Supporting Information

KOH-mediated Stereoselective Alkylation of 3-Bromooxindoles for the Synthesis of 3,3'-disubstituted oxindoles with two Contiguous all Carbon Quaternary Centre

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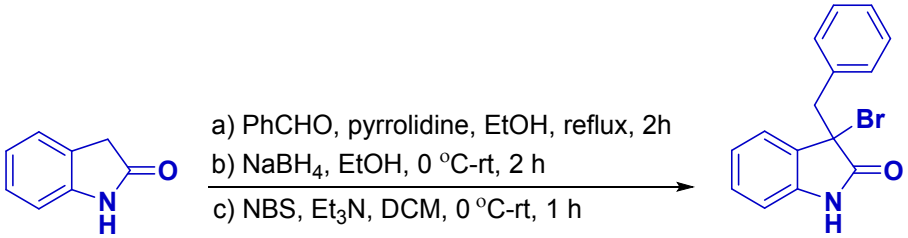
1. General considerations

Unless otherwise noted, all the reactions were performed in flame or oven-dried glassware under a dry nitrogen atmosphere using dry solvents. The Bruker AV-300 NMR spectrometer was used to record NMR spectra in deuterated solvents using their residual solvent proton signal as an internal reference. ^{1}H NMR data are reported as follows: chemical shift (δ, ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet), integration, coupling constant (Hz). ^{13}C NMR data are recorded in terms of chemical shift (δ, ppm). The IR spectrums were recorded using FT-IR spectrometer, and values were reported in cm^{-1}. The mass spectrum of compounds was recorded using a micrOTOF-Q mass spectrometer. Compounds were purified by column chromatography using silica gel (100–200 mesh) and EtOAc:hexane as eluent. The diastereomeric ratio was determined using ^{1}H NMR of the crude reaction mixture.

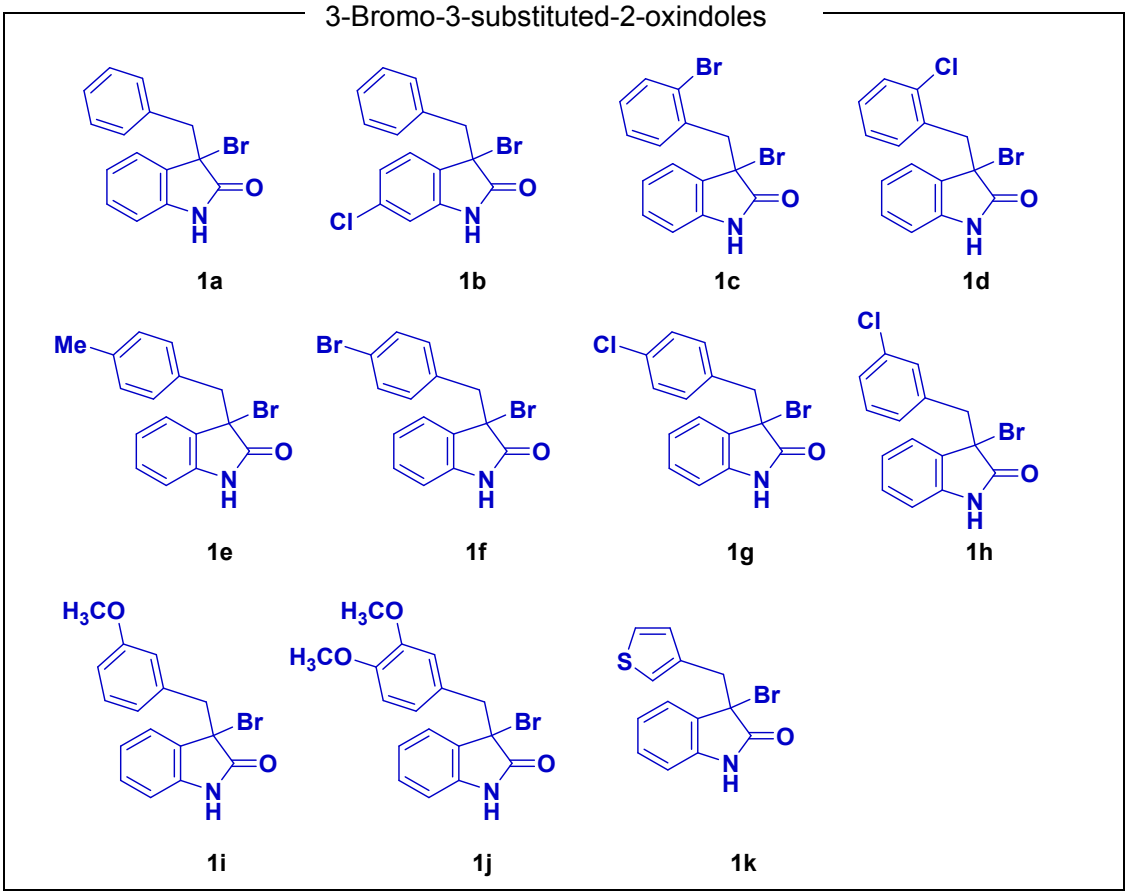
2.1. General procedure for the preparation of starting materials:

2.2. General procedure for the synthesis of 3-Bromo-3-substituted-2-oxindoles

3-Bromo-3-substituted-2-oxindoles **1a-1k** were prepared by following the modified reported literature procedure.[1]

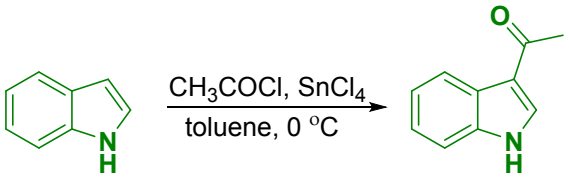


A mixture of indoline-2-one (0.665 g, 5 mmol), benzaldehyde (0.530 g, 5 mmol) and pyrrolidine (0.05 mL) in ethanol (15 mL) was refluxed for 2 hours. Then mixture was cooled to 0 °C, sodium hydroborate (0.95 g, 25 mmol) was added in batches. The reaction mixture was then further stirred for 2 hours at room temperature and then quenched by water. Extracted by dichloromethane, the organic phase was dried over anhydrous Na_2SO_4 and evaporated on vacuum. The residue was then dissolved in dichloromethane (20 mL), followed by triethylamine (0.15 mL) was added. After cooling to 0 °C, N-bromosuccinimide (0.885 g, 5 mmol) was added in portions over 30 minutes. The reaction mixture was then warmed to room temperature and stirred further for 1 hour. After concentrated on vacuum, the residue was purified by column chromatography (petroleum ether / ethyl acetate 9:1) on silica gel to afford 3-benzyl-3-bromoindolin-2-one (**1a**) as a light yellow solid. Other 3-Bromo-3-substituted-2-oxindoles were synthesized similarly.

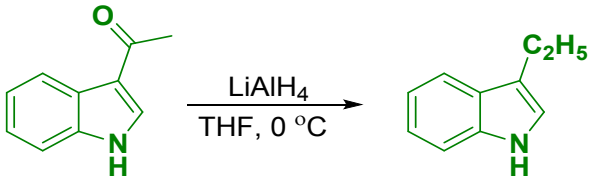


2.3. General procedure for the synthesis of indoles

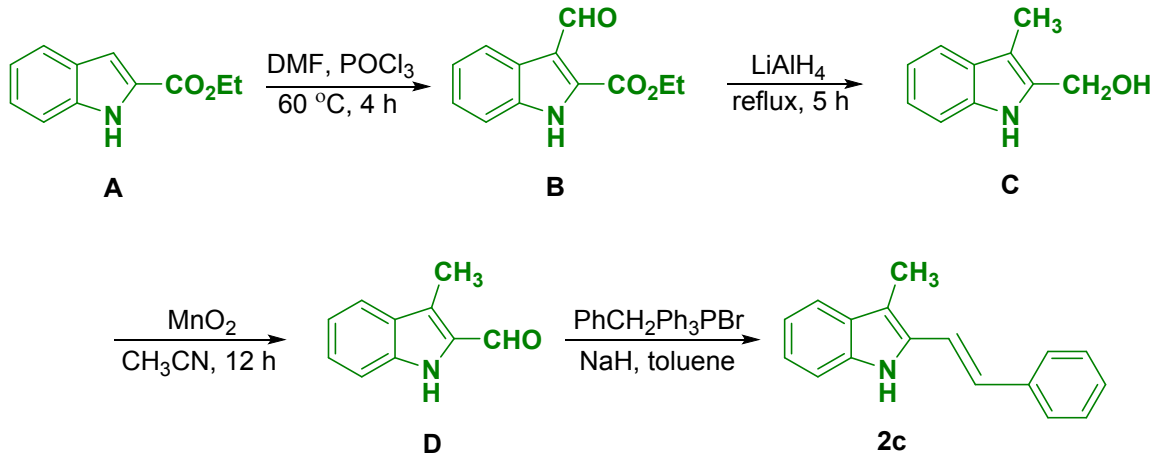
Indole **2a** was purchased from Sigma-Aldrich and was used without further purification. Other Indoles were prepared according to the modified reported literature methods.[2,3,4,5]



To a stirred solution of 1*H*-indol (0.590 g, 5 mmol) in 50 mL of anhydrous toluene at 0 °C was added acetyl chloride (0.7 mL, 10 mmol). After stirring it for 15 min at 0 °C, a solution of $SnCl_4$ (1.20 mL) in 22 mL of anhydrous toluene was then added. The resulting reaction mixture was stirred for 2 h at 0 °C and then 75 ml of 8% sodium hydrogen carbonate was added dropwise. The resulting slurry was diluted with ethyl acetate, dried over Na_2SO_4, and filtered. The solvent was removed under reduced pressure. The residue was then purified by column chromatography to get desired product.



In an oven-dried flask, 3-acetyl-1*H*-indole (6.3 mmol, 1.0 g) was added to a suspension of $LiAlH_4$ (16.8 mmol, 0.65 g) in THF solvent (70 mL) at 0 °C under N_2 atmospheric condition. The reaction mixture was then allowed to warm at room temperature and stirred for 4 hours. The reaction was cooled at 0 °C, and H_2O was added dropwise, followed by NaOH 10% (0.65 mL) and stirred the resulting solution vigorously for 30 minutes. The resulting slurry was diluted with ethyl acetate, dried over anhydrous Na2SO4. And the white precipitate was filtered, washed with ethyl acetate and the solvent was evaporated under reduced pressure to afford the crude product, which was then further purified by column chromatography to give the desired product (**2b**).



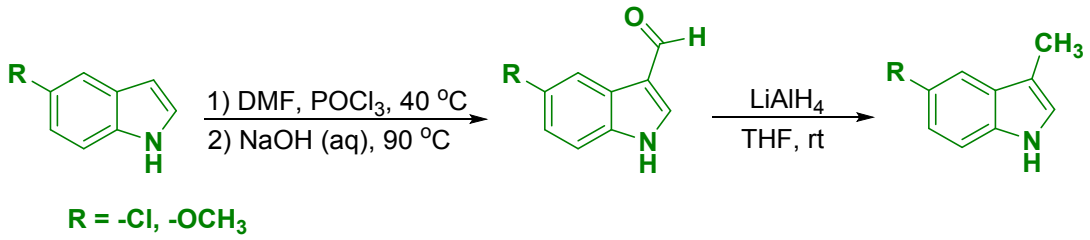
A to **B**: Under Nitrogen atmosphere, 5.4 mL anhydrous DMF (70 mmol) was added to a oven dried flask and cooled to 0 °C. Then, 2 mL $POCl_3$ (22 mmol) was added dropwise to the reaction mixture and stirred for 5 min at 0 °C. A solution of substrate **A** (20 mmol) was made in 8 mL anhydrous DMF and was added dropwise to the reaction mixture. Then, the reaction system was shifted at rt and stirred for 30 min and was warmed to 60 °C to react for further 4 h. After completion of the reaction, an aqueous solution of NaOH (2 M) was added to the reaction system at 0 °C and adjusted the pH to 7. Subsequently, a substantial amount of water was added to the reaction system and stirred for 5 min to produce a yellow solid (**B**), which was filtered and put to the next step.

B to **C**: Under N_2 atmosphere, compound **B** (10 mmol) was added to an oven dried flask and dissolved in THF (80 mL). Then, $LiAlH_4$ (50 mmol) was added to the reaction mixture in

portions at 0 °C and stirred for 10 min at rt, which was further put for reflux at 80 °C for 5 h. After stopping the reaction, aqueous solution of sodium hydroxide (1 M) was added to the reaction system at 0 °C and adjusted the pH to 7. Subsequently, the reaction mixture was extracted by ethyl acetate and evaporated under reduced pressure. Further purification was done by column chromatography to afford compound **C**.

C to **D**: To a stirring solution of compound **C** (10 mmol) in CH_3CN (80 mL), MnO_2 (60 mmol) was added in portions and then reacted at rt for 15 h, after completion of the reaction (determined by TLC). Then, the reaction mixture was filtered and evaporated under reduced pressure. Further purification was done by column chromatography to get compound **D**.

D to substrate **2c**: $PhCH_2Ph_3PBr$ (1.92 mmol) was dissolved in 6 mL anhydrous toluene in an oven dried flask under N_2 atmosphere. Then, sodium hydride (3.2 mmol) was added to the reaction mixture at 0 °C and stirred for 20 min at rt. Thereafter, the solution of compound **D** (1.6 mmol) in anhydrous toluene (6 mL) was added dropwise to the reaction mixture, which was reacted at 80 °C for 2 h. After completion of the reaction, saturated aqueous solution of NH_4Cl was added to the reaction system, which was extracted by ethyl acetate. The resulting solution was dried over anhydrous Na_2SO_4 and purified by column chromatography to afford substrate **2c.**

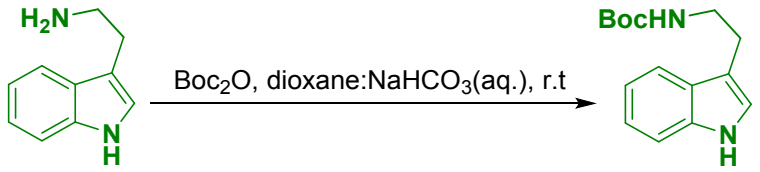


R = -Cl, -OCH_3

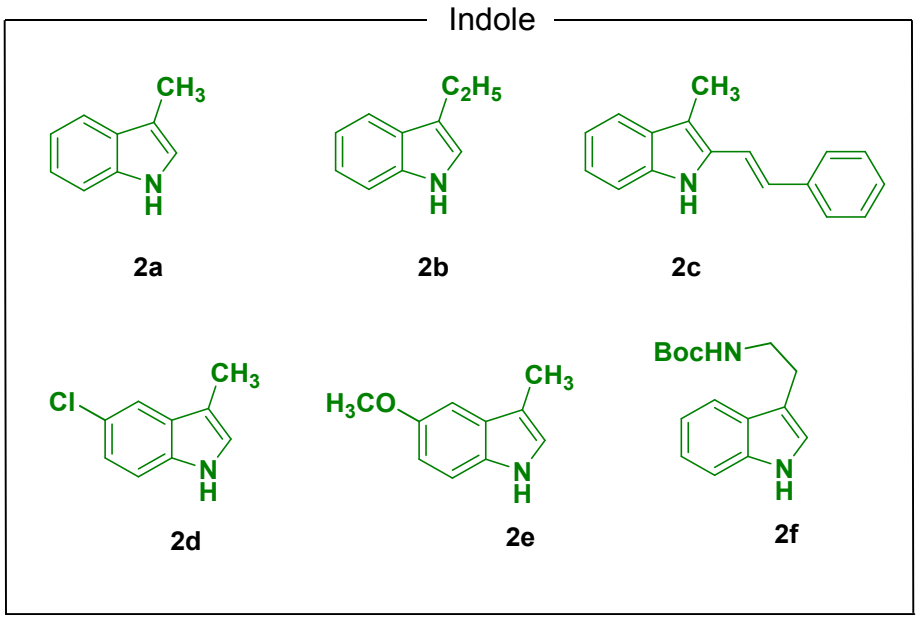
In an oven-dried flask, indole (5 mmol) and DMF (25 mmol) was stirred at 0 °C, followed by dropwise addition of $POCl_3$ (6 mmol) over a period of 30 min. The reaction mixture was warmed to 40°C and stirred for 2 h. Then, 2M aqueous solution of sodium hydroxide aqueous (30 mL) was added and the mixture was further heated at 90 °C for 1 h. The resulting solid was dissolved in ethyl acetate (15 mL) and then extraction was done with ethyl acetate. The organic layer was dried over anhydrous sodium sulphate and evaporated *in vacuo*. The corresponding aldehyde was directly utilised in the next step without purification.

The solution of the 1*H*-indole-3-carbaldehyde in THF (20 mL) was added dropwise in 15 min to a previously cooled solution of $LiAlH_4$ (7.5 mmol) in THF (20 mL) at 0 °C followed by overnight stirring at room temperature. Thereafter, water (0.5 mL) was added on the

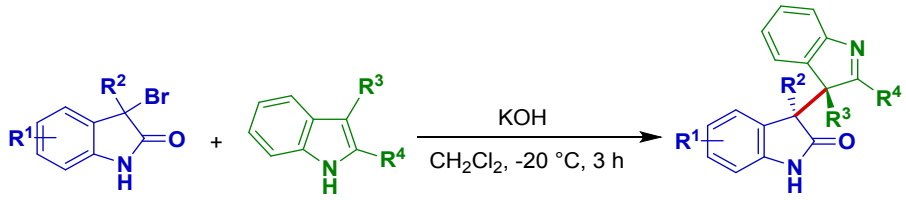
completion of reaction followed by sodium hydroxide (750 mg) and water (1.5 mL). Then, the reaction mixture was stirred for 15 min, and the solid obtained was filtered and was washed with ethyl acetate. The combined organic layer was dried over sodium sulphate and evaporated under reduced pressure. Further purification was done by flash chromatography to obtain the corresponding indoles **2d** and **2e**.



Boc_2O (1.02 g, 4.68 mmol) was added to a stirred solution of tryptamine (0.5 g, 3.12 mmol) in 1,4-dioxane/sodium bicarbonate (sat. aq.) (2:1, 9 mL) at room temperature. After stirring the reaction mixture for 2 h, H_2O (5 mL) was added to it. Then resulting reaction mixture was extracted with ethyl acetate, the combined organic phase was dried over anhydrous sodium sulphate and concentrated *in vacuo*. Then further purification was done by flash column chromatography to afford *N*-Boc-tryptamine **2f**.



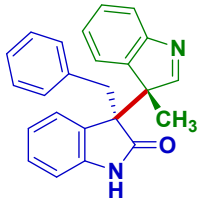
2.4. General procedure for stereoselective alkylation of 3-bromooxindoles with Indoles



1 2 3

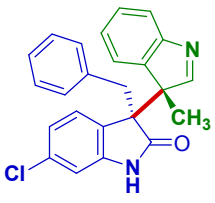
To a solution of substituted indole **2** (0.24 mmol, 1.2 equiv) in 1 mL CH_2Cl_2, KOH (0.4 mmol, 2 equiv) was added at -20 °C and was stirred for five minutes. A solution of 3-substituted-3-bromooxindole **1** (0.2 mmol, 1 equiv) in 1 mL CH_2Cl_2 was then added slowly to the previously stirred solution over a period of ten minutes. The resultant solution was then stirred until TLC showed complete consumption of the 3-bromooxindole compound **1**. After completion of the reaction, the reaction mixture was passed through celite and subsequently washed with CH_2Cl_2. Then distereomeric ratio was determined by ^{1}H NMR. The filtrate was then concentrated under reduced pressure and further purification was done by column chromatography to isolate the pure major alkylated adduct **3**.

3-Benzyl-3'-methyl-3,3'-biindolin-2-one **(3a):** light-yellow sticky solid (55 mg, 76% yield, *anti/syn* = 97:3), $\mathbf{R}_f$ = 0.16 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3a)** (500 MHz, $CDCl_3$) δ 8.20 (s, 1H), 7.79 (s, 1H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.37 (t, *J* = 8.0 Hz, 1H), 7.25 – 7.14 (m, 2H), 7.09 (t, *J* = 7.4 Hz, 1H), 7.00 – 6.93 (m, 3H), 6.88 (t, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 7.0 Hz, 3H), 6.55 (d, *J* = 7.7 Hz, 1H), 3.52 (d, *J* = 12.8 Hz, 1H), 3.27 (d, *J* = 12.8 Hz, 1H), 1.61 (s, 3H); **^{13}C NMR** (*anti* **3a)** (126 MHz, $CDCl_3$) *δ* 178.19, 175.79, 155.41, 141.06, 140.82, 135.09, 130.28, 128.79, 128.75, 128.61, 127.78, 126.65, 126.30, 125.27, 123.78, 121.80, 121.66, 109.70, 61.20, 57.57, 38.47, 15.90; **FTIR** (KBr) cm^{-1}: 3205, 2926, 1712, 1619, 1471, 754, 700, 576 cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{24}H_{20}N_2NaO$ 375.1467; found 375.1482.



3a

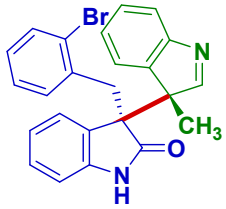
3-Benzyl-6-chloro-3'-methyl-3,3'-biindolin-2-on **(3b):** light yellow sticky solid (54 mg, 70% yield, *anti/syn* = 97:3), $\mathbf{R}_f$ = 0.3 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3b**) (500 MHz, $CDCl_3$) *δ* 8.11 (s, 1H), 7.80 (s, 1H), 7.57 (d, *J* = 7.7 Hz, 1H), 7.40 (t, *J* = 7.8 Hz, 1H), 7.32 – 7.24 (m, 2H), 7.05 – 6.97 (m, 3H), 6.80 (d, *J* = 7.2 Hz, 3H), 6.56 (dd, *J* = 12.7, 4.7 Hz, 2H), 3.57 (d, *J* = 12.8 Hz, 1H), 3.28 (d, *J* = 12.8 Hz, 1H), 1.64 (s, 3H); **^{13}C**



3b

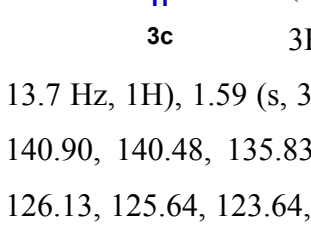
NMR (*anti* **3b**) (126 MHz, $CDCl_3$) δ 178.14, 175.41, 155.36, 142.01, 140.59, 134.67, 134.41, 130.24, 128.99, 127.99, 126.99, 126.88, 126.50, 125.92, 123.59, 121.85, 121.82, 110.29, 61.17, 57.09, 38.35, 15.56; FTIR (KBr) cm^{-1}: 3272, 2925, 1713, 1616, 1453, 701 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{24}H_{20}ClN_2O$ 387.1258; found 387.1258.

3-(2-Bromobenzyl)-3'-methyl-3,3'-biindolin-2-one **(3c):** white sticky solid (59 mg, 68% yield, *anti/syn* = 92:8), $\mathbf{R}_f$ = 0.24 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3c**) (500 MHz, $CDCl_3$) δ 8.46 (s, 1H), 8.20 (s, 1H), 7.52 (d, J = 7.7 Hz, 1H), 7.31 (t, J = 7.7 Hz, 1H), 7.28 – 7.22 (m, 1H), 7.20 – 6.97 (m, 4H), 6.92 (d, J = 7.5 Hz, 1H), 6.80 (ddd, J = 12.4, 11.9, 7.2 Hz, 3H), 6.59 (d, J = 7.7 Hz, 1H), 3.81 (d, J = 13.6 Hz, 1H), 3.61 (d, J = 13.7 Hz, 1H), 1.59 (s, 3H); **^{13}C NMR** (*anti* **3c**) (126 MHz, $CDCl_3$) δ 179.02, 175.47, 155.28, 140.90, 140.48, 135.83, 132.85, 130.02, 128.90, 128.79, 128.36, 127.91, 127.28, 126.31, 126.13, 125.64, 123.64, 121.71, 121.58, 109.58, 61.52, 57.77, 37.02, 16.08; **FTIR** (KBr) cm^{-1}: 3210, 2925, 1708, 1617, 1467, 747cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{24}H_{19}BrN_2NaO$ 453.0572; found 453.0592.



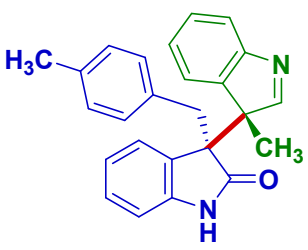
3c

3-(2-Chlorobenzyl)-3'-methyl-3,3'-biindolin-2-one **(3d):** light-yellow sticky solid (55 mg, 71% yield, *anti/syn* = 98:2), $\mathbf{R}_f$ = 0.23 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3d**) (500 MHz, $CDCl_3$) δ 8.59 (s, 1H), 8.23 (s, 1H), 7.54 (d, J = 7.7 Hz, 1H), 7.34 (t, J = 7.7 Hz, 1H), 7.17 (dd, J = 16.1, 9.3 Hz, 2H), 7.07 (t, J = 9.2 Hz, 2H), 6.98 (d, J = 7.3 Hz, 2H), 6.89 (t, J = 7.4 Hz, 1H), 6.81 (dd, J = 14.7, 7.3 Hz, 2H), 6.61 (d, J = 7.7 Hz, 1H), 3.83 (d, J = 13.5 Hz, 1H), 3.56 (d, J = 13.6 Hz, 1H), 1.61 (s, 3H); **^{13}C NMR** (*anti* **3d**) (126 MHz, $CDCl_3$) δ 178.55, 175.49, 155.32, 140.68, 140.53, 134.48, 134.04, 130.39, 129.49, 128.89, 128.81, 128.14, 127.86, 126.62, 126.35, 126.10, 123.59, 121.74, 121.65, 109.37, 61.54, 57.65, 34.28, 16.06; **FTIR** (KBr) cm^{-1}: 3285, 2928, 1700, 1619, 1473, 752 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for for $C_{24}H_{20}ClN_2O$ 387.1258; found 387.1266.



3d

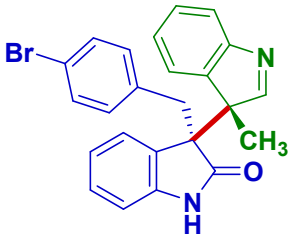
3'-Methyl-3-(4-methylbenzyl)-3,3'-biindolin-2-one **(3e):** light-yellow sticky solid (51 mg, 69% yield, *anti/syn* = 97:3), $\mathbf{R}_f$ = 0.25 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3e**) (500 MHz, $CDCl_3$) δ 8.19 (s, 1H), 7.91 (s, 1H), 7.54 (d, J= 7.7 Hz, 1H), 7.39 – 7.33 (m, 1H), 7.25 – 7.16 (m, 2H), 7.09 (t, J = 7.2 Hz, 1H), 6.87 (t, J = 7.6 Hz, 1H), 6.82 – 6.79 (m, 1H), 6.77 – 6.74 (m, 2H), 6.69 (d, J = 8.0 Hz, 2H), 6.54 (d, J = 7.7 Hz, 1H), 3.48 (d, J = 12.9 Hz, 1H), 3.24



3e

(d, *J* = 12.8 Hz, 1H), 2.11 (s, 3H), 1.60 (s, 3H); **^{13}C NMR** (*anti* **3e**) (126 MHz, $CDCl_3$) *δ* 178.35, 175.89, 155.32, 141.17, 140.82, 136.07, 131.92, 130.11, 128.74, 128.70, 128.51, 126.25, 125.17, 123.75, 121.72, 121.58, 109.79, 61.17, 57.61, 37.97, 21.03, 15.88; **FTIR** (KBr) cm^{-1}: 3247, 2925, 1712, 1617, 1470, 752, 619 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{25}H_{23}N_2O$ 367.1804; found 367.1818.

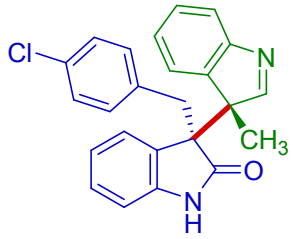
3-(4-Bromobenzyl)-3'-methyl-3,3'-biindolin-2-one **(3f):** light-yellow sticky solid (54 mg, 62% yield, *anti/syn* = 98:2), R_f = 0.26 (ethyl acetate/hexane = 1/2).



3f

^{1}H NMR (*anti* **3f**) (300 MHz, $CDCl_3$) δ 8.20 (s, 1H), 7.74 (s, 1H), 7.55 (d, *J* = 7.6 Hz, 1H), 7.41 – 7.34 (m, 1H), 7.24 (dd, *J* = 13.1, 3.6 Hz, 2H), 7.14 – 7.06 (m, 3H), 6.89 (t, *J* = 7.6 Hz, 1H), 6.80 (d, *J* = 7.5 Hz, 1H), 6.68 (d, *J* = 8.4 Hz, 2H), 6.58 (d, *J* = 7.8 Hz, 1H), 3.44 (d, *J* = 12.8 Hz, 1H), 3.20 (d, *J* = 12.8 Hz, 1H), 1.59 (s, 3H); **^{13}C NMR** (*anti* **3f**) (75 MHz, $CDCl_3$) *δ*177.85, 175.57, 155.36, 141.04, 140.61, 134.13, 132.01, 130.91, 129.04, 128.84, 128.26, 126.37, 125.14, 123.78, 121.96, 121.68, 120.85, 109.94, 61.11, 57.44, 37.83, 15.86; **FTIR** (KBr) cm^{-1}: 3211, 2924, 1713, 1617, 1466, 752 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{24}H_{20}BrN_2O$ 431.0753; found 431.0766.

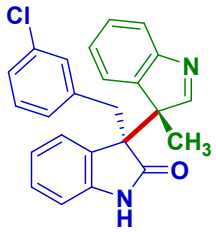
3-(4-Chlorobenzyl)-3'-methyl-3,3'-biindolin-2-one **(3g):** light-yellow sticky solid (54 mg, 70% yield, *anti/syn* = 92:8), R_f = 0.14 (ethyl acetate/hexane = 1/2**).**



3g

^{1}H NMR (*anti* **3g**) (500 MHz, $CDCl_3$) *δ* 8.46 (s, 1H), 8.19 (s, 1H), 7.50 (d, *J*= 7.7 Hz, 1H), 7.35 (dd, *J* = 10.4, 5.8 Hz, 1H), 7.20 (d, *J* = 5.1 Hz, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 6.90 (dd, *J* = 11.7, 8.1 Hz, 3H), 6.82 (d, *J*= 6.9 Hz, 1H), 6.73 (d, *J* = 8.3 Hz, 2H), 6.58 (d, *J* = 7.7 Hz, 1H), 3.44 (d, *J* = 12.9 Hz, 1H), 3.21 (d, *J* = 12.9 Hz, 1H), 1.57 (s, 3H); **^{13}C NMR** (*anti* **3g**) (126 MHz, $CDCl_3$) *δ* 178.23, 175.63, 155.19, 141.26, 140.57, 133.60, 132.53, 131.57, 128.97, 128.78, 128.26, 127.90, 126.33, 125.06, 123.74, 121.85, 121.55, 110.02, 61.03, 57.54, 37.70, 15.83; **FTIR** (KBr) cm^{-1}: 3265, 2908, 1712, 1624, 1558, 785,642 cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{24}H_{19}ClN_2NaO$ 409.1078; found 409.1071.

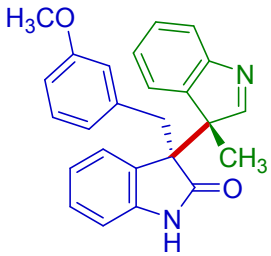
3-(3-Chlorobenzyl)-3'-methyl-3,3'-biindolin-2-one **(3h):** light-yellow sticky solid (59 mg, 76% yield, *anti/syn* = 96:4), R_f = 0.15 (ethyl acetate/hexane = 1/2.3). **^{1}H NMR** (*anti* **3h**) (500 MHz, $CDCl_3$) *δ* 8.20 (s, 1H), 7.58 (d, *J* = 7.9 Hz, 2H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.24 (dd, *J* = 15.2, 7.9 Hz, 2H), 7.12 (t, *J* = 7.7 Hz, 1H), 6.97 (d, *J* = 7.6 Hz, 1H), 6.89 (dd, *J* = 16.5, 8.2 Hz, 2H), 6.80 (s, 2H), 6.70 (d, *J*= 7.6 Hz, 1H), 6.59 (d, *J* = 7.7 Hz, 1H), 3.47 (d, J = 12.8 Hz, 1H),



3h

3.21 (d, J = 12.8 Hz, 1H), 1.60 (s, 3H); **^{13}C NMR** (*anti* **3h**) (126 MHz, $CDCl_3$) δ 177.71, 175.58, 155.39, 140.92, 140.60, 137.17, 133.50, 130.35, 129.07, 129.02, 128.87, 128.50, 128.16, 126.94, 126.41, 125.24, 123.82, 122.03, 121.74, 109.84, 61.13, 57.37, 38.08, 15.85; **FTIR** (KBr) cm^{-1}: 3269, 2901, 1715, 1614, 1544, 790, 652 cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{24}H_{19}ClN_2NaO$ 409.1078; found 409.1094.

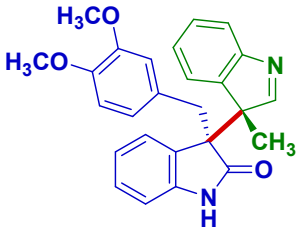
3-(3-Methoxybenzyl)-3'-methyl-3,3'-biindolin-2-one **(3i):** light-yellow sticky solid (57 mg, 75% yield, *anti/syn* = 98:2), $\mathbf{R_f}$ = 0.09 (ethyl acetate/hexane = 1/2).



3i

^{1}H NMR (*anti* **3i**) (300 MHz, $CDCl_3$) δ 8.28 (s, 1H), 8.18 (s, 1H), 7.53 (d, J = 7.7 Hz, 1H), 7.41 – 7.30 (m, 1H), 7.25 – 7.15 (m, 2H), 7.09 (t, J = 7.6 Hz, 1H), 6.84 (dt, J = 16.8, 7.1 Hz, 3H), 6.54 (dd, J= 13.5, 4.8 Hz, 2H), 6.45 (d, J = 7.5 Hz, 1H), 6.30 (s, 1H), 3.55 – 3.41 (m, 4H), 3.25 (d, J = 12.7 Hz, 1H), 1.60 (s, 3H); **^{13}C NMR** (*anti* **3i**) (75 MHz, $CDCl_3$) δ 178.47, 175.81, 158.81, 155.30, 141.32, 140.75, 136.54, 128.77, 128.72, 128.68, 126.28, 125.09, 123.72, 122.75, 121.68, 121.58, 115.01, 112.97, 109.92, 57.50, 54.98, 38.46, 15.81; **FTIR** (KBr) cm^{-1}: 3243, 2927, 1712, 1599, 1469, 753, 696 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{25}H_{23}N_2O_2$ 383.1754; found 383.1741.

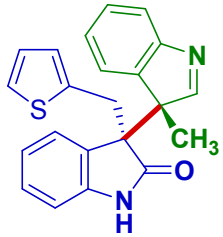
3-(3,4-Dimethoxybenzyl)-3'-methyl-3,3'-biindolin-2-one **(3j):** light yellow sticky solid (53 mg, 65% yield, *anti/syn* = 94:6), $\mathbf{R_f}$ = 0.11 (ethyl acetate/hexane = 1/2).



3j

^{1}H NMR (*anti* **3j)** (300 MHz, $CDCl_3$) δ8.58 (s, 1H), 8.17 (s, 1H), 7.52 (d, J= 7.7 Hz, 1H), 7.41 – 7.29 (m, 1H), 7.26 – 7.13 (m, 2H), 7.08 (dd, J = 7.6, 6.8 Hz, 1H), 6.87 (t, J = 7.5 Hz, 1H), 6.77 (d, J = 7.4 Hz, 1H), 6.57 (d, J = 7.7 Hz, 1H), 6.09 (t, J = 2.2 Hz, 1H), 5.97 (d, J = 2.2 Hz, 2H), 3.53 – 3.40 (m, 7H), 3.22 (d, J = 12.7 Hz, 1H), 1.59 (s, 3H); **^{13}C NMR** (*anti* **3j)** (75 MHz, $CDCl_3$) δ 178.56, 175.79, 159.87, 155.23, 141.47, 140.71, 137.24, 128.73, 126.25, 124.97, 123.68, 121.57, 121.50, 110.04, 107.96, 99.46, 61.08, 57.41, 55.07, 38.63, 15.72; **FTIR** (KBr) cm^{-1}: 3249, 2932, 1713, 1597, 1470, 753 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{26}H_{25}N_2O_3$ 413.1859; found 413.1859.

3'-Methyl-3-(thiophen-2-ylmethyl)-3,3'-biindolin-2-one **(3k):** yellow sticky solid (40 mg, 55.4% yield, *anti/syn* = 95:5), $\mathbf{R_f}$ = 0.15 (ethyl acetate/hexane = 1/2).

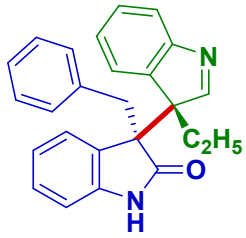


3k

^{1}H NMR (*anti* **3k**) (500 MHz, $CDCl_3$) δ 8.40 (s, 1H), 8.17 (s, 1H), 7.55 (d, J = 7.7 Hz, 1H), 7.37 (t, J = 7.5 Hz, 1H), 7.23 (dd, J = 17.4, 10.1 Hz, 2H), 7.17 (t, J = 7.6 Hz, 1H), 6.92 (t, J = 7.5 Hz, 1H), 6.84 (d, J = 4.9 Hz, 1H), 6.80 (d, J = 7.2 Hz, 1H), 6.67 (d, J = 7.7 Hz, 1H),

6.65 – 6.60 (m, 1H), 6.52 (d, *J* = 2.9 Hz, 1H), 3.73 (d, *J*= 14.0 Hz, 1H), 3.45 (d, *J*= 14.0 Hz, 1H), 1.56 (s, 3H); **^{13}C NMR** (*anti* **3k**) (126 MHz, $CDCl_3$) δ 178.52, 175.53, 155.32, 141.77, 140.52, 136.71, 129.15, 128.81, 128.66, 127.40, 126.38, 126.33, 125.04, 124.68, 123.85, 122.05, 121.65, 110.04, 60.95, 57.27, 32.84, 15.84; **FTIR** (KBr) cm^{-1}:3205, 2895, 1715, 1658, 1084, 765, 687 cm^{-1}; **HRMS ESI**: $[M+H]^+$, Calcd. for $C_{22}H_{19}N_2OS$ 359.1212; found 359.1210.

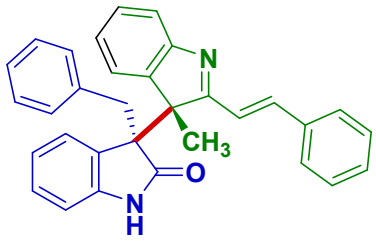
3-Benzyl-3'-ethyl-3,3'-biindolin-2-one **(3l):** light yellow sticky solid (45 mg, 60% yield, *anti/syn* = 98:2), R_f = 0.3 (ethyl acetate/hexane = 1/3). **^{1}H NMR** (*anti* **3l**) (500 MHz, $CDCl_3$) δ 8.33 (s, 1H), 8.15 (s, 1H), 7.54 (d, *J* = 7.6 Hz, 1H), 7.36 (dd, *J* = 20.0, 12.4 Hz, 2H), 7.27 – 7.23 (m, 1H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.96 – 6.85 (m, 4H), 6.79 (d, *J* = 7.2 Hz, 3H), 6.55 (d, *J* = 7.7 Hz, 1H), 3.45 (d, J = 12.8 Hz, 1H), 3.18 (d, J = 12.8 Hz, 1H), 2.61 (dq, J = 14.2, 7.1 Hz, 1H), 2.24 (dq, *J* = 14.5, 7.2 Hz, 1H), 0.29 (s, 3H);



3l

^{13}C NMR (*anti* **3l**) (126 MHz, $CDCl_3$) δ 178.69, 175.23, 156.60, 141.19, 138.50, 135.11, 130.27, 128.77, 128.74, 128.69, 127.70, 126.57, 126.26, 125.45, 124.21, 121.69, 121.35, 109.70, 66.47, 58.19, 38.42, 22.19, 7.90; **FTIR** (KBr) cm^{-1}: 3251, 2966, 1708, 1619, 1472, 752, 701, 577 cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{25}H_{22}N_2NaO$ 389.1624; found 389.1643.

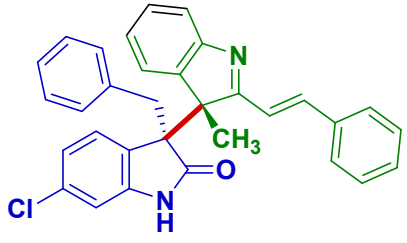
3-Benzyl-3'-methyl-2'-styryl-3,3'-biindolin-2-one **(3m):** light yellow sticky solid (63 mg, 68% yield, *anti/syn* = 98:2), R_f = 0.3 (ethyl acetate/hexane = 1/3). **^{1}H NMR** (*anti* **3m**) (300 MHz, $CDCl_3$) δ 8.12 (d, *J* = 11.0 Hz, 2H), 7.65 (d, *J* = 6.9 Hz, 2H), 7.49 – 7.31 (m, 5H), 7.18 (dt, *J* = 16.6, 9.8 Hz, 3H), 6.98 (ddd, *J* = 16.6, 14.8, 7.4 Hz, 5H), 6.84 (dt, *J* = 13.6, 7.2 Hz, 3H), 6.22 (d, *J* = 7.3 Hz, 1H), 3.84 (d, *J* = 12.1 Hz, 1H), 3.52 (d, *J* = 12.2 Hz, 1H), 1.96 (s, 3H);



3m

^{13}C NMR (*anti* **3m**) (75 MHz, $CDCl_3$) δ 179.34, 178.08, 154.02, 141.59, 140.37, 137.66, 136.01, 135.27, 130.45, 129.72, 129.06, 128.62, 128.47, 128.33, 127.95, 127.66, 126.65, 125.49, 124.33, 122.61, 121.71, 120.21, 120.16, 109.05, 60.66, 57.47, 38.99, 15.33; **FTIR** (KBr) cm^{-1}: 3204, 2935, 1714, 1639, 1501, 829, 689 cm^{-1}; **HRMS ESI**: $[M+Na]^+$, Calcd. for $C_{32}H_{26}N_2NaO$ 477.1937; found 477.1924.

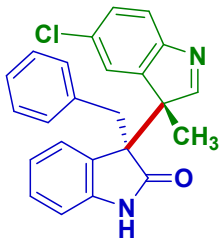
3-Benzyl-6-chloro-3'-methyl-2'-styryl-3,3'-biindolin-2-one **(3n):** light yellow sticky solid (61 mg, 62% yield, *anti/syn* = 98:2), R_f = 0.3 (ethyl acetate/hexane = 1/3). **^{1}H NMR** (*anti* **3n**) (300 MHz,



3n

$CDCl_3$) δ 8.34 (s, 1H), 8.10 (d, J = 15.9 Hz, 1H), 7.64 (d, J = 6.6 Hz, 2H), 7.49 – 7.39 (m, 3H), 7.38 – 7.31 (m, 2H), 7.20 – 7.09 (m, 3H), 7.07 – 6.96 (m, 4H), 6.80 (d, J = 7.8 Hz, 3H), 6.24 (d, J = 1.7 Hz, 1H), 3.83 (d, J = 12.2 Hz, 1H), 3.49 (d, J = 12.3 Hz, 1H), 1.93 (s, 3H); **^{13}C NMR** (*anti* **3n**) (75 MHz, $CDCl_3$) δ 179.09, 178.14, 154.00, 141.61, 141.26, 137.85, 135.88, 134.94, 133.95, 130.39, 129.86, 129.15, 128.74, 127.96, 127.87, 127.19, 126.86, 125.64, 125.22, 122.52, 121.71, 120.43, 119.94, 109.70, 60.59, 57.31, 38.86, 15.23; **FTIR** (KBr) cm^{-1}: 3315, 2963, 1708, 1619, 1524, 783, 641cm^{-1}; **HRMS ESI**: $[M+K]^+$, Calcd. for $C_{32}H_{25}ClKN_2O$ 527.1286; found 527.1302.

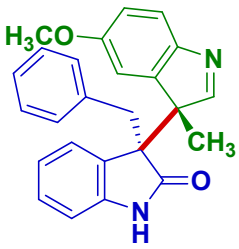
3-Benzyl-5'-chloro-3'-methyl-3,3'-biindolin-2-one **(3o):** light-yellow sticky solid (55 mg,71% yield, *anti/syn* = 97:3), $\mathbf{R}_f$ = 0.14 (ethyl acetate/hexane = 1/2**).**



3o

^{1}H NMR (*anti* **3o**) (300 MHz, $CDCl_3$) δ 8.33 (s, 1H), 8.12 (s, 1H), 7.43 (d, J = 7.6 Hz, 1H), 7.27 (t, J = 7.4 Hz, 1H), 7.19 – 7.11 (m, 2H), 7.03 (t, J = 7.6 Hz, 1H), 6.88 – 6.70 (m, 4H), 6.65 (d, J = 7.8 Hz, 2H), 6.50 (d, J = 7.7 Hz, 1H), 3.37 (d, J = 12.8 Hz, 1H), 3.13 (d, J = 12.8 Hz, 1H), 1.49 (s, 3H); **^{13}C NMR** (*anti* **3o**) (126 MHz, $CDCl_3$) δ 178.55, 175.82, 155.31, 141.26, 140.79, 135.07, 130.22, 128.76, 128.71, 128.60, 127.74, 126.62, 126.27, 125.18, 123.76, 121.71, 121.57, 109.81, 77.41, 77.16, 76.91, 61.14, 57.60, 38.41, 15.87; **FTIR** (KBr) cm^{-1}: 3427, 2924, 1722, 1616, 1261, 804, 648 cm^{-1}; **HRMS ESI**: $[M+K]^+$, Calcd. for $C_{24}H_{19}ClN_2NaO$ 409.1078; found 409.1075.

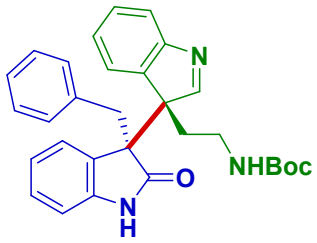
3-Benzyl-5'-methoxy-3'-methyl-3,3'-biindolin-2-one **(3p):** light-yellow sticky solid (57 mg, 74% yield, *anti/syn* = 94:6), $\mathbf{R}_f$ = 0.09 (ethyl acetate/hexane = 1/2). **^{1}H NMR** (*anti* **3p**) (500 MHz, $CDCl_3$) δ 8.26 (s, 1H), 8.09 (s, 1H), 7.43 (d, J = 8.5 Hz, 1H), 7.09 (t, J = 8.2 Hz, 1H), 6.99 – 6.90 (m, 5H), 6.88 – 6.85 (m, 1H), 6.79 (dd, J = 25.0, 8.6 Hz, 3H), 6.56 (d, J = 7.7 Hz, 1H), 3.73 (s, 3H), 3.48 (d, J = 12.8 Hz, 1H), 3.24 (d, J = 12.8 Hz, 1H), 1.56 (s, 3H);



3p

^{13}C NMR (*anti* **3p**) (126 MHz, $CDCl_3$) δ 178.39, 173.63, 158.43, 149.03, 142.34, 141.38, 135.12, 130.23, 128.75, 128.67, 127.74, 126.62, 125.36, 121.85, 121.74, 113.68, 109.76, 77.42, 77.16, 76.91, 61.14, 57.70, 55.67, 38.30, 16.29; **FTIR** (KBr) cm^{-1}: 3428, 2924, 1712, 1621, 1469, 749, 697 cm^{-1}; **HRMS ESI**: $[M+K]^+$, Calcd. for $C_{25}H_{22}N_2NaO_2$ 405.1573; found 405.1577.

Tert-butyl 2-(3-benzyl-2-oxo-3,3'-biindolin-3'-yl)ethylcarbamate **(3q):** White sticky solid (66 mg, 67% yield, *anti/syn* = 67:33) (inseparable diastereomeric mixture), $\mathbf{R}_f$ = 0.2 (ethyl acetate/hexane = 1/4 **). ^{1}H NMR** (*anti*

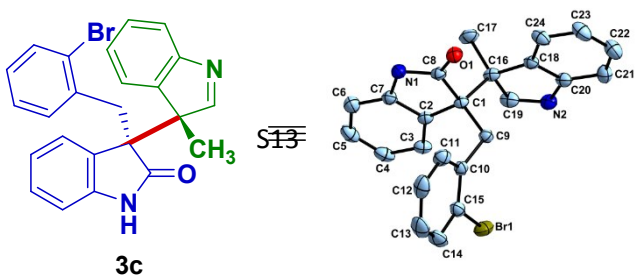


3q

3q) (500 MHz, $CDCl_3$) δ 7.41 (s, 1H), 7.19 – 7.11 (m, 2H), 6.95 (dd, *J* = 14.7, 7.5 Hz, 4.15H), 6.80 (t, *J* = 11.0 Hz, 5.13H), 6.52 – 6.47 (m, 3.44H), 6.16 (s, 1H), 5.11 (s, 1H), 3.47 (s, 1.34H), 3.40 (d, *J* = 12.6 Hz, 1.33H), 2.99 (qd, *J* = 10.7, 5.7 Hz, 2H), 2.30 (dd, *J* = 11.7, 5.9 Hz, 2H), 1.41 (s, 9H); **^{13}C NMR** (*anti* **3q**) (126 MHz, $CDCl_3$) δ 178.35, 178.27, 154.27, 153.38, 151.18, 150.63, 140.79, 140.51, 135.43, 135.28, 130.33, 129.49, 129.34, 128.78, 128.70, 128.32, 128.13, 127.64, 126.54, 126.48, 125.27, 125.01, 124.81, 121.69, 118.85, 118.34, 109.81, 109.19, 109.08, 80.46, 79.95, 78.06, 77.70, 77.41, 77.16, 76.90, 62.61, 61.44, 57.65, 57.49, 45.51, 44.96, 38.83, 38.70, 28.84, 28.59; **FTIR** (KBr) cm^{-1}: 3421, 2996, 1687, 1617, 1472, 1402, 1163, 1113, 1027, 751 cm^{-1}; **HRMS ESI**: $[M+K]^+$, Calcd. for $C_{30}H_{31}N_3NaO_3$ 504.2257; found 504.2265.

4. Single crystal X-ray structure of compound 3c (CCDC 2039264)

The single crystals suitable for X-ray structure analysis of compound **3c** were grown by slow evaporation method using $CHCl_3$/Heptane solution.



3c

Figure 1. X-ray molecular structure of compound **3c**. Thermal ellipsoids are drawn at the 30 % probability level and the hydrogen atoms were omitted for clarity.

Table S1. Crystal data and structure refinement for **3c**.

Identification code	MANJU01_0m_a	
Empirical formula	C25 H19 Br Cl3 N2 O	
Formula weight	549.67	
Temperature	273(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 21/n	
Unit cell dimensions	a = 12.0457(6) Å	α= 90°.
	b = 13.8112(6) Å	β= 92.314(2)°.
	c = 14.5205(6) Å	γ = 90°.
Volume	2413.74(19) $Å^3$	
Z	4	
Density (calculated)	1.513 Mg/m^3	
Absorption coefficient	2.056 mm^{-1}	
F(000)	1108	
Crystal size	0.18 x 0.15 x 0.10 mm^3	
Theta range for data collection	2.036 to 28.390°.	
Index ranges	-16<=h<=16, -18<=k<=18, -19<=l<=19	
Reflections collected	69097	
Independent reflections	6039 [R(int) = 0.0994]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	6039 / 0 / 290	
Goodness-of-fit on F^2	1.460	
Final R indices [I>2sigma(I)]	R1 = 0.0898, wR2 = 0.2211	
R indices (all data)	R1 = 0.1097, wR2 = 0.2348	
Extinction coefficient	n/a	

Largest diff. peak and hole	1.436 and -1.052 e.Å^{-3}

3. References:

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[2] (a) S. B. Bharate, R. R. Yadav, S. I. Khan, B. L. Tekwani, M. R. Jacob, I. A. Khan and R. A. Vishwakarma, *MedChemComm*. 2013, **4**, 1042. (b) C. Song, X. Dong, H. Yi, C.-W. Chiang and A. Lei, *ACS Catal.* 2018, **8**, 2195-2199.

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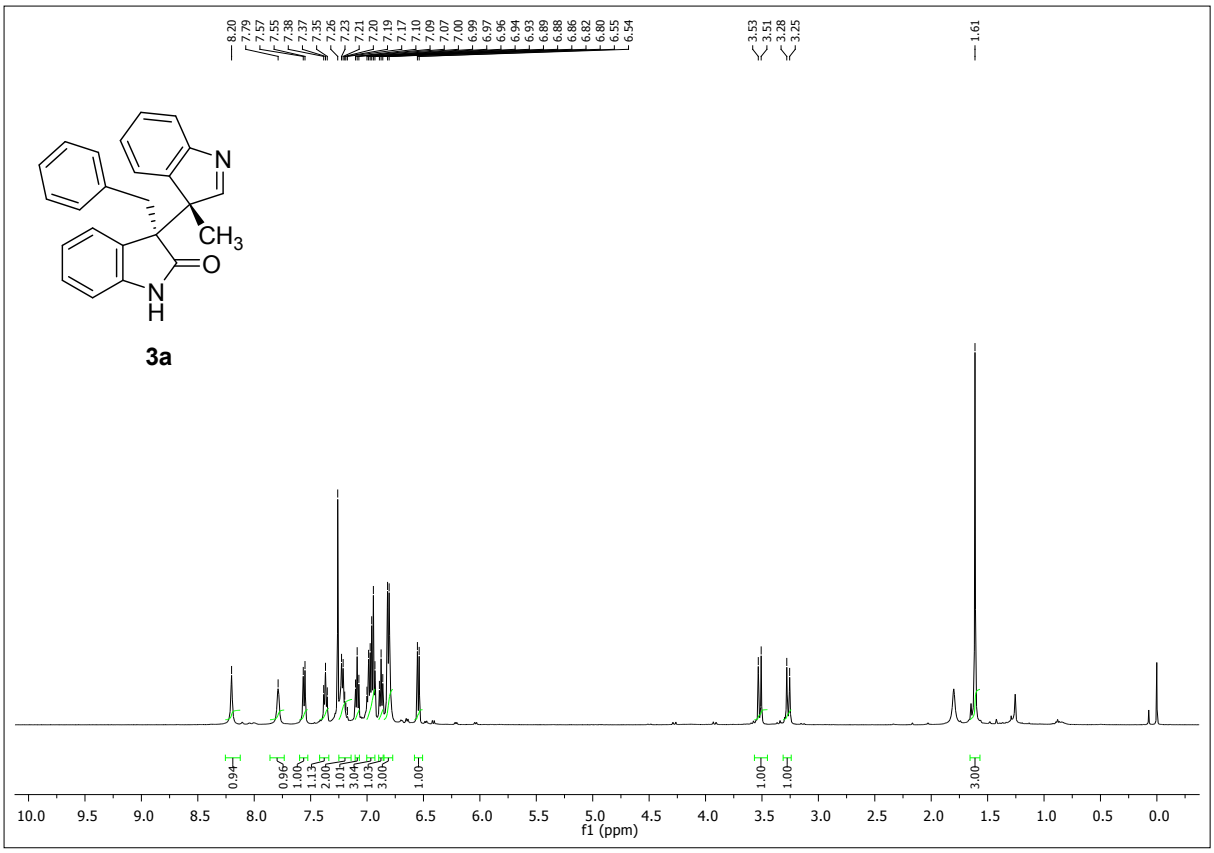
[4] S. Wang, Y.-B. Shen, L.-F. Li, B. Qiu, L. Yu, Q. Liu and J. Xiao, *Org. Lett.* 2019, **21**, 8904.

[5] J. Park and D. Y.-K. Chen, *Angew. Chem., Int. Ed.* 2018, **57**, 16152.

Copies of ^{1}H and ^{13}C NMR spectra


8.20
7.79
7.57
7.55
7.38
7.37
7.35
7.26
7.23
7.21
7.20
7.19
7.17
7.10
7.09
7.07
7.00
6.99
6.97
6.96
6.94
6.93
6.89
6.88
6.86
6.82
6.80
6.55
6.54
3.53
3.51
3.28
3.25
1.61
N
CH3
O
N
H
3a
0.94
0.96
1.00
1.13
2.06
1.01
3.04
1.03
3.00
1.00
1.00
1.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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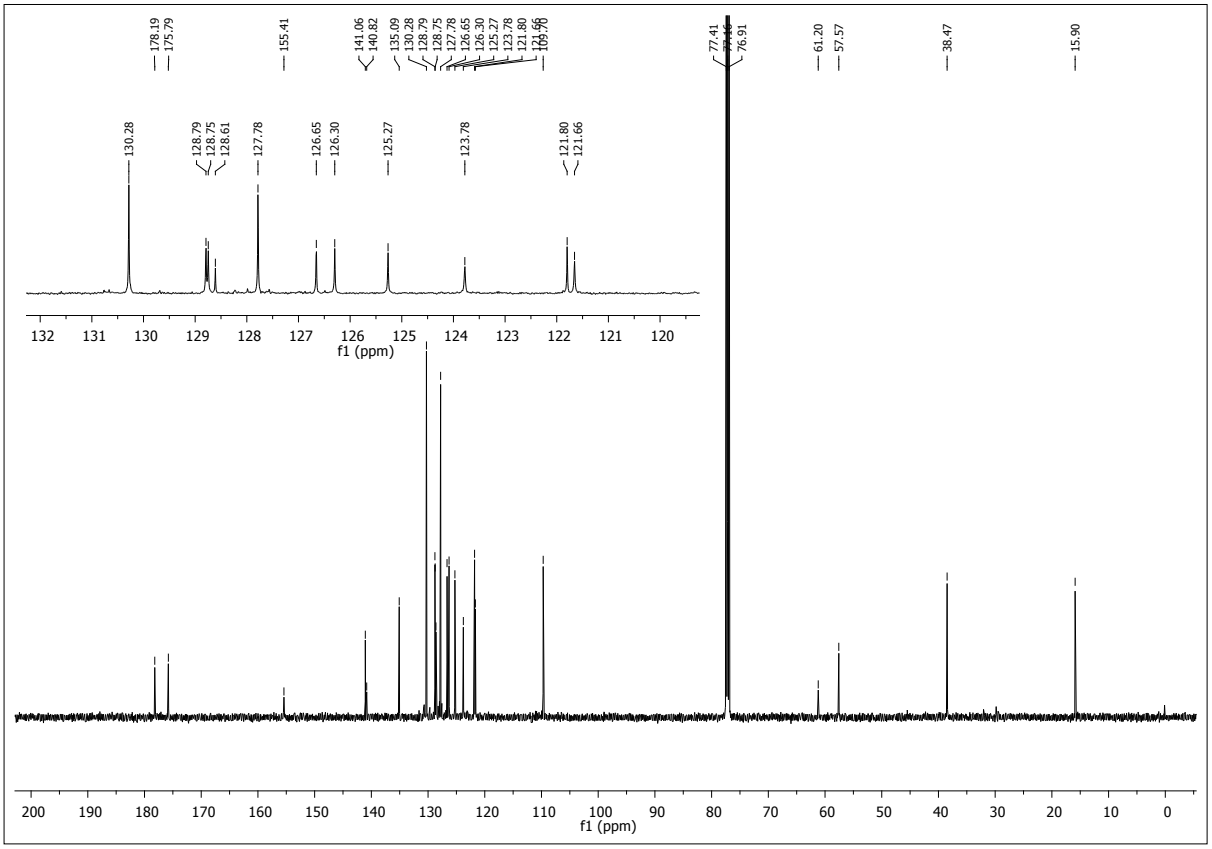
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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155.41
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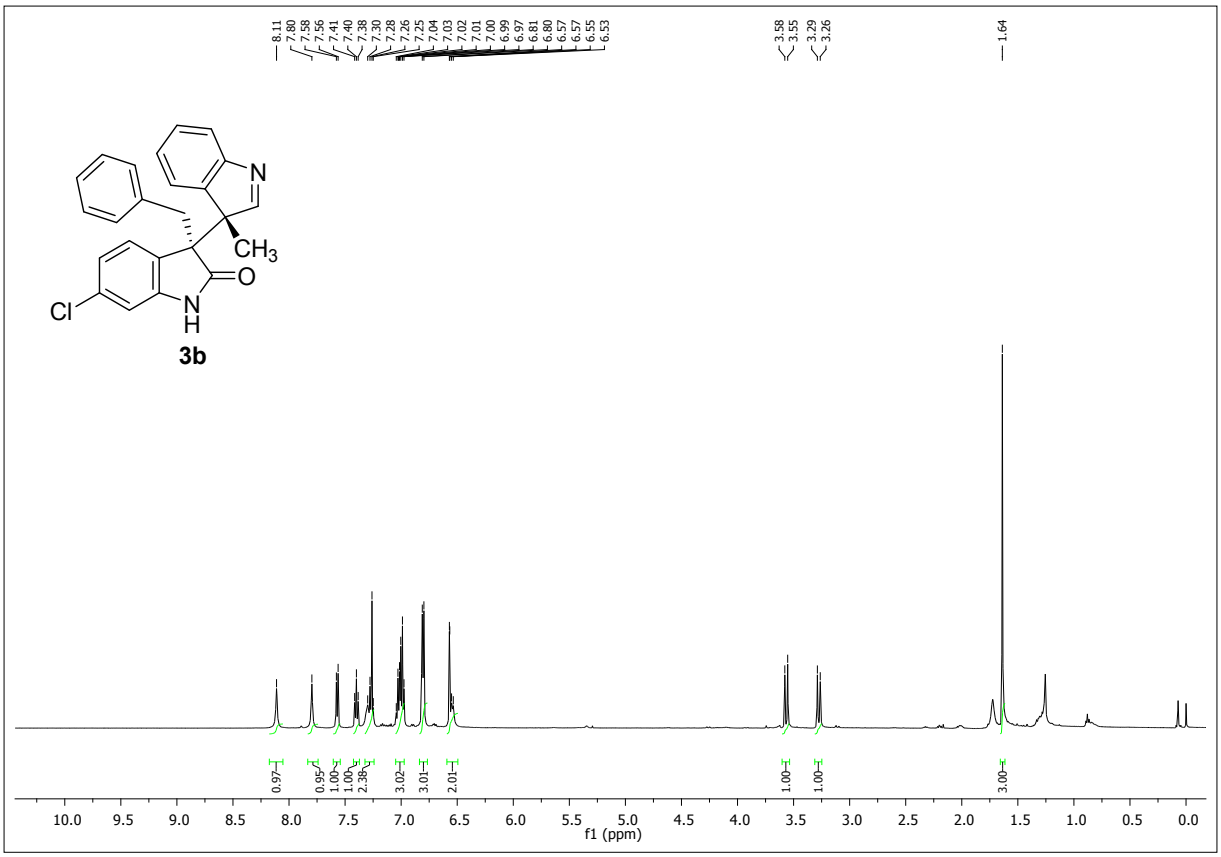
140.82
135.09
130.28
128.79
128.75
127.78
126.65
126.30
125.27
123.78
121.80
121.66
77.41
77.16
76.91
61.20
57.57
38.47
15.90
130.28
128.79
128.75
128.61
127.78
126.65
126.30
125.27
123.78
121.80
121.66
132
131
130
129
128
127
126
125
124
123
122
121
120
f1 (ppm)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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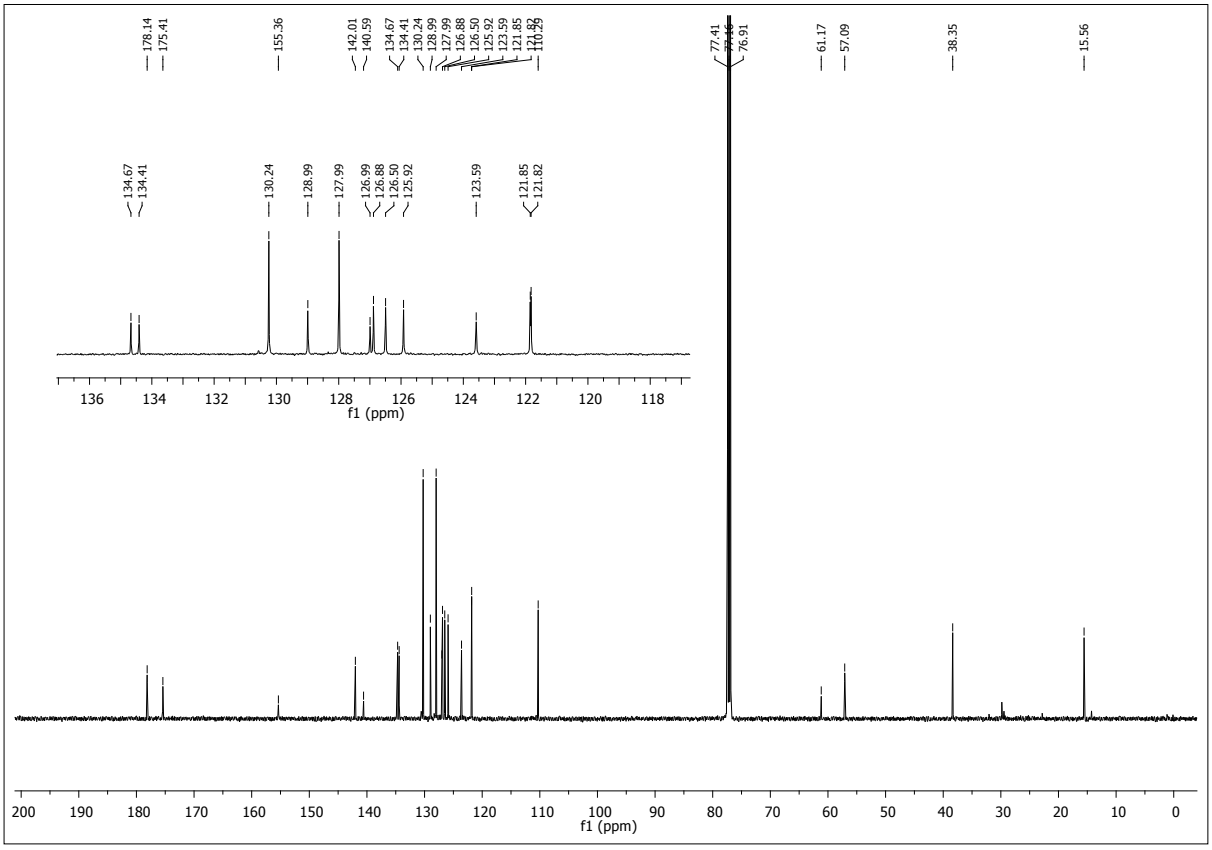
7.25
7.04
7.03
7.02
7.01
7.00
6.99
6.97
6.81
6.80
6.57
6.57
6.55
6.53
3.58
3.55
3.29
3.26
1.64
N
CH3
O
Cl
N
H
3b
0.97
0.95
1.00
1.00
2.38
3.02
3.01
2.01
1.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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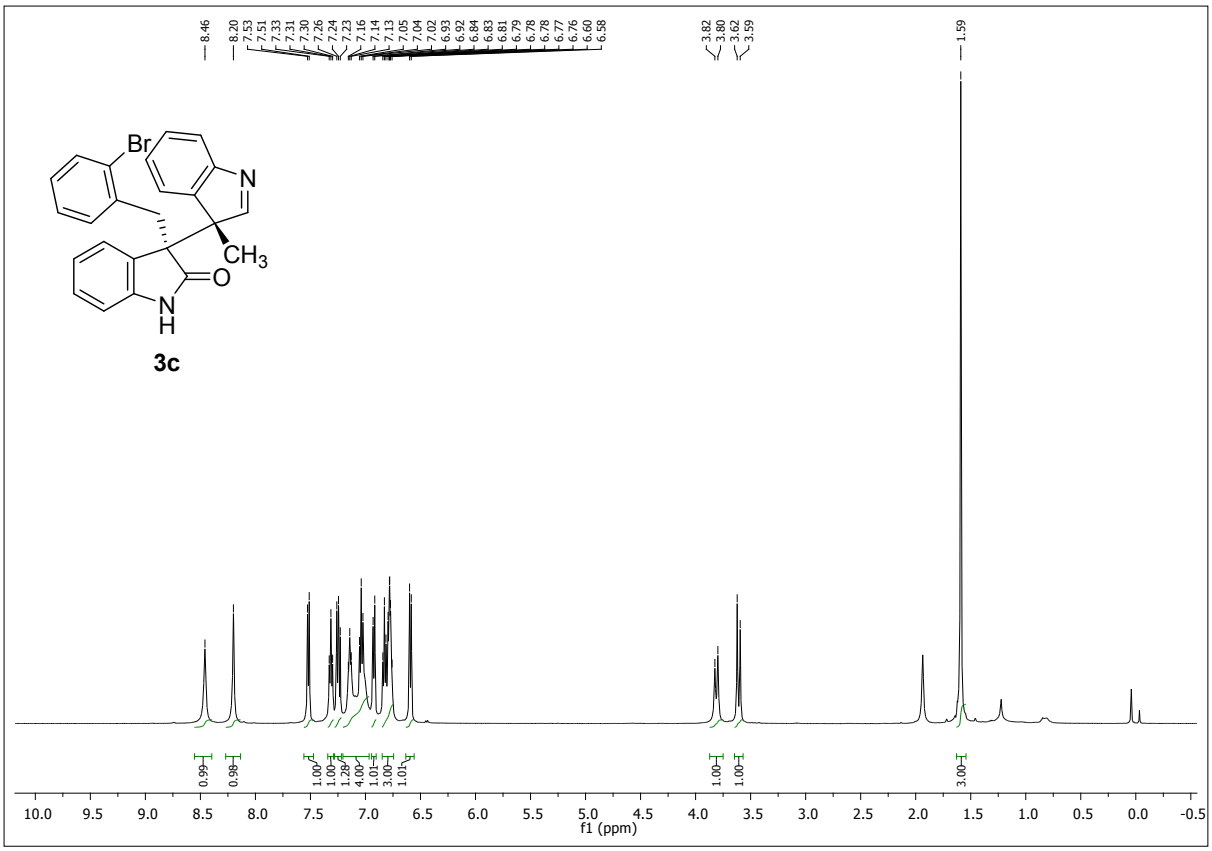
126.50
125.92
123.59
121.85
121.82
110.29
77.41
76.91
61.17
57.09
38.35
15.56
134.67
134.41
130.24
128.99
127.99
126.99
126.88
126.50
125.92
123.59
121.85
121.82
136 134 132 130 128 126 124 122 120 118
f1 (ppm)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.26
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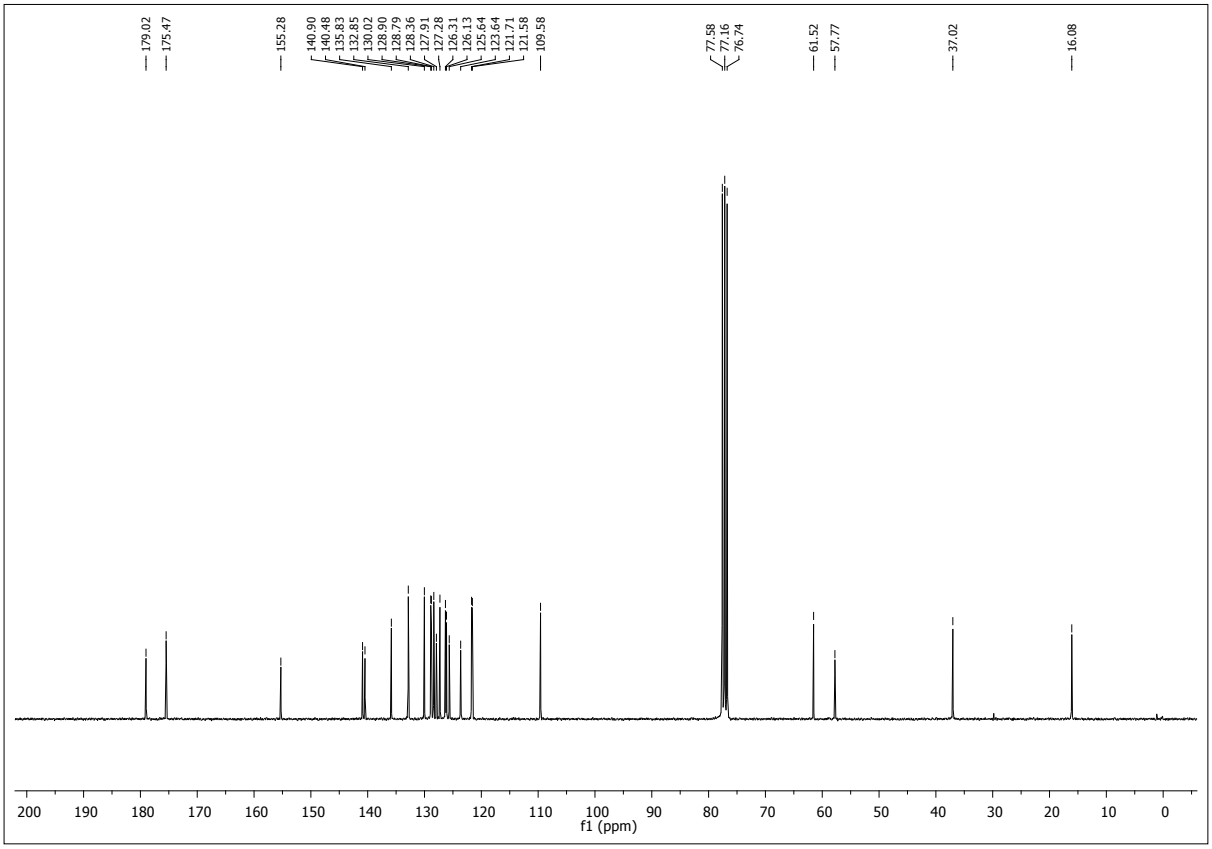
7.23
7.16
7.14
7.13
7.05
7.04
7.02
6.93
6.92
6.84
6.83
6.81
6.79
6.78
6.78
6.77
6.76
6.60
6.58
3.82
3.80
3.62
3.59
1.59
Br
N
CH3
O
N
H
0.99
0.98
1.00
1.00
1.28
4.00
1.01
3.00
1.01
1.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

3c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140.48
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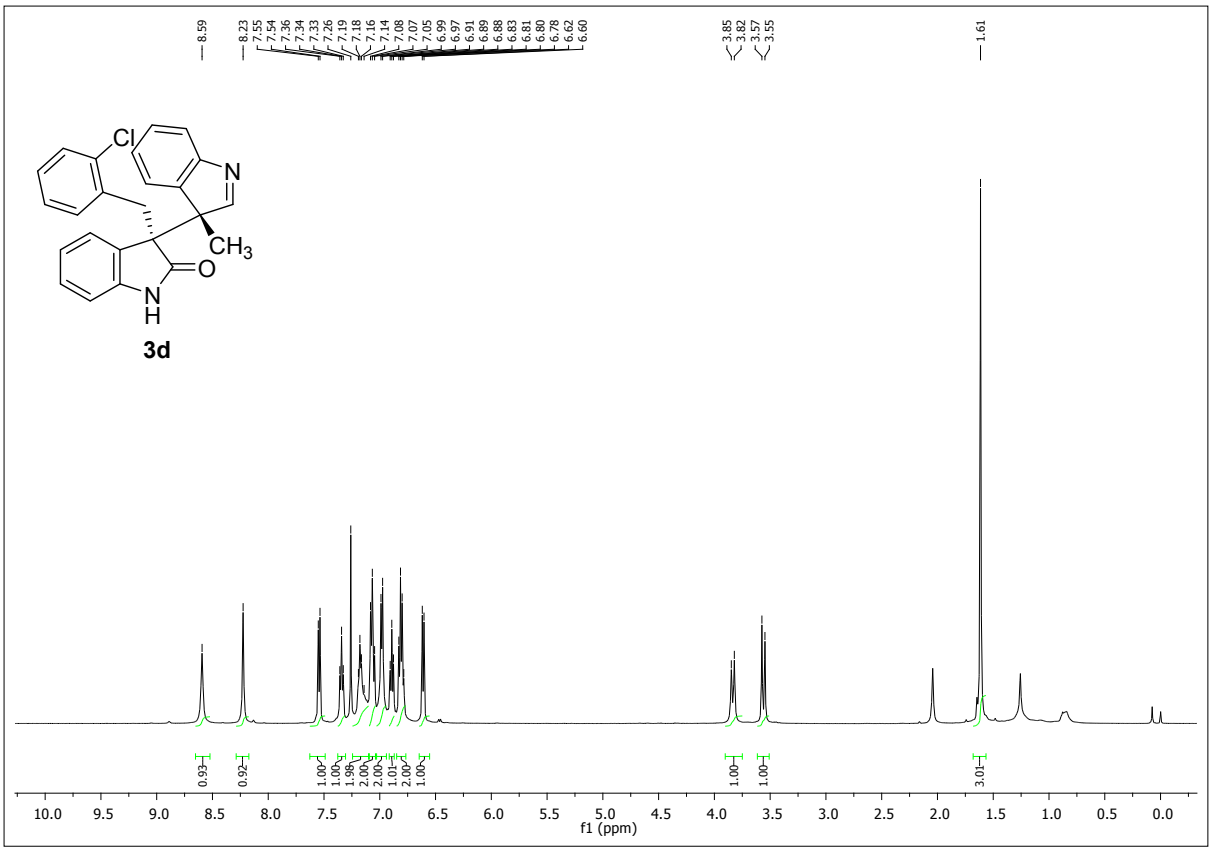
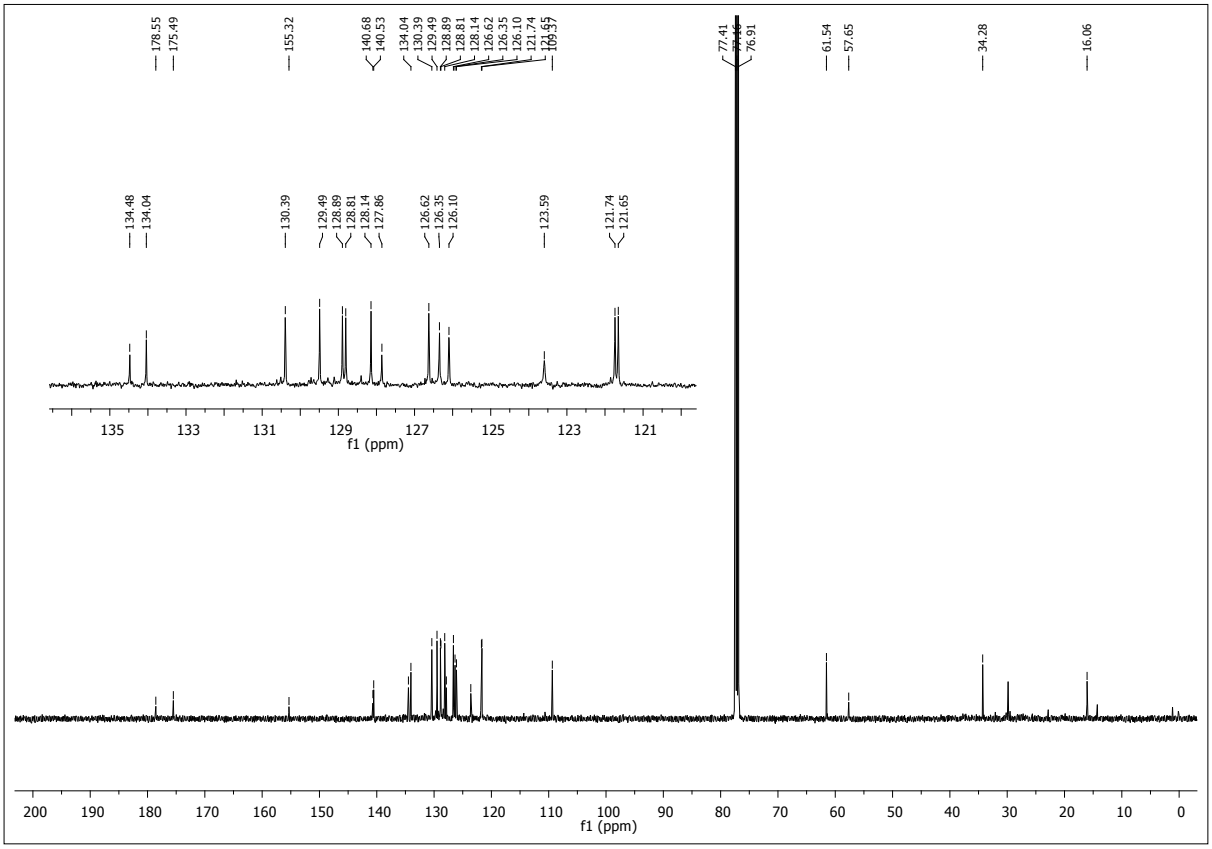
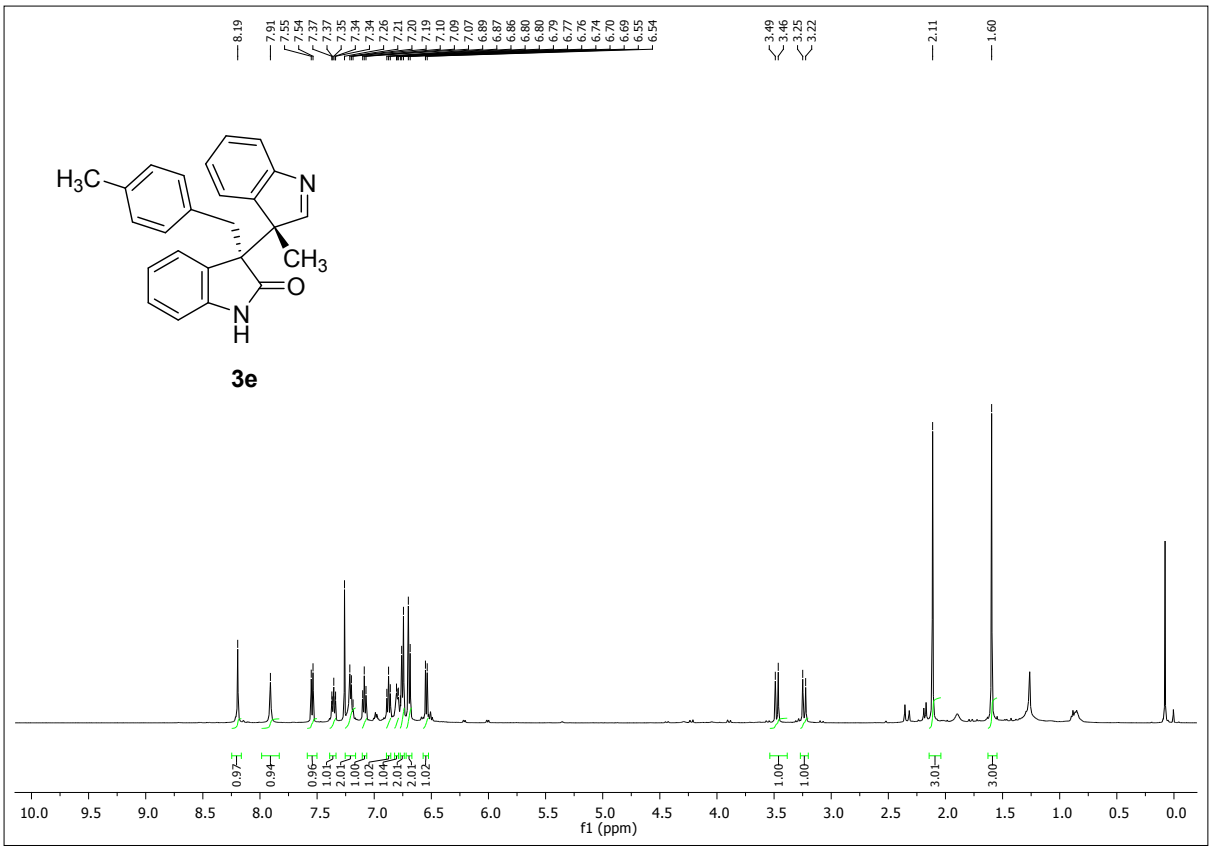
132.85
130.02
128.90
128.79
128.36
127.91
127.28
126.31
126.13
125.64
123.64
121.71
121.58
109.58
77.58
77.16
76.74
61.52
57.77
37.02
16.08
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


Cl
N
CH3
O
N
H
3d
f1 (ppm)


f1 (ppm)
f1 (ppm)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7.91
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7.54
7.37
7.37
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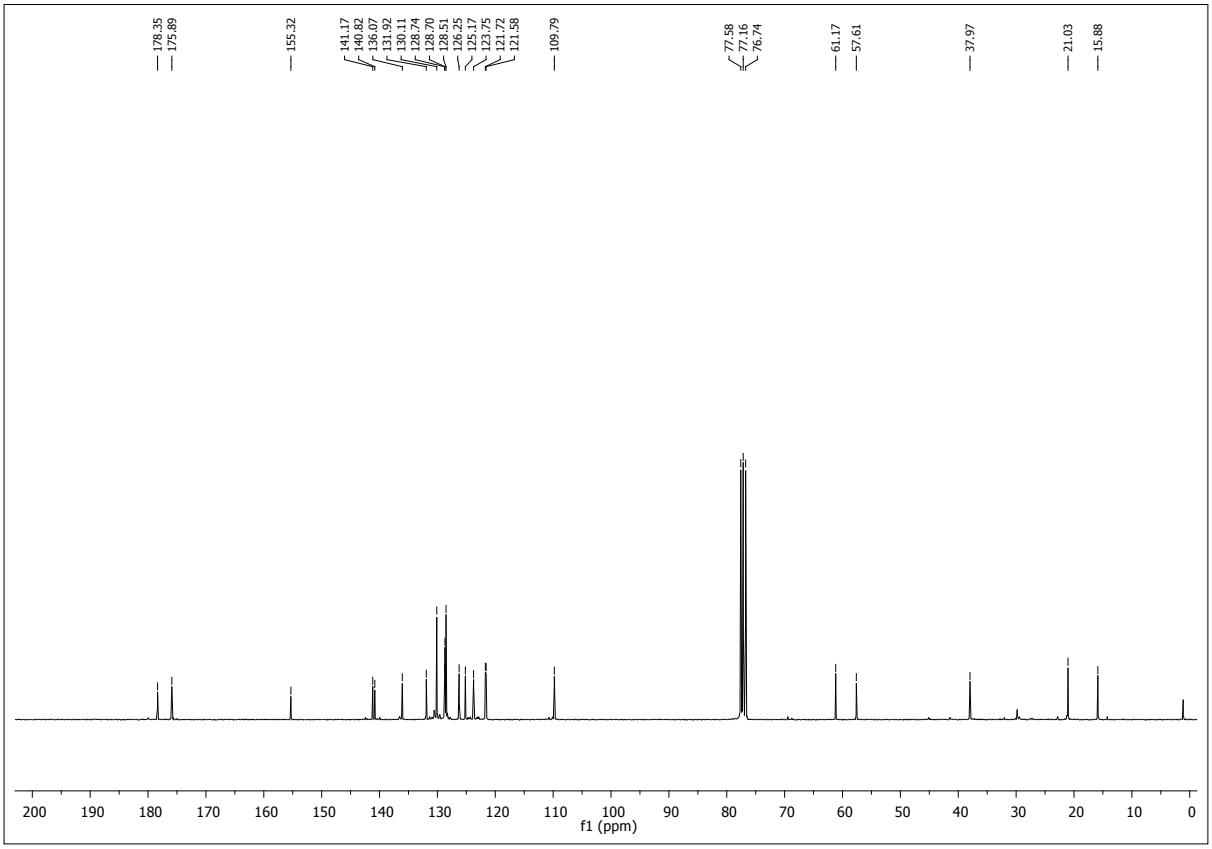
7.26
7.21
7.20
7.19
7.10
7.09
7.07
6.89
6.87
6.86
6.80
6.80
6.79
6.77
6.76
6.74
6.70
6.69
6.55
6.54
3.49
3.46
3.25
3.22
2.11
1.60
H3C
N
CH3
O
N
H
3e
0.97
0.94
0.96
1.01
2.01
1.00
1.02
1.04
2.01
2.01
1.02
1.00
1.00
3.01
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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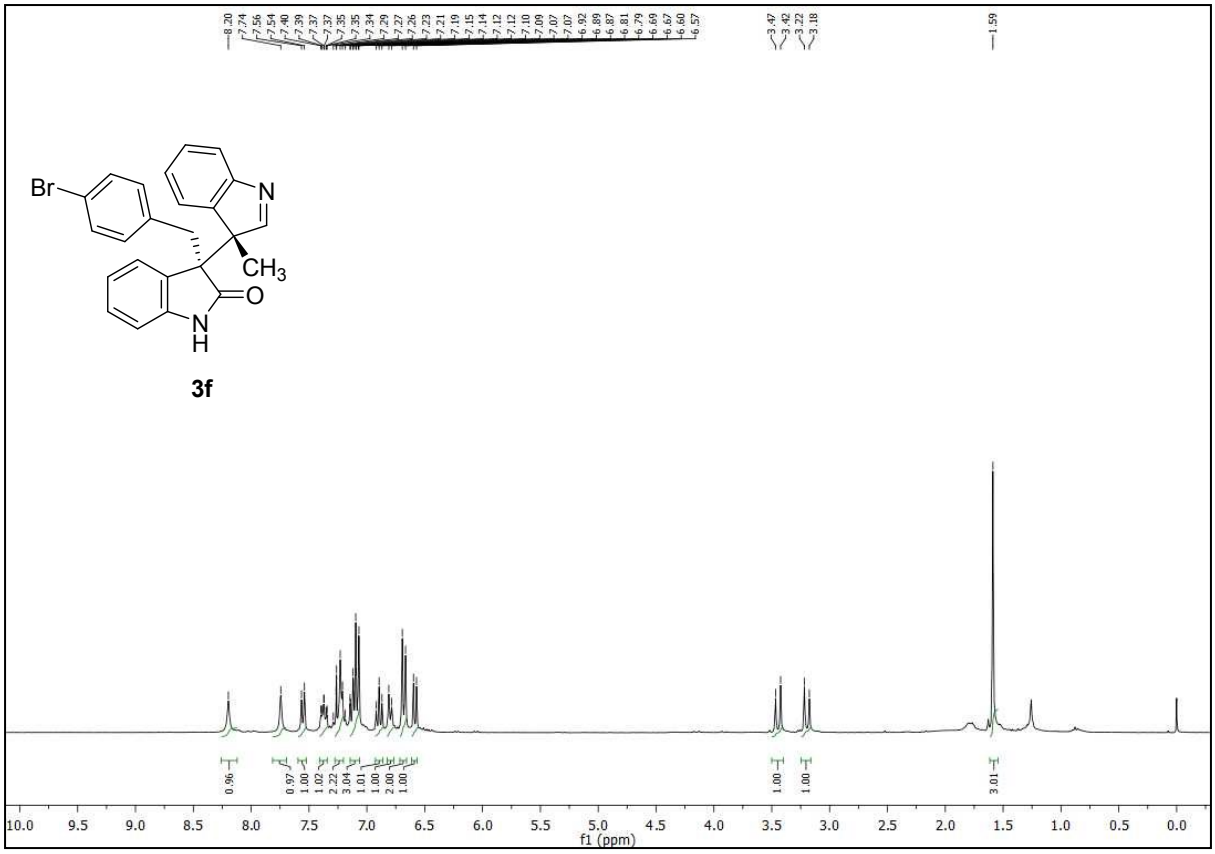
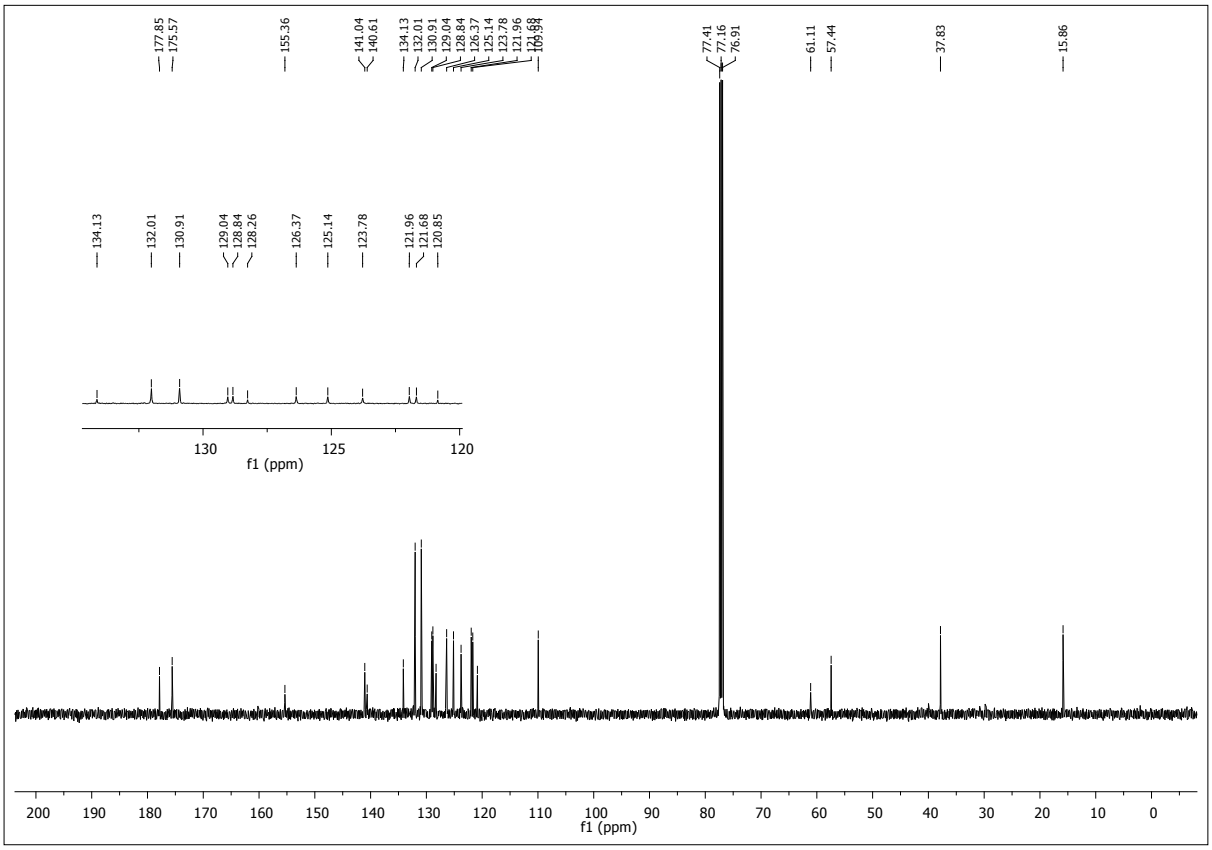
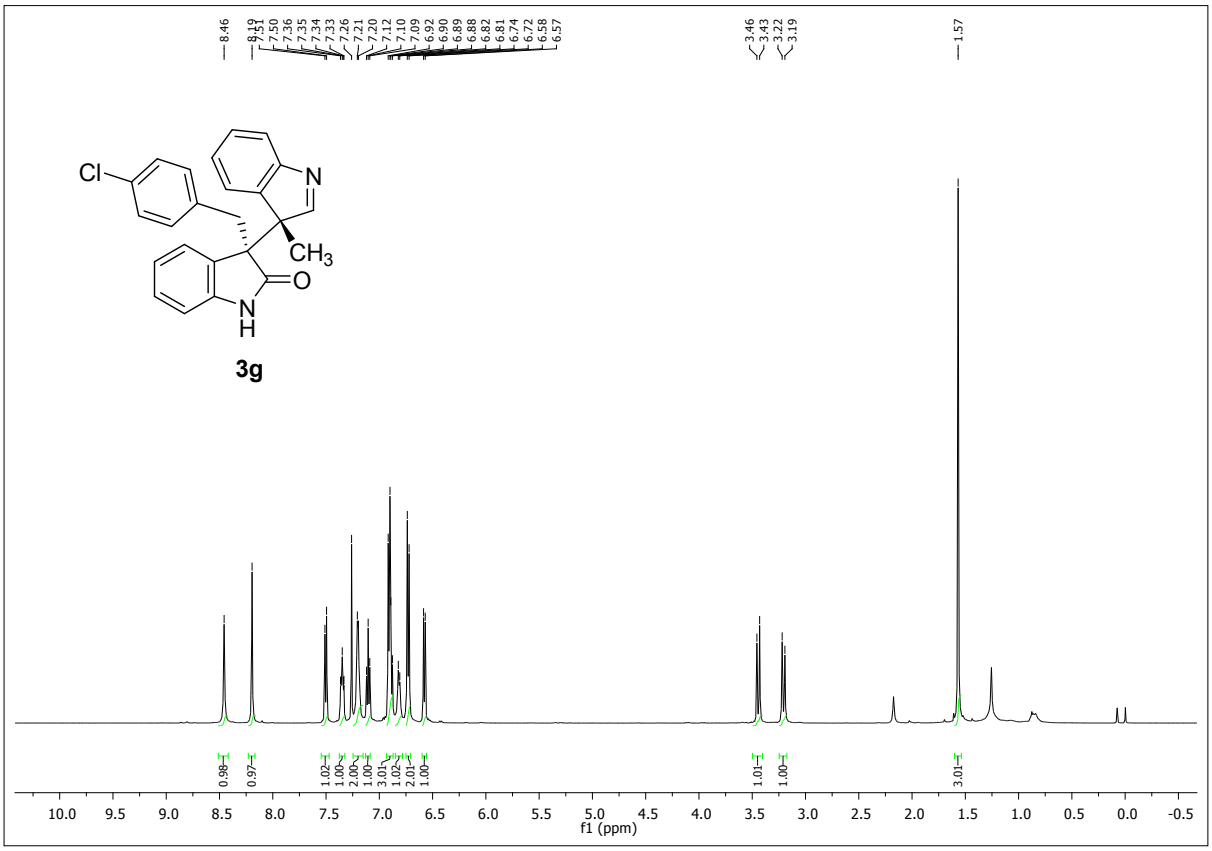
140.82
136.07
131.92
130.11
128.74
128.70
128.51
126.25
125.17
123.75
121.72
121.58
109.79
77.58
77.16
76.74
61.17
57.61
37.97
21.03
15.88
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

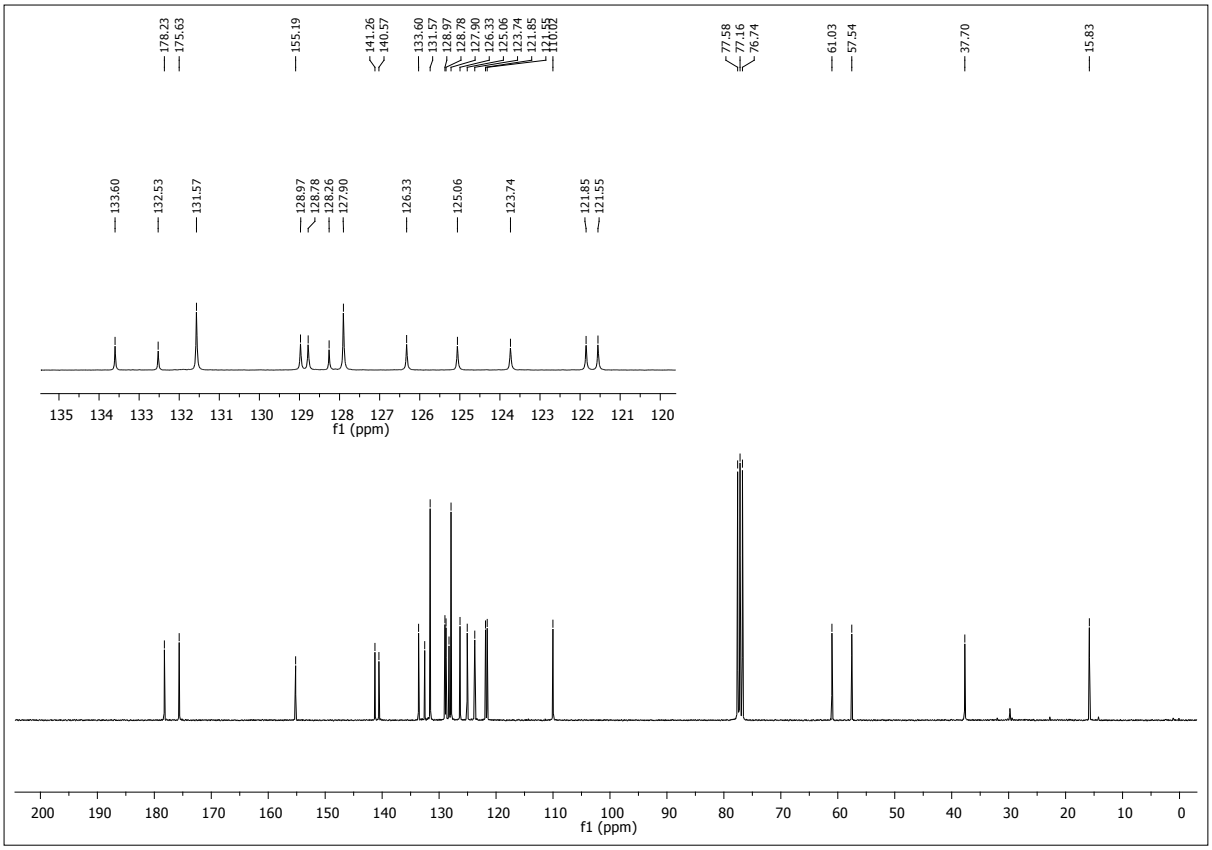


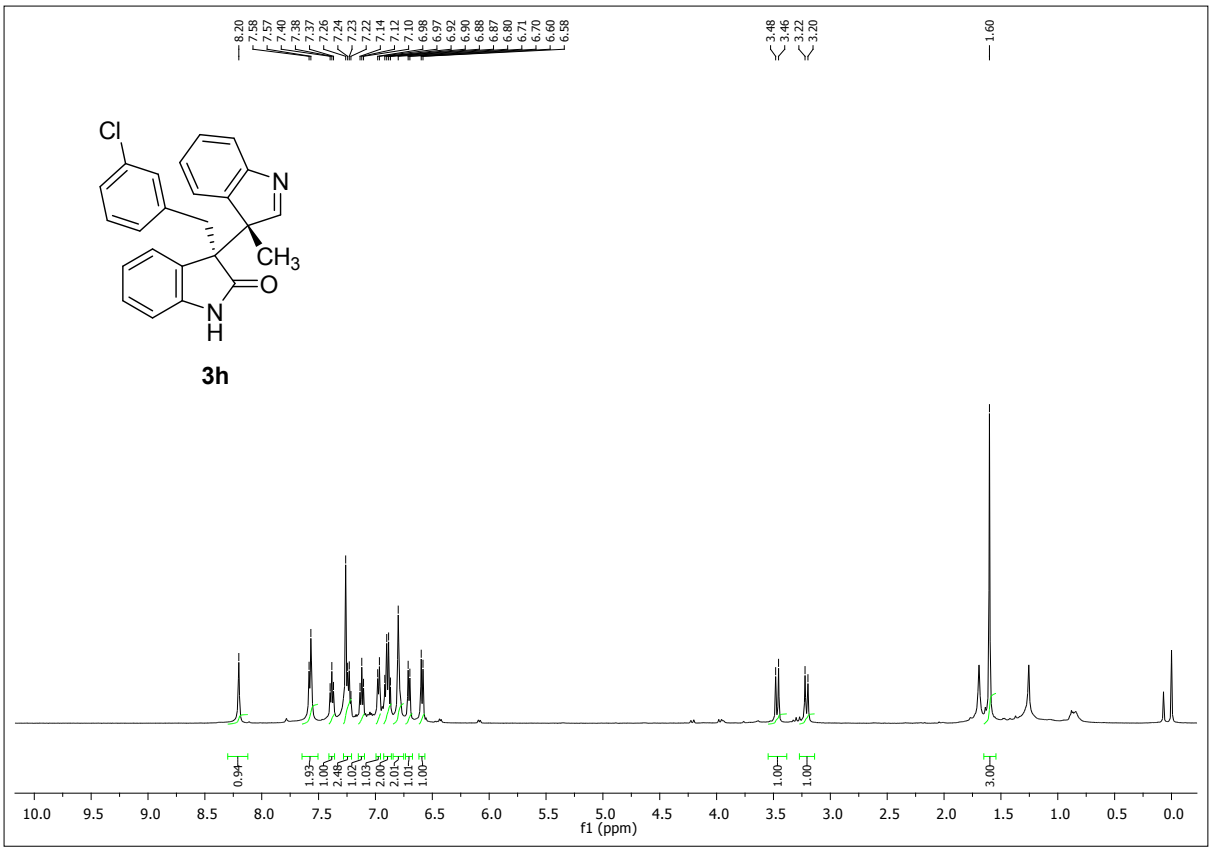
3f





3g

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7.57
7.40
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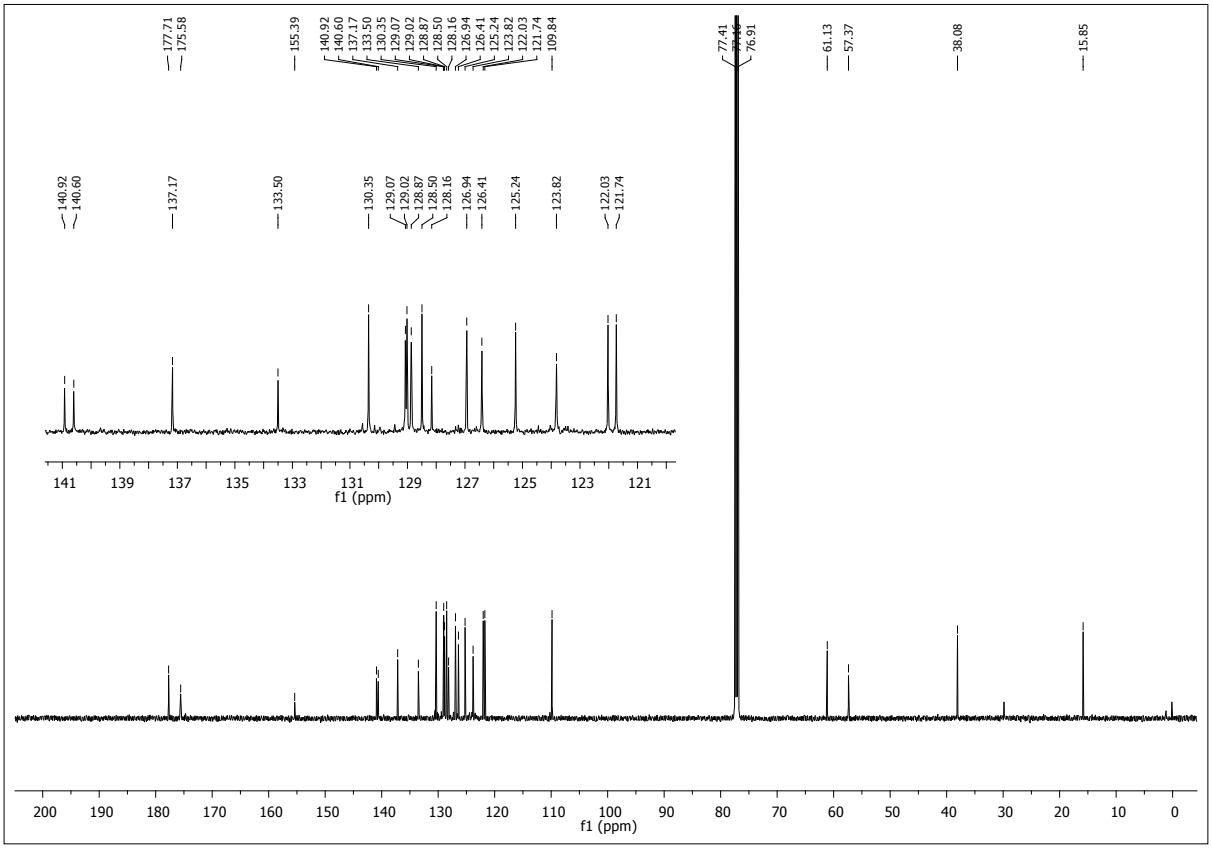
7.37
7.26
7.24
7.23
7.22
7.14
7.12
7.10
6.98
6.97
6.92
6.90
6.88
6.87
6.80
6.71
6.70
6.60
6.58
3.48
3.46
3.22
3.20
1.60
Cl
N
CH3
O
N
H
3h
0.94
1.93
1.00
2.48
1.02
1.03
2.00
2.01
1.01
1.00
1.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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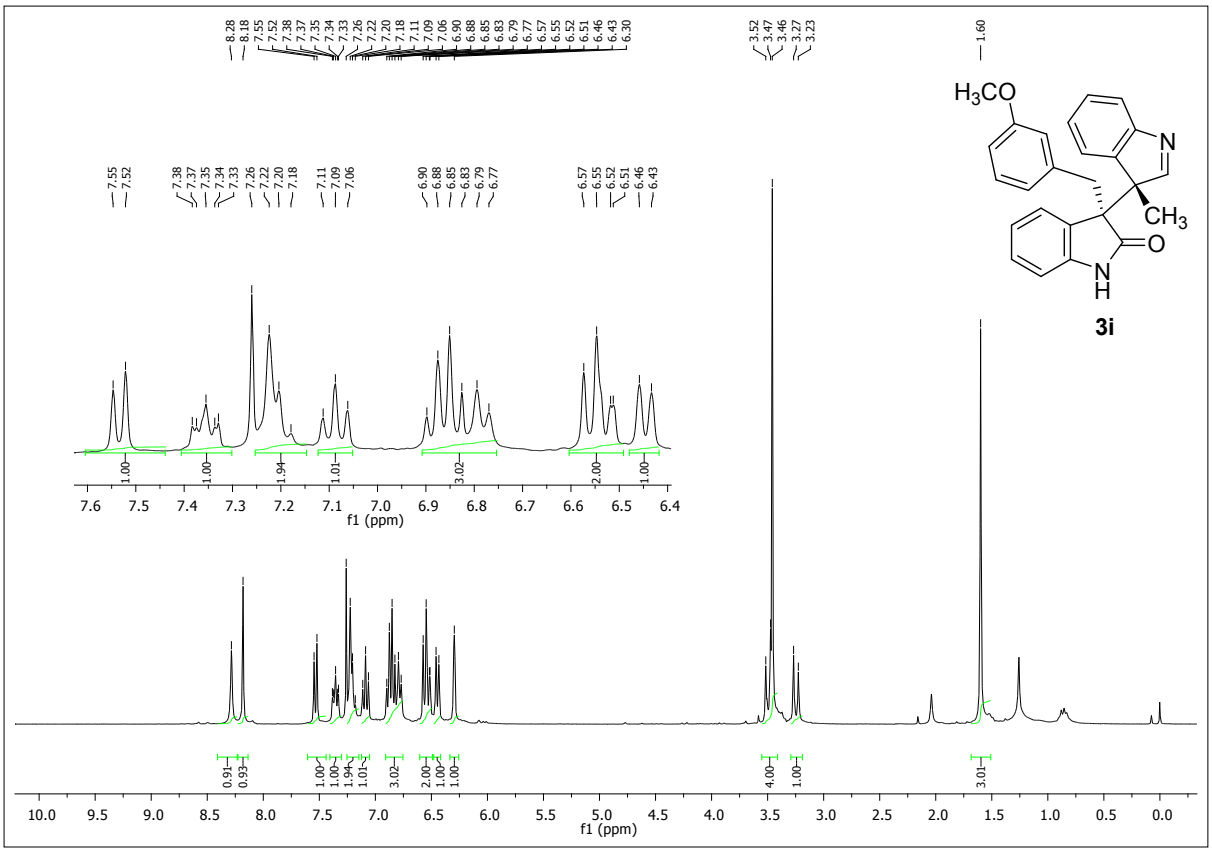
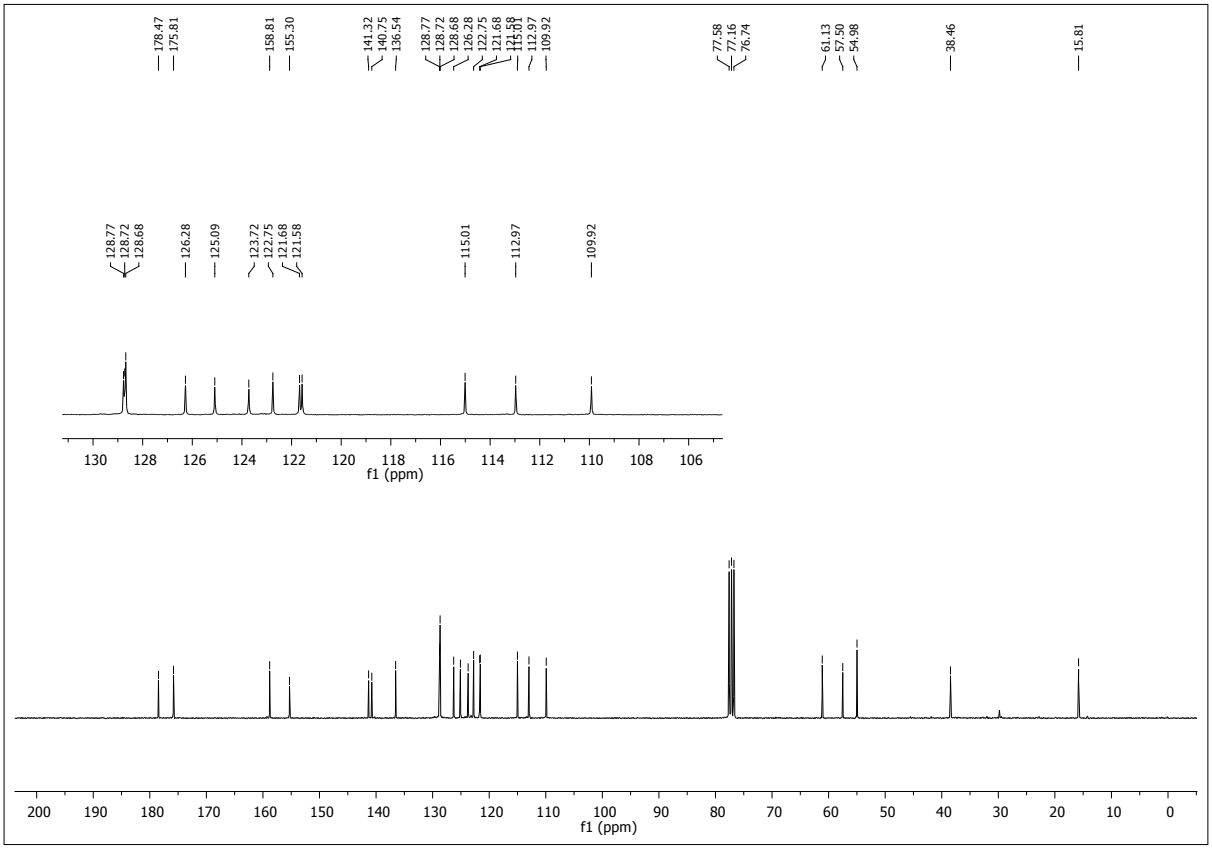
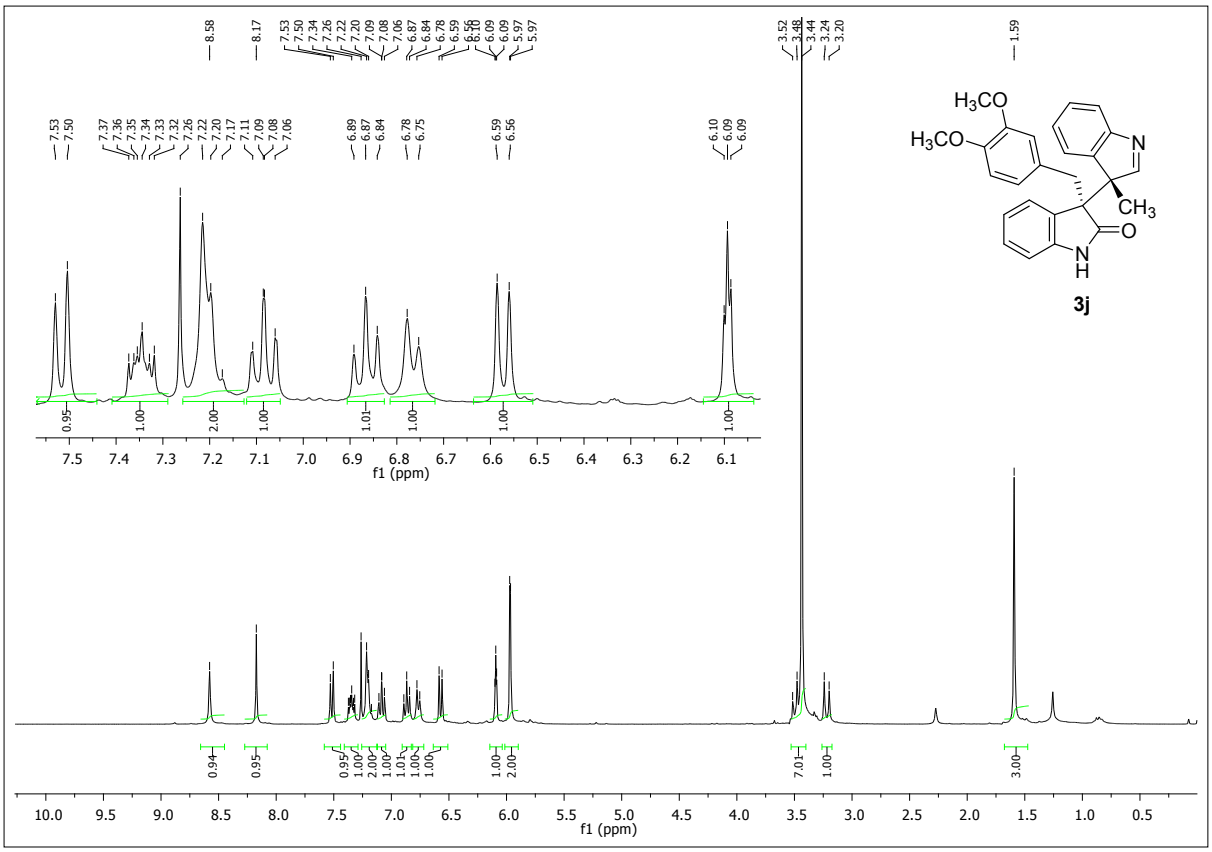
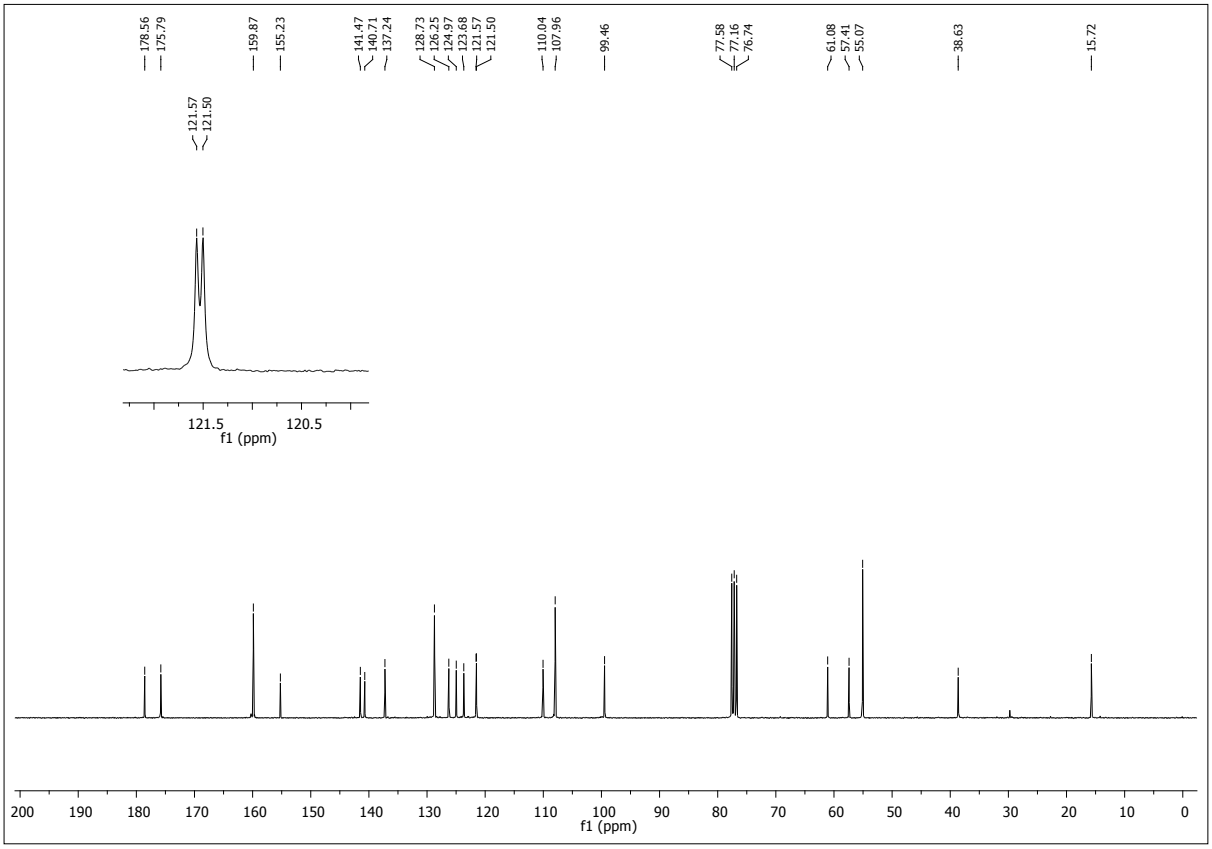
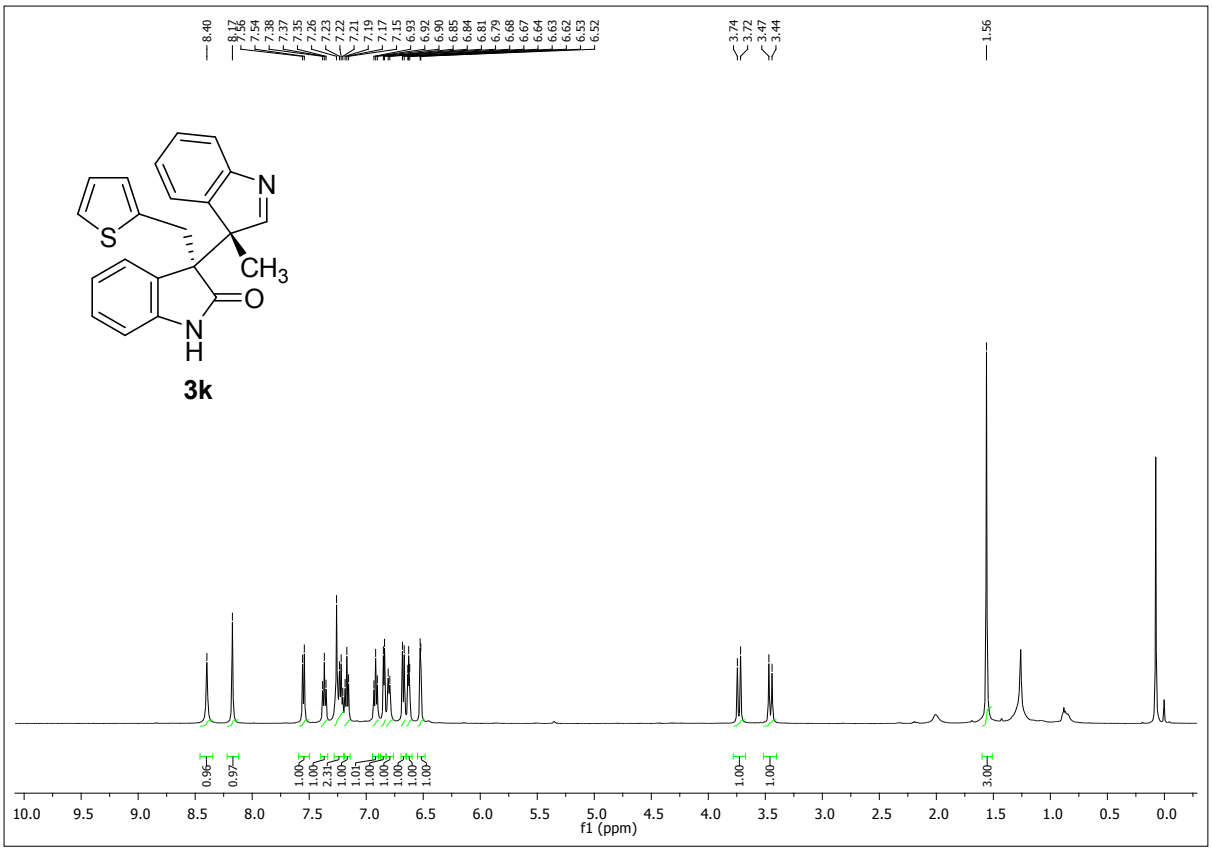
137.17
133.50
130.35
129.07
129.02
128.87
128.50
128.16
126.94
126.41
125.24
123.82
122.03
121.74
109.84
77.41
77.16
76.91
61.13
57.37
38.08
15.85
141 139 137 135 133 131 129 127 125 123 121
f1 (ppm)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


3i
f1 (ppm)


f1 (ppm)


3j
f1 (ppm)


f1 (ppm)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7.22
7.21
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7.17
7.15
6.93
6.92
6.90
6.85
6.84
6.81
6.79
6.68
6.67
6.64
6.63
6.62
6.53
6.52
3.74
3.72
3.47
3.44
1.56
N
S
CH3
O
N
H
3k
0.96
0.97
1.00
1.00
2.31
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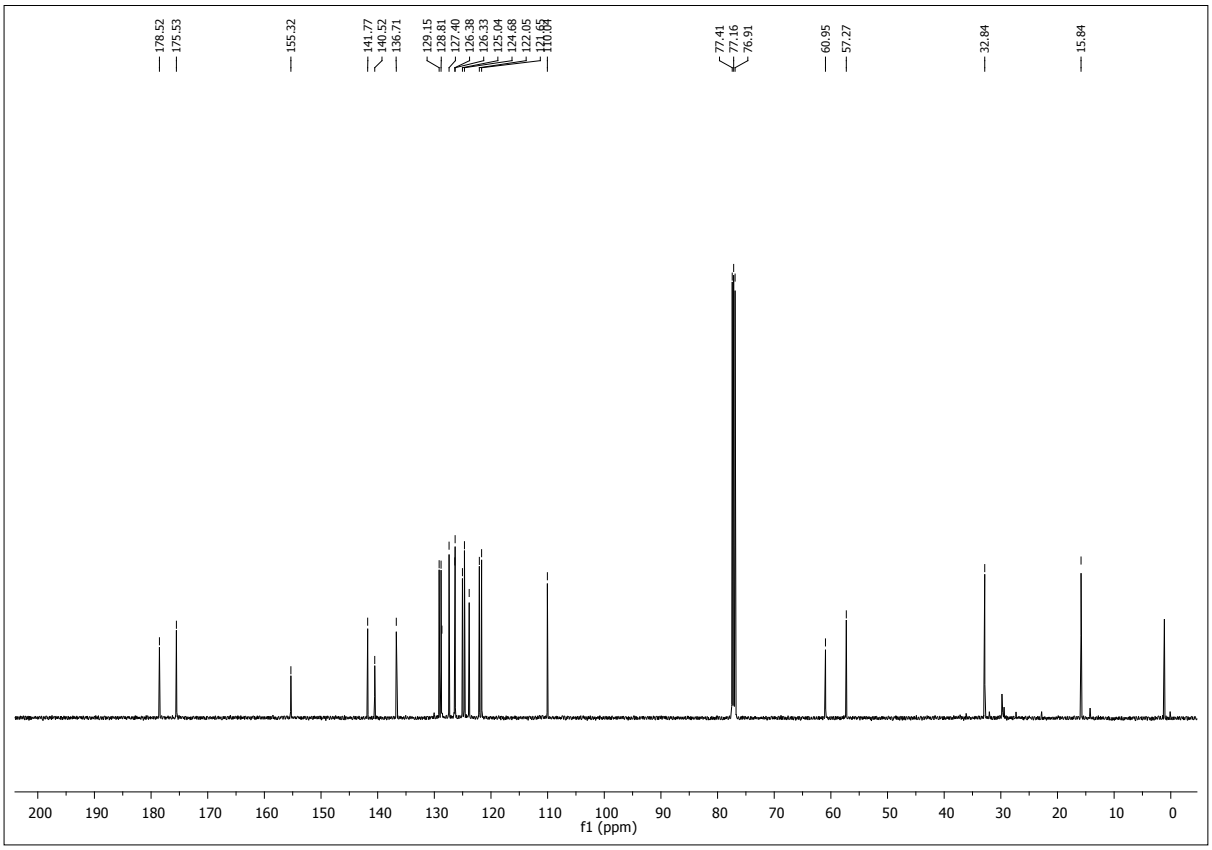
1.01
1.00
1.00
1.00
1.00
1.00
1.00
3.00
f1 (ppm)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127.40
126.38
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122.05
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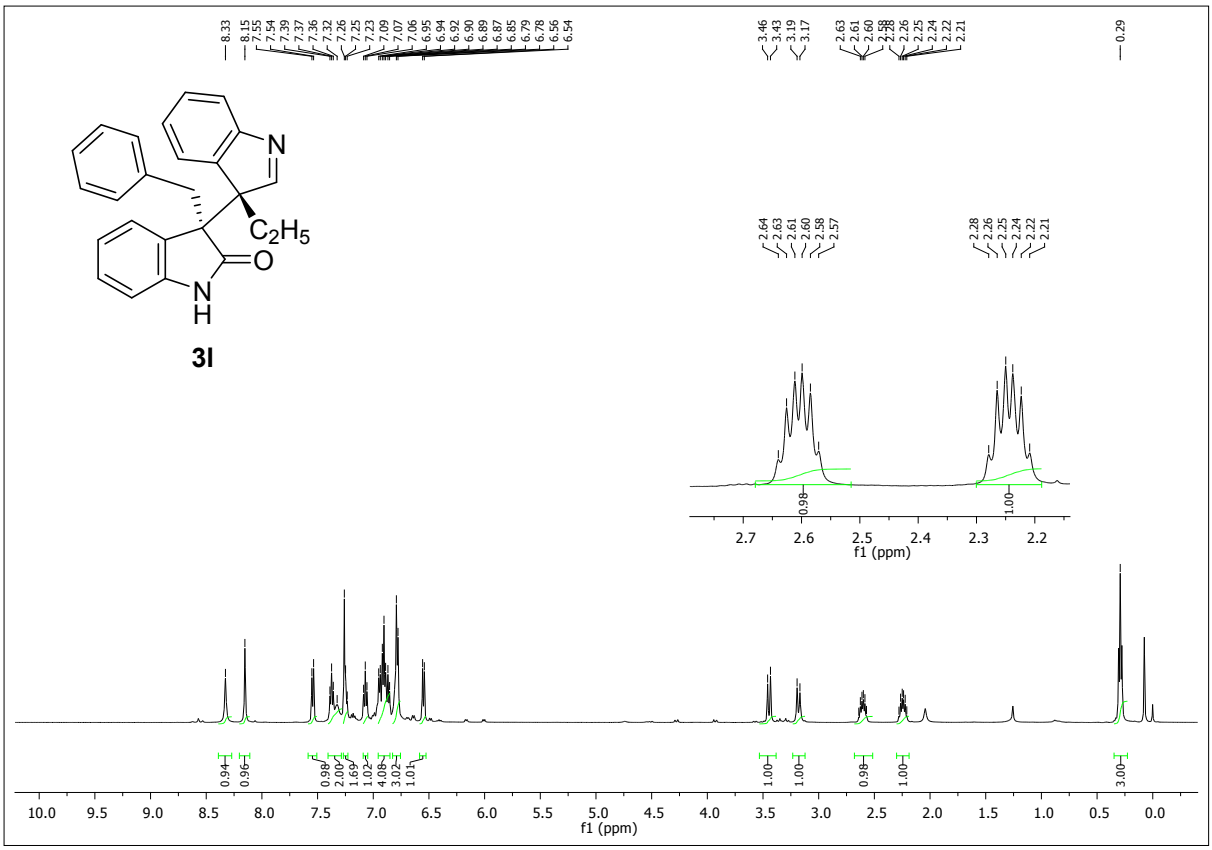
77.16
76.91
60.95
57.27
32.84
15.84
f1 (ppm)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7.23
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7.07
7.06
6.95
6.94
6.92
6.90
6.89
6.87
6.85
6.79
6.78
6.56
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3.17
2.63
2.61
2.60
2.58
2.57
2.28
2.26
2.25
2.24
2.22
2.21
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N
C2H5
O
N
H
3l
2.64
2.63
2.61
2.60
2.58
2.57
2.28
2.26
2.25
2.24
2.22
2.21
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2.7
2.6
2.5
2.4
2.3
2.2
f1 (ppm)
0.94
0.96
0.98
2.00
1.69
1.03
1.02
4.08
3.02
1.01
1.00
1.00
0.98
1.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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3.0
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2.0
1.5
1.0
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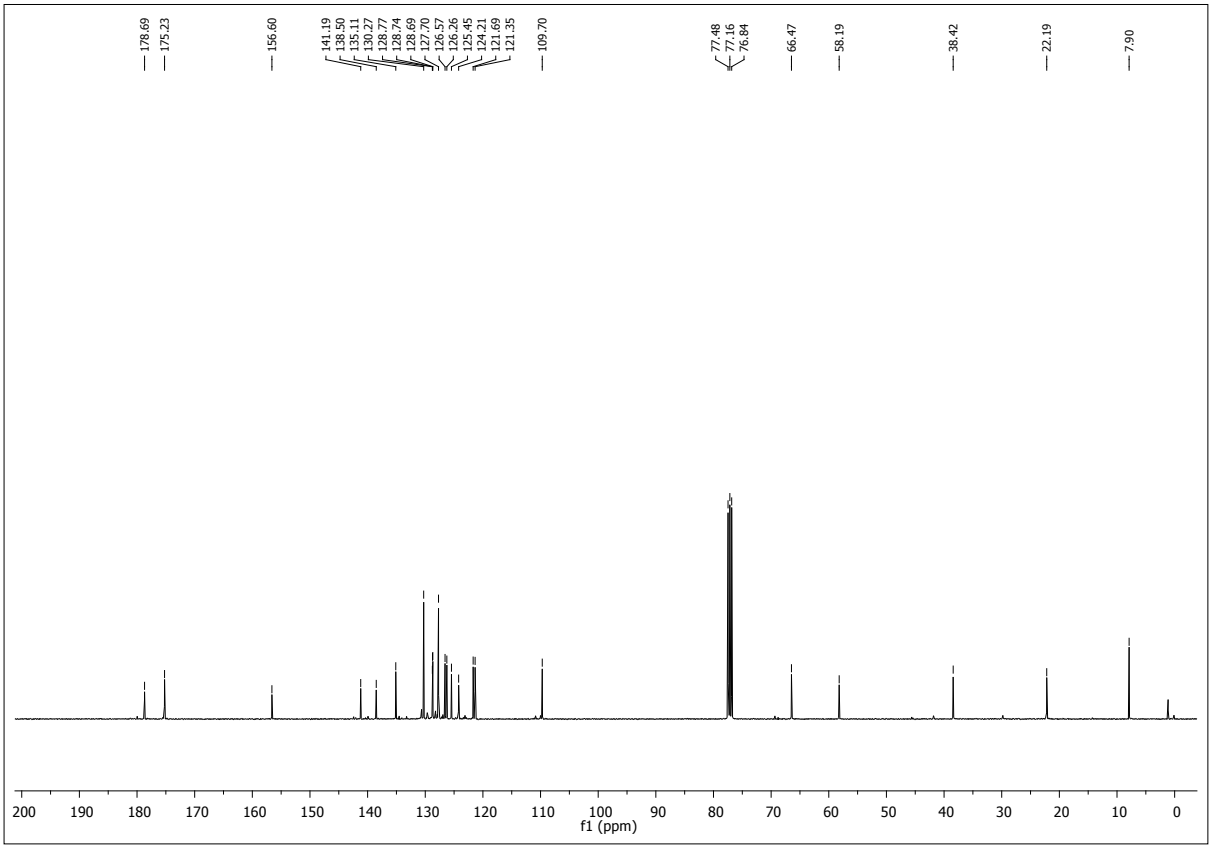
0.0
f1 (ppm)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126.26
125.45
124.21
121.69
121.35
109.70
77.48
77.16
76.84
66.47
58.19
38.42
22.19
7.90
200
190
180
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110
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70
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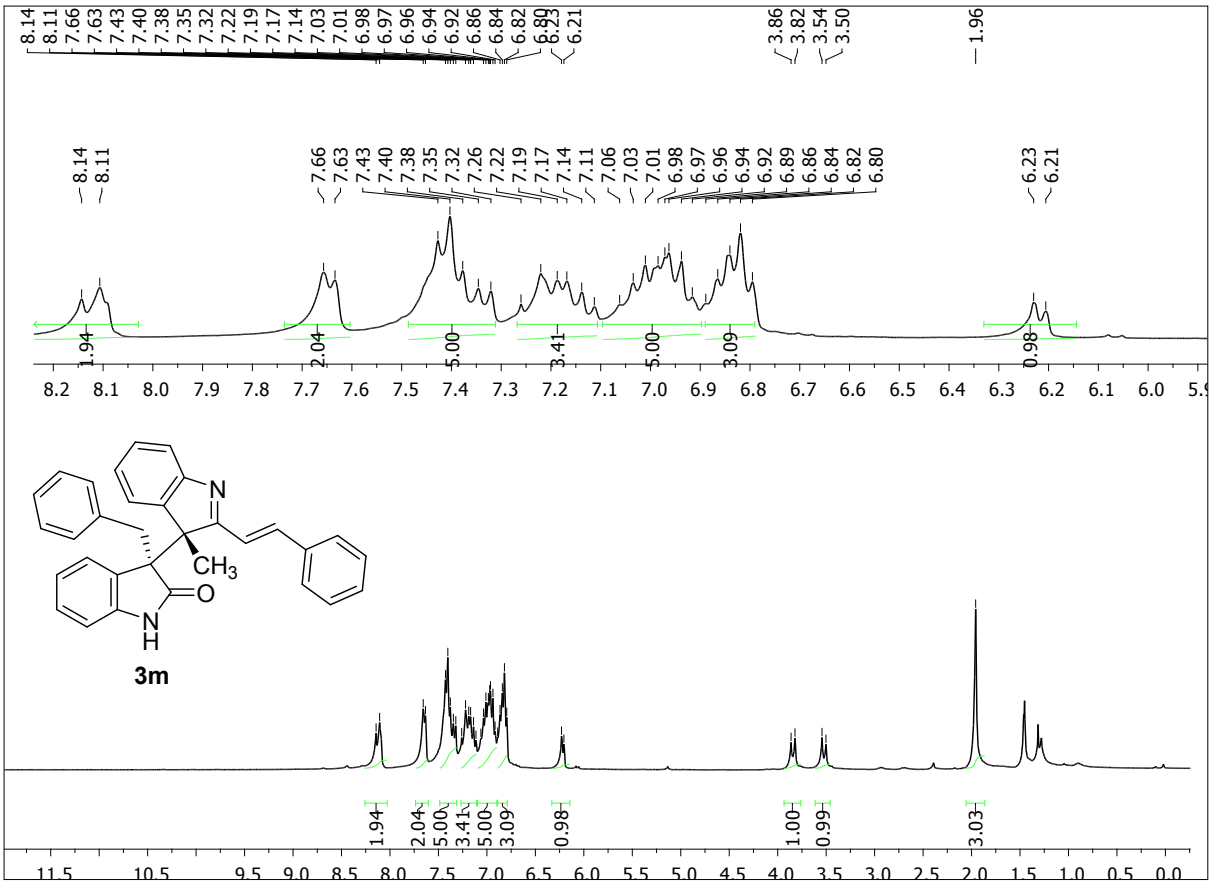
50
40
30
20
10
0
f1 (ppm)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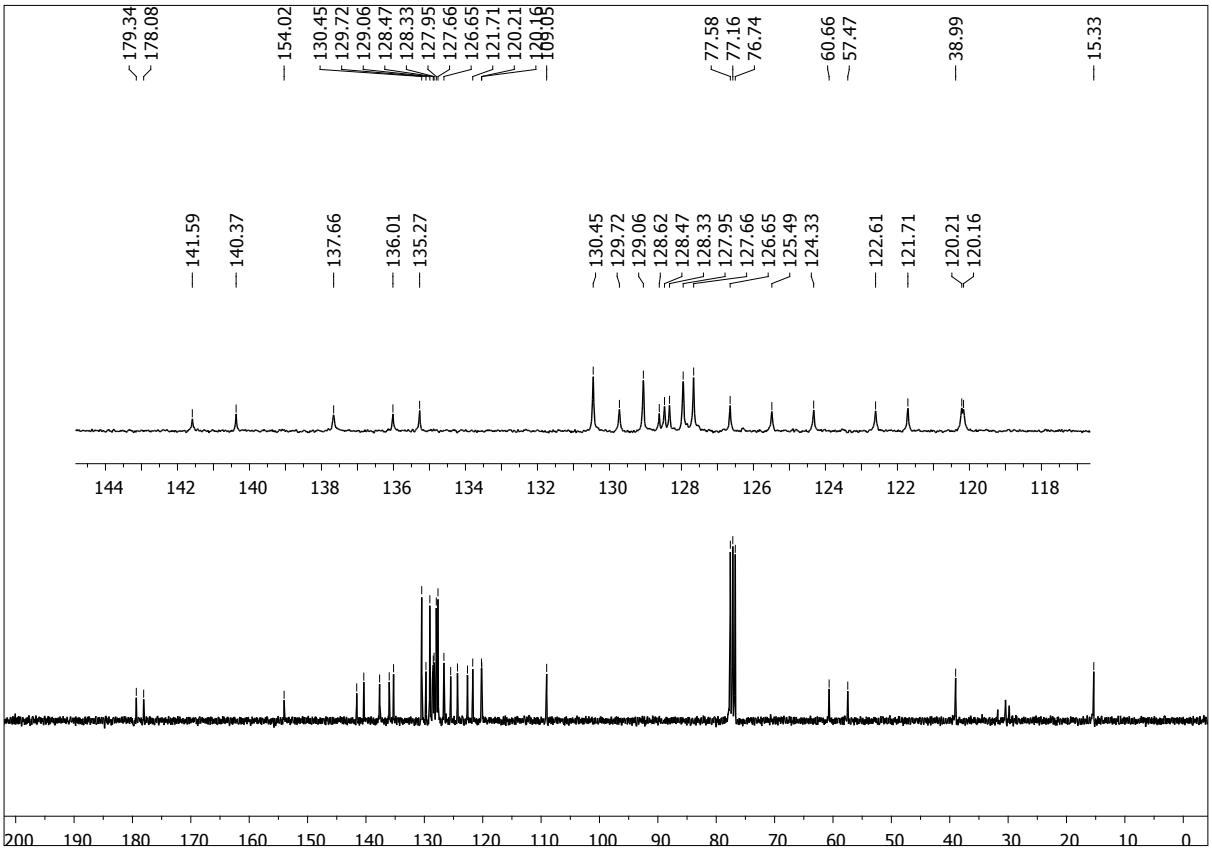

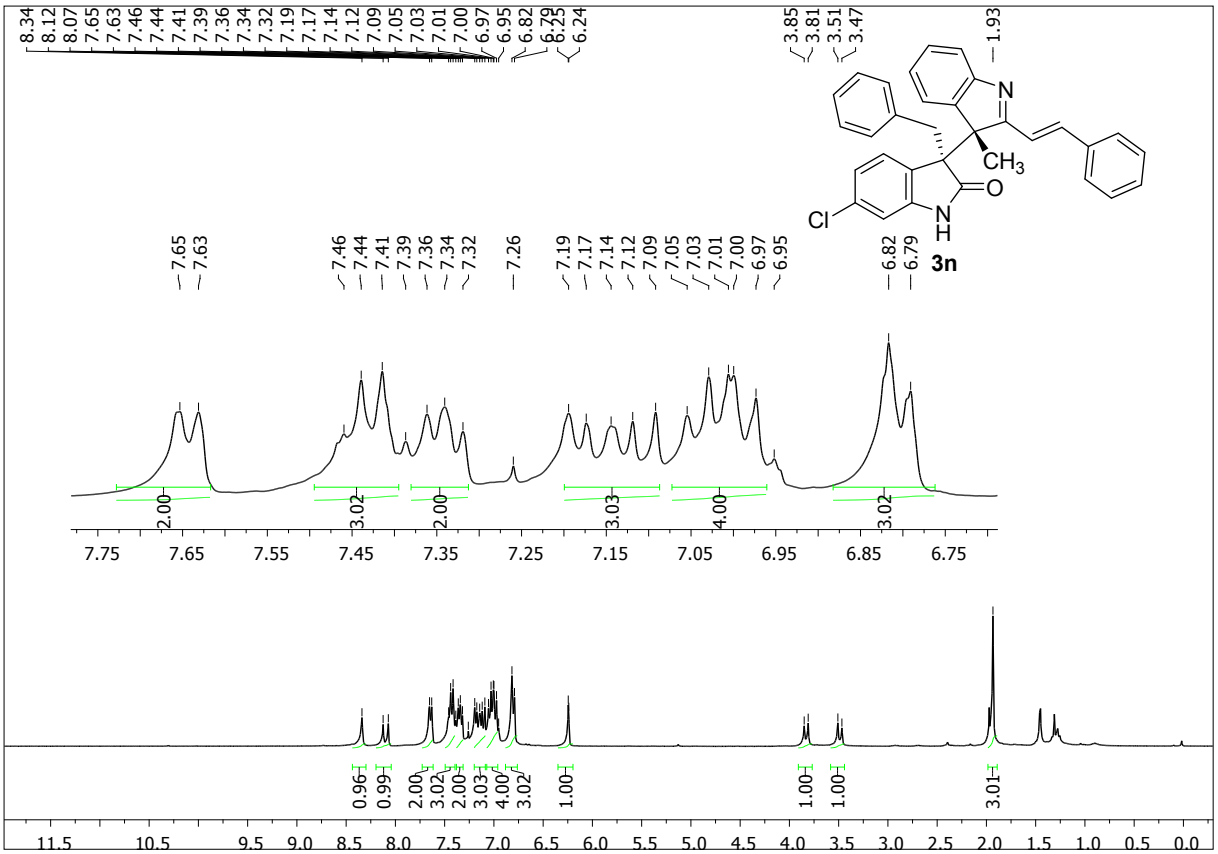
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7.36
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7.32
7.19
7.17
7.14
7.12
7.09
7.05
7.03
7.01
7.00
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6.95
6.82
6.79
6.25
6.24
3.85
3.81
3.51
3.47
1.93
N
CH3
O
Cl
N
H
3n
7.65
7.63
7.46
7.44
7.41
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7.36
7.34
7.32
7.26
7.19
7.17
7.14
7.12
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7.05
7.03
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6.97
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7.25
7.15
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6.95
6.85
6.75
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3.02
2.00
3.03
4.00
3.02
1.00
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1.00
3.01
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8.0
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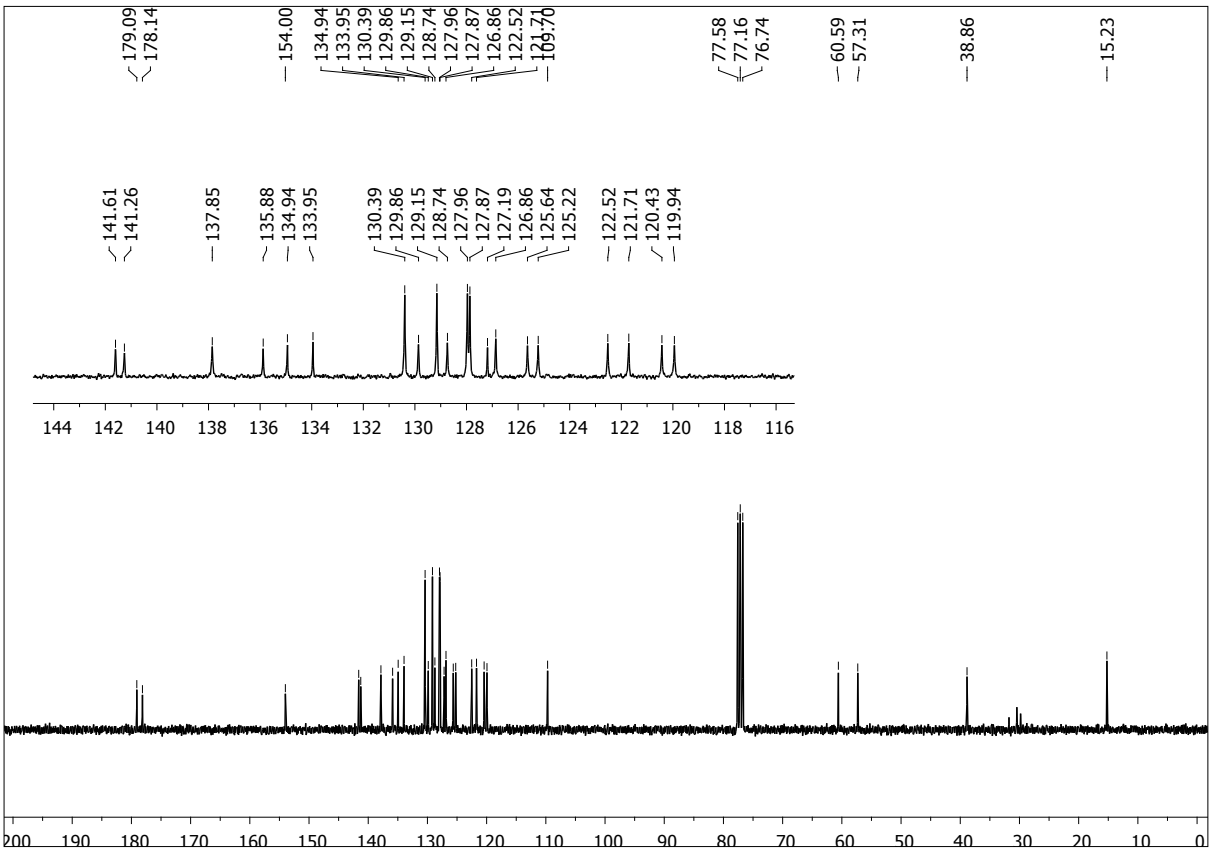
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60.59
57.31
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135.88
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133.95
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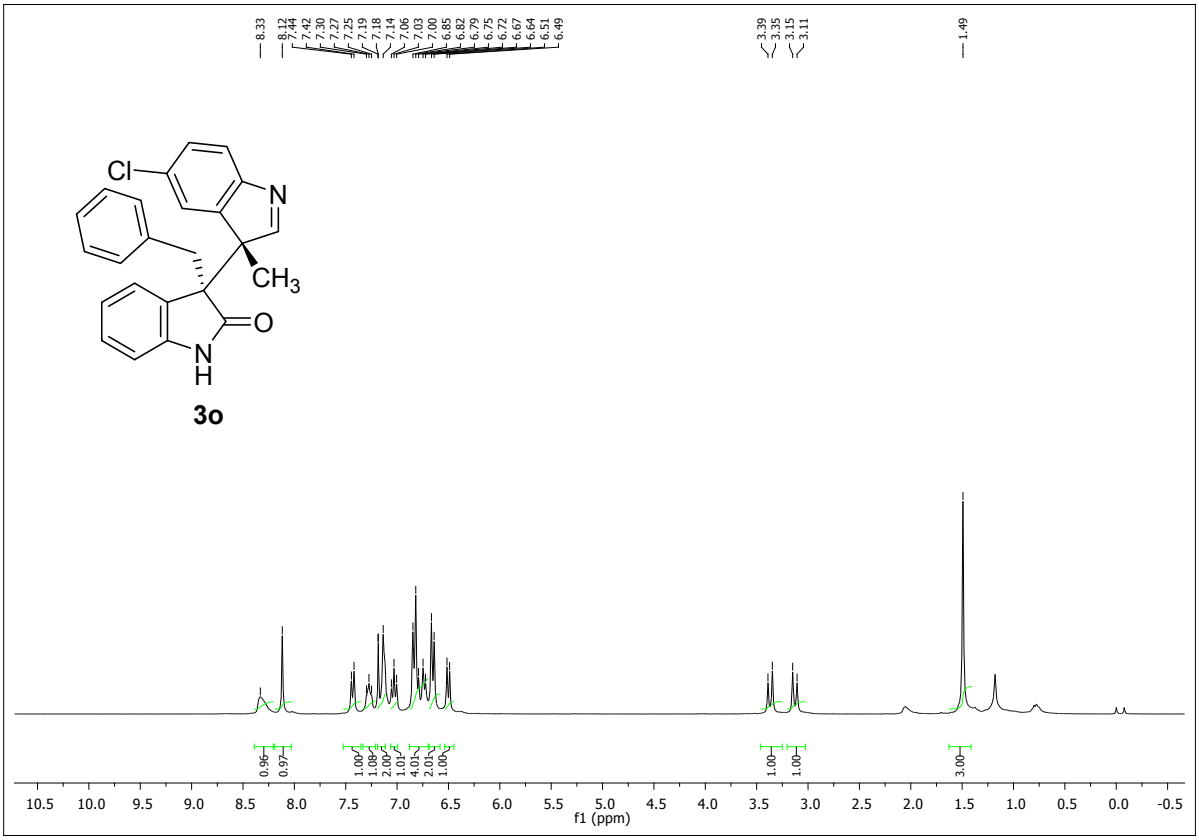
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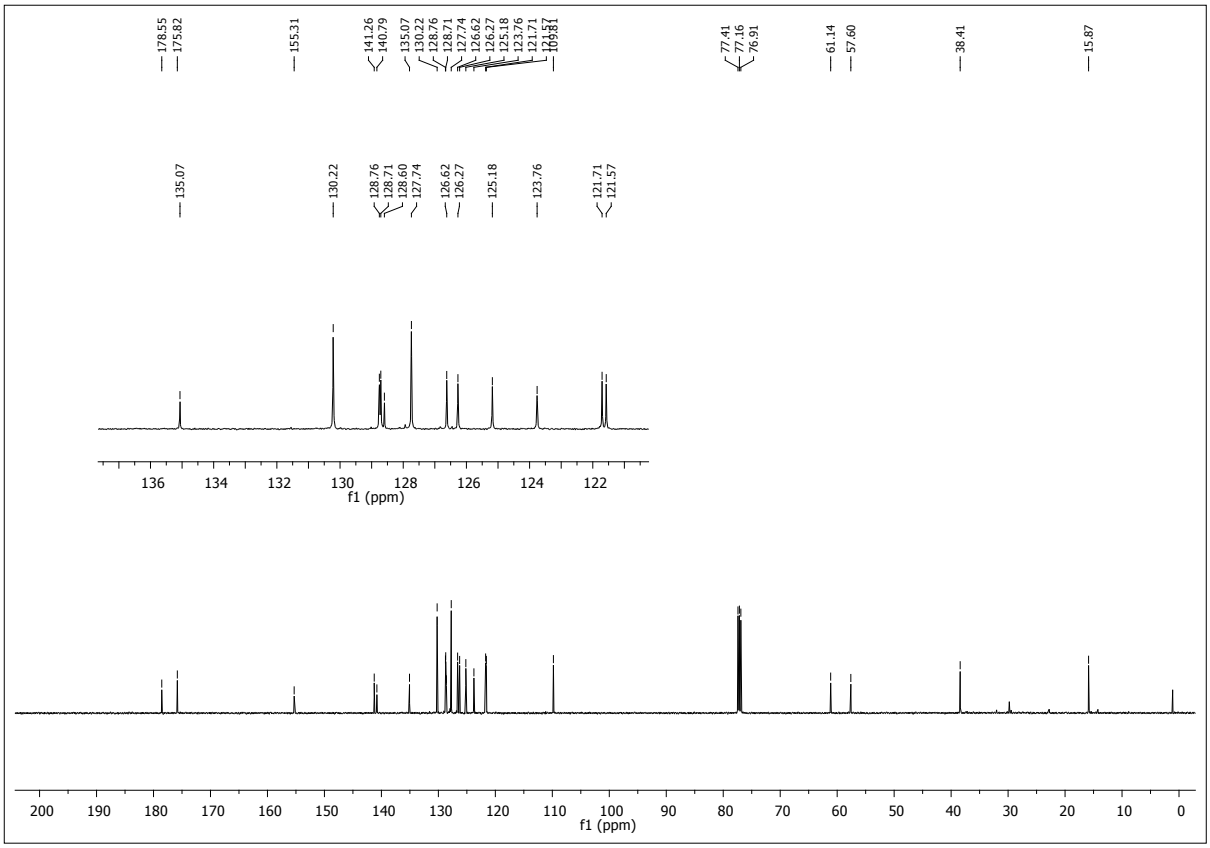
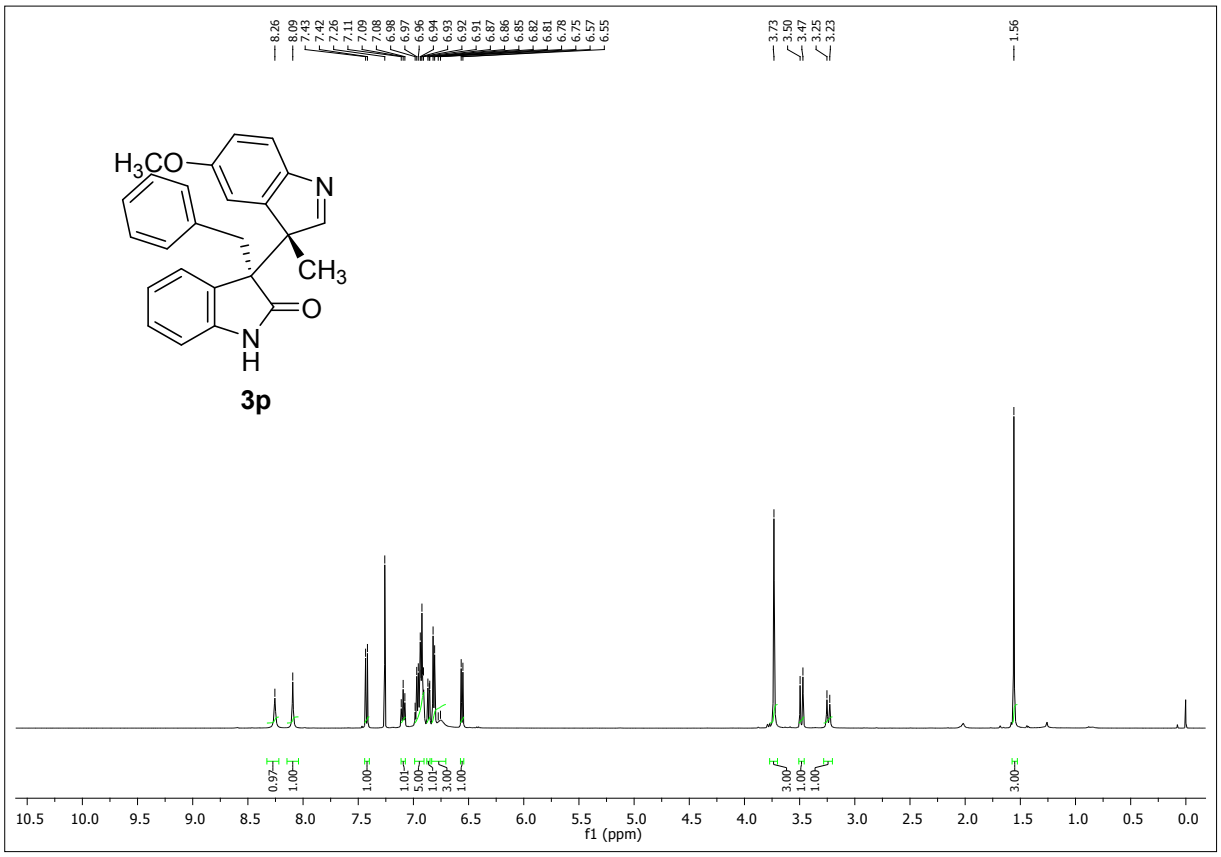
f1 (ppm)


f1 (ppm)
f1 (ppm)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6.92
6.91
6.87
6.86
6.85
6.82
6.81
6.78
6.75
6.57
6.55
3.73
3.50
3.47
3.25
3.23
1.56
H3CO
N
CH3
O
N
H
3p
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1.00
1.00
1.01
5.00
1.01
3.00
1.00
3.00
1.00
1.00
3.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
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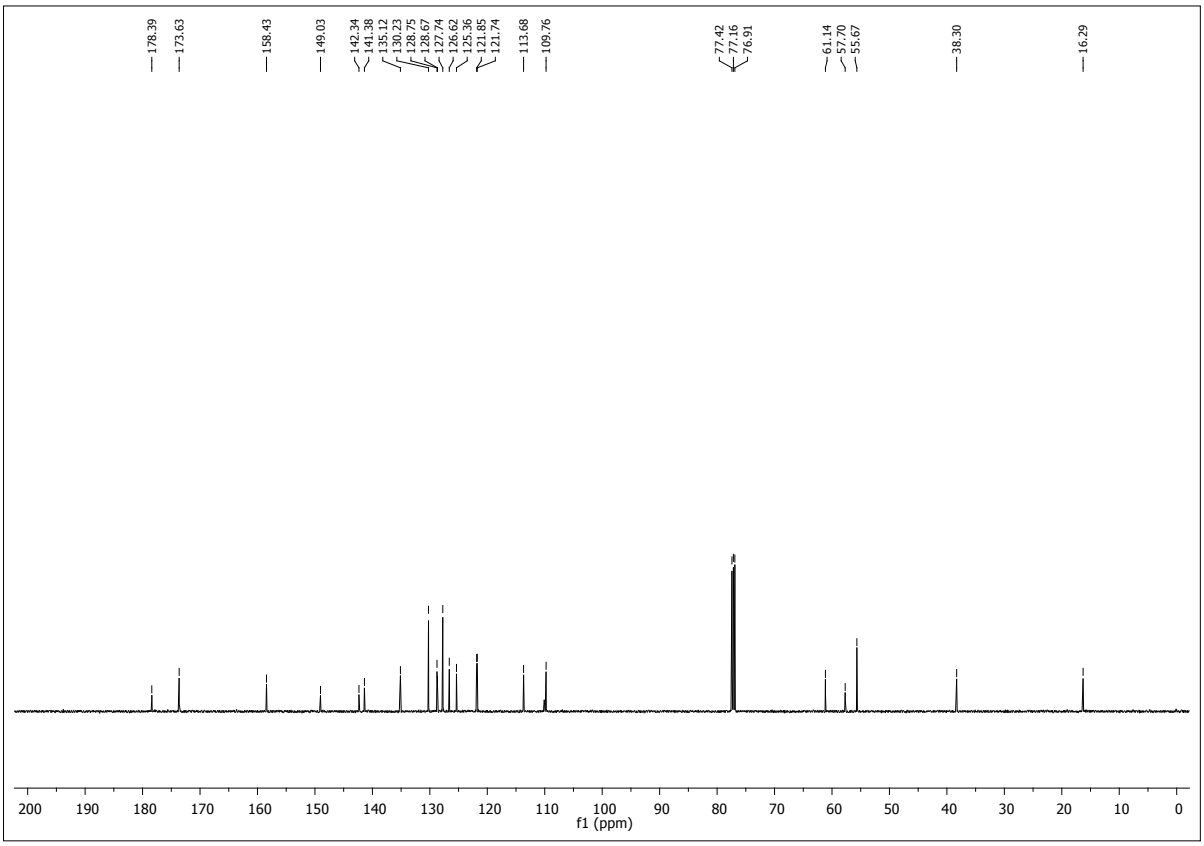
0.0
f1 (ppm)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77.16
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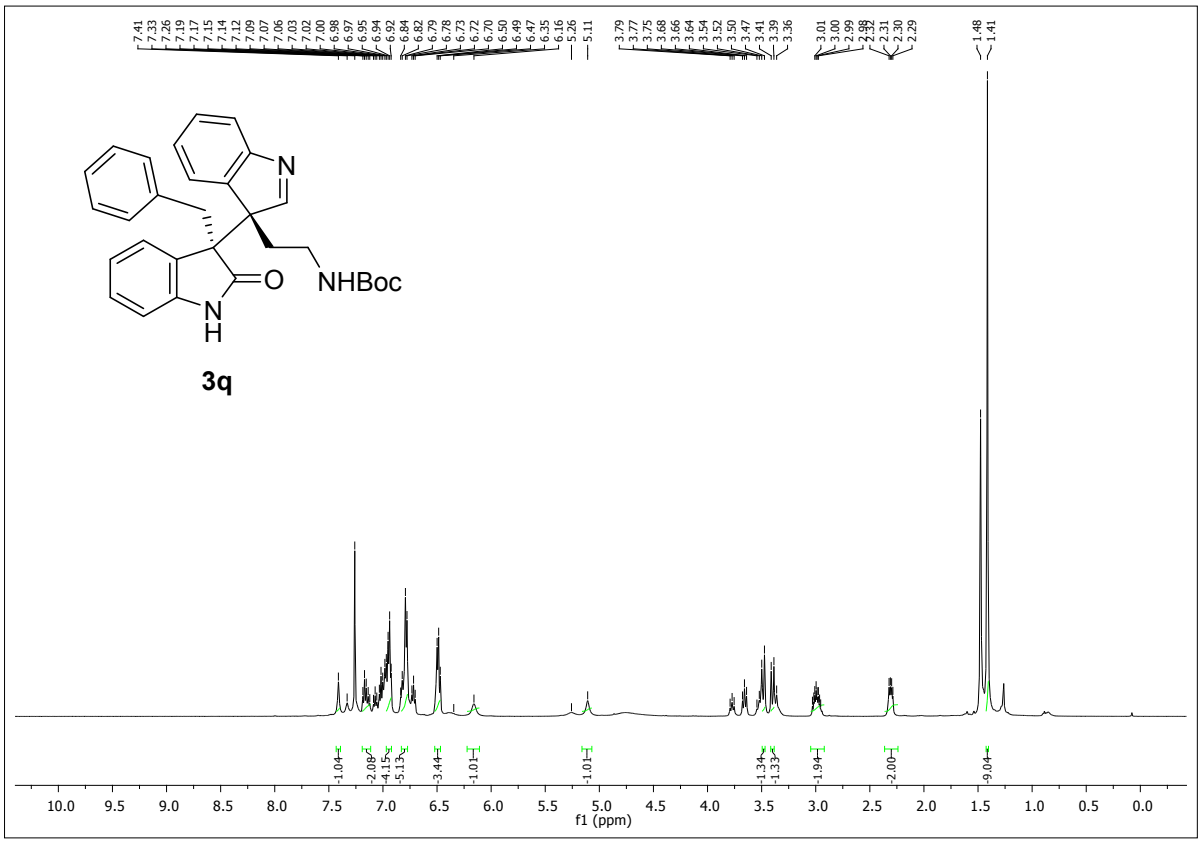
f1 (ppm)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6.97
6.95
6.94
6.92
6.84
6.82
6.79
6.78
6.73
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6.70
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6.47
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6.16
5.26
5.11
3.79
3.77
3.75
3.68
3.66
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3.50
3.47
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3.39
3.36
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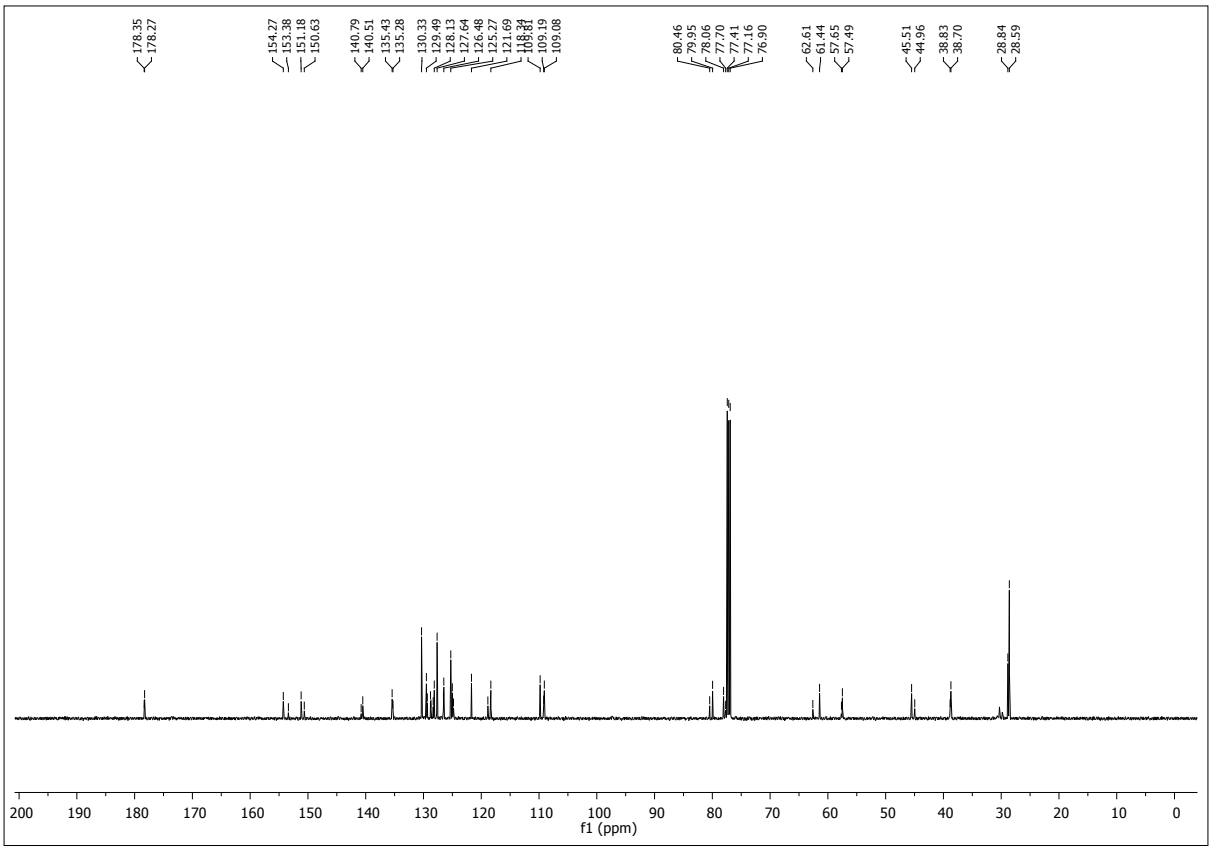
3.00
2.99
2.98
2.32
2.31
2.30
2.29
1.48
1.41
N
O
NHBoc
N
H
3q
1.04
2.08
4.15
5.13
3.44
1.01
1.01
1.34
1.33
1.94
2.00
9.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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125.27
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118.34
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109.19
109.08
80.46
79.95
78.06
77.70
77.41
77.16
76.90
62.61
61.44
57.65
57.49
45.51
44.96
38.83
38.70
28.84
28.59
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)