Enantioselective Formal [3+2]-Cycloadditions to Access Spirooxindoles Bearing Four Contiguous Stereocenters through Synergistic Catalysis

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Supporting Information

Contents

1. General Information

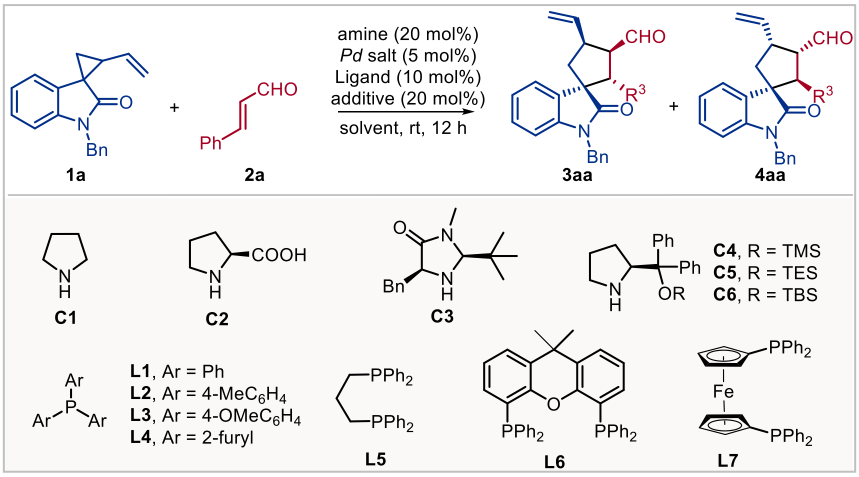
Unless otherwise noted, all the reagents were purchased from commercial suppliers and used without further purification. All solvents and commercially available reagents were either purified via literature procedures or used without further purification. ^{1}H NMR spectra were recorded on a Bruker Avance III 400 MHz. ^{13}C NMR data were collected at 100 MHz with complete proton decoupling. The chemical shifts were recorded in ppm relative to tetramethylsilane and with the solvent resonance as the internal standard. Data were reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz), integration. Chemical shifts were reported in ppm from the tetramethylsilane with the solvent resonance as internal standard. High resolution mass spectroscopy (HRMS) was recorded on TOF MS ESI^{+} mass spectrometer and acetonitrile was used to dissolve the sample. Melting points were determined with a WRX-4 melting apparatus. High-performance liquid chromatography (HPLC) was performed on a Shimadzu LC 20 system equipped with a variable wavelength detector using Chiralcel OD-H, AD-H, AS-H and IA column from Daicel. Optical rotations were measured on a WZZ-3 digital polarimeter with a sodium lamp and reported as follows; $[\alpha]_{\mathrm{D}}^{\mathrm{T}\,℃}$ (c = g/100 mL, solvent). Flash Column chromatography was carried out on silica gel (200-300 mesh). Thin layer chromatography was carried out on TLC plates coated with silica gel 60 F_{254} with fluorescence indicator. For the detection of the signals ultraviolet light (λ = 254 nm) was used. The spirovinylcyclopropyl oxindoles **1** were prepared according to the procedures reported previously.[1]

2. Experimental Procedures and Characterization Data

2.1 Optimization of reaction conditions

We also turned our attention to screening various additives to improve the yield of this reaction (Table S1, entries 1-10). Gratifyingly, acetic acid (AcOH) was selected as the best additive and gave the adduct in 89% yield with excellent ee value (Table S1, entry 3). Subsequently, a variety of palladium salts, including $Pd(OTFA)_2$ and Pd_2dba_3 were also screened, but led to inferior results (Table S1, entries 4-5). While using $PPh_3/Pd(OAc)_2$ as catalyst and AcOH as additive, other solvents such as MeCN (acetonitrile), THF (tetrahydrofuran), toluene, methanol and DMF (*N*,*N*-dimethylformamide) were next examined. To our delight, THF gave slightly better results in terms of diastereoselectivities and enantioselectivities in comparison with other solvents (Table S1, entry 7 *versus* entry 6 & entries 8-10).

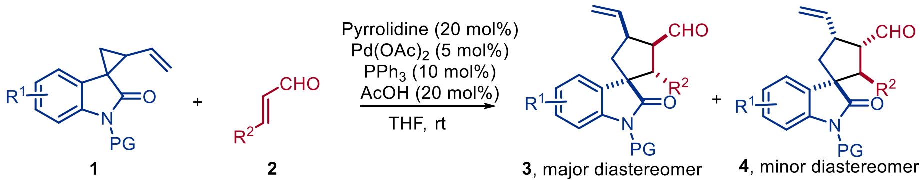
Table S1 Additive, catalyst and solvent screening of formal [3+2]-cycloadditions[a]



entry	amine	L	additive	solvent	yield (%)[b]	dr[c]	ee[d]
1[e]	C4	L1	OFBA	CH_2Cl_2	58	64:37	92/89
2[e]	C4	L1	*p*-TSA	CH_2Cl_2	66	67:33	89/82
3	C4	L1	AcOH	CH_2Cl_2	89	56:44	88/86
4[f]	C4	L1	AcOH	CH_2Cl_2	trace	-	-
5[g]	C4	L1	AcOH	CH_2Cl_2	83	62:38	82/75
6	C4	L1	AcOH	MeCN	81	54:46	92/52
7	**C4**	**L1**	**AcOH**	**THF**	**84**	**62:38**	**98/96**
8	C4	L1	AcOH	Toluene	71	52:48	90/92
9	C4	L1	AcOH	MeOH	90	51:49	90/-36
10	C4	L1	AcOH	DMF	86	60:40	96/8

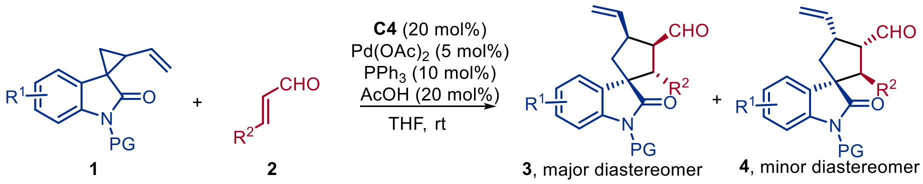
[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.24 mmol), $Pd(OAc)_2$ (5 mol%), ligand (10 mol%), amine (20 mol%), additive (20 mol%), and dichloromethane (2 mL) at room temperature. [b]Isolated yield. [c]Determined by isolated yields of **3aa** and **4aa**. [d]Determined by chiral HPLC. [e]Reaction time was 24 h. [f]$Pd(OTFA)_2$ was used instead of $Pd(OAc)_2$. [g]$Pd_2(dba)_3$ was used instead of $Pd(OAc)_2$. OFBA = *o*-fluorobenzoic acid; *p*-TSA = *p*-toluenesulfonic acid

2.2 General procedure for the synthesis of racemic spirooxindole 3 and 4

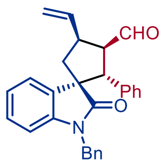


To a solution of spirovinylcyclopropyl oxindole **1** (0.2 mmol), and enal **2** (0.24 mmol, 1.2 equiv.) in THF (2 mL) were added $Pd(OAc)_2$ (2.2 mg, 5 mol%), PPh_3 (5.2 mg, 10 mol%), AcOH (2.4 mg, 20 mol%) and pyrrolidine (2.8 mg, 20 mol%), respectively. The mixture was stirred for about 12 h (TLC monitoring) at room temperature. The mixture was then concentrated in *vacuo* and purified by flash column chromatography on silica gel (Petroleum ether/EtOAc= 19:1 to 9:1) to give racemic **3** and **4**, respectively.

2.3 General procedure for the synthesis of enantioenriched spirooxindole 3 and 4

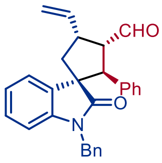


To a solution of spirovinylcyclopropyl oxindole **1** (0.2 mmol), and enal **2** (0.24 mmol, 1.2 equiv.) in THF (2 mL) were added $Pd(OAc)_2$ (2.2 mg, 5 mol%), PPh_3 (5.2 mg, 10 mol%), AcOH (2.4 mg, 20 mol%) and Jørgensen-Hayashi catalyst **C4** (2.8 mg, 20 mol%), respectively. The mixture was stirred for about 12 h (TLC monitoring) at room temperature. The mixture was then concentrated in *vacuo* and purified by flash column chromatography on silica gel (Petroleum ether/EtOAc= 19:1 to 9:1) to give enantioenriched **3** and **4**, respectively.

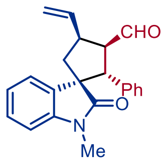


(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3aa**): white solid (32% yield, 26.0 mg, 0.064 mmol, 98% ee); m.p. 131-133 ℃; $[\alpha]_D^{25}$ –147.6 °(c 1, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.74-7.72 (m, 1H), 7.24-7.19 (m, 2H), 7.15-7.10 (m, 6H), 6.93 (d, *J* = 7.2 Hz, 2H), 6.54 (d, *J* = 7.2 Hz, 2H), 6.50-6.48 (m, 1H), 6.16-6.07 (m, 1H), 5.29 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz,1H), 4.88 (d, *J* = 16.8 Hz, 1H), 4.43 (d, *J* =

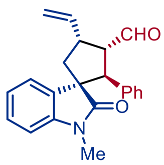
16.0 Hz, 1H), 4.35-4.29 (m, 1H), 4.22 (d, *J* = 11.2 Hz, 1H), 3.96-3.87 (m, 1H), 2.41 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.24 (dd, *J* = 13.2, 8.2 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.3, 142.8, 139.3, 136.8, 136.1, 131.0, 128.8, 128.5, 128.2, 127.6, 127.3, 126.8, 123.4, 123.0, 117.0, 109.2, 59.4, 56.8, 53.1, 43.0, 42.8, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{25}NO_2Na$ $[M+Na]^+$ 430.1778, found 430.1776; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 95:5; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 22.2 min, t_{major} = 27.1 min.



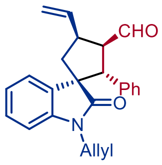
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4aa**): white solid (52% yield, 42.3 mg, 0.0104 mmol, 96% ee); m.p. 68-70 ℃; $[\alpha]_D^{25}$ –40.0 ° (c 1, CHCl3); ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.73 (d, *J* = 2.0 Hz, 1H), 7.64 (d, *J* = 6.0 Hz, 1H), 7.19-7.16 (m, 3H), 7.05 (t, *J* = 6.8 Hz, 2H), 7.00 (t, *J* = 6.0 Hz, 3H), 6.91-6.88 (m, 4H), 6.75 (d, *J* = 7.6 Hz, 1H), 6.59 (d, *J* = 6.4 Hz, 1H), 6.07-6.03 (m, 1H), 5.30 (d, *J* = 13.6 Hz, 1H), 5.15 (d, *J* = 8.4 Hz, 1H), 4.97 (d, *J* = 12.8 Hz, 1H), 4.65 (d, *J* = 12.8 Hz, 1H), 4.21 (d, *J* = 9.6 Hz, 1H), 4.15 (dt, *J* = 8.4, 2.0 Hz, 1H), 3.90-3.83 (m, 1H), 2.28 (dd, *J* = 10.4, 7.2 Hz, 1H), 2.13 (dd, *J* = 10.4, 6.4 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 203.9, 178.2, 142.2, 138.8, 136.8, 136.2, 131.1, 128.9, 128.3(2), 128.3(5), 127.6, 127.4, 125.2, 122.6, 117.3, 119.4, 59.7, 57.3, 53.6, 43.8, 43.5, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{25}NO_2Na$ $[M+Na]^+$ 430.1778, found 430.1797; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 9.0 min, t_{major} = 12.9 min.



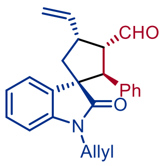
(1*S*,2*R*,3*R*,4*S*)-1'-methyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ab**): white solid (33% yield, 21.8 mg, 0.066 mmol, 96% ee); m.p. 132-133 ℃; $[\alpha]_D^{25}$ –61.1 °(c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.69 (d, *J* = 2.0 Hz, 1H), 7.64 (d, *J* = 7.2 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.11 (t, *J* = 7.4 Hz, 1H), 7.05-7.04 (m, 3H), 6.86-6.84 (m, 2H), 6.75 (d, *J* = 7.6 Hz, 1H), 6.11-6.01 (m, 1H), 5.25 (d, *J* = 16.8 Hz, 1H), 5.11 (d, *J* = 10.0 Hz, 1H), 4.17 (dt, *J* = 11.6, 2.0 Hz, 1H), 4.07 (d, *J* = 11.2 Hz, 1H), 3.91-3.82 (m, 1H), 2.79 (s, 3H), 2.31 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.16 (dd, *J* = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.2, 143.8, 139.3, 136.9, 130.8, 128.6, 128.2, 128.0, 127.5, 123.1, 122.8, 116.9, 108.5, 59.4, 57.0, 53.7, 43.0, 41.9, 26.0 (d, *J* = 4.0 Hz); HRMS (TOF-ESI$^+$) m/z: calcd for $C_{22}H_{21}NO_2Na$ $[M+Na]^+$ 354.1465, found 354.1462; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 6.0 min, t_{major} = 6.4 min.



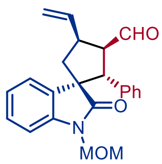
(1*S*,2*S*,3*S*,4*R*)-1'-methyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ab**): white solid (42% yield, 27.8 mg, 0.084 mmol, 99% ee); m.p. 139-140 ℃; $[\alpha]_D^{25}$ –84.2 °(c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (s, 1H), 7.57 (d, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 7.2 Hz, 1H), 7.01-6.98 (m, 4H), 6.88-6.86 (m, 2H), 6.77 (d, J = 7.6 Hz, 1H), 6.11-6.02 (m, 1H), 5.29 (d, J = 16.8 Hz, 1H), 5.15 (d, J = 10.0 Hz, 1H), 4.16-4.15 (m, 2H), 3.88-3.79 (m, 1H), 3.03 (s, 3H), 2.23 (dd, J = 13.2, 8.8 Hz, 1H), 2.10 (dd, J = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 143.1, 138.9, 136.9, 131.1, 128.3, 128.1, 127.8, 127.2, 124.8, 122.4, 117.2, 108.6, 56.9, 56.8, 53.3, 43.8, 42.9, 26.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{22}H_{21}NO_2Na$ $[M+Na]^+$ 354.1465, found 354.1482; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 9.5 min, t_{minor} = 9.9 min.



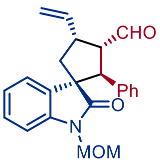
(1*S*,2*R*,3*R*,4*S*)-1'-allyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ac**, major diastereomer): white solid (36% yield, 25.7 mg, 0.072 mmol, 97% ee); m.p. 105-107 ℃; $[\alpha]_D^{25}$ –27.0 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.71 (d, J = 2.4 Hz, 1H), 7.69 (d, J = 6.4 Hz, 1H), 7.22-7.13 (m, 3H), 7.09-7.05 (m, 2H), 6.89-6.86 (m, 2H), 6.72-6.65 (m, 1H), 6.14-6.03 (m, 1H), 5.27 (d, J = 17.6 Hz, 1H), 5.13 (dd, J = 10.4, 1.6 Hz, 1H), 5.0 (dd, J = 24.4, 8.8 Hz, 1H), 4.76 (d, J = 10.4 Hz, 1H), 4.25-4.21 (m, 3H), 3.91-3.84 (m, 3H), 2.35 (dd, J = 13.2, 7.6 Hz, 1H), 2.20 (dd, J = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.8, 142.9, 139.3, 136.7, 131.7, 130.8, 129.9, 128.5, 128.2, 127.4, 123.3, 116.4, 109.1, 59.4, 56.8, 53.5, 43.0, 42.2, 41.4; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{24}H_{23}NO_2Na$ $[M+Na]^+$ 380.1621, found 380.1624; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.4 min, t_{major} = 6.4 min.



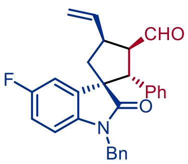
(1*S*,2*S*,3*S*,4*R*)-1'-allyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ac**, major diateromer): white solid (42% yield, 30.0 mg, 0.084 mmol, 92% ee); m.p. 88-90 ℃; $[\alpha]_D^{25}$ –28.9 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.62 (d, J = 7.6 Hz, 1H), 7.13 (t, J = 7.6 Hz, 1H), 7.04-7.00 (m, 3H), 6.91-6.89 (m, 2H), 6.69 (d, J = 7.6 Hz, 1H), 6.11-6.02 (m, 1H), 5.68-5.58 (m, 1H), 5.30 (d, J = 16.4 Hz, 1H), 5.15 (d, J = 10.0 Hz, 1H), 4.93 (d, J = 10.4 Hz, 1H), 4.58 (d, J = 17.2 Hz, 1H), 4.35 (td, J = 16.8, 2.4 Hz, 1H), 4.17 (d, J = 4.4 Hz, 2H), 4.10 (dd, J = 16.8, 4.8 Hz, 1H), 3.91-3.82 (m, 1H), 2.25 (dd, J = 12.8, 8.8 Hz, 1H), 2.12 (dd, J = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 177.8, 142.2, 138.8, 136.7, 131.8, 131.0, 128.3, 128.1, 127.3, 125.0, 122.4, 117.3, 116.7, 109.3, 59.6, 57.0, 53.5, 43.7, 43.1, 42.0; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{24}H_{23}NO_2Na$ $[M+Na]^+$ 380.1621, found 380.1633; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 9.0 min, t_{minor} = 11.1 min.



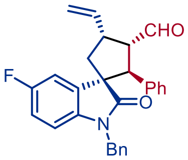
(1*S*,2*R*,3*R*,4*S*)-1'-methoxymethyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ad**): white solid (31% yield, 22.4 mg, 0.062 mmol, 73% ee); m.p. 121-122 ℃; $[\alpha]_D^{25}$ –32.1 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.72 (d, J = 2.4 Hz, 1H), 7.73 (d, J = 6.8 Hz, 1H), 7.27-7.19 (m, 3H), 7.07-7.06 (m, 2H), 6.90-6.85 (m, 3H), 6.14-6.05 (m, 1H), 5.28 (d, *J* = 16.8 Hz, 1H), 5.14 (dd, *J* = 10.0, 1.2 Hz, 1H), 4.80 (dd, *J* = 16.4, 11.2 Hz, 2H), 4.26 (dt, *J* = 11.2, 2.0 Hz, 1H), 4.17 (d, *J* = 11.6, 1H), 3.87 (t, *J* = 9.2, 1H), 2.54-2.49 (m, 3H), 2.38 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.20 (dd, *J* = 13.2, 8.0 Hz, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.9, 142.2, 139.2, 136.8, 130.6, 128.6, 128.3, 128.1, 127.5, 125.3, 123.0, 117.0, 109.6, 70.8, 59.7, 56.8, 55.2(d, *J* = 6.0 Hz), 53.3, 43.0, 42.8; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{23}H_{23}NO_3Na$ [M+Na]$^+$ 384.1570, found 384.1581; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 4.7 min, t_{major} = 6.3 min.



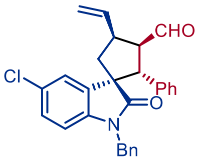
(1*S*,2*S*,3*S*,4*R*)-1'-methoxymethyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ad**): white solid (51% yield, 36.8 mg, 0.102 mmol, 89% ee); m.p. 100-102 ℃; $[\alpha]_D^{25}$ –6.8 ° (c 1.32, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.66 (d, *J* = 7.2 Hz, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.08 (d, *J* = 7.6 Hz, 1H), 7.21-7.08 (m, 3H), 6.94-6.92 (m, 2H), 6.88 (d, *J* = 8.0 Hz, 1H), 6.11-6.02 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (dd, *J* = 8.8, 1.2 Hz, 1H), 4.99 (dd, *J* = 20.0, 10.8 Hz, 2H), 4.22-4.17 (m, 2H), 3.91-3.83 (m, 1H), 2.96 (s, 3H), 2.26 (dd, *J* = 13.2, 9.2 Hz, 1H), 2.14 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.9, 141.6, 138.7, 136.8, 130.7, 128.4, 128.2, 128.1, 127.4, 125.3, 123.0, 117.3, 109.8, 71.3, 60.0, 57.1, 55.9, 53.5, 43.8, 43.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{23}H_{23}NO_3K$ [M+K]$^+$ 400.1310, found 400.1338; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 9.8 min, t_{major} = 11.6 min.



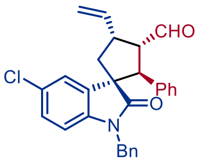
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-flouro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ae**): white solid (49% yield, 41.7 mg, 0.098 mmol, 93% ee); m.p. 131-132 ℃; $[\alpha]_D^{25}$ –107.7 ° (c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.71 (d, *J* = 2.4 Hz, 1H), 7.74 (dd, *J* = 8.4, 2.4 Hz, 1H), 7.22-7.19 (m, 1H), 7.16-7.07 (m, 5H), 6.97-6.92 (m, 3H), 6.52 (d, *J* = 7.2 Hz, 2H), 6.45 (dd, *J* = 8.4, 4.4 Hz, 1H), 6.13-6.04 (m, 1H), 5.28 (d, *J* = 17.2 Hz, 1H), 5.13 (dd, *J* = 10.0, 1.6 Hz, 1H), 4.86 (d, *J* = 16.4 Hz, 1H), 4.41 (d, *J* = 16.4 Hz, 1H), 4.31-4.28 (m, 1H), 4.23 (d, *J* = 11.6 Hz, 1H), 3.91-3.87 (m, 1H), 2.40 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.25 (dd, *J* = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 178.1, 159.2 (d, $J_{C\text{-}F}$ = 236.0 Hz), 139.3, 139.0, 136.6, 135.9, 134.4 (d, $J_{C\text{-}F}$ = 281 Hz), 128.9, 128.6, 128.2, 127.7, 127.4, 126.8, 117.0, 114.7 (d, $J_{C\text{-}F}$ = 230.0 Hz), 111.7 (d, $J_{C\text{-}F}$ = 26.0 Hz), 110.0 (d, $J_{C\text{-}F}$ = 8.0 Hz), 56.0, 56.7, 53.1, 42.9, 42.8, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ [M+Na]$^+$ 448.1683, found 448.1687; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.6 min, t_{major} = 7.5 min.



(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-flouro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ae**): white solid (45% yield, 38.3 mg, 0.090 mmol, 92% ee); m.p. 128-129 ℃; $[\alpha]_D^{25}$ –11.7 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.75 (s, 1H), 7.63 (d, *J* = 7.2 Hz, 1H), 7.22-7.21 (m, 3H), 7.06-7.03 (m, 3H), 6.96-6.90 (m, 5H), 6.59 (dd, *J* = 8.8, 4.4 Hz, 1H), 6.12-6.03 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 4.99 (d, *J* = 16.0 Hz, 1H), 4.68 (d, *J* = 16.0 Hz, 1H), 4.25-4.24 (m, 2H), 3.95-3.87 (m, 1H), 2.28 (dd, *J* = 12.8, 8.8 Hz, 1H), 2.19 (dd, *J* = 12.8, 7.6 Hz, 1H);^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.2, 158.8 (d, $J_{C\text{-}F}$ = 236.0 Hz), 138.7, 138.4, 136.7, 136.0, 132.9 (d, $J_{C\text{-}F}$ = 9.0), 128.9, 128.4, 128.2, 127.7, 127.5, 127.3, 117.4, 114.5 (d, $J_{C\text{-}F}$ = 23.0), 113.4 (d, $J_{C\text{-}F}$ = 25.0), 110.1 (d, *J* = 8.0 Hz), 60.2, 56.0, 53.5, 43.6, 43.4, 42.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ $[M+Na]^+$ 448.1683, found 448.1689; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 14.6 min, t_{minor} = 22.4 min.

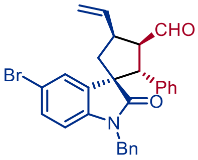


(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3af**): white solid (36% yield, 31.8 mg, 0.072 mmol, 96% ee); m.p. 154-155 ℃; $[\alpha]_D^{25}$ –152.1 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.70 (s, 1H), 7.92 (d, *J* = 2.0 Hz, 1H), 7.23-7.18 (m, 2H), 7.16-7.08 (m, 5H), 6.94 (d, *J* = 7.6 Hz, 2H), 6.48 (dd, *J* = 11.6, 7.2 Hz, 3H), 6.15-6.06 (m, 1H), 5.27 (d, *J* = 16.8 Hz, 1H), 5.13 (d, *J* = 10.0 Hz, 1H), 4.87 (d, *J* = 16.4 Hz, 1H), 4.41 (d, *J* = 16.0 Hz, 1H), 4.27-4.26 (m, 2H), 3.92-3.84 (m, 1H), 2.40 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.28 (dd, *J* = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 177.9, 141.7, 139.2, 136.6, 135.7, 133.2, 128.9, 128.6, 128.4, 128.2, 127.7, 127.4, 127.2, 126.8, 124.0, 117.0, 110.6, 59.8, 56.8, 53.0, 43.0, 42.7, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{25}ClNO_2$ $[M+H]^+$ 442.1568, found 442.1558; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.6 min, t_{major} = 7.6 min.

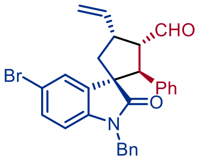


(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4af**): white solid (49% yield, 43.2 mg, 0.098 mmol, 94% ee); m.p. 157-158 ℃; $[\alpha]_D^{25}$ –61.3 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 1.6 Hz, 1H), 7.74 (s, 1H), 7.22-7.21 (m, 3H), 7.14 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.08-7.05 (m, 3H), 6.94-6.92 (m, 4H), 6.62 (d, *J* = 8.4 Hz, 1H), 6.11-6.02 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 4.99 (d, *J* = 16.0 Hz, 1H), 4.68 (d, *J* = 16.0 Hz, 1H), 4.30-4.21 (m, 2H), 3.94-3.85 (m, 1H), 2.30-2.19 (m, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 178.1, 141.1, 138.8, 136.6, 135.9, 133.3, 128.9, 128.4, 128.2, 127.7, 127.5, 127.3, 126.9, 125.3, 117.4, 110.7, 59.8, 57.0, 53.6, 43.6, 43.3, 43.2; HRMS

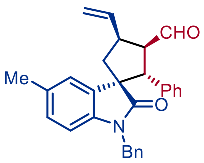
(TOF-ESI+) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ [M+Na]+ 464.1388, found 464.1385; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10 flow rate: 1 mL/min; λ = 254 nm; t_{major} = 15.6 min, t_{minor} = 21.1 min.



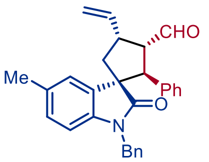
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-bromo-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ag**): white solid (33% yield, 32.0 mg, 0.066 mmol, 90% ee); m.p. 195-196 ℃; $[\alpha]_D^{25}$ –96.2 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.70 (s, 1H), 8.04 (s, 1H), 7.30 (d, *J* = 8.4 Hz, 1H), 7.21 (t, *J* = 7.2 Hz, 1H), 7.15-7.06 (m, 5H), 6.94 (d, *J* = 7.6 Hz, 2H), 6.50 (d, *J* = 7.2 Hz, 2H), 6.42 (d, *J* = 8.0 Hz, 1H), 6.15-6.06 (m, 1H), 5.27 (d, *J* = 16.8 Hz, 1H), 5.13 (d, *J* = 10.0 Hz, 1H), 4.86 (d, *J* = 16.0 Hz, 1H), 4.41 (d, *J* = 16.4 Hz, 1H), 4.27-4.26 (m, 1H), 3.90-3.88 (m, 1H), 2.39 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.28 (dd, *J* = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 177.8, 142.1, 139.2, 136.6, 135.7, 133.5, 131.2, 128.9, 128.6, 128.2, 127.7, 127.4, 126.8, 126.6, 117.0, 115.0, 111.1, 59.8, 56.8, 53.0, 43.0, 42.7, 42.6; HRMS (TOF-ESI+) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ [M+Na]+ 508.0883, found 508.0894; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.7 min, t_{major} = 7.9 min.



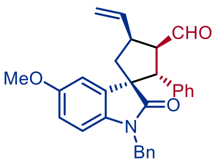
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-bromo-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ag**): white solid (46% yield, 44.6 mg, 0.092 mmol, 91% ee); m.p. 163-164 ℃; $[\alpha]_D^{25}$ +61.3 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.85 (s, 1H), 7.27 (d, *J* = 8.4 Hz, 1H), 7.22-7.21 (m, 3H), 7.10-7.03 (m, 3H), 6.97-6.92 (m, 4H), 6.58 (d, *J* = 8.4 Hz, 1H), 6.11-6.02 (m, 1H), 5.32 (d, *J* = 16.4 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 2H), 4.99 (d, *J* = 16.0 Hz, 1H), 4.67 (d, *J* = 16.0 Hz, 1H), 4.30-4.20 (m, 2H), 3.93-3.85 (m, 1H), 2.30-2.19 (m, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 178.0, 141.6, 138.8, 136.6, 135.9, 133.7, 131.1, 128.9, 128.4, 128.2, 127.9, 127.7, 127.5, 127.3, 117.4, 114.7, 111.3, 59.9, 57.0, 53.6, 43.6, 43.3, 43.2; HRMS (TOF-ESI+) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ [M+Na]+ 508.0883, found 508.0854; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 13.8 min, t_{minor} = 20.5 min.



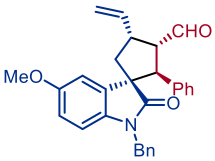
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-methyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ah**): white solid (29% yield, 24.4 mg, 0.058 mmol, 93% ee); m.p. 152-153 ℃; $[\alpha]_D^{25}$ –80.0 ° (c 0.2, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.72 (d, *J* = 2.4 Hz, 1H), 7.55 (s, 1H), 7.18 (d, *J* = 7.2 Hz, 1H), 7.13-7.07 (m, 5H), 6.92 (t, *J* = 8.8 Hz, 3H), 6.51 (d, *J* = 7.2 Hz, 2H), 6.35 (d, *J* = 7.6 Hz, 1H), 6.14-6.05 (m, 1H), 5.27 (d, J = 16.8 Hz, 1H), 5.13 (d, J = 10.4 Hz, 1H), 4.84 (d, J = 16.0 Hz, 1H), 4.38 (d, J = 16.4 Hz, 1H), 4.30-4.25 (m, 1H), 4.18 (d, J = 11.2 Hz, 1H), 3.93-3.85 (m, 1H), 2.37 (dd, J = 13.6, 8.0 Hz, 1H), 2.33 (s, 1H), 2.21 (dd, J = 12.8, 4.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.2, 140.5, 139.3, 136.9, 136.1, 132.0, 131.0, 128.8, 128.5, 128.3, 127.6, 127.3, 126.8, 124.0, 117.0, 109.0, 59.5, 57.0, 53.1, 43.0, 42.9, 42.6, 21.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ [M+Na]$^+$ 444.1934, found 444.1937; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.0 min, t_{major} = 7.4 min.



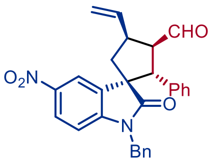
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-methyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ah**): white solid (37% yield, 31.2 mg, 0.074 mmol, 94% ee); m.p. 149-150 ℃; $[\alpha]_D^{25}$ +64.2 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.75 (d, J = 2.0 Hz, 1H), 7.51 (s, 1H), 7.19-7.17 (m, 3H), 7.07-7.05 (m, 3H), 6.93 (d, J = 7.2 Hz, 2H), 6.88-6.87 (m, 3H), 6.47 (d, J = 8.0 Hz, 1H), 6.12-6.03 (m, 1H), 5.31 (d, J = 16.8 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 4.97 (d, J = 16.0 Hz, 1H), 4.63 (d, J = 14.0 Hz, 1H), 4.23-4.17 (m, 2H), 3.90 (dd, J = 18.0, 9.2 Hz, 1H), 2.31 (s, 3H), 2.28-2.21 (m, 1H), 2.12 (dd, J = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.0, 139.8, 138.9, 136.9, 136.3, 131.6, 131.1, 128.8, 128.5, 128.4, 128.3, 127.5, 127.4, 127.2, 159.9, 117.2, 109.1, 59.8, 57.3, 53.5, 43.7, 43.5, 43.2, 21.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ [M+Na]$^+$ 444.1934, found 444.1930; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 12.5 min, t_{minor} = 18.5 min.



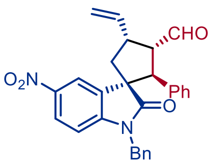
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-methoxyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ai**): white solid (42% yield, 36.7 mg, 0.084 mmol, 99% ee); m.p. 128-129 ℃; $[\alpha]_D^{25}$ –67.0 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.72 (d, J = 2.4 Hz, 1H), 7.42 (d, J = 2.4 Hz, 1H), 7.19 (t, J = 7.4 Hz, 1H), 7.15-7.06 (m, 5H), 6.96 (d, J = 7.6 Hz, 2H), 6.66 (dd, J = 8.4, 2.4 Hz, 1H), 6.52 (d, J = 6.8 Hz, 2H), 6.36 (d, J = 8.4 Hz, 1H), 6.15-6.05 (m, 1H), 5.27 (d, J = 17.2 Hz, 1H), 5.13 (d, J = 11.2 Hz, 1H), 4.84 (d, J = 16.4 Hz, 1H), 4.38 (d, J = 16.4 Hz, 1H), 4.28 (dd, J = 10.4, 1.6 Hz, 1H), 4.22 (d, J = 11.2 Hz, 1H), 3.93-3.84 (m, 1H), 3.77 (s, 3H), 2.37 (dd, J = 13.2, 8.0 Hz, 1H), 2.24 (dd, J_1 = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.0, 156.2, 139.4, 136.9, 136.2, 136.1, 132.2, 128.8, 128.5, 128.3, 127.6, 127.3, 126.8, 116.9, 113.2, 110.5, 109.7, 59.9, 56.9, 56.1, 56.0, 53.0, 42.9, 42.7.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ [M+Na]$^+$ 460.1883, found 460.1878; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 6.6 min, t_{major} = 8.2 min.



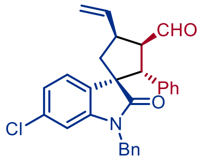
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-methoxyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ai**): white solid (46% yield, 40.2 mg, 0.092 mmol, 93% ee); m.p. 107-109 ℃; $[\alpha]_D^{25}$ +59.2 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.75 (s, 1H), 7.24-7.19 (m, 4H), 7.07-7.04 (m, 3H), 6.96-6.92 (m, 4H), 6.64 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.50 (d, *J* = 8.4 Hz, 1H), 6.12-6.03 (m, 1H), 5.32 (d, *J* = 17.2 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 4.96 (d, *J* = 16.0 Hz, 1H), 4.64 (d, *J* = 16.0 Hz, 1H), 4.24-4.20 (m, 2H), 3.88 (dd, *J* = 18.0, 9.6 Hz, 1H), 3.75 (s, 3H), 2.27 (dd, *J* = 12.8, 8.8 Hz, 1H), 2.16 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 178.0, 155.7, 138.9, 136.9, 136.3, 135.7, 132.5, 128.9, 128.3, 127.5, 127.4, 127.3, 117.2, 112.8, 112.6, 109.7, 100.0, 60.1, 57.1, 56.2, 53.3, 43.6, 43.5, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1887; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 12.5 min, t_{minor} = 18.8 min.



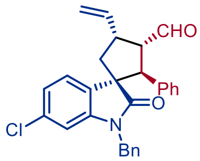
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-5'-nitro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3aj**): white solid (43% yield, 38.9 mg, 0.086 mmol); m.p. 132-134 ℃; $[\alpha]_D^{25}$ –56.5 ° (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, DMSO-d_6) δ 9.73 (d, *J* = 2.4 Hz, 1H), 8.79 (s, 1H), 8.11 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.16-7.08 (m, 5H), 6.94 (d, *J* = 7.6 Hz, 2H), 6.70 (d, *J* = 8.4 Hz, 1H), 6.49 (d, *J* = 7.2 Hz, 2H), 6.19-6.10 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.95 (d, *J* = 16.4 Hz, 1H), 4.52 (d, *J* = 16.4 Hz, 1H), 4.43 (d, *J* = 11.6 Hz, 1H), 4.28 (t, *J* = 11.2 Hz, 1H), 3.87-3.96 (m, 1H), 2.44 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 203.7, 178.6, 148.9, 143.5, 139.1, 136.3, 135.2, 132.1, 129.0, 128.7, 128.2, 127.9, 127.6, 126.7, 125.9, 119.7, 117.2, 109.4, 59.7, 56.5, 53.0, 43.0, 42.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{14}H_{13}ClNaO_5$ $[M+Na]^+$ 319.0344, found 319.0303; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}N_2O_4Na$ $[M+Na]^+$ 475.1628, found 475.1635; HPLC analysis: Daicel Chiralpak AS-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 15.6 min, t_{major} = 30.7 min.



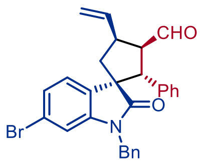
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-5'-nitro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4aj**): white solid (38% yield, 34.3 mg, 0.076 mmol); m.p. 164-166 ℃; $[\alpha]_D^{25}$ +41.1 ° (c 0.3, $CHCl_3$); ^1H NMR (400 MHz, DMSO-d_6) δ 9.75 (d, *J* = 2.0 Hz, 1H), 8.40 (d, *J* = 2.0 Hz, 1H), 8.067 (dd, *J* = 8.4, 2.0 Hz, 1H), 7.25-7.24 (m, 3H), 7.07-6.95 (m, 6H), 6.91-6.86 (m, 3H), 6.15-6.06 (m, 1H), 5.35 (d, *J* = 16.8 Hz, 1H), 5.18 (dd, *J* = 10.0, 1.2 Hz, 1H), 5.07 (d, *J* = 16.0 Hz, 1H), 4.78 (d, *J* = 16.0 Hz, 1H), 4.40-4.34 (m, 1H), 4.25 (d, *J* = 12.0 Hz, 1H), 3.98-3.90 (m, 1H), 2.37 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.29 (dd, *J* = 13.6, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 203.4, 179.2, 148.3, 143.0, 138.6, 136.2, 135.5, 132.4, 129.0, 128.5, 128.1, 127.9, 127.7, 127.4, 125.7, 120.6, 117.5, 109.5, 59.6, 57.0, 54.0, 43.7, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}N_2O_4Na$ [M+Na]$^+$ 475.1628, found 475.1618.



(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-6'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ak**): white solid (13% yield, 11.5 mg, 0.026 mmol, 94% ee); m.p. 187-188 ℃; $[\alpha]_D^{25}$ –71.3 ° (c 0.1, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.71 (d, *J* = 1.6 Hz, 1H), 7.77 (d, *J* = 7.6 Hz, 1H), 7.25-7.21 (m, 1H), 7.17-7.10 (m, 6H), 6.93 (d, *J* = 7.6 Hz, 2H), 6.58 (s, 1H), 6.53 (d, *J* = 7.2 Hz, 2H), 6.12-6.03 (m, 1H), 5.27 (d, *J* = 16.8 Hz, 1H), 5.13 (d, *J* = 10.4 Hz, 1H), 4.85 (d, *J* = 16.0 Hz, 1H), 4.46 (d, *J* = 16.0 Hz, 1H), 4.30 (t, *J* = 10.8 Hz, 1H), 4.21 (d, *J* = 11.2 Hz, 1H), 3.93-3.84 (m, 1H), 2.40 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.22 (dd, *J* = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.9, 178.3, 144.3, 139.2, 136.6, 135.7, 132.8, 129.9, 128.9, 128.6, 128.2, 127.7, 127.5, 126.8, 125.1, 122.6, 117.1, 109.5, 59.2, 56.7, 52.9, 42.9, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ [M+Na]$^+$ 464.1388, found 464.1392; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.7 min, t_{major} = 8.9 min.

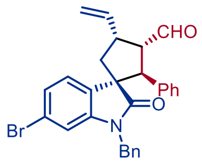


(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-6'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ak**, major diastereomer): white solid (53% yield, 46.7 mg, 0.106 mmol, 97% ee); m.p. 194-195 ℃; $[\alpha]_D^{25}$ +51.7 °(c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.67 (d, *J* = 8.0 Hz, 1H), 7.23 (t, *J* = 3.0 Hz, 1H), 7.15-7.12 (m, 1H), 7.07-7.04 (m, 3H), 6.96-6.92 (m, 4H), 6.74 (d, *J* = 1.6 Hz, 1H), 6.55 (d, *J* = 7.2 Hz, 1H), 6.14-6.03 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 2H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.99 (d, *J* = 16.0 Hz, 2H), 4.71 (d, *J* = 16.0 Hz, 1H), 4.22-4.14 (m, 1H), 3.93-3.82 (m, 1H), 3.03 (s, 3H), 2.28 (dd, *J*= 12.8, 8.8 Hz, 1H), 2.17 (dd, *J* = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.4, 143.8, 138.6, 136.6, 135.9, 132.8, 130.1, 129.9, 128.9, 128.6, 128.4, 128.3, 127.7, 127.6, 127.3, 126.8, 126.7, 122.1, 117.4, 109.7, 59.5, 57.1, 53.6, 52.9, 43.7, 43.4, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ [M+Na]$^+$ 464.1388, found 464.1396; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 95:5; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 15.3 min, t_{minor} = 16.4 min.

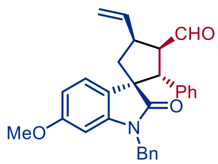


(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-6'-bromo-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3al**): white solid (6% yield, 5.8 mg, 0.012 mmol, 93% ee); m.p. 188-189 ℃; $[\alpha]_D^{25}$ –84.3 ° (c 0.05, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.71 (d, *J* = 2.0 Hz, 1H), 7.71 (d, *J* = 7.6 Hz, 1H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.0 Hz, 2H), 7.15-7.10 (m, 4H), 6.93 (d, *J* = 8.0 Hz, 2H), 6.70

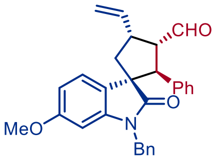
(s, 1H), 6.53 (d, J = 7.2 Hz, 2H), 6.12-6.03 (m, 1H), 5.27 (d, J = 17.2 Hz, 1H), 5.13 (d, J = 10.0 Hz, 1H), 4.85 (d, J = 16.0 Hz, 1H), 4.46 (d, J = 16.0 Hz, 1H), 4.30 (t, J = 10.0 Hz, 1H), 4.21 (d, J = 11.2 Hz, 1H), 3.93-3.84 (m, 1H), 2.40 (dd, J = 13.2, 7.6 Hz, 1H), 2.21 (dd, J = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.9, 178.2, 144.5, 139.2, 136.6, 135.7, 130.4, 128.9, 128.6, 128.2, 127.7, 127.5, 126.8, 125.6, 125.5, 121.1, 117.1, 112.1, 59.6, 59.3, 56.7, 52.9, 42.9, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{25}BrNO_2$ $[M+H]^+$ 486.1063, found 486.1061; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.8 min, t_{major} = 9.8 min.



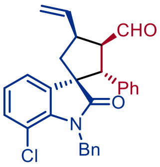
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-6'-bromo-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4al**, major diastereomer): white solid (34% yield, 33.0 mg, 0.068 mmol, 94% ee); m.p. 191-192 ℃; $[\alpha]_D^{25}$ –27.2 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, J = 2.4 Hz, 1H), 7.62 (d, J = 8.0 Hz, 1H), 7.23 (t, J = 3.0 Hz, 3H), 7.14 (t, J = 7.6 Hz, 2H), 7.06 (d, J = 7.6 Hz, 2H), 6.96-6.86 (m, 4H), 6.55 (d, J = 7.2 Hz, 1H), 6.12-6.03 (m, 1H), 5.30 (d, J = 16.8 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 4.98 (d, J = 16.4 Hz, 1H), 4.71 (d, J = 16.0 Hz, 1H), 4.25-4.15 (m, 2H), 3.93-3.83 (m, 1H), 2.27 (dd, J = 18.8, 12.8 Hz, 1H), 2.16 (dd, J = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.3, 143.9, 138.6, 136.6, 135.9, 135.7, 130.5, 130.4, 129.0, 128.6, 128.4, 128.3, 127.7, 127.6, 127.3, 127.1, 126.8, 125.1, 121.1, 117.4, 112.4, 59.5, 57.1, 53.5, 43.7, 43.2, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ $[M+Na]^+$ 508.0883, found 508.0885; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 95:5; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 23.3 min, t_{major} = 24.9 min.



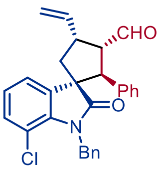
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-6'-methoxyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3am**): white solid (26% yield, 22.7 mg, 0.052 mmol, 96% ee); m.p. 135-136 ℃; $[\alpha]_D^{25}$ –116.2 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, J = 2.0 Hz, 1H), 7.62 (d, J = 8.4 Hz, 1H), 7.21 (t, J = 7.4 Hz, 1H), 7.15-7.09 (m, 6H), 6.95 (d, J = 7.2 Hz, 2H), 6.67 (dd, J = 8.0, 2.0 Hz, 1H), 6.57 (d, J = 7.2 Hz, 2H), 6.11-6.07 (m, 1H), 5.28 (d, J = 16.8 Hz, 1H), 5.14 (d, J = 10.0 Hz, 1H), 4.85 (d, J = 16.0 Hz, 1H), 4.43 (d, J = 16.4 Hz, 1H), 4.32-4.26 (m, 1H), 4.17 (d, J = 11.6 Hz, 1H), 3.90 (dd, J = 17.6, 8.4 Hz, 1H), 3.65 (s, 3H), 2.36 (dd, J = 13.2, 7.6 Hz, 1H), 2.19 (dd, J = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.8, 159.9, 144.0, 139.3, 136.9, 136.1, 128.8, 128.5, 128.3, 127.5, 127.4, 126.9, 124.1, 122.6, 118.2, 116.9, 106.8, 97.2, 59.1, 56.8, 55.7, 52.9, 43.0, 42.8, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1872; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 6.4 min, t_{major} = 8.7 min.



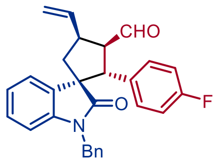
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-6'-methoxyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4am**): white solid (37% yield, 32.3 mg, 0.074 mmol, 98% ee); m.p. 138-139 ℃; $[\alpha]_D^{25}$ +41.8 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.56 (d, *J* = 8.4 Hz, 1H), 7.21-7.19 (m, 3H), 7.08-7.03 (m, 3H), 6.94-6.90 (m, 4H), 6.54 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.22 (d, *J* = 2.0 Hz, 1H), 6.11-6.02 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.97 (d, *J* = 16.0 Hz, 1H), 4.67 (d, *J* = 16.0 Hz, 1H), 4.21-4.09 (m, 2H), 3.89-3.80 (m, 1H), 3.63 (s, 3H), 2.27 (dd, *J* = 12.8, 9.2 Hz, 1H), 2.08 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.7, 159.7, 143.5, 138.8, 137.0, 136.3, 128.9, 128.4, 128.3, 127.6, 127.4, 127.3, 125.9, 122.9, 117.3, 106.4, 97.3, 59.3, 57.3, 55.6 (d, *J* = 5.0 Hz), 53.4, 43.8, 43.7, 43.1; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1884; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 20.5 min, t_{minor} = 23.2 min.



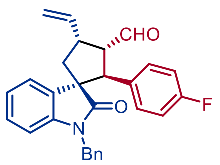
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-7'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3an**): white solid (29% yield, 25.6 mg, 0.058 mmol, 94% ee); m.p. 153-154 ℃; $[\alpha]_D^{25}$ –72.5 ° (c 0.25, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 2.4 Hz, 1H), 7.80 (dd, *J* = 6.0, 3.2 Hz, 1H), 7.26 (t, *J* = 7.2 Hz, 1H), 7.19-7.13 (m, 5H), 7.09-7.05 (m, 2H), 6.94 (d, *J* = 7.6 Hz, 2H), 6.37 (d, *J* = 7.2 Hz, 2H), 6.15-6.06 (m, 1H), 5.29 (d, *J* = 17.2 Hz, 1H), 5.15 (d, *J* = 11.2 Hz, 1H), 5.06 (d, *J* = 17.2 Hz, 1H), 4.90 (d, *J* = 17.2 Hz, 1H), 4.36-4.25 (m, 2H), 3.94-3.85 (m, 1H), 2.46 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.24 (dd, *J* = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 178.7, 139.2, 138.8, 137.8, 136.5, 134.3, 130.7, 128.8, 128.7, 128.2, 127.9, 126.9, 125.6, 124.4, 122.8, 117.1, 114.1, 59.3, 56.5, 53.2, 44.2, 43.3, 42.8; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1393; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 5.4 min, t_{major} = 11.7 min.



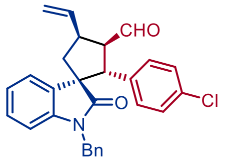
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-7'-chloro-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4an**): white solid (60% yield, 52.9 mg, 0.12 mmol, 80% ee); m.p. 132-133 ℃; $[\alpha]_D^{25}$ –19.1 ° (c 0.5, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.71 (d, *J* = 6.8 Hz, 1H), 7.19-7.17 (m, 3H), 7.15-7.13 (m, 1H), 7.12-7.05 (m, 4H), 6.94 (d, *J* = 6.8 Hz, 2H), 6.75-6.73 (m, 2H), 6.12-6.03 (m, 1H), 5.31 (d, J = 16.8 Hz, 1H), 5.20-5.13 (m, 3H), 4.28-4.17 (m, 2H), 3.94-3.85 (m, 2H), 2.34-2.21 (m, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 179.0, 138.6, 138.3, 137.8, 136.5, 134.5, 130.7, 128.8, 128.5, 127.7, 127.2, 126.0, 124.5, 124.0, 117.4, 114.4, 59.5, 57.4, 54.1, 44.9, 43.9, 43.8; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1394; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 14.8 min, t_{minor} = 21.9 min.



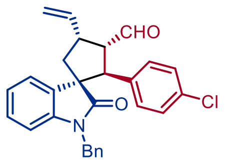
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(4-fluorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ao**): white solid (38% yield, 32.3 mg, 0.076 mmol, 87% ee); m.p. 135-136 ℃; $[\alpha]_D^{25}$ –103.2° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, J = 2.0 Hz, 1H), 7.73 (t, J = 4.2 Hz, 1H), 7.18-7.09 (m, 5H), 6.94 (d, J = 7.6 Hz, 4H), 6.60-6.53 (m, 3H), 6.15-6.06 (m, 1H), 5.30 (d, J = 16.8 Hz, 1H), 5.15 (d, J = 10.0 Hz, 1H), 4.89 (d, J = 16.0 Hz, 1H), 4.45 (d, J = 16.4 Hz, 1H), 4.31 (t, J = 10.8 Hz, 1H), 4.20 (d, J = 11.6 Hz, 1H), 3.95-3.86 (m, 1H), 2.42 (dd, J = 13.6, 8.0 Hz, 1H), 2.22 (dd, J = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.9, 178.2, 161.9 (d, J_{C-F} = 241.0 Hz), 142.8, 139.3, 136.1, 133.0, 130.8, 130.0 (d, J_{C-F} = 8.0 Hz), 128.6, 127.5, 126.9, 123.5, 123.1, 117.1, 115.2 (d, J_{C-F} = 21.0 Hz), 109.3, 59.4, 56.9, 52.2, 42.8, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ $[M+Na]^+$ 448.1683, found 448.1668; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 21.3 min, t_{major} = 24.5 min.



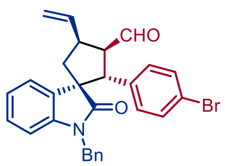
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(4-fluorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ao**): white solid (50% yield, 42.5 mg, 0.10 mmol, 73% ee); m.p. 137-138 ℃; $[\alpha]_D^{25}$ +15.7° (c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.67 (d, J = 7.2 Hz, 1H), 7.21-7.20 (m, 3H), 7.11 (t, J = 7.2 Hz, 1H), 7.03 (t, J = 7.2 Hz, 1H), 6.93-6.83 (m, 6H), 6.65 (d, J = 7.6 Hz, 1H), 6.11-6.02 (m, 1H), 5.32 (d, J = 16.8 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 4.99 (d, J = 16.0 Hz, 1H), 4.67 (d, J = 16.0 Hz, 1H), 4.22-4.12 (m, 2H), 3.93-3.87 (m, 1H), 2.26-2.31 (m, 1H), 2.16 (dd, J = 12.4, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 161.6 (d, J_{C-F} = 241.0 Hz), 142.2, 138.8, 136.3, 133.0, 130.2 (d, J_{C-F} = 8.0 Hz), 128.8, 128.5, 127.7, 127.3, 125.2, 122.7, 117.4, 115.0 (d, J_{C-F} = 21.0 Hz), 109.5, 59.6, 57.4, 53.0, 43.6, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ $[M+Na]^+$ 448.1683, found 448.1663; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{major} = 16.2 min, t_{minor} = 17.2 min.



(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(4-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ap**): white solid (47% yield, 41.5 mg, 0.094 mmol, 84% ee); m.p. 135-136 ℃; $[\alpha]_D^{25}$ –111.4 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 1.6 Hz, 1H), 7.75-7.73 (m, 1H), 7.19-7.13 (m, 7H), 6.92 (d, *J* = 8.4 Hz, 2H), 6.59-6.53 (m, 3H), 6.14-6.05 (m, 1H), 5.30 (d, *J* = 17.2 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.92 (d, *J* = 16.0 Hz, 1H), 4.44 (d, *J* = 16.0 Hz, 1H), 4.33 (t, *J* = 11.0 Hz, 1H), 4.19 (d, *J* = 11.6 Hz, 1H), 3.95-3.87 (m, 1H), 2.43 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.21 (dd, *J* = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 142.8, 139.3, 136.1, 136.0, 132.3, 130.7, 130.0, 128.7, 128.5, 127.5, 126.9, 123.5, 123.1, 117.1, 109.3, 59.3, 56.7, 52.2, 42.7, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1390; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 23.1 min, t_{major} = 25.6 min.

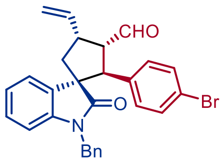


(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(4-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ap**): white solid (43% yield, 37.9 mg, 0.086 mmol, 83% ee); m.p. 134-135 ℃; $[\alpha]_D^{25}$ +8.3 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.68 (d, *J* = 7.2 Hz, 1H), 7.22-7.20 (m, 3H), 7.13-7.02 (m, 4H), 6.92-6.88 (m, 4H), 6.65 (d, *J* = 7.6 Hz, 1H), 6.10-6.01 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.13 (d, *J* = 10.0 Hz, 1H), 5.01 (d, *J* = 16.0 Hz, 1H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.17 (d, *J* = 4.0 Hz, 2H), 3.90 (s, 1H), 2.31-2.25 (m, 1H), 2.17 (dd, *J* = 12.8, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 178.0, 142.2, 138.8, 136.2, 135.9, 132.1, 130.8, 130.1, 128.8, 128.6, 128.3, 127.7, 127.3, 125.2, 122.7, 117.4, 109.6, 59.6, 57.2, 53.0, 43.6, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1393; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 23.7 min, t_{major} = 25.0 min.

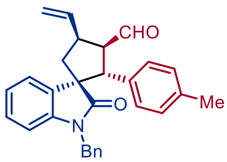


(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(4-bromophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3aq**, major diastereomer): white solid (29% yield, 28.1 mg, 0.058 mmol, 88% ee); m.p. 149-150 ℃; $[\alpha]_D^{25}$ –124.6 ° (c 0.2, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 2.0 Hz, 1H), 7.74-7.72 (m, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 7.18-7.12 (m, 5H), 6.87 (d, *J* = 8.4 Hz, 2H), 6.59-6.52 (m, 3H), 6.14-6.05 (m, 1H), 5.29 (d, *J* = 17.2 Hz, 1H), 5.17-5.14 (m, 1H), 4.93 (d, *J* = 16.0 Hz, 1H), 4.43 (d, *J* = 16.0 Hz, 1H), 4.34 (t, *J* = 10.0 Hz, 1H), 4.19 (d, *J* = 11.6 Hz, 1H), 3.92 (t, *J* = 9.4 Hz, 1H), 2.43 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.21 (dd, *J* = 13.6, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 142.8, 139.3, 136.4, 136.1, 131.4, 130.7, 130.4, 128.7(3), 128.6(6), 127.4, 126.9, 123.5, 123.1, 120.9, 117.1, 109.3, 59.2, 56.7, 52.3, 42.7; HRMS (TOF-ESI$^+$) m/z:

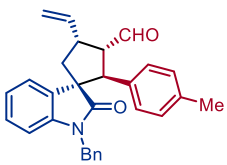
calcd for $C_{28}H_{24}BrNO_2Na$ $[M+Na]^+$ 508.0883, found 508.887; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 24.0 min, t_{major} = 26.8 min.



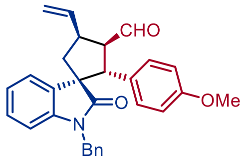
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(4-bromophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4aq**): white solid (46% yield, 44.6 mg, 0.092 mmol, 80% ee); m.p. 163-164 ℃; $[\alpha]_D^{25}$ +11.8 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.68 (d, *J* = 7.2 Hz, 1H), 7.21-7.22 (m, 5H), 7.12 (t, *J* = 7.6 Hz, 1H), 7.04 (t, *J* = 7.2 Hz, 1H), 6.89-6.84 (m, 4H), 6.64 (d, *J* = 7.6 Hz, 1H), 6.09-6.00 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 5.02 (d, *J* = 16.0 Hz, 1H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.20-4.16 (m, 2H), 3.92-3.88 (m, 1H), 2.27 (dd, *J* = 12.8, 9.2 Hz, 1H), 2.15 (dd, *J* = 12.8, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 177.9, 142.2, 138.8, 136.3, 136.2, 131.2, 130.8, 130.5, 128.8, 128.6, 127.6, 127.2, 125.2, 122.7, 120.7, 117.4, 109.6, 59.5, 57.2, 53.1, 43.5, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ $[M+Na]^+$ 508.0883, found 508.888; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 24.3 min, t_{major} = 26.2 min.



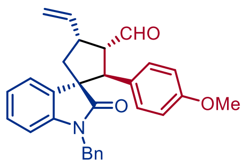
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(4-methylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ar**): white solid (37% yield, 31.2 mg, 0.074 mmol, 89% ee); m.p. 121-122 ℃; $[\alpha]_D^{25}$ –95.6 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.72-9.73 (m, 1H), 7.72-7.70 (m, 1H), 7.17-7.07 (m, 5H), 6.91 (d, *J* = 8.0 Hz, 2H),6.81 (d, *J* = 7.6 Hz, 2H), 6.60 (d, *J* = 7.2 Hz, 2H), 6.51-6.49 (m, 1H), 6.15-6.06 (m, 1H), 5.28 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.90 (d, *J* = 16.4 Hz, 1H), 4.44 (d, *J* = 16.4 Hz, 1H), 4.30-4.24 (m, 1H), 4.17 (d, *J* = 11.6 Hz, 1H), 3.94-3.85 (m, 1H), 2.40 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.27-2.20 (m, 4H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.3, 142.9, 139.3, 136.6, 136.1, 133.7, 131.0, 129.1, 128.7, 128.5, 128.1, 127.4, 126.9, 123.4, 122.9, 116.9, 109.2, 59.4, 57.0, 52.8, 43.0, 42.8, 42.7, 21.1; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ $[M+Na]^+$ 444.1934, found 444.1937; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{major} = 97.4 min, t_{minor} = 7.9 min.



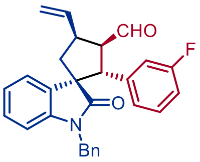
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(4-methylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ar**): white solid (53% yield, 44.6 mg, 0.106 mmol, 84% ee); m.p. 139-140 ℃; $[\alpha]_D^{25}$ +28.6 ° (c 0.4, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 2.4 Hz, 1H), 7.66 (d, *J* = 7.2 Hz, 1H), 7.21-7.17 (m, 3H), 7.09 (t, *J* = 7.2 Hz, 1H),7.02 (t, *J* = 7.0 Hz, 1H), 6.89 (d, *J* = 6.8 Hz, 2H), 6.82 (dd, *J* = 13.2, 8.0 Hz, 3H), 6.60 (d, *J* = 7.6 Hz, 1H), 6.12-6.03 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 5.00 (d, *J* = 16.0 Hz, 1H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.11 (dt, *J* = 10.8, 2.4 Hz, 2H), 3.91-3.82 (m, 1H), 2.32-2.23 (m, 2H), 2.15 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.9, 178.2, 142.2, 138.8, 136.4, 136.2, 133.7, 131.2, 128.9, 128.8, 128.4, 128.3, 127.6, 127.2, 125.2, 122.6, 117.3, 109.5, 59.7, 57.5, 53.4, 43.7, 43.5, 43.2, 21.0; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ [M+Na]$^+$ 444.1934, found 444.1927; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 7.8 min, t_{minor} = 10.5 min.



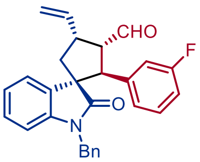
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(4-methoxylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3as**, major diateromer): white solid (44% yield, 38.5 mg, 0.088 mmol, 98% ee); m.p. 97-98 ℃; $[\alpha]_D^{25}$ –147.6° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.72 (d, *J* = 2.0 Hz, 1H), 7.72-7.69 (m, 1H), 7.14-7.07 (m, 6H), 6.84 (d, *J* = 8.8 Hz, 2H), 6.72-6.66 (m, 2H), 6.56 (d, *J* = 7.2 Hz, 1H), 6.51-6.49 (m, 1H), 6.16-6.01 (m, 1H), 5.27 (d, *J* = 16.8 Hz, 1H), 5.14 (d, *J* = 10.0 Hz, 1H), 4.92 (d, *J* = 16.0 Hz, 1H),4.43 (d, *J* = 16.4 Hz, 1H), 4.23-4.16 (m, 1H), 3.98-3.84 (m, 1H), 3.68 (s, 3H), 2.40 (dd, *J* = 13.6, 7.6 Hz, 1H), 2.22 (dd, *J* = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.2, 178.3, 158.9, 142.8, 141.8, 139.3, 136.1, 131.1, 129.3, 128.6, 128.5, 127.4, 126.9, 123.4, 122.9, 116.9, 113.8, 109.2, 59.5, 57.0, 55.4, 52.5, 43.0, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ [M+Na]$^+$ 460.1883, found 460.1877; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 6.4 min, t_{major} = 8.7 min.



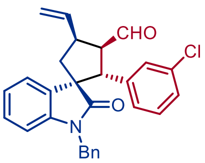
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(4-methoxylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4as**): white solid (40% yield, 35.0 mg, 0.08 mmol, 85% ee); m.p. 98-99 ℃; $[\alpha]_D^{25}$ –40.0° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 2.4 Hz, 1H), 7.66 (d, *J* = 7.2 Hz, 1H), 7.21-7.17 (m, 3H), 7.09 (d, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 7.2 Hz, 1H), 6.88 (d, *J* = 7.2 Hz, 2H), 6.82 (d, *J* = 8.4 Hz, 2H), 6.63-6.57 (m, 3H), 6.12-6.03 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 5.01 (d, *J* = 16.0 Hz, 1H), 4.65 (d, *J* = 16.0 Hz, 1H), 4.18 (d, *J* = 12.0 Hz, 1H), 4.09-4.03 (m, 1H), 3.86 (t, *J* = 9.2 Hz, 1H), 3.62 (s, 3H), 2.28 (dd, *J* = 13.2, 9.2 Hz, 1H), 2.13 (dd, *J* = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.2, 158.6, 142.2, 138.8, 136.2, 131.2, 129.4, 128.8, 128.5, 128.4, 127.6, 127.2, 125.2, 122.6, 117.3, 113.6, 109.5, 59.8, 57.6, 55.3(4), 55.2(9), 53.2, 43.7, 43.1; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1872; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 12.1 min, t_{minor} = 18.0 min.



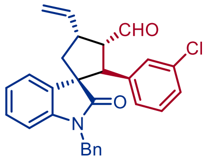
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(3-fluorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3at**): white solid (32% yield, 27.2 mg, 0.064 mmol, 98% ee); m.p. 128-129 ℃; $[\alpha]_D^{25}$ –83.6 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.74-7.75 (m, 1H), 7.18-7.14 (m, 6H), 7.04 (t, *J* = 8.0 Hz, 1H), 6.74-6.71 (m, 2H), 6.60 (d, *J* = 6.8 Hz, 2H), 6.56-6.55 (m, 1H), 6.13-6.04 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.0 Hz, 1H), 4.90 (d, *J* = 16.0 Hz, 1H), 4.45 (d, *J* = 16.0 Hz, 1H), 4.36 (t, *J* = 10.8 Hz, 1H), 4.22 (d, *J* = 11.2 Hz, 1H), 3.96-3.89 (m, 1H), 2.42 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.21 (dd, *J* = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 161.2 (d, $J_{C\text{-}F}$ = 242.0 Hz), 142.8, 139.9 (d, $J_{C\text{-}F}$ = 7.0 Hz), 136.1, 130.7, 130.3 (d, $J_{C\text{-}F}$ = 6.0 Hz), 129.0, 128.8, 128.7, 127.5, 126.8, 124.5, 123.5, 123.1, 117.1, 114.7 (d, $J_{C\text{-}F}$ = 25.0 Hz), 109.3, 59.4, 59.3, 56.6, 52.3, 42.7, 40.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ $[M+Na]^+$ 448.1683, found 448.1696; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 9.0 min, t_{major} = 10.7 min.



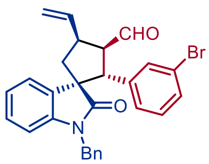
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(3-fluorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4at**): white solid (56% yield, 51.0 mg, 0.12 mmol, 87% ee); m.p. 125-127 ℃; $[\alpha]_D^{25}$ –8.7 ° (c 0.5, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.76 (s, 1H), 7.67 (d, *J* = 7.2 Hz, 1H), 7.22-7.21 (m, 3H), 7.10-7.03 (m, 3H), 6.96-6.92 (m, 2H), 6.89 (dt, *J* = 8.4, 2.0 Hz, 1H), 6.76 (d, *J* = 7.6 Hz, 1H), 6.71 (d, *J* = 10.8 Hz, 1H), 6.65 (d, *J* = 7.6 Hz, 1H), 6.10-6.01 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.16 (dd, *J* = 10.0, 1.2 Hz, 1H), 5.01 (d, *J* = 16.0 Hz, 1H), 4.68 (d, *J* = 16.0 Hz, 1H), 4.22 (d, *J* = 4.4 Hz, 1H), 3.93-3.86 (m, 1H), 2.28 (dd, *J* = 13.2, 8.8 Hz, 1H), 2.16 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.5, 178.1, 162.0 (d, $J_{C\text{-}F}$ = 242 Hz), 142.2, 139.9 (d, $J_{C\text{-}F}$ = 7.0 Hz), 138.7, 136.3, 130.8, 130.2 (d, $J_{C\text{-}F}$ = 8.0 Hz), 128.9, 128.5, 127.7, 127.2, 125.2, 124.6, 122.6, 117.4, 114.9 (d, $J_{C\text{-}F}$ = 21.0 Hz), 114.3 (d, $J_{C\text{-}F}$ = 21.0 Hz), 109.5, 59.5, 57.2, 53.0, 43.6, 43.4, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}FNO_2Na$ $[M+Na]^+$ 448.1683, found 448.1704; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 10.1 min, t_{minor} = 12.5 min.



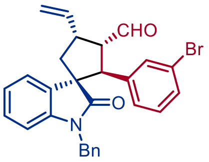
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(3-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3au**): white solid (46% yield, 40.6 mg, 0.092 mmol, 95% ee); m.p. 144-145 ℃; $[\alpha]_D^{25}$ –84.9 ° (c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 1.6 Hz, 1H), 7.75-7.72 (m, 1H), 7.27 (d, *J* = 7.6 Hz, 1H), 7.18-7.12 (m, 6H), 6.98 (s, 1H), 6.84 (d, *J* = 8.0 Hz, 1H), 6.62 (d, *J* = 6.8 Hz, 2H), 6.56-6.54 (m, 1H), 6.13-6.04 (m, 1H), 5.30 (d, J = 17.2 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 4.92 (d, J = 16.4 Hz, 1H), 4.44 (d, J = 16.0 Hz, 1H), 4.35 (t, J = 10.2 Hz, 1H), 4.21 (d, J = 11.2 Hz, 1H), 3.96-3.88 (m, 1H), 2.43 (dd, J = 13.2, 7.6 Hz, 1H), 2.20 (dd, J = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 142.8, 139.6, 139.3, 136.1, 133.2, 130.6, 130.3, 128.9, 128.7, 127.8, 127.7, 127.5, 127.2, 126.7, 123.5, 123.1, 117.1, 109.4, 59.3, 56.5, 52.2, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ [M+Na]$^+$ 464.1388, found 464.1378; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 9.7 min, t_{major} = 11.0 min.



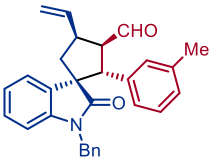
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(3-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4au**): white solid (46% yield, 40.6 mg, 0.092 mmol, 69% ee); m.p. 131-132 ℃; $[\alpha]_D^{25}$ +21.9 ° (c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.70 (d, J = 7.2 Hz, 1H), 7.29 (d, J = 8.4 Hz, 1H), 7.22-7.16 (m, 4H), 7.13-7.08 (m, 2H), 7.06 (t, J = 7.4 Hz, 1H), 6.92-6.78 (m, 3H), 6.67 (d, J = 7.6 Hz, 1H), 6.08-5.99 (m, 1H), 5.33 (d, J = 16.8 Hz, 1H), 5.17 (d, J = 10.0 Hz, 1H), 5.03 (d, J = 16.0 Hz, 1H), 4.65 (d, J = 16.0 Hz, 1H), 4.23 (t, J = 11.0 Hz, 1H), 4.15 (d, J = 12.0 Hz, 1H), 3.95-3.86 (m, 1H), 2.26 (dd, J = 13.2, 8.8 Hz, 1H), 2.18 (dd, J = 12.8, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.3, 177.8, 142.2, 138.7, 138.2, 136.2, 131.0, 130.5, 130.4, 130.3, 130.1, 128.8, 128.7, 127.7, 127.1, 125.2, 122.7, 117.5, 109.7, 59.4, 57.2, 52.6, 43.4, 43.3, 43.1; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ [M+Na]$^+$ 464.1388, found 464.1355; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 11.7 min, t_{major} = 16.4 min.



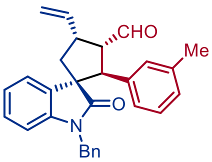
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(3-bromophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3av**): white solid (13% yield, 12.6 mg, 0.026 mmol, 0 ee); m.p. 163-164 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.74 (s, 1H), 7.74-7.73 (m, 1H), 7.40 (d, J = 7.6 Hz, 1H), 7.16-7.13 (m, 6H), 7.05 (t, J = 7.8 Hz, 1H), 6.88 (d, J = 7.6 Hz, 1H), 6.62 (d, J = 6.8 Hz, 1H), 6.55-6.54 (m, 1H), 6.13-6.04 (m, 1H), 5.30 (d, J = 16.8 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 4.92 (d, J = 16.4 Hz, 1H), 4.44 (d, J = 16.0 Hz, 1H), 4.35 (t, J = 10.8 Hz, 1H), 4.20 (d, J = 11.2 Hz, 1H), 3.96-3.87 (m, 1H), 2.42 (dd, J = 13.2, 8.0 Hz, 1H), 2.21 (dd, J = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 142.8, 139.8, 139.3, 136.1, 130.7, 130.6, 128.9, 128.7, 127.5, 126.8, 123.5, 123.1, 121.9, 117.1, 109.3, 59.3, 56.6, 52.3, 42.8, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ [M+Na]$^+$ 508.0883, found 508.0891; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 10.0 min, t_{major} = 11.4 min.



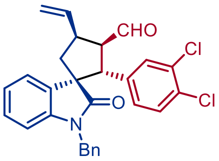
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(3-bromophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4av**): white solid (37% yield, 35.9 mg, 0.074 mmol, 56% ee); m.p. 131-132 ℃; $[\alpha]_D^{25}$ +15.9 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.75 (s, 1H), 7.69 (d, *J* = 7.2 Hz, 1H), 7.28 (dd, *J* = 8.0 Hz, 1H), 7.23-7.22 (m, 3H), 7.13-7.09 (m, 3H), 7.05 (t, *J* = 7.4 Hz, 1H), 6.98 (t, 1 *J* = 7.8 Hz, 1H), 6.93-6.91 (m, 3H), 6.62 (d, *J* = 7.6 Hz, 1H), 6.10-6.01 (m, 1H), 5.32 (d, *J* = 17.2 Hz, 1H), 5.17 (d, *J* = 10.8 Hz, 1H), 5.03 (d, *J* = 16.0 Hz, 1H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.25-4.17 (m, 2H), 3.94-3.85 (m, 1H), 2.28 (dd, *J* = 12.8, 8.8 Hz, 1H), 2.16 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.5, 178.0, 142.2, 139.8, 138.8, 136.3, 131.2, 130.7, 130.4, 129.0, 128.6, 127.6, 127.4, 127.1, 125.2, 122.6, 121.7, 117.5, 109.6, 59.6, 57.2, 53.0, 43.6, 43.4, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}BrNO_2Na$ $[M+Na]^+$ 508.0883, found 508.0854; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 9.6 min, t_{minor} = 11.2 min.



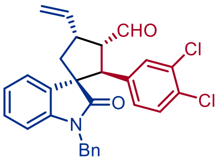
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(3-methylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3aw**): white solid (31% yield, 26.1 mg, 0.062 mmol, 94% ee); m.p. 151-152 ℃; $[\alpha]_D^{25}$ –94.1 ° (c 0.2, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.72-7.70 (m, 1H), 7.16-7.08 (m, 5H), 7.03-6.95 (m, 2H), 6.75 (s, 1H), 6.70 (d, *J* = 7.6 Hz, 1H), 6.56 (d, *J* = 7.2 Hz, 2H), 6.50-6.48 (m, 1H), 6.14-6.05 (m, 1H), 5.28 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.4 Hz, 1H), 4.91 (d, *J* = 16.0 Hz, 1H), 4.42 (d, *J* = 16.0 Hz, 1H), 4.31-4.25 (m, 1H), 4.17 (d, *J* = 11.2 Hz, 1H), 3.95-3.87 (m, 1H), 2.40 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.23 (dd, *J* = 13.6, 8.4 Hz, 1H), 2.07 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.1, 178.3, 142.9, 139.3, 137.4, 136.8, 136.1, 131.0, 130.3, 128.8, 128.5, 128.3, 127.4, 126.7, 125.6, 123.4, 122.9, 109.2, 59.4, 56.8, 53.0, 42.7, 31.5, 22.6, 21.5; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ $[M+Na]^+$ 444.1934, found 444.1937; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 9.2 min, t_{major} = 11.5 min.



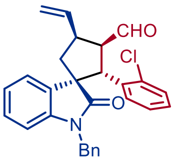
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(3-methylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4aw**): white solid (36% yield, 30.3 mg, 0.072 mmol, 73% ee); m.p. 121-122 ℃; $[\alpha]_D^{25}$ +27.0 ° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ 9.74 (d, *J* = 2.4 Hz, 1H), 7.66 (d, *J* = 7.6 Hz, 1H), 7.23-7.16 (m, 3H), 7.08 (t, *J* = 7.6 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.90-6.87 (m, 4H), 6.75-6.70 (m, 2H), 6.58 (d, *J* = 7.6 Hz, 1H), 6.12-6.03 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 5.02 (d, *J* = 16.0 Hz, 1H), 4.65 (d, *J* = 16.0 Hz, 1H), 4.19 (d, *J* = 12.0 Hz, 1H), 4.13 (dt, *J* = 10.0, 2.4 Hz, 1H), 3.92-3.83 (m, 1H), 2.29 (dd, *J* = 12.8, 9.2 Hz, 1H), 2.14 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.06 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.9, 178.2, 142.2, 138.8, 137.2, 136.7, 136.3, 131.2, 129.3, 128.9, 128.3, 128.1, 127.6, 127.1, 125.2, 122.5, 117.3, 109.5, 59.7, 57.5, 53.5, 43.8, 43.5, 43.2, 21.4; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_2Na$ $[M+Na]^+$ 444.1934, found 444.1938; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 8.0 min, t_{minor} = 10.1 min.



(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(3,4-dichlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ax**): white solid (22% yield, 20.9 mg, 0.044 mmol, 94% ee); m.p. 178-179 ℃; $[\alpha]_D^{25}$ –75.8 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 1.6 Hz, 1H), 7.74 (t, *J* = 4.2 Hz, 1H), 7.27 (d, *J* = 9.2 Hz, 1H), 7.18-7.12 (m, 6H), 6.99 (s, 1H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.61 (d, *J* = 7.2 Hz, 2H), 6.56-6.54 (m, 1H), 6.13-6.03 (m, 1H), 5.30 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.4 Hz, 1H), 4.92 (d, *J* = 16.0 Hz, 1H), 4.42-4.46 (m, 1H), 4.36 (t, *J* = 10.8 Hz, 1H), 4.21 (d, *J* = 11.2 Hz, 1H), 3.92 (dd, *J* = 18.0, 8.8 Hz, 1H), 2.43 (dd, *J* = 13.6, 8.0 Hz, 1H), 2.20 (dd, *J* = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.1, 142.8, 139.6, 139.3, 136.1, 133.2, 130.6, 130.3, 128.9, 128.7, 127.8, 127.7, 127.5, 127.1, 126.8, 123.5, 123.1, 117.1, 109.3, 59.3, 56.6, 53.2, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{23}Cl_2NO_2Na$ $[M+Na]^+$ 498.0998, found 498.0991; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 9.2 min, t_{major} = 10.4 min.

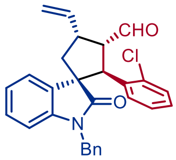


(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(3,4-dichlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ax**): white solid (33% yield, 31.4 mg, 0.066 mmol, 67% ee); m.p. 131-132 ℃; $[\alpha]_D^{25}$ +6.4 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.75 (s, 1H), 7.69 (d, *J* = 7.2 Hz, 1H), 7.22 (t, *J* = 3.2 Hz, 3H), 7.15-7.09 (m, 2H), 7.07-7.03 (m, 2H), 6.97 (s, 1H), 6.94-6.92 (m, 2H), 6.87 (d, *J* = 7.6 Hz, 1H), 6.63 (d, *J* = 7.6 Hz, 1H), 6.10-6.01 (m, 1H), 5.32 (d, *J* = 16.8 Hz, 1H), 5.17 (d, *J* = 10.0 Hz, 1H), 5.02 (d, *J* = 16.0 Hz, 1H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.26-4.17 (m, 2H), 3.94-3.85 (m, 1H), 2.27 (dd, *J* = 13.2, 9.2 Hz, 1H), 2.17 (dd, *J* = 12.8, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.5, 178.0, 142.2, 139.5, 138.7, 136.2, 133.0, 130.7, 130.1, 129.0, 128.6, 128.2, 127.7, 127.5, 127.1, 127.0, 125.2, 122.6, 117.5, 109.6, 59.5, 57.2, 53.0, 43.6, 43.4, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{23}Cl_2NO_2Na$ $[M+Na]^+$ 498.0998, found 498.0974; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 90:10; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 12.2 min, t_{major} = 17.0 min.

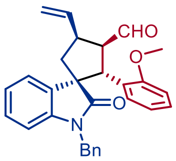


(1*S*,2*S*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(2-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ay**): white solid (16% yield, 14.1 mg, 0.032 mmol, 16% ee); m.p. 131-132 ℃; $[\alpha]_D^{25}$ –3.1 ° (c 0.1, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.57 (s, 1H), 7.30-7.26 (m, 8H), 7.17 (d, *J* = 5.6 Hz, 1H), 7.11 (t, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 7.6 Hz, 1H), 6.68 (t, *J* = 7.6 Hz, 1H), 6.19-6.11 (m, 2H), 5.24 (d, *J* = 17.2 Hz, 1H), 5.06 (d, *J* = 11.6 Hz, 2H), 4.83 (d, *J* = 15.6 Hz, 1H), 4.58 (d, *J* = 8.8 Hz, 1H), 3.95-4.06 (m, 2H), 2.43 (dd, *J* = 13.6, 10.0 Hz, 1H), 2.07 (dd, *J* = 14.0, 6.0 Hz, 1H); ^{13}C NMR

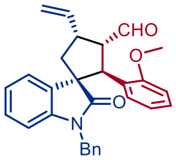
(DMSO-d_6, 100 MHz) δ 202.6, 180.0, 142.9, 142.4, 136.7, 135.3, 135.3, 130.1, 129.9, 129.4, 129.3, 129.0, 128.6, 127.8, 127.6, 127.4, 124.3, 122.2, 60.8, 58.1, 50.2, 43.0, 42.7, 41.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1378; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 9.4 min, t_{major} = 10.0 min.



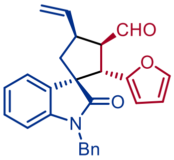
(1*S*,2*R*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(2-chlorophenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ay**): white solid (37% yield, 32.6 mg, 0.074 mmol, 94% ee); m.p. 195-196 ℃; $[\alpha]_D^{25}$ –62.0 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.73 (d, *J* = 2.0 Hz, 1H), 7.57 (d, *J* = 7.2 Hz, 1H), 7.25 (d, *J* = 8.0 Hz, 1H), 7.22-7.20 (m, 3H), 7.13 (d, *J* = 7.6 Hz, 1H), 7.06 (t, *J* = 7.6 Hz, 2H), 7.00-6.93 (m, 4H), 6.60 (d, *J* = 7.6 Hz, 1H), 6.31-6.22 (m, 1H), 5.32 (d, *J* = 17.2 Hz, 1H), 5.17 (dd, *J* = 10.0 Hz, 1H), 4.91 (d, *J* = 16.0 Hz, 1H), 4.76 (d, *J* = 11.6 Hz, 1H), 4.70 (d, *J* = 16.0 Hz, 1H), 4.18 (t, *J* = 10.4 Hz, 1H), 3.92-3.86 (m, 1H), 2.31 (d, *J* = 7.2 Hz, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 202.9, 178.7, 142.5, 138.8, 136.4, 135.2, 134.3, 131.3, 130.1, 129.6, 128.9, 128.8, 128.4, 127.6, 127.2, 126.5, 125.7, 122.3, 117.4, 109.2, 60.1, 58.0, 48.8, 44.4, 43.7, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{24}ClNO_2Na$ $[M+Na]^+$ 464.1388, found 464.1413; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 13.6 min, t_{major} = 14.5 min.



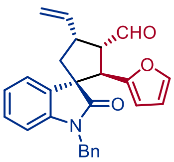
(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(2-methoxylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3az**): white solid (31% yield, 27.0 mg, 0.062 mmol, 76% ee); m.p. 185-186 ℃; $[\alpha]_D^{25}$ –74.6 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.72 (d, *J* = 2.4 Hz, 1H), 7.60-7.58 (m, 1H), 7.29 (d, *J* = 7.6 Hz, 1H), 7.18-7.12 (m, 4H), 7.08-7.06 (m, 2H), 6.79 (t, *J* = 7.6 Hz, 2H), 6.71 (d, *J* = 8.0 Hz, 1H), 6.66 (d, *J* = 6.8 Hz, 2H), 6.49-6.47 (m, 1H), 6.17-6.08 (m, 1H), 5.29 (d, *J* = 16.8 Hz, 1H), 5.16 (d, *J* = 10.0 Hz, 1H), 4.90 (d, *J* = 16.0 Hz, 1H), 4.79 (d, *J* = 11.2 Hz, 1H), 4.44 (d, *J* = 16.0 Hz, 1H), 4.16 (dt, *J* = 10.8, 2.4 Hz, 1H), 3.94 (t, *J* = 8.8 Hz, 1H), 3.20 (s, 3H), 2.38 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.26 (dd, *J* = 13.2, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.6, 157.7, 142.5, 139.1, 136.3, 131.2, 128.8, 128.4, 127.9, 127.4, 127.0, 125.5, 124.2, 122.3, 120.6, 117.1, 111.3, 108.8, 59.0, 58.1, 55.2, 44.7, 43.4, 43.1, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1881; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 21.8 min, t_{minor} = 23.4 min.



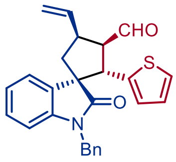
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(2-methoxylphenyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4az**, major diastereomer): white solid (41% yield, 35.8 mg, 0.082 mmol, 93% ee); m.p. 134-135 ℃; $[\alpha]_D^{25}$ -11.7 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.64 (d, *J* = 3.6 Hz, 1H), 7.35-7.32 (m, 5H), 7.29-7.26 (m, 1H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.94 (t, *J* = 7.6 Hz, 1H), 6.81 (t, *J* = 7.6 Hz, 1H), 6.73-6.68 (m, 2H), 6.62 (d, *J* = 7.2 Hz, 1H), 6.57 (d, *J* = 8.4 Hz, 1H), 6.05-5.96 (m, 1H), 5.28 (d, J = 17.2 Hz, 1H), 5.17-5.13 (m, 2H), 4.75 (d, J = 15.6 Hz, 1H), 4.28 (d, J = 11.6 Hz, 1H), 3.73 (dt, J = 11.2, 3.6 Hz, 1H), 3.26 (s, 3H), 2.31-2.26 (m, 1H), 2.00 (t, J = 12.2 Hz, 1H), 1.07 (t, J = 7.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 181.5, 157.2, 142.7, 139.0, 137.3, 131.9, 129.1, 128.3, 127.9, 127.8, 127.7, 126.5, 124.7, 121.8, 120.1, 117.0, 110.2, 108.4, 59.8, 56.0, 54.9, 47.4, 45.1, 44.9, 43.1; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ [M+Na]$^+$ 460.1883, found 460.1864; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 16.4 min, t_{minor} = 17.0 min.



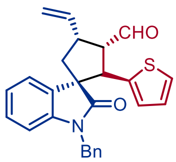
(1*S*,2*S*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(2-furanyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3ba**): white solid (41% yield, 32.6 mg, 0.082 mmol, 46% ee); m.p. 133-134 ℃; $[\alpha]_D^{25}$ –106.6° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.77 (d, J= 2.0 Hz, 1H), 7.64 (d, J= 7.2 Hz, 1H), 7.31 (s, 1H), 7.25-7.23 (m, 3H), 7.17 (t, J= 7.8 Hz, 1H), 7.10 (t, J= 7.4 Hz, 1H), 6.93 (d, J = 6.4 Hz, 2H), 6.68 (d, J = 7.6 Hz, 1H), 6.24 (s, 1H), 6.07-5.98 (m, 1H), 5.87 (d, J = 2.8 Hz, 1H), 5.27 (d, J = 17.2 Hz, 1H), 5.14 (d, J = 10.0 Hz, 1H), 4.94 (d, J = 16.0 Hz, 1H), 4.59 (d, J = 16.0 Hz, 1H), 4.32 (d, J = 10.8 Hz, 1H), 4.11 (t, J = 11.0 Hz, 1H), 3.94-3.87 (m, 1H), 2.31 (dd, J = 13.2, 7.6 Hz, 1H), 2.21 (dd, J = 12.8, 9.2 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 178.0, 152.1, 142.9, 142.4, 138.8, 136.4, 130.9, 129.0, 128.5, 127.6, 127.2, 123.2, 123.0, 117.2, 110.6, 109.2, 106.9, 57.8, 56.6, 46.5, 42.9, 42.7; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{26}H_{23}NO_3Na$ [M+Na]$^+$ 420.1570, found 420.1582; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 21.3 min, t_{major} = 27.3 min.



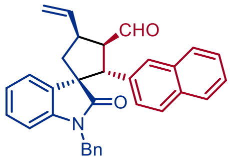
(1*S*,2*R*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(2-furanyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4ba**): white solid (36% yield, 30.2 mg, 0.072 mmol, 90% ee); m.p. 104-105 ℃; $[\alpha]_D^{25}$ –31.6° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.80 (d, J= 2.0 Hz, 1H), 7.42 (d, J= 7.6 Hz, 1H), 7.34 (t, J= 7.4 Hz, 2H), 7.28-7.23 (m, 3H), 7.17 (s, 1H), 7.10 (t, J= 7.6 Hz, 1H), 6.94 (t, J= 7.4 Hz, 1H), 6.75 (d, J = 7.6 Hz, 1H), 6.08-6.00 (m, 2H), 5.85-5.84 (m, 1H), 5.30 (d, J = 16.8 Hz, 1H), 5.16 (d, J = 10.0 Hz, 1H), 5.09 (d, J = 15.6 Hz, 1H), 4.80 (d, J = 16.0 Hz, 1H), 4.32 (d, J = 11.2 Hz, 1H), 4.04-3.98 (m, 1H), 3.82 (d, J = 9.0 Hz, 1H), 2.23 (dd, J = 12.8, 9.2 Hz, 1H), 2.08 (dd, J = 12.8, 7.2 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.2, 178.2, 152.3, 142.3, 142.1, 138.2, 136.6, 131.1, 129.0, 128.3, 127.7, 127.4, 124.8, 122.5, 117.6, 110.4, 109.4, 106.8, 57.8, 56.9, 46.4, 44.1, 43.7, 43.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{26}H_{23}NO_3Na$ [M+Na]$^+$ 420.1570, found 420.1566; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{major} = 20.8 min, t_{minor} = 22.9 min.



(1*S*,2*S*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(2-thienyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3bb**): white solid (25% yield, 20.7 mg, 0.05 mmol, 79% ee); m.p. 138-139 ℃; $[\alpha]_D^{25}$ –89.6 ° (c 0.2, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.76 (d, *J* = 2.4 Hz, 1H), 7.71 (d, *J* = 6.8 Hz, 1H), 7.23 (d, *J* = 5.2 Hz, 1H), 7.20-7.16 (m, 3H), 6.85-6.83 (m, 1H), 6.70-6.68 (m, 2H), 6.63-6.61 (m, 2H), 6.09-6.00 (m, 1H), 5.28 (d, *J* = 16.4 Hz, 1H), 5.14 (d, *J* = 9.6 Hz, 1H), 4.90 (d, *J* = 16.4 Hz, 1H), 4.48 (dd, *J* = 20.4, 16.0 Hz, 2H), 4.22 (dt, *J* = 11.2, 2.4 Hz, 1H), 3.94-3.85 (m, 1H), 2.37 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.25 (dd, *J* = 13.2, 8.8 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.7, 177.9, 143.3, 139.7, 139.1, 136.2, 130.5, 128.9, 128.8, 127.4, 126.9, 125.1, 125.0, 123.5, 123.4, 123.0, 117.2, 109.3, 59.3, 58.1, 48.4, 42.9,42.7, 42.3; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{26}H_{23}NO_2SNa$ $[M+Na]^+$ 436.1342, found 436.1347; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 9.7 min, t_{major} = 13.0 min.

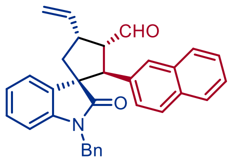


(1*S*,2*R*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(2-thienyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4bb**, major diatereomer): white solid (39% yield, 32.2 mg, 0.078 mmol, 83% ee); m.p. 107-108 ℃; $[\alpha]_D^{25}$ –9.2 °(c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.75 (s, 1H), 7.63 (d, *J* = 7.2 Hz, 1H), 7.22-7.20 (m, 2H), 7.18-7.14 (m, 2H), 7.05 (t, *J* = 7.4 Hz, 1H), 6.89-6.96 (m, 2H), 6.76-6.74 (m, 1H), 6.70 (d, *J* = 7.6 Hz, 1H), 6.62 (d, *J* = 2.4 Hz, 1H), 6.08-5.99 (m, 1H), 5.29 (d, *J* = 16.8 Hz, 1H), 5.15 (d, *J* = 10.4 Hz, 1H), 4.99 (d, *J* = 16.0 Hz, 1H), 4.76 (d, *J* = 16. 0 Hz, 1H), 4.51 (d, *J* = 10.8 Hz, 1H), 3.95-3.83 (m, 2H), 2.30-2.26 (m, 1H), 2.16-2.13 (m, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.6, 177.7, 142.6, 139.7, 138.4, 136.2, 130.8, 128.9, 127.6, 127.1, 126.7, 126.1, 125.4, 125.2, 123.1, 122.8, 117.5, 109.6, 59.7, 59.5, 49.2, 43.8, 43.2, 43.0; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{26}H_{23}NO_2SNa$ $[M+Na]^+$ 436.1342, found 436.1346; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 18.1 min, t_{minor} = 19.0 min.

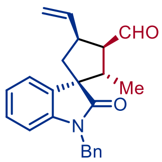


(1*S*,2*R*,3*R*,4*S*)-1'-benzyl-2'-oxo-2-(2-napthyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3bc**): white solid (38% yield, 34.7 mg, 0.076 mmol, 97% ee); m.p. 105-106 ℃; $[\alpha]_D^{25}$ –137.9 ° (c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.80 (d, *J* = 2.4 Hz, 1H), 7.82 (t, *J* = 8.4 Hz, 2H), 7.69 (d, *J* = 7.6 Hz, 1H), 7.62-7.56 (m, 2H), 7.51-7.45 (m, 2H), 7.17-7.10 (m, 2H), 6.97 (dd, *J* = 8.4, 1.2 Hz, 1H), 6.89 (t, *J* = 6.8 Hz, 1H), 6.49 (t, *J* = 7.6 Hz, 2H), 6.42 (d, *J* = 7.6 Hz, 1H), 6.29 (d, *J* = 7.6 Hz, 2H), 6.17-6.10 (m, 1H), 5.33 (d, *J* = 17.2 Hz, 1H), 5.18 (dd, *J* = 10.0, 1.6 Hz, 1H), 4.88 (d, *J* = 16.0 Hz, 1H), 4.52 (dt, *J* = 11.6, 2.4 Hz, 1H), 4.40 (d, *J* =

11.2 Hz, 1H), 4.33 (d, J = 27.6 Hz, 1H), 4.01-3.93 (m, 1H), 2.47 (dd, J = 13.6, 8.0 Hz, 1H), 2.29 (dd, J = 13.6, 8.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 204.0, 178.3, 142.8, 139.4, 135.8, 134.7, 133.2, 132.8, 131.0, 128.6, 128.2(9), 128.2(6), 127.8(4), 127.8(0), 126.5, 126.2, 123.5, 123.0, 117.1, 109.2, 59.5, 56.8, 53.1, 43.0, 42.8, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{32}H_{27}NO_2Na$ $[M+Na]^+$ 480.1934, found 480.1937; HPLC analysis: Daicel Chiralpak OD-H (*i*-PrOH: *n*-Hexane = 70:30; flow rate: 0.8 mL/min; λ = 254 nm; t_{minor} = 9.7 min, t_{major} = 12.1 min.



(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-(2-napthyl)-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**4bc**): white solid (43% yield, 39.3 mg, 0.086 mmol, 80% ee); m.p. 86-87 ℃; $[\alpha]_D^{25}$ +50.2 °(c 0.4, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.80 (d, J = 2.4 Hz, 1H), 7.77-7.76 (m, 2H), 7.70-7.67 (m, 1H), 7.55-7.53 (m, 3H), 7.44 (dd, J = 6.0, 3.2 Hz, 2H), 7.05-7.03 (m, 4H), 6.79 (t, J = 7.6 Hz, 2H), 6.72 (d, J = 7.6 Hz, 1H), 6.50 (dd, J = 5.2, 3.2 Hz, 1H), 6.17-6.08 (m, 1H), 5.35 (d, J = 17.2 Hz, 1H), 5.19 (d, J = 10.0 Hz, 1H), 5.02 (d, J = 16.0 Hz, 1H), 4.59 (d, J = 16.4 Hz, 1H), 4.41 (d, J = 12.0 Hz, 1H), 4.35-4.29 (m, 1H), 3.96 (t, J = 9.0 Hz, 1H), 2.35 (dd, J = 13.2, 9.2 Hz, 1H), 2.21 (dd, J = 13.2, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 203.8, 178.2, 142.2, 138.8, 136.0, 134.6, 133.0, 132.5, 131.1, 128.6, 128.4, 128.1, 127.8, 127.6, 127.5, 127.4, 126.9, 126.5, 126.3, 125.3, 122.6, 117.4, 109.5, 59.9, 57.5, 53.8, 43.9, 43.5, 43.2,; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{32}H_{27}NO_2K$ $[M+K]^+$ 496.1673, found 496.1693; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{major} = 11.7 min, t_{minor} = 13.7 min.



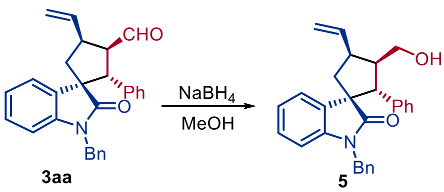
1'-benzyl-2'-oxo-2-methyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carbaldehyde (**3bd+4bd,** dr = 1:1): Yellowish oil (55% yield, 38.0 mg, 0.11 mmol, 96% ee); $[\alpha]_D^{25}$ –5.1 °(c 0.3, $CHCl_3$); ^{1}H NMR (DMSO-d_6, 400 MHz) δ 9.87 (d, J = 1.2 Hz, 1.0H), 9.74 (d, J = 2.4 Hz, 0.9H), 7.42-7.22 (m, 14.9H), 7.09-7.03 (m, 2.0H), 6.99-6.94 (m, 2.1H),6.04-5.87 (m, 2.1H), 5.23 (d, J = 16.8 Hz, 1.2H), 5.16-5.01 (m, 2.2H), 5.04-4.97 (m, 3.4H), 4.88 (d, J = 15.6 Hz, 2.1H), 3.70-3.64 (m, 2.0H), 3.19 (dt, J = 11.2, 2.4 Hz, 1.1H), 3.10-3.06 (m, 1.1H), 2.98-2.94 (m, 1.1H), 2.16-2.11 (m, 1.2H), 2.04-2.02 (m, 3.2H), 0.71 (d, J = 7.2 Hz, 3.3H), 0.46 (d, J = 6.8 Hz, 2.8H), ; ^{13}C NMR (DMSO-d_6, 100 MHz) δ 205.2, 204.1, 179.3, 178.8, 142.7, 142.5, 140.9, 138.8, 137.0, 131.3, 130.7, 129.2, 128.4, 127.9, 127.6, 127.5, 125.1, 124.7, 122.8, 122.6, 109.8, 109.7, 60.5, 58.8, 58.7, 58.2, 44.3, 43.0, 42.9, 42.4, 42.2, 29.5, 29.2, 14.0, 13.5; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{23}H_{23}NO_2Na$ $[M+Na]^+$ 368.1621, found 368.1619; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 10.1 min, t_{major} = 11.5 min.

2.4 Gram-scale synthesis of enantioenriched spirooxindole 3 and 4

To a solution of spirovinylcyclopropyl oxindole **1** (1.2 g, 4.4 mmol), and enal **2** (0.69 g, 5.2 mmol, 1.2 equiv.) in THF (40 mL) were added $Pd(OAc)_2$ (0.049 g, 0.22 mmol, 5 mol%), PPh_3 (0.2 g, 0.44 mmol, 10 mol%), AcOH (0.053 g, 0.88 mmol, 20 mol%) and *Jørgensen-Hayashi* catalyst **C4** (0.29 g, 0.88 mmol, 20 mol%), respectively. The mixture was stirred for about 48 h (TLC monitoring) at room temperature under Ar atmosphere. After the reaction completed, the solvent was removed under reduced pressure. The residue was then extracted with EtOAc (3×50 mL), subsequently washed with brine (3×50 mL). The combined organic layers were dried over $MgSO_4$, filtered, and concentrated in *vacuo*. The residue was purified by flash column chromatography on silica gel (Petroleum ether/EtOAc= 19:1 to 9:1) to afford enantioenriched **3** (0.66 g, 1.6 mmol, 96% ee) and **4** (0.59 g, 1.4 mmol, 91% ee), respectively.

2.5 Experimental procedure for the synthesis of alcohol derivative 5

(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-hydroxymethyl (**5**)

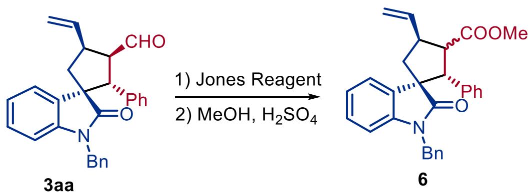


To a solution of spirooxindole **3aa** (40.7 mg, 0.1 mmol, 96% ee) in methanol (1 mL) was added sodium borohydride (4.2 mg, 0.11 mmol, 1.1 equiv.) at 0 ℃. The reaction was stirred for 0.5 h at 0 °C and another 0.5 h at room temperature. The reaction was then quenched by water (1 mL) and extracted with EtOAc (3×2 mL), subsequently washed with brine (3×2 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in *vacuo*. The residue was purified by flash column chromatography on silica gel (Petroleum ether/EtOAc= 9:1 to 3:1) to give alcohol derivative **5** (33.9 mg, 0.083 mmol, 83%, 96% ee) as a white solid. m.p. 143-144 ℃; $[\alpha]_D^{25}$ –27.1° (c 0.3, $CHCl_3$); ^1H NMR (DMSO-d_6, 400 MHz) δ7.57-7.54 (m, 1H), 7.21 (t, *J* = 7.2 Hz, 1H), 7.14-7.08 (m, 7H), 6.96 (d, *J* = 8.4 Hz, 2H), 6.52 (d, *J* = 7.2 Hz, 2H), 6.46-6.44 (m, 1H), 6.35-6.26 (m, 1H), 5.19 (d, *J* = 17.2 Hz, 1H), 5.13 (d, *J* = 11.2 Hz, 1H), 4.87 (d, *J* = 16.0 Hz, 1H), 4.48 (t, *J* = 4.4 Hz, 1H), 4.40 (d, *J* = 16.0 Hz, 1H), 3.59-3.52

(m, 2H), 3.41 (t, *J* = 5.0 Hz, 2H), 3.34-3.28 (m, 1H), 2.32 (dd, *J* = 13.2, 7.6 Hz, 1H), 2.12 (dd, *J* = 13.2, 7.6 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 178.8, 142.7, 140.7, 138.0, 136.2, 132.5, 128.8, 128.7, 128.4, 128.1, 127.3(3), 127.2(9), 126.8, 123.0, 122.8, 115.6, 109.0, 60.5, 59.4, 56.1, 47.4, 43.2, 42.7, 42.6; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{28}H_{27}NO_2Na$ $[M+Na]^+$ 432.1934, found 432.1938; HPLC analysis: Daicel Chiralpak AD-H (*i*-PrOH: *n*-Hexane = 80:20; flow rate: 1 mL/min; λ = 254 nm; t_{minor} = 10.4 min, t_{major} = 15.0 min.

2.6 Experimental procedure for the synthesis of ester derivative 6

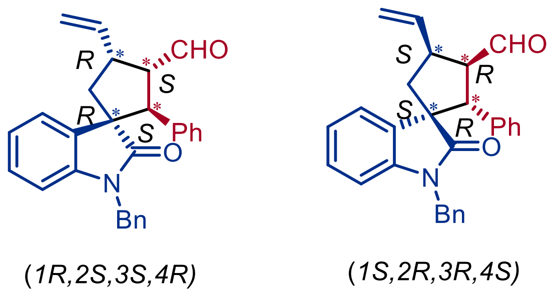
(1*S*,2*S*,3*S*,4*R*)-1'-benzyl-2'-oxo-2-phenyl-4-vinylspiro[cyclopentane-1,3'-indoline]-3-carboxymethyl (**6**, major diatereomer)



To a solution of spirooxindole **3aa** (40.7 mg, 0.1 mmol, 96% ee) in acetone (1 mL) was added Jones reagent (0.2 mL) at 0 ℃. The mixture was stirred for 1 h at 0 ℃ and then allowed to reach ambient temperature and was stirred for 6 h until full conversion of the starting material was confirmed by TLC analysis. The reaction mixture was poured into water (4 mL) and extracted with EtOAc (3×2 mL), subsequently washed with brine (3×2 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in *vacuo*. The residue was dissolved with methanol (1 mL) and a drop of concentrated sulfuric acid was added. The mixture was then refluxed for 2 h. After cooling to room temperature, solvent was removed under reduced pressure. The residue was extracted with EtOAc (2×2 mL) and washed with brine (2×2 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash column chromatography on silica gel (Petroleum ether/EtOAc= 19:1 to 9:1) to give **6** (18.8 mg, 0.043 mmol, 43%) as white solid. m.p. 123-124 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ 7.70 (d, *J* = 7.2 Hz, 1H), 7.20-7.19 (m, 2H), 7.09-7.00 (m, 5H), 6.91-6.88 (m, 3H), 6.59 (d, *J* = 7.6 Hz, 1H), 5.98-5.89 (m, 1H), 5.22 (d, *J* = 16.8 Hz, 1H), 5.11 (d, *J* = 10.0 Hz, 1H), 4.98 (d, *J* = 16.0 Hz, 1H), 4.65 (d, *J* = 16.0 Hz, 1H), 4.15-4.13 (m,2H), 3.55 (s, 3H), 2.26 (dd, *J* = 13.2, 8.8 Hz, 1H), 2.17 (dd, *J* = 12.8, 8.0 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ 178.2, 172.6, 142.2, 139.0, 136.7, 136.2, 131.2, 128.9, 128.2, 127.6, 127.2, 125.3, 122.6, 117.1, 109.4, 59.5, 56.1, 52.0 (d, J = 4.0 Hz), 51.8, 43.7, 43.3, 43.2; HRMS (TOF-ESI$^+$) m/z: calcd for $C_{29}H_{27}NO_3Na$ $[M+Na]^+$ 460.1883, found 460.1894.

2.7 Computational Details

2.7.1 Determination of the absolute configuration of 3an



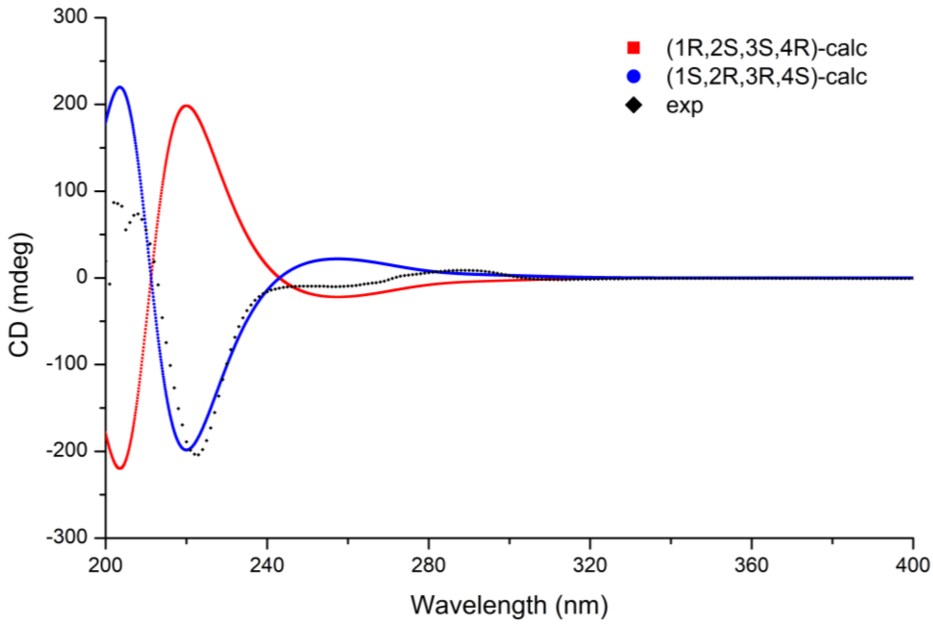
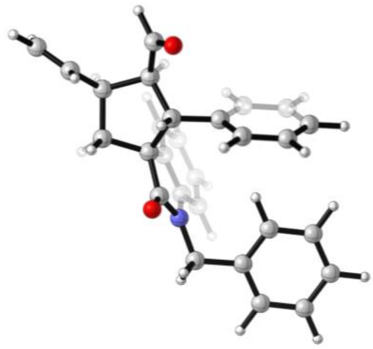


Figure S1 Experimental and calculated ECD spectra of compound **3an**.

The absolute configuration was assigned by X-ray crystallography and circular dichroism spectroscopy. The racemic crystallography data of **3an** suggests that the plausible configurations could be either (1*R*, 2*S*, 3*S*, 4*R*) or (1*S*, 2*R*, 3*R*, 4*S*). To figure out the dominant enantiomer in this asymmetric reaction, the CD spectrum of **3an** was collected. As shown in Figure **S1**, comparisons between experimental and predicted CD spectra suggest that the dominant configuration of the product **3an** is (1*S*, 2*R*, 3*R*, 4*S*) (Figure **S1-2**).



(1S,2R,3R,4S)

Figure S2 Predicted configuration of **3an** based on CD spectrum and X-ray crystallography.

2.7.2 Computational details of circular dichroism spectra

The ECD spectrum of **(1*R*,2*S*,3*S*,4*R*)-3an** was generated by TDDFT calculations as follows, while that of **(1*S*,2*R*,3*R*,4*S*)-3an** was obtained by mirror inversion from its enantiomer. Conformational search was carried out to access all possible stable conformations. The initial conformers were optimized at M06-2X[2]/def2-SVP[3] theoretical level in methanol with SMD solvent model[4] using Gaussian16 software.[5] Frequency calculations were carried out at the same theoretical level to obtain the thermal corrections and confirm well-defined minima on the potential energy surface. Quasi-harmonic approximation was employed for derivation of the vibrational entropy with a frequency cut-off, 100 cm^{-1}.[6] Single point energy calculations were performed at M06-2X/def2-TZVP-SMD(methanol) theoretical level. For all the optimized conformers, the Gibbs free energies were given by adding the thermal corrections (with vibrational entropy obtained by quasi-harmonic approximation) from frequency calculation to the electronic energy from single point energy calculation. The optimized stable conformers were then used for TDDFT calculation at the CAM-B3LYP[7]/def2-TZVP level in methanol using SMD solvent model. The number of excitation states was chosen to be 35. The overall ECD curves were weighted by Boltzmann distribution based on Gibbs free energies. The ECD spectra were generated with the help of SpecDis 1.7 software,[8] with a half-bandwidth of 0.3 eV. The calculated ECD curves were red-shift by 12 nm and scaled to fit better with the experimental curves.

2.7.3 Table of energies and other thermodynamic parameters.

Conformers	E	E(SP)	ZPE	H	T•S	G	$T•S_{qh}$	G_{qh}
(1R,2S,3S,4R)-3an_conf1	-1285.799385	-1287.21286	0.46350	-1285.30927	0.08399	-1285.39326	0.07832	-1285.38759
(1R,2S,3S,4R)-3an_conf2	-1285.797365	-1287.20973	0.46438	-1285.30662	0.08252	-1285.38914	0.07755	-1285.38417
(1R,2S,3S,4R)-3an_conf3	-1285.797488	-1287.21050	0.46423	-1285.30684	0.08316	-1285.39000	0.07782	-1285.38465
(1R,2S,3S,4R)-3an_conf4	-1285.796719	-1287.21073	0.46396	-1285.30617	0.08364	-1285.38981	0.07802	-1285.38419
(1R,2S,3S,4R)-3an_conf5	-1285.795005	-1287.20827	0.46423	-1285.30413	0.08586	-1285.38999	0.07906	-1285.38319
(1R,2S,3S,4R)-3an_conf6	-1285.794483	-1287.20907	0.46350	-1285.30406	0.08769	-1285.39175	0.07992	-1285.38398
(1R,2S,3S,4R)-3an_conf7	-1285.797035	-1287.21069	0.46359	-1285.30666	0.08621	-1285.39287	0.07929	-1285.38595
(1R,2S,3S,4R)-3an_conf8	-1285.796589	-1287.21130	0.46355	-1285.30630	0.08477	-1285.39107	0.07861	-1285.38491
(1R,2S,3S,4R)-3an_conf9	-1285.796414	-1287.21069	0.46374	-1285.30608	0.08422	-1285.39030	0.07834	-1285.38443
(1R,2S,3S,4R)-3an_conf10	-1285.796382	-1287.20997	0.46318	-1285.30638	0.08588	-1285.39226	0.07928	-1285.38566
(1R,2S,3S,4R)-3an_conf11	-1285.794250	-1287.20887	0.46351	-1285.30392	0.08636	-1285.39028	0.07939	-1285.38330
(1R,2S,3S,4R)-3an_conf12	-1285.795218	-1287.20867	0.46407	-1285.30466	0.08367	-1285.38833	0.07801	-1285.38267
(1R,2S,3S,4R)-3an_conf13	-1285.794688	-1287.20569	0.46378	-1285.30455	0.08303	-1285.38759	0.07776	-1285.38232
(1R,2S,3S,4R)-3an_conf14	-1285.793693	-1287.20565	0.46374	-1285.30357	0.08343	-1285.38699	0.07802	-1285.38158
(1R,2S,3S,4R)-3an_conf15	-1285.791938	-1287.20458	0.46359	-1285.30195	0.08344	-1285.38539	0.07799	-1285.37994
(1R,2S,3S,4R)-3an_conf16	-1285.798587	-1287.21009	0.46414	-1285.30807	0.08264	-1285.39070	0.07767	-1285.38573
(1R,2S,3S,4R)-3an_conf17	-1285.794983	-1287.20816	0.46383	-1285.30458	0.08485	-1285.38943	0.07857	-1285.38315

Notes: E, ZPE, H, T•S, and G are the electronic energies, sum of electronic and zero-point energies, sum of electronic and thermal enthalpies, the product of temperature (298.15 K) times the standard entropy (by rigid-rotor-harmonic-oscillator approximation) obtained using Gaussian16, and sum of electronic and thermal free energies, respectively, which were given at the M06-2X/def2-SVP theoretical level in methanol with SMD solvent model. $T•S_{qh}$ is the product of temperature (298.15 K) times the entropy given by quasi-harmonic approximation. G_{qh} is sum of electronic and thermal free energies with vibration entropies given by quasi-harmonic approximation. E(SP) were the electronic energies given at the M06-2X/def2-TZVP theoretical level in methanol with SMD solvent model.

2.7.4 Coordinates for stable conformations.

(1R,2S,3S,4R)-3an_conf1

0 imaginary frequency

C	0.680413	-1.788554	0.351883
C	-0.653877	-1.481445	0.659754
C	-1.169120	-1.846292	1.896692
C	-0.331908	-2.486342	2.821751
C	0.997584	-2.762178	2.503258
C	1.527887	-2.420705	1.253401
C	-0.128768	-0.832280	-1.556410
N	0.971223	-1.382908	-0.959496
C	2.252615	-1.543277	-1.604876
C	3.350758	-0.675532	-1.022471
C	3.079148	0.430373	-0.211778
C	4.681481	-0.986127	-1.328082
C	4.124995	1.216827	0.278201
C	5.723560	-0.198588	-0.843023
C	5.447448	0.907387	-0.036252
O	-0.177036	-0.402653	-2.694486
C	-1.266998	-0.796382	-0.536773
C	-1.690338	0.686560	-0.336979
C	-2.586236	-1.402177	-1.034086
C	-3.033369	0.566457	0.381591
C	-3.700459	-0.738290	-0.183011
C	-0.649299	1.601893	0.258354
C	-0.291273	1.553501	1.613137
C	0.007799	2.516880	-0.575713
C	0.699600	2.397552	2.116265
C	0.994580	3.365368	-0.073653
C	1.342749	3.308223	1.276143
C	-3.887830	1.795364	0.232061
O	-3.552187	2.778786	-0.384234
C	-4.934616	-0.483971	-1.003543
C	-6.126391	-1.036053	-0.777096
H	-2.208595	-1.639652	2.159313
H	-0.726092	-2.771032	3.798363
H	1.637620	-3.258676	3.234852
H	2.564672	-2.646721	0.999942
H	2.552376	-2.601942	-1.555509
H	2.101862	-1.295466	-2.665765
H	2.046291	0.682890	0.044794
H	4.899649	-1.855023	-1.954381
H	3.899311	2.076530	0.912307
H	6.756074	-0.451781	-1.091453
H	6.262122	1.523231	0.349130
H	-1.901345	1.051901	-1.355285
H	-2.607130	-2.497686	-0.963591
H	-2.706147	-1.120954	-2.092111
H	-2.891754	0.438815	1.468440
H	-3.969890	-1.395270	0.655220
H	-0.791399	0.854992	2.286900
H	-0.263397	2.561532	-1.633606
H	0.965199	2.347496	3.174048
H	1.491907	4.073446	-0.739450
H	2.111250	3.973710	1.674430
H	-4.876643	1.759750	0.741822
H	-4.806001	0.199209	-1.854291
H	-6.983310	-0.824397	-1.421303
H	-6.282218	-1.722763	0.060966

(1R,2S,3S,4R)-3an_conf2

0 imaginary frequency

C	-0.388320	2.093573	-0.246709
C	0.915586	1.734857	0.135559
C	1.551767	2.442059	1.146529
C	0.869625	3.490405	1.780570
C	-0.430823	3.818274	1.400850
C	-1.082893	3.124646	0.373974
C	0.167324	0.389922	-1.659248

N	-0.804828	1.281569	-1.314160
C	-2.104931	1.310548	-1.964175
C	-3.077144	0.315757	-1.367624
C	-3.256386	-0.937912	-1.963579
C	-3.798603	0.628545	-0.209207
C	-4.155946	-1.856858	-1.421671
C	-4.695155	-0.291082	0.335615
C	-4.879835	-1.533438	-0.273305
O	0.079714	-0.433596	-2.554381
C	1.339597	0.549419	-0.694335
C	1.471120	-0.781421	0.105482
C	2.714624	0.616595	-1.364197
C	2.862706	-0.681660	0.730863
C	3.717043	0.171752	-0.282946
C	0.304060	-1.102774	1.006635
C	0.149330	-0.523494	2.273361
C	-0.693932	-1.970092	0.540722
C	-0.976958	-0.800046	3.049425
C	-1.814541	-2.257224	1.320138
C	-1.962515	-1.667044	2.575721
C	3.439668	-2.035430	1.049219
O	2.876393	-3.078500	0.816664
C	4.951439	-0.526209	-0.795507
C	5.241748	-0.815972	-2.064439
H	2.567476	2.191009	1.458708
H	1.360778	4.049583	2.578200
H	-0.953573	4.632612	1.905772
H	-2.096977	3.392874	0.076214
H	-2.497943	2.333004	-1.892175
H	-1.940474	1.083455	-3.025839
H	-2.690863	-1.188596	-2.864216
H	-3.668365	1.606330	0.260882
H	-4.294023	-2.828209	-1.900699
H	-5.257434	-0.033149	1.235296
H	-5.586335	-2.250750	0.149043
H	1.520003	-1.566449	-0.666367
H	2.945517	1.610368	-1.771059
H	2.696933	-0.104380	-2.195081
H	2.831736	-0.145249	1.693532
H	4.072184	1.059700	0.261238
H	0.912416	0.153656	2.662207
H	-0.582517	-2.429365	-0.445462
H	-1.081714	-0.337541	4.032826
H	-2.574012	-2.945252	0.944321
H	-2.841053	-1.886866	3.185752
H	4.433260	-2.035654	1.549136
H	5.686025	-0.786311	-0.024979
H	6.183140	-1.309962	-2.317334
H	4.574818	-0.573272	-2.895394

(1R,2S,3S,4R)-3an_conf3

0 imaginary frequency

C	0.685447	-1.775535	0.432744
C	-0.635168	-1.454859	0.783934
C	-1.091458	-1.760693	2.059645
C	-0.214676	-2.364768	2.972150
C	1.098031	-2.660649	2.605986
C	1.572002	-2.371709	1.320982
C	-0.196404	-0.879543	-1.471726
N	0.923996	-1.416748	-0.902409
C	2.182839	-1.588594	-1.587676
C	3.291753	-0.691775	-1.073354
C	4.614735	-1.003174	-1.409826
C	3.036291	0.441331	-0.295416
C	5.664759	-0.190465	-0.987403
C	4.090162	1.253053	0.131945
C	5.404701	0.942217	-0.213091
O	-0.287523	-0.483038	-2.619261
C	-1.296846	-0.814617	-0.412463
C	-1.728139	0.669512	-0.251634
C	-2.626449	-1.440889	-0.854187
C	-3.058597	0.577485	0.498433

C	-3.690349	-0.796965	0.053130
C	-0.681133	1.614780	0.283335
C	-0.056682	2.507128	-0.598906
C	-0.283061	1.613425	1.627861
C	0.938897	3.377339	-0.154347
C	0.716558	2.478850	2.073522
C	1.328372	3.365245	1.185168
C	-3.935492	1.773944	0.238335
O	-3.636835	2.678087	-0.505157
C	-5.068210	-0.682453	-0.547269
C	-5.438148	-1.042699	-1.776779
H	-2.113852	-1.530384	2.365156
H	-0.564382	-2.603087	3.977690
H	1.769640	-3.128121	3.328329
H	2.596962	-2.607800	1.031180
H	2.494410	-2.642315	-1.513776
H	1.992203	-1.377939	-2.650180
H	4.820739	-1.892800	-2.010608
H	2.009886	0.695388	-0.015251
H	6.691040	-0.444901	-1.259279
H	3.877058	2.133648	0.741291
H	6.225743	1.577789	0.123654
H	-1.964859	0.995835	-1.276743
H	-2.625873	-2.537557	-0.791980
H	-2.783617	-1.150711	-1.903790
H	-2.903764	0.557061	1.590332
H	-3.801736	-1.409756	0.960288
H	-0.359555	2.515718	-1.649013
H	-0.758461	0.933604	2.337639
H	1.411028	4.066634	-0.857172
H	1.014262	2.464726	3.123784
H	2.104578	4.047081	1.538315
H	-4.896448	1.803969	0.797518
H	-5.833324	-0.283503	0.128418
H	-6.476543	-0.929852	-2.097978
H	-4.740649	-1.465419	-2.504179

(1R,2S,3S,4R)-3an_conf4

0 imaginary frequency

C	-0.436725	2.096240	0.034061
C	0.892780	1.696524	0.246946
C	1.624116	2.262300	1.281747
C	1.004191	3.200476	2.119724
C	-0.325718	3.563112	1.911404
C	-1.069891	3.019707	0.856745
C	0.001145	0.647415	-1.674887
N	-0.941221	1.455071	-1.108902
C	-2.287469	1.582000	-1.641765
C	-3.219833	0.499639	-1.141941
C	-3.821676	0.600858	0.118238
C	-3.485609	-0.622254	-1.935417
C	-4.688125	-0.394670	0.570173
C	-4.355531	-1.616751	-1.485748
C	-4.961354	-1.502565	-0.233999
O	-0.158232	-0.018758	-2.683375
C	1.244328	0.658747	-0.787522
C	1.411529	-0.782937	-0.213754
C	2.578526	0.840643	-1.515995
C	2.827072	-0.742886	0.373144
C	3.646538	0.136202	-0.636612
C	0.287564	-1.262985	0.670913
C	-0.711301	-2.075253	0.115792
C	0.179310	-0.890253	2.017851
C	-1.787093	-2.514399	0.887004
C	-0.903956	-1.317651	2.786489
C	-1.888667	-2.131438	2.224763
C	3.375430	-2.128911	0.570176
O	3.836509	-2.525698	1.613675
C	4.631041	-0.640509	-1.469769
C	5.955170	-0.509212	-1.389480
H	2.667807	1.988440	1.449063
H	1.567894	3.648933	2.938994

H	-0.798305	4.291029	2.573388
H	-2.104658	3.320260	0.689638
H	-2.665341	2.577042	-1.371983
H	-2.208772	1.533257	-2.735917
H	-3.621840	1.474352	0.743601
H	-3.012613	-0.708821	-2.916569
H	-5.157371	-0.301058	1.551569
H	-4.562819	-2.482973	-2.117240
H	-5.644680	-2.278542	0.116685
H	1.437467	-1.433062	-1.105751
H	2.819014	1.896043	-1.698777
H	2.501035	0.331779	-2.489460
H	2.830200	-0.258843	1.359148
H	4.208656	0.877113	-0.051396
H	-0.636431	-2.369607	-0.934657
H	0.943652	-0.259097	2.475667
H	-2.547869	-3.157364	0.440799
H	-0.974645	-1.016832	3.833559
H	-2.732414	-2.469539	2.829871
H	3.319614	-2.805477	-0.313416
H	4.201700	-1.351772	-2.186595
H	6.624734	-1.097988	-2.021360
H	6.413569	0.195732	-0.688634

(1R,2S,3S,4R)-3an_conf5

0 imaginary frequency

C	1.083973	0.574343	0.827139
C	-0.117386	-0.034654	1.224829
C	-0.555132	0.114101	2.533805
C	0.215703	0.870792	3.428762
C	1.403456	1.469917	3.011674
C	1.861390	1.329595	1.695703
C	0.359312	-0.506943	-1.045552
N	1.332546	0.296213	-0.525834
C	2.508573	0.725714	-1.252969
C	3.759434	-0.019216	-0.834906
C	4.942664	0.673475	-0.566136
C	3.745830	-1.415104	-0.727236
C	6.100161	-0.017140	-0.201349
C	4.899566	-2.105395	-0.359723
C	6.080521	-1.407423	-0.096300
O	0.335502	-0.945968	-2.182116
C	-0.710546	-0.728893	0.023732
C	-2.055481	-0.121810	-0.473959
C	-1.099306	-2.201810	0.188502
C	-3.107698	-0.791734	0.414093
C	-2.492360	-2.179995	0.836149
C	-2.056607	1.385124	-0.577197
C	-2.421969	2.221031	0.485858
C	-1.601243	1.975464	-1.764998
C	-2.334030	3.608558	0.362926
C	-1.508549	3.361391	-1.888601
C	-1.875773	4.183449	-0.822609
C	-4.447039	-0.887993	-0.268339
O	-4.662061	-0.499806	-1.391774
C	-3.362533	-3.372689	0.534030
C	-3.047663	-4.412349	-0.239562
H	-1.487196	-0.341618	2.873720
H	-0.119824	0.991278	4.459848
H	1.991421	2.056796	3.719670
H	2.793891	1.792670	1.369862
H	2.296843	0.548888	-2.317393
H	2.642465	1.808017	-1.110885
H	4.956830	1.763769	-0.640960
H	2.825012	-1.966053	-0.939047
H	7.018251	0.535300	0.007786
H	4.878263	-3.193966	-0.280144
H	6.983524	-1.948502	0.192550
H	-2.186193	-0.524427	-1.491512
H	-0.367486	-2.776251	0.773035
H	-1.151205	-2.630841	-0.823729
H	-3.295491	-0.211785	1.331945

H	-2.372869	-2.156885	1.930020
H	-2.776187	1.793813	1.425873
H	-1.316488	1.332701	-2.602621
H	-2.625502	4.243570	1.201809
H	-1.152720	3.800045	-2.822841
H	-1.808246	5.268905	-0.916733
H	-5.270060	-1.325401	0.338549
H	-4.334750	-3.376972	1.039403
H	-3.750628	-5.238527	-0.371447
H	-2.090598	-4.490678	-0.761390

(1R,2S,3S,4R)-3an_conf6

0 imaginary frequency

C	1.087462	0.424417	0.827062
C	-0.135571	-0.182542	1.153934
C	-0.613016	-0.103719	2.454343
C	0.129350	0.608500	3.408349
C	1.329513	1.225278	3.057248
C	1.836003	1.137676	1.754048
C	0.440146	-0.607987	-1.101121
N	1.393902	0.176145	-0.519893
C	2.599388	0.621114	-1.185839
C	3.835419	-0.124592	-0.726411
C	3.815165	-1.518898	-0.603310
C	5.014014	0.567981	-0.437014
C	4.958003	-2.208150	-0.200943
C	6.160438	-0.121536	-0.037457
C	6.134473	-1.510646	0.082240
O	0.469020	-1.029919	-2.243761
C	-0.696399	-0.808744	-0.097656
C	-1.961085	-0.069000	-0.644243
C	-1.199779	-2.252912	0.002160
C	-3.080640	-0.664222	0.216344
C	-2.706666	-2.175831	0.369563
C	-1.833605	1.435690	-0.692946
C	-1.160881	2.020818	-1.776209
C	-2.304592	2.267611	0.330603
C	-0.948284	3.397437	-1.828204
C	-2.097161	3.647268	0.276747
C	-1.414804	4.215823	-0.798066
C	-4.431719	-0.410173	-0.391620
O	-5.333913	0.143063	0.191058
C	-3.532719	-3.100292	-0.484893
C	-4.371066	-4.019894	-0.006887
H	-1.547323	-0.590967	2.741071
H	-0.236070	0.677713	4.433958
H	1.893736	1.778158	3.810512
H	2.784725	1.603616	1.483856
H	2.436294	0.461668	-2.261779
H	2.721354	1.701789	-1.020216
H	2.897813	-2.069893	-0.829321
H	5.032963	1.657386	-0.522768
H	4.931310	-3.295643	-0.109219
H	7.074832	0.430841	0.187473
H	7.028824	-2.050802	0.398372
H	-2.085645	-0.442083	-1.676784
H	-0.623601	-2.844953	0.725053
H	-1.081797	-2.715981	-0.989591
H	-3.089507	-0.203694	1.212483
H	-2.862945	-2.455228	1.420470
H	-0.802686	1.383507	-2.589501
H	-2.843288	1.846219	1.181315
H	-0.422001	3.833273	-2.679600
H	-2.473309	4.280249	1.082740
H	-1.252538	5.294572	-0.837210
H	-4.563445	-0.743311	-1.446418
H	-3.410588	-2.992998	-1.570198
H	-4.943728	-4.669649	-0.673311
H	-4.509871	-4.154836	1.070557

(1R,2S,3S,4R)-3an_conf7

0 imaginary frequency

C	1.086234	0.351764	0.856828
C	-0.135231	-0.261912	1.176225
C	-0.575854	-0.266691	2.491875
C	0.203903	0.366322	3.471568
C	1.403479	0.989625	3.129865
C	1.871358	0.987797	1.809426
C	0.364228	-0.526308	-1.121233
N	1.347335	0.201413	-0.513626
C	2.539147	0.679114	-1.180606
C	3.781215	-0.099050	-0.797389
C	4.980296	0.568796	-0.534314
C	3.747007	-1.496136	-0.719391
C	6.132680	-0.147601	-0.206228
C	4.896221	-2.212474	-0.388170
C	6.092746	-1.539619	-0.131334
O	0.351636	-0.860629	-2.292499
C	-0.742905	-0.785526	-0.099825
C	-2.012108	0.002552	-0.554364
C	-1.269339	-2.223299	-0.083171
C	-3.119072	-0.635101	0.281044
C	-2.730199	-2.146614	0.433911
C	-1.856295	1.504217	-0.514942
C	-1.310097	2.153695	-1.631448
C	-2.162907	2.268704	0.617980
C	-1.068522	3.526947	-1.616220
C	-1.926249	3.644186	0.633718
C	-1.375997	4.277516	-0.480710
C	-4.492074	-0.412104	-0.289253
O	-4.711169	0.241037	-1.281725
C	-3.628765	-3.078254	-0.331774
C	-4.296142	-4.101947	0.200157
H	-1.512448	-0.754877	2.770214
H	-0.132265	0.369434	4.509423
H	1.996870	1.480883	3.903132
H	2.818197	1.460556	1.544506
H	2.348565	0.585916	-2.259853
H	2.673380	1.747317	-0.954301
H	5.010312	1.660201	-0.584136
H	2.813460	-2.028175	-0.923110
H	7.062924	0.385771	-0.001292
H	4.858226	-3.301995	-0.330861
H	6.991797	-2.100953	0.129807
H	-2.173578	-0.294094	-1.604798
H	-0.648129	-2.895192	0.523757
H	-1.260819	-2.591029	-1.121094
H	-3.152913	-0.199413	1.293340
H	-2.768003	-2.421152	1.496971
H	-1.070979	1.567764	-2.523273
H	-2.587580	1.794501	1.504908
H	-0.642876	4.012420	-2.496586
H	-2.173859	4.223529	1.525327
H	-1.191280	5.353281	-0.466032
H	-5.329612	-0.882854	0.272646
H	-3.708554	-2.879385	-1.409362
H	-4.923241	-4.753155	-0.413689
H	-4.233220	-4.324035	1.270188

(1R,2S,3S,4R)-3an_conf8

0 imaginary frequency

C	0.719124	-1.723284	0.502869
C	-0.629303	-1.414998	0.739283
C	-1.176337	-1.663913	1.991272
C	-0.355837	-2.186793	3.001086
C	0.987816	-2.464487	2.751189
C	1.549948	-2.241638	1.488436
C	-0.051015	-0.994408	-1.518586
N	1.041997	-1.449405	-0.835209
C	2.343448	-1.652555	-1.426295
C	3.415733	-0.720814	-0.897363
C	4.756279	-1.027436	-1.161821
C	3.112707	0.435720	-0.173390
C	5.776766	-0.187633	-0.720935

C	4.137005	1.274732	0.273126
C	5.469215	0.968103	0.000363
O	-0.075419	-0.692940	-2.697810
C	-1.219873	-0.875476	-0.540023
C	-1.669541	0.614699	-0.507522
C	-2.514680	-1.553584	-1.004980
C	-3.023151	0.543260	0.211225
C	-3.664967	-0.800843	-0.287547
C	-0.654341	1.604903	0.007038
C	0.050058	2.397955	-0.909168
C	-0.365515	1.738542	1.372655
C	1.015400	3.307425	-0.476267
C	0.604026	2.643031	1.806541
C	1.293711	3.432998	0.884706
C	-3.854763	1.762772	-0.075049
O	-4.367830	2.442227	0.781492
C	-4.859554	-0.621792	-1.185972
C	-6.101959	-0.986639	-0.869209
H	-2.228207	-1.458600	2.199463
H	-0.774848	-2.379042	3.989857
H	1.614106	-2.869436	3.548163
H	2.597856	-2.469491	1.288229
H	2.652927	-2.698125	-1.269866
H	2.220439	-1.507155	-2.509542
H	4.999151	-1.934968	-1.720651
H	2.072125	0.686897	0.050235
H	6.817175	-0.438462	-0.936621
H	3.886684	2.173123	0.840952
H	6.267111	1.624778	0.351907
H	-1.866898	0.861526	-1.565149
H	-2.526783	-2.631515	-0.797100
H	-2.595927	-1.410883	-2.093904
H	-2.887147	0.501742	1.300801
H	-3.989913	-1.361212	0.600112
H	-0.164254	2.296709	-1.976173
H	-0.903636	1.135764	2.106974
H	1.550882	3.918827	-1.205200
H	0.816001	2.736787	2.873368
H	2.044815	4.146901	1.228517
H	-3.966947	2.033113	-1.150447
H	-4.664112	-0.164693	-2.164115
H	-6.933133	-0.837091	-1.562750
H	-6.327858	-1.451039	0.095962

(1R,2S,3S,4R)-3an_conf9

0 imaginary frequency

C	0.700815	-1.685985	0.624975
C	-0.629038	-1.326373	0.892836
C	-1.121113	-1.454302	2.185447
C	-0.270410	-1.926064	3.195326
C	1.050828	-2.267906	2.908586
C	1.561071	-2.154944	1.609909
C	-0.126233	-1.056629	-1.406787
N	0.978105	-1.505303	-0.738744
C	2.258118	-1.753721	-1.358195
C	3.351195	-0.798574	-0.920529
C	4.680936	-1.128276	-1.210385
C	3.077454	0.399398	-0.254242
C	5.719372	-0.272181	-0.850169
C	4.119882	1.255008	0.111436
C	5.441072	0.924258	-0.185631
O	-0.185984	-0.816693	-2.598959
C	-1.259453	-0.864507	-0.398510
C	-1.710473	0.623265	-0.443725
C	-2.567557	-1.563755	-0.788103
C	-3.058776	0.608081	0.301015
C	-3.658391	-0.811156	-0.005966
C	-0.681413	1.640395	-0.016095
C	0.014434	2.357298	-0.999287
C	-0.363198	1.865781	1.330729
C	1.000369	3.280664	-0.650407
C	0.626632	2.784408	1.681027

C	1.308289	3.497128	0.692642
C	-3.909351	1.750361	-0.179869
O	-4.340849	2.621395	0.536339
C	-5.020215	-0.790096	-0.651609
C	-5.384591	-1.436714	-1.759068
H	-2.151334	-1.187128	2.427479
H	-0.647712	-2.025254	4.214116
H	1.700985	-2.632307	3.706002
H	2.593593	-2.424124	1.382742
H	2.567106	-2.789953	-1.148748
H	2.100731	-1.672986	-2.443699
H	4.901054	-2.067546	-1.724428
H	2.046143	0.670586	-0.011067
H	6.750982	-0.541939	-1.084478
H	3.892471	2.185680	0.635257
H	6.253218	1.594016	0.102905
H	-1.926901	0.803130	-1.510833
H	-2.556544	-2.641289	-0.575844
H	-2.702658	-1.422251	-1.871416
H	-2.916652	0.741040	1.382143
H	-3.797845	-1.299374	0.971646
H	-0.221875	2.183523	-2.052225
H	-0.893897	1.323757	2.115942
H	1.529183	3.831263	-1.430859
H	0.861250	2.949642	2.734340
H	2.076263	4.221655	0.970627
H	-4.113121	1.765648	-1.276339
H	-5.777131	-0.206382	-0.112293
H	-6.412997	-1.379367	-2.123823
H	-4.687924	-2.049712	-2.337102

(1R,2S,3S,4R)-3an_conf10

0 imaginary frequency

C	1.124996	0.717920	0.616561
C	-0.046918	0.277771	1.247967
C	-0.426573	0.834688	2.459578
C	0.368438	1.845700	3.019271
C	1.523254	2.280974	2.368800
C	1.926834	1.718075	1.151249
C	0.335669	-0.937087	-0.741100
N	1.318495	-0.003373	-0.571786
C	2.451198	0.158136	-1.455348
C	3.749453	-0.341830	-0.854889
C	4.946768	0.329909	-1.119245
C	3.773726	-1.488165	-0.053218
C	6.153012	-0.142102	-0.600053
C	4.978196	-1.958347	0.469596
C	6.171436	-1.287334	0.196449
O	0.274487	-1.741913	-1.653936
C	-0.698568	-0.761388	0.371478
C	-2.029250	-0.260557	-0.303594
C	-1.095173	-2.081783	1.084553
C	-3.101673	-0.817391	0.623507
C	-2.618890	-2.266705	0.901575
C	-2.038084	1.213628	-0.623387
C	-1.383587	1.654088	-1.782300
C	-2.618063	2.166110	0.222343
C	-1.290581	3.013642	-2.078294
C	-2.532714	3.526886	-0.075927
C	-1.863225	3.955569	-1.222354
C	-4.495103	-0.772254	0.069176
O	-4.776770	-0.317683	-1.014135
C	-2.936551	-3.192234	-0.245033
C	-3.854998	-4.157372	-0.195178
H	-1.331182	0.496380	2.970618
H	0.081577	2.294288	3.971567
H	2.131299	3.068859	2.817066
H	2.837867	2.048124	0.649845
H	2.214556	-0.404271	-2.370724
H	2.544782	1.219415	-1.730829
H	4.932645	1.232224	-1.735802
H	2.842891	-2.018989	0.164709

H	7.081008	0.391958	-0.813321
H	4.984551	-2.853778	1.094074
H	7.113567	-1.654857	0.607305
H	-2.110609	-0.804927	-1.258302
H	-0.847724	-2.002554	2.151073
H	-0.538277	-2.936956	0.676043
H	-3.114481	-0.281168	1.588830
H	-3.087620	-2.659682	1.814237
H	-0.947003	0.917620	-2.463549
H	-3.141820	1.849587	1.127041
H	-0.775290	3.337806	-2.984569
H	-2.991785	4.256411	0.594157
H	-1.794604	5.020436	-1.452405
H	-5.285867	-1.202825	0.725035
H	-2.356388	-3.044537	-1.164752
H	-4.052281	-4.800636	-1.056335
H	-4.439182	-4.338818	0.712964

(1R,2S,3S,4R)-3an_conf11

0 imaginary frequency

C	1.114373	0.726720	0.624626
C	-0.072670	0.262785	1.209750
C	-0.505528	0.804152	2.410539
C	0.251627	1.823818	3.005821
C	1.421198	2.283617	2.400559
C	1.878381	1.736886	1.194425
C	0.402619	-0.928721	-0.774431
N	1.362359	0.018476	-0.561405
C	2.518323	0.213511	-1.410230
C	3.797266	-0.309091	-0.789843
C	3.829920	-1.583803	-0.211926
C	4.960272	0.465062	-0.800156
C	5.009876	-2.076584	0.342593
C	6.143929	-0.028815	-0.248054
C	6.170713	-1.299767	0.325068
O	0.386179	-1.726315	-1.695900
C	-0.675728	-0.776837	0.299530
C	-1.980948	-0.278551	-0.422967
C	-1.097421	-2.106426	0.974737
C	-3.086533	-0.817487	0.487418
C	-2.622165	-2.273123	0.757337
C	-1.983195	1.192116	-0.758197
C	-1.281571	1.625525	-1.892607
C	-2.607703	2.147494	0.052255
C	-1.184319	2.982551	-2.196438
C	-2.517571	3.506273	-0.255507
C	-1.800151	3.928185	-1.374578
C	-4.444816	-0.709670	-0.143185
O	-5.403358	-0.220986	0.406572
C	-2.916333	-3.212265	-0.384630
C	-3.792029	-4.215257	-0.320479
H	-1.421818	0.446912	2.886213
H	-0.077138	2.259794	3.950370
H	1.998757	3.078569	2.875819
H	2.800476	2.086673	0.728031
H	2.305951	-0.317306	-2.349773
H	2.615585	1.284447	-1.641851
H	2.924052	-2.196592	-0.201811
H	4.937749	1.464382	-1.242249
H	5.024856	-3.072644	0.789146
H	7.046093	0.585773	-0.260546
H	7.094296	-1.685732	0.760450
H	-2.030501	-0.838367	-1.371726
H	-0.867913	-2.057584	2.046993
H	-0.542405	-2.956878	0.554115
H	-3.112508	-0.274193	1.443873
H	-3.114312	-2.658339	1.660693
H	-0.811346	0.885681	-2.547201
H	-3.172564	1.835498	0.933389
H	-0.632072	3.302389	-3.082185
H	-3.010991	4.238758	0.386199
H	-1.727803	4.991328	-1.611338

H	-4.530840	-1.106682	-1.181076
H	-2.343782	-3.054162	-1.307518
H	-3.962152	-4.877922	-1.172680
H	-4.367648	-4.408517	0.590544

(1R,2S,3S,4R)-3an_conf12

0 imaginary frequency

C	0.742304	-1.600457	0.886714
C	-0.612686	-1.339578	1.134768
C	-1.093434	-1.397553	2.435402
C	-0.199391	-1.672742	3.479693
C	1.150839	-1.901814	3.214455
C	1.646031	-1.877750	1.905007
C	-0.168309	-1.321285	-1.187621
N	0.986839	-1.559304	-0.495216
C	2.264738	-1.820023	-1.114401
C	3.304697	-0.740288	-0.887925
C	3.015925	0.465015	-0.243133
C	4.606429	-0.968037	-1.353431
C	4.013920	1.428787	-0.071060
C	5.599400	-0.006382	-1.184710
C	5.305420	1.197975	-0.540191
O	-0.267826	-1.269079	-2.400478
C	-1.296205	-1.074269	-0.183802
C	-1.784596	0.393294	-0.392344
C	-2.582535	-1.899335	-0.427974
C	-3.161224	0.372327	0.279406
C	-3.786642	-0.930057	-0.312836
C	-0.820898	1.487362	-0.008318
C	-0.617617	1.872068	1.324498
C	-0.090597	2.134025	-1.014540
C	0.301507	2.873283	1.639614
C	0.822025	3.141574	-0.701721
C	1.021581	3.512275	0.628116
C	-3.923612	1.636553	0.001473
O	-4.437293	2.311985	0.861386
C	-4.509776	-0.653718	-1.612271
C	-4.034248	-0.822747	-2.847131
H	-2.151953	-1.234517	2.649132
H	-0.564756	-1.712478	4.506892
H	1.835284	-2.114573	4.037645
H	2.698977	-2.072286	1.695654
H	2.650314	-2.784551	-0.746414
H	2.075083	-1.935304	-2.191266
H	2.008109	0.661699	0.131341
H	4.839100	-1.910655	-1.855849
H	3.773659	2.365584	0.436151
H	6.608247	-0.197104	-1.555875
H	6.082788	1.952013	-0.403910
H	-1.963191	0.478132	-1.478040
H	-2.657341	-2.700693	0.317409
H	-2.547246	-2.376346	-1.416035
H	-3.071425	0.278321	1.370864
H	-4.526365	-1.316219	0.401206
H	-1.184710	1.391128	2.124123
H	-0.242913	1.838493	-2.056063
H	0.448708	3.162769	2.681874
H	1.380648	3.635384	-1.499286
H	1.733276	4.301813	0.877406
H	-3.977443	1.946931	-1.067599
H	-5.518791	-0.240302	-1.494943
H	-4.642274	-0.563347	-3.717433
H	-3.030986	-1.213018	-3.042152

(1R,2S,3S,4R)-3an_conf13

0 imaginary frequency

C	-1.099535	0.794418	-1.559776
C	0.265791	1.016998	-1.328006
C	0.808894	2.269544	-1.575027
C	-0.031121	3.294350	-2.033968
C	-1.391445	3.059536	-2.235515
C	-1.952316	1.797178	-2.003290

C	-0.290357	-1.238167	-0.919004
N	-1.404101	-0.551234	-1.306270
C	-2.732540	-1.128496	-1.357653
C	-3.550137	-0.769240	-0.134942
C	-3.052776	-1.056067	1.143659
C	-4.794453	-0.147838	-0.259516
C	-3.791472	-0.723092	2.277148
C	-5.537652	0.182321	0.876462
C	-5.036716	-0.102423	2.145691
O	-0.256130	-2.435014	-0.682715
C	0.876422	-0.253431	-0.796508
C	1.273988	-0.218034	0.726802
C	2.142467	-0.777629	-1.486785
C	2.145149	-1.476479	0.882567
C	2.830598	-1.755501	-0.495929
C	1.952479	1.078815	1.105790
C	3.319666	1.302514	0.901782
C	1.175830	2.120696	1.629701
C	3.890699	2.541863	1.198493
C	1.742923	3.357912	1.929855
C	3.104258	3.574305	1.709372
C	1.393843	-2.633249	1.500270
O	0.424443	-2.510562	2.211022
C	2.790242	-3.187178	-0.962509
C	3.876075	-3.932189	-1.172501
H	1.871349	2.459452	-1.405454
H	0.382743	4.284726	-2.229608
H	-2.033596	3.869802	-2.585772
H	-3.014148	1.609489	-2.168512
H	-3.237533	-0.792068	-2.273934
H	-2.597211	-2.217258	-1.423155
H	-2.083605	-1.552757	1.251642
H	-5.184845	0.080024	-1.254627
H	-3.396291	-0.952523	3.268619
H	-6.508673	0.668998	0.766763
H	-5.614583	0.158264	3.034363
H	0.367032	-0.309731	1.341686
H	2.804583	0.077208	-1.687660
H	1.911419	-1.248641	-2.453285
H	2.933158	-1.299404	1.637659
H	3.891596	-1.481139	-0.412576
H	3.956695	0.507745	0.507321
H	0.107505	1.956387	1.794419
H	4.958035	2.698286	1.030617
H	1.119742	4.156292	2.337483
H	3.552109	4.542309	1.941773
H	1.846974	-3.636895	1.342284
H	1.797309	-3.606170	-1.156881
H	3.798626	-4.960147	-1.535607
H	4.880999	-3.537638	-0.990103

(1R,2S,3S,4R)-3an_conf14

0 imaginary frequency

C	1.033179	-1.390938	0.271468
C	-0.198231	-1.200763	-0.372104
C	-0.771768	-2.249682	-1.077447
C	-0.109731	-3.485232	-1.113853
C	1.108293	-3.657470	-0.455787
C	1.706910	-2.605630	0.248842
C	0.540874	0.805992	0.625285
N	1.432252	-0.194542	0.885746
C	2.693813	-0.000923	1.570013
C	3.875475	0.022775	0.622985
C	3.836449	0.809513	-0.534603
C	5.021079	-0.728040	0.898482
C	4.928297	0.844943	-1.400254
C	6.117106	-0.690362	0.034163
C	6.072297	0.095031	-1.117157
O	0.681837	1.970474	0.961426
C	-0.646045	0.221226	-0.148224
C	-1.937990	0.429500	0.720524
C	-0.930933	1.043621	-1.416140

C	-2.300339	1.901542	0.448232
C	-1.794419	2.259350	-0.987178
C	-3.019869	-0.566110	0.366383
C	-3.120906	-1.752041	1.105239
C	-3.891953	-0.375840	-0.712765
C	-4.055663	-2.729857	0.768948
C	-4.827349	-1.354472	-1.054735
C	-4.909396	-2.536215	-0.318321
C	-1.858290	2.824281	1.560780
O	-1.723079	2.477824	2.709827
C	-1.064239	3.571043	-1.111499
C	-1.485997	4.589132	-1.862459
H	-1.725497	-2.118952	-1.594010
H	-0.551549	-4.317996	-1.663061
H	1.611331	-4.625434	-0.494084
H	2.666752	-2.734897	0.750956
H	2.613024	0.956103	2.105099
H	2.821445	-0.796492	2.318051
H	2.945694	1.404436	-0.755983
H	5.053344	-1.349763	1.796799
H	4.888043	1.462681	-2.299435
H	7.006124	-1.282573	0.259373
H	6.926678	0.122131	-1.796065
H	-1.692826	0.295254	1.783688
H	-1.497582	0.410006	-2.113887
H	-0.001020	1.339793	-1.923846
H	-3.398070	2.030422	0.478480
H	-2.667450	2.320076	-1.652380
H	-2.447703	-1.910761	1.951615
H	-3.849116	0.543587	-1.300779
H	-4.117643	-3.646866	1.358151
H	-5.496998	-1.188821	-1.900863
H	-5.641259	-3.300654	-0.585846
H	-1.751582	3.896192	1.283065
H	-0.121543	3.656469	-0.560781
H	-0.909493	5.514306	-1.941301
H	-2.422861	4.530917	-2.426118

(1R,2S,3S,4R)-3an_conf15

0 imaginary frequency

C	-1.069345	-1.423666	-0.281822
C	0.185265	-1.257807	0.322245
C	0.749145	-2.310549	1.029843
C	0.055212	-3.526780	1.104001
C	-1.185446	-3.675465	0.483609
C	-1.775458	-2.618322	-0.220354
C	-0.517942	0.746371	-0.707064
N	-1.451499	-0.227199	-0.907932
C	-2.713450	-0.019512	-1.586959
C	-3.888957	0.034912	-0.633583
C	-3.821984	0.811910	0.528970
C	-5.058093	-0.678372	-0.910461
C	-4.909615	0.874808	1.398536
C	-6.149602	-0.613100	-0.042375
C	-6.076919	0.162383	1.114337
O	-0.608508	1.896265	-1.107824
C	0.657845	0.152058	0.074353
C	1.949299	0.348872	-0.792141
C	0.954500	0.974633	1.339231
C	2.324521	1.822562	-0.532386
C	1.832136	2.182306	0.910228
C	3.023556	-0.653780	-0.432084
C	3.108109	-1.849924	-1.156632
C	3.902915	-0.459938	0.640418
C	4.034171	-2.833454	-0.813251
C	4.829267	-1.444624	0.989752
C	4.895308	-2.635906	0.267432
C	1.864876	2.735327	-1.650675
O	1.875709	3.939986	-1.586468
C	1.107966	3.492312	1.076508
C	1.471660	4.430344	1.951286
H	1.719153	-2.197731	1.519574

H	0.489889	-4.362954	1.653715
H	-1.713163	-4.628529	0.551672
H	-2.752430	-2.728745	-0.692997
H	-2.619038	0.929998	-2.133255
H	-2.860076	-0.820989	-2.325365
H	-2.912189	1.376350	0.752715
H	-5.111754	-1.293104	-1.812562
H	-4.847269	1.484341	2.302026
H	-7.057038	-1.176297	-0.268583
H	-6.927719	0.210653	1.796544
H	1.698770	0.195716	-1.853462
H	1.512621	0.334392	2.037914
H	0.028624	1.283461	1.846832
H	3.422469	1.931807	-0.577400
H	2.710505	2.223719	1.569675
H	2.428984	-2.012804	-1.997509
H	3.873369	0.466430	1.217824
H	4.083406	-3.758040	-1.391686
H	5.504541	-1.275823	1.830749
H	5.620259	-3.404841	0.540769
H	1.594403	2.224961	-2.603204
H	0.205716	3.631036	0.472665
H	0.890281	5.347259	2.076629
H	2.366934	4.314526	2.570824

(1R,2S,3S,4R)-3an_conf16

0 imaginary frequency

C	-0.567023	1.698729	-1.092900
C	0.781648	1.705695	-0.703661
C	1.333466	2.853634	-0.155041
C	0.517369	3.978652	0.032489
C	-0.827017	3.944800	-0.335270
C	-1.393087	2.801127	-0.913129
C	0.212249	-0.359183	-1.695629
N	-0.875728	0.463608	-1.685842
C	-2.163478	0.085681	-2.246444
C	-3.072717	-0.586052	-1.240368
C	-3.978691	0.159657	-0.478371
C	-3.004523	-1.972339	-1.052307
C	-4.807712	-0.469324	0.452096
C	-3.832403	-2.602195	-0.123169
C	-4.738919	-1.851541	0.628485
O	0.235050	-1.483265	-2.170409
C	1.363380	0.338986	-0.970341
C	1.657648	-0.460737	0.347426
C	2.715838	0.314181	-1.726806
C	3.102823	-0.081234	0.641016
C	3.792029	-0.217949	-0.753171
C	0.619832	-0.269814	1.424556
C	-0.548531	-1.041307	1.371401
C	0.741273	0.695520	2.431480
C	-1.581922	-0.841337	2.286425
C	-0.288356	0.893408	3.352530
C	-1.455481	0.131925	3.278716
C	3.759344	-0.906009	1.709105
O	3.219329	-1.823568	2.280012
C	4.229684	-1.645380	-0.987572
C	3.578405	-2.579668	-1.681683
H	2.388213	2.888564	0.126925
H	0.938937	4.886228	0.467085
H	-1.452455	4.826046	-0.181590
H	-2.440260	2.786324	-1.215950
H	-2.634051	0.990604	-2.653678
H	-1.957716	-0.597497	-3.081092
H	-4.047051	1.240249	-0.623606
H	-2.297922	-2.558505	-1.645024
H	-5.515282	0.122707	1.035733
H	-3.774567	-3.684216	0.010272
H	-5.390939	-2.344658	1.352108
H	1.654864	-1.525387	0.058896
H	2.968414	1.331907	-2.050177
H	2.647562	-0.307351	-2.629505

H	3.189300	0.972770	0.954282
H	4.687531	0.417645	-0.780674
H	-0.644261	-1.813024	0.601807
H	1.644470	1.305728	2.500532
H	-2.484344	-1.453336	2.226281
H	-0.177437	1.649795	4.132034
H	-2.260995	0.290500	3.998226
H	4.809345	-0.627196	1.955226
H	5.167015	-1.923130	-0.490012
H	3.976772	-3.594657	-1.756822
H	2.629167	-2.378266	-2.186378

(1R,2S,3S,4R)-3an_conf17

0 imaginary frequency

C	1.023355	0.707670	0.666321
C	-0.139524	0.199066	1.263662
C	-0.578265	0.726459	2.468778
C	0.141603	1.780914	3.050099
C	1.281833	2.288872	2.428307
C	1.749140	1.753600	1.220839
C	0.378715	-0.994699	-0.708234
N	1.295889	-0.003233	-0.512215
C	2.431940	0.239803	-1.375186
C	3.743111	-0.205491	-0.761747
C	4.864545	0.627035	-0.801238
C	3.848449	-1.465446	-0.160939
C	6.078560	0.205371	-0.255442
C	5.058684	-1.886060	0.387795
C	6.177605	-1.051171	0.341086
O	0.402850	-1.806474	-1.617884
C	-0.710698	-0.863601	0.357589
C	-2.019026	-0.388354	-0.369846
C	-1.131811	-2.189865	1.032276
C	-3.109862	-0.837760	0.605955
C	-2.673096	-2.294701	0.945013
C	-2.003854	1.056553	-0.803093
C	-1.332290	1.401990	-1.984968
C	-2.581624	2.075128	-0.035426
C	-1.219453	2.734652	-2.378320
C	-2.476290	3.409319	-0.432762
C	-1.789264	3.743507	-1.599548
C	-4.479454	-0.701569	0.003588
O	-5.388356	-0.108414	0.534596
C	-3.198659	-3.285892	-0.067890
C	-2.534222	-3.804010	-1.101845
H	-1.468690	0.331389	2.962647
H	-0.193664	2.205414	3.997582
H	1.829440	3.111232	2.892204
H	2.651413	2.137565	0.742751
H	2.238812	-0.314265	-2.305448
H	2.469703	1.311337	-1.621916
H	4.784550	1.615307	-1.261081
H	2.975737	-2.123797	-0.128190
H	6.947614	0.865152	-0.290696
H	5.130349	-2.871094	0.852902
H	7.124858	-1.380621	0.772032
H	-2.101916	-1.019864	-1.271586
H	-0.811494	-2.180965	2.081762
H	-0.642081	-3.045787	0.549091
H	-3.091674	-0.235702	1.525362
H	-3.096827	-2.566814	1.921274
H	-0.897769	0.611823	-2.604467
H	-3.122014	1.831507	0.881929
H	-0.691005	2.985806	-3.300036
H	-2.933686	4.191479	0.176127
H	-1.704750	4.787586	-1.906711
H	-4.619875	-1.169841	-0.997988
H	-4.248104	-3.571076	0.074057
H	-3.025054	-4.502267	-1.784579
H	-1.491937	-3.549701	-1.314148

3. References

(1) (a) Xiao, J.-A.; Li, Y.-C.; Luo, Z.-J.; Cheng, X.-L.; Deng, Z.-X.; Chen, W.; Su, W.; Yang, H. *J. Org. Chem.* **2019**, *84*, 2297; (b) Xiao, J.-A.; Cheng, X.-L.; Li, Y.-C.; He, Y.-M.; Li, J.-L.; Liu, Z.-P.; Xia, P.-J.; Su, W.; Yang, H. *Org. Biomol. Chem.* **2019**, *17*, 103; (c) Wan, Q.; Chen, L.; Li, S.; Kang, Q.; Yuan, Y.; Du, Y. *Org. Lett.* **2020**, *22*, 9539.

(2) Zhao, Y.; Truhlar, D. G. *Theor. Chem. Acc.* **2008**, *120*, 215.

(3) (a) Weigend, F.; Ahlrichs, R. *Phys. Chem. Chem. Phys.* **2005**, *7*, 3297. (b) Weigend, F. *Phys. Chem. Chem. Phys.*, **2006**, *8*, 1057.

(4) Marenich, A. V.; Cramer, C. J.; Truhlar, D. G. *J. Phys. Chem. B* **2009**, *113*, 6378.

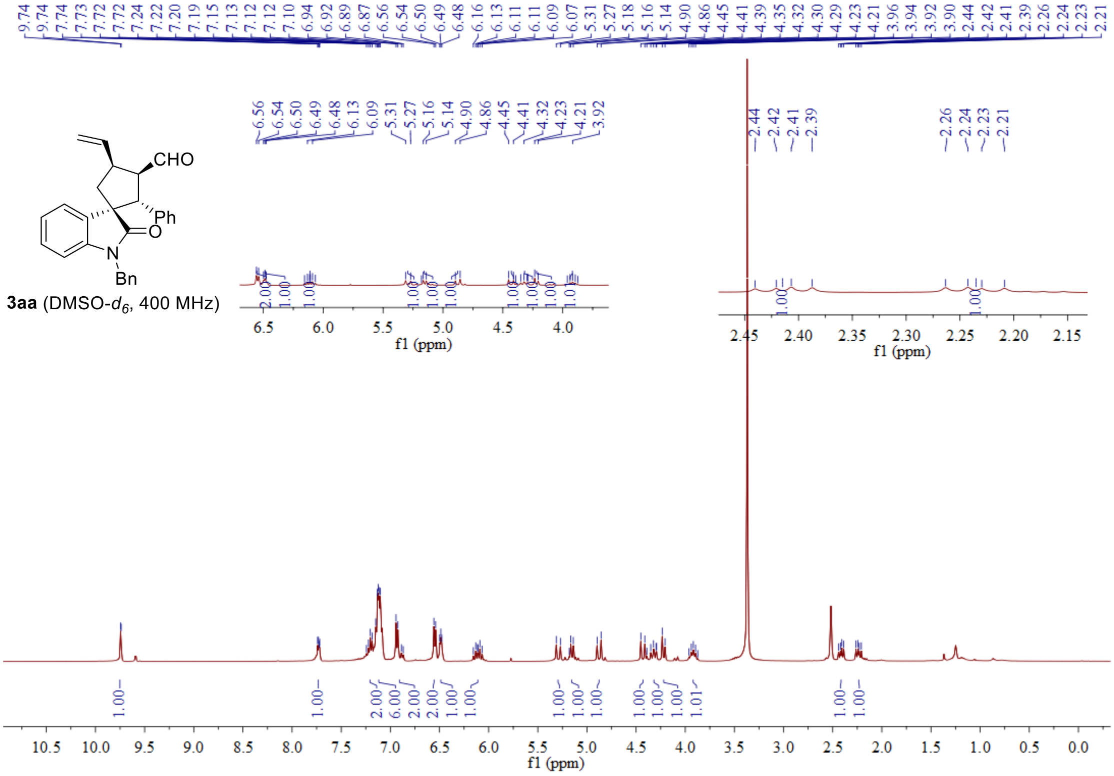
(5) Gaussian 16 Rev. A.03, Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Scalmani, G.; Barone, V.; Petersson, G. A.; Nakatsuji, H.; Li, X.; Caricato, M.; Marenich, A. V.; Bloino, J.; Janesko, B. G.; Gomperts, R.; Mennucci, B.; Hratchian, H. P.; Ortiz, J. V.; Izmaylov, A. F.; Sonnenberg, J. L.; Williams; Ding, F.; Lipparini, F.; Egidi, F.; Goings, J.; Peng, B.; Petrone, A.; Henderson, T.; Ranasinghe, D.; Zakrzewski, V. G.; Gao, J.; Rega, N.; Zheng, G.; Liang, W.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Vreven, T.; Throssell, K.; Montgomery Jr., J. A.; Peralta, J. E.; Ogliaro, F.; Bearpark, M. J.; Heyd, J. J.; Brothers, E. N.; Kudin, K. N.; Staroverov, V. N.; Keith, T. A.; Kobayashi, R.; Normand, J.; Raghavachari, K.; Rendell, A. P.; Burant, J. C.; Iyengar, S. S.; Tomasi, J.; Cossi, M.; Millam, J. M.; Klene, M.; Adamo, C.; Cammi, R.; Ochterski, J. W.; Martin, R. L.; Morokuma, K.; Farkas, O.; Foresman, J. B.; Fox, D. J., Gaussian Inc. Wallingford CT, 2016.

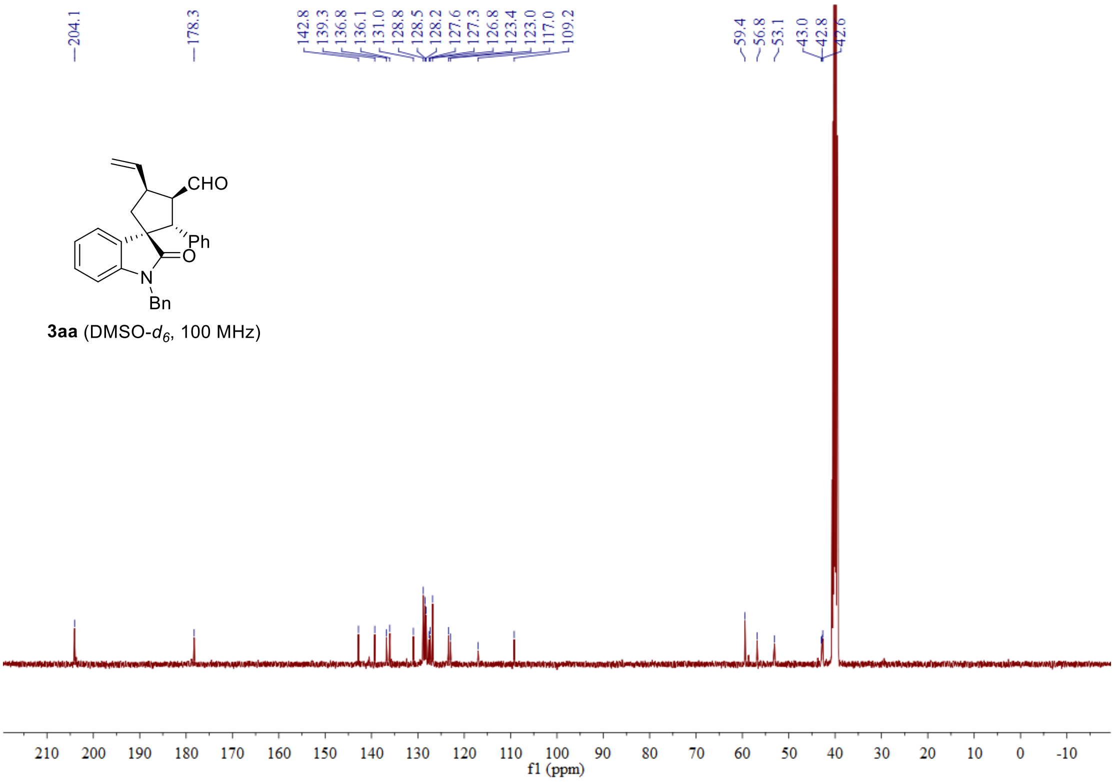
(6) Grimme, S. *Chem. Eur. J.* **2012**, *18*, 9955.

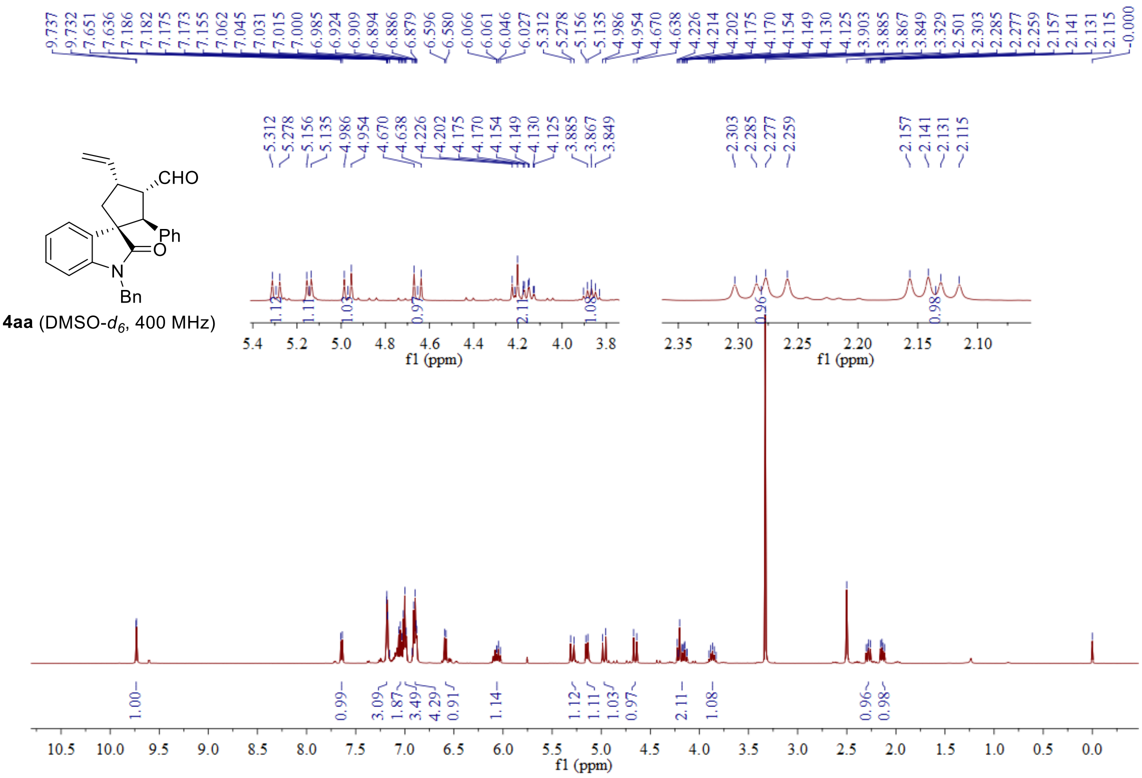
(7) Yanai, T.; Tew, D.; Handy, N. *Chem. Phys. Lett.* **2004**, *393*, 51.

(8) (a) Bruhn, T.; Schauml öffel, A.; Hemberger, Y.; Bringmann, G. SpecDis version 1.70, University of Wuerzburg, Germany, 2017, https://specdis-software.jimdo.com. (b) Bruhn, T.; Schauml öffel, A.; Hemberger, Y.; Bringmann, G. *Chirality*, **2013**, *25*, 243. (c) Bruhn, T.; Pescitelli, G. *Chirality*, **2016**, *28*, 466.

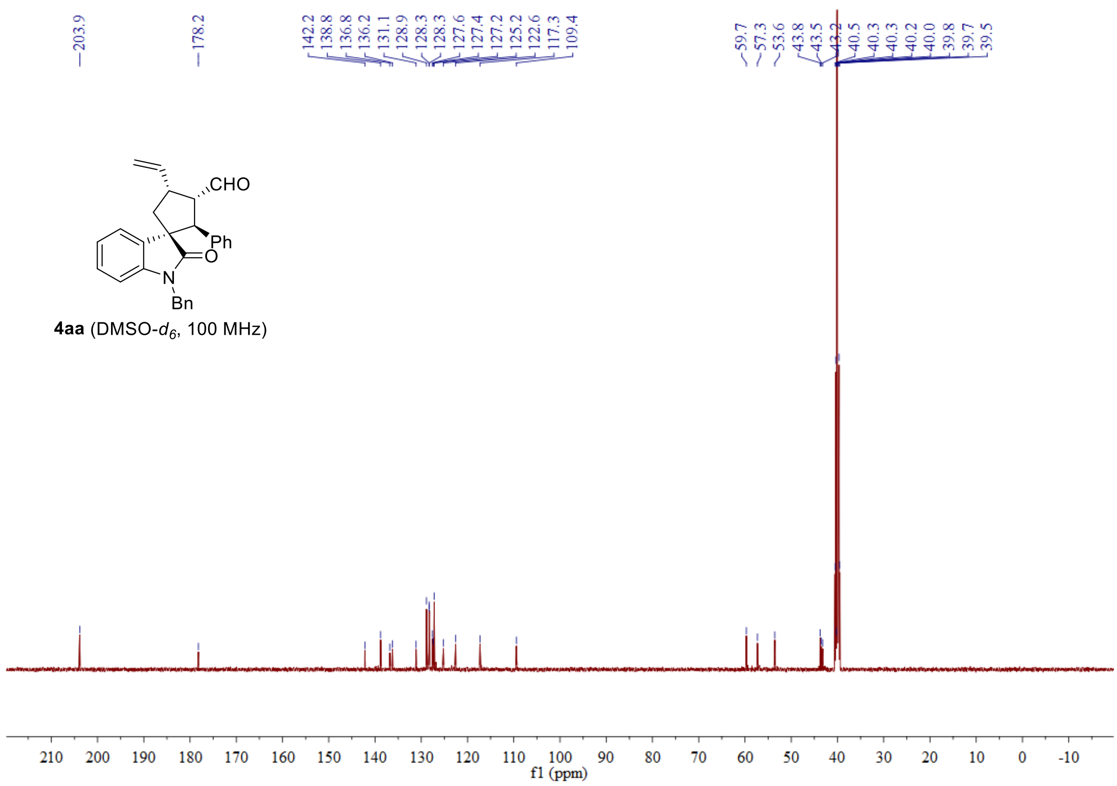
4. NMR and HPLC Spectra



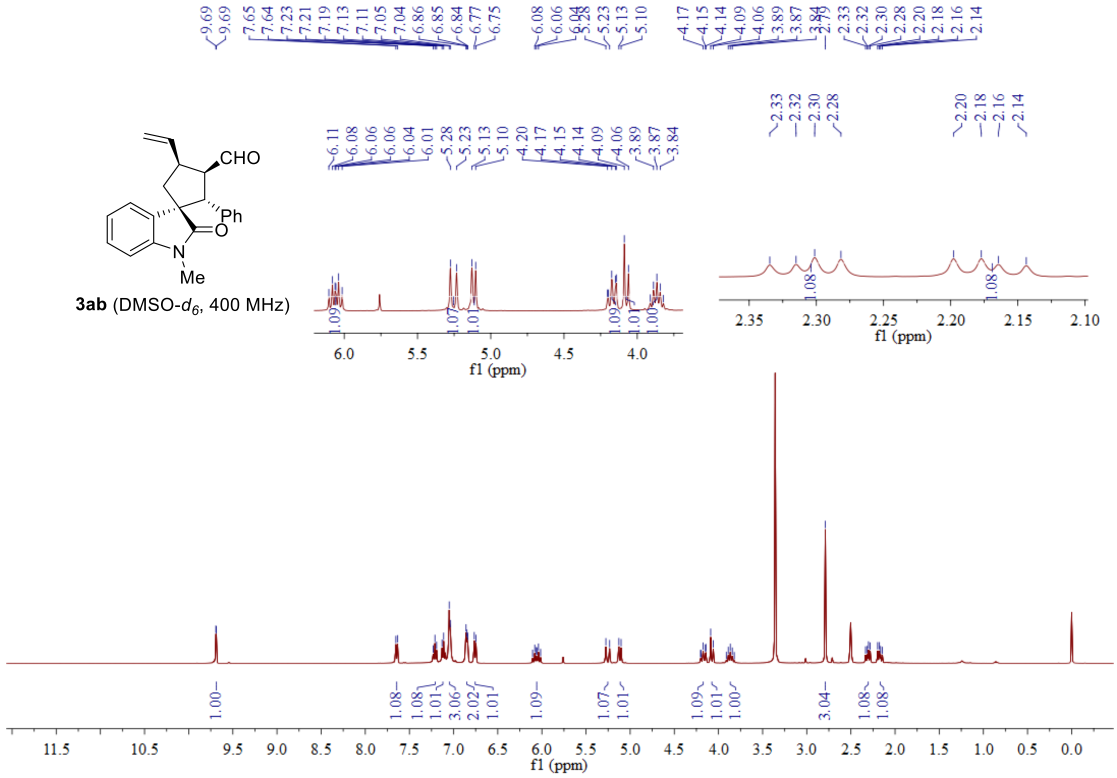


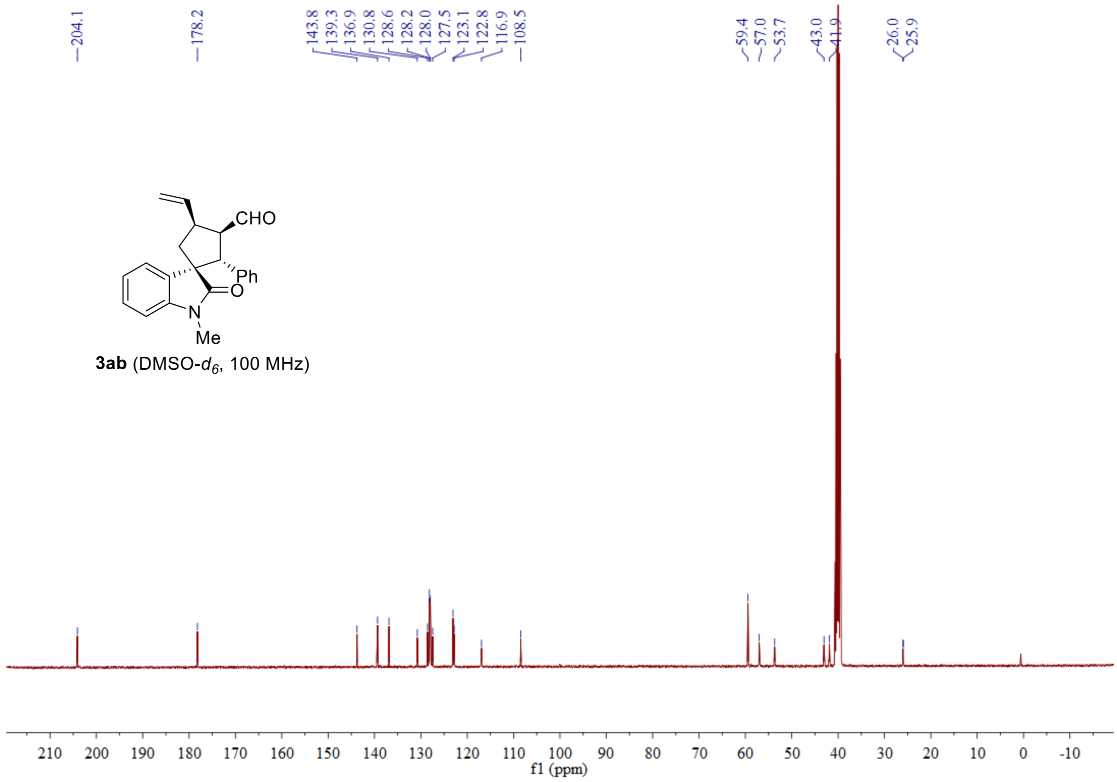


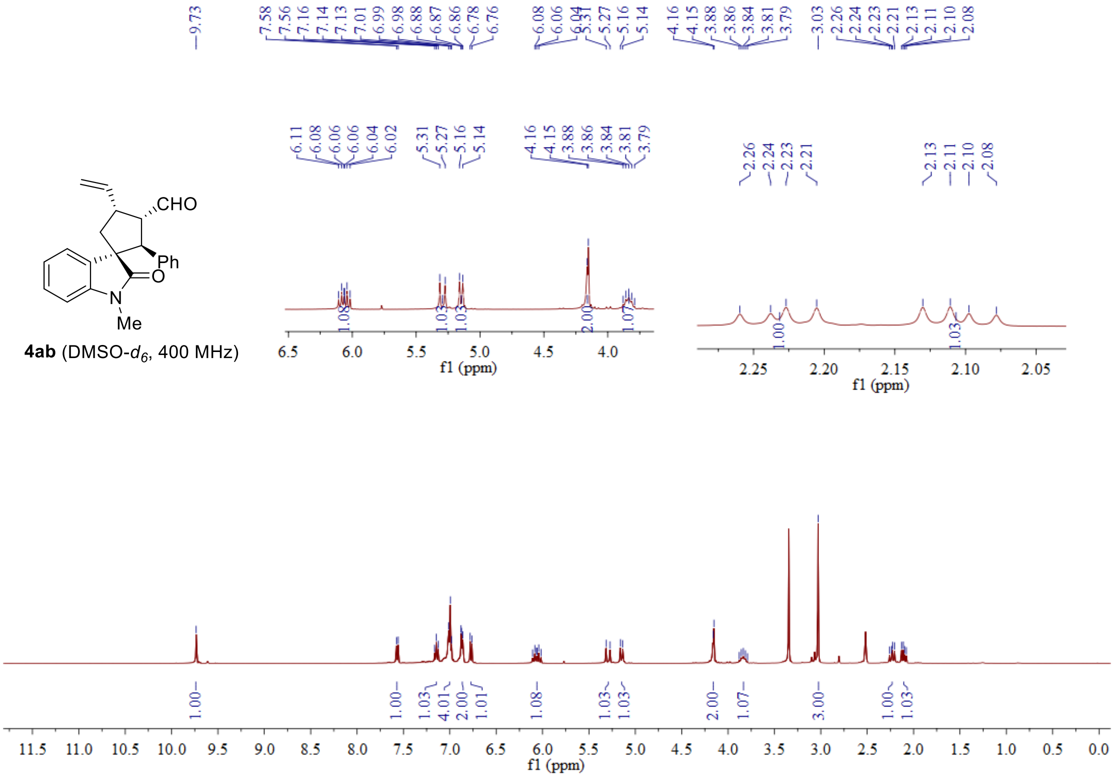
4aa (DMSO-d_6, 400 MHz)



4aa (DMSO-d_6, 100 MHz)


CHO
Ph
O
N
Me
3ab (DMSO-d_6, 400 MHz)
f1 (ppm)


204.1
178.2
143.8
139.3
136.9
130.8
128.6
128.2
128.0
127.5
123.1
122.8
116.9
108.5
59.4
57.0
53.7
43.0
41.9
26.0
25.9
CHO
Ph
O
N
Me
3ab (DMSO-d_6, 100 MHz)
f1 (ppm)



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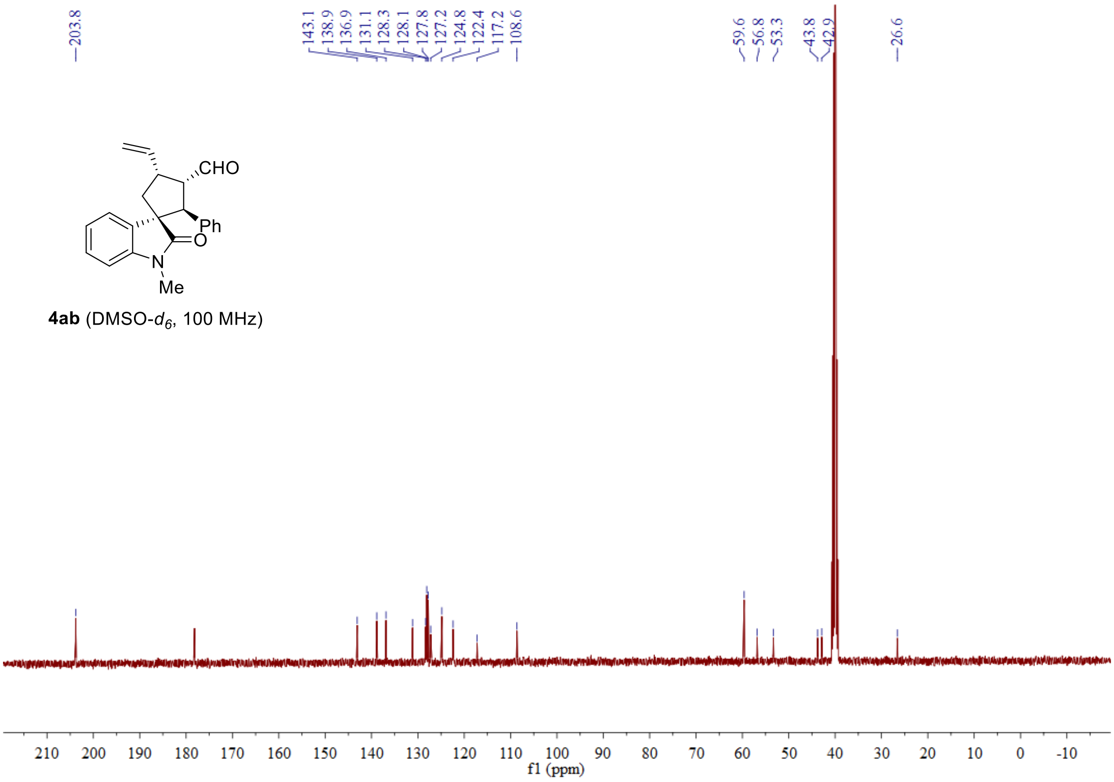

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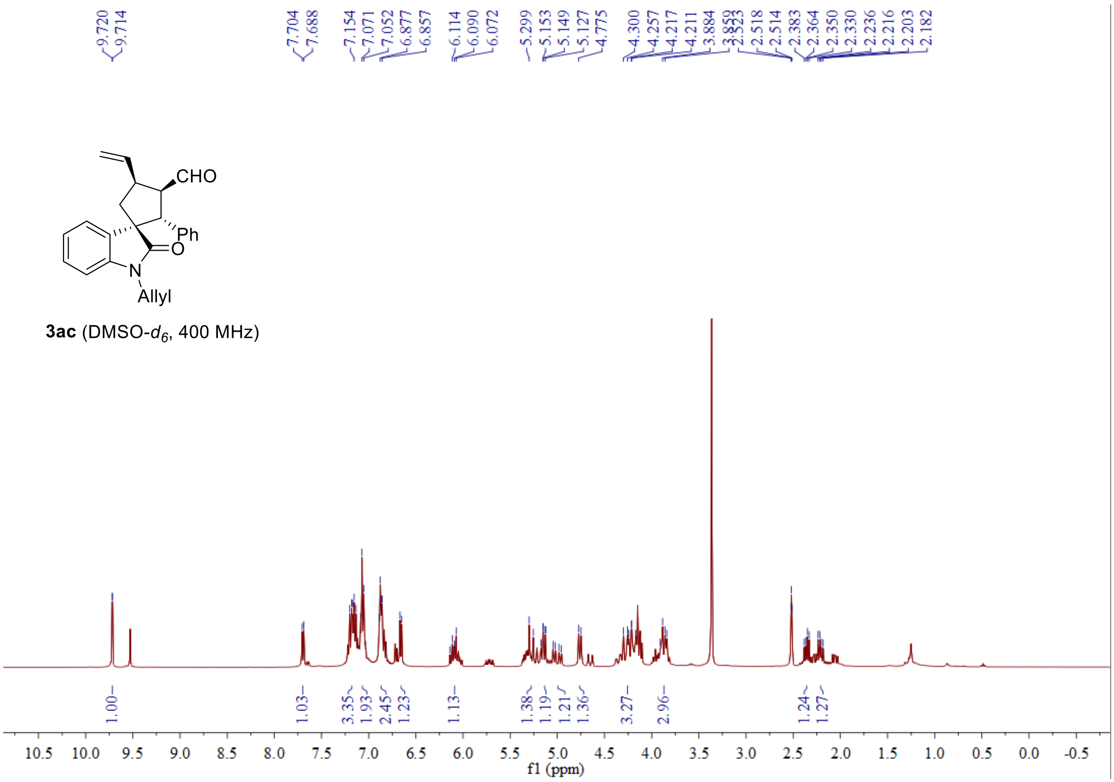

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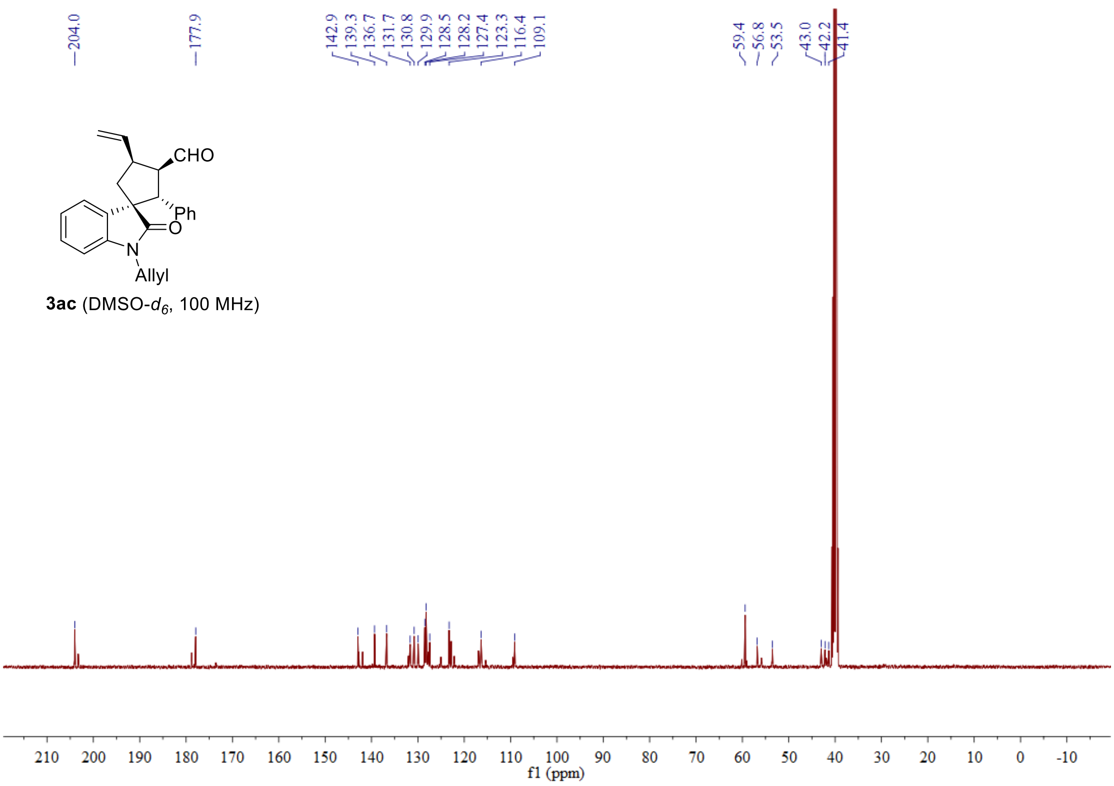

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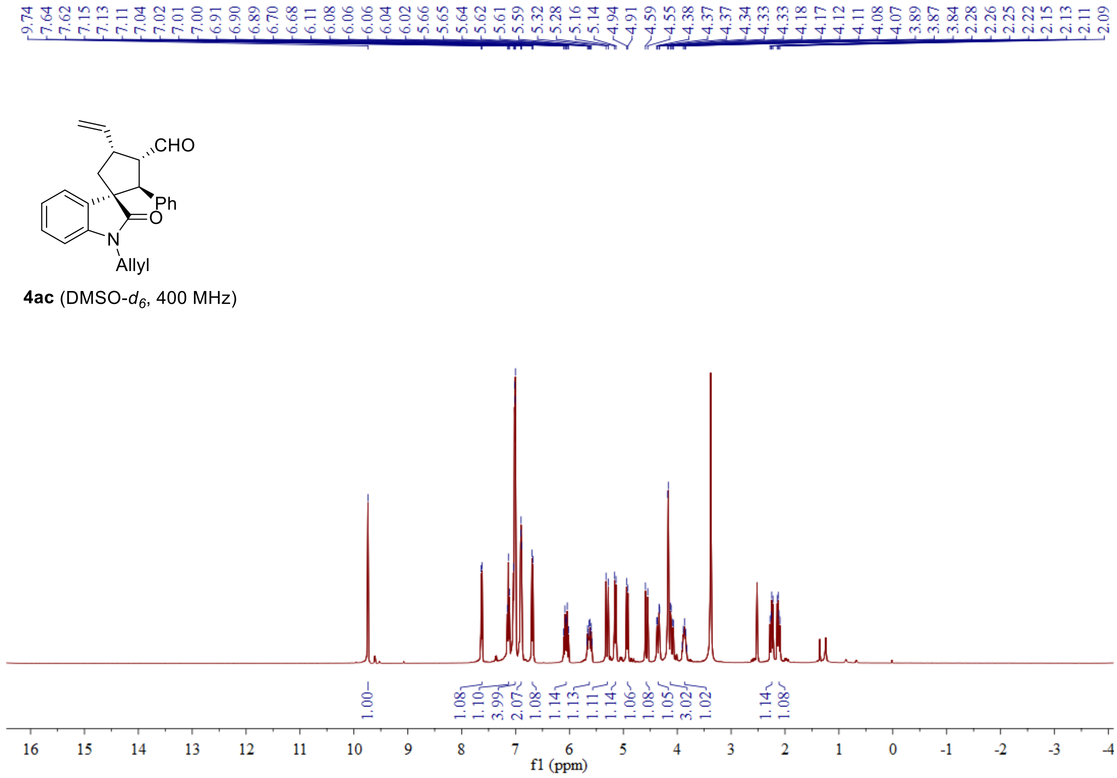

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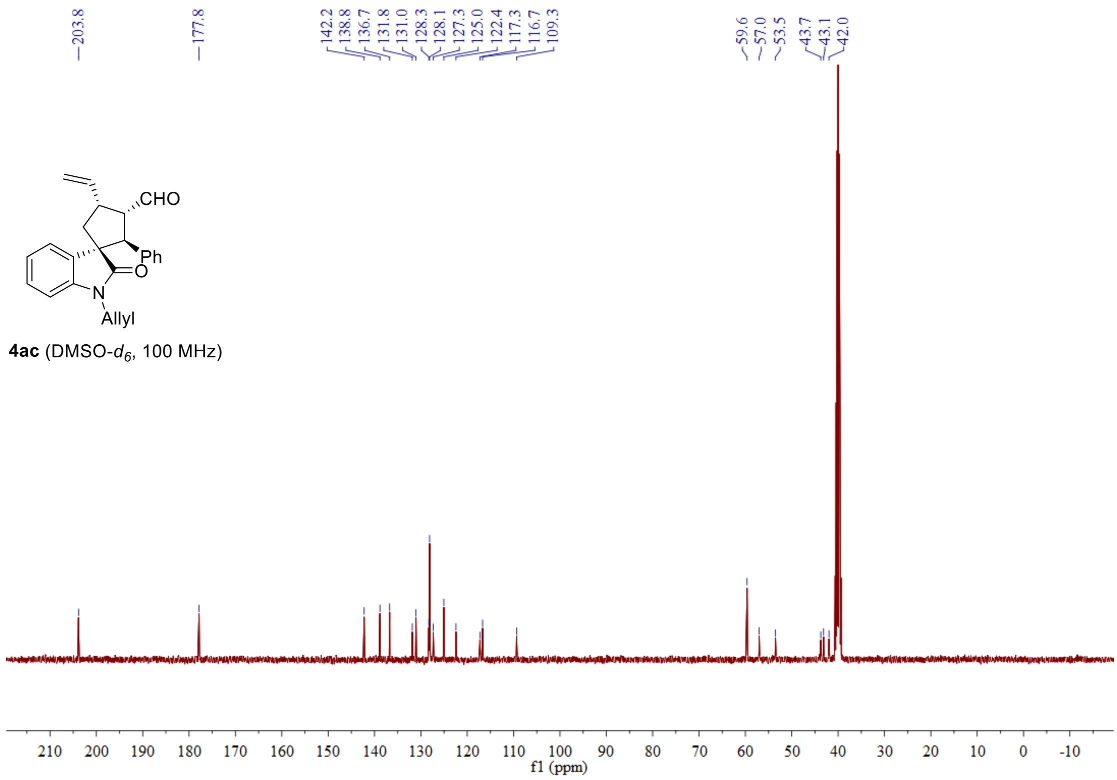
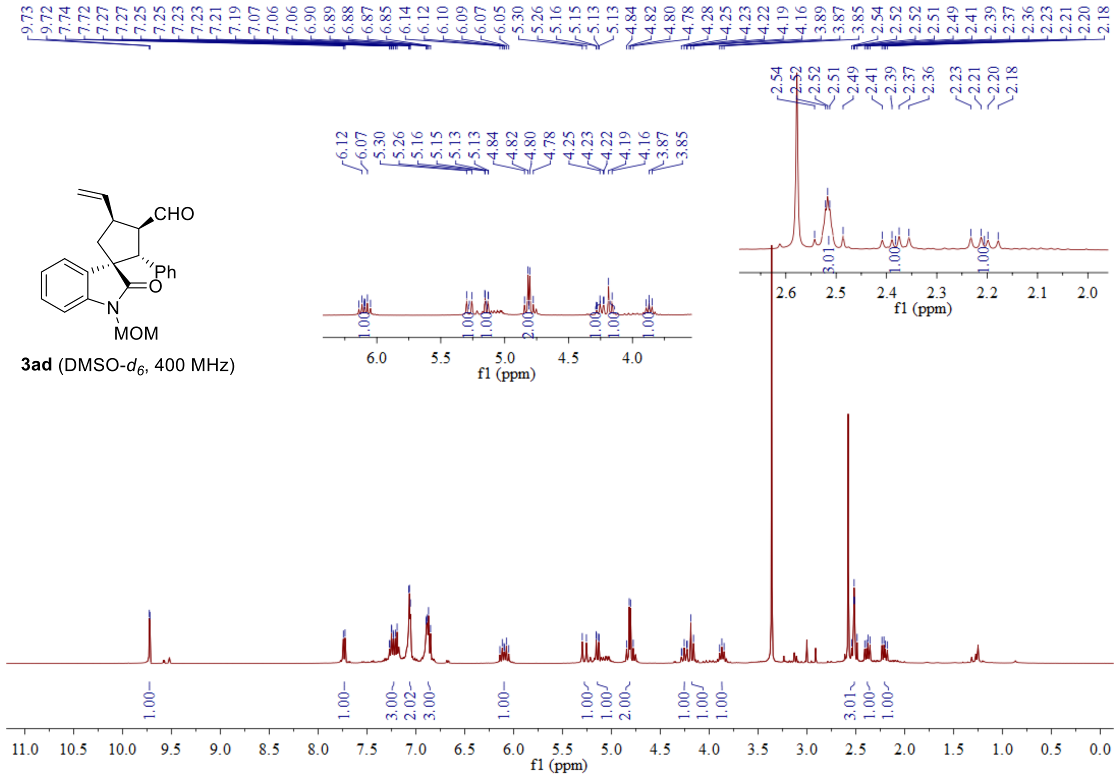
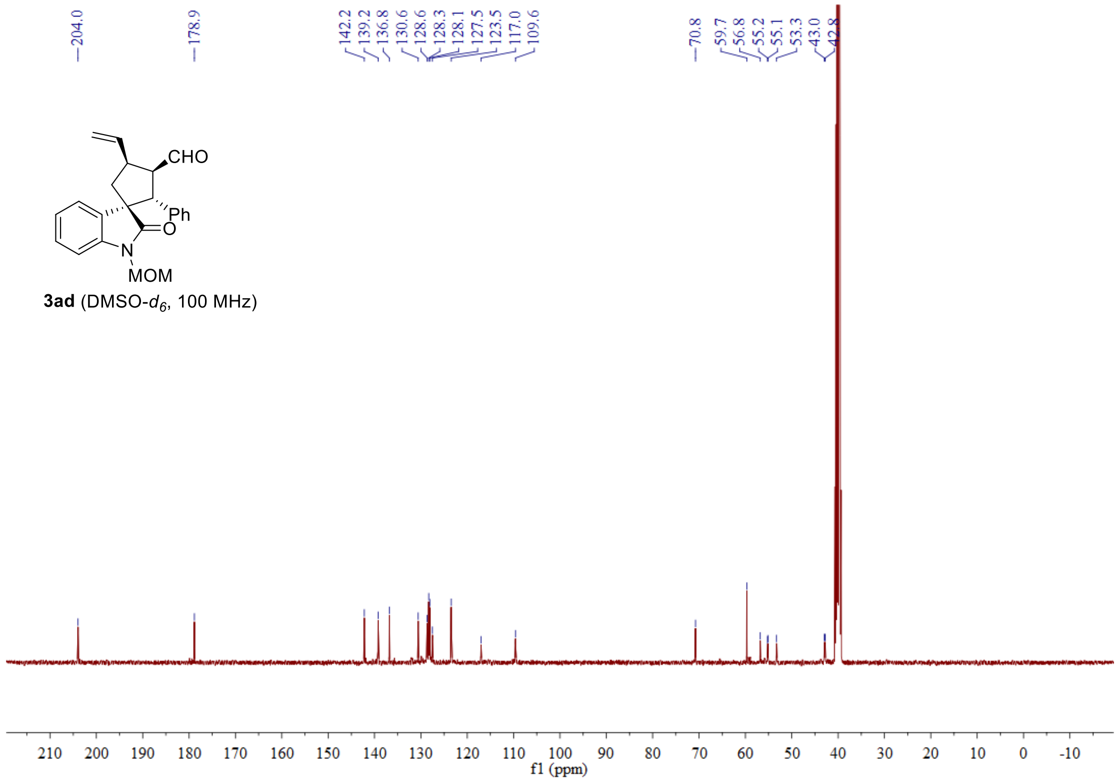


4ac (DMSO-d_6, 100 MHz)



3ad (DMSO-d_6, 400 MHz)



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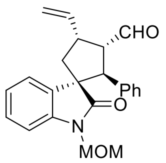

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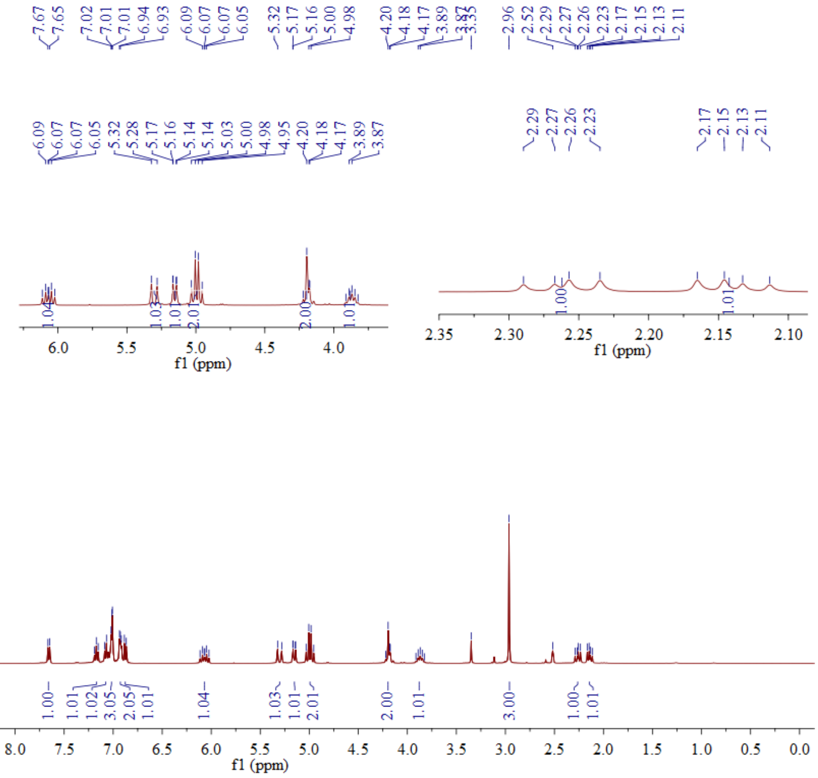

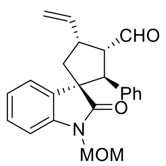

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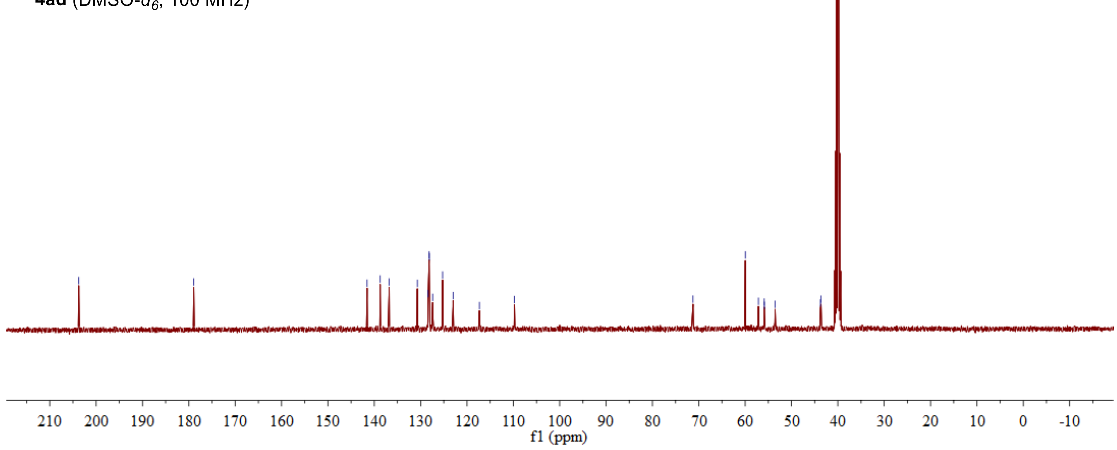

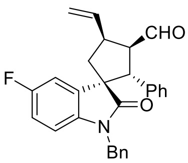

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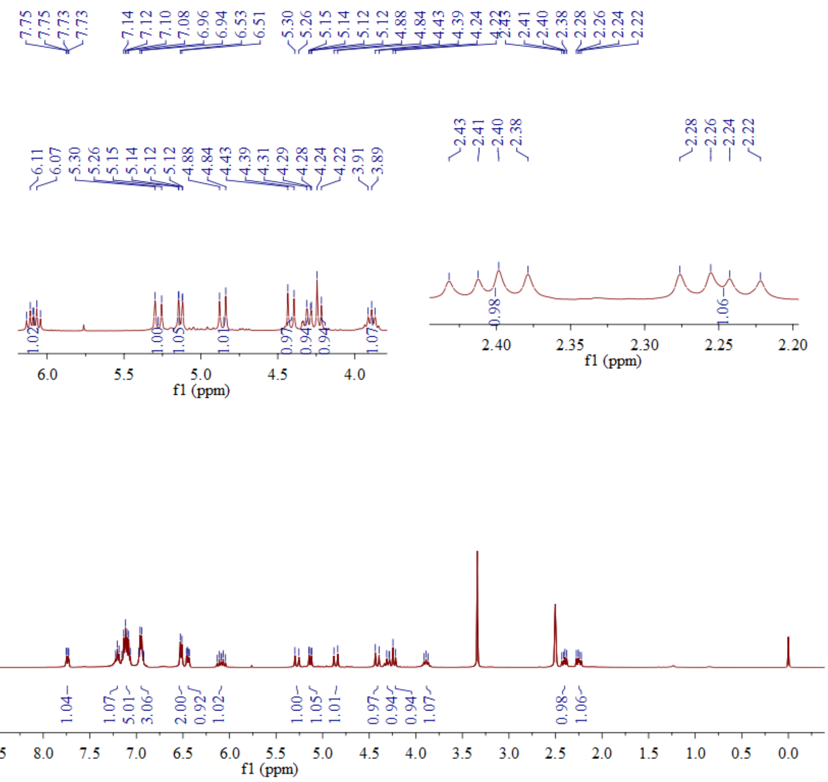

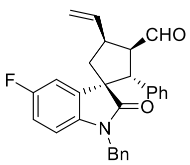

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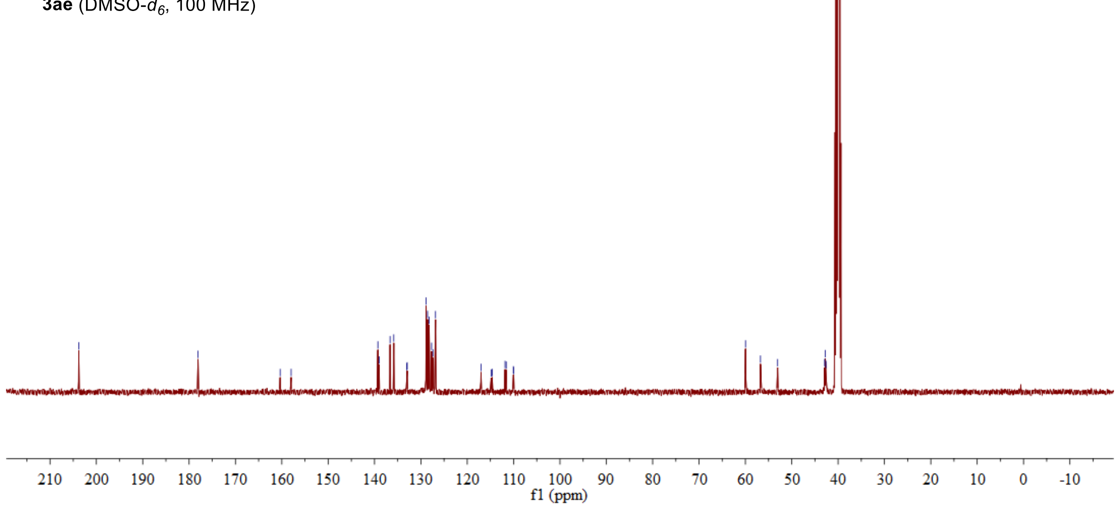

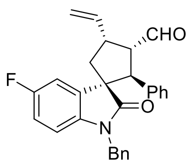

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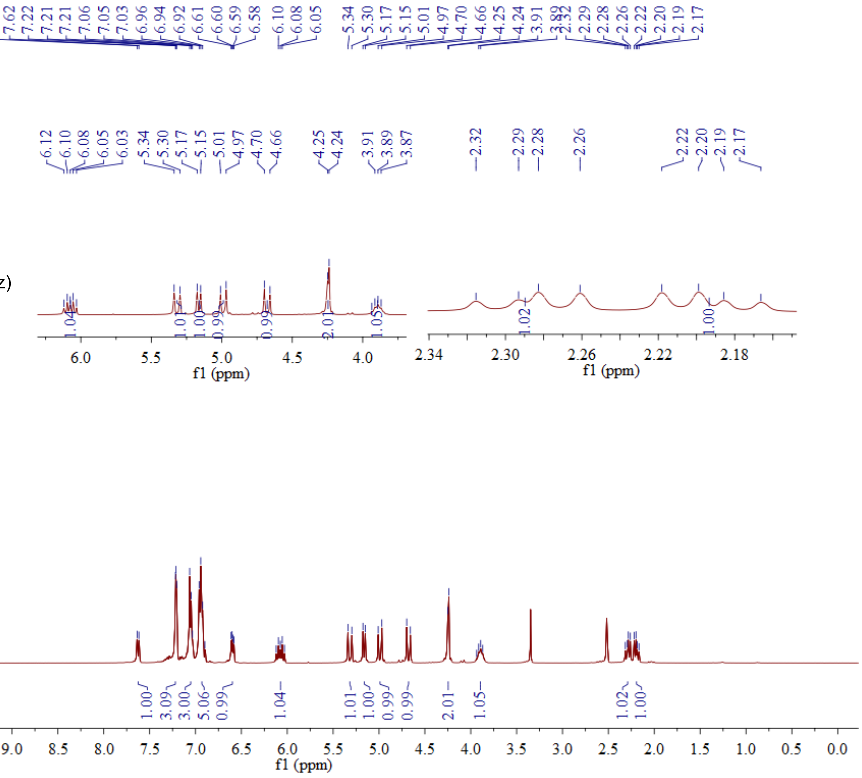

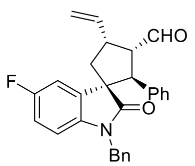

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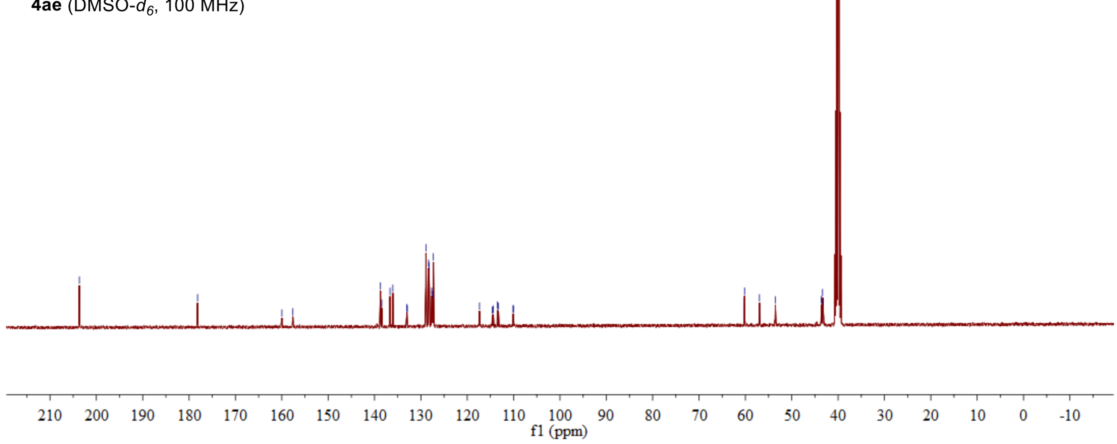

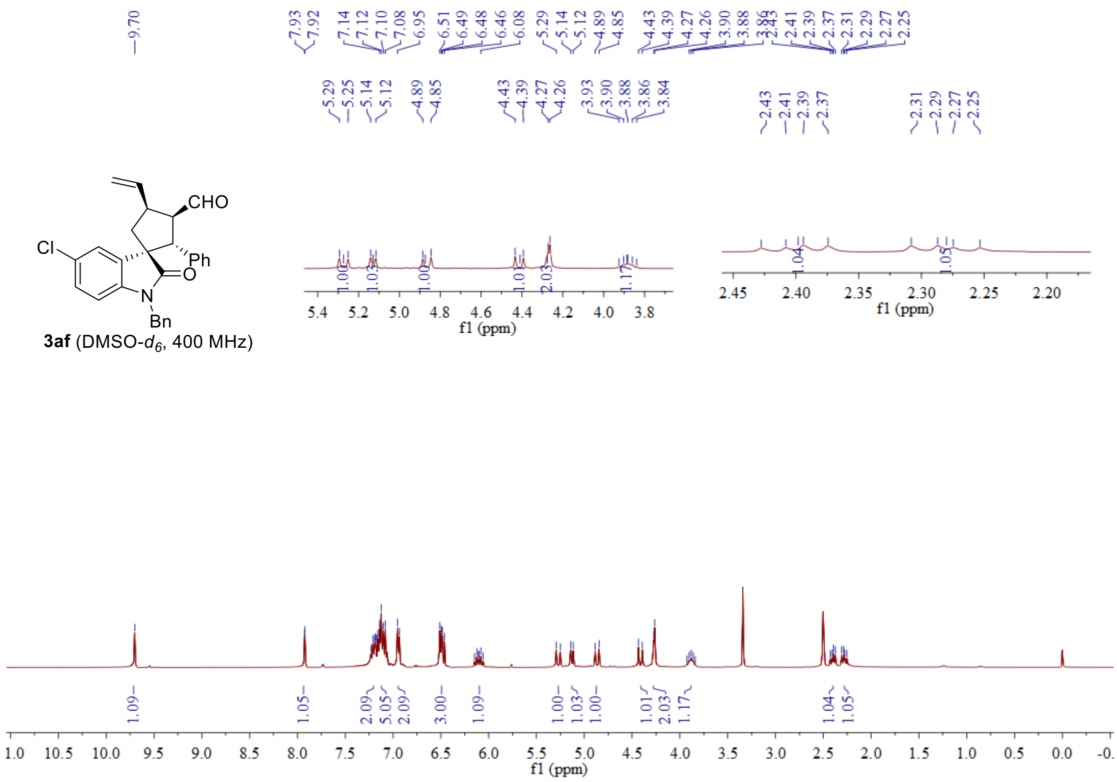

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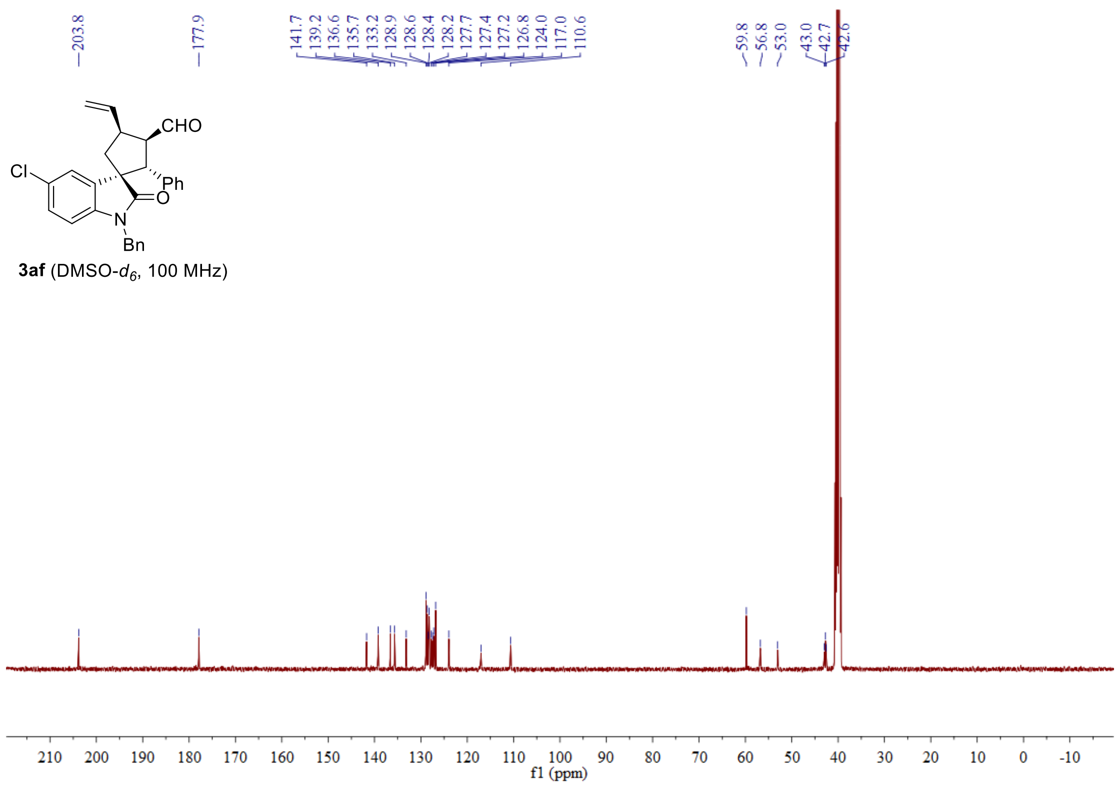

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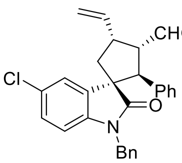

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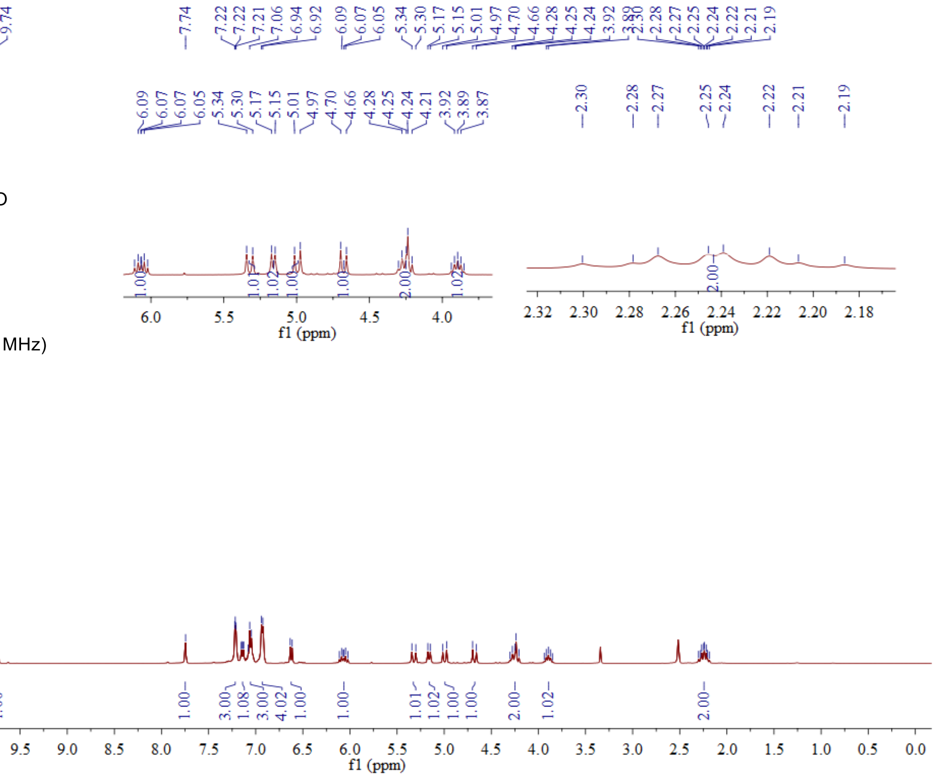
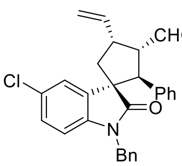
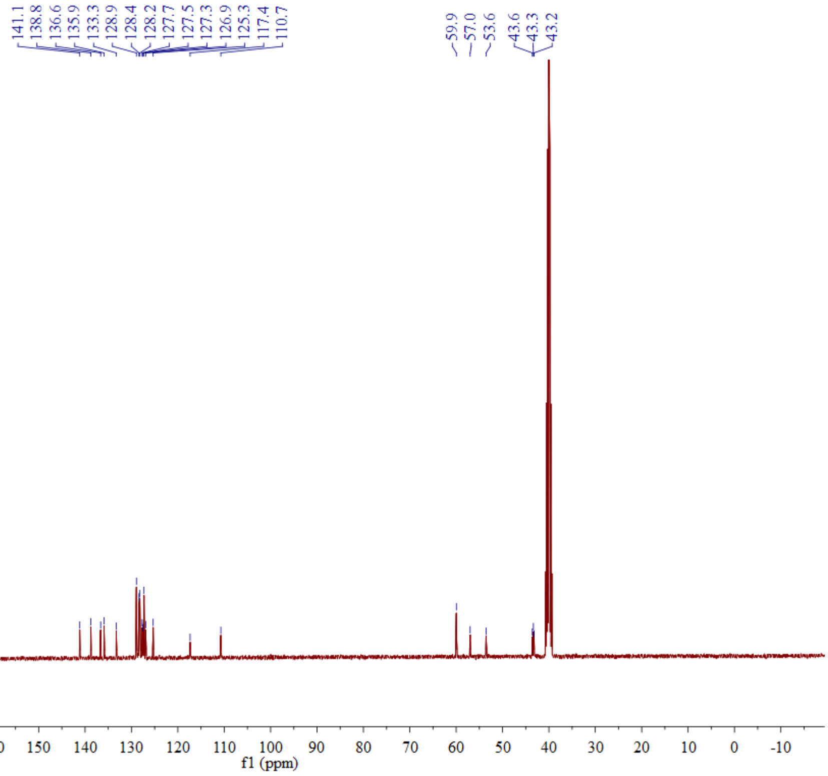
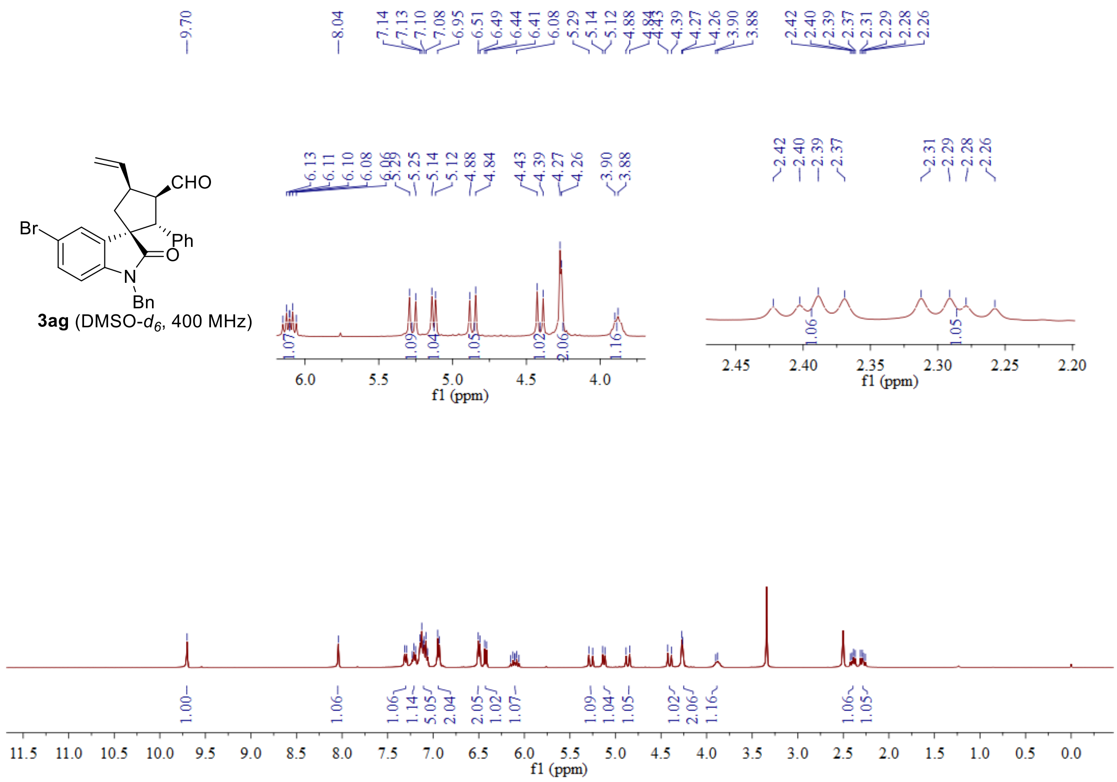
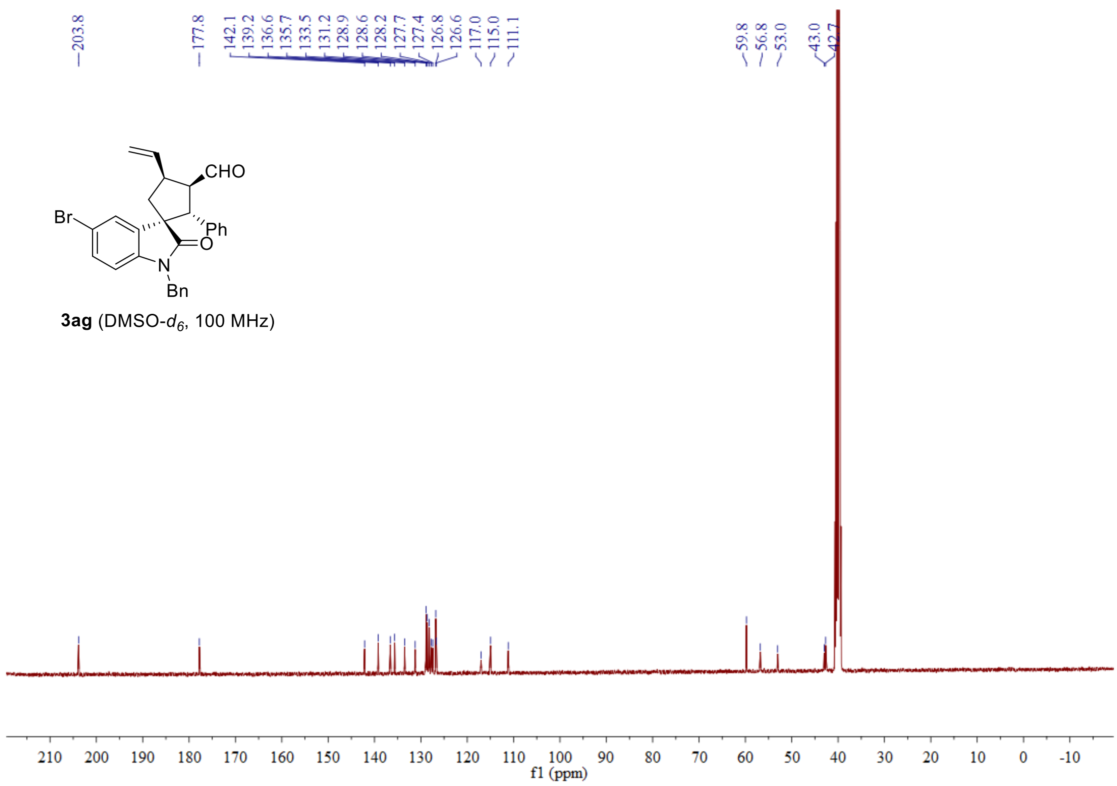


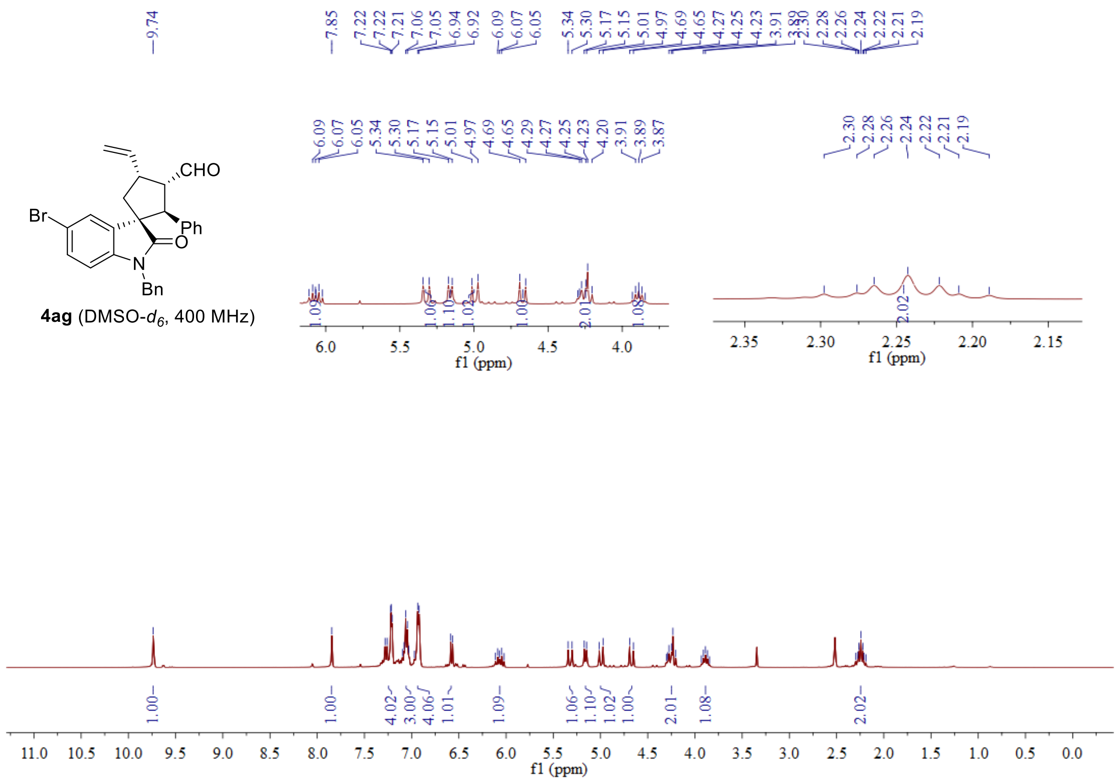


4af (DMSO-d_6, 100 MHz)

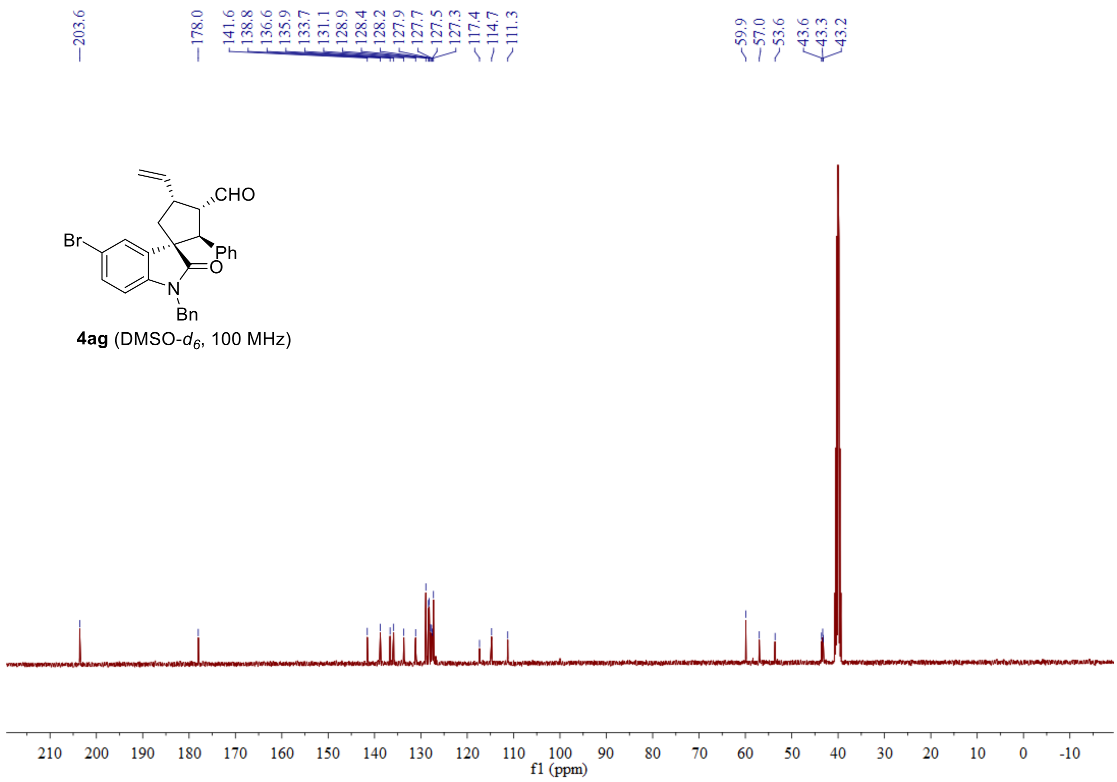




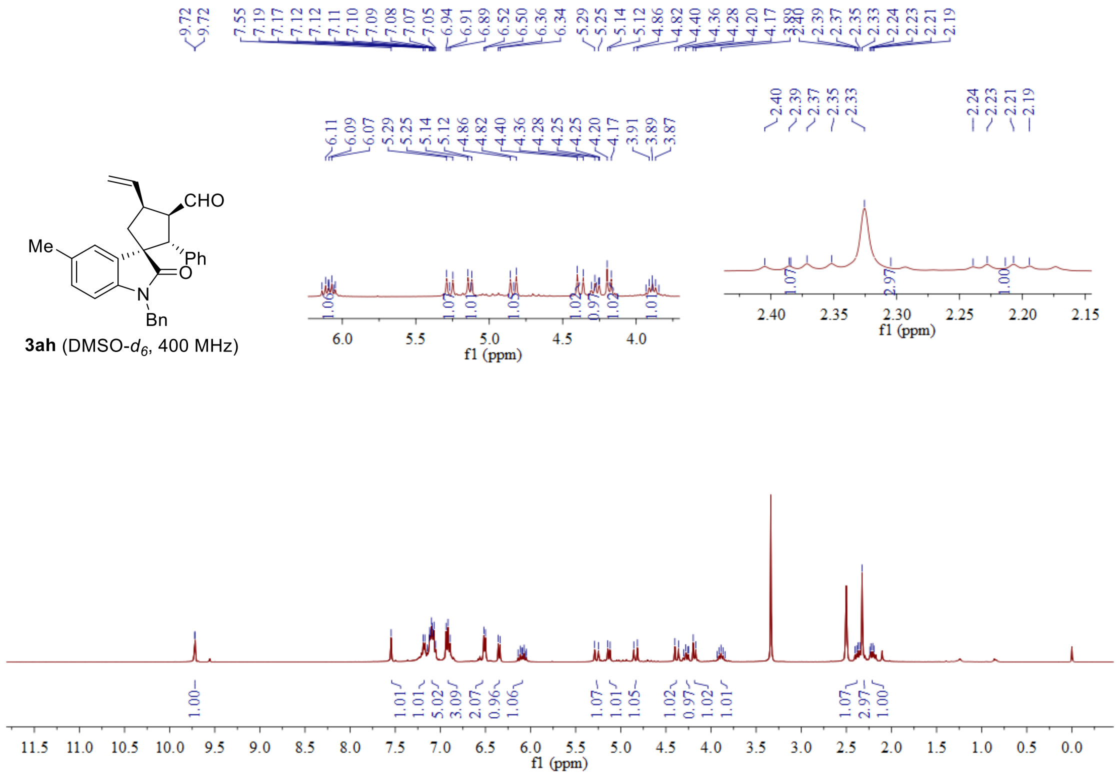




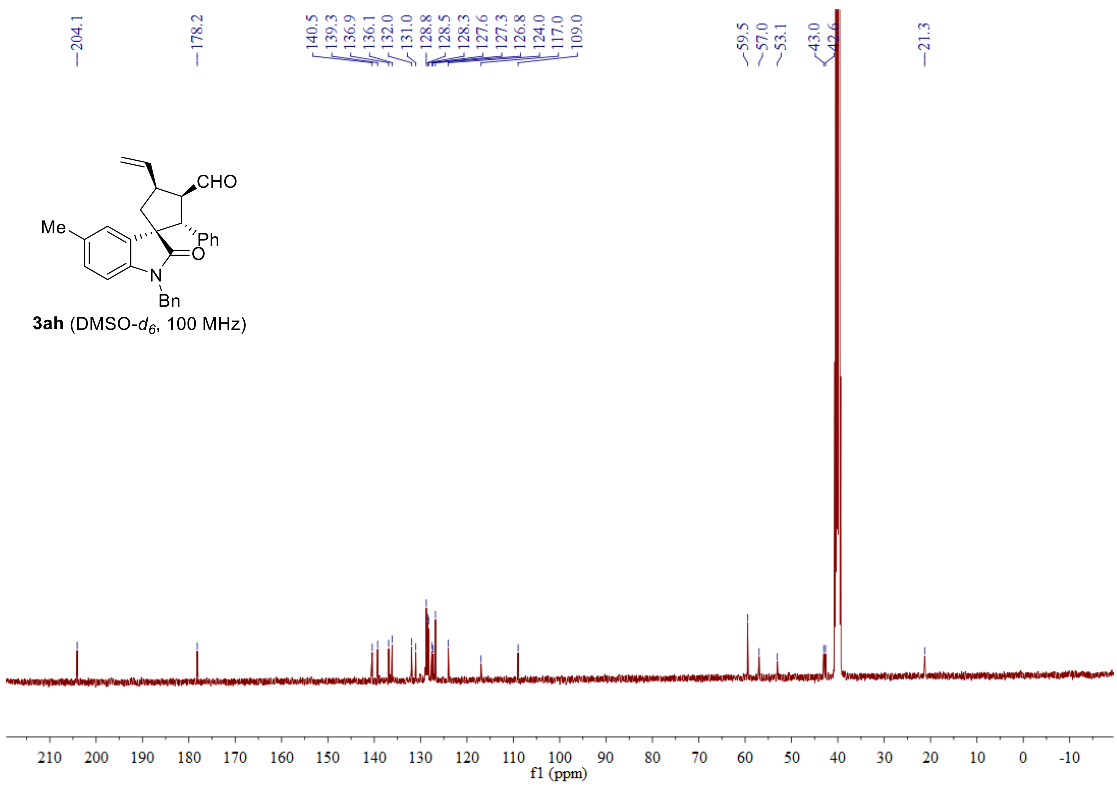
4ag (DMSO-d_6, 400 MHz)



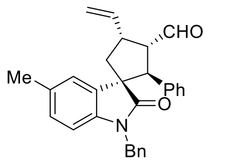
4ag (DMSO-d_6, 100 MHz)

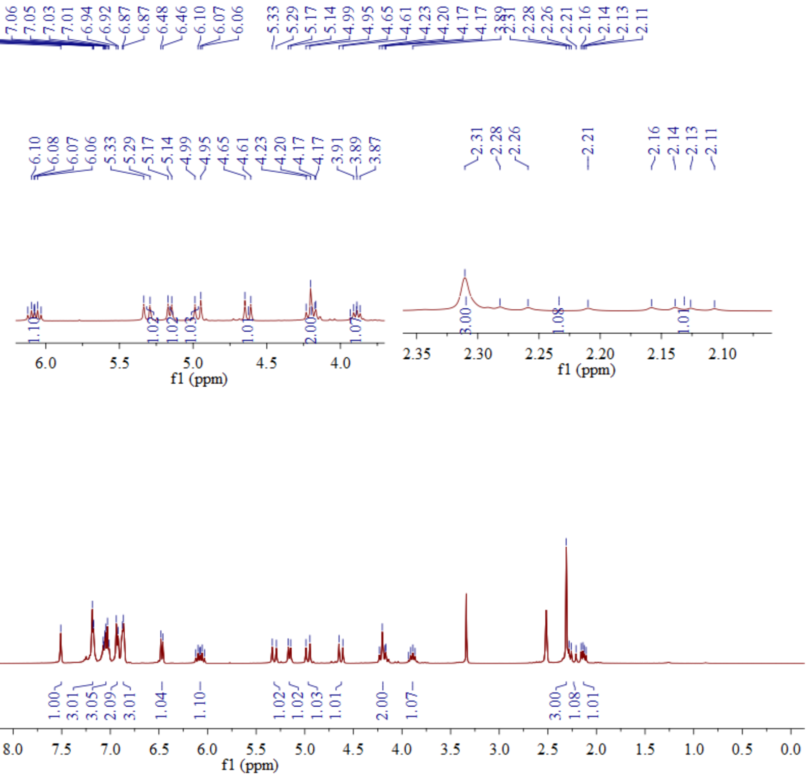


3ah (DMSO-d_6, 400 MHz)

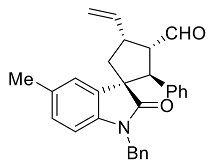


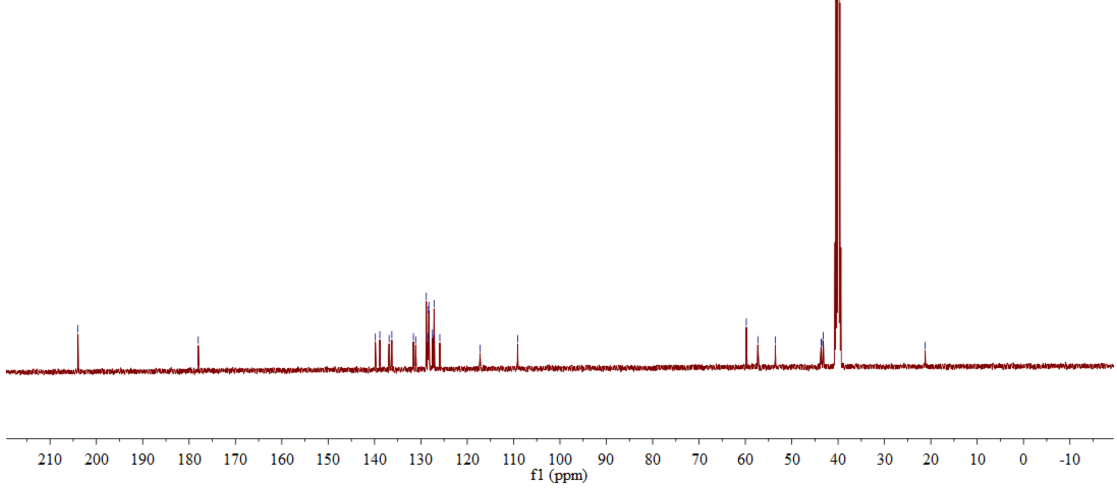
3ah (DMSO-d_6, 100 MHz)



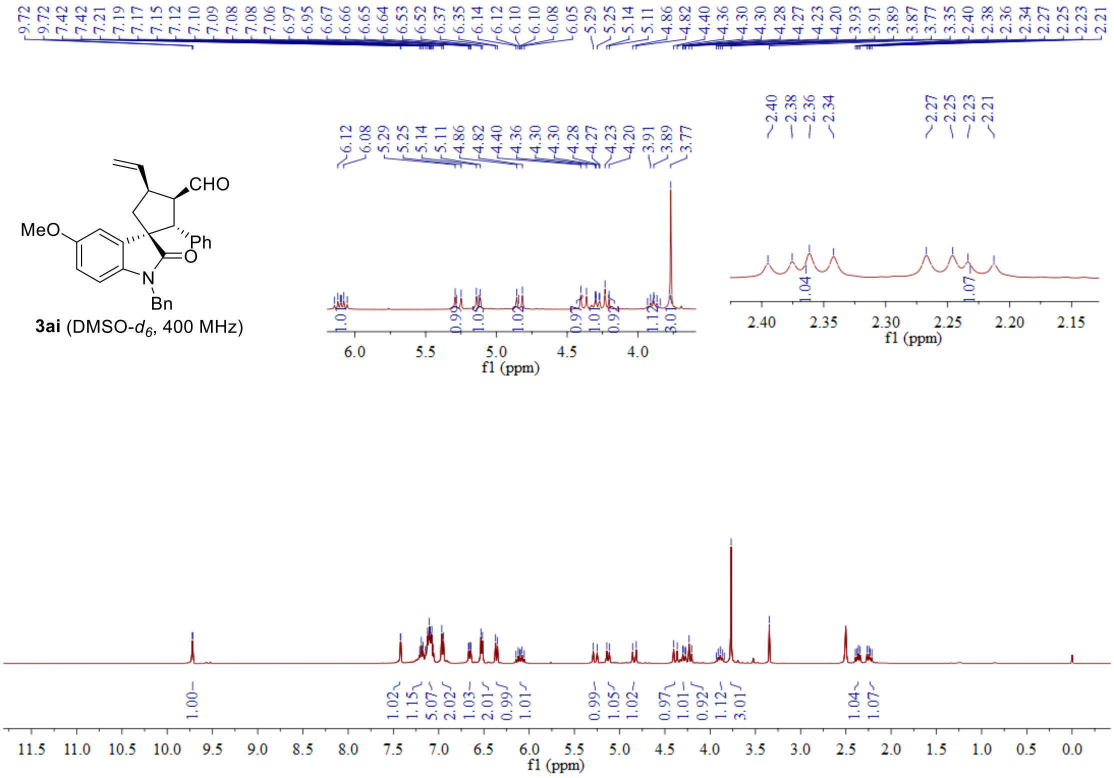


4ah (DMSO-d_6, 400 MHz)

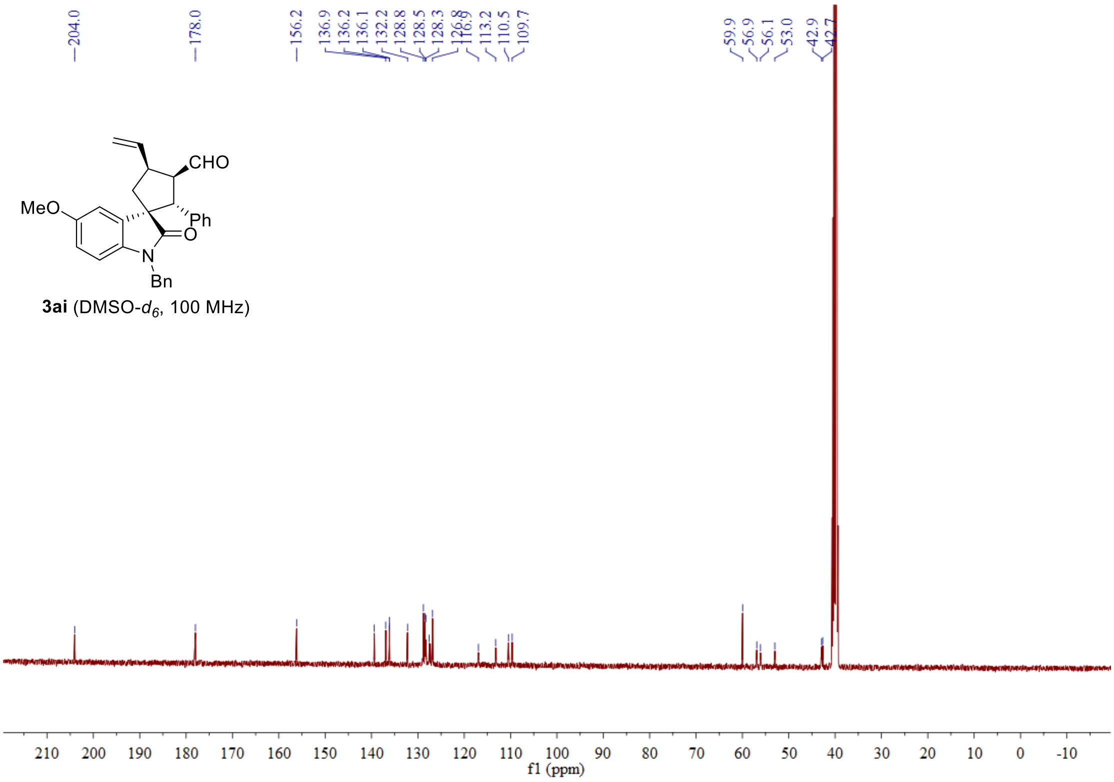




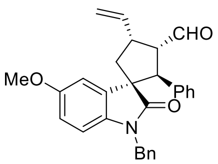
4ah (DMSO-d_6, 100 MHz)



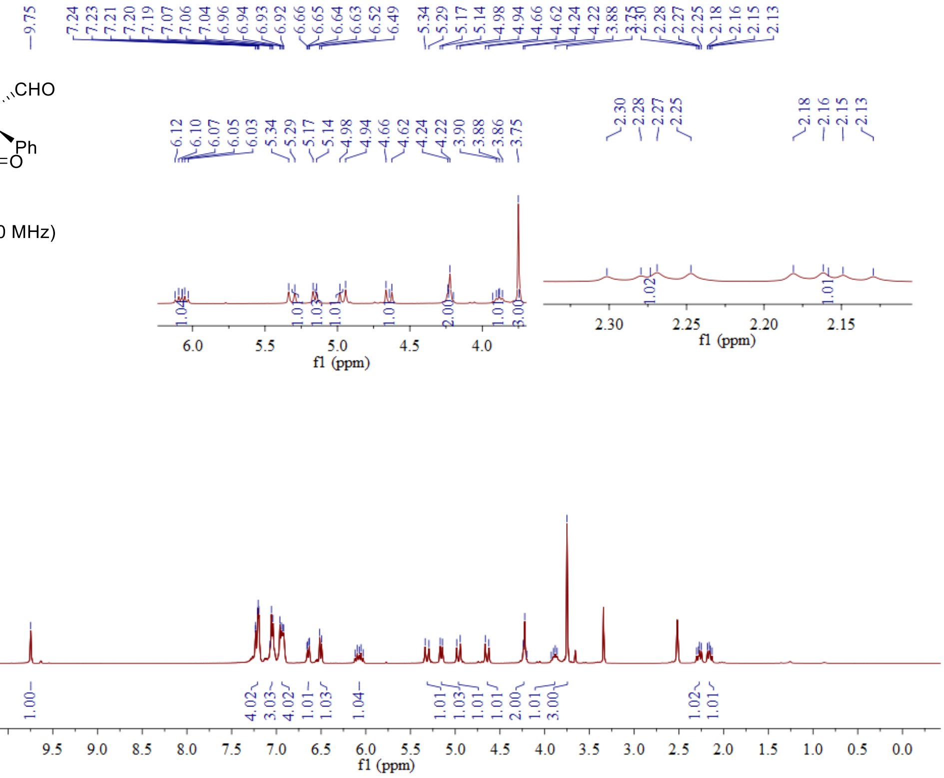
3ai (DMSO-d_6, 400 MHz)

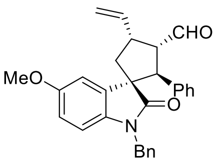


3ai (DMSO-d_6, 100 MHz)

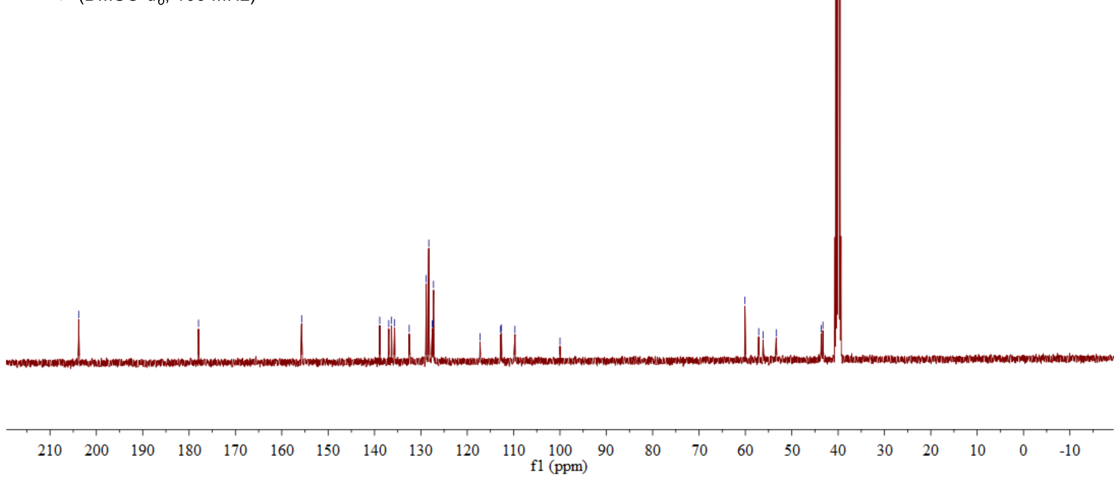


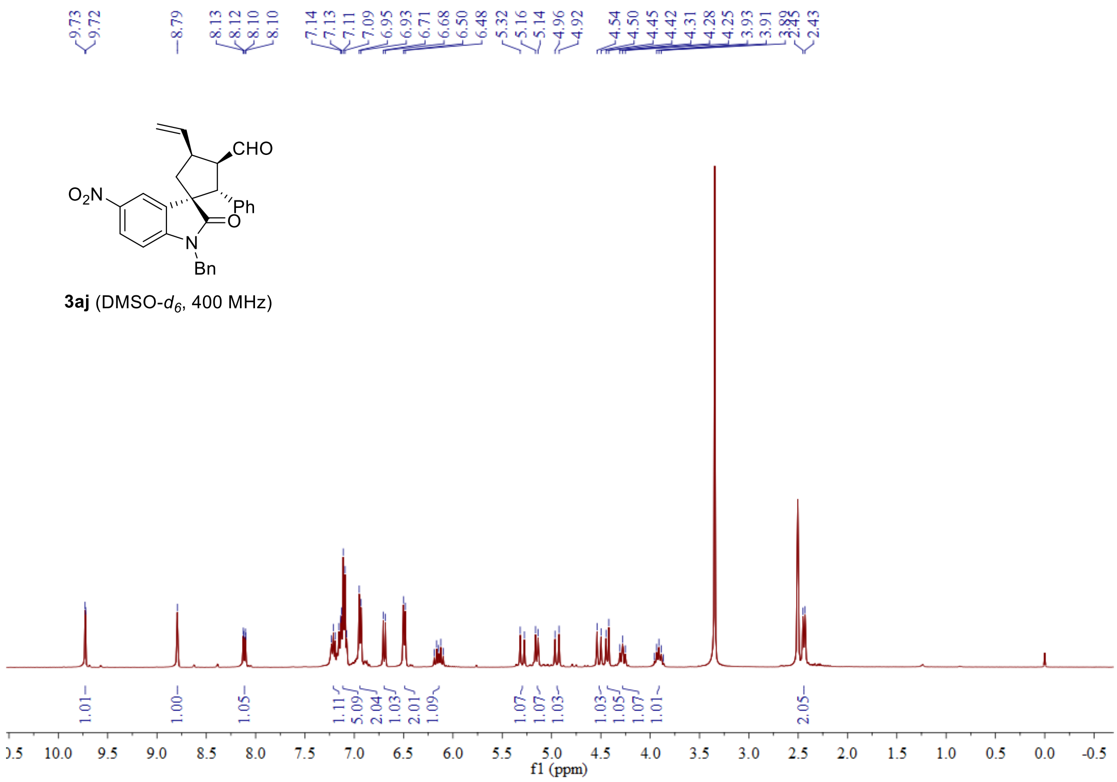
4ai (DMSO-d_6, 400 MHz)



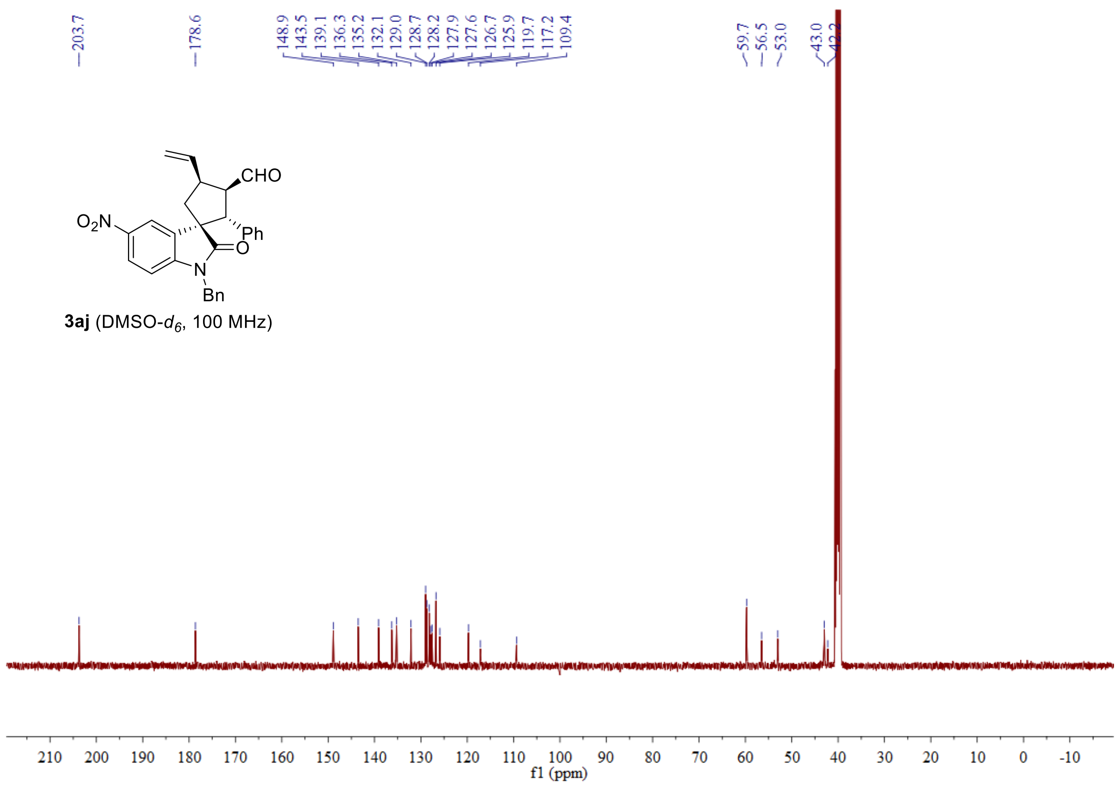


4ai (DMSO-d_6, 100 MHz)

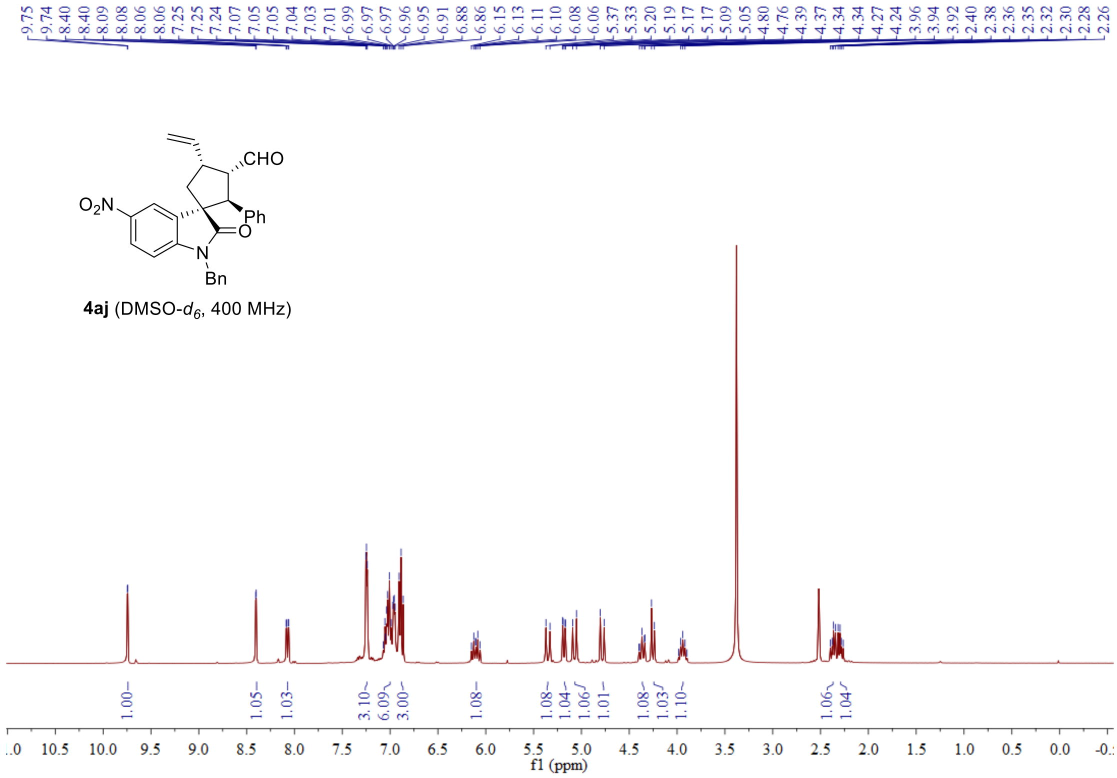


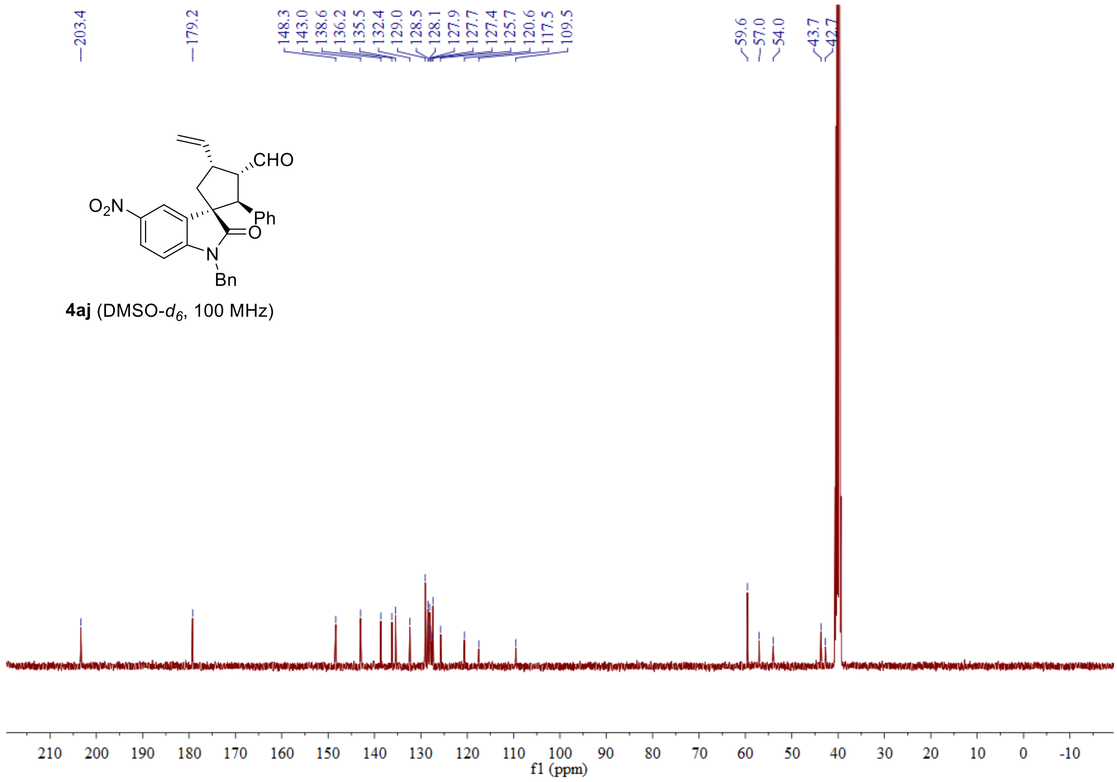


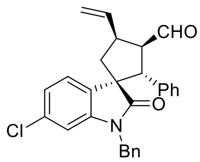
3aj (DMSO-d_6, 400 MHz)



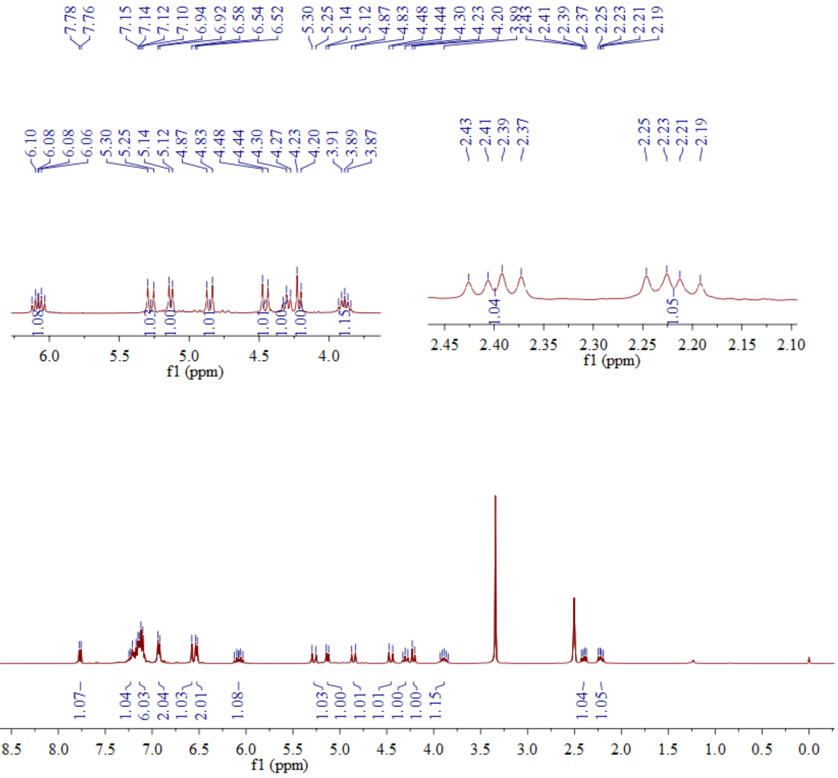
3aj (DMSO-d_6, 100 MHz)

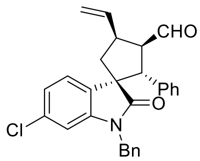

9.75 9.74 8.40 8.09 8.08 8.06 7.25 7.25 7.24 7.07 7.05 7.05 7.04 7.03 7.01 6.99 6.97 6.97 6.96 6.95 6.91 6.88 6.86 6.15 6.13 6.11 6.10 6.08 6.06 5.37 5.33 5.20 5.19 5.17 5.17 5.09 5.05 4.80 4.76 4.39 4.37 4.34 4.34 4.27 4.24 3.96 3.94 3.92 2.40 2.38 2.36 2.35 2.32 2.30 2.28 2.26
CHO
O_2N
Ph
O
N
Bn
4aj (DMSO-d_6, 400 MHz)
1.00 1.05 1.03 3.10 6.09 3.00 1.08 1.08 1.04 1.06 1.01 1.08 1.03 1.10 1.06 1.04
f1 (ppm)


203.4 179.2 148.3 143.0 138.6 136.2 135.5 132.4 129.0 128.5 128.1 127.9 127.7 127.4 125.7 120.6 117.5 109.5 59.6 57.0 54.0 43.7 42.7
CHO
O_2N
Ph
O
N
Bn
4aj (DMSO-d_6, 100 MHz)
f1 (ppm)

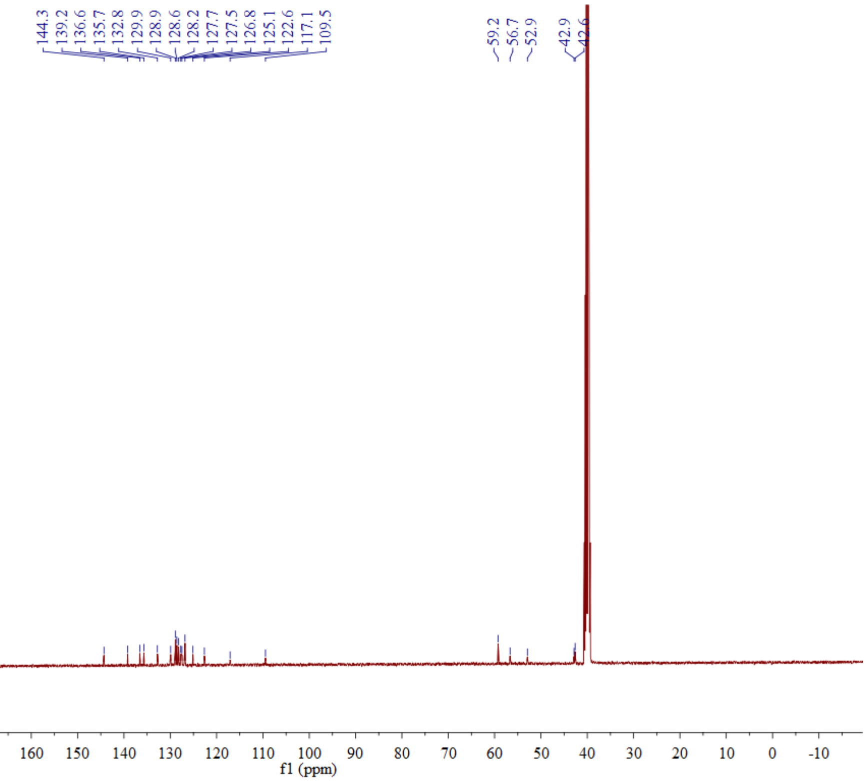


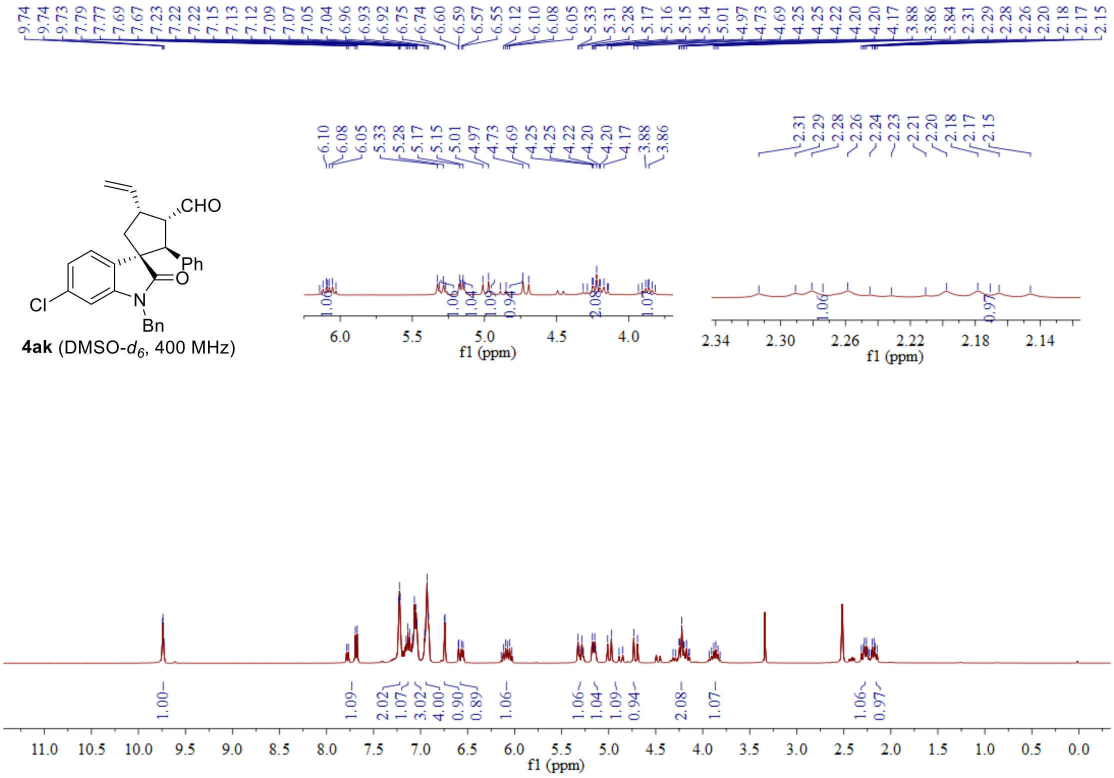
3ak (DMSO-d_6, 400 MHz)



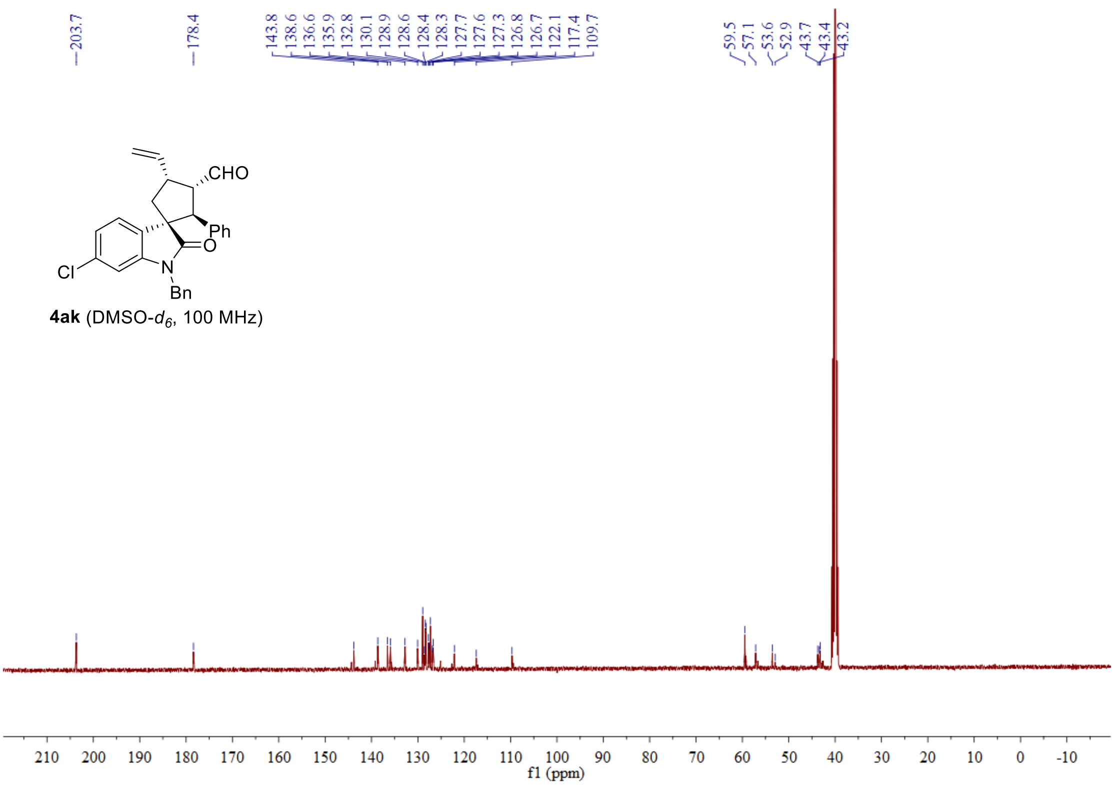


3ak (DMSO-d_6, 100 MHz)

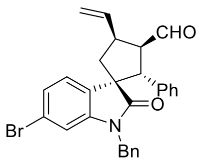




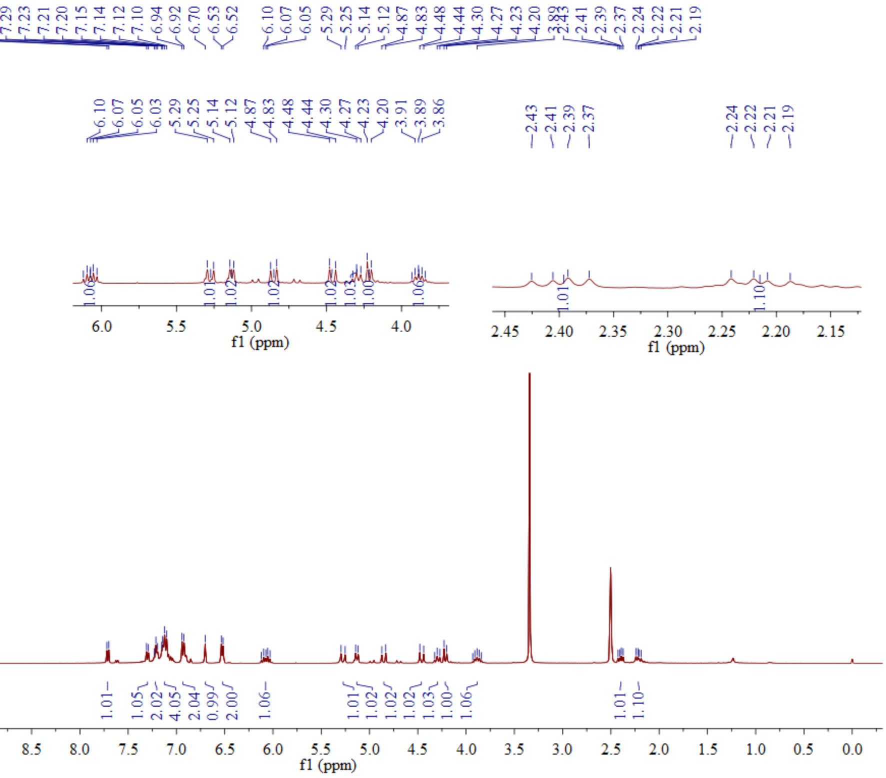
4ak (DMSO-d_6, 400 MHz)

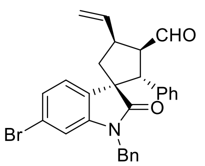


4ak (DMSO-d_6, 100 MHz)

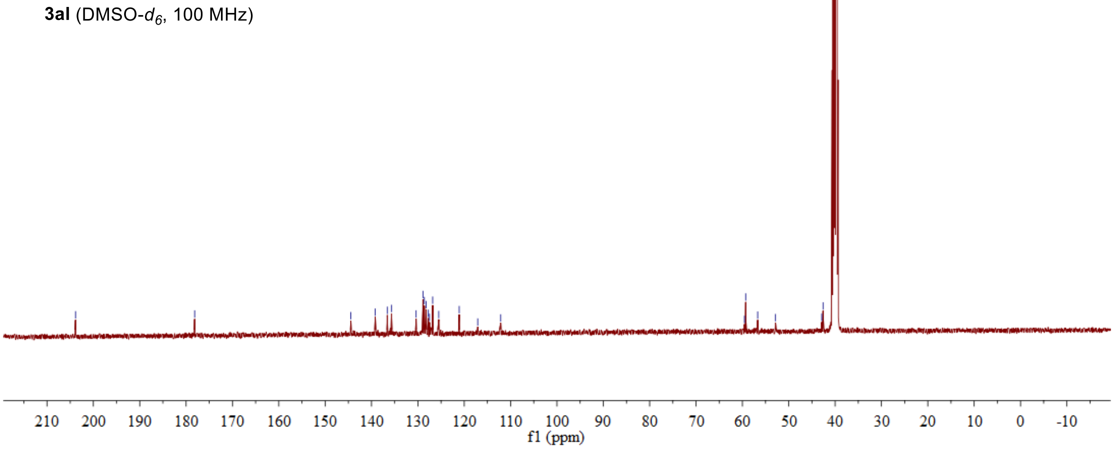


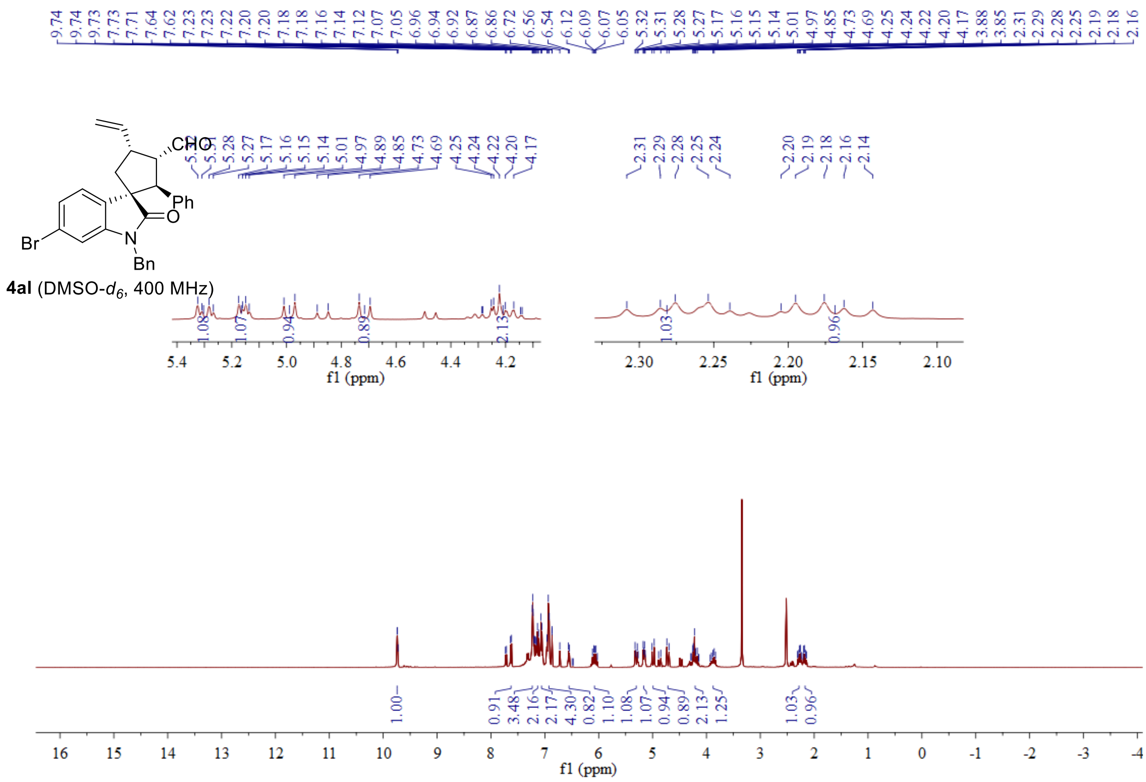
3al (DMSO-d_6, 400 MHz)

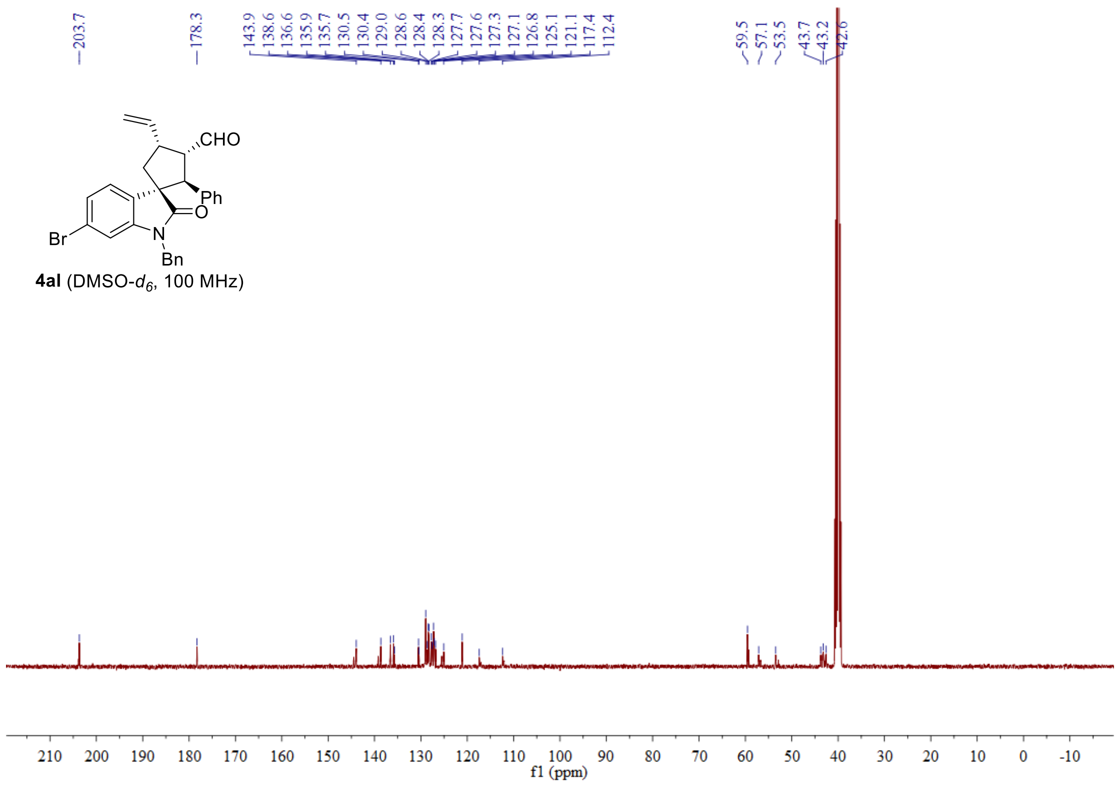


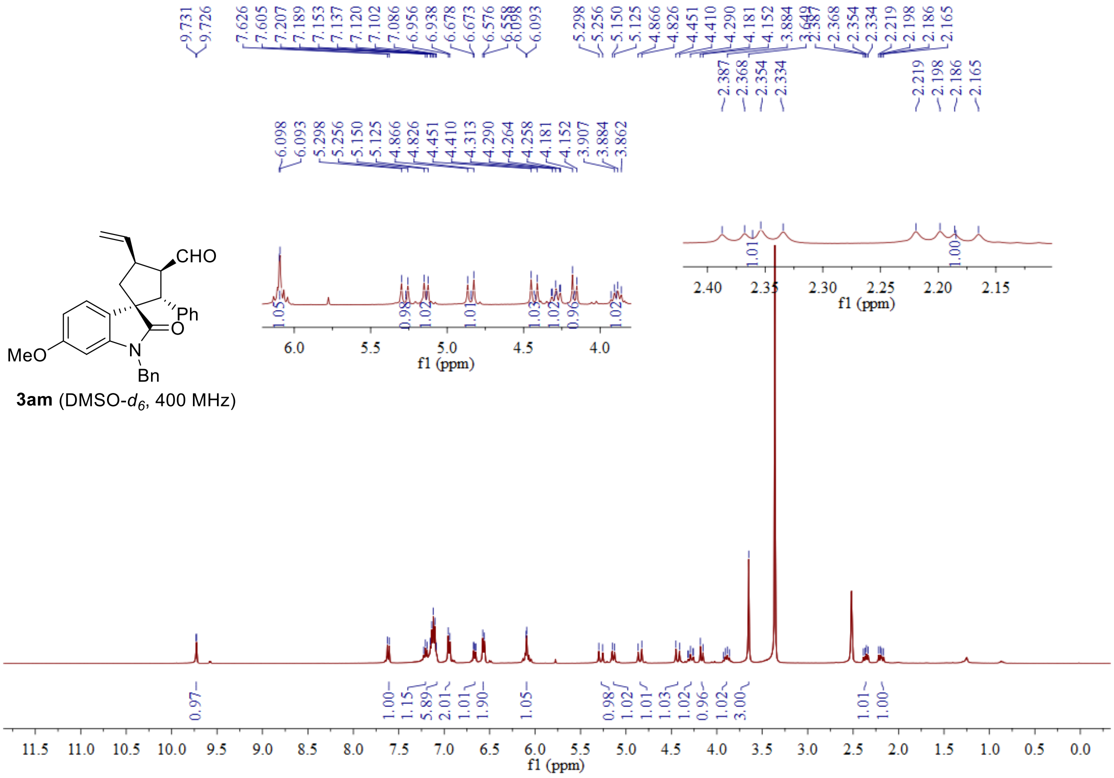


3al (DMSO-d_6, 100 MHz)

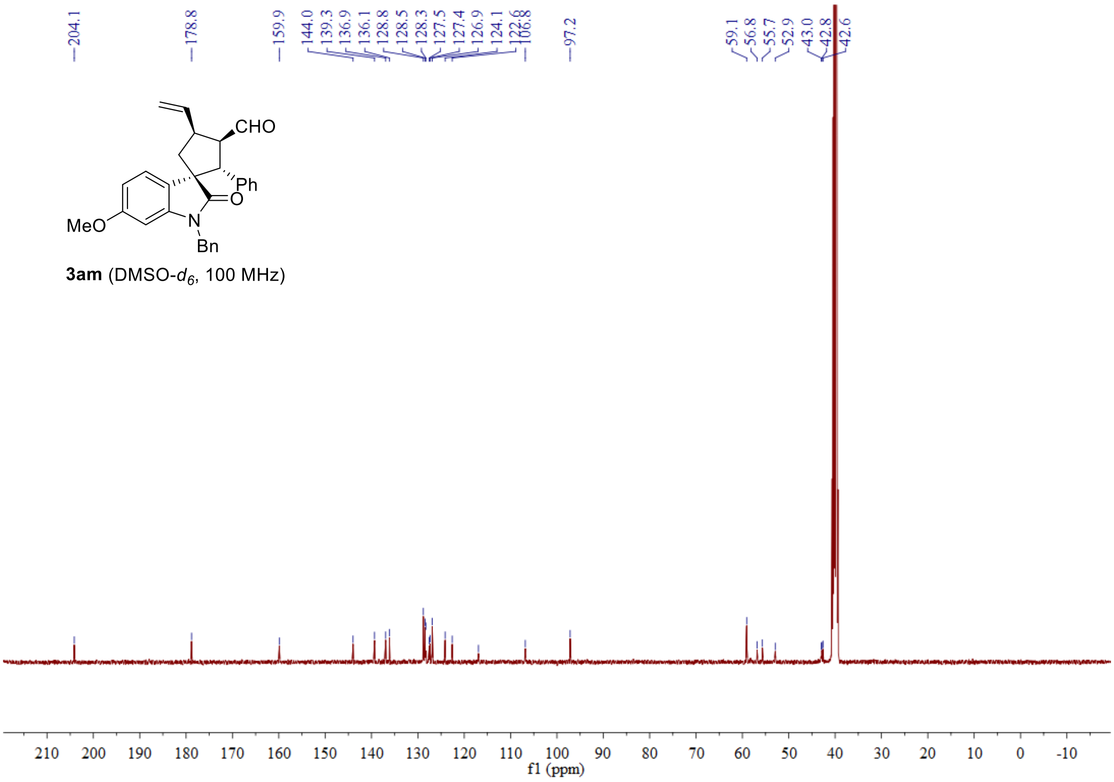



9.74 9.74 9.73 7.73 7.71 7.64 7.62 7.23 7.23 7.22 7.20 7.20 7.18 7.18 7.16 7.14 7.12 7.07 7.05 6.96 6.94 6.92 6.87 6.86 6.72 6.56 6.54 6.12 6.09 6.07 6.05 5.32 5.31 5.28 5.27 5.17 5.16 5.15 5.14 5.01 4.97 4.85 4.73 4.69 4.25 4.24 4.22 4.20 4.17 3.88 3.85 2.31 2.29 2.28 2.25 2.19 2.18 2.16
CHO
Ph
Br
N
O
Bn
4al (DMSO-d_6, 400 MHz)
f1 (ppm)

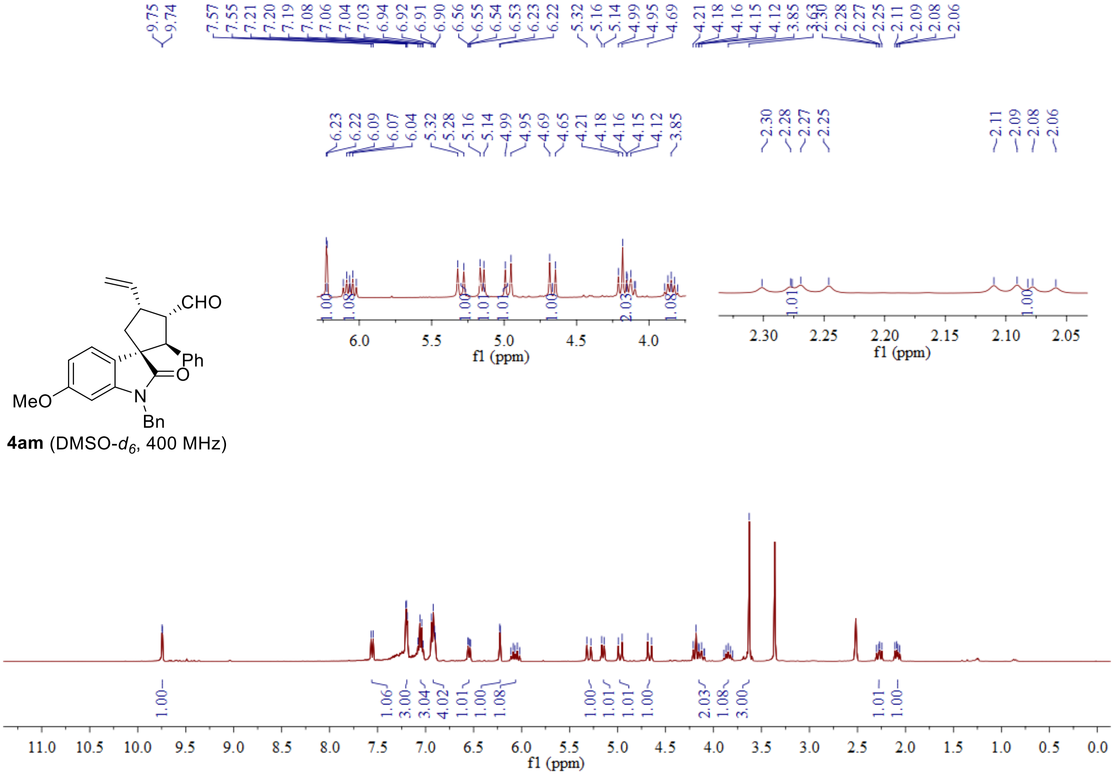

203.7
178.3
143.9 138.6 136.6 135.9 135.7 130.5 130.4 129.0 128.6 128.4 128.3 127.7 127.6 127.3 127.1 126.8 125.1 121.1 117.4 112.4
59.5 57.1 53.5 43.7 43.2 42.6
CHO
Ph
Br
N
O
Bn
4al (DMSO-d_6, 100 MHz)
f1 (ppm)



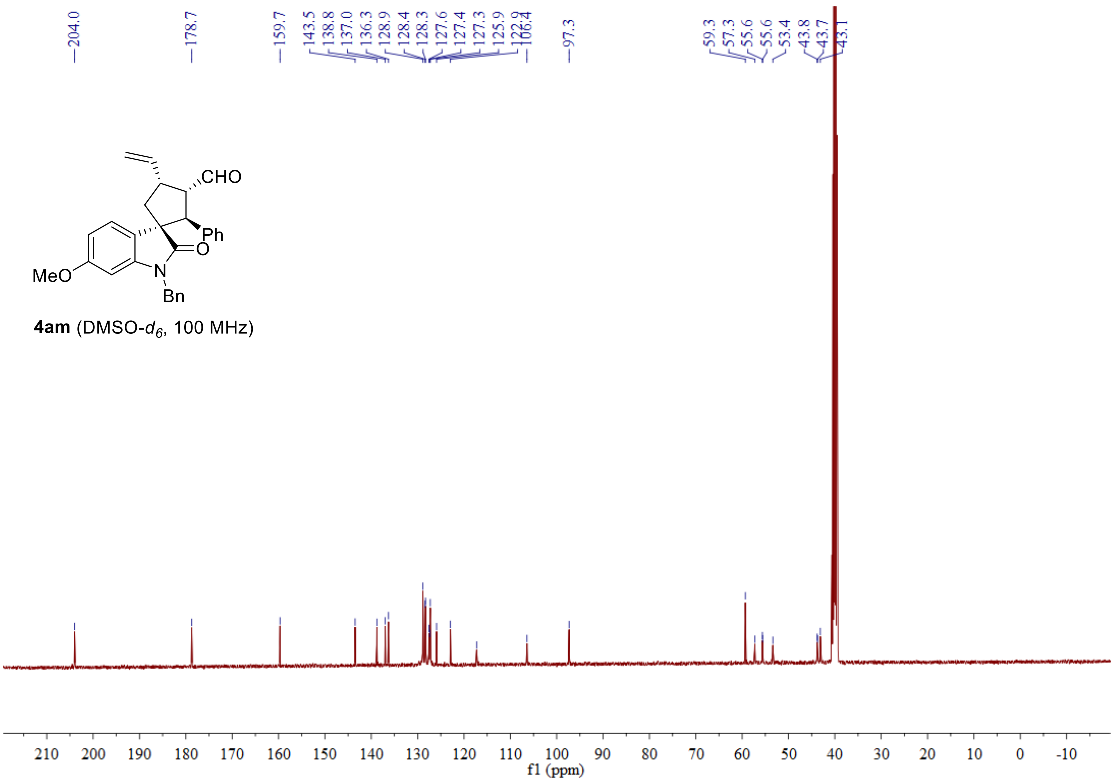
3am (DMSO-d_6, 400 MHz)



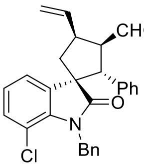
3am (DMSO-d_6, 100 MHz)



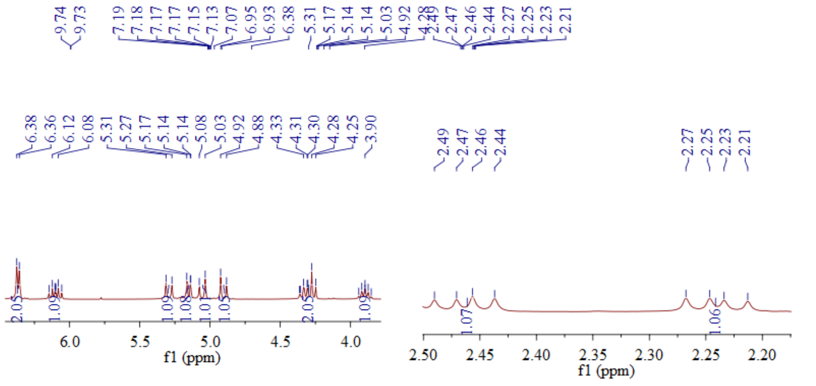
4am (DMSO-d_6, 400 MHz)

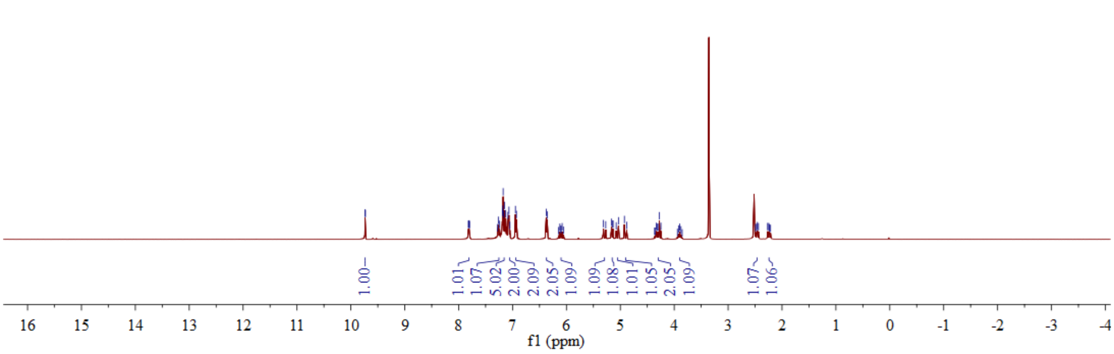


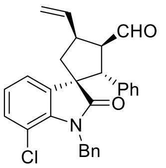
4am (DMSO-d_6, 100 MHz)



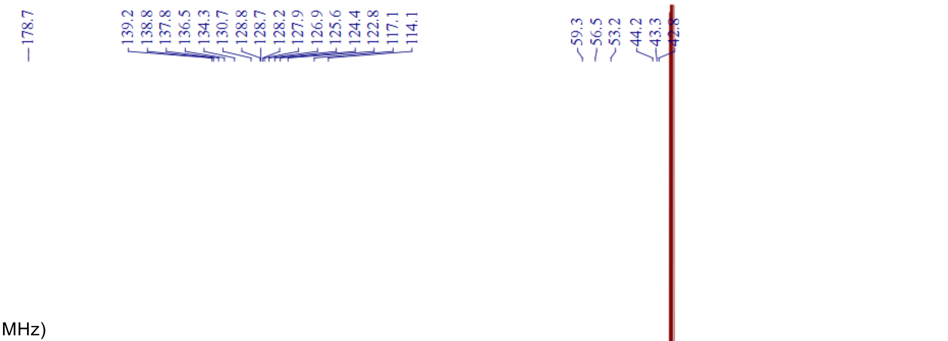
3an (DMSO-d_6, 400 MHz)

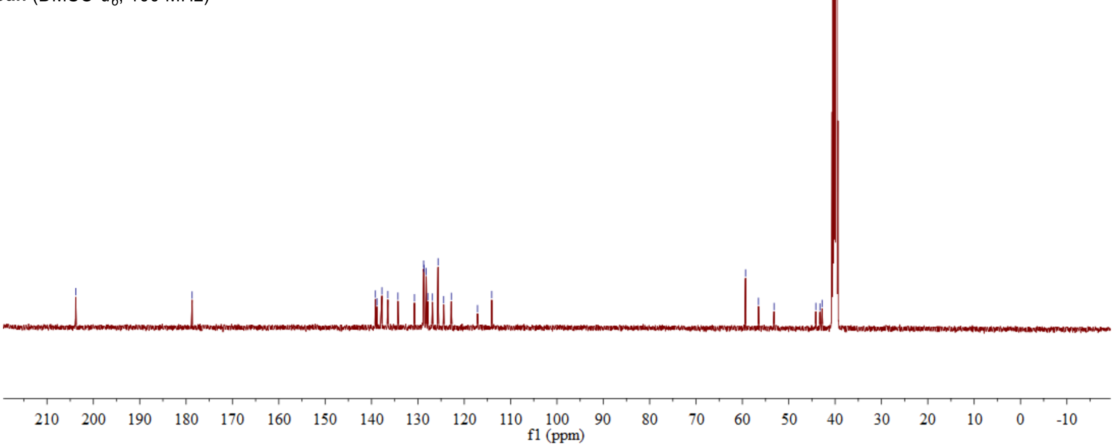


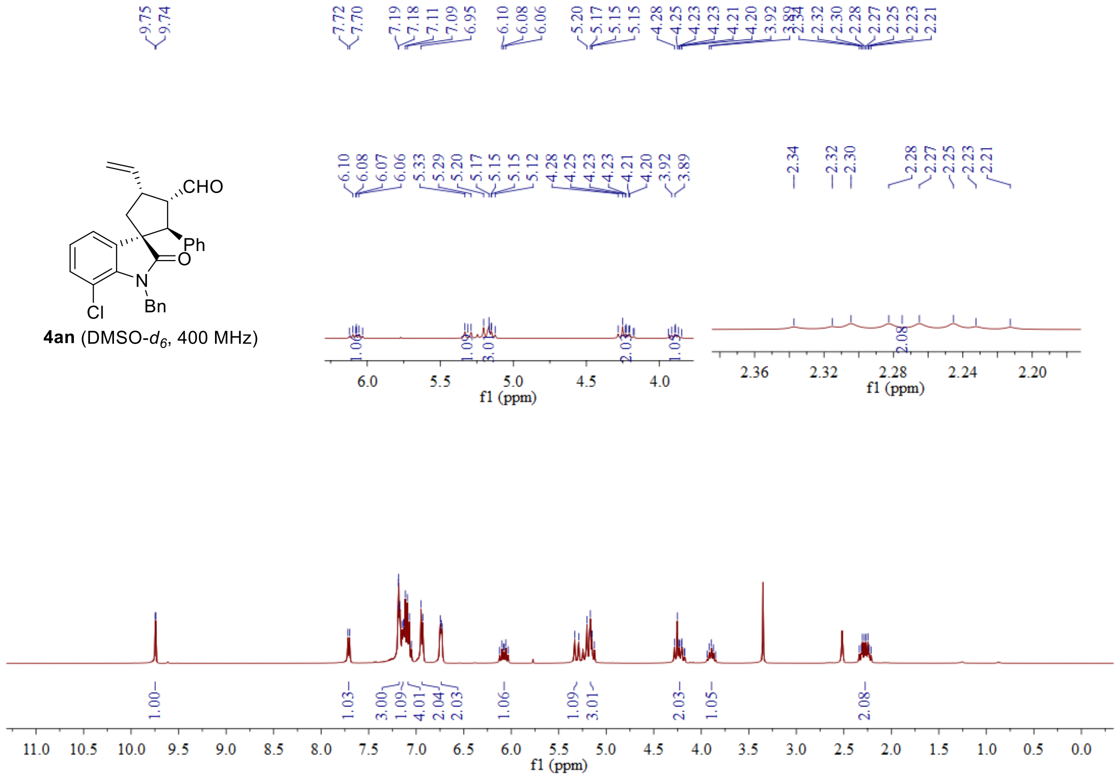




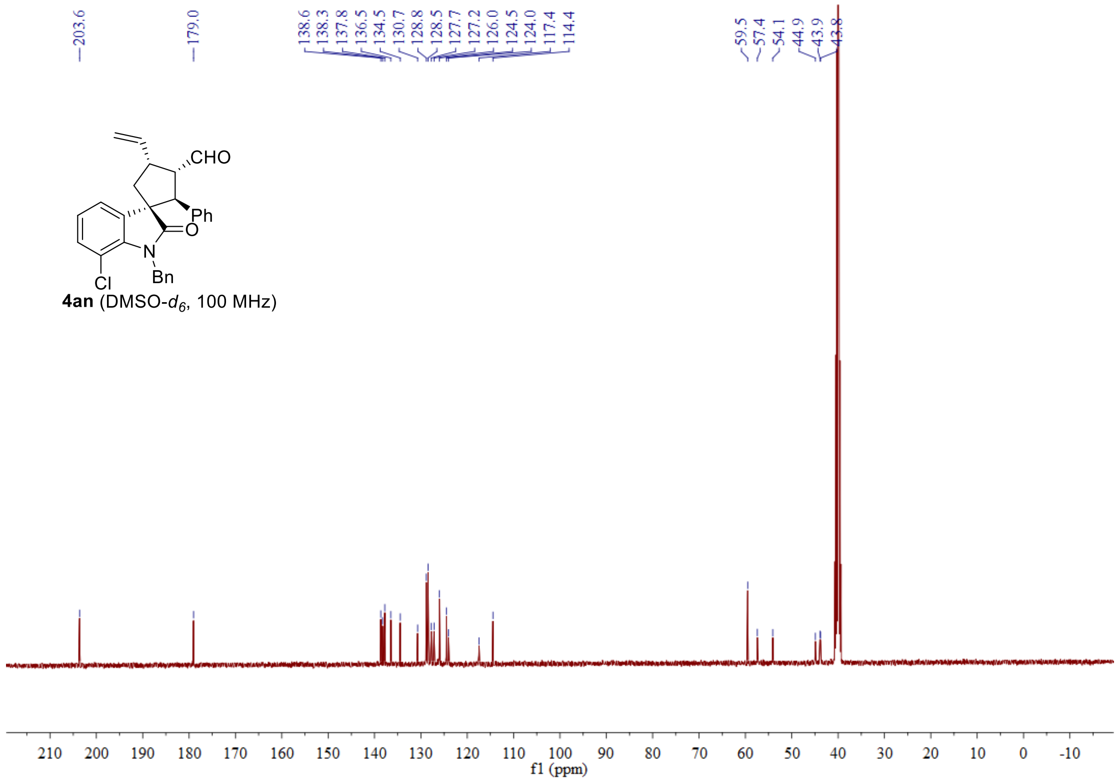
3an (DMSO-d_6, 100 MHz)



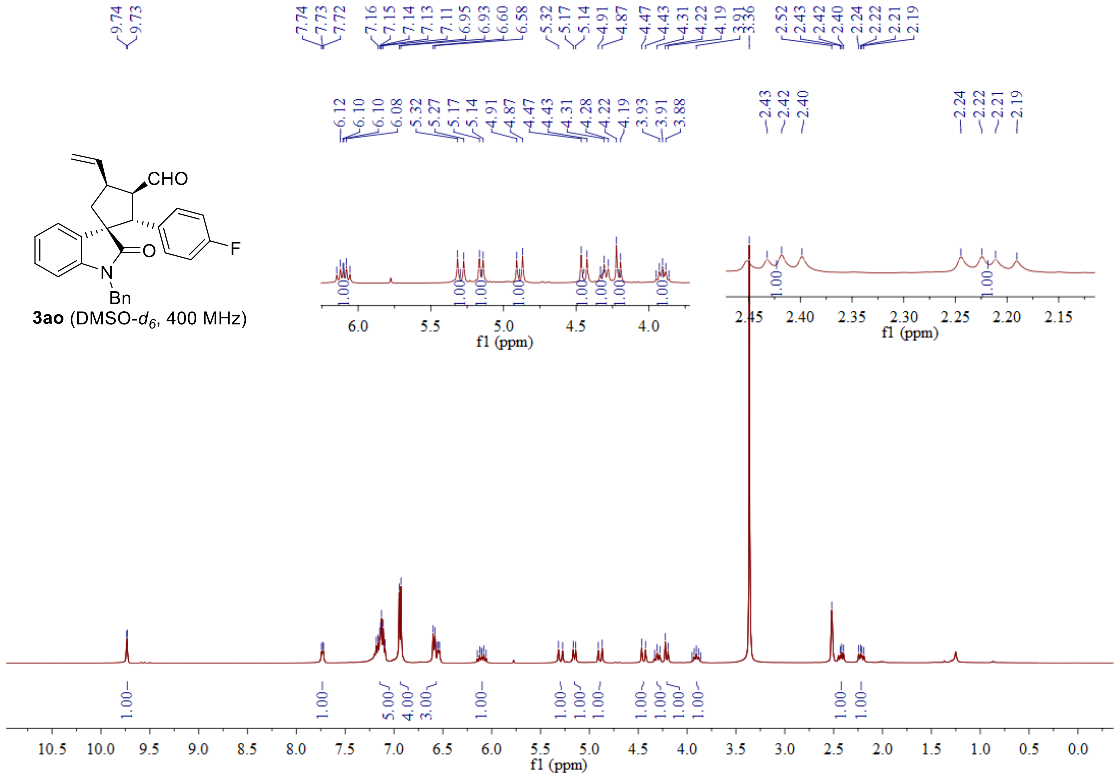




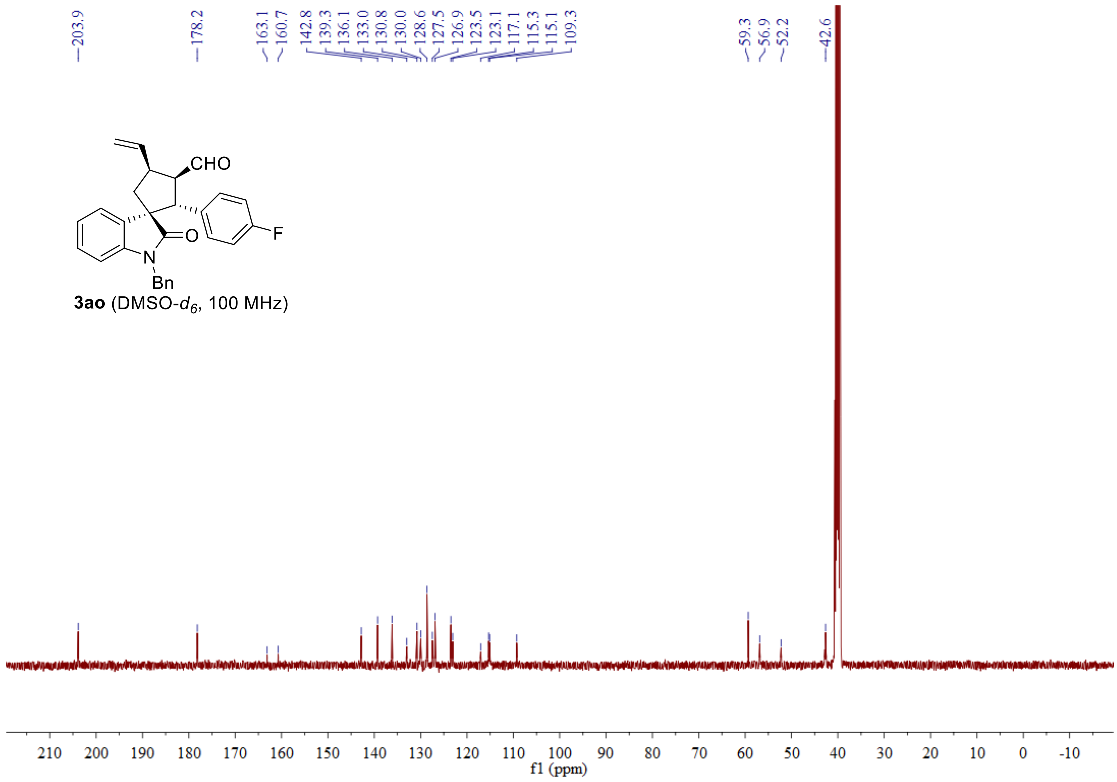
4an (DMSO-d_6, 400 MHz)



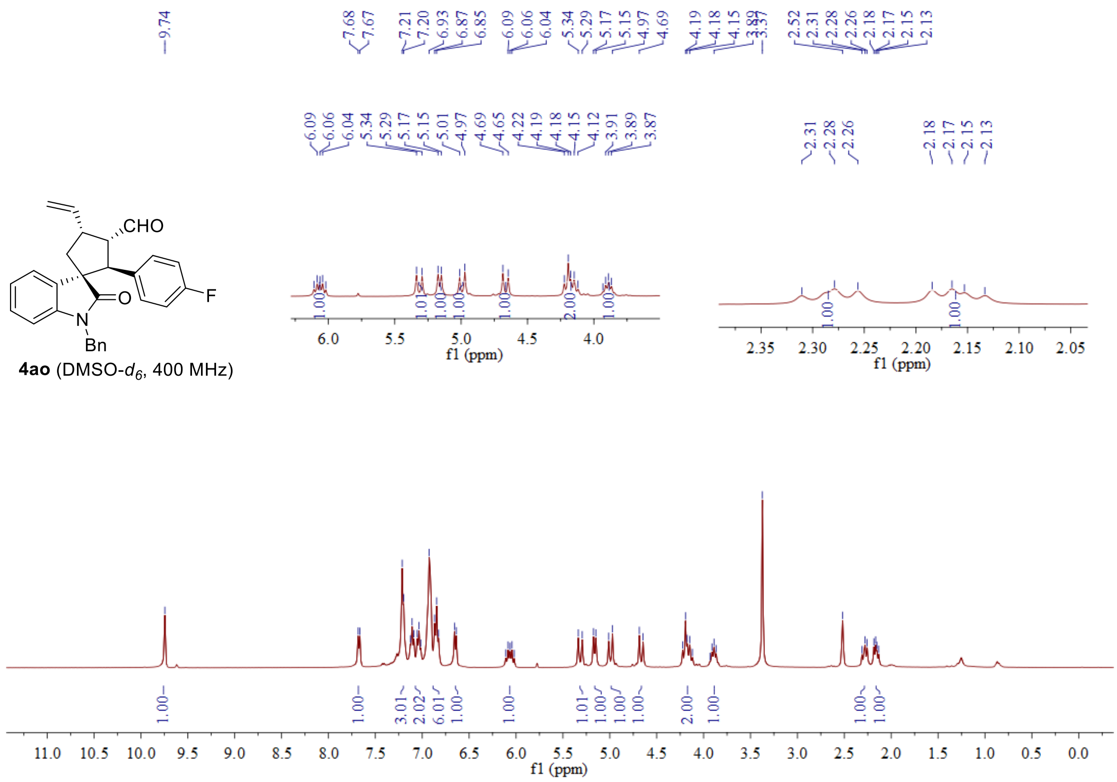
4an (DMSO-d_6, 100 MHz)



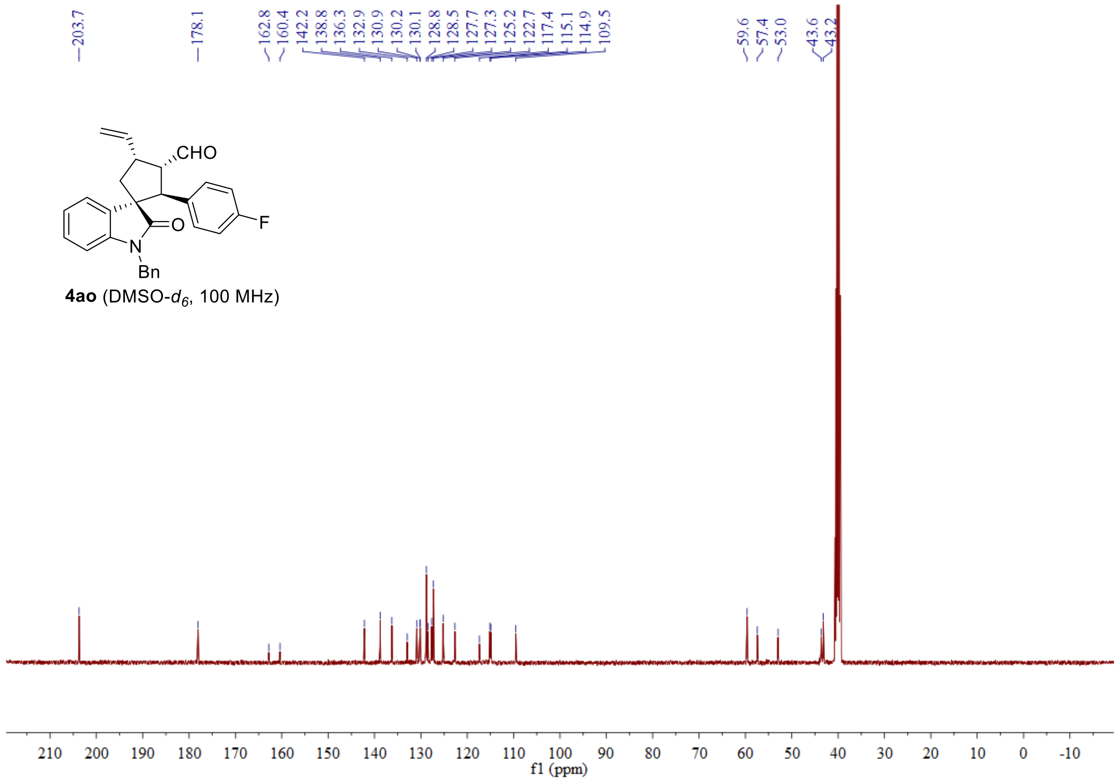
3ao (DMSO-d_6, 400 MHz)



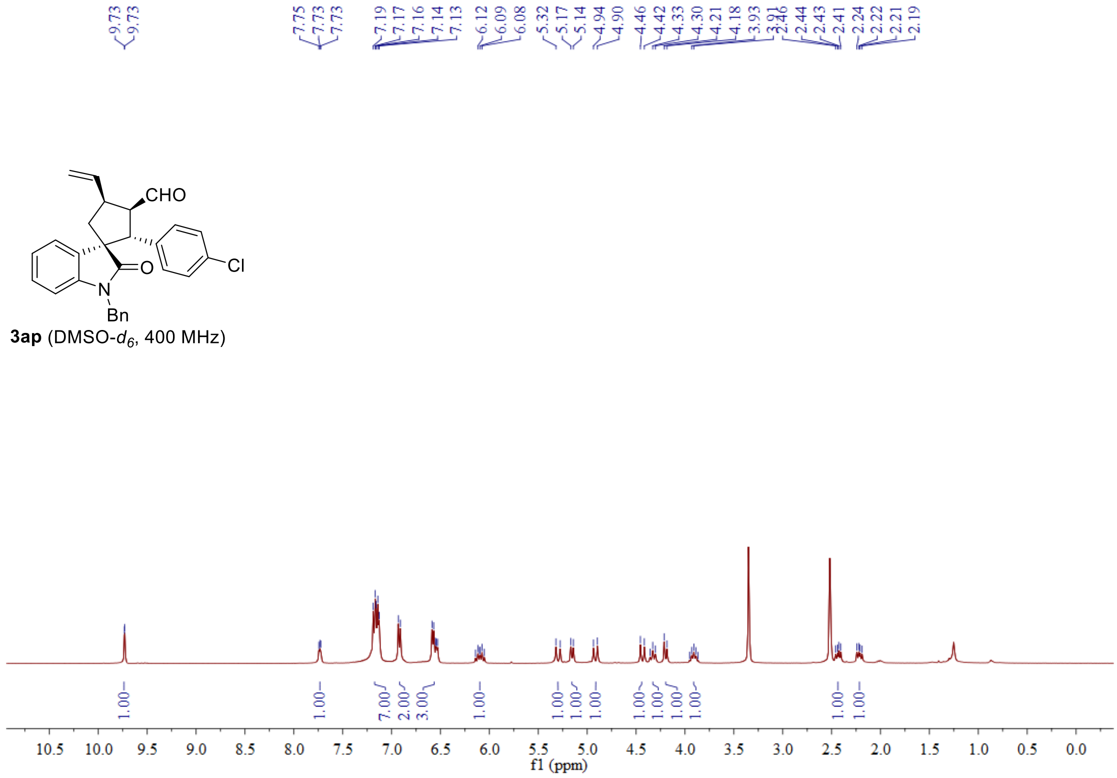
3ao (DMSO-d_6, 100 MHz)



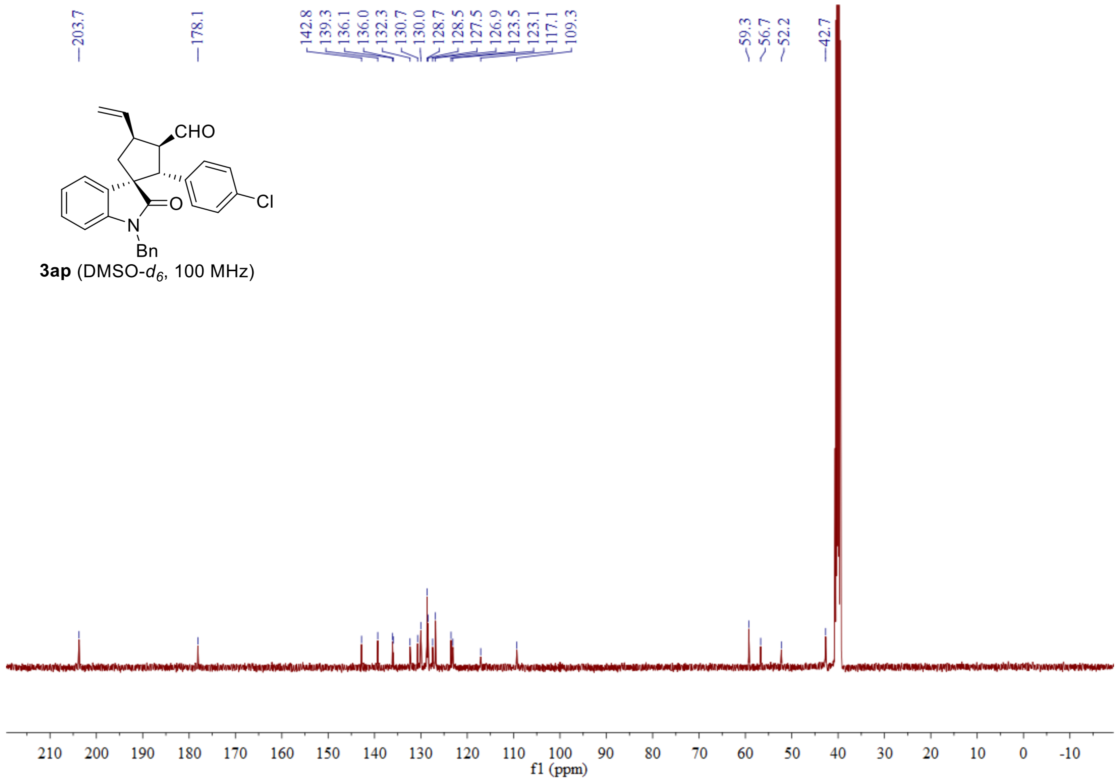
4ao (DMSO-d_6, 400 MHz)



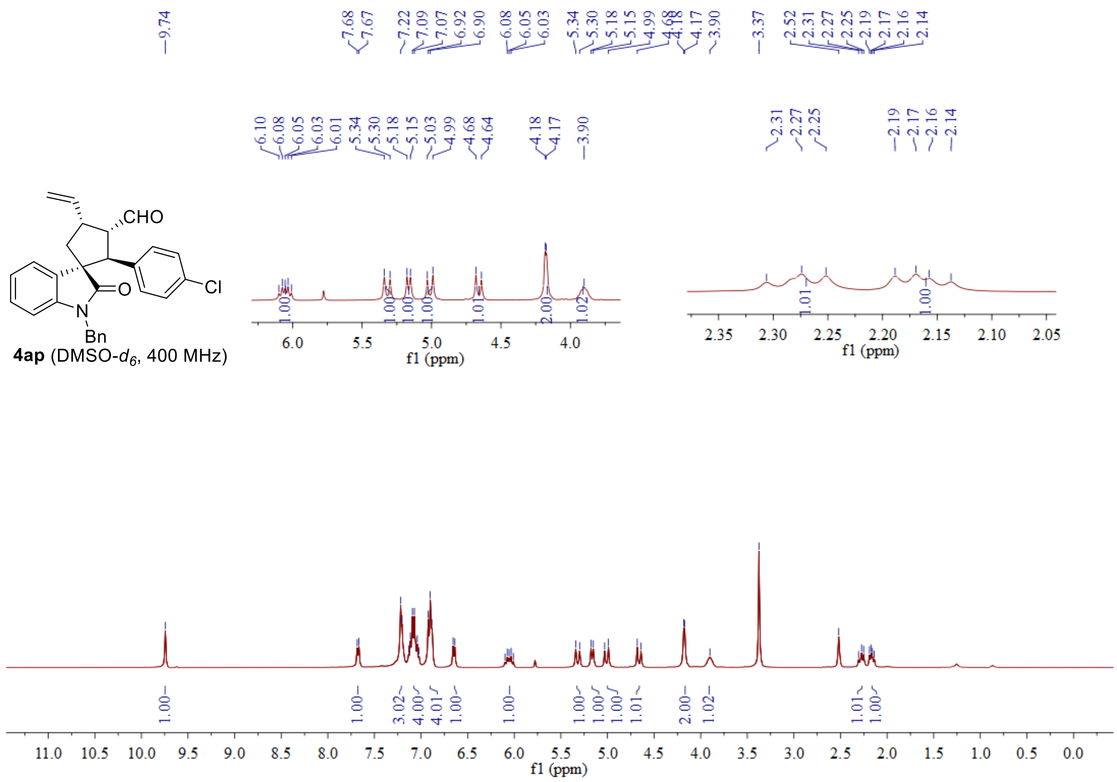
4ao (DMSO-d_6, 100 MHz)



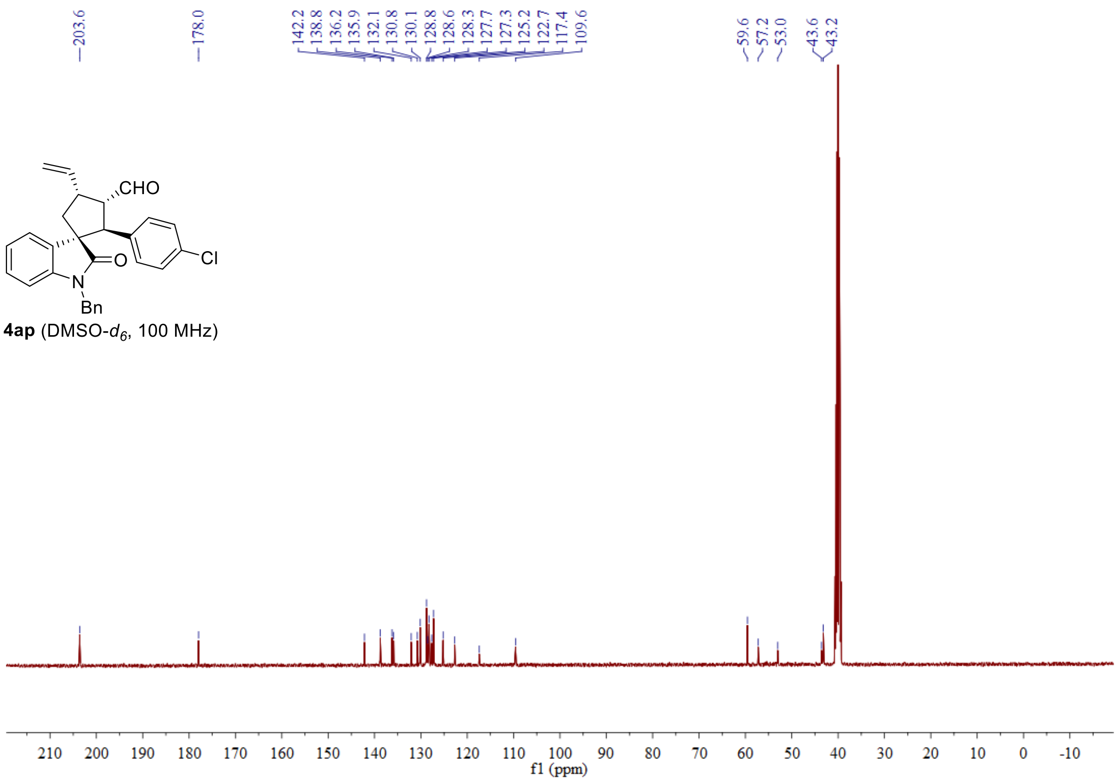
3ap (DMSO-d_6, 400 MHz)



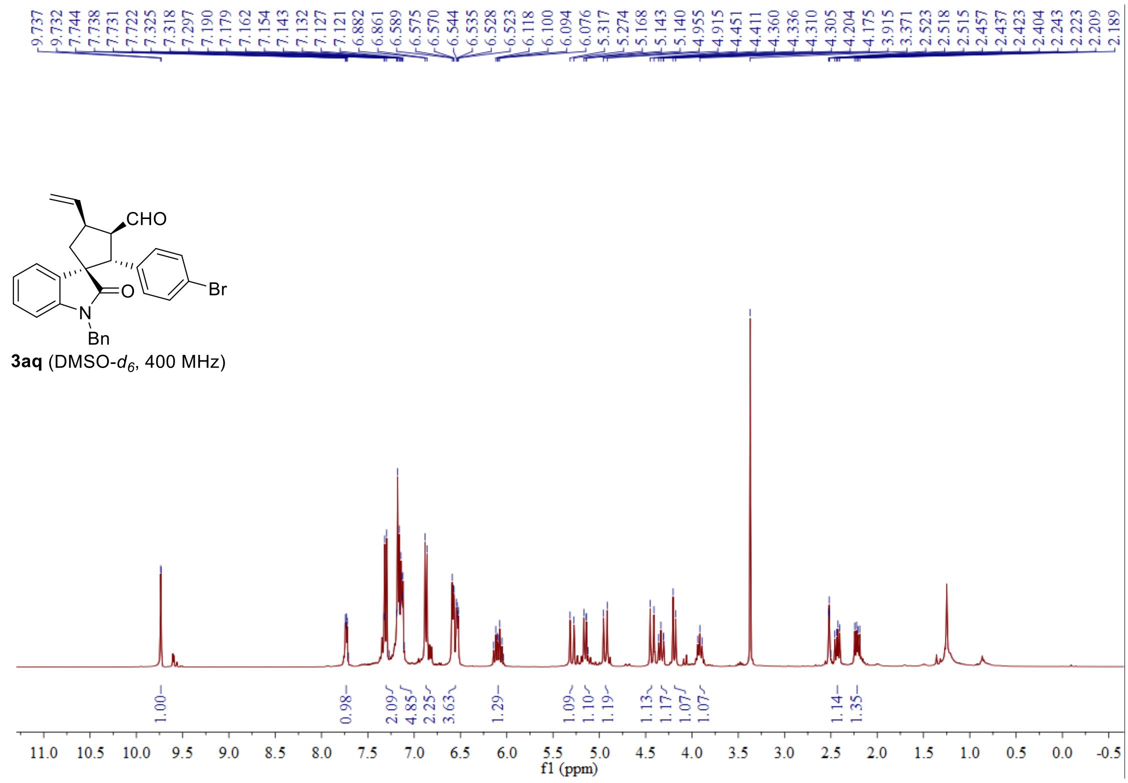
3ap (DMSO-d_6, 100 MHz)



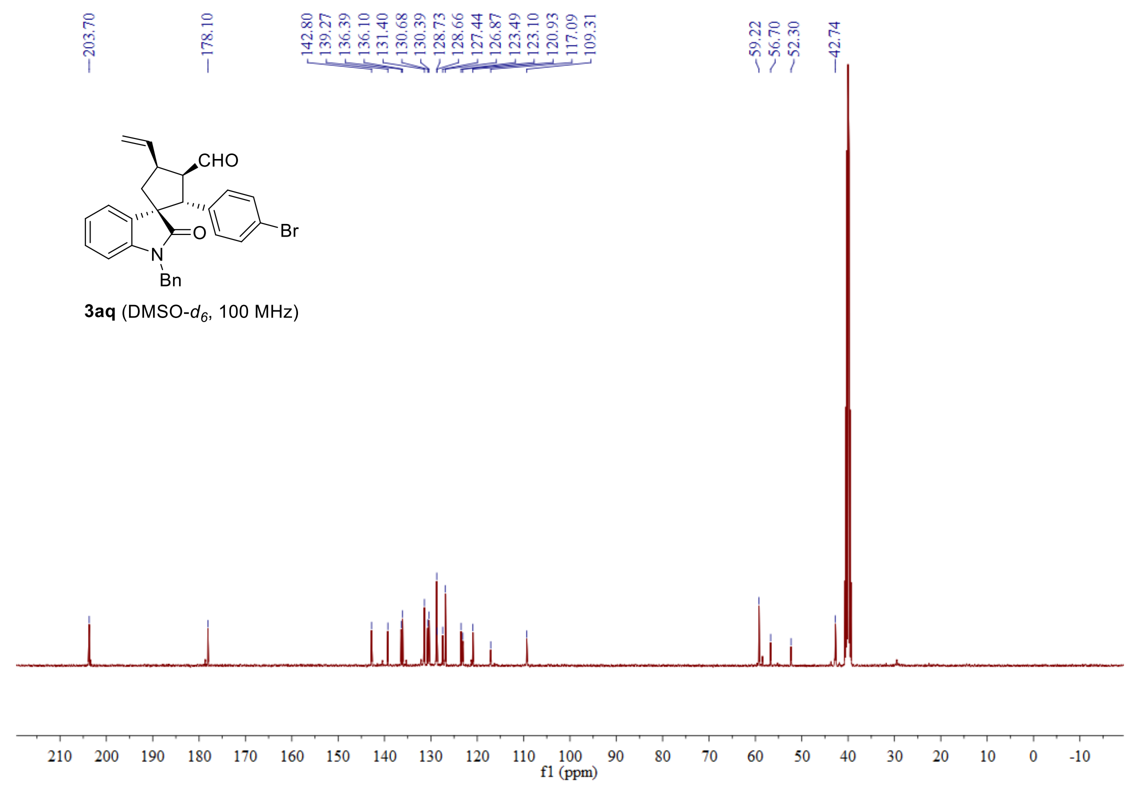
4ap (DMSO-d_6, 400 MHz)
f1 (ppm)



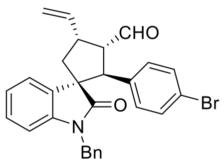
4ap (DMSO-d_6, 100 MHz)
f1 (ppm)



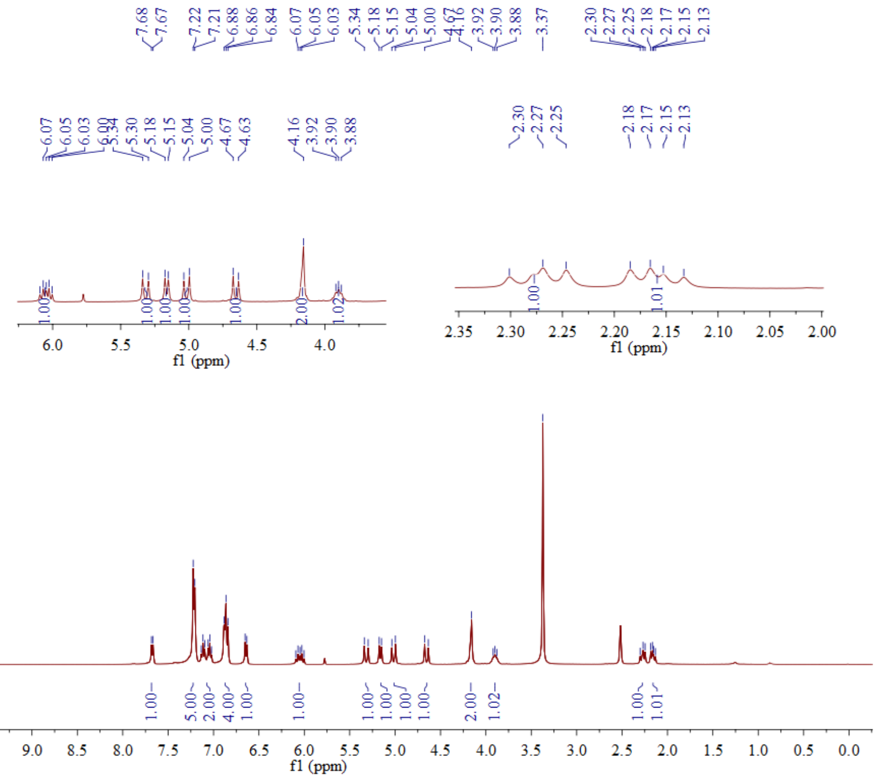
3aq (DMSO-d_6, 400 MHz)

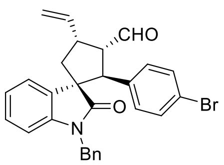


3aq (DMSO-d_6, 100 MHz)

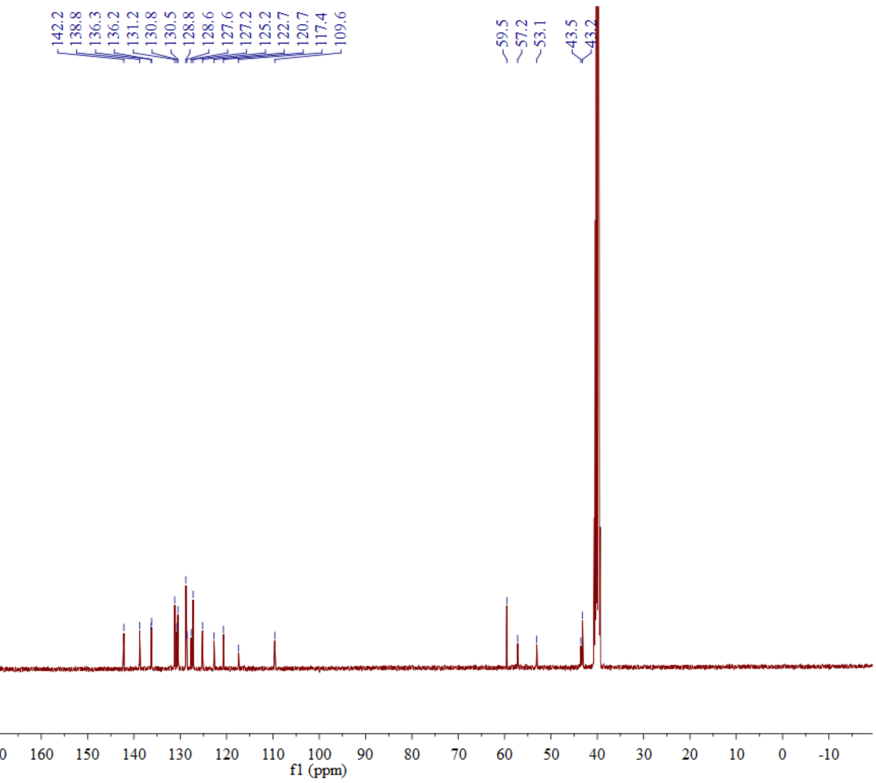


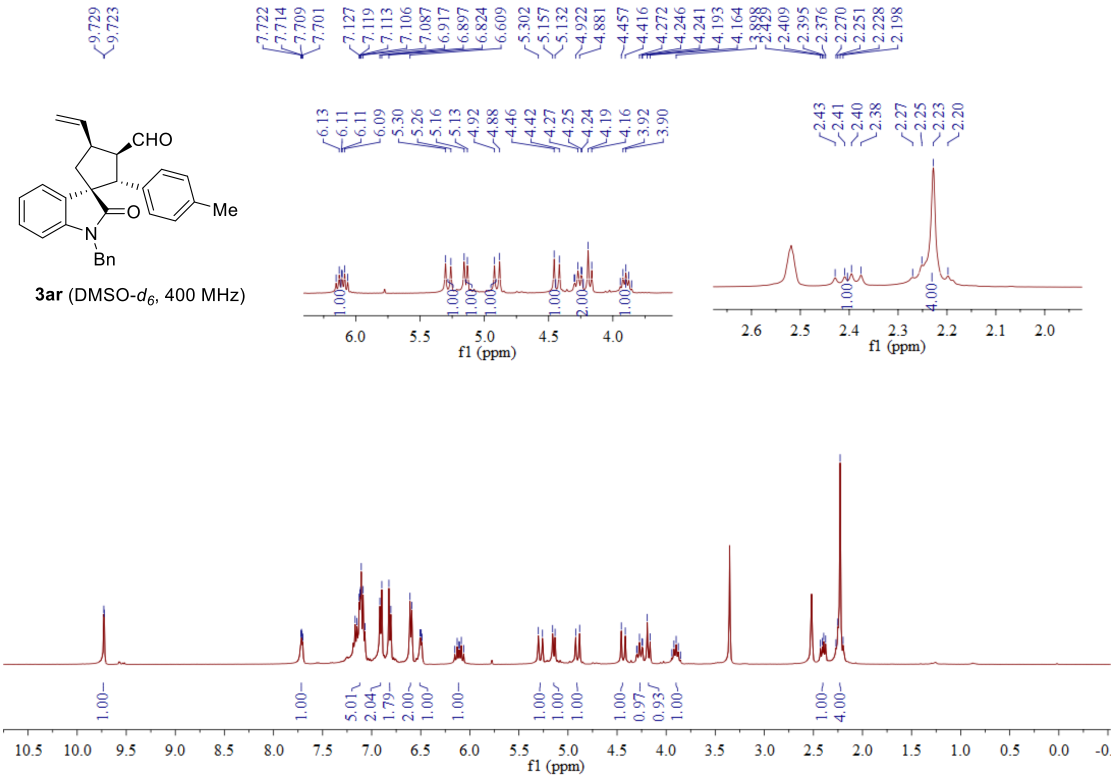
4aq (DMSO-d_6, 400 MHz)



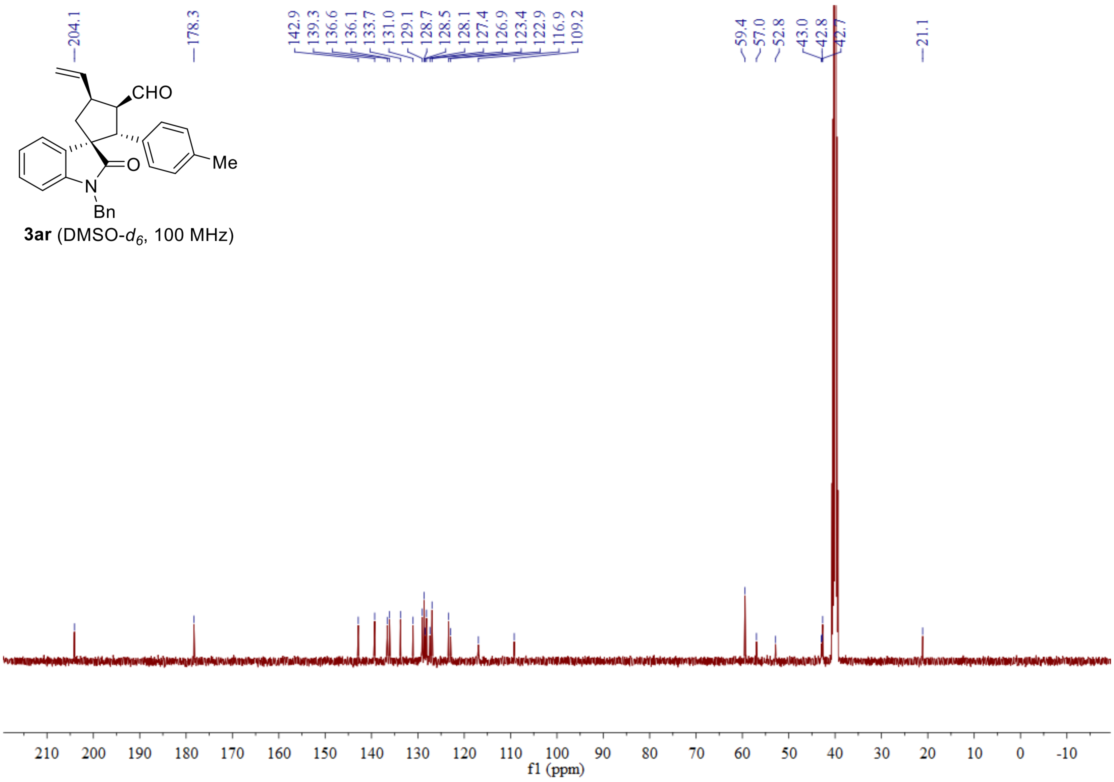


4aq (DMSO-d_6, 100 MHz)

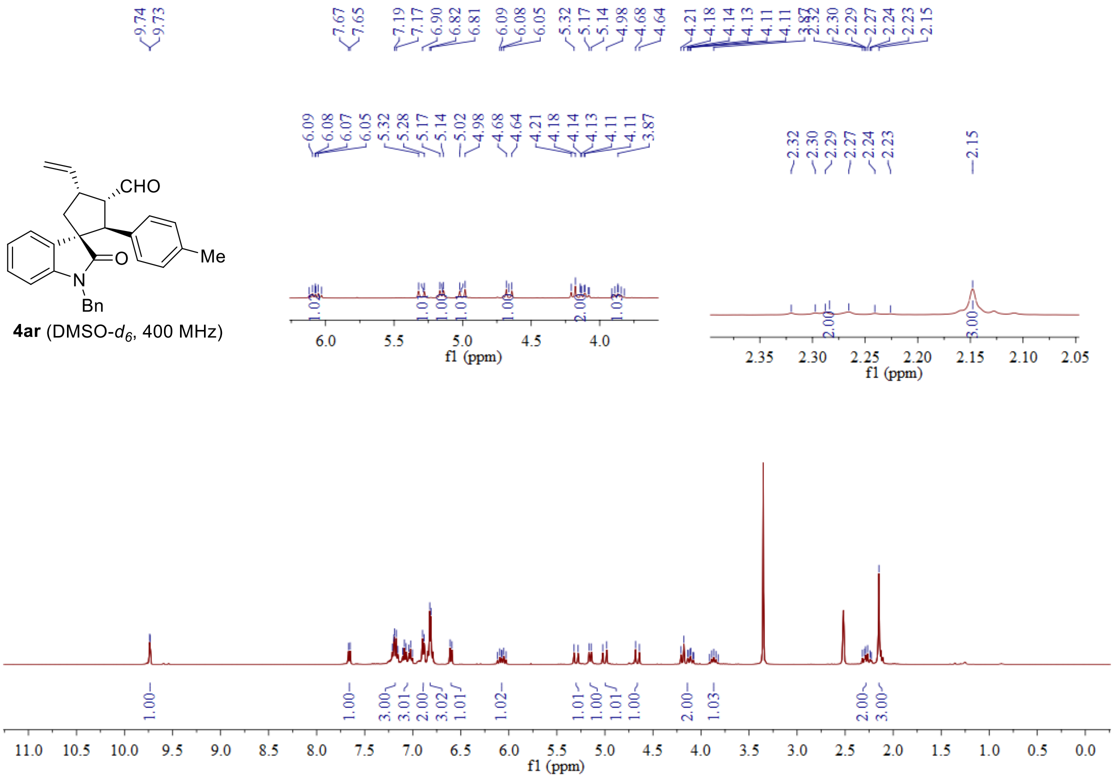


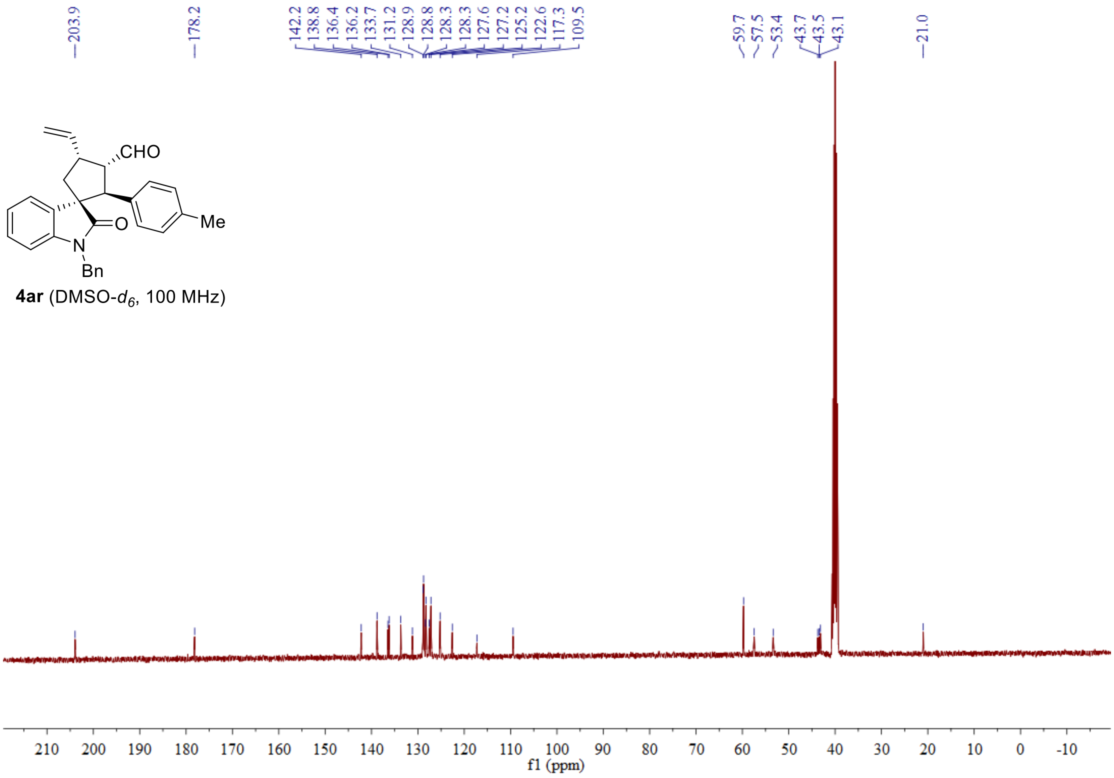


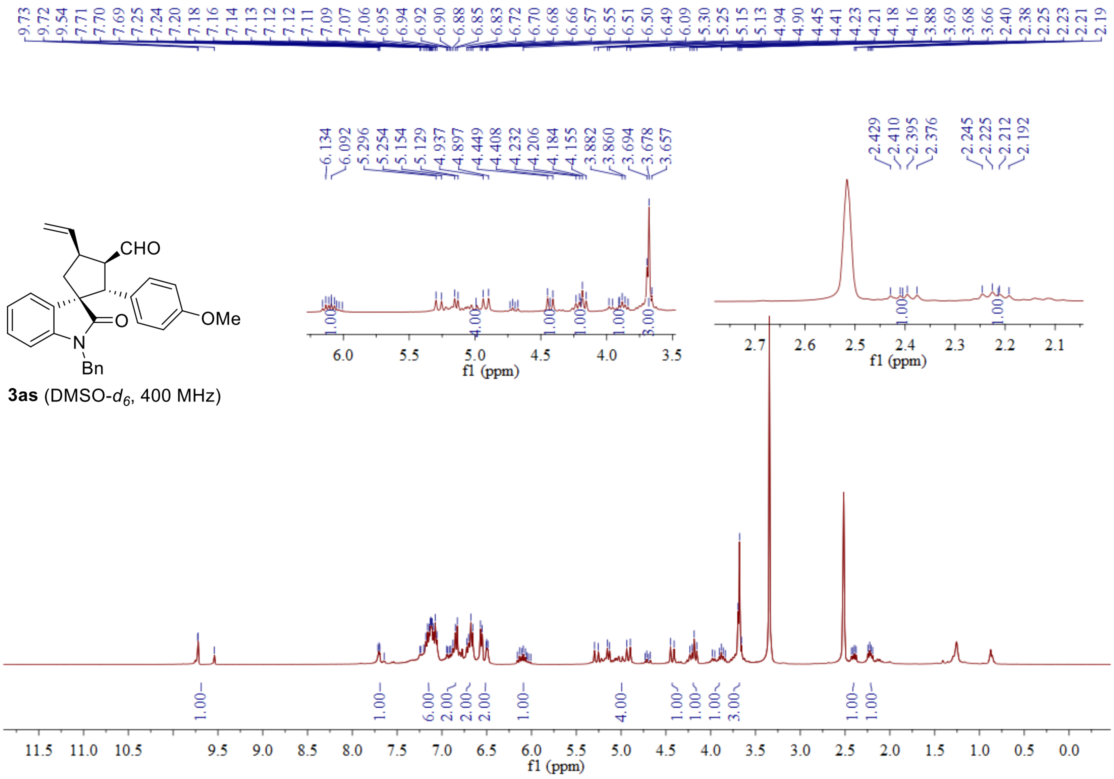
3ar (DMSO-d_6, 400 MHz)



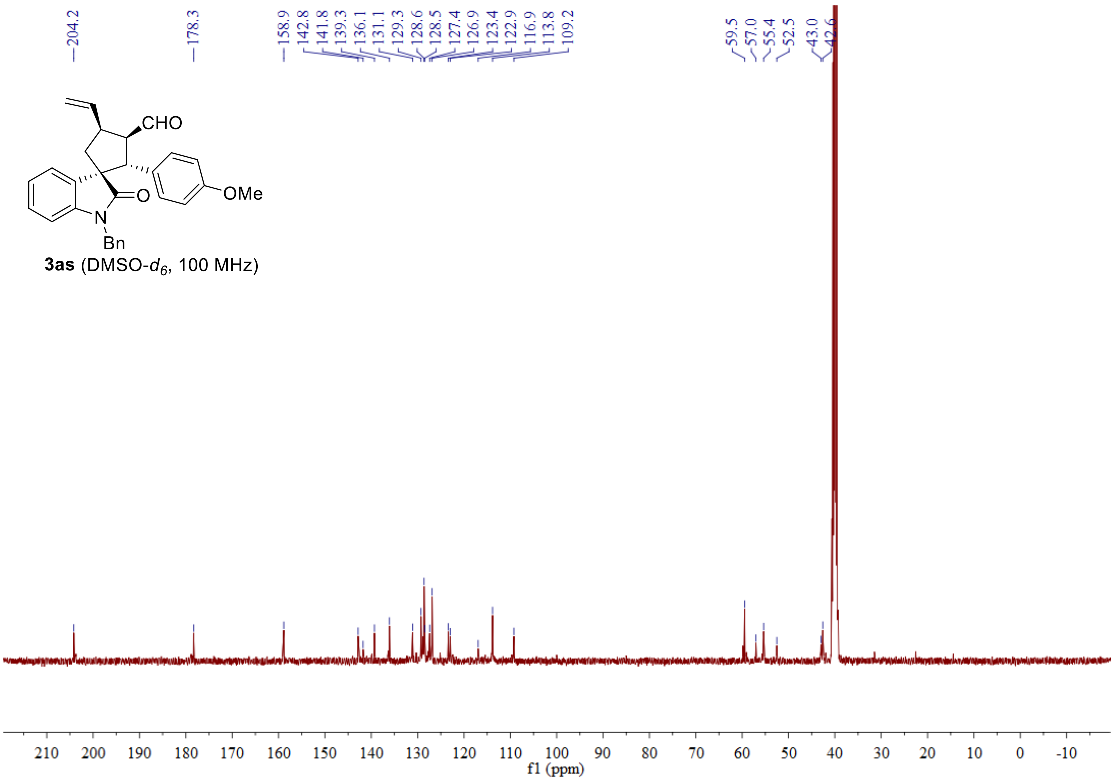
3ar (DMSO-d_6, 100 MHz)


CHO
Me
N
Bn
O
4ar (DMSO-d_6, 400 MHz)
f1 (ppm)

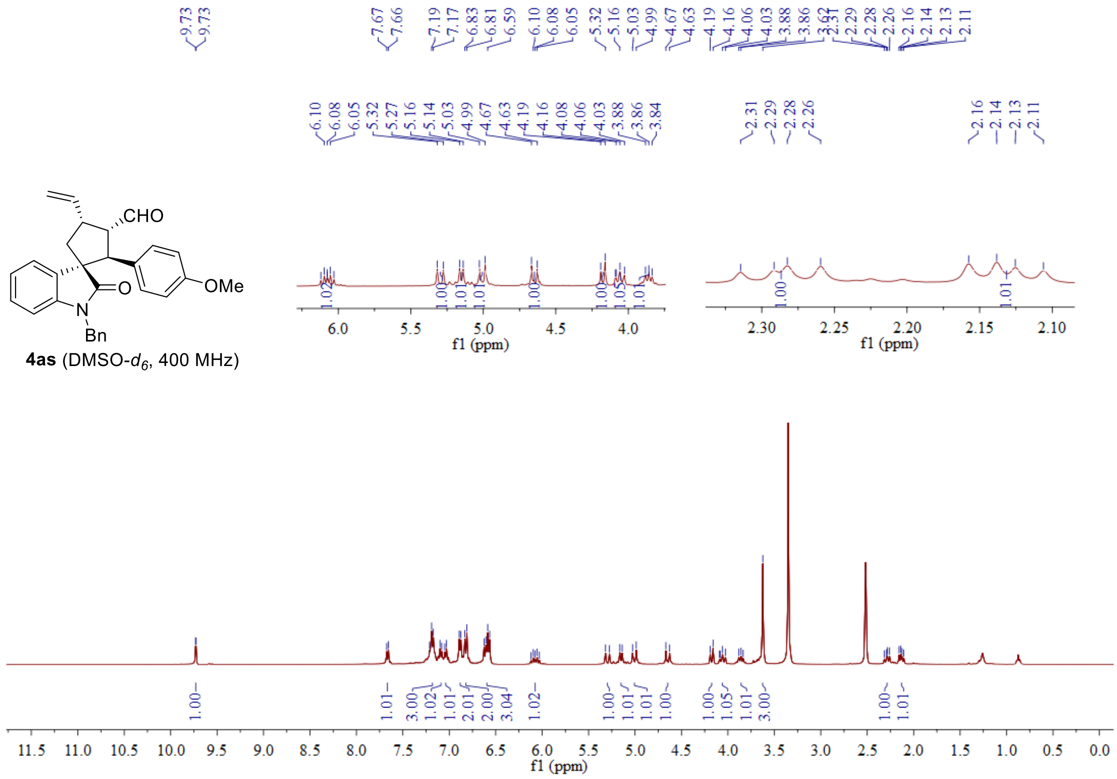

CHO
Me
N
Bn
O
4ar (DMSO-d_6, 100 MHz)
f1 (ppm)



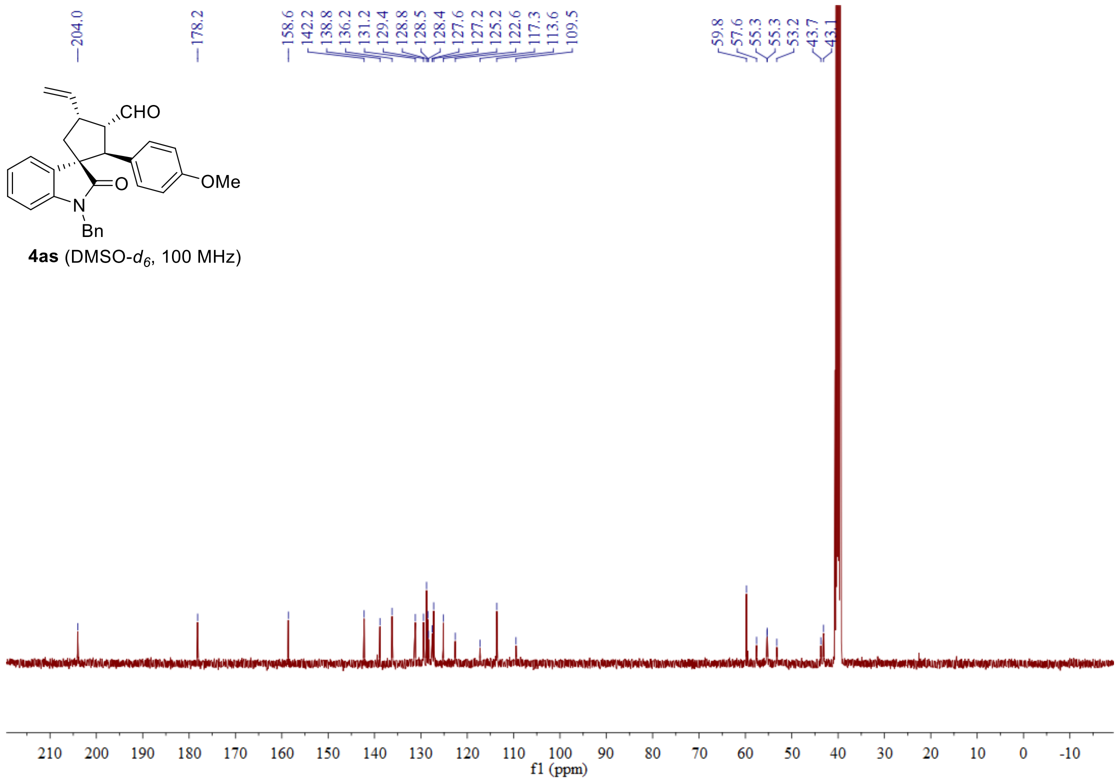
3as (DMSO-d_6, 400 MHz)



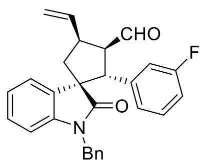
3as (DMSO-d_6, 100 MHz)



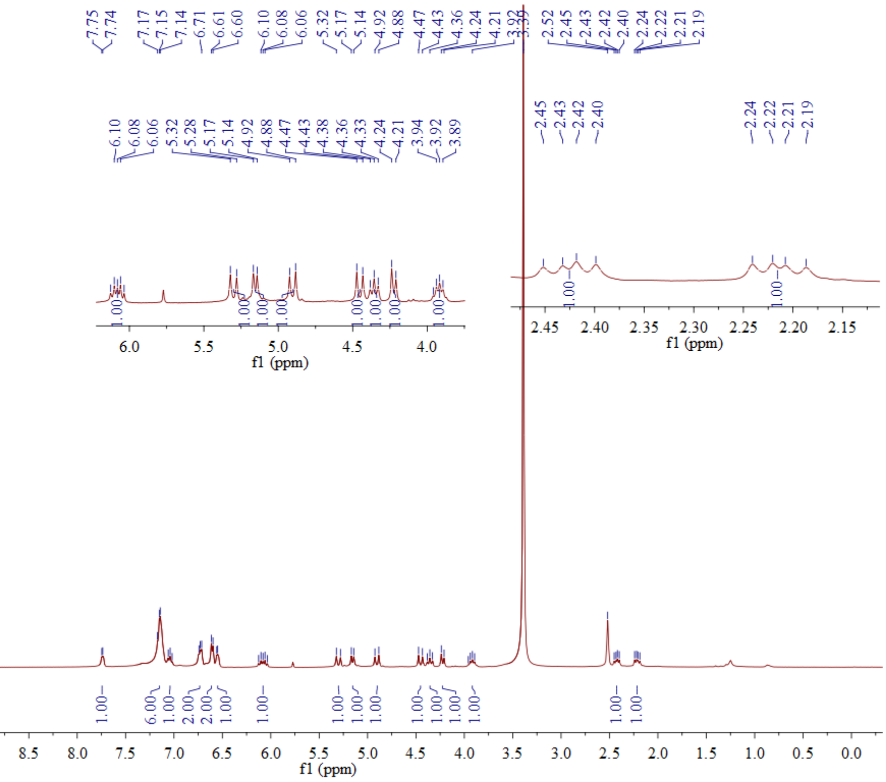
4as (DMSO-d_6, 400 MHz)

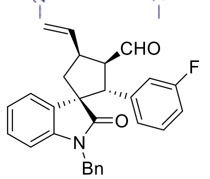


4as (DMSO-d_6, 100 MHz)

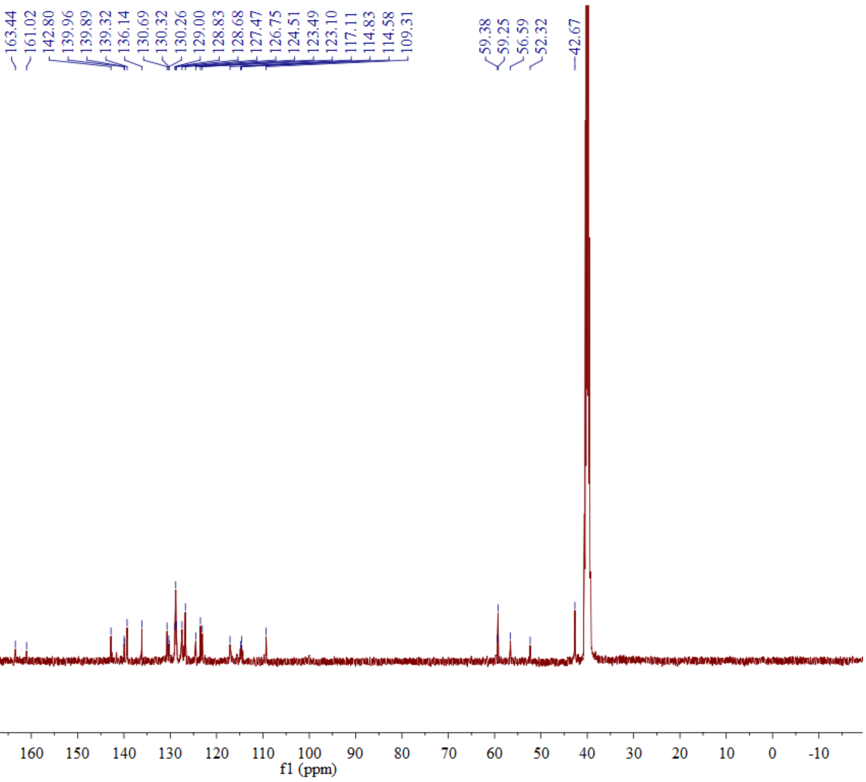


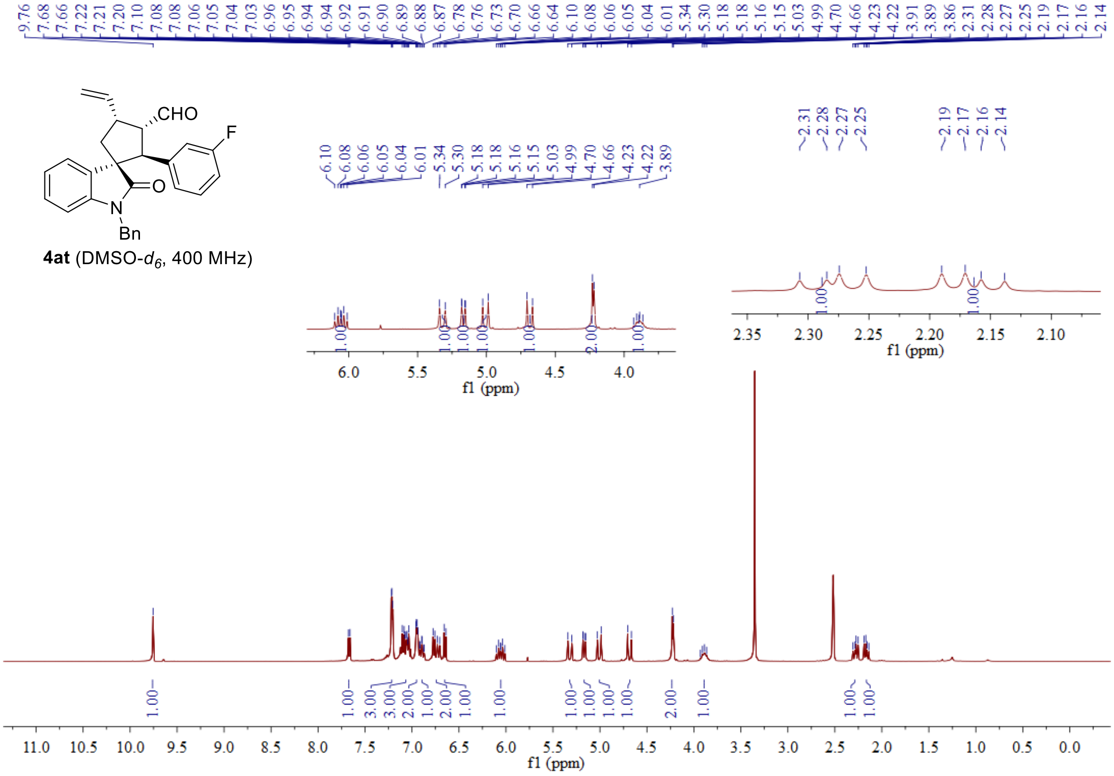
3at (DMSO-d_6, 400 MHz)



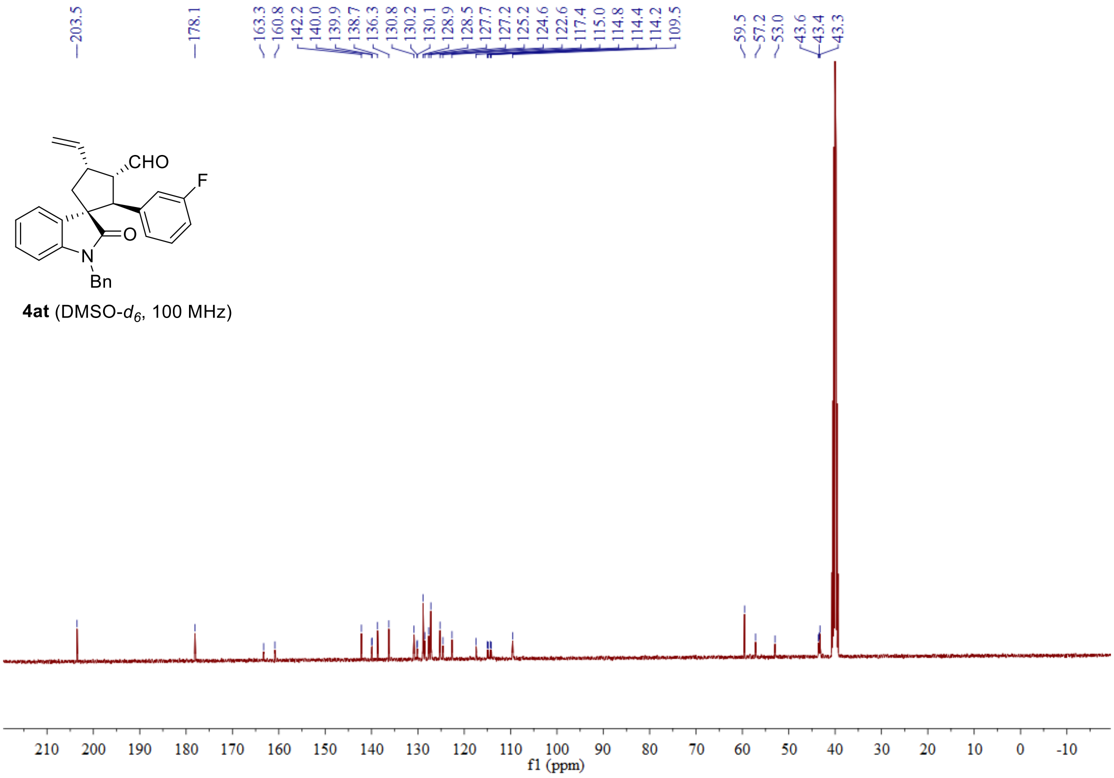


3at (DMSO-d_6, 100 MHz)

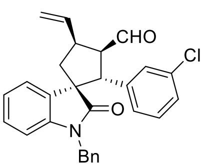




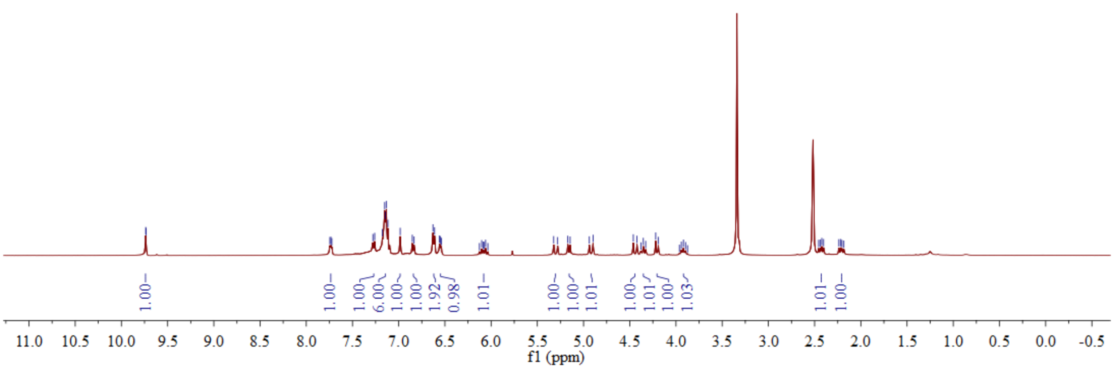
4at (DMSO-d_6, 400 MHz)

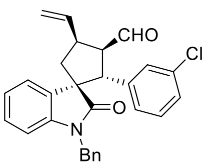


4at (DMSO-d_6, 100 MHz)

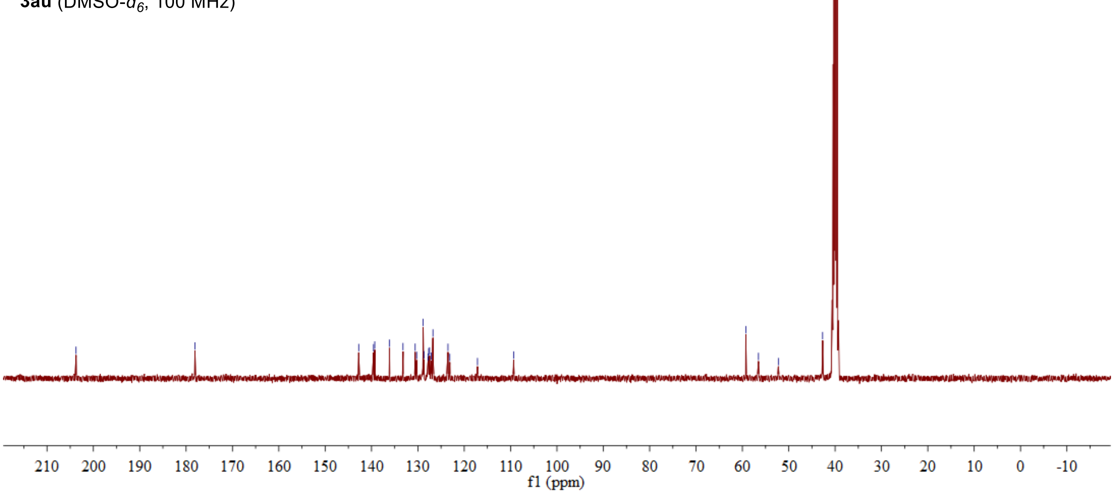


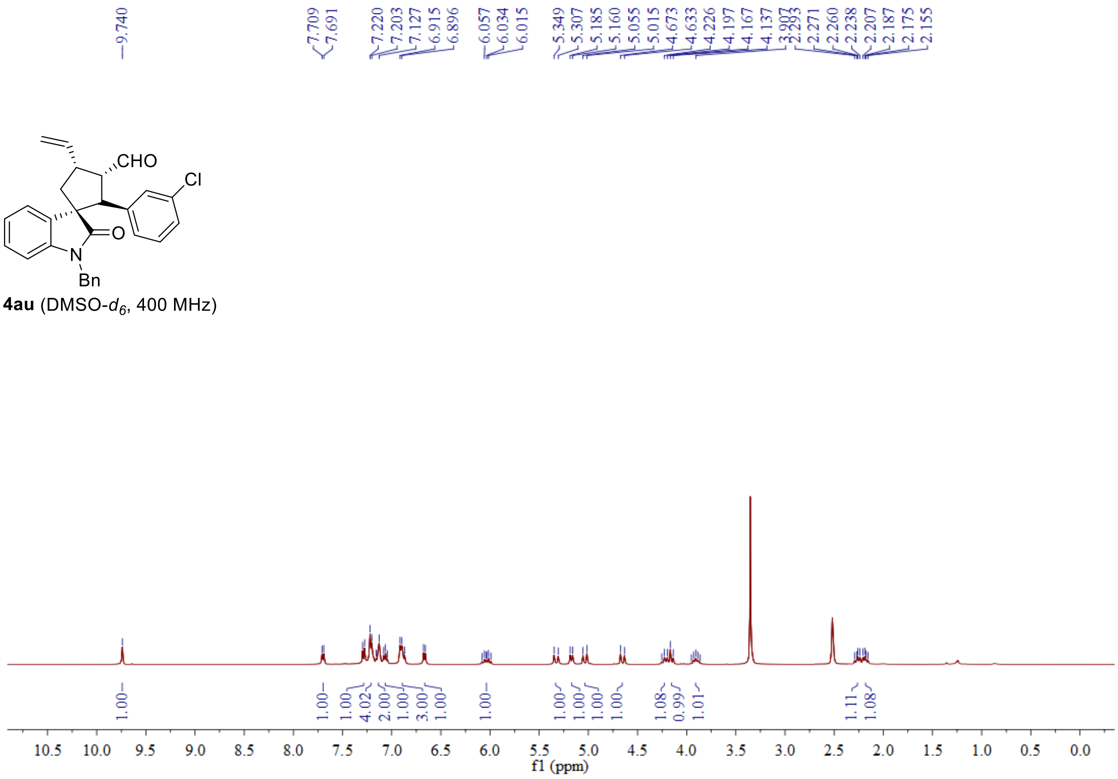
3au (DMSO-d_6, 400 MHz)

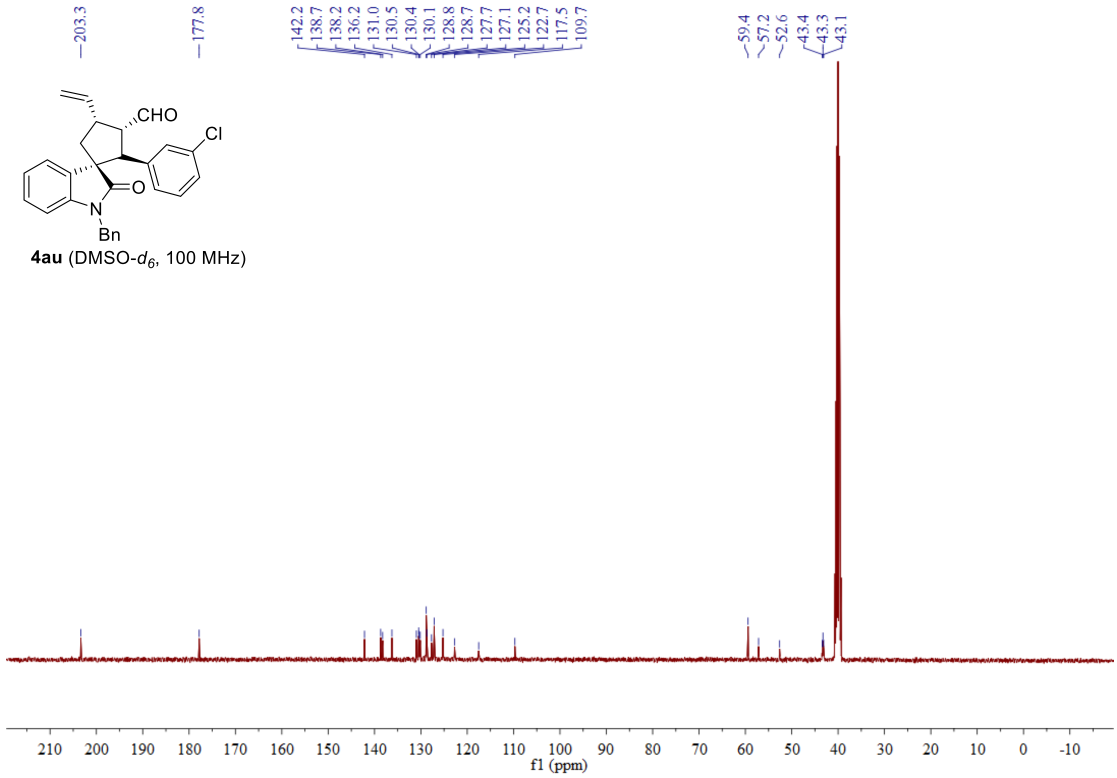


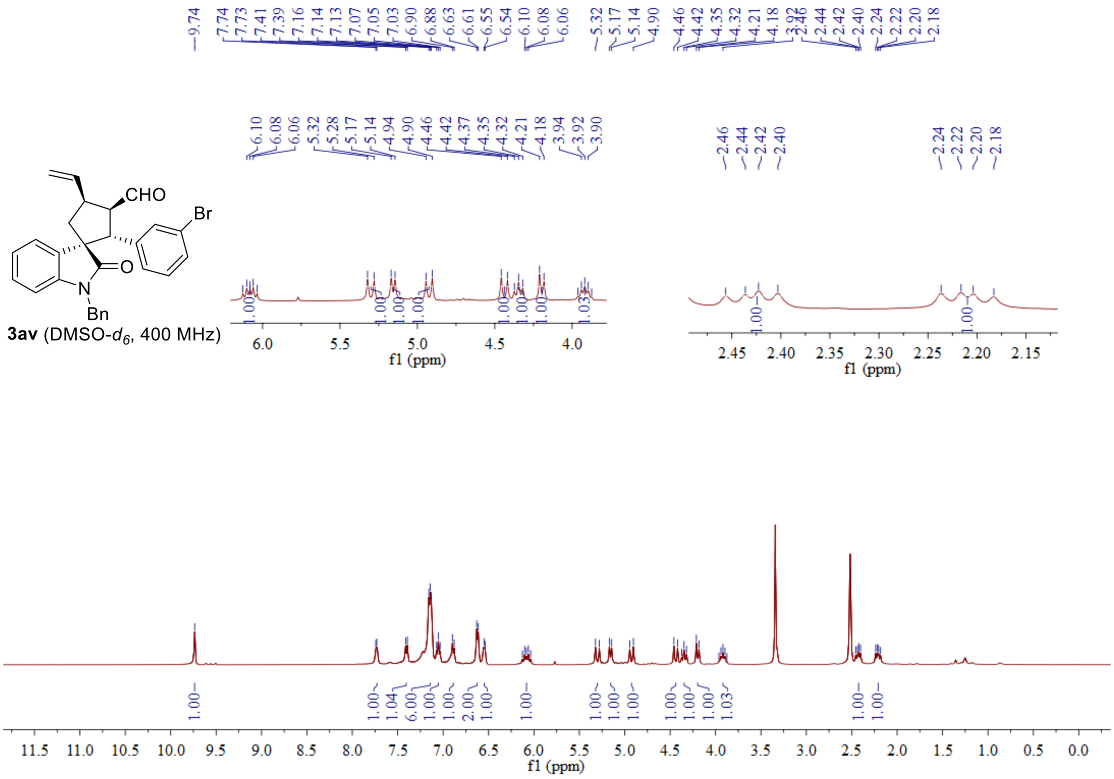


3au (DMSO-d_6, 100 MHz)

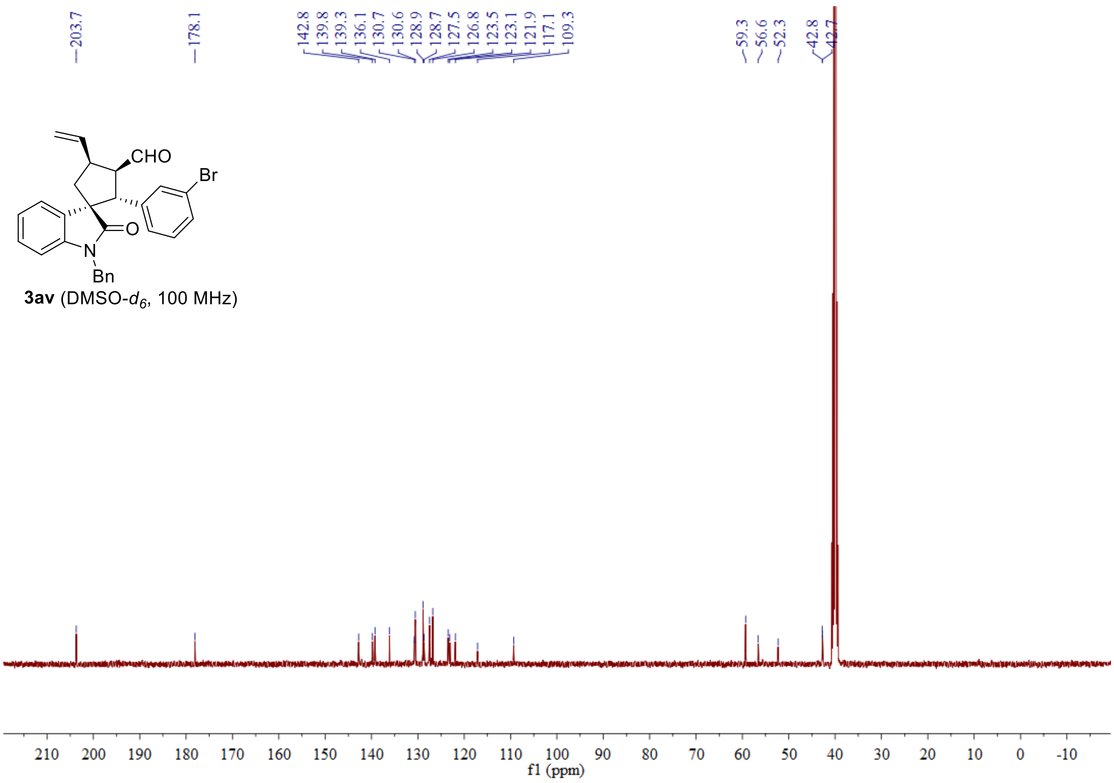



9.740
7.709 7.691
7.220 7.203 7.127 6.915 6.896
6.057 6.034 6.015
5.349 5.307 5.185 5.160 5.055 5.015 4.673 4.633 4.226 4.197 4.167 4.137 3.907 3.893 2.271 2.260 2.238 2.207 2.187 2.175 2.155
CHO
Cl
O
N
Bn
4au (DMSO-d_6, 400 MHz)
1.00 1.00 1.00 4.02 2.00 1.00 3.00 1.00 1.00 1.00 1.00 1.00 1.08 0.99 1.01 1.11 1.08
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

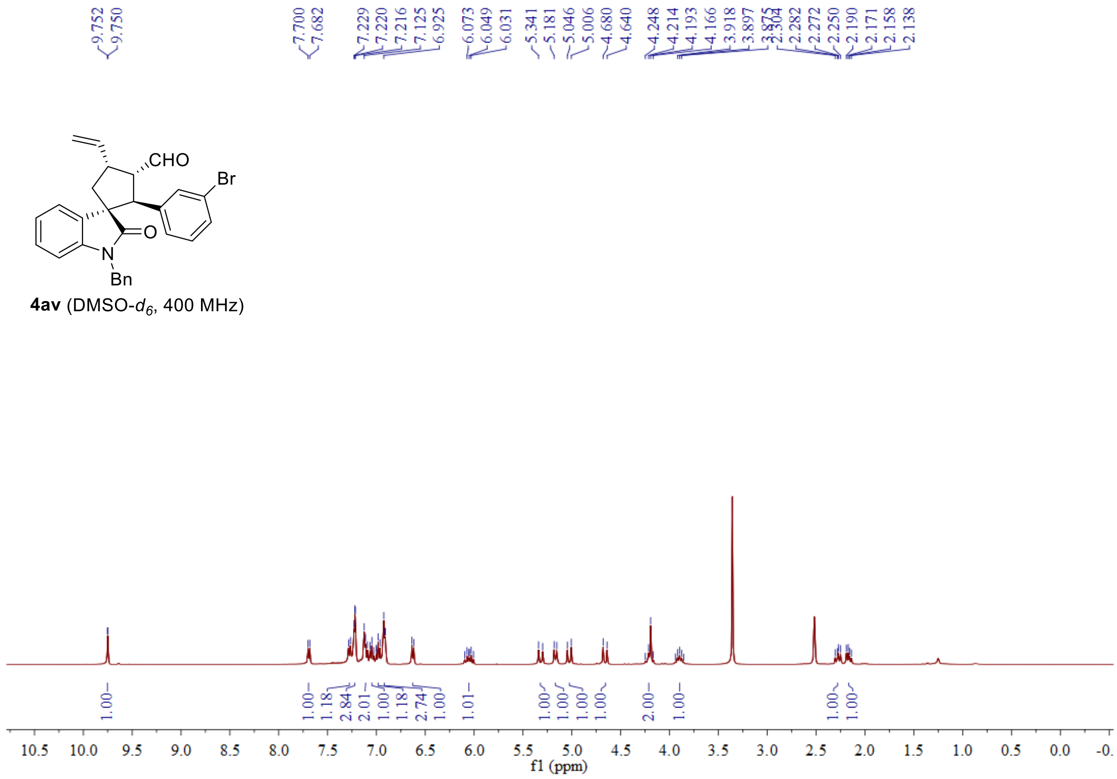

203.3
177.8
142.2 138.7 138.2 136.2 131.0 130.5 130.4 130.1 128.8 128.7 127.7 127.1 125.2 122.7 117.5 109.7
59.4 57.2 52.6 43.4 43.3 43.1
CHO
Cl
O
N
Bn
4au (DMSO-d_6, 100 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



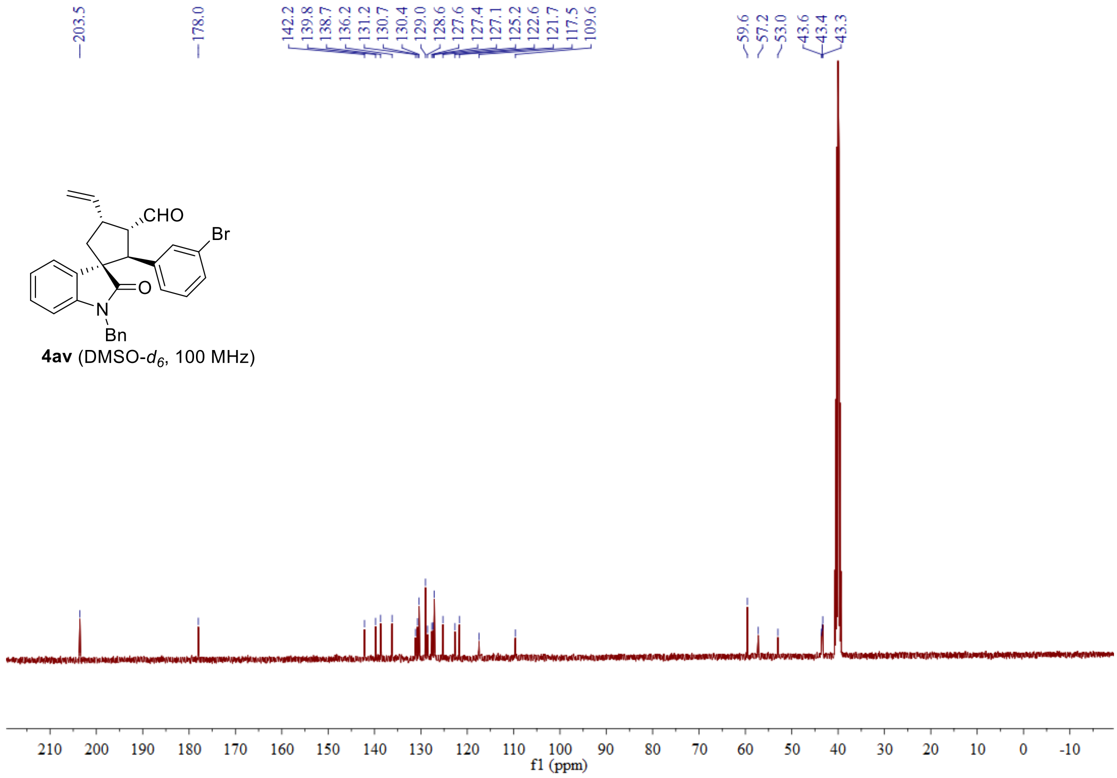
3av (DMSO-d_6, 400 MHz)



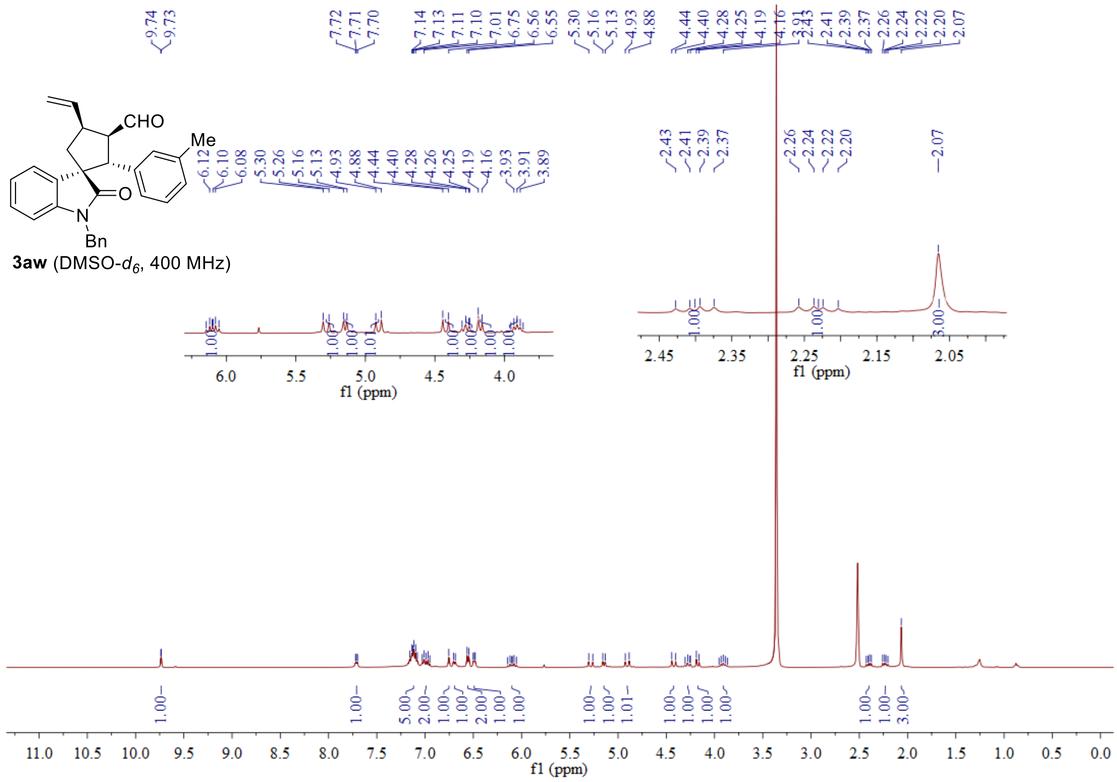
3av (DMSO-d_6, 100 MHz)

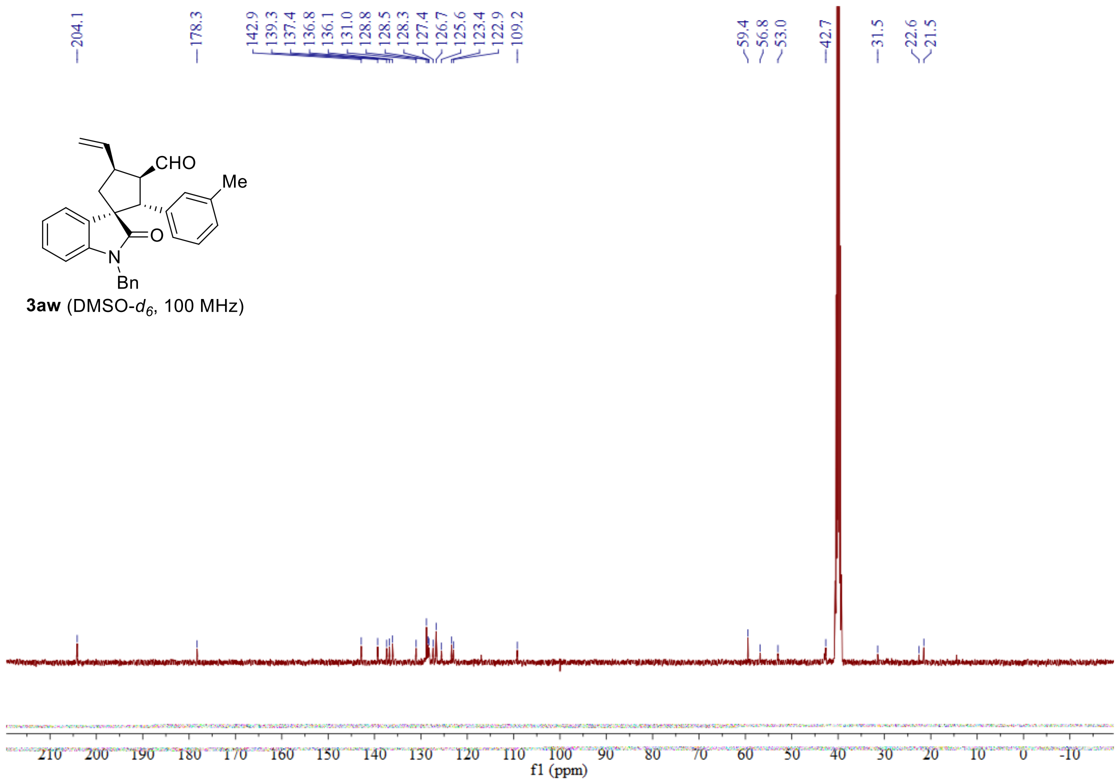


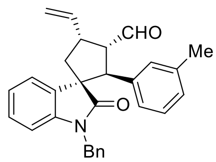
4av (DMSO-d_6, 400 MHz)



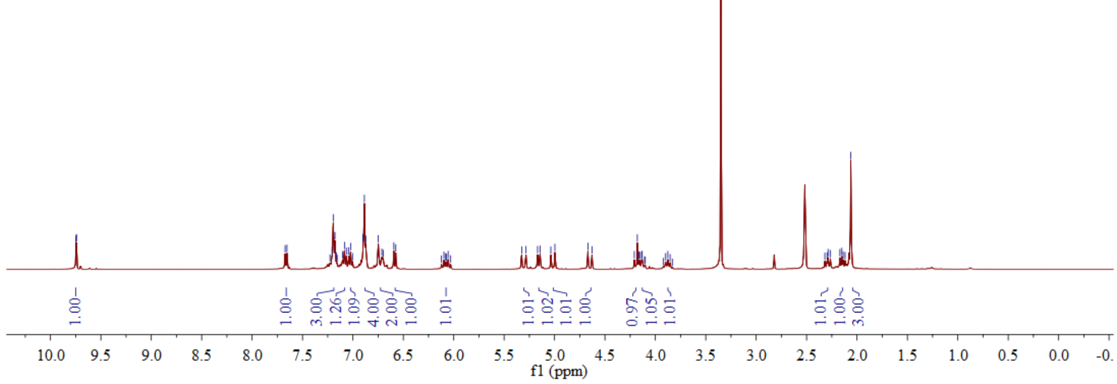
4av (DMSO-d_6, 100 MHz)

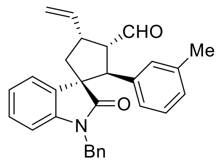

9.74
9.73
7.72
7.71
7.70
7.14
7.13
7.11
7.10
7.01
6.75
6.56
6.55
5.30
5.16
5.13
4.93
4.88
4.44
4.40
4.28
4.25
4.19
4.16
3.91
2.43
2.41
2.39
2.37
2.26
2.24
2.22
2.20
2.07
CHO
Me
O
N
Bn
3aw (DMSO-d_6, 400 MHz)
6.12
6.10
6.08
5.30
5.26
5.16
5.13
4.93
4.88
4.44
4.40
4.28
4.26
4.25
4.19
4.16
3.93
3.91
3.89
2.43
2.41
2.39
2.37
2.26
2.24
2.22
2.20
2.07
f1 (ppm)


204.1
178.3
142.9
139.3
137.4
136.8
136.1
131.0
128.8
128.5
128.3
127.4
126.7
125.6
123.4
122.9
109.2
59.4
56.8
53.0
42.7
31.5
22.6
21.5
CHO
Me
O
N
Bn
3aw (DMSO-d_6, 100 MHz)
f1 (ppm)

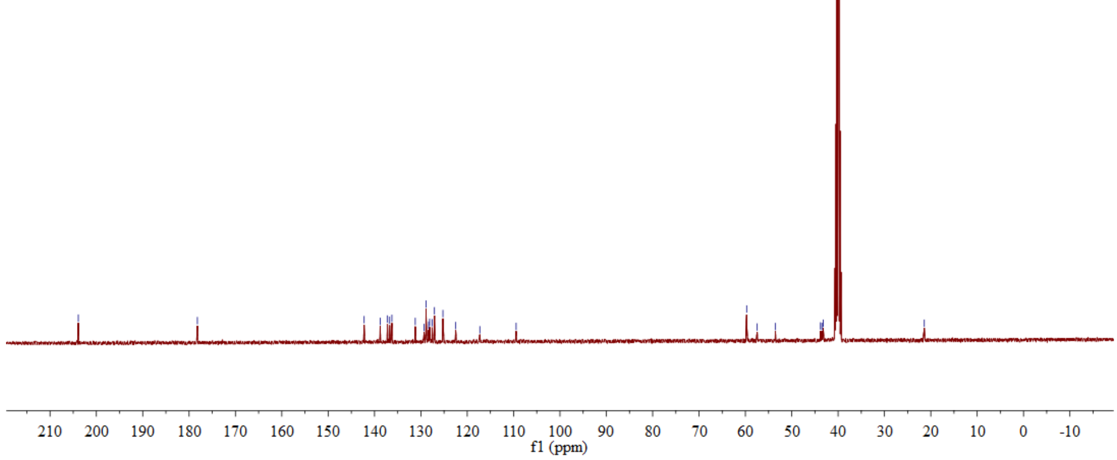


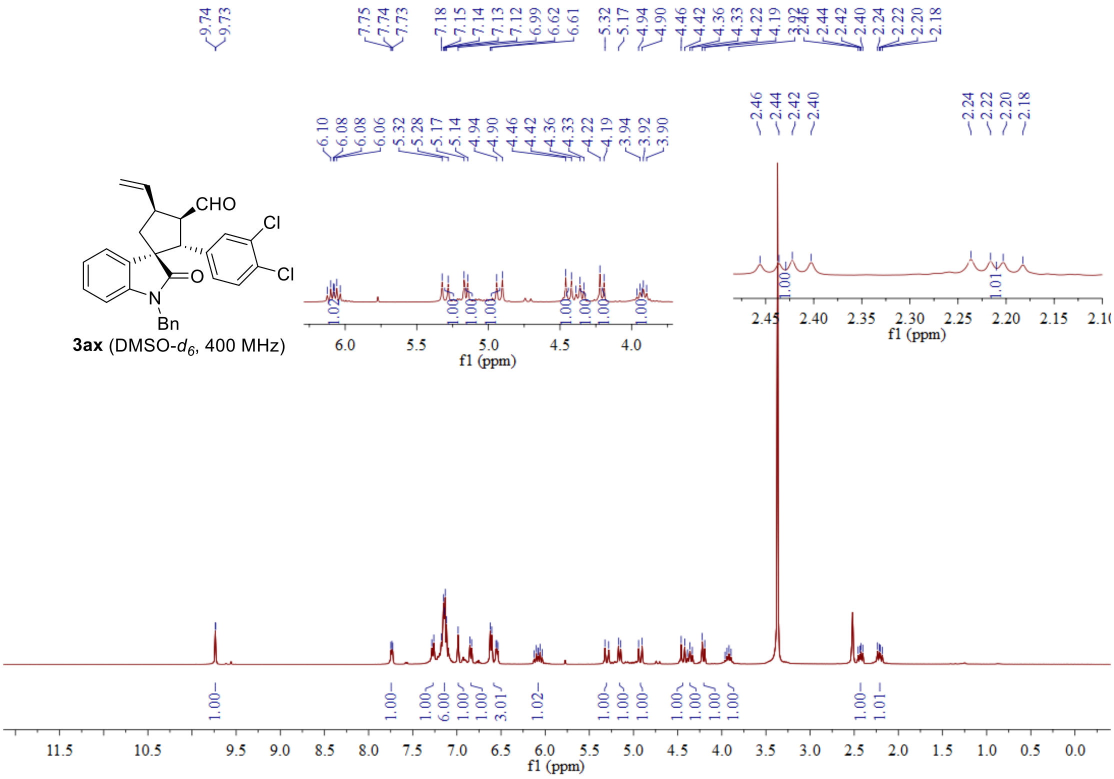
4aw (DMSO-d_6, 400 MHz)

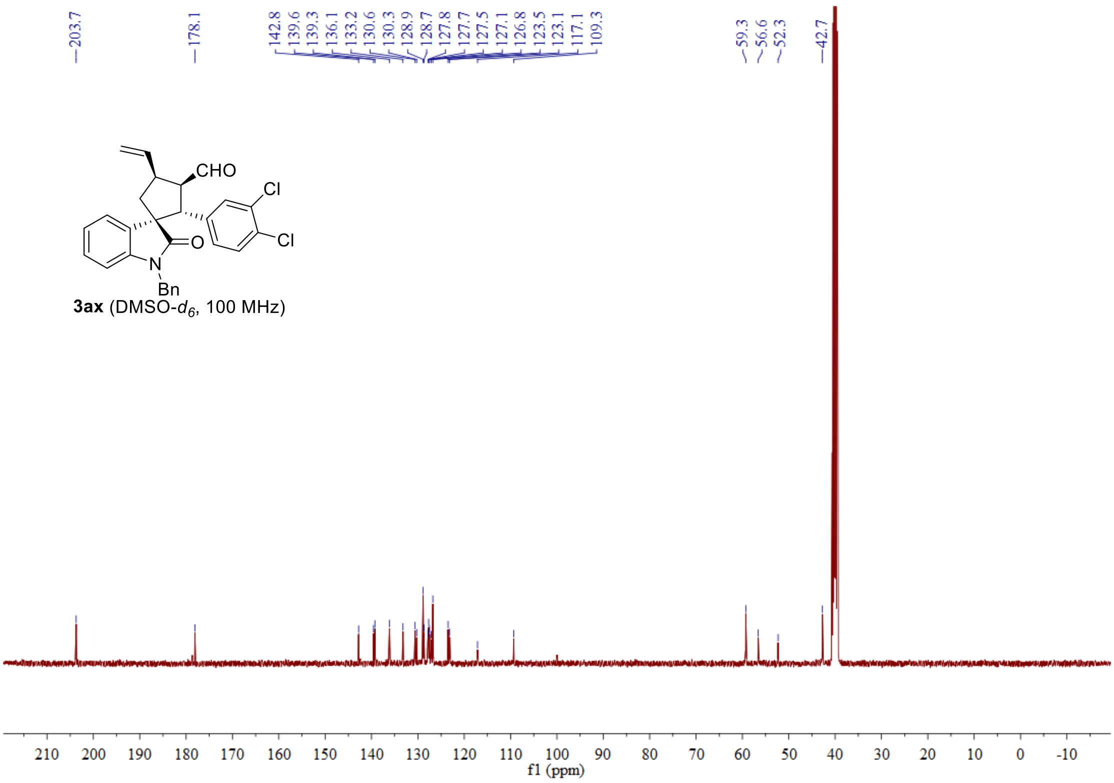


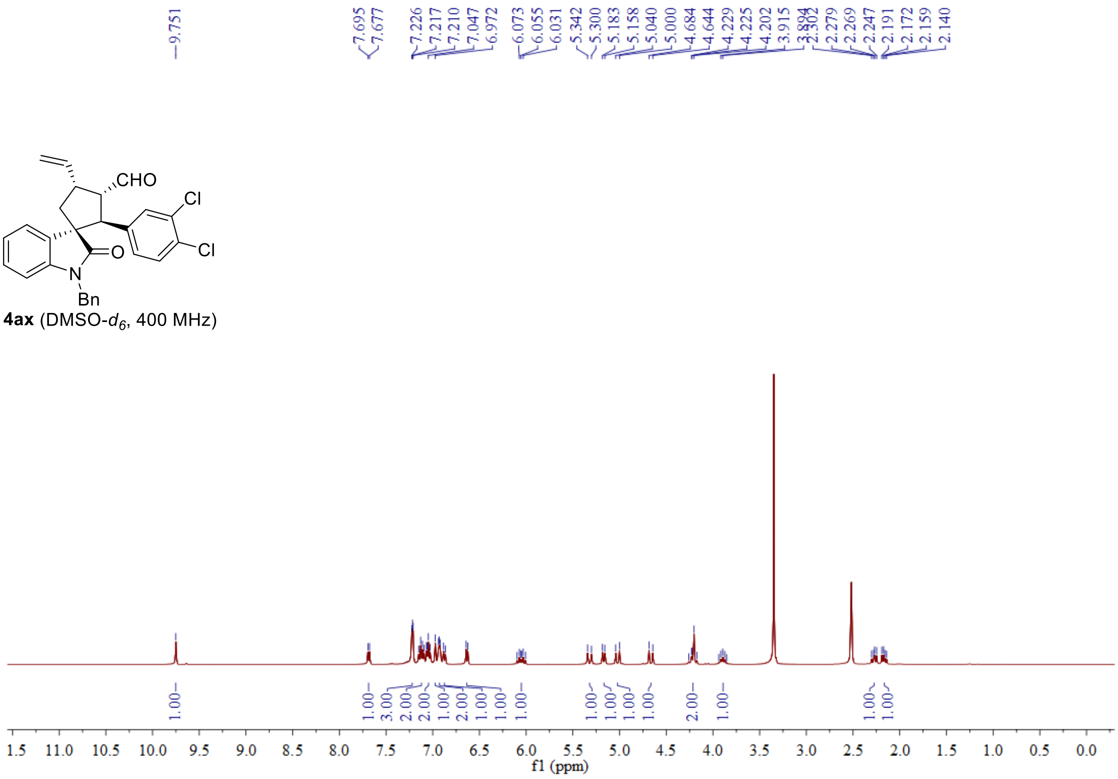


4aw (DMSO-d_6, 100 MHz)

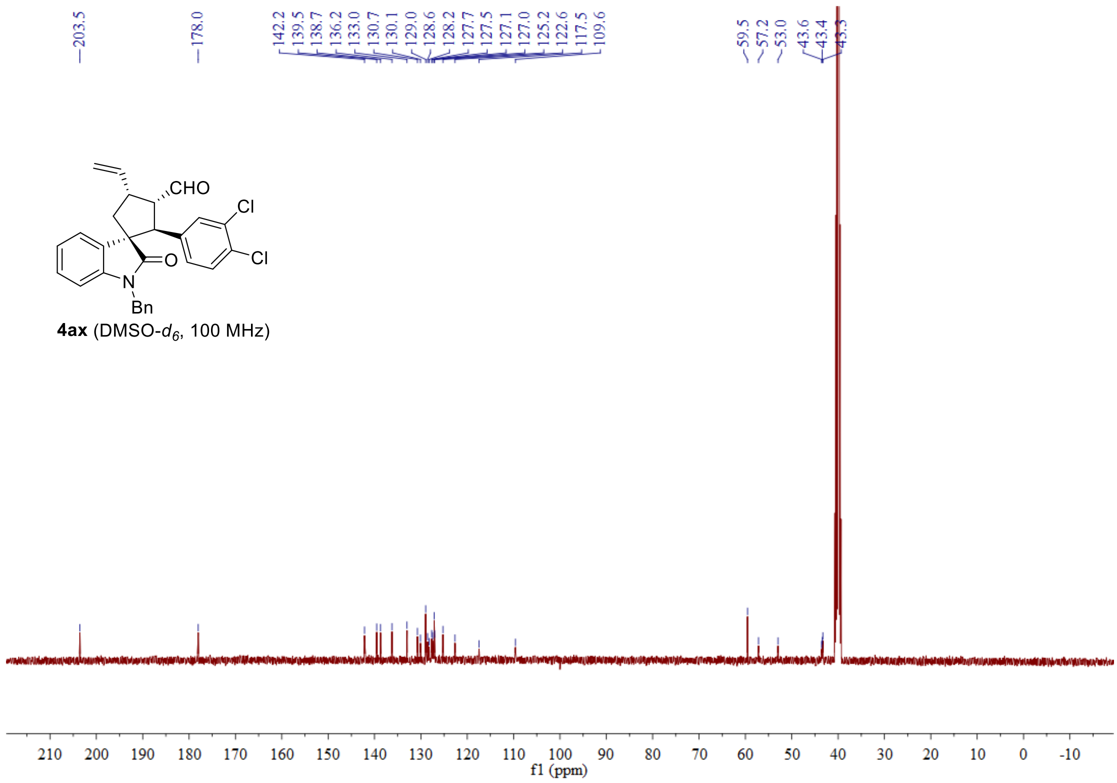



9.74 9.73 7.75 7.74 7.73 7.18 7.15 7.14 7.13 7.12 6.99 6.62 6.61 5.32 5.17 4.94 4.90 4.46 4.42 4.36 4.33 4.22 4.19 3.92 2.46 2.44 2.42 2.40 2.24 2.22 2.20 2.18
6.10 6.08 6.08 6.06 5.32 5.28 5.17 5.14 4.94 4.90 4.46 4.42 4.36 4.33 4.22 4.19 3.94 3.92 3.90
2.46 2.44 2.42 2.40
2.24 2.22 2.20 2.18
CHO
Cl
Cl
O
N
Bn
3ax (DMSO-d6, 400 MHz)
f1 (ppm)

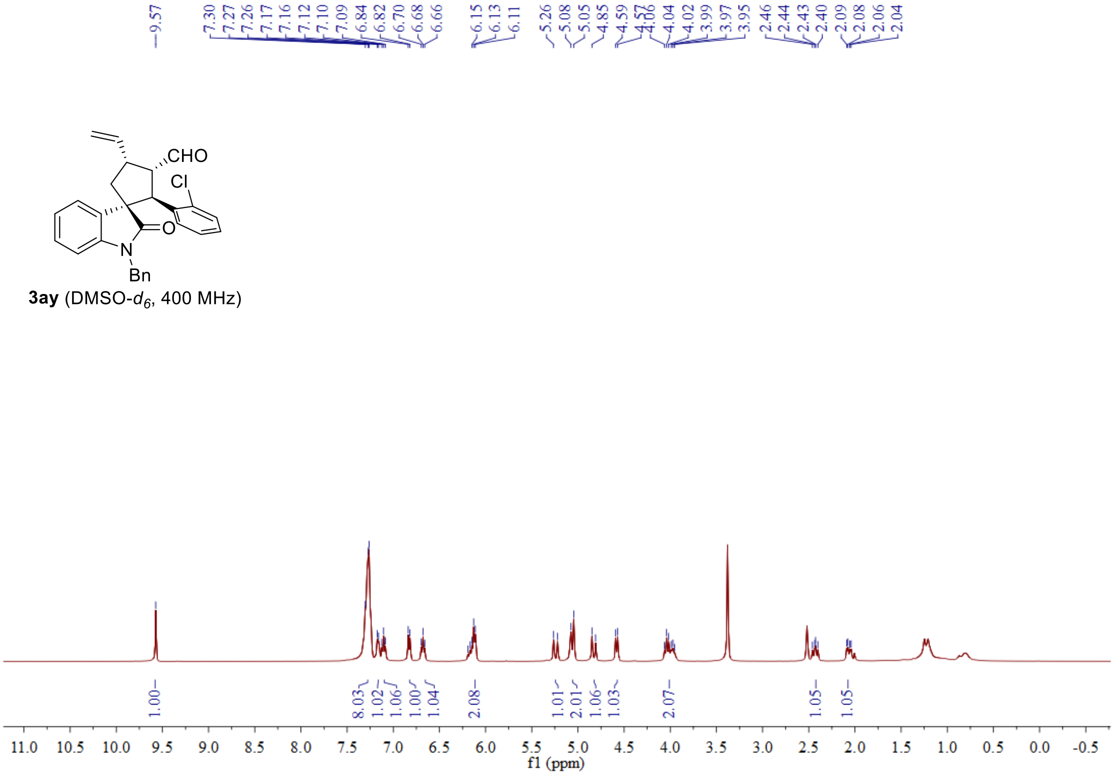

203.7
178.1
142.8 139.6 139.3 136.1 133.2 130.6 130.3 128.9 128.7 127.8 127.7 127.5 127.1 126.8 123.5 123.1 117.1 109.3
59.3 56.6 52.3
42.7
CHO
Cl
Cl
O
N
Bn
3ax (DMSO-d6, 100 MHz)
f1 (ppm)



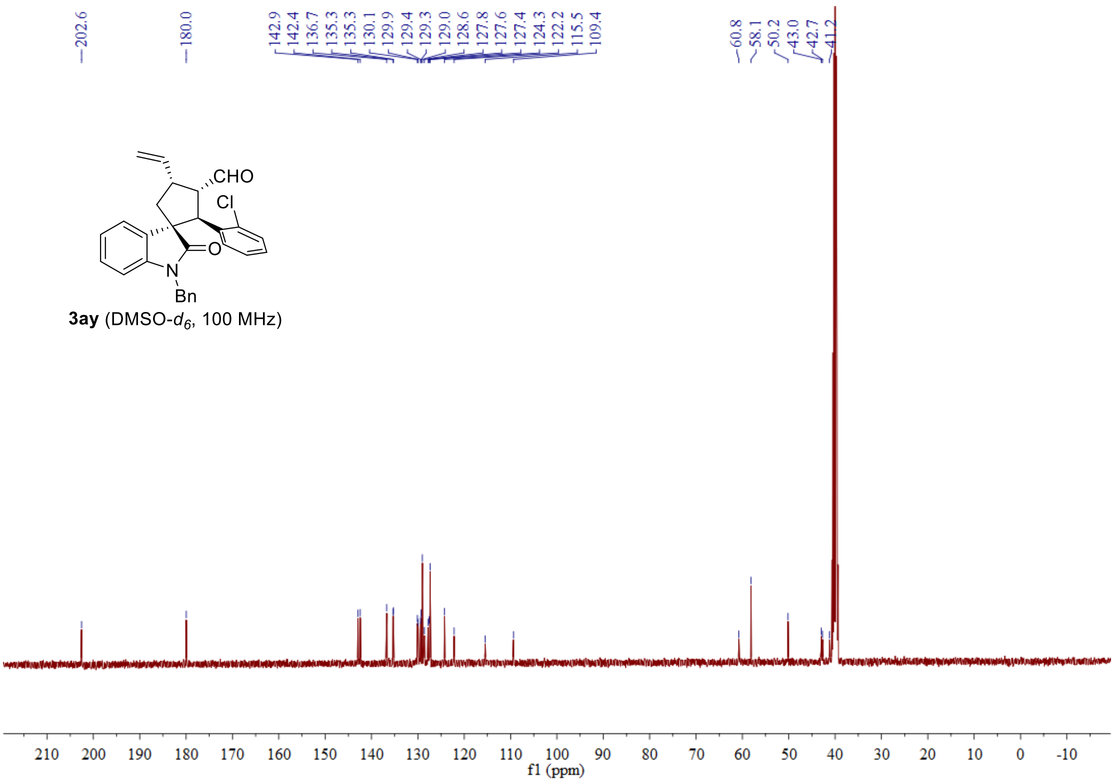
4ax (DMSO-d_6, 400 MHz)



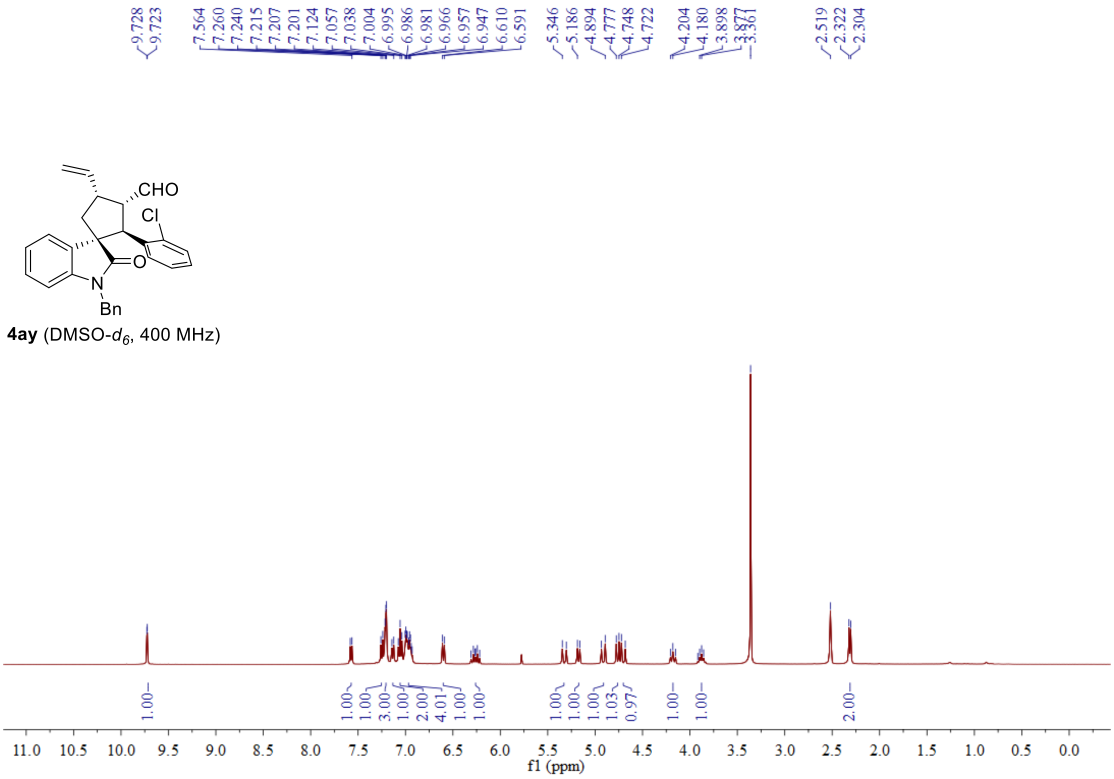
4ax (DMSO-d_6, 100 MHz)



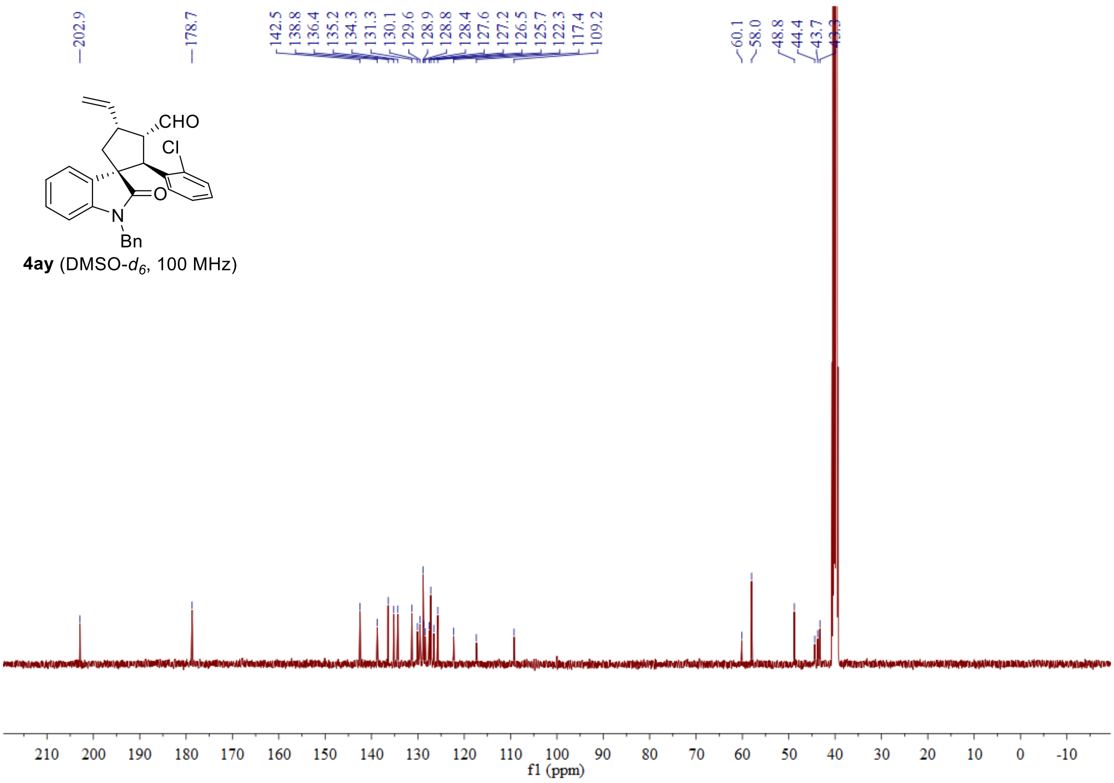
3ay (DMSO-d_6, 400 MHz)



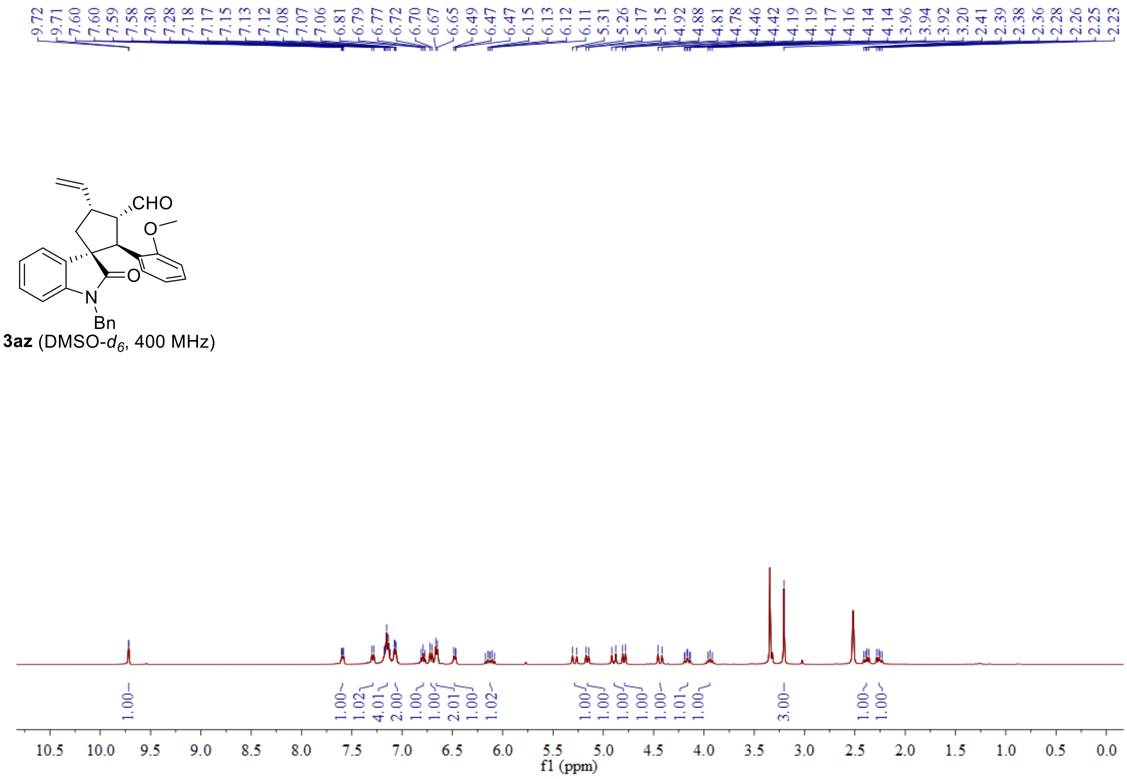
3ay (DMSO-d_6, 100 MHz)



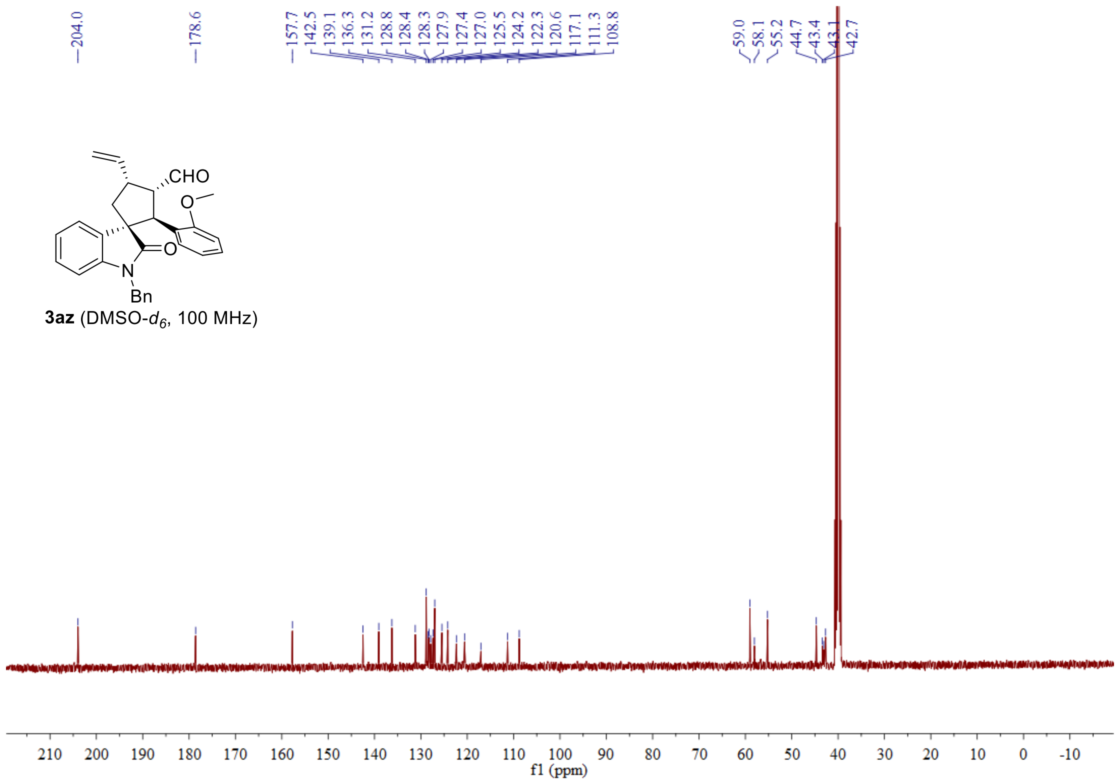
4ay (DMSO-d_6, 400 MHz)



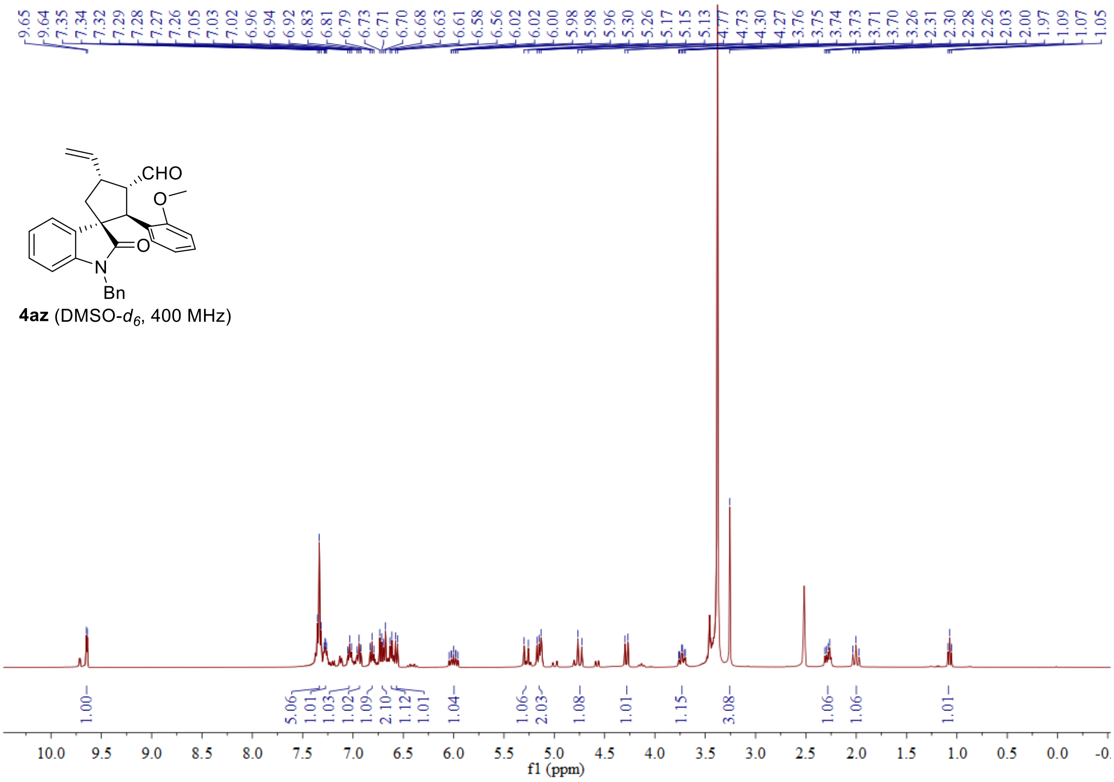
4ay (DMSO-d_6, 100 MHz)

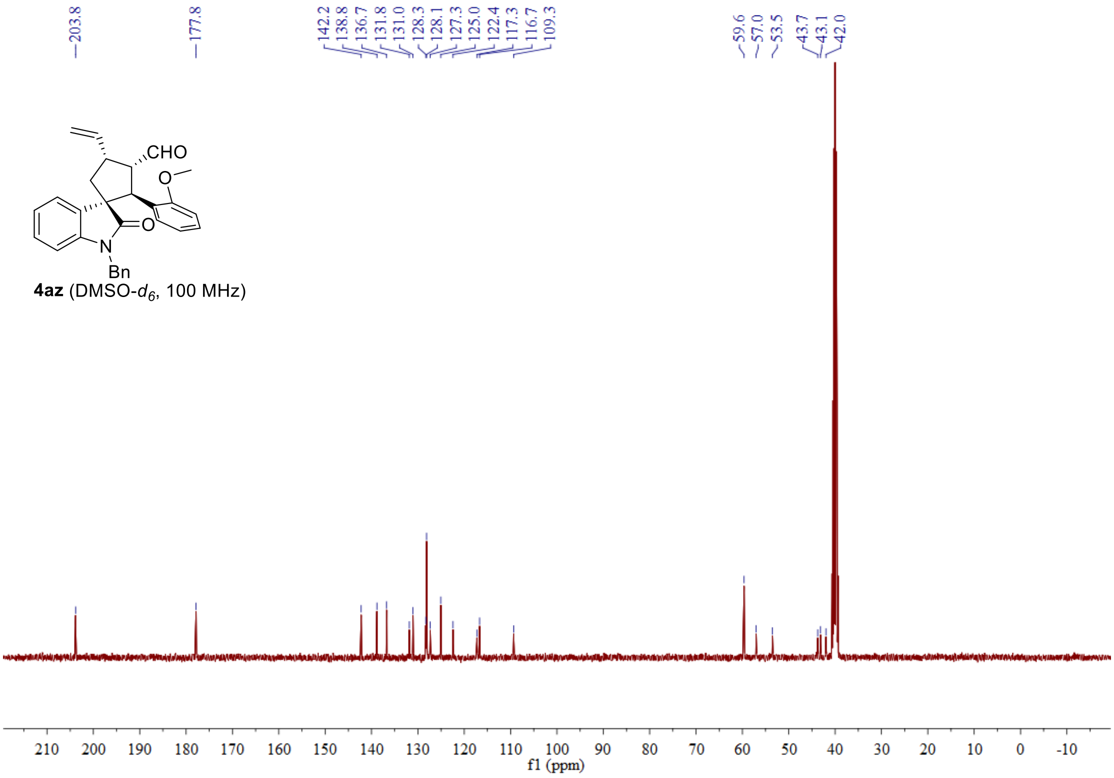


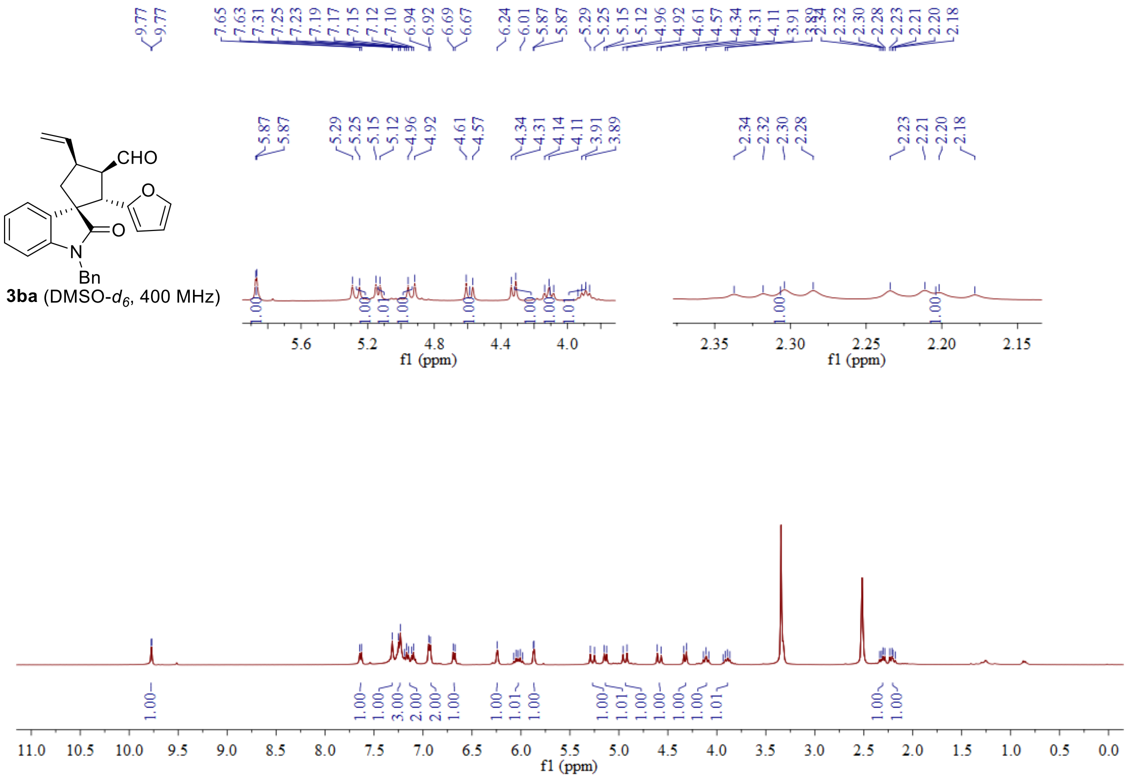
3az (DMSO-d_6, 400 MHz)



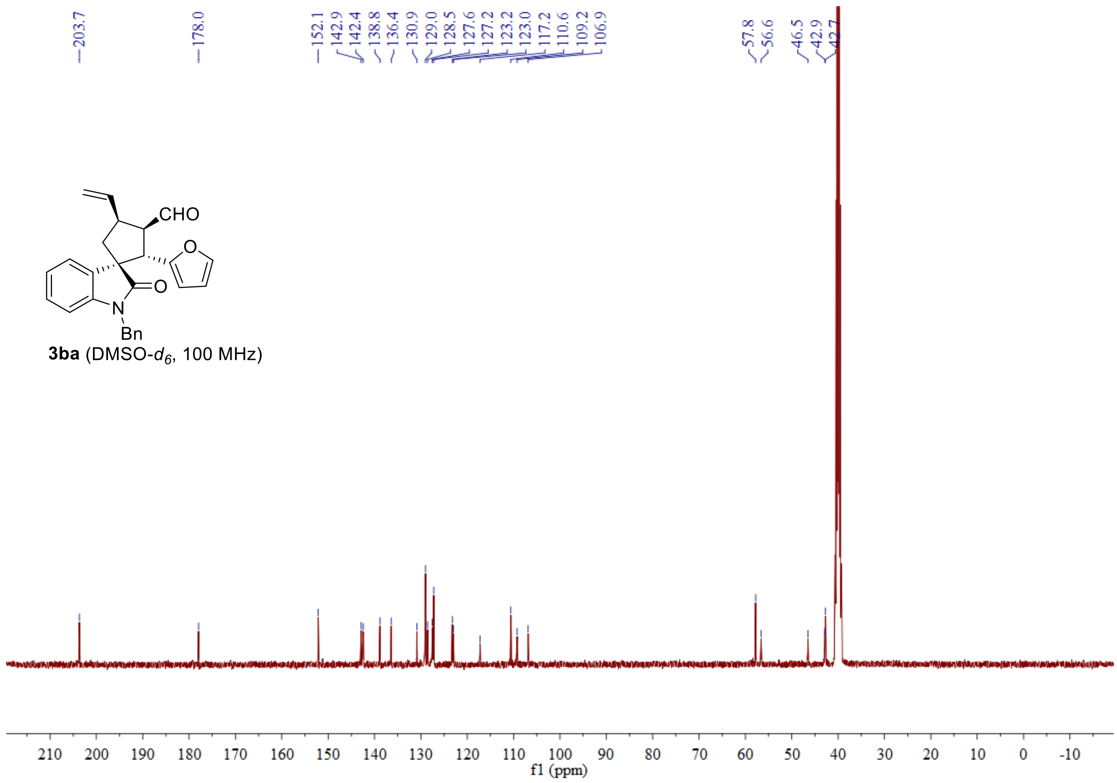
3az (DMSO-d_6, 100 MHz)


9.65
9.64
7.35
7.34
7.32
7.29
7.28
7.27
7.26
7.05
7.03
7.02
6.96
6.94
6.92
6.83
6.81
6.79
6.73
6.71
6.70
6.68
6.63
6.61
6.58
6.56
6.02
6.02
6.00
5.98
5.98
5.96
5.30
5.26
5.17
5.15
5.13
4.77
4.73
4.30
4.27
3.76
3.75
3.74
3.73
3.71
3.70
3.26
2.31
2.30
2.28
2.26
2.03
2.00
1.97
1.09
1.07
1.05
CHO
O
O
N
Bn
4az (DMSO-d_6, 400 MHz)
1.00
5.06
1.01
1.03
1.02
1.09
2.10
1.12
1.01
1.04
1.06
2.03
1.08
1.01
1.15
3.08
1.06
1.06
1.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.
f1 (ppm)

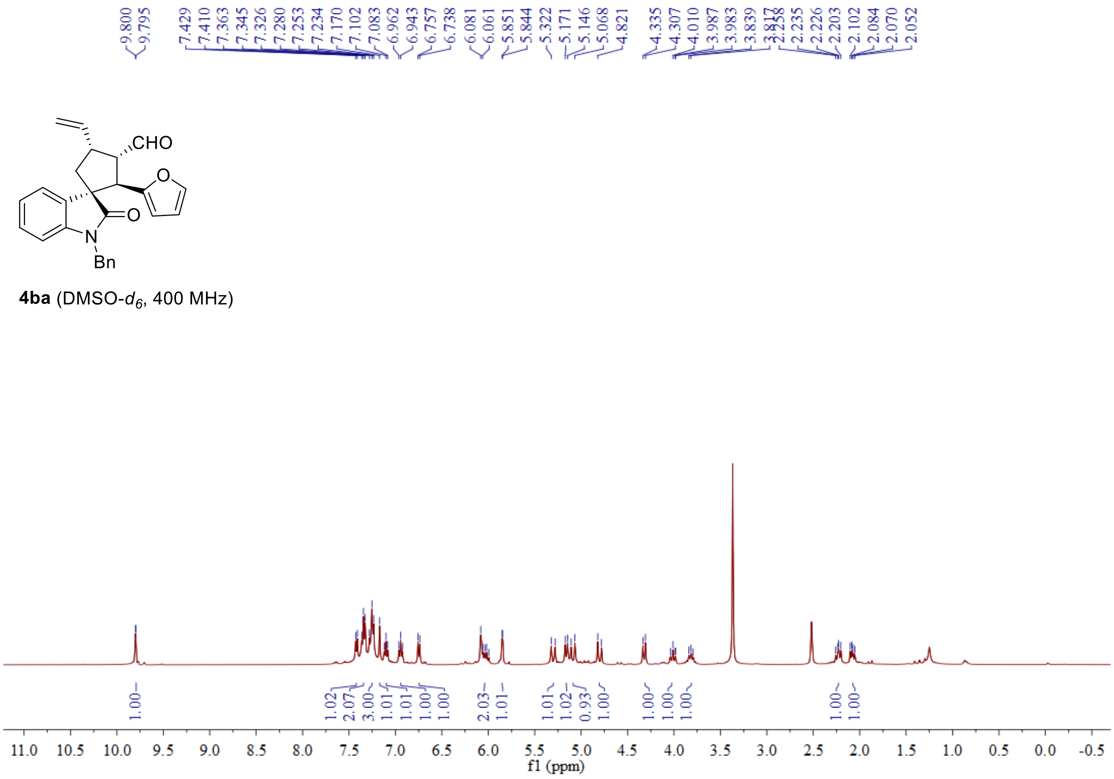

203.8
177.8
142.2
138.8
136.7
131.8
131.0
128.3
128.1
127.3
125.0
122.4
117.3
116.7
109.3
59.6
57.0
53.5
43.7
43.1
42.0
CHO
O
O
N
Bn
4az (DMSO-d_6, 100 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



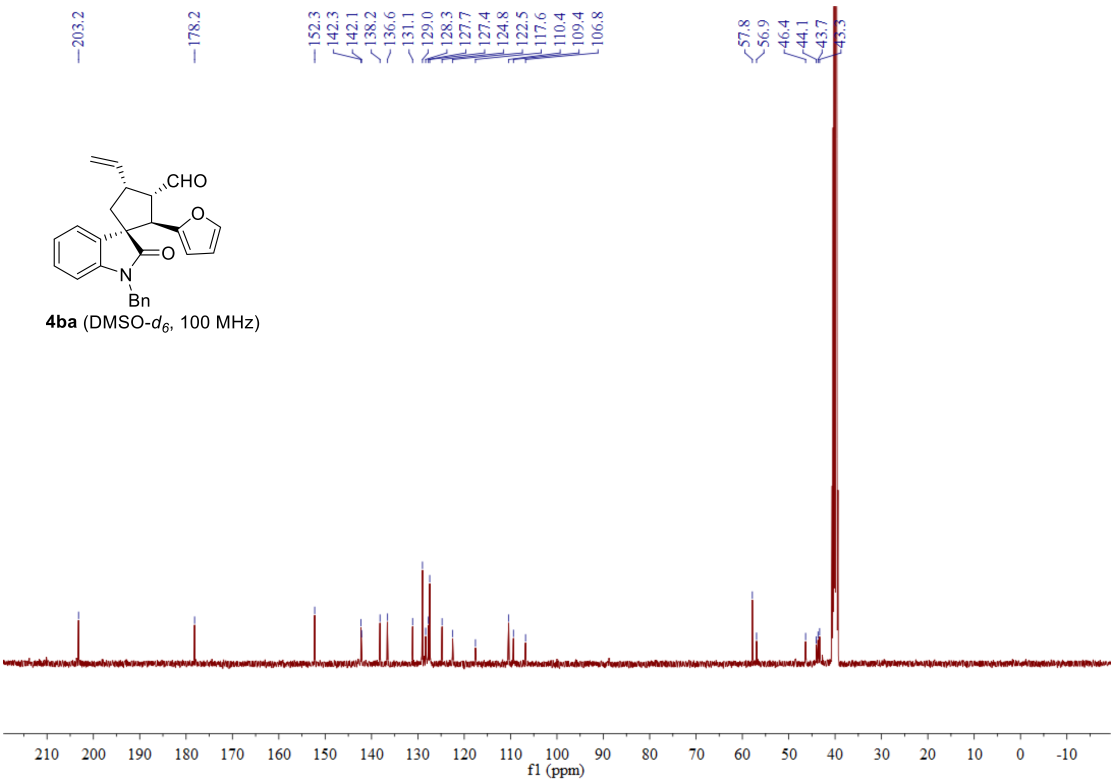
3ba (DMSO-d_6, 400 MHz)



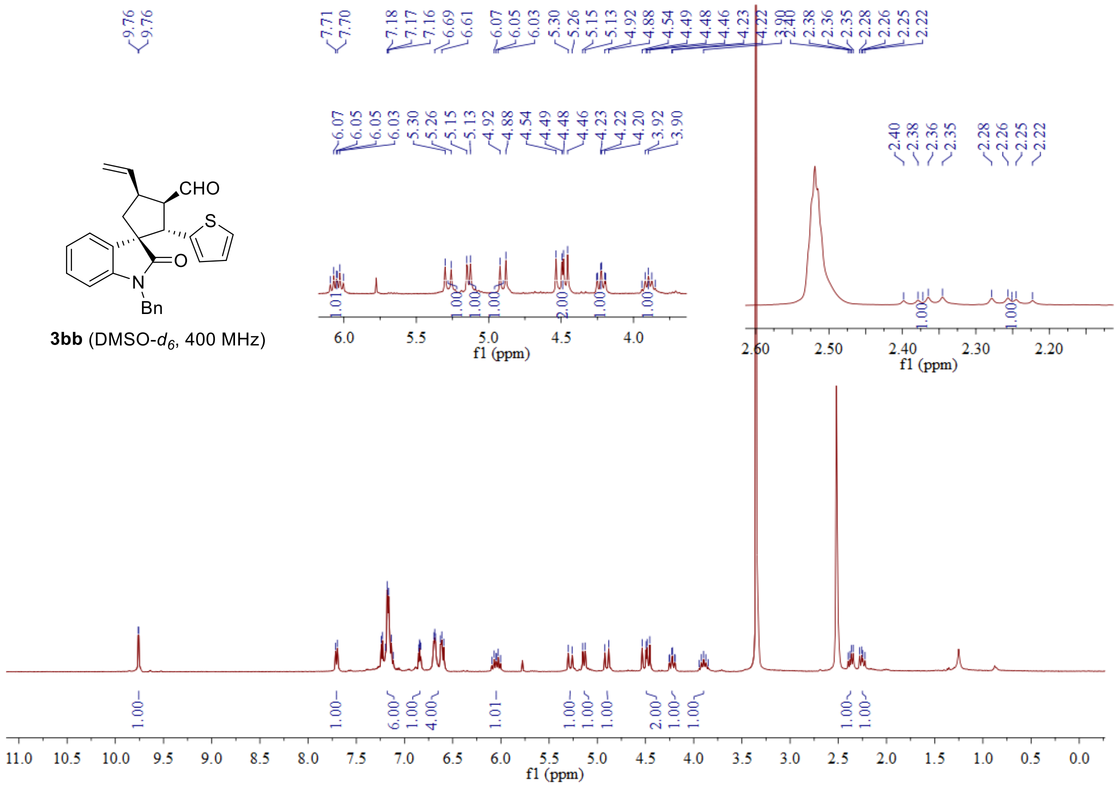
3ba (DMSO-d_6, 100 MHz)



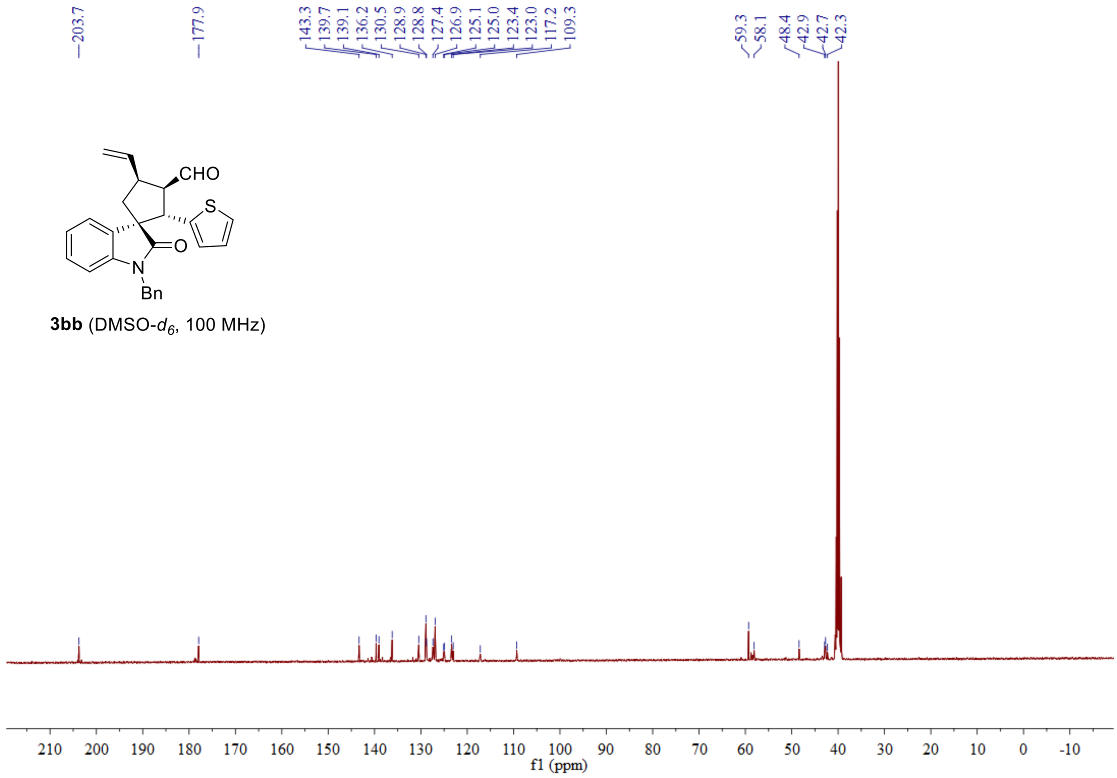
4ba (DMSO-d_6, 400 MHz)



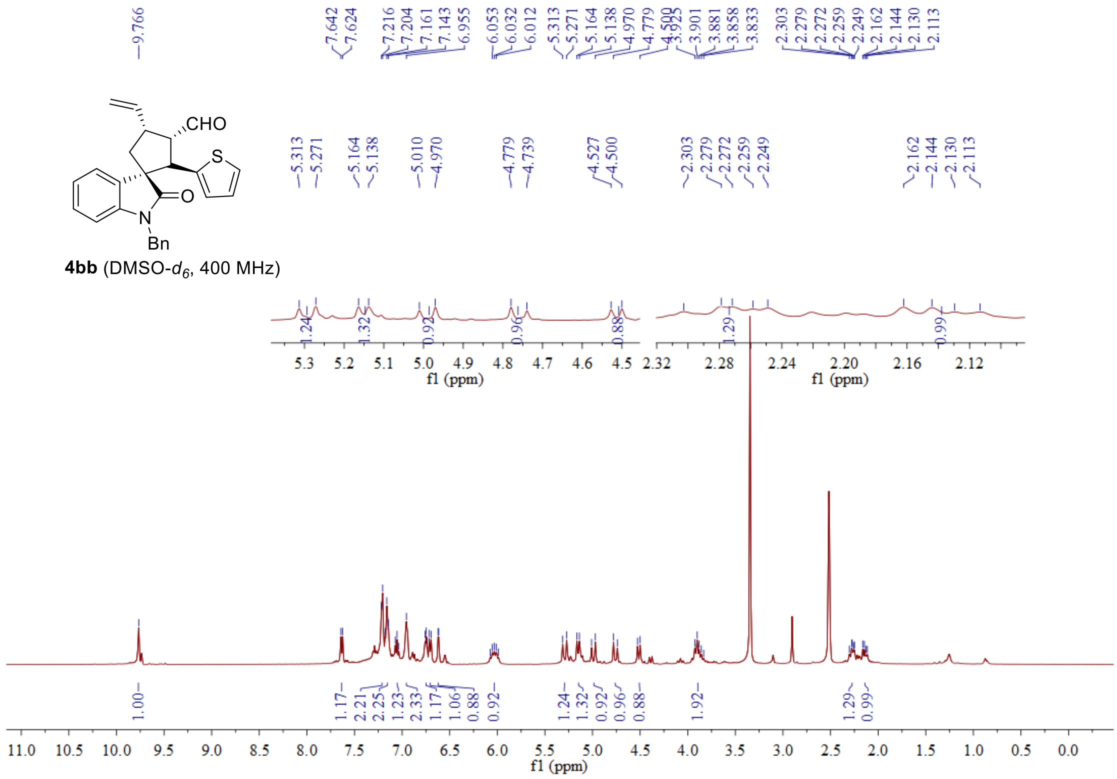
4ba (DMSO-d_6, 100 MHz)



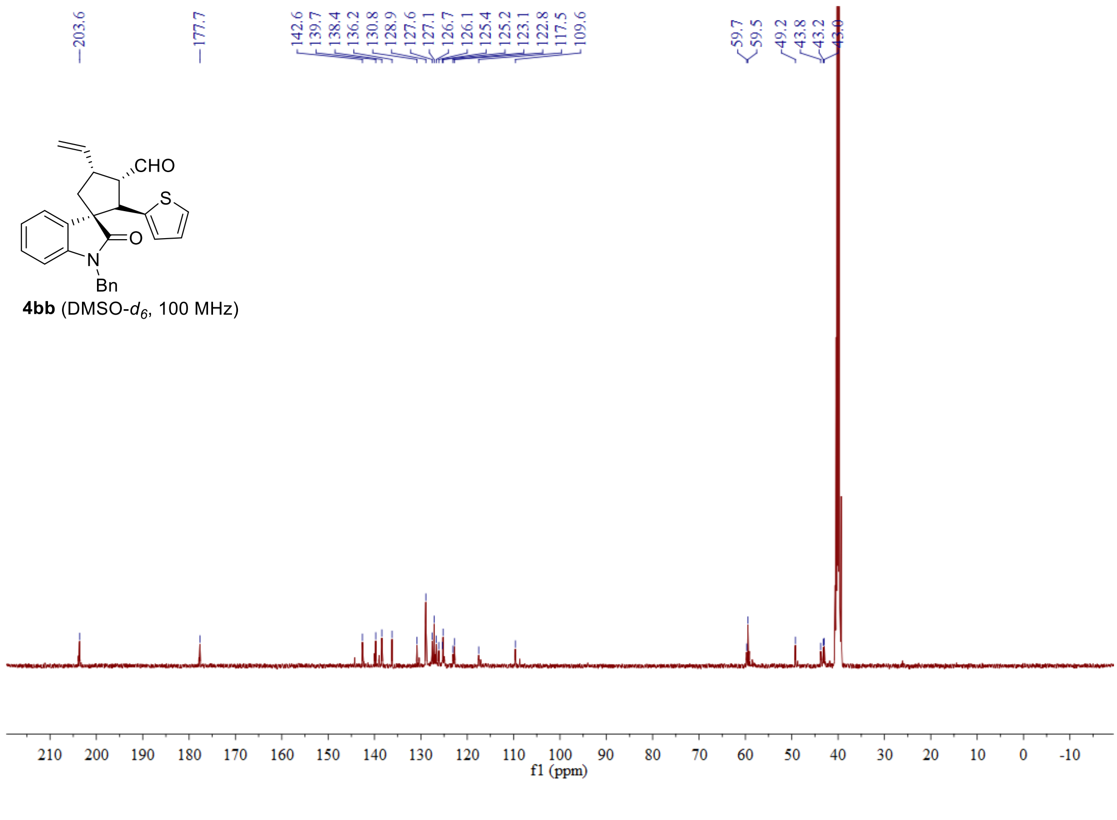
3bb (DMSO-d_6, 400 MHz)



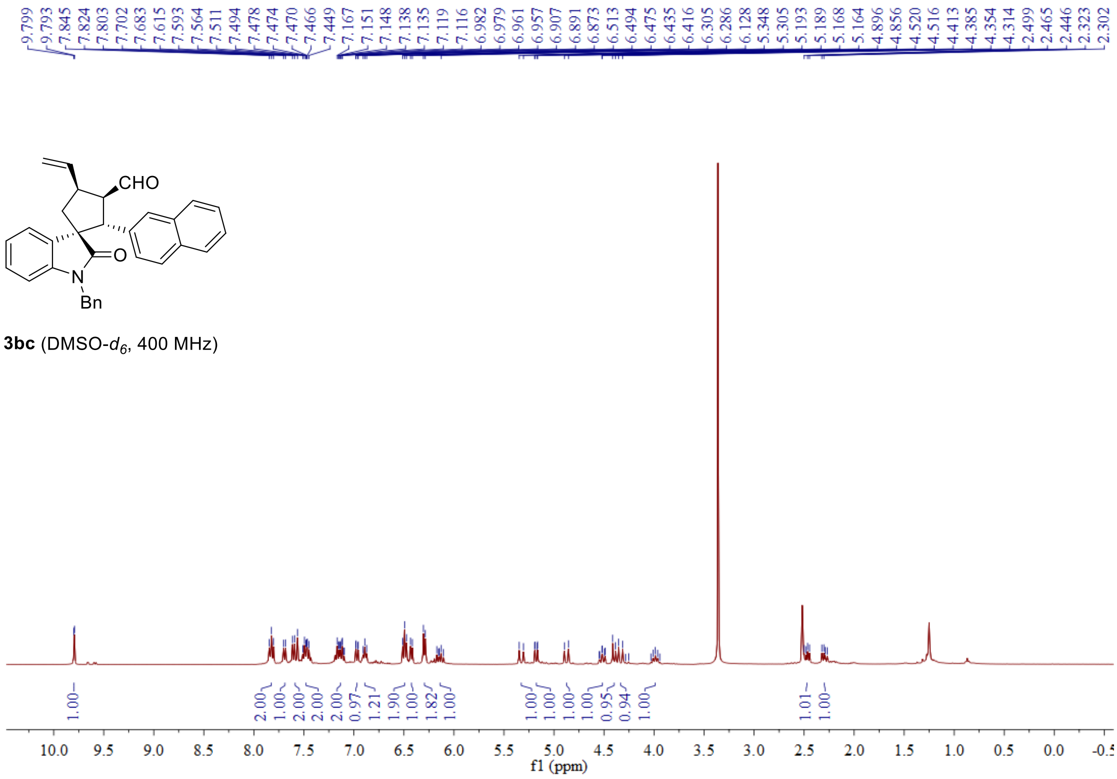
3bb (DMSO-d_6, 100 MHz)



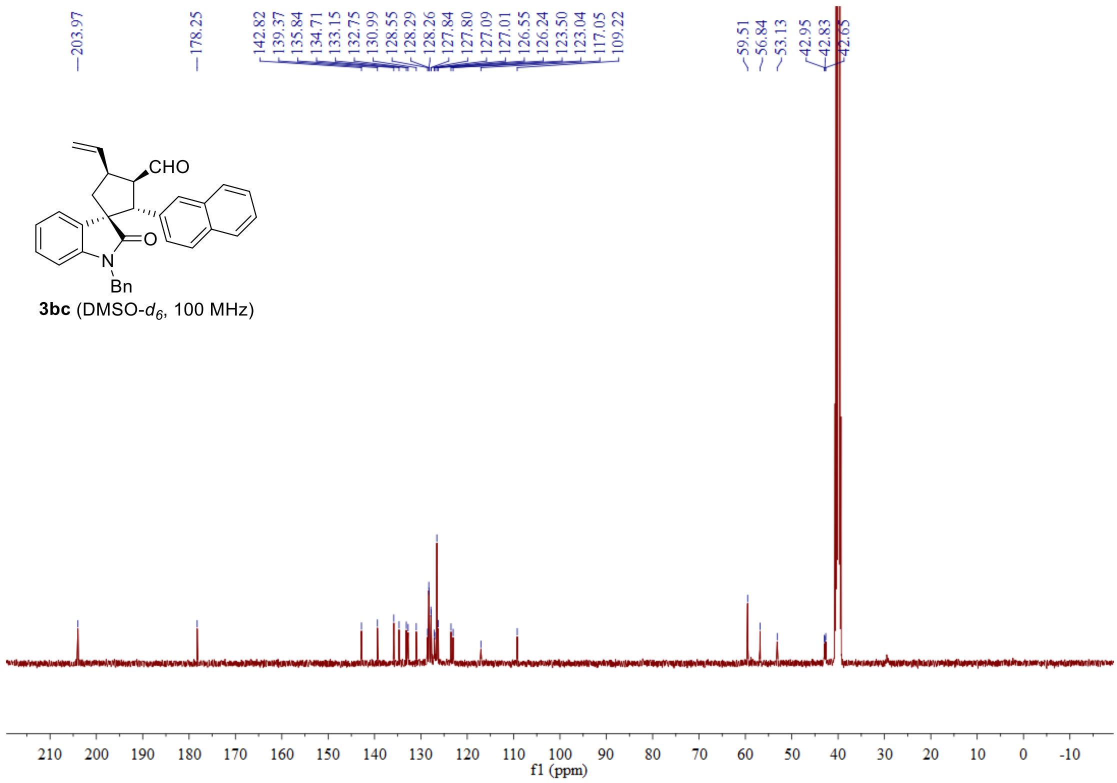
4bb (DMSO-d_6, 400 MHz)



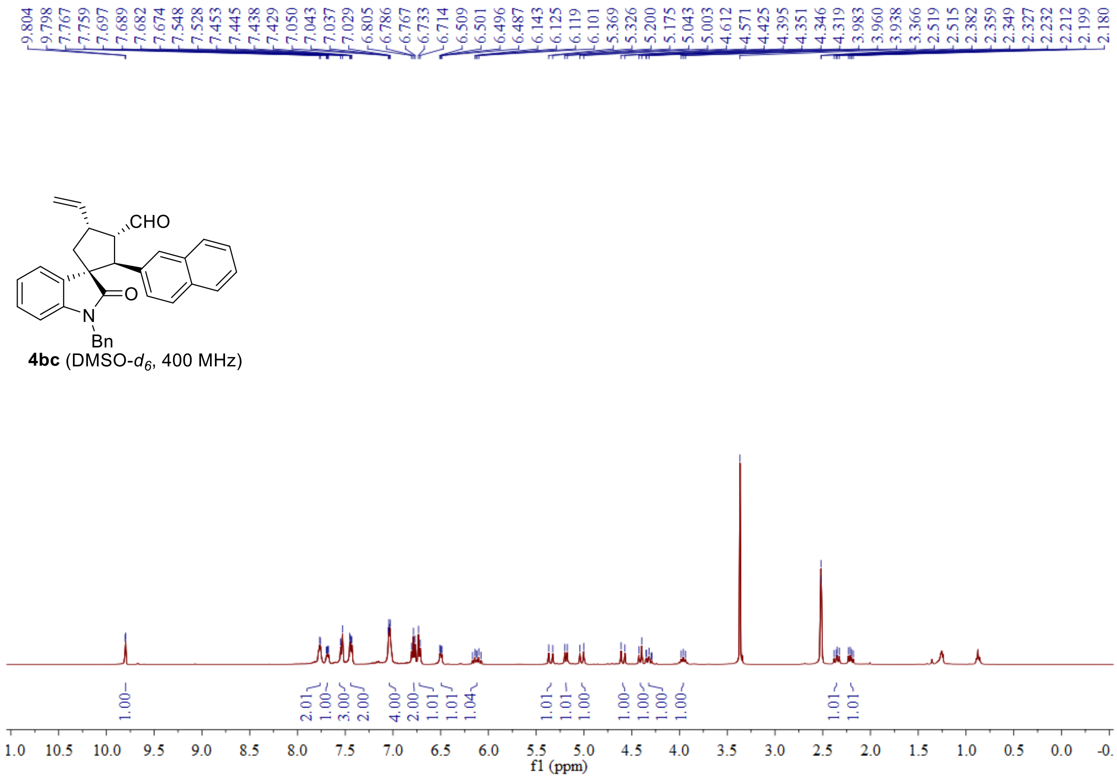
4bb (DMSO-d_6, 100 MHz)

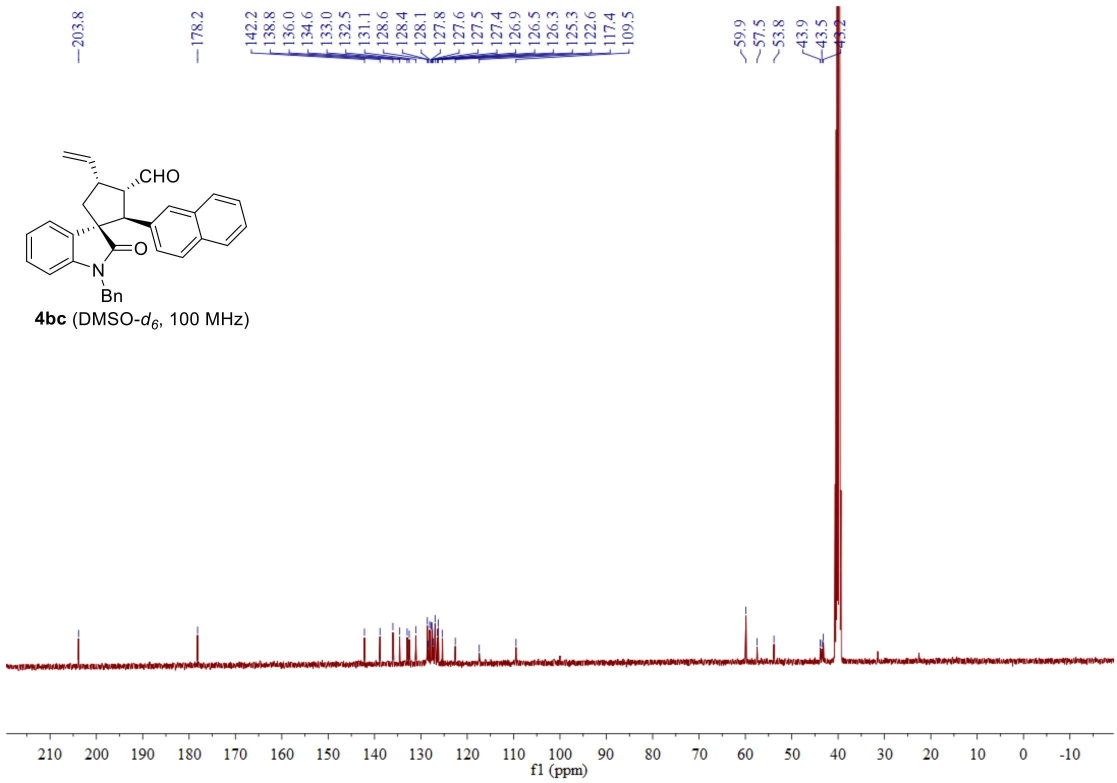


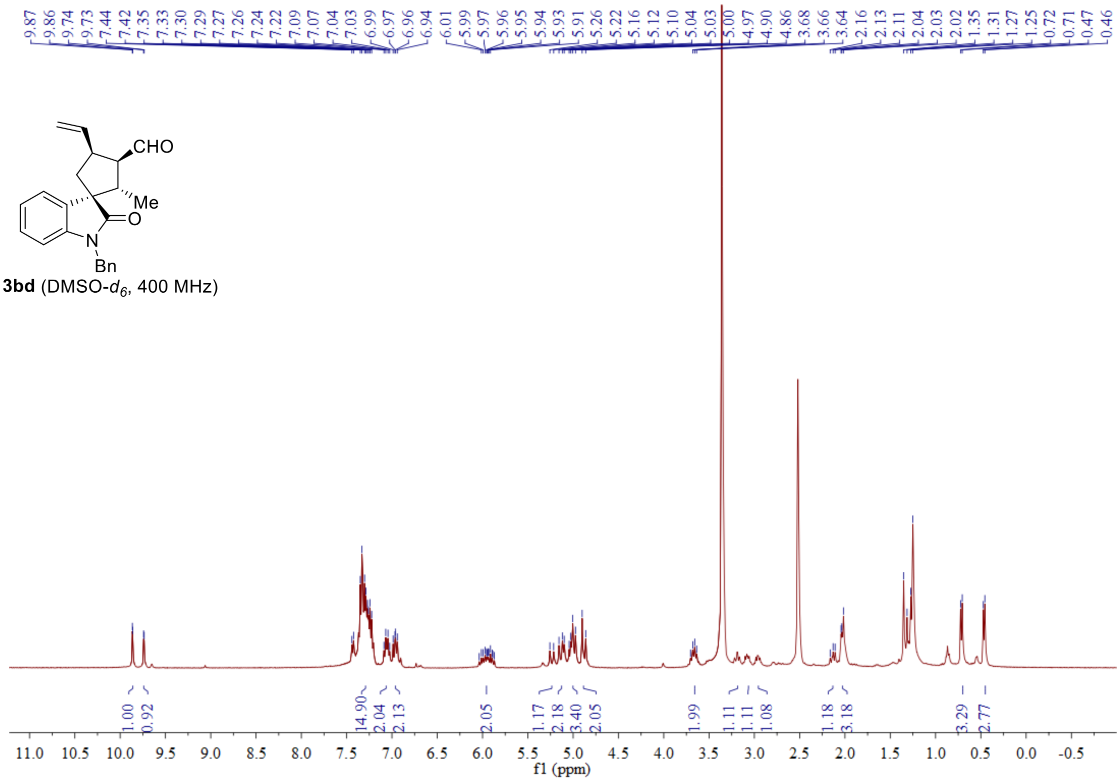
3bc (DMSO-d_6, 400 MHz)



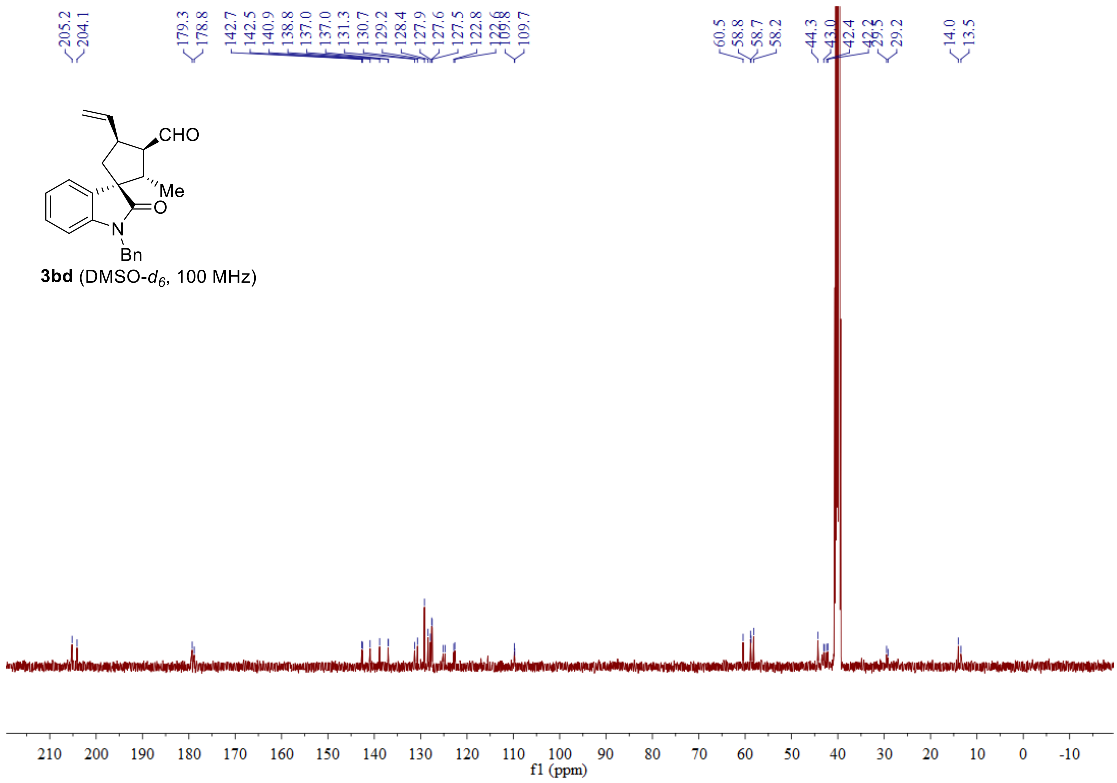
3bc (DMSO-d_6, 100 MHz)


9.804 9.798 7.767 7.759 7.697 7.689 7.682 7.674 7.548 7.528 7.453 7.445 7.438 7.429 7.050 7.043 7.037 7.029 6.805 6.786 6.767 6.733 6.714 6.509 6.501 6.496 6.487 6.143 6.125 6.119 6.101 5.369 5.326 5.200 5.175 5.043 5.003 4.612 4.571 4.425 4.395 4.351 4.346 4.319 3.983 3.960 3.938 3.366 2.519 2.515 2.382 2.359 2.349 2.327 2.232 2.212 2.199 2.180
CHO
O
N
Bn
4bc (DMSO-d_6, 400 MHz)
1.00 2.01 1.00 3.00 2.00 4.00 2.00 1.01 1.01 1.04 1.01 1.01 1.00 1.00 1.00 1.00 1.00 1.01 1.01
f1 (ppm)

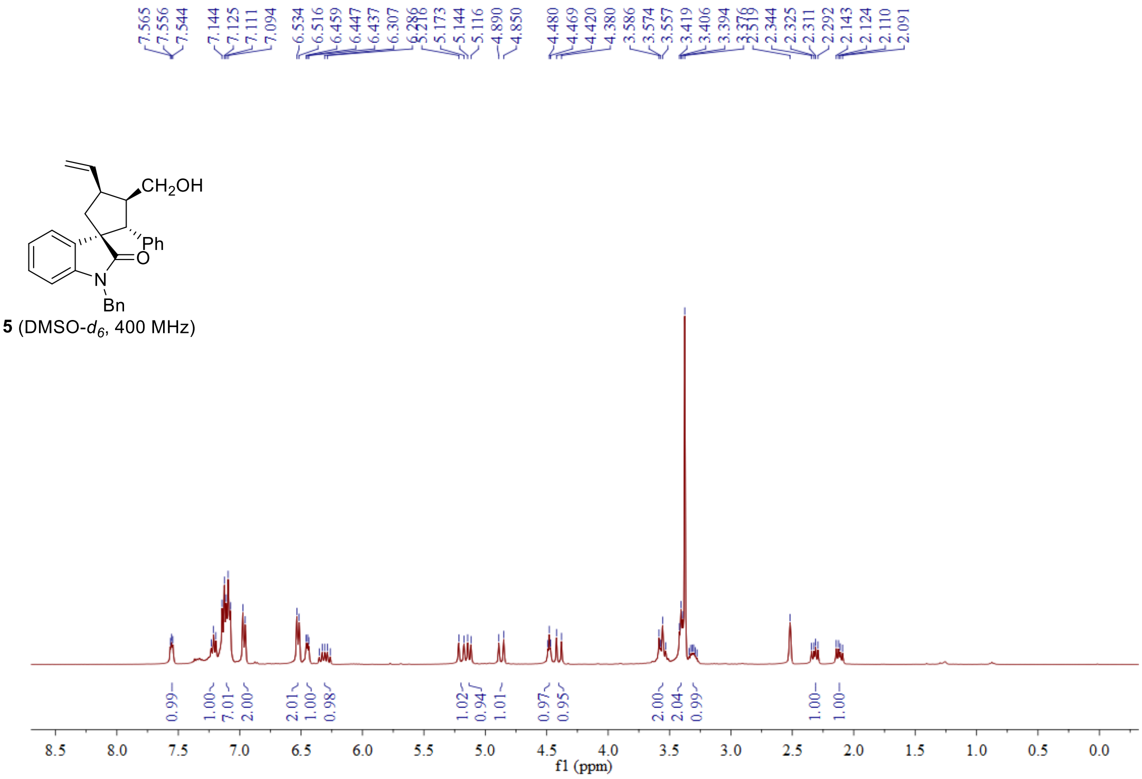

203.8 178.2 142.2 138.8 136.0 134.6 133.0 132.5 131.1 128.6 128.4 128.1 127.8 127.6 127.5 127.4 126.9 126.5 126.3 125.3 122.6 117.4 109.5 59.9 57.5 53.8 43.9 43.5 43.2
CHO
O
N
Bn
4bc (DMSO-d_6, 100 MHz)
f1 (ppm)



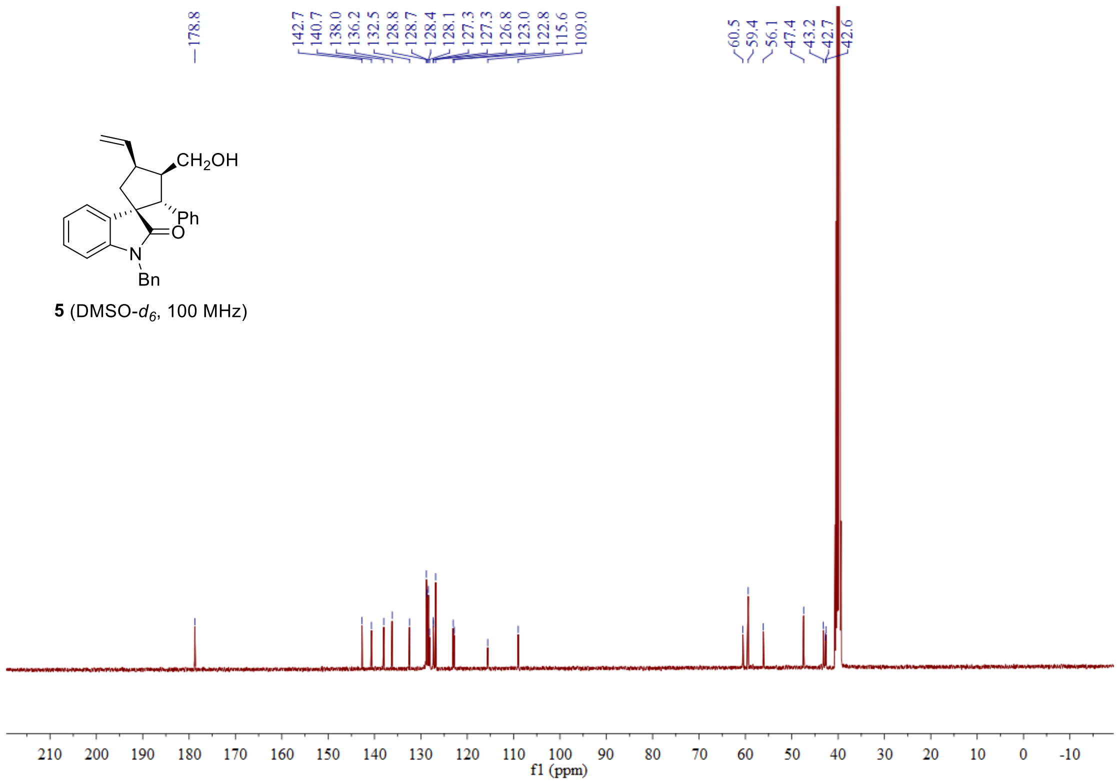
3bd (DMSO-d_6, 400 MHz)



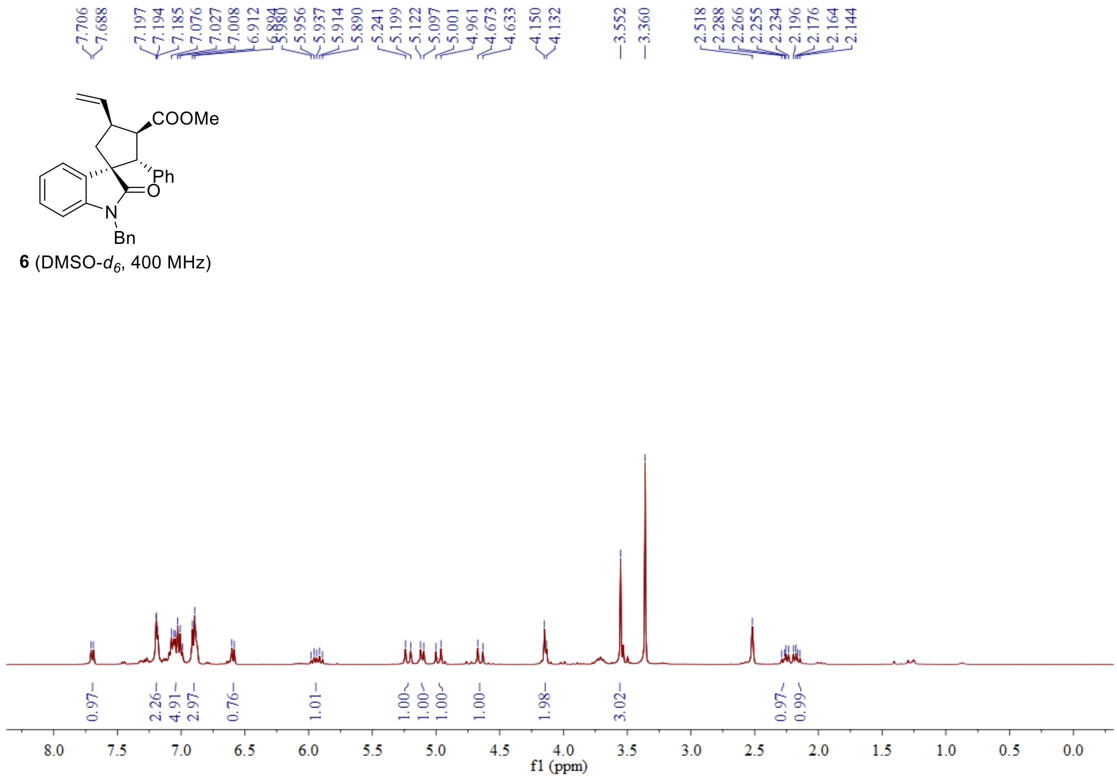
3bd (DMSO-d_6, 100 MHz)



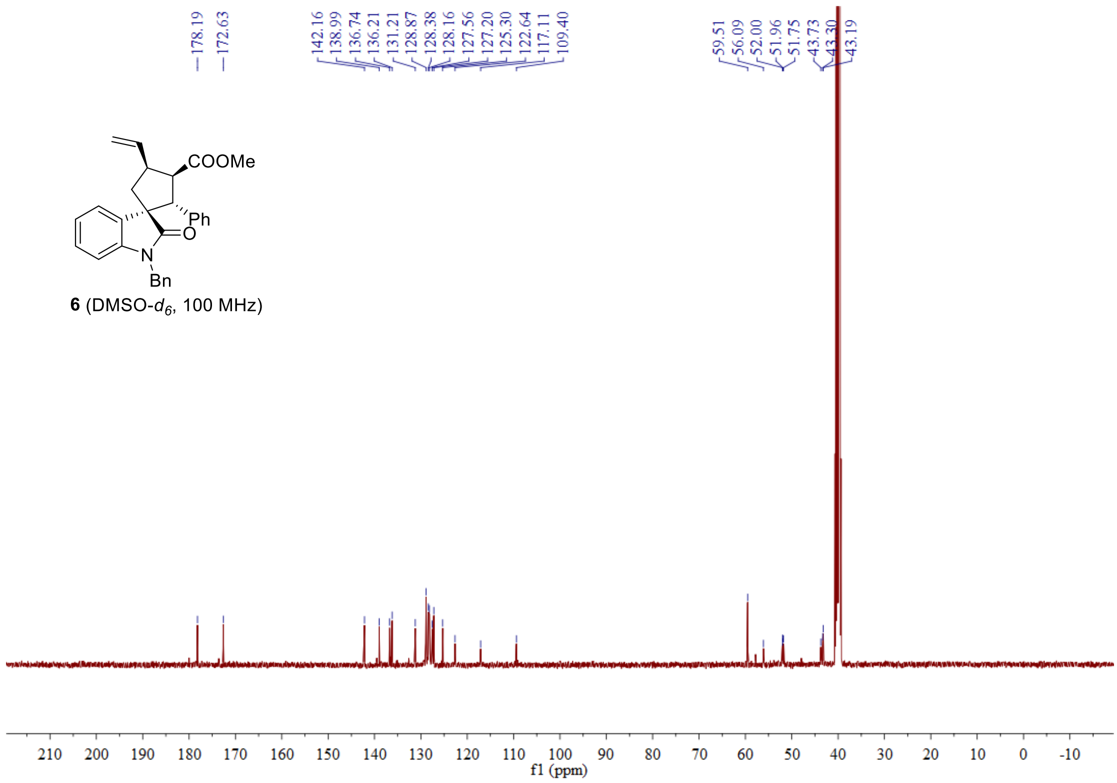
5 (DMSO-d_6, 400 MHz)



5 (DMSO-d_6, 100 MHz)

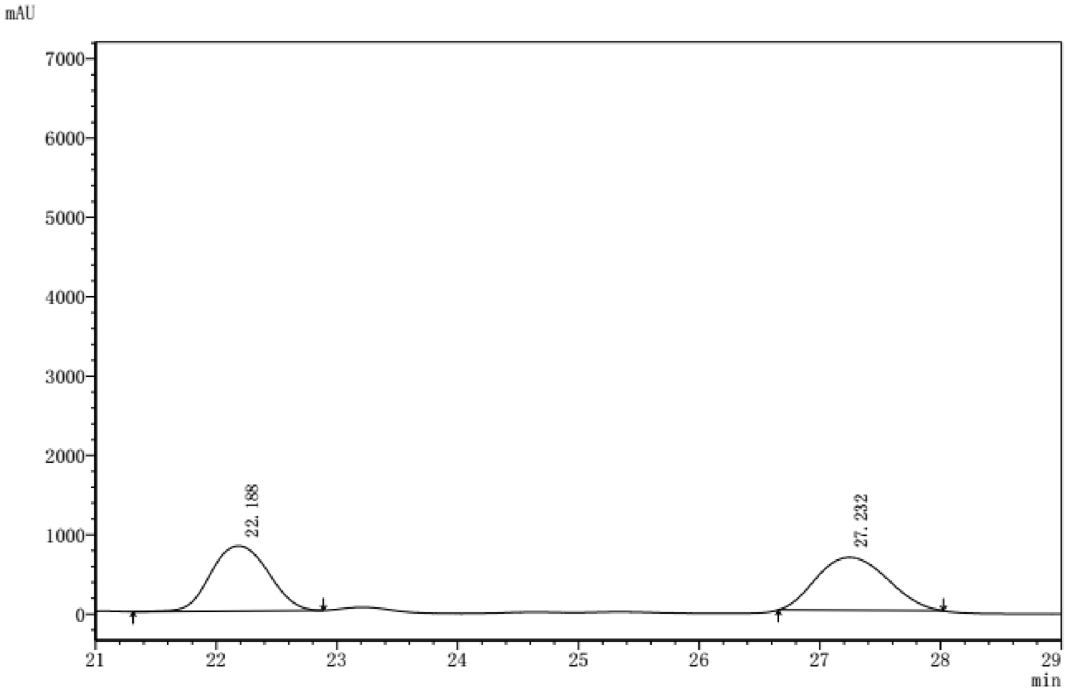


6 (DMSO-d_6, 400 MHz)



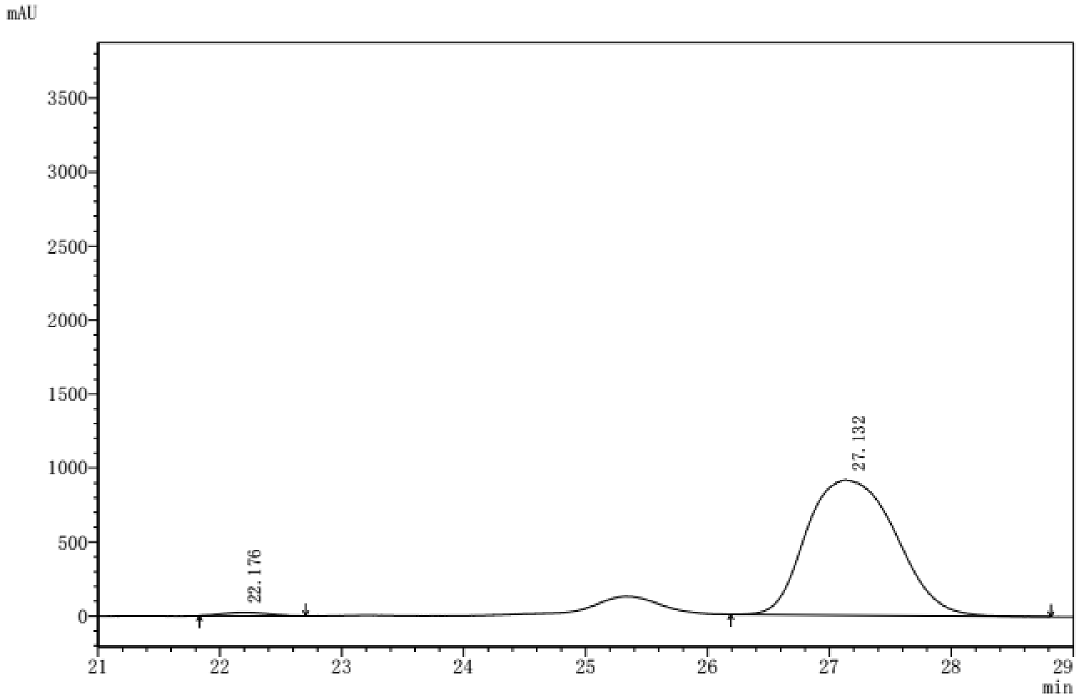
6 (DMSO-d_6, 100 MHz)

HPLC spectra of *racemic*-**3aa**



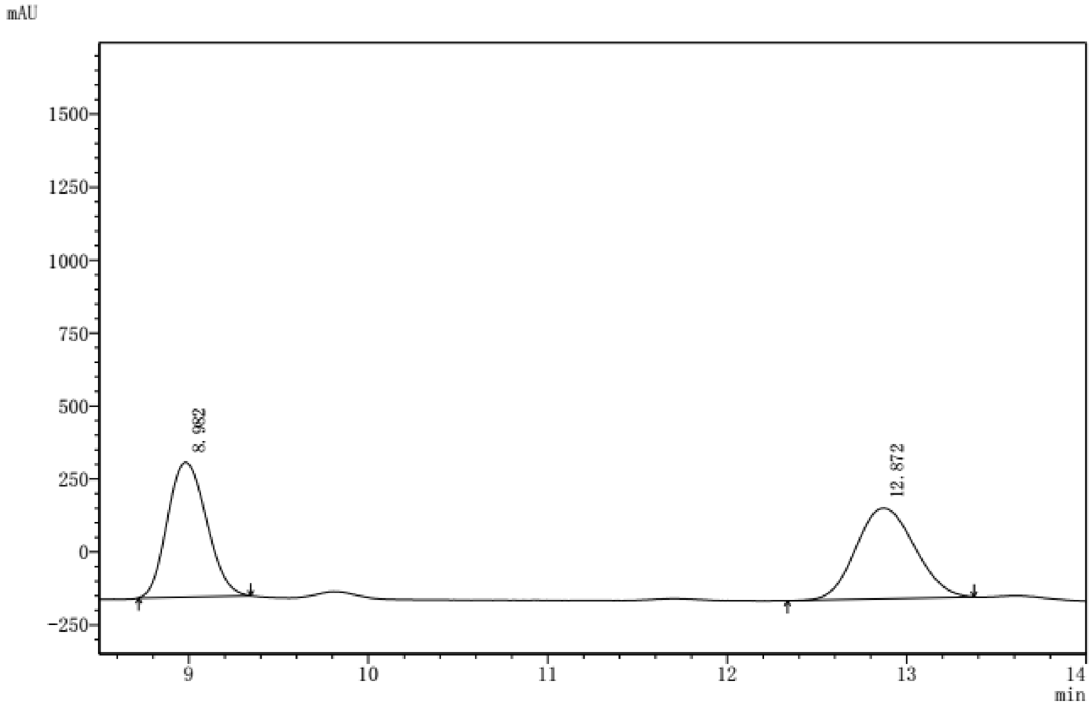
Peak	RetTime	Area	Height	Area%
1	22.188	27091039	818491	49.700
2	27.232	27417623	669415	50.300

HPLC spectra of **enantioenriched-3aa**



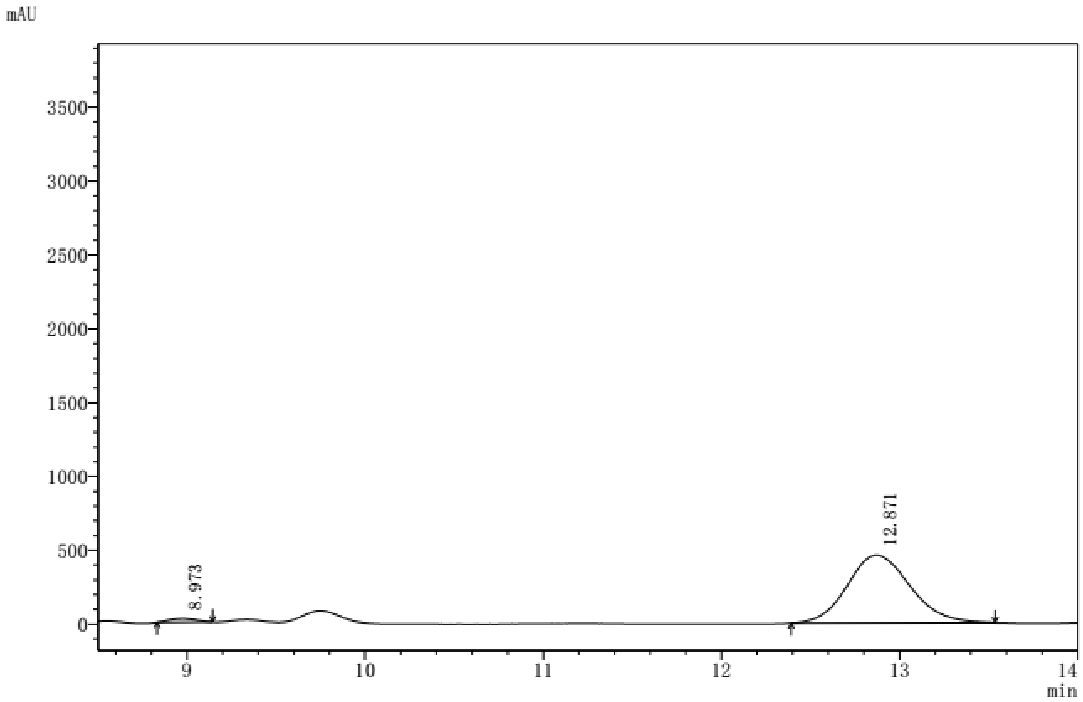
Peak	RetTime	Area	Height	Area%
1	22.176	586372	22981	1.243
2	27.132	46587217	915116	98.757

HPLC spectra of *racemic*-**4aa**



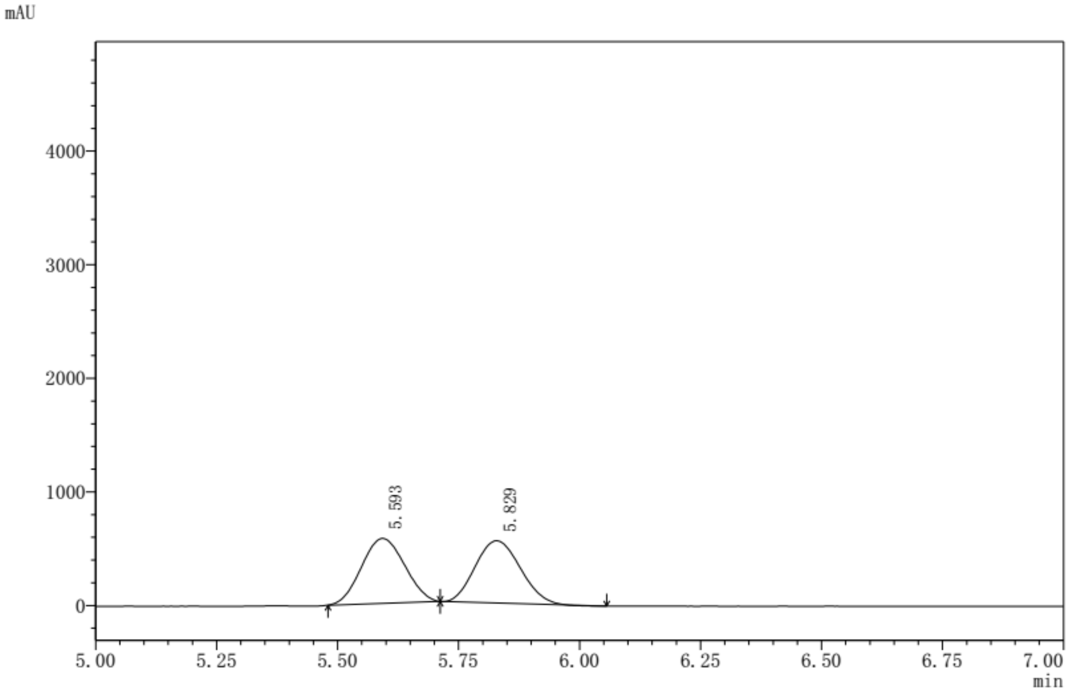
Peak	RetTime	Area	Height	Area%
1	8.982	7001479	461524	49.743
2	12.872	7073750	310838	50.257

HPLC spectra of **enantioenriched-4aa**



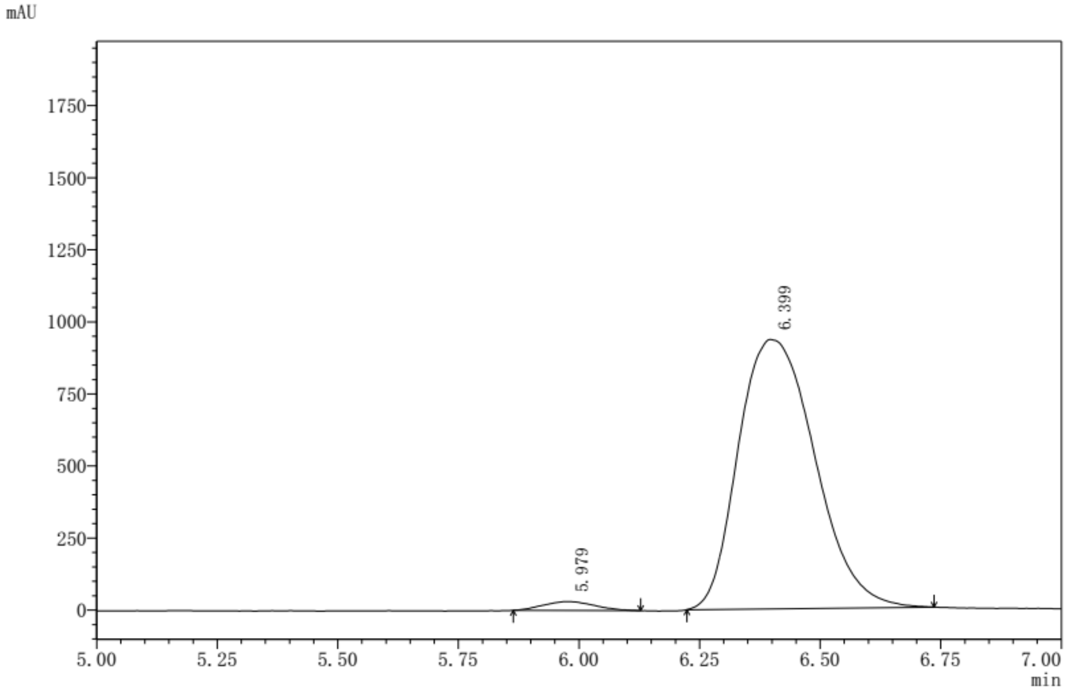
Peak	RetTime	Area	Height	Area%
1	8.973	251417	24053	2.190
2	12.871	11229851	458528	97.810

HPLC spectra of *racemic*-**3ab**



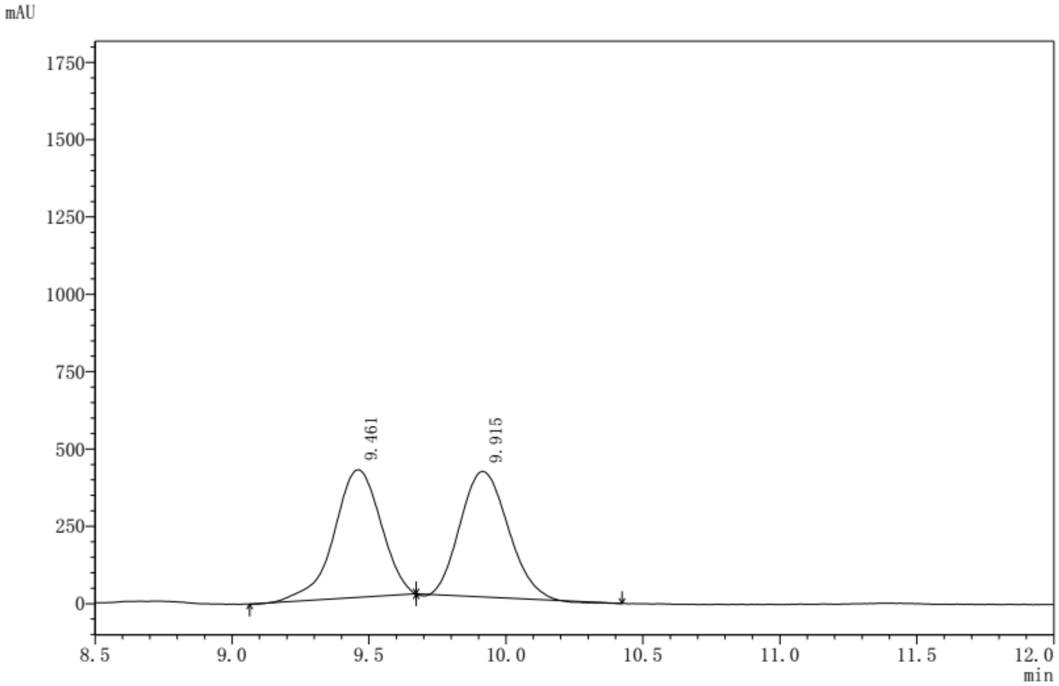
Peak	RetTime	Area	Height	Area%
1	5.593	3544074	570545	50.036
2	5.829	3538916	547951	49.964

HPLC spectra of **enantioenriched-3ab**



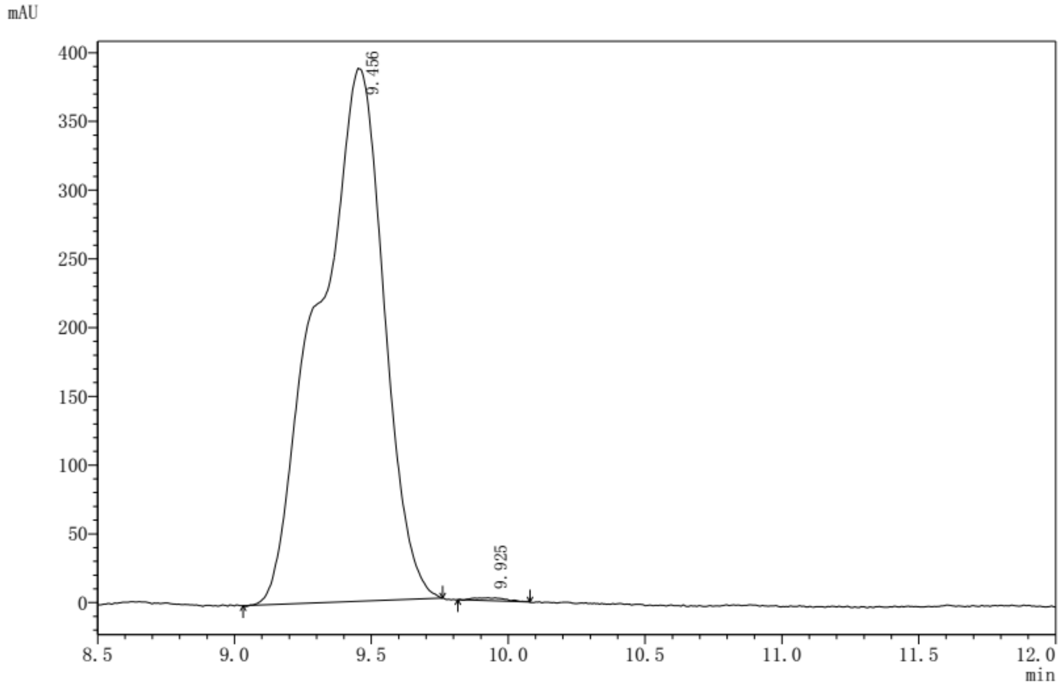
Peak	RetTime	Area	Height	Area%
1	5.979	225667	30527	2.137
2	6.399	10334928	934231	97.863

HPLC spectra of *racemic*-**4ab**



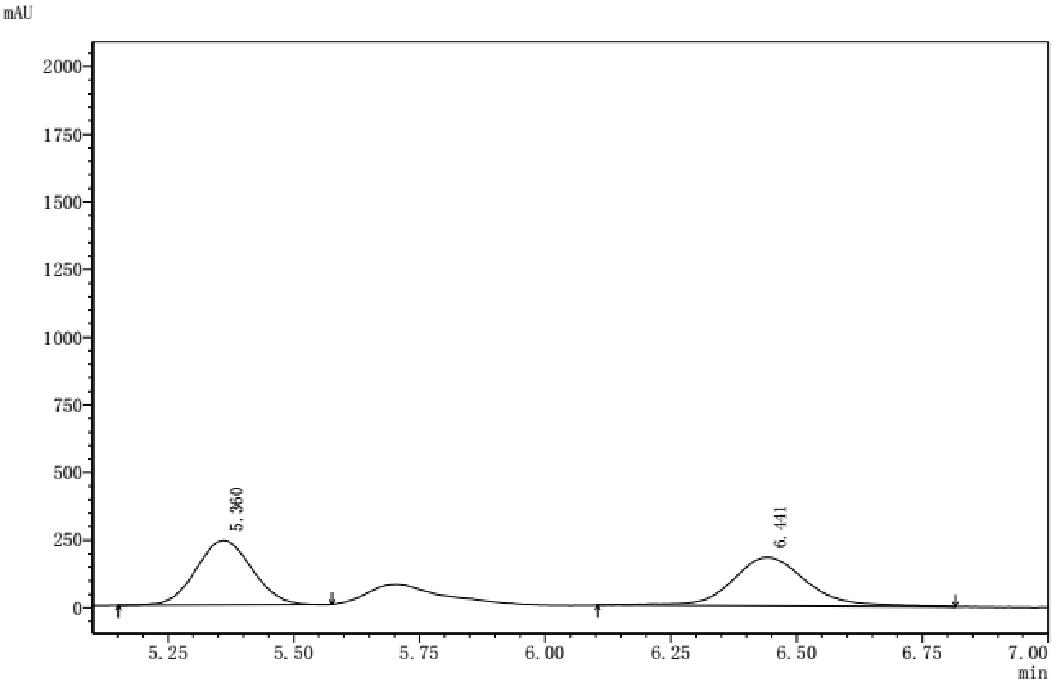
Peak	RetTime	Area	Height	Area%
1	9.461	4913228	412375	49.994
2	9.915	4914323	405556	50.006

HPLC spectra of **enantioenriched-4ab**



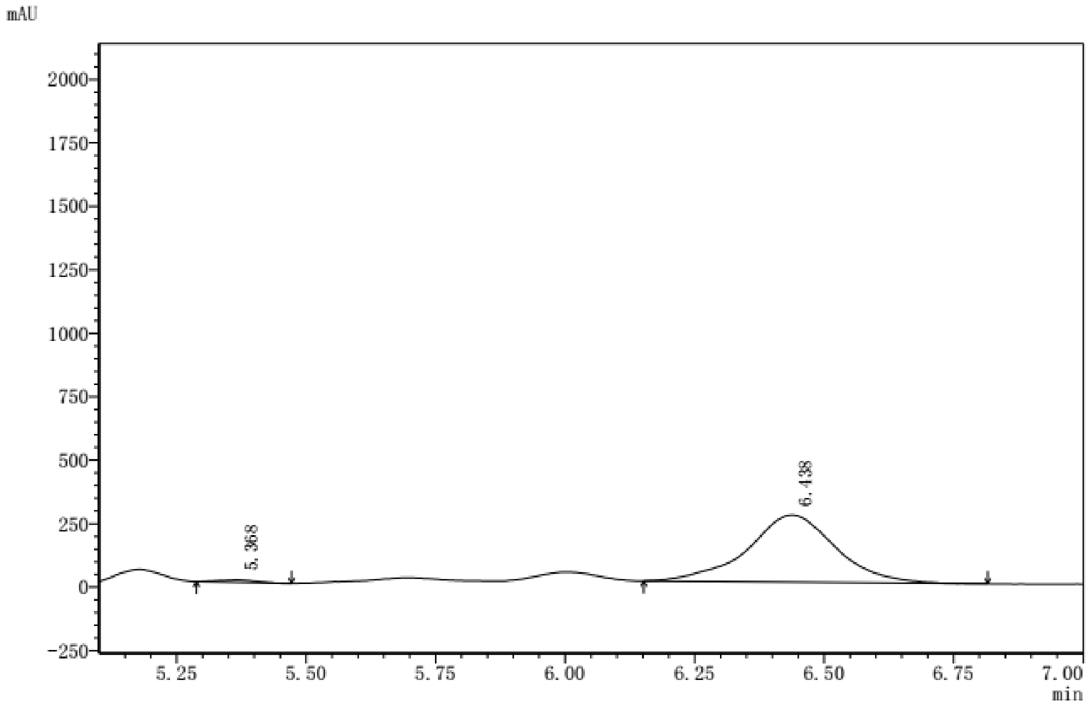
Peak	RetTime	Area	Height	Area%
1	9.456	6447316	387514	99.743
2	9.925	16609	2079	0.257

HPLC spectra of *racemic*-**3ac**



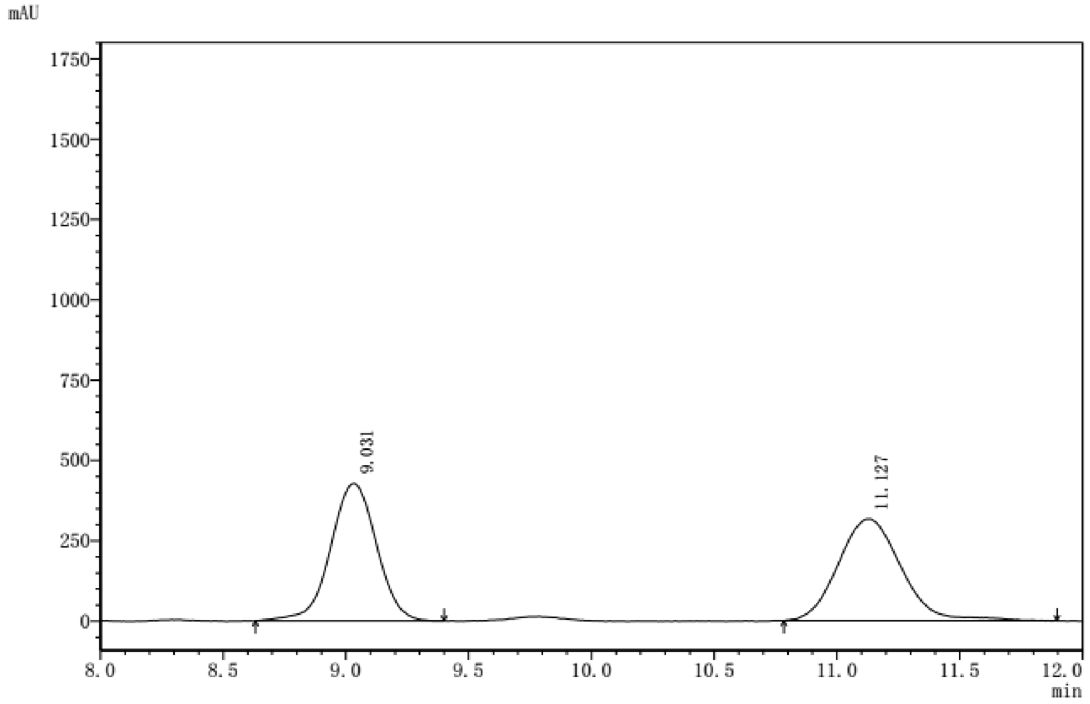
Peak	RetTime	Area	Height	Area%
1	5.360	1838917	238079	49.869
2	6.441	1848562	179064	50.131

HPLC spectra of **enantioenriched-3ac**



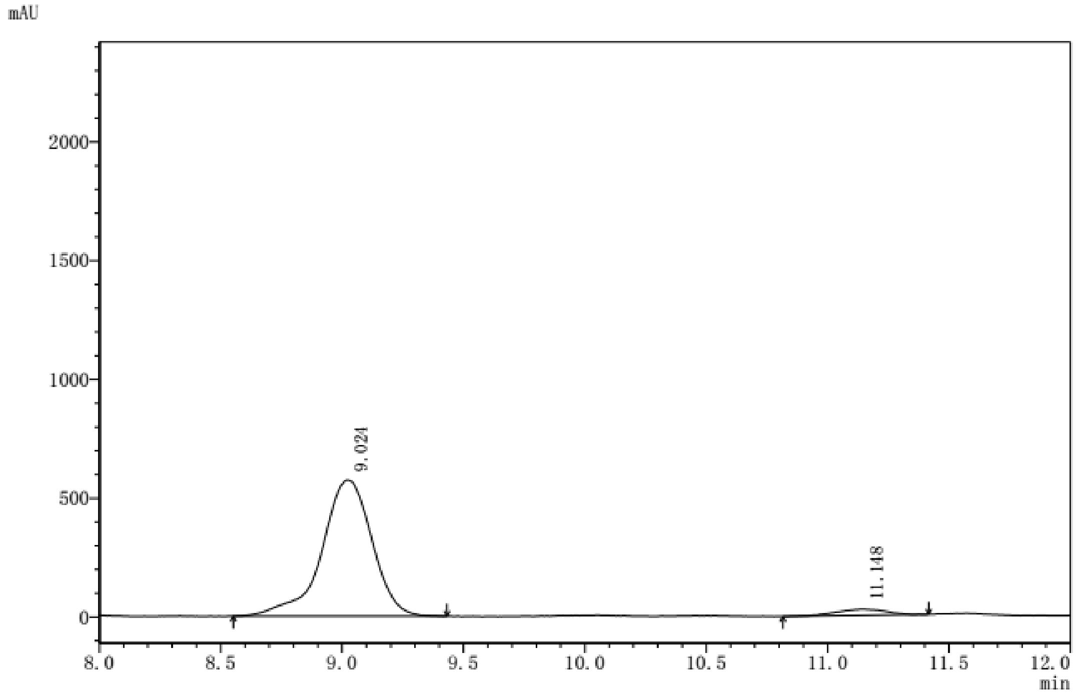
Peak	RetTime	Area	Height	Area%
1	5.368	47171	9705	1.487
2	6.438	3124336	264283	98.513

HPLC spectra of *racemic*-**4ac**



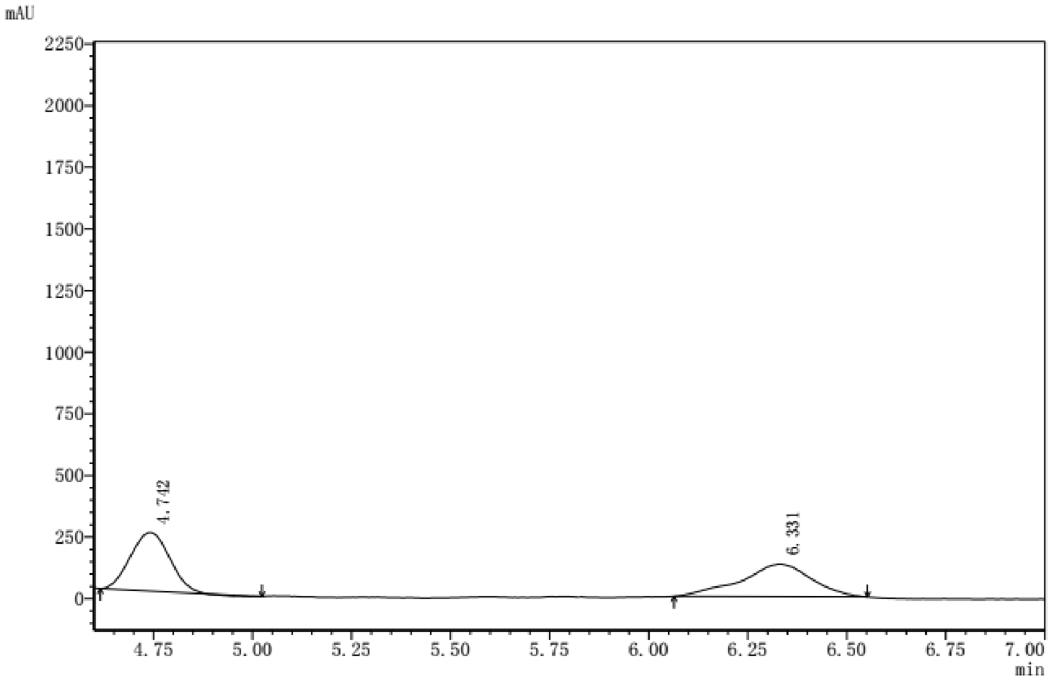
Peak	RetTime	Area	Height	Area%
1	9.031	5579644	427502	49.791
2	11.127	5626483	316263	50.209

HPLC spectra of **enantioenriched-4ac**



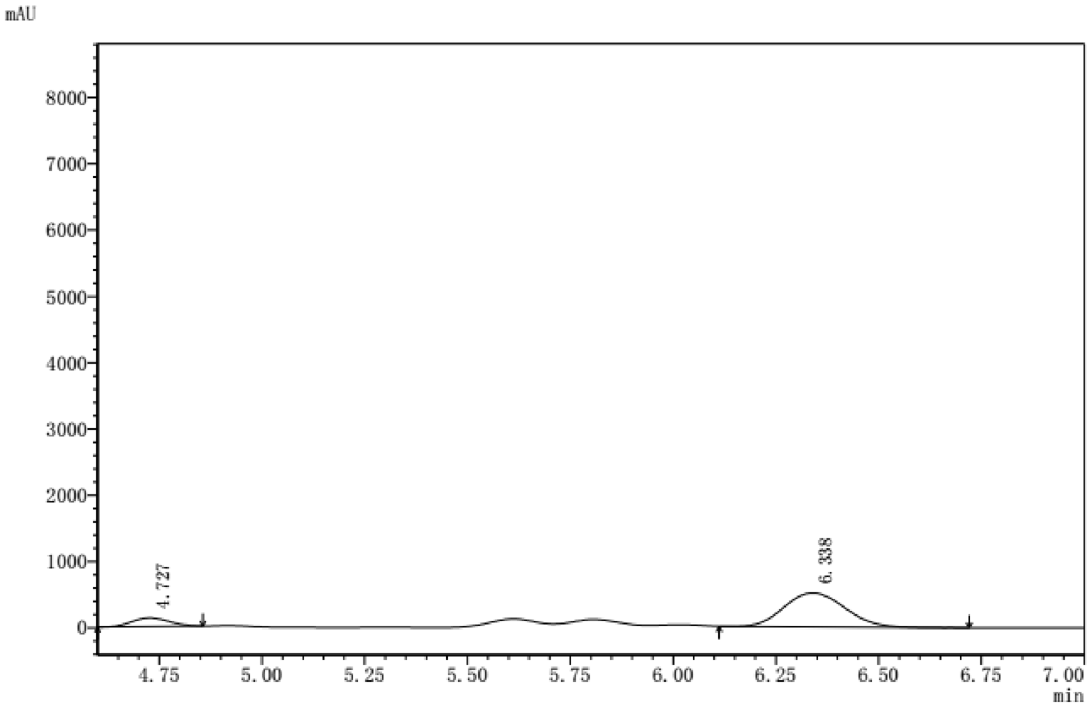
Peak	RetTime	Area	Height	Area%
1	9.024	8251998	572731	95.829
2	11.148	359134	25416	4.171

HPLC spectra of *racemic*-**3ad**



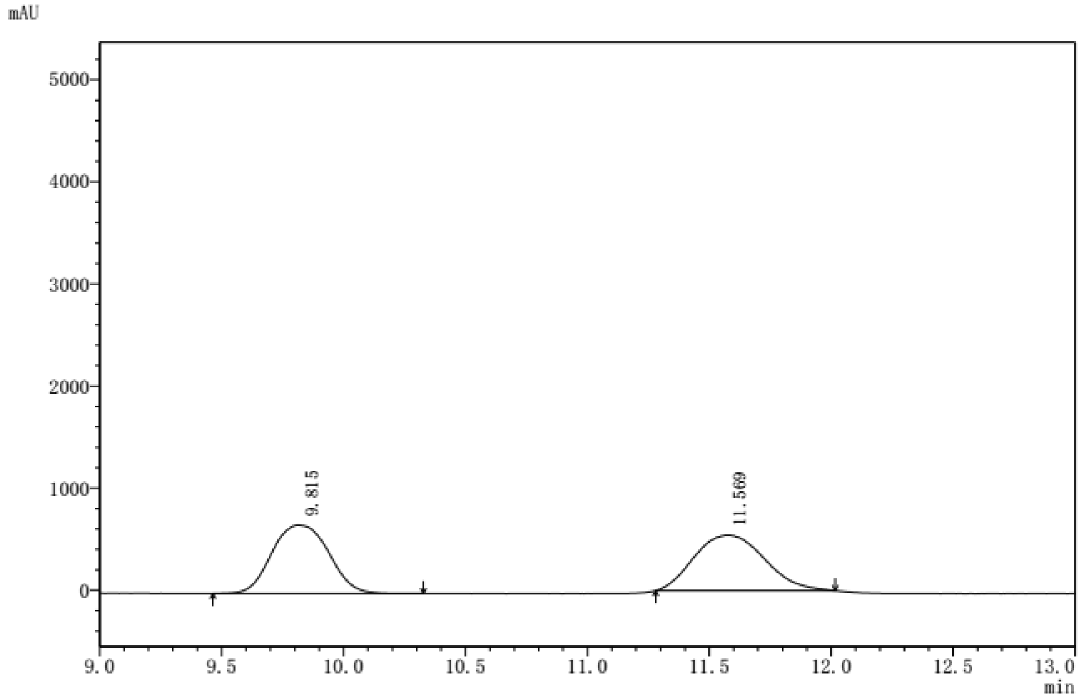
Peak	RetTime	Area	Height	Area%
1	4.742	1619037	237427	49.731
2	6.331	1636528	131840	50.269

HPLC spectra of **enantioenriched-3ad**



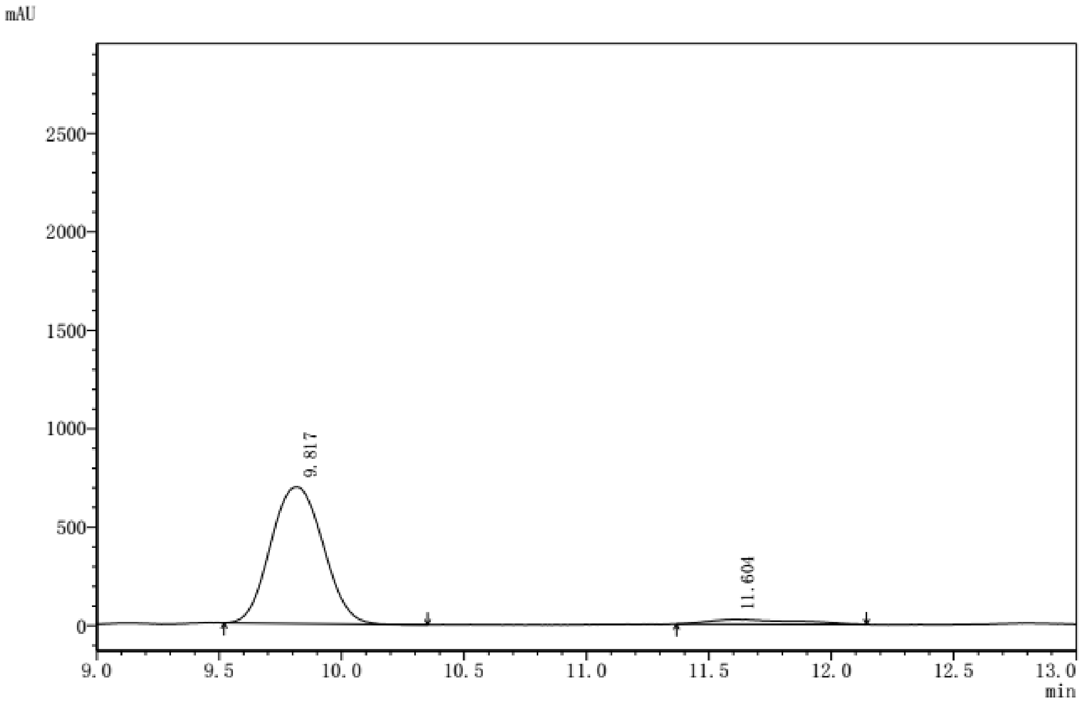
Peak	RetTime	Area	Height	Area%
1	4.727	833300	131390	13.722
2	6.338	5239259	507998	86.278

HPLC spectra of *racemic*-**4ad**



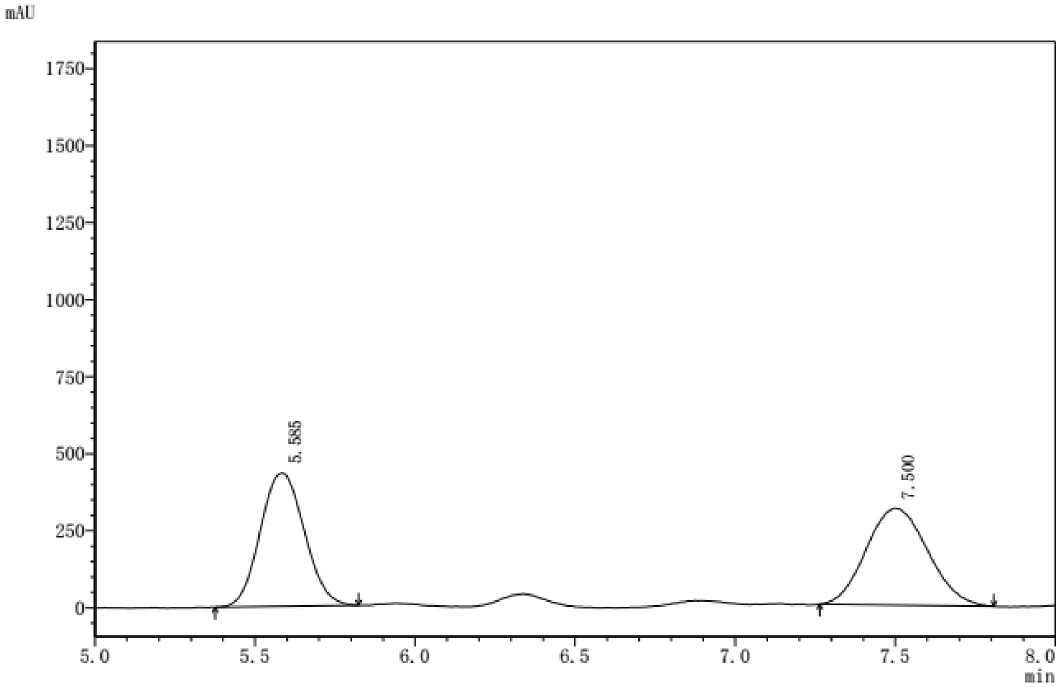
Peak	RetTime	Area	Height	Area%
1	9.815	10868090	670311	49.826
2	11.569	10944051	543102	50.174

HPLC spectra of **enantioenriched-4ad**



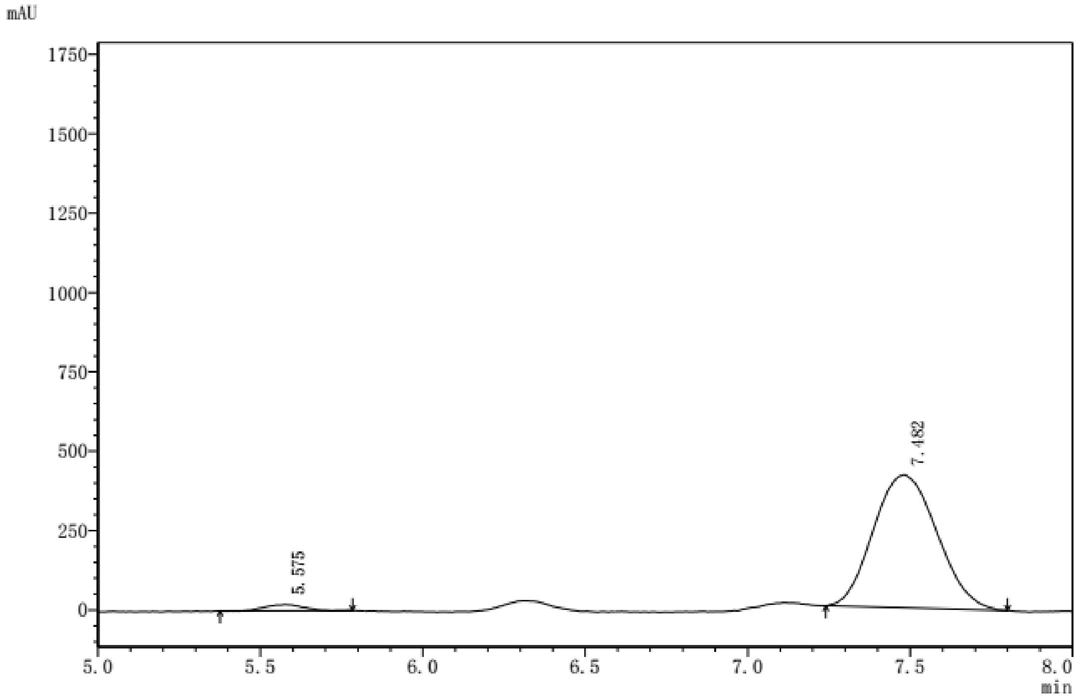
Peak	RetTime	Area	Height	Area%
1	9.817	10333743	692694	94.567
2	11.604	593681	23910	5.433

HPLC spectra of *racemic*-**3ae**



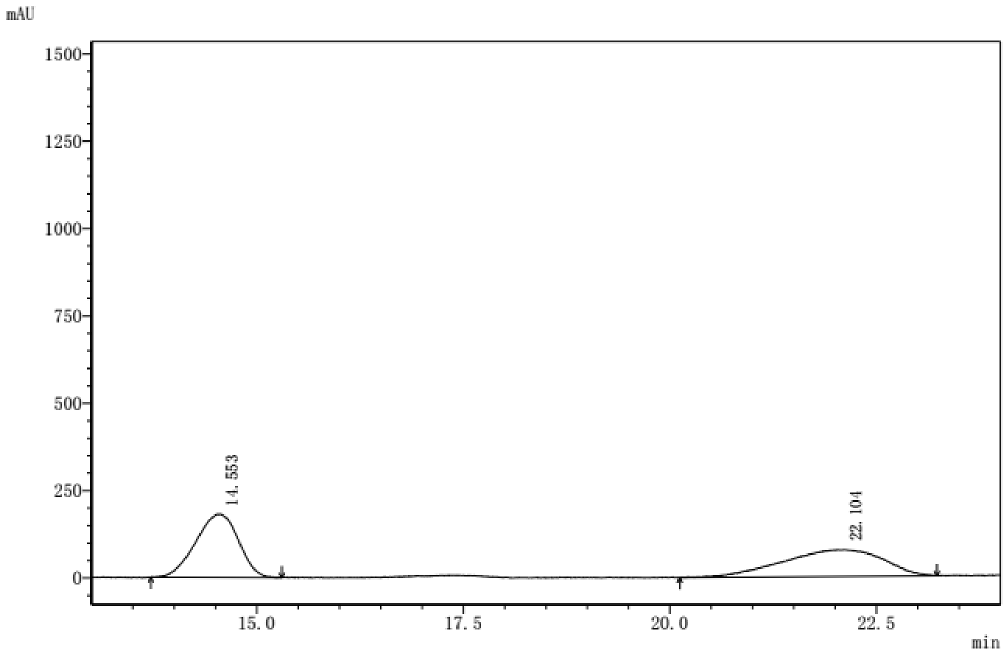
Peak	RetTime	Area	Height	Area%
1	5.585	4150119	431972	49.732
2	7.500	4194833	313533	50.268

HPLC spectra of **enantioenriched-3ae**



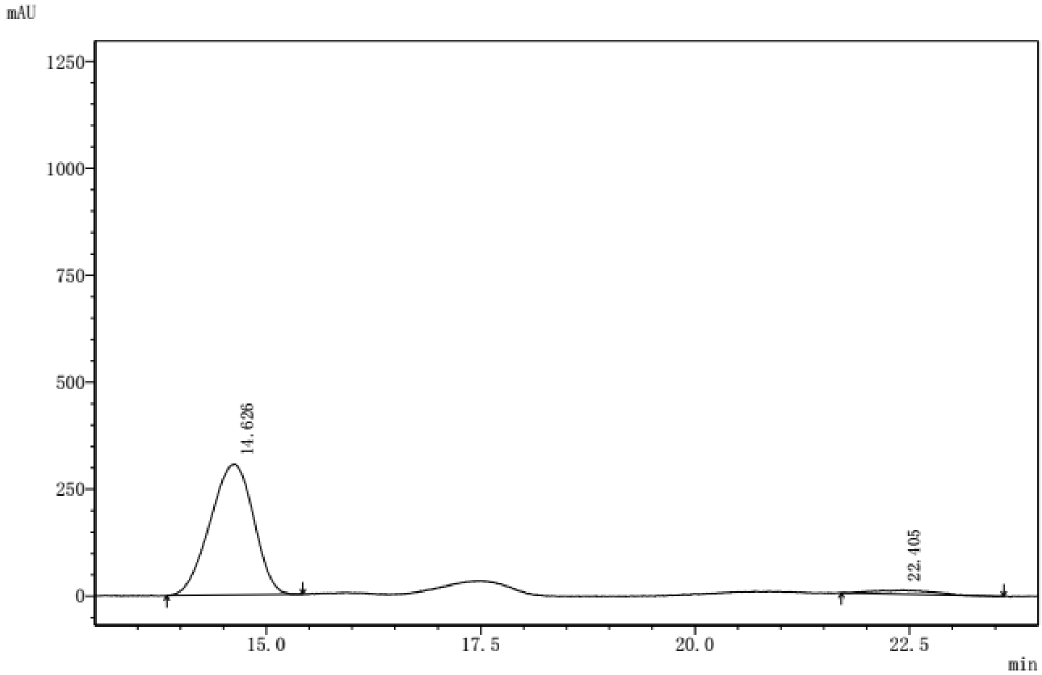
Peak	RetTime	Area	Height	Area%
1	5.559	417611	51195	3.632
2	7.456	11079941	698765	96.368

HPLC spectra of *racemic*-**4ae**



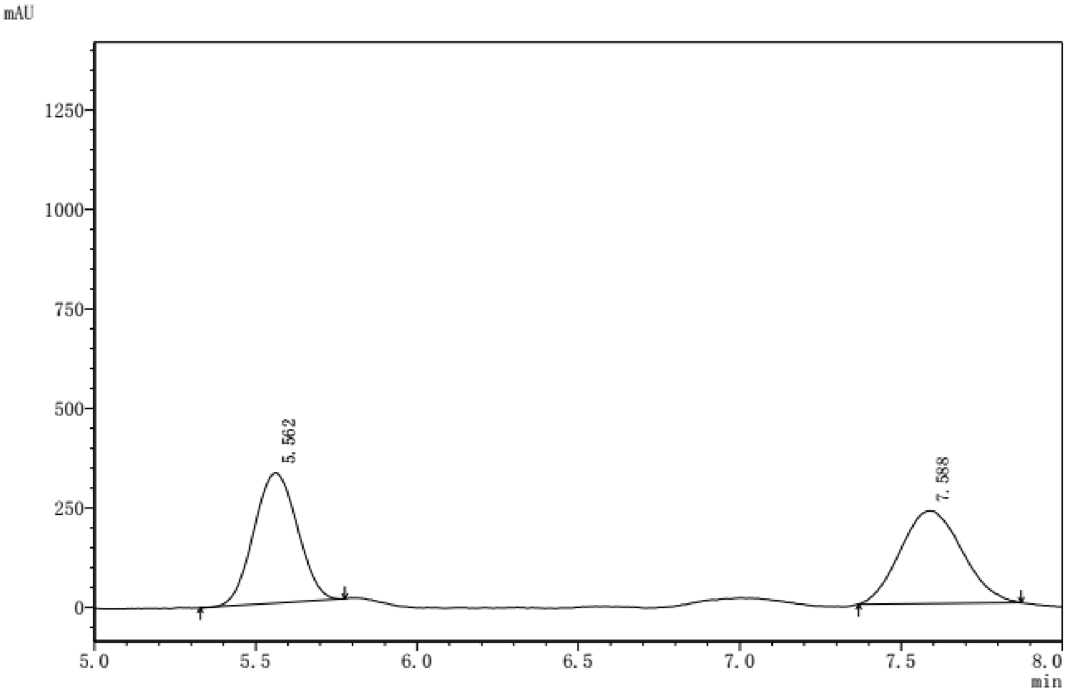
Peak	RetTime	Area	Height	Area%
1	14.553	6549800	181329	50.249
2	22.104	6484877	76175	49.751

HPLC spectra of **enantioenriched-4ae**



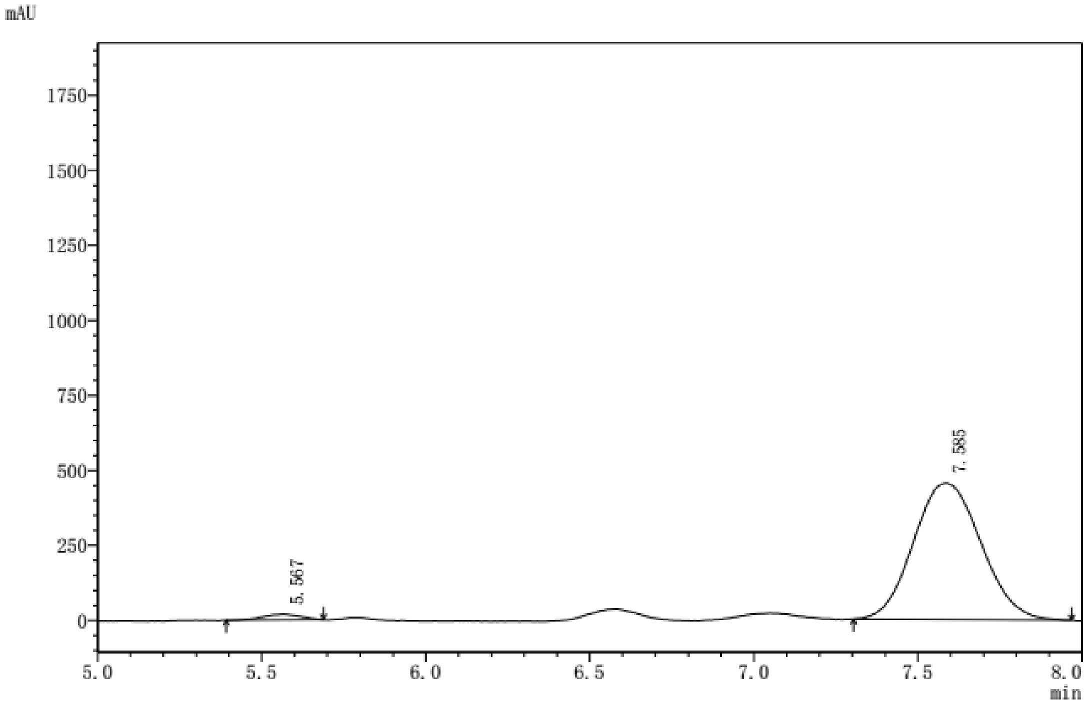
Peak	RetTime	Area	Height	Area%
1	14.626	10776223	305192	96.124
2	22.405	434472	9421	3.876

HPLC spectra of *racemic*-**3af**



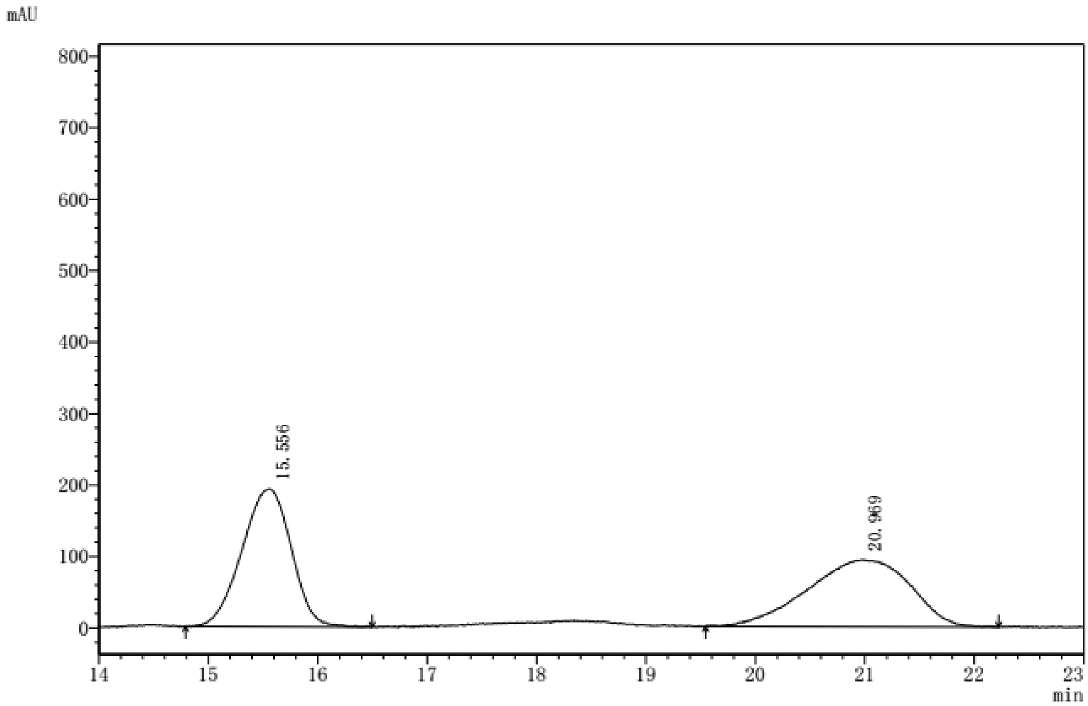
Peak	RetTime	Area	Height	Area%
1	5.562	3062325	326078	49.718
2	7.588	3097066	232382	50.282

HPLC spectra of **enantioenriched-3af**



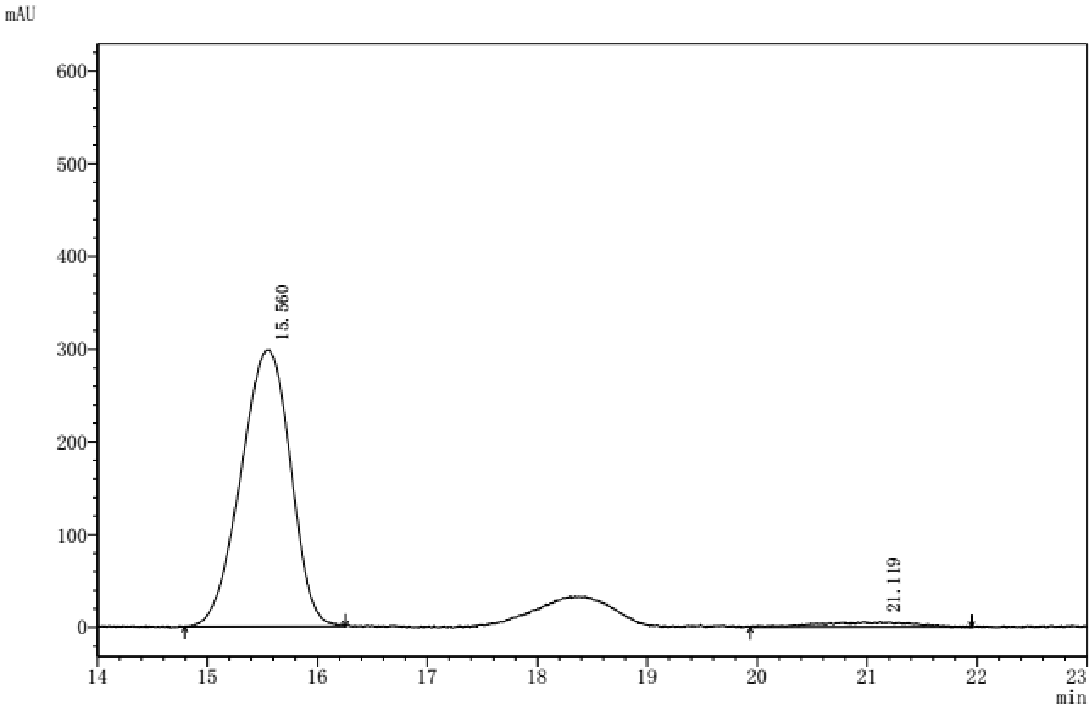
Peak	RetTime	Area	Height	Area%
1	5.567	141432	17746	2.130
2	7.585	6498034	454123	97.870

HPLC spectra of *racemic*-**4af**



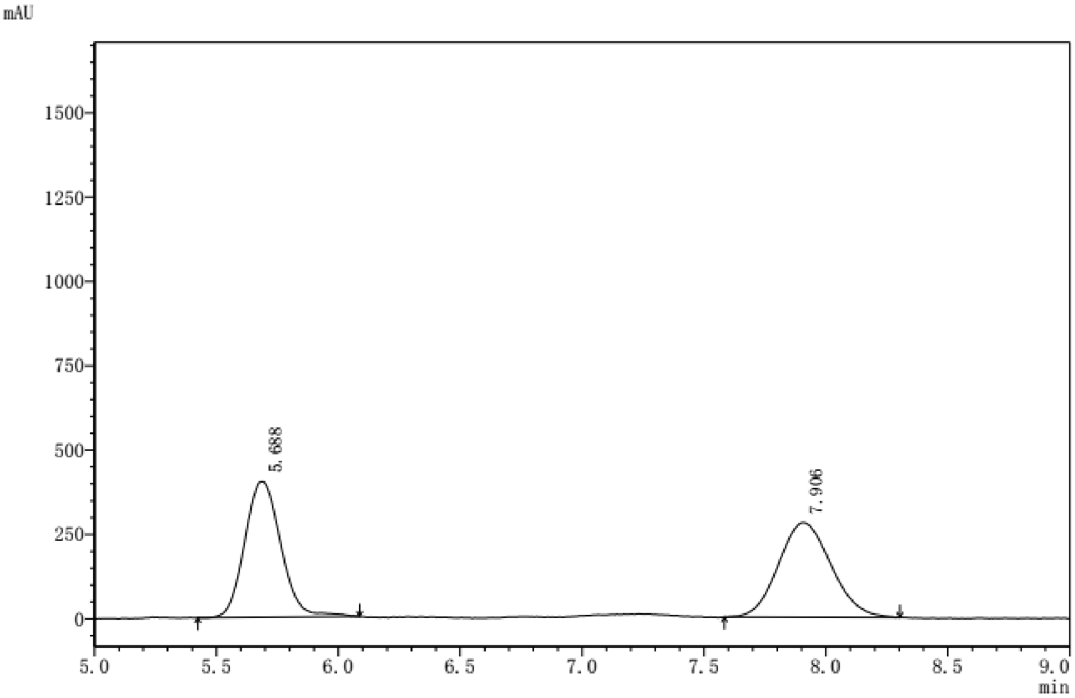
Peak	RetTime	Area	Height	Area%
1	15.556	6052927	192746	49.723
2	20.969	6120268	93699	50.277

HPLC spectra of **enantioenriched-4af**



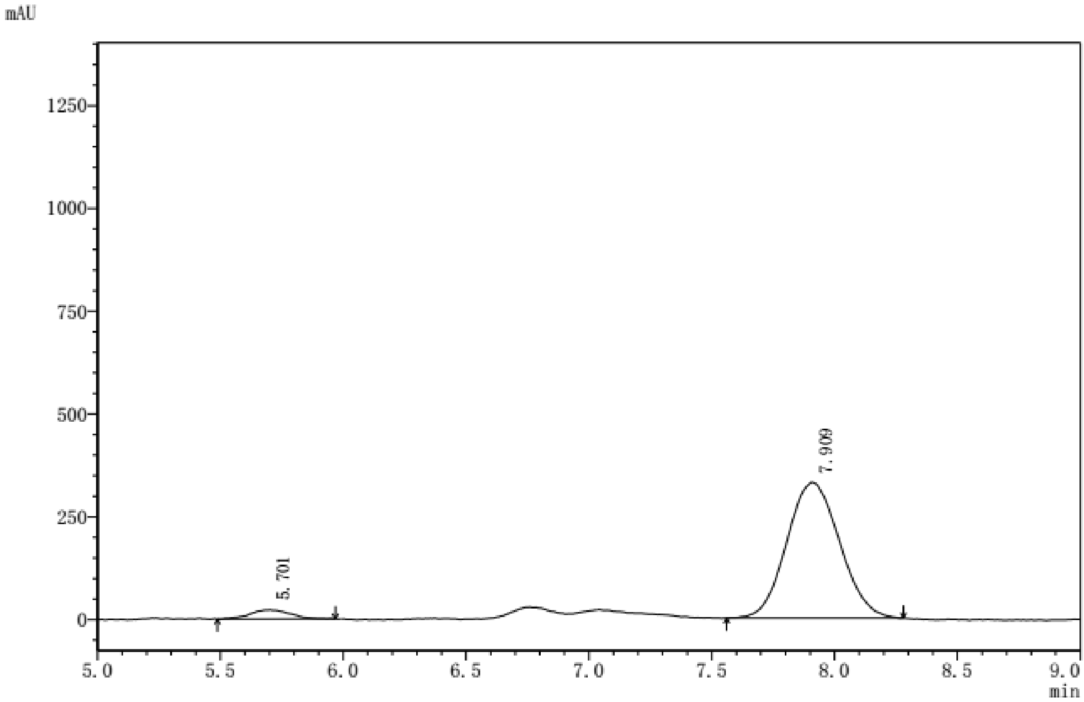
Peak	RetTime	Area	Height	Area%
1	15.560	9377205	298446	96.718
2	21.119	318223	5645	3.282

HPLC spectra of *racemic*-**3ag**



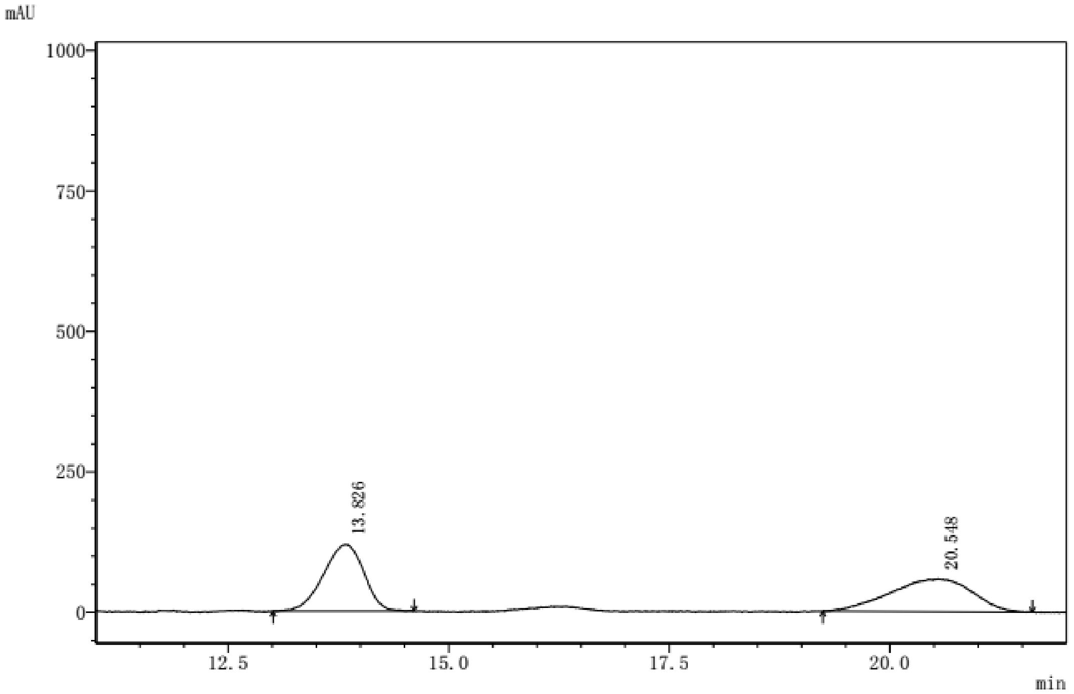
Peak	RetTime	Area	Height	Area%
1	5.688	4136508	401676	49.608
2	7.906	4201919	279884	50.392

HPLC spectra of **enantioenriched-3ag**



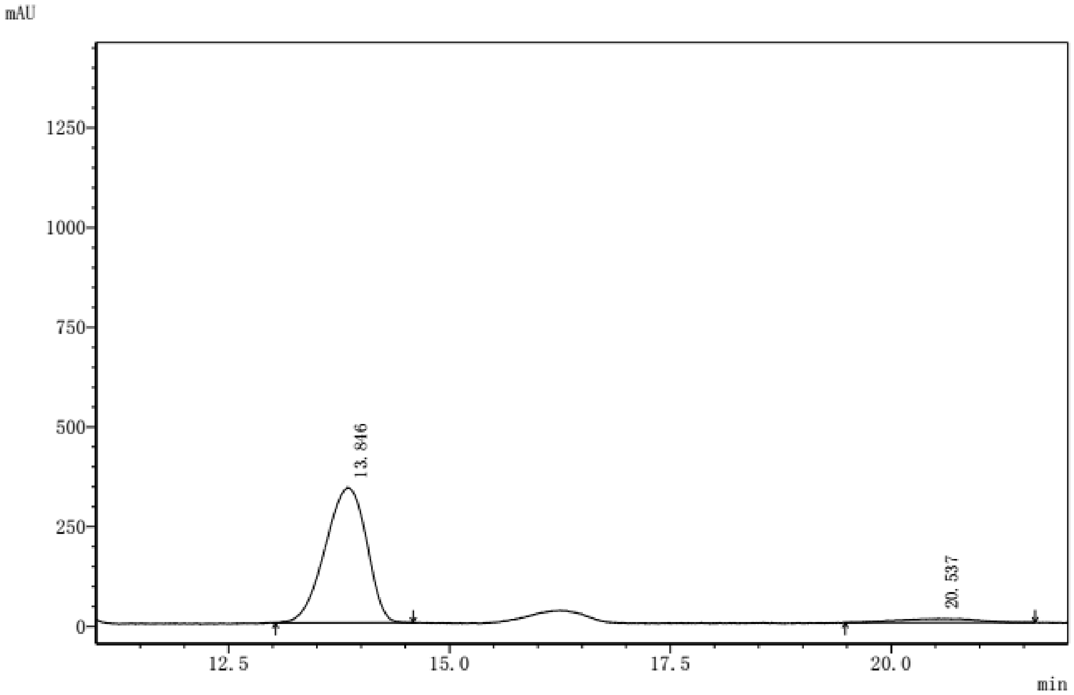
Peak	RetTime	Area	Height	Area%
1	5.701	251130	22249	4.835
2	7.909	4942898	329918	95.165

HPLC spectra of *racemic*-**4ag**



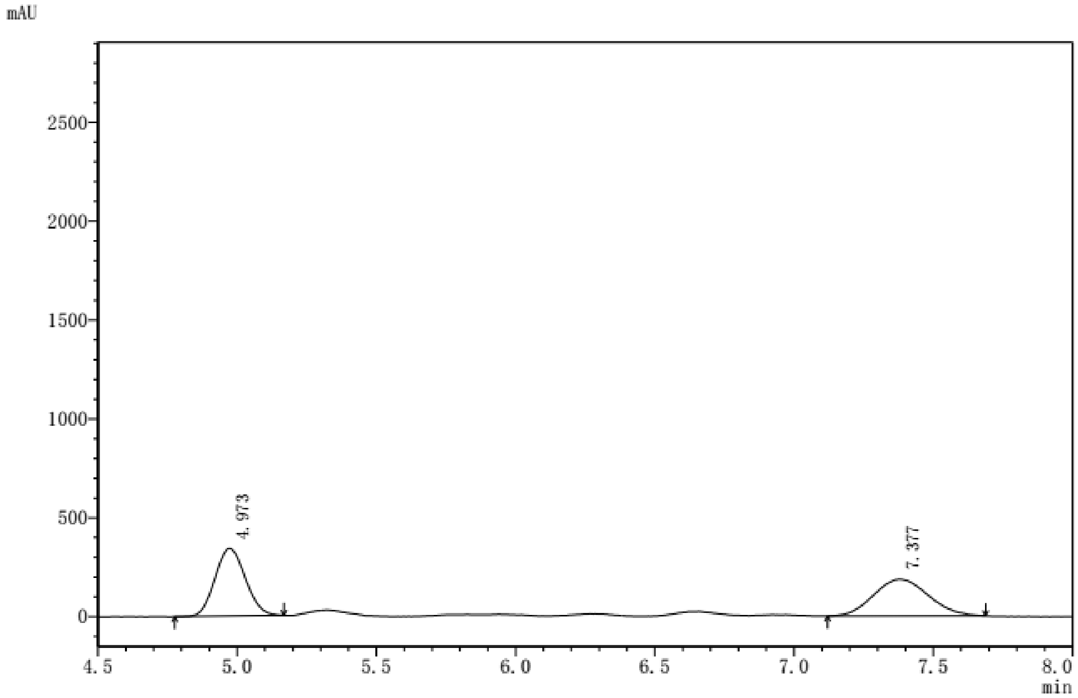
Peak	RetTime	Area	Height	Area%
1	13.826	3808931	118667	49.997
2	20.548	3809323	58725	50.003

HPLC spectra of **enantioenriched-4ag**



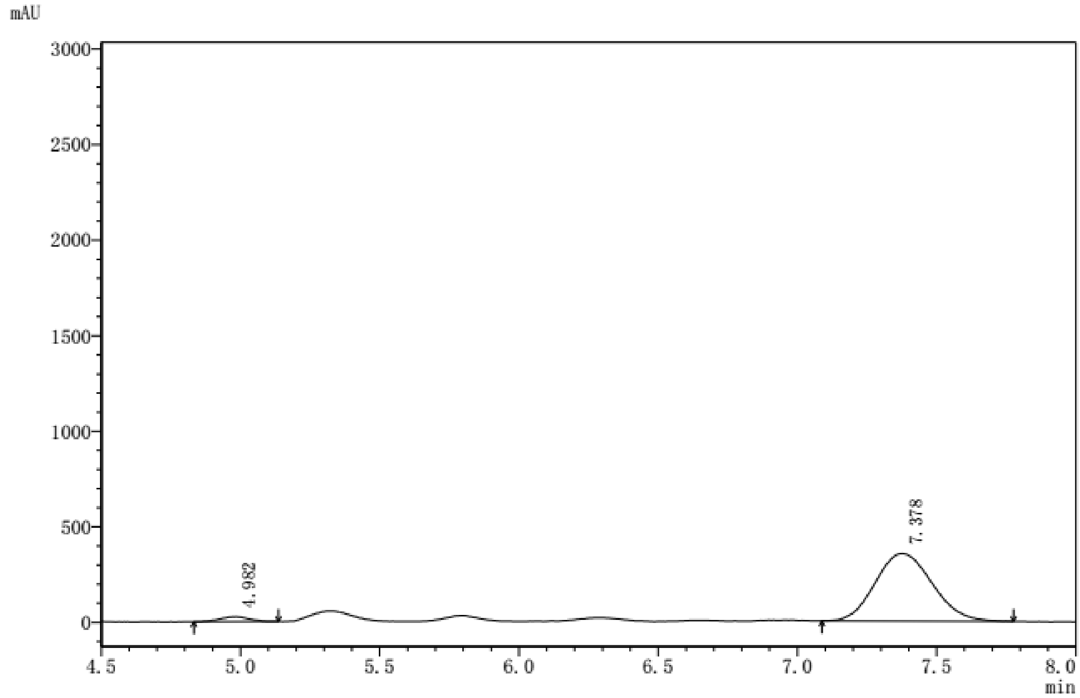
Peak	RetTime	Area	Height	Area%
1	13.846	11029943	338974	95.415
2	20.537	530058	9269	4.585

HPLC spectra of *racemic*-**3ah**



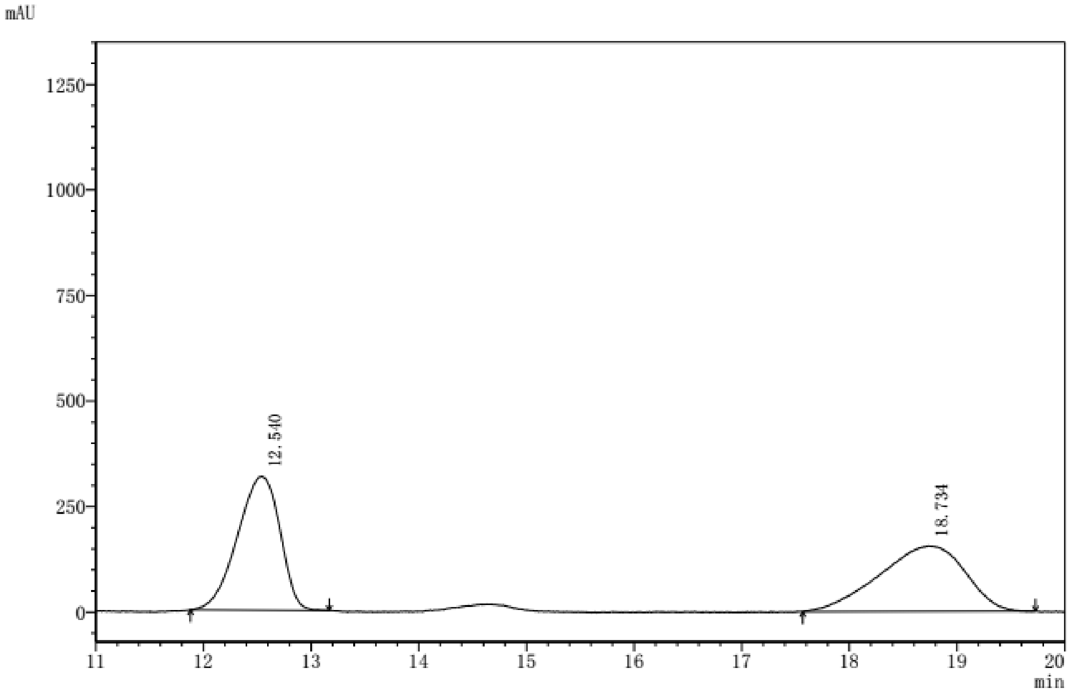
Peak	RetTime	Area	Height	Area%
1	4.973	2591518	341558	50.393
2	7.377	2551055	185778	49.607

HPLC spectra of **enantioenriched-3ah**



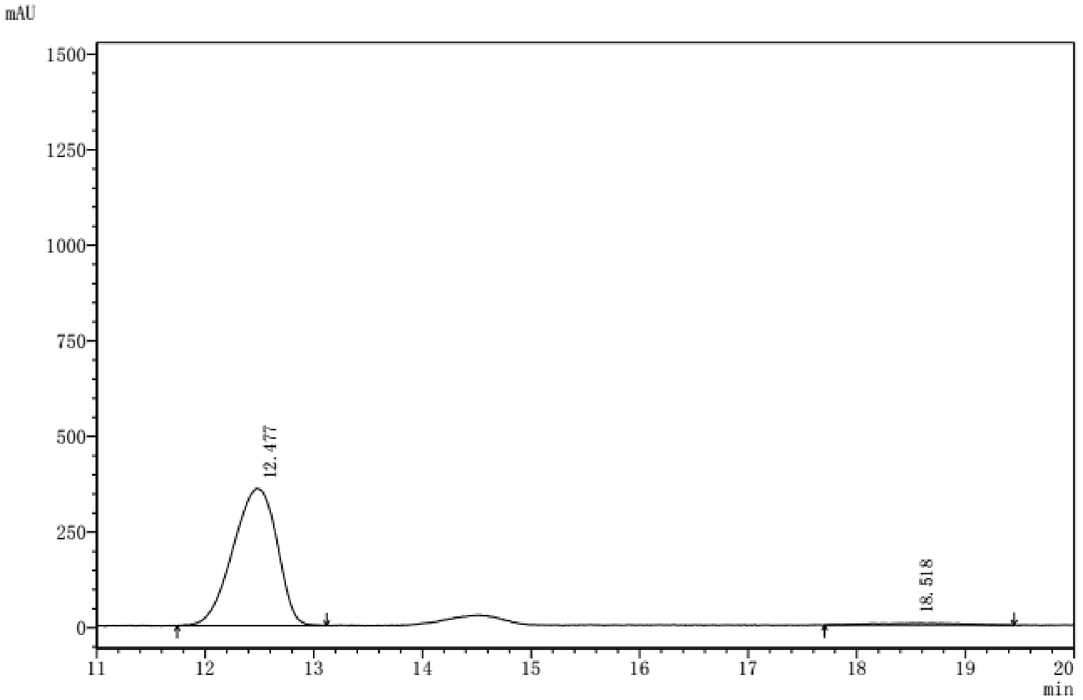
Peak	RetTime	Area	Height	Area%
1	4.982	181638	25414	3.488
2	7.378	5025320	353101	96.512

HPLC spectra of *racemic*-**4ah**



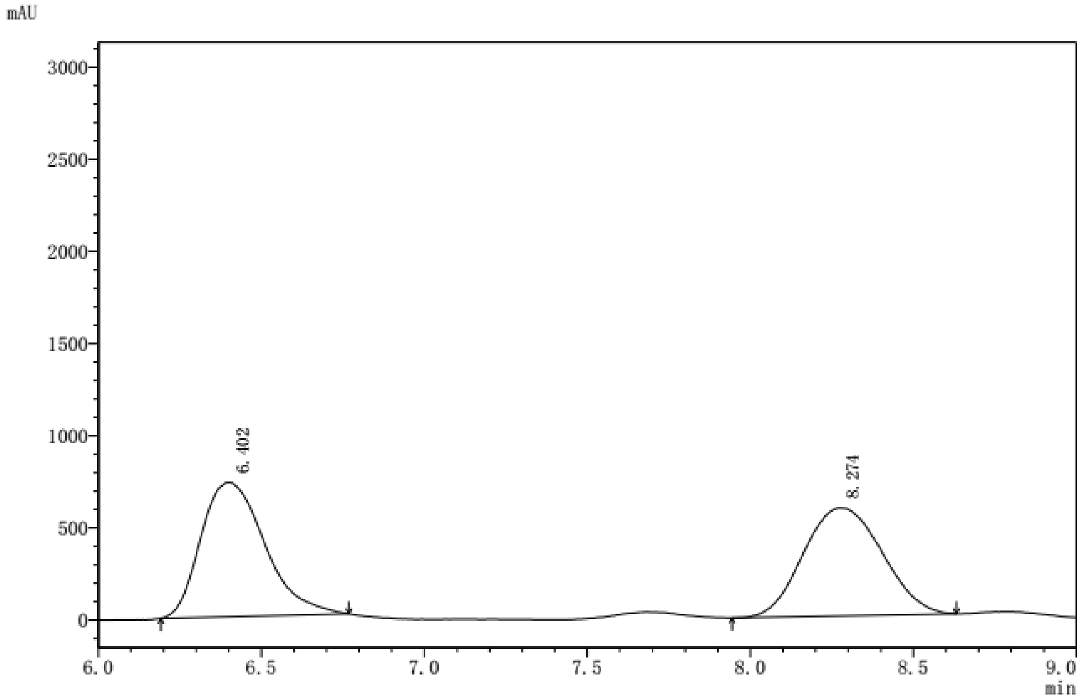
Peak	RetTime	Area	Height	Area%
1	12.540	8728726	316931	50.412
2	18.734	8586030	155214	49.588

HPLC spectra of **enantioenriched-4ah**



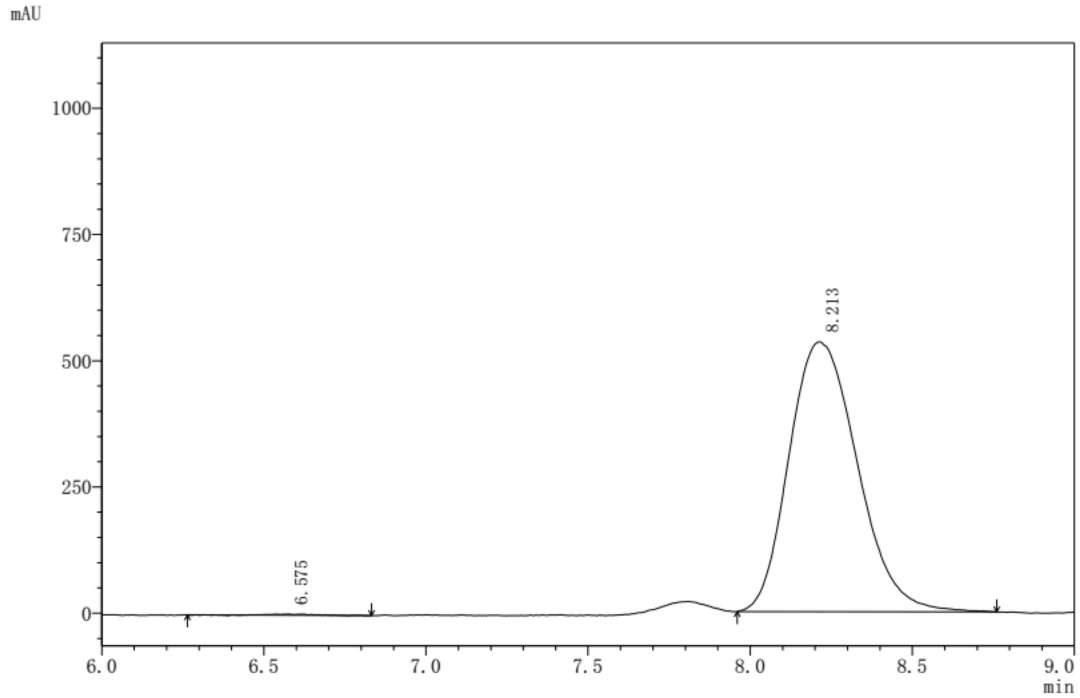
Peak	RetTime	Area	Height	Area%
1	12.477	10133284	358689	97.190
2	18.518	292973	5582	2.810

HPLC spectra of *racemic*-**3ai**



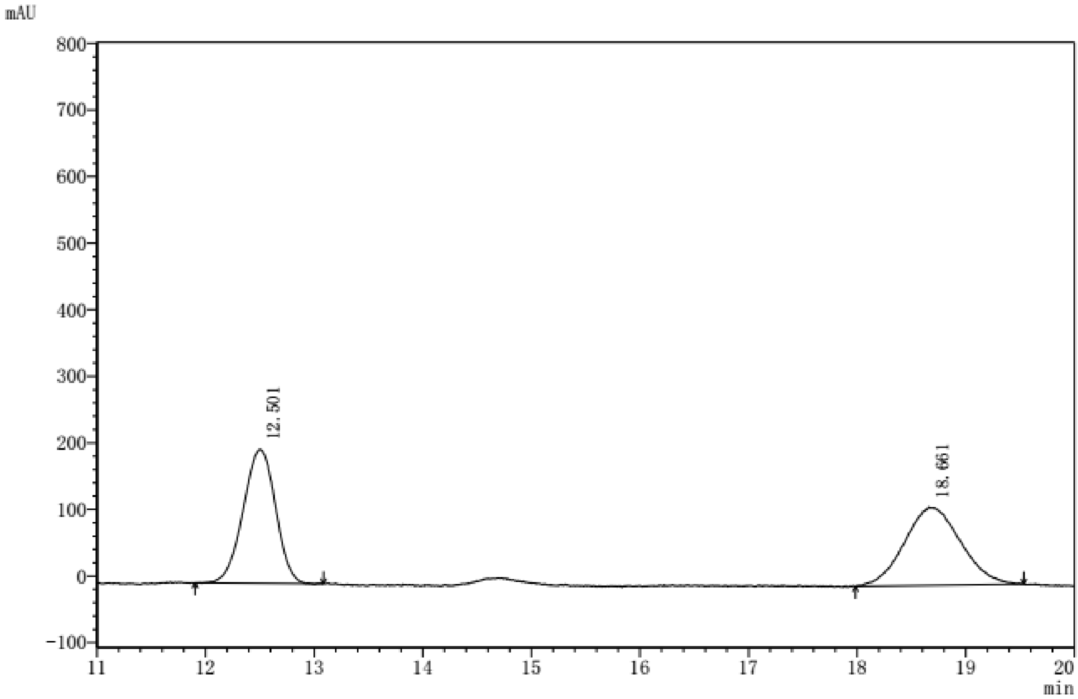
Peak	RetTime	Area	Height	Area%
1	6.402	9942510	727076	50.236
2	8.274	9849056	585460	49.764

HPLC spectra of **enantioenriched-3ai**



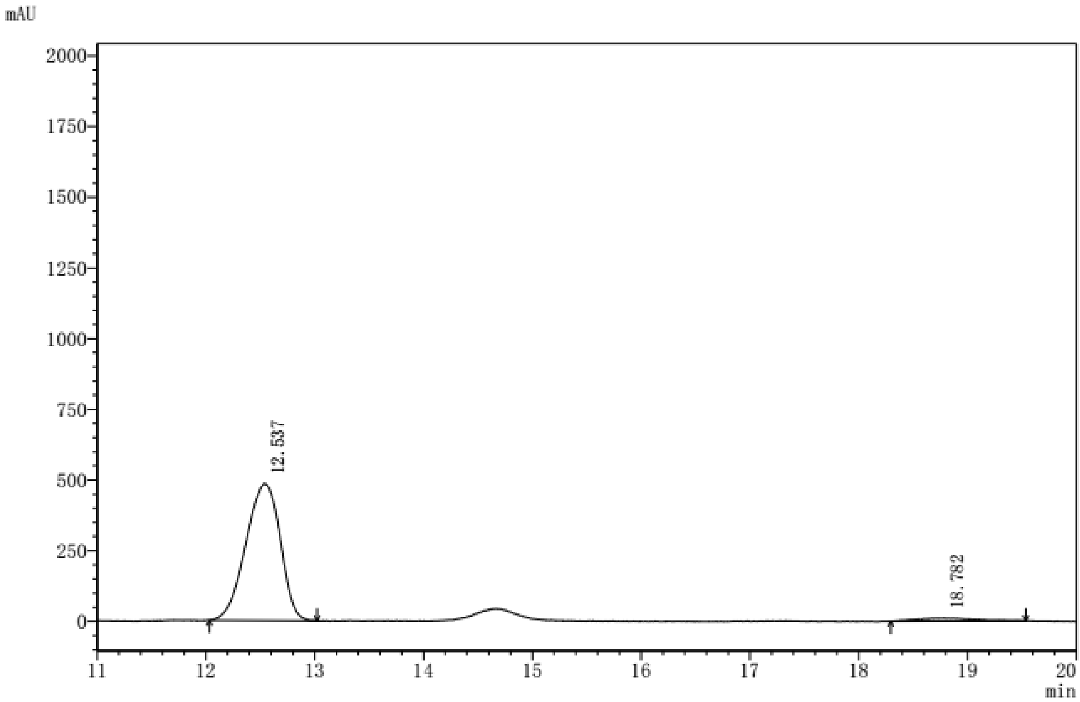
Peak	RetTime	Area	Height	Area%
1	6.575	23386	2342	0.297
2	8.213	7845615	534474	99.703

HPLC spectra of *racemic*-**4ai**



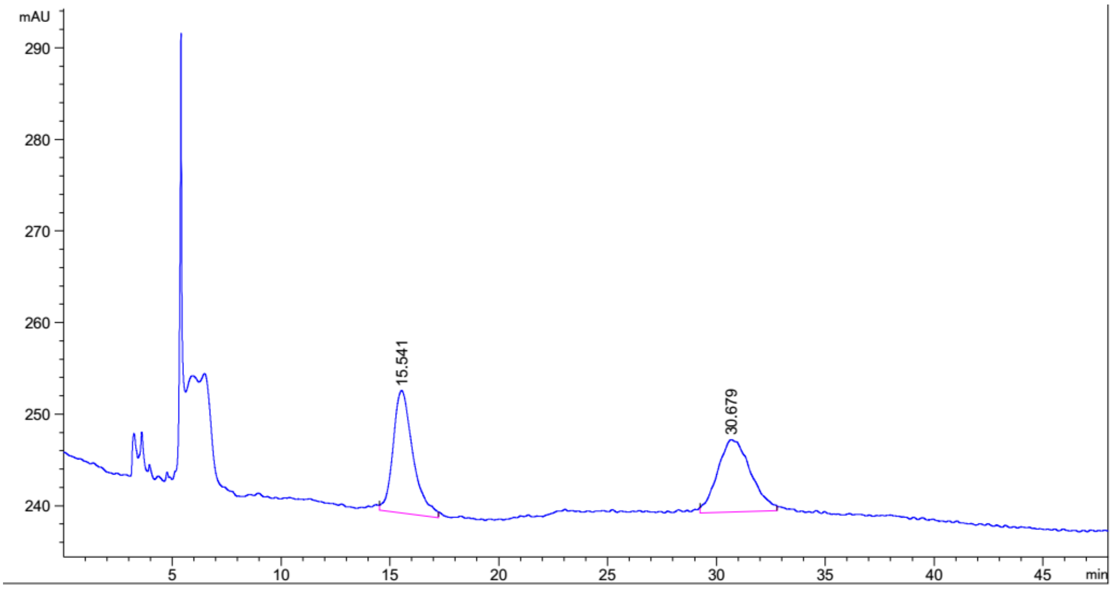
Peak	RetTime	Area	Height	Area%
1	12.501	4170980	200896	49.808
2	18.661	4203080	117205	50.192

HPLC spectra of **enantioenriched-4ai**



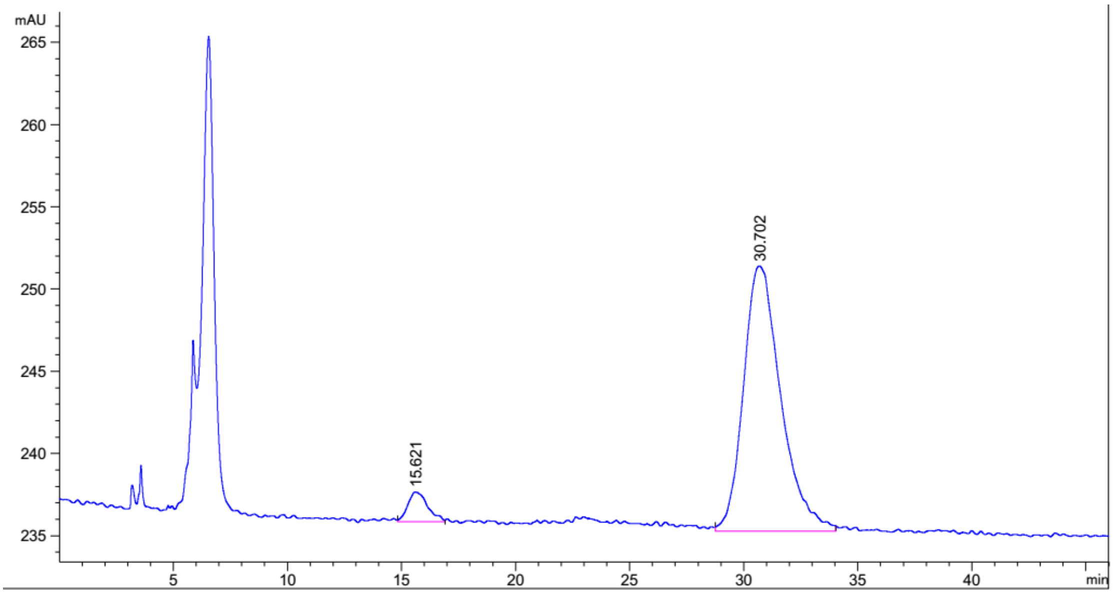
Peak	RetTime	Area	Height	Area%
1	12.537	10640953	482765	96.644
2	18.782	369468	10196	3.356

HPLC spectra of *racemic*-**3aj**



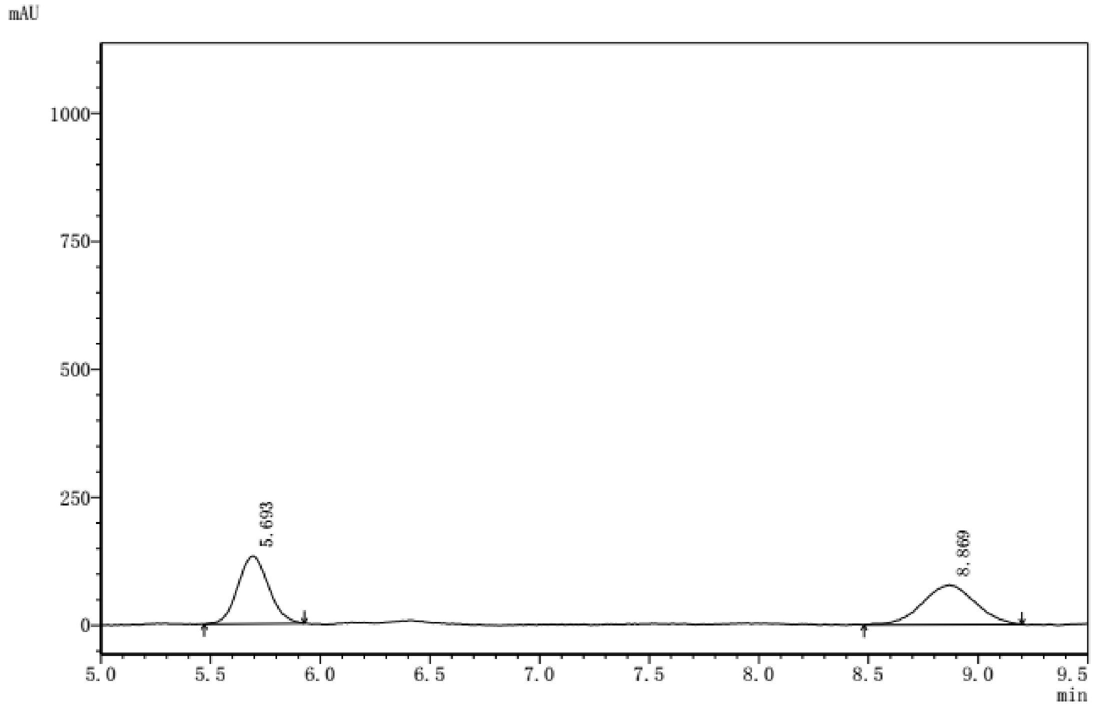
Peak	RetTime	Area	Height	Area%
1	15.54	852.45789	13.36509	50.5
2	30.68	836.43781	7.88785	49.5

HPLC spectra of **enantioenriched-3aj**



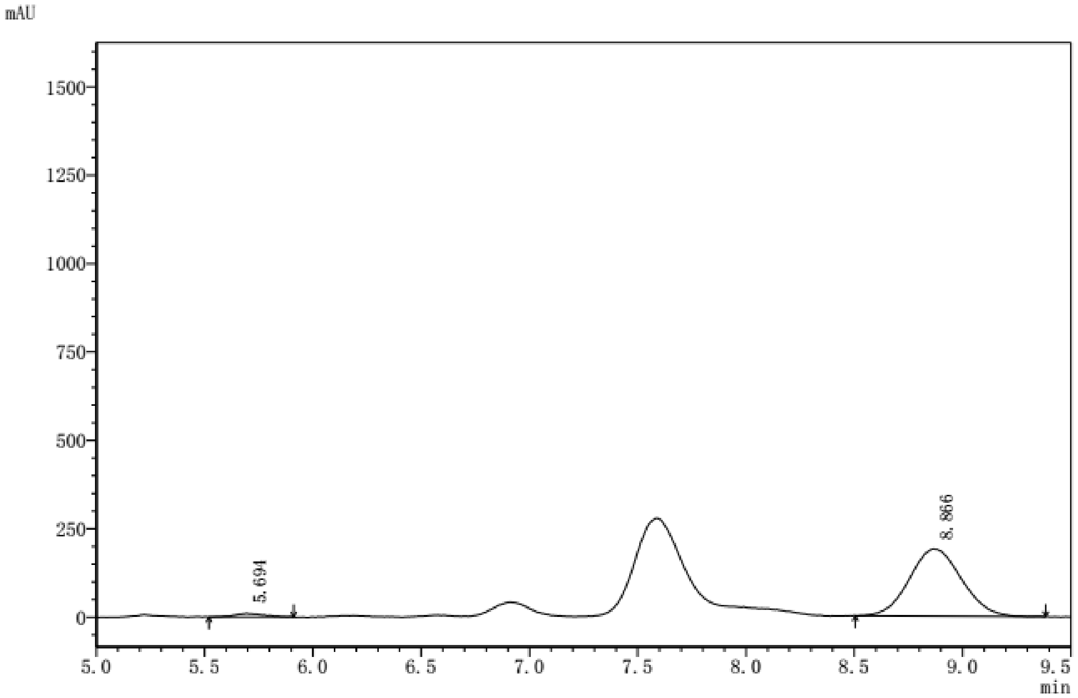
Peak	RetTime	Area	Height	Area%
1	15.62	111.60094	1.81803	5.7
2	30.70	1834.08960	16.11733	94.3

HPLC spectra of *racemic*-**3ak**



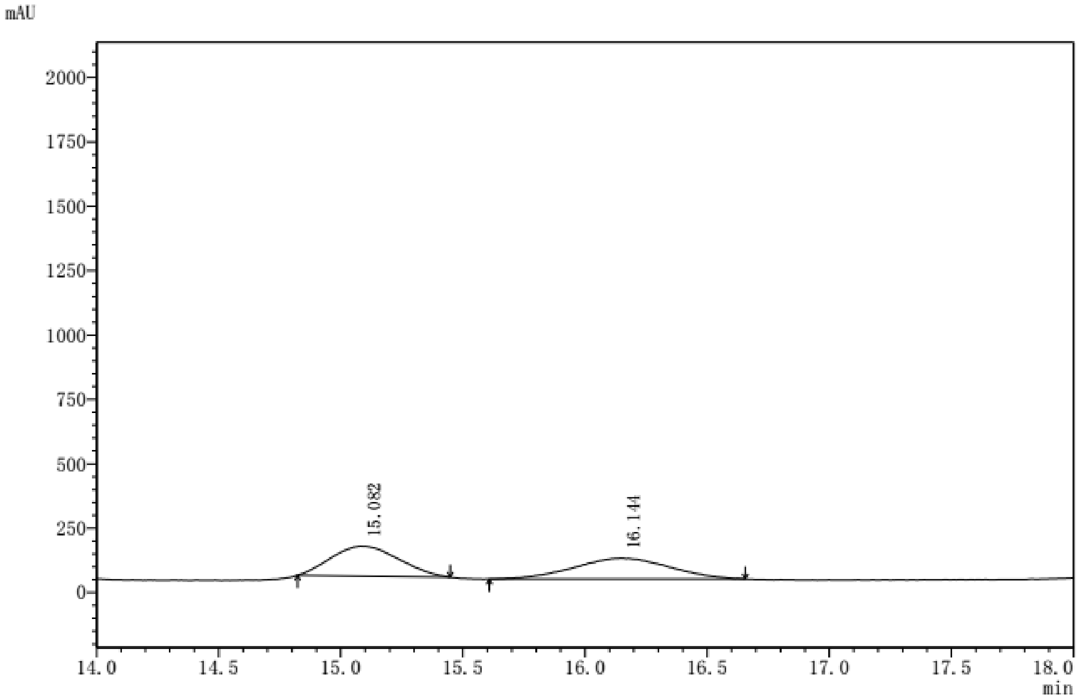
Peak	RetTime	Area	Height	Area%
1	5.693	1289295	131724	49.922
2	8.869	1293318	77220	50.078

HPLC spectra of **enantioenriched-3ak**



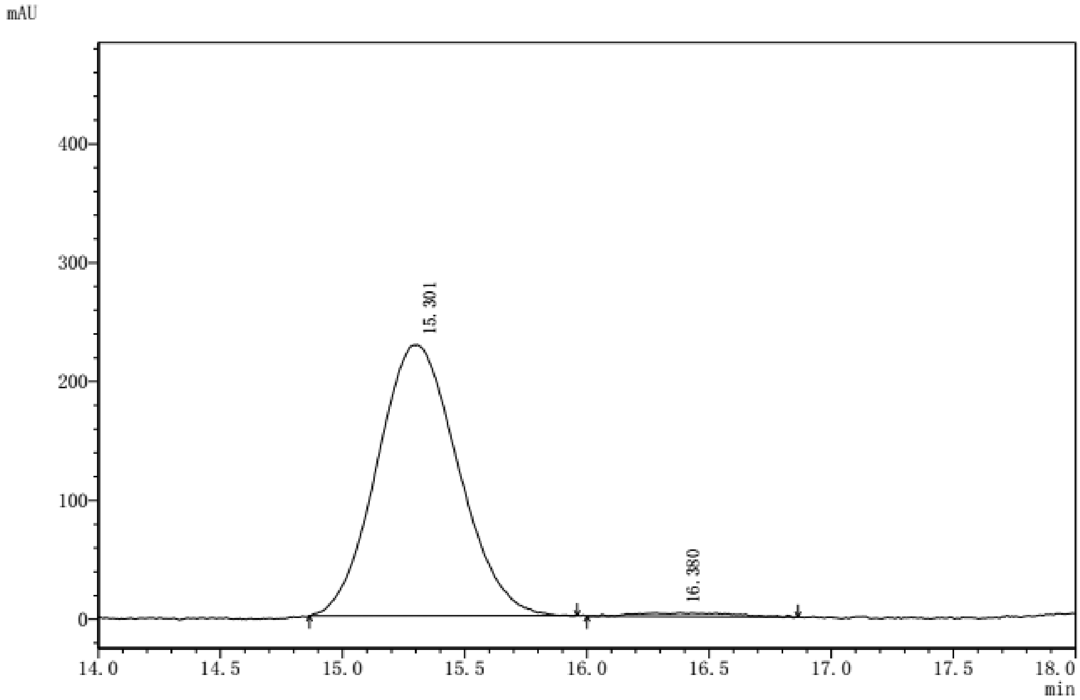
Peak	RetTime	Area	Height	Area%
1	5.694	95991	10333	2.927
2	8.866	3182966	189990	97.073

HPLC spectra of *racemic*-**4ak**



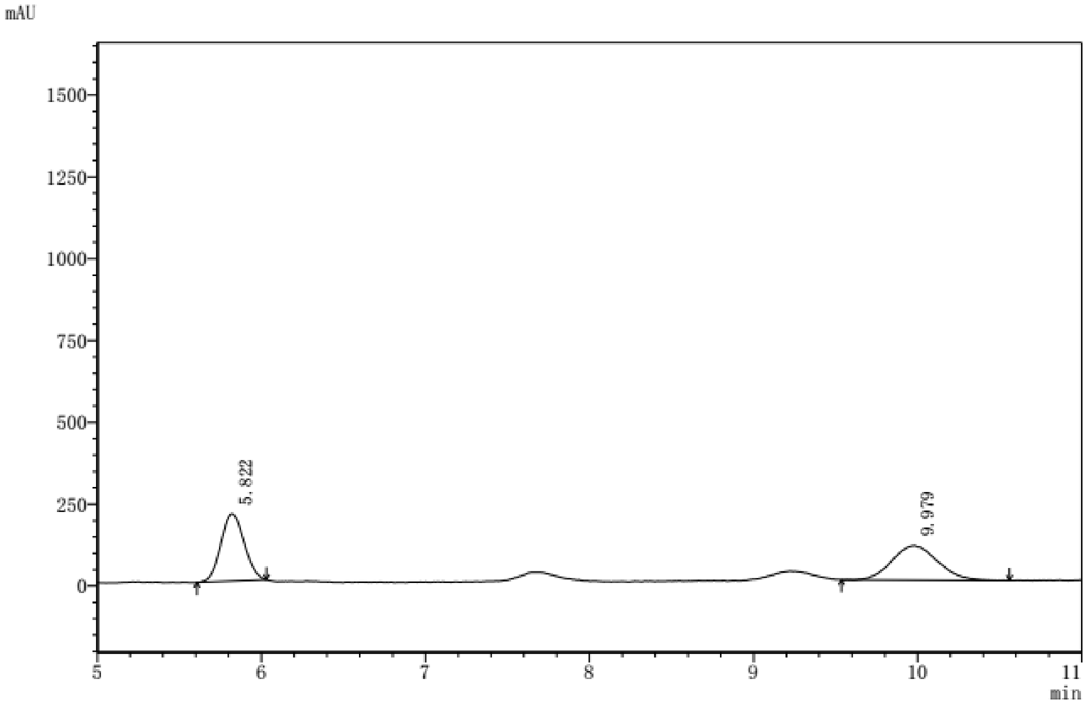
Peak	RetTime	Area	Height	Area%
1	15.082	2232871	115912	50.222
2	16.144	2213171	80978	49.778

HPLC spectra of **enantioenriched-4ak**



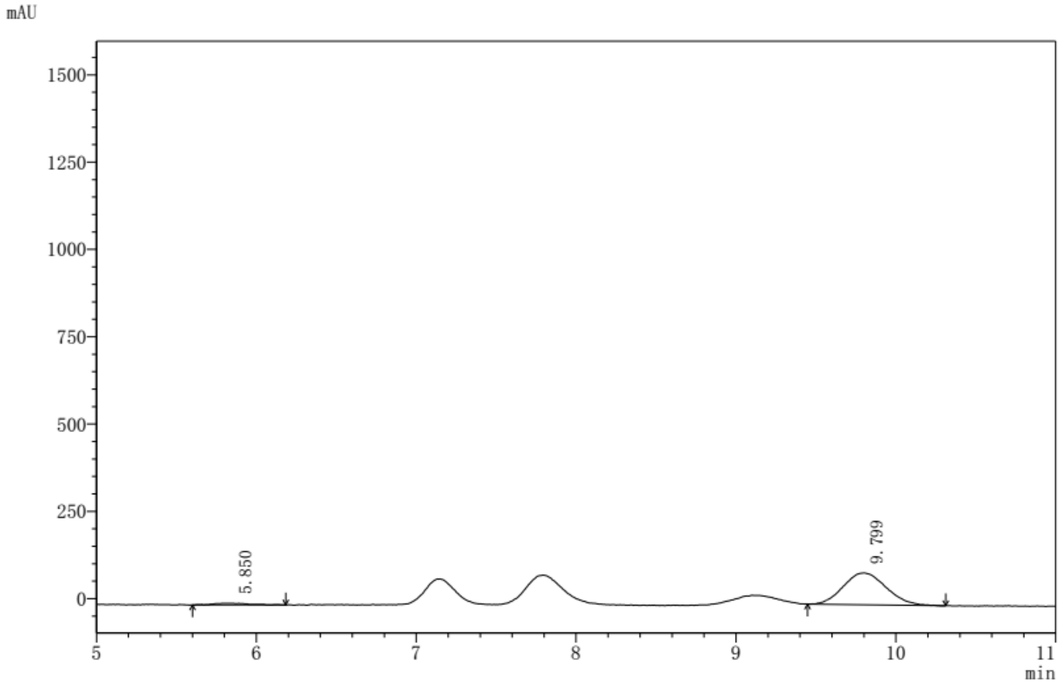
Peak	RetTime	Area	Height	Area%
1	15.301	5268465	227879	98.442
2	16.380	83391	3152	1.558

HPLC spectra of *racemic*-**3al**



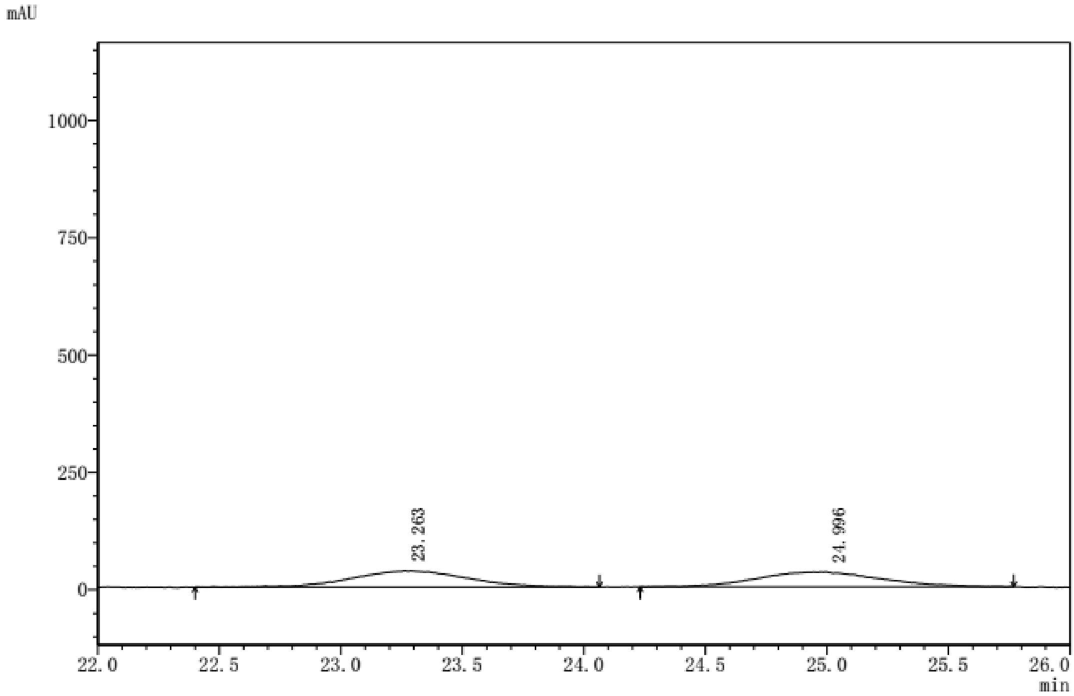
Peak	RetTime	Area	Height	Area%
1	5.822	4703883	166411	49.765
2	9.979	4748247	122015	50.235

HPLC spectra of **enantioenriched-3al**



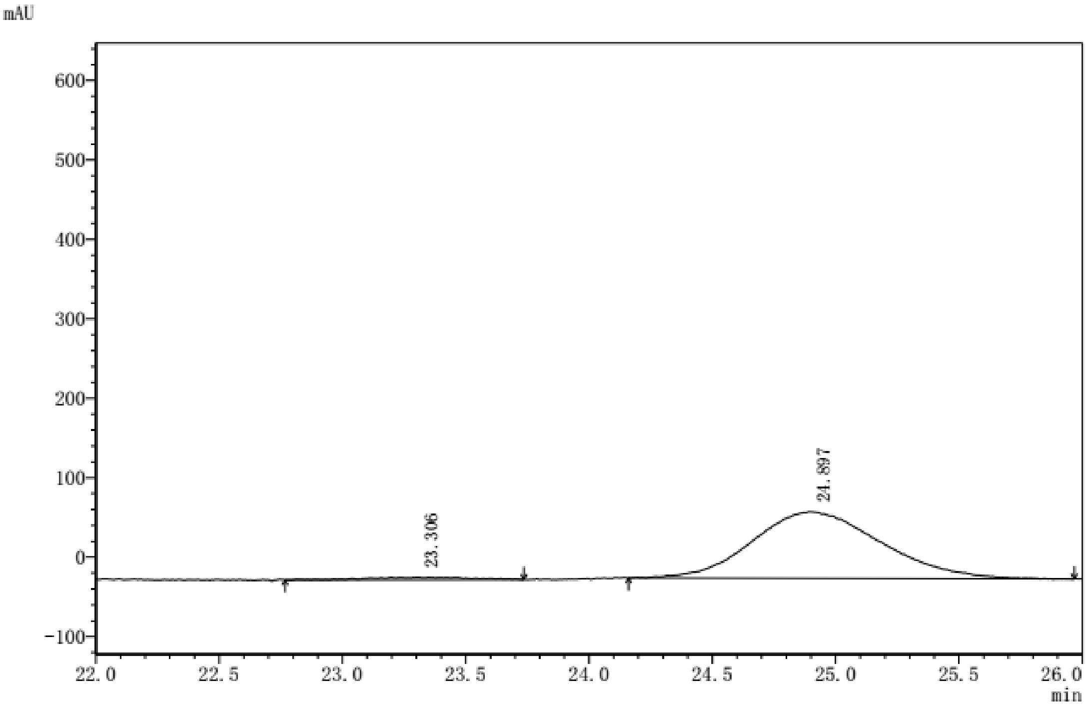
Peak	RetTime	Area	Height	Area%
1	5.850	66661	4712	3.781
2	9.799	1696455	91209	96.219

HPLC spectra of *racemic*-**4al**



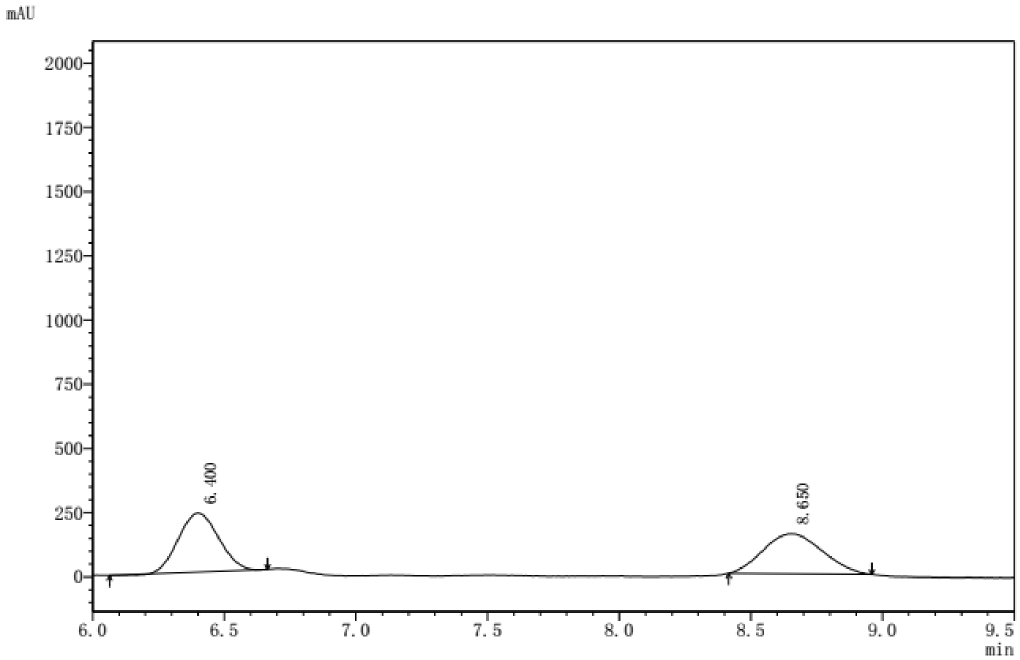
Peak	RetTime	Area	Height	Area%
1	23.263	1122480	34912	50.195
2	24.996	1113771	32196	49.805

HPLC spectra of **enantioenriched-4al**



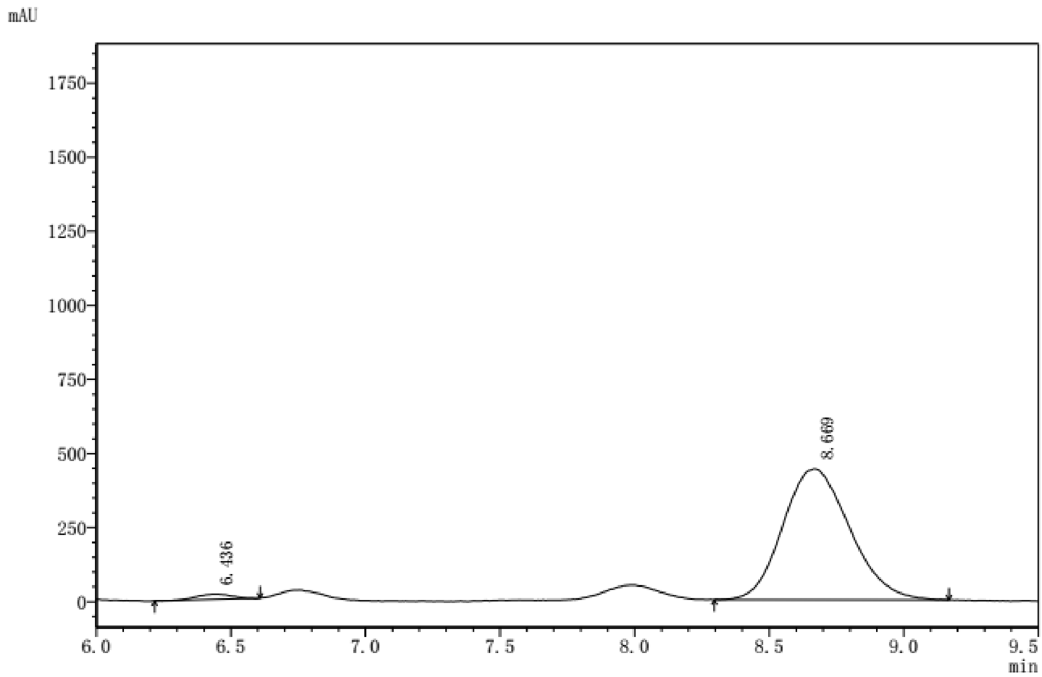
Peak	RetTime	Area	Height	Area%
1	23.306	92466	3317	2.953
2	24.897	3038695	83797	97.047

HPLC spectra of *racemic*-**3am**



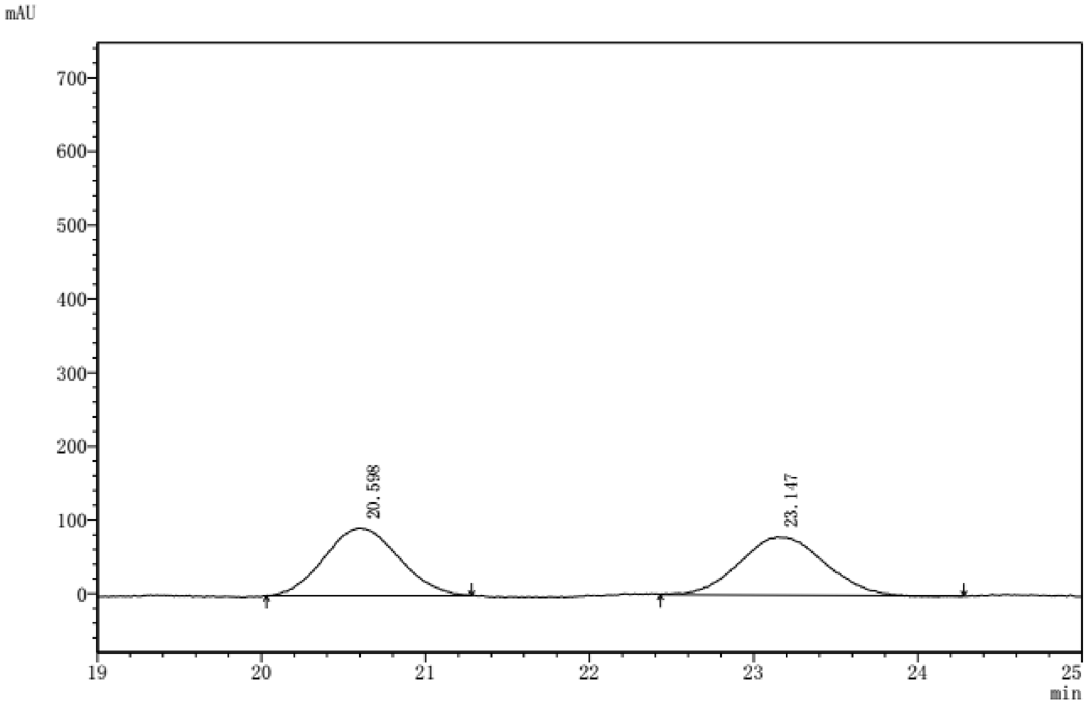
Peak	RetTime	Area	Height	Area%
1	6.400	2418414	228678	49.747
2	8.650	2442972	155569	50.253

HPLC spectra of **enantioenriched-3am**



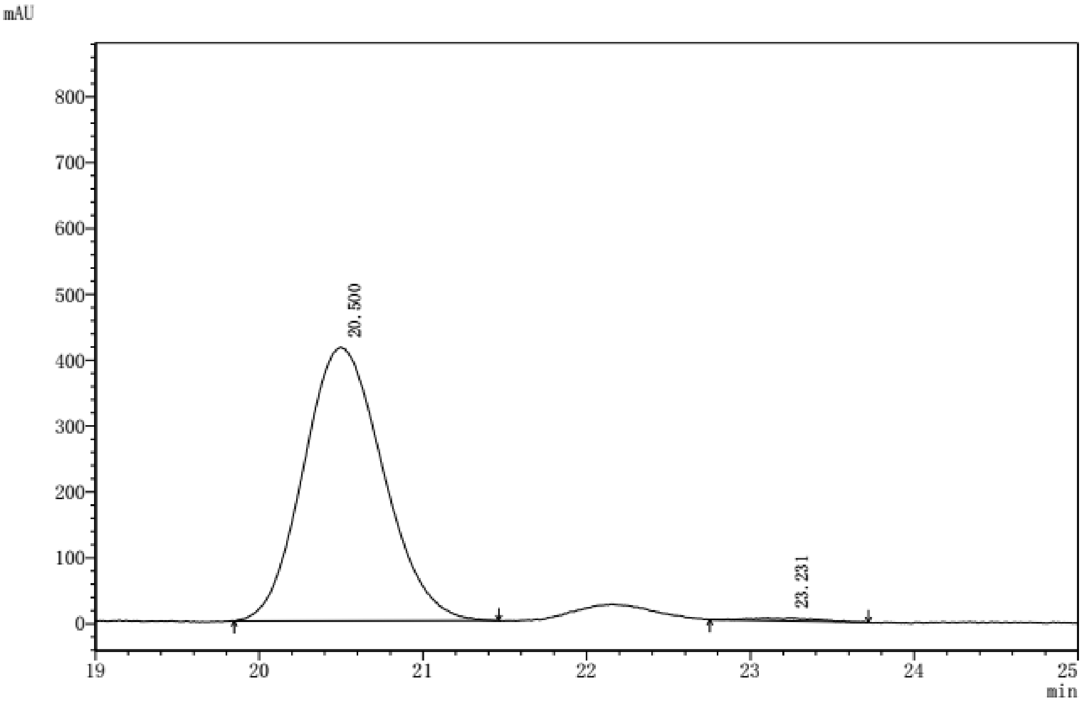
Peak	RetTime	Area	Height	Area%
1	6.436	151105	17140	1.934
2	8.669	7660130	442006	98.066

HPLC spectra of *racemic*-**4am**



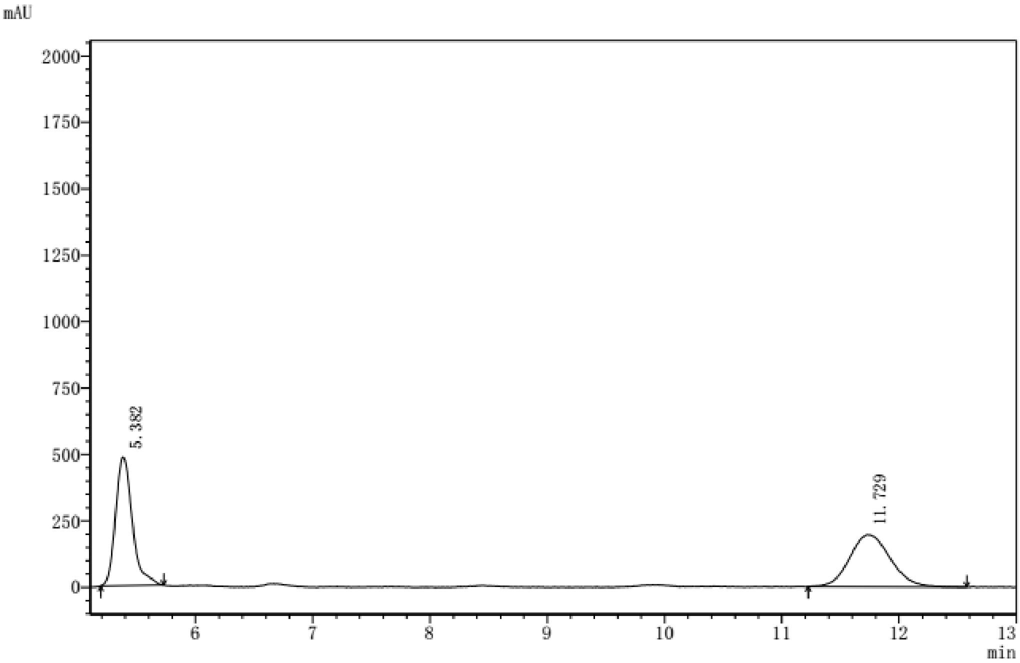
Peak	RetTime	Area	Height	Area%
1	20.598	2894974	91346	50.463
2	23.147	2841863	78979	49.537

HPLC spectra of **enantioenriched-4am**



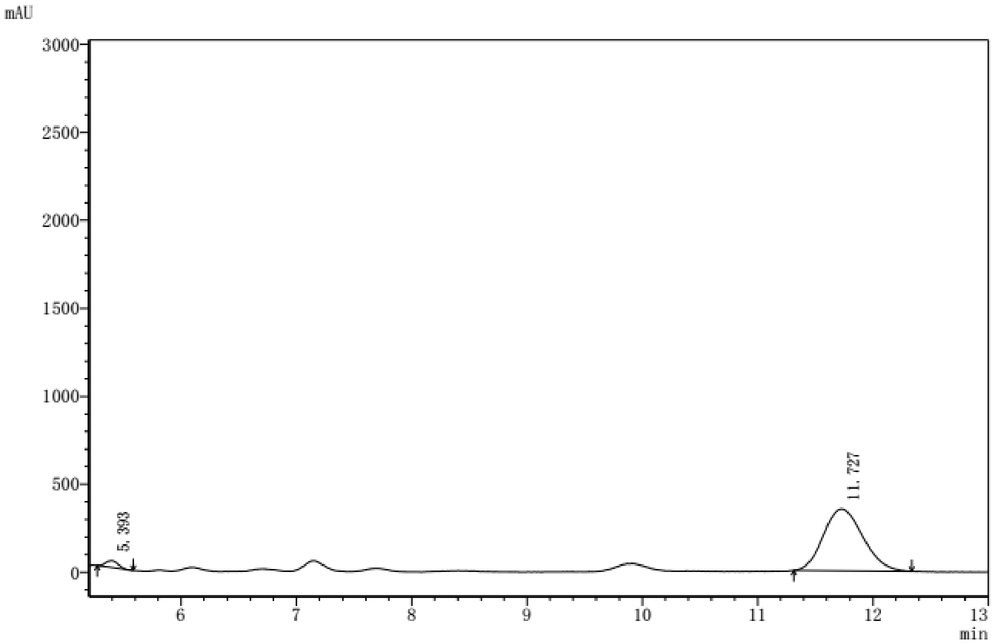
Peak	RetTime	Area	Height	Area%
1	20.500	14024952	415263	99.155
2	23.231	119452	4648	0.845

HPLC spectra of *racemic*-**3an**



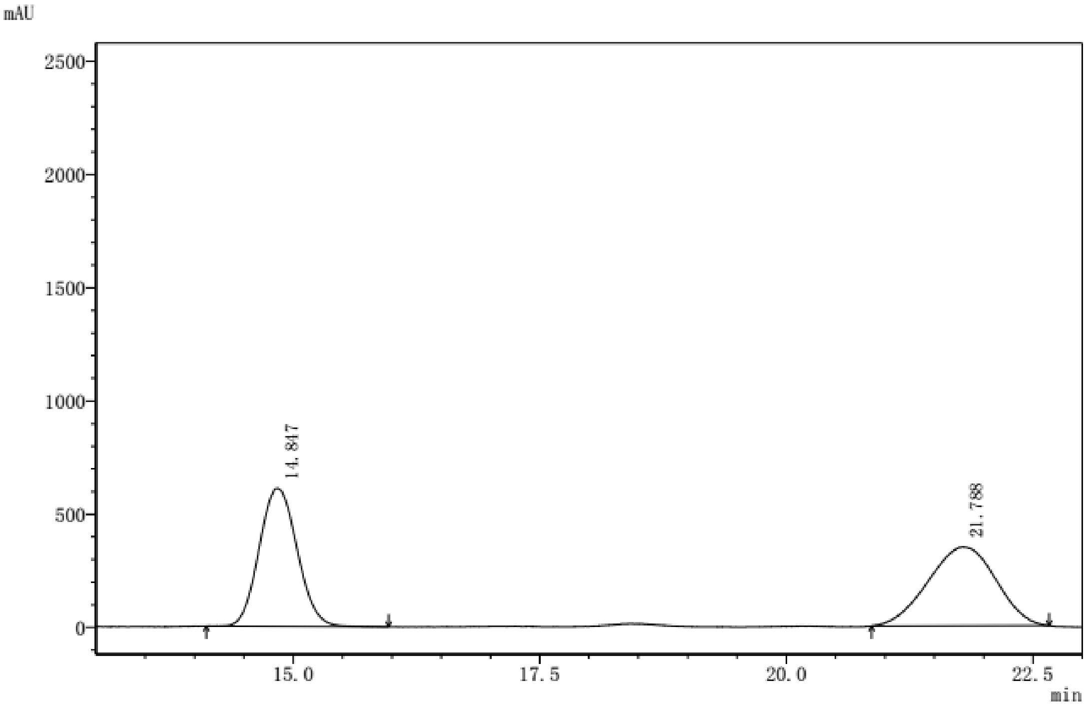
Peak	RetTime	Area	Height	Area%
1	5.382	4836968	483753	50.586
2	11.729	4724845	196109	49.414

HPLC spectra of **enantioenriched-3an**



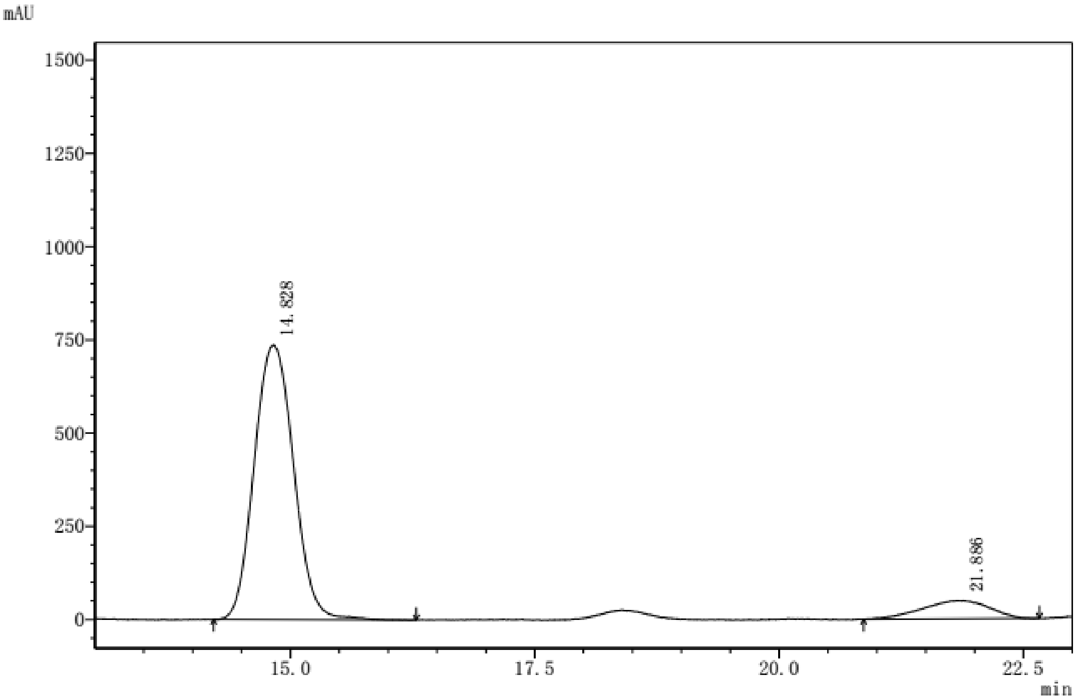
Peak	RetTime	Area	Height	Area%
1	5.393	277595	37634	3.223
2	11.727	8335984	350979	96.777

HPLC spectra of *racemic*-**4an**



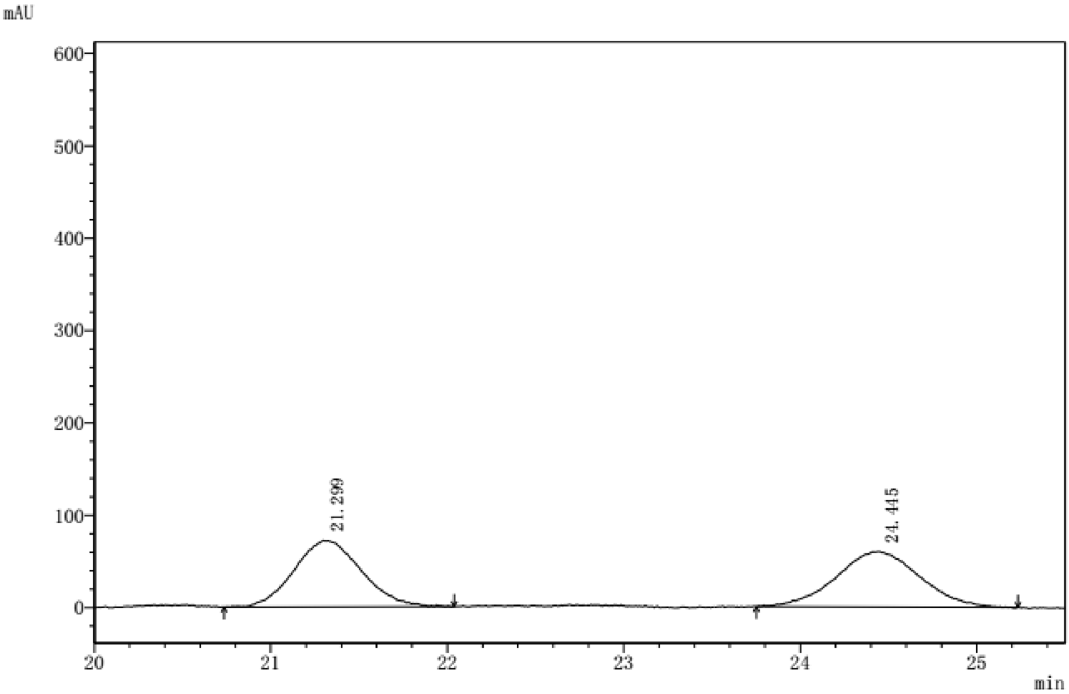
Peak	RetTime	Area	Height	Area%
1	14.847	16362108	609331	49.619
2	21.788	16613211	348746	50.381

HPLC spectra of **enantioenriched-4an**



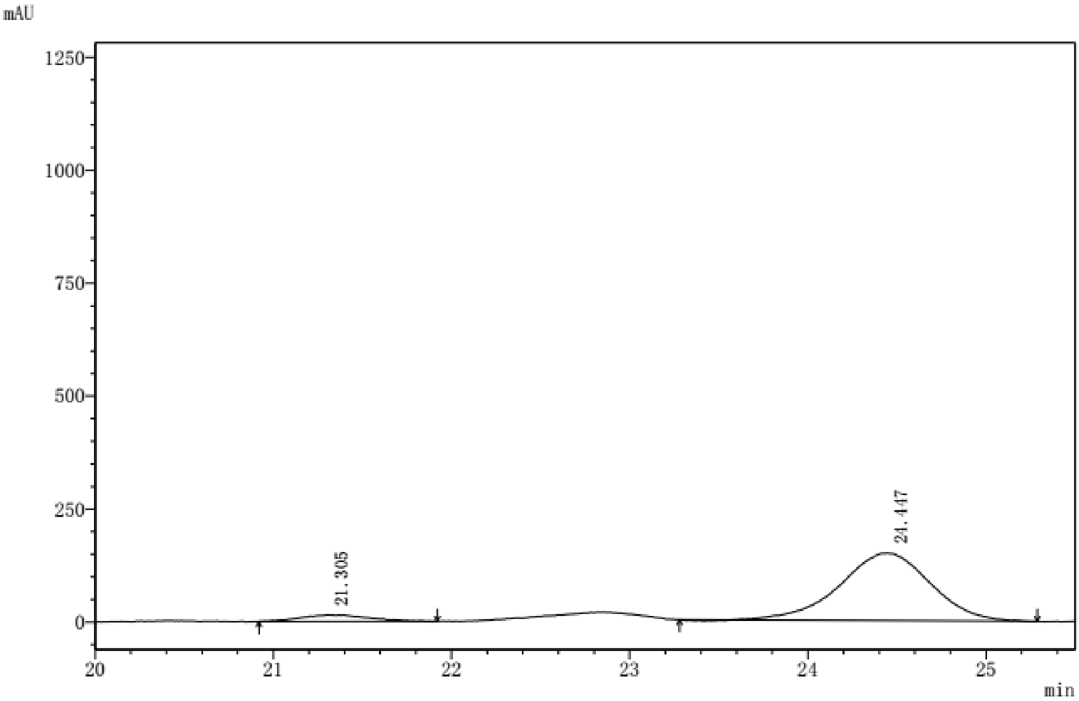
Peak	RetTime	Area	Height	Area%
1	14.828	20686224	736243	90.090
2	21.886	2275425	48452	9.910

HPLC spectra of *racemic*-**3ao**



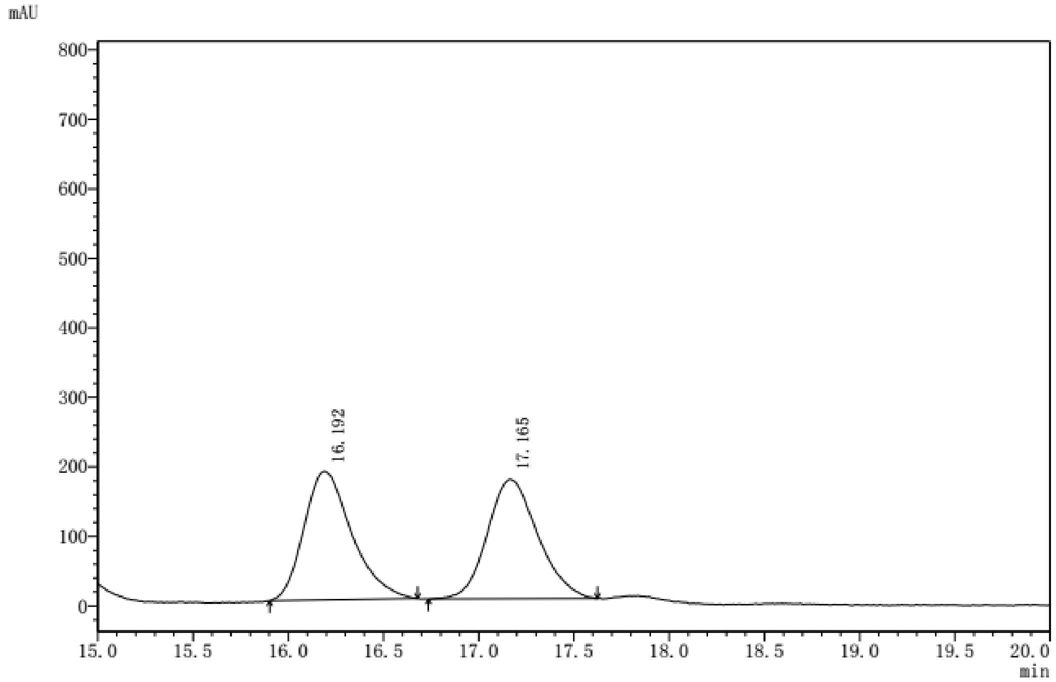
Peak	RetTime	Area	Height	Area%
1	21.299	1894483	71836	49.145
2	24.445	1960414	60010	50.855

HPLC spectra of **enantioenriched-3ao**



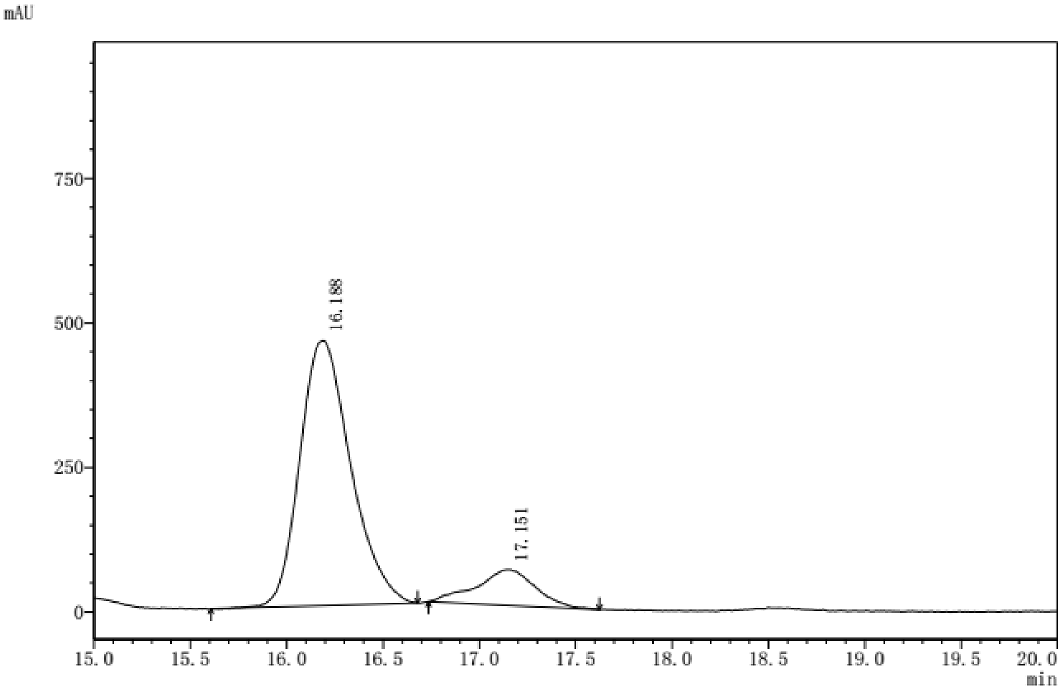
Peak	RetTime	Area	Height	Area%
1	21.305	363899	14275	6.442
2	24.447	5284929	149592	93.558

HPLC spectra of *racemic*-**4ao**



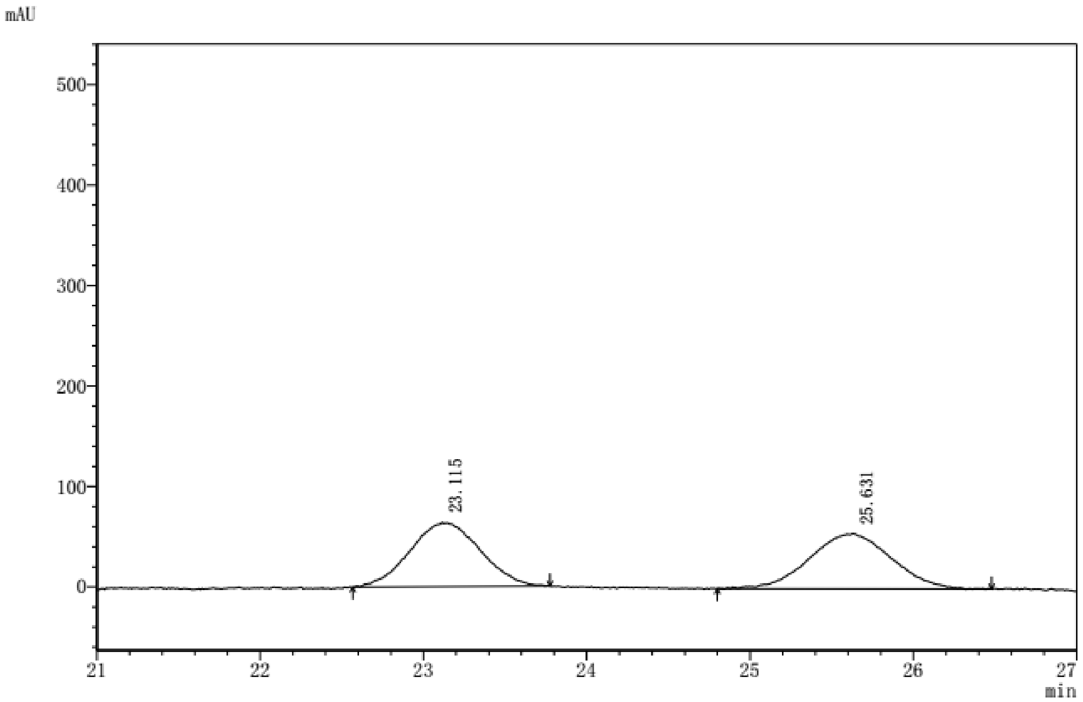
Peak	RetTime	Area	Height	Area%
1	16.192	3234023	184629	50.518
2	17.165	3167757	171682	49.482

HPLC spectra of **enantioenriched-4ao**



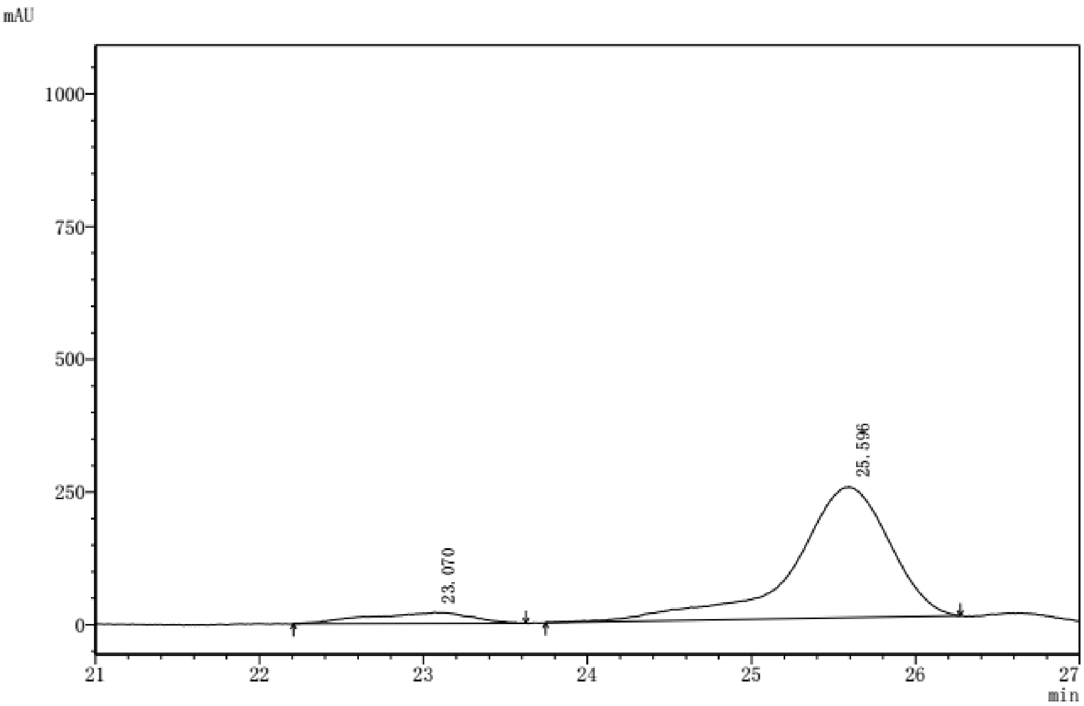
Peak	RetTime	Area	Height	Area%
1	16.188	8417229	458433	86.527
2	17.151	1310678	61727	13.473

HPLC spectra of *racemic*-**3ap**



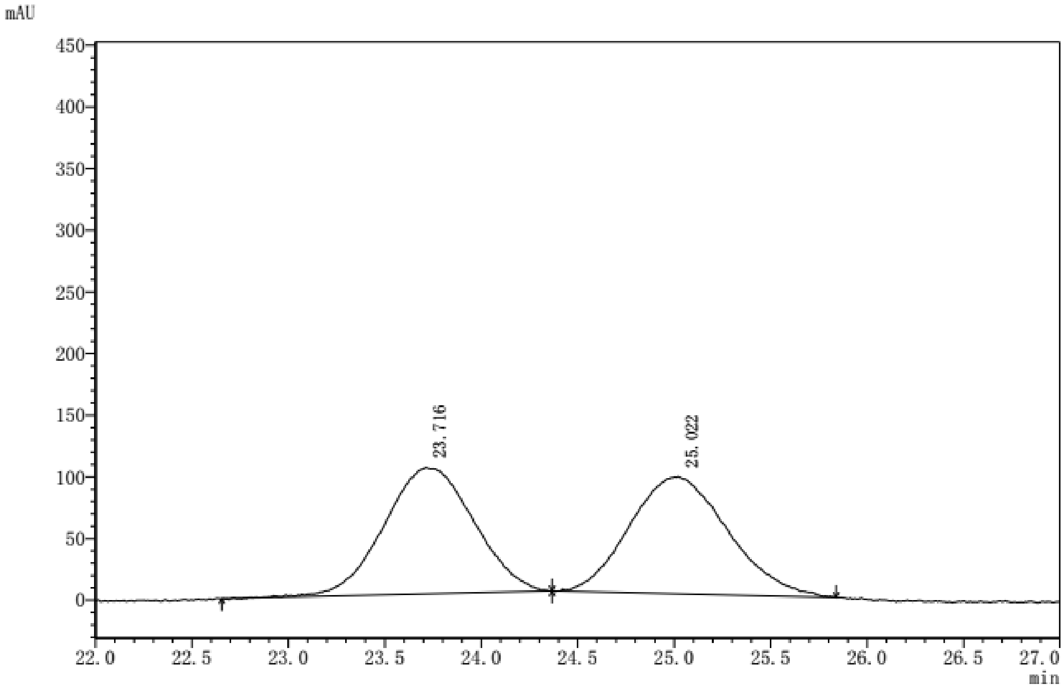
Peak	RetTime	Area	Height	Area%
1	23.115	1901958	63392	50.111
2	25.631	1893568	54817	49.889

HPLC spectra of **enantioenriched-3ap**



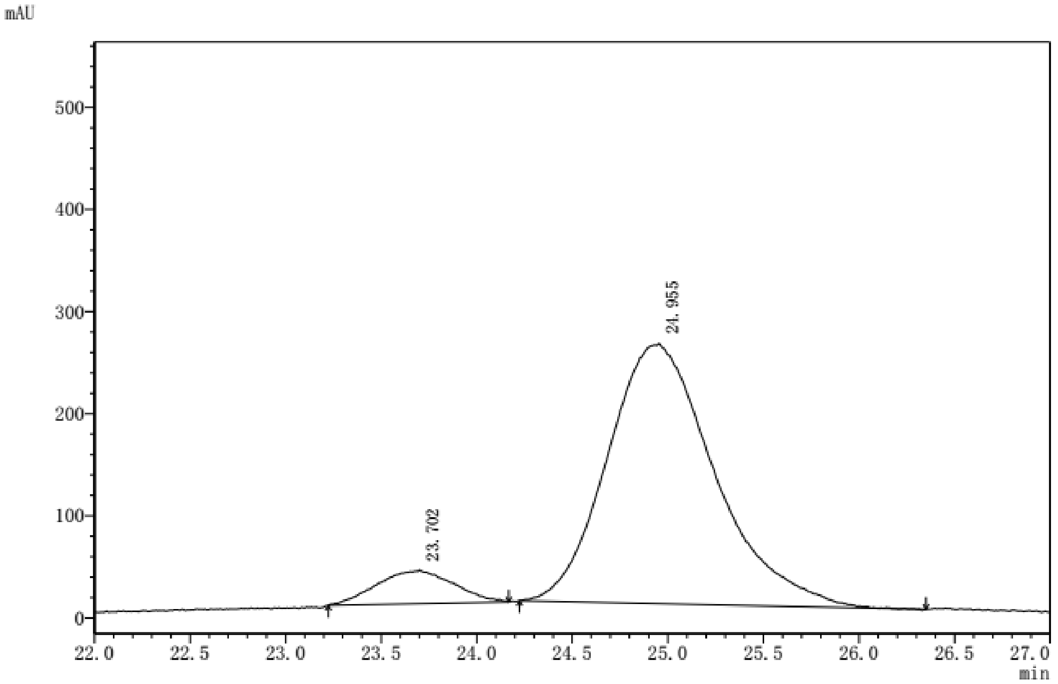
Peak	RetTime	Area	Height	Area%
1	23.070	875503	20572	8.038
2	25.596	10016722	245825	91.962

HPLC spectra of *racemic*-**4ap**



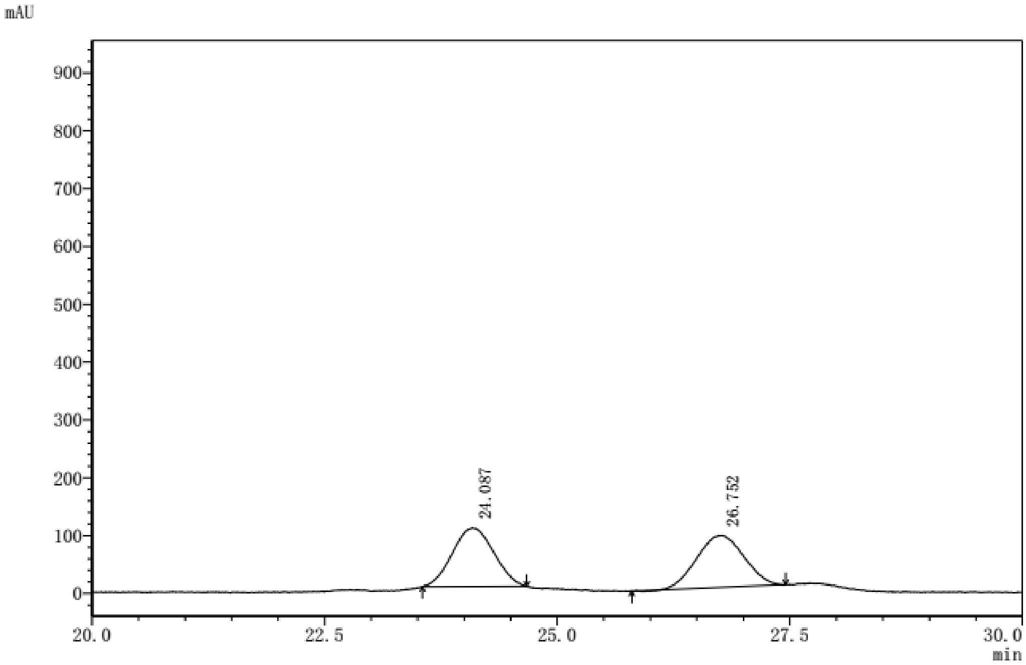
Peak	RetTime	Area	Height	Area%
1	23.716	3315920	102425	49.673
2	25.022	3359638	95050	50.327

HPLC spectra of **enantioenriched-4ap**



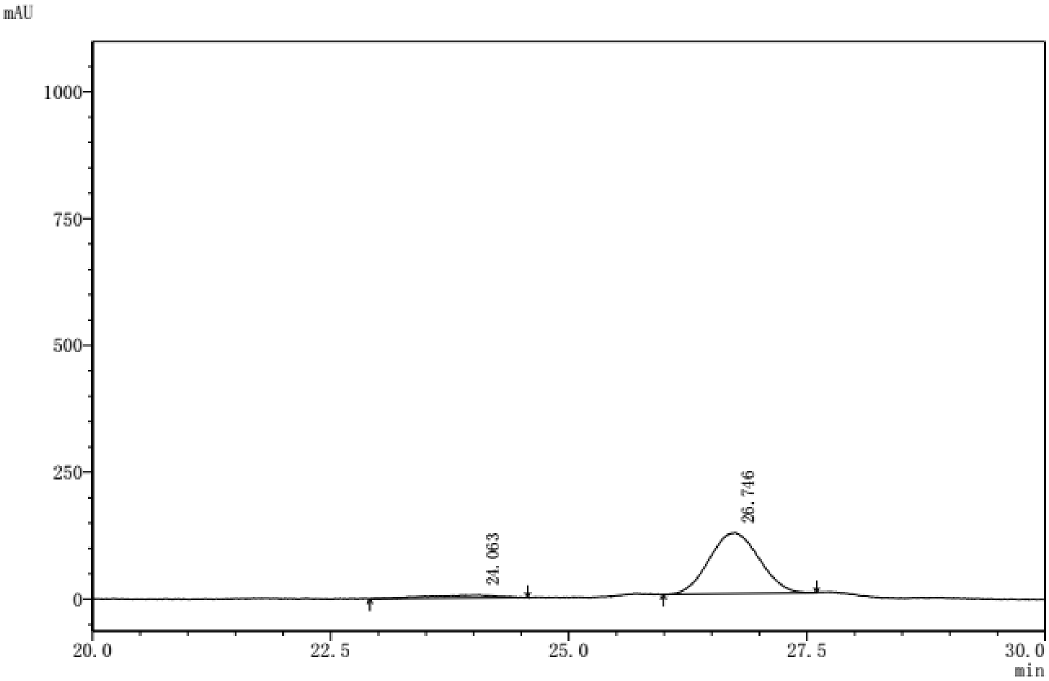
Peak	RetTime	Area	Height	Area%
1	23.702	911601	32917	8.429
2	24.955	9904091	254457	91.571

HPLC spectra of *racemic*-**3aq**



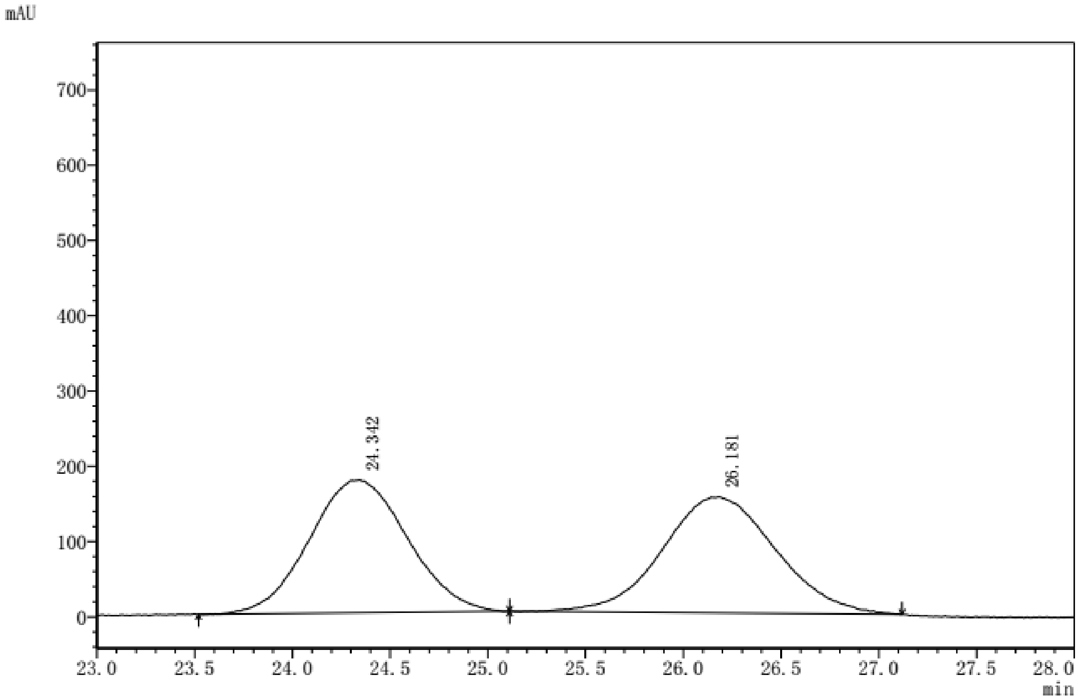
Peak	RetTime	Area	Height	Area%
1	24.087	3146238	101730	49.931
2	26.752	3154940	89731	50.069

HPLC spectra of **enantioenriched-3aq**



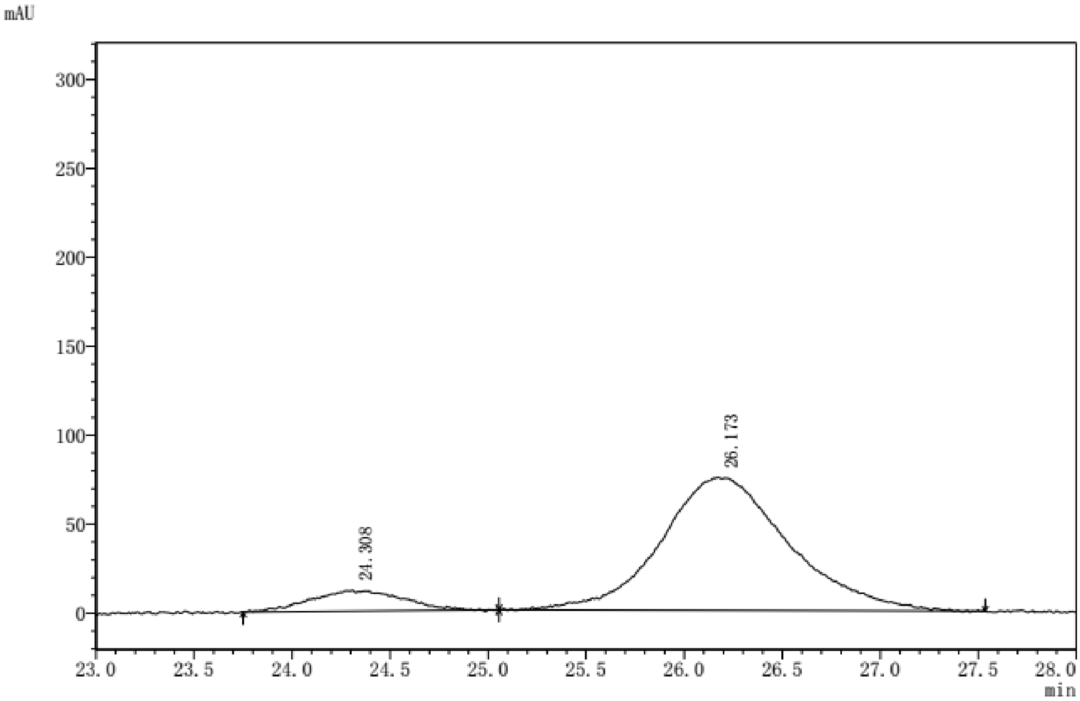
Peak	RetTime	Area	Height	Area%
1	24.063	284881	5913	6.146
2	26.746	4350142	119745	93.854

HPLC spectra of *racemic*-**4aq**



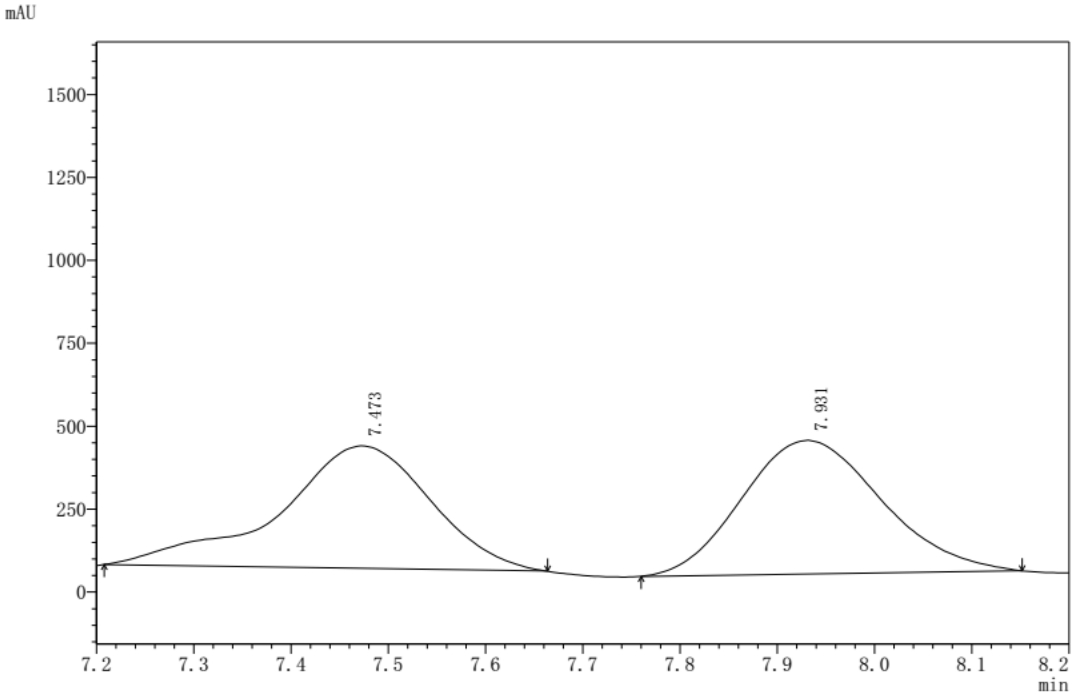
Peak	RetTime	Area	Height	Area%
1	24.342	6153328	176243	49.718
2	26.181	6223164	154358	50.282

HPLC spectra of **enantioenriched-4aq**



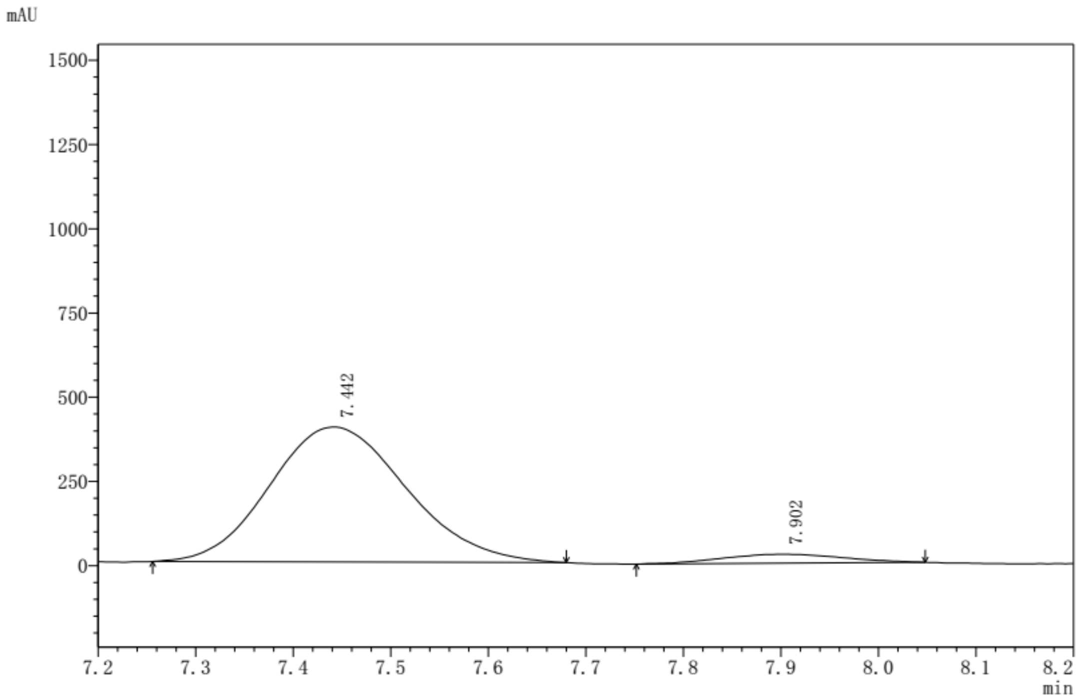
Peak	RetTime	Area	Height	Area%
1	24.308	378303	11690	10.063
2	26.173	3381166	74738	89.937

HPLC spectra of *racemic*-**3ar**



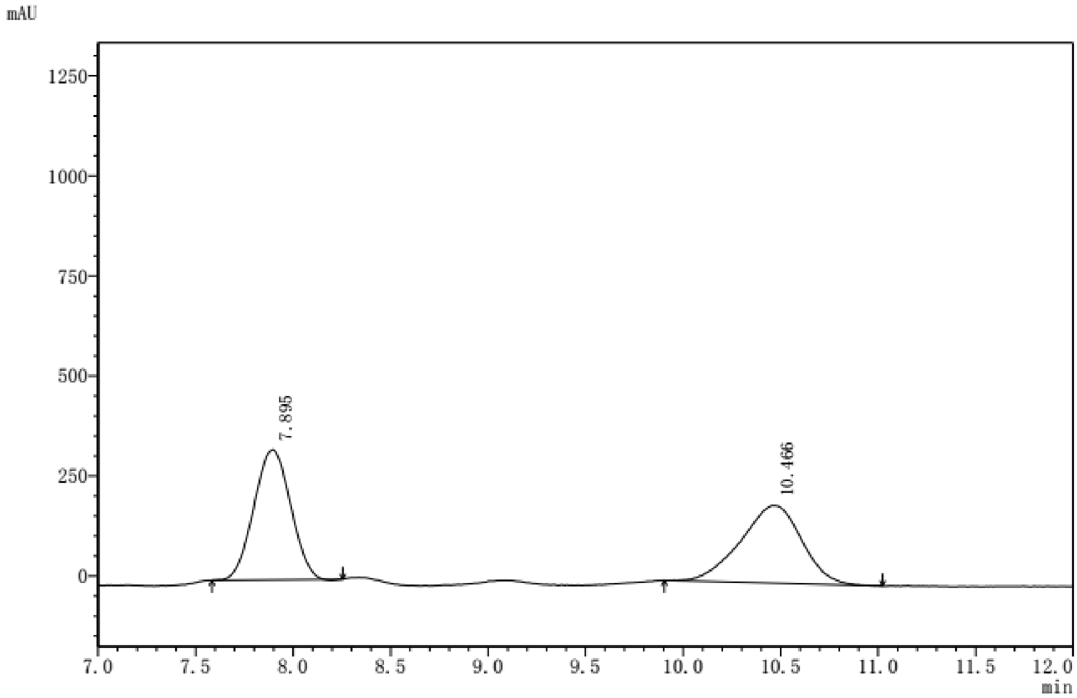
Peak	RetTime	Area	Height	Area%
1	7.473	3988044	368632	49.864
2	7.931	4009819	402107	50.136

HPLC spectra of **enantioenriched-3ar**



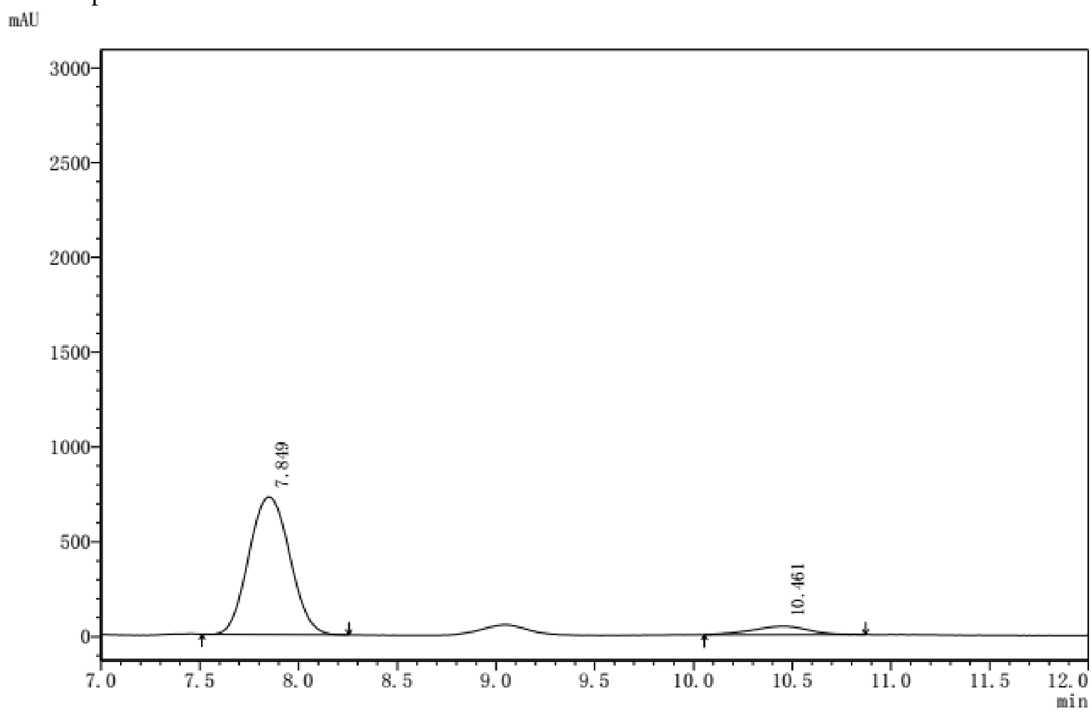
Peak	RetTime	Area	Height	Area%
1	7.442	3903699	399721	94.513
2	7.902	226620	26347	5.487

HPLC spectra of *racemic*-**4ar**



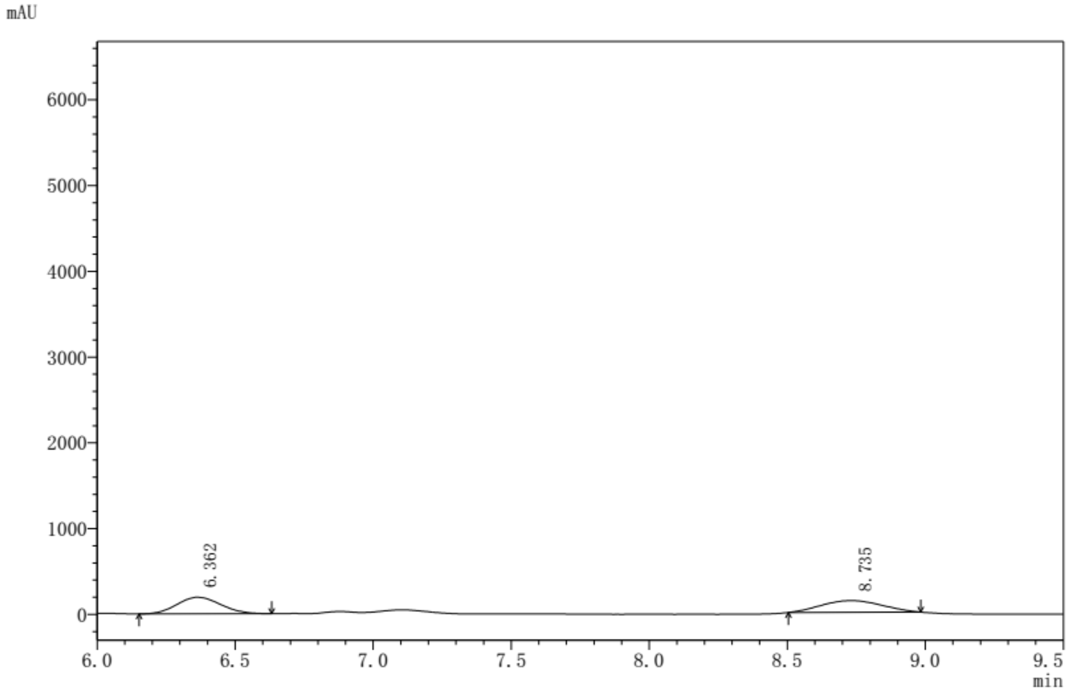
Peak	RetTime	Area	Height	Area%
1	7.895	4251379	324929	49.987
2	10.466	4253668	194130	50.013

HPLC spectra of **enantioenriched-4ar**



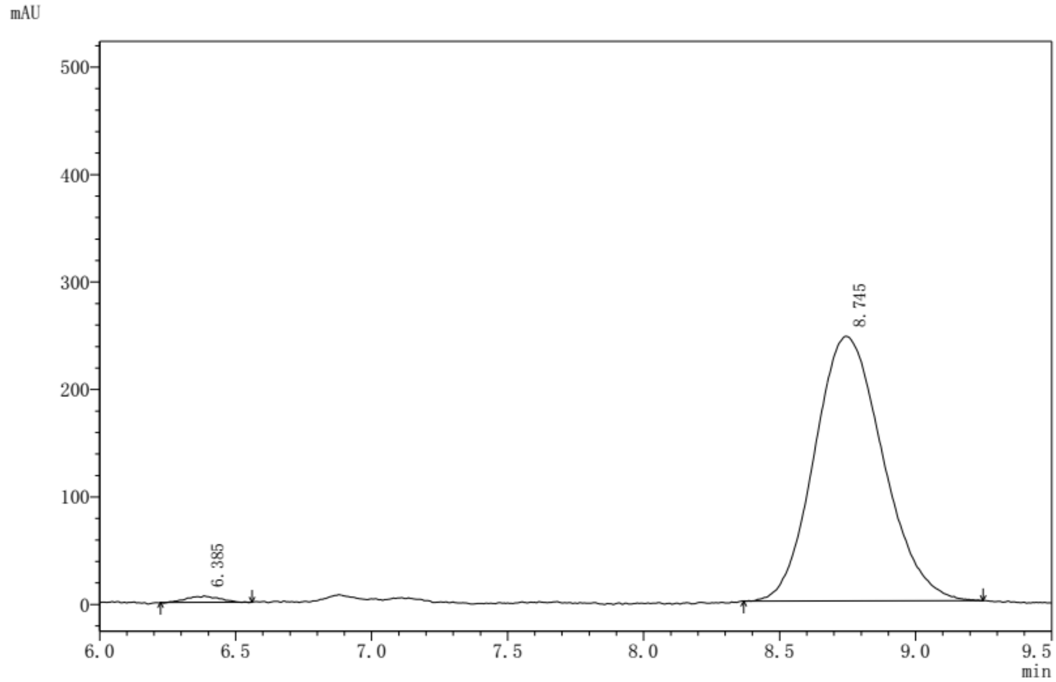
Peak	RetTime	Area	Height	Area%
1	7.849	10490401	725719	92.152
2	10.461	893422	44935	7.848

HPLC spectra of *racemic*-**3as**



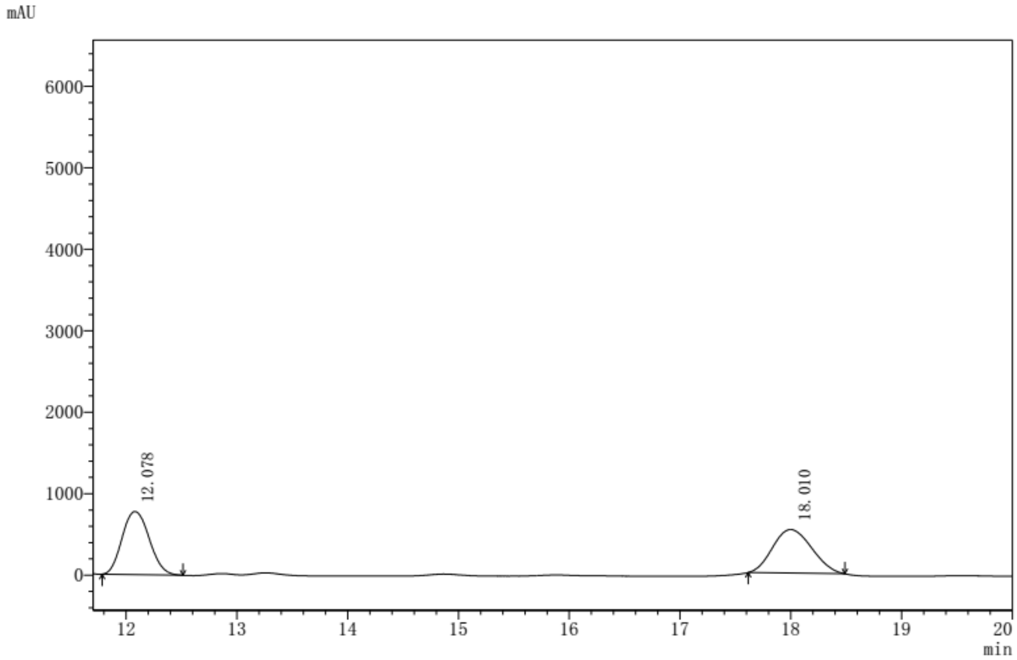
Peak	RetTime	Area	Height	Area%
1	6.362	2119135	192101	50.340
2	8.735	2090492	136066	49.660

HPLC spectra of **enantioenriched-3as**



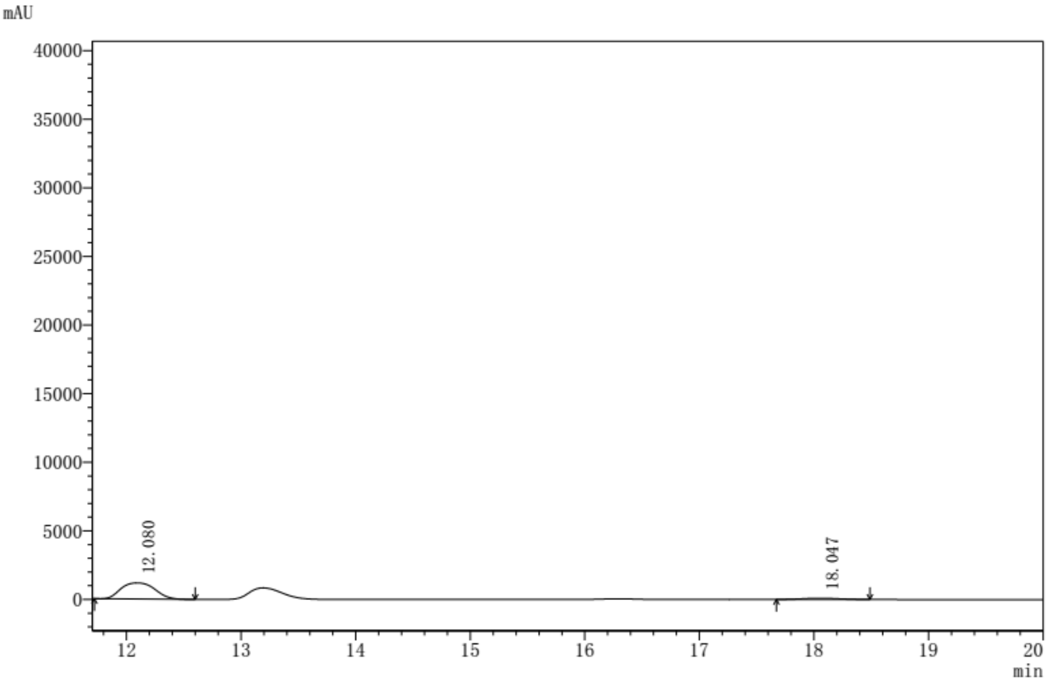
Peak	RetTime	Area	Height	Area%
1	6.385	48346	5880	1.110
2	8.745	4305490	246043	98.890

HPLC spectra of *racemic*-**4as**



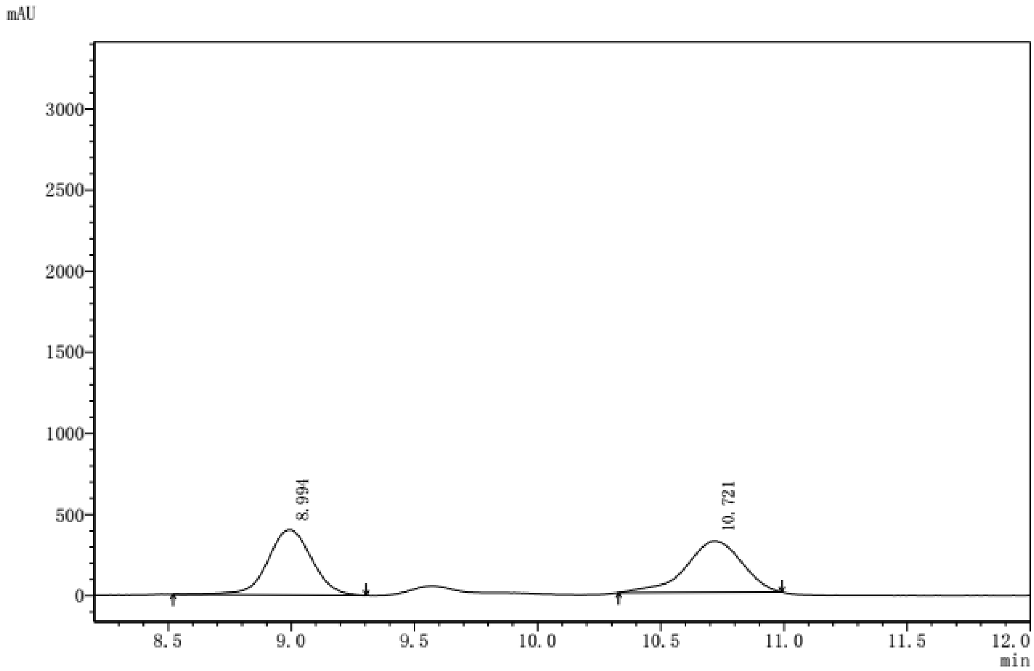
Peak	RetTime	Area	Height	Area%
1	12.078	13245721	773793	50.166
2	18.010	13157941	533625	49.834

HPLC spectra of **enantioenriched-4as**



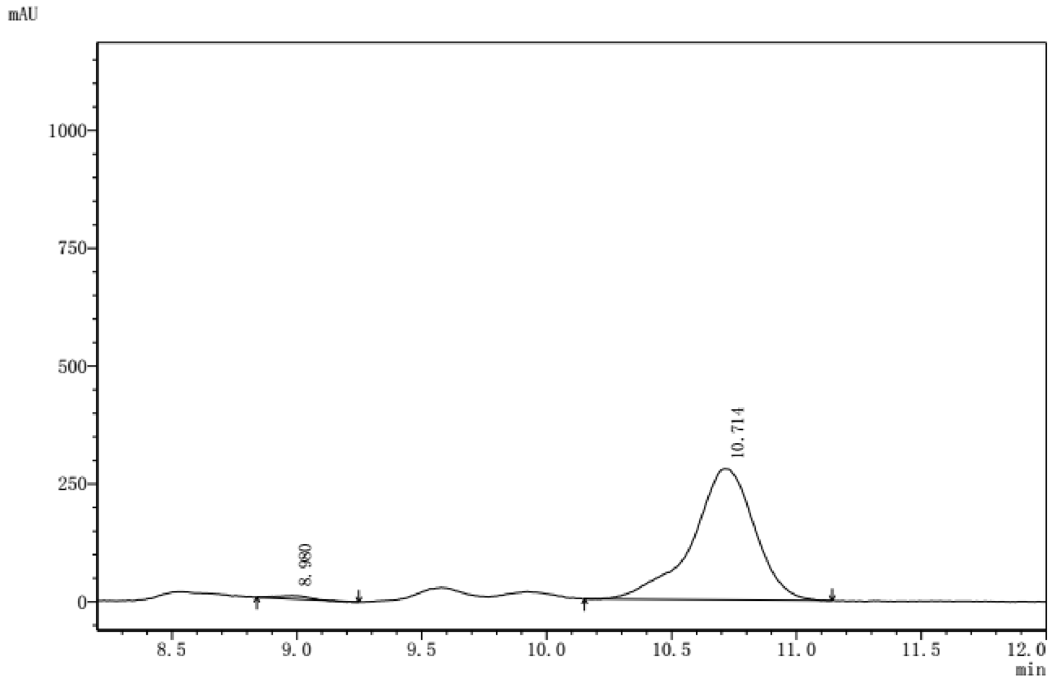
Peak	RetTime	Area	Height	Area%
1	12.080	23897377	1169605	92.369
2	18.047	1974176	87105	7.631

HPLC spectra of *racemic*-**3at**



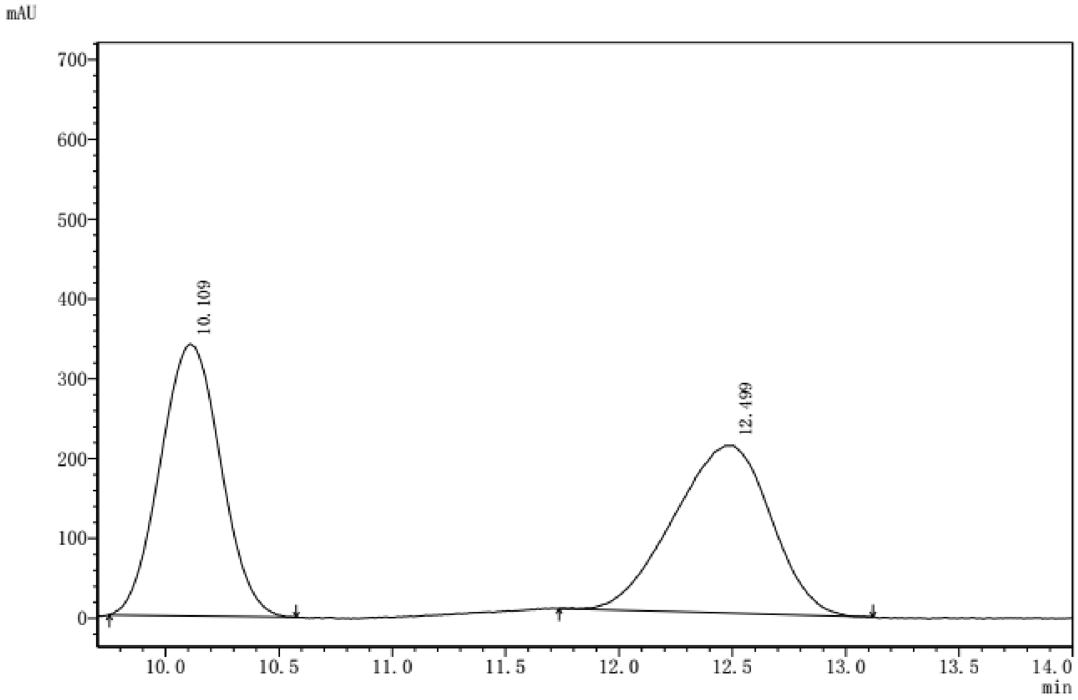
Peak	RetTime	Area	Height	Area%
1	8.994	4976445	401009	49.910
2	10.721	4994311	315020	50.090

HPLC spectra of **enantioenriched-3at**



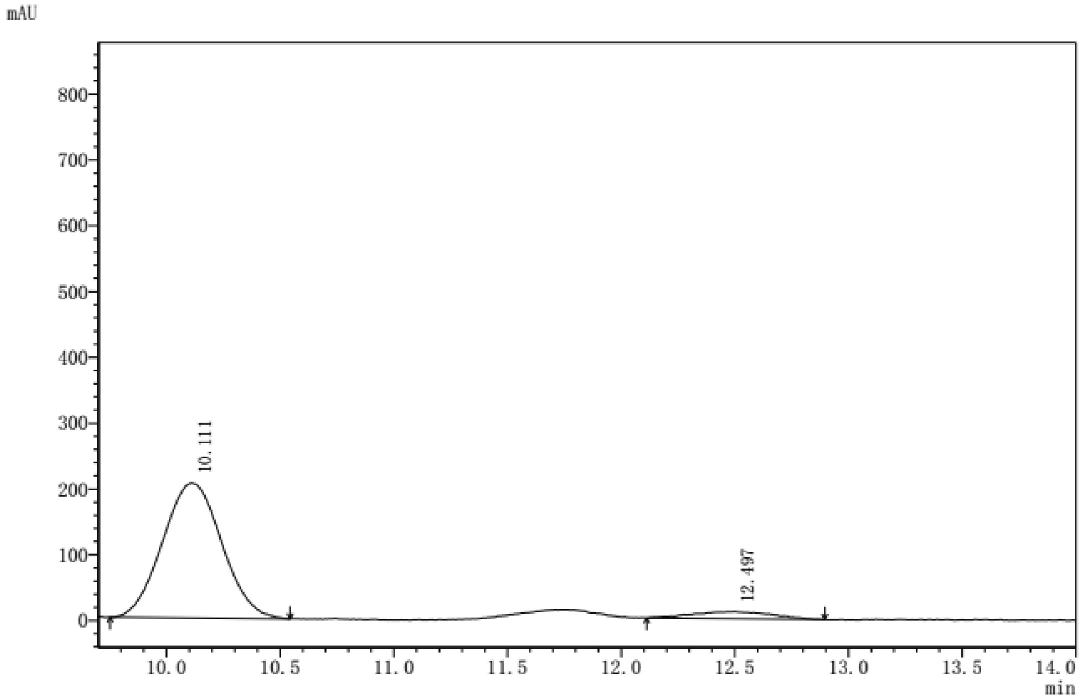
Peak	RetTime	Area	Height	Area%
1	8.980	57494	6788	1.180
2	10.714	4814394	277980	98.820

HPLC spectra of *racemic*-**4at**



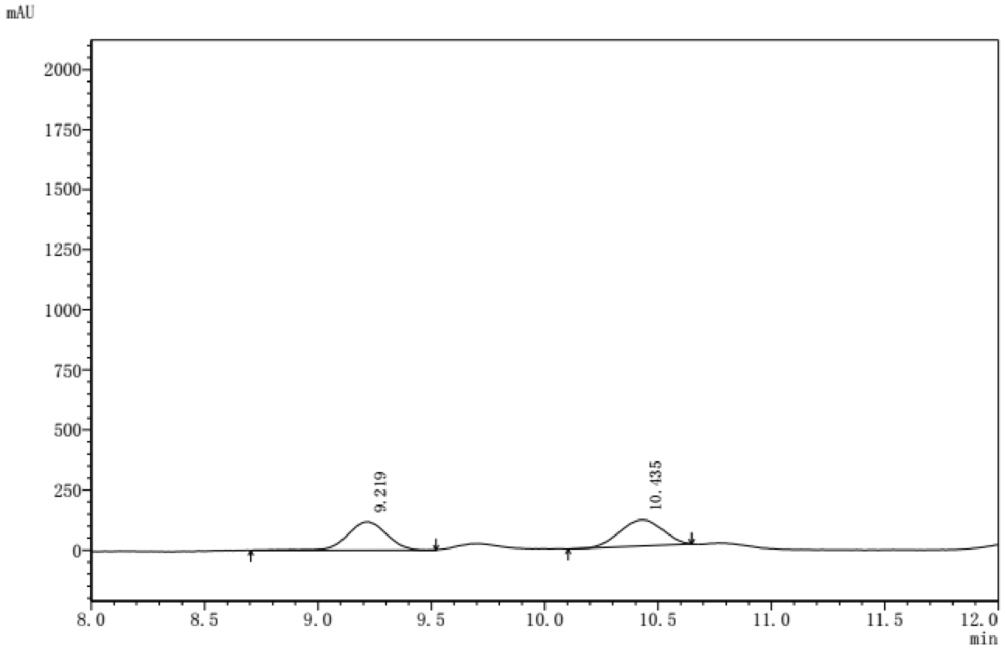
Peak	RetTime	Area	Height	Area%
1	10.109	6297241	340229	50.167
2	12.499	6255247	209743	49.833

HPLC spectra of **enantioenriched-4at**



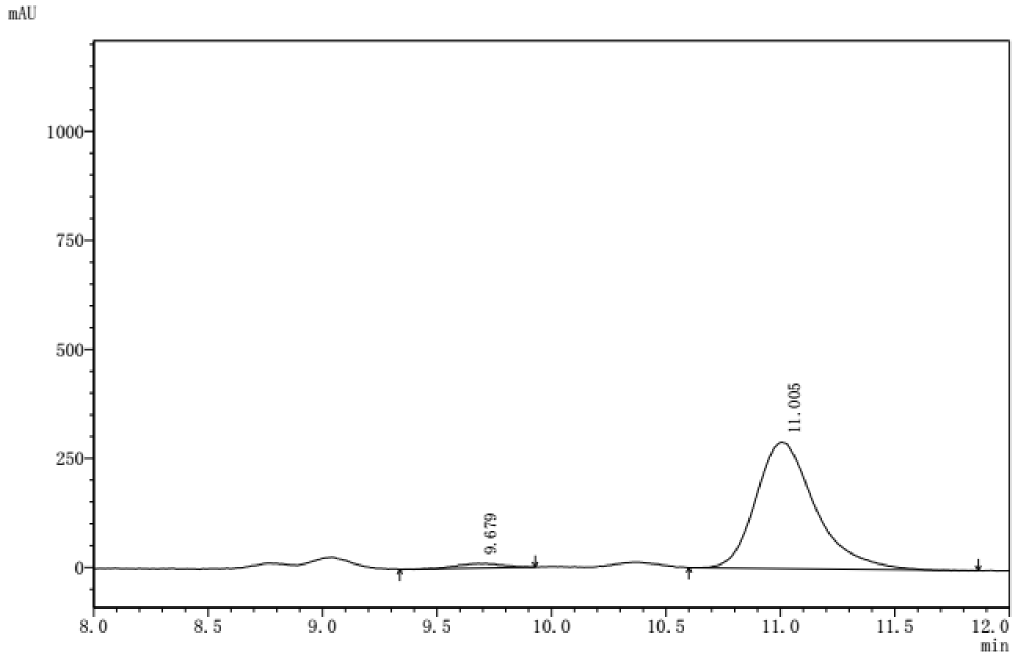
Peak	RetTime	Area	Height	Area%
1	10.111	3712907	205007	93.552
2	12.497	255892	10664	6.448

HPLC spectra of *racemic*-**3au**



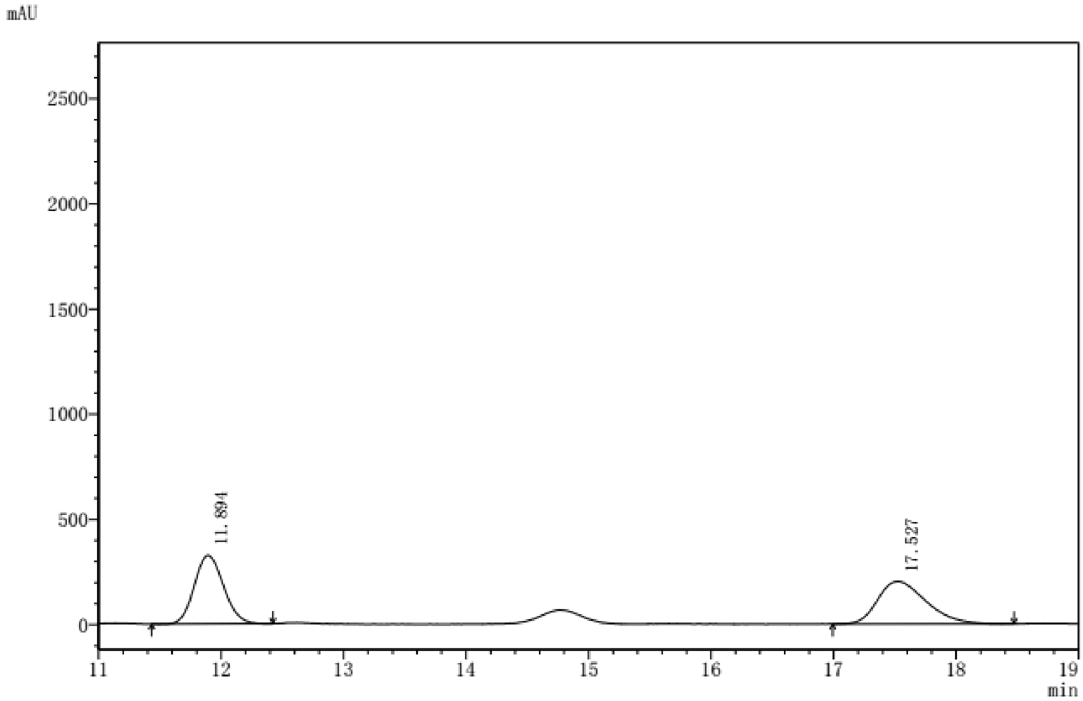
Peak	RetTime	Area	Height	Area%
1	9.219	1422814	118525	50.003
2	10.435	1422638	108392	49.997

HPLC spectra of **enantioenriched-3a**u



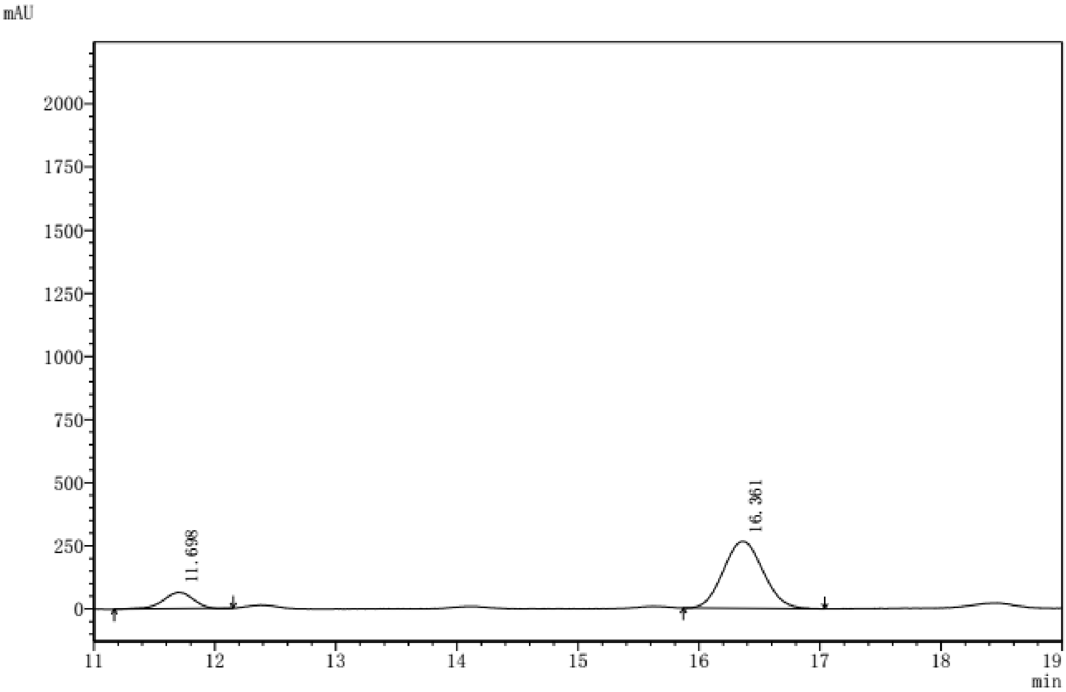
Peak	RetTime	Area	Height	Area%
1	9.679	141298	10334	2.642
2	11.005	5207154	289700	97.358

HPLC spectra of *racemic*-**4au**



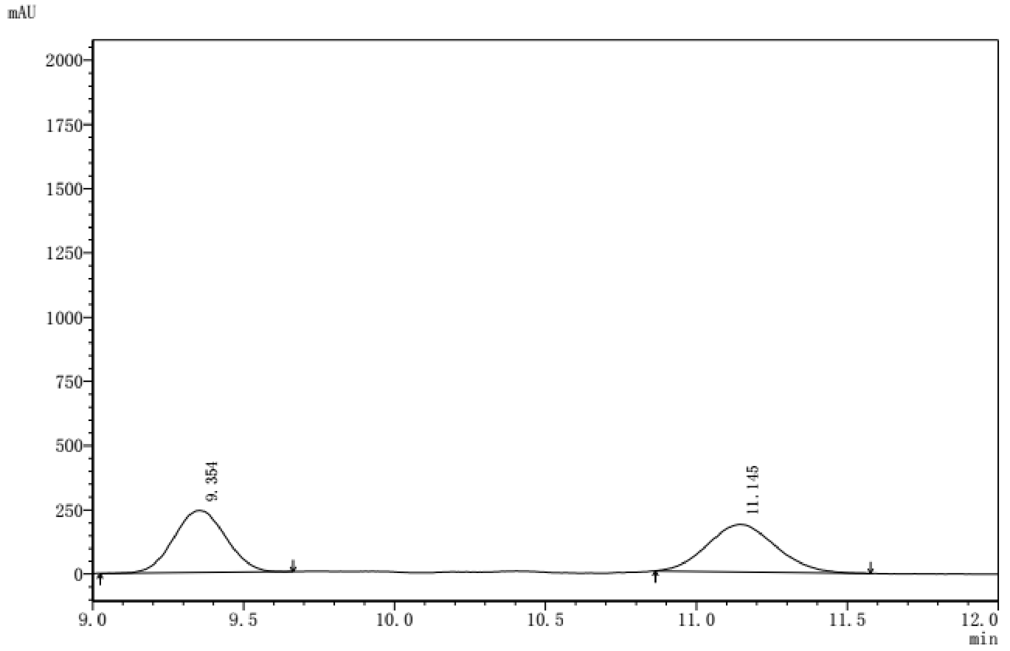
Peak	RetTime	Area	Height	Area%
1	11.894	5382312	324808	49.324
2	17.527	5529749	202160	50.676

HPLC spectra of **enantioenriched-4au**



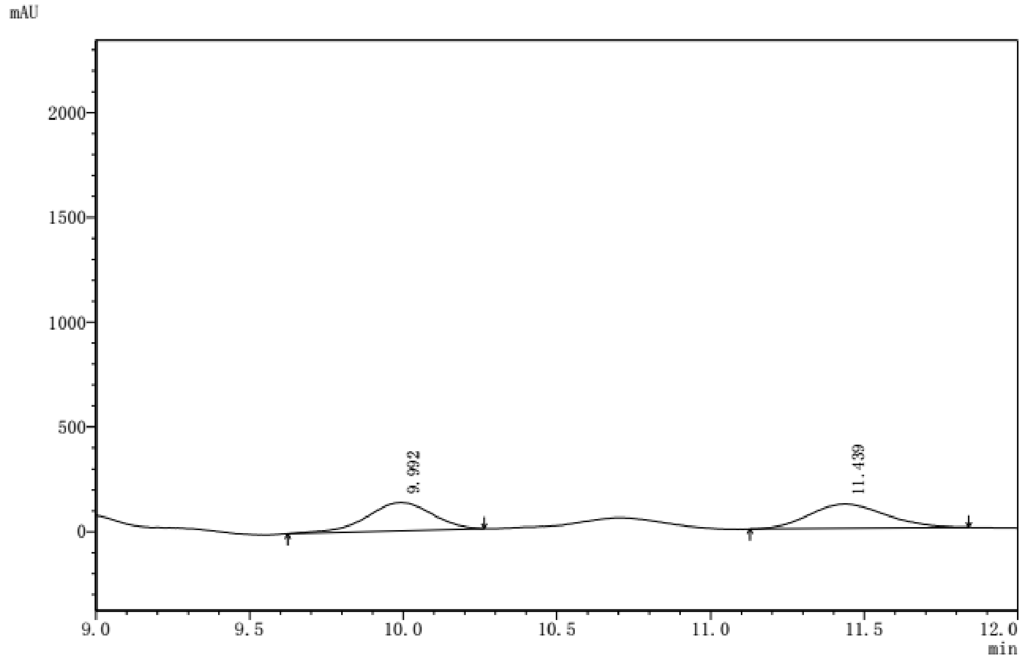
Peak	RetTime	Area	Height	Area%
1	11.698	1110786	64580	15.439
2	16.361	6084035	265106	84.561

HPLC spectra of *racemic*-**3av**



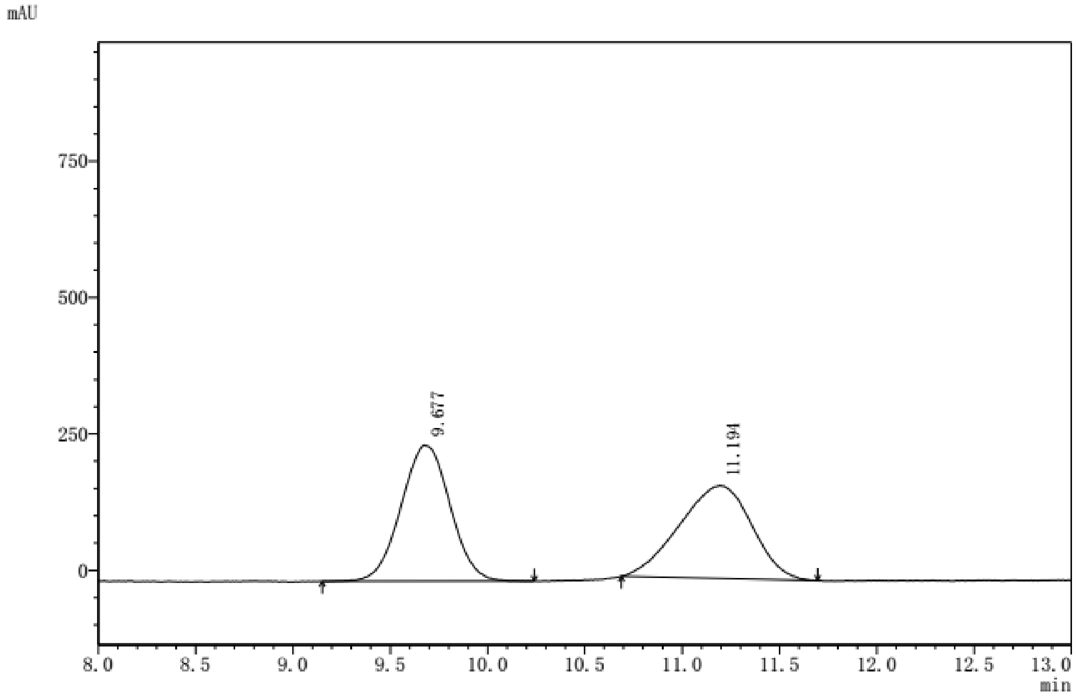
Peak	RetTime	Area	Height	Area%
1	9.354	2899099	241001	49.714
2	11.145	2932465	185332	50.286

HPLC spectra of **enantioenriched-3av**



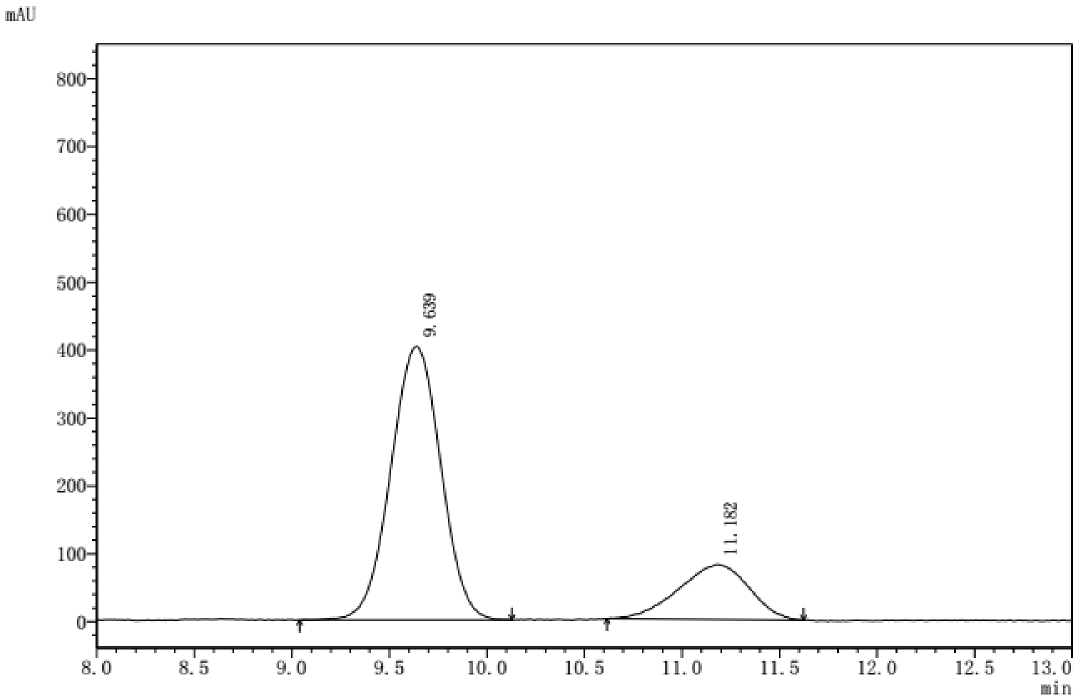
Peak	RetTime	Area	Height	Area%
1	9.992	1982734	134018	49.899
2	11.439	1990766	115110	50.101

HPLC spectra of *racemic*-**4av**



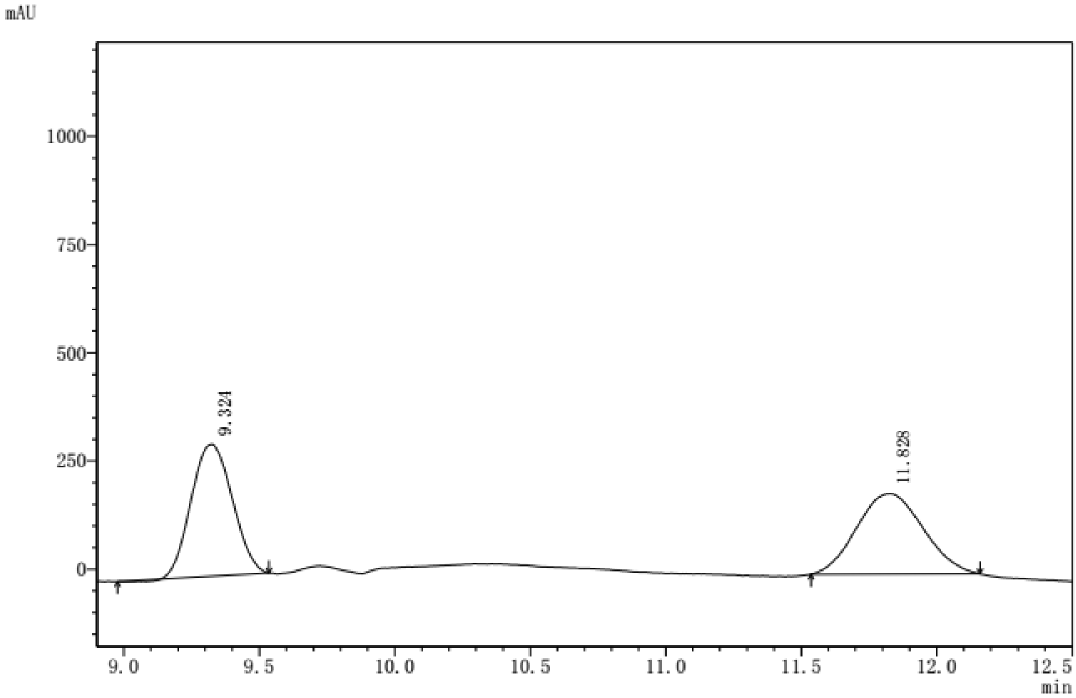
Peak	RetTime	Area	Height	Area%
1	9.677	4366479	249292	49.787
2	11.194	4403871	170100	50.213

HPLC spectra of **enantioenriched-4av**



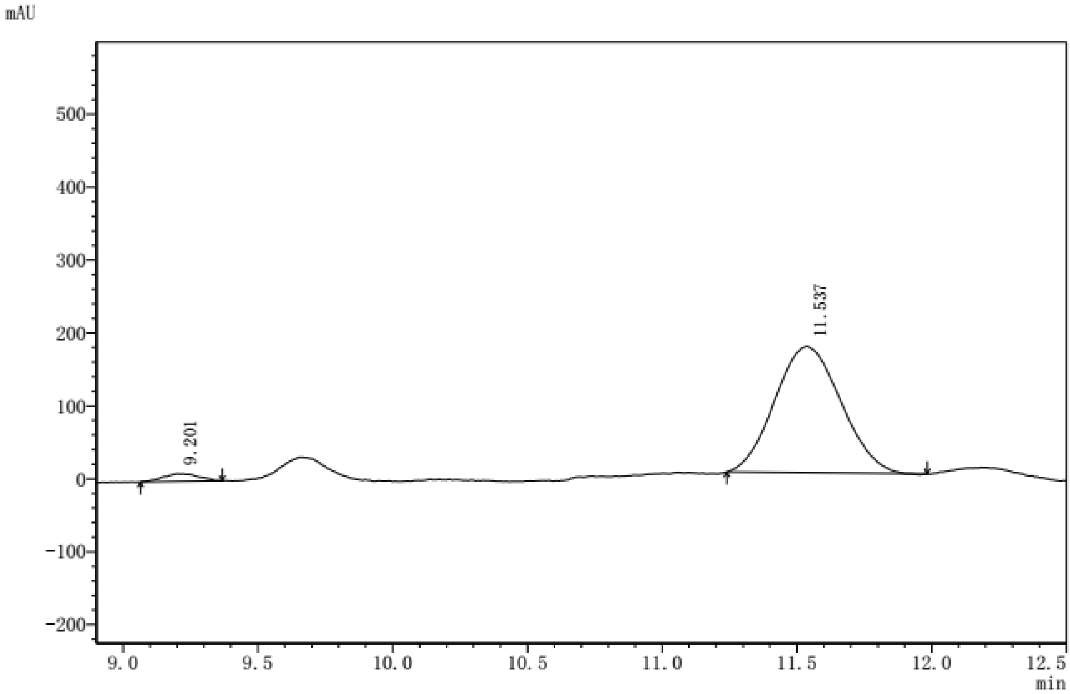
Peak	RetTime	Area	Height	Area%
1	9.639	7202632	402677	78.123
2	11.182	2017005	80878	21.877

HPLC spectra of *racemic*-**3aw**



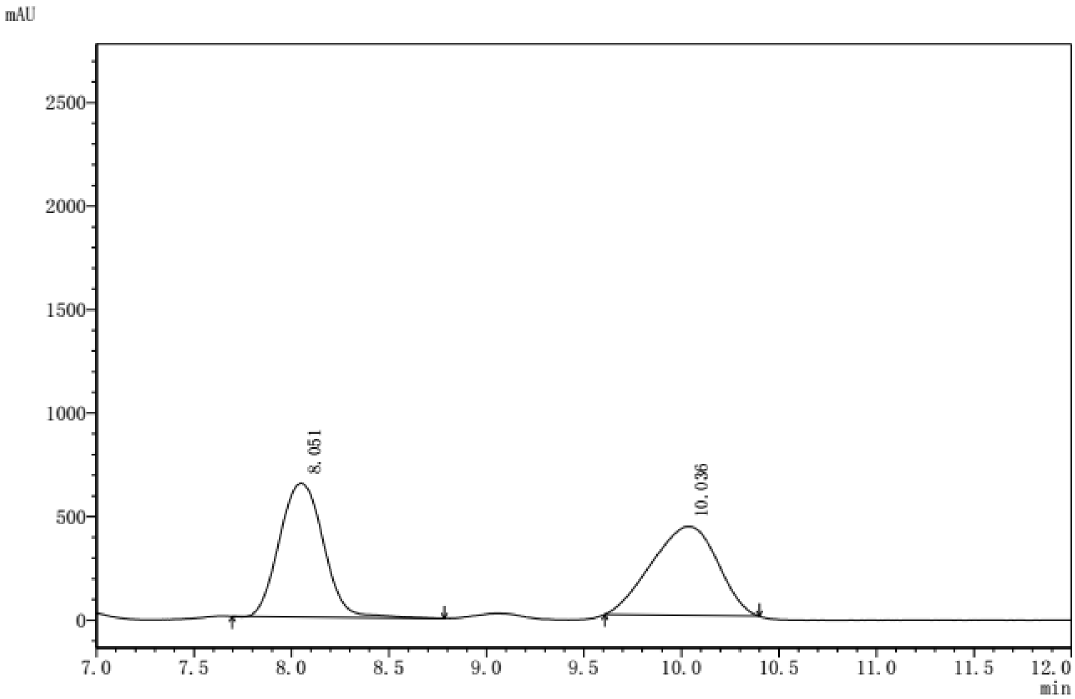
Peak	RetTime	Area	Height	Area%
1	9.324	3228431	304639	50.411
2	11.828	3175779	186047	49.589

HPLC spectra of **enantioenriched-3aw**



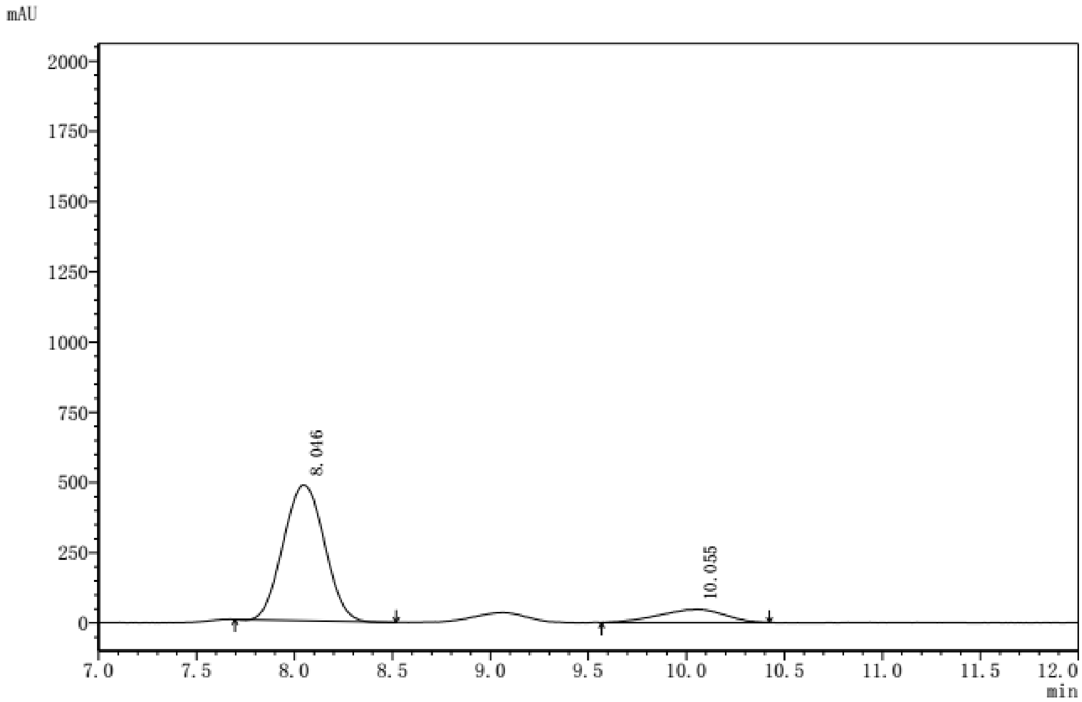
Peak	RetTime	Area	Height	Area%
1	9.201	96492	10469	3.170
2	11.537	2947648	172935	96.830

HPLC spectra of *racemic*-**4aw**



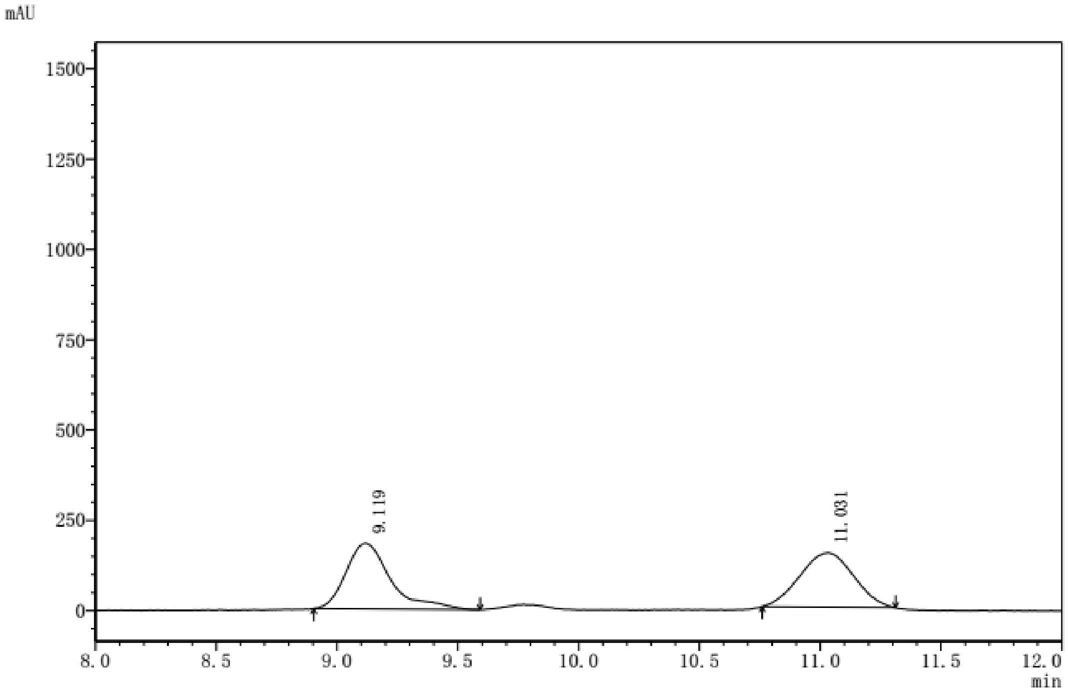
Peak	RetTime	Area	Height	Area%
1	8.051	10189434	646766	50.139
2	10.036	10133056	428489	49.861

HPLC spectra of **enantioenriched-4aw**



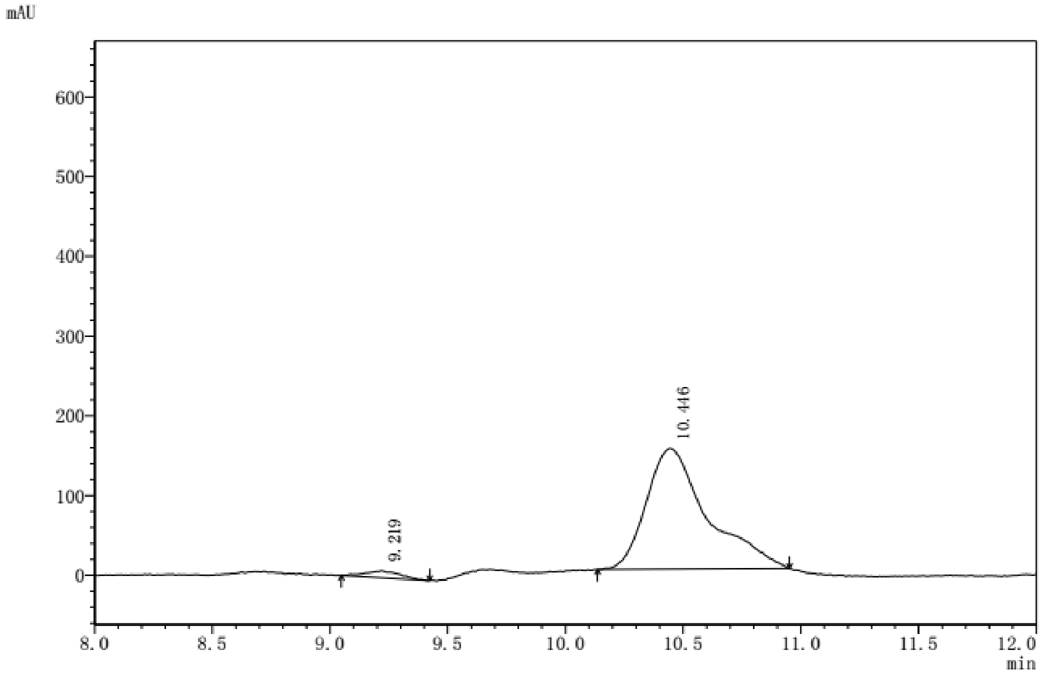
Peak	RetTime	Area	Height	Area%
1	8.046	7094113	482895	86.559
2	10.055	1101554	47664	13.441

HPLC spectra of *racemic*-**3ax**



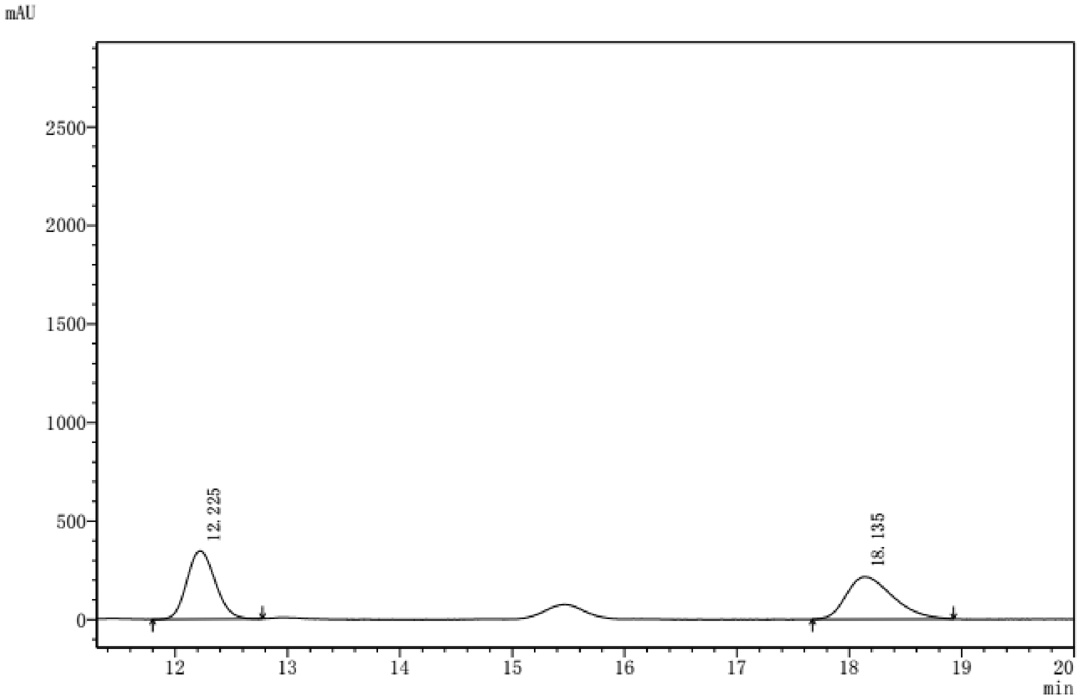
Peak	RetTime	Area	Height	Area%
1	9.119	2329158	182350	49.985
2	11.031	2330553	150190	50.015

HPLC spectra of **enantioenriched-3ax**



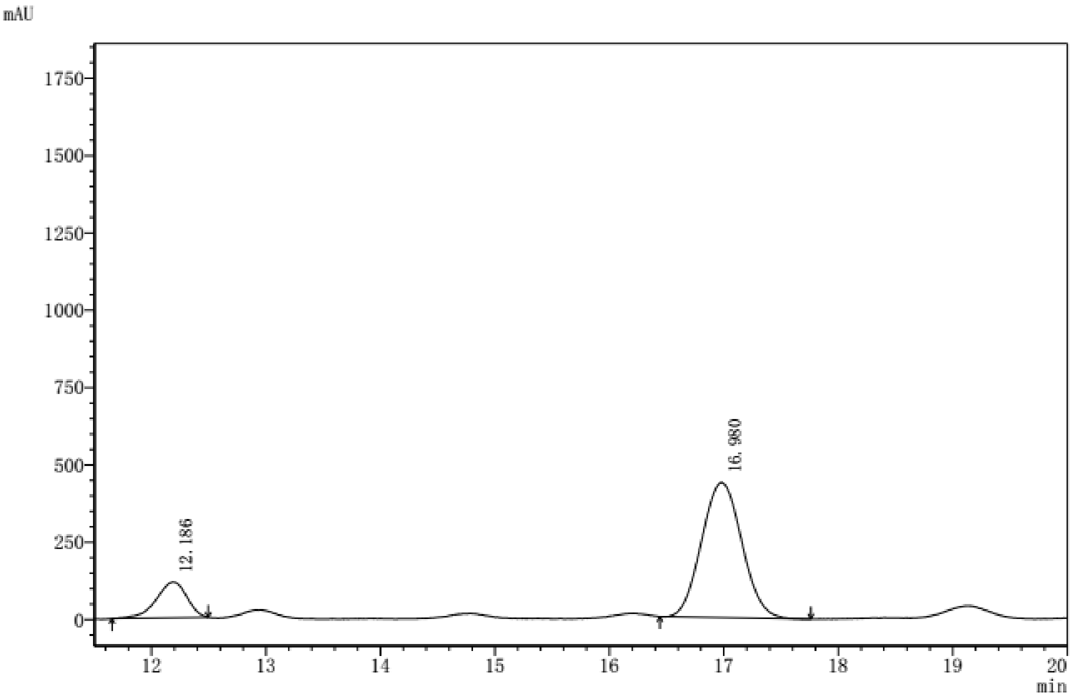
Peak	RetTime	Area	Height	Area%
1	9.219	85798	8455	3.057
2	10.446	2720731	151314	96.943

HPLC spectra of *racemic*-**4ax**



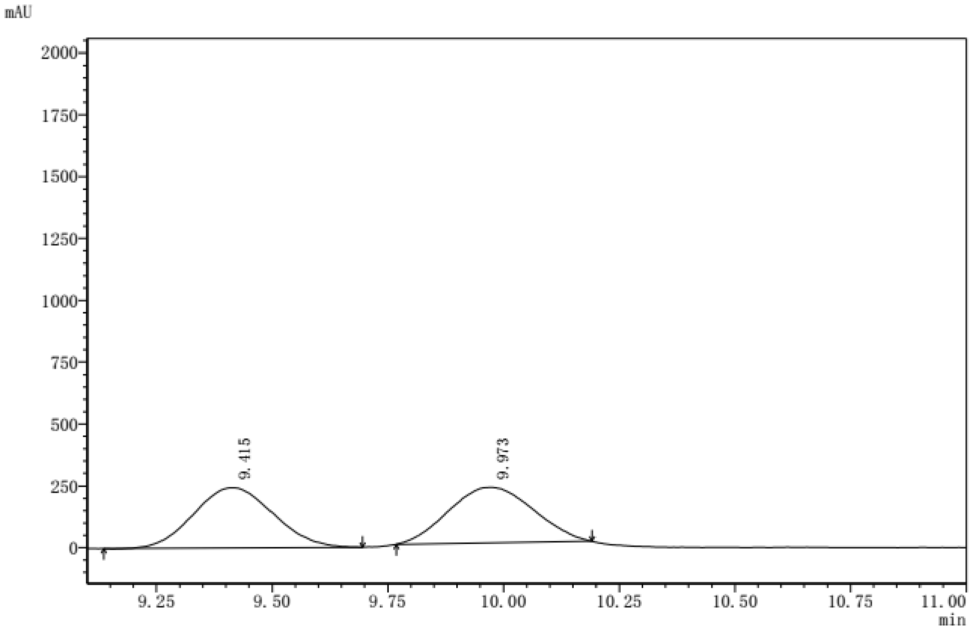
Peak	RetTime	Area	Height	Area%
1	12.225	6044255	345405	49.683
2	18.135	6121505	214040	50.317

HPLC spectra of **enantioenriched-4ax**



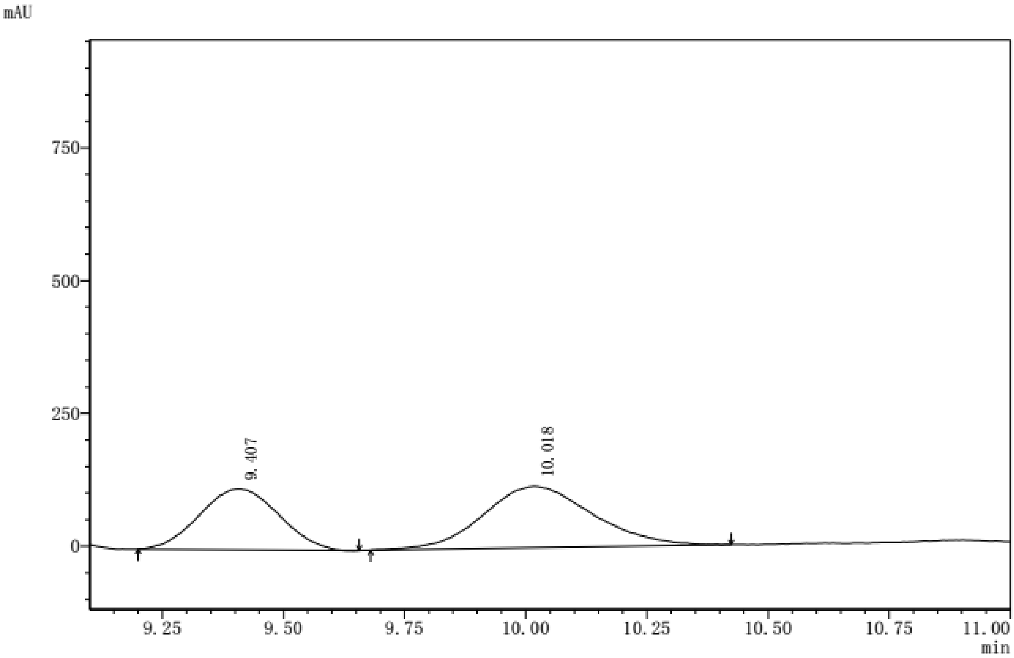
Peak	RetTime	Area	Height	Area%
1	12.186	2142053	115444	16.678
2	16.980	10701362	437353	83.322

HPLC spectra of *racemic*-**3ay**



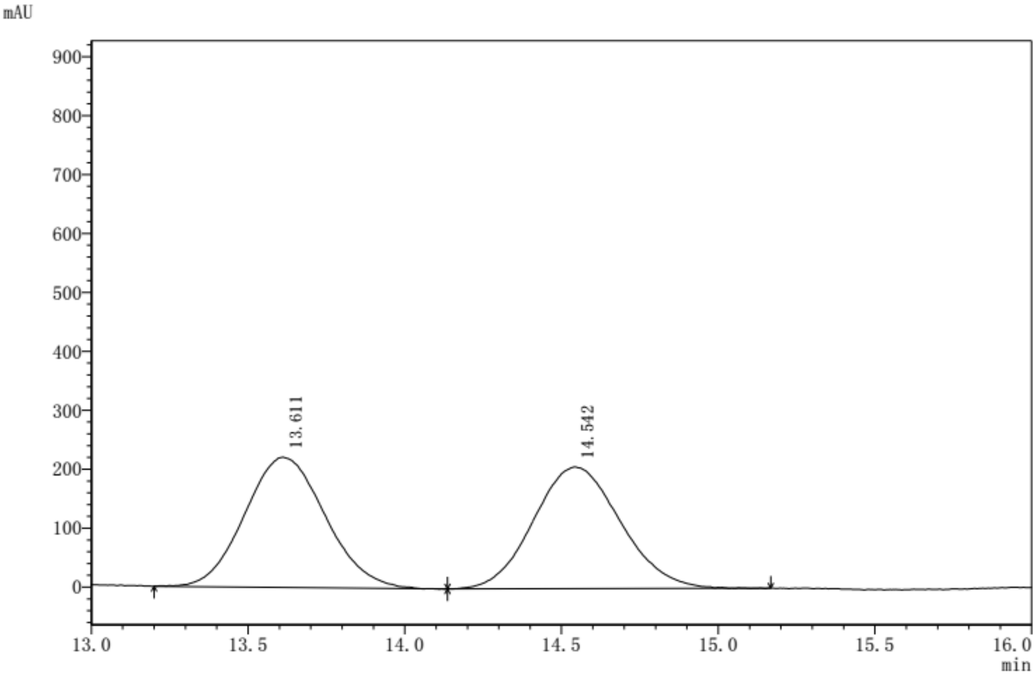
Peak	RetTime	Area	Height	Area%
1	9.415	2925171	244061	50.498
2	9.973	2867461	225272	49.502

HPLC spectra of **enantioenriched-3ay**



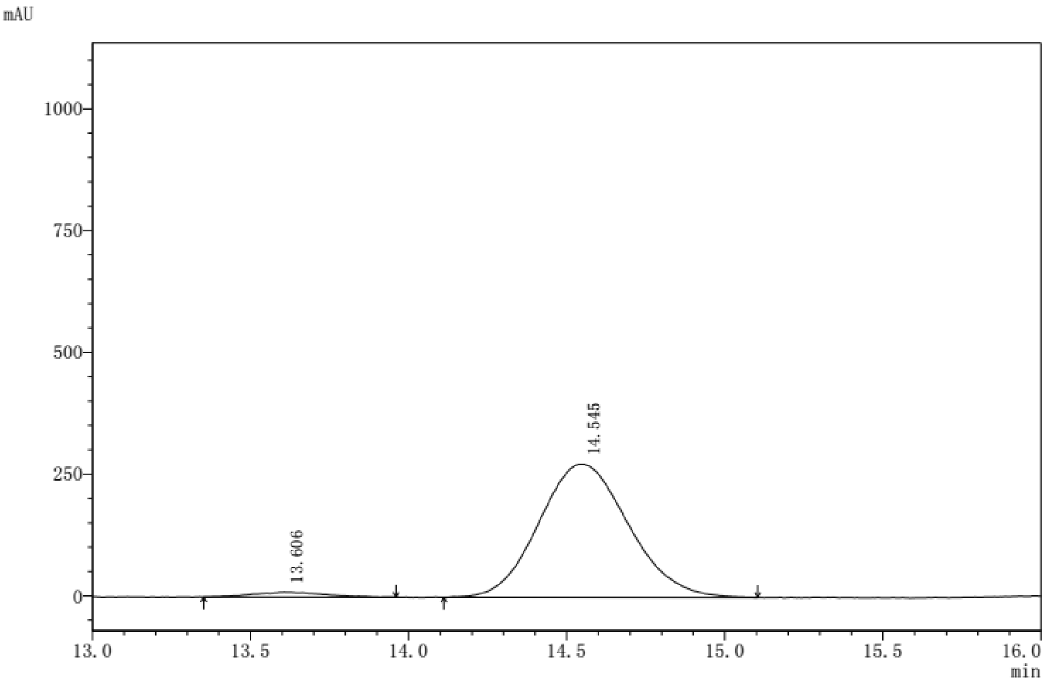
Peak	RetTime	Area	Height	Area%
1	9.407	1302862	114699	41.833
2	10.018	1811591	115605	58.167

HPLC spectra of *racemic*-**4ay**



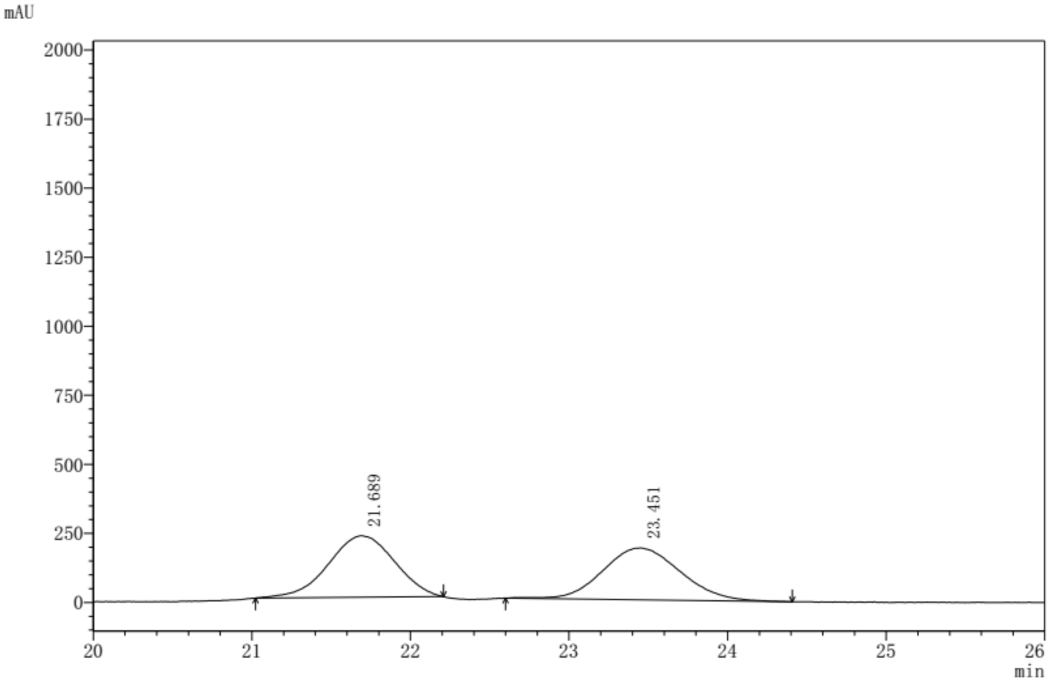
Peak	RetTime	Area	Height	Area%
1	13.611	3956267	220785	49.795
2	14.542	3988830	206546	50.205

HPLC spectra of **enantioenriched-4ay**



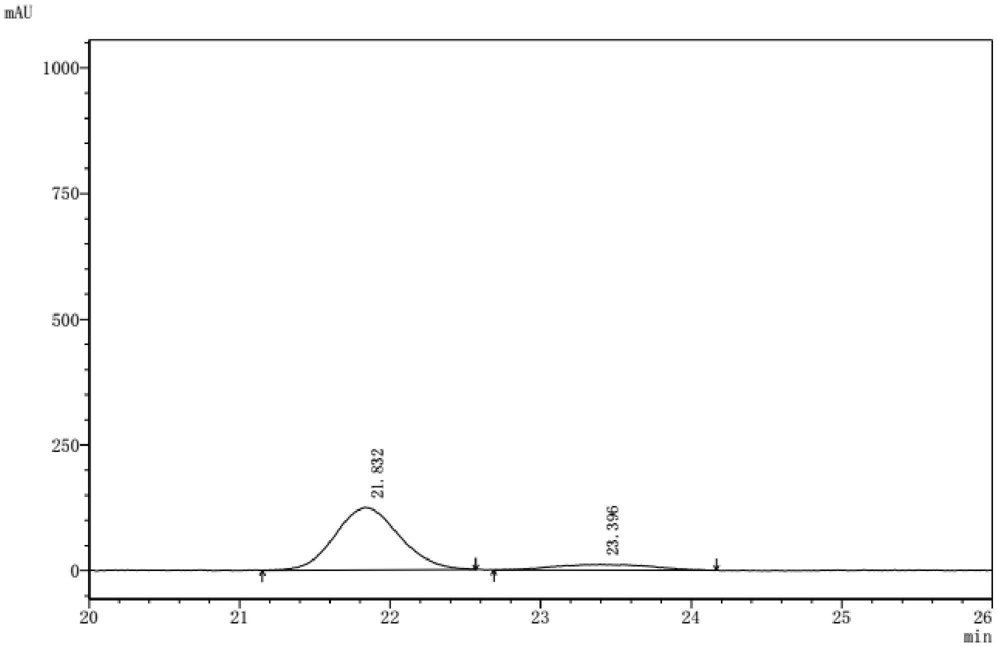
Peak	RetTime	Area	Height	Area%
1	13.606	157672	10162	2.842
2	14.545	5391070	273248	97.158

HPLC spectra of *racemic*-**3az**



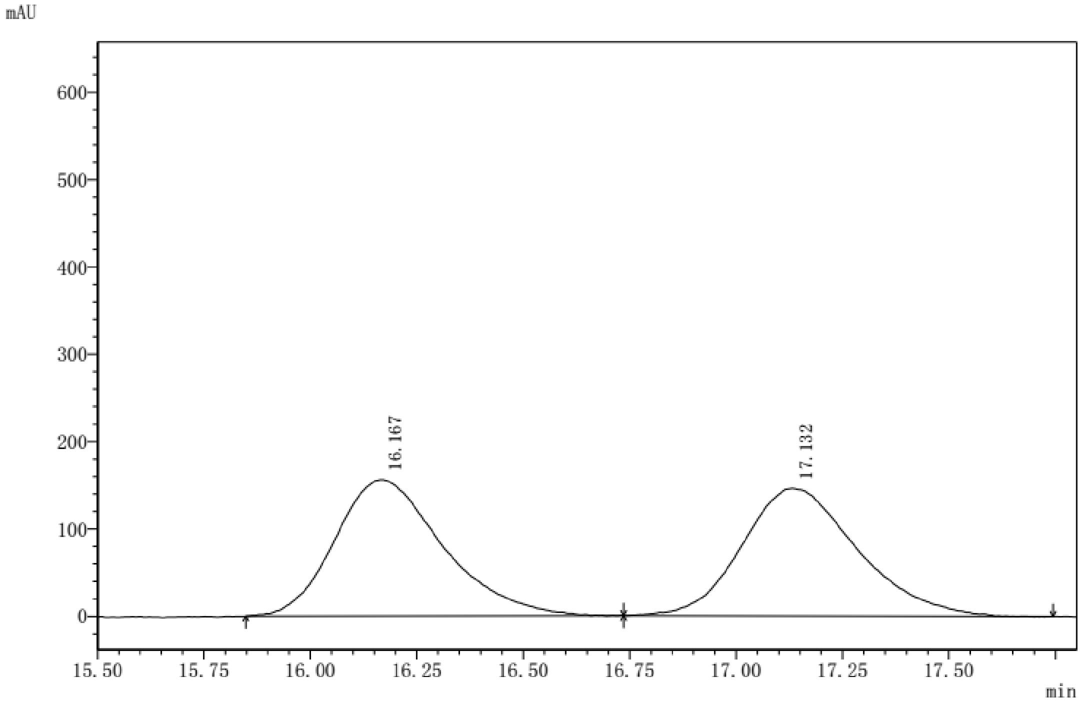
Peak	RetTime	Area	Height	Area%
1	21.689	6469757	222917	50.353
2	23.451	6378959	187898	49.647

HPLC spectra of **enantioenriched-3az**



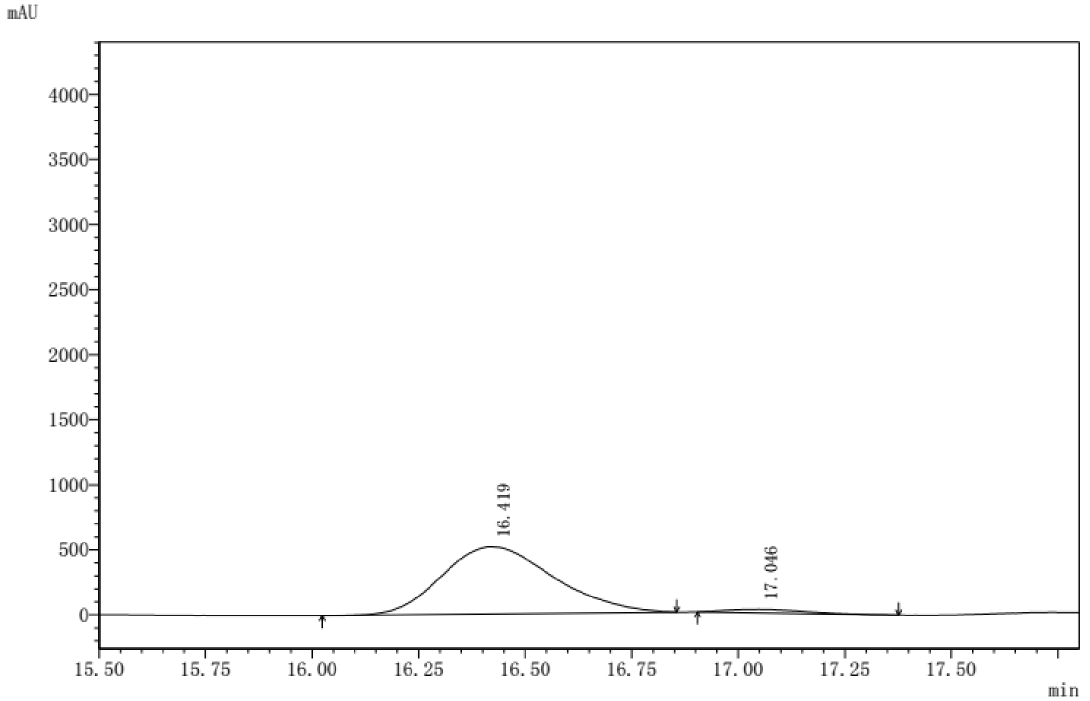
Peak	RetTime	Area	Height	Area%
1	21.832	3712395	124256	87.928
2	23.396	509706	11671	12.072

HPLC spectra of *racemic*-**4az**



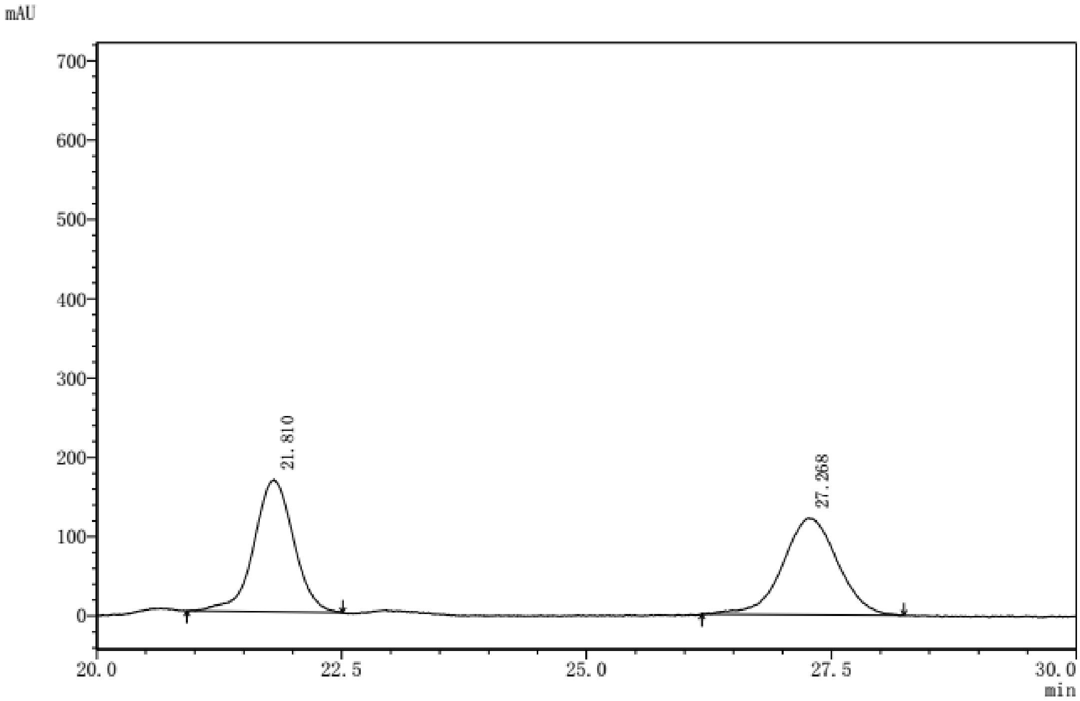
Peak	RetTime	Area	Height	Area%
1	16.167	2743812	155970	49.999
2	17.132	2743962	145783	50.001

HPLC spectra of **enantioenriched-4az**



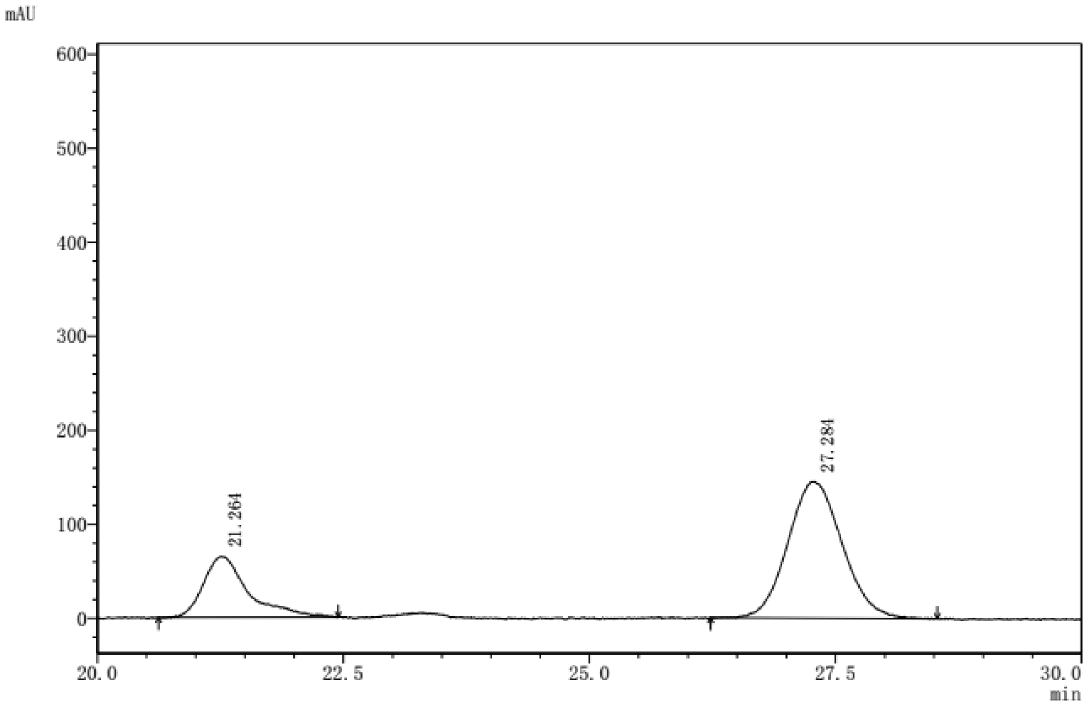
Peak	RetTime	Area	Height	Area%
1	16.419	9380498	515482	96.586
2	17.046	331590	26644	3.414

HPLC spectra of *racemic*-**3ba**



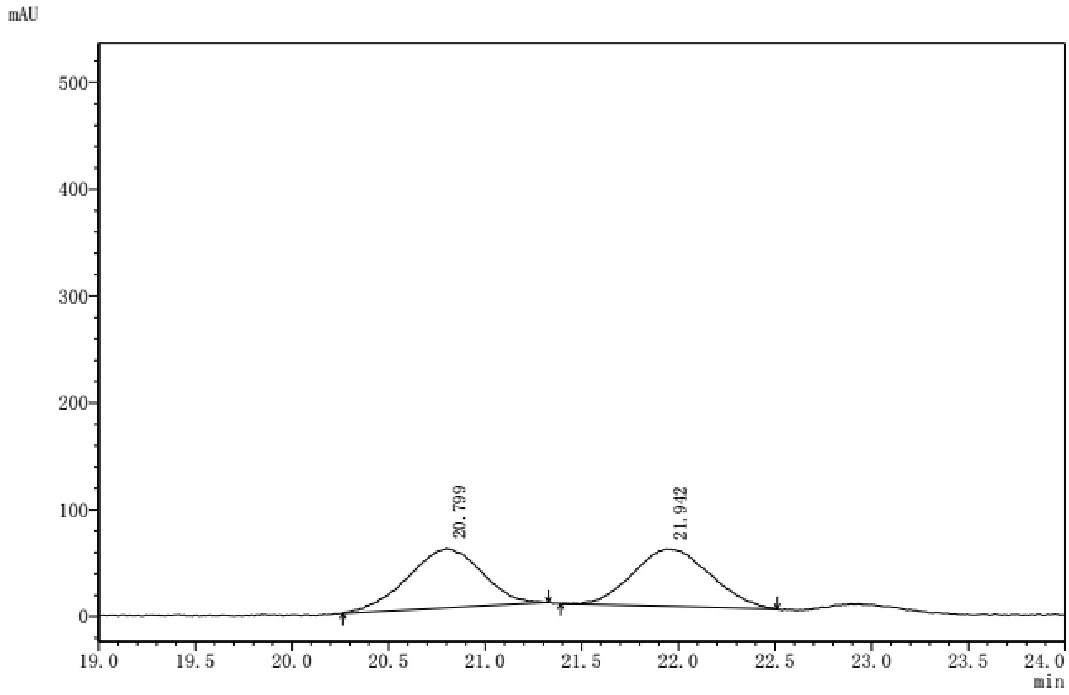
Peak	RetTime	Area	Height	Area%
1	21.810	4703883	166411	49.765
2	27.268	4748247	122015	50.235

HPLC spectra of **enantioenriched-3ba**



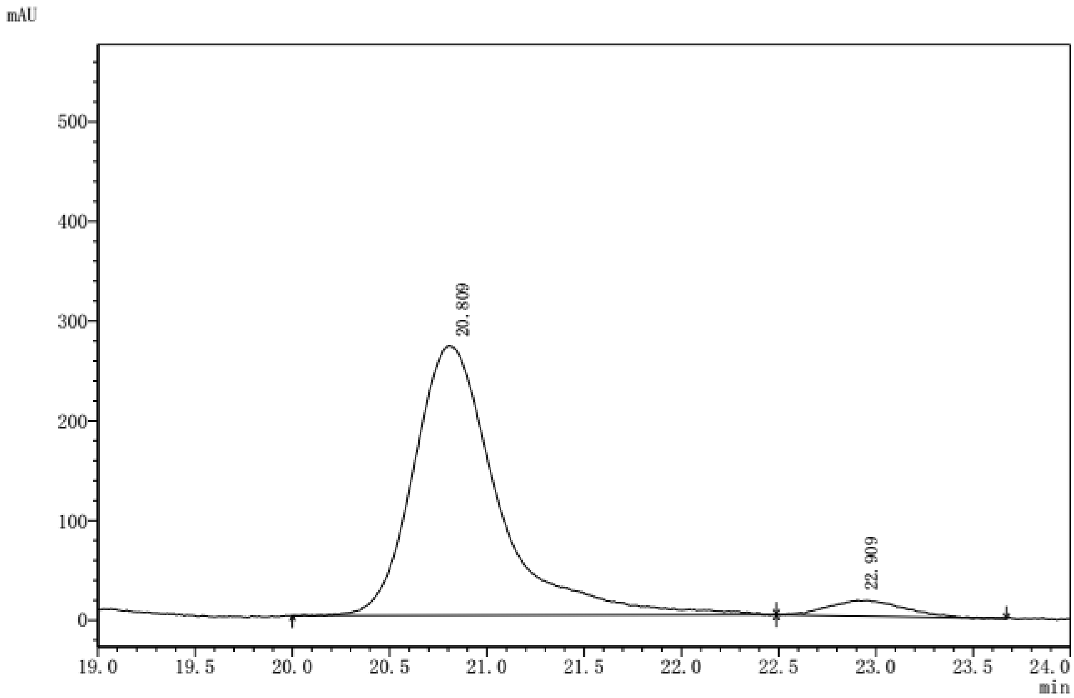
Peak	RetTime	Area	Height	Area%
1	21.264	2049231	64611	26.891
2	27.284	5571290	145185	73.109

HPLC spectra of *racemic*-**4ba**



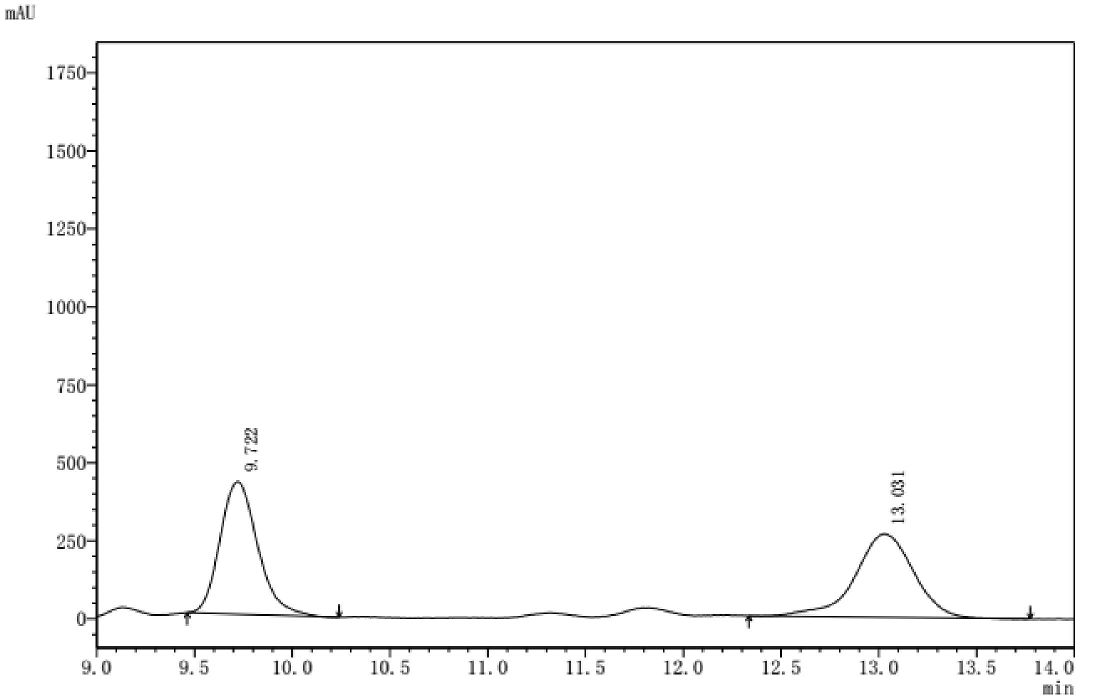
Peak	RetTime	Area	Height	Area%
1	20.799	1466520	55452	49.686
2	21.942	1485045	53374	50.314

HPLC spectra of **enantioenriched-4ba**



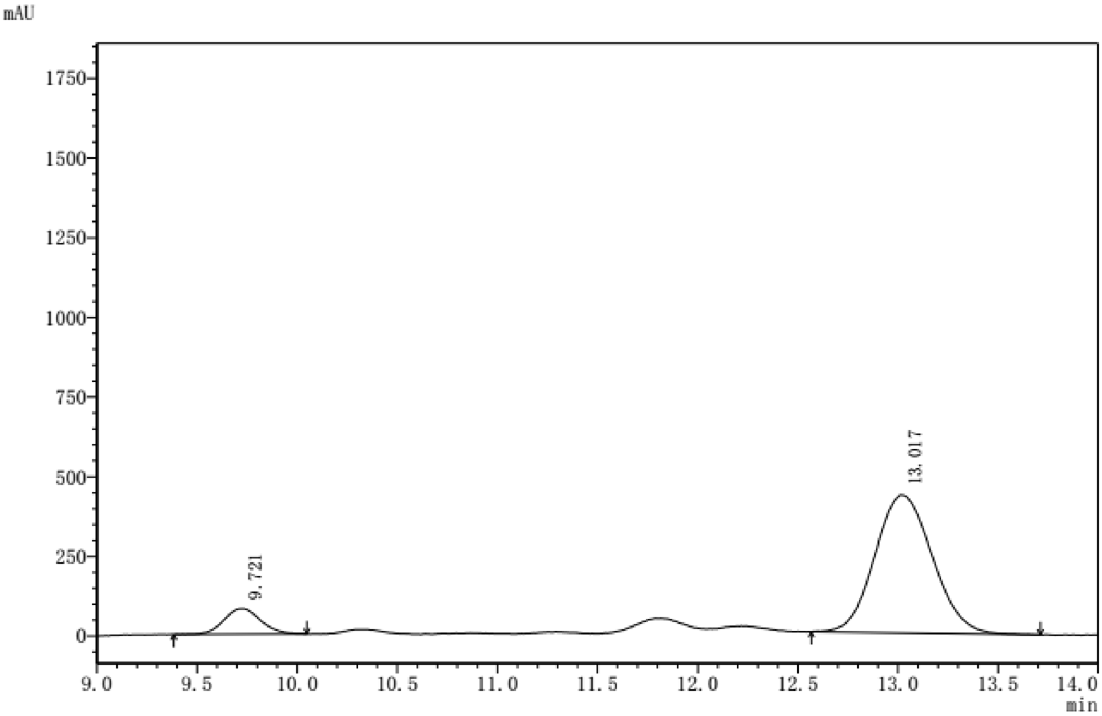
Peak	RetTime	Area	Height	Area%
1	20.809	8124410	269964	94.998
2	22.909	427763	15899	5.002

HPLC spectra of *racemic*-**3bb**



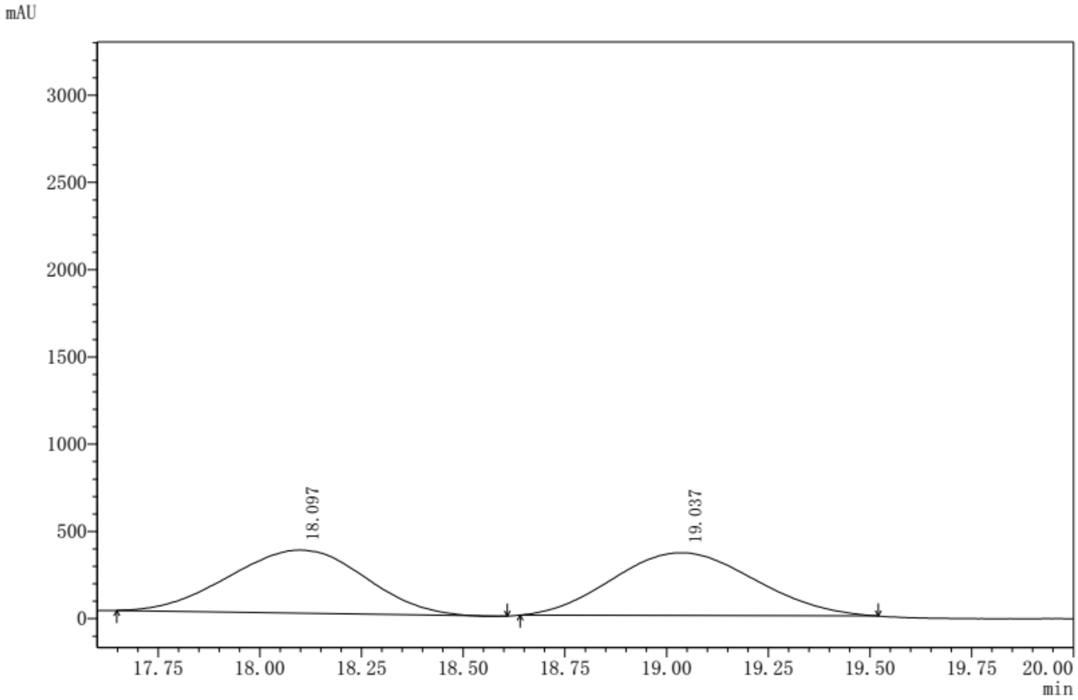
Peak	RetTime	Area	Height	Area%
1	9.722	5687214	424150	50.580
2	13.031	5556874	267043	49.420

HPLC spectra of **enantioenriched-3bb**



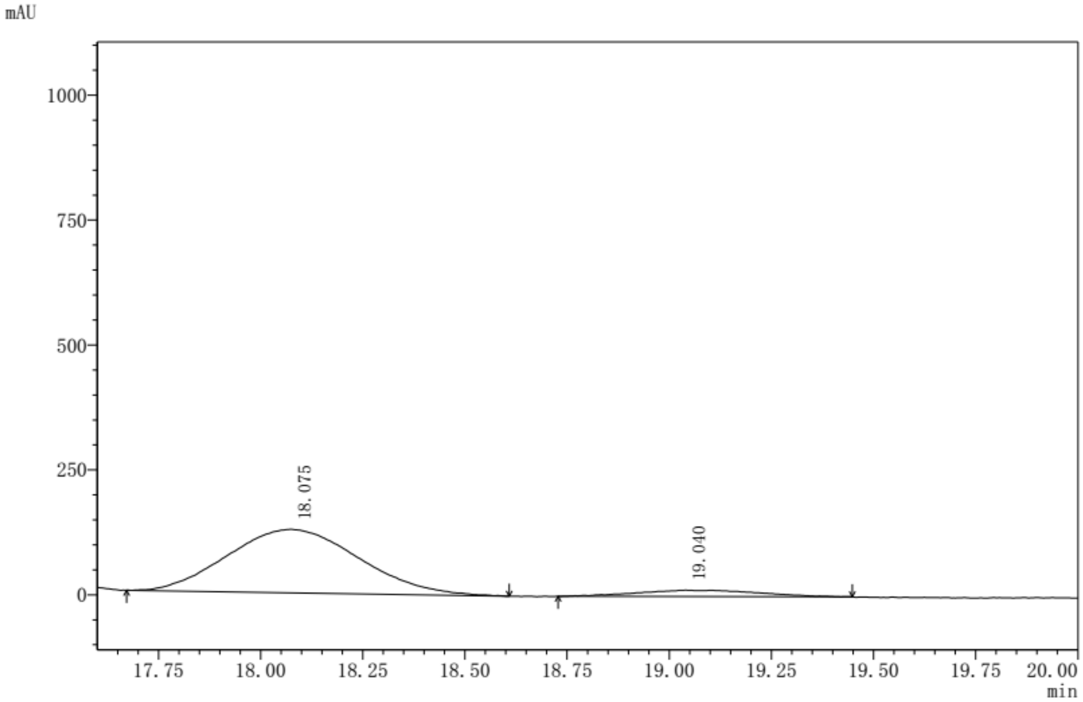
Peak	RetTime	Area	Height	Area%
1	9.721	980386	79087	10.276
2	13.017	8560128	431551	89.724

HPLC spectra of *racemic*-**4bb**



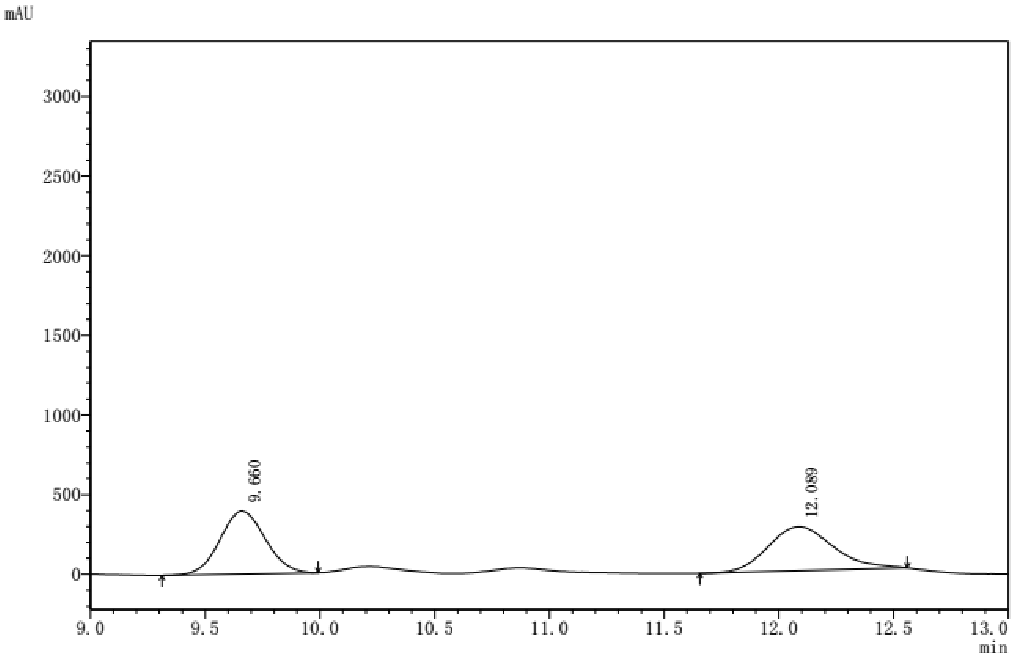
Peak	RetTime	Area	Height	Area%
1	18.097	8340296	360853	48.780
2	19.037	8757489	359140	51.220

HPLC spectra of **enantioenriched-**4**bb**



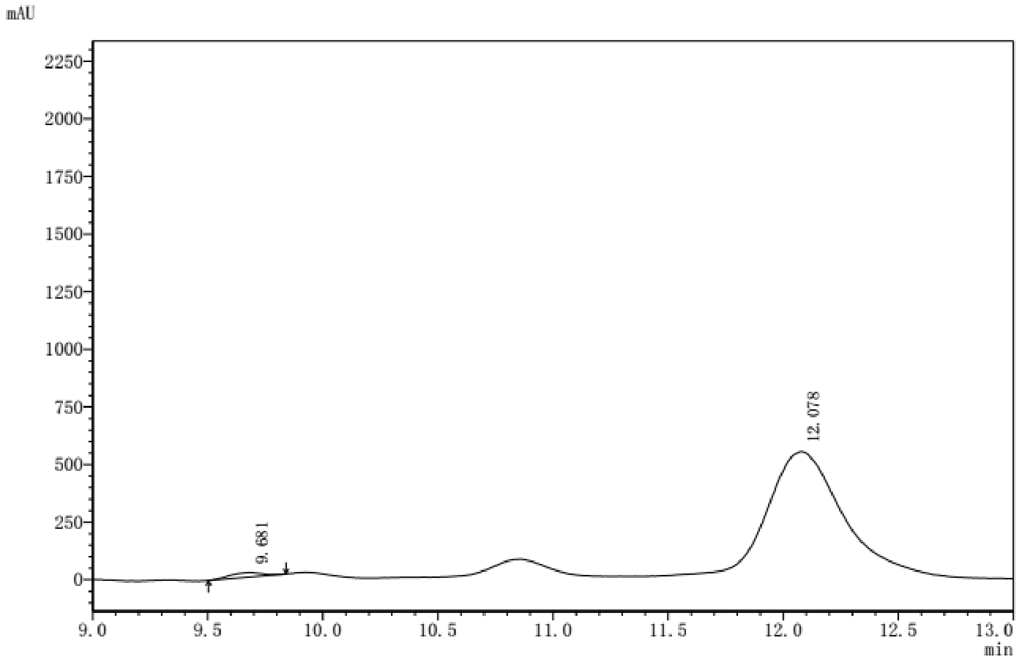
Peak	RetTime	Area	Height	Area%
1	18.075	2838085	127037	91.567
2	19.040	261384	12612	8.433

HPLC spectra of *racemic*-**3bc**



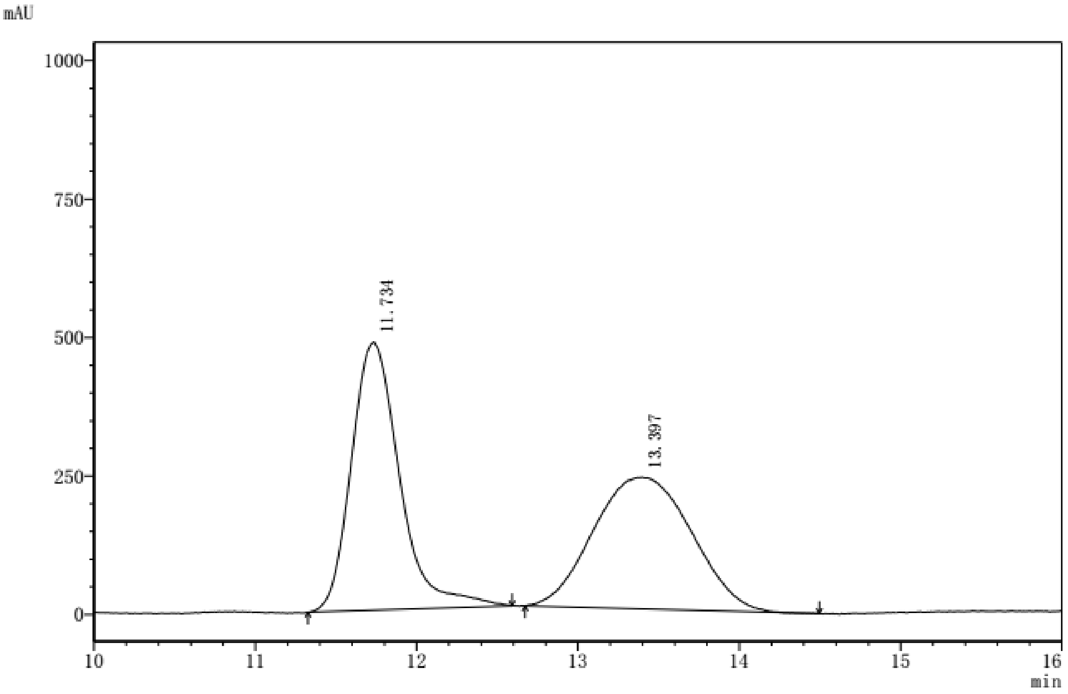
Peak	RetTime	Area	Height	Area%
1	9.660	5408293	395521	49.867
2	12.089	5437226	275760	50.133

HPLC spectra of **enantioenriched-3bc**



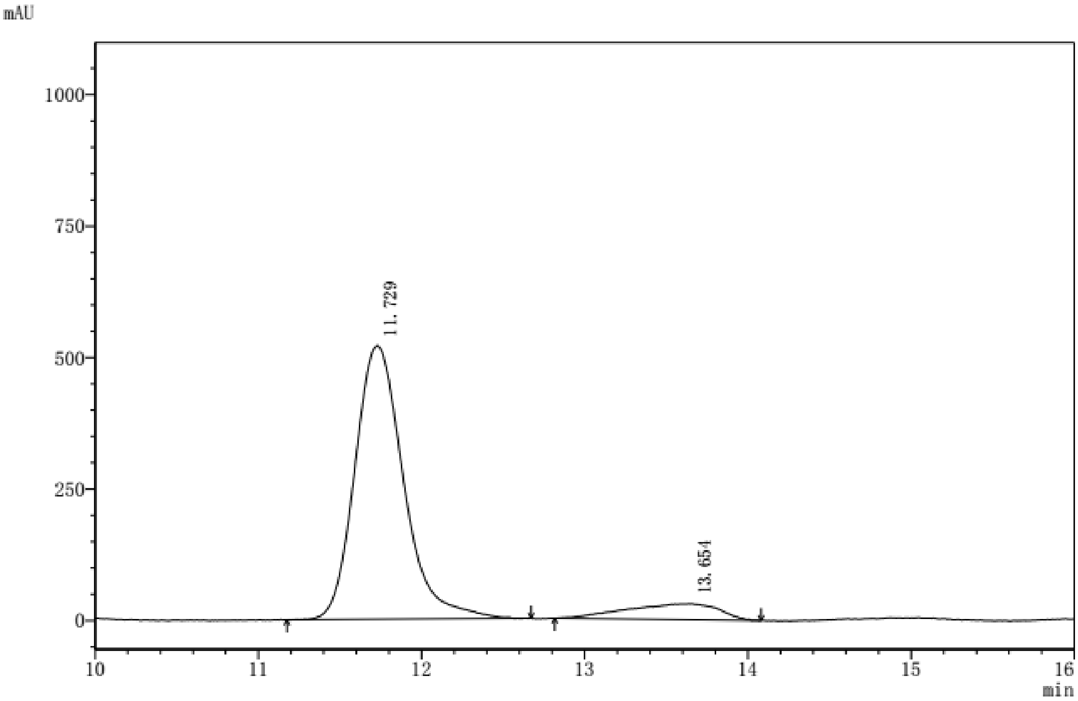
Peak	RetTime	Area	Height	Area%
1	9.681	206677	20456	1.624
2	12.078	12517870	543756	98.376

HPLC spectra of *racemic*-**4bc**



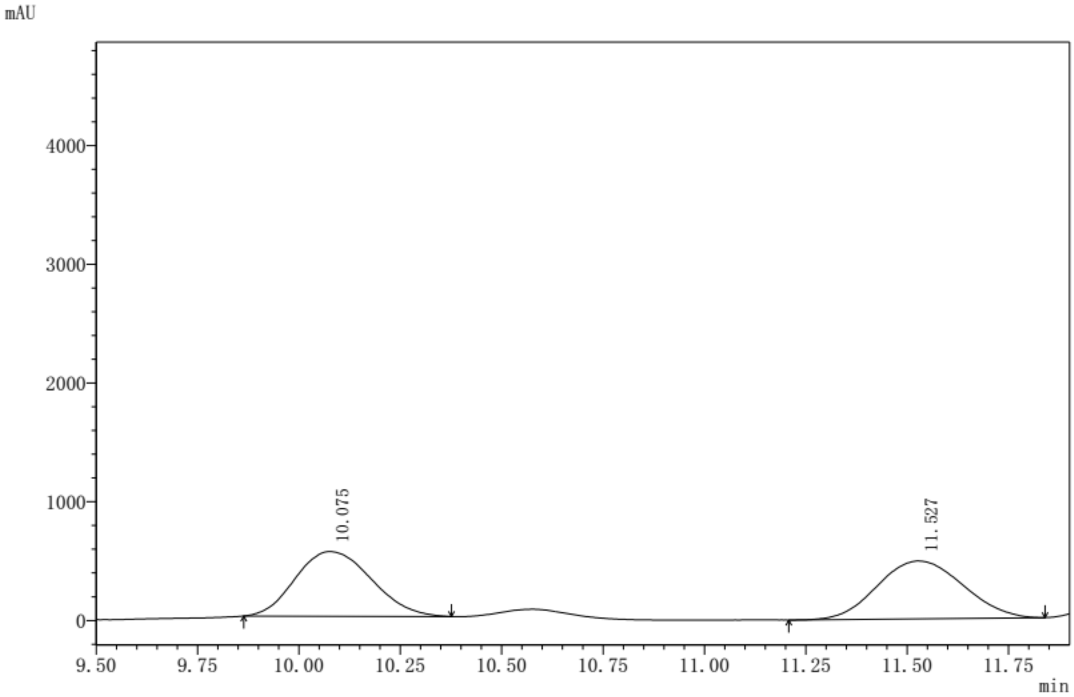
Peak	RetTime	Area	Height	Area%
1	11.734	10065872	483693	50.096
2	13.397	10027104	237645	49.904

HPLC spectra of **enantioenriched-4bc**



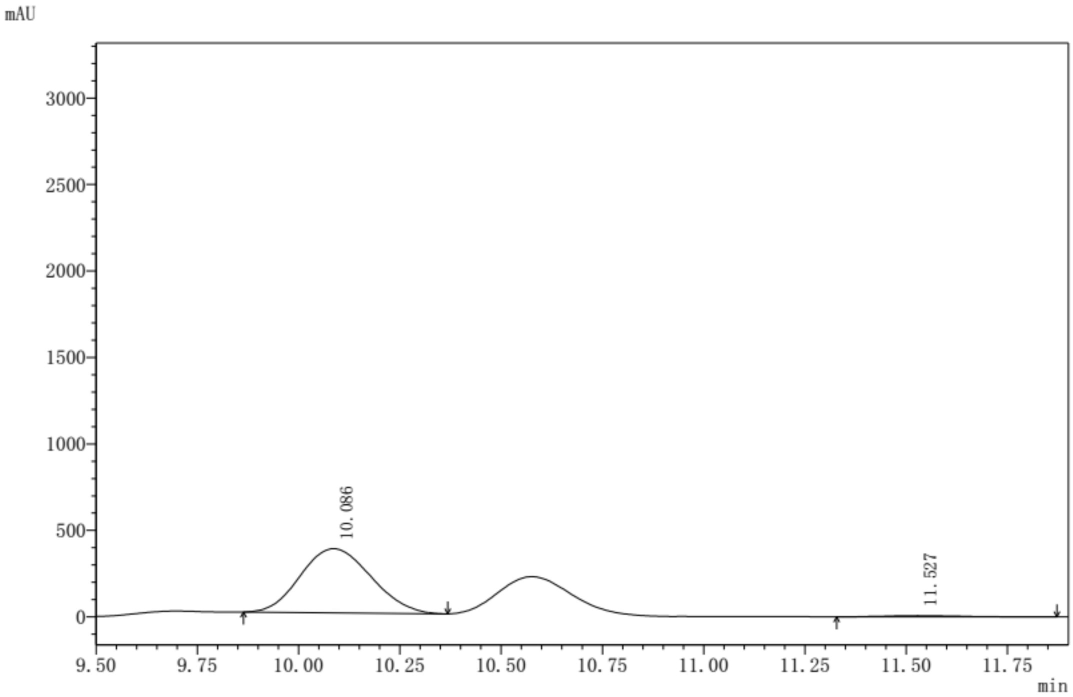
Peak	RetTime	Area	Height	Area%
1	11.729	10790537	520050	90.036
2	13.654	1194206	30827	9.964

HPLC spectra of *racemic*-**3bd**



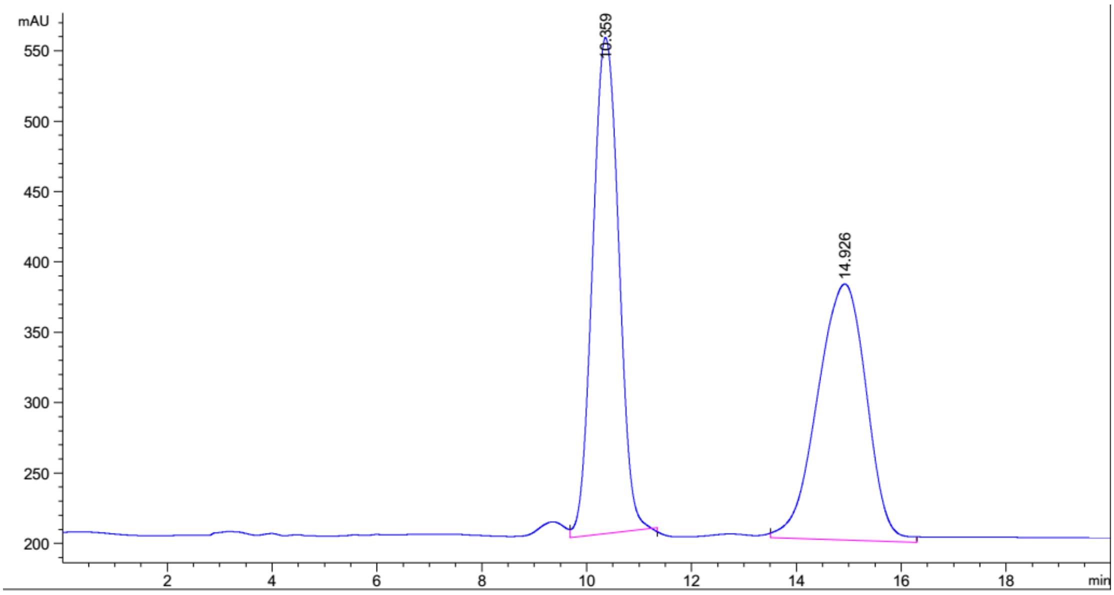
Peak	RetTime	Area	Height	Area%
1	10.075	7117117	543869	49.923
2	11.527	7139037	487223	50.077

HPLC spectra of **enantioenriched-3bd**



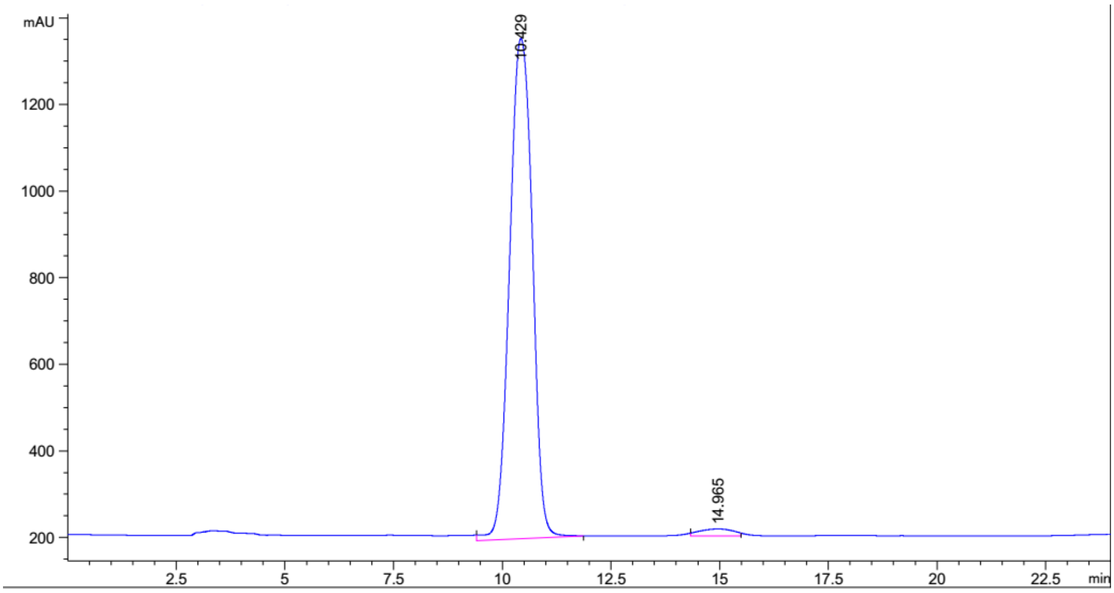
Peak	RetTime	Area	Height	Area%
1	10.086	4503082	371661	98.179
2	11.527	83533	6795	1.821

HPLC spectra of *racemic*-**5**



Peak	RetTime	Area	Height	Area%
1	10.359	1.22011e4	352.34674	50.8352
2	14.926	1.18001e4	181.88972	49.1648

HPLC spectra of **enantioenriched-5**



Peak	RetTime	Area	Height	Area%
1	10.429	4.21804e4	1155.45996	97.9998
2	14.965	860.92230	15.88589	2.0002

5. X-Ray Crystal Structures

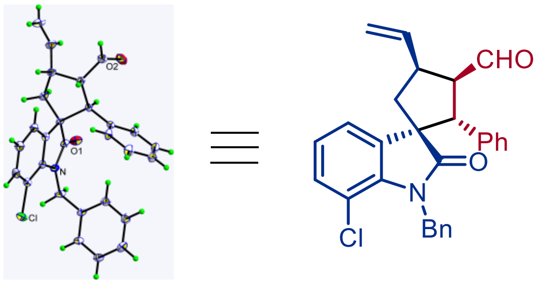


Figure S3 X-ray structure of **3an**

Displacement ORTEP plots are drawn at the 20% probability level. (Solvent: dichloromethane/n-hexane)

<table>
<tr><td colspan="3">Compound 3an</td><td colspan="3">CCDC: 2007712</td></tr>
<tr><td colspan="3">Bond precision: C-C = 0.0034 Å</td><td colspan="3">Wavelength = 0.71076</td></tr>
<tr><td colspan="2">a = 9.5170(5)</td><td colspan="2">b = 16.0000(8)</td><td colspan="2">a = 9.5170(5)</td></tr>
<tr><td colspan="2">alpha = 90</td><td colspan="2">beta = 97.6142(16)</td><td colspan="2">alpha = 90</td></tr>
<tr><td colspan="3">Cell setting: monoclinic</td><td colspan="3">Moiety formula: $C_{28}H_{24}ClNO_2$</td></tr>
<tr><td colspan="3">Cell volume = 2233.6(2)</td><td colspan="3">Space group: P21/n</td></tr>
<tr><td colspan="3">Data completeness = 0.998</td><td colspan="3">Theta(max) = 27.550</td></tr>
<tr><td colspan="3">R(reflections) = 0.0575(2867)</td><td colspan="3">WR2(reflections) = 0.1557(5149)</td></tr>
<tr><td colspan="3">S = 1.081</td><td colspan="3">Radiation type: MoK\a</td></tr>
<tr><td colspan="3">Measurement device type: CCD area detector</td><td colspan="3">Measurement method: phi and omega scans</td></tr>
<tr><td colspan="3">Structure solution: SHELXS-97</td><td colspan="3">Structure refinement: SHELXL-97</td></tr>
<tr><td colspan="3">Solution primary: direct</td><td colspan="3">Solution secondary: difmap</td></tr>
<tr><td colspan="3">Solution hydrogens: geom</td><td colspan="3">Hydrogen treatment: mixed</td></tr>
</table>

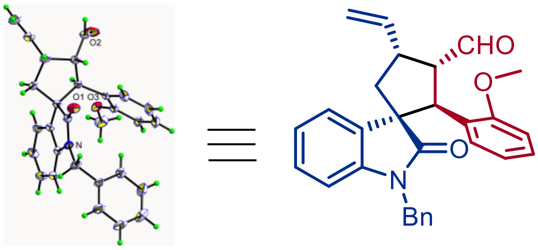


Figure S4 X-ray structure of **4az**

Displacement ORTEP plots are drawn at the 20% probability level. (Solvent: dichloromethane/n-hexane)

Compound 4az	**CCDC:** 2007726	Flack Parameter = -0.2
Bond precision: C-C = 0.0037 Å	Wavelength = 1.54178	
a = 8.6247(4)	b = 14.0350(6)	c = 19.2606(9)
alpha = 90	beta = 90	gamma = 90
Cell setting: Orthorhombic	Moiety formula: $C_{29}H_{27}NO_3$	
Cell volume = 2331.45(18)	Space group: P2(1)2(1)2(1)	
Data completeness = 0.98	Theta(max) = 66.580	
R(reflections) = 0.0461(3530)	WR2(reflections) = 0.1285(4052)	
S = 1.025	Radiation type: CuK\a	
Measurement device type: CCD area detector	Measurement method: phi and omega scans	
Structure solution: SHELXS-97	Structure refinement: SHELXL-97	
Solution primary: direct	Solution secondary: difmap	
Solution hydrogens: geom	Hydrogen treatment: mixed	

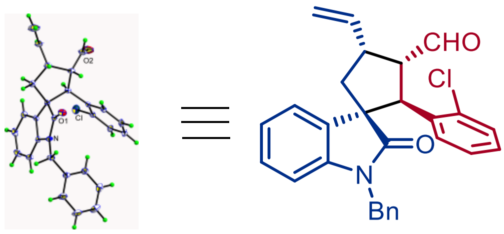


Figure S5 X-ray structure of **4ay**

Displacement ORTEP plots are drawn at the 20% probability level. (Solvent: dichloromethane/n-hexane)

Compound 4ay	**CCDC:** 2003071	Flack Parameter = -0.02
Bond precision: C-C = 0.0037 Å	Wavelength = 0.71076	
a = 8.3579(8)	b = 13.8057(13)	c = 19.3031(19)
alpha = 90	beta = 90	gamma = 90
Cell setting: Orthorhombic	Moiety formula: $C_{28}H_{24}ClNO_2$	
Cell volume = 2227.3(4)	Space group: P212121	
Data completeness = 1.00	Theta(max) = 27.490	
R(reflections) = 0.0503(3561)	WR2(reflections) = 0.1124(5093)	
S = 1.021	Radiation type: MoK\a	
Measurement device type: CCD area detector	Measurement method: phi and omega scans	
Structure solution: SHELXS-97	Structure refinement: SHELXL-97	
Solution primary: direct	Solution secondary: difmap	
Solution hydrogens: geom	Hydrogen treatment: mixed	