Supporting Information

Asymmetric Organocatalytic Synthesis of 4,6-Bis(1*H*-indole-3-yl)-piperidine-2 carboxylates

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1 Materials and methods

^{1}H NMR spectra were recorded on a BRUKER Avance 300 (300 MHz), an AGILENT Technologies 400-MR (400/54 Premium Shielded) (400 MHz), a VARIAN 400-MR (400 MHz), a BRUKER Avance 400 (400 MHz), or a BRUKER Avance 600 (600 MHz) device as solutions at room temperature. Chemical shifts are expressed in parts per million (ppm, δ), downfield from tetramethylsilane (TMS) and referenced to chloroform (7.26 ppm) or acetone-d_5 (2.05 ppm) as internal standards. All coupling constants are absolute values and *J* values are expressed in Hertz (Hz). The spectra were analyzed according to first order and the descriptions of signals include: s = singlet, bs = broad singlet, d = doublet, dd = doublet of doublets, t = triplet, q = quartet, m = multiplet. **^{13}C NMR** spectra were recorded on a BRUKER Avance 300 (75 MHz), an AGILENT Technologies 400-MR (400/54 Premium Shielded) (100 MHz), a VARIAN 400-MR (100 MHz), a BRUKER Avance 400 (100 MHz), or a BRUKER Avance 600 (125 MHz) device as solutions at room temperature. Chemical shifts are expressed in parts per million (ppm, δ), downfield from tetramethylsilane (TMS) and referenced to $CDCl_3$ (77.0 ppm) or acetone-d_6 (29.8 ppm) as internal standards. The signal structure was analyzed by DEPT and is described as follows: + = primary or tertiary C-atom (positive signal), – = secondary C-atom (negative signal), and C_q = quaternary C-atom (no signal).

EI-MS (electron impact mass spectrometry) and **FAB-MS** (fast atom bombardment mass spectrometry) were performed by using a *Finnigan* MAT 90 (70 eV). The molecular fragments are quoted as the relation between mass and charge (*m/z*), the intensities as a percentaged value relative to the intensity of the base signal (100%). The abbreviation $[M]^+$ refers to the molecule ion. ESI-MS was performed by using an *Agilent* 6230 TOF LC/MS.

IR (infrared spectroscopy) data were recorded on FT-IR *Bruker* IFS 88 and are reported as follows: frequency of absorption (cm^{-1}), intensity of absorption (s = strong, m = medium, w = weak, br = broad).

Optical rotations were determined on a *Perkin Elmer* 241 polarimeter at 20 °C with a glass cuvette (l = 1 dm) and the D line of sodium. The values were calculated according to the following formula: $[\alpha]_D^{20} = \alpha/\beta \times d$ with D = sodium D line (λ = 589.3 nm); α = average of the obtained optical rotations; d = length of the cuvette (in dm, d = 1); β = concentration in

g/ml. Information is given as, e.g. $[\alpha]_D^{20}$ = –64.8 (c = 0.58, $CHCl_3$) with c = concentration in g/100 mL.

HPLC-determination of *ee*s was performed on either a *Waters* HPLC device (*Waters* Temperature Control Module II, *Waters* 515 HPLC Pump, and *Waters* 2489 UV/Visible Detector) or a Varian 920-LC (with a chiller/heater by *Echo therm*, C030) with chirally modified columns by *Chiralpak*®.

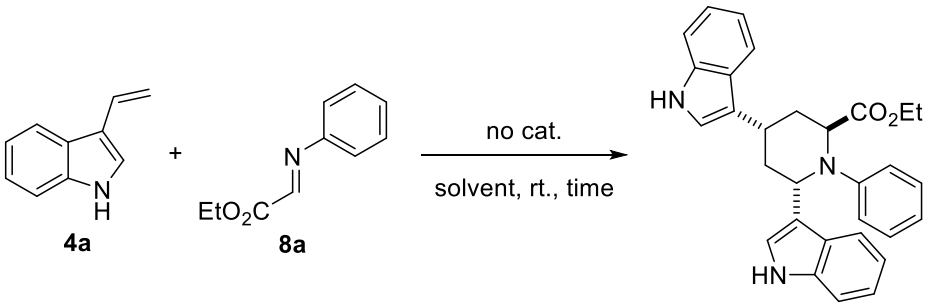
CD measurements were performed using a JASCO J-815-150S CD spectrometer. A solution of the product (0.05 mg/mL in methanol) was prepared and transferred in a 1-mm thick quartz cell. The spectrum was measured at 293 K.

Reactions were monitored by silica gel coated glass plates (*Huanghai* GF254) or by silica gel coated aluminium plates (*Merck*, silica gel 60, F_{254}). Detection was performed by examination under UV light (254 nm) and by staining with molybdato phosphate (5% phosphor molybdic acid in ethanol) or potassium permanganate (0.75% $KMnO_4$ in H_2O). Solvents, reagents and chemicals were purchased from *Sinopharm*, *Aladdin Chemistry Co., Ltd.*, *Jinxie*, *Sigma-Aldrich*, *ABCR*, and *Fisher Scientific*. Catalyst **16** was prepared according to a literature-known procedure.[1] Tetrahydrofuran was distilled from sodium/potassium prior to use. Dichloromethane was purchased from *Acros* over molecular sieves. Toluene was distilled from sodium. All reactions involving moisture sensitive reactants were executed under argon atmosphere using oven dried glassware. All other solvents, reagents and chemicals were used as purchased unless stated otherwise.

[1] W. Hu, J. Zhou, X. Xu, W. Liu, L. Gong, *Org. Synth.* **2011**, *88*, 406-417.

2 Optimization of reactions

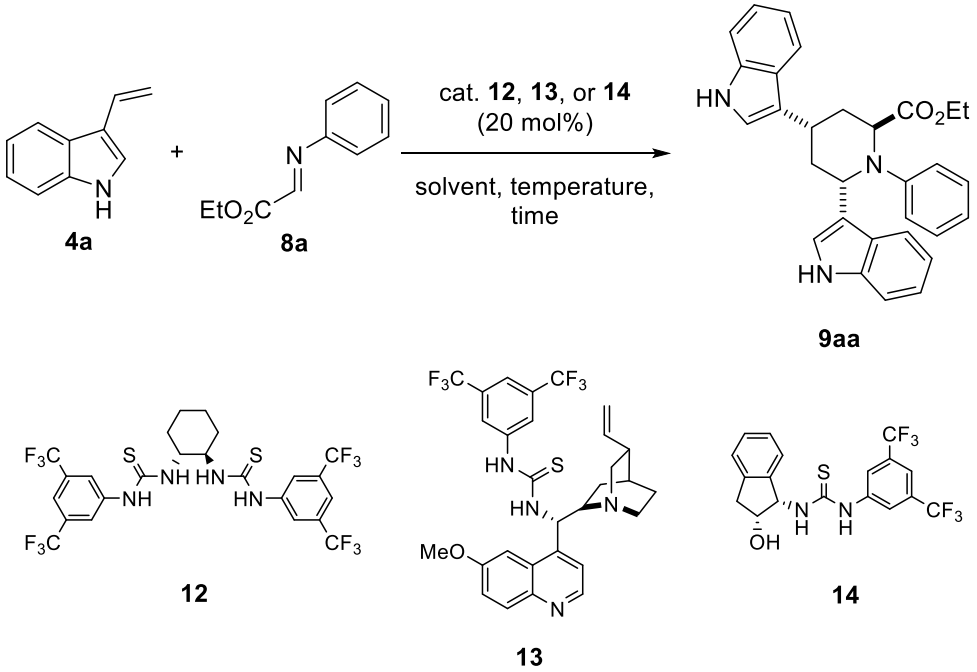
Table S1. Screening of reaction conditions without catalyst.



entry	Equivalents 4a:8a	solvent	time	yield[a]
1	2 : 1	toluene	1 h	25%
2	1 : 1	toluene	3.5 h	56%
3	2 : 1	CH_2Cl_2	5.5 h	35%
4	1 : 1.25	CH_2Cl_2	2.75 h	46%
5[b]	2 : 1	CH_2Cl_2	3 d	35%
6	1 : 1	CH_2Cl_2	1 d	43%
7	2 : 1	CH_2Cl_2	1 d	43%
8	3 : 1	CH_2Cl_2	1 d	43%
9[c]	2 : 1	CH_2Cl_2	1 d	35%
10	1 : 2	CH_2Cl_2	1 d	47%

Screening procedure: 3-vinylindole (**4a**, 0.1 mmol) was added in one portion to a solution of imine **8a** (0.05 mmol) in the solvent (1 mL). After consumption of the starting material the crude mixture was purified *via* preparative TLC (petrol ether/ethyl acetate 3:1). [a] Isolated yield after preparative TLC; [b] diluted reaction mixture (5 mL); [c] inverse experimental procedure: a solution of imine **8a** was slowly added to 3-vinylindole (**4a**).

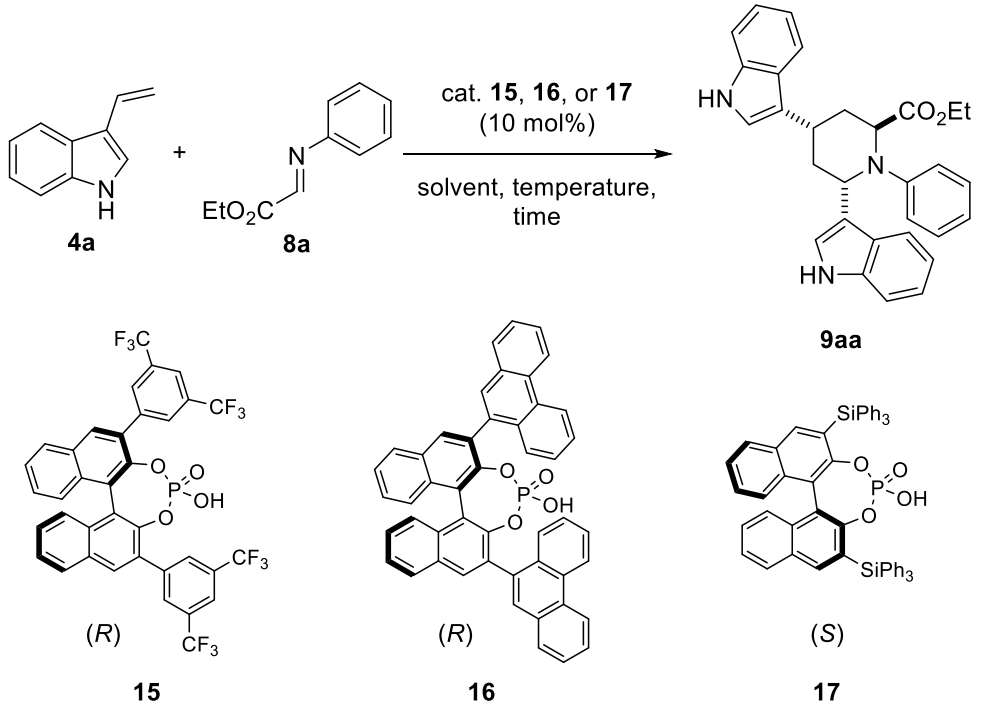
Table S2. Screening of reaction conditions with chiral thioureas **12**–**14**.



entry	equivalents 4a:8a	cat.	solvent	temp.	yield[a]	*ee*[b]
1	1 : 1	**12**	*n*hexane:toluene 2 : 1	rt.	22%	3%
2	2 : 1	**12**	CH_2Cl_2	–78 °C	13%	3%
3	1 : 1	**13**	*n*hexane:toluene 2 : 1	rt.	15%	0%
4	2 : 1	**14**	CH_2Cl_2	rt.	52%	2%
5	2 : 1	**14**	*n*hexane	rt.	13%	7.5%
6	2 : 1	**14**	Et_2O	rt.	30%	1.5%
7	2 : 1	**14**	THF	rt.	No reaction	-
8	2 : 1	**14**	MeCN	rt.	17%	1%
9	2 : 1	**14**	toluene	rt.	traces	-

Screening procedure: The catalyst, then 3-vinylindole (**4a**, 0.1 mmol) were added to a solution of imine **8a** (0.05–0.1 mmol) in dry solvent (1 mL). After consumption of the starting material the crude mixture was purified *via* preparative TLC (petrol ether/ethyl acetate 3:1). [a] Isolated yield; [b] determined by HPLC.

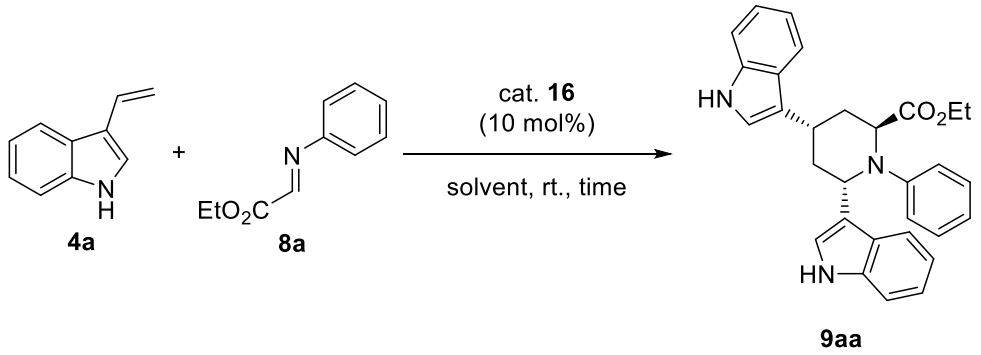
Table S3. Screening of chiral phosphoric acid catalysts.



entry	equivalents 4a:8a	cat.	solvent, additive	temp.	time	yield[a]	*ee*[b]
1	1.5 : 1	**15**	toluene	rt.	2 h	46%	69%
2	2 : 1	**15**	toluene	0 °C	2.5 h	51%	56%
3[c]	2 : 1	**15**	toluene	0 °C	5 h	54%	54%
4	2 : 1	**16**	toluene	rt.	2 h	47%	88%
5	2 : 1	**16**	toluene	–78 °C	5 h	traces	n.d.
6	2 : 1	**16**	toluene	–40 °C	4 h	30%	79%
7	1 : 1	**16**	toluene	rt.	2.5 h	61%	91%
9	1 : 1	**16**	toluene, MS 4 Å	rt.	2.5 h	13%	92%
10	1 : 1	**16**	toluene	50 °C	20 min	69%	91%
11	1 : 1	**16**	toluene, $MgSO_4$	rt.	2.5 h	47%	89%
12	1 : 1	**17**	toluene	rt.	1 h	43%	72%

Screening procedure: The catalyst, then 3-vinylindole (**4a**, 0.1 mmol) were added to a solution of imine **8a** (0.05–0.1 mmol) in dry solvent (1 mL). After consumption of the starting material the crude mixture was purified *via* preparative TLC (petrol ether/ethyl acetate 3:1). [a] Isolated yield; [b] determined by HPLC; [c] imine **8a** was prepared *in situ*: aniline (0.05 mmol), toluene (1 mL), ethyl glyoxylate (0.05 mmol), catalyst **15** (10 mol%), and 3-vinylindole (**4a**, 0.1 mmol) were subsequently added to a flask at 0 °C; n.d. = not determined.

Table S4. Screening of solvents.

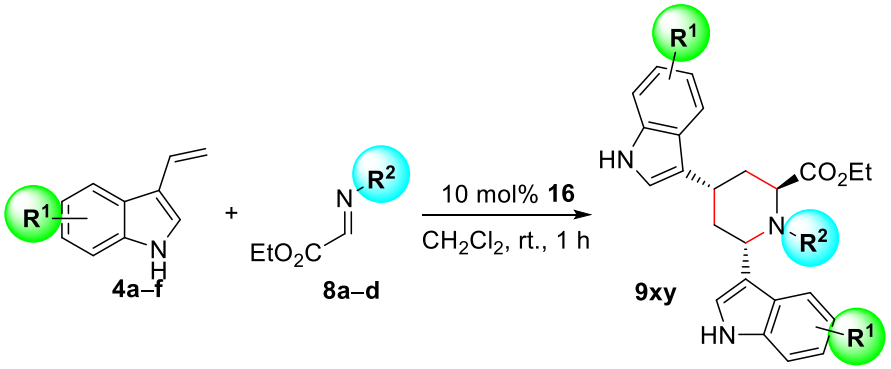


4a **8a** **9aa**

entry	equivalents 4a:8a	solvent	time	yield[a]	*ee*[b]
1	1:1	toluene	60 min	60%	92%
2	1:1	THF	4.5 h	70%	91%
3	1:1	Et_2O	70 min	65%	93%
4	1:1	CH_2Cl_2	60 min	64%	94%
5	1:1	MeCN	90 min	67%	87%
6[c]	2:1	CH_2Cl_2	60 min	57%	94%
7	3:1	CH_2Cl_2	60 min	61%	98%

Screening procedure: Catalyst **16**, then 3-vinylindole (**4a**, 0.1 mmol) were added to a solution of imine **8a** (0.1 mmol) in dry solvent (1 mL). After consumption of the starting material the crude mixture was purified *via* preparative TLC (entries 1–5: petrol ether/ethyl acetate 3:1; entry 7: cyclohexane/ethyl acetate 3:1) or *via* column chromatography (entry 6: cyclohexane/ethyl acetate 3:1). [a] Isolated yield; [b] determined by HPLC; [c] reaction was performed on a gram scale (14 mmol of **4a** and 7 mmol of **8a**).

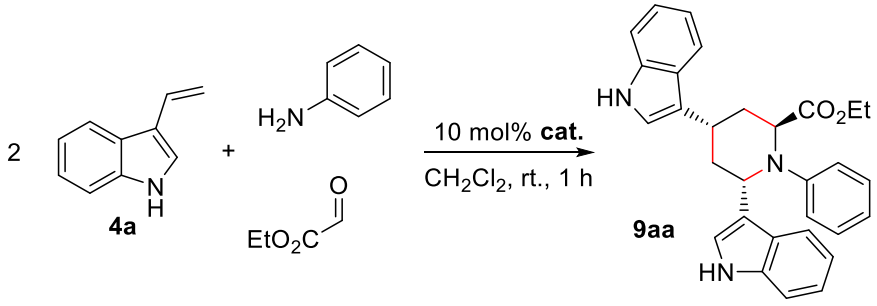
Table S5. Synthesis of bisindole derivatives.



entry	equivalents 4x:8y	R^1 (4x)	R^2 (8y)	yield[a]	*ee*[b]
1	1:1	H (**4a**)	Ph (**8a**)	64% **9aa**	94%
2	1:1	5-Br (**4b**)	Ph (**8a**)	51% **9ba**	90%
3	2:1	7-Me (**4c**)	Ph (**8a**)	43% **9ca**	>99%
4	2:1	5-Br (**4b**)	3,5-Dimethyl-phenyl (**8b**)	58% **9bb**	94%
5	2:1	H (**4a**)	4-OMe-C_6H_4 (**8c**)	56% **9ac**	97%
6	2:1	H (**4a**)	4-Br-C_6H_4 (**8d**)	28% **9ad**	93%
7	2:1	5-OMe (**4d**)	Ph (**8a**)	21% **9da**	87%
8	2:1	5-Br-7-Me (**4e**)	Ph (**8a**)	25% **9ea**	75%
9	2:1	6-F (**4f**)	Ph (**8a**)	34% **9fa**	89%
10	2:1	6-F (**4f**)	4-OMe-C_6H_4 (**8c**)	48% **9fc**	n.d.

Screening procedure: The catalyst (10 mol%), then 3-vinylindole derivative (**4x**, 0.1–0.2 mmol) were added to a solution of imine **8y** (0.05–0.1 mmol) in dry dichloromethane (1–2 mL). After 1 h the crude mixture was purified *via* preparative TLC (cyclohexane/ethyl acetate). [a] Isolated yield; [b] determined by HPLC; n.d. = not determined, as no separation of the enantiomers could be achieved.

Table S6. Four-component reactions.

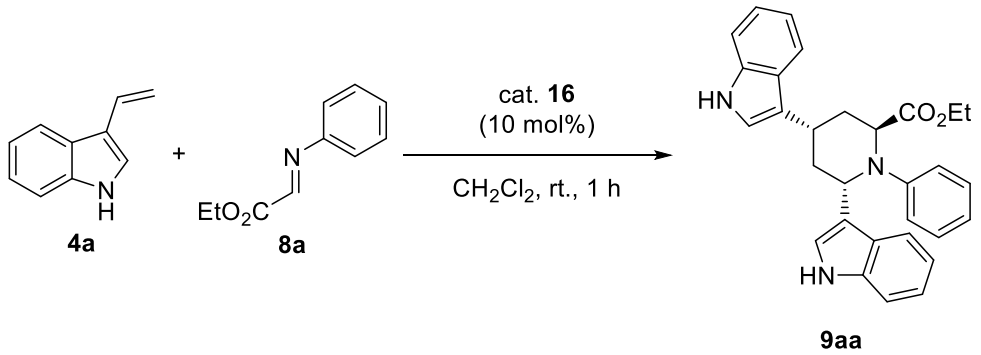


entry	Amount (4a:aniline:ethyl glyoxylate)	cat.	solvent	time	temp.	yield[a]	*ee*[b]
1[c]	0.1:0.05:0.05 mmol	**15**	toluene	5 h	0 °C	54%	54%
2	0.2:0.1:0.1 mmol	**16**	CH_2Cl_2 + 20 mg $MgSO_4$	1 h	rt.	30%	91%

Procedure: Aniline, the solvent (entry 1: 1 mL; entry 2: 2 mL), ethyl glyoxylate, the catalyst (10 mol%), and 3-vinylindole (**4a**) were subsequently added to a flask. After consumption of the starting material the crude mixture was purified *via* preparative TLC (petrol ether/ethyl acetate 3:1 or cyclohexane/ethyl acetate 2:1). [a] Isolated yield; [b] determined by HPLC; [c] see also Table S3, entry 3.

We generally discovered that adding anhydrous $MgSO_4$ (entry 2) led to lower yields of product **9aa** (see also: Table S3, entry 11). This implies that working in absolute solvents is not necessary for the reaction, as in entry 1 the yield was good even though the condensing water was not removed from the reaction mixture.

Table S7. Recycling of the catalyst.



cycle	yield[a]	*ee*[b]
1	52%	89%
2	32%	89%
3	23%	94%
4	40%	94%

Procedure: The catalyst **16** (10 mol%) and 3-vinylindole (0.2 mmol) were added to a solution of imine **8a** (0.1 mmol) in dichloromethane (2 mL) and it was stirred at rt. for 1 h. The crude mixture was purified *via* preparative TLC (cyclohexane/ethyl acetate = 2:1). Catalyst **16** was reisolated from the baseline of the TLC, dissolved in CH_2Cl_2/MeOH 98:2, and concentrated. To the residue were added again imine **8a**, dichloromethane (2 mL), and 3-vinylindole (**4a**) for the second reaction cycle, and so forth. [a] Isolated yield after preparative TLC; [b] determined by HPLC.

3 General procedures

General procedure A for the preparation of 3-vinylindoles by Wittig olefination:

To a suspension of methyltriphenyl phosphonium iodide (1.15 equiv.) in abs. THF (4 mL per mmol) was added *n*-BuLi (2.5 M in hexanes, 1.00 equiv.) dropwise at –50 °C. It was allowed to warm up to 0 °C over 1 h. Then, it was cooled to –30 °C and treated with a mixture of indole-3-carboxaldehyde (1.00 equiv.), THF (1.4 mL per mmol) and NaHMDS (1 M in THF, 1.00 equiv.). It was stirred at rt. until TLC control showed complete consumption of the starting material. The reaction mixture was poured into H_2O (12 mL per mmol), the phases were separated, the aqueous phase was extracted with Et_2O, and the combined organic layers were dried over Na_2SO_4 and concentrated. The product was obtained after column chromatography.

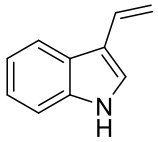
General procedure B for the asymmetric synthesis of functionalized bisindole piperidines:

A solution of imine **8y** (1.00 equiv.) in anhydrous CH_2Cl_2 (1–2 mL) was treated with catalyst **16** (10 mol%). Then, 3-vinylindole **4x** (1.00–2.00 equiv.) was added in one portion and the mixture stirred at rt. under an argon atmosphere for 1 h. The mixture was concentrated under reduced pressure and the residue purified by preparative TLC or column chromatography to give bisindole piperidines **9xy**.

Racemic samples for HPLC were prepared with the same procedure, but without addition of the catalyst.

4 Syntheses

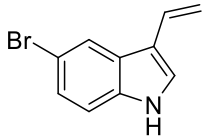
3-Vinyl-1*H*-indole (4a):



This compound was synthesized according to the **general procedure A** with indole-3-carboxaldehyde (2.90 g, 20.0 mmol); reaction time: 1 h. The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as an off-white powder (2.67 g, 93%).

***R*f** (cHex/EtOAc = 5:1) = 0.26. – **M. p.** = 88–91 °C. – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 5.08 (dd, $^{3}J_{cis}$ = 11.3, ^{2}J = 1.6 Hz, 1H, CH=C*H*H), 5.68 (dd, $^{3}J_{trans}$ = 17.9, ^{2}J = 1.6 Hz, 1H, CH=CH*H*), 6.93 (ddd, $^{3}J_{trans}$ = 17.9, $^{3}J_{cis}$ = 11.3, ^{4}J = 0.5 Hz, 1H, C*H*=CH_2), 7.07–7.19 (m, 2H, CH_{Ar}), 7.39–7.47 (m, 2H, CH_{Ar}), 7.87 (d, ^{3}J = 7.8 Hz, 1H, CH_{Ar}), 10.34 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 109.6 (–, CH=*C*H_2), 112.5 (+, C*H*), 115.7 (C_q), 120.5 (+, C*H*), 120.6 (+, C*H*), 122.7 (+, C*H*), 125.7 (+, C*H*), 126.6 (C_q), 131.1 (+, C*H*), 138.2 (C_q) ppm. – **IR (ATR):** ν^{-1} = 3387 (m), 3099 (w), 3055 (w), 1631 (m), 1566 (w), 1526 (w), 1455 (m), 1425 (m), 1413 (m), 1352 (w), 1332 (w), 1247 (m), 1096 (m), 1033 (w), 990 (m), 929 (w), 874 (m), 825 (m), 738 (s), 686 (m), 594 (m), 509 (m), 425 (m) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 143 (100) $[M]^+$, 115 (45) $[C_8H_5N]^+$. – **HRMS** (EI, $C_{10}H_9N$): calcd. 143.0730; found: 143.0732.

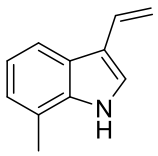
5-Bromo-3-vinyl-1*H*-indole (4b):



This compound was synthesized according to the **general procedure A** with 5-bromo-indole-3-carboxaldehyde (448 mg, 2.00 mmol); reaction time: 14 h (overnight). The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as a white powder (262 mg, 59%).

***R*f** (cHex/EtOAc = 5:1) = 0.21. – **M. p.** = 76–78 °C. – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 5.11 (dd, $^{3}J_{cis}$ = 11.4, ^{2}J = 1.2 Hz, 1H, CH=C*H*H), 5.66 (dd, $^{3}J_{trans}$ = 17.9, ^{2}J = 1.2 Hz, 1H, CH=CH*H*), 6.90 (dd, $^{3}J_{trans}$ = 17.9, $^{3}J_{cis}$ = 11.4 Hz, 1H, *C*H=CH$_2$), 7.27 (dd, ^{3}J = 8.6, ^{4}J = 1.9 Hz, 1H, C*H*$_{Ar}$), 7.41 (d, ^{3}J = 8.6 Hz, 1H, C*H*$_{Ar}$), 7.53 (d, ^{3}J = 2.5 Hz, 1H, C*H*$_{Ar}$), 8.00 (d, *J* = 1.6 Hz, 1H, C*H*$_{Ar}$), 10.55 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 110.5 (–, CH=*C*H$_2$), 113.5 (C$_q$), 114.4 (+, C*H*), 115.4 (C$_q$), 122.8 (+, C*H*), 125.3 (+, C*H*), 126.9 (+, C*H*), 128.3 (C$_q$), 130.3 (+, C*H*), 136.8 (C$_q$) ppm. – **IR (ATR):** ν^{-1} = 3419 (w), 2919 (vw), 1691 (vw), 1628 (w), 1557 (vw), 1524 (vw), 1456 (w), 1335 (vw), 1243 (w), 1136 (vw), 1096 (w), 1050 (vw), 997 (w), 879 (w), 830 (vw), 795 (w), 753 (vw), 727 (vw), 630 (vw), 580 (w), 549 (vw), 492 (w), 416 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 223/221 (99/100) [M]$^+$, 142 (20) [M – Br]$^+$, 115 (53) [C_8H_5N]$^+$. – **HRMS** (EI, $C_{10}H_8NBr$): calcd. 220.9840; found: 220.9842.

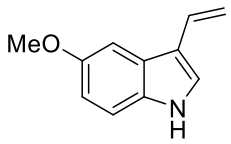
7-Methyl-3-vinyl-1*H*-indole (4c):



This compound was synthesized according to the **general procedure A** with 7-methyl-indole-3-carboxaldehyde (478 mg, 2.00 mmol); reaction time: 14 h (overnight). The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as a white powder (157 mg, 33%).

***R*f** (cHex/EtOAc = 5:1) = 0.32. – **M. p.** = 108–110 °C. – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 2.49 (s, 3H, C*H*$_3$), 5.06 (dd, $^{3}J_{cis}$ = 11.3, ^{2}J = 1.6 Hz, 1H, CH=C*H*H), 5.67 (dd, $^{3}J_{trans}$ = 17.8, ^{2}J = 1.6 Hz, 1H, CH=CH*H*), 6.91 (dd, $^{3}J_{trans}$ = 17.8, $^{3}J_{cis}$ = 11.3 Hz, 1H, *C*H=CH$_2$), 6.95–7.06 (m, 2H, C*H*$_{Ar}$), 7.43 (d, *J* = 2.6 Hz, 1H, C*H*$_{Ar}$), 7.70 (d, ^{3}J = 7.9 Hz, 1H, C*H*$_{Ar}$), 10.30 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 16.9 (+, *C*H$_3$), 109.5 (–, CH=*C*H$_2$), 116.2 (C$_q$), 118.3 (+, C*H*), 120.8 (+, C*H*), 121.7 (C$_q$), 123.3 (+, C*H*), 125.3 (+, C*H*), 126.3 (C$_q$), 131.2 (+, C*H*), 137.6 (C$_q$) ppm. – **IR (ATR):** ν^{-1} = 3388 (w), 1626 (m), 1524 (w), 1495 (vw), 1457 (w), 1433 (w), 1413 (w), 1376 (w), 1338 (w), 1281 (w), 1249 (w), 1218 (w), 1177 (w), 1099 (m), 1023 (w), 988 (w), 926 (w), 875 (m), 822 (w), 782 (m), 746 (m), 707 (m), 602 (w), 564 (w), 519 (m), 483 (m) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 157 (100) [M]$^+$, 128 (13), 77 (8). – **HRMS** (EI, $C_{11}H_{11}N$): calcd. 157.0886; found: 157.0887.

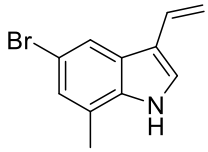
5-Methoxy-3-vinyl-1*H*-indole (4d):



This compound was synthesized according to the **general procedure A** with 5-methoxy-indole-3-carboxaldehyde (876 mg, 5.00 mmol); reaction time: 14 h (overnight). The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as a yellow oil (557 mg, 78%).

***R*$_f$** (cHex/EtOAc = 3:1) = 0.44. – **M. p.** = 111 °C. – **^{1}H NMR** (400 MHz, acetone-d$_6$): δ = 3.86 (s, 3H, OC*H*$_3$), 5.06 (dd, $^3J_{cis}$ = 11.3, ^2J = 1.6 Hz, 1H, CH=C*H*H), 5.64 (dd, $^3J_{trans}$ = 17.8, ^2J = 1.6 Hz, 1H, CH=CH*H*), 6.81 (dd, ^3J = 8.9, J = 2.3 Hz, 1H, C*H*$_{Ar}$), 6.90 (dd, $^3J_{trans}$ = 17.8, $^3J_{cis}$ = 11.3 Hz, 1H, C*H*=CH$_2$), 7.30–7.36 (m, 2H, C*H*$_{Ar}$), 7.41–7.43 (m, 1H, C*H*$_{Ar}$), 10.31 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d$_6$): δ = 55.9 (+, O*C*H$_3$), 102.5 (+, *C*H), 109.1 (–, CH=*C*H$_2$), 112.7 (+, *C*H), 113.1 (+, *C*H), 115.5 (C$_q$), 126.2 (+, *C*H), 127.0 (C$_q$), 131.2 (*C*H), 133.3 (C$_q$), 155.5 (+, *C*$_q$) ppm. – **IR (ATR):** $\tilde{\nu}^{-1}$ = 3403 (vw), 2920 (vw), 2828 (vw), 1709 (vw), 1621 (vw), 1578 (vw), 1480 (w), 1437 (w), 1345 (vw), 1285 (vw), 1250 (vw), 1208 (w), 1169 (w), 1094 (vw), 1024 (w), 921 (vw), 792 (w), 752 (vw), 606 (vw), 428 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 173 (100) [M]$^+$, 158 (47) [M – CH$_3$]$^+$, 143 (4), 130 (49), 115 (10), 103 (16), 77 (22), 69 (28), 57 (19), 43 (36). – **HRMS** (EI, C$_{11}$H$_{11}$NO): calcd. 173.0841; found: 173.0843.

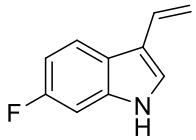
5-Bromo-7-methyl-3-vinyl-1*H*-indole (4e):



This compound was synthesized according to the **general procedure A** with 5-bromo-7-methyl-indole-3-carboxaldehyde (513 mg, 2.15 mmol); reaction time: 1.5 h. The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as a yellow oil (392 mg, 77%).

***R*f** (cHex/EtOAc = 5:1) = 0.23. – **^{1}H NMR** (300 MHz, acetone-d_6): δ = 2.50 (s, 3H, OC*H*$_3$), 5.10 (d, $^{3}J_{cis}$ = 11.3 Hz, 1H, CH=C*H*H), 5.65 (d, $^{3}J_{trans}$ = 17.7 Hz, 1H, CH=CH*H*), 6.89 (dd, $^{3}J_{trans}$ = 17.7, $^{3}J_{cis}$ = 11.3 Hz, 1H, *C*H=CH$_2$), 7.12 (s, 1H, C*H*$_{Ar}$), 7.50 (s, 1H, C*H*$_{Ar}$), 7.84 (s, 1H, C*H*$_{Ar}$), 10.52 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 16.6 (+, CH$_3$), 110.4 (–, CH=*C*H$_2$), 113.6 (C$_q$), 115.9 (C$_q$), 120.5 (+, *C*H), 122.7 (C$_q$), 125.6 (+, *C*H), 126.4 (+, *C*H), 127.8 (C$_q$), 130.4 (+, *C*H), 136.3 (C$_q$) ppm. – **IR (ATR):** ν^{-1} = 3423 (vw), 2921 (w), 2852 (w), 1692 (w), 1612 (vw), 1577 (vw), 1452 (w), 1377 (vw), 1310 (vw), 1251 (w), 1135 (vw), 1088 (vw), 1024 (vw), 868 (w), 842 (w), 808 (w), 741 (vw), 583 (w), 474 (vw) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 237/235 (53/47) [M]+, 219 (36), 181 (26), 169 (45), 156 (29) [M – Br]+, 131 (27), 119 (30), 69 (81), 43 (100). – **HRMS** (EI, $C_{11}H_{10}N^{79}Br$): calcd. 234.9991; found 234.9993.

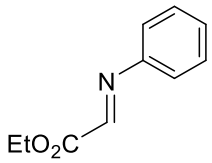
6-Fluoro-3-vinyl-1*H*-indole (4f):



This compound was synthesized according to the **general procedure A** with 6-fluoro-indole-3-carboxaldehyde (653 mg, 4.00 mmol); reaction time: 15 h. The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as an orange solid (476 mg, 74%).

***R*f** (cHex/EtOAc = 5:1) = 0.38. – **M. p.** = 43–45 °C. – **^{1}H NMR** (300 MHz, acetone-d_6): δ = 5.09 (dd, $^{3}J_{cis}$ = 11.3, ^{2}J = 1.3 Hz, 1H, CH=C*H*H), 5.67 (dd, $^{3}J_{trans}$ = 17.9, ^{2}J = 1.3 Hz, 1H, CH=CH*H*), 6.82–7.02 (m, 2H, C*H*), 7.18 (dd, ^{3}J = 9.9, ^{4}J = 2.3 Hz, 1H, C*H*$_{Ar}$), 7.46 (d, ^{4}J = 2.3 Hz, 1 H, C*H*$_{Ar}$), 7.48 (dd, ^{3}J = 8.7, J = 5.4 Hz, 1H, C*H*$_{Ar}$), 10.43 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 98.5 (+, d, ^{2}J = 25.8 Hz, *C*HCF), 108.9 (+, d, ^{2}J = 24.3 Hz, *C*HCF), 110.1 (–, CH=*C*H$_2$), 115.9 (C$_q$), 121.5 (+, d, ^{3}J = 12.7 Hz, *C*H$_{Ar}$), 123.3 (C$_q$), 126.3 (+, *C*H$_{Ar}$), 130.7 (+, *C*H=CH$_2$), 138.2 (C$_q$, d, ^{3}J = 12.7 Hz, *C*$_q$CHCF), 160.6 (C$_q$, d, ^{1}J = 235.6 Hz, *C*F) ppm. – **^{19}F NMR** (376 MHz, acetone-d_6): δ = –122.7 ppm. – **IR (ATR):** ν^{-1} = 3413 (w), 2923 (vw), 1706 (vw), 1621 (w), 1550 (vw), 1530 (vw), 1495 (w), 1453 (w), 1409 (vw), 1338 (w), 1302 (w), 1241 (w), 1134 (w), 1089 (w), 1043 (vw), 996 (vw), 951 (w), 875 (vw), 830 (vw), 798 (w), 592 (vw), 475 (w), 429 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 161 (100) [M]$^{+}$, 133 (35) [M – C_2H_4]$^{+}$. – **HRMS** (EI, $C_{10}H_8NF$): calcd. 161.0635; found 161.0636.

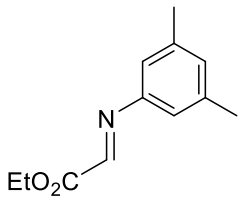
Ethyl 2-(phenylimino)acetate (8a):



To a solution of ethyl glyoxylate (50 wt.-% in toluene, 0.99 mL, 5.00 mmol, 1.00 equiv.) in dry toluene (2.5 mL) were added anhydrous $MgSO_4$ (1.00 g) and aniline (0.46 mL, 466 mg, 5.00 mmol, 1.00 equiv.). It was stirred at rt. for 1.5 h. Then the solids were filtered off and the solvent removed under reduced pressure. The product **8a** was obtained as a yellow oil (886 mg, 99%) and used in the next step without further purification.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.41 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 4.43 (q, ^3J = 7.1 Hz, 2H, CH_2CH_3), 7.26–7.30 (m, 2H, H_{Ar}), 7.32–7.36 (m, 1H, H_{Ar}), 7.39–7.44 (m, 2H, H_{Ar}), 7.91 (s, 1H, N=C*H*) ppm. – **^{13}C NMR** (100 MHz, $CDCl_3$): δ = 14.1 (+, CH_2CH_3), 62.1 (–, CH_2CH_3), 121.4 (+, 2 × CH_{Ar}), 128.5 (+, CH_{Ar}), 129.3 (+, 2 × CH_{Ar}), 148.8 (C_q, C_{Ar}), 151.2 (+, N=*C*H), 163.2 (C_q, CO_2Et) ppm.

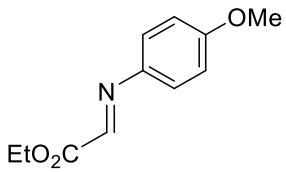
Ethyl 2-((3,5-dimethylphenyl)imino)acetate (8b):



To a solution of ethyl glyoxylate (50 wt.-% in toluene, 0.99 mL, 5.00 mmol, 1.00 equiv.) in dry toluene (2.5 mL) were added anhydrous $MgSO_4$ (1.00 g) and 3,5-dimethylaniline (606 mg, 5.00 mmol, 1.00 equiv.). It was stirred at rt. for 30 min. Then the solids were filtered off and the solvent removed under reduced pressure. The product **8b** was obtained as a yellow oil (840 mg, 82%) and used in the next step without further purification.

^{1}H NMR (300 MHz, acetone-d_6): δ = 1.38 (t, ^3J = 6.0 Hz, 3H, CH_2CH_3), 2.35 (s, 6H, 2 $C_{Ar}CH_3$), 4.24 (m, 2H, CH_2CH_3), 7.04–7.15 (m, 3H, H_{Ar}), 7.50 (s, 1H, N=C*H*) ppm. – **^{13}C NMR** (75 MHz, $CDCl_3$): δ = 14.2 (+, CH_2CH_3), 21.8 (+, 2 × C_qCH_3), 61.2 (–, CH_2CH_3), 124.0 (+, 2 CH_{Ar}), 129.8 (+, CH_{Ar}), 135.8 (+, N=*C*H), 137.6 (C_q, 2 × $C_{Ar}CH_3$), 149.8 (C_q, $C_{Ar}N$), 167.5 (C_q, CO_2Et) ppm.

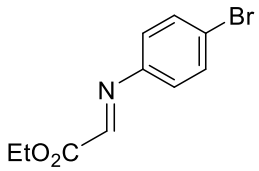
Ethyl 2-((4-methoxyphenyl)imino)acetate (8c):



To a solution of ethyl glyoxylate (50 wt.-% in toluene, 0.99 mL, 5.00 mmol, 1.00 equiv.) in dry toluene (2.5 mL) were added anhydrous $MgSO_4$ (1.00 g) and *p*-anisidine (616 mg, 5.00 mmol, 1.00 equiv.). It was stirred at rt. for 30 min. Then the solids were filtered off and the solvent removed under reduced pressure. The product **8c** was obtained as a brown oil (1.01 g, 98%) and used in the next step without further purification.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.40 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 3.84 (s, 3H, OCH_3), 4.42 (q, ^3J = 7.1 Hz, 2H, CH_2CH_3), 6.93 (d, ^3J = 9.1 Hz, 2H, H_{Ar}), 7.36 (d, ^3J = 9.1 Hz, 2H, H_{Ar}), 7.94 (s, 1H, NC*H*) ppm. – **^{13}C NMR** (100 MHz, $CDCl_3$): δ = 14.2 (+, CH_2CH_3), 55.5 (+, OCH_3), 61.9 (–, CH_2CH_3), 114.5 (+, 2 × CH_{Ar}), 123.6 (+, 2 × CH_{Ar}), 141.3 (C_q, NC_{Ar}), 148.0 (+, NCH), 160.5 (C_q, OC_{Ar}), 163.6 (C_q, CO_2Et) ppm.

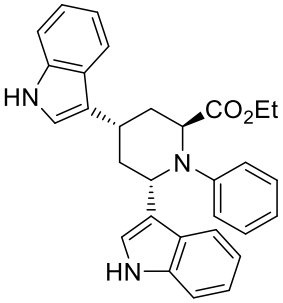
Ethyl 2-((4-bromophenyl)imino)acetate (8d):



To a solution of ethyl glyoxylate (50 wt.-% in toluene, 0.99 mL, 5.00 mmol, 1.00 equiv.) in dry toluene (2.5 mL) were added anhydrous $MgSO_4$ (1.00 g) and *p*-bromoaniline (860 mg, 5.00 mmol, 1.00 equiv.). It was stirred at rt. for 30 min. Then the solids were filtered off and the solvent removed under reduced pressure. The product **8d** was obtained as a yellow oil (1.02 g, 79%) and used in the next step without further purification.

^{1}H NMR (300 MHz, acetone-d_6): δ = 1.34 (t, ^3J = 7.2 Hz, 3H, CH_2CH_3), 4.33 (q, ^3J = 7.2 Hz, 2H, CH_2CH_3), 7.29 (d, ^3J = 8.7 Hz, 2H, H_{Ar}), 7.63 (d, ^3J = 8.7 Hz, 2H, H_{Ar}), 7.99 (s, 1H, NC*H*) ppm.

Ethyl (2*S*,4*S*,6*S*)-4,6-di(1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9aa):



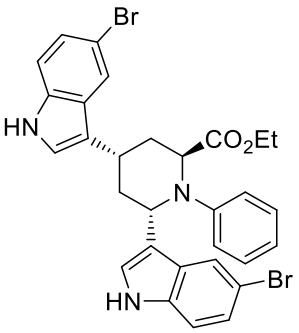
This compound was synthesized following the **general procedure B** with 14.3 mg (0.100 mmol, 1.00 equiv.) of 3-vinylindole (**4a**) and 17.7 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-(phenylimino)acetate (**8a**) in 1 mL dichloromethane. The crude product was purified by preparative TLC (petrol ether/ethyl acetate = 3:1) to give **9aa** as an off-white powder (16.0 mg, 69% yield). The *ee* of the product was determined by HPLC using a Chiralpak® AD-H column (*n*-hexane/*i*-PrOH = 70:30; flow rate = 0.7 mL/min; T = 35 °C; λ = 214 nm; t_R (minor enantiomer) = 11.70 min; t_R (major enantiomer) = 22.87 min; *ee* = 94%).

Gram scale synthesis: To a solution of ethyl 2-(phenylimino)acetate (**8a**, 1.24 g, 6.98 mmol, 1.00 equiv.) in dichloromethane (140 mL) were added catalyst **16** (489 mg, 0.698 mmol, 10 mol%) and 3-vinylindole (**4a**, 2.00 g, 14.0 mmol, 2.00 equiv.) respectively. The mixture was stirred at rt. for 1 h, then the solvent was removed under reduced pressure. The crude product was purified by column chromatography (cyclohexane/ethyl acetate = 3:1) and bisindole **9aa** was obtained as an off-white powder (1.84 g, 57% yield). The *ee* of the product was determined by HPLC using a Chiralpak® OD column (*n*-heptane/*i*-PrOH = 70:30; flow rate = 0.7 mL/min; T = 25 °C; λ = 214 nm; t_R (major enantiomer) = 10.09 min; t_R (minor enantiomer) = 11.63 min; *ee* = 94%).

***R*$_f$** (petrol ether/ethyl acetate = 3:1) = 0.36. – **[α]$_D^{20}$** = +137.7 (c = 1.01, acetone). – **M. p.** = 88–92 °C. – **^{1}H NMR** (300 MHz, acetone-d_6): δ = 1.21 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.23 (q, J = 12.6 Hz, 1H, NCHC*H*H), 2.37–2.53 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.65 (ddd, ^2J = 13.2, ^3J = 5.0, ^3J = 2.4 Hz, 1H, CH*H*CHCO$_2$Et), 3.30–3.43 (m, 1H, CH_2CHCH_2), 3.99–4.25 (m, 2H, CH_2CH_3), 4.82 (dd, ^3J = 5.5, ^3J = 2.2 Hz, 1H, NC*H*CO$_2$Et), 5.65 (dd, ^3J = 11.2, ^3J = 3.6 Hz, 1H, NC*H*C$_{Ind}$), 6.67 (t, ^3J = 7.3 Hz, 1H, H$_{Ar}$), 6.88–7.26 (m, 11H, H$_{Ar}$), 7.37 (d, ^3J = 8.0 Hz, 1H, H$_{Ar}$), 7.62 (d, ^3J = 7.8 Hz, 1H, H$_{Ar}$), 7.86–7.97 (m, 1H, H$_{Ar}$), 9.84 (bs, 1H, N*H*), 10.00 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, $CDCl_3$): δ = 14.3 (+, CH_2CH_3), 29.4 (+, CH_2CHCH_2), 36.1 (–, $CHCH_2$), 42.1 (–, $CHCH_2$), 51.5 (+, NCHC$_{Ind}$), 60.3 (–, CH_2CH_3), 64.7

(+, N*C*HCO$_2$Et), 110.8 (+, CH$_{Ar}$), 111.2 (+, CH$_{Ar}$), 118.8 (+, CH$_{Ar}$), 119.0 (+, CH$_{Ar}$), 119.1 (+, CH$_{Ar}$), 119.6 (+, CH$_{Ar}$), 119.72, 119.73 (1 × +, CH$_{Ar}$, 1 × C$_q$), 120.3 (C$_q$), 121.57 (+, CH$_{Ar}$), 121.58 (+, CH$_{Ar}$), 121.96 (+, CH$_{Ar}$), 122.03 (+, CH$_{Ar}$), 124.1 (+, 2 × C$_{Ph}$), 125.8 (C$_q$), 126.4 (C$_q$), 127.6 (+, 2 × C$_{Ph}$), 136.0 (C$_q$), 136.3 (C$_q$), 150.0 (C$_q$, *C*$_{Ph}$), 173.3 (C$_q$, *C*O$_2$Et) ppm. – **IR (ATR):** ν^{-1} = 3414 (vw), 2925 (vw), 2854 (vw), 1720 (w), 1595 (w), 1493 (w), 1456 (w), 1420 (vw), 1370 (vw), 1338 (vw), 1275 (vw), 1222 (vw), 1178 (w), 1093 (w), 1011 (w), 930 (vw), 848 (vw), 808 (vw), 763 (w), 739 (m), 697 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 463 (16) [M]$^+$, 450 (12), 390 (14), 320 (14), 271 (77), 247 (23), 143 (100). – **HRMS** (ESI, C$_{30}$H$_{29}$N$_3$O$_2$): calcd. 463.2260; found: 463.2272.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(5-bromo-1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9ba):

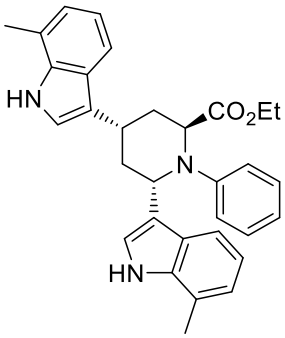


This compound was synthesized following the **general procedure B** with 44.4 mg (0.200 mmol, 1.00 equiv.) of 5-bromo-3-vinylindole (**4b**) and 35.4 mg (0.200 mmol, 1.00 equiv.) of ethyl 2-(phenylimino)acetate (**8a**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 3:1) to give **9ba** as an orange oil (31.4 mg, 50.5 µmol, 51% yield). The *ee* of the product was determined by HPLC using a Chiralpak® OD column (*n*-heptane/*i*-PrOH = 80:20; flow rate = 0.7 mL/min; T = 25 °C; λ = 214 nm; t$_R$ (major enantiomer) = 15.09 min; t$_R$ (minor enantiomer) = 17.96 min; *ee* = 89%).

***R*$_f$** (cyclohexane/ethyl acetate = 2:1) = 0.38. – **[α]$_D^{20}$** = +99.6 (c = 0.52, acetone). – **^{1}H NMR** (400 MHz, acetone-d$_6$): δ = 1.25 (t, ^3J = 7.1 Hz, 3H, CH$_2$C*H*$_3$), 2.19 (q, *J* = 12.5 Hz, 1H, NCHC*H*H), 2.38–2.49 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.64 (ddd, ^2J = 13.2, ^3J = 5.3, ^3J = 2.6 Hz, 1H, CH*H*CHCO$_2$Et), 3.33 (tt, ^3J = 12.6, ^3J = 2.9 Hz, 1H, CH$_2$C*H*CH$_2$), 4.02–4.10, 4.17–4.25 (2 × m, 2H, C*H*$_2$CH$_3$), 4.82 (dd, ^3J = 5.5, ^3J = 2.3 Hz, 1H, NC*H*CO$_2$Et), 5.61 (dd, ^3J

= 11.3, ^3J = 3.5 Hz, 1H, NC*H*C_{Ind}), 6.69 (t, ^3J = 7.3 Hz, 1H, H_{Ar}), 6.95–7.01 (m, 2H, H_{Ar}), 7.08 (dd, ^3J = 8.6, ^3J = 1.9 Hz, 1H, H_{Ar}), 7.17–7.26 (m, 5H, H_{Ar}), 7.25 (d, ^3J = 1.8 Hz, 1H, H_{Ar}), 7.36 (d, ^3J = 8.7 Hz, 1H, H_{Ar}), 7.78 (d, ^3J = 1.8 Hz, 1H, H_{Ar}), 8.11 (d, ^3J = 1.9 Hz, 1H, H_{Ar}), 10.08 (bs, 1H, N*H*), 10.25 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 14.7 (+, CH_2*C*H_3), 30.3 (+, CH_2*C*HCH_2), 36.6 (–, CH*C*H_2), 43.0 (–, CH*C*H_2), 52.7 (+, N*C*HC_{Ind}), 60.7 (–, *C*$H_2$$CH_3$), 65.6 (+, N*C*HC$O_2$Et), 112.2 ($C_q$, *C*Br), 112.3 ($C_q$, *C*Br), 113.8 (+, CH_{Ar}), 114.2 (+, CH_{Ar}), 119.5 (C_q), 120.1 (C_q), 121.7 (+, CH_{Ar}), 122.5 (+, CH_{Ar}), 122.9 (+, CH_{Ar}), 123.4 (+, CH_{Ar}), 124.4 (+, CH_{Ar}), 124.8 (+, CH_{Ar}), 125.46 (+, CH_{Ar}), 125.53 (+, CH_{Ar}), 128.3 (+, CH_{Ar}), 128.5 (C_q), 129.4 (C_q), 136.4 (C_q), 136.5 (C_q), 151.7 (C_q, C_{Ph}), 173.5 (C_q, *C*O_2Et) ppm. – **IR (ATR):** ν^{-1} = 3414 (vw), 2924 (vw), 2853 (vw), 1718 (w), 1596 (w), 1492 (w), 1458 (w), 1371 (vw), 1241 (w), 1219 (w), 1176 (w), 1094 (w), 1036 (w), 882 (w), 793 (w), 750 (w), 697 (w), 582 (w), 472 (vw), 419 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 623/621/619 (3.3/4.9/2.4) $[M]^+$, 550/548/546 (4.6/9.2/3.4), 431/429/427 (12/25/13), 400/398 (43/45), 325 (100), 246 (24), 130 (85). – **HRMS** (EI, $C_{30}H_{27}N_3O_2Br_2$): calcd. 619.0470; found: 619.0473.

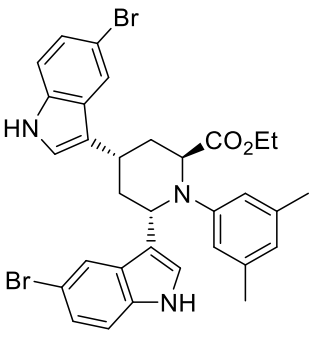
Ethyl (2*S*,4*S*,6*S*)-4,6-bis(7-methyl-1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9ca):



This compound was synthesized following the **general procedure B** with 31.4 mg (0.200 mmol, 1.00 equiv.) of 7-methyl-3-vinylindole (**4c**) and 35.4 mg (0.200 mmol, 1.00 equiv.) of ethyl 2-(phenylimino)acetate (**8a**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 2:1) to give **9ca** as an orange oil (27.5 mg, 55.9 µmol, 56% yield). The *ee* of the product was determined by HPLC using a Chiralpak® IC column (*n*-heptane/*i*-PrOH = 97:3; flow rate = 0.7 mL/min; T = 10 °C; λ = 214 nm; t_R (major enantiomer) = 55.52 min; t_R (major enantiomer) = 64.87 min; *ee* >99%).

***R*$_f$** (cyclohexane/ethyl acetate = 2:1) = 0.52. – **[α]$_D^{20}$** = +94.4 (c = 0.59, acetone). – **^{1}H NMR** (400 MHz, acetone-d$_6$): δ = 1.21 (t, ^3J = 7.1 Hz, 3H, CH$_2$C*H*$_3$), 2.22 (q, *J* = 12.6 Hz, 1H, NCHC*H*H), 2.36 (s, 3H, C*H*$_3$), 2.38–2.50 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.46 (s, 3H, C*H*$_3$), 2.65 (ddd, ^2J = 13.2, ^3J = 5.3, ^3J = 2.6 Hz, 1H, CH*H*CHCO$_2$Et), 3.35 (tt, ^3J = 12.4, ^3J = 2.9 Hz, 1H, CH$_2$C*H*CH$_2$), 4.02–4.11, 4.13–4.23 (2 × m, 2H, C*H*$_2$CH$_3$), 4.81 (dd, ^3J = 5.6, ^3J = 2.3 Hz, 1H, NC*H*CO$_2$Et), 5.64 (dd, ^3J = 11.2, ^3J = 3.6 Hz, 1H, NC*H*C$_{Ind}$), 6.65–6.70 (m, 1H, H$_{Ar}$), 6.80 (d, ^3J = 7.0 Hz, 1H, H$_{Ar}$), 6.85–7.00 (m, 5H, H$_{Ar}$), 7.12 (dd, ^3J = 9.8, ^3J = 2.2 Hz, 2H, H$_{Ar}$), 7.18–7.22 (m, 2H, H$_{Ar}$), 7.46 (d, ^3J = 7.4 Hz, 1H, H$_{Ar}$), 7.77 (d, ^3J = 7.9 Hz, 1H, H$_{Ar}$), 9.78 (bs, 1H, N*H*), 9.95 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d$_6$): δ = 14.7 (+, CH$_2$*C*H$_3$), 16.8 (+, *C*H$_3$), 16.9 (+, *C*H$_3$), 30.5 (+, CH$_2$*C*HCH$_2$), 37.0 (–, CH*C*H$_2$), 43.3 (–, CH*C*H$_2$), 52.8 (+, N*C*HC$_{Ind}$), 60.6 (–, *C*H$_2$CH$_3$), 65.7 (+, N*C*HCO$_2$Et), 117.0 (+, CH$_{Ar}$), 118.4 (+, CH$_{Ar}$), 119.56 (+, CH$_{Ar}$), 119.64 (+, CH$_{Ar}$), 120.4 (C$_q$), 120.7 (+, CH$_{Ar}$), 120.9 (C$_q$), 121.0 (C$_q$), 121.5 (C$_q$), 122.2 (+, CH$_{Ar}$), 122.4 (+, CH$_{Ar}$), 122.7 (+, CH$_{Ar}$), 123.4 (+, CH$_{Ar}$), 125.3 (+, 2 × CH$_{Ph}$), 126.5 (C$_q$), 127.2 (C$_q$), 128.2 (+, 2 × CH$_{Ph}$), 137.1 (C$_q$), 137.3 (C$_q$), 152.0 (C$_q$, *C*$_{Ph}$), 173.7 (C$_q$, *C*O$_2$Et) ppm. – **IR (ATR):** ν^{-1} = 3399 (w), 3051 (vw), 2931 (vw), 2854 (vw), 1723 (w), 1597 (vw), 1491 (w), 1433 (vw), 1370 (vw), 1343 (vw), 1299 (vw), 1299 (vw), 1226 (w), 1174 (w), 1161 (w), 1120 (w), 1108 (w), 1092 (w), 1059 (w), 1020 (w), 940 (vw), 829 (vw), 783 (w), 746 (w), 695 (w), 585 (vw), 514 (vw), 485 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 491 (3) [M]$^+$, 418 (1.7), 299 (10), 261 (4), 207 (5), 157 (5), 40 (100). – **HRMS** (EI, C$_{32}$H$_{33}$N$_3$O$_2$): calcd. 491.2573; found: 491.2574.

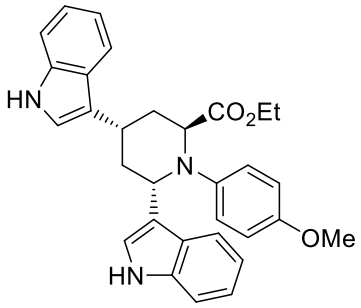
Ethyl (2*S*,4*S*,6*S*)-4,6-bis(5-bromo-1*H*-indol-3-yl)-1-(3,5-dimethylphenyl)piperidine-2-carboxylate (9bb):



This compound was synthesized following the **general procedure B** with 44.4 mg (0.200 mmol, 2.00 equiv.) of 5-bromo-3-vinylindole (**9b**) and 20.5 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-((3,5-dimethylphenyl)imino)acetate (**8b**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 3:1) to give **9bb** as a yellow oil (37.8 mg, 58.2 µmol, 58% yield). The *ee* of the product was determined by HPLC using a Chiralpak® OD column (*n*-heptane/*i*-PrOH = 95:5; flow rate = 0.7 mL/min; T = 10 °C; λ = 214 nm; t_R (major enantiomer) = 21.73 min; t_R (minor enantiomer) = 30.95 min; *ee* = 83%).

***R*$_f$** (cyclohexane/ethyl acetate = 3:1) = 0.40. – **[α]$_D^{20}$** = +39.8 (c = 1.45, acetone). – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 1.26 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.04 (s, 6H, 2 × CCH_3), 2.14–2.25 (m, 1H, NCHC*H*H), 2.35–2.47 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.62 (ddd, ^2J = 13.1, ^3J = 5.1, ^3J = 2.6 Hz, 1H, CH*H*CHCO$_2$Et), 3.27–3.37 (m, 1H, CH_2CHCH_2), 4.03–4.11 (m, 1H, CH_2CH_3), 4.19–4.27 (m, 1H, CH_2CH_3), 4.76 (dd, ^3J = 5.5, ^3J = 2.2 Hz, 1H, NC*H*CO$_2$Et), 5.58 (dd, ^3J = 11.3, ^3J = 3.5 Hz, 1H, NC*H*C$_{Ind}$), 6.32 (s, 1H, H_{Ar}), 6.85 (s, 2H, H_{Ar}), 7.08 (dd, ^3J = 8.6, ^3J = 1.9 Hz, 1H, H_{Ar}), 7.17–7.24 (m, 3H, H_{Ar}), 7.32 (d, ^3J = 2.4 Hz, 1H, H_{Ar}), 7.36 (d, ^3J = 8.6 Hz, 1H, H_{Ar}), 7.76 (d, ^3J = 1.7 Hz, 1H, H_{Ar}), 8.11 (d, ^3J = 1.8 Hz, 1H, H_{Ar}), 10.07 (bs, 1H, N*H*), 10.24 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 14.8 (+, CH_2CH_3), 21.4 (+, 2 × CCH_3), 30.3 (+, CH_2CHCH_2), 36.7 (–, $CHCH_2$), 42.9 (–, $CHCH_2$), 52.7 (+, NCHC$_{Ind}$), 60.6 (–, CH_2CH_3), 65.7 (+, NCHCO$_2$Et), 112.2 (C_q, *C*Br), 112.3 (C_q, *C*Br), 113.8 (+, CH_{Ar}), 114.2 (+, CH_{Ar}), 119.8 (C_q), 120.1 (C_q), 121.8 (+, CH_{Ar}), 122.9 (+, CH_{Ar}), 123.4 (+, 2 × CH_{Ar}), 123.5 (+, CH_{Ar}), 124.38 (+, CH_{Ar}), 124.41 (+, CH_{Ar}), 124.8 (+, CH_{Ar}), 125.5 (+, CH_{Ar}), 128.7 (C_q), 129.4 (C_q), 136.4 (C_q), 136.5 (C_q), 137.2 (C_q, 2 × *C*CH$_3$), 151.6 (C_q), 173.6 (C_q, *C*O$_2$Et) ppm. – **IR (ATR):** ν^{-1} = 3410 (vw), 2917 (vw), 2850 (vw), 1717 (w), 1593 (w), 1457 (w), 1370 (vw), 1314 (vw), 1292 (vw), 1217 (vw), 1176 (w), 1093 (w), 1033 (w), 938 (vw), 883 (w), 861 (vw), 841 (vw), 792 (w), 751 (vw), 706 (vw), 679 (vw), 582 (w), 466 (vw), 419 (w) cm^{-1}. – **MS** (FAB, 3-NBA), *m/z* (%): 650/648/646 (16/20/9) $[M - H]^+$, 578/576/574 (16/29/12), 429 (88), 206 (100), 132 (87). – **HRMS** (FAB, $C_{32}H_{32}O_2Br_2N_3$): calcd. 648.0861; found: 648.0865.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(1*H*-indol-3-yl)-1-(4-methoxyphenyl)piperidine-2-carboxylate (9ac):

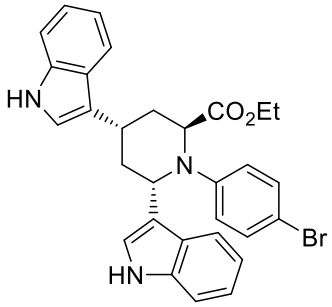


This compound was synthesized following the **general procedure B** with 28.6 mg (0.200 mmol, 1.00 equiv.) of 3-vinylindole (**4a**) and 20.7 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-((4-methoxyphenyl)imino)acetate (**8c**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 3:1) to give **9ac** as a brownish powder (27.8 mg, 56% yield). The *ee* of the product was determined by HPLC using a Chiralpak® AS column (*n*-heptane/*i*-PrOH = 80:20; flow rate = 0.7 mL/min; T = 25 °C; λ = 214 nm; t_R (major enantiomer) = 9.57 min; t_R (minor enantiomer) = 10.76 min; *ee* = 97%).

***R*$_f$** (cyclohexane/ethyl acetate = 3:1) = 0.21. – **[α]$_D^{20}$** = +91.1 (c = 0.59, acetone). – **M. p.** = 187–192 °C. – **^{1}H NMR** (400 MHz, $CDCl_3$): δ = 1.26 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.12 (q, *J* = 12.7 Hz, 1H, NCHC*H*H), 2.34 (td, ^2J = 13.1, ^3J = 5.7 Hz, 1H, C*H*HCHCO$_2$Et), 2.53 (ddd, ^2J = 12.9, ^3J = 5.7, ^3J = 2.9 Hz, 1H, NCHCH*H*), 2.68 (ddd, ^2J = 13.4, ^3J = 5.0, ^3J = 2.6 Hz, 1H, CH*H*CHCO$_2$Et), 3.38 (tt, ^3J = 12.5, ^3J = 2.8 Hz, 1H, CH_2CHCH_2), 3.62 (s, 3H, OCH_3), 4.05–4.25 (m, 2H, CH_2CH_3), 4.61 (dd, ^3J = 5.6, ^3J = 2.1 Hz, 1H, NC*H*CO$_2$Et), 5.60 (dd, ^3J = 11.3, ^3J = 3.3 Hz, 1H, NC*H*C$_{Ind}$), 6.53–6.59 (m, 2H, H$_{Ar}$), 6.90 (dd, ^3J = 8.1, ^3J = 2.2 Hz, 2H, H$_{Ar}$), 7.05–7.14 (m, 5H, H$_{Ar}$), 7.16–7.23 (m, 2H, H$_{Ar}$), 7.34 (d, ^3J = 8.1 Hz, 1H, H$_{Ar}$), 7.65 (d, ^3J = 7.7 Hz, 1H, H$_{Ar}$), 7.78 (bs, 1H, N*H*), 7.88–7.91 (m, 1H, H$_{Ar}$), 7.93 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, $CDCl_3$): δ = 14.3 (+, CH_2CH_3), 29.5 (+, CH_2CHCH_2), 36.1 (–, $CHCH_2$), 42.1 (–, $CHCH_2$), 51.7 (+, NCHC$_{Ind}$), 55.0 (+, OCH_3), 60.1 (–, CH_2CH_3), 65.1 (+, NCHCO$_2$Et), 110.9 (+, CH$_{Ar}$), 111.1 (+, CH$_{Ar}$), 112.9 (+, 2 × NCCH$_{Ar}$), 118.86 (+, CH$_{Ar}$), 118.92 (+, CH$_{Ar}$), 119.1 (+, CH$_{Ar}$), 119.5 (+, CH$_{Ar}$), 119.7 (+, CH$_{Ar}$), 119.9 (C$_q$), 120.5 (C$_q$), 121.5 (+, CH$_{Ar}$), 122.0 (+, CH$_{Ar}$), 122.1 (+, CH$_{Ar}$), 125.7 (+, 2 × CHCOMe), 125.9 (C$_q$), 126.5 (C$_q$), 136.0 (C$_q$), 136.3 (C$_q$), 143.7 (C$_q$), 154.4 (C$_q$, COMe), 173.5 (C$_q$, CO$_2$Et) ppm. – **IR (neat):** $\tilde{\nu}^{-1}$ = 3172 (vw), 2969 (vw), 2925 (vw), 1718 (w), 1618 (w), 1584 (vw), 1529 (vw), 1501 (vw), 1474 (vw), 1458 (vw), 1435 (vw), 1413 (vw), 1372 (vw), 1329 (vw), 1313 (vw),

1271 (vw), 1242 (vw), 1221 (w), 1173 (vw), 1148 (vw), 1109 (w), 1020 (w), 978 (vw), 956 (vw), 941 (vw), 906 (vw), 859 (vw), 829 (w), 790 (vw), 766 (vw), 739 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 493 (14) $[M]^+$, 420 (6), 376 (20), 350 (16), 303 (28), 271 (53), 143 (51), 134 (100), 117 (38). – **HRMS** (EI, $C_{31}H_{31}N_3O_3$): calcd. 493.2360; found 493.2362.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(1*H*-indol-3-yl)-1-(4-bromophenyl)piperidine-2-carboxylate (9ad)

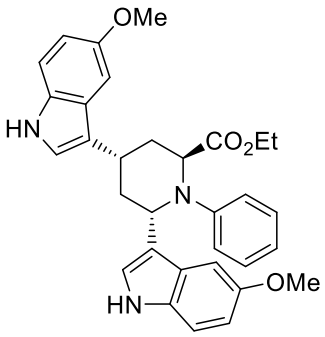


This compound was synthesized following the **general procedure B** with 28.6 mg (0.200 mmol, 1.00 equiv.) of 3-vinylindole (**4a**) and 25.6 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-((4-bromophenyl)imino)acetate (**8d**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 3:1) to give **9ad** as a yellow oil (15.0 mg, 28% yield). The *ee* of the product was determined by HPLC using a Chiralpak® IC column (*n*-heptane/*i*-PrOH = 95:5; flow rate = 0.7 mL/min; T = 10 °C; λ = 214 nm; t_R (major enantiomer) = 37.23 min; t_R (minor enantiomer) = 41.07 min; *ee* = 93%).

***R*$_f$** (cyclohexane/ethyl acetate = 3:1) = 0.27. – **$[\alpha]_D^{20}$** = +25.1 (c = 0.60, acetone). – **^{1}H NMR** (400 MHz, $CDCl_3$): δ = 1.25 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.23 (q, *J* = 12.5 Hz, 1H, NCHC*H*H), 2.38–2.50 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.69 (ddd, ^2J = 13.3, ^3J = 5.1, ^3J = 2.5 Hz, 1H, CH*H*CHCO$_2$Et), 3.31 (tt, ^3J = 12.2, ^3J = 2.6 Hz, 1H, CH_2CHCH_2), 4.06–4.15, 4.17–4.25 (2 × m, 2H, C*H*$_2$CH$_3$), 4.84 (dd, ^3J = 5.6, ^3J = 2.3 Hz, 1H, NC*H*CO$_2$Et), 5.56 (dd, ^3J = 11.3, ^3J = 3.6 Hz, 1H, NC*H*C$_{Ind}$), 6.92–7.04 (m, 3H, H$_{Ar}$), 7.05–7.31 (m, 8H, H$_{Ar}$), 7.37 (d, ^3J = 8.0 Hz, 1H, H$_{Ar}$), 7.62 (d, ^3J = 7.7 Hz, 1H, H$_{Ar}$), 7.89 (d, ^3J = 7.4 Hz, 1H, H$_{Ar}$), 9.91 (bs, 1H, N*H*), 10.02 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, $CDCl_3$): δ = 14.7 (+, CH_2CH_3), 30.5 (+, CH_2CHCH_2), 36.8 (–, $CHCH_2$), 43.1 (–, $CHCH_2$), 53.0 (+, NCHC$_{Ind}$), 60.9 (–, CH_2CH_3), 65.5 (+, NCHCO$_2$Et), 112.1 (+, CH$_{Ar}$), 112.3 (+, CH$_{Ar}$), 114.3 (C$_q$), 119.27 (+, CH$_{Ar}$), 119.32 (C$_q$), 119.36 (+, CH$_{Ar}$), 120.2 (C$_q$), 120.7 (+, CH$_{Ar}$), 121.1 (+, CH$_{Ar}$), 121.9 (+, CH$_{Ar}$), 122.2 (+, CH$_{Ar}$), 123.9 (+, CH$_{Ar}$), 126.7 (C$_q$), 127.3 (+, CH$_{Ar}$), 127.6 (C$_q$), 131.1 (+,

CH_{Ar}), 132.5 (+, CH_{Ar}), 137.7 (C_q), 137.9 (C_q), 151.4 (C_q, C_{Ph}), 173.5 (C_q, CO_2Et) ppm. – **IR (ATR):** ν^{-1} = 3399 (vw), 2931 (vw), 1717 (w), 1590 (vw), 1486 (w), 1455 (w), 1337 (vw), 1221 (w), 1176 (w), 1093 (w), 1007 (w), 931 (vw), 820 (w), 739 (w), 658 (vw), 581 (vw), 497 (w), 423 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 543/541 (10/10) $[M]^+$, 470/468 (5/6), 370 (18), 271 (100), 184/182 (59/59), 143 (85), 69 (43). – **HRMS** (EI, $C_{30}H_{28}N_3O_2{}^{79}Br$): calcd. 541.1359; found 541.1358.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(5-methoxy-1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9da):

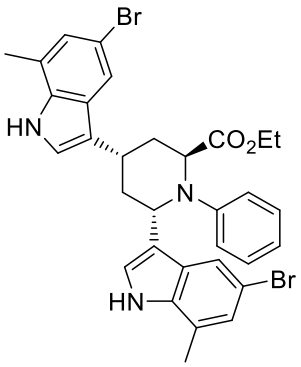


This compound was synthesized following the **general procedure B** with 34.6 mg (0.200 mmol, 2.00 equiv.) of 5-methoxy-3-vinylindole (**4d**) and 17.7 mg (0.100 mmol, 1.00 equiv.) of 2-(phenylimino)acetate (**8a**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 2:1) to give **9da** as an orange oil (10.9 mg, 20.8 µmol, 21% yield). The *ee* of the product was determined by HPLC using a Chiralpak® IC column (*n*-heptane/*i*-PrOH = 90:10; flow rate = 0.7 mL/min; T = 15 °C; λ = 214 nm; t_R (minor enantiomer) = 46.24 min; t_R (major enantiomer) = 54.20 min; *ee* = 87%).

$\boldsymbol{R_f}$ (cyclohexane/ethyl acetate = 2:1) = 0.23. – $\boldsymbol{[\alpha]_D^{20}}$ = +94.6 (c = 0.47, acetone). – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 1.22 (t, ^3J = 6.6 Hz, 3H, CH_2CH_3), 2.21 (q, *J* = 12.5 Hz, 1H, NCHC*H*H), 2.31–2.50 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.58–2.68 (m, 1H, CH*H*CHCO$_2$Et), 3.30 (t, ^3J = 12.0 Hz, 1H, CH_2CHCH_2), 3.81 (s, 6H, 2 × OCH_3), 3.98–4.29 (2 × m, 2H, CH_2CH_3), 4.76–4.86 (m, 1H, NC*H*CO$_2$Et), 5.59 (m, 1H, NC*H*C_{Ind}), 6.57–6.71 (m, 2H, H_{Ar}), 6.76 (d, ^3J = 8.6 Hz, 1H, H_{Ar}), 6.92–7.02 (m, 2H, H_{Ar}), 7.04–7.15 (m, 4H, H_{Ar}), 7.18–7.25 (m, 2H, H_{Ar}), 7.27 (d, ^3J = 7.6 Hz, 1H, H_{Ar}), 7.43–7.49 (m, 1H, H_{Ar}), 9.69 (bs, 1H, N*H*), 9.85 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 14.7 (+, CH_2CH_3), 30.1

(+, CH_2CHCH_2), 36.8 (–, $CHCH_2$), 42.9 (–, $CHCH_2$), 52.8 (+, $NCHC_{Ind}$), 55.9 (+, OCH_3), 60.0 (+, OCH_3), 60.6 (–, CH_2CH_3), 65.7 (+, $NCHCO_2Et$), 101.3 (+, CH_{Ar}), 102.7 (+, CH_{Ar}), 112.0 (+, CH_{Ar}), 112.3 (+, CH_{Ar}), 112.5 (+, CH_{Ar}), 112.9 (+, CH_{Ar}), 119.6 (C_q), 120.2 (C_q), 121.9 (+, CH_{Ar}), 122.2 (+, CH_{Ar}), 124.3 (+, CH_{Ar}), 125.3 (+, 2 × CH_{Ph}), 127.2 (C_q), 127.9 (C_q), 128.2 (+, 2 × CH_{Ph}), 132.9 (C_q), 133.1 (C_q), 152.0 (C_q, C_{Ph}), 154.4 (C_q, *C*OMe), 154.6 (C_q, *C*OMe), 173.8 (C_q, CO_2Et) ppm. – **IR (ATR):** ν^{-1} = 3397 (vw), 2925 (w),1724 (w), 1622 (vw), 1596 (w), 1483 (w), 1452 (w), 1370 (w), 1284 (w), 1209 (w), 1171 (m), 1024 (w), 924 (vw), 795 (w), 750 (w), 696 (w), 626 (vw), 430 (vw) cm^{-1}. – **MS** (FAB, 3-NBA), *m/z* (%): 523 (1) $[M]^+$, 433 (3), 419 (4), 377 (2), 331 (6), 275 (5), 178 (21), 149 (49), 109 (51), 95 (88), 81 (100). – **HRMS** (FAB, $C_{32}H_{33}N_3O_4$): calcd. 523.2466; found: 523.2467.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(5-bromo-7-methyl-1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9ea):

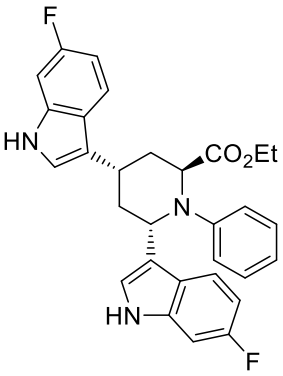


This compound was synthesized following the **general procedure B** with 47.2 mg (0.200 mmol, 1.00 equiv.) of 5-bromo-7-methyl-3-vinylindole (**4e**), which was added as a solution in 1 mL dichloromethane, and 35.4 mg (0.200 mmol, 1.00 equiv.) of ethyl 2-(phenylimino)acetate (**8a**) in 1 mL dichloromethane (total volume 2 mL). The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 2:1) to give **9ea** as a yellow oil (16.0 mg, 24.6 µmol, 25% yield). The *ee* of the product was determined by HPLC using a Chiralpak® OD column (*n*-heptane/*i*-PrOH = 90:10; flow rate = 0.7 mL/min; T = 20 °C; λ = 214 nm; t_R (minor enantiomer) = 34.96 min; t_R (major enantiomer) = 41.16 min; *ee* = 75%).

R_f (cyclohexane/ethyl acetate = 2:1) = 0.43. – $[\alpha]_D^{20}$ = +83.7 (c = 0.81, acetone). – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 1.24 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.13–2.25 (m, 1H, NCHC*H*H), 2.36 (s, 3H, $C_{Ar}CH_3$), 2.37–2.45 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.47 (s, 3H, $C_{Ar}CH_3$),

2.62 (ddd, ^2J = 13.0, ^3J = 5.3, ^3J = 2.5 Hz, 1H, CH*H*CHCO$_2$Et), 3.29 (tt, ^3J = 12.6, ^3J = 3.0 Hz, 1H, CH$_2$C*H*CH$_2$), 4.01–4.10, 4.16–4.25 (2 × m, 2H, C*H*$_2$CH$_3$), 4.80 (dd, ^3J = 5.3, ^3J = 2.3 Hz, 1H, NC*H*CO$_2$Et), 5.59 (dd, ^3J = 11.3, ^3J = 3.6 Hz, 1H, NC*H*C$_{Ind}$), 5.59 (t, ^3J = 7.3 Hz, 1H, H$_{Ar}$), 6.92 (d, ^4J = 0.7 Hz, 1H, H$_{Ar}$), 6.95–7.01 (m, 2H, H$_{Ar}$), 7.05 (d, ^4J = 0.7 Hz, 1H, H$_{Ar}$), 7.17–7.23 (m, 3H, H$_{Ar}$), 7.25 (d, J = 2.4 Hz, 1H, H$_{Ar}$), 7.60 (d, J = 1.6 Hz, 1H, H$_{Ar}$), 7.94 (d, J = 1.6 Hz, 1H, H$_{Ar}$), 10.06 (bs, 1H, N*H*), 10.24 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d$_6$): δ = 14.7 (+, CH$_2$*C*H$_3$), 16.6 (+, C$_{Ar}$C*H*$_3$), 16.7 (+, C$_{Ar}$C*H*$_3$), 30.6 (+, CH$_2$*C*HCH$_2$), 36.8 (–, CH*C*H$_2$), 43.0 (–, CH*C*H$_2$), 52.7 (+, N*C*HC$_{Ind}$), 60.7 (–, *C*H$_2$CH$_3$), 65.7 (+, N*C*HCO$_2$Et), 111.35 (C$_q$), 111.41 (C$_q$), 119.4 (+, CH$_{Ar}$), 120.0 (C$_q$), 120.5 (C$_q$), 121.0 (+, CH$_{Ar}$), 122.45 (+, CH$_{Ar}$), 122.50 (+, CH$_{Ar}$), 123.6 (C$_q$), 124.1 (C$_q$), 124.9 (+, CH$_{Ar}$), 125.1 (+, CH$_{Ar}$), 125.2 (+, CH$_{Ar}$), 125.5 (+, 2 × CH$_{Ph}$), 128.0 (C$_q$), 128.3 (+, 2 × CH$_{Ph}$), 128.9 (C$_q$), 135.9 (C$_q$), 136.0 (C$_q$), 151.7 (C$_q$, *C*$_{Ph}$), 173.5 (C$_q$, *C*O$_2$Et) ppm. – **IR (ATR):** ν^{-1} = 3421 (vw), 2922 (vw), 2850 (vw), 1718 (w), 1595 (vw), 1450 (vw), 1377 (vw), 1225 (vw), 1176 (w), 1022 (vw), 944 (vw), 869 (vw), 843 (vw), 814 (vw), 765 (vw), 697 (w), 584 (vw), 445 (vw) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 651/649/647 (0.5/0.9/0.4) [M]$^+$, 578/576/574 (0.9/1.7/1.0), 414/412 (32/33), 341/339 (49/58), 237/235 (33/37), 130 (100). – **HRMS** (EI, C$_{32}$H$_{33}$N$_3$O$_2$Br$_2$): calcd. 649.0934; found: 649.0937.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(6-fluoro-1*H*-indol-3-yl)-1-phenylpiperidine-2-carboxylate (9fa):

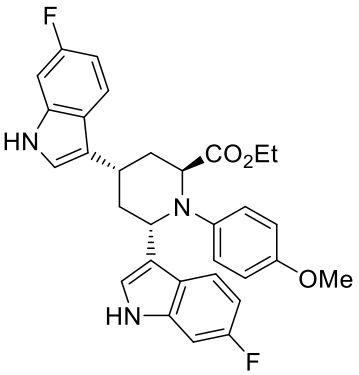


This compound was synthesized following the **general procedure B** with 32.2 mg (0.200 mmol, 2.00 equiv.) of 6-fluoro-3-vinylindole (**4f**) and 17.7 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-(phenylimino)acetate (**8a**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 2:1) to give **9fa** as a yellow oil (17.0 mg, 34.0 µmol, 34% yield). The *ee* of the product was determined by HPLC using a

Chiralpak® OD column (*n*-heptane/*i*-PrOH = 80:20; flow rate = 0.7 mL/min; T = 25 °C; λ = 214 nm; t_R (major enantiomer) = 35.89 min; t_R (minor enantiomer) = 43.67 min; *ee* = 89%).

***R*$_f$** (cyclohexane/ethyl acetate = 2:1) = 0.29. – **[α]$_D^{20}$** = +101.7 (c = 0.87, acetone). – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 1.20 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.19 (q, J = 12.5 Hz, 1H, NCHC*H*H), 2.39–2.49 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.62 (ddd, ^2J = 13.1, ^3J = 5.3, ^3J = 2.6 Hz, 1H, CH*H*CHCO$_2$Et), 3.34 (tt, ^3J = 12.5, ^3J = 2.9 Hz, 1H, CH_2CHCH_2), 4.01–4.11, 4.12–4.21 (2 × m, 2H, CH_2CH_3), 4.80 (dd, ^3J = 5.6, ^3J = 2.3 Hz, 1H, NC*H*CO$_2$Et), 5.61 (dd, ^3J = 11.3, ^3J = 3.5 Hz, 1H, NC*H*C$_{Ind}$), 6.68 (t, ^3J = 7.3 Hz, 1H, H$_{Ar}$), 6.71–6.78 (m, 1H, H$_{Ar}$), 6.81–6.88 (m, 1H, H$_{Ar}$), 7.93–7.00 (m, 3H, H$_{Ar}$), 7.09–7.22 (m, 5H, H$_{Ar}$), 7.58 (dd, ^3J = 8.7, ^4J = 5.3 Hz, 1H, H$_{Ar}$), 7.91 (dd, ^3J = 8.7, ^4J = 5.6 Hz, 1H, H$_{Ar}$), 9.95 (bs, 1H, N*H*), 10.12 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 14.7 (+, CH_2CH_3), 30.3 (+, CH_2CHCH_2), 36.7 (–, $CHCH_2$), 43.3 (–, $CHCH_2$), 52.8 (+, NCHC$_{Ind}$), 60.6 (–, CH_2CH_3), 65.6 (+, NCHCO$_2$Et), 97.9 (+, d, ^2J = 25.7 Hz, CH$_{Ar}$), 98.3 (+, d, ^2J = 25.8 Hz, CH$_{Ar}$), 107.6 (+, d, ^2J = 24.2 Hz, CH$_{Ar}$), 107.8 (+, d, ^2J = 25.7 Hz, CH$_{Ar}$), 120.0 (C$_q$), 120.2 (+, d, ^3J = 10.2 Hz, CH$_{Ar}$), 120.6 (C$_q$), 121.71, 121.74, 121.8, 121.9 (+, 2 × CH$_{Ar}$), 122.4 (+, CH$_{Ar}$), 123.5 (C$_q$), 124.3 (+, CH$_{Ar}$), 124.4 (C$_q$), 125.5 (+, 2 × CH$_{Ph}$), 128.3 (+, 2 × CH$_{Ph}$), 137.5 (C$_q$, d, ^3J = 12.5 Hz, C$_q$CHCF), 137.7 (C$_q$, d, ^3J = 12.5 Hz, C$_q$CHCF), 151.8 (C$_q$, C$_{Ph}$), 160.3 (C$_q$, d, ^1J = 234.4 Hz, CF), 160.5 (C$_q$, d, ^1J = 234.4 Hz, CF), 173.7 (C$_q$, CO$_2$Et) ppm. – **^{19}F NMR** (376 MHz, acetone-d_6): δ = –123.7, –124.1 ppm. – **IR (ATR):** $\tilde{\nu}^{-1}$ = 3411 (vw), 2926 (vw), 1718 (w), 1625 (w), 1596 (w), 1552 (vw), 1493 (w), 1370 (vw), 1342 (vw), 1304 (w), 1217 (w), 1177 (w), 1136 (w), 1091 (w), 1023 (w), 951 (w), 833 (w), 799 (w), 750 (w), 695 (w), 602 (vw), 572 (vw), 476 (w), 433 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 499 (18) [M]$^+$, 426 (20), 338 (25), 307 (100), 265 (52), 161 (68), 148 (49), 130 (70), 104 (68), 77 (39). – **HRMS** (EI, $C_{30}H_{27}N_3O_2F_2$): calcd. 499.2066; found: 499.2068.

Ethyl (2*S*,4*S*,6*S*)-4,6-bis(6-fluoro-1*H*-indol-3-yl)-1-(4-methoxyphenyl)piperidine-2-carboxylate (9fc):

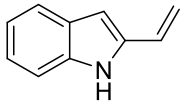


This compound was synthesized following the **general procedure B** with 32.2 mg (0.200 mmol, 2.00 equiv.) of 6-fluoro-3-vinylindole (**4f**) and 20.7 mg (0.100 mmol, 1.00 equiv.) of ethyl 2-((4-methoxyphenyl)imino)acetate (**8c**) in 2 mL dichloromethane. The crude product was purified by preparative TLC (cyclohexane/ethyl acetate = 2:1) to give **9fc** as a yellow oil (25.2 mg, 47.6 µmol, 48% yield). The *ee* of the product was not determined, as no separation of the enantiomers by HPLC could be achieved.

***R*$_f$** (cyclohexane/ethyl acetate = 2:1) = 0.23. – **[α]$_D^{20}$** = +65.1 (c = 1.35, acetone). – **^{1}H NMR** (400 MHz, acetone-d$_6$): δ = 1.21 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 2.19 (q, J = 12.4 Hz, 1H, NCHC*H*H), 2.33–2.49 (m, 2H, C*H*HCHCO$_2$Et, NCHCH*H*), 2.57 (d, ^2J = 13.1, 1H, CH*H*CHCO$_2$Et), 3.36 (t, ^3J = 12.5 Hz, 1H, CH_2CHCH_2), 4.01–4.11, 4.12–4.21 (2 × m, 2H, CH_2CH_3), 4.60 (dd, ^3J = 5.5, ^3J = 1.9 Hz, 1H, NC*H*CO$_2$Et), 5.56–5.64 (m, 1H, NC*H*C$_{Ind}$), 6.54 (d, ^3J = 8.9 Hz, 2H, H$_{Ar}$), 6.71–6.78 (m, 1H, H$_{Ar}$), 6.81–6.88 (m, 1H, H$_{Ar}$), 6.95 (dd, ^3J = 10.1, J = 2.2 Hz, 1H, H$_{Ar}$), 7.08–7.20 (m, 5H, H$_{Ar}$), 7.58 (dd, ^3J = 8.6, ^4J = 5.4 Hz, 1H, H$_{Ar}$), 7.93 (dd, ^3J = 8.7, ^4J = 5.6 Hz, 1H, H$_{Ar}$), 9.92 (bs, 1H, N*H*), 10.12 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d$_6$): δ = 14.7 (+, CH_2CH_3), 30.3 (+, CH_2CHCH_2), 36.8 (–, $CHCH_2$), 43.3 (–, $CHCH_2$), 53.0 (+, NCHC$_{Ind}$), 55.2 (+, OCH_3), 60.5 (–, CH_2CH_3), 66.0 (+, NCHCO$_2$Et), 97.9 (+, d, ^2J = 25.7 Hz, CH_{Ar}), 98.3 (+, d, ^2J = 25.9 Hz, CH_{Ar}), 107.5 (+, d, ^2J = 24.9 Hz, CH_{Ar}), 107.7 (+, d, ^2J = 25.1 Hz, CH_{Ar}), 113.5 (+, 2 × CH_{Ar}), 120.0 (C$_q$), 120.1 (+, d, ^3J = 10.3 Hz, CH_{Ar}), 120.6 (C$_q$), 121.69, 121.72, 121.9, 122.0 (+, 2 × CH_{Ar}), 123.6 (C$_q$), 124.35 (C$_q$), 124.40 (+, CH_{Ar}), 127.0 (+, 2 × CH_{Ar}), 137.6 (C$_q$, d, ^3J = 12.5 Hz, C_qCHCF), 137.7 (C$_q$, d, ^3J = 12.5 Hz, C_qCHCF), 144.8 (C$_q$), 155.8 (C$_q$, $COCH_3$), 160.2 (C$_q$, d, ^1J = 234.2 Hz, *C*F), 160.5 (C$_q$, d, ^1J = 234.6 Hz, *C*F), 173.9 (C$_q$, CO_2Et) ppm. – **^{19}F NMR** (376 MHz, acetone-d$_6$): δ = –123.7, –124.2 ppm. – **IR (ATR):** ν^{-1} = 3349 (vw), 2929 (vw), 1719 (w),

1623 (w), 1589 (vw), 1551 (vw), 1503 (m), 1454 (w), 1220 (m), 1137 (m), 1030 (w), 951 (w), 799 (m), 604 (w), 526 (w), 476 (w), 435 (w) cm^{-1}. – **MS** (FAB, 3-NBA), *m/z* (%): 529 (4) $[M]^+$, 368 (22), 307 (19), 154 (100), 136 (92), 107 (60), 91 (51). – **HRMS** (FAB, $C_{31}H_{29}N_3O_3F_2$): calcd. 529.2172; found: 529.2174.

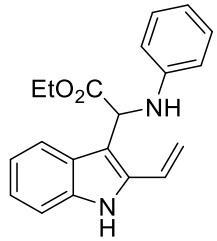
2-Vinyl-1*H*-indole (18):



To a suspension of methyltriphenylphosphonium bromide (2.68 g, 7.50 mmol, 1.50 equiv.) in abs. THF (35 mL) was added NaHMDS (1 M in THF, 6.50 mL, 6.50 mmol, 1.30 equiv.) dropwise at rt. It was stirred at rt. for 1 h and this mixture was added dropwise to a solution of indole-2-carboxaldehyde (726 mg, 5.00 mmol, 1.00 equiv.) in THF (25 mL). It was stirred at rt. for 14 h. The reaction mixture was poured into H_2O (60 mL), the phases separated, the aqueous phase was extracted with Et_2O (3 x 60 mL), the combined organic layers were dried over Na_2SO_4 and concentrated. The product was obtained after column chromatography (cyclohexane/ethyl acetate = 5:1) as an orange solid (656 mg, 92%).

***R*$_f$** (cyclohexane/ethyl acetate = 3:1) = 0.64. – **M. p.** = 75–77 °C. – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 5.23 (d, $^3J_{cis}$ = 11.3 Hz, 1H, CH=C*H*H), 5.77 (d, $^3J_{trans}$ = 17.8 Hz, 1H, CH=CH*H*), 6.48 (d, ^4J = 1.7 Hz, 1H, C*H*=C_qCH=CH_2), 6.79 (dd, $^3J_{trans}$ = 17.8, $^3J_{cis}$ = 11.3 Hz, 1H, C*H*=CH_2), 6.98 (ddd, ^3J = 8.1, ^3J = 7.1, ^4J = 1.1 Hz, 1H, CH_{Ar}), 7.09 (ddd, ^3J = 8.1, ^3J = 7.1, ^4J = 1.1 Hz, 1H, CH_{Ar}), 7.33 (dd, ^3J = 8.1, ^4J = 0.9 Hz, 1H, CH_{Ar}), 7.50 (d, ^3J = 7.9 Hz, 1 H, CH_{Ar}), 10.44 (bs, 1H, N*H*) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 103.3 (+, *C*H), 111.8 (+, *C*H), 112.6 (–, CH=*C*H_2), 120.3 (+, *C*H), 121.2 (+, *C*H), 123.0 (+, *C*H), 128.9 (+, *C*H), 129.7 (C_q), 137.7 (C_q), 138.2 (C_q) ppm. – **IR (ATR):** ν^{-1} = 3390 (w), 1608 (vw), 1449 (w), 1422 (w), 1399 (w), 1340 (w), 1285 (w), 1231 (w), 1151 (w), 984 (w), 930 (w), 900 (w), 792 (m), 739 (m), 718 (w), 656 (vw), 608 (vw), 577 (w), 467 (w), 433 (m) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 143 (100) $[M]^+$, 115 (13) $[C_8H_5N]^+$. – **HRMS** (EI, $C_{10}H_9N$): calcd. 143.0730; found: 143.0729.

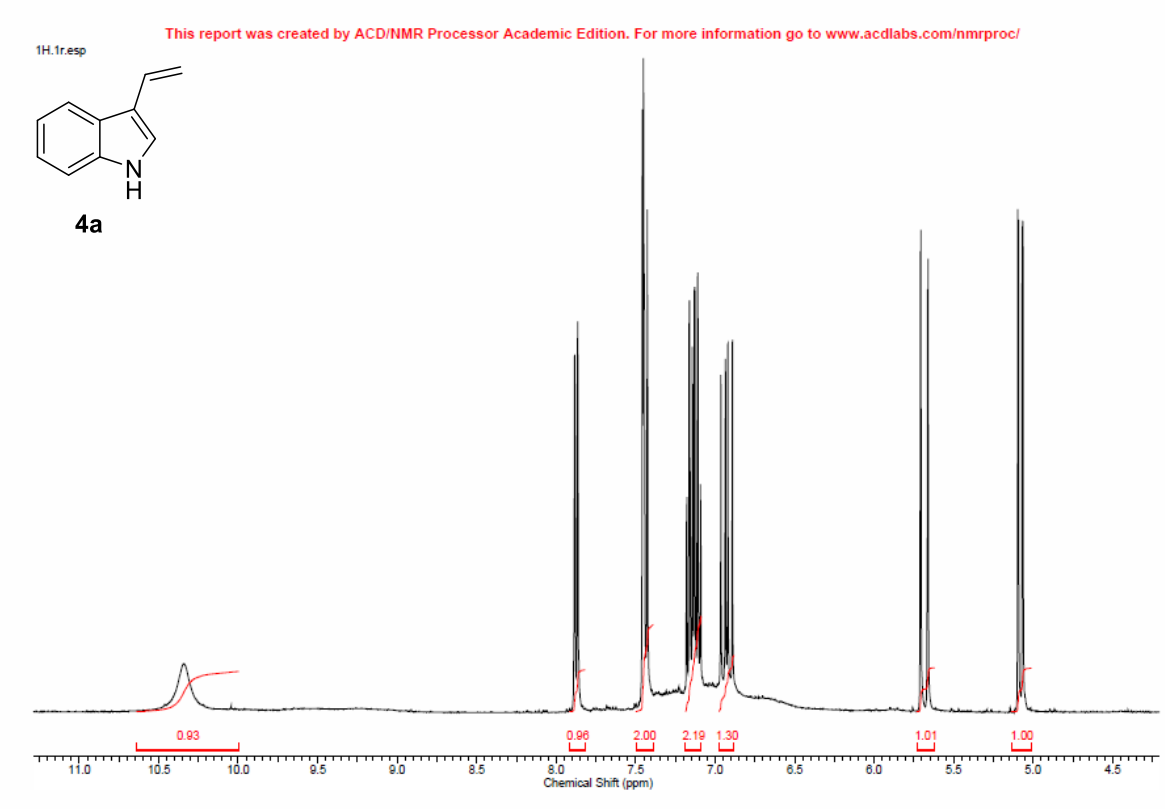
Ethyl 2-(phenylamino)-2-(2-vinyl-1*H*-indol-3-yl)acetate (19):



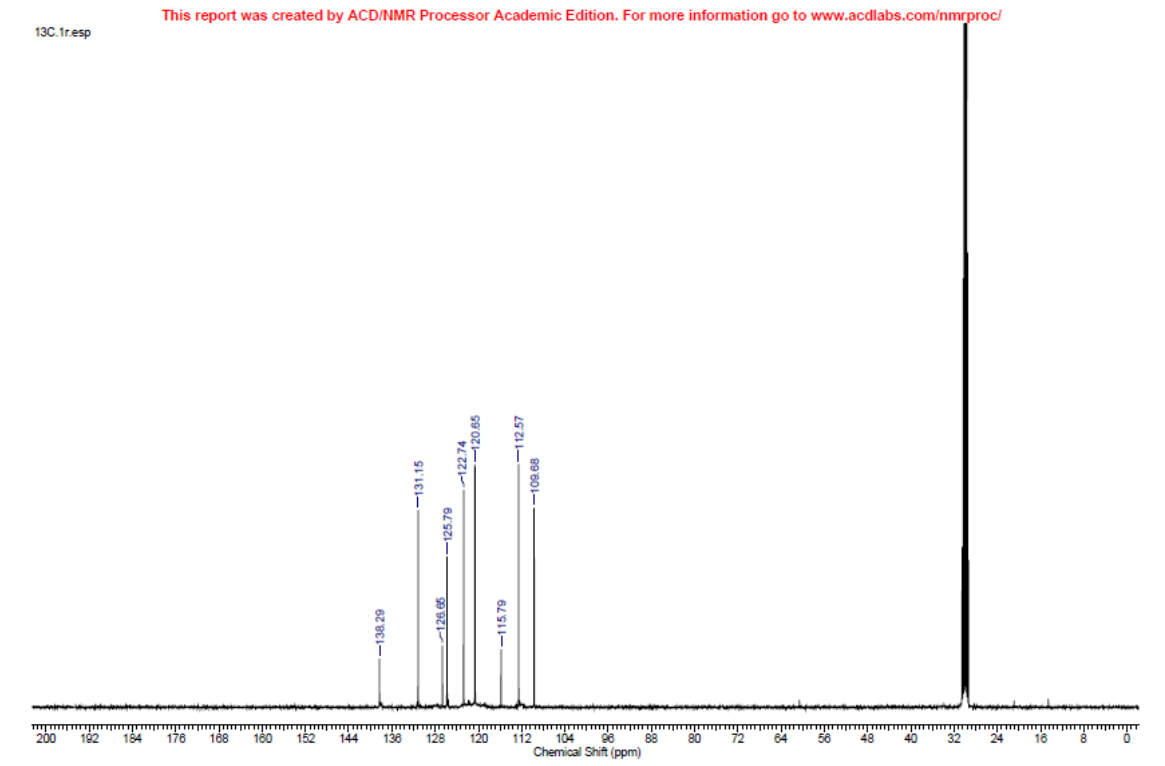
To a solution of 17.7 mg (0.100 mmol, 1.00 equiv.) ethyl 2-(phenylimino)acetate (**8a**) in abs. dichloromethane (2 mL) were subsequently added 7.0 mg catalyst **16** (10 mol%) and 28.6 mg (0.200 mmol, 2.00 equiv.) 2-vinyl-1*H*-indole (**18**). The solution was stirred at rt. for 90 min. The solvent was evaporated under reduced pressure and the residue purified by preparative TLC (cyclohexane/ethyl acetate = 3:1). The product **19** was isolated as a yellow oil (23.2 mg, 72.4 µmol, 73%). The *ee* of the product was determined by HPLC using a Chiralpak® OD column (*n*-heptane/*i*-PrOH = 95:5; flow rate = 0.7 mL/min; T = 10 °C; λ = 214 nm; t_R (major enantiomer) = 13.63 min; t_R (minor enantiomer) = 15.15 min; *ee* = 7%).

***R*$_f$** (cyclohexane/ethyl acetate = 3:1) = 0.41. – **^{1}H NMR** (400 MHz, acetone-d_6): δ = 1.13 (t, ^3J = 7.1 Hz, 3H, CH_2CH_3), 4.01–4.11 (m, 1H, CH_2CH_3), 4.15–4.25 (m, 1H, CH_2CH_3), 5.39 (dd, $^3J_{cis}$ = 11.4, ^2J = 0.7 Hz, 1H, CH=CHH), 5.47–5.55 (m, 2H, CHNH), 5.86 (dd, $^3J_{trans}$ = 17.6, ^2J = 0.7 Hz, 1H, CH=CHH), 6.67 (tt, ^3J = 5.0, ^4J = 2.0 Hz, 1H, *p*-H_{Ph}), 6.70–6.76 (m, 2H, H_{Ph}), 6.99–7.15 (m, 4H, H_{Ar}), 7.23 (dd, $^3J_{trans}$ = 17.6, $^3J_{cis}$ =11.4 Hz, 1H, CH=CH_2), 7.30–7.36 (m, 1H, H_{Ar}), 7.82 (d, ^3J = 8.0 Hz, 1H, H_{Ar}), 10.54 (bs, 1H, NH$_{Ind}$) ppm. – **^{13}C NMR** (100 MHz, acetone-d_6): δ = 14.4 (+, CH_2CH_3) 54.1 (+, CHNH), 61.7 (–, CH_2CH_3), 111.2 (C_q), 111.8 (+, CH_{Ar}), 113.9 (+, 2 × CH_{Ph}), 114.2 (–, CH=CH_2), 117.9 (+, CH_{Ar}), 120.3 (+, CH_{Ar}), 120.8 (+, CH_{Ar}), 123.6 (+, CH_{Ar}), 126.5 (+, CH_{Ar}), 127.8 (C_q), 129.7 (+, 2 × CH_{Ph}), 135.3 (C_q), 137.6 (C_q), 148.2 (C_q, C_{Ph}), 172.6 (C_q, CO_2Et) ppm. – **IR (ATR):** ν^{-1} = 3387 (w), 3051 (w), 2978 (w), 2928 (w), 1723 (m), 1600 (m), 1502 (m), 1443 (m), 1368 (w), 1313 (m), 1242 (m), 1194 (m), 1140 (m), 1095 (w), 1015 (m), 979 (w), 903 (w), 745 (m), 691 (m), 537 (w), 479 (w), 431 (w) cm^{-1}. – **MS** (EI, 70 eV), *m/z* (%): 320 (21) $[M]^+$, 247 (100), 154 (31), 93 (32). – **HRMS** (EI, $C_{20}H_{20}N_2O_2$): calcd. 320.1519; found: 320.1519.

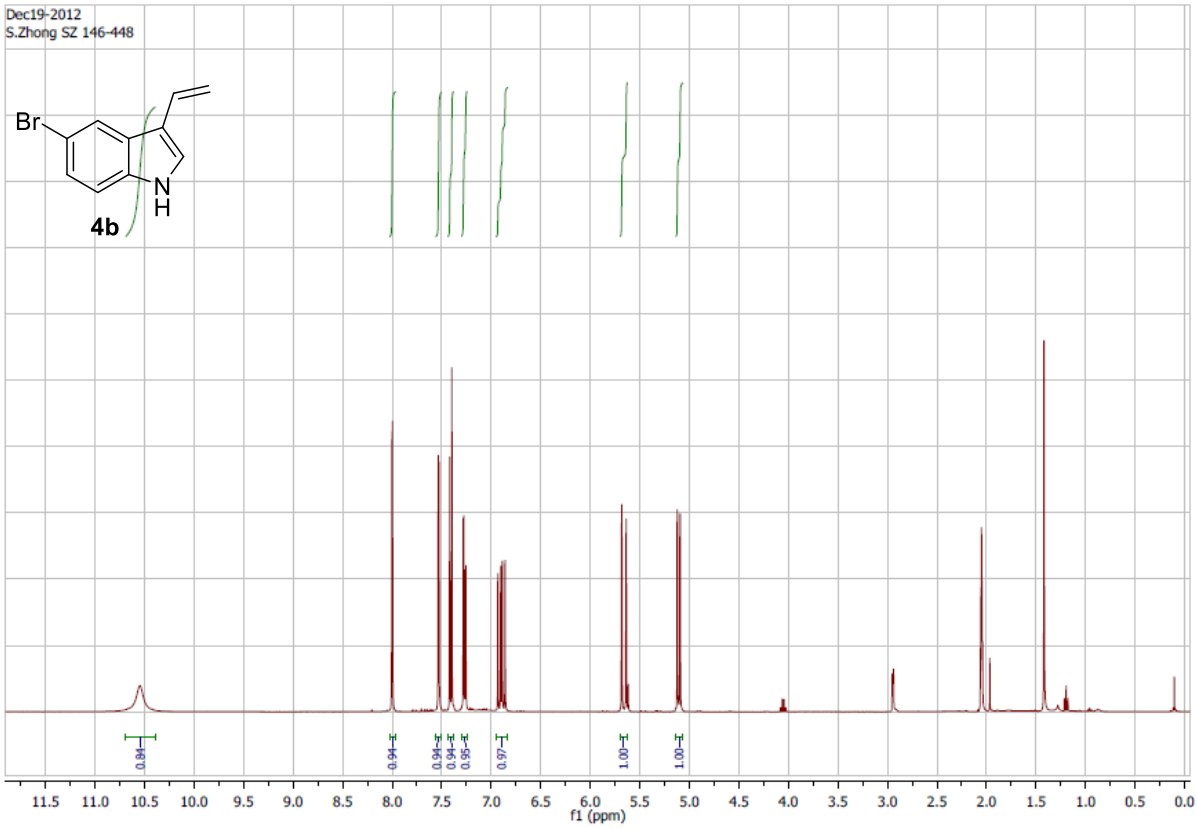
5 NMR spectra of all vinylindoles and bisindoles



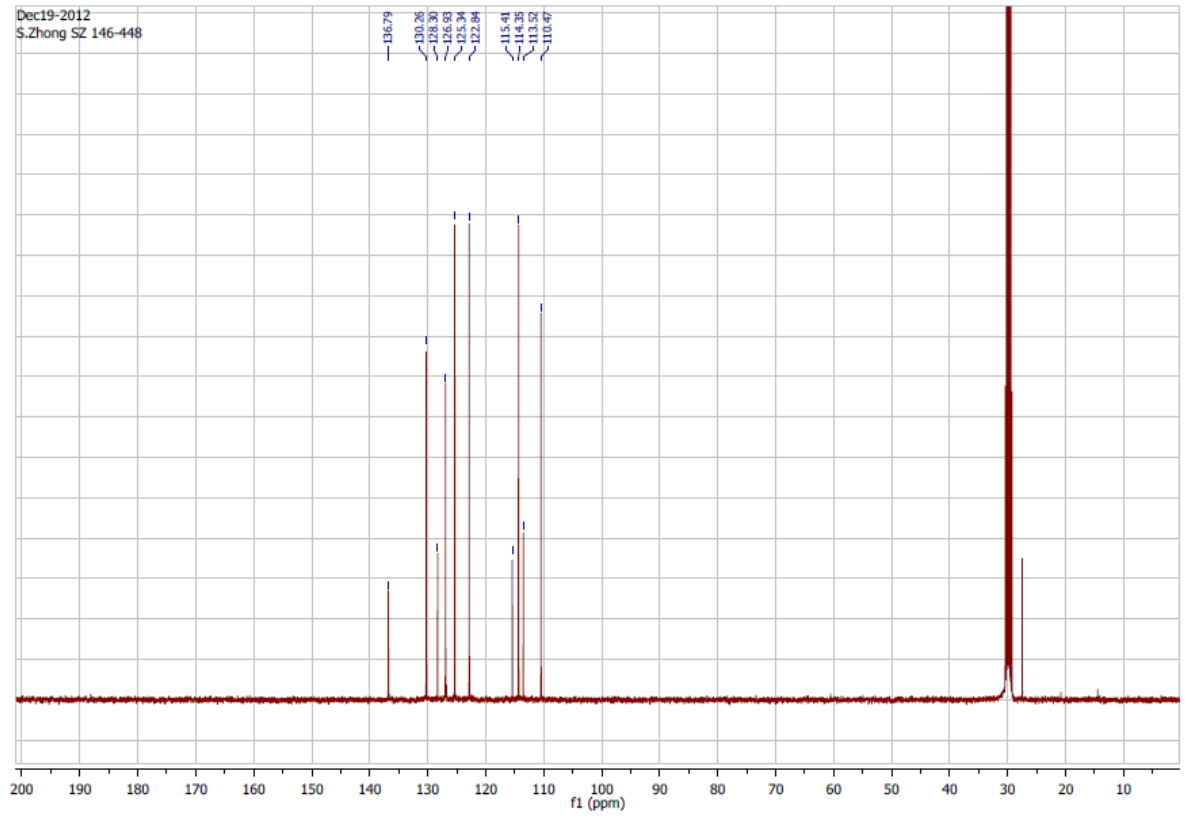
^{1}H NMR, 400 MHz, acetone-d_6



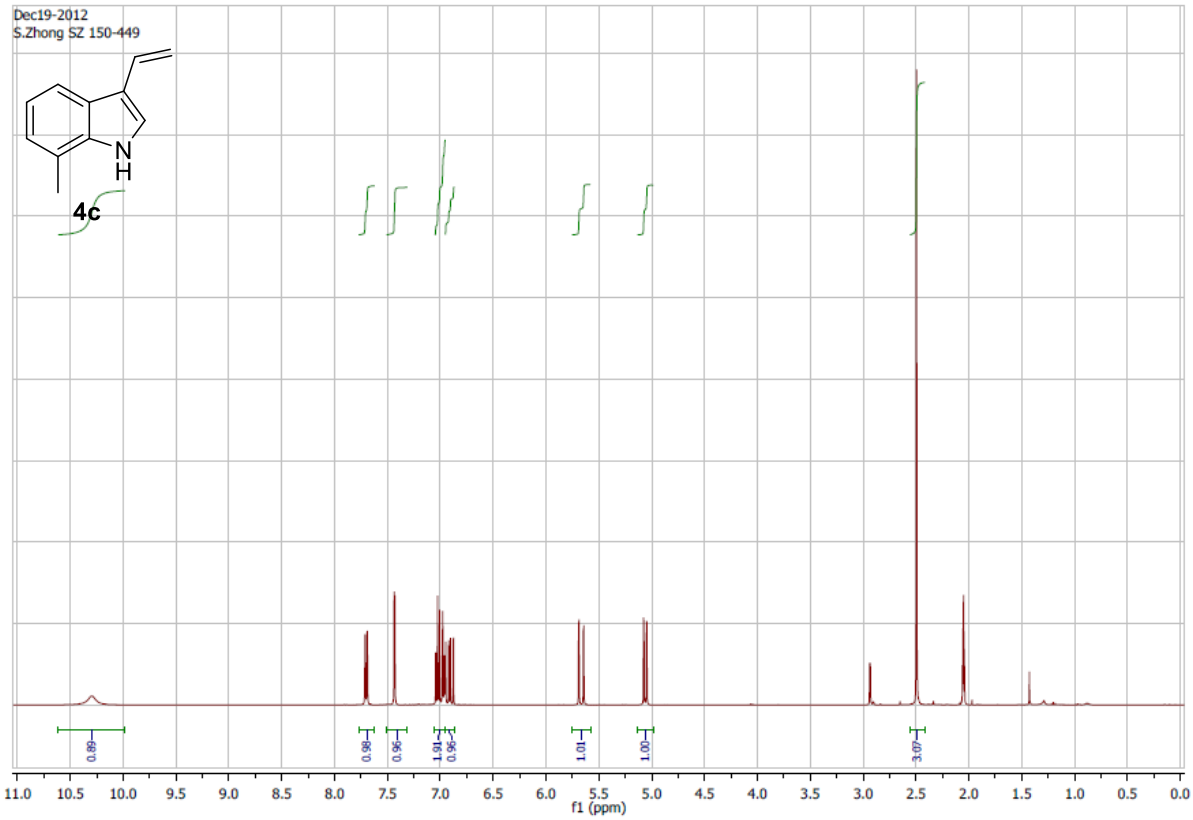
^{13}C NMR, 100 MHz, acetone-d_6



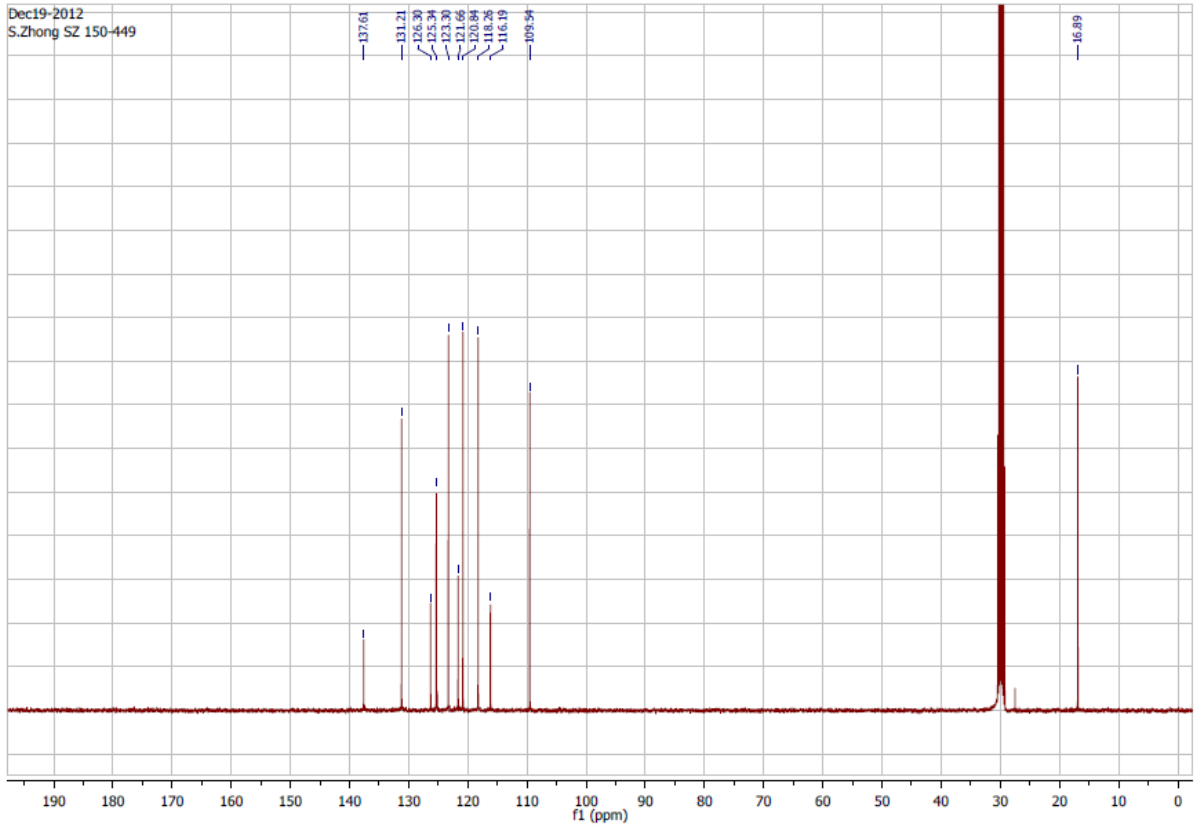
^{1}H NMR, 400 MHz, acetone-d_6



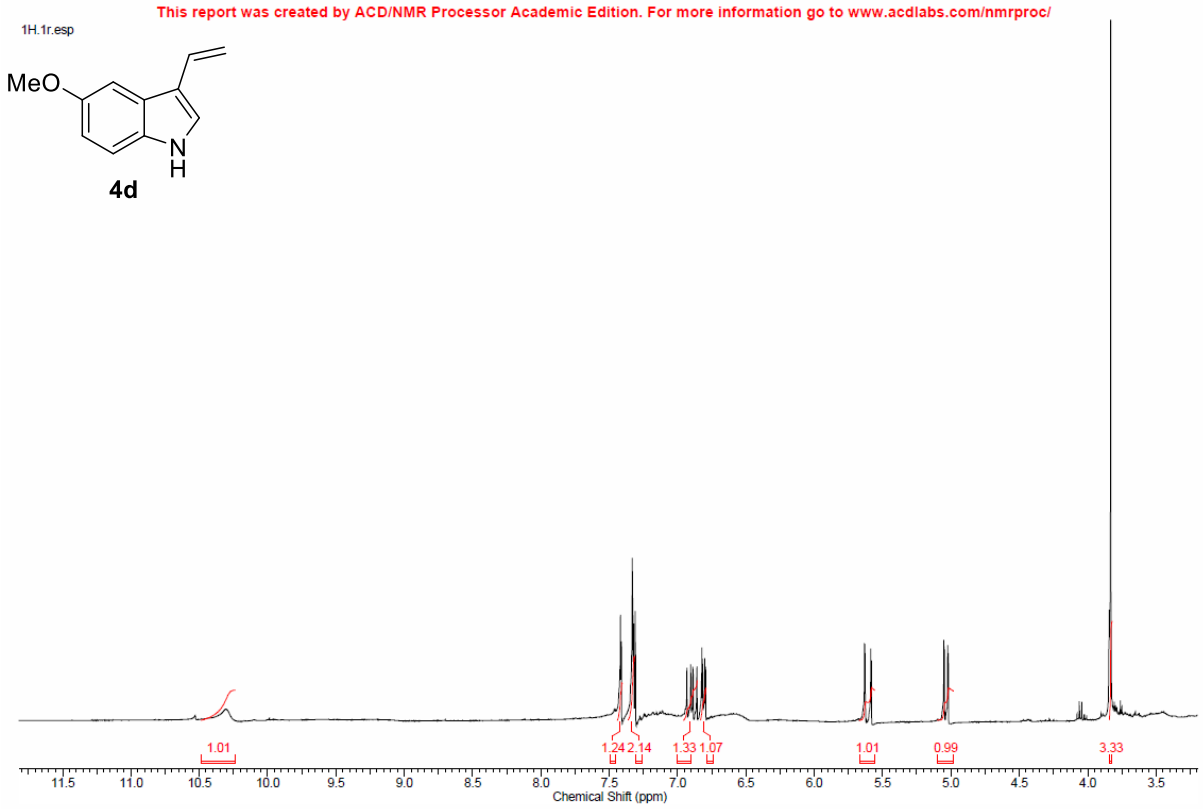
^{13}C NMR, 100 MHz, acetone-d_6



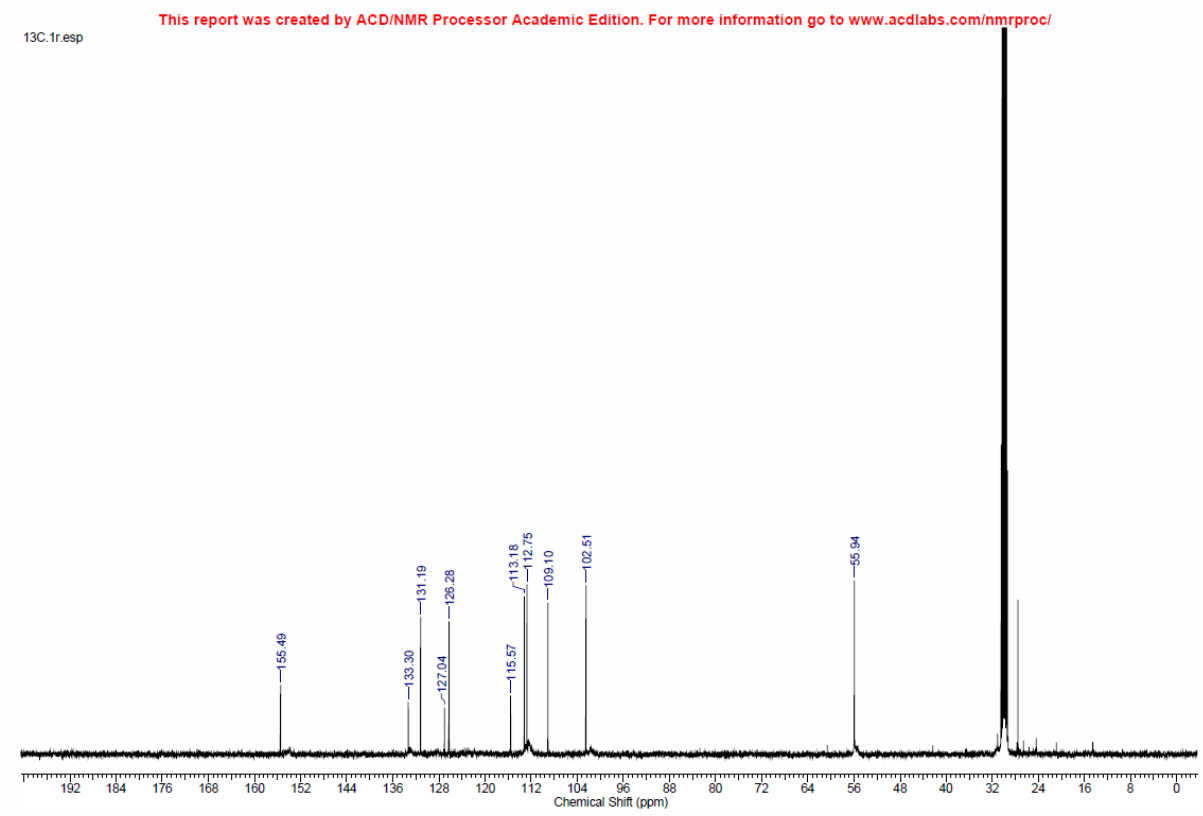
^{1}H NMR, 400 MHz, acetone-d_6



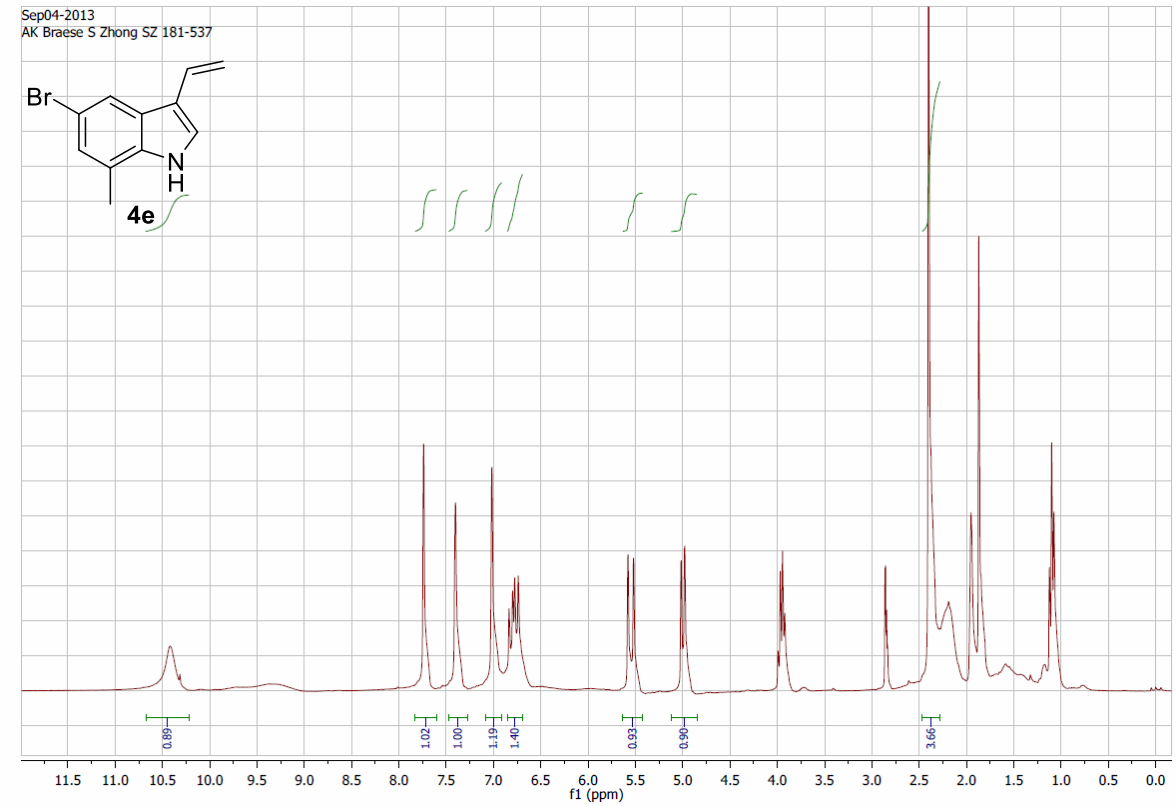
^{13}C NMR, 100 MHz, acetone-d_6



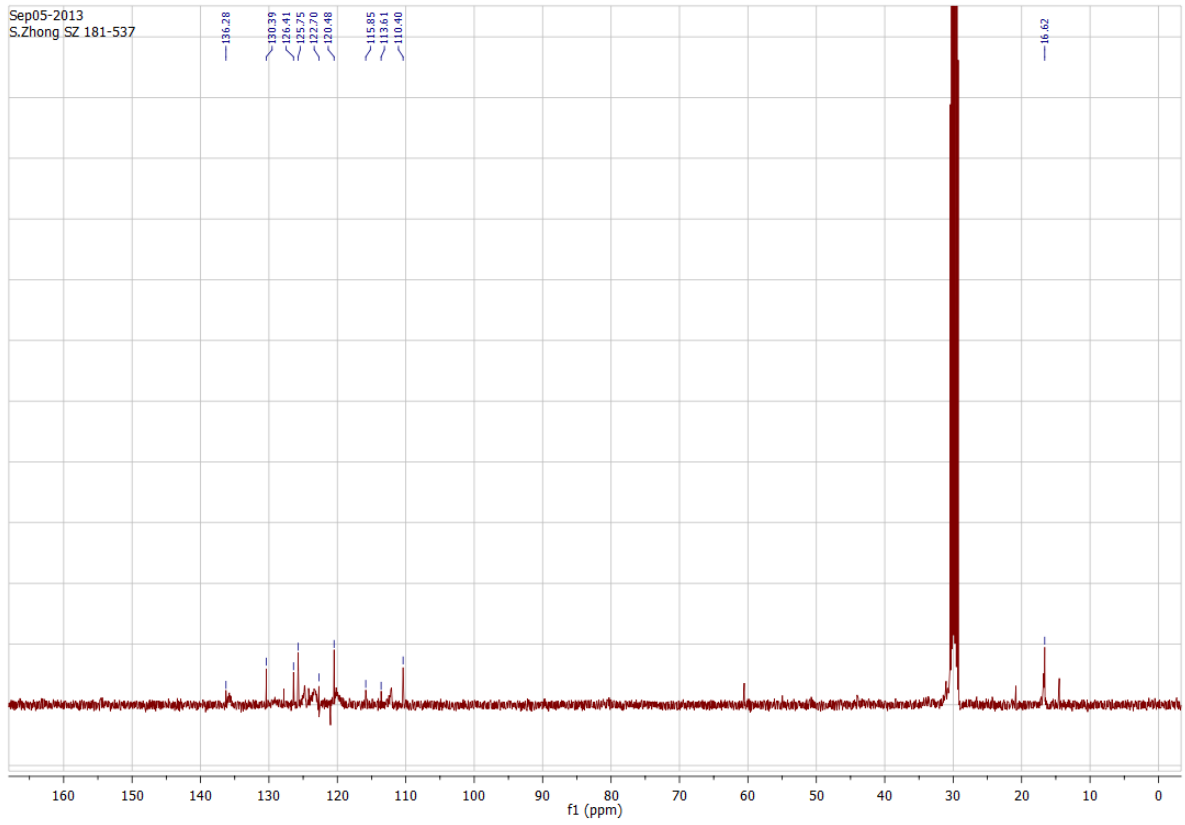
^{1}H NMR, 400 MHz, acetone-d_6



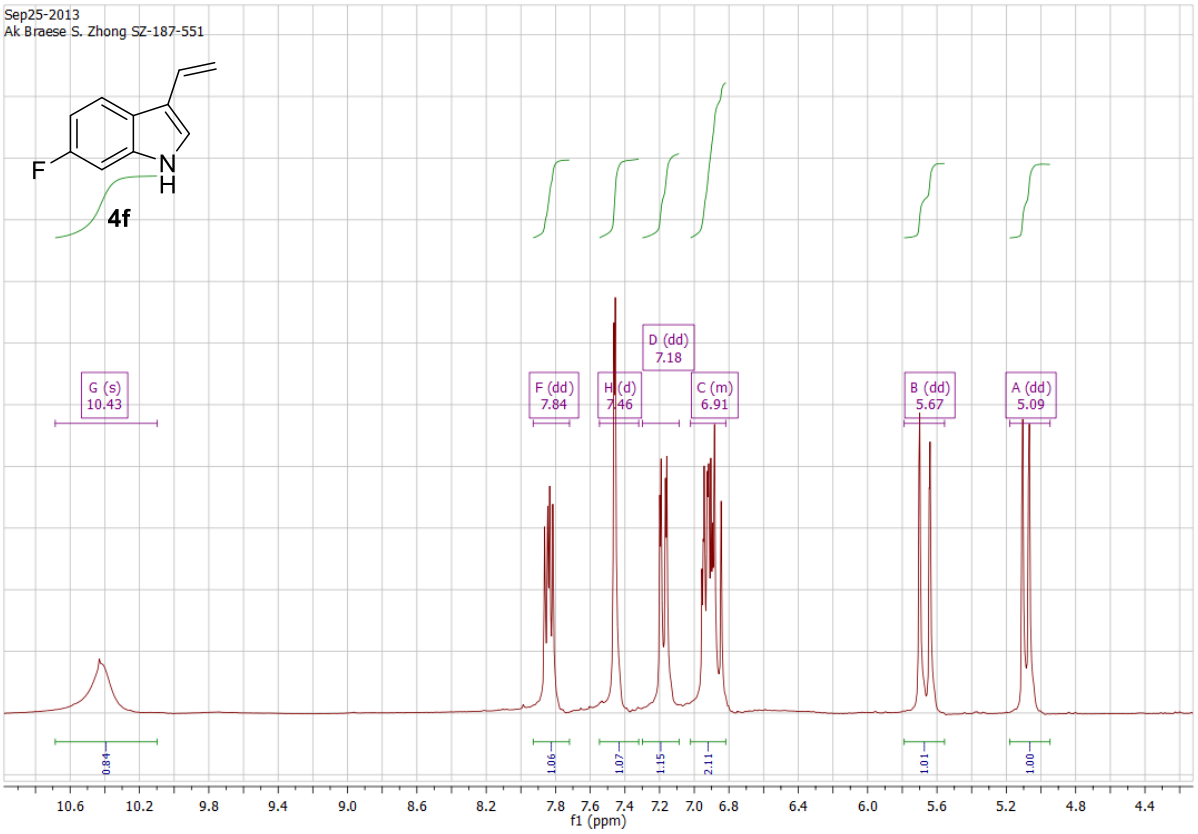
^{13}C NMR, 100 MHz, acetone-d_6



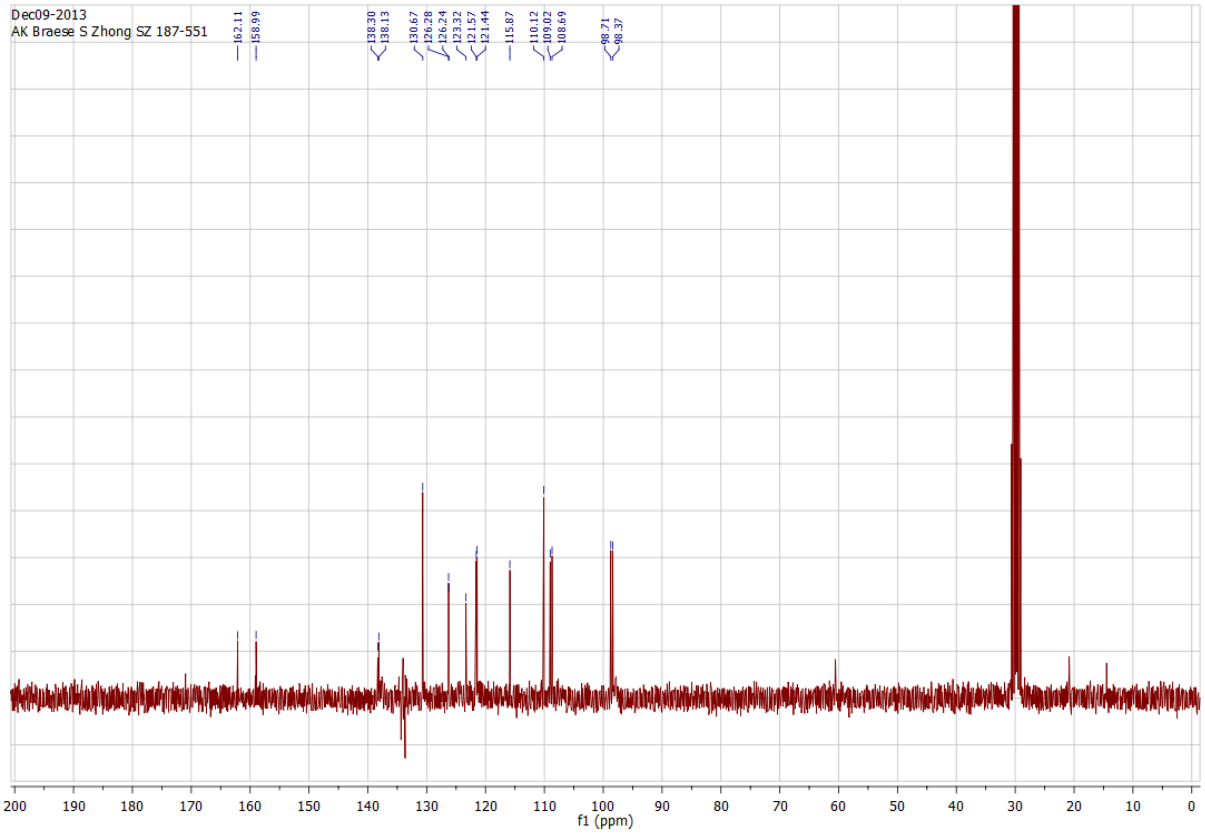
^{1}H NMR, 300 MHz, acetone-d_6



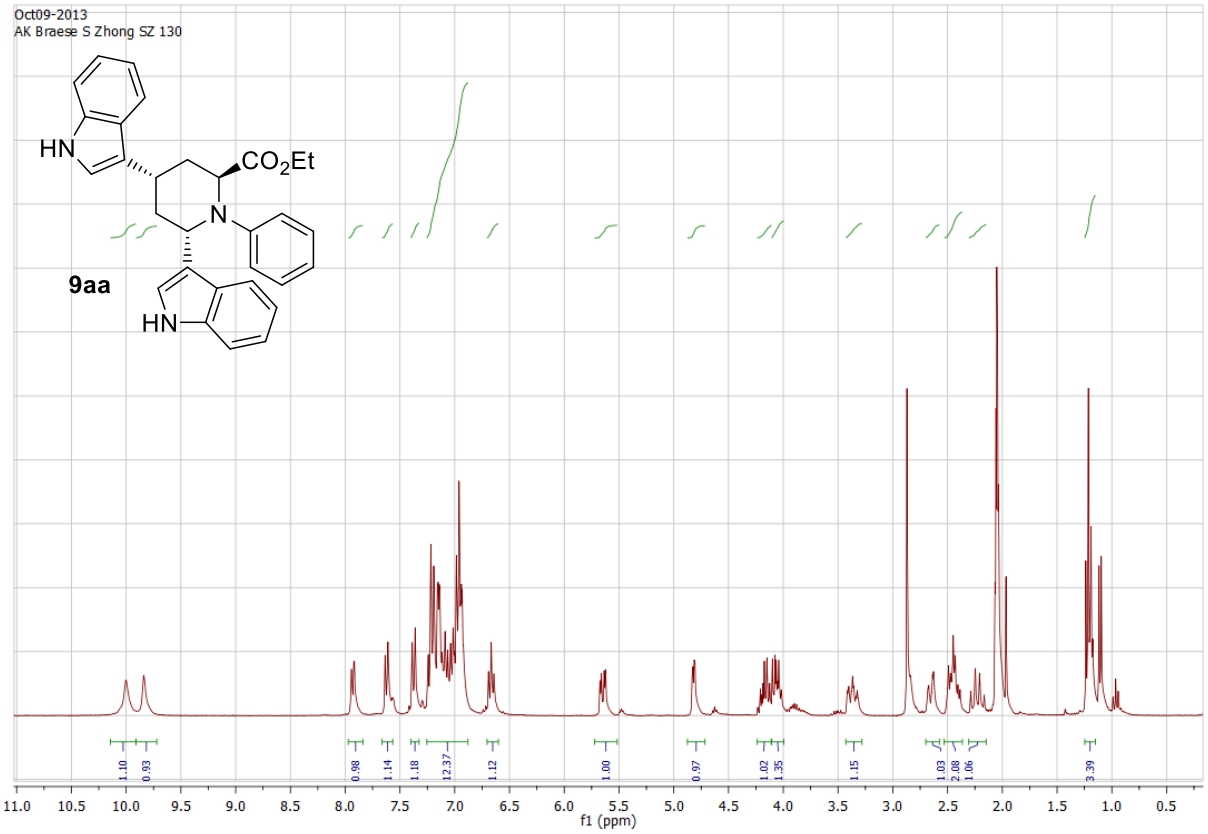
^{13}C NMR, 100 MHz, acetone-d_6



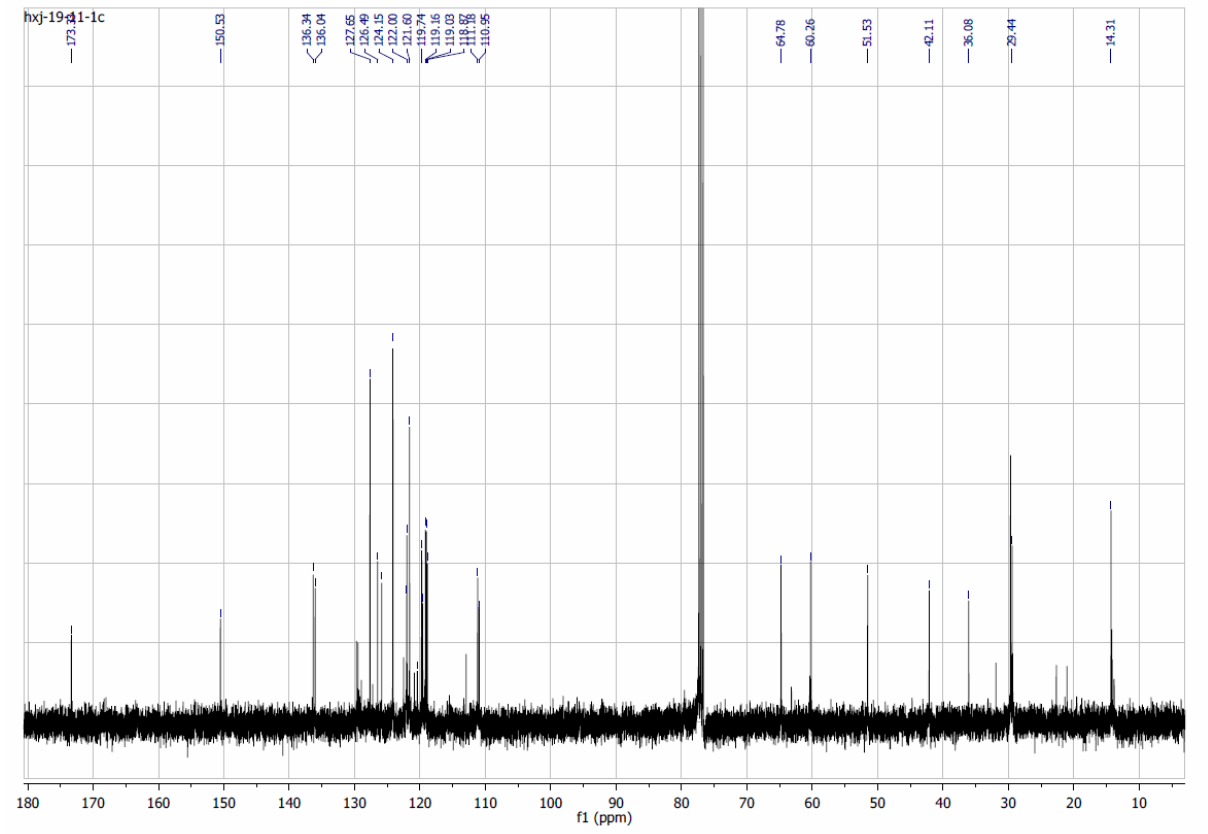
^{1}H NMR, 300 MHz, acetone-d_6



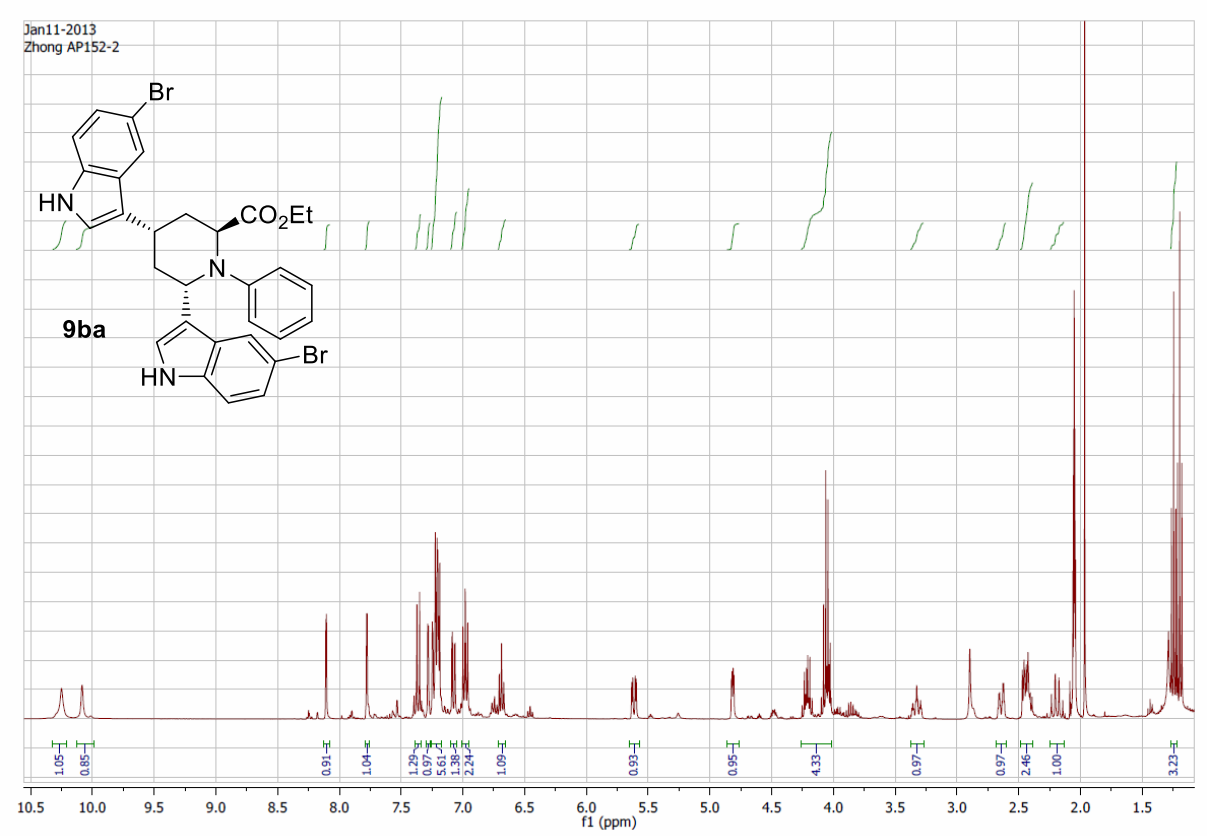
^{13}C NMR, 100 MHz, acetone-d_6



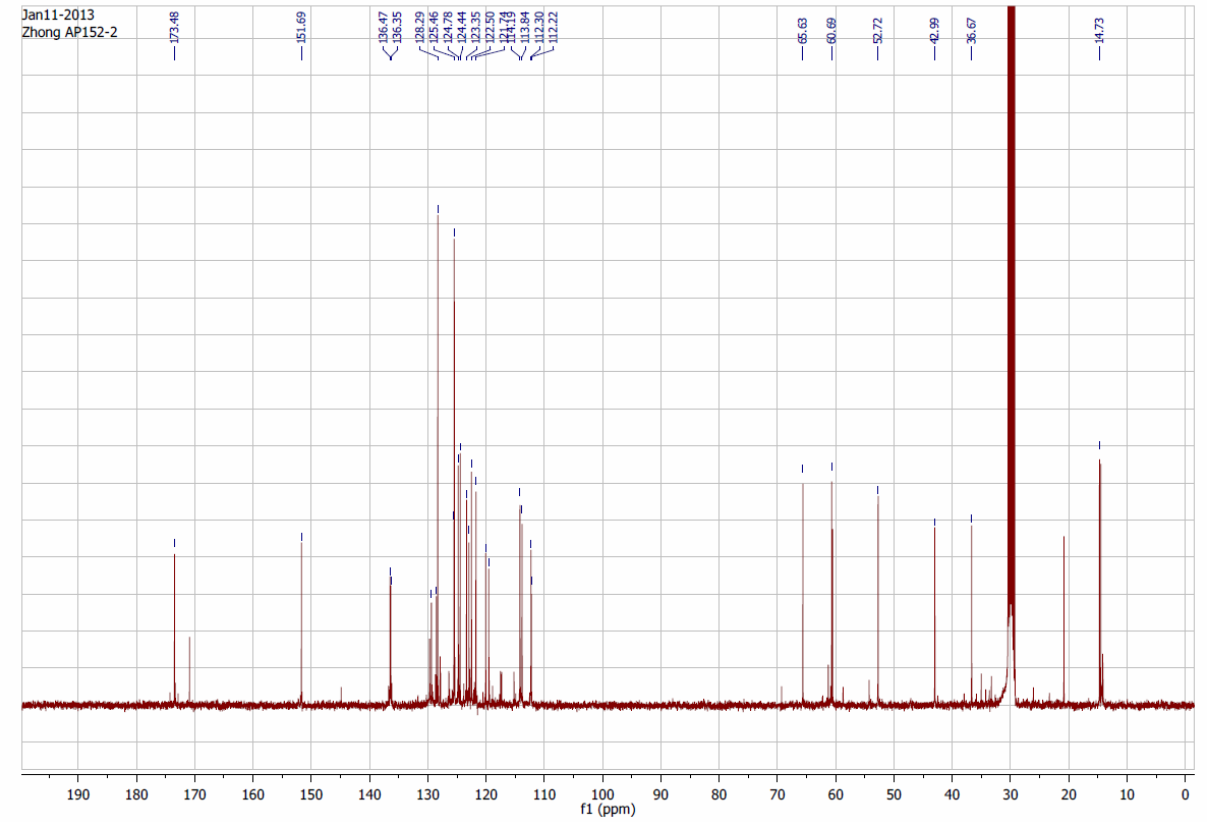
^{1}H NMR, 300 MHz, acetone-d_6



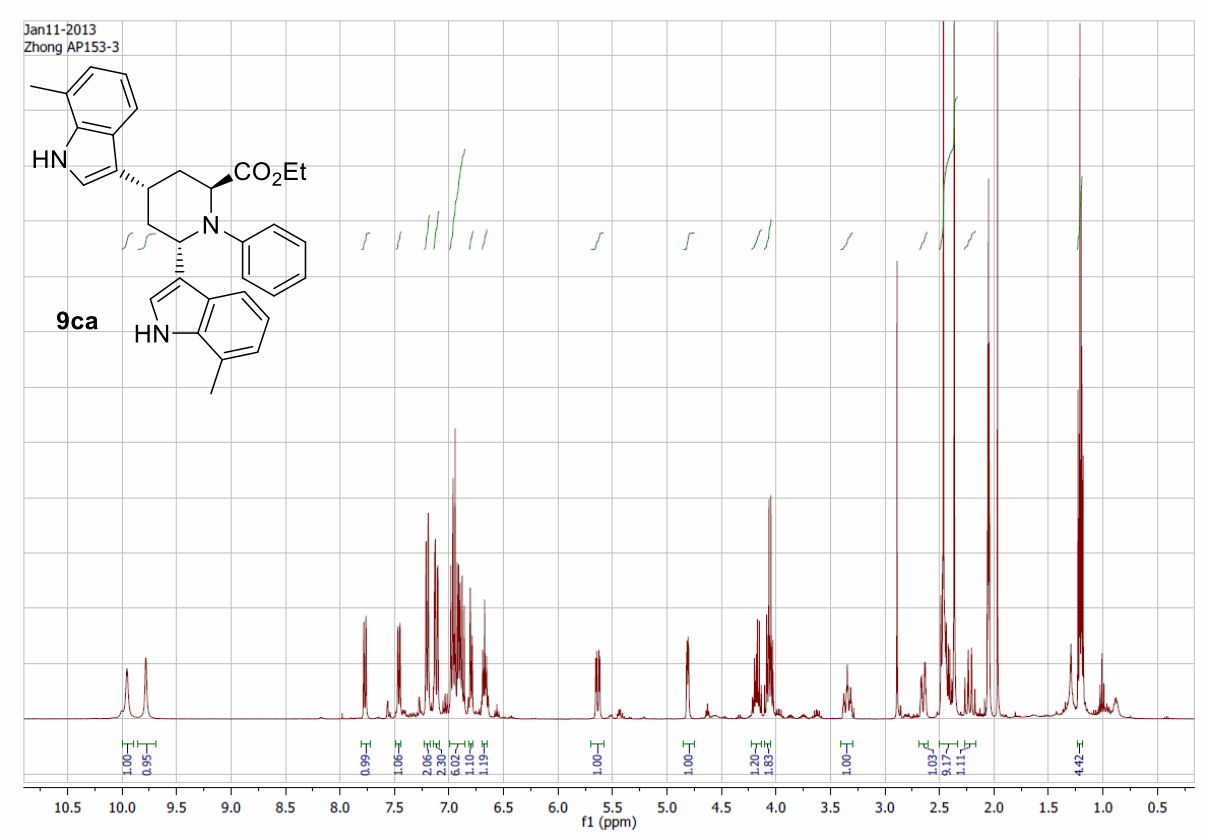
^{13}C NMR, 100 MHz, $CDCl_3$



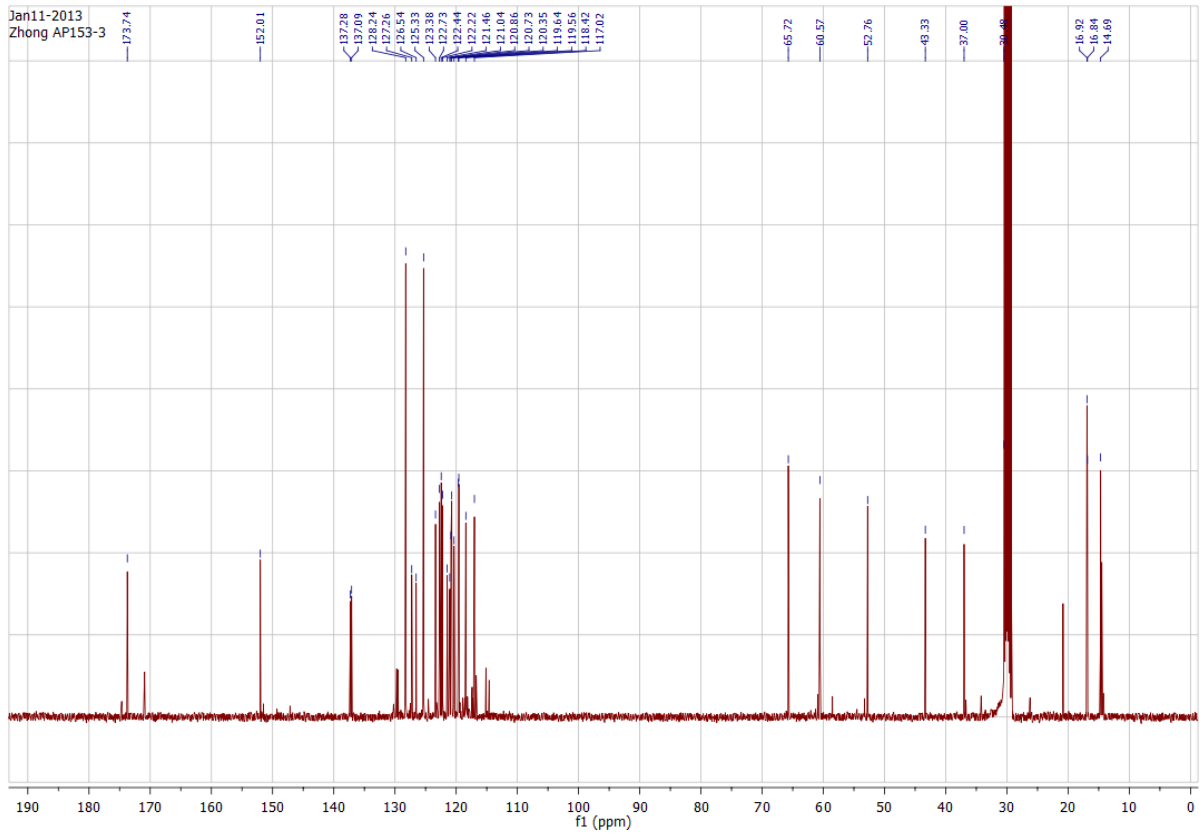
^{1}H NMR, 400 MHz, acetone-d_6



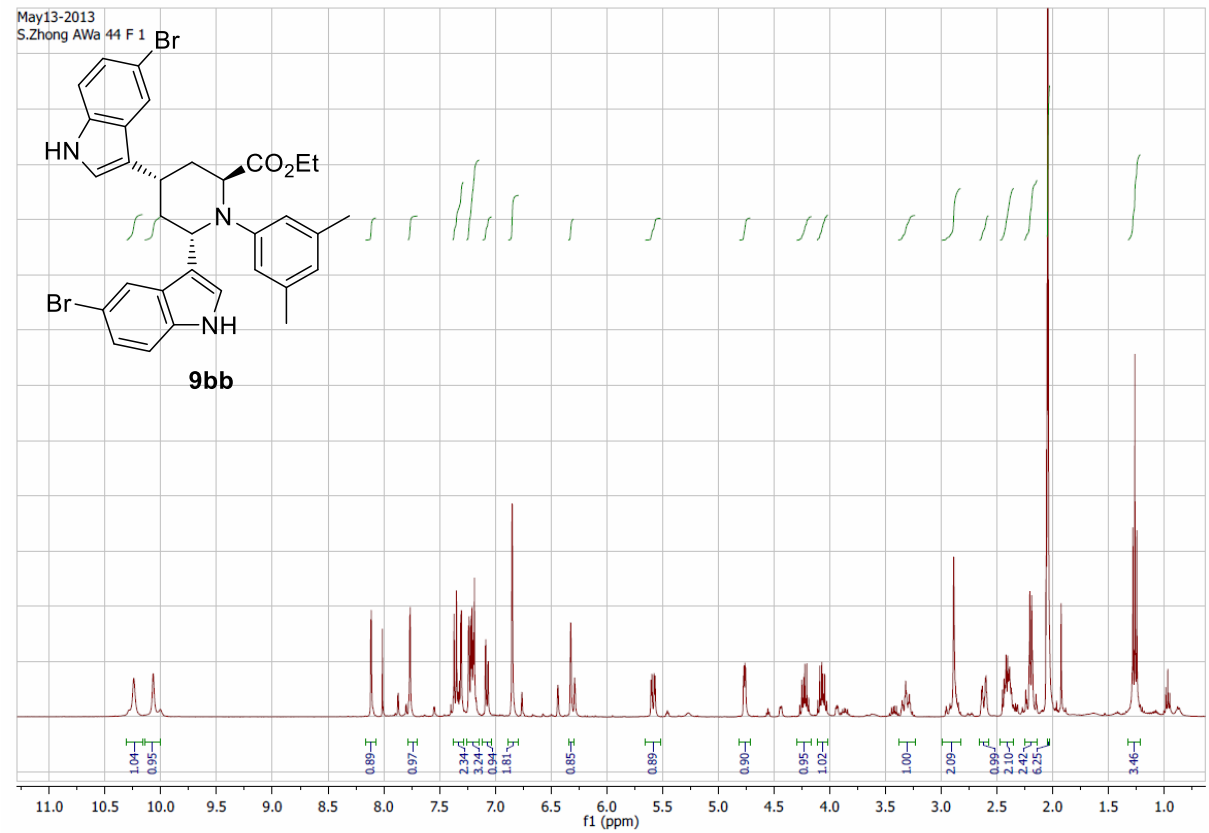
^{13}C NMR, 100 MHz, acetone-d_6



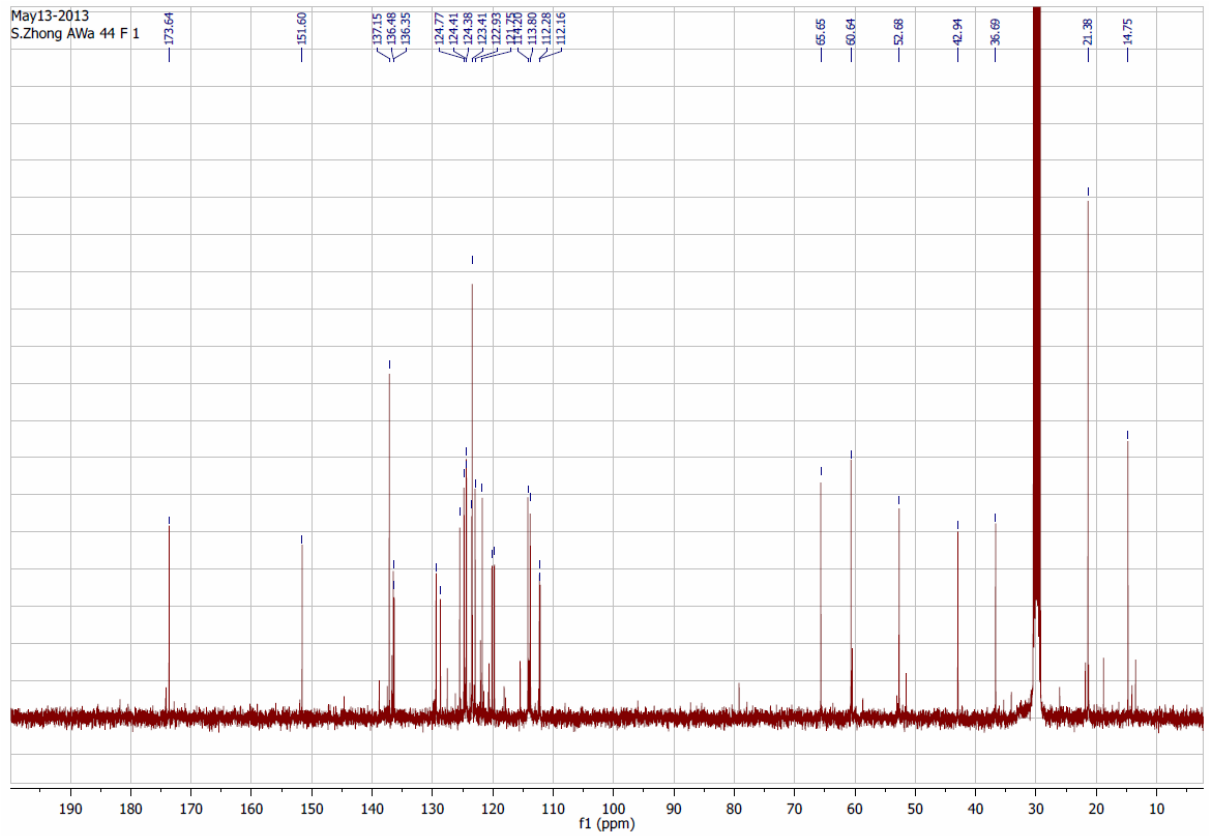
^{1}H NMR, 400 MHz, acetone-d_6



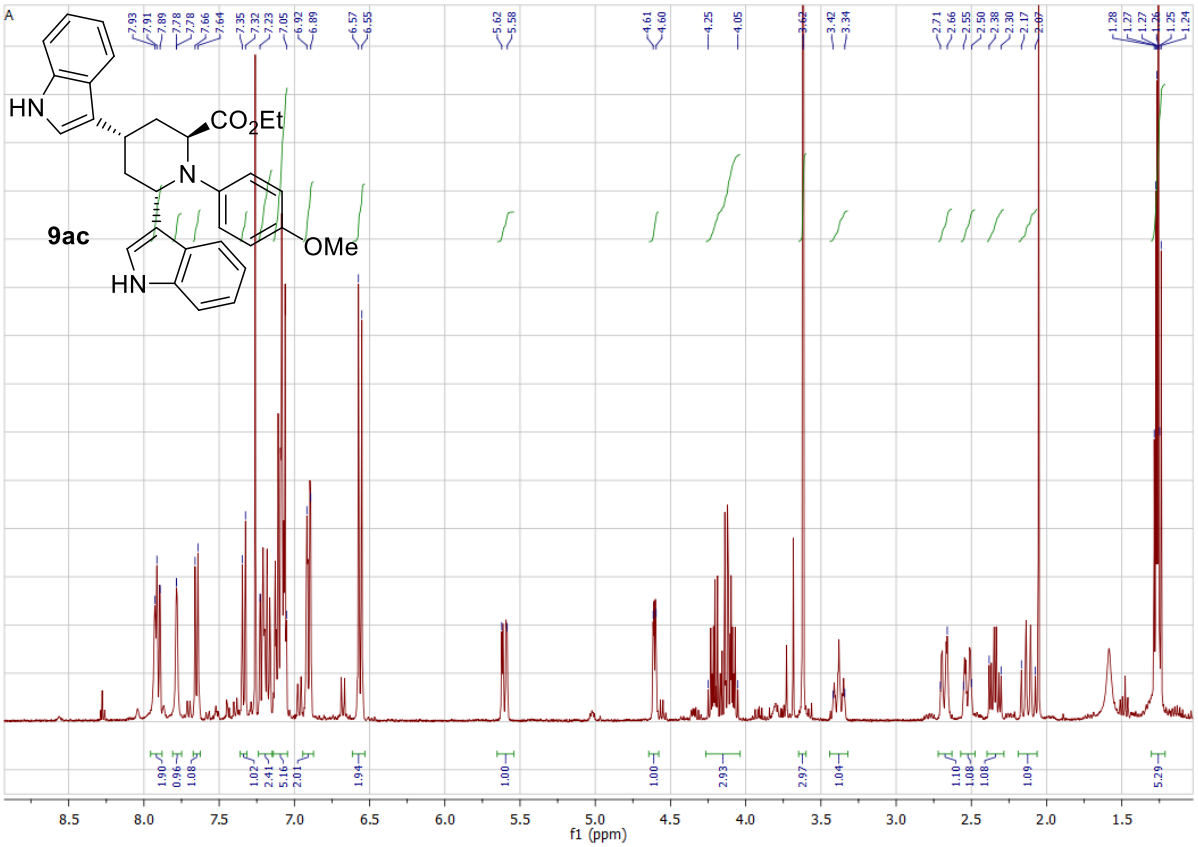
^{13}C NMR, 100 MHz, acetone-d_6



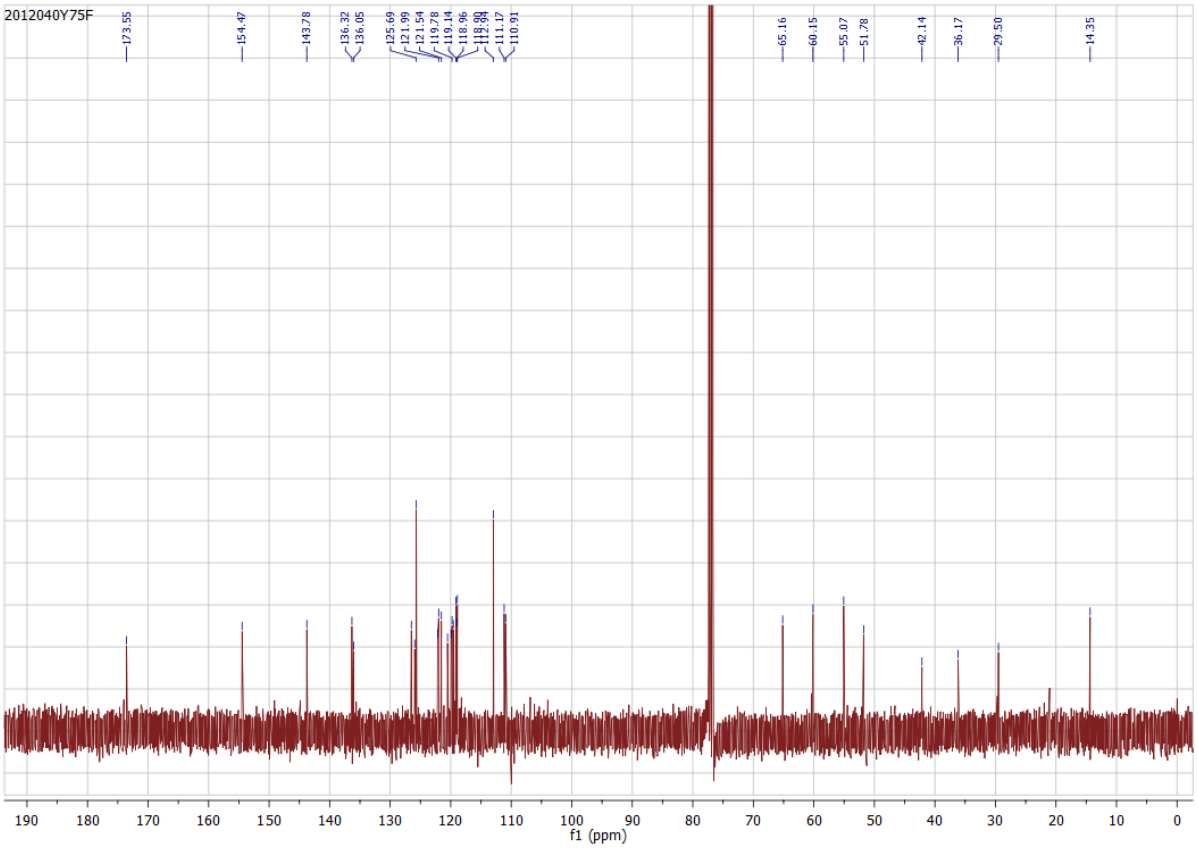
^{1}H NMR, 400 MHz, acetone-d_6



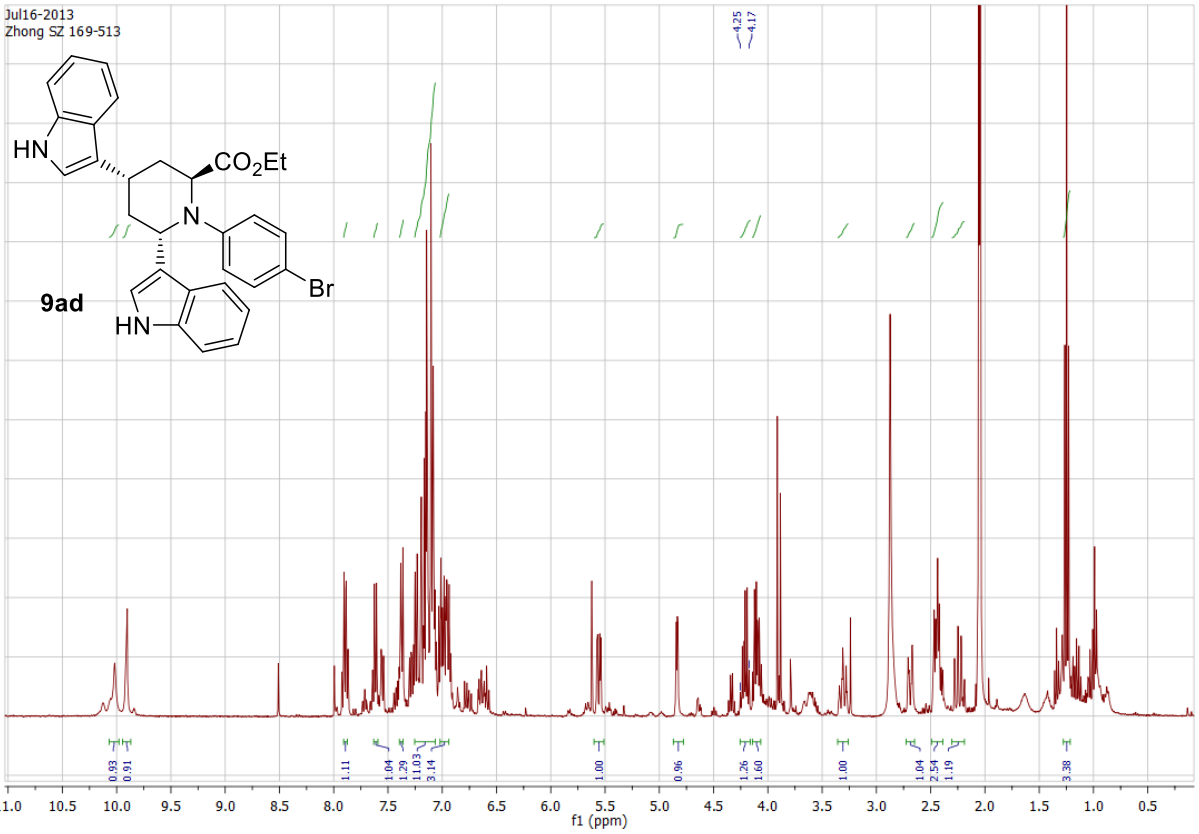
^{13}C NMR, 100 MHz, acetone-d_6



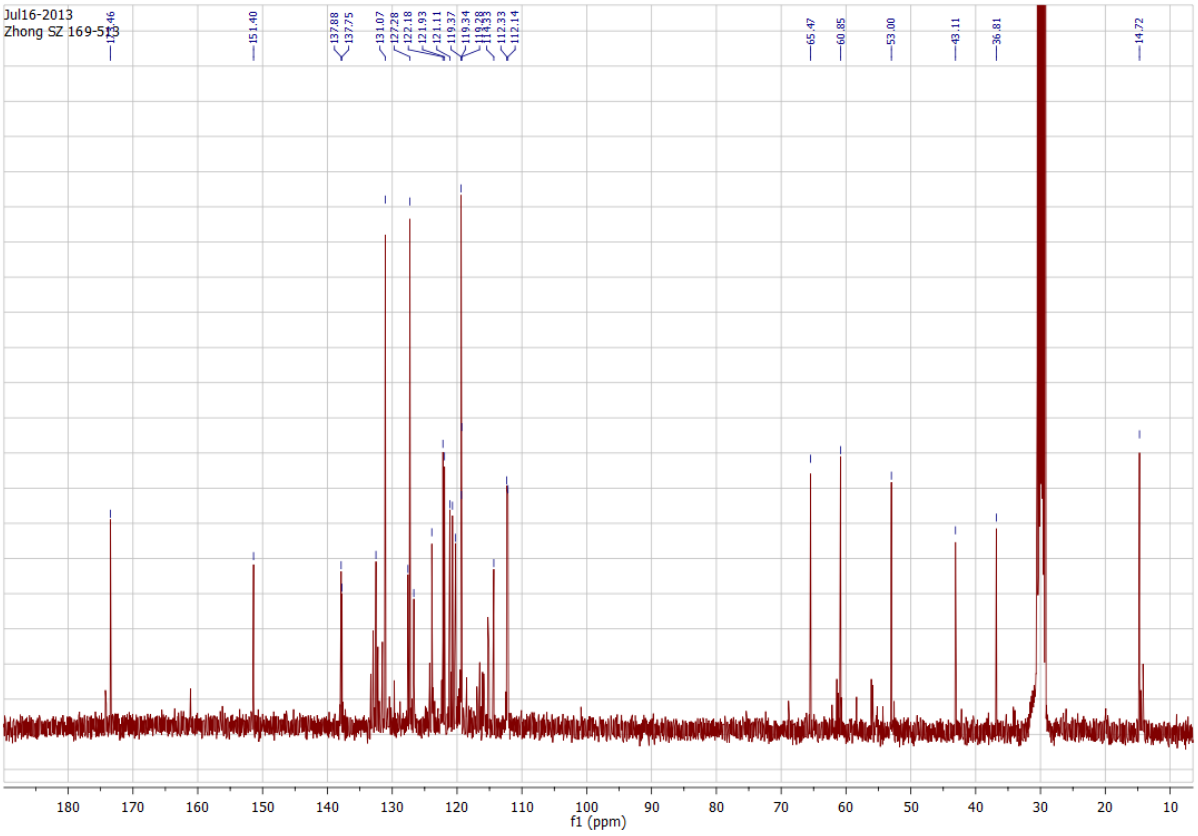
^{1}H NMR, 400 MHz, $CDCl_3$



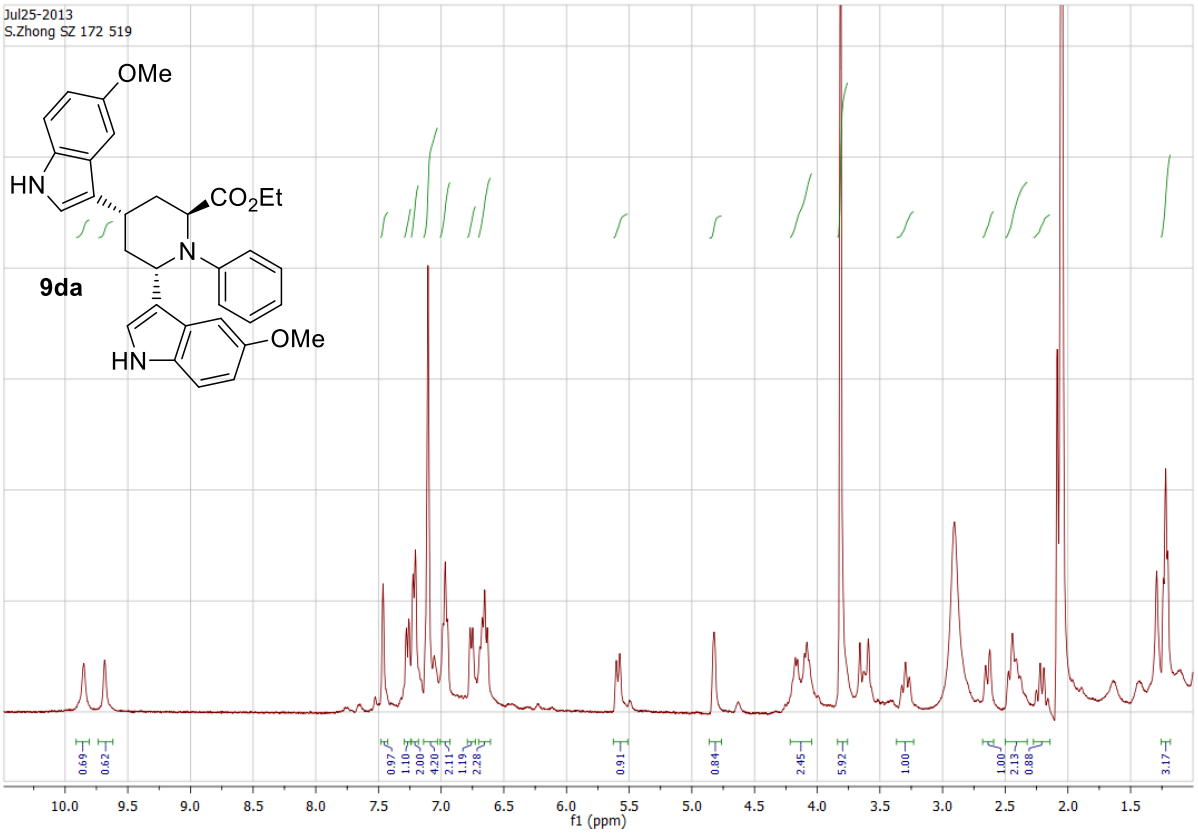
^{13}C NMR, 100 MHz, $CDCl_3$



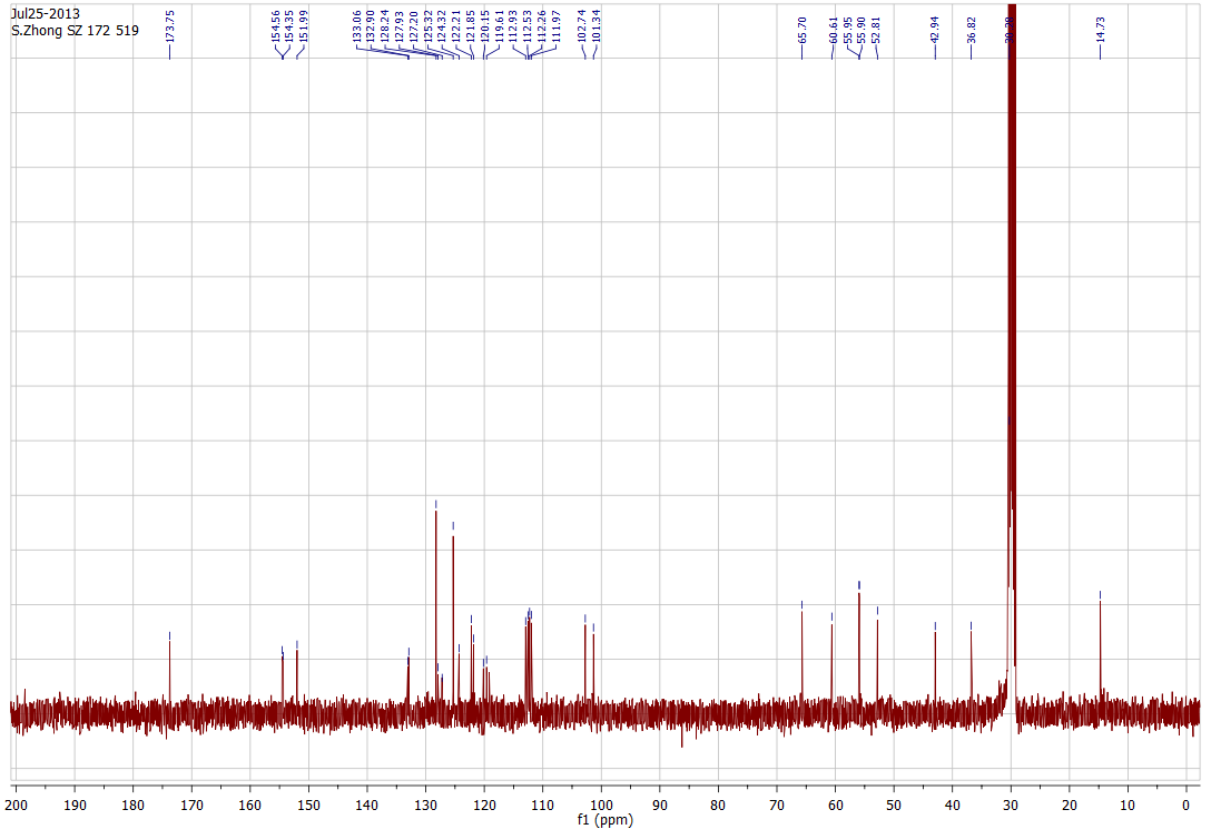
^{1}H NMR, 400 MHz, acetone-d_6



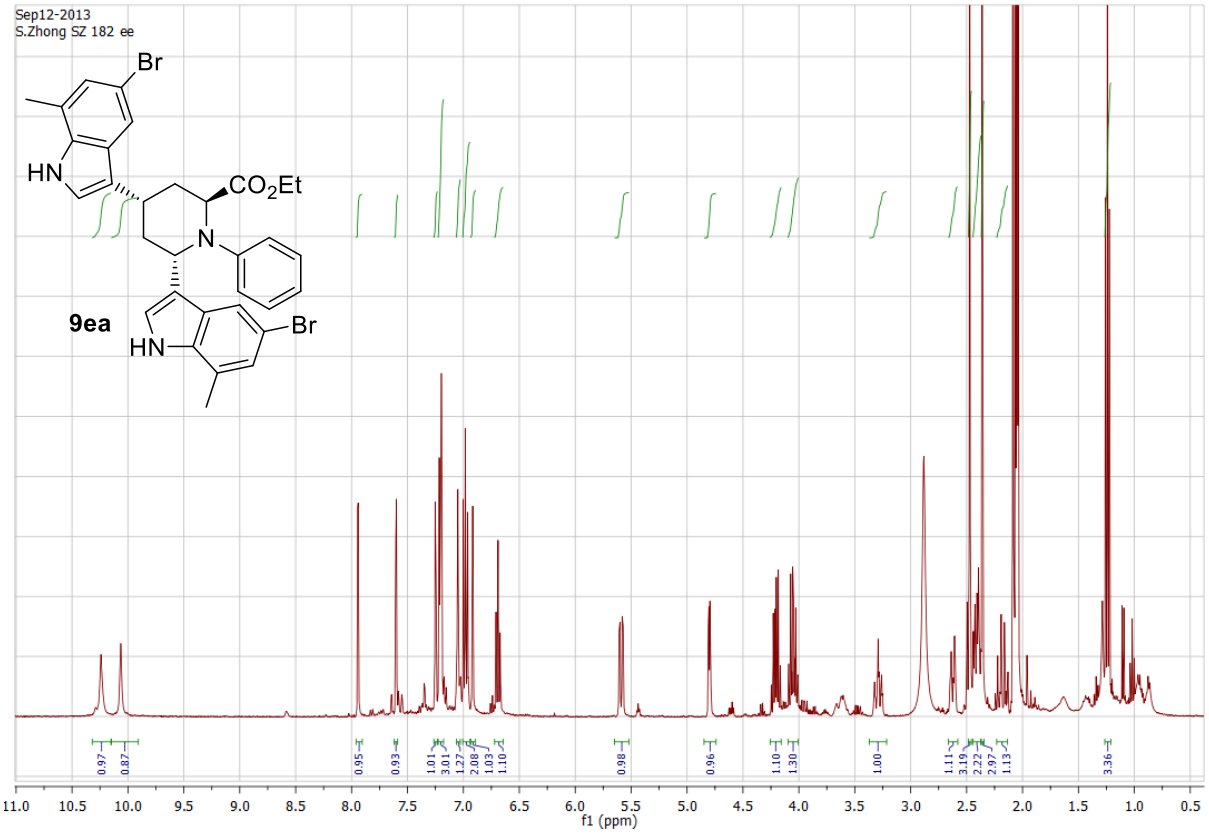
^{13}C NMR, 100 MHz, acetone-d_6



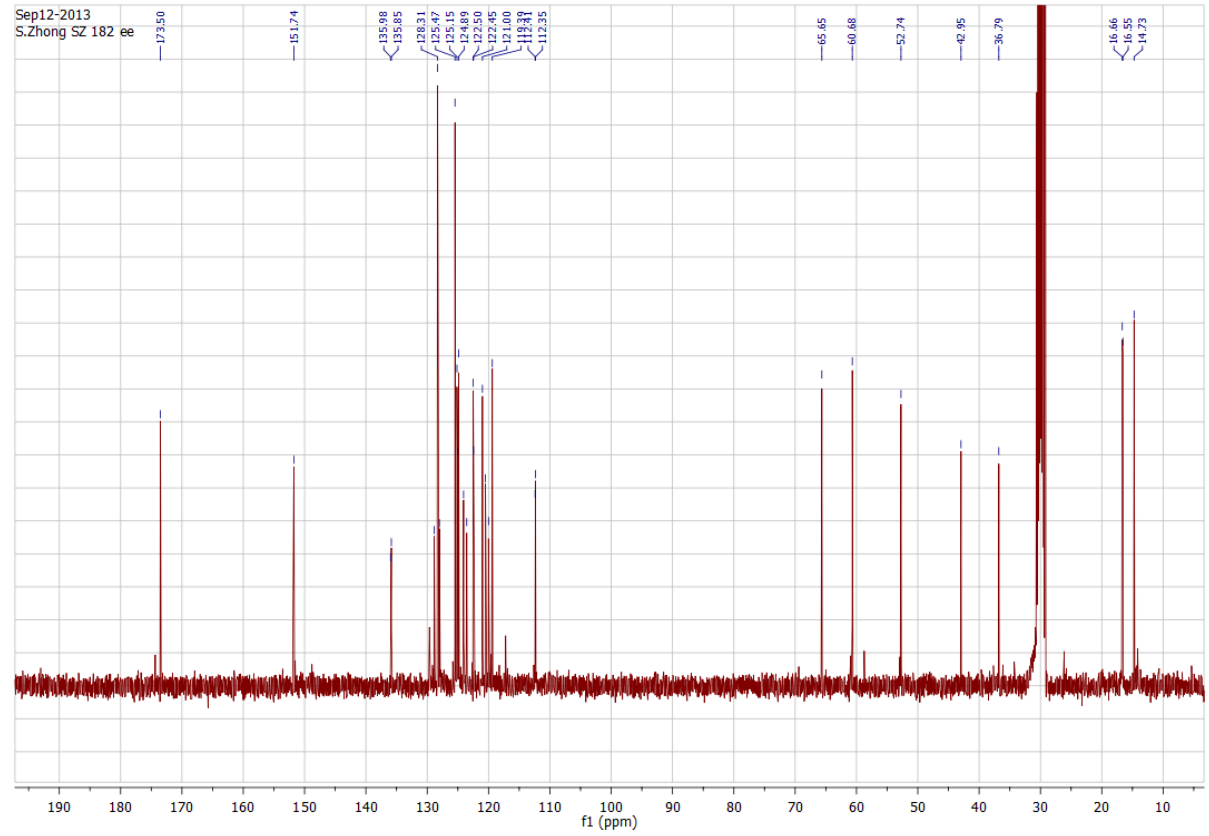
^{1}H NMR, 400 MHz, acetone-d_6



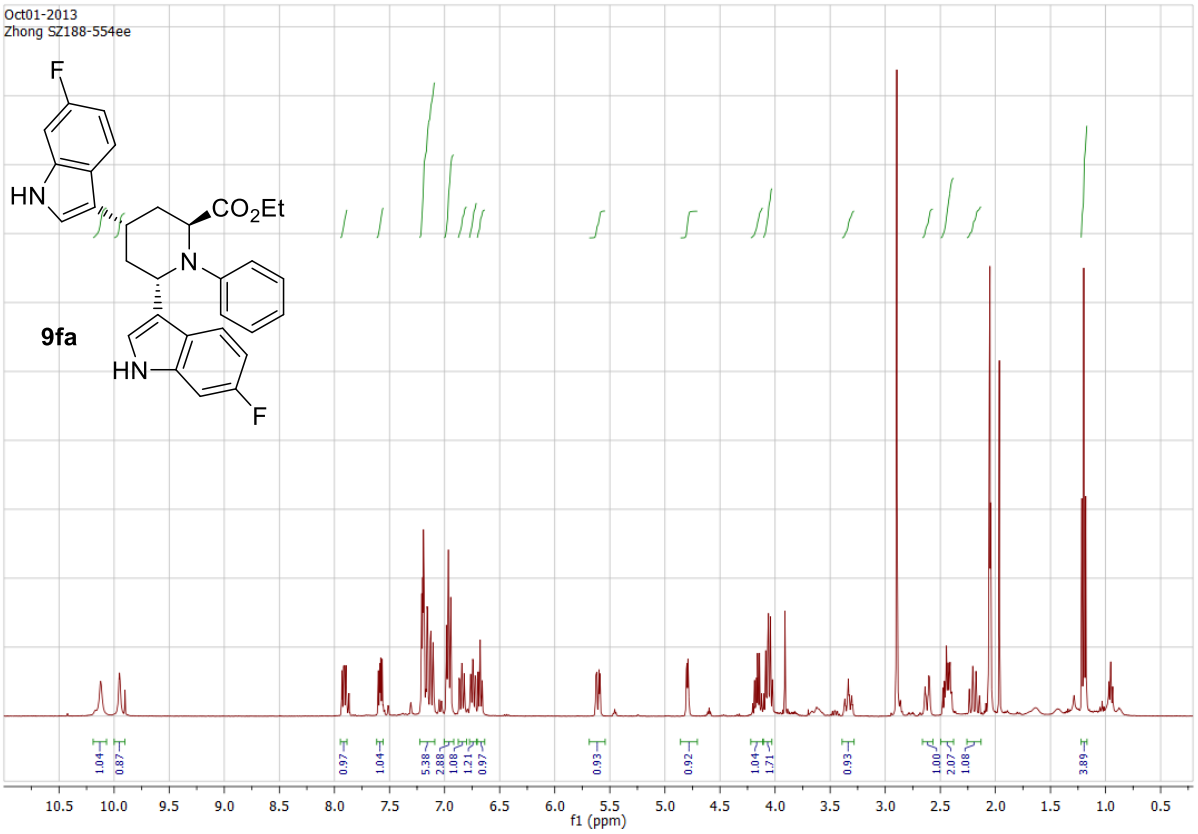
^{13}C NMR, 100 MHz, acetone-d_6



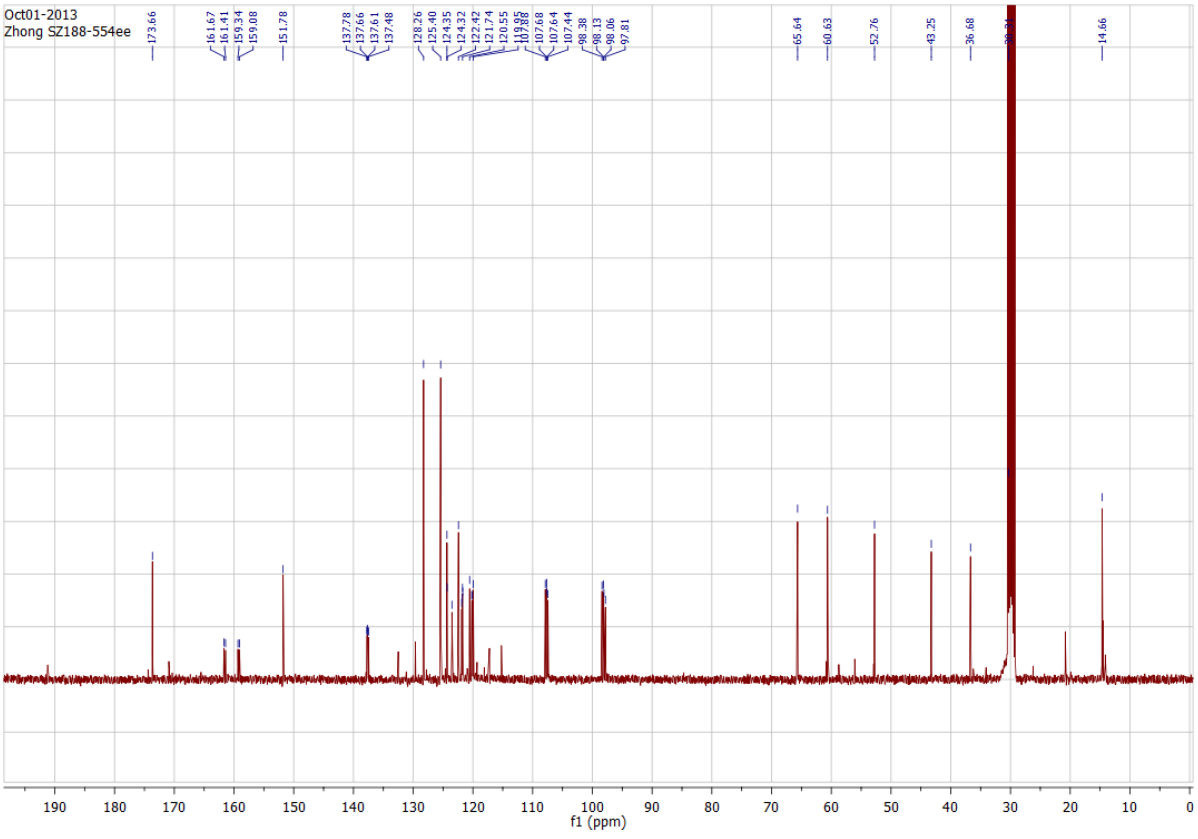
^{1}H NMR, 400 MHz, acetone-d_6



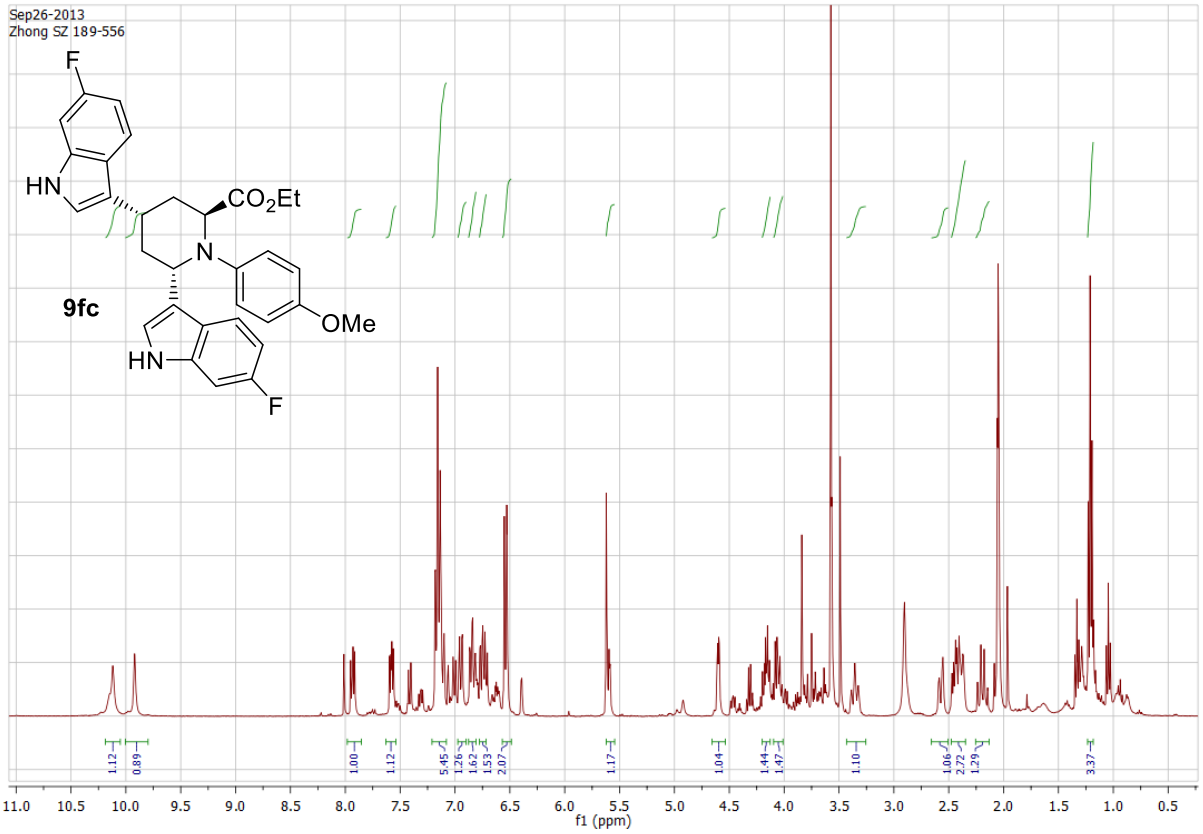
^{13}C NMR, 100 MHz, acetone-d_6



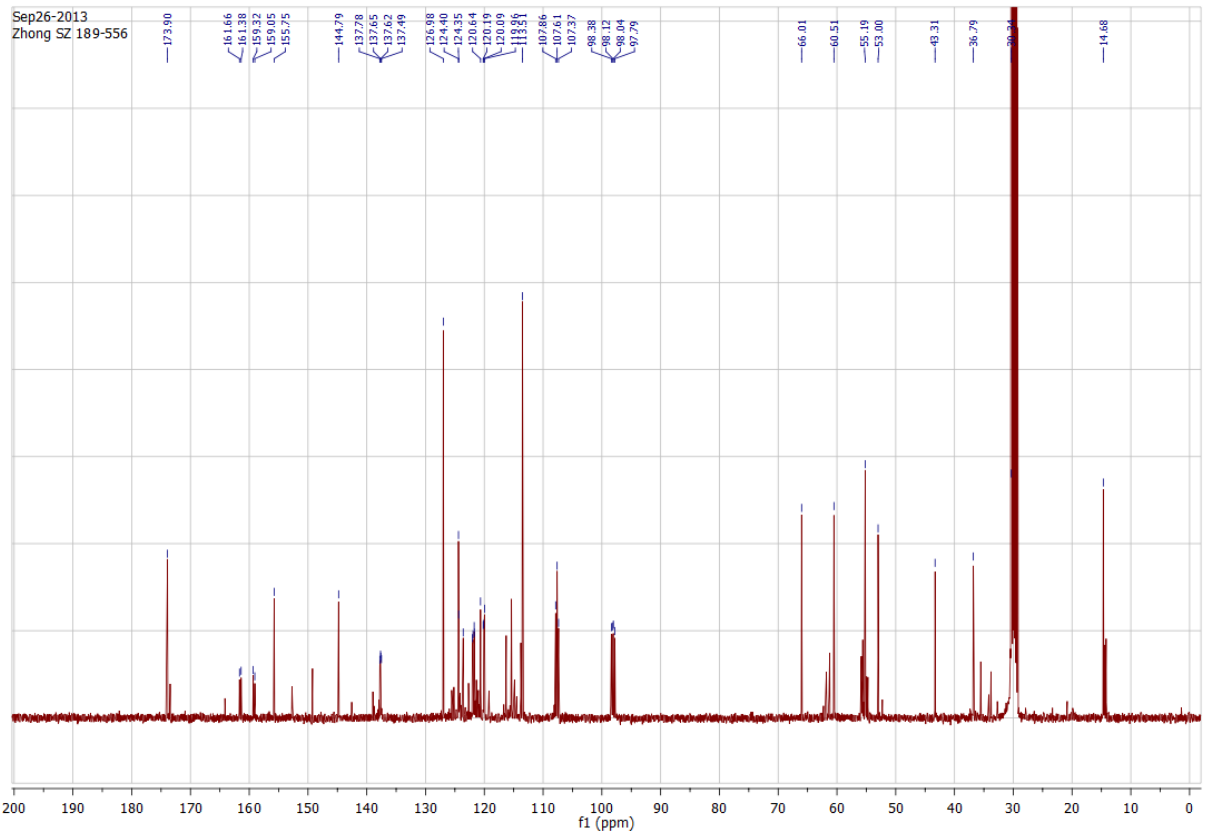
^{1}H NMR, 400 MHz, acetone-d_6



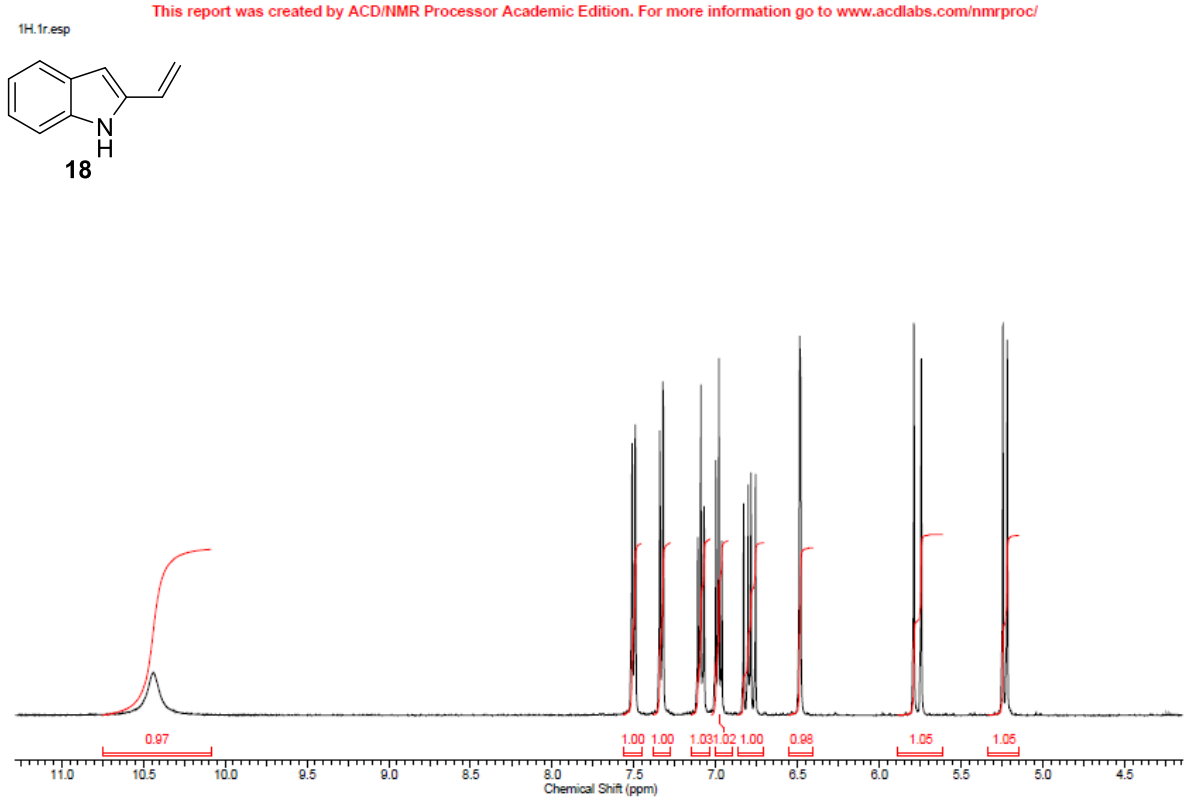
^{13}C NMR, 100 MHz, acetone-d_6



^{1}H NMR, 400 MHz, acetone-d_6



^{13}C NMR, 100 MHz, acetone-d_6



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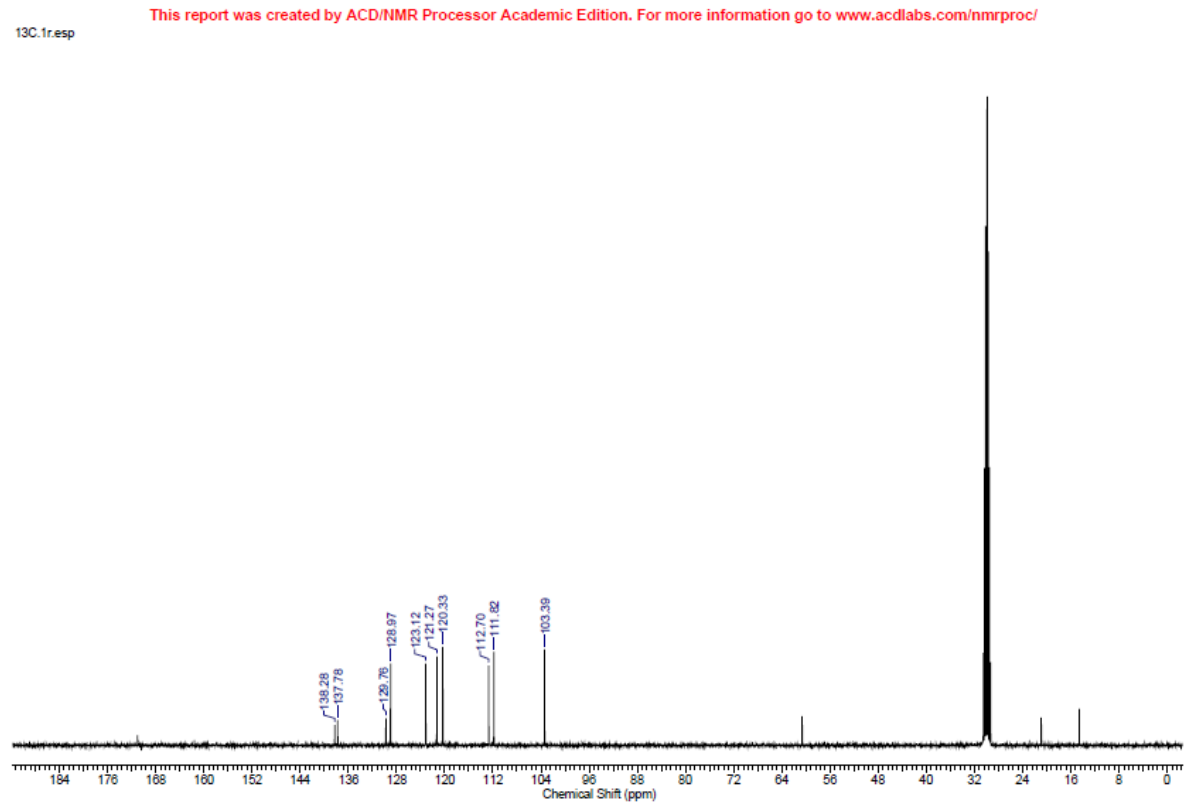

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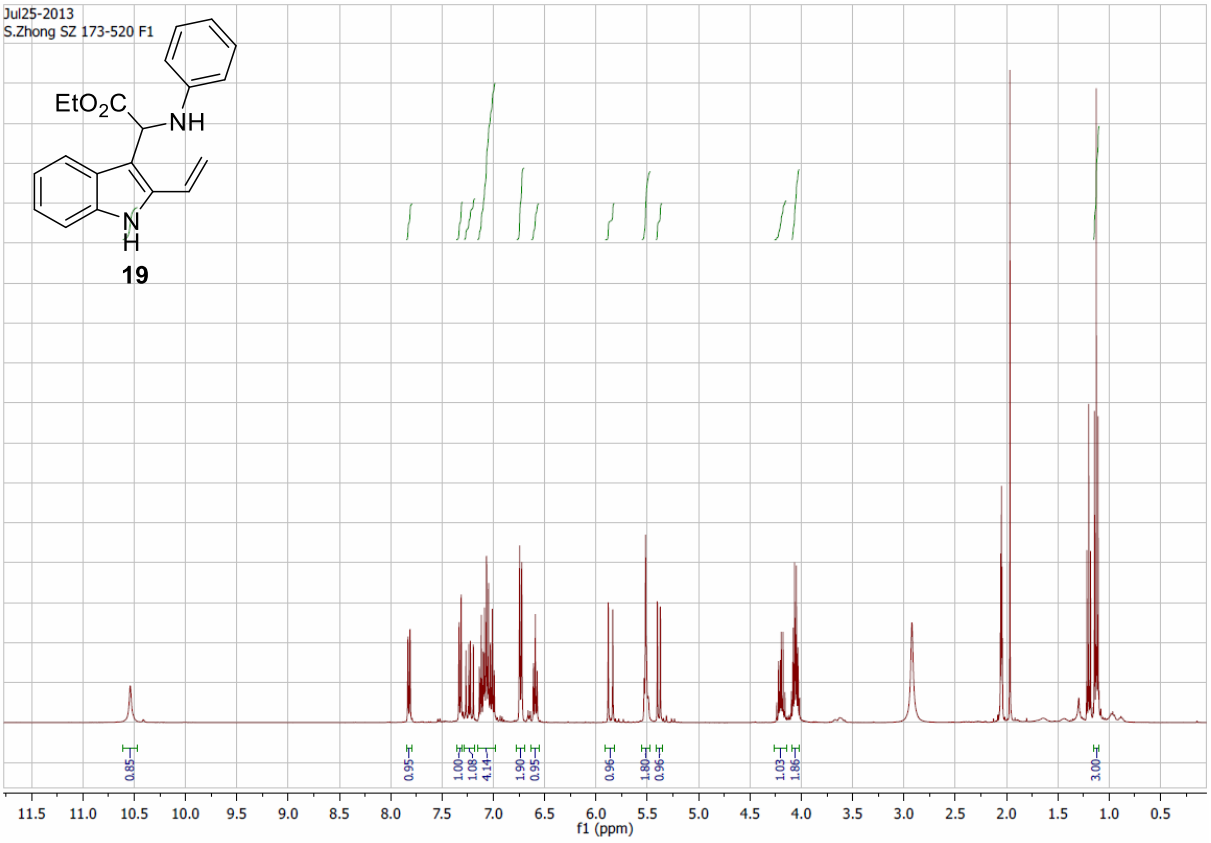
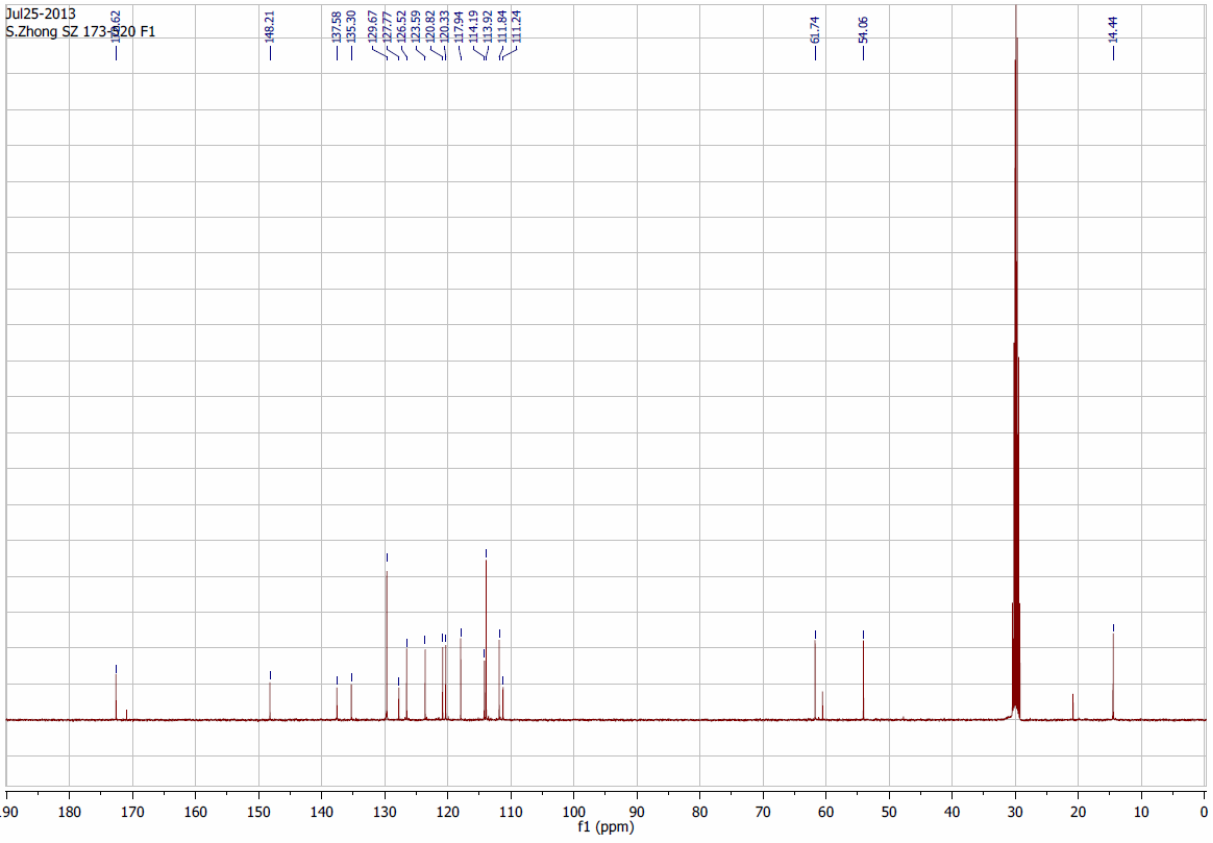
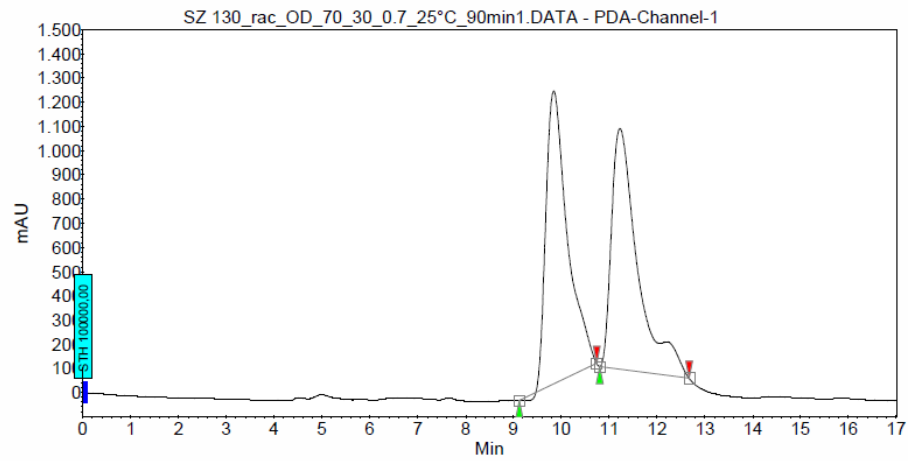


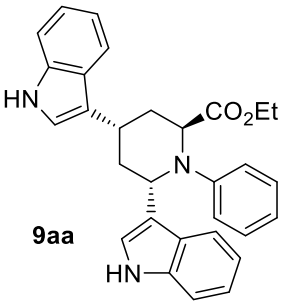
^{1}H NMR, 400 MHz, acetone-d_6



^{13}C NMR, 100 MHz, acetone-d_6

6 HPLC traces of bisindoles 9xy and compound 19

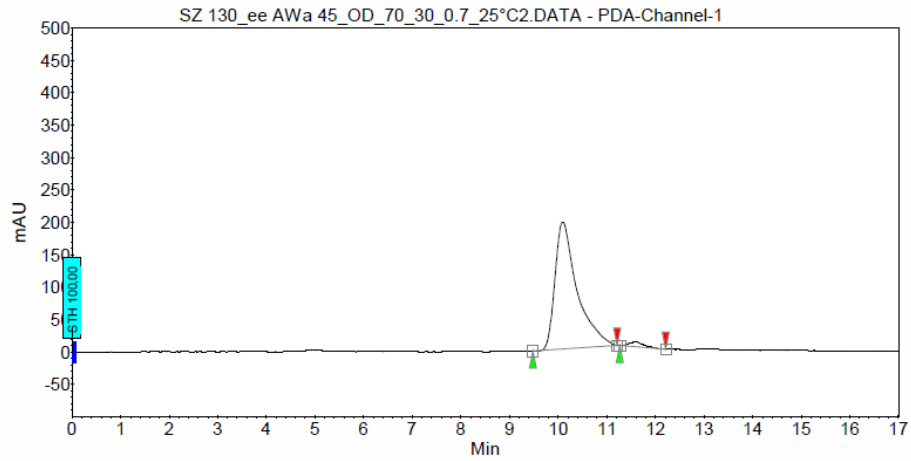




9aa

Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	9,84	49,89	1212,2	629,4	49,893
2	UNKNOWN	11,23	50,11	996,1	632,1	50,107
Total			100,00	2208,3	1261,4	100,000



Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
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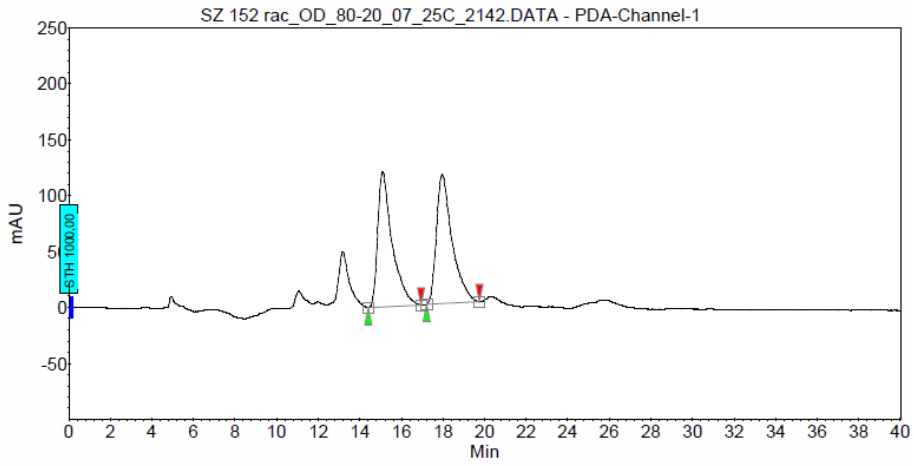
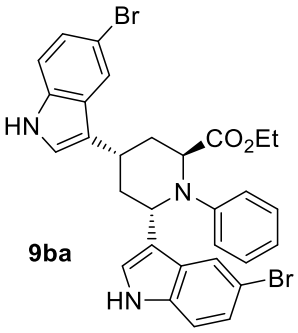
2	UNKNOWN	11,63	2,41	6,8	2,6	2,413
Total			100,00	203,1	105,9	100,000

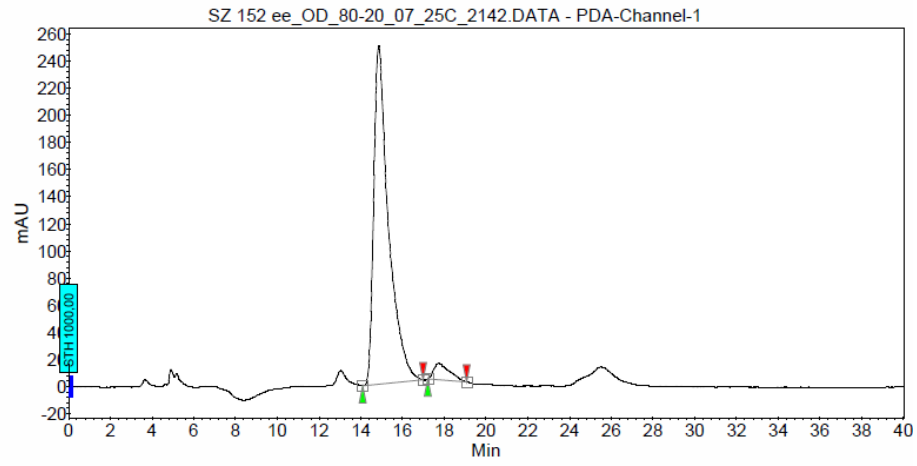




9ba

Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	15,09	49,08	120,7	97,2	49,082
2	UNKNOWN	17,96	50,92	115,2	100,8	50,918
Total			100,00	235,9	198,0	100,000



Peak results :

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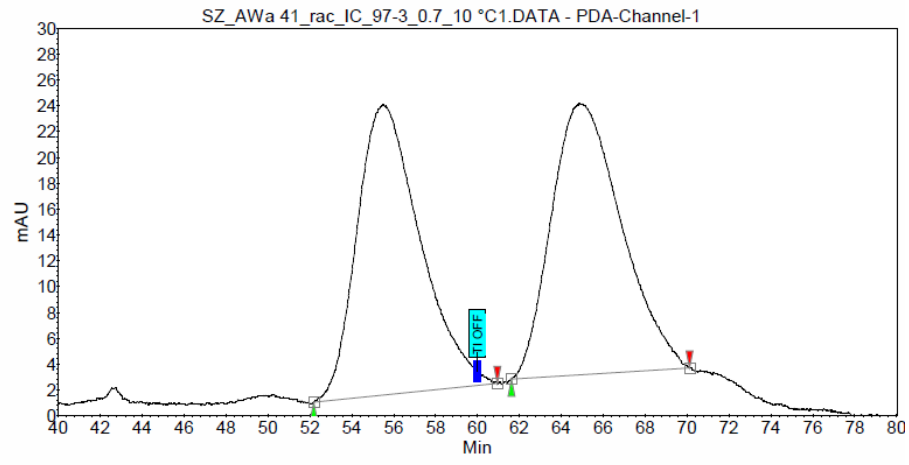
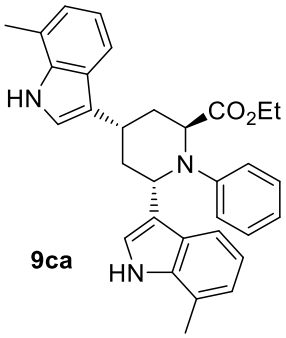
2	UNKNOWN	17,73	5,06	12,1	10,9	5,056
Total			100,00	261,3	214,6	100,000





9ca

Peak results :

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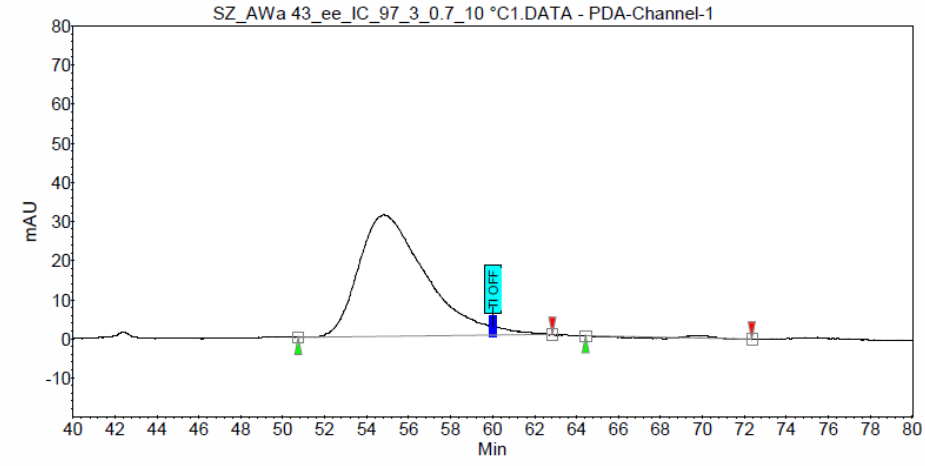
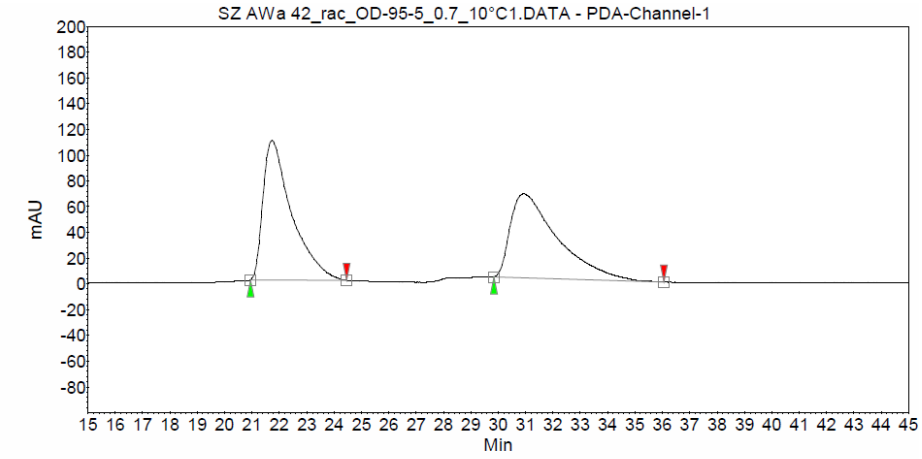
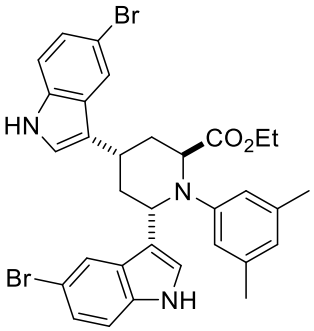
1	UNKNOWN	55,52	49,03	22,5	78,5	49,034
2	UNKNOWN	64,87	50,97	21,0	81,6	50,966
Total			100,00	43,6	160,2	100,000



Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	54,81	99,84	31,1	115,9	99,837
2	UNKNOWN	70,16	0,16	0,7	0,2	0,163
Total			100,00	31,8	116,1	100,000

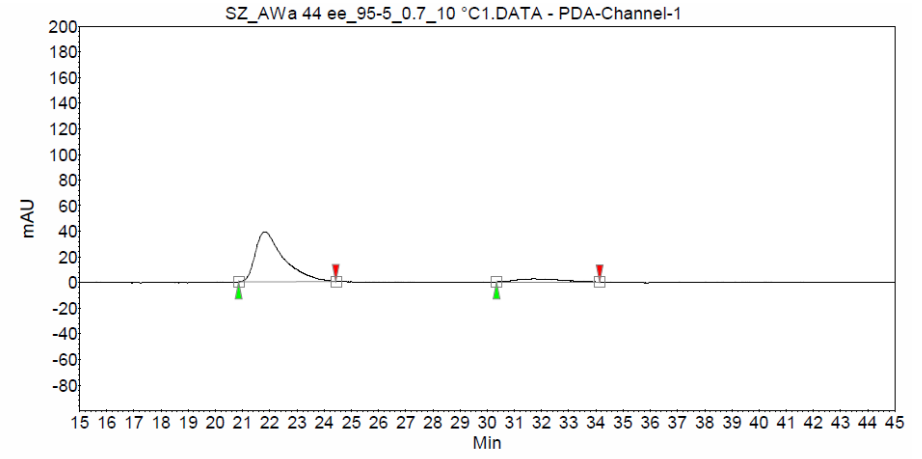




9bb

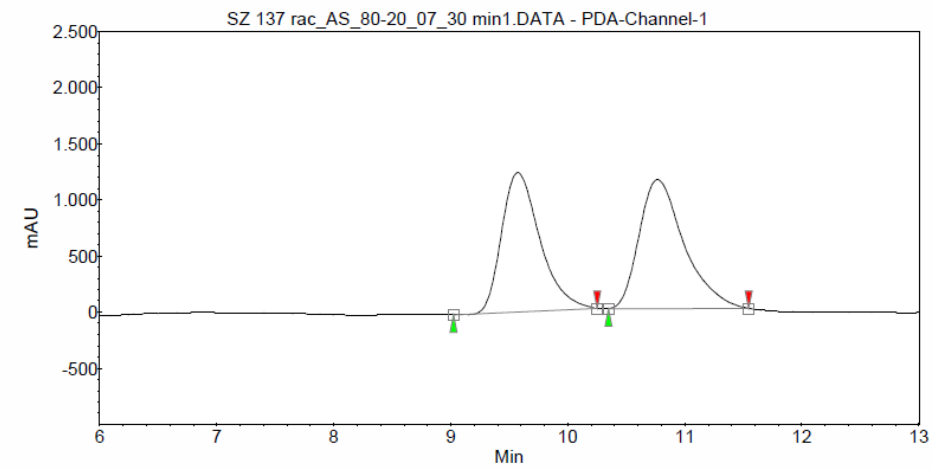
Peak results :

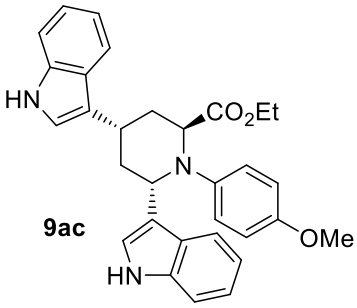
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	21,73	50,13	108,3	131,4	50,132
2	UNKNOWN	30,95	49,87	65,3	130,8	49,868
Total			100,00	173,5	262,2	100,000



Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	21,83	91,49	39,0	46,7	91,489
2	UNKNOWN	31,67	8,51	2,5	4,3	8,511
Total			100,00	41,5	51,0	100,000

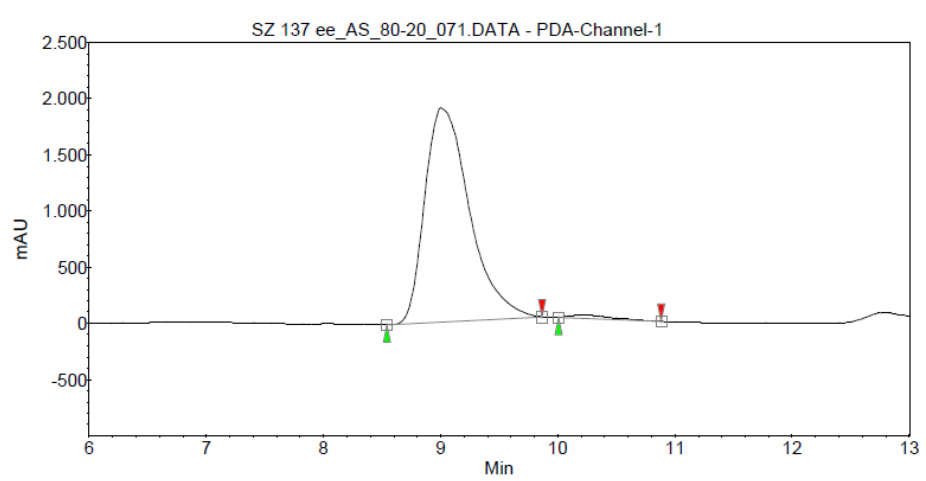




9ac

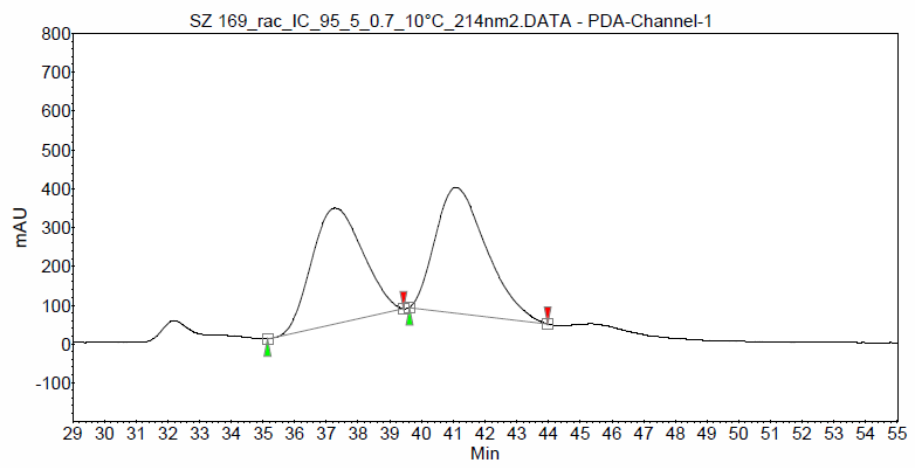
Peak results :

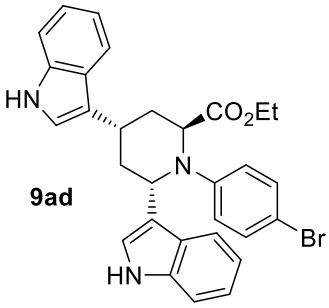
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	9,57	47,94	1243,8	471,2	47,944
2	UNKNOWN	10,76	52,06	1150,4	511,7	52,056
Total			100,00	2394,2	982,9	100,000



Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	9,00	98,54	1909,5	845,4	98,544
2	UNKNOWN	10,24	1,46	30,8	12,5	1,456
Total			100,00	1940,3	857,8	100,000

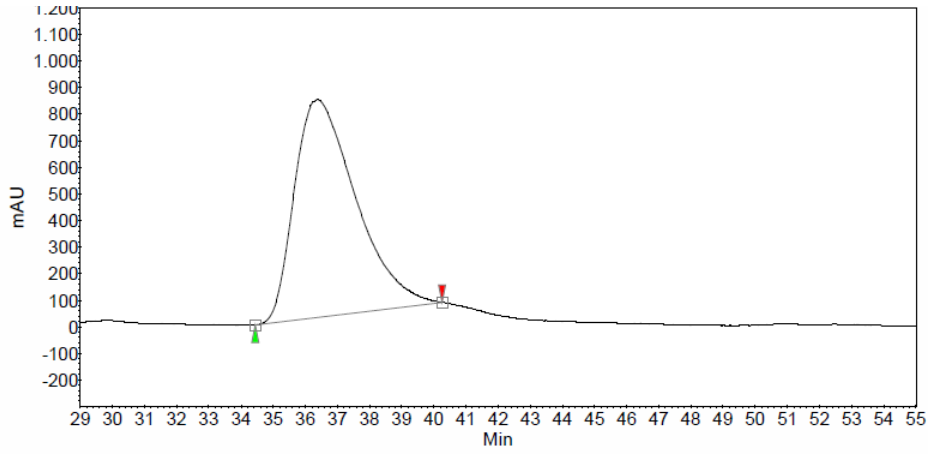




9ad

Peak results :

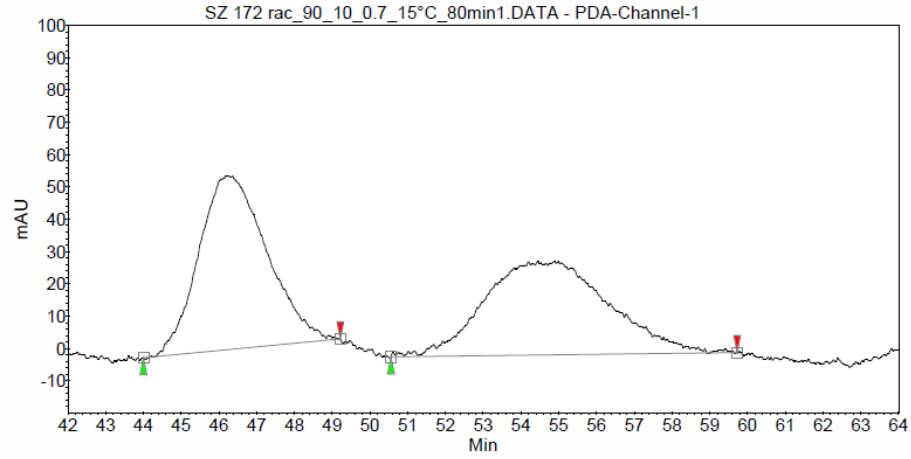
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	37,23	47,74	299,2	555,3	47,740
2	UNKNOWN	41,07	52,26	324,3	607,8	52,260
Total			100,00	623,5	1163,1	100,000

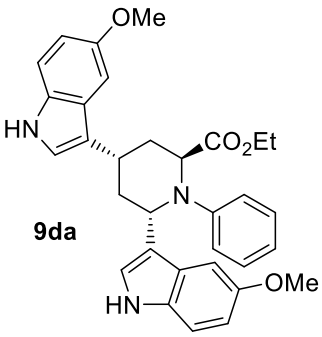


Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	36,39	100,00	822,1	1817,5	100,000
Total			100,00	822,1	1817,5	100,000

The *ee* of compound was estimated at 93% as there is no baseline separation of enantiomers.

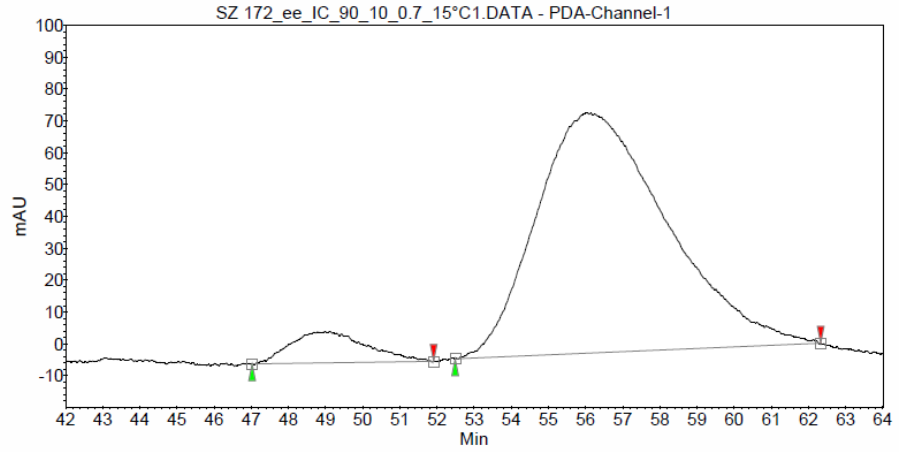




9da

Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	46,24	50,44	53,8	112,3	50,442
2	UNKNOWN	54,88	49,56	28,9	110,4	49,558
Total			100,00	82,7	222,7	100,000



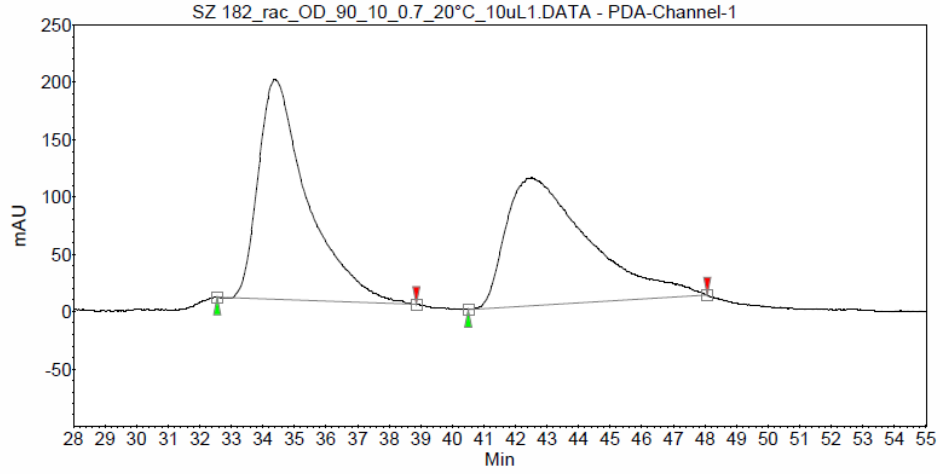
Peak results :

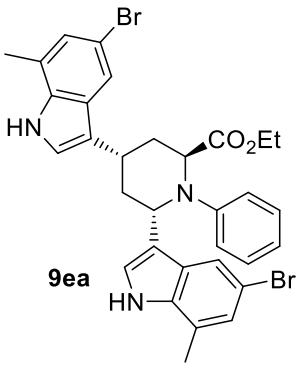
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	48,99	7,09	10,0	23,4	7,094
2	UNKNOWN	56,04	92,91	75,6	306,7	92,906
Total			100,00	85,5	330,1	100,000

Chromatogram : SZ 182_rac_OD_90_10_0.7_20°C_10uL1_channel1

System : LC_920
Method : 90_10_ISO_10°C_0,7ml_
User : AK Paradies

Acquired : 09.09.2013 16:43:38
Processed : 10.12.2013 10:51:02
Printed : 10.12.2013 10:51:14





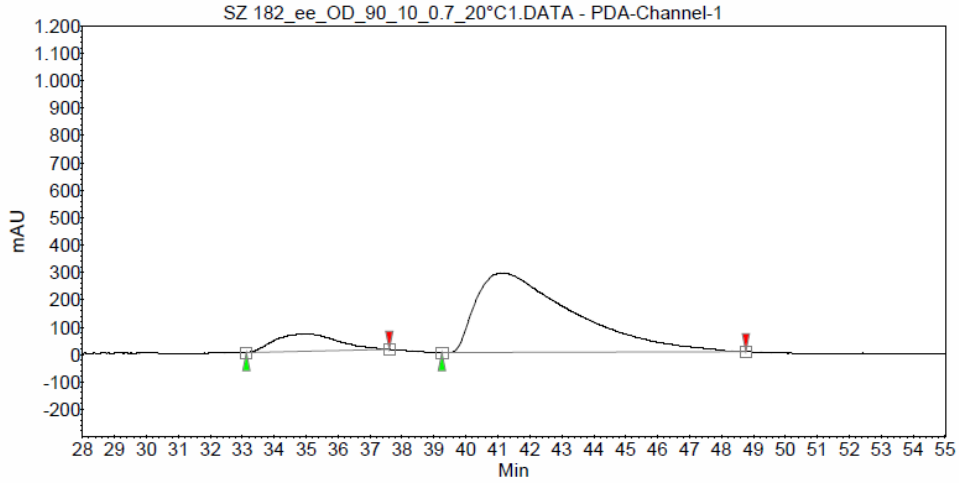
9ea

Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	34,41	50,65	191,8	346,9	50,647
2	UNKNOWN	42,51	49,35	111,8	338,1	49,353
Total			100,00	303,5	685,0	100,000

System : LC_920
Method : 90_10_ISO_10°C_0,7ml_
User : AK Paradies

Acquired : 09.09.2013 18:03:13
Processed : 18.12.2013 20:04:54
Printed : 18.12.2013 20:05:33



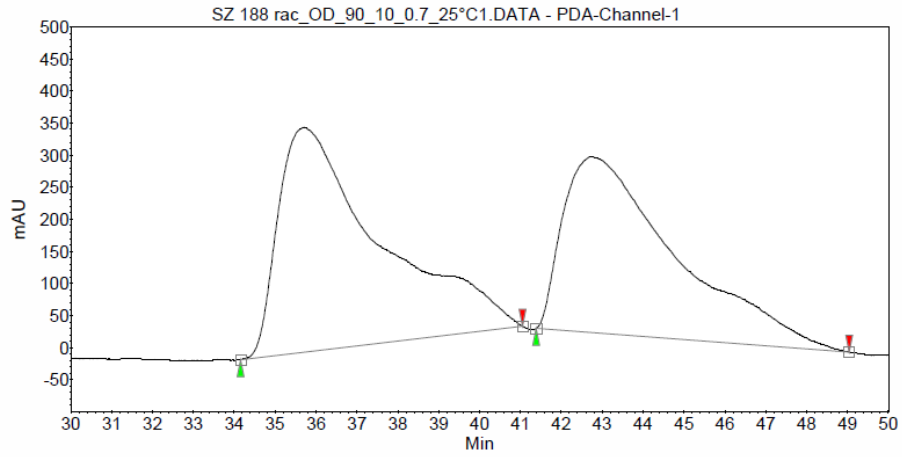
Peak results :

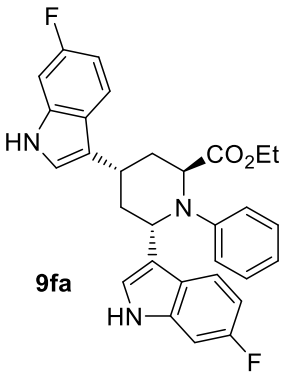
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	34,96	12,51	64,0	147,3	12,509
2	UNKNOWN	41,16	87,49	291,6	1030,3	87,491
Total			100,00	355,5	1177,6	100,000

Chromatogram : SZ 188
rac_OD_90_10_0.7_25°C1_channel1

System : LC_920
Method : 90_10_ISO_10°C_0,7ml_
User : AK Paradies

Acquired : 11.10.2013 15:16:12
Processed : 18.12.2013 10:39:19
Printed : 18.12.2013 10:49:11





9fa

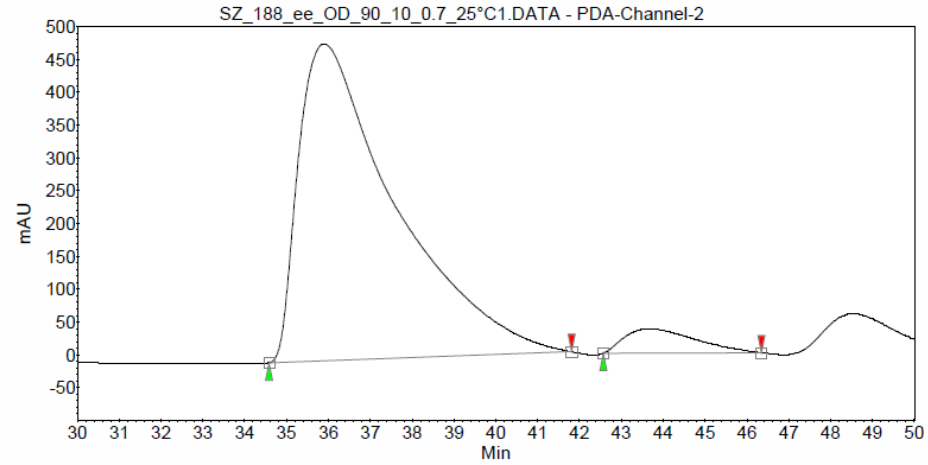
Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	35,69	53,51	350,8	1006,3	53,508
2	UNKNOWN	42,71	46,49	274,6	874,3	46,492
Total			100,00	625,4	1880,6	100,000

Chromatogram :
SZ_188_ee_OD_90_10_0.7_25°C1_channel2

System : LC_920
Method : 90_10_ISO_10°C_0,7ml_
User : AK Paradies

Acquired : 16.12.2013 17:05:02
Processed : 18.12.2013 10:45:50
Printed : 18.12.2013 10:49:53



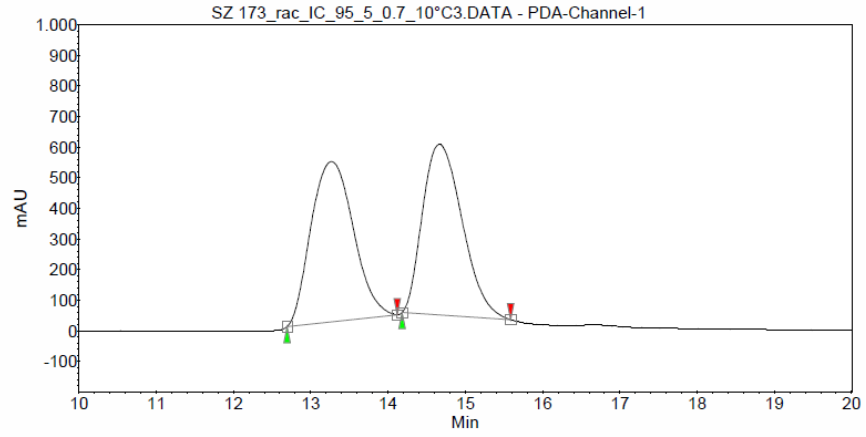
Peak results :

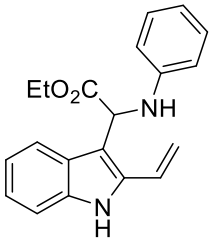
Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	35,89	94,70	482,6	1293,1	94,700
2	UNKNOWN	43,67	5,30	36,9	72,4	5,300
Total			100,00	519,5	1365,5	100,000

Chromatogram : SZ 173_rac_IC_95_5_0.7_10°C3_channel1

System : LC_920
Method : 95_5_ISO_15C_07mL
User : AK Paradies

Acquired : 30.07.2013 16:19:59
Processed : 18.12.2013 20:13:56
Printed : 18.12.2013 20:14:07





19

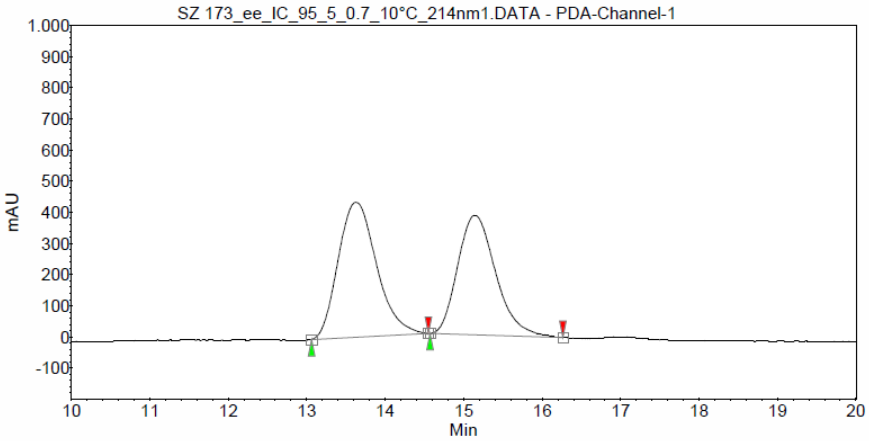
Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	13,27	50,12	523,8	333,5	50,118
2	UNKNOWN	14,67	49,88	557,3	331,9	49,882
Total			100,00	1081,1	665,4	100,000

Chromatogram : SZ 173_ee_IC_95_5_0.7_10°C_214nm1_channel1

System : LC_920
Method : 95_5_ISO_15C_07mL
User : AK Paradies

Acquired : 01.08.2013 12:54:57
Processed : 18.12.2013 20:18:16
Printed : 18.12.2013 20:18:58



Peak results :

Index	Name	Time [Min]	Quantity [% Area]	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	13,63	53,26	433,3	245,6	53,263
2	UNKNOWN	15,15	46,74	383,9	215,5	46,737
Total			100,00	817,1	461,2	100,000

7 CD-spectral measurements and computational investigation of CD spectra

In order to simulate the electronic CD spectra of bisindole **9aa** and its C-4 epimer, quantum chemical calculations have been carried out. The comparison of computed and experimental CD spectra can be of great help for distinguishing diastereomers and furthermore allows the assignment of the absolute configuration. In the examined cases, the difficulty of the computational treatment lies in the high flexibility of the molecular structure. The central six-membered ring can adopt several conformations and all substituents may rotate about the bond which connects them to the central ring. As those groups constitute the chromophores, the overall shape of the CD spectrum (sign and magnitude of the rotatory strengths) is highly affected by conformational changes. It is thus important to include the low energy structures in the simulation of the spectra. We therefore performed a careful systematic search regarding conformational isomers which included various conformations of the central six-membered ring (chair, twist boat etc.), rotations about the substituent groups (both indoles, ethyl ester and phenyl) as well as the inversion of the NPh nitrogen atom. In total, 112 conformational isomers of (4*R*)-**9aa** and 110 conformational isomers of **9aa** have been considered. For the final CD spectra, the contributions of these isomers were weighted according to a Boltzmann distribution of the relative energies.

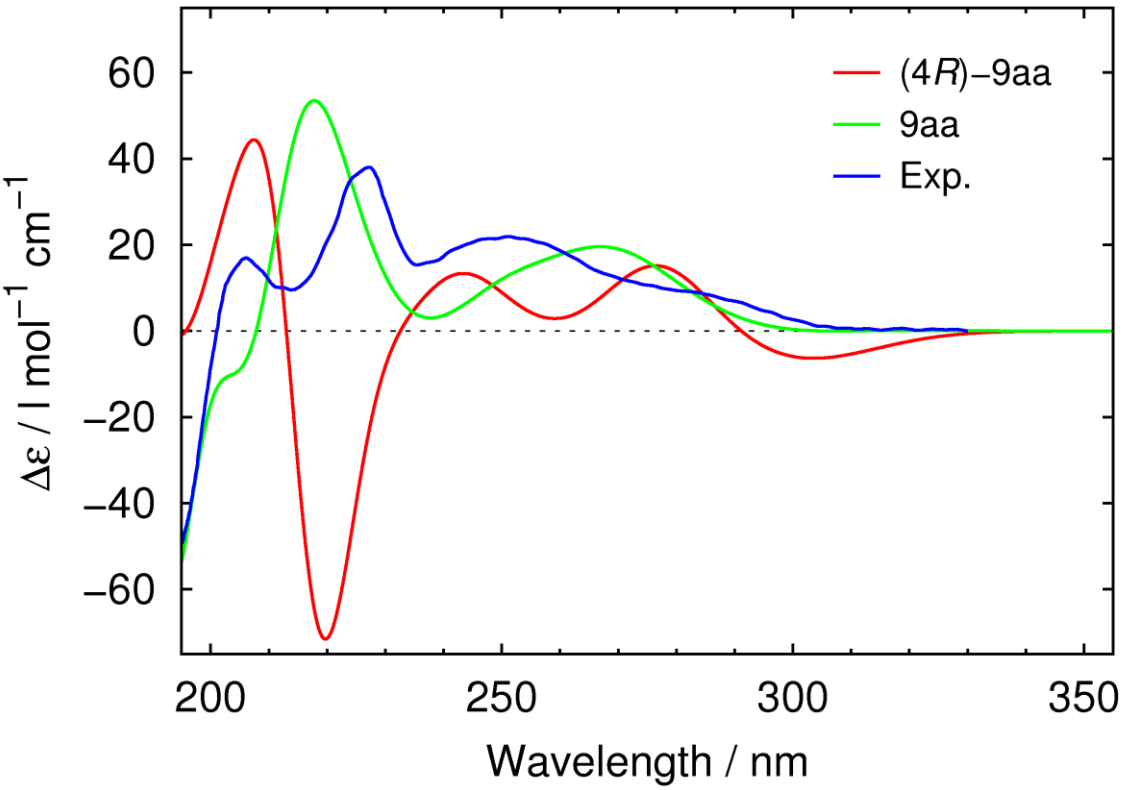


Fig. S 1. Experimental CD spectrum of compound **9aa** (blue curve, 94% *ee*) and calculated CD spectra of **9aa** (green curve) and its C-4 epimer (red curve); conditions: c = 0.05 mg/mL; MeOH, 20 °C.

Details of the calculations

All quantum chemical calculations in this work were carried out using density functional theory (DFT) and time-dependent density functional theory (TDDFT) methods as implemented in the TURBOMOLE program package.[2]

Optimizations of the multitude of conformational isomers were performed with the TPSS functional[3] and a def2-SVP[4] basis set using the efficient resolution of the identity (RI) approximation for Coulomb integrals. Solvent effects were accounted for with the continuum solvent model COSMO[5] (dielectric constant of methanol: ε = 33.0), and fine quadrature grids

[2] TURBOMOLE, Version 6.4; University of Karlsruhe and Forschungszentrum Karlsruhe GmbH, 1989–2007, Turbomole GmbH since 2007; http://www.turbomole.com.
[3] J. Tao, J. P. Perdew, V. N. Staroverov, G. E. Scuseria, *Phys. Rev. Lett.* **2003**, *91*, 146401.
[4] F. Weigend, R. Ahlrichs, *Phys. Chem. Chem. Phys*. **2005**, *7*, 3297–3305.
[5] A. Klamt, G. J. Schüürmann, *J. Chem. Soc., Perkin Trans. 2* **1993**, 99–805.

of quality *m*4 as well as tight convergence criteria were employed (SCF energy: 10^{-8} E_h, energy gradient: 10^{-4} E_h a_0^{-1} and inclusion of the derivatives of quadrature weights).

Excitation energies and rotatory strengths for CD spectra were computed in the framework of TDDFT response theory using the B3LYP hybrid functional[6] and diffuse augmented basis sets designed for molecular response calculations (def2-SVPD[7]). The influence of the solvent was taken into account for the ground state.

CD spectra were simulated by Gaussian broadening (empirical line width: 0.15 eV) and superposition of the computed rotatory strengths. The final CD spectra for 293 K were obtained by using the Boltzmann average based on the relative electronic energies of the conformational isomers.

Further geometry optimizations at the TPSS/def2-TZVP level including the solvent model COSMO as well as an empirical correction for dispersion interactions (DFT-D3[8]) were carried out in order to examine the effect of dispersion on the relative energies and the geometries of the conformational isomers. We found that the geometries of the energetically low lying structures are only marginally affected. The CD spectra based on the relative energies including dispersion interactions qualitatively agree with the spectra shown in Fig. S 1.

[6] A. D. Becke, *J. Chem. Phys*. **1993**, *98*, 5648–5652.
[7] D. Rappoport, F. Furche, *J. Chem. Phys*. **2010**, *133*, 134105.
[8] a) S. Grimme, J. Antony, S. Ehrlich, H. Krieg, *J. Chem. Phys.* **2010**, *132*, 154104. b) S. Grimme, S. Ehrlich, L. Goerigk, *J. Comput. Chem.* **2011**, *32*, 1456–1465.

8 Crystallographic data

Crystal Structure Determination of 9aa

The single-crystal X-ray diffraction study was carried out on an SuperNova Dual diffractometer at 120(2) K using CuKα radiation (λ = 1.54178 Å). Direct Methods (SHELXS-97)[9] were used for structure solution and refinement was carried out using SHELXL-2013[8] (full-matrix least-squares on F^2). Hydrogen atoms were localized by difference electron density determination and refined using a riding model (H(N) free). The absolute structure of **9aa** could be determined reliably by refinement of Flack's x-parameter (Parsons Flack parameter x = 0.01(6)[10,11]) as well as using Bayesian statistics on Bijvoet differences (y = 0.02(5)[12]).

Crystallographic data (excluding structure factors) for the structures reported in this work have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-977608 (**9aa**). Copies of the data can be obtained free of charge on application to The Director, CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (Fax: int.code +(1223)336-033; e-mail: deposit@ccdc.cam.ac.uk).

[9] G. M. Sheldrick, *Acta Crystallogr.* **2008**, *A64*, 112–122.
[10] H. D. Flack, *Acta Crystallogr.* **1983**, *A39*, 876–881.
[11] S. Parsons, H. D. Flack, *Acta Crystallogr.* **2004**, *A60*, s61.
[12] R.W.W. Hooft, L. H. Straver, A. L. Spek, *J. Appl. Crystallogr.* **2008**, *41*, 96–103.

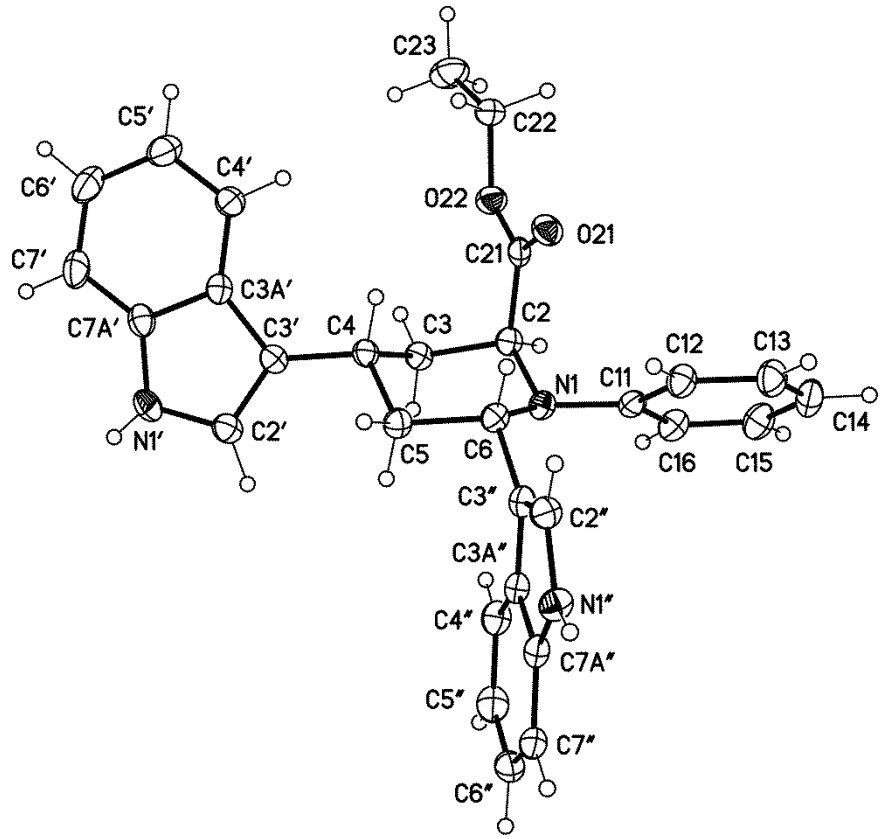


Fig. S 2. Molecular structure of **9aa** (displacement parameters are drawn at 50 % probability level).

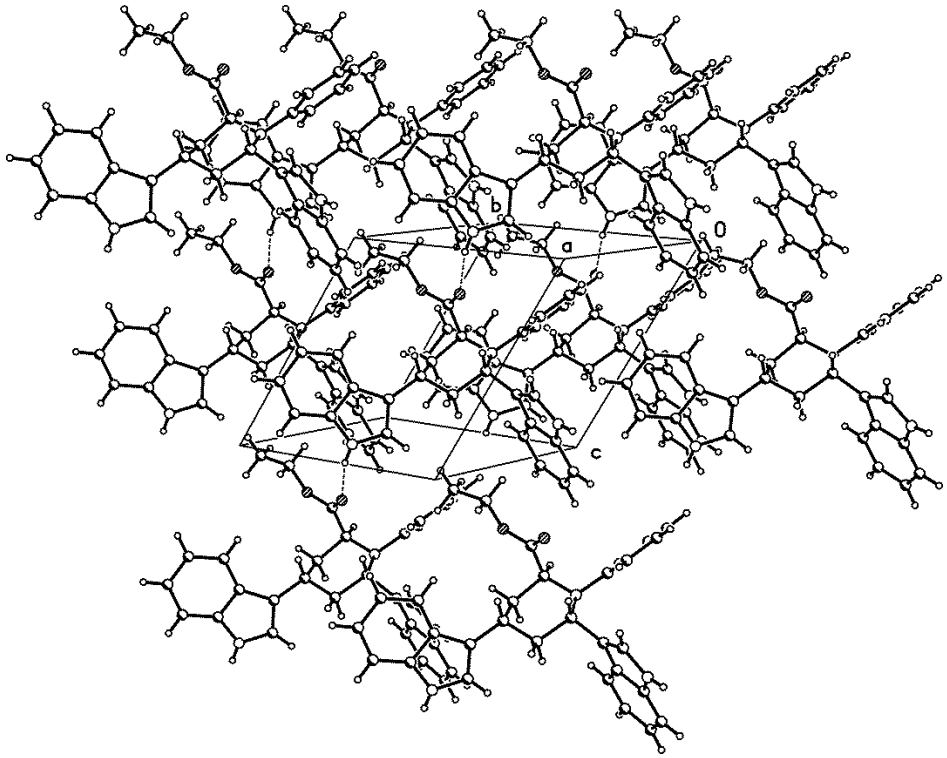


Fig. S 3. Packing of **9aa**.

Computing details

Data collection: *CrysAlis PRO*, Agilent Technologies, Version 1.171.36.32 (release 02-08-2013 CrysAlis171 .NET) (compiled Aug 2 2013,16:46:58); cell refinement: *CrysAlis PRO*, Agilent Technologies, Version 1.171.36.32 (release 02-08-2013 CrysAlis171 .NET) (compiled Aug 2 2013,16:46:58); data reduction: *CrysAlis PRO*, Agilent Technologies, Version 1.171.36.32 (release 02-08-2013 CrysAlis171 .NET) (compiled Aug 2 2013,16:46:58); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL2013* (Sheldrick, 2013); molecular graphics: *SHELXTL-Plus* (Sheldrick, 2008); software used to prepare material for publication: *publCIF*.

Crystal data for **9aa**

$C_{30}H_{29}N_3O_2$	$Z = 1$
$M_r = 463.56$	$F(000) = 246$
Triclinic, $P1$	$D_x = 1.229$ Mg m^{-3}
$a = 7.9687$ (8) Å	Cu $K\alpha$ radiation, $\lambda = 1.54178$ Å
$b = 9.4665$ (9) Å	Cell parameters from 8138 reflections
$c = 9.6211$ (9) Å	$\theta = 5.3–76.3°$
$\alpha = 62.398$ (9)°	$\mu = 0.61$ mm^{-1}
$\beta = 77.124$ (8)°	$T = 120$ K
$\gamma = 81.985$ (8)°	Plates, colourless
$V = 626.45$ (12) Å^3	0.27 × 0.12 × 0.08 mm

Data collection for **9aa**

SuperNova, Dual, Cu at zero, Atlas diffractometer	4786 independent reflections
Radiation source: SuperNova (Cu) X-ray Source	4736 reflections with $I > 2\sigma(I)$
Detector resolution: 10.3953 pixels mm^{-1}	$R_{int} = 0.019$
ω scans, 2°	$\theta_{max} = 76.6°$, $\theta_{min} = 5.3°$
Absorption correction: analytical *CrysAlis PRO*, Agilent Technologies, Version 1.171.36.32 (release 02-08-2013 CrysAlis171 .NET) (compiled Aug 2 2013,16:46:58) Analytical numeric absorption correction using a multifaceted crystal model based on expressions derived by R.C. Clark & J.S. Reid. (Clark, R. C. & Reid, J. S. (1995). Acta Cryst. A51, 887-897)	$h = -9\rightarrow9$
$T_{min} = 0.903$, $T_{max} = 0.957$	$k = -11\rightarrow11$
9604 measured reflections	$l = -12\rightarrow12$

Refinement for **9aa**

Refinement on F^2	Hydrogen site location: difference Fourier map
Least-squares matrix: full	H atoms treated by a mixture of independent and constrained refinement
$R[F^2 > 2\sigma(F^2)] = 0.026$	$w = 1/[\sigma^2(F_o^2) + (0.0316P)^2 + 0.1014P]$ where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.067$	$(\Delta/\sigma)_{max} < 0.001$
$S = 1.05$	$\Delta\rangle_{max} = 0.19$ e Å^{-3}
4786 reflections	$\Delta\rangle_{min} = -0.13$ e Å^{-3}
323 parameters	Extinction correction: *SHELXL*, $Fc^*=kFc[1+0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$
5 restraints	Extinction coefficient: 0.0140 (12)
Primary atom site location: structure-invariant direct methods	Absolute structure: Flack x determined using 2171 quotients [(I+)-(I-)]/[(I+)+(I-)] (Parsons and Flack (2004), Acta Cryst. A60, s61). Hooft's y parameter 0.02(5) (Hooft, Straver, Spek (2008), J. Appl. Cryst. 46, 96-103).
Secondary atom site location: difference Fourier map	Absolute structure parameter: 0.01 (6)

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2) for **9aa**

	x	*y*	*z*	U_{iso}*/U_{eq}
N1	0.47895 (18)	0.37724 (16)	0.52724 (16)	0.0192 (3)
C2	0.5042 (2)	0.54805 (19)	0.46547 (19)	0.0197 (3)
H2	0.3904	0.6063	0.4468	0.024*
C3	0.5664 (2)	0.58163 (19)	0.58577 (19)	0.0203 (3)
H3A	0.4794	0.5485	0.6852	0.024*
H3B	0.5819	0.6974	0.5418	0.024*
C4	0.7380 (2)	0.48917 (19)	0.62217 (18)	0.0192 (3)
H4	0.8202	0.5207	0.5186	0.023*
C5	0.7066 (2)	0.3124 (2)	0.6896 (2)	0.0209 (3)
H5A	0.6279	0.2784	0.7939	0.025*
H5B	0.8174	0.2512	0.7088	0.025*
C6	0.6291 (2)	0.26964 (19)	0.58160 (19)	0.0194 (3)
H6	0.7186	0.2803	0.4865	0.023*
C11	0.3871 (2)	0.34568 (19)	0.43329 (19)	0.0202 (3)
C12	0.4603 (2)	0.2663 (2)	0.3417 (2)	0.0244 (4)
H12	0.5765	0.2264	0.3425	0.029*
C13	0.3640 (3)	0.2452 (2)	0.2490 (2)	0.0291 (4)
H13	0.4150	0.1904	0.1875	0.035*

C14	0.1946 (3)	0.3032 (2)	0.2453 (2)	0.0306 (4)
H14	0.1304	0.2905	0.1800	0.037*
C15	0.1199 (2)	0.3800 (2)	0.3381 (2)	0.0301 (4)
H15	0.0038	0.4198	0.3367	0.036*
C16	0.2145 (2)	0.3990 (2)	0.4329 (2)	0.0248 (4)
H16	0.1611	0.4489	0.4985	0.030*
C21	0.6322 (2)	0.6167 (2)	0.30706 (19)	0.0193 (3)
O21	0.71502 (16)	0.54009 (15)	0.24145 (14)	0.0246 (3)
O22	0.64602 (16)	0.77212 (14)	0.25447 (14)	0.0252 (3)
C22	0.7739 (2)	0.8517 (2)	0.1120 (2)	0.0267 (4)
H22A	0.7419	0.8513	0.0185	0.032*
H22B	0.8886	0.7973	0.1263	0.032*
C23	0.7764 (3)	1.0196 (2)	0.0887 (3)	0.0367 (5)
H23A	0.8602	1.0790	-0.0069	0.055*
H23B	0.8090	1.0180	0.1819	0.055*
H23C	0.6617	1.0713	0.0760	0.055*
N1'	0.8768 (2)	0.54191 (19)	0.93940 (17)	0.0256 (3)
H1'	0.856 (3)	0.539 (3)	1.033 (2)	0.031*
C2'	0.7796 (2)	0.4692 (2)	0.8907 (2)	0.0235 (4)
H2'	0.6989	0.3896	0.9598	0.028*
C3'	0.8164 (2)	0.52846 (19)	0.72786 (19)	0.0196 (3)
C3A'	0.9423 (2)	0.6465 (2)	0.67244 (19)	0.0195 (3)
C4'	1.0261 (2)	0.7511 (2)	0.5202 (2)	0.0230 (3)
H4'	1.0048	0.7498	0.4275	0.028*
C5'	1.1398 (3)	0.8556 (2)	0.5074 (2)	0.0305 (4)
H5'	1.1983	0.9254	0.4049	0.037*
C6'	1.1707 (3)	0.8608 (3)	0.6437 (3)	0.0340 (4)
H6'	1.2487	0.9347	0.6316	0.041*
C7'	1.0891 (3)	0.7600 (3)	0.7945 (2)	0.0311 (4)
H7'	1.1093	0.7635	0.8865	0.037*
C7A'	0.9764 (2)	0.6531 (2)	0.8072 (2)	0.0233 (4)
N1"	0.59749 (19)	-0.16783 (17)	0.77263 (17)	0.0225 (3)
H1"	0.634 (3)	-0.266 (2)	0.786 (3)	0.027*
C2"	0.6620 (2)	-0.0265 (2)	0.6526 (2)	0.0222 (3)
H2"	0.7521	-0.0174	0.5659	0.027*
C3"	0.5785 (2)	0.0990 (2)	0.67564 (19)	0.0197 (3)
C3A"	0.4530 (2)	0.03146 (19)	0.82057 (19)	0.0196 (3)
C4"	0.3312 (2)	0.0947 (2)	0.9096 (2)	0.0249 (4)
H4"	0.3137	0.2067	0.8724	0.030*
C5"	0.2373 (2)	-0.0097 (2)	1.0526 (2)	0.0286 (4)
H5"	0.1554	0.0318	1.1141	0.034*

C6"	0.2606 (2)	-0.1757 (2)	1.1088 (2)	0.0278 (4)
H6"	0.1955	-0.2440	1.2083	0.033*
C7"	0.3759 (2)	-0.2419 (2)	1.0226 (2)	0.0243 (4)
H7"	0.3899	-0.3542	1.0594	0.029*
C7A"	0.4711 (2)	-0.1363 (2)	0.8786 (2)	0.0205 (3)

Atomic displacement parameters ($Å^2$)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
N1	0.0201 (7)	0.0173 (6)	0.0224 (7)	-0.0001 (5)	-0.0044 (5)	-0.0105 (5)
C2	0.0209 (8)	0.0186 (8)	0.0214 (8)	0.0001 (6)	-0.0038 (6)	-0.0107 (6)
C3	0.0239 (8)	0.0182 (7)	0.0204 (7)	0.0001 (6)	-0.0034 (6)	-0.0105 (6)
C4	0.0233 (8)	0.0190 (7)	0.0178 (7)	-0.0022 (6)	-0.0032 (6)	-0.0101 (6)
C5	0.0226 (8)	0.0183 (7)	0.0231 (8)	0.0000 (6)	-0.0055 (6)	-0.0100 (6)
C6	0.0195 (8)	0.0188 (8)	0.0213 (7)	-0.0005 (6)	-0.0029 (6)	-0.0105 (6)
C11	0.0211 (8)	0.0184 (7)	0.0211 (8)	-0.0040 (6)	-0.0025 (6)	-0.0087 (6)
C12	0.0220 (8)	0.0270 (8)	0.0282 (8)	-0.0011 (7)	-0.0034 (7)	-0.0162 (7)
C13	0.0313 (10)	0.0320 (9)	0.0319 (9)	-0.0029 (8)	-0.0048 (8)	-0.0209 (8)
C14	0.0320 (10)	0.0313 (9)	0.0362 (10)	-0.0037 (8)	-0.0126 (8)	-0.0182 (8)
C15	0.0226 (9)	0.0302 (9)	0.0407 (10)	0.0003 (7)	-0.0089 (8)	-0.0175 (8)
C16	0.0221 (8)	0.0240 (8)	0.0307 (9)	-0.0007 (6)	-0.0030 (7)	-0.0151 (7)
C21	0.0200 (7)	0.0211 (8)	0.0199 (7)	-0.0007 (6)	-0.0080 (6)	-0.0098 (6)
O21	0.0275 (6)	0.0271 (6)	0.0205 (6)	-0.0013 (5)	-0.0022 (5)	-0.0127 (5)
O22	0.0285 (6)	0.0217 (6)	0.0235 (6)	-0.0045 (5)	-0.0024 (5)	-0.0088 (5)
C22	0.0260 (9)	0.0289 (9)	0.0206 (8)	-0.0076 (7)	-0.0035 (7)	-0.0058 (7)
C23	0.0369 (11)	0.0251 (9)	0.0365 (10)	-0.0066 (8)	-0.0051 (8)	-0.0034 (8)
N1'	0.0324 (8)	0.0298 (8)	0.0183 (7)	0.0000 (6)	-0.0062 (6)	-0.0134 (6)
C2'	0.0285 (9)	0.0212 (8)	0.0214 (8)	-0.0009 (7)	-0.0042 (7)	-0.0101 (6)
C3'	0.0225 (8)	0.0182 (7)	0.0191 (7)	0.0013 (6)	-0.0041 (6)	-0.0097 (6)
C3A'	0.0186 (8)	0.0219 (8)	0.0223 (8)	0.0019 (6)	-0.0044 (6)	-0.0138 (6)
C4'	0.0242 (9)	0.0257 (8)	0.0220 (8)	-0.0016 (7)	-0.0016 (6)	-0.0140 (7)
C5'	0.0281 (9)	0.0332 (10)	0.0315 (9)	-0.0084 (8)	0.0024 (7)	-0.0170 (8)
C6'	0.0267 (10)	0.0424 (11)	0.0433 (11)	-0.0104 (8)	-0.0012 (8)	-0.0276 (9)
C7'	0.0275 (9)	0.0438 (11)	0.0345 (10)	-0.0026 (8)	-0.0084 (7)	-0.0265 (9)
C7A'	0.0224 (8)	0.0283 (9)	0.0235 (8)	0.0028 (7)	-0.0063 (6)	-0.0153 (7)
N1"	0.0253 (7)	0.0173 (7)	0.0269 (7)	0.0005 (6)	-0.0032 (6)	-0.0124 (6)
C2"	0.0233 (8)	0.0222 (8)	0.0225 (8)	-0.0008 (6)	-0.0022 (6)	-0.0121 (6)
C3"	0.0201 (8)	0.0204 (8)	0.0224 (8)	-0.0001 (6)	-0.0057 (6)	-0.0119 (6)
C3A"	0.0191 (8)	0.0210 (8)	0.0224 (8)	-0.0009 (6)	-0.0062 (6)	-0.0118 (6)
C4"	0.0232 (9)	0.0268 (8)	0.0291 (9)	0.0013 (7)	-0.0058 (7)	-0.0165 (7)
C5"	0.0218 (9)	0.0391 (10)	0.0298 (9)	-0.0002 (7)	-0.0013 (7)	-0.0212 (8)

C6"	0.0241 (9)	0.0366 (10)	0.0214 (8)	-0.0076 (7)	-0.0032 (7)	-0.0105 (7)
C7"	0.0252 (9)	0.0240 (8)	0.0248 (8)	-0.0047 (7)	-0.0093 (7)	-0.0086 (7)
C7A"	0.0199 (8)	0.0217 (8)	0.0242 (8)	-0.0002 (6)	-0.0079 (6)	-0.0122 (7)

Geometric parameters (Å, º) for (cu_sb632) for **9aa**

N1—C11	1.431 (2)	C23—H23B	0.9800
N1—C2	1.468 (2)	C23—H23C	0.9800
N1—C6	1.479 (2)	N1'—C7A'	1.378 (2)
C2—C3	1.525 (2)	N1'—C2'	1.380 (2)
C2—C21	1.536 (2)	N1'—H1'	0.865 (19)
C2—H2	1.0000	C2'—C3'	1.371 (2)
C3—C4	1.534 (2)	C2'—H2'	0.9500
C3—H3A	0.9900	C3'—C3A'	1.436 (3)
C3—H3B	0.9900	C3A'—C4'	1.406 (2)
C4—C3'	1.504 (2)	C3A'—C7A'	1.413 (2)
C4—C5	1.524 (2)	C4'—C5'	1.379 (3)
C4—H4	1.0000	C4'—H4'	0.9500
C5—C6	1.540 (2)	C5'—C6'	1.411 (3)
C5—H5A	0.9900	C5'—H5'	0.9500
C5—H5B	0.9900	C6'—C7'	1.381 (3)
C6—C3"	1.502 (2)	C6'—H6'	0.9500
C6—H6	1.0000	C7'—C7A'	1.391 (3)
C11—C12	1.395 (2)	C7'—H7'	0.9500
C11—C16	1.397 (2)	N1"—C2"	1.372 (2)
C12—C13	1.392 (3)	N1"—C7A"	1.372 (2)
C12—H12	0.9500	N1"—H1"	0.895 (19)
C13—C14	1.386 (3)	C2"—C3"	1.364 (2)
C13—H13	0.9500	C2"—H2"	0.9500
C14—C15	1.387 (3)	C3"—C3A"	1.444 (2)
C14—H14	0.9500	C3A"—C4"	1.405 (2)
C15—C16	1.389 (3)	C3A"—C7A"	1.416 (2)
C15—H15	0.9500	C4"—C5"	1.385 (3)
C16—H16	0.9500	C4"—H4"	0.9500
C21—O21	1.210 (2)	C5"—C6"	1.404 (3)
C21—O22	1.328 (2)	C5"—H5"	0.9500
O22—C22	1.456 (2)	C6"—C7"	1.381 (3)
C22—C23	1.501 (3)	C6"—H6"	0.9500
C22—H22A	0.9900	C7"—C7A"	1.397 (2)
C22—H22B	0.9900	C7"—H7"	0.9500
C23—H23A	0.9800		

C11—N1—C2	112.54 (13)	C22—C23—H23A	109.5
C11—N1—C6	117.04 (13)	C22—C23—H23B	109.5
C2—N1—C6	115.61 (13)	H23A—C23—H23B	109.5
N1—C2—C3	111.28 (13)	C22—C23—H23C	109.5
N1—C2—C21	113.13 (13)	H23A—C23—H23C	109.5
C3—C2—C21	108.49 (14)	H23B—C23—H23C	109.5
N1—C2—H2	107.9	C7A'—N1'—C2'	109.03 (14)
C3—C2—H2	107.9	C7A'—N1'—H1'	124.2 (16)
C21—C2—H2	107.9	C2'—N1'—H1'	124.4 (16)
C2—C3—C4	109.41 (12)	C3'—C2'—N1'	110.07 (16)
C2—C3—H3A	109.8	C3'—C2'—H2'	125.0
C4—C3—H3A	109.8	N1'—C2'—H2'	125.0
C2—C3—H3B	109.8	C2'—C3'—C3A'	106.10 (15)
C4—C3—H3B	109.8	C2'—C3'—C4	128.86 (16)
H3A—C3—H3B	108.2	C3A'—C3'—C4	124.96 (14)
C3'—C4—C5	113.67 (13)	C4'—C3A'—C7A'	118.76 (16)
C3'—C4—C3	112.59 (13)	C4'—C3A'—C3'	133.54 (16)
C5—C4—C3	107.56 (13)	C7A'—C3A'—C3'	107.67 (14)
C3'—C4—H4	107.6	C5'—C4'—C3A'	119.03 (17)
C5—C4—H4	107.6	C5'—C4'—H4'	120.5
C3—C4—H4	107.6	C3A'—C4'—H4'	120.5
C4—C5—C6	114.36 (13)	C4'—C5'—C6'	121.15 (18)
C4—C5—H5A	108.7	C4'—C5'—H5'	119.4
C6—C5—H5A	108.7	C6'—C5'—H5'	119.4
C4—C5—H5B	108.7	C7'—C6'—C5'	120.93 (18)
C6—C5—H5B	108.7	C7'—C6'—H6'	119.5
H5A—C5—H5B	107.6	C5'—C6'—H6'	119.5
N1—C6—C3"	111.11 (13)	C6'—C7'—C7A'	117.80 (17)
N1—C6—C5	110.75 (13)	C6'—C7'—H7'	121.1
C3"—C6—C5	107.67 (13)	C7A'—C7'—H7'	121.1
N1—C6—H6	109.1	N1'—C7A'—C7'	130.54 (17)
C3"—C6—H6	109.1	N1'—C7A'—C3A'	107.11 (15)
C5—C6—H6	109.1	C7'—C7A'—C3A'	122.33 (17)
C12—C11—C16	118.46 (16)	C2"—N1"—C7A"	109.04 (14)
C12—C11—N1	123.77 (15)	C2"—N1"—H1"	127.1 (15)
C16—C11—N1	117.77 (14)	C7A"—N1"—H1"	123.8 (14)
C13—C12—C11	120.33 (16)	C3"—C2"—N1"	110.34 (15)
C13—C12—H12	119.8	C3"—C2"—H2"	124.8
C11—C12—H12	119.8	N1"—C2"—H2"	124.8
C14—C13—C12	120.72 (17)	C2"—C3"—C3A"	106.36 (15)

C14—C13—H13	119.6	C2"—C3"—C6	125.49 (15)
C12—C13—H13	119.6	C3A"—C3"—C6	127.49 (14)
C13—C14—C15	119.32 (18)	C4"—C3A"—C7A"	118.63 (15)
C13—C14—H14	120.3	C4"—C3A"—C3"	134.66 (16)
C15—C14—H14	120.3	C7A"—C3A"—C3"	106.68 (14)
C14—C15—C16	120.17 (17)	C5"—C4"—C3A"	118.66 (16)
C14—C15—H15	119.9	C5"—C4"—H4"	120.7
C16—C15—H15	119.9	C3A"—C4"—H4"	120.7
C15—C16—C11	120.94 (16)	C4"—C5"—C6"	121.43 (16)
C15—C16—H16	119.5	C4"—C5"—H5"	119.3
C11—C16—H16	119.5	C6"—C5"—H5"	119.3
O21—C21—O22	124.11 (16)	C7"—C6"—C5"	121.50 (17)
O21—C21—C2	125.31 (15)	C7"—C6"—H6"	119.3
O22—C21—C2	110.51 (13)	C5"—C6"—H6"	119.3
C21—O22—C22	116.92 (13)	C6"—C7"—C7A"	116.96 (16)
O22—C22—C23	106.18 (15)	C6"—C7"—H7"	121.5
O22—C22—H22A	110.5	C7A"—C7"—H7"	121.5
C23—C22—H22A	110.5	N1"—C7A"—C7"	129.62 (15)
O22—C22—H22B	110.5	N1"—C7A"—C3A"	107.55 (14)
C23—C22—H22B	110.5	C7"—C7A"—C3A"	122.79 (15)
H22A—C22—H22B	108.7		
C11—N1—C2—C3	167.62 (13)	C2'—C3'—C3A'—C4'	-177.79 (18)
C6—N1—C2—C3	-54.25 (17)	C4—C3'—C3A'—C4'	-0.8 (3)
C11—N1—C2—C21	-69.94 (17)	C2'—C3'—C3A'—C7A'	0.02 (18)
C6—N1—C2—C21	68.19 (18)	C4—C3'—C3A'—C7A'	177.03 (15)
N1—C2—C3—C4	59.73 (17)	C7A'—C3A'—C4'—C5'	0.5 (2)
C21—C2—C3—C4	-65.36 (16)	C3'—C3A'—C4'—C5'	178.13 (18)
C2—C3—C4—C3'	174.44 (13)	C3A'—C4'—C5'—C6'	-1.0 (3)
C2—C3—C4—C5	-59.56 (16)	C4'—C5'—C6'—C7'	0.7 (3)
C3'—C4—C5—C6	-179.06 (13)	C5'—C6'—C7'—C7A'	0.3 (3)
C3—C4—C5—C6	55.59 (17)	C2'—N1'—C7A'—C7'	177.12 (18)
C11—N1—C6—C3"	-56.77 (18)	C2'—N1'—C7A'—C3A'	-1.24 (19)
C2—N1—C6—C3"	167.03 (14)	C6'—C7'—C7A'—N1'	-178.93 (18)
C11—N1—C6—C5	-176.38 (14)	C6'—C7'—C7A'—C3A'	-0.8 (3)
C2—N1—C6—C5	47.41 (17)	C4'—C3A'—C7A'—N1'	178.94 (15)
C4—C5—C6—N1	-48.86 (18)	C3'—C3A'—C7A'—N1'	0.74 (18)
C4—C5—C6—C3"	-170.52 (13)	C4'—C3A'—C7A'—C7'	0.4 (3)
C2—N1—C11—C12	112.34 (17)	C3'—C3A'—C7A'—C7'	-177.78 (16)
C6—N1—C11—C12	-25.1 (2)	C7A"—N1"—C2"—C3"	-1.0 (2)
C2—N1—C11—C16	-67.12 (19)	N1"—C2"—C3"—C3A"	0.1 (2)

C6—N1—C11—C16	155.39 (15)	N1"—C2"—C3"—C6	171.40 (15)
C16—C11—C12—C13	1.8 (3)	N1—C6—C3"—C2"	131.29 (17)
N1—C11—C12—C13	-177.70 (16)	C5—C6—C3"—C2"	-107.27 (19)
C11—C12—C13—C14	0.4 (3)	N1—C6—C3"—C3A"	-59.3 (2)
C12—C13—C14—C15	-1.4 (3)	C5—C6—C3"—C3A"	62.1 (2)
C13—C14—C15—C16	0.3 (3)	C2"—C3"—C3A"—C4"	178.4 (2)
C14—C15—C16—C11	1.9 (3)	C6—C3"—C3A"—C4"	7.4 (3)
C12—C11—C16—C15	-2.9 (3)	C2"—C3"—C3A"—C7A"	0.73 (18)
N1—C11—C16—C15	176.60 (16)	C6—C3"—C3A"—C7A"	-170.28 (16)
N1—C2—C21—O21	-4.7 (2)	C7A"—C3A"—C4"—C5"	1.8 (3)
C3—C2—C21—O21	119.27 (18)	C3"—C3A"—C4"—C5"	-175.69 (18)
N1—C2—C21—O22	178.08 (14)	C3A"—C4"—C5"—C6"	-0.5 (3)
C3—C2—C21—O22	-57.93 (16)	C4"—C5"—C6"—C7"	-1.1 (3)
O21—C21—O22—C22	-2.3 (2)	C5"—C6"—C7"—C7A"	1.4 (3)
C2—C21—O22—C22	174.95 (14)	C2"—N1"—C7A"—C7"	-176.28 (17)
C21—O22—C22—C23	-174.09 (16)	C2"—N1"—C7A"—C3A"	1.46 (19)
C7A'—N1'—C2'—C3'	1.3 (2)	C6"—C7"—C7A"—N1"	177.40 (18)
N1'—C2'—C3'—C3A'	-0.79 (19)	C6"—C7"—C7A"—C3A"	0.0 (2)
N1'—C2'—C3'—C4	-177.65 (15)	C4"—C3A"—C7A"—N1"	-179.46 (16)
C5—C4—C3'—C2'	-40.7 (2)	C3"—C3A"—C7A"—N1"	-1.34 (18)
C3—C4—C3'—C2'	82.0 (2)	C4"—C3A"—C7A"—C7"	-1.5 (2)
C5—C4—C3'—C3A'	143.04 (15)	C3"—C3A"—C7A"—C7"	176.59 (16)
C3—C4—C3'—C3A'	-94.34 (18)		

Hydrogen-bond geometry (Å, º) for (cu_sb632) for **9aa**

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
N1′—H1′···O21^{i}	0.87 (2)	2.07 (2)	2.8977 (19)	159 (2)
N1"—H1"···N1′^{ii}	0.90 (2)	2.65 (2)	3.298 (2)	130 (2)

Symmetry codes: (i) *x*, *y*, *z*+1; (ii) *x*, *y*-1, *z*