Supplementary Materials

Synthesis of chiral *spiro*-indenes via Pd-catalyzed asymmetric (4 + 2) dipolar cyclization

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1. General Information

NMR spectra: ^{1}H NMR spectra were recorded on a 400 MHz spectrometer. Chemical shifts are reported in parts per million (ppm) and the spectra are calibrated to the resonance resulting from incomplete deuteration of the solvent ($CDCl_3$: 7.26 ppm). ^{13}C NMR spectra were recorded on the same spectrometer with complete proton decoupling. Chemical shifts are reported in ppm with the solvent resonance as the internal standard ($^{13}CDCl_3$: 77.0 ppm). Data are reported as follows: chemical shift δ/ppm, integration (^{1}H only), multiplicity (s = singlet, d = doublet, t = triplet of doublets, m = multiplet or combinations thereof. ^{13}C signals are singlets unless otherwise stated), coupling constants *J* in Hz, assignment. ^{19}F NMR spectra were recorded on the same Spectrometer.

High Resolution Mass Spectrometry (HRMS): All were recorded on Bruker micrOTOF II ESI-TOF by ESI or APCI. Measured values are reported to 4 decimal places of the calculated value. The calculated values are based on the most abundant isotope.

Chromatography: Analytical thin layer chromatography was performed using Qingdao Puke Parting Materials Co. silica gel plates (Silicagel 60 F254). Visualisation was by ultraviolet fluorescence (λ = 254 nm) and/or staining with Phosphomolybdic acid or potassium permanganate ($KMnO_4$). Flash column chromatography was performed using 200-300 mesh silica gel. Optical rotations were measured with a polarimeter. [α]. D values are reported at a given temperature (ºC) in degrees $cm^2\ g^{-1}$ with concentration in mg mL^{-1}.

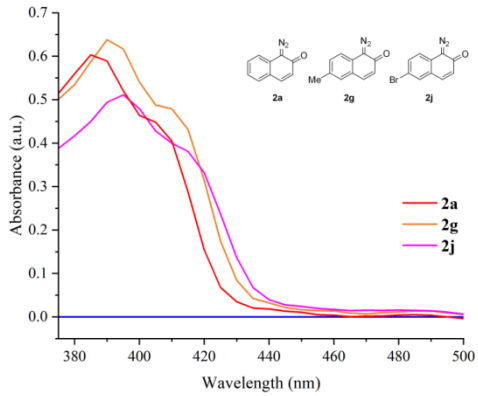
Chiral HPLC: Enantiomeric excesses (ee) values were determined by chiral HPLC with chiral AD-H, AZ-H, IA-H, IC-H, IF-H, IG-H columns with hexane and *i*-PrOH as solvents.

UV-vis: Measurements were made on a Shimadzu RF-6000 Spectro Fluorophotometer.

Materials: All the solvents were treated according to standard methods or through solvent purification systems before use. Substrates **1**[1-3] and **2**[4-6] were prepared according to previous methods and sulfides, copper salts and chiral ligands are commercially available.

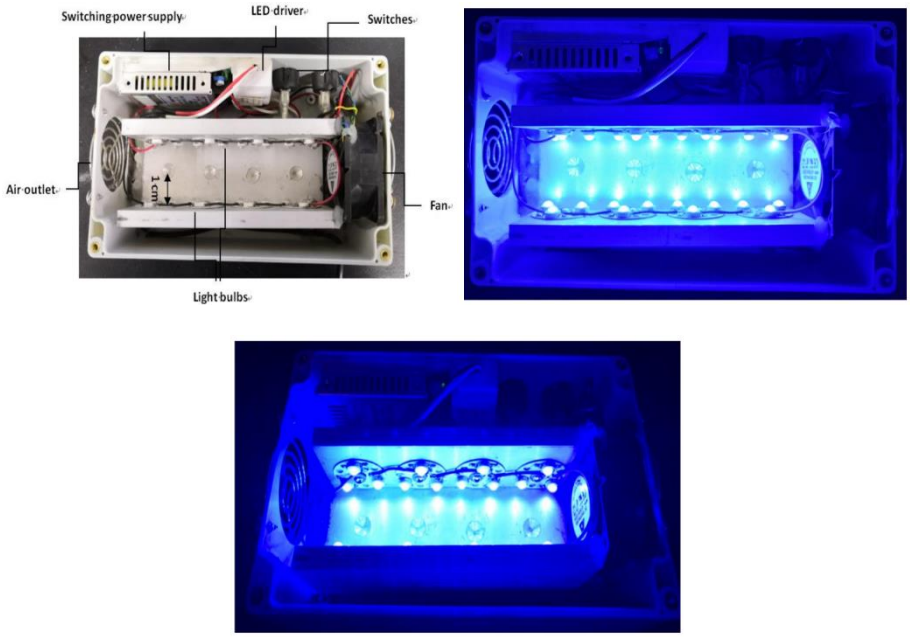
Photoreactor: The photoreactors used in this research were bought from GeAo Chem (blue LEDs, light intensity = 32.8 mw/cm^2, 1 W for every light bulb; every Schlenk tube was irradiated by 6 light bulbs from the side).

2. UV-vis Absorption Spectra



Supplementary Figure 1 UV-vis absorption spectra of **2a**, **2g** and **2j** (0.1 mmol/L in DCM)

3. Photoreactor Setup

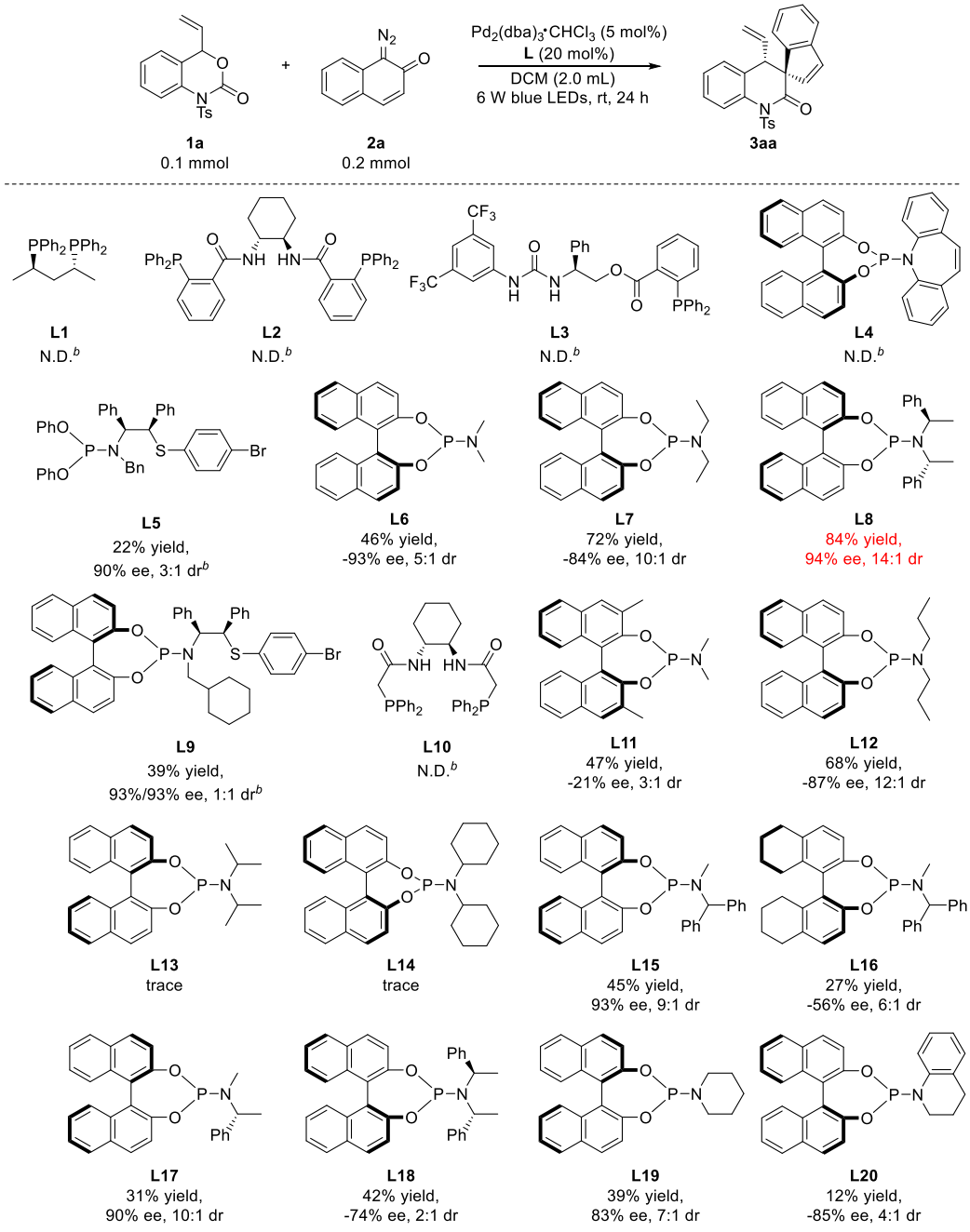


Supplementary Figure 2 Photoreactor used in this research (6 W blue LEDs, λ_{max} = 456 nm)

Supplementary Figure 3 Photoreactor used in this research (20 W blue LEDs, λ_{max} = 456 nm)

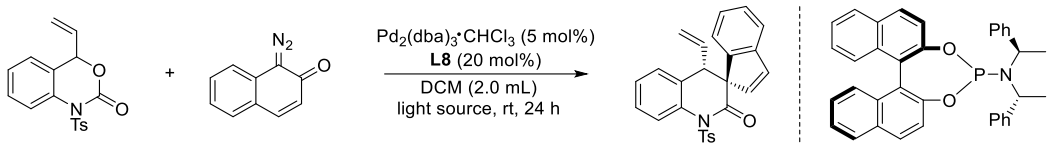
4. Details for Condition Optimizations

Supplementary Table 1. The Effect of Chiral Ligands[a]



[a]Reaction conditions: **1a** (0.1 mmol), **2a** (0.2 mmol), $Pd_2(dba)_3 \cdot CHCl_3$ (5 mol%) and chiral ligand (20 mol%) in DCM (2.0 mL) at rt for 24 h under the irradiation of 6 W blue LEDs (λ_{max} = 456 nm). Yield was determined by analyzing the ^{1}H NMR of reaction mixture with 1,3,5-trimethoxybenzene as an internal standard, N.D. = not detected. ee was determined by chiral HPLC and dr was determined by the ^{1}H NMR analysis of the reaction mixture. [b]Ligand (10 mol%) was used instead.

Supplementary Table 2. The Effect of Light Sources[a]

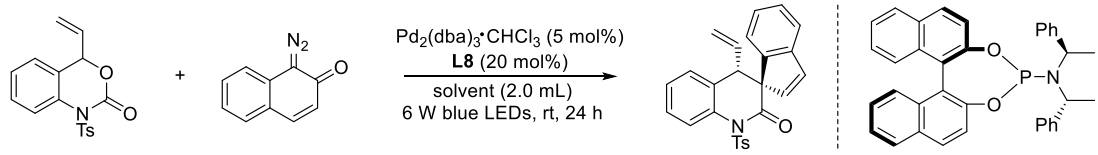


1a 0.1 mmol | **2a** 0.2 mmol | **3aa** | **L8**

entry	light source	yield[b] (%)	dr[c]	ee[d] (%)
1	6 W 370 nm white LEDs	52	10:1	91
2	6 W 390 nm purple LEDs	57	11:1	92
3	6 W 456 nm blue LEDs	84	14:1	94

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (0.2 mmol), $Pd_2(dba)_3 \cdot CHCl_3$ (5 mol%) and **L8** (20 mol%) in DCM (2.0 mL) at rt for 24 h under the irradiation of 6 W different light source. [b]Determined by analyzing the ^1H NMR of reaction mixture with 1,3,5-trimethoxybenzene as an internal standard. [c]Determined by the ^1H NMR analysis of the reaction mixture. [d]Determined by chiral HPLC.

Supplementary Table 3. The Effect of Solvents[a]

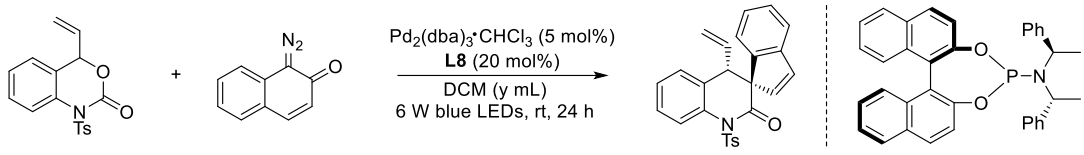


1a 0.1 mmol | **2a** 0.2 mmol | **3aa** | **L8**

entry	solvent	yield[b] (%)	dr[c]	ee[d] (%)
1	DMF	N.D.	-	-
2	DMSO	N.D.	-	-
3	DCM	84	14:1	94
4	$CHCl_3$	41	8:1	93
5	Toluene	35	9:1	93
6	Acetone	38	10:1	94
7	EtOAc	51	11:1	91
8	Et_2O	44	9:1	90
9	THF	21	6:1	92

[a]Reaction conditions: **1a** (0.1 mmol), **II-2a** (0.2 mmol), $Pd_2(dba)_3 \cdot CHCl_3$ (5 mol%) and **L8** (20 mol%) in solvent (2.0 mL) at rt for 24 h under the irradiation of 6 W blue LEDs (λ_{max} = 456 nm). [b]Determined by analyzing the ^1H NMR of reaction mixture with 1,3,5-trimethoxybenzene as an internal standard, N.D. = not detected. [c]Determined by the ^1H NMR analysis of the reaction mixture. [d]Determined by chiral HPLC.

Supplementary Table 4. The Effect of Concentration[a]



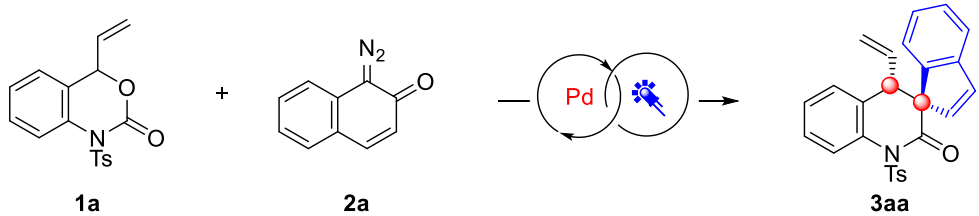
1a 0.1 mmol | **2a** x mmol | **3aa** | **L8**

entry	**2a** (x mmol)	**DCM** (y mL)	yield[b] (%)	dr[c]	ee[d] (%)
1	0.1 mmol	2.0 mL	67	13:1	93
2	0.2 mmol	2.0 mL	84 (84)[e]	14:1	94
3	0.3 mmol	2.0 mL	82	14:1	94
4	0.2 mmol	1.5 mL	79	14:1	93
5	0.2 mmol	3.0 mL	81	13:1	93

[a]Reaction conditions: **1a** (0.1 mmol), **2a** (x mmol), $Pd_2(dba)_3 \cdot CHCl_3$ (5 mol%) and **L8** (20 mol%) in DCM (y mL) at rt for 24 h under the irradiation of 6 W blue LEDs (λ_{max} = 456 nm). [b]Determined by analyzing the ^1H NMR of reaction mixture with 1,3,5-trimethoxybenzene as an internal standard. [c]Determined by the ^1H NMR analysis of the reaction mixture. [d]Determined by chiral HPLC. [e]Isolated yield.

5. General Procedures and Characterization Data of Products

5.1 General Procedures

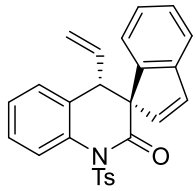


1a **2a** **3aa**

General procedure (one-pot procedure with product **3aa** as an example)**:** Under argon atmosphere, a flame-dried 10 mL Schlenk tube was charged with $Pd_2(dba)_3 \cdot CHCl_3$ (0.005 mmol, 5 mol%), **L8** (0.02 mmol, 20 mol%) and anhydrous DCM (1.0 mL) and the resulting solution was stirred for 30 min at room temperature. Then, vinylbenzoxazinanone **1a** (0.1 mmol, 1.0 equiv.), 1-diazonaphthalen-2(1*H*)-one **2a** (0.2 mmol, 2.0 equiv.) and anhydrous DCM (1.0 mL) were added to the reaction mixture. After that, the reaction solution was stirred under the irradiation of 6 W blue LEDs for 24 h at rt. The combined solution was concentrated under vacuum and the residue was purified by flash column chromatography on silica gel (petrol ether/ethyl acetate = 20/1 to 15/1) to afford the desired product **3aa**.

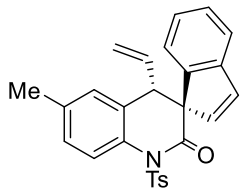
5.2 Characterization Data of Products

(1*S*,4'*S*)-1'-Tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3aa)



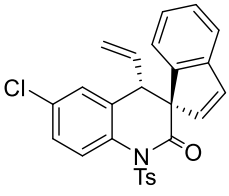
84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -6.73 (c = 0.77 in $CHCl_3$); 94% ee, 14:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 10.09 min, t_R (minor) = 14.73 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.07 – 7.96 (m, 2H), 7.79 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.47 (td, *J* = 7.9, 1.6 Hz, 1H), 7.35 – 7.27 (m, 3H), 7.24 – 7.14 (m, 3H), 6.93 (td, *J* = 7.4, 1.5 Hz, 1H), 6.82 (d, *J* = 5.6 Hz, 1H), 6.25 (d, *J* = 7.6 Hz, 1H), 6.08 (d, *J* = 5.6 Hz, 1H), 5.71 – 5.62 (m, 1H), 5.17 – 5.07 (m, 2H), 3.59 (d, *J* = 8.4 Hz, 1H), 2.44 (s, 3H).; **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 145.1, 144.0, 143.8, 136.3, 134.9, 134.8, 134.6, 133.9, 131.3, 129.4, 129.1, 128.3, 127.9, 127.8, 126.7, 126.0, 123.5, 123.1, 121.8, 120.0, 65.9, 48.9, 21.7. **HRMS** (ESI) for $C_{26}H_{21}NO_3S$ $[M+Na]^+$: calcd 450.1134, found 450.1137.

(1*S*,4'*S*)-6'-Methyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ab)



82% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 7.70 (c = 0.79 in $CHCl_3$); 93% ee, 13:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.5 mL/min, λ = 254 nm, 25 °C), t_R (major) = 29.71 min, t_R (minor) = 36.00 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.99 (d, *J* = 8.1 Hz, 2H), 7.67 (d, *J* = 8.2 Hz, 1H), 7.36 – 7.27 (m, 3H), 7.24 – 7.16 (m, 2H), 6.95 (d, *J* = 6.6 Hz, 2H), 6.81 (d, *J* = 5.6 Hz, 1H), 6.28 (d, *J* = 7.7 Hz, 1H), 6.09 (d, *J* = 5.6 Hz, 1H), 5.69 – 5.60 (m, 1H), 5.17 – 5.07 (m, 2H), 3.52 (d, *J* = 8.4 Hz, 1H), 2.44 (s, 3H), 2.37 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 145.0, 144.0, 143.8, 136.7, 136.4, 134.7, 134.1, 132.5, 131.1, 129.4, 129.1, 129.0, 128.4, 128.3, 128.2, 126.0, 123.4, 123.2, 121.8, 119.8, 65.9, 48.9, 21.7, 21.0. **HRMS** (ESI) for $C_{27}H_{23}NO_3S$ $[M+Na]^+$: calcd 464.1291, found 464.1289.

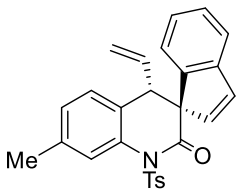
(1*S*,4'*S*)-6'-Chloro-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ac)



83% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -2.33 (c = 0.71 in $CHCl_3$); 94% ee, 19:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 14.02 min, t_R (minor) = 19.76 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.98 (d, *J* = 8.3 Hz, 2H, major+minor), 7.74 (d, *J* = 8.7 Hz, 1H, major+minor), 7.44 (dd, *J* = 8.7, 2.4 Hz, 1H, major+minor), 7.34 (d, *J* = 8.1 Hz, 2H, major+minor), 7.25 – 7.14 (m, 3H, major+minor), 7.01 (m, 1H, major+minor), 6.83 (d, *J* = 5.6 Hz, 1H, major), 6.76 (d, *J* = 5.6 Hz, 1H, minor), 6.41 (d, *J* = 7.6 Hz, 1H, major+minor), 6.00 (d, *J* = 5.6 Hz, 1H, major+minor), 5.56 – 5.48 (m, 1H, major+minor), 5.26 – 5.20 (m, 2H, minor), 5.17 – 5.08 (m, 2H, major), 3.63 (d, *J* = 8.5 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ

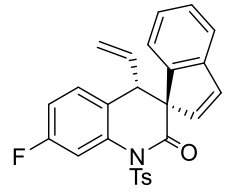
(ppm) 169.7, 145.4, 143.8, 143.7, 136.0, 135.3, 133.5, 133.4, 133.3, 132.7, 132.3, 129.5, 129.1, 128.4, 127.9, 127.6, 126.3, 124.8, 123.1, 122.0, 120.8, 65.7, 48.4, 21.7. **HRMS** (ESI) for $C_{26}H_{20}ClNO_3S$ $[M+Na]^+$: calcd 484.0745, found 484.0750.

(1*S*,4'*S*)-7'-Methyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (**3ad**)



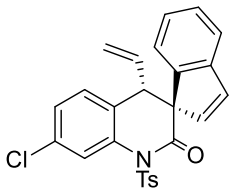
78% Isolated yield, white semi-solid, $[\alpha]_D^{25}$ = -7.73 (c = 0.81 in $CHCl_3$); 94% ee, 17:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 95:5 v/v, flow rate 0.3 mL/min, λ = 254 nm, 25 °C), t_R (major) = 43.73 min, t_R (minor) = 54.77 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.99 (d, *J* = 8.0 Hz, 2H, major+minor), 7.61 (s, 1H, major+minor), 7.33 (d, *J* = 8.1 Hz, 2H, major+minor), 7.23 – 7.16 (m, 2H, major+minor), 7.09 (d, *J* = 7.6 Hz, 1H, major+minor), 7.02 (d, *J* = 7.7 Hz, 1H, major+minor), 6.94 (t, *J* = 7.4, 1.5 Hz, 1H, major+minor), 6.81 (d, *J* = 5.6 Hz, 1H, major), 6.73 (d, *J* = 5.6 Hz, 1H, minor), 6.25 (d, *J* = 7.7 Hz, 1H, major+minor), 6.08 (d, *J* = 5.6 Hz, 1H, major), 5.96 (d, *J* = 5.6 Hz, 1H, minor), 5.69 – 5.60 (m, 1H, major+minor), 5.21 – 5.17 (m, 2H, minor), 5.13 – 5.07 (m, 2H, major), 3.53 (d, *J* = 8.3 Hz, 1H, major+minor), 2.50 (s, 3H, major+minor), 2.45 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.3, 145.0, 144.1, 143.8, 137.9, 136.4, 134.8, 134.7, 134.2, 129.4, 129.4, 129.1, 128.2, 128.2, 127.6, 127.4, 126.0, 124.1, 123.2, 121.8, 119.7, 66.0, 48.6, 21.7, 21.6. **HRMS** (ESI) for $C_{27}H_{23}NO_3S$ $[M+Na]^+$: calcd 464.1291, found 464.1290.

(1*S*,4'*S*)-7'-Fluoro-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ae)



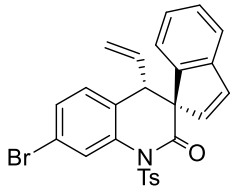
80% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -12.67 (c = 0.71 in $CHCl_3$); 94% ee, 9:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 11.03 min, t_R (minor) = 13.76 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.1 Hz, 2H, major+minor), 7.59 (dd, *J* = 10.2, 2.5 Hz, 1H, major+minor), 7.34 (d, *J* = 8.1 Hz, 2H, major+minor), 7.24 – 7.19 (m, 2H, major+minor), 7.13 – 7.10 (m, 1H, major+minor), 7.02 – 6.96 (m, 2H, major+minor), 6.84 (d, *J* = 5.6 Hz, 1H, major), 6.77 (d, *J* = 5.6 Hz, 1H, minor), 6.33 (d, *J* = 7.7 Hz, 1H, major+minor), 6.08 (d, *J* = 5.7 Hz, 1H, major), 5.98 (d, *J* = 5.7 Hz, 1H, minor), 5.68 – 5.59 (m, 1H, major+minor), 5.24 – 5.19 (m, 2H, minor), 5.16 – 5.08 (m, 2H, major), 3.58 (d, *J* = 8.3 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor). **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.8, 161.7 (d, *J* = 244.8 Hz), 145.4, 143.8, 136.0, 135.9 (d, *J* =10.6 Hz), 135.0, 134.2, 133.7, 129.5, 129.1, 129.0, 128.9 (d, *J* = 9.1 Hz), 128.4, 127.0 (d, *J* = 3.2 Hz), 126.1, 123.0, 122.0, 120.2, 113.4 (d, *J* = 21.2 Hz), 111.3 (d, *J* = 26.6 Hz), 65.7, 48.3, 21.7. **^{19}F NMR** (376 MHz, $CDCl_3$) δ (ppm) -112.15, -112.29. **HRMS** (ESI) for $C_{26}H_{20}FNO_3S$ $[M+Na]^+$: calcd 468.1040, found 468.1033.

(1*S*,4'*S*)-7'-Chloro-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (**3af**)



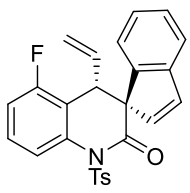
76% Isolated yield, white solid, $[\alpha]_D^{25}$ = -1.77 (c = 0.52 in $CHCl_3$); 97% ee, 11:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 95:5 v/v, flow rate 0.3 mL/min, λ = 254 nm, 25 °C), t_R (major) = 46.43 min, t_R (minor) = 56.03 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.01 – 7.97 (m, 2H, major+minor), 7.82 (d, *J* = 2.0 Hz, 1H, major+minor), 7.34 (d, *J* = 8.1 Hz, 2H, major+minor), 7.24 – 7.18 (m, 2H, major+minor), 7.09 (d, *J* = 8.2 Hz, 1H, major+minor), 7.01 – 6.95 (m, 1H, major+minor), 6.83 (d, *J* = 5.6 Hz, 1H, major), 6.76 (d, *J* = 5.6 Hz, 1H, minor), 6.48 (d, *J* = 7.6 Hz, 1H, minor), 6.37 (d, *J* = 7.6 Hz, 1H, major), 6.05 (d, *J* = 5.6 Hz, 1H, major), 5.97 (d, *J* = 5.6 Hz, 1H, minor), 5.64 – 5.55 (m, 1H, major+minor), 5.25 – 5.18 (m, 2H, minor), 5.16 – 5.08 (m, 2H, major), 3.59 (d, *J* = 8.4 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.7, 145.4, 143.8, 143.7, 135.9, 135.8, 135.1, 133.9, 133.4, 133.3, 129.8, 129.5, 129.1, 128.7, 128.4, 126.7, 126.2, 123.6, 123.0, 122.0, 120.4, 65.6, 48.3, 21.7. **HRMS** (ESI) for $C_{26}H_{20}ClNO_3S$ $[M+Na]^+$: calcd 484.0745, found 484.0737.

(1*S*,4'*S*)-7'-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (**3ag**)



81% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -2.55 (c = 0.46 in $CHCl_3$); 96% ee, 13:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 97:3 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 40.43 min, t_R (minor) = 49.45 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.01 – 7.96 (m, 3H, major+minor), 7.42 (dd, *J* = 8.1, 1.8 Hz, 1H, major+minor), 7.35 (d, *J* = 8.1 Hz, 2H, major+minor), 7.24 – 7.19 (m, 2H, major+minor), 7.04 – 6.97 (m, 2H, major+minor), 6.83 (d, *J* = 5.6 Hz, 1H, major), 6.76 (d, *J* = 5.6 Hz, 1H, minor), 6.37 (d, *J* = 7.7 Hz, 1H, major+minor), 6.05 (d, *J* = 5.6 Hz, 1H, major), 5.96 (d, *J* = 5.6 Hz, 1H, minor), 5.63 – 5.54 (m, 1H, major+minor), 5.25 – 5.18 (m, 2H, minor), 5.16 – 5.08 (m, 2H, major), 3.58 (d, *J* = 8.4 Hz, 1H, major+minor), 2.45 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.7, 145.4, 143.8, 143.7, 135.9, 135.9, 135.2, 133.9, 133.2, 130.3, 129.6, 129.5, 129.1, 129.0, 128.5, 126.4, 126.2, 123.1, 122.0, 121.1, 120.5, 65.6, 48.4, 21.7. **HRMS** (ESI) for $C_{26}H_{20}BrNO_3S$ $[M+Na]^+$: calcd 528.0239, found 528.0230.

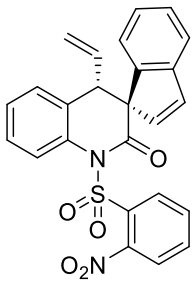
(1*S*,4'*R*)-5'-Fluoro-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ah)



68% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 107.77 (c = 1.02 in $CHCl_3$); 81% ee, 5:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.3 mL/min, λ = 254 nm, 25 °C), t_R (major) = 47.58 min, t_R (minor) = 38.78 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.01 – 7.96 (m, 2H, major+minor), 7.69 (d, *J* = 8.3 Hz, 1H, major), 7.63 (d, *J* = 8.3 Hz, 1H, minor), 7.51 – 7.45 (m, 1H, major), 7.42 – 7.37 (m, 1H, minor), 7.34 – 7.29 (m, 2H, major+minor), 7.25 – 7.15 (m, 2H, major+minor), 7.06

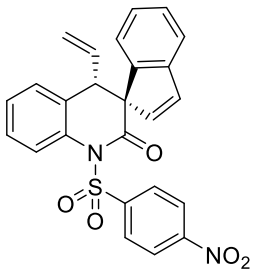
(td, *J* = 8.4, 1.0 Hz, 1H, major+minor), 6.89 (d, *J* = 5.7 Hz, 1H, major), 6.78 (td, *J* = 7.6, 1.3 Hz, 1H, major+minor), 6.72 (d, *J* = 5.7 Hz, 1H, minor), 6.44 (d, *J* = 5.7 Hz, 1H, major+minor), 6.09 – 5.95 (m, 1H, major+minor), 5.82 (d, *J* = 5.7 Hz, 1H, major), 5.70 (d, *J* = 5.7 Hz, 1H, minor), 5.28 – 5.10 (m, 2H, major+minor), 3.55 (d, *J* = 7.7 Hz, 1H, major), 3.47 (d, *J* = 7.7 Hz, 1H, minor), 2.45 (s, 3H, minor), 2.43 (s, 3H, major); **^{13}C NMR** δ (ppm) 169.4, 160.0 (d, J = 245.7 Hz), 145.4, 143.6, 143.1, 137.1, 136.7 (d, J = 5.4 Hz), 135.9, 134.7, 134.3, 129.4, 129.3, 128.8 (d, J = 9.1 Hz), 128.7, 125.9, 122.2 (d, J = 11.7 Hz), 119.3, 119.3, 119.3, 118.8 (d, J = 20.5 Hz), 113.5 (d, J = 21.7 Hz), 64.3, 42.78, 21.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ (ppm) -118.11, -118.83. **HRMS** (ESI) for $C_{26}H_{20}FNO_3S$ $[M+Na]^+$: calcd 468.1040, found 468.1036.

(1*S*,4'*S*)-1'-((2-Nitrophenyl)sulfonyl)-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ai)



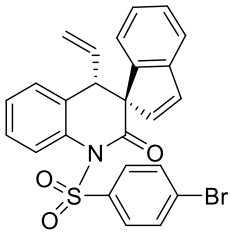
76% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -64.93 (c = 0.91 in $CHCl_3$); 92% ee, 14:1 dr, determined by HPLC analysis (Chiralpak IC-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.5 mL/min, λ = 254 nm, 25 °C), t_R (major) = 32.63 min, t_R (minor) = 30.20 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.45 (dd, *J* = 7.6, 1.9 Hz, 1H), 7.87 (dd, *J* = 7.5, 1.9 Hz, 1H), 7.81 – 7.74 (m, 3H), 7.47 – 7.42 (m, 1H), 7.34 – 7.29 (m, 1H), 7.26 – 7.20 (m, 3H), 7.06 (m, 1H), 6.83 (d, *J* = 5.6 Hz, 1H), 6.72 (d, *J* = 7.6 Hz, 1H), 5.93 (d, *J* = 5.6 Hz, 1H), 5.44 – 5.35 (m, 1H), 5.13 – 5.07 (m, 2H), 4.23 (d, *J* = 9.2 Hz, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.0, 147.7, 144.1, 144.0, 135.6, 135.5, 134.7, 133.8, 133.6, 132.3, 132.1, 132.0, 131.3, 128.3, 127.7, 127.1, 126.9, 126.3, 124.6, 123.4, 122.9, 121.9, 121.0, 65.9, 47.6. **HRMS** (ESI) for $C_{25}H_{18}N_2O_5S$ $[M+Na]^+$: calcd 481.0829, found 481.0831.

(1*S*,4'*S*)-1'-((4-Nitrophenyl)sulfonyl)-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3aj)



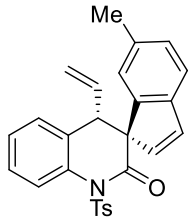
74% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -35.57 (c = 0.96 in $CHCl_3$); 92% ee, 11:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 18.15 min, t_R (minor) = 33.49 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.39 – 8.35 (m, 2H, major+minor), 8.30 (m, 2H, major+minor), 7.79 (d, *J* = 8.2 Hz, 1H, major+minor), 7.52 (t, *J* = 7.9 Hz, 1H, major+minor), 7.34 (t, *J* = 7.5 Hz, 1H, major+minor), 7.21 (m, 3H, major+minor), 6.95 (t, *J* = 7.5 Hz, 1H, major+minor), 6.86 (d, *J* = 5.6 Hz, 1H, major), 6.77 (d, *J* = 5.6 Hz, 1H, minor), 6.25 (d, *J* = 7.6 Hz, 1H, major+minor), 6.10 (d, *J* = 5.6 Hz, 1H, major), 5.95 (d, *J* = 5.6 Hz, 1H, minor), 5.74 – 5.65 (m, 1H, major+minor), 5.28 – 5.25 (m, 2H, minor), 5.21 – 5.10 (m, 2H, major), 3.61 (d, *J* = 8.0 Hz, 1H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.6, 150.6, 144.8, 143.7, 143.4, 135.3, 134.4, 134.0, 133.8, 131.2, 130.5, 128.6, 128.4, 128.2, 127.2, 126.2, 124.0, 123.2, 123.0, 122.1, 120.4, 65.6, 48.8. **HRMS** (ESI) for $C_{25}H_{18}N_2O_5S$ $[M+Na]^+$: calcd 481.0829, found 481.0824.

(1*S*,4'*S*)-1'-((4-Bromophenyl)sulfonyl)-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ak)



79% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -34.40 (c = 0.92 in $CHCl_3$); 92% ee, 10:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 12.72 min, t_R (minor) = 26.01 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.07 – 8.05 (m, 2H, minor), 8.00 – 7.96 (m, 2H, major), 7.76 (d, *J* = 8.2 Hz, 1H, major+minor), 7.69 – 7.66 (m, 2H, major+minor), 7.48 (t, *J* = 7.8 Hz, 1H, major+minor), 7.30 (t, *J* = 7.5 Hz, 1H, major+minor), 7.23 – 7.14 (m, 3H, major+minor), 6.95 (t, *J* = 7.5 Hz, 1H, major+minor), 6.84 (d, *J* = 5.6 Hz, 1H, major), 6.76 (d, *J* = 5.6 Hz, 1H, minor), 6.41 (d, *J* = 7.6 Hz, 1H, minor), 6.25 (d, *J* = 7.6 Hz, 1H, major), 6.09 (d, *J* = 5.6 Hz, 1H, major), 5.96 (d, *J* = 5.6 Hz, 1H, minor), 5.72 – 5.63 (m, 1H, major+minor), 5.25 – 5.19 (m, 2H, minor), 5.18 – 5.09 (m, 2H, major), 3.68 (d, *J* = 8.2 Hz, 1H, minor), 3.59 (d, *J* = 8.2 Hz, 1H, major); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.3, 143.8, 143.8, 138.2, 135.0, 134.7, 134.3, 133.8, 132.2, 131.1, 130.6, 129.3, 128.4, 128.1, 128.0, 126.9, 126.1, 123.4, 123.1, 121.9, 120.2, 65.8, 48.8. **HRMS** (ESI) for $C_{25}H_{18}BrNO_3S$ $[M+Na]^+$: calcd 514.0083, found 514.0086.

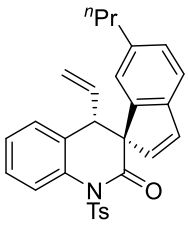
(1*S*,4'*S*)-6-Methyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ba)



86% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -20.60 (c = 0.84 in $CHCl_3$); 90% ee, 10:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 13.95 min, t_R (minor) = 16.60 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.02 (d, *J* = 8.2 Hz, 1H, major+minor), 7.77 (d, *J* = 8.2 Hz, 1H, major+minor), 7.49 – 7.44 (m, 1H, major+minor), 7.34 (d, *J* = 8.2 Hz, 2H, major+minor), 7.29 (d, *J* = 7.6 Hz, 1H, major+minor), 7.17 – 7.09 (m, 2H, major+minor), 7.00 (d, *J* = 7.7 Hz, 1H, major+minor), 6.77 (d, *J* = 5.6 Hz, 1H, major), 6.70 (d, *J* = 5.6 Hz, 1H, minor), 6.09 (s, 1H, major+minor), 5.94 (d, *J* = 5.6 Hz, 1H, major), 5.85 (d, *J* = 5.6 Hz, 1H, minor), 5.64 – 5.56 (m, 1H, major+minor), 5.26 – 5.19 (m, 2H, minor), 5.14 – 5.08 (m, 2H, major), 3.63 (d, *J* = 8.4 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor), 2.14 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.5, 145.1, 144.4, 141.2, 136.3, 135.8, 134.9, 134.8, 133.6, 133.1, 131.5, 129.4, 129.2, 128.9, 127.7, 127.7, 126.6, 124.1, 123.5, 121.4, 120.1, 65.9, 48.7, 21.7, 21.5. **HRMS** (ESI) for $C_{27}H_{23}NO_3S$ $[M+Na]^+$: calcd 464.1291, found 464.1298.

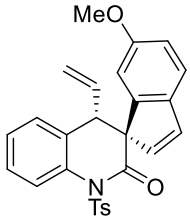
(1*S*,4'*S*)-6-Isopropyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ca)

81% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -2.80 (c = 0.68 in $CHCl_3$); 92% ee, 10:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 12.88 min, t_R (minor) = 11.58 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.02 – 7.98 (d, *J* = 8.2 Hz, 1H, major+minor), 7.83 (d,



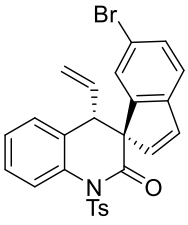
J = 8.2 Hz, 1H, major+minor), 7.50 – 7.46 (m, 1H, major+minor), 7.34 – 7.27 (m, 3H, major+minor), 7.16 – 7.10 (m, 2H, major+minor), 7.02 (dd, *J* = 7.8, 1.5 Hz, 1H, major+minor), 6.79 (d, *J* = 5.6 Hz, 1H, major), 6.71 (d, *J* = 5.6 Hz, 1H, minor), 6.06 (d, *J* = 5.7 Hz, 1H, major+minor), 5.98 (d, *J* = 5.6 Hz, 1H, major), 5.92 (d, *J* = 5.6 Hz, 1H, minor), 5.76 – 5.67 (m, 1H, major+minor), 5.24 – 5.19 (m, 2H, minor), 5.15 – 5.07 (m, 2H, major), 3.48 (d, *J* = 8.2 Hz, 1H, major+minor), 2.68 – 2.61(m, 1H, major+minor), 2.44 (s, 3H, major+minor), 1.00 (d, J = 1.9 Hz, 3H, major+minor), 0.99 (d, J = 1.9 Hz, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.3, 146.7, 145.0, 144.2, 141.4, 136.4, 135.2, 134.5, 134.3, 134.0, 131.4, 129.3, 129.2, 128.1, 127.9, 126.6, 126.6, 123.7, 121.4, 121.2, 119.7, 65.6, 49.3, 33.9, 24.1, 23.2, 21.7. **HRMS** (ESI) for $C_{29}H_{27}NO_3S$ $[M+Na]^+$: calcd 492.1604, found 492.1597.

(1*S*,4'*S*)-6-Methoxy-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3da)



78% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -30.27 (c = 1.05 in $CHCl_3$); 94% ee, 11:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.6 mL/min, λ = 254 nm, 25 °C), t_R (major) = 27.29 min, t_R (minor) = 74.31 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.01 (d, *J* = 8.1 Hz, 2H, major+minor), 7.79 (d, *J* = 8.1 Hz, 1H, major+minor), 7.49 – 7.44 (m, 1H, major+minor), 7.35 – 7.28 (m, 3H, major+minor), 7.17 (d, *J* = 7.6 Hz, 1H, major+minor), 7.11 (d, *J* = 8.2 Hz, 1H, major+minor), 6.77 – 6.70 (m, 2H, major+minor), 5.93 (d, *J* = 5.6 Hz, 1H, major+minor), 5.82 (s, 1H, major+minor), 5.69 – 5.60 (m, 1H, major+minor), 5.25 – 5.20 (m, 2H, minor), 5.16 – 5.10 (m, 2H, major), 3.58 (s, 1H, major+minor), 3.55 (s, 3H, major+minor), 2.44 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 158.3, 145.8, 145.1, 136.6, 136.3, 135.0, 134.4, 133.8, 132.2, 131.3, 129.4, 129.2, 128.0, 127.8, 126.7, 123.6, 122.1, 120.0, 113.5, 109.9, 65.8, 55.2, 48.9, 21.7. **HRMS** (ESI) for $C_{27}H_{23}NO_4S$ $[M+Na]^+$: calcd 480.1240, found 480.1247.

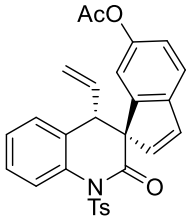
(1*S*,4'*S*)-6-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ea)



74% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -1.57 (c = 0.89 in $CHCl_3$); 90% ee, 6:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.5 mL/min, λ = 254 nm, 25 °C), t_R (major) = 39.61 min, t_R (minor) = 37.27 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.04 (d, *J* = 8.2 Hz, 2H, major+minor), 7.77 (d, *J* = 8.2 Hz, 1H, major+minor), 7.51 – 7.47 (m, 1H, major+minor), 7.38 – 7.31 (m, 4H, major+minor), 7.17 (d, *J* = 7.6 Hz, 1H, major+minor), 7.08 (d, *J* = 8.0 Hz, 1H, major+minor), 6.76 (d, *J* = 5.6 Hz, 1H, major), 6.69 (d, *J* = 5.6 Hz, 1H, minor), 6.34 (s, 1H, major+minor), 6.01 (d, *J* = 5.6 Hz, 1H, major), 5.95 (d, *J* = 5.6 Hz, 1H, minor), 5.61 – 5.52 (m, 1H, major+minor), 5.28 – 5.21 (m, 2H, minor), 5.17 – 5.09 (m, 2H, major), 3.64 (d, *J* = 8.6 Hz, 1H, major+minor), 2.48 (s, 3H, major), 2.46 (s, 3H, minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.6, 146.2, 145.4, 142.8, 136.0, 134.7, 134.4, 134.3,

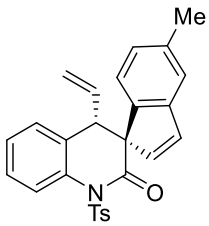
132.7, 131.3, 131.0, 129.5, 129.2, 128.0, 127.5, 126.9, 126.6, 123.8, 122.9, 120.8, 120.1, 66.4, 48.4, 21.8. HRMS (ESI) for $C_{26}H_{20}BrNO_3S$ $[M+Na]^+$: calcd 528.0239, found 528.0233.

(1*S*,4'*S*)-2'-Oxo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -6-yl acetate (3fa)



84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -39.67 (c = 0.88 in $CHCl_3$); 93% ee, 14:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 22.53 min, t_R (minor) = 41.66 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.03 – 7.99 (m, 2H, major+minor), 7.77 (dd, *J* = 8.2, 1.1 Hz, 1H, major+minor), 7.46 (td, *J* = 7.9, 1.6 Hz, 1H, major+minor), 7.36 – 7.28 (m, 3H, major+minor), 7.22 – 7.16 (m, 2H, major+minor), 6.94 (dd, *J* = 8.1, 2.1 Hz, 1H, major+minor), 6.78 (d, *J* = 5.6 Hz, 1H, major), 6.70 (d, *J* = 5.6 Hz, 1H, minor), 6.10 – 5.98 (m, 2H, major), 5.92 – 5.90 (m, 2H, minor), 5.68 – 5.59 (m, 1H, major+minor), 5.28 – 5.20 (m, 2H, minor), 5.18 – 5.12 (m, 2H, major), 3.64 (d, *J* = 8.5 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor), 2.20 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.8, 169.1, 149.0, 145.3, 145.2, 141.4, 136.3, 134.8, 134.2, 131.2, 129.6, 129.5, 129.1, 128.9, 127.9, 127.8, 126.8, 123.6, 122.0, 121.4, 120.5, 117.3, 66.3, 48.7, 21.7, 21.1. **HRMS** (ESI) for $C_{28}H_{23}NO_5S$ $[M+Na]^+$: calcd 508.1189, found 508.1194.

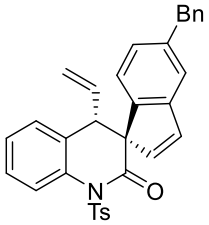
(1*S*,4'*S*)-5-Methyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3ga)



80% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -22.53 (c = 0.94 in $CHCl_3$); 93% ee, 14:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 15.67 min, t_R (minor) = 28.49 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.0 Hz, 2H, major+minor), 7.79 (d, *J* = 8.2 Hz, 1H, major), 7.67 (d, *J* = 8.2 Hz, 1H, minor), 7.46 (t, *J* = 7.9 Hz, 1H, major+minor), 7.33 – 7.27 (m, 3H, major+minor), 7.14 (d, *J* = 7.5 Hz, 1H, major+minor), 7.04 (s, 1H, major+minor), 6.78 – 6.73 (m, 2H, major), 6.70 – 6.69 (m, 2H, minor), 6.11 – 6.07 (m, 2H, major), 5.95 – 5.94 (m, 2H, minor), 5.73 – 5.64 (m, 1H, major+minor), 5.23 – 5.19 (m, 2H, minor), 5.16 – 5.09 (m, 2H, major), 3.55 (d, *J* = 8.3 Hz, 1H, major+minor), 2.44 (s, 3H, major+minor), 2.26 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.4, 145.1, 144.1, 141.2, 138.2, 136.4, 135.0, 134.1, 131.4, 129.5, 129.4, 129.2, 129.1, 127.9, 127.9, 126.8, 126.7, 123.6, 122.8, 122.7, 119.9, 65.6, 49.1, 21.8, 21.4. **HRMS** (ESI) for $C_{27}H_{23}NO_3S$ $[M+Na]^+$: calcd 464.1291, found 464.1285.

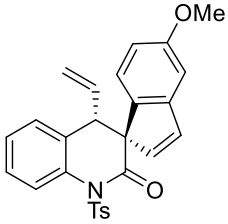
(1*S*,4'*S*)-5-Benzyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3ha)

79% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -3.57 (c = 0.87 in $CHCl_3$); 94% ee, 13:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow



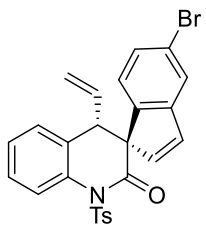
rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 26.93 min, t_R (minor) = 32.38 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.99 (d, *J* = 8.4 Hz, 2H, major+minor), 7.78 (dd, *J* = 8.2, 1.1 Hz, 1H, major), 7.69 (dd, *J* = 8.2, 1.1 Hz, 1H, minor), 7.45 (td, *J* = 7.9, 1.6 Hz, 1H, major+minor), 7.34 – 7.27 (m, 3H, major+minor), 7.26 – 7.23 (m, 2H, major+minor), 7.20 – 7.11 (m, 4H, major+minor), 7.04 (d, *J* = 1.6 Hz, 1H, major+minor), 6.77 (d, *J* = 5.6 Hz, 1H, major+minor), 6.74 – 6.70 (m, 1H, major+minor), 6.13 (d, J = 5.7 Hz, 1H, major+minor), 6.05 (d, *J* = 7.9 Hz, 1H, major), 6.00 (d, *J* = 7.9 Hz, 1H, minor), 5.77 – 5.69 (m, 1H, major+minor), 5.24 – 5.20 (m, 2H, minor), 5.17 – 5.09 (m, 2H, major), 3.89 (s, 2H, major+minor), 3.49 (d, *J* = 8.2 Hz, 1H, major+minor), 2.44 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 145.1, 144.2, 141.7, 141.5, 140.7, 136.3, 135.4, 135.0, 134.6, 134.4, 131.3, 129.4, 129.1, 129.0, 128.4, 128.1, 127.9, 126.7, 126.6, 126.1, 123.5, 123.0, 122.4, 119.7, 65.4, 49.2, 41.7, 21.7. **HRMS** (ESI) for $C_{33}H_{27}NO_3O_2$ $[M+Na]^+$: calcd 540.1604, found 540.1601.

(1*S*,4'*S*)-5-Methoxy-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ia)



73% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -13.27 (c = 1.06 in $CHCl_3$); 90% ee, 12:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 210 nm, 25 °C), t_R (major) = 23.49 min, t_R (minor) = 48.61 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.3 Hz, 2H, major+minor), 7.79 (dd, *J* = 8.2, 1.1 Hz, 1H, major+minor), 7.49 – 7.44 (m, 1H, major+minor), 7.34 – 7.26 (m, 3H, major+minor), 7.15 (dd, *J* = 7.6, 1.5 Hz, 1H, major+minor), 6.77 (dd, J = 4.2, 1.5 Hz, 2H, major), 6.70 (dd, *J* = 4.2, 1.5 Hz, 2H, minor), 6.44 (dd, *J* = 8.4, 2.5 Hz, 1H, major+minor), 6.14 (d, *J* = 5.7 Hz, 1H, major), 6.07 (d, *J* = 8.4 Hz, 1H, major+ minor), 6.00 (d, *J* = 5.7 Hz, 1H, minor), 6.14 (d, *J* = 5.7 Hz, 1H, major+minor), 6.07 (d, *J* = 8.4 Hz, 1H, major+minor), 5.75 – 5.66 (m, 1H, major+minor), 5.24 – 5.20 (m, 2H, minor), 5.17 – 5.08 (m, 2H, major), 3.72 (s, 3H, major+minor), 3.51 (d, *J* = 8.3 Hz, 1H, major+minor), 2.44 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.3, 160.0, 145.4, 145.1, 136.4, 136.0, 135.0, 134.6, 134.2, 133.6, 131.4, 129.4, 129.1, 128.0, 127.9, 126.7, 123.6, 123.6, 119.8, 111.1, 107.9, 65.1, 55.3, 49.3, 21.7. **HRMS** (ESI) for $C_{27}H_{23}NO_4S$ $[M+Na]^+$: calcd 480.1240, found 480.1249.

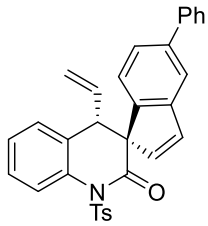
(1*S*,4'*S*)-5-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ja)



72% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -3.98 (c = 0.83 in $CHCl_3$); 91% ee, 10:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 220 nm, 25 °C), t_R (major) = 15.53 min, t_R (minor) = 32.59 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.02 – 7.98 (m, 2H, major+minor), 7.79 (d, *J* = 8.2 Hz, 1H, major+minor), 7.47 (td, *J* = 7.8, 1.6 Hz, 1H, major+minor), 7.36 – 7.27 (m, 4H, major+minor), 7.15 (dd, *J* = 7.7, 1.5 Hz, 1H, major+minor), 7.08 (dd, *J* = 8.1, 1.9 Hz, 1H, major+minor), 6.75 (d, *J* = 5.6 Hz, 1H, major), 6.68 (d, *J* = 5.6 Hz,

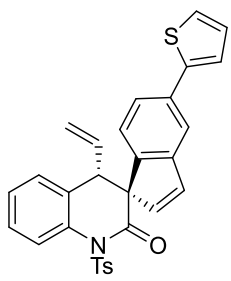
1H, minor), 6.14 (d, *J* = 8.1 Hz, 1H, major+minor), 6.09 (d, *J* = 5.6 Hz, 1H, major), 6.00 (d, *J* = 5.6 Hz, 1H, minor), 5.57 – 5.66 (m, 1H, major+minor), 5.25 – 5.19 (m, 2H, minor), 5.18 – 5.09 (m, 2H, major), 3.60 (d, *J* = 8.5 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.5, 145.9, 145.2, 142.8, 136.2, 136.0, 134.8, 133.8, 133.3, 131.0, 129.4, 129.1, 128.8, 128.0, 127.7, 126.8, 125.0, 124.4, 123.6, 122.4, 120.4, 65.8, 48.6, 21.7. HRMS (ESI) for $C_{26}H_{20}BrNO_3S$ $[M+Na]^+$: calcd 528.0239, found 528.0232.

(1*S*,4'*S*)-5-Phenyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3ka)



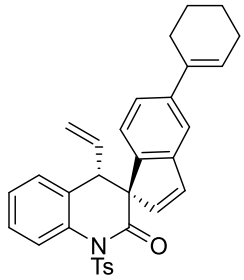
85% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -43.43 (c = 1.0 in $CHCl_3$); 92% ee, 14:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 31.95 min, t_R (minor) = 51.13 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.02 (d, *J* = 8.3 Hz, 2H, major+minor), 7.82 (d, *J* = 8.1 Hz, 1H, major+minor), 7.50 – 7.47 (m, 3H, major+minor), 7.42 (m, 2H, major+minor), 7.35 – 7.29 (m, 5H, major+minor), 7.18 – 7.14 (m, 2H, major+minor), 6.87 (d, *J* = 5.6 Hz, 1H, major), 6.69 (d, *J* = 5.6 Hz, 1H, minor), 6.28 (d, *J* = 7.8 Hz, 1H, major+minor), 6.15 (d, *J* = 5.6 Hz, 1H, major), 6.01 (d, *J* = 5.6 Hz, 1H, minor), 5.77 – 5.68 (m, 1H, major+minor), 5.27 – 5.22 (m, 2H, minor), 5.18 – 5.13 (m, 2H, major), 3.61 (d, *J* = 8.3 Hz, 1H, major+minor), 2.43 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.1, 145.1, 144.5, 142.9, 141.6, 140.8, 136.3, 135.3, 135.0, 134.7, 133.9, 131.3, 129.6, 129.4, 129.1, 128.7, 127.9, 127.3, 127.1, 126.7, 125.1, 123.6, 123.3, 120.6, 120.0, 65.7, 49.0, 21.7. HRMS (ESI) for $C_{32}H_{25}NO_3S$ $[M+Na]^+$: calcd 526.1447, found 526.1457.

(1*S*,4'*S*)-5-(Thiophen-2-yl)-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3' -quinolin]-2'-one (3la)



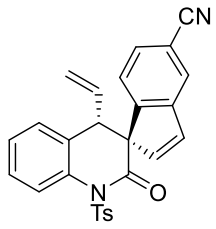
83% Isolated yield, colorless oil, $[\alpha]D^{25}$ = -70.27 (c = 0.85 in $CHCl_3$); 92% ee, 16:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/i-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 42.52 min, t_R (minor) = 70.79 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.01 (d, *J* = 8.4 Hz, 2H, major+minor), 7.81 (dd, *J* = 8.2, 1.1 Hz, 1H, major+minor), 7.50 – 7.46 (m, 2H, major+minor), 7.34 – 7.28 (m, 3H, major+minor), 7.24 – 7.16 (m, 4H, major+minor), 7.03 (dd, *J* = 5.0, 3.6 Hz, 1H, major+minor), 6.84 (d, *J* = 5.7 Hz, 1H, major), 6.77 (d, *J* = 5.7 Hz, 1H, minor), 6.22 (d, *J* = 8.0 Hz, 1H, major+minor), 6.14 (d, *J* = 5.7 Hz, 1H, major), 6.02 (d, *J* = 5.7 Hz, 1H, minor), 5.74 – 5.65 (m, 1H, major+minor), 5.26 – 5.21 (m, 2H, minor), 5.18 – 5.11 (m, 2H, major), 3.59 (d, *J* = 8.3 Hz, 1H, major+minor), 2.44 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.9, 145.2, 144.7, 144.0, 143.0, 136.3, 135.5, 134.9, 134.6, 134.5, 133.8, 133.8, 131.2, 129.4, 129.1, 127.9, 127.9, 126.7, 124.9, 123.9, 123.6, 123.4, 123.2, 120.1, 119.3, 65.8, 49.0, 21.7. **HRMS** (ESI) for $C_{30}H_{23}NO_3S_2$ [M+Na]+: calcd 532.1012, found 532.1016.

(1*S*,4'*S*)-5-(Cyclohex-1-en-1-yl)-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ma)



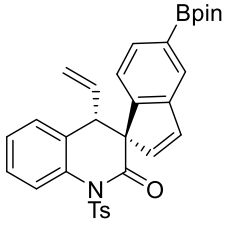
82% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -30.40 (c = 0.92 in $CHCl_3$); 90% ee, 12:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 22.14 min, t_R (minor) = 52.48 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.1 Hz, 2H), 7.80 (d, *J* = 8.1 Hz, 1H), 7.49 – 7.45 (m, 1H), 7.35 – 7.27 (m, 3H), 7.23 (d, *J* = 1.7 Hz, 1H), 7.14 (dd, *J* = 7.7, 1.5 Hz, 1H), 6.92 (dd, *J* = 8.0, 1.7 Hz, 1H), 6.81 (d, *J* = 5.6 Hz, 1H), 6.12 – 6.01 (m, 3H), 5.76 – 5.67 (m, 1H), 5.16 – 5.09 (m, 2H), 3.52 (d, *J* = 8.3 Hz, 1H), 2.44 (s, 3H), 2.33 – 2.28 (m, 2H), 2.18 – 2.12 (m, 2H), 1.75 – 1.71 (m, 2H), 1.64 – 1.60 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 145.1, 143.9, 143.1, 142.0, 136.3, 136.3, 135.0, 134.9, 134.2, 131.3, 129.4, 129.1, 128.9, 128.0, 127.9, 126.6, 125.1, 123.6, 122.8, 122.7, 119.8, 118.5, 65.6, 49.2, 27.4, 25.8, 23.0, 22.1, 21.7. **HRMS** (ESI) for $C_{32}H_{29}NO_3S$ $[M+Na]^+$: calcd 530.1760, found 530.1766.

(1*S*,4'*S*)-2'-Oxo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinoline]-5-carbonitrile (3na)



73% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -36.53 (c = 1.1 in $CHCl_3$); 91% ee, 6:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 80:20 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 61.55 min, t_R (minor) = 128.33 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (m, 2H, major+minor), 7.80 (d, *J* = 8.2 Hz, 1H, major+minor), 7.50 (m, 1.8 Hz, 2H, major+minor), 7.37 – 7.28 (m, 4H, major+minor), 7.16 (dd, *J* = 7.7, 1.5 Hz, 1H, major+minor), 6.81 (d, *J* = 5.7 Hz, 1H, major), 6.74 (d, *J* = 5.7 Hz, 1H, minor), 6.61 (d, *J* = 7.9 Hz, 1H, minor), 6.49 (d, *J* = 7.9 Hz, 1H, major), 6.14 (d, *J* = 5.7 Hz, 1H, major), 6.07 (d, *J* = 5.7 Hz, 1H, minor), 5.57 – 5.49 (m, 1H, major+minor), 5.27 – 5.19 (m, 2H, minor), 5.18 – 5.09 (m, 2H, major), 3.71 (d, *J* = 8.7 Hz, 1H, major), 3.69 (d, *J* = 8.7 Hz, 1H, minor), 2.46 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 168.9, 148.8, 145.4, 144.8, 136.4, 136.0, 134.6, 133.6, 132.4, 130.7, 130.2, 129.5, 129.0, 128.2, 127.4, 127.0, 124.9, 124.0, 123.6, 121.0, 118.7, 112.2, 66.8, 48.3, 21.7. HRMS (ESI) for $C_{27}H_{20}N_2O_3S$ $[M+Na]^+$: calcd 475.1087, found 475.1089.

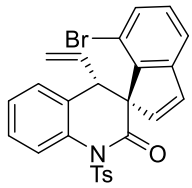
(1*S*,4'*S*)-5-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3oa)



75% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -18.00 (c = 1.0 in $CHCl_3$); 94% ee, 10:1 dr, determined by HPLC analysis (Chiralpak IA-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 0.5 mL/min, λ = 254 nm, 25 °C), t_R (major) = 24.65 min, t_R (minor) = 48.08 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.3 Hz, 2H), 7.78 (d, *J* = 8.2 Hz, 1H), 7.67 (s, 1H), 7.46 (m, 2H), 7.33 (d, *J* = 8.1 Hz, 2H), 7.29 – 7.26 (m, 1H), 7.13 (d, *J* = 7.7 Hz, 1H), 6.81 (d, *J* = 5.6 Hz, 1H), 6.29 (d, *J* = 7.6 Hz, 1H),

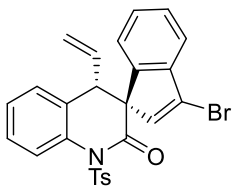
6.02 (d, *J* = 5.6 Hz, 1H), 5.66 – 5.57 (m, 1H), 5.14 – 5.06 (m, 2H), 3.61 (d, *J* = 8.4 Hz, 1H), 2.45 (s, 3H), 1.30 (s, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.0, 147.2, 145.1, 143.3, 136.3, 134.9, 134.9, 133.9, 133.5, 132.9, 131.3, 129.4, 129.1, 127.9, 127.9, 127.7, 126.7, 123.6, 122.6, 120.2, 83.8, 66.2, 48.7, 24.9, 24.8, 21.7. **HRMS** (ESI) for $C_{32}H_{32}BNO_5S$ $[M+Na]^+$: calcd 576.1986, found 576.1998.

(1*S*,4'*S*)-7-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3pa)



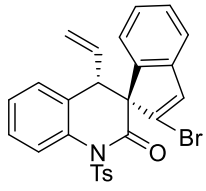
48% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -98.53 (c = 1.08 in $CHCl_3$); 96% ee, 19:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 11.87 min, t_R (minor) = 16.98 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.00 (d, *J* = 8.4 Hz, 2H), 7.79 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.43 (td, *J* = 7.7, 7.2, 1.3 Hz, 1H), 7.35 – 7.28 (m, 3H), 7.24 – 7.15 (m, 3H), 7.12 – 7.06 (m, 1H), 6.70 (d, *J* = 5.6 Hz, 1H), 5.65 (d, *J* = 5.6 Hz, 1H), 5.28 – 5.12 (m, 2H), 5.04 (dd, J = 9.6, 2.3 Hz, 1H), 4.95 (d, J = 8.8 Hz, 1H), 2.46 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 167.5, 147.0, 145.3, 142.7, 136.1, 135.0, 134.3, 132.1, 131.7, 130.3, 130.3, 130.0, 129.9, 129.3, 127.4, 126.6, 125.6, 123.7, 121.1, 120.7, 119.4, 68.8, 42.7, 21.7. HRMS (ESI) for $C_{26}H_{20}BrNO_3S$ $[M+Na]^+$: calcd 528.0239, found 528.0228.

(1*R*,4'*S*)-3-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3qa)



53% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -6.17 (c = 0.90 in $CHCl_3$); 93% ee, 9:1 dr, determined by HPLC analysis (Chiralpak IG-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 220 nm, 25 °C), t_R (major) = 55.01 min, t_R (minor) = 98.06 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.99 (d, *J* = 8.2 Hz, 2H, major+minor), 7.79 (d, *J* = 8.1 Hz, 1H, major+minor), 7.51 – 7.46 (m, 1H, major+minor), 7.35 – 7.28 (m, 5H, major+minor), 7.16 (d, *J* = 7.6 Hz, 1H, major+minor), 7.05 (t, *J* = 7.3 Hz, 1H, major+minor), 6.31 (d, *J* = 7.7 Hz, 1H, major+minor), 6.18 (s, 1H, major), 6.04 (s, 1H, minor), 5.67 – 5.58 (m, 1H, major+minor), 5.28 – 5.20 (m, 2H, minor), 5.17 – 5.11 (m, 2H, major), 3.67 (d, *J* = 8.5 Hz, 1H, major+minor), 2.45 (s, 3H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 169.0, 145.3, 142.5, 142.2, 136.3, 134.8, 133.2, 132.6, 131.0, 129.5, 129.1, 128.7, 128.1, 127.8, 127.4, 126.9, 125.1, 123.7, 122.9, 121.2, 120.6, 65.9, 48.8, 21.7. HRMS (ESI) for $C_{26}H_{20}BrNO_3S$ $[M+Na]^+$: calcd 528.0239, found 528.0230.

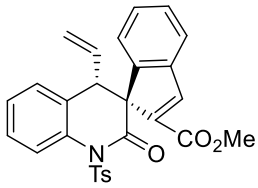
(1*R*,4'*S*)-2-Bromo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin] -2'-one (3ra)



58% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -79.50 (c = 0.94 in $CHCl_3$); 87% ee, 4:1 dr, determined by HPLC analysis (Chiralpak AZ-H column, hexane/*i*-PrOH, 85:15 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 66.29 min, t_R (minor) = 52.24 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.04 – 8.00 (m, 2H), 7.78 (dd, *J* = 8.3, 4.4 Hz, 1H), 7.53 – 7.50 (m, 1H), 7.38 – 7.33 (m, 3H), 7.22 – 7.14 (m, 3H), 6.91 (t, *J* = 2.7 Hz,

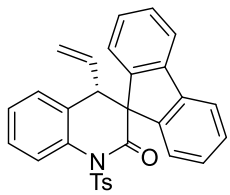
1H), 6.79 – 6.74 (m, 1H), 5.69 (d, *J* = 7.6 Hz, 1H), 5.45 – 5.38 (m, 1H), 5.27 – 5.22 (m, 1H), 4.95 – 4.85 (m, 1H), 4.29 (d, *J* = 9.4 Hz, 1H), 2.45 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 167.9, 145.3, 143.6, 140.1, 136.1, 135.7, 134.6, 130.2, 129.6, 129.5, 129.4, 129.3, 128.8, 128.1, 127.6, 126.8, 125.6, 123.5, 122.7, 121.9, 121.1, 68.0, 45.6, 21.7. HRMS (ESI) for $C_{26}H_{20}BrNO_3S$ [M+Na]$^+$: calcd 528.0239, found 528.0227.

Methyl (1*S*,4'*S*)-2'-oxo-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinoline]-2-carboxylate (3sa)



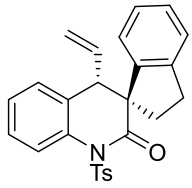
36%/37% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -1.73 (c = 0.47 in $CHCl_3$); 78%/65% ee, 1:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 75:25 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 17.79 min, t_R (minor) = 22.26 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.12 (d, *J* = 8.1 Hz, 2H), 7.70 – 7.66 (m, 2H), 7.43 – 7.36 (m, 4H), 7.25 – 7.21 (m, 2H), 7.09 (t, *J* = 7.8 Hz, 2H), 6.43 (d, *J* = 7.7 Hz, 1H), 5.87 – 5.77 (m, 1H), 4.96 – 4.85 (m, 2H), 3.75 (d, *J* = 9.6 Hz, 1H), 3.38 (s, 3H), 2.46 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.2, 163.8, 148.7, 145.1, 145.0, 140.7, 138.7, 136.7, 135.7, 133.7, 129.7, 129.6, 129.1, 128.9, 128.7, 127.9, 127.5, 126.1, 124.0, 122.5, 121.9, 118.4, 65.8, 51.5, 50.8, 21.7. HRMS (ESI) for $C_{28}H_{23}NO_5S$ [M+Na]$^+$: calcd 508.1189, found 508.1198.

(*S*)-1'-Tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[fluorene-9,3'-quinolin]-2'-one (3ta)



74% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = -55.87 (c = 1.05 in $CHCl_3$); 79% ee, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 14.27 min, t_R (minor) = 30.80 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.07 – 8.05 (m, 2H), 7.79 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.64 – 7.60 (m, 2H), 7.53 (td, *J* = 7.8, 1.5 Hz, 1H), 7.39 – 7.27 (m, 5H), 7.18 (td, *J* = 7.6, 1.2 Hz, 2H), 6.90 (td, *J* = 7.7, 1.2 Hz, 1H), 6.74 (d, *J* = 7.6 Hz, 1H), 6.02 (d, *J* = 7.7 Hz, 1H), 5.10 – 4.94 (m, 3H), 4.19 (d, *J* = 8.5 Hz, 1H), 2.46 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 171.7, 145.4, 145.1, 142.1, 141.2, 141.0, 136.5, 135.2, 131.6, 130.9, 129.5, 129.0, 128.8, 128.4, 128.1, 128.0, 127.9, 127.1, 126.7, 124.6, 123.9, 123.3, 121.2, 120.2, 119.9, 64.0, 49.4, 21.7. HRMS (ESI) for $C_{30}H_{23}NO_3S$ [M+Na]$^+$: calcd 500.1291, found 500.1292.

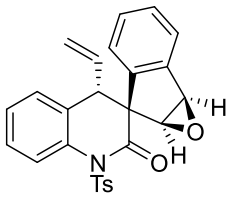
(1*S*,4'*S*)-5-Phenyl-1'-tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (3ua)



79% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 150.67 (c = 1.05 in $CHCl_3$); 93% ee, 12:1 dr, determined by HPLC analysis (Chiralpak IF-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 18.01 min, t_R (minor) = 19.98 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.04 (d, *J* = 8.3 Hz, 2H, minor), 7.98 (d, *J* = 8.3 Hz, 2H, major), 7.76 (d, J = 8.2 Hz, 1H, major+minor), 7.45 – 7.41 (m, 1H, major+minor), 7.33 (d, *J* = 8.0 Hz, 2H, major+minor), 7.26 – 7.24 (m, 1H, major+minor), 7.17 – 7.08 (m, 3H, major+minor), 6.95 (t, *J* = 7.6 Hz, 1H, minor), 6.82 (t, *J* = 7.6 Hz, 1H, major), 5.94 (d, *J*

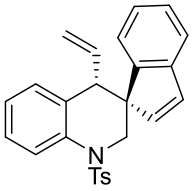
= 7.8 Hz, 1H, major+minor), 5.79 – 5.70 (m, 1H, major), 5.67 – 5.57 (m, 1H, minor), 5.24 – 5.21 (m, 2H, minor), 5.14 – 5.08 (m, 2H, major), 3.52 (d, J = 8.4 Hz, 1H, major+minor), 3.10 – 3.02 (m, 1H, major+minor), 2.92 – 2.82 (m, 1H, major+minor), 2.50 – 2.45 (m, 1H, major+minor), 2.44 (s, 3H, major+minor), 2.03 – 1.97 (m, 1H, major+minor); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 173.3, 145.0, 144.6, 142.2, 136.5, 134.8, 134.4, 131.1, 129.3, 129.0, 128.5, 128.1, 127.7, 126.5, 126.4, 124.9, 123.9, 123.4, 119.3, 60.6, 51.6, 33.9, 30.8, 21.7. HRMS (ESI) for $C_{26}H_{23}NO_3S$ $[M+Na]^+$: calcd 452.1291, found 452.1298.

(1a*R*,4'*S*,6*S*,6a*S*)-1'-Tosyl-4'-vinyl-1a,1',4',6a-tetrahydro-2'*H*-spiro[indeno[1,2-b] oxirene-6,3'-quinolin]-2'-one (**4a**)



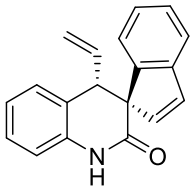
84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 175.60 (c = 0.95 in $CHCl_3$); 94% ee, 14:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 30.72 min, t_R (minor) = 20.91 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.99 – 7.97 (m, 2H), 7.84 (d, *J* = 8.4 Hz, 1H), 7.50 (t, *J* = 8.0 Hz, 1H), 7.43 (d, *J* = 7.4 Hz, 1H), 7.34 – 7.29 (m, 3H), 7.21 – 7.12 (m, 2H), 6.87 (t, *J* = 7.7 Hz, 1H), 6.12 – 6.02 (m, 1H), 5.57 (d, *J* = 7.9 Hz, 1H), 5.27 – 5.21 (m, 2H), 4.31 (t, *J* = 2.7 Hz, 1H), 4.20 (t, *J* = 2.6 Hz, 1H), 3.63 (d, *J* = 7.2 Hz, 1H), 2.45 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.6, 145.3, 143.1, 141.1, 136.1, 135.1, 134.7, 129.9, 129.4, 129.3, 129.3, 129.0, 128.3, 128.1, 126.9, 125.8, 124.9, 123.6, 119.3, 61.6, 59.6, 58.7, 48.2, 21.7. **HRMS** (ESI) for $C_{26}H_{21}NO_4S$ $[M+Na]^+$: calcd 466.1083, found 466.1081.

(1*S*,4'*S*)-4'-Vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinolin]-2'-one (**4b**)



84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 64.47 (c = 0.79 in $CHCl_3$); 94% ee, 14:1 dr, determined by HPLC analysis (Chiralpak IC-H column, hexane/i-PrOH, 90:10 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 29.33 min, t_R (minor) = 19.39 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.68 – 7.61 (m, 3H), 7.56 (d, *J* = 7.2 Hz, 1H), 7.34 – 7.28 (m, 3H), 7.25 – 7.17 (m, 5H), 6.88 (d, *J* = 5.7 Hz, 1H), 6.14 (d, *J* = 5.7 Hz, 1H), 5.21 – 5.12 (m, 1H), 4.39 (d, *J* = 10.2 Hz, 1H), 4.06 (d, *J* = 7.9 Hz, 1H), 3.79 (d, *J* = 17.0 Hz, 1H), 3.52 (d, *J* = 11.0 Hz, 1H), 2.90 (d, *J* = 11.0 Hz, 1H), 2.31 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 148.2, 143.8, 143.2, 137.6, 136.1, 135.7, 135.4, 135.3, 133.8, 129.8, 129.7, 127.4, 127.4, 126.9, 126.4, 126.0, 125.5, 123.7, 121.7, 116.9, 65.0, 62.1, 43.5, 21.3. **HRMS** (ESI) for $C_{26}H_{23}NO_2S$ $[M+Na]^+$: calcd 436.1342, found 436.1348.

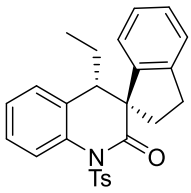
(1*S*,4'*R*)-1'-Tosyl-4'-vinyl-1',4'-dihydro-2'*H*-spiro[indene-1,3'-quinoline (**4c**)



84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 117.67 (c = 0.86 in $CHCl_3$); 94% ee, 14:1 dr, determined by HPLC analysis (Chiralpak AD-H column, hexane/*i*-PrOH, 92:8 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 38.83 min, t_R (minor) = 36.15 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 8.55 (s, 1H), 7.31 (d, *J* = 7.4 Hz, 1H), 7.28 – 7.26 (m, 1H), 7.25 – 7.22 (m, 1H), 7.10 (d, *J* = 7.4 Hz, 1H), 7.06 – 7.02 (m,

2H), 6.93 – 6.89 (m, 2H), 6.84 (d, *J* = 7.8 Hz, 1H), 6.46 (d, *J* = 5.6 Hz, 1H), 5.89 – 5.80 (m, 1H), 5.08 (dd, *J* = 10.1, 1.4 Hz, 1H), 5.01 (d, *J* = 17.0 Hz, 1H), 3.65 (d, *J* = 8.8 Hz, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 170.4, 145.1, 143.8, 136.4, 135.7, 135.4, 134.2, 128.3, 128.1, 125.9, 123.6, 123.0, 121.8, 118.4, 115.3, 62.6, 49.9. **HRMS** (ESI) for $C_{19}H_{15}NO$ $[M+Na]^+$: calcd 296.1046, found 296.1045.

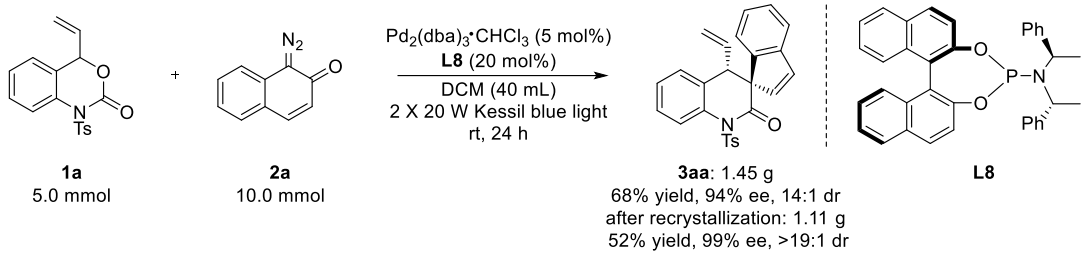
(1*S*,4'*S*)-4'-Ethyl-1'-tosyl-1',2,3,4'-tetrahydro-2'H-spiro[indene-1,3'-quinolin]-2'-one (**4d**)



84% Isolated yield, colorless oil, $[\alpha]_D^{25}$ = 73.60 (c = 0.75 in $CHCl_3$); 94% ee, 14:1 dr, determined by HPLC analysis (Chiralpak IC-H column, hexane/*i*-PrOH, 85:15 v/v, flow rate 1.0 mL/min, λ = 254 nm, 25 °C), t_R (major) = 27.87 min, t_R (minor) = 34.22 min; **^{1}H NMR** (400 MHz, $CDCl_3$) δ (ppm) 7.96 – 7.92 (m, 2H), 7.75 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.46 – 7.41 (m, 1H), 7.33 – 7.26 (m, 3H), 7.13 (dd, *J* = 7.5, 1.8 Hz, 2H), 7.06 (td, *J* = 7.4, 1.1 Hz, 1H), 6.73 (t, *J* = 7.6 Hz, 1H), 5.60 (d, *J* = 7.7 Hz, 1H), 3.15 – 3.11 (m, 1H), 2.86 – 2.79 (m, 1H), 2.65 – 2.59 (m, 1H), 2.43 (s, 3H), 1.98 – 1.90 (m, 1H), 1.74 – 1.64 (m, 1H), 1.28 – 1.16 (m, 1H), 0.90 (t, J = 7.4 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ (ppm) 173.4, 144.9, 144.9, 142.6, 136.4, 134.9, 132.1, 130.0, 129.3, 129.0, 128.0, 127.5, 126.3, 126.0, 125.0, 123.9, 123.8, 61.2, 49.4, 35.1, 31.0, 23.2, 21.7, 12.2. **HRMS** (ESI) for $C_{26}H_{25}NO_3S$ $[M+Na]^+$: calcd 454.1447, found 454.1442.

6. Demonstration of the Synthetic Utility

6.1 A Gram-Scale Reaction

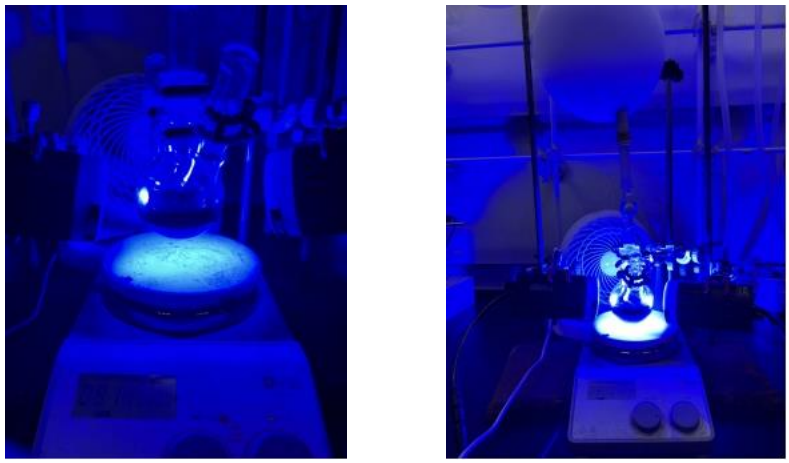


1a
5.0 mmol

2a
10.0 mmol

3aa: 1.45 g
68% yield, 94% ee, 14:1 dr
after recrystallization: 1.11 g
52% yield, 99% ee, >19:1 dr

L8



Supplementary Figure 4 Set up of gram-scale reaction

Procedure I: Under argon atmosphere, a flame-dried 100 mL three-necked flask was charged with $Pd_2(dba)_3 \cdot CHCl_3$ (0.25 mmol, 5 mol%), **L8** (1.0 mmol, 20 mol%) and anhydrous DCM (20 mL) and the resulting solution was stirred for 30 min at room temperature. Then, vinyl benzoxazinanone **1a** (5.0 mmol, 1.0 equiv.), 1-diazonaphthalen-2(1*H*)-one **2a** (10.0 mmol, 2.0 equiv.) and DCM (20 mL) were added to the reaction mixture. After that, the reaction solution was stirred under the irradiation of 2×20 W Kessil blue LEDs for 24 h at rt. The combined solution was concentrated under vacuum and the residue was purified by column chromatography to afford the desired product **3aa** in 68% yield, 94% ee and 14:1 dr. Then, it can be obtained by recrystallization with 52% yield, 99% ee and >19:1 dr.

6.2 A Sunlight-Driven Reaction

1a
0.1 mmol

2a
0.2 mmol

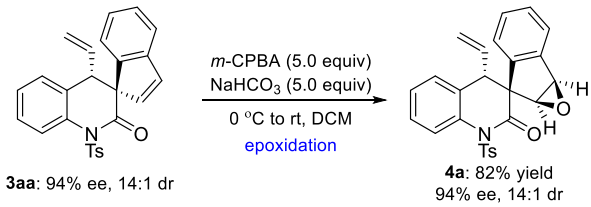
3aa: 76% yield
94% ee, 14:1 dr

L8

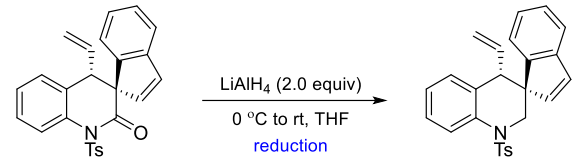
Supplementary Figure 5 Set up of sunlight-driven reaction

Procedure II: Under argon atmosphere, a flame-dried 10 mL Schlenk tube was charged with $Pd_2(dba)_3 \cdot CHCl_3$ (0.005 mmol, 5 mol%), **L8** (0.02 mmol, 20 mol%) and anhydrous DCM (1.0 mL) and the resulting solution was stirred for 30 min at room temperature. Then, vinyl benzoxazinanone **1a** (0.1 mmol, 1.0 equiv.), 1-diazonaphthalen-2(1*H*)-one **2a** (0.2 mmol, 2.0 equiv.) and DCM (1.0 mL) were added to the reaction mixture. After that, the reaction solution was stirred under sunlight from 8:00 am to 4:00 pm. Upon the completion of reaction as monitored by TLC, the solvent was removed by vacuum and the crude reaction mixture was purified by flash chromatography on silica gel (petrol ether/ethyl acetate = 20/1 to 15/1) to afford the product **3aa** in 76% yield, 94% ee and 14:1 dr.

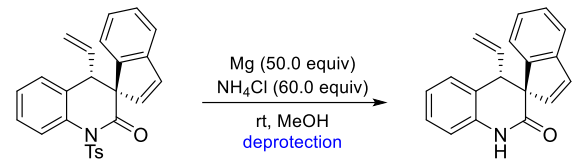
6.3 Synthetic Transformation



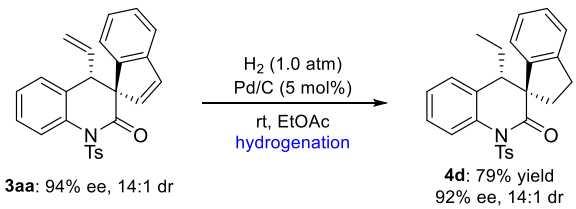
Procedure III: Under argon atmosphere, a flame-dried 10 mL Schlenk tube was charged with compound **3aa** (42.7 mg, 0.10 mmol), $NaHCO_3$ (42.0 mg, 0.50 mmol) and anhydrous DCM (2.0 mL) and cooled to 0 °C. To this solution, *m*-CPBA (86.3 mg, 0.50 mmol) was added dropwise, and the reaction mixture was stirred until the consumption of **3aa** as monitored by TLC. The reaction was quenched with saturated NH_4Cl aqueous solution and extracted with ethyl acetate. The combined organic layer was dried with Na_2SO_4, and evaporated under reduced pressure. The residue was purified by column chromatography to afford the desired product **4a** in 82% yield, 94% ee and 14:1 dr.



Procedure IV: Under argon atmosphere, a flame-dried 10 mL Schlenk tube was charged with compound **3aa** (42.7 mg, 0.10 mmol) and anhydrous THF (2.0 mL) and cooled to 0 °C. To this solution, $LiAlH_4$ (2.0 equiv., 1.0 M in THF) was added dropwise, and the reaction mixture was stirred at rt until the consumption of **3aa** as monitored by TLC. The reaction was quenched with saturated NH_4Cl aqueous solution and extracted with ethyl acetate. The combined organic layer was dried with Na_2SO_4, and evaporated under reduced pressure. The residue was purified by column chromatography to afford the desired product **4b** in 91% yield, 94% ee and 14:1 dr.

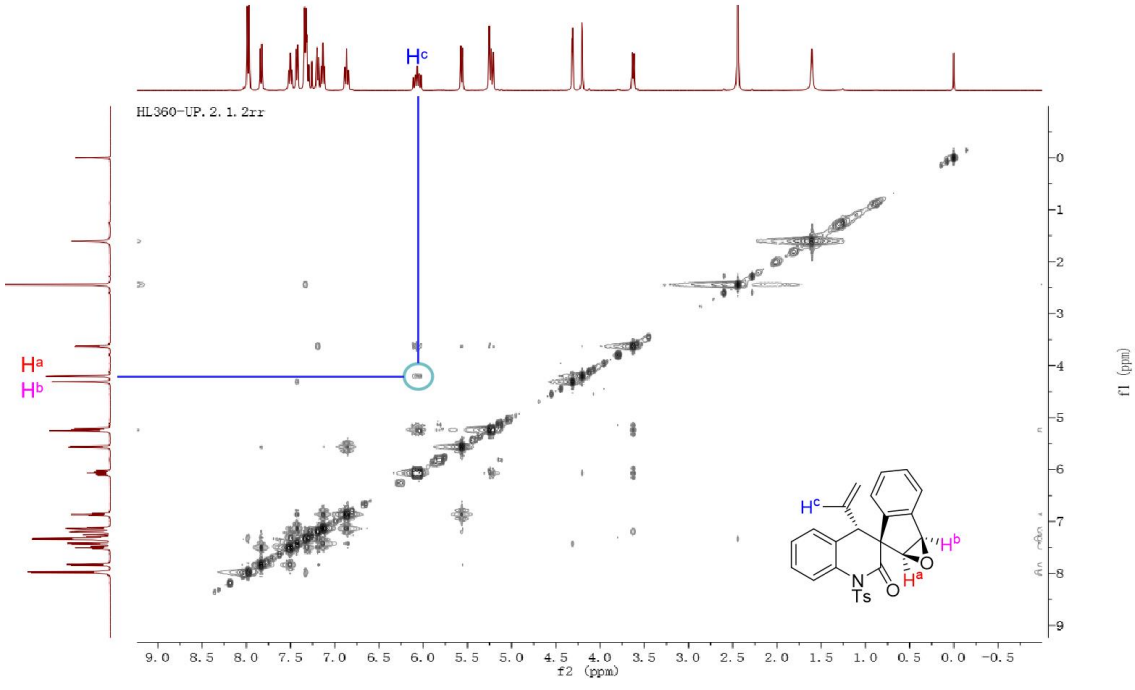


Procedure V: Under argon atmosphere, a flame-dried 10 mL Schlenk tube was charged with compound **3aa** (42.7 mg, 0.10 mmol) and Mg (120 mg, 5.0 mmol, 200-300 mesh) and NH_4Cl (321mg, 6.0 mmol) and anhydrous MeOH (4.0 mL). The resulting solution was in MW for 4 h. Then NH_4Cl (3.0 mL) was added to the reaction mixture to quench excess magnesium powder. The aqueous phase was extracted with ethyl acetate (4×5.0 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by column chromatography afford the desired product **4c** in 89% yield, 94% ee and 14:1 dr.



Procedure VI: In a flame-dried 10 ml Schlenk tube **3aa** (42.7 mg, 0.10 mmol), Pd/C (5.3 mg, 5 mol%, wt = 10%) were dissolved in EtOAc (2.0 mL). The reaction mixture was stirred at room temperature for about 4 h after pumped by H_2 balloon. Then the reaction was filtered by the diatomite and washed by ethyl acetate. The product was purified by flash column chromatography on silica gel (petrol ether/ethyl acetate = 20/1 to 10/1) to afford the desired product **4d** in 79% yield, 92% ee and 14:1 dr.

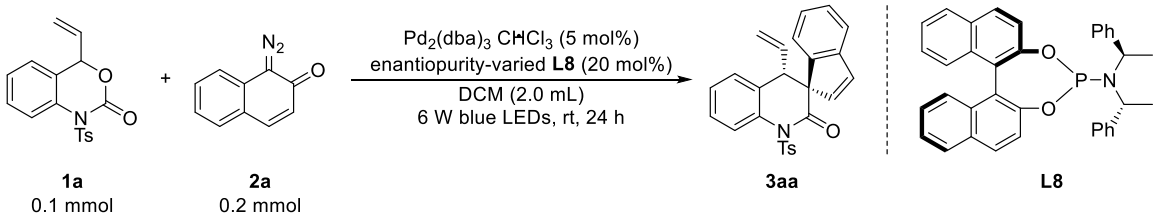
6.4 Cope of the NOESY Spectroscopy of Product 4a



Supplementary Figure 6 NOESY spectroscopy of **4a**

7. Mechanistic Investigations

7.1 Non-Linear Relationship



1a 0.1 mmol

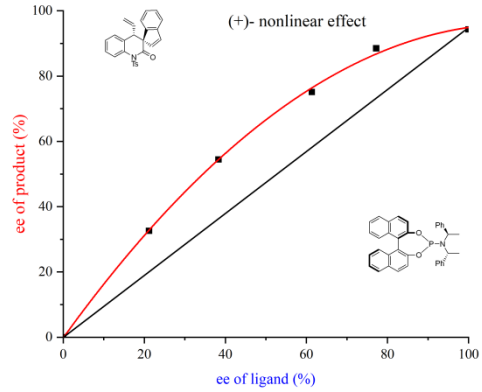
2a 0.2 mmol

3aa

L8

We carried out non-linear effect study with chiral phosphoramidte ligand **L8** under the optimized condition. Six different reactions were performed with chiral ligand **L8** with different levels of enantiopurity using the following procedure. Under argon atmosphere, a flame-dried 10 ml Schlenk tube was charged with $Pd_2(dba)_3{\cdot}CHCl_3$ (0.005 mmol, 5 mol%), chiral phosphoramidte ligand **L8** (0.02 mmol, 20 mol%, x% ee) with desired level of enantiopurity (prepared by mixing two enantiomers of the ligand **L8** in appropriate amount) and DCM (1.0 mL). The resulting solution was stirred for 30 mins at room temperature. Then vinylbenzoxazinanone **1a** (0.1 mmol, 1.0 equiv.) and 1-diazonaphthalen-2(1*H*)-one **2a** (0.2 mmol, 2.0 equiv.) in DCM (1.0 ml) were added. The resulting solution was stirred under the irridation of 6W blue LEDs for 24 h at rt. After the reaction was over, the reaction mixture was purified by flash silica gel chromatography (petrolether/EtOAc = 10:1) to give the lactoneproduct **3aa**. The pure product was dissolved in *i*-PrOH and small aliquot was injected onto a chiral HPLC for ee analysis. The enantioselectivity of the obtained product were plotted against the enantiopurity of the chiral ligand **L8** (Supplementary Figure 7).

ee of ligand (%)	0	21.17	38.29	61.34	77.22	99.99
ee of product (%)	0	32.60	54.45	75.13	88.52	94.32



Supplementary Figure 7 Relationship between ee of ligand (**L8**) and product (**3aa**)

7.2 A Preliminary Explanation for Selectivity of the Reaction via DFT Calculations

(1) Computational details

All of the calculations were performed using the Gaussian 16 program.[1] Structures were optimized at the B3LYP level of density functional theory[2] with Grimme's D3(BJ) dispersion correction[3] in gas phase. For optimizations, Ahlrichs's def2SVP basis set was used for all atoms.[4] Frequency calculations have been performed to verify the optimized structures as local minima or transition state and to obtain Gibbs free energy at 298 K. To reduce error caused by the breakdown of the harmonic oscillator approximation, Truhlar's quasi-harmonic correction was used to compute molecular entropies by setting all positive frequencies that are less than 100 cm^{-1} to 100 cm^{-1}.[5] Intrinsic reaction coordinate (IRC) calculations were carried out to make sure that every transition state links relevant intermediates.[6] The electronic energies were further refined by carrying out single-point energy calculations using B3LYP functional with Grimme's D3(BJ) dispersion correction. The def2TZVP basis set was applied for all atoms.[4] The SMD solvation model with DCM as the solvent was employed to account for solvation effect.[7] The three-dimensional (3D) structures were depicted using CYLview software.

(2) References

1. M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, G. A. Petersson, H. Nakatsuji, X. Li, M. Caricato, A. V. Marenich, J. Bloino, B. G. Janesko, R. Gomperts, B. Mennucci, H. P. Hratchian, J. V. Ortiz, A. F. Izmaylov, J. L. Sonnenberg, Williams, F. Ding, F. Lipparini, F. Egidi, J. Goings, B. Peng, A. Petrone, T. Henderson, D. Ranasinghe, V. G. Zakrzewski, J. Gao, N. Rega, G. Zheng, W. Liang, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, K. Throssell, J. A. Montgomery Jr., J. E. Peralta, F. Ogliaro, M. J. Bearpark, J. J. Heyd, E. N. Brothers, K.

N. Kudin, V. N. Staroverov, T. A. Keith, R. Kobayashi, J. Normand, K. Raghavachari, A. P. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, J. M. Millam, M. Klene, C. Adamo, R. Cammi, J. W. Ochterski, R. L. Martin, K. Morokuma, O. Farkas, J. B. Foresman, D. J. Fox Gaussian 16 Rev. A.03, Wallingford, CT, **2016**.

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(3) B3LYP geometries for all the optimized compounds and transition states

3aa

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6	1.37437000	2.22300300	-0.09443400
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3b

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3c

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3d

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6	-3.00753500	3.28699900	-2.01946900
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6	-2.06759500	3.92398500	-1.20130800
1	-1.79228100	4.96728200	-1.37410300
6	-1.48668300	3.20519000	-0.15608300
6	-0.49723600	3.63011200	0.83643800
1	-0.06542700	4.63105700	0.88358500
6	-0.21226300	2.60560800	1.65794800
1	0.49883100	2.59393600	2.48078200
6	-0.00220200	0.20370000	1.09522600
6	-1.02807000	1.36634700	1.30509900
6	-2.08189300	-1.40667200	1.93654800
1	-1.15566900	-1.63791300	2.47426800
6	-2.68871500	-0.22080000	2.11386100
1	-3.56688000	-0.00068300	1.50005000

6	-1.91675500	0.97479300	2.56623900
1	-1.22768000	0.75254700	3.39503600
1	-2.53904600	1.84028600	2.83349400

INT1

E = -4603.46190114 G = -4602.444271

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6	6.47527500	1.15921100	-2.57425800
6	6.00553400	0.01319500	-1.96753400
6	5.03955200	0.08414800	-0.92457800
6	4.55340400	1.37760800	-0.53124900
6	5.05512400	2.53794500	-1.18276500
6	6.00064800	2.43384400	-2.17894000
1	7.21197700	1.08131000	-3.37765200
1	6.36531600	-0.96148100	-2.29650800
6	4.48211300	-1.08573000	-0.30393100
6	3.55250000	1.48607600	0.47288800
1	4.64170800	3.50565400	-0.89618100
1	6.37221000	3.33085000	-2.67953100
6	2.99798100	0.35716600	1.03381600
6	3.45509300	-0.90697800	0.61073300
1	3.18927800	2.47213000	0.76697500
1	2.20635100	0.43247100	1.78080300
6	4.90219500	-2.46603500	-0.66911200
6	6.24907100	-2.93136800	-0.48843400
6	3.96332200	-3.35814600	-1.17015100
6	7.25363800	-2.12784900	0.12044400
6	6.59987800	-4.26085700	-0.90291800
6	4.29973400	-4.67026200	-1.57324000
6	8.53914900	-2.59951300	0.28060500
1	6.99272100	-1.12828800	0.46689100
6	7.93785800	-4.71150600	-0.73235600
6	5.59911300	-5.10543100	-1.45679000
1	3.51222200	-5.30741100	-1.97932600
6	8.89097800	-3.89960500	-0.15771300
1	9.29246600	-1.96567200	0.75402100
1	8.19402100	-5.72216400	-1.06057800
1	5.87467800	-6.11340000	-1.77610100
1	9.91482100	-4.25823500	-0.02946500
8	2.77962100	-2.04069500	1.08026900
8	2.64342800	-2.96095700	-1.30818700
15	1.67197400	-2.65565500	0.02112000
7	1.35846800	-4.10295200	0.78105500
6	-6.70503800	-0.12236500	-3.46477800
6	-6.16971000	-0.61032900	-2.29140900
6	-4.97823700	-1.38935300	-2.29482300
6	-4.32655700	-1.62067800	-3.55377500
6	-4.91542700	-1.11832900	-4.74664800
6	-6.08223600	-0.38746700	-4.70823300
1	-7.61569300	0.48012700	-3.43337000
1	-6.65522300	-0.38784600	-1.34250600
6	-4.37262800	-1.88009500	-1.08579800
6	-3.08082700	-2.30635400	-3.58071600
1	-4.41201700	-1.31041000	-5.69740500
1	-6.51946600	0.00144200	-5.63037600
6	-2.48364200	-2.72035100	-2.41325300
6	-3.13179000	-2.49568900	-1.17555900
1	-2.59210000	-2.47833600	-4.54252700
1	-1.51159400	-3.21599200	-2.41072200
6	-4.97312600	-1.64534300	0.25299700
6	-6.29784600	-2.08153600	0.59933200
6	-4.22754000	-0.98094600	1.21895700
6	-7.08489000	-2.89250500	-0.26548600
6	-6.84557900	-1.72169200	1.87689200
6	-4.76489800	-0.61313100	2.47437600
6	-8.35326000	-3.29554700	0.09583800
1	-6.66946500	-3.20290100	-1.22405200
6	-8.16103300	-2.14397500	2.21257100
6	-6.05660000	-0.96355000	2.78630800
1	-4.13342200	-0.04365100	3.15799800
6	-8.90471400	-2.91044100	1.34180700
1	-8.93603300	-3.92190200	-0.58358100
1	-8.56916500	-1.85405400	3.18413300
1	-6.48797700	-0.67570300	3.74795800
1	-9.91292300	-3.23118100	1.61340200
8	-2.47993300	-2.88518400	-0.02313200
8	-2.92637300	-0.61990400	0.95969700
15	-1.65083500	-1.68137700	0.83378900
7	-1.42262200	-2.52950300	2.23799000
6	-0.21509600	-2.35288900	3.03803200
1	0.30285300	-3.31877200	3.15150300
1	0.46620200	-1.63628700	2.56739800
1	-0.46184600	-1.95217600	4.03112500
6	-2.47173200	-3.32308800	2.86558400
1	-2.06016500	-4.30117000	3.16850300
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1	-3.29510700	-3.50066000	2.16470000

6	0.17665400	-4.86585100	0.41168500	6	0.60289200	3.15996600	1.16838700
1	-0.33444700	-5.23270400	1.31747400	6	0.11568300	2.24665000	2.14704600
1	-0.53911900	-4.24229500	-0.13675500	6	0.82966200	1.98419700	3.38669800
1	0.44087500	-5.73740800	-0.21470300	6	2.03866500	2.47072200	3.91625100
6	2.37107300	-4.84822500	1.52303700	1	2.59500400	3.23168700	3.36996400
1	1.92281500	-5.24731200	2.44877900	6	2.49788700	1.97680000	5.13719100
1	2.76204800	-5.69388600	0.93039500	1	3.43713900	2.35457200	5.55095500
1	3.20334700	-4.19083900	1.79620800	6	1.76924800	1.00416400	5.85211600
6	-0.81459100	0.76381100	-1.71092900	1	2.15029900	0.63785600	6.80951400
1	-1.28835000	0.05832700	-2.40427900	6	0.56631000	0.51311400	5.34924600
6	0.59264500	0.79683100	-1.72700800	1	-0.00306900	-0.23451400	5.91159000
1	1.13779700	1.56589300	-1.18568600	6	0.08584900	0.99066400	4.11699700
6	1.31251400	-0.31929300	-2.19374000	6	-1.08097900	0.66453900	3.34090700
1	0.89274800	-0.97138200	-2.96773300	1	-1.87161800	-0.02281000	3.63990100
1	2.39917300	-0.32722200	-2.10379500	6	-1.05284600	1.40668800	2.16926900
6	-1.75449000	1.73106700	-1.14321000	1	-1.83613900	1.37545000	1.42595100
6	-1.41157400	2.86951200	-0.37277700				
6	-3.12219000	1.47215400	-1.35807900				
6	-2.41563700	3.67900700	0.16734100	**TS1a*RR***			
6	-4.11707200	2.27587400	-0.81322100	E =	-4603.44170859	G = -4602.425559	
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6	-3.76327800	3.38423200	-0.03712000	6	3.44983200	3.12364800	0.64238400
1	-2.11348900	4.53948000	0.76601000	1	3.63679500	4.02722700	0.06334500
1	-5.16602100	2.03325500	-0.99469800	6	4.49366300	2.42831800	1.26138800
1	-4.53386400	4.02197400	0.40163700	1	5.52025700	2.78704300	1.16163200
7	-0.05714400	3.22410900	-0.12594600	6	4.21904300	1.28350900	2.01248100
6	0.57767500	5.85361800	-0.84700200	1	5.02988700	0.74544700	2.50361100
6	-0.55433200	6.57306800	-1.23567400	6	2.91078900	0.81033400	2.12533700
1	-1.31188300	6.09337100	-1.85610600	1	2.71637400	-0.10942700	2.67779700
6	-0.67978900	7.90289000	-0.83024800	6	1.85772400	1.47816100	1.49179400
1	-1.56230400	8.47402300	-1.12966800	6	-0.01333900	4.53932700	-2.10645100
6	0.31246500	8.51972800	-0.05447200	6	-1.28642200	4.40010600	-2.65722900
6	1.44524700	7.76895100	0.30679600	1	-1.76850200	3.42301800	-2.66653500
1	2.22870100	8.23636200	0.90931800	6	-1.91737800	5.52752900	-3.17543800
6	1.58725500	6.43886600	-0.07825200	1	-2.91505300	5.42944200	-3.61104100
1	2.44580300	5.84253800	0.22265200	6	-1.29999500	6.78960000	-3.13773200
6	0.17680300	9.95212100	0.39238600	6	-0.01552300	6.89073500	-2.58086400
1	1.05308900	10.54793200	0.08922600	1	0.48326000	7.86260400	-2.55143200
1	0.10918400	10.01659100	1.49129100	6	0.63936500	5.77031900	-2.07021700
1	-0.72095500	10.42614200	-0.02980200	1	1.64258200	5.84985200	-1.64947000
8	-0.17813300	3.98042800	-2.52726000	6	-2.01650500	8.00685800	-3.66070700
8	2.10885400	3.76160900	-1.47291300	1	-2.74821000	8.37461300	-2.92078200
16	0.70341700	4.15514600	-1.36714500	1	-1.31789000	8.82938800	-3.87200200
8	1.60381200	3.87503600	1.29366100	1	-2.57390400	7.78019100	-4.58252700

7	1.03891900	3.37239400	0.20297200	1	-1.91225800	0.78610100	-1.53264100
8	-1.20883600	3.76628800	0.33217900	6	-5.16412200	-2.29022900	-0.26620500
8	0.02296300	1.90149100	-1.74602600	6	-6.44904300	-2.66682800	-0.79197500
8	2.20465900	3.13313300	-2.05429200	6	-4.36144700	-3.28620800	0.28073600
16	0.84251900	3.10137000	-1.51193600	6	-7.28061900	-1.75406900	-1.50090500
6	-1.36932000	2.85907600	3.13395700	6	-6.90832000	-4.01902600	-0.64065200
6	-2.66326000	2.51500500	2.74425400	6	-4.81096000	-4.62025900	0.42610000
1	-2.92903700	2.50045200	1.69213400	6	-8.50840800	-2.14261000	-1.99363900
6	-3.60976800	2.18970000	3.72401800	1	-6.93170200	-0.73460000	-1.66013100
1	-4.62312500	1.92074000	3.41750700	6	-8.18550800	-4.38310400	-1.14878000
6	-3.26856200	2.21141100	5.08427900	6	-6.06633100	-4.97323900	-0.00666100
1	-4.02079000	1.95527200	5.83494500	1	-4.13651200	-5.34099900	0.89127300
6	-1.97442700	2.55966000	5.48923400	6	-8.97544000	-3.46624200	-1.80698400
1	-1.71084900	2.57547400	6.55038900	1	-9.12463600	-1.42273600	-2.53744000
6	-1.02285200	2.88536100	4.51797700	1	-8.52505600	-5.41342100	-1.01437000
6	0.37922000	3.26984600	4.61599200	1	-6.42497400	-5.99846200	0.11328800
1	0.93011000	3.40330000	5.54760500	1	-9.95337200	-3.75920000	-2.19581800
6	0.88490700	3.43601800	3.35756600	8	-2.69815400	-1.71268300	-1.42760200
1	1.90463900	3.73036900	3.12101900	8	-3.08918100	-2.99751100	0.72011400
6	-0.18879000	3.49325400	0.94654200	15	-1.81927400	-2.62565300	-0.32577700
6	-0.15036600	3.12919500	2.36476900	7	-1.53900000	-3.94436000	-1.30945600
6	0.44737300	1.08361700	1.60467900	6	7.46883700	-1.04683400	2.76528200
1	-0.16916100	1.26451900	0.72450100	6	6.69559800	-1.10378000	1.62521800
6	-0.01202800	0.02135600	2.44316300	6	5.54102600	-1.93477800	1.55708500
1	0.63305400	-0.31369600	3.25910800	6	5.18404500	-2.68748000	2.72697400
6	-1.28723300	-0.55470000	2.29694400	6	6.00852000	-2.61257000	3.88382300
1	-2.06857300	-0.02473800	1.74855800	6	7.13123300	-1.81512100	3.90609900
1	-1.64213100	-1.27919400	3.03246700	1	8.34627500	-0.39639500	2.79076100
46	-0.13005400	-1.42145200	0.62526200	1	6.95785100	-0.49071200	0.76499000
6	-7.20714400	1.15465900	1.53693500	6	4.70246700	-2.00198700	0.39066300
6	-6.55599900	0.06328500	1.00076600	6	3.99578400	-3.46809700	2.72155300
6	-5.36946400	0.22152700	0.23104200	1	5.72550700	-3.19689500	4.76311000
6	-4.84560400	1.54742500	0.06011100	1	7.75370600	-1.76356100	4.80222400
6	-5.54853000	2.65163000	0.61506000	6	3.18229500	-3.49673400	1.61362300
6	-6.70852100	2.46445700	1.33425500	6	3.54426200	-2.76484100	0.45922200
1	-8.11170300	1.00575900	2.13136400	1	3.72932600	-4.03297100	3.61797000
1	-6.94488200	-0.93926800	1.17614100	1	2.25381900	-4.06945300	1.59533000
6	-4.65926300	-0.89270800	-0.33715600	6	4.98145100	-1.19937300	-0.83041900
6	-3.60270700	1.73124800	-0.60636500	6	6.21530200	-1.29470500	-1.55976900
1	-5.13045600	3.65212500	0.48216600	6	4.01676000	-0.30750800	-1.28734700
1	-7.23236300	3.31990000	1.76651200	6	7.19621200	-2.28553100	-1.27358300
6	-2.89269300	0.65182000	-1.07663300	6	6.46454800	-0.38676700	-2.64385800
6	-3.43410200	-0.64686500	-0.94134800	6	4.26363400	0.60647500	-2.33877800
1	-3.17835700	2.73359400	-0.68347000	6	8.37053900	-2.35489800	-1.99338700

1	7.00471100	-3.00337200	-0.47589900	6	-0.24463900	-0.04428600	2.42604800
6	7.69153500	-0.47733900	-3.35618000	1	0.41652700	-0.28428900	3.26214300
6	5.47432400	0.57565700	-2.98817600	6	-1.45085600	-0.75815900	2.24280400
1	3.48556800	1.33319400	-2.57684300	1	-2.28102900	-0.28667500	1.70885700
6	8.62967500	-1.43596600	-3.03904200	1	-1.74015800	-1.52621100	2.96359900
1	9.10513300	-3.12863300	-1.75773400	6	1.39421000	3.60840900	-2.30441200
1	7.87261800	0.22746200	-4.17193400	6	2.61786100	2.94609100	-2.40311600
1	5.68404000	1.28438800	-3.79319200	1	2.73511600	1.96829200	-1.93681100
1	9.56644600	-1.49662500	-3.59782800	6	3.66759300	3.57142900	-3.07479700
8	2.69656400	-2.81360600	-0.62783700	1	4.63549100	3.06795600	-3.14122400
8	2.77475300	-0.27552500	-0.70287400	6	3.50419500	4.83969300	-3.65445300
15	1.65195500	-1.51428300	-0.85794000	6	2.25296900	5.47263100	-3.54603700
7	1.36915000	-1.76055000	-2.48639500	1	2.10791700	6.45749000	-3.99742800
6	0.18404200	-1.16623200	-3.08810500	6	1.19299300	4.86696700	-2.87391600
1	-0.30880200	-1.89689300	-3.75149600	1	0.21796000	5.35004100	-2.79444000
1	-0.53357100	-0.87773000	-2.31382300	6	4.63236200	5.50595900	-4.39759600
1	0.43472100	-0.26152600	-3.66829300	1	4.45936200	5.46845900	-5.48672300
6	2.38916100	-2.18871200	-3.43512300	1	4.72069100	6.56833900	-4.12186500
1	1.95202300	-2.92511700	-4.13182600	1	5.59572600	5.01598900	-4.19569700
1	2.77664500	-1.33975200	-4.02495000	7	0.36196700	3.40428600	0.20467000
1	3.22509400	-2.66255900	-2.90936800	8	-1.21306400	3.34648200	-1.86172600
6	-0.29365200	-4.68350900	-1.18854600	8	0.32709900	1.37767200	-1.47242200
1	0.24107900	-4.70531900	-2.15379800	16	0.07379500	2.83253100	-1.40333300
1	0.36682600	-4.20124100	-0.45652100	6	-1.68017200	4.56805200	0.93547900
1	-0.47616800	-5.72420300	-0.86509500	6	-2.92657500	4.73088800	1.67962300
6	-2.50304500	-4.48563600	-2.25678200	6	-3.48700900	4.02832300	2.75162800
1	-2.03563000	-4.57976200	-3.25298900	1	-2.95006000	3.18597300	3.18791300
1	-2.85621700	-5.48394700	-1.94355000	6	-4.73385000	4.42729200	3.24402100
1	-3.36719700	-3.81831000	-2.34667100	1	-5.18359600	3.88140700	4.07732000
TS1b				6	-5.42157200	5.51170300	2.67435100
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6	1.54575700	2.84643800	0.78755200	6	-4.86727300	6.22823000	1.60792100
6	2.76292700	3.52181000	0.70420300	1	-5.40282900	7.07755900	1.17414500
1	2.80536400	4.47303400	0.17325500	6	-3.61314100	5.85114000	1.11078800
6	3.89759200	2.97114100	1.30411200	6	-2.77223300	6.40204900	0.05883400
1	4.85577800	3.49083000	1.23393300	1	-3.01604400	7.27832900	-0.54276300
6	3.80348100	1.76472400	2.00496300	6	-1.63147700	5.64835600	-0.03353400
1	4.68684300	1.33400900	2.47712000	1	-0.80103200	5.82173500	-0.71424000
6	2.58124800	1.10076500	2.10554400	8	-0.79524700	2.72401600	2.11314100
1	2.52511300	0.14805500	2.63304400	46	-0.14832300	-1.41802600	0.66689500
6	1.43979400	1.63141100	1.49297900	6	-7.16422700	0.77508200	1.56085800
6	0.10400500	1.02212200	1.55238600	6	-6.47736400	-0.28724100	1.00957200
1	-0.50156500	1.11267100	0.65736500	6	-5.29552000	-0.07508300	0.24674300
6	-0.77067800	3.54840600	1.14102800	6	-4.81212300	1.27160300	0.10500500

6	-5.55199200	2.34395600	0.67385000	6	2.57664900	-3.14647900	2.23373000
6	-6.70864200	2.10302900	1.38223100	6	3.25206700	-2.63918400	1.09981000
1	-8.06666700	0.58666600	2.14786500	1	2.58230900	-3.30737300	4.37279900
1	-6.83651100	-1.30443900	1.16383400	1	1.64774900	-3.69891900	2.08497800
6	-4.55546200	-1.15299200	-0.35350400	6	5.04254800	-1.38427600	-0.05182200
6	-3.59024000	1.51363200	-0.58145000	6	6.39710700	-1.67754200	-0.43263000
1	-5.17339900	3.36043900	0.55975300	6	4.26312100	-0.61267700	-0.90900100
1	-7.25412800	2.93744400	1.82687900	6	7.22035000	-2.57432600	0.30553200
6	-2.86096400	0.46719800	-1.09900900	6	6.94295700	-1.08383700	-1.62027000
6	-3.35124200	-0.85044500	-0.97144800	6	4.79741500	-0.04577900	-2.09200400
1	-3.21861200	2.53522600	-0.67980600	6	8.51850500	-2.83271100	-0.08112500
1	-1.91022400	0.63580000	-1.60147800	1	6.80951200	-3.06780300	1.18573000
6	-5.01400000	-2.56807900	-0.31298600	6	8.28911800	-1.36109600	-1.98392900
6	-6.28594700	-2.97521200	-0.84767200	6	6.11339900	-0.25691600	-2.42578900
6	-4.18053500	-3.55084500	0.20858300	1	4.13807600	0.54652100	-2.72609000
6	-7.14792200	-2.07209600	-1.53194800	6	9.06703000	-2.21191300	-1.22947900
6	-6.69884100	-4.34572500	-0.73094400	1	9.12771500	-3.52779800	0.50135000
6	-4.58173800	-4.90261600	0.32058200	1	8.69284900	-0.89203000	-2.88492100
6	-8.36206500	-2.48916100	-2.03473600	1	6.53035600	0.18714900	-3.33309200
1	-6.83388000	-1.03735600	-1.66201800	1	10.09890200	-2.42017300	-1.52102500
6	-7.96359100	-4.73938700	-1.24842800	8	2.68347800	-2.83463400	-0.14571300
6	-5.82490300	-5.28708400	-0.12160700	8	2.94287500	-0.36377800	-0.62423700
1	-3.88372500	-5.61176400	0.76874000	15	1.73628300	-1.54880800	-0.69026400
6	-8.78381600	-3.83243300	-1.88270800	7	1.58409000	-2.01522900	-2.28225600
1	-9.00308100	-1.77628600	-2.55861100	6	0.44658600	-1.52951200	-3.05253300
1	-8.26865900	-5.78353700	-1.14056200	1	-0.04044200	-2.36686800	-3.57924000
1	-6.14868500	-6.32650000	-0.02754400	1	-0.29368000	-1.06323700	-2.39375100
1	-9.75184900	-4.14767500	-2.27891200	1	0.76151600	-0.77286000	-3.79203900
8	-2.57353100	-1.88891700	-1.47677900	6	2.65513000	-2.61978800	-3.06028100
8	-2.91636100	-3.22676700	0.65899500	1	2.25295400	-3.46742800	-3.64222300
15	-1.67640100	-2.76296100	-0.37515200	1	3.10142400	-1.89859200	-3.76761400
7	-1.29184200	-4.05238200	-1.36255300	1	3.44178300	-2.99918400	-2.39821000
6	6.57993900	-0.56736700	3.98138300	6	-0.07060400	-4.80322000	-1.12688400
6	6.11184400	-0.82892300	2.71091100	1	0.50491900	-4.90256700	-2.06326500
6	4.96256400	-1.64303300	2.50258100	1	0.56833800	-4.28524200	-0.40066900
6	4.28424300	-2.16197800	3.65734700	1	-0.28756700	-5.81754000	-0.74470900
6	4.79913000	-1.88009600	4.95291800	6	-2.21319500	-4.63805400	-2.32753700
6	5.92469300	-1.10333300	5.11647600	1	-1.69883000	-4.77543300	-3.29484200
1	7.46104200	0.06481300	4.11340300	1	-2.58204800	-5.62174400	-1.98724500
1	6.61900500	-0.39818500	1.84886600	1	-3.07087500	-3.97483300	-2.48529100
6	4.43257000	-1.91553100	1.19503500				
6	3.09327800	-2.92059300	3.48806100				
1	4.27457600	-2.28618600	5.82142900	**TS1c**			
1	6.30663000	-0.89011000	6.11723400	E =	-4603.42184408	G = -4602.406674	

6	1.86560400	2.24533200	0.52792800	6	0.59676400	4.02829600	2.14268900
6	3.21613000	2.49749400	0.25594300	6	0.08817000	0.92102700	1.68815000
1	3.47161200	3.32959500	-0.40142300	1	-0.61010100	1.44936100	1.04294100
6	4.21284600	1.73251700	0.84965600	6	-0.38740000	-0.38146700	2.11257300
1	5.26351900	1.94362500	0.64228300	1	0.30595600	-1.04943100	2.62964700
6	3.85568800	0.70105600	1.72412400	6	-1.74092500	-0.74123300	2.03486900
1	4.62469500	0.10827800	2.21798400	1	-2.50202500	0.01177400	1.80984200
6	2.51953000	0.42932700	1.97439200	1	-2.10117000	-1.63897300	2.54157000
1	2.26672300	-0.38197100	2.65574400	46	-0.88650900	-1.27369500	0.06439900
6	1.48517000	1.18242600	1.38066900	6	-6.13134900	2.37653800	2.86103700
6	1.77344400	3.43278400	-2.65718200	6	-6.02551100	1.33653900	1.96139900
6	2.15625700	4.77525000	-2.73980600	6	-5.07831300	1.37714600	0.90017800
1	1.60308700	5.53199100	-2.18006800	6	-4.21177400	2.51991200	0.80700800
6	3.26811100	5.10131100	-3.51222200	6	-4.36235100	3.58379400	1.73910300
1	3.58387900	6.14564600	-3.58062000	6	-5.30106500	3.51785700	2.74566800
6	3.99373100	4.11391500	-4.20485700	1	-6.86006400	2.31723700	3.67295000
6	3.57747000	2.77823600	-4.10002800	1	-6.66626800	0.46105800	2.06498300
1	4.13217700	1.99840000	-4.62837000	6	-4.93106600	0.30291500	-0.04438000
6	2.46966600	2.42739800	-3.32652300	6	-3.20333600	2.55528800	-0.19552100
1	2.14696200	1.39178100	-3.21826600	1	-3.70676100	4.45328600	1.64762300
6	5.18185000	4.49552600	-5.04835000	1	-5.39965300	4.33804600	3.46033700
1	5.86454700	5.16185600	-4.49778100	6	-3.01367200	1.48176500	-1.03311400
1	5.75009800	3.61189100	-5.37247400	6	-3.87055200	0.36356400	-0.93789300
1	4.86129000	5.03920800	-5.95313600	1	-2.55662500	3.42902600	-0.29459000
7	0.91284400	3.18004800	-0.02568300	1	-2.20633700	1.47203700	-1.76279100
8	0.83116100	5.50614400	0.19567900	6	-5.84943400	-0.86638100	-0.08886700
8	-0.70326100	3.92487400	-1.83182900	6	-7.26589800	-0.70282400	-0.28605700
8	0.18048200	1.53947300	-1.79929100	6	-5.34263800	-2.15907800	0.00076900
16	0.39534600	2.98334700	-1.62794200	6	-7.86163400	0.56741400	-0.52892500
6	1.65260500	3.66852600	3.08945900	6	-8.12175700	-1.85562000	-0.27674000
6	2.97448500	4.09706500	3.24084900	6	-6.18695900	-3.29643700	-0.00010800
1	3.37994400	4.88319600	2.59939700	6	-9.22286600	0.69516600	-0.70898900
6	3.76992000	3.49988100	4.22312700	1	-7.22570400	1.45001900	-0.58104900
1	4.80231700	3.83361500	4.35491100	6	-9.52246900	-1.68788700	-0.45333300
6	3.26463400	2.47762400	5.04435700	6	-7.54718600	-3.14601300	-0.11543700
1	3.90835500	2.02837200	5.80445900	1	-5.72184400	-4.27825200	0.10266800
6	1.95085800	2.02639000	4.89176400	6	-10.06790600	-0.43957600	-0.65907000
1	1.56699800	1.21449600	5.51538200	1	-9.65192400	1.68209800	-0.89759100
6	1.13891400	2.61478300	3.91651000	1	-10.15982200	-2.57578100	-0.43212800
6	-0.19639400	2.29653900	3.44709700	1	-8.20339700	-4.01977800	-0.10302900
1	-0.91690000	1.69072700	3.99723500	1	-11.14542700	-0.32384900	-0.79669000
6	-0.52833900	3.28741900	2.45683400	8	-3.60685800	-0.72921600	-1.74603300
1	-1.45374400	3.28866900	1.88495600	8	-3.99737500	-2.38599500	0.14464900
6	0.78780500	4.42272200	0.71578700	15	-2.79088000	-1.98030500	-0.96793400

7	-2.87509000	-3.10860200	-2.19739000	1	2.67067900	-2.36938700	-3.32719000
6	4.85071700	-2.69597300	3.96199800	6	-1.77973300	-4.03742900	-2.41171200
6	4.62775600	-2.56710300	2.60716500	1	-1.48089000	-4.04022800	-3.47480700
6	3.43560600	-3.05715600	2.00371500	1	-0.90357600	-3.74188100	-1.82046800
6	2.46346900	-3.68801300	2.85257300	1	-2.05993100	-5.07031000	-2.13302800
6	2.73004300	-3.81670000	4.24370700	6	-4.08815000	-3.36874200	-2.95722900
6	3.89664900	-3.33134000	4.79257200	1	-3.85502000	-3.40610500	-4.03573200
1	5.77126700	-2.30094100	4.39791800	1	-4.54817500	-4.33197100	-2.67024800
1	5.37175500	-2.07541000	1.98366100	1	-4.81820400	-2.56684400	-2.79582300
6	3.14786900	-2.89447700	0.60301600				
6	1.23866700	-4.14756200	2.29460400				
1	1.98059200	-4.30241000	4.87386300	**TS1d**			
1	4.08518800	-3.42942100	5.86398700	E =	-4603.41456192	G = -4602.398942	
6	0.96040300	-3.95576800	0.96293400	6	-2.47810500	-0.88952500	1.20045900
6	1.91228400	-3.31563600	0.13328200	6	-2.69221300	-0.44812900	2.51133600
1	0.50867000	-4.63260700	2.94687900	1	-3.70153500	-0.48820100	2.92036700
1	0.01113000	-4.26562300	0.52510300	6	-1.61884500	-0.00293100	3.27947700
6	4.07904700	-2.21771600	-0.33661000	1	-1.78273600	0.33765600	4.30346100
6	5.42633800	-2.68296500	-0.53381100	6	-0.32371500	-0.01200300	2.74480500
6	3.64871500	-1.11100800	-1.06437900	1	0.52245100	0.30726200	3.35277800
6	5.90317300	-3.89702900	0.03661100	6	-0.11493000	-0.41530900	1.42882100
6	6.32700300	-1.92898400	-1.35808500	1	0.89179700	-0.39892500	1.00592100
6	4.54220300	-0.36628200	-1.87493600	6	-1.19435600	-0.81682700	0.62771700
6	7.20190600	-4.31771400	-0.16019600	6	-6.21300100	-0.68335300	-0.21557900
1	5.22229400	-4.50502000	0.63162400	6	-6.85511700	-1.20392100	-1.33971100
6	7.66276000	-2.38272600	-1.53070100	1	-6.29310600	-1.33318800	-2.26282200
6	5.85304700	-0.75233800	-2.00067000	6	-8.19573500	-1.56253900	-1.23604000
1	4.15933700	0.52714900	-2.36521500	1	-8.70932100	-1.97118000	-2.11034700
6	8.09874000	-3.54947600	-0.94083700	6	-8.89782100	-1.42294400	-0.02578700
1	7.53939900	-5.25617000	0.28606000	6	-8.22250600	-0.89189000	1.08305100
1	8.33801500	-1.78936800	-2.15285200	1	-8.75523600	-0.76580200	2.02892300
1	6.54458200	-0.16701500	-2.61194400	6	-6.88279800	-0.51133900	0.99531800
1	9.12679600	-3.88988400	-1.08410700	1	-6.36401500	-0.07207800	1.84806100
8	1.56168500	-3.03494900	-1.17176400	6	-10.33767200	-1.85477400	0.07338800
8	2.36724500	-0.64222100	-0.98646900	1	-10.92503100	-1.49106700	-0.78448400
15	0.93404600	-1.46301000	-1.34687800	1	-10.41581500	-2.95543900	0.07479400
7	0.81292300	-1.42921200	-3.01042600	1	-10.80973100	-1.48579600	0.99540200
6	-0.33838100	-0.82270100	-3.65882400	7	-3.56658300	-1.40252500	0.42678700
1	-0.78381500	-1.52809600	-4.38213300	8	-4.44454800	-2.71152300	-1.18388500
1	-1.10063000	-0.56106800	-2.91686200	8	-4.13820300	0.04974500	-1.72954400
1	-0.05727000	0.10274000	-4.18967800	8	-4.37774900	1.00236100	0.59536000
6	1.90611400	-1.81631100	-3.88598700	16	-4.52193200	-0.13441200	-0.32189900
1	1.53039500	-2.47417200	-4.68886300	6	-2.03001900	-4.25973600	1.24374300
1	2.37947200	-0.93601000	-4.35964600	6	-1.48226200	-3.62757700	2.37789900

1	-1.73049100	-2.60382600	2.62703800	6	8.45628000	-1.12130700	1.63338600
6	-0.62365800	-4.32316100	3.22801500	1	6.48170000	-1.94531600	1.63427800
1	-0.23641100	-3.81650700	4.11589700	6	8.89256500	0.70209900	0.10951600
6	-0.26661700	-5.66105800	2.97309200	6	7.09733900	1.49686100	-1.40289700
1	0.41399300	-6.18351000	3.65084100	1	5.44827100	2.02129400	-2.69589100
6	-0.79869900	-6.32318900	1.86878900	6	9.33927600	-0.15802100	1.08862200
1	-0.54389900	-7.36860900	1.67246900	1	8.81814000	-1.82033100	2.39096800
6	-1.68707000	-5.65046800	1.01456100	1	9.56862400	1.43736000	-0.33439000
6	-2.39592100	-6.11360300	-0.14828300	1	7.79160000	2.22163500	-1.83480300
1	-2.35175000	-7.12418500	-0.55456600	1	10.37374500	-0.10880900	1.43594400
6	-3.13333300	-5.06315600	-0.64002400	8	3.78140000	-2.08551700	-1.82419400
1	-3.79889800	-5.07057300	-1.50093600	8	3.63707900	0.44423600	-1.80749800
6	-3.67050300	-2.68023900	-0.22480100	15	2.87513200	-0.86585600	-2.53947100
6	-2.92495400	-3.86655500	0.17006800	7	3.45864600	-0.97847300	-4.09206300
6	-1.05488900	-1.28099200	-0.77034500	6	-0.66659100	3.47672300	4.45615500
1	-1.93287700	-1.06967700	-1.38654900	6	-0.86017700	3.53919800	3.09270300
6	-0.48084000	-2.58998000	-0.95072300	6	0.20055800	3.25462500	2.18862200
1	0.18300000	-2.97455000	-0.17627200	6	1.47164600	2.87031700	2.73153200
6	-1.07649000	-3.48581900	-1.81116900	6	1.64390300	2.83517700	4.14258300
1	-1.85375200	-3.15836300	-2.50596700	6	0.59937700	3.13238600	4.99060100
1	-0.75993900	-4.52810500	-1.86023300	1	-1.50076000	3.68395600	5.13046900
46	0.65052800	-0.74930500	-1.85288000	1	-1.84450100	3.78038000	2.69333100
6	4.07002300	-0.26332700	3.99582400	6	0.01794400	3.27282800	0.76378600
6	4.46464000	-0.28946200	2.67456600	6	2.51502400	2.47433200	1.85271700
6	3.93856900	-1.25249000	1.76916300	1	2.61838400	2.54188000	4.53985800
6	2.98756900	-2.20430100	2.27181300	1	0.73964400	3.09014700	6.07326500
6	2.60138800	-2.14892500	3.63879300	6	2.30161400	2.40273000	0.49708100
6	3.12713500	-1.19843900	4.48631400	6	1.05066500	2.79211300	-0.02918000
1	4.48432500	0.49166200	4.66847300	1	3.47733300	2.18403400	2.27289000
1	5.18286900	0.44360000	2.30893400	1	3.06193300	2.04640900	-0.19437300
6	4.27909100	-1.26834300	0.37172700	6	-1.25074200	3.72853900	0.13740400
6	2.42580900	-3.17275200	1.39446400	6	-1.78506300	5.04587000	0.34990400
1	1.86307200	-2.86974600	3.99329400	6	-1.94038500	2.86936600	-0.70383500
1	2.81513200	-1.16021600	5.53230600	6	-1.09460200	6.04214600	1.09523800
6	2.73137000	-3.15076900	0.05400400	6	-3.04902700	5.39168900	-0.23709800
6	3.61608900	-2.17058600	-0.44894800	6	-3.18895600	3.19734900	-1.27895500
1	1.71744400	-3.90320300	1.79213900	6	-1.63630500	7.29715800	1.27969200
1	2.29191600	-3.85912100	-0.64832800	1	-0.11932000	5.80536500	1.51962600
6	5.27636000	-0.34482300	-0.23147800	6	-3.58314700	6.69066000	-0.01791500
6	6.64107100	-0.30040200	0.22303000	6	-3.73495100	4.43358100	-1.03484600
6	4.91613800	0.46525300	-1.30239600	1	-3.69563400	2.43548600	-1.87062300
6	7.14508400	-1.19155600	1.21208500	6	-2.89800700	7.62538100	0.72799700
6	7.55045900	0.64748700	-0.35658000	1	-1.08472100	8.04549800	1.85377700
6	5.81357900	1.39449500	-1.88085800	1	-4.55169000	6.93634200	-0.46116800

1	-4.70778500	4.69795000	-1.45630600
1	-3.31990000	8.62052600	0.88681800
8	0.86922800	2.67694300	-1.40184900
8	-1.40845100	1.62932600	-0.98703300
15	-0.07109100	1.42323300	-1.95430800
7	-0.40112100	2.01627800	-3.48125900
6	-0.94352900	1.08767300	-4.46208500
1	-0.48591800	1.26641800	-5.45002500
1	-0.72593800	0.05162800	-4.15960700
1	-2.03983800	1.18663900	-4.55778300
6	-0.63679100	3.42788000	-3.76621000
1	-0.17887000	3.68610200	-4.73621800
1	-1.71569000	3.65713700	-3.81369300
1	-0.17959600	4.04980200	-2.98867400
6	2.57479800	-0.68562700	-5.20763300
1	2.63050600	-1.48642600	-5.96488500
1	1.53657600	-0.61825900	-4.85352600
1	2.83621500	0.27163700	-5.69500700
6	4.87482000	-1.10733000	-4.40483600
1	5.02059100	-1.88479700	-5.17386500
1	5.29119300	-0.15760700	-4.78659500
1	5.43453900	-1.40460600	-3.50982800

INT2a$_{RR}$

E = -4603.45863579 G = -4602.440296

6	2.12485200	2.38344600	0.69209500
6	3.46236900	2.71173600	0.46593900
1	3.71485800	3.56693800	-0.16060800
6	4.45912400	1.93768500	1.06073900
1	5.51054800	2.17885600	0.89021400
6	4.11008200	0.86728100	1.88742800
1	4.88820700	0.27578500	2.36772700
6	2.76808100	0.54594500	2.09762700
1	2.51609200	-0.31214400	2.71907700
6	1.75724400	1.29573400	1.49355600
6	1.24584200	5.10732400	-1.83118400
6	0.26998100	6.07435000	-1.57048800
1	-0.68871900	5.77571400	-1.14828700
6	0.57234200	7.40843300	-1.82797600
1	-0.18042100	8.17419800	-1.62305900
6	1.82321500	7.79080400	-2.34519000
6	2.77357300	6.79254800	-2.60442500
1	3.74760200	7.06933800	-3.01525200
6	2.49425600	5.44832200	-2.35294300
1	3.22387000	4.66672600	-2.56808400
6	2.12471100	9.24308900	-2.60657700
1	2.10848300	9.82257100	-1.66857800
1	3.11270200	9.37613600	-3.06968400
1	1.37029600	9.69049500	-3.27376300
7	1.05552400	3.18850400	0.18584000
8	-0.87132900	4.31938600	0.67694500
8	-0.49338300	3.10489100	-1.89530000
8	1.97587400	2.59041700	-2.12047100
16	0.89521400	3.38693300	-1.53978300
6	-1.60613500	2.62540500	2.79484100
6	-2.81090400	2.35069300	2.16807900
1	-2.83990100	2.07706400	1.11629300
6	-3.99686000	2.42775300	2.91175400
1	-4.94908200	2.20638500	2.42654700
6	-3.96249000	2.78604100	4.26473800
1	-4.89498300	2.84068500	4.83212000
6	-2.74828500	3.08445800	4.89659300
1	-2.72526200	3.37715100	5.94934700
6	-1.56925800	3.00645800	4.15150200
6	-0.17189200	3.27527300	4.50794700
1	0.16290000	3.59780300	5.49539200
6	0.62337300	3.06458300	3.43967400
1	1.70560000	3.17586700	3.40707700
6	-0.06030200	3.48435600	0.99955000
6	-0.19575700	2.57864800	2.24715400
6	0.27210700	1.14564100	1.73504900
1	-0.22203800	1.04579500	0.75350300
6	-0.10646300	-0.06399800	2.55369500
1	0.59939500	-0.37002900	3.32900000
6	-1.39013000	-0.59866000	2.60055500
1	-2.23759100	-0.11116100	2.11960200
1	-1.65048500	-1.31202300	3.38694200
46	-0.39582800	-1.65283800	0.94089300
6	-7.16617700	2.14707700	0.51645100
6	-6.61863000	0.90443500	0.27281700
6	-5.35567700	0.77130500	-0.37046400
6	-4.64735700	1.96942700	-0.72253900
6	-5.24348400	3.23375500	-0.46431100
6	-6.48059900	3.32597800	0.13487400
1	-8.13405400	2.22182200	1.01792800
1	-7.15184100	0.00667600	0.58399100
6	-4.75578000	-0.50693300	-0.64337000

6	-3.33682500	1.87553800	-1.26624800
1	-4.68392900	4.13349200	-0.73045100
1	-6.92371400	4.30365700	0.33700600
6	-2.73639600	0.65006200	-1.43352700
6	-3.45289500	-0.53152400	-1.12644500
1	-2.77936900	2.78176700	-1.50582300
1	-1.71567200	0.58039400	-1.81052800
6	-5.47040800	-1.79170700	-0.41690200
6	-6.74144300	-2.07564200	-1.02941100
6	-4.88310600	-2.78069900	0.36619900
6	-7.35039600	-1.19720400	-1.97031600
6	-7.41550400	-3.30680700	-0.72534100
6	-5.54577900	-3.99655200	0.66192200
6	-8.56973700	-1.49559300	-2.54095300
1	-6.83491800	-0.27886900	-2.24789200
6	-8.67846800	-3.57703800	-1.32004400
6	-6.79423000	-4.24377500	0.14514700
1	-5.03488700	-4.71285400	1.30733900
6	-9.25135300	-2.69024300	-2.20513200
1	-9.01104400	-0.80504200	-3.26354500
1	-9.18303700	-4.51326600	-1.06723500
1	-7.31606100	-5.17494700	0.37933700
1	-10.22046000	-2.91127100	-2.65836000
8	-2.83884500	-1.74299900	-1.35127700
8	-3.62878600	-2.60226000	0.89401600
15	-2.21962500	-2.62174500	-0.04703900
7	-2.13789500	-4.09996200	-0.82777300
6	7.69159400	-1.12372300	2.28894200
6	6.75463900	-1.35806900	1.30516900
6	5.60031000	-2.15343400	1.55835400
6	5.42324000	-2.67680900	2.88379100
6	6.41545300	-2.42713700	3.87195800
6	7.53054000	-1.67110700	3.58513800
1	8.56314900	-0.50312000	2.06765700
1	6.88386600	-0.91088700	0.32134900
6	4.58964400	-2.38877800	0.56267000
6	4.24006100	-3.39999000	3.19713600
1	6.26742800	-2.83978700	4.87326400
1	8.28207900	-1.48173200	4.35493300
6	3.26178700	-3.58413300	2.24969400
6	3.44314500	-3.07689000	0.94161900
1	4.11143700	-3.79174800	4.20896900
1	2.33476800	-4.11533000	2.47062300
6	4.69927200	-1.81821900	-0.80819700
6	5.80825600	-2.09031200	-1.67883100
6	3.69714300	-0.96938000	-1.26685700
6	6.79827800	-3.06565900	-1.37111600
6	5.91417800	-1.38681700	-2.92648000
6	3.81012300	-0.24985600	-2.48067700
6	7.84891500	-3.31085600	-2.23010200
1	6.71198200	-3.62976900	-0.44231500
6	7.01774000	-1.65420500	-3.78196100
6	4.90864800	-0.44463000	-3.28310800
1	3.02006100	0.46148800	-2.72661400
6	7.96955300	-2.59206000	-3.44418100
1	8.59227600	-4.06947700	-1.97364900
1	7.09125800	-1.10400000	-4.72376300
1	5.01364800	0.11062900	-4.21859600
1	8.80976500	-2.79054600	-4.11361500
8	2.44099200	-3.30201900	0.02914600
8	2.54923400	-0.80887300	-0.53854600
15	1.40648000	-2.05147800	-0.42274600
7	1.15071400	-2.60592900	-1.99359500
6	0.09227000	-1.98279500	-2.76902500
1	-0.52693300	-2.74732000	-3.26884500
1	-0.56995200	-1.40210400	-2.11795800
1	0.50308200	-1.30514300	-3.54033300
6	2.10488600	-3.36848900	-2.78665400
1	1.56487300	-4.15192400	-3.34758000
1	2.63794600	-2.72932400	-3.51300100
1	2.84217600	-3.85107500	-2.13755000
6	-1.04408200	-5.00368600	-0.51615300
1	-0.45894900	-5.23621800	-1.42342200
1	-0.36413100	-4.53681600	0.21010500
1	-1.41667300	-5.95212400	-0.08837400
6	-3.10581900	-4.59368900	-1.79478000
1	-2.59021000	-4.88645900	-2.72726700
1	-3.64725700	-5.47523000	-1.40815300
1	-3.83462300	-3.81324500	-2.03928200

INT2b

E = -4603.44405864 G = -4602.425369

6	1.97590000	2.61415300	0.99534900
6	3.24078100	3.19159500	1.11660600
1	3.44996700	4.13884500	0.61941400
6	4.20776000	2.54230400	1.88550900
1	5.20410600	2.97662800	1.99079300

6	3.89834200	1.34314700	2.53287300	6	-0.92669500	5.62672200	0.28066800
1	4.65237400	0.85060500	3.14480700	1	-0.02890700	5.86476000	-0.28401700
6	2.62664000	0.77520100	2.41147400	8	-0.61762300	2.17434500	1.64908700
1	2.40706800	-0.16999500	2.90759000	46	-0.65702800	-1.95153400	1.23105100
6	1.65123700	1.41379500	1.64422500	6	-6.38940300	2.76060500	0.02665500
6	0.21686500	0.98098000	1.46703700	6	-6.10978600	1.41070500	-0.00843300
1	0.07157900	0.67403000	0.42148600	6	-4.87141900	0.93444200	-0.52327000
6	-0.32467000	3.26354900	0.92673700	6	-3.89651300	1.90342900	-0.93883100
6	-0.29023300	-0.07510000	2.41363900	6	-4.22214000	3.28705800	-0.89986500
1	0.32467700	-0.27847500	3.29342100	6	-5.44976300	3.70893900	-0.44310600
6	-1.64386600	-0.41360500	2.45280300	1	-7.34425200	3.10354700	0.43229500
1	-2.36450700	0.08398700	1.79835000	1	-6.84240100	0.69415800	0.36210000
1	-2.06502200	-0.89320700	3.33993100	6	-4.55669900	-0.46500900	-0.63045800
6	2.48403900	3.48744000	-1.96911300	6	-2.61393000	1.47013300	-1.36913600
6	3.55633000	2.59960000	-2.04376500	1	-3.46727900	4.00735900	-1.22092000
1	3.41212900	1.54509700	-1.81570100	1	-5.68214600	4.77361700	-0.40113000
6	4.81143800	3.09125400	-2.40057400	6	-2.29576300	0.13196000	-1.39259300
1	5.65602700	2.40022300	-2.45770500	6	-3.27652300	-0.82055000	-1.03364000
6	5.00508200	4.45312600	-2.67731400	1	-1.88453600	2.21837600	-1.67695100
6	3.89950800	5.32025500	-2.59703100	1	-1.30301000	-0.20294700	-1.69466700
1	4.03279500	6.38269900	-2.81651700	6	-5.53817100	-1.54016500	-0.32175500
6	2.63690800	4.84803300	-2.24781300	6	-6.81511300	-1.61924500	-0.98124000
1	1.77524300	5.51513900	-2.19520700	6	-5.20941200	-2.54057000	0.58835900
6	6.35785400	4.98094100	-3.07633200	6	-7.18167600	-0.74165200	-2.04108500
1	6.38571400	5.20524200	-4.15631500	6	-7.74977300	-2.64094100	-0.60054200
1	6.59434000	5.91685900	-2.54656200	6	-6.12838200	-3.55118800	0.96015400
1	7.15460500	4.25326800	-2.86610800	6	-8.41213400	-0.83908900	-2.65554700
7	0.93089600	3.26723700	0.25343000	1	-6.47006100	0.01294000	-2.37277300
8	-0.16094800	3.72089900	-2.04060800	6	-9.01629100	-2.70414400	-1.24404700
8	0.86750600	1.43051100	-1.66531300	6	-7.37974200	-3.58650500	0.39446500
16	0.89210400	2.88743100	-1.46129000	1	-5.80971900	-4.28339500	1.70392200
6	-1.16421100	4.33570400	0.92269300	6	-9.34807500	-1.81989300	-2.24691100
6	-2.47399700	4.42655300	1.58289200	1	-8.66495100	-0.15459400	-3.46874100
6	-3.21635400	3.51949400	2.33990300	1	-9.72045600	-3.48002200	-0.93216300
1	-2.83280000	2.51957300	2.53681600	1	-8.09818700	-4.35637900	0.68668000
6	-4.46405700	3.91885600	2.83498100	1	-10.32295100	-1.88099900	-2.73623700
1	-5.06133300	3.21317500	3.41686900	8	-2.94333500	-2.16316600	-1.09493600
6	-4.95889600	5.20570300	2.58691400	8	-3.96947700	-2.57288200	1.18291600
1	-5.93547100	5.49458000	2.98404100	15	-2.54036700	-2.92083200	0.35474700
6	-4.21901900	6.12398800	1.83088400	7	-2.63274000	-4.49865800	-0.19331400
1	-4.60931100	7.12716700	1.63902900	6	7.32435000	0.04848100	2.15184200
6	-2.97745400	5.73549400	1.32393400	6	6.39657000	-0.53510700	1.31585300
6	-1.99051700	6.44744200	0.51284900	6	5.43596300	-1.46280500	1.80991600
1	-2.09742900	7.47495800	0.16369600	6	5.43539400	-1.74161500	3.21830800

6	6.41250900	-1.13122000	4.05232600	6	-3.64543600	-4.99995200	-1.10862200
6	7.34371200	-0.25741800	3.53423400	1	-3.16298300	-5.50379300	-1.96564600
1	8.04396400	0.76301400	1.74538300	1	-4.31432800	-5.72597900	-0.61297200
1	6.38035000	-0.26719500	0.26112300	1	-4.25031200	-4.17303800	-1.49757300
6	4.44355500	-2.07038700	0.96543600				
6	4.42691700	-2.58258700	3.76205400				
1	6.40034800	-1.35944600	5.12111100	**INT2c**			
1	8.08486000	0.20960400	4.18667900	E =	-4603.42753338	G = -4602.409753	
6	3.44958400	-3.11313600	2.95516100	6	1.80340100	2.33606800	0.54297100
6	3.46151700	-2.85474900	1.56350400	6	3.16034500	2.50169600	0.22991500
1	4.42866000	-2.78585200	4.83554400	1	3.43974300	3.29294800	-0.46743500
1	2.65266500	-3.74420300	3.35120800	6	4.13061200	1.69859500	0.81707700
6	4.40340500	-1.80329300	-0.49876900	1	5.18480900	1.83681900	0.56975600
6	5.51575700	-2.06056400	-1.37075800	6	3.73354400	0.72306900	1.73145800
6	3.23847900	-1.28622100	-1.05396600	1	4.47228800	0.08847600	2.22012600
6	6.69246800	-2.73081200	-0.93199300	6	2.38568600	0.54862700	2.02643200
6	5.43589700	-1.66674200	-2.75026400	1	2.11200500	-0.22383100	2.74334700
6	3.15434200	-0.89710800	-2.41259100	6	1.38017300	1.33911200	1.44760300
6	7.74360200	-2.96387600	-1.79346600	6	1.67028800	3.48010700	-2.69773800
1	6.75243300	-3.06954100	0.10201600	6	2.03289000	4.82388600	-2.83219900
6	6.54461400	-1.90835200	-3.60749600	1	1.48796100	5.59135500	-2.27840800
6	4.24276500	-1.06256100	-3.23613700	6	3.11178300	5.14014200	-3.65324300
1	2.21817200	-0.45557800	-2.75668900	1	3.41160100	6.18553500	-3.76398300
6	7.67850300	-2.53825900	-3.14262700	6	3.82442100	4.14063400	-4.34260800
1	8.63299100	-3.48603600	-1.43292100	6	3.42929700	2.80404500	-4.18395000
1	6.47330800	-1.59371000	-4.65196300	1	3.97461500	2.01532400	-4.70865600
1	4.19534600	-0.75256600	-4.28301000	6	2.35399300	2.46275000	-3.36137100
1	8.52077300	-2.72294700	-3.81330100	1	2.04923900	1.42667700	-3.21141500
8	2.47902600	-3.44745400	0.81175500	6	4.97747800	4.51127800	-5.23794800
8	2.11447500	-1.16773500	-0.28220200	1	5.53461000	3.62382900	-5.57055800
15	1.22861800	-2.56571700	0.10551300	1	4.62044000	5.04099400	-6.13724200
7	1.15071500	-3.48841000	-1.30294700	1	5.67976700	5.18683200	-4.72434900
6	0.04199800	-3.26375900	-2.21585300	7	0.91374200	3.31563500	-0.04077300
1	-0.41585000	-4.22273200	-2.51533600	8	0.64055800	5.62507800	0.15820600
1	-0.73825500	-2.65313800	-1.74952700	8	-0.78655900	3.96735400	-1.81345100
1	0.37987400	-2.74310400	-3.13084900	8	0.13350500	1.59804400	-1.71799300
6	2.24373300	-4.26040500	-1.87968500	16	0.33154900	3.04851500	-1.61289300
1	1.85360800	-5.23151600	-2.23204700	6	1.36826500	3.75391200	3.14156100
1	2.70123100	-3.74035000	-2.74008700	6	2.62434400	4.25804500	3.47319500
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6	2.18096400	3.13315800	1.86219700	1	1.67478600	1.71753700	-4.15164700
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1	0.64642600	3.15889000	6.22149000	6	4.89446900	0.64118800	-4.14823600
6	1.89133100	3.20665800	0.52078000	1	4.98609000	0.37081000	-5.21458300
6	0.57607300	3.51634800	0.10663100	1	5.40875300	1.60715200	-3.99200500
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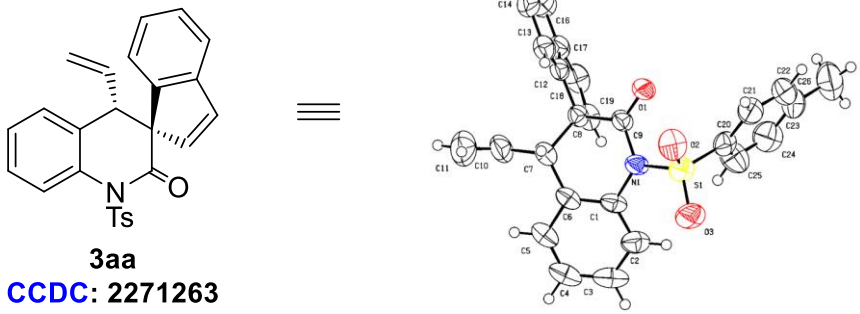
8. X-Ray Structures of Product 3aa



3aa
CCDC: 2271263

Supplementary Figure 8 X-ray crystallography of **3aa**

Crystal data and structure refinement for mo_230601a_0m.

Identification code	mo_230601a_0m	
Empirical formula	C26 H21 N O3 S	
Formula weight	427.50	
Temperature	296.15 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 1 21 1	
Unit cell dimensions	a = 9.163(2) Å	a= 90°
	b = 12.687(3) Å	b= 104.805(4)°
	c = 9.805(3) Å	g = 90°
Volume	1102.1(5) $Å^3$	
Z	2	
Density (calculated)	1.288 Mg/m^3	
Absorption coefficient	0.174 mm^{-1}	
F(000)	448	
Crystal size	0.3 x 0.2 x 0.2 mm^3	
Theta range for data collection	2.299 to 29.028°	
Index ranges	-12<=h<=12, -16<=k<=17, -13<=l<=13	
Reflections collected	10523	
Independent reflections	5579 [R(int) = 0.0418]	
Completeness to theta = 25.242?	99.7 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7458 and 0.5818	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	5579 / 1 / 277	
Goodness-of-fit on F^2	0.974	

Final R indices [I>2sigma(I)]	R1 = 0.0487, wR2 = 0.1050
R indices (all data)	R1 = 0.0937, wR2 = 0.1244
Absolute structure parameter	0.09(6)
Extinction coefficient	0.012(3)
Largest diff. peak and hole	0.290 and -0.229 e.Å^{-3}

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1 Wang C, Li Y, Wu Y, Wang Q, Shi W, Yuan C, Zhou L, Xiao Y, Guo H. Enantioselective construction of tetrahydroquinazoline motifs via palladium-catalyzed [4+2] cycloaddition of vinyl benzoxazinones with sulfamate-derived cyclic imines. *Org Lett* 2018;20:2880-3.

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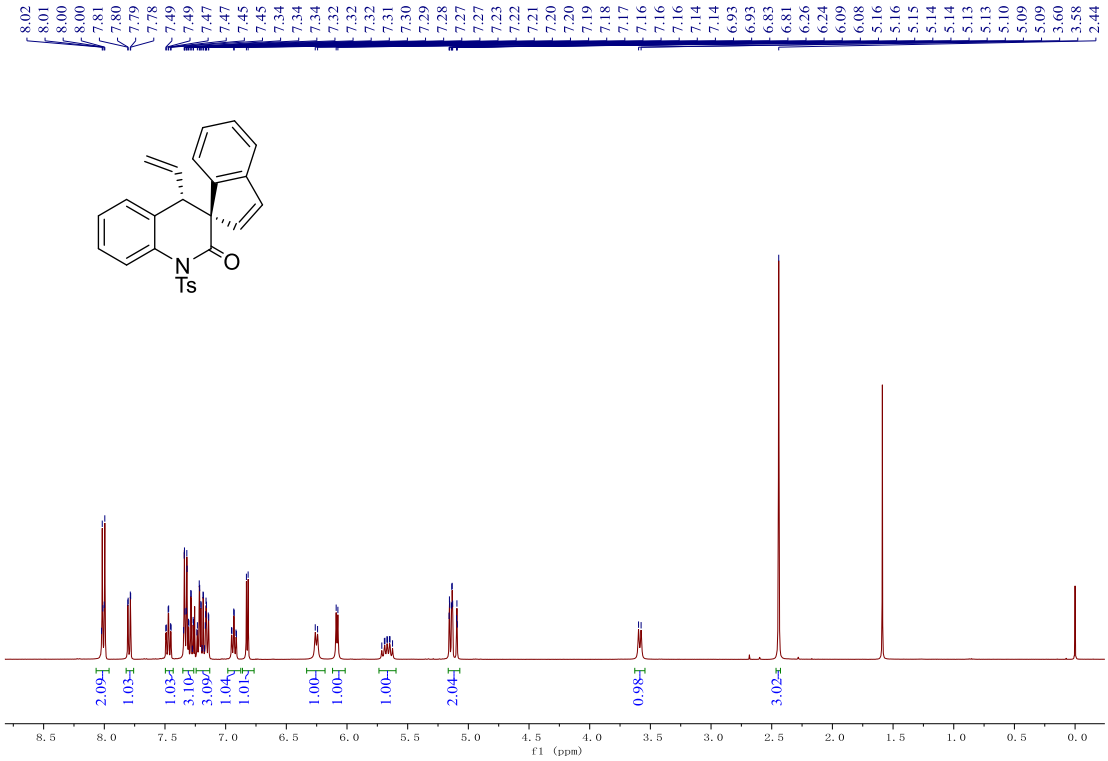
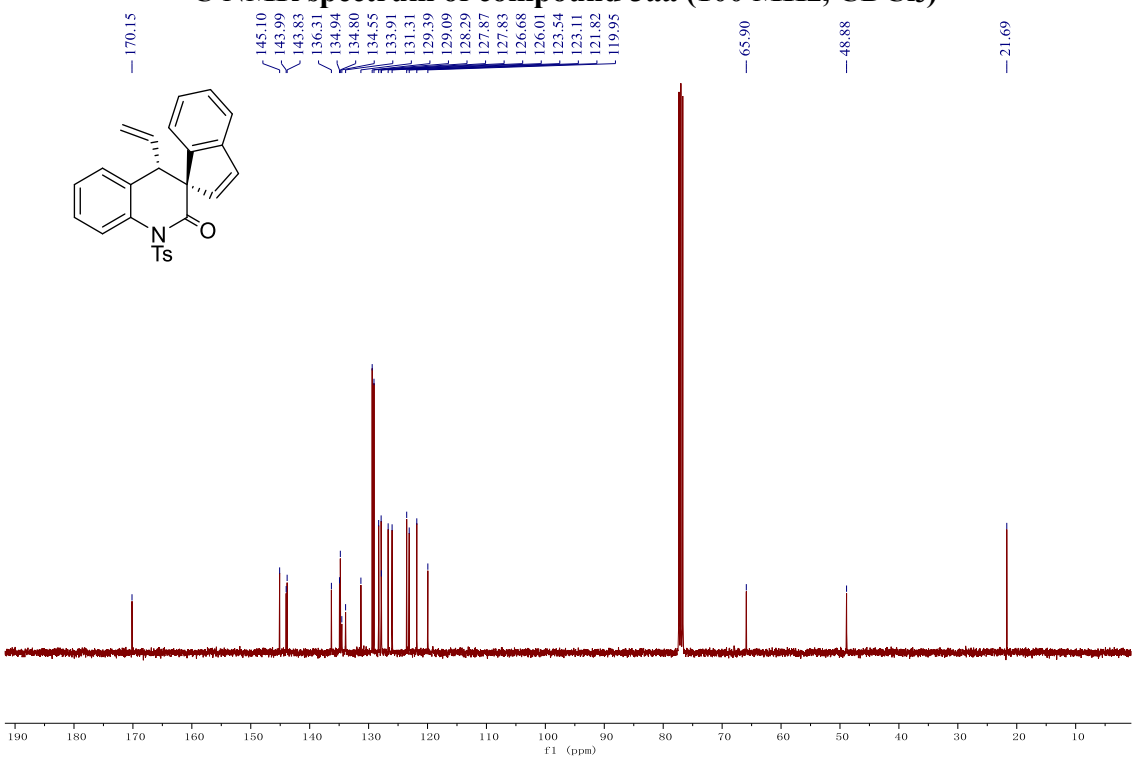
9. Copies of NMR Spectra

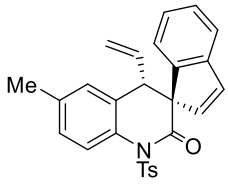
^{1}H NMR spectrum of compound 3aa (400 MHz, $CDCl_3$)

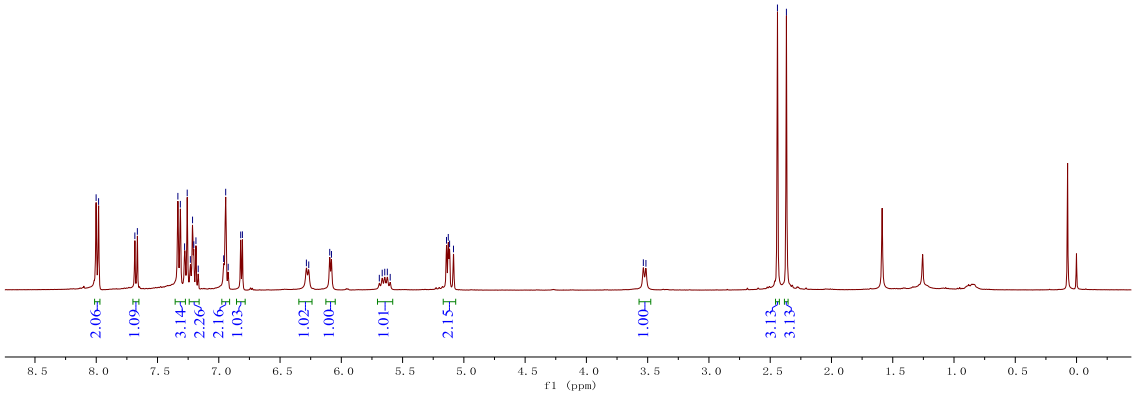


^{13}C NMR spectrum of compound 3aa (100 MHz, $CDCl_3$)



^{1}H NMR spectrum of compound 3ab (400 MHz, $CDCl_3$)





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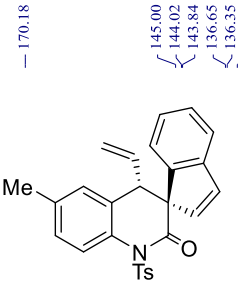
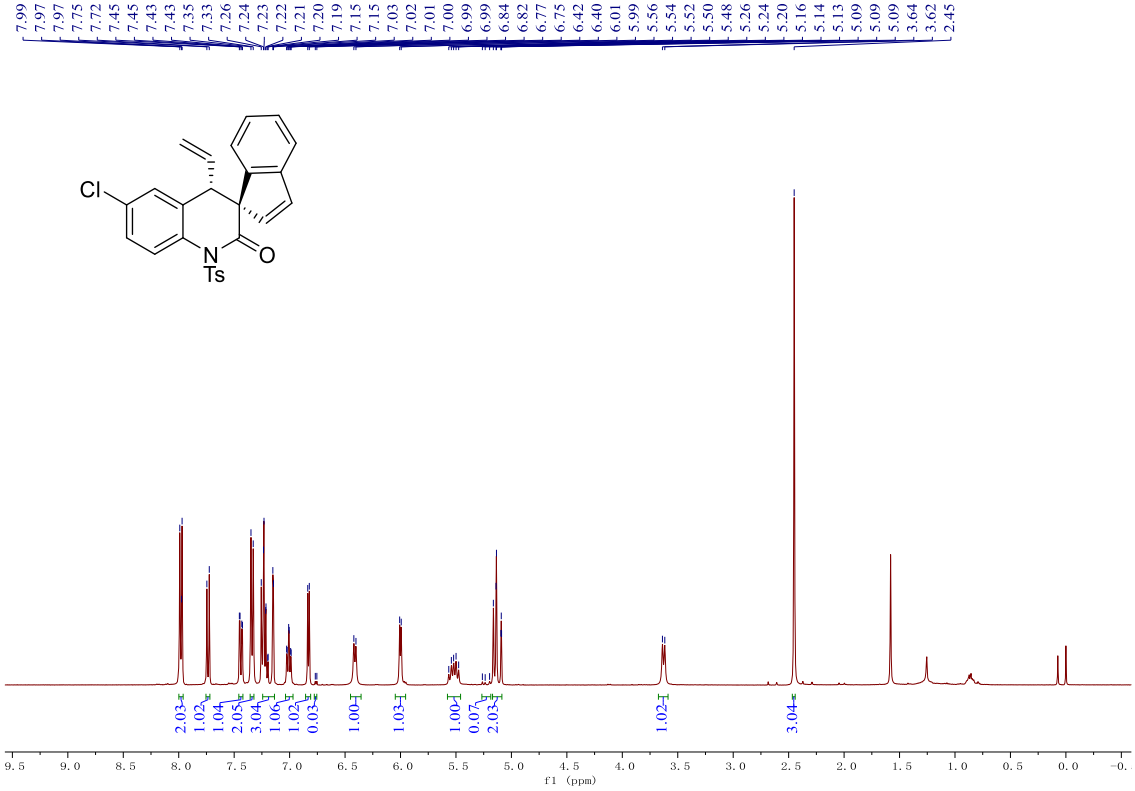
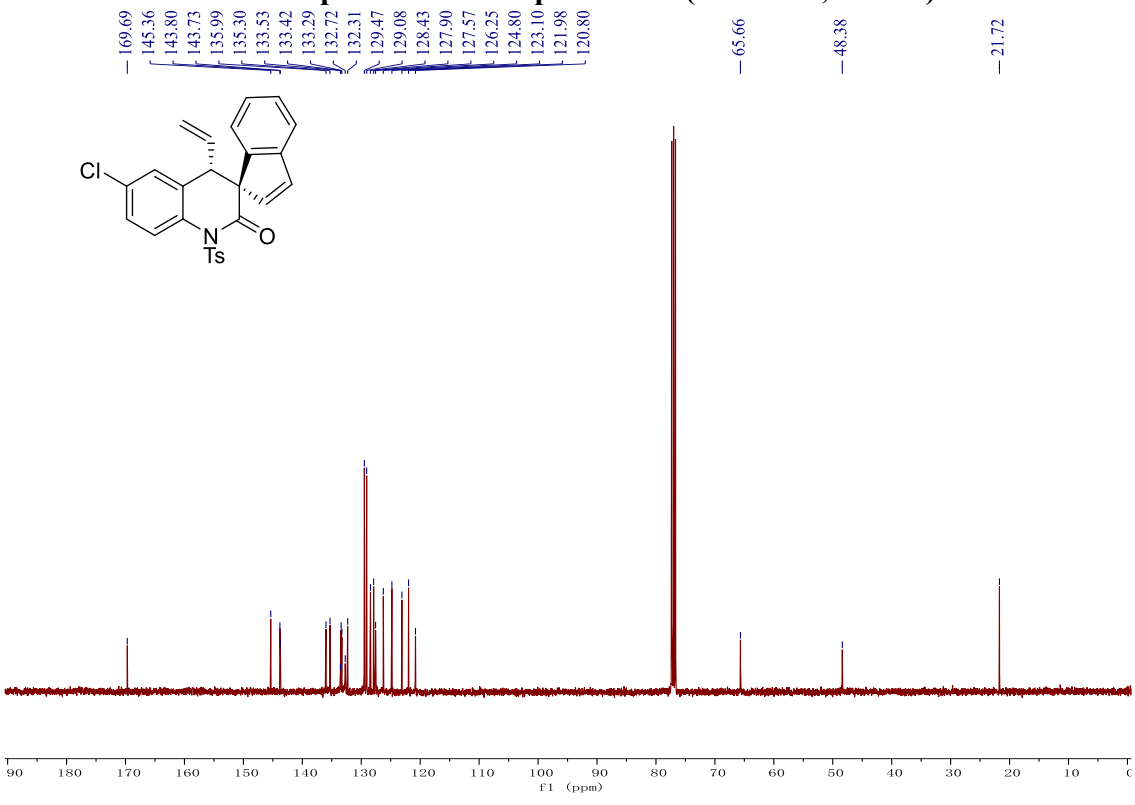


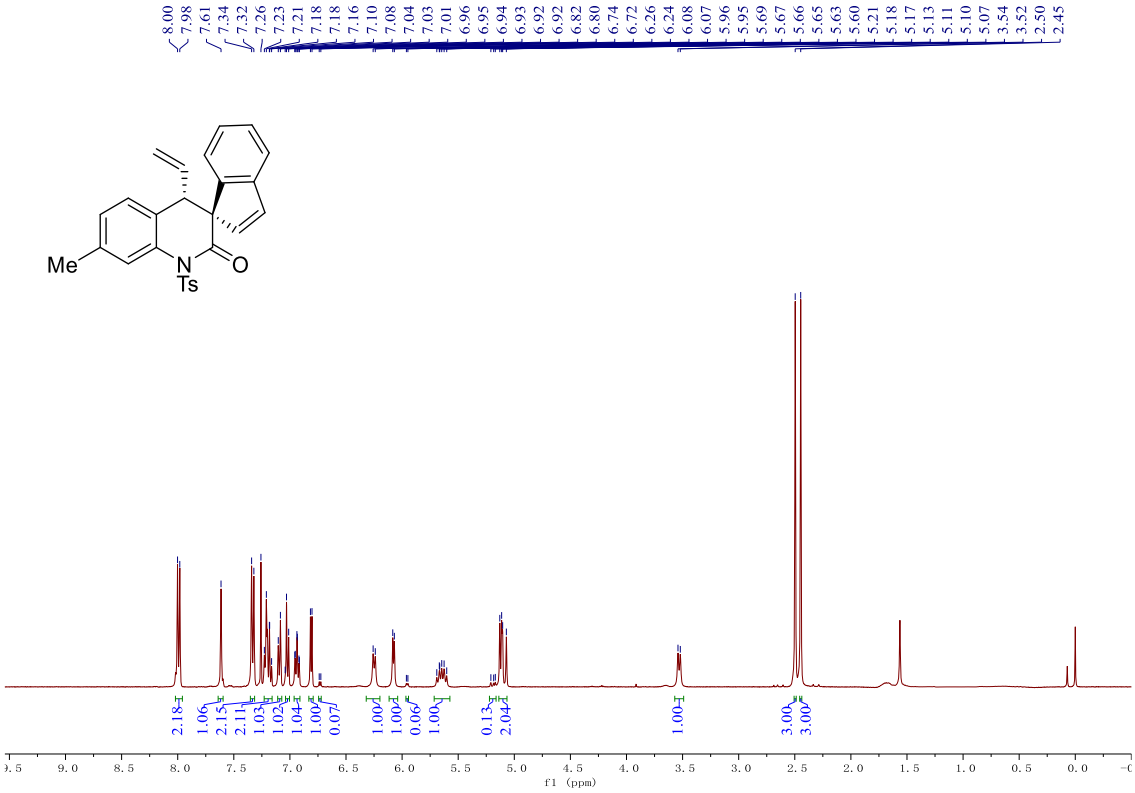
^{1}H NMR spectrum of compound 3ac (400 MHz, $CDCl_3$)



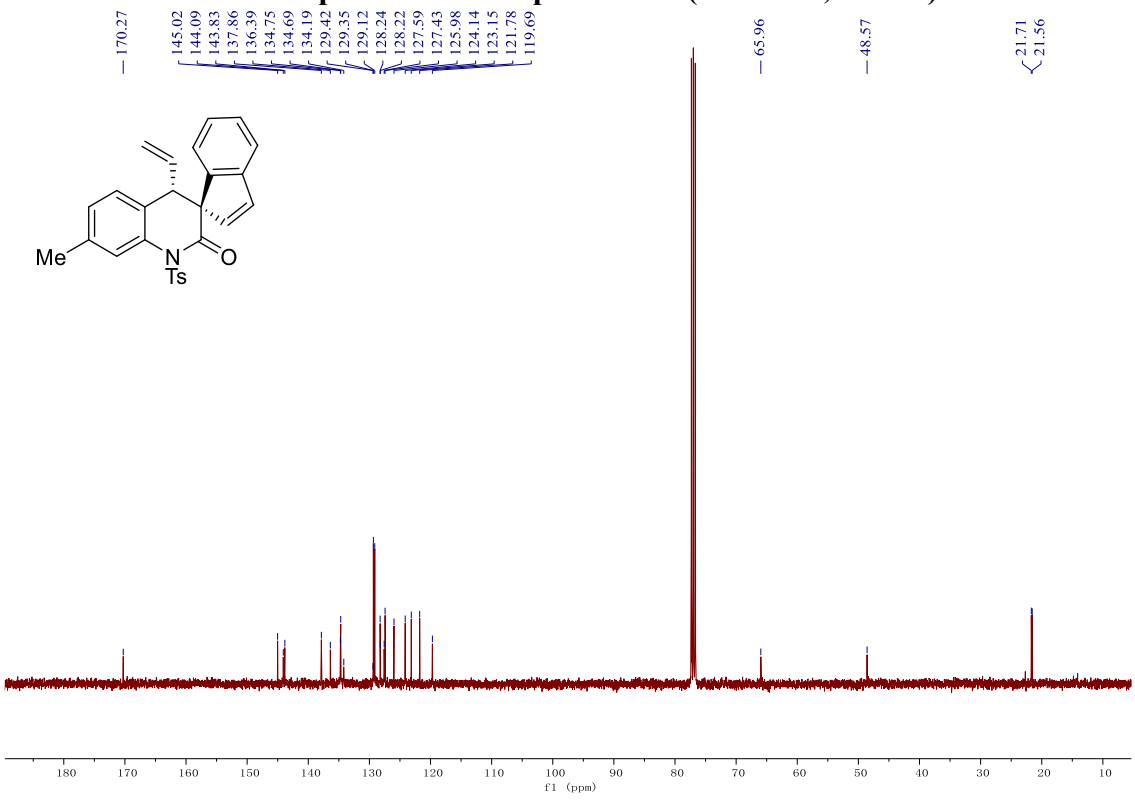
^{13}C NMR spectrum of compound 3ac (100 MHz, $CDCl_3$)



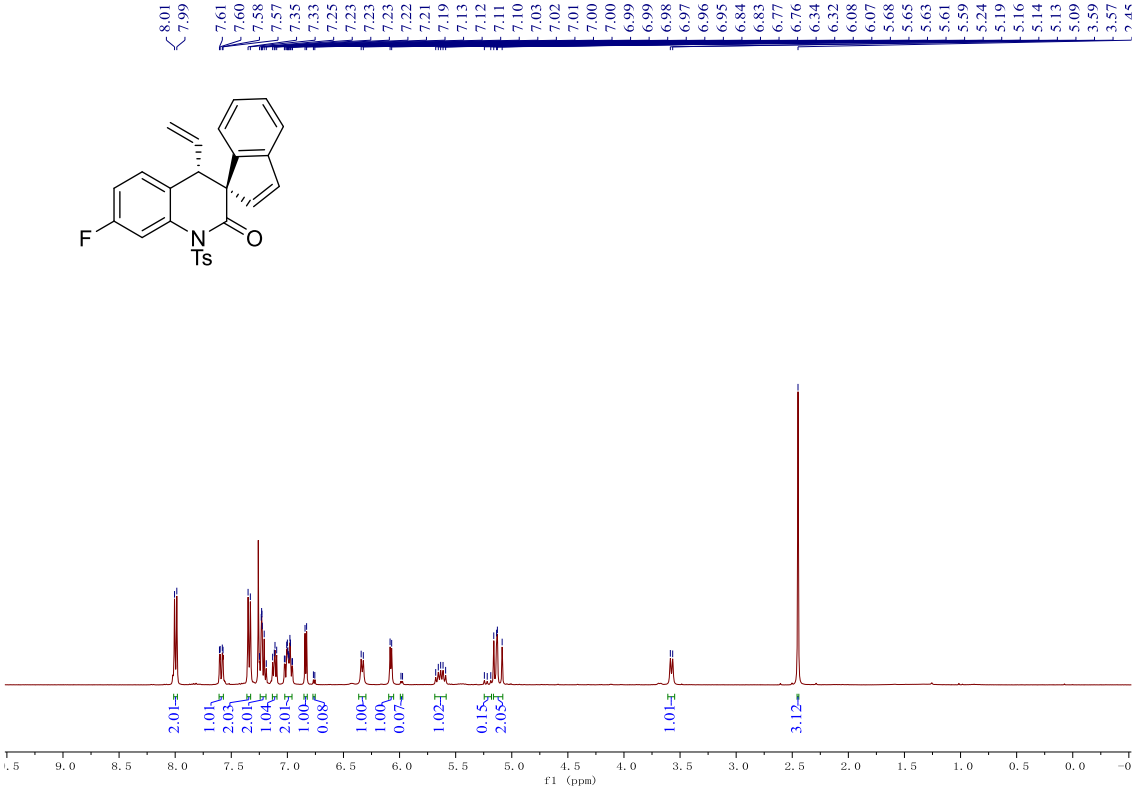
^{1}H NMR spectrum of compound 3ad (400 MHz, $CDCl_3$)



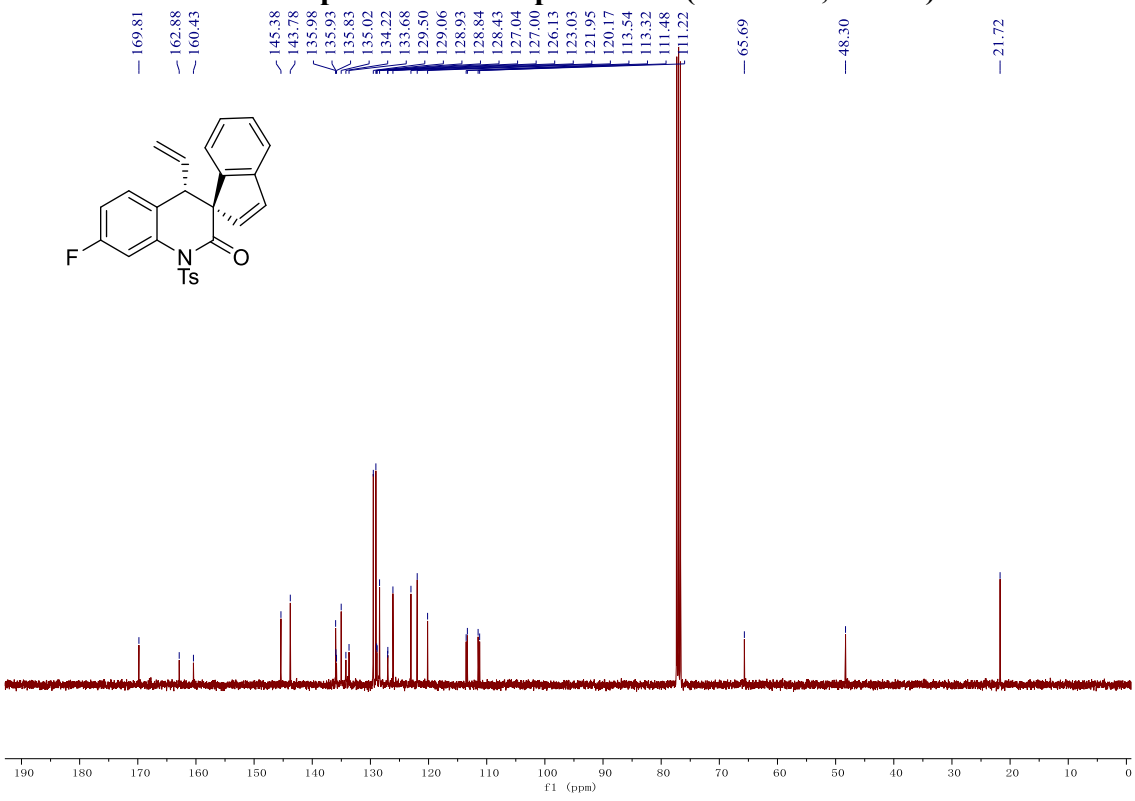
^{13}C NMR spectrum of compound 3ad (100 MHz, $CDCl_3$)



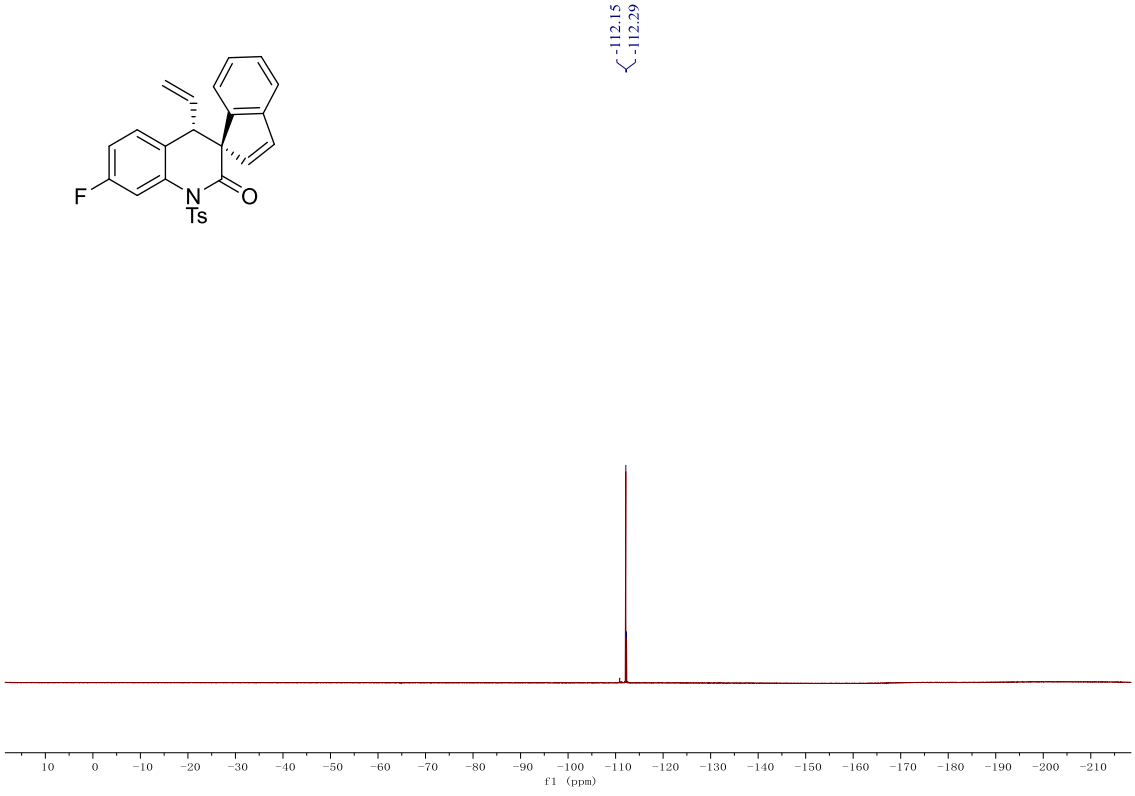
^{1}H NMR spectrum of compound 3ae (400 MHz, $CDCl_3$)



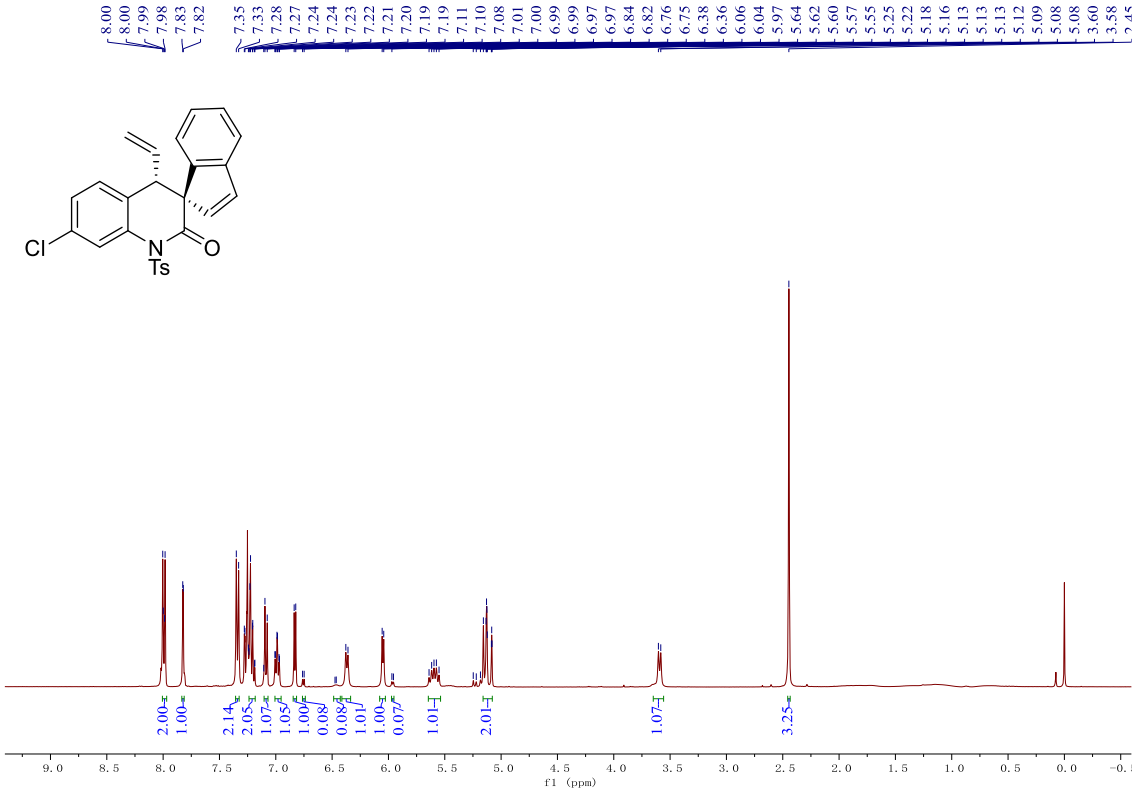
^{13}C NMR spectrum of compound 3ae (100 MHz, $CDCl_3$)



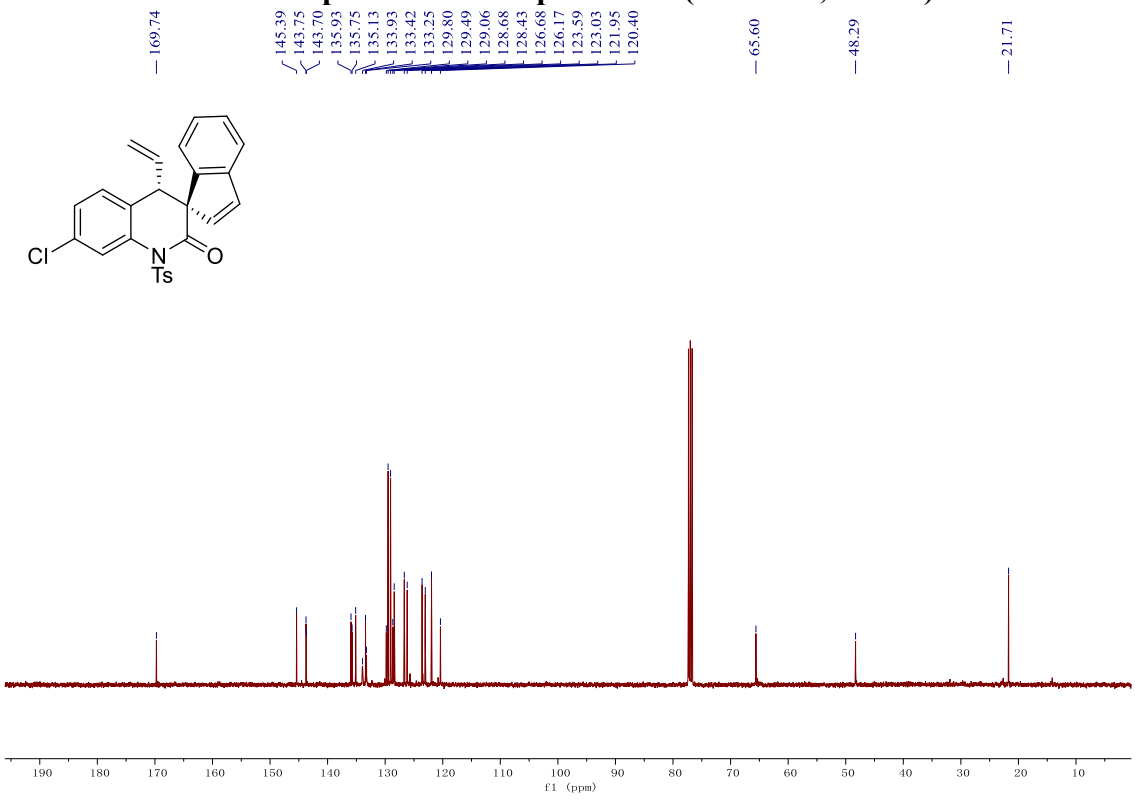
^{19}F NMR spectrum of compound 3ae (376 MHz, $CDCl_3$)



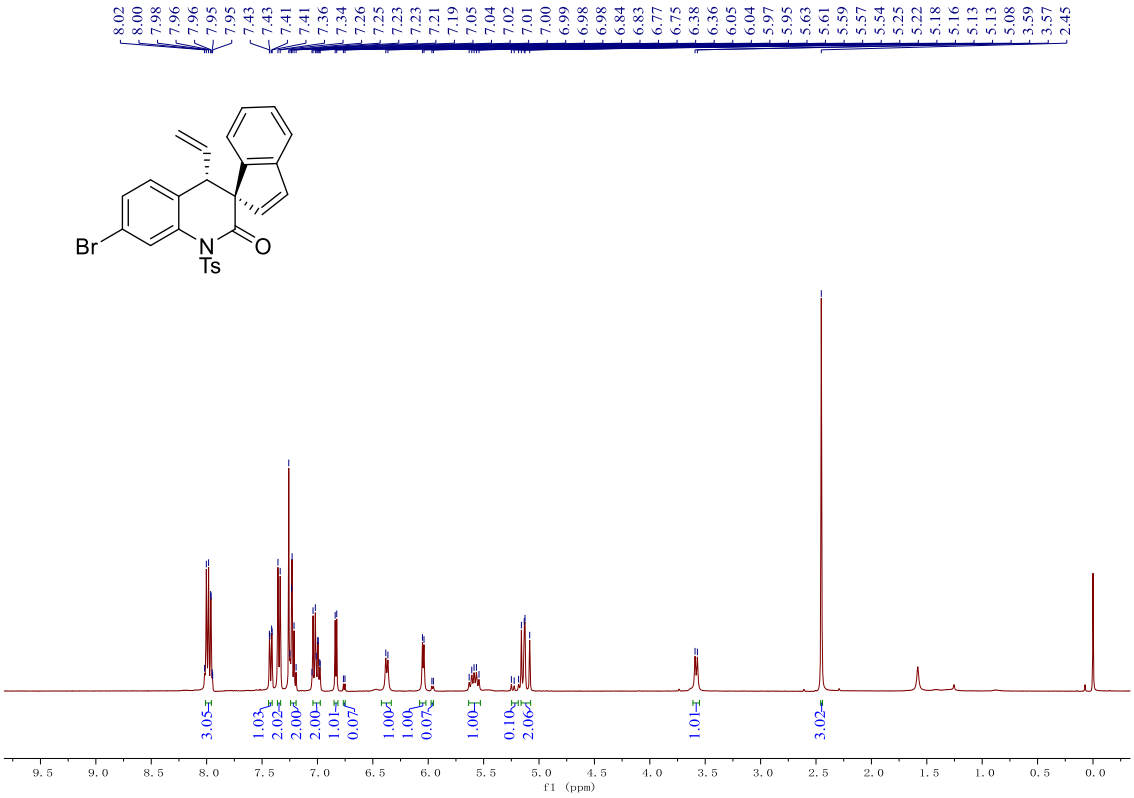
^{1}H NMR spectrum of compound 3af (400 MHz, $CDCl_3$)



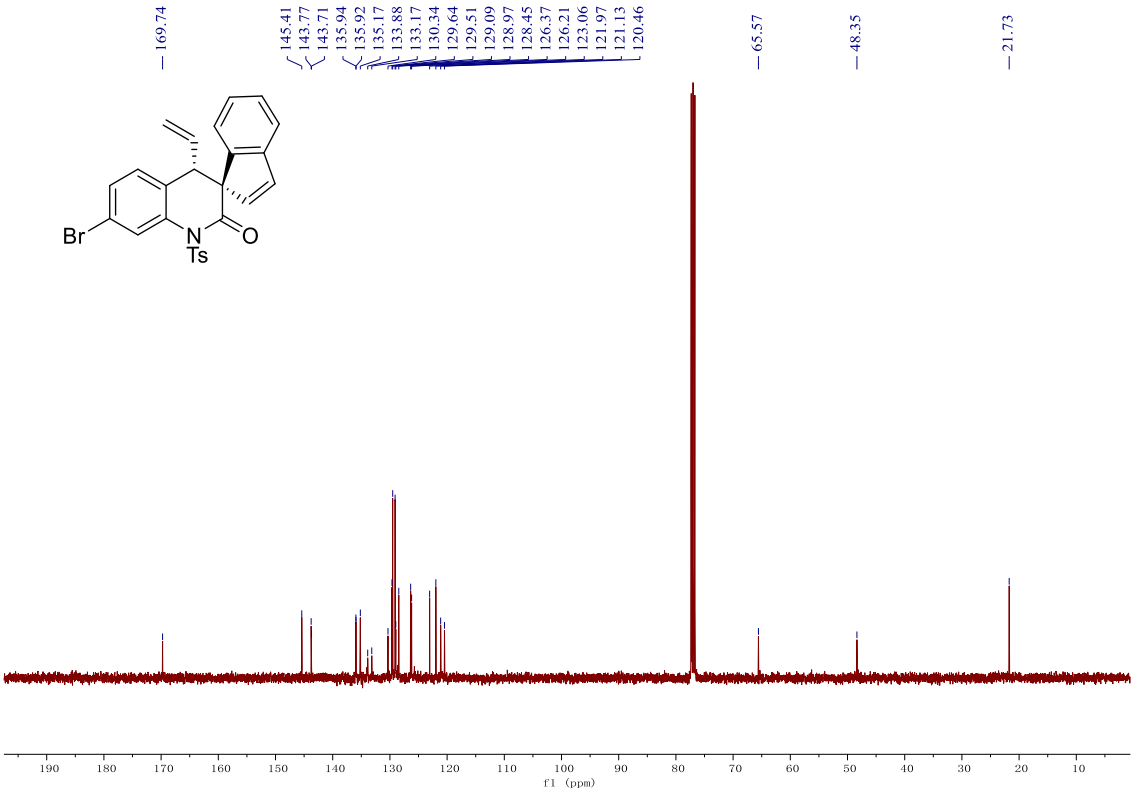
^{13}C NMR spectrum of compound 3af (100 MHz, $CDCl_3$)



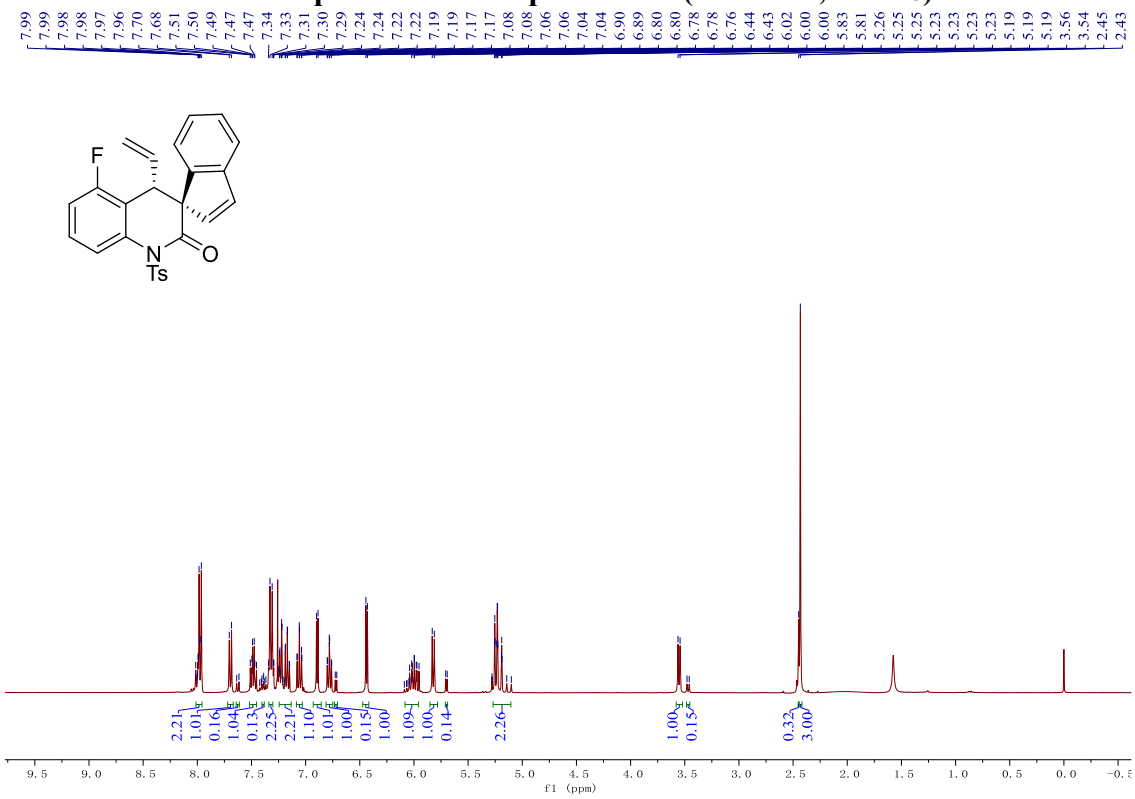
1H NMR spectrum of compound 3ag (400 MHz, CDCl3)



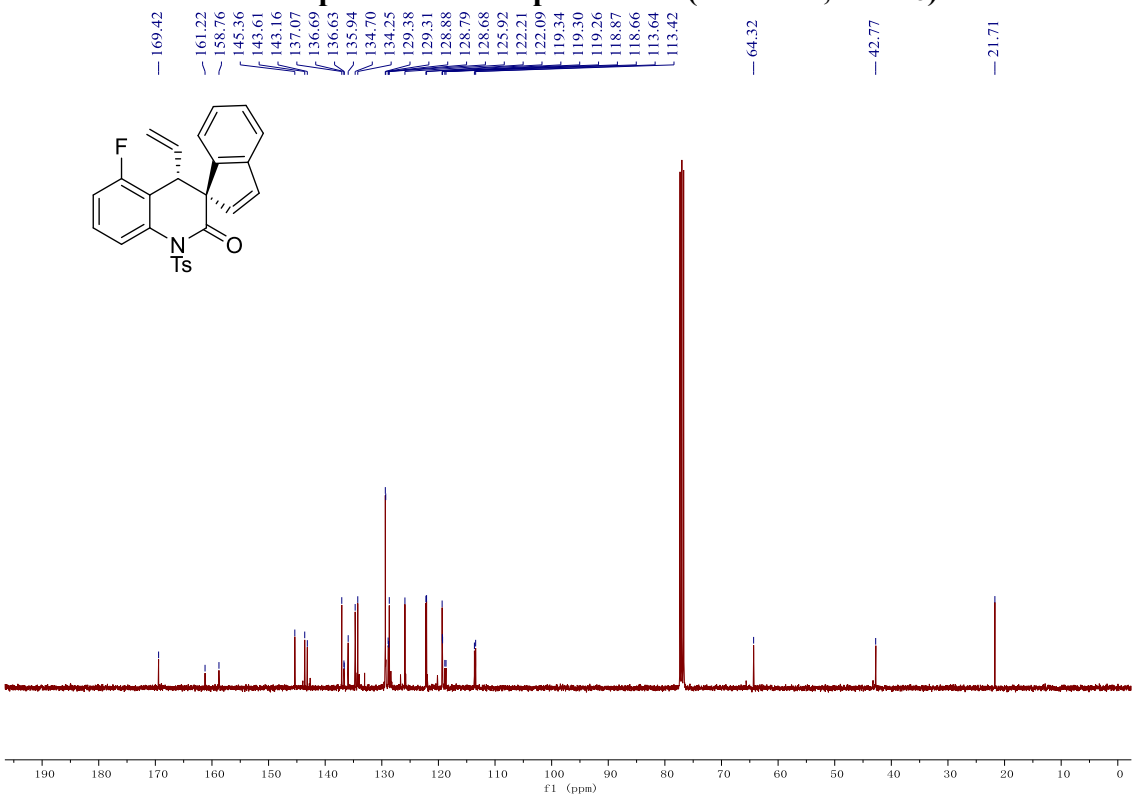
^{13}C NMR spectrum of compound 3ag(100 MHz, $CDCl_3$)



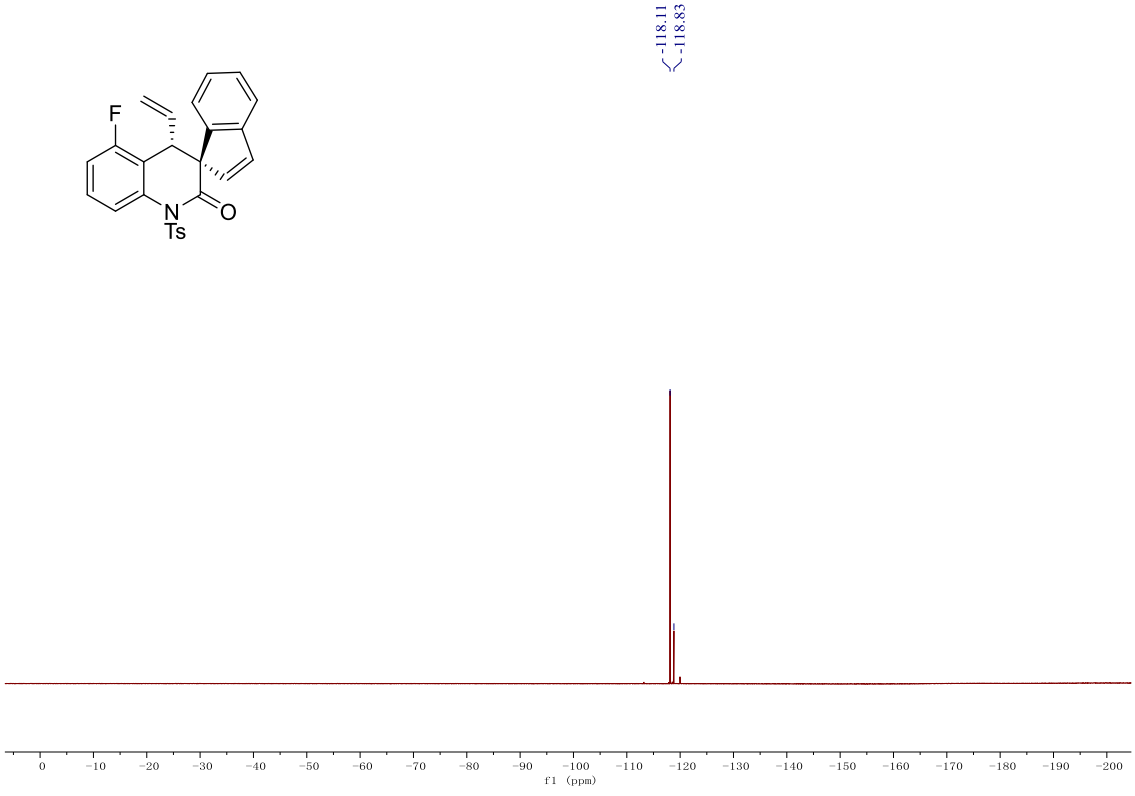
^{1}H NMR spectrum of compound 3ah (400 MHz, $CDCl_3$)



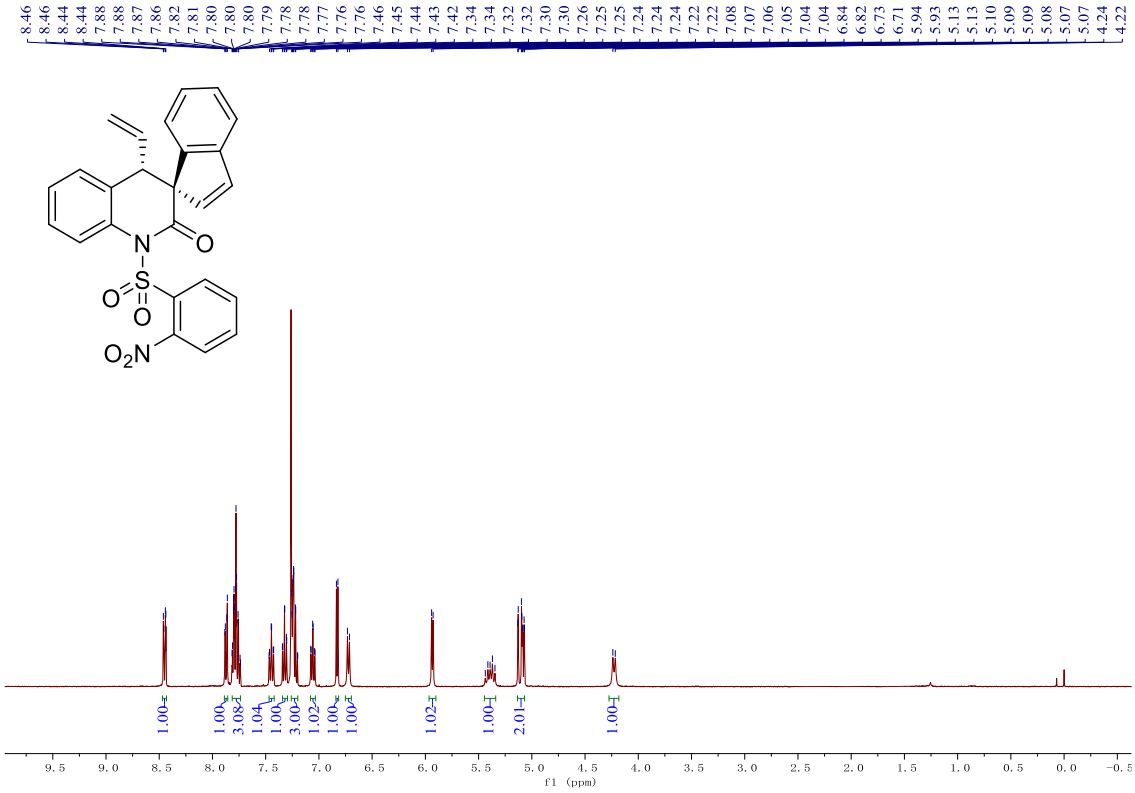
^{13}C NMR spectrum of compound 3ah (100 MHz, $CDCl_3$)



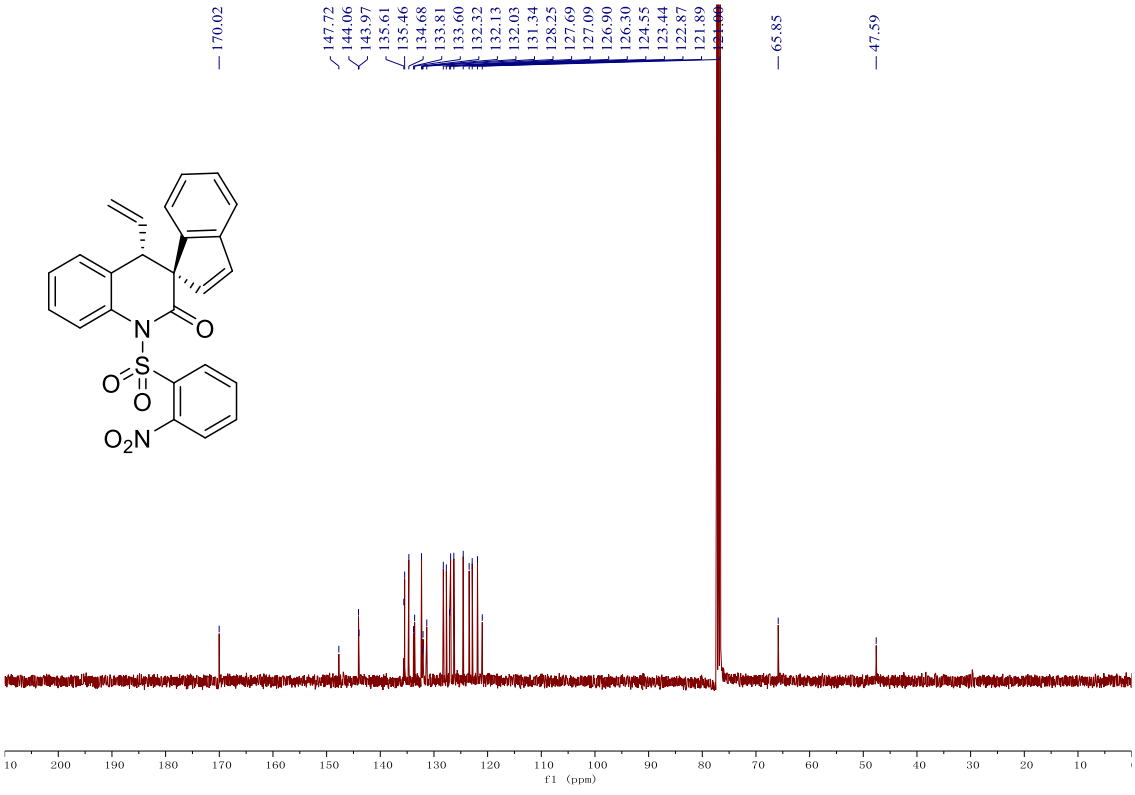
^{19}F NMR spectrum of compound 3ah (376 MHz, $CDCl_3$)



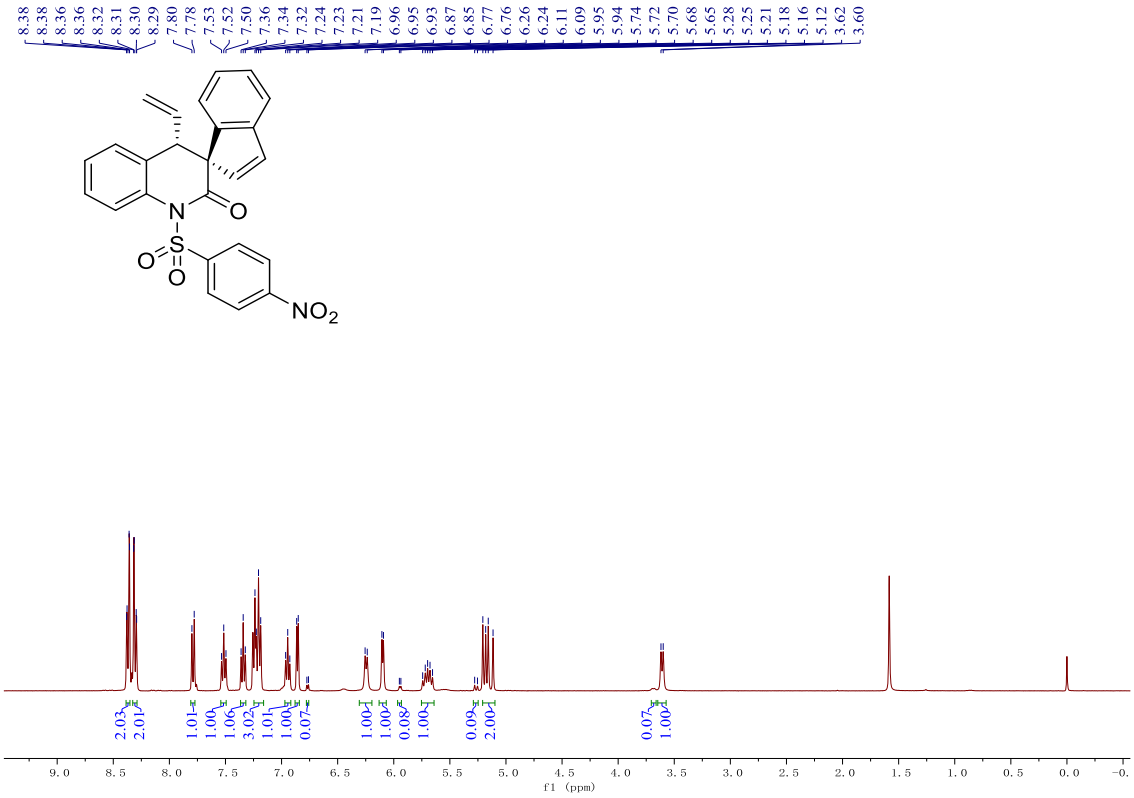
^{1}H NMR spectrum of compound 3ai (400 MHz, $CDCl_3$)



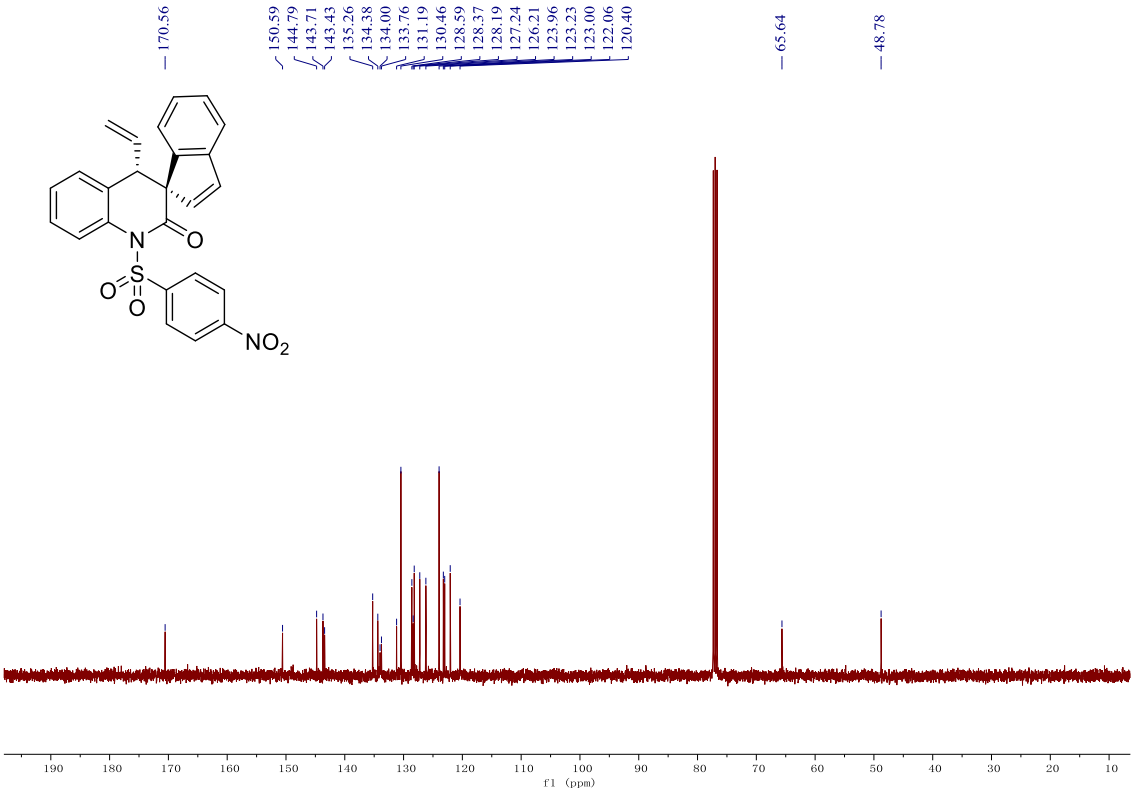
^{13}C NMR spectrum of compound 3ai (100 MHz, $CDCl_3$)



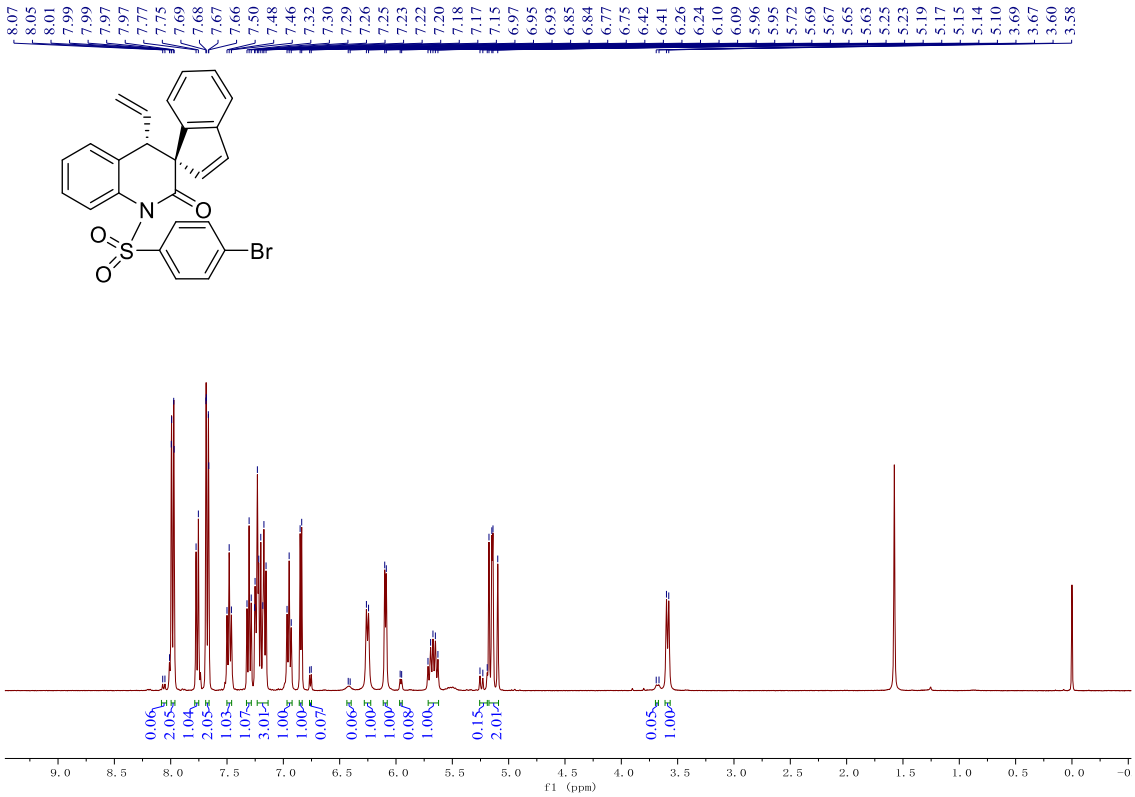
^{1}H NMR spectrum of compound 3aj (400 MHz, $CDCl_3$)



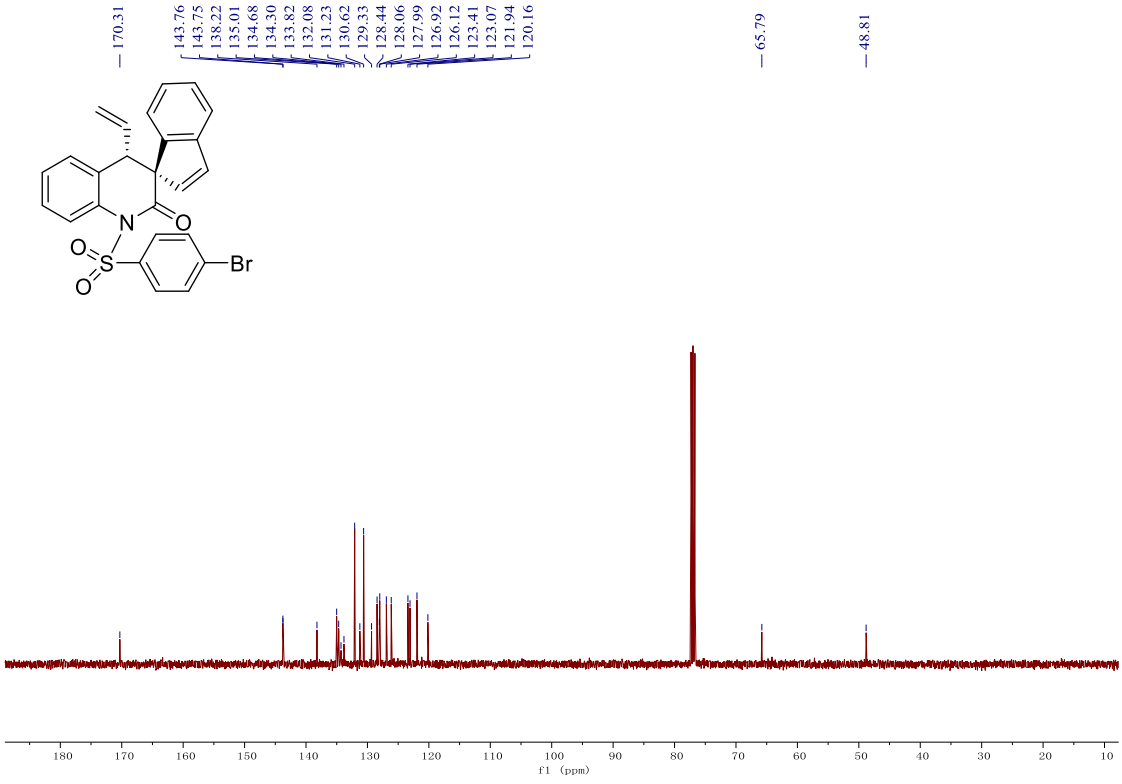
^{13}C NMR spectrum of compound 3aj (100 MHz, $CDCl_3$)



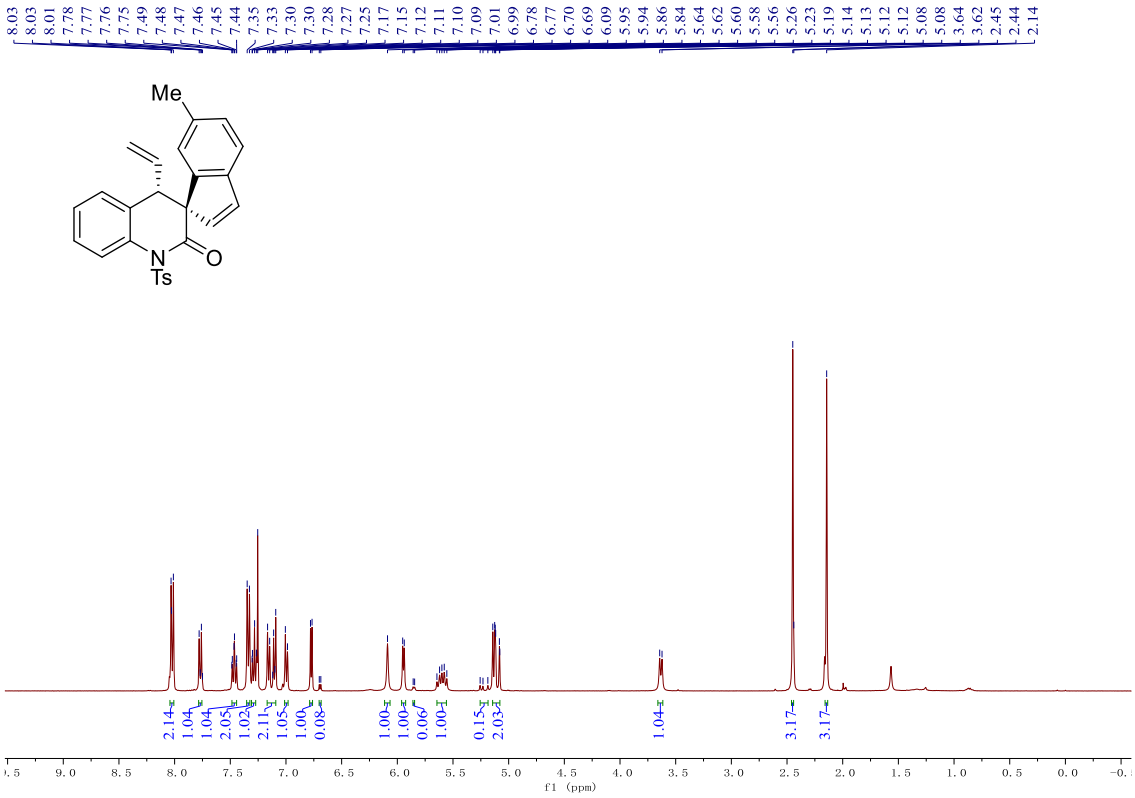
^{1}H NMR spectrum of compound 3ak (400 MHz, $CDCl_3$)



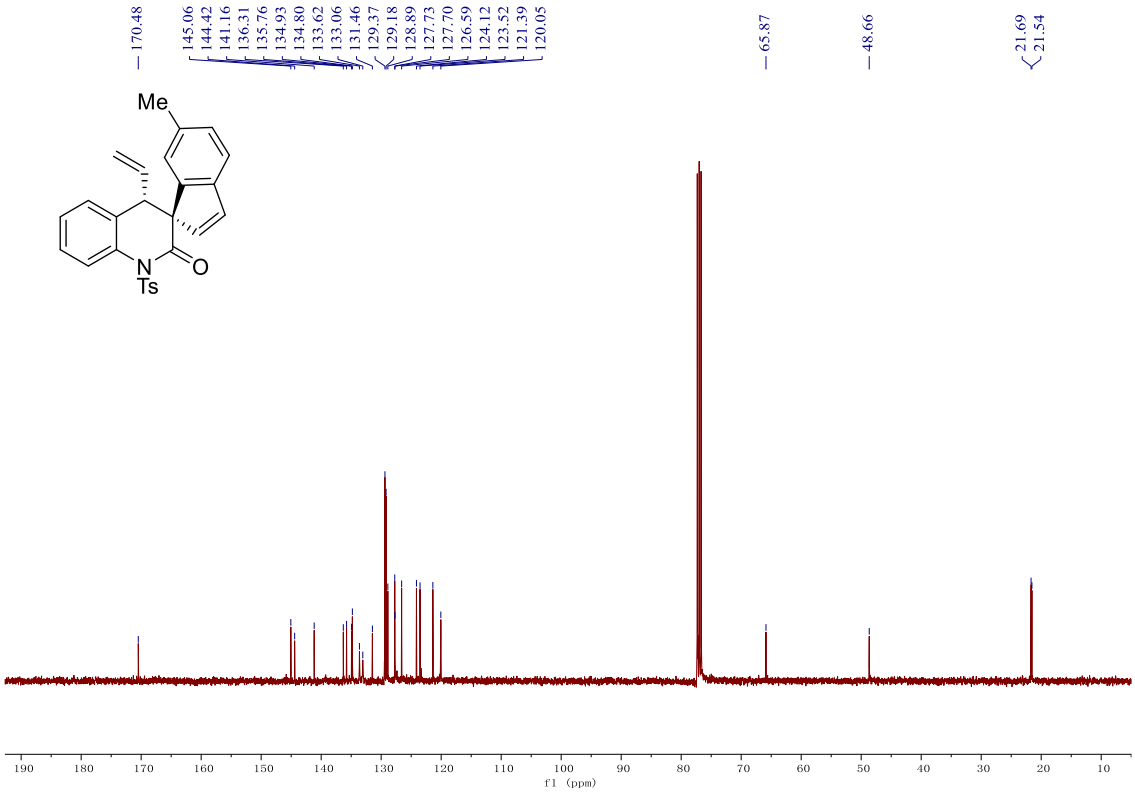
^{13}C NMR spectrum of compound 3ak (100 MHz, $CDCl_3$)



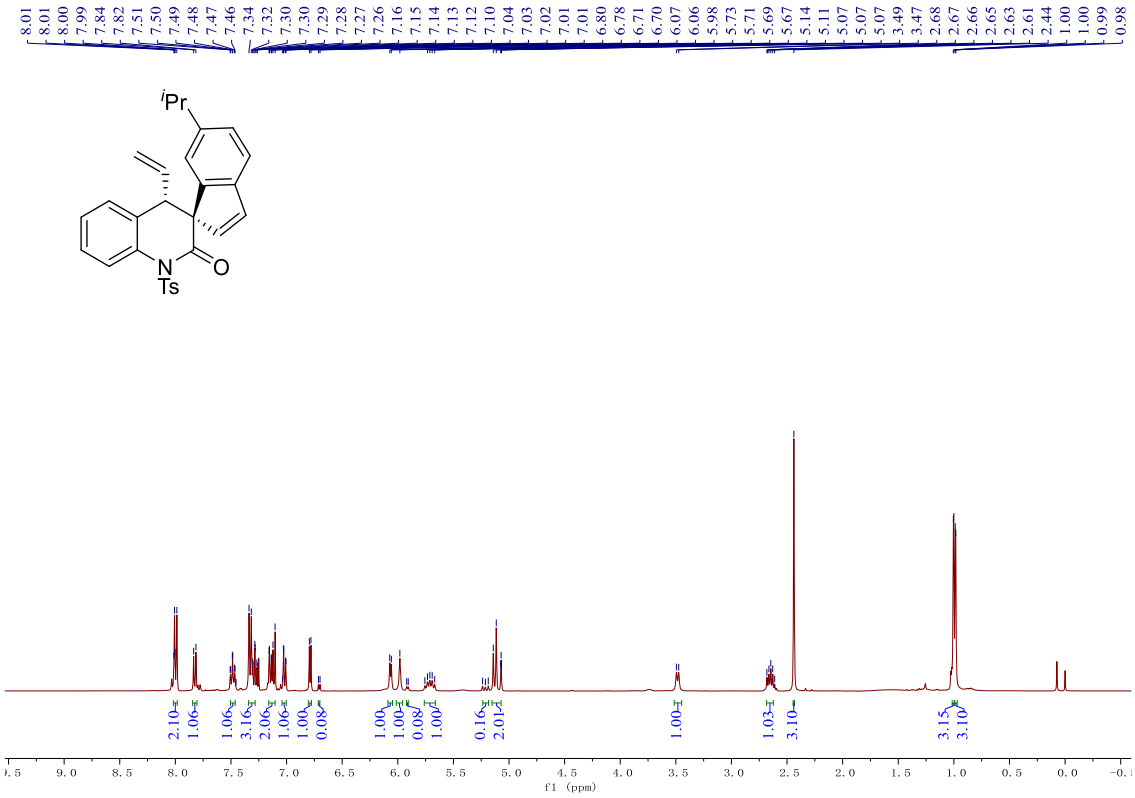
^{1}H NMR spectrum of compound 3ba (400 MHz, $CDCl_3$)



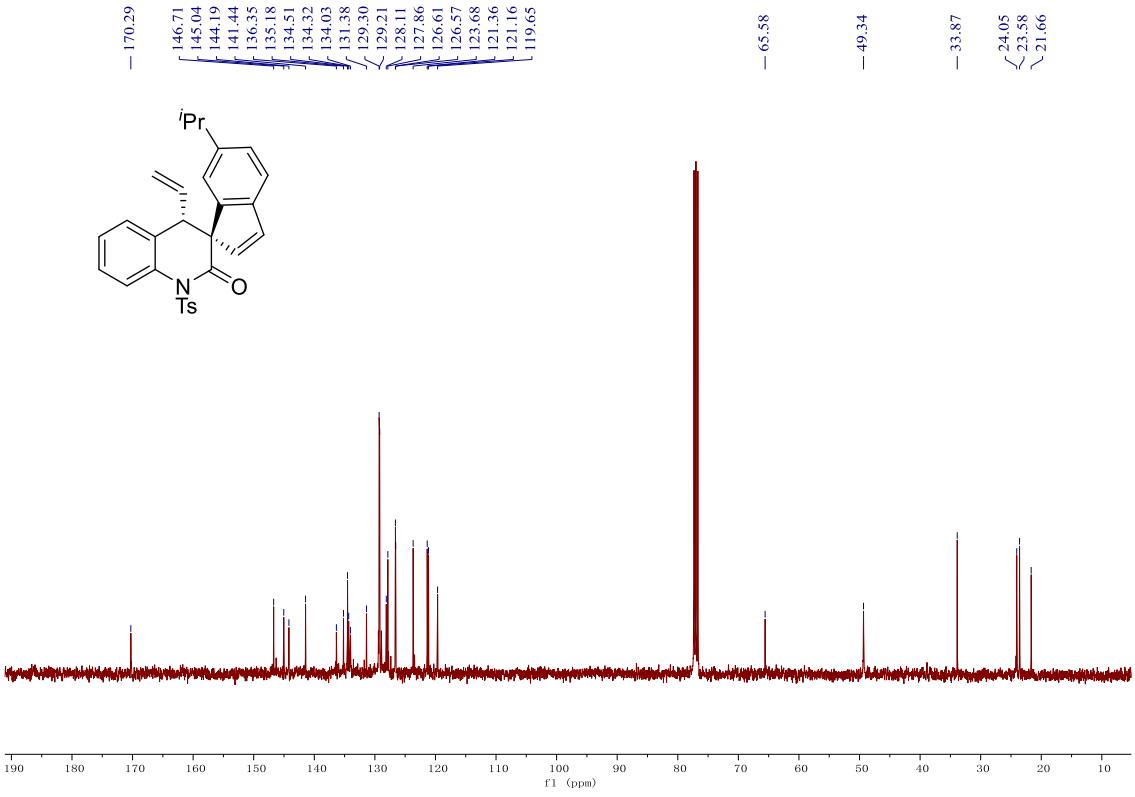
^{13}C NMR spectrum of compound 3ba (100 MHz, $CDCl_3$)



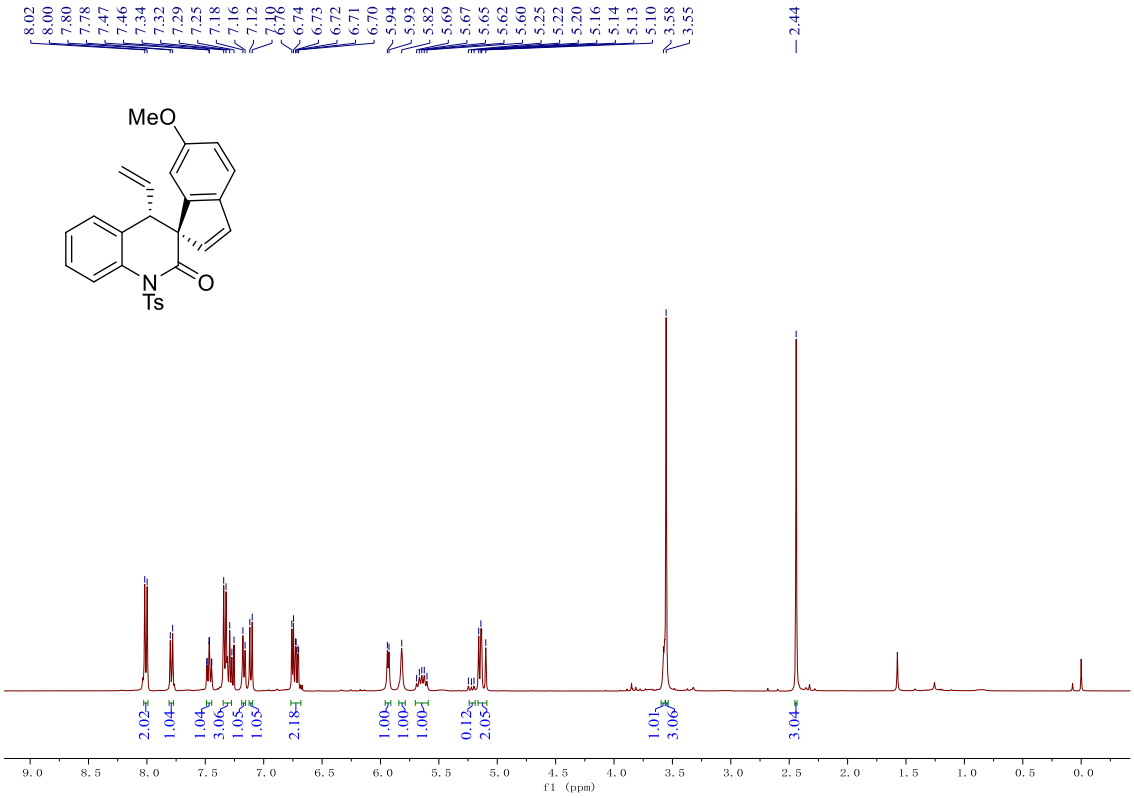
^{1}H NMR spectrum of compound 3ca (400 MHz, $CDCl_3$)



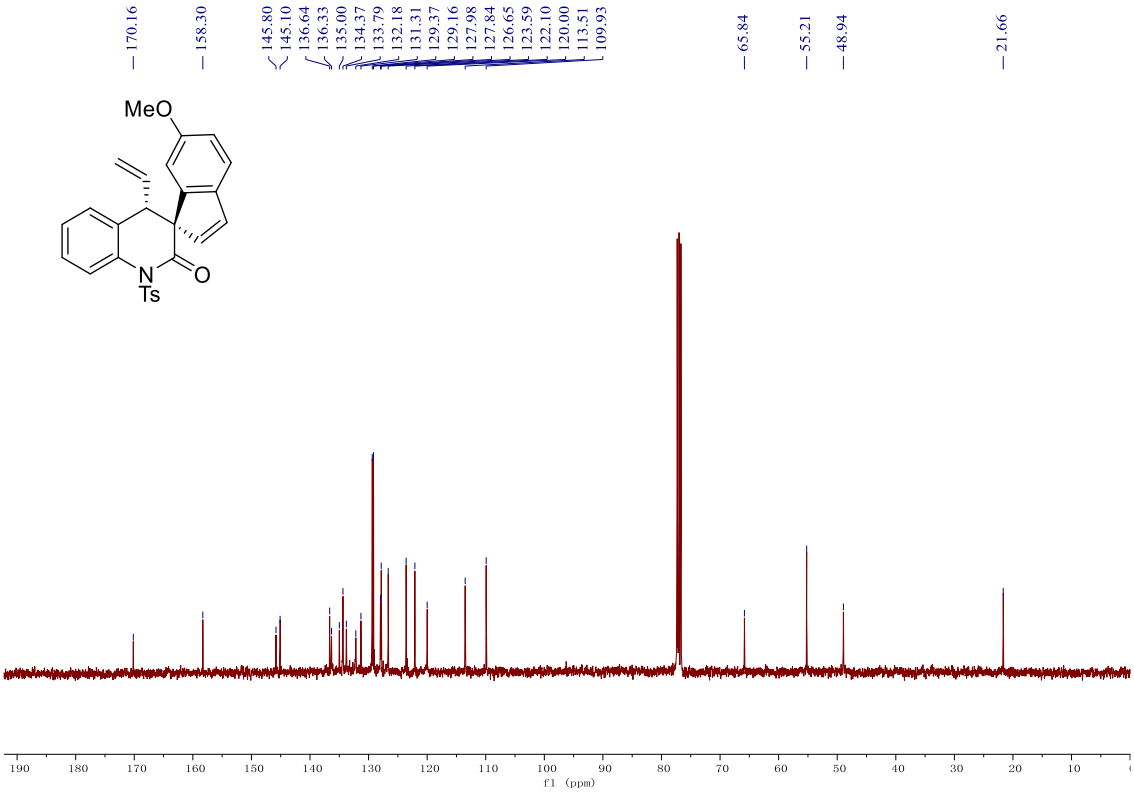
^{13}C NMR spectrum of compound 3ca (100 MHz, $CDCl_3$)



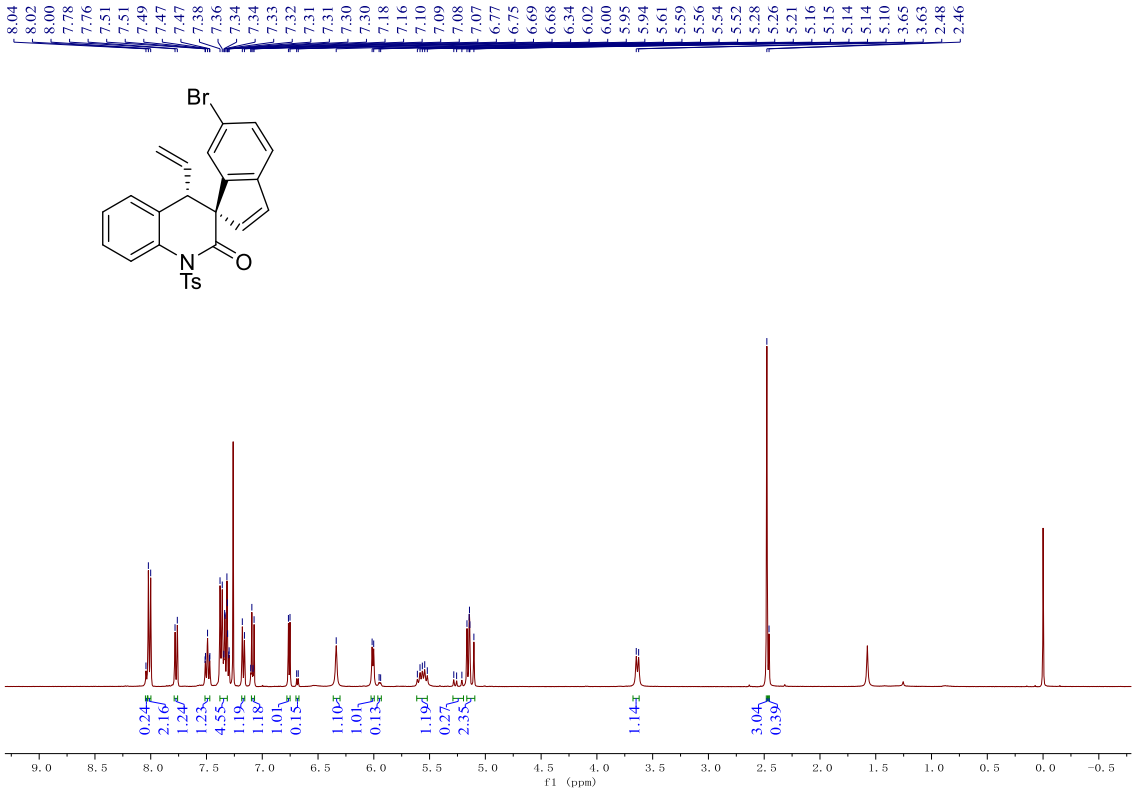
^{1}H NMR spectrum of compound 3da (400 MHz, $CDCl_3$)



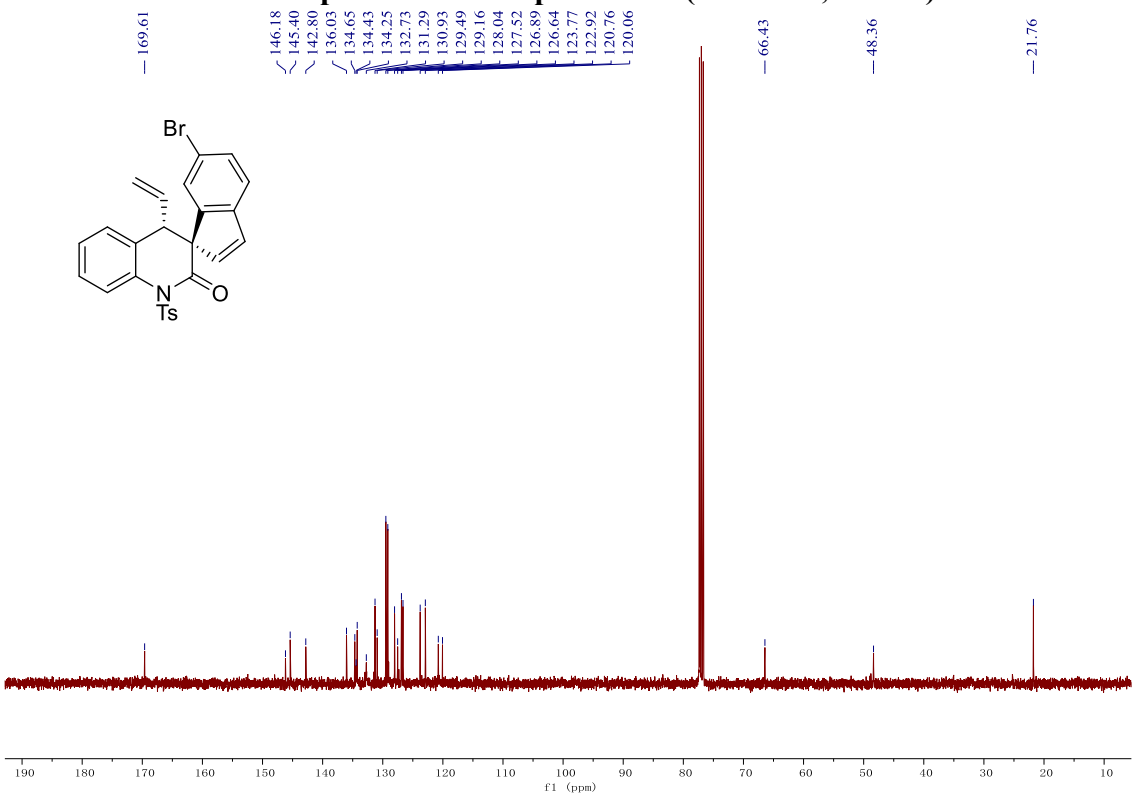
^{13}C NMR spectrum of compound 3da (100 MHz, $CDCl_3$)



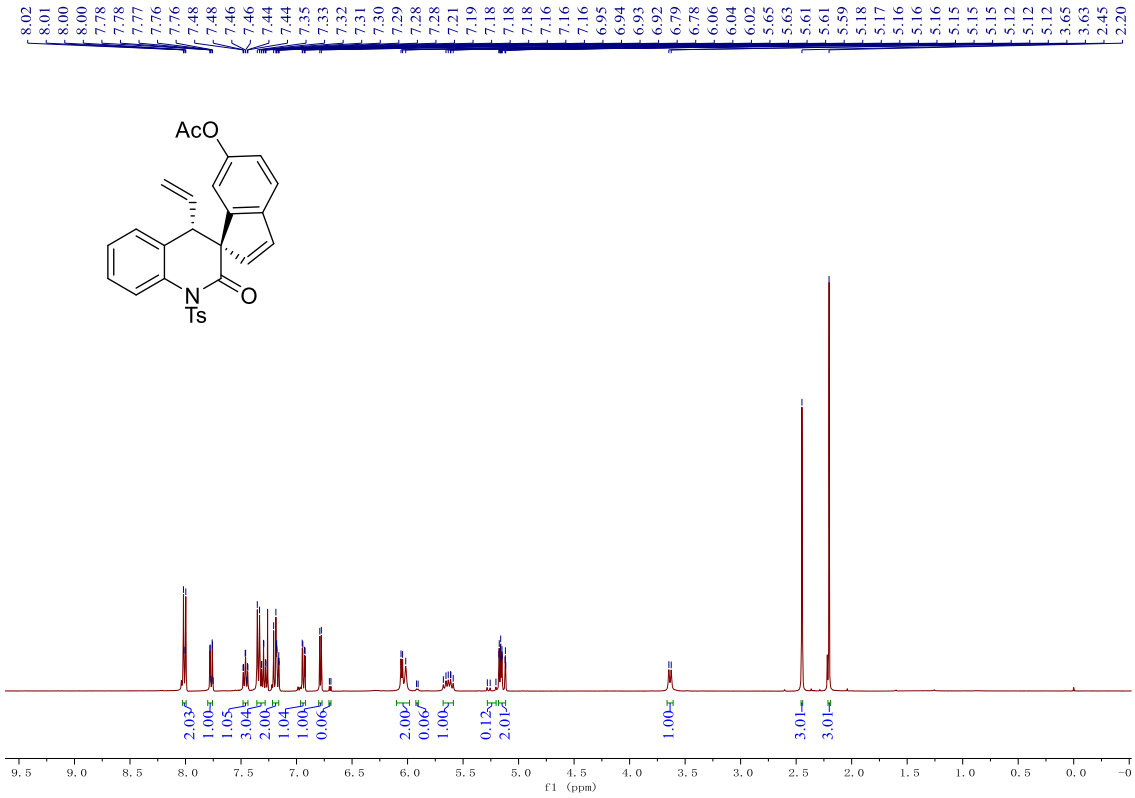
^{1}H NMR spectrum of compound 3ea (400 MHz, $CDCl_3$)



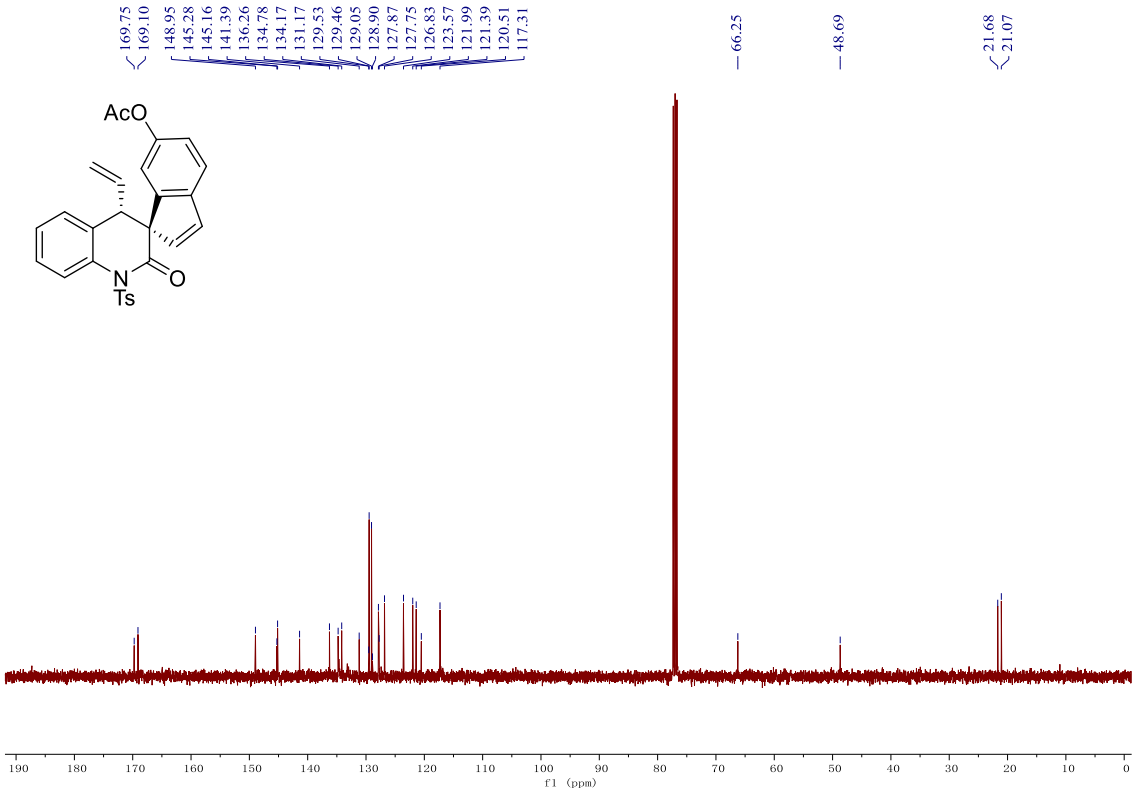
^{13}C NMR spectrum of compound 3ea (100 MHz, $CDCl_3$)



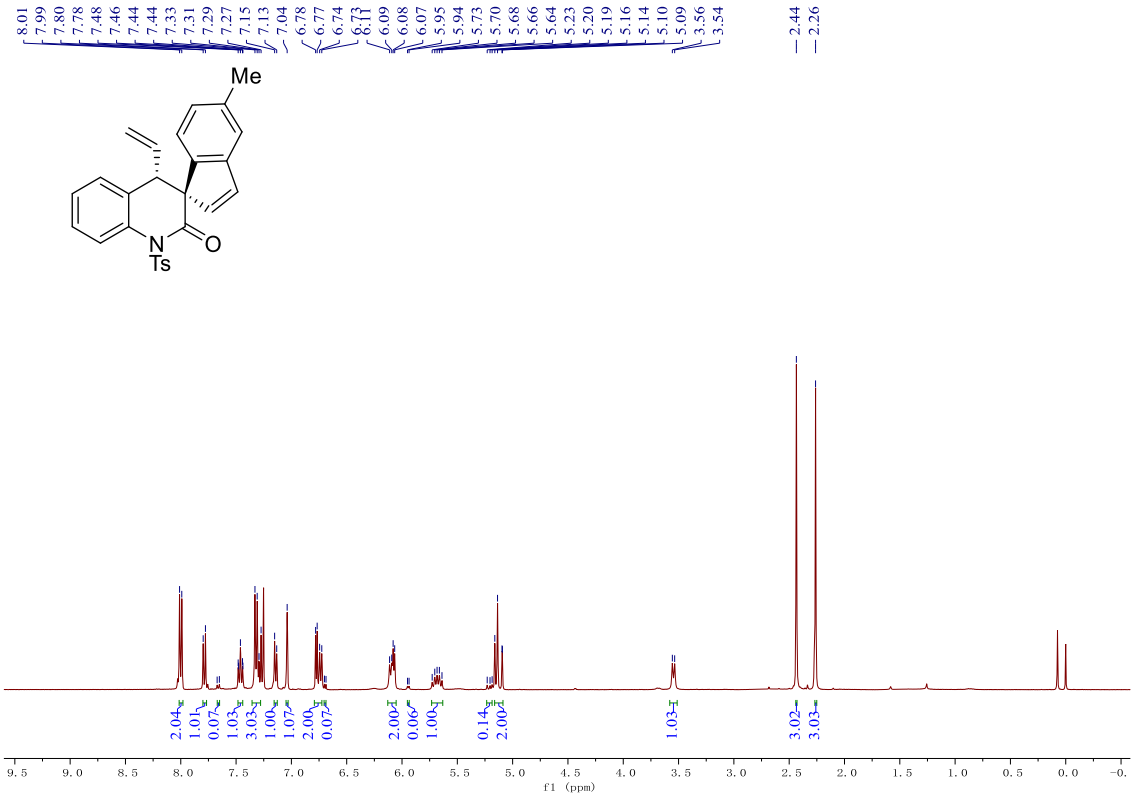
^{1}H NMR spectrum of compound 3fa (400 MHz, $CDCl_3$)



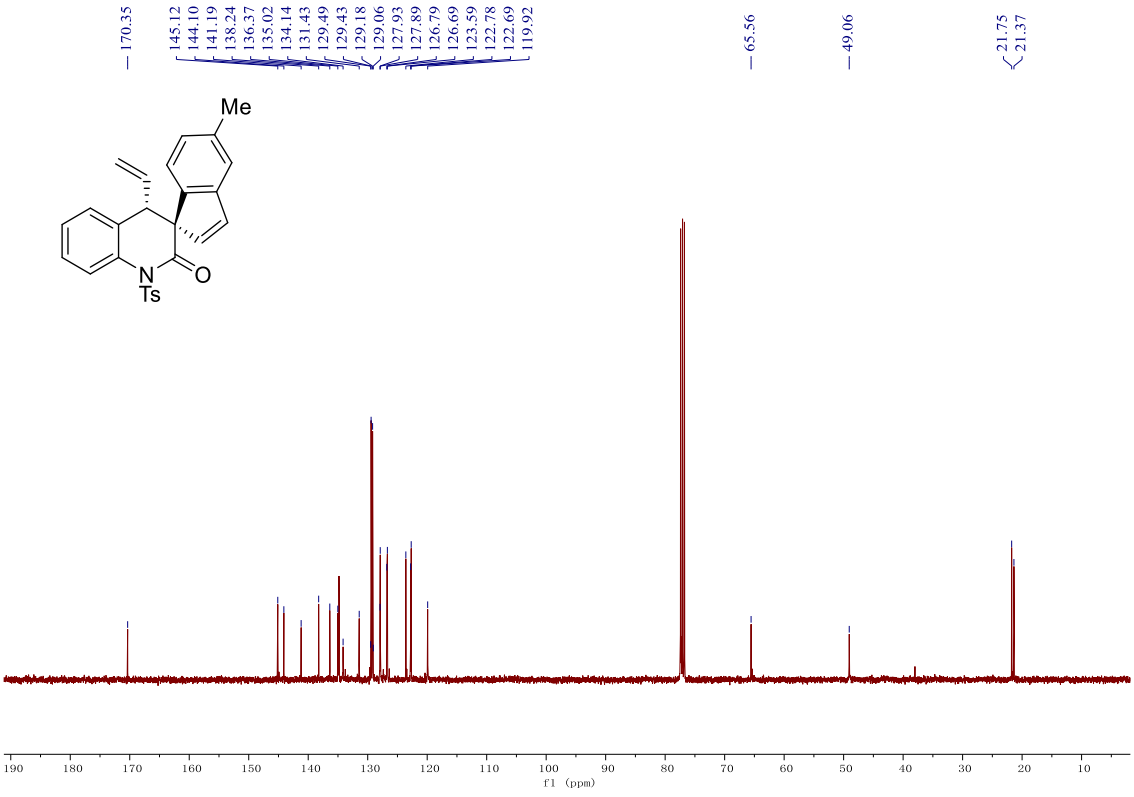
^{13}C NMR spectrum of compound 3fa (100 MHz, $CDCl_3$)



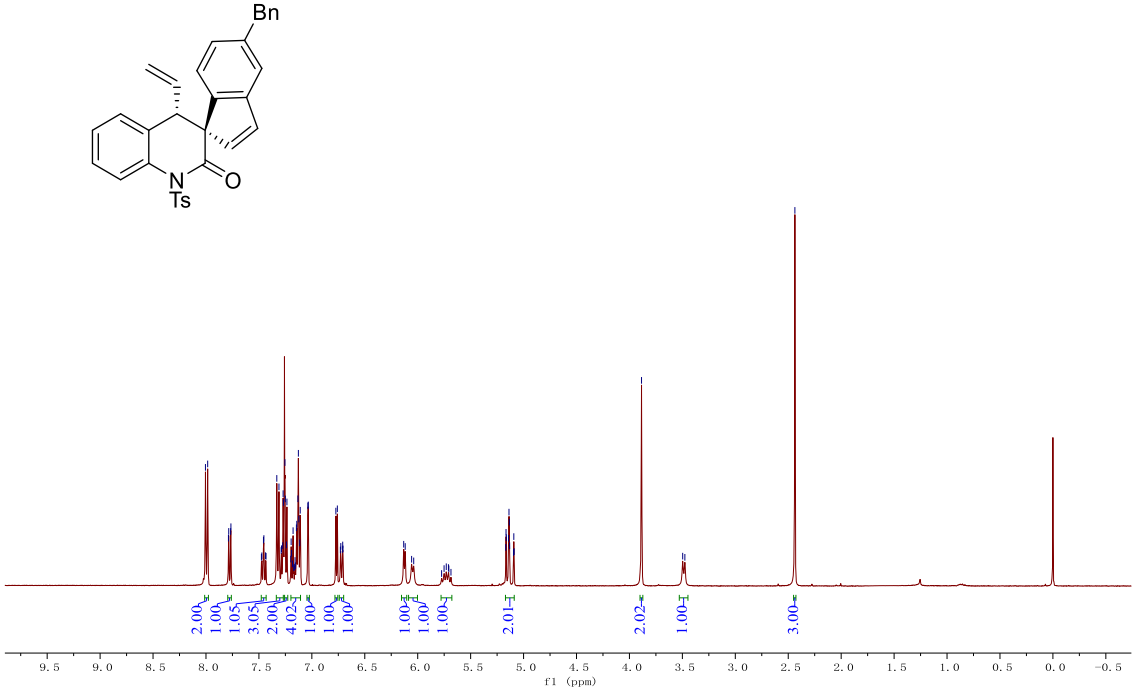
^{1}H NMR spectrum of compound 3ga (400 MHz, $CDCl_3$)



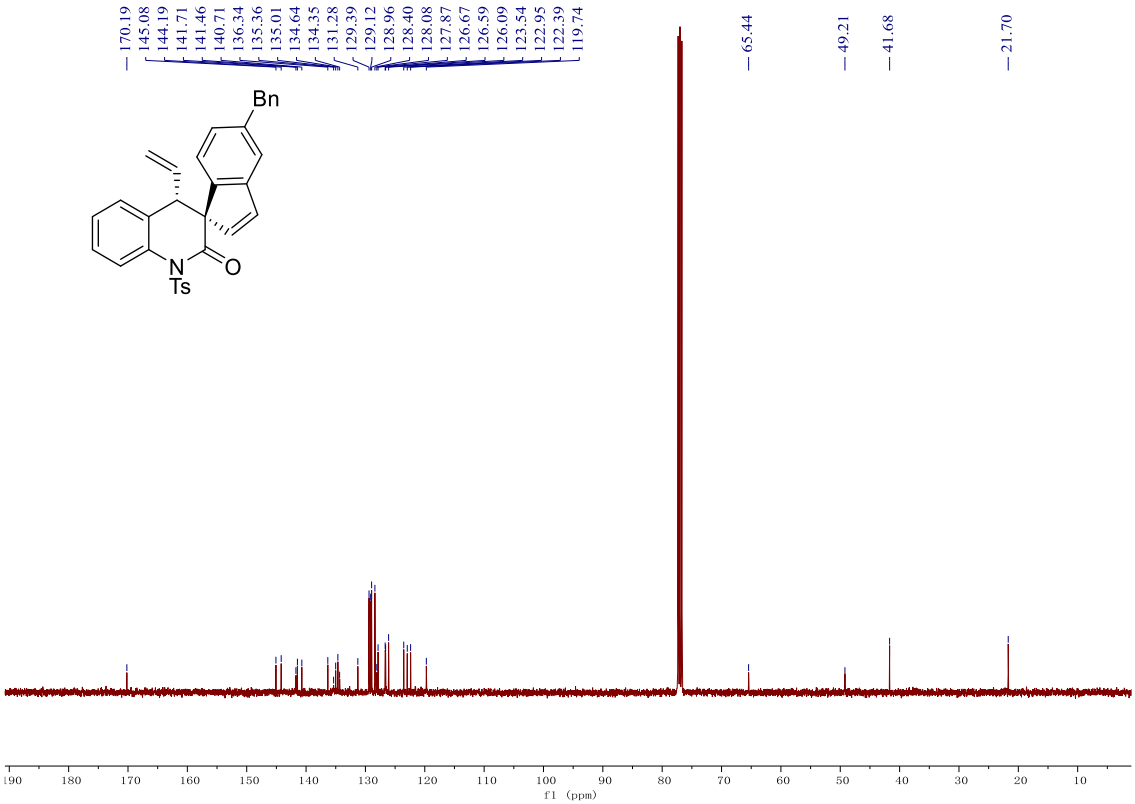
^{13}C NMR spectrum of compound 3ga (100 MHz, $CDCl_3$)



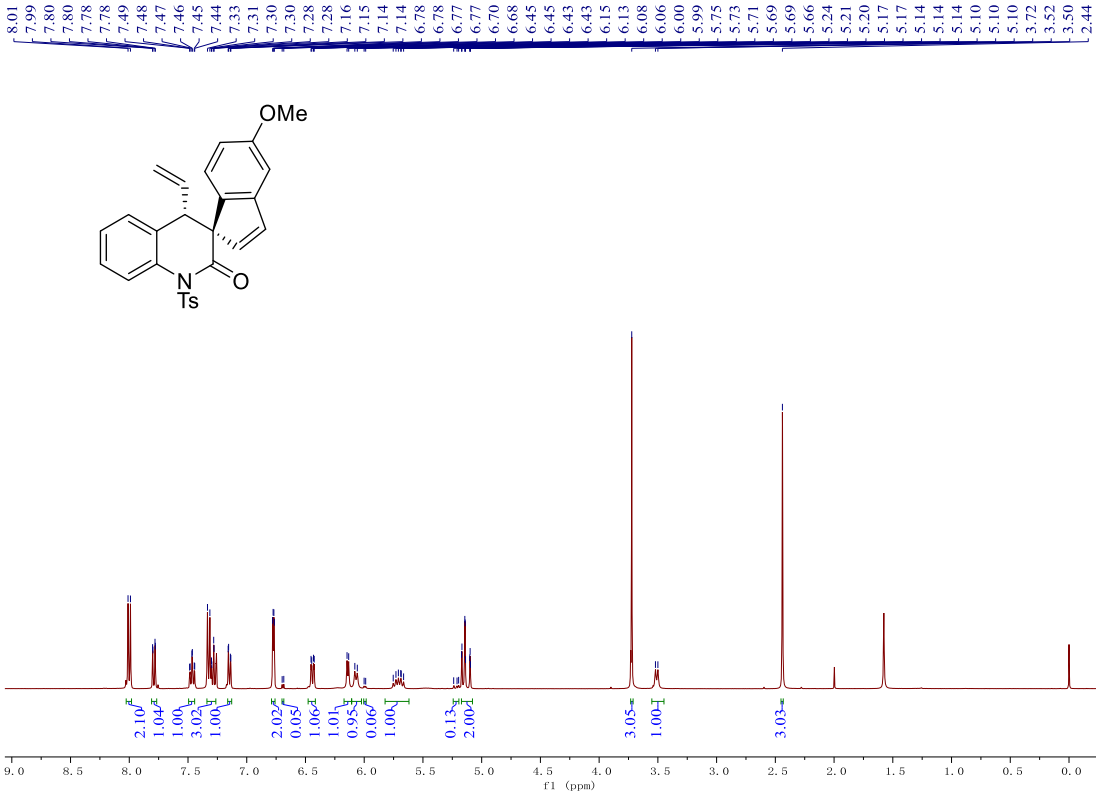
^{1}H NMR spectrum of compound 3ha (400 MHz, $CDCl_3$)



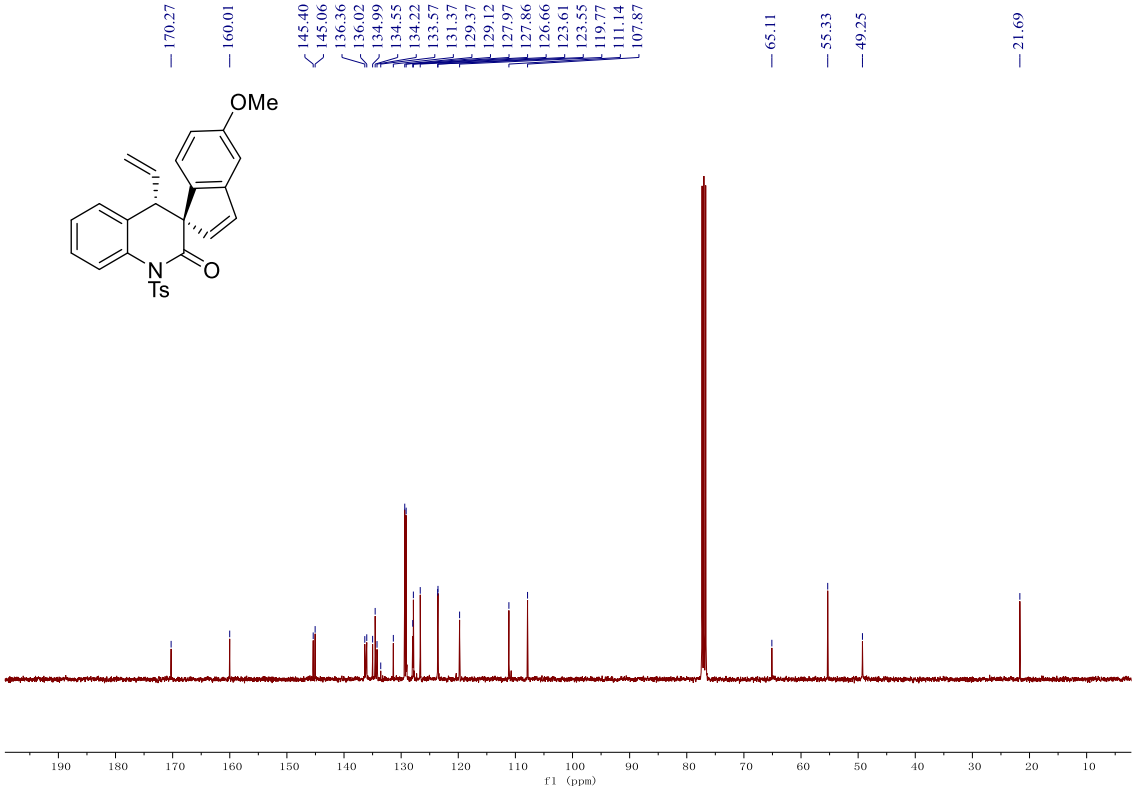
^{13}C NMR spectrum of compound 3ma (100 MHz, $CDCl_3$)



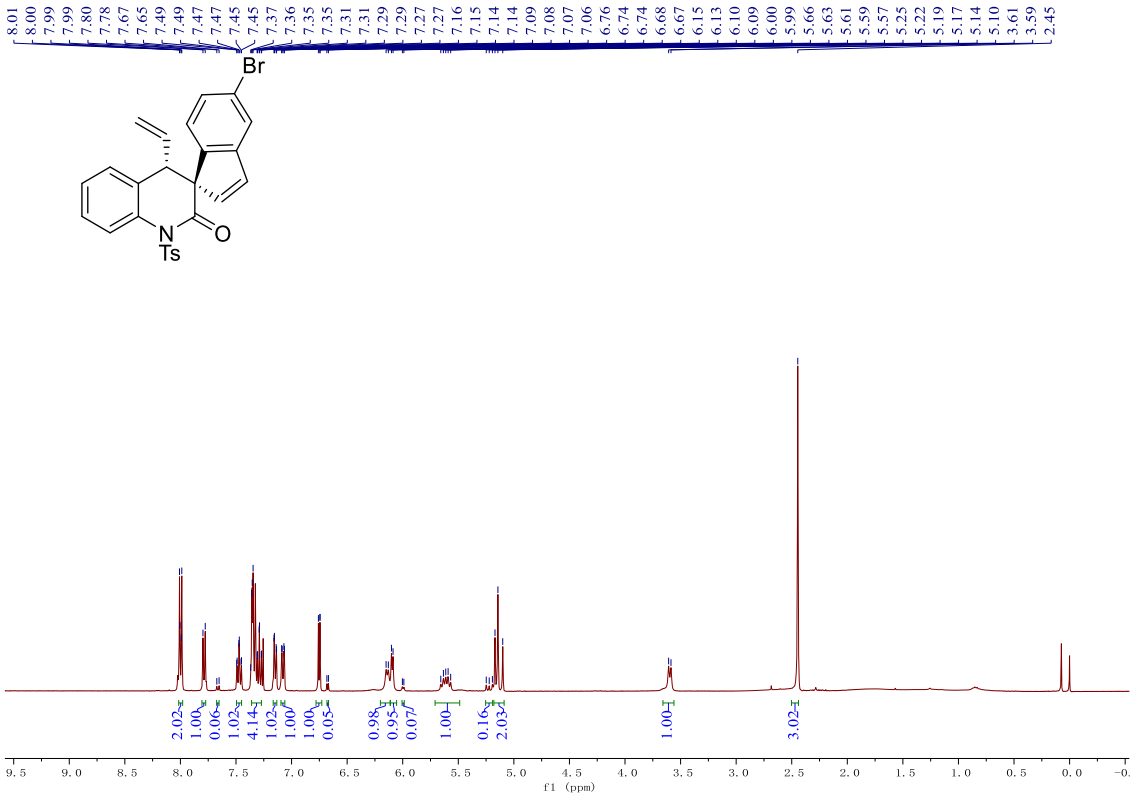
^{1}H NMR spectrum of compound 3ia (400 MHz, $CDCl_3$)



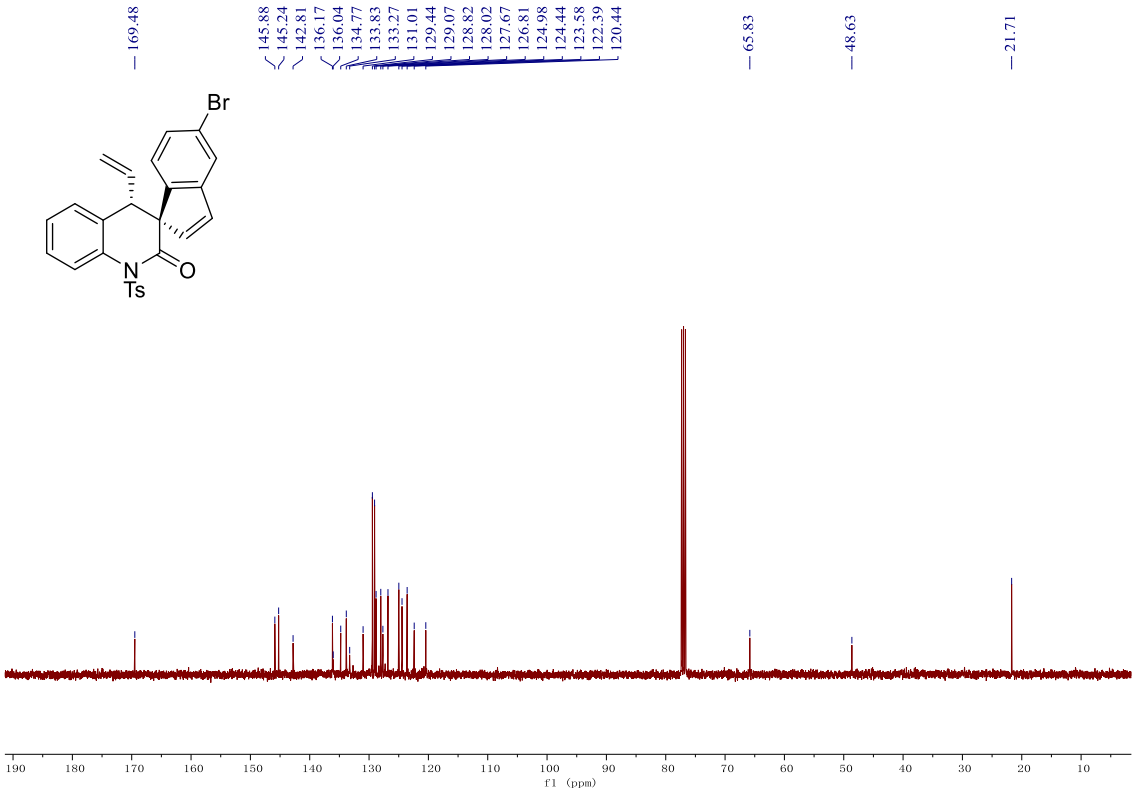
^{13}C NMR spectrum of compound 3ia (100 MHz, $CDCl_3$)



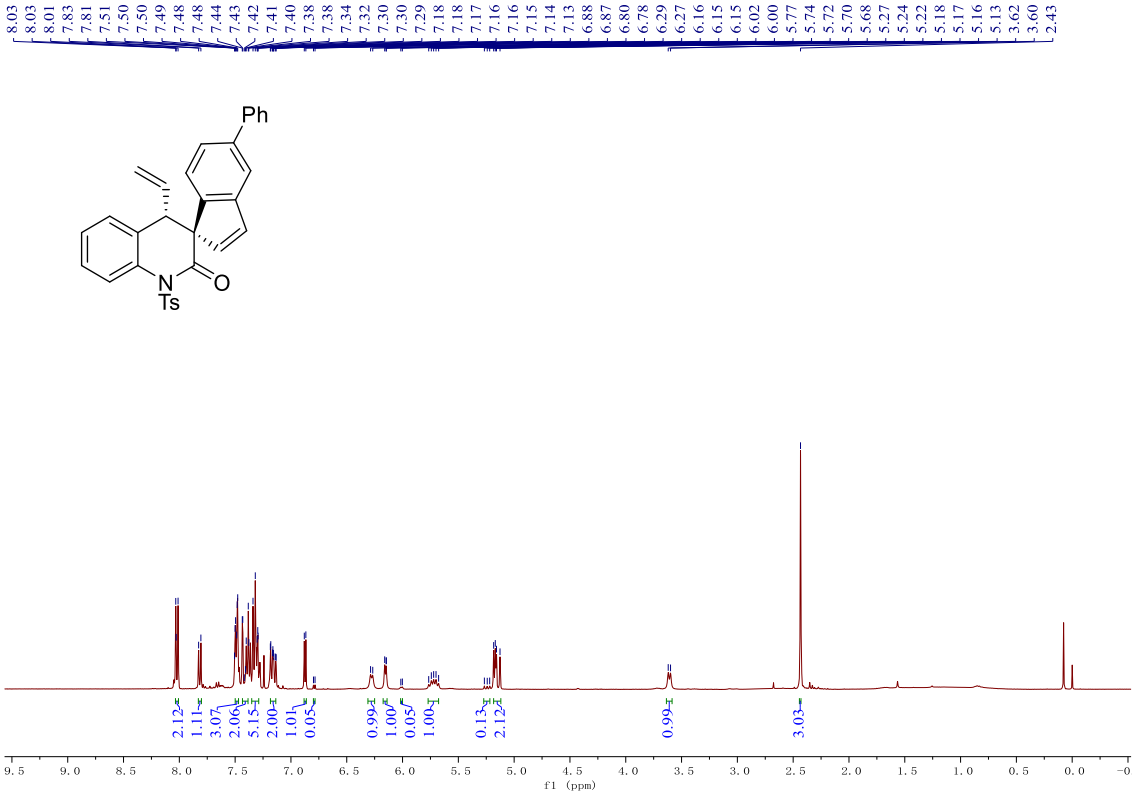
^{1}H NMR spectrum of compound 3ja (400 MHz, $CDCl_3$)



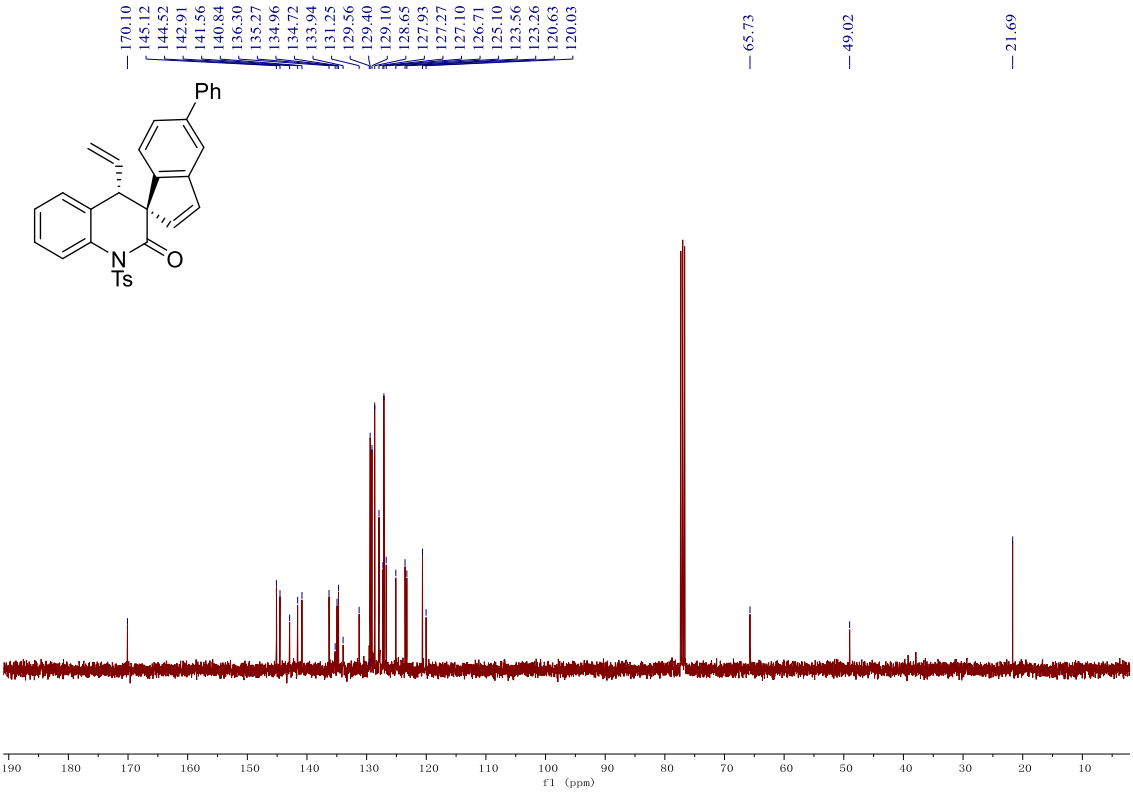
^{13}C NMR spectrum of compound 3ja (100 MHz, $CDCl_3$)



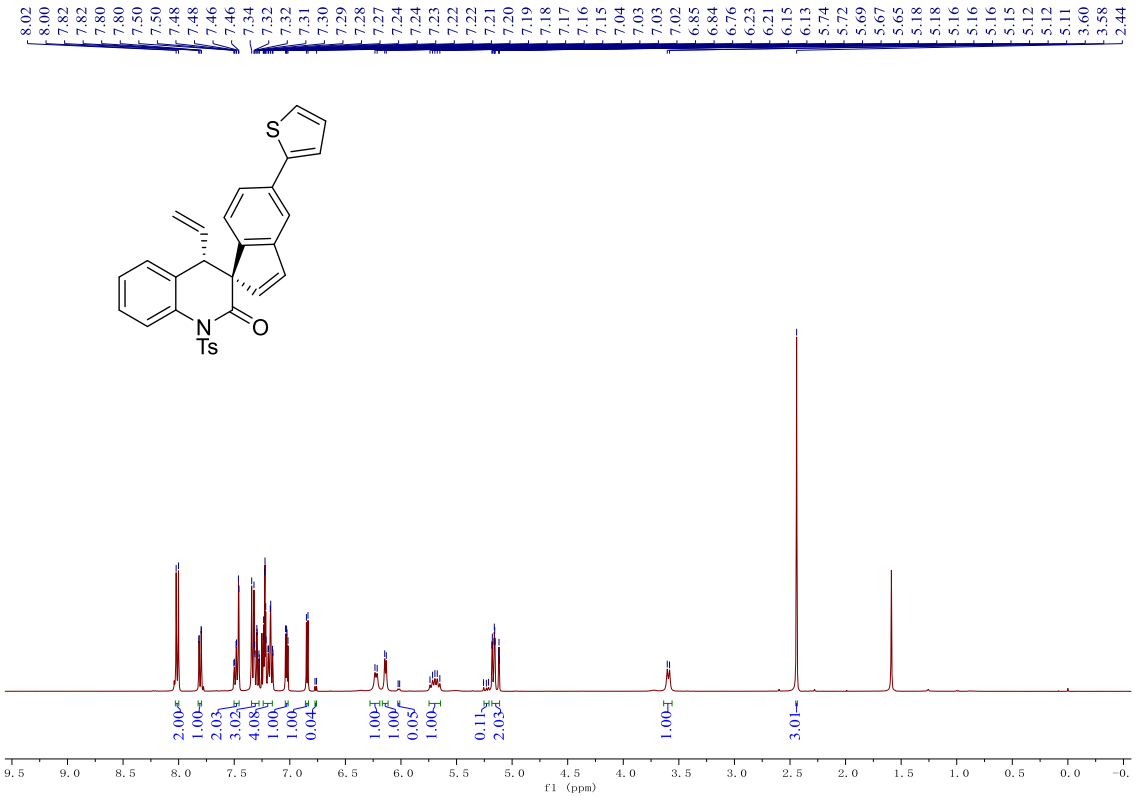
^{1}H NMR spectrum of compound 3ka (400 MHz, $CDCl_3$)



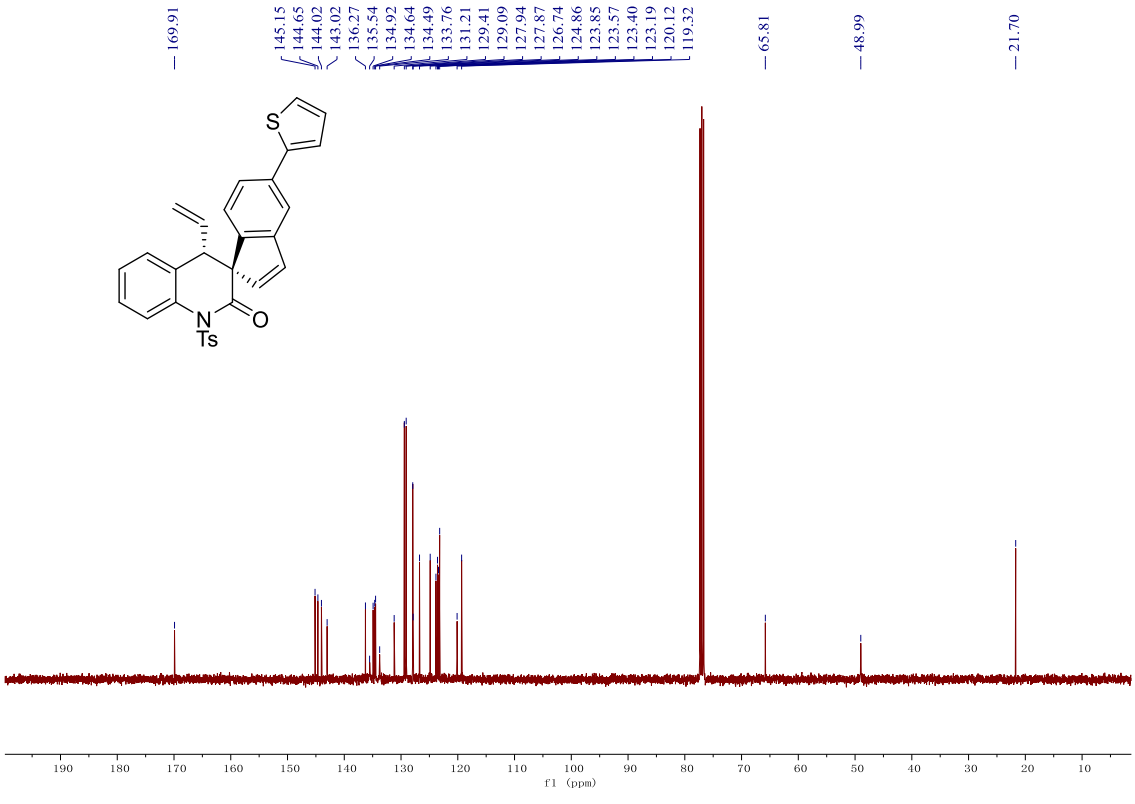
^{13}C NMR spectrum of compound 3ka (100 MHz, $CDCl_3$)



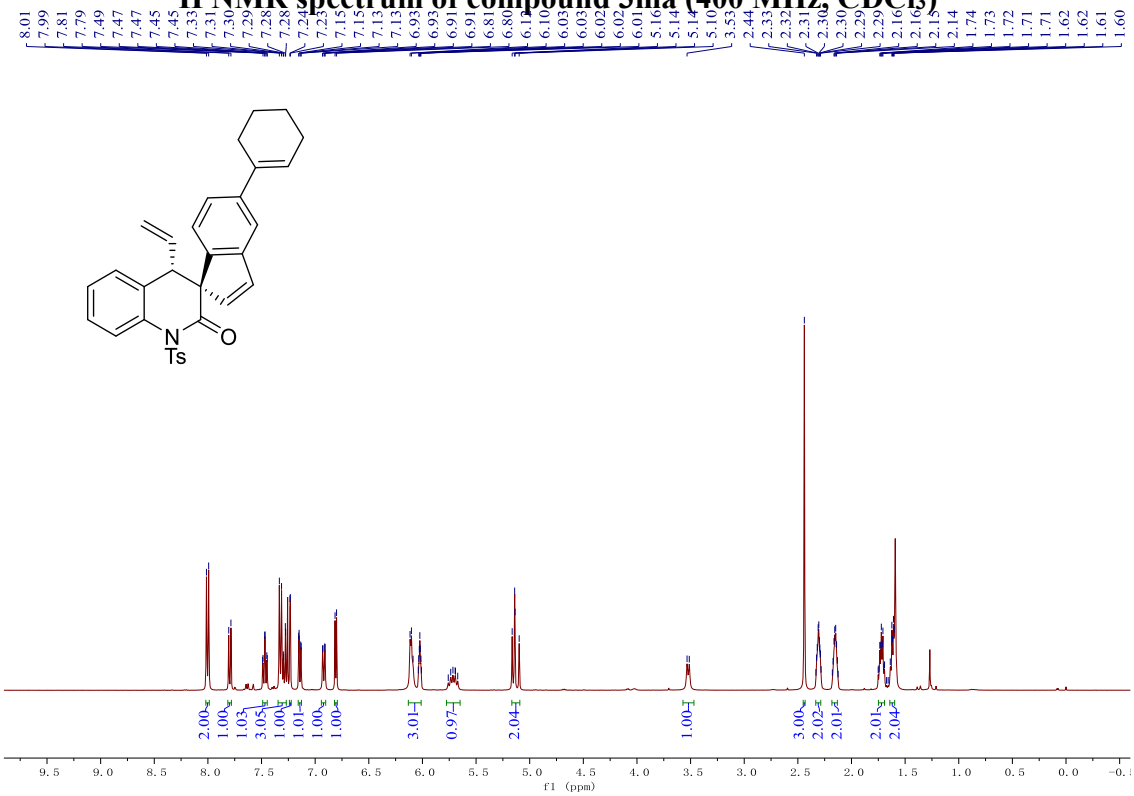
^{1}H NMR spectrum of compound 3la (400 MHz, $CDCl_3$)



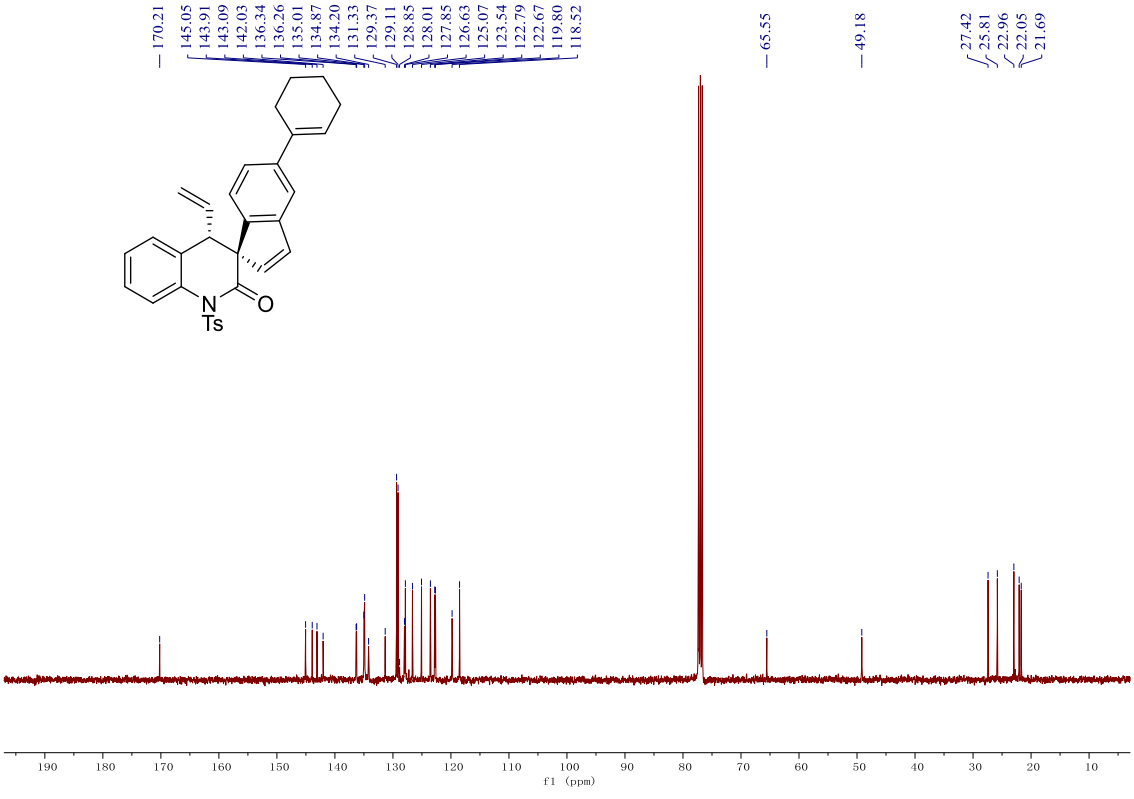
^{13}C NMR spectrum of compound 3la (100 MHz, $CDCl_3$)



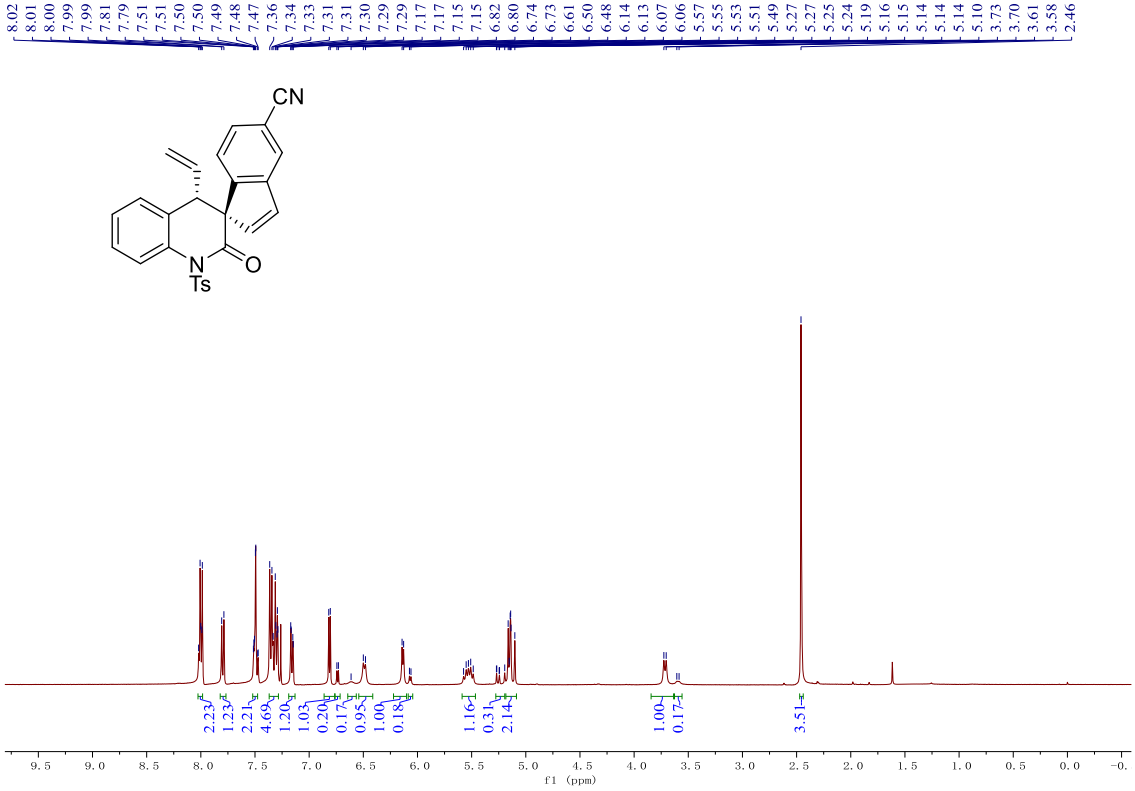
^{1}H NMR spectrum of compound 3ma (400 MHz, $CDCl_3$)



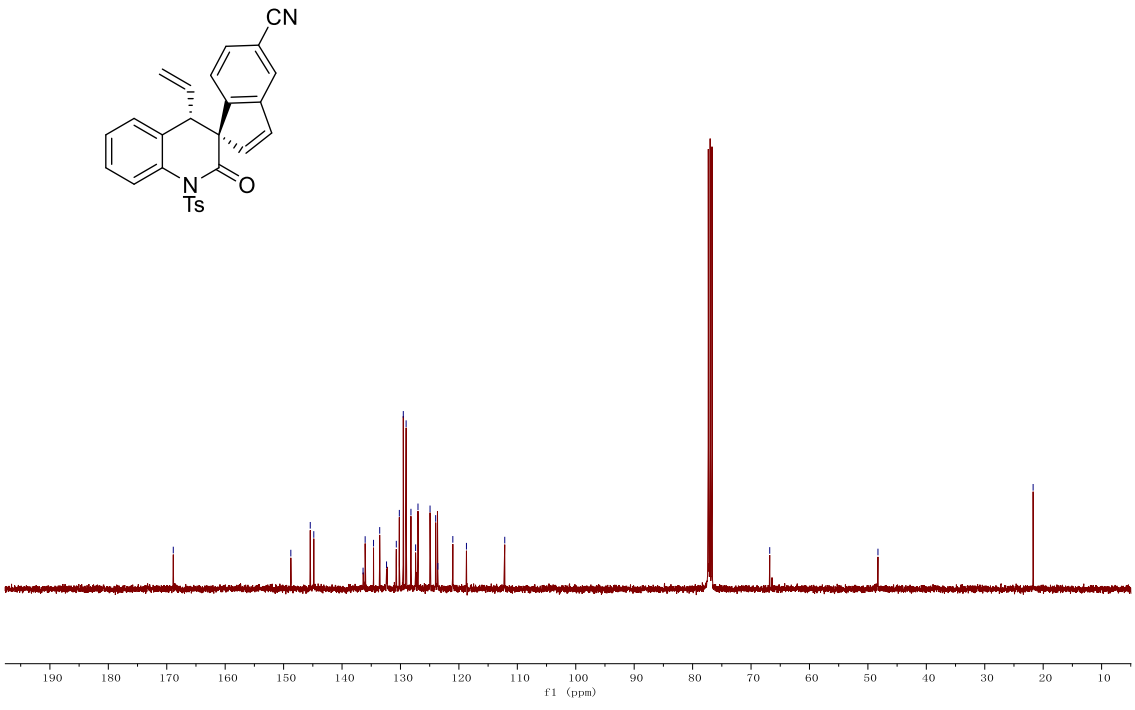
^{13}C NMR spectrum of compound 3ma (100 MHz, $CDCl_3$)



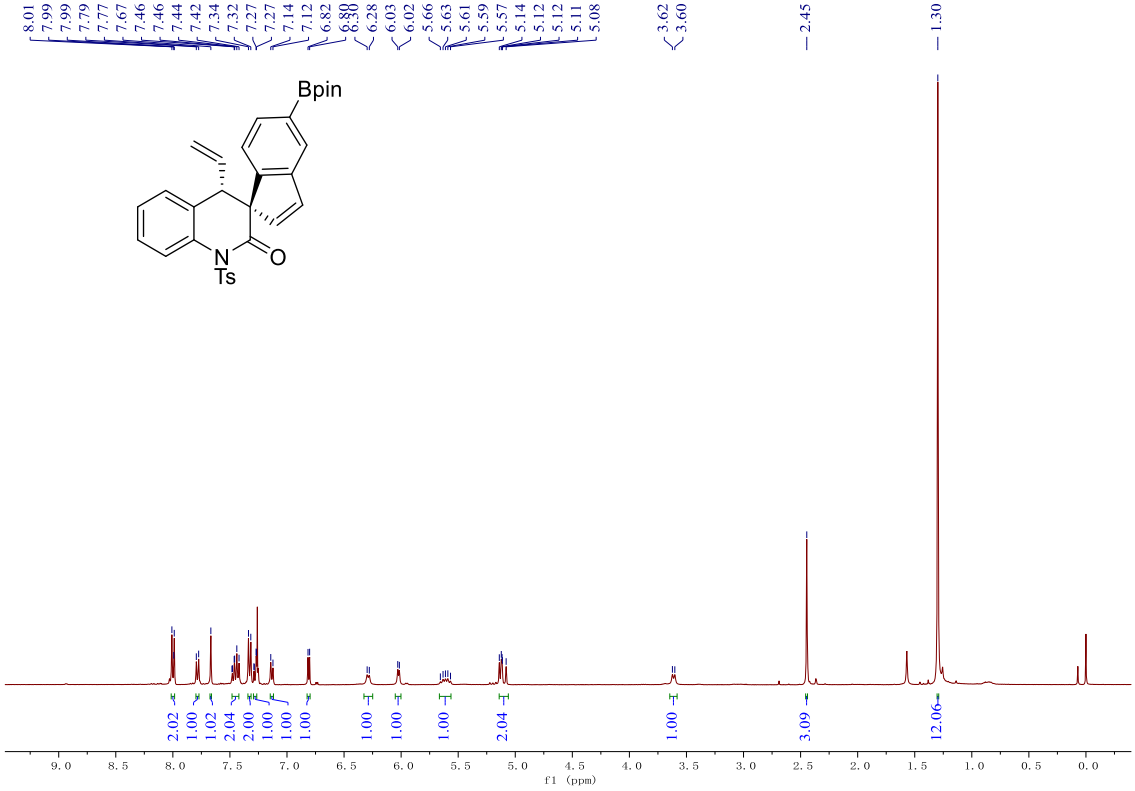
^{1}H NMR spectrum of compound 3na (400 MHz, $CDCl_3$)



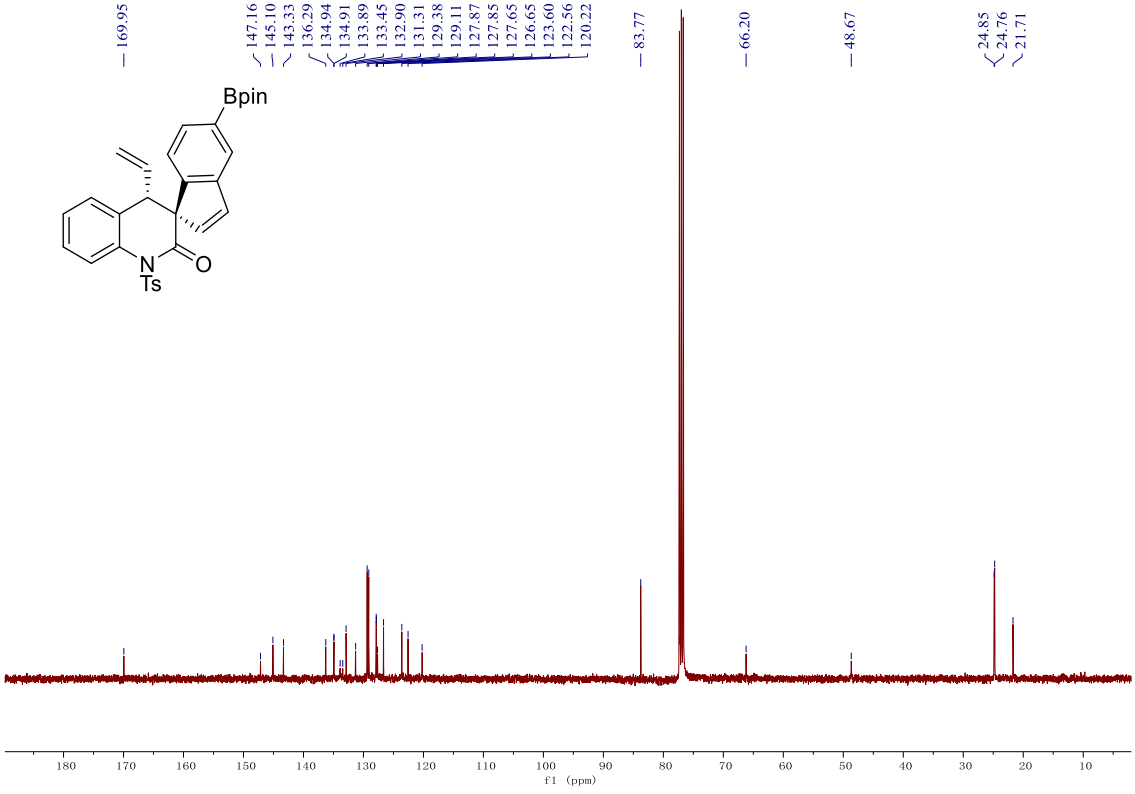
^{13}C NMR spectrum of compound 3na (100 MHz, $CDCl_3$)



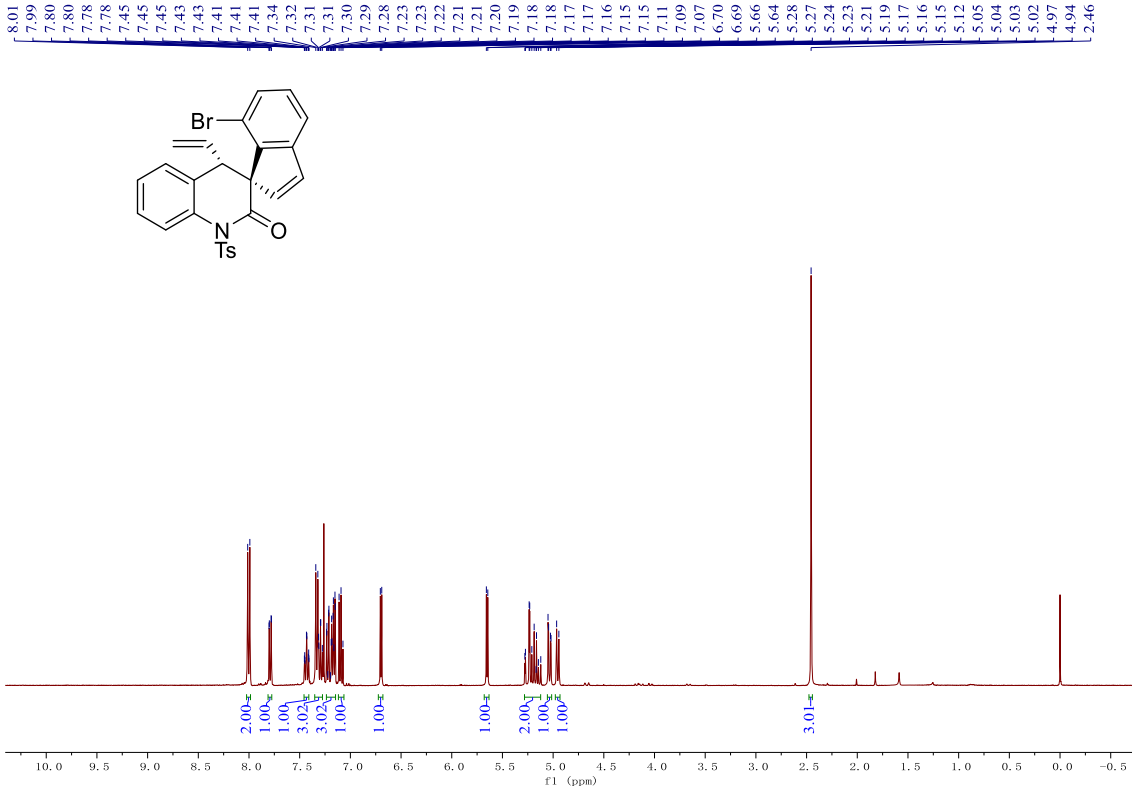
^{1}H NMR spectrum of compound 3oa (400 MHz, $CDCl_3$)



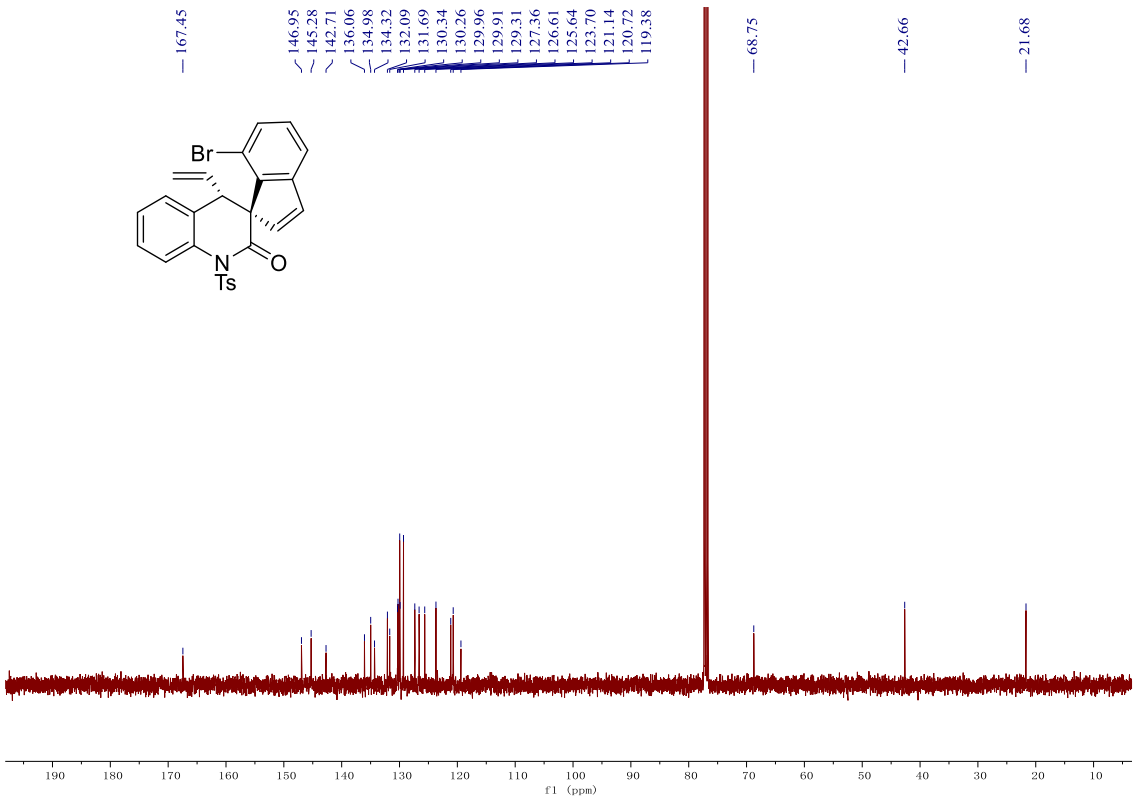
^{13}C NMR spectrum of compound 3oa (100 MHz, $CDCl_3$)



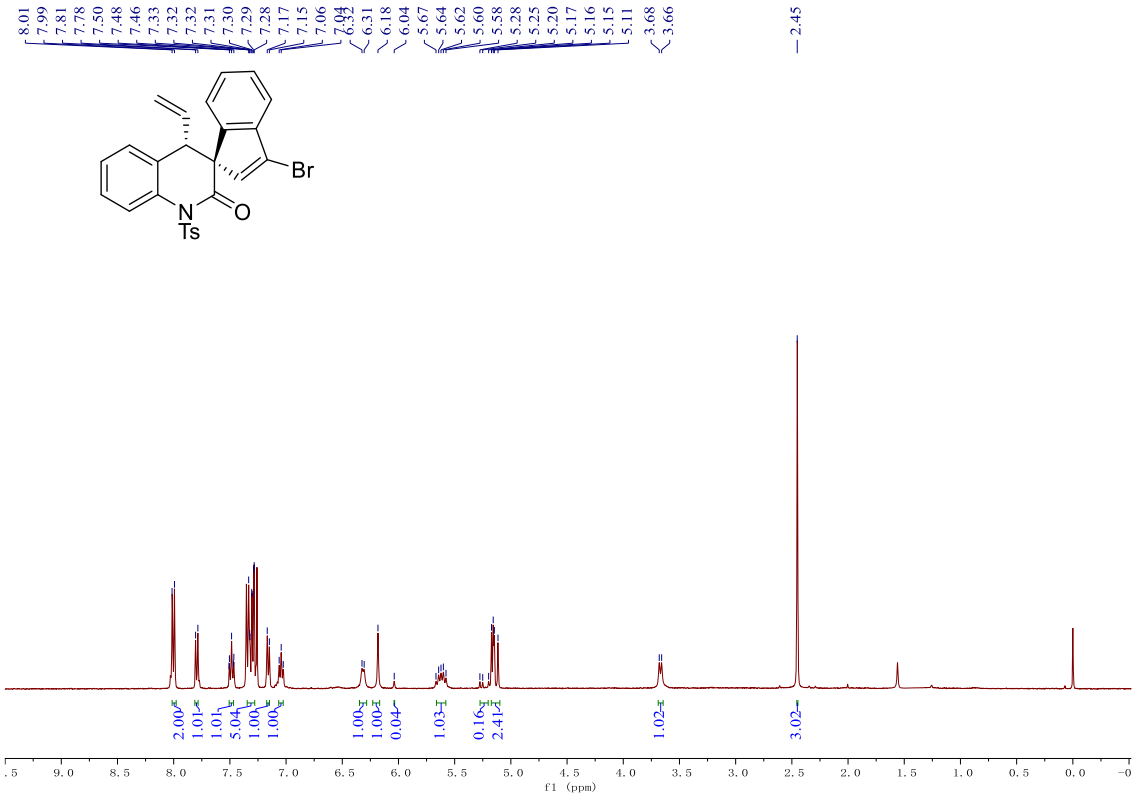
^{1}H NMR spectrum of compound 3pa (400 MHz, $CDCl_3$)



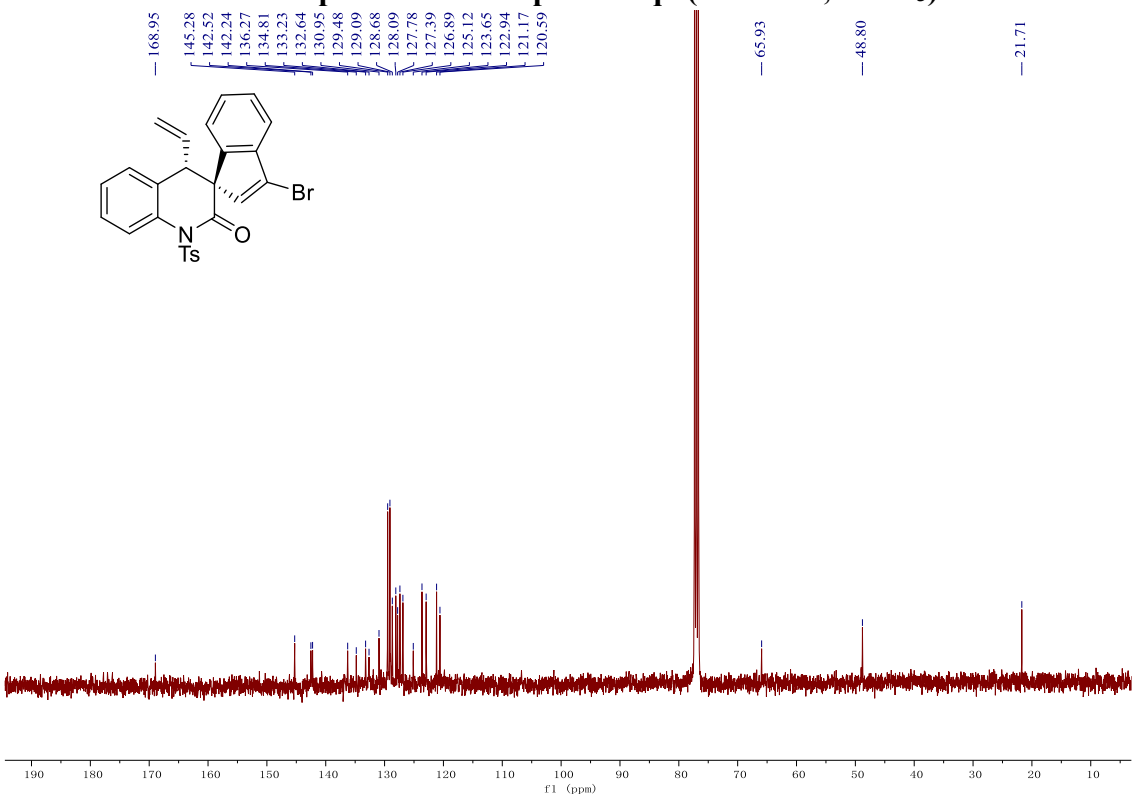
^{13}C NMR spectrum of compound 3pa (100 MHz, $CDCl_3$)



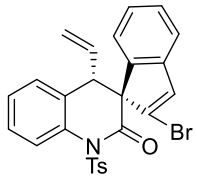
^{1}H NMR spectrum of compound 3qa (400 MHz, $CDCl_3$)

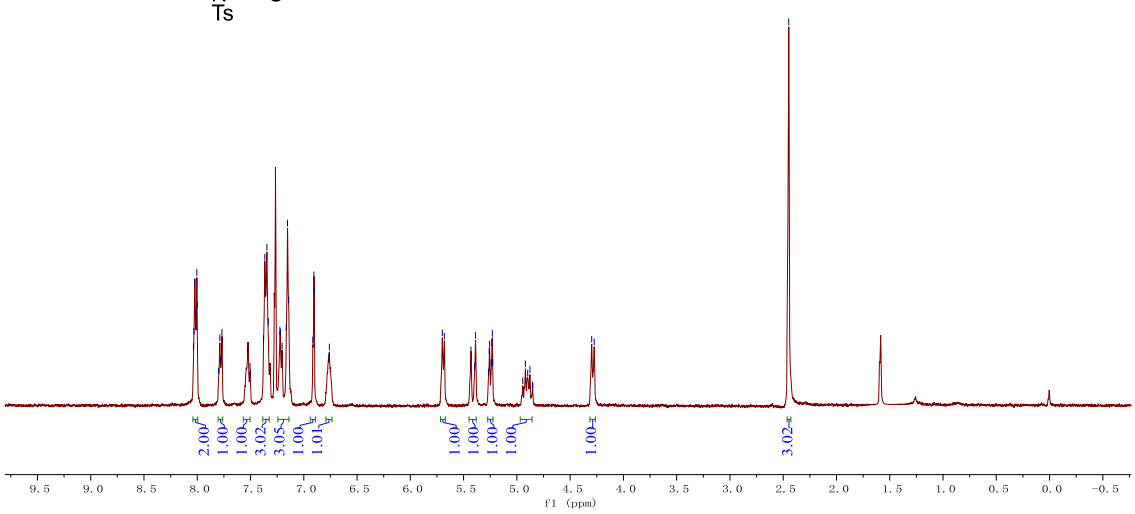


^{13}C NMR spectrum of compound 3qa (100 MHz, $CDCl_3$)

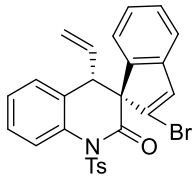


^{1}H NMR spectrum of compound 3ra (400 MHz, $CDCl_3$)

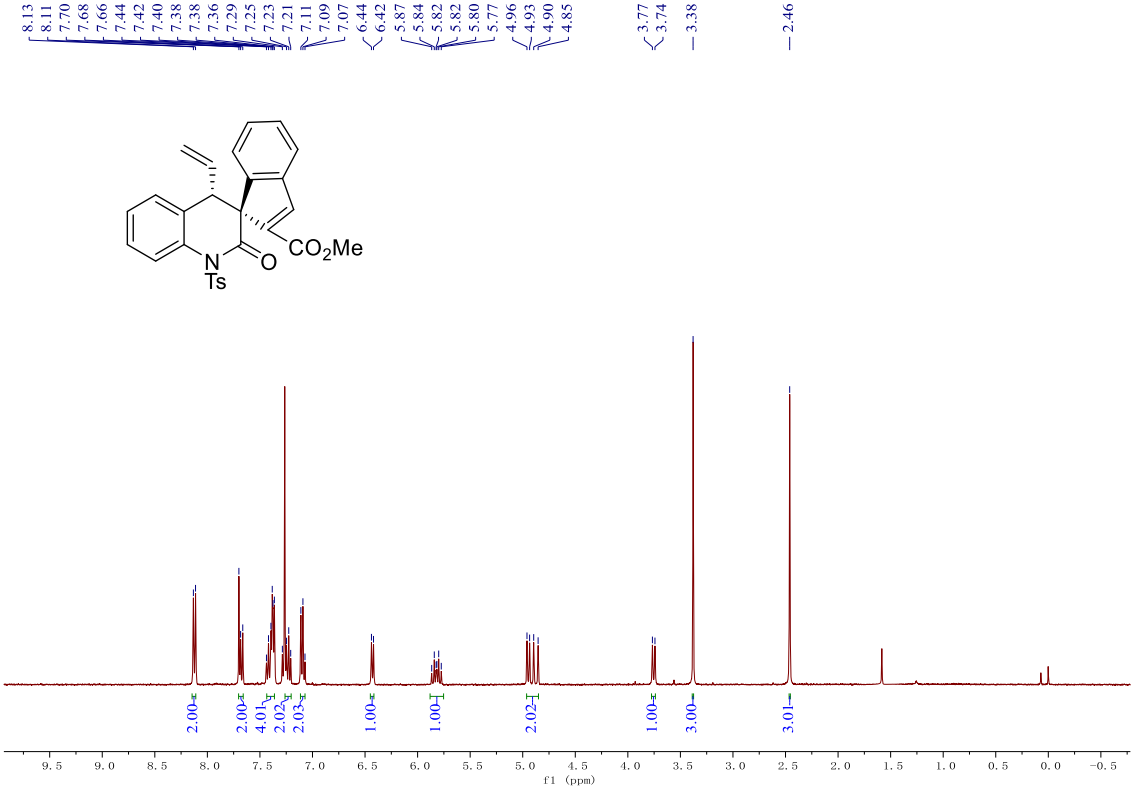




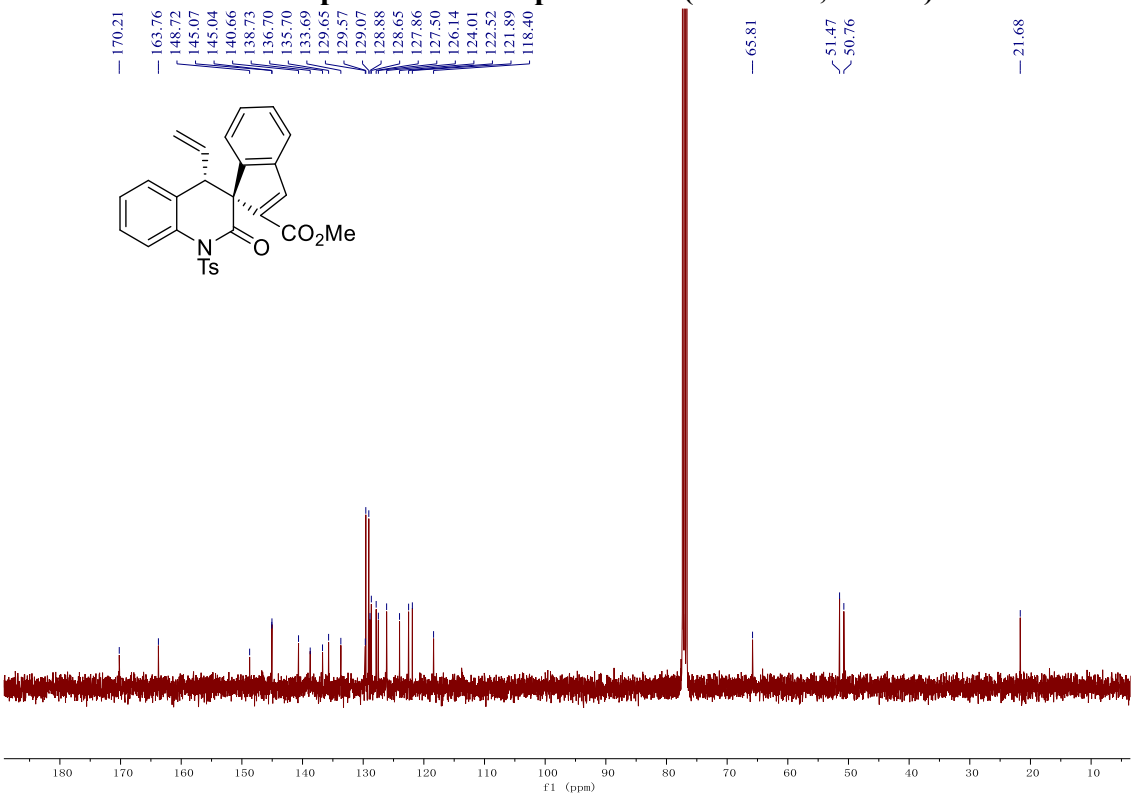
^{13}C NMR spectrum of compound 3ra (100 MHz, $CDCl_3$)



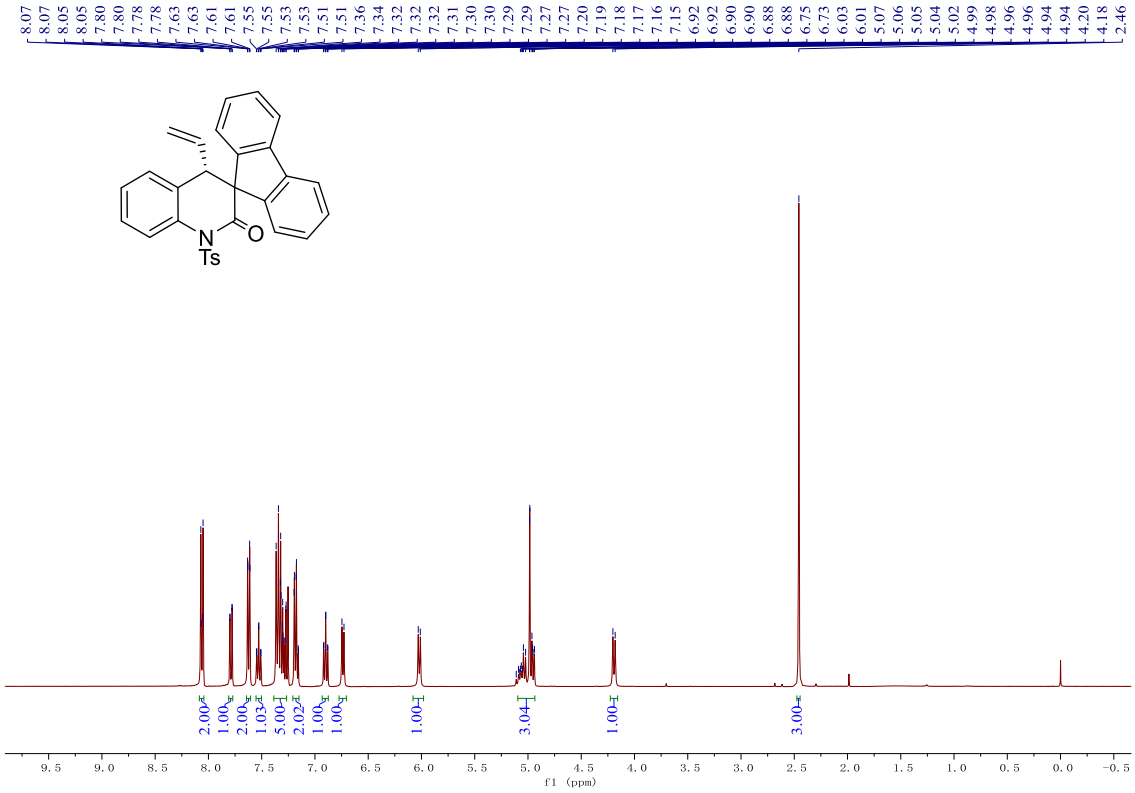
^{1}H NMR spectrum of compound 3sa (400 MHz, $CDCl_3$)



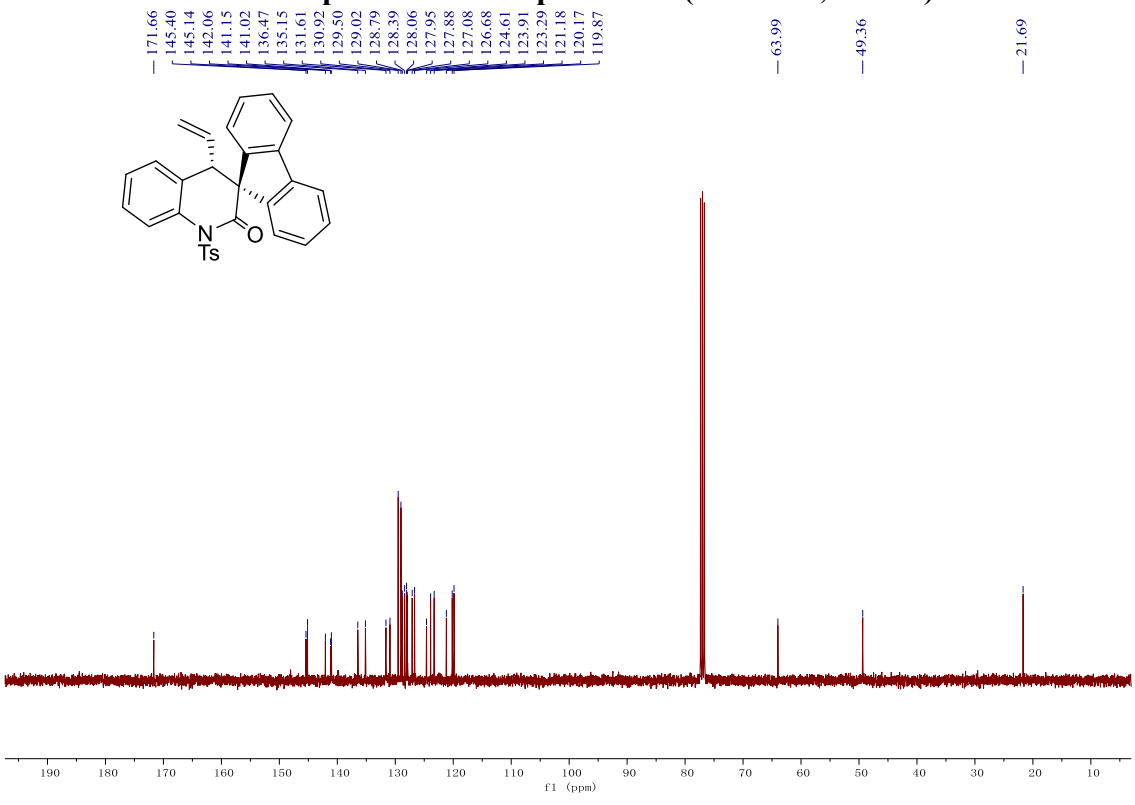
^{13}C NMR spectrum of compound 3sa (100 MHz, $CDCl_3$)



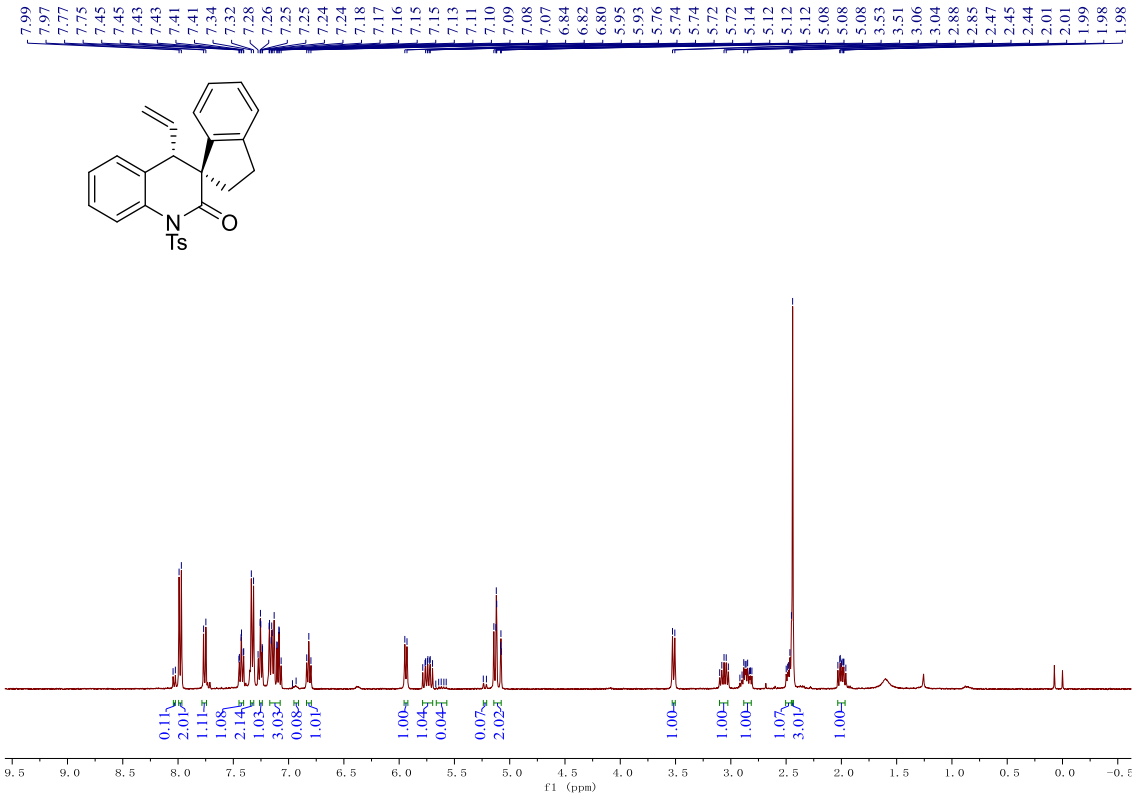
^{1}H NMR spectrum of compound 3ta (400 MHz, $CDCl_3$)



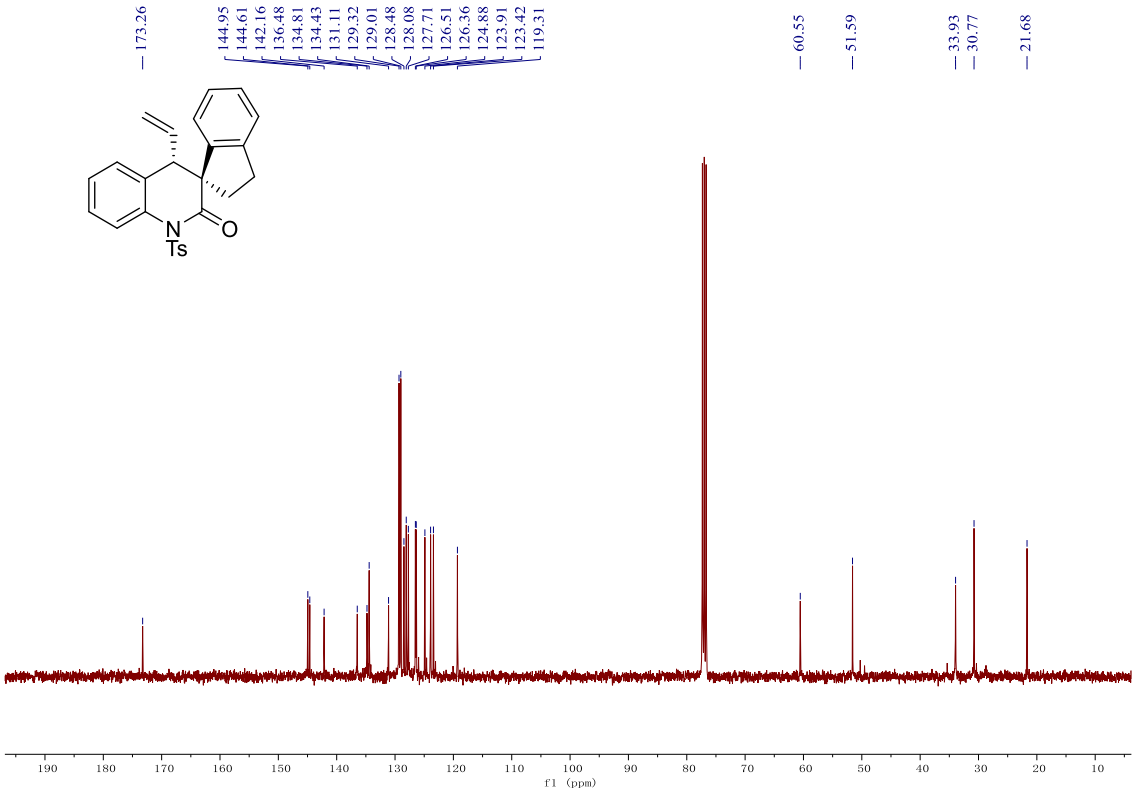
^{13}C NMR spectrum of compound 3ta (100 MHz, $CDCl_3$)



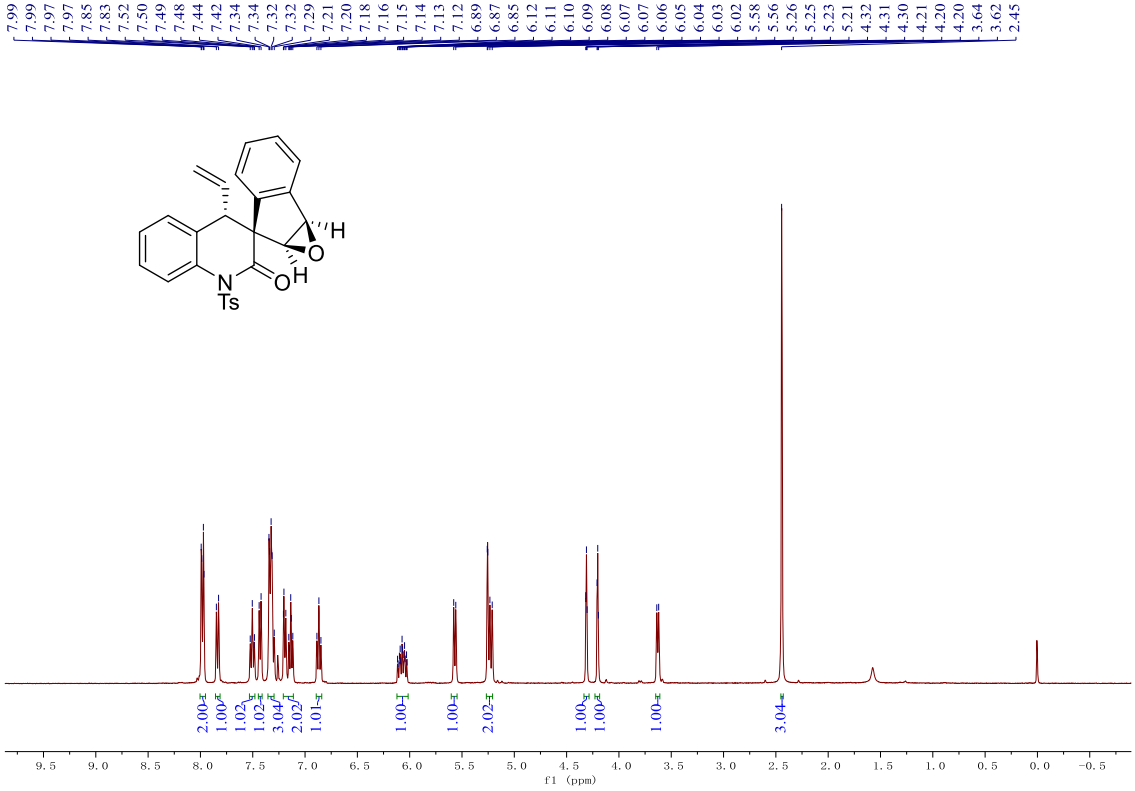
^{1}H NMR spectrum of compound 3ua (400 MHz, $CDCl_3$)



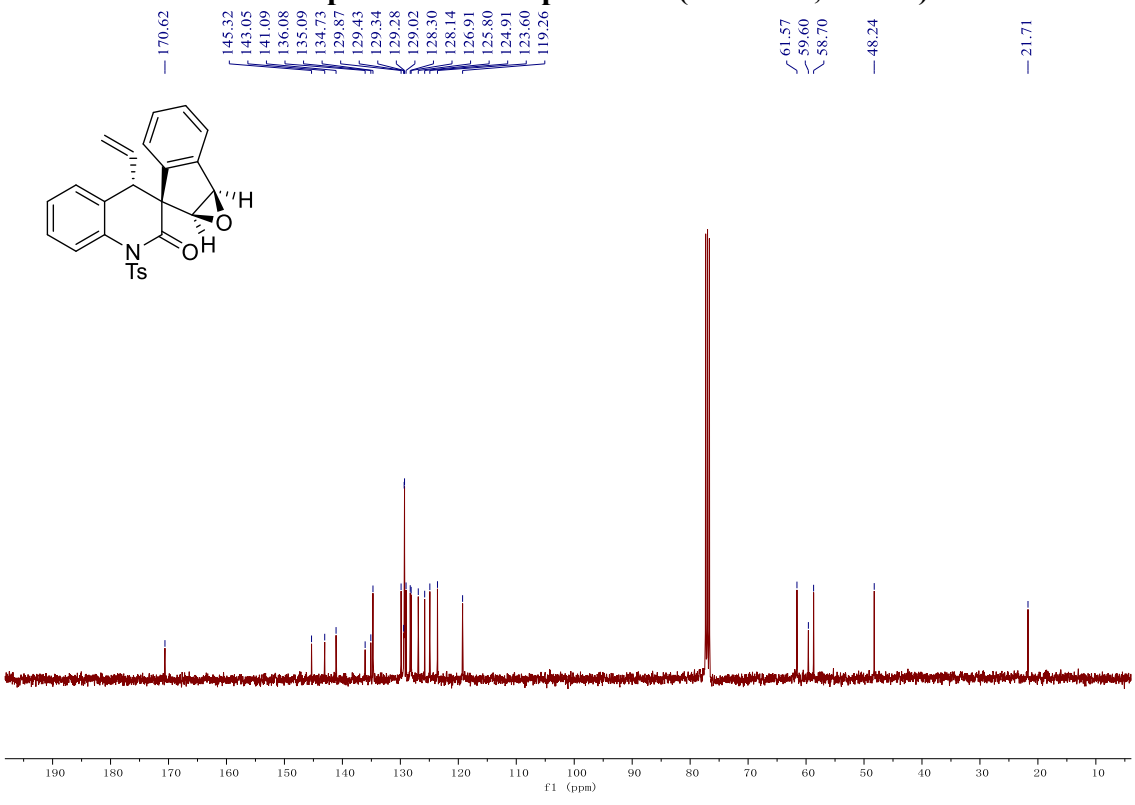
^{13}C NMR spectrum of compound 3ua (100 MHz, $CDCl_3$)



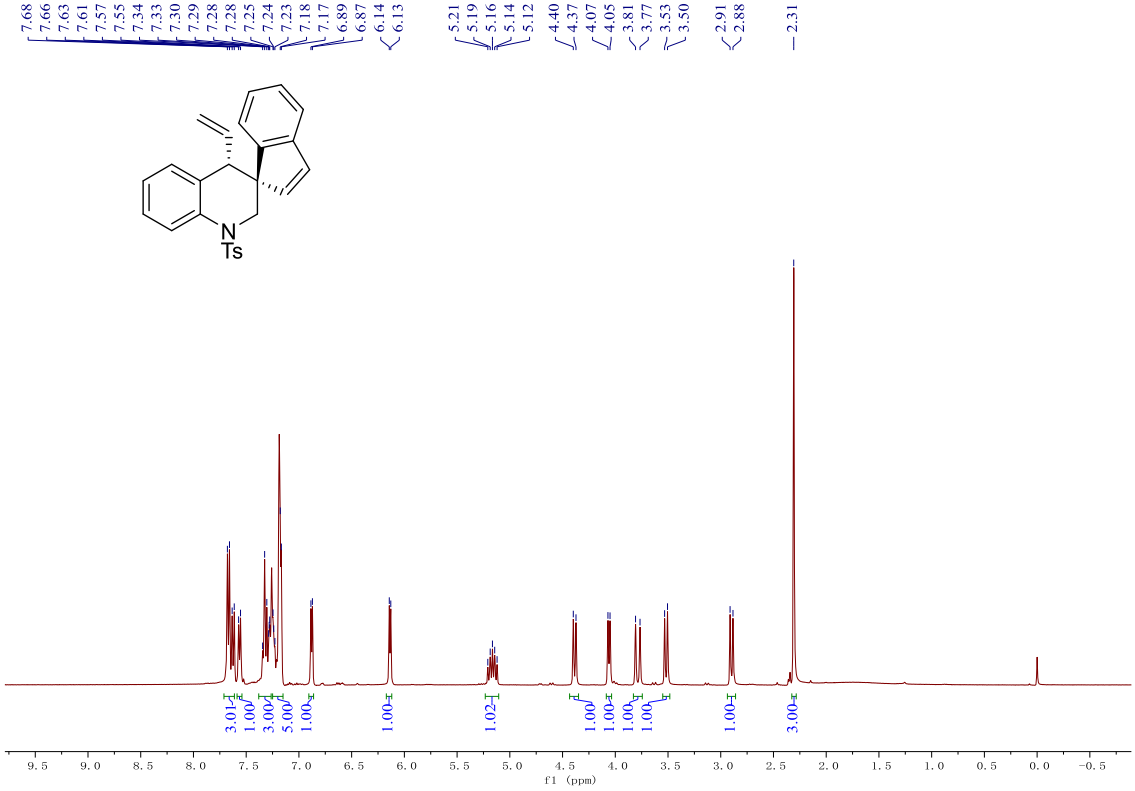
^{1}H NMR spectrum of compound 4a (400 MHz, $CDCl_3$)



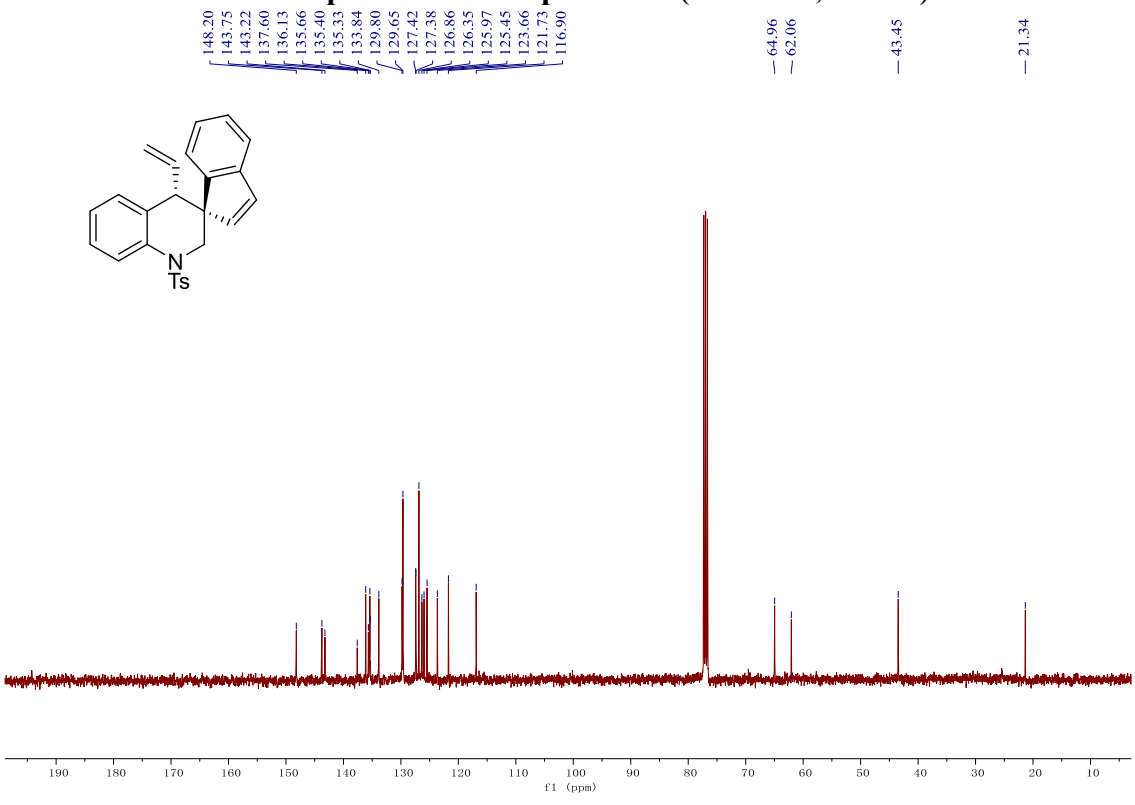
^{13}C NMR spectrum of compound 4a (100 MHz, $CDCl_3$)



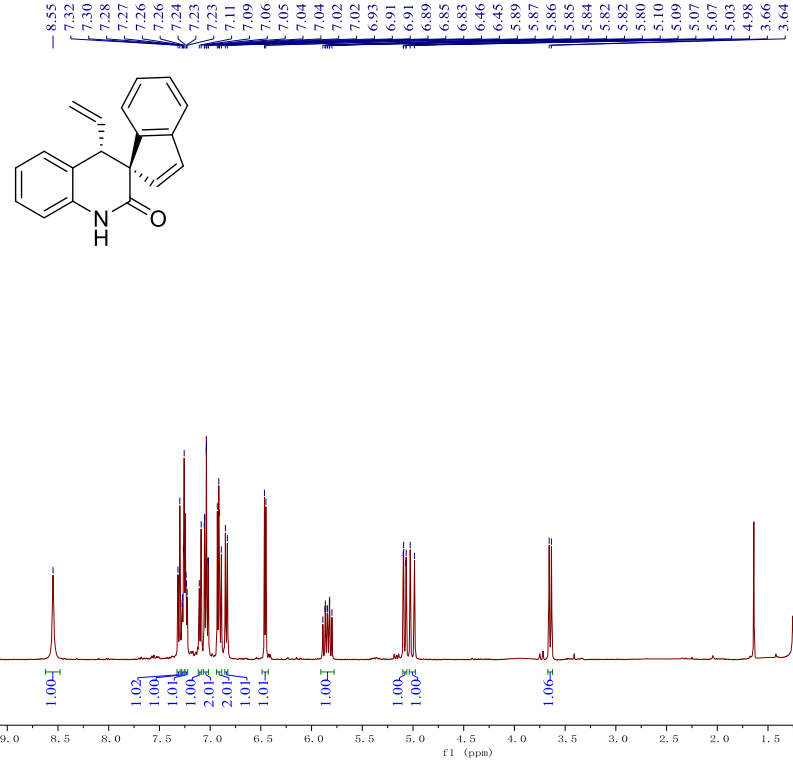
^{1}H NMR spectrum of compound 4b (400 MHz, $CDCl_3$)



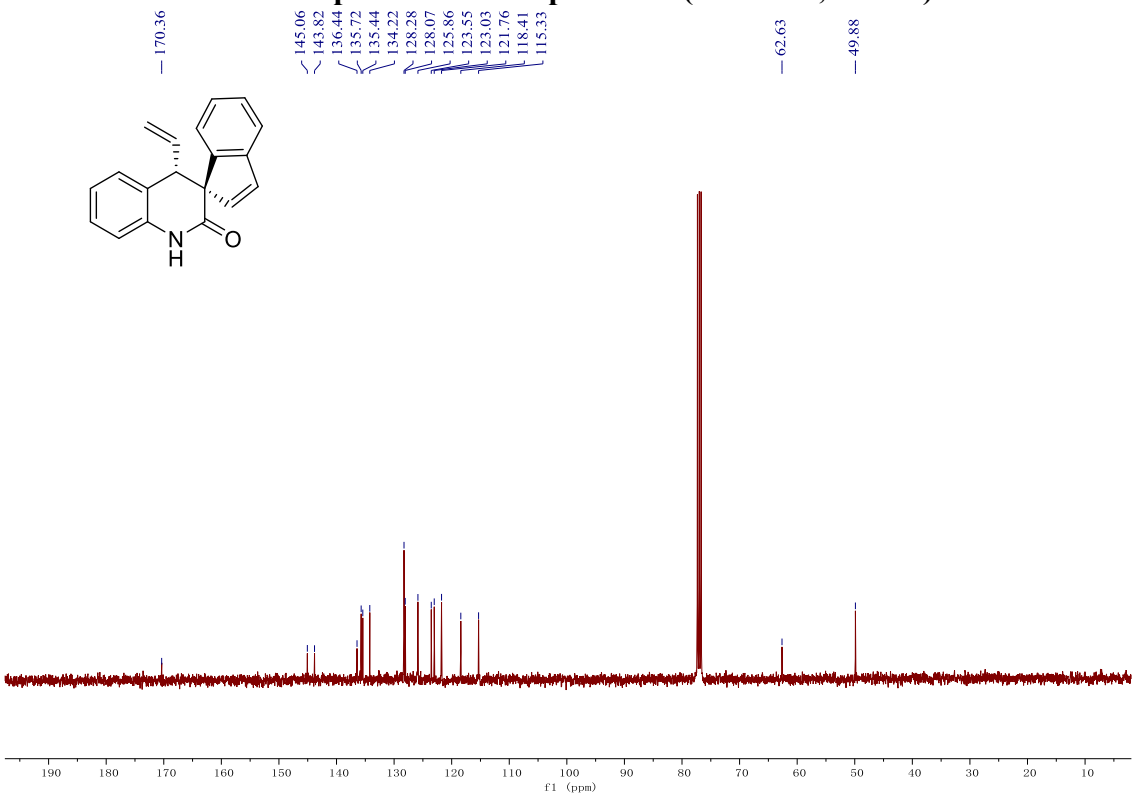
^{13}C NMR spectrum of compound 4b (100 MHz, $CDCl_3$)



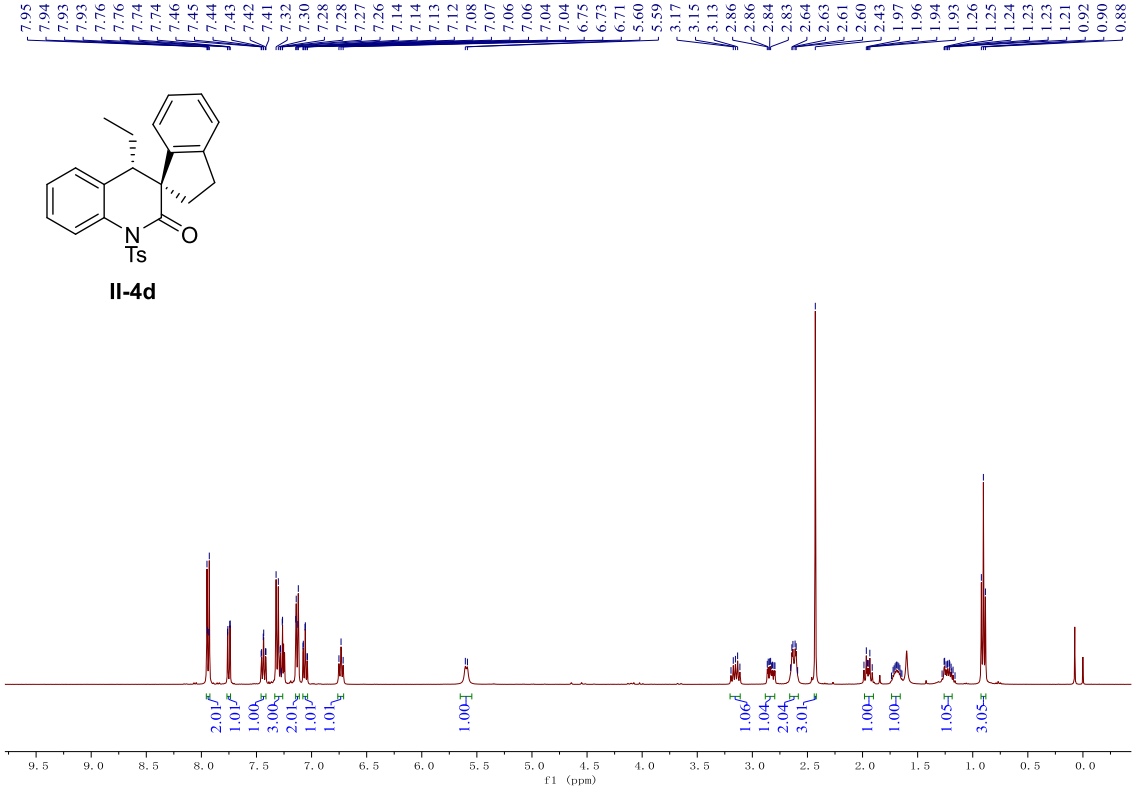
^{1}H NMR spectrum of compound 4c (400 MHz, $CDCl_3$)



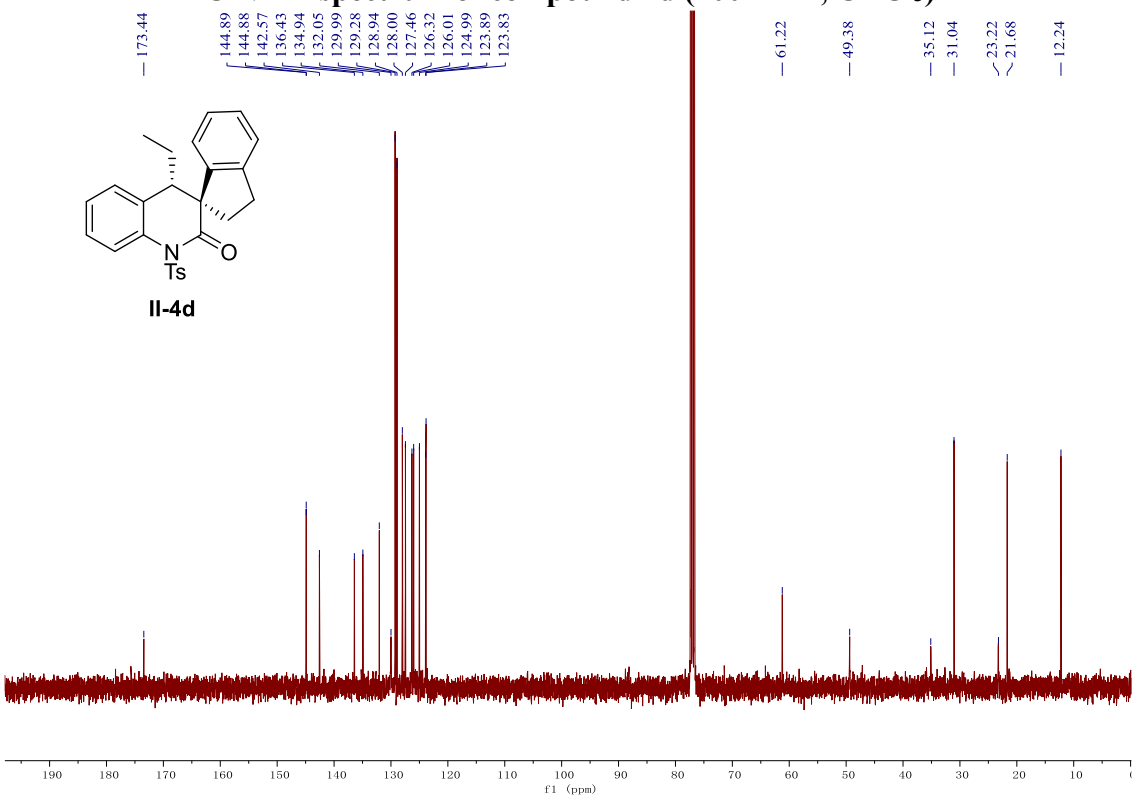
^{13}C NMR spectrum of compound 4c (100 MHz, $CDCl_3$)



^{1}H NMR spectrum of compound 4d (400 MHz, $CDCl_3$)

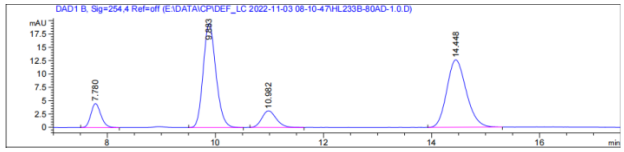


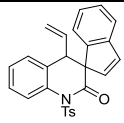
^{13}C NMR spectrum of compound 4d (100 MHz, $CDCl_3$)



10.Copies of HPLC Spectra

HPLC spectrum of racemic 3aa

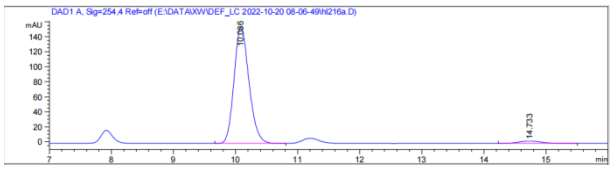


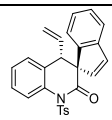


***rac*-3aa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.780	BB	0.1962	57.93724	4.50101	7.7025
2	9.883	BB	0.2510	319.45932	19.50990	42.4705
3	10.982	BB	0.2809	57.94067	3.11663	7.7029
4	14.448	BB	0.3883	316.85379	12.64558	42.1241

HPLC spectrum of 3aa

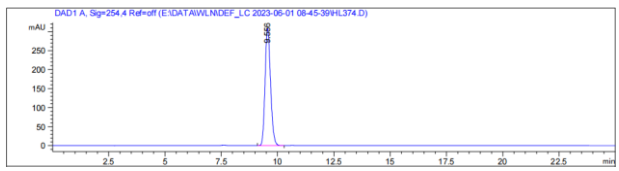


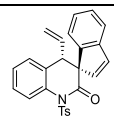


3aa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.086	BB	0.2568	8707.02051	521.34503	97.1578
2	14.731	BB	0.3839	254.70792	10.24973	2.8422

HPLC spectrum of 3aa (after recrystallization)

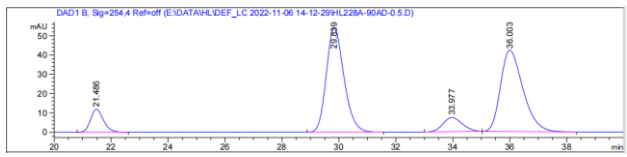


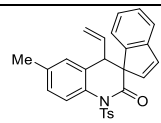


II-3aa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.556	BB	0.2609	5204.46240	308.43994	100.0000

HPLC spectrum of racemic 3ab

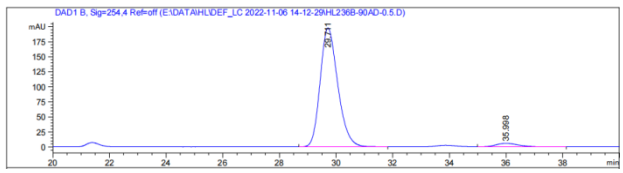


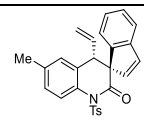


***rac*-3ab**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	21.486	BB	0.4835	371.73453	11.86695	6.9526
2	29.839	BB	0.6614	2324.21631	54.29158	43.4701
3	33.977	BB	0.5926	345.48111	7.34748	6.4616
4	36.003	BB	0.8292	2305.26709	42.20680	43.1157

HPLC spectrum of 3ab

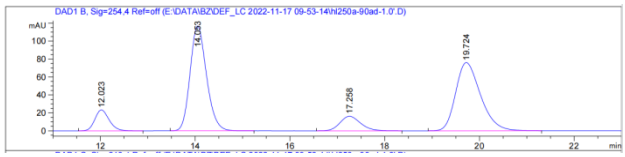


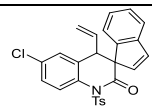


3ab

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.711	BB	0.6663	8539.90820	197.56136	96.4403
2	35.998	BB	0.6859	315.21396	5.74700	3.5597

HPLC spectrum of racemic 3ac

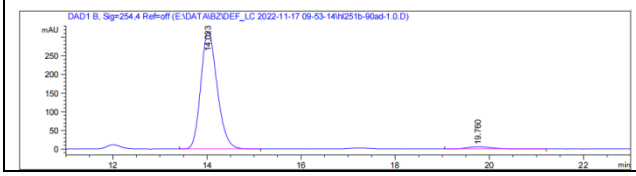


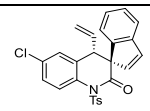


***rac*-3ac**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.023	BB	0.3207	484.50351	23.28733	7.3968
2	14.053	BB	0.3729	2808.72656	116.66686	42.8804
3	17.258	BB	0.4616	487.03900	16.16002	7.4355
4	19.724	BB	0.5596	2769.87793	75.93716	42.2873

HPLC spectrum of 3ac

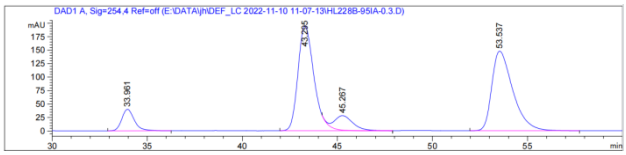


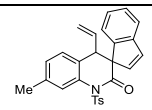


3ac

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.023	BB	0.3710	7586.85986	315.00839	97.1417
2	19.760	BB	0.5368	223.23389	6.07384	2.8583

HPLC spectrum of racemic 3ad

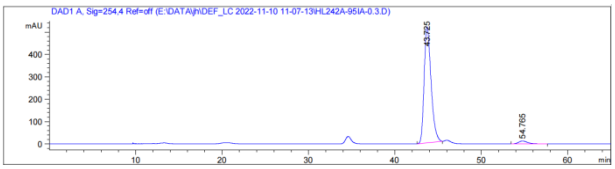


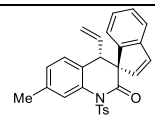


***rac*-3ad**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	33.961	BB	0.6940	1823.63818	39.84595	6.9121
2	43.295	BV R	0.8991	1.14450e4	194.91000	43.3796
3	45.267	VB E	0.9873	1793.10132	26.84259	6.7963
4	53.537	BB	1.1668	1.13217e4	147.61801	42.9120

HPLC spectrum of 3ad

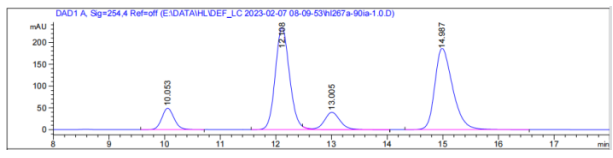


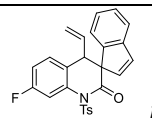


3ad

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	43.725	BB	0.8589	2.88698e4	519.05542	96.9216
2	54.765	BB	0.9524	916.95117	12.82030	3.0784

HPLC spectrum of racemic 3ae

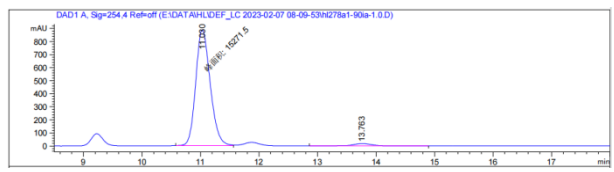


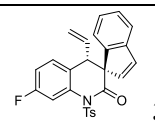


***rac*-3ae**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.053	BB	0.2359	742.15106	48.66212	7.5552
2	12.108	BV R	0.2758	4168.31543	234.00243	42.4338
3	13.005	VB E	0.2980	772.66559	39.53851	7.8658
4	14.987	BB	0.3417	4139.96680	185.99294	42.1452

HPLC spectrum of 3ae

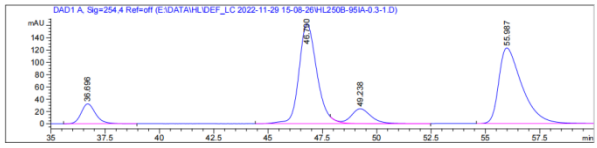


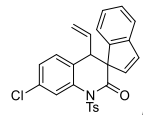


3ae

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.030	MM	0.2865	1.52715e4	888.39105	97.2540
2	13.763	VB	0.3469	431.18860	18.84971	2.7460

HPLC spectrum of racemic 3af

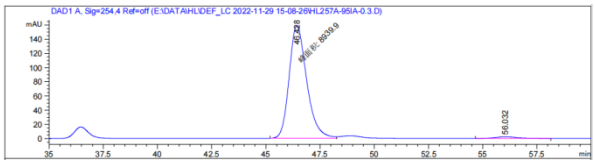


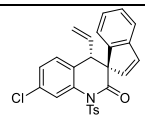


***rac*-3af**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	36.696	BB	0.7052	1488.06799	32.31787	6.9492
2	46.790	BV R	0.8738	9296.68750	162.40465	43.4150
3	49.238	VB E	0.9416	1506.90234	24.03176	7.0371
4	55.987	BB	1.1165	9121.87402	122.81918	42.5986

HPLC spectrum of 3af

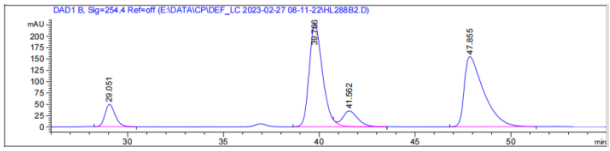


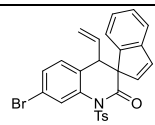


3af

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	46.428	MM	0.9381	8939.90430	158.82639	98.3270
2	56.032	BB	0.8330	152.11055	2.17225	1.6730

HPLC spectrum of racemic 3ag

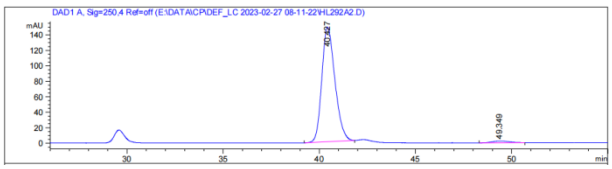


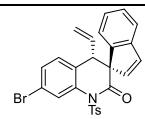


***rac*-3ag**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.051	BB	0.5583	1820.78198	49.13707	7.0944
2	39.766	BV R	0.7426	1.10563e4	225.28391	43.0791
3	41.562	VB E	0.6921	1841.92175	34.10275	7.1768
4	47.855	BB	1.0061	1.09461e4	154.58386	42.6498

HPLC spectrum of 3ag

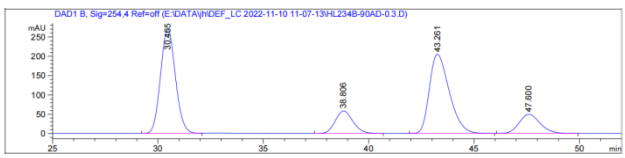


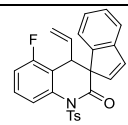


3ag

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	40.427	BB	0.7322	7013.39355	148.16573	98.1715
2	49.349	BB	0.7294	130.62527	2.15439	1.8285

HPLC spectrum of racemic 3ah

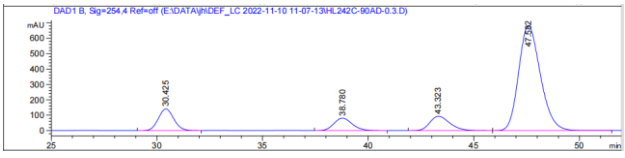


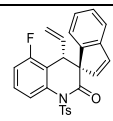


***rac*-3ah**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.465	BB	0.7637	1.32719e4	270.84818	39.6436
2	38.806	BB	0.8975	3390.18774	58.03740	10.1266
3	43.261	BB	1.0024	1.34025e4	204.56905	40.0336
4	47.600	BB	1.0394	3413.50000	49.32220	10.1962

HPLC spectrum of 3ah

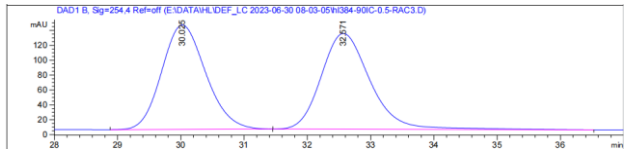


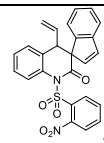


3ah

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.425	BB	0.7945	7084.90918	139.98291	10.6524
2	38.780	BB	0.9262	4816.06494	80.71114	7.2411
3	43.323	BB	0.9942	6023.51611	92.68636	9.0565
4	47.582	BB	1.1081	4.85857e4	681.19043	73.0500

HPLC spectrum of racemic 3ai

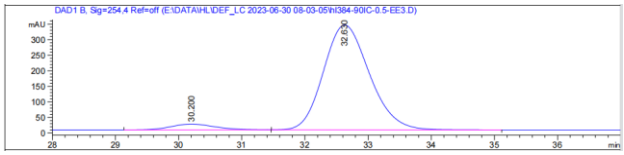


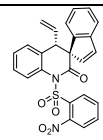


***rac*-3ai**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.025	BB	0.7448	6789.74365	140.26143	49.4213
2	32.571	BB	0.8277	6948.75391	128.75110	50.5787

HPLC spectrum of 3ai

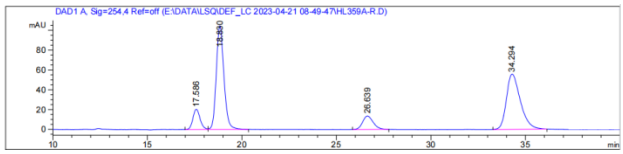


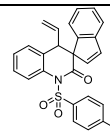


3ai

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.200	BB	0.7164	890.77588	18.54449	4.9768
2	32.630	BB	0.7855	1.70078e4	336.58252	95.0232

HPLC spectrum of racemic 3aj

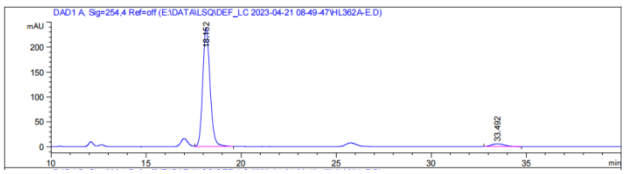


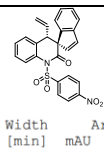


***rac*-3aj**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	17.586	BV	0.3935	543.85797	20.49864	7.9129
2	18.830	VB	0.4340	2944.90161	104.73521	42.8473
3	26.639	BB	0.5252	531.77740	13.68934	7.7372
4	34.294	BB	0.7627	2852.47656	55.77593	41.5026

HPLC spectrum of 3aj

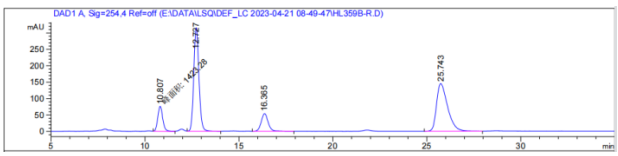


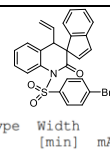


3aj

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.152	VB	0.4137	6400.18018	238.05692	96.1726
2	33.492	BB	0.5604	254.70657	5.41843	3.8274

HPLC spectrum of racemic 3ak

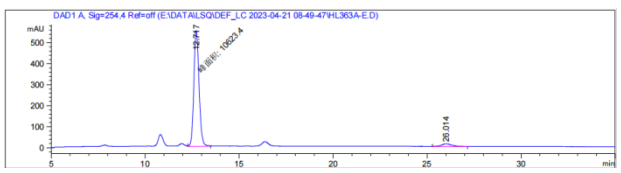


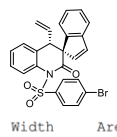


***rac*-3ak**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	10.807	MM	0.3107	1423.28455	76.35758	9.6050
2	12.727	VB	0.2962	6060.92139	315.38828	40.9021
3	16.365	BB	0.3936	1394.54004	53.94146	9.4110
4	25.743	BB	0.6287	5939.38867	145.34663	40.0819

HPLC spectrum of 3ak

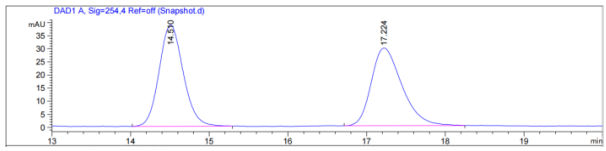


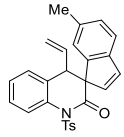


3ak

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.717	MM	0.3205	1.06234e4	552.38477	95.8903
2	26.014	BB	0.5033	455.29749	11.87400	4.1097

HPLC spectrum of racemic 3ba

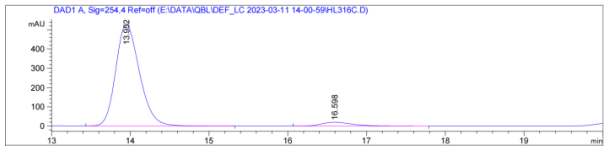


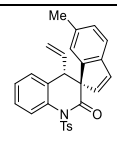


***rac*-3ba**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.510	BB	0.3278	821.60779	38.68610	50.6467
2	17.224	BB	0.4030	800.62549	29.65655	49.3533

HPLC spectrum of 3ba

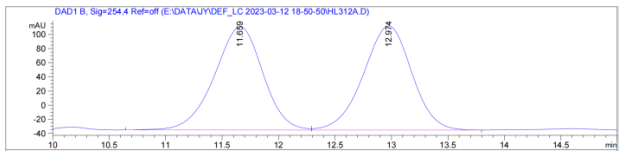


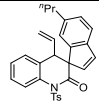


3ba

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	13.952	BB	0.3258	1.10371e4	528.15466	95.2884
2	16.598	BB	0.4052	545.74194	19.94716	4.7116

HPLC spectrum of racemic 3ca

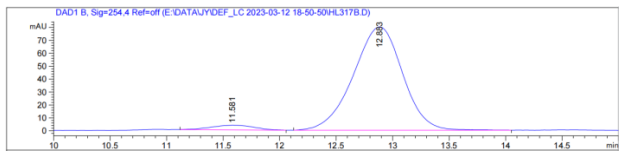


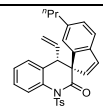


***rac*-3ca**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.659	BV	0.4592	4367.05566	145.91435	49.8569
2	12.974	VB	0.4605	4392.12744	147.05061	50.1431

HPLC spectrum of 3ca

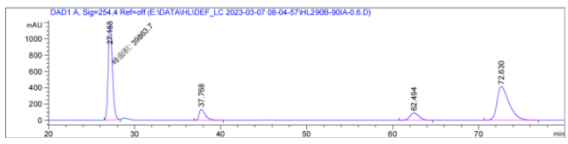


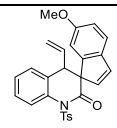


3ca

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.581	BB	0.3283	94.45248	3.66990	3.7495
2	12.883	BB	0.4641	2424.60083	79.88641	96.2505

HPLC spectrum of racemic 3da

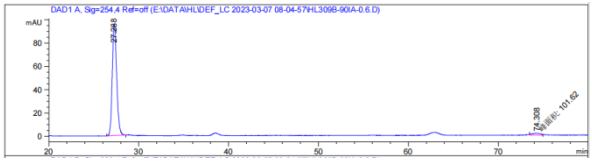


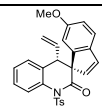


***rac*-3da**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.158	MM	0.5724	3.98637e4	1160.79102	42.7947
2	37.768	BB	0.7229	6638.58252	134.26016	7.1267
3	62.494	BB	1.0111	6596.16797	89.78175	7.0812
4	72.630	BB	1.3485	4.00524e4	413.33801	42.9974

HPLC spectrum of 3da

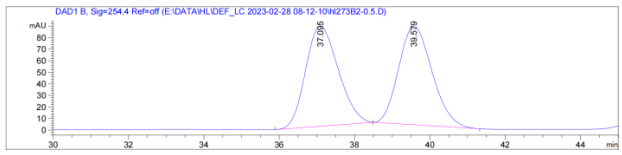


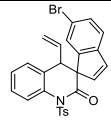


3da

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.288	BB	0.5261	3267.70825	95.77471	96.9840
2	74.308	MM	1.1108	101.61981	1.52479	3.0160

HPLC spectrum of racemic 3ea

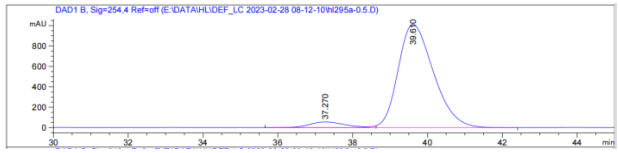


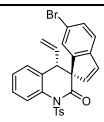


***rac*-3ea**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	37.095	BB	0.8888	5226.60693	86.76807	49.805
2	39.579	BB	0.8918	5267.45752	85.61821	50.194

HPLC spectrum of 3ea

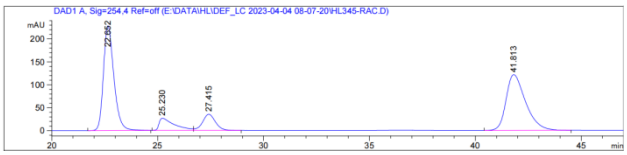


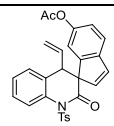


3ea

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	37.270	BV E	0.9048	3619.72266	55.80313	5.166
2	39.610	VB R	0.9977	6.64475e4	1012.42084	94.833

HPLC spectrum of racemic 3fa

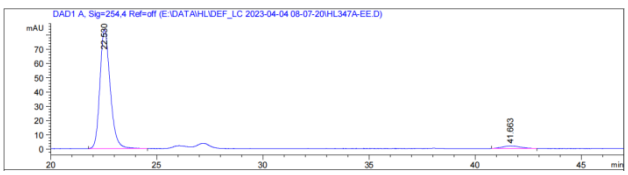


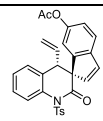


***rac*-3fa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.652	BB	0.5237	7823.64697	228.35587	42.5309
2	25.230	BV	0.6723	1314.18225	26.51469	7.1441
3	27.415	VB	0.6288	1484.92432	35.29906	8.0723
4	41.813	BB	0.9542	7772.47314	121.51455	42.2527

HPLC spectrum of 3fa

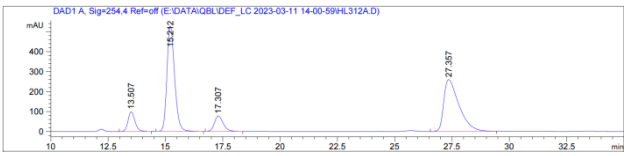


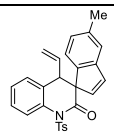


3fa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.530	BB	0.5103	2807.55371	83.48415	96.4136
2	41.663	BB	0.6732	104.43680	1.82606	3.5864

HPLC spectrum of racemic 3ga

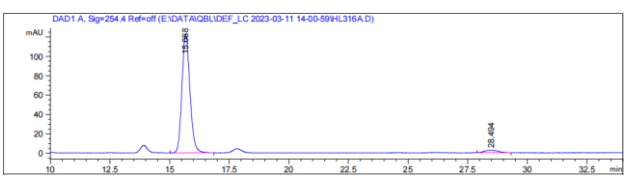


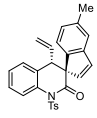


***rac*-3ga**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	13.507	BB	0.3220	2062.47632	98.60070	7.2965
2	15.212	BB	0.3583	1.22295e4	527.80243	43.2648
3	17.307	BB	0.4025	2032.24536	77.36565	7.1895
4	27.357	BB	0.6822	1.19424e4	258.89291	42.2492

HPLC spectrum of 3ga

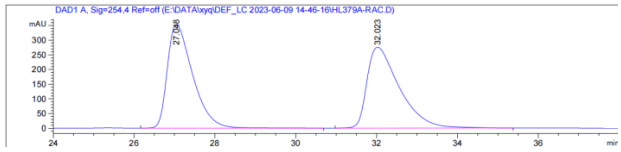


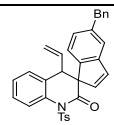


3ga

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.668	BB	0.3562	2859.39404	122.54195	96.4643
2	28.494	BB	0.4685	104.80539	2.69010	3.5357

HPLC spectrum of racemic 3ha

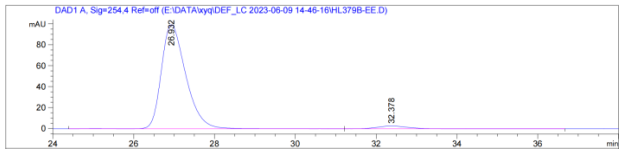


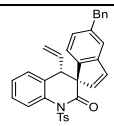


***rac*-3ha**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.048	BB	0.6601	1.53395e4	353.58615	49.9934
2	32.023	BB	0.8317	1.53435e4	275.54031	50.0066

HPLC spectrum of 3ha

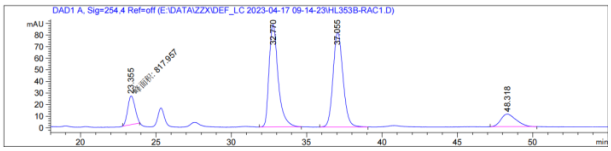


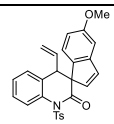


3ha

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	26.932	VV R	0.6510	4179.10352	99.30707	96.7785
2	32.378	VB	0.8108	139.11108	2.62276	3.2215

HPLC spectrum of racemic 3ia

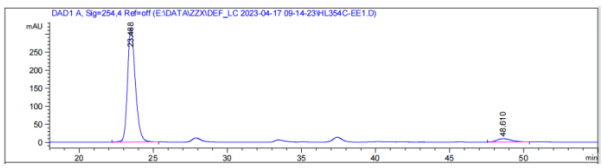


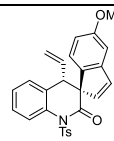


***rac*-3ia**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	23.355	MM	0.5538	817.95679	24.61469	9.0627
2	32.770	BB	0.6614	3696.87158	88.13589	40.9600
3	37.055	BB	0.6968	3744.16919	81.67739	41.4841
4	48.318	BB	0.8379	766.56287	10.82832	8.4932

HPLC spectrum of 3ia

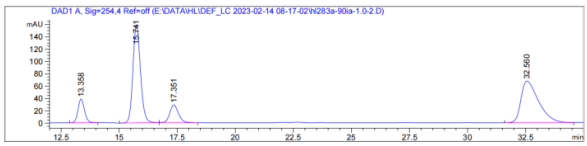


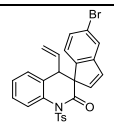


3ia

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	23.488	BB	0.5595	1.16573e4	316.63455	94.8480
2	48.610	BB	0.8175	633.20819	9.14819	5.1520

HPLC spectrum of racemic 3ja

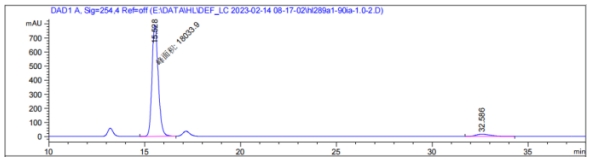


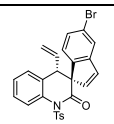


***rac*-3ja**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	13.358	BB	0.2974	750.95074	38.53163	8.6795
2	15.741	BB	0.3482	3604.12354	159.17711	41.6564
3	17.351	BB	0.3959	744.09656	28.75341	8.6003
4	32.560	BB	0.7605	3552.85059	67.67094	41.0638

HPLC spectrum of 3ja

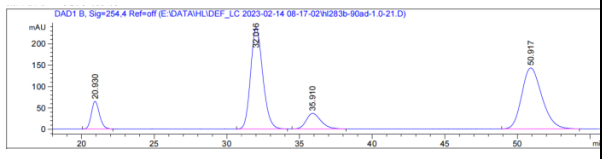


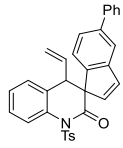


3ja

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.528	MM	0.3785	1.80339e4	794.05481	95.5235
2	32.586	BB	0.6756	845.11310	16.89570	4.4765

HPLC spectrum of racemic 3ka

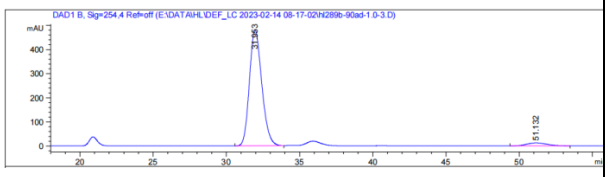


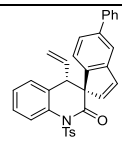


***rac*-3ka**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	20.930	BB	0.6003	2497.46460	64.42068	7.6866
2	32.016	BB	0.8831	1.37506e4	236.21318	42.3208
3	35.910	BB	0.9306	2512.97949	36.07872	7.7343
4	50.917	BB	1.3447	1.37303e4	142.42239	42.2583

HPLC spectrum of 3ka

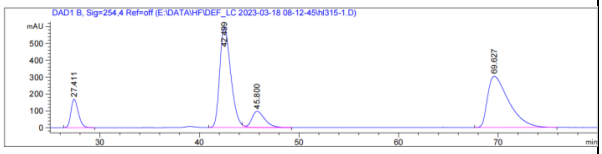


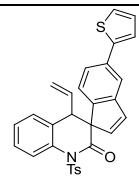


3ka

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	31.953	BB	0.8979	2.81663e4	480.47113	96.0279
2	51.132	BB	1.1272	1165.07983	12.21028	3.9721

HPLC spectrum of racemic 3la

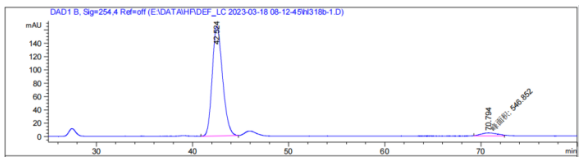


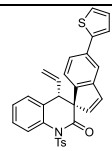


***rac*-3la**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.411	BB	0.7960	8691.08887	168.42078	8.0206
2	42.499	BV R	1.1517	4.61223e4	598.05658	42.5638
3	45.800	VB E	1.2049	8607.98242	96.47797	7.9439
4	69.627	BB	2.0279	4.49389e4	304.13571	41.4718

HPLC spectrum of 3la

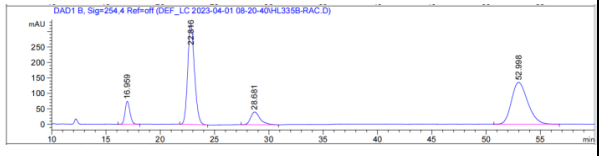


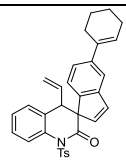


3la

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	42.524	BB	1.1305	1.22822e4	164.23651	95.7374
2	70.794	MM	1.9702	546.85229	4.62612	4.2626

HPLC spectrum of racemic 3ma

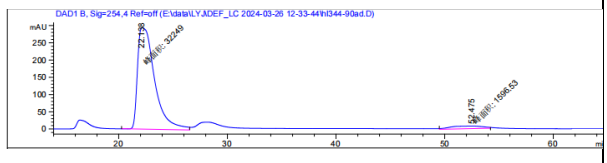


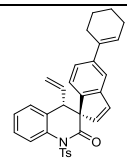


***rac*-3ma**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.959	BB	0.4834	2328.20215	74.33793	7.0734
2	22.816	BB	0.6597	1.40419e4	322.67844	42.6610
3	28.681	BB	0.9172	2468.67773	41.19395	7.5001
4	52.998	BB	1.5400	1.40763e4	135.26993	42.7655

HPLC spectrum of 3ma

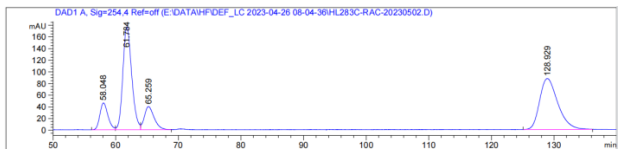


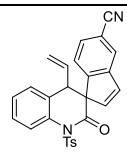


3ma

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.138	MM	1.8271	3.22490e4	294.17593	95.2829
2	52.475	MM	3.6039	1596.53406	7.38342	4.7171

HPLC spectrum of racemic 3na

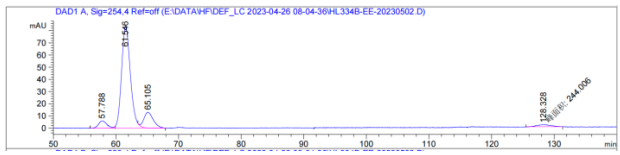


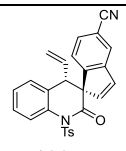


***rac*-3na**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	58.048	BV	1.3164	4122.10498	46.04667	9.5291
2	61.784	VV	1.5081	1.73588e4	176.39973	40.1283
3	65.259	VB	1.4792	4284.85254	39.57546	9.9053
4	128.929	BB	2.3637	1.74924e4	87.22348	40.4373

HPLC spectrum of 3na

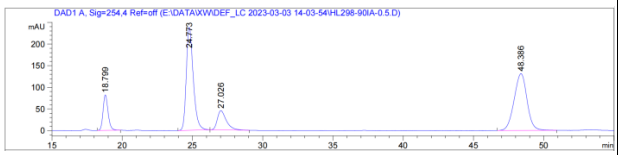


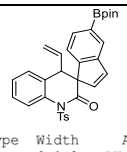


3na

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	57.788	BV E	1.0890	556.55969	6.09689	5.3447
2	61.546	VV R	1.4703	8283.10547	84.01314	79.5431
3	65.105	VB E	1.3448	1329.68359	12.83365	12.7690
4	128.328	MM	2.6282	244.00635	1.54736	2.3432

HPLC spectrum of racemic 3oa

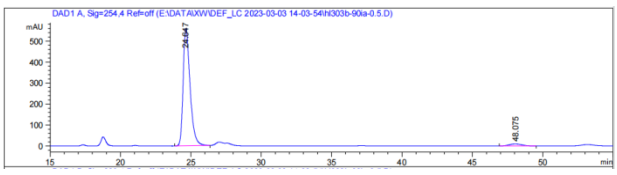


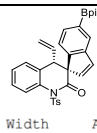


***rac*-3oa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.799	BB	0.3785	2041.21814	81.96458	9.9271
2	24.773	BB	0.5252	8185.13965	238.00629	39.8071
3	27.026	BB	0.6639	1988.78723	44.62706	9.6722
4	48.386	BB	0.9619	8346.84375	131.26118	40.5936

HPLC spectrum of 3oa

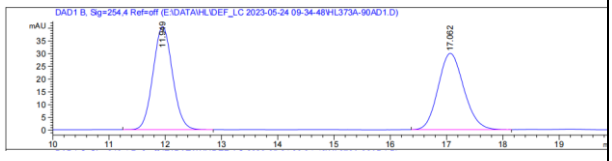




3oa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	24.647	BB	0.5210	1.91288e4	559.26935	96.9255
2	48.075	BB	0.7227	606.76495	10.01690	3.0745

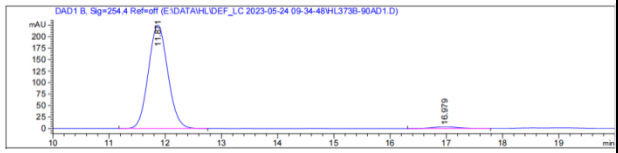
HPLC spectrum of racemic 3pa



***rac*-3pa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.949	BB	0.3742	970.03577	40.38537	50.5541
2	17.062	BB	0.4844	948.77020	29.88663	49.4459

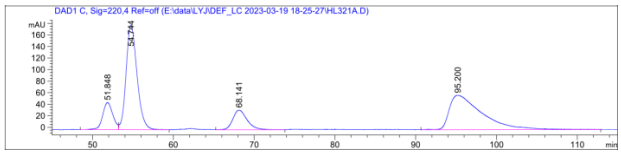
HPLC spectrum of 3pa

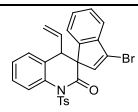


3pa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	11.871	BB	0.3738	5381.51123	224.42938	97.9259
2	16.979	BB	0.4556	113.98019	3.63704	2.0741

HPLC spectrum of racemic 3qa

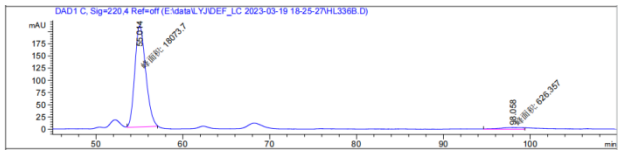


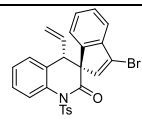


***rac*-3qa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	51.848	BV	1.3401	4107.91650	46.97926	9.7668
2	54.744	VB	1.4510	1.70211e4	180.69141	40.4684
3	68.141	BB	1.8725	4147.49854	33.96795	9.8609
4	95.200	BB	3.9807	1.67837e4	59.46859	39.9039

HPLC spectrum of 3qa

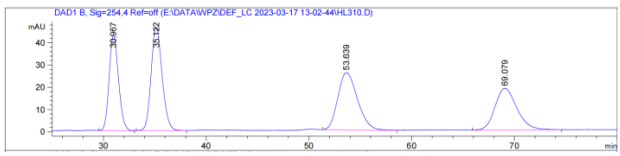


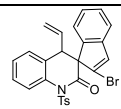


3qa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	55.014	MM	1.4526	1.80737e4	207.36961	96.6505
2	98.058	MM	3.0914	626.35669	3.37688	3.3495

HPLC spectrum of racemic 3ra

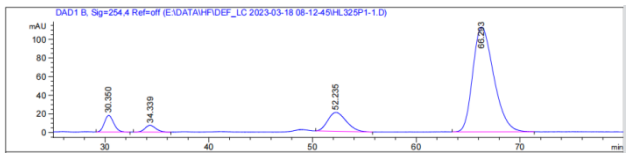


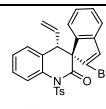


***rac*-3ra**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.967	BB	0.9757	2719.98462	42.67128	21.9516
2	35.122	BB	1.1414	3462.26099	46.46345	27.9422
3	53.639	BB	1.9645	3418.00977	25.75257	27.5851
4	69.079	BB	2.1778	2790.54688	18.82055	22.5211

HPLC spectrum of 3ra

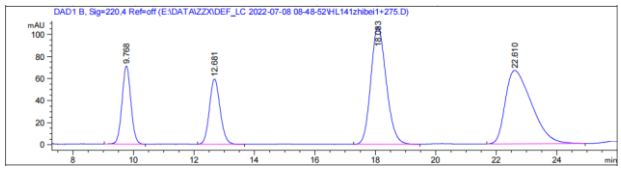


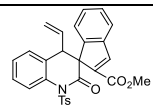


3ra

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.350	BB	0.9493	1115.61951	17.74875	5.6020
2	34.339	BB	0.9011	531.17041	7.26415	2.6672
3	52.235	BB	1.4698	2503.35449	20.20057	12.5704
4	66.293	BB	2.0925	1.57645e4	112.38577	79.1604

HPLC spectrum of racemic 3sa

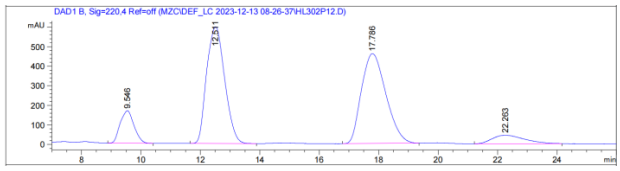


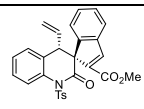


***rac*-3sa**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.768	BB	0.3140	1442.44153	70.70805	13.5557
2	12.681	BB	0.3795	1444.71545	59.02767	13.5771
3	18.083	BB	0.5443	3758.04346	106.35136	35.3171
4	22.610	BB	0.8766	3995.64893	66.35068	37.5501

HPLC spectrum of 3sa

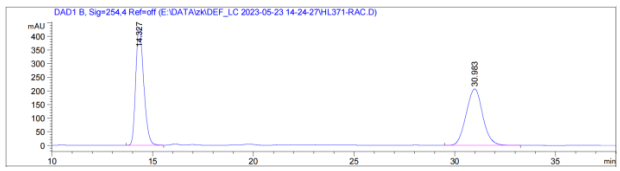


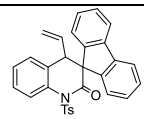


3sa

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	9.546	BV R	0.4413	5356.16699	165.60658	8.9276
2	12.511	BV R	0.6134	2.51081e4	596.09613	41.8499
3	17.786	BB	0.7174	2.62756e4	459.33301	43.7958
4	22.263	VB R	0.8822	3255.78027	43.85217	5.4267

HPLC spectrum of racemic 3ta

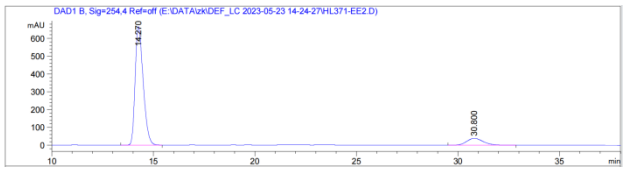


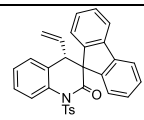


***rac*-3ta**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.327	BB	0.4246	1.18629e4	431.69141	50.0829
2	30.983	BB	0.8885	1.18237e4	206.95361	49.9171

HPLC spectrum of 3ta

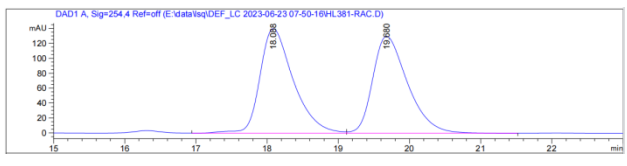


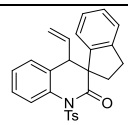


3ta

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	14.270	BB	0.4245	1.82747e4	665.15302	89.3363
2	30.800	BB	0.8748	2181.37524	38.51583	10.6637

HPLC spectrum of racemic 3ua

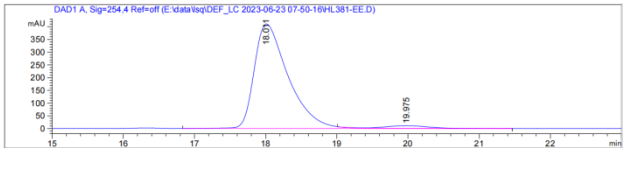


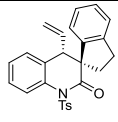


***rac*-3ua**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.088	VV	0.4897	4592.12305	140.36517	50.8706
2	19.680	VB	0.5177	4434.94678	130.09996	49.1294

HPLC spectrum of 3ua

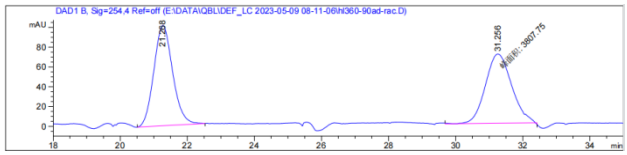


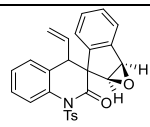


3ua

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.011	BV R	0.4972	1.35437e4	410.18701	96.6832
2	19.975	VB E	0.6678	464.62540	10.75890	3.3168

HPLC spectrum of racemic 4a

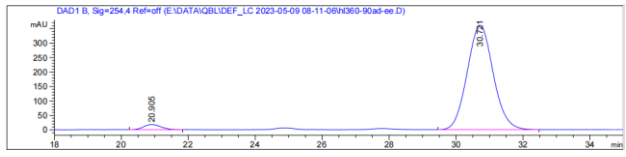


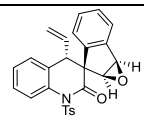


***rac*-4a**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	21.268	BB	0.5888	3956.06519	101.47679	50.9552
2	31.256	MM	0.9057	3807.74683	70.06674	49.0448

HPLC spectrum of 4a

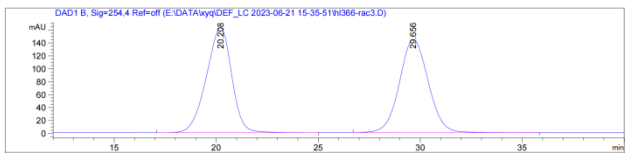


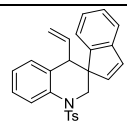


4a

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	20.905	BB	0.4604	649.56207	17.85642	3.2306
2	30.721	BB	0.8311	1.94568e4	360.84402	96.7694

HPLC spectrum of racemic 4b

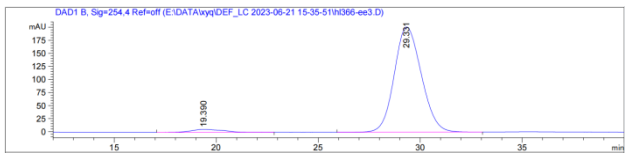


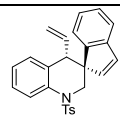


***rac*-4b**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	20.208	BB	1.3357	1.39358e4	161.98613	49.7626
2	29.656	BB	1.5159	1.40687e4	143.48932	50.2374

HPLC spectrum of 4b

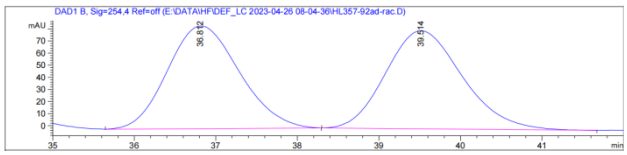


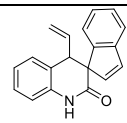


4b

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.390	BB	1.4662	610.72046	5.73591	3.1758
2	29.331	BB	1.4306	1.86199e4	201.40834	96.8242

HPLC spectrum of racemic 4c

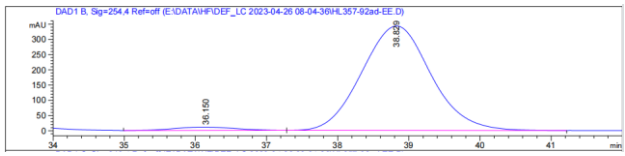


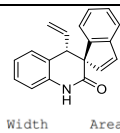


***rac*-4c**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	36.812	BB	0.8105	5215.11914	84.91241	49.5621
2	39.514	BB	0.9117	5307.27002	81.07278	50.4379

HPLC spectrum of 4c

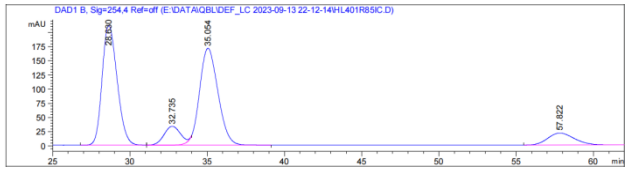


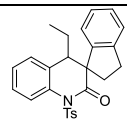


4c

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	36.150	BB	0.7248	681.24554	11.27609	2.8501
2	38.829	BB	1.0038	2.32213e4	343.01492	97.1499

HPLC spectrum of racemic 4d

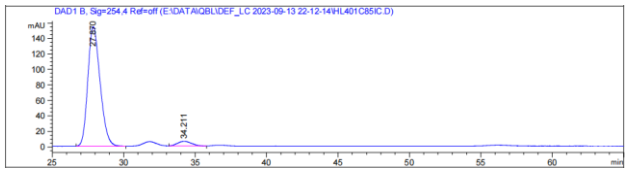


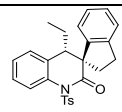


***rac*-4d**

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	28.630	BV	1.0491	1.42749e4	211.06267	42.5614
2	32.735	VV E	1.1045	2430.67896	33.11080	7.2472
3	35.054	VB R	1.3116	1.42840e4	170.81622	42.5887
4	57.822	BB	1.6367	2549.88721	21.05850	7.6027

HPLC spectrum of 4d





4d

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.870	BB	0.9014	9181.82715	154.04274	95.7462
2	34.211	BB	0.8019	407.92734	6.04058	4.2538