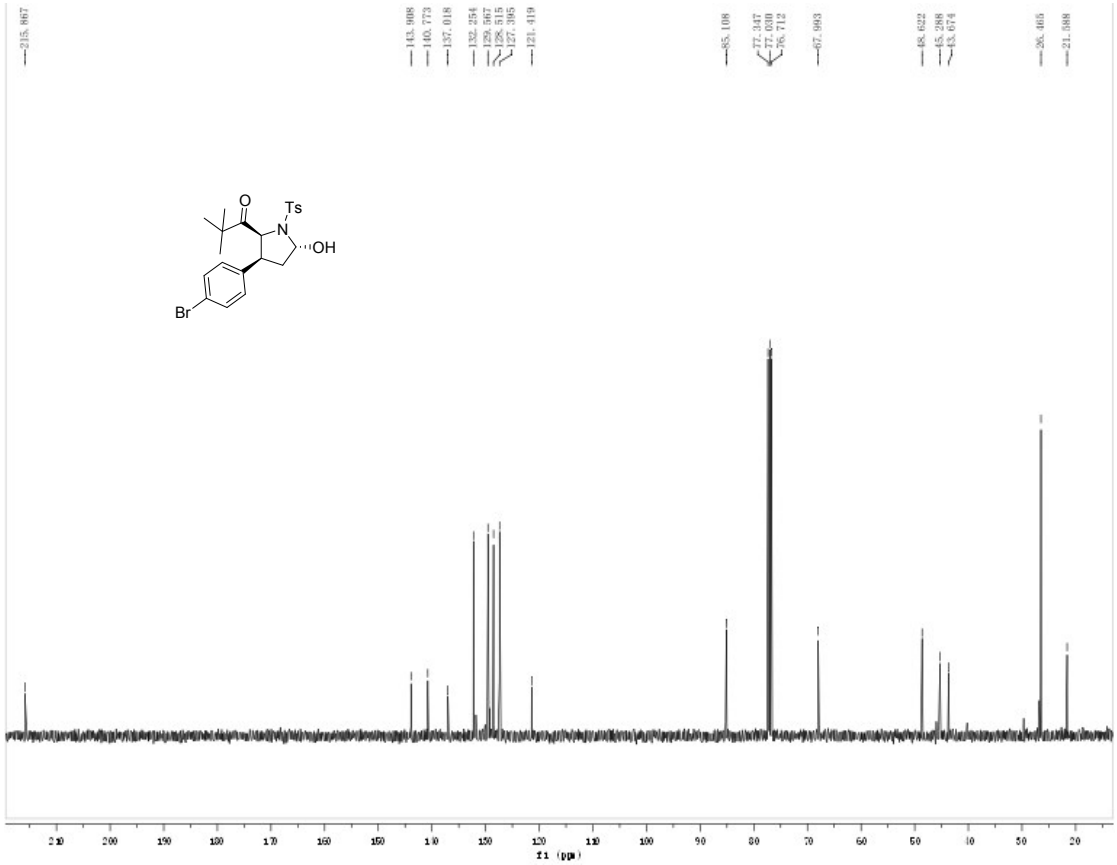
Compound **3cf** ^{1}H NMR



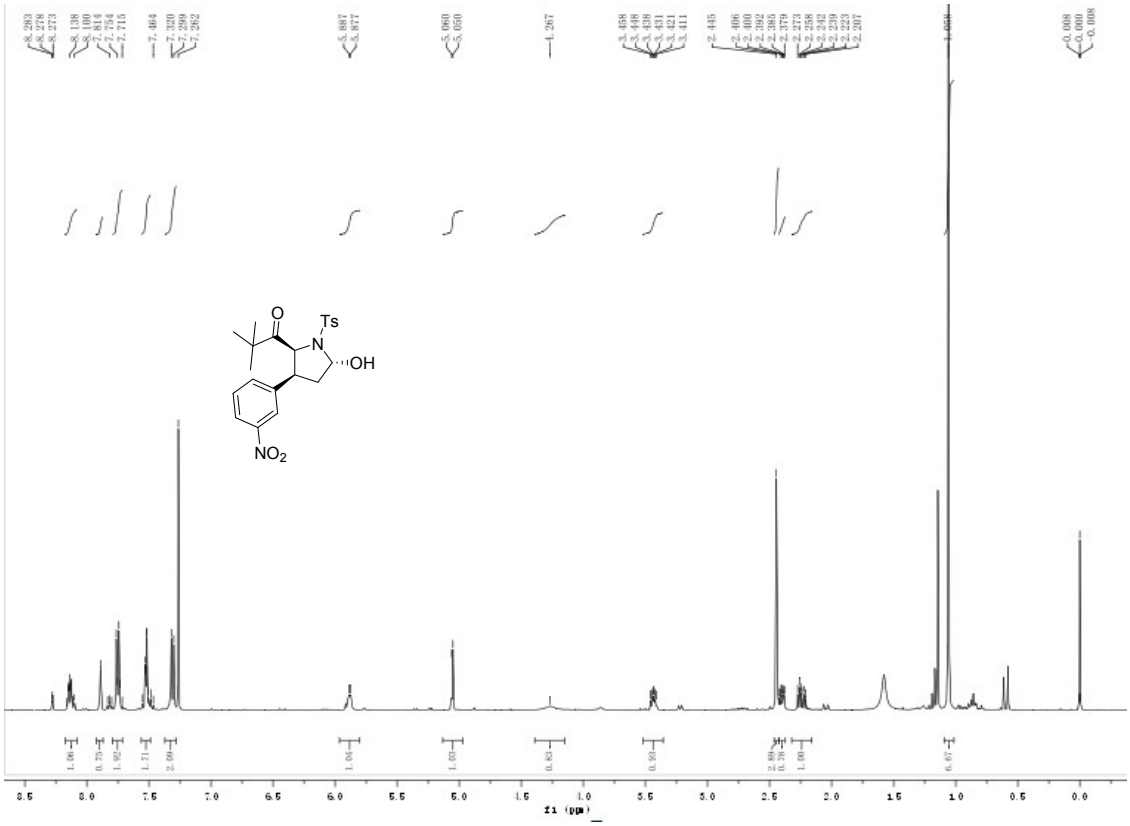
Compound **3cf** ^{13}C NMR



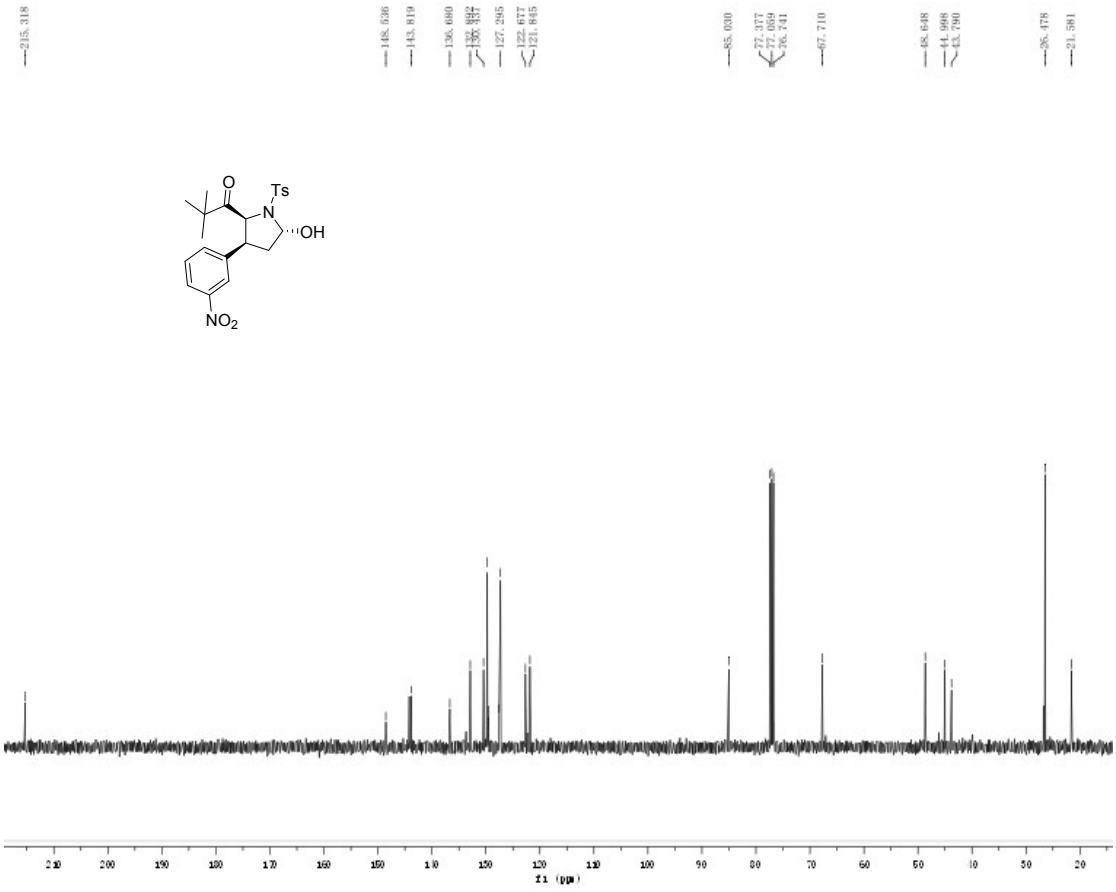
Compound **3df** ^{1}H NMR



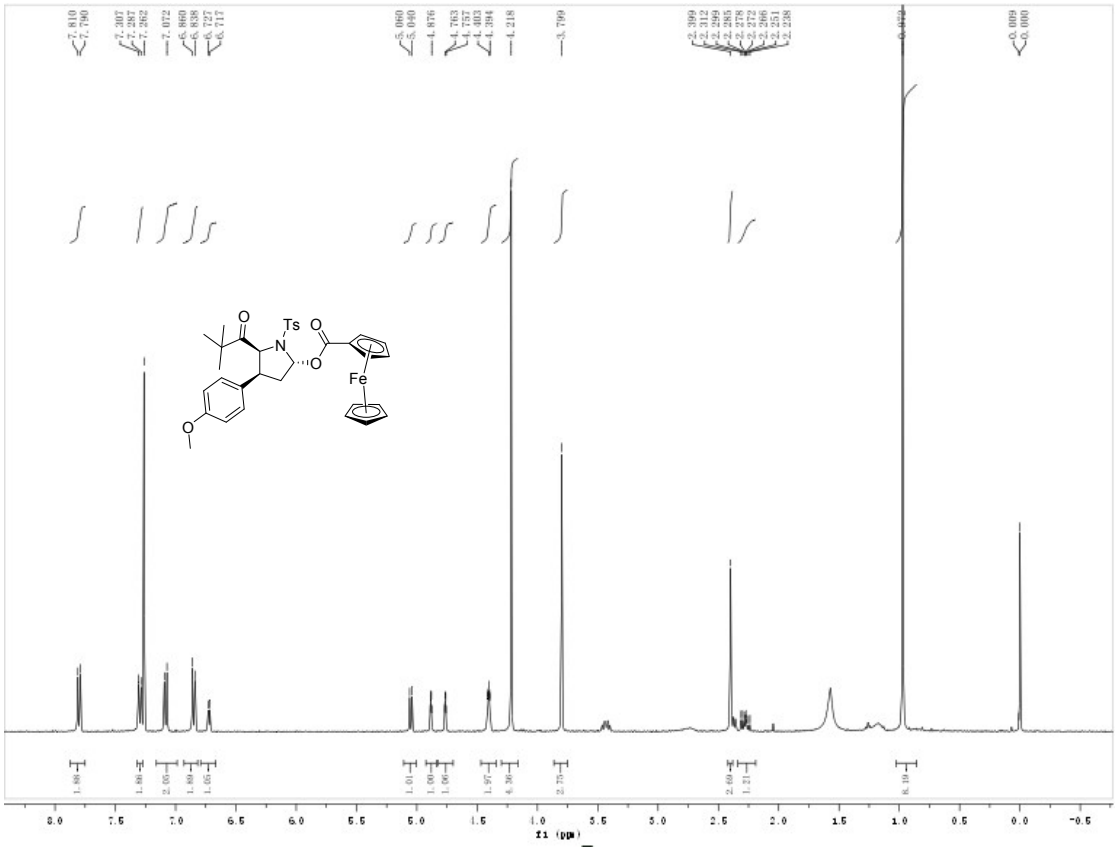
Compound **df** ^{13}C NMR



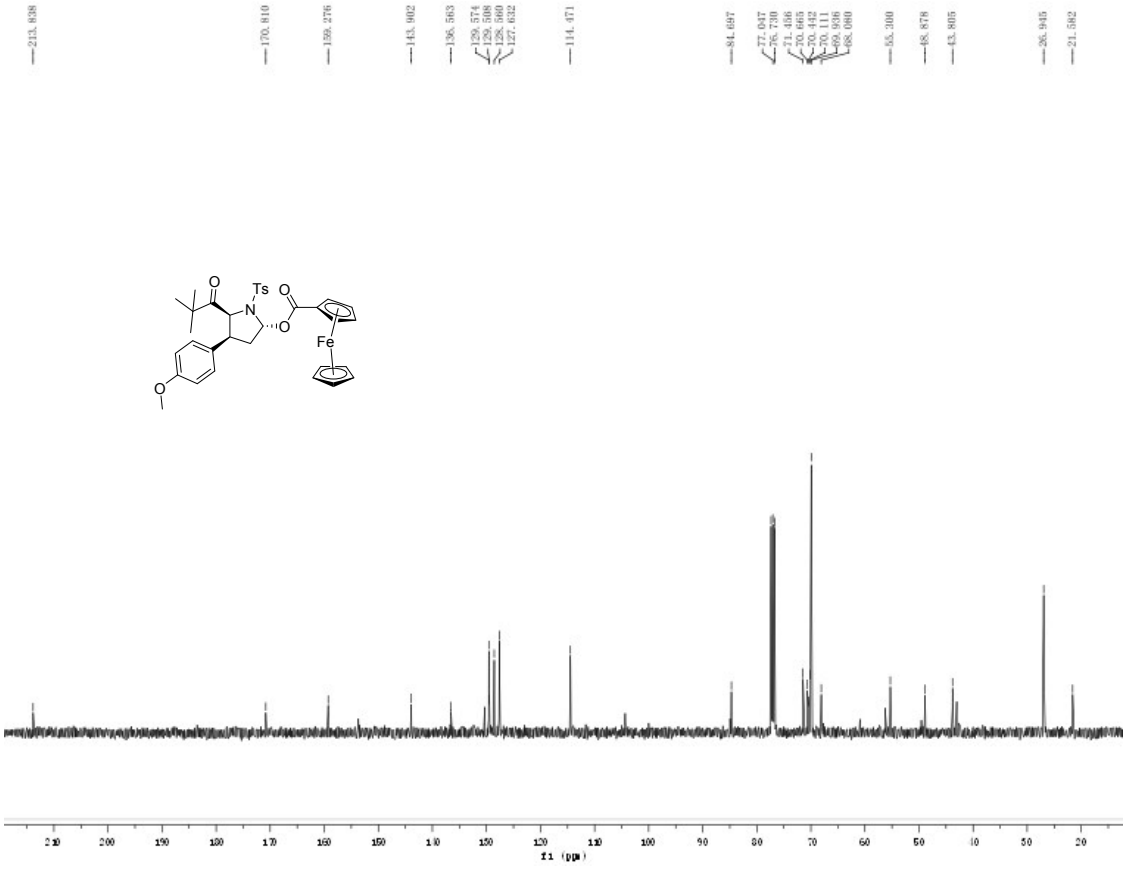
Compound **3ef** ^{1}H NMR



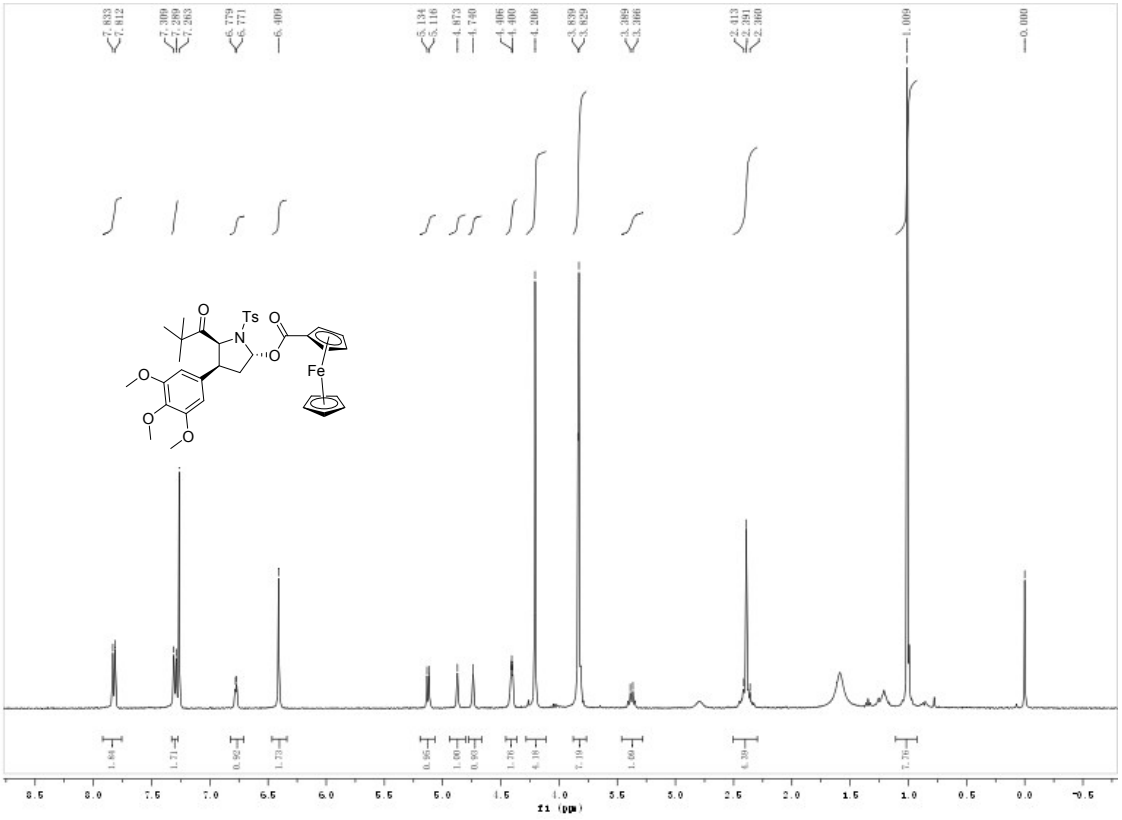
Compound **3ef** ^{13}C NMR



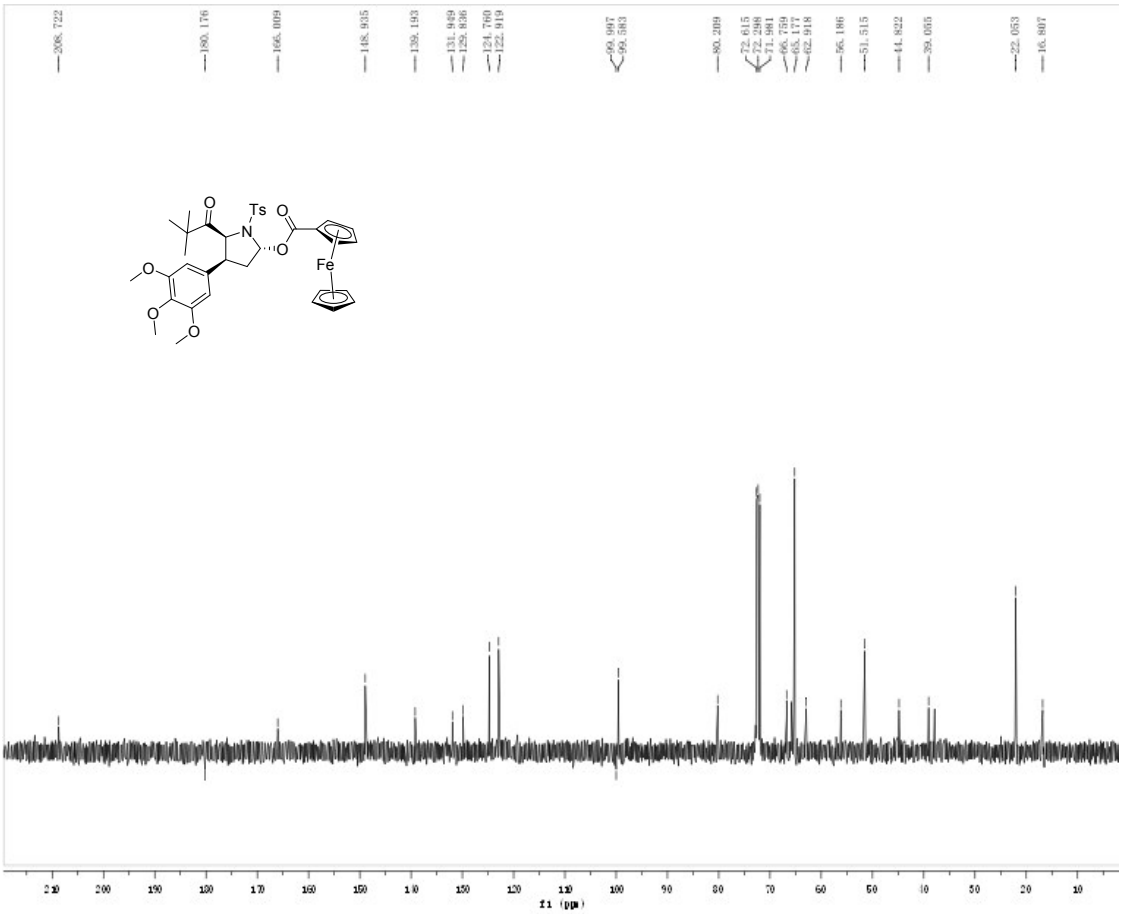
Compound **3ff** ^{1}H NMR



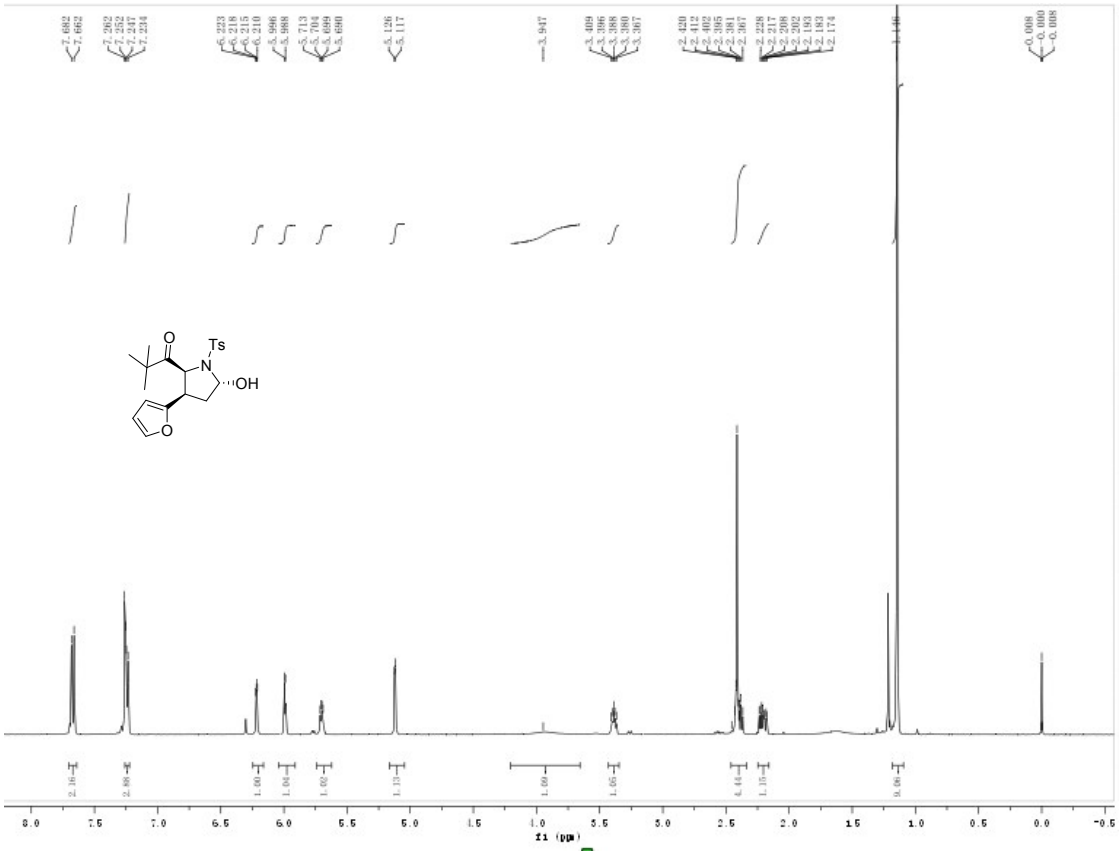
Compound **3ff** ^{13}C NMR



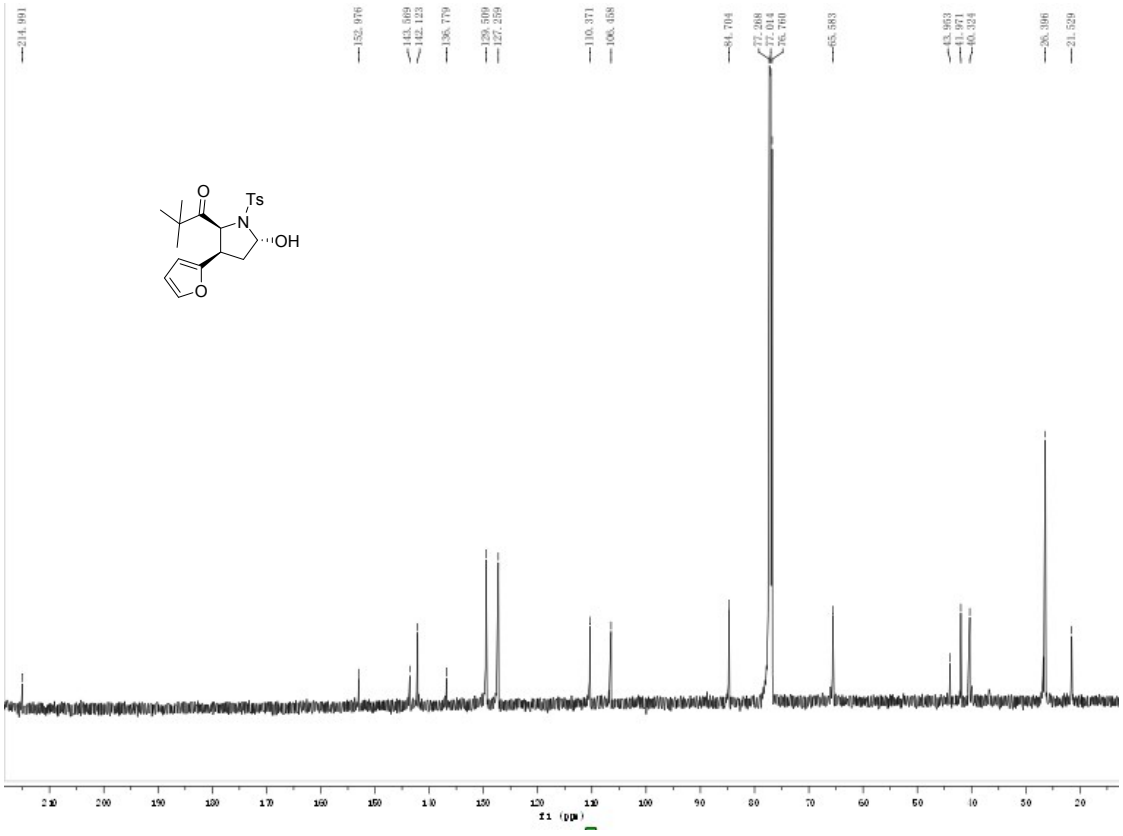
Compound **3gf** ^{1}H NMR



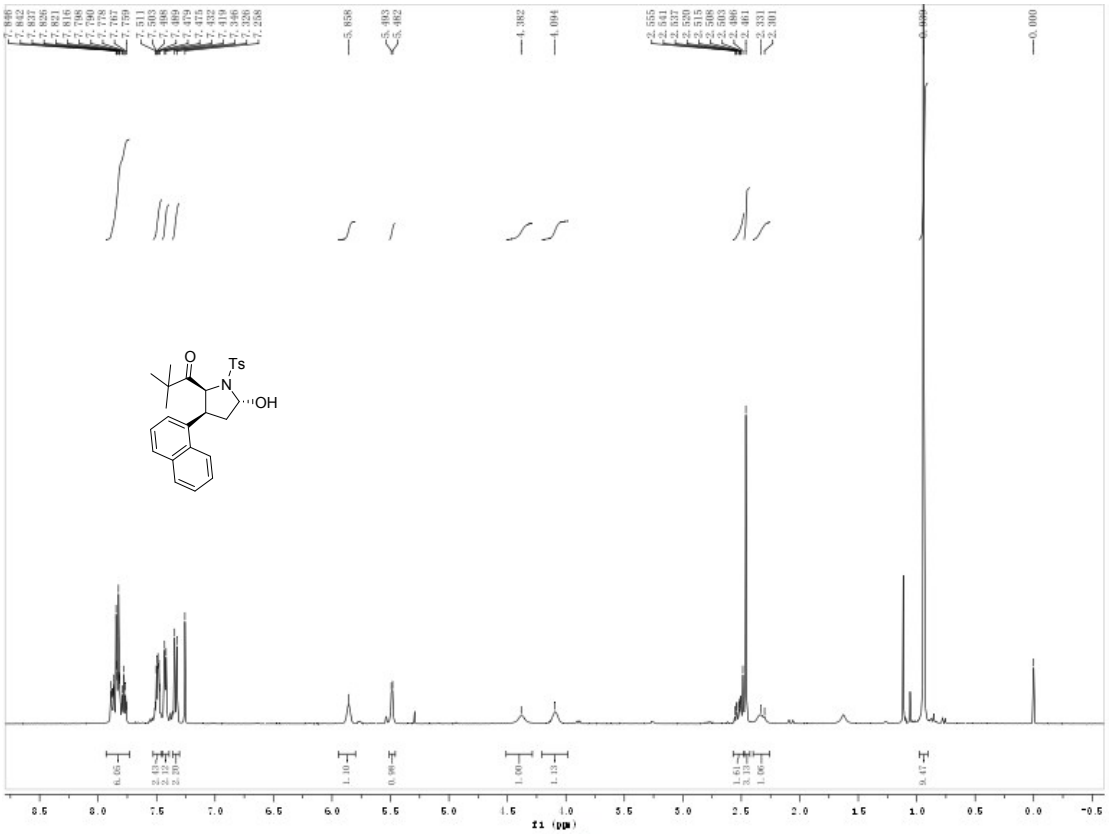
Compound **3gf** ^{13}C NMR



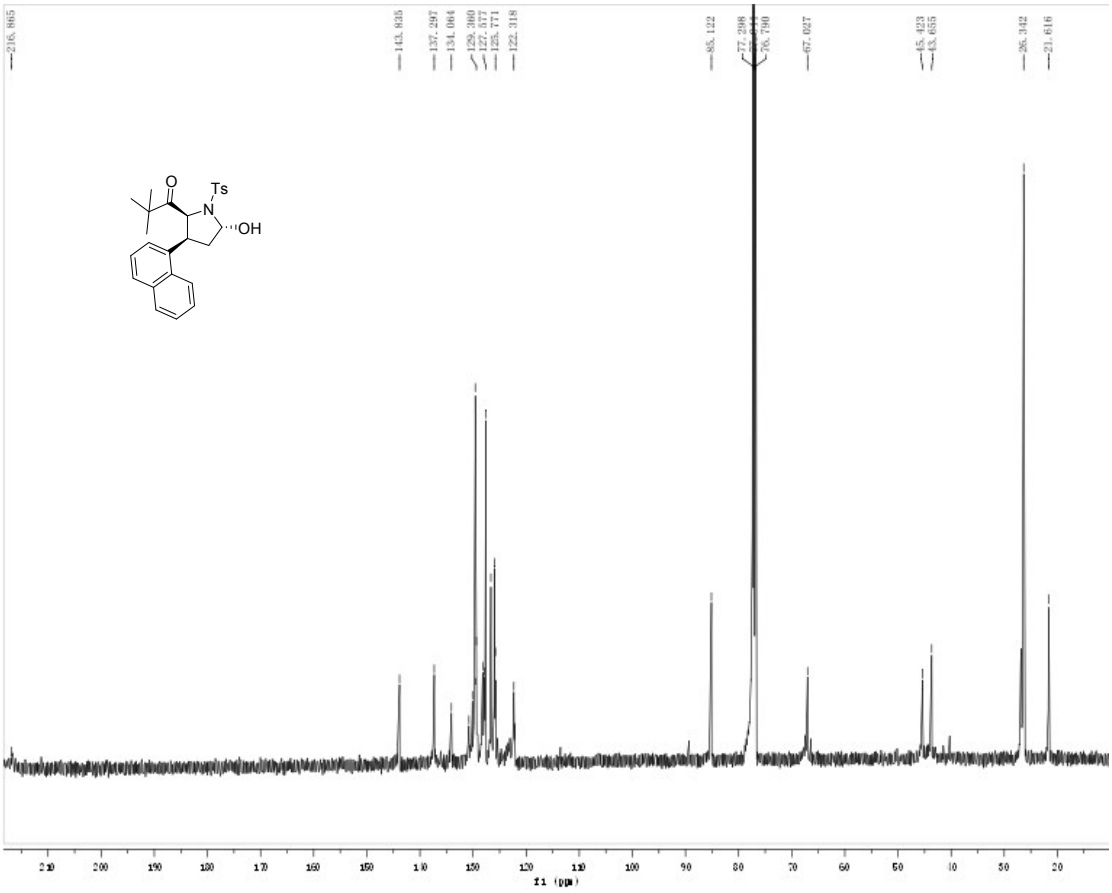
Compound **3hf** ^{1}H NMR



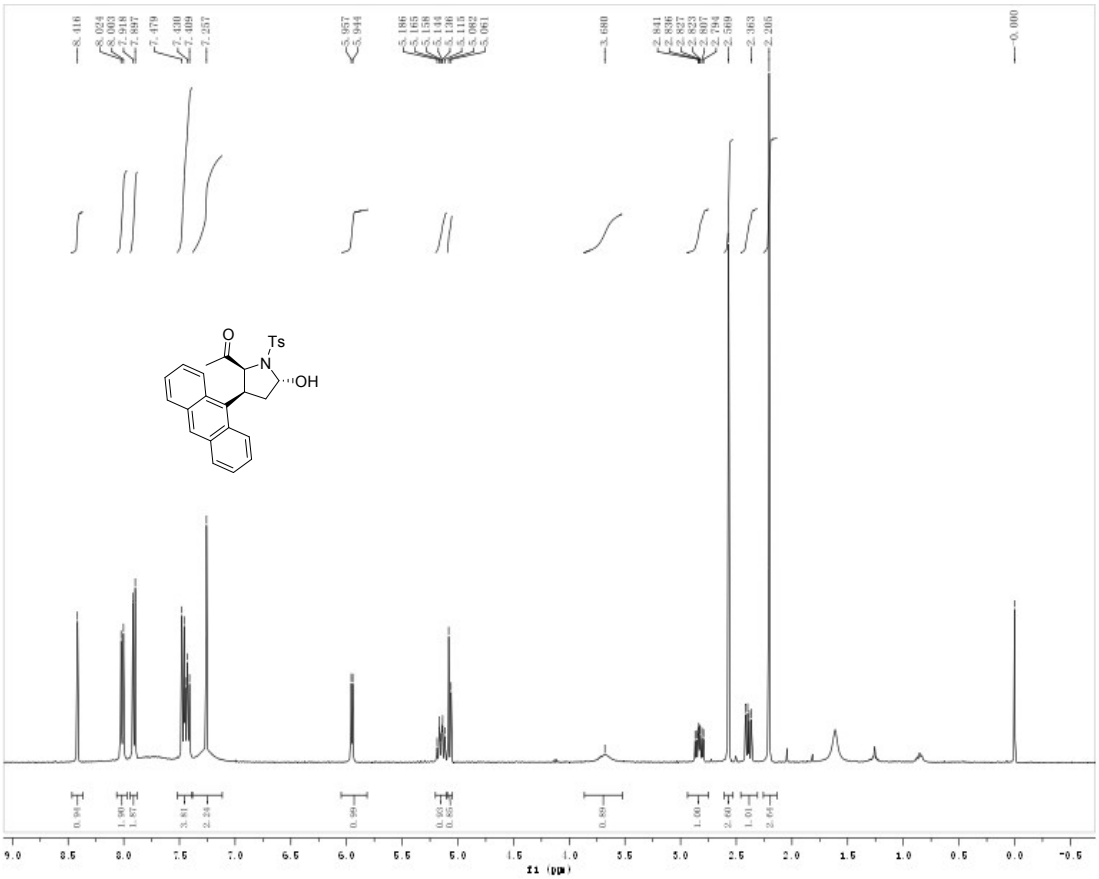
Compound **3hf** ^{13}C NMR



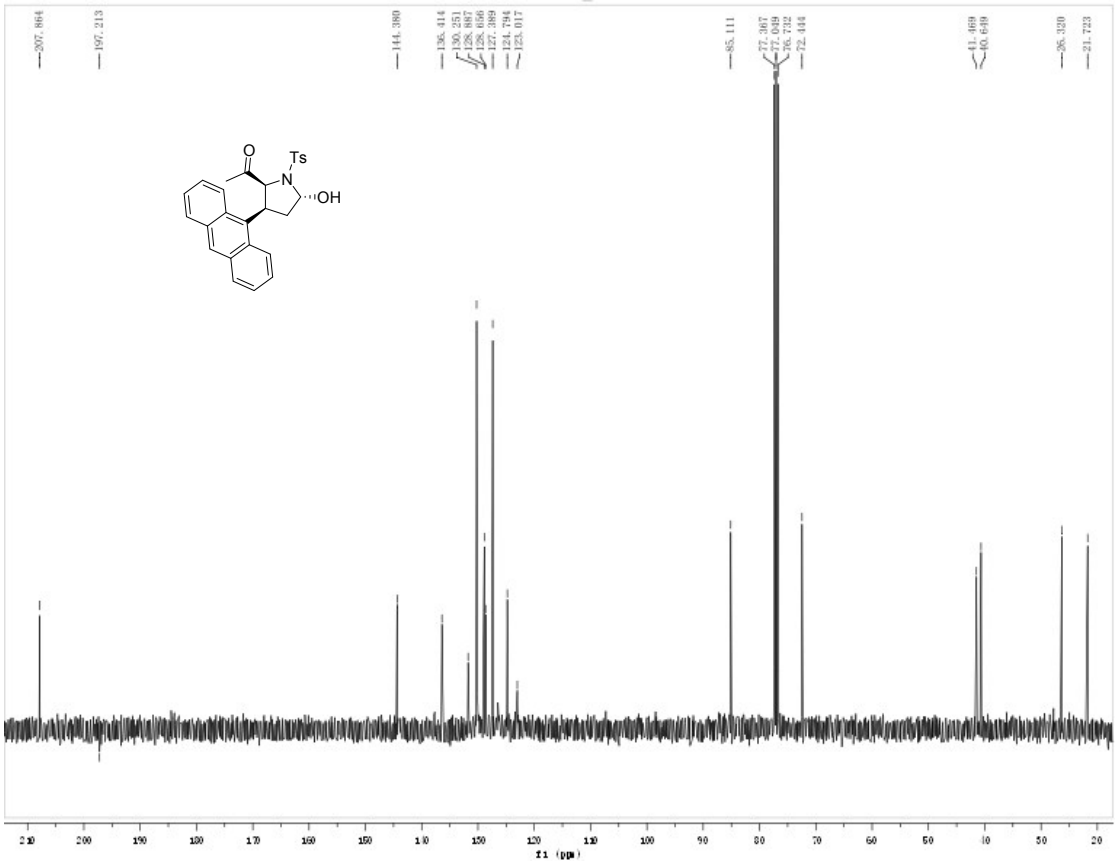
Compound **3if** ^{1}H NMR



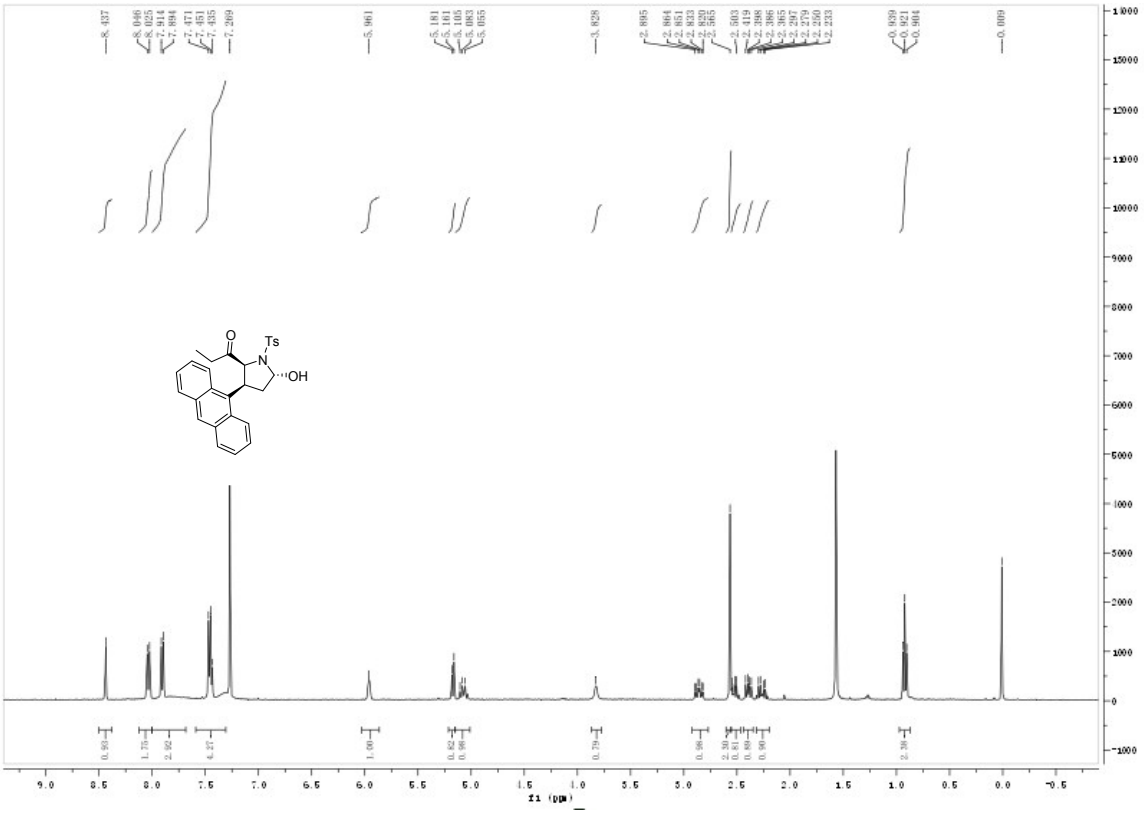
Compound **3if** ^{13}C NMR



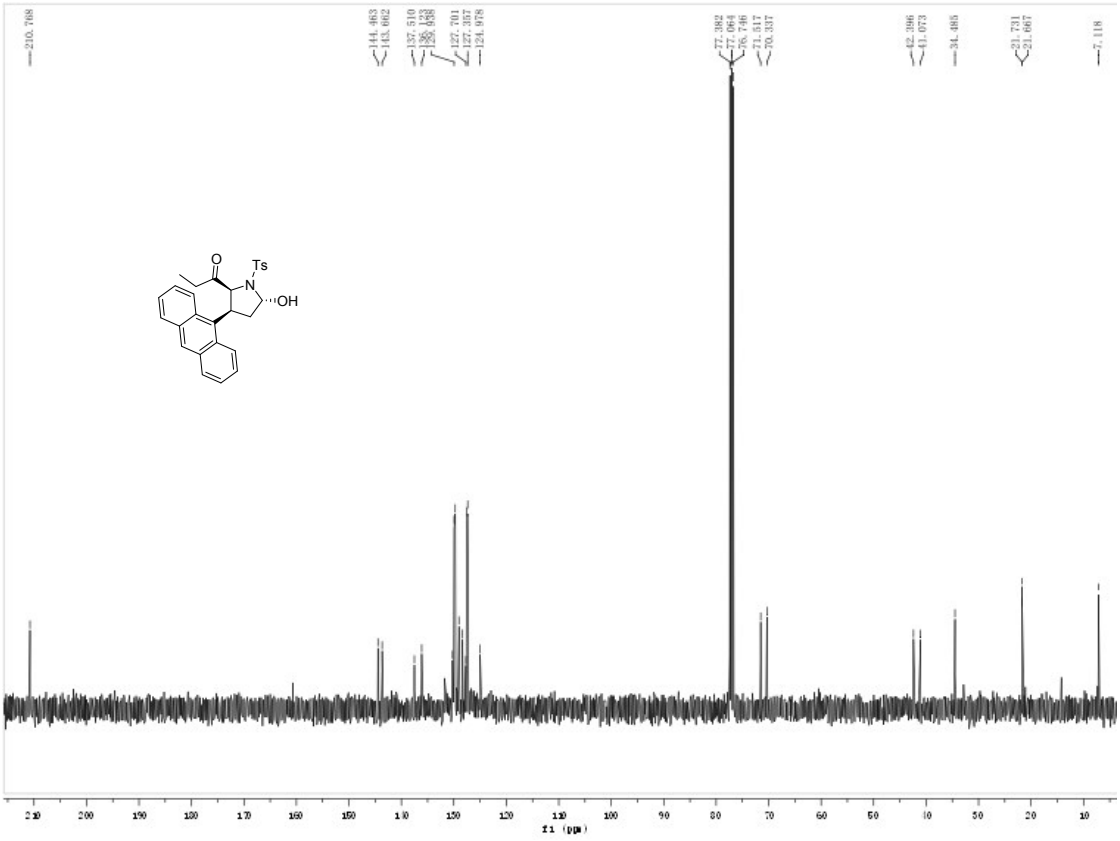
Compound **3ja** ^{1}H NMR



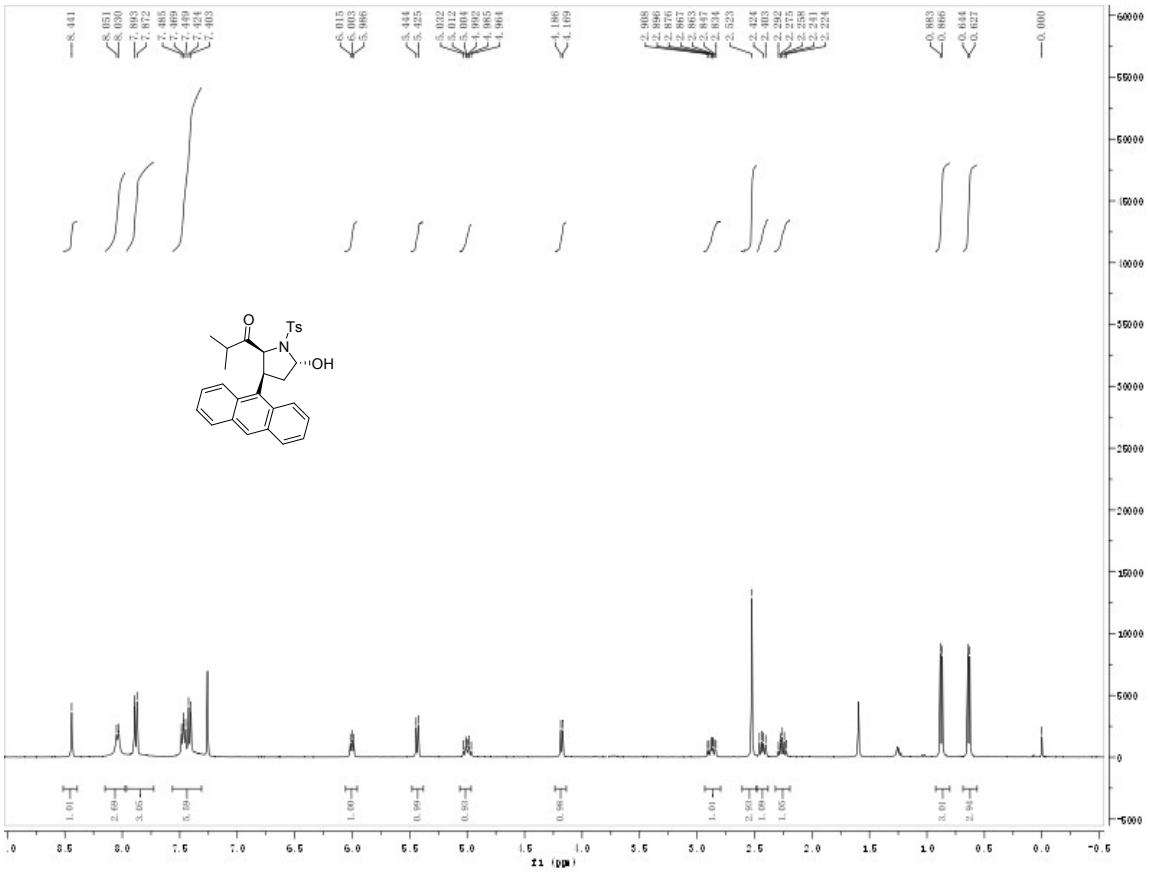
Compound **3ja** ^{13}C NMR



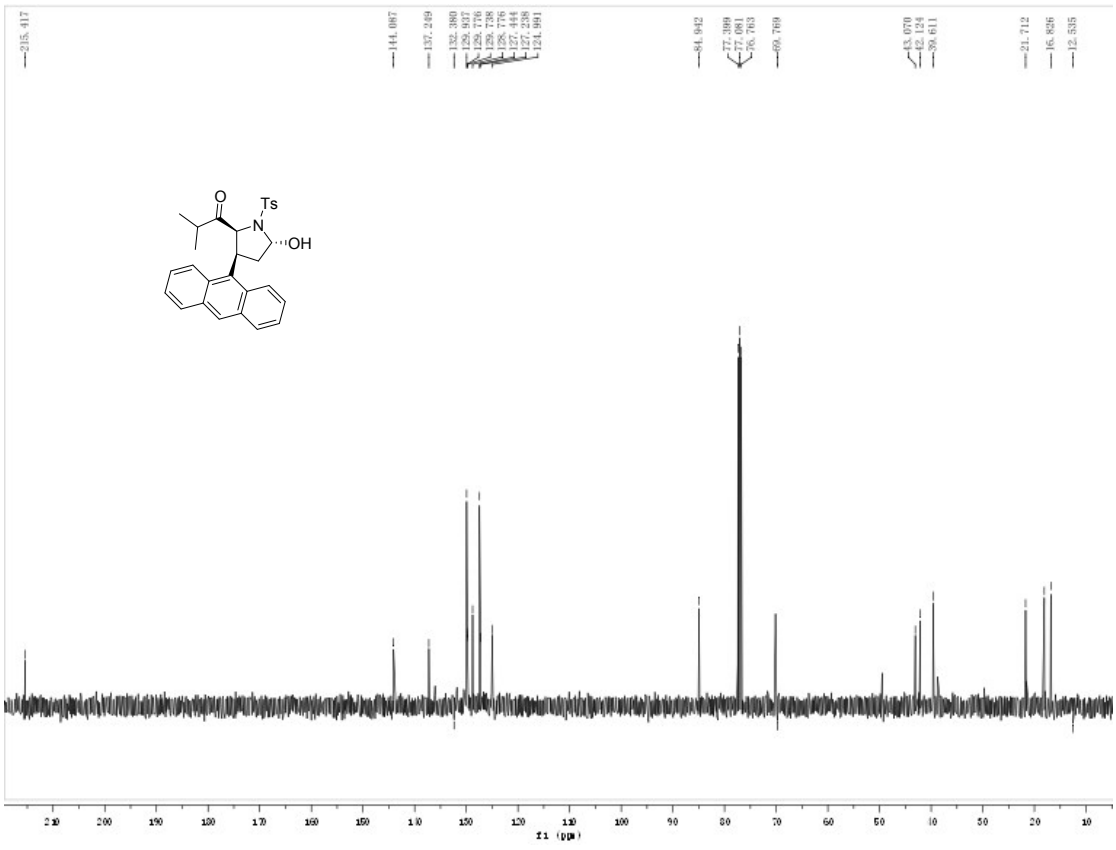
Compound **3jd** ^{1}H NMR



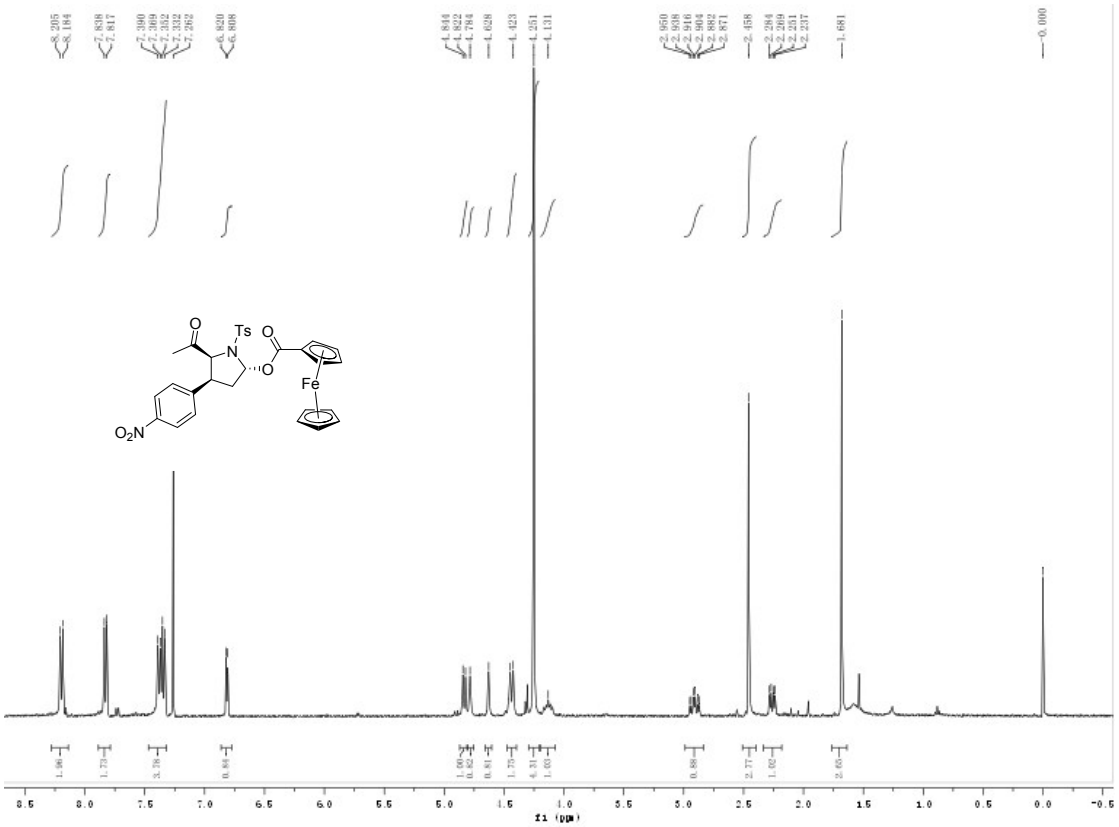
Compound **3jd** ^{13}C NMR



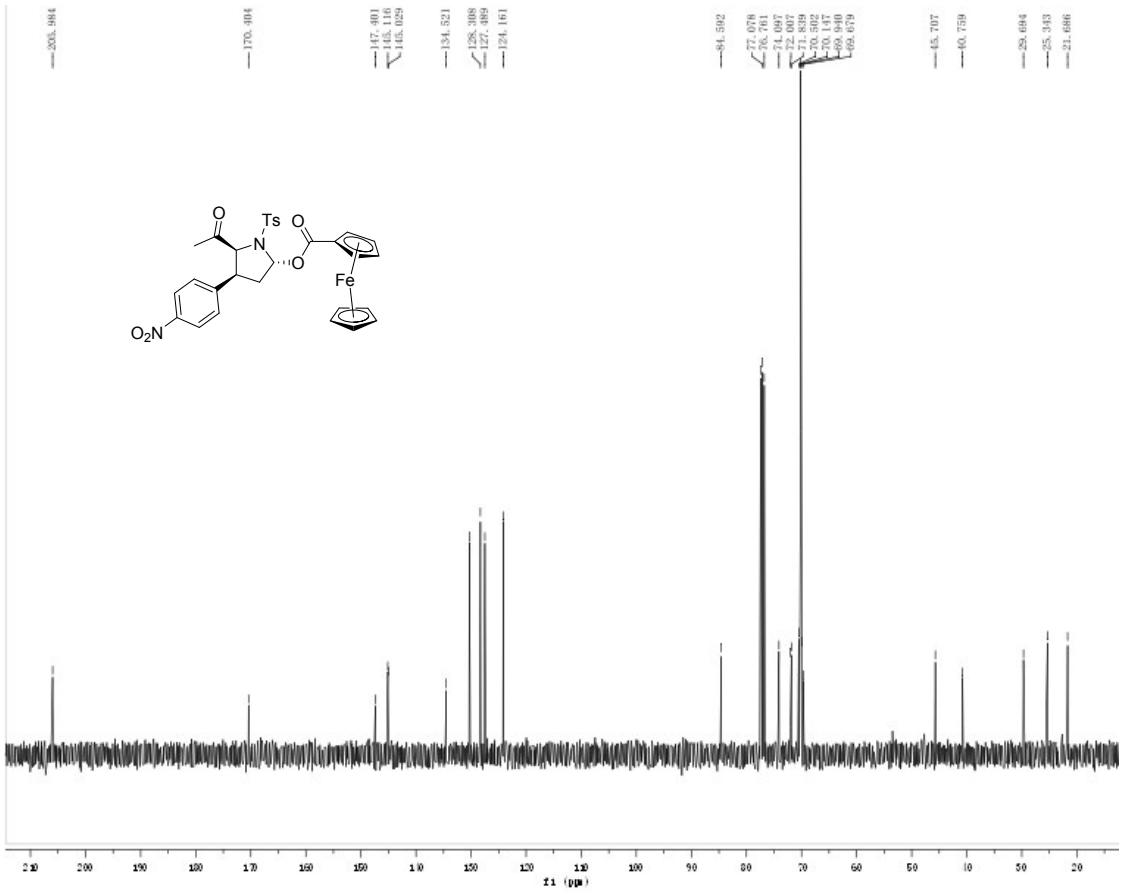
Compound **3je** ^{1}H NMR



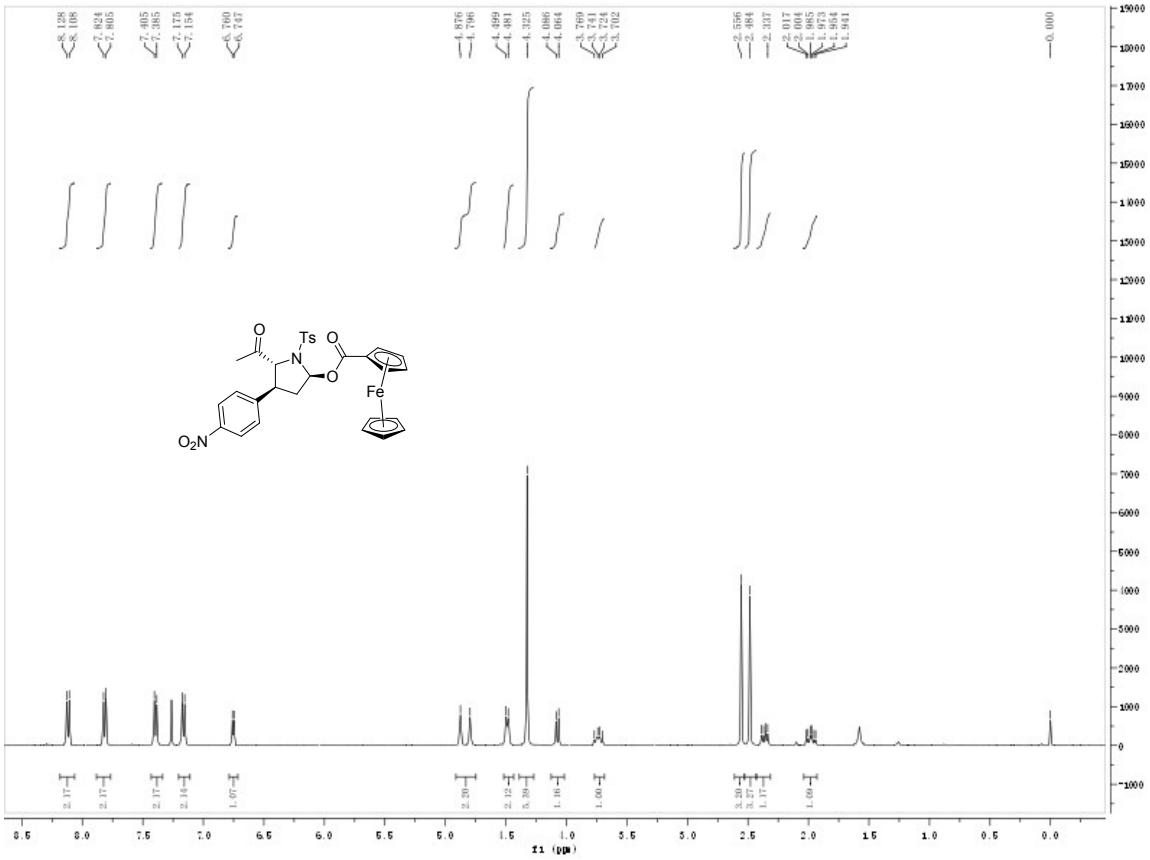
Compound **3je** ^{13}C NMR



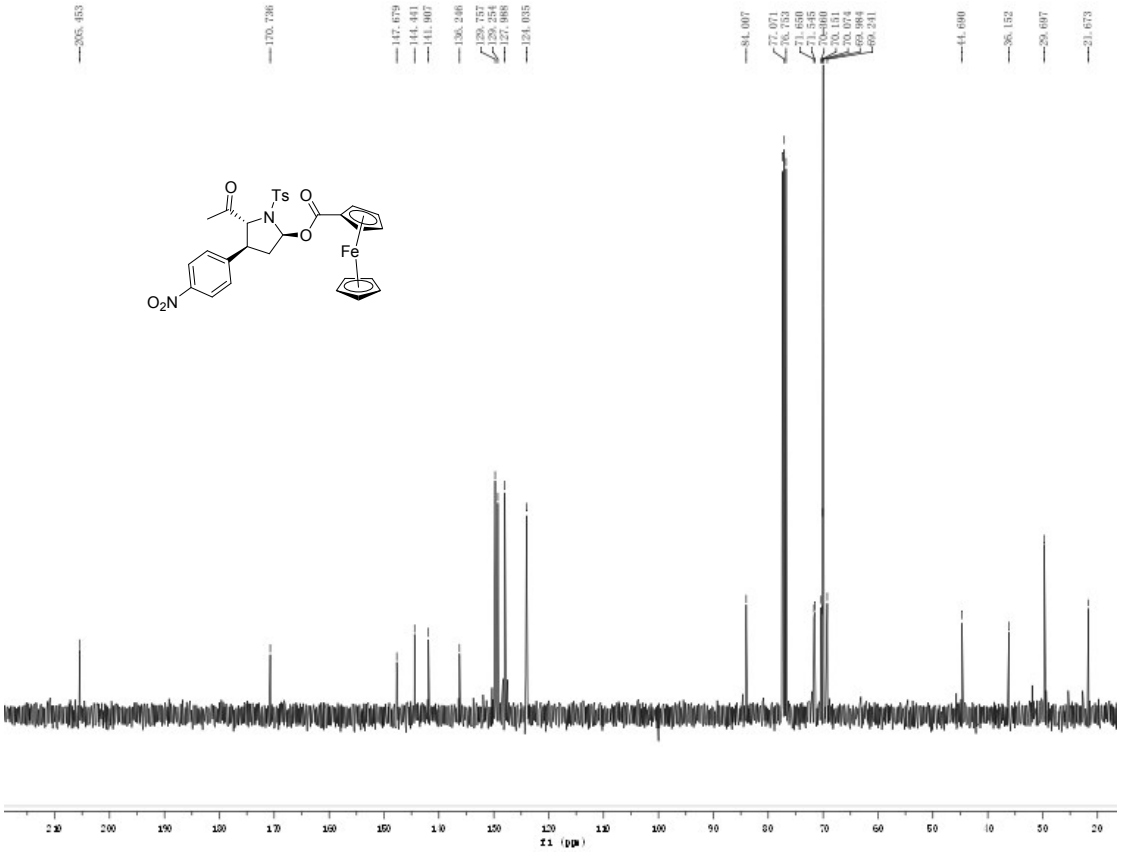
Compound **3ca** ^{1}H NMR



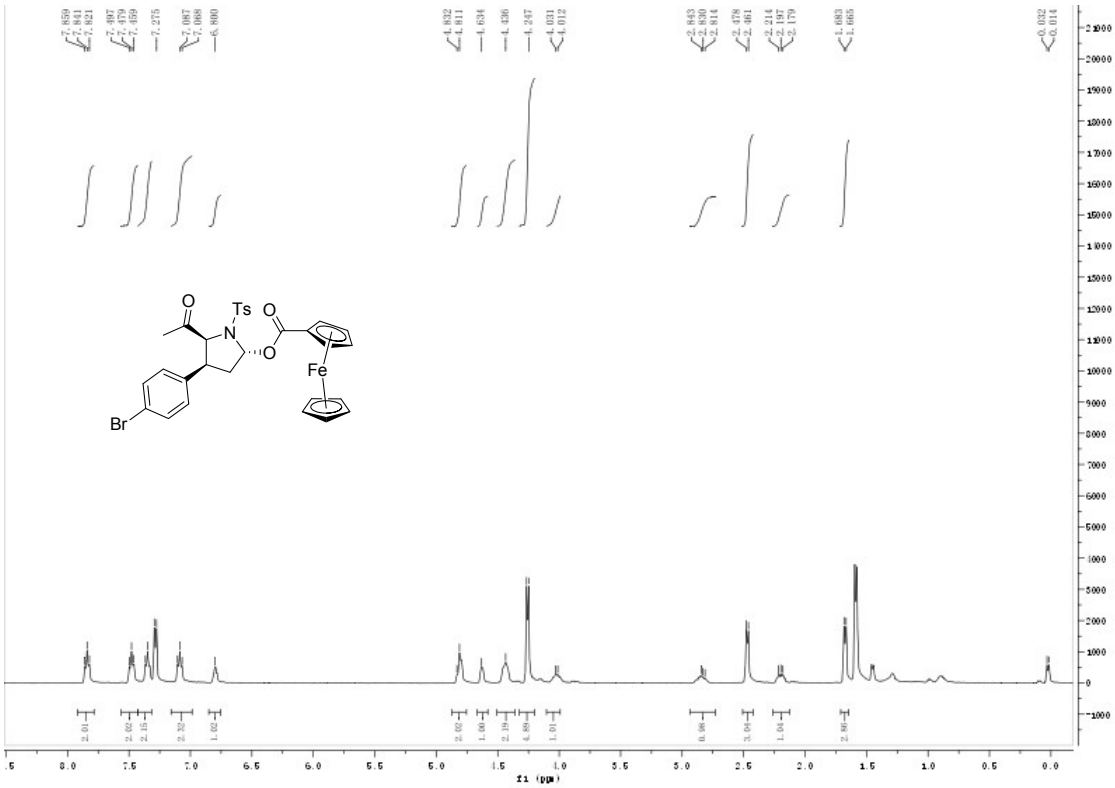
Compound **3ca** ^{13}C NMR



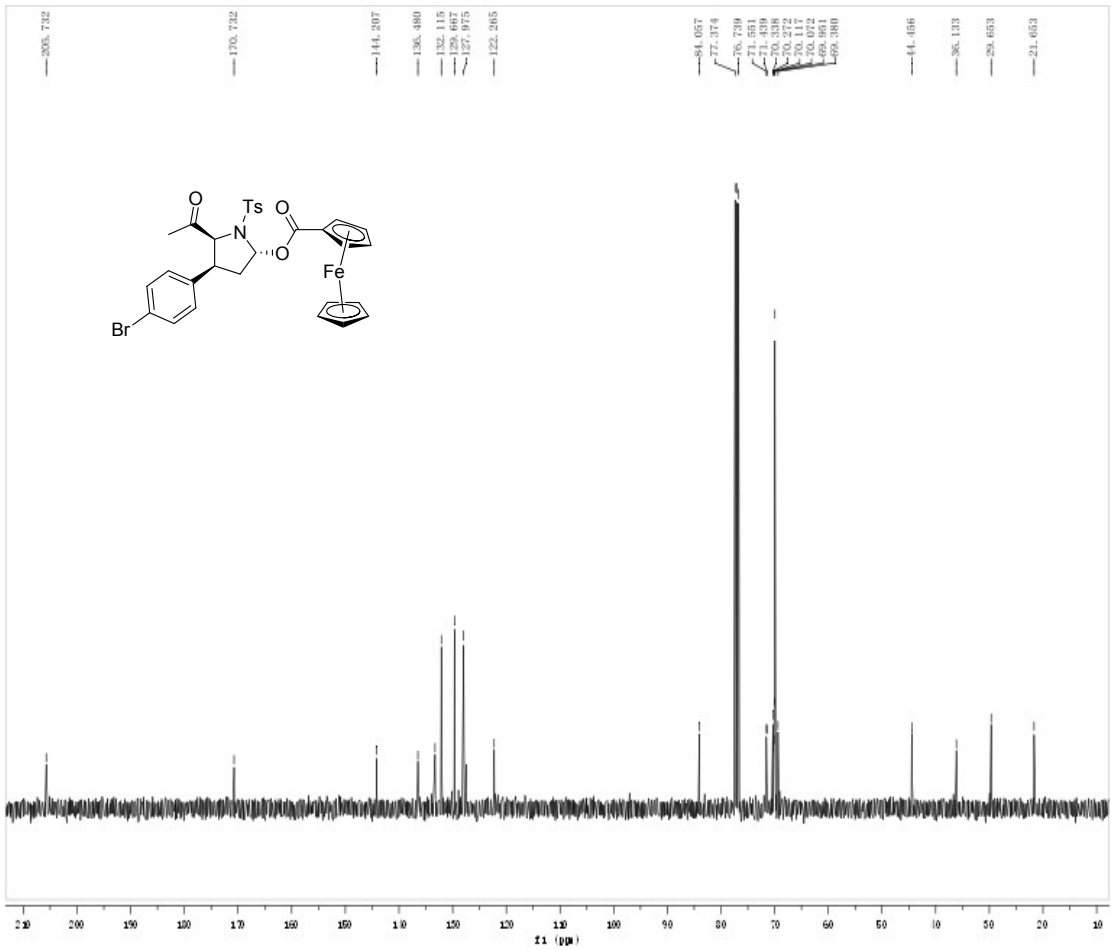
Compound **3ca'** ^{1}H NMR



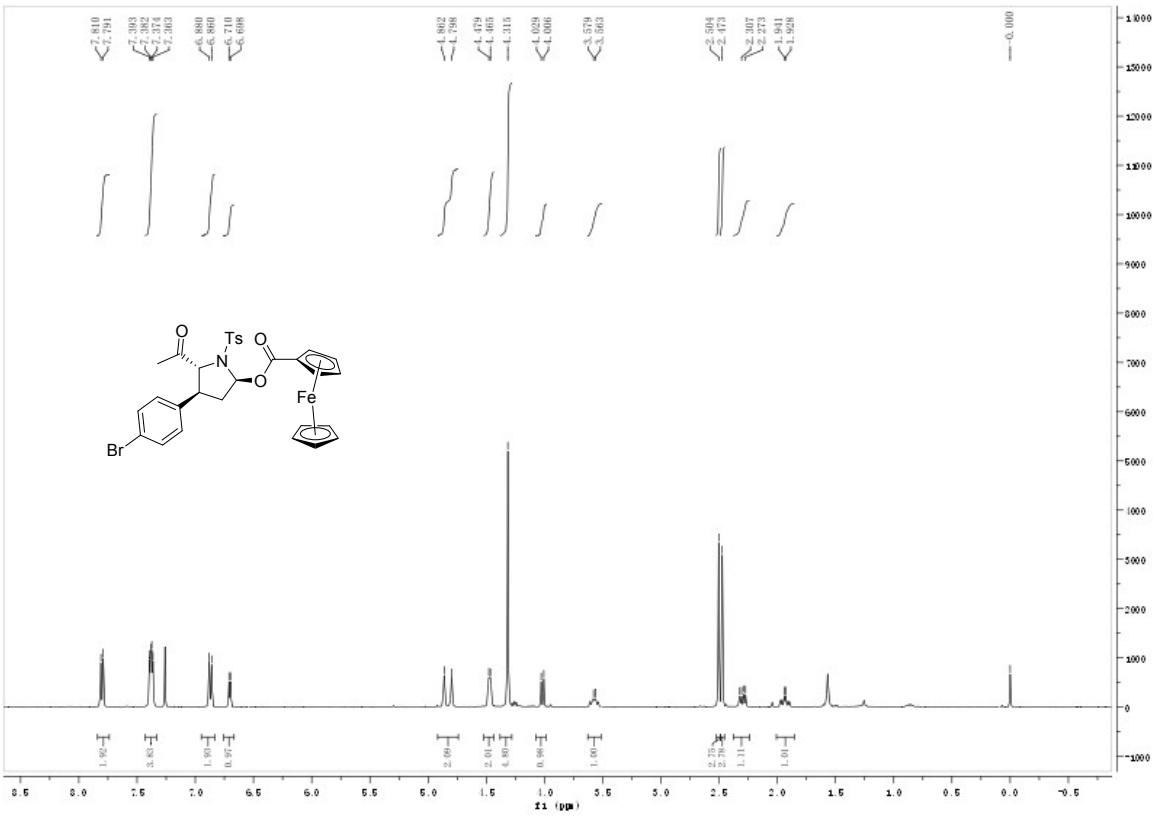
Compound **3ca'** ^{13}C NMR



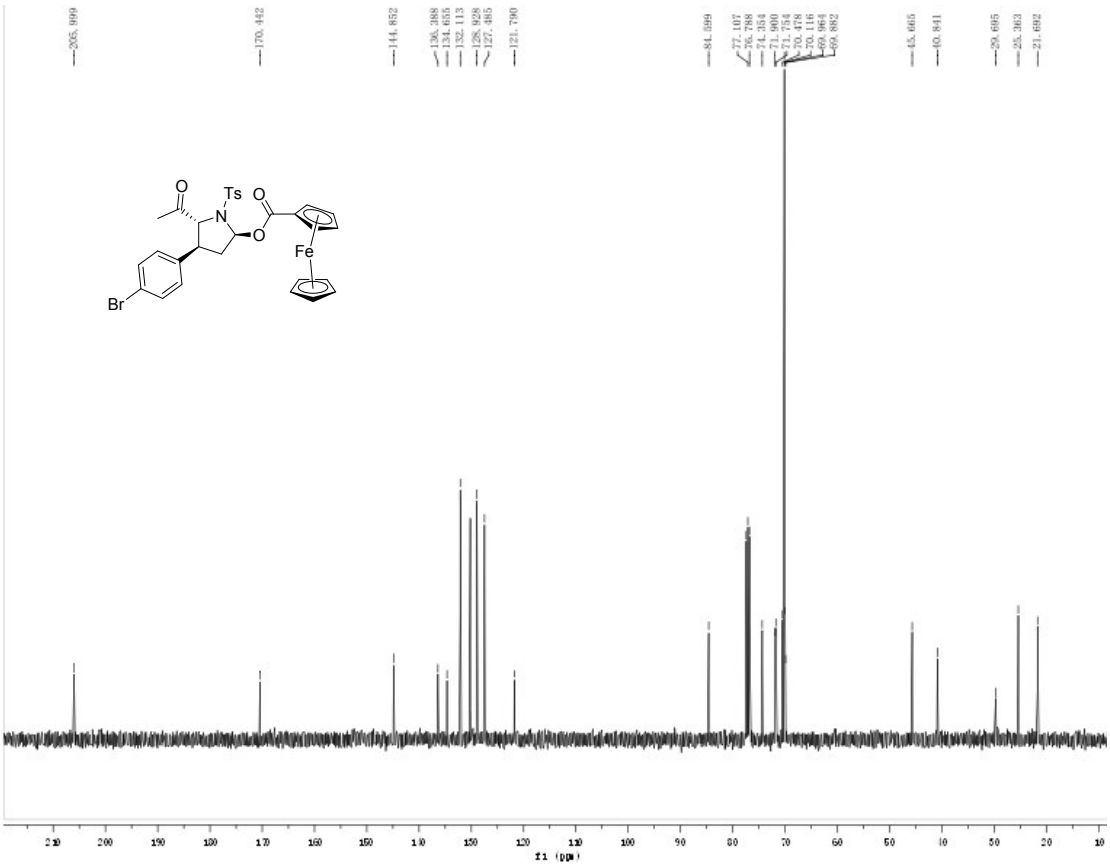
Compound **3da** ^{1}H NMR



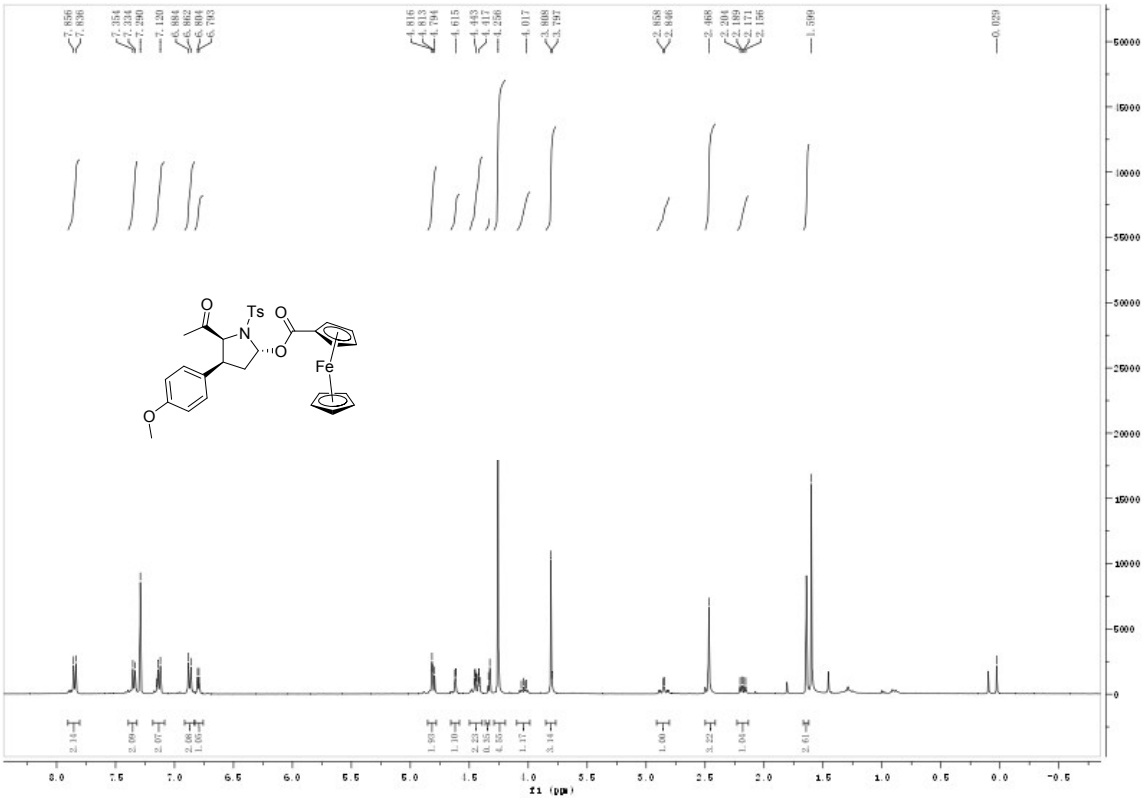
Compound **3da** ^{13}C NMR



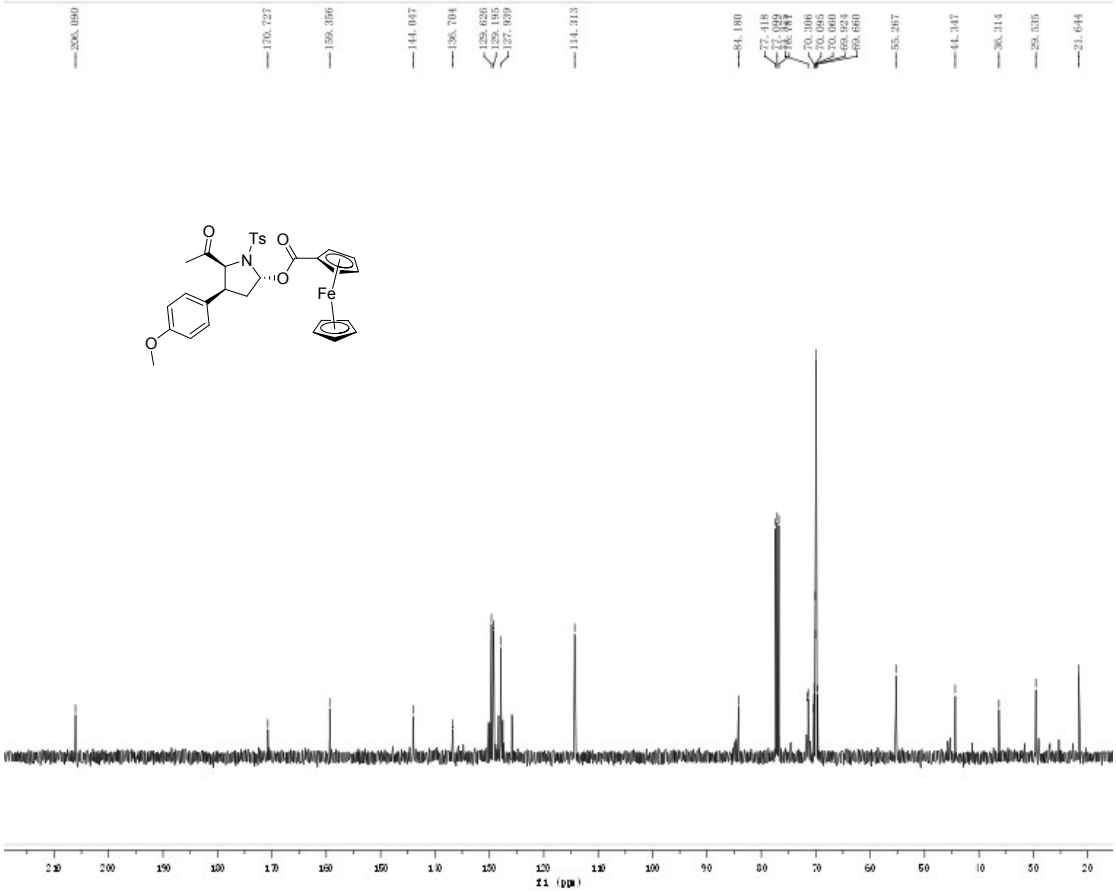
Compound **3da'** ^{1}H NMR



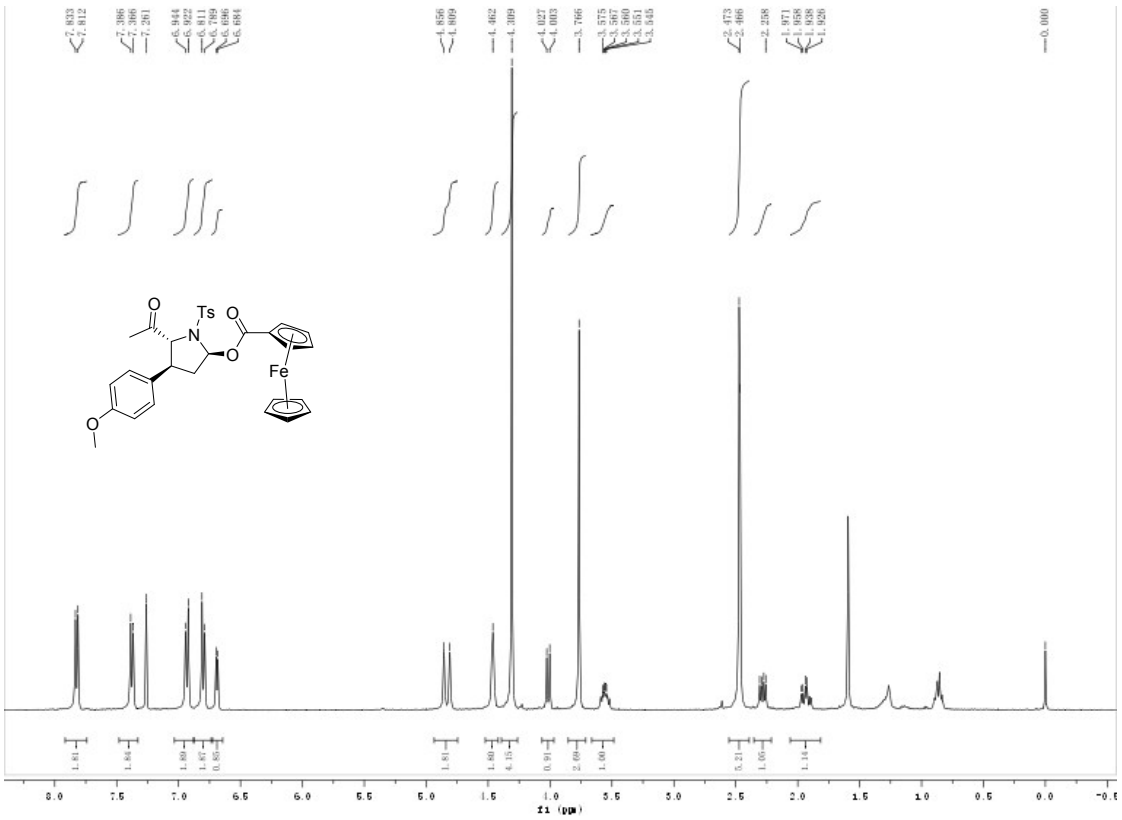
Compound **3da'** ^{13}C NMR



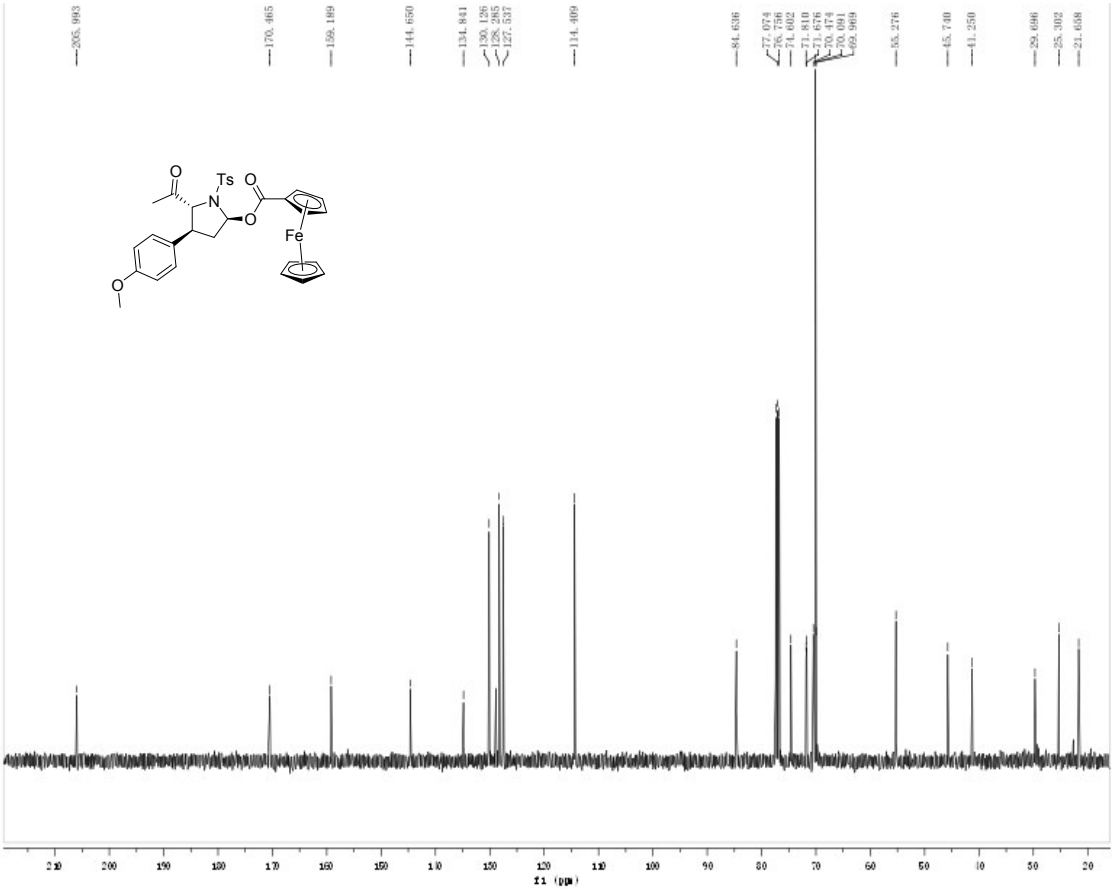
Compound **3fa** ^{1}H NMR



Compound **3fa** ^{13}C NMR



Compound **3fa'** ^{1}H NMR



Compound **3fa** ^{13}C NMR