Electronic Supplementary Material (ESI) for Chemical Communications.

Supporting Information

N-Heterocyclic carbene catalyzed desymmetrization of diols: access to enantioenriched oxindoles having a C3-quaternary stereocenter

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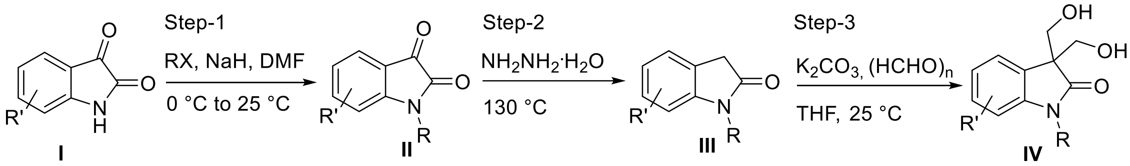
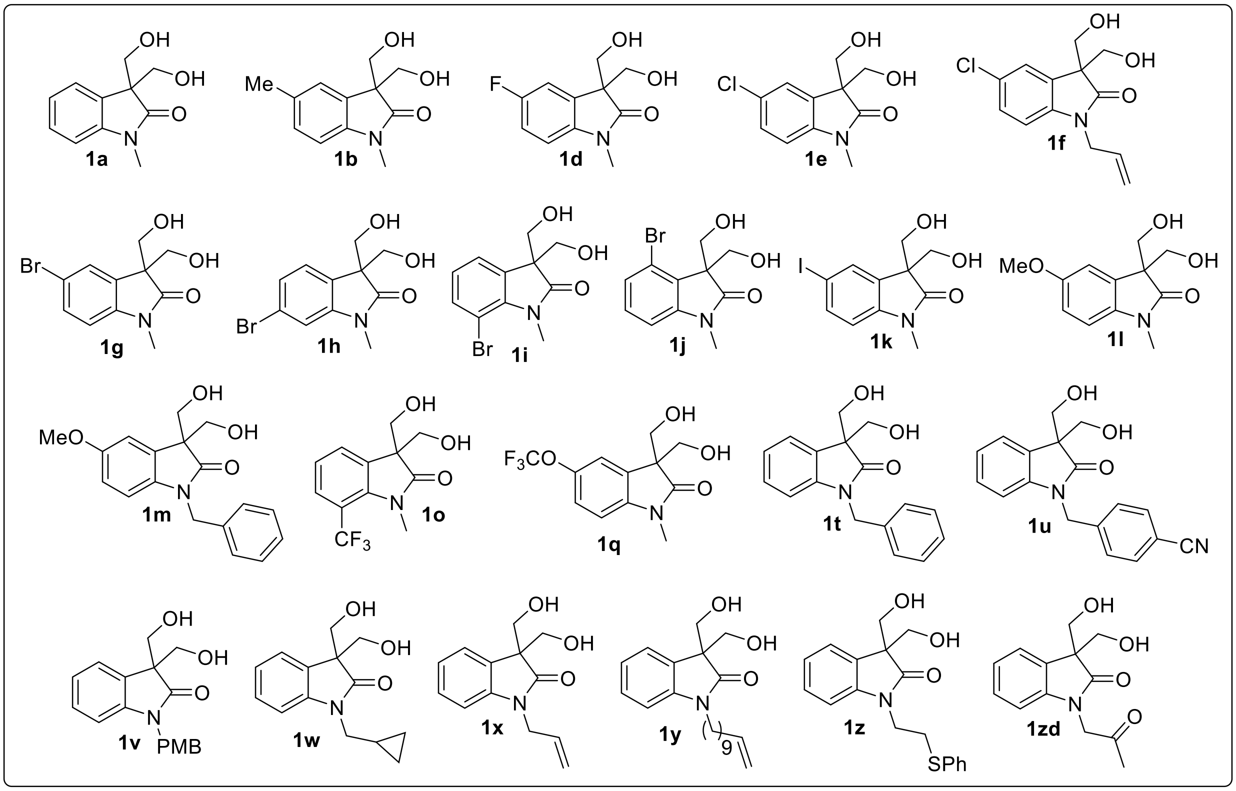
1. General information:

Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification. THF was freshly dried prior to the reaction over sodium (Na). Molecular sieve (MS) (4 Å) was activated by heating at elevated temperature (>150 ºC) under vacuum for 12 h. All the reactions were performed in flame-dried Schlenk tubes (inner diameter = 18 mm, length = 105 mm) with glass stoppers/silicon septum and Teflon coated magnetic stirring bar. Reactions were monitored by thin layer chromatography (TLC) analysis on silica gel GF254, 325 mesh and visualization was accomplished with short wave UV light at 254 nm or $KMnO_4$ staining solutions followed by heating. The crude product was purified by column chromatography on Merck silica gel (100-200 mesh). ^1H and ^{13}C NMR spectra were recorded on Bruker AVANCE III 600, 500, 400 and 300 MHz spectrometers in deuterated solvents. Proton chemical shifts are reported in ppm (δ) relative to tetramethylsilane (TMS) with the solvent resonance employed as the internal standard ($CDCl_3$ δ 7.26 ppm, DMSO-d_6 δ 2.50 ppm and acetone-d_6 δ 2.05 ppm).^1H NMR data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, dd= doublet of doublet, t = triplet, dt = doublet of triplet, m = multiplet, br = broad, p = pentet) coupling constants (Hz) and integration. ^{13}C chemical shifts are reported in ppm (δ) from tetramethylsilane (TMS) with the solvent resonance as the internal standard ($CDCl_3$ δ 77.16 ppm, DMSO-d_6 δ 39.52 and acetone-d_6 δ 29.84 ppm). High resolution mass spectra were recorded on Q-T of micro MS system by electron spray ionization (ESI) technique. The enantiomeric ratio was determined by HPLC (Shimadzu) analysis on a chiral stationary phase (column specified at the individual measurement). Optical rotations were measured on an Anton Paar (MCP-200) automatic polarimeter and are reported as follows: concentration (c = g/dL) and solvent. Single crystal X-ray analysis was done on Bruker's Kappa Apex II CCD Duo diffractometer with graphite monochromated MoKα radiation (0.71073 Å) at the temperature of 134 K. Scaling and multi-scan absorption corrections were employed using SADABS. The structure was solved by direct methods and all the non-hydrogen atoms were refined anisotropically while the hydrogen atoms fixed in the predetermined positions by Shelxs-97 and Shelxl-97 packages, respectively.

2. General procedure I (GP-I): Synthesis of substituted 3-dihydroxymethyl-2-indolones (1a, 1b, 1d-1m, 1o, 1q, 1t-1z, 1zd)

Different substituent 3-dihydroxymethyl-2-indolones were synthesized in good to moderate yields starting from commercially available isatin derivatives in three steps. Following the similar reported procedures,[1-3] the protection of isatin **I** afforded the corresponding N-protected isatin **II** (step-1). The N-protected isatin was then treated with $NH_2NH_2.H_2O$ to afford the corresponding 2-indolone **III** (step-2). Finally, 2-indolone **III** was allow to react with paraformaldehyde to obtain the desired 3-dihydroxymethyl-2-indolone derivatives (step-3).





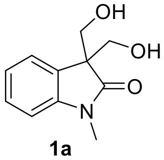
Step-1: To an oven dried 50 mL Schlenk flask equipped with a magnetic stir bar were charged with isatin (1.0 equiv) and dry DMF (0.2 M). The solution was cooled to 0 °C before NaH (1.2 equiv) was added slowly. The mixture was stirred for 30 min at 0 °C. To the stirred solution, appropriate electrophile (1.1 equiv) was added while maintaining the reaction mixture at 0 °C.

The reaction mixture was then allowed to warm to room temperature (25 °C) and stirred for another 1.0 h. The progress of the reaction was monitored by TLC analysis. After complete consumption of starting material, the reaction was quenched by slow addition of water. The organic layer was separated and aqueous layer was extracted with EtOAc (three times). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude material was purified by column chromatography on silica gel to obtain the desired N-protected isatin **II**.[1]

Step-2: Compound **III** was synthesized according to a modified literature procedure.[2] To a 50 mL round bottom flask equipped with a magnetic stir bar and fitted with a reflux condenser were added N-protected isatin (1.0 equiv) and hydrazine hydrate 99% (1.0 M). The reaction mixture was heated under reflux at 130 °C (oil bath temperature) for 1.5-2.0 h (the progress of the reaction was monitored by TLC analysis). The reaction mixture was brought to room temperature and acidified up to pH = 2 by adding aqueous 2 N hydrochloric acid. The organic layer was separated and aqueous layer was extracted with EtOAc (three times). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under vacuum. The crude material was purified by column chromatography to afford the corresponding N-protected oxindole **III**.

Step-3: Compound **IV** was synthesized according to a modified literature procedure.[3] To a 50 mL round bottom flask equipped with a magnetic stir bar were added N-protected oxindole **III** (1.0 equiv), K_2CO_3 (3.0 equiv) and THF (0.1 M). The reaction mixture was stirred at 25 °C for 10 min. To the stirred solution, paraformaldehyde was added (5.5 equiv) and the reaction was continued at room temperature for 1.0-1.5 h. The progress of the reaction was monitored by TLC analysis. After complete consumption of the starting material, the mixture was filtered off through a celite pad and the filtrate was concentrated under vacuum. The crude material was purified by column chromatography on silica gel to afford the desired prochiral diol **IV**.

3,3-Bis(hydroxymethyl)-1-methylindolin-2-one (1a): Synthesized following **GP-I** to furnish the desired product as white solid with 73% yield.



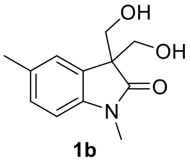
1a

^{1}H NMR (300 MHz, DMSO-d_6) δ = 7.35 (d, *J* = 6.9 Hz, 1H), 7.28 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.03-6.99 (m, 1H), 6.95 (d, *J* = 7.8 Hz, 1H), 4.72 (t, *J* = 5.4 Hz, 2H), 3.76 (dd, *J* = 10.5, 5.1 Hz, 2H), 3.61 (dd, *J* = 10.2, 5.4 Hz, 2H), 3.09 (s, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 177.0, 144.7, 130.5, 127.5, 123.8, 121.5, 107.7, 63.1, 57.3, 25.9 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{14}NO_3$ [M+H]$^+$ 208.0974, found 208.0976.

3,3-Bis(hydroxymethyl)-1,5-dimethylindolin-2-one (1b): Synthesized following **GP-I** to furnish the desired product as white solid with 42% yield.



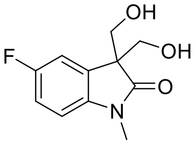
1b

^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.24 (s, 1H), 7.09 (d, *J* = 7.5 Hz, 1H), 6.83 (d, *J* = 7.8 Hz, 1H), 3.94 (dd, *J* = 9.6, 3.9 Hz, 2H), 3.83-3.74 (m, 4H), 3.13 (s, 3H), 2.30 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 178.0, 143.5, 131.7, 130.9, 128.9, 125.8, 108.2, 64.7, 57.7, 26.1, 21.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{12}H_{15}NO_3Na$ [M+Na]$^+$ 244.0950, found 244.0952.

5-Fluoro-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1d): Synthesized following **GP-I** to furnish the desired product as white solid with 59% yield.



1d

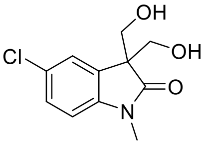
^{1}H NMR (400 MHz, acetone-d$_6$) δ = 7.25 (dd, *J* = 8.4, 2.8 Hz, 1H), 7.06 (dt, *J* = 11.2, 8.8, 2.8 Hz, 1H), 6.94-6.90 (m, 1H), 3.98 (dd, *J* = 10.4, 4.8 Hz, 2H), 3.91 (t, *J* = 6.4 Hz, 2H), 3.83 (dd, *J* = 10.0, 6.4 Hz, 2H), 3.15 (s, 3H) ppm.

^{13}C NMR (150 MHz, acetone-d$_6$) δ = 177.6, 160.5 (d, J_{C-F} = 235.5 Hz), 142.1, 133.0 (d, J_{C-F} = 7.5 Hz), 114.5 (d, J_{C-F} = 22.5 Hz), 113.1 (d, J_{C-F} = 25.5 Hz), 108.9 (d, J_{C-F} = 9.0 Hz), 64.5, 58.5, 26.2 ppm.

^{19}F NMR (564 MHz, acetone-d$_6$) δ = -123.90 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{12}FNO_3Na$ [M+Na]$^+$ 248.0699, found 248.0698.

5-Chloro-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1e): Synthesized following **GP-I** to furnish the desired product as white solid with 51% yield.



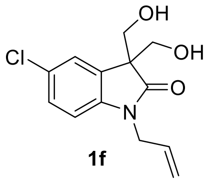
1e

^{1}H NMR (400 MHz, DMSO-d$_6$) δ = 7.39 (s, 1H), 7.32 (d, *J* = 8.0 Hz, 1H), 6.97 (d, *J* = 8.4 Hz, 1H), 4.80 (t, *J* = 5.2 Hz, 2H), 3.77 (dd, *J* = 10.4, 5.2 Hz, 2H), 3.61 (dd, *J* = 10.0, 5.6 Hz, 2H), 3.09 (s, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 176.7, 143.7, 132.6, 127.2, 125.7, 124.1, 108.9, 62.8, 57.9, 26.0 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{12}ClNO_3Na$ $[M+Na]^+$ 264.0403, found 264.0401.

1-Allyl-5-chloro-3,3-bis(hydroxymethyl)indolin-2-one (1f): Synthesized following **GP-I** to furnish the desired product as white solid with 63% yield.



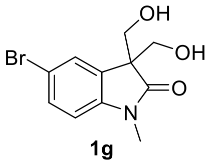
1f

^{1}H NMR (400 MHz, DMSO-d_6) δ = 7.42 (s, 1H), 7.28 (t, *J* = 6.4 Hz, 1H), 6.87 (d, *J* = 8.0 Hz, 1H), 5.82-5.74 (m, 1H), 5.15-5.06 (m, 2H), 4.86-4.78 (m, 2H), 4.27 (s, 2H), 3.79 (dd, *J* = 10.0, 4.8 Hz, 2H), 3.63 (dd, *J* = 10.0, 5.6 Hz, 2H) ppm.

^{13}C NMR (75 MHz, DMSO-d_6) δ = 176.6, 142.7, 132.6, 131.4, 127.1, 125.7, 124.1, 116.1, 109.5, 62.8, 58.0, 41.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{13}H_{14}ClNO_3Na$ $[M+Na]^+$ 290.0560, found 290.0561.

5-Bromo-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1g): Synthesized following **GP-I** to furnish the desired product as white solid with 55% yield.



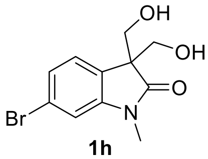
1g

^{1}H NMR (400 MHz, acetone-d_6) δ = 7.56 (d, *J* = 2.0 Hz, 1H), 7.45 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 3.97 (d, *J* = 8.0 Hz, 4H), 3.84-3.80 (m, 2H), 3.15 (s, 3H) ppm.

^{13}C NMR (100 MHz, acetone-d_6) δ = 177.4, 145.4, 133.6, 131.4, 128.1, 114.8, 110.2, 64.5, 58.5, 26.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{12}BrNO_3Na$ $[M+Na]^+$ 307.9898, found 307.9899.

6-Bromo-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1h): Synthesized following **GP-I** to furnish the desired product as white solid with 59% yield.



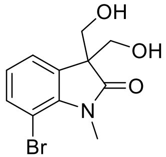
1h

^{1}H NMR (400 MHz, acetone-d_6) δ = 7.35 (d, *J* = 7.6 Hz, 1H), 7.19 (d, *J* = 7.6 Hz, 1H), 7.12 (s, 1H), 3.96-3.92 (m, 2H), 3.90-3.87 (m, 2H), 3.82-3.78 (m, 2H), 3.16 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d_6) δ = 177.8, 147.7, 130.3, 126.5, 125.1, 121.8, 111.8, 64.5, 58.0, 26.3 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{12}BrNO_3Na$ $[M+Na]^+$ 307.9898, found 307.9896.

7-Bromo-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1i): Synthesized following **GP-I** to furnish the desired product as white solid with 56% yield.



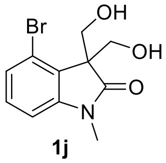
1i

^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.43 (dd, *J* = 6.0, 1.6 Hz, 1H), 7.41 (dd, *J* = 7.2, 1.2 Hz, 1H), 6.97 (dd, *J* = 11.2, 9.6 Hz, 1H), 3.95-3.90 (m, 4H), 3.85-3.79 (m, 2H), 3.51 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 178.5, 143.1, 134.6, 134.1, 124.2, 124.1, 102.0, 64.8, 58.0 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{12}BrNO_3Na$ [M+Na]$^+$ 307.9898, found 307.9896.

4-Bromo-3,3-bis(hydroxymethyl)-1-methylindolin-2-one (1j): Synthesized following **GP-I** to furnish the desired product as white solid with 47% yield.



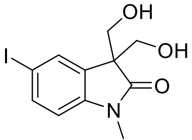
1j

^{1}H NMR (400 MHz, acetone-d$_6$) δ = 7.22 (t, *J* = 8.0 Hz, 1H), 7.15 (d, *J* = 8.0 Hz, 1H), 6.94 (d, *J* = 7.2 Hz, 1H), 4.28-4.25 (m, 2H), 3.87-3.83 (m, 2H), 3.80 - 3.77 (m, 2H), 3.16 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 178.1, 149.0, 130.6, 128.2, 126.6, 119.4, 107.7, 61.5, 55.6, 26.3 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{13}BrNO_3$ [M+H]$^+$ 286.0079, found 286.0077.

3,3-Bis(hydroxymethyl)-5-iodo-1-methylindolin-2-one (1k): Synthesized following **GP-I** to furnish the desired product as white solid with 43% yield.



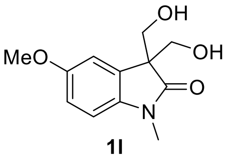
1k

^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.72 (d, *J* = 1.8 Hz, 1H), 7.63 (dd, *J* = 8.1, 1.5 Hz, 1H), 6.81 (d, *J* = 8.1 Hz, 1H), 3.96 (d, *J* = 10.8 Hz, 4H), 3.80 (d, *J* = 9.6 Hz, 2H), 3.13 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 177.2, 146.0, 137.4, 133.8, 133.7, 110.8, 84.7, 64.5, 58.3, 26.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{11}H_{13}INO_3$ [M+H]$^+$ 333.9940, found 333.9941.

3,3-Bis(hydroxymethyl)-5-methoxy-1-methylindolin-2-one (1l): Synthesized following **GP-I** to furnish the desired product as white solid with 48% yield.



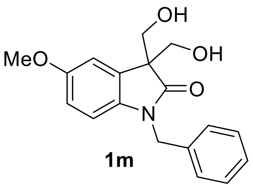
1l

^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.06 (d, *J* = 1.5 Hz, 1H), 6.83 (d, *J* = 1.2 Hz, 2H), 3.93-3.88 (m, 2H), 3.84-3.79 (m, 4H), 3.76 (s, 3H), 3.12 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 177.7, 156.6, 139.3, 132.2, 112.8, 112.7, 108.7, 64.7, 58.1, 55.9, 26.2 ppm.

HRMS (ESI+) *m/ z* calculated for $C_{12}H_{15}NO_4Na$ [M+Na]$^+$ 260.0899, found 260.0898.

1-Benzyl-3,3-bis(hydroxymethyl)-5-methoxyindolin-2-one (1m): Synthesized following **GP-I** to furnish the desired product as white solid with 46% yield.



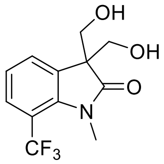
1m

^{1}H NMR (400 MHz, DMSO-d$_6$) δ= 7.32-7.20 (m, 5H), 7.02 (d, *J* = 2.0 Hz, 1H), 6.70 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.60 (d, *J* = 8.4 Hz, 1H), 4.86 (s, 2H), 4.83 (t, *J* = 5.2 Hz, 2H), 3.81-3.77 (m, 2H), 3.72-3.64 (m, 5H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 176.9, 155.0, 137.0, 136.4, 131.9, 128.3, 127.0, 126.9, 111.6, 111.4, 108.5, 63.1, 57.9, 55.3, 42.4 ppm.

HRMS (ESI+) *m/z* calculated for $C_{18}H_{19}NO_4Na$ [M+Na]$^+$ 336.1212, found 336.1213.

3,3-Bis(hydroxymethyl)-1-methyl-7-(trifluoromethyl)indolin-2-one (1o): Synthesized following **GP-I** to furnish the desired product as white solid with 46% yield.



1o

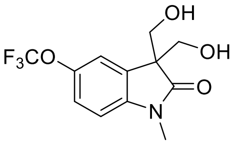
^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.72 (d, *J* = 7.2 Hz, 1H), 7.62 (dd, *J* = 8.1, 0.6 Hz, 1H), 7.23 (d, *J* = 7.2 Hz, 1H), 4.01-3.95 (m, 4H), 3.88-3.82 (m, 2H), 3.35 (q, *J* = 2.4 Hz, 3H) ppm.

^{13}C NMR (150 MHz, acetone-d$_6$) δ = 179.0, 143.8, 134.0, 128.7, 127.7 (q, $J_{C\text{-}F}$ = 270.0 Hz), 126.3 (q, $J_{C\text{-}F}$ = 6.0 Hz), 122.2, 112.1 (q, $J_{C\text{-}F}$ = 33.0 Hz), 64.6, 56.8, 28.8 (q, $J_{C\text{-}F}$ = 6.0 Hz) ppm.

^{19}F NMR (564 MHz, acetone-d$_6$) δ = -53.41 ppm.

HRMS (ESI+) *m/z* calculated for $C_{12}H_{13}F_3NO_3$ [M+H]$^+$ 276.0847, found 276.0846.

3,3-Bis(hydroxymethyl)-1-methyl-5-(trifluoromethoxy)indolin-2-one (1q): Synthesized following **GP-I** to furnish the desired product as white solid with 52% yield.



1q

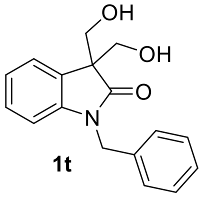
^{1}H NMR (300 MHz, acetone-d$_6$) δ = 7.41 (d, *J* = 1.8 Hz, 1H), 7.27-7.23 (m, 1H), 7.03 (d, *J* = 8.4 Hz, 1H), 4.02-3.97 (m, 4H), 3.86 (dd, *J* = 11.4, 7.5 Hz, 2H), 3.18 (s, 3H) ppm.

^{13}C NMR (150 MHz, acetone-d$_6$) δ = 177.7, 145.0, 133.0, 124.1 (q, $J_{C\text{-}F}$ = 253.5. Hz), 121.7, 118.9, 109.0, 64.5, 58.5, 26.3 ppm.

^{19}F NMR (564 MHz, acetone-d$_6$) δ = -58.84 ppm.

HRMS (ESI+) *m/z* calculated for $C_{12}H_{13}F_3NO_4$ $[M+H]^+$ 292.0797, found 292.0796.

1-Benzyl-3,3-bis(hydroxymethyl)indolin-2-one (1t): Synthesized following **GP-I** to furnish the desired product as white solid with 68% yield.



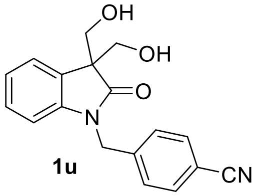
1t

^{1}H NMR (400 MHz, DMSO-d_6) δ = 7.37 (d, *J* = 6.8 Hz, 1H), 7.32-7.25 (m, 4H), 7.23-7.20 (m, 1H), 7.15 (dt, *J* = 8.0, 1.2 Hz, 1H), 7.00 (t, *J* = 7.2 Hz, 1H), 6.71 (d, *J* = 8.0 Hz, 1H), 4.88 (s, 2H), 4.85 (t, *J* = 5.2 Hz, 2H), 3.81 (dd, *J* = 10.0, 4.8 Hz, 2H), 3.70 (dd, *J* = 10.0, 5.6 Hz, 2H) ppm.

^{13}C NMR (75 MHz, DMSO-d_6) δ = 177.4, 143.7, 136.4, 130.6, 128.5, 127.4, 127.1, 127.0, 123.9, 121.7, 108.4, 63.2, 57.6, 42.5 ppm.

HRMS (ESI+) *m/z* calculated for $C_{17}H_{17}NO_3Na$ $[M+Na]^+$ 306.1106, found 306.1108.

4-((3,3-Bis(hydroxymethyl)-2-oxoindolin-1-yl)methyl)benzonitrile (1u): Synthesized following **GP-I** to furnish the desired product as white solid with 41% yield.



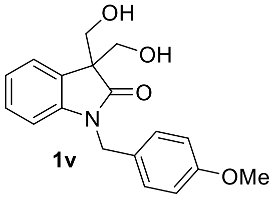
1u

^{1}H NMR (400 MHz, acetone-d_6) δ= 7.69 (d, *J* = 8.4 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.46 (d, *J* = 7.2 Hz, 1H), 7.17 (t, *J* = 7.2 Hz, 1H), 7.04 (t, *J* = 7.2 Hz, 1H), 6.74 (d, *J* = 8.0 Hz, 1H), 5.06 (s, 2H), 4.04-3.97 (m, 4H), 3.94-3.90 (m, 2H) ppm.

^{13}C NMR (75 MHz, acetone-d_6) δ = 178.4, 144.6, 143.2, 133.1, 131.1, 128.9, 128.6, 125.0, 122.9, 119.2, 111.8, 109.1, 64.8, 58.4, 43.3 ppm.

HRMS (ESI+) *m/z* calculated for $C_{18}H_{16}N_2O_3Na$ $[M+Na]^+$ 331.1059, found 331.1057.

3,3-Bis(hydroxymethyl)-1-(4-methoxybenzyl)indolin-2-one (1v): Synthesized following **GP-I** to furnish the desired product as white solid with 43% yield.



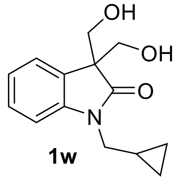
1v

^{1}H NMR (400 MHz, acetone-d_6) δ = 7.42 (d, *J* = 7.2 Hz, 1H), 7.32 (d, *J* = 8.8 Hz, 2H), 7.16 (t, *J* = 7.6 Hz, 1H), 7.00 (t, *J* = 7.6 Hz, 1H), 6.84 (d, *J* = 8.8 Hz, 2H), 6.77 (d, *J* = 7.6 Hz, 1H), 4.87 (s, 2H), 4.03-3.96 (m, 2H), 3.93-3.86 (m, 4H), 3.73 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d_6) δ = 178.3, 159.9, 144.9, 131.1, 129.3, 128.5, 125.0, 122.6, 114.7, 109.5, 64.8, 58.0, 55.4, 43.1 ppm.

HRMS (ESI+) *m/z* calculated for $C_{18}H_{19}NO_4Na$ $[M+Na]^+$ 336.1212, found 336.1210.

1-(Cyclopropylmethyl)-3,3-bis(hydroxymethyl)indolin-2-one (1w): Synthesized following **GP-I** to furnish the desired product as white solid with 47% yield.



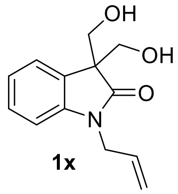
1w

^{1}H NMR (300 MHz, acetone-d_6) δ = 7.43 (d, *J* = 7.8 Hz, 1H), 7.30 (dt, *J* = 8.1, 1.5 Hz, 1H), 7.06-6.99 (m, 2H), 3.98-3.92 (m, 2H), 3.83 (d, *J* = 5.1 Hz, 4H), 3.63 (d, *J* = 6.6 Hz, 2H), 1.22-1.12 (m, 1H), 0.47-0.40 (m, 2H), 0.38-0.33 (m, 2H) ppm.

^{13}C NMR (75 MHz, acetone-d_6) δ = 178.2, 145.4, 131.0, 128.7, 125.1, 122.4, 109.1, 64.7, 57.5, 44.1, 10.4, 3.9 ppm.

HRMS (ESI+) *m/z* calculated for $C_{14}H_{17}NO_3Na$ $[M+H]^+$ 270.1106, found 270.1108.

1-Allyl-3,3-bis(hydroxymethyl)indolin-2-one (1x): Synthesized following **GP-I** to furnish the desired product as white solid with 51% yield.



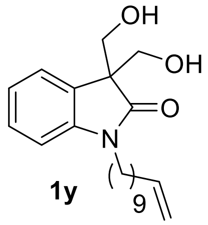
1x

^{1}H NMR (300 MHz, DMSO-d_6) δ = 7.37 (d, *J* = 7.2 Hz, 1H), 7.23 (dt, *J* = 8.7, 7.8, 0.9 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.85 (d, *J* = 7.8 Hz, 1H), 5.86-5.74 (m, 1H), 5.18-5.05 (m, 2H), 4.76 (t, *J* = 5.1 Hz, 2H), 4.27-4.26 (m, 2H), 3.78 (dd, *J* = 10.2, 5.1 Hz, 2H), 3.64 (dd, *J* = 10.2, 5.7 Hz, 2H) ppm.

^{13}C NMR (75 MHz, DMSO-d_6) δ = 176.9, 143.7, 131.7, 130.5, 127.3, 123.8, 121.4, 116.1, 108.2, 63.1, 57.4, 41.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{13}H_{15}NO_3Na$ $[M+Na]^+$ 256.0950, found 256.0951.

3,3-Bis(hydroxymethyl)-1-(undec-10-en-1-yl)indolin-2-one (1y): Synthesized following **GP-I** to furnish the desired product as yellow solid with 42% yield.



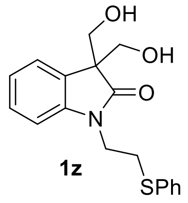
1y

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.35-7.30 (m, 2H), 7.11 (t, *J* = 5.4 Hz, 1H), 6.91 (d, *J* = 6.0 Hz, 1H), 5.85-5.75 (m, 1H), 5.00-4.90 (m, 2H), 4.01 (q, *J* = 8.1 Hz, 4H), 3.73 (t, J = 5.4 Hz, 2H), 2.16 (brs, 2H), 2.05 (dd, *J* = 10.5, 5.1 Hz, 2H), 1.68 (t, *J* = 5.1 Hz, 2H), 1.32-1.24 (m, 12H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 178.3, 143.5, 139.3, 128.8, 124.0, 122.8, 114.2, 108.9, 64.1, 55.3, 40.1, 33.9, 29.7, 29.6, 29.5, 29.5, 29.4, 29.3, 29.2, 29.0, 27.5, 26.9 ppm.

HRMS (ESI+) *m/z* calculated for $C_{21}H_{32}NO_3$ $[M+H]^+$ 346.2382, found 346.2383.

3,3-Bis(hydroxymethyl)-1-(2-(phenylthio)ethyl)indolin-2-one (1z): Synthesized following **GP-I** to furnish the desired product as white solid with 47% yield.



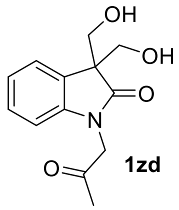
1z

^{1}H NMR (400 MHz, DMSO-d$_6$) δ = 7.42 (d, *J* = 7.2 Hz, 2H), 7.36-7.33 (m, 3H), 7.24-7.20 (m, 2H), 7.03 (t, *J* = 7.2 Hz, 1H), 6.94 (d, *J* = 8.0 Hz, 1H), 4.76 (t, *J* = 5.2 Hz, 2H), 3.86 (t, *J* = 7.2 Hz 2H), 3.75 (dd, *J* = 10.4, 5.2 Hz, 2H), 3.62 (dd, *J* = 10.4, 5.6 Hz, 2H), 3.17 (t, *J* = 7.6 Hz, 2H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 177.1, 143.3, 135.3, 130.4, 129.1, 128.3, 127.4, 126.0, 124.1, 121.5, 107.8, 63.1, 57.1, 29.7 ppm.

HRMS (ESI+) *m/z* calculated for $C_{18}H_{20}NO_3S$ $[M+H]^+$ 330.1164, found 330.1166.

3,3-Bis(hydroxymethyl)-1-(2-oxopropyl)indolin-2-one (1zd): Synthesized following **GP-I** to furnish the desired product as white solid with 37% yield.



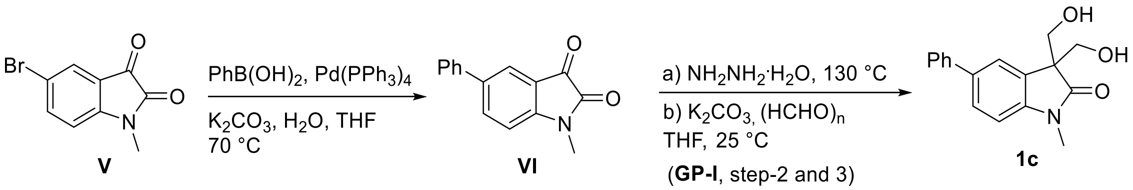
1zd

^{1}H NMR (500 MHz, DMSO-d$_6$) δ = 7.38 (d, *J* = 7.5 Hz, 1H), 7.22 (t, *J* = 7.5 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.87 (d, *J* = 8.0 Hz, 1H), 4.80 (t, *J* = 5.0 Hz, 2H), 4.53 (s, 2H), 3.80 (dd, *J* = 10.5, 5.0 Hz, 2H), 3.64 (dd, *J* = 10.5, 5.5 Hz, 2H), 2.14 (s, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 202.9, 177.1, 143.6, 130.2, 127.4, 124.2, 121.7, 108.0, 63.2, 57.1, 49.0, 27.0 ppm.

HRMS (ESI+) *m/z* calculated for $C_{13}H_{15}NO_4Na$ $[M+Na]^+$ 272.0899, found 272.0897.

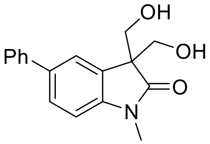
3. Synthesis of compound 1c:



Compound **V** was prepared following **GP-I** (step-1) from commercially available 5-bromoisatin. Compound **VI** was synthesized according to a modified literature procedure.[4] In a round bottom flask equipped with a magnetic stir bar were added $Pd(PPh_3)_4$ (120.0 mg, 0.10 mmol, 5 mol%), **V** (500.0 mg, 2.08 mmol, 1.0 equiv), phenyl boronic acid (304.0 mg, 2.50 mmol, 1.2 equiv) and K_2CO_3 (862.0 mg, 6.24 mmol, 3.0 equiv) in degassed THF/H_2O (22.5 mL/10.0 mL, 15:7) under argon atmosphere. The reaction mixture was heated under reflux at 70 °C for 8 h. After complete consumption of the starting materials, the reaction mixture was allowed to cool to room temperature, acidified with 1 N HCl. The organic layer was separated and aqueous layer was extracted with EtOAc (three times). The combined organic layer was washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (SiO_2, 25% EtOAc-PE, $R_f = 0.5$) to obtain isatin **VI** (391.0 mg, 79%) as an orange solid.

According to **GP-I** (step 2 and 3), compound **VI** was converted to prochiral diol **1c** (337.0 mg, 72%).

3,3-Bis(hydroxymethyl)-1-methyl-5-phenylindolin-2-one (1c): White solid, 57% yield.



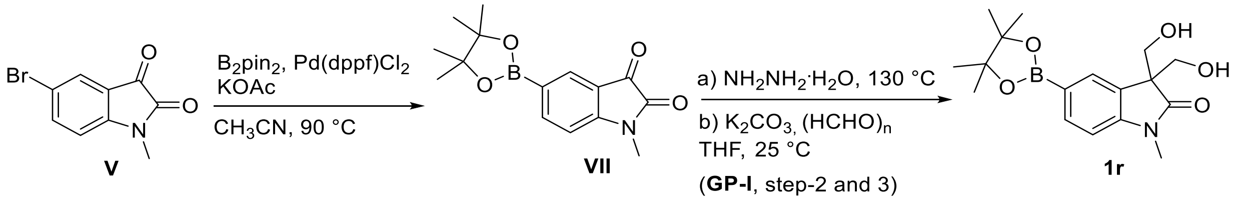
1c

^{1}H NMR (300 MHz, DMSO-d$_6$) δ = 7.66-7.63 (m, 3H), 7.58 (dd, *J* = 8.1, 2.1 Hz, 1H), 7.47 (t, *J* = 7.5 Hz, 2H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.05 (d, *J* = 8.1 Hz, 1H), 4.78 (t, *J* = 5.4 Hz, 2H), 3.83 (dd, *J* = 10.2, 5.1 Hz, 2H), 3.66 (dd, *J* = 10.5, 5.7 Hz, 2H), 3.13 (s, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 177.1, 144.3, 140.6, 133.8, 131.1, 128.8, 126.6, 126.3, 125.9, 122.4, 107.9, 63.1, 57.6, 25.9 ppm.

HRMS (ESI+) *m/z* calculated for $C_{17}H_{17}NO_3Na$ $[M+Na]^+$ 306.1106, found 306.1105.

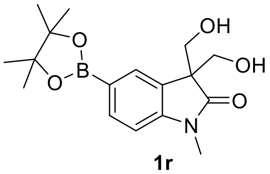
4. Synthesis of compound 1r:



Compound **VII** was synthesized following a modified literature procedure.[5] To an oven dried round bottom flask equipped with a magnetic stir bar were added **V** (500.0 mg, 2.08 mmol, 1.0 equiv), bis(pinacolato)diboron (579.0 mg, 2.28 mmol, 1.1 equiv), Pd(dppf)Cl_2 (75.0 mg, 0.10 mmol, 5 mol%), KOAc (612.5 mg, 6.24 mmol, 3.0 equiv), and degassed acetonitrile (21.0 mL, 0.1 M) under an argon atmosphere. The resulting mixture was stirred at 90 °C for 24 h. The reaction mixture was then filtered through celite and washed with EtOAc. The filtrate was evaporated under reduced pressure. The crude product was purified by column chromatography (SiO_2, 15% EtOAc-PE, $R_f = 0.5$) to furnish the desired compound **VII** (293.0 mg, 49% yield).

Compound **VII** was transformed to prochiral diol **1r** (231.0 mg, 68%) following **GP-I** (step-2 and step-3).

3,3-Bis(hydroxymethyl)-1-methyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)indolin-2-one (1r): White Solid, 33% yield.



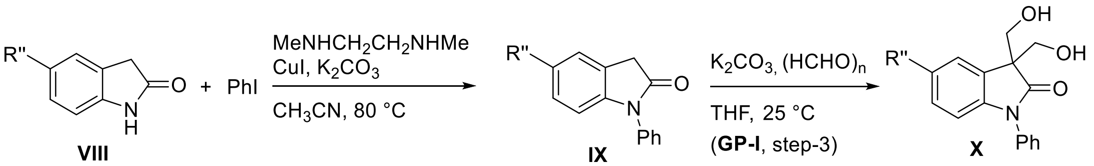
1r

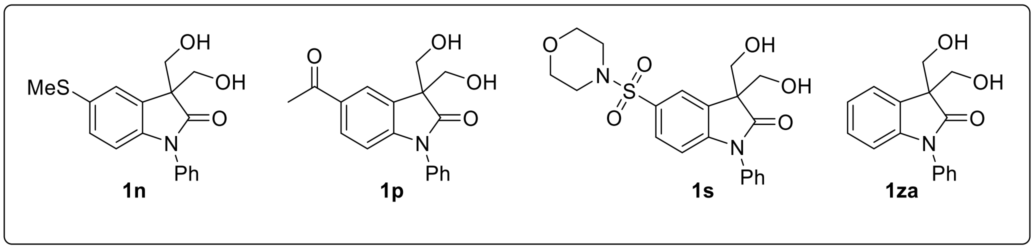
^{1}H NMR (300 MHz, acetone-d_6) δ = 7.77 (s, 1H), 7.72 (dd, *J* = 7.8, 1.2 Hz, 1H), 6.97 (d, *J* = 7.8 Hz, 1H), 3.99-3.95 (m, 2H), 3.90-3.80 (m, 4H), 3.17 (s, 3H), 1.33 (s, 12H) ppm.

^{13}C NMR (75 MHz, acetone-d_6) δ = 178.3, 148.8, 136.1, 130.7, 130.3, 108.0, 84.2, 64.7, 57.8, 26.2, 25.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{17}H_{25}BNO_5$ $[M+H]^+$ 334.1829, found 334.1827.

5. General procedure II: Synthesis of substituted 3-dihydroxymethyl-2-indolones (1n, 1p, 1s, 1za):

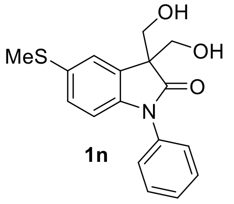




Compound **IX** was synthesized accordingly to literature procedure.[6] To a solution of substituted 2-indolone derivative (**VIII**) (1.0 equiv) in CH_3CN (0.3 M), CuI (0.1 equiv) and K_2CO_3 (2.2 equiv) were added. To the solution, PhI (1.2 equiv) and $MeNHCH_2CH_2NHMe$ (0.2 equiv) were added under argon atmosphere. The reaction mixture was then stirred under reflux at 80 °C for 12 h. The reaction mixture was then allowed to cool to room temperature, acidify with 1 N HCl (aq). The mixture was extracted with EtOAc (three times). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford the corresponding N-arylated 2-indolone derivative **IX** as a white solid.

Compound **IX** transformed to desired prochiral diols following **GP-I** (step-3).

3,3-Bis(hydroxymethyl)-5-(methylthio)-1-phenylindolin-2-one (1n): White Solid, 59% yield.

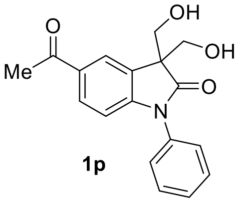

1n

^{1}H NMR (400 MHz, acetone-d$_6$) δ = 7.56 (dd, *J* = 15.6, 8.0 Hz, 3H), 7.40 (d, *J* = 7.2 Hz, 3H), 7.21 (d, *J* = 8.4 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 4.07-4.0 (m, 4H), 3.96-3.92 (m, 2H), 2.48 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 177.3, 144.0, 136.1, 132.1 132.0, 130.2, 128.5, 128.2, 127.5, 125.5, 109.9, 64.9, 58.5, 17.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{17}H_{17}NO_3SNa$ $[M+Na]^+$ 338.0827, found 338.0829.

5-Acetyl-3,3-bis(hydroxymethyl)-1-phenylindolin-2-one (1p): Yellow Solid, 63% yield.

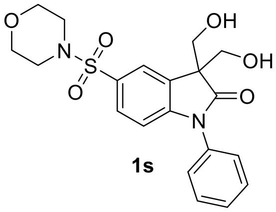

1p

^{1}H NMR (300 MHz, acetone-d$_6$) δ = 8.15 (d, *J* = 1.5 Hz, 1H), 7.95 (dd, *J* = 8.1, 1.8 Hz, 1H), 7.60-7.55 (m, 2H), 7.49-7.42 (m, 3H), 6.87 (d, *J* = 8.1 Hz, 1H), 4.13-4.07 (m, 4H), 4.01 (dd, *J* = 12.3, 8.4 Hz, 2H), 2.55 (s, 3H) ppm.

^{13}C NMR (75 MHz, acetone-d$_6$) δ = 196.7, 178.0, 150.1, 135.7, 133.0, 131.2, 130.5, 130.3, 128.9, 127.7, 125.2, 108.9, 64.8, 58.6, 26.5 ppm.

HRMS (ESI+) *m/z* calculated for $C_{18}H_{17}NO_5Na$ $[M+Na]^+$ 334.1055, found 334.1056.

3,3-Bis(hydroxymethyl)-5-(morpholinosulfonyl)-1-phenylindolin-2-one (1s): White Solid, 46% yield.

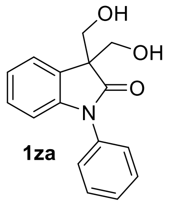

1s

^{1}H NMR (300 MHz, DMSO-d$_6$) δ = 7.79 (d, *J* = 1.8 Hz, 1H), 7.63-7.57 (m, 3H), 7.51 (t, *J* = 7.2 Hz, 1H), 7.41 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 1H), 5.07 (t, *J* = 5.4 Hz, 2H), 3.93 (dd, *J* = 10.5, 5.1 Hz, 2H), 3.79 (dd, *J* = 10.2, 5.7 Hz, 2H), 3.65-3.62 (m, 4H), 2.89-2.86 (m, 4H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 177.0, 148.7, 134.0, 131.4, 129.7, 128.8, 128.4, 127.7, 126.7, 123.7, 108.4, 65.3, 63.1, 58.0, 45.8 ppm.

HRMS (ESI+) *m/z* calculated for $C_{20}H_{23}N_2O_6S$ $[M+H]^+$ 419.1277, found 419.1278

3,3-Bis(hydroxymethyl)-1-phenylindolin-2-one (1za): White Solid, 71% yield.



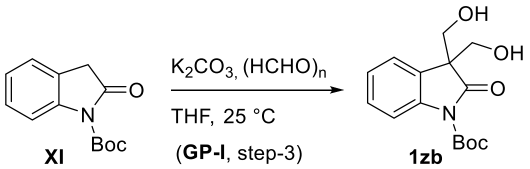
1za

^{1}H NMR (300 MHz, DMSO-d$_6$) δ = 7.58 (t, *J* = 7.5 Hz, 2H), 7.45 (d, *J* = 6.0 Hz, 2H), 7.39 (d, *J* = 8.4 Hz, 2H), 7.23 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.10-7.05 (m, 1H), 6.73 (d, *J* = 7.5 Hz, 1H), 4.88 (t, *J* = 5.1 Hz, 2H), 3.85 (dd, *J* = 10.2, 5.1 Hz, 2H), 3.76 (dd, *J* = 10.5, 5.7 Hz, 2H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 176.7, 144.3, 134.7, 130.4, 129.4, 127.6, 127.5, 126.5, 124.3, 122.1, 108.1, 63.3, 57.5 ppm.

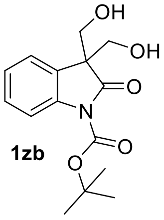
HRMS (ESI+) *m/z* calculated for $C_{16}H_{16}NO_3$ $[M+H]^+$ 270.1130, found 270.1131.

6. Synthesis of compound 1zb



Compound **XI** was prepared accordingly to literature procedure.[6] Starting from **XI** (300.0 mg, 1.30 mmol), prochiral diol **1zb** (263.0 mg, 69%) was synthesized following **GP-I** (step-3).

Tert-butyl 3,3-bis(hydroxymethyl)-2-oxoindoline-1-carboxylate (1zb): White Solid, 69% yield.



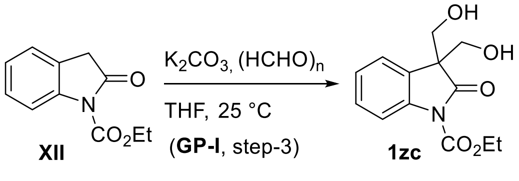
1zb

^{1}H NMR (300 MHz, DMSO-d$_6$) δ = 7.72 (d, *J* = 8.1 Hz, 1H), 7.43 (dd, *J* = 7.5, 1.2 Hz, 1H), 7.33 (dt, *J* = 7.8, 1.5 Hz, 1H), 7.20-7.15 (m, 1H), 4.91 (t, *J* = 5.4 Hz, 2H), 3.74-3.64 (m, 4H), 1.57 (s, 9H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 176.0, 148.6, 140.4, 129.6, 127.6, 123.8, 113.8, 83.3, 63.5, 58.2, 27.6 ppm.

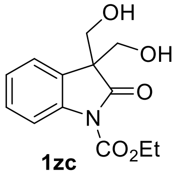
HRMS (ESI+) *m/z* calculated for $C_{15}H_{19}NO_5Na$ $[M+Na]^+$ 316.1161, found 316.1163.

7. Synthesis of compound 1zc:



Compound **XII** was prepared accordingly to literature procedure.[6] Ethyl 2-oxoindoline-1-carboxylate (**XII**) (250.0 mg, 1.20 mmol) was transformed to the desired prochiral diol **1zc** (178.0 mg, 56%) following **GP-I** (step-3).

Ethyl 3,3-bis(hydroxymethyl)-2-oxoindoline-1-carboxylate (1zc): White Solid, 56% yield.



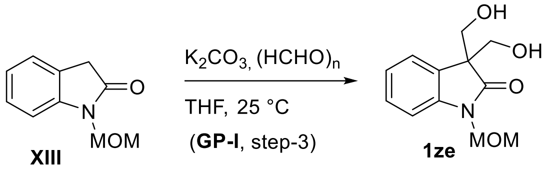
1zc

^{1}H NMR (400 MHz, DMSO-d$_6$) δ = 7.77 (d, *J* = 8.0 Hz, 1H), 7.45 (d, *J* = 7.2 Hz, 1H), 7.34 (t, *J* = 8.0 Hz, 1H), 7.22 (t, *J* = 7.2 Hz, 1H), 4.91 (t, *J* = 5.2 Hz, 2H), 4.39 (q, *J* = 6.8 Hz, 2H), 3.75-3.67 (m, 4H), 1.36 (t, *J* = 6.8 Hz, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 176.0, 150.3, 140.2, 129.8, 127.7, 124.1, 123.9, 113.9, 63.5, 62.7, 58.3, 14.0 ppm.

HRMS (ESI+) *m/z* calculated for $C_{13}H_{15}NO_5Na$ $[M+Na]^+$ 288.0848, found 288.0849.

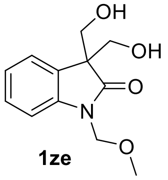
8. Synthesis of compound 1ze:



XIII 1ze

Compound **XIII** was prepared accordingly to literature procedure.[7] Using this MOM-protected oxindole **XIII** (262.0 mg, 1.47 mmol), the required prochiral diol **1ze** (220.0 mg, 63%) was synthesized following **GP-I** (step-3).

3,3-Bis(hydroxymethyl)-1-(methoxymethyl)indolin-2-one(1ze): White Solid, 63% yield.



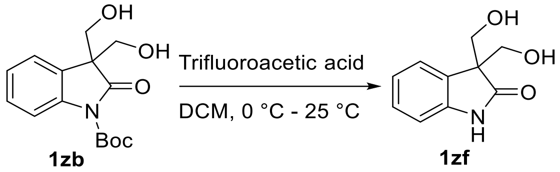
1ze

^{1}H NMR (400 MHz, DMSO-d$_6$) δ = 7.39 (d, *J* = 7.2 Hz, 1H), 7.26 (t, *J* = 7.6 Hz, 1H), 7.07 (t, *J* = 7.2 Hz, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 5.05 (s, 2H), 4.78 (t, *J* = 4.8 Hz, 2H), 3.77 (dd, *J* = 10.4, 4.8 Hz, 2H), 3.65 (dd, *J* = 10.4, 5.6 Hz, 2H), 3.17 (s, 3H) ppm.

^{13}C NMR (75 MHz, DMSO-d$_6$) δ = 177.9, 142.59 130.1, 127.4, 123.9, 122.0, 108.7, 70.1, 63.1, 57.9, 55.2 ppm.

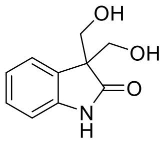
HRMS (ESI+) *m/z* calculated for $C_{12}H_{15}NO_4Na$ $[M+Na]^+$ 260.0899, found 260.0898.

9. Synthesis of compound 1zf:



To an oven dried 100 mL round bottom flask equipped with magnetic stir bar were added **1zb** (500.0 mg, 1.70 mmol, 1.0 equiv) and 17.0 mL of dichloromethane. The reaction mixture was cooled to 0 °C then TFA was added (3.0 mL) and stirred at 25 °C for 1 h. The reaction was quenched with ice water and extracted with EtOAc (three times). The combined organic phase was washed with brine and dried over Na_2SO_4. After removal of solvent, the residue was purified by column chromatography (SiO_2, EtOAc, R_f = 0.5) to furnish the desired product **1zf** (273.0 mg, 83%) as white solid

3,3-Bis(hydroxymethyl)indolin-2-one 1zf: White solid, 83% yield.



1zf

^{1}H NMR (300 MHz, DMSO-d_6) δ = 10.17 (s, 1H), 7.29 (d, *J* = 6.9 Hz, 1H), 7.17 (dt, *J* = 7.8, 1.5 Hz, 1H), 6.95-6.88 (m, 1H), 6.78 (d, *J* = 7.5 Hz, 1H), 4.68 (brs, 2H), 3.72 (d, *J* = 10.2 Hz, 2H), 3.58 (d, *J* = 10.2 Hz, 2H) ppm.

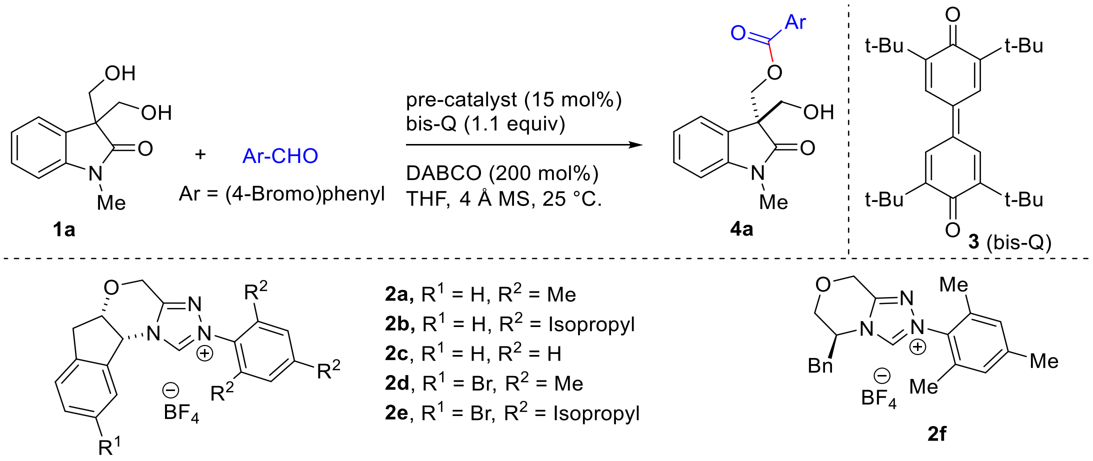
^{13}C NMR (75 MHz, DMSO-d_6) δ = 178.8, 143.1, 136.4, 131.2, 127.2, 124.1, 120.7, 108.6, 63.1, 57.4 ppm.

HRMS (ESI+) *m/z* calculated for $C_{10}H_{11}NO_3Na$ $[M+Na]^+$ 216.0637, found 216.0636

10. Reaction optimization:

We began our study towards the development of N-heterocyclic carbene (NHC) catalyzed asymmetric desymmetrization of 3,3’-bis(hydroxymethyl)oxindole using diol **1a** as model substrate. Following related literature[8, 9] and earlier work of our group,[10] at first, **1a** was allowed to react with commecially available 4-bromobenzaldehyde using different azolium salts **2a-f** as catalysts, DABCO as base and bis-Q **3** as oxidant in THF at 25 °C in the presence of 4 Å MS. The results are summaraized in Table 1. With catalyst **2a**, the reaction afforded mono-ester **4a** with 74% ee. This result proves the feasibility of developing an enantioselective desymmetrization of prochiral C3-quarternary oxindoles via NHC-catalyzed transfer acylation of primery alcohol using inexpensive aromatic aldehyde as the source of acylating agent. Inspired by the intial result,

Table 1: Screening of azolium salts

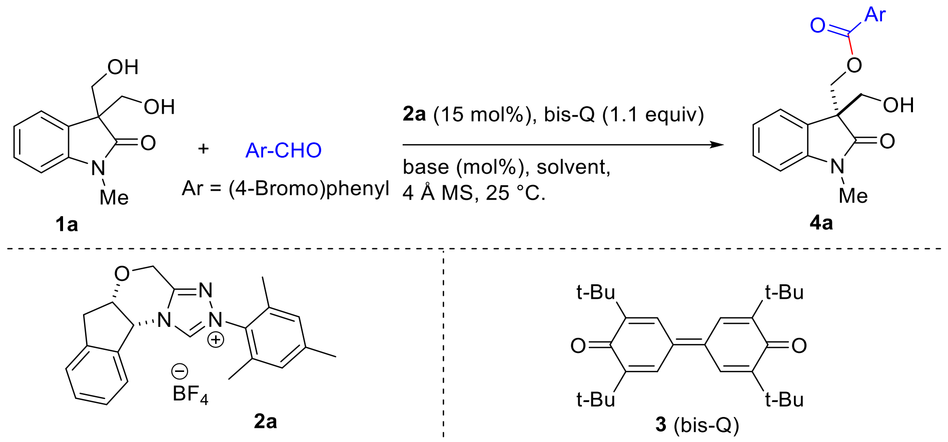


entry[a]	azolium salt	yield (%)	ee (%)
1	**2a**	86	74
2	**2b**	77	74
3	**2c**	90	72
4	**2d**	90	68
5	**2e**	95	67
6	**2f**	90	48

[a]Reaction conditions: **1a** (20.7 mg, 0.1 mmol), 4-bromobenzalaldehyde (18.5 mg, 0.1 mmol), **3** (45.0 mg, 0.11 mmol), **2a-f** (0.015 mmol, 15 mol%), DABCO (22.5 mg, 0.2 mmol) and activated 4 Å MS (35.0 mg) in THF (1.0 mL, 0.1 M) at 25 °C; enantiomeric excess (ee) determined by HPLC analysis on a chiral stationary phase.

we examined other structurally different azolium salts to improve enantioselectivity of the product. Among all the catalysts examined in this reaction, the azolium salts **2a** and **2b** were found to be the most selective. Further reaction optimization studies were then conducted with varying base as well as solvents with **2a**. Accordingly, the standard reaction was performed using different organic and inorganic bases, which indicates DABCO was the most superior base for the catalytic desymmetrization process. The solvent screening studies revealed that the reaction worked well with initially used THF delivering the desired product with 74% ee. At this stage, we decided to

Table 2: Screening of base and solvent

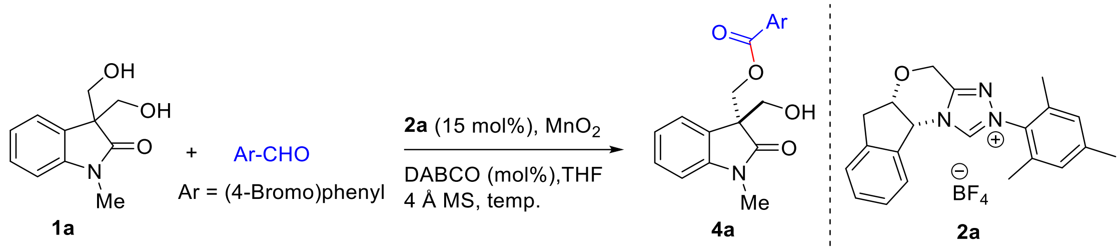


entry[a]	solvent	base	yield (%)	ee (%)
1	THF	DBU	90	36
2	THF	Cs_2CO_3	70	68
3	THF	DIPEA	90	73
4	THF	NaOAc	50	66
5	THF	K_2CO_3	50	66
6	Toluene	DABCO	90	72
7	DCM	DABCO	70	49
8	Chloroform	DABCO	60	47
9	MTBE	DABCO	50	69
10	Chlorobenzene	DABCO	40	67

[a] Reaction conditions: **1a** (20.7 mg, 0.1 mmol), 4-bromobenzalaldehyde (18.5 mg, 0.1 mmol), **3** (45.0 mg, 0.11 mmol), **2a** (6.2 mg, 0.015 mmol, 15 mol%), base (0.2 mmol) and activated 4 Å MS (35 mg) in solvent (1.0 mL, 0.1 M) at 25 °C; enantiomeric excess (ee) determined by HPLC analysis on a chiral stationary phase.

check the effect of oxidant in the reaction efficiency. It has been reported that, in some cases, replacing bis-Q oxidant with MnO_2 could be advantageous for the asymmetric transfer acylation of alcohol via oxidative NHC-catalysis.[11, 12] Accordingly, we performed the reaction using MnO_2 as oxidant, which gave **4a** with 87% ee at 25 °C. Further improvement in ee value of **4a** was noticed when the reaction was carrying out at 0 °C using reduced amount of DABCO. With the optimizing conditions including NHC-precursor **2a** (15 mol%), DABCO (0.5 equiv), MnO_2 (5.0 equiv), 4 Å MS in THF at 0 °C, the reaction afforded mono-ester **4a** in 75% isolated yield with 93% ee.

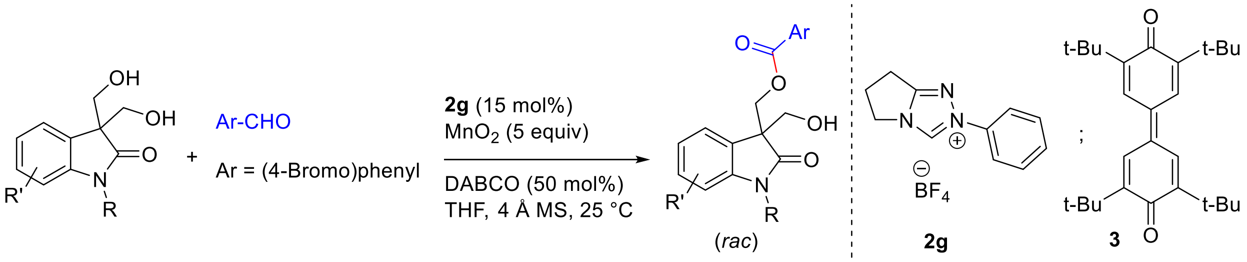
Table 3: Screening of oxidant, temperature and base equivalency



entry[a]	MnO_2 (equiv)	temp. (°C)	DABCO (mol%)	yield (%)	ee (%)
1	(5)	25	(200)	78	87
2	(5)	25	(100)	78	88
3[b]	(5)	25	(200)	70	84
4	(5)	25	(50)	81	90
5	(5)	25	(20)	40	90
9	(5)	10	(50)	79	91
7	(5)	0	(50)	82, 75[c]	93
6	(5)	0	(20)	50	93
8[b]	(5)	0	(50)	77	91
9	(5)	0	(100)	70	92
10	(10)	0	(50)	75	88
11	(2.5)	0	(50)	40	80

[a]Reaction conditions: **1a** (20.7 mg, 0.1 mmol), 4-bromobenzalaldehyde (18.5 mg, 0.1 mmol), MnO_2, **2a** (6.2 mg, 0.015 mmol, 15 mol%), DABCO and activated 4 Å MS (35 mg) in THF (1.0 mL, 0.1 M); enantiomeric excess (ee) determined by HPLC analysis on a chiral stationary phase; [b]reaction performed without molecular sieve; [c]isoalted yield.

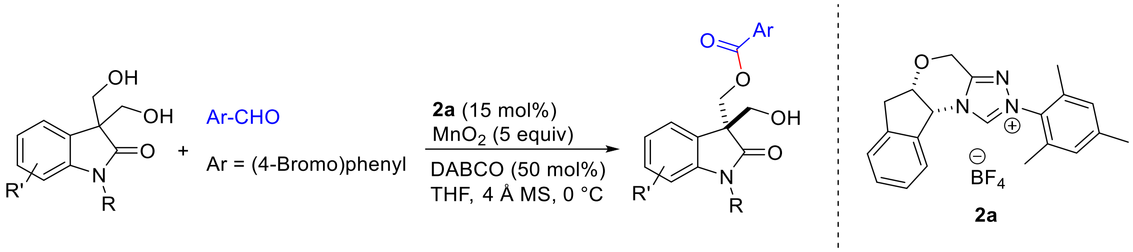
11. General procedure III (GP-III): Synthesis of racemates



To a flame dried 10 mL Schlenk tube equipped with a magnetic stir bar, carbene precursor **2g** (0.015 mmol, 15 mol%), activated 4 Å MS (35.0 mg), prochiral diol (0.1 mmol, 1.0 equiv), 4-bromobenzaldehyde (0.1 mmol, 1.0 equiv), manganese dioxide (0.5 mmol, 5.0 equiv) and dry THF (0.6 mL) were placed under argon. The resulting mixture was allowed to stir at 25 °C for 10 min. before a solution of DABCO (0.05 mmol, 50 mol%) in 0.4 mL THF was added dropwise under argon atmosphere. The reaction was continued for 12 h, at 25 °C. The progress of the reaction was monitored by TLC analysis. The reaction was quenched with 1.0 mL of water and extracted with EtOAc. The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The crude material was purified by preparative TLC.

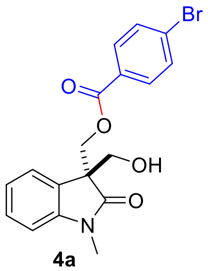
Racemic compounds (***rac*-4-21, *rac*-23-31, *rac*-33-35**) and (***rac*-22**, ***rac*-32**) were synthesized according to **GP-III** at 25 °C using MnO_2 as oxidant and at 0 °C using bis-Q (**3**) as oxidant respectively.

12. General procedure IV (GP-IV): NHC-catalyzed enantioselective desymmetrization of prochiral diols:



To a flame dried 10 mL Schlenk tube equipped with a magnetic stir bar, carbene precursor **2a** (0.015 mmol, 15 mol%), activated 4 Å MS (35.0 mg), prochiral diols (0.1 mmol, 1.0 equiv), 4-bromobenzaldehyde (0.1 mmol, 1.0 equiv), manganese dioxide (MnO_2) (0.5 mmol, 5.0 equiv) and dry THF (0.6 mL) were placed under argon atmosphere. The resulting mixture was allowed to stir at 25 °C for 10 min. The reaction mixture was then cooled to 0 °C and stirring was continued for another 10 min. To the cold mixture, a solution of 1,4-diazabicyclo[2.2.2]octane (DABCO) (0.05 mmol, 50 mol%) in 0.4 mL THF was added dropwise. The reaction was continued for 48 h, while maintaining the reaction temperature at 0 °C. The progress of the reaction was monitored by TLC analysis. After running the reaction to an appropriate time, the reaction was quenched with 1.0 mL of water and extracted with EtOAc. The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The crude material was purified by column chromatography to afford the desired compound.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (4a):



4a

Compound **4a** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **4a** (29.5 mg, 75%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.70 (d, *J* = 8.8 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.36-7.31 (m, 2H), 7.09 (dt, *J* =7.6, 0.8 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 4.84 (d, *J* = 10.8 Hz, 1H), 4.68 (d, *J* = 10.8 Hz, 1H), 4.07 (d, *J* = 11.2 Hz, 1H), 3.91 (d, *J* = 11.2 Hz, 1H), 3.27 (s, 3H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.8, 165.3, 144.1, 131.9, 131.1, 129.3, 128.6, 128.4, 127.6, 124.0, 123.2, 108.6, 65.1, 64.1, 53.8, 26.5 ppm.

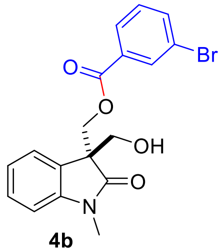
HRMS (ESI+) *m/z* calculated for $C_{18}H_{17}BrNO_4$ $[M+H]^+$ 390.0341, found 390.0342.

IR (Neat) ν_{max} = 3430, 2964, 2883, 1716, 1614, 1470, 1376, 1266, 1174, 1100, 1068, 1011, 753, 682 cm^{-1}.

$[\alpha]_D^{25}$ = +23.97 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 18.16 min, τ_{minor} = 25.14 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 3-bromobenzoate (4b):



4b

Compound **4b** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 3-bromobenzaldehyde (11.7 μL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **4b** (12.5 mg, 32%) as yellow gelly.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.90 (s, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.65 (d, *J* = 8.0 Hz, 1H), 7.35-7.31 (m, 2H), 7.28-7.24 (m, 1H), 7.10 (t, *J* = 7.6 Hz, 1H), 6.93 (d, *J* = 7.6 Hz, 1H), 4.85 (d, *J* = 10.8 Hz, 1H), 4.68 (d, *J* = 11.2 Hz, 1H), 4.08-4.03 (m, 1H), 3.92 (d, *J* = 10.8 Hz, 1H), 3.28 (s, 3H), 2.72 (d, *J* = 6.8 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.8, 164.7, 144.1, 136.1, 132.6, 131.6, 130.1, 129.3, 128.1, 127.6, 123.9, 123.2, 122.5, 108.6, 65.4, 64.0, 53.8, 26.5 ppm.

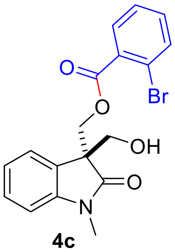
HRMS (ESI+) *m/z* calculated for $C_{18}H_{17}BrNO_4$ $[M+H]^+$ 390.0341, found 390.0340.

IR (Neat) ν_{max} = 3445, 3068, 2889, 1716, 1614, 1570, 1494, 1470, 1377, 1280, 1252, 1123, 1100, 1066, 1011, 745, 672 cm^{-1}.

$[\alpha]_D^{25}$ = +25.44 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 97) was determined by HPLC analysis using Daicel Chiralpak ID-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 10.31 min, τ_{minor} = 10.99 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 2-bromobenzoate (4c):



4c

Compound **4c** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 2-bromobenzaldehyde (11.7 µL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **4c** (13.5 mg, 35%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.58-7.53 (m, 2H), 7.36 (t, *J* = 8.0 Hz, 2H), 7.29-7.27 (m, 2H), 7.10 (t, *J* =7.6 Hz, 1H), 6.90 (d, *J* = 7.6 Hz, 1H), 4.92 (d, *J* = 11.2 Hz, 1H), 4.70 (d, *J* = 10.8 Hz, 1H), 4.06-4.01 (m, 1H), 3.91 (dd, *J* = 11.2, 2.8 Hz, 1H), 3.25 (s, 3H), 2.67 (dd, *J* = 9.2, 3.2 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.8, 165.8, 144.3, 134.4, 132.8, 131.8, 131.6, 129.2, 127.6, 127.2, 124.1, 123.1, 121.6, 108.6, 65.6, 64.4, 53.7, 26.5 ppm.

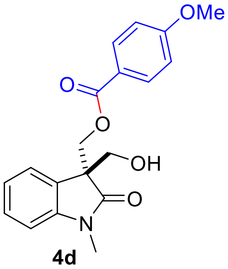
HRMS (ESI+) *m/z* calculated for $C_{18}H_{16}BrNO_4Na$ $[M+Na]^+$ 412.0160, found 412.0163.

IR (Neat) ν_{max} = 3427, 3058, 2938, 2879, 1713, 1614, 1494, 1470, 1377, 1289, 1248, 1103, 1028, 746 cm^{-1}.

$[\alpha]_D^{25}$ = +19.24 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 96) was determined by HPLC analysis using Daicel Chiralpak IC-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 60:40, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 20.09 min, τ_{minor} = 34.40 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-methoxybenzoate (4d):



4d

Compound **4d** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-anisaldehyde (12.2 µL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 40% EtOAc-PE, R_f = 0.4) to afford title compound **4d** (14.0 mg, 41%) as white solid.

^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.82 (d, *J* = 8.8 Hz, 2H), 7.35-7.30 (m, 2H), 7.08 (t, *J* = 7.6 Hz, 1H), 6.90-6.85 (m, 3H), 4.79 (d, *J* = 10.8 Hz, 1H), 4.62 (d, *J* = 10.8 Hz, 1H), 4.07 (d, *J* = 9.6 Hz, 1H), 3.92 (d, *J* = 11.2 Hz, 1H), 3.82 (s, 3H), 3.26 (s, 3H) 2.83 (brs 1H) ppm.

^{13}C NMR (75 MHz, CDCl$_3$) δ = 176.9, 165.8, 163.6, 144.1, 131.6, 129.1, 127.9, 124.0, 123.0, 122.1, 113.8, 108.5, 64.6, 64.1, 55.5, 53.9, 26.4 ppm.

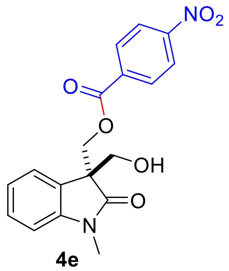
HRMS (ESI+) *m/z* calculated for $C_{19}H_{19}NO_5Na$ $[M+Na]^+$ 364.1161, found 364.1160.

IR (Neat) ν_{max} = 3446, 2925, 2854, 1713, 1606, 1511, 1494, 1469, 1376, 1350, 1257, 1168, 1100, 1063, 1026, 848, 753, 697 cm^{-1}.

$[\alpha]_D^{25}$ = +48.80 (c = 1.0, CHCl$_3$).

HPLC: The enantiomeric excess (% of ee = 89) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 17.88 min, τ_{minor} = 26.40 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-nitrobenzoate (4e): Compound **4e** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-nitrobenzaldehyde (15.1 mg, 0.1 mmol, 1.0 equiv), MnO$_2$ (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO$_2$, 30% acetone-PE, R$_f$ = 0.4) to afford title compound **4e** (17.0 mg, 48%) as yellow solid.



4e

^{1}H NMR (400 MHz, CDCl$_3$) δ = 8.24 (d, *J* = 9.2 Hz, 2H), 7.99 (d, *J* = 8.8 Hz, 2H), 7.37-7.32 (m, 2H), 7.11 (t, *J* =7.6 Hz, 1H), 6.93 (d, *J* = 7.6 Hz, 1H), 4.91 (d, *J* = 11.2 Hz, 1H), 4.76 (d, *J* = 11.2 Hz, 1H), 4.08 (d, *J* = 10.8 Hz, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.28 (s, 3H), 2.62 (brs, 1H) ppm.

^{13}C NMR (75 MHz, CDCl$_3$) δ = 176.7, 164.2, 150.7, 144.1, 135.1, 130.7, 129.5, 127.3, 123.9, 123.7, 123.2, 108.7, 65.7, 64.1, 53.7, 26.5 ppm.

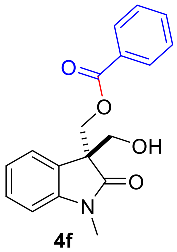
HRMS (ESI+) *m/z* calculated for $C_{18}H_{16}N_2O_6Na$ $[M+Na]^+$ 379.0906, found 379.0905.

IR (Neat) ν_{max} = 3436, 2922, 2857, 1716, 1613, 1526, 1472, 1349, 1271, 1102, 754,719 cm^{-1}.

$[\alpha]_D^{25}$ = +17.60 (c = 0.4, CHCl$_3$).

HPLC: The enantiomeric excess (% of ee = 87) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.64 min, τ_{minor} = 17.77 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl benzoate (4f): Compound **4f** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), benzaldehyde (10.2 µL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.3) to afford title compound **4f** (20.0 mg, 64%) as white gelly.



4f

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.86 (d, *J* = 7.2 Hz, 2H), 7.54 (d, *J* = 7.6 Hz, 1H), 7.40-7.30 (m, 4H), 7.09 (t, *J* =7.6 Hz, 1H), 6.91 (d, *J* = 7.6 Hz, 1H), 4.84 (d, *J* = 11.2 Hz, 1H), 4.65 (d, *J* = 10.8 Hz, 1H), 4.09-4.05 (m, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.26 (s, 3H), 2.82 (brs, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.8, 166.0, 144.1, 133.2, 129.7, 129.6, 129.2, 128.5, 127.8, 124.0, 123.1, 108.5, 64.9, 64.1, 53.8, 26.4 ppm.

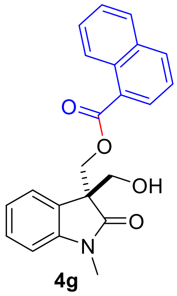
HRMS (ESI+) *m/z* calculated for $C_{18}H_{17}NO_4$ Na $[M+Na]^+$ 334.1055, found 334.1056.

IR (Neat) ν_{max} = 3424, 3061, 2938, 2879, 1715, 1613, 1493, 1470, 1451, 1269, 1376, 1350, 1269, 1176, 1096, 1068, 1025, 753, 687 cm^{-1}.

$[\alpha]_D^{25}$ = +58.04 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:0, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 10.67 min, τ_{minor} = 12.20 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 1-naphthoatenaphthoate (4g): Compound **4g** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 1-naphthaldehyde (13.6 µL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **4g** (18.0 mg, 50%) as white solid.



4g

^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.51-8.49 (m, 1H), 7.98 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 7.2 Hz, 1H), 7.84-7.82 (m, 1H), 7.49-7.47 (m, 2H), 7.44-7.33 (m, 3H), 7.11 (t, *J* = 7.6 Hz, 1H), 6.92 (t, *J* = 7.6 Hz, 1H), 4.98 (d, *J* = 11.2 Hz, 1H), 4.79 (d, *J* = 11.2 Hz, 1H), 4.10 (d, *J* = 10.4 Hz, 1H), 3.96 (d, *J* = 11.2 Hz, 1H), 3.25 (s, 3H), 2.79 (brs, 1H)ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 177.0, 167.2, 144.3, 133.8, 133.6, 131.2, 130.3, 129.2, 128.6, 127.88, 127.83, 126.8, 126.3, 125.7, 124.5, 124.1, 123.1, 108.6, 65.3, 64.3, 53.9, 26.5 ppm.

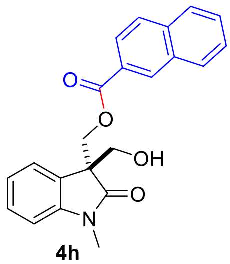
HRMS (ESI+) *m/z* calculated for $C_{22}H_{19}NO_4Na$ $[M+Na]^+$ 384.1212, found 384.1213.

IR (Neat) ν_{max} = 3423, 3064, 2932, 1710, 1614, 1510, 1494, 1470, 1377, 1348, 1240, 1194, 1105, 1066, 1013, 781, 753, 685 cm^{-1}.

$[\alpha]_D^{25}$ = +37.32 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 98) was determined by HPLC analysis using Daicel Chiralpak IC-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 24.19 min, τ_{minor} = 47.02 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 2-naphthoate (4h): Compound **4h** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), 2-naphthaldehyde (15.6 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.3) to afford title compound **4h** (25.5 mg, 71%) as white solid.



4h

^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.39 (s, 1H), 7.88-7.80 (m, 4H), 7.59-7.50 (m, 2H), 7.40 (d, *J* =7.6 Hz, 1H), 7.34 (t, *J* =7.6 Hz, 1H), 7.09 (t, *J* =7.2 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 4.91 (d, *J* = 11.2 Hz, 1H), 4.74 (d, *J* = 10.8 Hz, 1H), 4.15 (d, *J* = 11.6 Hz, 1H), 3.99 (d, *J* = 11.2 Hz, 1H), 3.29 (s, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.9, 166.2, 144.1, 135.6, 132.4, 131.2, 129.4, 129.2, 128.5, 128.3, 127.9, 127.8, 126.9, 126.8, 125.0, 124.1, 123.1, 108.5, 65.0, 64.0, 54.0, 26.5 ppm.

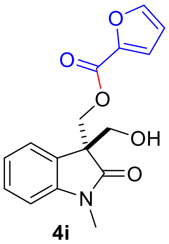
HRMS (ESI+) *m/z* calculated for $C_{22}H_{20}NO_4$ $[M+H]^+$ 362.1392, found 362.1391.

IR (Neat) ν_{max} = 3424, 3057, 2936, 1712, 1630, 1613, 1469, 1376, 1279, 1195, 1129, 1061, 1024, 867, 777, 752, cm^{-1}.

$[\alpha]_D^{25}$ = +43.0 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 96) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 17.10 min, τ_{minor} = 24.23 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl furan-2-carboxylate (4i):



4i

Compound **4i** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), furfural (8.3 μL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 50% EtOAc-PE, R_f = 0.5) to afford title compound **4i** (12.0 mg, 40%) as brown liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.55 (s, 1H), 7.38 (m, 2H), 7.09 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 3.6 Hz, 1H), 6.90 (d, *J* = 7.6 Hz, 1H), 6.47 (m, 1H), 4.85 (d, *J* = 11.2 Hz, 1H), 4.54 (d, *J* = 15.6 Hz, 1H), 4.07 (d, *J* = 10.8 Hz, 1H), 3.89 (d, *J* = 11.2 Hz, 1H), 3.25 (s, 3H), 2.74 (brs, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.6, 158.1, 146.7, 144.1, 144.0, 129.2, 127.6, 124.2, 123.1, 118.4, 111.9, 108.5, 64.5, 64.0, 53.6, 26.4 ppm.

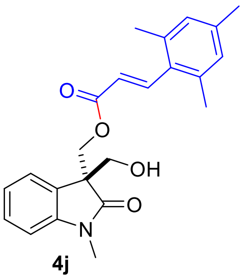
HRMS (ESI+) *m/z* calculated for $C_{16}H_{16}NO_5$ $[M+H]^+$ 302.1028, found 302.1027.

IR (Neat) ν_{max} = 3443, 2938, 1712, 1613, 1472, 1376, 1294, 1180, 1121, 1063, 1018, 884, 755 cm^{-1}.

$[\alpha]_D^{25}$ = +66.60 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IC-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 60:40, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 24.61 min, τ_{minor} = 42.38 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl (E)-3-mesitylacrylate (4j):



4j

Compound **4j** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), (*E*)-3-mesitylacrylaldehyde (17.4 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 40% EtOAc-PE, R_f = 0.4) to afford title compound **4j** (19.0 mg, 50%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, *J* = 16.4 Hz, 1H), 7.34-7.31 (m, 2H), 7.10 (t, *J* = 6.4 Hz, 1H), 6.89-6.86 (m, 3H), 5.94 (d, *J* = 16.4 Hz, 1H), 4.80 (d, *J* = 11.2 Hz, 1H), 4.54 (d, *J* = 11.2 Hz, 1H), 4.05 (d, *J* = 10.4 Hz, 1H), 3.88 (d, *J* = 11.2 Hz, 1H), 3.25 (s, 3H), 2.73 (brs, 1H), 2.27 (s, 3H), 2.25 (s, 6H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 177.0, 166.3, 144.1, 144.0, 138.6, 136.9, 130.7, 129.3, 129.1, 127.8, 124.1, 123.0, 122.3, 108.5, 64.3, 64.2, 53.8, 26.4, 21.1 ppm.

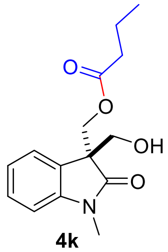
HRMS (ESI+) *m/z* calculated for $C_{23}H_{25}NO_4Na$ $[M+Na]^+$ 402.1681, found 402.1680.

IR (Neat) ν_{max} = 3445, 2922, 2883, 1708, 1612, 1494, 1469, 1376, 1257, 1165, 1122, 1061, 1019, 752 cm^{-1}.

$[\alpha]_D^{25}$ = +43.44 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 85) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 8.74 min, τ_{minor} = 10.42 min.

(*S*)-(3-(Tydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl butyrate (4k): Compound **4k** was prepared according to **GP-IV** combining **1a** (20.7 mg, 0.1 mmol, 1.0 equiv), **2a** (6.2 mg, 0.015 mmol, 15 mol%), n-butyraldehyde (9.0 μL, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 40% EtOAc-PE, R_f = 0.4) to afford title compound **4k** (8.0 mg, 29%) as yellow liquid.



4k

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.35-7.28 (m, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 6.89 (d, *J* = 8.0 Hz, 1H), 4.71 (d, *J* = 10.8 Hz, 1H), 4.37 (d, *J* = 11.2 Hz, 1H), 3.97 (d, *J* = 11.2 Hz, 1H), 3.82 (d, *J* = 11.2 Hz, 1H), 3.24 (s, 3H), 2.63 (brs, 1H), 2.18 (t, *J* = 7.2 Hz, 2H), 1.51 (p, *J* = 7.2 Hz, 2H), 0.81 (t, *J* = 7.2 Hz, 3H), ppm.

^{13}C NMR (150 MHz, $CDCl_3$) δ = 177.0, 173.1, 144.2, 129.1, 127.7, 124.0, 123.0, 108.5, 64.1, 64.0, 53.7, 36.0, 26.4, 18.3, 13.5 ppm.

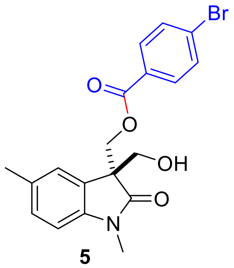
HRMS (ESI+) *m/z* calculated for $C_{15}H_{19}NO_4Na$ $[M+Na]^+$ 300.1212, found 300.1211.

IR (Neat) ν_{max} = 3450, 2964, 2879, 1714, 1614, 1494, 1469, 1377, 1255, 1176, 1063, 753 cm^{-1}.

[α]$_D$^{25} = +11.84 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 48) was determined by HPLC analysis using Daicel Chiralpak IC-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 60:40, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.82 min, τ_{minor} = 36.12 min.

(*S*)-(3-(Hydroxymethyl)-1,5-dimethyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (5):



5

Compound **5** was prepared according to **GP-IV** combining **1b** (22.1 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **5** (23.0 mg, 57%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.71 (d, *J* = 8.7 Hz, 2H), 7.54 (d, *J* = 8.7 Hz, 2H), 7.13 (d, *J* = 6.3 Hz, 2H), 6.80 (d, *J* = 8.1 Hz, 1H), 4.80 (d, *J* = 11.1 Hz, 1H), 4.69 (d, *J* = 11.1 Hz, 1H), 4.05 (d, *J* = 11.4 Hz, 1H), 3.90 (d, *J* = 11.1 Hz, 1H), 3.24 (s, 3H), 2.30 (s, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.7, 165.3, 141.7, 132.7, 131.9, 131.1, 129.5, 128.7, 128.4, 127.6, 124.7, 108.3, 65.2, 64.1, 53.7, 26.5, 21.2 ppm.

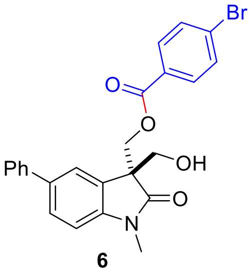
HRMS (ESI+) *m/z* calculated for $C_{19}H_{18}BrNO_4Na$ $[M+Na]^+$ 426.0317, found 426.0318.

IR (Neat) ν_{max} = 3397, 2922, 2857, 1712, 1678, 1605, 1589, 1499, 1457, 1364, 1267, 1150, 1102, 1053, 1011, 772, 758 cm^{-1}.

[α]$_D$^{25} = -20.89 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.89 min, τ_{minor} = 20.14 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxo-5-phenylindolin-3-yl)methyl 4-bromobenzoate (6):



6

Compound **6** was prepared according to **GP-IV** combining **1c** (28.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, $R_f = 0.4$) to afford title compound **6** (26.0 mg, 56%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.74 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 7.6 Hz, 2H), 7.53 (d, *J* = 8.8 Hz, 2H), 7.45 (d, *J* = 7.2 Hz, 2H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.33 (t, *J* = 7.2 Hz, 1H), 6.98 (d, *J* = 8.4 Hz, 1H), 4.89 (d, *J* = 11.2 Hz, 1H), 4.73 (d, *J* = 11.2 Hz, 1H), 4.11 (d, *J* = 11.2 Hz, 1H), 3.97 (d, *J* = 11.2 Hz, 1H), 3.30 (s, 3H), 2.73 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.8, 165.3, 143.4, 140.6, 136.6, 131.9, 131.1, 129.0, 128.6, 128.5, 128.2, 128.0, 127.3, 126.9, 123.1, 108.8, 64.9, 64.1, 54.0, 26.6 ppm.

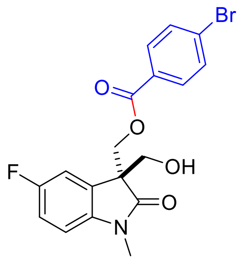
HRMS (ESI+) *m/z* calculated for $C_{24}H_{20}BrNO_4Na$ $[M+Na]^+$ 488.0473, found 488.0475.

IR (Neat) ν_{max} = 3426, 3032, 2942, 2876, 1714, 1618, 1590, 1485, 1360, 1265, 1173, 1100, 1068, 1011, 754 cm^{-1}.

$[\alpha]_D^{25}$ = -59.92 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.36 min, τ_{minor} = 22.06 min.

(*S*)-(5-Fluoro-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (7):



7

Compound **7** was prepared according to **GP-IV** combining **1d** (22.5 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, $R_f = 0.4$) to afford title compound **7** (24.5 mg, 60%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.70 (d, *J* = 8.1 Hz, 2H), 7.54 (d, *J* = 8.1 Hz, 2H), 7.11 (dd, *J* = 7.5, 2.4 Hz, 1H), 7.07 (dt, *J* = 9.0, 2.4 Hz, 1H), 6.84 (dd, *J* = 8.4, 3.9 Hz, 1H), 4.82 (d, *J* = 11.1 Hz, 1H), 4.66 (d, *J* = 11.1 Hz, 1H), 4.04 (d, *J* = 11.1 Hz, 1H), 3.94 (d, *J* = 11.4 Hz, 1H), 3.25 (s, 3H) ppm.

^{13}C NMR (150 MHz, $CDCl_3$) δ = 176.3, 165.3, 160.2 (d, $J_{C\text{-}F}$ = 241.5 Hz), 140.0, 131.9, 131.1, 129.4 (d, $J_{C\text{-}F}$ = 9.0 Hz), 128.6, 128.4, 115.5 (d, $J_{C\text{-}F}$ = 24.0 Hz), 112.5, (d, $J_{C\text{-}F}$ = 25.5 Hz), 109.1 (d, $J_{C\text{-}F}$ = 7.5 Hz), 64.9, 63.9, 54.3, 26.6 ppm.

^{19}F NMR (564 MHz, $CDCl_3$) δ = -119.42 ppm.

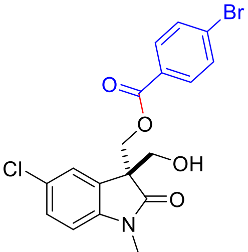
HRMS (ESI+) m/z calculated for $C_{18}H_{15}BrFNO_4Na$ $[M+Na]^+$ 430.0066, found 430.0064.

IR (Neat) ν_{max}= 3425, 3016, 2967, 2850, 1715, 1623, 1590, 1495, 1469, 1358, 1264, 1219, 1100, 1053, 1011, 771, 753 cm^{-1}.

$[\alpha]_D^{25}$ = +10.38 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20 flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.62 min, τ_{minor} = 20.16 min.

(*S*)-(5-Chloro-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (8):



8

Compound **8** was prepared according to **GP-IV** combining **1e** (24.1 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **8** (30.0 mg, 71%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.71 (d, *J* = 8.8 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.33-7.30 (m, 2H), 6.84 (d, *J* = 9.2 Hz, 1H), 4.79 (d, *J* = 10.8 Hz, 1H), 4.67 (d, *J* = 11.2 Hz, 1H), 4.03 (d, *J* = 11.2 Hz, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.25 (s, 3H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.2, 165.3, 142.7, 132.0, 131.7, 131.1, 129.5, 129.2, 128.6, 128.5, 124.7, 109.4, 64.9, 64.0, 54.2, 26.6 ppm.

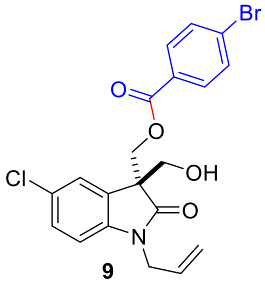
HRMS (ESI+) *m/z* calculated for $C_{18}H_{15}BrClNO_4Na$ $[M+Na]^+$ 445.9771, found 445.9770.

IR (Neat) ν_{max} = 3438, 2965, 2880, 1720, 1611, 1590, 1562, 1489, 1250, 1100, 1021, 775, cm^{-1}

$[\alpha]_D^{25}$ = -26.78 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.08 min, τ_{minor} = 21.20 min.

(*S*)-(1-Allyl-5-chloro-3-(hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (9):



9

Compound **9** was prepared according to **GP-IV** combining **1f** (26.7 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **9** (37.0 mg, 82%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.61 (d, *J* = 8.4 Hz, 2H), 7.46 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 1.6 Hz, 1H), 7.19 (s, 1H), 6.75 (d, *J* = 8.4 Hz, 1H), 5.78-5.68 (m, 1H), 5.16 (t, *J* = 15.6 Hz, 2H), 4.74 (d, *J* = 11.2 Hz, 1H), 4.62 (d, *J* = 11.2 Hz, 1H), 4.39 (dd, *J* = 16.4, 4.8 Hz, 1H), 4.25 (dd, *J* = 16.4, 5.2 Hz, 1H), 3.97 (d, *J* = 10.8 Hz, 1H), 3.88 (d, *J* = 10.8 Hz, 1H), 2.45 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 175.9, 165.3, 141.9, 131.9, 131.1, 130.7, 129.5, 129.1, 128.6, 128.5, 128.4, 124.7, 118.2, 110.3, 65.0, 64.2, 54.3, 42.6 ppm.

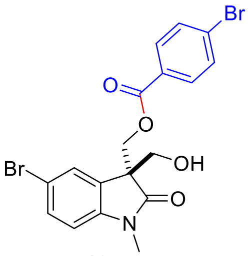
HRMS (ESI+) *m/z* calculated for $C_{20}H_{18}BrClNO_4$ $[M+H]^+$ 450.0108, found 450.0107.

IR (Neat) ν_{max} = 3434, 2964, 2879, 1719, 1610, 1590, 1484, 1265, 1101, 1011, 771 cm^{-1}.

$[\alpha]_D^{25}$ = -35.95 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 10.99 min, τ_{minor} = 15.14 min.

(*S*)-(5-Bromo-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (10):



10

Compound **10** was prepared according to **GP-IV** combining **1g** (28.6 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.28 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.60 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **10** (28.0 mg, 60%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.70 (d, *J* = 8.4 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.47 (dd, *J* = 4.0, 2.4 Hz, 2H), 6.79 (t, *J* = 4.4 Hz, 1H), 4.77 (d, *J* = 11.2 Hz, 1H), 4.65 (d, *J* = 10.8 Hz, 1H), 4.02 (d, *J* = 11.2 Hz, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.24 (s, 3H), 2.60 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.0, 165.3, 143.2, 132.1, 132.0, 131.1, 129.8, 128.6, 128.4, 127.4, 115.8, 109.9, 64.9, 63.9, 54.1, 26.6 ppm.

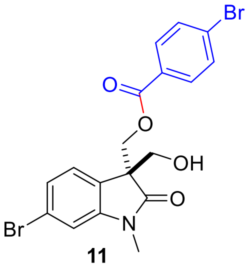
HRMS (ESI+) *m/z* calculated for $C_{18}H_{15}Br_2NO_4Na$ $[M+Na]^+$ 489.9265, found 489.9254.

IR (Neat) ν_{max} = 3434, 2967, 2873, 1718, 1608, 1590, 1487, 1362, 1265, 1174, 1116, 1100, 1068, 1011, 772 cm^{-1}.

$[\alpha]_D^{25}$ = -24.97 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 97) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.02 min, τ_{minor} = 22.64 min.

(*S*)-(6-Bromo-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (11):



11

Compound **11** was prepared according to **GP-IV** combining **1h** (28.6 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **11** (31.0 mg, 66%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.70 (d, *J* = 8.4 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.22-7.178 (m, 2H), 7.05 (s, 1H), 4.80 (d, *J* = 11.2 Hz, 1H), 4.65 (d, *J* = 11.2 Hz, 1H), 4.02 (d, *J* = 11.2 Hz, 1H), 3.91 (d, *J* = 11.2 Hz, 1H), 3.24 (s, 3H), 2.51 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.5, 165.3, 145.5, 132.0, 131.1, 128.6, 128.4, 126.6, 125.9, 125.3, 123.0, 112.1, 64.7, 64.0, 53.8, 26.6 ppm.

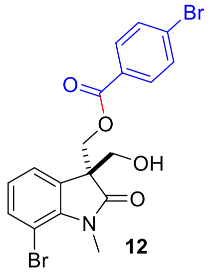
HRMS (ESI+) *m/z* calculated for $C_{18}H_{16}Br_2NO_4$ $[M+H]^+$ 467.9446, found 467.9446.

IR (Neat) ν_{max} = 3421, 2925, 2850, 1720, 1606, 1493, 1268, 1101, 1011, 772 cm^{-1}.

$[\alpha]_D^{25}$ = +7.19 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 91) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.95 min, τ_{minor} = 18.97 min.

(*S*)-(7-Bromo-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (12):



12

Compound **12** was prepared according to **GP-IV** combining **1i** (28.6 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), oxidant (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **12** (33.0 mg, 70%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.62 (d, *J* = 8.0 Hz, 2H), 7.48 (d, *J* = 8.4 Hz, 2H), 7.36 (d, *J* = 8.0 Hz, 1H), 7.19 (d, *J* = 6.0 Hz, 1H), 6.85 (t, *J* = 7.6 Hz, 1H), 4.71 (d, *J* = 10.8 Hz, 1H), 4.58 (d, *J* = 11.2 Hz, 1H), 3.95 (d, *J* = 10.8 Hz, 1H), 3.84 (d, *J* = 10.8 Hz, 1H), 3.56 (s, 3H), 2.58 (brs, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 177.2, 165.2, 141.4, 134.8, 131.9, 131.1, 130.8, 128.6, 128.4, 124.2, 122.9, 102.9, 65.1, 64.1, 53.6, 30.1 ppm.

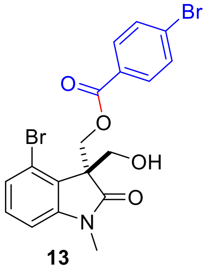
HRMS (ESI+) *m/z* calculated for $C_{18}H_{15}Br_2NO_4Na$ $[M+Na]^+$ 489.9265, found 489.9256.

IR (Neat) ν_{max} = 3442, 2957, 2876, 1719, 1605, 1590, 1460, 1337, 1266, 1101, 1011, 771 cm^{-1}.

$[\alpha]_D^{25}$ = +44.74 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 13.08 min, τ_{minor} = 16.48 min.

(*S*)-(4-Bromo-3-(hydroxymethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (13):



13

Compound **13** was prepared according to **GP-IV** combining **1j** (28.6 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **13** (23.0 mg, 49%) as white solid.

^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.49 (q, *J* = 15.6, 8.4 Hz, 4H), 7.20 (d, *J* = 4.8 Hz, 2H), 6.85 (t, *J* = 4.4 Hz, 1H), 5.17-5.13 (m, 1H), 4.78-4.74 (m, 1H), 4.33-4.30 (m, 1H), 4.22 (d, *J* = 11.2 Hz, 1H), 3.25 (s, 3H), 2.50 (brs, 1H) ppm.

^{13}C NMR (100 MHz, CDCl$_3$) δ = 176.9, 164.9, 146.7, 131.8, 130.9, 130.7, 128.5, 128.3, 127.2, 125.5, 119.2, 107.4, 63.3, 61.9, 56.7, 26.7 ppm.

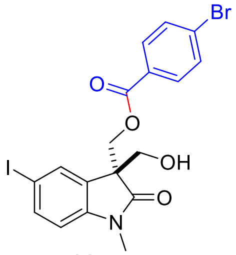
HRMS (ESI+) *m/z* calculated for $C_{18}H_{15}Br_2NO_4Na$ $[M+Na]^+$ 489.9265, found 489.9254.

IR (Neat) ν_{max} = 3444, 2928, 2883, 1720, 1606, 1456, 1340, 1267, 1219, 1174, 1102, 773 cm^{-1}.

$[\alpha]_D^{25}$ = -18.97 (c = 1.0, CHCl$_3$).

HPLC: The enantiomeric excess (% of ee = 24) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 18.22 min, τ_{minor} = 23.36 min.

(*S*)-(3-(Hydroxymethyl)-5-iodo-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (14):



14

Compound **14** was prepared according to **GP-IV** combining **1k** (33.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO$_2$ (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO$_2$, 20% acetone-PE, R_f = 0.4) to afford title compound **14** (33.0 mg, 64%) as white solid.

Compound **14,** was crystallized by the slow evaporation of its concentrated CHCl$_3$ solution. From the X-Ray crystal data, the absolute stereochemistry of **14** was unambiguously determined to be *S*.

^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.70 (d, *J* = 8.4 Hz, 2H), 7.66 (d, *J* = 9.2 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 6.69 (d, *J* = 8.0 Hz, 1H), 4.76 (d, *J* = 11.2 Hz, 1H), 4.63 (d, *J* = 11.2 Hz, 1H), 4.01 (d, *J* = 11.2 Hz, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.23 (s, 3H), 2.63 (brs, 1H) ppm.

^{13}C NMR (100 MHz, CDCl$_3$) δ = 175.9, 165.3, 143.9, 138.0, 133.0, 131.9, 131.1, 130.2, 128.6, 128.4, 110.5, 85.6, 64.9, 63.9, 54.0, 26.5 ppm.

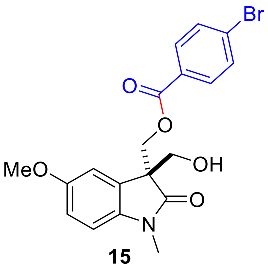
HRMS (ESI+) *m/z* calculated for $C_{18}H_{15}BrINO_4Na$ $[M+Na]^+$ 537.9127, found 537.9129.

IR (Neat) ν_{max} = 3426, 2957, 2879, 1715, 1604, 1590, 1464, 1360, 1265, 1174, 1100, 1067, 1011 771 cm^{-1}.

[α]$_{D}$^{25} = -55.93 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 97) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.02 min, τ_{minor} = 22.64 min.

(*S*)-(3-(Hydroxymethyl)-5-methoxy-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (15): Compound **15** was prepared according to **GP-IV** combining **1l** (23.7 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **15** (22.0 mg, 52%) as white solid.



15

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.72 (d, *J* = 8.7 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 6.93(d, *J* = 2.4 Hz, 1H), 6.86-6.79 (m, 2), 4.82 (d, *J* = 11.1 Hz, 1H), 4.68 (d, *J* = 10.8 Hz, 1H), 4.05 (d, *J* = 11.1 Hz, 1H), 3.9 (d, *J* = 11.1 Hz, 1H), 3.74 (s, 3H), 3.24 (s, 3H) ppm.

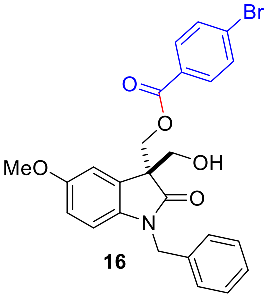
^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.4, 165.3, 156.3, 137.5, 131.9, 131.1, 128.9, 128.6, 128.4, 113.3, 111.6, 108.9, 65.1, 64.1, 55.9, 54.0, 26.6 ppm.

HRMS (ESI+) *m/z* calculated for $C_{19}H_{18}BrNO_5Na$ $[M+Na]^+$ 422.0266, found 422.0268.

IR (Neat) ν_{max} = 3434, 2925, 2850, 1718, 1589, 1498, 1268, 772 cm^{-1}.

[α]$_{D}$^{25} = +3.99 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 17.22 min, τ_{minor} = 25.78 min.



16

(*S*)-(1-Benzyl-3-(hydroxymethyl)-5-methoxy-2-oxoindolin-3-yl)methyl 4-bromobenzoate (16): Compound **16** was prepared according to **GP-IV** combining **1m** (31.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO$_2$ (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO$_2$, 30% acetone-PE, R$_f$ = 0.4) to afford title compound **16** (27.5 mg, 55%) as white solid.

^{1}H NMR (400 MHz, CDCl$_3$) δ = 7.60 (d, *J* = 8.4 Hz, 2H), 7.46 (d, *J* = 8.4 Hz, 2H), 7.27 (brs, 5H), 6.93 (s, 1H), 6.73 (q, *J* = 14.8, 8.0 Hz, 2H), 5.08 (d, *J* = 15.2 Hz, 1H), 4.88 (d, *J* = 10.8 Hz, 1H), 4.81 (t, *J*= 16.4 Hz, 1H), 4.77 (d, *J* = 11.6 Hz, 1H), 4.08 (d, *J* = 10.8 Hz, 1H), 3.96 (d, *J* = 10.8 Hz, 1H), 3.71 (s, 3H) ppm.

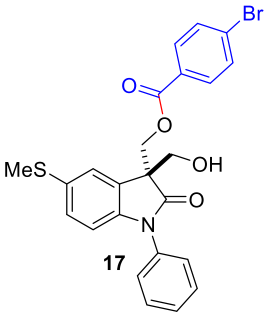
^{13}C NMR (100 MHz, CDCl$_3$) δ = 176.6, 165.3, 156.3, 136.6, 135.6, 131.8, 131.1, 128.9, 128.6, 128.3, 127.9, 127.4, 113.3, 111.5, 110.0, 65.3, 64.5, 55.8, 54.3, 44.1 ppm.

HRMS (ESI+) *m/z* calculated for $C_{25}H_{23}BrNO_5$ [M+H]$^+$ 496.0760, found 496.0761.

IR (Neat) ν_{max} = 3444, 2958, 2841, 1710, 1590, 1494, 1455, 1267, 1101, 1069, 1012, 755, cm^{-1}.

$[\alpha]_D^{25}$ = -11.98 (c = 1.0, CHCl$_3$).

HPLC: The enantiomeric excess (% of ee = 93.5) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.34 min, τ_{minor} = 23.84 min.



17

(*S*)-(3-(Hydroxymethyl)-5-(methylthio)-2-oxo-1-phenylindolin-3-yl)methyl 4-bromobenzoate (17): Compound **17** was prepared according to **GP-IV** combining **1n** (31.5 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO$_2$ (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO$_2$, 20% acetone-PE, R$_f$ = 0.4) to afford title compound **17** (25.0 mg, 50%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.74 (d, *J* = 8.7 Hz, 2H), 7.56 (t, *J* = 7.5 Hz, 4H), 7.46 (d, *J* = 7.2 Hz, 1H), 7.39-7.35 (m, 3H), 7.21 (dd, *J* = 8.1, 1.5 Hz, 1H), 6.83 (d, *J* = 8.1 Hz, 1H), 4.90 (d, *J* = 11.1 Hz, 1H), 4.80 (d, *J* = 11.1 Hz, 1H), 4.14 (d, *J* = 11.1 Hz, 1H), 4.05 (d, *J* = 11.1 Hz, 1H), 2.72 (s, 1H), 2.42 (s, 3H) ppm.

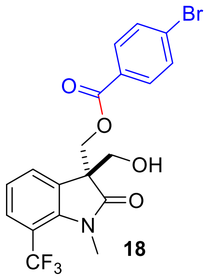
^{13}C NMR (75 MHz, $CDCl_3$) δ = 175.9, 165.3, 142.2, 133.9, 133.0, 131.9, 131.1, 129.9, 128.8, 128.6, 128.5, 128.4, 126.4, 124.2, 110.3, 65.4, 64.3, 54.2, 17.5 ppm.

HRMS (ESI+) *m/z* calculated for $C_{24}H_{20}BrNO_4SNa$ $[M+Na]^+$ 520.0194, found 520.0196.

IR (Neat) ν_{max} = 3445, 2961, 2920, 2863, 1719, 1590, 1501, 1476, 1424, 1357, 1263, 1099, 1068, 1011, 770, 753 cm^{-1}.

$[\alpha]_D^{25}$ = -15.98 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 94) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 17.14 min, τ_{minor} = 31.55 min.



18

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxo-7-(trifluoromethyl)indolin-3-yl)methyl 4-bromobenzoate (18): Compound **18** was prepared according to **GP-IV** combining **1o** (27.5 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **18** (27.5 mg, 60%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (dd, *J* = 8.4, 2.0 Hz, 3H), 7.53-7.50 (m, 3H), 7.17 (t, *J* = 8.0 Hz, 1H), 4.81 (d, *J* = 11.2 Hz, 1H), 4.68 (d, *J* = 10.8 Hz, 1H), 4.05 (d, *J* = 11.2 Hz, 1H), 3.96 (d, *J* = 11.2 Hz, 1H), 3.47 (s, 3H), 2.62 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 177.6, 165.2, 142.1, 131.9, 131.0, 130.4, 128.6, 128.3, 127.6 (q, J_{C-F} = 270.0 Hz), 127.3, 127.2 (q, J_{C-F} = 5.0 Hz), 124.9, 122.5, 122.2, 113.6 (q, J_{C-F} = 33.0 Hz), 65.3, 64.0, 52.5, 29.2 (q, J_{C-F} = 6.0 Hz) ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ = -53.28 ppm.

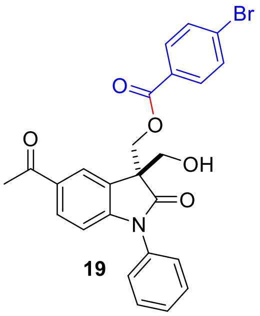
HRMS (ESI+) *m/z* calculated for $C_{19}H_{15}BrF_3NO_4Na$ $[M+Na]^+$ 480.0034, found 480.0032.

IR (Neat) ν_{max} = 3445, 2961, 2879, 1722, 1597, 1461, 1341, 1263, 1174, 1116, 1101, 1066, 770, 749 cm^{-1}.

[α]$_D$^{25} = +7.99 (c = 0.5, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 8.08 min, τ_{minor} = 9.46 min.

(*S*)-(5-Acetyl-3-(hydroxymethyl)-2-oxo-1-phenylindolin-3-yl)methyl 4-bromobenzoate (19):



19

Compound **19** was prepared according to **GP-IV** combining **1p** (31.1 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **19** (26.0 mg, 53%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 8.06 (d, *J* = 1.8 Hz, 1H), 7.91 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 2H), 7.58-7.44 (m, 5H), 7.39 (d, *J* = 7.5 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 1H), 4.91 (d, *J* = 11.1 Hz, 1H), 4.79 (d, *J* = 11.1 Hz, 1H), 4.18 (d, *J* = 10.8 Hz, 1H), 4.11 (d, *J* = 10.8 Hz, 1H), 2.54 (s, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 196.6, 176.5, 165.2, 148.4, 133.6, 132.9, 131.9, 131.1, 130.8, 130.0, 129.0, 128.6, 128.3, 128.0, 126.5, 124.3, 109.3, 65.3, 64.2, 54.3, 26.5 ppm

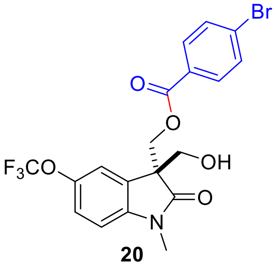
HRMS (ESI+) *m/z* calculated for $C_{25}H_{20}BrNO_5Na$ $[M+Na]^+$ 516.0422, found 516.0423.

IR (Neat) ν_{max} = 3444, 2926, 2857, 1724, 1674, 1610, 1591, 1502, 1448, 1398, 1333, 1262, 1218, 1100, 1053, 1012, 770, 753 cm^{-1}.

[α]$_D$^{25} = -36.75 (c = 0.5, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 60:40, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 10.28 min, τ_{minor} = 22.60 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxo-5-(trifluoromethoxy)indolin-3-yl)methyl 4-bromobenzoate (20): Compound **20** was prepared according to **GP-IV** combining **1q** (29.1 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **20** (26.0 mg, 55%) as white solid.



20

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.70 (d, *J* = 8.4 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.24 (s, 1H), 7.22 (d, *J* = 8.4 Hz, 1H), 6.89 (d, *J* = 8.4 Hz, 1H), 4.84 (d, *J* = 11.2 Hz, 1H), 4.64 (d, *J* = 11.2 Hz, 1H), 4.04 (d, *J* = 11.2 Hz, 1H), 3.95 (d, *J* = 11.2 Hz, 1H), 3.26 (s, 3H), 2.65 (brs, 3H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.4, 165.3, 145.0, 142.7, 131.9, 131.0, 129.2, 128.6, 128.4, 124.4 (q, $J_{C\text{-}F}$ = 256.0 Hz), 122.3, 118.3, 108.9, 64.7, 63.9, 54.3, 26.7 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ = -58.32 ppm.

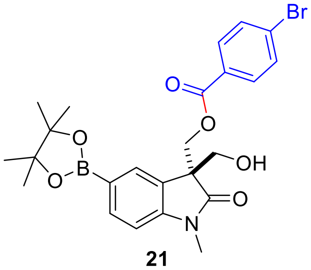
HRMS (ESI+) *m/z* calculated for $C_{19}H_{15}BrF_3NO_5Na$ $[M+Na]^+$ 495.9984, found 495.9986.

IR (Neat) ν_{max} = 3444, 2949, 2886, 1719, 1621, 1591, 1495, 1469, 1398, 1254, 1217, 1164, 1100, 1069, 1012, 772, 754 cm^{-1}.

$[\alpha]_D^{25}$ = +15.98 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 7.35 min, τ_{minor} = 9.23 min.

(*S*)-(3-(Hydroxymethyl)-1-methyl-2-oxo-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)indolin-3-yl)methyl 4-bromobenzoate (21): Compound **21** was prepared according to **GP-IV** combining **1r** (33.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **21** (21.0 mg, 40%) as white solid.



21

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.83 (dd, *J* = 7.8, 0.6 Hz, 1H), 7.74 (s, 1H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.53 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 7.8 Hz, 1H), 4.77 (d, *J* = 11.1 Hz, 1H), 4.69 (d, *J* = 10.8 Hz, 1H), 4.10 (d, *J* = 11.4 Hz, 1H), 3.93 (d, *J* = 11.4 Hz, 1H), 3.27 (s, 3H), 1.32 (s, 6H), 1.31 (s, 6H) ppm.

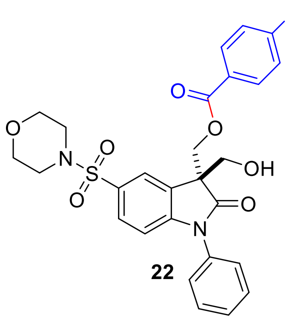
^{13}C NMR (150 MHz, $CDCl_3$) δ = 177.1, 165.3, 146.9, 136.6, 131.8, 131.2, 129.9, 128.7, 128.3, 126.9, 108.0, 84.0, 65.1, 64.0, 53.6, 26.5, 25.0, 24.9 ppm.

HRMS (ESI+) *m/z* calculated for $C_{24}H_{27}BBrNO_6Na$ $[M+Na]^+$ 538.1017, found 538.1018.

IR (Neat) ν_{max} = 3445, 2978, 2931, 2876, 1716, 1612, 1591, 1483, 1446, 1350, 1314, 1262, 1142, 1099, 1085, 1011, 751 cm^{-1}.

$[\alpha]_D^{25}$ = -34.35 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 95) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 9.84 min, τ_{minor} = 11.68 min.



22

(*S*)-(3-(Hydroxymethyl)-5-(morpholinosulfonyl)-2-oxo-1-phenylindolin-3-yl)methyl 4-bromobenzoate (22): Compound **22** was prepared according to **GP-IV** combining **1s** (41.8 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **22** (31.5 mg, 52%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.81 (d, *J* = 1.8 Hz, 1H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.65 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.60-7.48 (m, 5H), 7.37 (d, *J* = 7.5 Hz, 2H), 6.93 (d, *J* = 8.1 Hz, 1H), 5.10 (d, *J* = 11.1 Hz, 1H), 4.75 (d, *J* = 11.1 Hz, 1H), 4.13 (s, 2H), 3.69 (t, *J* = 4.5 Hz, 4H), 2.96-2.89 (m, 2H), 2.87-2.80 (m, 2H) ppm.

^{13}C NMR (150 MHz, $CDCl_3$) δ = 176.0, 165.0, 148.4, 133.3, 132.1, 131.1, 130.2, 130.0, 129.8, 129.2, 128.9, 128.4, 128.0, 126.5, 124.4, 109.6, 66.1, 64.8, 64.0, 54.8, 46.0 ppm.

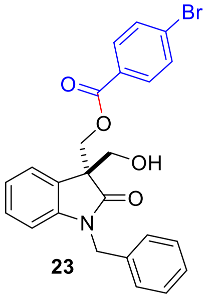
HRMS (ESI+) *m/z* calculated for $C_{27}H_{26}BrN_2O_7S$ $[M+H]^+$ 601.0644, found 601.0647.

IR (Neat) ν_{max} = 3474, 3022, 2964, 2857, 1723, 1608, 1590, 1477, 1364, 1325, 1159, 1112, 1091, 1069, 752, 731 cm^{-1}.

$[\alpha]_D^{25}$ = +7.99 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 11.50 min, τ_{minor} = 15.00 min.

(*S*)-(1-Benzyl-3-(hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (23):



23

Compound **23** was prepared according to **GP-IV** combining **1t** (28.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **23** (22.5 mg, 48%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.58 (d, *J* = 8.4 Hz, 2H), 7.45 (d, *J* = 8.4 Hz, 2H), 7.33-7.29 (m, 4H), 7.23-7.19 (m, 3H), 7.05 (t, *J* = 7.6 Hz, 1H), 6.81 (d, *J* = 8.0 Hz, 1H), 5.11 (d, *J* = 15.6 Hz, 1H), 4.92 (d, *J* = 10.8 Hz, 1H), 4.84 (d, *J* = 15.6 Hz, 1H), 4.78 (d, *J* = 10.8 Hz, 1H), 4.09 (d, *J* = 8.4 Hz, 1H), 3.97 (d, *J* = 11.2 Hz, 1H), 2.60 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 177.0, 165.4, 143.4, 135.6, 131.8, 131.1, 129.2, 129.0, 128.6, 128.3, 127.9, 127.6, 127.4, 123.9, 123.1, 109.6, 65.3, 64.5, 54.1, 44.0 ppm.

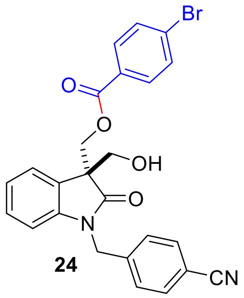
HRMS (ESI+) *m/z* calculated for $C_{24}H_{20}BrNO_4Na$ $[M+Na]^+$488.0473, found 488.0474.

IR (Neat) ν_{max} = 3440, 2928, 2863, 1716, 1612, 1488, 1466, 1364, 1269, 1101, 1059, 1013, 772 cm^{-1}.

$[\alpha]_D^{25}$ = +7.99 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90.5) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 18.32 min, τ_{minor} = 26.47 min.

(*S*)-(1-(4-Cyanobenzyl)-3-(hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (24):



24

Compound **24** was prepared according to **GP-IV** combining **1u** (30.8 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **24** (24.5 mg, 50%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.61 (d, *J* = 8.4 Hz, 2H), 7.53 (dd, *J* = 11.2, 8.4 Hz, 4H), 7.39 (t, *J* = 7.2 Hz, 3H), 7.24 (d, *J* = 7.6 Hz, 1H), 7.11 (t, *J* = 7.6 Hz, 1H), 6.70 (d, *J* = 8.0 Hz, 1H), 5.05 (d, *J* = 16.0 Hz, 1H), 4.98 (d, *J* = 16.0 Hz, 1H), 4.85 (d, *J* = 10.8 Hz, 1H), 4.75 (d, *J* = 11.2 Hz, 1H), 4.13 (d, *J* = 10.8 Hz, 1H), 4.02 (d, *J* = 10.8 Hz, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.9, 165.3, 142.8, 140.9, 132.8, 131.9, 131.0, 129.3, 128.6, 128.4, 127.9, 127.6, 124.2, 123.5, 118.4, 112.0, 109.1, 65.1, 64.5, 54.3, 43.6 ppm.

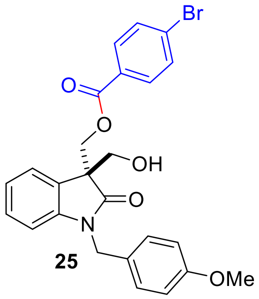
HRMS (ESI+) *m/z* calculated for $C_{25}H_{19}BrN_2O_4Na$ $[M+Na]^+$ 513.0426, found 513.0428.

IR (Neat) ν_{max} = 3459, 2964, 2870, 2229, 1716, 1612, 1590, 1488, 1466, 1267, 1219, 1174, 1068, 1011, 771, 754 cm^{-1}.

$[\alpha]_D^{25}$ = +26.36 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 96) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 27.74 min, τ_{minor} = 36.75 min.

(*S*)-(3-(Hydroxymethyl)-1-(4-methoxybenzyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (25): Compound **25** was prepared according to **GP-IV** combining **1v** (31.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **25** (32.5 mg, 65%) as white solid.



25

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.51 (d, *J* = 8.7 Hz, 2H), 7.43 (d, *J* = 8.7 Hz, 2H), 7.32 (d, *J* = 7.2 Hz, 1H),7.25 (t, *J* = 8.4 Hz, 3H), 7.05 (t, *J* = 6.9 Hz, 1H), 6.85 (d, *J* = 7.8 Hz, 1H), 6.76 (d, *J* = 8.7 Hz, 2H), 5.08 (d, *J* = 15.3 Hz, 1H), 4.90 (d, *J* = 10.8 Hz, 1H), 4.78 (d, *J* = 10.8 Hz, 1H), 4.73 (d, *J* = 15.3 Hz, 1H), 4.08 (d, *J* = 11.4 Hz, 1H), 3.95 (d, *J* = 11.1 Hz, 1H), 3.75 (s, 3H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 177.0, 165.3, 159.3, 143.4, 131.8, 131.1, 129.1, 128.9, 128.5, 128.2, 127.6, 127.6, 123.8, 123.0, 114.3, 109.5, 65.4, 64.5, 55.3, 54.0, 43.5 ppm.

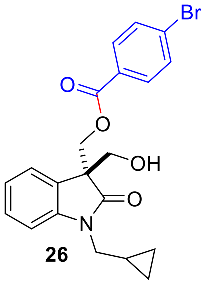
HRMS (ESI+) *m/z* calculated for $C_{25}H_{23}BrNO_5$ $[M+H]^+$ 496.0760, found 496.0761.

IR (Neat) ν_{max} = 3457, 3055, 2837, 1716, 1612, 1590, 1514, 1488, 1466, 1269, 1176, 1102, 1011, 771, 754cm^{-1}.

$[\alpha]_D^{25}$ = +19.97 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 21.77 min, τ_{minor} = 30.59 min.

(*S*)-(1-(Cyclopropylmethyl)-3-(hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (26): Compound **26** was prepared according to **GP-IV** combining **1w** (24.7 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **26** (26.0 mg, 61%) as white solid.



26

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, *J* = 8.4 Hz, 2H), 7.50 (d, *J* = 8.4 Hz, 2H), 7.33 (dd, *J* = 6.8, 4.8 Hz, 2H), 7.08 (t, *J* = 7.2 Hz, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 4.87 (d, *J* = 11.2 Hz, 1H), 4.71 (d, *J* = 10.8 Hz, 1H), 4.04 (d, *J* = 11.2 Hz, 1H), 3.90 (d, *J* = 11.2 Hz, 1H), 3.72 (dd, *J* = 14.8, 7.2 Hz, 1H), 3.62 (dd, *J* = 14.4, 6.4 Hz, 1H), 2.67 (brs, 1H), 1.22 (ddd, *J* = 12.0, 7.2, 4.8 Hz, 1H), 0.55-0.45 (m, 2H), 0.42-0.40 (m, 2H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ= 176.9, 165.3, 143.8, 131.8, 131.1, 129.2, 128.7, 128.3, 127.7, 124.0, 122.9, 109.0, 65.3, 64.3, 53.7, 44.5, 9.8, 4.0, 3.9 ppm.

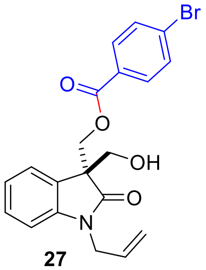
HRMS (ESI+) *m/z* calculated for $C_{21}H_{20}BrNO_4Na$ $[M+Na]^+$ 452.0473, found 452.0475.

IR (Neat) ν_{max} = 3425, 2932, 2873, 1705, 1611, 1590, 1487, 1466, 1265, 1100, 1068, 1011, 771, 751 cm^{-1}.

[α]$_D$^{25} = +31.96 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.90 min, τ_{minor} = 18.98 min.

(*S*)-(1-Allyl-3-(hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (27):



27

Compound **27** was prepared according to **GP-IV** combining **1x** (23.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **27** (21.0 mg, 51%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.68 (d, *J* = 8.4 Hz, 2H), 7.52 (d, *J* = 8.4 Hz, 2H), 7.34-7.26 (m, 2H), 7.09 (t, *J* = 7.2 Hz, 1H), 6.90 (d, *J* = 7.8 Hz, 1H), 5.90-5.77 (m, 1H), 5.26-5.19 (m, 2H), 4.87 (d, *J* = 10.8 Hz, 1H), 4.71 (d, *J* = 11.1 Hz, 1H), 4.49 (dd, *J* = 16.5, 5.1 Hz, 1H), 4.35 (dd, *J* = 16.2, 5.1 Hz, 1H), 4.08 (d, *J* = 11.4 Hz, 1H), 3.93 (d, *J* = 11.1 Hz, 1H) 2.62 (brs, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ= 176.6, 165.3, 143.3, 131.8, 131.1, 131.0, 129.2, 128.6, 128.4, 127.6, 123.9, 123.1, 118.0, 109.5, 65.2, 64.3, 53.9, 42.4 ppm.

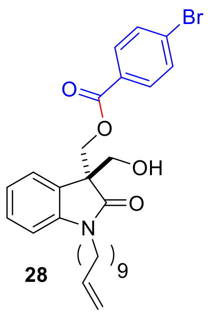
HRMS (ESI+) *m/z* calculated for $C_{20}H_{19}BrNO_4Na$ $[M+Na]^+$ 416.0497, found 416.0498.

IR (Neat) ν_{max} = 3443, 3087, 3058, 2964, 2876, 1711, 1645, 1612, 1590, 1487, 1466, 1398, 1361, 1263, 1099, 1068, 1011, 751 cm^{-1}.

[α]$_D$^{25} = +15.98 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 94) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 12.82 min, τ_{minor} = 15.44 min.

(*S*)-(3-(Hydroxymethyl)-2-oxo-1-(undec-10-en-1-yl)indolin-3-yl)methyl 4-bromobenzoate (28):



28

Compound **28** was prepared according to **GP-IV** combining **1y** (34.5 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 15% acetone-PE, R_f = 0.5) to afford title compound **28** (34.5 mg, 65%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.67 (d, *J* = 8.4 Hz, 2H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.33-7.29 (m, 2H), 7.08 (t, *J* = 7.2 Hz, 1H), 6.91 (d, *J* = 8.4 Hz, 1H), 5.87-5.73 (m, 1H), 5.02-4.90 (m, 2H), 4.85 (d, *J* = 10.8 Hz, 1H), 4.71 (d, *J* = 11.1 Hz, 1H), 4.06 (t, *J* = 10.8 Hz, 1H), 3.89 (d, *J* = 12.0 Hz, 1H), 3.82-3.75 (m, 1H), 3.71-3.62 (m, 1H), 2.71 (s, 1H), 2.06 (dd, J = 14.1, 6.6 Hz, 2H), 1.72-1.62 (m, 2H), 1.35-1.24 (m, 12H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ= 176.8, 165.3, 143.6, 139.3, 131.8, 131.1, 129.2, 128.6, 128.4, 127.8, 124.0, 122.9, 114.2, 108.8, 65.3, 64.3, 53.7, 40.3, 33.9, 29.5, 29.4, 29.2, 29.0, 27.6, 27.0 ppm.

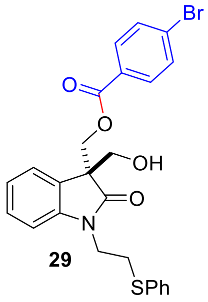
HRMS (ESI+) *m/z* calculated for $C_{28}H_{35}BrNO_4$ $[M+Na]^+$ 528.1749, found 527.1748.

IR (Neat) ν_{max} = 3444, 2925, 2854, 1715, 1612, 1590, 1488, 1397, 1365, 1265, 1100, 1068, 1012, 772, 753 cm^{-1}.

$[\alpha]_D^{25}$ = +56.73 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 94) was determined by HPLC analysis using Daicel Chiralpak IC-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.65 min, τ_{minor} = 24.99 min.

(*S*)-(3-(Hydroxymethyl)-2-oxo-1-(2-(phenylthio)ethyl)indolin-3-yl)methyl 4-bromobenzoate (29):



29

Compound **29** was prepared according to **GP-IV** combining **1z** (32.9 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **29** (36.0 mg, 70%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, *J* = 8.0 Hz, 2H), 7.49 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 7.6 Hz, 2H), 7.34-7.22 (m, 5H), 7.08 (t, *J* = 7.2 Hz, 1H), 6.77 (d, *J* = 7.6 Hz, 1H), 4.83 (d, *J* = 10.8 Hz, 1H), 4.66 (d, *J* = 10.8 Hz, 1H), 4.01-3.91 (m, 3H), 3.87 (d, *J* = 11.2 Hz, 1H), 3.22 (t, *J* = 6.8 Hz, 2H), 2.58 (brs, 1H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ = 176.8, 165.3, 143.1, 134.8, 131.9, 131.1, 130.1, 129.3, 129.2, 128.5, 128.4, 127.6, 127.0, 124.2, 123.1, 108.6, 65.0, 64.3, 53.8, 39.6, 31.3 ppm

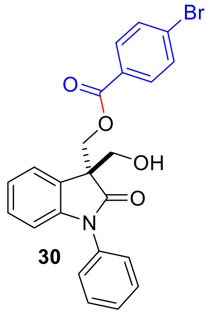
HRMS (ESI+) *m/z* calculated for $C_{25}H_{23}BrNO_4S$ $[M+Na]^+$ 512.0531, found 512.0530.

IR (Neat) ν_{max} = 3444, 3061, 2948, 2886, 1716, 1611, 1590, 1486, 1466, 1363, 1173, 1101, 1012, 772, 753 cm^{-1}.

$[\alpha]_D^{25}$ = +19.17 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 95) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.94 min, τ_{minor} = 20.61 min.

(*S*)-(3-(Hydroxymethyl)-2-oxo-1-phenylindolin-3-yl)methyl 4-bromobenzoate (30):



30

Compound **30** was prepared according to **GP-IV** combining **1za** (26.9 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **30** (23.0 mg, 51%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.73 (d, *J* = 8.4 Hz, 2H), 7.57-7.50 (m, 4H), 7.46-7.38 (m, 4H), 7.28-7.23 (m, 1H), 7.14-7.089 (m, 1H), 6.89 (d, *J* = 7.8 Hz, 1H), 4.94 (d, *J* = 11.1 Hz, 1H), 4.82 (d, *J* = 11.1 Hz, 1H), 4.16 (d, *J* = 11.1 Hz, 1H), 4.05 (d, *J* = 11.1 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 176.4, 165.3, 144.2, 134.0, 131.9, 131.1, 129.9, 129.2, 128.6, 128.5, 127.4, 126.5, 124.2, 123.6, 109.9, 65.5, 64.4, 54.0 ppm.

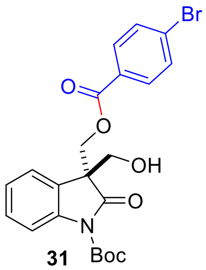
HRMS (ESI+) *m/z* calculated for $C_{23}H_{18}BrNO_4Na$ $[M+Na]^+$ 474.0317, found 474.0319.

IR (Neat) ν_{max} = 3444, 3064, 2941, 2889, 1719, 1612, 1590, 1500, 1464, 1373, 1266, 1101, 1068, 1011, 770, 752 cm^{-1}.

$[\alpha]_D^{25}$ = +39.95 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90.5) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 16.96 min, τ_{minor} = 28.99 min.

(*S*)-Tert-butyl-3-(((4-bromobenzoyl)oxy)methyl)-3-(hydroxymethyl)-2-oxoindoline-1-carboxylate (31): Compound **31** was prepared according to **GP-IV** combining **1zb** (29.3 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **31** (31.0 mg, 65%) as white solid.



31

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.89 (d, *J* = 8.0 Hz, 1H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.37 (t, *J* = 7.6 Hz, 2H), 7.19 (t, *J* = 7.2 Hz, 1H), 4.80 (d, *J* = 11.2 Hz, 1H), 4.70 (d, *J* = 10.8 Hz, 1H), 4.06 (d, *J* = 10.8 Hz, 1H), 3.98 (d, *J* = 11.2 Hz, 1H), 2.37 (brs, 1H), 1.65 (s, 9H) ppm.

^{13}C NMR (100 MHz, $CDCl_3$) δ= 175.5, 165.2, 149.0, 140.3, 131.9, 131.1, 129.5, 128.5, 128.4, 126.5, 124.9, 123.6, 115.4, 85.0, 65.6, 64.5, 54.5, 28.2 ppm.

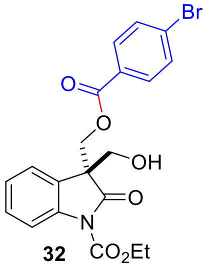
HRMS (ESI+) *m/z* calculated for $C_{22}H_{22}BrNO_6Na$ $[M+Na]^+$ 498.0528, found 498.0526.

IR (Neat) ν_{max} = 3506, 2981, 2886, 1729, 1590, 1481, 1465, 1267, 1150, 1100, 1068, 1011, 772, 754 cm^{-1}.

$[\alpha]_D^{25}$ = +31.96 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 93) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 7.41 min, τ_{minor} = 10.22 min.

(*S*)-Ethyl-3-(((4-bromobenzoyl)oxy)methyl)-3-(hydroxymethyl)-2-oxoindoline-1-carboxylate (32): Compound **32** was prepared according to **GP-IV** combining **1zc** (26.5 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The



32

crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **32** (18.0 mg, 40%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.96 (d, *J* = 8.1 Hz, 1H), 7.66 (d, *J* = 8.4 Hz, 2H), 7.52 (d, *J* = 8.7 Hz, 2H), 7.40-7.35 (m, 2H), 7.23 (t, *J* = 7.5 Hz, 1H), 4.80 (d, *J* = 10.8 Hz, 1H), 4.72 (d, *J* = 11.1 Hz, 1H), 4.53 (q, *J* = 7.2 Hz, 2H), 4.08 (d, *J* = 11.1 Hz, 1H), 4.00 (d, *J* = 11.1 Hz, 1H), 2.36 (brs, 1H), 1.48 (t, *J* = 7.2 Hz, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ= 175.4, 165.3, 150.7, 140.0, 131.9, 131.1, 129.6, 128.6, 128.3, 126.5, 125.2, 123.7, 115.5, 65.4, 64.7, 63.9, 54.7, 14.3 ppm.

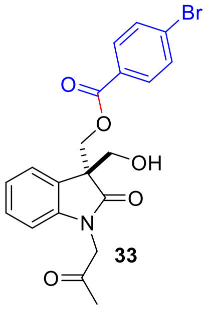
HRMS (ESI+) *m/z* calculated for $C_{20}H_{18}BrNO_6Na$ $[M+Na]^+$ 470.0215, found 470.0216.

IR (Neat) ν_{max} = 3493, 2962, 2928, 2873, 1790, 1765, 1725, 1590, 1481, 1397, 1370, 1345, 1261, 1233, 1171, 1094, 1068, 1022, 1011, 847, 802, 771, 751 cm^{-1}.

$[\alpha]_D^{25}$ = +11.98 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 91) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 μm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 11.62 min, τ_{minor} = 18.13 min.

(*S*)-(3-(Hydroxymethyl)-2-oxo-1-(2-oxopropyl)indolin-3-yl)methyl 4-bromobenzoate (33):



33

Compound **33** was prepared according to **GP-IV** combining **1zd** (24.9 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **33** (24.0 mg, 56%) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.76 (d, *J* = 8.4 Hz, 2H), 7.53 (d, *J* = 8.4 Hz, 2H), 7.36 (d, *J* = 7.2 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.10 (t, *J* = 7.2 Hz, 1H), 6.68 (d, *J* = 8.0 Hz, 1H), 4.88 (d, *J* = 11.2 Hz, 1H), 4.70 (d, *J* = 11.2 Hz, 1H), 4.61 (d, *J* = 18.0 Hz, 1H), 4.50 (d, *J* = 18.0 Hz, 1H), 4.07 (d, *J* = 11.2 Hz, 1H), 3.96 (d, *J* = 11.2 Hz, 1H), 2.24 (s, 3H) ppm.

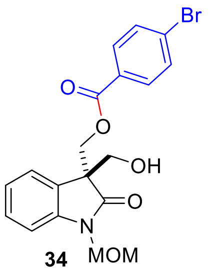
^{13}C NMR (100 MHz, $CDCl_3$) δ = 200.8, 176.9, 165.5, 143.0, 131.9, 131.3, 129.2, 128.5, 128.5, 127.4, 124.1, 123.5, 108.5, 64.9, 64.5, 54.2, 49.7, 27.2 ppm.

HRMS (ESI+) *m/z* calculated for $C_{20}H_{18}BrNO_5Na$ $[M+Na]^+$ 454.0266, found 454.0265.

IR (Neat) ν_{max} = 3437, 2928, 2886, 1716, 1614, 1590, 1491, 1467, 1269, 1219, 1100, 1067, 1011 772 cm^{-1}.

$[\alpha]_D^{25}$ = +12.78 (c = 0.5, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 15.33 min, τ_{minor} = 19.11 min.



34

(*S*)-(3-(Hydroxymethyl)-1-(methoxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (34): Compound **34** was prepared according to **GP-IV** combining **1ze** (23.7 mg, 0.1 mmol, 1.0 equiv), azolium salt **2a** (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 20% acetone-PE, R_f = 0.4) to afford title compound **34** (23.0 mg, 55%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.67 (d, *J* = 8.4 Hz, 2H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.36 (t, *J* = 7.8 Hz, 2H), 7.13 (t, *J* = 7.5 Hz, 2H), 5.21 (dd, *J* = 16.5, 11.1 Hz, 2H), 4.84 (d, *J* = 10.8 Hz, 1H), 4.70 (d, *J* = 11.1 Hz, 1H), 4.08 (d, *J* = 10.5 Hz, 1H), 3.97 (d, *J* = 11.1 Hz, 1H), 3.30 (s, 3H), 2.56 (brs, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 177.5, 165.3, 142.5, 131.9, 131.1, 129.4, 128.5, 127.1, 123.9, 123.6, 110.0, 71.4, 65.2, 64.4, 56.5, 54.5 ppm.

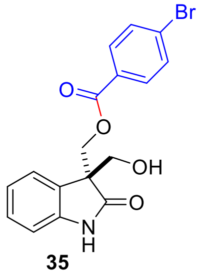
HRMS (ESI+) *m/z* calculated for $C_{19}H_{18}BrNO_5Na$ $[M+Na]^+$ 442.0266, found 442.0268.

IR (Neat) ν_{max} = 3445, 3016, 2889, 1824, 1716, 1614, 1590, 1487, 1467, 1398, 1350, 1116, 1082, 1069, 1011, 770, 752 cm^{-1}.

$[\alpha]_D^{25}$ = +12.78 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 13.86 min, τ_{minor} = 15.65 min.

(*S*)-(3-(Hydroxymethyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (35): Compound **35** was prepared according to **GP-IV** combining **1zf** (19.3 mg, 0.1 mmol, 1.0 equiv), azolium salt 1a (6.2 mg, 0.015 mmol, 15 mol%), 4-bromobenzaldehyde (18.5 mg, 0.1 mmol, 1.0 equiv), MnO_2 (43.4 mg, 0.5 mmol, 5.0 equiv), DABCO (5.6 mg, 0.05 mmol, 0.5 equiv) and activated 4 Å MS (35.0 mg) in THF (1.0 mL) for 48 h. The crude material was purified by gradient column chromatography (SiO_2, 30% acetone-PE, R_f = 0.4) to afford title compound **35** (22.5 mg, 60%) as white solid.



35

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.72 (d, *J* = 8.7 Hz, 2H), 7.62 (brs, 1H) 7.53 (d, *J* = 8.4 Hz, 2H), 7.32 (t, *J* = 7.5 Hz, 1H), 7.0 (t, *J* = 7.5 Hz, 2H), 6.94 (d, *J* = 7.8 Hz, 1H), 4.87 (d, *J* = 11.1 Hz, 1H), 4.72 (d, *J* = 11.1 Hz, 1H), 4.07 (d, *J* = 11.4 Hz, 1H), 3.96 (d, *J* = 11.4 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 179.1, 165.4, 141.2, 131.9, 131.9, 131.1, 129.3, 128.5 128.1, 124.3, 123.2, 110.3, 65.0, 64.2, 54.5 ppm.

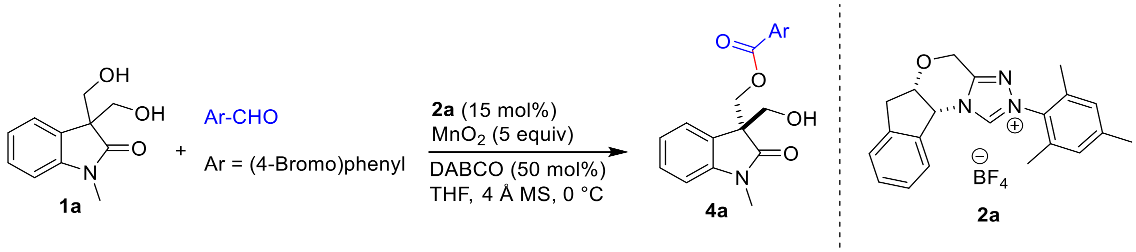
HRMS (ESI+) *m/z* calculated for $C_{17}H_{14}BrNO_4$ $[M+H]^+$ 375.0106, found 375.0108.

IR (Neat) ν_{max} = 3474, 3022, 2964, 2857, 1723, 1608, 1590, 1477, 1364, 1325, 1159, 1112, 1091, 1069, 752, 731 cm^{-1}.

$[\alpha]_D^{25}$ = +7.99 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 90) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 75:25, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 11.50 min, τ_{minor} = 15.00 min.

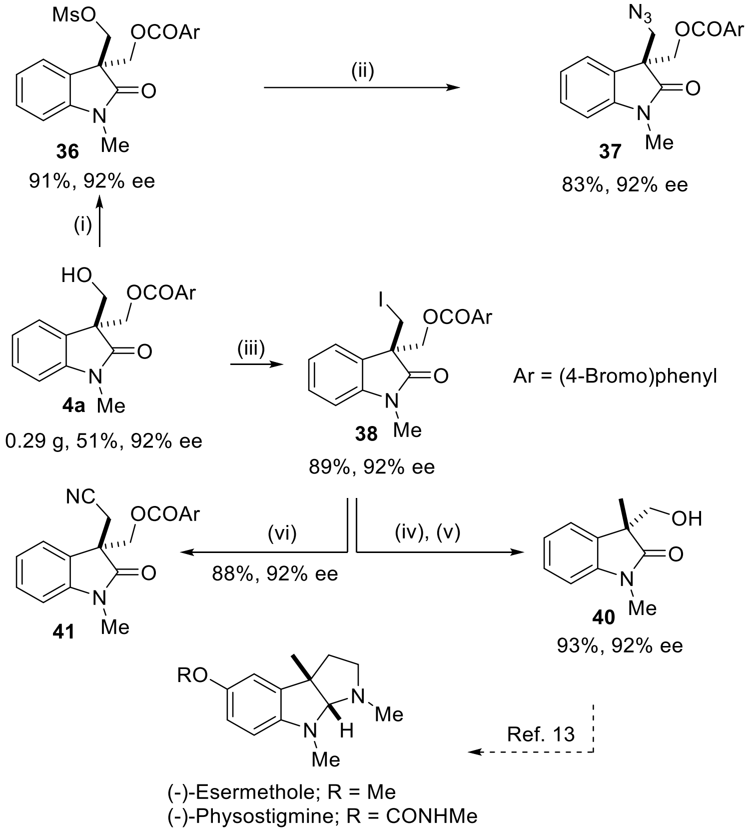
13. Preparative scale experiment:



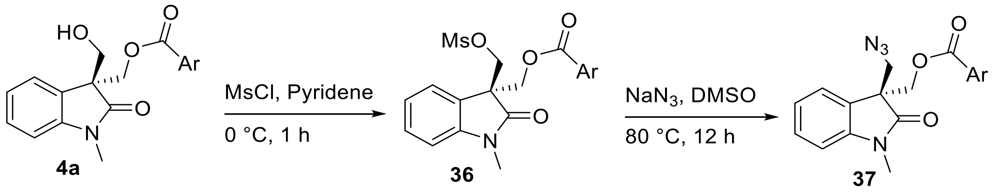
To a flame dried 50 mL Schlenk round bottom flask equipped with a magnetic stir bar, carbene precursor **2a** (91.2 mg, 0.015 mmol, 15 mol%), activated 4 Å MS (500.0 mg), prochiral diols (300.0 mg, 0.1 mmol, 1.0 equiv), 4-bromobenzaldehyde (268.3 mg, 0.1 mmol, 1.0 equiv), manganese dioxide (MnO_2) (630.3 mg, 0.5 mmol, 5.0 equiv) and dry THF (12.0 mL) were placed under argon atmosphere. The resulting mixture was allowed to stir at 25 °C for 10 min. The reaction mixture was then cooled to 0 °C and stirring was continued for another 15 min. To the cold mixture, a solution of 1,4-diazabicyclo[2.2.2]octane (DABCO) (81.3 mg, 0.05 mmol, 50 mol%) in 3.0 mL THF was added dropwise. The reaction was continued for 48 h, while maintaining the reaction temperature at 0 °C. The progress of the reaction was monitored by TLC analysis. After running the reaction to an appropriate time, the reaction was quenched with 1.0 mL of water and extracted with EtOAc. The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The crude material was purified by column chromatography (SiO_2, 20% acetone-PE, $R_f = 0.4$) to afford title compound **4a** (0.29 g, 51%) with 92% enantioselectivity as white solid.

14. Synthetic application:

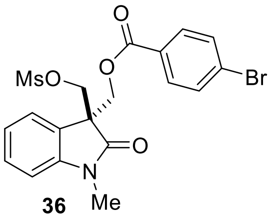
To demonstrate synthetic utility of the method, the enantioenriched product **4a** was converted to various highly functionalized molecules in good yields with conservation of enantiomeric excess.



Reaction condition: (i) MsCl, Py, 0 °C, 1 h; (ii) NaN_3, DMSO, 80 °C, 12 h; (iii) PPh_3, imidazole, I_2, THF, 80 °C, 12 h; (iv) $(TMS)_3SiH$, AIBN, toluene, 85 °C, 4 h; (v) $NH_2NH_2.H_2O$, EtOH, 0 °C 18 h; (vi) NaCN, DMSO, 25 °C, 24 h.



(*R*)-(1-Methyl-3-(((methylsulfonyl)oxy)methyl)-2-oxoindolin-3-yl)methyl 4-bromobenzoate (36): To an oven dried round bottom flask equipped with magnetic stir bar were added enantioenriched alcohol **4a** (100.0 mg, 0.26 mmol, 1.0 equiv) and pyridine (0.4 mL, 0.7 M). The mixture was allowed to cool to 0 °C and methanesulfonyl chloride (MsCl) (40.0 µL, 0.52 mmol, 2.0



36

equiv) was added dropwise under argon atmosphere maintaining the reaction temperature 0 °C. The resulting heterogeneous mixture was stirred for 1 h. After complete consumption of the starting material, as indicated by TLC, pyridine was removed under reduced pressure. Water (2.0 mL) and EtOAc (10.0 mL) were added successively to dissolve the resultant solid residue. The organic layer was separated, and aqueous layer was extracted with EtOAc (twice). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The solid residue was purified by column chromatography (SiO_2, 30% EtOAc-PE, Rf = 0.5) to afford the title compound **36** (111.0 mg, 91%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.75 (d, *J* = 8.7 Hz, 2H), 7.56 (d, *J* = 8.4 Hz, 2H), 7.39-7.33 (m, 2H), 7.12 (t, *J* = 7.5 Hz, 1H), 6.92 (d, *J* = 7.8 Hz, 1H), 4.75 (dd, *J* = 9.9, 6.6 Hz, 2H), 4.55 (d, *J* = 11.4 Hz, 2H), 3.26 (s, 3H), 2.90 (s, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 173.8, 165.0, 144.0, 132.0, 131.1, 129.9, 128.7, 128.2, 126.1, 124.5, 123.3, 108.8, 69.4, 64.8, 52.1, 37.4, 26.7 ppm.

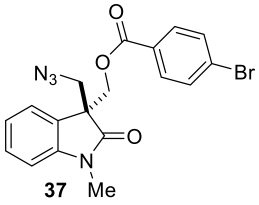
HRMS (ESI+) m/z calculated for $C_{19}H_{18}BrNNaO_6S$ $[M+Na]^+$ 489.9936, found 489.9939.

IR (Neat) ν_{max} = 3023, 2934, 1714, 1613, 1590, 1494, 1470, 1398, 1352, 1116, 1068, 1030, 751 cm^{-1}.

$[\alpha]_D^{25}$ = +20.64 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IA-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 70:30, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 13.55 min, τ_{minor} = 23.57 min.

(*S*)-(3-(Azidomethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (37): To an oven dried round bottom flask equipped with a magnetic stir bar were added mesyl derivative **36** (70.0 mg, 0.15 mmol, 1.0 equiv), DMSO (1.5 mL, 0.1 M) followed by NaN_3 (19.5 mg, 0.30 mmol, 2.0 equiv). The flask was then fitted with a reflux condenser and the reaction mixture was heated to 80 °C while stirring for about 12 h. After complete conversion of the starting material, EtOAc (2.0 mL) and water (5.0 mL) was added to the reaction mixture. The organic layer was separated and the aqueous layer was washed three times with EtOAc. The combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated under reduced



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pressure. The residue was purified by column chromatography on silica gel (SiO_2, 10% EtOAc-PE, Rf = 0.5) to get the desired azide **37** as a yellowish solid (52.0 mg, 83%).

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.71 (d, *J* = 8.7 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.39-7.33 (m, 2H), 7.12 (t, *J* = 8.1 Hz, 1H), 6.92 (d, *J* = 7.8 Hz, 1H), 4.71 (d, *J* = 11.1 Hz, 1H), 4.51 (d, *J* = 11.1 Hz, 1H), 3.94 (d, *J* = 12.3 Hz, 1H), 3.80 (d, *J* = 12.0 Hz, 1H), 3.27 (s, 3H) ppm.

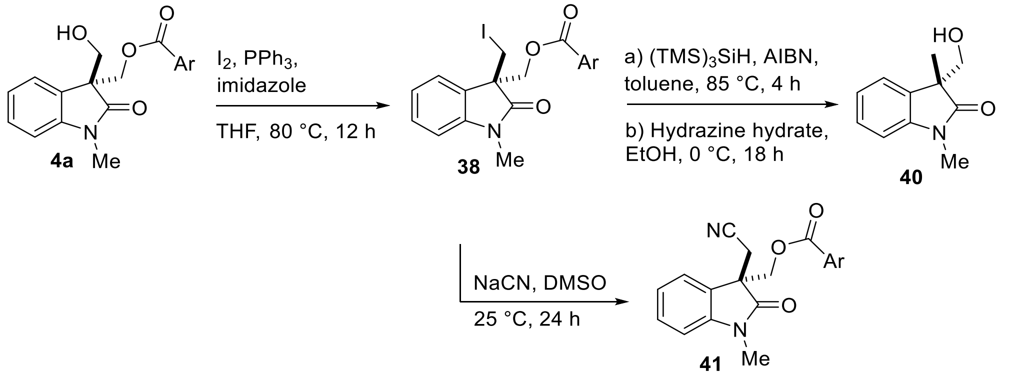
^{13}C NMR (75 MHz, $CDCl_3$) δ = 175.0, 165.0, 144.1, 131.9, 131.1, 129.6, 128.5, 128.3, 127.2, 124.1, 123.1, 108.6, 65.6, 53.7, 52.6, 26.6 ppm.

HRMS (ESI+) m/z calculated for $C_{18}H_{16}BrN_4O_3$ $[M+Na]^+$ 415.0406, found 415.0405.

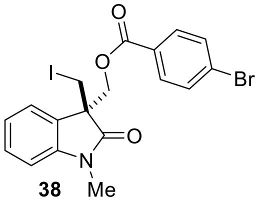
IR (Neat) ν_{max} = 3058, 2934, 2102, 1712, 1613, 1590, 1493, 1484, 1374, 1346, 1260, 1115, 1098, 751 cm^{-1}.

$[\alpha]_D^{25}$ = +19.60 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IA-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 80:20, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 8.80 min, τ_{minor} = 12.29 min.



(*S*)-(3-(Iodomethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (38): To an oven dried 15 mL pressure tube equipped with a magnetic stir bar, enantioenriched alcohol **4a** (100.0 mg, 0.26 mmol, 1.0 equiv), PPh_3 (136.5 mg, 0.52 mmol, 2.0 equiv), imidazole (42.5 mg, 0.62 mmol, 2.4 equiv), and dry THF (2.5 mL, 0.1 M) were added under atmosphere. The reaction was allowed to cool to 0 °C. To the cold reaction mixture, was added I_2 (165.0 mg, 0.65 mmol, 2.5 equiv) under argon atmosphere. The resulting mixture was then allowed heat to 80 °C while stirring for 12 h. After complete consumption of the starting alcohol, as indicated by TLC, the reaction mixture was allowed to cool to room temperature and



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diluted with EtOAc. The reaction mixture was washed with saturated $Na_2S_2O_3$ and NaCl solution, sequentially. The combined organic phase was then dried over anhydrous Na_2SO_4, concentrated under reduced pressure and the crude product was purified by column chromatography (SiO_2, 10% EtOAc-PE, $R_f = 0.5$) to afford the desired iodide **38** (114.0 mg, 89%) as white solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.71 (d, *J* = 8.4 Hz, 2H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.39-7.33 (m, 2H), 7.13 (t, *J* = 7.5 Hz, 1H), 6.91 (d, *J* = 7.8 Hz, 1H), 4.73 (d, *J* = 10.8 Hz, 1H), 4.54 (d, *J* = 11.1 Hz, 1H), 3.60 (d, *J* = 1.5 Hz, 2H), 3.28 (s, 3H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 175.0, 165.0, 144.0, 131.9, 131.1, 129.6, 128.6, 128.4, 125.3, 123.7, 123.1, 108.5, 66.9, 52.7, 26.6, 4.9 ppm.

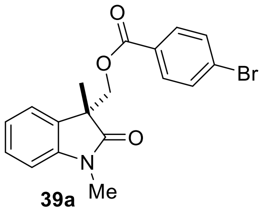
HRMS (ESI+) m/z calculated for $C_{18}H_{16}BrINO_3$ $[M+H]^+$ 499.9358, found 499.9359.

IR (Neat) ν_{max} = 3019, 2939, 1709, 1613, 1589, 1493, 1484, 1420, 1260, 1115, 1100, 1038, 749 cm^{-1}.

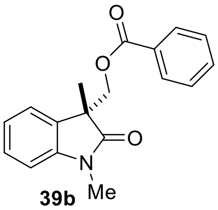
$[\alpha]_D^{25}$ = +5.36 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IA-3 column (particle size- 3.0 µm, dimension- 4.6 mm $\phi \times$ 250 mm L): *n*-hexane:*i*-PrOH = 90:10, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 14.14 min, τ_{minor} = 19.11 min.

(*R*)-(1,3-Dimethyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (39a, 39b): To an oven dried 15 mL screw capped pressure tube equipped with a magnetic stir bar, were added **38** (50.0 mg, 0.1 mmol, 1.0 equiv), dry toluene (1.0 mL, 0.1 M) and azobisisobutyronitrile (AIBN) (3.5 mg, 0.02 mmol, 20 mol%) with a flow of argon. The resultant solution was allowed to stir at room temperature for 5 min, followed by the addition of $(Me_3Si)_3SiH$ (0.5 mL, 0.15 mmol, 1.5 equiv). After complete addition of all the reaction components, the reaction mixture was heated at 85 °C for 4 h. After complete consumption of the starting material, the reaction mixture was allowed to cool to room temperature and concentrated under reduced pressure. The crude material was purified by silica gel (SiO_2, 15% EtOAc-PE, $R_f = 0.4$), which gave an inseparable mixture of products **39a** along with **39b** (32.5 mg, 87% combined yield) as a colorless oil. The mixture **(39a, 39b)** was used for the next step.

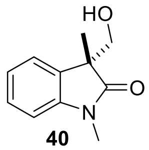


39a



39b

(*R*)-3-(Hydroxymethyl)-1,3-dimethylindolin-2-one (40): To an oven dried 15 mL sealed tube


40

equipped with a magnetic stir bar, the mixture of **39a** and **39b** (25.0 mg, 0.067 mmol, 1.0 equiv) and dry EtOH (0.7 mL, 0.1 M) were placed. The resultant solution was allowed to stir at 0 °C for 10 min, followed by the addition of hydrazine hydrate 99% (0.2 mL, 2.68 mmol, 40.0 equiv). After complete addition of all the reaction components, the reaction mixture was capped properly and stirred at 0 °C for 18 h. After complete consumption of the starting material, the reaction mixture was allowed to cool to room temperature and concentrated under reduced pressure. The crude material was purified by column chromatography (SiO_2, 40% EtOAc-PE, R_f = 0.3) to furnish the desired product **40** (12.0 mg, 93%) as a white solid.

The absolute stereochemistry of **40** was determined to be *R* by comparison with the reported optical rotation value.[13]

^{1}H NMR (600 MHz, $CDCl_3$) δ = 7.33 (t, *J* = 7.6 Hz, 1H), 7.23 (d, *J* = 7.2 Hz, 1H), 7.11 (t, *J* = 7.2 Hz, 1H), 6.89 (d, *J* = 7.6 Hz, 1H), 3.86 (d, *J* = 10.0 Hz, 1H), 3.75 (d, *J* = 10.8 Hz, 1H), 3.23 (s, 3H), 2.25 (brs, 1H), 1.41 (s, 3H) ppm.

^{13}C NMR (150 MHz, $CDCl_3$) δ = 180.0, 143.7, 131.8, 128.5, 125.3, 122.9, 122.8, 108.4, 67.7, 50.0, 26.3, 19.1 ppm.

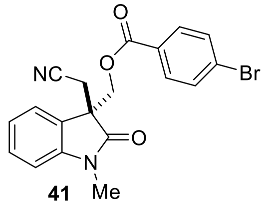
HRMS (ESI+) m/z calculated for $C_{11}H_{13}NO_2Na$ $[M+Na]^+$ 214.0844, found 214.0843.

IR (Neat) ν_{max} = 3363, 3058, 2925, 2864, 1688, 1612, 1493, 1466, 1350, 1389, 1308, 1104, 1069, 753 cm^{-1}.

$[\alpha]_D^{25}$ = -6.20 (c = 1.0, $CHCl_3$). The optical rotation and enantiomeric excess of literature compound **40** was **$[\alpha]_D^{29}$** = -8.5 (c = 0.41, $CHCl_3$), enantiomeric excess (% of ee = 99).[13]

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IG-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 85:15, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 10.47 min, τ_{minor} = 12.01 min.

(*S*)-(3-(Azidomethyl)-1-methyl-2-oxoindolin-3-yl)methyl 4-bromobenzoate (41): To an oven


41

dried round bottom flask equipped with a magnetic stir bar were added iodo derivative **38** (25.0 mg, 0.05 mmol, 1.0 equiv), DMSO (0.5 mL, 0.1 M) followed by NaCN (5.0 mg, 0.1 mmol, 2.0 equiv) under argon atmosphere. The resulting solution was stirred at 25 °C for 24 h. After complete consumption of starting material, EtOAc and water was added to the reaction mixture. The organic layer was separated and the aqueous layer was washed three times with EtOAc. The combined organic layer was washed with brine and dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (SiO_2, 15% EtOAc-PE, $R_f = 0.3$) to obtain the desired cyanide **41** as a white solid (17.5 mg, 88%).

^{1}H NMR (300 MHz, $CDCl_3$) δ = 7.77 (d, *J* = 8.4 Hz, 2H), 7.55 (d, *J* = 8.54 Hz, 2H), 7.53 (d, *J* = 6.9 Hz, 1H), 7.42 (dt, *J* = 8.1, 1.2 Hz, 1H), 7.16 (dt, *J* = 7.8, 0.9 Hz, 1H), 6.95 (d, *J* = 7.8 Hz, 1H), 4.73 (d, *J* = 11.1 Hz, 1H), 4.54 (d, *J* = 11.1 Hz, 1H), 3.28 (s, 3H), 3.12 (d, *J* = 16.8 Hz, 1H), 2.84 (d, *J* = 16.8 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ = 174.4, 165.0, 143.6, 132.0, 131.2, 130.2, 128.8, 128.2, 126.7, 124.2, 123.6, 115.9, 109.0, 66.4, 48.7, 26.8, 22.5 ppm.

HRMS (ESI+) m/z calculated for $C_{19}H_{15}BrN_2O_3Na$ $[M+Na]^+$ 421.0164, found 421.0165.

IR (Neat) ν_{max} = 3020, 2937, 2229, 1720, 1618, 1592, 1469, 1372, 1266, 1119, 1097 cm^{-1}.

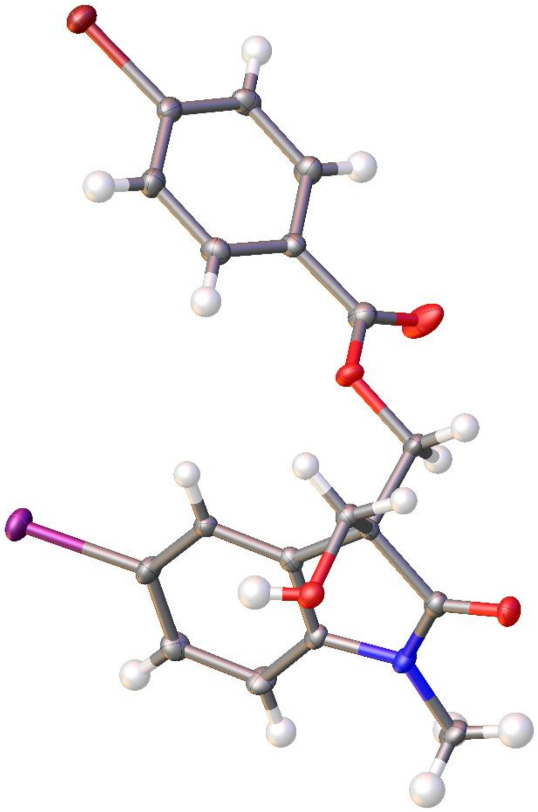
$[\alpha]_D^{25}$ = +4.96 (c = 1.0, $CHCl_3$).

HPLC: The enantiomeric excess (% of ee = 92) was determined by HPLC analysis using Daicel Chiralpak IA-3 column (particle size- 3.0 µm, dimension- 4.6 mm ϕ × 250 mm L): *n*-hexane:*i*-PrOH = 85:15, flow rate 1.0 mL/min, λ = 254 nm: τ_{major} = 11.67 min, τ_{minor} = 18.00 min.

15. X-Ray crystallographic data of compound 14:

Data collections for was performed at 134 K for compound **14** on a Bruker D8VENTURE Micro-focus diffractometer equipped with PHOTON II Detector, with Mo Kα radiation (λ = 0.71073 Å), controlled by the APEX3 (v2017.3-0) software package. The raw data were integrated and corrected for Lorentz and polarization effects with the aid of the Bruker APEX III program suite. Absorption corrections were performed by using SADABS. Space groups were assigned by systematic absences (determined by XPREP) and analysis of metric symmetry and were further checked by PLATON[14, 15] for additional symmetry. Structures were solved by direct methods and refined against all data in the reported 2θ ranges by full matrix least squares on F2 using the SHELXL program suite[16] in the OLEX 2[17] interface. S76 Hydrogen atoms at idealized positions were included in final refinements. The OLEX 2 interface was used for structure visualization as well as for drawing ORTEP plots.[18, 19]

Compound reference	**Compound 14**
Chemical formula	$C_{18}H_{15}BrINO_4$
Formula weight	516.1295
Temperature/K	134.0
Crystal system	orthorhombic
Space group	$P2_12_12_1$
a/Å	9.8468 (4)
b/Å	10.3709 (4)
c/Å	17.4196 (8)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	1778.89 (13)
Z	4
ρ_{calc}g/cm^3	1.927
μ/mm^{-1}	4.069
F(000)	1000.0
Crystal size/mm^3	0.5 × 0.3 × 0.1
Radiation	MoKα (λ = 0. 0.71073)
2Θ range for data collection/°	4.57 to 55.052
Index ranges	$-12 \leq h \leq 12$, $-13 \leq k \leq 12$, $-20 \leq l \leq 22$
Reflections collected	20967
Independent reflections	4089 [R_{int} = 0.0615, R_{sigma} = 0.0447]
Data/restraints/parameters	4089/0/229
Goodness-of-fit on F^2	1.061
Final R indexes [I>=2σ (I)]	R_1 = 0.0270, wR_2 = 0.0638
Final R indexes [all data]	R_1 = 0.0283, wR_2 = 0.0643
Largest diff. peak/hole / e Å^{-3}	1.10/-0.65
Flack parameter	0.117 (6)
CCDC number	2232966



Single-crystal X-ray structure of **14**, showing 50% probability thermal ellipsoid.

16. References:

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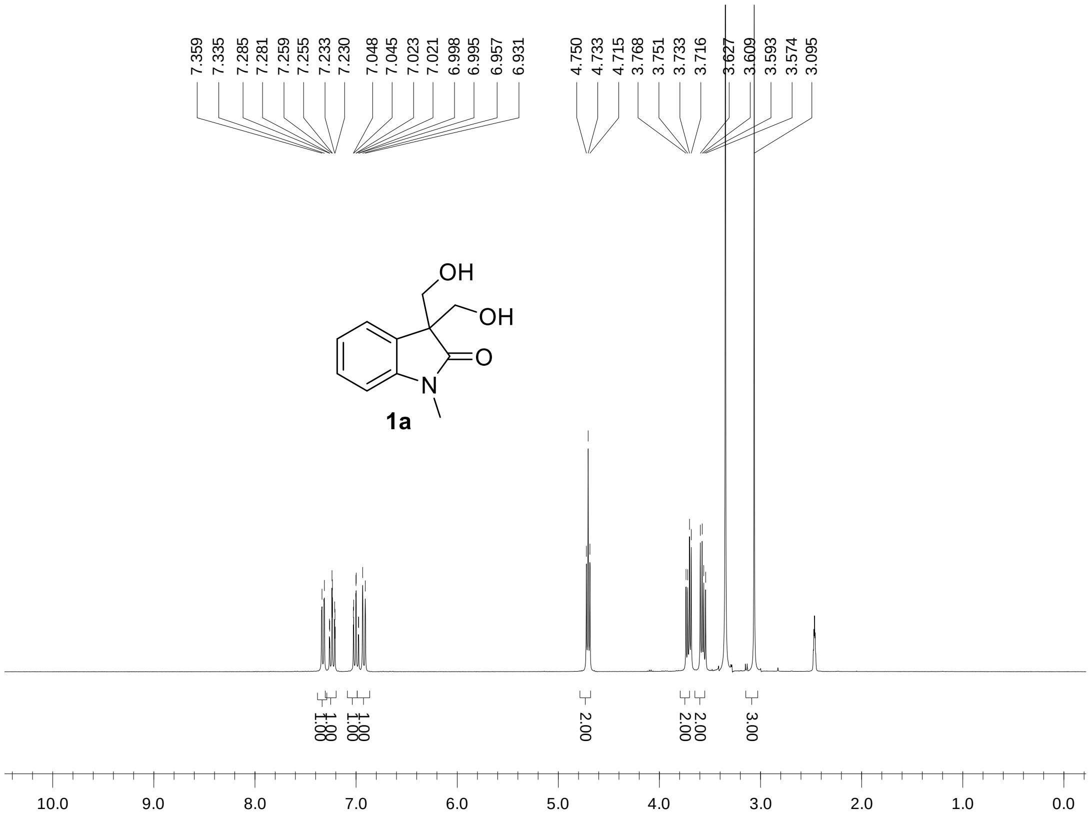
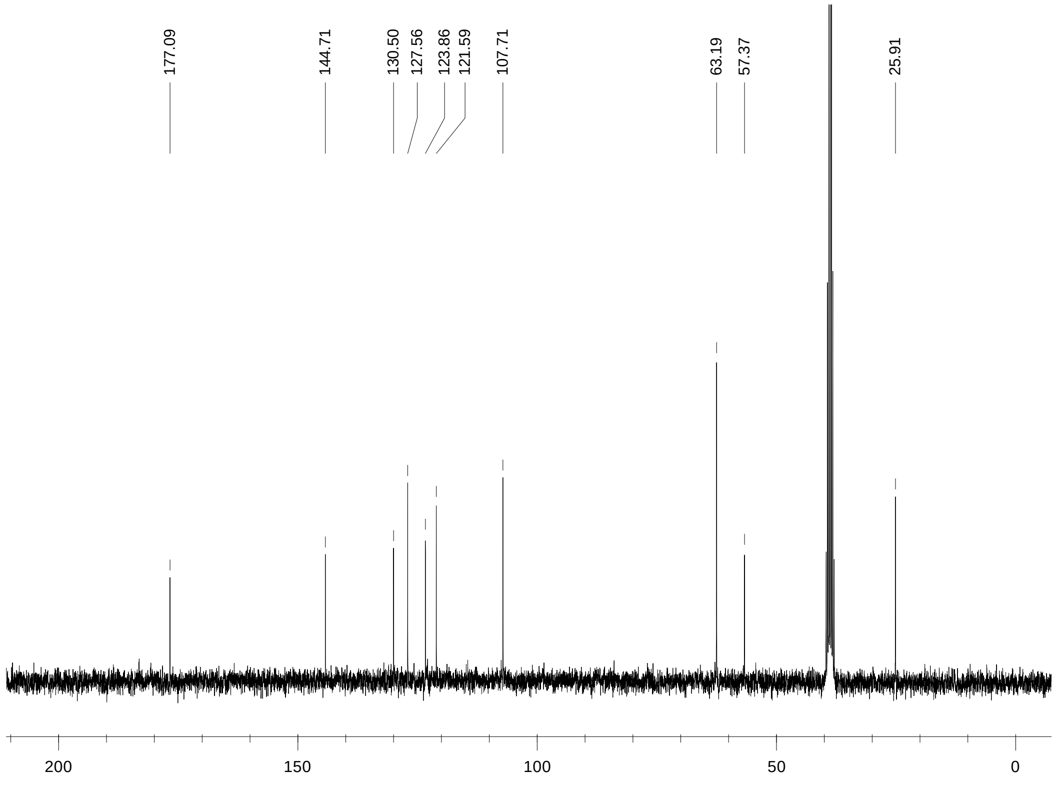
17. ^{1}H, ^{13}C and ^{19}F NMR spectra:

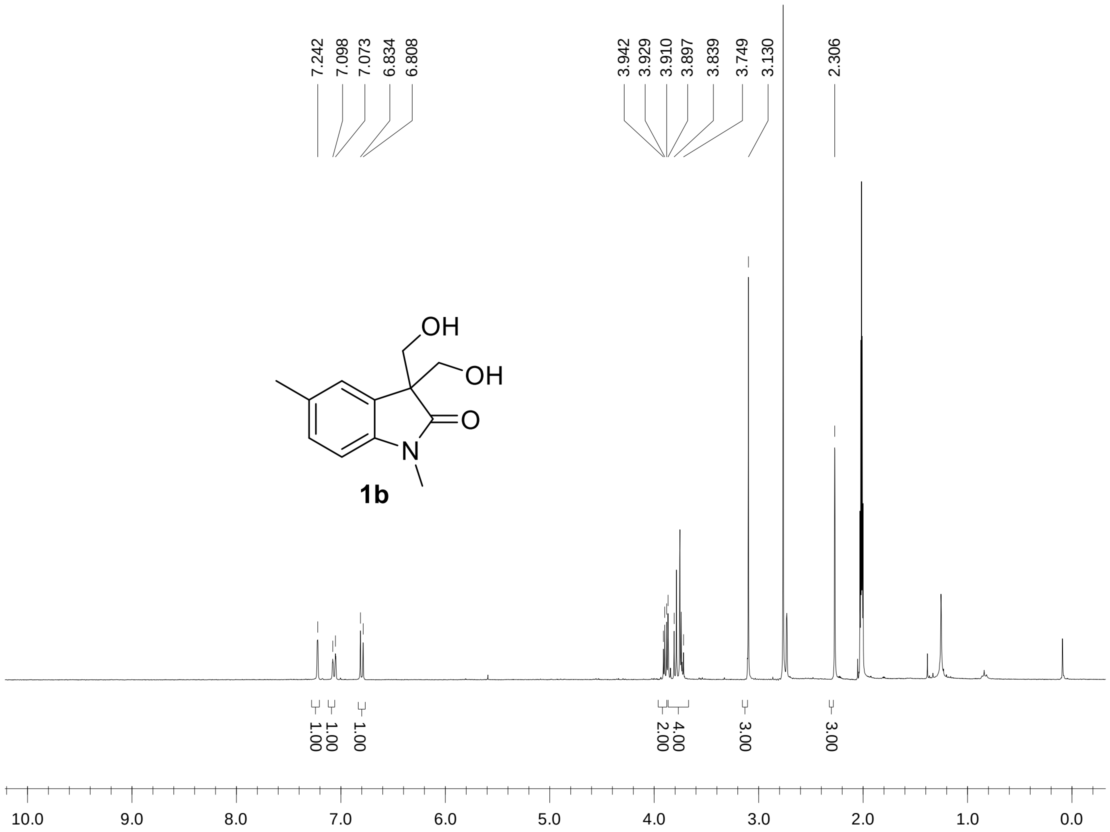
^{1}H NMR (300 MHz, DMSO-d$_6$)



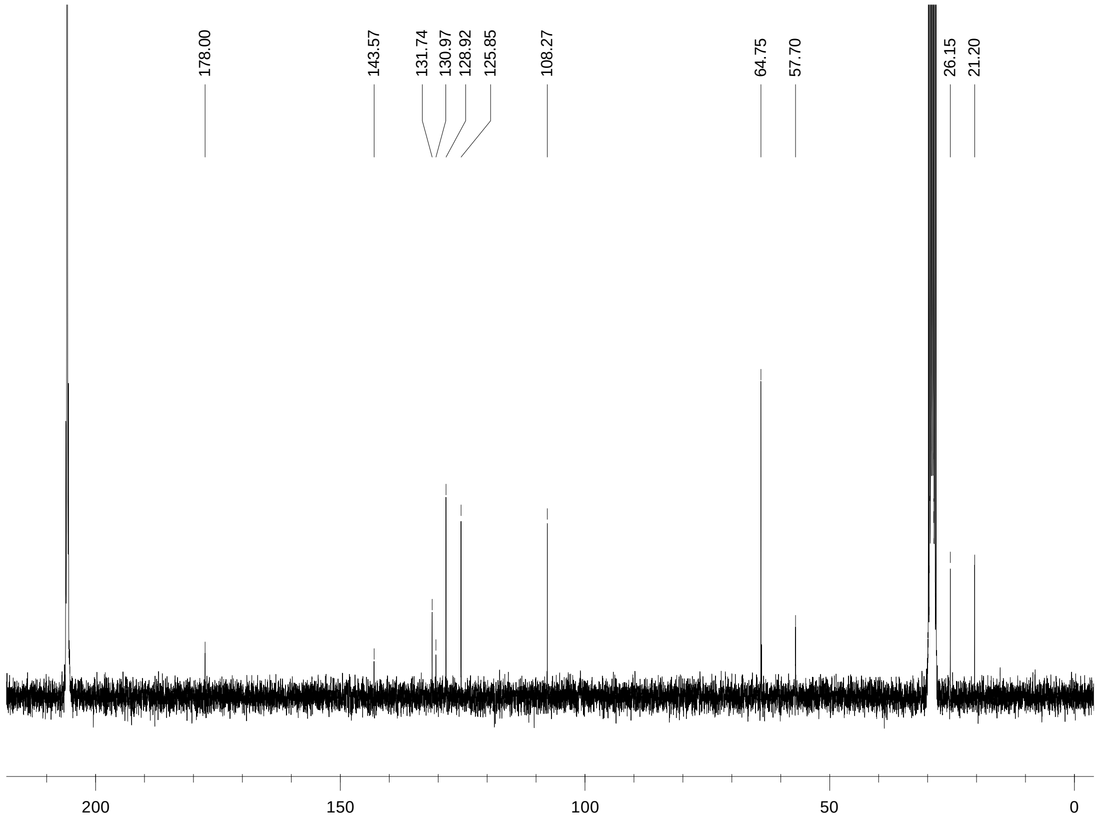
^{13}C NMR (75 MHz, DMSO-d$_6$)



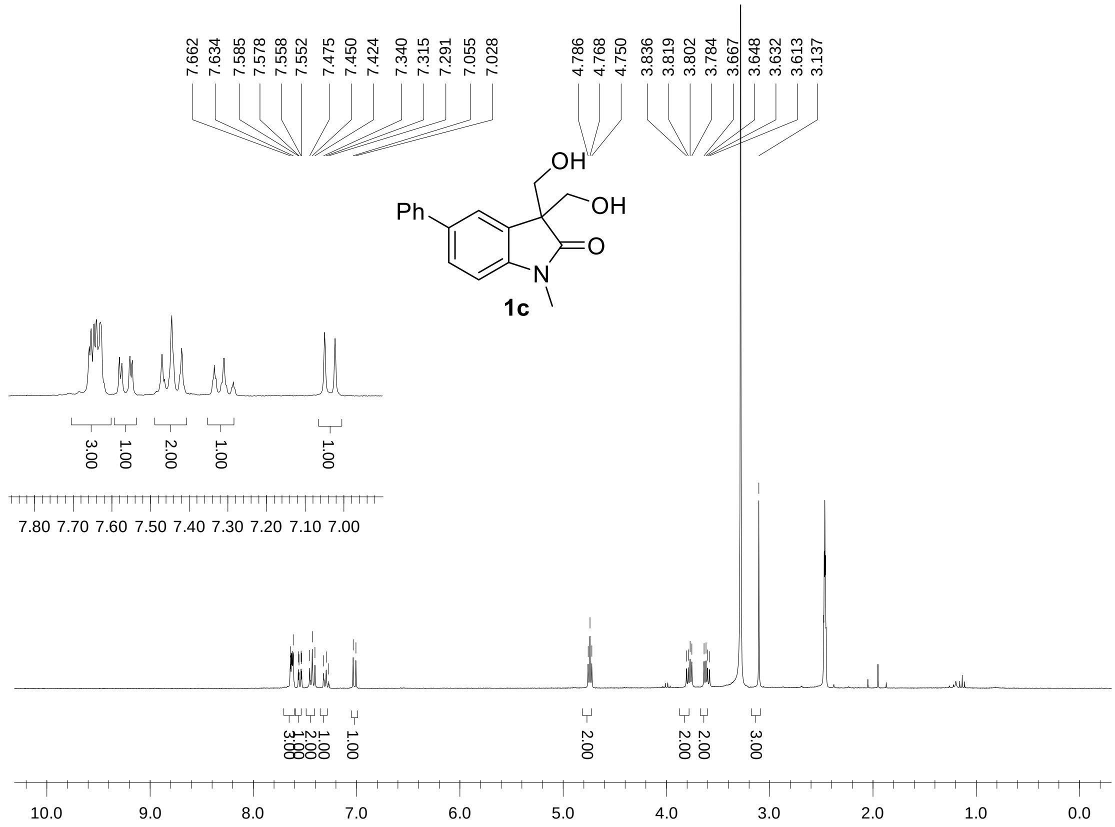
^{1}H NMR (300 MHz, acetone-d$_6$)



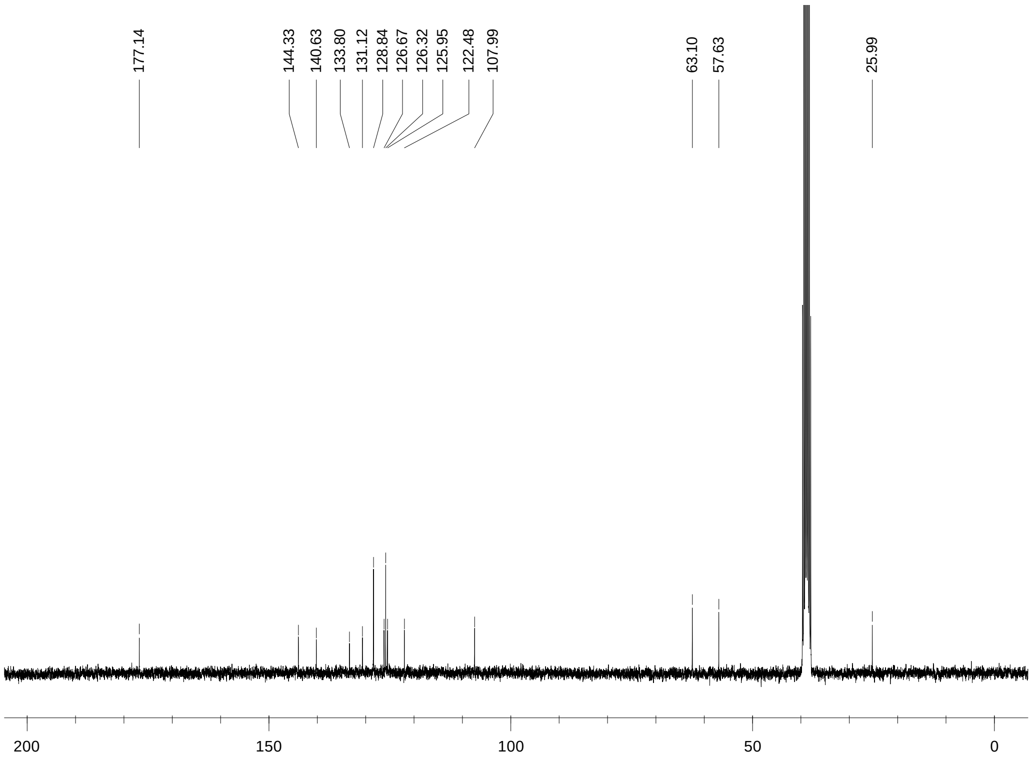
^{13}C NMR (75 MHz, acetone-d$_6$)



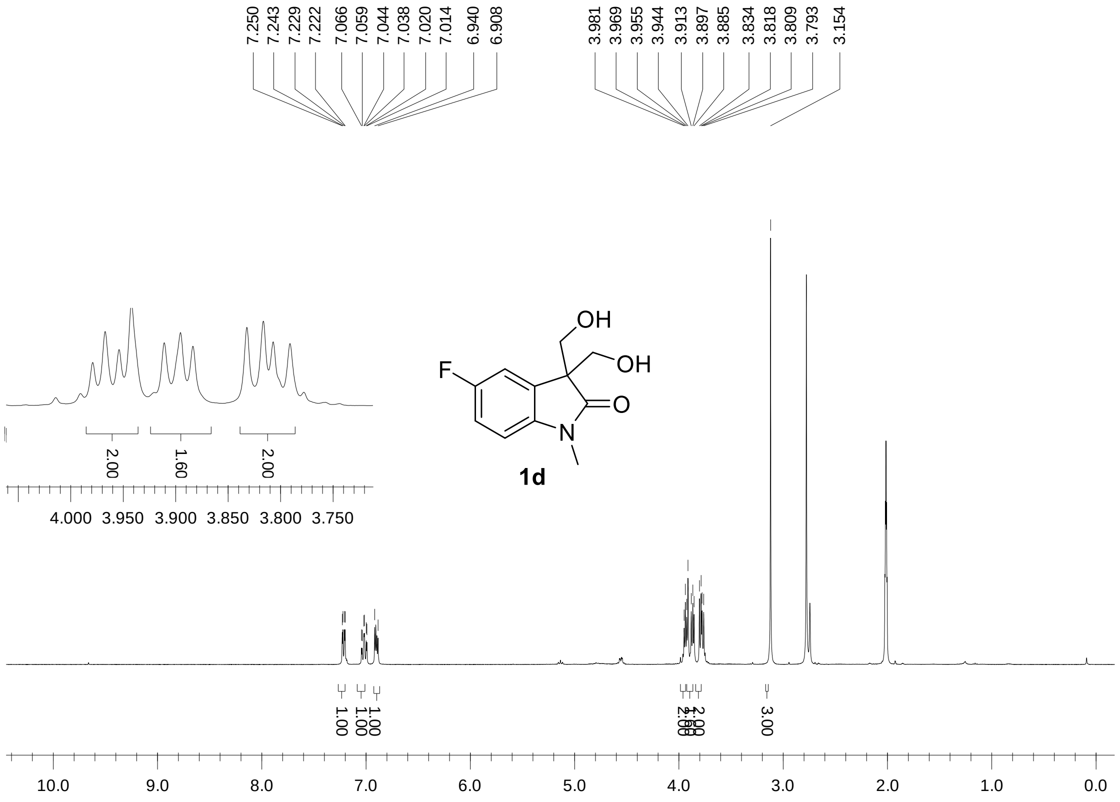
^{1}**H NMR** (300 MHz, DMSO-d_6)



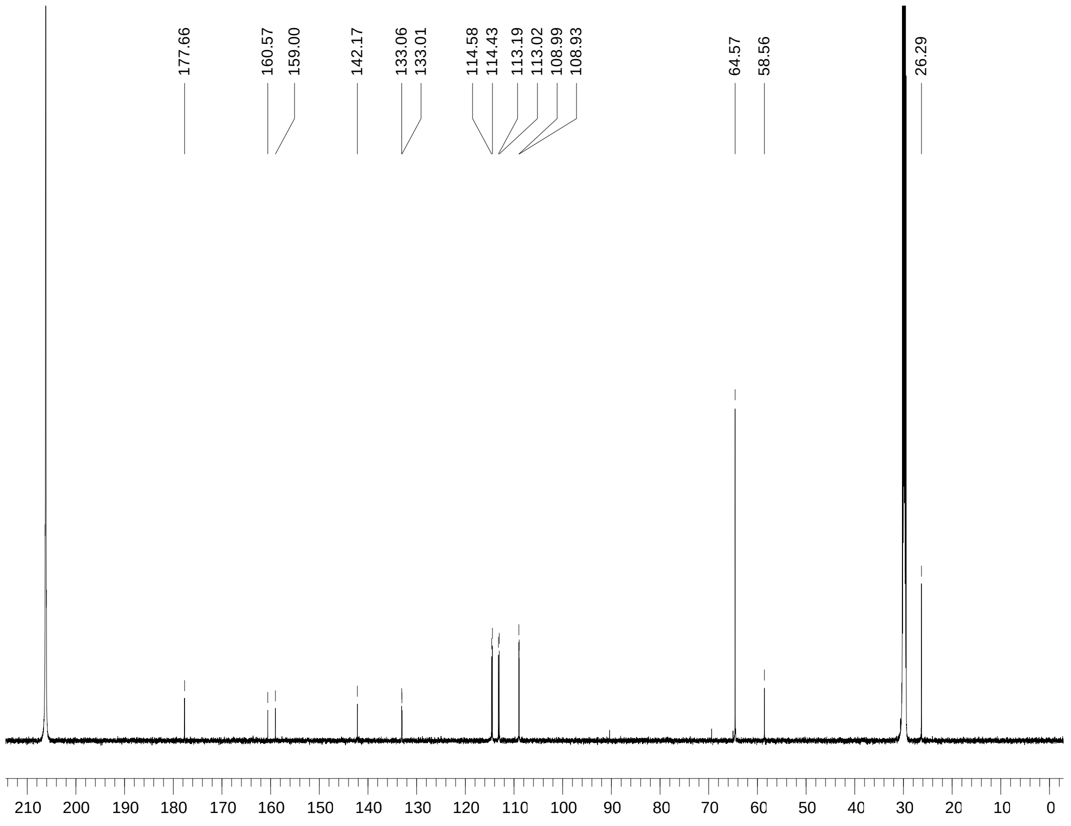
^{13}**C NMR** (75 MHz, DMSO-d_6)



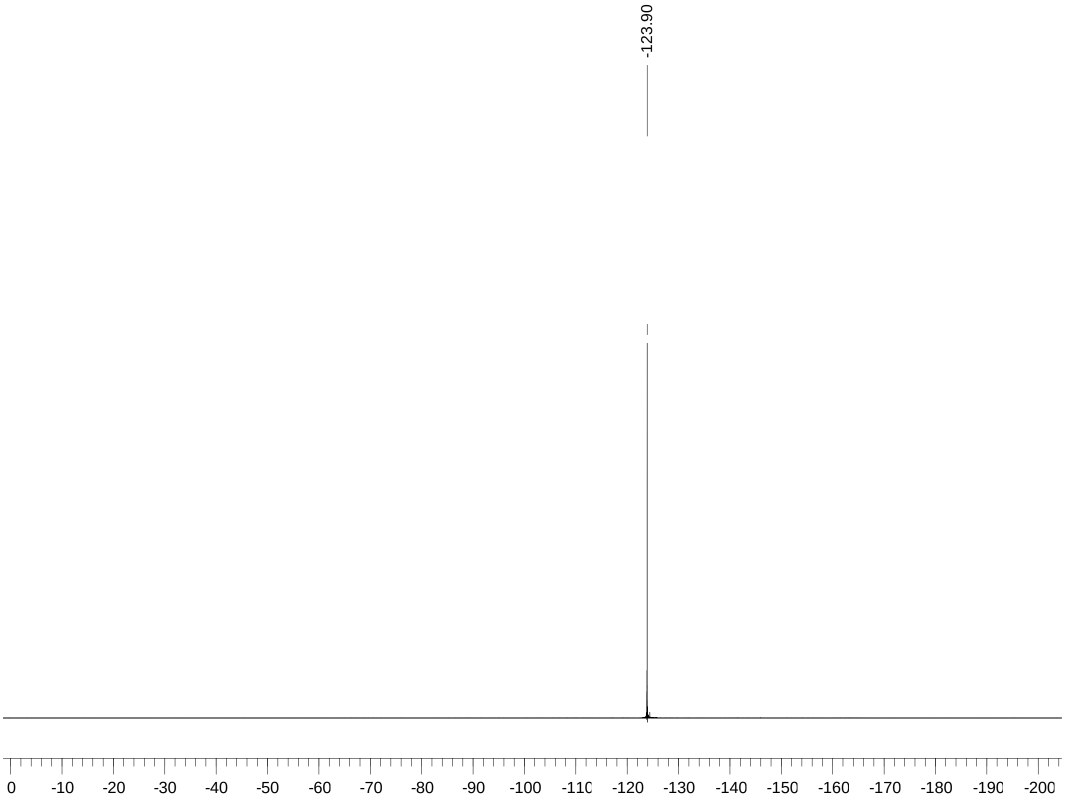
^{1}H NMR (400 MHz, acetone-d$_6$)



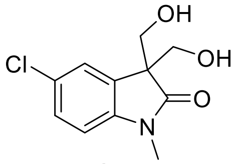
^{13}C NMR (150 MHz, acetone-d$_6$)



^{19}F NMR (564 MHz, acetone-d$_6$)



^{1}H NMR (400 MHz, DMSO-d$_6$)



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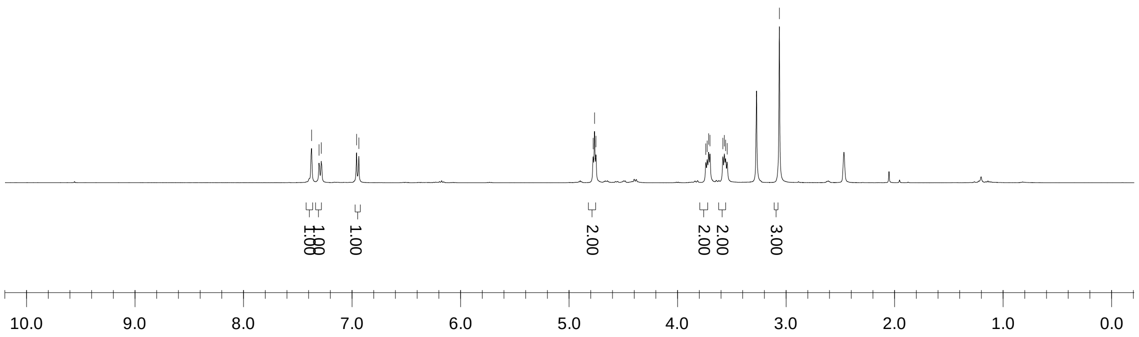
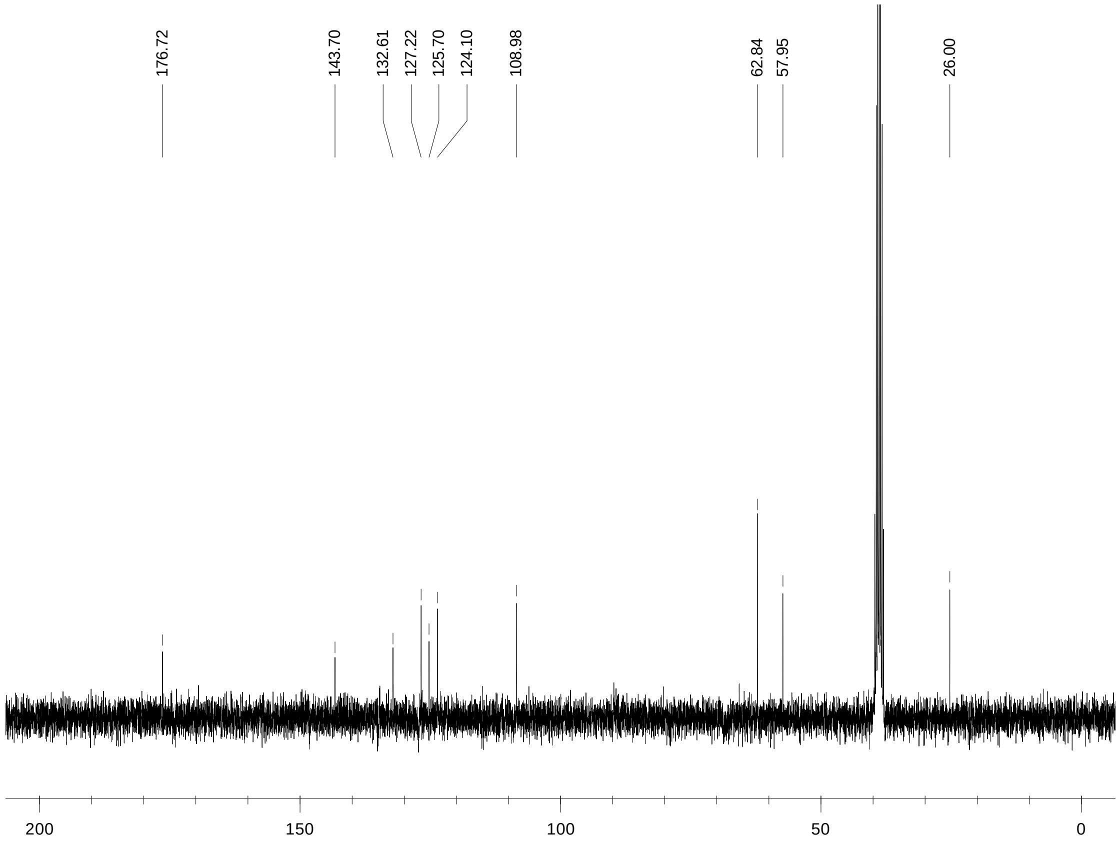
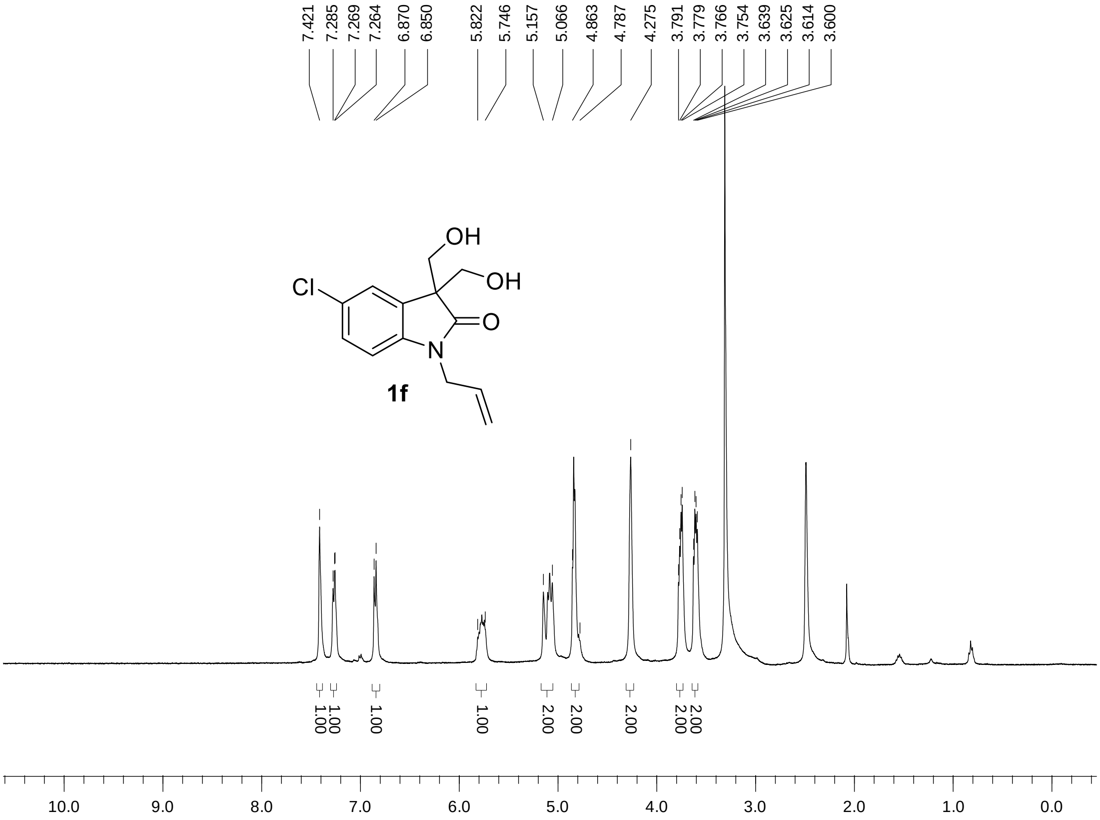


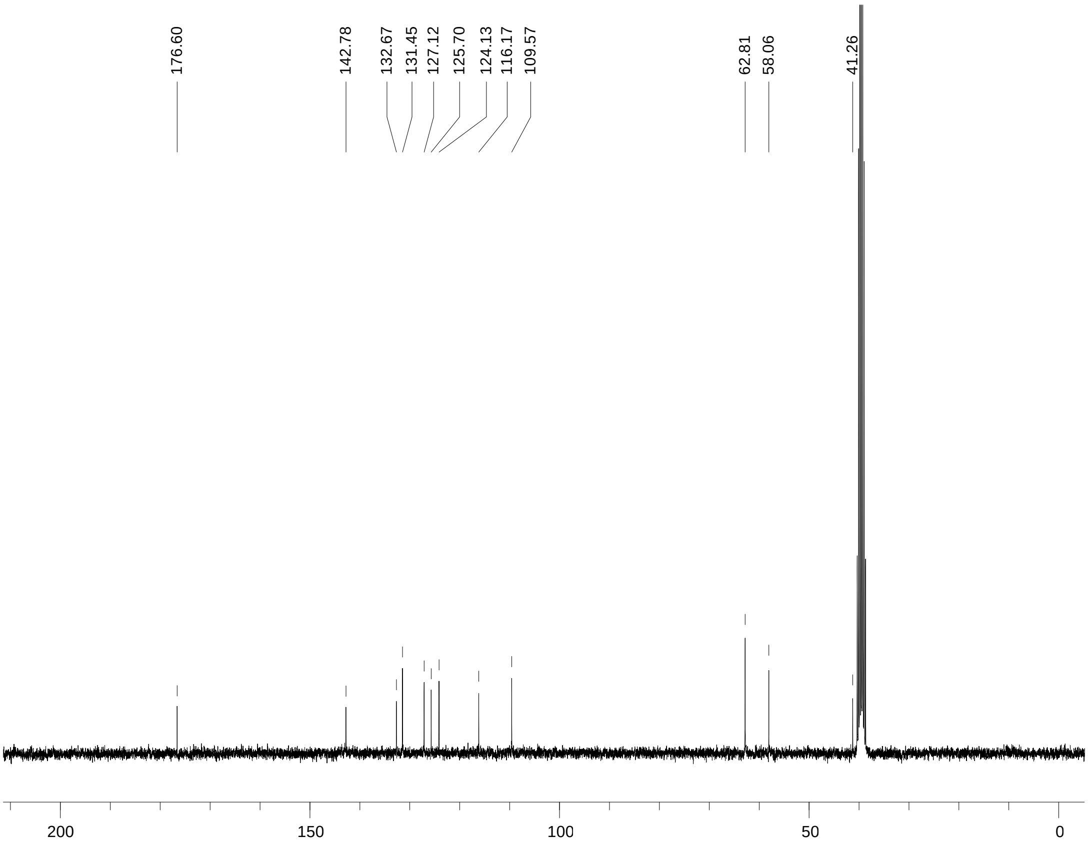
^{13}C NMR (75 MHz, DMSO-d$_6$)



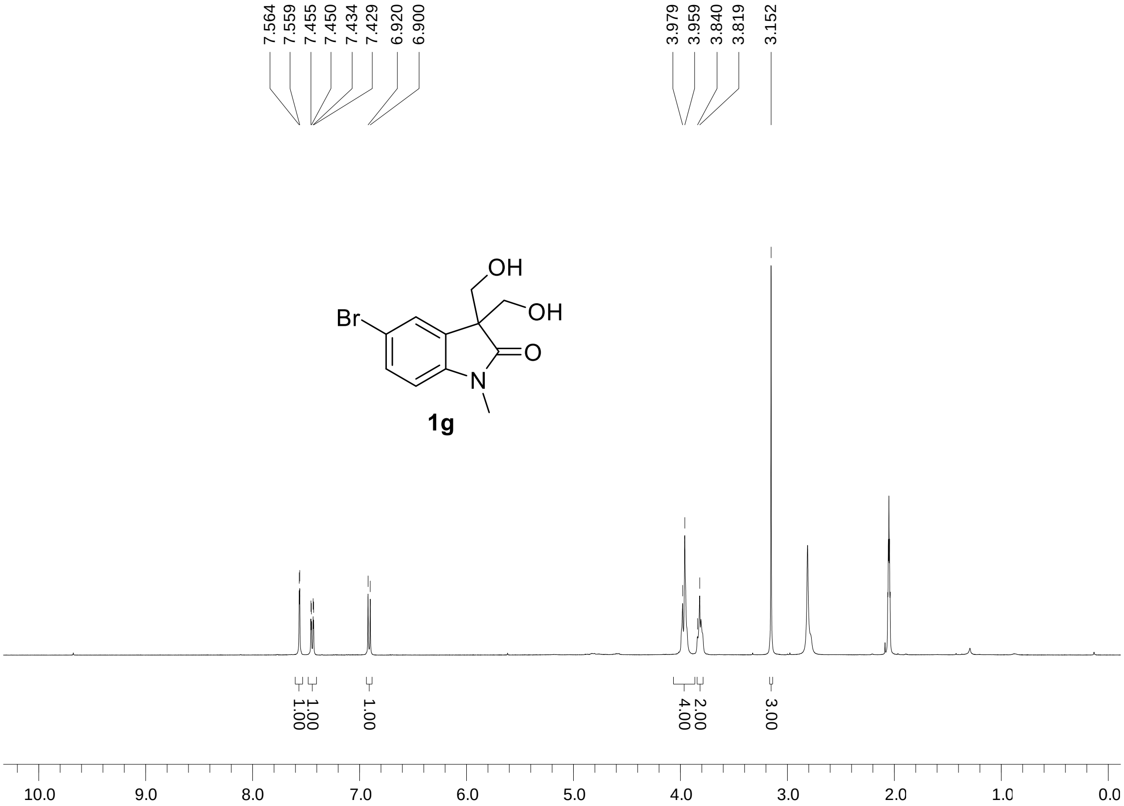
^{1}H NMR (400 MHz, DMSO-d_6)



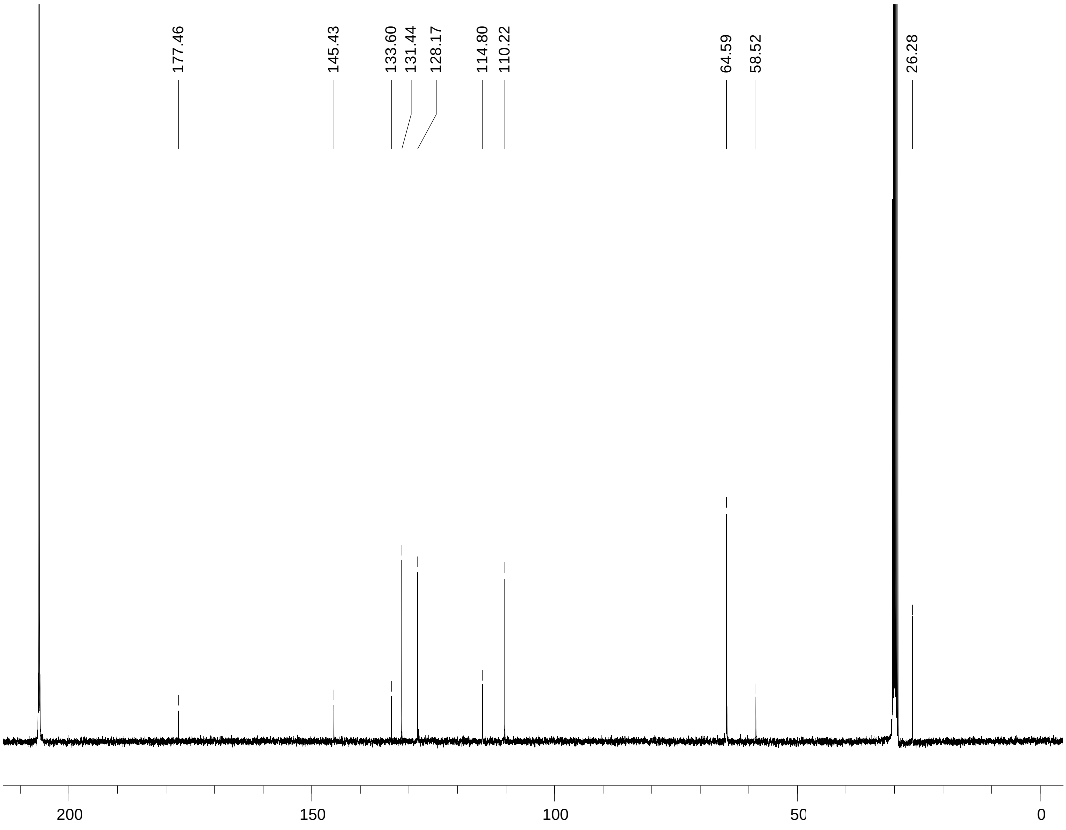
^{13}C NMR (75 MHz, DMSO-d_6)



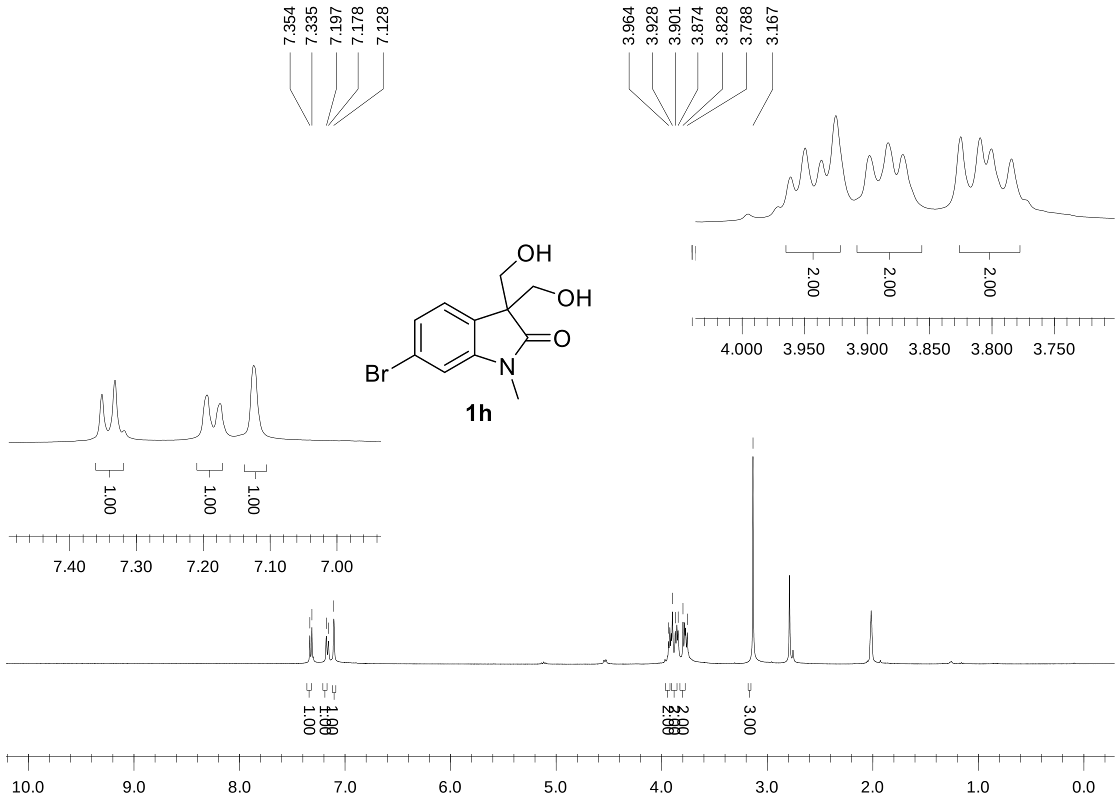
^{1}H NMR (400 MHz, acetone-d_6)



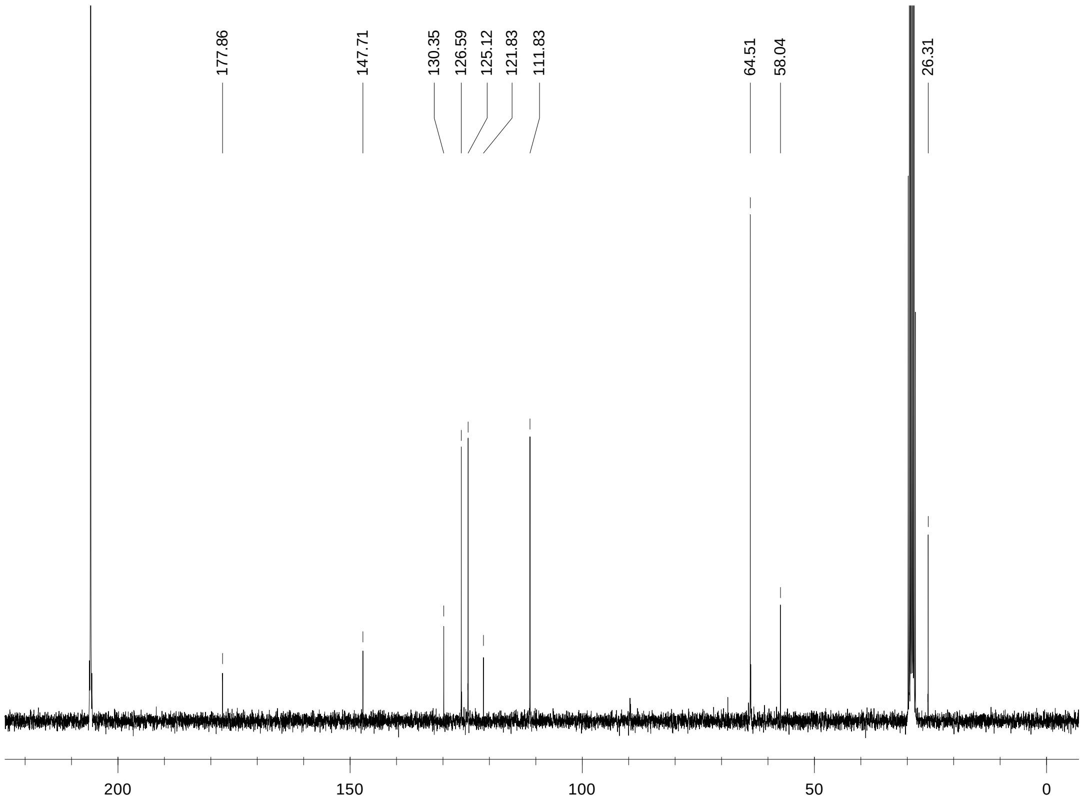
^{13}C NMR (100 MHz, acetone-d_6)



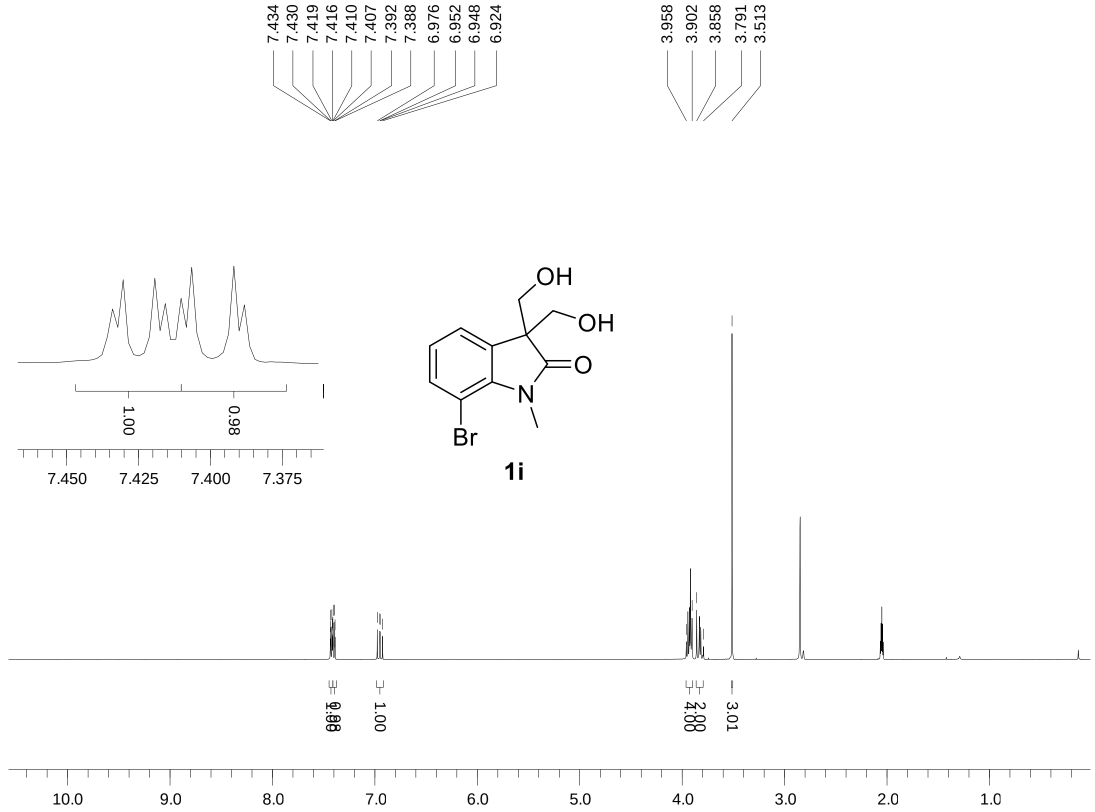
^{1}**H NMR** (400 MHz, acetone-d$_6$)



^{13}**C NMR** (75 MHz, acetone-d$_6$)



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



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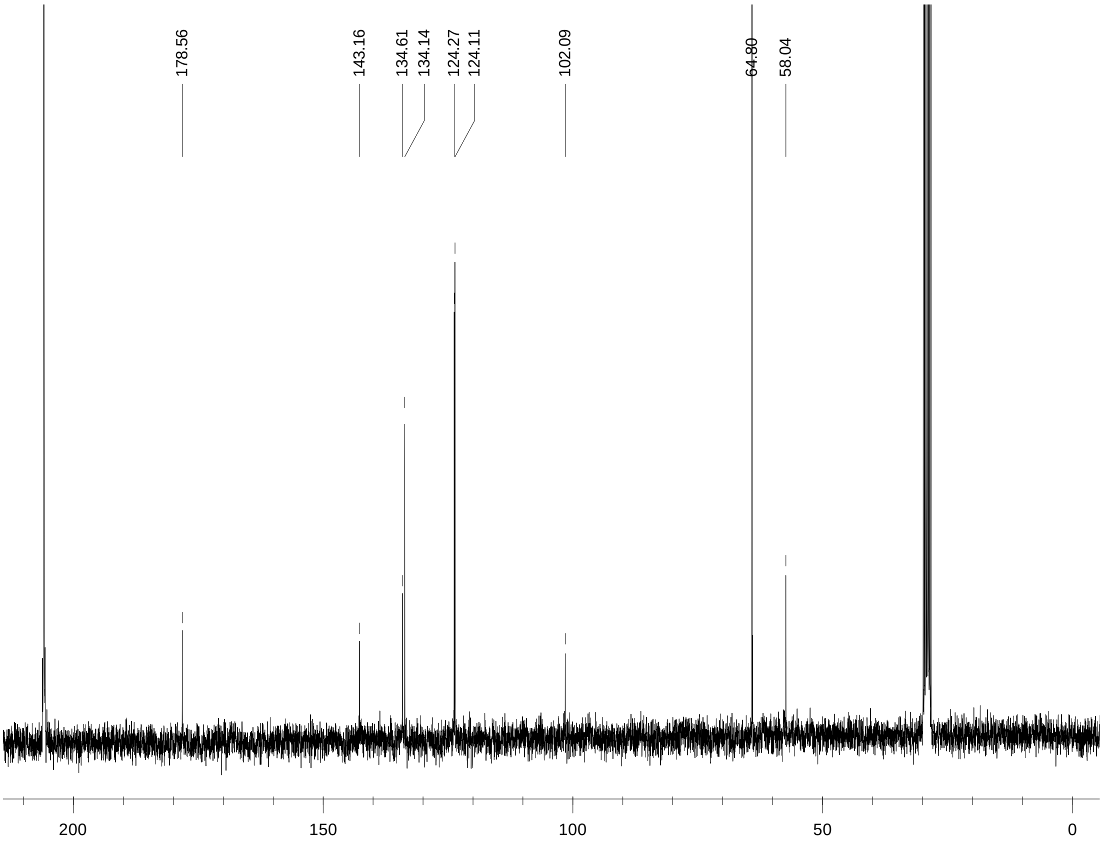
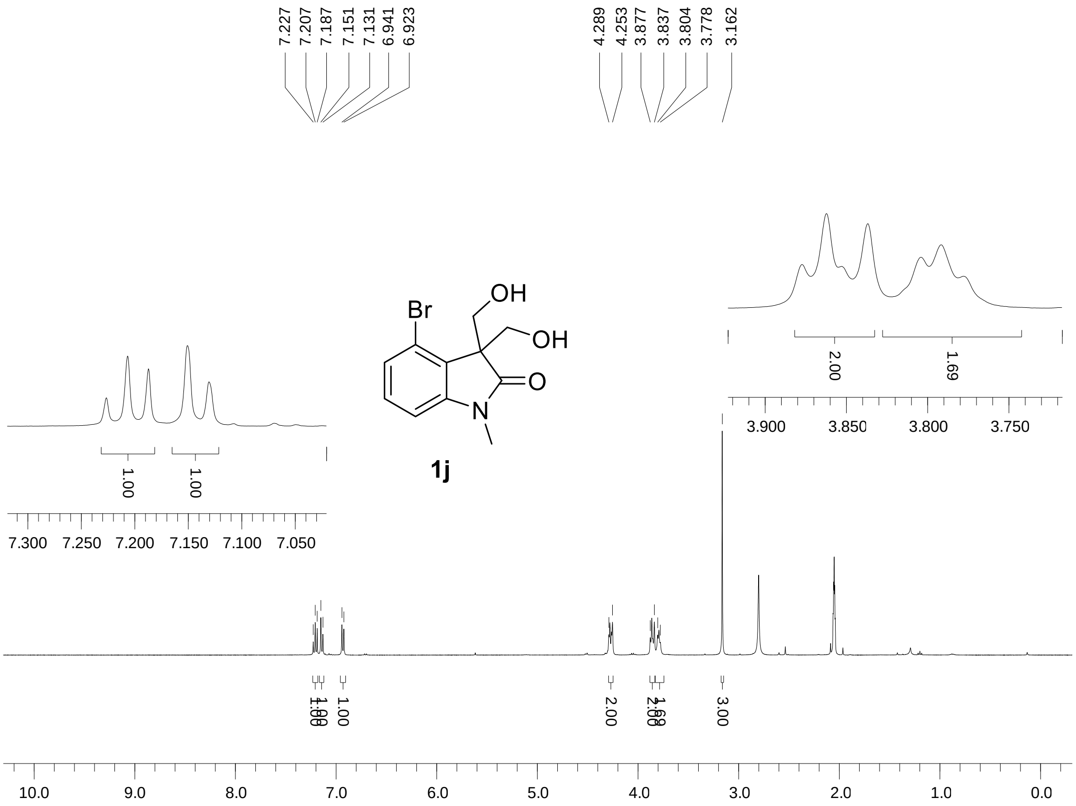
^{13}C NMR (75 MHz, acetone-d_6)



^{1}H NMR (400 MHz, acetone-d$_6$)



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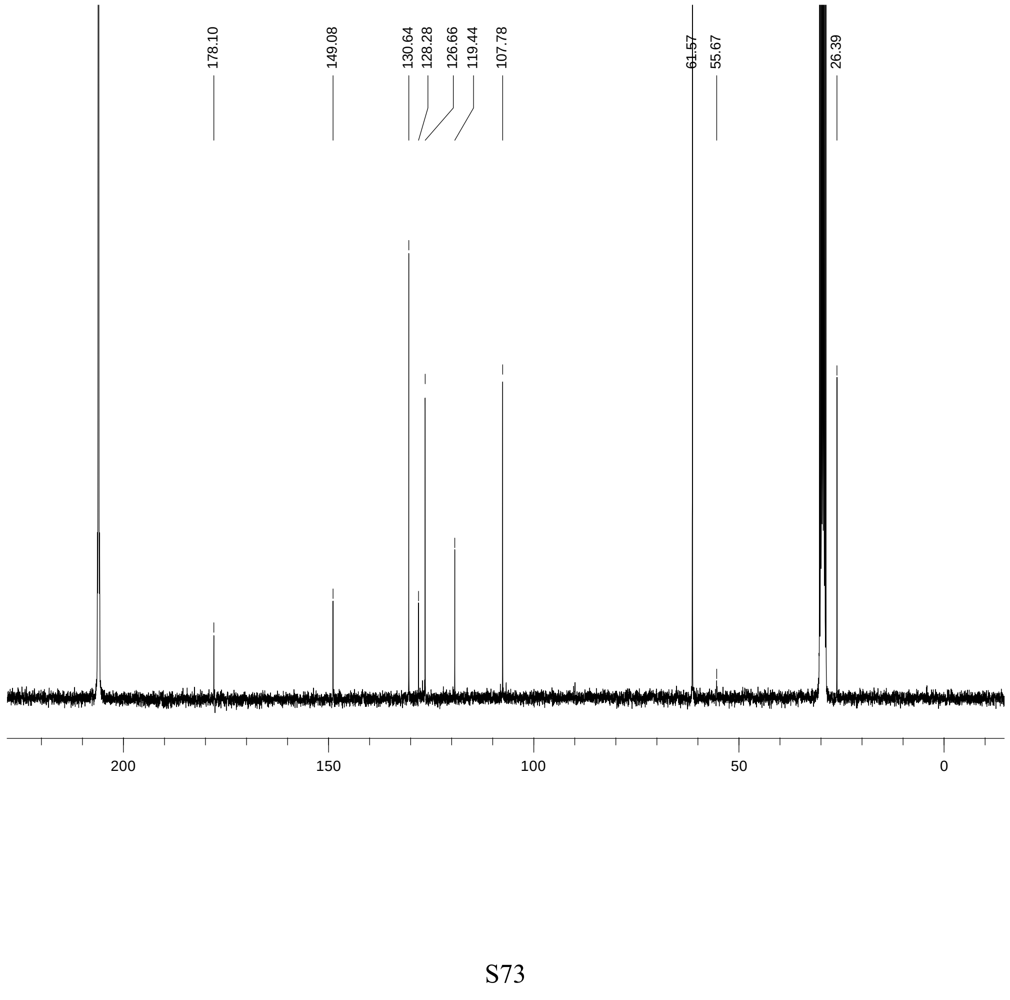
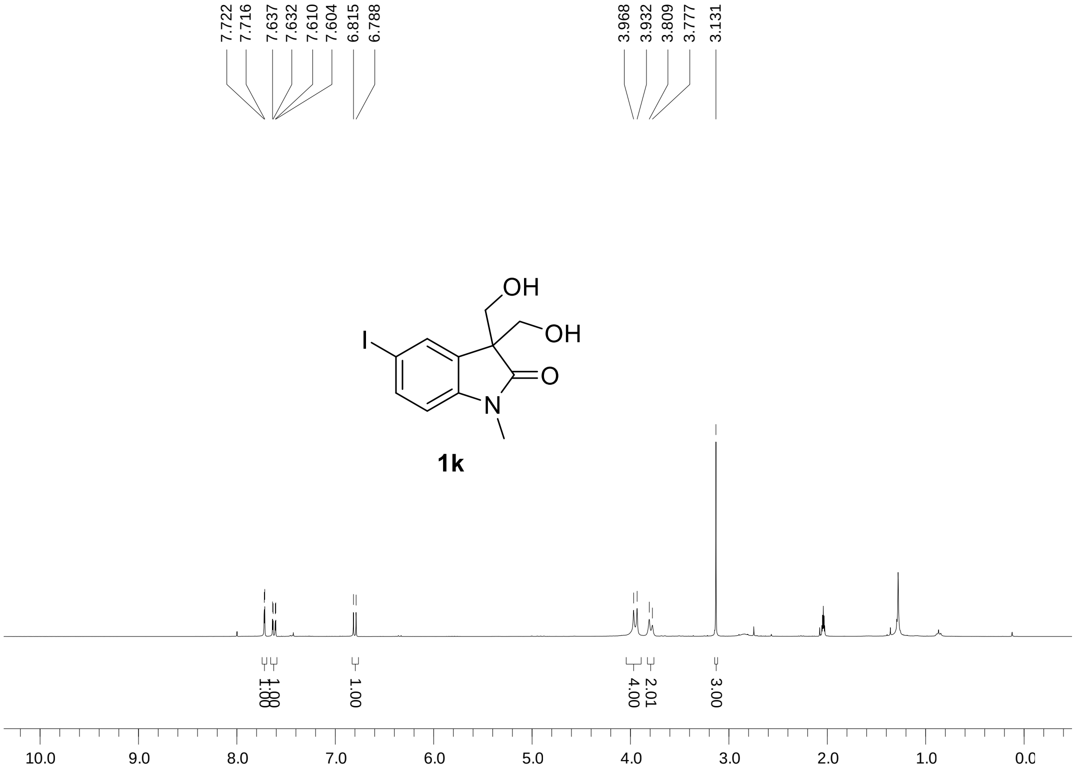
^{13}C NMR (75 MHz, acetone-d$_6$)



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



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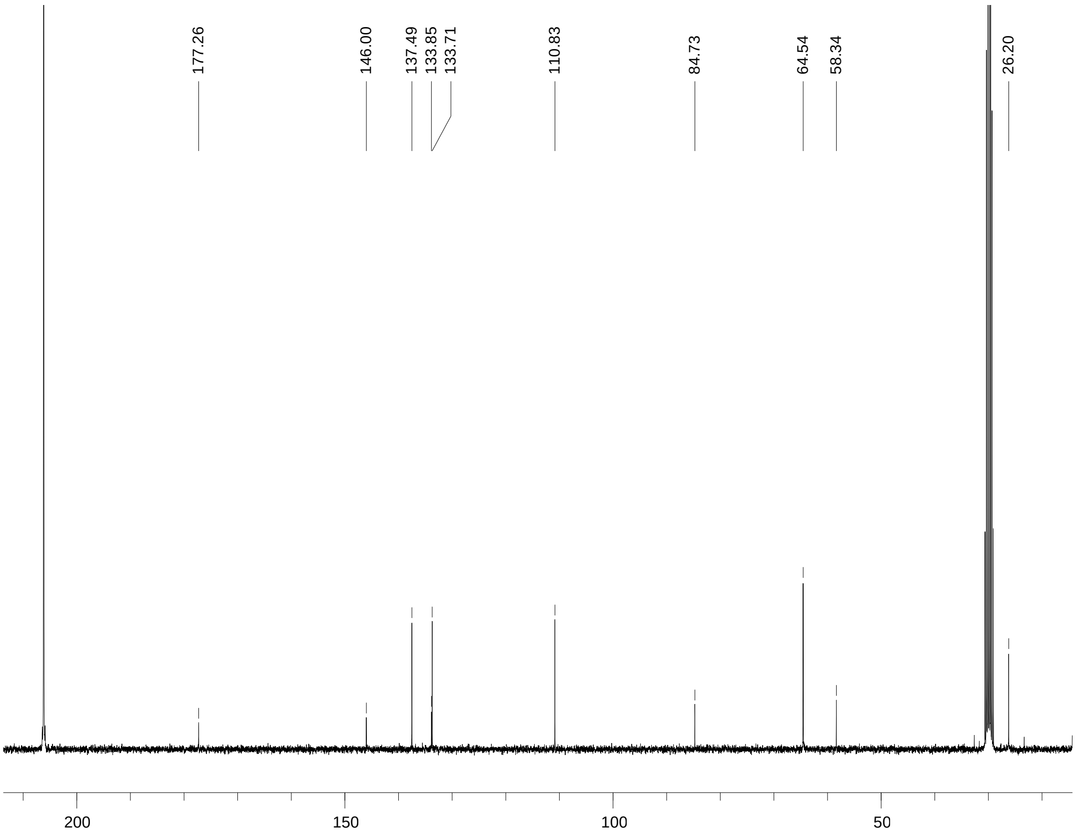
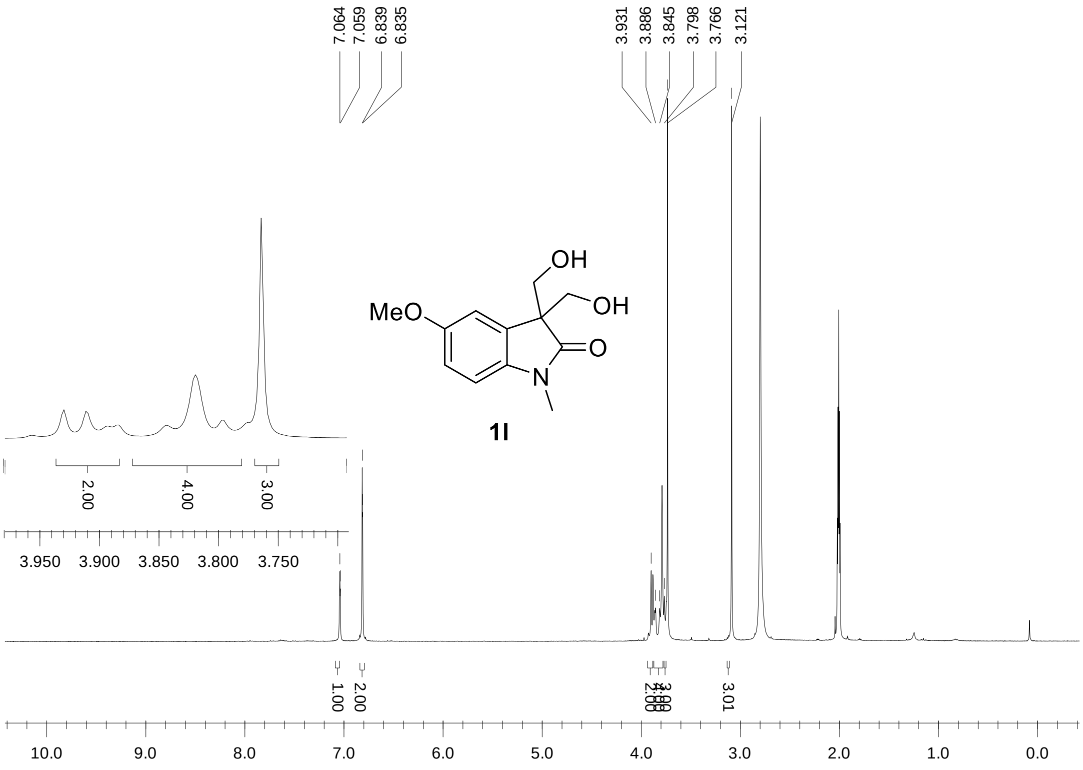
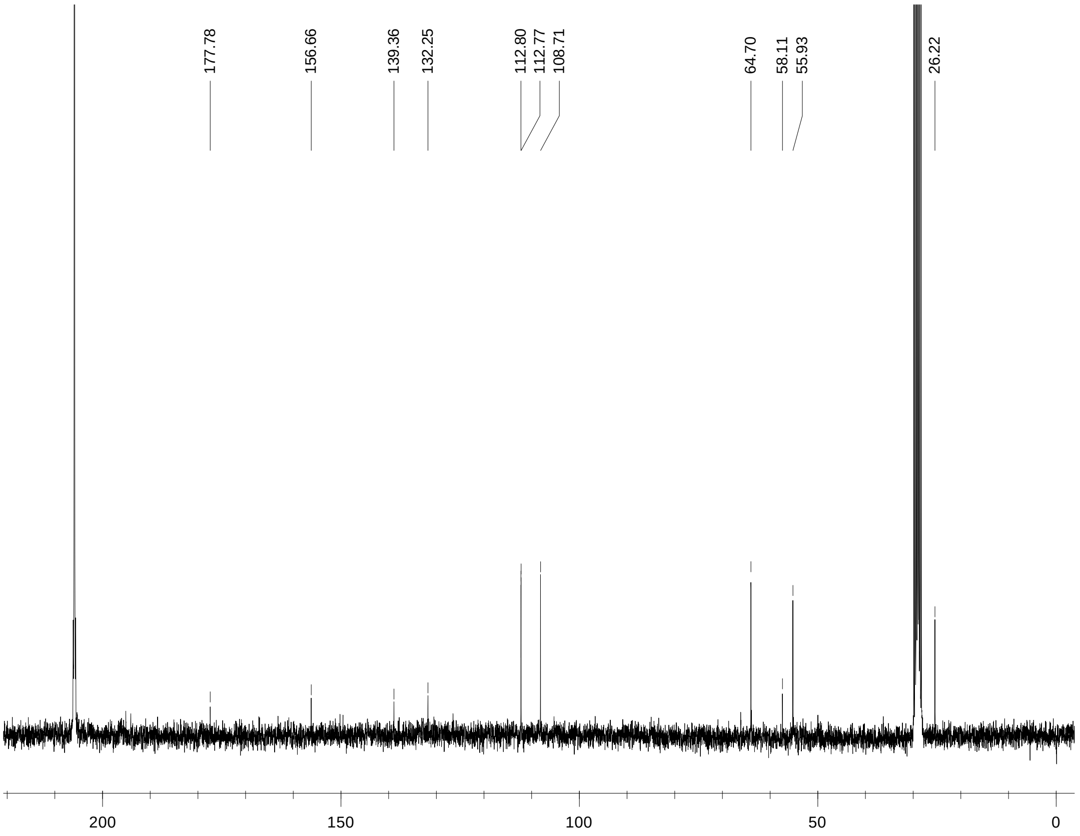
^{13}C NMR (75 MHz, acetone-d_6)



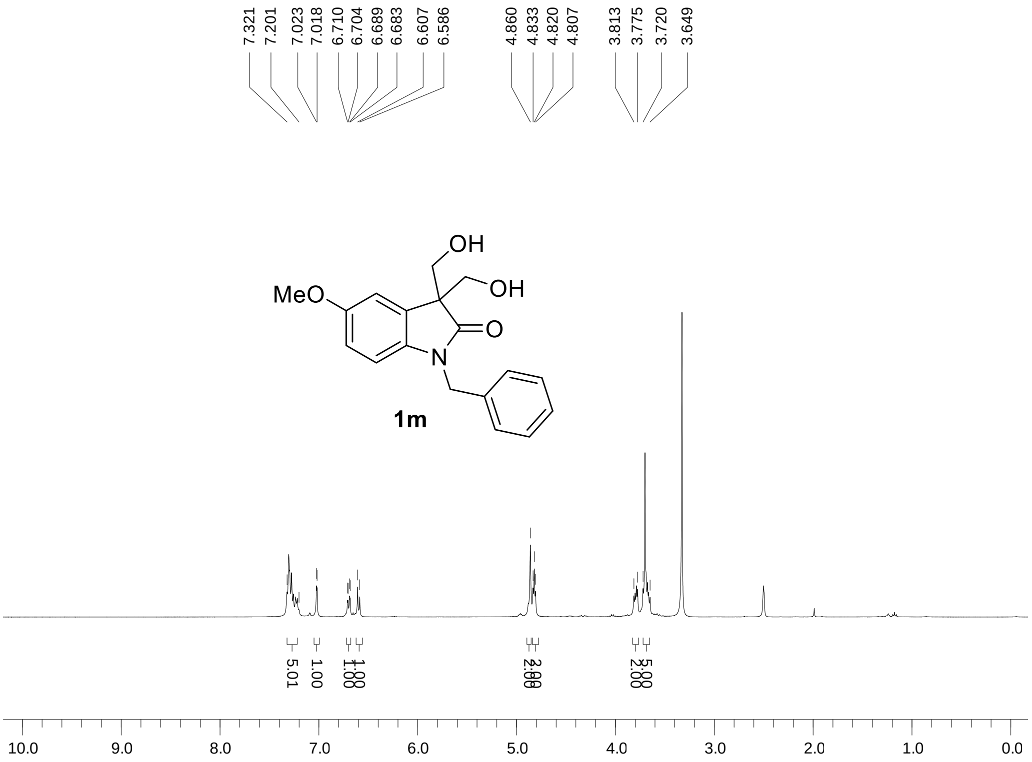
^{1}H NMR (300 MHz, acetone-d$_6$)



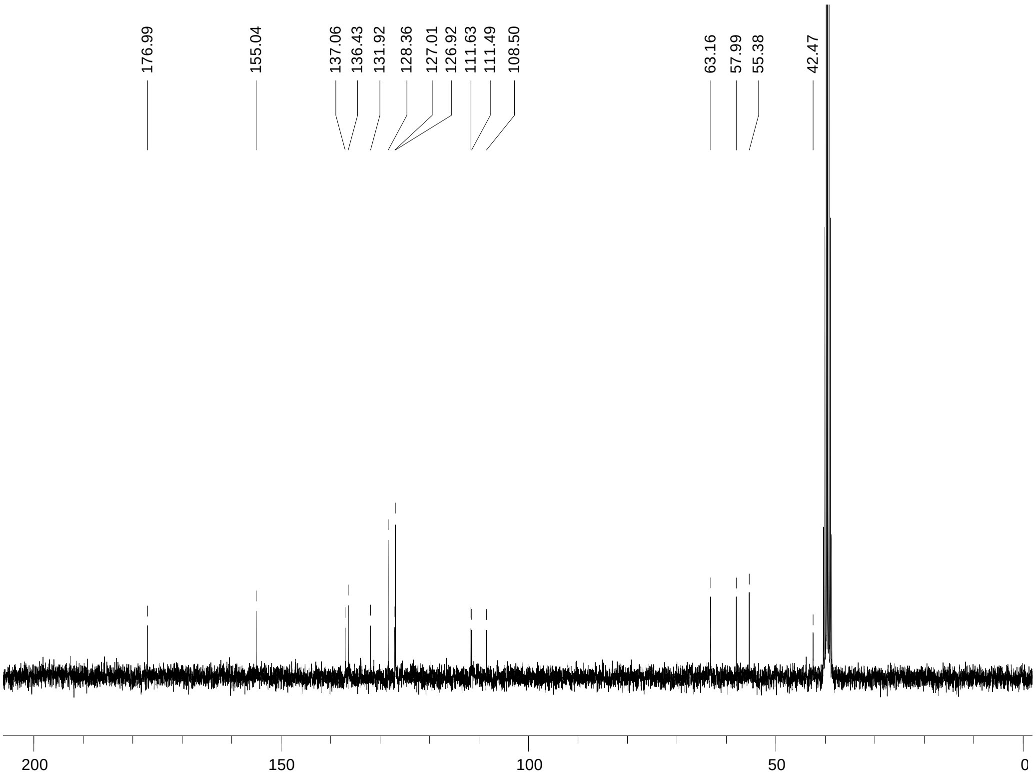
^{13}C NMR (75 MHz, acetone-d$_6$)



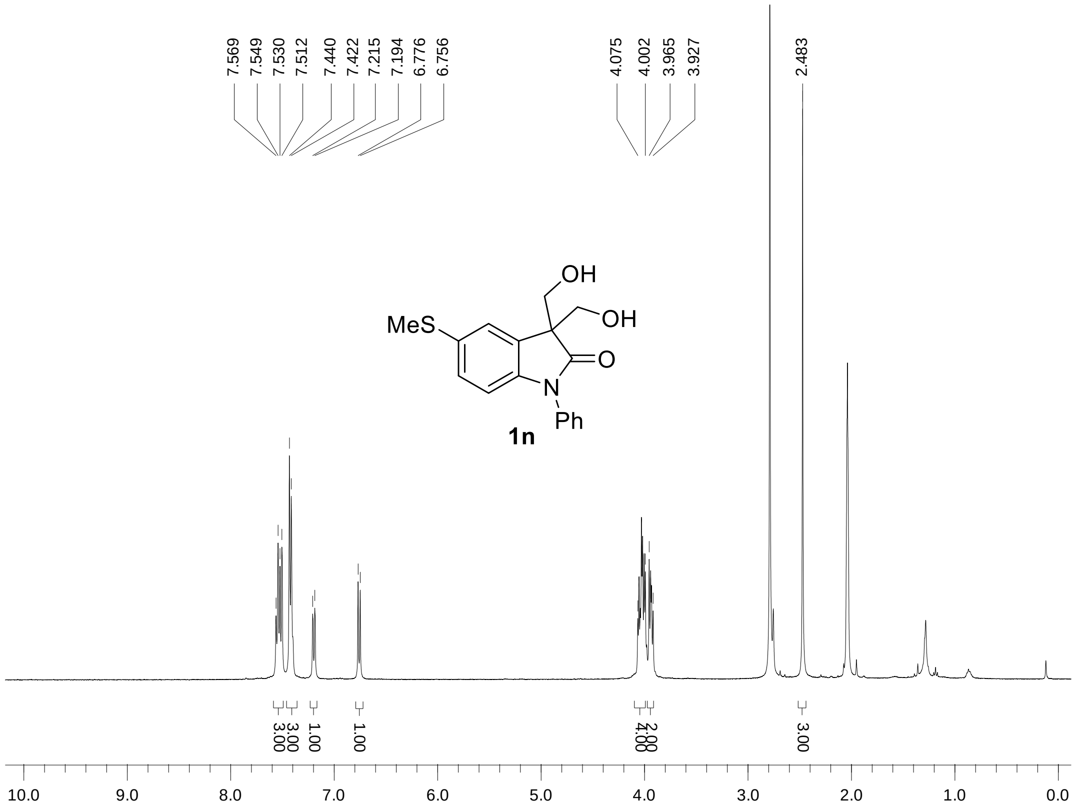
^{1}H NMR (400 MHz, DMSO-d$_6$)



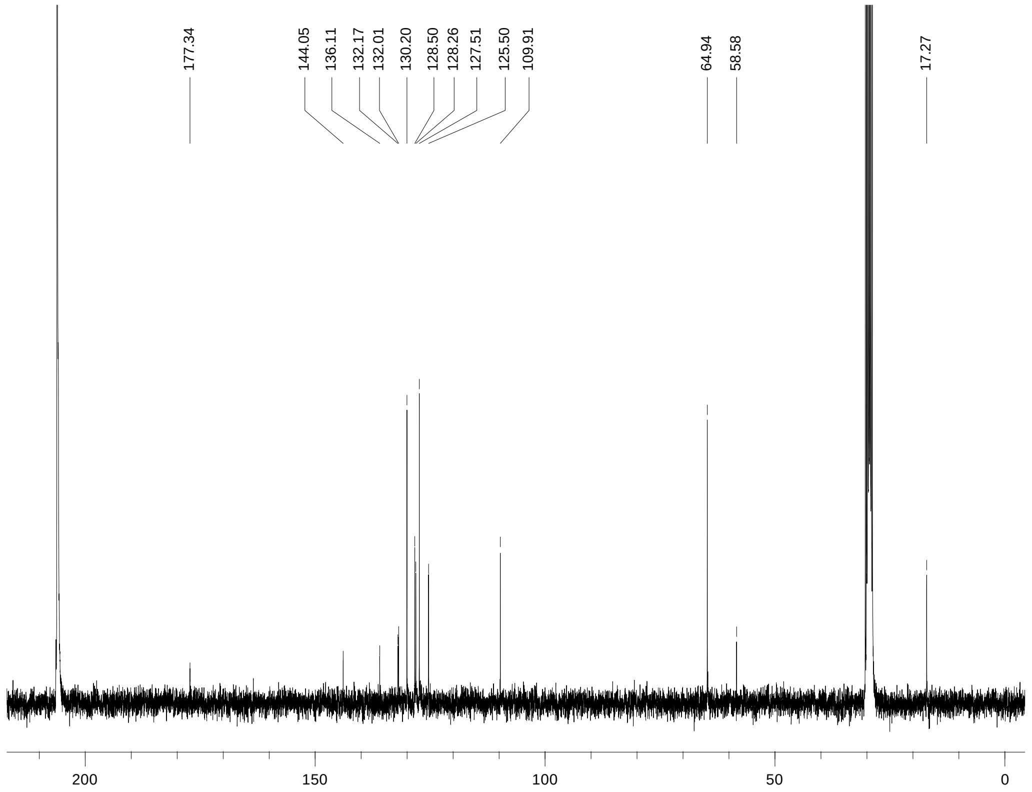
^{13}C NMR (75 MHz, DMSO-d$_6$)



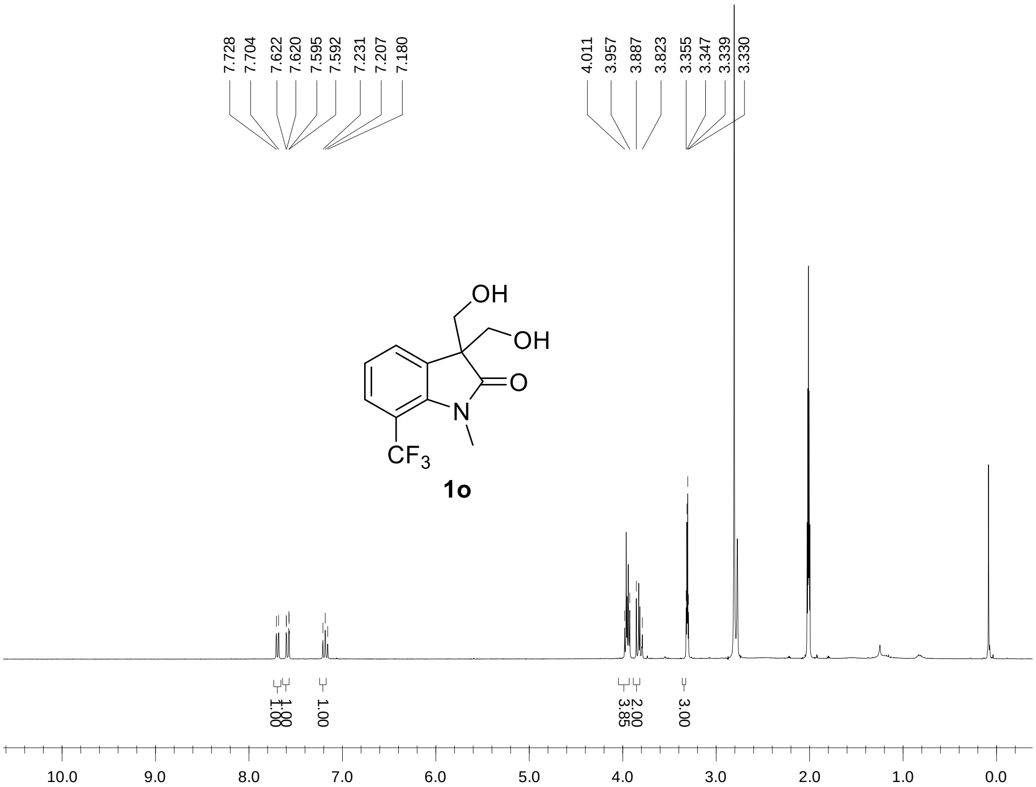
^{1}H NMR (400 MHz, acetone-d$_6$)



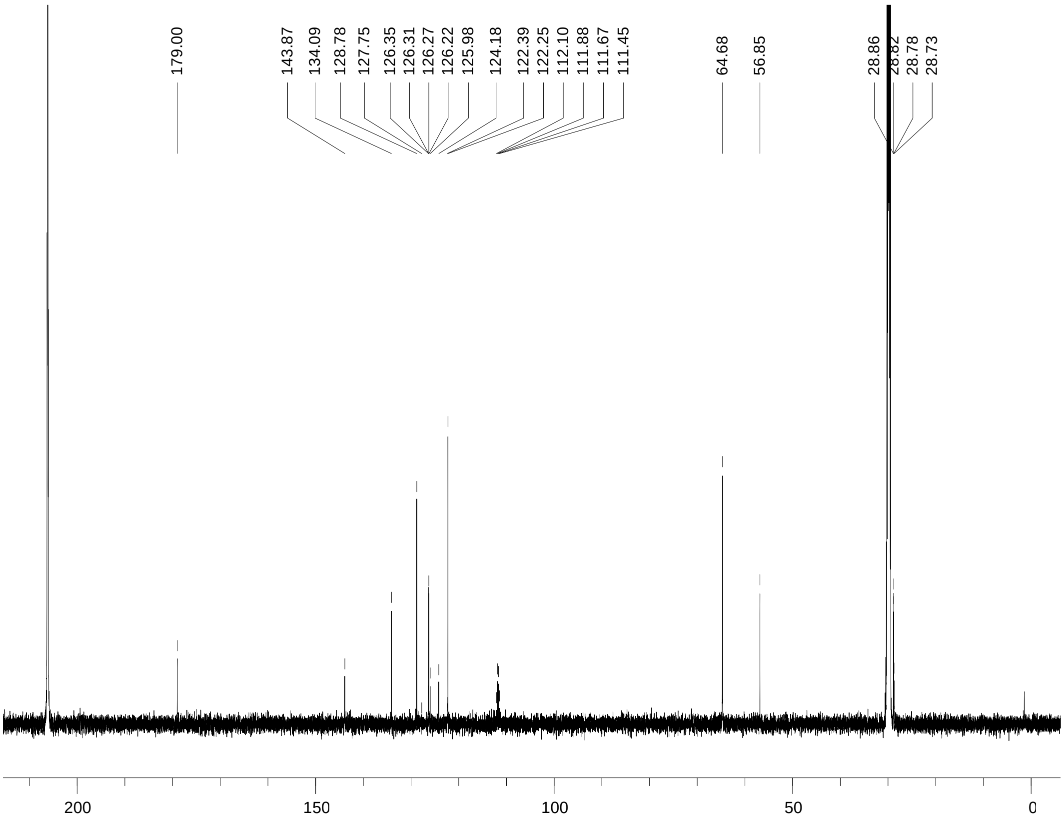
^{13}C NMR (75 MHz, acetone-d$_6$)



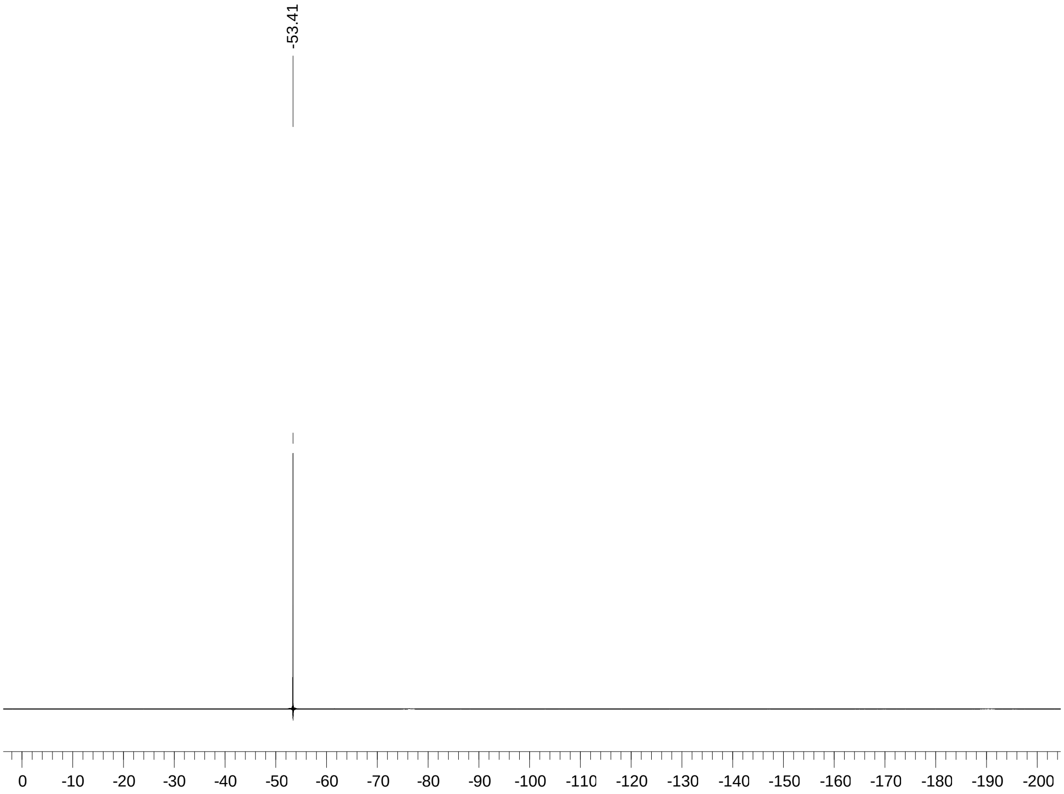
^{1}H NMR (300 MHz, acetone-d_6)



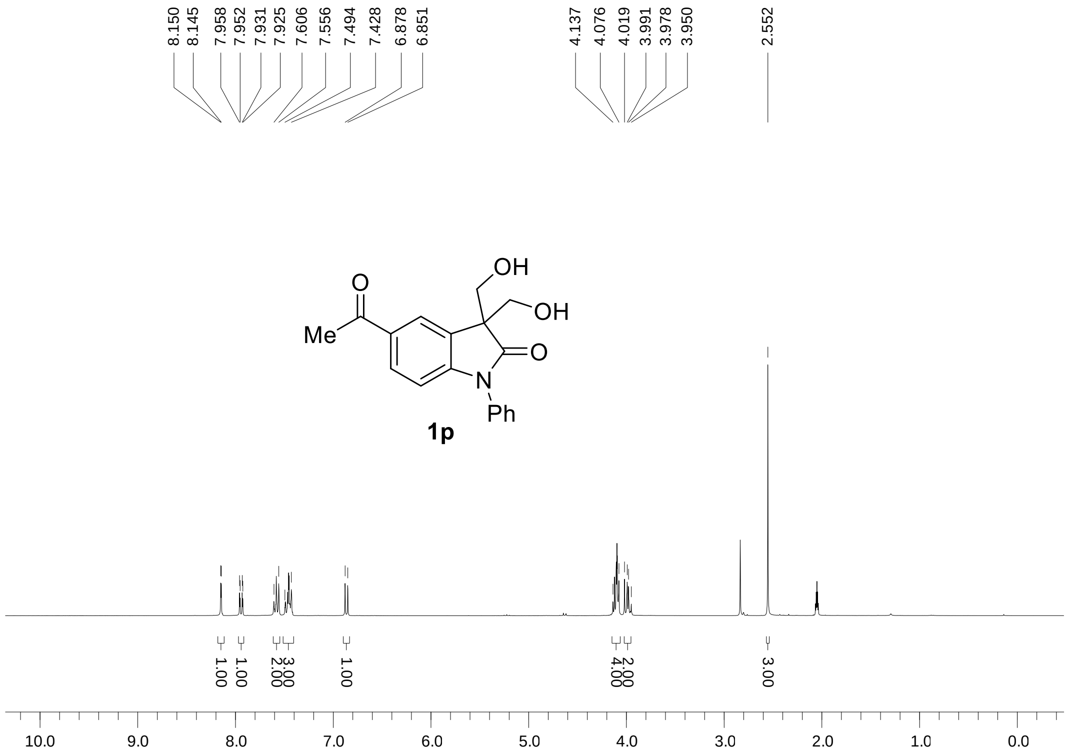
^{13}C NMR (150 MHz, acetone-d_6)



^{19}**F NMR** (564 MHz, acetone-d$_6$)



^{1}H NMR (300 MHz, acetone-d$_6$)



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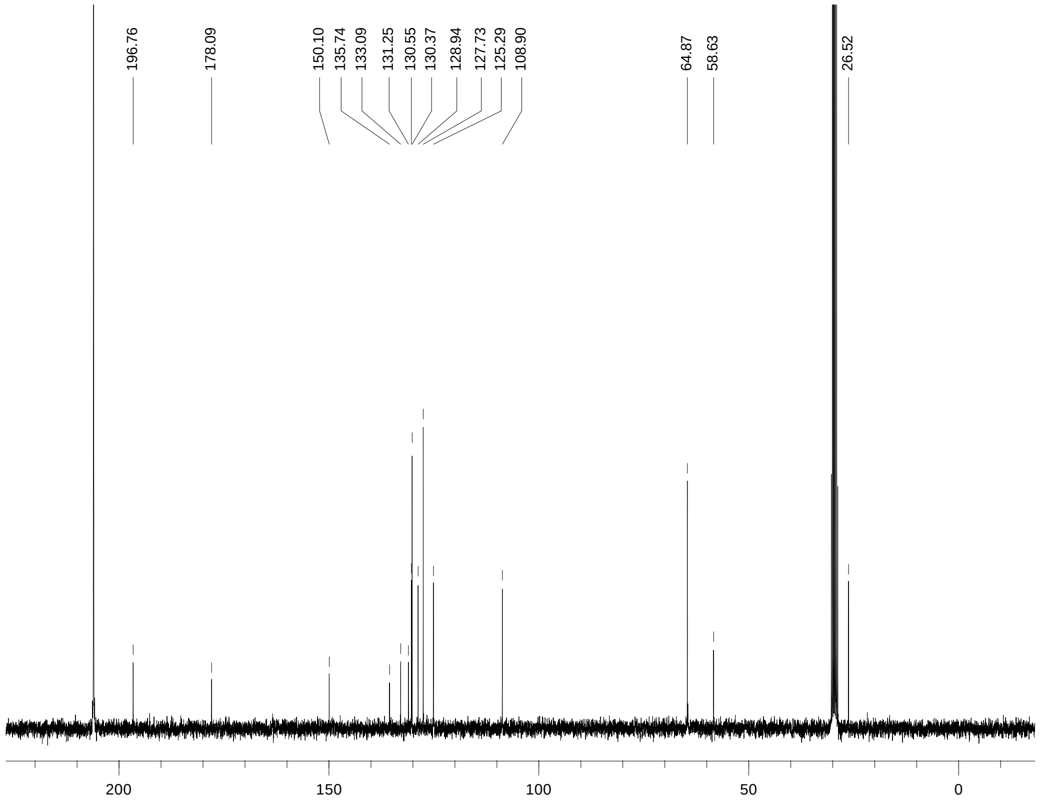
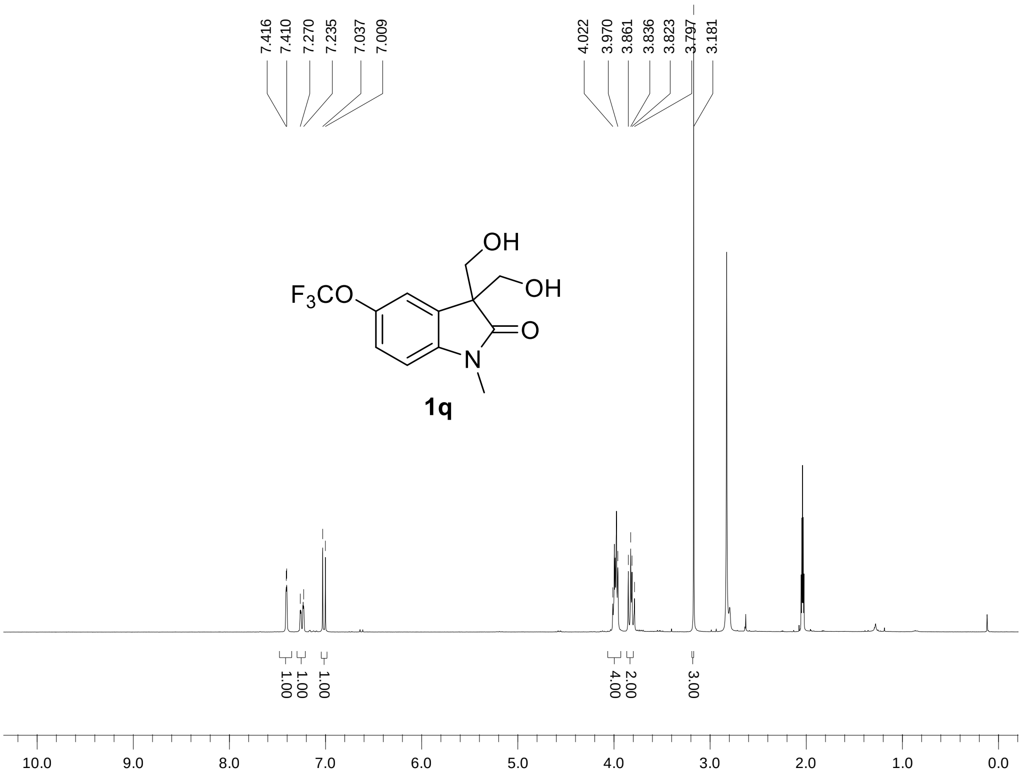
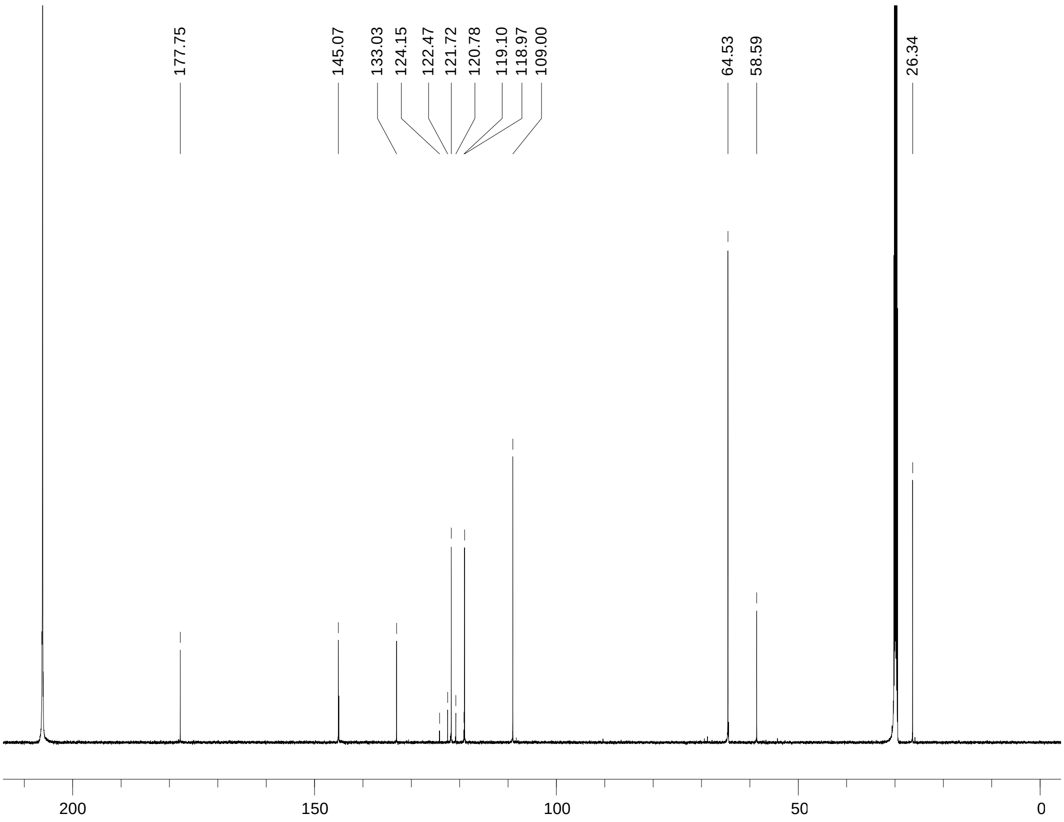
^{13}C NMR (75 MHz, acetone-d$_6$)



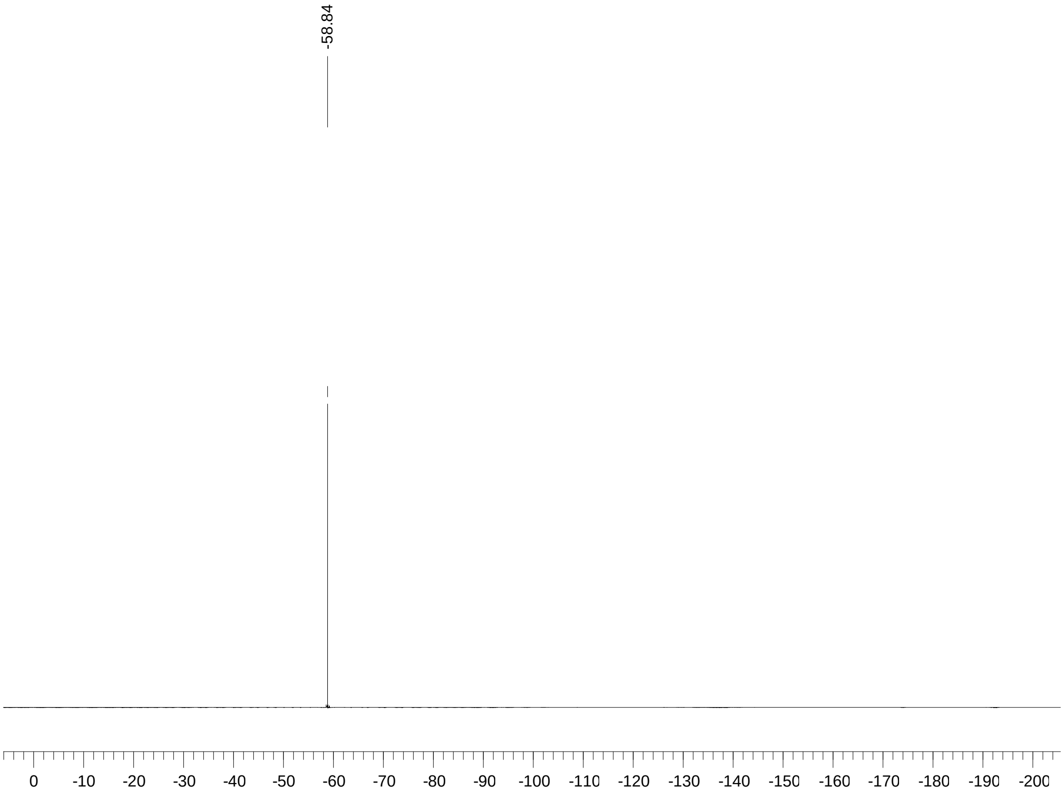
^{1}H NMR (300 MHz, acetone-d_6)



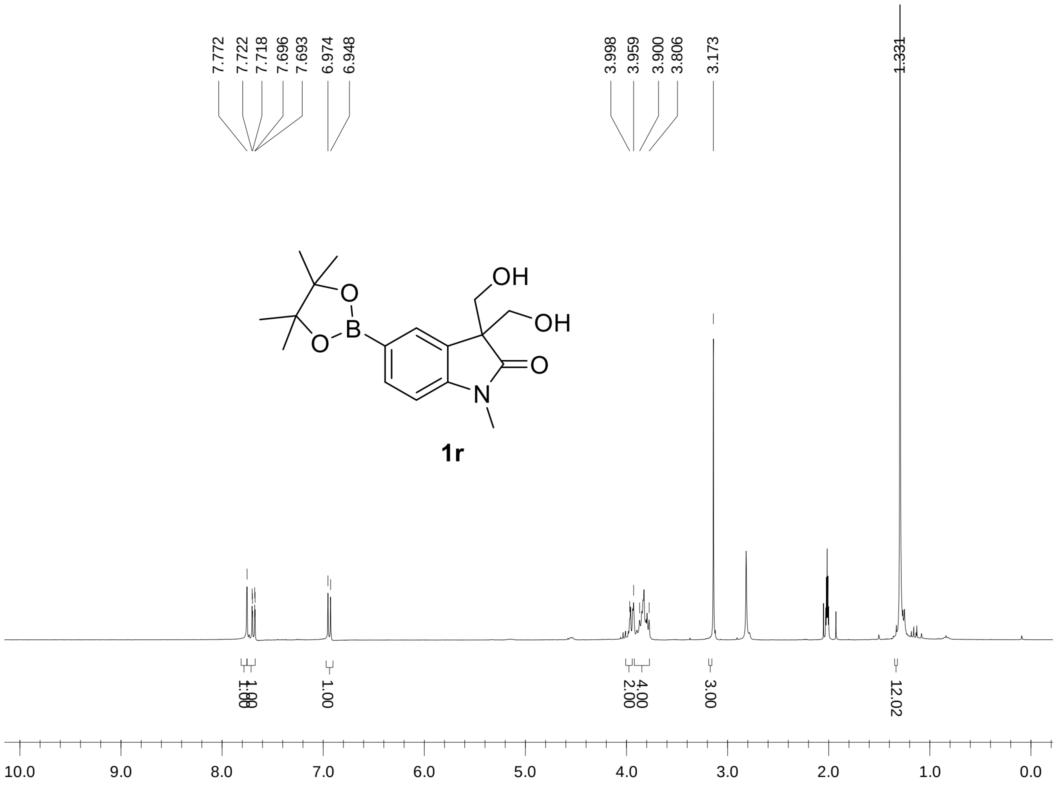
^{13}C NMR (150 MHz, acetone-d_6)



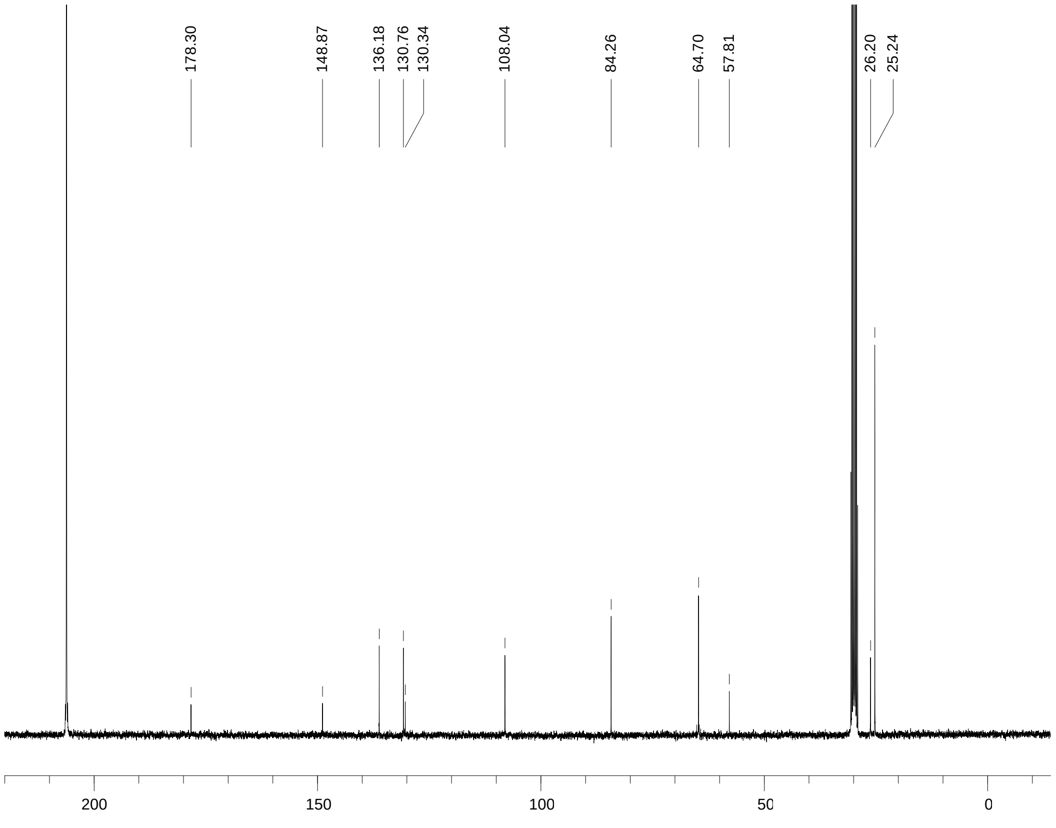
^{19}**F NMR** (564 MHz, acetone-d_6)



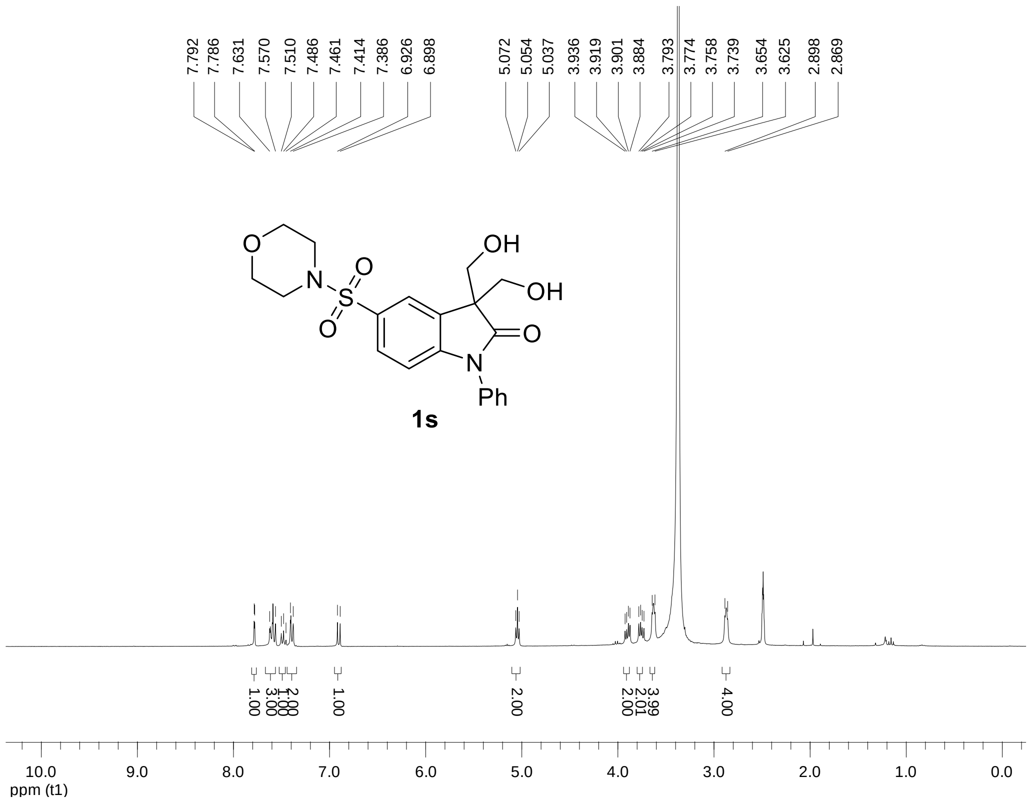
^{1}H NMR (300 MHz, acetone-d_6)



^{13}C NMR (75 MHz, acetone-d_6)



^{1}H NMR (300 MHz, DMSO-d_6)



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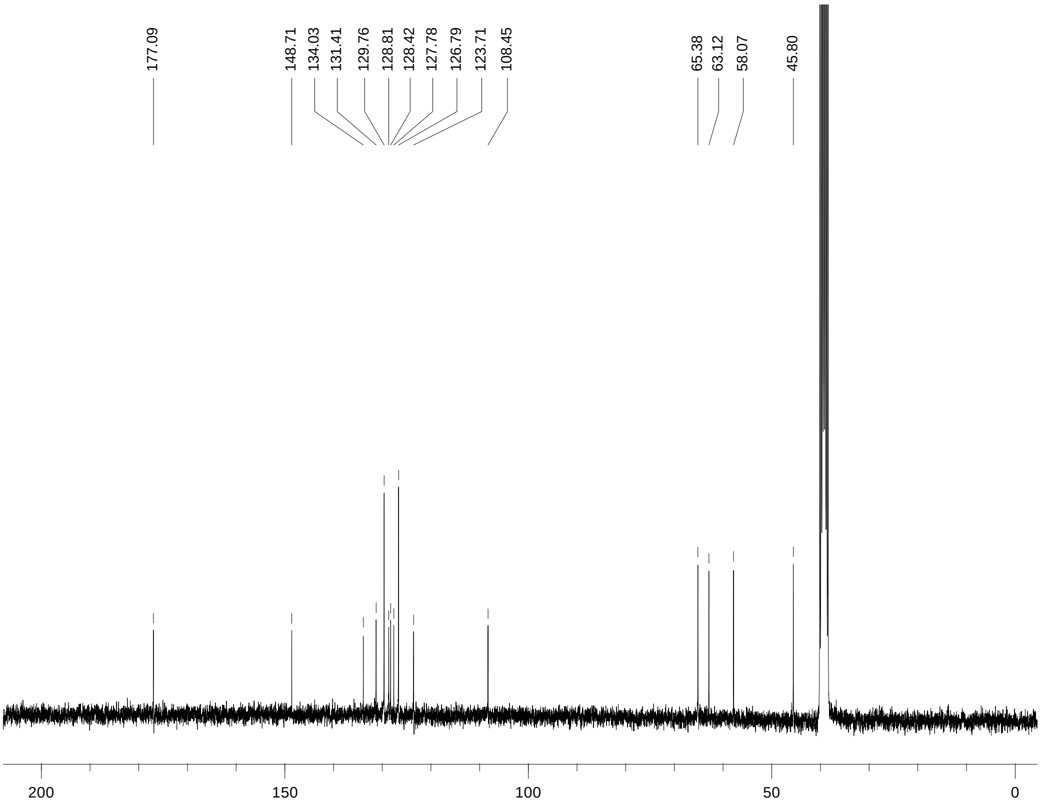
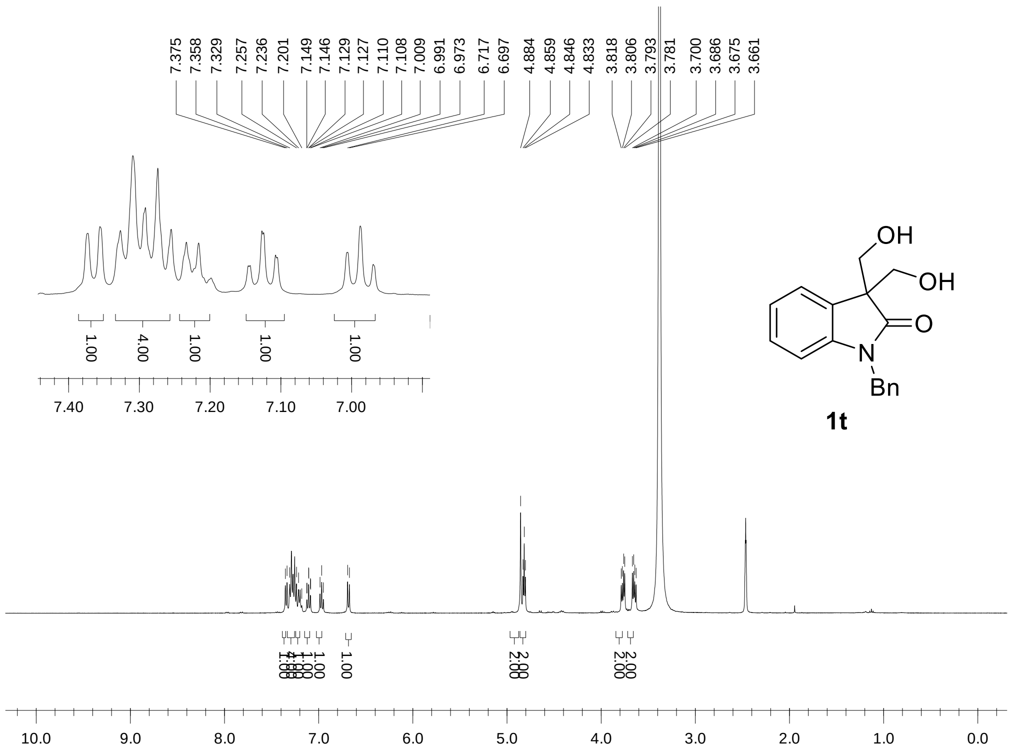
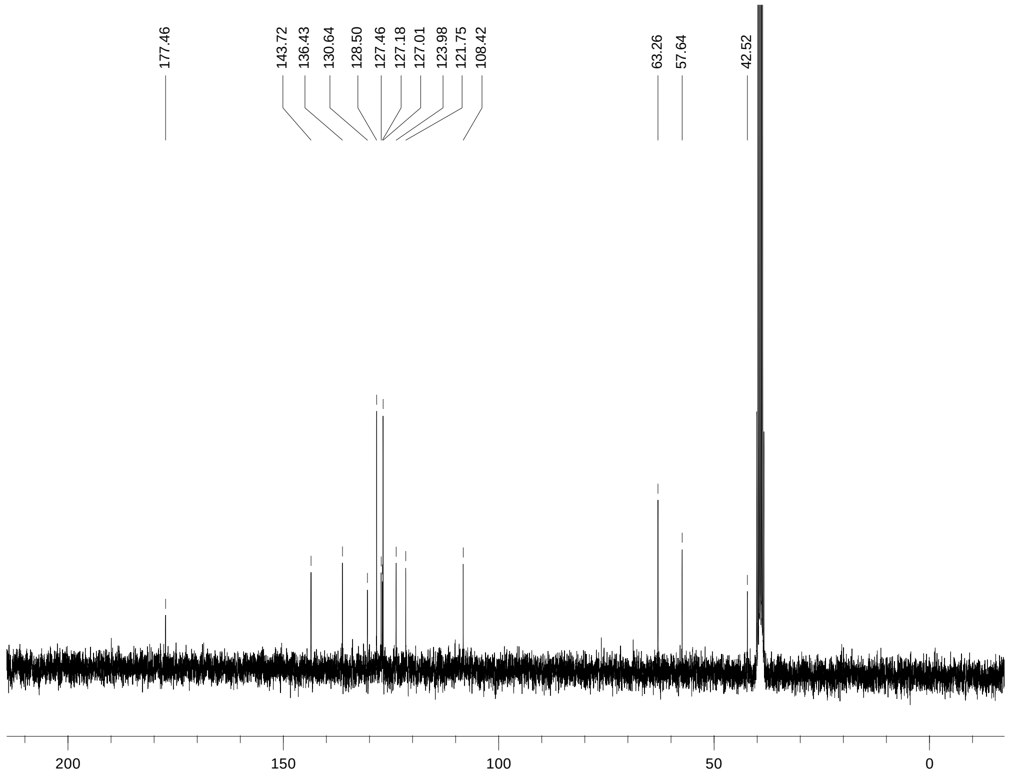


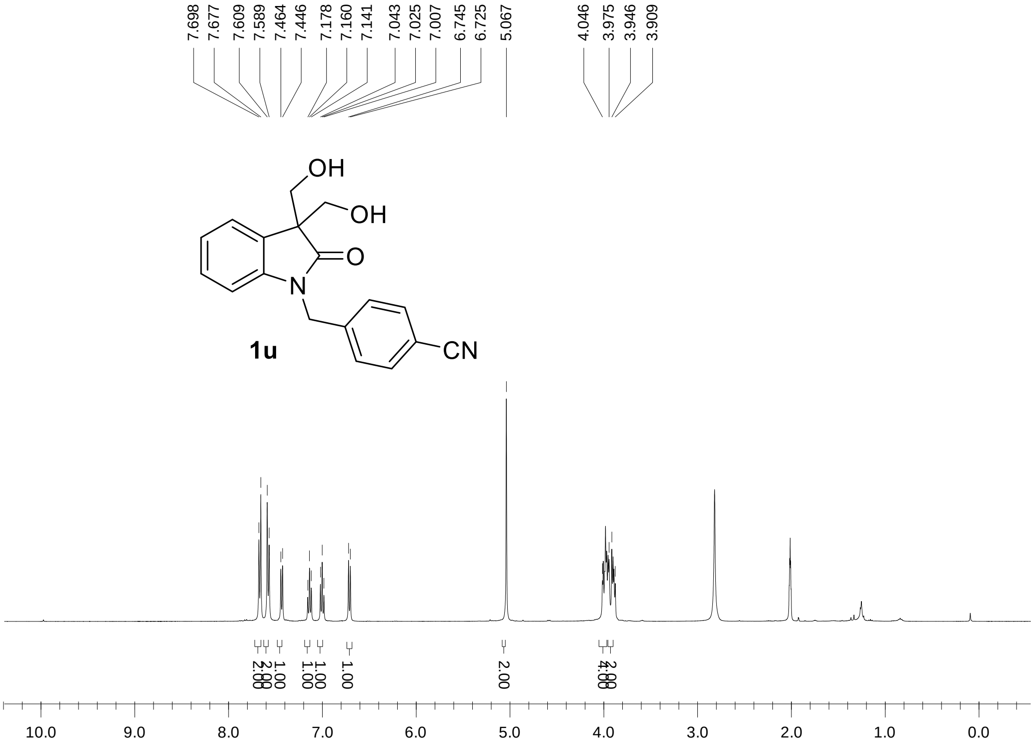
^{1}H NMR (400 MHz, DMSO-d_6)



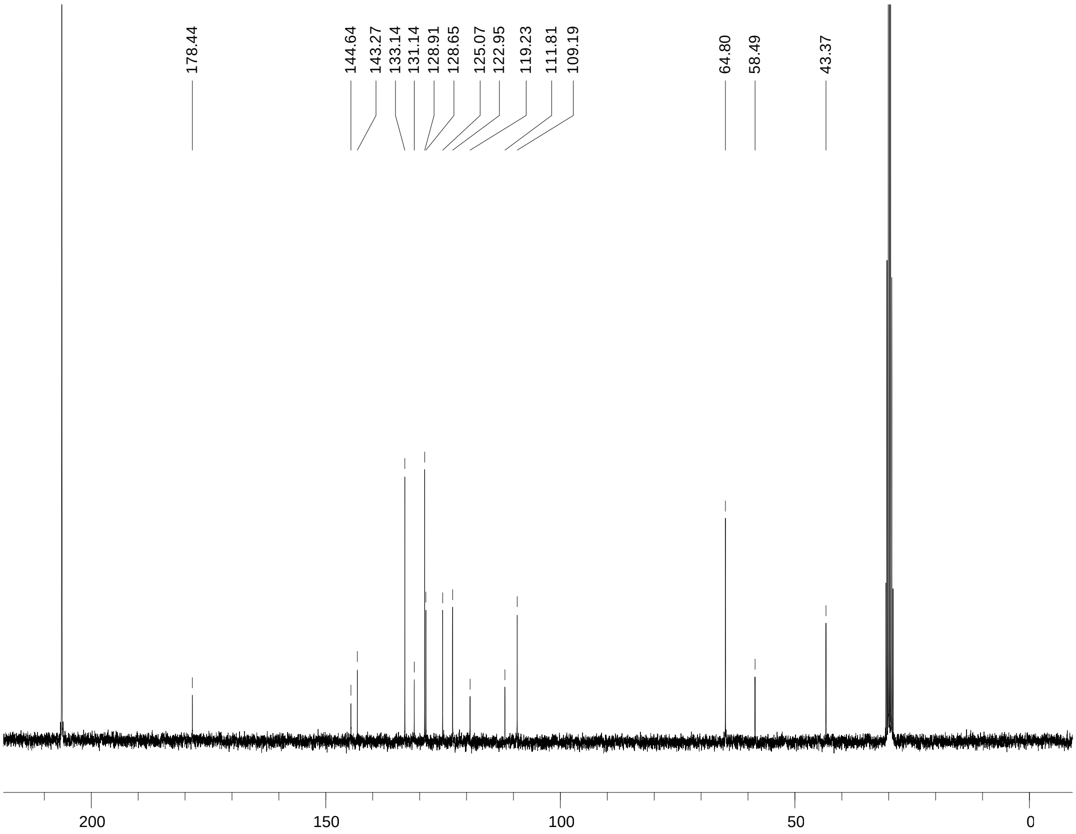
^{13}C NMR (75 MHz, DMSO-d_6)



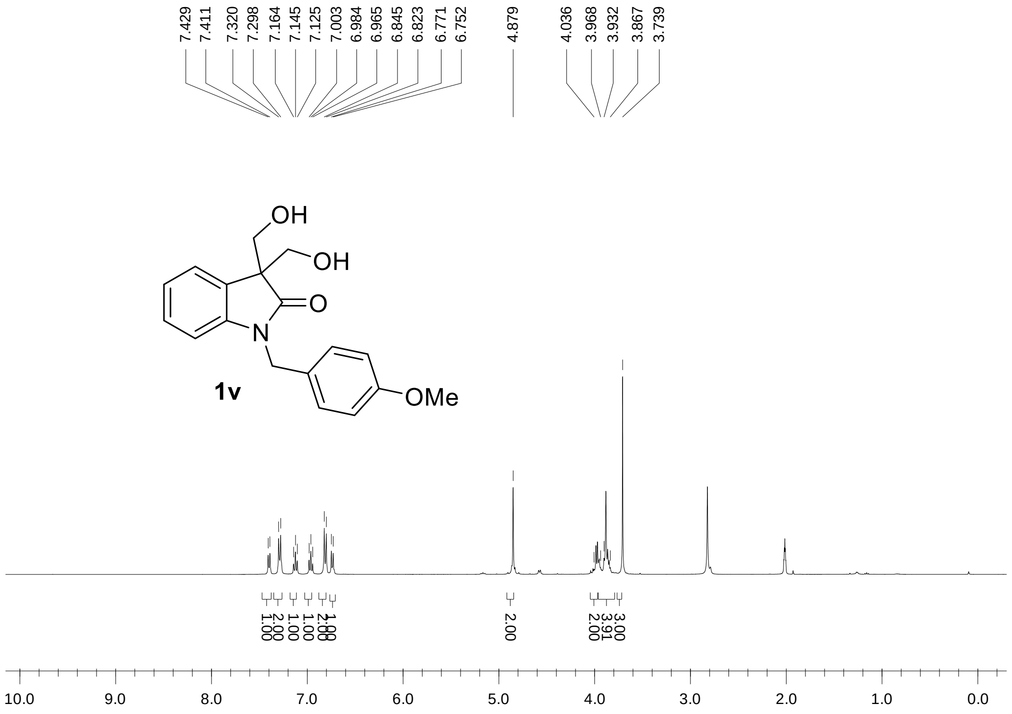
^{1}H NMR (400 MHz, acetone-d_6)



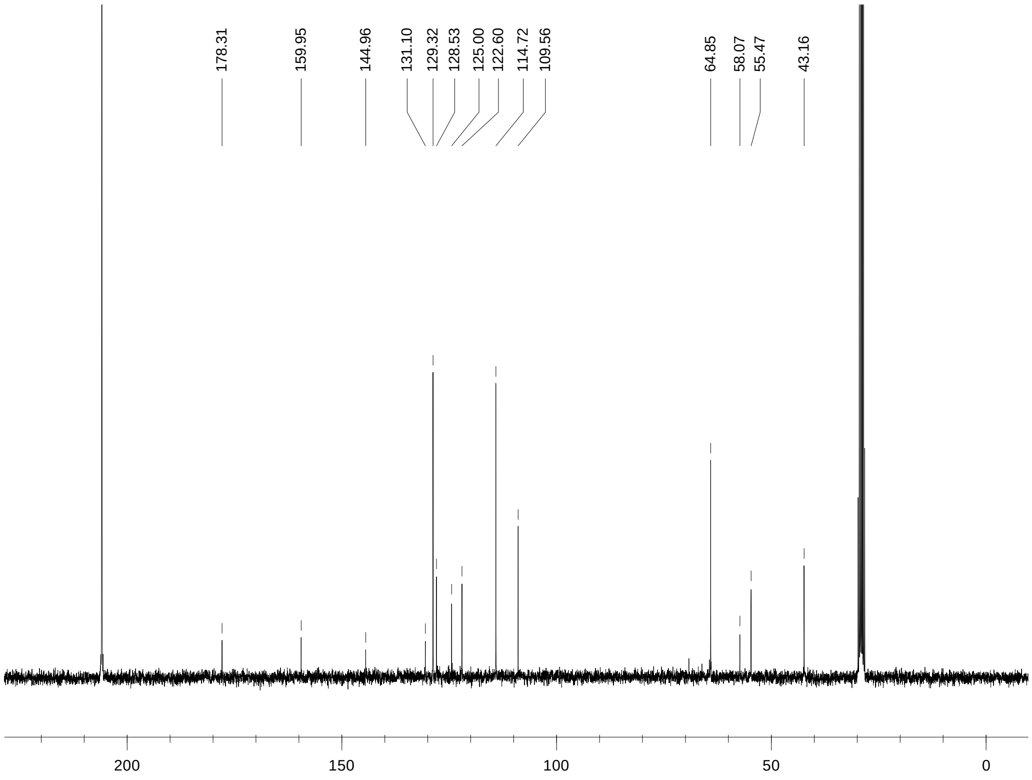
^{13}C NMR (75 MHz, acetone-d_6)



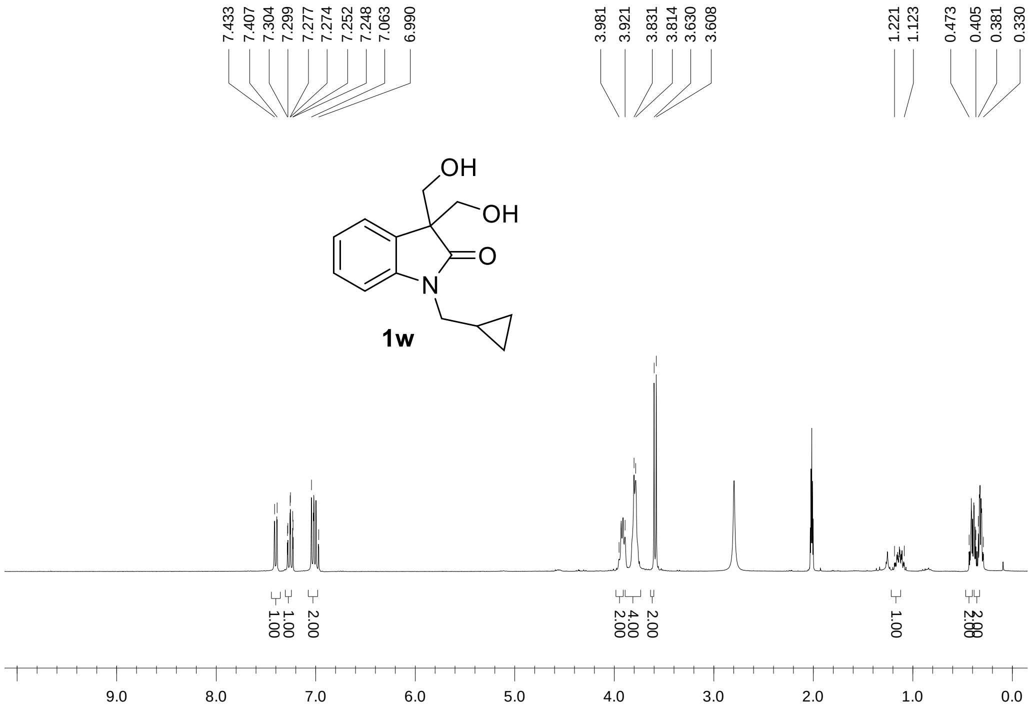
^{1}H NMR (400 MHz, acetone-d$_6$)



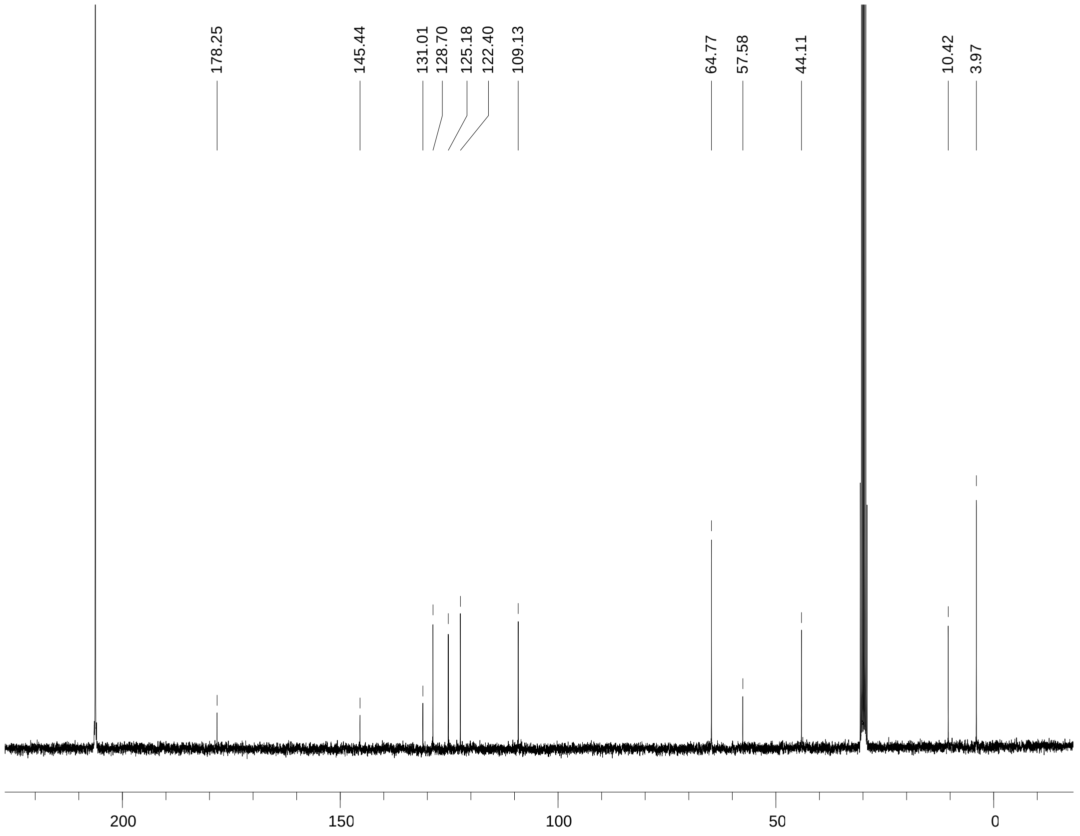
^{13}C NMR (75 MHz, acetone-d$_6$)



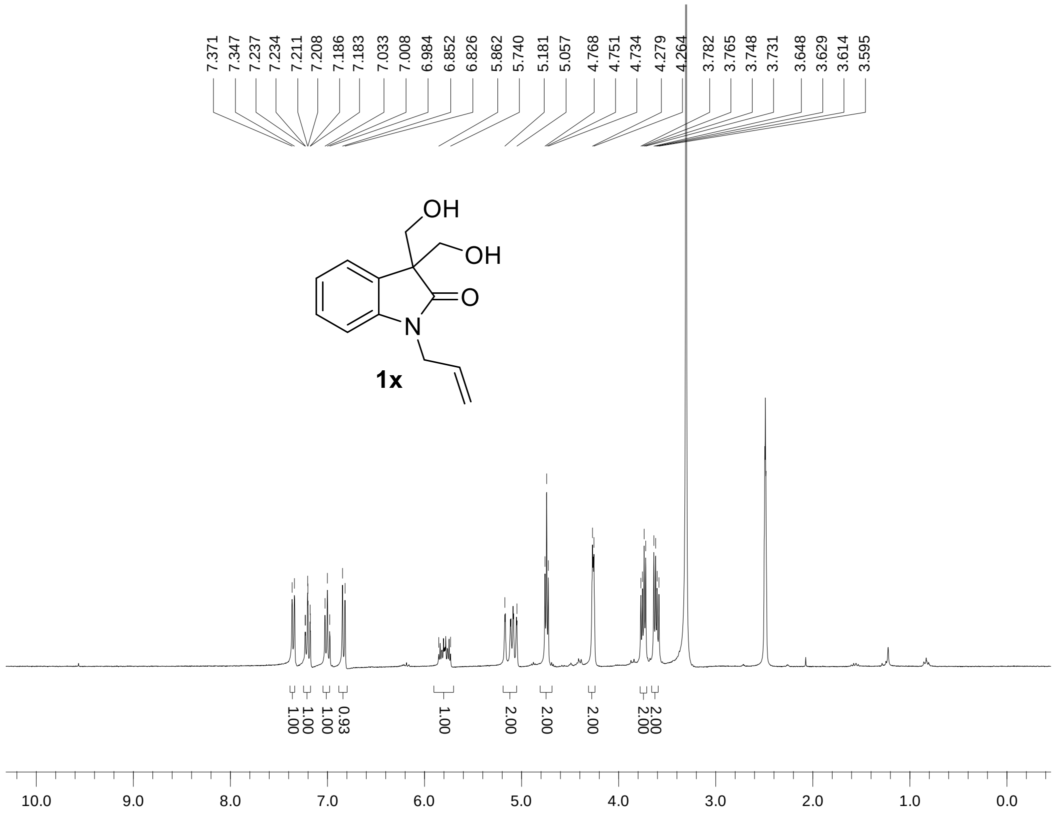
^{1}H NMR (300 MHz, acetone-d$_6$)



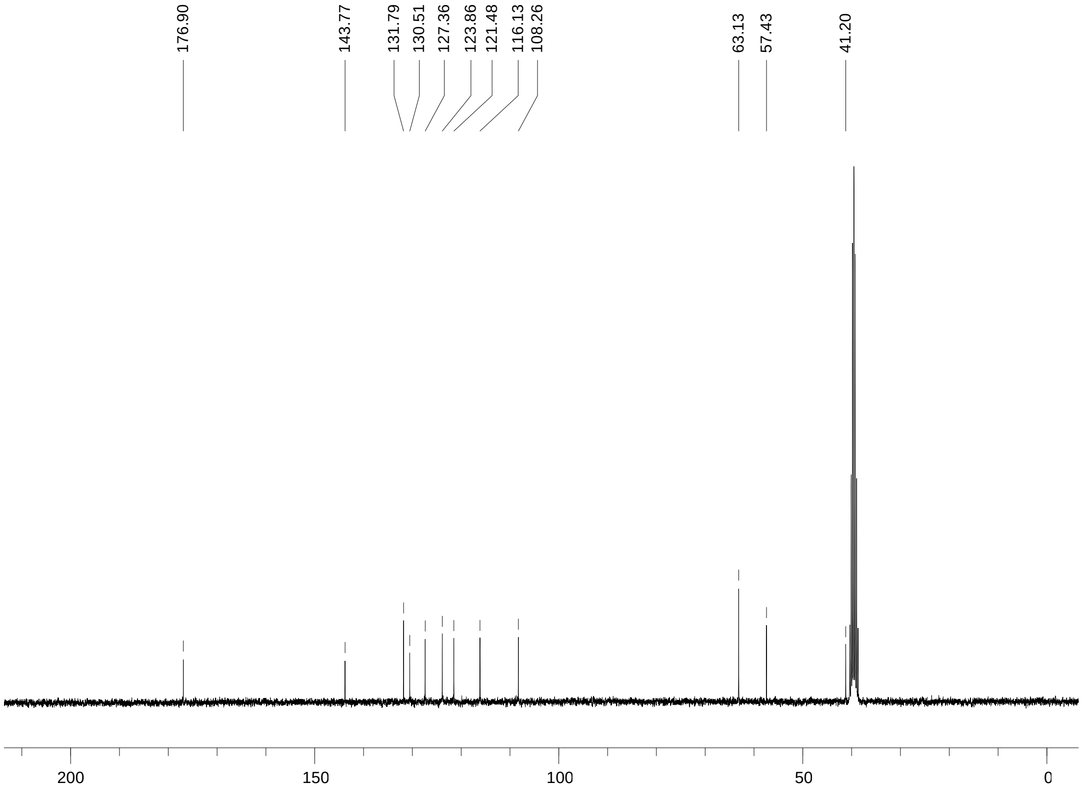
^{13}C NMR (75 MHz, acetone-d$_6$)



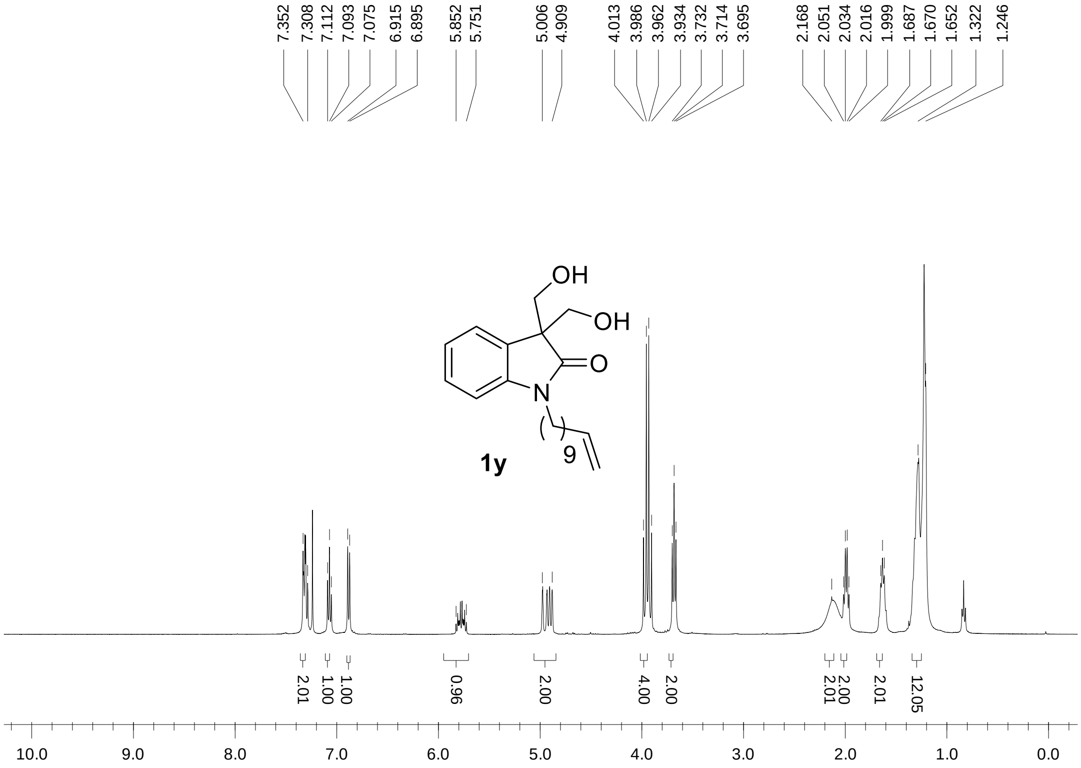
^{1}H NMR (300 MHz, DMSO-d$_6$)



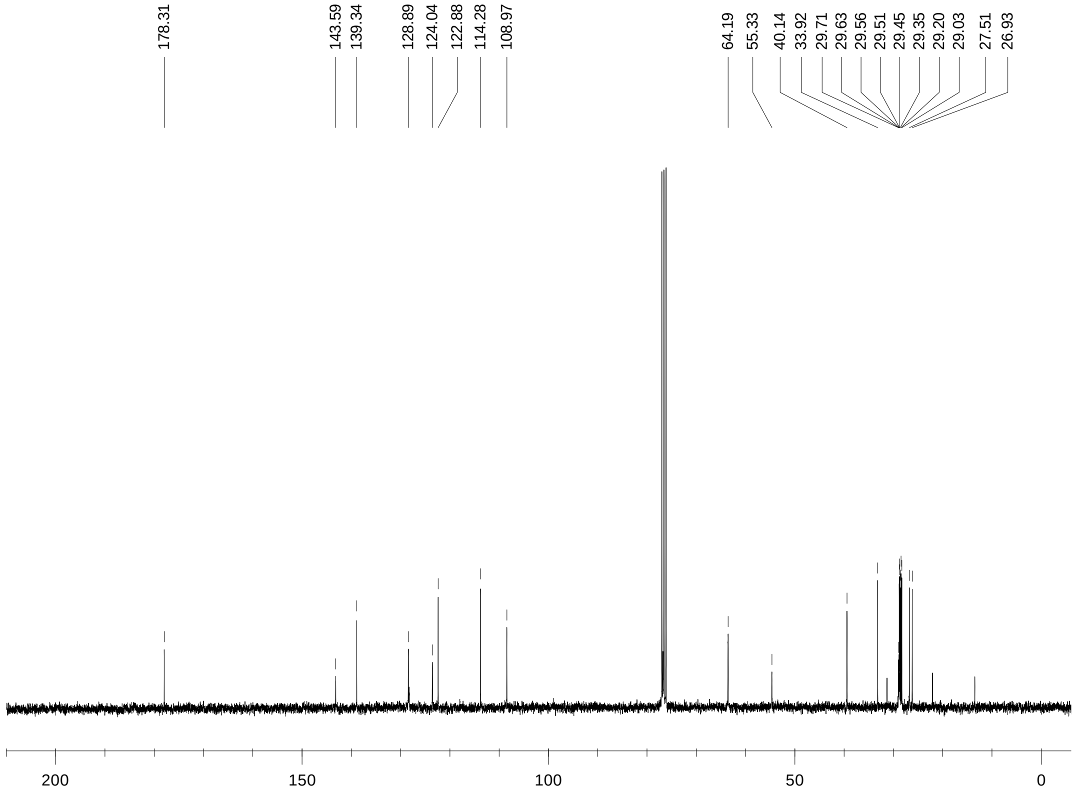
^{13}C NMR (75 MHz, DMSO-d$_6$)



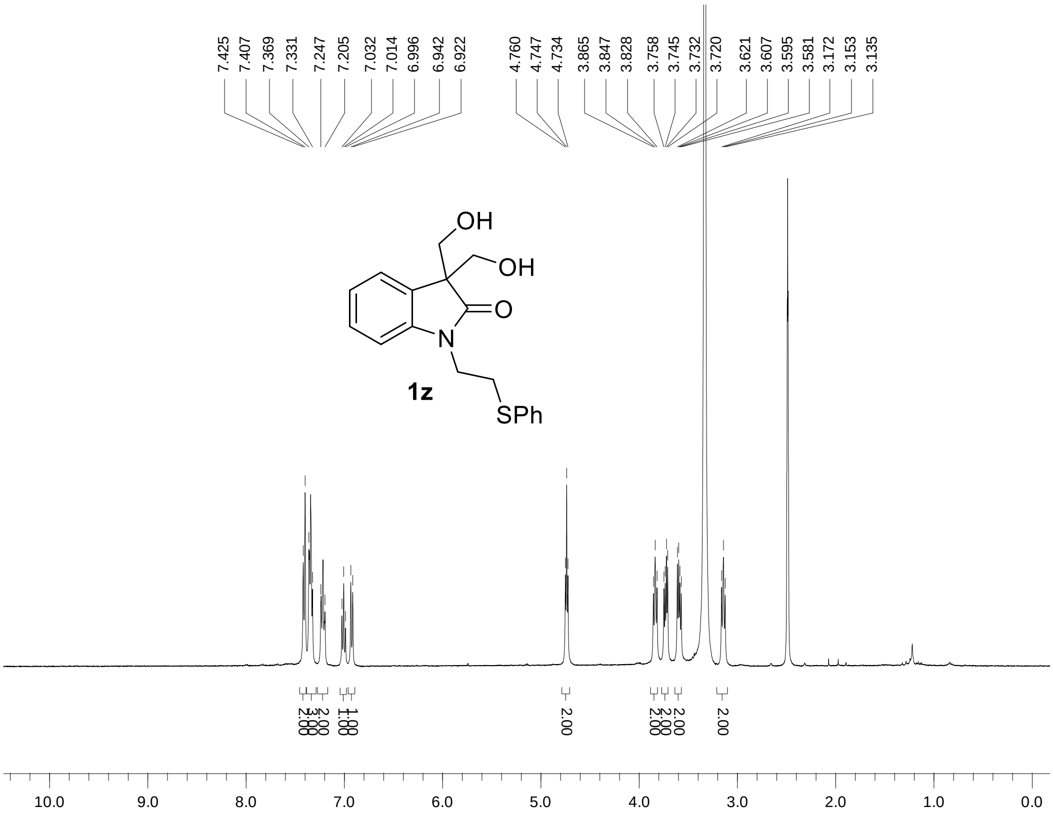
^{1}**H NMR** (300 MHz, CDCl$_3$)



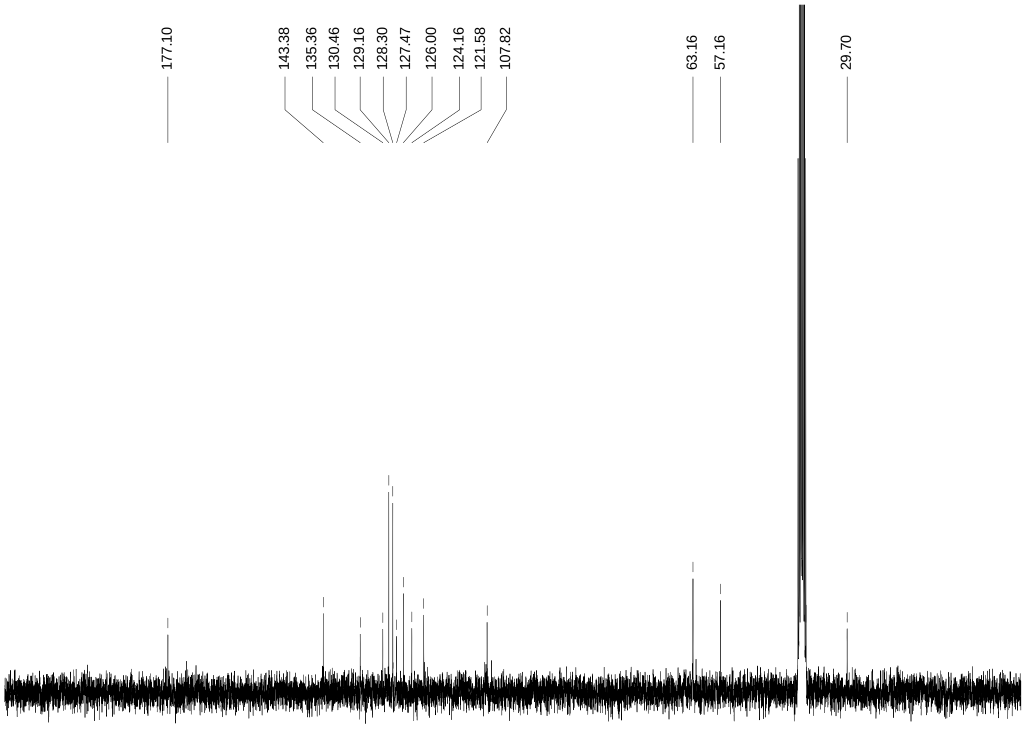
^{13}**C NMR** (75 MHz, CDCl$_3$)



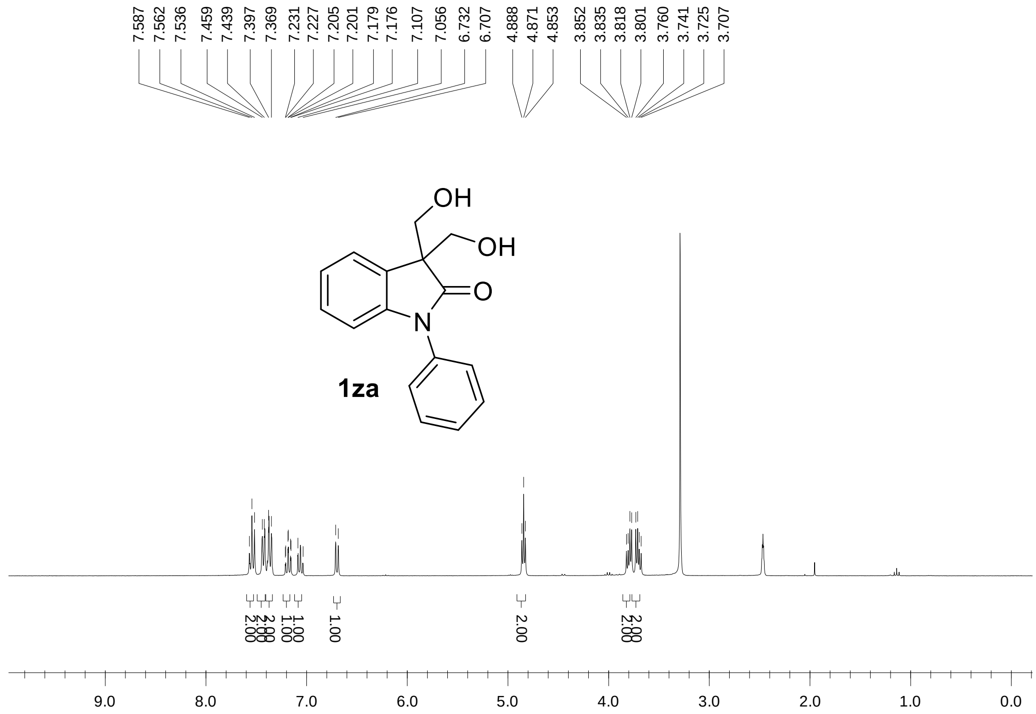
^{1}H NMR (400 MHz, DMSO-d$_6$)



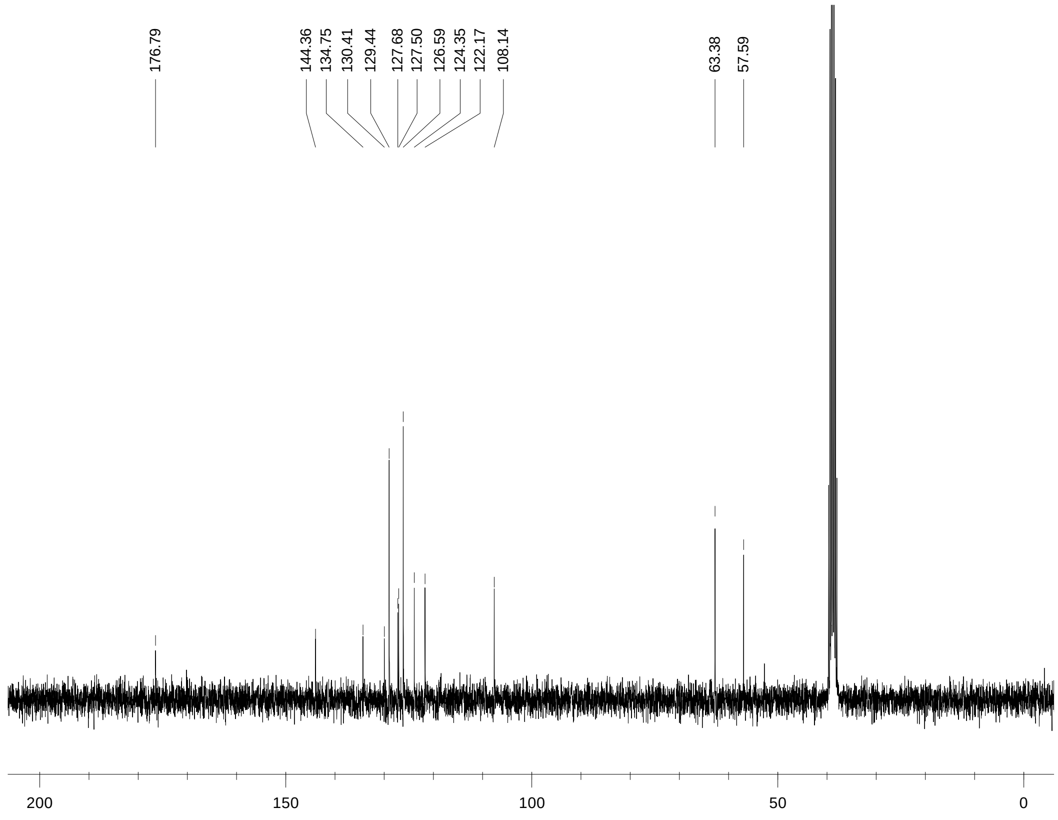
^{13}C NMR (75 MHz, DMSO-d$_6$)



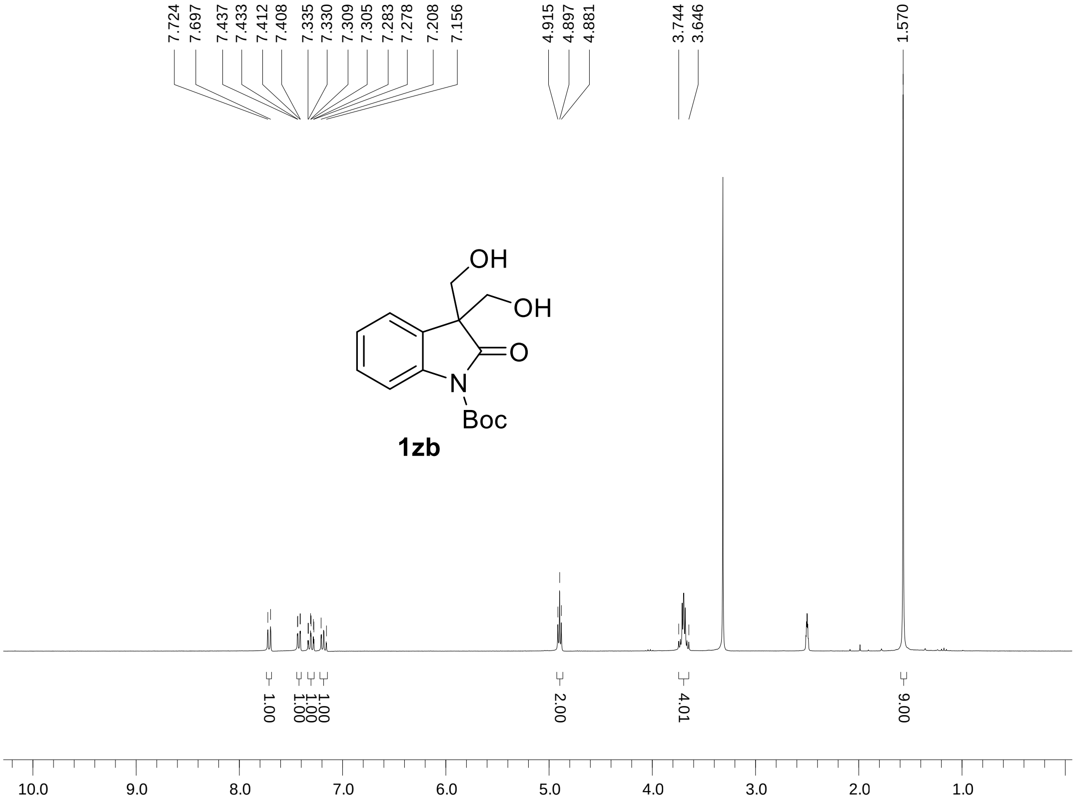
^{1}H NMR (300 MHz, DMSO-d_6)



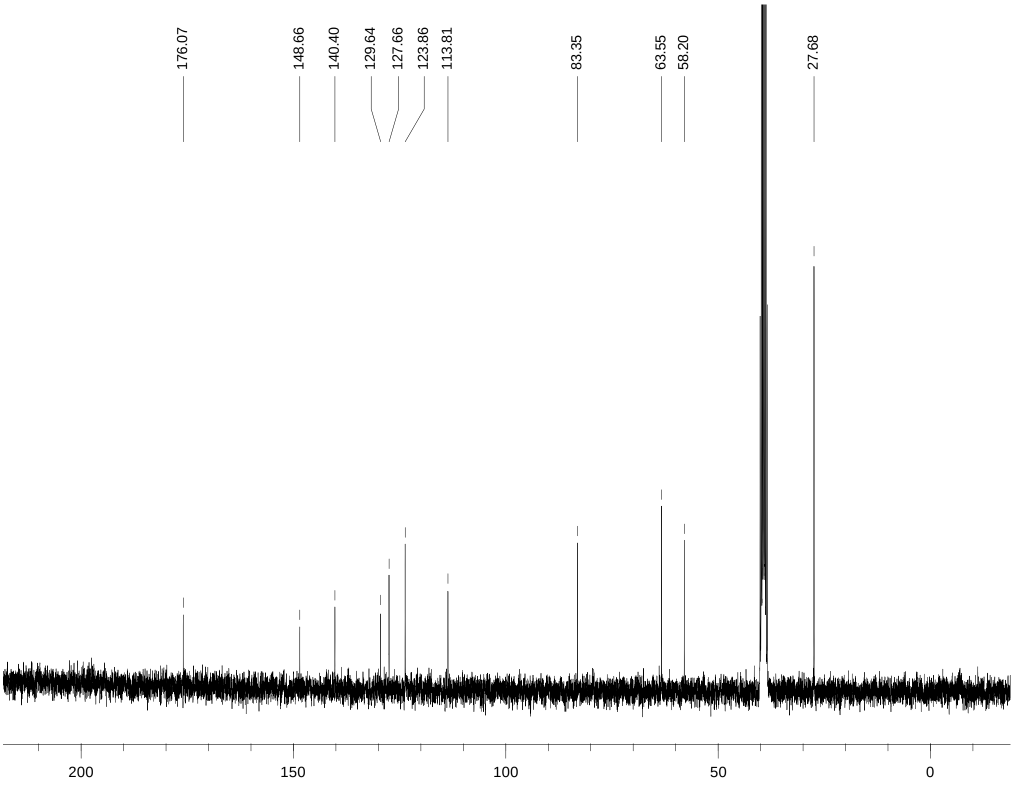
^{13}C NMR (75 MHz, DMSO-d_6)



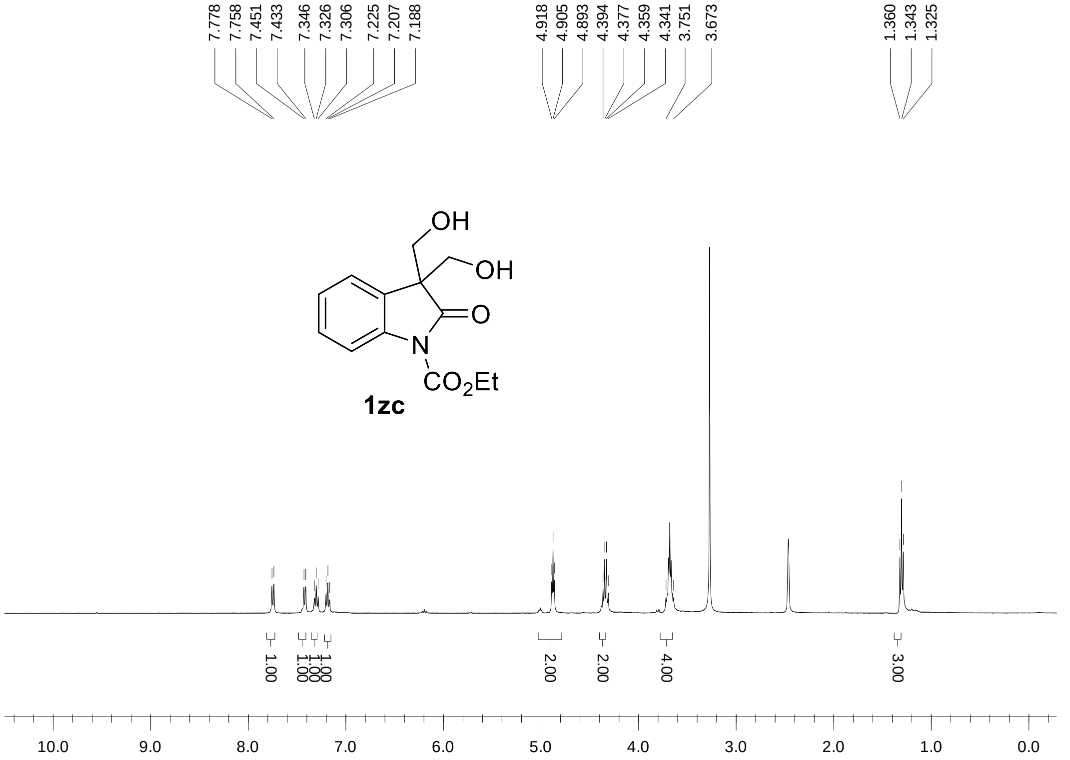
^{1}H NMR (300 MHz, DMSO-d$_6$)



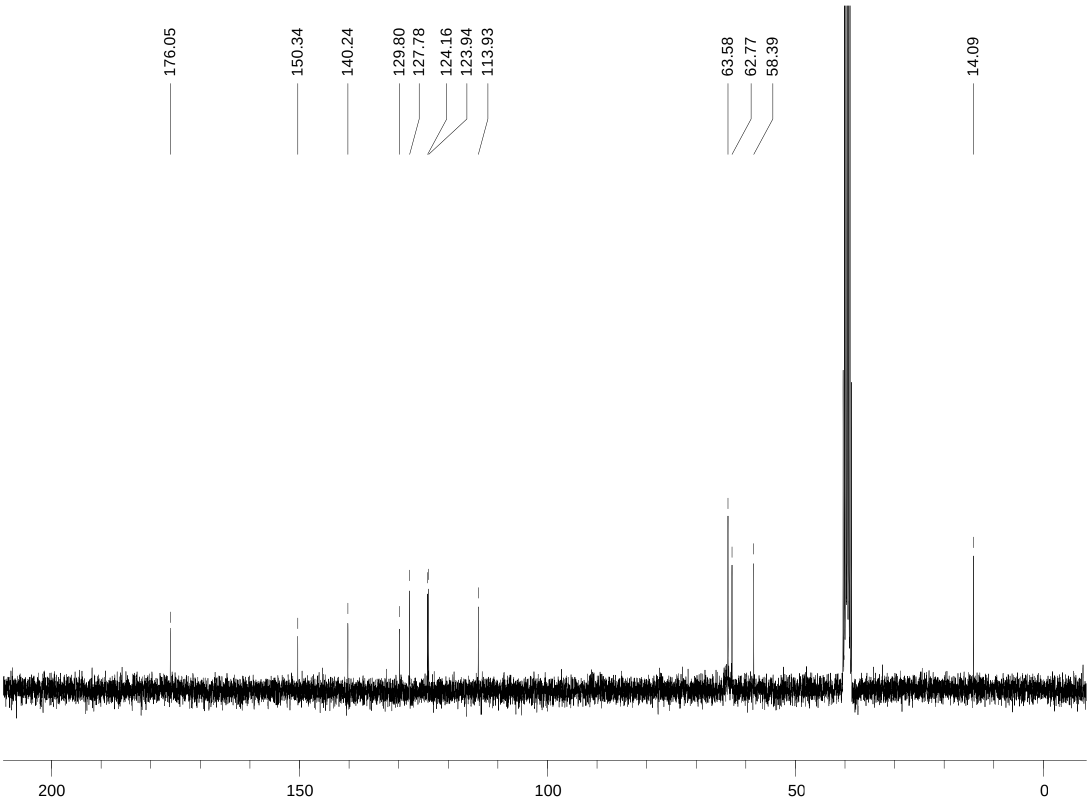
^{13}C NMR (75 MHz, DMSO-d$_6$)



^{1}H NMR (400 MHz, DMSO-d$_6$)



^{13}C NMR (75 MHz, DMSO-d$_6$)



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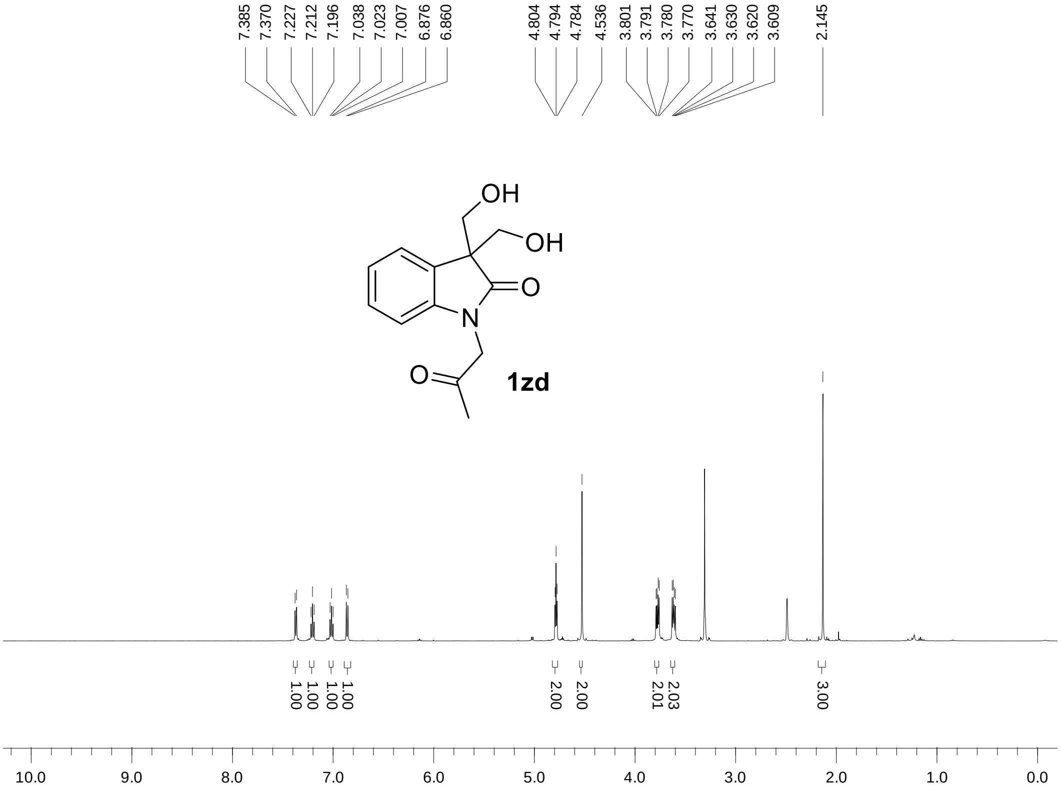
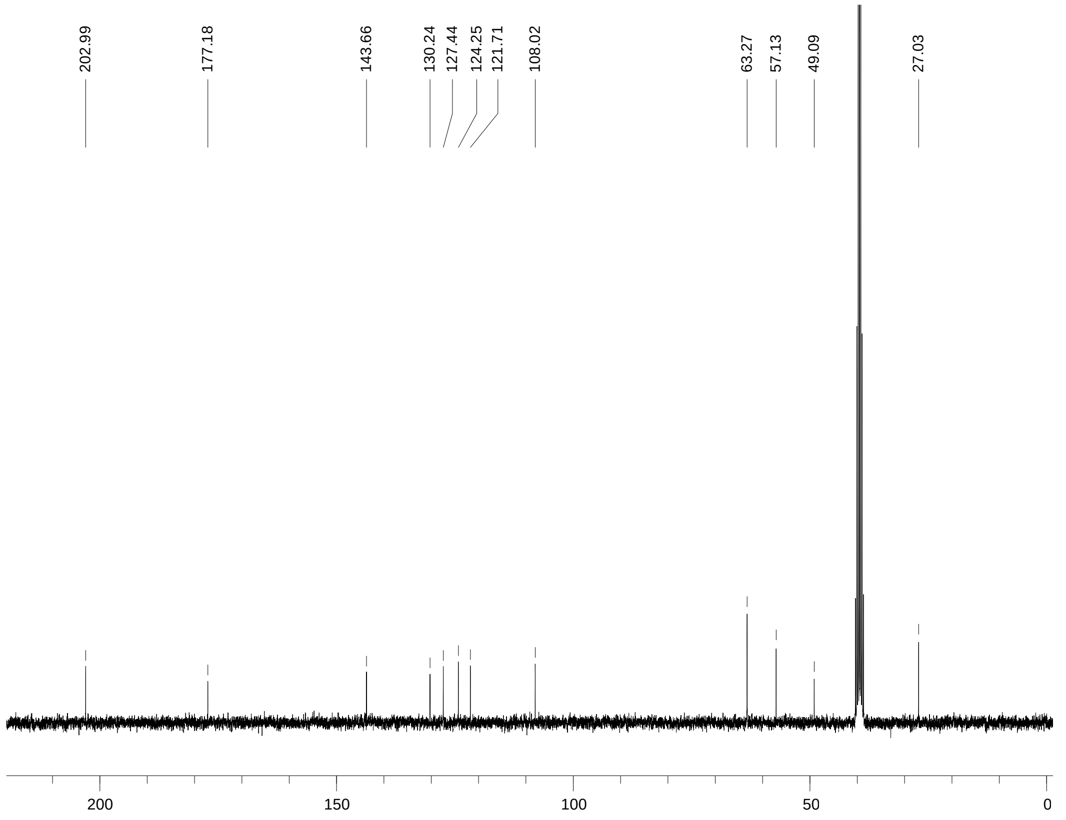
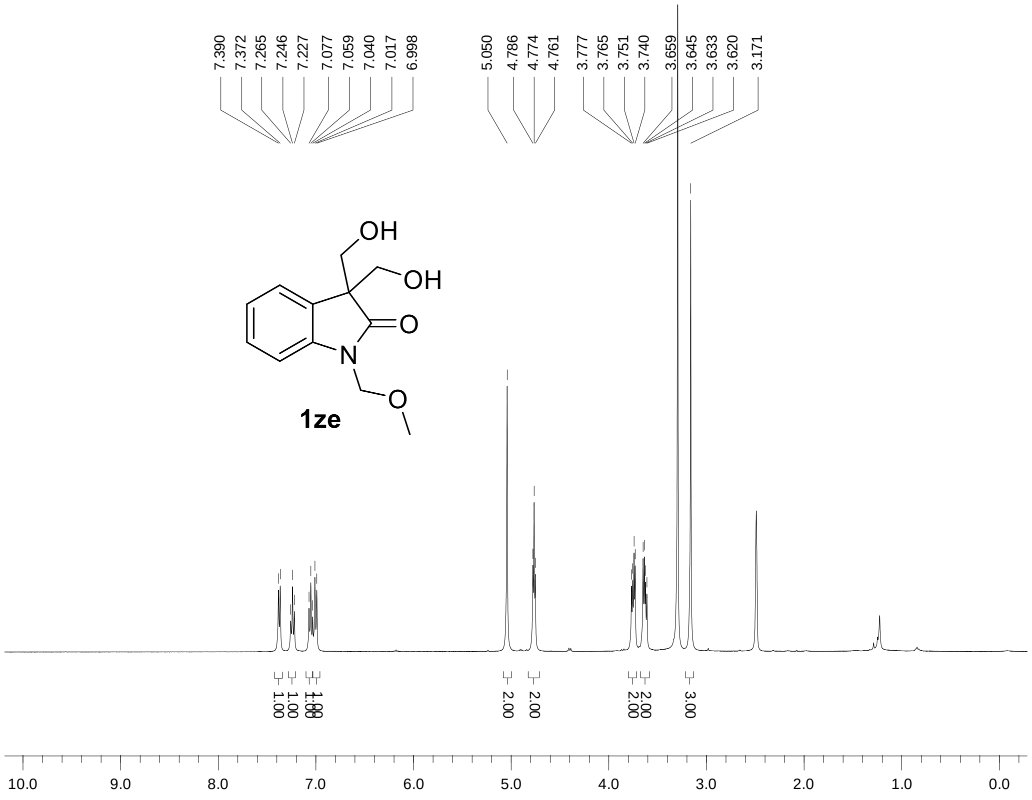


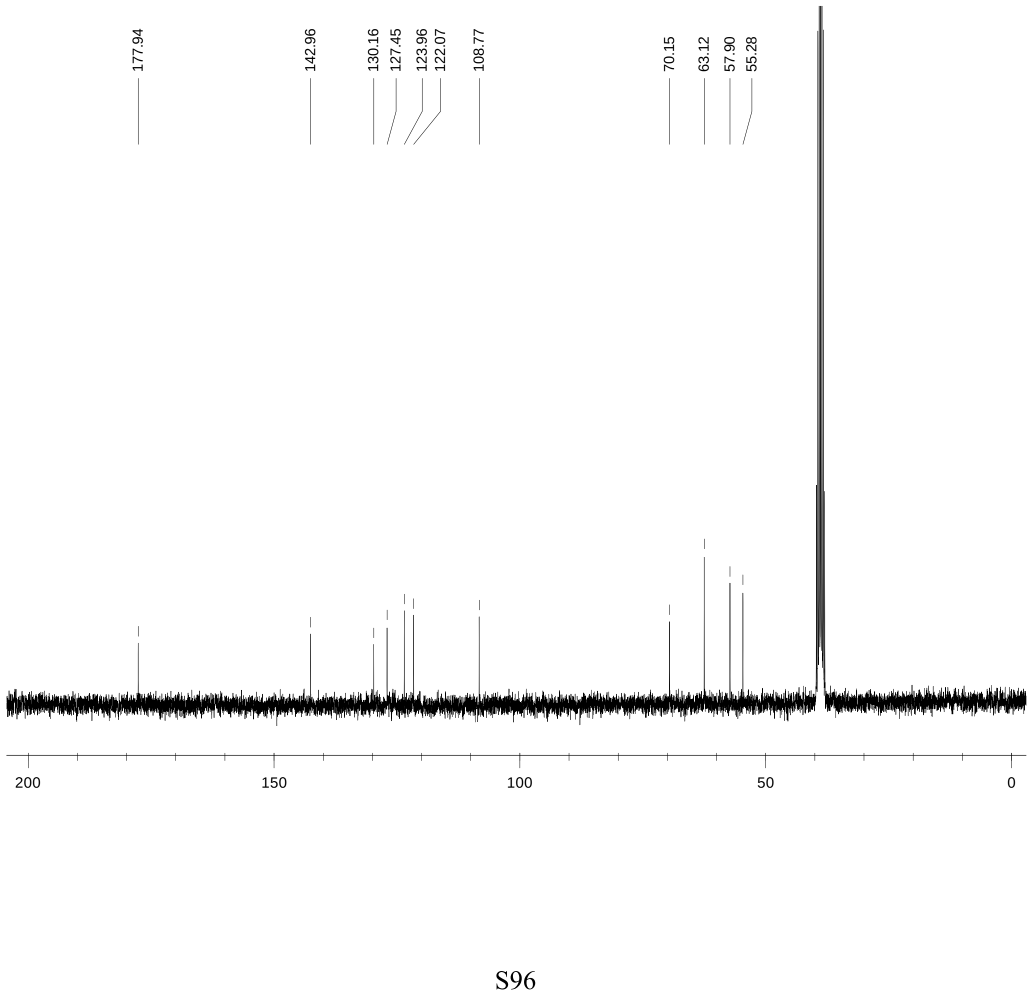
^{13}C NMR (75 MHz, DMSO-d$_6$)



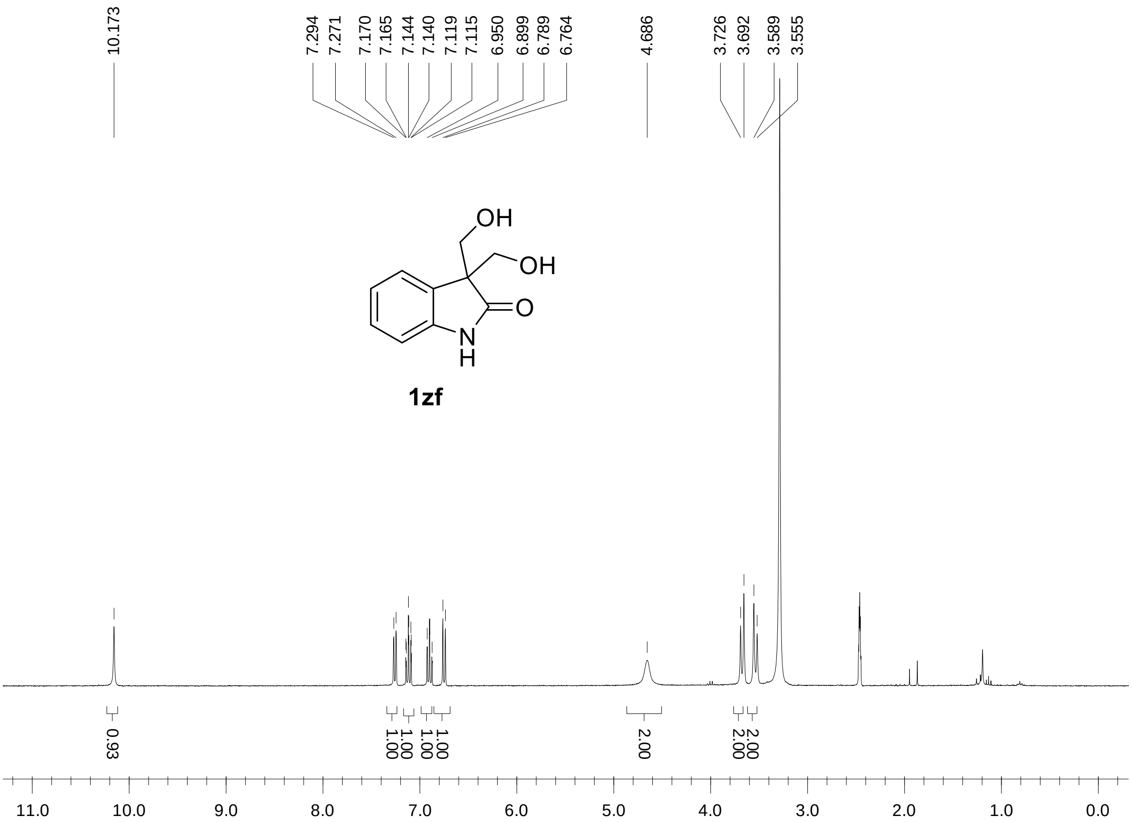
^{1}H NMR (400 MHz, DMSO-d$_6$)



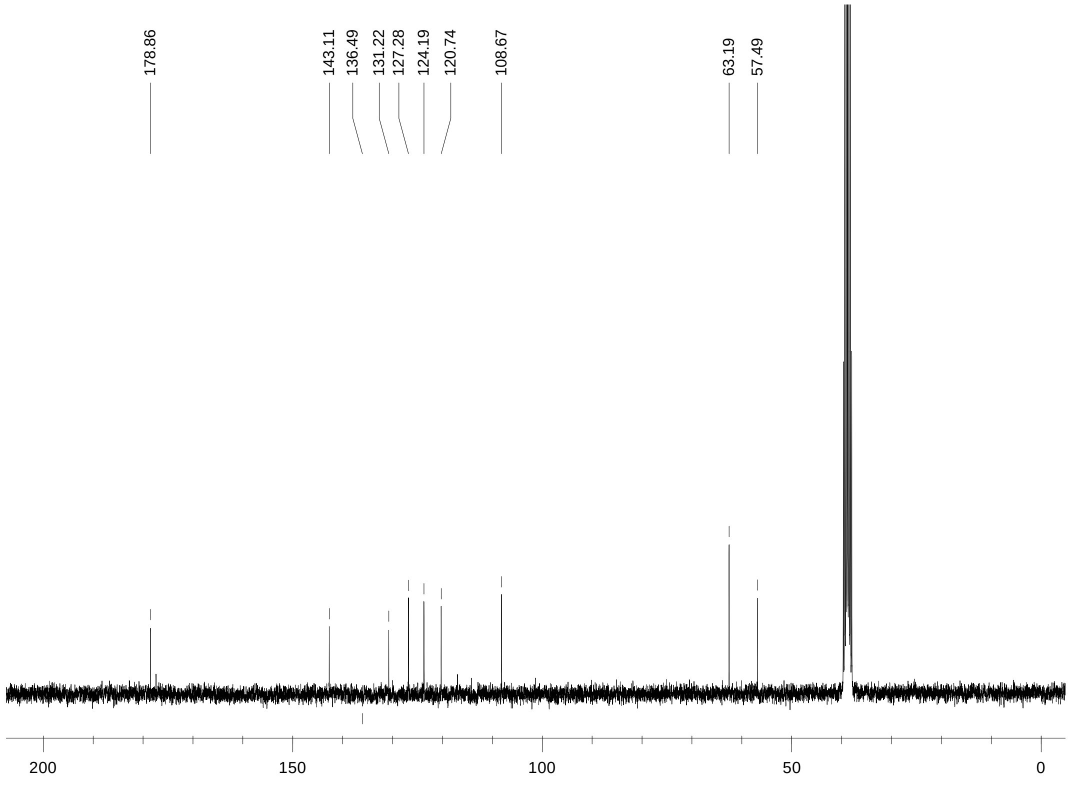
^{13}C NMR (75 MHz, DMSO-d$_6$)



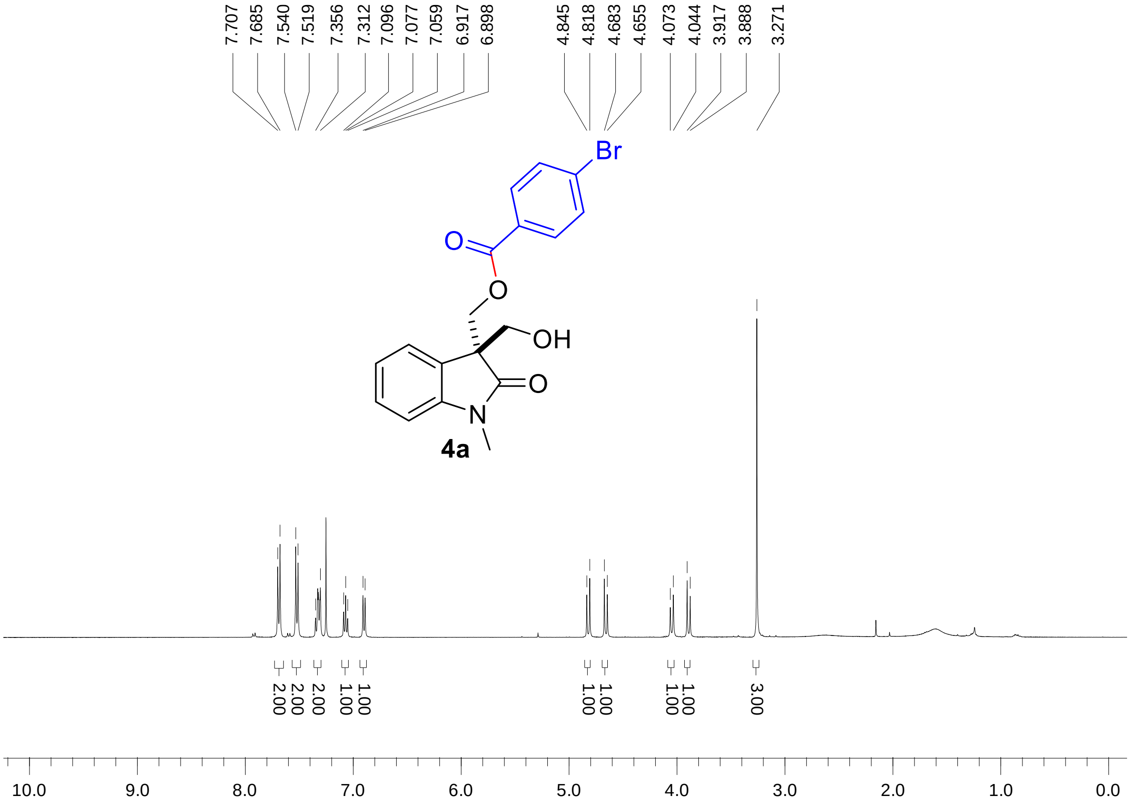
^{1}H NMR (300 MHz, DMSO-d$_6$)



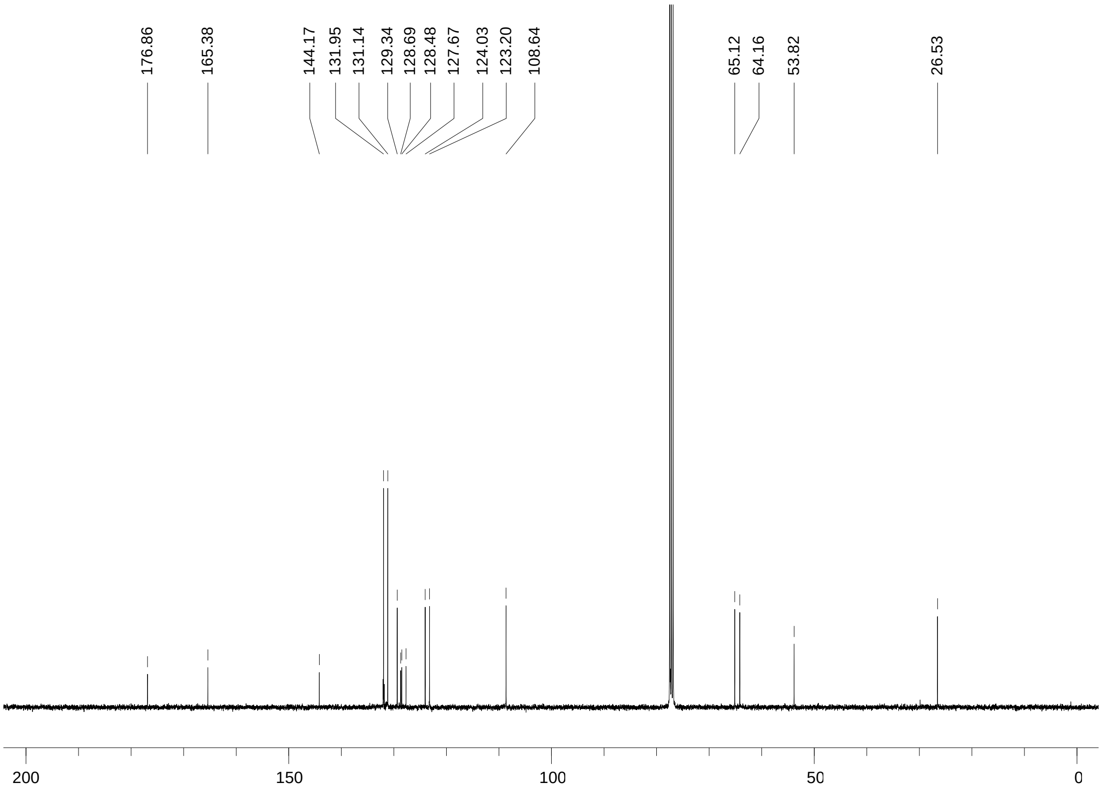
^{13}C NMR (75 MHz, DMSO-d$_6$)



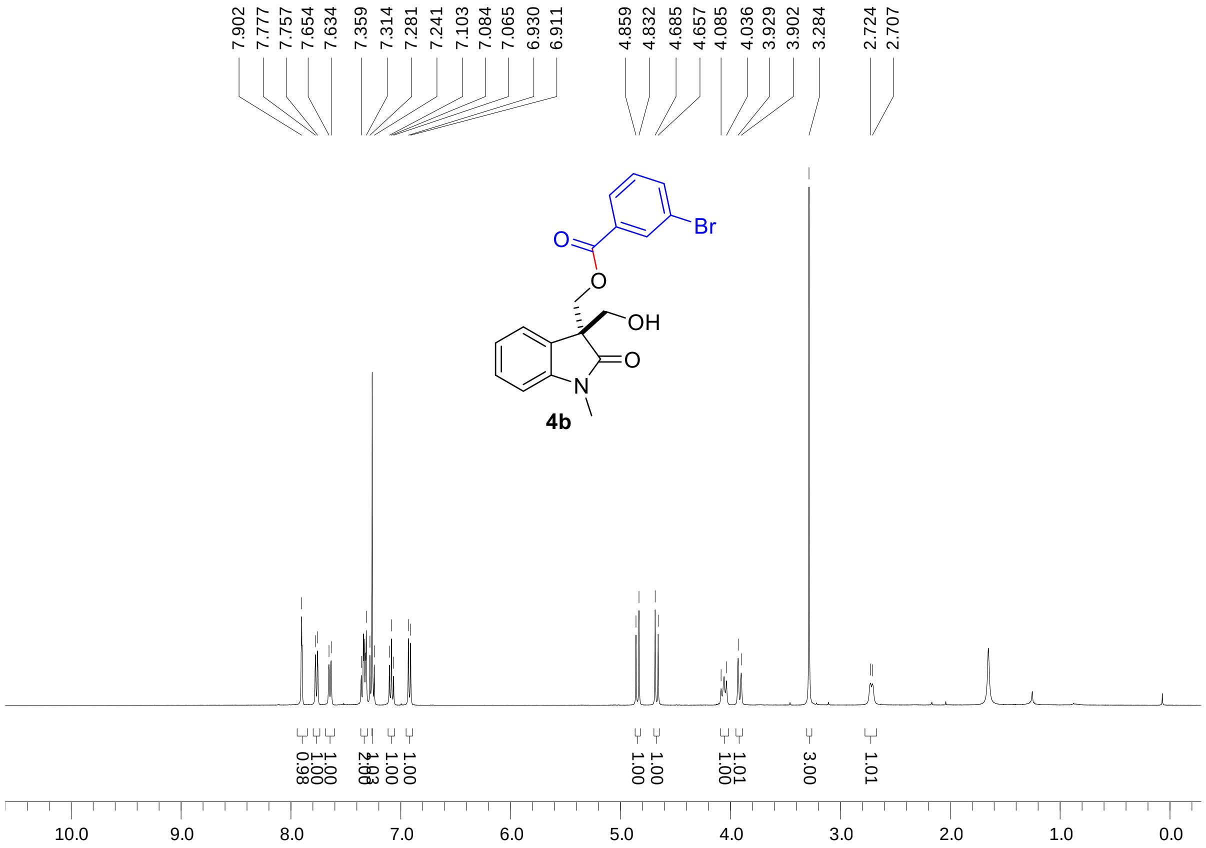
^{1}H NMR (400 MHz, $CDCl_3$)



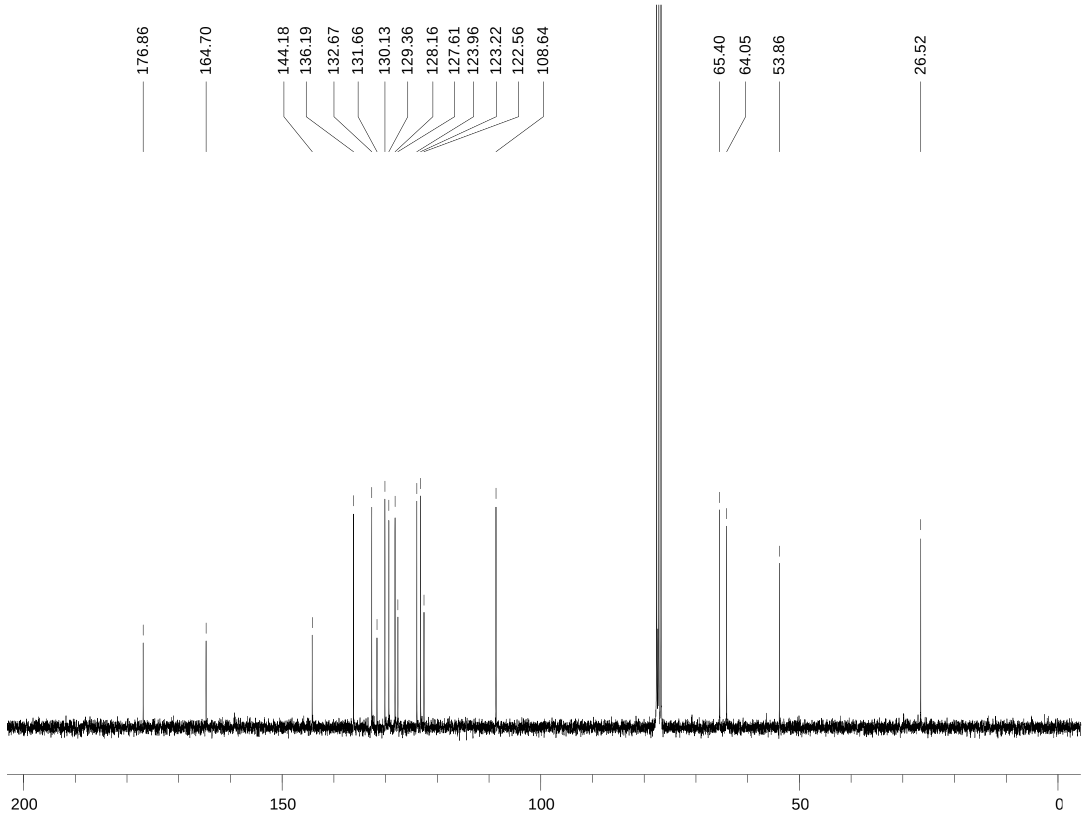
^{13}C NMR (100 MHz, $CDCl_3$)



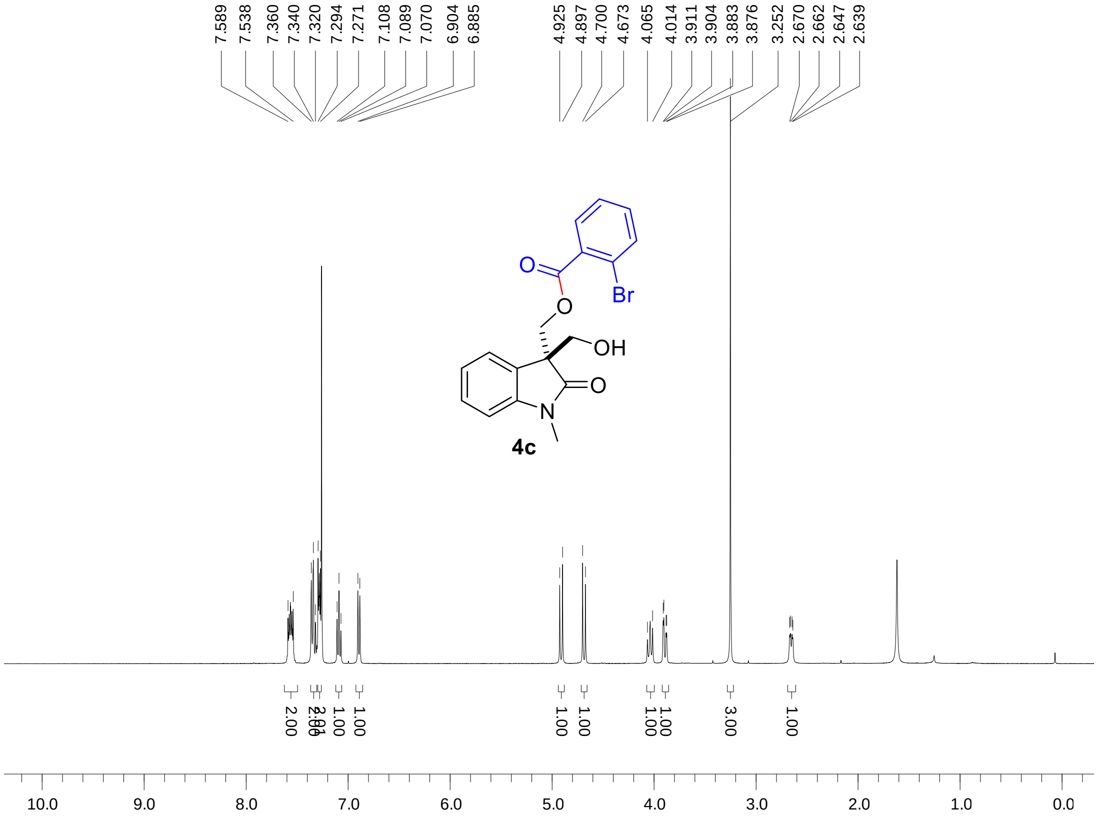
^{1}H NMR (400 MHz, CDCl$_3$)



^{13}C NMR (75 MHz, CDCl$_3$)



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



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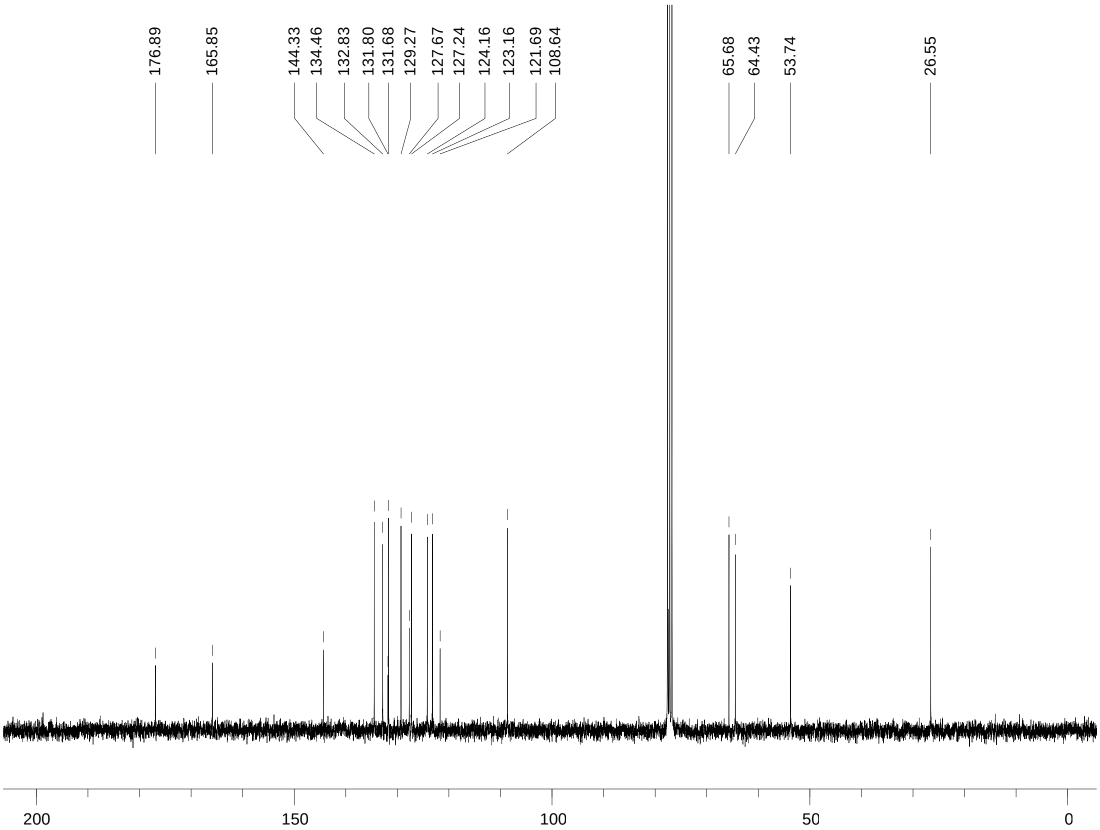
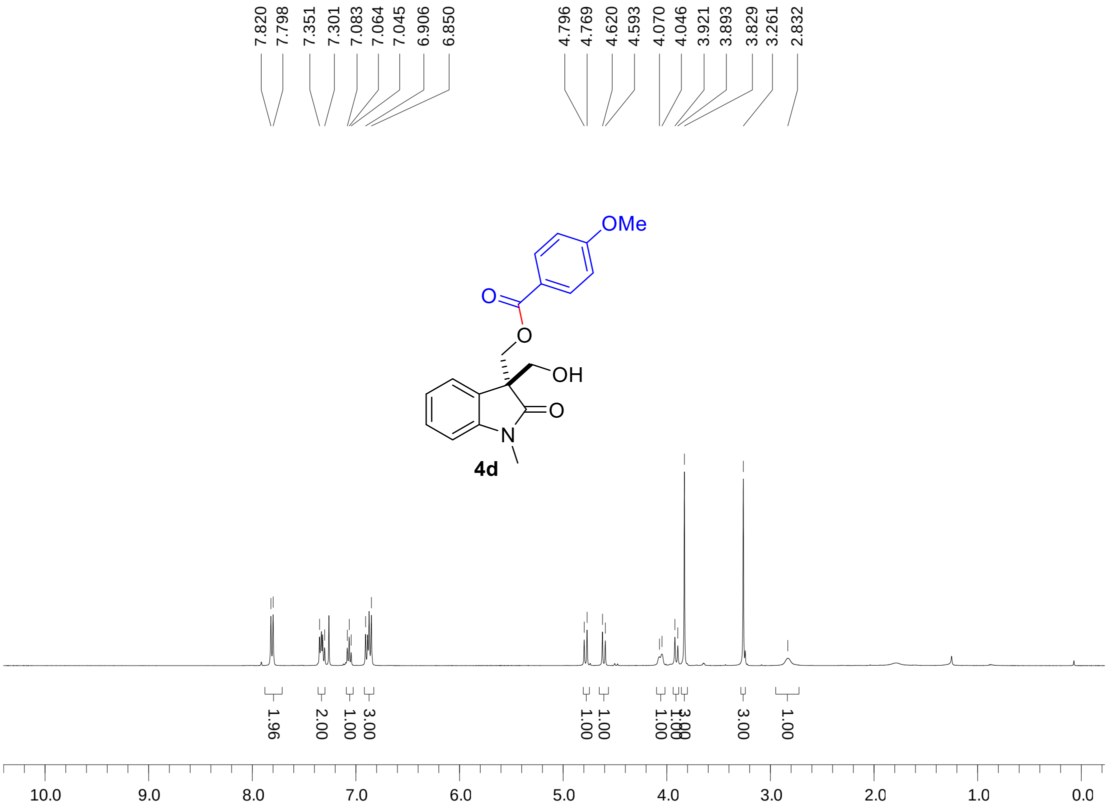
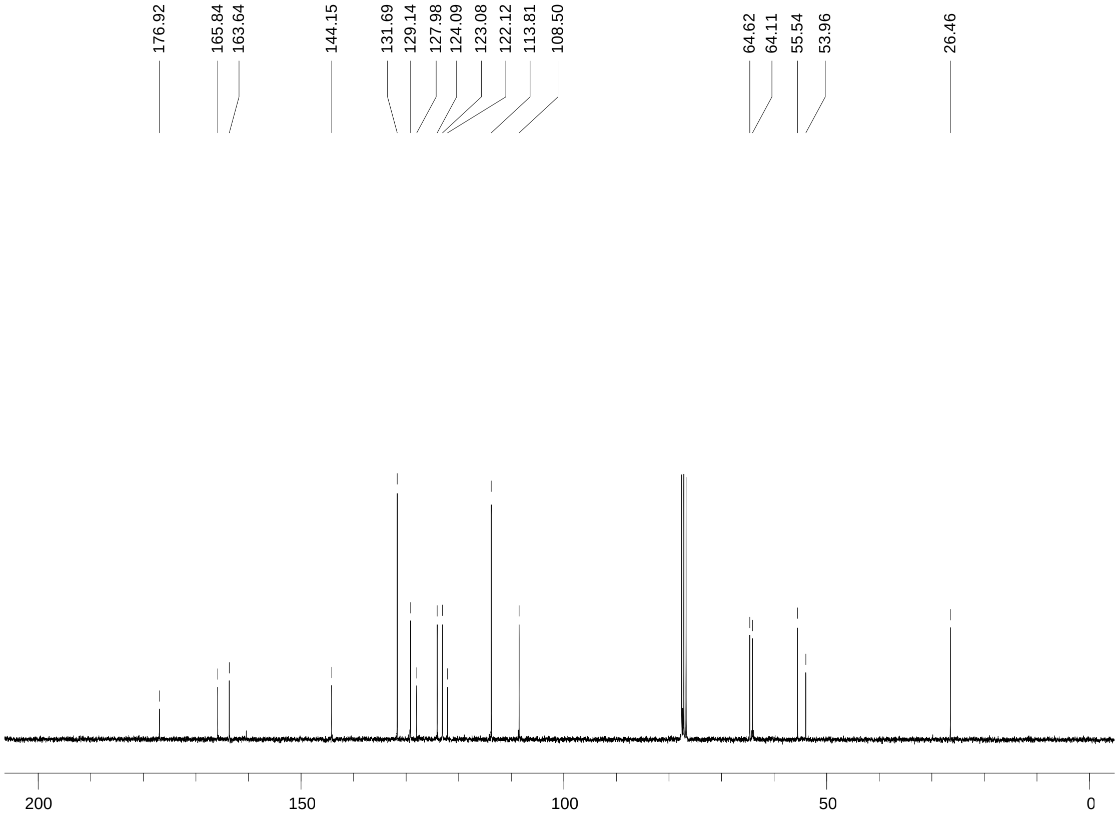


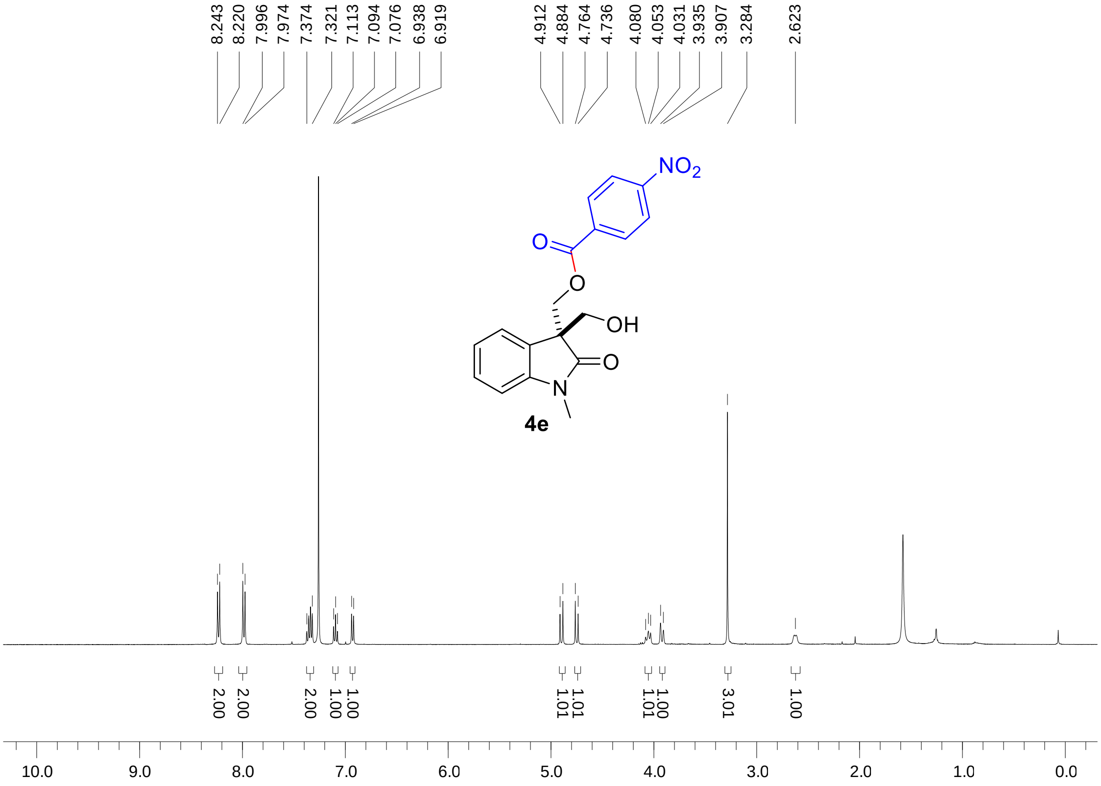
^{1}H NMR (400 MHz, $CDCl_3$)



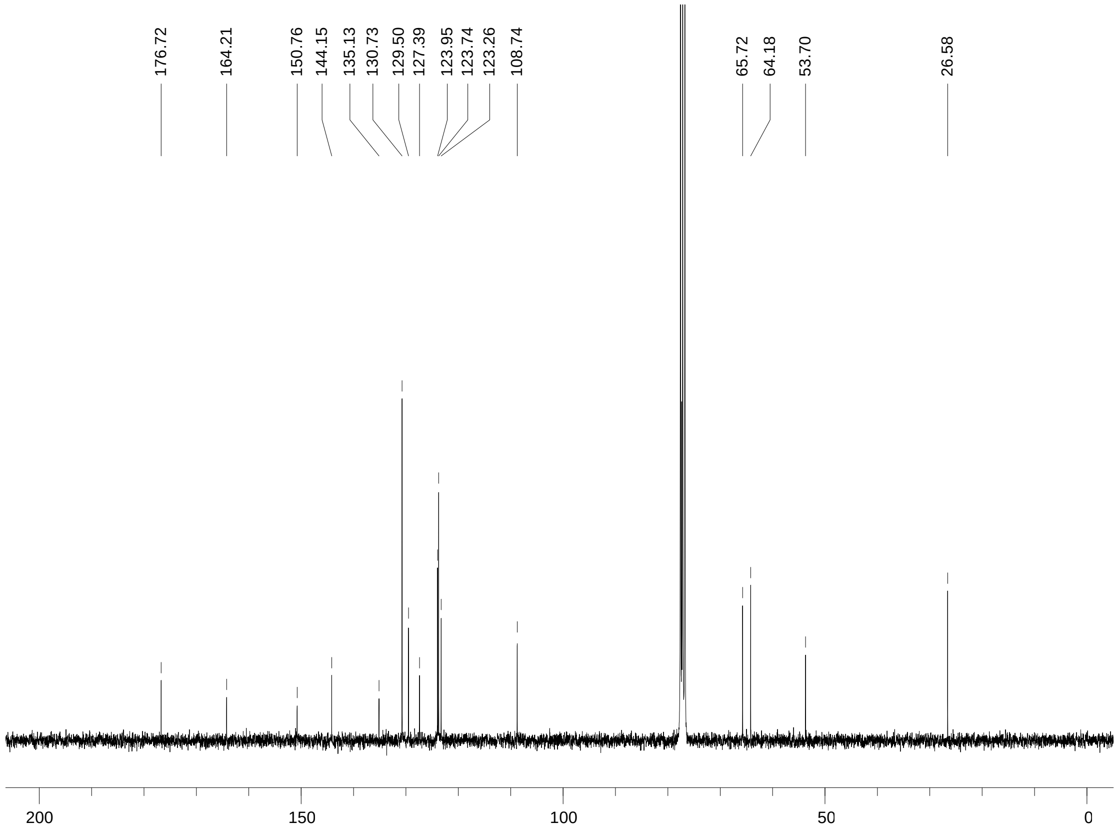
^{13}C NMR (75 MHz, $CDCl_3$)



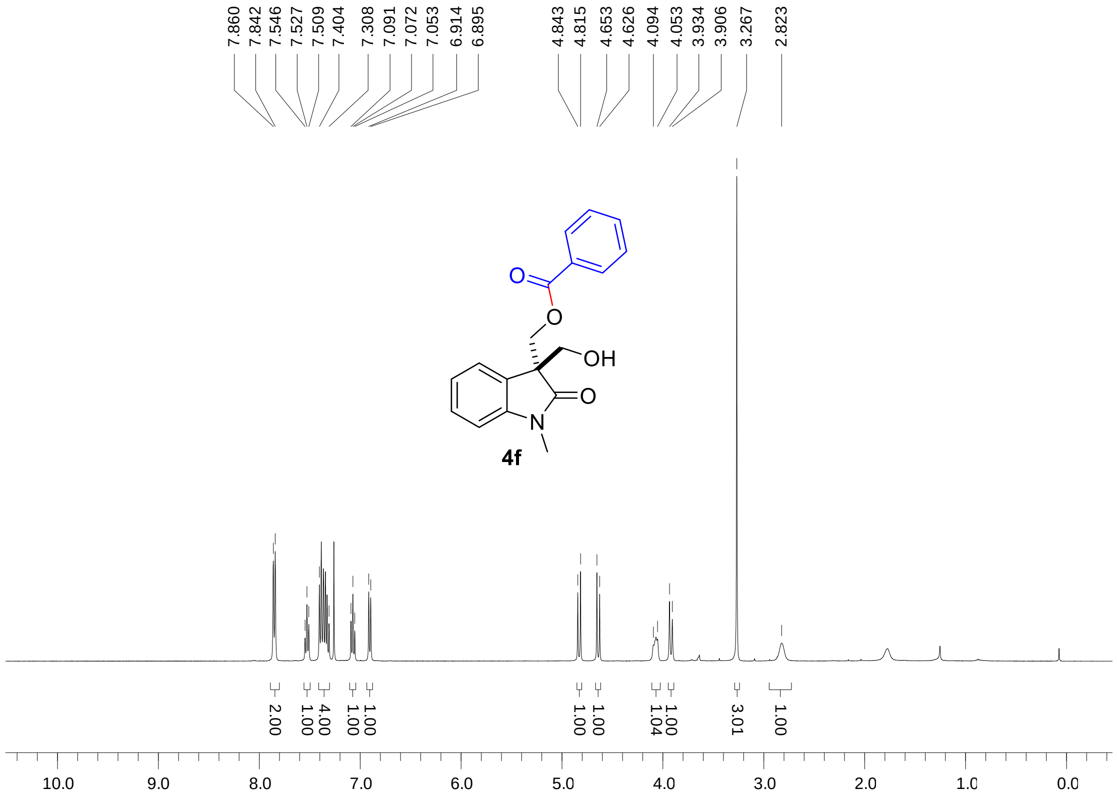
^{1}H NMR (400 MHz, CDCl$_3$)



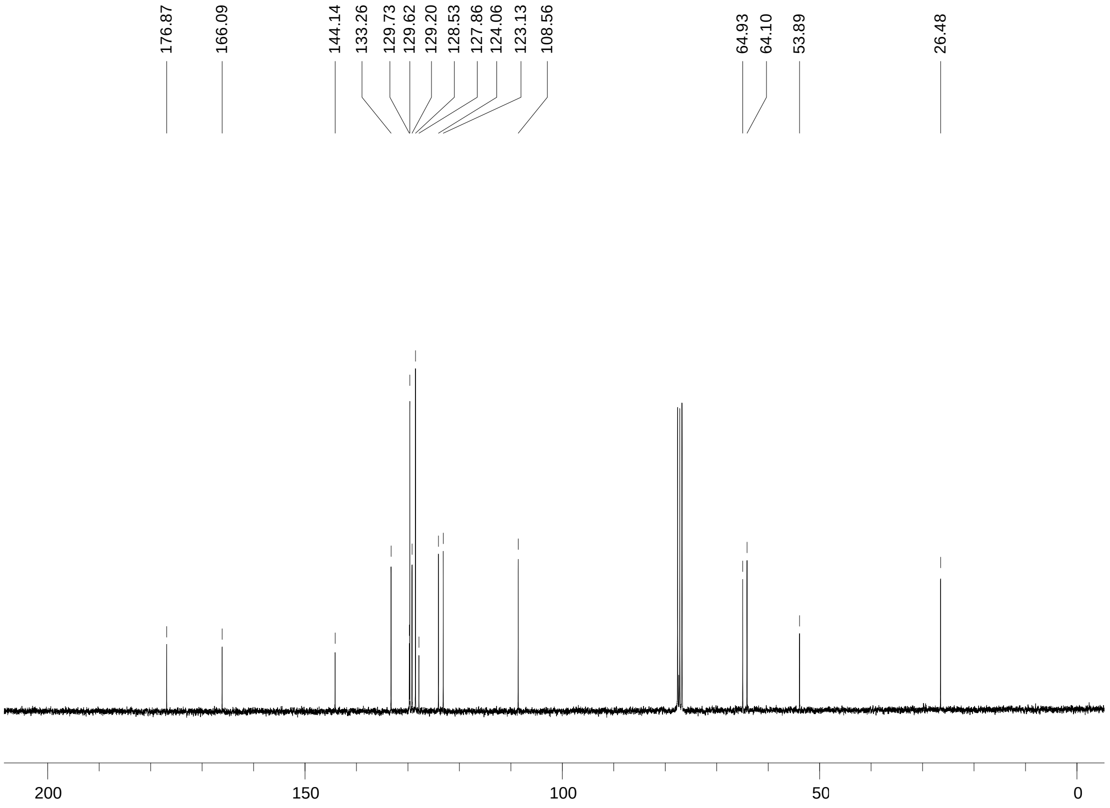
^{13}C NMR (75 MHz, CDCl$_3$)



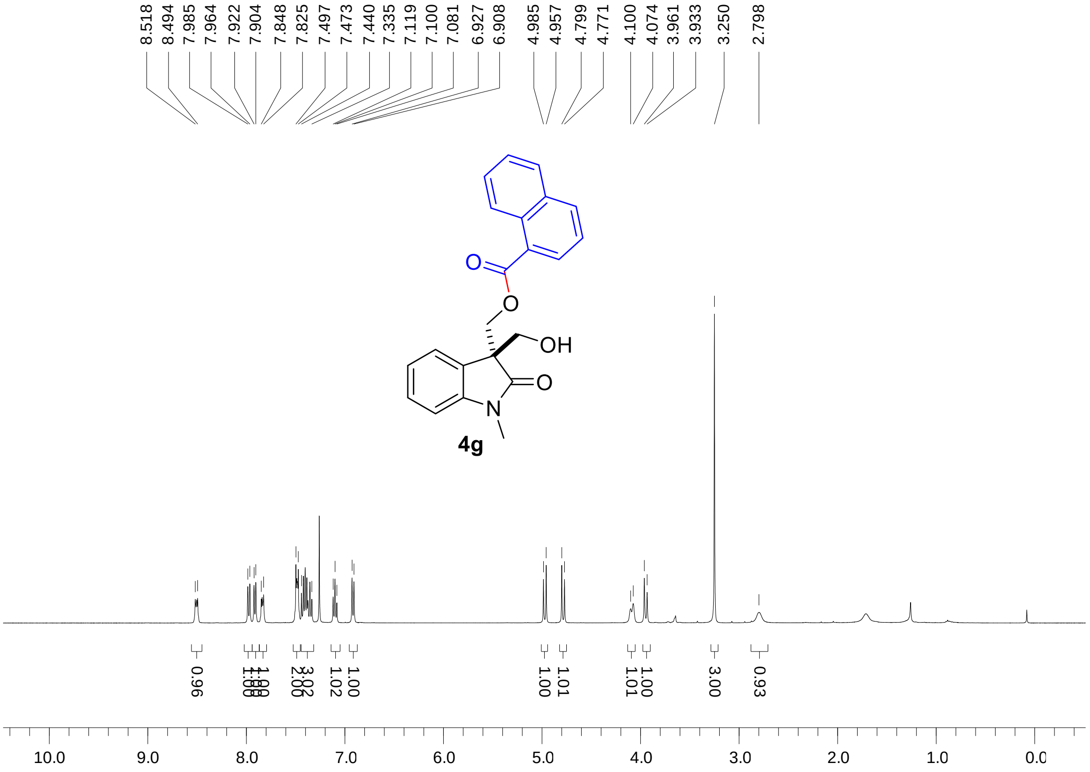
^{1}H NMR (400 MHz, CDCl$_3$)



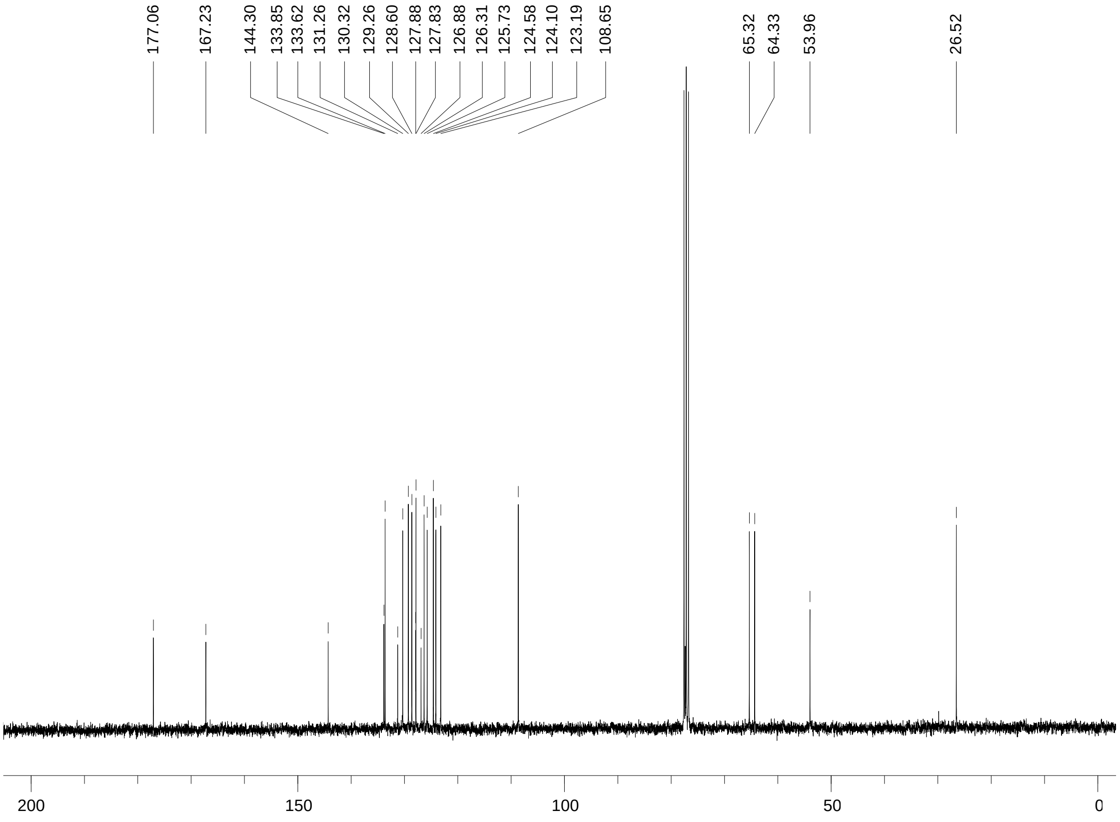
^{13}C NMR (75 MHz, CDCl$_3$)



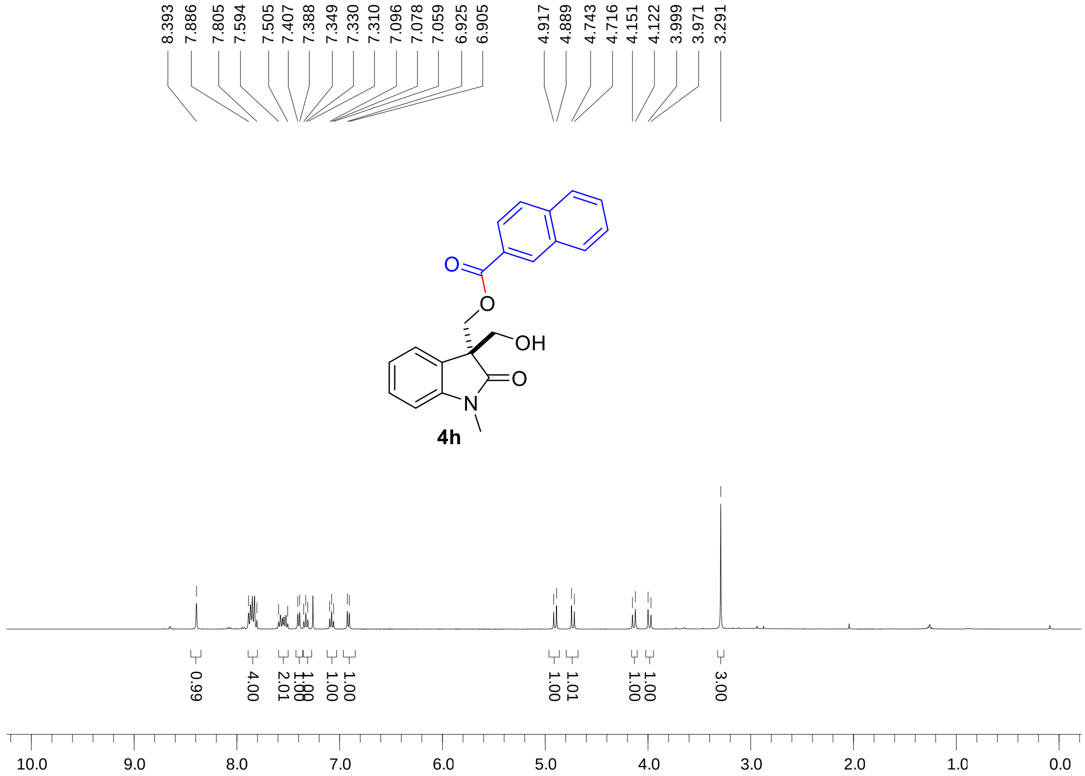
^{1}H NMR (400 MHz, CDCl$_3$)



^{13}C NMR (75 MHz, CDCl$_3$)



^{1}H NMR (400 MHz, CDCl$_3$)



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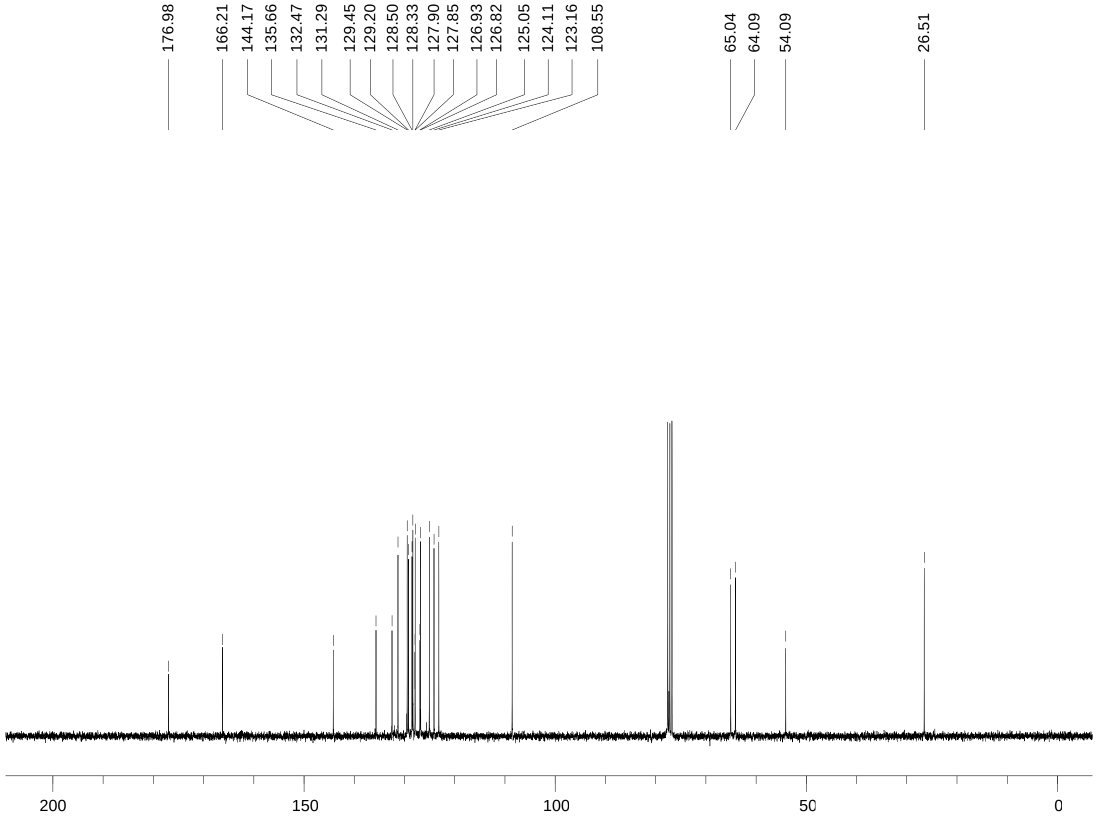
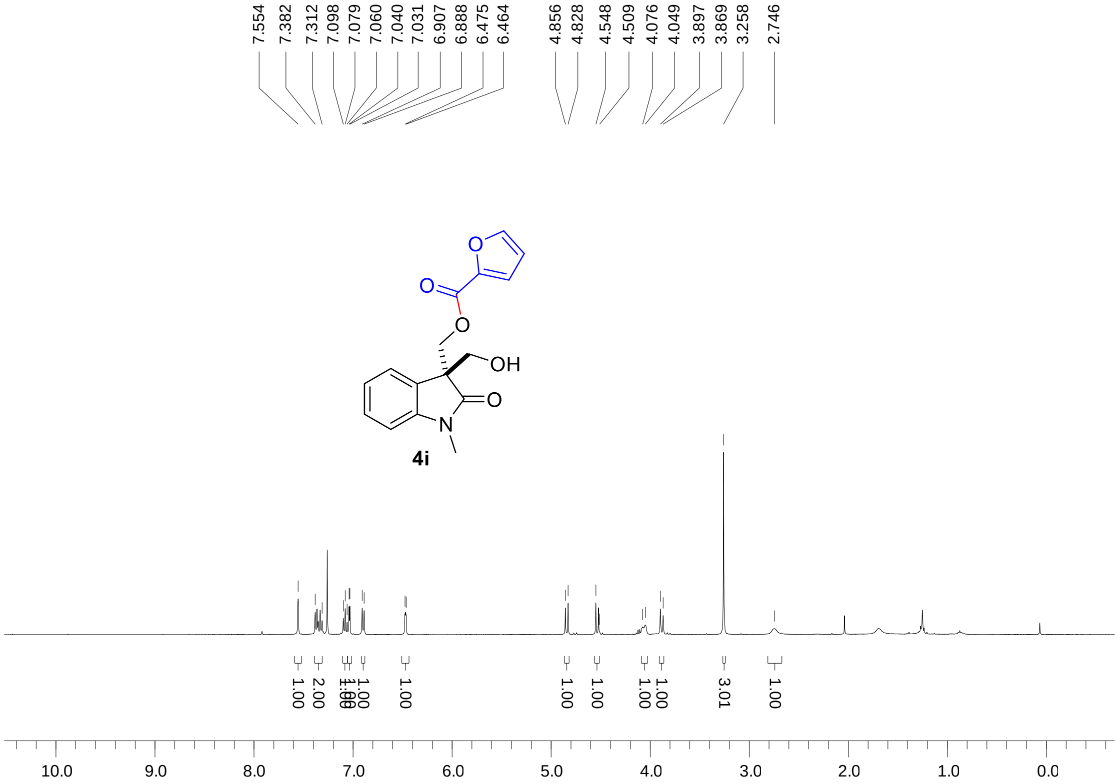
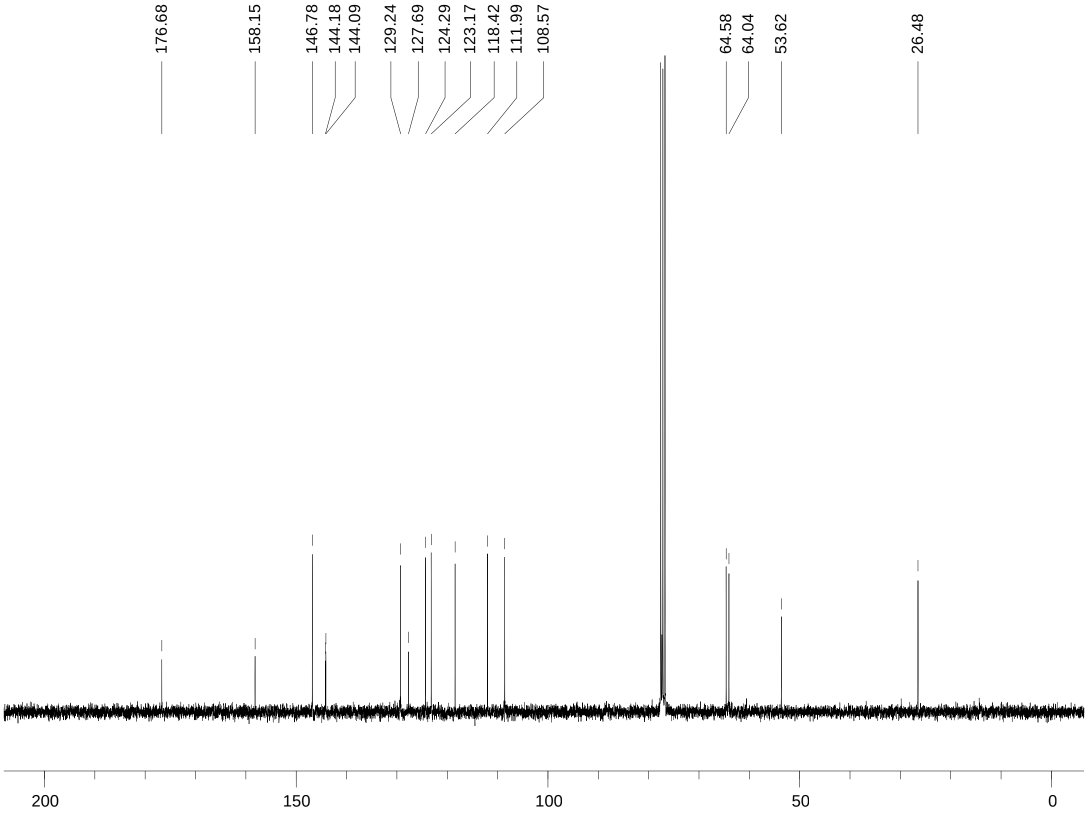


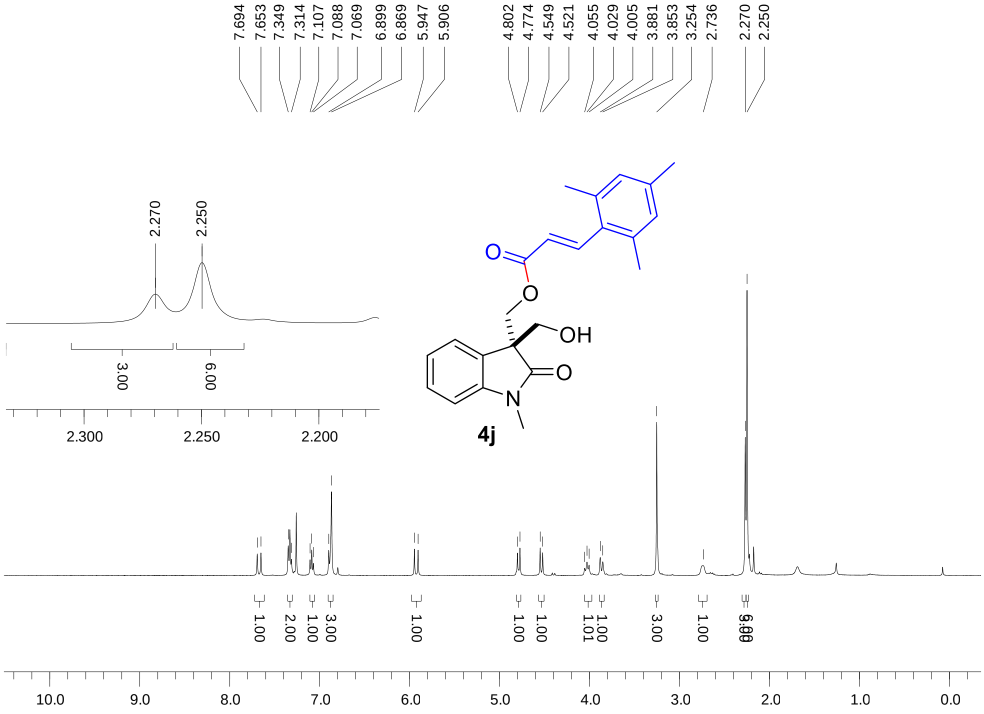
^{1}H NMR (400 MHz, CDCl$_3$)



^{13}C NMR (75 MHz, CDCl$_3$)

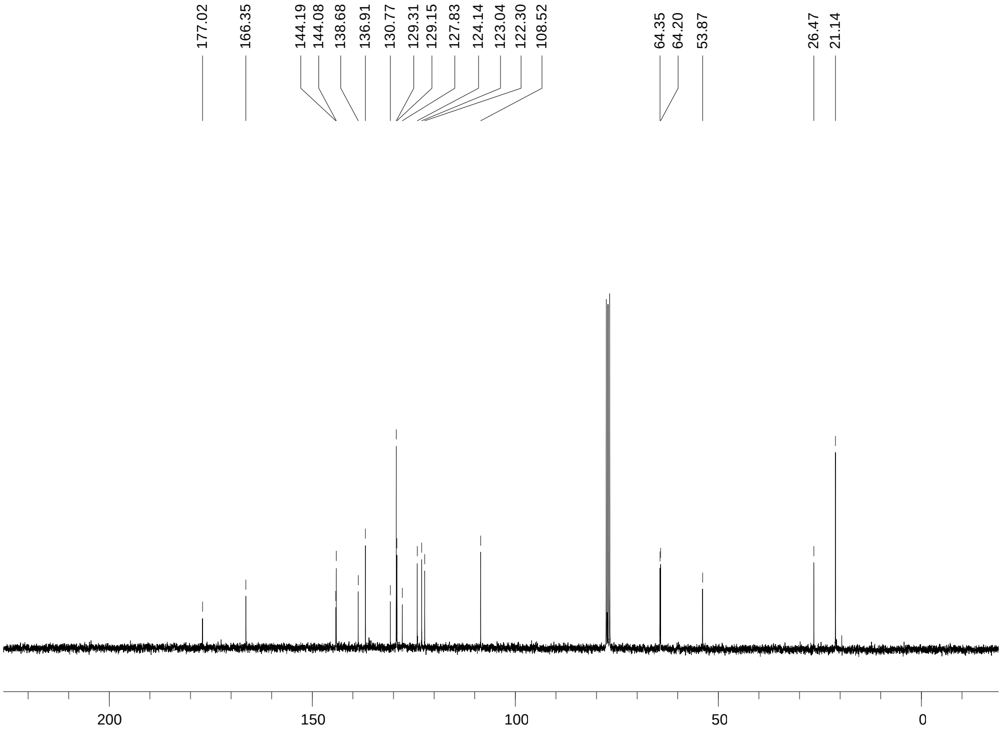


^{1}H NMR (400 MHz, CDCl$_3$)

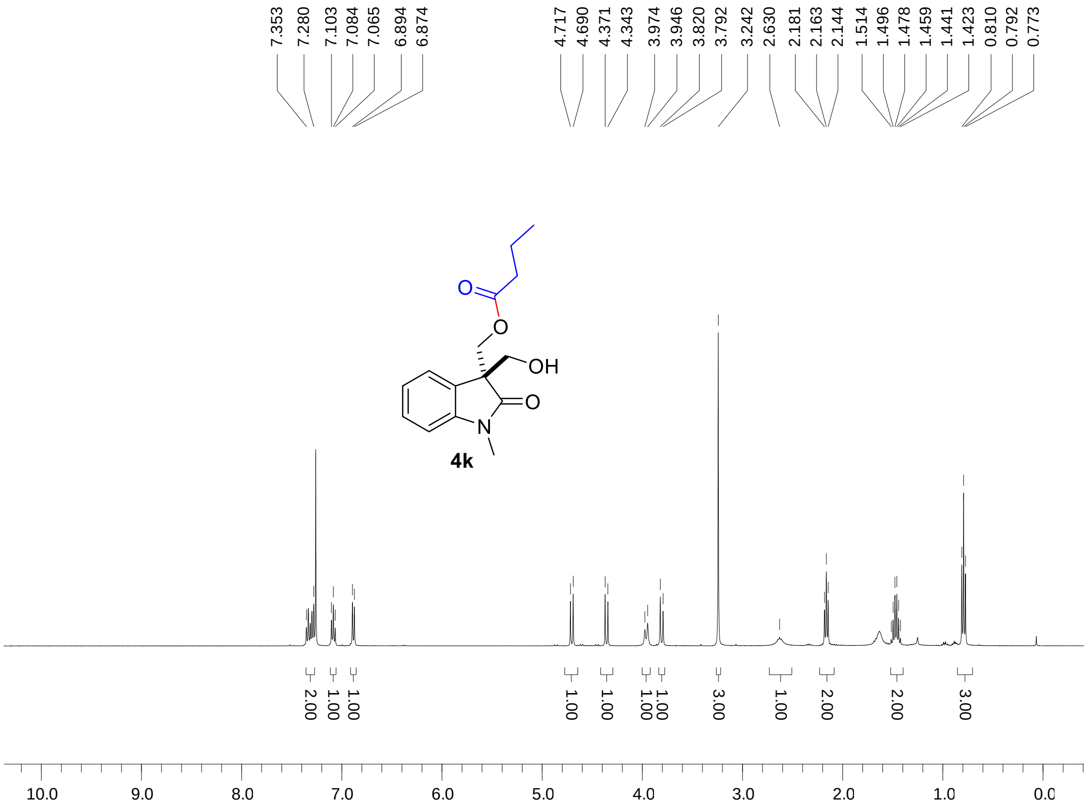


4j

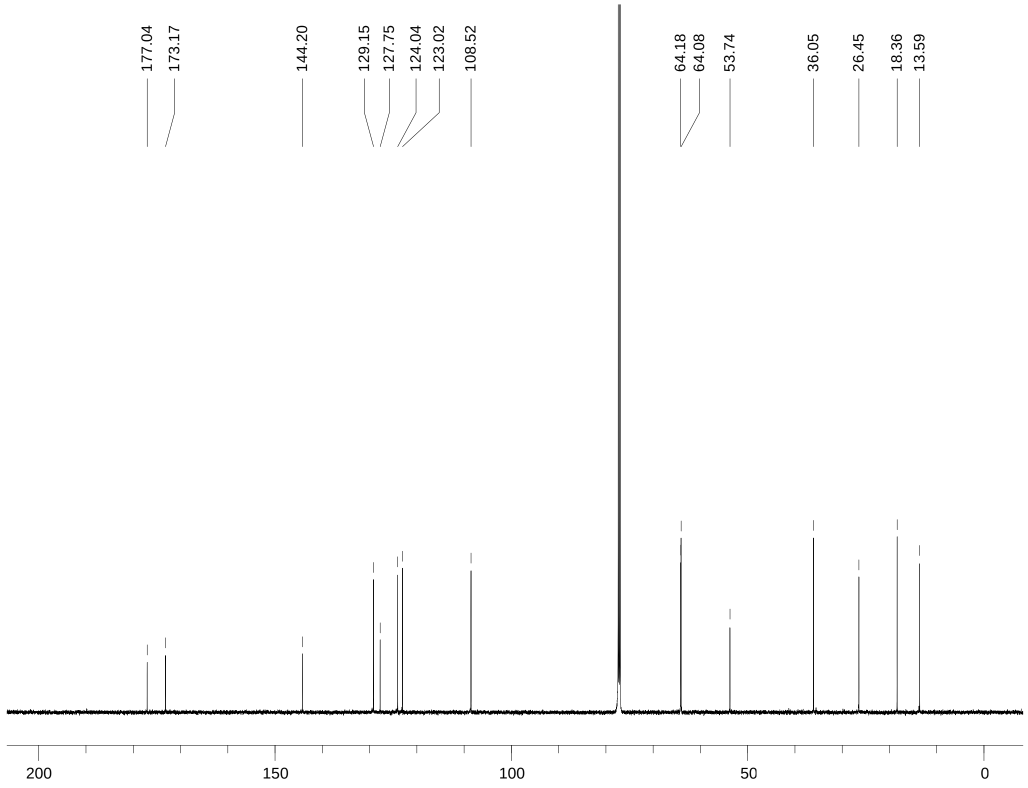
^{13}C NMR (75 MHz, CDCl$_3$)



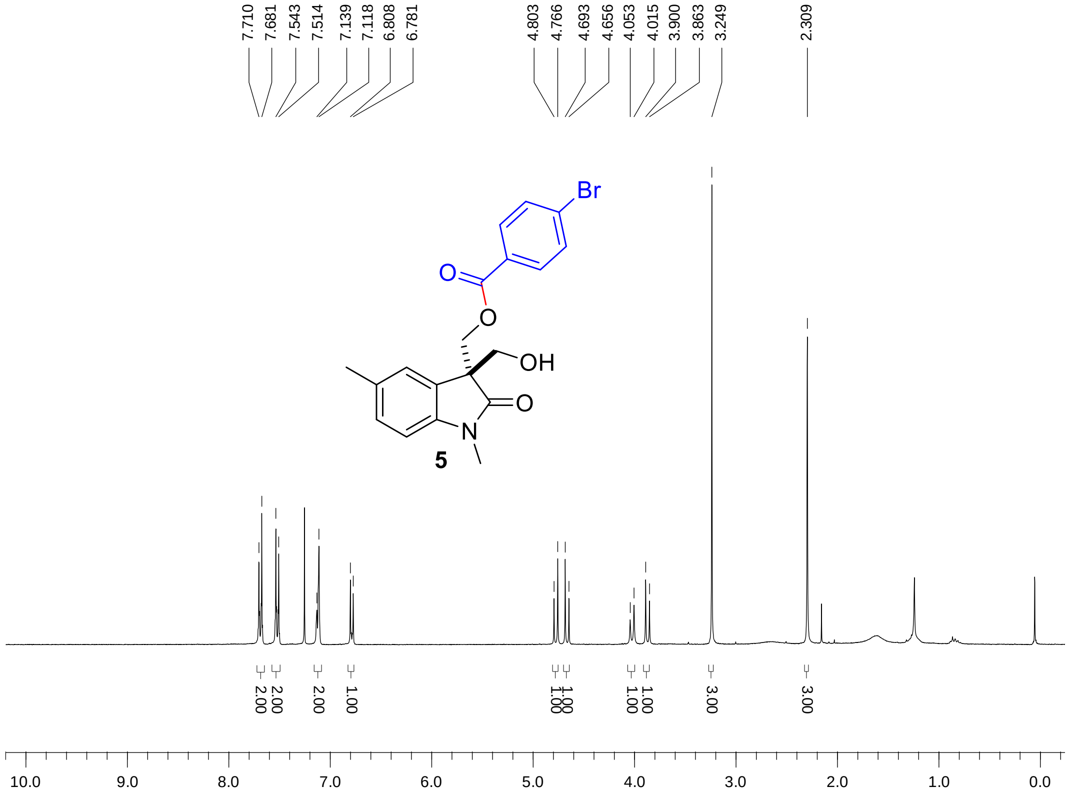
^{1}H NMR (400 MHz, CDCl$_3$)



^{13}C NMR (150 MHz, CDCl$_3$)

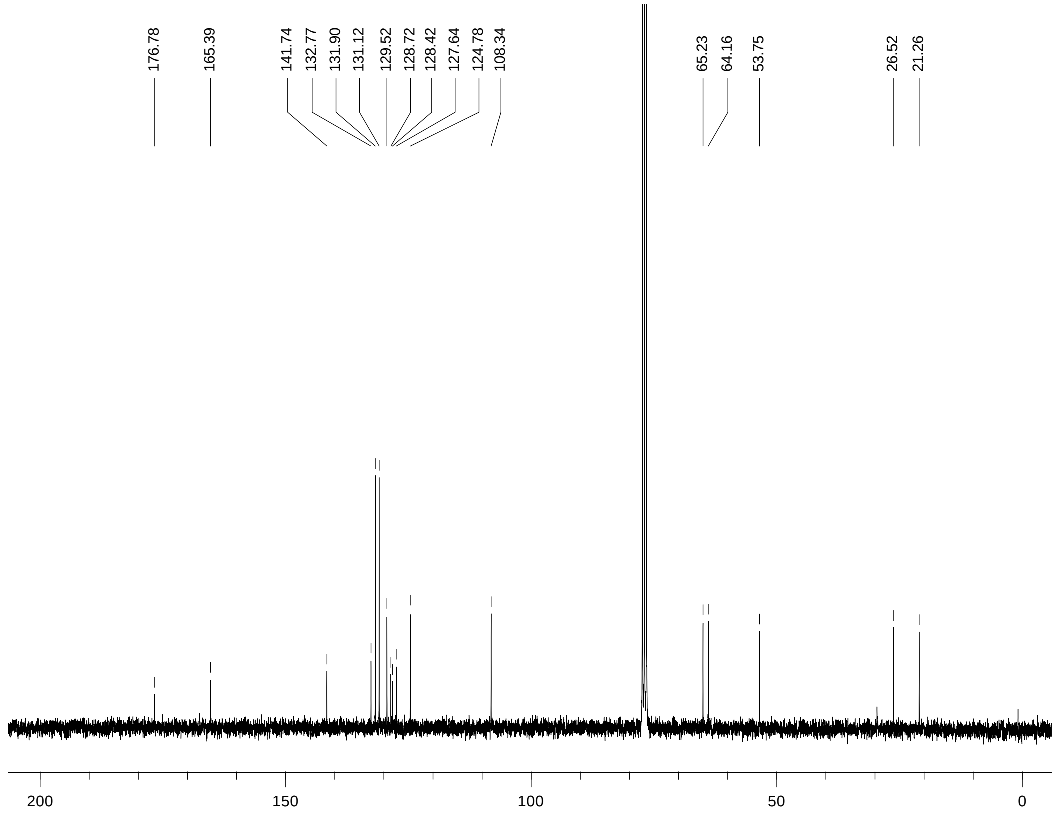


^{1}H NMR (300 MHz, $CDCl_3$)

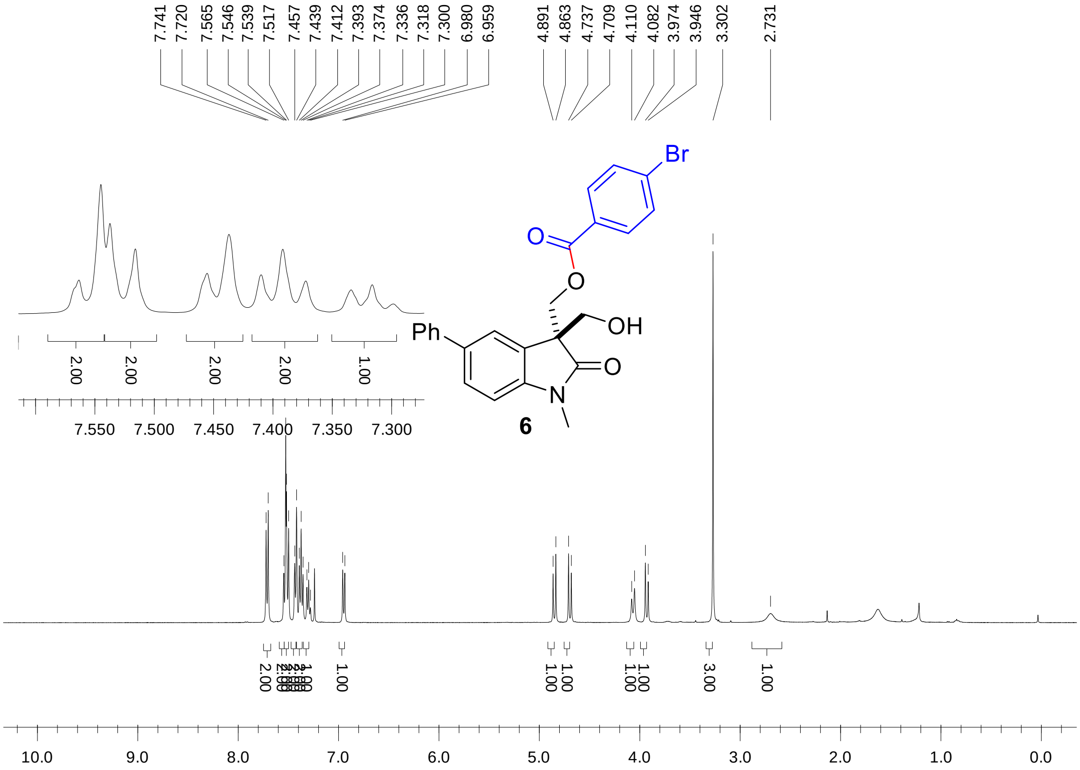


5

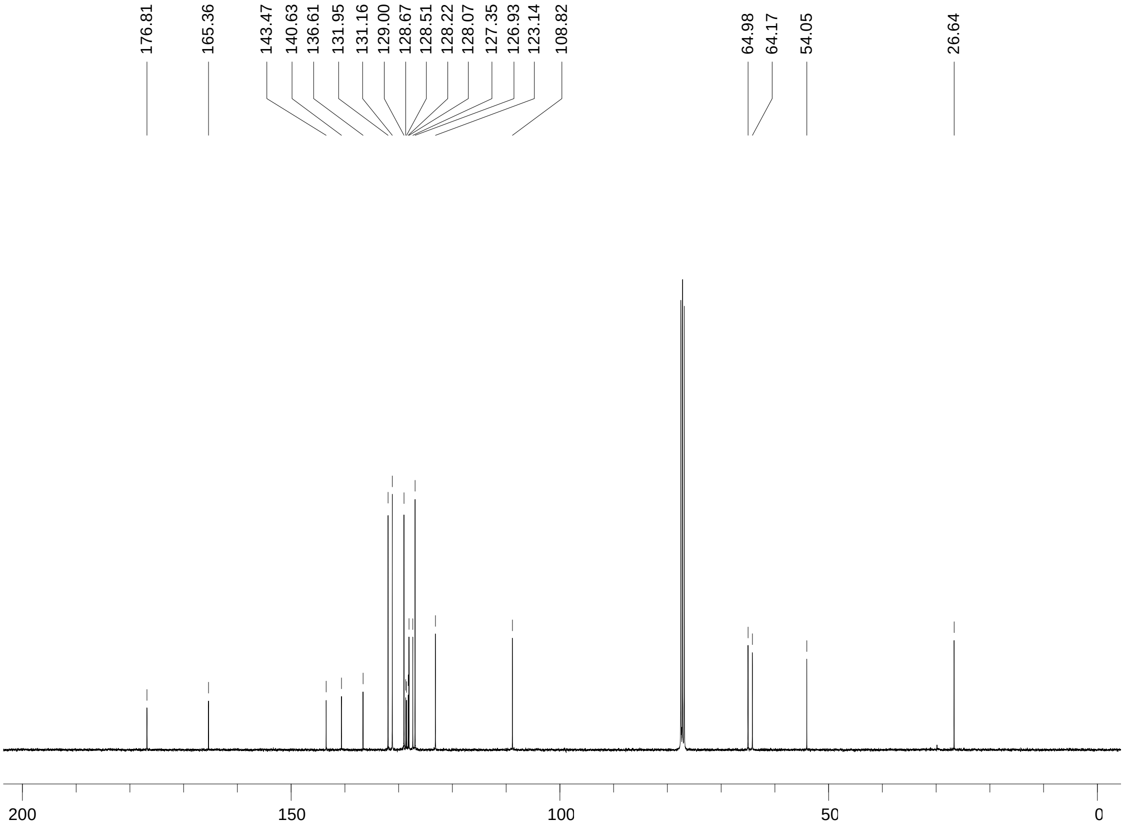
^{13}C NMR (75 MHz, $CDCl_3$)



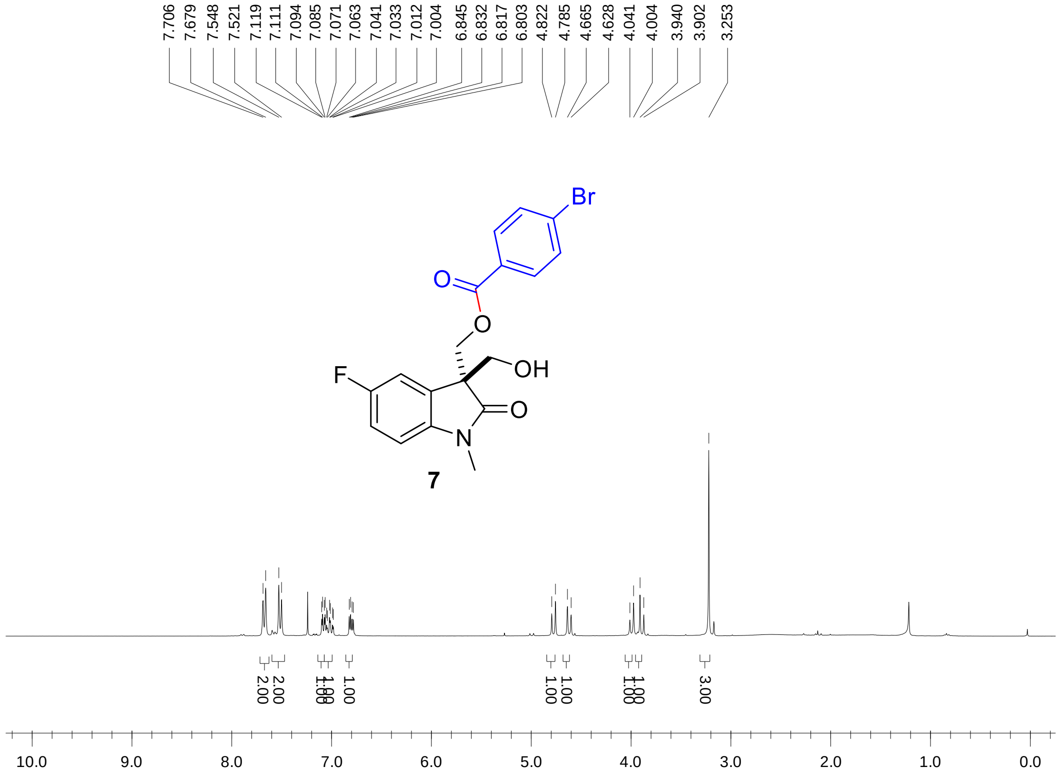
^{1}H NMR (400 MHz, CDCl$_3$)



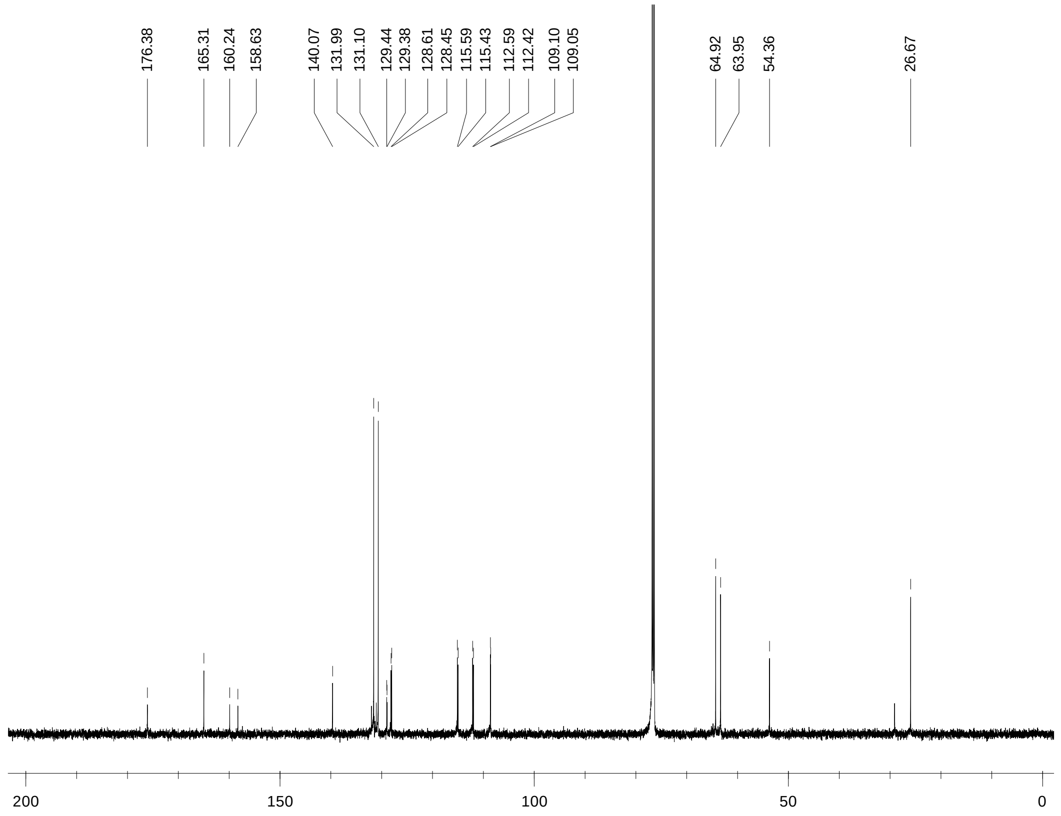
^{13}C NMR (100 MHz, CDCl$_3$)



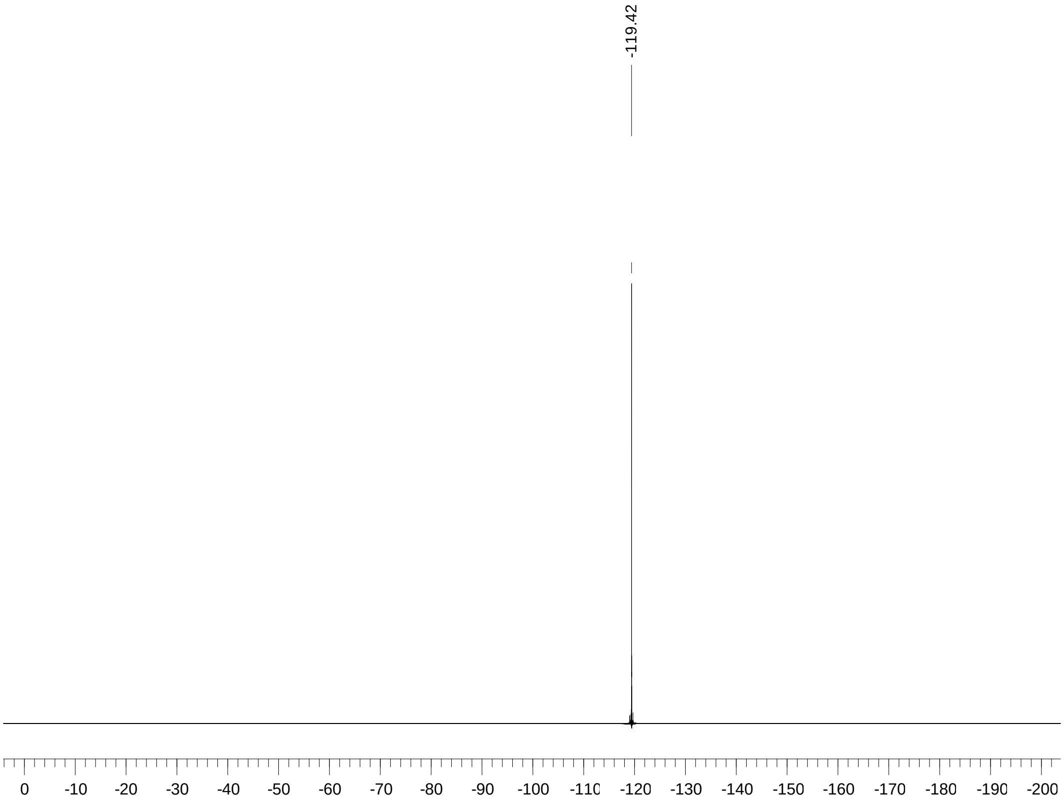
^{1}H NMR (300 MHz, CDCl$_3$)



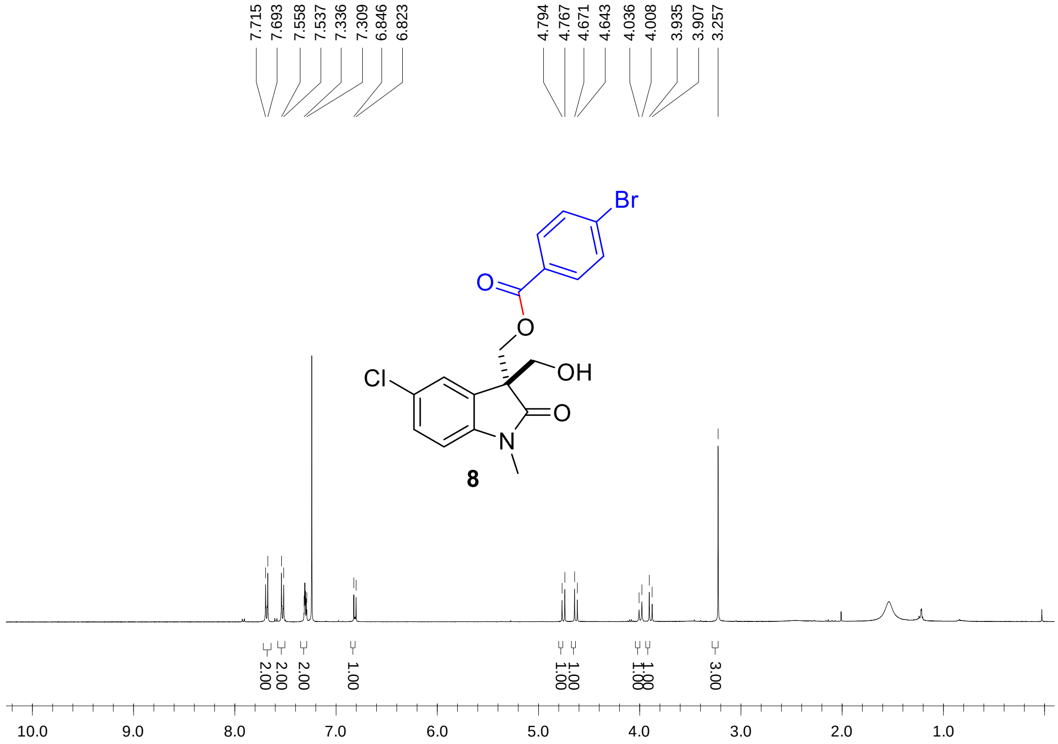
^{13}C NMR (150 MHz, CDCl$_3$)



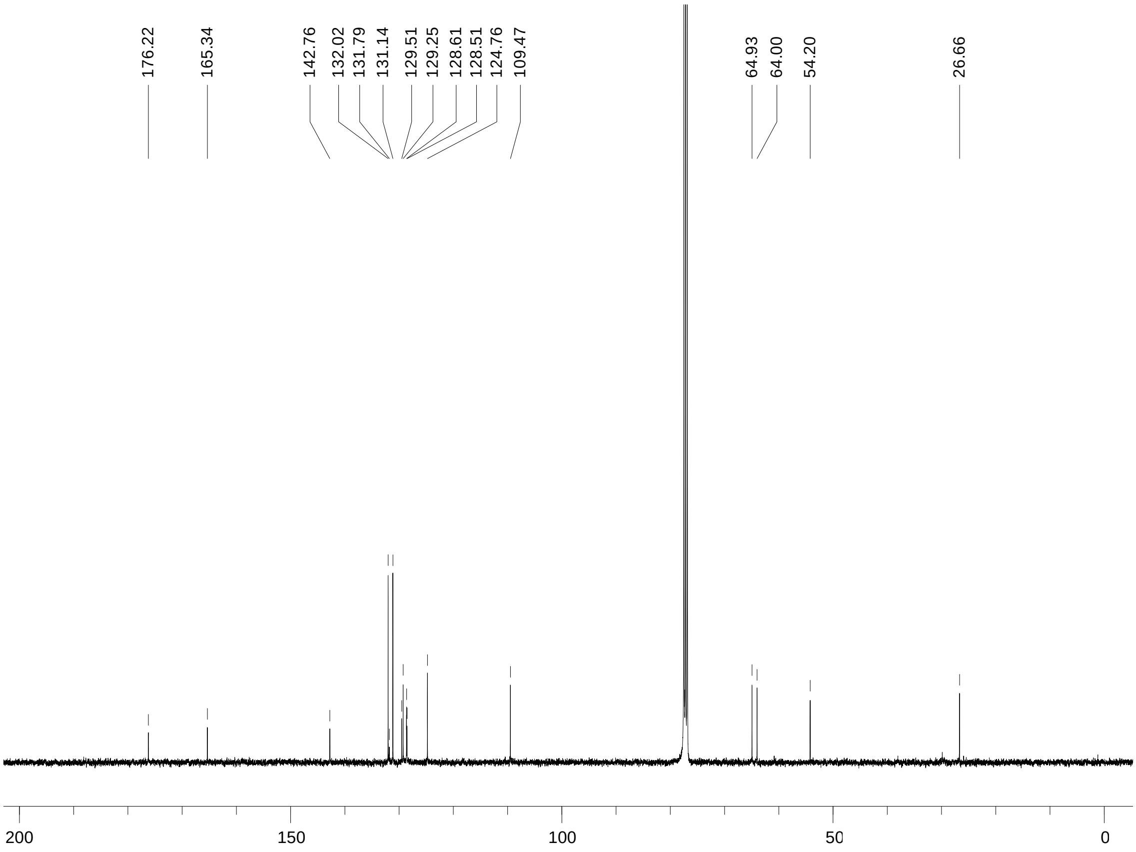
^{19}F NMR (564 MHz, $CDCl_3$)



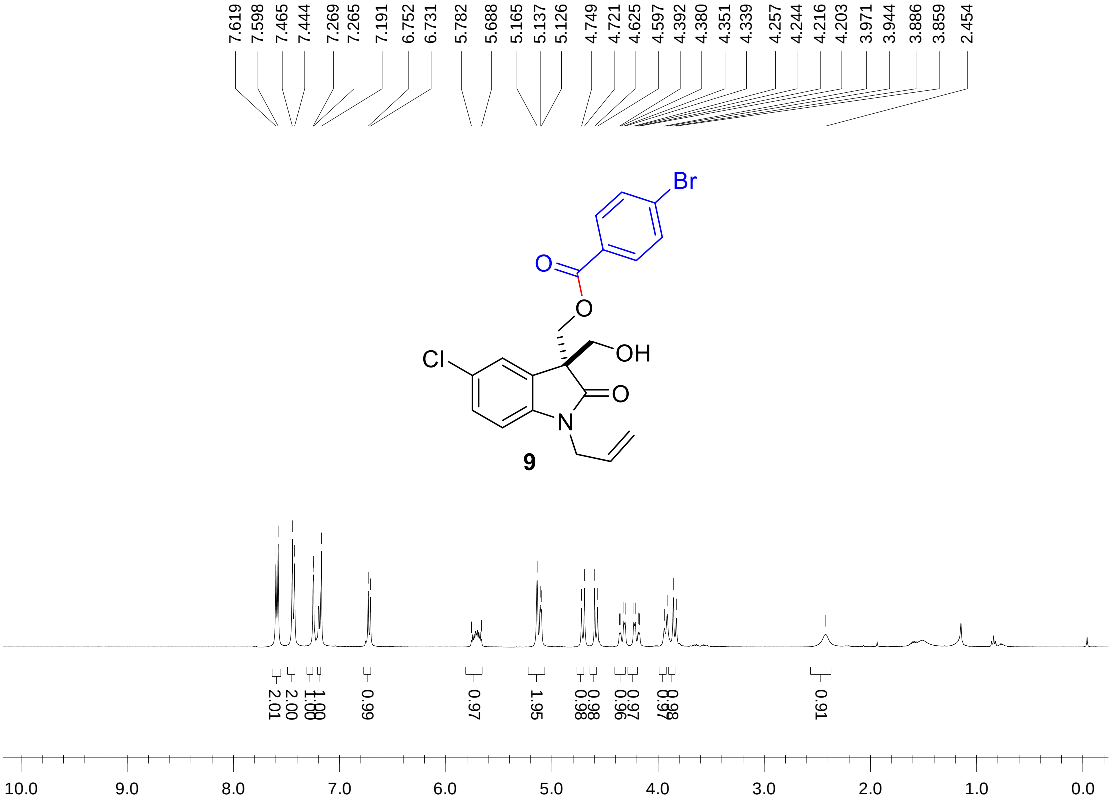
^{1}H NMR (400 MHz, CDCl$_3$)



^{13}C NMR (100 MHz, CDCl$_3$)



^{1}H NMR (400 MHz, CDCl$_3$)



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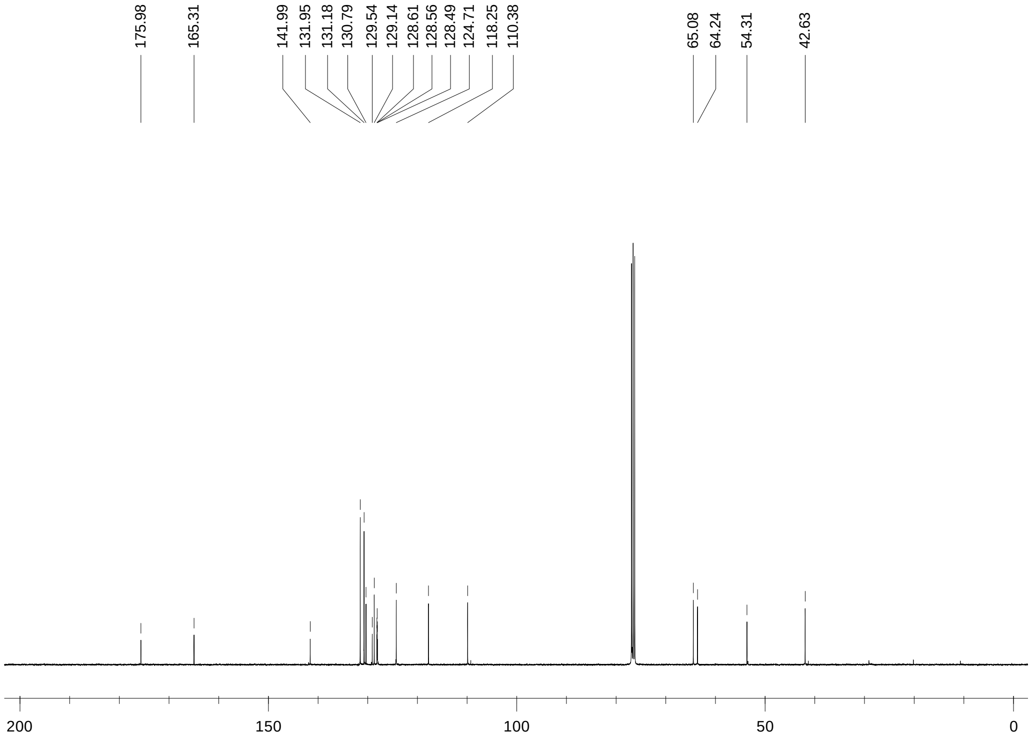
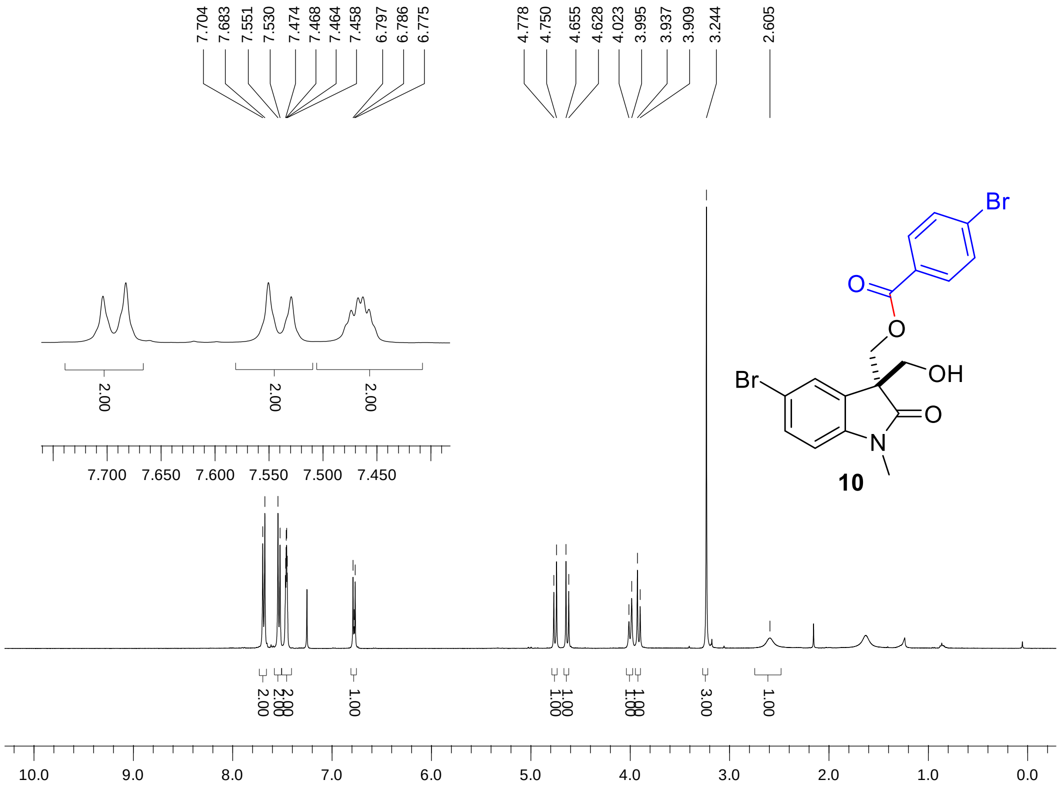
^{13}C NMR (100 MHz, CDCl$_3$)

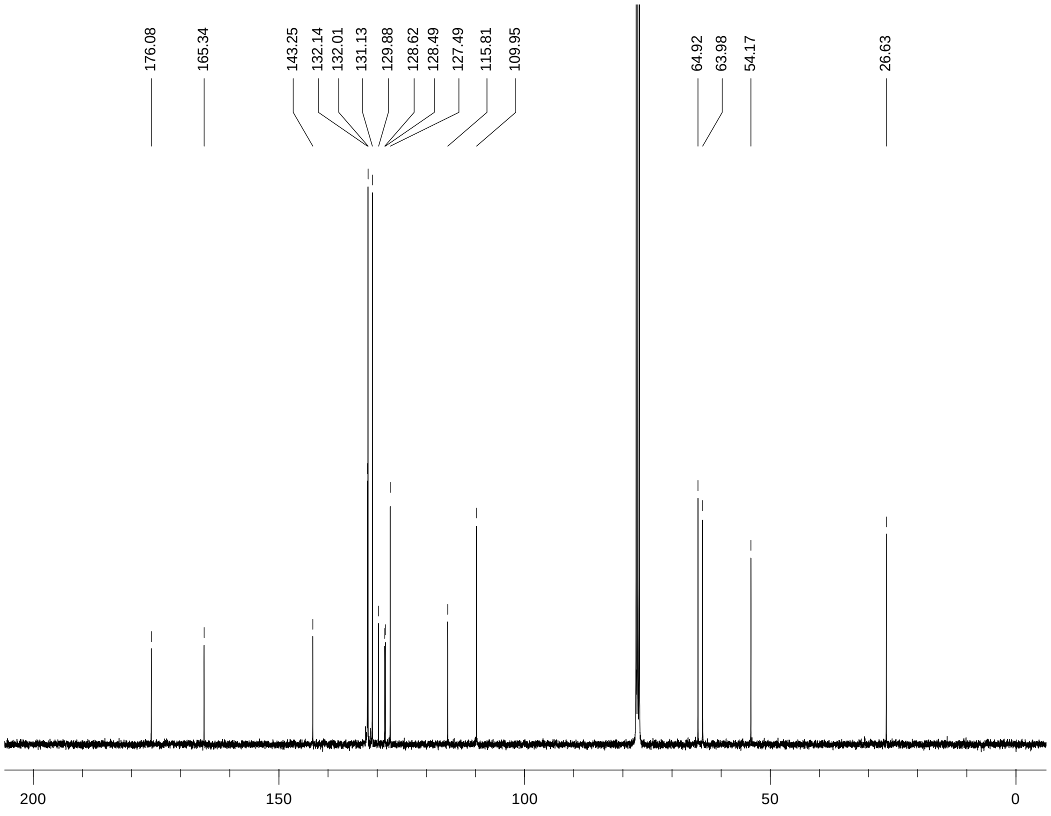


^{1}H NMR (400 MHz, CDCl$_3$)

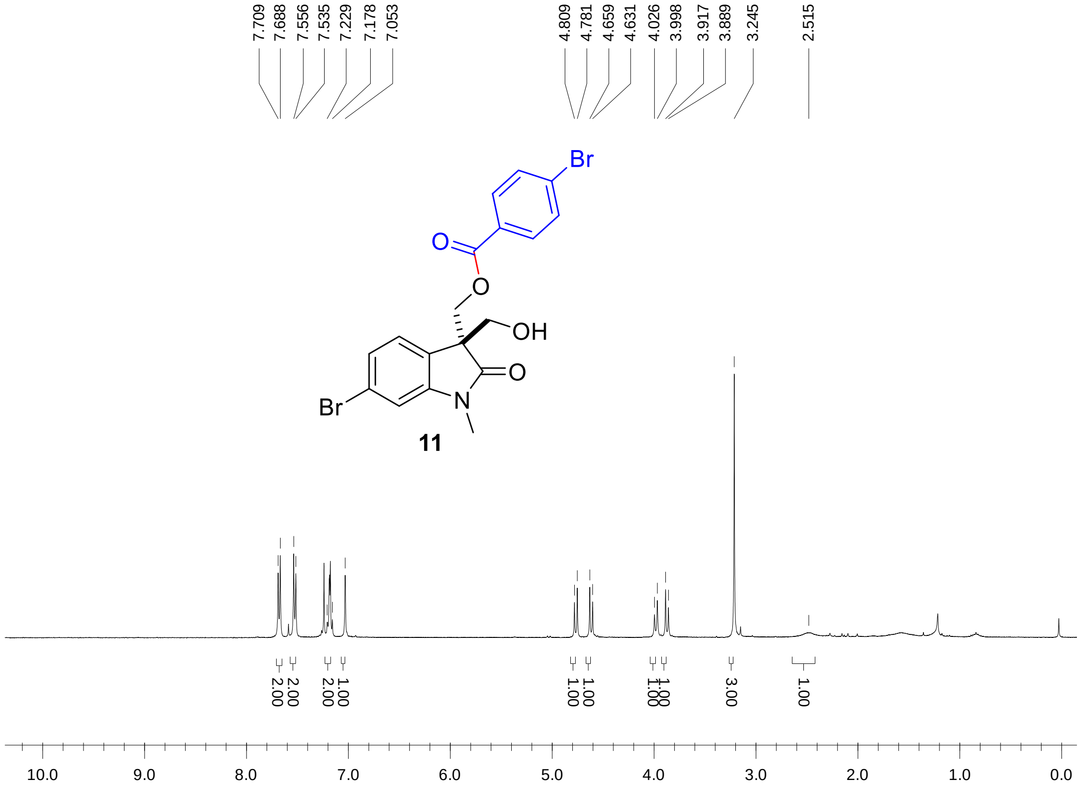


10

^{13}C NMR (100 MHz, CDCl$_3$)

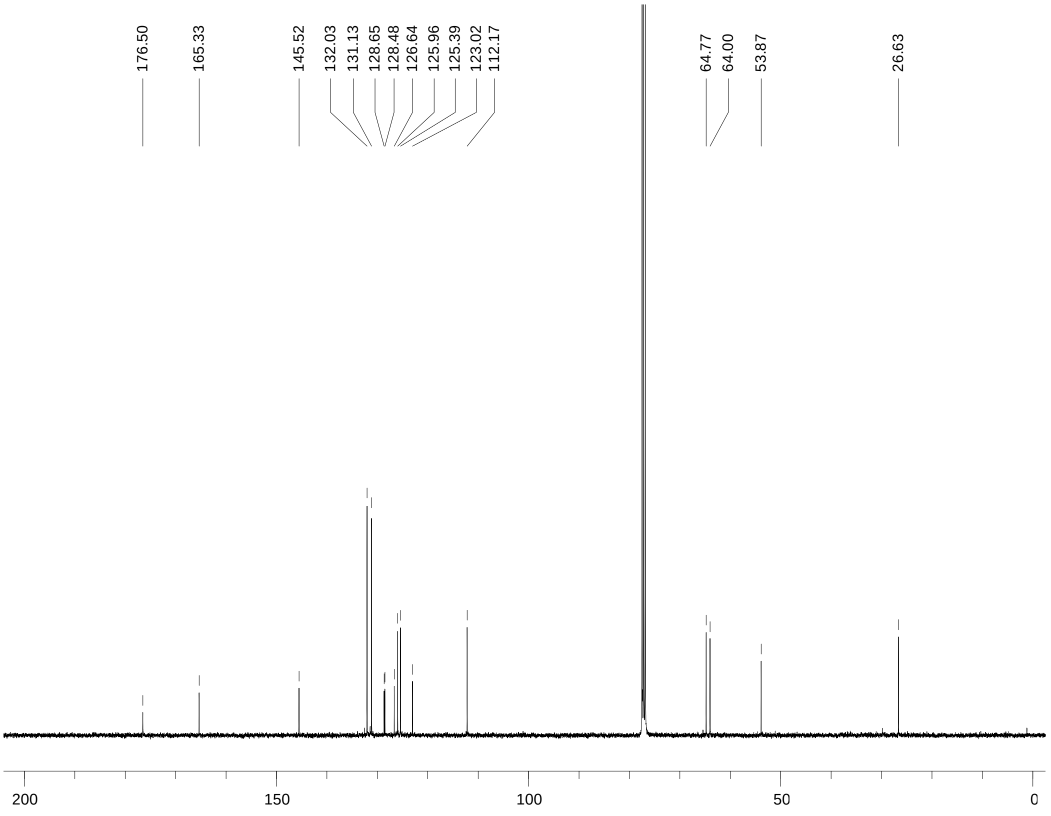


^{1}**H NMR** (400 MHz, CDCl$_3$)

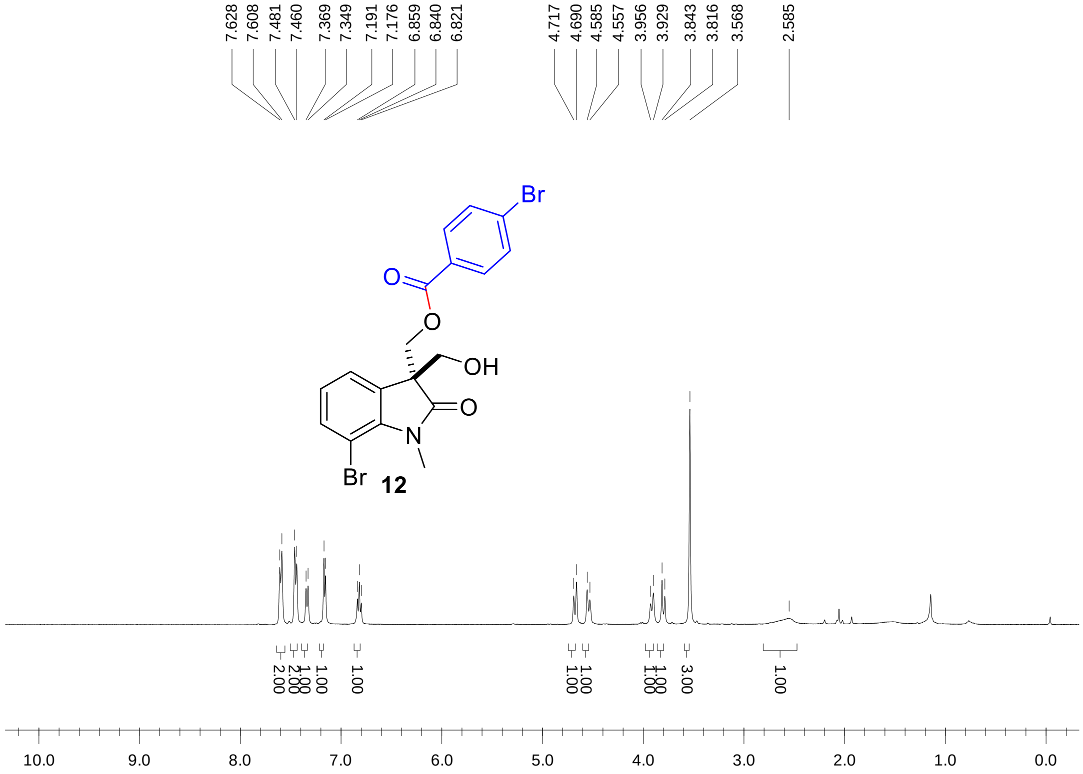


11

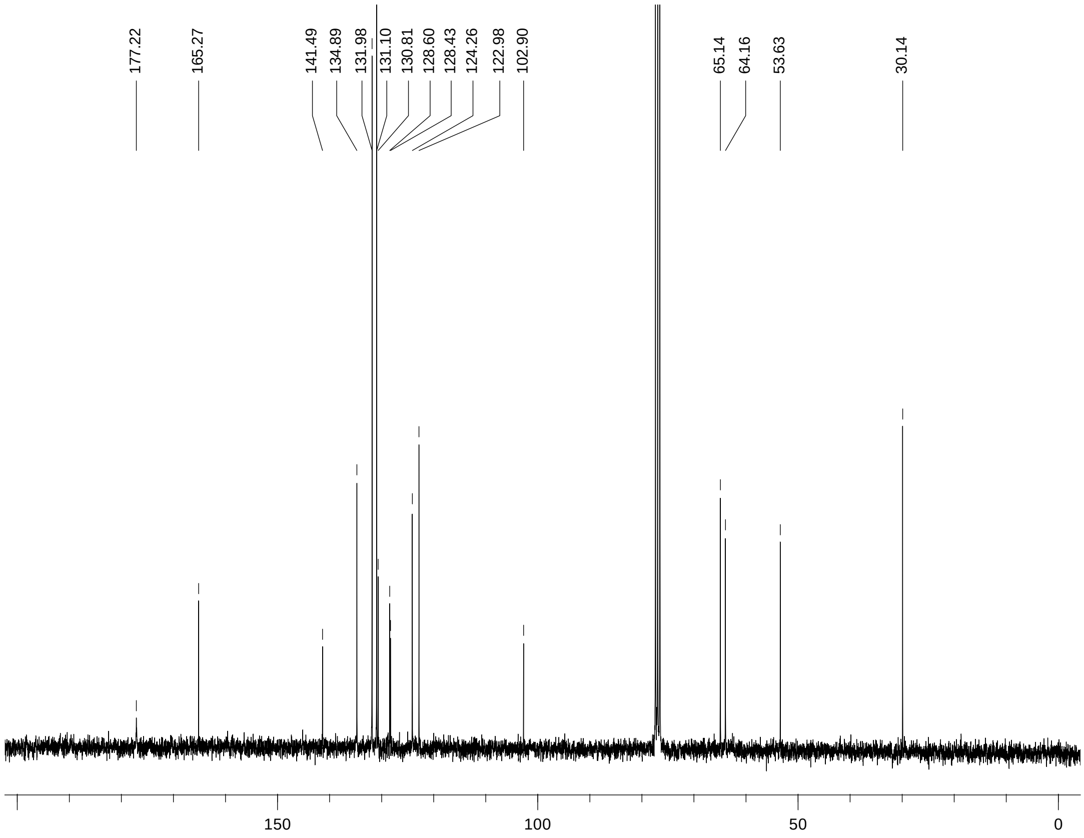
^{13}**C NMR** (100 MHz, CDCl$_3$)



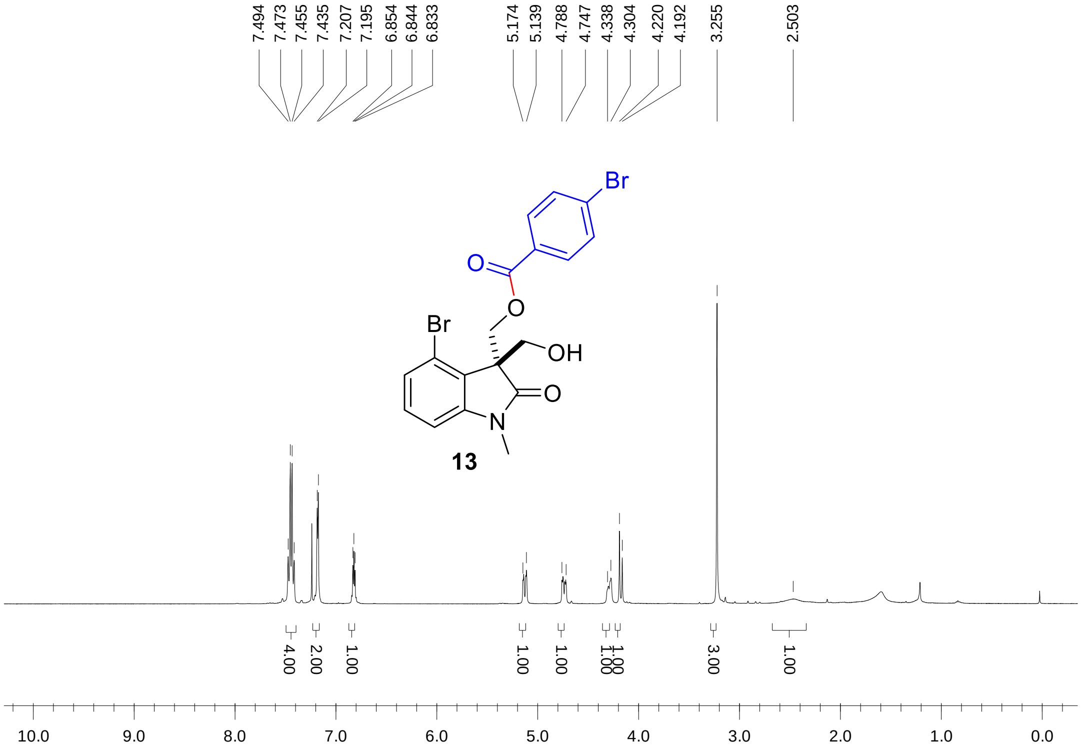
^{1}H NMR (400 MHz, CDCl$_3$)



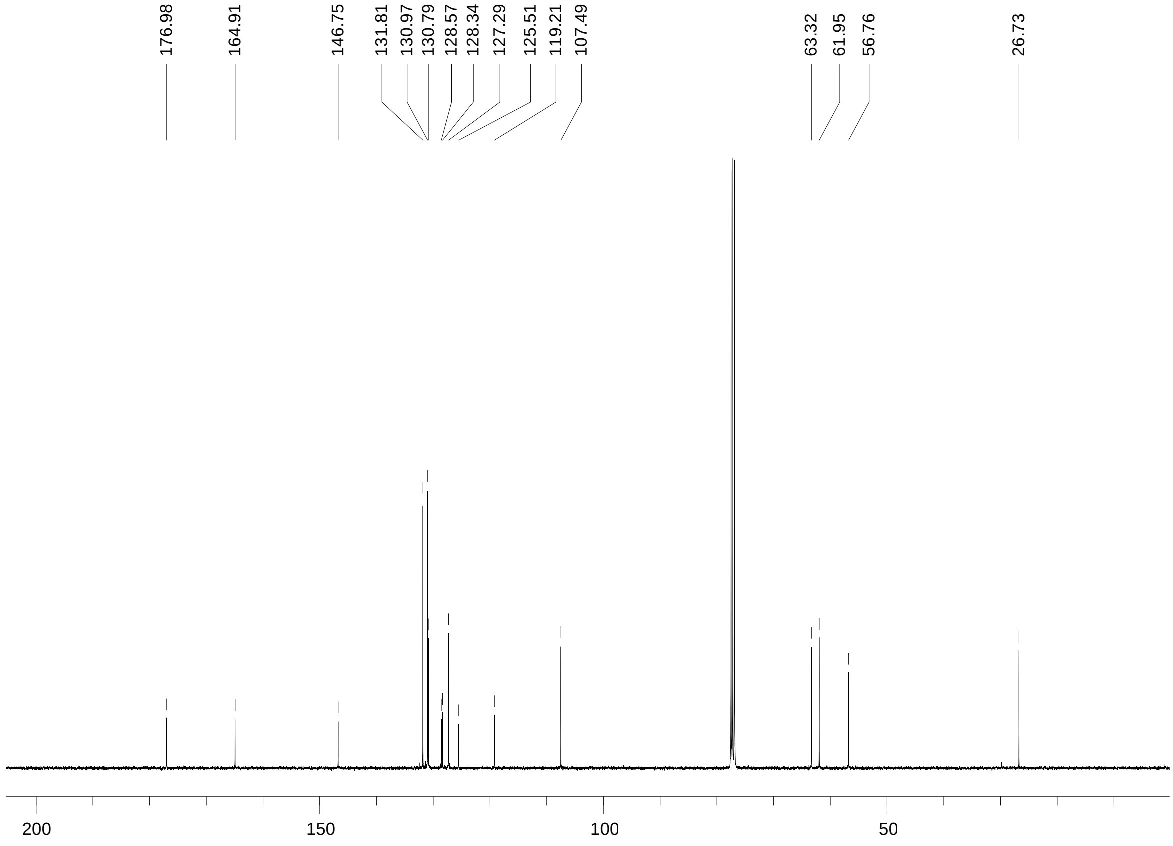
^{13}C NMR (75 MHz, CDCl$_3$)



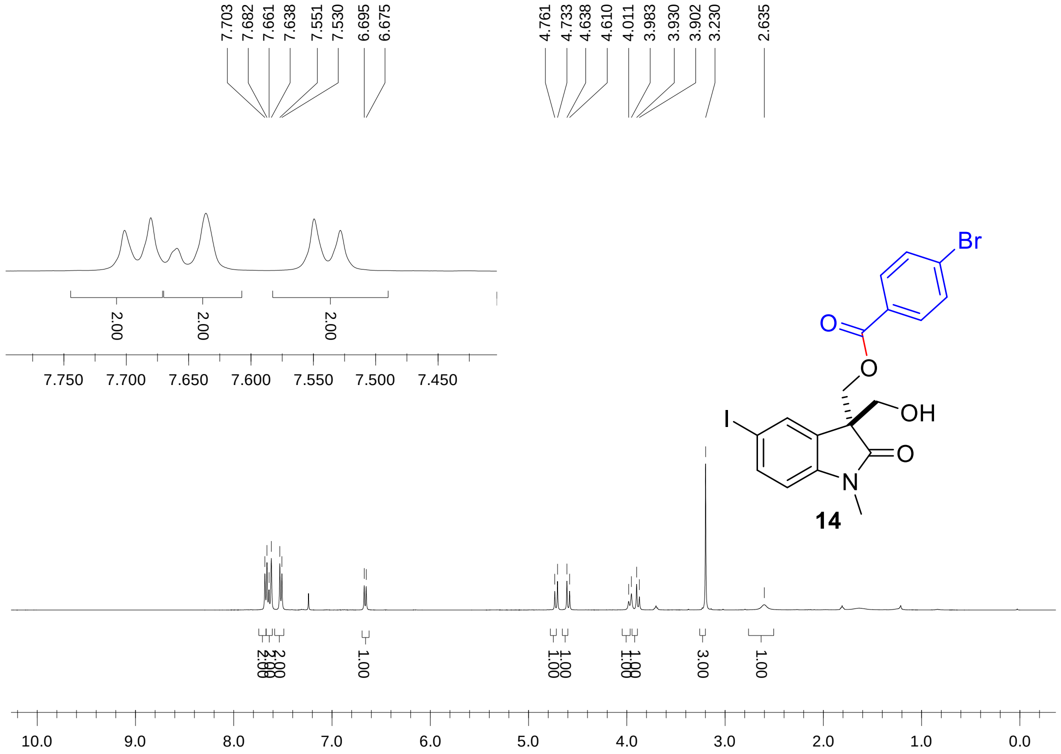
^{1}H NMR (400 MHz, $CDCl_3$)



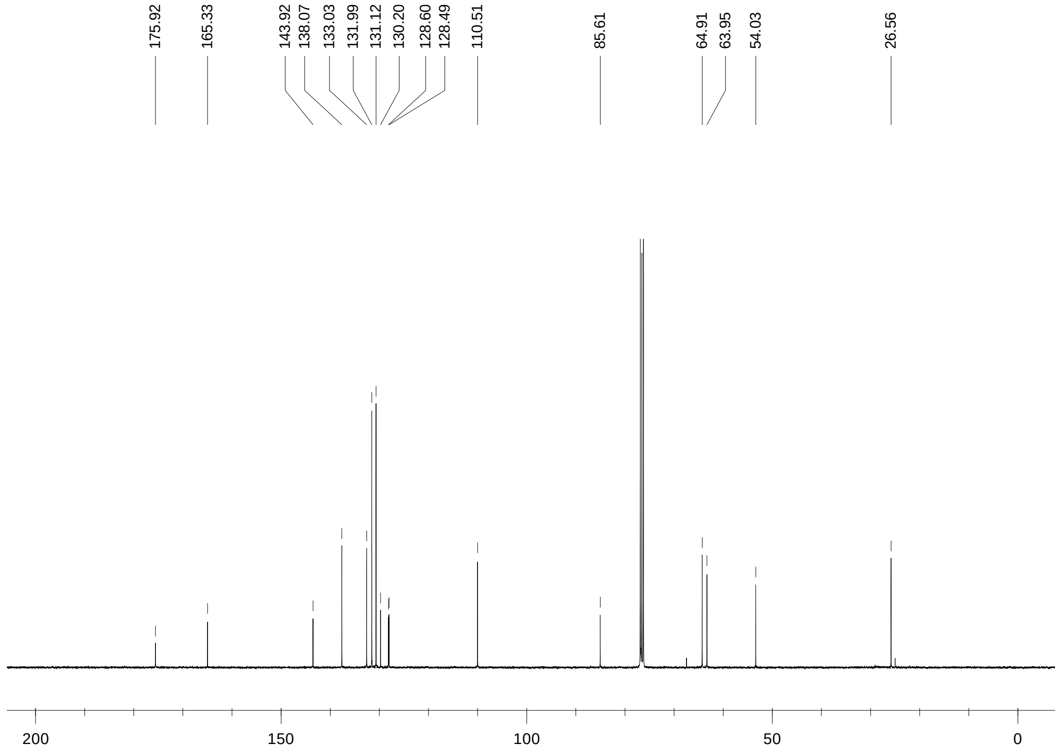
^{13}C NMR (100 MHz, $CDCl_3$)



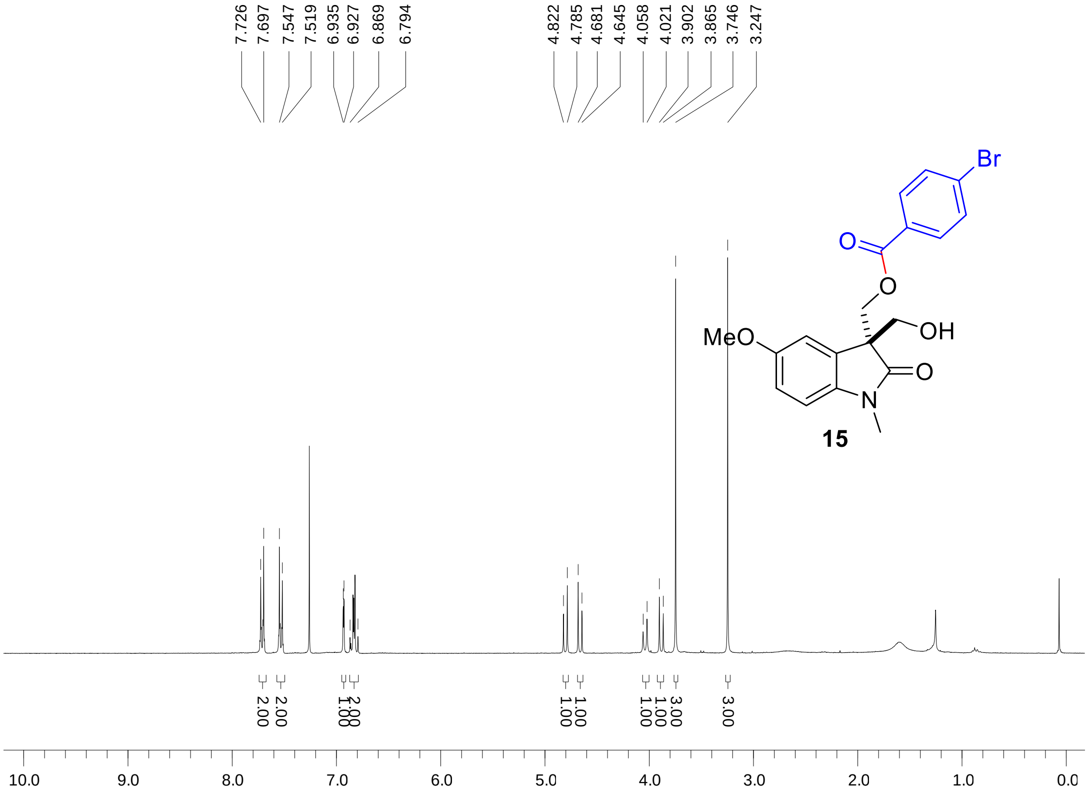
^{1}H NMR (400 MHz, CDCl$_3$)



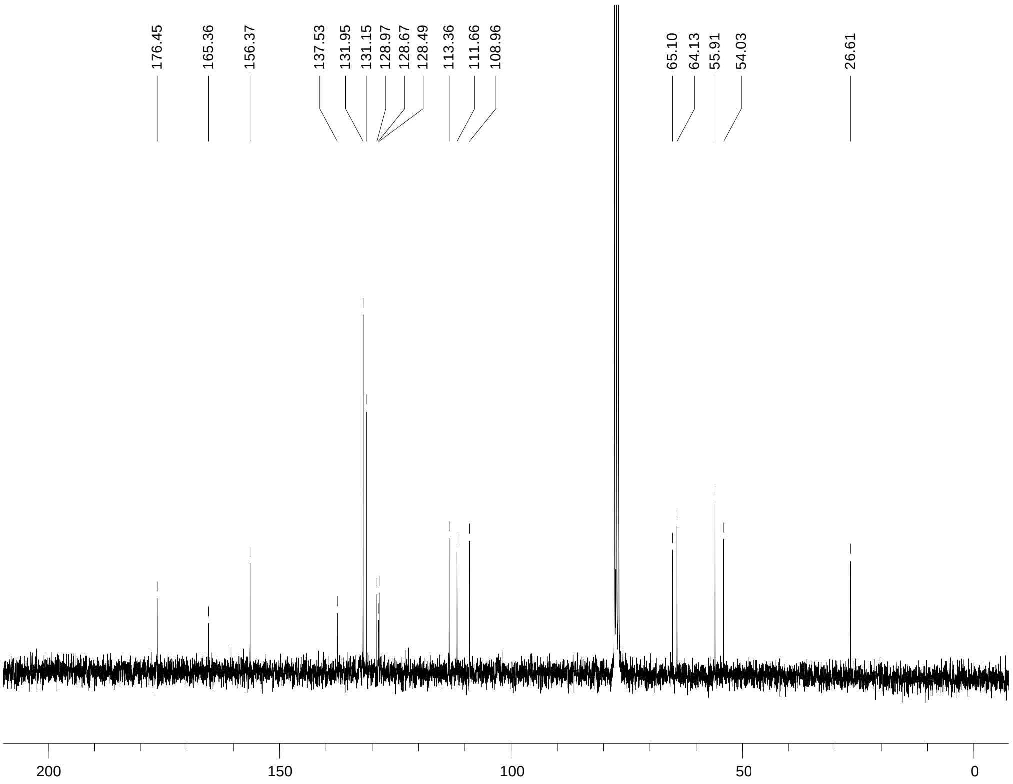
^{13}C NMR (100 MHz, CDCl$_3$)



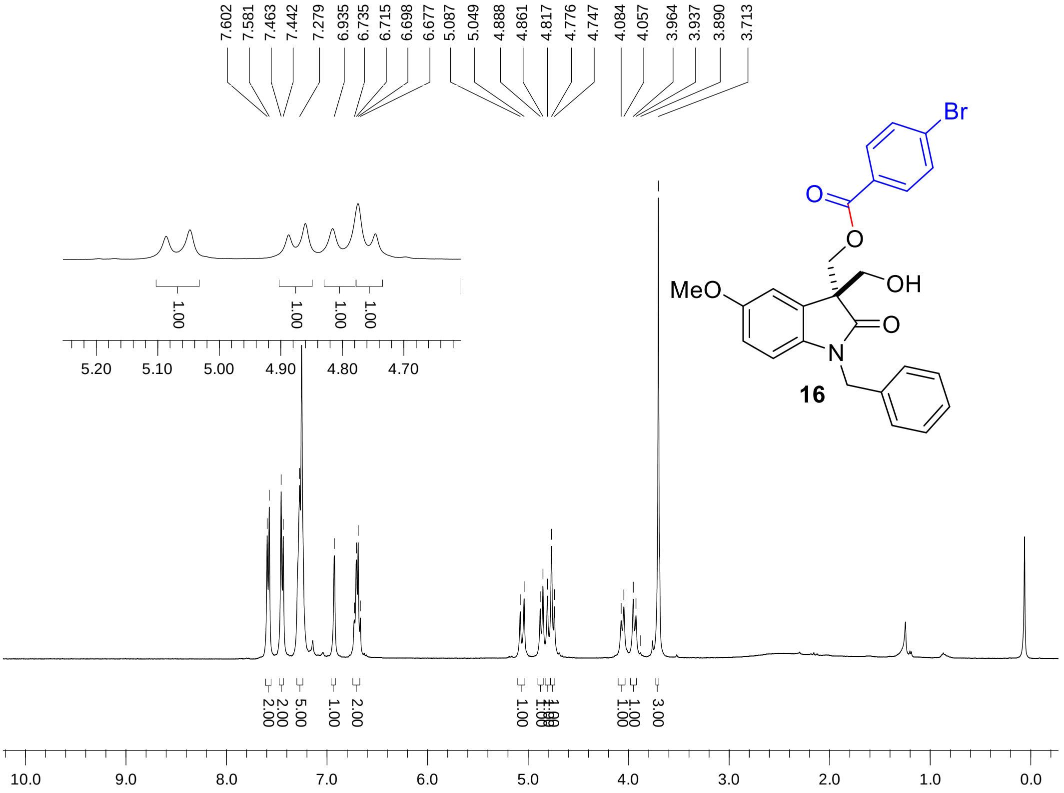
^{1}H NMR (300 MHz, CDCl$_3$)



^{13}C NMR (75 MHz, CDCl$_3$)

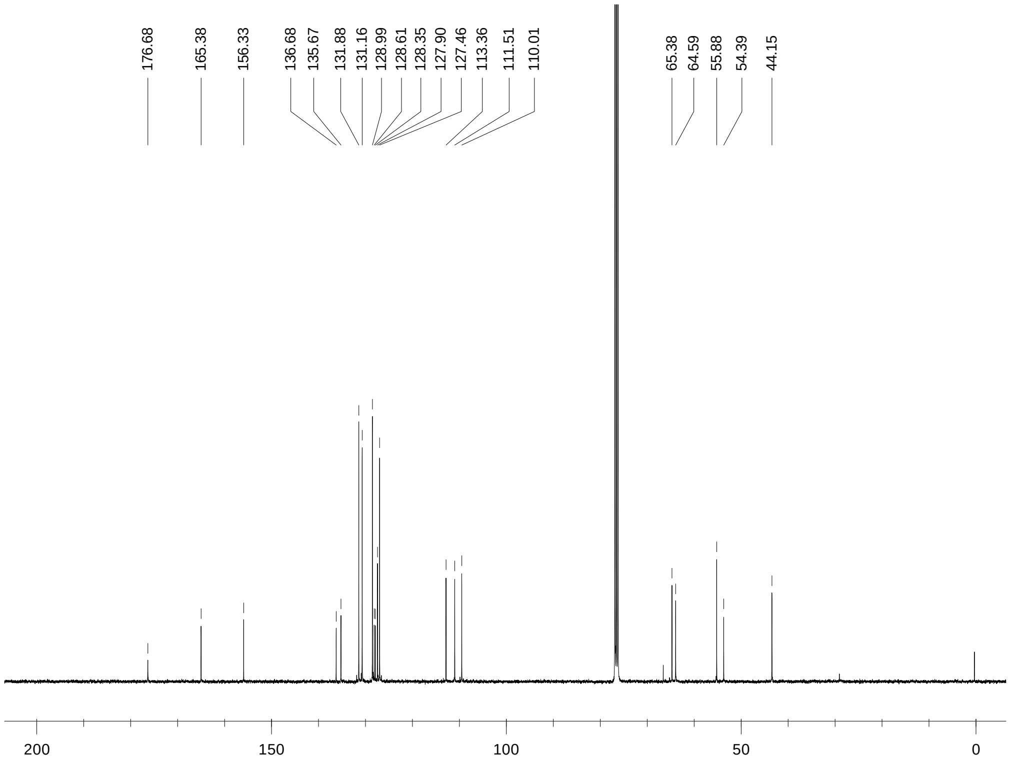


^{1}H NMR (400 MHz, CDCl$_3$)

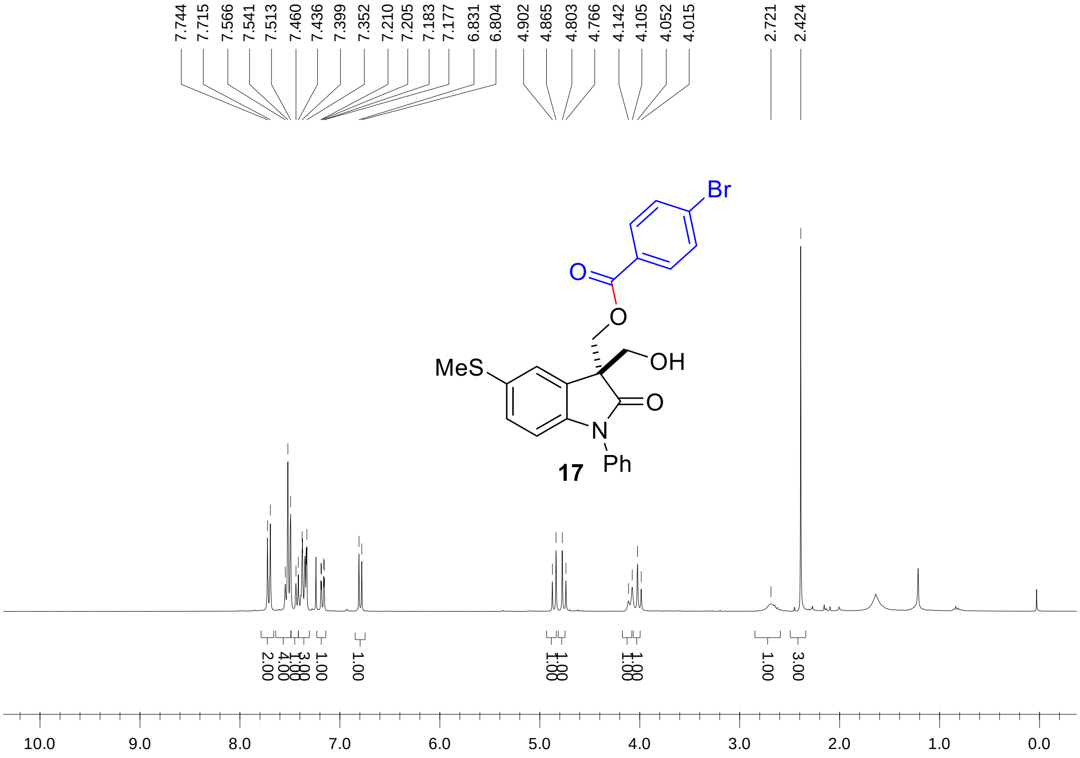


16

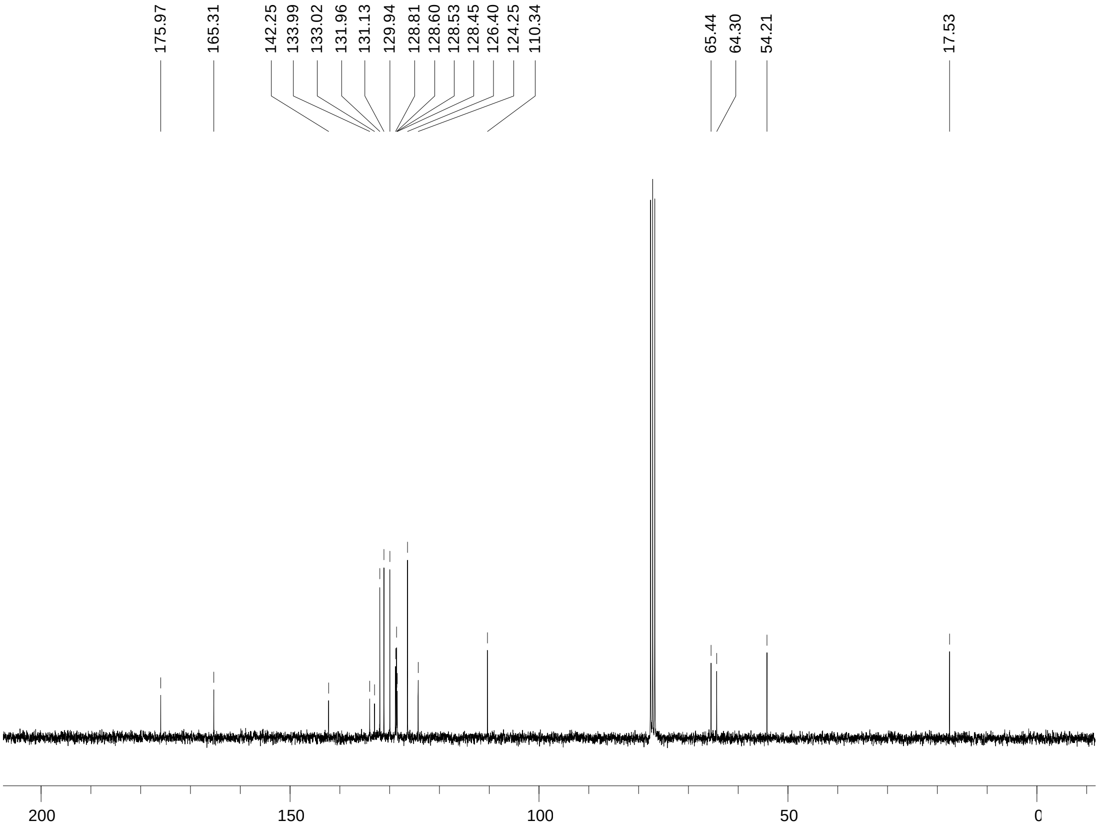
^{13}C NMR (100 MHz, CDCl$_3$)



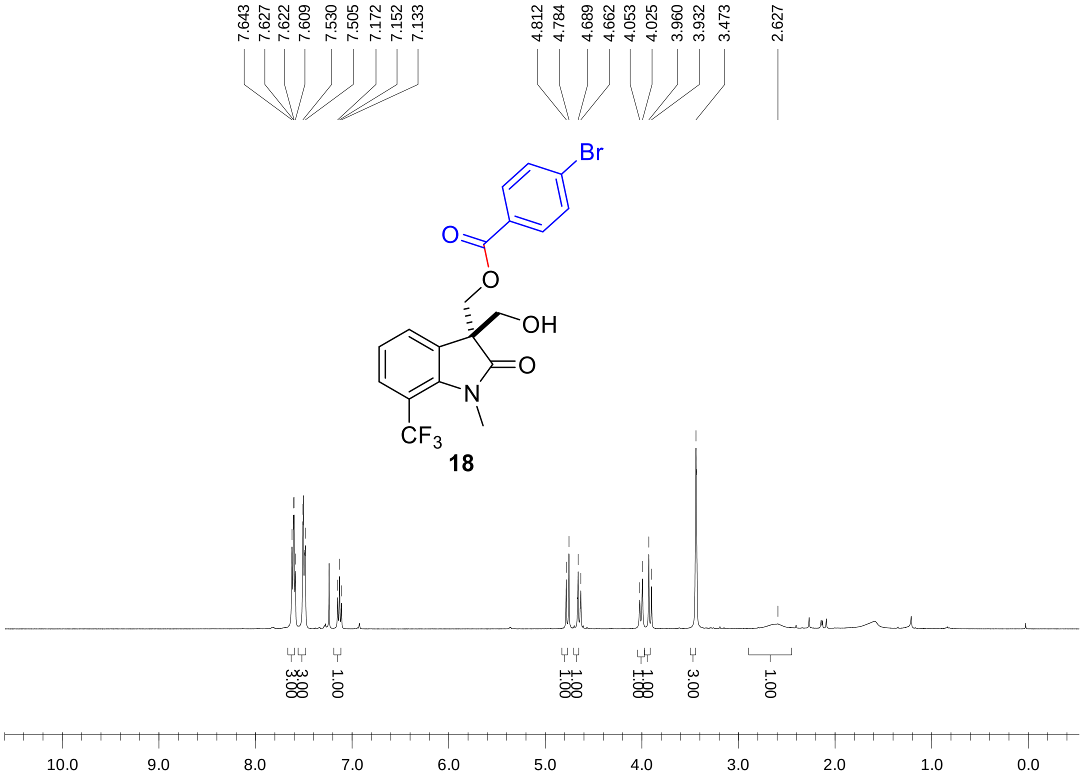
^{1}H NMR (300 MHz, CDCl$_3$)



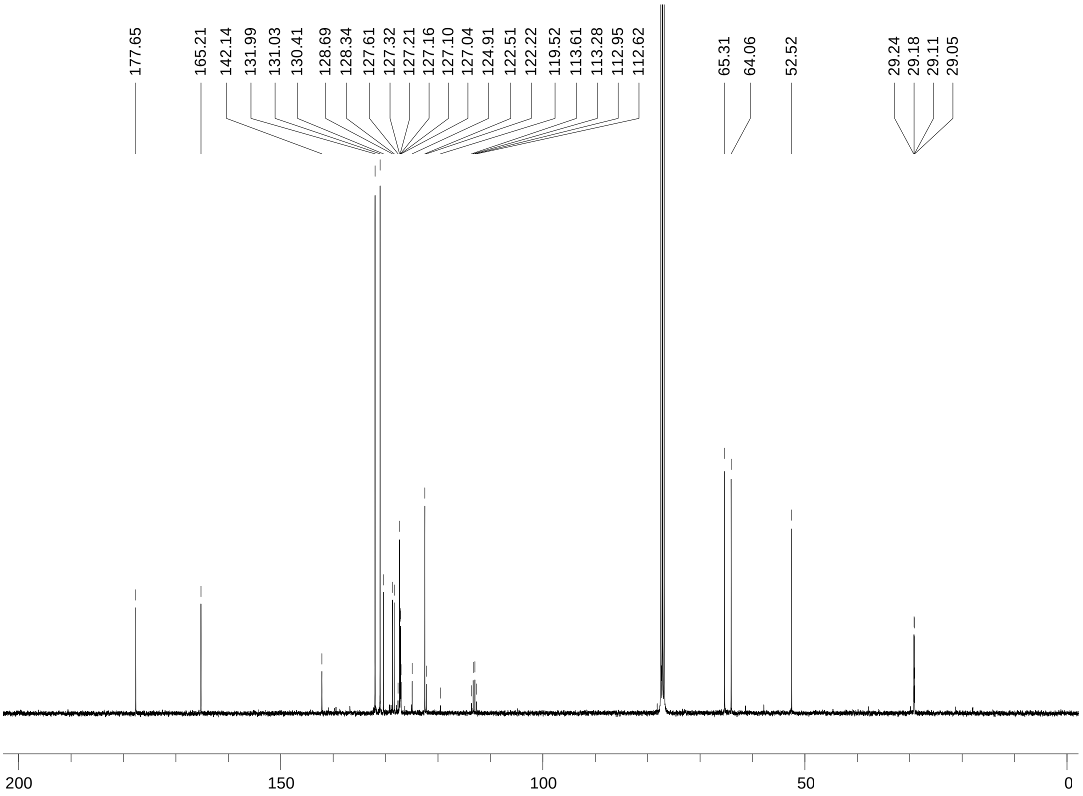
^{13}C NMR (75 MHz, CDCl$_3$)



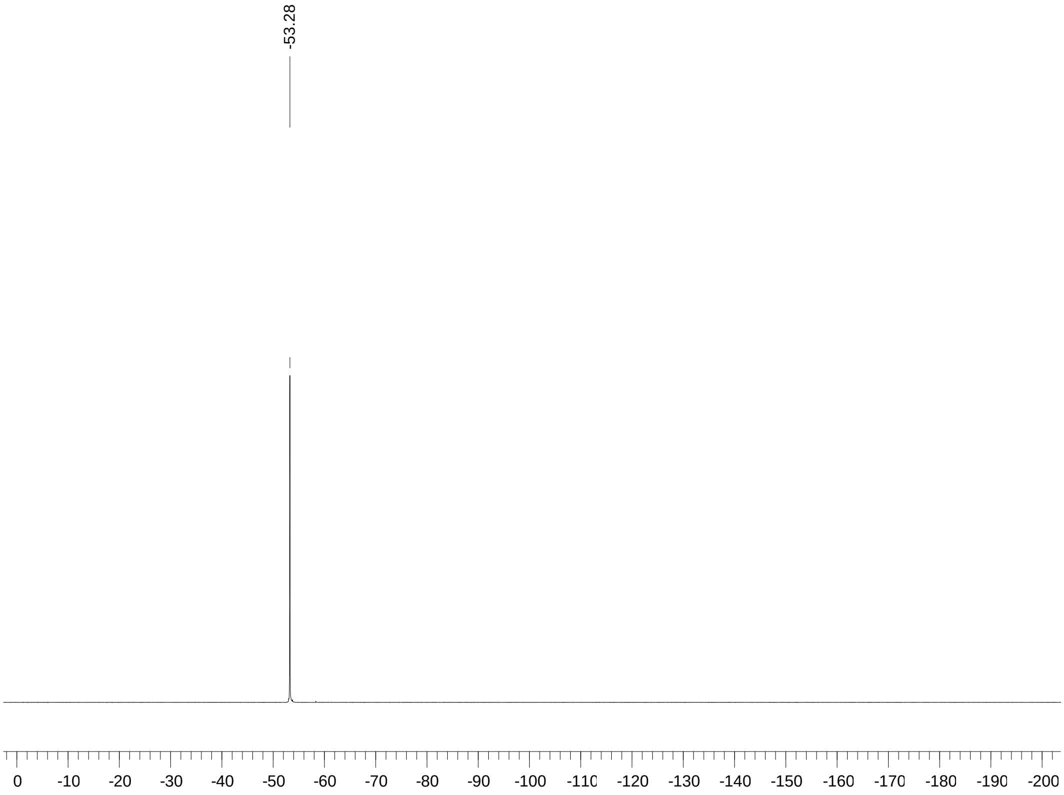
^{1}H NMR (400 MHz, $CDCl_3$)



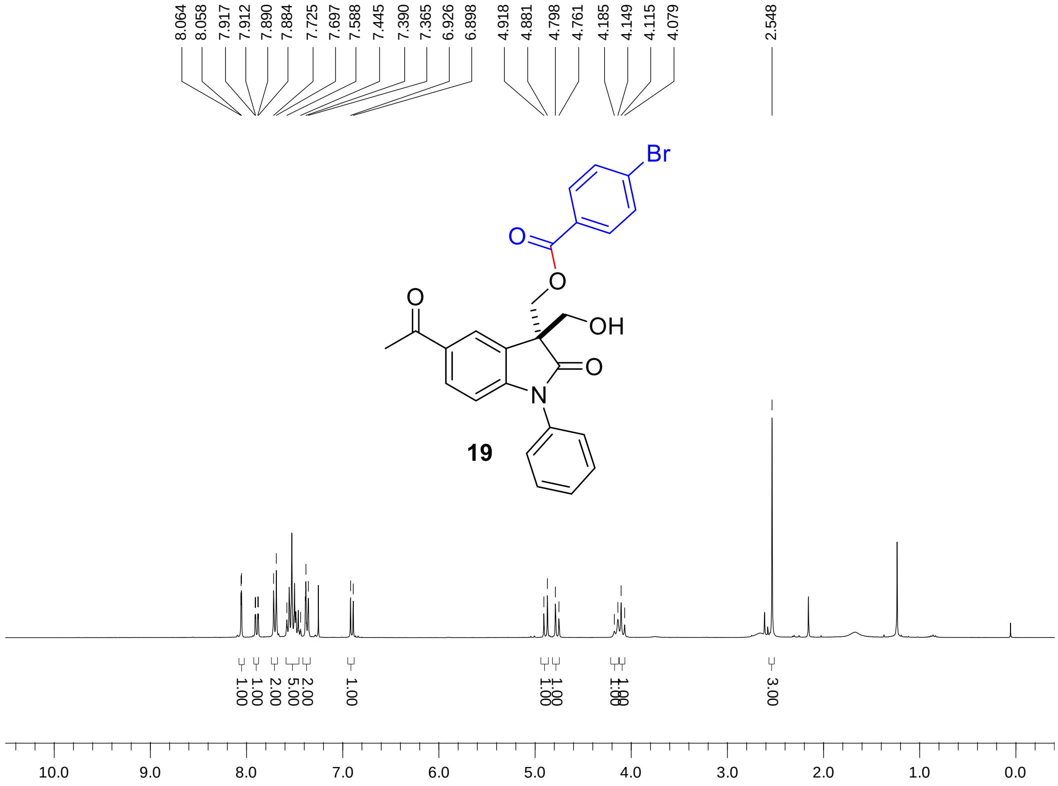
^{13}C NMR (100 MHz, $CDCl_3$)



^{19}F NMR (376 MHz, $CDCl_3$)

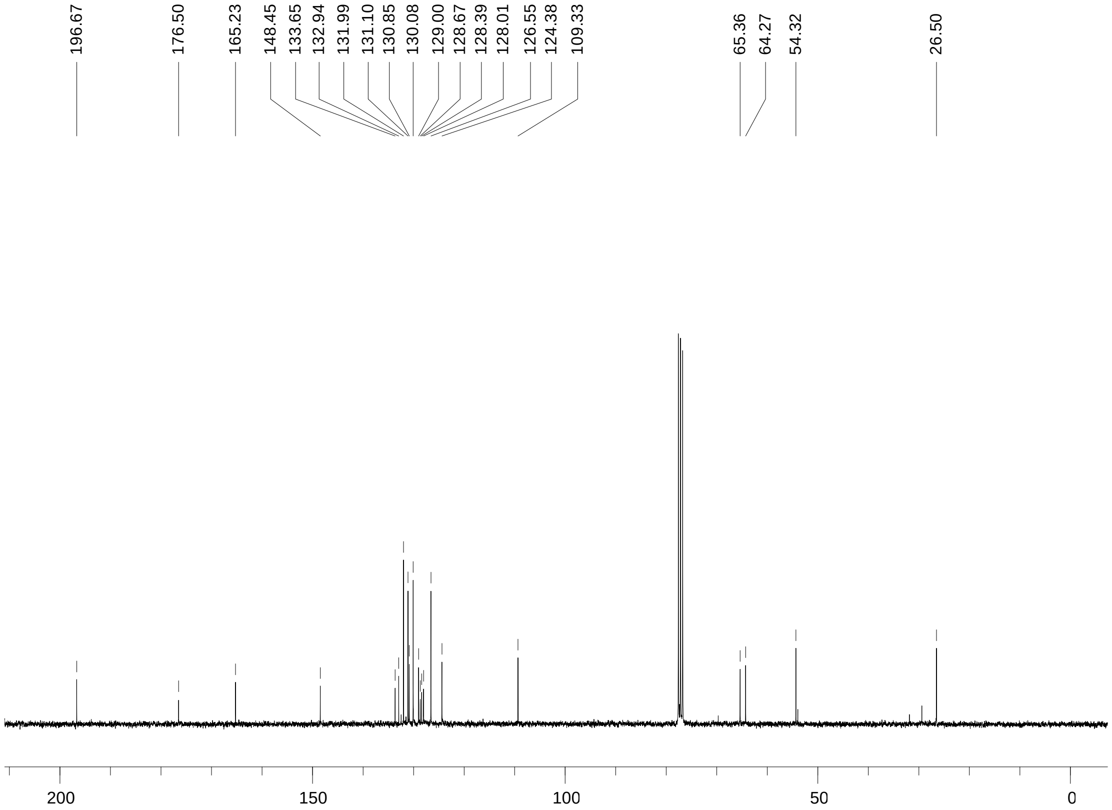


^{1}H NMR (300 MHz, CDCl$_3$)

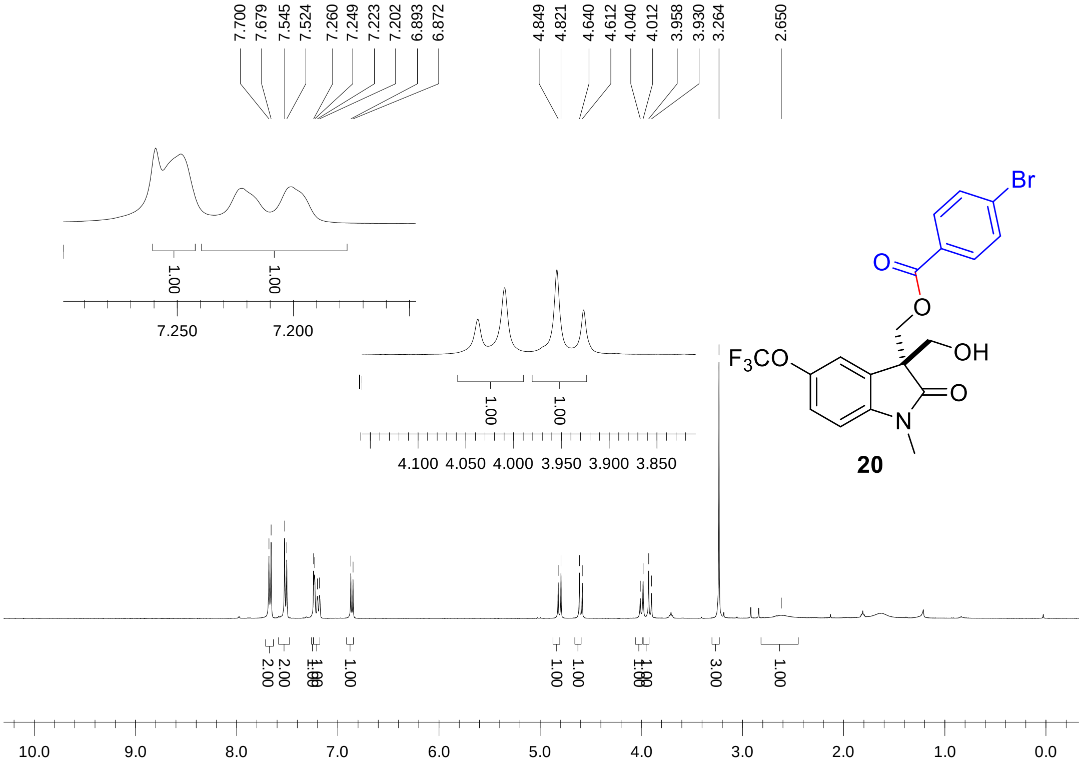


19

^{13}C NMR (75 MHz, CDCl$_3$)

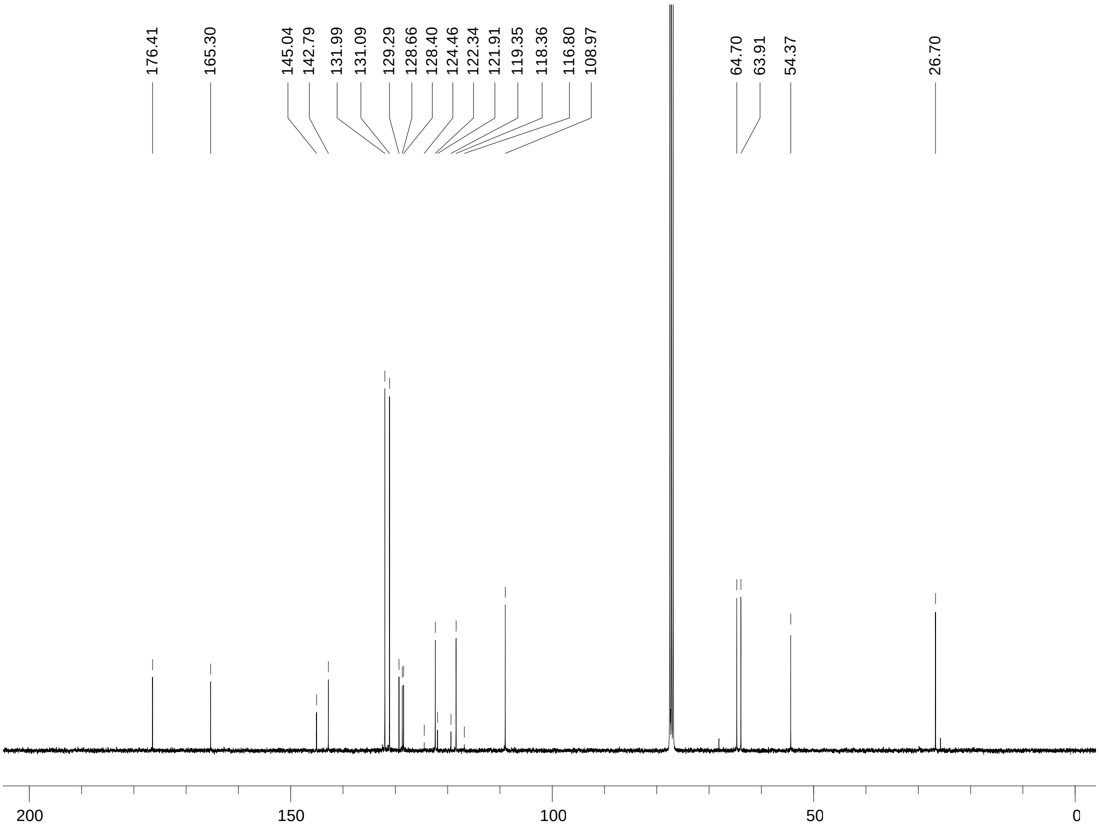


^{1}H NMR (400 MHz, $CDCl_3$)

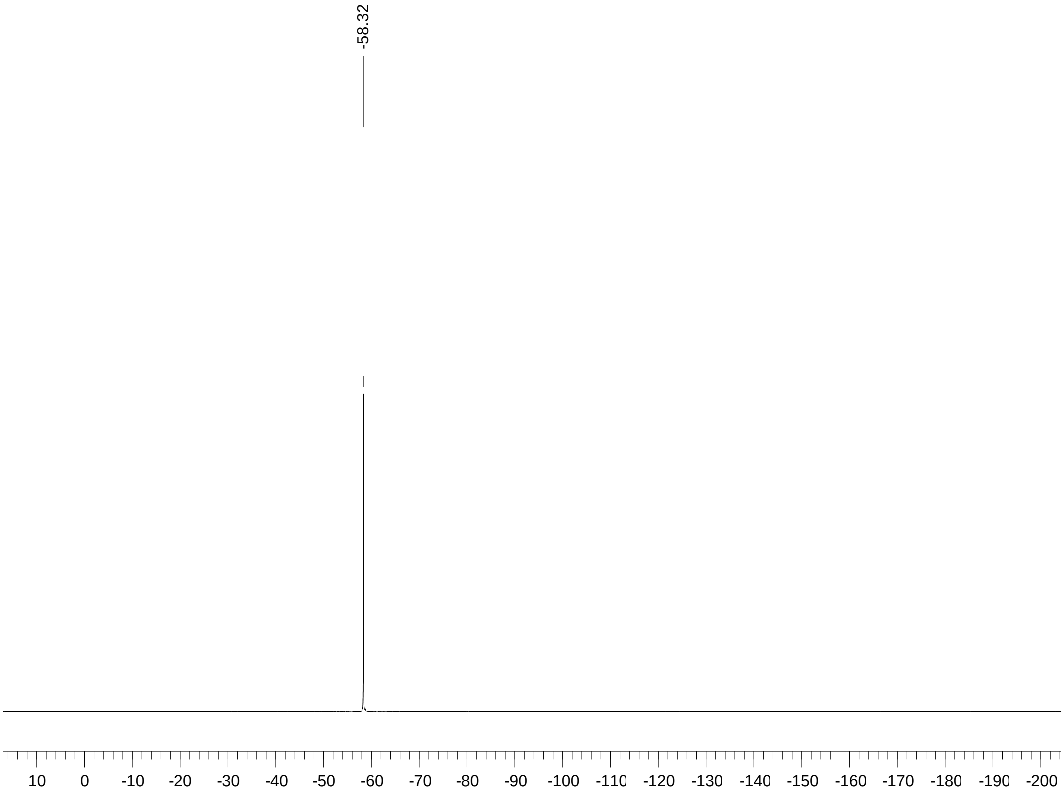


20

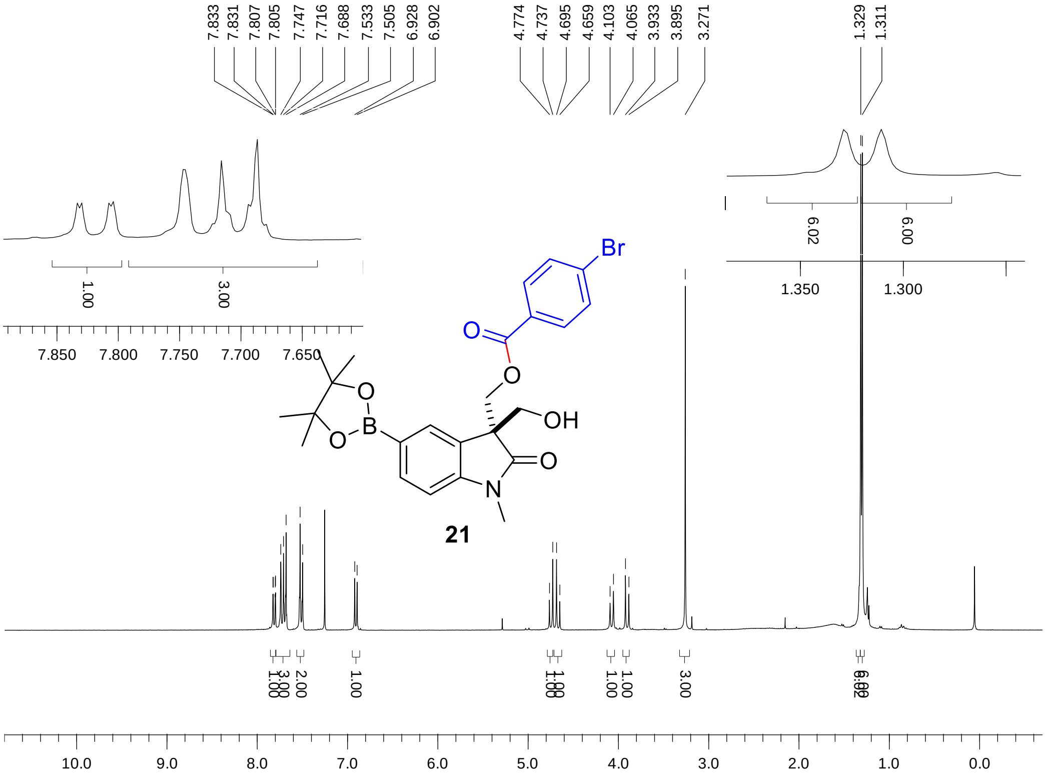
^{13}C NMR (100 MHz, $CDCl_3$)



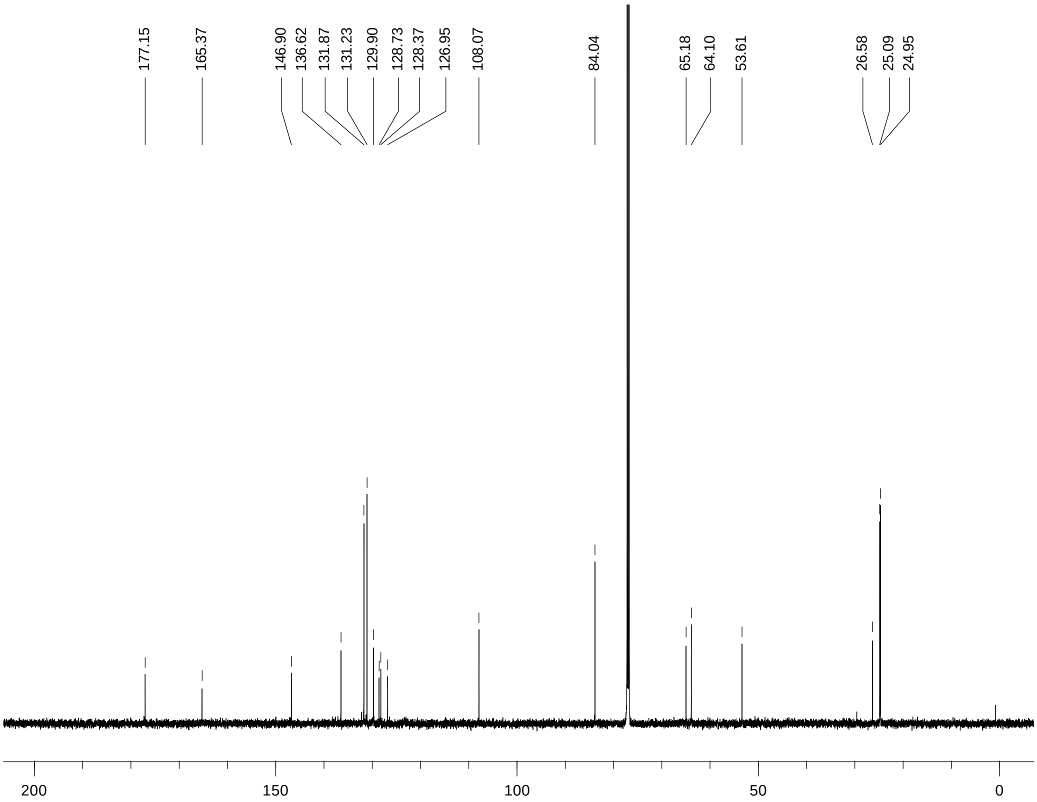
^{19}F NMR (376 MHz, $CDCl_3$)



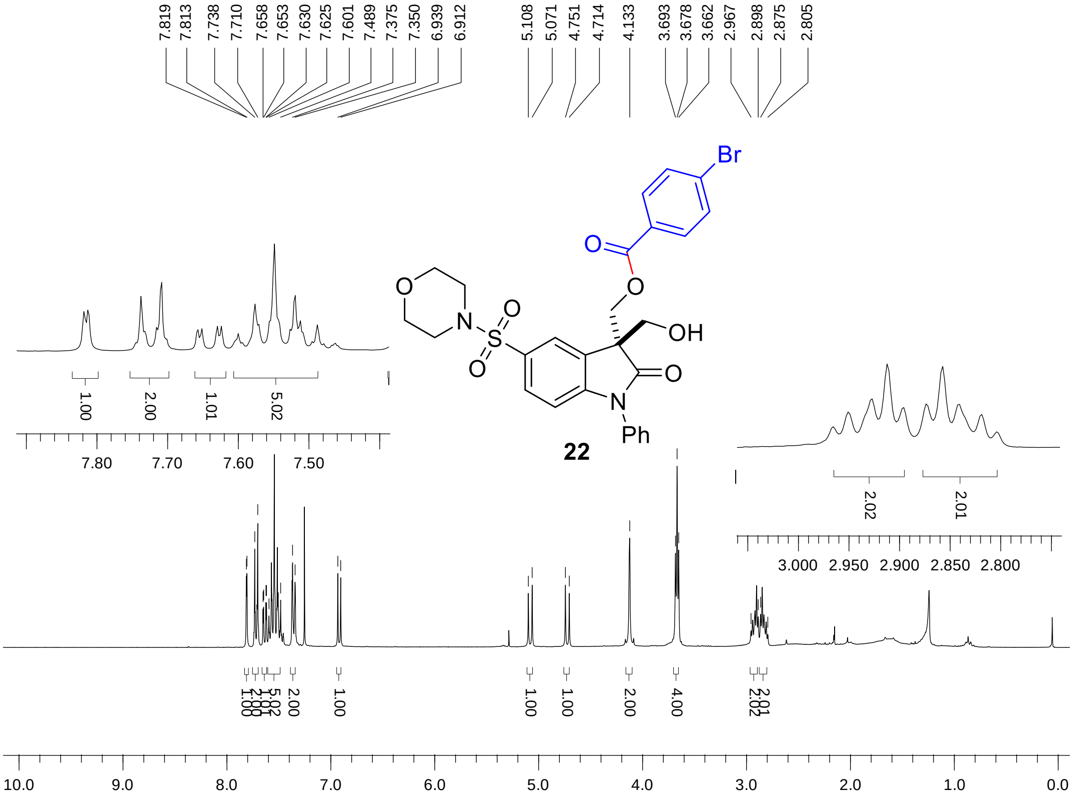
^{1}H NMR (300 MHz, CDCl$_3$)



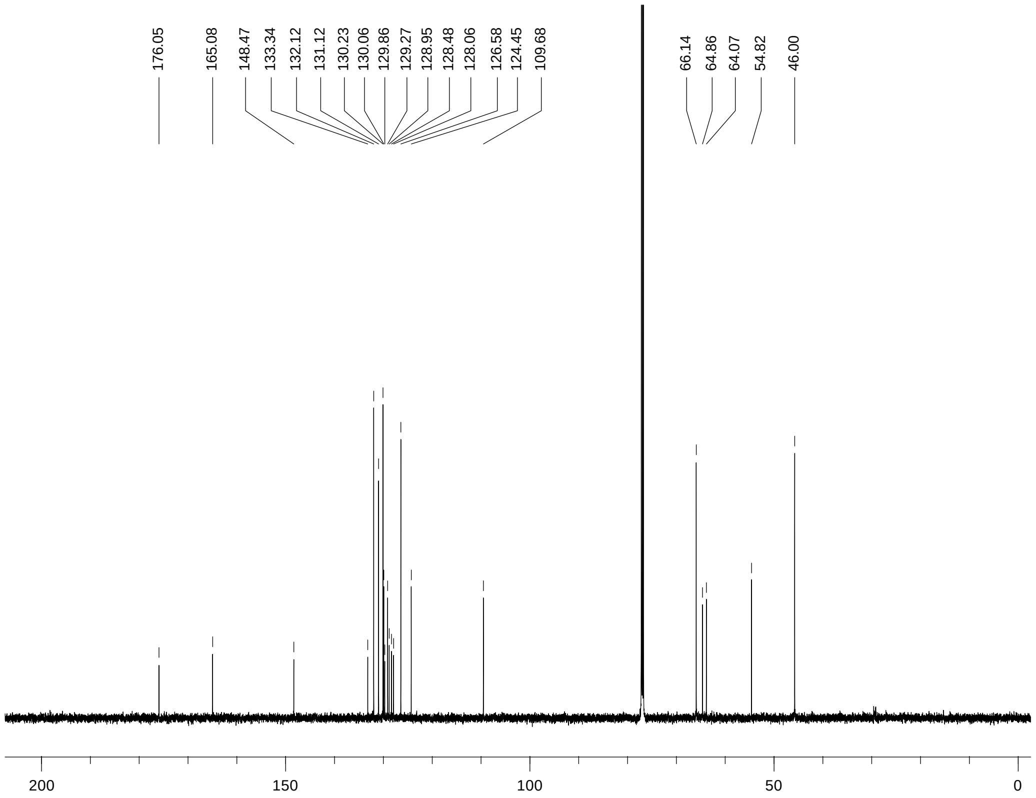
^{13}C NMR (150 MHz, CDCl$_3$)



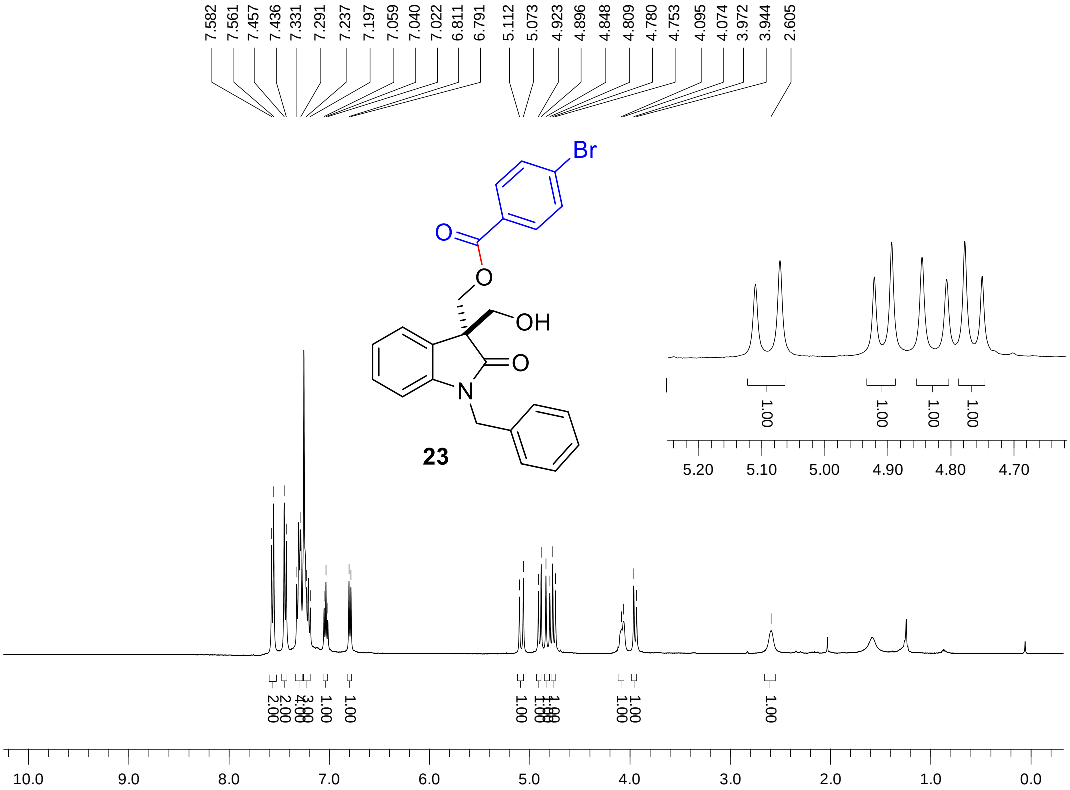
^{1}H NMR (300 MHz, CDCl$_3$)



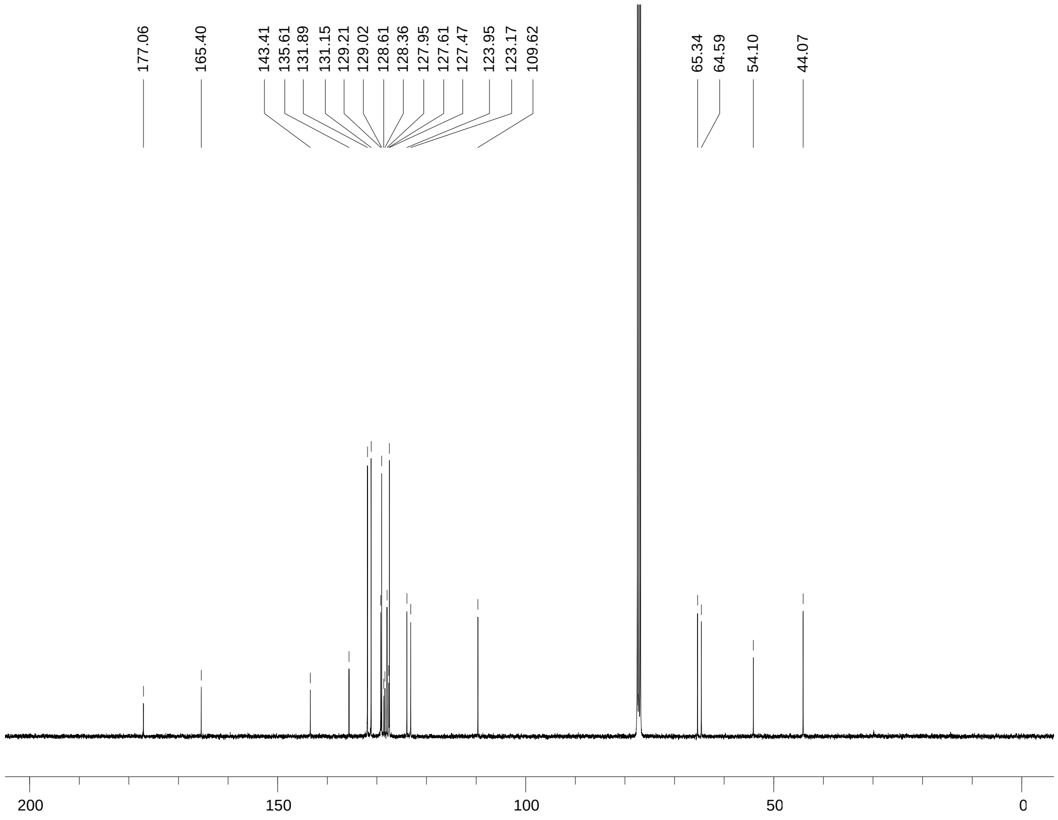
^{13}C NMR (150 MHz, CDCl$_3$)



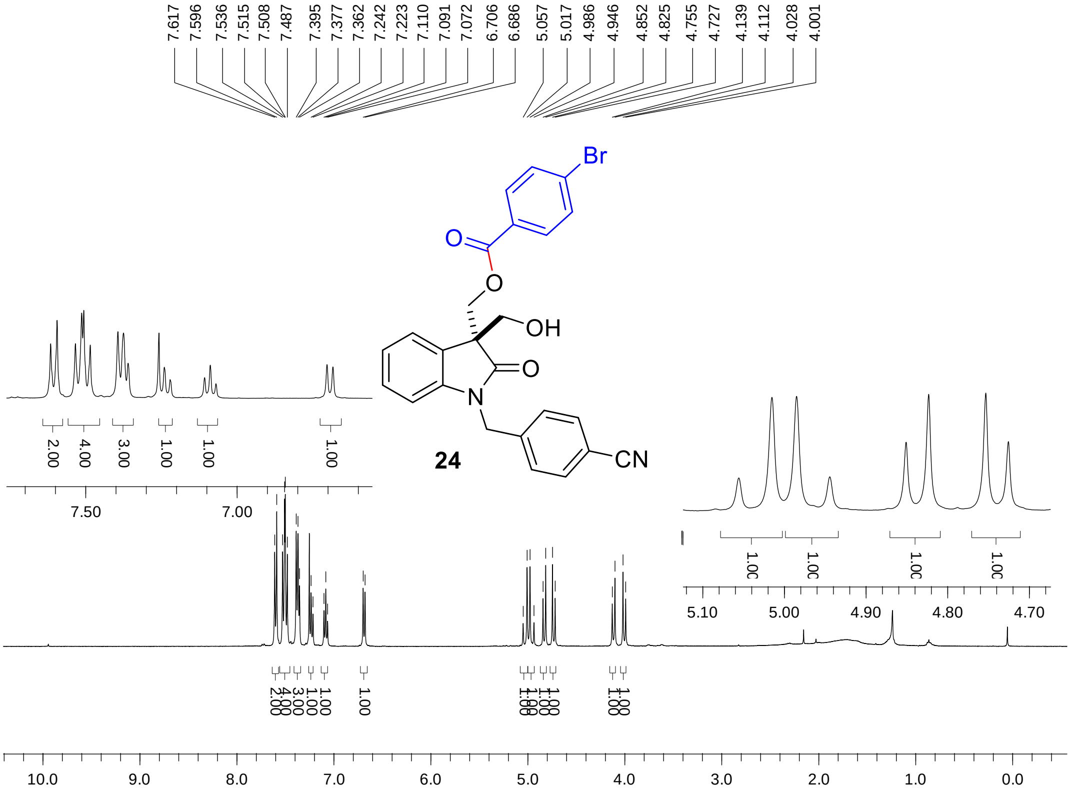
^{1}**H NMR** (400 MHz, CDCl$_3$)



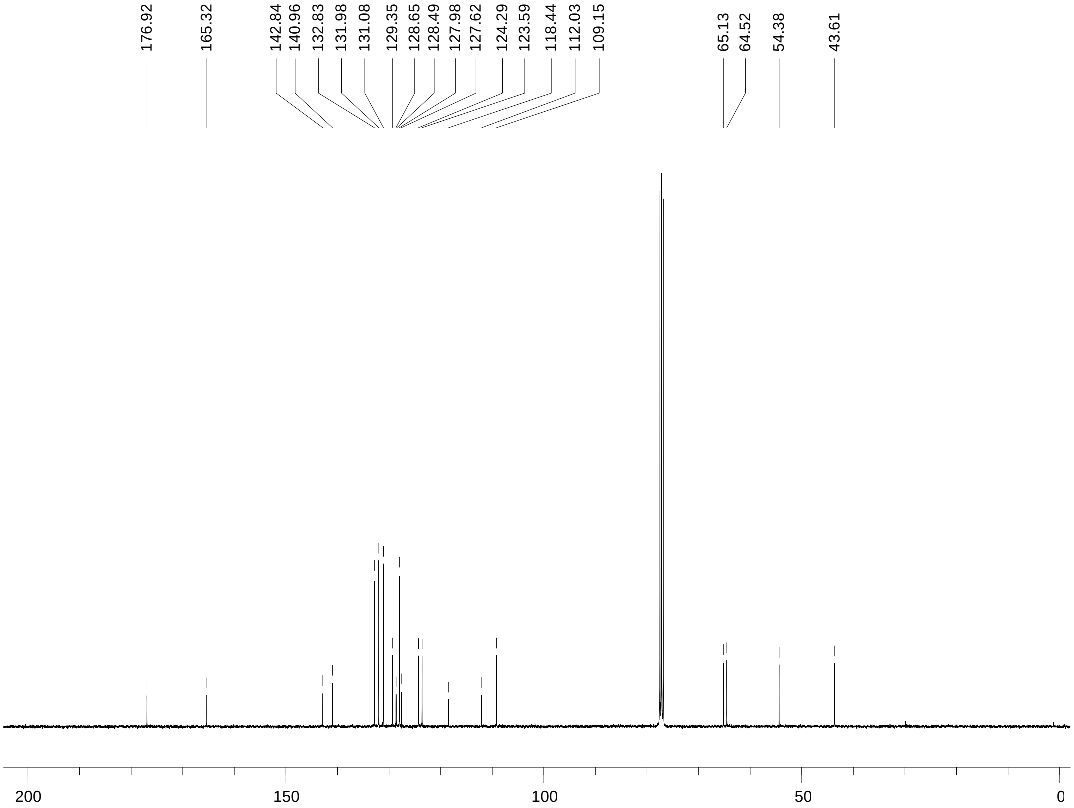
^{13}**C NMR** (100 MHz, CDCl$_3$)



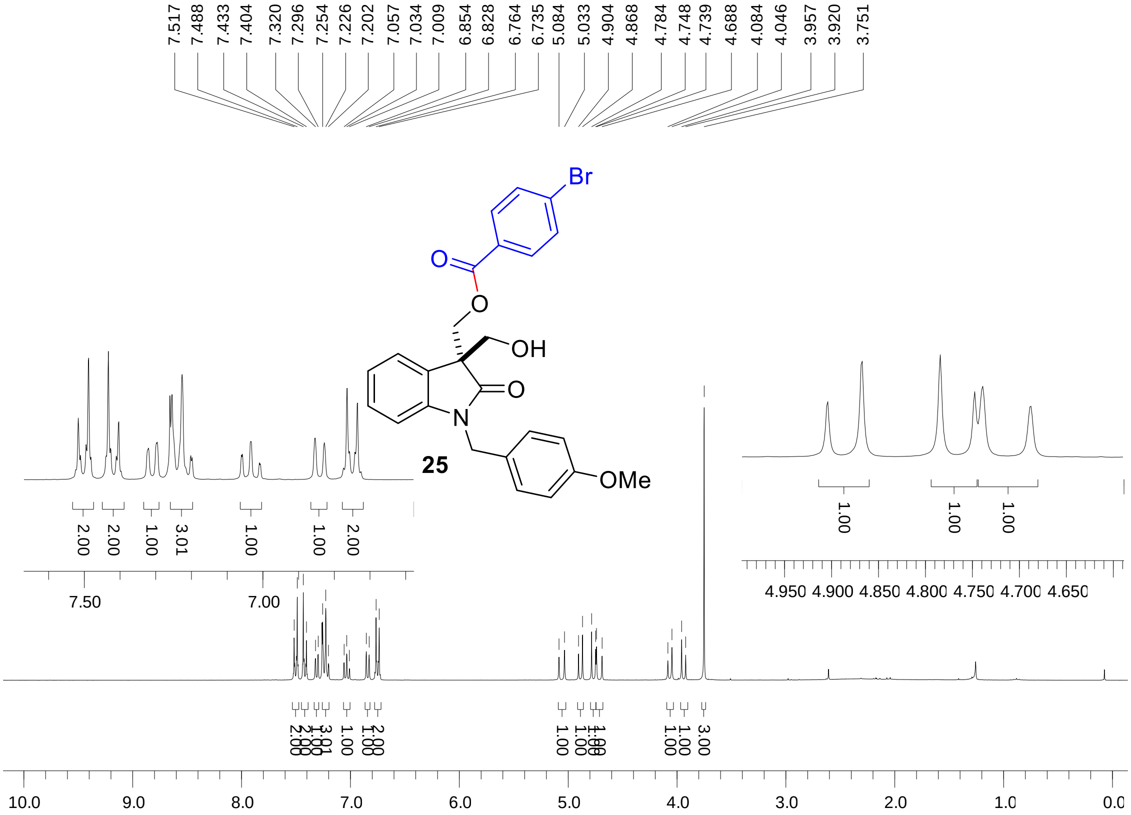
^{1}H NMR (400 MHz, $CDCl_3$)



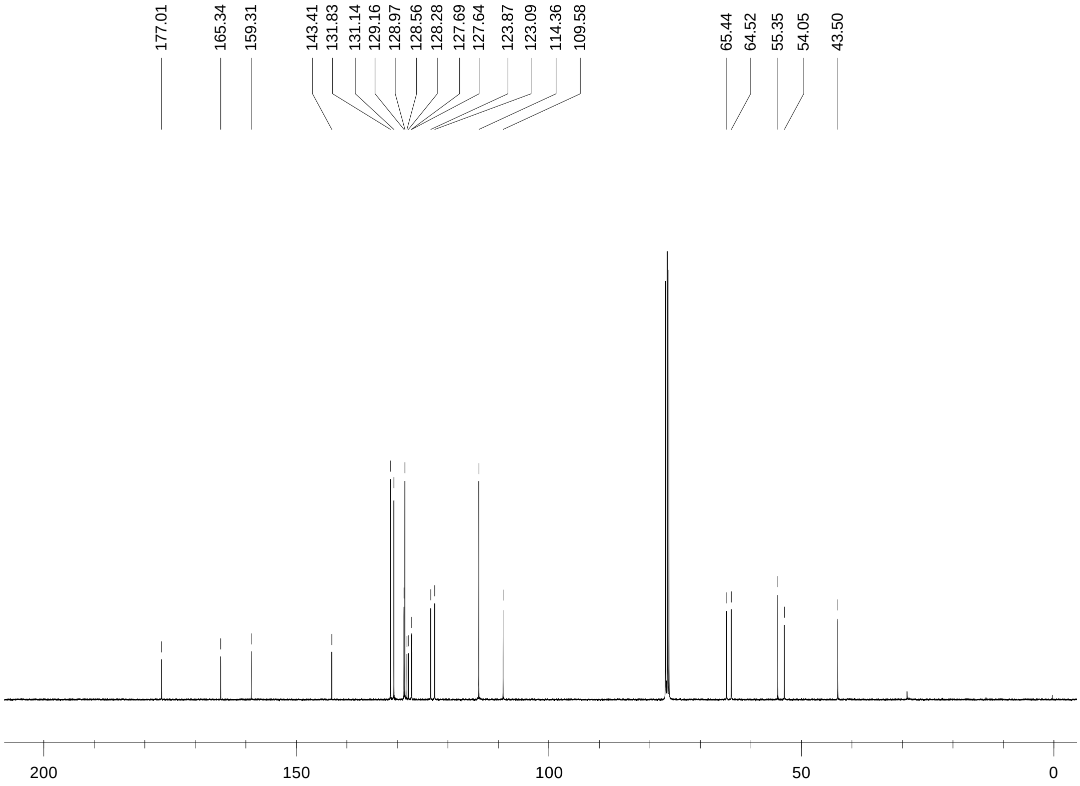
^{13}C NMR (100 MHz, $CDCl_3$)



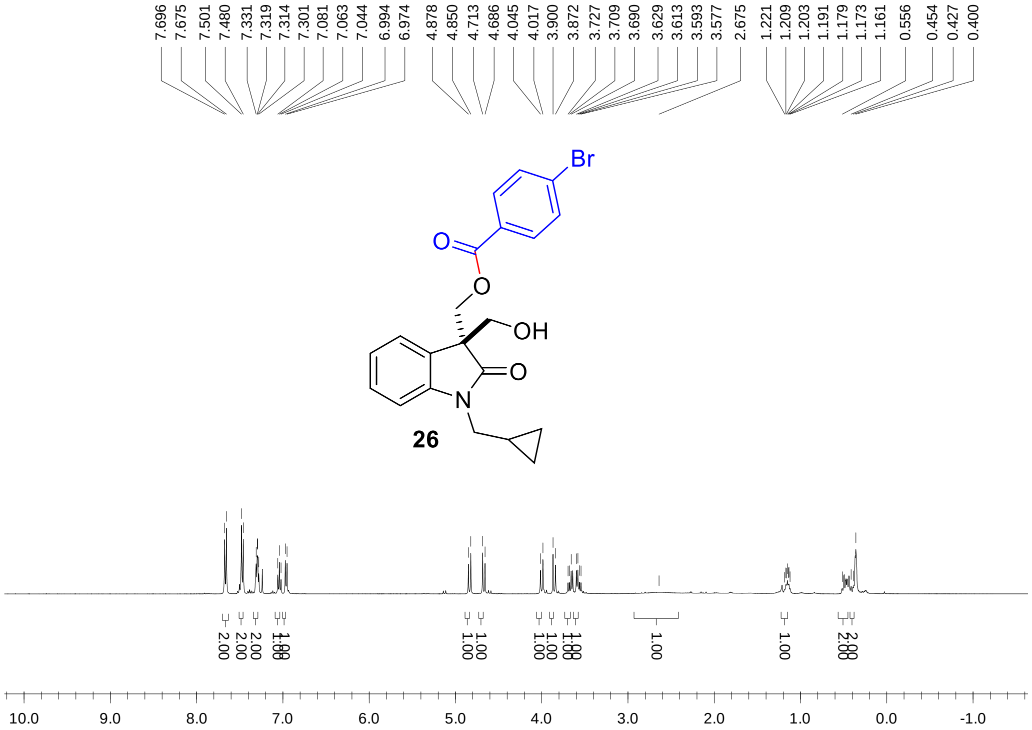
^{1}H NMR (300 MHz, CDCl$_3$)



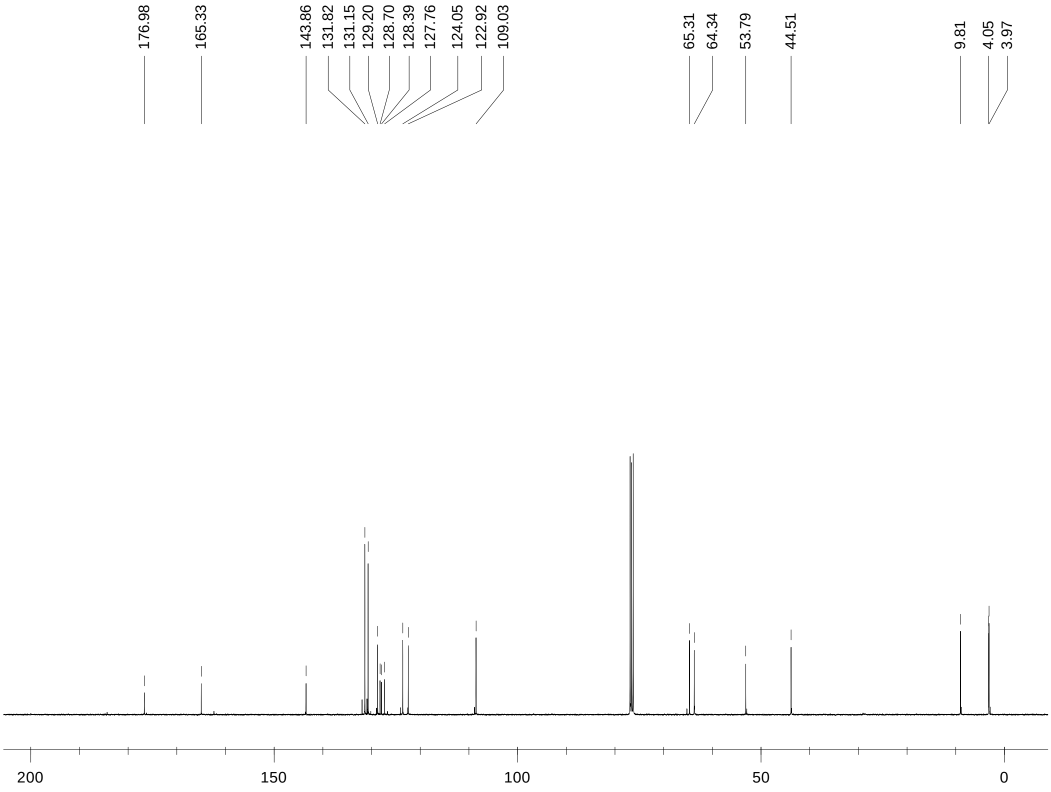
^{13}C NMR (100 MHz, CDCl$_3$)



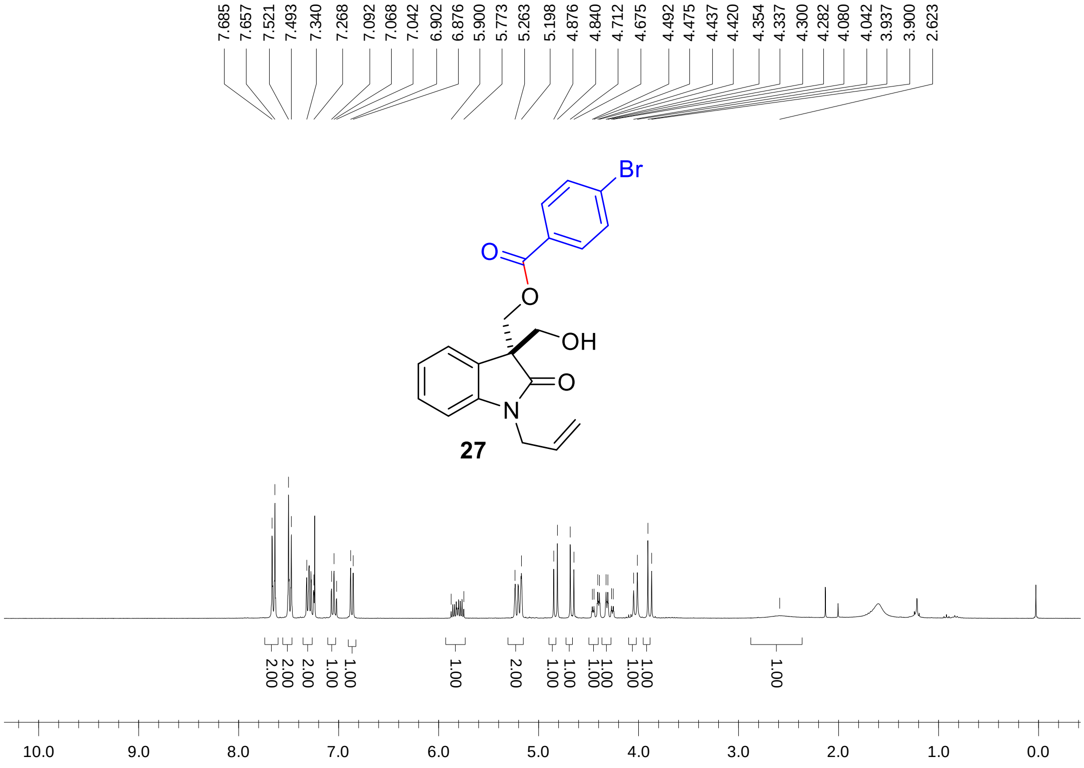
^{1}H NMR (400 MHz, CDCl$_3$)



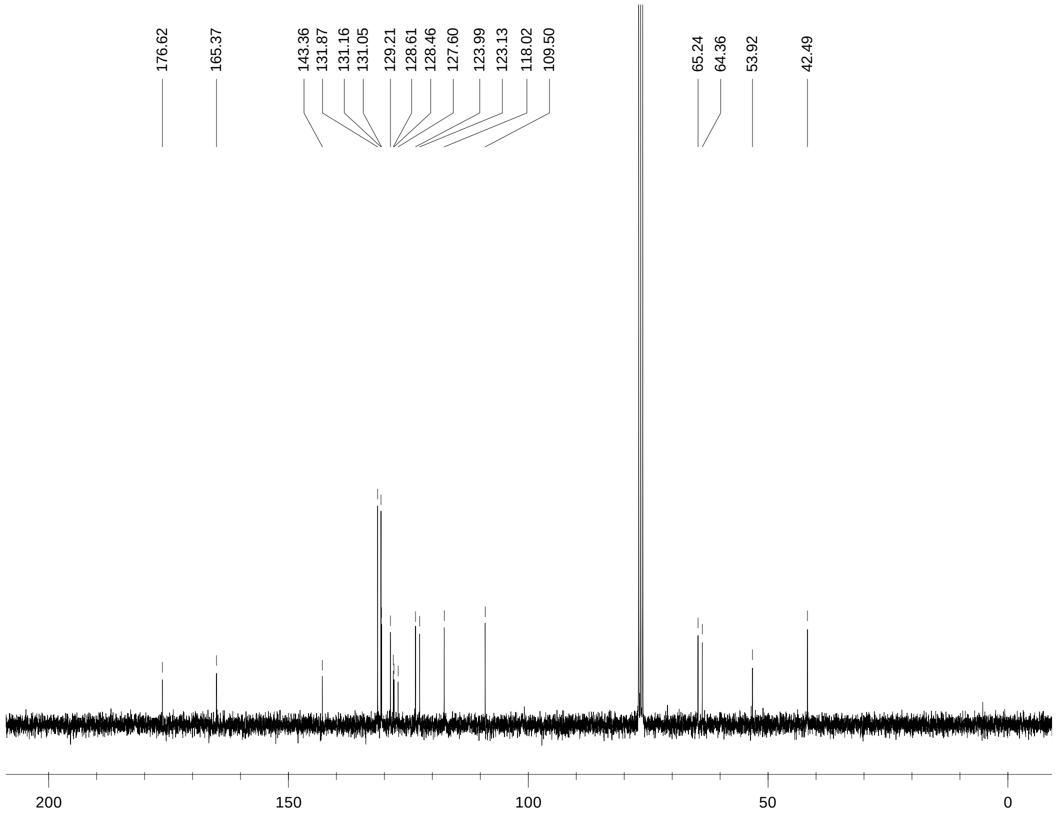
^{13}C NMR (100 MHz, CDCl$_3$)



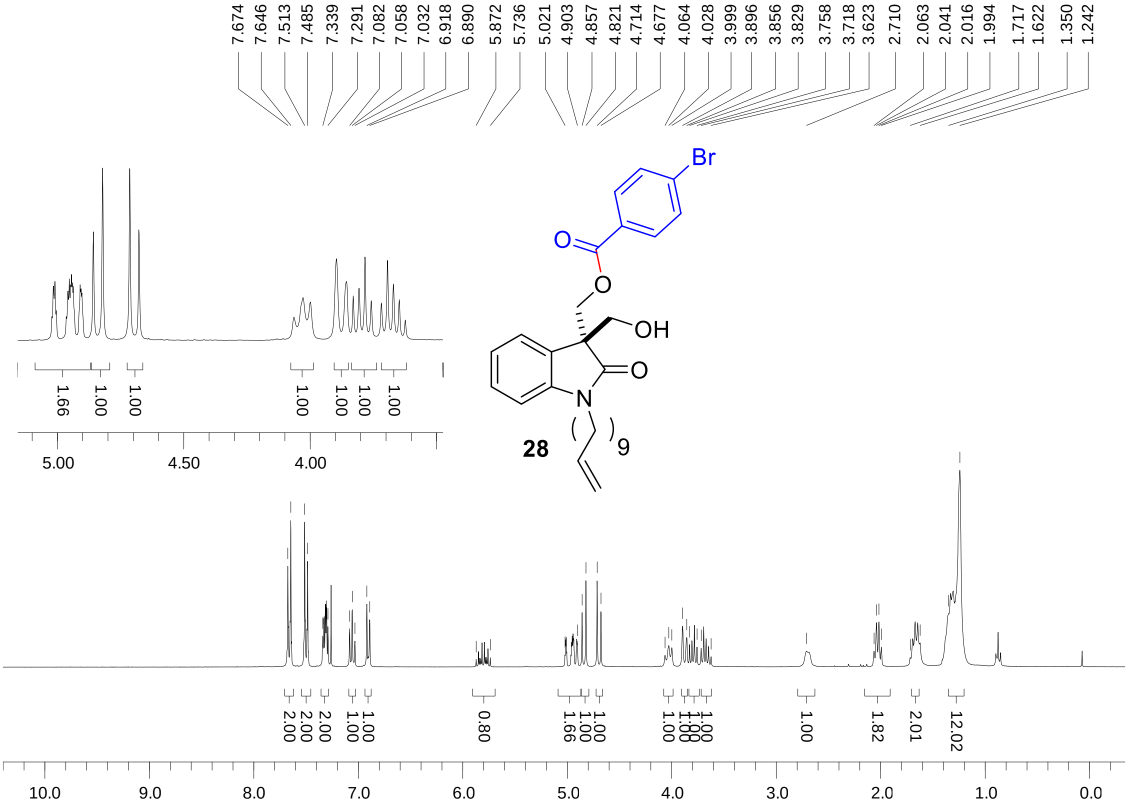
^{1}H NMR (300 MHz, CDCl$_3$)



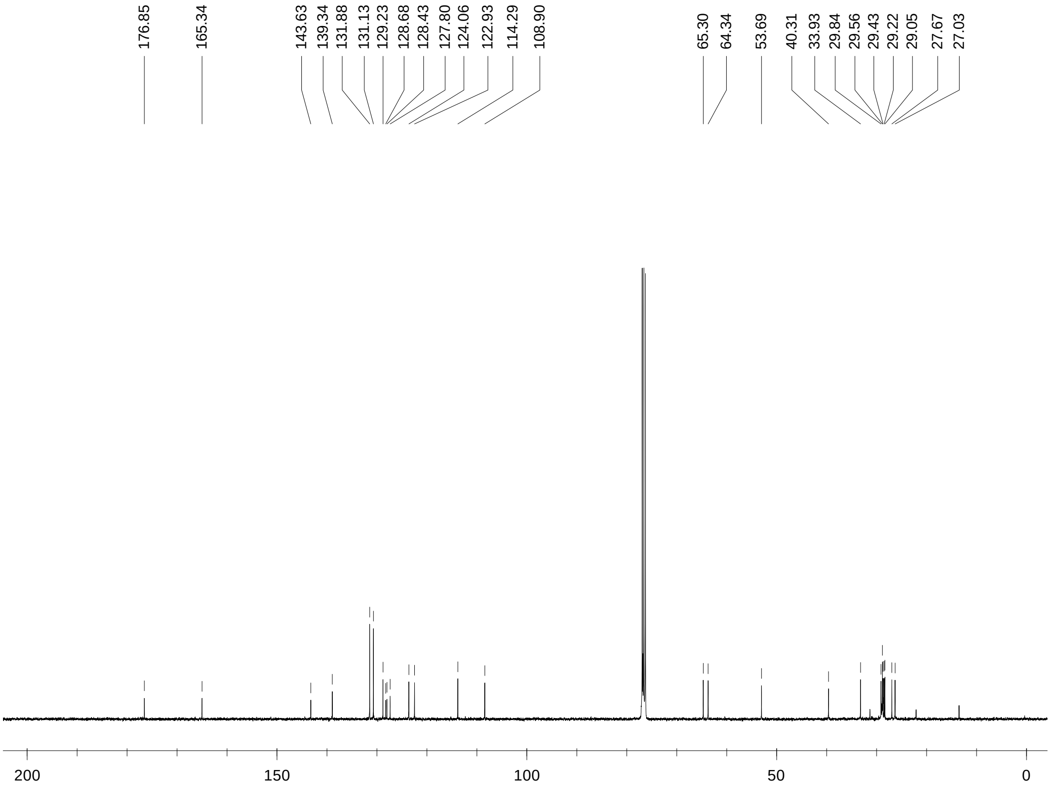
^{13}C NMR (75 MHz, CDCl$_3$)



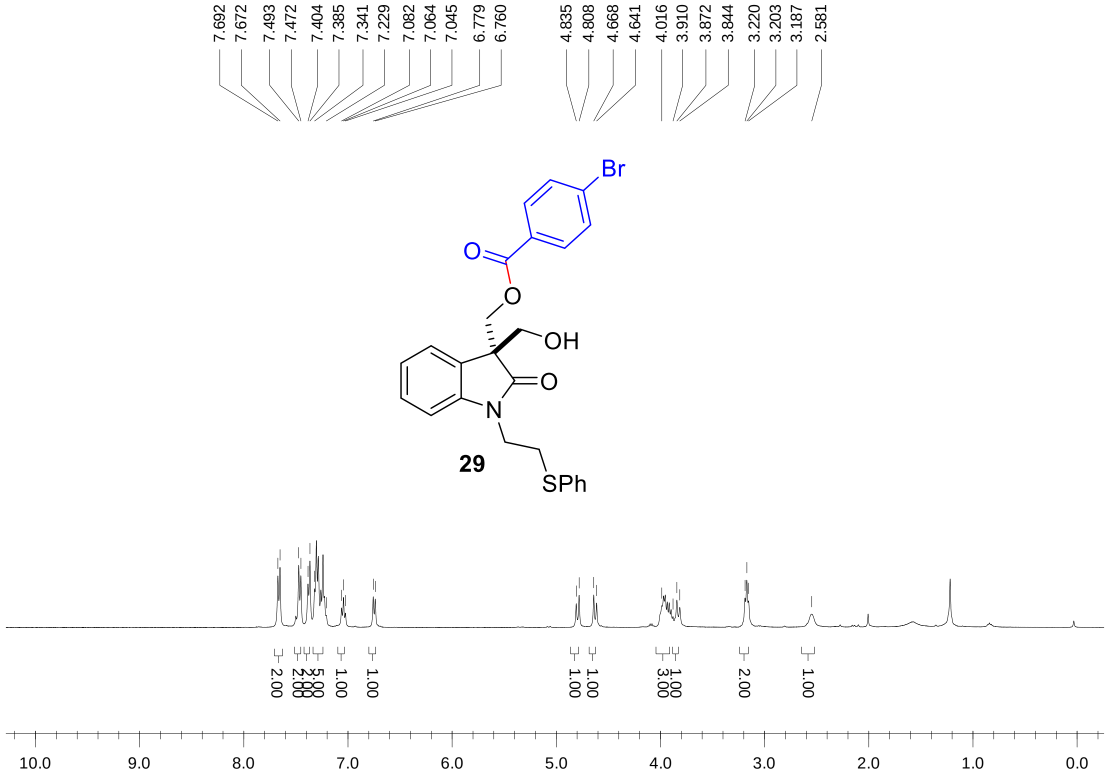
^{1}H NMR (300 MHz, CDCl$_3$)



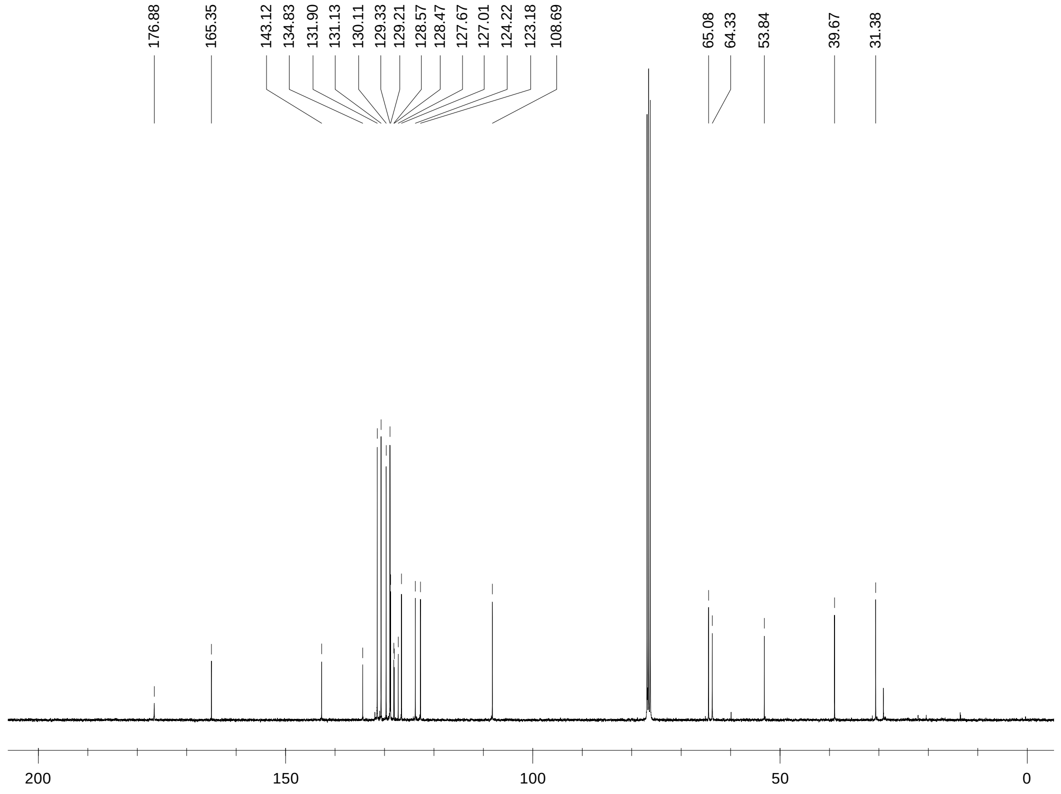
^{13}C NMR (100 MHz, CDCl$_3$)



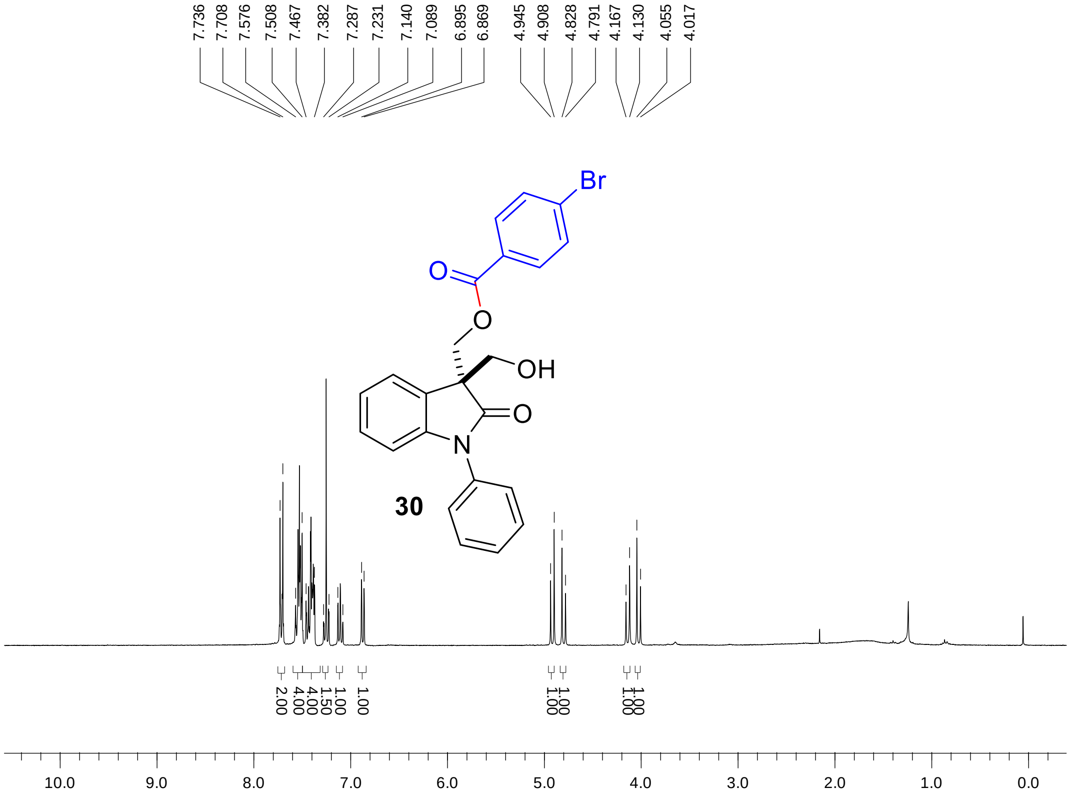
^{1}H NMR (400 MHz, $CDCl_3$)



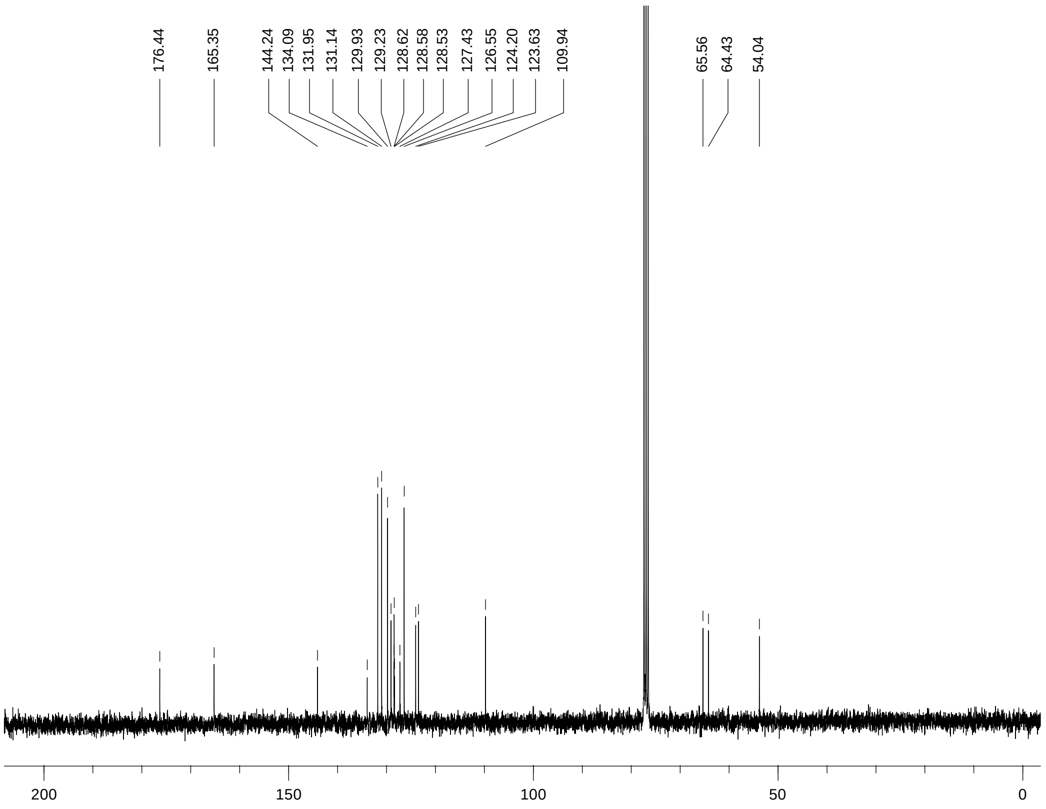
^{13}C NMR (100 MHz, $CDCl_3$)



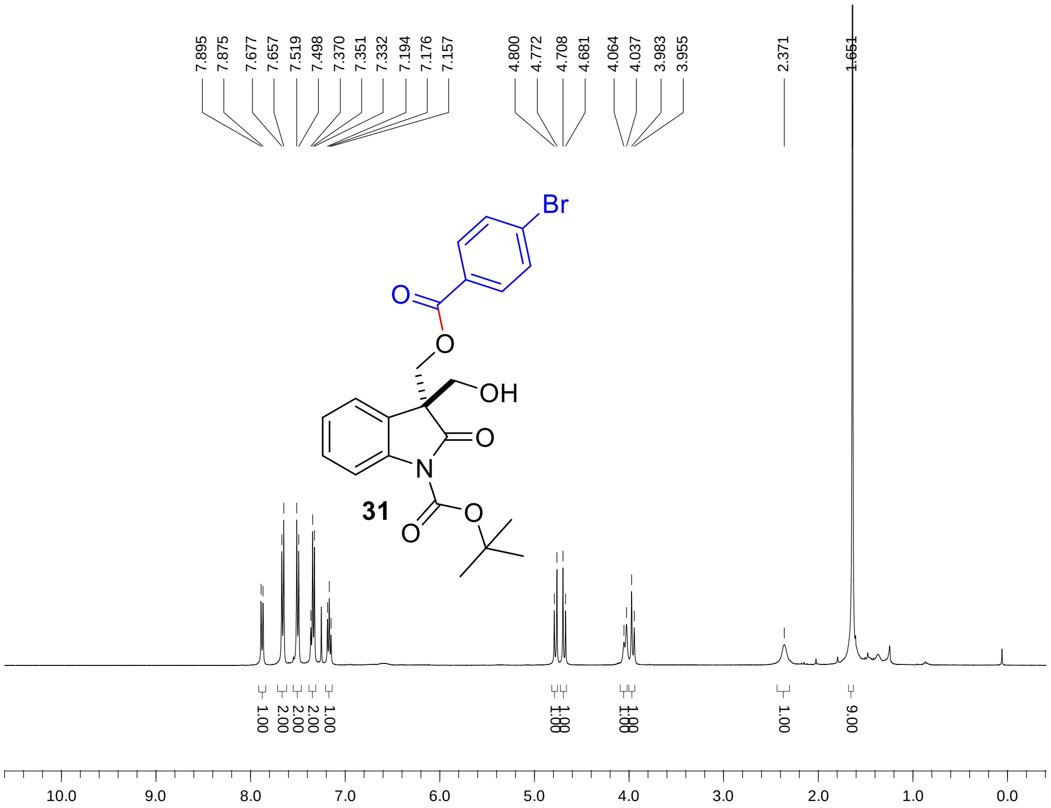
^{1}H NMR (300 MHz, CDCl$_3$)



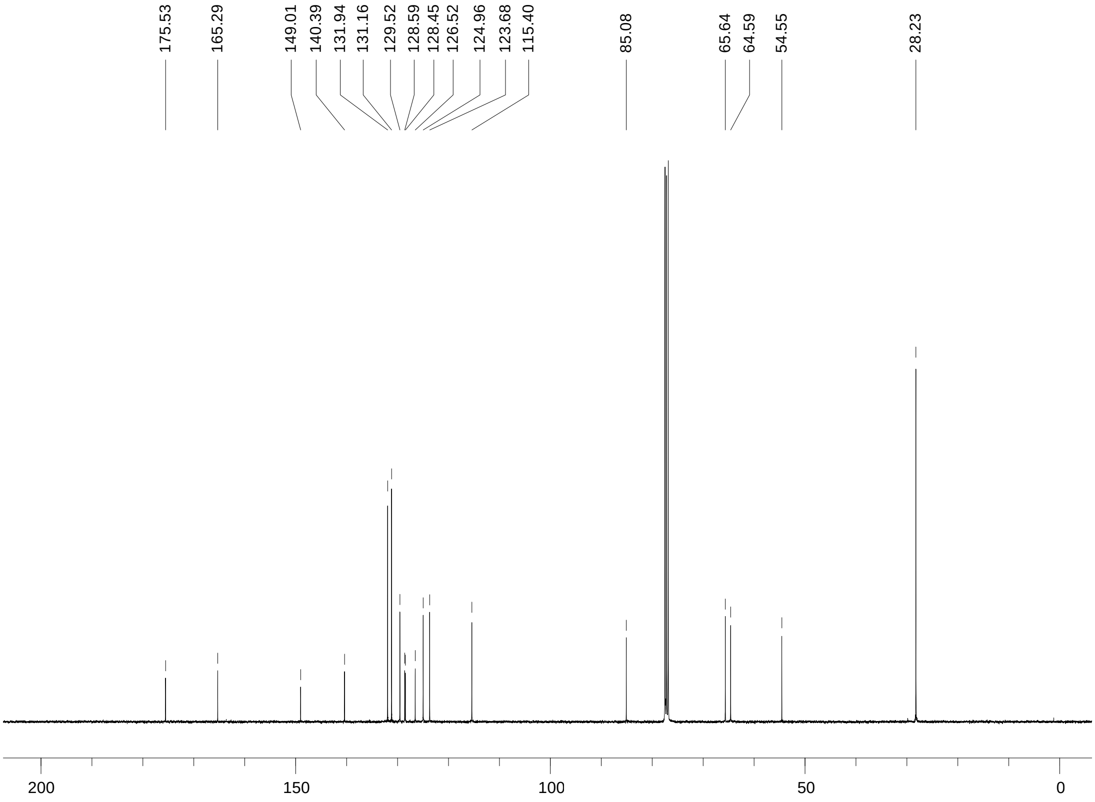
^{13}C NMR (75 MHz, CDCl$_3$)



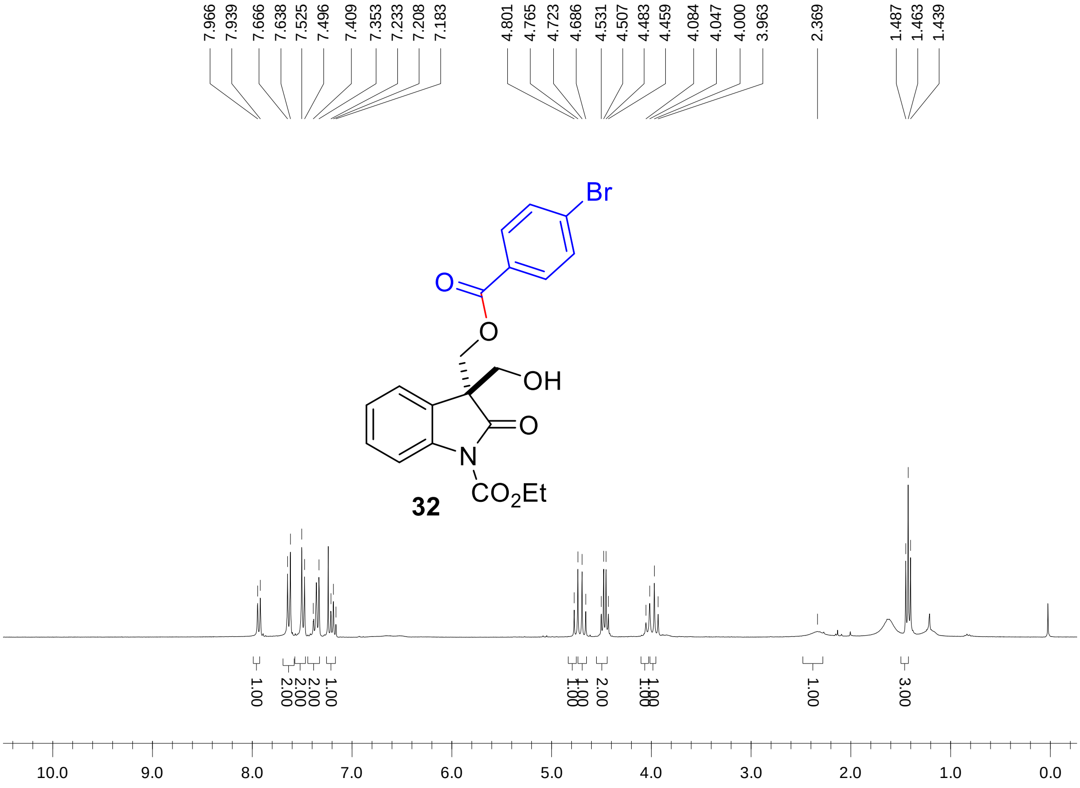
^{1}H NMR (400 MHz, $CDCl_3$)



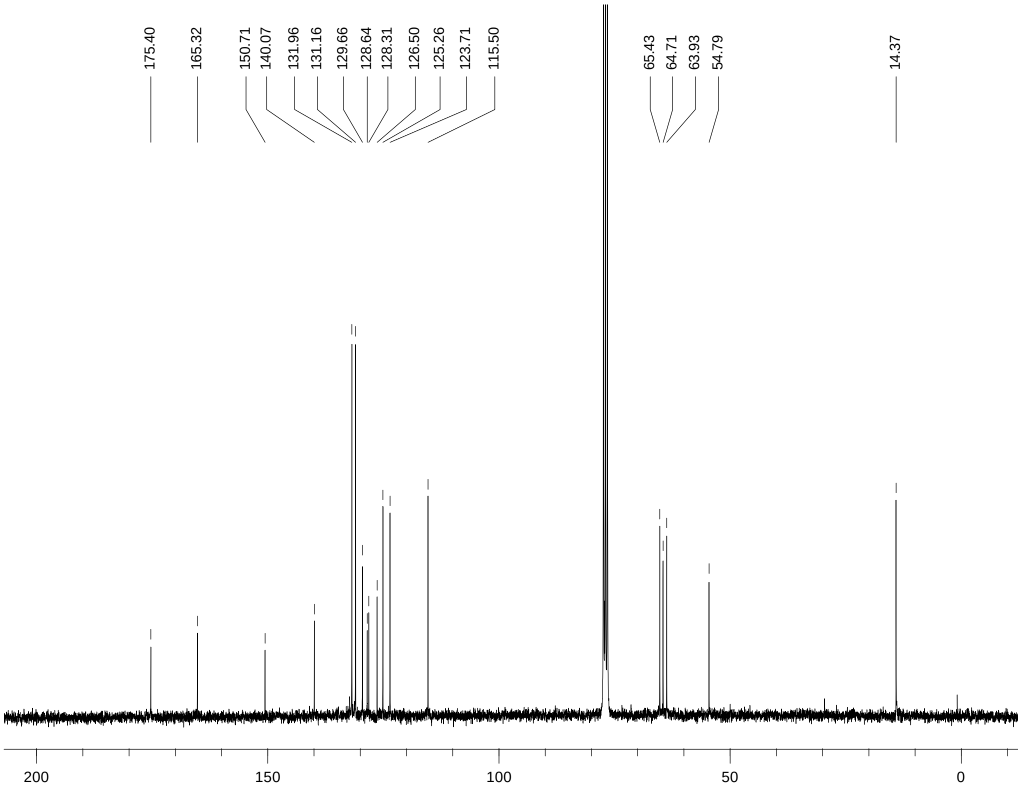
^{13}C NMR (100 MHz, $CDCl_3$)



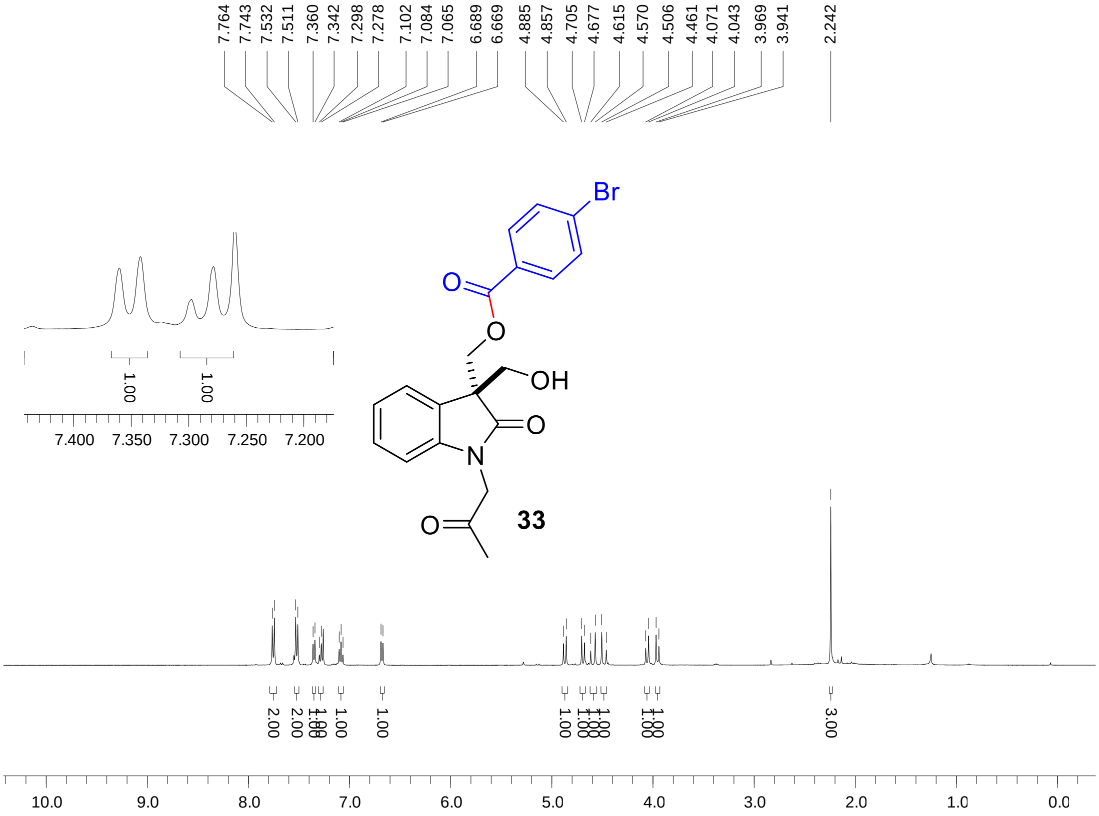
^{1}H NMR (300 MHz, $CDCl_3$)


32

^{13}C NMR (75 MHz, $CDCl_3$)

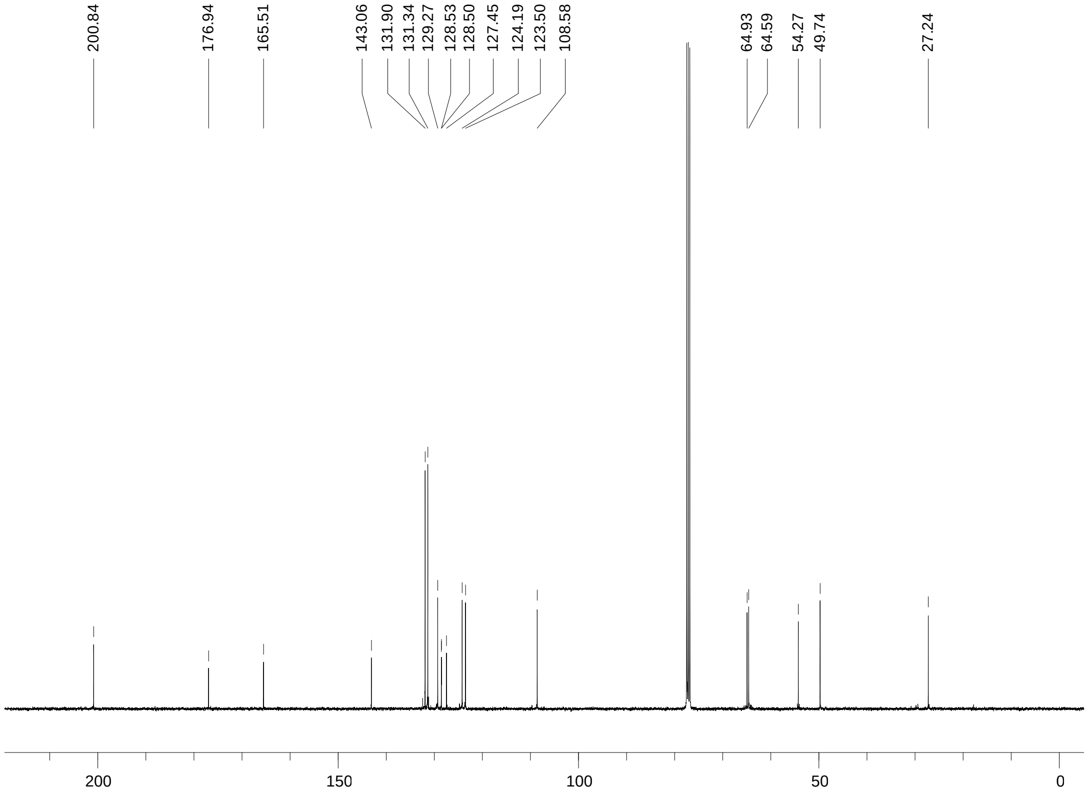


^{1}H NMR (400 MHz, $CDCl_3$)

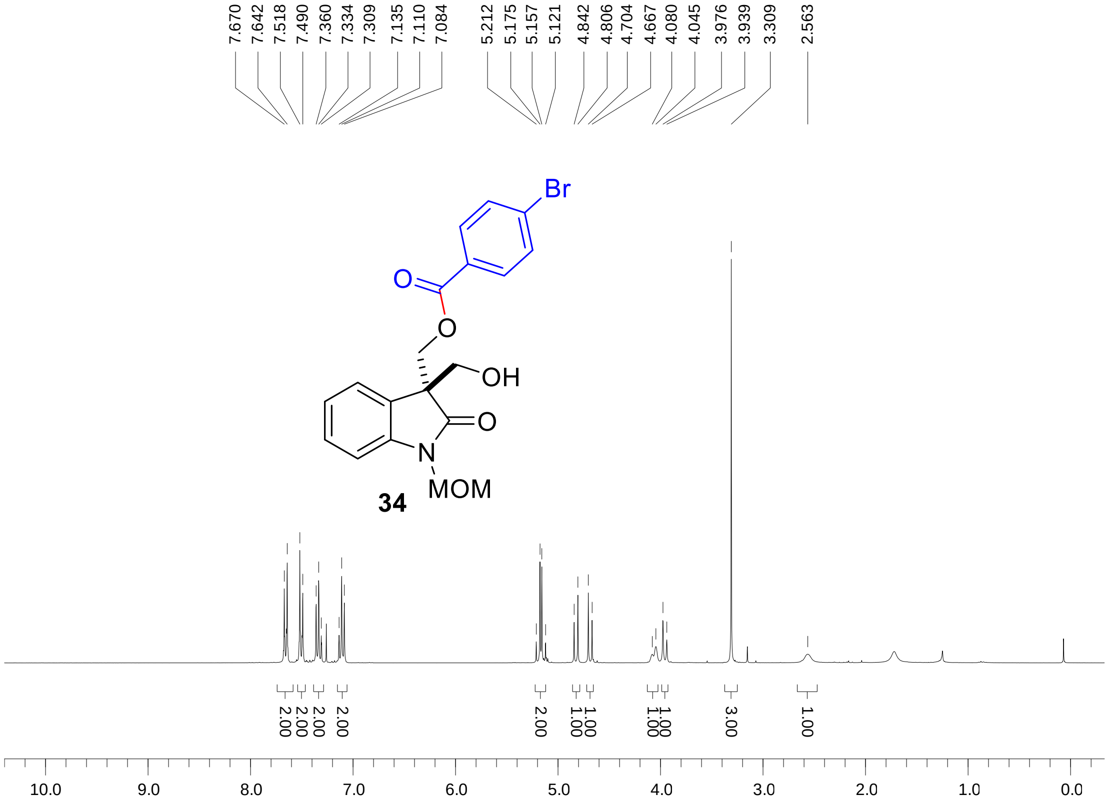


33

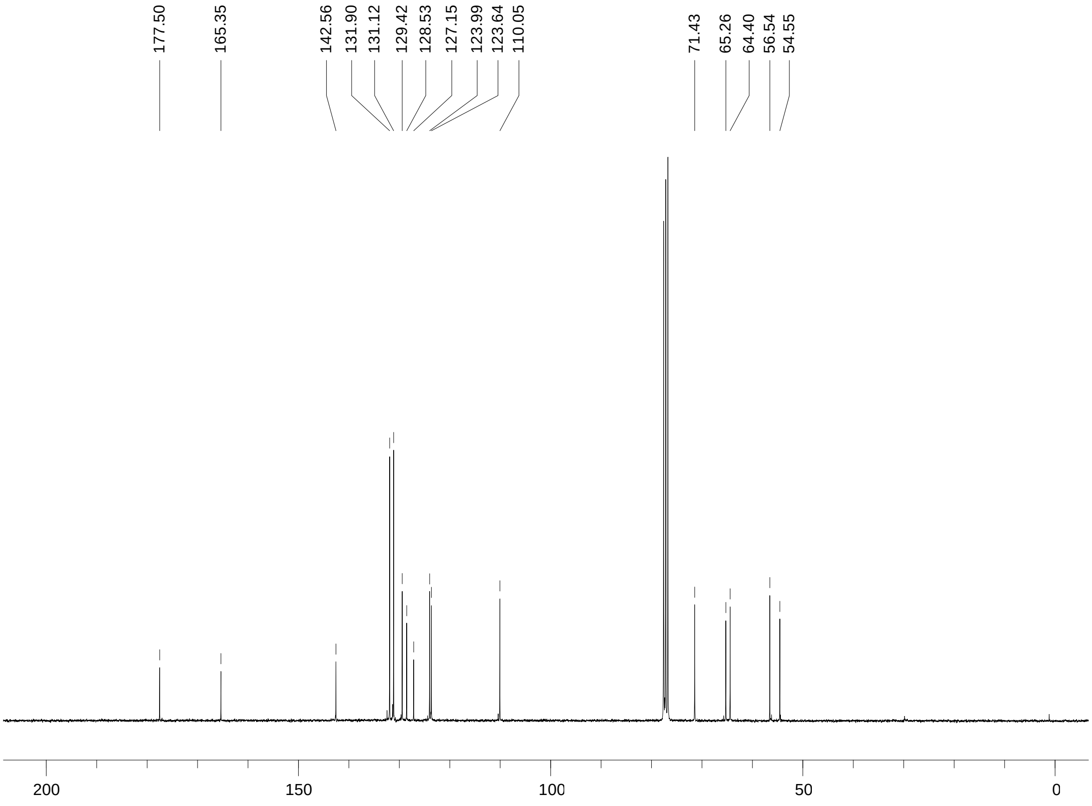
^{13}C NMR (100 MHz, $CDCl_3$)



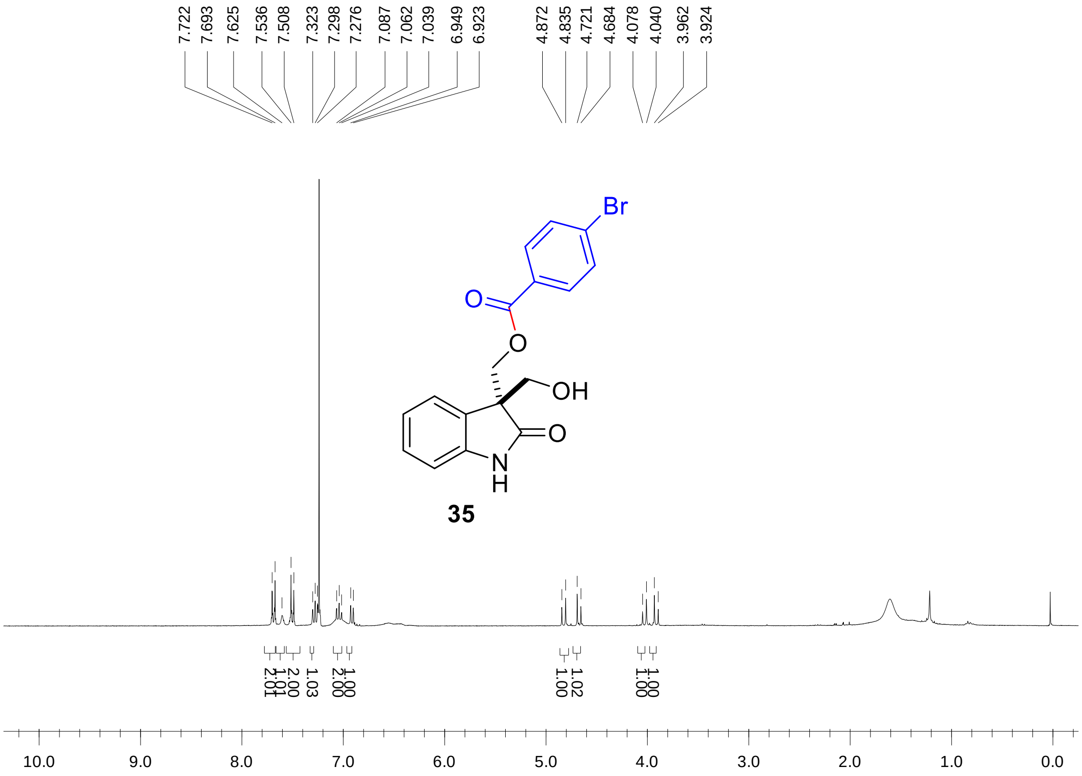
^{1}H NMR (300 MHz, $CDCl_3$)



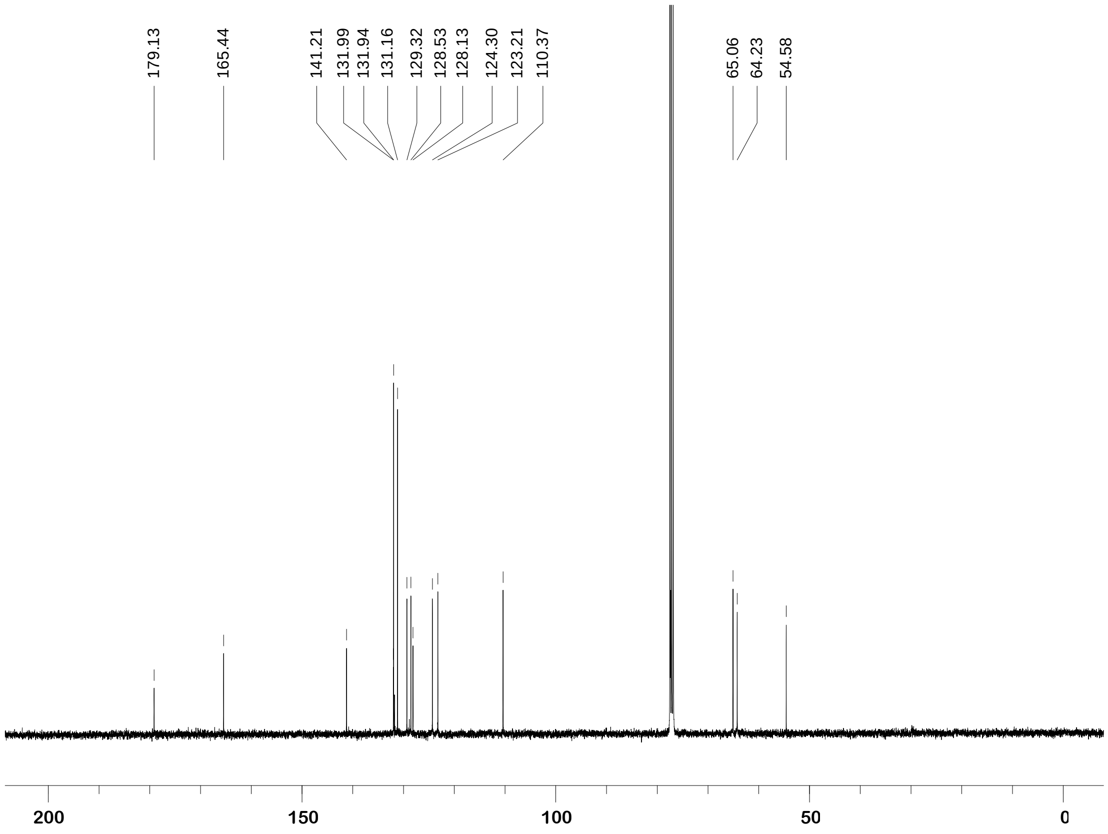
^{13}C NMR (75 MHz, $CDCl_3$)



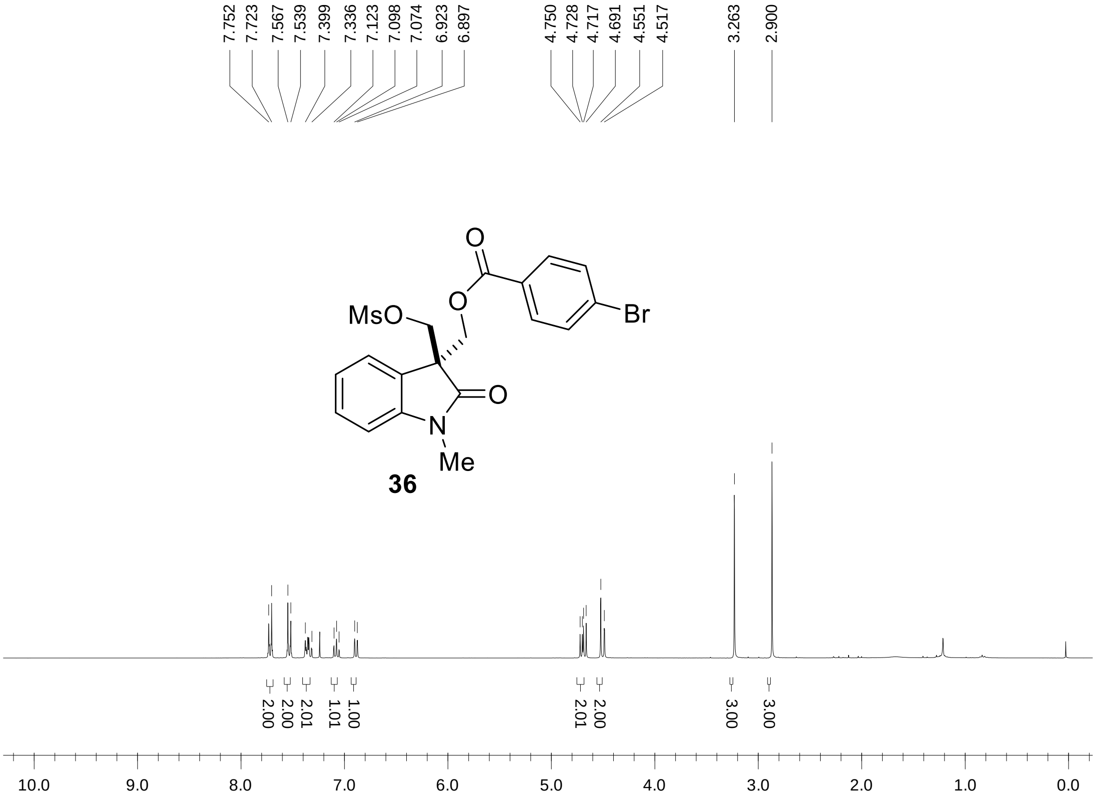
^{1}H NMR (300 MHz, CDCl$_3$)



^{13}C NMR (75 MHz, CDCl$_3$)

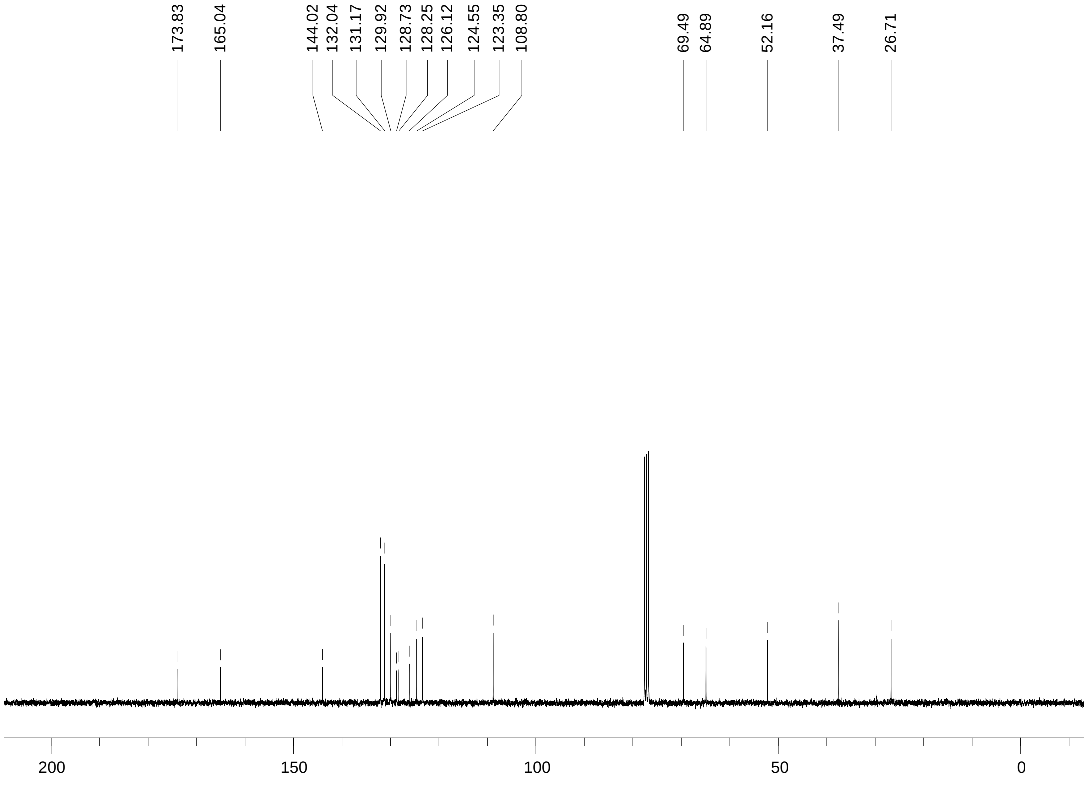


^{1}H NMR (300 MHz, CDCl$_3$)

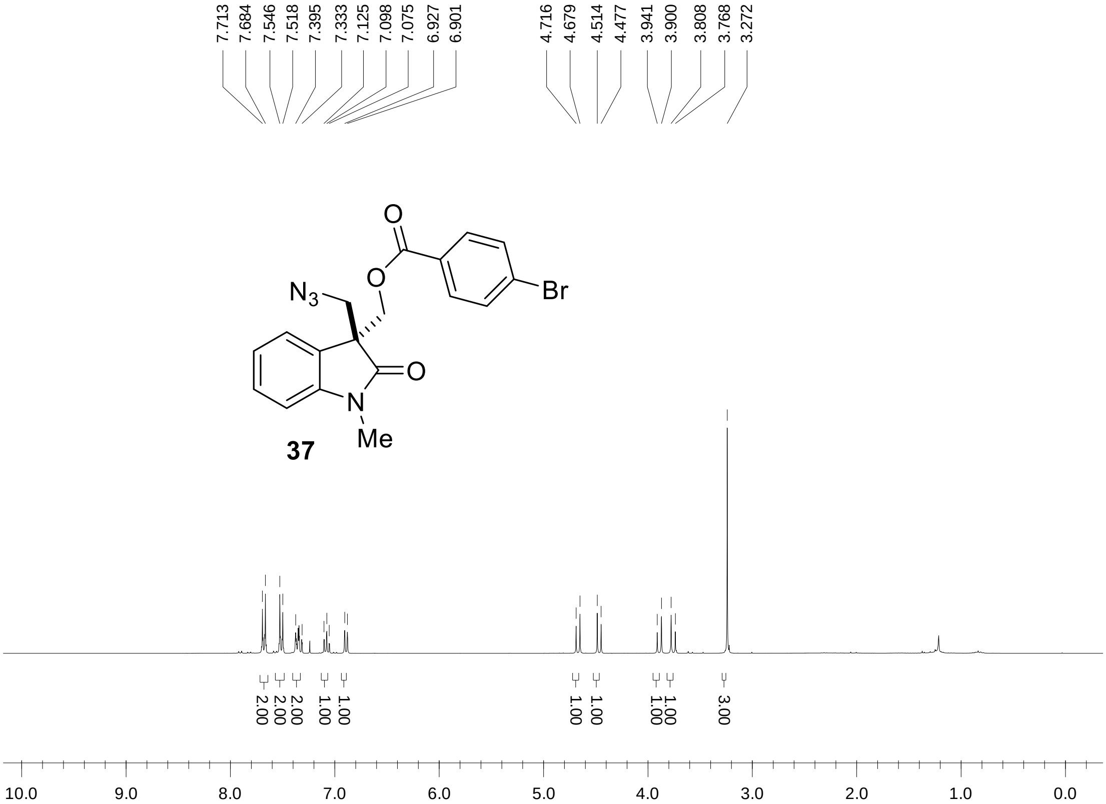


36

^{13}C NMR (75 MHz, CDCl$_3$)

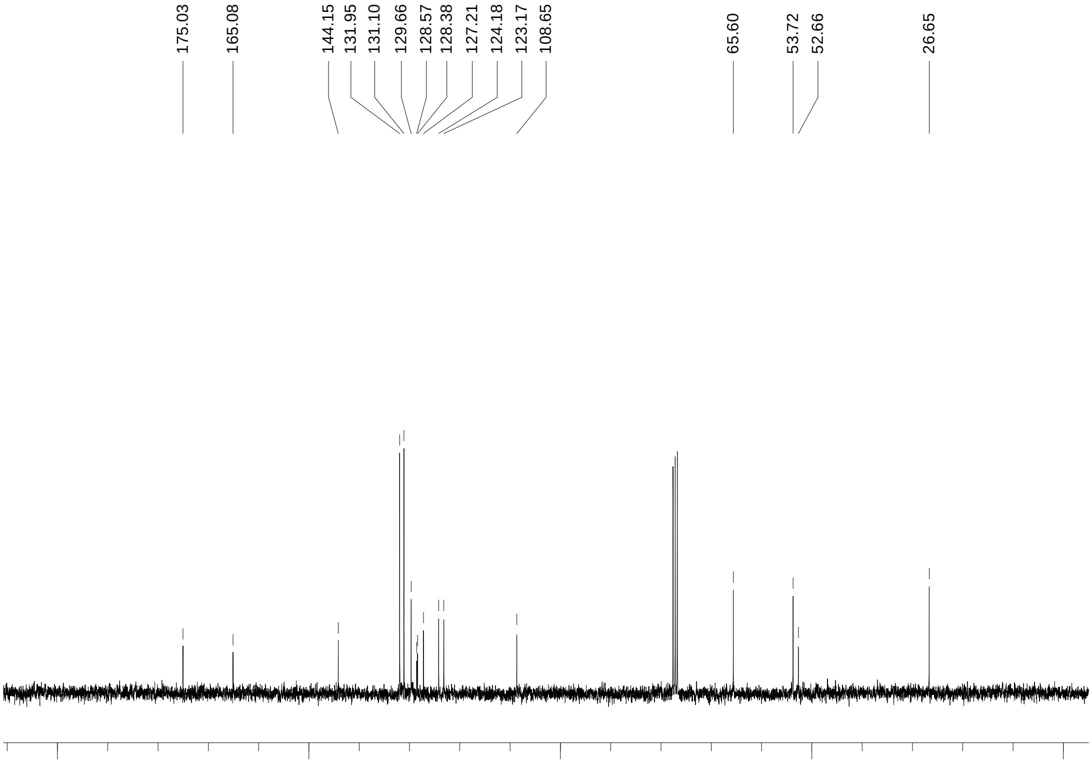


^{1}H NMR (300 MHz, $CDCl_3$)

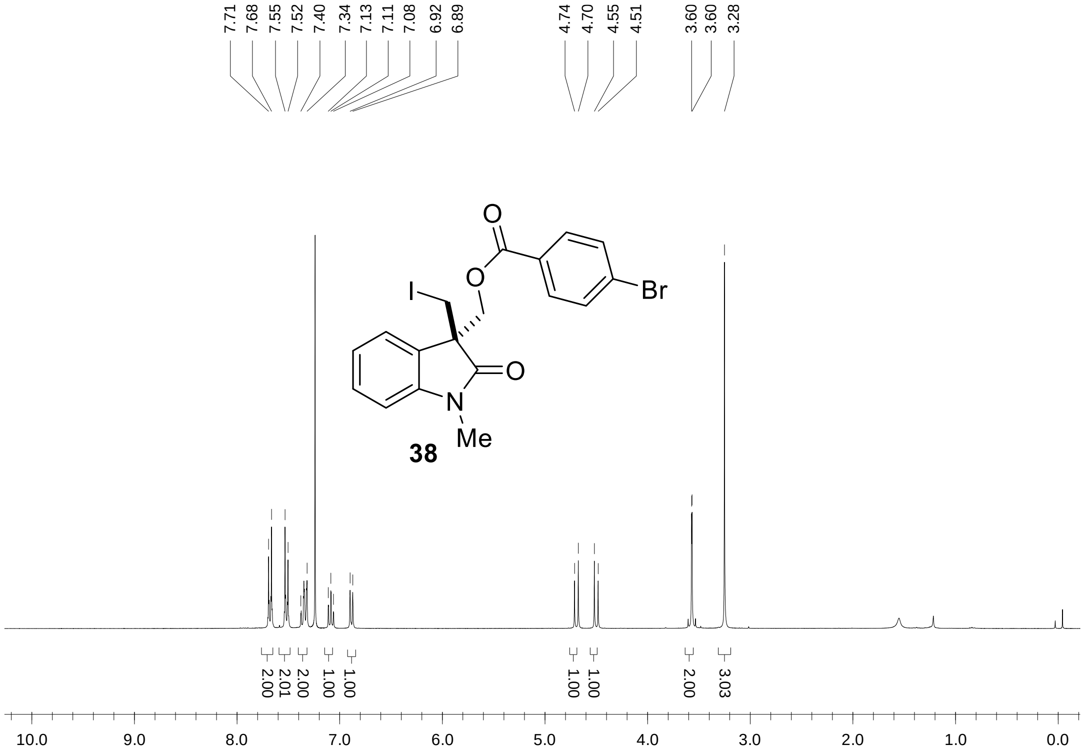


37

^{13}C NMR (75 MHz, $CDCl_3$)

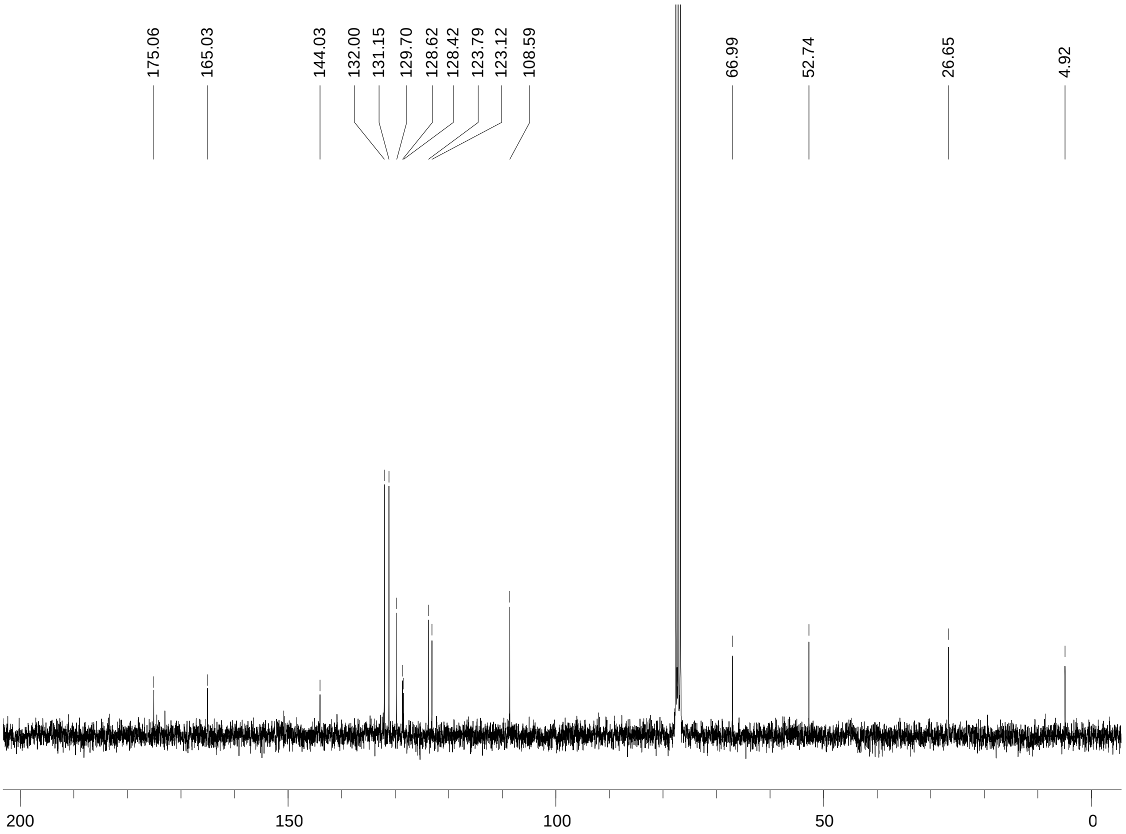


^{1}H NMR (300 MHz, $CDCl_3$)

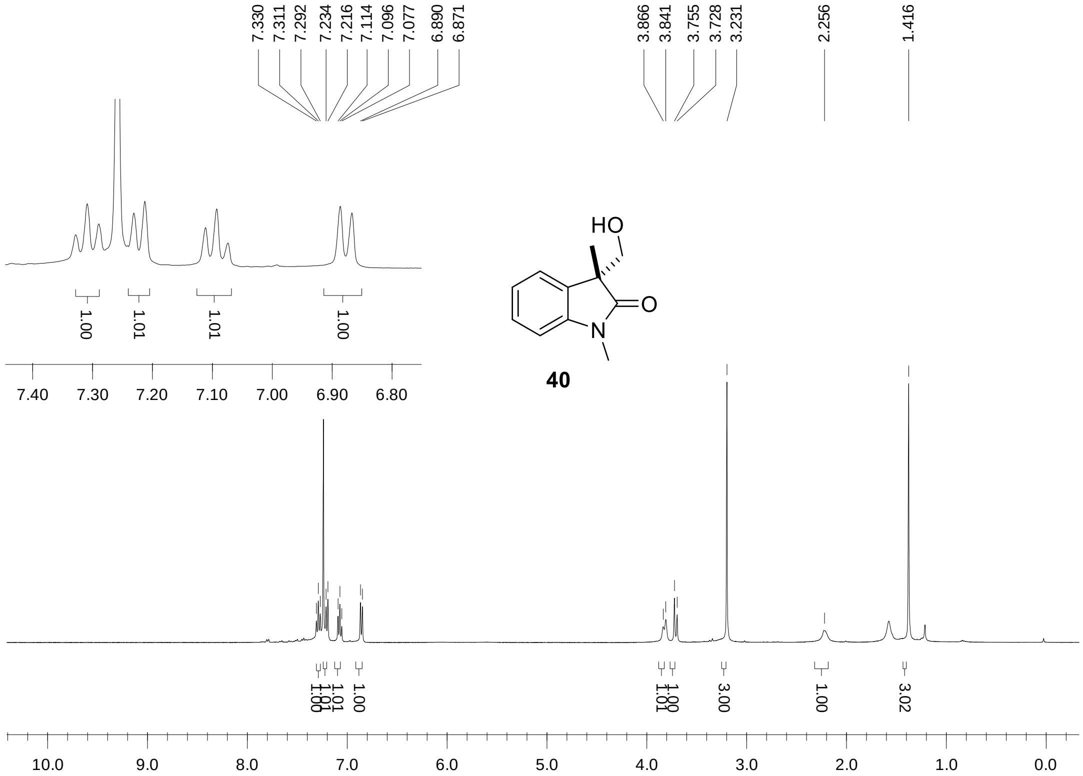


38

^{13}C NMR (75 MHz, $CDCl_3$)

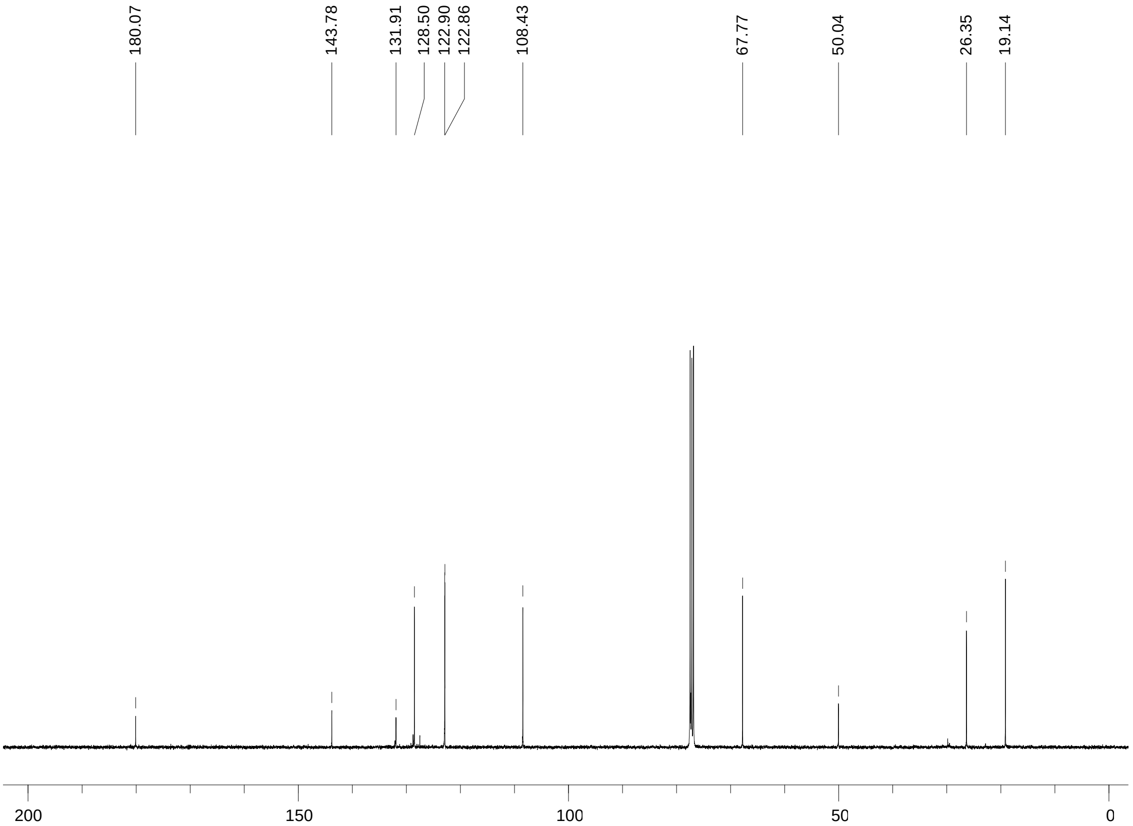


^{1}H NMR (600 MHz, $CDCl_3$)

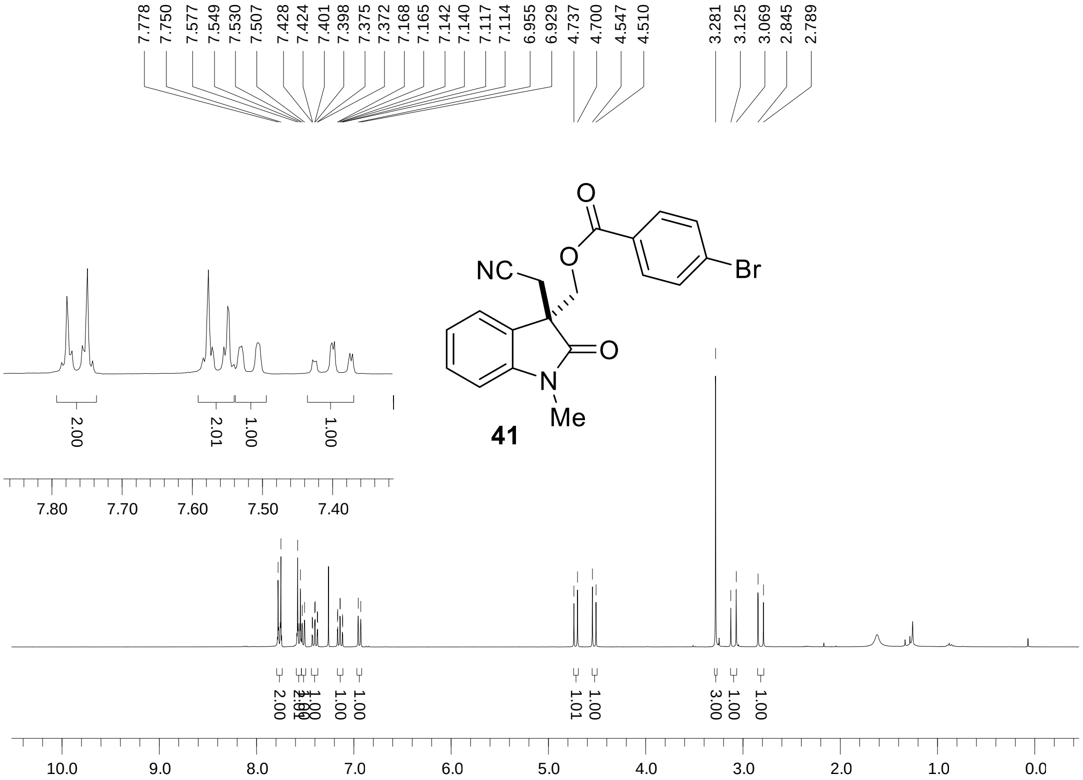


40

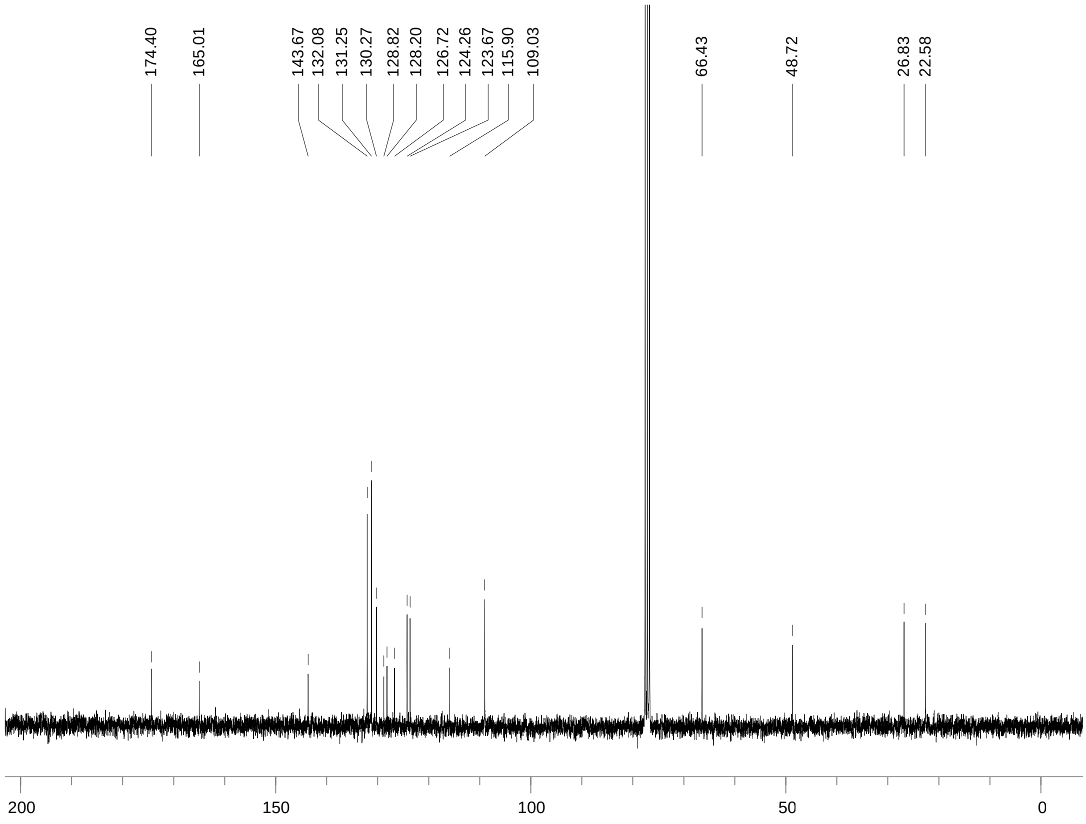
^{13}C NMR (150 MHz, $CDCl_3$)



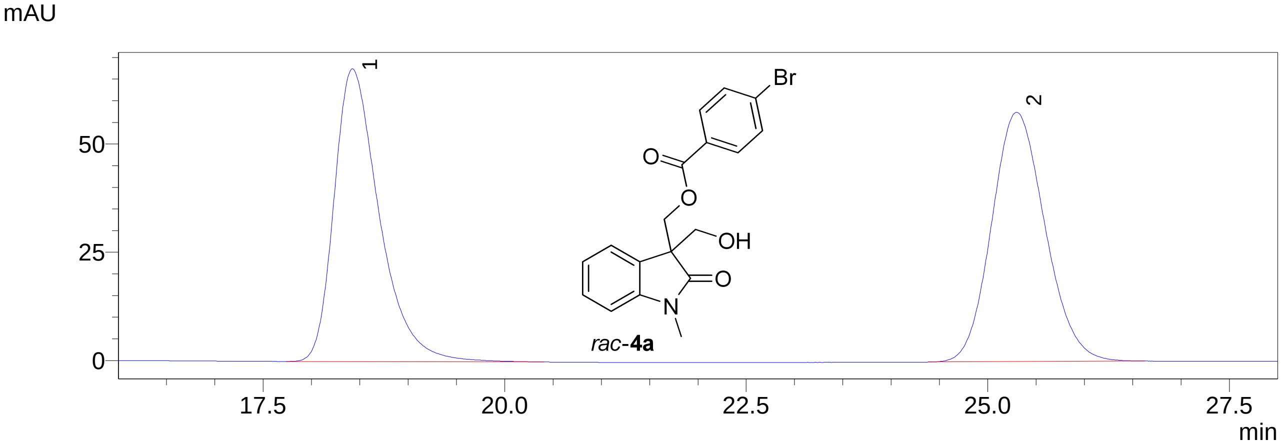
^{1}H NMR (300 MHz, $CDCl_3$)



^{13}C NMR (75 MHz, $CDCl_3$)

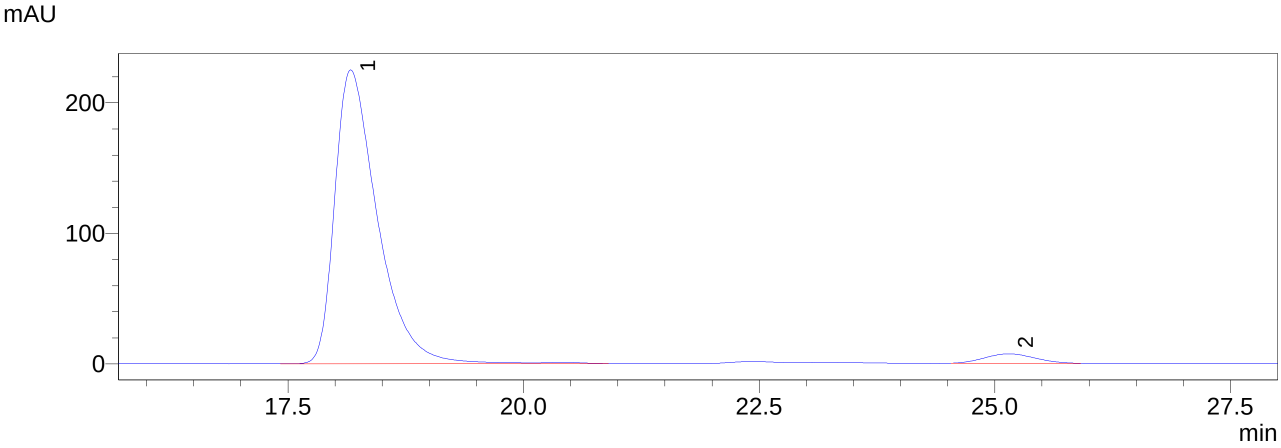


18. HPLC traces:



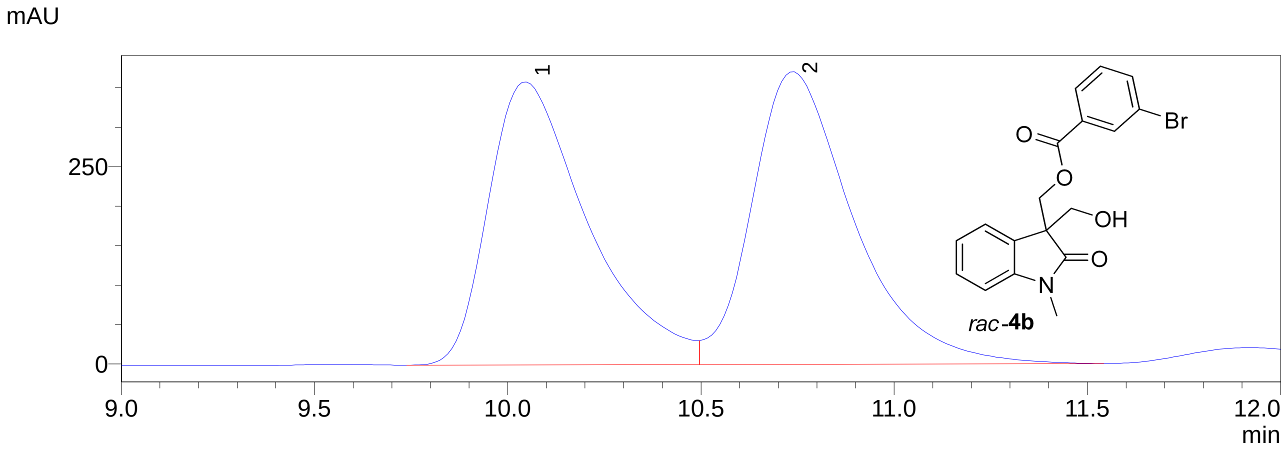
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	18.42	49.89
2	25.30	50.11
Total		100.00



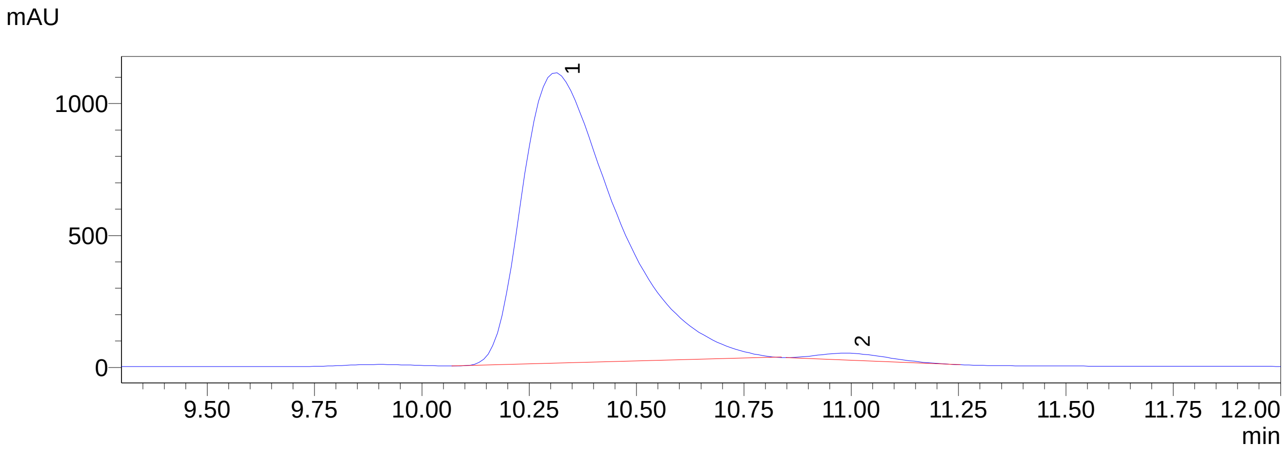
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	18.16	96.31
2	25.14	3.69
Total		100.00



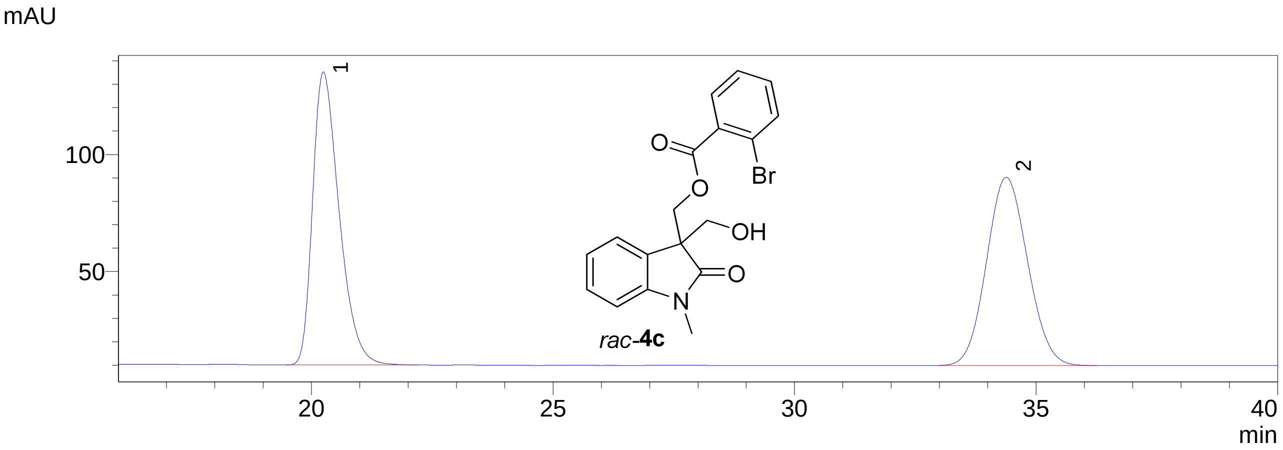
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.04	48.82
2	10.74	51.18
Total		100.00



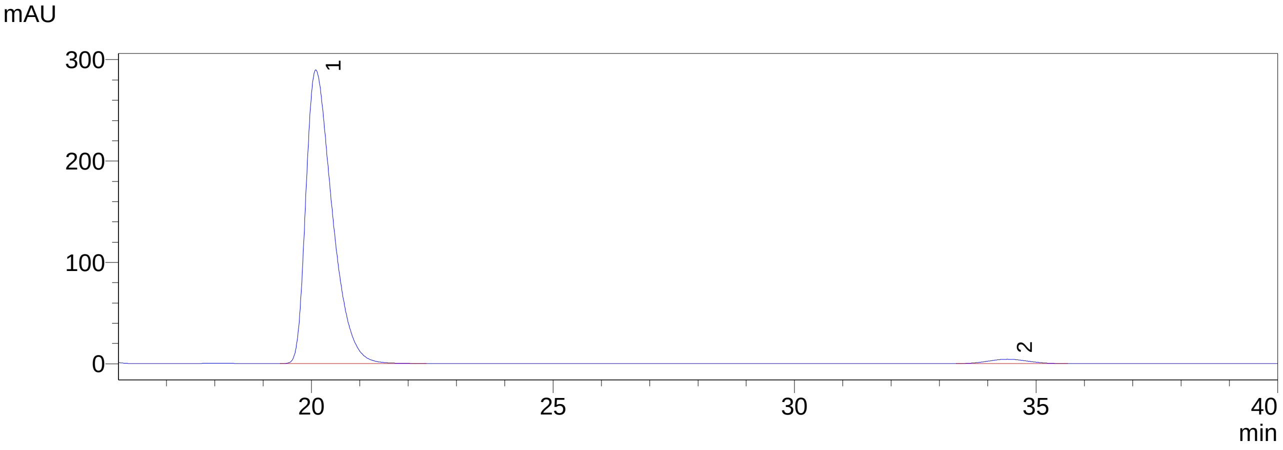
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.31	98.34
2	10.99	1.66
Total		100.00



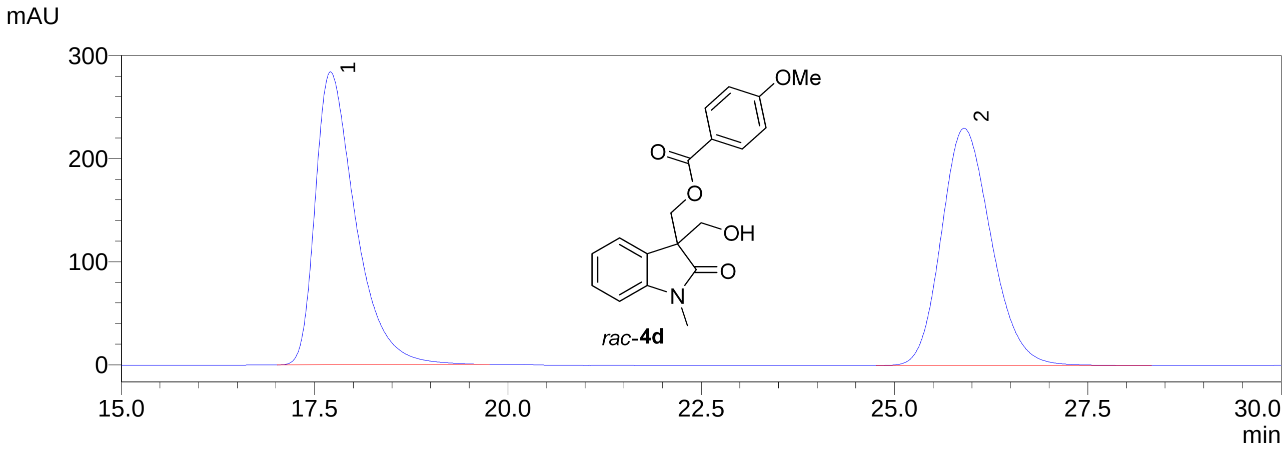
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	20.24	50.14
2	34.38	49.86
Total		100.00



PDA Ch1 254nm

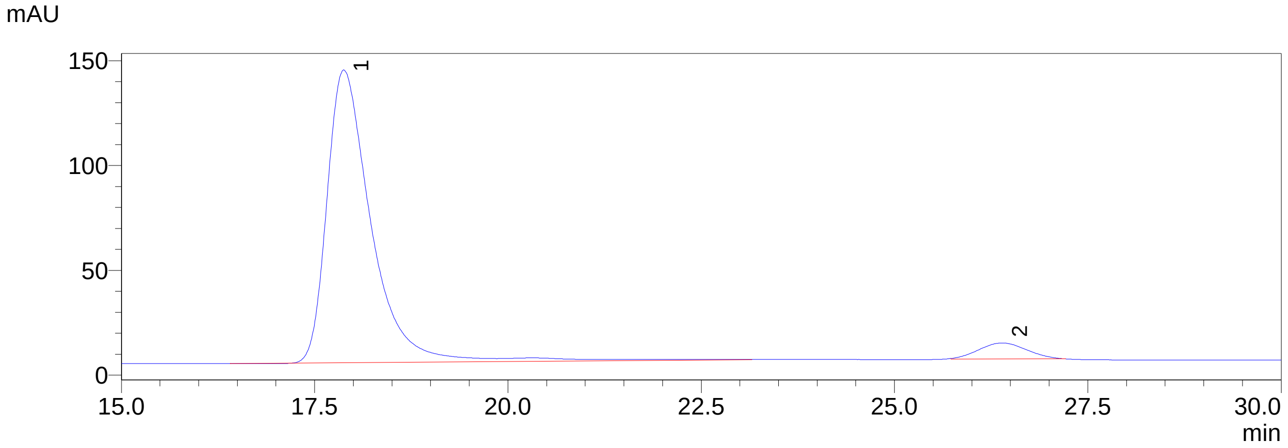
Peak#	Ret. Time	Area%
1	20.09	97.79
2	34.40	2.21
Total		100.00



rac-**4d**

PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.71	49.99
2	25.90	50.01
Total		100.00



PDA Ch1 260nm

Peak#	Ret. Time	Area%
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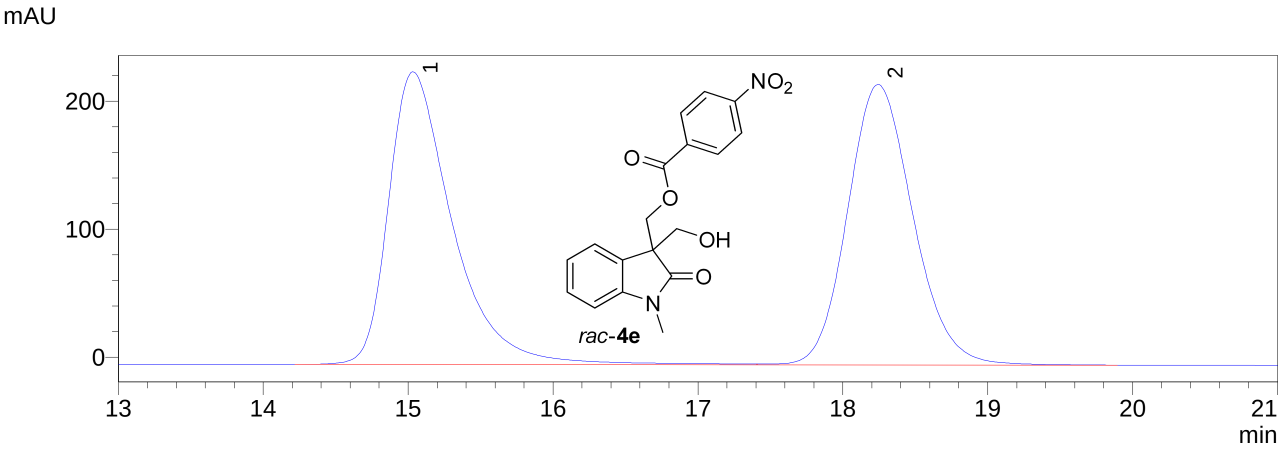
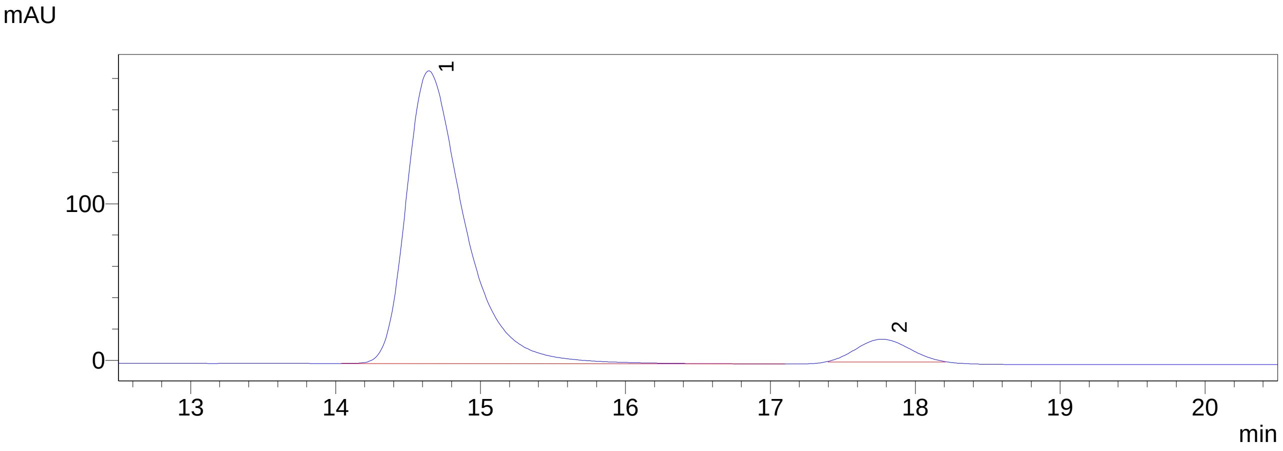
2	26.40	5.54
Total		100.00



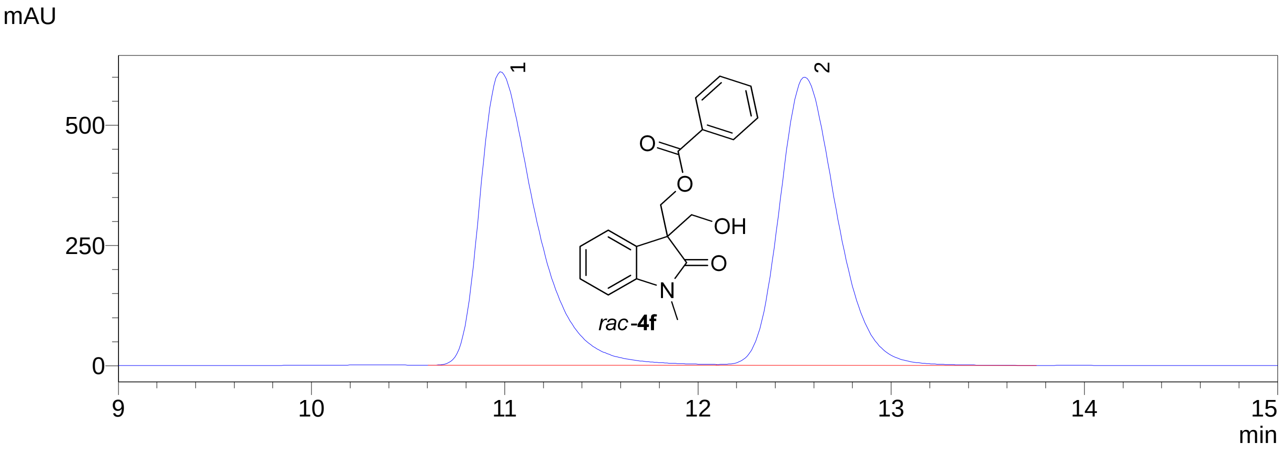
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.03	50.52
2	18.24	49.48
Total		100.00



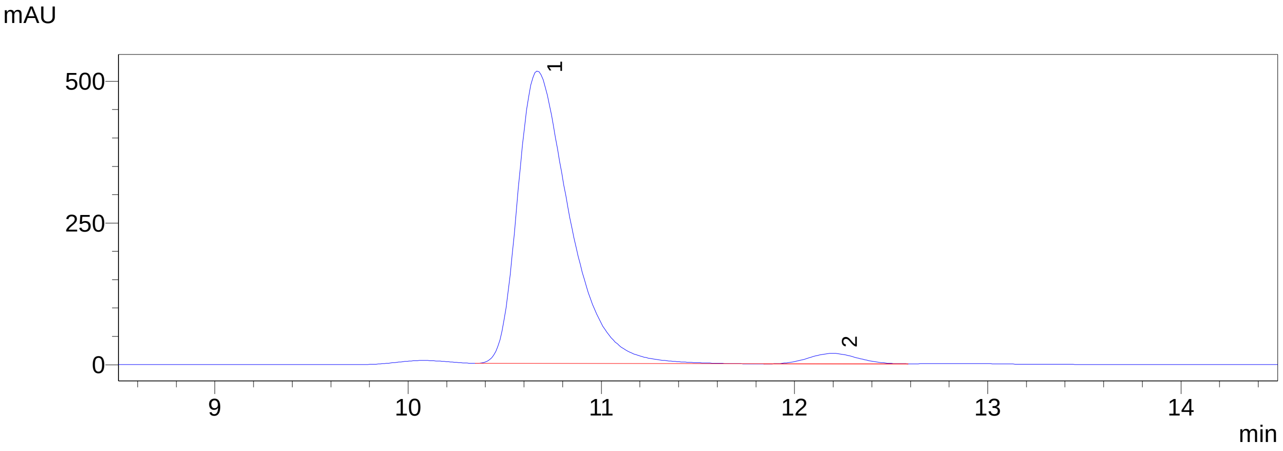
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.64	93.49
2	17.77	6.51
Total		100.00



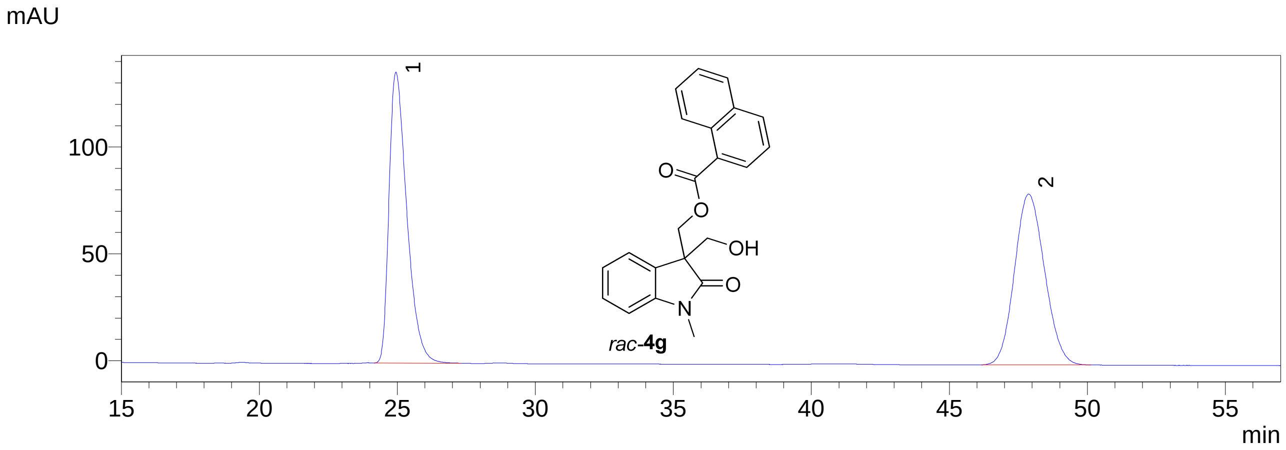
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.98	50.34
2	12.55	49.66
Total		100.00



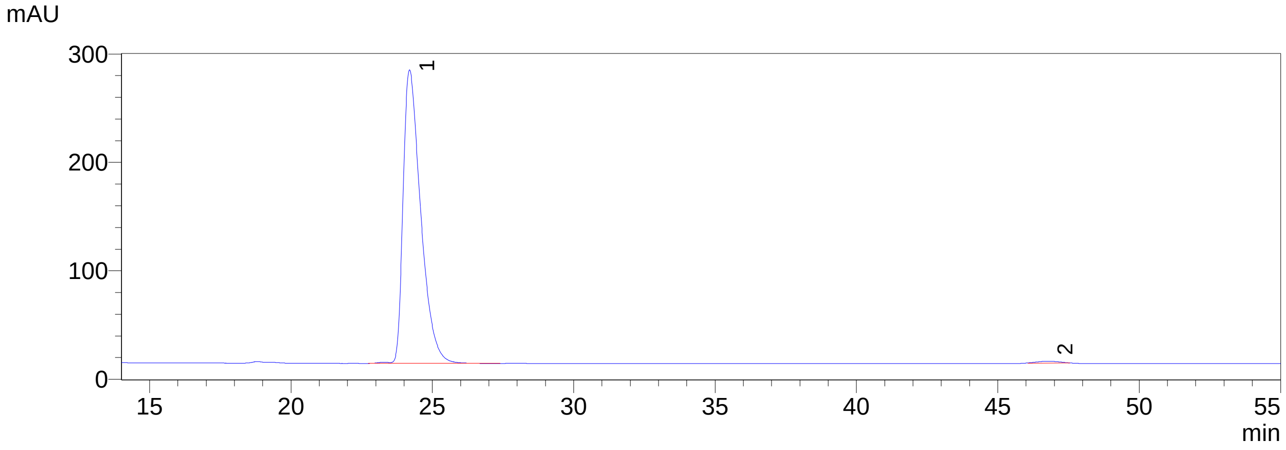
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.67	96.75
2	12.20	3.25
Total		100.00



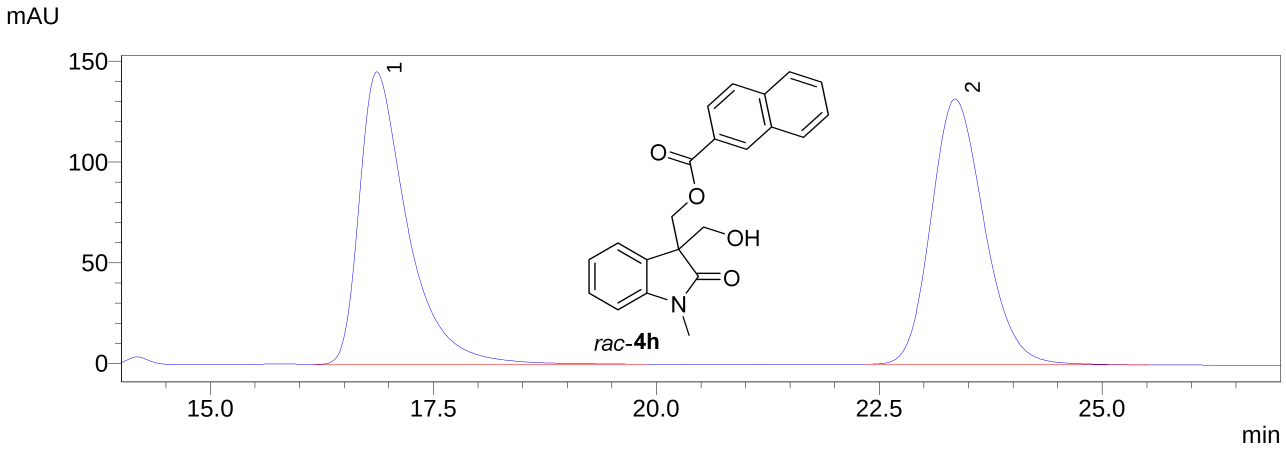
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	24.95	50.24
2	47.87	49.76
Total		100.00



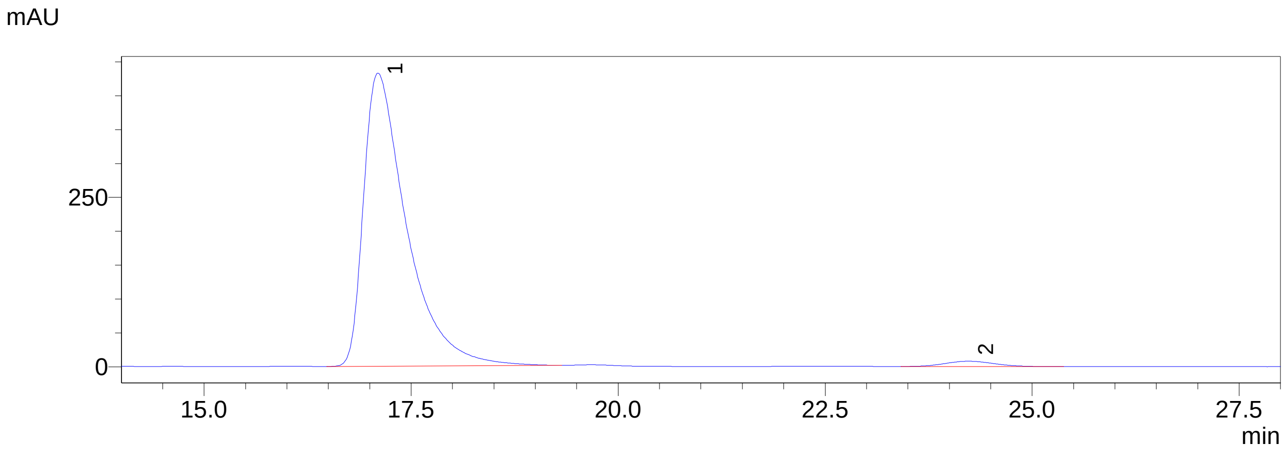
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	24.19	99.21
2	47.02	0.79
Total		100.00



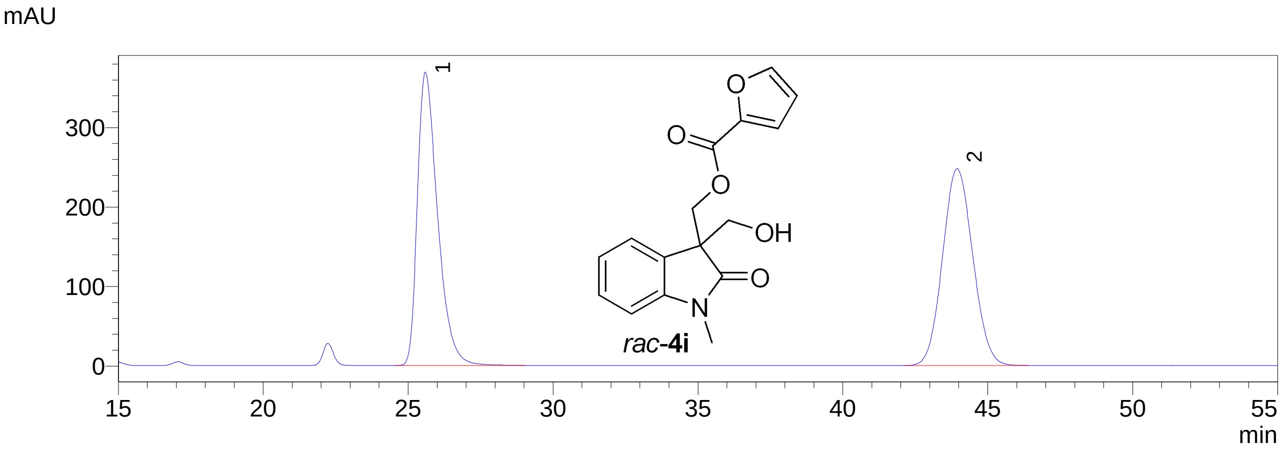
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	16.87	50.02
2	23.35	49.98
Total		100.00



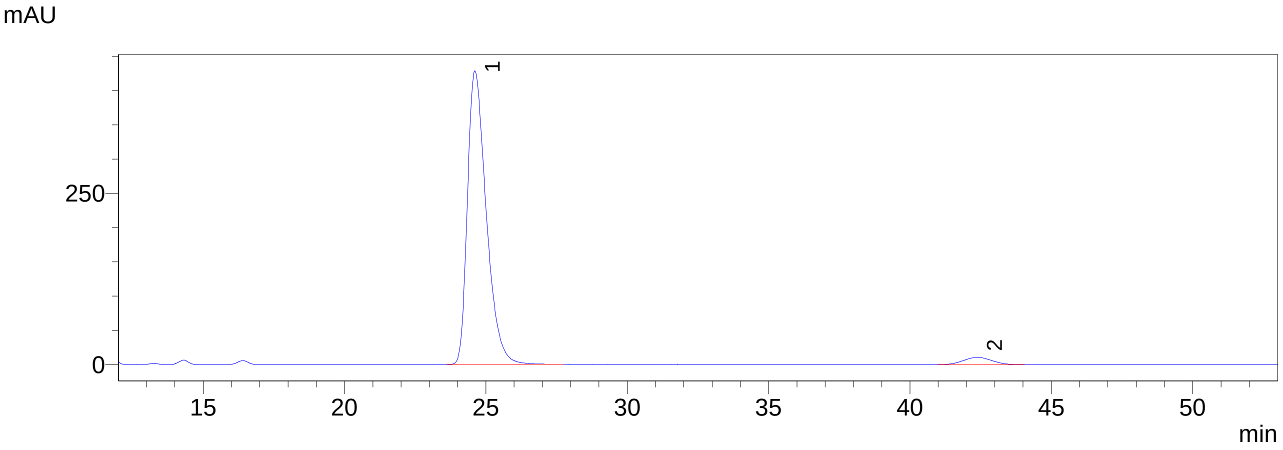
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.10	97.96
2	24.23	2.04
Total		100.00



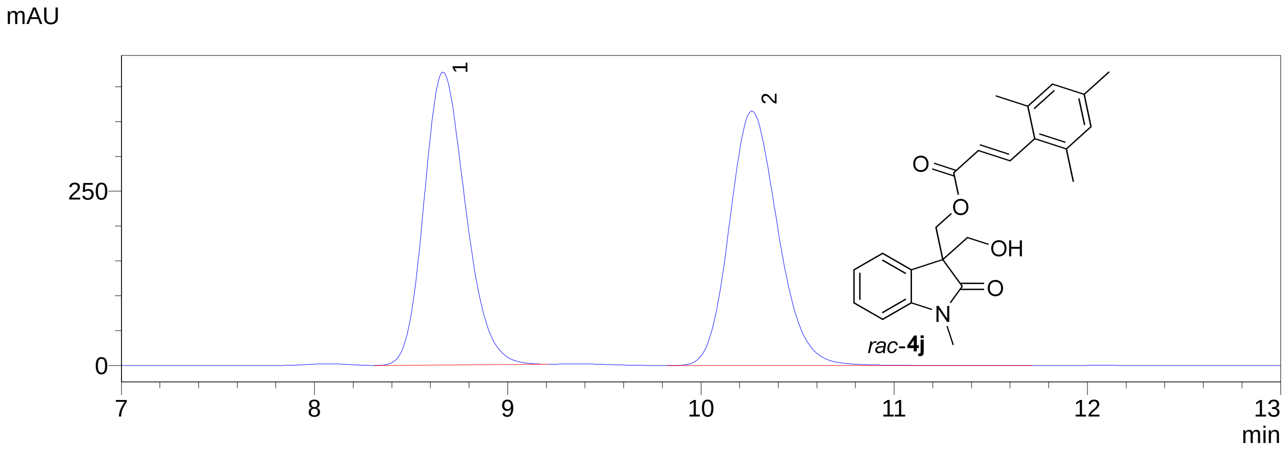
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	25.59	49.88
2	43.94	50.12
Total		100.00



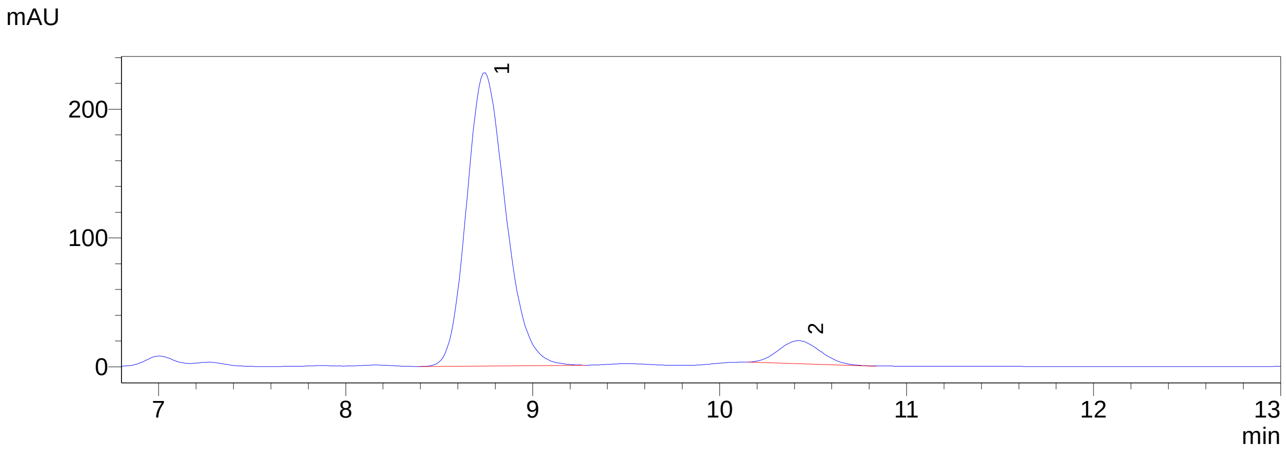
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	24.61	96.38
2	42.38	3.62
Total		100.00



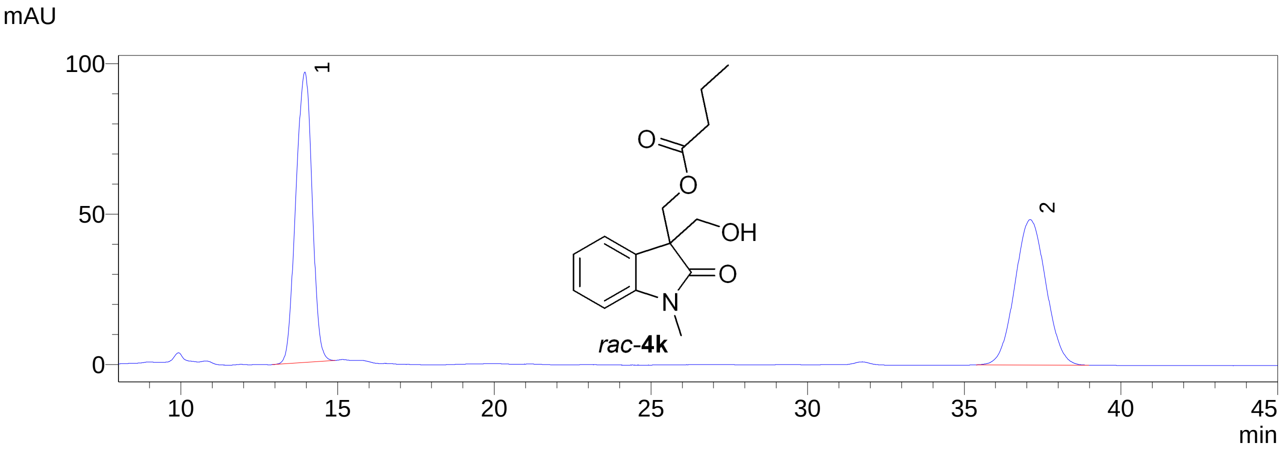
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	8.66	49.70
2	10.26	50.30
Total		100.00



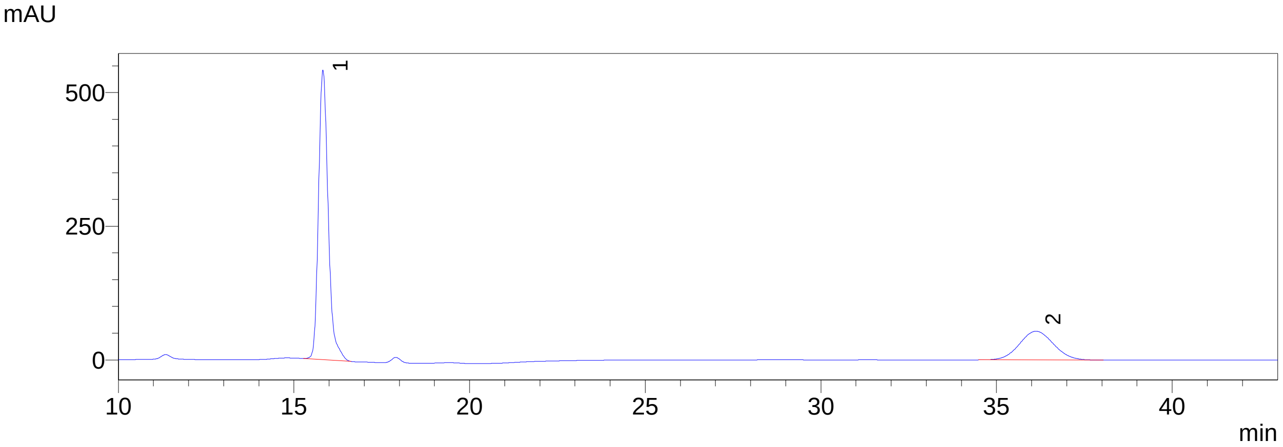
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	8.74	92.27
2	10.42	7.73
Total		100.00



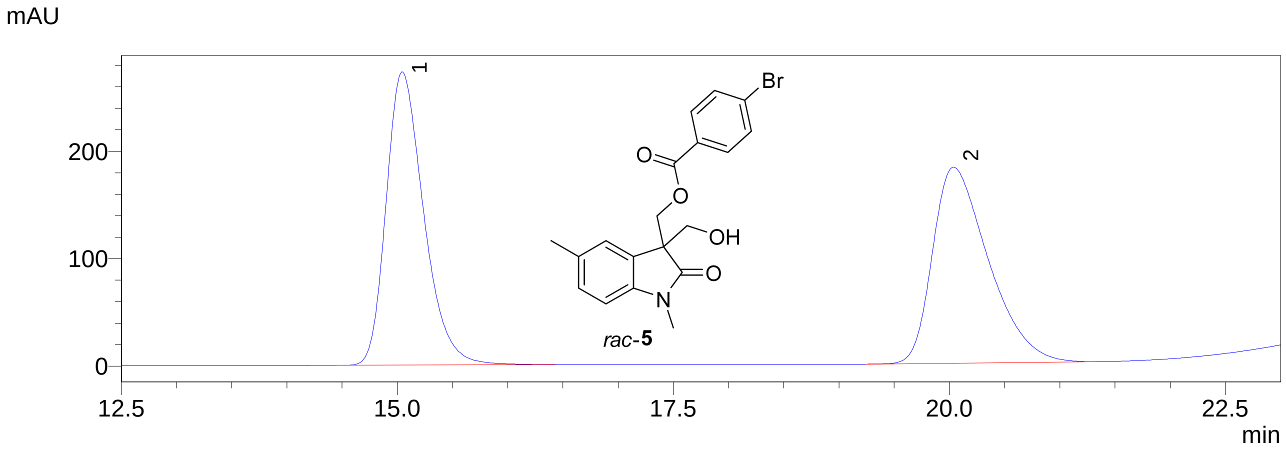
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.95	51.18
2	37.10	48.82
Total		100.00



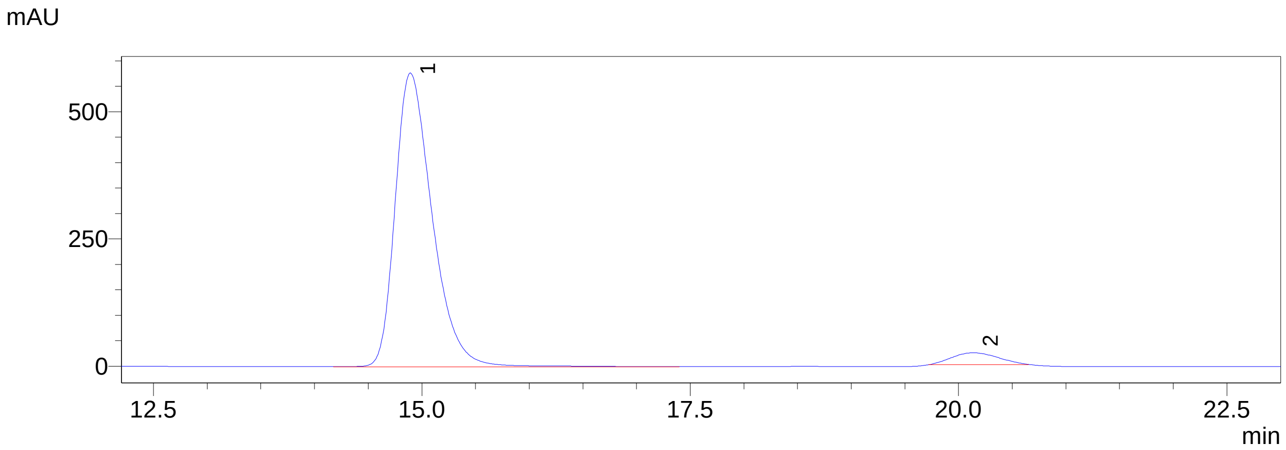
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.82	74.08
2	36.12	25.92
Total		100.00



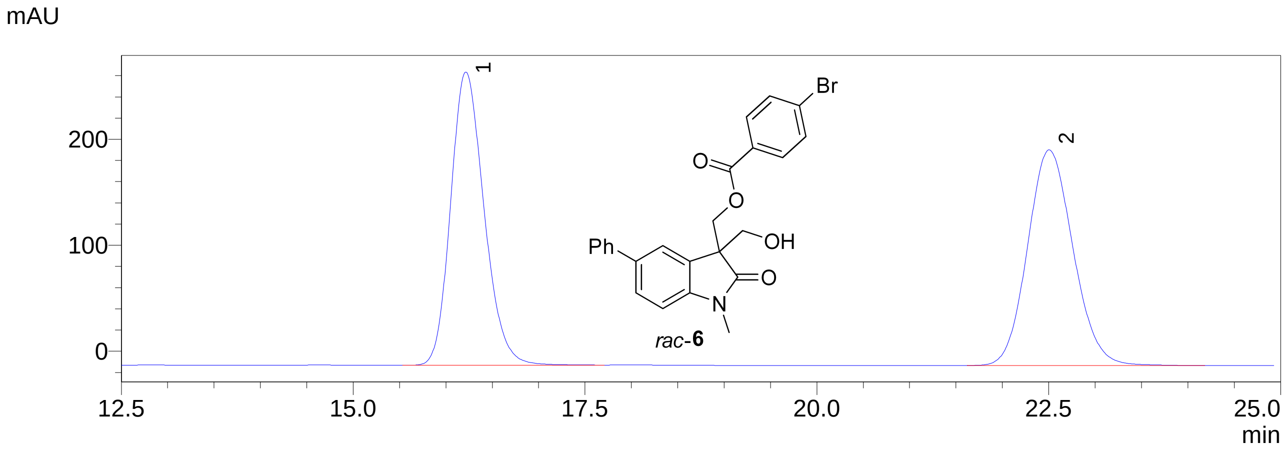
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.04	50.19
2	20.04	49.81
Total		100.00



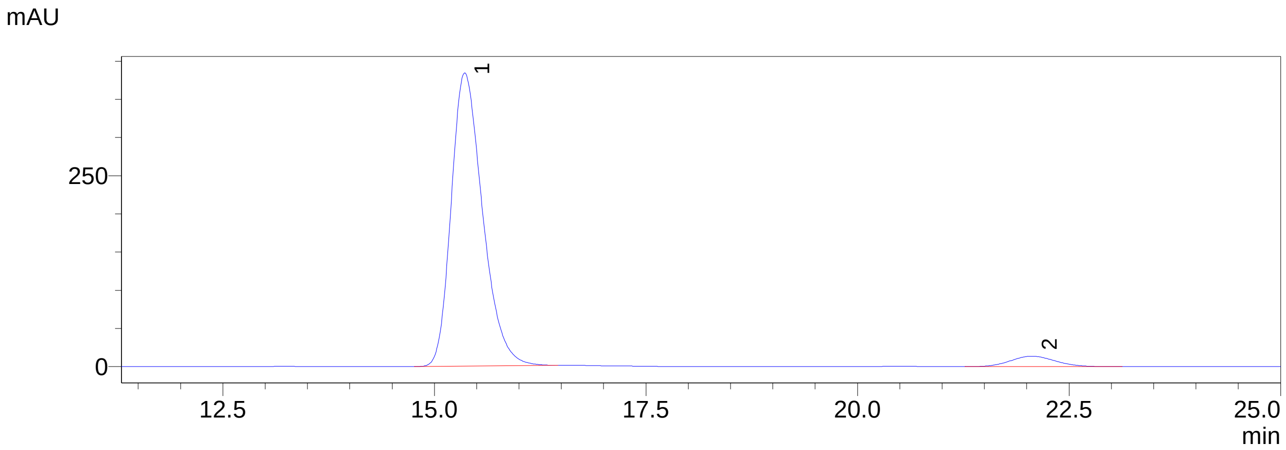
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.89	95.22
2	20.14	4.78
Total		100.00



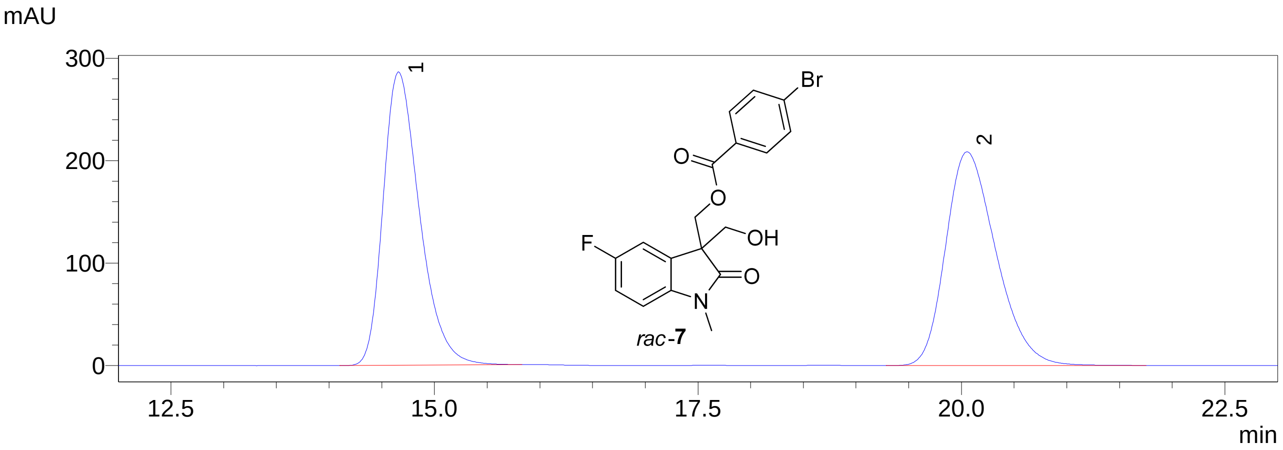
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	16.21	49.99
2	22.50	50.01
Total		100.00



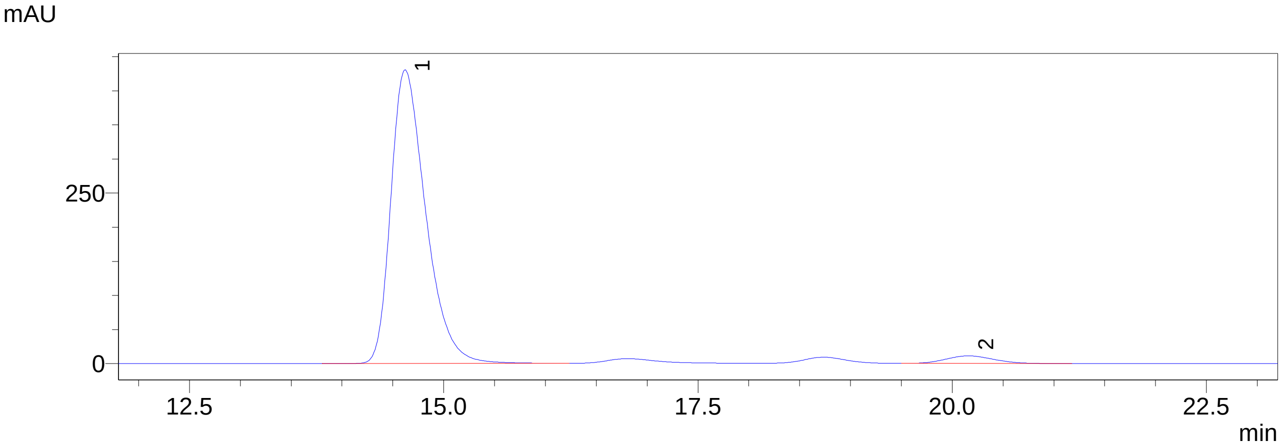
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.36	95.15
2	22.06	4.85
Total		100.00



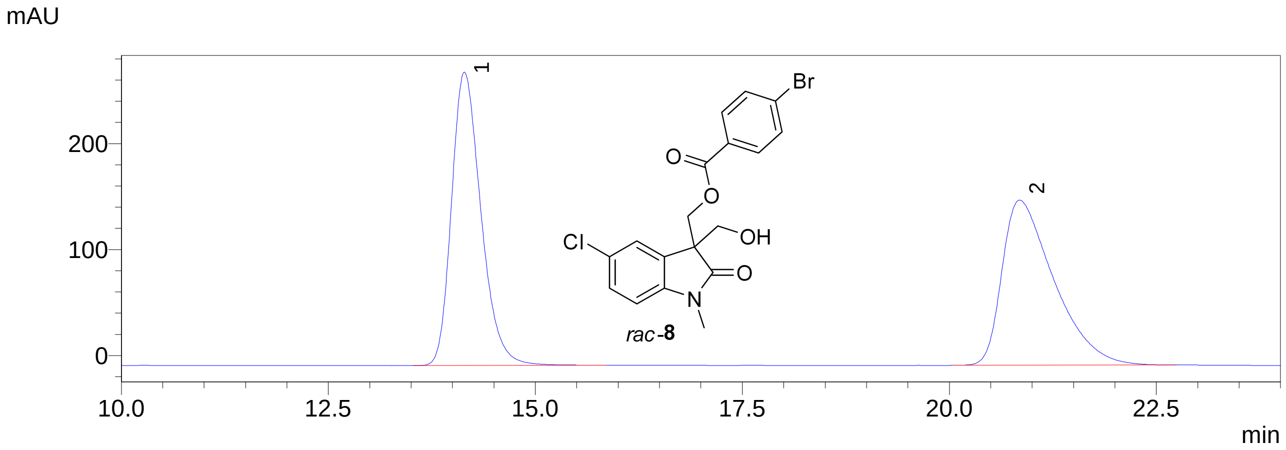
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.66	49.83
2	20.05	50.17
Total		100.00



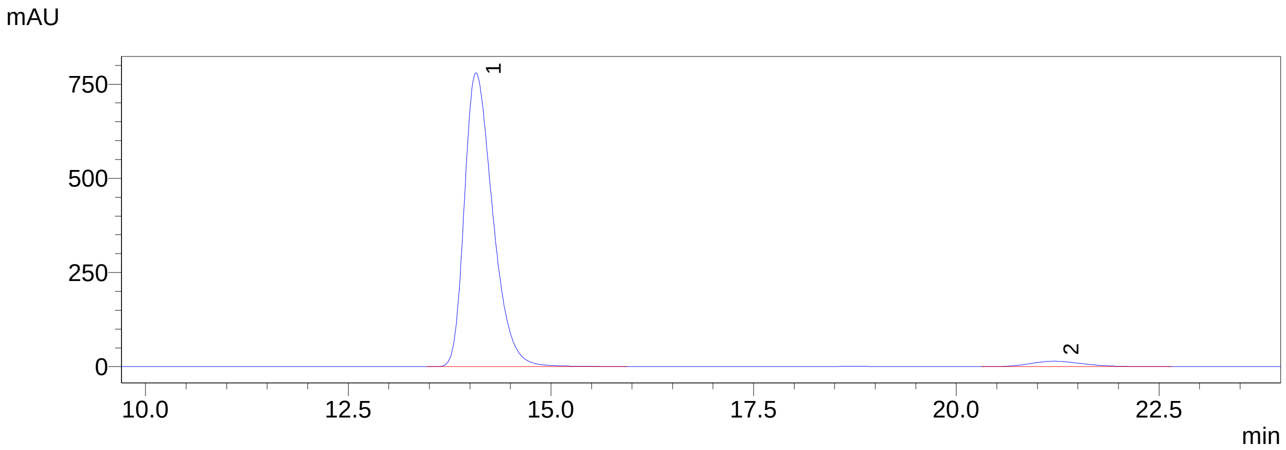
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.62	96.57
2	20.16	3.43
Total		100.00



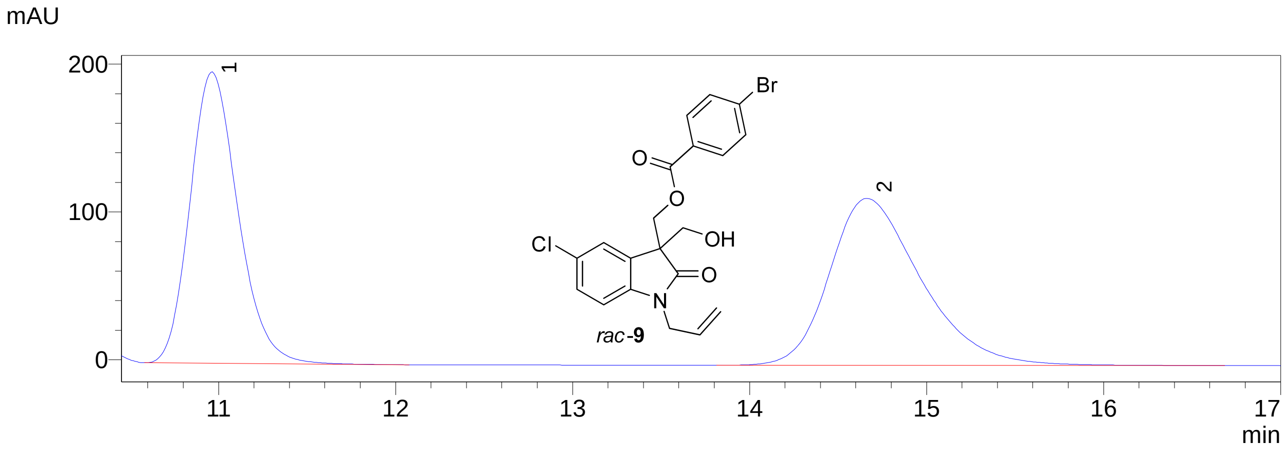
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.14	50.24
2	20.85	49.76
Total		100.00



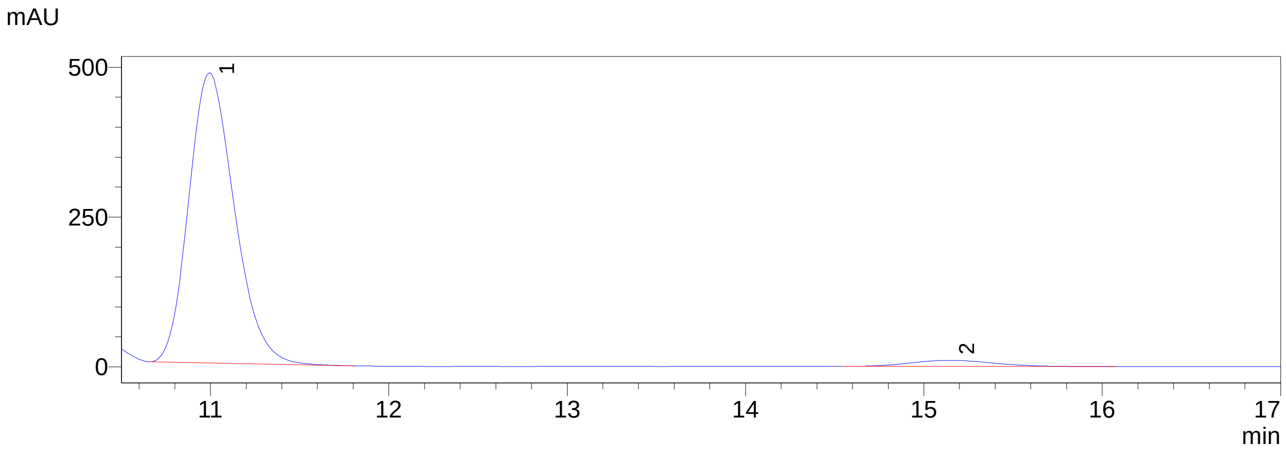
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.08	96.68
2	21.20	3.32
Total		100.00



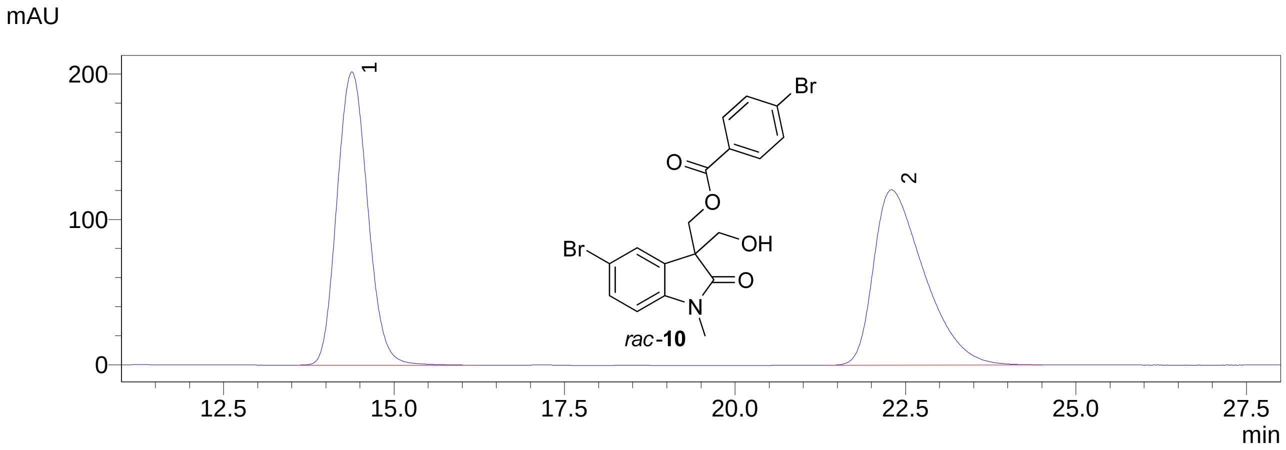
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.96	47.68
2	14.66	52.32
Total		100.00



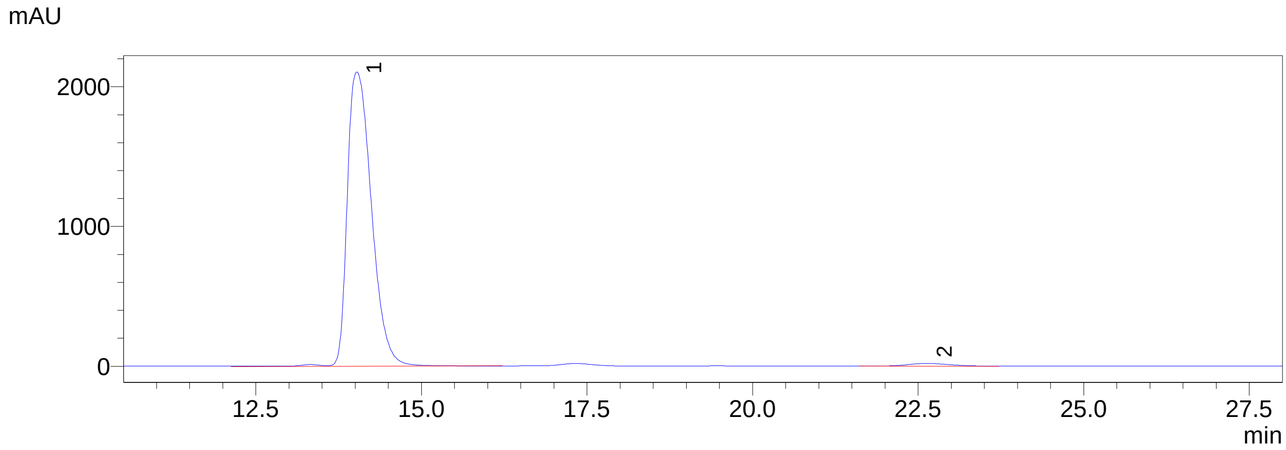
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.99	96.28
2	15.14	3.72
Total		100.00



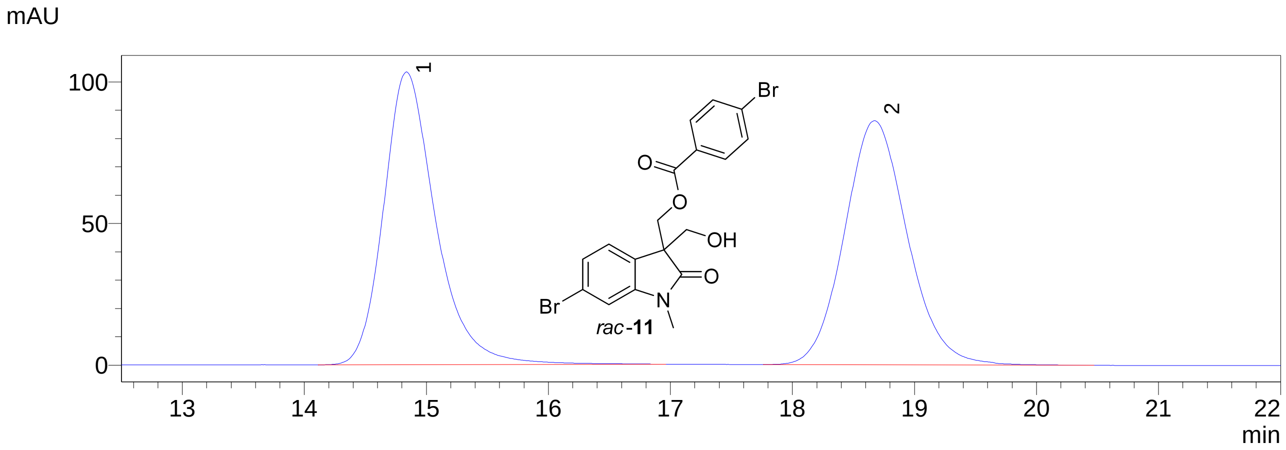
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.38	50.24
2	22.29	49.76
Total		100.00



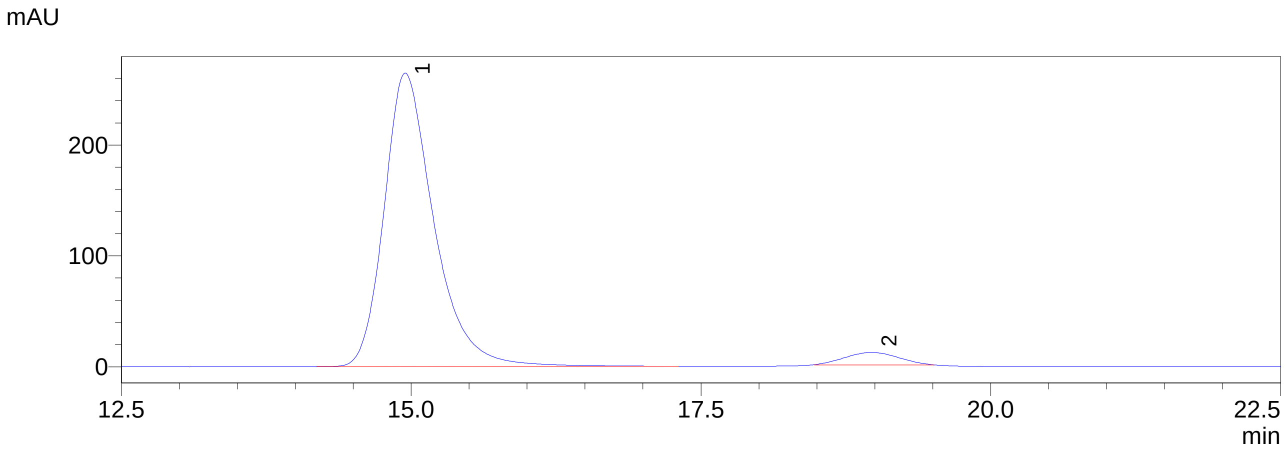
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.02	98.53
2	22.64	1.47
Total		100.00



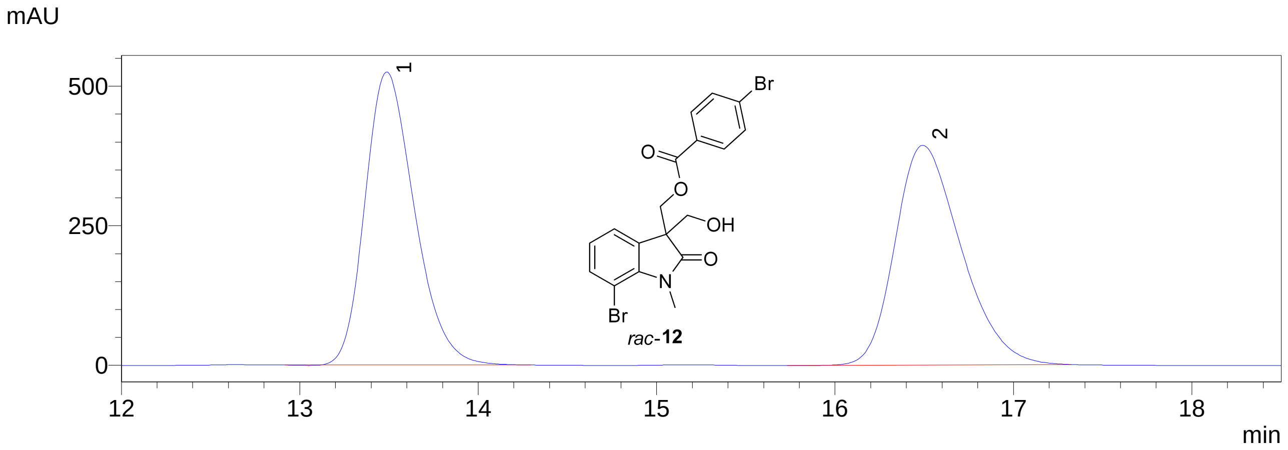
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.84	49.85
2	18.67	50.15
Total		100.00



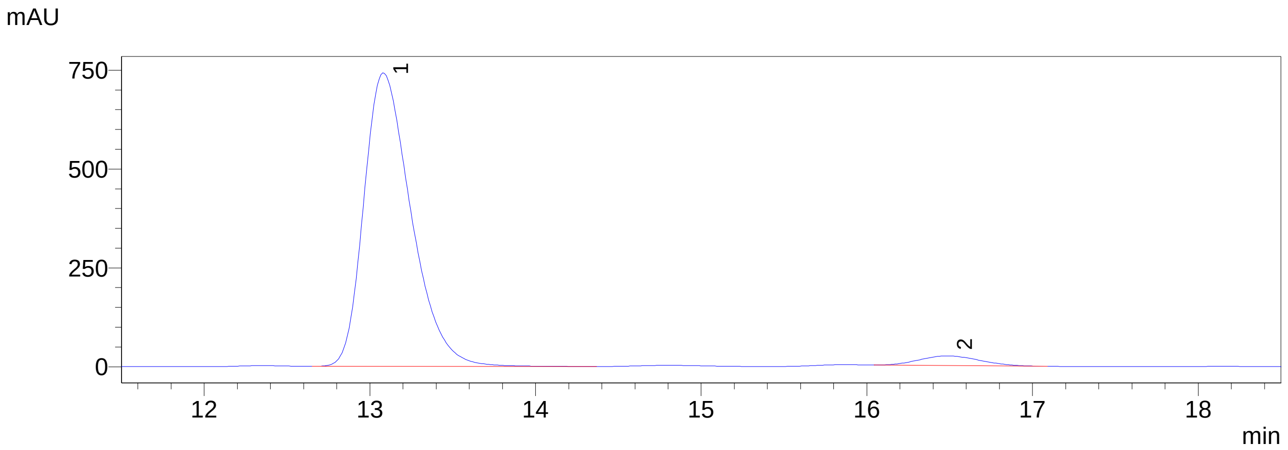
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.95	95.66
2	18.97	4.34
Total		100.00



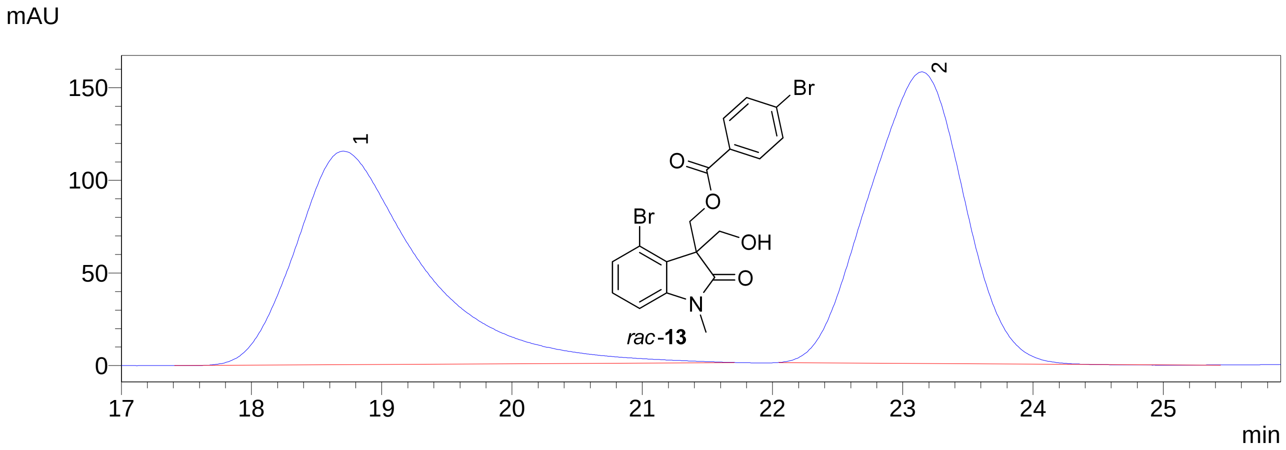
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.49	49.96
2	16.49	50.04
Total		100.00



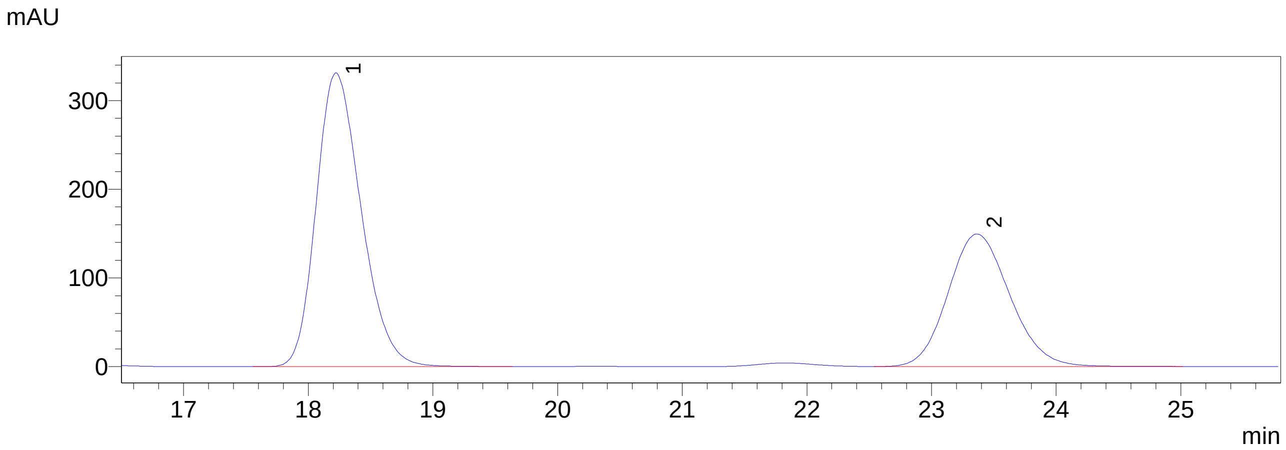
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.08	95.95
2	16.48	4.05
Total		100.00



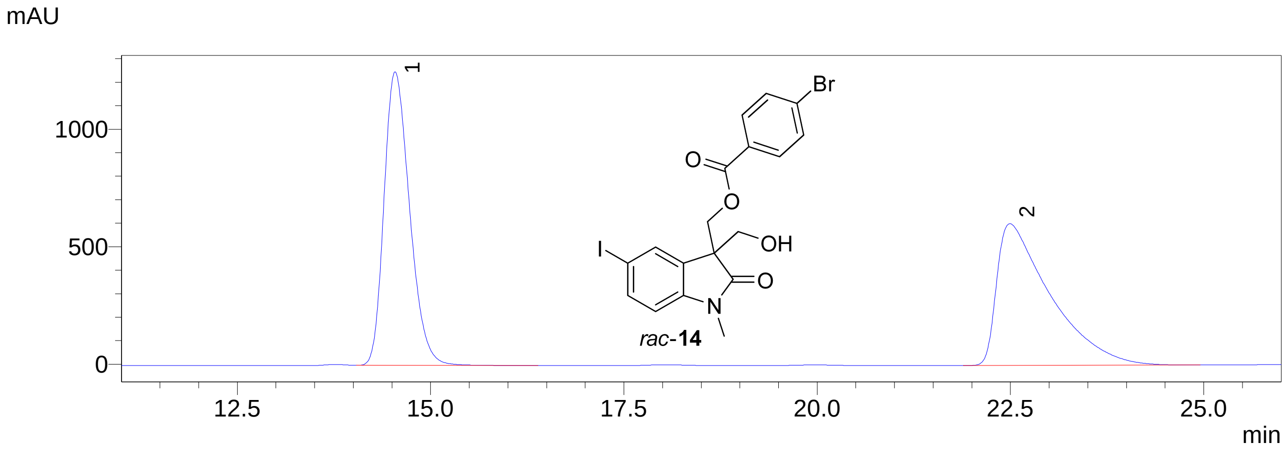
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	18.70	49.12
2	23.15	50.88
Total		100.00



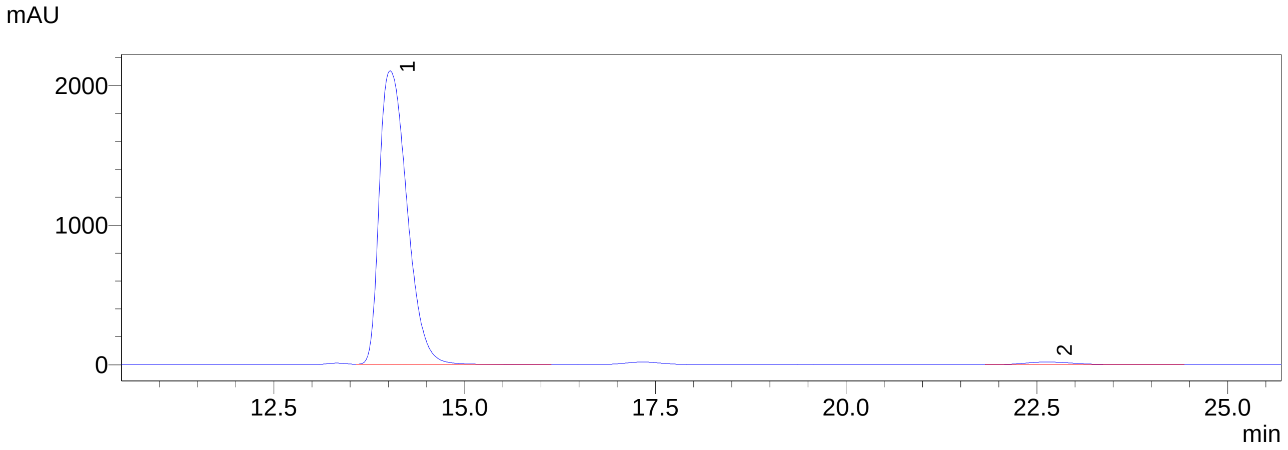
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	18.22	61.76
2	23.36	38.24
Total		100.00



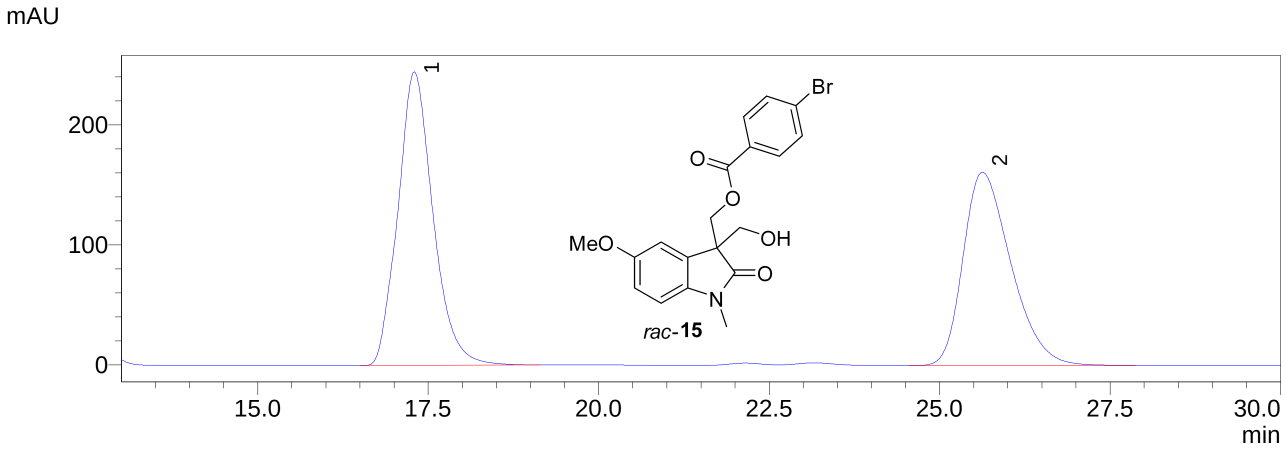
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.54	49.80
2	22.49	50.20
Total		100.00



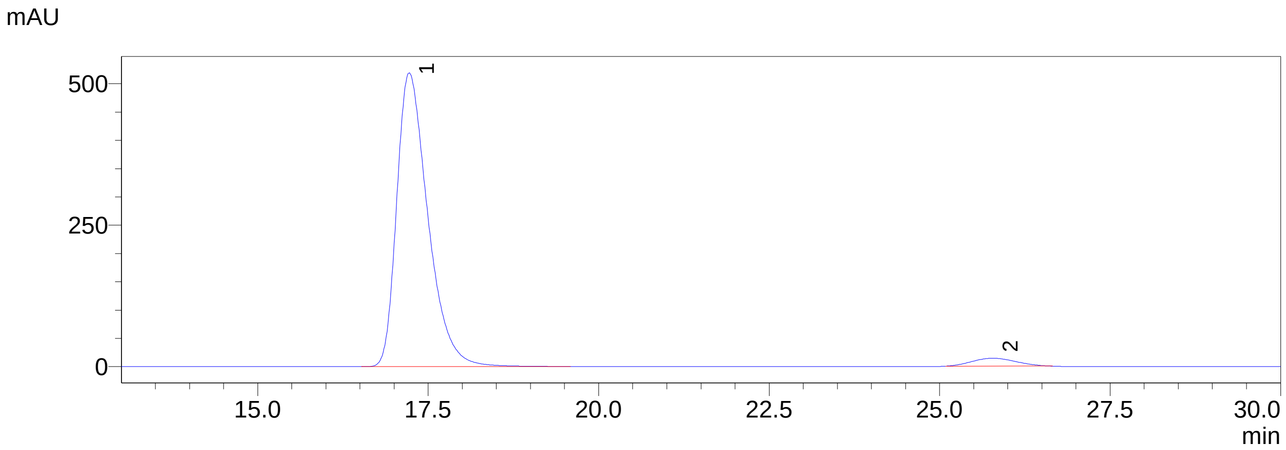
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.02	98.38
2	22.64	1.62
Total		100.00



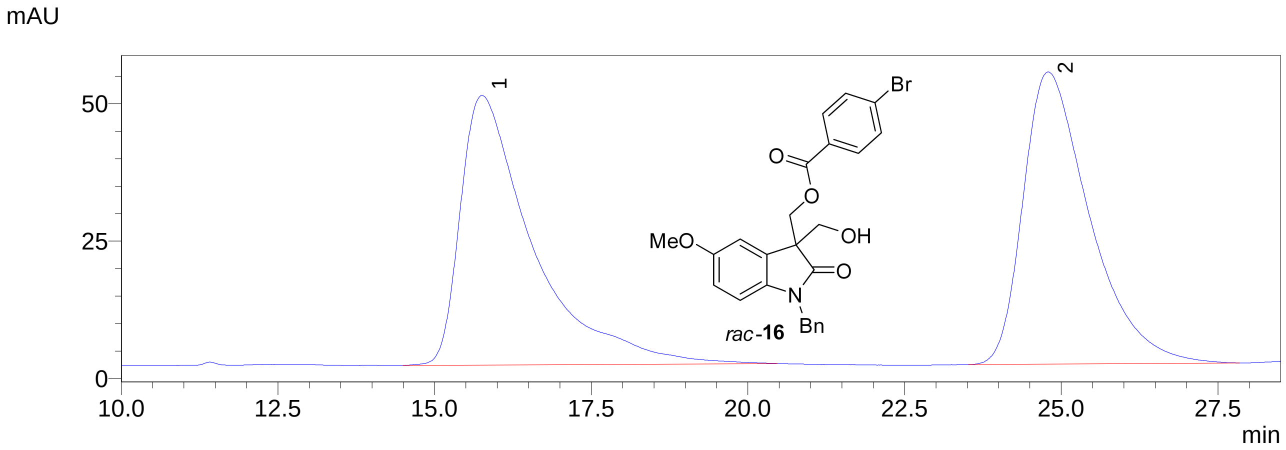
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.30	52.77
2	25.63	47.23
Total		100.00



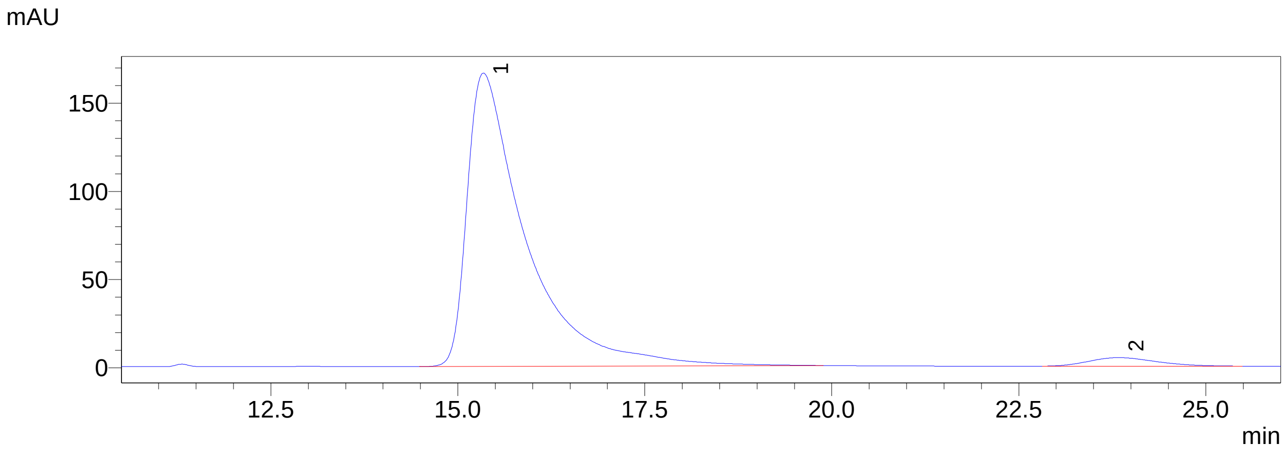
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.22	96.38
2	25.78	3.62
Total		100.00



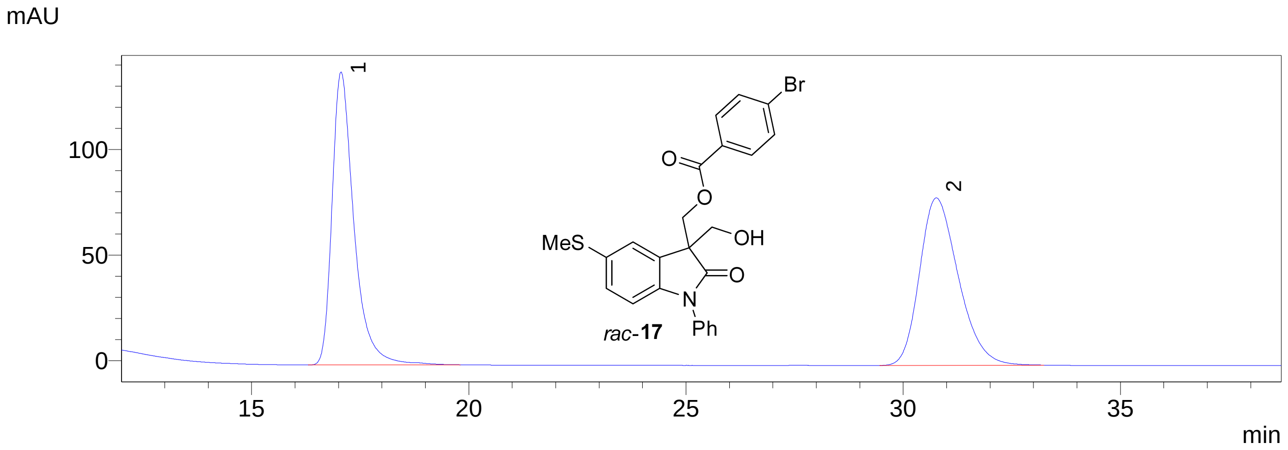
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.75	50.13
2	24.79	49.87
Total		100.00



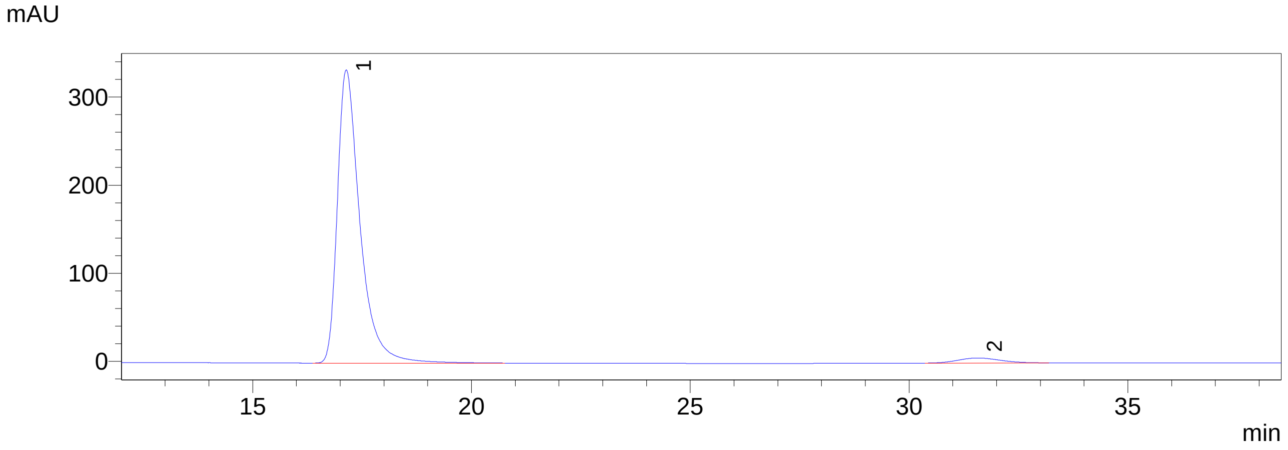
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.34	96.74
2	23.84	3.26
Total		100.00



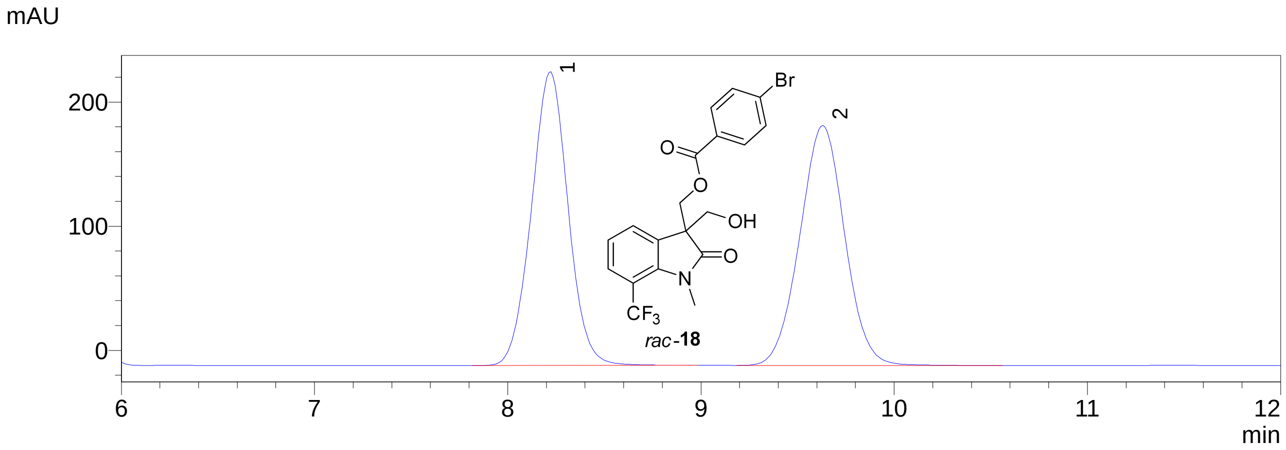
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.06	49.68
2	30.76	50.32
Total		100.00



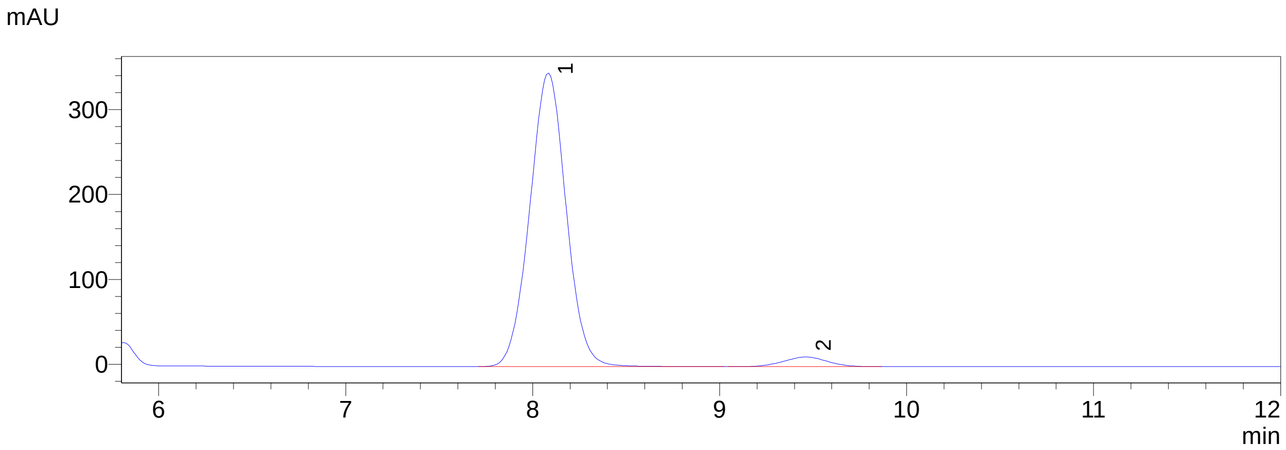
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.14	96.89
2	31.55	3.11
Total		100.00



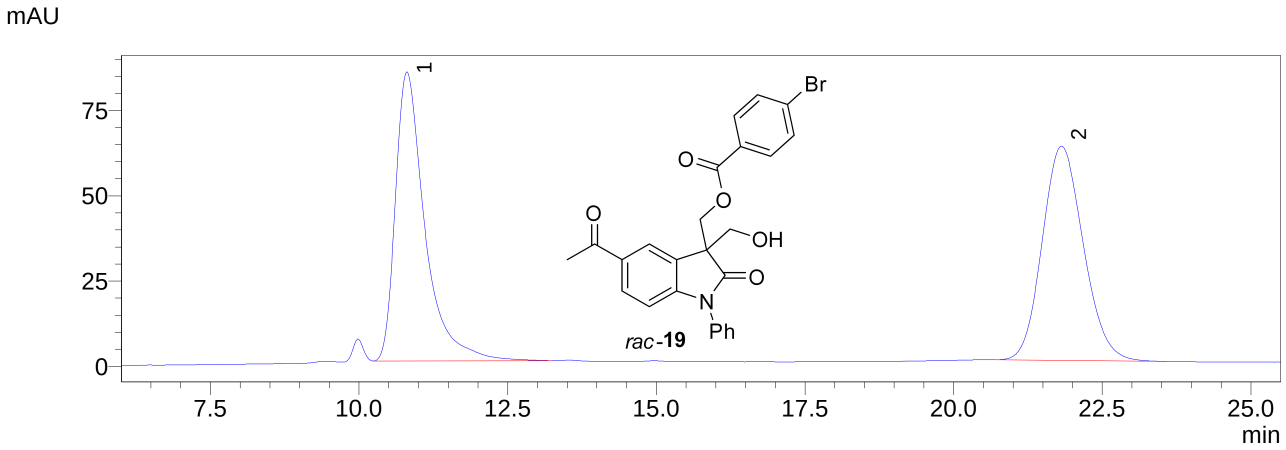
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	8.22	49.97
2	9.63	50.03
Total		100.00



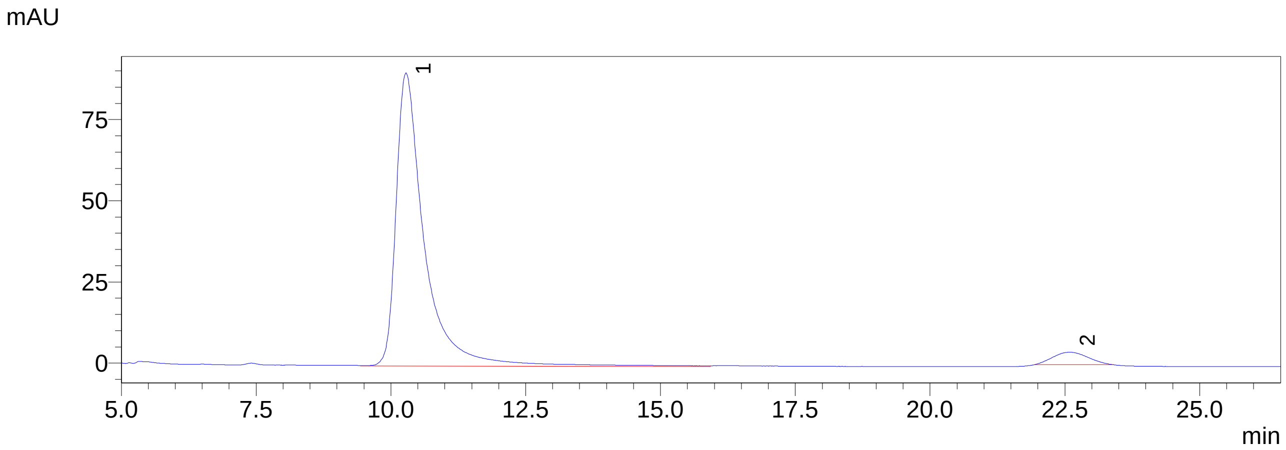
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	8.08	96.22
2	9.46	3.78
Total		100.00



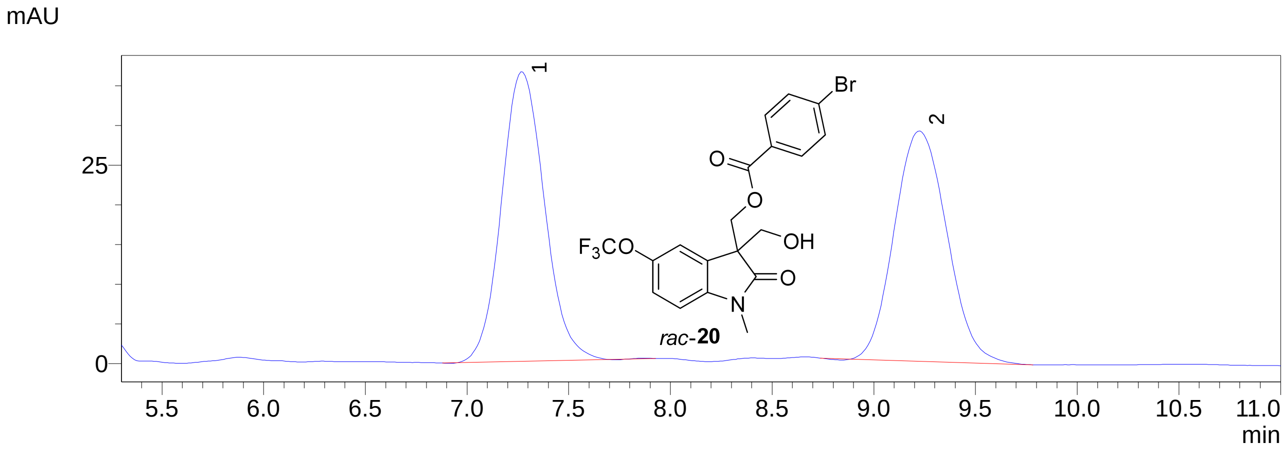
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.80	49.17
2	21.81	50.83
Total		100.00



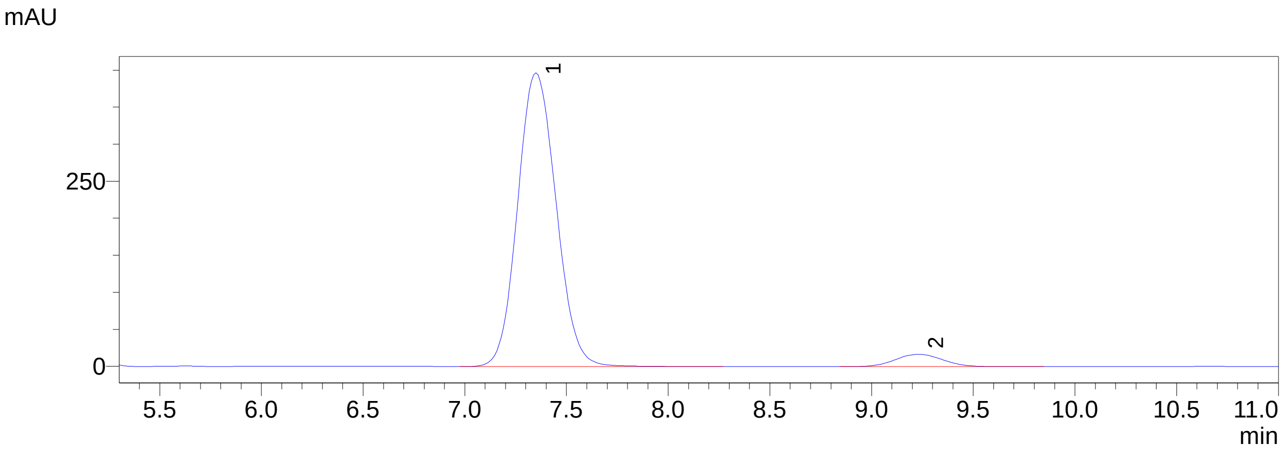
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.28	95.06
2	22.60	4.94
Total		100.00



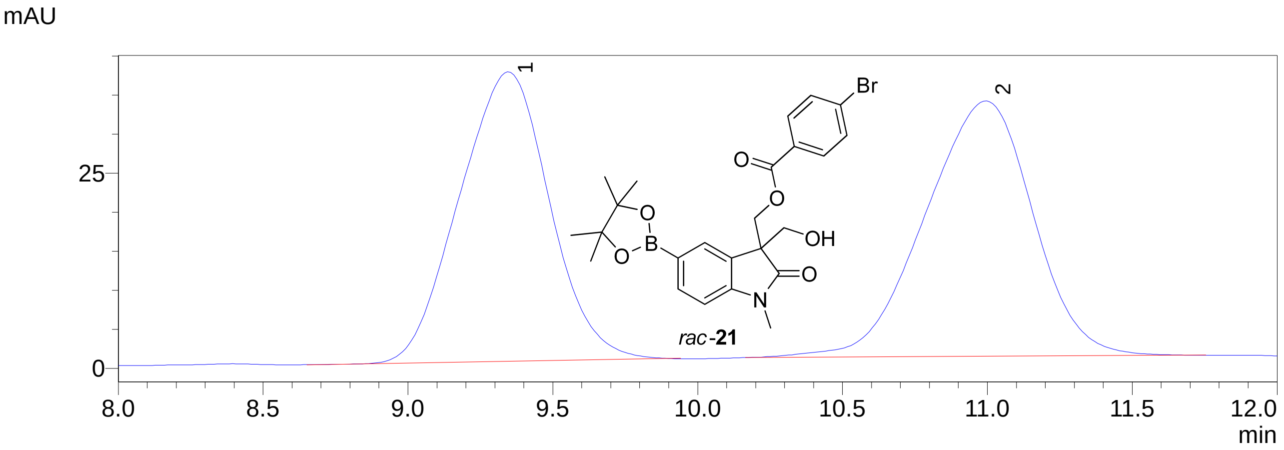
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	7.27	50.71
2	9.22	49.29
Total		100.00



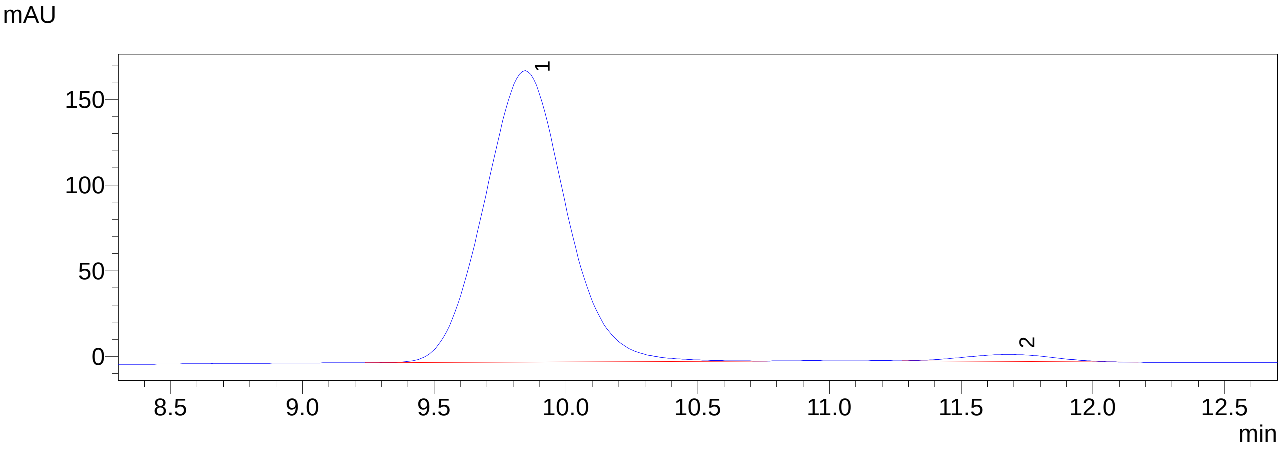
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	7.35	95.06
2	9.23	4.94
Total		100.00



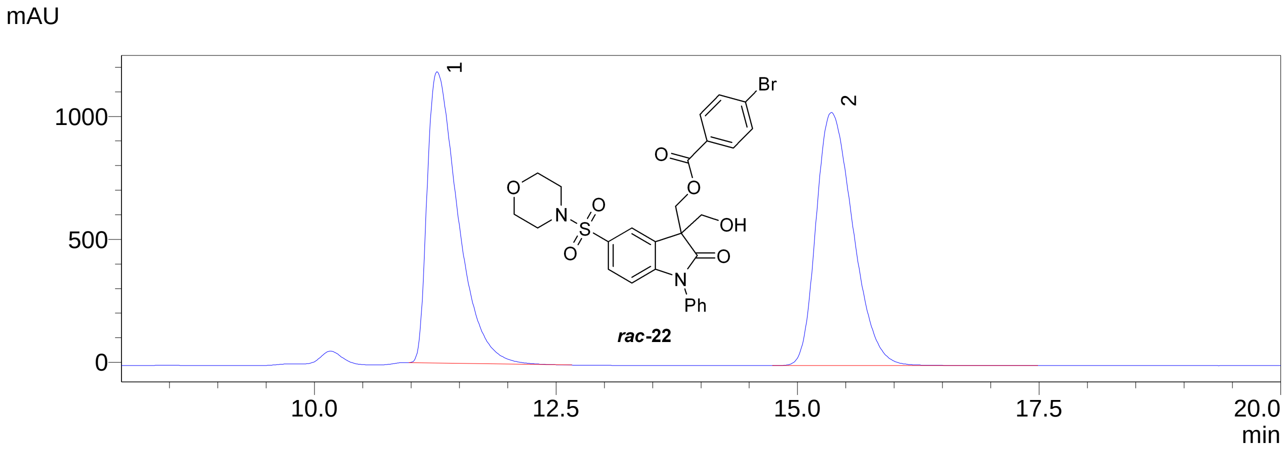
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	9.35	48.65
2	10.99	51.35
Total		100.00



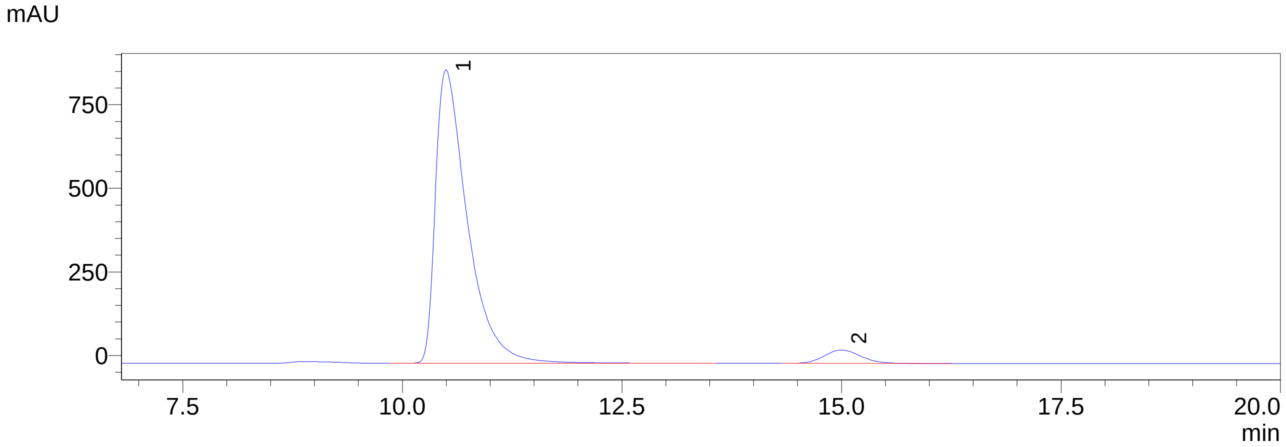
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	9.84	97.49
2	11.68	2.51
Total		100.00



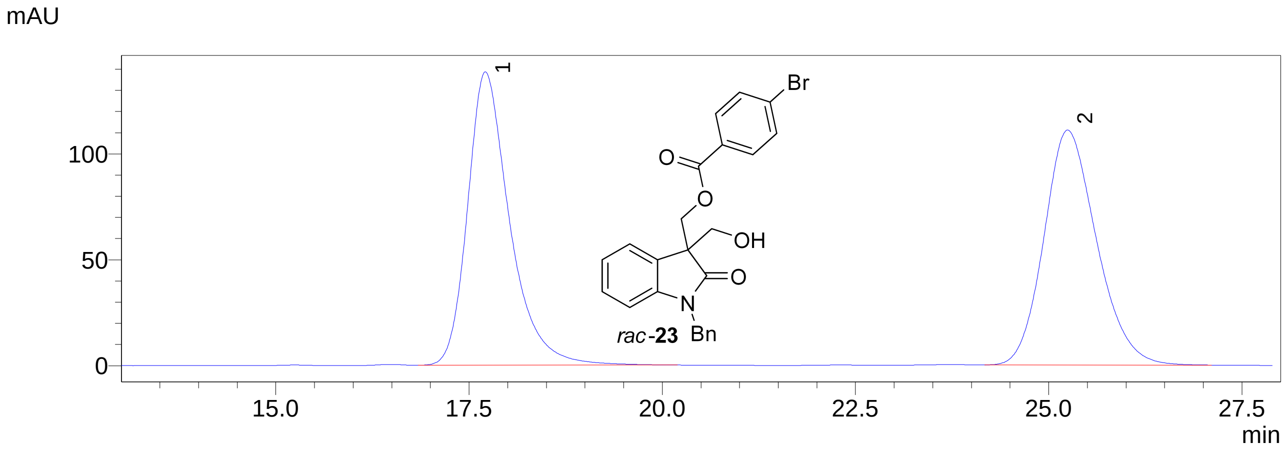
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.27	49.03
2	15.35	50.97
Total		100.00



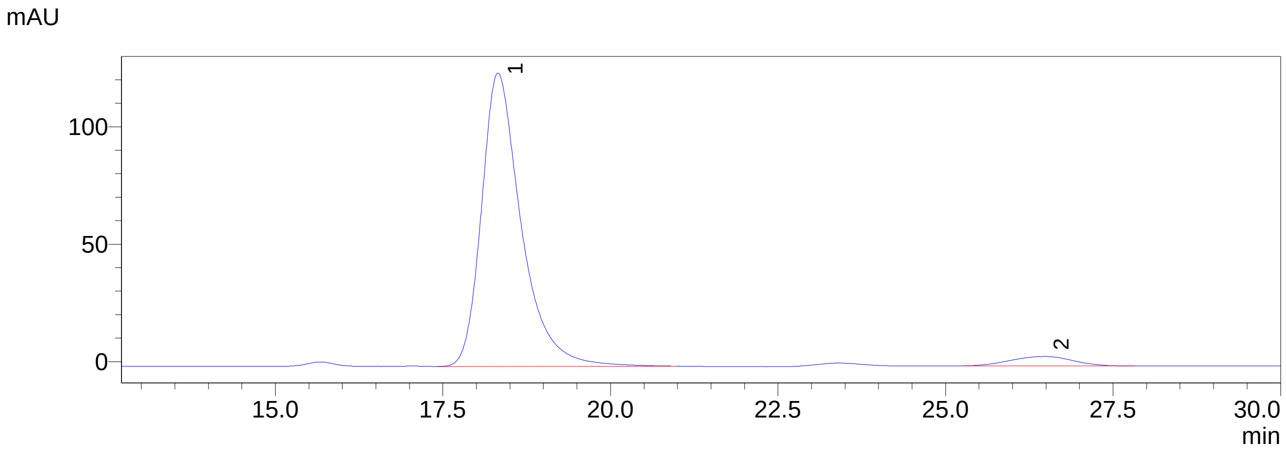
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.50	95.02
2	15.00	4.98
Total		100.00



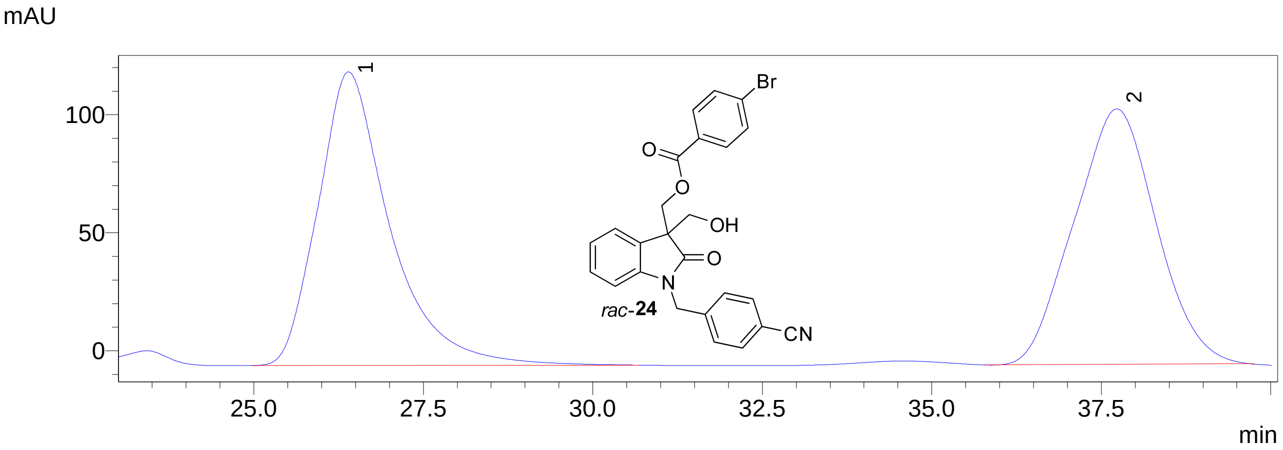
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.71	50.02
2	25.24	49.98
Total		100.00



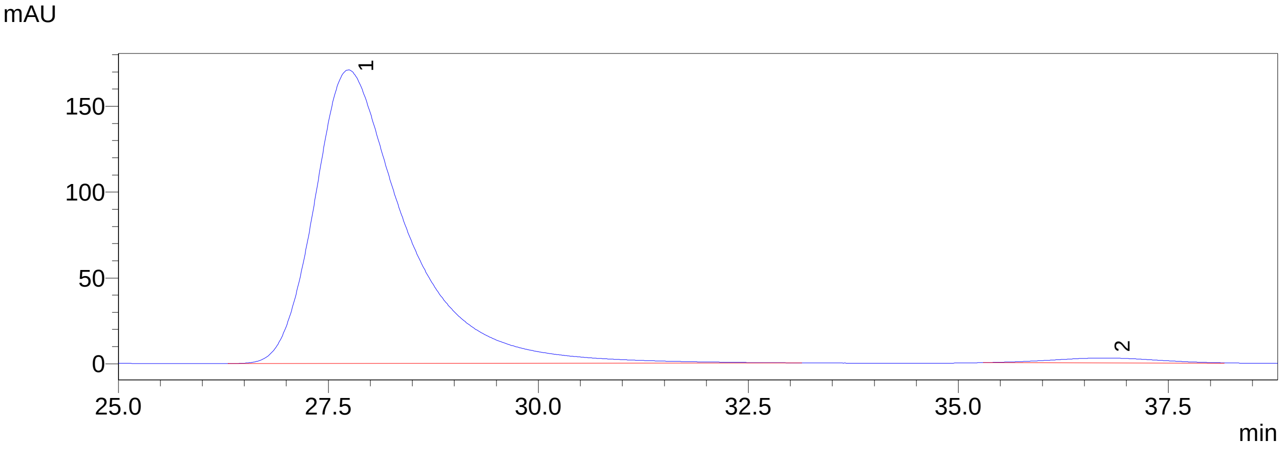
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	18.32	95.25
2	26.47	4.75
Total		100.00



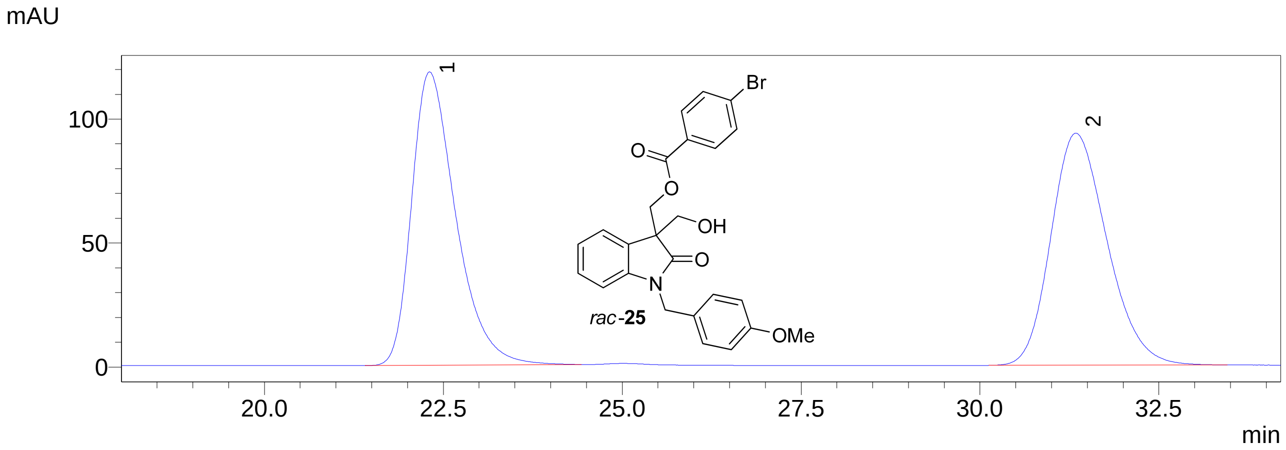
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	26.39	50.09
2	37.73	49.91
Total		100.00



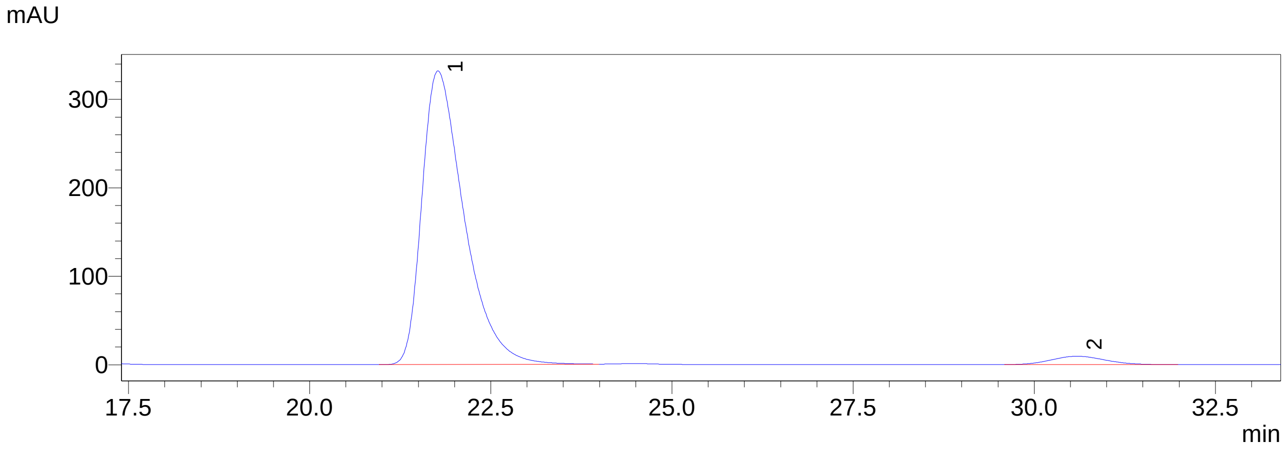
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	27.74	98.11
2	36.75	1.89
Total		100.00



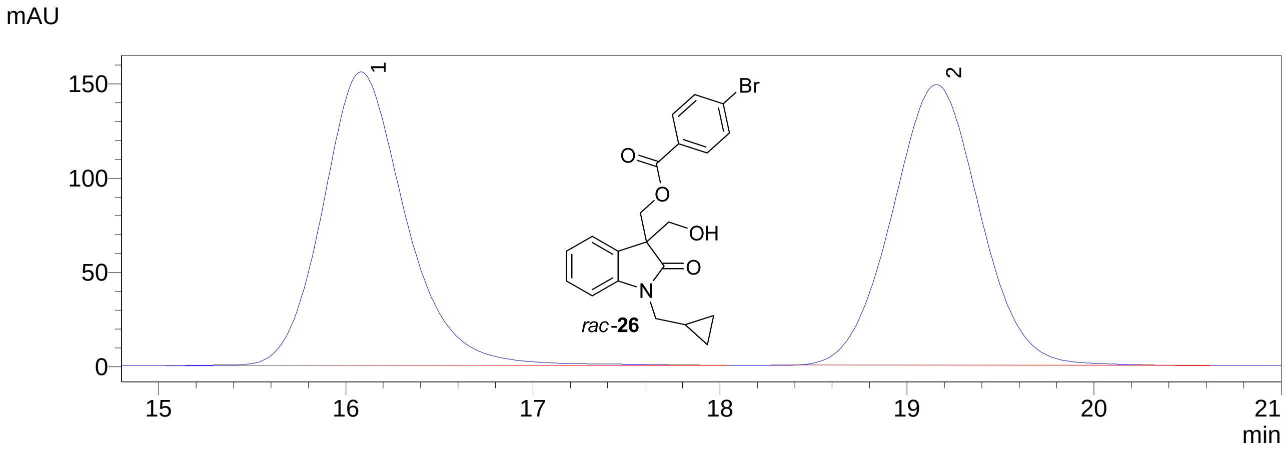
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	22.31	49.89
2	31.34	50.11
Total		100.00



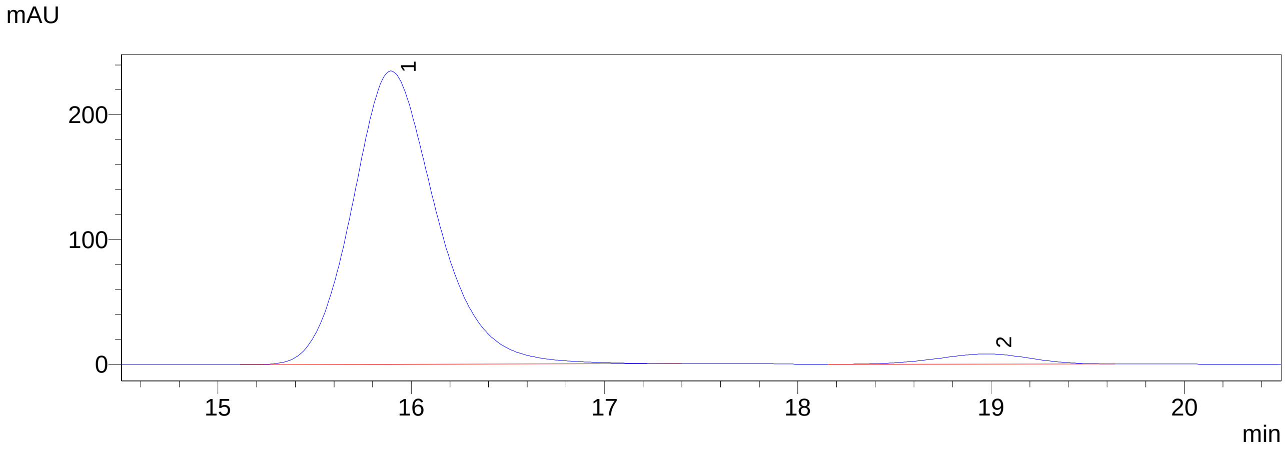
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	21.77	96.47
2	30.59	3.53
Total		100.00



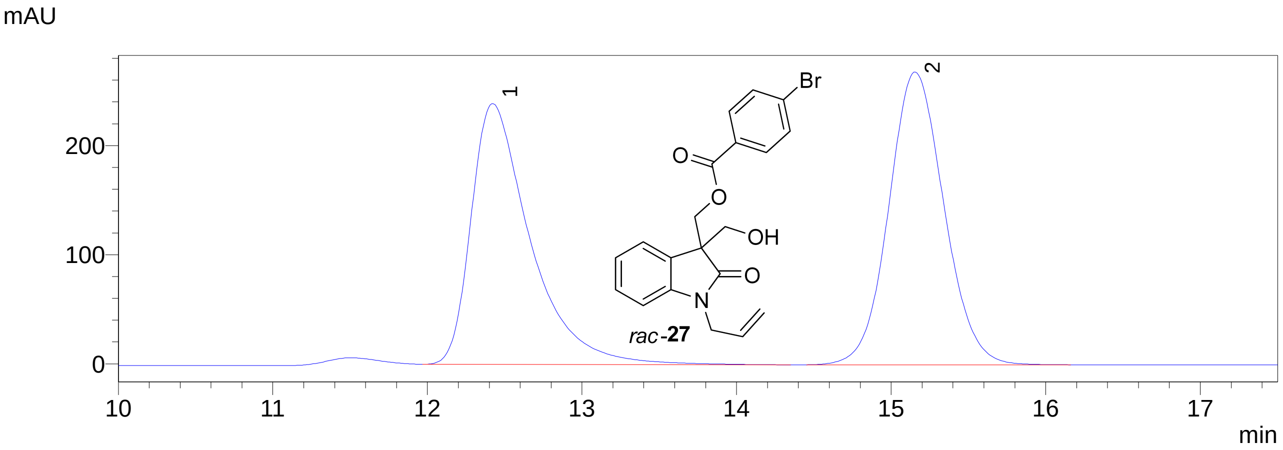
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	16.08	49.88
2	19.16	50.12
Total		100.00



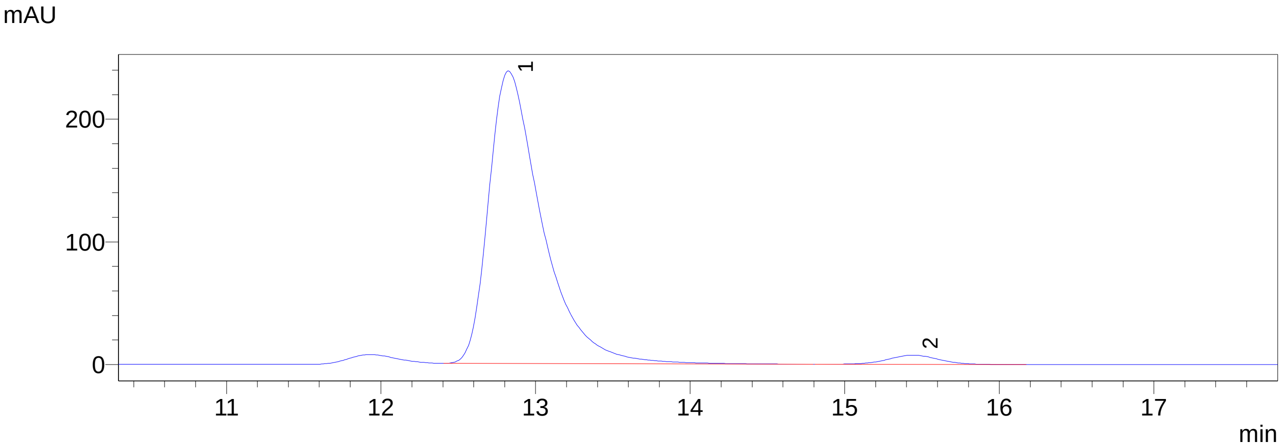
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.90	96.39
2	18.98	3.61
Total		100.00



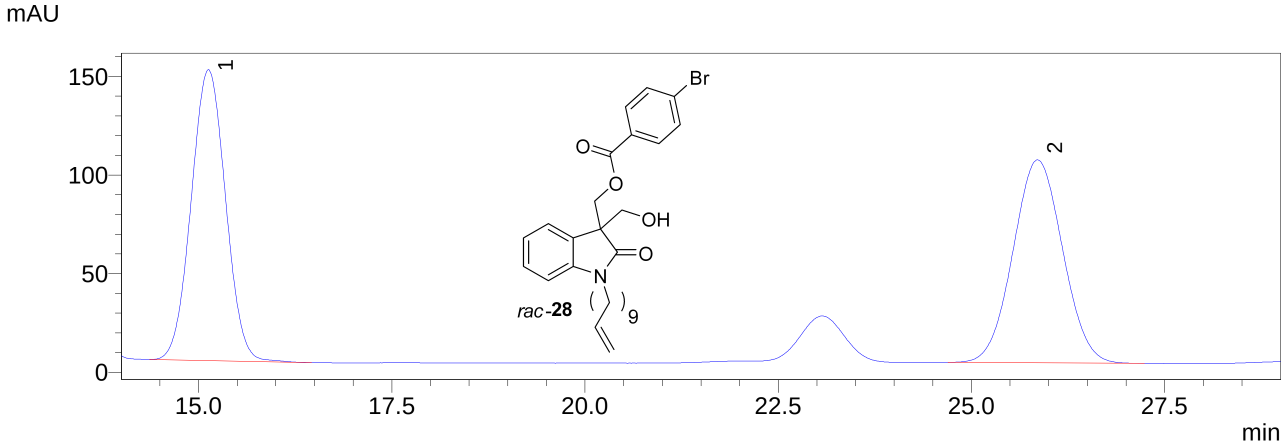
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	12.42	48.82
2	15.15	51.18
Total		100.00



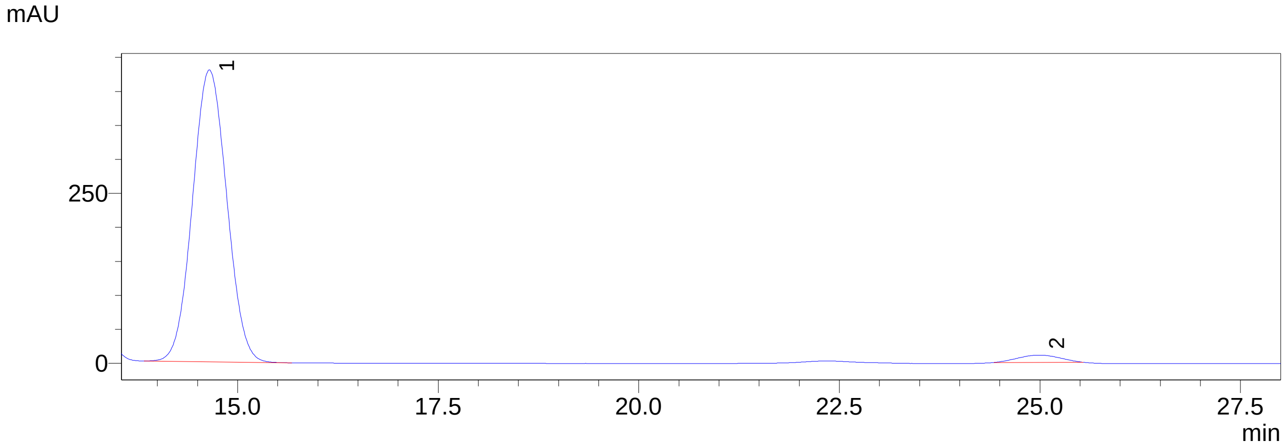
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	12.82	97.07
2	15.44	2.93
Total		100.00



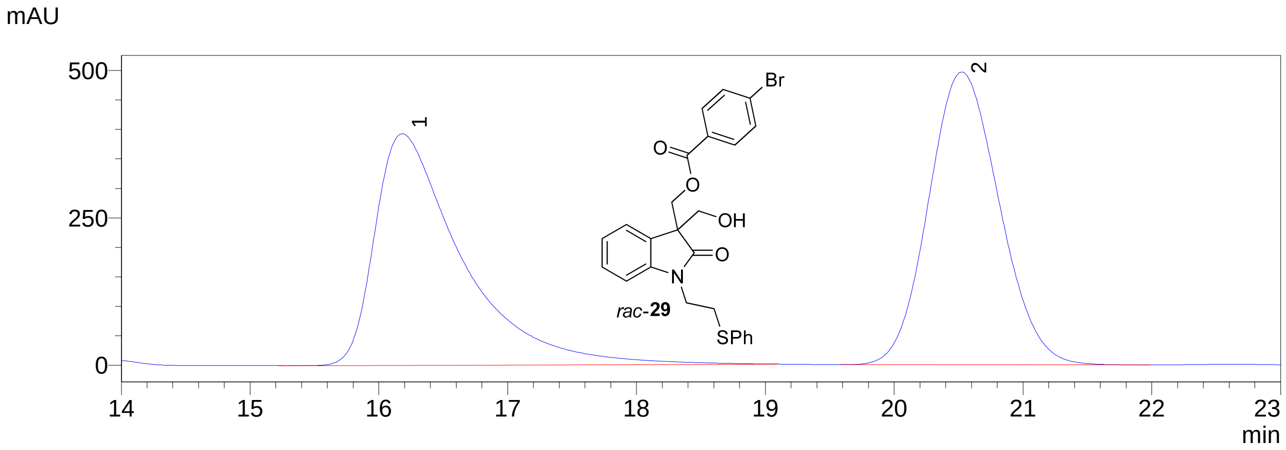
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.13	49.85
2	25.86	50.15
Total		100.00



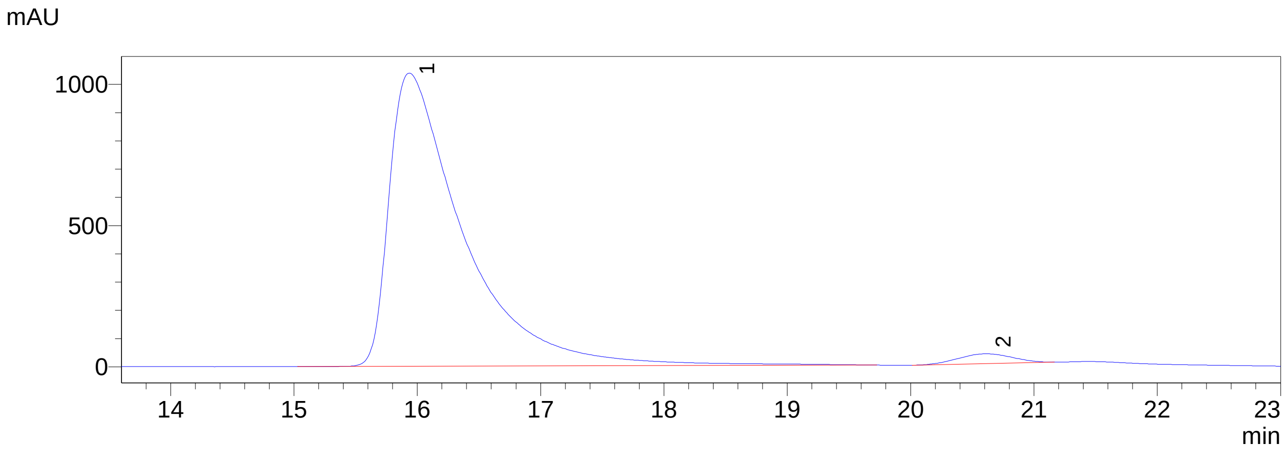
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.65	96.95
2	24.99	3.05
Total		100.00



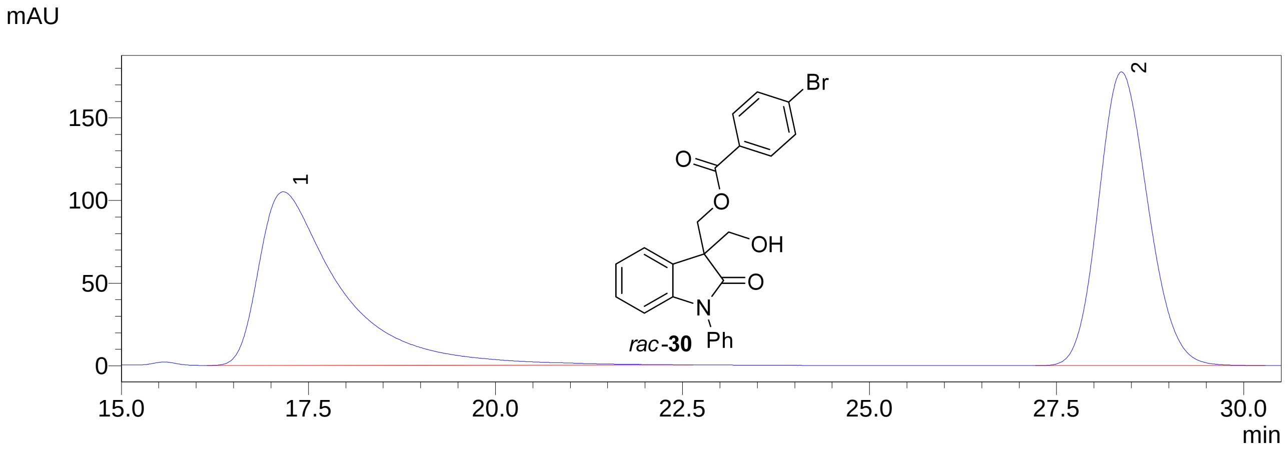
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	16.18	49.43
2	20.52	50.57
Total		100.00



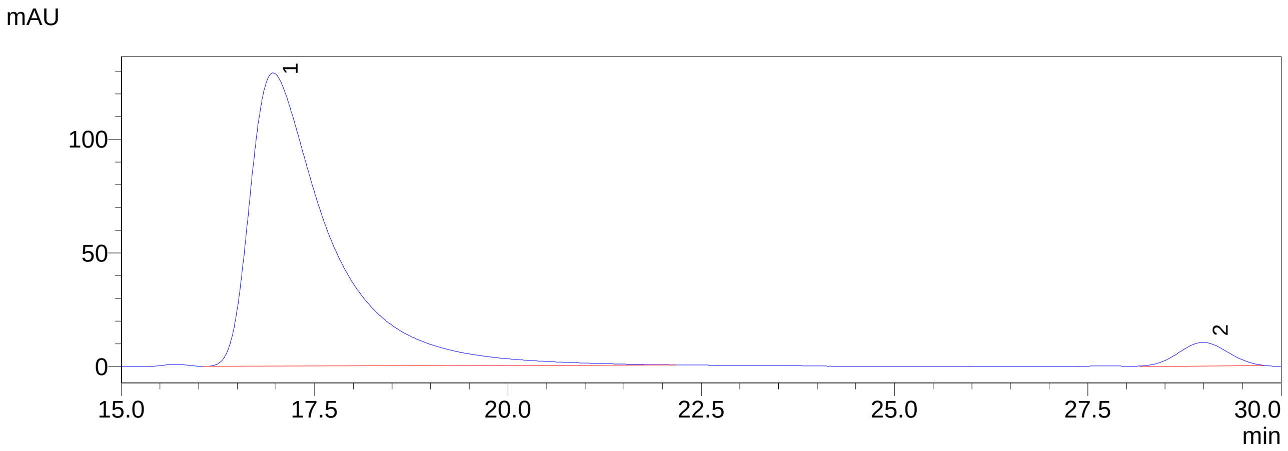
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.94	97.60
2	20.61	2.40
Total		100.00



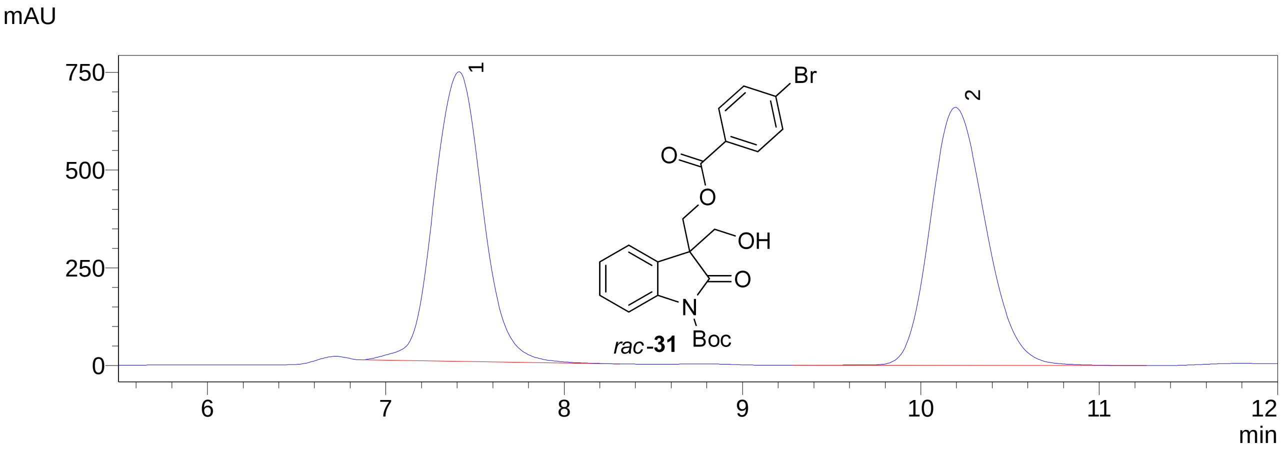
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	17.16	49.30
2	28.37	50.70
Total		100.00



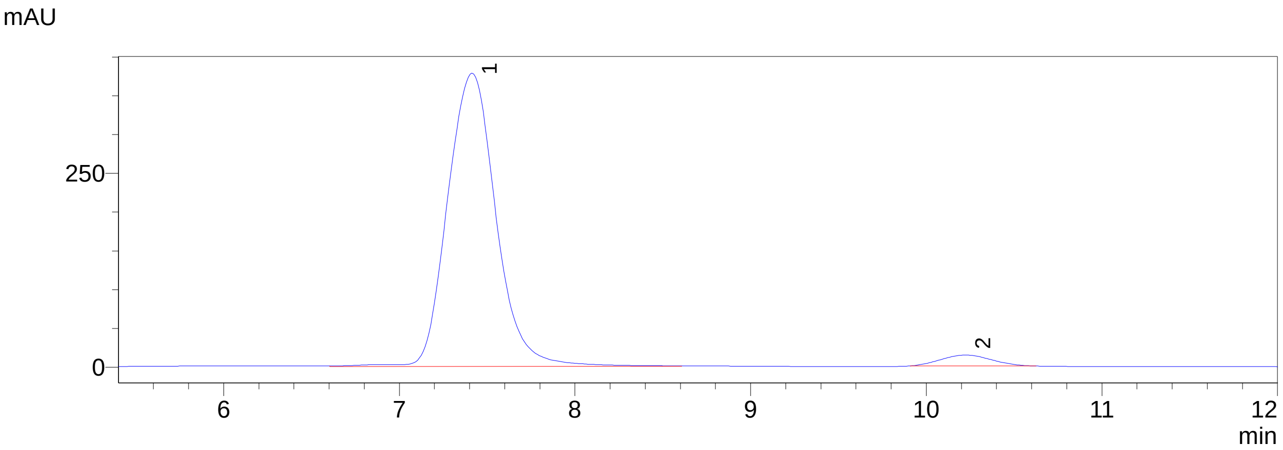
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	16.96	95.25
2	28.99	4.75
Total		100.00



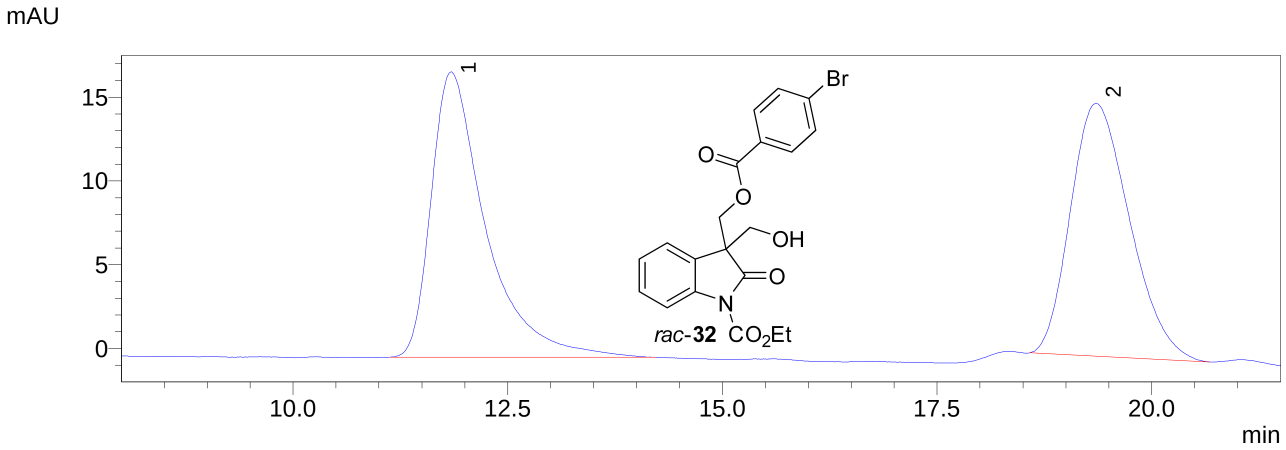
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	7.41	49.65
2	10.19	50.35
Total		100.00



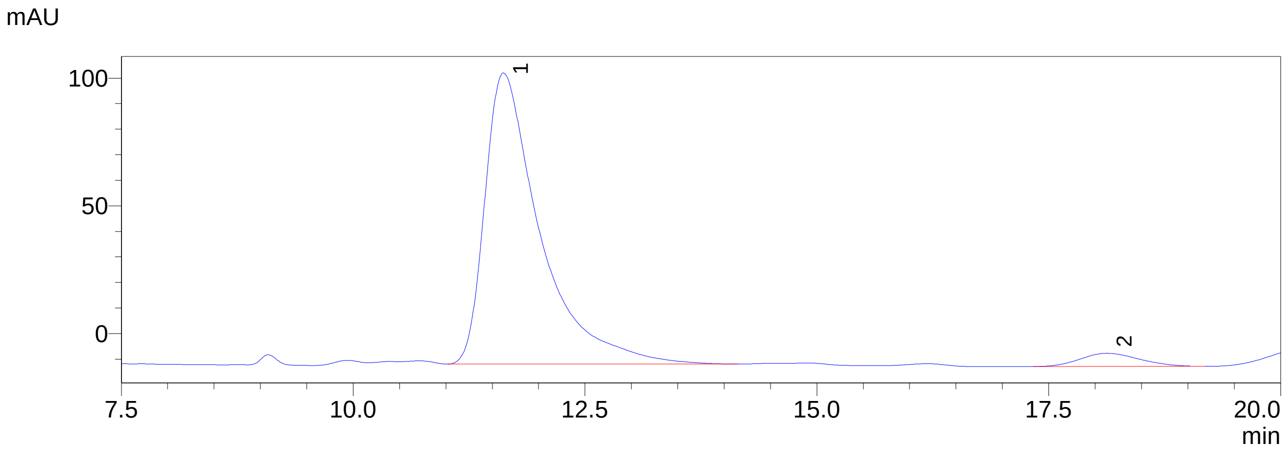
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	7.41	96.32
2	10.22	3.68
Total		100.00



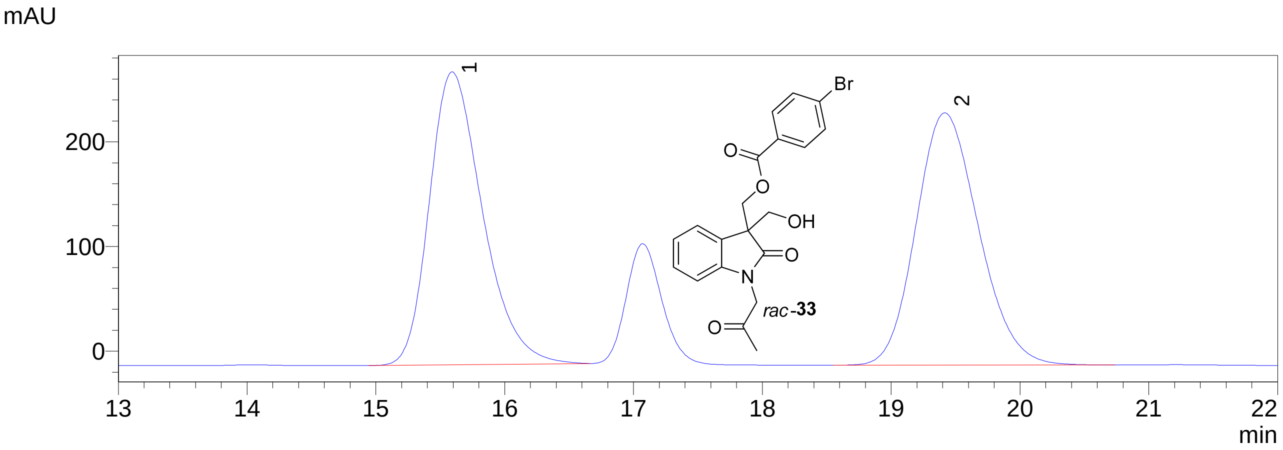
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.84	50.92
2	19.35	49.08
Total		100.00



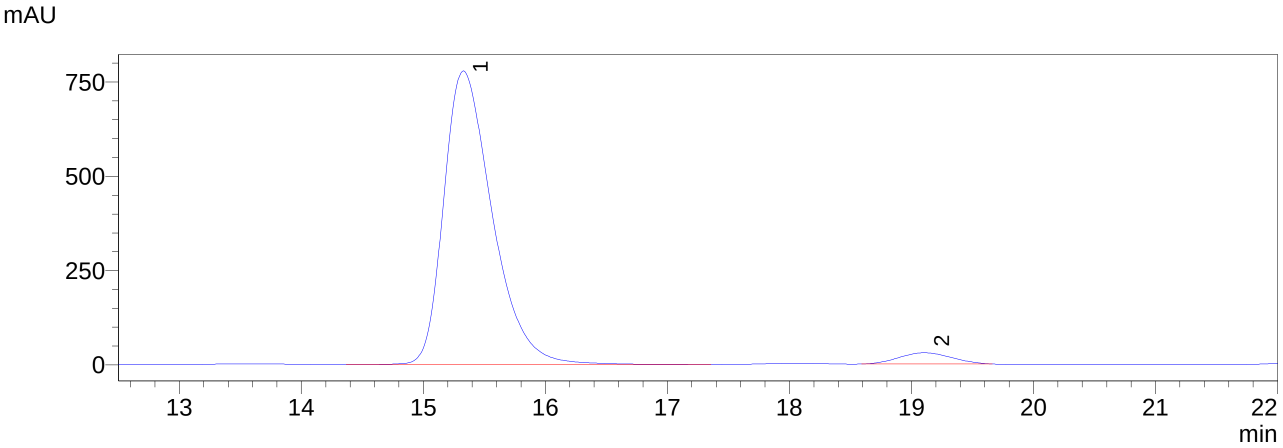
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.62	95.38
2	18.13	4.62
Total		100.00



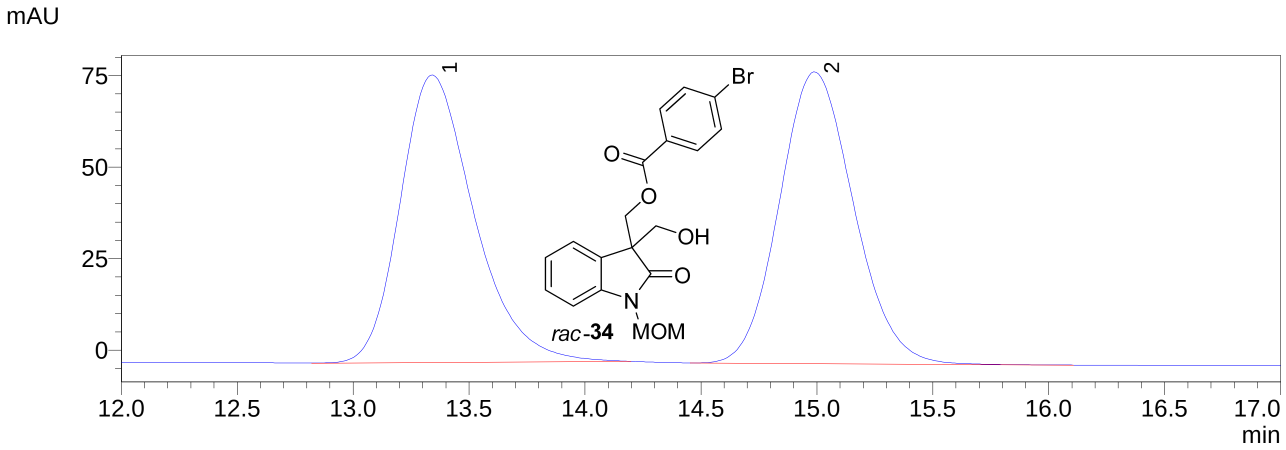
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.59	49.69
2	19.42	50.31
Total		100.00



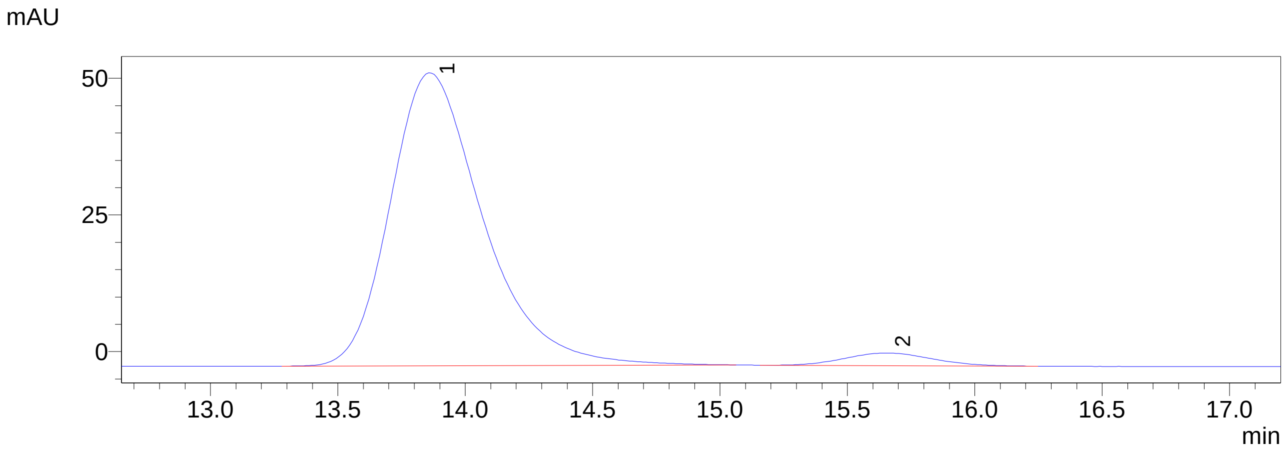
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	15.33	96.01
2	19.11	3.99
Total		100.00



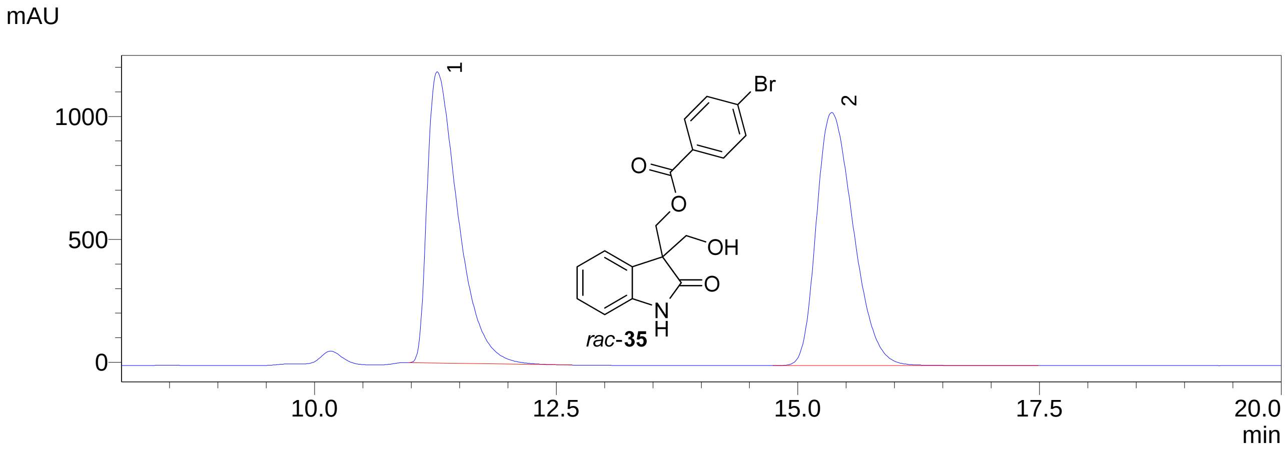
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.34	49.61
2	14.99	50.39
Total		100.00



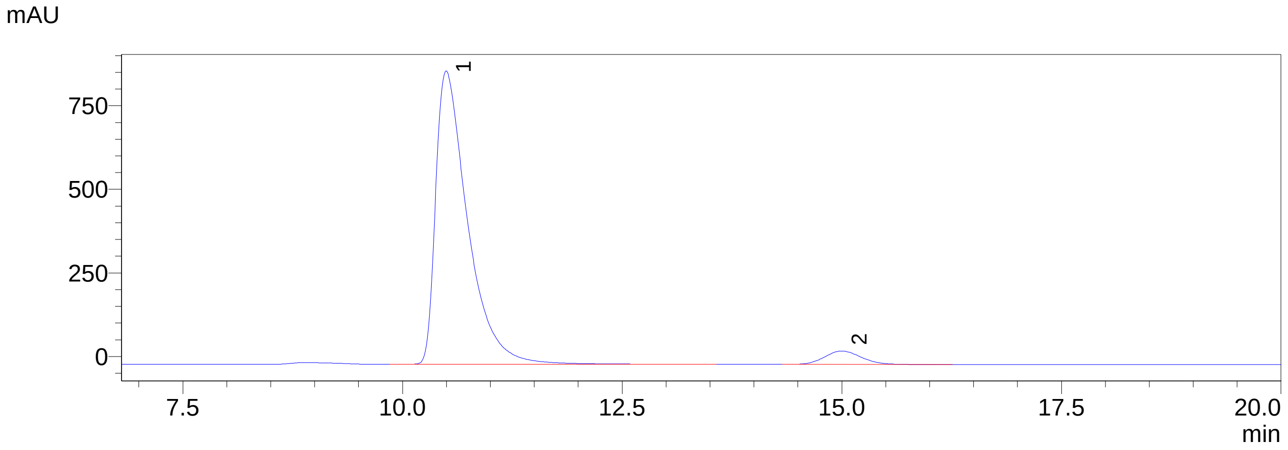
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.86	96.07
2	15.65	3.93
Total		100.00



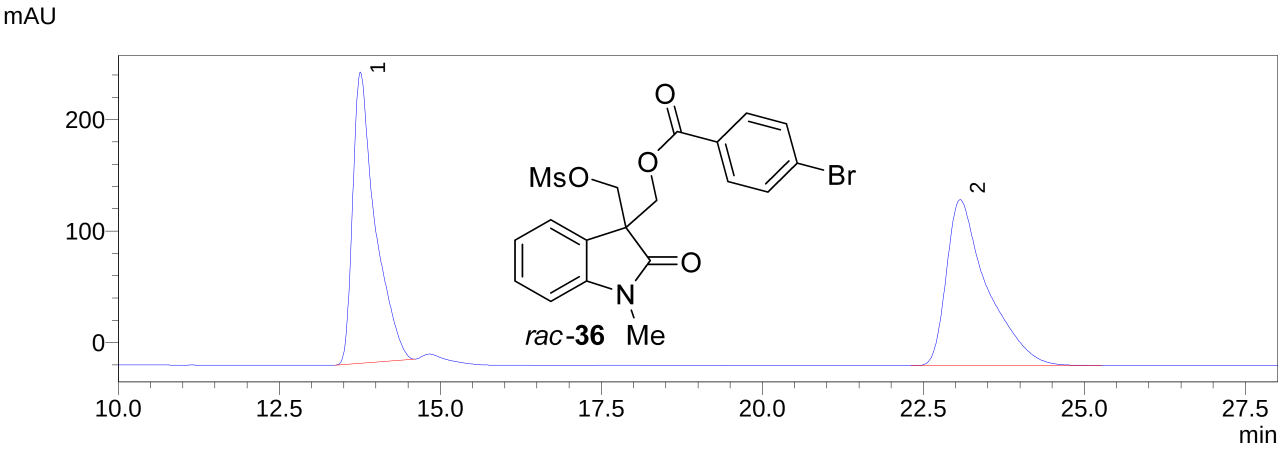
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.27	49.03
2	15.35	50.97
Total		100.00



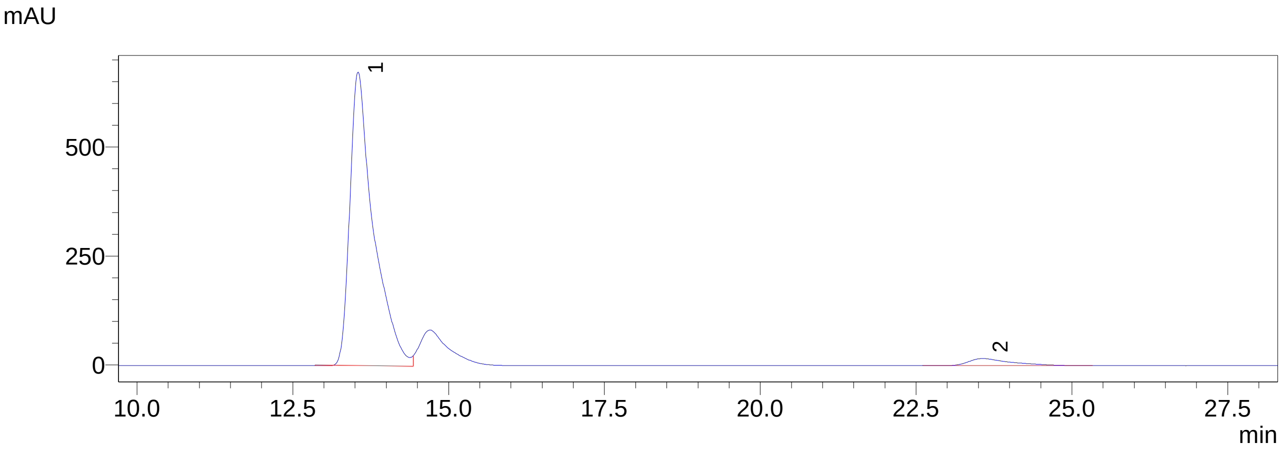
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.50	95.02
2	15.00	4.98
Total		100.00



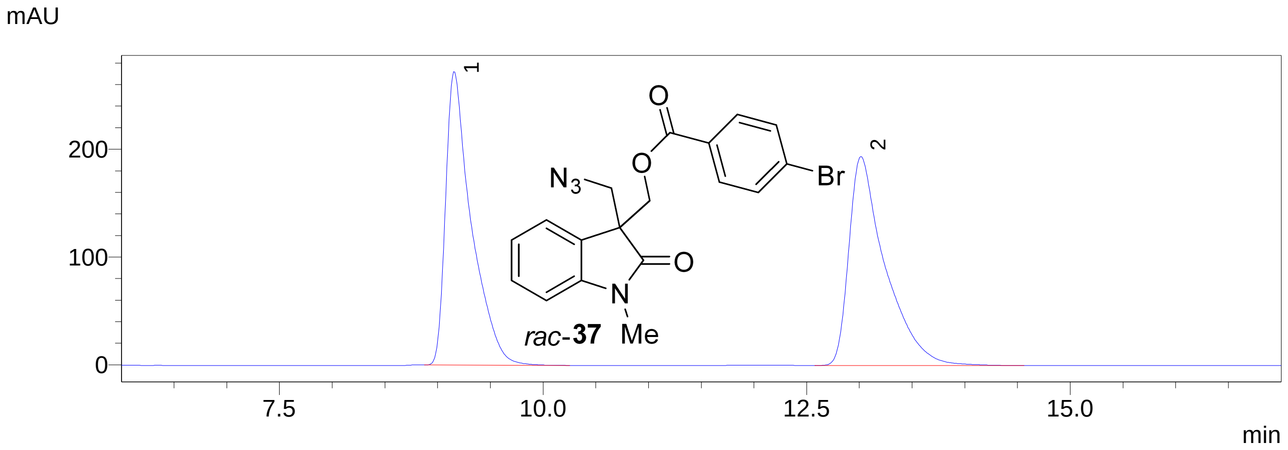
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.76	49.16
2	23.07	50.84
Total		100.00



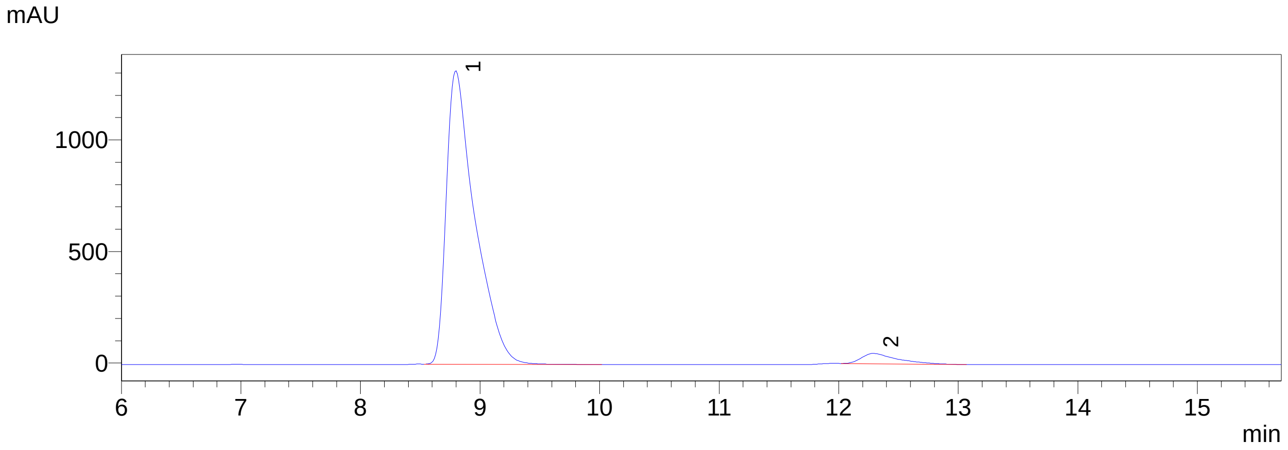
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	13.55	95.79
2	23.57	4.21
Total		100.00



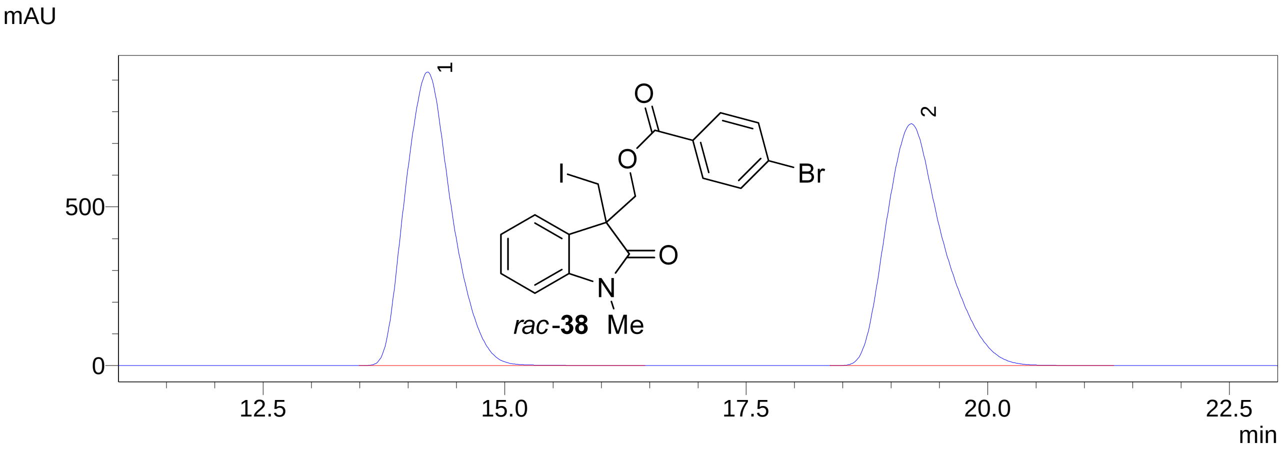
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	9.16	49.94
2	13.02	50.06
Total		100.00



PDA Ch1 254nm

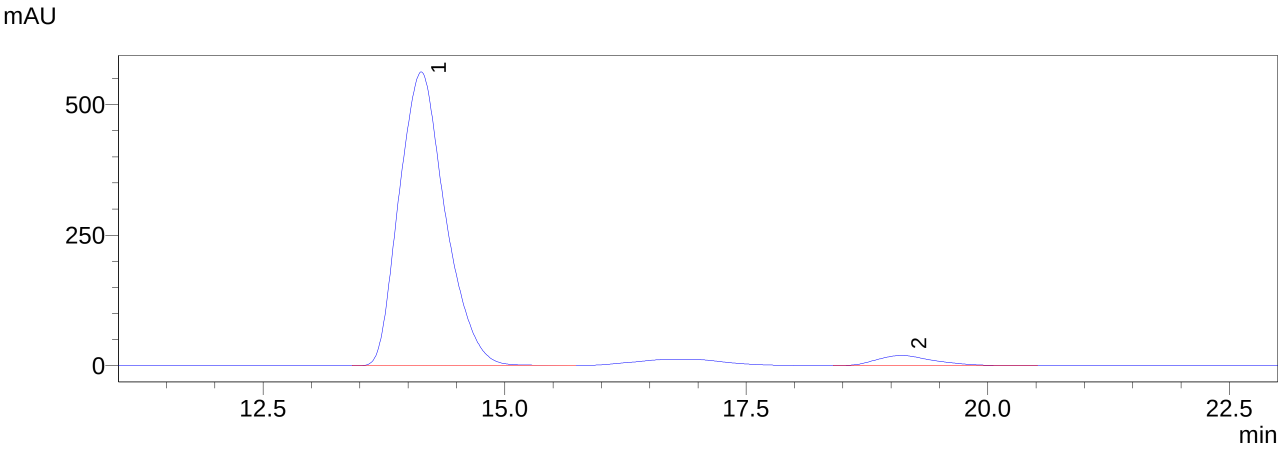
Peak#	Ret. Time	Area%
1	8.80	95.82
2	12.29	4.18
Total		100.00



rac-**38**

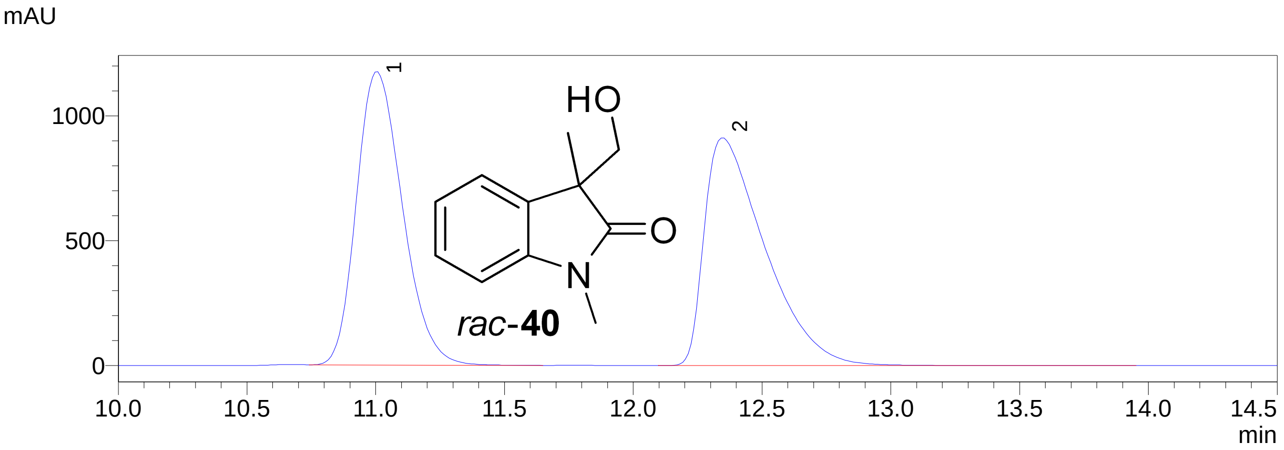
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	14.20	49.81
2	19.21	50.19
Total		100.00



PDA Ch1 254nm

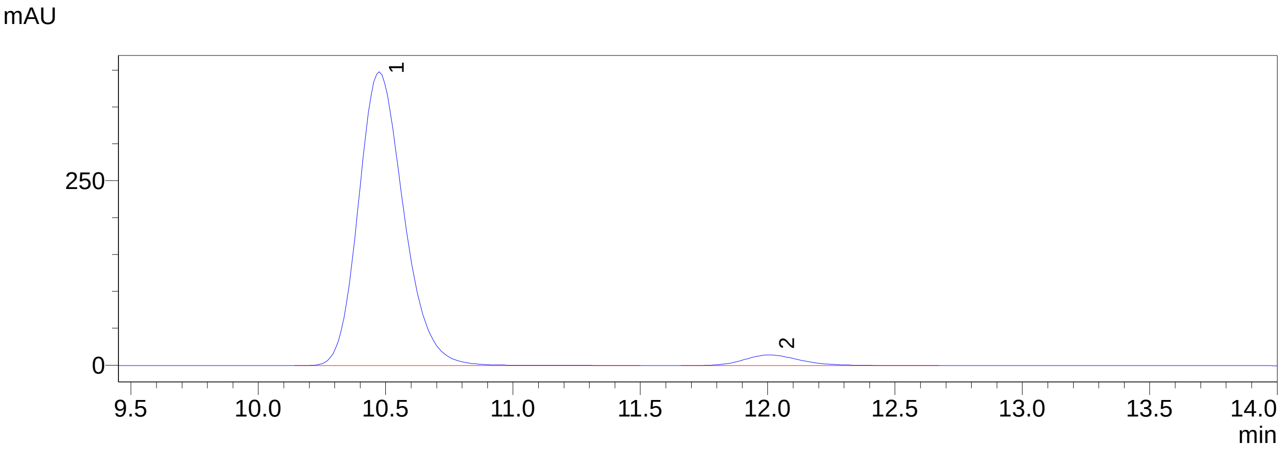
Peak#	Ret. Time	Area%
1	14.14	95.91
2	19.11	4.09
Total		100.00



rac-**40**

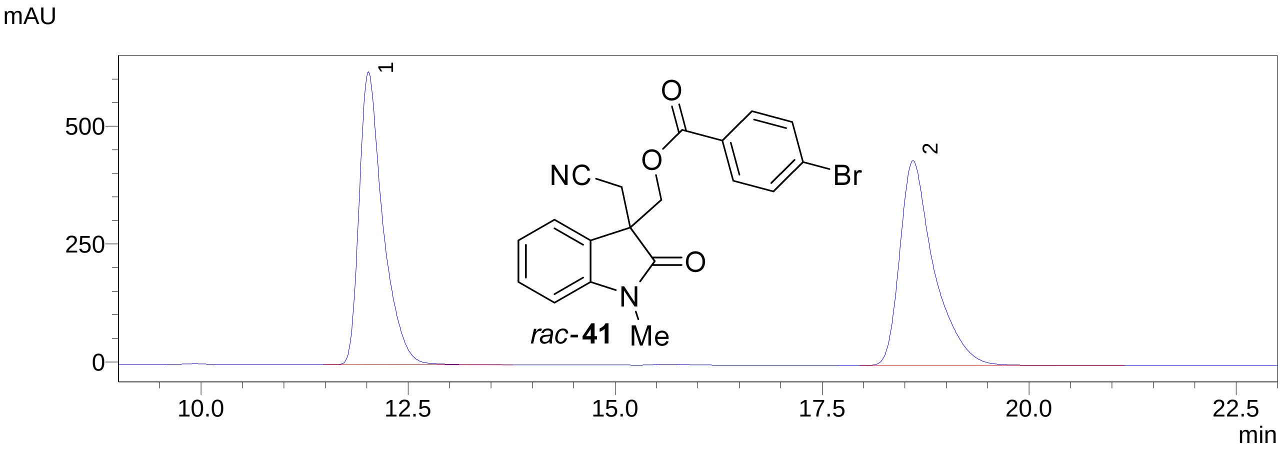
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.00	49.42
2	12.35	50.58
Total		100.00



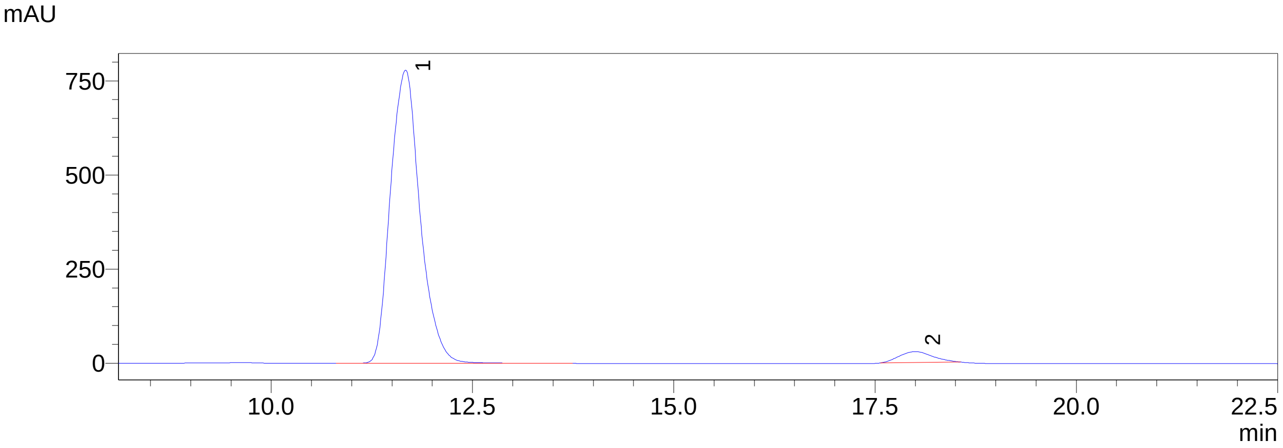
PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	10.47	95.72
2	12.01	4.28
Total		100.00



PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	12.02	49.79
2	18.60	50.21
Total		100.00



PDA Ch1 254nm

Peak#	Ret. Time	Area%
1	11.67	96.02
2	18.00	3.98
Total		100.00