Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry

Supporting Information

Synthesis of 3,3-Disubstituted Oxindoles by One-pot Integrated Brønsted Base-catalyzed Trichloroacetimidation of 3-Hydroxyoxindoles and Brønsted Acid-catalyzed Nucleophilic Substitution Reaction

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General information:

Reagents and solvents were purchased from commercial sources (Aldrich, Acros, Merck, Fluka and VWR international) and stored under argon. More sensitive compounds were stored in a desiccator or glove box if required. Reagents were used without further purification unless otherwise noted.

All reactions were performed under argon (or nitrogen). When needed, glassware was dried overnight in an oven (T > 130 °C) and under vacuum with a heat gun (T > 200 °C).

When solvents are indicated as dry they were either purchased as such, distilled prior to use or dried by a passage through a column of anhydrous alumina or copper using a Puresolv MD 5 from Innovative Technology Inc., based on the Grubbs' design [Pangborn, A. B. et al. *Organometallics* **1996,** *15,* 1518–1520].

Flash column chromatography was performed using Fluka 60 Å silica gel: 230-400 mesh (40-63 μm) silica.

Reactions were monitored using Merck Kieselgel 60 F_{254} aluminium. TLC's were visualized by UV fluorescence (254 nm) then one of the following: $KMnO_4$, ninhydrine, phosphomolybdic acid, *p*-anisaldehyde or vanillin.

NMR spectra were recorded on a Brüker Avance III-400, Brüker Avance-400 or Brüker DPX-400 spectrometer at room temperature; ^{1}H frequency is at 400.13 MHz, ^{13}C frequency is at 100.62. Chemical shifts (δ) were reported in parts per million (ppm) relative to tetramethylsilane (TMS) with the solvent resonance employed as the internal standard (ref: *$CDCl_3$ [^{1}H: 7.26, ^{13}C: 77.2], CD_3OD [^{1}H: 3.31, ^{13}C 49.0]).* Coupling constants (*J*) are reported in Hz to the nearest 0.1 Hz. Multiplicity is indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet) and br (broad). Attribution of peaks was done using the multiplicities and integrals of the peaks.

IR spectra were recorded in a Jasco FT/IR-4100 spectrometer outfitted with a PIKE technology MIRacle™ ATR accessory as neat films compressed onto a Zinc Selenide window. The spectra are reported in cm^{-1}. Abbreviations used are: w (weak), m (medium), s (strong) and br (broad).

Mass spectra were determined with a Waters ACQUITY H-class UPLC/MS ACQ-SQD by electron ionization (EI positive and negative) or a Finnigan TSQ7000 by electrospray ionization (ESI+). The accurate masses were done by the mass spectrometry service of the EPFL by ESI-TOF using a QTOF Ultima from Waters.

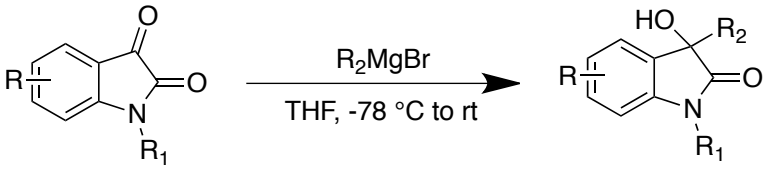
Melting points were determined using a Stuart SMP30 and were uncorrected.

All *N*-protected isatins were synthesized according to the reported procedures.[1]

[1] (a) B. M. Trost and Y. Zhang, *J. Am. Chem. Soc.*, 2007, **129**, 14548 – 14549; (b) N. Sin, B. L. Venables, X. Liu, S. Huang, Q. Gao, A. Ng, R. Dalterio, R. Rajamani and N. A. Meanwell, *J. Heterocyclic Chem.,* 2009, **46**, 432 – 442; (c) Y. Ferandin, K. Bettayeb, M. Kritsanida, O. Lozach, P. Polychronopoulos, P. Magiatis, A.-L. Skaltsounis and L. Meijer, *J. Med. Chem.,* 2006, **49**, 4638 – 4649.

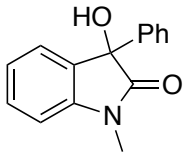
Synthesis of starting materials

General procedure A for compounds 1[2]



To a solution of N-protected indolin-2,3-dione (1 equiv) in dry THF (0.2 M) at -78 °C was added methylmagnesium bromide (3.0 M in Et_2O, 1.2 equiv) or phenylmagnesium bromide (1.0 M in THF, 1.2 equiv). The reaction mixture was allowed to warm to room temperature. The reaction was followed by TLC until completion. A saturated solution of NH_4Cl was added to quench the reaction. The aqueous layer was extracted with EtOAc (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by flash column chromatography on silica gel (EtOAc/petroleum ether) to afford pure N-protected 3-hydroxy-3-methylindolin-2-one or 3-hydroxy-3-phenylindolin-2-one.

3-hydroxy-1-methyl-3-phenylindolin-2-one (1a)



General procedure A was followed using 1-methylindolin-2,3-dione (400 mg, 2.48 mmol) and phenylmagnesium bromide (1.0 M in THF, 2.98 mL, 2.98 mmol) in dry THF (12 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **1a** as a slightly yellow solid (535 mg, 90%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.31 – 7.11 (m, 7H), 6.97 (td, *J* = 7.6, 1.0 Hz, 1H), 6.79 (br d, *J* = 7.8 Hz, 1H), 3.56 (br s, 1H), 3.12 (s, 3H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.7, 143.6, 140.2, 131.7, 130.0, 128.7, 128.4, 125.5, 125.1, 123.7, 108.8, 78.1, 26.6.

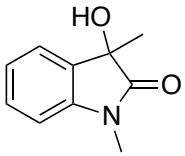
ATR-IR v 3383 (br), 1704 (s), 1613 (s), 1492 (w), 1470 (m), 1371 (m), 1351 (m), 1190 (w), 1089 (m), 1027 (w), 929 (w), 909 (w), 752 (m), 729 (m), 698 (m), 642 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{13}NNaO_2$, $[M+Na]^+$: 262.0838, found: 262.0842.

Mp: 141-142 °C (lit.[3] 141-142 °C).

3-hydroxy-1,3-dimethylindolin-2-one (1b)

[2] B. M. Trost and M. U. Frederiksen, *Angew. Chem. Int. Ed.,* 2005, **44**, 308 – 310.
[3] S. Kafka, A. Klasek and J. Kosmrlj, *J. Org. Chem.,* 2001, **66**, 6394 – 6399.



General procedure A was followed using 1-methylindolin-2,3-dione (800 mg, 4.96 mmol) and methylmagnesium bromide (3.0 M in Et_2O, 1.99 mL, 5.96 mmol) in dry THF (25 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:1) to afford the title compound **1b** as a white solid (660 mg, 75%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.41 (dd, *J* = 7.8, 1.0 Hz, 1H), 7.33 (td, *J* = 7.8, 1.0 Hz, 1H), 7.11 (td, *J* = 7.8, 1.0 Hz, 1H), 6.84 (d, *J* = 7.8 Hz, 1H), 3.20 (s, 3H), 3.01 (br s, 1H), 1.61 (s, 3H).

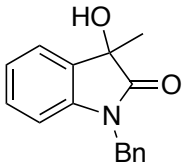
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.7, 143.0, 131.5, 129.8, 123.6, 123.4, 108.7, 73.8, 26.4, 25.0.

ATR-IR v 3315 (br), 1698 (s), 1618 (m), 1497 (w), 1472 (w), 1382 (w), 1355 (w), 1220 (w), 1130 (w), 1098 (w), 1028 (w), 941 (w), 750 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{10}H_{11}NNaO_2$, $[M+Na]^+$: 200.0682, found: 200.0687.

Mp: 140-143 °C (lit.[4] 140-142 °C).

1-benzyl-3-hydroxy-3-methylindolin-2-one (1c)



General procedure A was followed using 1-benzyl indolin-2,3-dione (2.0 g, 8.43 mmol) and methylmagnesium bromide (3.0 M in Et_2O, 3.37 mL, 10.1 mmol) in dry THF (42 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **1c** as a white solid (1.56 g, 73%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.42 (ddd, *J* = 7.5, 1.3, 1.0 Hz, 1H), 7.34 – 7.25 (m, 5H), 7.20 (td, *J* = 7.5, 1.3 Hz, 1H), 7.07 (td, *J* = 7.5, 1.0 Hz, 1H), 6.72 (d, *J* = 7.8 Hz, 1H), 4.97 (d, *J* = 15.6 Hz, 1H), 4.82 (d, *J* = 15.6 Hz, 1H), 2.99 (br s, 1H), 1.67 (s, 3H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.8, 142.0, 135.6, 131.5, 129.68, 129.0, 127.9, 127.3, 123.6, 123.4, 109.7, 73.9, 43.9, 25.2.

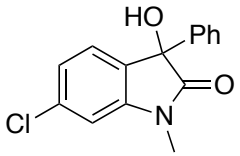
ATR-IR v 3386 (br), 1703 (s), 1614 (m), 1489 (w), 1469 (m), 1455 (w), 1366 (m), 1180 (m), 1153 (w), 1113 (w), 944 (w), 753 (m), 699 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{15}NNaO_2$, $[M+Na]^+$: 276.0995, found: 276.0990.

Mp: 146-148 °C (lit.[5] 146-148 °C).

6-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (1d)

[4] I. Gorokhovik, L. Neuville and J. Zhu, *Org. Lett.,* 2011, **13**, 5536 – 5539.
[5] J. E. Thomson, A. F. Kyle, C. Concellón, K. A. Gallagher, P. Lenden, L. C. Morrill, A. J. Miller, C. Joannesse, A. M. Z. Slawin and A. D. Smith, *Synthesis,* 2008, **17**, 2805 – 2818.



General procedure A was followed using 6-chloro-1-methylindolin-2,3-dione (287 mg, 1.47 mmol) and phenylmagnesium bromide (1.0 M in THF, 1.76 mL, 1.76 mmol) in dry THF (7.3 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **1d** as a light yellow solid (297 mg, 74%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.39 – 7.29 (m, 5H), 7.20 (d, *J* = 7.9 Hz, 1H), 7.06 (dd, *J* = 7.9, 1.8 Hz, 1H), 6.91 (d, *J* = 1.8 Hz, 1H), 3.28 (br s, 1H), 3.24 (s, 3H).

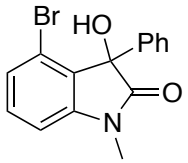
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.5, 144.9, 139.7, 135.9, 129.9, 128.9, 128.7, 126.1, 125.4, 123.5, 109.7, 77.7, 26.8.

ATR-IR v 3393 (br), 1713 (s), 1610 (s), 1494 (m), 1451 (w), 1369 (m), 1189 (w), 1070 (m), 1027 (w), 935 (w), 718 (w), 695 (w), 655 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}ClNNaO_2$, $[M+Na]^+$: 296.0449, found: 296.0452.

Mp: 174-176 °C.

4-bromo-3-hydroxy-1-methyl-3-phenylindolin-2-one (1e)



General procedure A was followed using 4-bromo-1-methylindolin-2,3-dione (300 mg, 1.25 mmol) and phenylmagnesium bromide (1 M in THF, 1.50 mL, 1.50 mmol) in dry THF (6.3 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **1e** as a light orange solid (298 mg, 75%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.36 – 7.27 (m, 5H), 7.23 (m, 1H), 7.19 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.85 (dd, *J* = 7.5, 1.2 Hz, 1H), 3.35 (s, 1H), 3.18 (s, 3H).

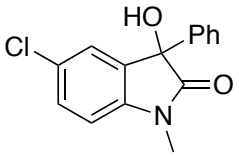
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 175.8, 146.0, 137.7, 131.6, 129.9, 128.7, 128.7, 127.3, 125.7, 120.2, 107.8, 79.2, 26.8.

ATR-IR v 3394 (br), 1713 (s), 1605 (s), 1455 (m), 1359 (w), 1192 (w), 1118 (w), 1029 (w), 930 (w), 778 (w), 765 (w), 739 (w), 698 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}BrNNaO_2$, $[M+Na]^+$: 339.9944, found: 339.9955.

Mp: 165-166 °C.

5-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (1f)



General procedure A was followed using 5-chloro-1-methylindolin-2,3-dione (300 mg, 1.53 mmol) and phenylmagnesium bromide (1.0 M in THF, 1.84 mL, 1.84 mmol) in dry THF (7.7 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **1f** as a yellow solid (260 mg, 62%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.36 – 7.21 (m, 6H), 7.18 (d, *J* = 1.2 Hz, 1H), 6.77 (d, *J* = 8.3 Hz, 1H), 3.19 (br s, 4H).

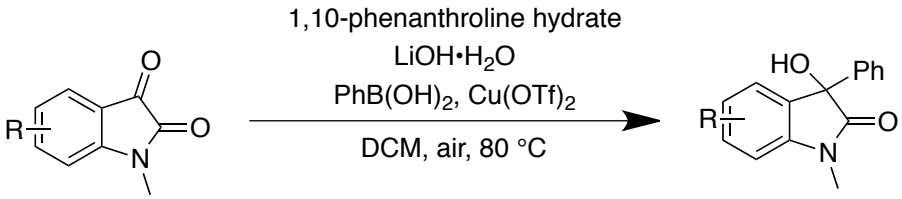
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.2, 142.2, 139.6, 133.1, 130.0, 129.1, 128.9, 128.8, 125.7, 125.3, 109.9, 78.0, 26.8.

ATR-IR v 3375 (br), 1709 (s), 1611 (w), 1489 (m), 1360 (w), 1189 (w), 1102 (m), 1027 (w), 814 (w), 716 (m), 703 (w), 652 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}ClNNaO_2$, $[M+Na]^+$: 296.0449, found: 296.0458.

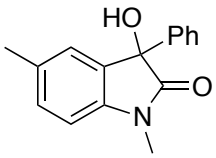
Mp: 171-172 °C (lit.[6] 172-173 °C).

General procedure B for compounds 1[7]



To a sealed tube was added indolin-2,3-dione (1 equiv), phenylboronic acid (4 equiv), $Cu(OTf)_2$ (5 mol%), 1,10-phenanthroline hydrate (0.1 equiv) and $LiOH•H_2O$ (3 equiv) followed by DCM (0.1 M). The reaction mixture was heated at 80 °C under air atmosphere for 48 h. The reaction mixture was cooled to room temperature, filtered through a pad of Celite and washed with EtOAc (3x). The filtrate was concentrated *in vacuo* and the crude mixture was purified by flash column chromatography on silica gel (EtOAc/petroleum ether) to afford pure 3-hydroxy-3-phenylindolin-2-one.

3-hydroxy-1,5-dimethyl-3-phenylindolin-2-one (1g)



General procedure B was followed using 1,5-dimethylindolin-2,3-dione (300 mg, 1.71 mmol), phenylboronic acid (835 mg, 6.85 mmol), $Cu(OTf)_2$ (31 mg, 0.09 mmol), 1,10-phenanthroline hydrate (34 mg, 0.17 mmol) and $LiOH•H_2O$ (216 mg, 5.14 mmol) in DCM (17 mL) to give a crude mixture which was purified by flash

[6] K. Ishizumi, S. Inaba and H. Yamamoto, *J. Org. Chem.,* 1974, **39**, 2581 – 2587.
[7] J. Zhang, J. Chen, J. Ding, M. Lui and H. Wu, *Tetrahedron,* 2011, **67**, 9347 – 9351.

column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **1g** as a white solid (312 mg, 72%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.30-7.28 (m, 2H), 7.26 – 7.16 (m, 3H), 7.05 (d, *J* = 7.9 Hz, 1H), 7.01 (s, 1H), 6.70 (d, *J* = 7.9 Hz, 1H), 3.70 (s, 1H), 3.12 (s, 3H), 2.20 (s, 3H).

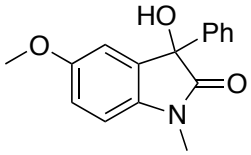
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.7, 141.1, 140.4, 133.3, 131.8, 130.1, 128.6, 128.3, 125.7, 125.4, 108.5, 78.2, 26.6, 21.2.

ATR-IR v 3383 (br), 1703 (s), 1621 (w), 1605 (w), 1498 (m), 1358 (m), 1097 (m), 1027 (w), 910 (w), 811 (m), 725 (s), 697 (m), 657 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{15}NNaO_2$, $[M+Na]^+$: 276.0995, found: 276.1001.

Mp: 120-121 °C (lit.[4] 120-121 °C).

3-hydroxy-5-methoxy-1-methyl-3-phenylindolin-2-one (1h)



General procedure B was followed using 5-methoxy-1-methylindolin-2,3-dione (300 mg, 1.57 mmol), phenylboronic acid (765 mg, 6.28 mmol), $Cu(OTf)_2$ (28 mg, 0.08 mmol), 1,10-phenanthroline hydrate (31 mg, 0.16 mmol) and LiOH•H_2O (198 mg, 4.71 mmol) in DCM (16 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:1) to afford the title compound **1h** as a light yellow solid (338 mg, 80%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.41 – 7.28 (m, 5H), 6.89-6.87 (m, 2H), 6.82 (d, *J* = 8.1 Hz, 1H), 3.75 (s, 3H), 3.37 (br s, 1H), 3.24 (s, 3H).

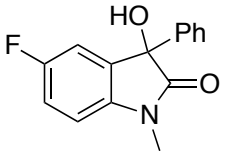
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.4, 156.8, 140.2, 136.9, 132.8, 128.8, 128.5, 125.4, 114.8, 111.8, 109.4, 78.5, 56.0, 26.8.

ATR-IR v 3320 (br), 1691 (s), 1605 (w), 1491 (s), 1364 (m), 1283 (m), 1228 (m), 1153 (w), 1105 (m), 1034 (m), 948 (w), 878 (w), 802 (w), 757 (m), 733 (s), 703 (m), 656 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{15}NNaO_3$, $[M+Na]^+$: 292.0944, found: 292.0948.

Mp: 184-185 °C.

5-fluoro-3-hydroxy-1-methyl-3-phenylindolin-2-one (1i)



General procedure B was followed using 5-fluoro-1-methylindolin-2,3-dione (300 mg, 1.68 mmol), phenylboronic acid (817 mg, 6.70 mmol), $Cu(OTf)_2$ (30 mg, 0.08 mmol), 1,10-phenanthroline hydrate (33 mg, 0.17 mmol) and LiOH•H_2O (211 mg, 5.02 mmol) in DCM (17 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **1i** as a light yellow solid (383 mg, 89%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.43 – 7.28 (m, 5H), 7.09 – 6.99 (m, 2H), 6.84 (m, 1H), 3.40 (br s, 1H), 3.25 (s, 3H).

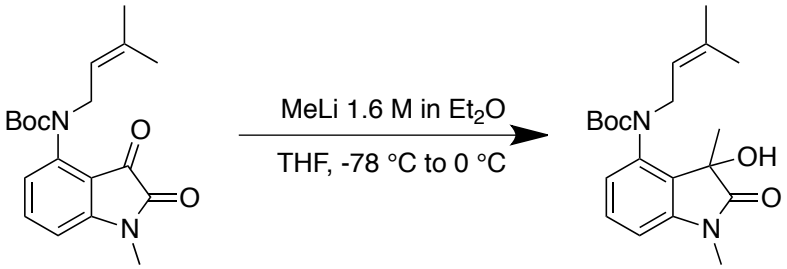
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.4, 159.8 (d, *J* = 242.5 Hz), 139.7, 139.5, 133.1 (d, *J* = 7.8 Hz), 128.9 , 128.7 , 125.3 , 116.3 (d, *J* = 23.7 Hz), 113.3 (d, *J* = 25.0 Hz), 109.5 (d, *J* = 8.0 Hz), 78.2 , 26.9.

ATR-IR v 3375 (br), 1708 (s), 1621 (w), 1495 (s), 1471 (m), 1365 (w), 1266 (w), 1108 (w), 1027 (w), 866 (w), 816 (w), 726 (w), 706 (w), 658 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}FNNaO_2$, $[M+Na]^+$: 280.0744, found: 280.0745.

Mp: 148-150 °C.

Synthesis of compound 1j[8]



To a solution of *tert*-butyl (1-methyl-2,3-dioxoindolin-4-yl)(3-methylbut-2-en-1-yl)carbamate (50 mg, 0.15 mmol, 1 equiv) in dry THF (1.1 mL) was added MeLi (1.6 M in Et_2O, 0.10 mL, 0.16 mmol, 1.1 equiv) dropwise at -78 °C over 5 min. The reaction mixture was allowed to warm to 0 °C and stirred at this temperature until the starting material was consumed (monitored by TLC). The reaction mixture was quenched with water. The aqueous layer was extracted with EtOAc (3x). The combined organic layers were washed with brine, dried over Na_2SO_4, and evaporated *in vacuo*. The crude mixture was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:5) to afford the title compound **1j** as a yellow solid (mixture of two rotamers, 26 mg, 50%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.32 – 7.09 (m, 1H), 6.85 – 6.53 (m, 2H), 5.86 – 5.07 (m, 1H), 4.54 – 3.73 (m, 2H), 3.12 (s, 3H), 1.64 (br s, 3H), 1.49 (br s, 3H), 1.45 (br s, 9H), 1.25 (br s, 3H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.0, 177.1, 156.5, 154.7, 144.6, 144.1, 139.9, 138.84, 136.2, 135.7, 130.6, 129.6, 127.8, 127.5, 125.5, 125.4, 121.0, 120.2, 107.6, 107.2, 82.4, 80.0, 74.1, 72.6, 49.0, 47.8, 28.5, 28.4, 26.4, 25.8, 23.3, 22.4, 18.0, 14.2.

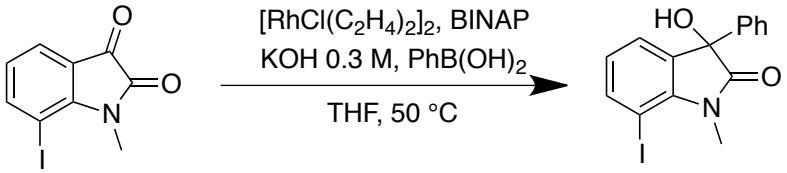
ATR-IR v 3392 (w), 2976 (w), 2929 (w), 1701 (s), 1611 (m), 1468 (m), 1394 (m), 1367 (m), 1295 (m), 1251 (w), 1166 (m), 1072 (w), 1037 (w), 943 (w), 871 (w), 760 (w), 670 (w), 634 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{24}N_2NaO_4$, $[M+Na]^+$: 367.1628, found: 367.1631.

Mp: 168-170 °C.

[8] T. D. Owens, S. Sethofer, K. A. M. Walker and S.-H. Zhao, Benzimidazole derivatives as 5-HT6,5-HT24. Eur. Pat. Appl. 063788, July 03, 2006.

Synthesis of compound 1k[9]



A solution of $[RhCl(C_2H_4)_2]_2$ (10 mg, 0.03 mmol, 0.05 equiv of Rh,) and BINAP (59 mg, 0.10 mmol, 0.1 equiv) in dry THF (5 mL) was stirred at room temperature for 10 min. KOH (0.3 M in H_2O, 0.48 mL, 0.15 equiv), 7-iodo-1-methylindolin-2,3-dione (274 mg, 0.96 mmol, 1 equiv) and $PhB(OH)_2$ (233 mg, 1.91 mmol, 2 equiv) were added successively with additional dry THF (5 mL) and the resulting mixture was stirred at 50 °C for 24 h. The reaction mixture was then directly passed through a pad of silica gel and washed with diethyl ether. After evaporation of the solvent under vacuum, the crude product was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the titled product **1k** as a light red solid (279 mg, 80%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.73 (dd, *J* = 8.1, 1.2 Hz, 1H), 7.37 – 7.28 (m, 5H), 7.21 (dd, *J* = 7.3, 1.2 Hz, 1H), 6.78 (dd, *J* = 8.1, 7.3 Hz, 1H), 3.72 (br s, 1H), 3.62 (s, 3H).

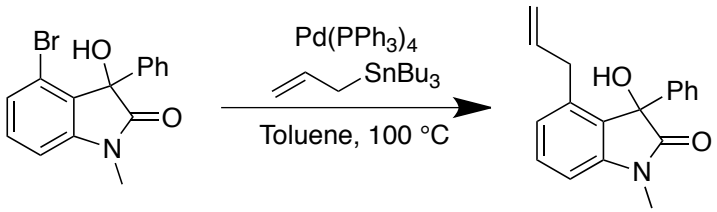
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.5, 143.8, 142.3, 139.7, 134.7, 128.7, 128.5, 125.3, 125.2, 124.9, 71.9, 30.5.

ATR-IR v 3377 (br), 1712 (s), 1665 (w), 1601 (w), 1449 (s), 1360 (m), 1247 (w), 1187 (w), 1097 (s), 1059 (m), 1027 (w), 939 (w), 910 (w), 782 (w), 736 (m), 699 (m), 647 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}INNaO_2$, $[M+Na]^+$: 387.9805, found: 387.9812.

Mp: 144-145 °C.

Synthesis of compound 1l[10]



To a solution of $Pd(PPh_3)_4$ (73 mg, 0.06 mmol, 0.1 equiv) and 4-bromo-3-hydroxy-1-methyl-3-phenylindolin-2-one (200 mg, 0.63 mmol, 1 equiv) in degassed dry toluene (6.3 mL) was added a solution of allyltributyltin (234 µL, 0.75 mmol, 1.2 equiv) in degassed dry toluene. The mixture was stirred at 110 °C for 14 h, cooled to room temperature, diluted with a saturated solution of KF and passed through a pad of Celite. The Celite was washed with EtOAc (3x). The filtrate was concentrated *in vacuo*. The crude product was dissolved in DCM (0.2 M) and stirred with CsF:CsOH (2:1, 1.5 parts by weight) and with silica (1 part by weight) for 3 h.[11] The solvent was evaporated *in vacuo* and the crude mixture

[9] R. Shintani, M. Inoue and T. Hayashi, *Angew. Chem. Int. Ed.,* 2006, **45**, 3353 – 3356.
[10] A. V. Kalinin, B. A. Chauder, S. Rakhit and V. Snieckus, *Org. Lett.,* 2003, **5**, 3519 – 3521.
[11] B. S. Edelson, B. M. Stoltz and E. J. Corey, *Tetrahedron Lett.,* 1999, **40**, 6729 – 6730.

was purified by flash column chromatography (EtOAc/petroleum ether 2:3) to afford the title compound **1l** as a white solid (137 mg, 78%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.34 – 7.18 (m, 6H), 6.89 (d, *J* = 7.9 Hz, 1H), 6.75 (d, *J* = 7.8 Hz, 1H), 5.64 (ddt, *J* = 16.9, 9.8, 6.8 Hz, 1H), 4.88 (d, *J* = 9.8 Hz, 1H), 4.83 (d, *J* = 16.9 Hz, 1H), 3.88 (s, 1H), 3.24 (dd, *J* = 15.0, 9.8 Hz, 1H), 3.16 (s, 3H), 3.10 (dd, *J* = 15.0, 6.8 Hz, 1H).

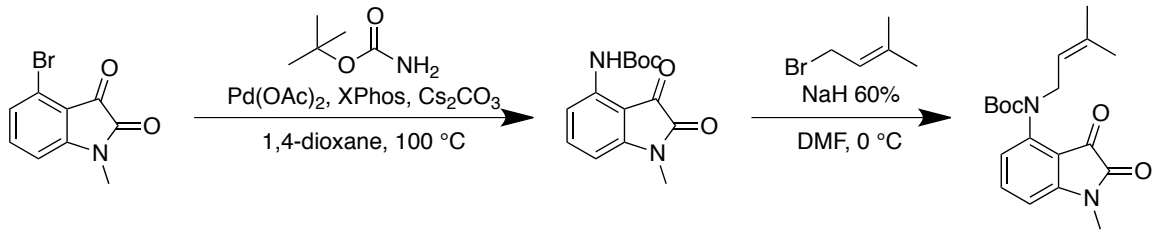
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.5, 144.0, 139.4, 138.6, 136.5, 130.0, 129.4, 128.6, 128.1, 125.2, 124.7, 116.2, 106.6, 78.5, 35.6, 26.7.

ATR-IR v 3378 (br), 1704 (s), 1603 (s), 1466 (m), 1357 (m), 1293 (w), 1174 (w), 1147 (w), 1047 (w), 993 (w), 914 (w), 778 (w), 750 (w), 729 (w), 698 (m), 652 (w) cm^{-1}.

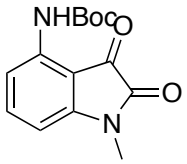
HRMS (ESI+) m/z calcd for $C_{18}H_{17}NNaO_2$, $[M+Na]^+$: 302.1151, found: 302.1156.

Mp: 125-127 °C.

Synthesis of intermediate 4 and 5 for compound 1j[12]



***tert*-butyl (1-methyl-2,3-dioxoindolin-4-yl)carbamate (4)**



A solution of palladium acetate (5.6 mg, 0.03 mmol, 3 mol%), XPhos (36 mg, 0.08 mmol, 9 mol%), Cs_2CO_3 (380 mg, 1.16 mmol, 1.4 equiv), tert-butyl carbamate (117 mg, 1.00 mmol, 1.2 equiv) and 4-bromo-1-methylindolin-2,3-dione (200 mg, 0.83 mmol, 1 equiv) in dry 1,4-dioxane (8.3 mL) was stirred at 100 °C for 3 h. The reaction mixture was allowed to cool to room temperature and was poured into H_2O, extracted with EtOAc (3x). The combined organic layers were dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by flash column chromatography (EtOAc/petroleum ether 1:3) to afford the titled product **4** as a red solid (166 mg, 72%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 8.71 (br s, 1H), 7.91 (d, *J* = 8.8 Hz, 1H), 7.49 (t, *J* = 8.8 Hz, 1H), 6.43 (d, *J* = 8.8 Hz, 1H), 3.22 (s, 3H), 1.54 (s, 9H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 183.1, 158.9, 152.0, 150.3, 140.7, 140.6, 113.3, 104.0, 102.8, 82.4, 28.3, 26.5.

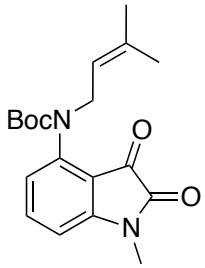
[12] L. Qin, H. Cui, D. Zou, J. Li, Y. Wu, Z. Zhu and Y. Wu, *Tetrahedron. Lett.,* 2010, **51**, 4445 – 4448.

ATR-IR v 2356 (s), 2340 (s), 1713 (s), 1620 (s), 1530 (m), 1458 (m), 1368 (w), 1303 (w), 1232 (w), 1149 (s), 923 (w), 794 (w), 736 (w), 652 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{14}H_{16}N_2NaO_4$, $[M+Na]^+$: 299.1002, found: 299.1011.

Mp: 189-191 °C.

tert-butyl (1-methyl-2,3-dioxoindolin-4-yl)(3-methylbut-2-en-1-yl)carbamate (5)



To a stirred solution of *tert*-butyl (1-methyl-2,3-dioxoindolin-4-yl)carbamate (150 mg, 0.54 mmol, 1 equiv) in dry DMF (5.4 mL) was added NaH (60% in mineral oil, 26 mg, 0.65 mmol, 1.2 equiv) in one portion at 0 °C. After stirring for 5 min, 1-bromo-3-methylbut-2-ene (76 µL, 0.65 mmol, 1.2 equiv) was added dropwise. The reaction mixture was kept at 0 °C for 4 h. The reaction mixture was quenched with water and the aqueous phase was extracted with EtOAc (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash column chromatography (EtOAc/petroleum ether 1:5) to afford the title compound **5** as an orange solid (168 mg, 90%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.52 (t, *J* = 8.0 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.70 (d, *J* = 8.0 Hz, 1H), 5.18 (t, *J* = 6.8 Hz, 1H), 4.26 (d, *J* = 6.8 Hz, 2H), 3.24 (s, 3H), 1.63 (s, 3H), 1.53 (s, 3H), 1.44 (s, 9H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 180.4, 158.2, 153.6, 151.6, 141.7, 138.2, 135.4, 122.6, 120.5, 113.4, 107.2, 81.5, 47.9, 28.4, 26.5, 25.8, 18.0.

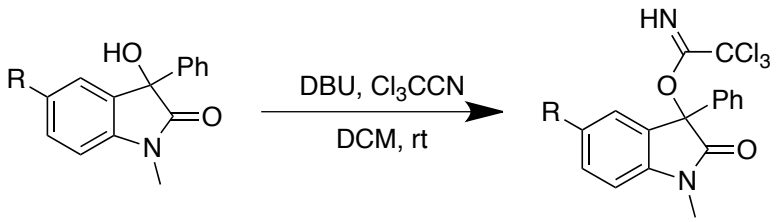
ATR-IR v 3733 (w), 3628 (w), 2975 (w), 1737 (s), 1703 (s), 1608 (s), 1459 (w), 1354 (w), 1161 (m), 1081 (w), 671 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{24}N_2NaO_4$, $[M+Na]^+$: 367.1628, found: 367.1632.

Mp: 166-167 °C.

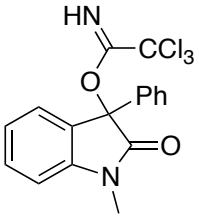
Synthesis of the trichloroacetimidate intermediates 3

General procedure C for the synthesis of 1-methyl-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate



To a solution of 3-hydroxy-1-methyl-3-phenylindolin-2-one (1 equiv) in dry DCM (0.1 M) was added dropwise DBU (0.1 equiv). After 5 minutes, trichloroacetonitrile (1.5 equiv) was added dropwise. After complete conversion of the alcohol to the trichloroacetimidate, the reaction mixture was quenched with saturated solution of NH_4Cl. The aqueous layer was extracted with DCM (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and evaporated *in vacuo*. The crude material was purified by a quick flash column chromatography (EtOAc/petroleum ether) to afford the desired product.

1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate (3a)



General procedure C was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (291 mg, 0.82 mmol), DBU (12 µL, 0.08 mmol) and trichloroacetonitrile (124 µL, 1.23 mmol) in dry DCM (8.2 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:8) to afford the title compound **3a** as a light yellow solid (457 mg, 98%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 8.39 (s, 1H), 7.48 – 7.39 (m, 3H), 7.38 – 7.33 (m, 3H), 7.32-7.30 (m, 1H), 7.13 (td, *J* = 7.6, 1.0 Hz, 1H), 6.93 (br d, *J* = 7.7 Hz, 1H), 3.23 (s, 3H).

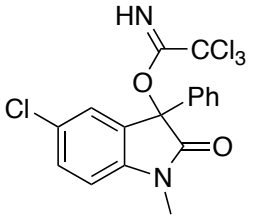
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 173.7, 159.0, 145.3, 136.8, 130.5, 129.2, 128.8, 127.2, 126.4, 124.4, 123.2, 108.5, 90.7, 83.9, 26.9.

ATR-IR v 1730 (s), 1675 (m), 1615 (m), 1494 (m), 1470 (m), 1370 (w), 1346 (m), 1309 (m), 1186 (w), 1132 (w), 1090 (m), 1064 (m), 1014 (m), 981 (w), 911 (w), 867 (w), 833 (m), 794 (s), 752 (s), 733 (s), 695 (m), 644 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{17}H_{13}Cl_3N_2NaO_2$, $[M+Na]^+$: 404.9935, found: 404.9940.

Mp: 112-113 °C.

5-chloro-1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate (3b)



General procedure C was followed using 5-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (291 mg, 1.06 mmol), DBU (16 µL, 0.11 mmol) and trichloroacetonitrile (160 µL, 1.60 mmol) in dry DCM (11 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:11) to afford the title compound **3b** as a light yellow solid (457 mg, 98%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 8.41 (br s, 1H), 7.44 – 7.33 (m, 6H), 7.27 (d, *J* = 2.5 Hz, 1H), 6.85 (d, *J* = 8.3 Hz, 1H), 3.21 (s, 3H).

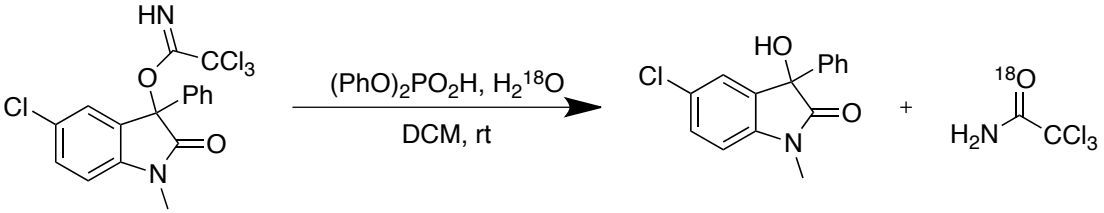
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 173.3, 159.0, 143.8, 136.2, 130.4, 129.4, 129.0, 128.9, 128.6, 126.2, 124.7, 109.5, 90.5, 83.6, 27.1.

ATR-IR v 3338 (w), 2361 (m), 2343 (m), 1738 (s), 1677 (m), 1613 (m), 1491 (m), 1343 (w), 1310 (m), 1187 (w), 1141 (w), 1102 (w), 1063 (w), 1014 (w), 976 (w), 881 (w), 835 (m), 794 (m), 717 (w), 667 (w), 646 (w), 613 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{17}H_{12}Cl_4N_2NaO_2$, $[M+Na]^+$: 438.9545, found: 438.9541.

Mp: 121-122 °C.

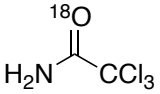
Incorporation of $H_2{}^{18}O$ on 5-chloro-1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate



To a solution of 5-chloro-1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate (10 mg, 0.02 mmol, 1 equiv) in dry DCM was added $H_2{}^{18}O$ (97 atom %, 4 µL, 0.24 mmol, 12 equiv). The reaction mixture was stirred 5 days at room temperature. The solvant was evaporated *in vacuo*. The crude material was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:11 to 1:5) to afford the indol-2-one **1f** as a yellow solid and the trichloroacetimidate **6** as a yellow solid. The alcohol was submitted to HRMS.

HRMS (ESI+) m/z calcd for $C_{15}H_{12}ClNNaO_2$, $[M+Na]^+$: 296.0449, found: 296.0452 indicated no incorporation of $H_2{}^{18}O$ in the indol-2-one.

^{18}O-2,2,2-trichloroacetamide (6)



^{1}H NMR (400.13 MHz, $CDCl_3$) δ 6.64 (br s, 1H), 6.26 (br s, 1H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 163.9, 91.9.

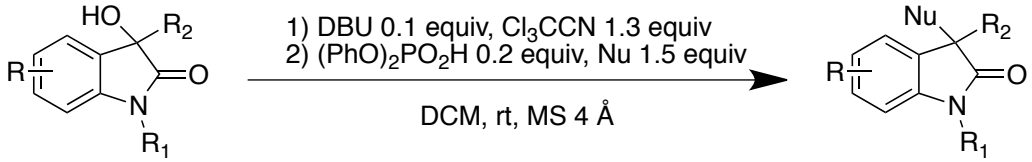
ATR-IR v 3370 (w), 3321 (w), 3245 (w), 3187 (w), 1692 (m), 1616 (w), 1383 (w), 1110 (w), 834 (m), 750 (w), 650 (w), 617 (w), 519 (m), 493 (s), 484 (s), 452 (m), 392 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_2H_2Cl_3NNa^{18}O$, $[M+Na]^+$: 185.9137, found: 185.9130.

Mp: 139-140 °C.

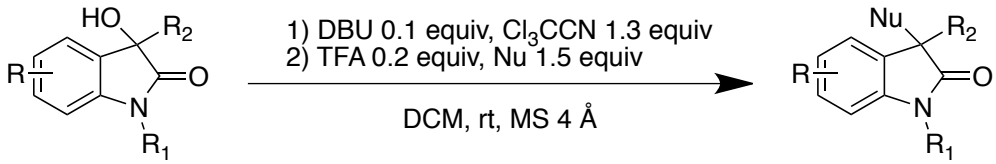
General procedures for the nucleophilic substitution

General procedure D using diphenyl phosphoric acid



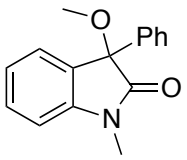
To a solution of 3-hydroxy-indolin-2-one (1 equiv) in dry DCM (0.1 M) was added dropwise DBU (0.1 equiv). After 5 minutes, trichloroacetonitrile (1.3 equiv) was added dropwise. After complete conversion of the alcohol to the trichloroacetimidate, the nucleophile (1.5 equiv) and diphenyl phosphoric acid (0.2 equiv) were added. After complete conversion of the trichloroacetimidate, the reaction mixture was quenched with a saturated solution of $NaHCO_3$. The aqueous layer was extracted with DCM (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by flash column chromatography on silica gel (EtOAc/petroleum ether) to afford the desired compound.

General procedure E using trifluoroacetic acid



To a solution of 3-hydroxy-indolin-2-one (1 equiv) in dry DCM (0.1 M) was added dropwise DBU (0.1 equiv). After 5 minutes, trichloroacetonitrile (1.3 equiv) was added dropwise. After complete conversion of the alcohol to the trichloroacetimidate, the nucleophile (1.5 equiv) and TFA (0.2 equiv) were added. After complete conversion of the trichloroacetimidate, the reaction mixture was quenched with a saturated solution of $NaHCO_3$. The aqueous layer was extracted with DCM (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by flash column chromatography on silica gel (EtOAc/petroleum ether) to afford the desired compound.

3-methoxy-1-methyl-3-phenylindolin-2-one (2a)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and methanol (13 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **2a** as a white solid (52 mg, 98%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.44 – 7.35 (m, 3H), 7.33 – 7.26 (m, 4H), 7.14 (td, *J* = 7.5, 1.0 Hz, 1H), 6.93 (d, *J* = 7.9 Hz, 1H), 3.24 (s, 3H), 3.23 (s, 3H).

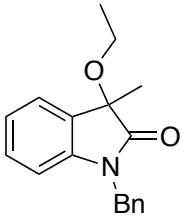
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 175.3, 144.5, 138.6, 130.2, 128.4, 128.0, 126.3, 125.7, 123.3, 108.6, 84.0, 53.1, 26.4.

ATR-IR v 3366 (w), 3285 (w), 2934 (w), 2827 (w), 1713 (s), 1612 (m), 1492 (w), 1470 (m), 1369 (m), 1350 (w), 1248 (w), 1194 (w), 1104 (w), 985 (w), 829 (m), 760 (w), 697 (m), 631 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{15}NNaO_2$, $[M+Na]^+$: 276.0995, found: 276.0990.

Mp: 79-80 °C (lit.[13] 77–79 °C).

1-benzyl-3-ethoxy-3-methylindolin-2-one (2b)



General procedure D was followed using 1-benzyl-3-hydroxy-3-methylindolin-2-one (50 mg, 0.20 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (26 µL, 0.26 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and ethanol (17 µL, 0.30 mmol) in dry DCM (2.0 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:9) to afford the title compound **2b** as a colorless solid (49 mg, 89%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.38 – 7.24 (m, 6H), 7.20 (td, *J* = 7.7, 1.3 Hz, 1H), 7.07 (td, *J* = 7.5, 1.0 Hz, 1H), 6.71 (dt, *J* = 7.9, 0.8 Hz, 1H), 4.94 (d, *J* = 15.6 Hz, 1H), 4.89 (d, *J* = 15.6 Hz, 1H), 3.26 (dq, *J* = 8.3, 7.0 Hz, 1H), 3.09 (dq, *J* = 8.3, 7.0 Hz, 1H), 1.16 (t, *J* = 7.0 Hz, 3H).

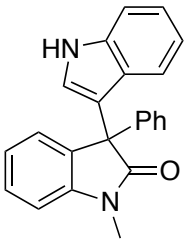
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.1, 142.5, 135.8, 129.6, 129.0, 127.9, 127.4, 123.8, 123.2, 109.6, 79.2, 61.2, 43.9, 24.7, 15.6.

ATR-IR v 2985 (w), 2925 (w), 1723 (s), 1613 (m), 1488 (w), 1467 (m), 1363 (w), 1262 (w), 1181 (w), 1135 (w), 1066 (w), 999 (w), 868 (w), 752 (m), 701 (w), 668 (w), 630 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{18}H_{19}NNaO_2$, $[M+Na]^+$: 304.1308, found: 304.1310.

Mp: 103-105 °C.

3-(1*H*-indol-3-yl)-1-methyl-3-phenylindolin-2-one (2c)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-

[13] L. Ackermann, R. Vicente and N. Hofmann, *Org. Lett.,* 2009, **11**, 4274 – 4276.

one (1.01 g, 4.22 mmol), DBU (63 µL, 0.42 mmol), Cl_3CCN (550 µL, 5.49 mmol), diphenyl phosphoric acid (211 mg, 0.84 mmol) and indole (742 mg, 6.33 mmol) in dry DCM (42 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **2c** as a light yellow solid (1.32 g, 95%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.37 – 7.24 (m, 8H), 7.20 (d, *J* = 8.1 Hz, 1H), 7.13 (ddd, *J* = 8.2, 7.0, 1.2 Hz, 1H), 7.05 (td, *J* = 7.6, 1.0 Hz, 1H), 6.98 – 6.91 (m, 2H), 6.87 (m, 1H), 3.31 (s, 3H).

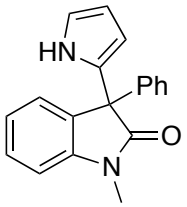
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.8, 143.1, 140.5, 137.2, 133.8, 128.6, 128.3, 128.0, 127.4, 125.9, 125.6, 124.1, 122.9, 122.4, 121.8, 119.8, 116.7, 111.3, 108.5, 57.7, 29.9.

ATR-IR v 3726 (w), 3280 (w), 2923 (s), 2853 (m), 1699 (s), 1612 (m), 1492 (m), 1468 (m), 1373 (m), 1348 (m), 1246 (w), 1241 (w), 1130 (w), 1090 (w), 1024 (w), 906 (w), 739 (s), 697 (s), 669 (s), 643 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{23}H_{18}N_2NaO$, $[M+Na]^+$: 361.1311, found: 361.1302.

Mp: 112-114 °C.

1-methyl-3-phenyl-3-(1*H*-pyrrol-2-yl)indolin-2-one (2d)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and pyrrole (22 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **2d** as a light brown solid (56 mg, 92%).

^{1}H NMR (400.13 MHz, $CDCl_3$/CD_3OD) δ 7.38 – 7.22 (m, 7H), 7.17 – 7.05 (m, 3H), 6.97 (d, *J* = 7.7 Hz, 1H), 6.76 (m, 2H), 3.32 (s, 3H).

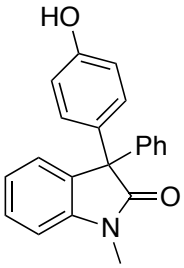
^{13}C NMR (100.62 MHz, $CDCl_3$/CD_3OD) δ 178.5, 156.1, 142.8, 142.2, 133.4, 132.4, 129.6, 128.4, 128.3, 128.2, 127.2, 126.0, 123.0, 115.2, 108.6, 62.0, 26.6.

ATR-IR v 3372 (w), 2926 (w), 1694 (s), 1612 (w), 1493 (w), 1471 (w), 1372 (w), 1337 (w), 1250 (w), 1110 (w), 1089 (w), 1034 (w), 910 (w), 835 (w), 738 (w), 697 (w), 620 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{16}N_2NaO$, $[M+Na]^+$: 311.1155, found: 311.1152.

Mp: 81-83 °C.

3-(4-hydroxyphenyl)-1-methyl-3-phenylindolin-2-one (2e)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and phenol (29 mg, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:2) to afford the title compound **2e** as a white solid (63 mg, 95%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.38 – 7.18 (m, 7H), 7.17 – 7.02 (m, 3H), 6.93 (d, *J* = 7.8 Hz, 1H), 6.69 (d, *J* = 8.7 Hz, 2H), 5.50 (br s, 1H), 3.29 (s, 3H).

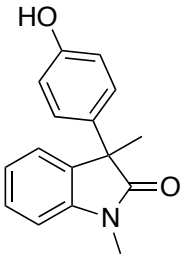
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.1, 155.1, 142.9, 142.1, 133.5, 133.3, 129.8, 128.4, 128.3, 128.3, 127.2, 126.0, 123.0, 115.4, 108.6, 62.0, 26.7.

ATR-IR v 3345 (w), 2926 (w), 1694 (s), 1610 (m), 1513 (m), 1510 (m), 1375 (m), 1261 (w), 1179 (w), 1131 (w), 1089 (w), 1024 (w), 910 (w), 829 (m), 751 (m), 699 (m), 644 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{21}H_{17}NNaO_2$, $[M+Na]^+$: 338.1151, found: 338.1149.

Mp: 98-99 °C.

3-(4-hydroxyphenyl)-1,3-dimethylindolin-2-one (2f)



General procedure D was followed using 3-hydroxy-1,3-dimethylindolin-2-one (50 mg, 0.28 mmol), DBU (4 µL, 0.03 mmol), Cl_3CCN (37 µL, 0.37 mmol), diphenyl phosphoric acid (14 mg, 0.06 mmol) and phenol (40 mg, 0.42 mmol) in dry DCM (2.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:2) to afford the title compound **2f** as a white solid (67 mg, 95%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.32 (td, *J* = 7.7, 1.4 Hz, 1H), 7.17 (ddd, *J* = 7.4, 1.4, 0.6 Hz, 1H), 7.13 – 7.07 (m, 3H), 6.92 (d, *J* = 7.8 Hz, 1H), 6.72 – 6.64 (m, 2H), 5.19 (br s, 1H), 3.24 (s, 3H), 1.75 (s, 3H).

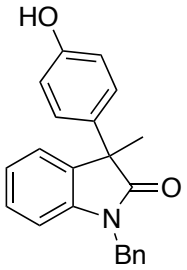
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 180.1, 155.0, 143.3, 135.3, 132.8, 128.2, 128.1, 124.3, 123.0, 115.5, 108.5, 51.7, 26.6, 23.9.

ATR-IR v 3733 (m), 3628 (w), 1751 (m), 1682 (m), 1624 (w), 1514 (s), 1388 (m), 1270 (m), 1180 (m), 1055 (m), 964 (m), 873 (m), 785 (m), 672 (s), 660 (s), 614 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{15}NNaO_2$, $[M+Na]^+$: 276.0995, found: 276.0990.

Mp: 74-76 °C.

1-benzyl-3-(4-hydroxyphenyl)-3-methylindolin-2-one (2g)



General procedure D was followed using 1-benzyl-3-hydroxy-3-methylindolin-2-one (1.01 g, 3.96 mmol), DBU (60 µL, 0.40 mmol), Cl_3CCN (517 µL, 5.15 mmol), diphenyl phosphoric acid (198 mg, 0.79 mmol) and phenol (560 mg, 5.95 mmol) in dry DCM (40 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2g** as a colorless solid (1.19 g, 91%).

^{1}H NMR (400.13 MHz, $CDCl_3/CD_3OD$) δ 7.52 (br s, 1H), 7.35 – 6.98 (m,10H), 6.83 (d, *J* = 7.8 Hz, 1H), 6.74 (d, *J* = 8.0 Hz, 2H), 4.97 (d, *J* = 15.7 Hz, 1H), 4.89 (d, *J* = 15.7 Hz, 1H), 1.78 (s, 3H).

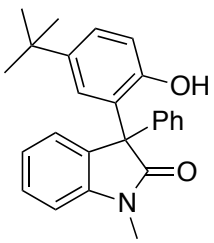
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 182.3, 157.6, 143.2, 137.2, 136.9, 132.8, 130.1, 129.3, 129.1, 129.0, 128.4, 125.4, 124.5, 116.7, 110.9, 53.1, 45.0, 24.6.

ATR-IR v 3344 (w), 2922 (w), 2851 (w), 1697 (s), 1610 (m), 1515 (m), 1489 (m), 1468 (m), 1378 (m), 1271 (w), 1178 (m), 1106 (w), 1080 (w), 1028 (w), 1008 (w), 827 (m), 746 (w), 697 (w), 669 (w), 636 (m), 623 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{22}H_{19}NNaO_2$, $[M+Na]^+$: 352.1308, found: 352.1300.

Mp: 100-101 °C.

3-(5-(*tert*-butyl)-2-hydroxyphenyl)-1-methyl-3-phenylindolin-2-one (2h)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and 4-*tert*-butylphenol (47 mg, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **2h** as a colorless solid (66 mg, 85%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 9.26 (s, 1H), 7.28 (ddd, *J* = 7.8, 6.7, 2.2 Hz, 1H), 7.23 – 7.19 (m, 2H), 7.18 – 7.12 (m, 2H), 7.10 – 7.03 (m, 2H), 7.01 – 6.95 (m, 3H), 6.92 (d, *J* = 7.8 Hz, 1H), 6.86 (d, *J* = 8.4 Hz, 1H), 3.30 (s, 3H), 1.11 (s, 9H).

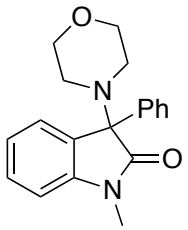
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 181.0, 154.7, 142.5, 142.2, 140.7, 132.5, 128.9, 128.7, 127.6, 127.1, 127.0, 126.5, 126.1, 124.2, 123.5, 119.7, 109.5, 62.9, 34.4, 31.6, 27.0.

ATR-IR v 3281 (w), 2960 (m), 1720 (s), 1681 (s), 1606 (m), 1492 (s), 1472 (m), 1422 (w), 1374 (m), 1275 (w), 1246 (m), 1161 (w), 1130 (w), 1082 (w), 1024 (w), 911 (w), 827 (m), 753 (m), 699 (m), 654 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{25}H_{25}NNaO_2$, $[M+Na]^+$: 394.1778, found: 394.1770.

Mp: 90-92 °C (lit.[14]).

1-methyl-3-morpholino-3-phenylindolin-2-one (2i)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and morpholine (28 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **2i** as a light yellow solid (56 mg, 87%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.56-7.54 (m, 2H), 7.42 – 7.26 (m, 5H), 7.09 (t, *J* = 7.5 Hz, 1H), 6.87 (d, *J* = 7.5 Hz, 1H), 3.73-3.65 (m, 4H), 3.23 (s, 3H), 2.62-2.54 (m, 4H).

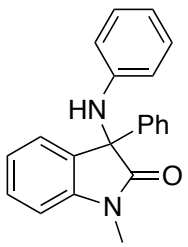
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 175.7, 143.7, 129.2, 129.1, 128.8, 128.7, 128.2, 127.9, 126.0, 122.9, 108.5, 74.3, 67.7, 47.8, 26.3.

ATR-IR v 2957 (w), 2924 (w), 2853 (w), 1712 (s), 1610 (m), 1492 (w), 1470 (m), 1371 (w), 1347 (w), 1257 (w), 1115 (m), 1087 (w), 1009 (w), 892 (w), 825 (w), 752 (w), 700 (w), 642 (w), 620 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{20}N_2NaO_2$, $[M+Na]^+$: 331.1417, found: 331.1410.

Mp: 151-152 °C (lit.[15] 150-151 °C).

1-methyl-3-phenyl-3-(phenylamino)indolin-2-one (2j)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-

[14] A. Natarajan, Y.-H. Fan, H. Chen, Y. Guo, J. Iyasere, F. Harbinski, W. J. Christ, H. Aktas and J. A. Halperin, *J. Med. Chem.,* 2004, **47***,* 1882 – 1885.
[15] S. P. Marsden, E. L. Watson and S. A. Raw, *Org. Lett.*, 2008, **10**, 2905 – 2908.

one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and aniline (29 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **2j** as a colorless solid (57 mg, 87%).

^{1}H NMR (400.13 MHz, $CDCl_3/CD_3OD$) δ 7.45 (d, *J* = 6.6 Hz, 2H), 7.35 – 7.23 (m, 5H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.96 – 6.88 (m, 3H), 6.60 (t, *J* = 7.5 Hz, 1H), 6.27 (d, *J* = 8.0 Hz, 2H), 3.19 (s, 3H).

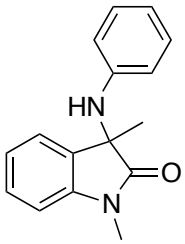
^{13}C NMR (100.62 MHz, $CDCl_3/CD_3OD$) δ 179.2, 146.6, 144.3, 141.4, 131.8, 130.8, 130.3, 130.0, 127.8, 126.5, 124.9, 120.6, 116.7, 110.4, 69.6, 27.9.

ATR-IR v 3352 (w), 3057 (w), 2933 (w), 1711 (s), 1602 (s), 1498 (m), 1469 (m), 1368 (m), 1349 (w), 1315 (w), 1257 (w), 1161 (w), 1120 (w), 1080 (w), 1034 (w), 827 (w), 751 (m), 695 (m), 634 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{21}H_{18}N_2NaO$, $[M+Na]^+$: 337.1311, found: 337.1300.

Mp: 121-122 °C.

1,3-dimethyl-3-(phenylamino)indolin-2-one (2k)



General procedure D was followed using 3-hydroxy-1,3-dimethylindolin-2-one (50 mg, 0.28 mmol), DBU (4 µL, 0.03 mmol), Cl_3CCN (37 µL, 0.37 mmol), diphenyl phosphoric acid (14 mg, 0.06 mmol) and aniline (39 µL, 0.42 mmol) in dry DCM (2.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:2) to afford the title compound **2k** as a light brown solid (65 mg, 92%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.38 – 7.29 (m, 2H), 7.08 (t, *J* = 7.2 Hz, 1H), 7.00 – 6.90 (m, 3H), 6.64 (t, *J* = 7.2 Hz, 1H), 6.17 (d, *J* = 7.6 Hz, 2H), 4.33 (br s, 1H), 3.27 (s, 3H), 1.62 (s, 3H).

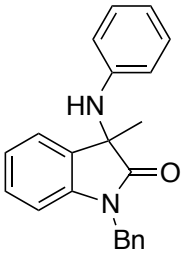
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.6, 145.4, 142.4, 131.7, 129.2, 129.1, 123.4, 123.2, 119.2, 114.7, 108.8, 61.3, 27.7, 26.6.

ATR-IR v 3356 (w), 3053 (w), 2927 (w), 1715 (s), 1612 (m), 1498 (m), 1470 (m), 1374 (w), 1322 (w), 1293 (w), 1238 (w), 1127 (w), 1031 (w), 751 (m), 692 (w), 631 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{16}N_2NaO$, $[M+Na]^+$: 275.1155, found: 275.1145.

Mp: 89-90 °C.

1-benzyl-3-methyl-3-(phenylamino)indolin-2-one (2l)



General procedure D was followed using 1-benzyl-3-hydroxy-3-methylindolin-2-one (50 mg, 0.20 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (26 µL, 0.26 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and aniline (27 µL, 0.30 mmol) in dry DCM (2.0 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **2l** as a white solid (59 mg, 90%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.42 – 7.25 (m, 6H), 7.22 (td, *J* = 7.8, 1.3 Hz, 1H), 7.04 (td, *J* = 7.5, 1.0 Hz, 1H), 6.96 (dt, *J* = 7.9, 0.8 Hz, 1H), 6.89 – 6.78 (m, 2H), 6.66 – 6.44 (m, 1H), 6.18 (dt, *J* = 7.8, 1.1 Hz, 2H), 5.08 (d, *J* = 15.5 Hz, 1H), 4.85 (d, *J* = 15.4 Hz, 1H), 1.60 (s, 3H).

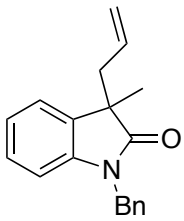
^{13}C NMR (100.62 MHz, CD_3OD) δ 181.4, 147.5, 142.6, 137.5, 133.6, 130.0, 129.9, 129.1, 129.0, 124.7, 124.2, 119.6, 116.0, 111.4, 62.8, 45.0, 27.8.

ATR-IR v 3348 (w), 1703 (s), 1604 (m), 1499 (m), 1487 (m), 1467 (m), 1355 (m), 1181 (m), 1118 (w), 1029 (w), 975 (m), 888 (w), 824 (m), 749 (s), 692 (s), 625 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{22}H_{20}N_2NaO$, $[M+Na]^+$: 351.1468, found: 351.1465.

Mp: 145-146 °C (lit.[16] 147-148 °C).

3-allyl-1-benzyl-3-methylindolin-2-one (2m)



General procedure D was followed using 1-benzyl-3-hydroxy-3-methylindolin-2-one (50 mg, 0.20 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (26 µL, 0.26 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and allyltributyltin (92 µL, 0.30 mmol) in dry DCM (2.0 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:6) to afford the title compound **2m** as a colorless solid (50 mg, 92%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.37 – 7.23 (m, 5H), 7.20 (d, *J* = 7.4 Hz, 1H), 7.13 (t, *J* = 7.4 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.69 (d, *J* = 7.4 Hz, 1H), 5.46 – 5.31 (m, 1H), 5.01 – 4.82 (m, 3H), 4.73 (d, *J* = 15.5 Hz, 1H), 2.70 – 2.50 (m, 2H), 1.43 (s, 3H).

[16] T. Zhang, L. Cheng, L. Liu, D. Wang and Y.-L. Chen, *Tetrahedron: Asymmetry,* 2010, **21**, 2800 – 2806.

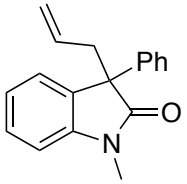
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 180.4, 142.4, 136.2, 133.7, 132.8, 128.8, 127.8, 127.6, 127.4, 123.1, 122.5, 119.0, 109.2, 60.6, 43.8, 42.7, 23.3.

ATR-IR v 3734 (w), 3623 (w), 1719 (w), 1543 (w), 671 (w), 565 (m), 538 (m), 524 (m), 505 (m), 432 (s), 410 (s), 365 (s), 325 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{19}NNaO$, $[M+Na]^+$: 300.1359, found: 300.1356.

Mp: 31-33 °C (lit.[17] Oil).

3-allyl-1-methyl-3-phenylindolin-2-one (2n)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and allyltributyltin (97 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture. Following a reported procedure,[11] the crude product was dissolved in DCM (0.2 M) and stirred with CsF:CsOH (2:1, 1.5 parts by weight) and silica gel (1 part by weight) for 3 h. The solvent was evaporated *in vacuo* and the residue was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2n** as a white solid (46 mg, 83%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.37 – 7.18 (m, 7H), 7.08 (td, *J* = 7.5, 1.1 Hz, 1H), 6.86 (d, *J* = 7.8 Hz, 1H), 5.35 (ddt, *J* = 17.1, 10.1, 7.1 Hz, 1H), 4.99 (ddt, *J* = 17.1, 2.5, 1.4 Hz, 1H), 4.88 (ddt, *J* = 10.1, 2.5, 0.9 Hz, 1H), 3.17 (s, 3H), 2.99 (dt, *J* = 7.1, 1.1 Hz, 2H).

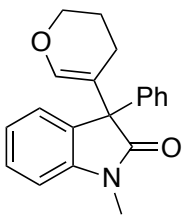
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.1, 144.0, 139.6, 132.5, 131.8, 128.7, 128.3, 127.5, 127.2, 125.3, 122.6, 119.3, 108.3, 56.5, 42.1, 26.5.

ATR-IR v 1707 (w), 1613 (w), 1494 (w), 1471 (w), 1374 (w), 1352 (w), 1258 (w), 1082 (w), 906 (s), 826 (w), 729 (s), 650 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{18}H_{17}NNaO$, $[M+Na]^+$: 286.1202, found: 286.1199.

Mp: 58-60 °C.

3-(3,4-dihydro-2*H*-pyran-5-yl)-1-methyl-3-phenylindolin-2-one (2o)



General procedure D was followed using 3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.21 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (27 µL, 0.27 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and 3,4-dihydro-2H-pyran (29 µL, 0.31 mmol) in dry DCM (2.1 mL) to give a crude mixture which was purified by

[17] B. M. Trost and Y. Zhang, *Chem. Eur. J.,* 2011, **17**, 2916 – 2922.

flash column chromatography on silica gel (EtOAc/petroleum ether 1:5) to afford the title compound **2o** as a light yellow solid (55 mg, 86%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.35 – 7.30 (m, 2H), 7.29 – 7.19 (m, 4H), 7.18 – 7.15 (m, 1H), 7.02 (td, *J* = 7.5, 1.1 Hz, 1H), 6.84 (d, *J* = 7.4 Hz, 1H), 6.25 (t, *J* = 1.5 Hz, 1H), 3.96 – 3.80 (m, 2H), 3.22 (s, 3H), 2.10 – 1.89 (m, 2H), 1.84 – 1.72 (m, 2H).

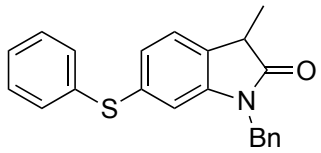
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 177.0, 143.8, 143.2, 139.0, 131.4, 128.6, 128.3, 128.0, 127.4, 125.8, 122.5, 112.6, 108.5, 65.6, 60.6, 26.6, 22.4, 21.0.

ATR-IR v 3278 (w), 2940 (w), 2873 (w), 1703 (s), 1650 (m), 1609 (m), 1493 (w), 1471 (w), 1369 (w), 1348 (m), 1275 (w), 1231 (w), 1162 (s), 1088 (w), 962 (w), 827 (m), 740 (w), 702 (w), 638 (w), 630 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{20}H_{19}NNaO_2$, $[M+Na]^+$: 328.1308, found: 328.1302.

Mp: 124-125 °C.

1-benzyl-3-methyl-6-(phenylthio)indolin-2-one (2p)



General procedure D was followed using 1-benzyl-3-hydroxy-3-methylindolin-2-one (50 mg, 0.20 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (26 µL, 0.26 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and thiophenol (30 µL, 0.30 mmol) in dry DCM (2.0 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:7) to afford the title compound **2p** as a light yellow solid (62 mg, 91%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.29 – 7.14 (m, 8H), 7.13 – 7.02 (m, 3H), 6.92 (dd, *J* = 7.7, 1.6 Hz, 1H), 6.56 (d, *J* = 1.6 Hz, 1H), 4.73 (s, 2H), 3.50 (q, *J* = 7.7 Hz, 1H), 1.44 (d, *J* = 7.7 Hz, 3H).

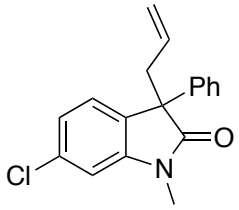
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.8, 144.0, 136.1, 135.7, 135.0, 131.7, 129.5, 129.4, 128.9, 127.8, 127.6, 127.5, 124.5, 124.2, 110.9, 43.8, 40.5, 15.7.

ATR-IR v 3298 (w), 1716 (w), 1541 (w), 671 (w), 550 (w), 497 (m), 474 (m), 428 (s), 396 (s), 358 (s), 338 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{22}H_{19}NNaOS$, $[M+Na]^+$: 368.1080, found: 368.1076.

Mp: 116-118 °C.

3-allyl-6-chloro-1-methyl-3-phenylindolin-2-one (2q)



General procedure E was followed using 6-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.18 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (24 µL, 0.24 mmol), TFA (3 µL, 0.04 mmol) and allyltributyltin (85 µL, 0.27 mmol) in dry

DCM (1.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2q** as a white solid (47 mg, 86%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.33 – 7.15 (m, 5H), 7.09 (dd, *J* = 7.9, 0.4 Hz, 1H), 7.01 (dd, *J* = 7.9, 1.8 Hz, 1H), 6.82 (d, *J* = 1.8 Hz, 1H), 5.30 (ddt, *J* = 17.2, 10.1, 7.1 Hz, 1H), 5.01 – 4.90 (m, 1H), 4.86 (ddt, *J* = 10.1, 1.8, 0.9 Hz, 1H), 3.11 (s, 3H), 2.93 (dt, *J* = 7.2, 1.1 Hz, 2H).

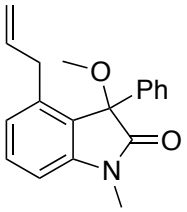
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.0, 145.2, 139.0, 134.2, 132.2, 130.1, 128.8, 127.7, 127.1, 126.2, 122.4, 119.7, 109.1, 56.3, 42.0, 26.6.

ATR-IR v 3072 (w), 2920 (w), 1719 (s), 1608 (m), 1494 (m), 1488 (w), 1437 (w), 1368 (m), 1295 (w), 1244 (w), 1144 (w), 1070 (w), 1000 (w), 954 (w), 927 (w), 841 (w), 812 (w), 771 (w), 734 (w), 699 (w), 651 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{18}H_{16}ClNNaO$, $[M+Na]^+$: 320.0813, found: 320.0810.

Mp: 98-99 °C.

4-allyl-3-methoxy-1-methyl-3-phenylindolin-2-one (2r)



General procedure D was followed using 4-allyl-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.18 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (23 µL, 0.23 mmol), diphenyl phosphoric acid (9 mg, 0.04 mmol) and methanol (11 µL, 0.27 mmol) in dry DCM (1.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2r** as a white solid (40 mg, 75%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.37 (t, *J* = 7.8 Hz, 1H), 7.34 – 7.22 (m, 5H), 6.98 (d, *J* = 7.8 Hz, 1H), 6.79 (d, *J* = 7.8 Hz, 1H), 5.68 (ddt, *J* = 16.9, 10.0, 7.0 Hz, 1H), 4.98 – 4.87 (m, 2H), 3.22 (s, 3H), 3.20 (s, 3H), 3.27 – 3.01 (m, 2H).

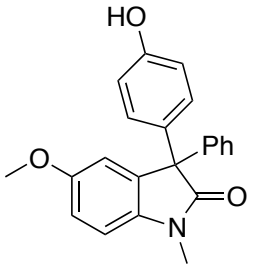
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 171.0, 145.0, 139.4, 138.5, 135.8, 130.4, 128.5, 128.3, 125.9, 125.2, 124.5, 116.5, 106.4, 84.8, 53.3, 35.1, 26.6.

ATR-IR v 2930 (w), 1728 (s), 1603 (m), 1467 (m), 1364 (w), 1341 (w), 1295 (w), 1152 (w), 1104 (w), 1068 (w), 1010 (w), 915 (w), 792 (w), 768 (w), 750 (w), 699 (w), 672 (w), 617 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{19}H_{19}NNaO_2$, $[M+Na]^+$: 316.1308, found: 316.1300.

Mp: 105-107 °C.

3-(4-hydroxyphenyl)-5-methoxy-1-methyl-3-phenylindolin-2-one (2s)



General procedure D was followed using 3-hydroxy-5-methoxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.19 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (24 µL, 0.24 mmol), diphenyl phosphoric acid (9 mg, 0.04 mmol) and phenol (26 mg, 0.28 mmol) in dry DCM (1.9 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2s** as a colorless solid (52 mg, 79%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.30 – 7.20 (m, 5H), 7.06 (d, *J* = 6.9 Hz, 2H), 6.83 (m, 3H), 6.68 (d, *J* = 6.9 Hz, 2H), 5.72 (br s, 1H), 3.76 (s, 3H), 3.27 (s, 3H).

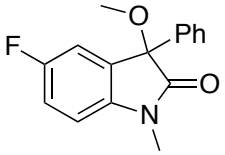
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.0, 156.2, 155.3, 142.1, 136.6, 134.7, 133.5, 129.9, 128.6, 128.4, 127.4, 115.5, 113.6, 112.4, 109.0, 62.5, 55.9, 26.9.

ATR-IR v 3324 (w), 1688 (s), 1602 (m), 1471 (m), 1362 (w), 1289 (m), 1236 (w), 1178 (w), 1137 (m), 913 (w), 816 (w), 737 (m), 700 (m), 674 (m), 651 (m), 637 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{22}H_{19}NNaO_3$, $[M+Na]^+$: 368.1257, found: 368.1248.

Mp: 145-146 °C.

5-fluoro-3-methoxy-1-methyl-3-phenylindolin-2-one (2t)



General procedure E was followed using 5-fluoro-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.19 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (25 µL, 0.25 mmol), TFA (3 µL, 0.04 mmol) and methanol (12 µL, 0.29 mmol) in dry DCM (1.9 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:6) to afford the title compound **2t** as a colorless solid (48 mg, 91%).

^{1}H NMR (400.13 MHz, CD_3OD) δ 7.33 – 7.27 (m, 5H), 7.20 (ddd, *J* = 9.2, 8.6, 2.6 Hz, 1H), 7.12 (dd, *J* = 8.6, 4.1 Hz, 1H), 7.00 (dd, *J* = 7.5, 2.6 Hz, 1H), 3.26 (s, 3H), 3.18 (s, 3H).

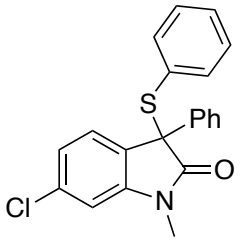
^{13}C NMR (100.62 MHz, CD_3OD) δ 177.1, 161.2 (d, *J* = 241.6 Hz), 141.7 (d, *J* = 2.0 Hz), 139.8, 131.4 (d, *J* = 7.6 Hz), 129.5, 129.5, 126.9, 117.7 (d, *J* = 23.9 Hz), 114.1 (d, *J* = 25.1 Hz), 111.5 (d, *J* = 7.9 Hz), 85.6 (d, *J* = 1.7 Hz), 53.5 , 26.7.

ATR-IR v 3348 (w), 2483 (w), 1711 (s), 1620 (w), 1493 (s), 1469 (m), 1451 (m), 1353 (w), 1268 (w), 1195 (w), 1149 (w), 1128 (w), 1108 (w), 976 (w), 870 (w), 821 (s), 759 (s), 721 (s), 703 (s), 646 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{14}FNNaO_2$, $[M+Na]^+$: 294.0901, found: 294.0905.

Mp: 61-62 °C (lit.[18] 61.3-61.9 °C).

6-chloro-1-methyl-3-phenyl-3-(phenylthio)indolin-2-one (2u)



General procedure E was followed using 6-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.18 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (24 µL, 0.24 mmol), TFA (3 µL, 0.04 mmol) and thiophenol (28 µL, 0.27 mmol) in dry DCM (1.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:5) to afford the title compound **2u** as a light yellow solid (57 mg, 85%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.74 – 7.65 (m, 2H), 7.46 – 7.31 (m, 4H), 7.26 (m, 1H), 7.20 – 7.07 (m, 5H), 6.54 (d, *J* = 1.9 Hz, 1H), 2.83 (s, 3H).

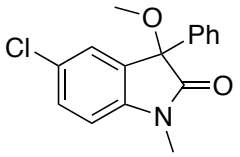
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 174.9, 144.2, 136.5, 135.5, 134.6, 129.9, 129.8, 128.8, 128.6, 128.5, 128.4, 128.2, 127. 2, 122.7, 108.8, 62.4, 26.4.

ATR-IR v 3062 (w), 2929 (w), 1723 (s), 1606 (m), 1492 (m), 1470 (m), 1438 (m), 1364 (m), 1314 (w), 1293 (w), 1247 (w), 1161 (w), 1072 (m), 1027 (w), 955 (w), 912 (w), 844 (w), 813 (w), 752 (m), 736 (m), 694 (m), 617 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{21}H_{16}ClNNaOS$, $[M+Na]^+$: 388.0533, found: 388.0530.

Mp: 145-147 °C.

5-chloro-3-methoxy-1-methyl-3-phenylindolin-2-one (2v)



General procedure E was followed using 5-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.18 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (24 µL, 0.24 mmol), TFA (3 µL, 0.04 mmol) and methanol (11 µL, 0.27 mmol) in dry DCM (1.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the title compound **2v** as a colorless solid (45 mg, 86%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.39 - 7.25 (m, 7H), 6.86 (d, *J* = 8.3 Hz, 1H), 3.24 (s, 3H), 3.23 (s, 3H).

^{13}C NMR (100.62 MHz, $CDCl_3$) δ 175.2, 143.4, 138.4, 130.5, 130.4, 129.3, 129.1, 129.0, 126.6, 126.5, 110.0, 84.3, 53.7, 27.0.

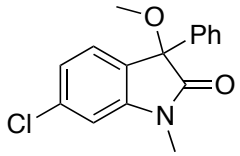
ATR-IR v 1719 (w), 1489 (w), 1359 (w), 1102 (w), 818 (w), 578 (m), 543 (s), 522 (s), 493 (s), 453 (s), 397 (s), 377 (s), 337 (s) cm^{-1}.

[18] J. M. Hillgren and S. P. Marsden, *J. Org. Chem.,* 2008, **73**, 6459 – 6461.

HRMS (ESI+) m/z calcd for $C_{16}H_{14}ClNNaO_2$, $[M+Na]^+$: 310.0605, found: 310.0607.

Mp: 129-130 °C (lit.[6] 128-132 °C).

6-chloro-3-methoxy-1-methyl-3-phenylindolin-2-one (2w)



General procedure E was followed using 6-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.18 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (24 µL, 0.24 mmol), TFA (3 µL, 0.04 mmol) and methanol (11 µL, 0.27 mmol) in dry DCM (1.8 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:4) to afford the title compound **2w** as a white solid (47 mg, 90%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.39 – 7.28 (m, 5H), 7.20 (dd, *J* = 7.9, 0.4 Hz, 1H), 7.12 (dd, *J* = 7.9, 1.8 Hz, 1H), 6.93 (d, *J* = 1.8 Hz, 1H), 3.22 (s, 3H), 3.22 (s, 3H).

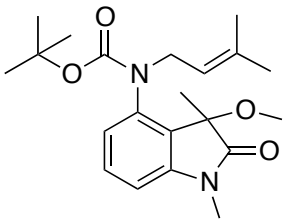
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 175.2, 145.8, 138.2, 136.1, 128.7, 128.6, 126.8, 126.4, 126.3, 123.3, 109.5, 83.7, 53.3, 26.6.

ATR-IR v 3066 (w), 2936 (w), 2827 (w), 1730 (s), 1608 (s), 1493 (m), 1451 (w), 1435 (w), 1362 (m), 1310 (w), 1291 (w), 1240 (w), 1189 (w), 1097 (w), 1073 (m), 985 (m), 952 (w), 873 (w), 846 (w), 814 (w), 769 (w), 737 (w), 717 (w), 696 (w), 642 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{16}H_{14}ClNNaO_2$, $[M+Na]^+$: 310.0605, found: 310.0608.

Mp: 155-157 °C.

***tert*-butyl (3-methoxy-1,3-dimethyl-2-oxoindolin-4-yl)(3-methylbut-2-en-1-yl)carbamate (2x)**



General procedure D was followed using *tert*-butyl (3-hydroxy-1,3-dimethyl-2-oxoindolin-4-yl)(3-methylbut-2-en-1-yl)carbamate (50 mg, 0.14 mmol), DBU (2 µL, 0.01 mmol), Cl_3CCN (18 µL, 0.18 mmol), diphenyl phosphoric acid (7 mg, 0.03 mmol) and methanol (8 µL, 0.21 mmol) in dry DCM (1.4 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:6) to afford the title compound **2x** as a white solid (mixture of two rotamers 43 mg, 83%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.33-7.25 (m, 1H), 6.88 – 6.77 (m, 2H), 5.33 (m, 1H), 4.61 (m, 1H), 3.75 (br s, 1H), 3.22 (s, 3H), 3.06 (s, 3H), 1.71, 1.58, 1.57, 1.52, 1.30 (five br s, 18H).

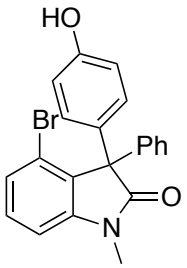
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.0, 177.1, 156.5, 154.7, 144.6, 144.1, 139.9, 138.84, 136.2, 135.7, 130.6, 129.6, 127.8, 127.5, 125.5, 125.4, 121.0, 120.2, 107.6, 107.2, 82.4, 80.0, 74.1, 72.6, 49.0, 47.8, 28.5, 28.4, 26.4, 25.8, 25.7, 23.3, 22.4, 18.0, 14.2.

ATR-IR v 2925 (w), 2853 (w), 1728 (w), 1702 (w), 1609 (w), 1466 (w), 1367 (w), 1258 (w), 1167 (w), 569 (m), 535 (m), 439 (s), 419 (s), 361 (s), 313 (s) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{21}H_{30}N_2NaO_4$, $[M+Na]^+$: 397.2098, found: 397.2100.

Mp: 78-80 °C.

4-bromo-3-(4-hydroxyphenyl)-1-methyl-3-phenylindolin-2-one (2y)



General procedure D was followed using 4-bromo-3-hydroxy-1-methyl-3-phenylindolin-2-one (50 mg, 0.16 mmol), DBU (2 µL, 0.02 mmol), Cl_3CCN (20 µL, 0.20 mmol), diphenyl phosphoric acid (8 mg, 0.03 mmol) and phenol (22 mg, 0.24 mmol) in dry DCM (1.6 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the title compound **2y** as a light yellow solid (48 mg, 76%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 5H), 7.23 – 7.17 (m, 4H), 6.92-6.90 (m, 1H), 6.78 – 6.71 (m, 2H), 4.92 (br s, 1H), 3.27 (s, 3H).

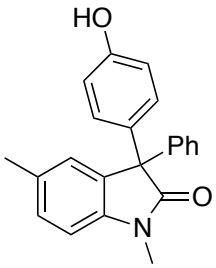
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 178.3, 155.2, 145.5, 137.7, 132.1, 131.1, 130.1, 129.6, 129.3, 128.1, 127.8, 127.8, 121.8, 115.0, 107.7, 63.6, 27.1.

ATR-IR v 3362 (w), 1745 (m), 1721 (s), 1601 (s), 1514 (w), 1454 (m), 1355 (w), 1238 (w), 1184 (w), 1102 (w), 1067 (w), 1019 (w), 937 (w), 822 (w), 765 (m), 739 (m), 699 (m), 634 (m) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{21}H_{16}BrNNaO_2$, $[M+Na]^+$: 416.0257, found: 416.0251.

Mp: 157-158 °C.

3-(4-hydroxyphenyl)-1,5-dimethyl-3-phenylindolin-2-one (2z)



General procedure D was followed using 3-hydroxy-1,5-dimethyl-3-phenylindolin-2-one (50 mg, 0.20 mmol), DBU (3 µL, 0.02 mmol), Cl_3CCN (26 µL, 0.26 mmol), diphenyl phosphoric acid (10 mg, 0.04 mmol) and phenol (28 mg, 0.30 mmol) in

dry DCM (2.0 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:5) to afford the title compound **2z** as a colorless solid (58 mg, 88%).

^{1}H NMR (400.13 MHz, $CDCl_3/CD_3OD$) δ 7.23 – 7.11 (m, 5H), 7.07 – 6.91 (m, 4H), 6.64 – 6.62 (m, 1H), 6.57 – 6.53 (m, 2H), 3.29 (br s, 1H), 3.19 (s, 3H), 2.23 (s, 3H).

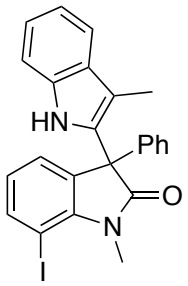
^{13}C NMR (100.62 MHz, $CDCl_3/CD_3OD$) δ 178.5, 156.1, 142.3, 140.4, 133.4, 132.6, 132.5, 129.6, 128.5, 128.3, 128.3, 127.1, 126.6, 115.2, 108.4, 62.2, 26.6, 21.1.

ATR-IR v 3337 (w), 1691 (s), 1605 (m), 1512 (m), 1499 (m), 1447 (w), 1363 (m), 1268 (w), 1232 (w), 1178 (w), 1143 (w), 1093 (w), 1035 (w), 828 (m), 739 (w), 700 (w), 655 (w), 610 (w) cm^{-1}.

HRMS (ESI+) m/z calcd for $C_{22}H_{19}NNaO_2$, $[M+Na]^+$: 352.1308, found: 352.1305.

Mp: 131-133 °C.

7-iodo-1-methyl-3-(3-methyl-1*H*-indol-2-yl)-3-phenylindolin-2-one (2A)



General procedure D was followed using 3-hydroxy-7-iodo-1-methyl-3-phenylindolin-2-one (50 mg, 0.14 mmol), DBU (2 µL, 0.01 mmol), Cl_3CCN (18 µL, 0.18 mmol), diphenyl phosphoric acid (7 mg, 0.03 mmol) and 3-methylindole (27 mg, 0.21 mmol) in dry DCM (1.4 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:5) to afford the title compound **2A** as a light yellow solid (40 mg, 77%).

^{1}H NMR (400.13 MHz, $CDCl_3$) δ 7.81 (br s, 1H), 7.71 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.48 (d, *J* = 8.4 Hz, 1H), 7.31 – 7.26 (m, 4H), 7.21 (dd, *J* = 7.4, 1.2 Hz, 1H), 7.19 – 7.15 (m, 2H), 6.99 – 6.93 (m, 2H), 6.82 – 6.72 (m, 1H), 3.69 (s, 3H), 2.29 (s, 3H).

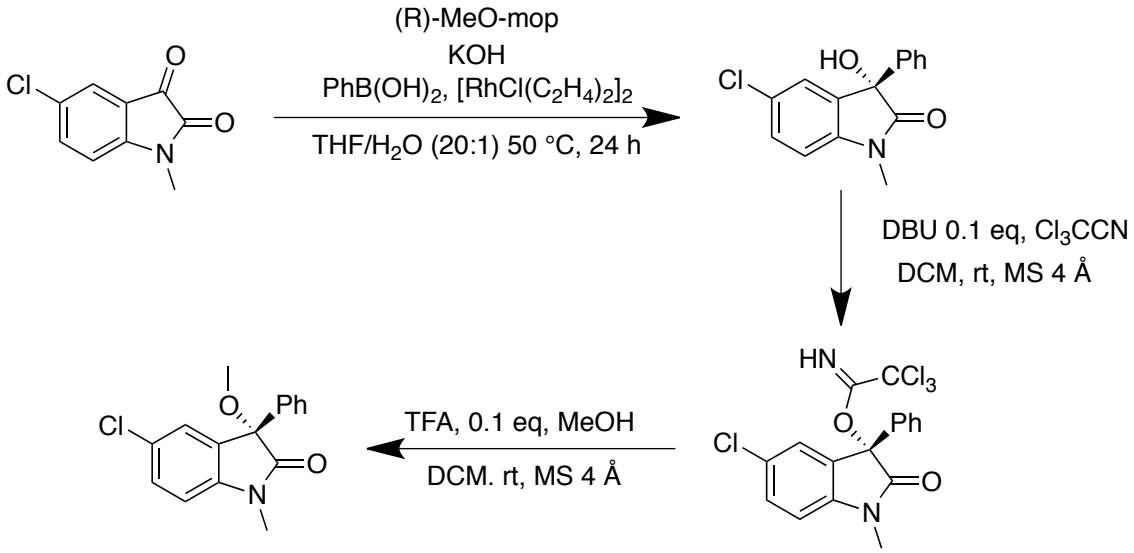
^{13}C NMR (100.62 MHz, $CDCl_3$) δ 179.1, 143.5, 142.2, 140.9, 136.7, 136.2, 135.3, 129.2, 128.7, 128.5, 127.5, 126.4, 124.5, 122.5, 120.0, 119.0, 111.8, 111.3, 71.9, 30.9, 9.8.

ATR-IR v 3353 (w), 2927 (w), 1713 (s), 1595 (w), 1571 (w), 1496 (w), 1451 (s), 1358 (w), 1332 (w), 1260 (w), 1098 (s), 1076 (m), 1046 (m), 909 (w), 807 (w), 734 (m), 698 (m), 662 (m) cm^{-1}.

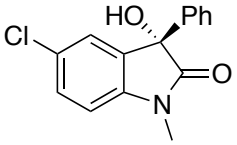
HRMS (ESI+) m/z calcd for $C_{24}H_{19}IN_2NaO$, $[M+Na]^+$: 501.0434, found: 501.0425.

Mp: 145-146 °C.

Mechanistic evidence: reaction with enantioenriched material



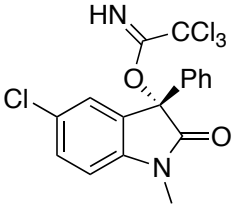
5-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (1f)[19]



A solution of $[RhCl(C_2H_4)_2]_2$ (5 mg, 0.25 mmol, 0.05 equiv of Rh,) and (R)-MeO-mop (24 mg, 0.51 mmol, 0.1 equiv) in THF (2.6 mL) was stirred at room temperature for 10 min. KOH (0.3 M in H_2O, 0.26 mL, 0.15 equiv), 5-chloro-1-methylindolin-2,3-dione (100 mg, 0.51 mmol, 1 equiv) and $PhB(OH)_2$ (125 mg, 1.02 mmol, 2 equiv) were added successively with additional dry THF (2.6 mL) and the resulting mixture was stirred at 50 °C for 24 h. The reaction mixture was then directly passed through a pad of silica gel with diethyl ether. After evaporation of the solvent under vacuum, the crude product was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 2:3) to afford the desired product **1f** as yellow solid (112 mg, 80%).

The ee was not determined at this stage.

5-chloro-1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate (3b)



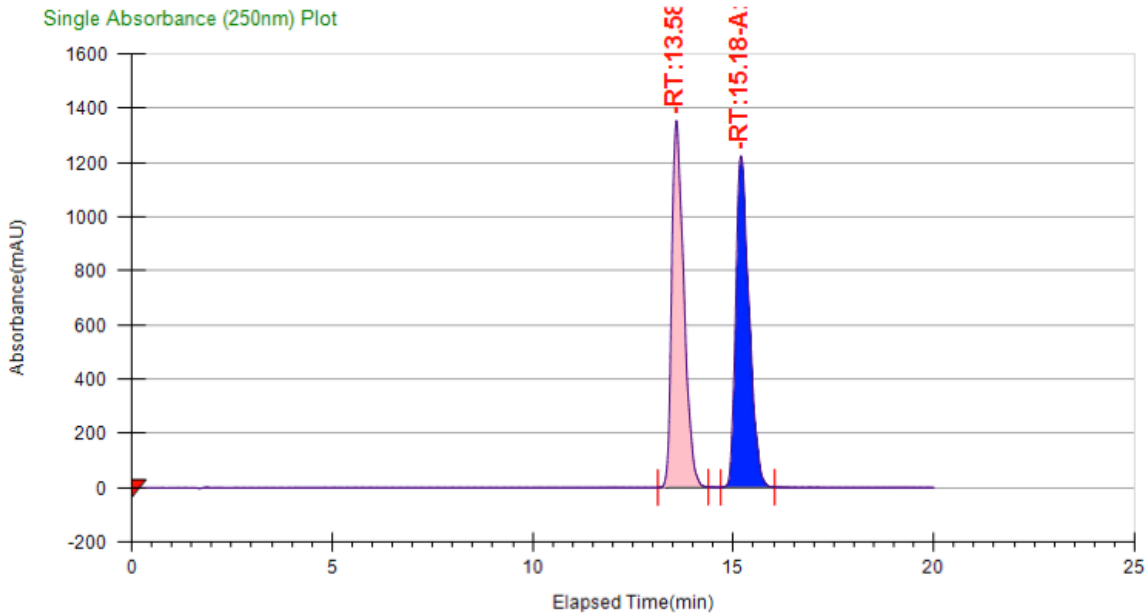
General procedure C was followed using 5-chloro-3-hydroxy-1-methyl-3-phenylindolin-2-one (112 mg, 0.41 mmol), DBU (6 µL, 0.04 mmol) and trichloroacetonitrile (53 µL, 0.53 mmol) in dry DCM (4.1 mL) to give a crude mixture which was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:11) to afford the title compound **3b** as a light yellow

[19] R. Shintani, M. Inoue and T. Hayashi, *Angew. Chem. Int. Ed.,* 2006, **45**, 3353 – 3356.

solid (169 mg, 99%, er 4:96).

The enantiomeric ratio was determined on a Daicel Chiralcel OD-H column by SFC with 10% MeOH, flow = 3 mL/min with UV detection at 250 nm. Retention times: 13.69 min and 14.98 min.

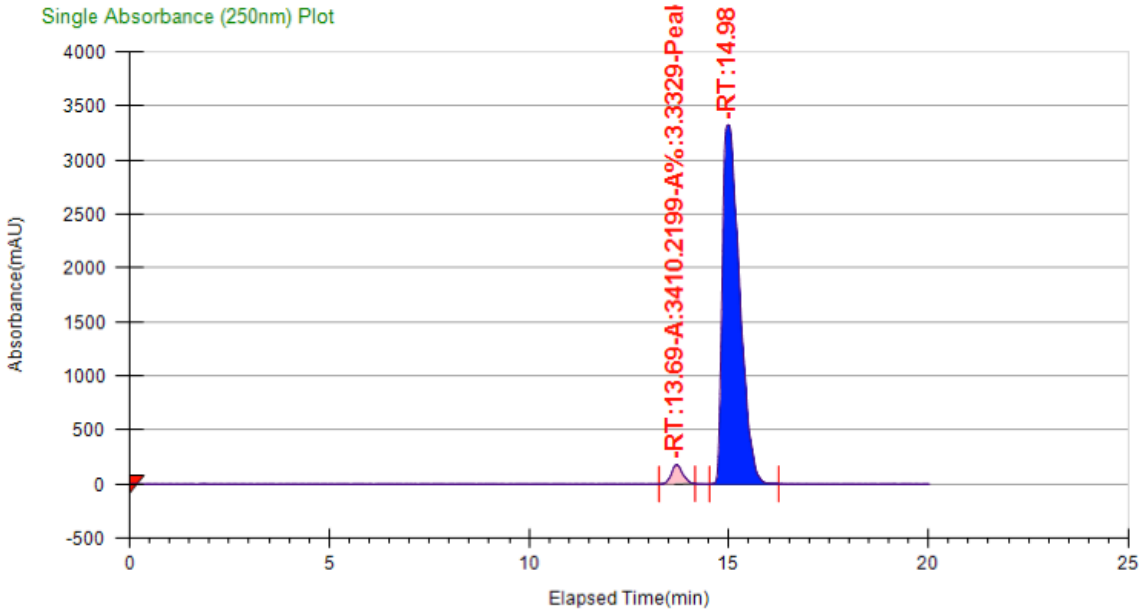
SFC spectra of the racemic mixture



Peak Information

Peak No	% Area	Area	Ret. Time	Height	Cap. Factor
1	49.9829	28094.2532	13.58 min	1353.7742	0
2	50.0171	28113.5111	15.18 min	1222.2278	0

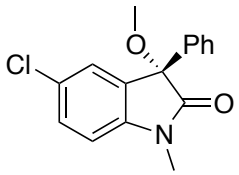
SFC spectra of the enantioenriched mixture



Peak Information

Peak No	% Area	Area	Ret. Time	Height	Cap. Factor
1	3.3329	3410.2199	13.69 min	175.0751	0
2	96.6671	98910.1513	14.98 min	3324.8434	0

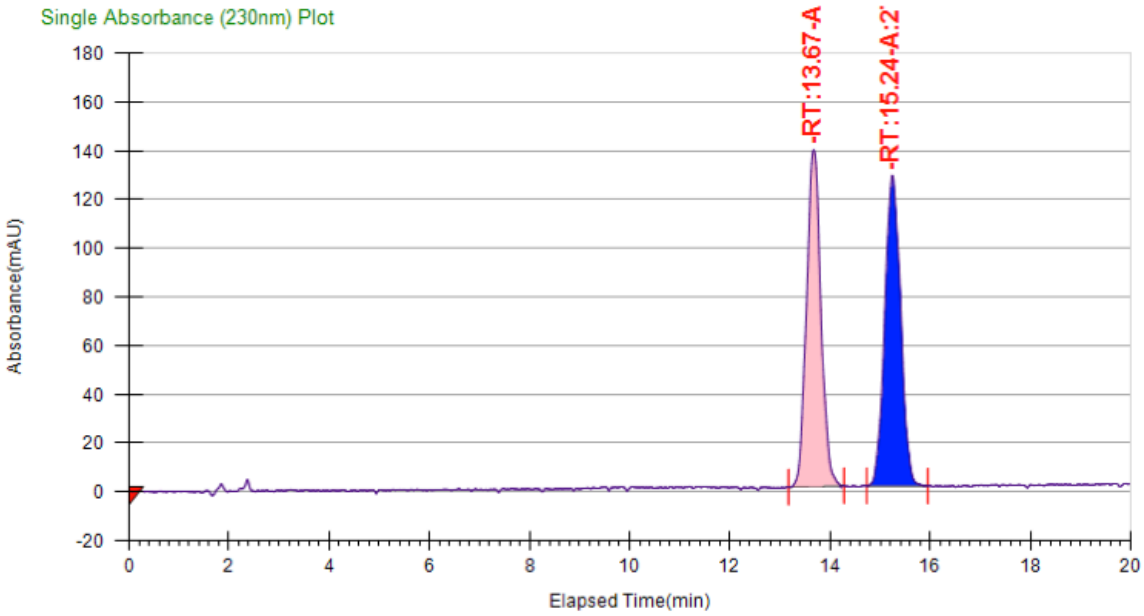
6-chloro-3-methoxy-1-methyl-3-phenylindolin-2-one (2v)



To a solution of 5-chloro-1-methyl-2-oxo-3-phenylindolin-3-yl 2,2,2-trichloroacetimidate (100mg, 0.24 mmol, 1 equiv) in dry DCM (2.0 mL) were added methanol (14 µL, 0.36 mmol, 1.5 equiv) and TFA (2 µL, 0.03 mmol, 0.1 equiv). After complete conversion of the trichloroacetimidate, the reaction mixture was quenched with a saturated solution of $NaHCO_3$. The aqueous layer was extracted with DCM (3x). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified by flash column chromatography on silica gel (EtOAc/petroleum ether 1:3) to afford the desired compound **2v** as a colorless solid (59 mg, 85 %, er 50:50).

The enantiomeric ratio was determined on a Daicel Chiralpak AD-H column by SFC with 10% MeOH, flow = 3 mL/min with UV detection at 230 nm. Retention times: 13.67 min and 15.24 min.

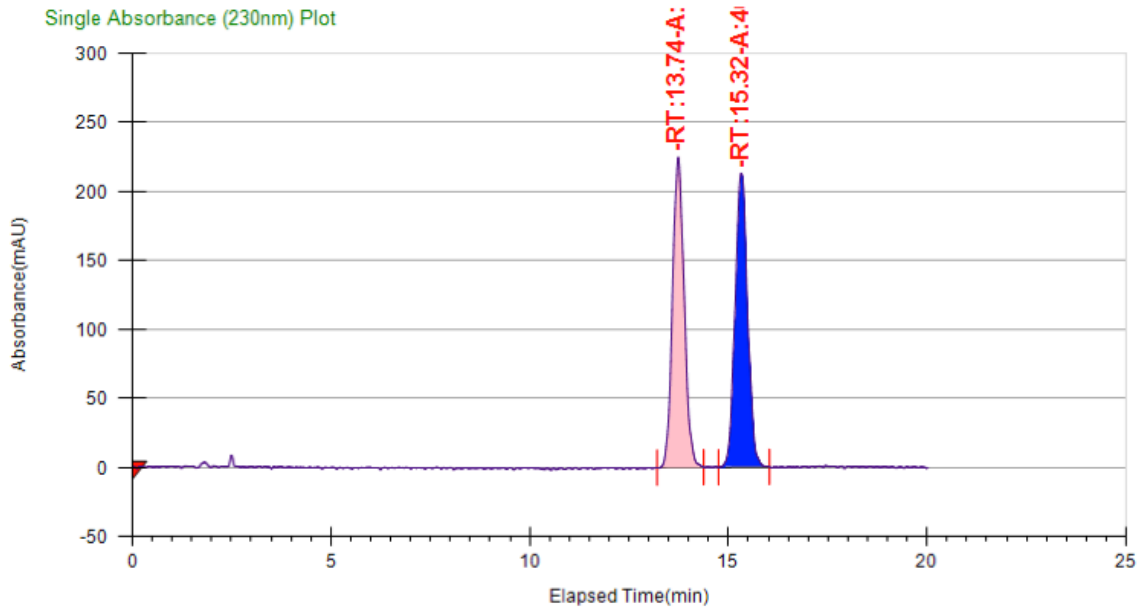
SFC spectra of the racemic mixture



Peak Information

Peak No	% Area	Area	Ret. Time	Height	Cap. Factor
1	49.6872	2732.7694	13.67 min	138.1098	0
2	50.3128	2767.1751	15.24 min	127.5272	0

SFC spectra of the enantioenriched mixture

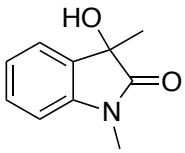


Peak Information

Peak No	% Area	Area	Ret. Time	Height	Cap. Factor
1	49.5268	4531.4273	13.74 min	224.9111	0
2	50.4732	4618.0212	15.32 min	213.1288	0

Computational details

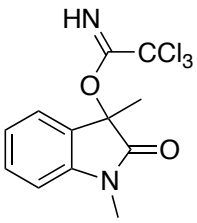
Coordinates and bond dissociation energy of the optimized geometry



BDE= -16699.07 kJ/mol

C	-0.75970929	-0.0093534	0.82611402
C	-4.41610721	2.15649001	0.98049808
C	-5.30229554	0.8833704	0.84719409
N	-4.48342913	-0.19050095	0.67697412
C	-0.64620968	1.3610693	1.03761065
C	-1.7913665	2.16236472	1.10870855
C	-3.02899082	1.56635231	0.97289882
C	-3.12999809	0.18815346	0.76754781
C	-2.0091194	-0.6220119	0.6866994

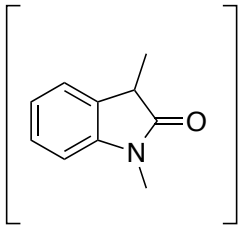
O	-6.52799	0.86950805	0.88210281
H	-1.70511102	3.22790708	1.2700758
C	-4.93814073	-1.55696992	0.48911583
C	-4.68495071	3.08706546	-0.2026992
O	-4.65955026	2.80757706	2.2338838
H	0.13236531	-0.61705492	0.76880133
H	0.33042777	1.81081476	1.14452654
H	-2.08891984	-1.6871995	0.52523339
H	-4.5385732	-1.9603015	-0.44071213
H	-6.02205216	-1.54973342	0.4426649
H	-4.61481107	-2.18258617	1.32090122
H	-4.04278733	3.96521967	-0.13358912
H	-5.72970514	3.40356563	-0.19782047
H	-4.48264958	2.57642459	-1.14546516
H	-5.57818589	3.1185068	2.2334963



BDE= -20278.61 kJ/mol

C	-0.55853766	-0.01498416	-0.30259196
C	-4.24423437	1.79831304	0.77467682
C	-5.11854152	0.70660235	0.08786467
N	-4.27440672	-0.11737345	-0.59632763
C	-0.46679443	1.08103222	0.54981438
C	-1.62339569	1.74593464	0.97231174
C	-2.84856451	1.28377263	0.53749387
C	-2.93033694	0.17887329	-0.31262787
C	-1.79699181	-0.48554472	-0.75101513
O	-6.34022918	0.65714906	0.10165964
Cl	-4.94584919	0.06515651	5.59971244
C	-4.7082267	-1.27003461	-1.36476544
C	-4.50919841	3.14348852	0.1060375
O	-4.59297796	1.99562547	2.16922351
H	0.3425711	-0.51782927	-0.62474141
H	0.501585	1.42169876	0.88755483
H	-1.85819516	-1.33968063	-1.41000707
H	-4.31398962	-1.21823648	-2.3786008
H	-5.79243456	-1.26569313	-1.39843642
H	-4.36434624	-2.19047637	-0.89154471
H	-3.88224906	3.91020848	0.56001312
H	-5.55876995	3.41246922	0.22229951
H	-4.27214155	3.07876585	-0.9556484

C	-4.59544116	0.93816606	2.99969656
N	-4.36223162	-0.24144004	2.63529936
C	-4.93433897	1.42679034	4.43103627
Cl	-6.56747557	2.19180949	4.4146433
Cl	-3.68890619	2.62537389	4.95214399
H	-4.41698318	-0.89979968	3.40793837
H	-1.55498308	2.59758401	1.6353076



BDE= -14896.87 kJ/mol

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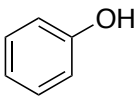
C	-5.08120999	0.87753652	0.31636772
N	-4.28029054	-0.2793172	0.46172956
C	-0.49181991	1.38119857	0.73255269
C	-1.58440983	2.17332638	0.58132474
C	-2.87429927	1.55615972	0.49258233
C	-2.98904111	0.10061125	0.56659816
C	-1.85146913	-0.68888633	0.7217561
O	-6.27191797	0.89755426	0.20032252
H	-1.49666848	3.24799531	0.52696407
C	-4.81251335	-1.63905654	0.48911203
C	-4.6154945	3.45093191	0.2140766
H	-5.16985494	3.55523156	-0.72439164
H	0.25952577	-0.63336503	0.92092585
H	0.49663334	1.81018383	0.80276346
H	-1.90886128	-1.76569029	0.77716421
H	-4.4111237	-2.21698664	-0.34160547
H	-5.89133969	-1.56725543	0.39009383
H	-4.56792871	-2.11898771	1.43515554
H	-3.81797263	4.18711921	0.24997618
H	-5.34061559	3.65503891	1.00866155



BDE= -9023.61 kJ/mol

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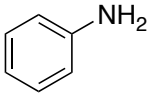
C	-1.11036791	-4.10425254	-0.17104519
C	0.08935122	-4.7849388	0.01877534
C	1.27061535	-4.0590734	0.16127805
C	1.25871463	-2.66940015	0.11541577
H	-2.07131038	-2.18671307	-0.36672875

H	-2.03429099	-4.65468593	-0.28305356
H	0.1043806	-5.86508261	0.05523261
H	2.20897137	-4.57570316	0.30924409
H	2.17182394	-2.1000542	0.22530683
O	0.08834591	-0.6246044	-0.1136716
H	-0.80756473	-0.28677042	-0.25000173



BDE= -9573.74 kJ/mol

C	0.05919582	-1.99862818	-0.07730109
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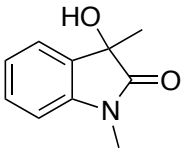
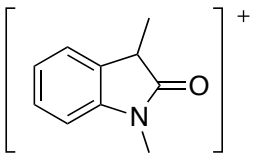
C	-1.10303506	-4.12439812	-0.17096949
C	0.09391496	-4.81232565	0.01837591
C	1.2734576	-4.0838317	0.16001463
C	1.26119518	-2.69437637	0.11531924
H	-2.06371129	-2.2138914	-0.36437729
H	-2.02919364	-4.67145589	-0.28595988
H	0.10749969	-5.89251478	0.05247305
H	2.21335467	-4.59899122	0.30632643
H	2.18553561	-2.14151372	0.2295205
N	0.03333965	-0.59947757	-0.06520161
H	0.90445643	-0.16673493	-0.33704164
H	-0.7401319	-0.19483103	-0.57330452

Mulliken, Voronoi and Hirschfeld charges

Alcohol: 

Intermediate: 

- **Hirschfeld**

Alcohol		Intermediate		Difference
C	-0.048	C	0.0622	0.1102
C	0.0689	C	0.1108	0.0419
C	0.1661	C	0.2295	0.0634
C	-0.0625	C	-0.0173	0.0452
C	-0.0451	C	0.0215	0.0666
C	-0.026	C	0.0171	0.0431
C	0.0447	C	0.1312	0.0865
C	-0.0596	C	-0.0232	0.0364
C	-0.0459	C	-0.0319	0.014
C	-0.1166	C	-0.0807	0.0359
N	-0.0307	N	-0.0149	0.0158
O	-0.3357	O	-0.2057	0.13

C	-0.048	C	0.0622	0.1102
C	0.0689	C	0.1108	0.0419
C	0.1661	C	0.2295	0.0634
C	-0.0625	C	-0.0173	0.0452
C	-0.0451	C	0.0215	0.0666
C	-0.026	C	0.0171	0.0431
C	0.0447	C	0.1312	0.0865
C	-0.0596	C	-0.0232	0.0364
C	-0.0459	C	-0.0319	0.014
C	-0.1166	C	-0.0807	0.0359
N	-0.0307	N	-0.0149	0.0158
O	-0.3357	O	-0.2057	0.13

- **Mulliken**

Alcohol		Intermediate		Difference
C	0.0822	C	0.206	0.1238
C	0.2348	C	0.055	-0.1798
C	0.552	C	0.6122	0.0602
N	-0.2476	N	-0.2366	0.011
C	0.0318	C	0.0755	0.0437
C	0.122	C	0.1784	0.0564
C	-0.0598	C	-0.0262	0.0336
C	0.1642	C	0.2386	0.0744
C	0.0711	C	0.118	0.0469
O	-0.6626	O	-0.5112	0.1514
C	0.629	C	0.6325	0.0035
C	0.543	C	0.5305	-0.0125
C	0.0822	C	0.206	0.1238
C	0.2348	C	0.055	-0.1798
C	0.552	C	0.6122	0.0602
N	-0.2476	N	-0.2366	0.011
C	0.0318	C	0.0755	0.0437
C	0.122	C	0.1784	0.0564
C	-0.0598	C	-0.0262	0.0336
C	0.1642	C	0.2386	0.0744
C	0.0711	C	0.118	0.0469
O	-0.6626	O	-0.5112	0.1514
C	0.629	C	0.6325	0.0035
C	0.543	C	0.5305	-0.0125

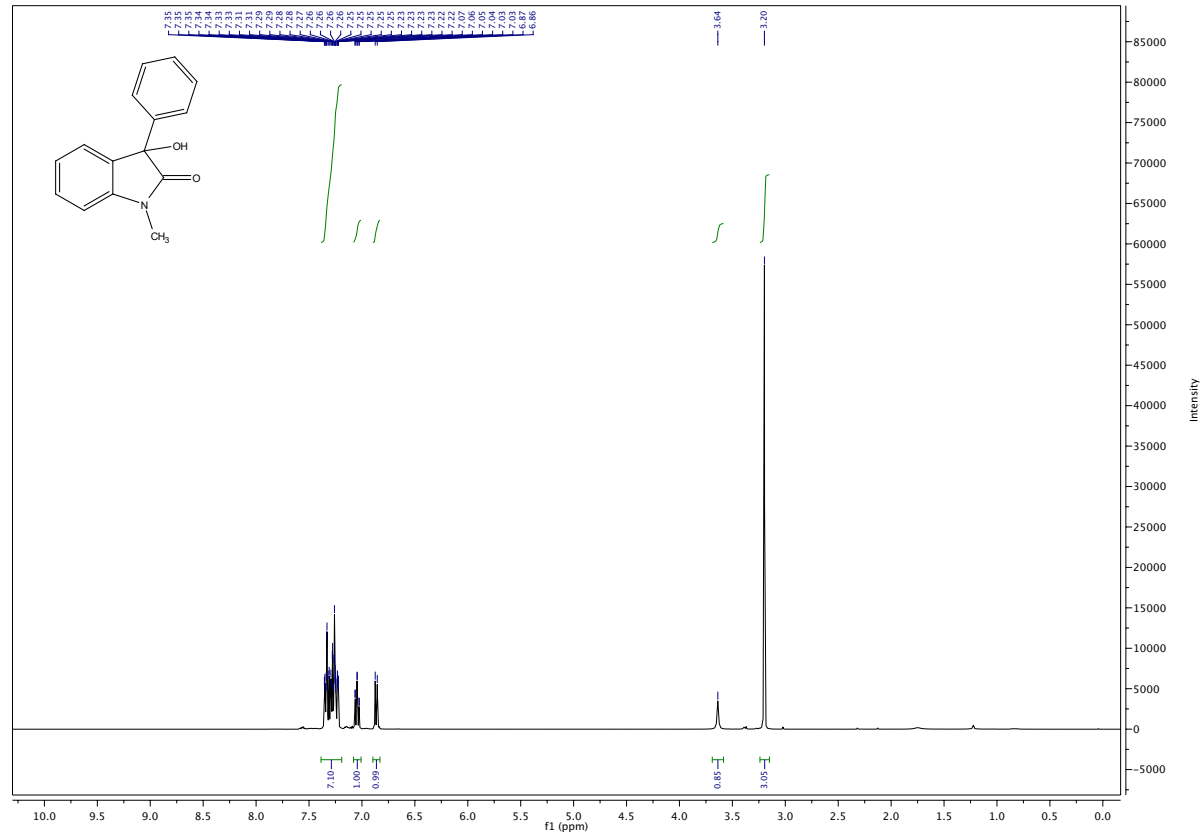
- **Voronoi**

Alcohol		Intermediate		Difference
C	-0.057	C	0.049	0.106
C	0.018	C	0.076	0.058

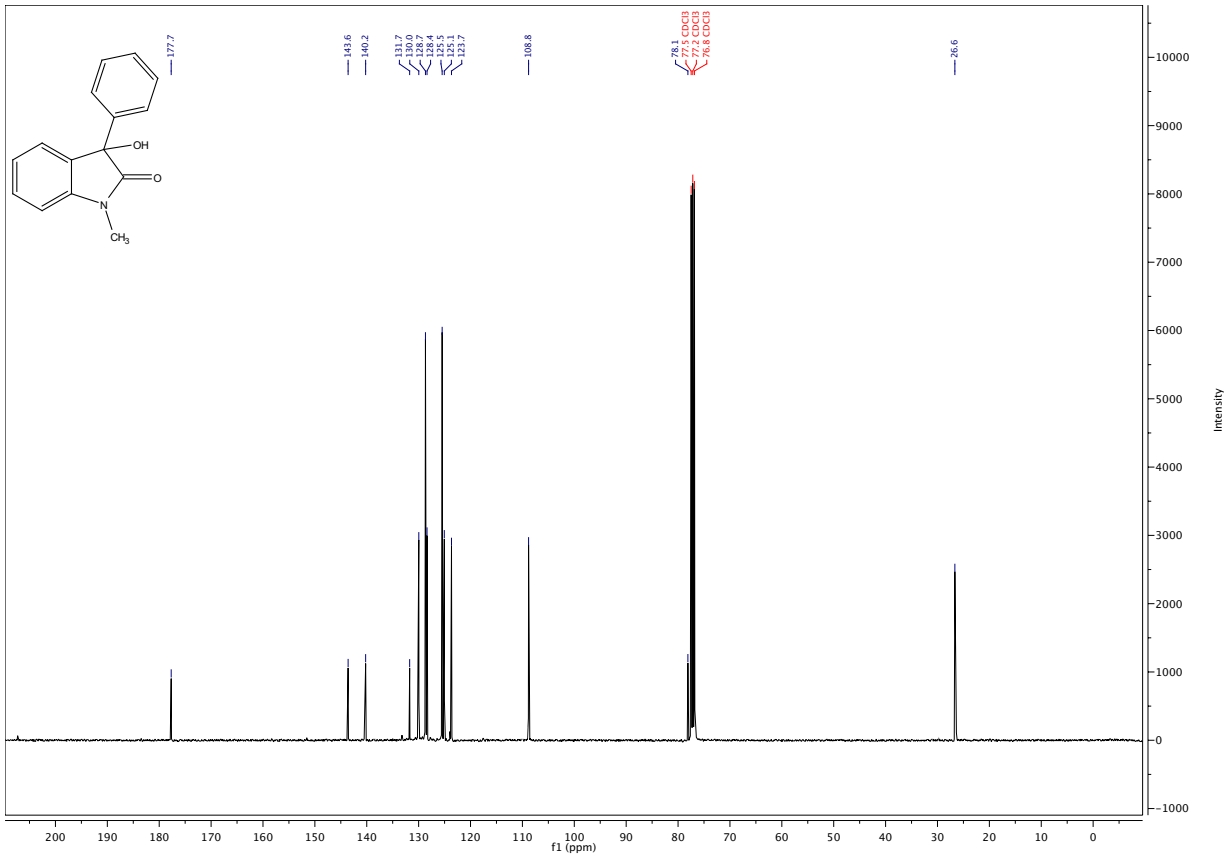
C	0.184	C	0.24	0.056
N	-0.064	N	-0.051	0.013
C	-0.078	C	-0.053	0.025
C	-0.062	C	-0.004	0.058
C	-0.054	C	-0.012	0.042
C	0.044	C	0.145	0.101
C	-0.088	C	-0.075	0.013
O	-0.375	O	-0.221	0.154
C	-0.048	C	-0.044	0.004
C	-0.109	C	-0.115	-0.006
C	-0.057	C	0.049	0.106
C	0.018	C	0.076	0.058
C	0.184	C	0.24	0.056
N	-0.064	N	-0.051	0.013
C	-0.078	C	-0.053	0.025
C	-0.062	C	-0.004	0.058
C	-0.054	C	-0.012	0.042
C	0.044	C	0.145	0.101
C	-0.088	C	-0.075	0.013
O	-0.375	O	-0.221	0.154
C	-0.048	C	-0.044	0.004
C	-0.109	C	-0.115	-0.006

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

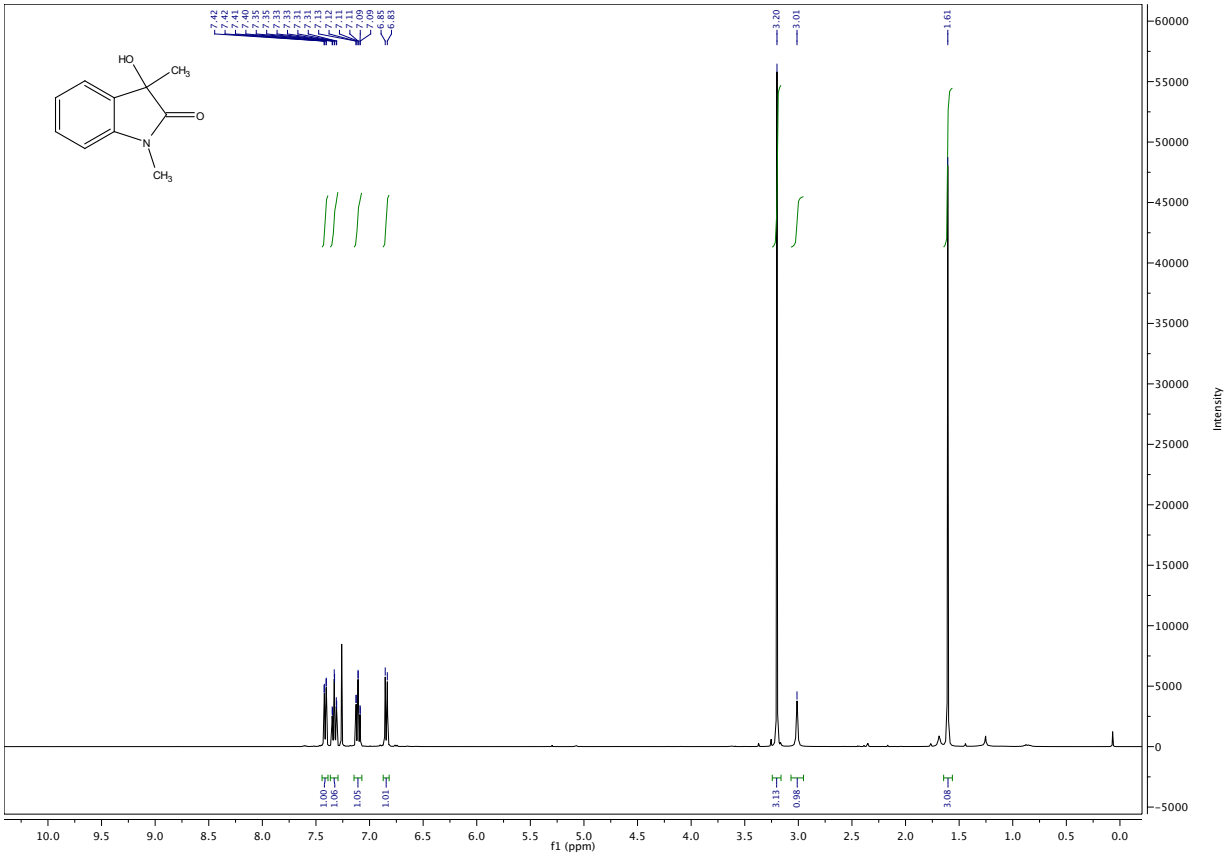
^{1}H NMR spectra (400.13 MHz) of compound **1a** in $CDCl_3$



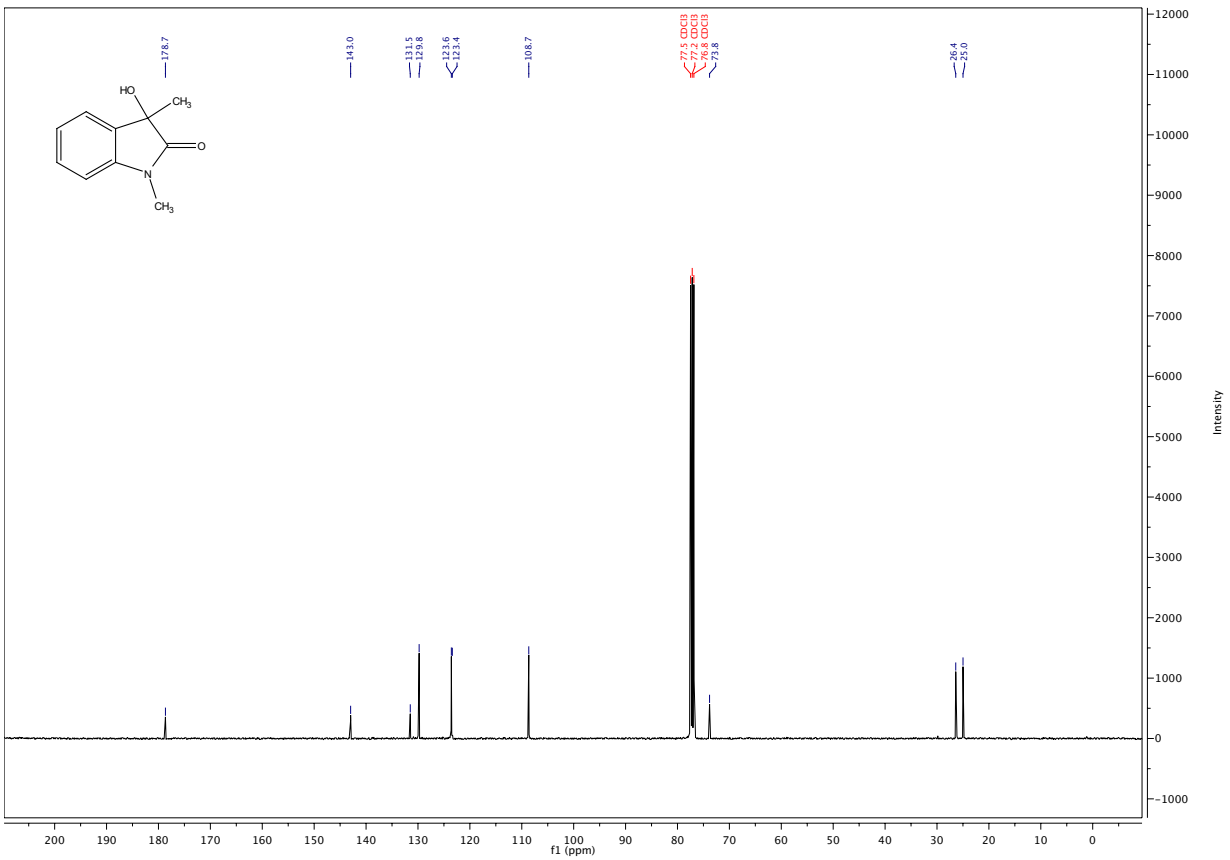
^{13}C NMR spectra (100.62 MHz) of compound **1a** in $CDCl_3$



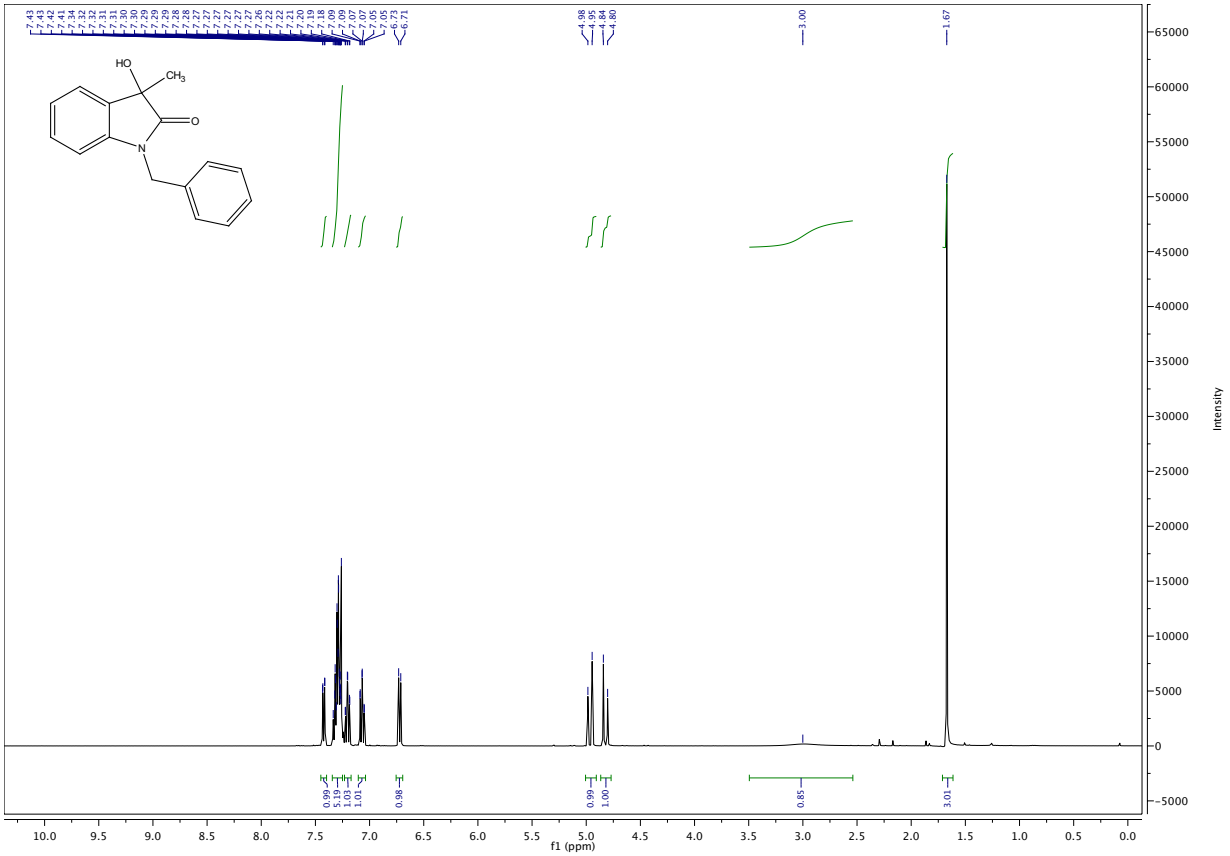
^{1}H NMR spectra (400.13 MHz) of compound **1b** in $CDCl_3$



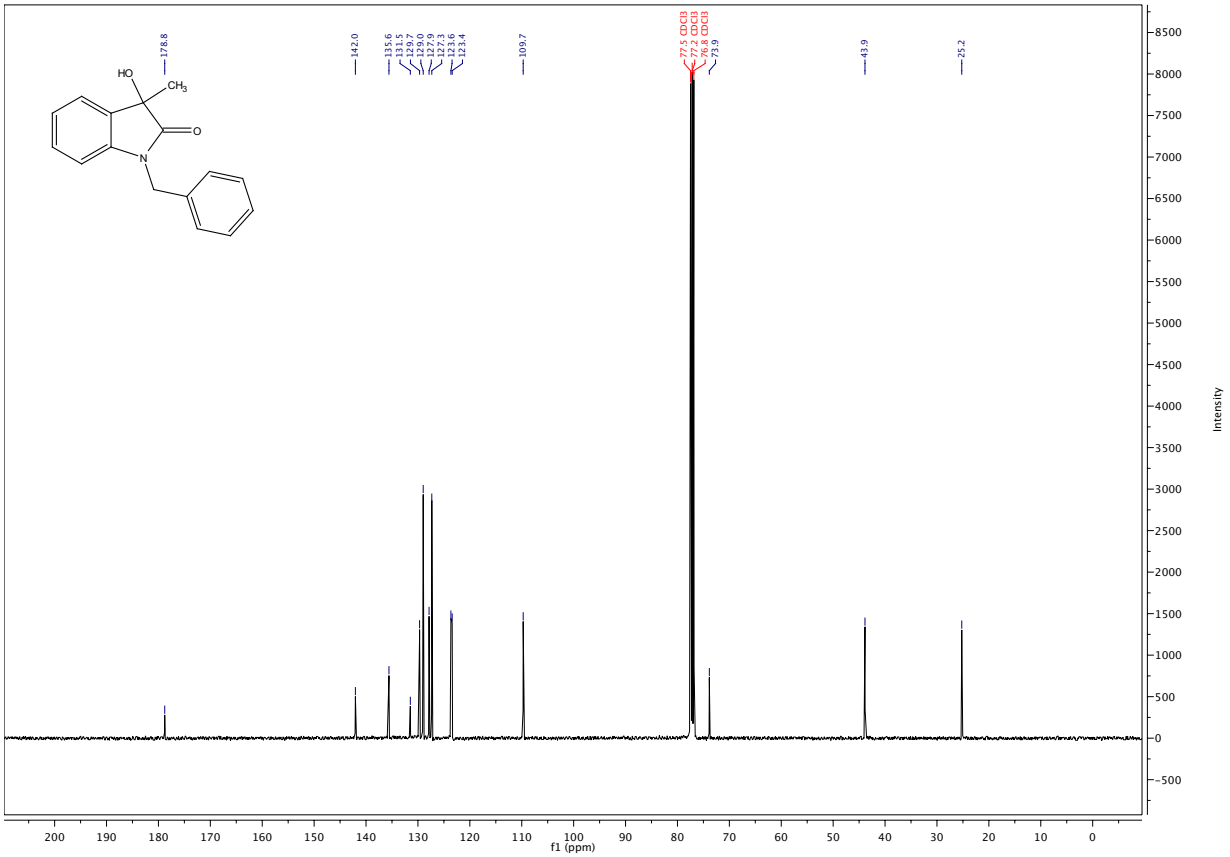
^{13}C NMR spectra (100.62 MHz) of compound **1b** in $CDCl_3$



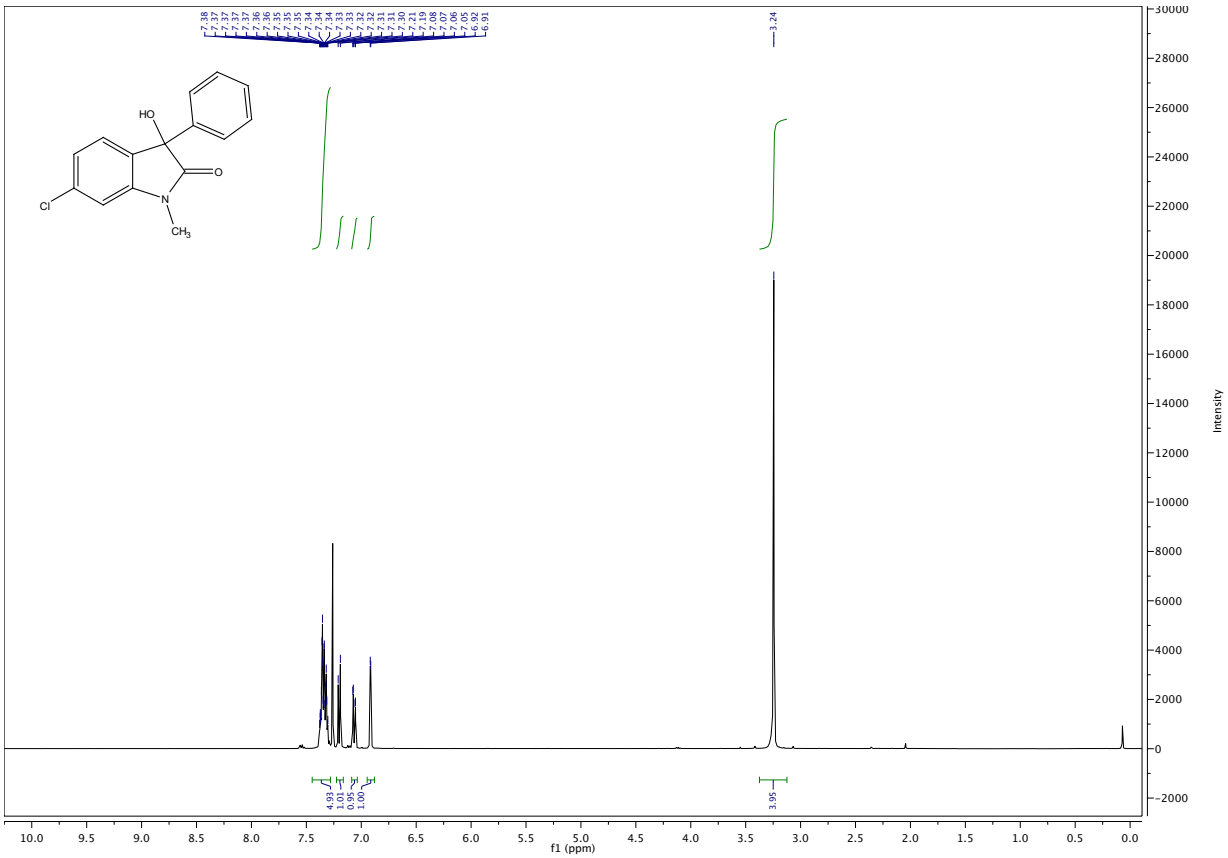
^{1}H NMR spectra (400.13 MHz) of compound **1c** in $CDCl_3$



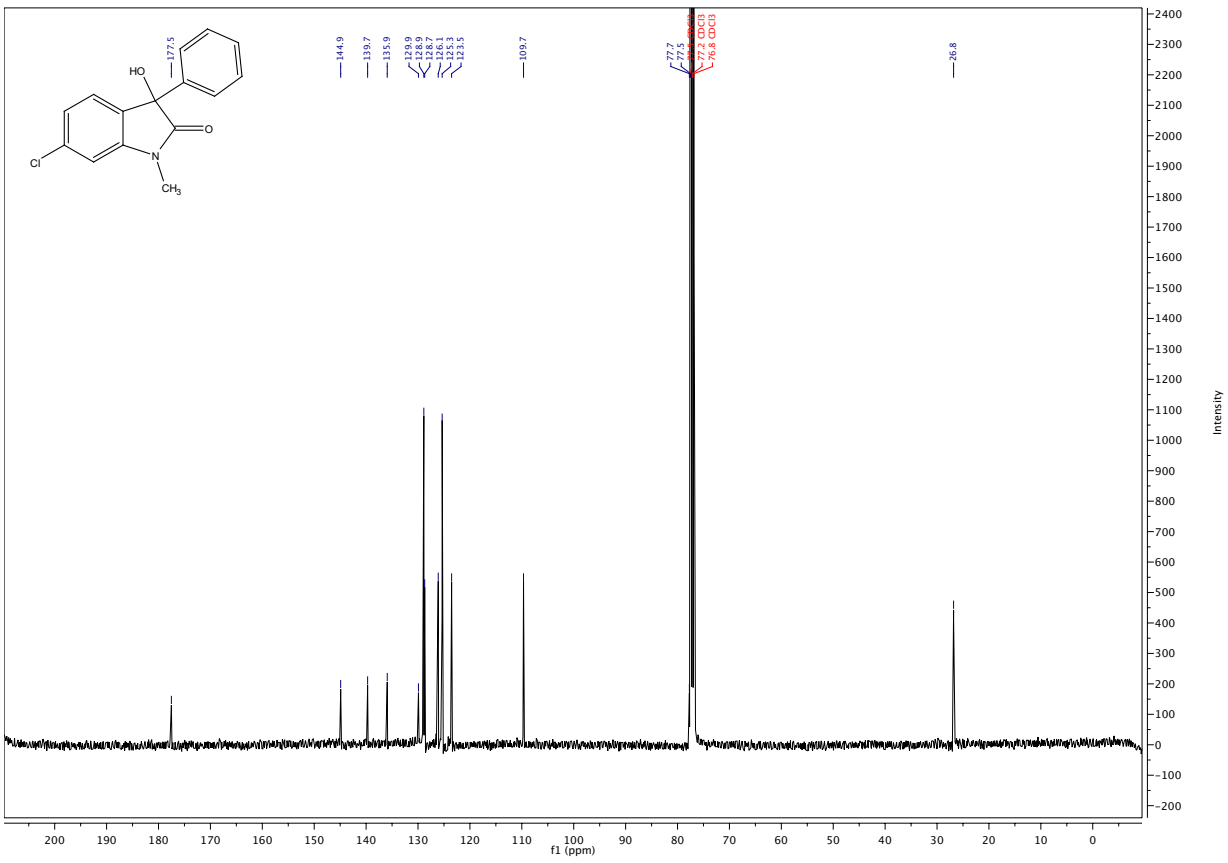
^{13}C NMR spectra (100.62 MHz) of compound **1c** in $CDCl_3$



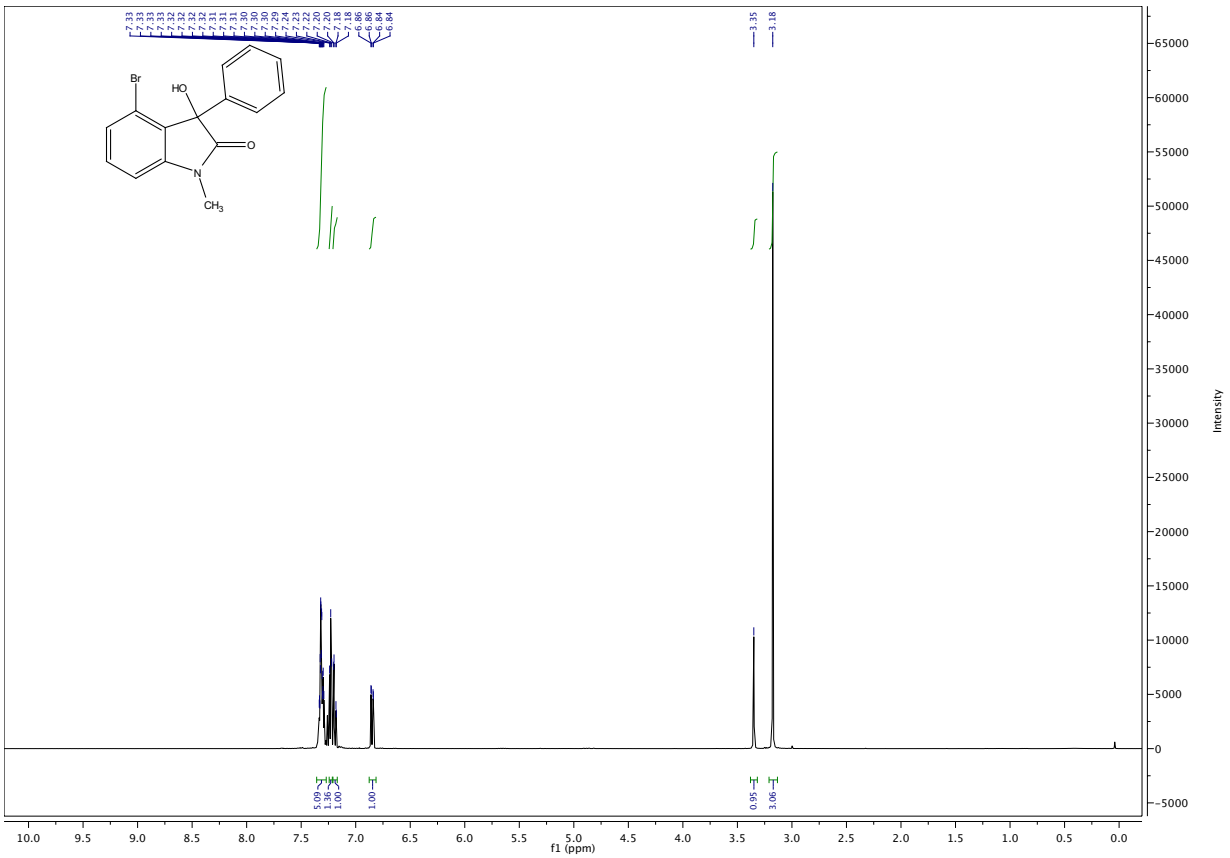
^{1}H NMR spectra (400.13 MHz) of compound **1d** in $CDCl_3$



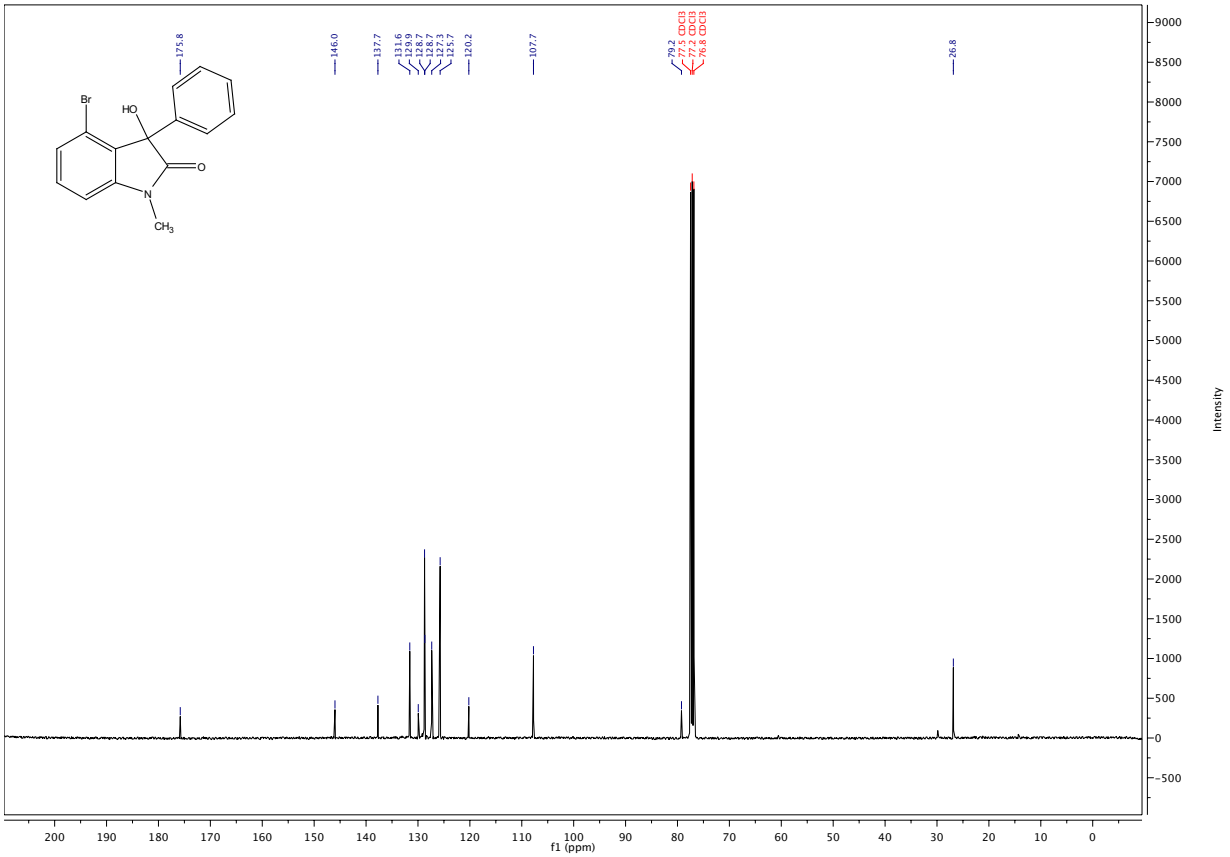
^{13}C NMR spectra (100.62 MHz) of compound **1d** in $CDCl_3$



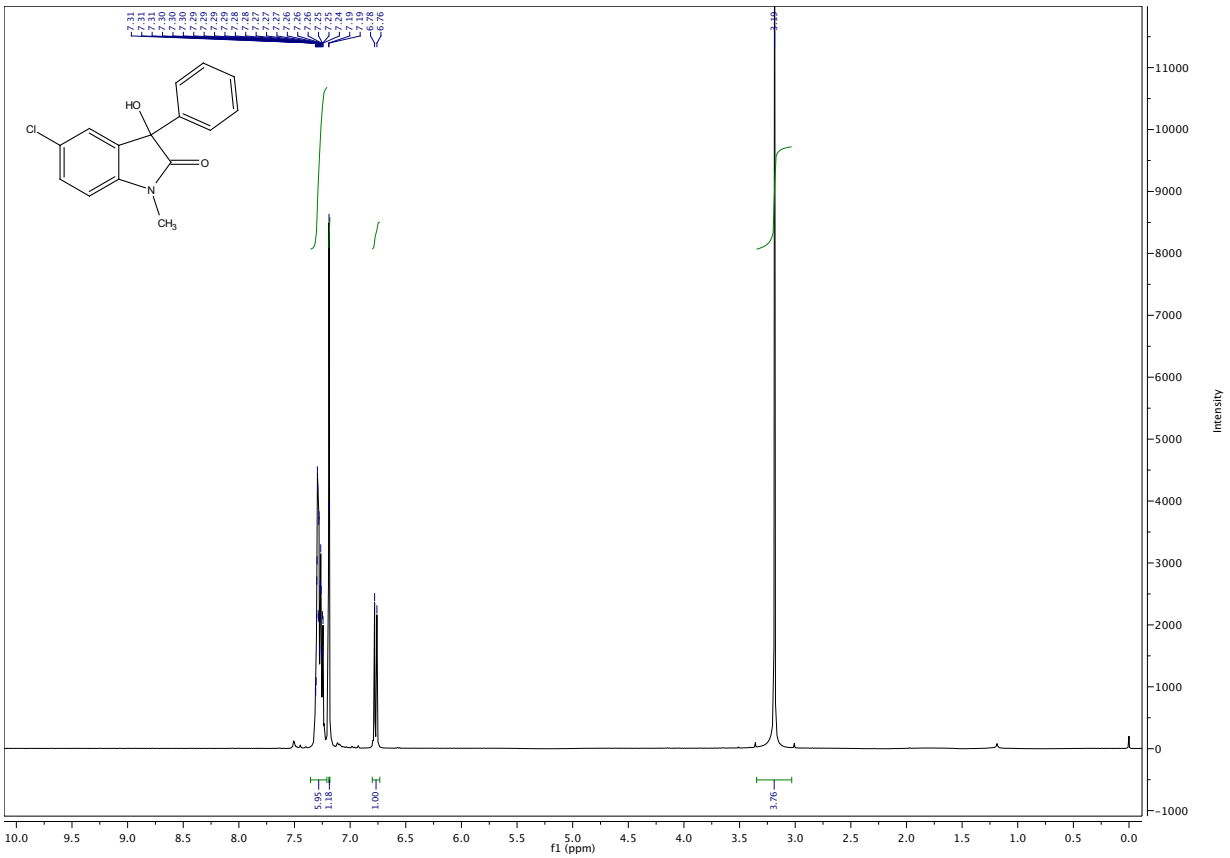
^{1}H NMR spectra (400.13 MHz) of compound **1e** in $CDCl_3$



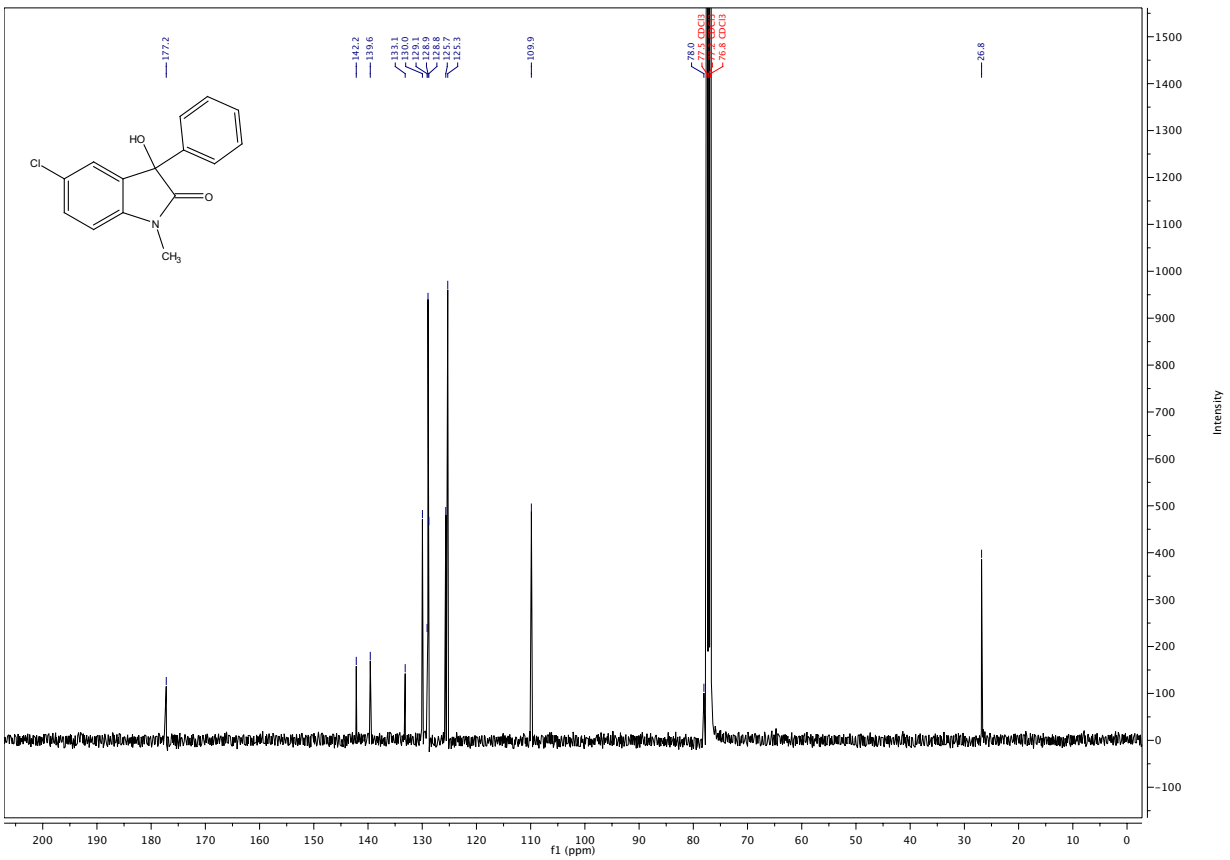
^{13}C NMR spectra (100.62 MHz) of compound **1e** in $CDCl_3$



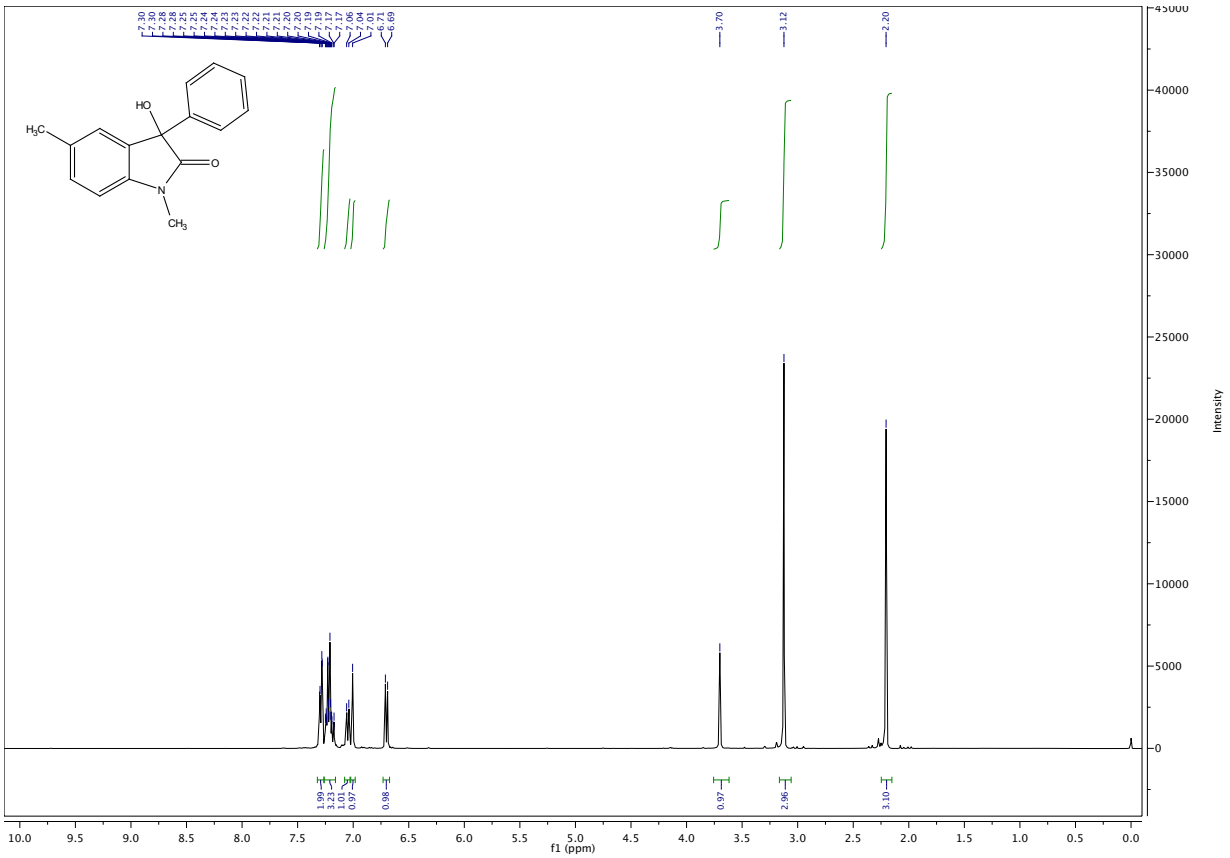
^{1}H NMR spectra (400.13 MHz) of compound **1f** in $CDCl_3$



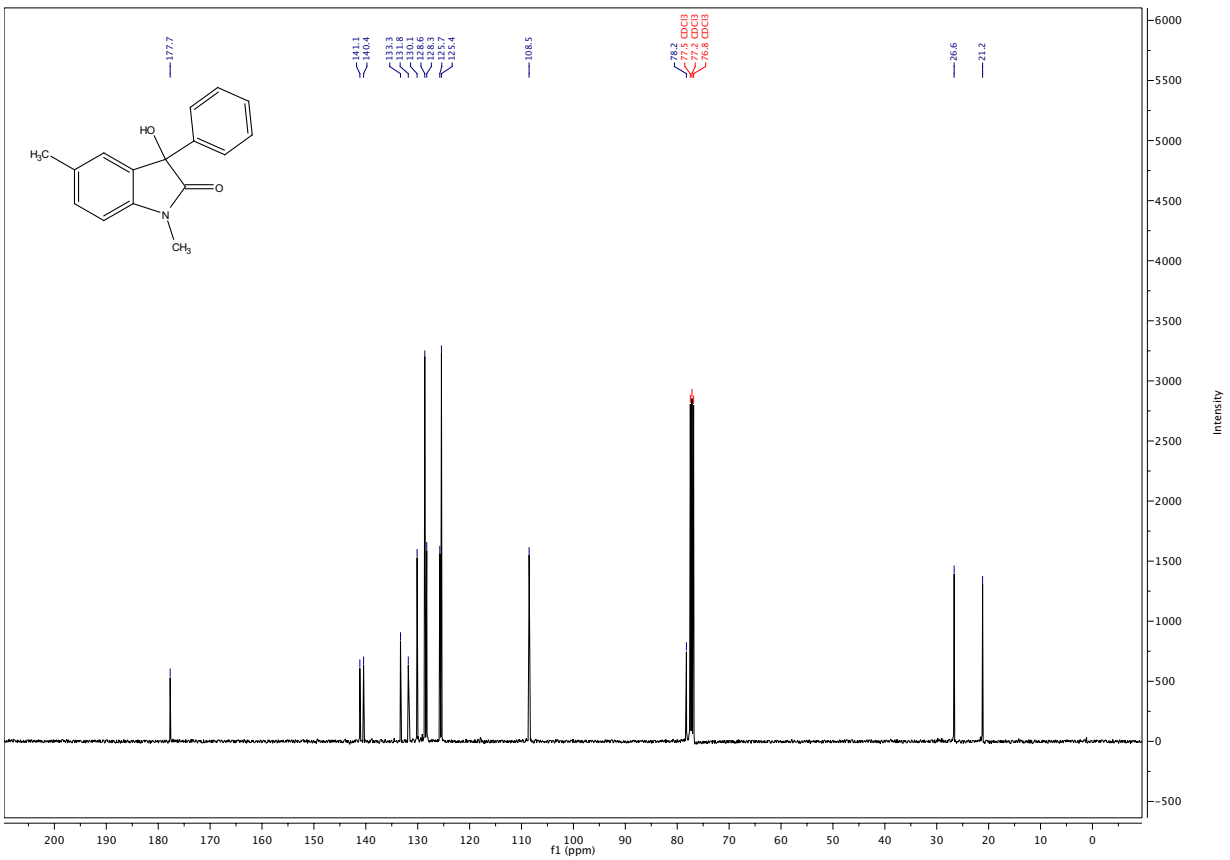
^{13}C NMR spectra (100.62 MHz) of compound **1f** in $CDCl_3$



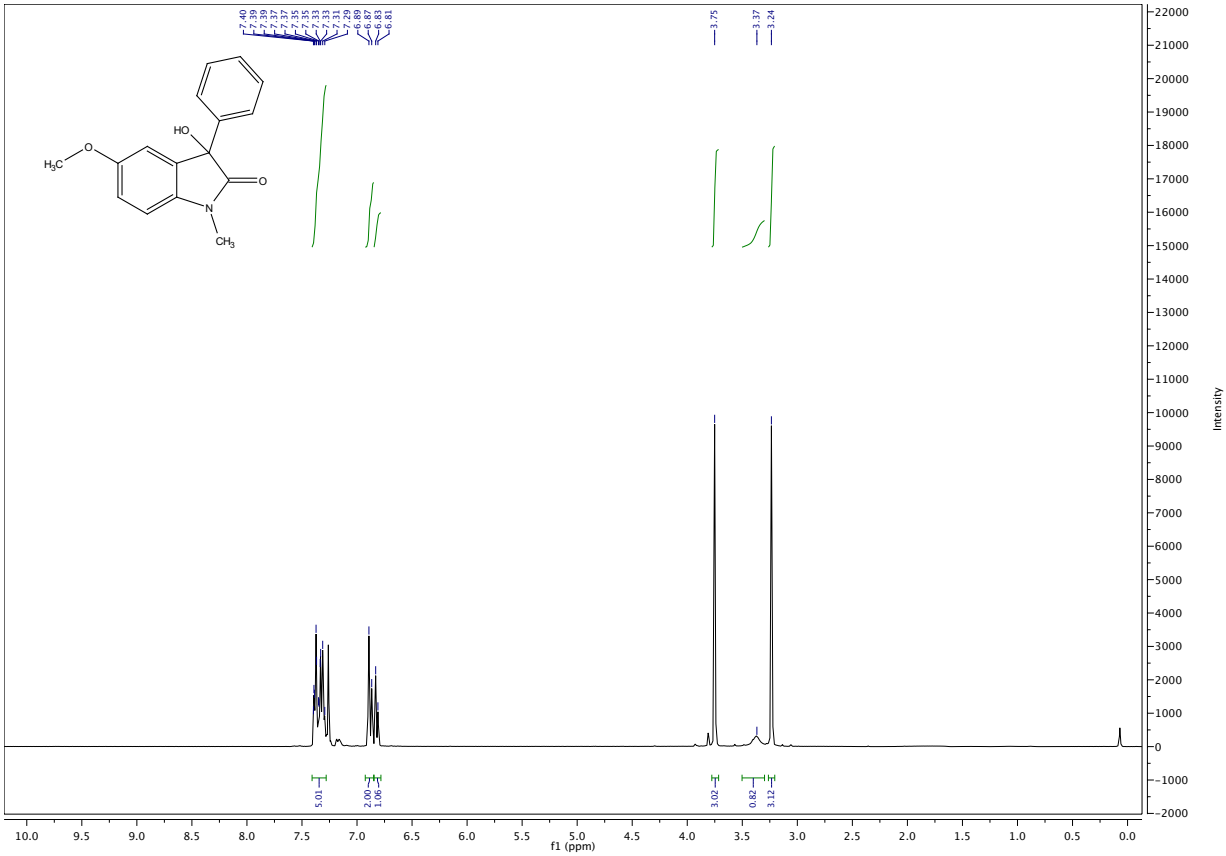
^{1}H NMR spectra (400.13 MHz) of compound **1g** in $CDCl_3$



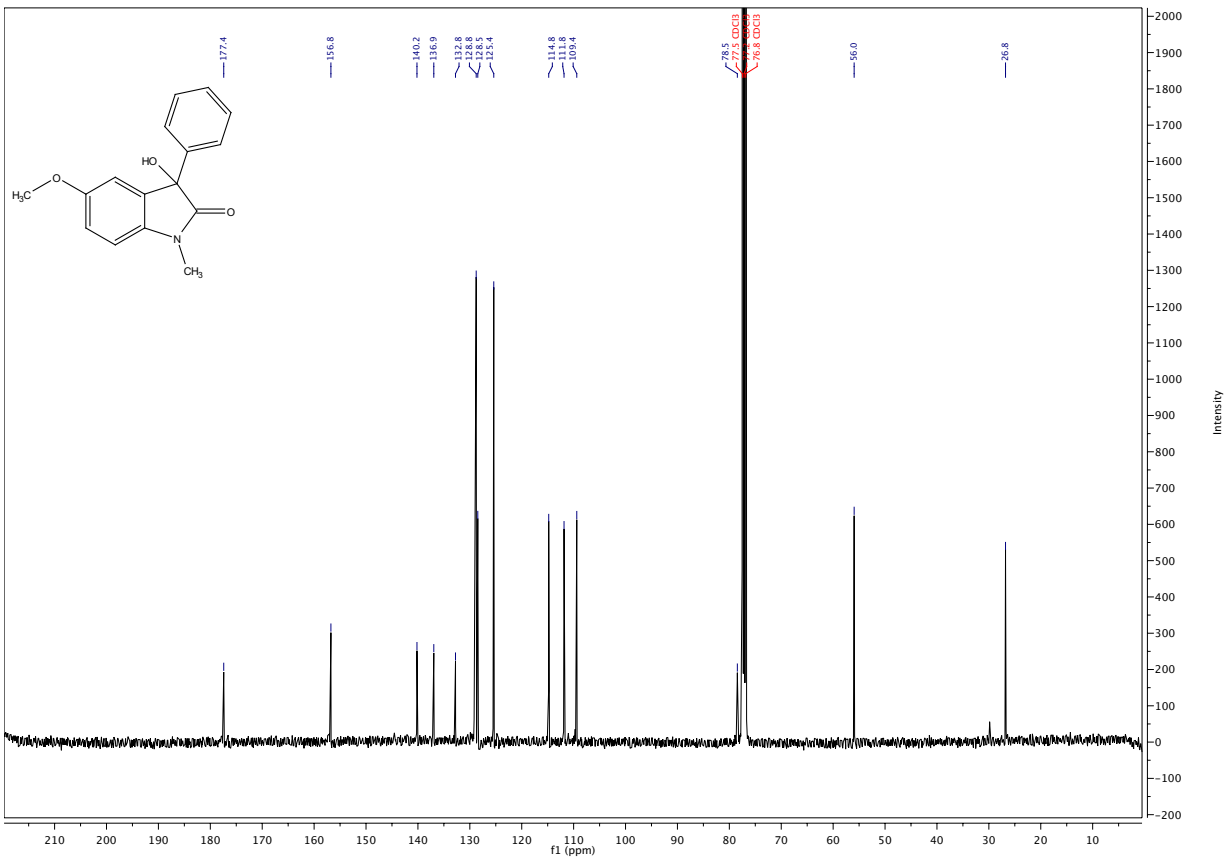
^{13}C NMR spectra (100.62 MHz) of compound **1g** in $CDCl_3$



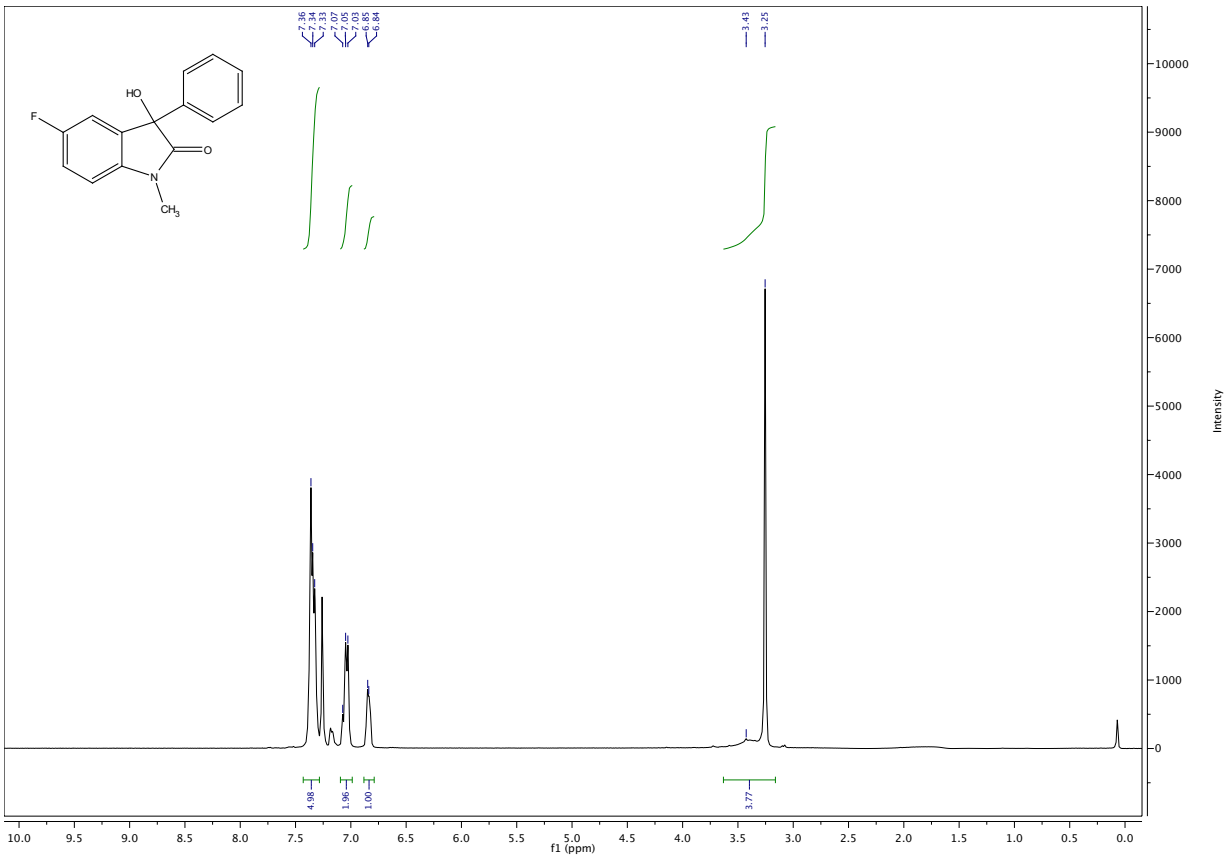
^{1}H NMR spectra (400.13 MHz) of compound **1h** in $CDCl_3$



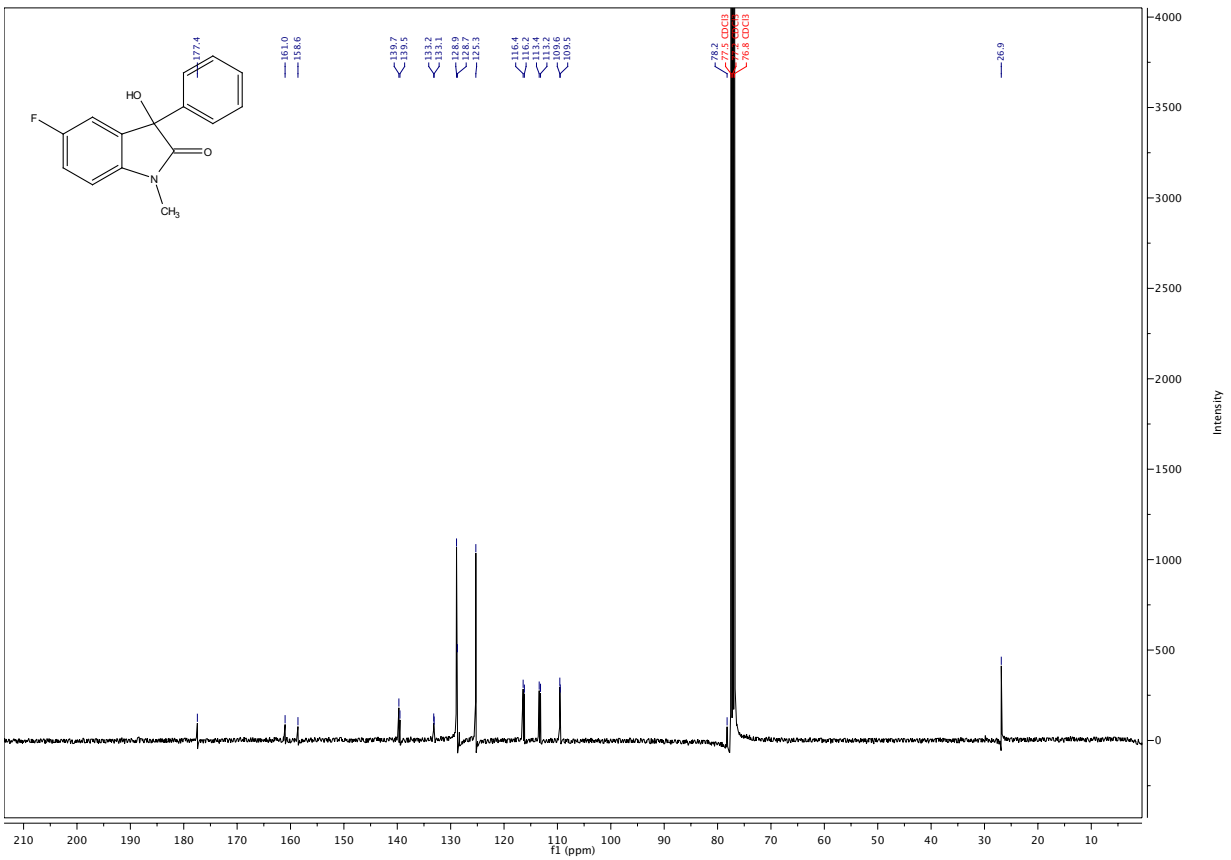
^{13}C NMR spectra (100.62 MHz) of compound **1h** in $CDCl_3$



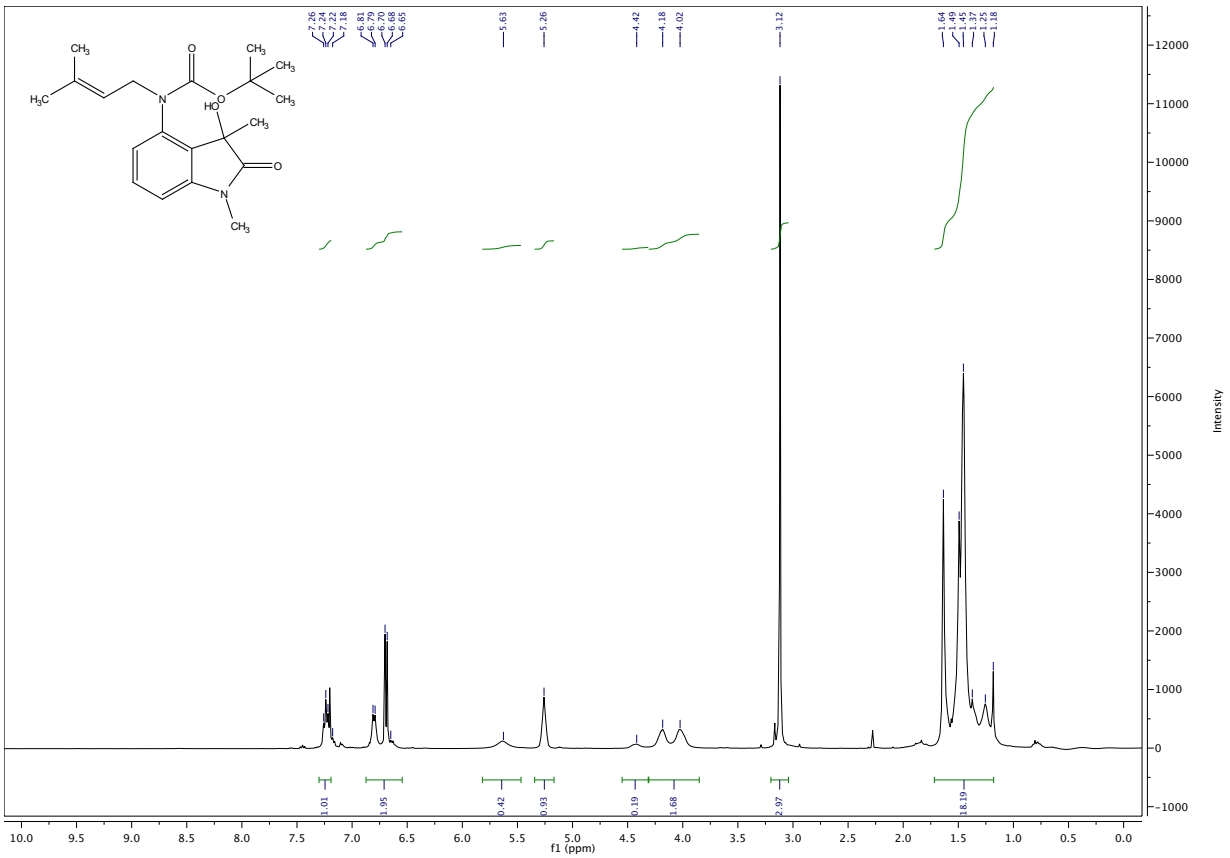
^{1}H NMR spectra (400.13 MHz) of compound **1i** in $CDCl_3$



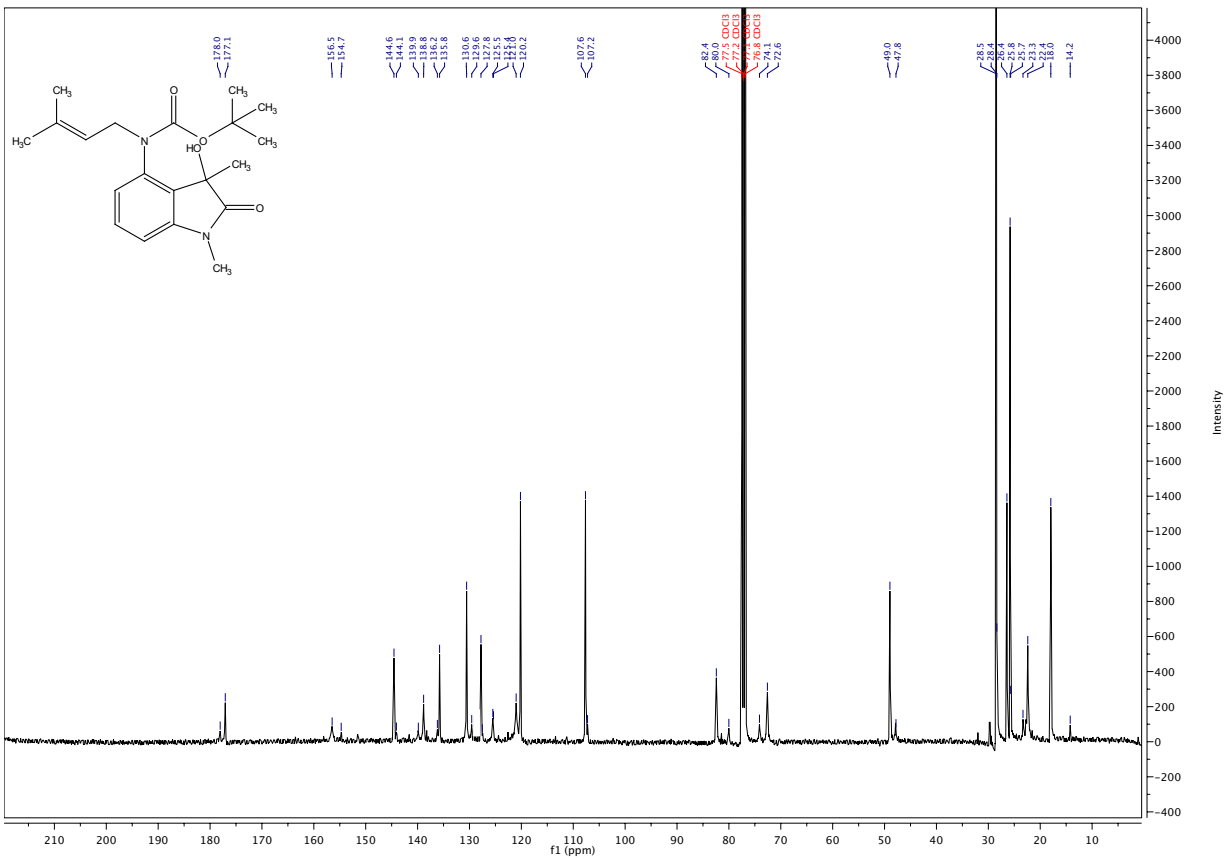
^{13}C NMR spectra (100.62 MHz) of compound **1i** in $CDCl_3$



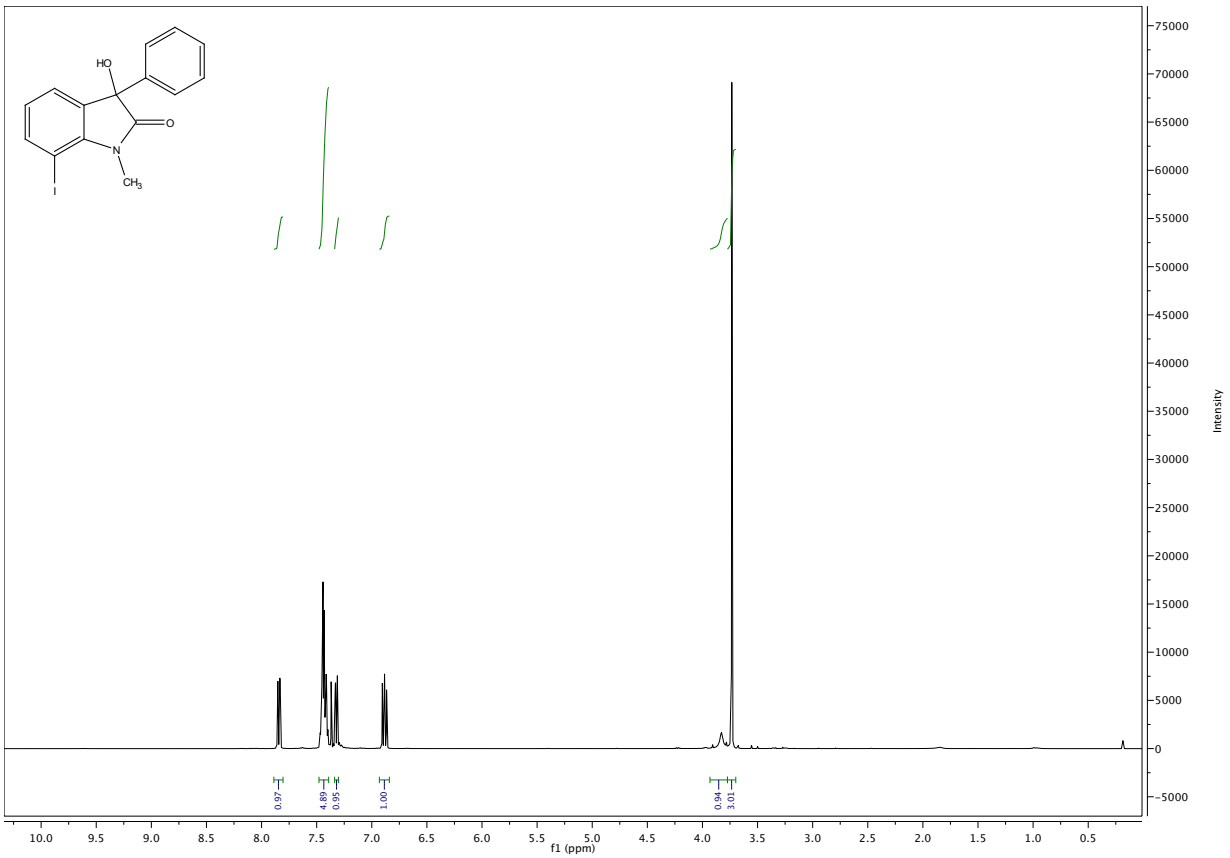
^{1}H NMR spectra (400.13 MHz) of compound **1j** in $CDCl_3$



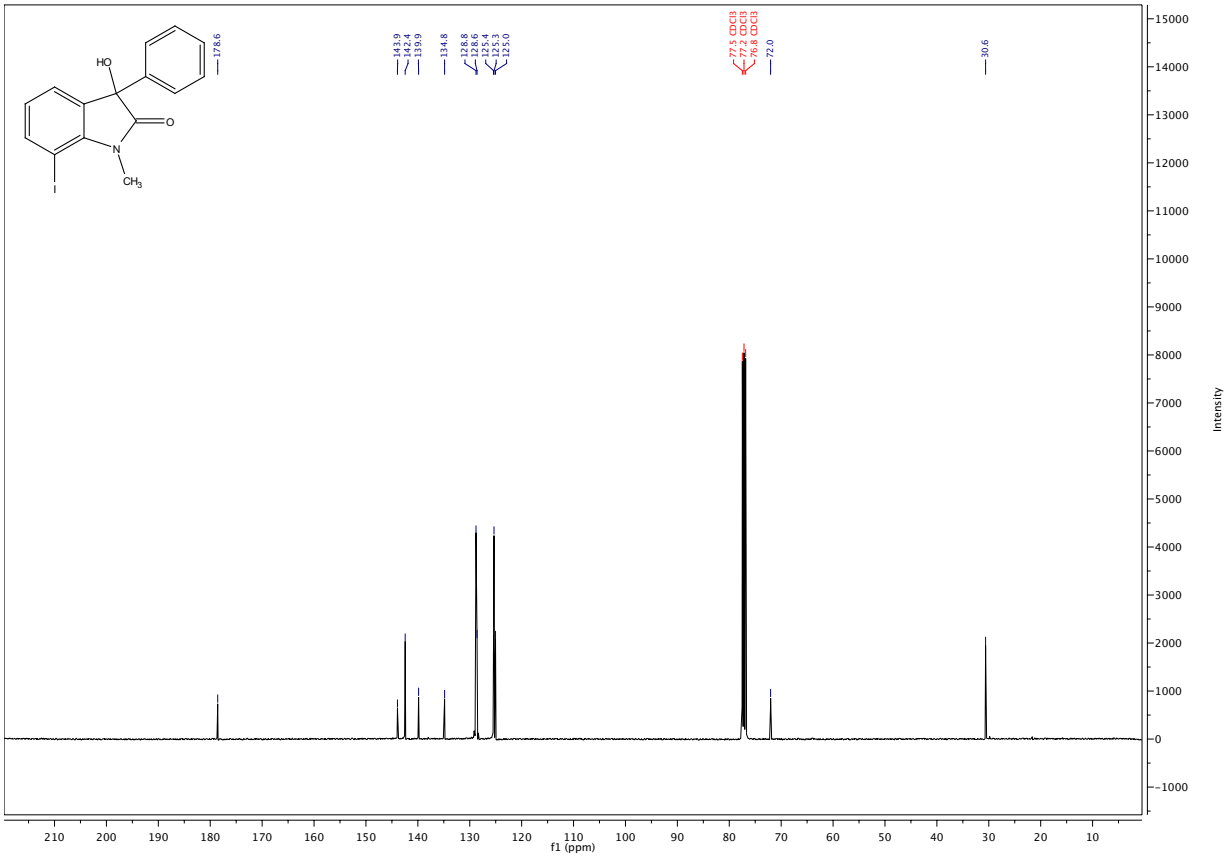
^{13}C NMR spectra (100.62 MHz) of compound **1j** in $CDCl_3$



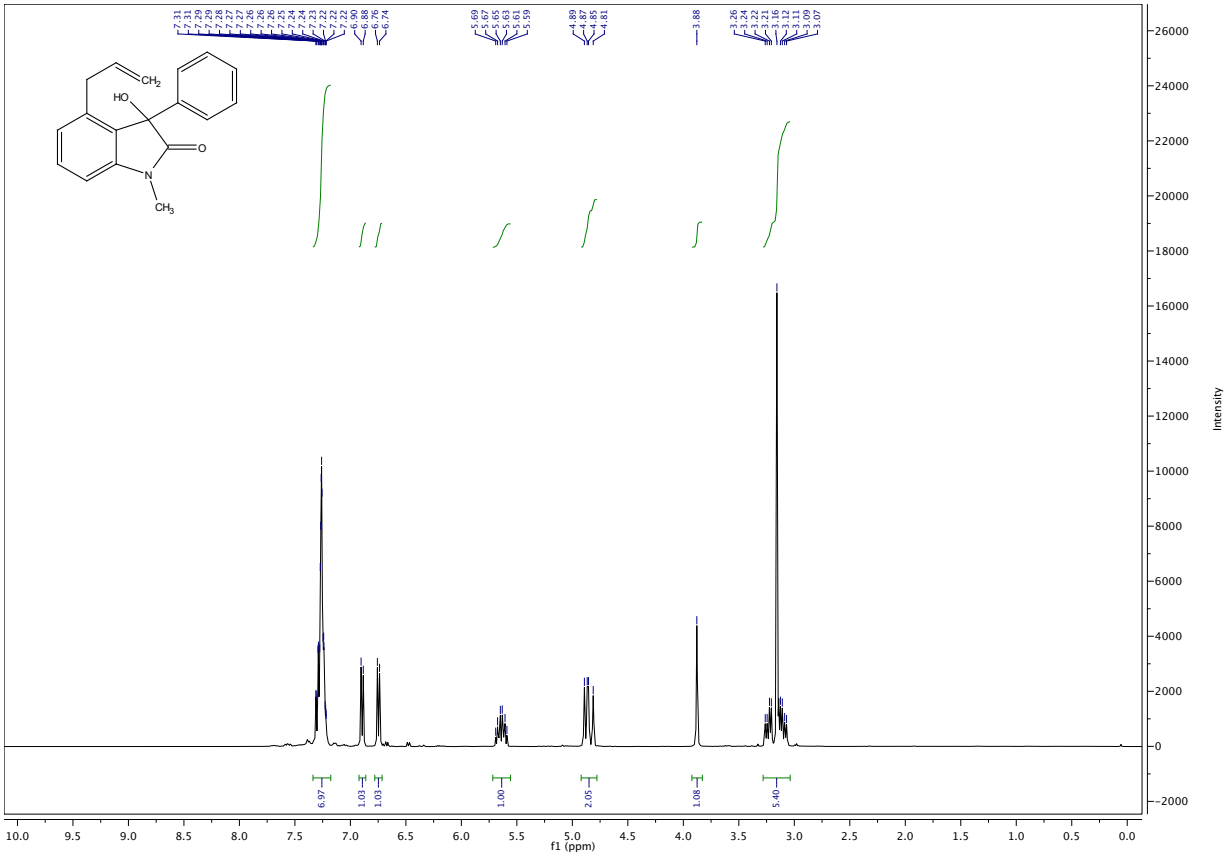
^{1}H NMR spectra (400.13 MHz) of compound **1k** in $CDCl_3$



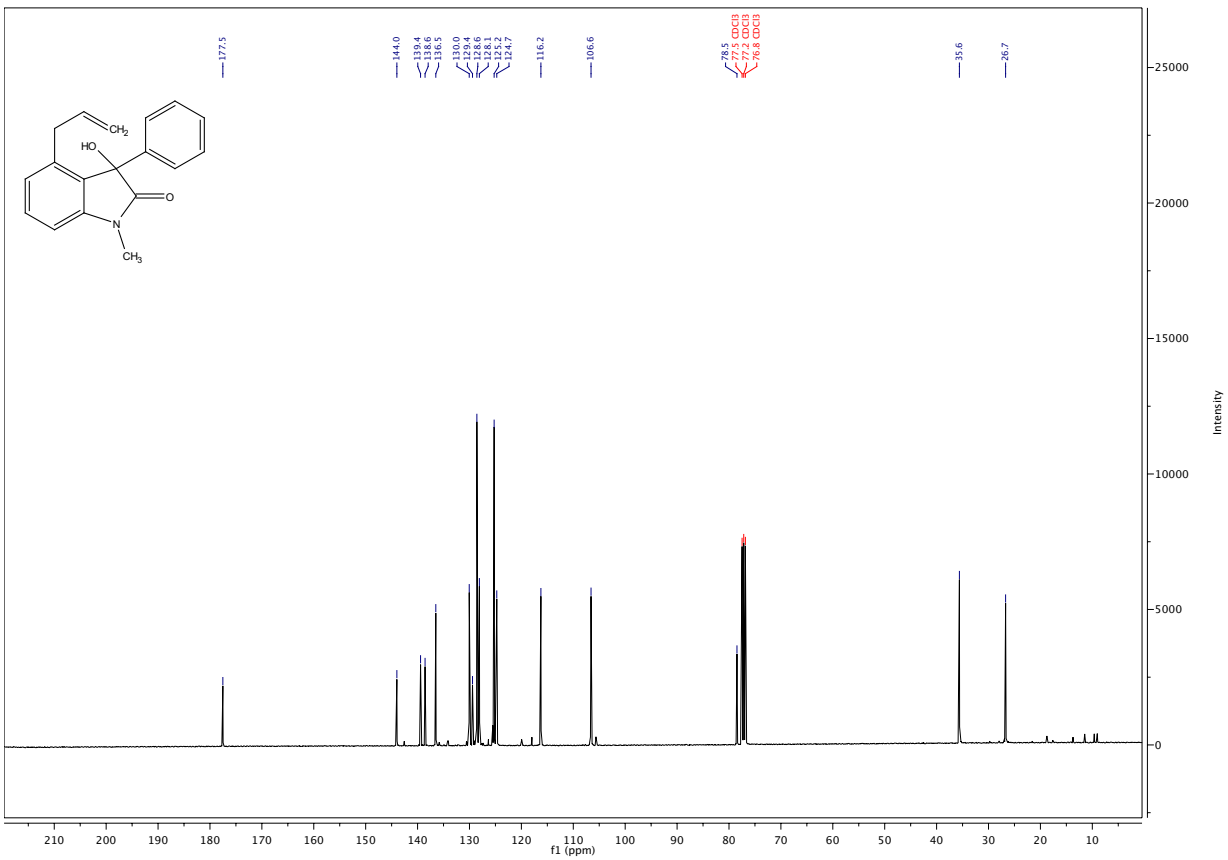
^{13}C NMR spectra (100.62 MHz) of compound **1k** in $CDCl_3$



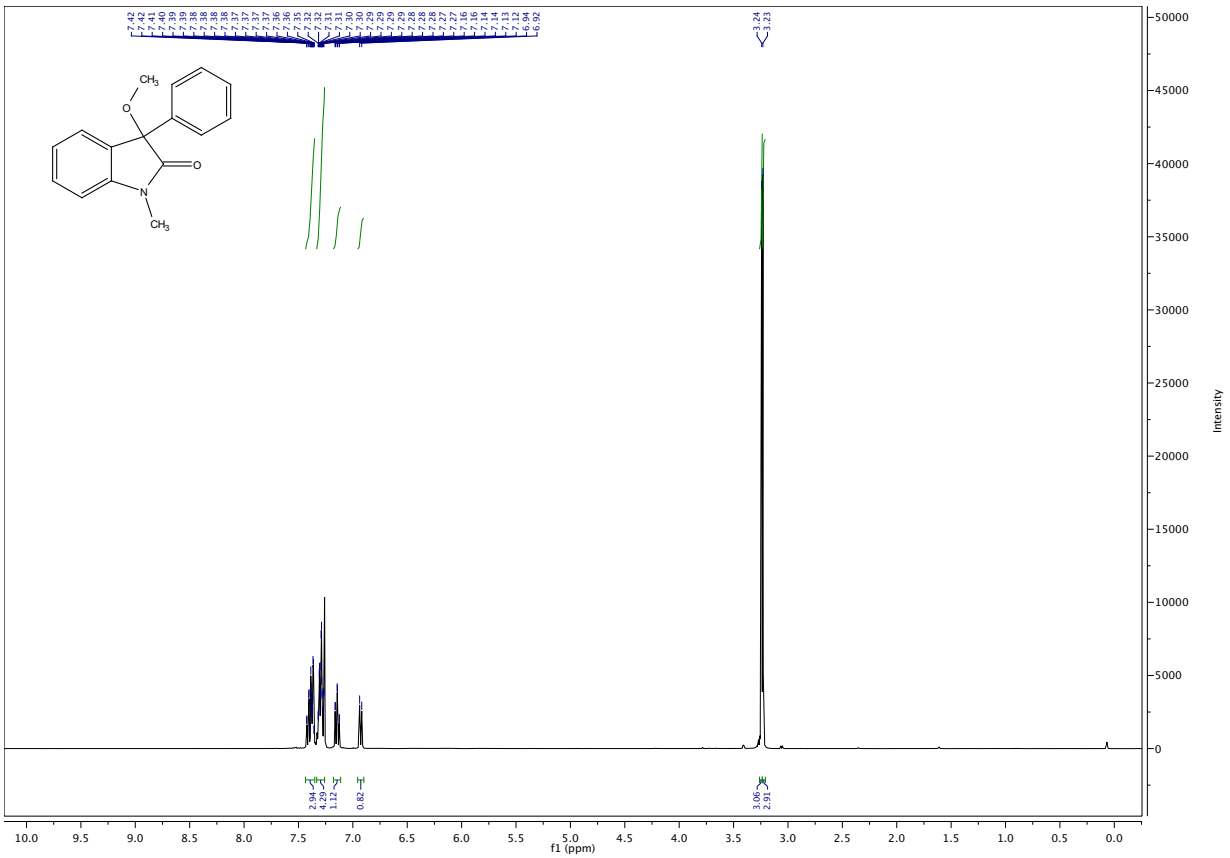
^{1}H NMR spectra (400.13 MHz) of compound **1l** in $CDCl_3$



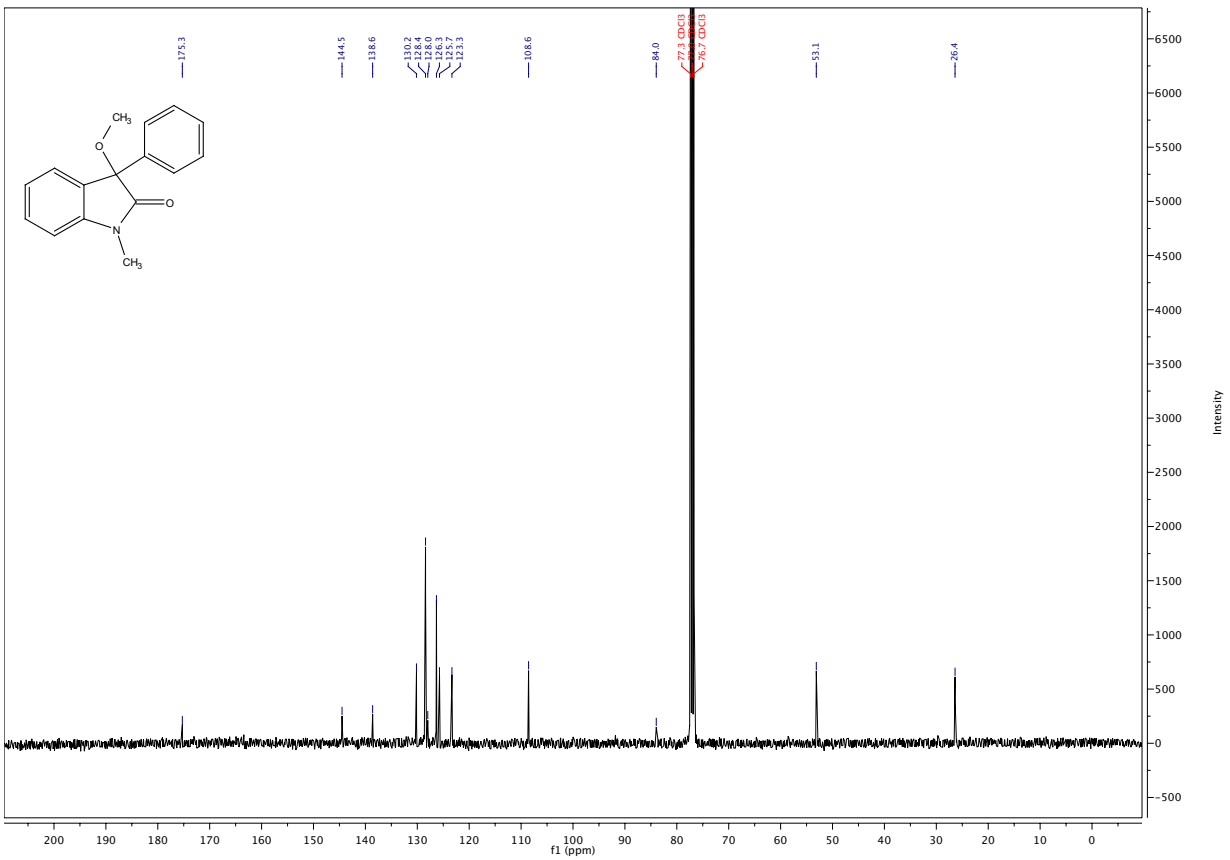
^{13}C NMR spectra (100.62 MHz) of compound **1l** in $CDCl_3$



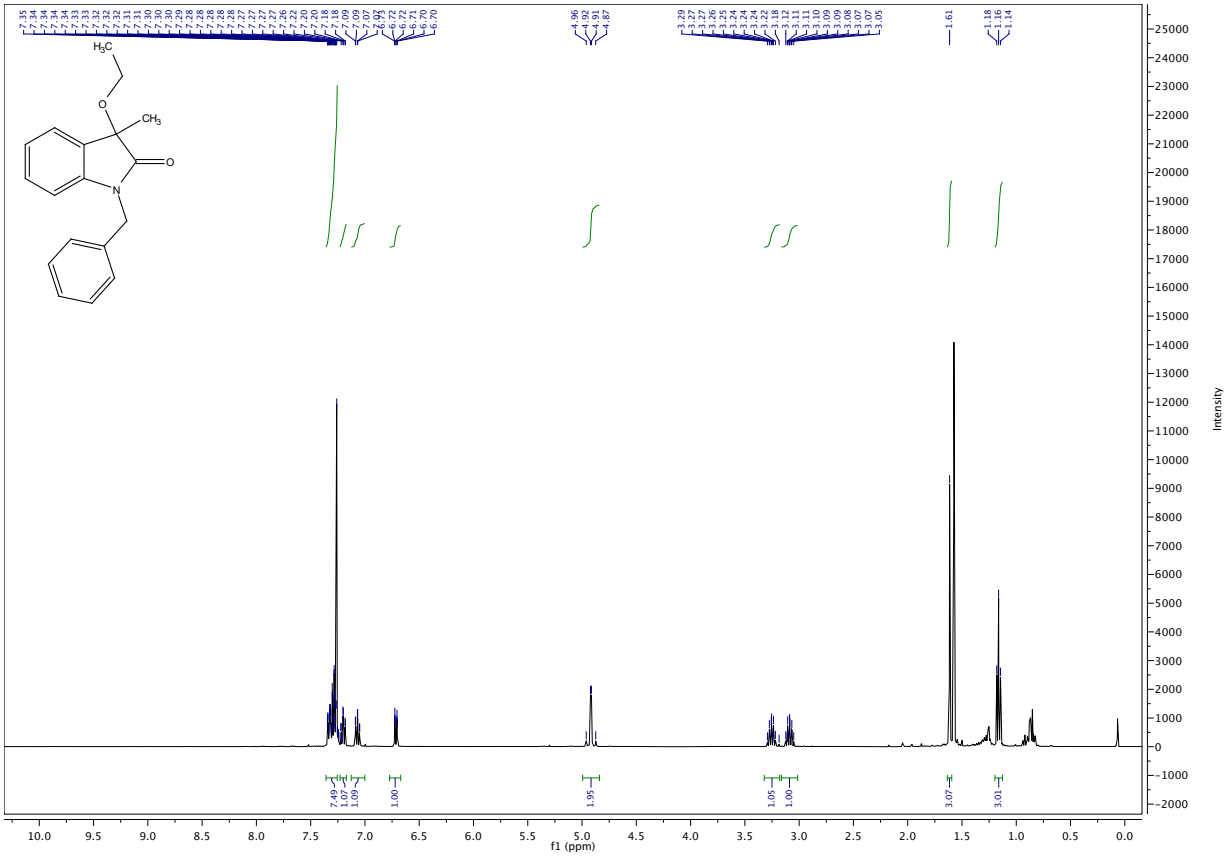
^{1}H NMR spectra (400.13 MHz) of compound **2a** in $CDCl_3$



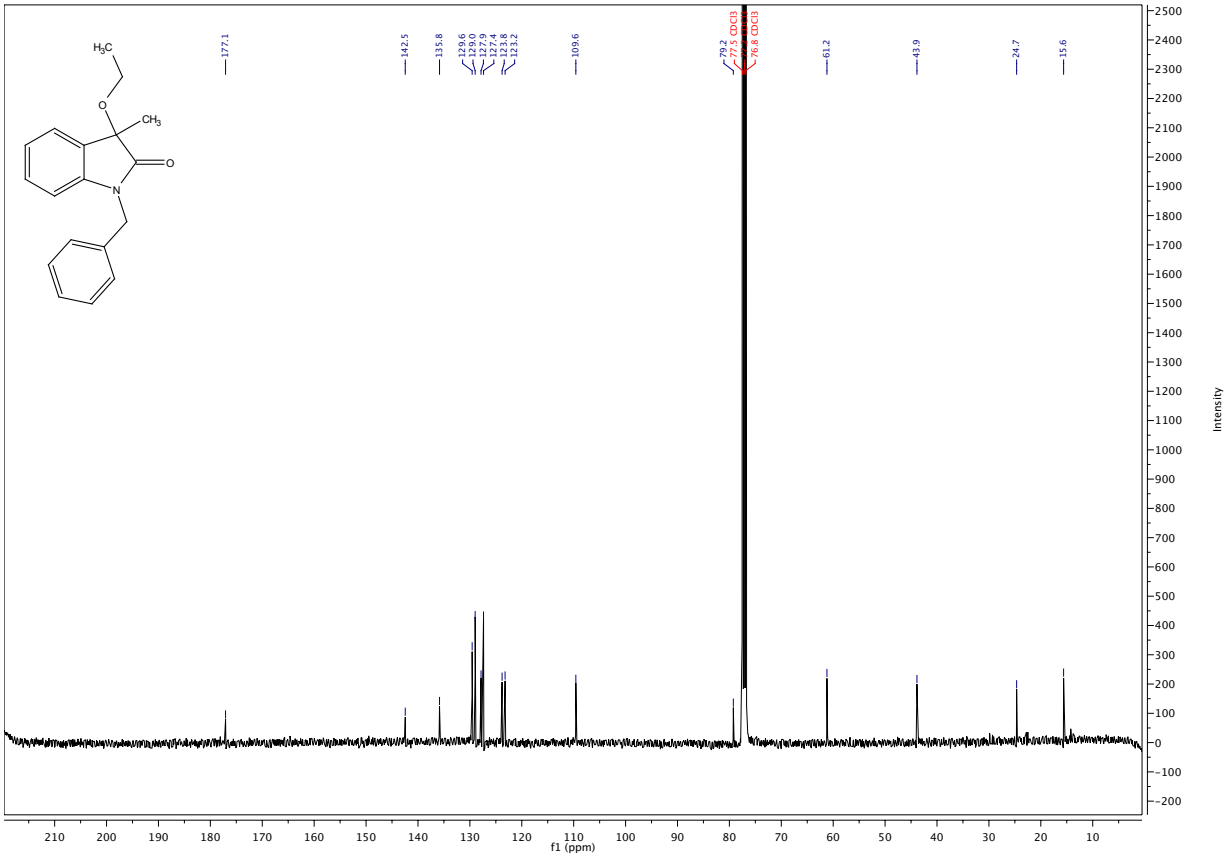
^{13}C NMR spectra (100.62 MHz) of compound **2a** in $CDCl_3$



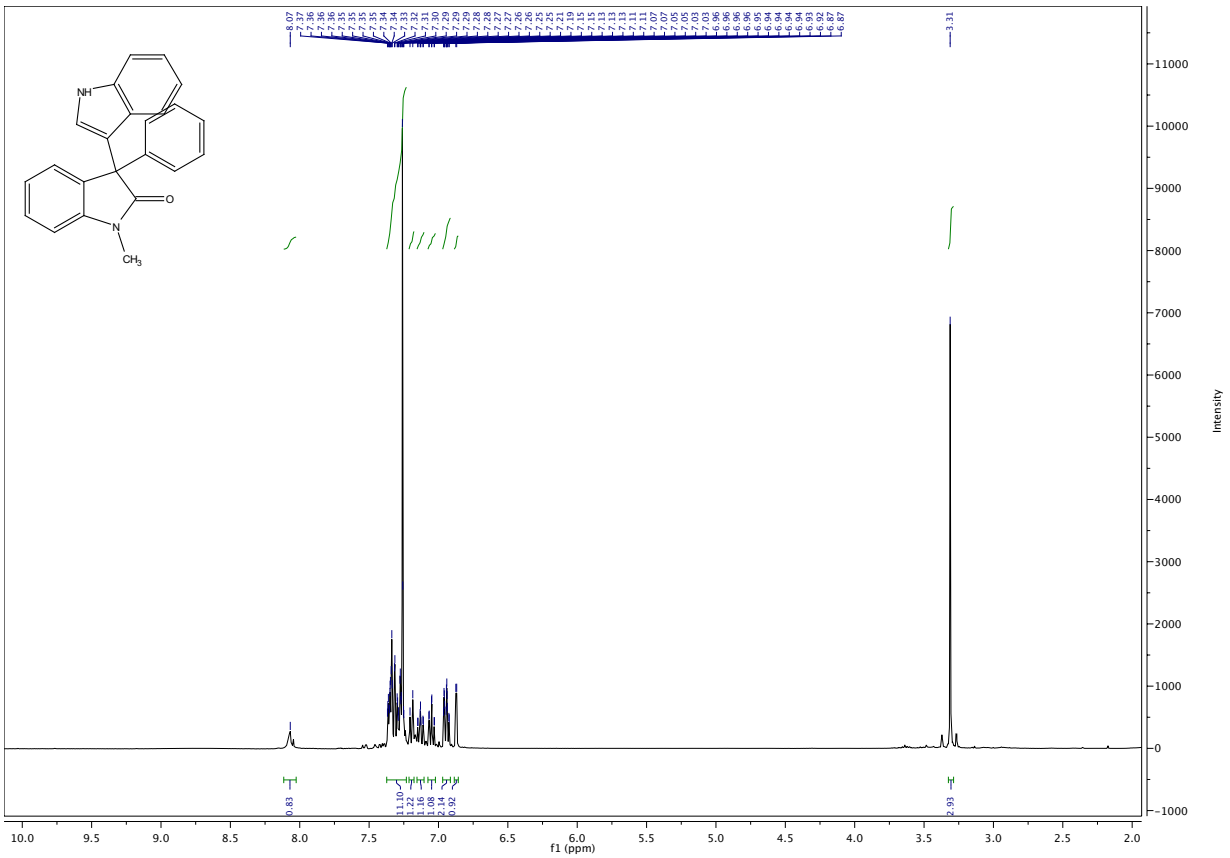
^{1}H NMR spectra (400.13 MHz) of compound **2b** in $CDCl_3$



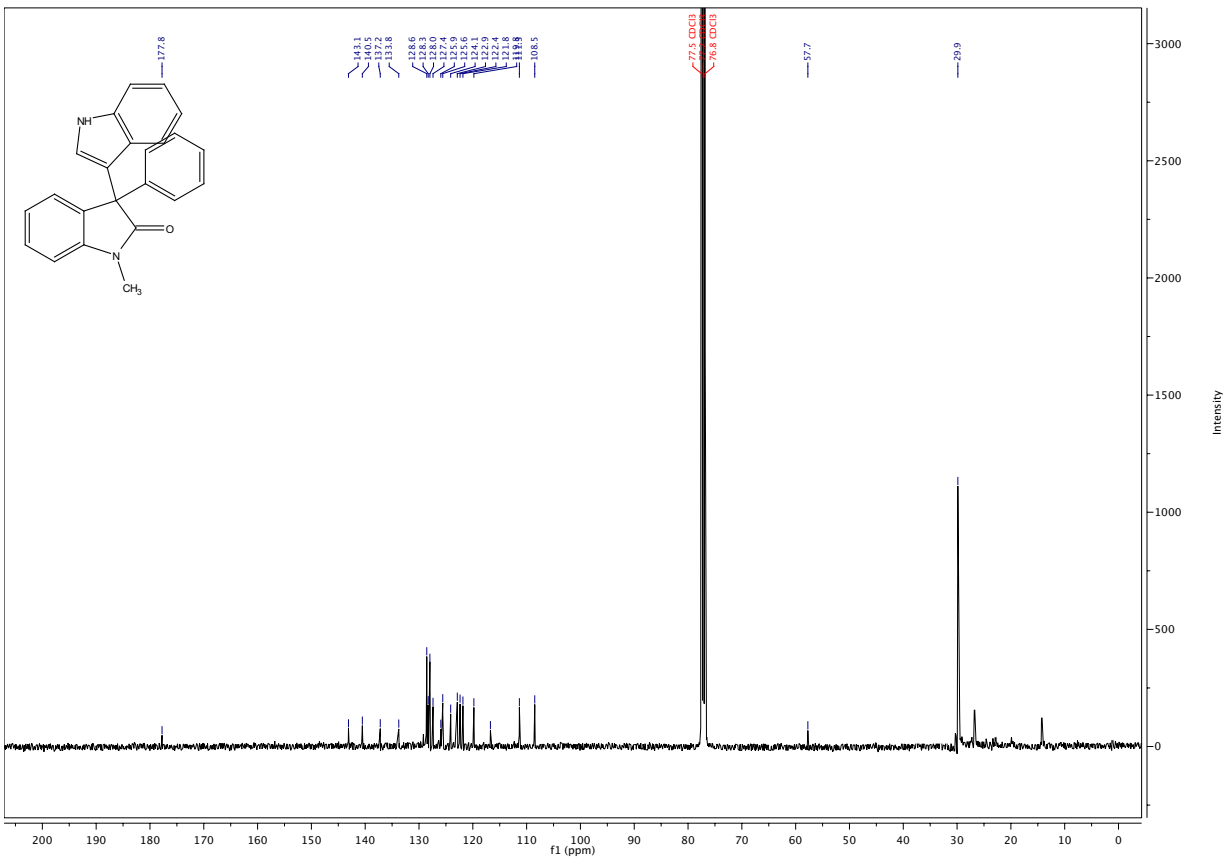
^{13}C NMR spectra (100.62 MHz) of compound **2b** in $CDCl_3$



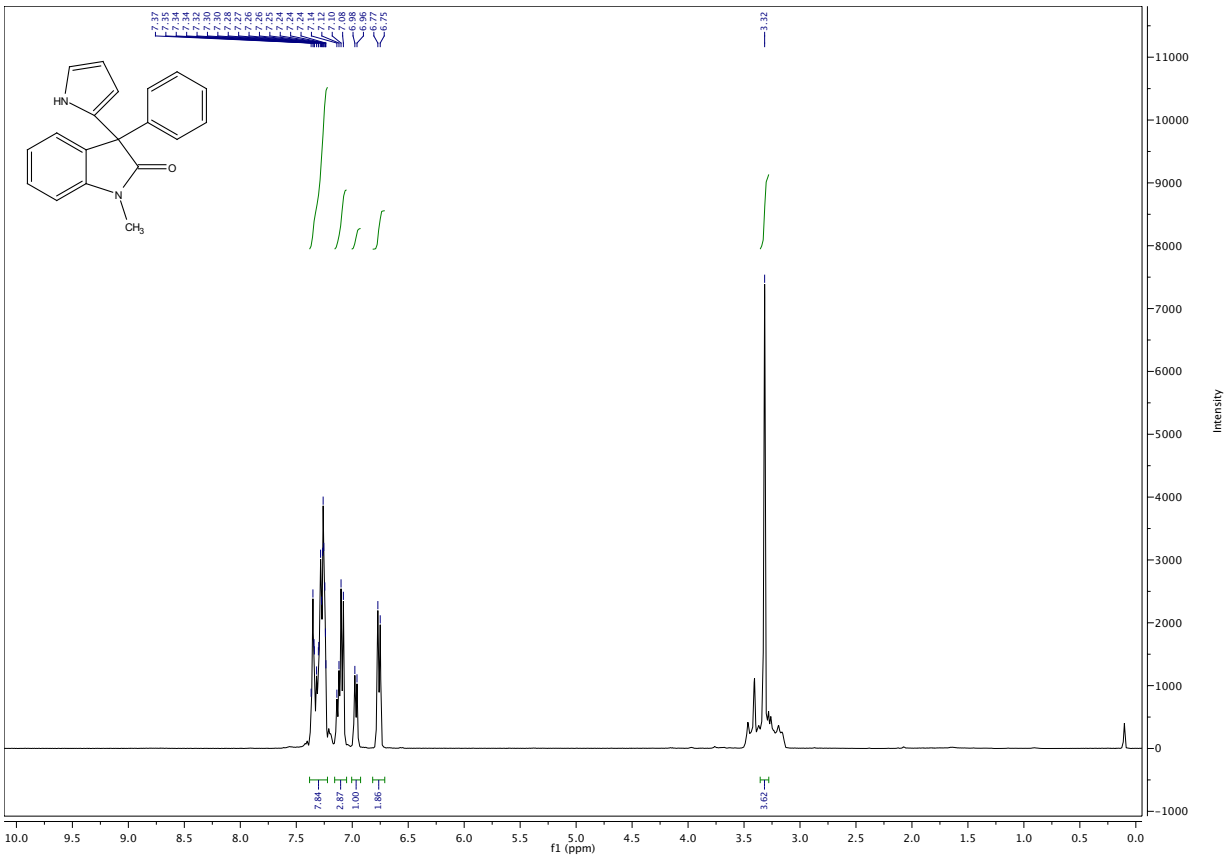
^{1}H NMR spectra (400.13 MHz) of compound **2c** in $CDCl_3$



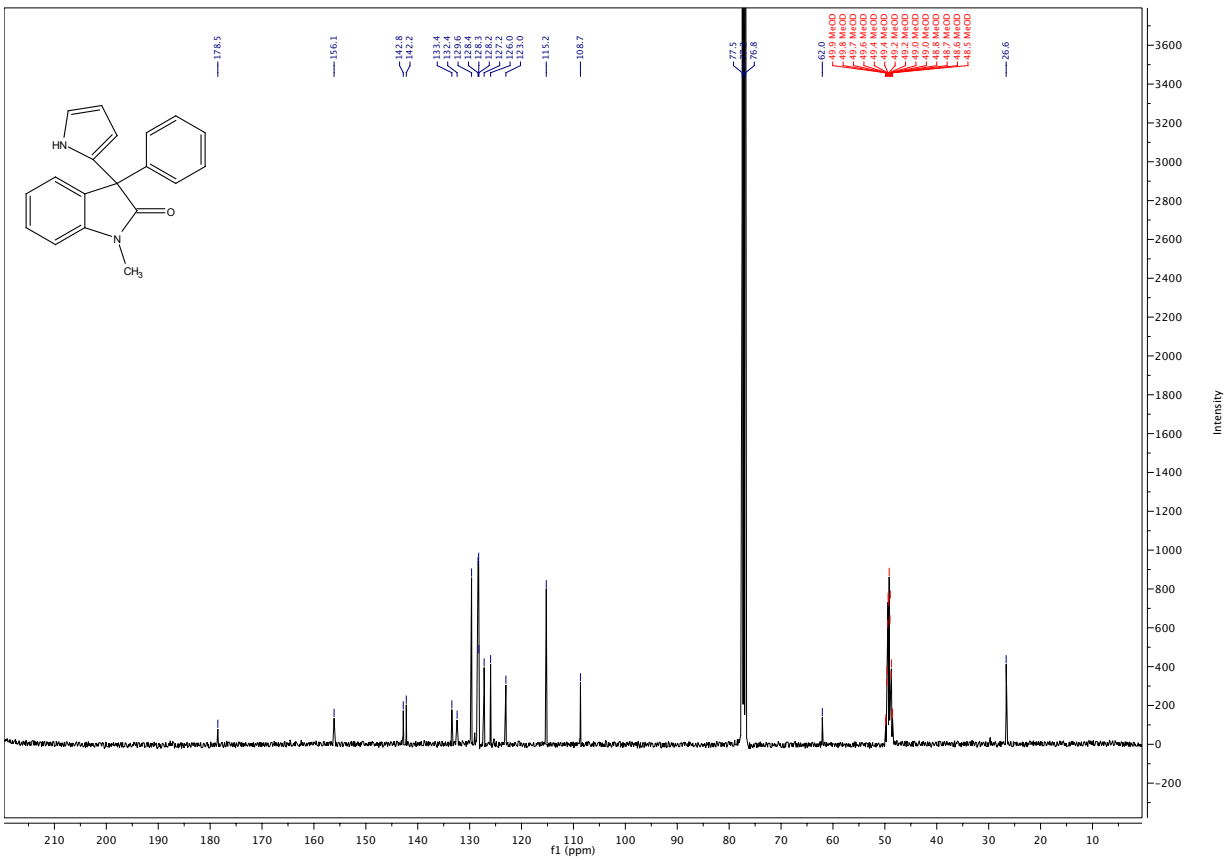
^{13}C NMR spectra (100.62 MHz) of compound **2c** in $CDCl_3$



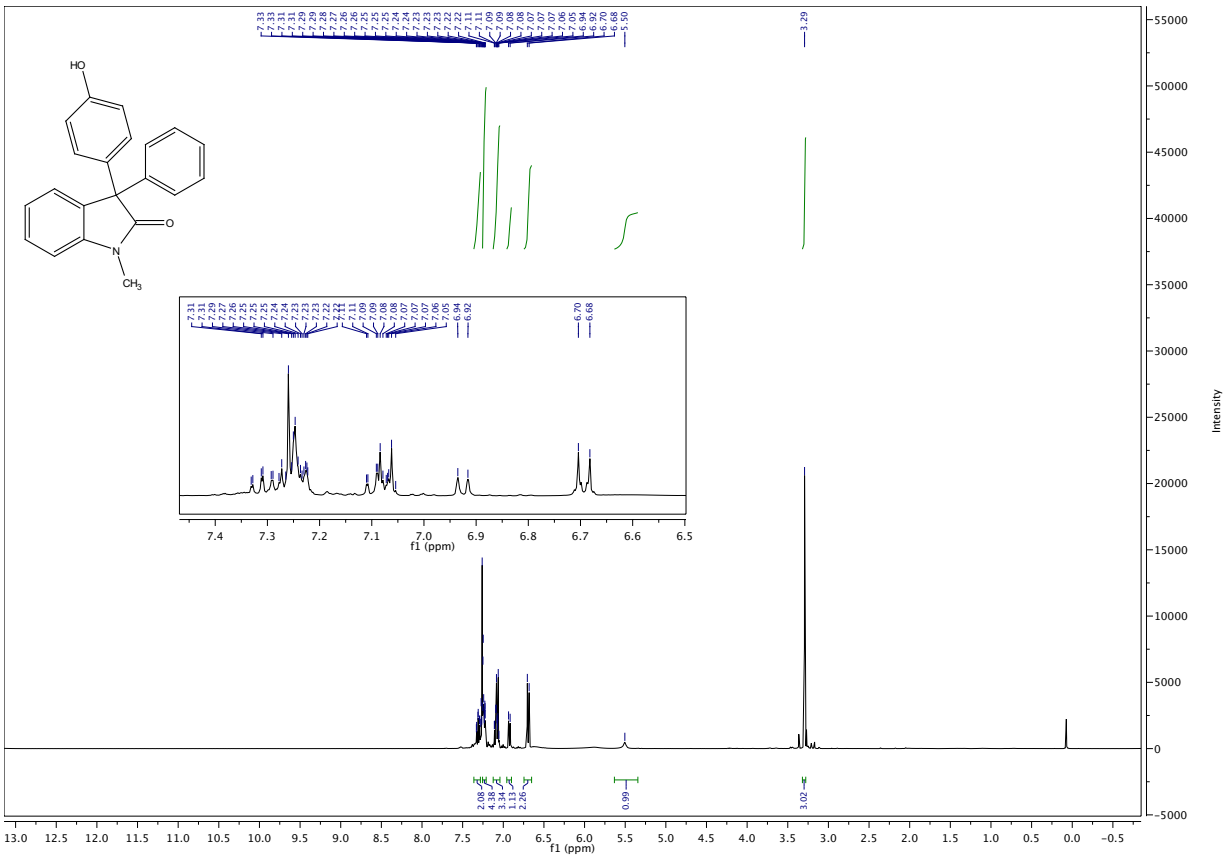
^{1}H NMR spectra (400.13 MHz) of compound **2d** in $CDCl_3/CD_3OD$



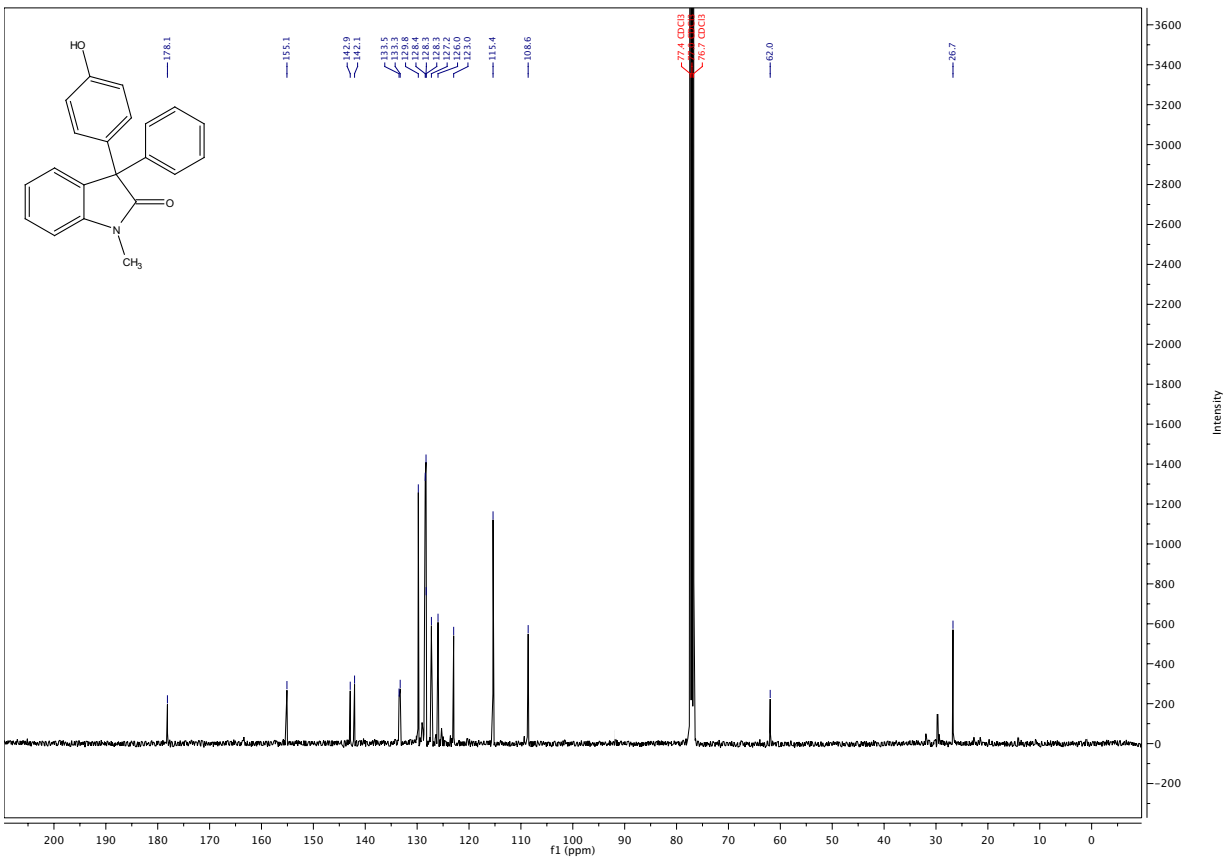
^{13}C NMR spectra (100.62 MHz) of compound **2d** in $CDCl_3/CD_3OD$



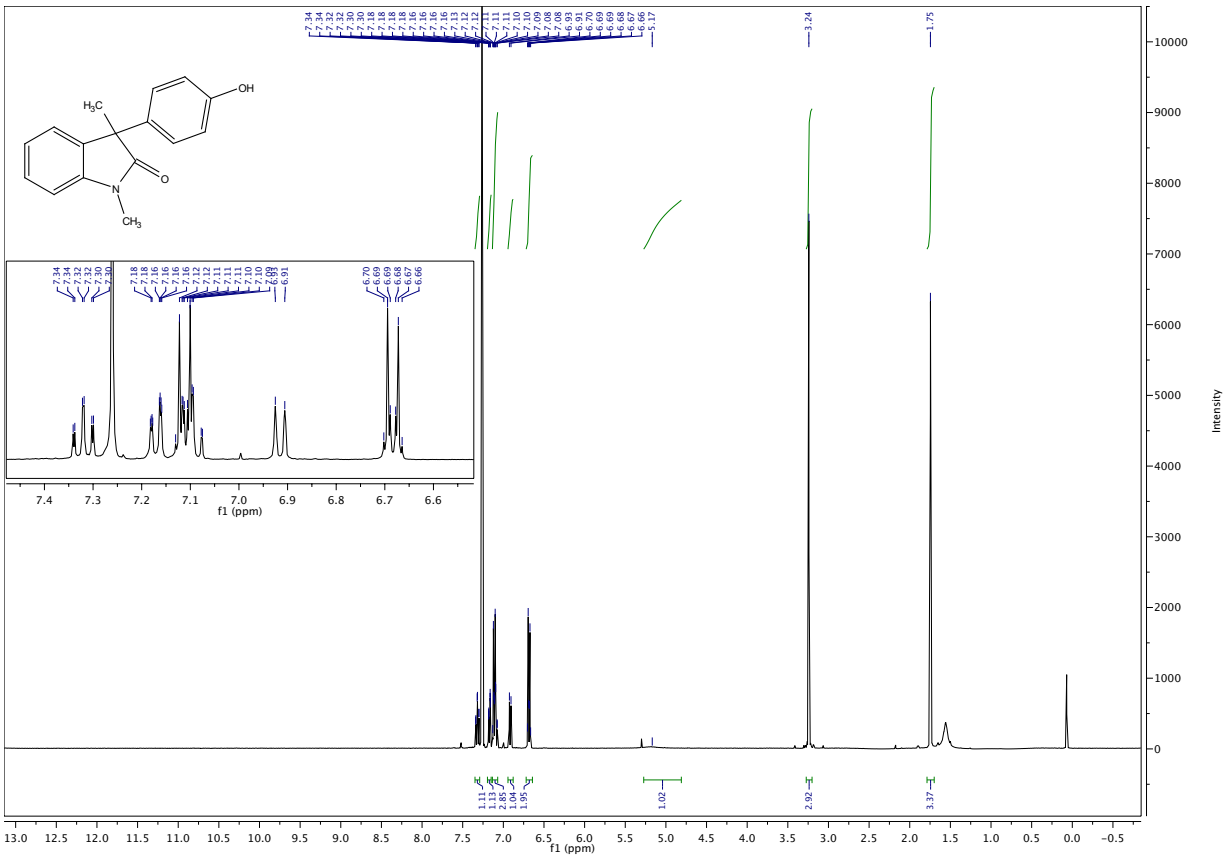
^{1}H NMR spectra (400.13 MHz) of compound **2e** in $CDCl_3$



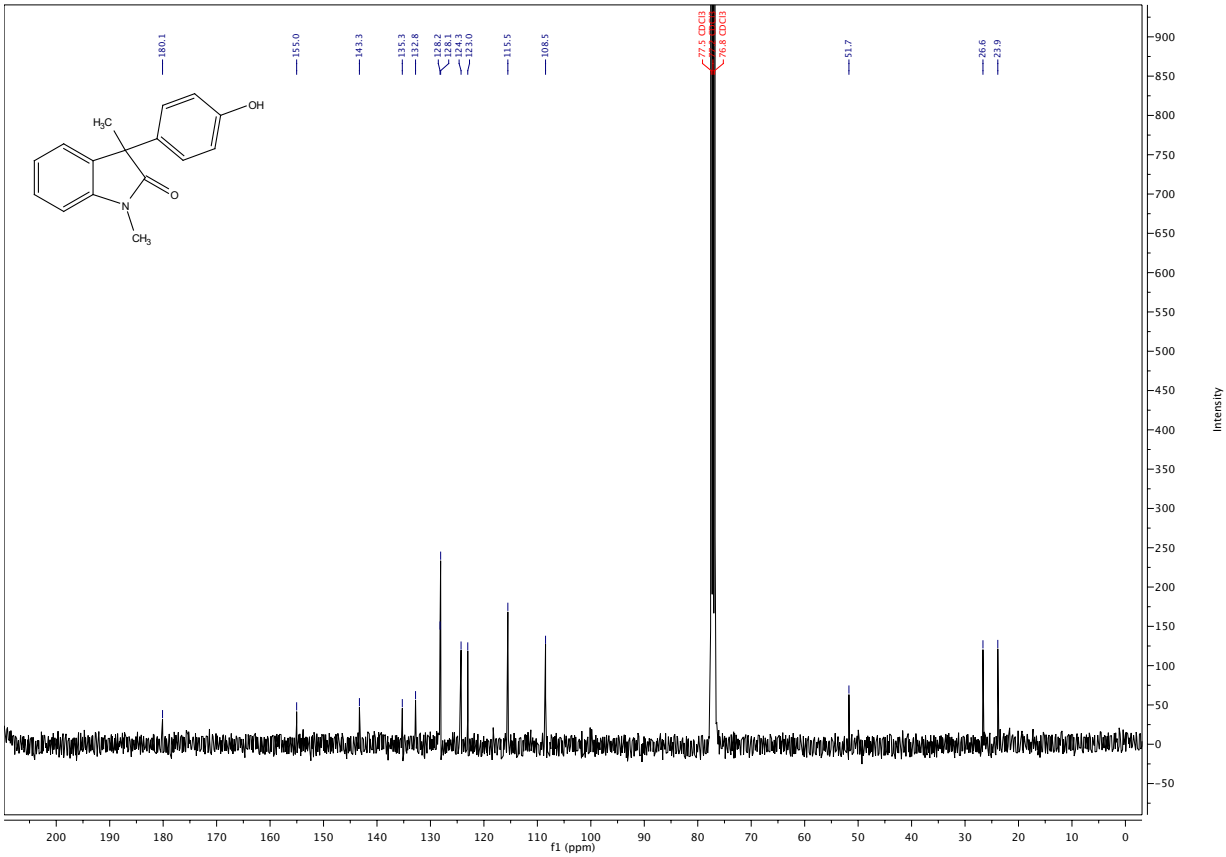
^{13}C NMR spectra (100.62 MHz) of compound **2e** in $CDCl_3$



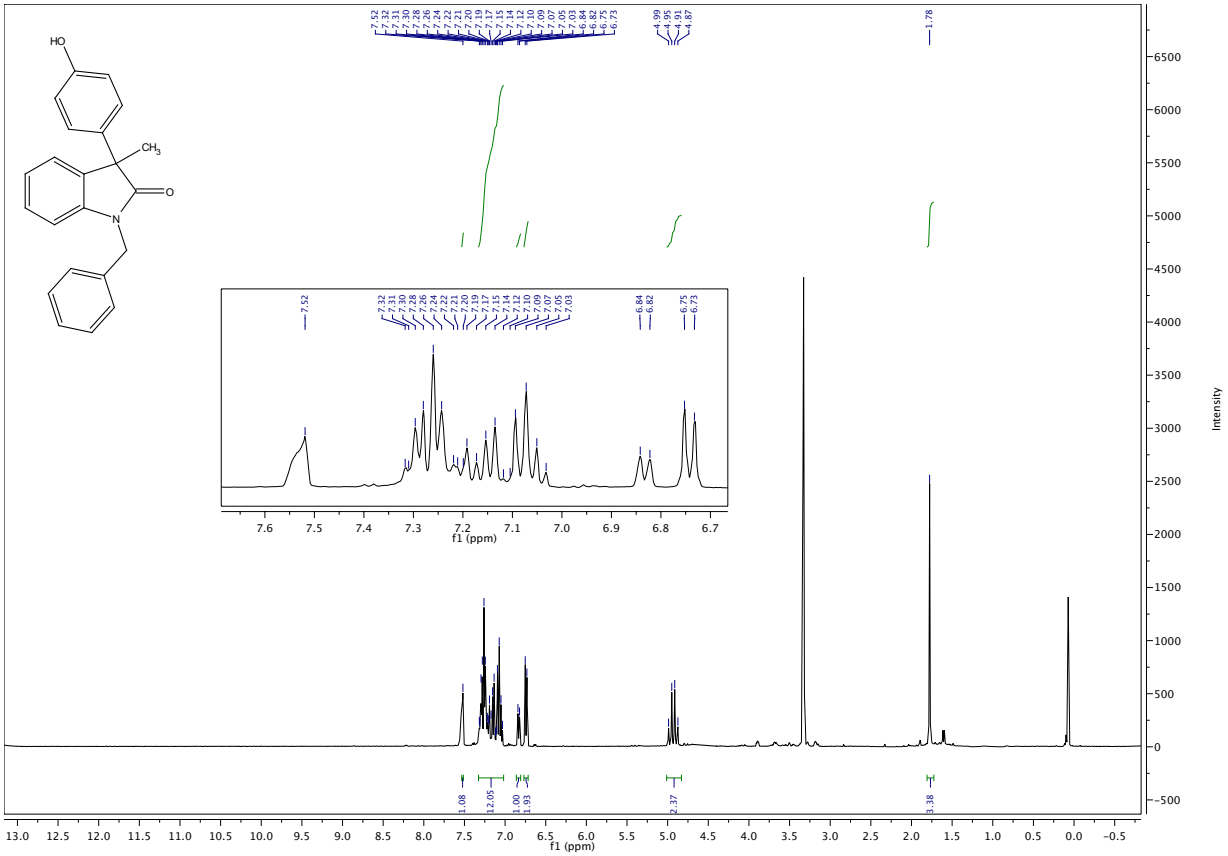
^{1}H NMR spectra (400.13 MHz) of compound **2f** in $CDCl_3$



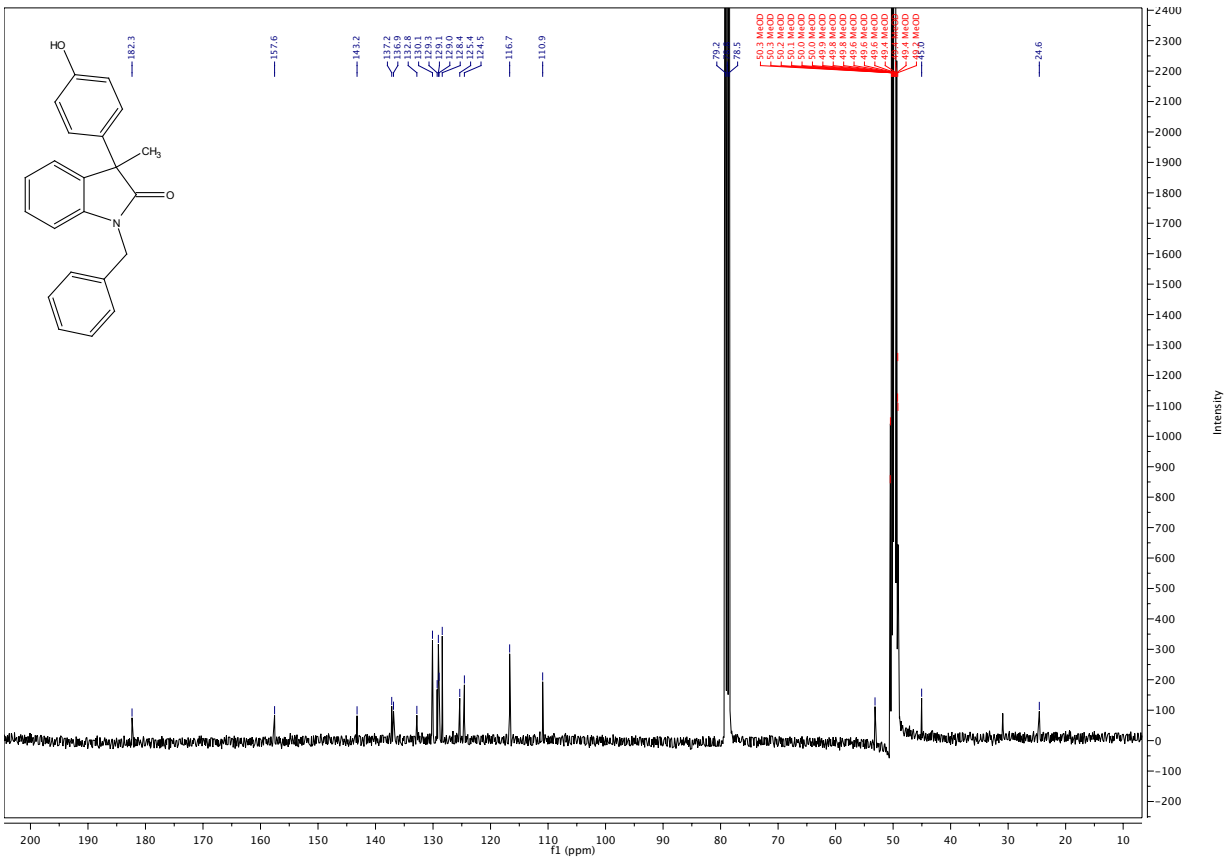
^{13}C NMR spectra (100.62 MHz) of compound **2f** in $CDCl_3$



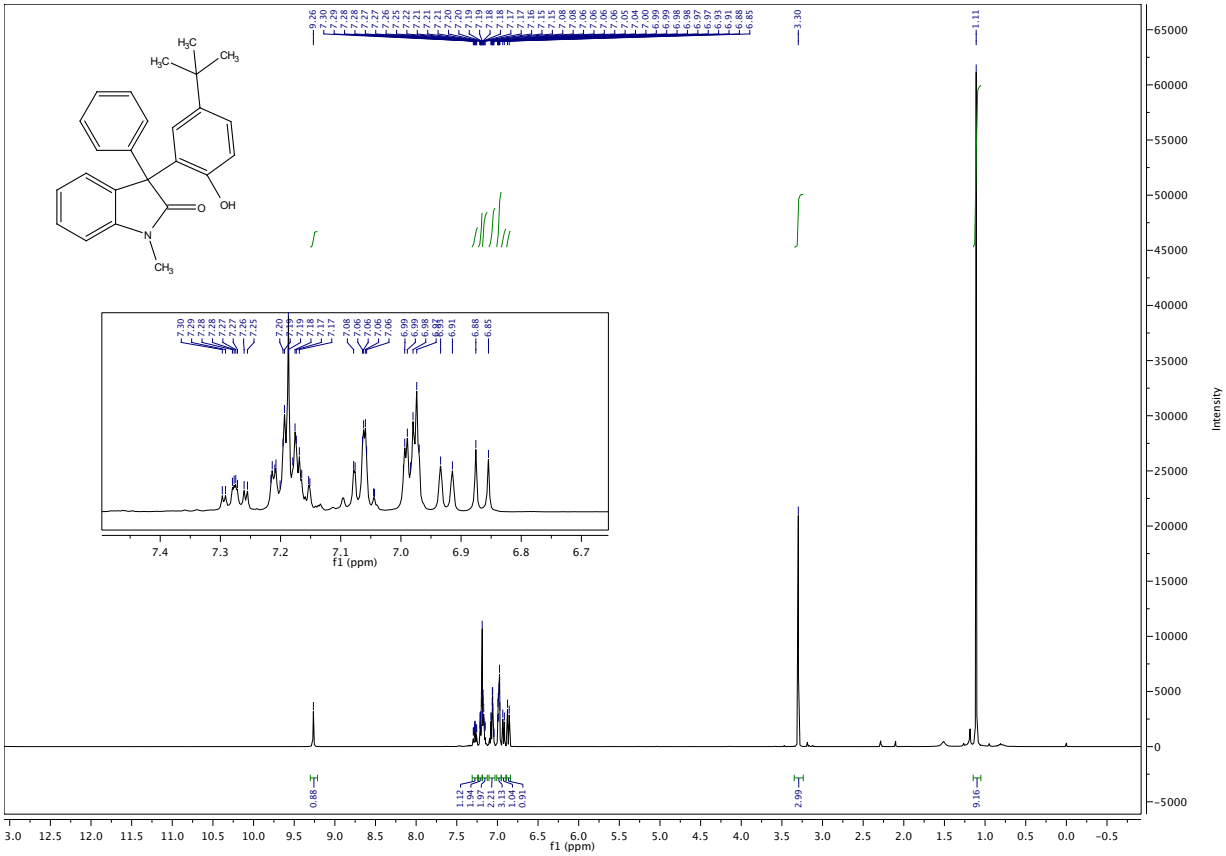
^{1}H NMR spectra (400.13 MHz) of compound **2g** in $CDCl_3/CD_3OD$



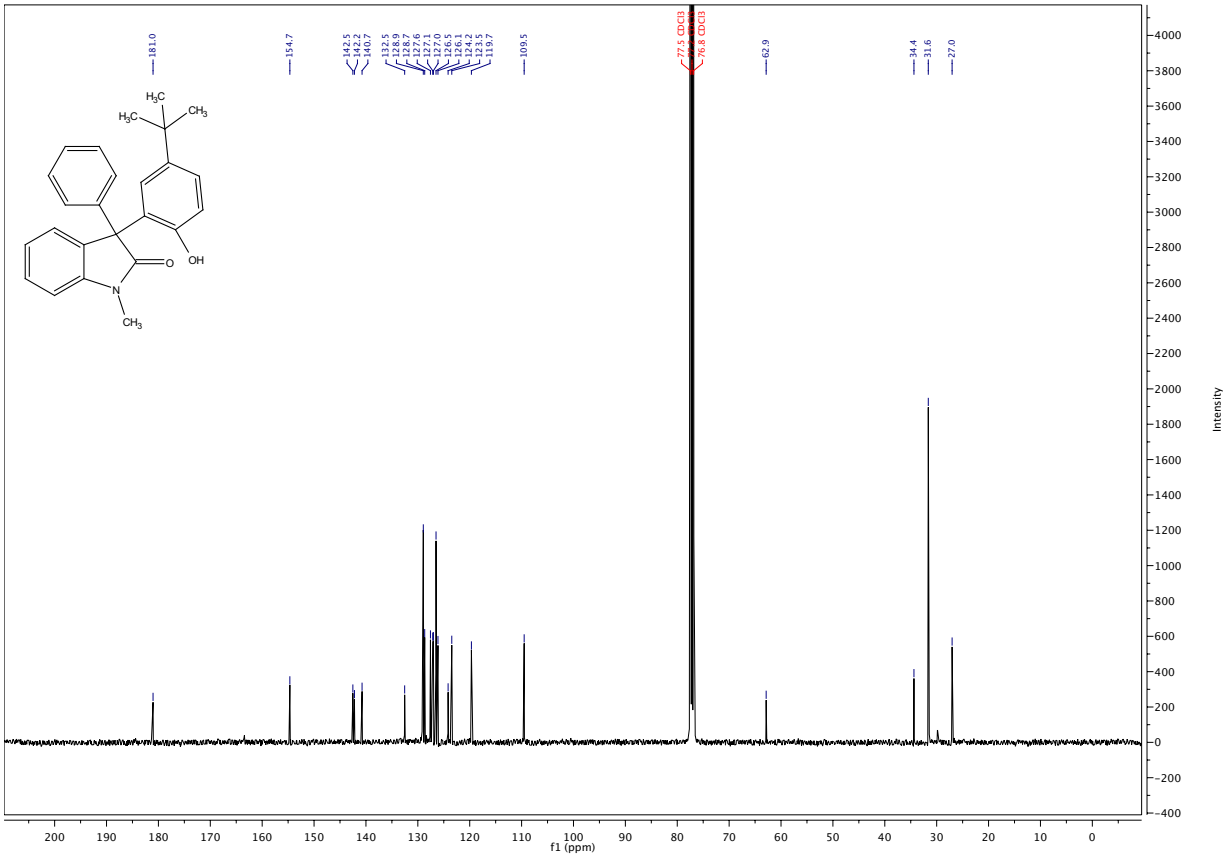
^{13}C NMR spectra (100.62 MHz) of compound **2g** in $CDCl_3/CD_3OD$



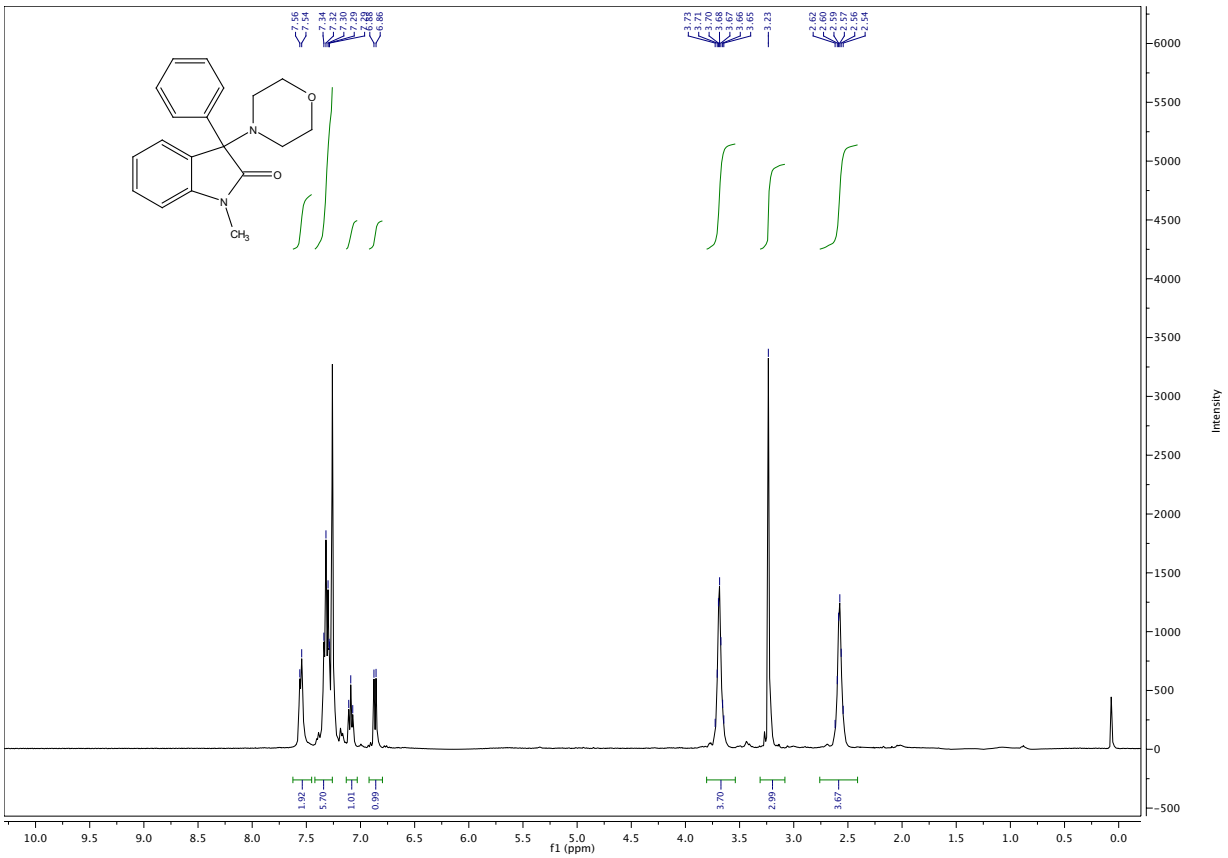
^{1}H NMR spectra (400.13 MHz) of compound **2h** in $CDCl_3$



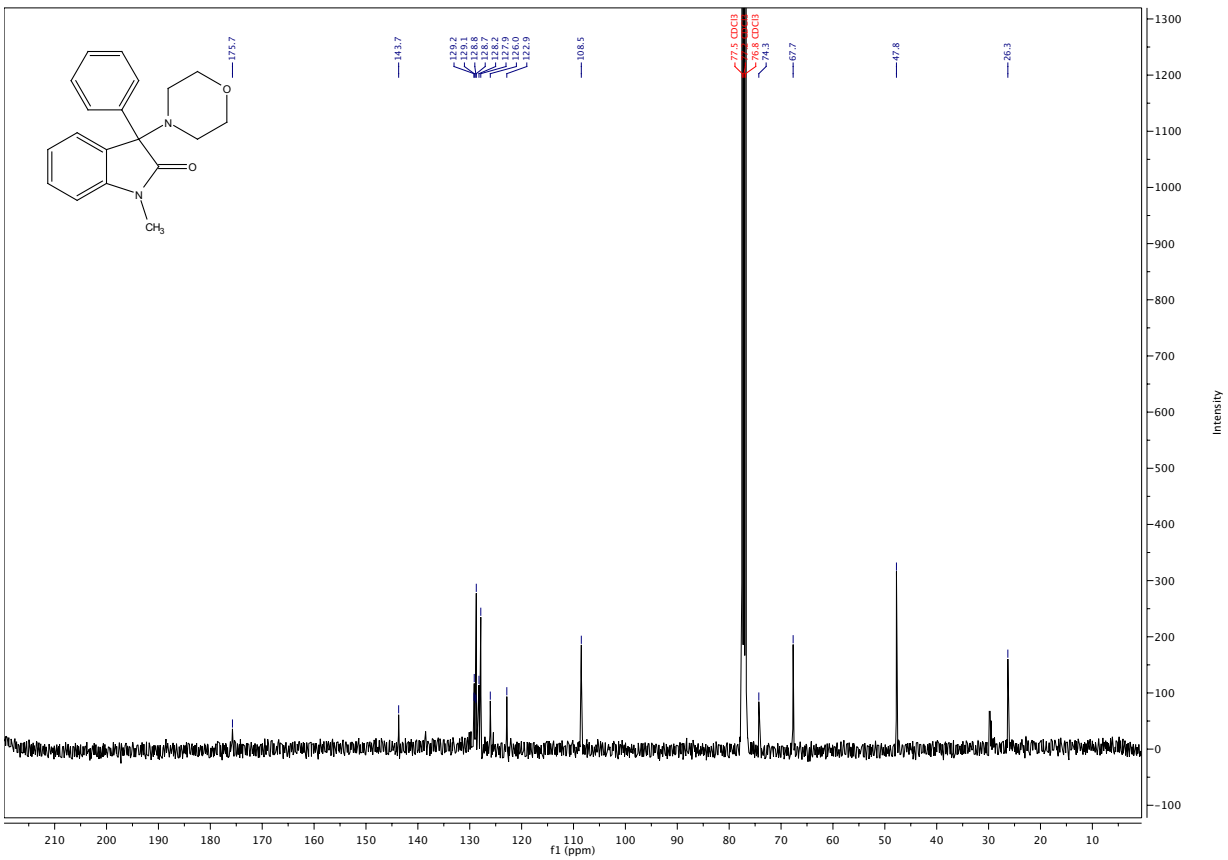
^{13}C NMR spectra (100.62 MHz) of compound **2h** in $CDCl_3$



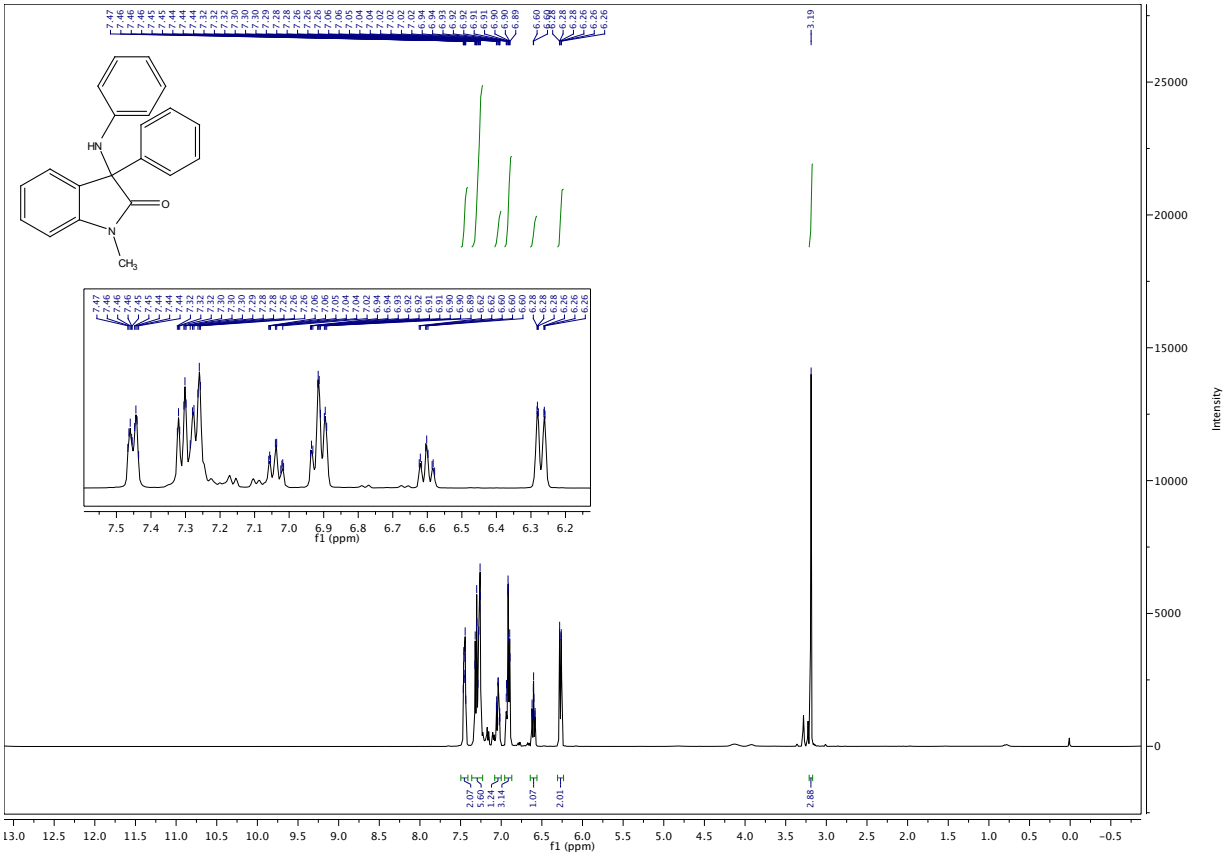
^{1}H NMR spectra (400.13 MHz) of compound **2i** in $CDCl_3$



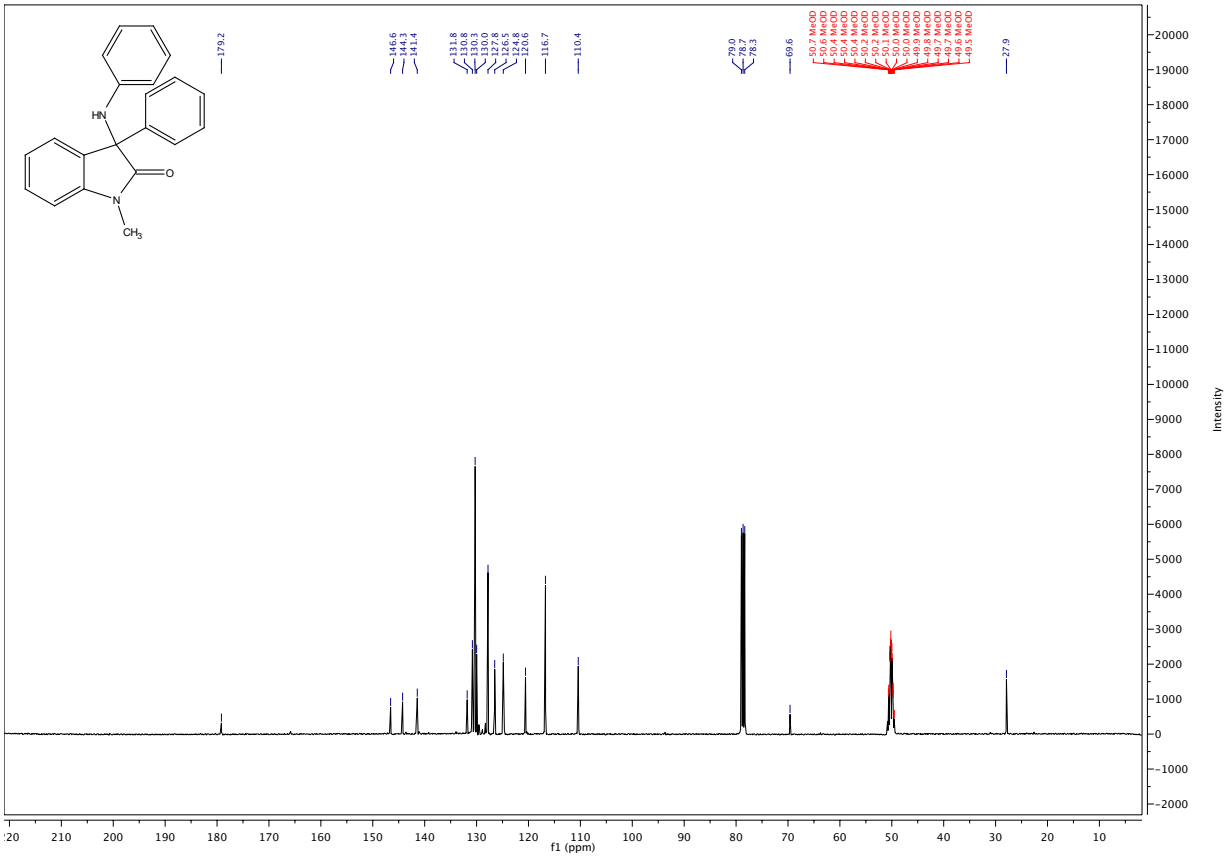
^{13}C NMR spectra (100.62 MHz) of compound **2i** in $CDCl_3$



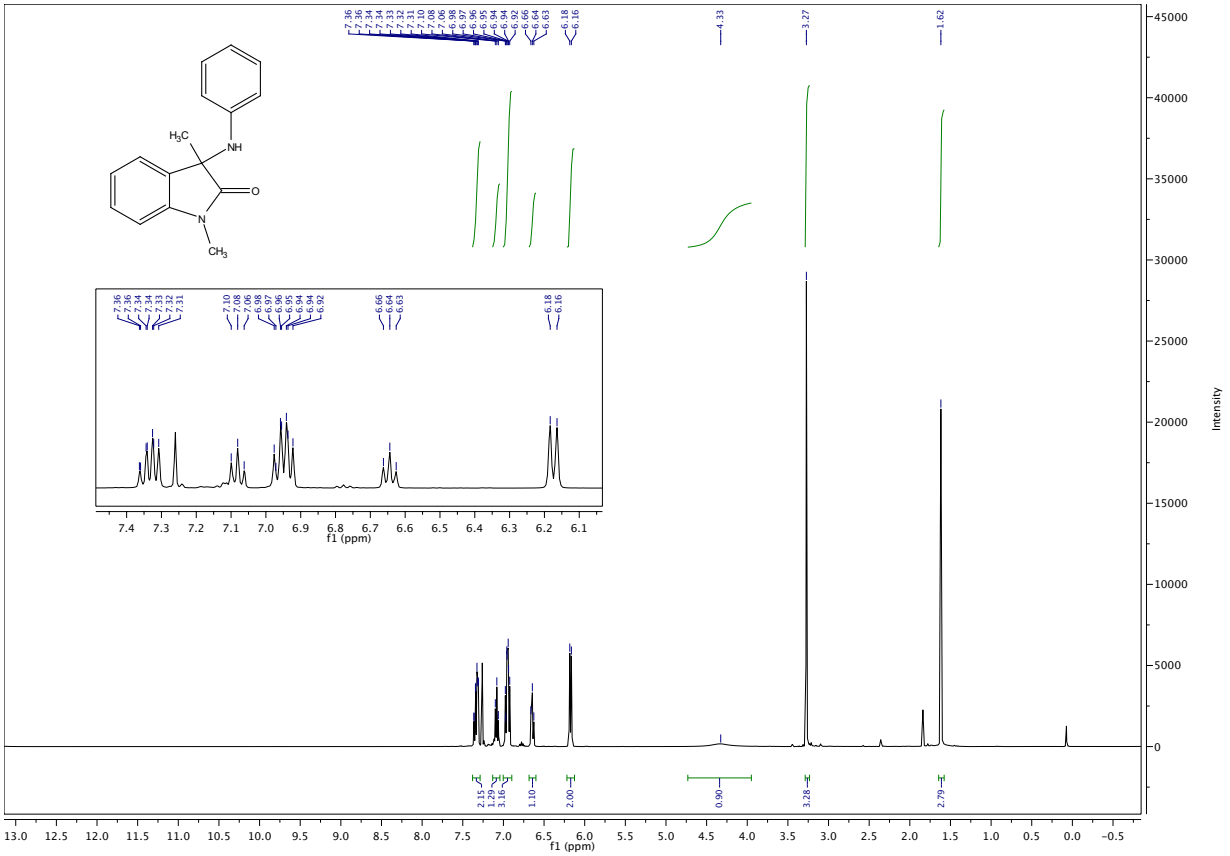
^{1}H NMR spectra (400.13 MHz) of compound **2j** in $CDCl_3/CD_3OD$



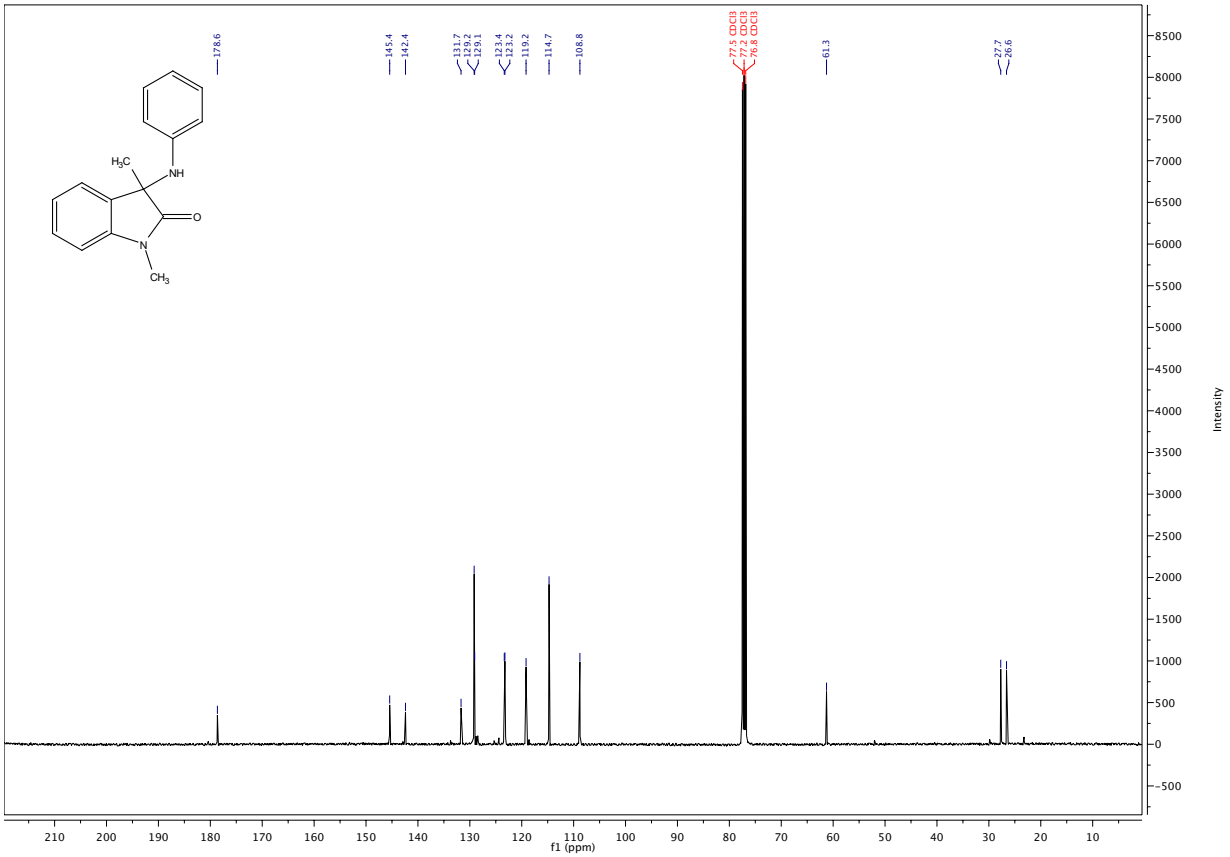
^{13}C NMR spectra (100.62 MHz) of compound **2j** in $CDCl_3/CD_3OD$



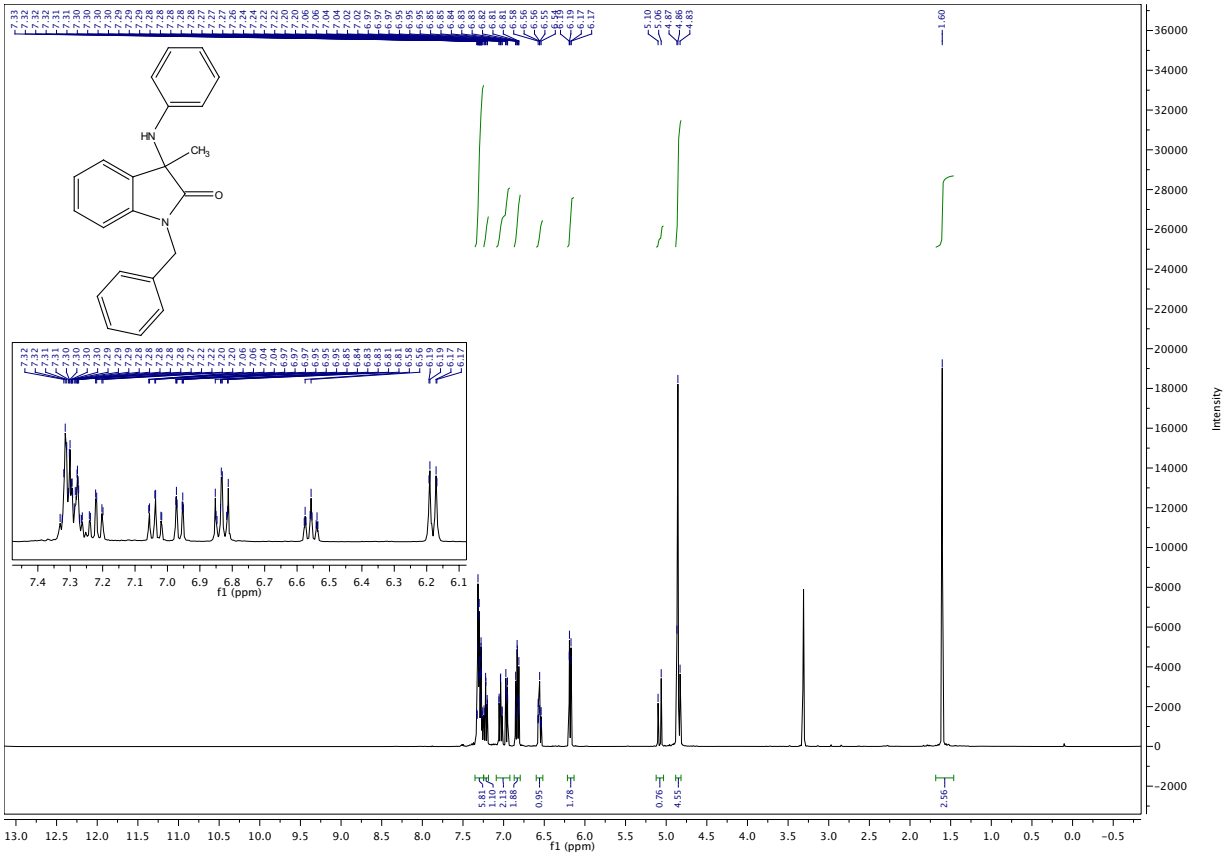
^{1}H NMR spectra (400.13 MHz) of compound **2k** in $CDCl_3$



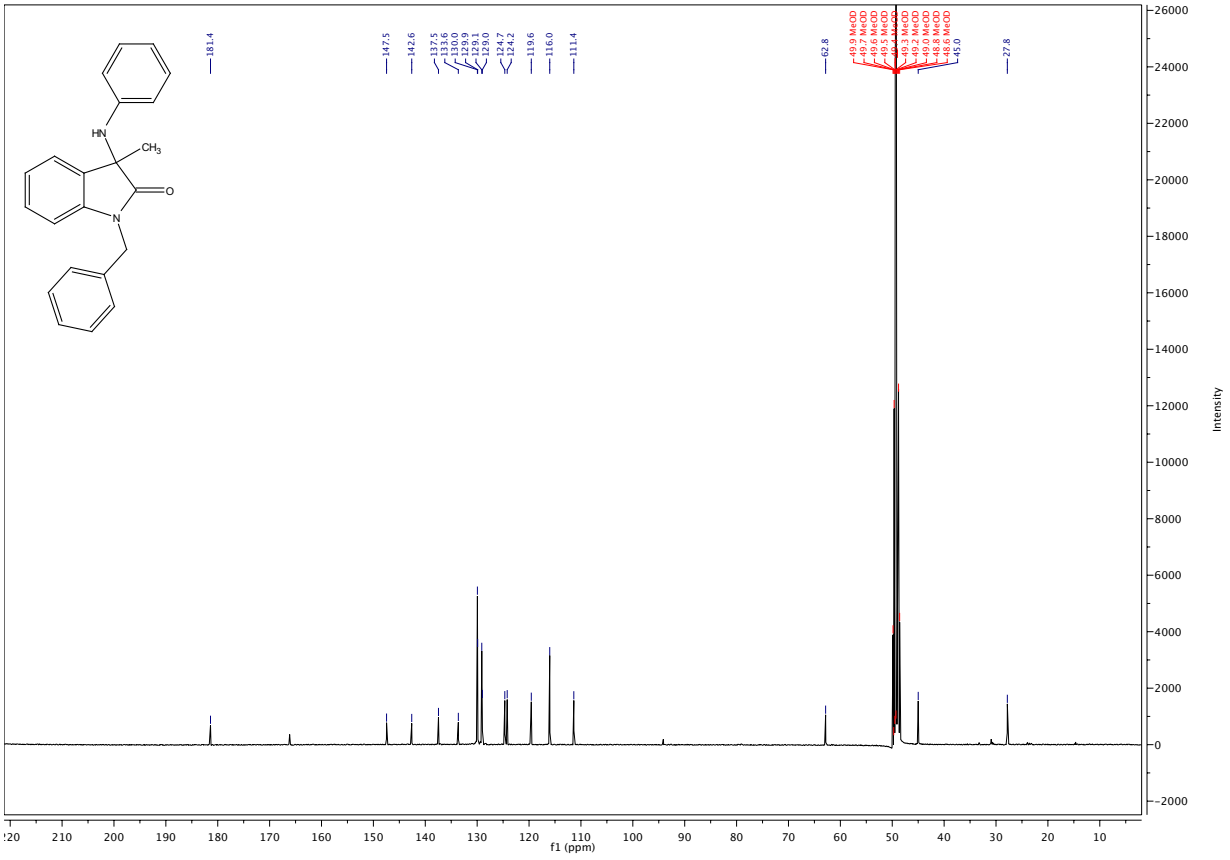
^{13}C NMR spectra (100.62 MHz) of compound **2k** in $CDCl_3$



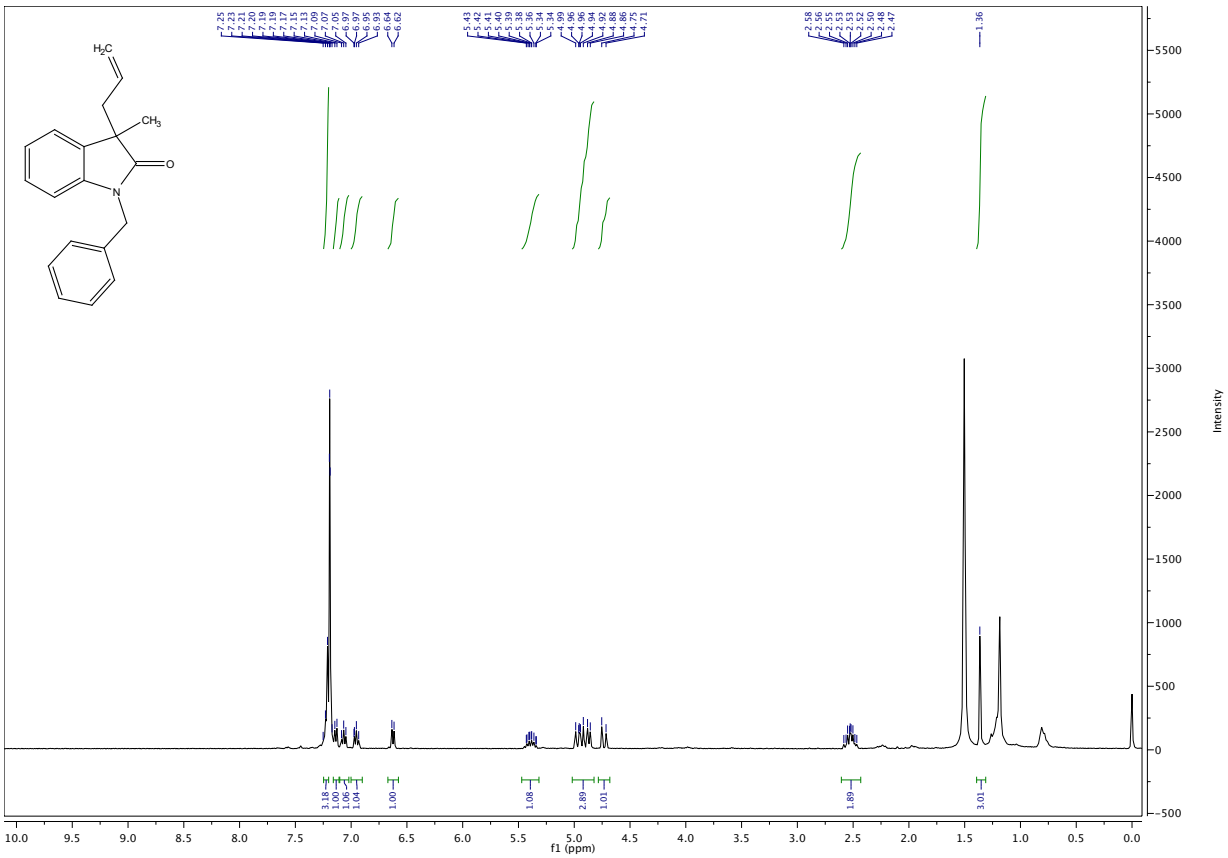
^{1}H NMR spectra (400.13 MHz) of compound **2l** in CD_3OD



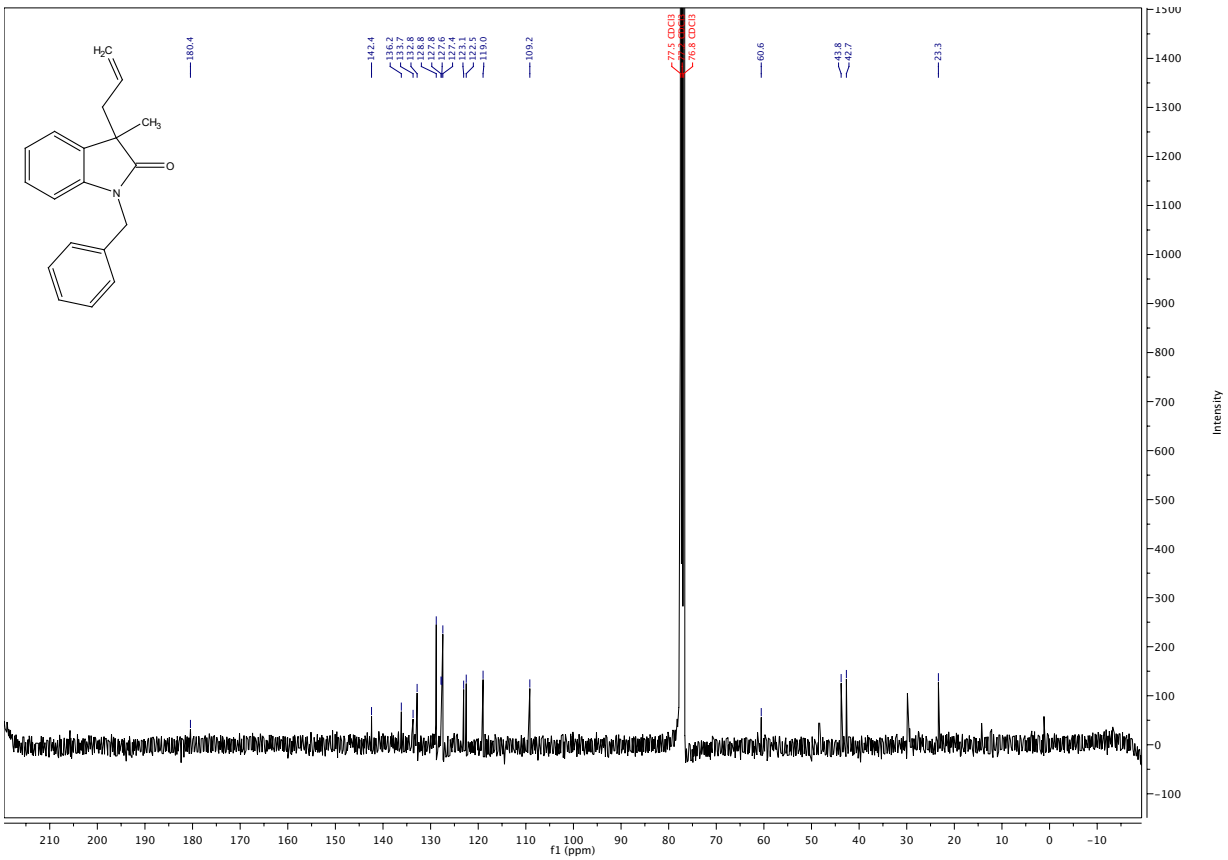
^{13}C NMR spectra (100.62 MHz) of compound **2l** in CD_3OD



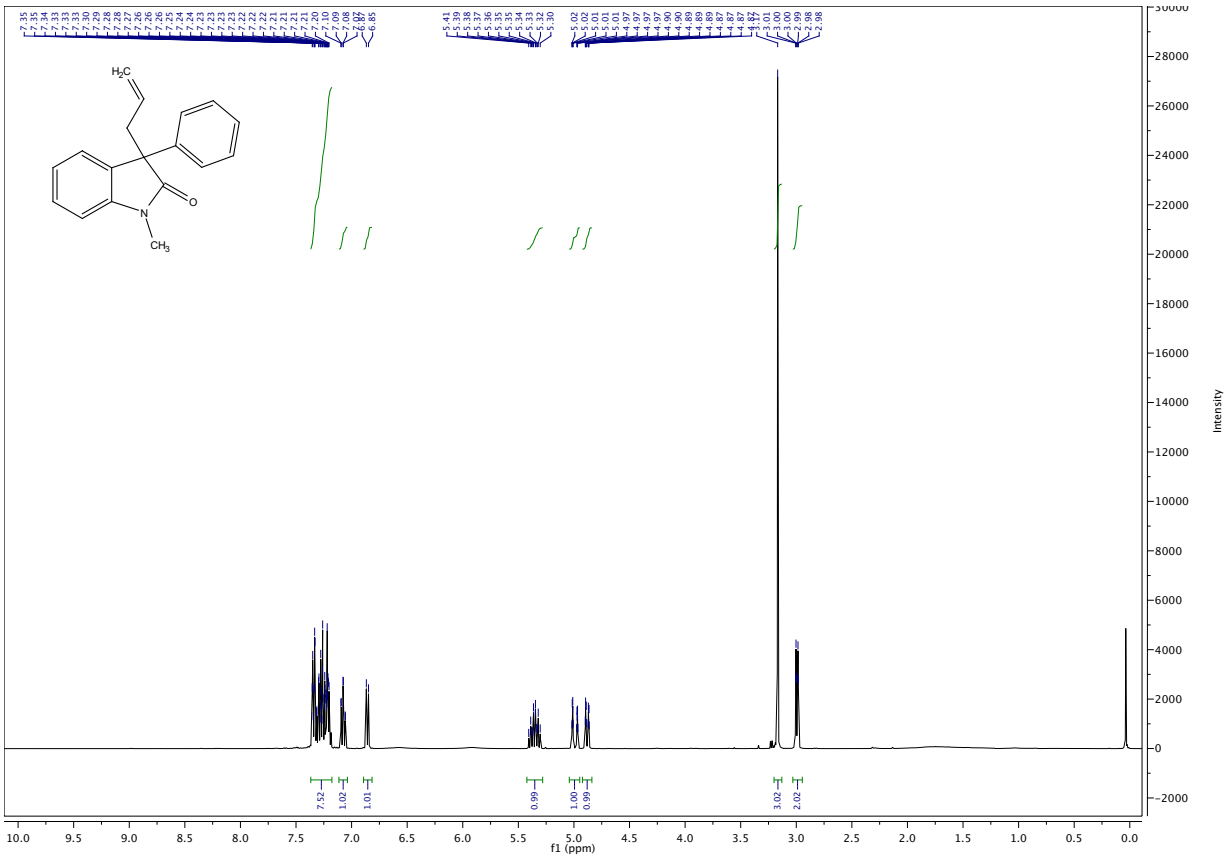
^{1}H NMR spectra (400.13 MHz) of compound **2m** in $CDCl_3$



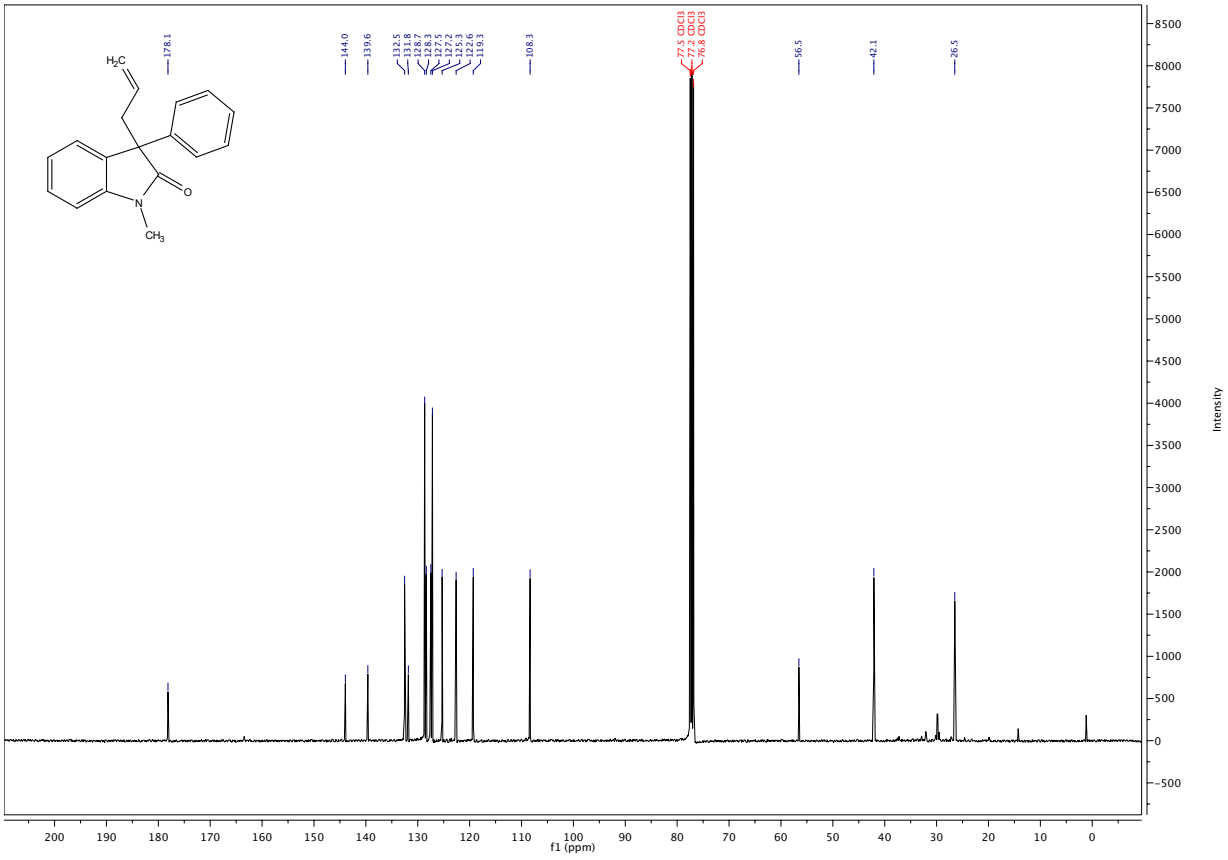
^{13}C NMR spectra (100.62 MHz) of compound **2m** in $CDCl_3$



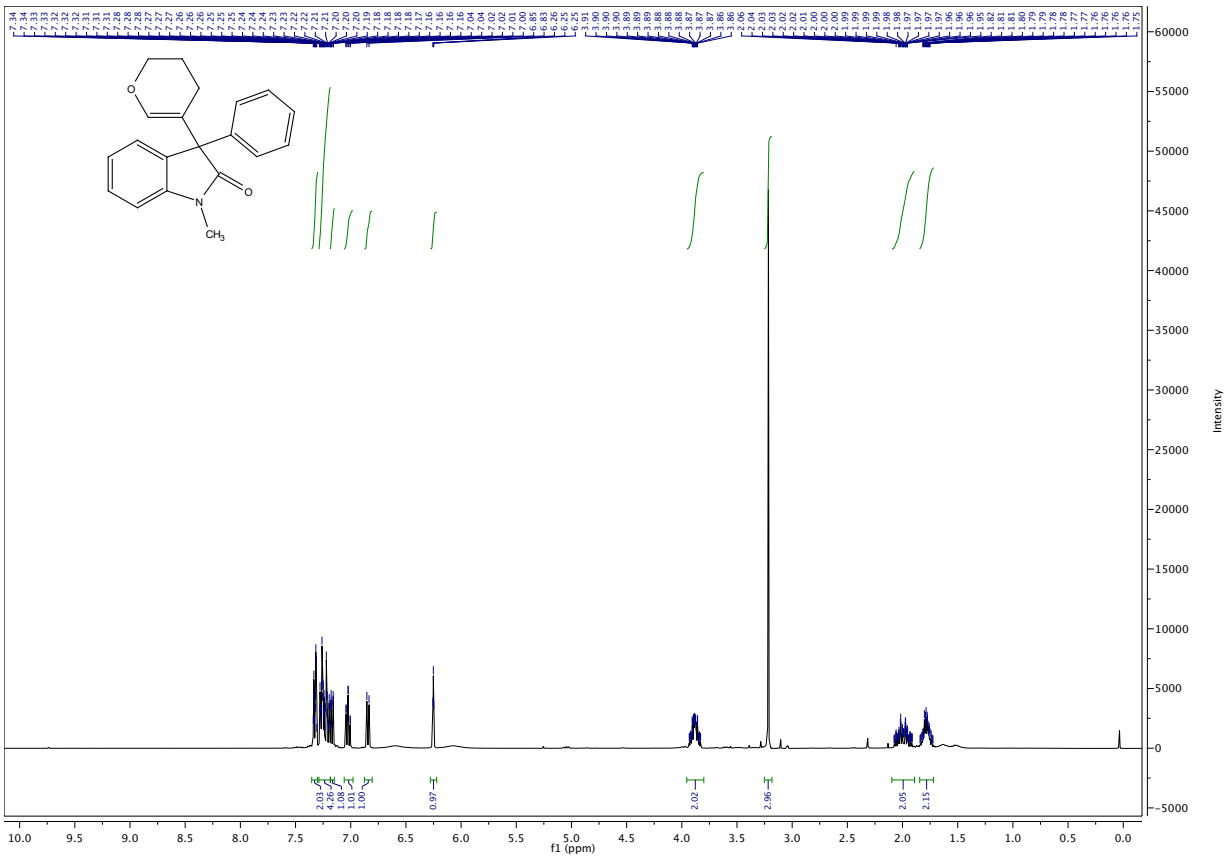
^{1}H NMR spectra (400.13 MHz) of compound **2n** in $CDCl_3$



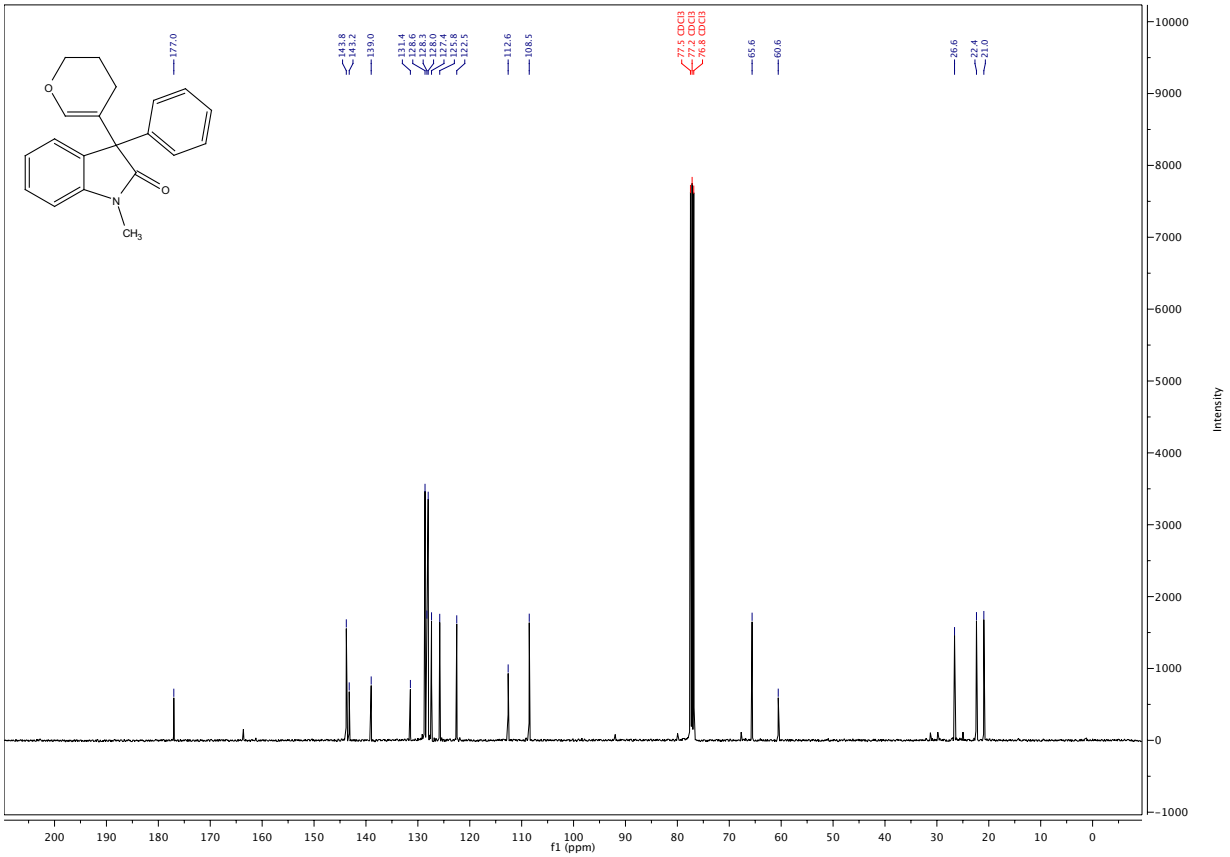
^{13}C NMR spectra (100.62 MHz) of compound **2n** in $CDCl_3$



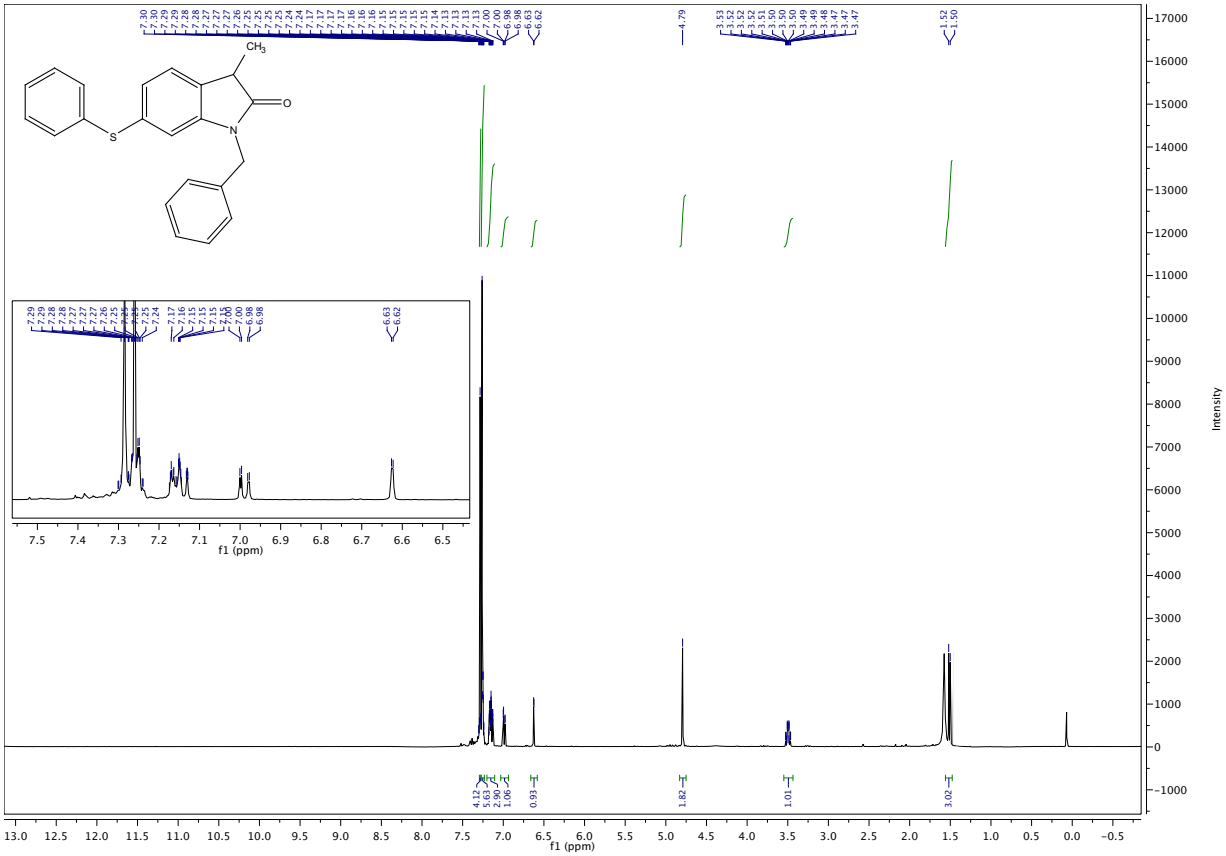
^{1}H NMR spectra (400.13 MHz) of compound **2o** in $CDCl_3$



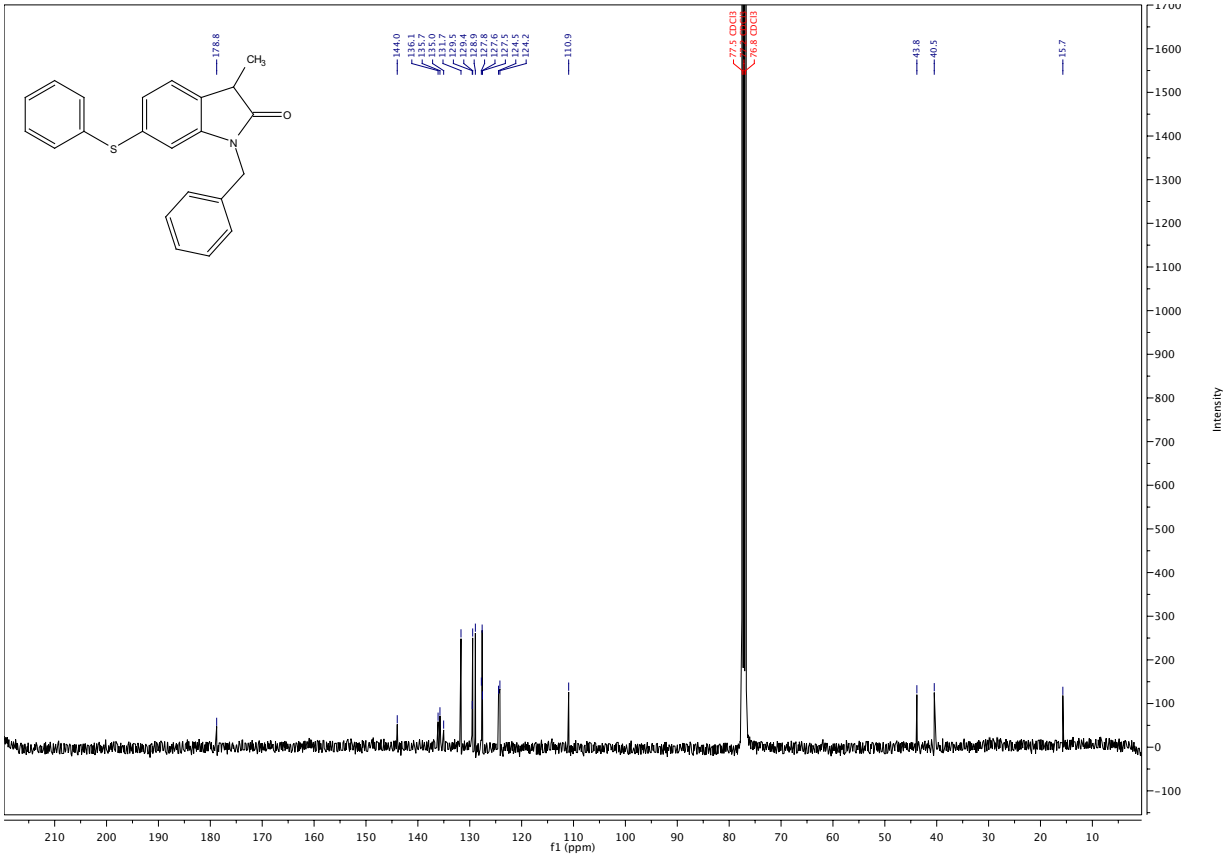
^{13}C NMR spectra (100.62 MHz) of compound **2o** in $CDCl_3$



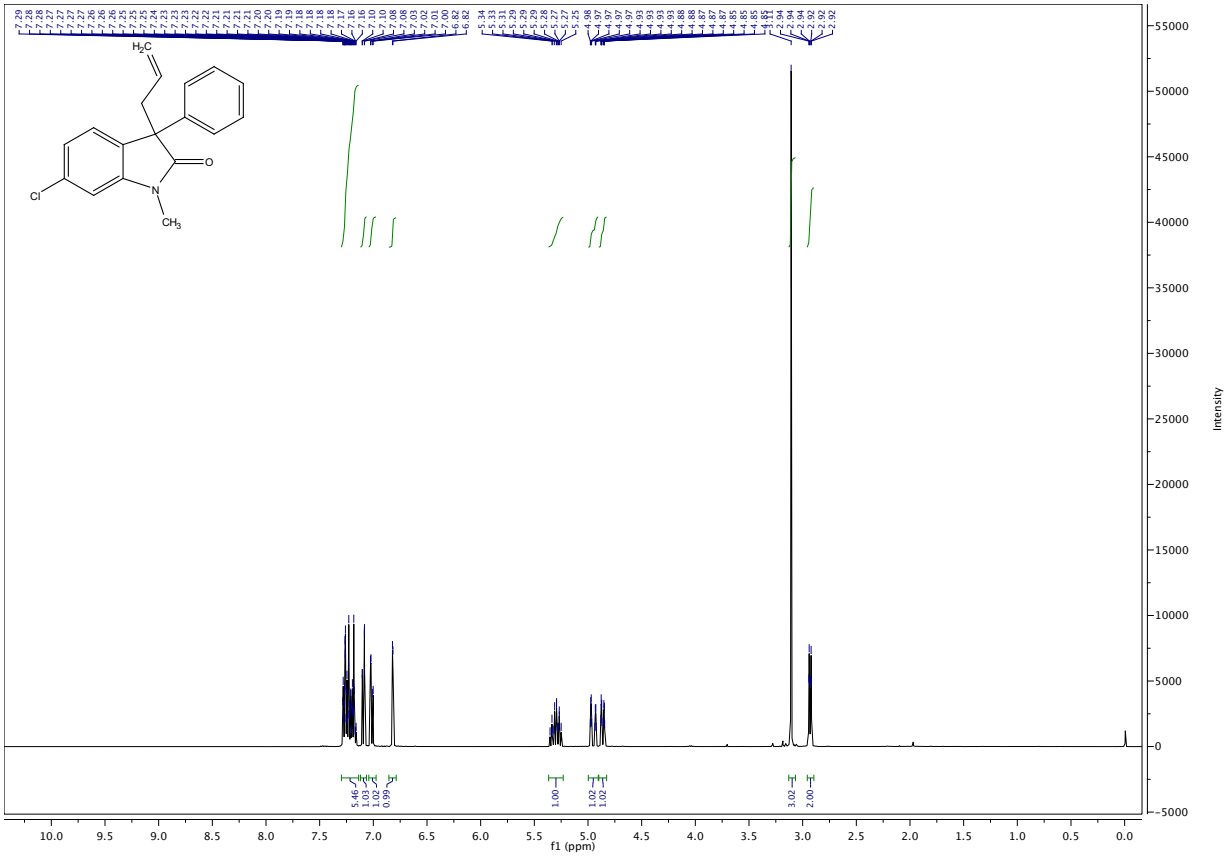
^{1}H NMR spectra (400.13 MHz) of compound **2p** in $CDCl_3$



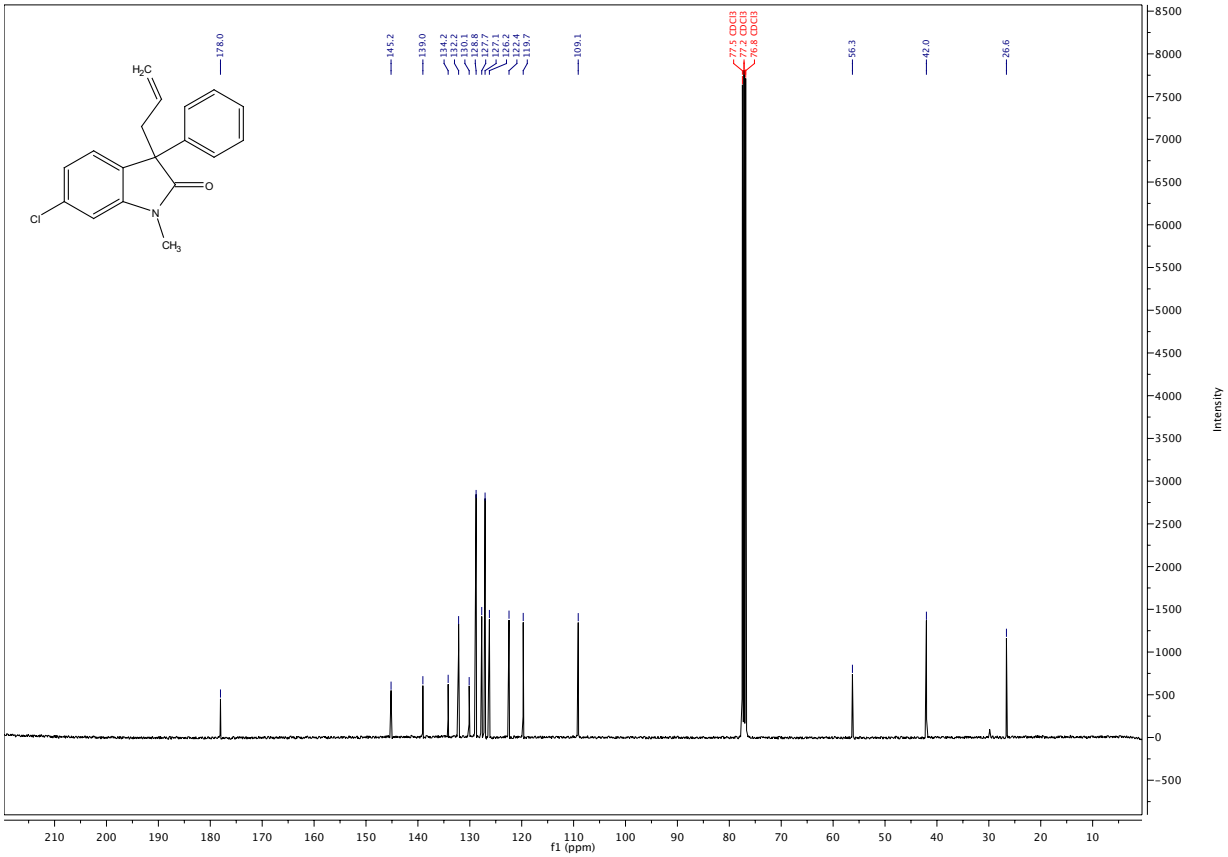
^{13}C NMR spectra (100.62 MHz) of compound **2p** in $CDCl_3$



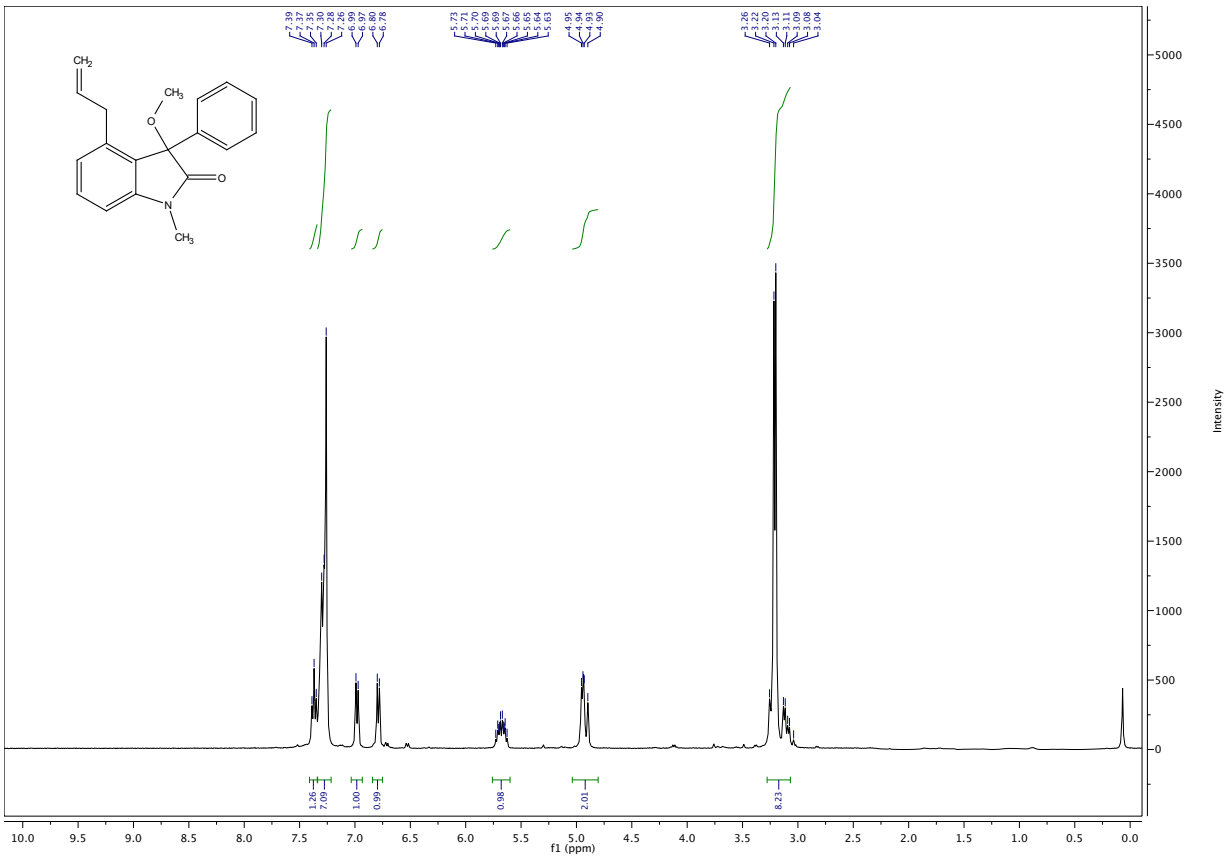
^{1}H NMR spectra (400.13 MHz) of compound **2q** in $CDCl_3$



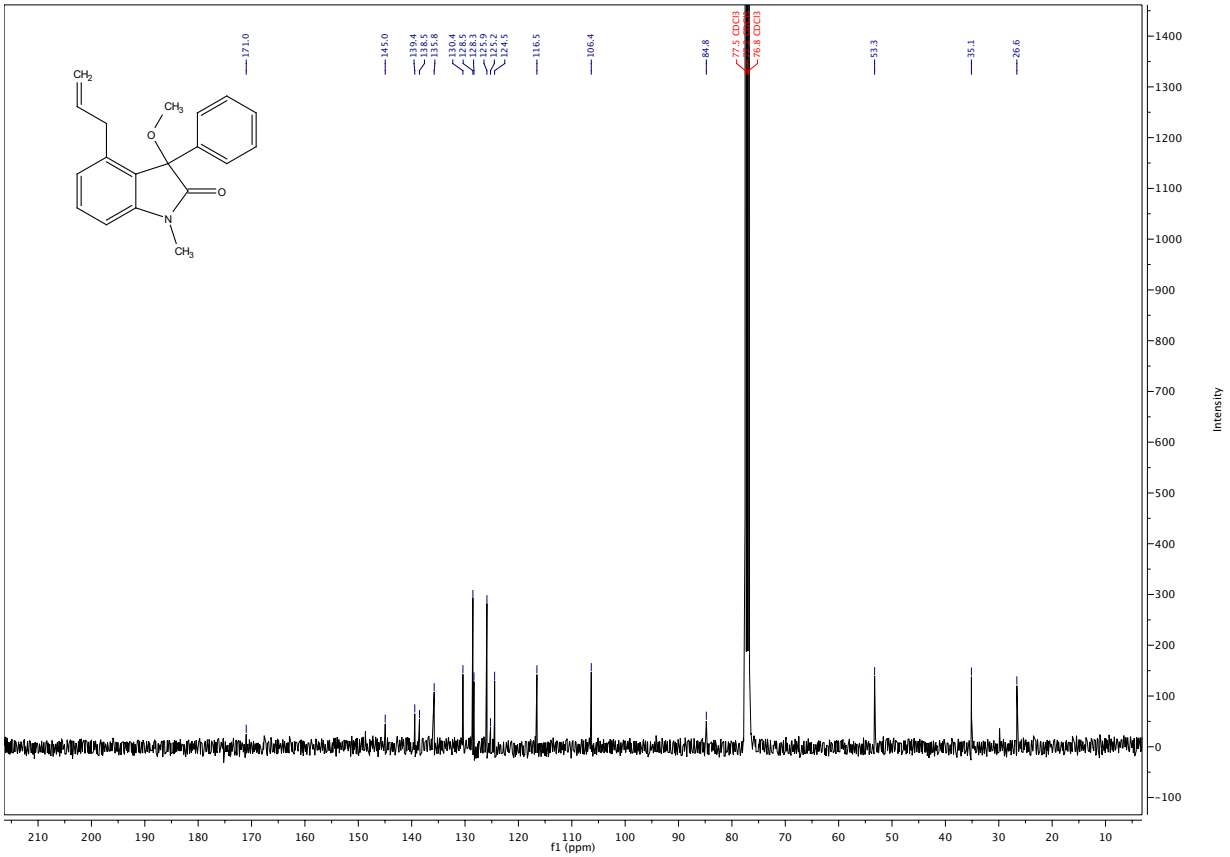
^{13}C NMR spectra (100.62 MHz) of compound **2q** in $CDCl_3$



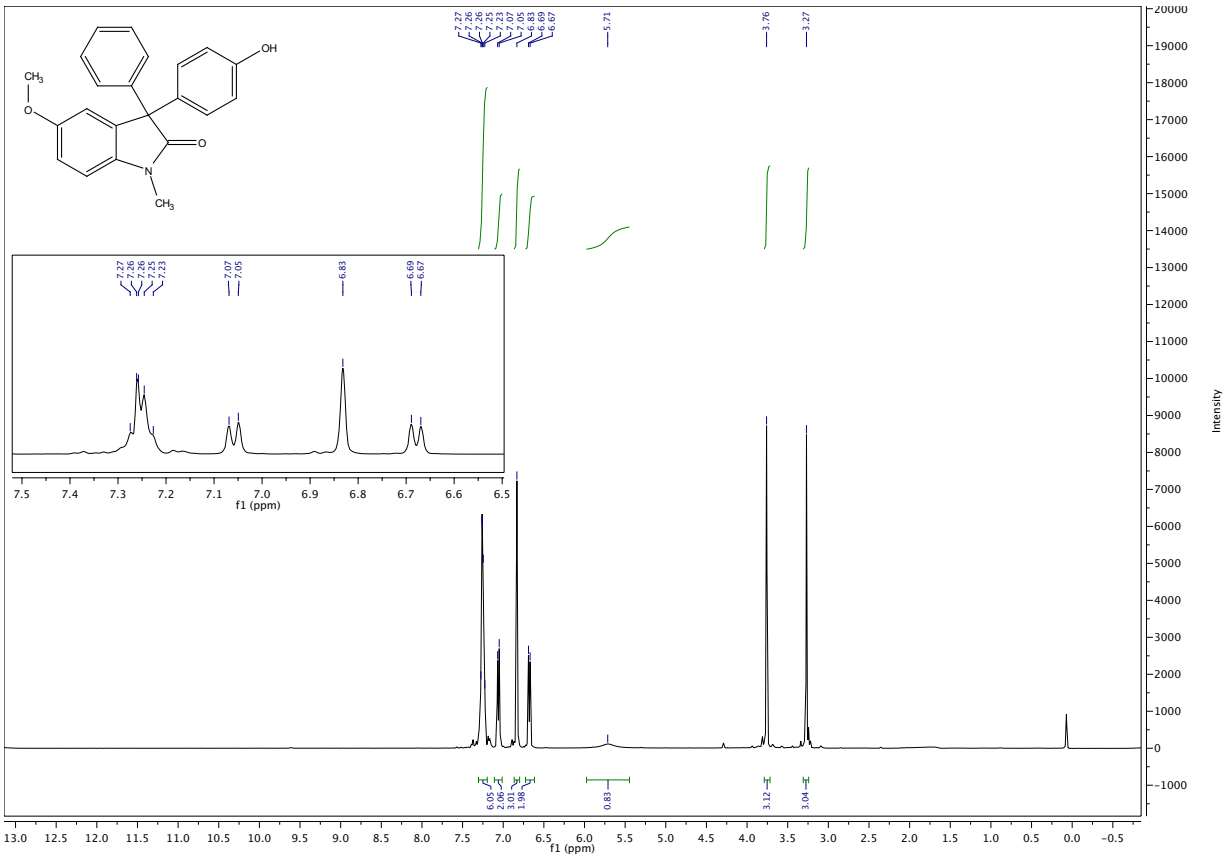
^{1}H NMR spectra (400.13 MHz) of compound **2r** in $CDCl_3$



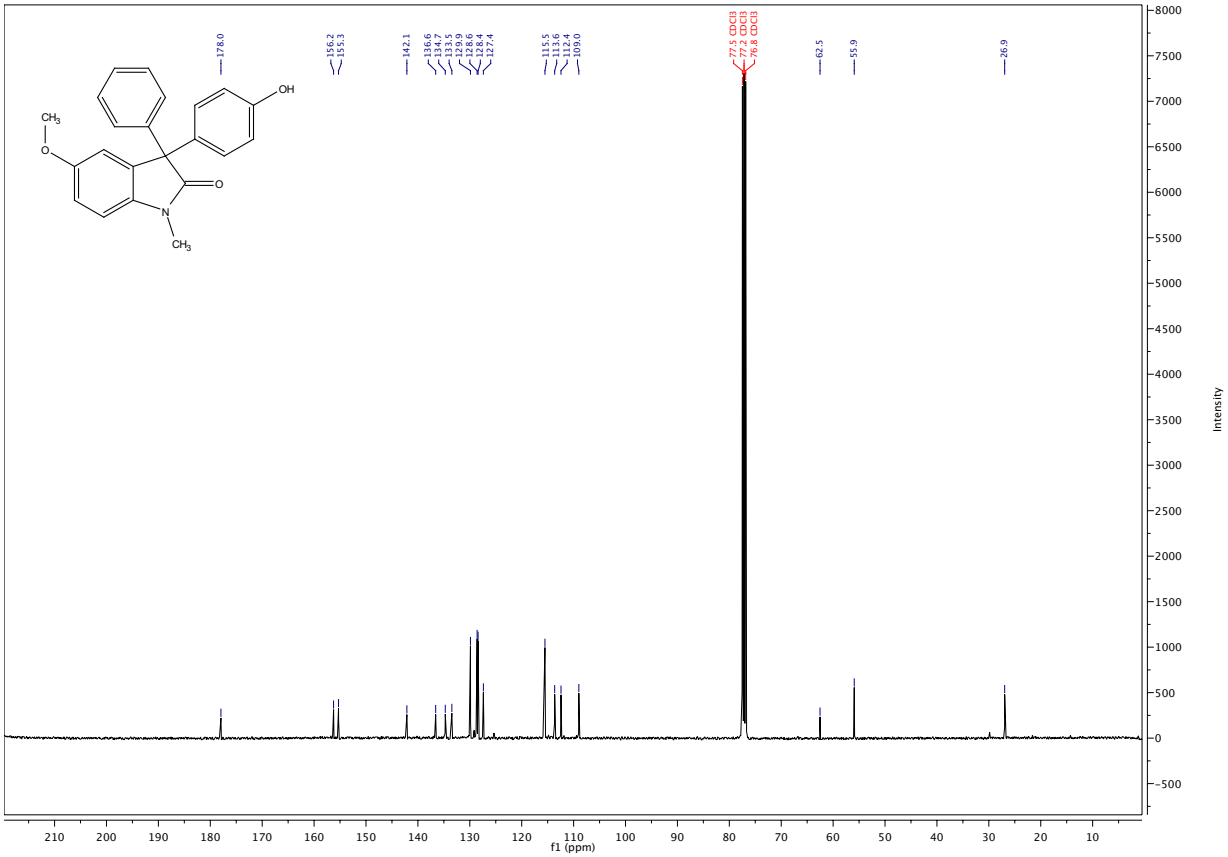
^{13}C NMR spectra (100.62 MHz) of compound **2r** in $CDCl_3$



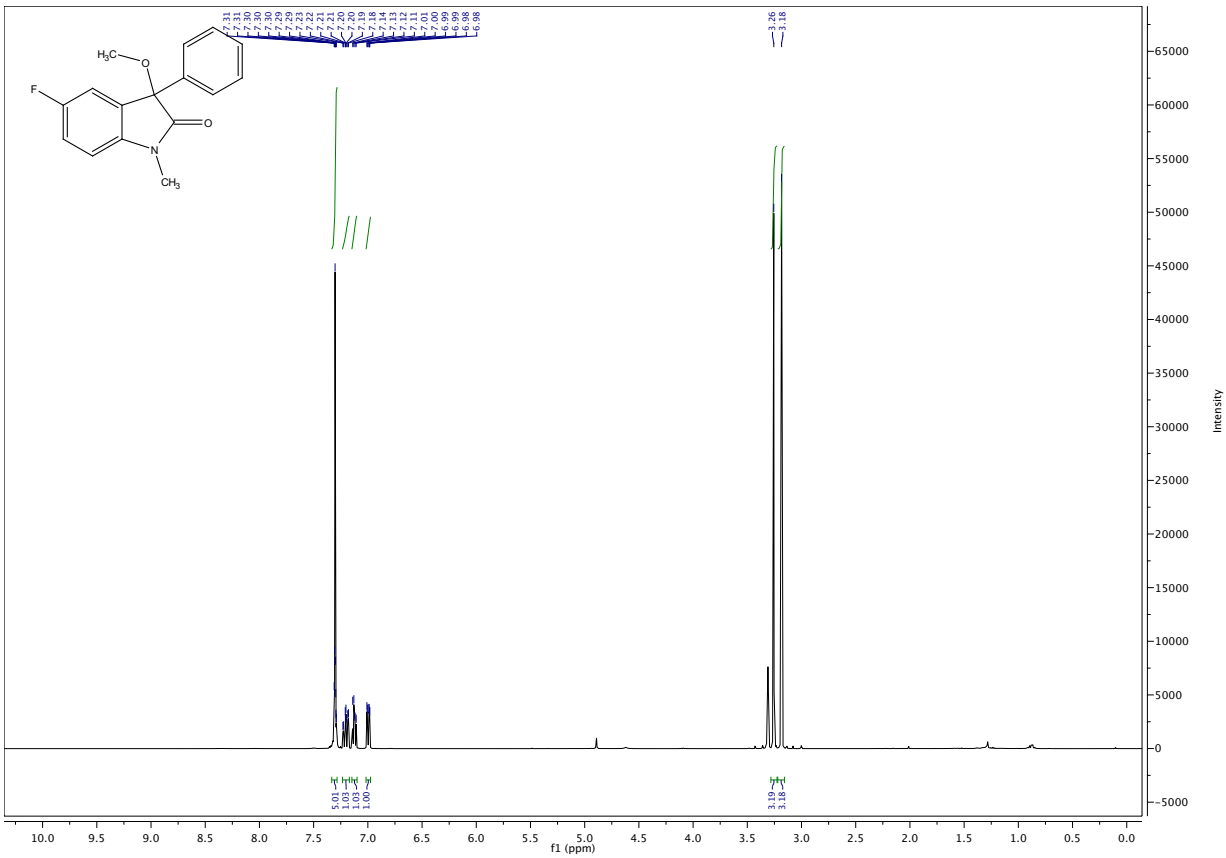
^{1}H NMR spectra (400.13 MHz) of compound **2s** in $CDCl_3$



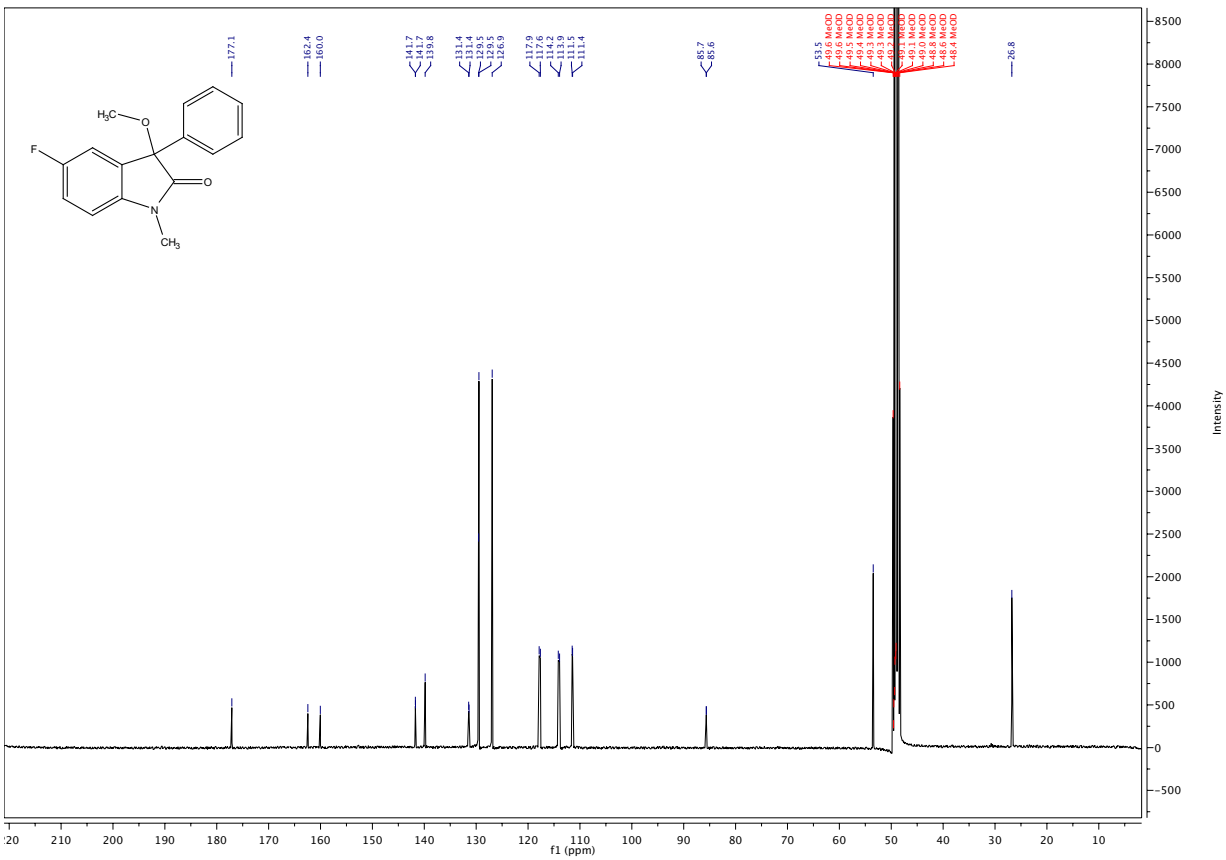
^{13}C NMR spectra (100.62 MHz) of compound **2s** in $CDCl_3$



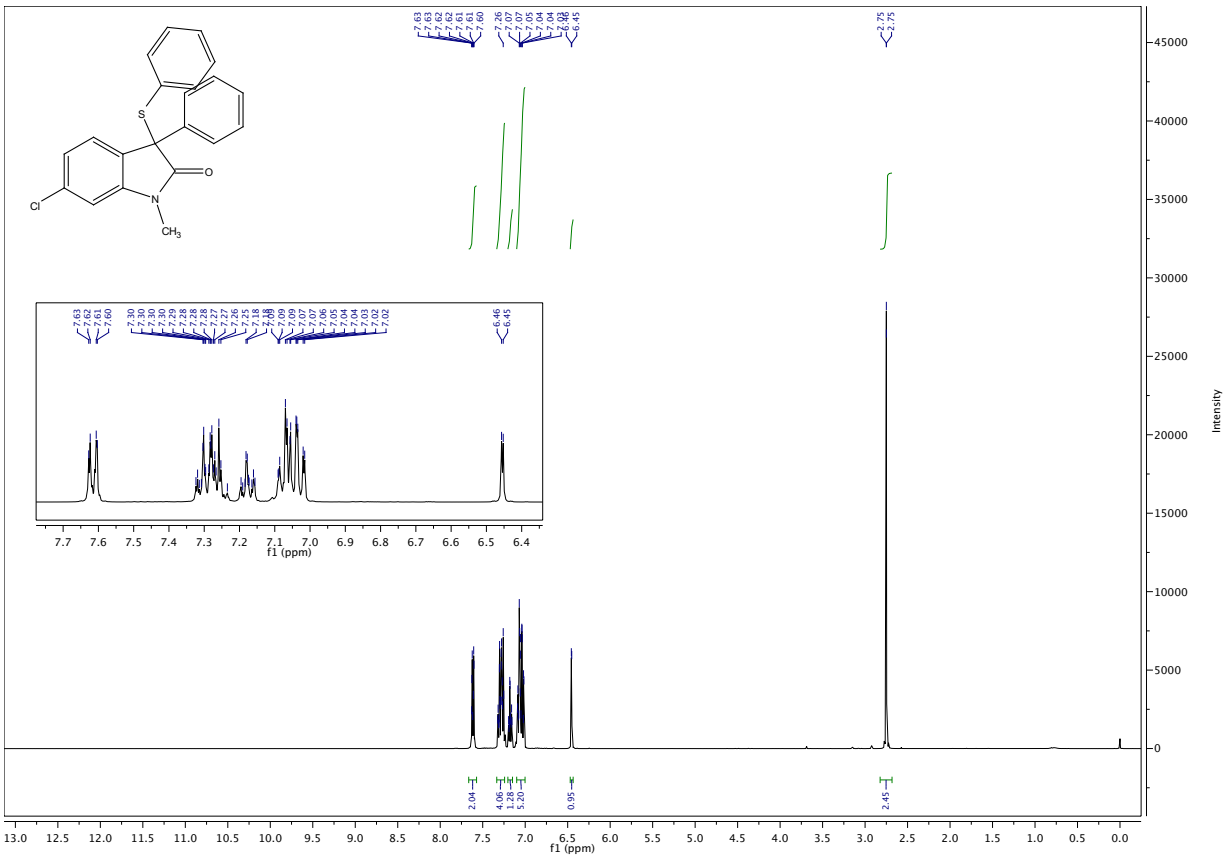
^{1}H NMR spectra (400.13 MHz) of compound **2t** in CD_3OD



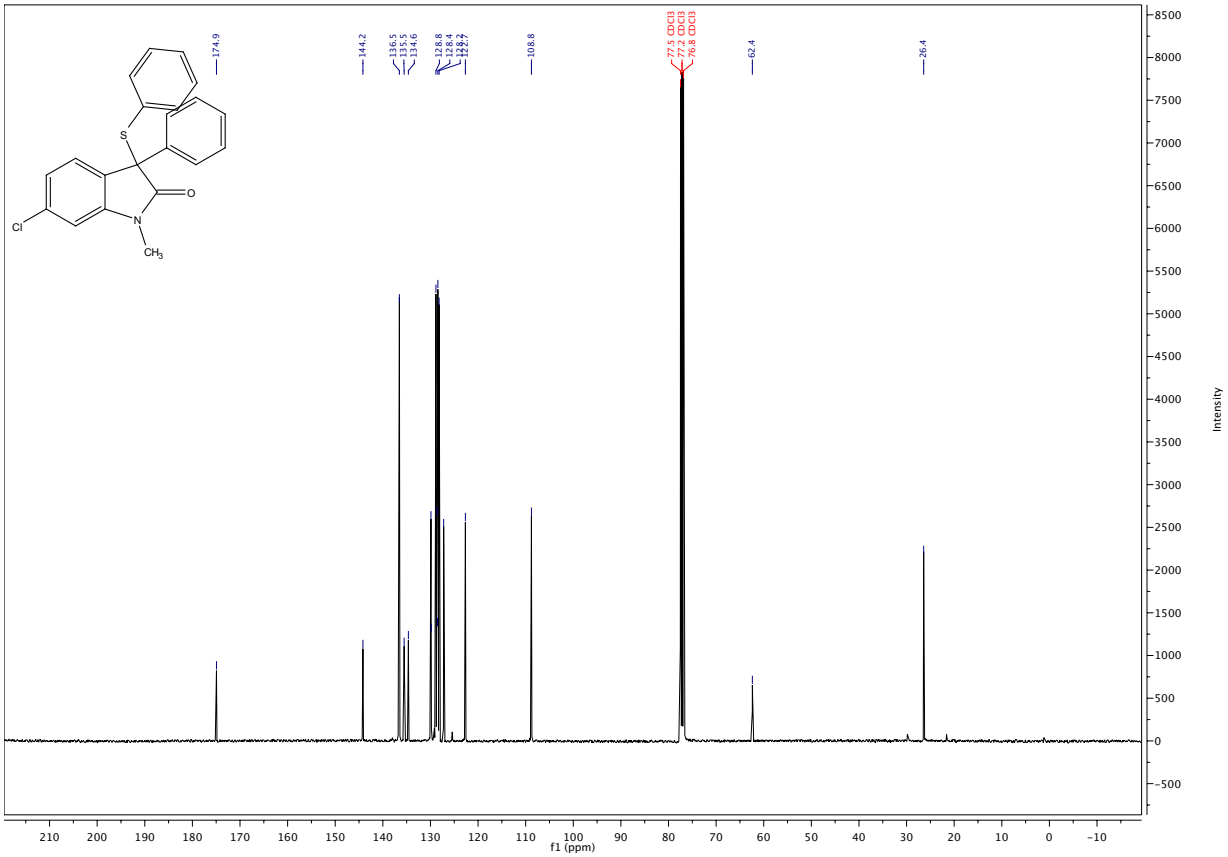
^{13}C NMR spectra (100.62 MHz) of compound **2t** in CD_3OD



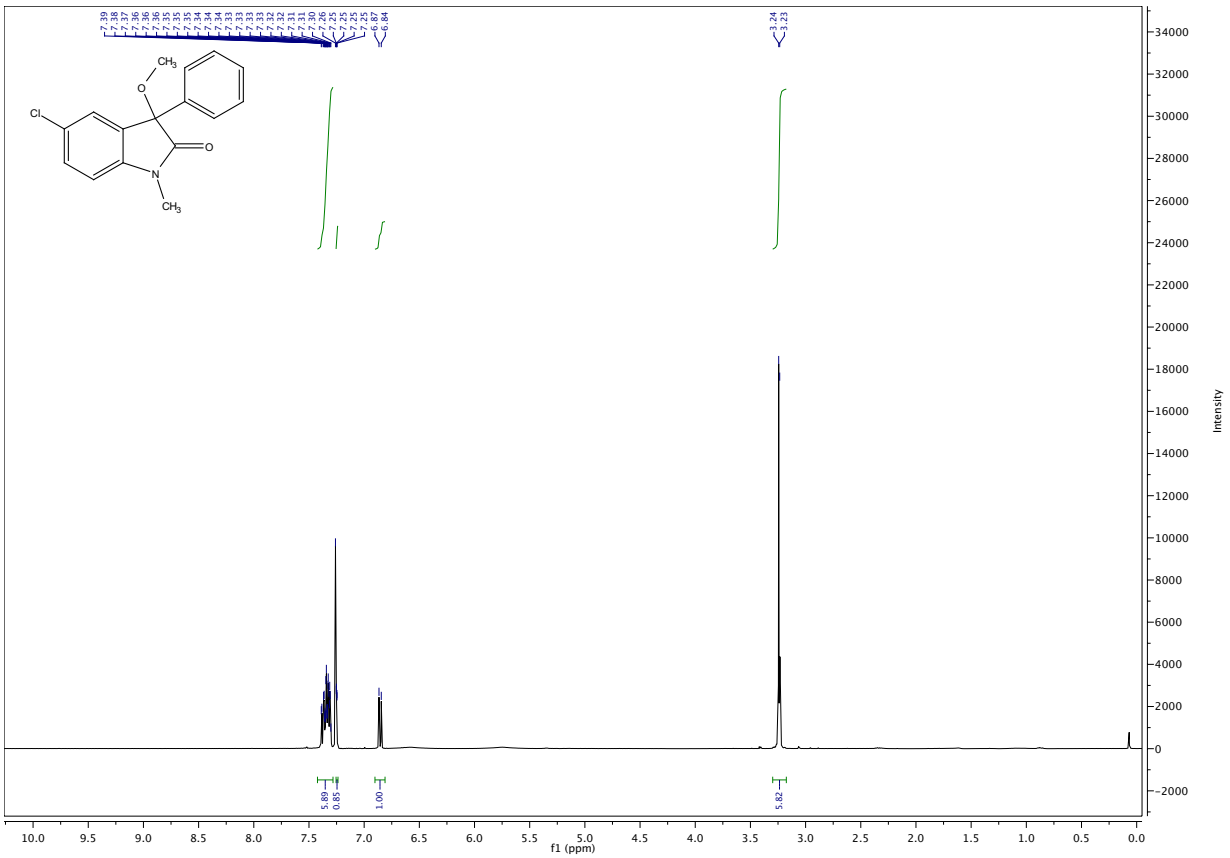
^{1}H NMR spectra (400.13 MHz) of compound **2u** in $CDCl_3$



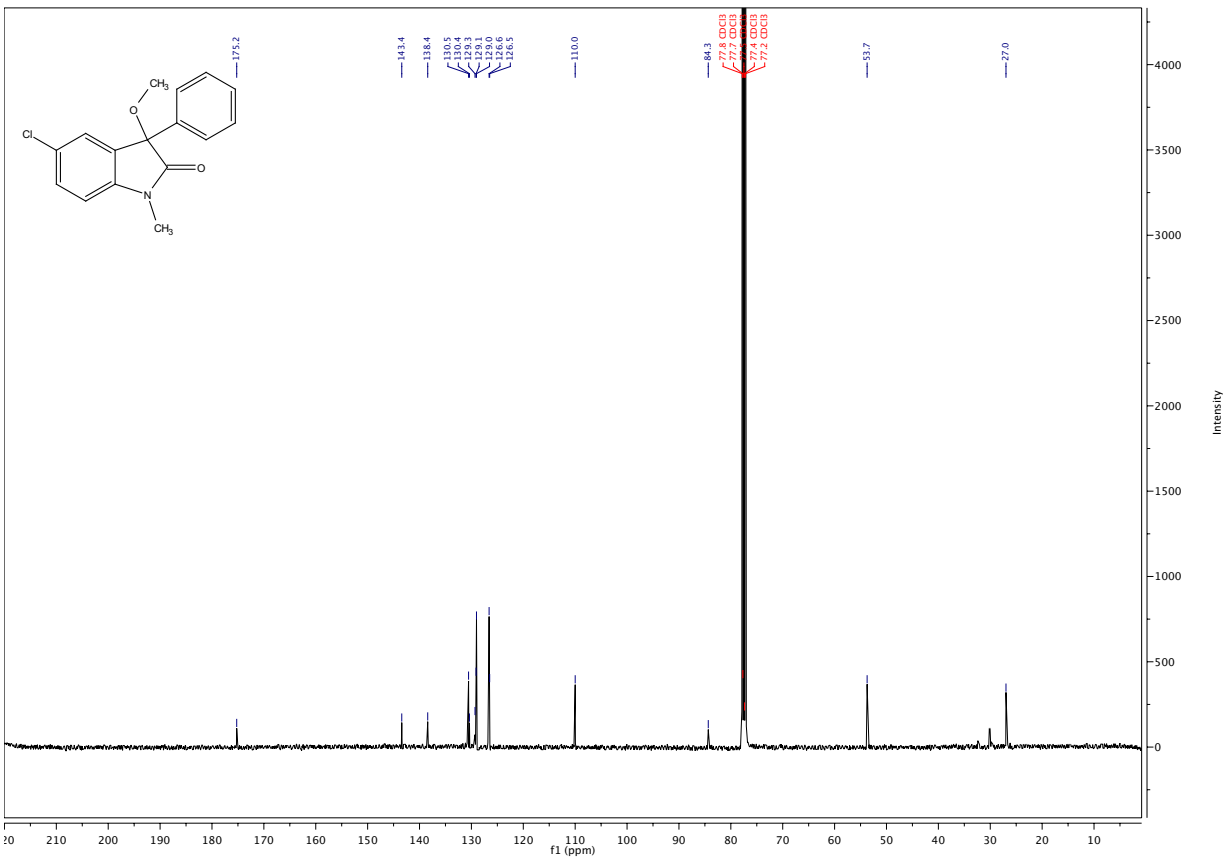
^{13}C NMR spectra (100.62 MHz) of compound **2u** in $CDCl_3$



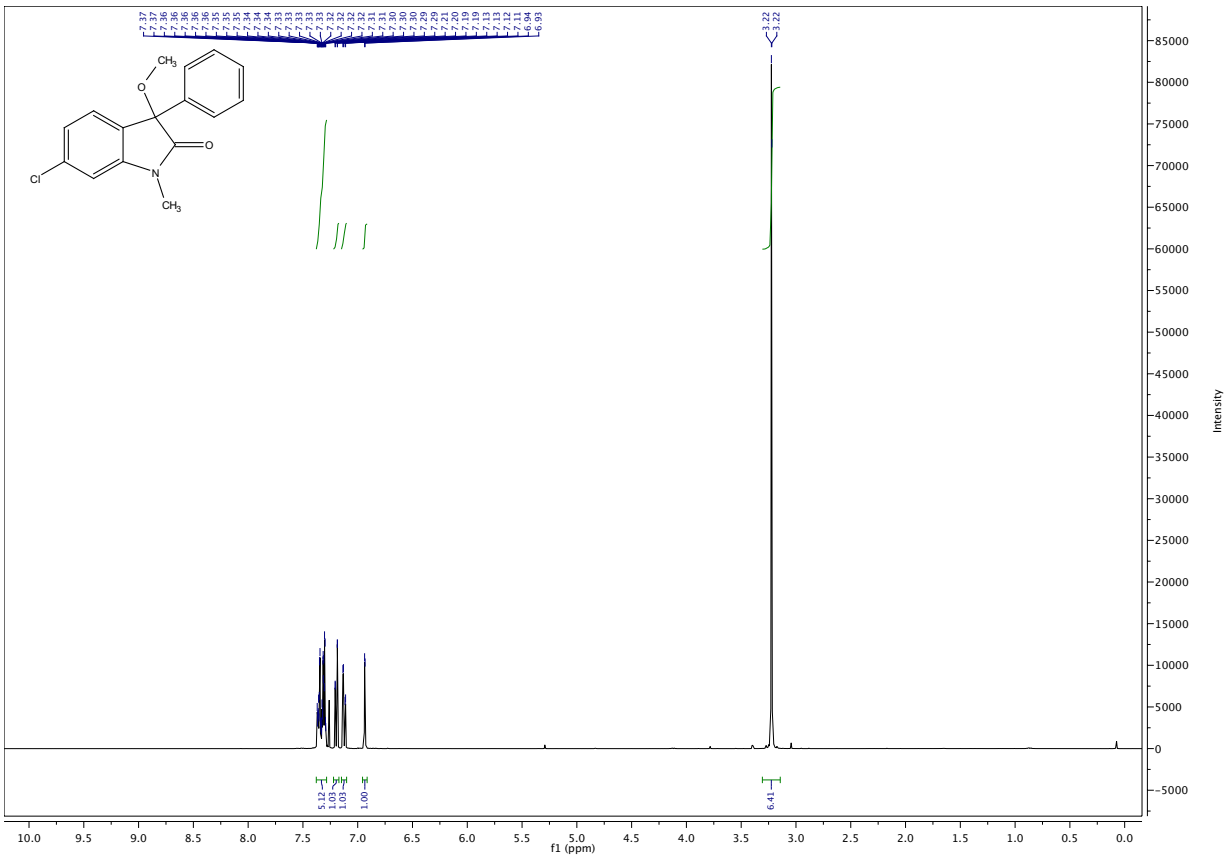
^{1}H NMR spectra (400.13 MHz) of compound **2v** in $CDCl_3$



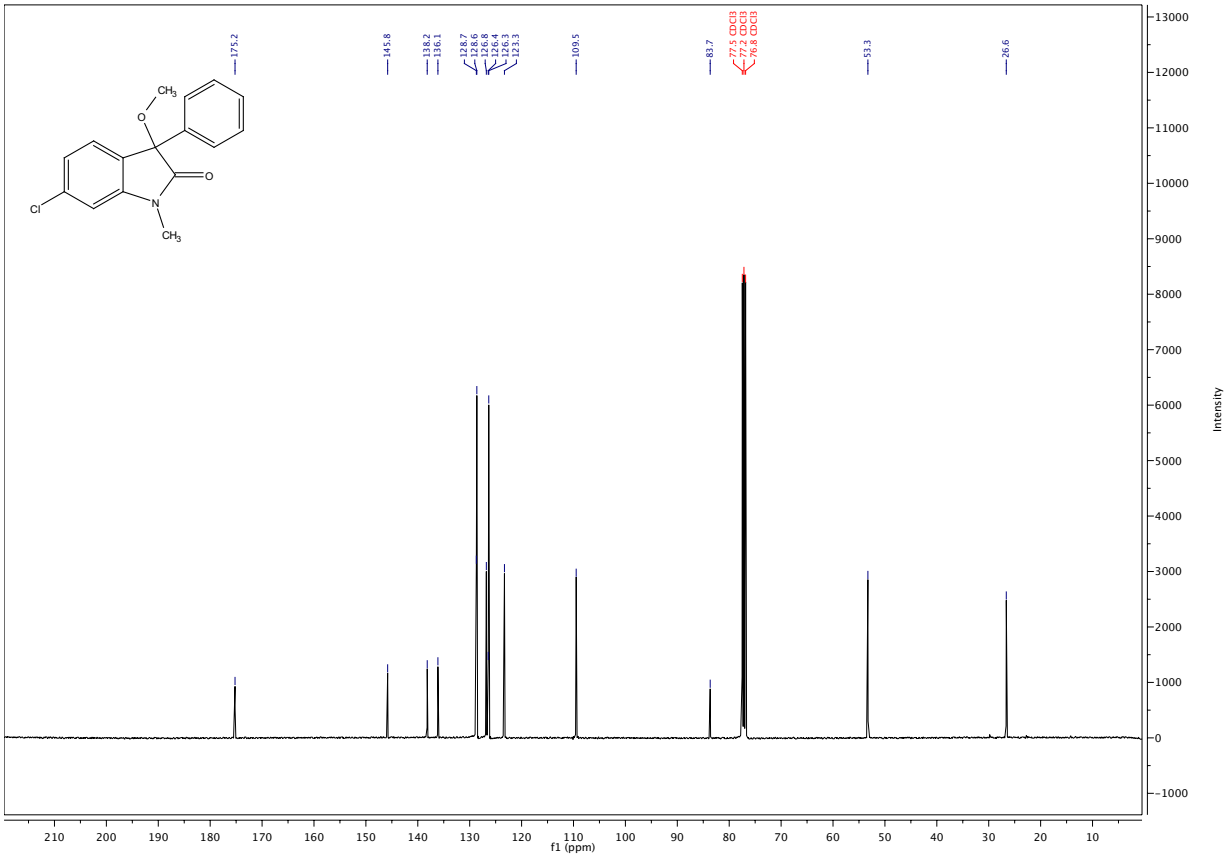
^{13}C NMR spectra (100.62 MHz) of compound **2v** in $CDCl_3$



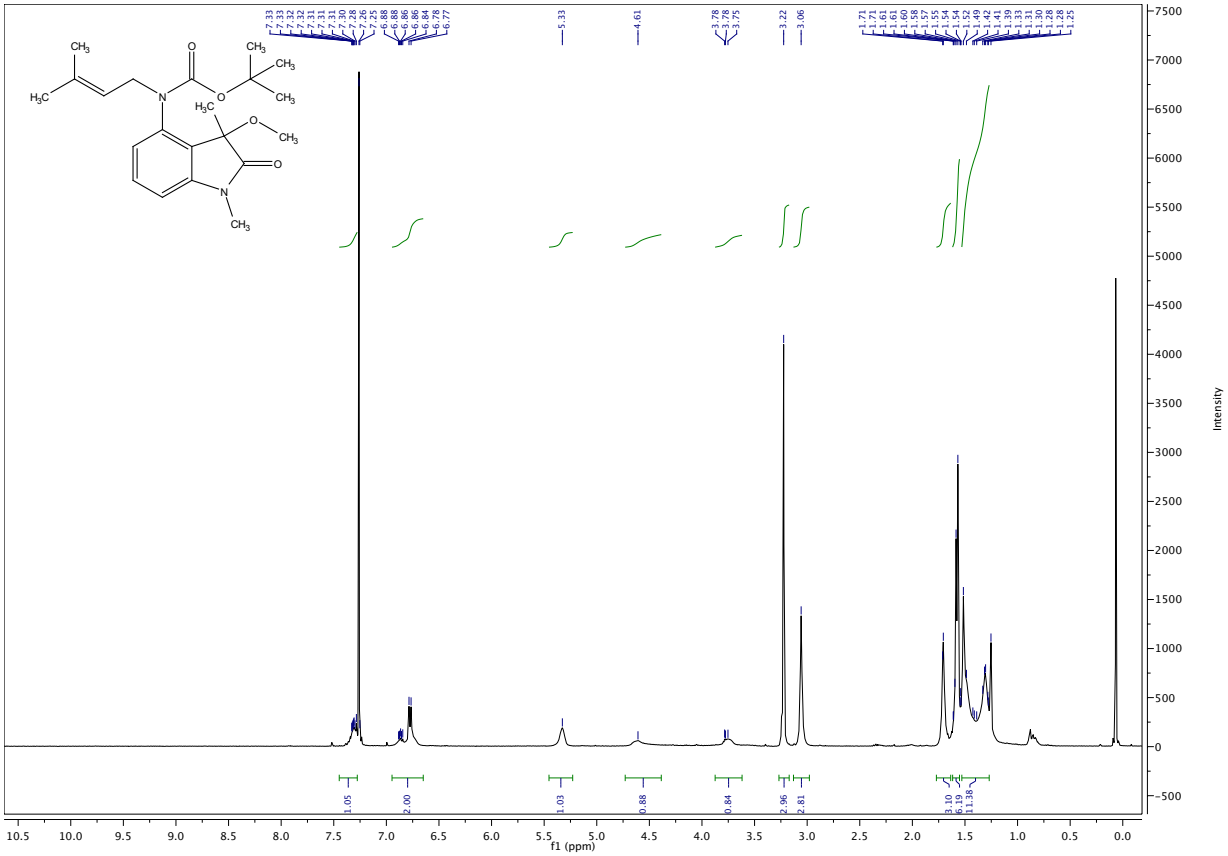
^{1}H NMR spectra (400.13 MHz) of compound **2w** in $CDCl_3$



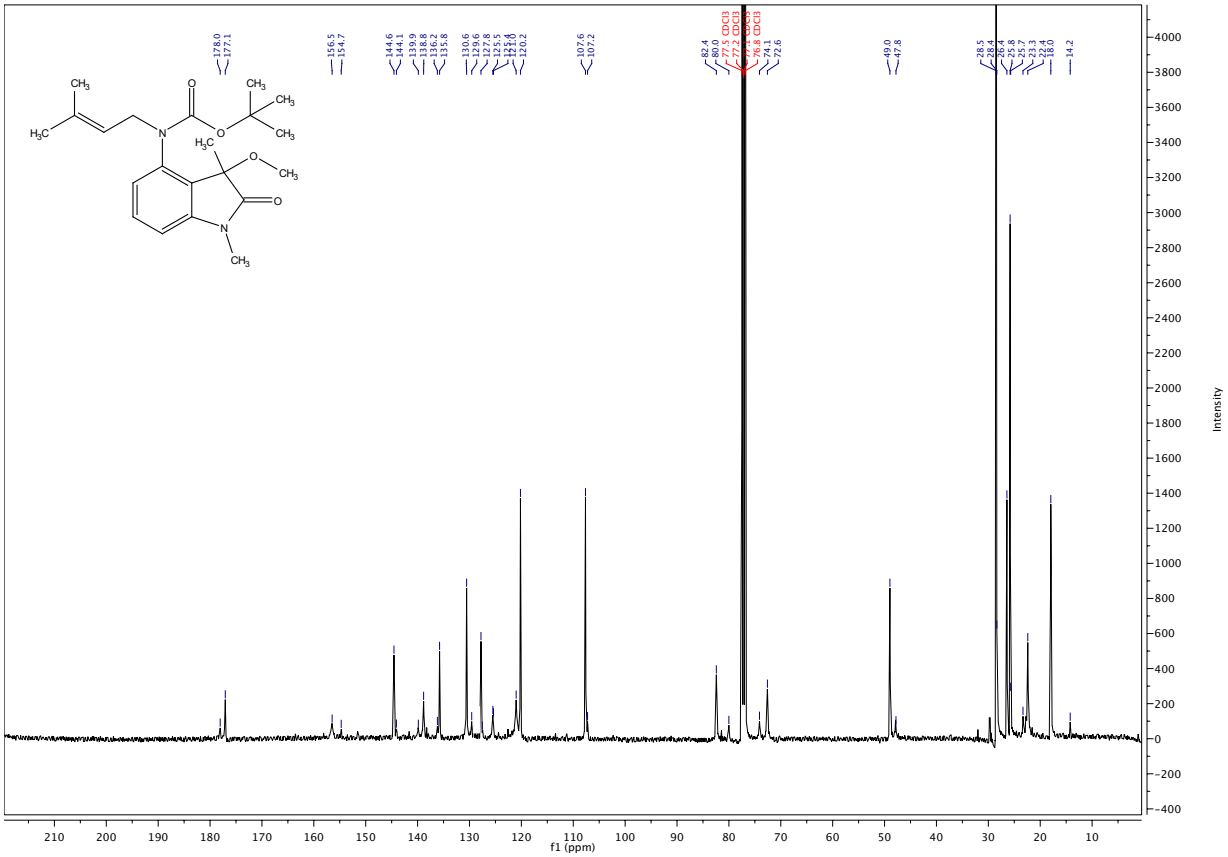
^{13}C NMR spectra (100.62 MHz) of compound **2w** in $CDCl_3$



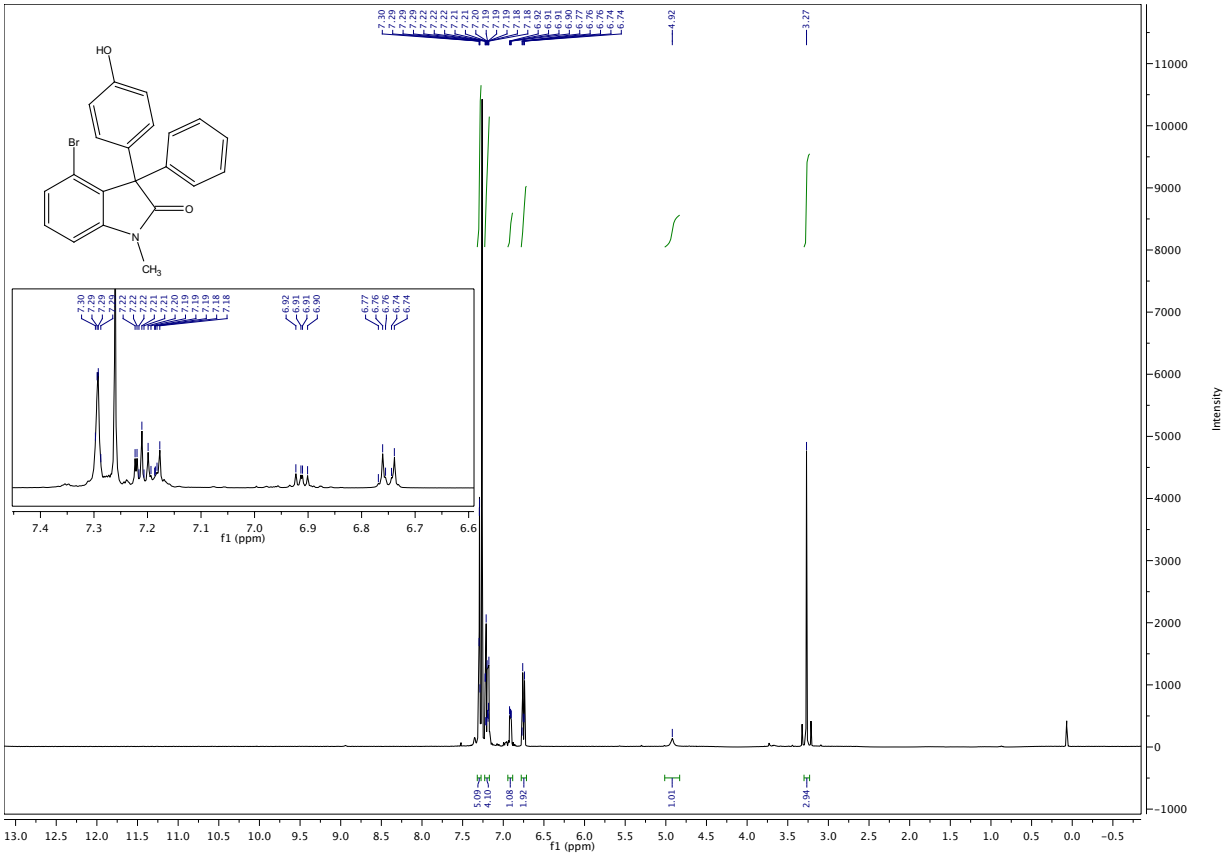
^{1}H NMR spectra (400.13 MHz) of compound **2x** in $CDCl_3$



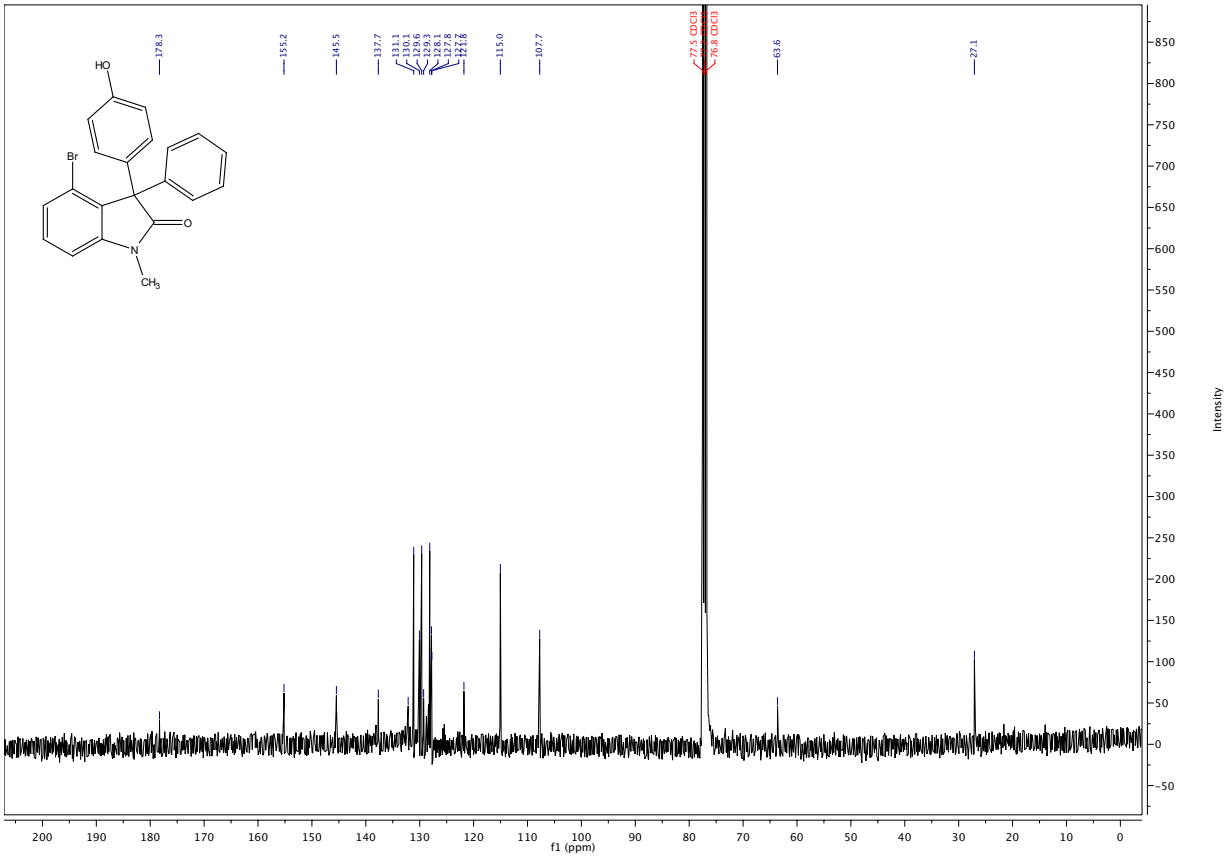
^{13}C NMR spectra (100.62 MHz) of compound **2x** in $CDCl_3$



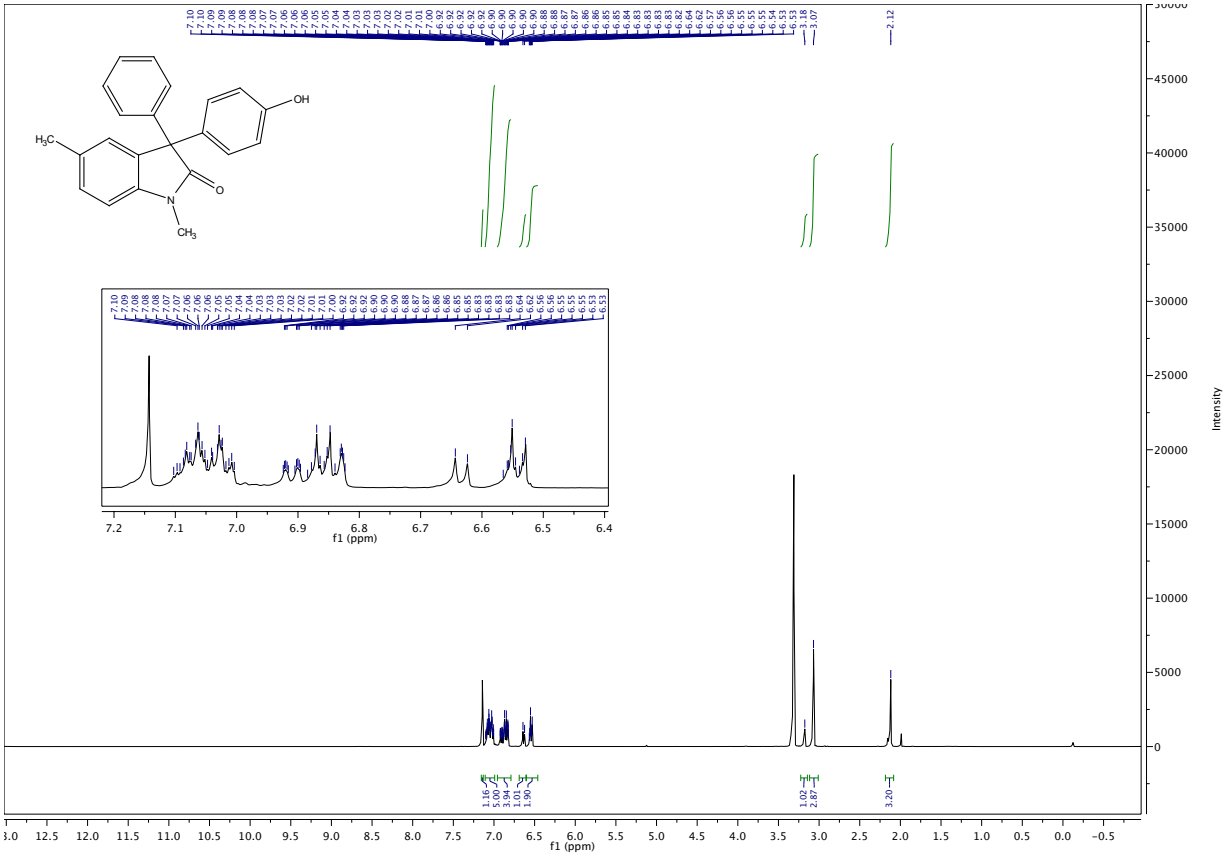
^{1}H NMR spectra (400.13 MHz) of compound **2y** in $CDCl_3$



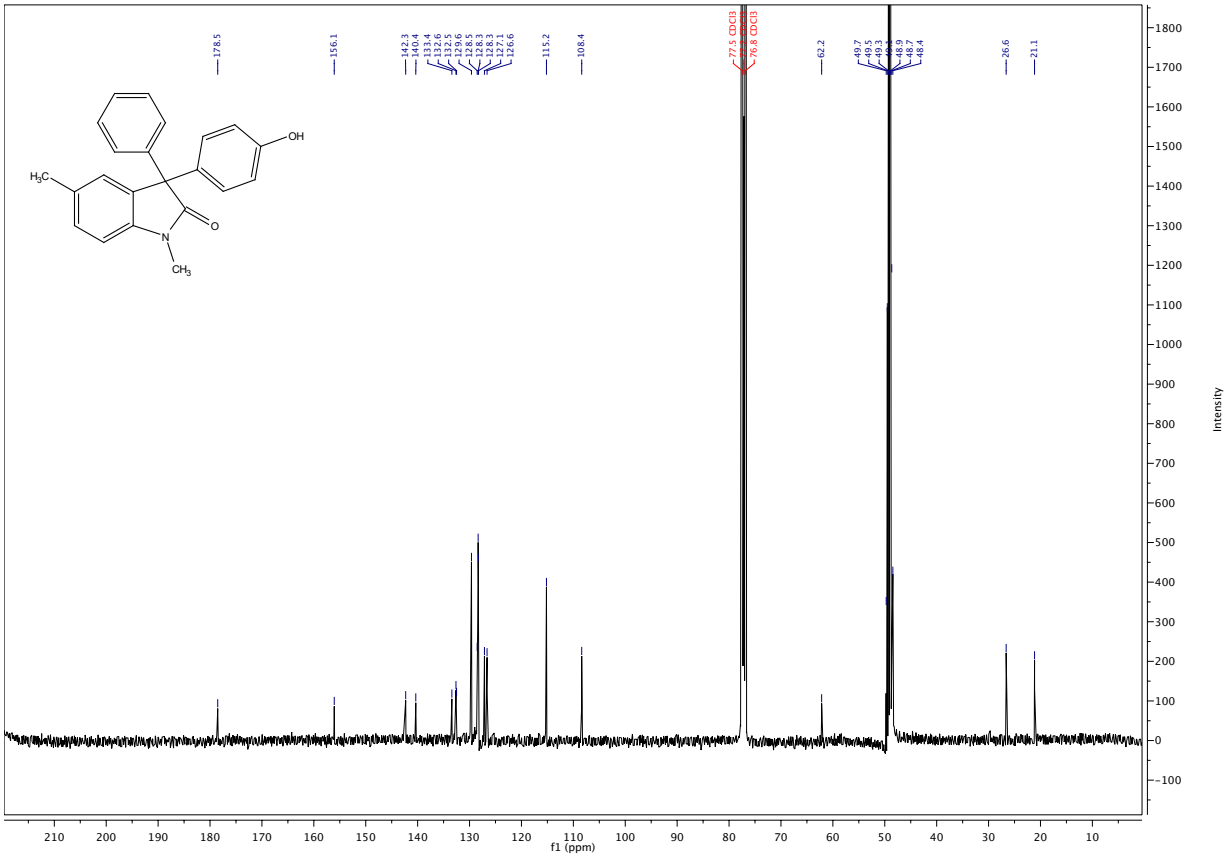
^{13}C NMR spectra (100.62 MHz) of compound **2y** in $CDCl_3$



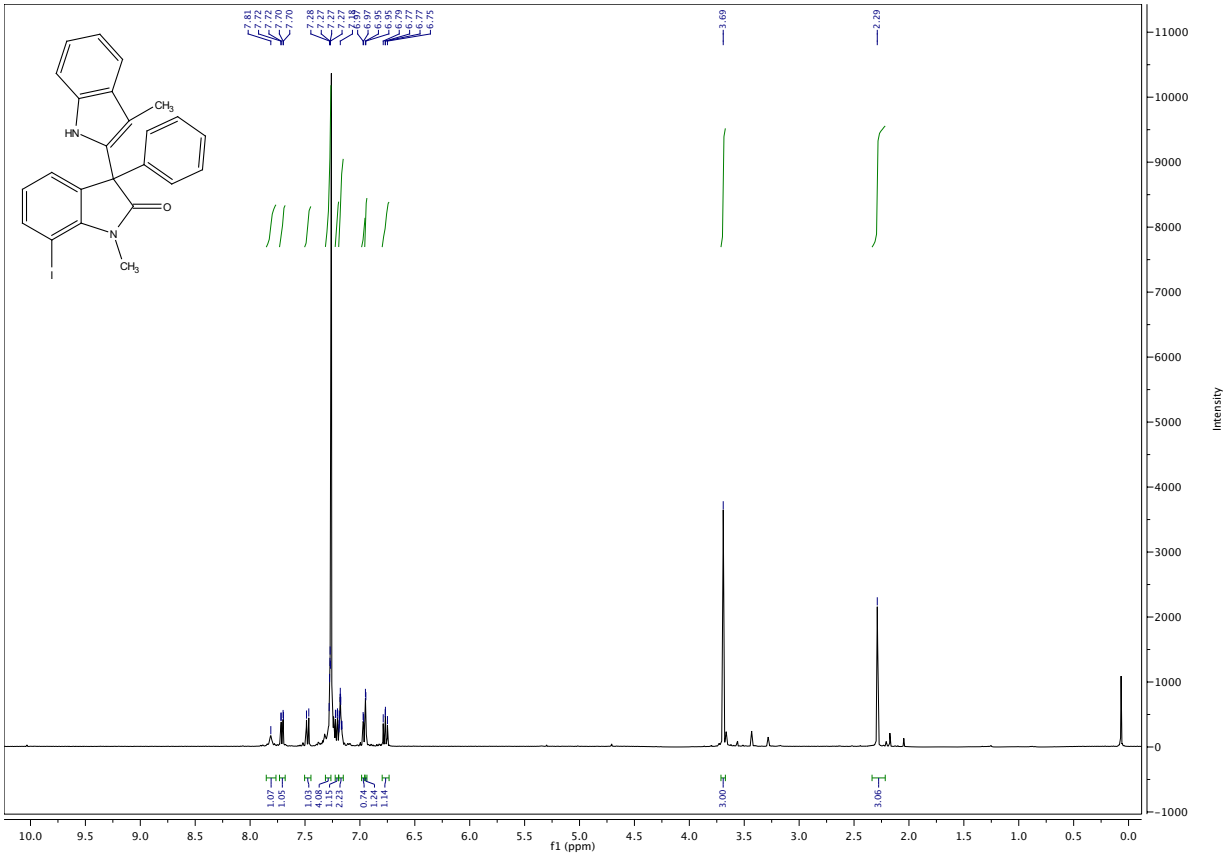
^{1}H NMR spectra (400.13 MHz) of compound **2z** in $CDCl_3/CD_3OD$



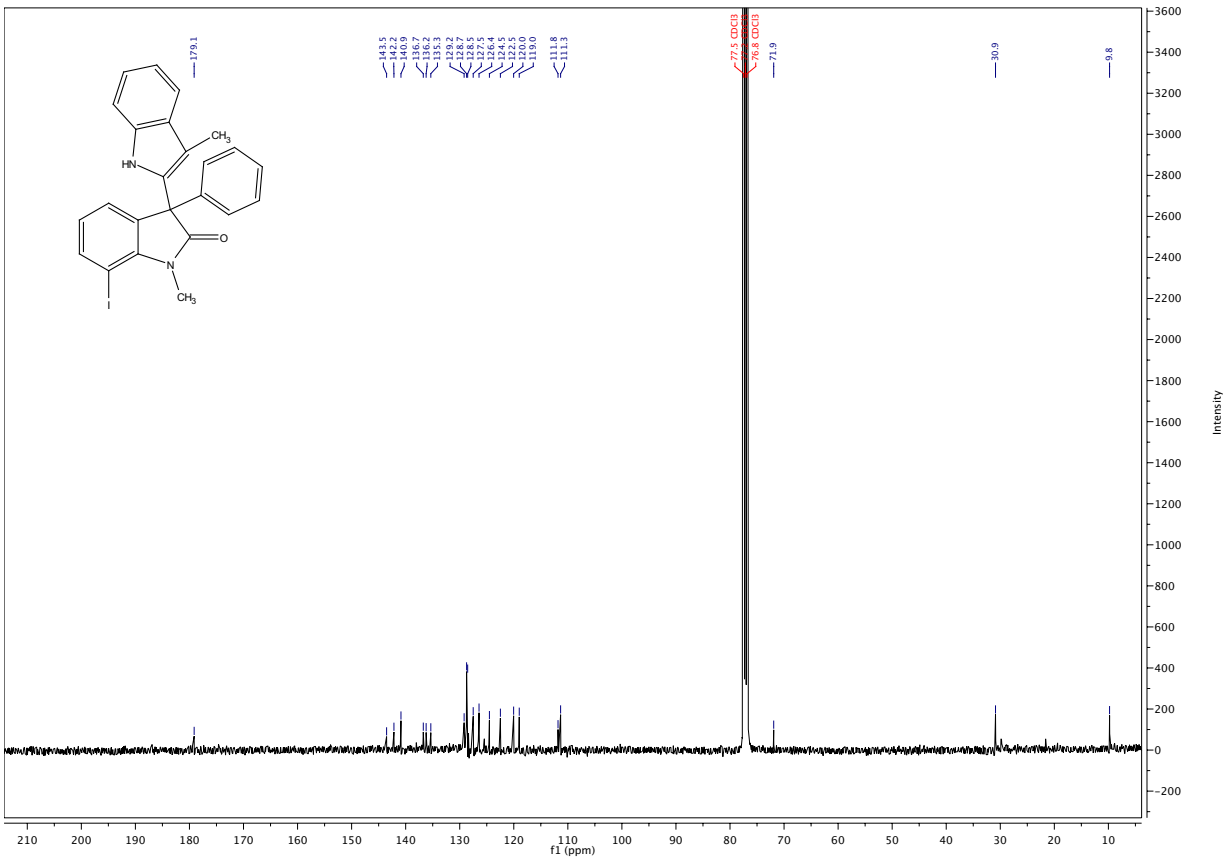
^{13}C NMR spectra (100.62 MHz) of compound **2z** in $CDCl_3/CD_3OD$



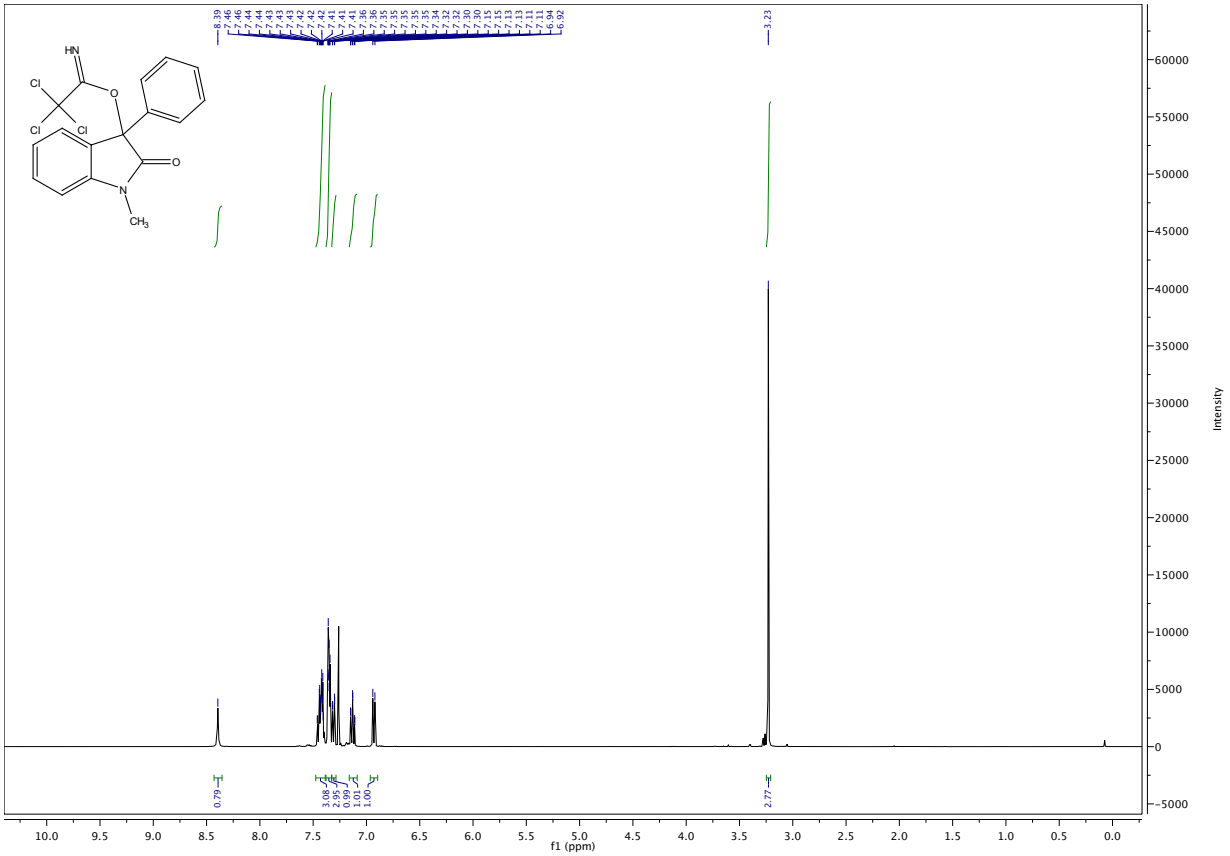
^{1}H NMR spectra (400.13 MHz) of compound **2A** in $CDCl_3$



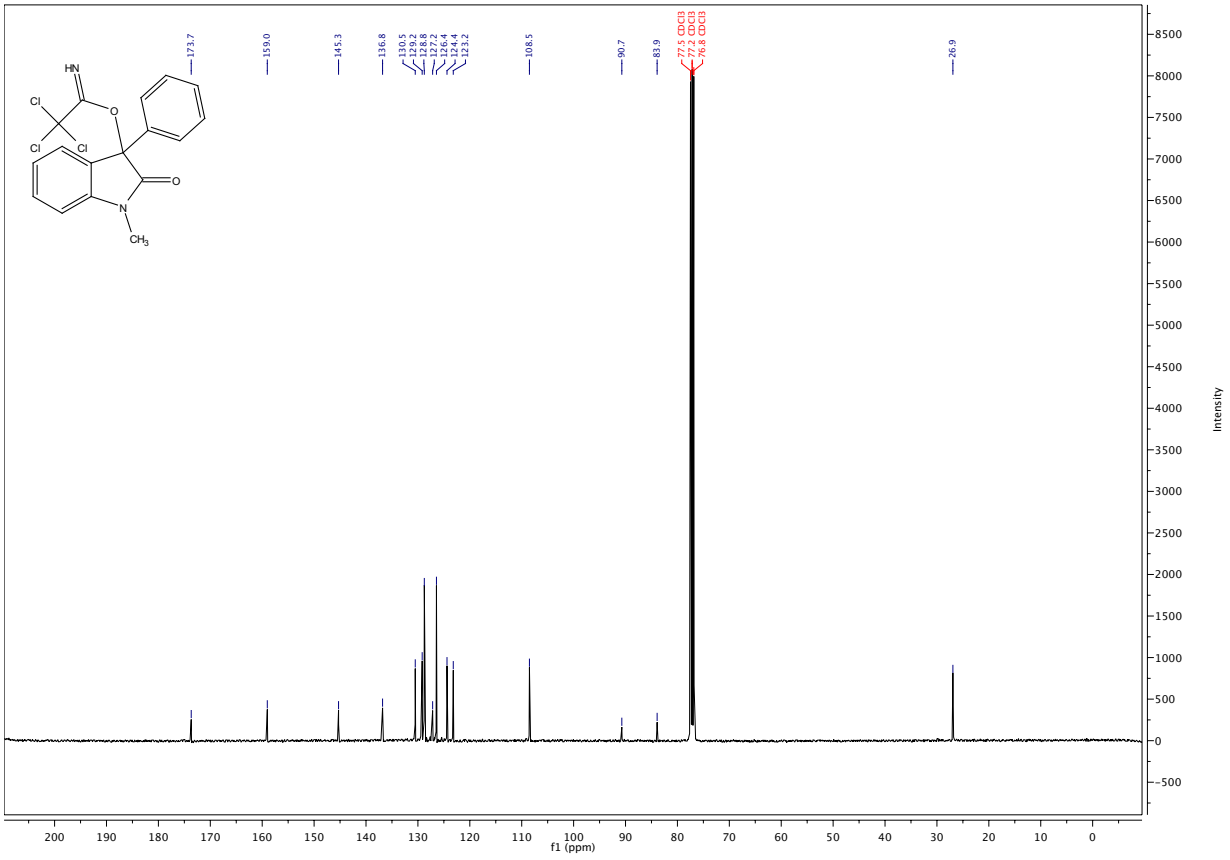
^{13}C NMR spectra (100.62 MHz) of compound **2A** in $CDCl_3$



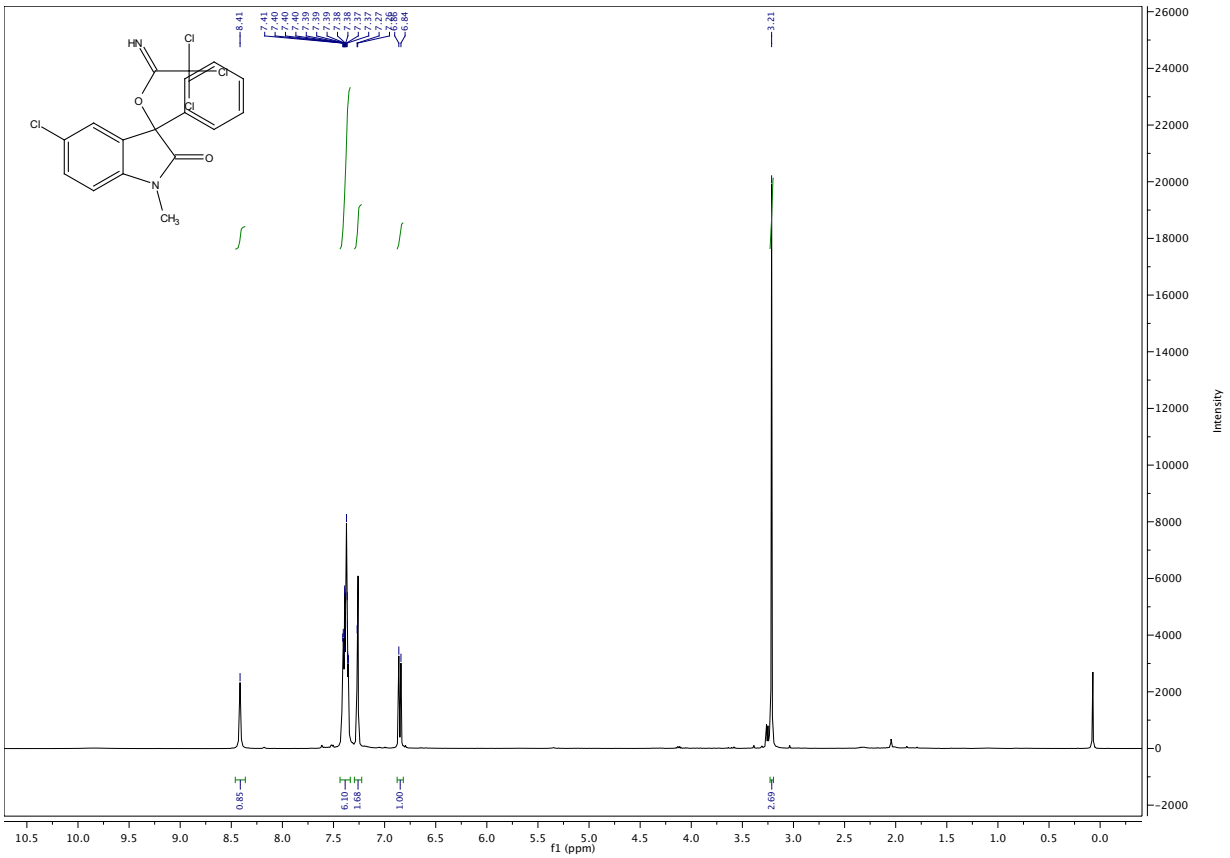
^{1}H NMR spectra (400.13 MHz) of compound **3a** in $CDCl_3$



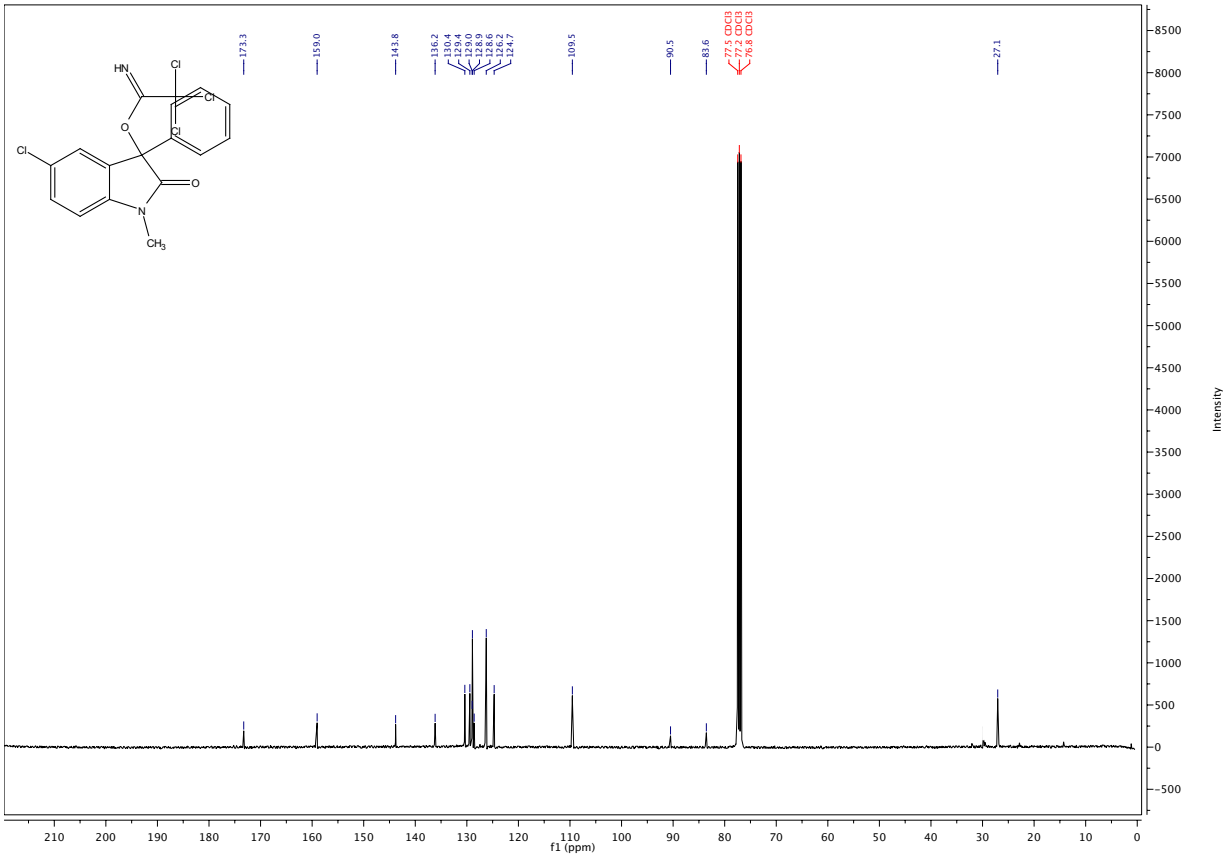
^{13}C NMR spectra (100.62 MHz) of compound **3a** in $CDCl_3$



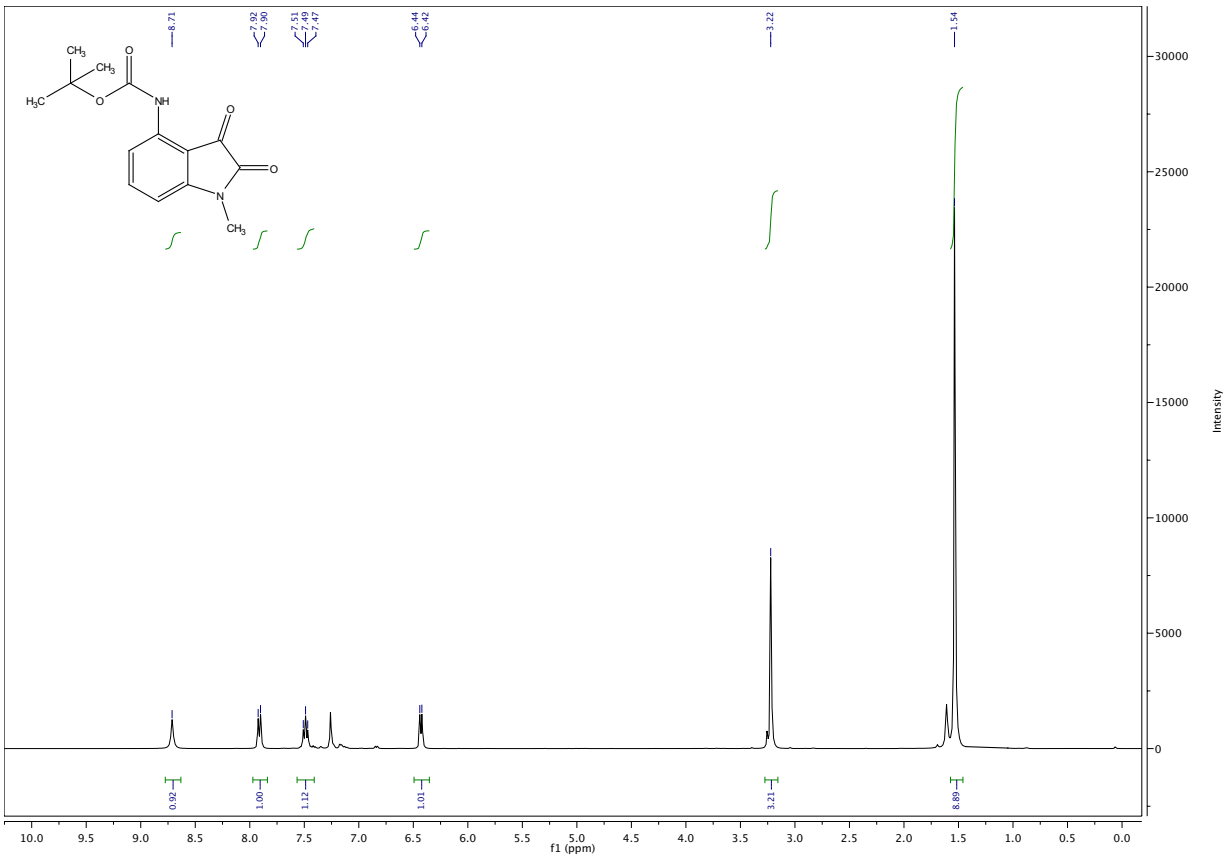
^{1}H NMR spectra (400.13 MHz) of compound **3b** in $CDCl_3$



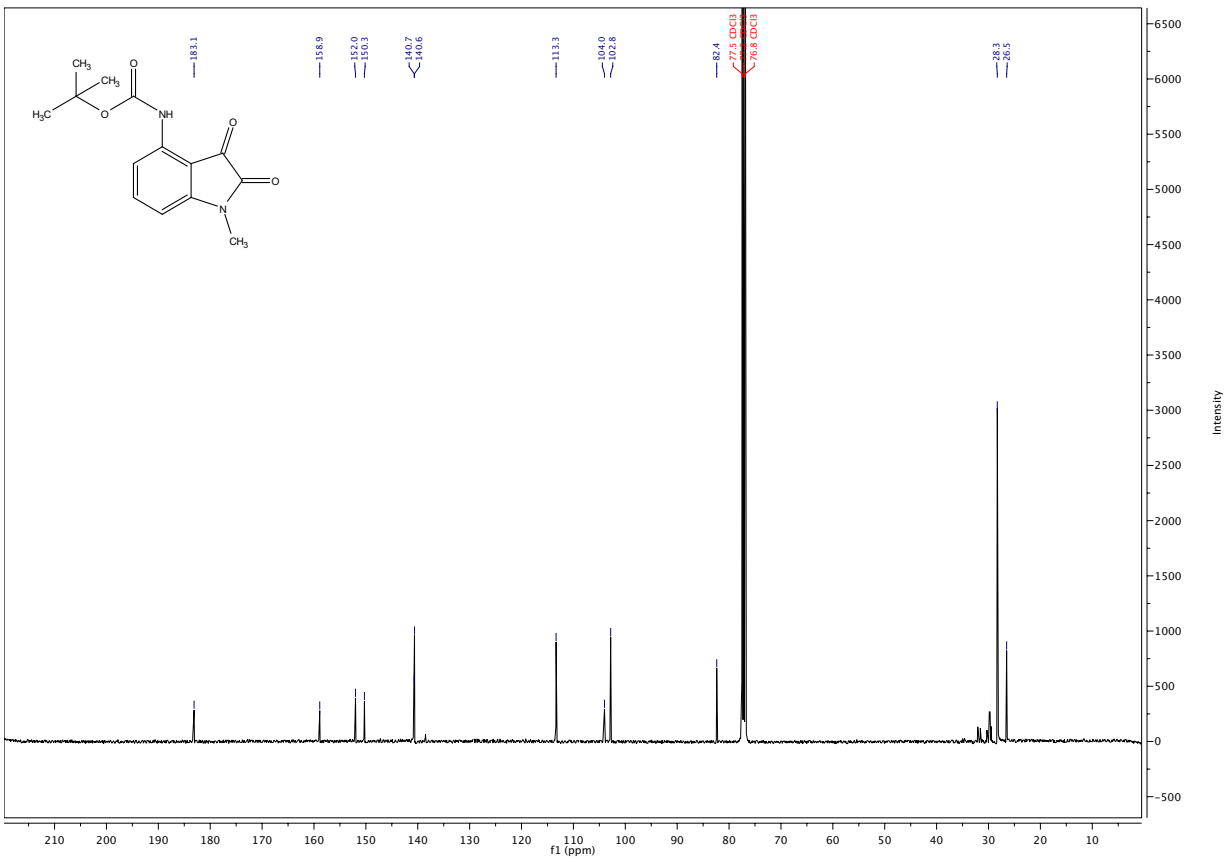
^{13}C NMR spectra (100.62 MHz) of compound **3b** in $CDCl_3$



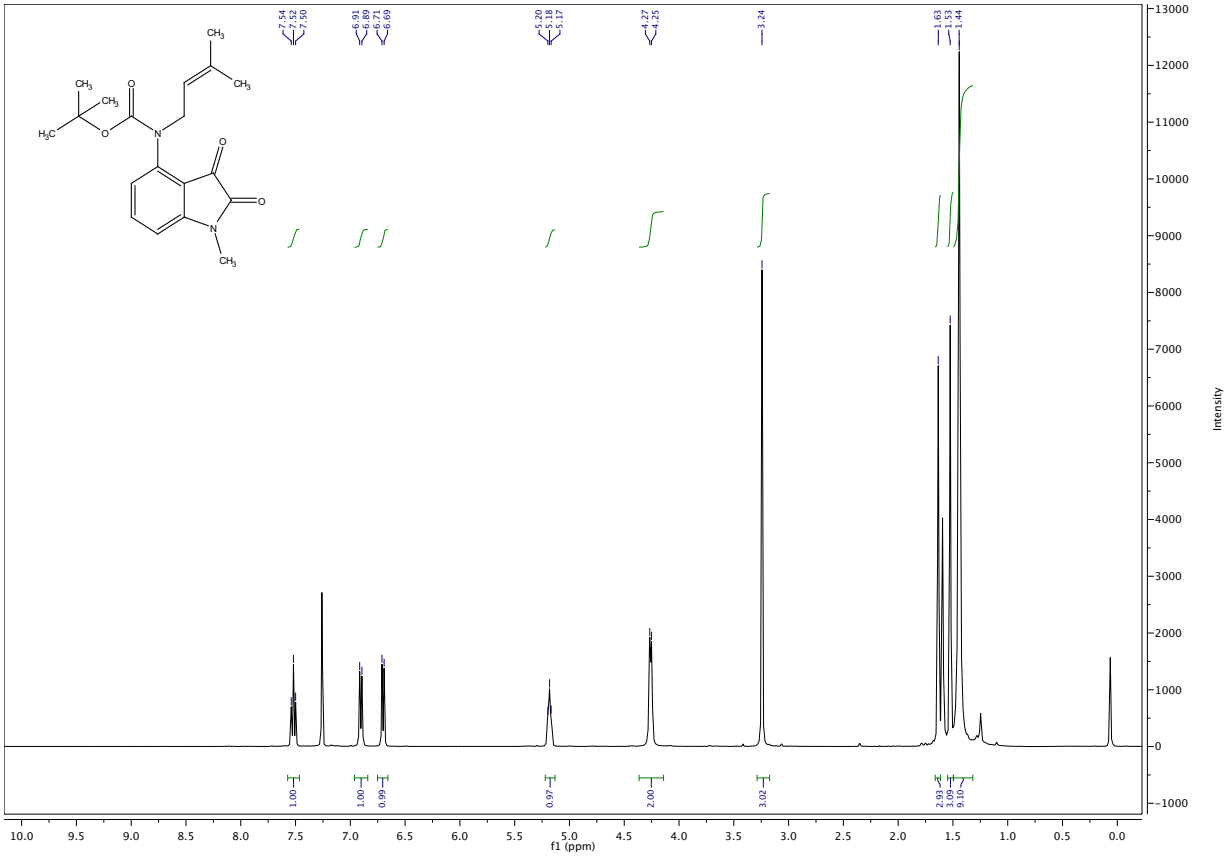
^{1}H NMR spectra (400.13 MHz) of compound **4** in $CDCl_3$



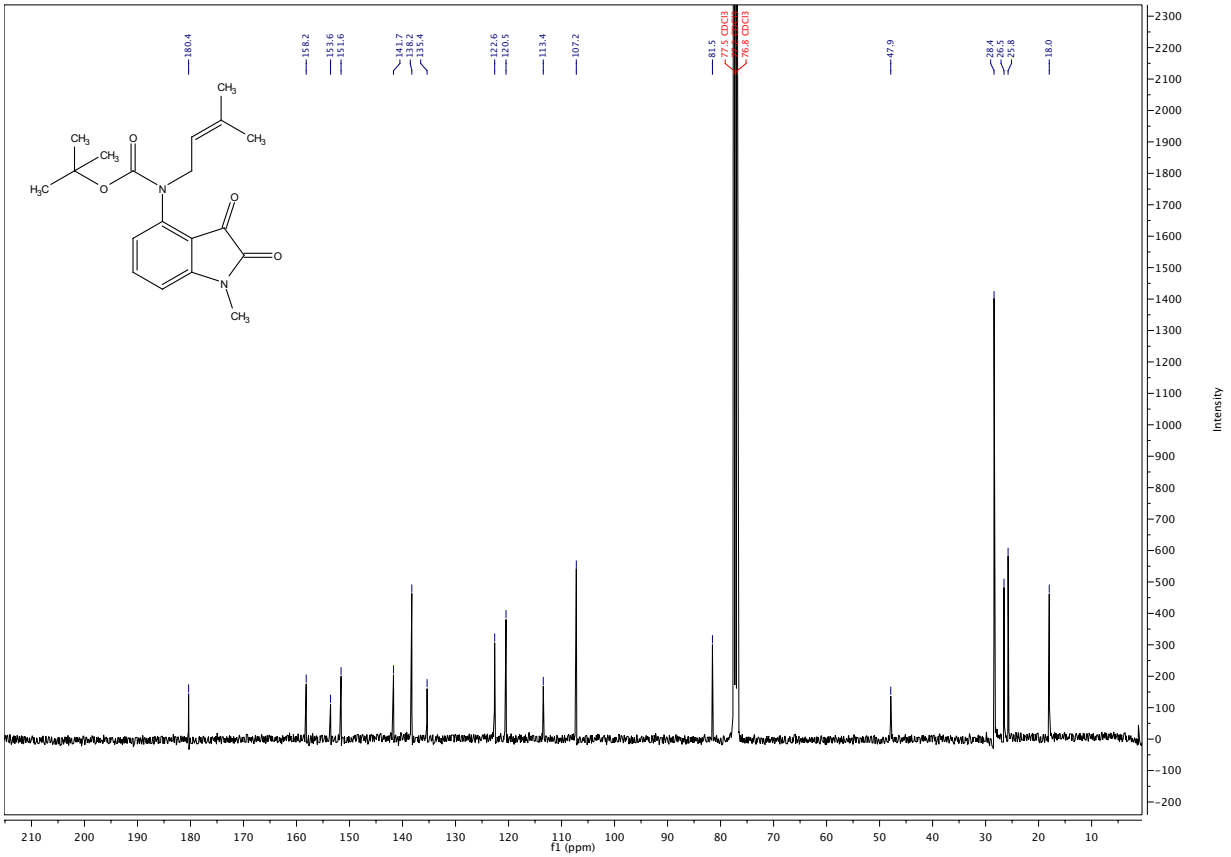
^{13}C NMR spectra (100.62 MHz) of compound **4** in $CDCl_3$



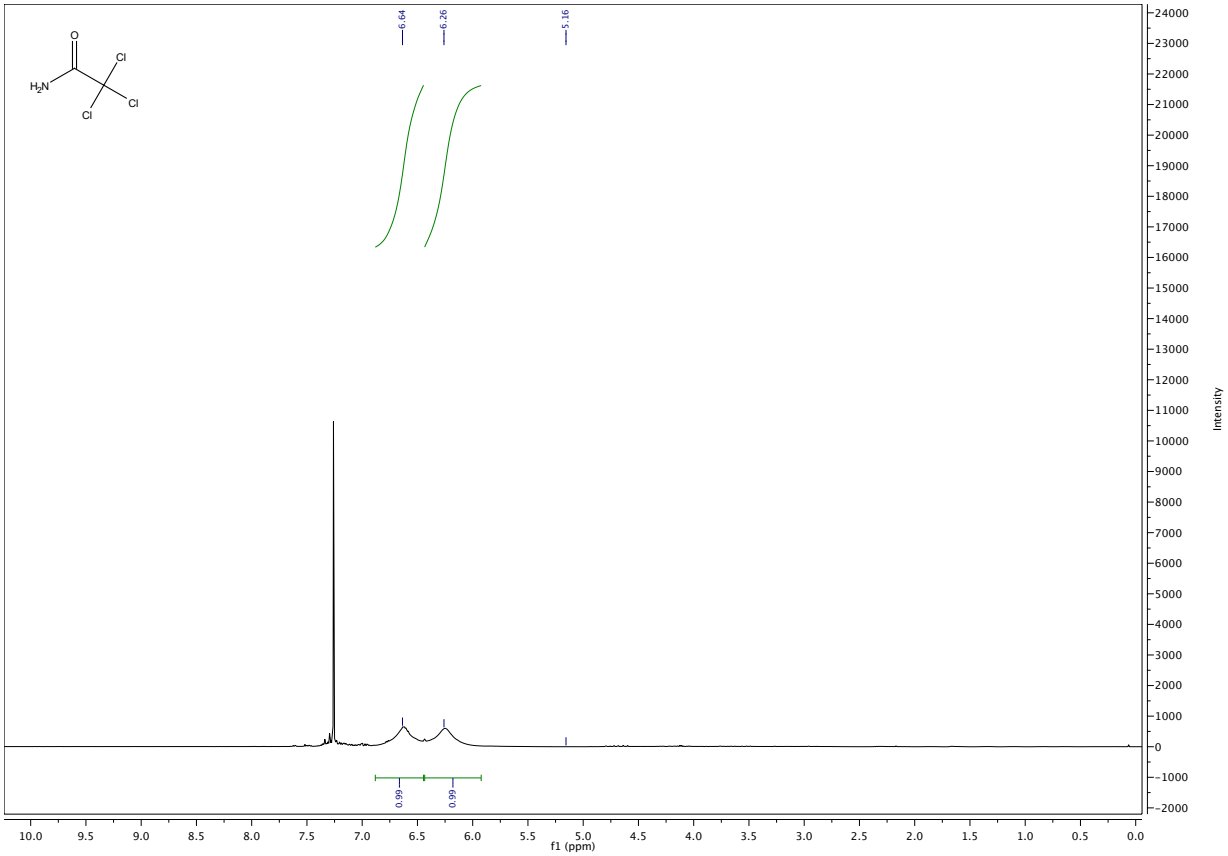
^{1}H NMR spectra (400.13 MHz) of compound **5** in $CDCl_3$



^{13}C NMR spectra (100.62 MHz) of compound **5** in $CDCl_3$



^{1}H NMR spectra (400.13 MHz) of compound **6** in $CDCl_3$



^{13}C NMR spectra (100.62 MHz) of compound **6** in $CDCl_3$