Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information For

Preparation of Pyridyltriazole Ruthenium Complexes as Effective Catalysts for the Selective Alkylation and One-Pot C-H Hydroxylation of 2-Oxindole with Alcohols under Solvent-Free Fashion and Mechanism Exploration

Qiang Wu,[a] Le Pan,[b] Guangming Du,[b] Chi Zhang,*[c] and Dawei Wang*[a,b]

[a] *The Key Laboratory of Food Colloids and Biotechnology, Ministry of Education, School of Chemical and Material Engineering, Jiangnan University, Wuxi 214122, China.*

[b] *Chemical Engineering College, Xinjiang Agricultural University, Urumqi 830052, China*

[c] *School of Chemical Science and Engineering, Tongji University, Shanghai 200092, P. R. China*
E-mail: wangdw@jiangnan.edu.cn, chizhang@tongji.edu.cn

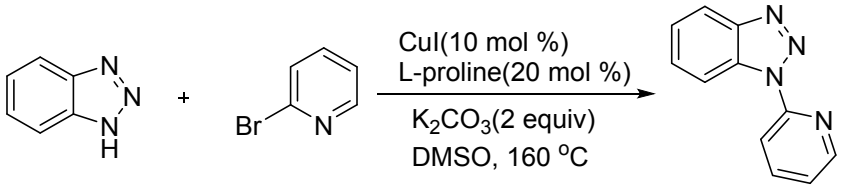
Table of contents

1. General Methods and Materials

All of the reactions dealing with air were carried out in a high purity argon or nitrogen atmosphere using standard Schlenk techniques or glovebox techniques. All the obtained products were characterized by ^{1}H-NMR, ^{13}C-NMR and melting points (m.p), melting points were measured on an Electrothemal WRS X-4A microscopy digital apparatus and without correction. ^{1}H NMR and ^{13}C NMR spectra were obtained on Bruker Advance III HD 400 MHz spectrometer and referenced to $CDCl_3$ (7.26 ppm for ^{1}H, and 77.1 ppm for ^{13}C) or DMSO-d_6 (2.50 ppm for ^{1}H, and 39.5 ppm for ^{13}C) with tetramethylsilane as internal standard (0 ppm). Chemical shifts were reported in parts per million (ppm δ) downfield from TMS and coupling constants are reported in Hertz. The following abbreviations were used to explain NMR peak multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, m = multiplet, br = broad. High resolution mass spectra (HRMS) were recorded on LTQ-FTUHRA mass spectrometer. TLC was performed using commercially prepared 100-400 mesh silica gel plates (GF254), and visualization was effected at shortwave UV light (254 nm) and $KMnO_4$. Flash column chromatography was performed on 230-430 mesh silica gel. Unless otherwise stated, all the reagents were purchased from commercial sources (J&K Chemic, Acros, TCI, SCRC, Energy Chemical), used without further purification.

2. Preparation of Pyridyltriazole Ruthenium Complexes

2.1 Procedure for synthesis of 1-(pyridin-2-yl)-1H-benzo[d][1,2,3]triazole[1]



To an oven-dried 250-mL Schlenk tube were successively added *1H*-benzotriazole (1.430 g, 12 mmol), 2-bromopyridine (1.580 g, 10 mmol), copper (I) iodide (0.190 g, 1 mmol), potassium carbonate (2.764 g, 20 mmol), L-proline (0.230 g, 2 mmol), and dimethylsulfoxide (40 mL) under N_2 atmosphere. Then, the resulting mixture was stirred at 160 °C for 18 h and monitored by TLC until complete disappearance of 2-bromopyridine. After cooling down to ambient temperature, the reaction mixture was added water and extracted with ethyl acetate three times. The combined organic phases were dried over anhydrous $MgSO_4$ and concentrated by removing the solvent under vacuum. Finally, the residue was purified by flash column chromatography with ethyl acetate/ petroleum ether to give the desired product (1.334 g, 68% yield).

2.2 Preparation of pyridyltriazole ruthenium complexes

Procedure for the synthesis of [{Ru(*p*-cymene)}(Pyridyltriazole)Cl][Cl]

In an oven-dried 50-mL Schlenk tube equipped with a stir bar were successively added $[RuCl_2(p\text{-cymene})]_2$ (1.224 g, 2 mmol), triazole ligand (0.804 g, 4.1 mmol) and methanol (20 mL). The tube was evacuated and refilled with high purity nitrogen, and the mixture was vigorously stirred for 24 h at room temperature. All the volatiles were evaporated under reduced pressure, and the resultant residue was purified by column chromatography on silica gel with methanol/dichloromethane to give the PTA-Ru product **1a**.

Yellow solid, 89% yield; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.72 (d, J = 4.9 Hz, 1H), 8.85 (d, J = 8.4 Hz, 1H), 8.76 (d, J = 8.7 Hz, 1H), 8.47 (dd, J = 17.9, 8.0 Hz, 2H), 7.97 (t, J = 7.6 Hz, 1H), 7.82 (dd, J = 14.6, 7.6 Hz, 2H), 6.44 (d, J = 6.2 Hz, 1H), 6.40 (d, J = 6.4 Hz, 1H), 6.25 (d, J = 6.3 Hz, 1H), 6.11 (d, J = 6.2 Hz, 1H), 2.81 (dq, J = 13.8, 6.9 Hz, 1H), 2.17 (s, 3H), 1.15 (dd, J = 6.9, 2.8 Hz, 6H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 156.06, 147.14, 146.96, 143.39, 132.40, 131.07, 128.16, 125.65, 120.50, 114.17, 112.76, 106.66, 103.86, 88.72, 87.19, 85.71, 85.65, 30.92, 22.59, 21.81, 18.43. Anal. Calcd for $C_{21}H_{22}Cl_2N_4Ru$: C, 50.20; H, 4.41; N, 11.15. Found: C, 50.08; H, 4.36; N, 11.08.

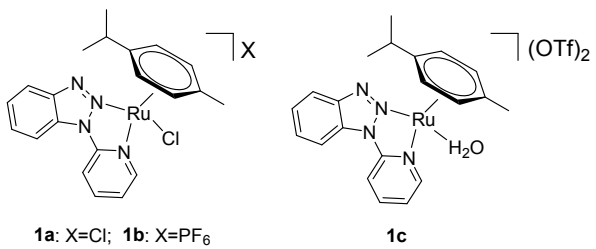
Procedure for the synthesis of [{Ru(*p*-cymene)}(pyridyltriazole)Cl][PF_6]

Under N_2 atmosphere, [{Ru(*p*-cymene)}(pyridyltriazole)Cl][Cl] (0.934 g, 2 mmol) and methanol (20 mL) was added to an oven-dried 100-mL Schlenk tube equipped with a stir bar. Then, the tube was closed and the resulting mixture was stirred at room temperature for 1 h. After water (20 mL) were introduced into the solution, NH_4PF_6 (0.815 g, 5 mmol, 2.5 equiv) was added in portions with vigorously stirring for 2 h. The precipitate was isolated by vacuum filtration and washed with diethyl ether three times. The remaining residue was purified through recrystallization to give the PTA-Ru product **1b**.

Yellow solid, 84% yield; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.58 (d, J = 5.4 Hz, 1H), 8.74 (s, 1H), 8.67 (d, J = 8.6 Hz, 1H), 8.47 (dd, J = 12.7, 8.2 Hz, 2H), 7.99 (t, J = 7.8 Hz, 1H), 7.90 – 7.71 (m, 2H), 6.38 (t, J = 6.9 Hz, 2H), 6.19 (d, J = 6.2 Hz, 1H), 6.06 (d, J = 6.1 Hz, 1H), 2.83 (dt, J = 13.6, 6.8 Hz, 1H), 2.16 (s, 3H), 1.16 (dd, J = 6.7, 2.0 Hz, 6H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 155.71, 147.25, 146.99, 143.30, 132.39, 131.11, 128.16, 125.59, 120.54, 114.03, 112.62, 106.75, 103.84, 88.71, 87.15, 85.68, 85.65, 30.93, 22.54, 21.79, 18.40. Anal. Calcd for $C_{21}H_{22}ClF_6N_4PRu$: C, 41.22; H, 3.62; N, 9.16. Found: C, 41.09; H, 3.54; N, 9.07. CCDC number: 1846966.

For further analysis of thermogravimetric curves of pyridyltriazole ruthenium complexes, as follows:

"For compound **1a**, the weight loss at 242 °C should be caused by the loss of chlorine element, while the weight loss at 261 °C might be attributed to the loss in ligand. In comparison, after the loss of one chlorine element in the beginning, the great weight loss at 218 °C might be attributed to the quick loss of non-coordinating anions (PF_6^-) and then the loss of ligand at 223 °C happened."



1a: X=Cl; **1b**: X=PF_6 **1c**

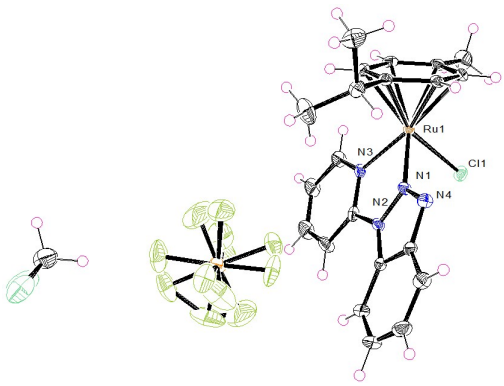


Figure S1. ORTEP structure of [{Ru(p-cymene)}(Pyridyltriazole)Cl][PF_6] (thermal ellipsoids set at 50% probability，DCM as co-crystallized solvent molecules).

Table S1. Crystallographic data for [{Ru(p-cymene)}(Pyridyltriazole)Cl][PF_6]

Empirical formula	C_{22} H_{24} Cl_3 F_6 N_4 P Ru
Formula weight	696.84
Temperature	100 K
Wavelength	0.71075 Å
Crystal system, space group	Monoclinic, P 1 21/n1
Unit cell dimensions	a=8.1716(4) Å, alpha=90°
	b=30.1115(13) Å, beta=95.159(2)°
	c=10.9853(5) Å, gamma=90°
Volume	2692.1(2) $Å^3$
Z, Calculated density	4, 1.719 mg/m^3
Absorption coefficient	1.001 mm^{-1}
F(000)	1392
Theta range for data collection	2.982 to 26.413°
Limiting indices	-10<=h<=10, -37<=k<=37, -13<=l<=13
Reflections collected / unique	30775/5494 [R(int) = 0.0283]
Completeness to theta = 25.242°	99.4%
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7454 and 0.6661
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	5494/198/392
Goodness-of-fit on F^2	1.266
Final R indices [I>2sigma(I)]	R1=0.0457, wR2=0.0973
R indices (all data)	R1 = 0.0490, wR2 = 0.0986
Largest diff. peak and hole	1.247 and -1.152 e. $Å^{-3}$
CCDC number	1846966

Procedure for the synthesis of[{Ru(*p*-cymene)}(pyridyltriazole)H_2O][$OTf]_2$

Under N_2 atmosphere, [{Ru(*p*-cymene)}(pyridyltriazole)Cl][Cl] (0.467 g, 1 mmol) and water (10 mL) was added to an oven-dried 100-mL Schlenk tube equipped with a stir bar. Then, the tube was closed and the resulting mixture was stirred at room temperature for 1 h. AgOTf (0.642 g, 2.5 mmol, 2.5 equiv) was added in portions with vigorously stirring for 2 h. After completion, the suspensions were filtered through a syringe filter (0.2 μm, nylon)

into a clean round-bottom flask. The solvent was removed under vacuum and the resulting solid was dried overnight in vacuo to give the PTA-Ru product **1c**.

Yellow oil, 75 % yield; ^{1}H NMR (400 MHz, D_2O) δ 9.52 (d, *J* = 5.6 Hz, 1H), 8.51 – 8.36 (m, 2H), 8.27 (dd, *J* = 20.2, 8.6 Hz, 2H), 7.90 (t, *J* = 7.9 Hz, 1H), 7.83 – 7.66 (m, 2H), 6.36 (dd, *J* = 15.4, 6.3 Hz, 2H), 6.11 (t, *J* = 6.1 Hz, 2H), 2.64 (dt, *J* = 13.8, 6.9 Hz, 1H), 2.13 (s, 3H), 1.01 (dd, *J* = 11.3, 6.9 Hz, 6H). ^{13}C NMR (101 MHz, D_2O) δ 154.99, 147.76, 147.56, 144.35, 133.36, 131.41, 128.30, 126.13, 120.61, 114.16, 111.66, 104.97, 104.82, 87.85, 86.88, 84.27, 84.18, 30.59, 21.34, 21.00, 17.76. Anal. Calcd for $C_{23}H_{22}F_6N_4O_6RuS_2$: C, 37.86; H, 3.04; N, 7.68. Found: C, 37.71; H, 3.13; N, 7.60.

3. General procedure for the alkylation of 2-oxindole with alcohols

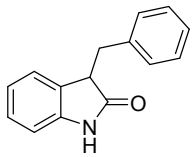
Under N_2 atmosphere, 2-oxindole (0.5 mmol), alcohols (1.0 mmol), pyridyltriazole ruthenium(II) catalyst **1b** (1 mol%), KOH (2.0 equiv.), were introduced in a Schlenk tube (25 mL), successively. The tube was evacuated and refilled with high purity nitrogen for three times. Then, the Schlenk tube was closed and the resulting mixture was stirred at 130 °C for 1 h under solvent-free conditions. After cooling down to room temperature, water was added to quench the reaction and extracted with EtOAc (3x5 mL), the organic phases were concentrated by removing the solvent under vacuum. Finally, the residue was purified by column chromatography with petroleum ether/ethyl acetate (petroleum ether /ethyl acetate = 10:1) as eluent to give the desired product.

4. General procedure for the C-H hydroxylation process

Under N_2 atmosphere, 2-oxindole (0.5 mmol), alcohols (1.0 mmol), pyridyltriazole ruthenium(II) catalyst **1b** (1 mol%), KOH (2.0 equiv.) were introduced in a Schlenk tube (50 mL), successively. The tube was evacuated and refilled with high purity nitrogen for three times. Then, the Schlenk tube was closed and the resulting mixture was stirred at 130 °C for 1 h. After cooling down to room temperature, EtOAc (5 mL) was introduced, the reaction mixture was stirred under air for 12 h. Finally, concentrated by removing the solvent under vacuum, and the residue was purified by column chromatography with petroleum ether/ethyl acetate (petroleum ether /ethyl acetate = 3:1) as eluent to give the desired product.

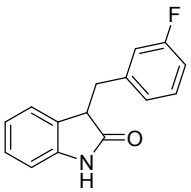
5. Analytical data of the obtained compounds

(1) 3-benzyl-1,3-dihydroindol-2-one (4aa).[2]



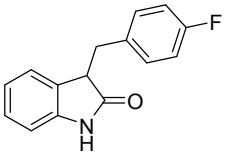
Pale yellow needles; Mp. 128-130 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.18 (s, 1H), 7.28 – 7.13 (m, 6H), 6.88 (dd, *J* = 14.1, 7.4 Hz, 2H), 6.73 (d, *J* = 7.4 Hz, 1H), 3.75 (dd, *J* = 9.3, 4.5 Hz, 1H), 3.50 (dd, *J* = 13.7, 4.5 Hz, 1H), 2.93 (dd, *J* = 13.7, 9.3 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 180.05, 141.56, 137.81, 129.41, 128.99, 128.33, 127.95, 126.66, 124.79, 121.98, 109.84, 47.60, 36.61.

(2) 3-(3-fluoro-benzyl)-1,3-dihydroindol-2-one (4ab)



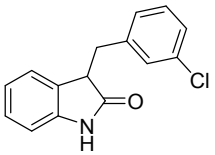
Pale yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.36 (s, 1H), 7.23 – 7.14 (m, 2H), 6.99 – 6.84 (m, 5H), 6.78 (d, *J* = 7.4 Hz, 1H), 3.74 (dd, *J* = 8.9, 4.6 Hz, 1H), 3.46 (dd, *J* = 13.8, 4.6 Hz, 1H), 2.96 (dd, *J* = 13.8, 9.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.91, 162.71 (d, *J* = 245.8 Hz), 141.64, 140.36 (d, *J* = 7.3 Hz), 129.81 (d, *J* = 8.3 Hz), 128.66, 128.20, 125.15 (d, *J* = 2.8 Hz), 124.66, 122.20, 116.30 (d, *J* = 21.2 Hz), 113.68 (d, *J* = 21.0 Hz), 110.07, 47.38, 36.24. HRMS (ESI) m/z Calculated for $C_{15}H_{12}FNO$ $[M+H]^+$ 242.0981, found 242.0985.

(3) 3-(4-fluoro-benzyl)-1,3-dihydroindol-2-one (4ac).[2]



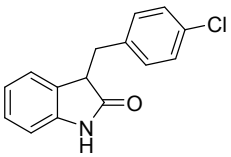
Colorless needles; Mp. 150-151 °C; 1H NMR (400 MHz, CDCl3) δ 8.95 (s, 1H), 7.17 (t, J = 7.7 Hz, 1H), 7.13 – 7.07 (m, 2H), 6.96 – 6.80 (m, 5H), 3.72 (dd, *J* = 8.5, 4.6 Hz, 1H), 3.42 (dd, *J* = 13.8, 4.6 Hz, 1H), 2.99 (dd, *J* = 13.8, 8.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.56, 161.76 (d, *J* = 244.7 Hz), 141.51, 133.23 (d, *J* = 3.3 Hz), 130.92 (d, *J* = 7.9 Hz), 128.69, 128.13, 124.71, 122.15, 115.13 (d, *J* = 21.2 Hz), 109.84, 47.59, 35.69.

(4) 3-(3-chloro-benzyl)-1,3-dihydroindol-2-one (4ad)



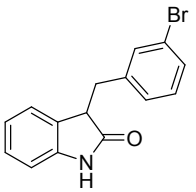
Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.04 (s, 1H), 7.22–7.13 (m, 4H), 7.06 (d, *J* = 6.7 Hz, 1H), 6.93 (t, *J* = 7.2 Hz, 1H), 6.87 (d, *J* = 7.8 Hz, 1H), 6.79 (d, *J* = 7.4 Hz, 1H), 3.74 (dd, *J* = 8.9, 4.7 Hz, 1H), 3.44 (dd, *J* = 13.8, 4.7 Hz, 1H), 2.95 (dd, *J* = 13.8, 9.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.58, 141.52, 139.83, 134.11, 129.60, 129.53, 128.56, 128.23, 127.64, 126.97, 124.68, 122.22, 110.00, 47.30, 36.20. HRMS (ESI) m/z Calculated for $C_{15}H_{12}ClNO$ $[M+H]^+$ 258.0686, found 258.0685.

(5) 3-(4-chloro-benzyl)-1,3-dihydroindol-2-one (4ae).[2]



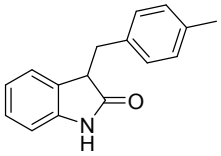
Pale yellow crystals; Mp. 138-140 °C; 1H NMR (400 MHz, CDCl3) δ 8.43 (s, 1H), 7.25 – 7.17 (m, 3H), 7.10 (d, *J* = 8.4 Hz, 2H), 6.96 (t, *J* = 7.5 Hz, 1H), 6.86 (t, *J* = 8.3 Hz, 2H), 3.75 (dd, *J* = 8.4, 4.6 Hz, 1H), 3.43 (dd, *J* = 13.8, 4.6 Hz, 1H), 3.03 (dd, *J* = 13.8, 8.5 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.88, 141.65, 136.12, 132.54, 130.82, 128.64, 128.46, 128.20, 124.65, 122.19, 110.05, 47.47, 35.84.

(6) 3-(3-bromo-benzyl)-1,3-dihydroindol-2-one (4af)



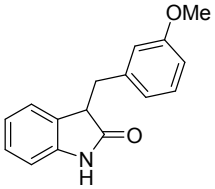
Pale yellow crystals; Mp. 158-160 °C; 1H NMR (400 MHz, CDCl3) δ 9.34 (s, 1H), 7.36 – 7.30 (m, 2H), 7.18 (t, J = 7.7 Hz, 1H), 7.10 (d, *J* = 5.5 Hz, 2H), 6.93 (t, *J* = 7.5 Hz, 1H), 6.88 (d, *J* = 7.7 Hz, 1H), 6.78 (d, *J* = 7.4 Hz, 1H), 3.72 (dd, *J* = 8.9, 4.7 Hz, 1H), 3.43 (dd, *J* = 13.8, 4.7 Hz, 1H), 2.92 (dd, *J* = 13.8, 9.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.68, 141.53, 140.09, 132.39, 129.85, 129.83, 128.51, 128.18, 128.04, 124.61, 122.31, 122.16, 110.02, 47.28, 36.11. HRMS (ESI) m/z Calculated for $C_{15}H_{12}BrNO$ $[M+H]^+$ 302.0181, found 302.0183.

(7) 3-(4-methyl-benzyl)-1,3-dihydroindol-2-one (4ag).[2]



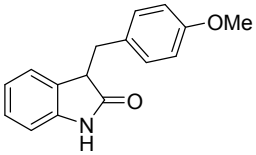
White powder; Mp. 149-150 °C; 1H NMR (400 MHz, CDCl3) δ 9.35 (s, 1H), 7.15 (t, J = 7.7 Hz, 1H), 7.09 – 7.02 (m, 4H), 6.92 – 6.84 (m, 2H), 6.74 (d, *J* = 7.4 Hz, 1H), 3.72 (dd, *J* = 9.3, 4.5 Hz, 1H), 3.45 (dd, *J* = 13.7, 4.5 Hz, 1H), 2.88 (dd, *J* = 13.7, 9.4 Hz, 1H), 2.29 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 180.22, 141.64, 136.18, 134.76, 129.32, 129.21, 129.08, 127.95, 124.85, 122.00, 109.89, 47.73, 36.25, 21.11.

(8) 3-(3-methoxy-benzyl)-1,3-dihydroindol-2-one (4ah)



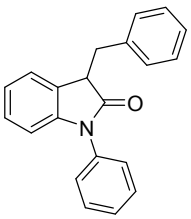
Colorless needles; Mp. 121-121 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.47 (s, 1H), 7.15 (t, *J* = 7.8 Hz, 2H), 6.92 – 6.84 (m, 2H), 6.81 – 6.70 (m, 4H), 3.74 (dd, *J* = 9.3, 4.5 Hz, 1H), 3.70 (s, 3H), 3.47 (dd, *J* = 13.7, 4.5 Hz, 1H), 2.89 (dd, *J* = 13.7, 9.4 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 180.27, 159.55, 141.73, 139.48, 129.36, 129.10, 128.03, 124.85, 122.05, 121.87, 114.78, 112.46, 110.00, 55.15, 47.60, 36.70. HRMS (ESI) m/z Calculated for $C_{16}H_{15}NO_2$ $[M+H]^+$ 254.1181, found 254.1186.

(9) 3-(4-methoxy-benzyl)-1,3-dihydroindol-2-one (4ai).[2]



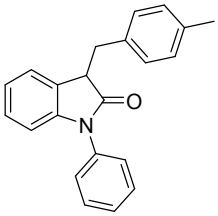
Colorless needles; Mp. 110-111 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 (s, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.10 (d, *J* = 8.5 Hz, 2H), 6.94 (t, *J* = 7.5 Hz, 1H), 6.86 (d, *J* = 7.7 Hz, 1H), 6.81 (t, *J* = 8.0 Hz, 3H), 3.79 (s, 3H), 3.74 (dd, *J* = 8.8, 4.3 Hz, 1H), 3.45 (dd, *J* = 13.8, 4.4 Hz, 1H), 2.94 (dd, *J* = 13.8, 9.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 180.17, 158.28, 141.64, 130.38, 129.73, 129.10, 127.90, 124.76, 121.95, 113.67, 109.85, 55.13, 47.81, 35.71.

(10) 3-benzyl-1-phenylindolin-2-one (4aj).[2]



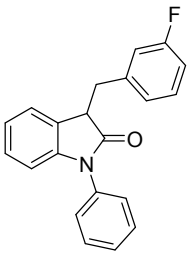
Pale yellow needles; Mp. 158-161 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (t, *J* = 7.6 Hz, 2H), 7.42 (t, *J* = 7.4 Hz, 1H), 7.29 – 7.22 (m, 5H), 7.21 – 7.14 (m, 3H), 7.05 – 6.99 (m, 2H), 6.69 (d, *J* = 7.9 Hz, 1H), 3.96 (dd, *J* = 8.1, 4.4 Hz, 1H), 3.56 (dd, *J* = 13.5, 4.4 Hz, 1H), 3.21 (dd, *J* = 13.5, 8.2 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.46, 144.43, 137.31, 134.50, 129.62, 129.61, 128.22, 128.14, 128.08, 127.91, 126.74, 126.69, 124.74, 122.55, 109.21, 47.26, 37.16.

(11) 3-(4-methyl-benzyl)-1-phenylindolin-2-one (4ak)



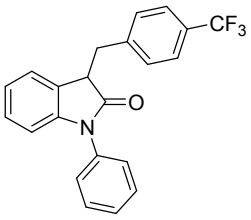
Pale yellow needles; Mp. 169-171 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (t, *J* = 7.6 Hz, 2H), 7.42 (t, *J* = 7.5 Hz, 1H), 7.28 (d, *J* = 8.5 Hz, 2H), 7.21 – 7.15 (m, 1H), 7.09 (s, 4H), 7.05 – 6.99 (m, 2H), 6.71 (d, *J* = 7.9 Hz, 1H), 3.94 (dd, *J* = 8.3, 4.4 Hz, 1H), 3.53 (dd, *J* = 13.6, 4.4 Hz, 1H), 3.16 (dd, *J* = 13.6, 8.3 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.55, 144.42, 136.21, 134.59, 134.28, 129.59, 129.47, 128.93, 128.32, 128.04, 127.84, 126.70, 124.78, 122.51, 109.19, 47.32, 36.77, 21.10. HRMS (ESI) m/z Calculated for $C_{22}H_{19}NO$ $[M+H]^+$ 314.1545, found 314.1546.

(12) 3-(3-fluoro-benzyl)-1-phenylindolin-2-one (4al)



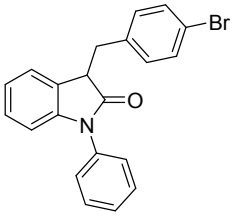
Pale yellow needles; Mp. 131-134 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (t, *J* = 7.7 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.22 – 7.17 (m, 2H), 7.12 (dtd, *J* = 9.8, 7.8, 2.9 Hz, 2H), 6.97 (dd, *J* = 6.6, 5.7 Hz, 2H), 6.93 – 6.80 (m, 3H), 6.64 (d, *J* = 7.9 Hz, 1H), 3.87 (dd, *J* = 7.8, 4.6 Hz, 1H), 3.45 (dd, *J* = 13.6, 4.5 Hz, 1H), 3.17 (dd, *J* = 13.6, 7.8 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 175.09, 161.52 (d, *J* = 245.7 Hz), 143.28, 138.77 (d, *J* = 7.3 Hz), 133.32, 128.60, 128.55, 128.52, 127.04 (d, *J* = 3.6 Hz), 126.64, 125.52, 124.25 (d, *J* = 2.8 Hz), 123.50, 121.62, 115.31 (d, *J* = 21.2 Hz), 112.57 (d, *J* = 20.9 Hz), 108.26, 45.85, 35.60. HRMS (ESI) m/z Calculated for $C_{21}H_{16}FNO$ $[M+H]^+$ 318.1294, found 318.1289.

(13) 1-phenyl-3-(4-(trifluoromethyl)-benzyl)indolin-2-one (4am)



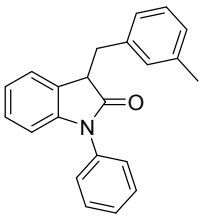
White needles; Mp. 138-140 °C ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (dd, *J* = 7.5, 6.2 Hz, 4H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.17 – 7.09 (m, 3H), 7.08 – 6.93 (m, 2H), 6.64 (d, *J* = 7.9 Hz, 1H), 3.93 (dd, *J* = 7.4, 4.5 Hz, 1H), 3.49 (dd, *J* = 13.5, 4.5 Hz, 1H), 3.29 (dd, *J* = 13.5, 7.5 Hz, 1H).^{13}C NMR (101 MHz, $CDCl_3$) δ 175.95, 144.44, 141.37, 134.33, 130.00, 129.66, 129.11 (d, *J* = 32.4 Hz), 128.23 (d, *J* = 6.2 Hz), 127.54, 126.55, 125.65, 125.07 (q, *J* = 3.7 Hz), 124.52, 122.95, 122.78, 109.46, 46.89, 36.81. HRMS (ESI) m/z Calculated for $C_{22}H_{16}F_3NO$ $[M+H]^+$ 368.1262, found 368.1263.

(14) 3-(4-bromo-benzyl)-1-phenylindolin-2-one (4an)



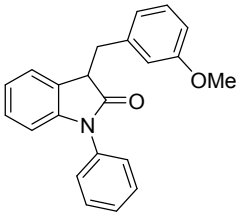
Pale yellow needles; Mp. 170-171 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (t, *J* = 7.7 Hz, 2H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 7.18 – 7.15 (m, 2H), 7.11 (ddd, *J* = 8.1, 4.6, 1.4 Hz, 1H), 6.99 (dt, *J* = 16.3, 7.0 Hz, 4H), 6.63 (d, *J* = 7.9 Hz, 1H), 3.85 (dd, *J* = 7.5, 4.5 Hz, 1H), 3.38 (dd, *J* = 13.6, 4.5 Hz, 1H), 3.16 (dd, *J* = 13.6, 7.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.14, 144.41, 136.24, 134.40, 131.41, 131.29, 129.68, 128.18, 128.16, 127.71, 126.61, 124.61, 122.73, 120.77, 109.43, 46.99, 36.42. HRMS (ESI) m/z Calculated for $C_{21}H_{16}BrNO$ $[M+H]^+$ 378.0494, found 378.0492.

(15) 3-(3-methyl-benzyl)-1-phenylindolin-2-one (4ao)



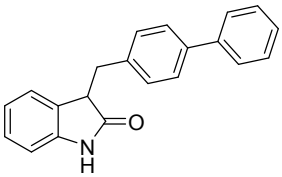
Pale yellow needles; Mp. 155-157 °C ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (t, *J* = 7.7 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.24 – 7.17 (m, 1H), 7.09 (t, *J* = 7.4 Hz, 1H), 7.03 – 6.87 (m, 2H), 6.63 (d, *J* = 7.9 Hz, 1H), 3.87 (dd, *J* = 8.2, 4.5 Hz, 1H), 3.46 (dd, *J* = 13.5, 4.5 Hz, 1H), 3.08 (dd, *J* = 13.5, 8.3 Hz, 1H), 2.25 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 175.42, 143.29, 136.65, 136.20, 133.48, 129.23, 128.48, 127.16, 126.98, 126.93, 126.75, 126.33, 125.58, 125.54, 123.70, 121.39, 108.06, 46.12, 36.03, 20.27. HRMS (ESI) m/z Calculated for $C_{22}H_{19}NO$ $[M+H]^+$ 314.1545, found 314.1549.

(16) 3-(3-methoxy-benzyl)-1-phenylindolin-2-one (4ap)



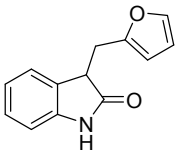
Pale yellow needles; Mp. 141-142 °C ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (t, *J* = 7.7 Hz, 2H), 7.35 (t, *J* = 7.4 Hz, 1H), 7.21 (dd, *J* = 5.8, 4.5 Hz, 2H), 7.15 – 7.07 (m, 2H), 6.97 (dd, *J* = 6.5, 5.6 Hz, 2H), 6.79 – 6.71 (m, 2H), 6.64 (d, *J* = 7.8 Hz, 2H), 3.89 (dd, *J* = 8.2, 4.4 Hz, 1H), 3.66 (s, 3H), 3.48 (dd, *J* = 13.5, 4.4 Hz, 1H), 3.12 (dd, *J* = 13.5, 8.2 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.43, 159.48, 144.46, 138.91, 134.55, 129.62, 129.21, 128.20, 128.08, 127.93, 126.70, 124.79, 122.56, 122.05, 114.68, 112.77, 109.25, 55.15, 47.18, 37.24. HRMS (ESI) m/z Calculated for $C_{22}H_{19}NO_2$ $[M+H]^+$ 330.1494, found 330.1495.

(17) 3-([1,1'-biphenyl]-4-ylmethyl)-1-phenylindolin-2-one (4aq).[2]



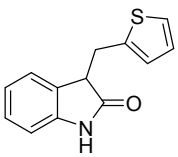
White solid; Mp. 153-154 °C ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.08 (s, 1H), 7.60 – 7.52 (m, 2H), 7.47 (d, *J* = 8.2 Hz, 2H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.32 (t, *J* = 7.3 Hz, 1H), 7.26 – 7.21 (m, 2H), 7.17 (t, *J* = 7.7 Hz, 1H), 6.87 (ddd, *J* = 28.4, 17.5, 7.4 Hz, 3H), 3.78 (dd, *J* = 9.1, 4.5 Hz, 1H), 3.52 (dd, *J* = 13.7, 4.5 Hz, 1H), 2.98 (dd, *J* = 13.7, 9.2 Hz, 1H).^{13}C NMR (101 MHz, $CDCl_3$) δ 179.67, 141.47, 140.70, 139.42, 136.87, 129.84, 128.97, 128.73, 128.02, 127.18, 126.96, 126.93, 124.83, 122.07, 109.80, 47.49, 36.24.

(18) 3-(furan-2-ylmethyl)indolin-2-one (4ar).[2]



White powder; Mp. 146-147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.29 (s, 1H), 7.33 (d, *J* = 1.3 Hz, 1H), 7.19 (t, *J* = 7.7 Hz, 1H), 6.92 (dd, *J* = 14.2, 7.5 Hz, 2H), 6.78 (d, *J* = 7.4 Hz, 1H), 6.28 (dd, *J* = 3.0, 1.9 Hz, 1H), 6.03 (d, *J* = 3.1 Hz, 1H), 3.82 (dd, *J* = 9.5, 4.6 Hz, 1H), 3.48 (dd, *J* = 15.0, 4.6 Hz, 1H), 2.98 (dd, *J* = 15.1, 9.5 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.62, 151.92, 141.55, 141.47, 128.77, 128.10, 124.64, 122.25, 110.36, 109.82, 107.30, 45.21, 29.04.

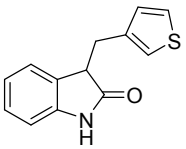
(19) 3-(thiophen-2-ylmethyl)indolin-2-one (4as).[2]



Yellow needles; Mp. 154-155 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.90 (s, 1H), 7.12 (ddd, *J* = 7.1, 4.7, 1.6 Hz, 1H), 7.01 (dd, *J* = 5.1, 0.7 Hz, 1H), 6.92 – 6.85 (m, 2H), 6.79 (dd, *J* = 8.1, 4.6 Hz, 2H), 6.70 (d, *J* = 3.2 Hz, 1H), 3.68

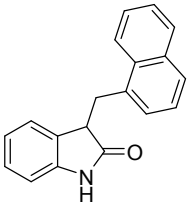
(dd, *J* = 8.2, 4.4 Hz, 1H), 3.53 (dd, *J* = 14.8, 4.3 Hz, 1H), 3.26 (dd, *J* = 14.8, 8.2 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 178.20, 140.70, 138.62, 127.53, 127.21, 125.64, 125.38, 123.61, 123.25, 121.21, 108.84, 46.65, 29.64.

(20) 3-(thiophen-3-ylmethyl)indolin-2-one (4at)



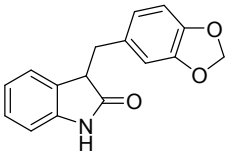
Yellow needles; Mp. 141-142 °C ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 7.22 – 7.14 (m, 2H), 6.94 (dd, *J* = 13.2, 5.4 Hz, 2H), 6.90 – 6.82 (m, 3H), 3.72 (dd, *J* = 8.5, 4.4 Hz, 1H), 3.43 (dd, *J* = 14.2, 4.4 Hz, 1H), 3.10 (dd, *J* = 14.2, 8.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.46, 141.48, 137.82, 129.04, 128.44, 128.05, 125.49, 124.59, 122.45, 122.17, 109.70, 47.04, 30.96. HRMS (ESI) m/z Calculated for $C_{13}H_{11}NOS$ $[M+H]^+$ 230.0640, found 230.0644.

(21) 3-(naphthalen-1-ylmethyl)indolin-2-one (4au).[2]



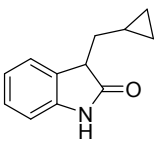
Yellow needless; Mp. 112-113 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.37 (s, 1H), 7.78 (dd, *J* = 6.0, 3.4 Hz, 1H), 7.74 – 7.68 (m, 2H), 7.59 (s, 1H), 7.45 – 7.39 (m, 2H), 7.33 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.13 (t, *J* = 7.7 Hz, 1H), 6.83 (t, *J* = 7.6 Hz, 2H), 6.70 (d, *J* = 7.4 Hz, 1H), 3.83 (dd, *J* = 9.4, 4.5 Hz, 1H), 3.63 (dd, *J* = 13.7, 4.5 Hz, 1H), 3.05 (dd, *J* = 13.7, 9.5 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 180.15, 141.68, 135.50, 133.43, 132.39, 129.11, 128.14, 128.10, 128.08, 127.73, 127.70, 127.63, 126.08, 125.63, 124.89, 122.11, 110.01, 47.57, 36.90.

(22) 3-(benzo[d][1,3]dioxol-5-ylmethyl)indolin-2-one (4av).[2]



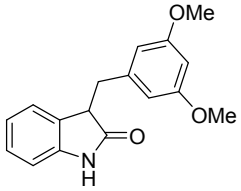
Pale yellow needles; Mp. 135-136 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.99 (s, 1H), 7.20 (t, *J* = 7.7 Hz, 1H), 6.95 (t, *J* = 7.5 Hz, 1H), 6.87 (dd, *J* = 13.9, 7.6 Hz, 2H), 6.70 (dd, *J* = 4.7, 3.1 Hz, 2H), 6.63 (dd, *J* = 8.0, 1.5 Hz, 1H), 5.93 (s, 2H), 3.71 (dd, *J* = 9.0, 4.6 Hz, 1H), 3.42 (dd, *J* = 13.8, 4.6 Hz, 1H), 2.91 (dd, *J* = 13.8, 9.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.66, 147.55, 146.30, 141.50, 131.47, 128.93, 128.00, 124.82, 122.57, 122.08, 109.79, 109.65, 108.06, 100.88, 47.71, 36.33.

(23) 3-(cyclopropylmethyl)indolin-2-one (4aw)



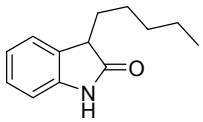
Pale yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.71 (s, 1H), 7.33 (d, *J* = 7.4 Hz, 1H), 7.23 (t, *J* = 7.7 Hz, 1H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.97 (d, *J* = 7.7 Hz, 1H), 3.61 – 3.54 (m, 1H), 2.11 – 2.01 (m, 1H), 1.85 – 1.73 (m, 1H), 0.91 – 0.80 (m, 1H), 0.51 – 0.37 (m, 2H), 0.28 – 0.20 (m, 1H), 0.14 – 0.08 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.35, 141.98, 130.00, 127.79, 124.42, 122.08, 109.90, 46.83, 35.58, 8.05, 5.31, 4.16. HRMS (ESI) m/z Calculated for $C_{12}H_{13}NO$ $[M+H]^+$ 188.1075, found 188.1073.

(24) 3-(3,5-dimethoxybenzyl)indolin-2-one (4ax)



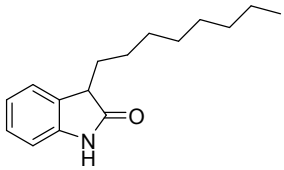
Yellow needless; Mp. 166-168 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.24 (s, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 6.98 – 6.83 (m, 3H), 6.42 – 6.33 (m, 3H), 3.77 (dd, *J* = 9.4, 4.3 Hz, 1H), 3.73 (s, 6H), 3.47 (dd, *J* = 13.7, 4.4 Hz, 1H), 2.87 (dd, *J* = 13.7, 9.5 Hz, 1H).^{13}C NMR (101 MHz, $CDCl_3$) δ 179.95, 160.68, 141.60, 140.22, 129.07, 128.00, 124.92, 122.05, 109.86, 107.34, 99.02, 55.26, 47.45, 36.94. HRMS (ESI) m/z Calculated for $C_{17}H_{17}NO_3$ $[M+H]^+$ 284.1287, found 284.1291.

(25) 3-pentylindolin-2-one (4ay).[2]



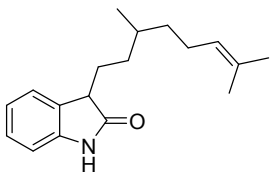
Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.34 (d, *J* = 44.7 Hz, 1H), 7.24 (dd, *J* = 12.2, 7.5 Hz, 2H), 7.04 (t, *J* = 7.3 Hz, 1H), 6.95 (d, *J* = 7.7 Hz, 1H), 3.50 (t, *J* = 6.0 Hz, 1H), 2.09 – 1.89 (m, 2H), 1.54 – 1.41 (m, 1H), 1.38 – 1.22 (m, 5H), 0.88 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.15, 141.78, 129.99, 127.76, 124.08, 122.18, 109.82, 46.23, 31.79, 30.52, 25.47, 22.40, 14.00.

(26) 3-octylindolin-2-one (4az)



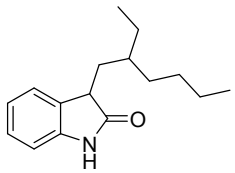
Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.56 (s, 1H), 7.23 (dd, *J* = 12.5, 7.5 Hz, 2H), 7.04 (t, *J* = 7.2 Hz, 1H), 6.96 (d, *J* = 7.7 Hz, 1H), 3.50 (t, *J* = 6.0 Hz, 1H), 2.08 – 1.91 (m, 2H), 1.51 – 1.39 (m, 1H), 1.37 – 1.21 (m, 11H), 0.89 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.28, 141.88, 130.00, 127.76, 124.06, 122.16, 109.87, 46.27, 31.83, 30.57, 29.63, 29.34, 29.24, 25.82, 22.63, 14.08. HRMS (ESI) m/z Calculated for $C_{16}H_{23}NO$ $[M+H]^+$ 246.1858, found 246.1855.

(27) 3-(3,7-dimethyloct-6-en-1-yl)indolin-2-one (4b)



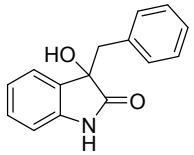
Colorless oil ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.50 (d, *J* = 15.2 Hz, 1H), 7.23 (dd, *J* = 12.1, 7.5 Hz, 2H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.96 (d, *J* = 7.7 Hz, 1H), 5.15 – 5.02 (m, 1H), 3.49 (t, *J* = 5.9 Hz, 1H), 2.07 – 1.86 (m, 4H), 1.69 (s, 3H), 1.60 (s, 3H), 1.52 – 1.24 (m, 4H), 1.22 – 1.08 (m, 2H), 0.90 (d, *J* = 6.5 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.21, 141.87, 131.13, 129.96, 127.78, 124.82, 124.07, 122.19, 109.86, 46.36, 36.88, 32.69, 32.45, 28.08, 25.71, 25.46, 19.41, 17.64. HRMS (ESI) m/z Calculated for $C_{18}H_{25}NO$ $[M+H]^+$ 272.2014, found 272.2018.

(28) 3-(2-ethylhexyl)indolin-2-one (4c)



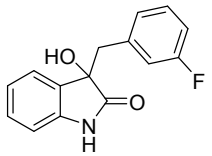
Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.34 (s, 1H), 7.23 (t, *J* = 7.7 Hz, 2H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.96 (d, *J* = 7.7 Hz, 1H), 3.50 (t, *J* = 7.2 Hz, 1H), 2.02 – 1.89 (m, 1H), 1.85 – 1.67 (m, 2H), 1.48 – 1.23 (m, 8H), 0.98 – 0.86 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 181.58, 141.65, 130.52, 127.71, 124.30, 122.06, 109.88, 44.10, 35.72, 35.27, 32.76, 28.57, 25.99, 23.04, 14.08, 10.23. HRMS (ESI) m/z Calculated for $C_{16}H_{23}NO$ $[M+H]^+$ 246.1858, found 246.1855.

(29) 3-benzyl-3-hydroxyindolin-2-one (5aa)



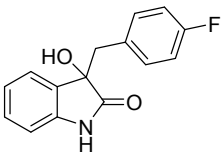
White solid; Mp. 122-124 °C; ^{1}H NMR (400 MHz, DMSO-d6) δ 10.05 (s, 1H), 7.17 – 7.04 (m, 5H), 6.99 – 6.84 (m, 3H), 6.61 (d, *J* = 7.5 Hz, 1H), 6.12 (s, 1H), 3.17 (d, *J* = 12.6 Hz, 1H), 3.01 (d, *J* = 12.6 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d6) δ 179.24, 142.14, 135.56, 131.44, 130.60, 129.31, 127.94, 126.79, 125.05, 121.64, 109.74, 77.06, 43.96. HRMS (ESI) m/z Calculated for $C_{15}H_{12}NO_2$ $[M+H]^+$ 240.1025, found 240.1029.

(30) 3-(3-fluorobenzyl)-3-hydroxyindolin-2-one (5ab)



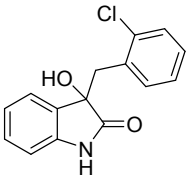
Pale yellow solid; Mp. 144-145 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.17 (s, 1H), 7.18 – 7.11 (m, 3H), 6.98 – 6.90 (m, 2H), 6.75 (dd, *J* = 15.9, 8.9 Hz, 2H), 6.67 (d, *J* = 7.7 Hz, 1H), 6.24 (s, 1H), 3.22 (d, *J* = 12.7 Hz, 1H), 3.05 (d, *J* = 12.7 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.16, 161.91 (d, *J* = 242.4 Hz), 142.08, 138.50 (d, *J* = 7.6 Hz), 131.21, 129.73 (d, *J* = 8.3 Hz), 129.49, 126.80 (d, *J* = 2.5 Hz), 125.05, 121.78, 117.19 (d, *J* = 21.1 Hz), 113.66 (d, *J* = 20.8 Hz), 109.89, 76.90, 43.47. HRMS (ESI) m/z Calculated for $C_{15}H_{12}FNO_2$ $[M+H]+$ 258.0930, found 258.0926.

(31) 3-(4-fluorobenzyl)-3-hydroxyindolin-2-one (5ac)



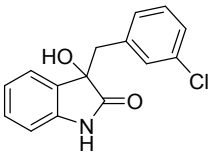
Pale yellow solid; Mp. 126-127 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.09 (s, 1H), 7.12 (ddd, J = 10.4, 8.4, 4.3 Hz, 2H), 6.93 (d, J = 7.4 Hz, 5H), 6.63 (d, J = 7.6 Hz, 1H), 6.14 (s, 1H), 3.15 (d, J = 12.8 Hz, 1H), 2.98 (d, J = 12.8 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.20, 161.45 (d, J = 242.1 Hz), 142.08, 132.37 (d, J = 8.0 Hz), 131.74 (d, J = 3.0 Hz), 131.28, 129.40, 125.03, 121.72, 114.69 (d, J = 21.0 Hz), 109.79, 76.95, 42.98. HRMS (ESI) m/z Calculated for $C_{15}H_{12}FNO_2$ $[M+H]^+$ 258.0930, found 258.0931.

(32) 3-(2-chlorobenzyl)-3-hydroxyindolin-2-one (5ad)



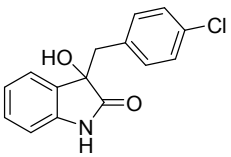
White solid; Mp. 168-171 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.15 (s, 1H), 7.21 – 7.07 (m, 4H), 6.99 – 6.82 (m, 3H), 6.64 (d, J = 7.6 Hz, 1H), 6.20 (s, 1H), 3.20 – 3.14 (m, 1H), 3.02 – 2.97 (m, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.05, 142.04, 138.17, 132.52, 131.13, 130.38, 129.75, 129.51, 129.37, 126.85, 125.06, 121.75, 109.88, 76.82, 43.31. HRMS (ESI) m/z Calculated for $C_{15}H_{12}ClNO_2$ $[M+H]^+$ 274.0635, found 274.0630.

(33) 3-(3-chlorobenzyl)-3-hydroxyindolin-2-one (5ae)



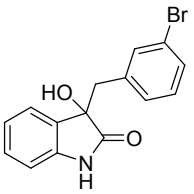
Pale yellow needles; Mp. 155-157 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.26 (s, 1H), 7.39 – 7.33 (m, 1H), 7.29 – 7.24 (m, 1H), 7.23 – 7.16 (m, 2H), 7.12 (ddd, J = 7.7, 6.5, 2.5 Hz, 1H), 6.85 – 6.78 (m, 2H), 6.70 (d, J = 7.7 Hz, 1H), 6.20 (s, 1H), 3.30 (d, J = 13.5 Hz, 1H), 3.13 (d, J = 13.5 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.47, 141.84, 134.57, 133.65, 132.61, 131.07, 129.42, 129.36, 128.81, 126.87, 125.08, 121.60, 109.80, 76.34, 76.34. HRMS (ESI) m/z Calculated for $C_{15}H_{12}ClNO_2$ $[M+H]^+$ 274.0635, found 274.0636.

(34) 3-(4-chlorobenzyl)-3-hydroxyindolin-2-one (5af)



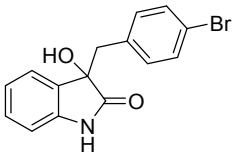
Pale yellow needles; Mp. 142-143 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.10 (s, 1H), 7.19 – 7.08 (m, 4H), 6.92 (dt, J = 6.6, 2.8 Hz, 3H), 6.63 (d, J = 7.6 Hz, 1H), 6.17 (s, 1H), 3.16 (d, J = 12.7 Hz, 1H), 2.99 (d, J = 12.7 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.09, 142.05, 134.63, 132.40, 131.62, 131.19, 129.46, 127.94, 125.03, 121.78, 109.84, 76.88, 43.14. HRMS (ESI) m/z Calculated for $C_{15}H_{12}ClNO_2$ $[M+H]^+$ 274.0635, found 274.0638.

(35) 3-(3-bromobenzyl)-3-hydroxyindolin-2-one (5ag)



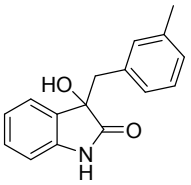
Pale yellow needles; Mp. 135-136 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.15 (s, 1H), 7.31 (dd, J = 8.0, 1.0 Hz, 1H), 7.12 (ddt, J = 15.6, 12.4, 4.5 Hz, 4H), 6.92 (ddd, J = 10.3, 5.6, 1.7 Hz, 2H), 6.65 (d, J = 7.7 Hz, 1H), 6.20 (s, 1H), 3.17 (d, J = 12.7 Hz, 1H), 2.98 (d, J = 12.7 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.04, 142.04, 138.45, 133.29, 131.12, 130.06, 129.75, 129.74, 129.51, 125.06, 121.75, 121.21, 109.90, 76.84, 43.30. HRMS (ESI) m/z Calculated for $C_{15}H_{12}BrNO_2$ $[M+H]^+$ 318.0130, found 318.0129.

(36) 3-(4-bromobenzyl)-3-hydroxyindolin-2-one (5ah)



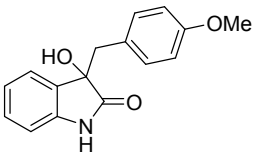
Pale yellow needles; Mp. 161-162 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.12 (s, 1H), 7.30 (d, J = 8.4 Hz, 2H), 7.16 – 7.09 (m, 2H), 6.93 (td, J = 7.5, 0.8 Hz, 1H), 6.87 (d, J = 8.4 Hz, 2H), 6.65 (d, J = 7.6 Hz, 1H), 6.19 (s, 1H), 3.15 (d, J = 12.7 Hz, 1H), 2.98 (d, J = 12.7 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.09, 142.06, 135.04, 132.80, 131.19, 130.86, 129.48, 125.03, 121.80, 120.21, 109.87, 76.84, 43.22. HRMS (ESI) m/z Calculated for $C_{15}H_{12}BrNO_2$ $[M+H]^+$ 318.0130, found 318.0133.

(37) 3-hydroxy-3-(3-methylbenzyl)indolin-2-one (5ai)



Pale yellow needles; Mp. 155-156 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.06 (s, 1H), 7.15 – 7.08 (m, 2H), 6.92 (tt, J = 4.8, 2.9 Hz, 3H), 6.73 (s, 1H), 6.68 (d, J = 7.4 Hz, 1H), 6.62 (d, J = 7.6 Hz, 1H), 6.11 (s, 1H), 3.14 (d, J = 12.6 Hz, 1H), 2.98 (d, J = 12.6 Hz, 1H), 2.11 (s, 3H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.29, 142.18, 136.76, 135.46, 131.55, 131.36, 129.29, 127.80, 127.69, 127.45, 125.09, 121.61, 109.76, 77.10, 43.96, 21.43. HRMS (ESI) m/z Calculated for $C_{16}H_{15}NO_2$ $[M+H]^+$ 254.1181, found 254.1179.

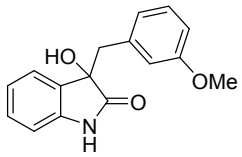
(38) 3-hydroxy-3-(4-methoxybenzyl)indolin-2-one (5aj)



Pale yellow needles; Mp. 122-124 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.03 (s, 1H), 7.12 (t, J = 7.7 Hz, 2H), 6.92 (t, J = 7.1 Hz, 1H), 6.80 (d, J = 8.7 Hz, 2H), 6.63 (dd, J = 15.1, 8.1 Hz, 3H), 6.06 (s, 1H), 3.64 (s, 3H), 3.09 (d, J = 12.8 Hz, 1H), 2.94 (d, J = 12.8 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.32, 158.21, 142.18, 131.58,

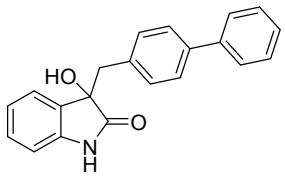
131.55, 129.28, 127.35, 125.01, 121.66, 113.38, 109.72, 77.12, 55.28, 43.07. HRMS (ESI) m/z Calculated for $C_{16}H_{15}NO_3$ $[M+H]^+$ 270.1130, found 270.1135.

(39) 3-hydroxy-3-(3-methoxybenzyl)indolin-2-one (5ak)



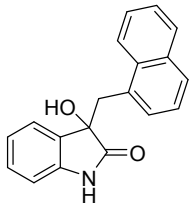
Pale yellow needles; Mp. 136-137 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.06 (s, 1H), 7.18 (d, J = 7.3 Hz, 1H), 7.12 (t, J = 7.6 Hz, 1H), 6.99 (t, J = 7.9 Hz, 1H), 6.93 (t, J = 7.4 Hz, 1H), 6.67 – 6.60 (m, 2H), 6.49 (d, J = 7.6 Hz, 1H), 6.42 (s, 1H), 6.14 (s, 1H), 3.54 (s, 3H), 3.15 (d, J = 12.6 Hz, 1H), 3.01 (d, J = 12.5 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.21, 158.84, 142.22, 137.00, 131.51, 129.36, 128.93, 125.08, 122.96, 121.68, 116.03, 112.37, 109.79, 77.09, 55.10, 43.97. HRMS (ESI) m/z Calculated for $C_{16}H_{15}NO_3$ $[M+H]^+$ 270.1130, found 270.1131.

(40) 3-([1,1'-biphenyl]-4-ylmethyl)-3-hydroxyindolin-2-one (5al)



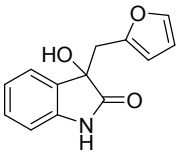
Pale yellow needles; Mp. 149-151 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.13 (s, 1H), 7.60 (d, J = 7.5 Hz, 2H), 7.43 (t, J = 8.4 Hz, 4H), 7.33 (t, J = 7.3 Hz, 1H), 7.21 – 7.11 (m, 2H), 7.02 (d, J = 8.1 Hz, 2H), 6.95 (t, J = 7.3 Hz, 1H), 6.65 (d, J = 7.7 Hz, 1H), 6.19 (s, 1H), 3.23 (d, J = 12.7 Hz, 1H), 3.07 (d, J = 12.6 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.23, 142.17, 140.14, 138.43, 134.90, 131.49, 131.23, 129.38, 129.32, 127.70, 126.85, 126.12, 125.07, 121.74, 109.81, 77.00, 43.54. HRMS (ESI) m/z Calculated for $C_{21}H_{17}NO_2$ $[M+H]^+$ 316.1338, found 316.1336.

(41) 3-hydroxy-3-(naphthalen-1-ylmethyl)indolin-2-one (5am)



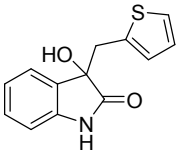
Pale yellow needles; Mp. 145-146 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.12 (s, 1H), 7.84 – 7.78 (m, 1H), 7.73 – 7.67 (m, 1H), 7.65 (d, J = 8.5 Hz, 1H), 7.48 (s, 1H), 7.43 (dd, J = 6.1, 3.3 Hz, 2H), 7.22 (d, J = 7.3 Hz, 1H), 7.12 (t, J = 8.4 Hz, 2H), 6.95 (t, J = 7.3 Hz, 1H), 6.61 (d, J = 7.6 Hz, 1H), 6.30 (s, 1H), 3.40 (d, J = 12.6 Hz, 1H), 3.26 (d, J = 12.6 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.29, 142.13, 133.37, 133.04, 132.20, 131.50, 129.39, 129.17, 129.13, 127.86, 127.82, 127.16, 126.28, 125.93, 125.14, 121.73, 109.81, 77.25, 44.16. HRMS (ESI) m/z Calculated for $C_{19}H_{15}NO_2$ $[M+H]^+$ 290.1181, found 290.1182.

(42) 3-(furan-2-ylmethyl)-3-hydroxyindolin-2-one (5an)



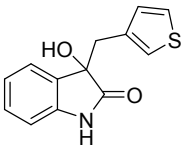
White needles; Mp. 119-121 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.19 (s, 1H), 7.35 (d, J = 1.1 Hz, 1H), 7.15 (td, J = 7.6, 1.1 Hz, 1H), 7.10 (d, J = 7.2 Hz, 1H), 6.91 (t, J = 7.5 Hz, 1H), 6.70 (d, J = 7.7 Hz, 1H), 6.21 (dd, J = 3.0, 1.9 Hz, 1H), 6.16 (s, 1H), 5.78 (d, J = 3.1 Hz, 1H), 3.21 (d, J = 14.4 Hz, 1H), 3.06 (d, J = 14.4 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6)) δ 183.67, 155.09, 147.03, 146.73, 136.30, 134.22, 129.53, 126.59, 115.52, 114.58, 112.68, 80.17, 41.20. HRMS (ESI) m/z Calculated for $C_{13}H_{11}NO_3$ $[M+H]^+$ 230.0817, found 230.0821.

(43) 3-hydroxy-3-(thiophen-2-ylmethyl)indolin-2-one (5ao)



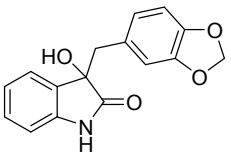
Pale yellow needles; Mp. 115-116 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.21 (s, 1H), 7.27 – 7.14 (m, 3H), 6.97 (t, J = 7.3 Hz, 1H), 6.84 (dd, J = 5.1, 3.5 Hz, 1H), 6.73 (d, J = 7.7 Hz, 1H), 6.63 (d, J = 3.0 Hz, 1H), 6.28 (s, 1H), 3.39 (d, J = 14.0 Hz, 1H), 3.30 (d, J = 14.0 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 178.91, 142.53, 137.14, 131.32, 129.63, 127.56, 126.59, 125.40, 124.89, 121.85, 109.90, 76.36, 38.22. HRMS (ESI) m/z Calculated for $C_{13}H_{11}NO_2S$ $[M+H]^+$ 246.0589, found 246.0591.

(44) 3-hydroxy-3-(thiophen-3-ylmethyl)indolin-2-one (5ap)



Pale yellow needles; Mp. 105-106 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.10 (s, 1H), 7.25 (dd, J = 4.9, 3.0 Hz, 1H), 7.13 (td, J = 7.7, 1.1 Hz, 1H), 7.07 (d, J = 7.2 Hz, 1H), 6.91 (t, J = 7.3 Hz, 1H), 6.86 (d, J = 2.2 Hz, 1H), 6.66 (d, J = 7.7 Hz, 1H), 6.60 (dd, J = 4.9, 0.8 Hz, 1H), 6.11 (s, 1H), 3.17 (d, J = 13.3 Hz, 1H), 3.03 (d, J = 13.3 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.32, 142.25, 135.91, 131.74, 129.76, 129.34, 125.11, 124.79, 123.68, 121.71, 109.79, 76.45, 38.41. HRMS (ESI) m/z Calculated for $C_{13}H_{11}NO_2S$ $[M+H]^+$ 246.0589, found 246.0593.

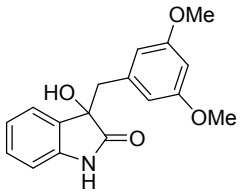
(45) 3-(benzo[d][1,3]dioxol-5-ylmethyl)-3-hydroxyindolin-2-one (5aq)



Pale yellow needles; Mp. 160-162 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.10 (s, 1H), 7.13 (t, J = 7.1 Hz, 2H), 6.93 (t, J = 7.2 Hz, 1H), 6.65 (dd, J = 7.7, 5.1 Hz, 2H), 6.45 (d, J = 1.4 Hz, 1H), 6.36 (dd, J = 8.0, 1.4 Hz, 1H), 6.10 (s, 1H), 5.90 (d, J = 0.8 Hz, 2H), 3.10 (d, J = 12.8 Hz, 1H), 2.94 (d, J = 12.8 Hz, 1H). ^{13}C NMR (101 MHz,

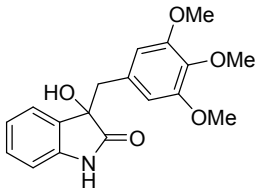
DMSO-d_6) δ 179.31, 146.83, 146.11, 142.17, 131.49, 129.34, 129.21, 125.05, 123.78, 121.70, 110.76, 109.80, 107.89, 101.05, 77.07, 43.48. HRMS (ESI) m/z Calculated for $C_{16}H_{13}NO_4$ $[M+H]^+$ 284.0923, found 284.0925.

(46) 3-(3,5-dimethoxybenzyl)-3-hydroxyindolin-2-one (5ar)



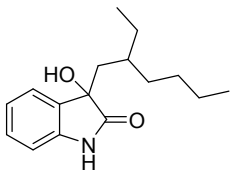
White solid; Mp. 127-128 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.07 (s, 1H), 7.25 (d, J = 7.3 Hz, 1H), 7.14 (t, J = 7.6 Hz, 1H), 6.96 (t, J = 7.4 Hz, 1H), 6.64 (d, J = 7.7 Hz, 1H), 6.23 (t, J = 2.0 Hz, 1H), 6.14 (s, 1H), 6.04 (d, J = 2.1 Hz, 2H), 3.54 (s, 6H), 3.12 (d, J = 12.5 Hz, 1H), 2.99 (d, J = 12.5 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.14, 159.96, 142.31, 137.66, 131.61, 129.34, 125.08, 121.64, 109.80, 108.59, 98.82, 77.07, 55.25, 44.23. HRMS (ESI) m/z Calculated for $C_{17}H_{17}NO_4$ $[M+H]^+$ 300.1236, found 300.1239.

(47) 3-hydroxy-3-(3,4,5-trimethoxybenzyl)indolin-2-one (5as)



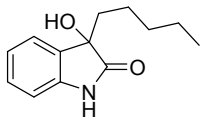
White solid; Mp. 160-161°C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.34 (s, 1H), 7.12 (t, J = 7.6 Hz, 1H), 6.94 (d, J = 7.2 Hz, 1H), 6.88 (t, J = 7.3 Hz, 1H), 6.76 (d, J = 7.7 Hz, 1H), 6.44 (s, 2H), 3.82 (dd, J = 7.8, 4.8 Hz, 1H), 3.65 (s, 5H), 3.61 (s, 3H), 3.28 (dd, J = 13.8, 4.8 Hz, 1H), 2.93 – 2.82 (m, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 178.64, 152.80, 143.18, 136.41, 134.09, 129.59, 128.05, 124.90, 121.35, 109.60, 106.99, 60.42, 56.12, 46.86, 36.12. HRMS (ESI) m/z Calculated for $C_{18}H_{19}NO_5$ $[M+H]^+$ 330.1341, found 330.1342.

(48) 3-(2-ethylhexyl)-3-hydroxyindolin-2-one (5at)



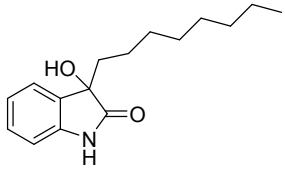
Colorless oil; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.46 (s, 1H), 7.64 (d, J = 7.6 Hz, 1H), 7.21 (t, J = 7.7 Hz, 1H), 6.96 (t, J = 7.6 Hz, 1H), 6.85 (d, J = 7.7 Hz, 1H), 6.55 (d, J = 10.9 Hz, 1H), 3.10 – 2.81 (m, 1H), 1.72 – 1.51 (m, 2H), 1.52 – 1.31 (m, 2H), 1.33 – 1.09 (m, 4H), 0.99 – 0.67 (m, 6H).^{13}C NMR (101 MHz, DMSO-d_6) δ 168.52, 145.89, 142.68, 129.43, 128.75, 123.76, 122.52, 121.82, 110.28, 40.49, 34.56, 29.69, 28.02, 22.77, 14.32, 12.15. HRMS (ESI) m/z Calculated for $C_{16}H_{23}NO_2$ $[M+H]^+$ 262.1807, found 262.1805.

(49) 3-hydroxy-3-pentylindolin-2-one (5au)



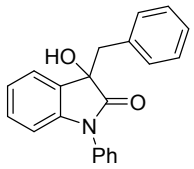
Pale yellow needles; Mp. 135-136 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.21 (s, 1H), 7.24 (d, J = 7.3 Hz, 1H), 7.19 (t, J = 7.7 Hz, 1H), 6.96 (t, J = 7.4 Hz, 1H), 6.80 (d, J = 7.7 Hz, 1H), 5.82 (s, 1H), 1.82 – 1.67 (m, 2H), 1.22 – 1.09 (m, 4H), 1.09 – 0.99 (m, 1H), 0.98 – 0.87 (m, 1H), 0.77 (t, J = 6.7 Hz, 3H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.86, 142.22, 132.63, 129.20, 124.21, 121.98, 109.89, 76.13, 38.16, 31.77, 22.80, 22.29, 14.21. HRMS (ESI) m/z Calculated for $C_{13}H_{17}NO_2$ $[M+H]^+$ 220.1338, found 220.1340.

(50) 3-hydroxy-3-octylindolin-2-one (5av)



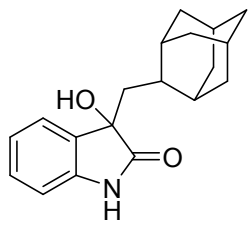
Colorless oil; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.21 (s, 1H), 7.23 (d, J = 7.3 Hz, 1H), 7.19 (t, J = 7.7 Hz, 1H), 6.95 (t, J = 7.2 Hz, 1H), 6.80 (d, J = 7.7 Hz, 1H), 5.82 (s, 1H), 1.86 – 1.68 (m, 2H), 1.14 (s, 9H), 1.08 – 0.99 (m, 1H), 0.91 (td, J = 12.9, 7.4 Hz, 1H), 0.82 (t, J = 6.9 Hz, 3H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 179.88, 142.23, 132.62, 129.16, 124.19, 121.94, 109.88, 76.13, 38.22, 31.65, 29.58, 29.21, 28.98, 23.13, 22.52, 14.36. HRMS (ESI) m/z Calculated for $C_{16}H_{23}NO_2$ $[M+H]^+$ 262.1807, found 262.1805.

(51) 3-benzyl-3-hydroxy-1-phenylindolin-2-one (5aw)



Yellow solid; Mp. 163-165 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.44 (ddd, J = 29.6, 15.0, 7.5 Hz, 1H), 7.18 – 7.06 (m, 1H), 6.98 (d, J = 7.7 Hz, 1H), 6.88 (d, J = 6.9 Hz, 1H), 6.52 (s, 1H), 6.42 (d, J = 7.6 Hz, 1H), 3.32 (d, J = 12.4 Hz, 1H), 3.25 (d, J = 12.3 Hz, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 176.96, 143.29, 135.00, 134.47, 130.79, 130.45, 129.98, 129.53, 128.40, 128.00, 127.03, 126.77, 125.06, 123.12, 108.88, 77.42, 45.00. HRMS (ESI) m/z Calculated for $C_{21}H_{17}NO_2$ $[M+H]^+$ 316.1338, found 316.1339.

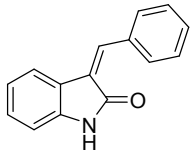
(52) (5ax)



White solid; Mp. 123-124 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.22 (s, 1H), 7.25 (d, J = 7.3 Hz, 1H), 7.20 (t, J = 7.3 Hz, 1H), 6.93 (t, J = 7.4 Hz, 1H), 6.81 (d, J = 7.7 Hz, 1H), 5.67 (s, 1H), 1.89 (d, J = 13.8 Hz, 1H), 1.81 (d, J =

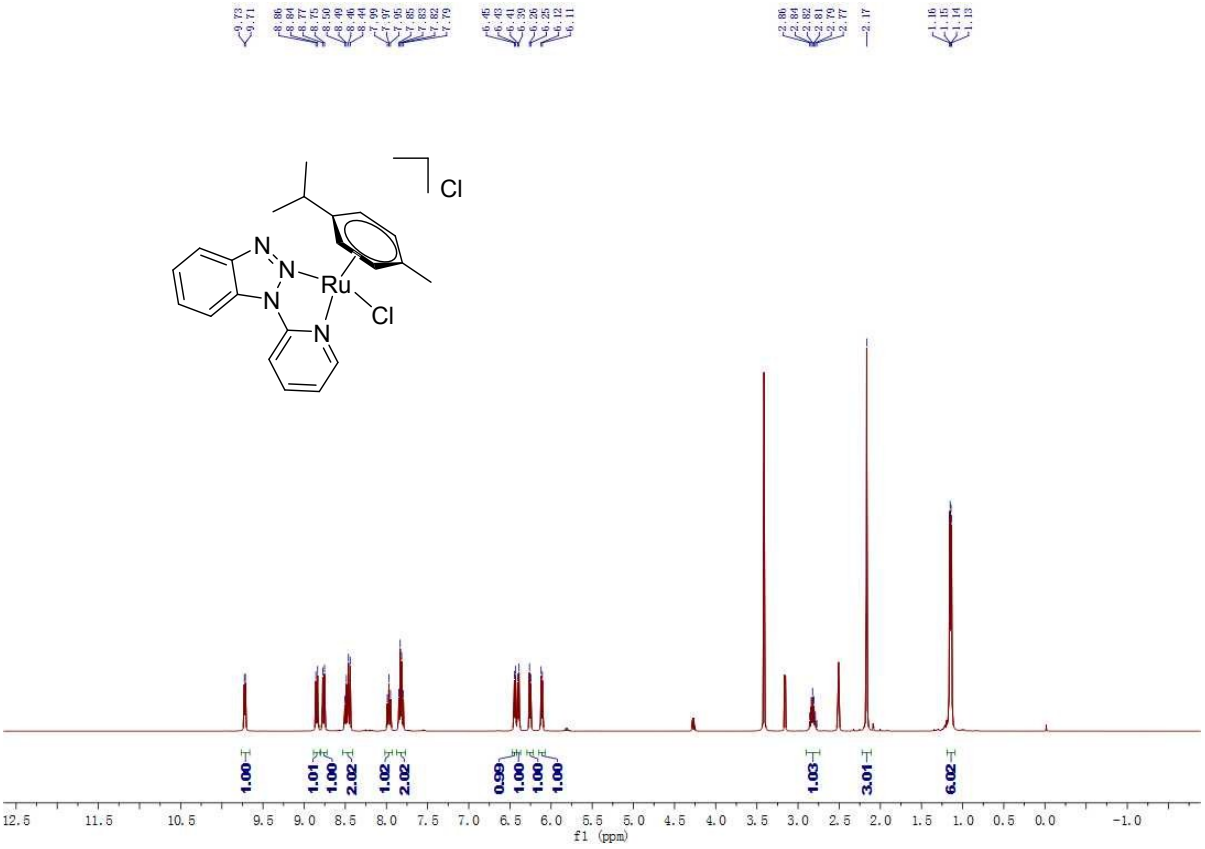
13.8 Hz, 1H), 1.71 (s, 3H), 1.51 (d, J = 11.8 Hz, 3H), 1.37 (d, J = 11.5 Hz, 3H), 1.22 (q, J = 12.1 Hz, 6H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 180.08, 142.17, 133.03, 129.43, 125.48, 121.63, 109.96, 74.23, 52.07, 43.27, 36.75, 31.93, 28.36. HRMS (ESI) m/z Calculated for $C_{19}H_{23}NO_2$ $[M+H]^+$ 298.1807, found 298.1808.

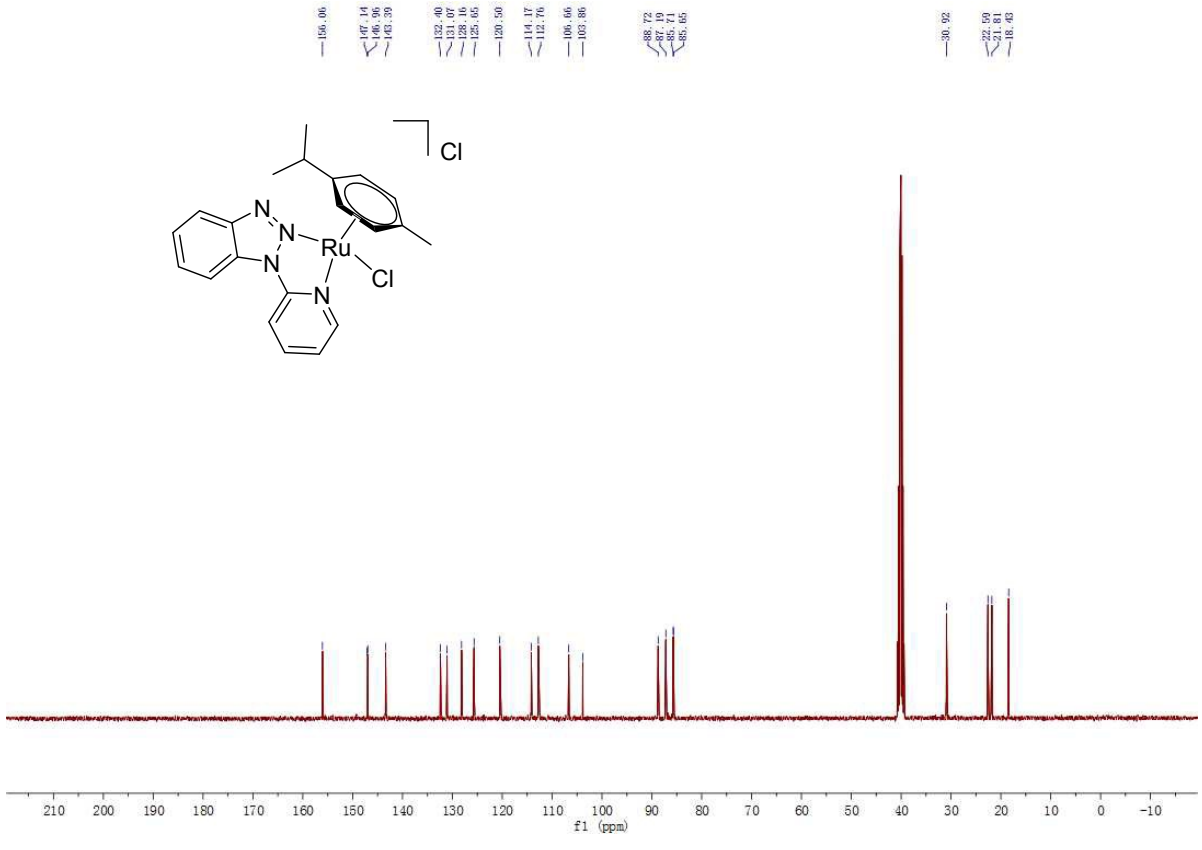
Intermediate C

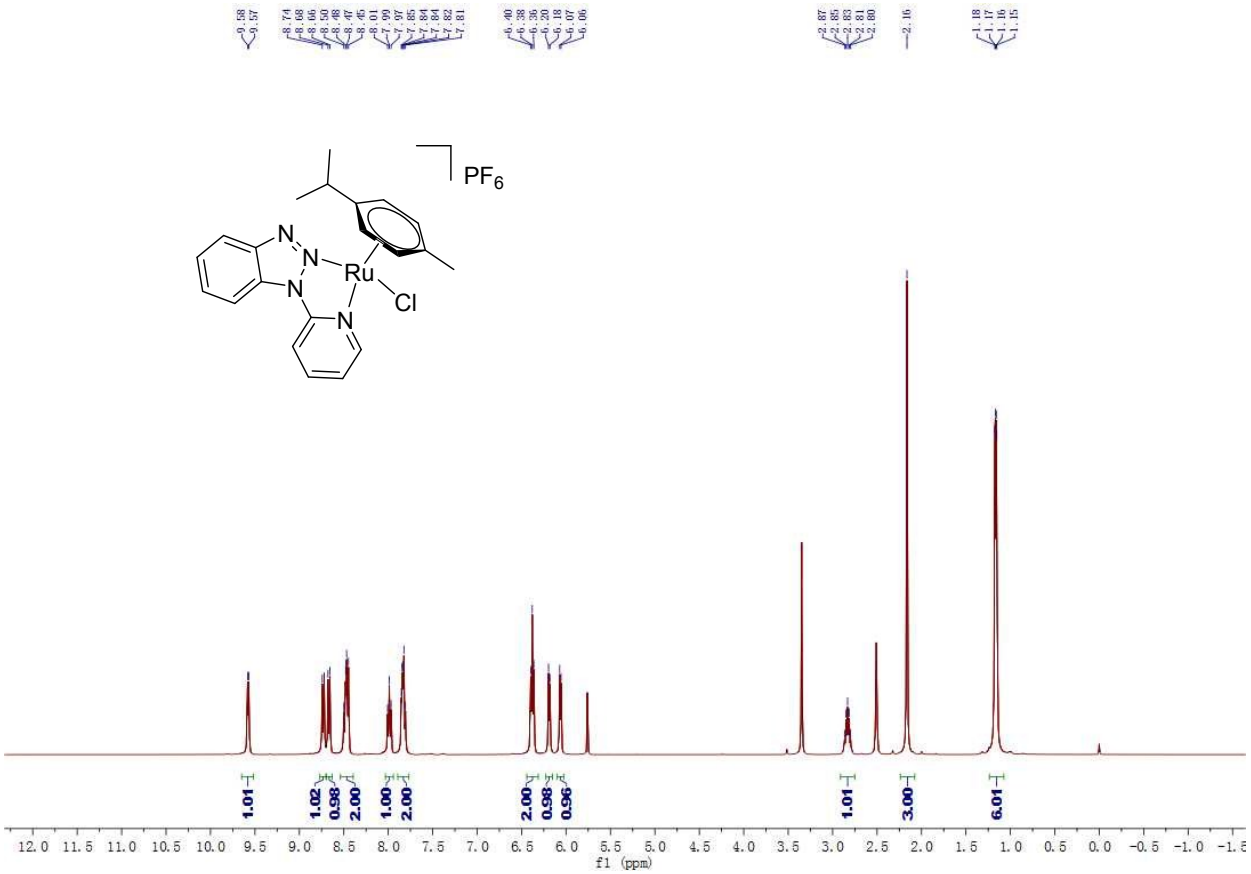


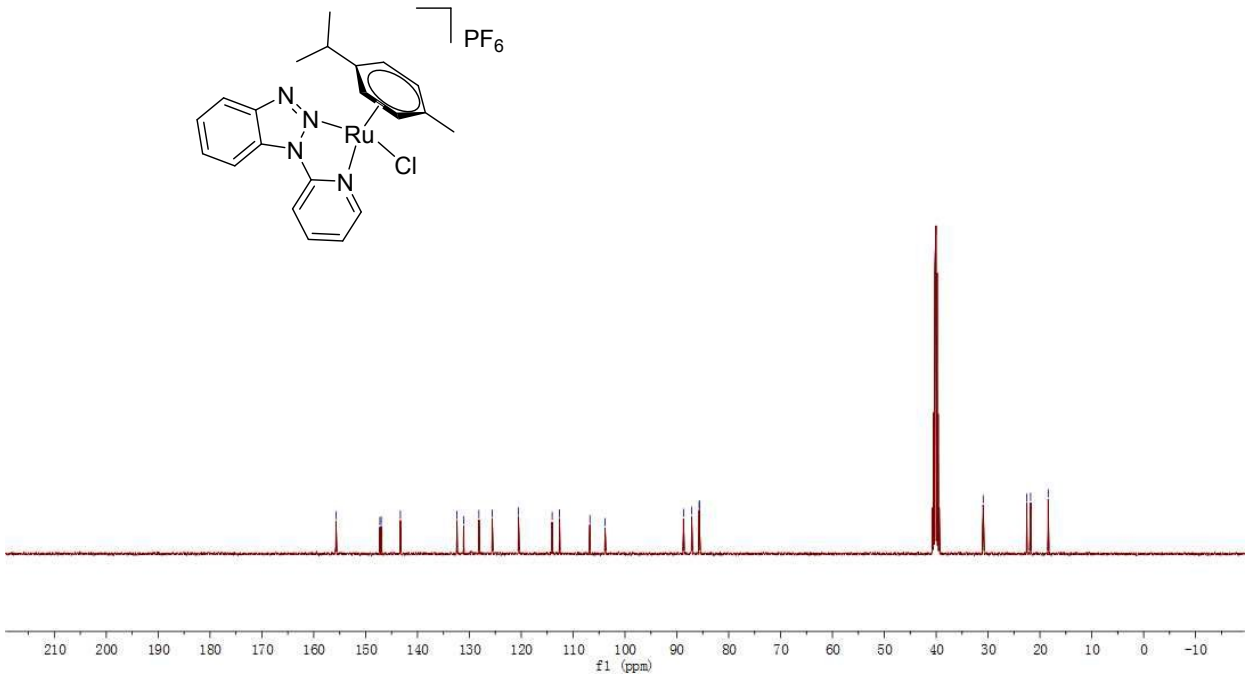
Yellow needles; Mp. 175-176 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.33 (s, 1H), 7.89 (s, 1H), 7.68 (dd, J = 13.7, 7.4 Hz, 3H), 7.58 – 7.42 (m, 3H), 7.24 (t, J = 7.2 Hz, 1H), 6.98 (d, J = 7.7 Hz, 1H), 6.89 (t, J = 7.7 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.67, 141.84, 137.54, 134.90, 129.93, 129.68, 129.36, 128.68, 127.77, 123.04, 121.83, 121.73, 110.40. HRMS (ESI) m/z Calculated for $C_{15}H_{11}NO$ $[M+H]^+$ 222.0919, found 222.0917.

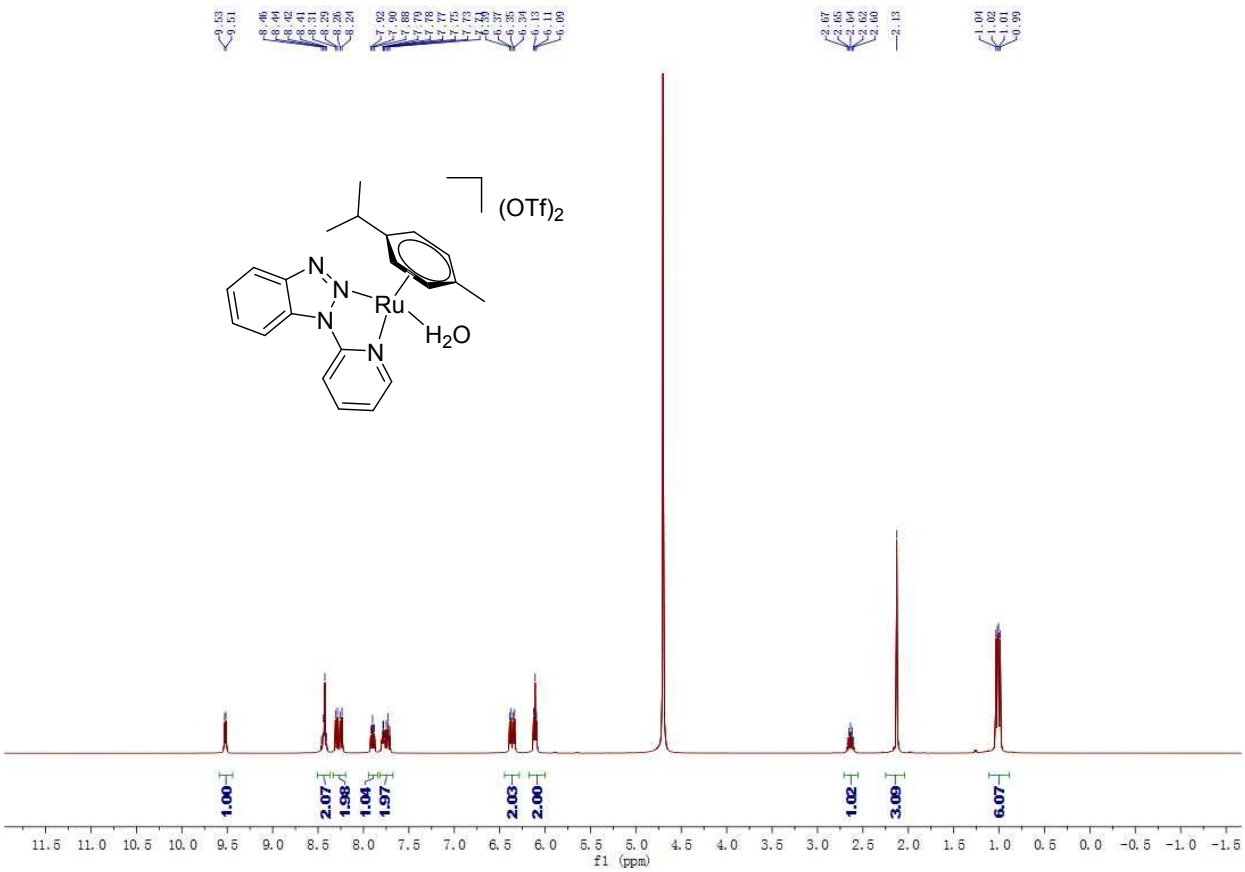
6. NMR spectra of obtained compounds

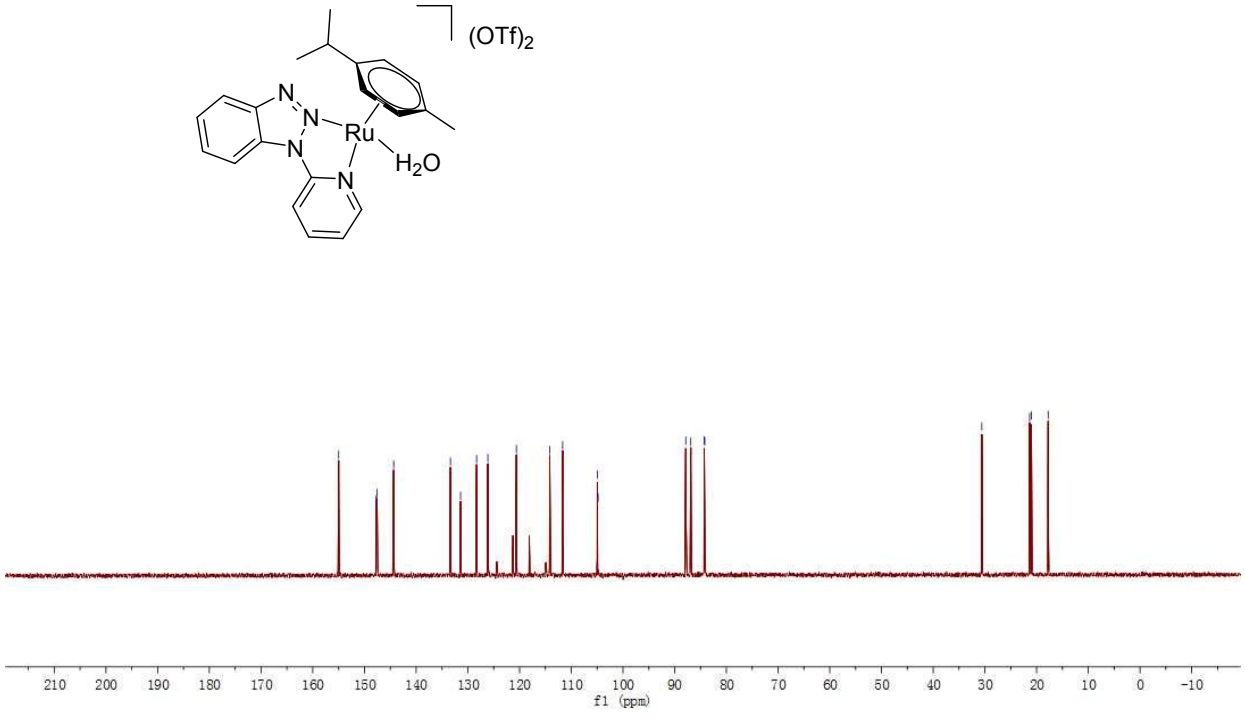


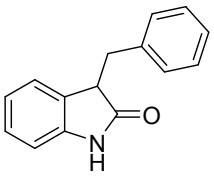



PF6
N
N
Ru
Cl
N
f1 (ppm)

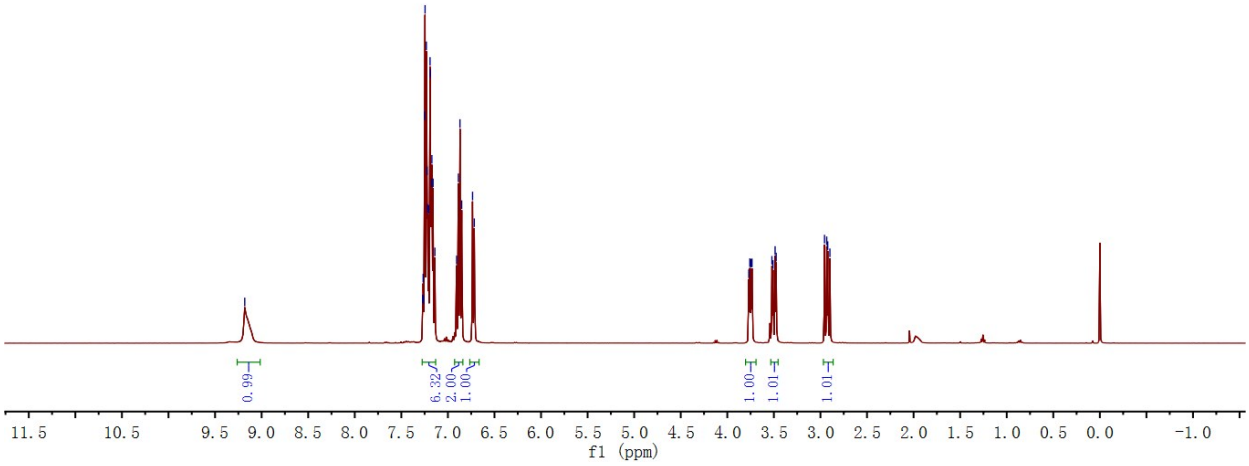

PF6
N
N
Ru
Cl
N
f1 (ppm)

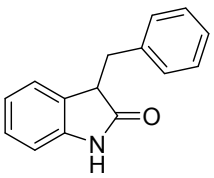

(OTf)2
N
N
Ru
N
H2O
1.00
2.07
1.98
1.04
1.97
2.03
2.00
1.02
3.09
6.07
f1 (ppm)


(OTf)2
N
N
Ru
N
H2O
f1 (ppm)

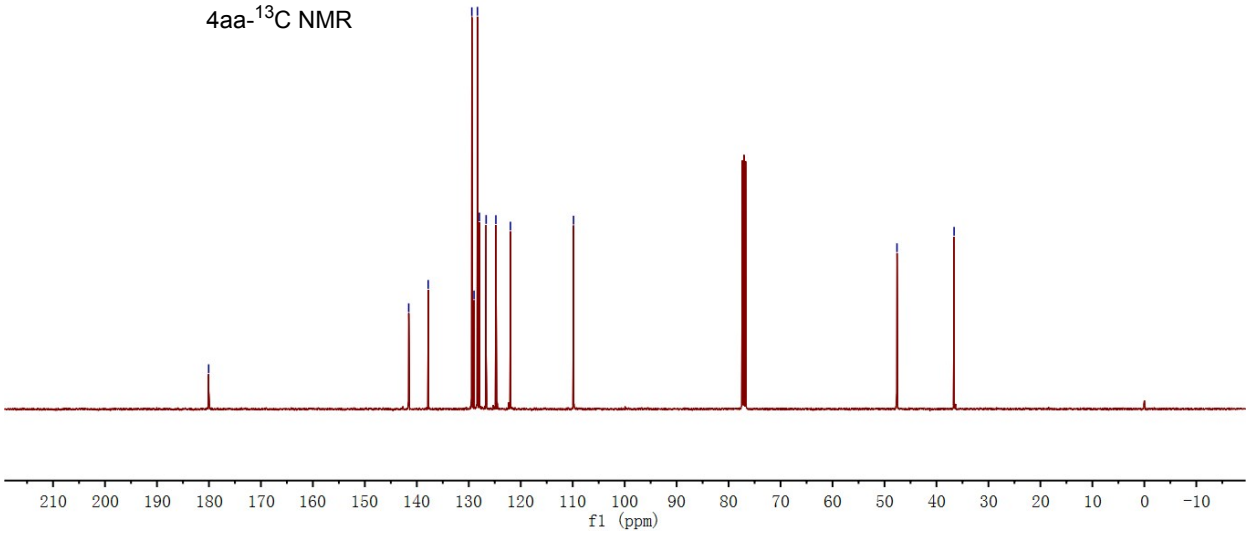


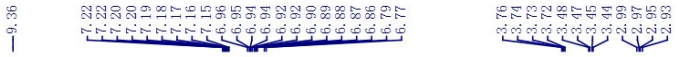
4aa-^{1}H NMR

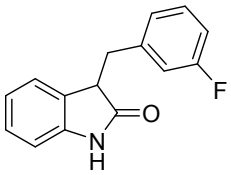




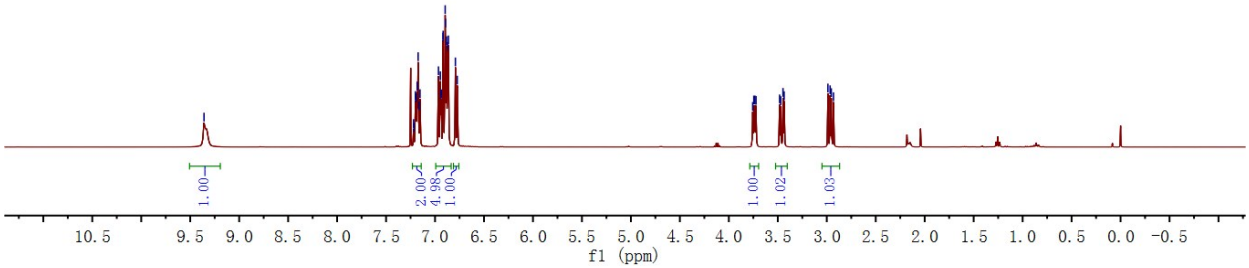
4aa-^{13}C NMR

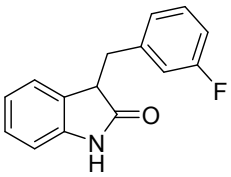




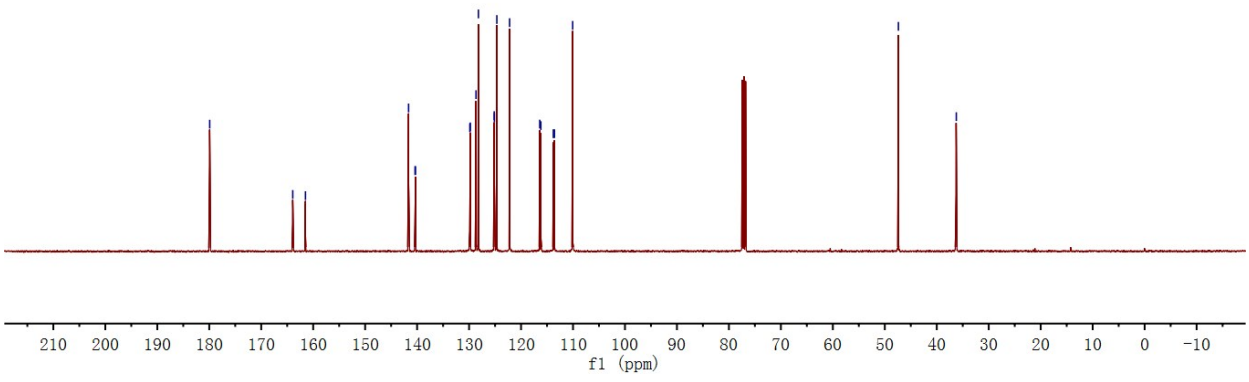


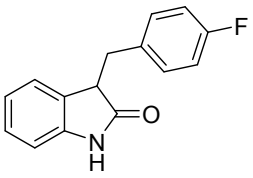
4ab-^{1}H NMR



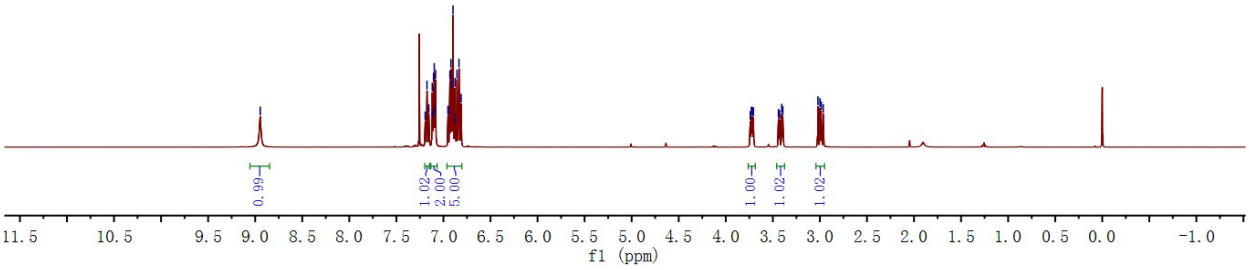


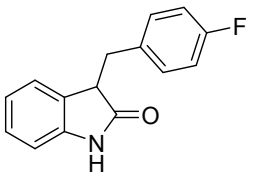
4ab-^{13}C NMR



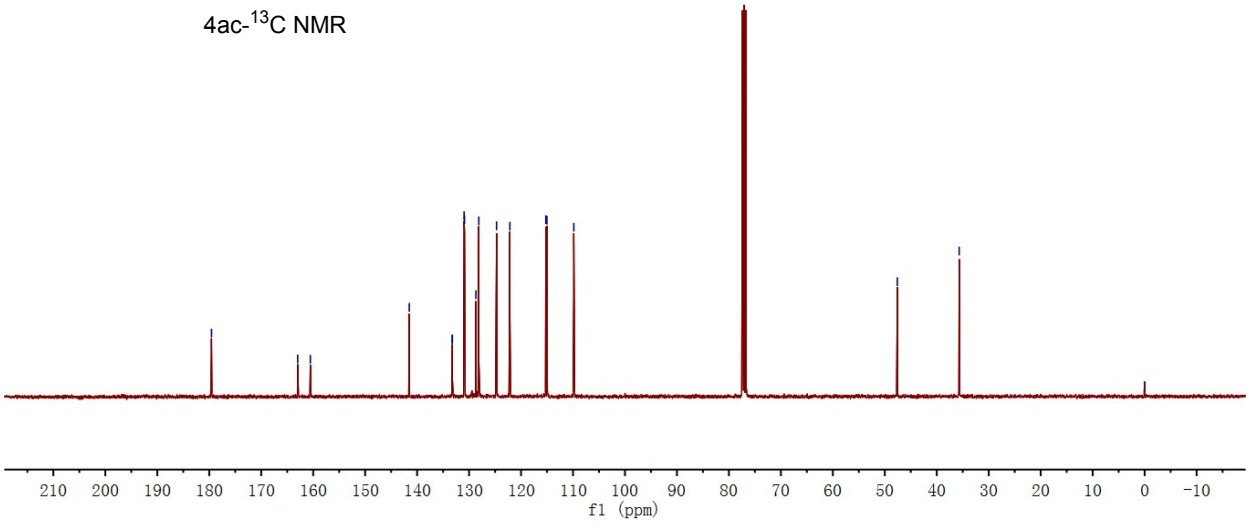


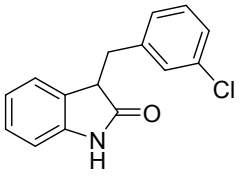
4ac-^{1}H NMR



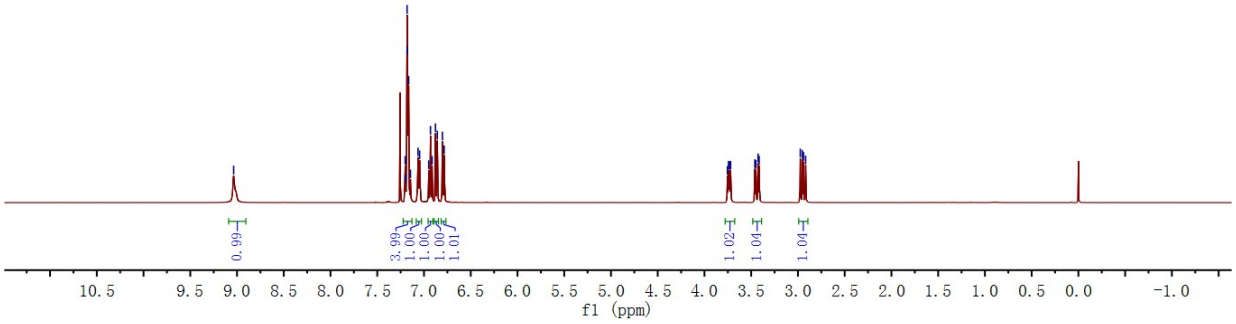


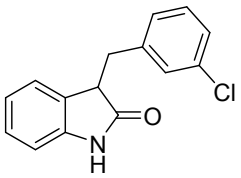
4ac-^{13}C NMR



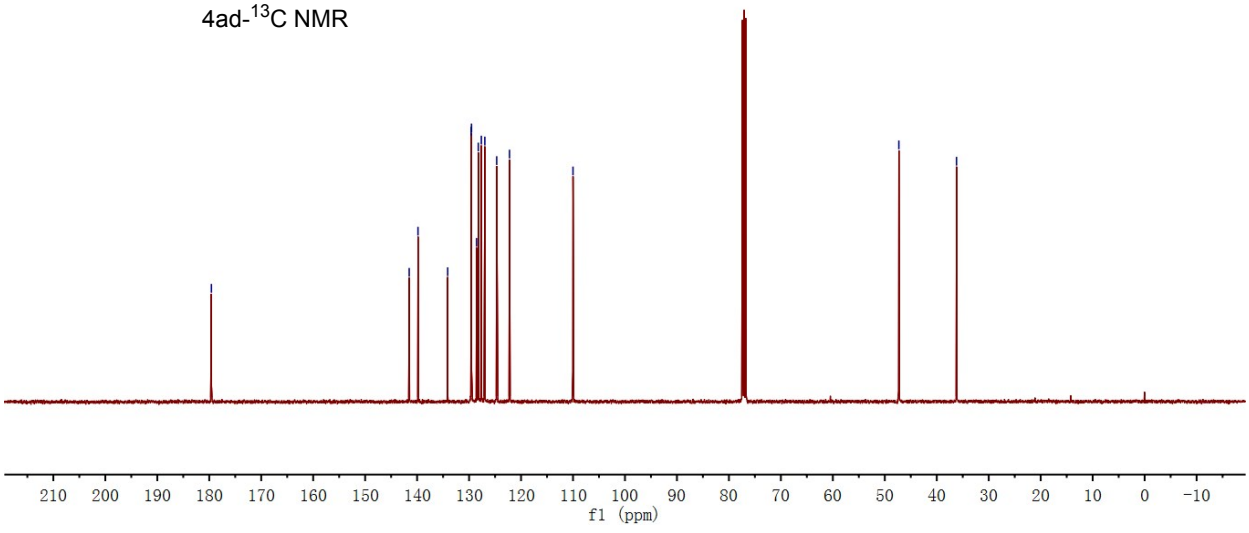


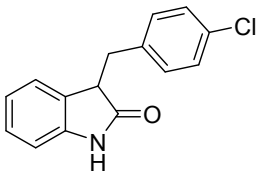
4ad-^{1}H NMR



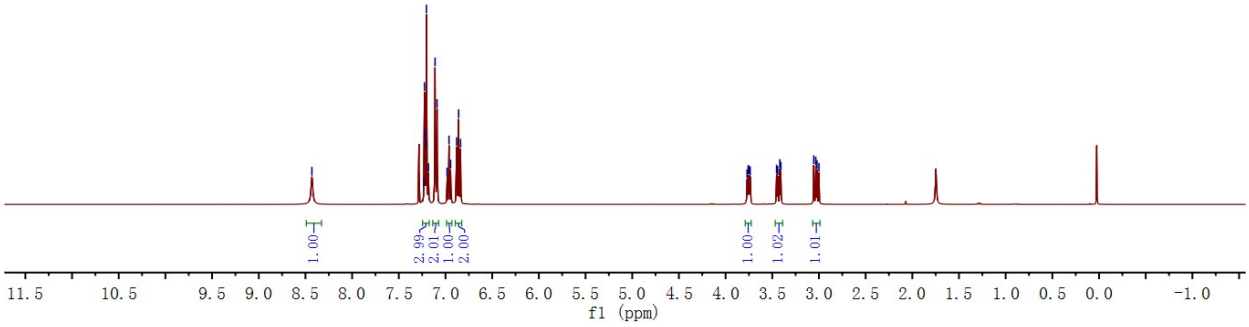


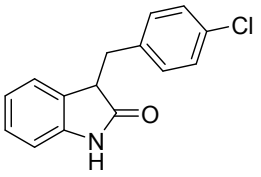
4ad-^{13}C NMR



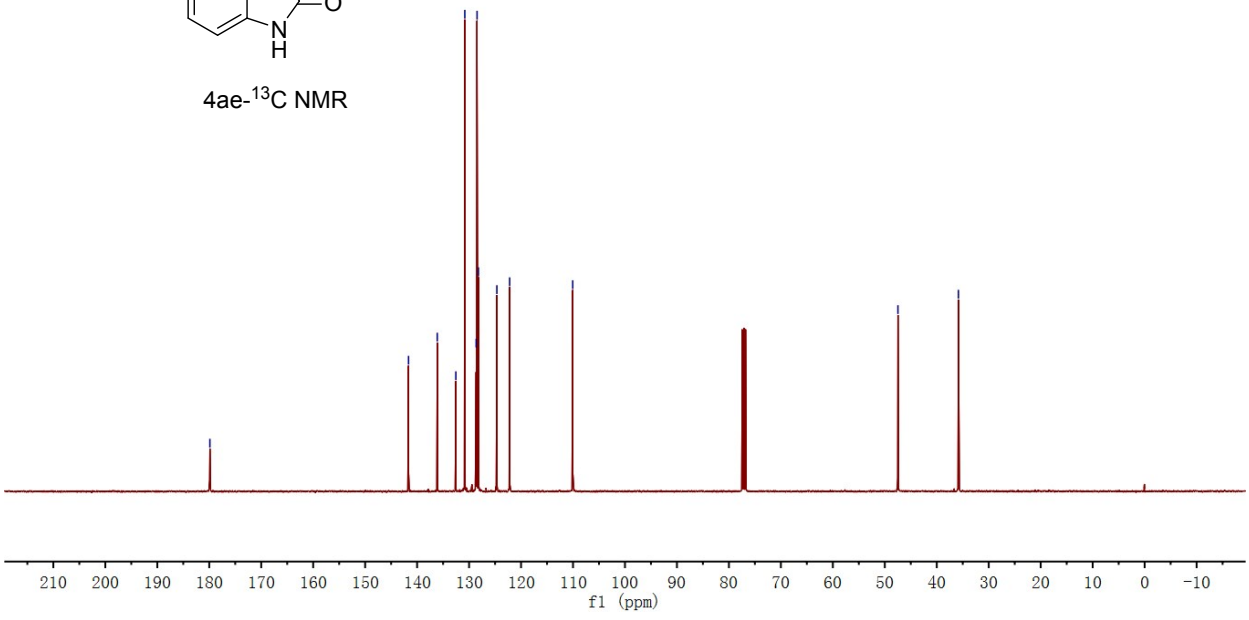


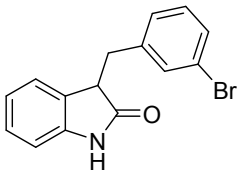
4ae-^{1}H NMR



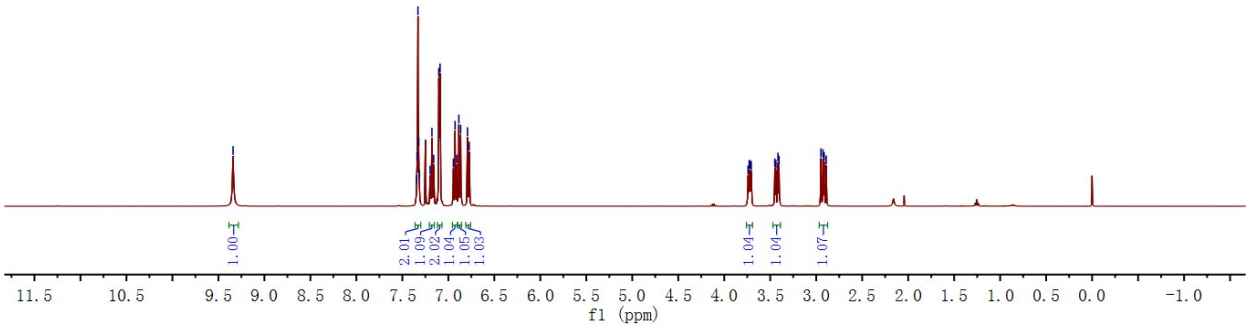


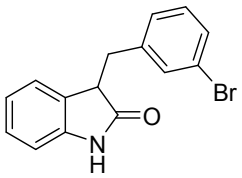
4ae-^{13}C NMR



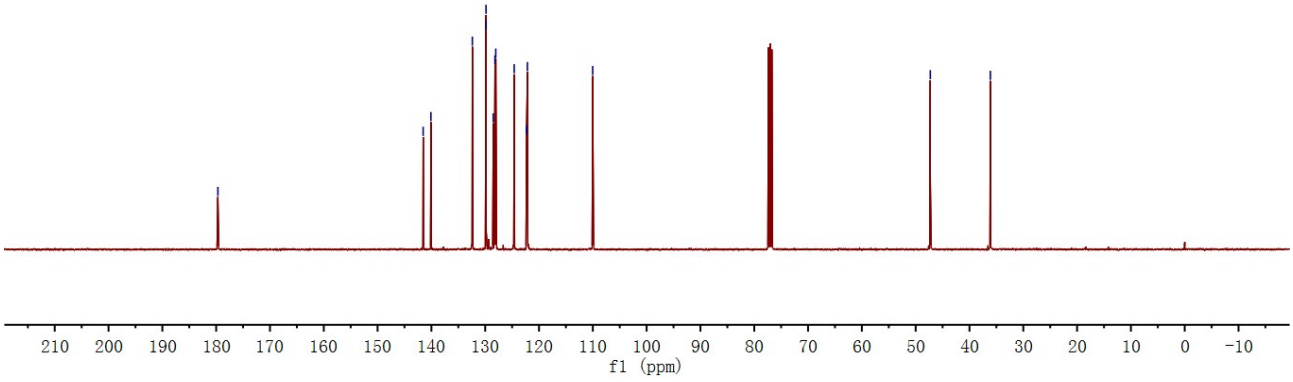


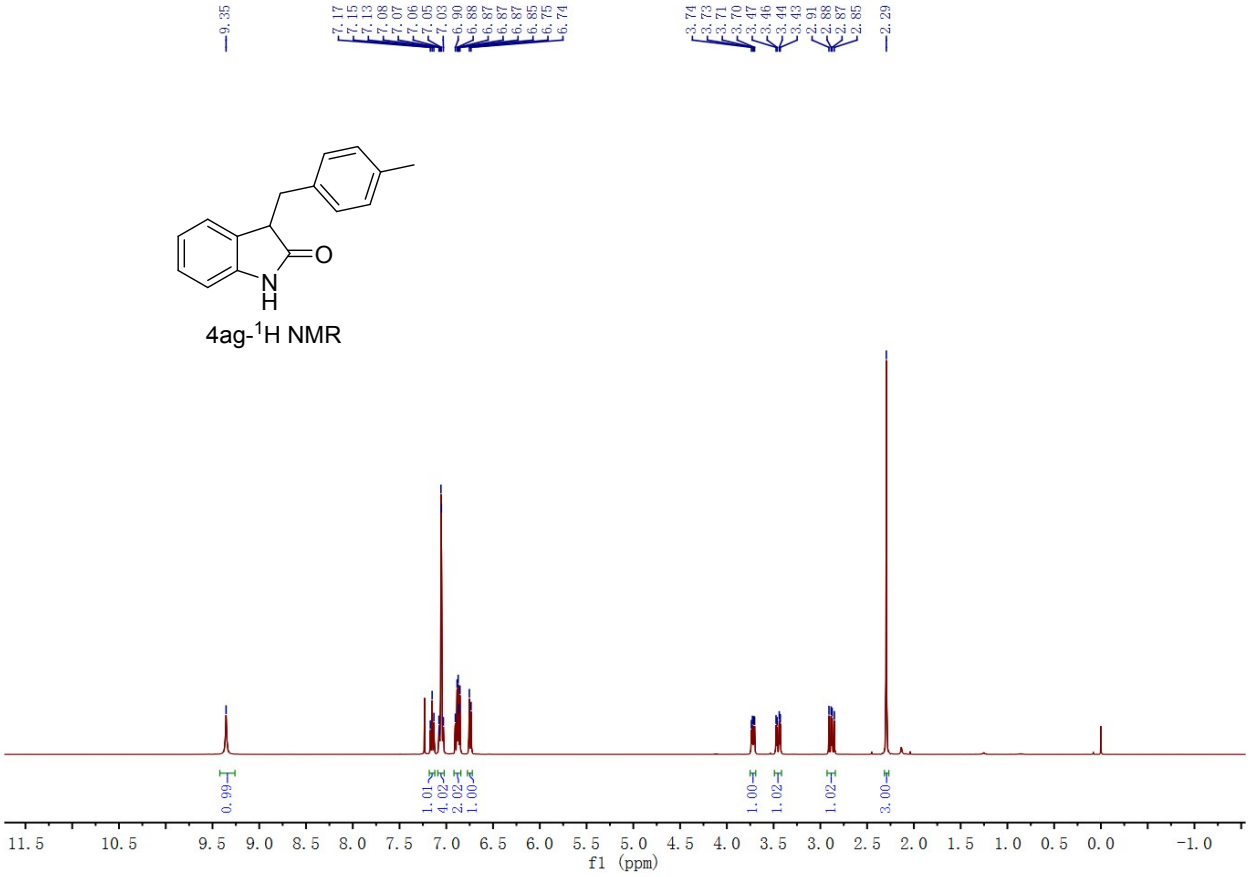
4af-^{1}H NMR



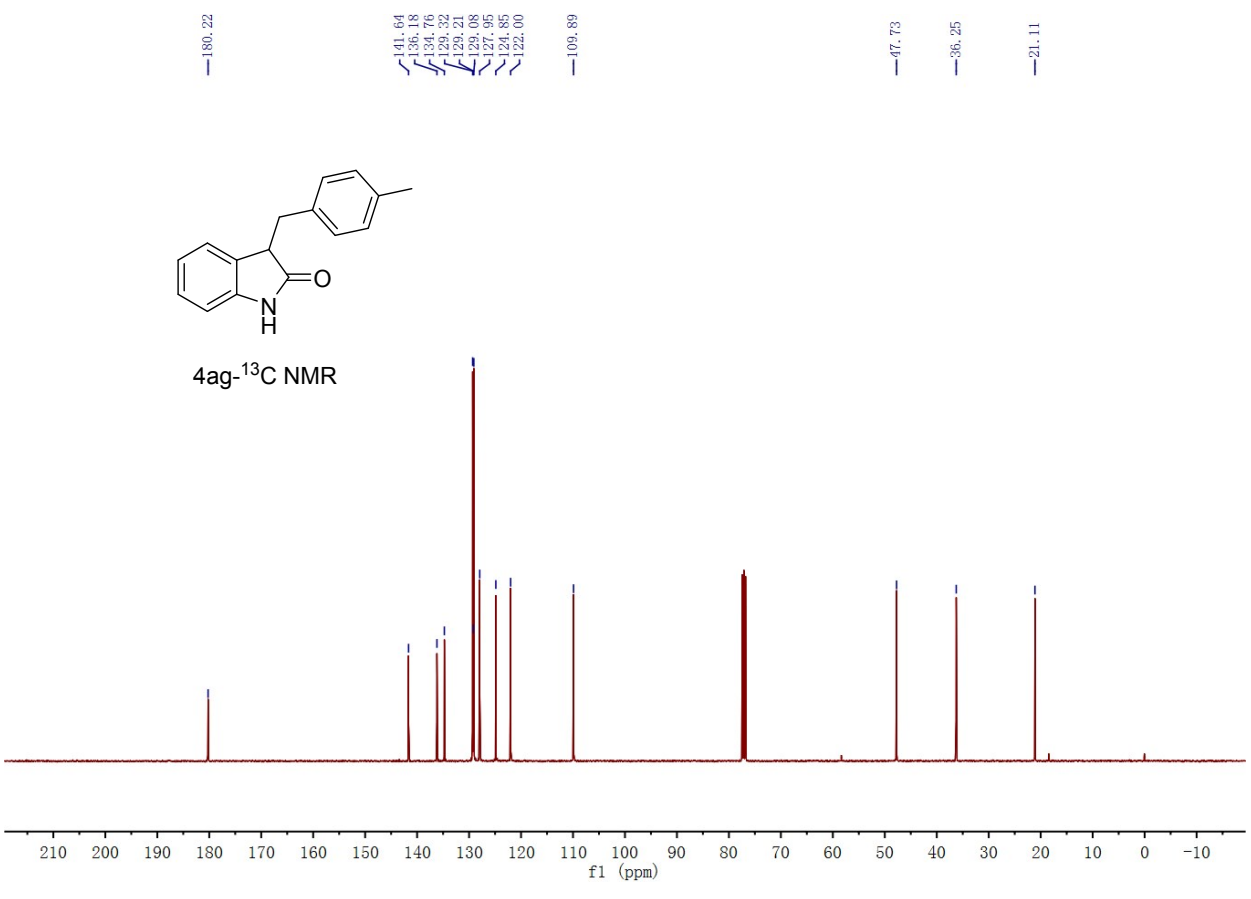


4af-^{13}C NMR

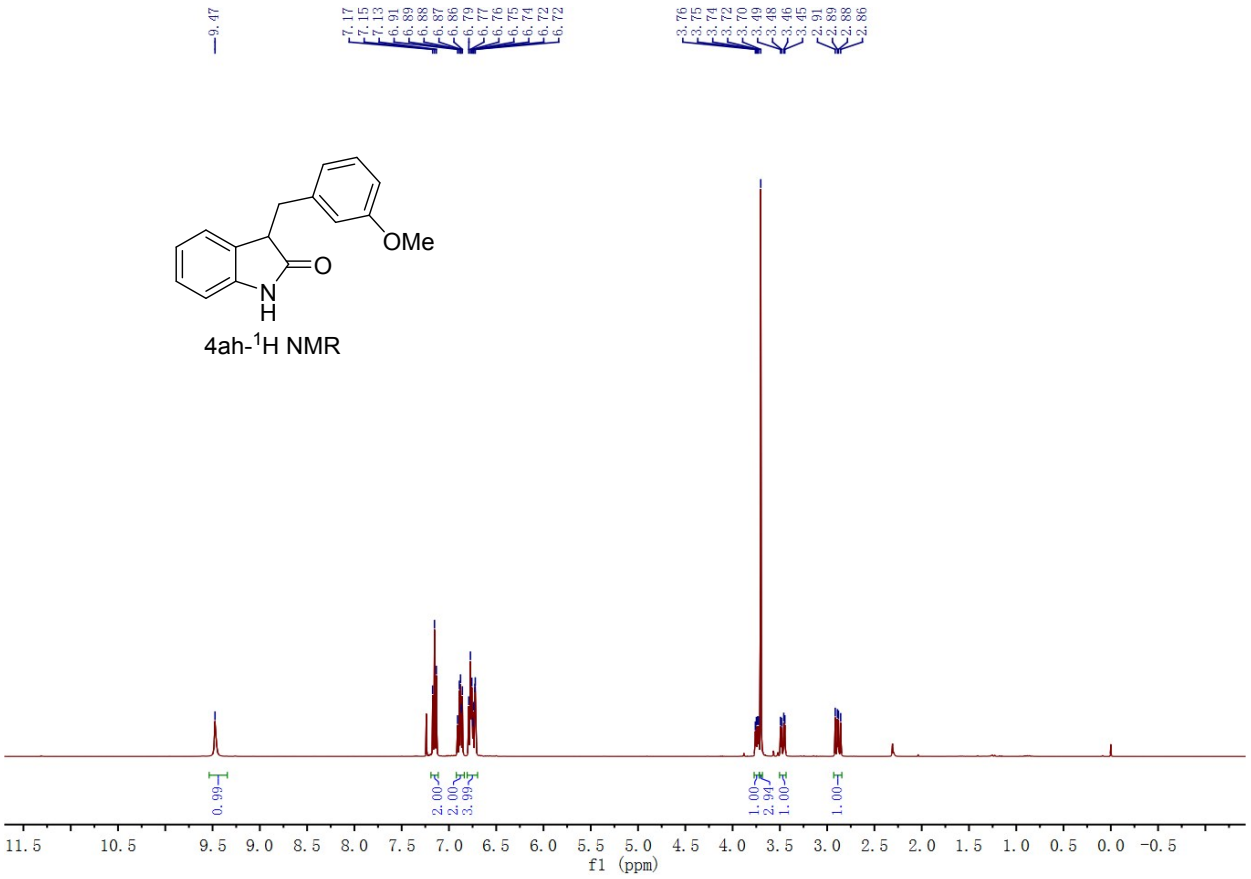




4ag-^{1}H NMR

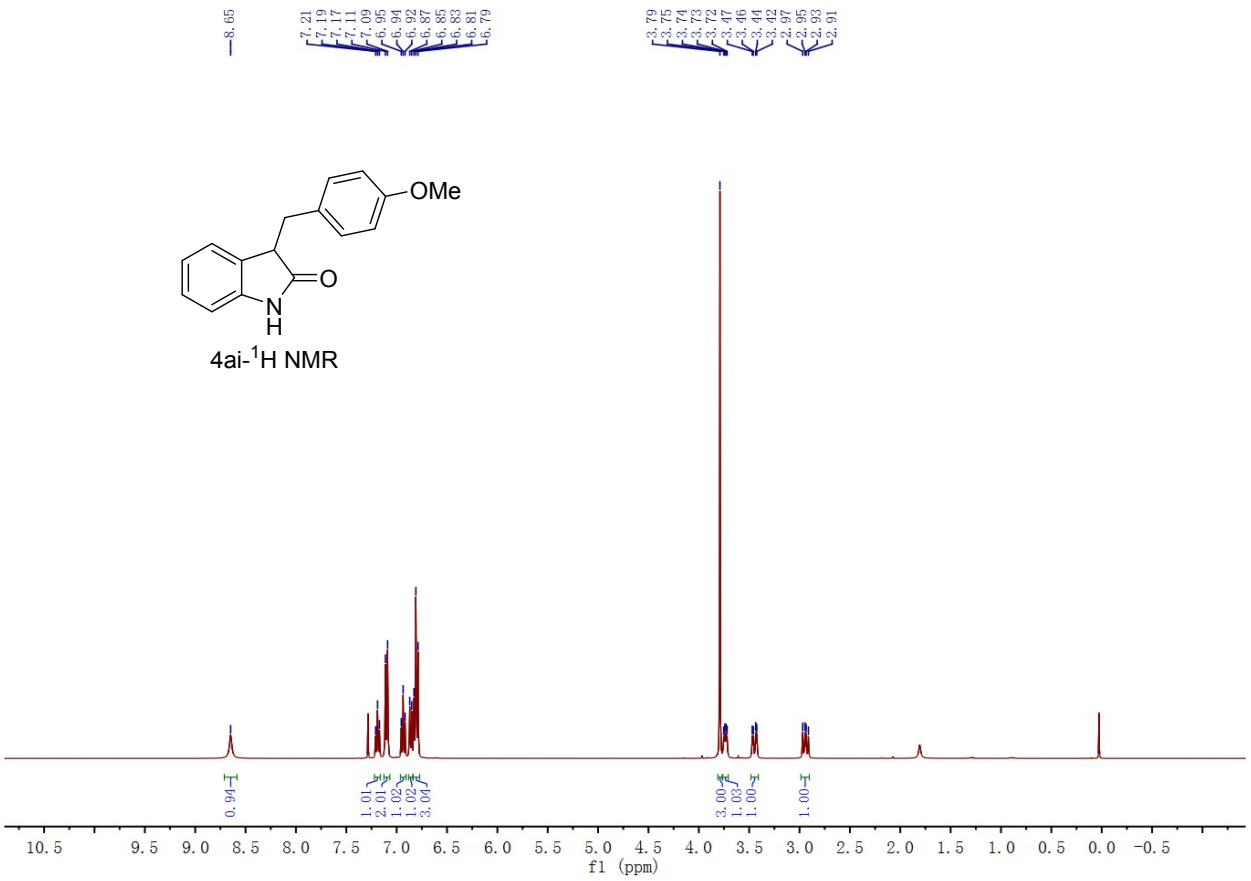


4ag-^{13}C NMR

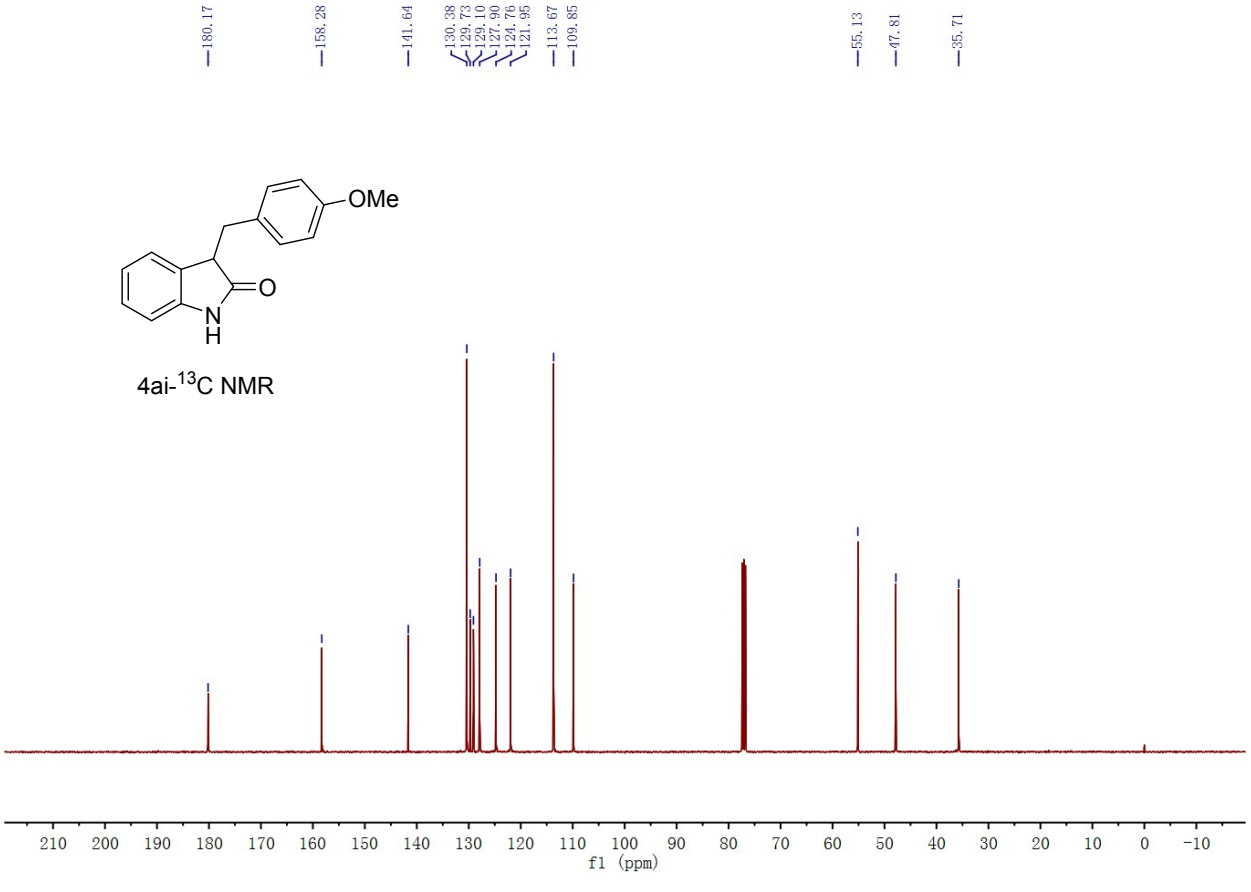


4ah-^{1}H NMR

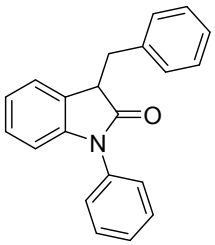
4ah-^{13}C NMR



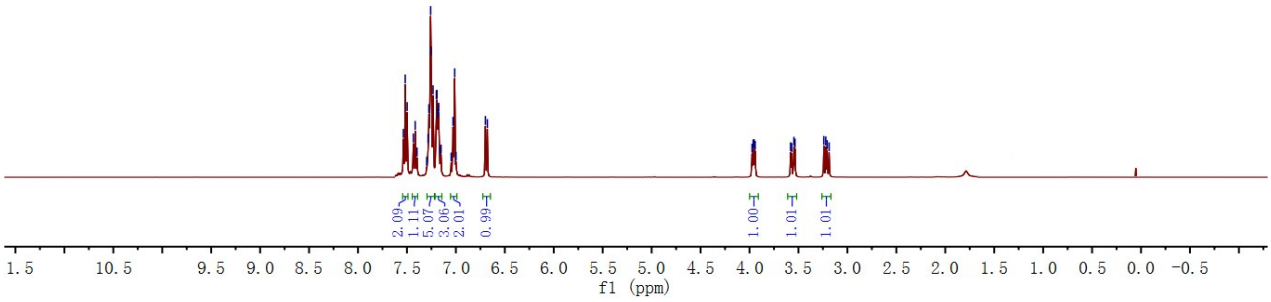
4ai-^{1}H NMR

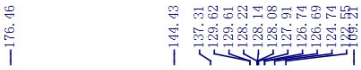


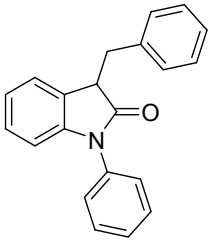
4ai-^{13}C NMR



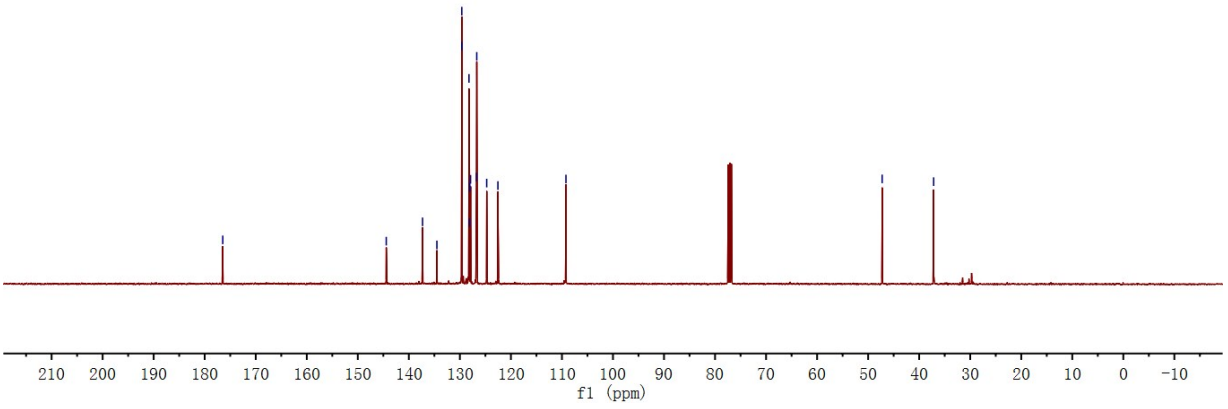
4aj-^{1}H NMR

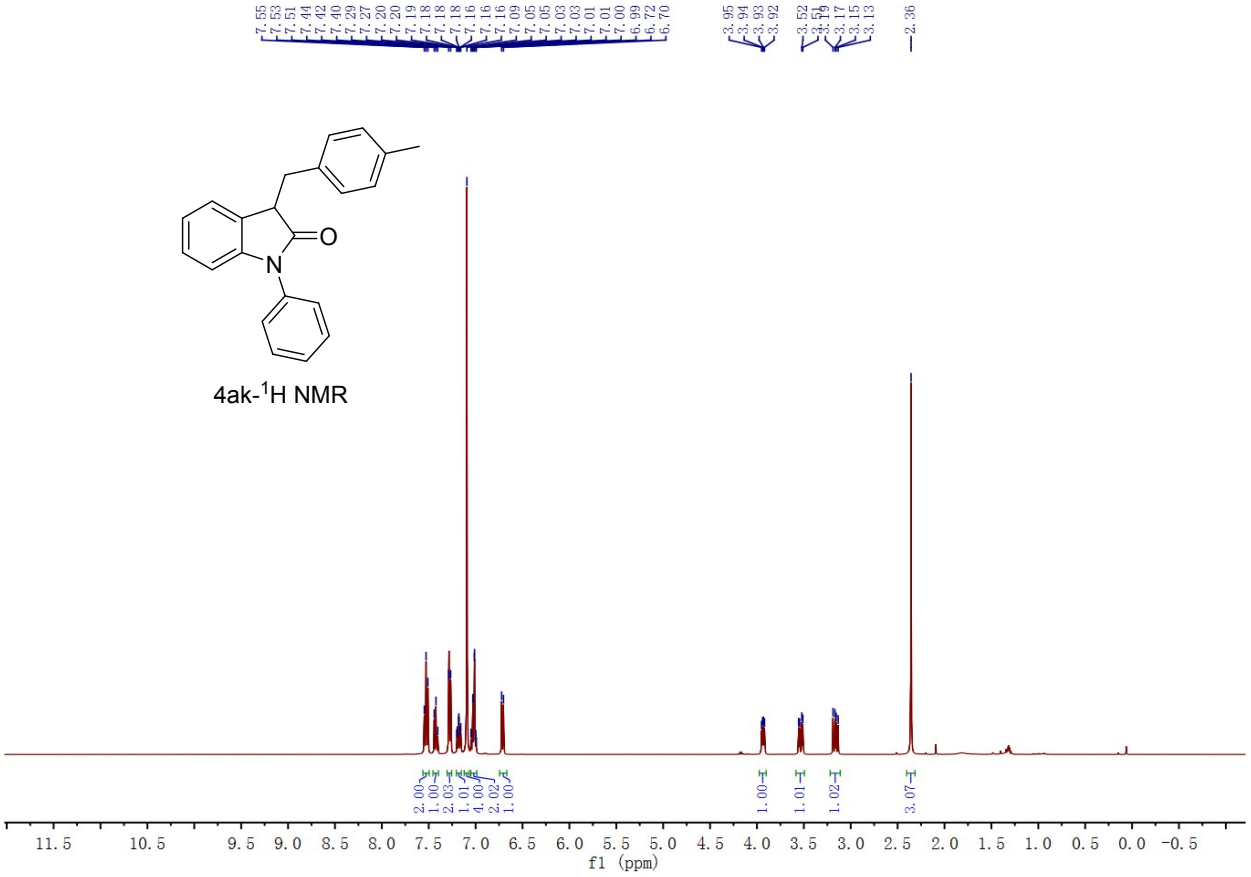




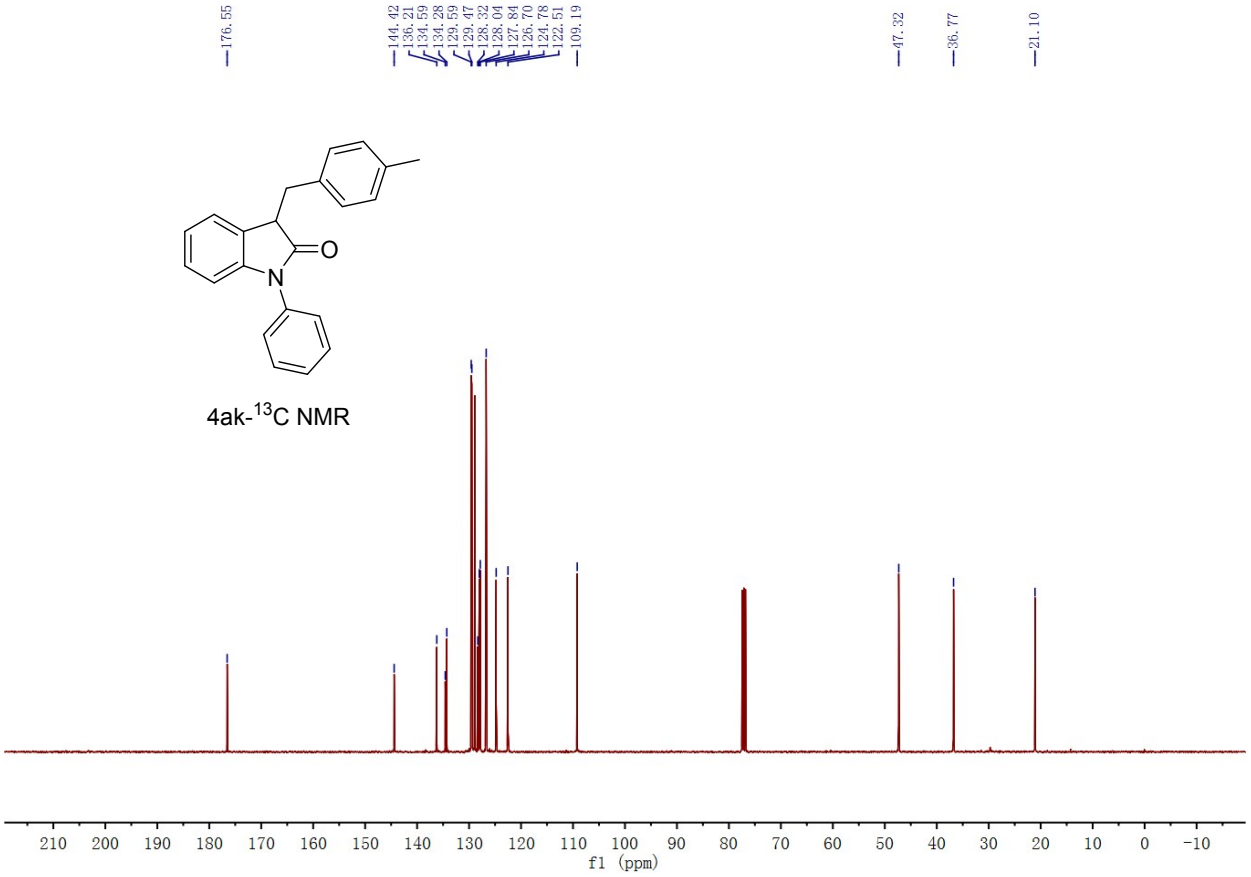


4aj-^{13}C NMR

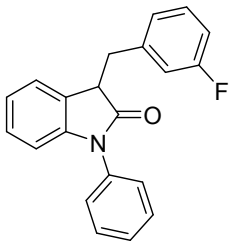




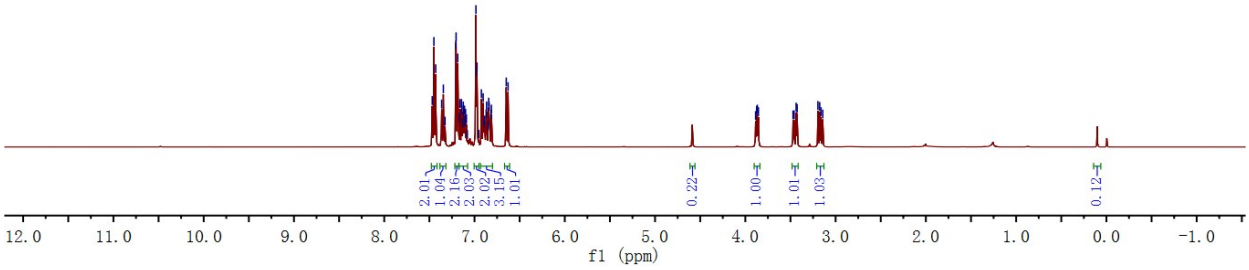
4ak-^{1}H NMR

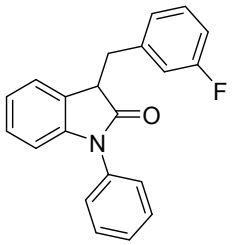


4ak-^{13}C NMR

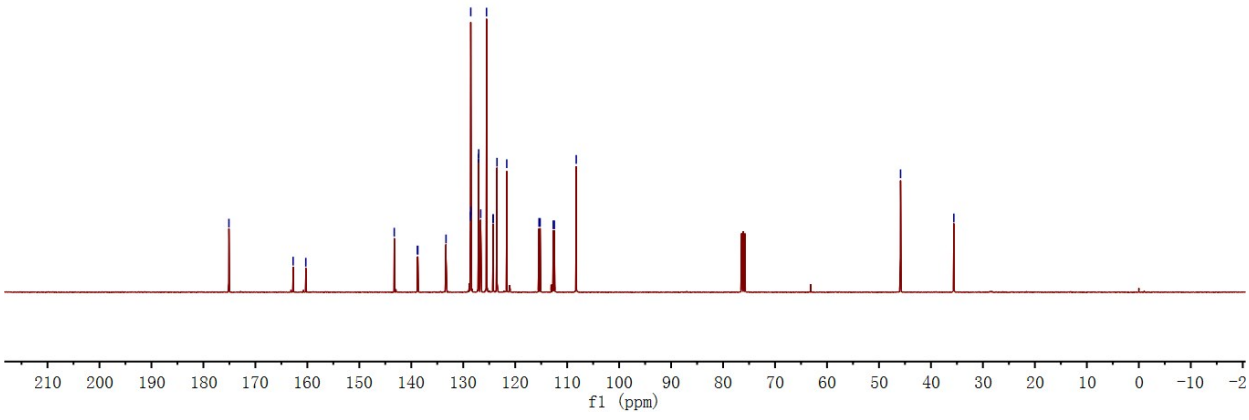


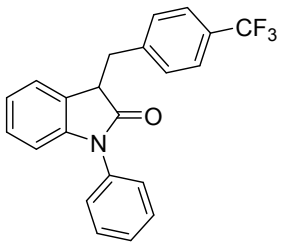
4al-^{1}H NMR



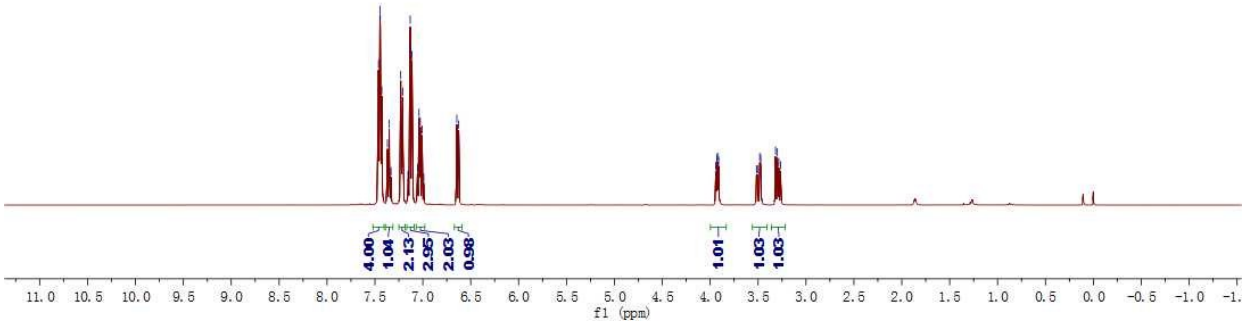


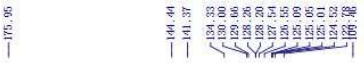
4al-^{13}C NMR

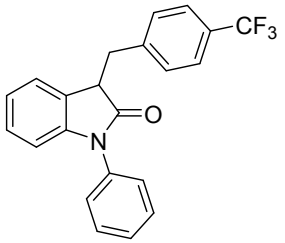




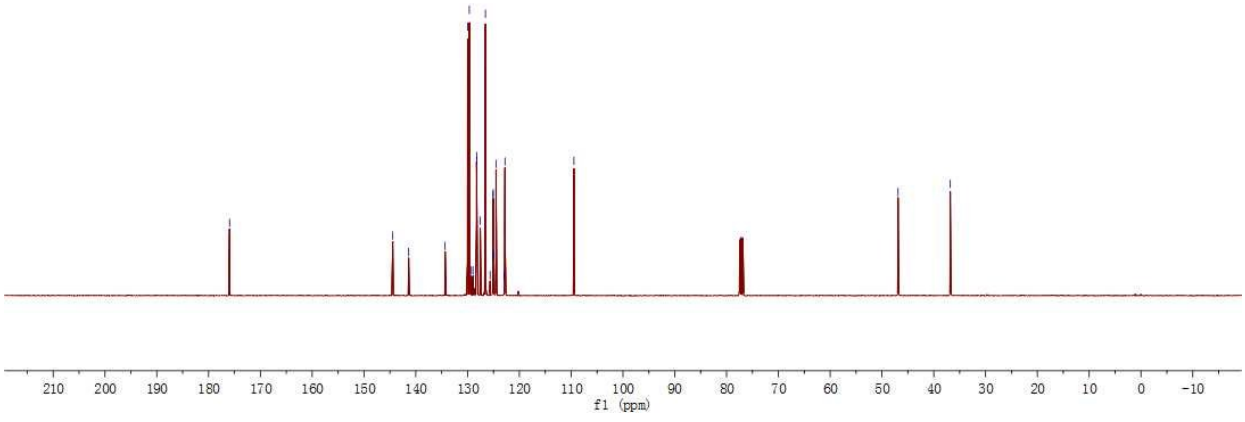
4am-^{1}H NMR

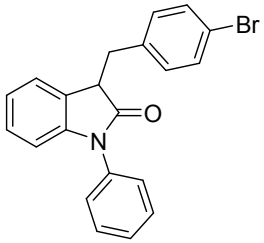




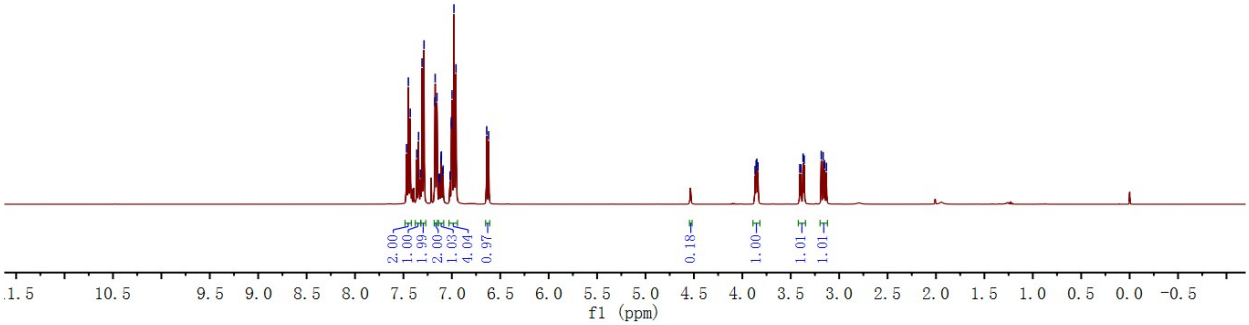


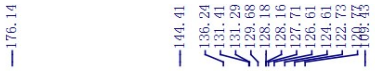
4am-^{13}C NMR

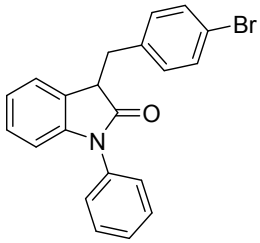




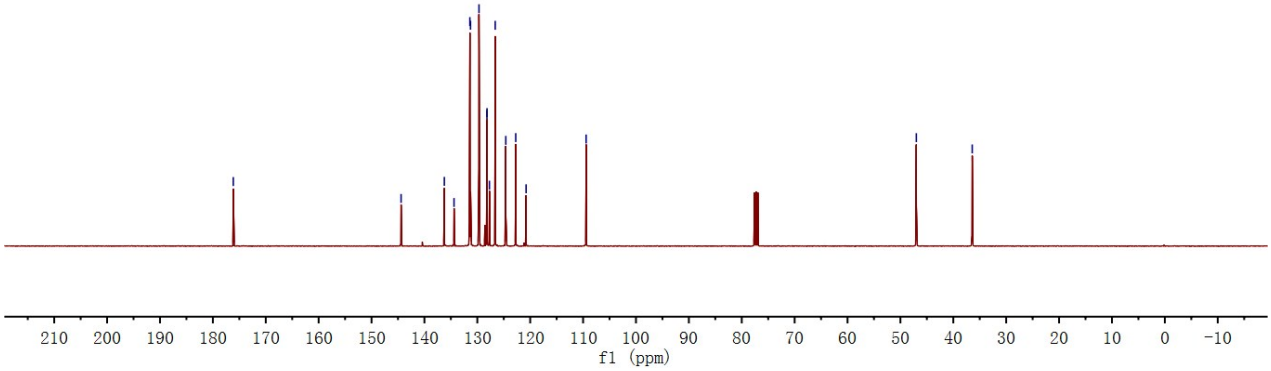
4an-^{1}H NMR

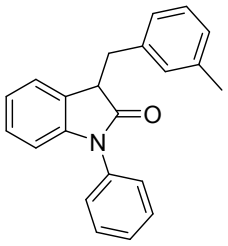




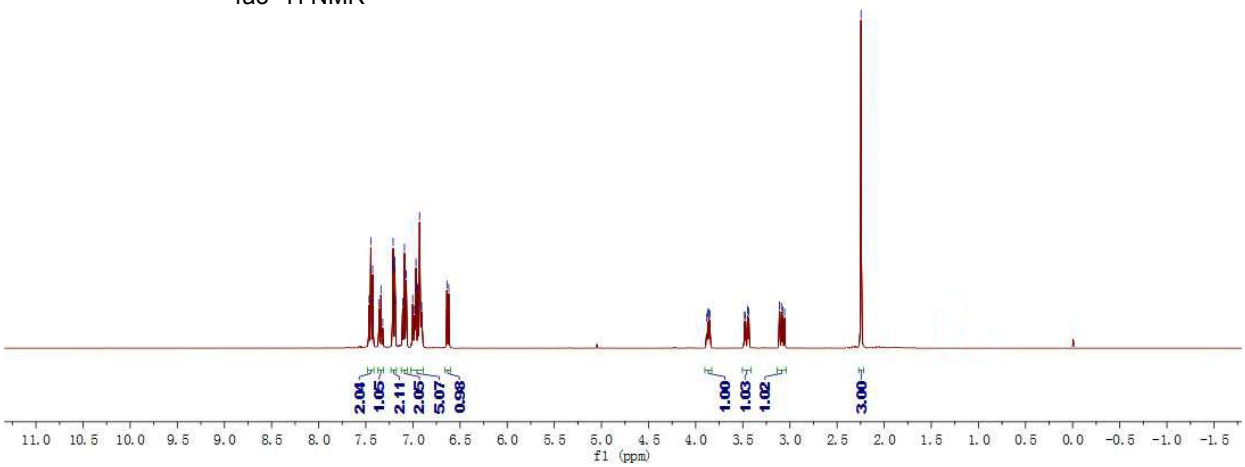


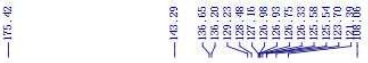
4an-^{13}C NMR

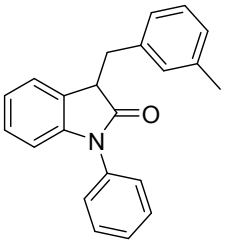




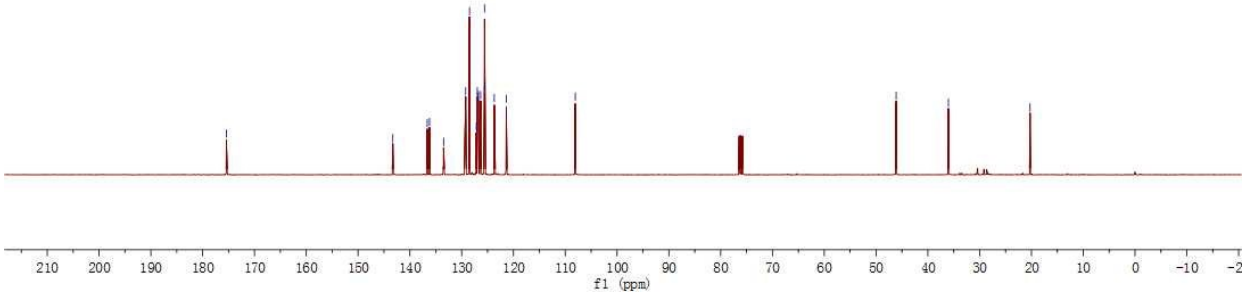
4ao-^{1}H NMR

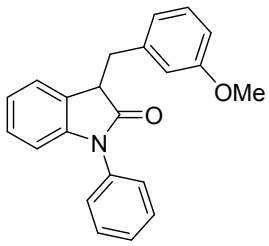




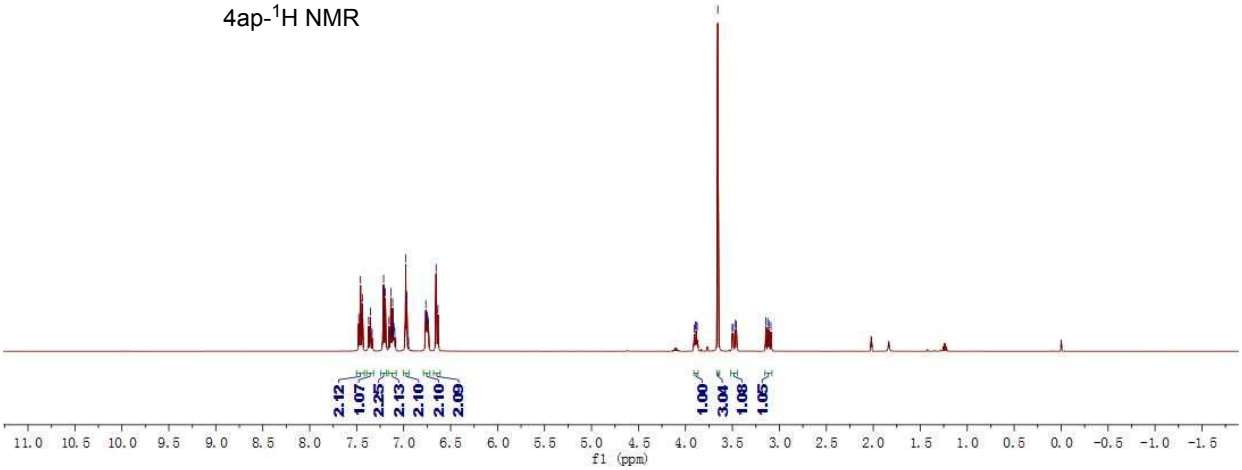


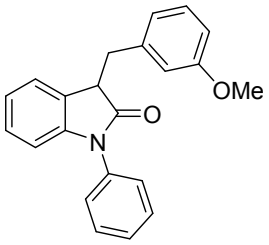
4ao-^{13}C NMR



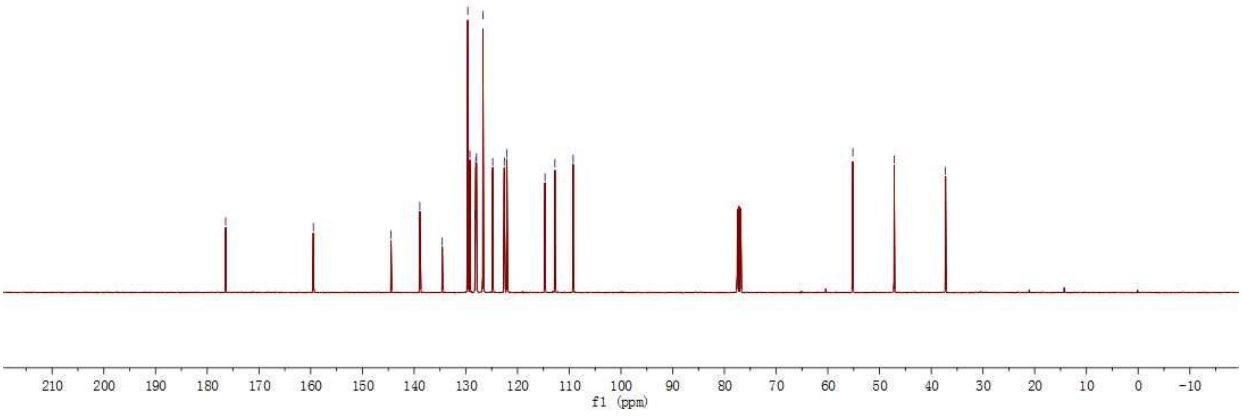


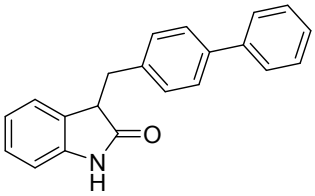
4ap-^{1}H NMR



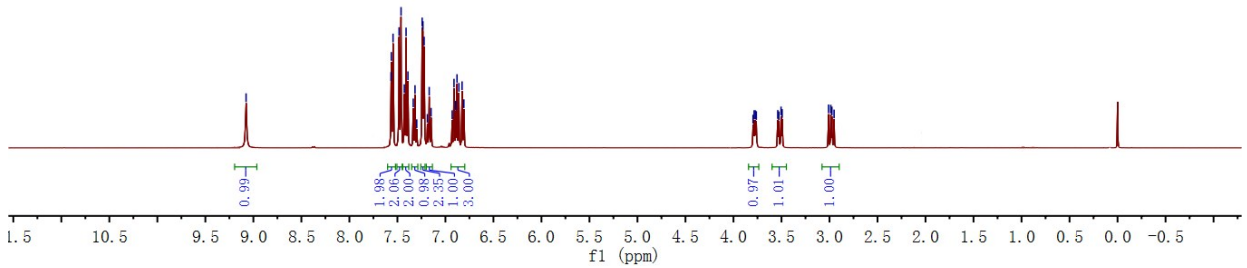


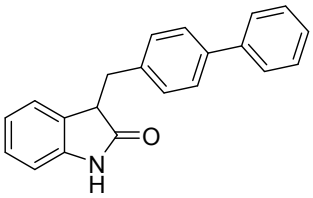
4ap-^{13}C NMR



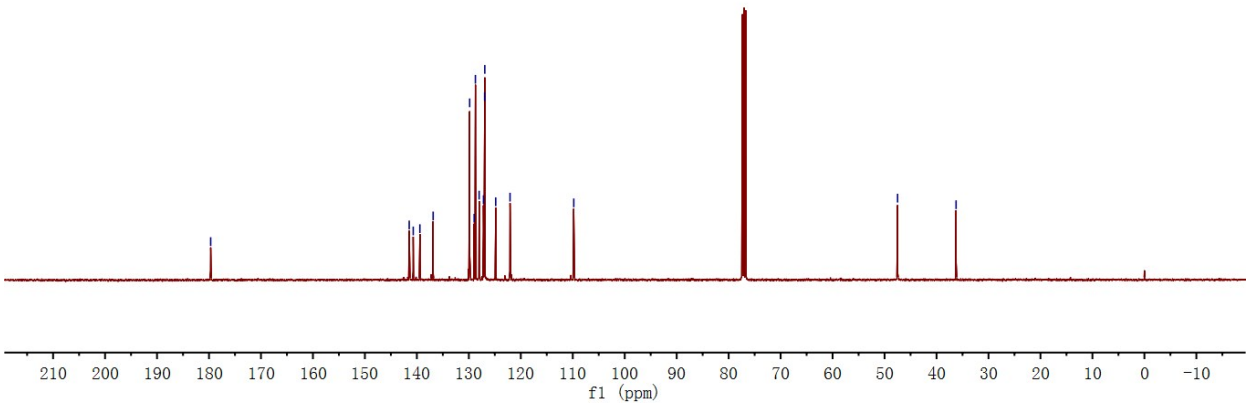


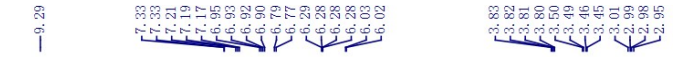
4aq-^{1}H NMR

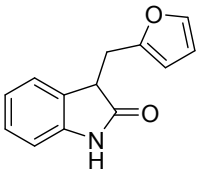




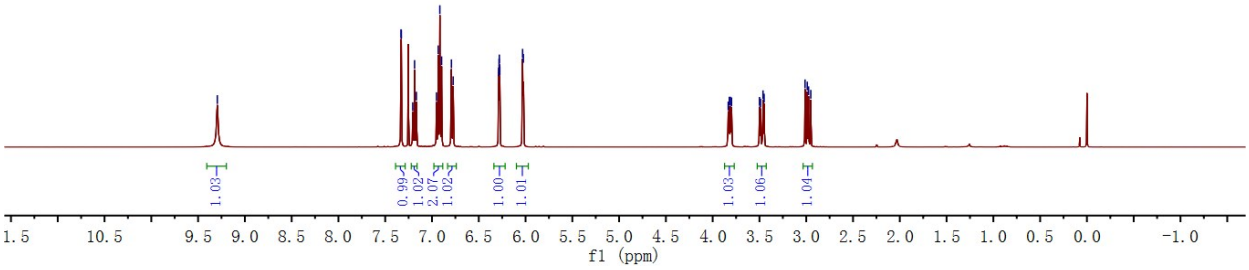
4aq-^{13}C NMR

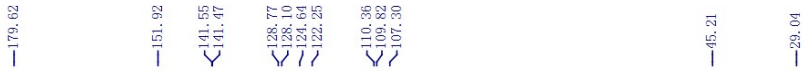


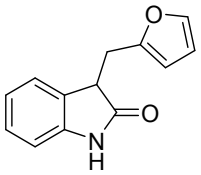




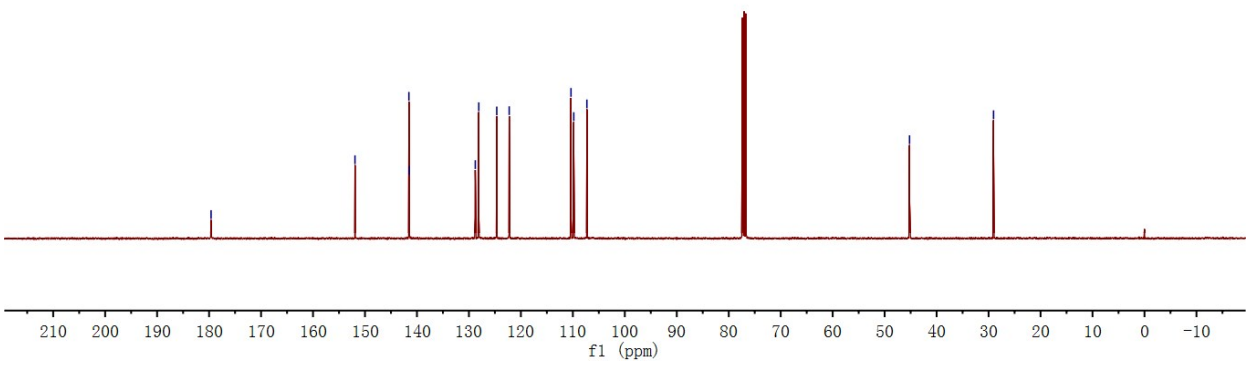
4ar-^{1}H NMR

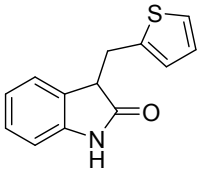




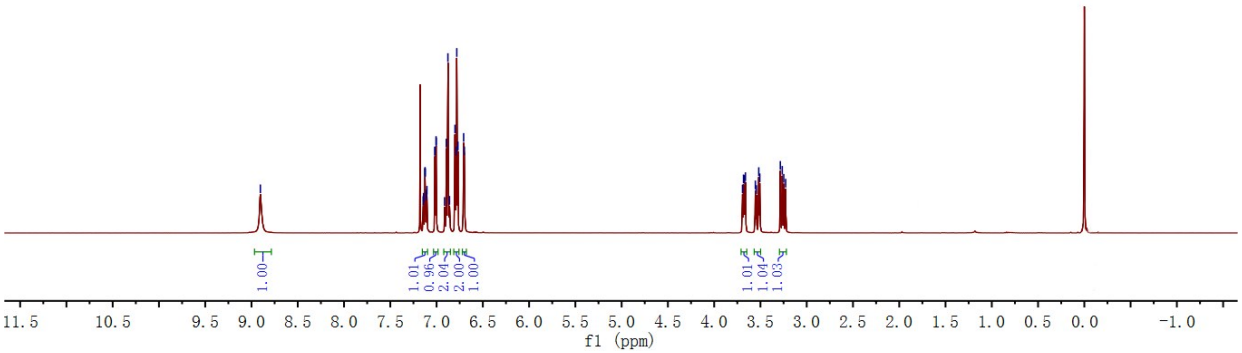


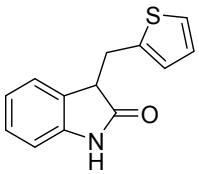
4ar-^{13}C NMR



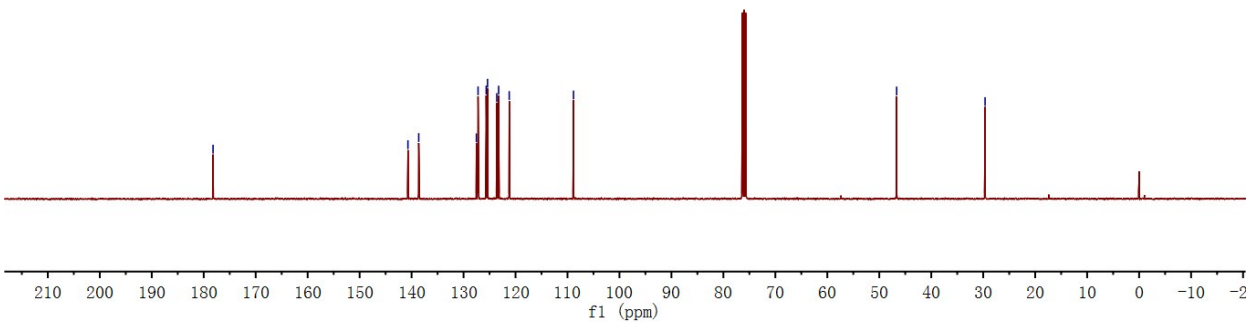


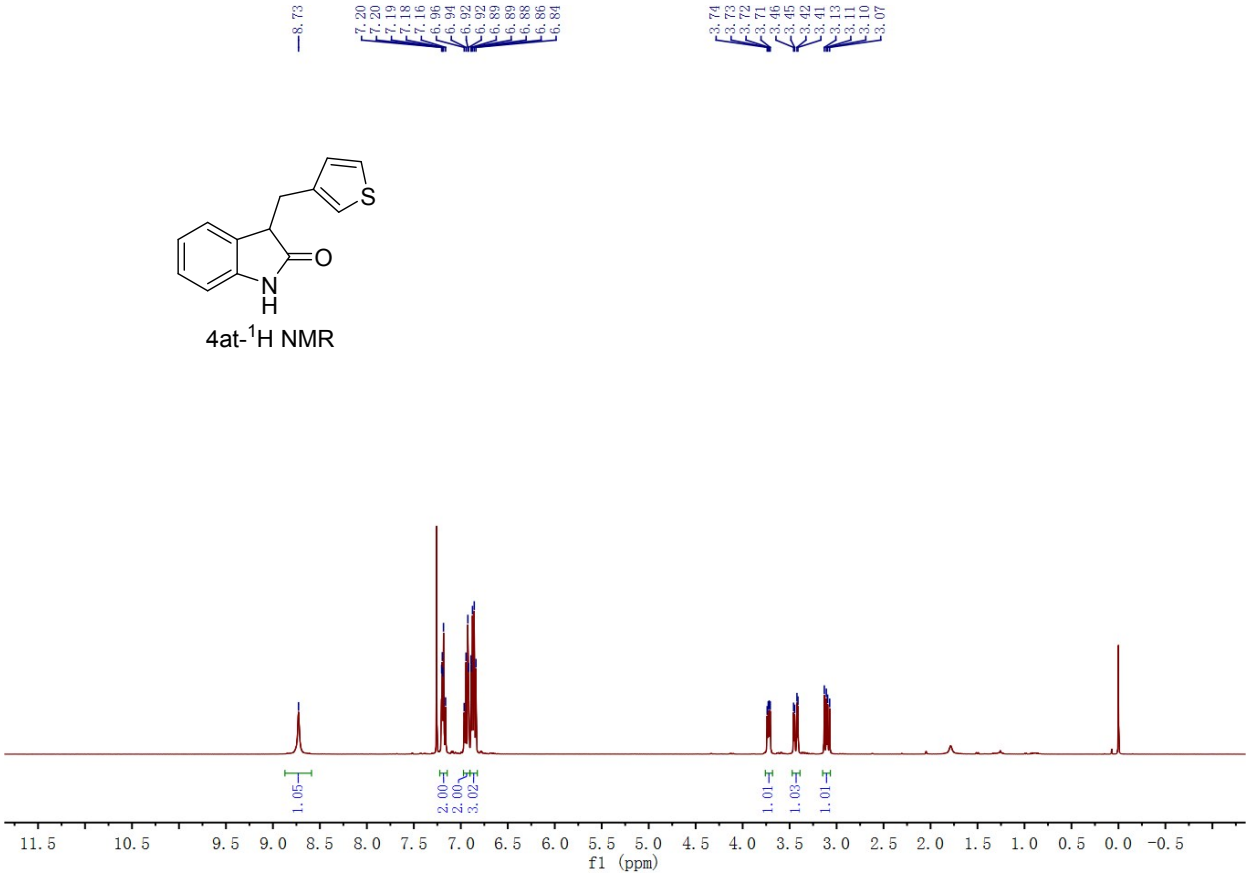
4as-^{1}H NMR



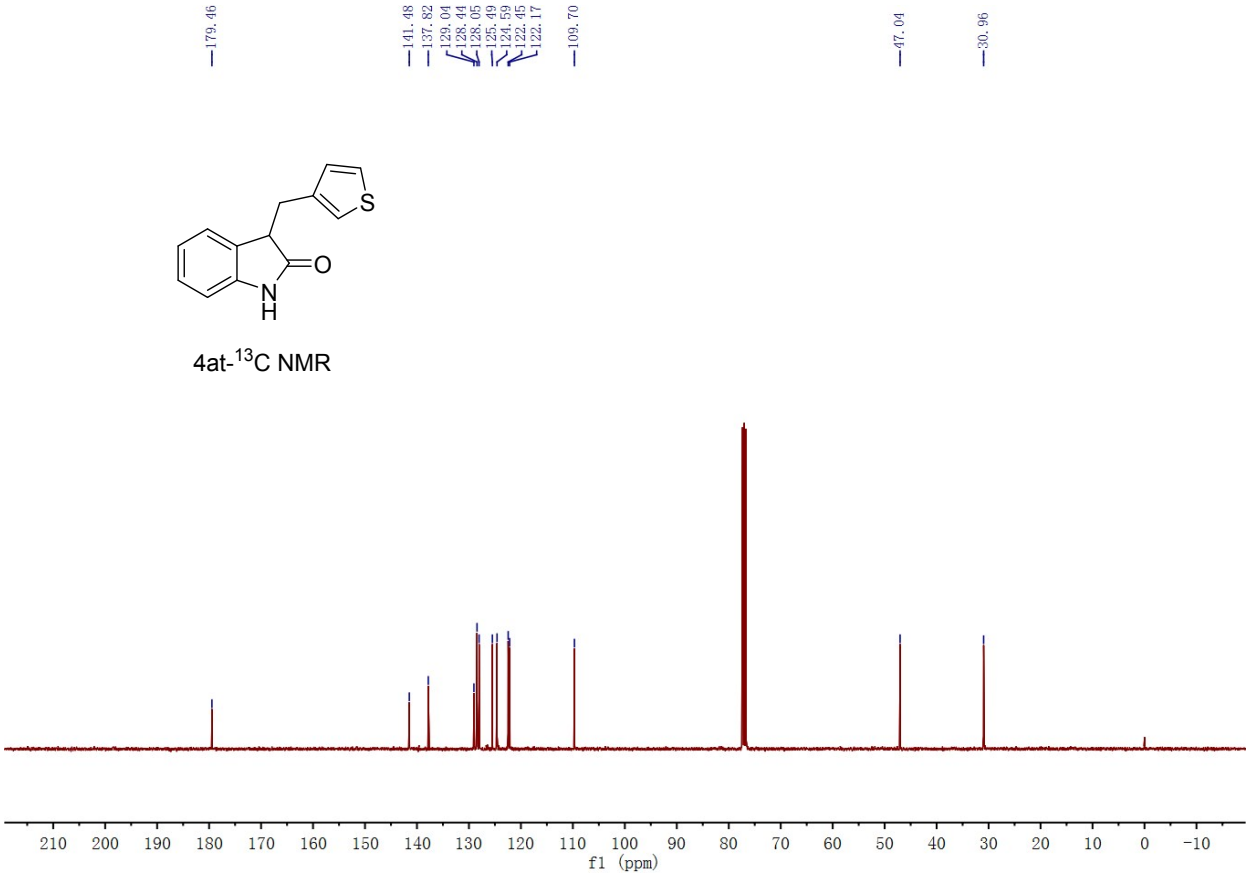


4as-^{13}C NMR

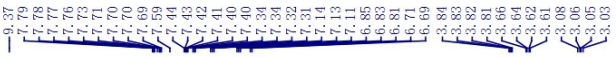


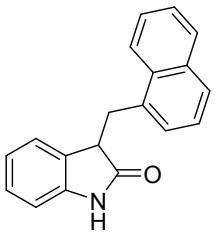


4at-^{1}H NMR

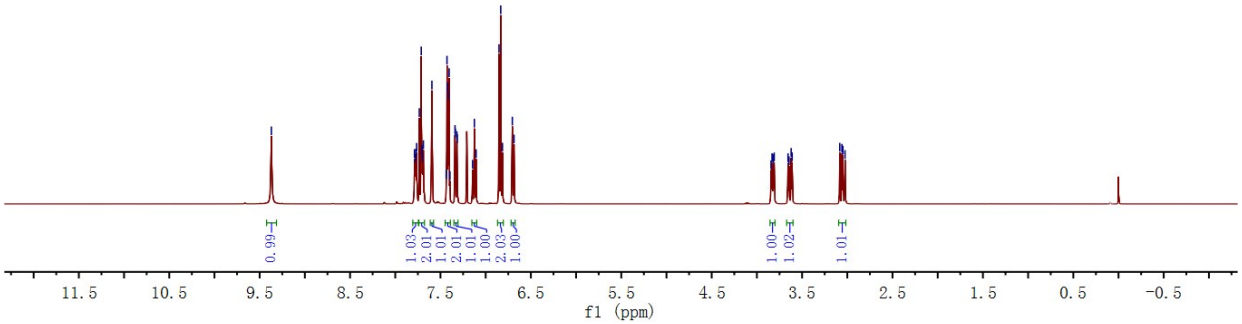


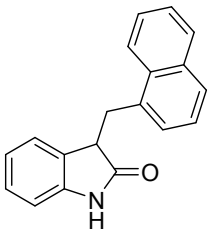
4at-^{13}C NMR



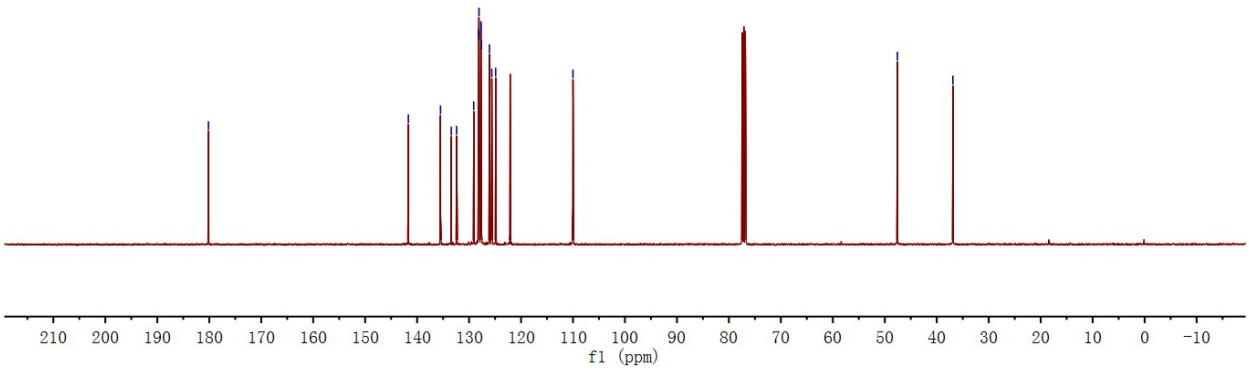


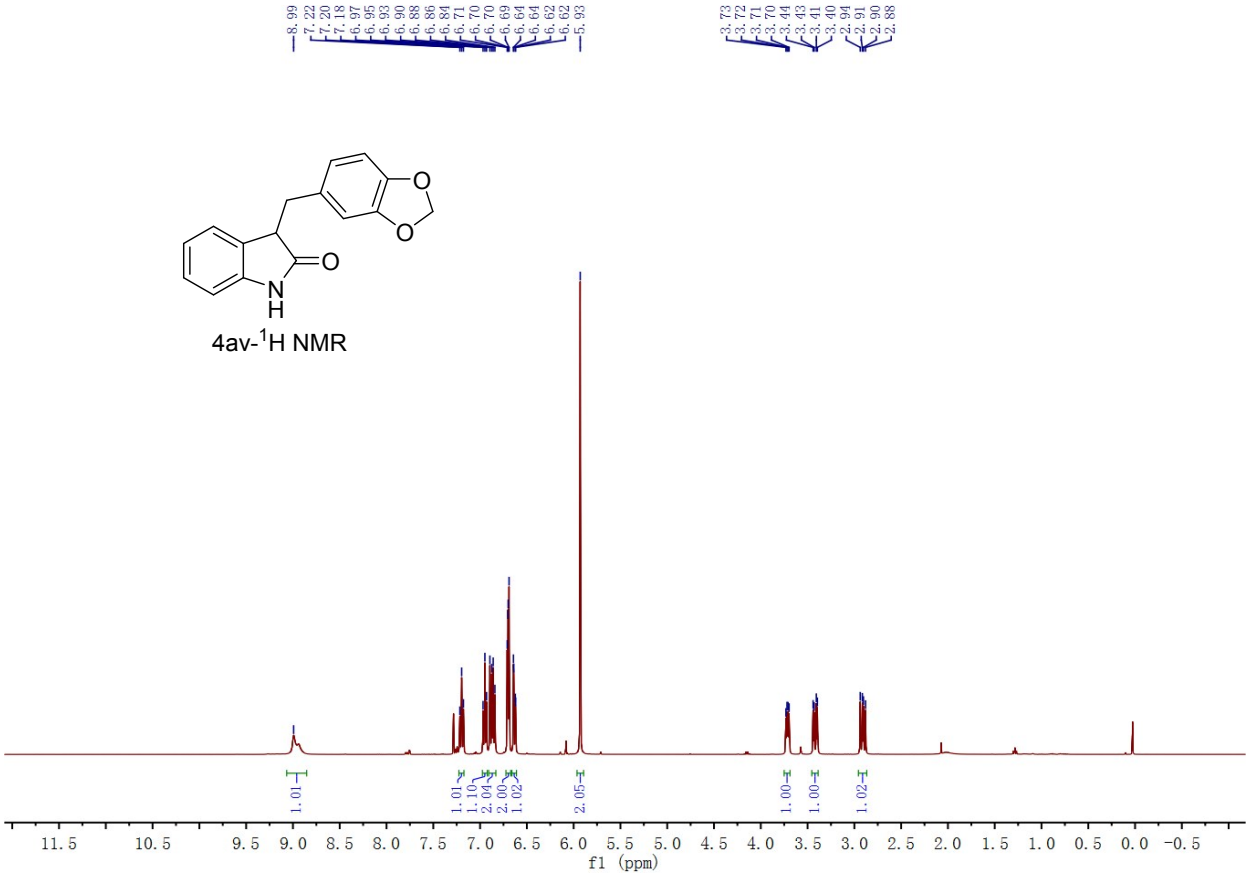
4au-^{1}H NMR



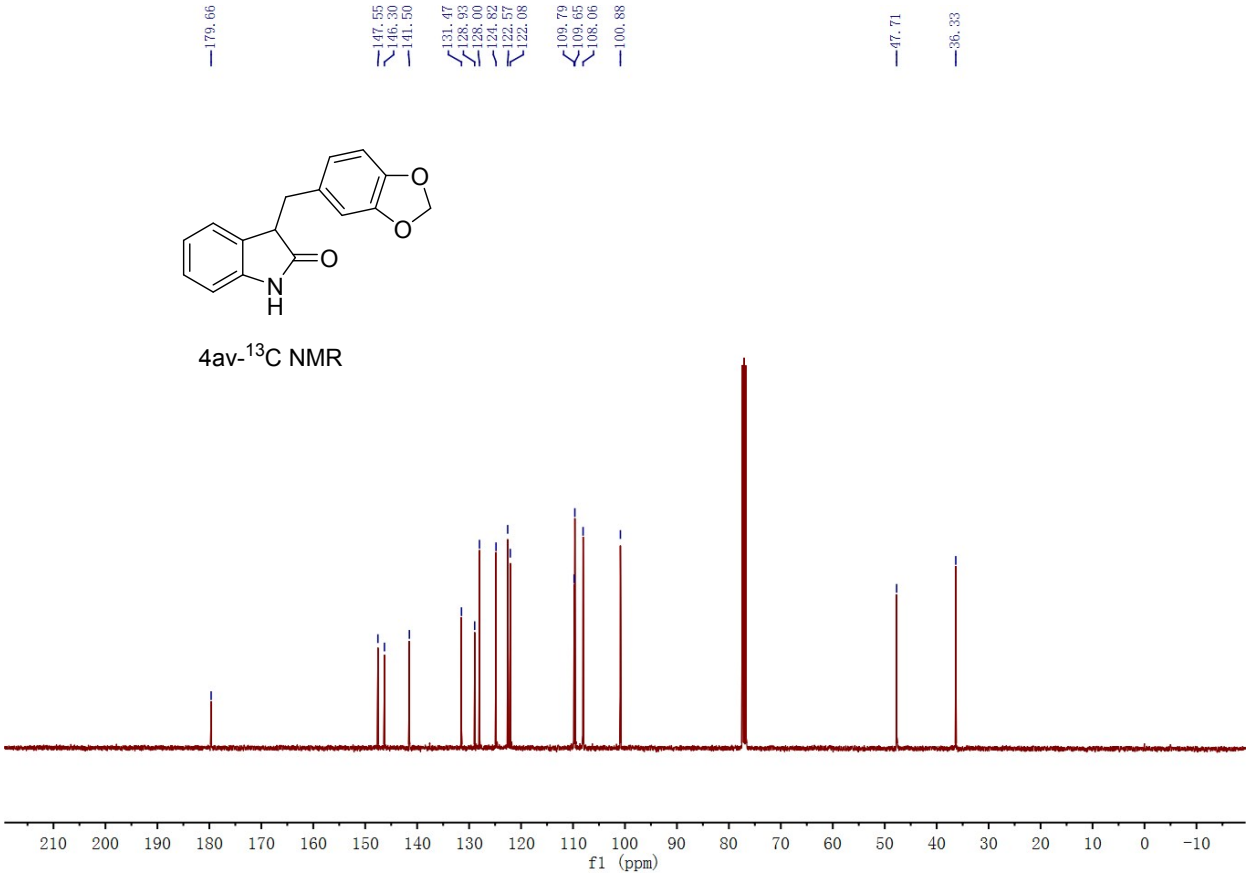


4au-^{13}C NMR

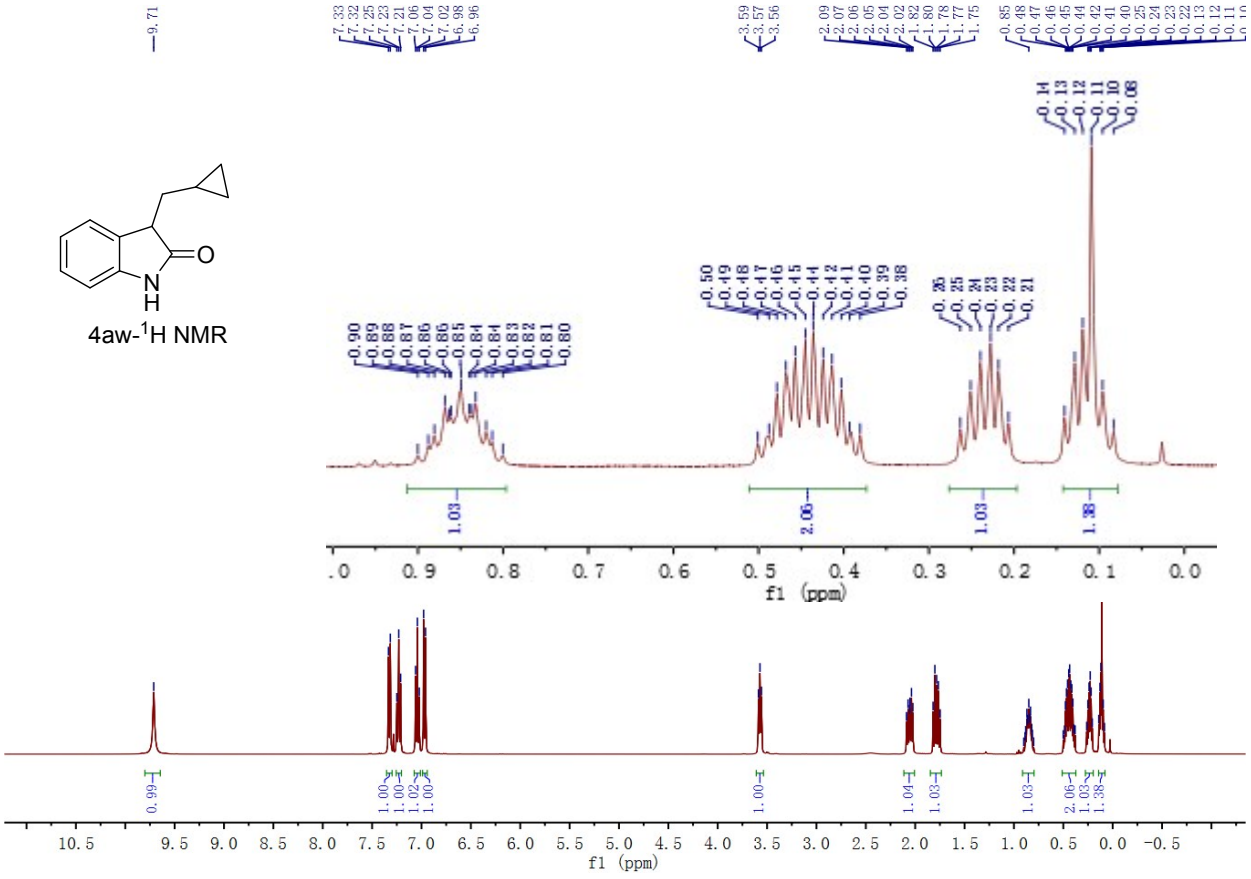




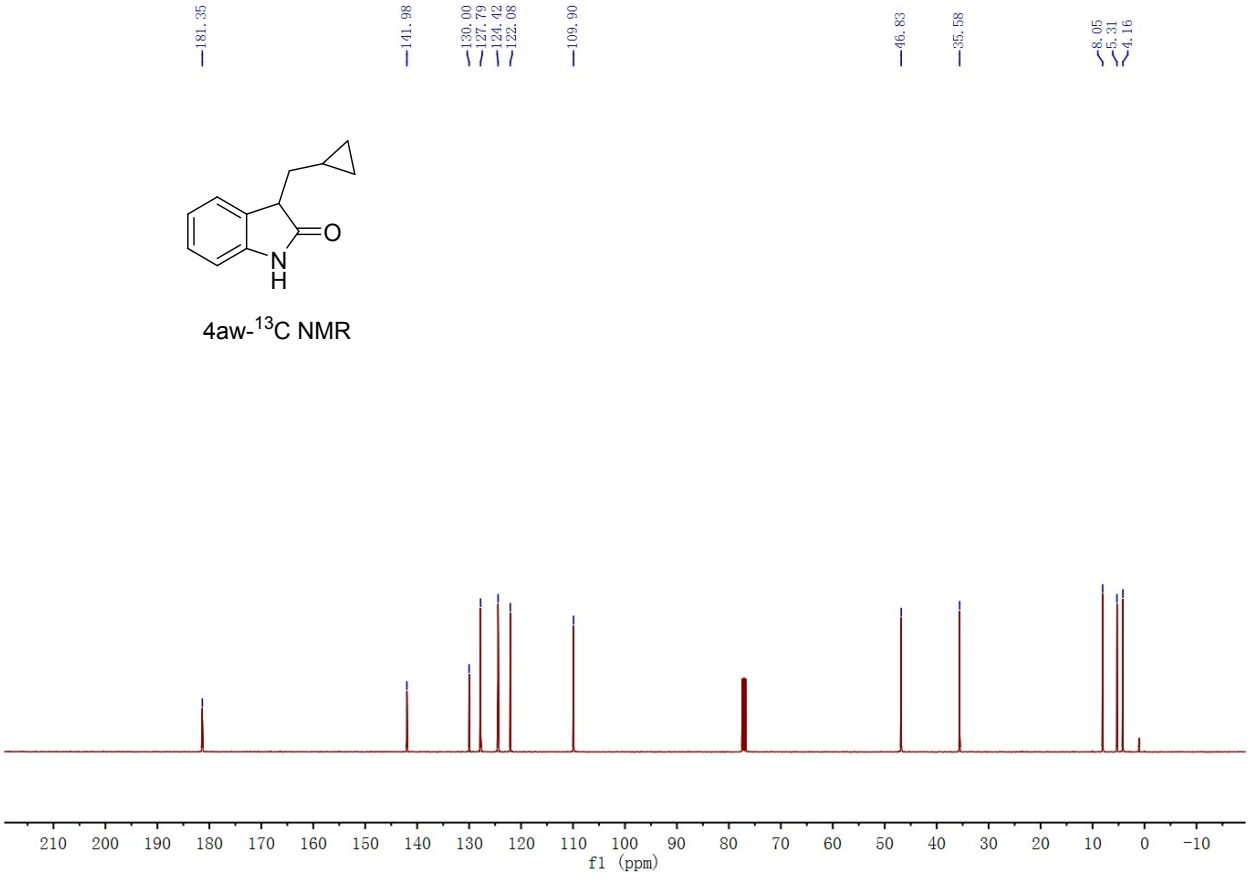
4av-^{1}H NMR



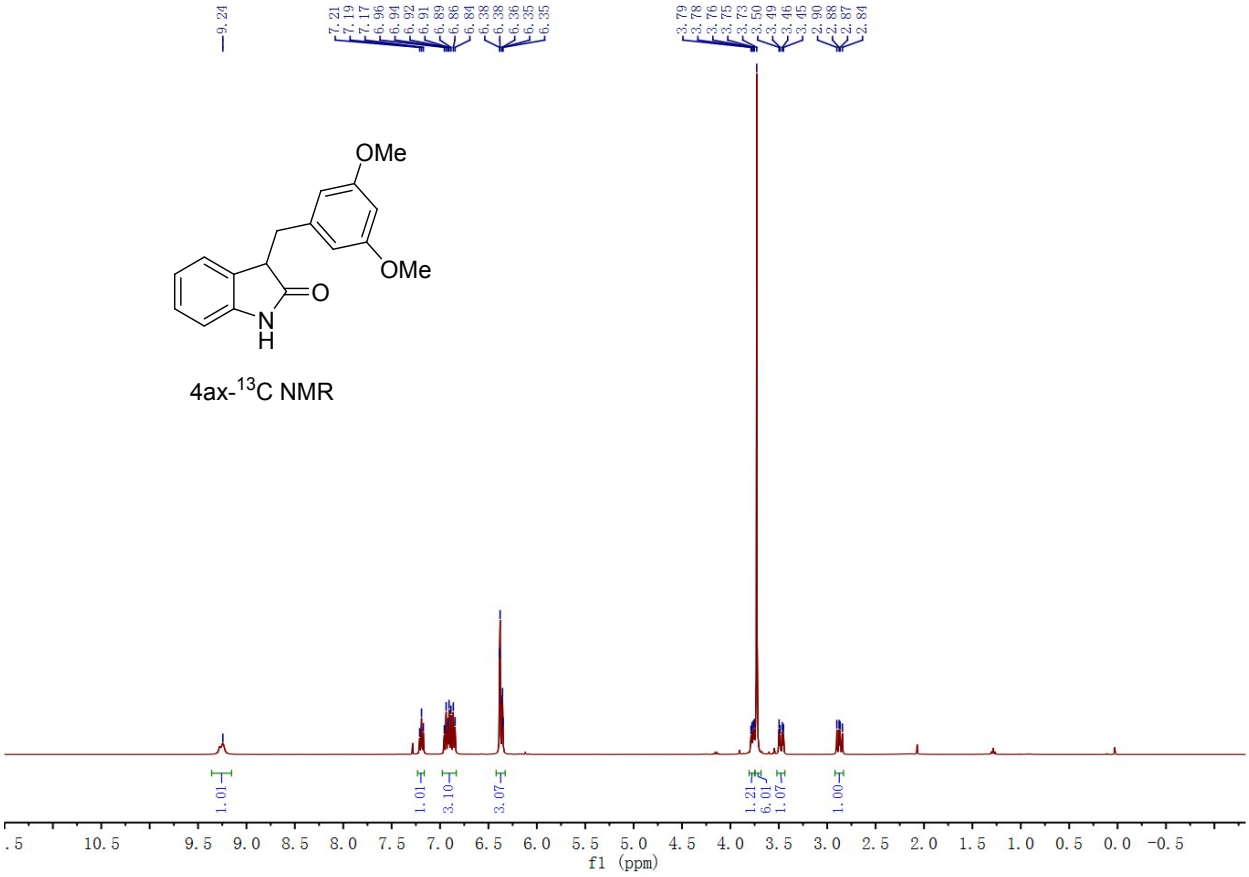
4av-^{13}C NMR



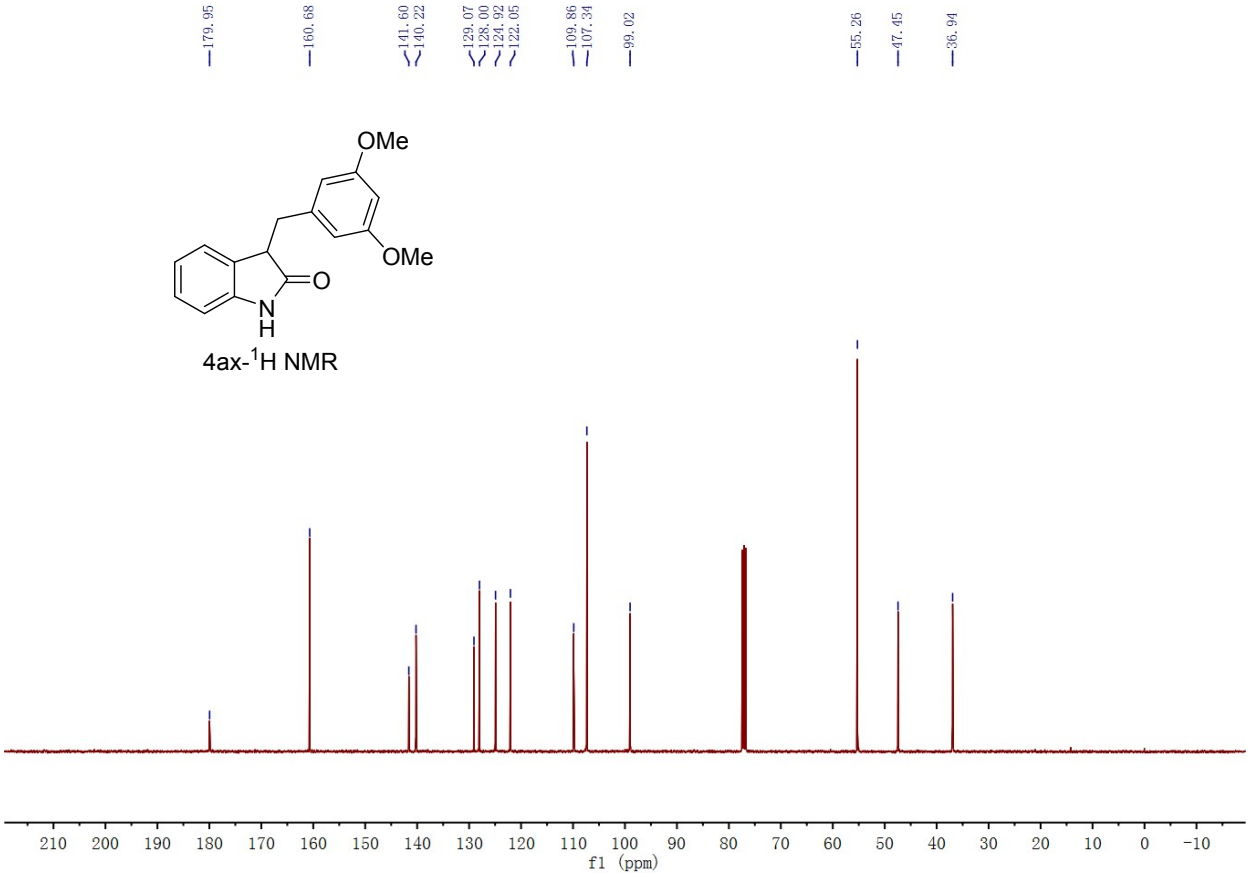
4aw-^{1}H NMR



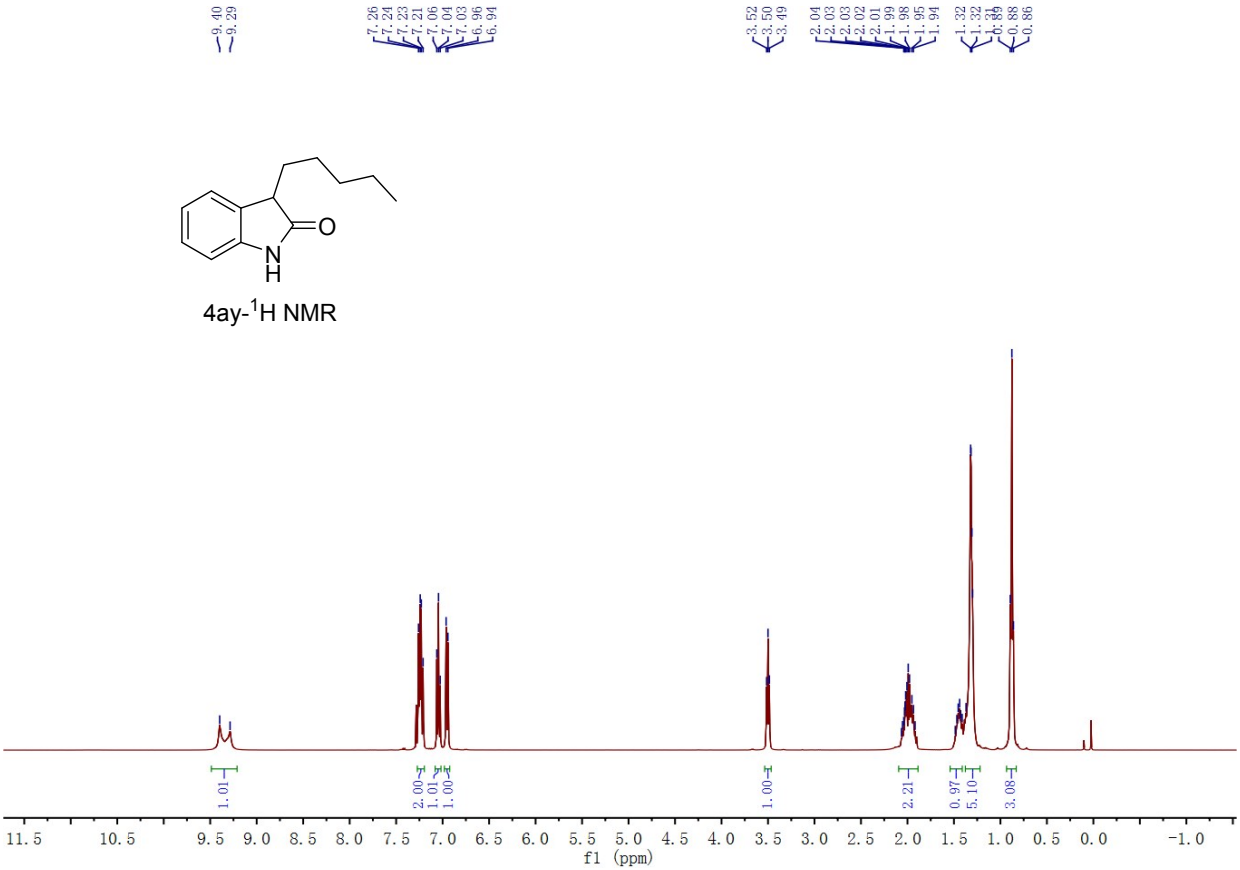
4aw-^{13}C NMR



4ax-^{13}C NMR

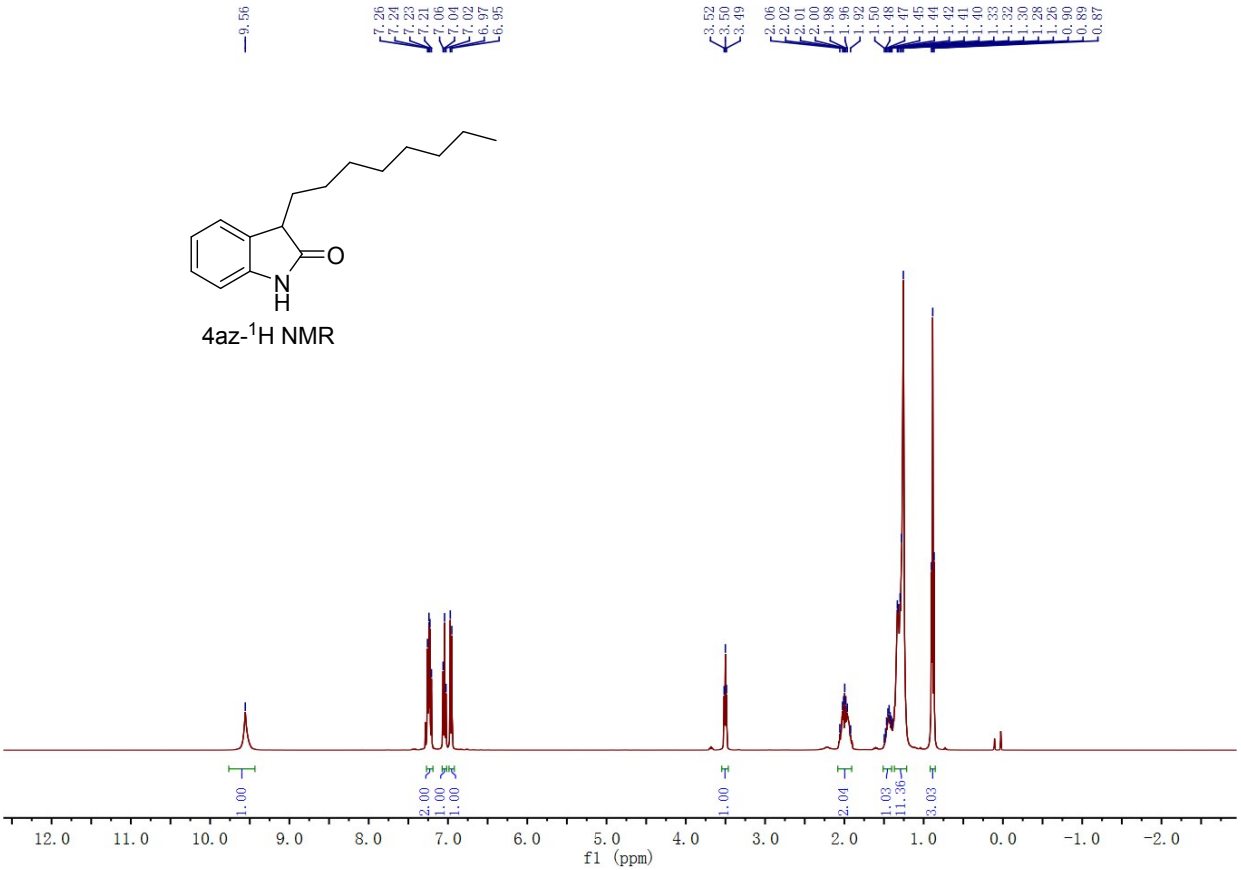


4ax-^{1}H NMR

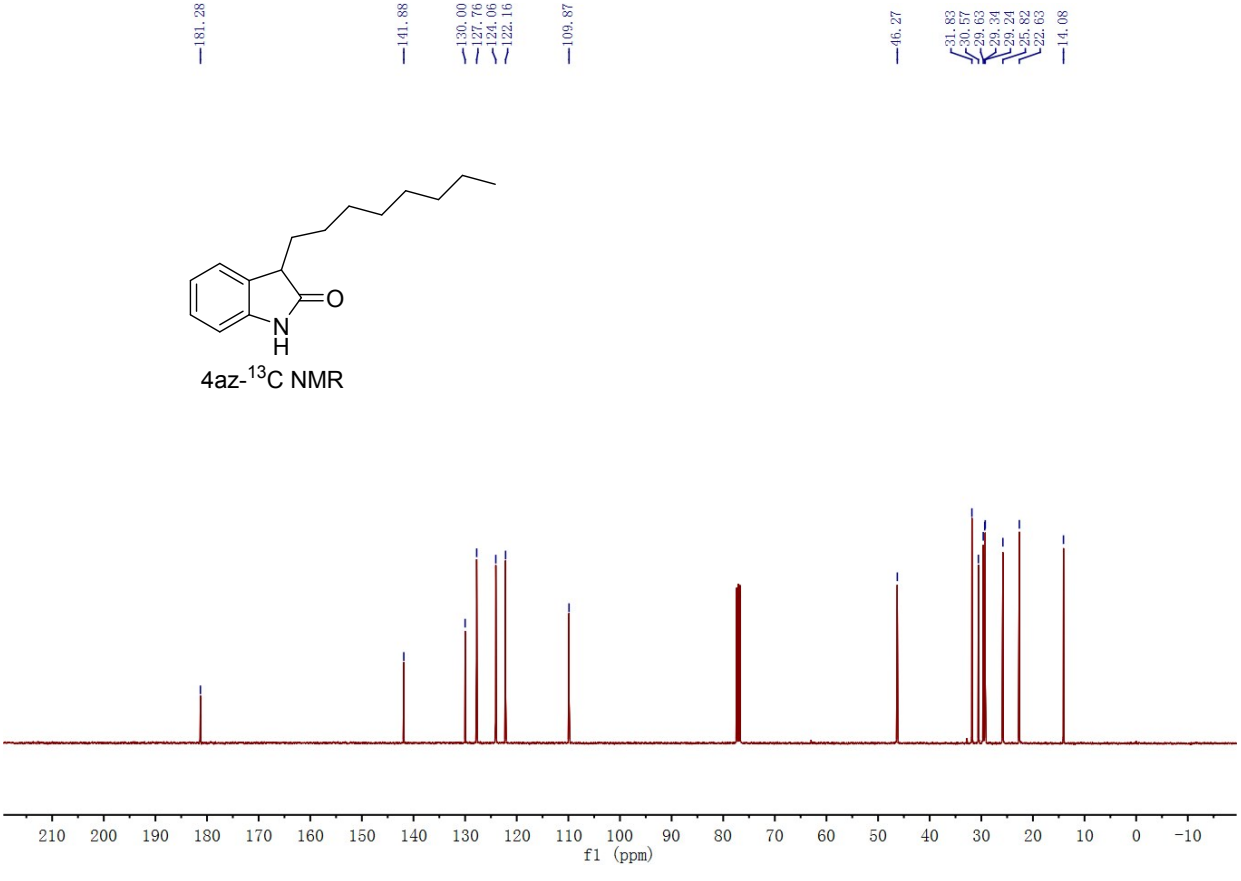


4ay-^{1}H NMR

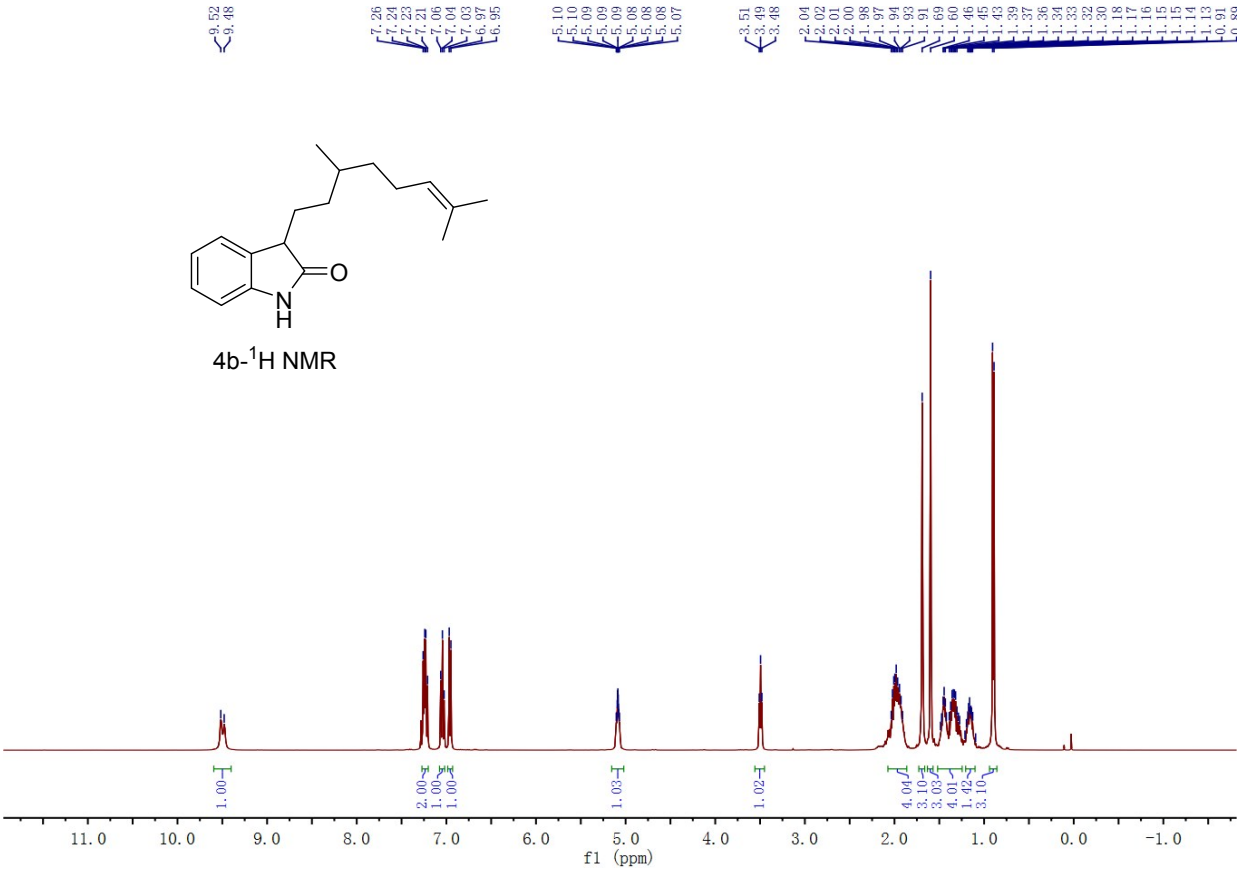
4ay-^{13}C NMR



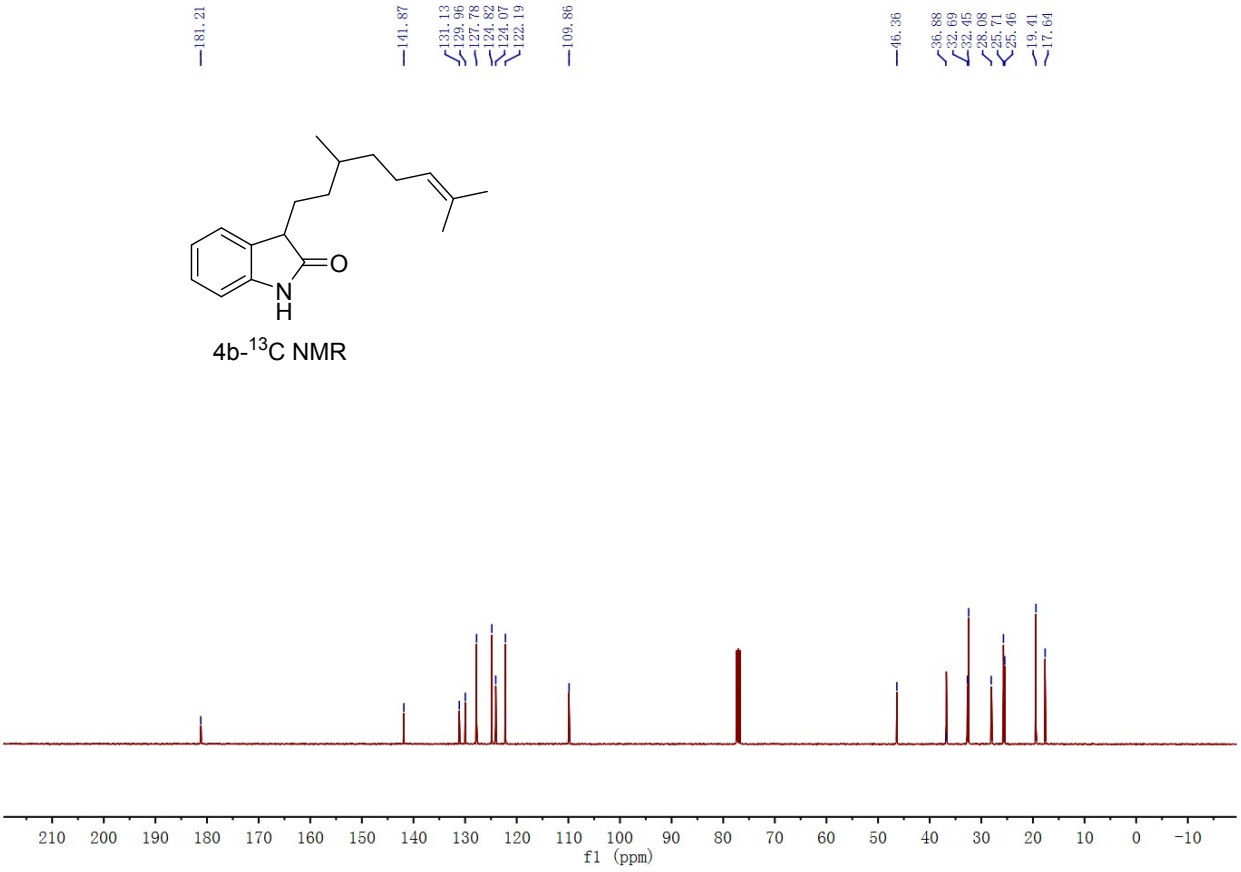
4az-^{1}H NMR



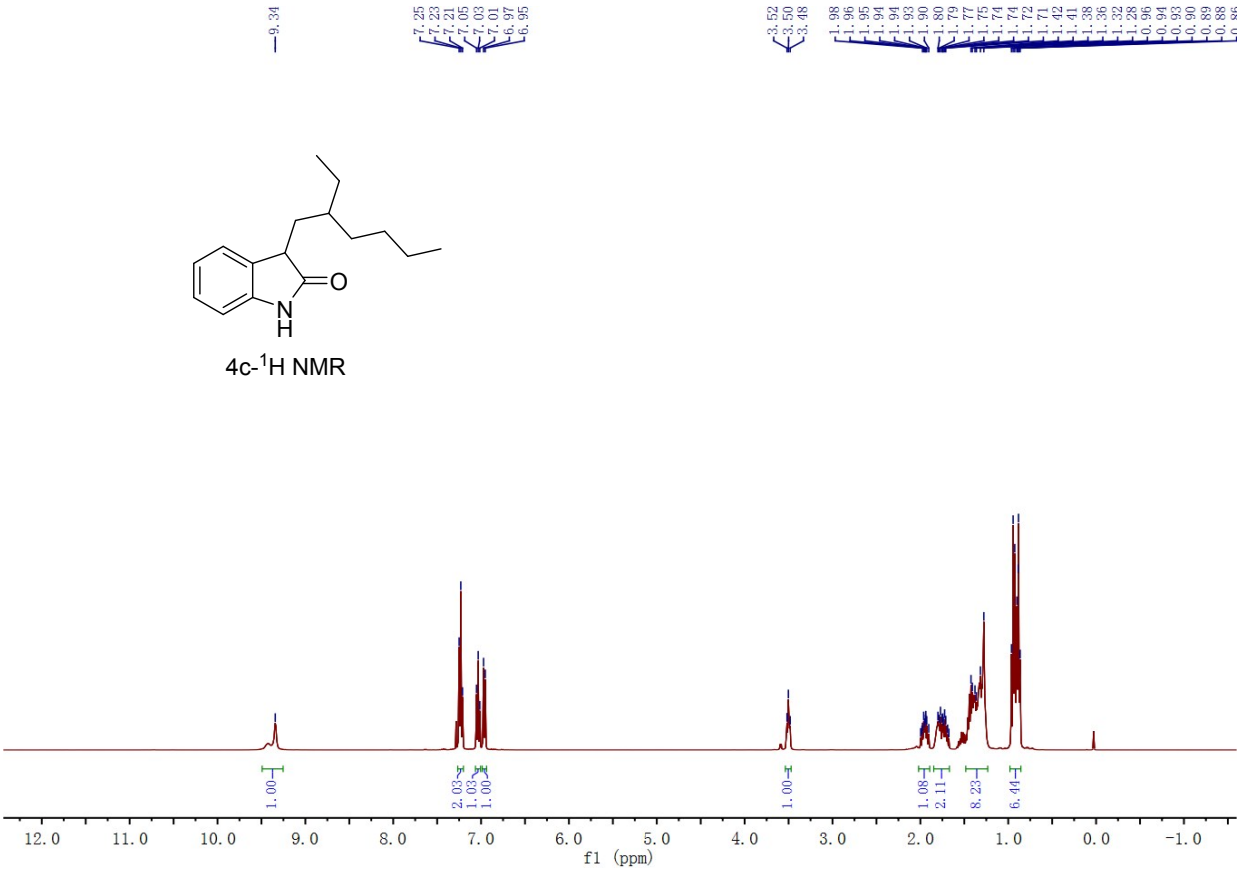
4az-^{13}C NMR



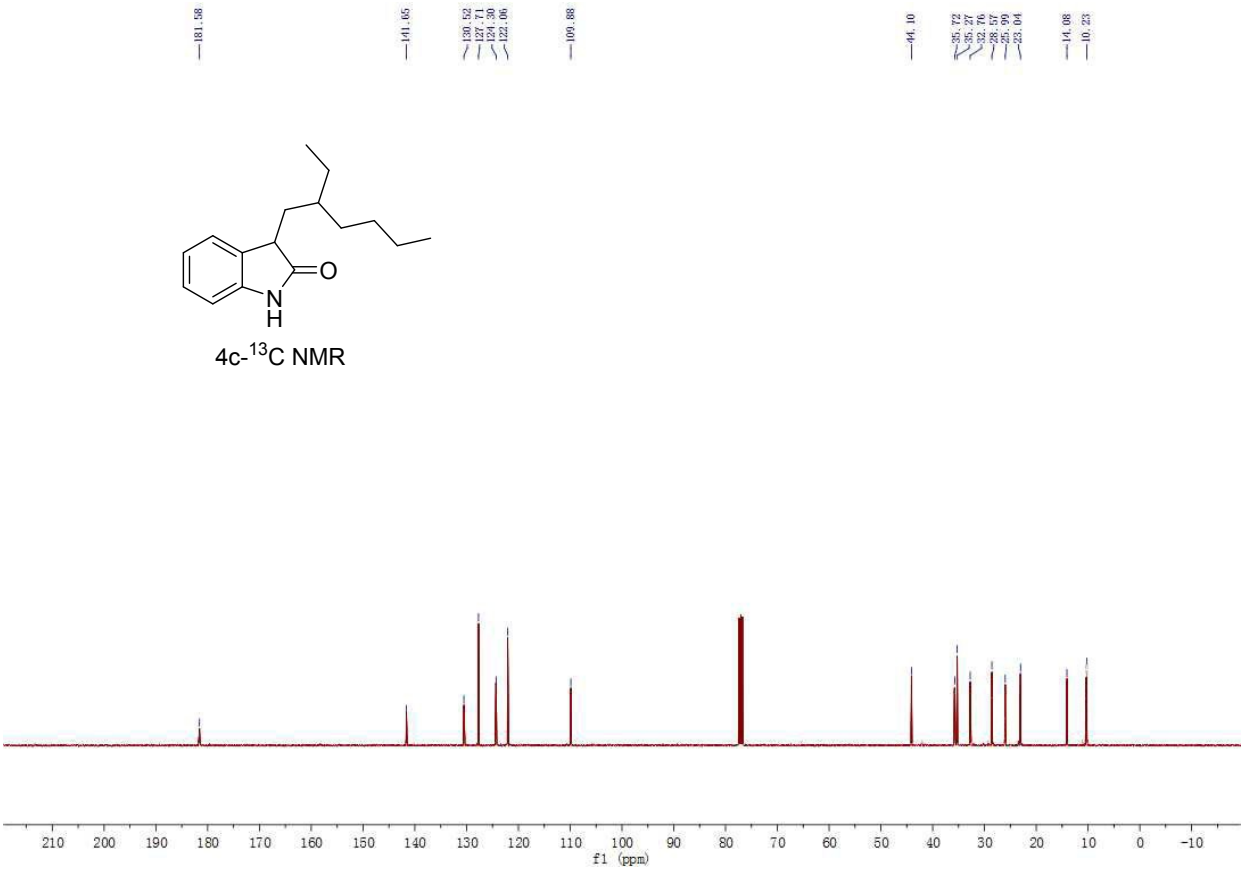
4b-^{1}H NMR



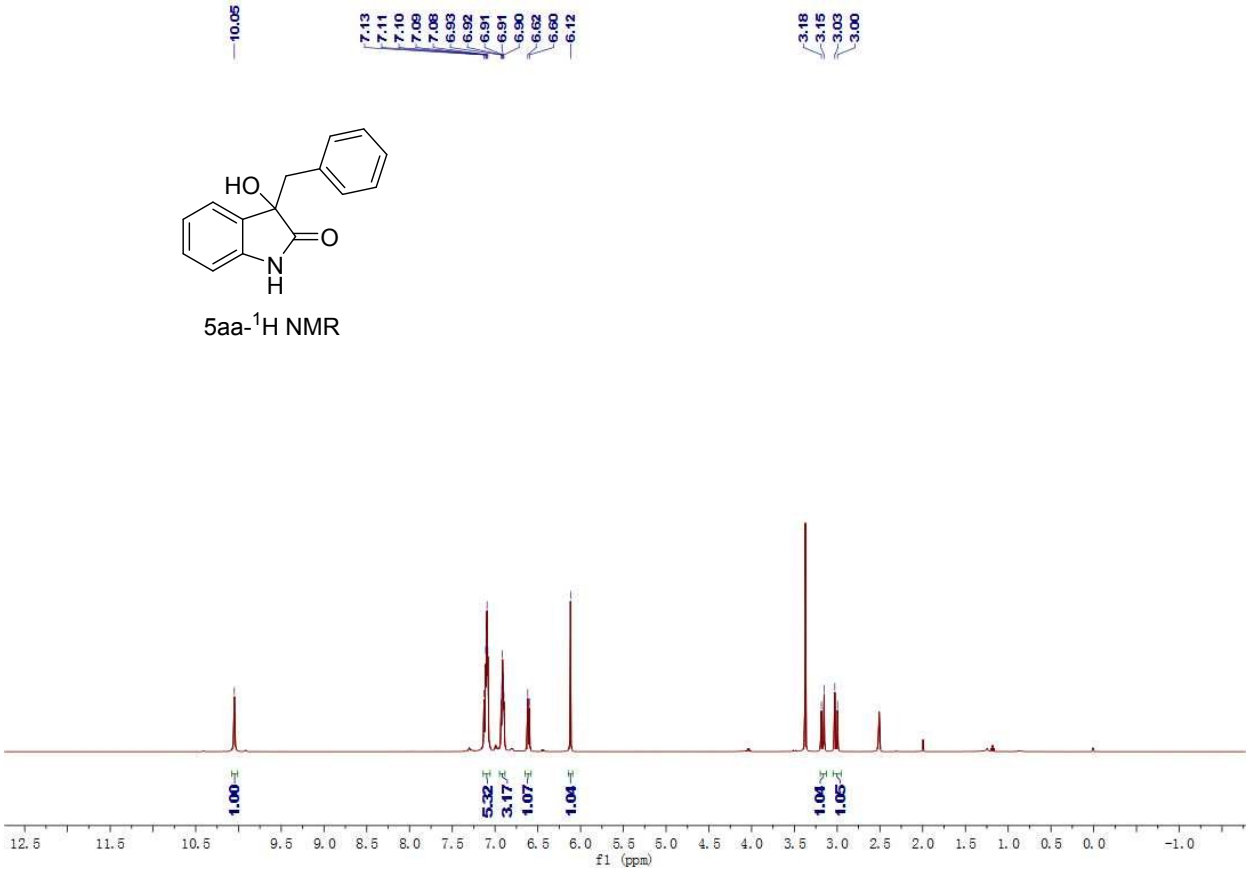
4b-^{13}C NMR



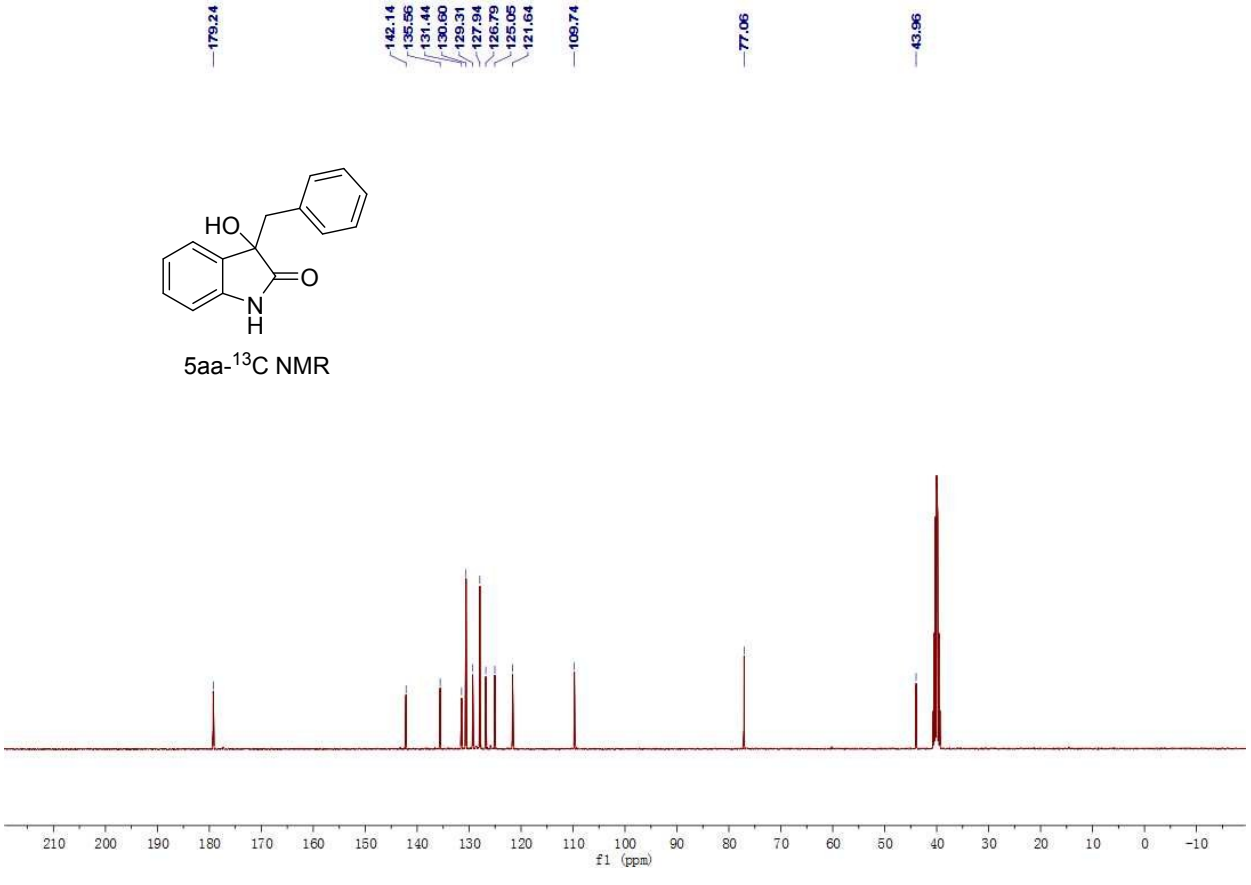
4c-^{1}H NMR



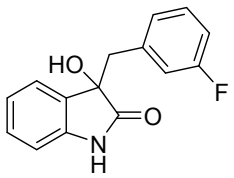
4c-^{13}C NMR



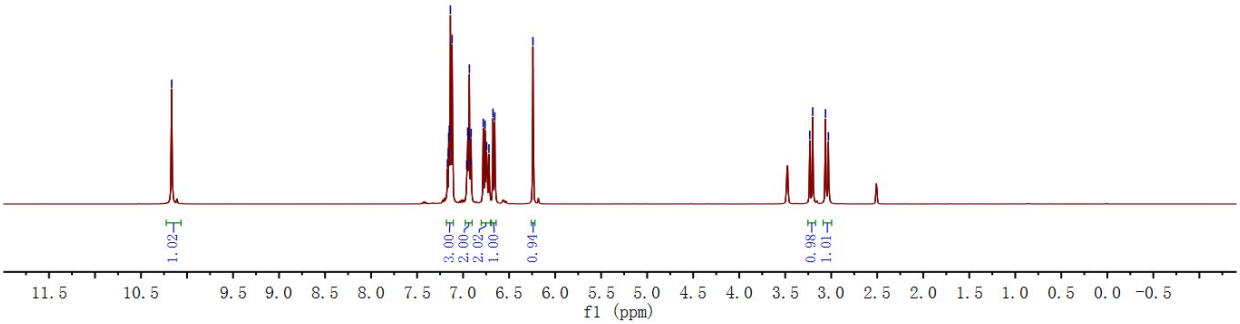
5aa-^{1}H NMR

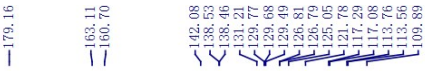


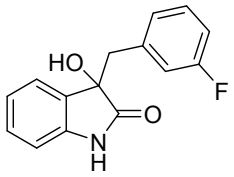
5aa-^{13}C NMR



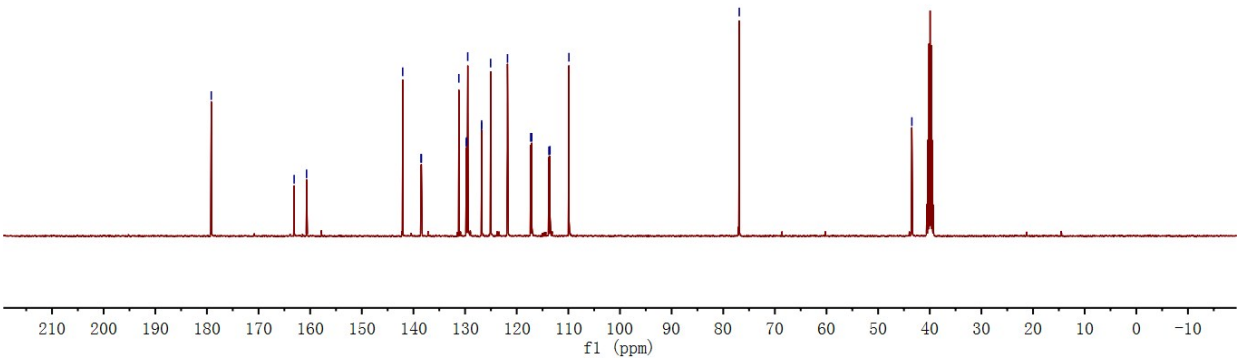
5ab-^{1}H NMR

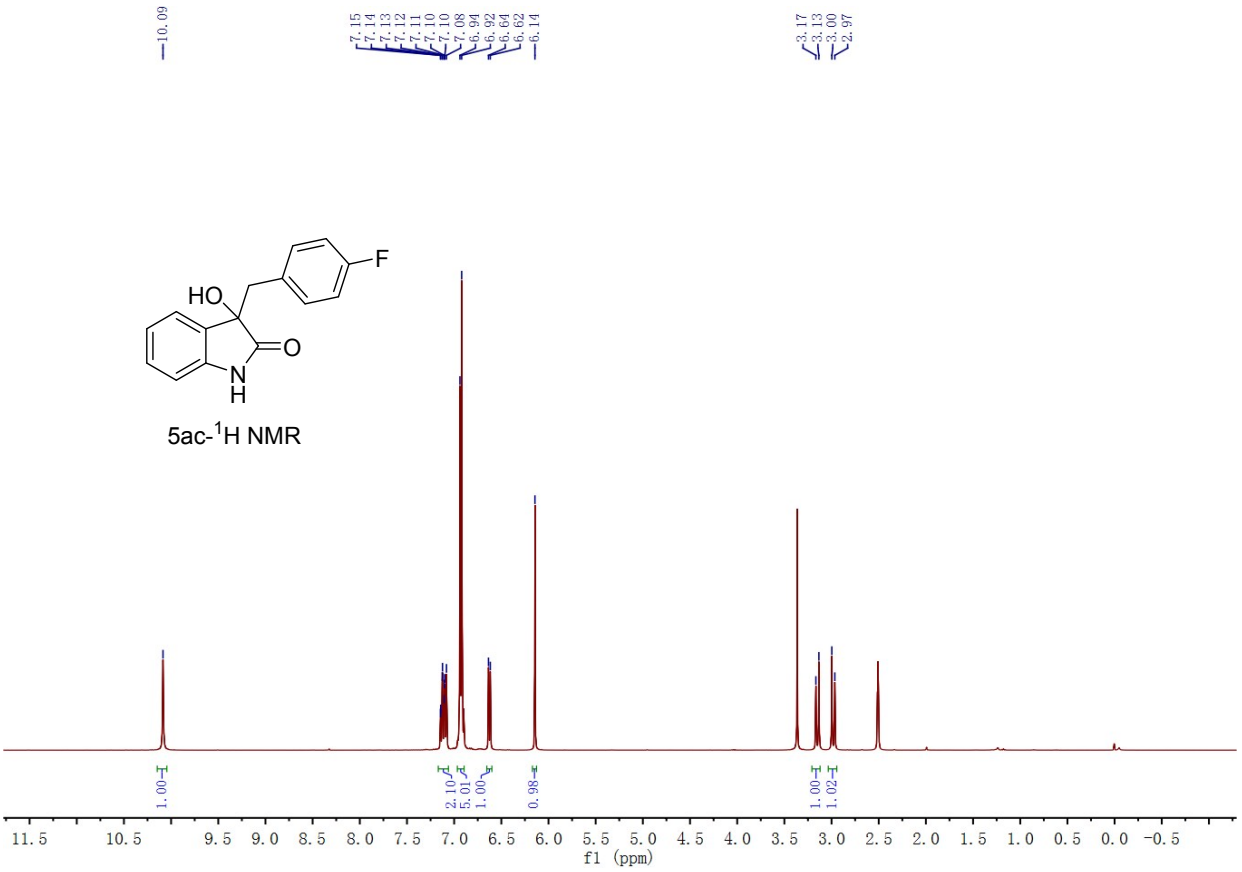




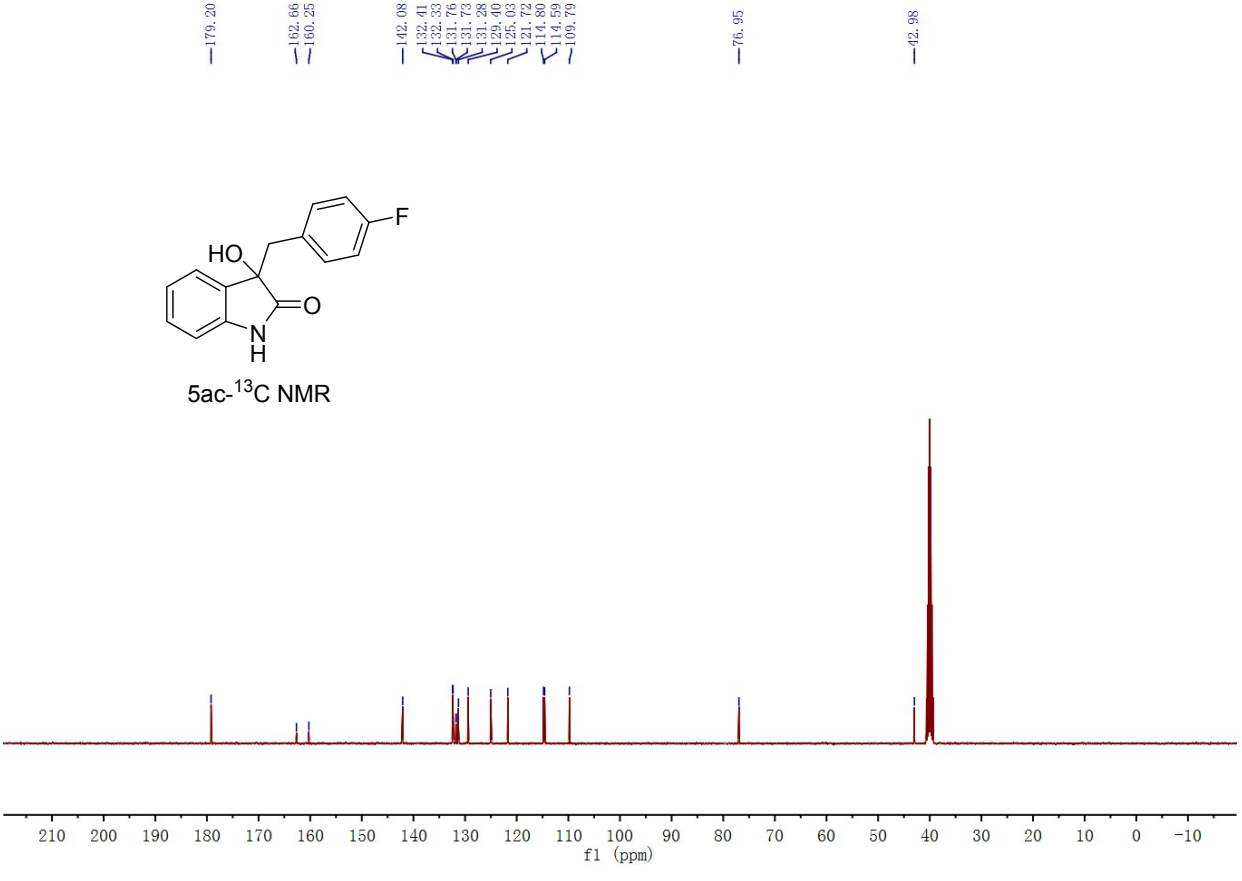


5ab-^{13}C NMR

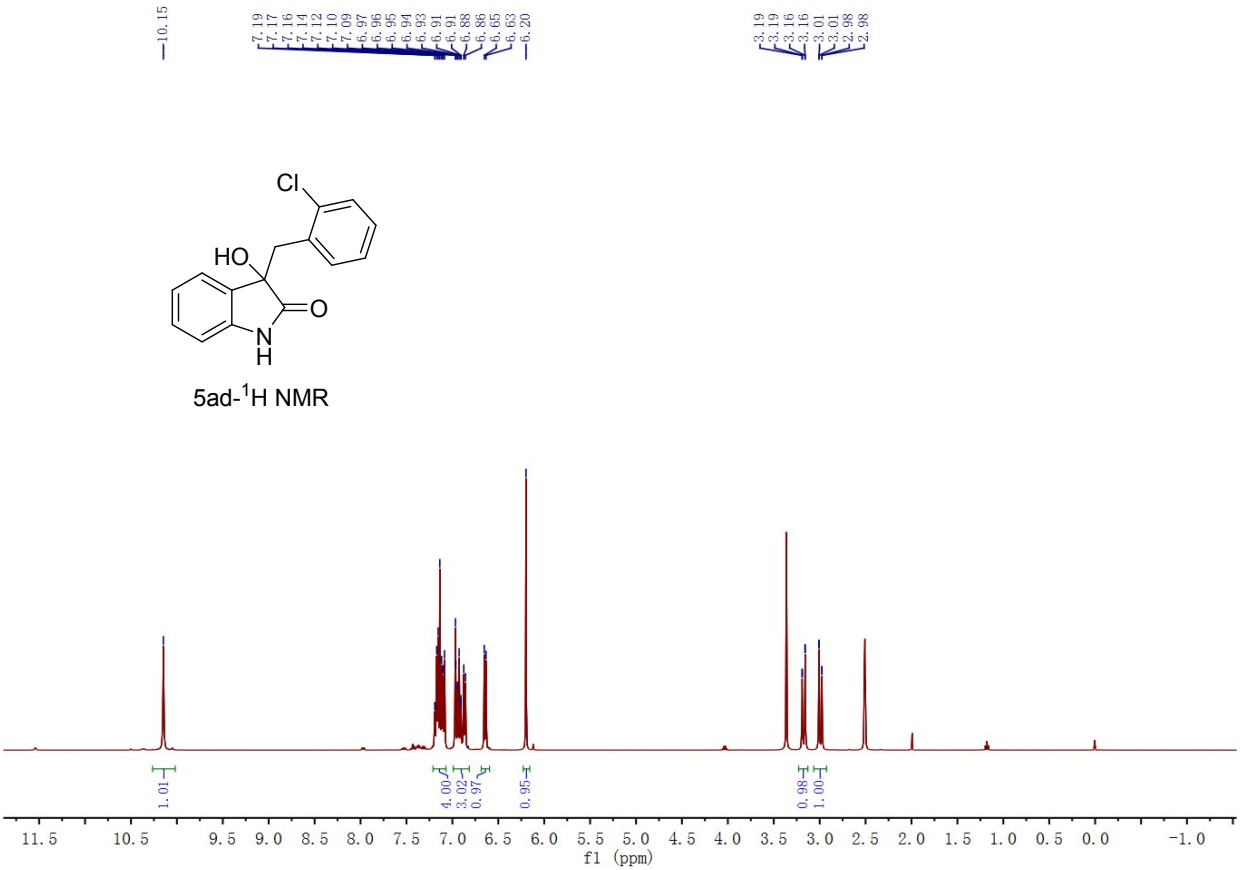




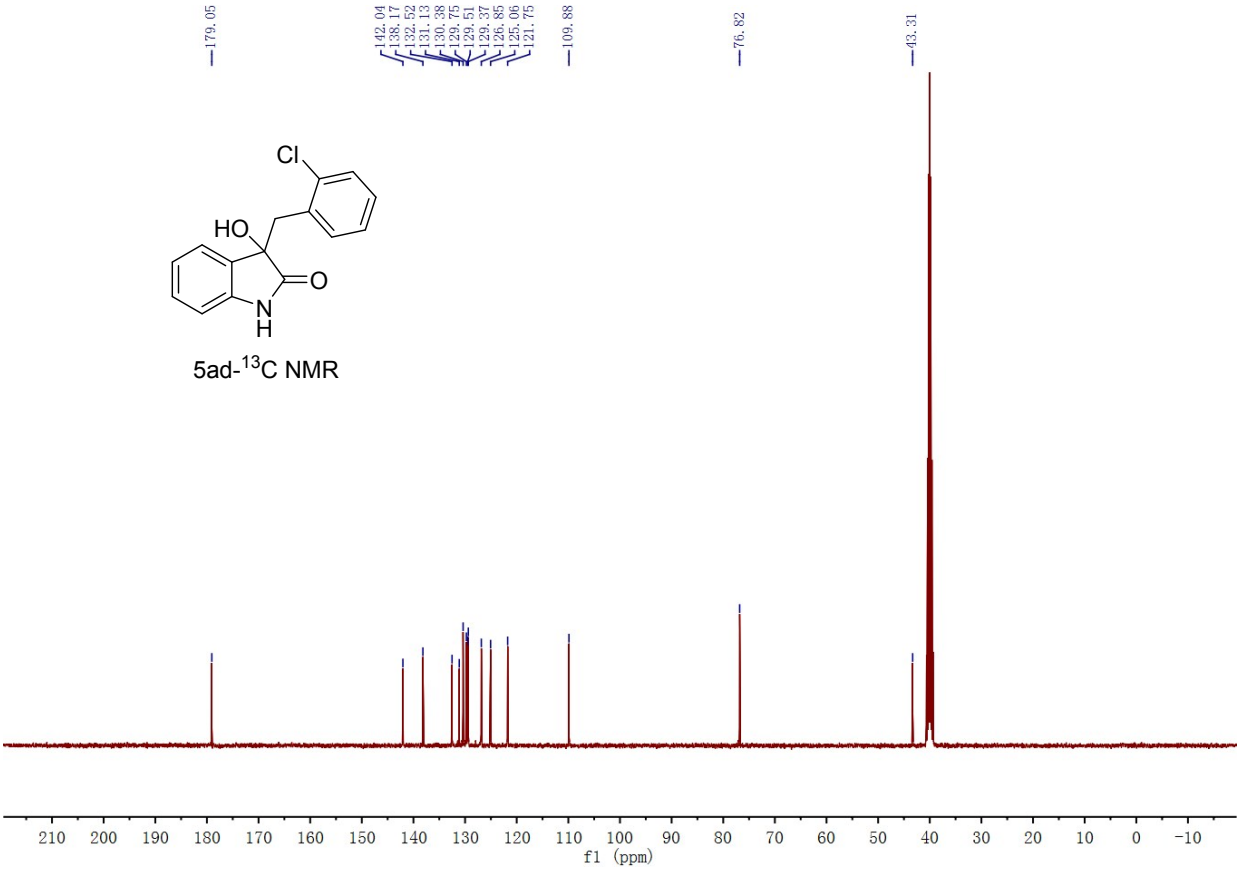
5ac-^{1}H NMR



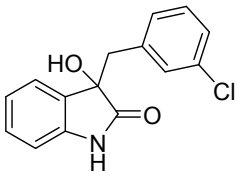
5ac-^{13}C NMR



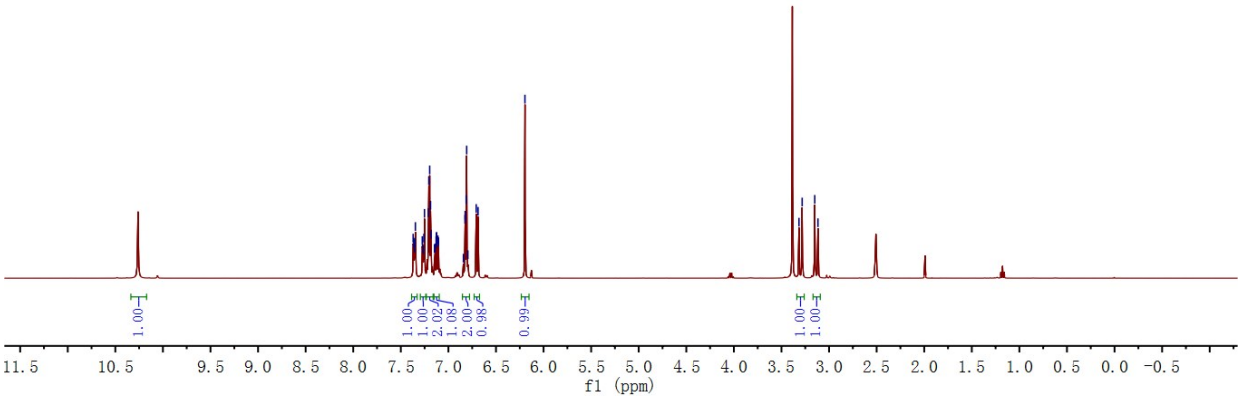
5ad-^{1}H NMR

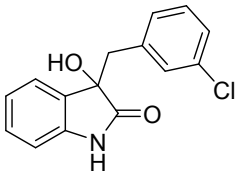


5ad-^{13}C NMR

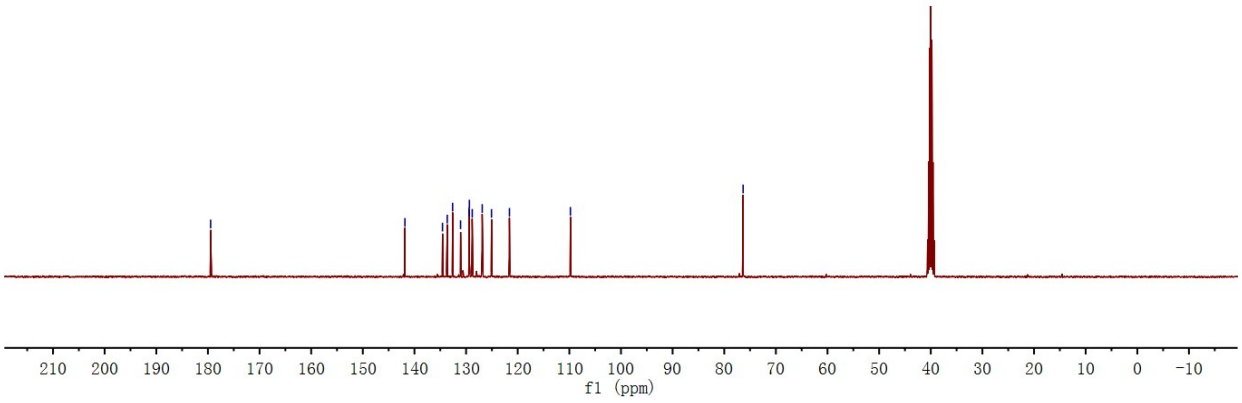


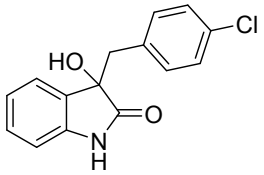
5ae-^{1}H NMR



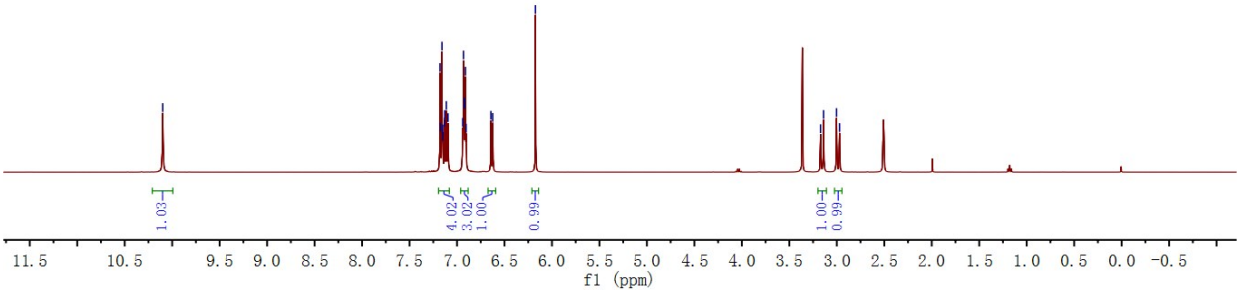


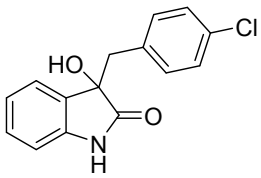
5ae-^{13}C NMR



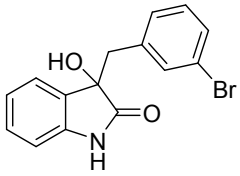


5af-^{1}H NMR

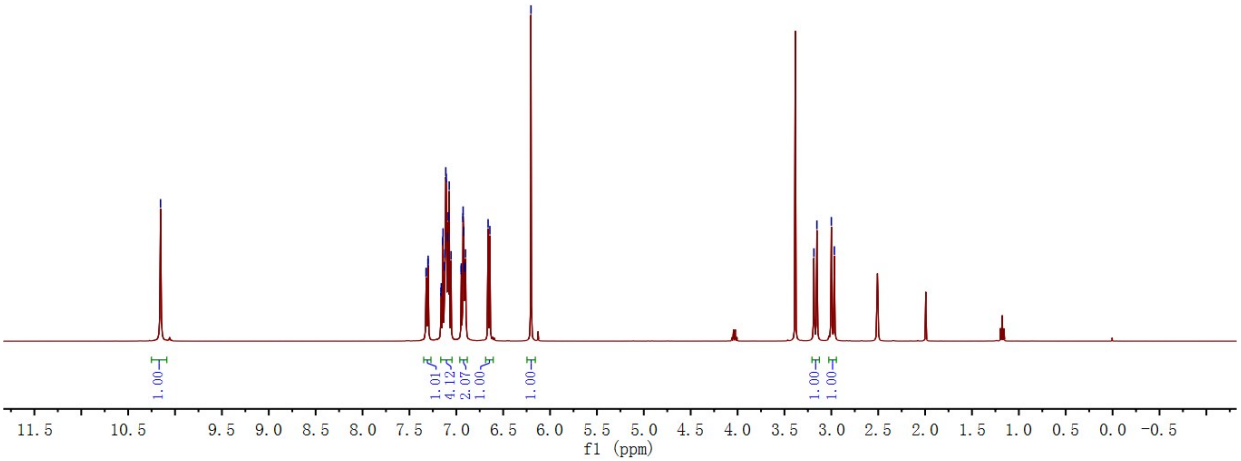


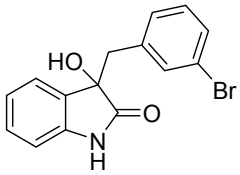


5af-^{13}C NMR

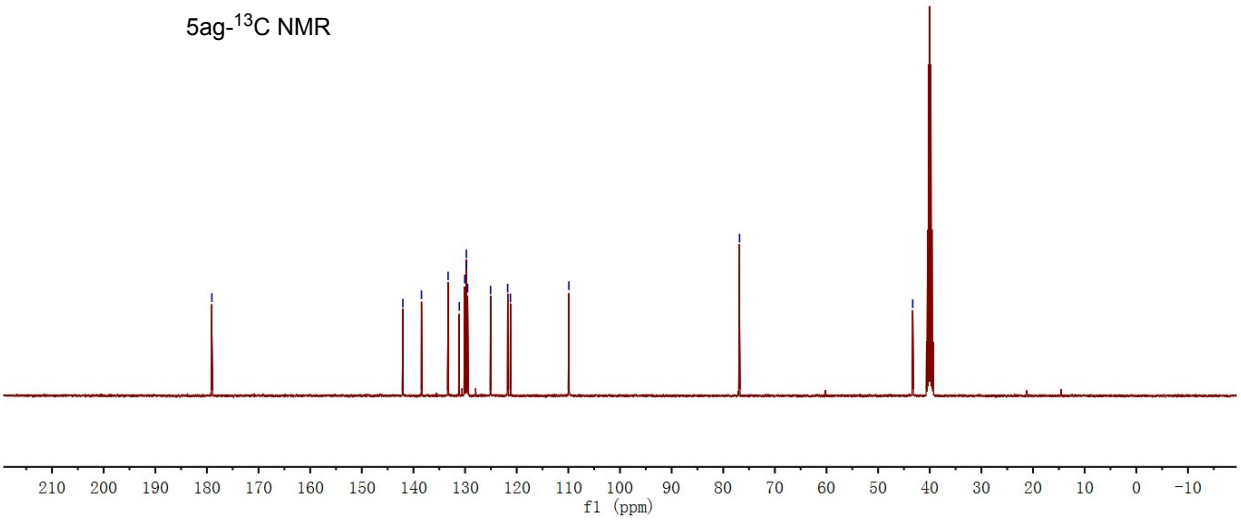


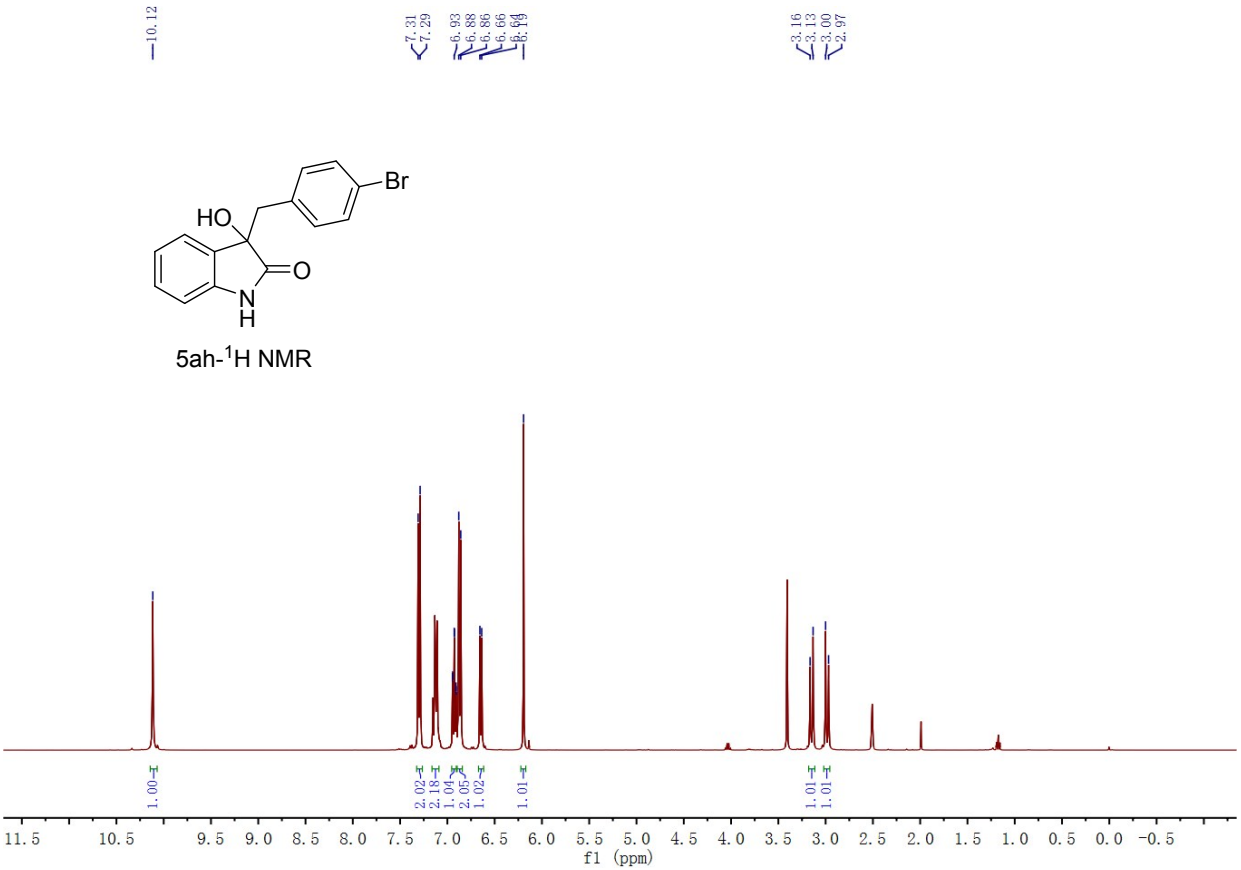
5ag-^{1}H NMR



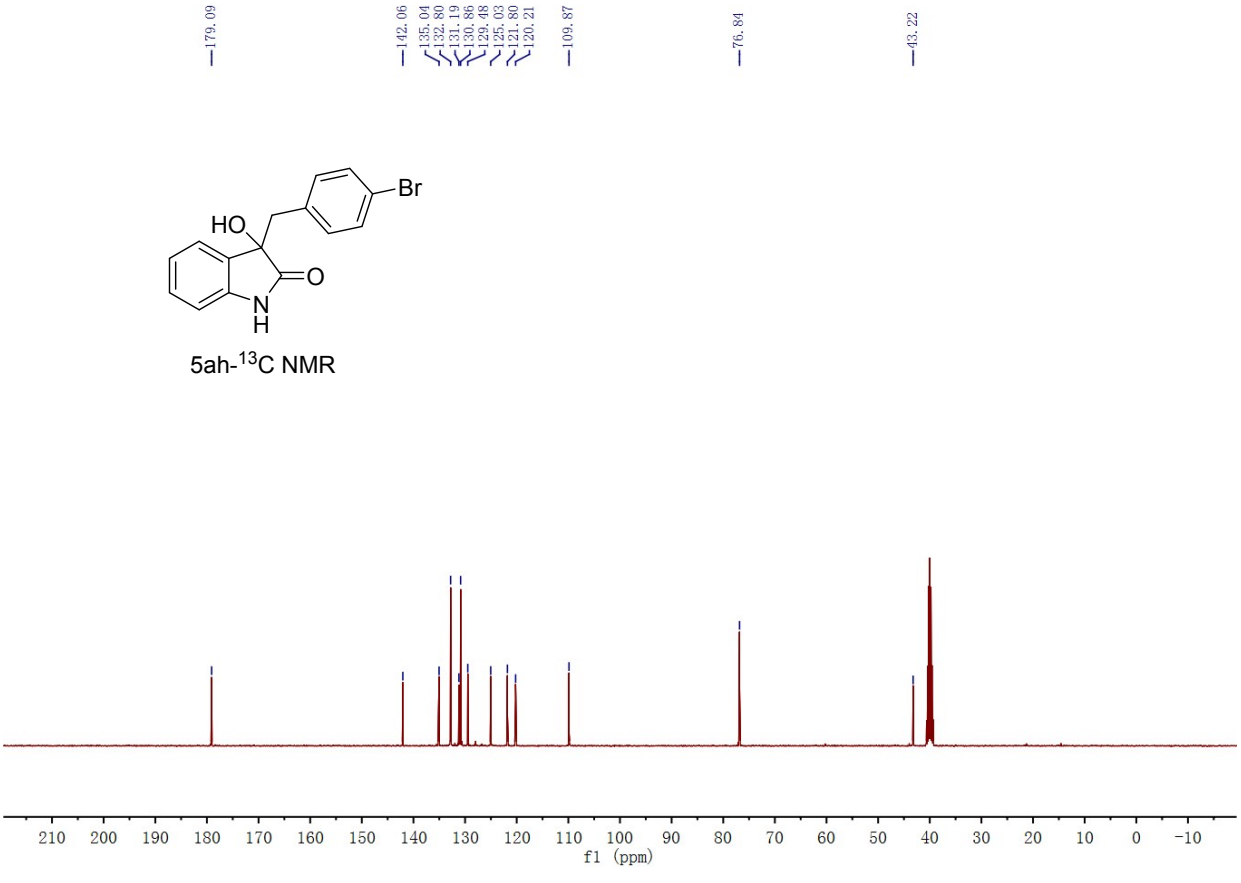


5ag-^{13}C NMR

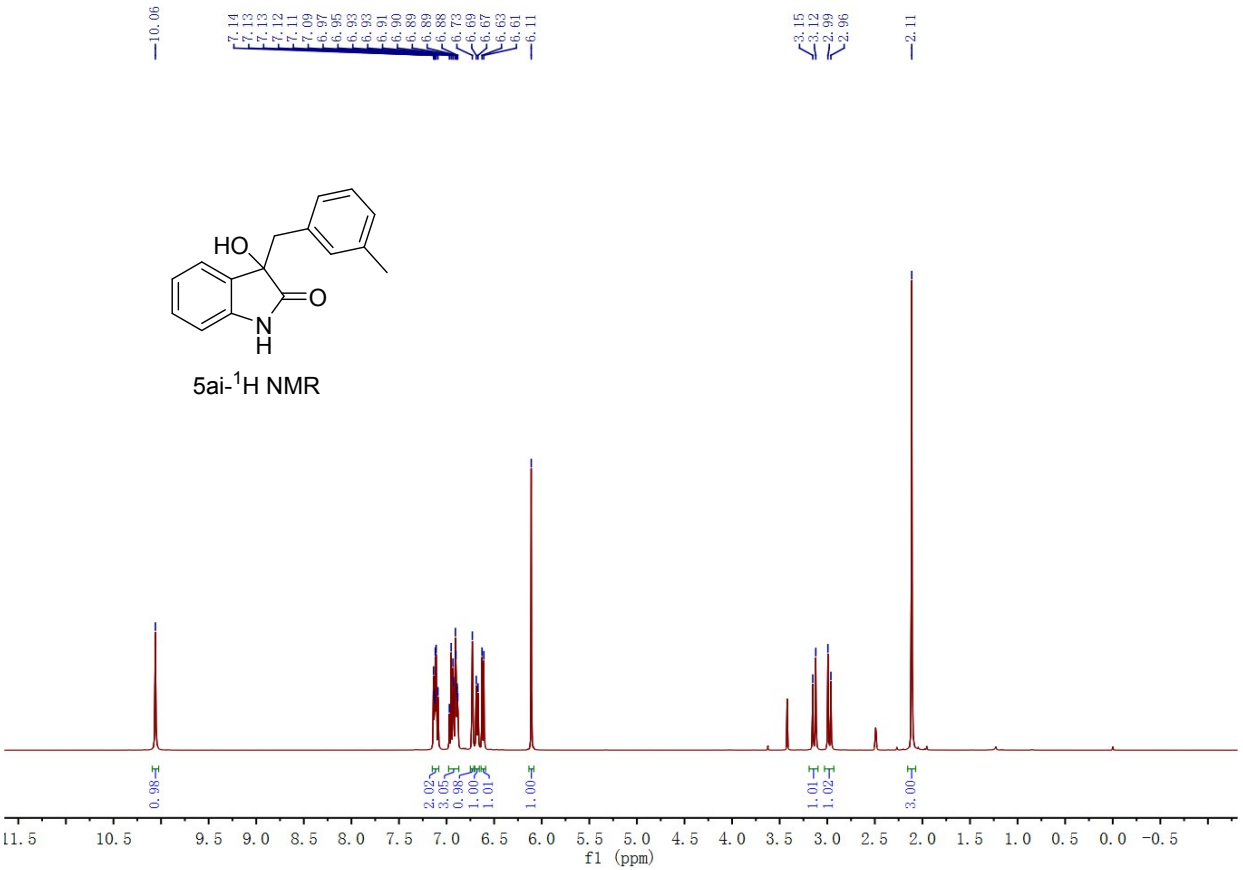




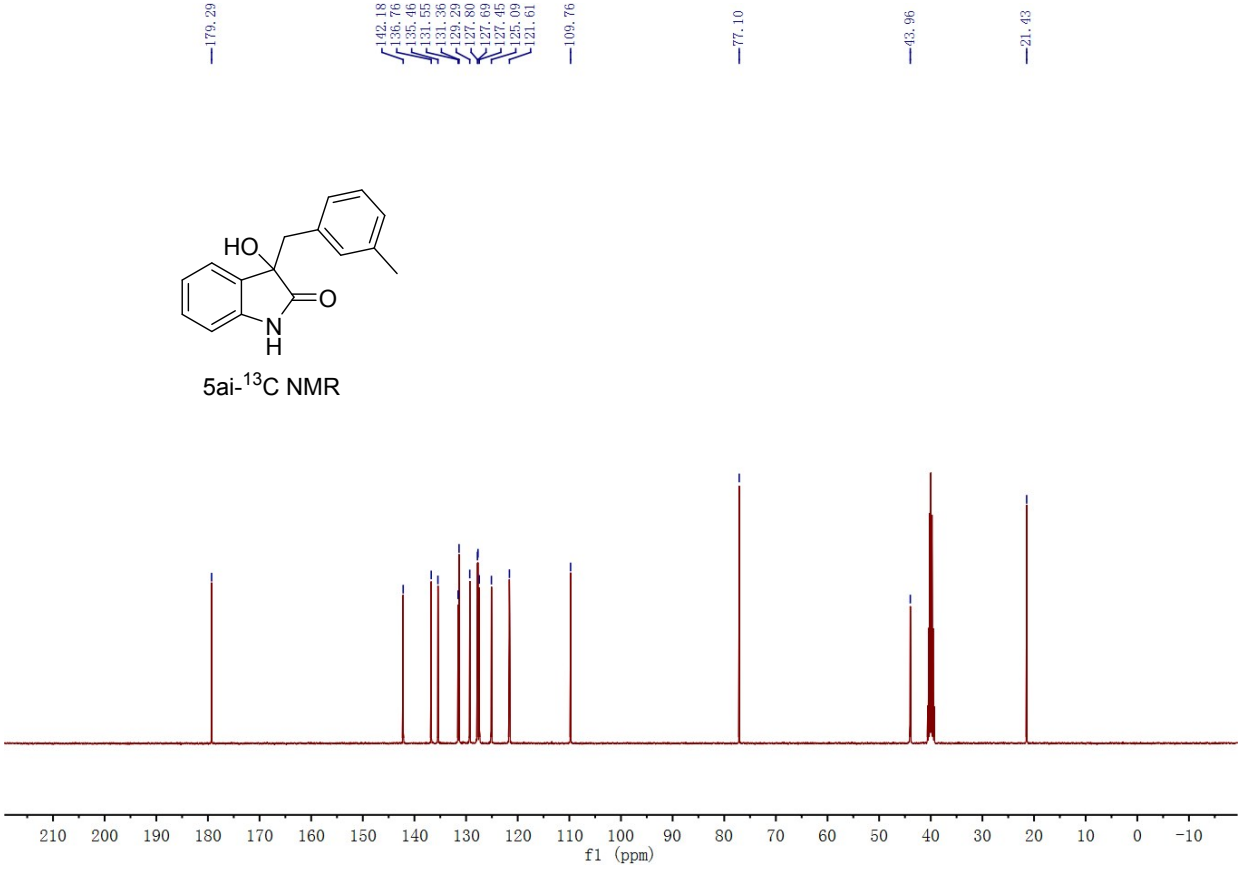
5ah-^{1}H NMR



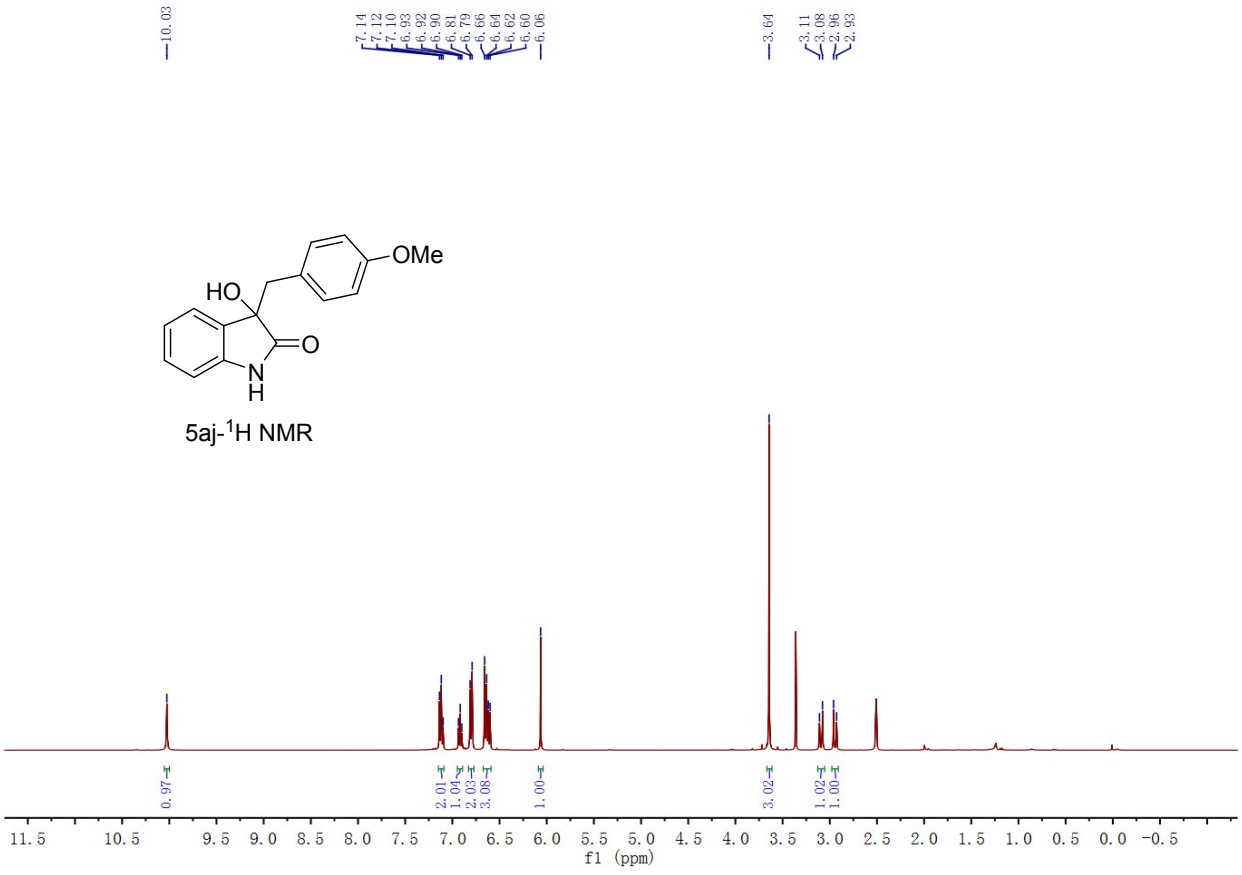
5ah-^{13}C NMR



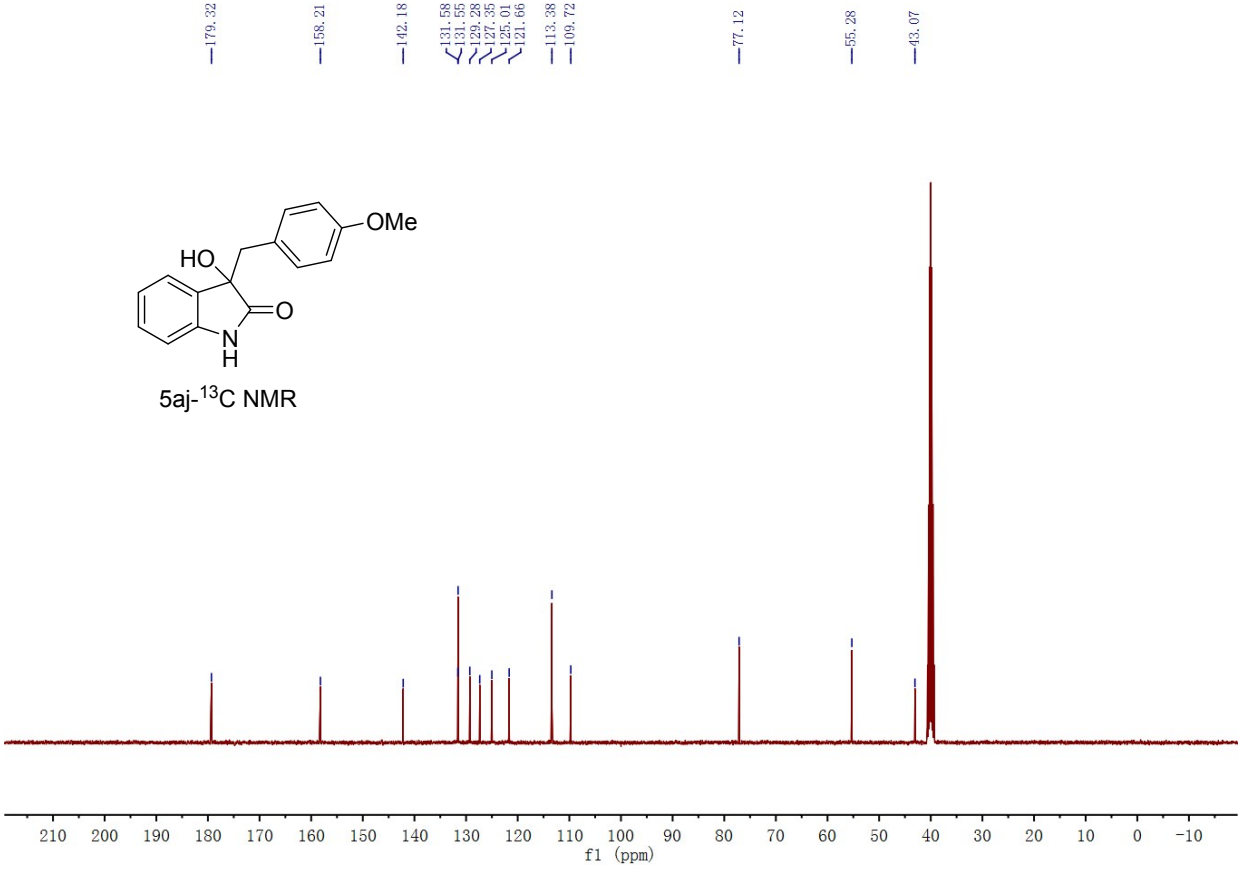
5ai-^{1}H NMR



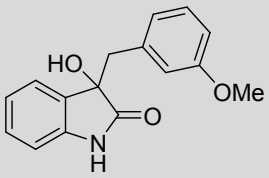
5ai-^{13}C NMR



5aj-^{1}H NMR

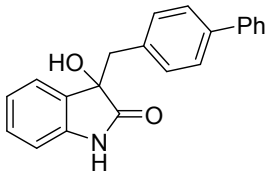


5aj-^{13}C NMR

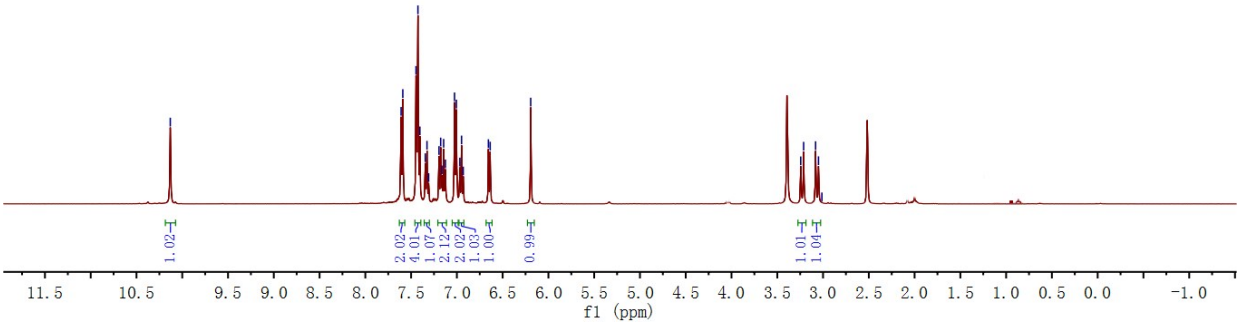


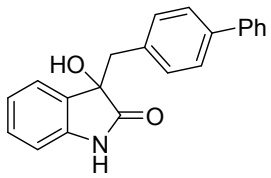
5ak-^{1}H NMR

5ak-^{13}C NMR

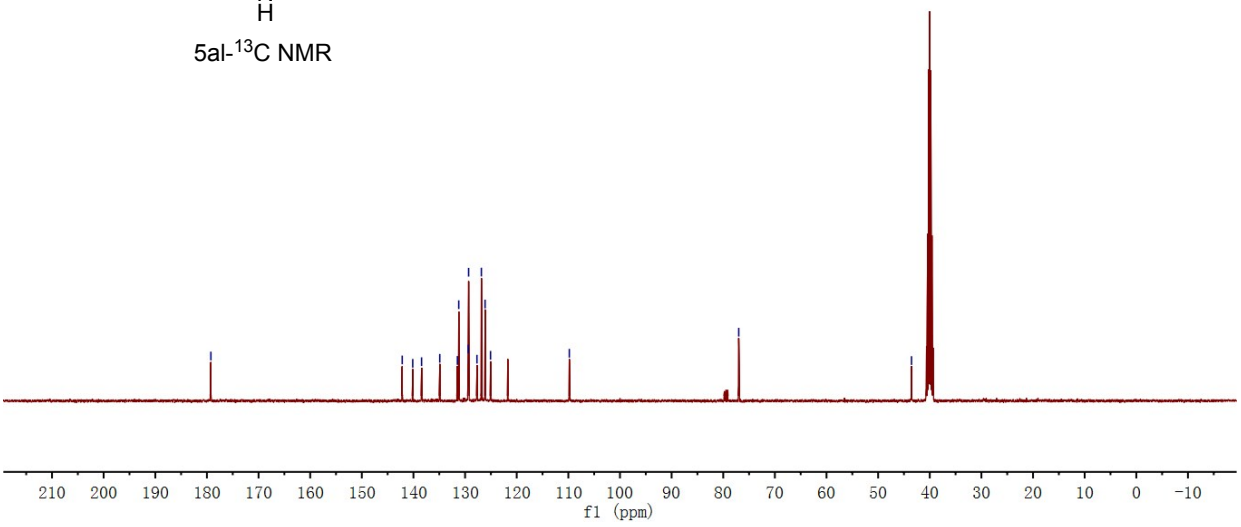


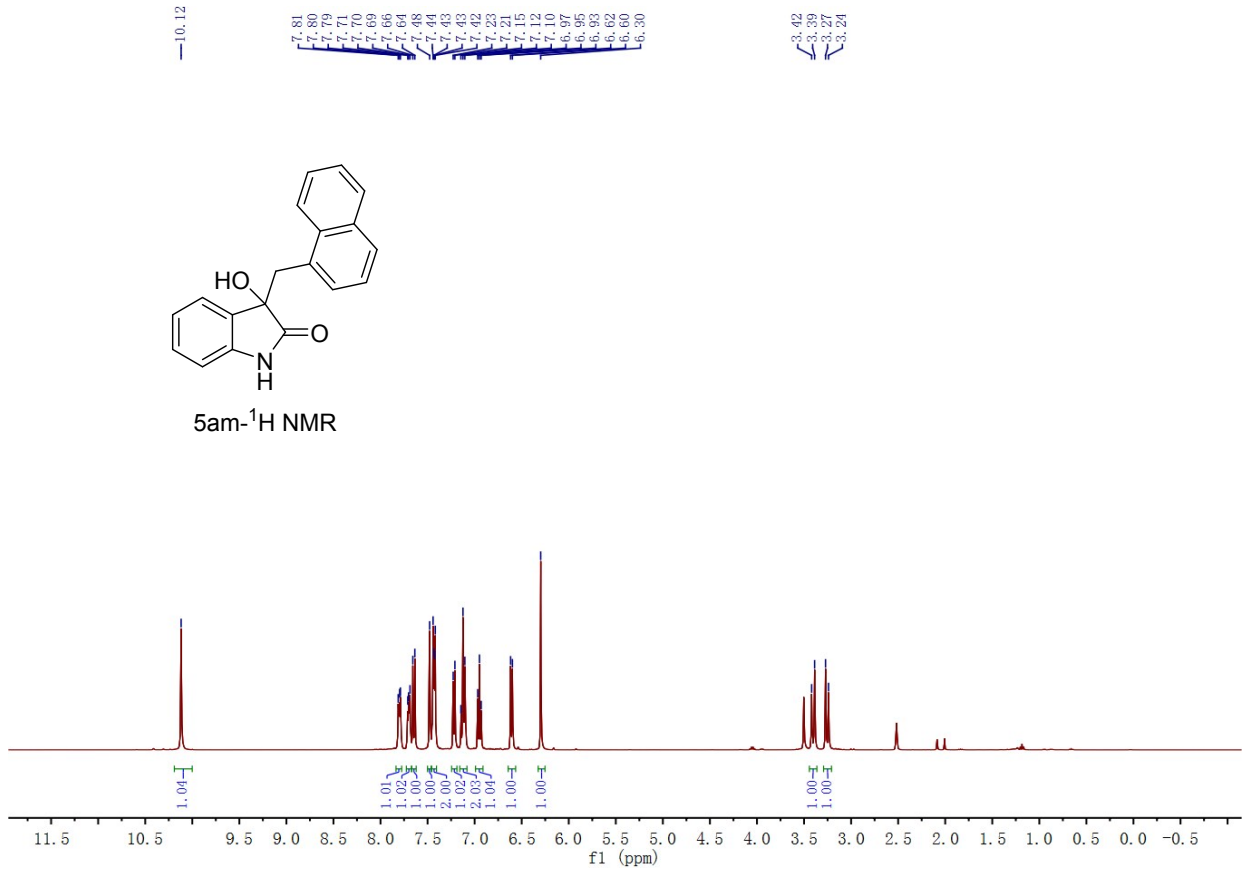
5al-^{1}H NMR



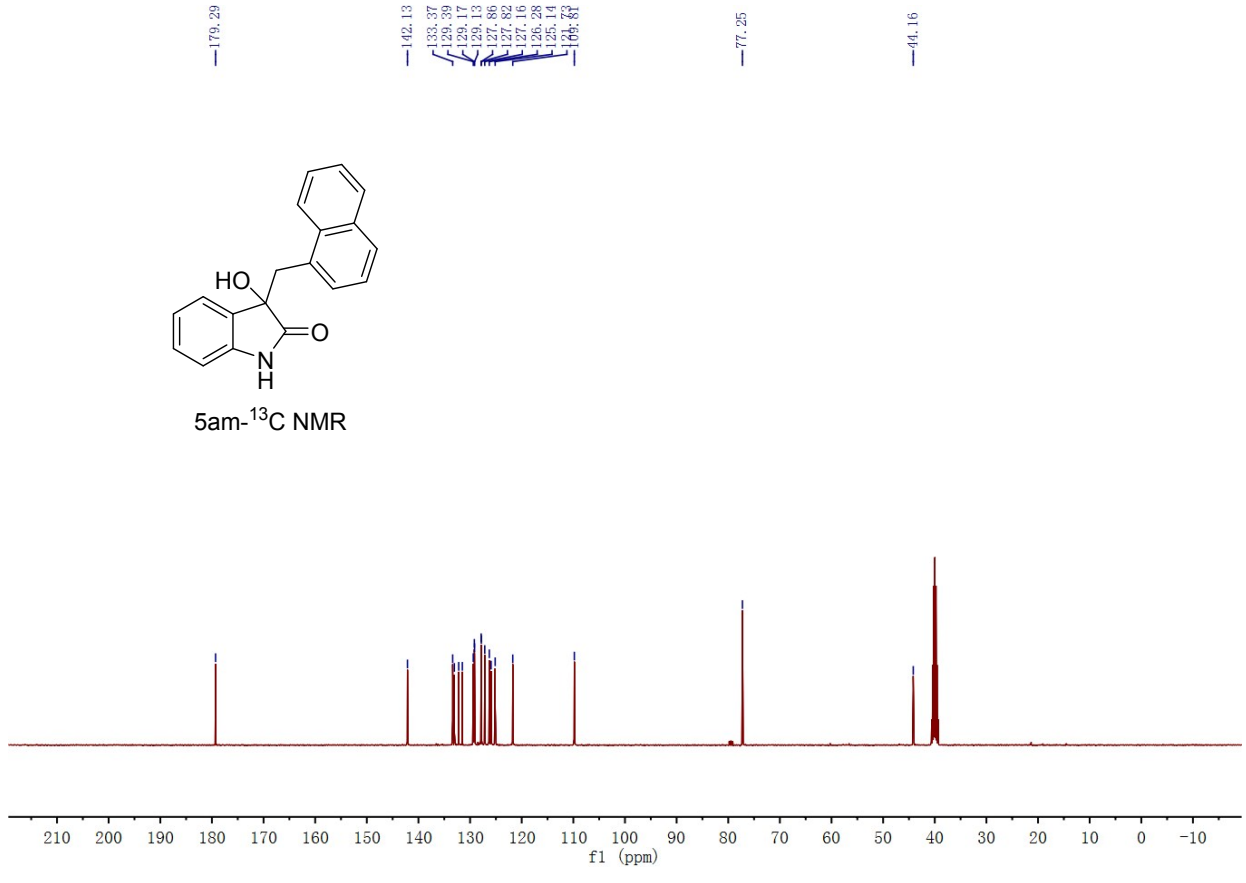


5al-^{13}C NMR

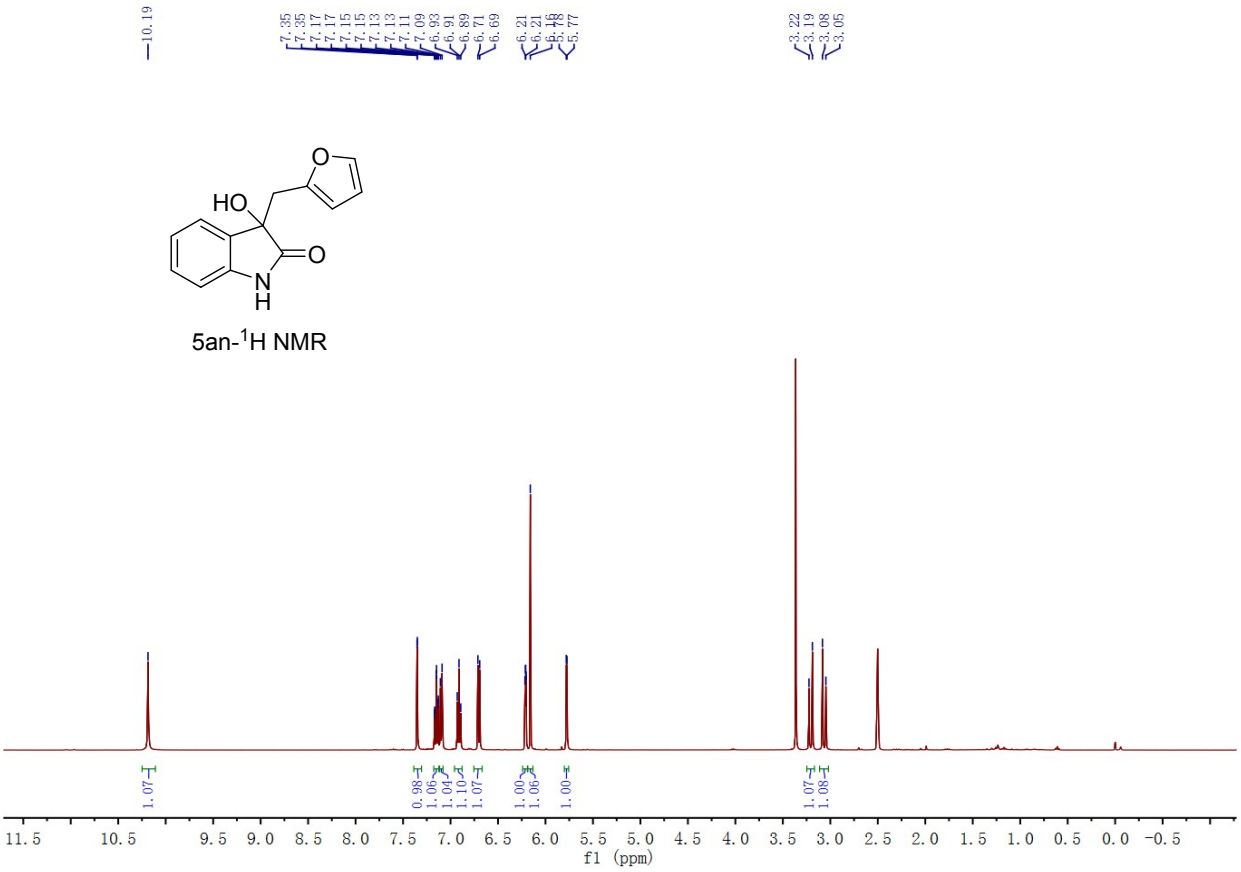




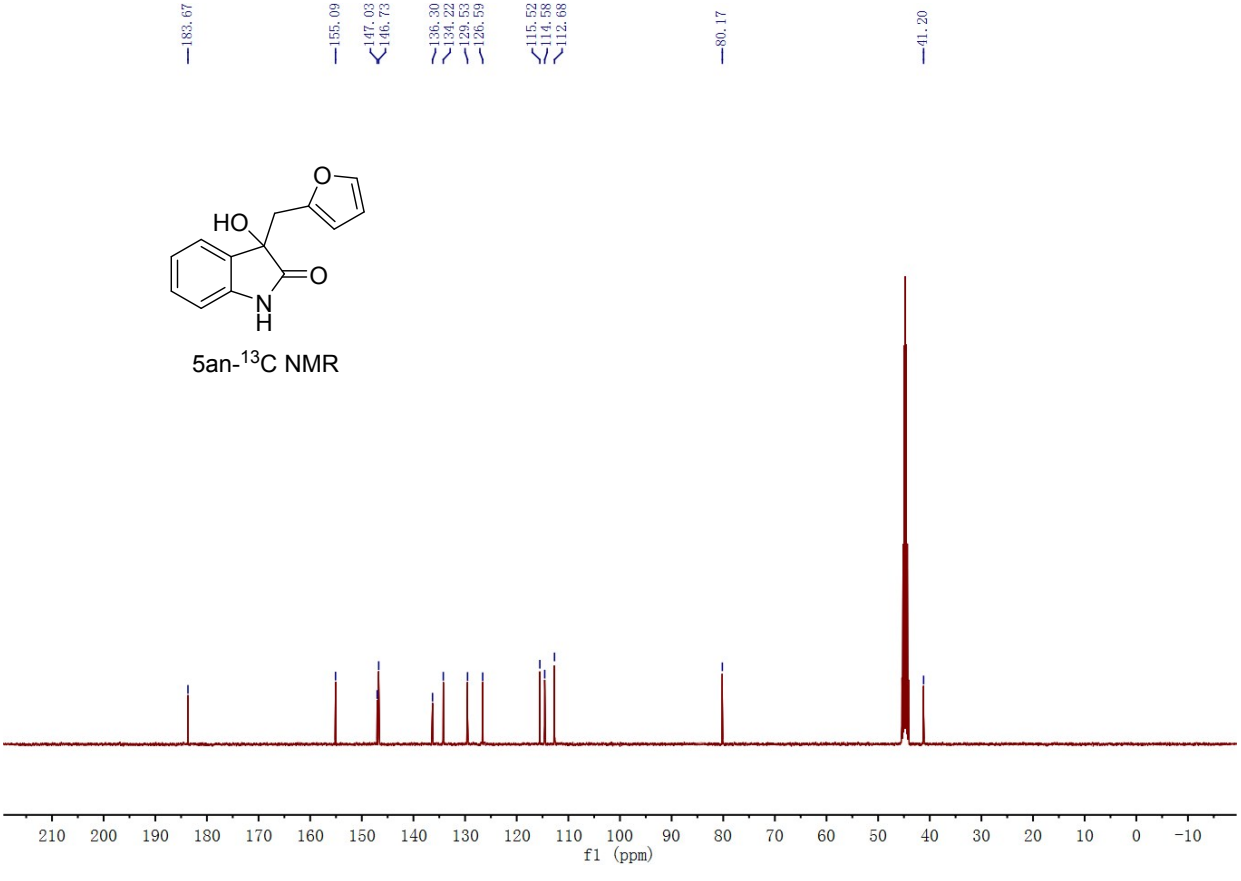
5am-^{1}H NMR



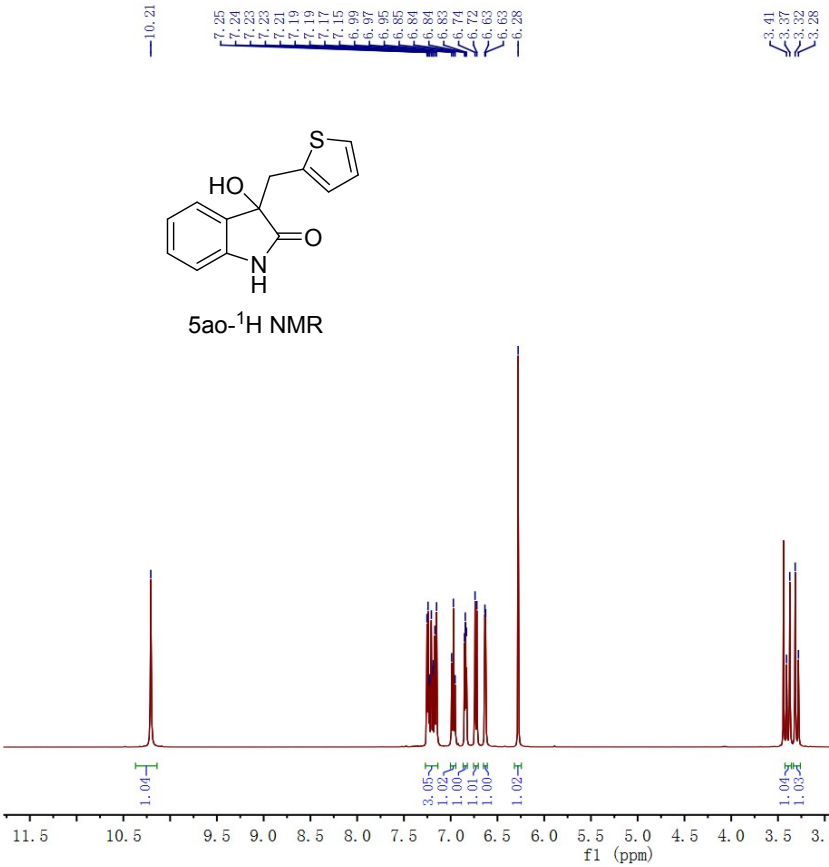
5am-^{13}C NMR



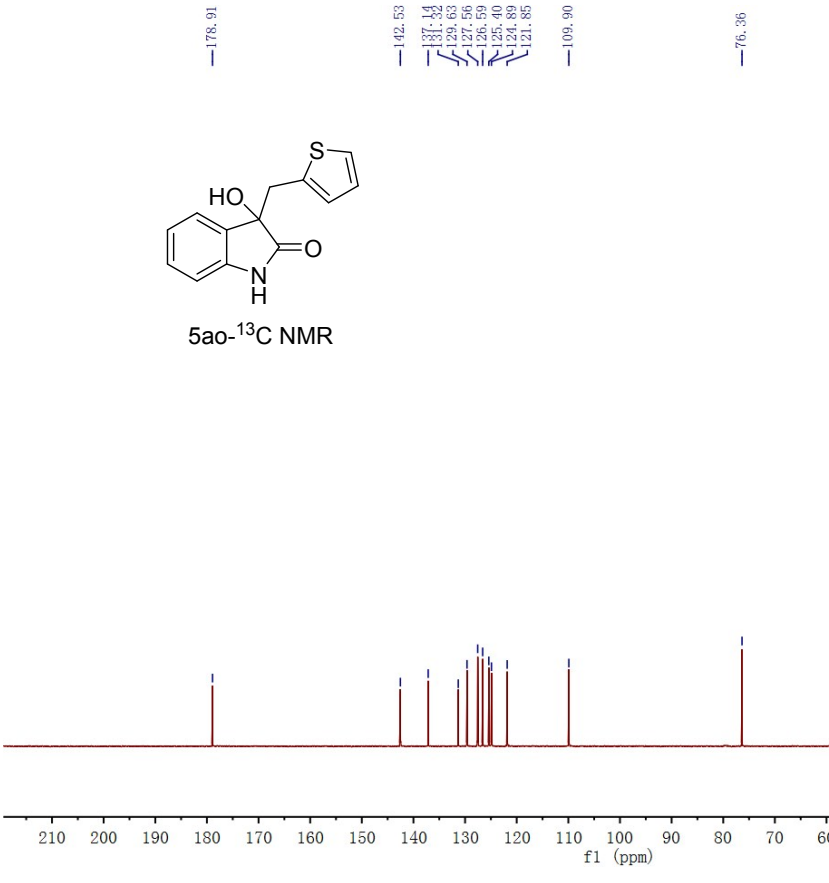
5an-^{1}H NMR



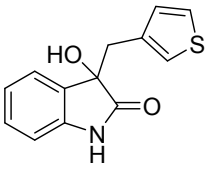
5an-^{13}C NMR



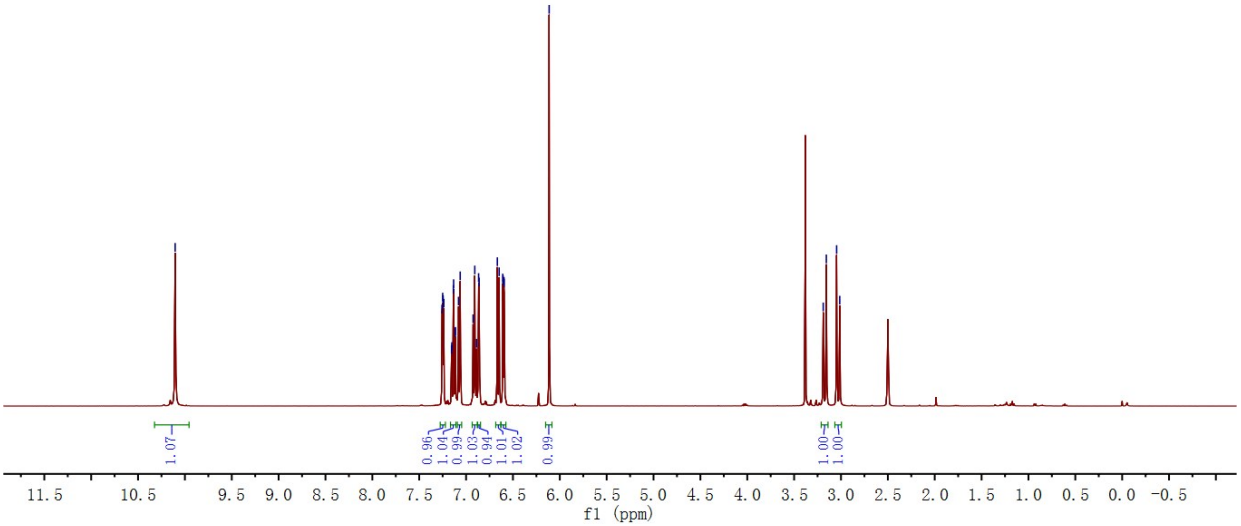
5ao-^{1}H NMR

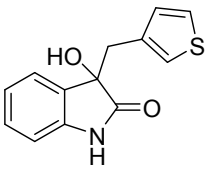


5ao-^{13}C NMR

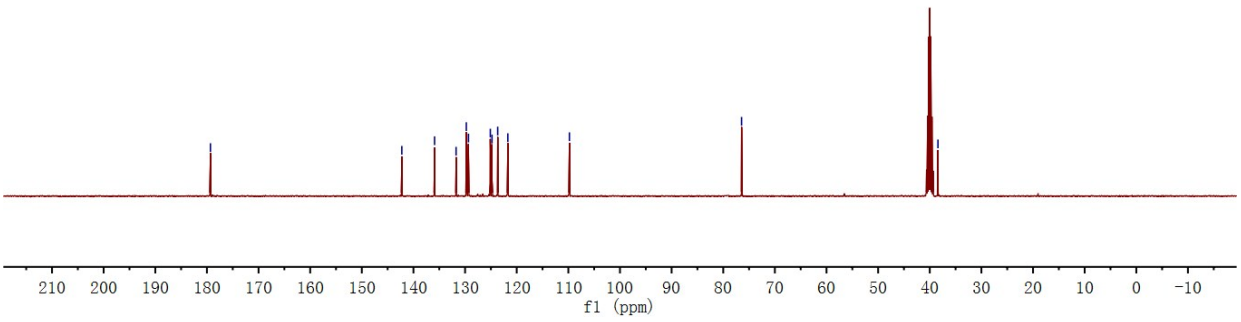


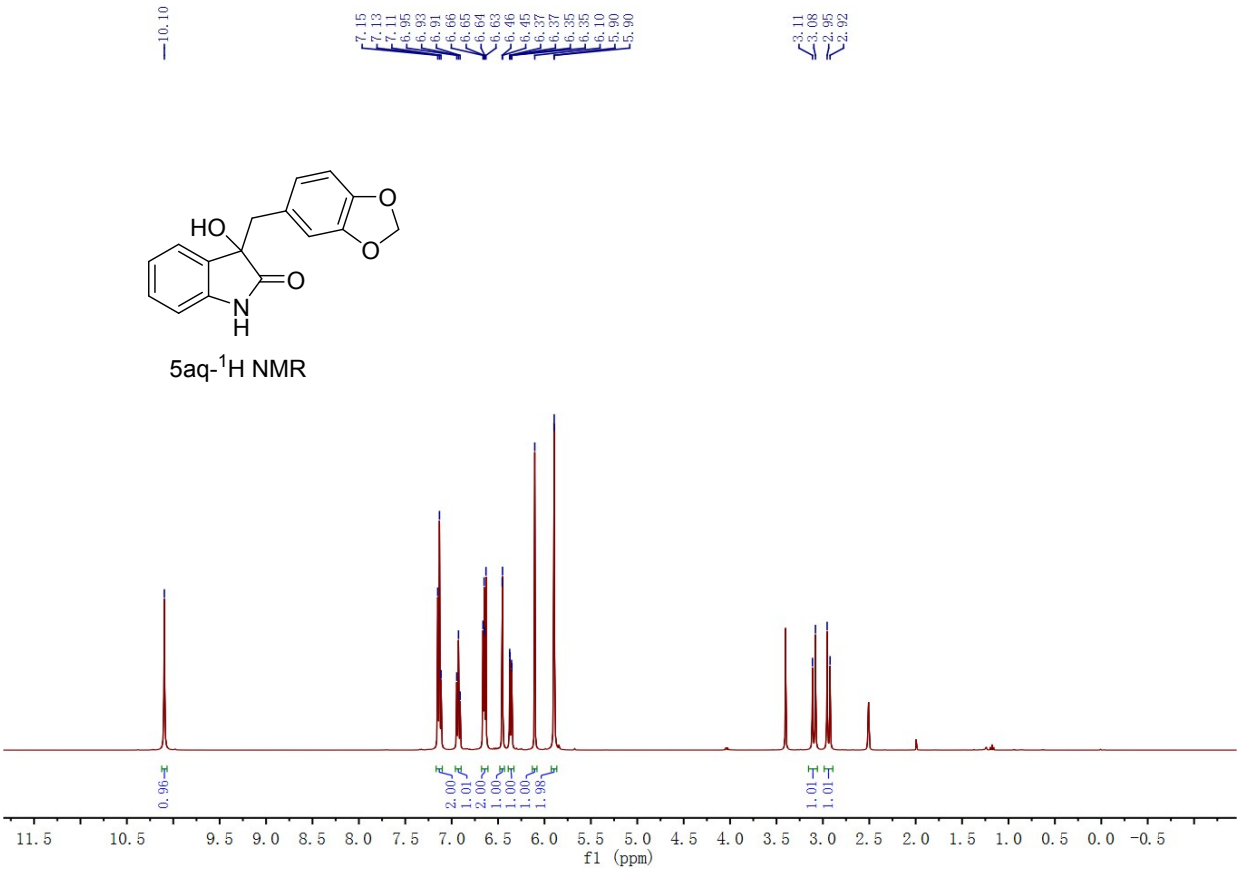
5ap-^{1}H NMR





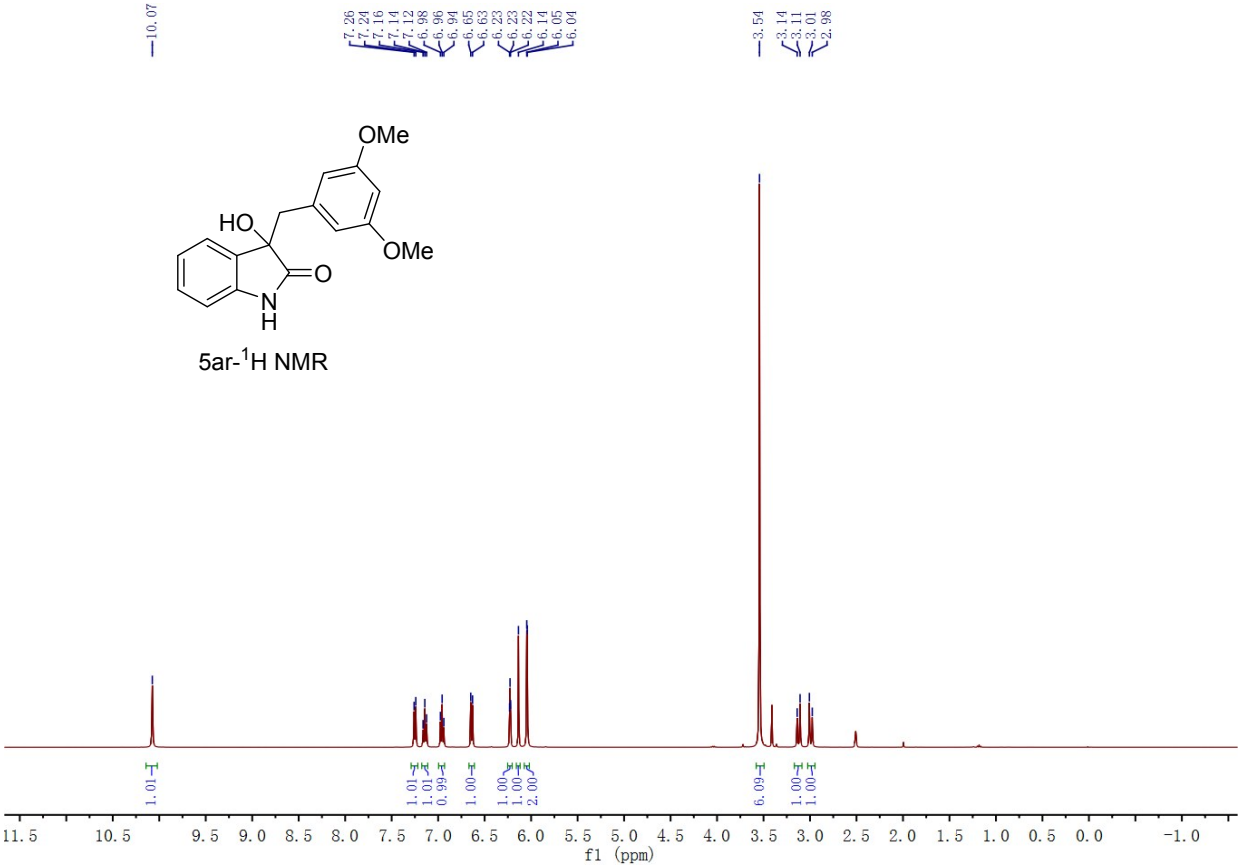
5ap-^{13}C NMR



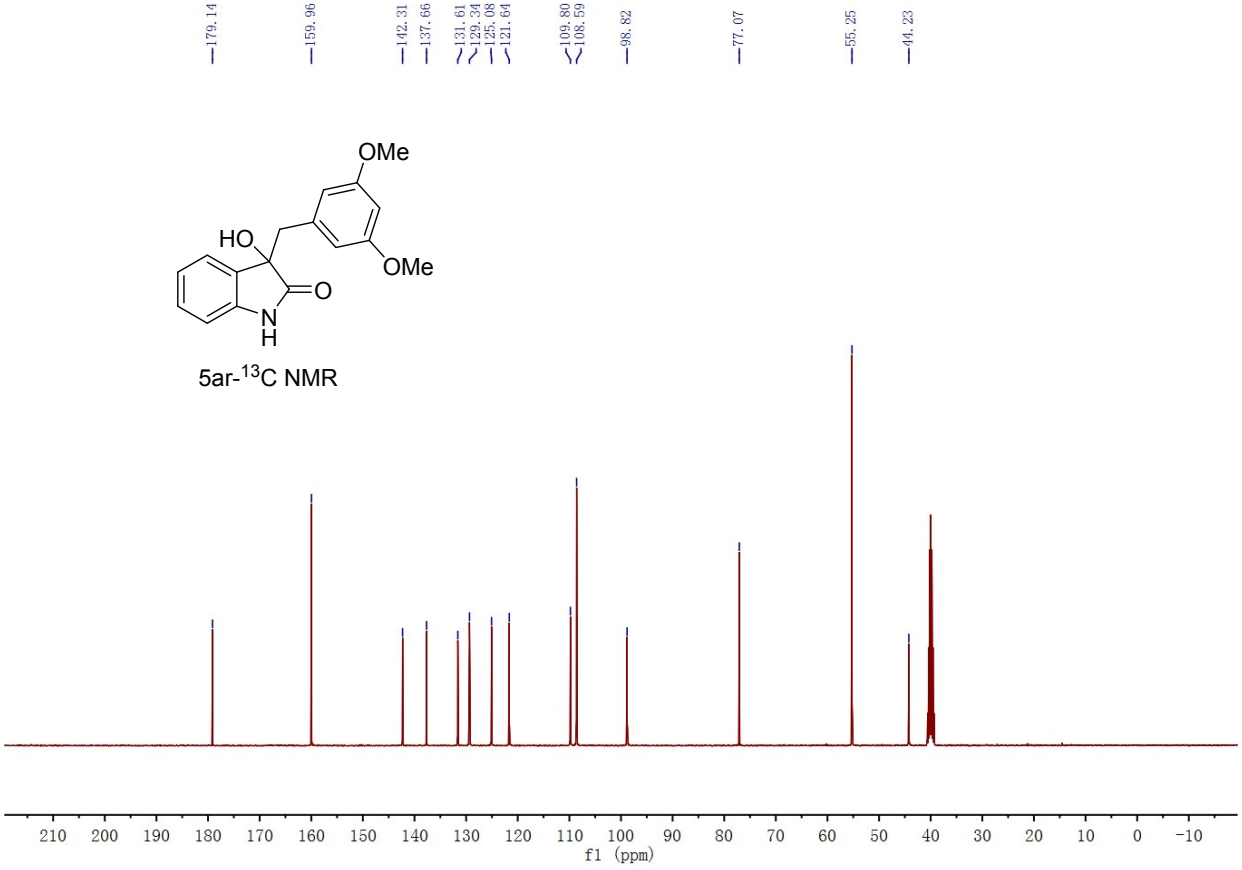


5aq-^{1}H NMR

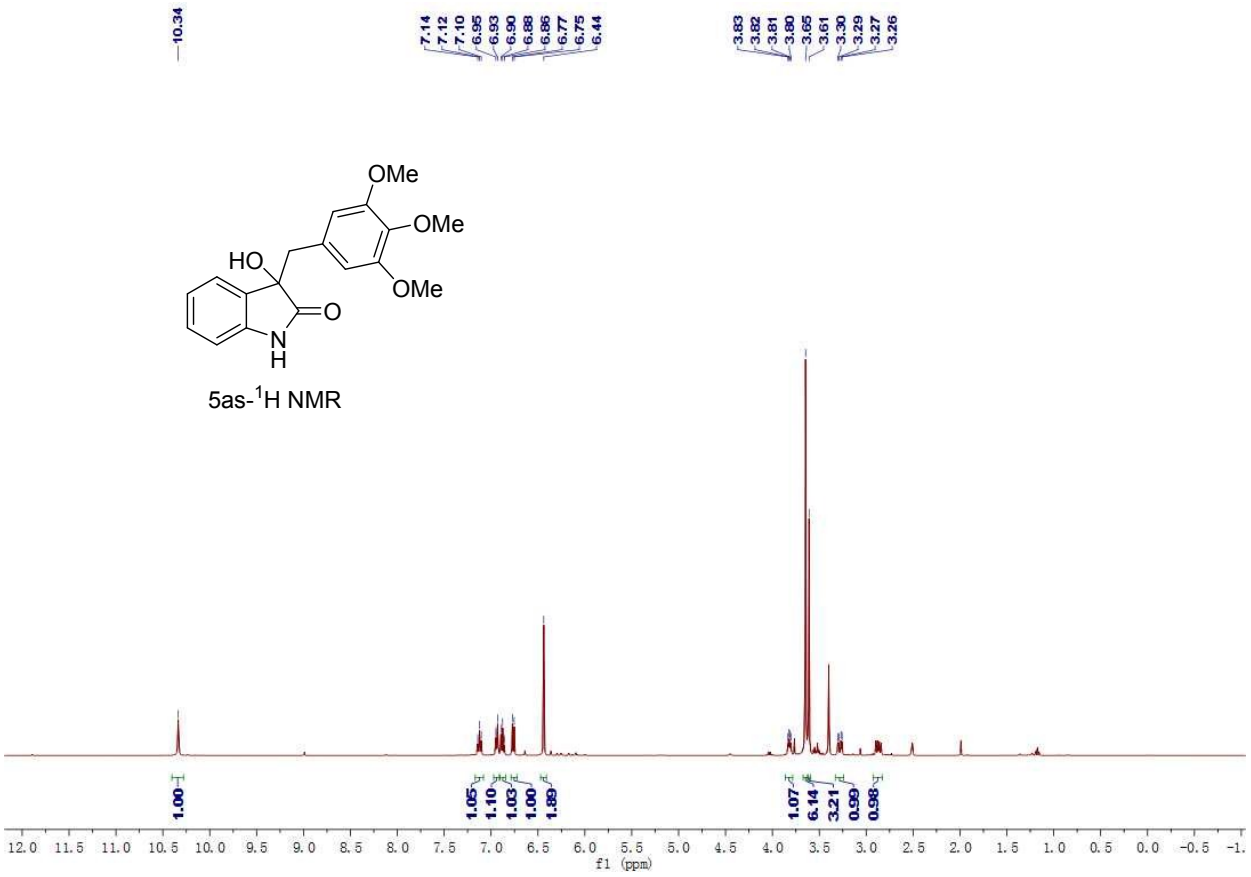
5aq-^{13}C NMR



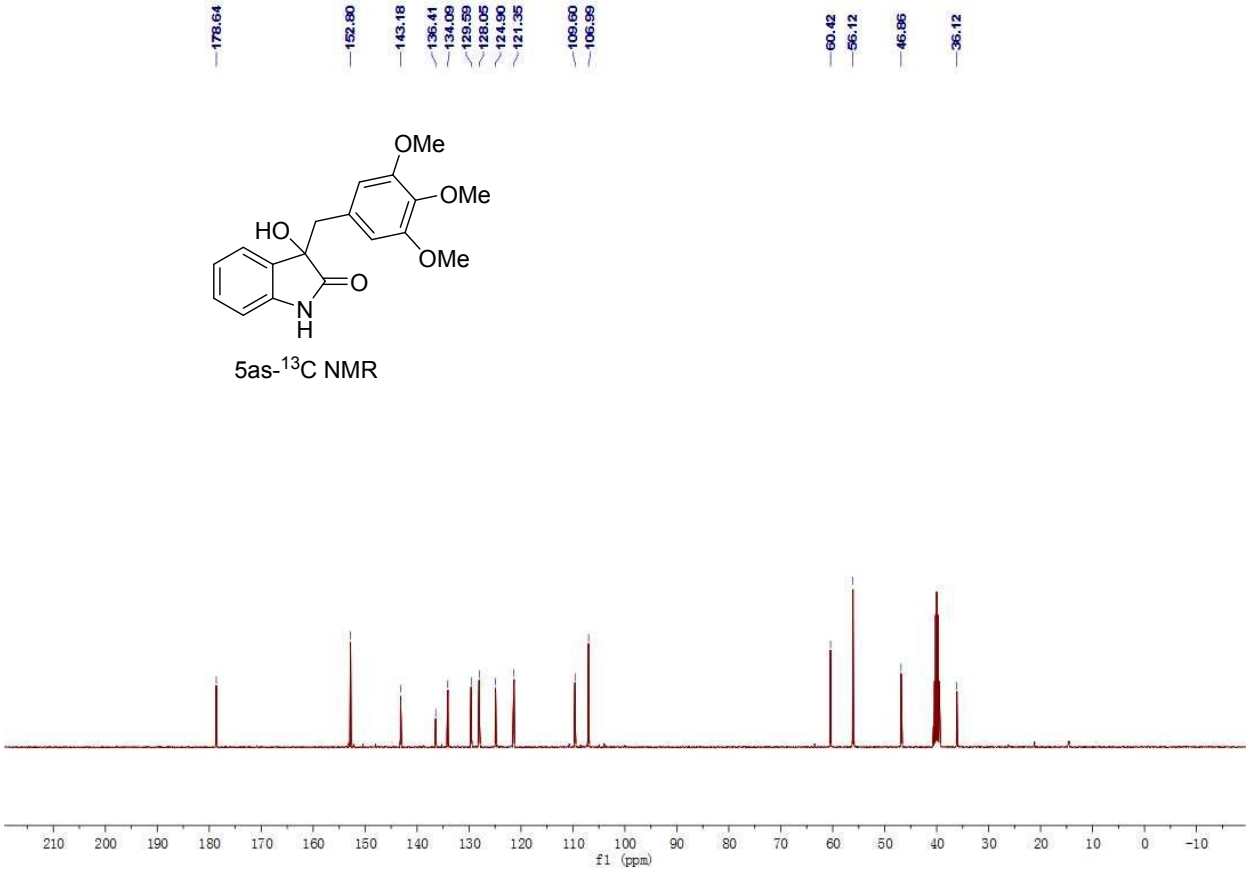
5ar-^{1}H NMR



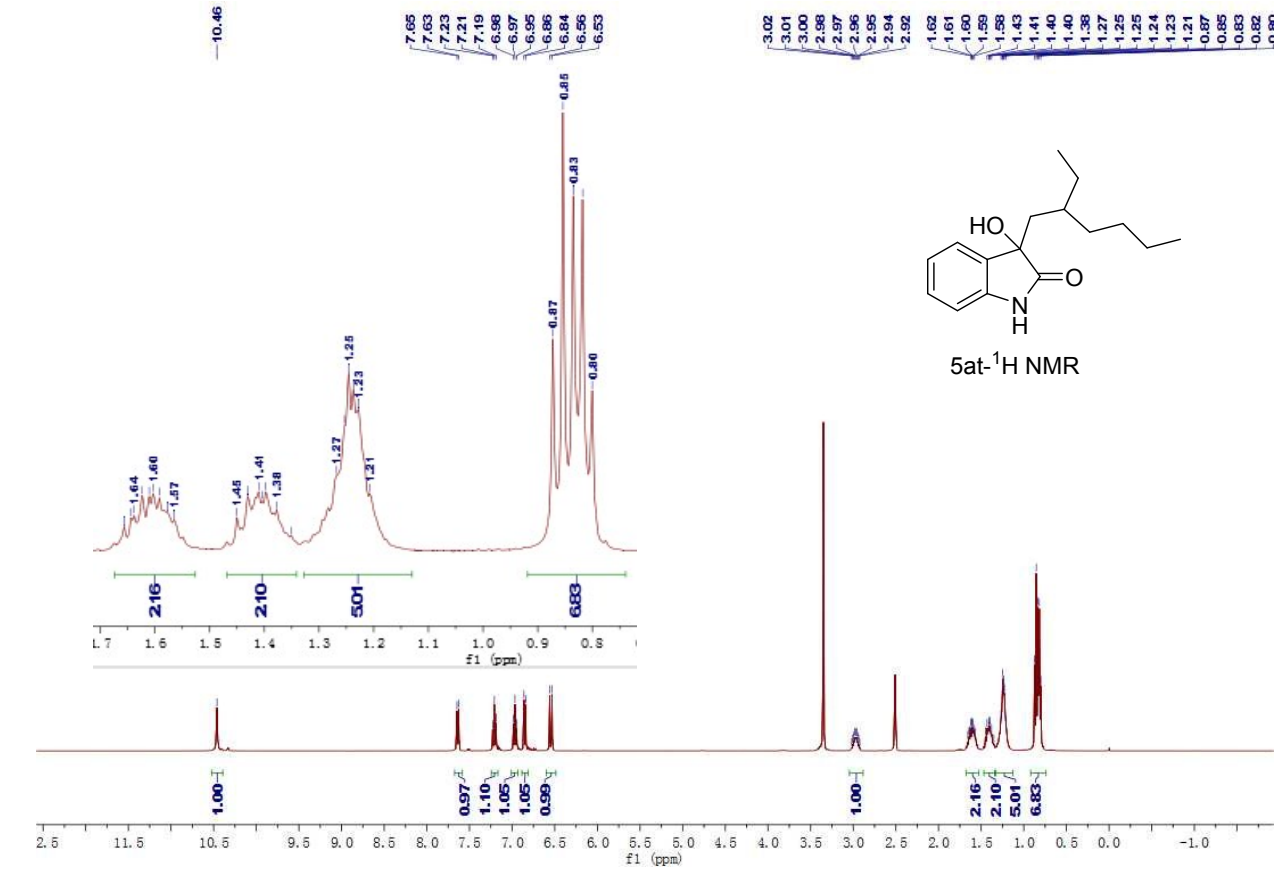
5ar-^{13}C NMR



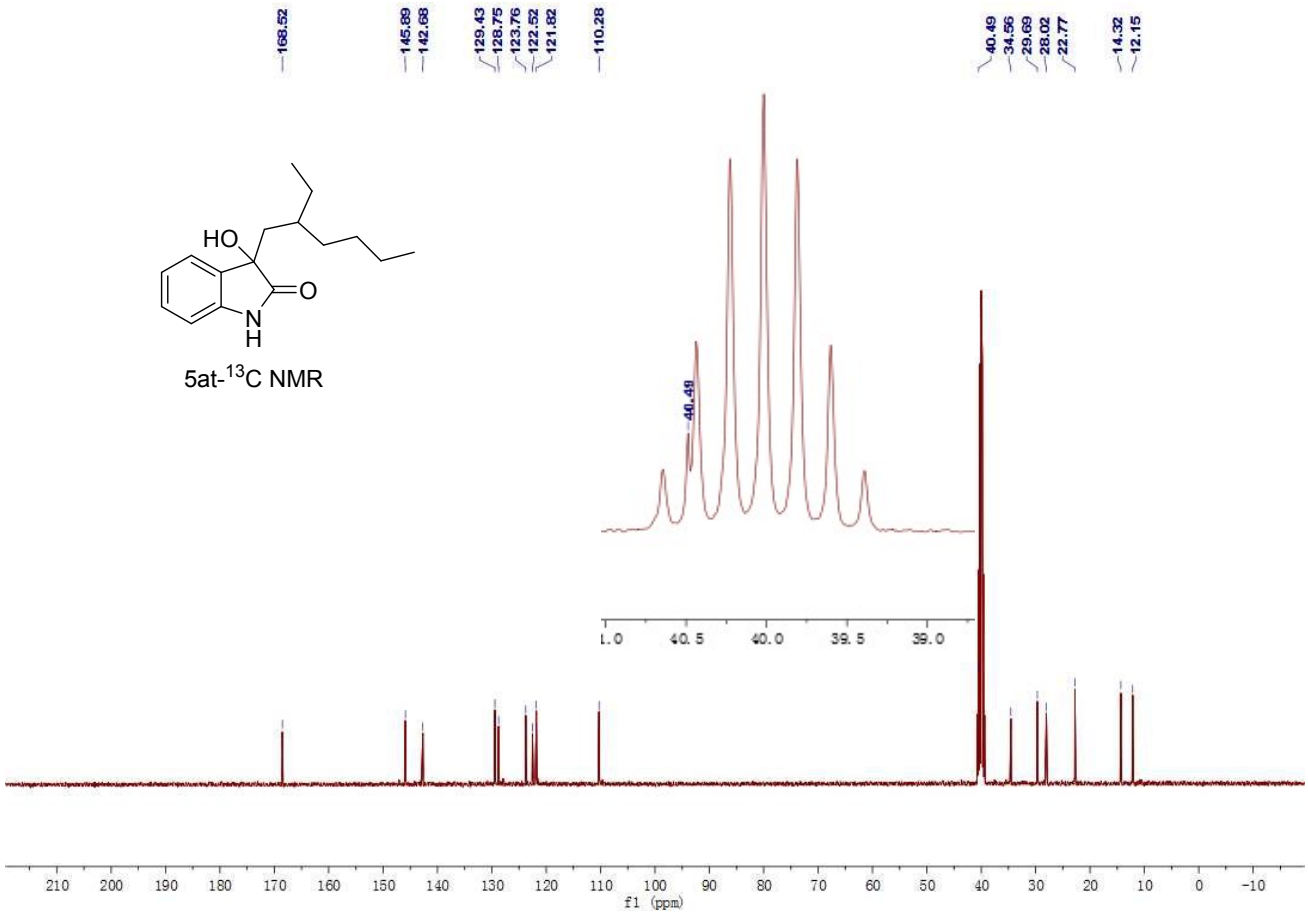
5as-^{1}H NMR



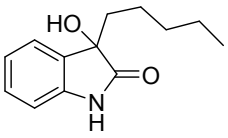
5as-^{13}C NMR



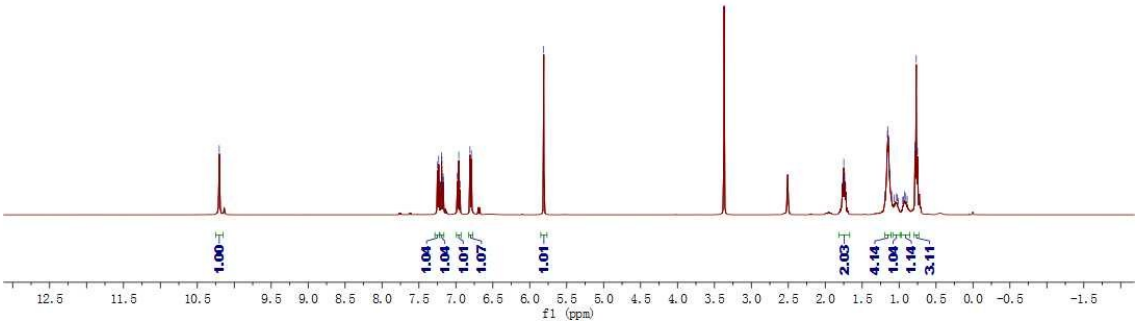
5at-^{1}H NMR

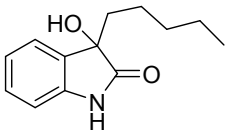


5at-^{13}C NMR

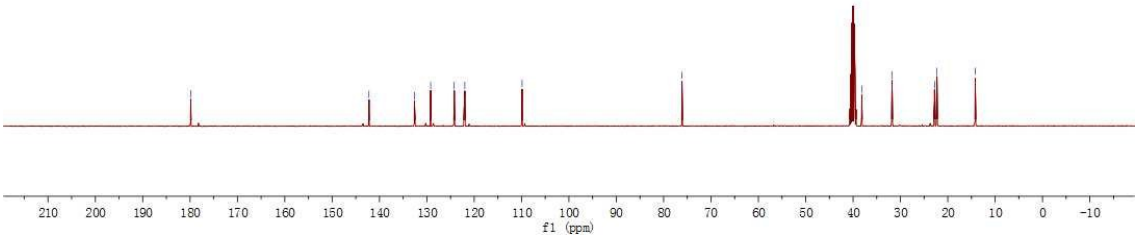


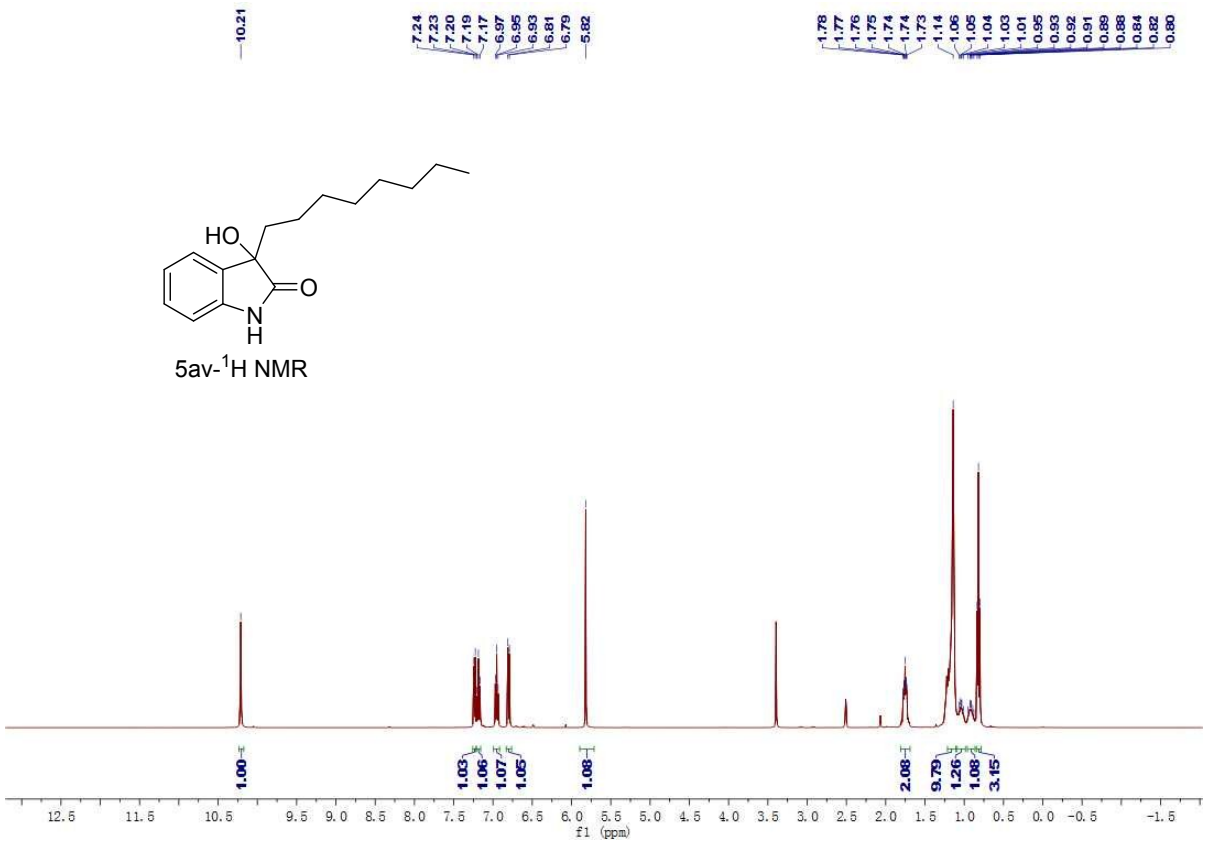
5au-^{1}H NMR



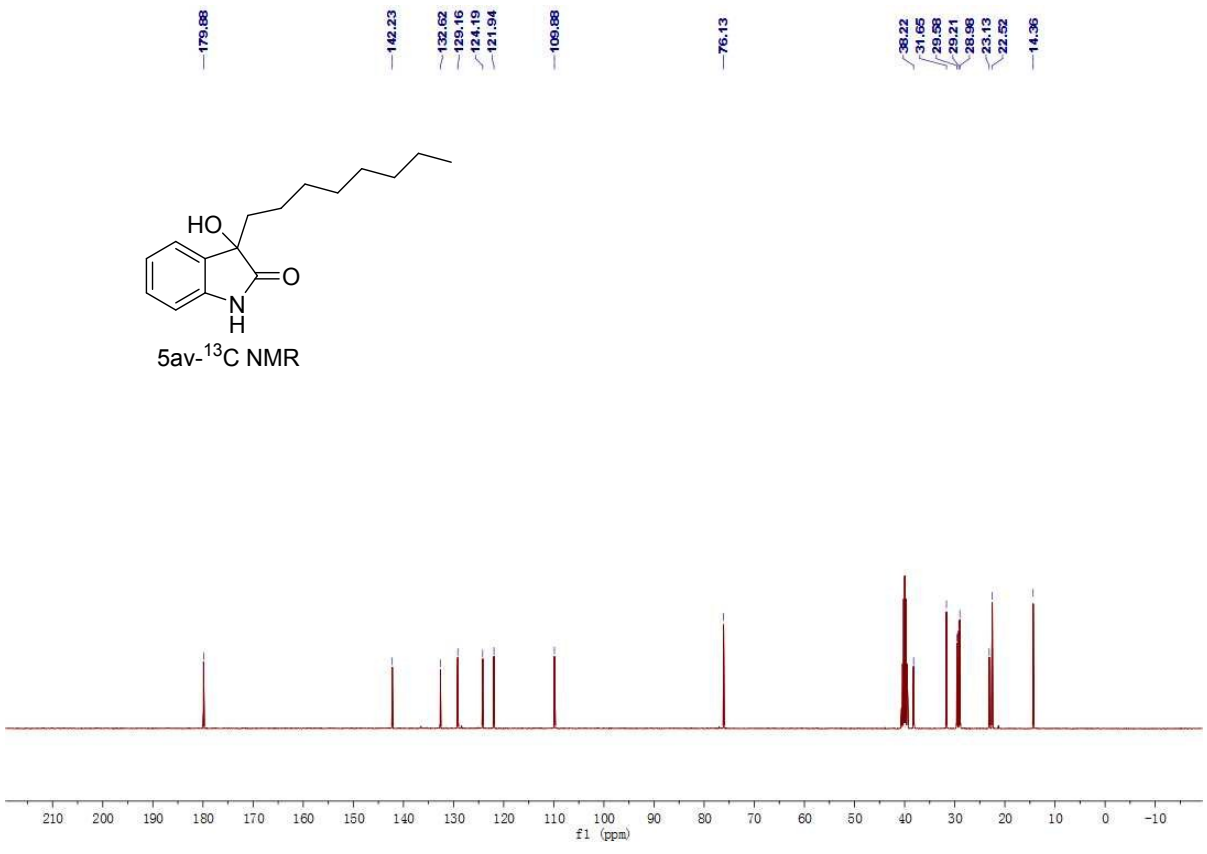


5au-^{13}C NMR

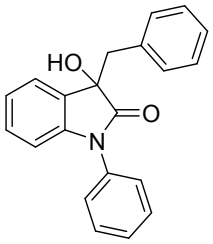




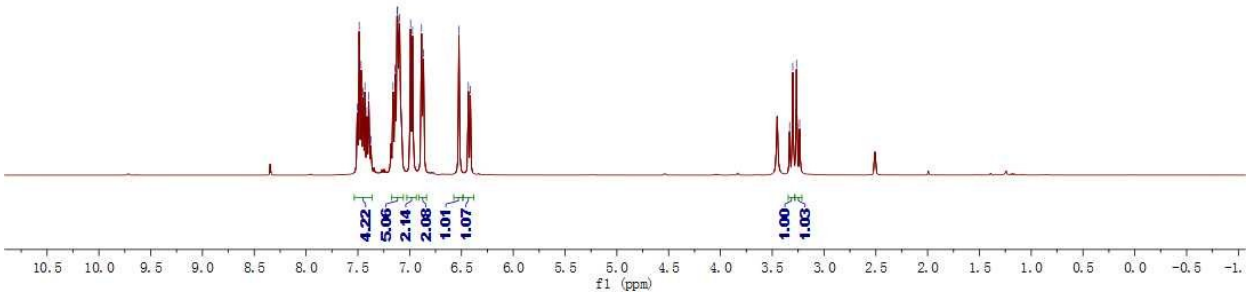
5av-^{1}H NMR

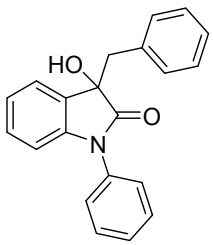


5av-^{13}C NMR

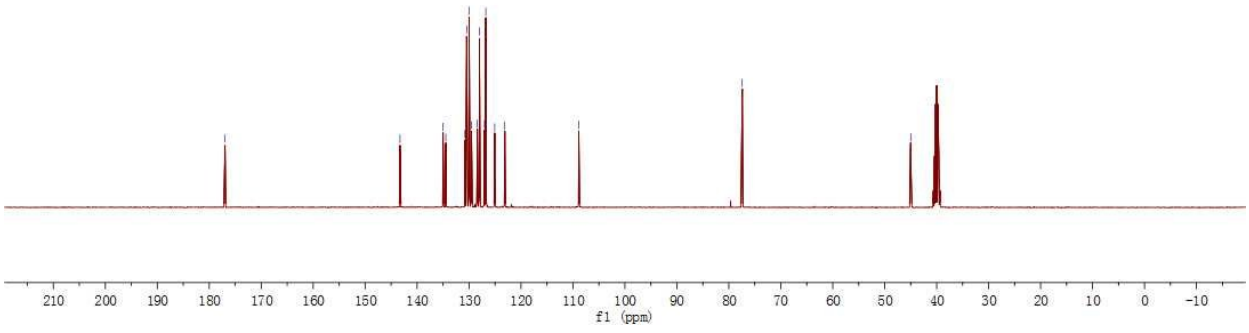


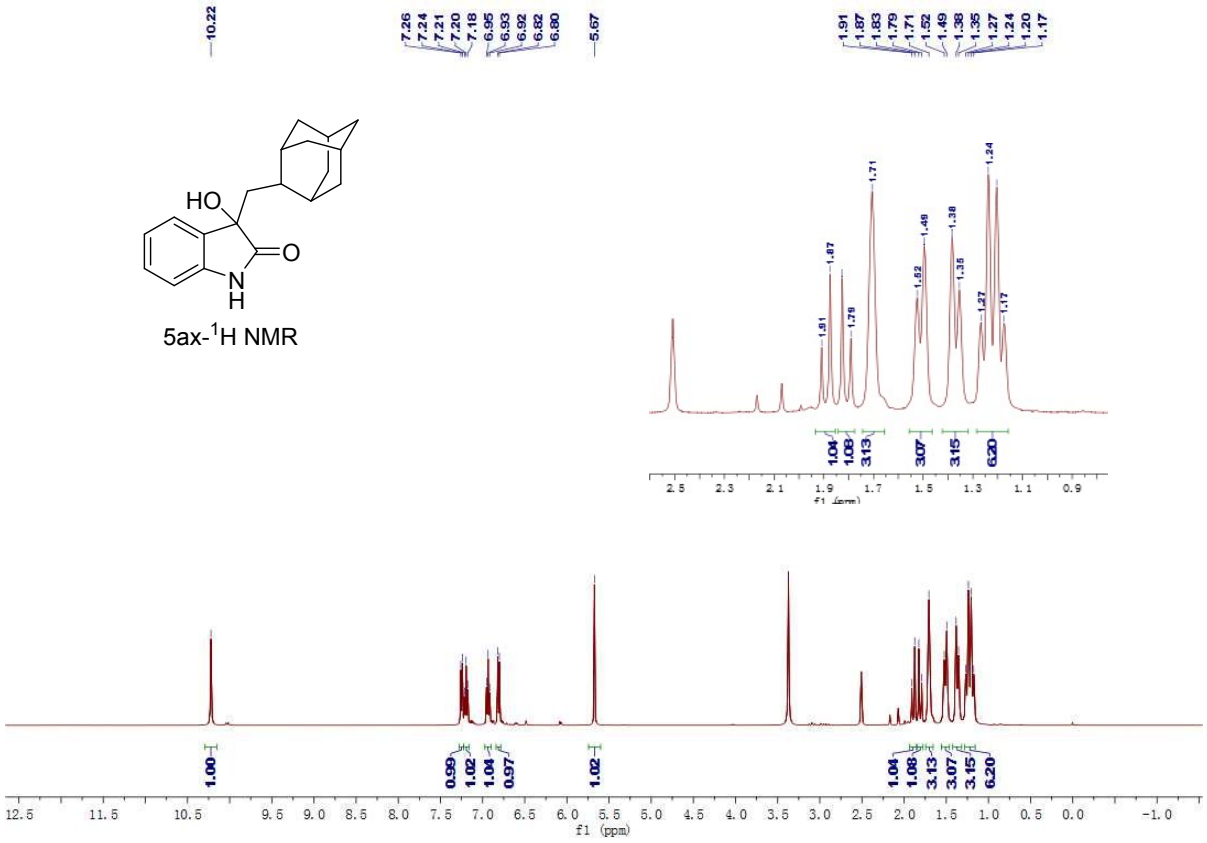
5aw-^{1}H NMR



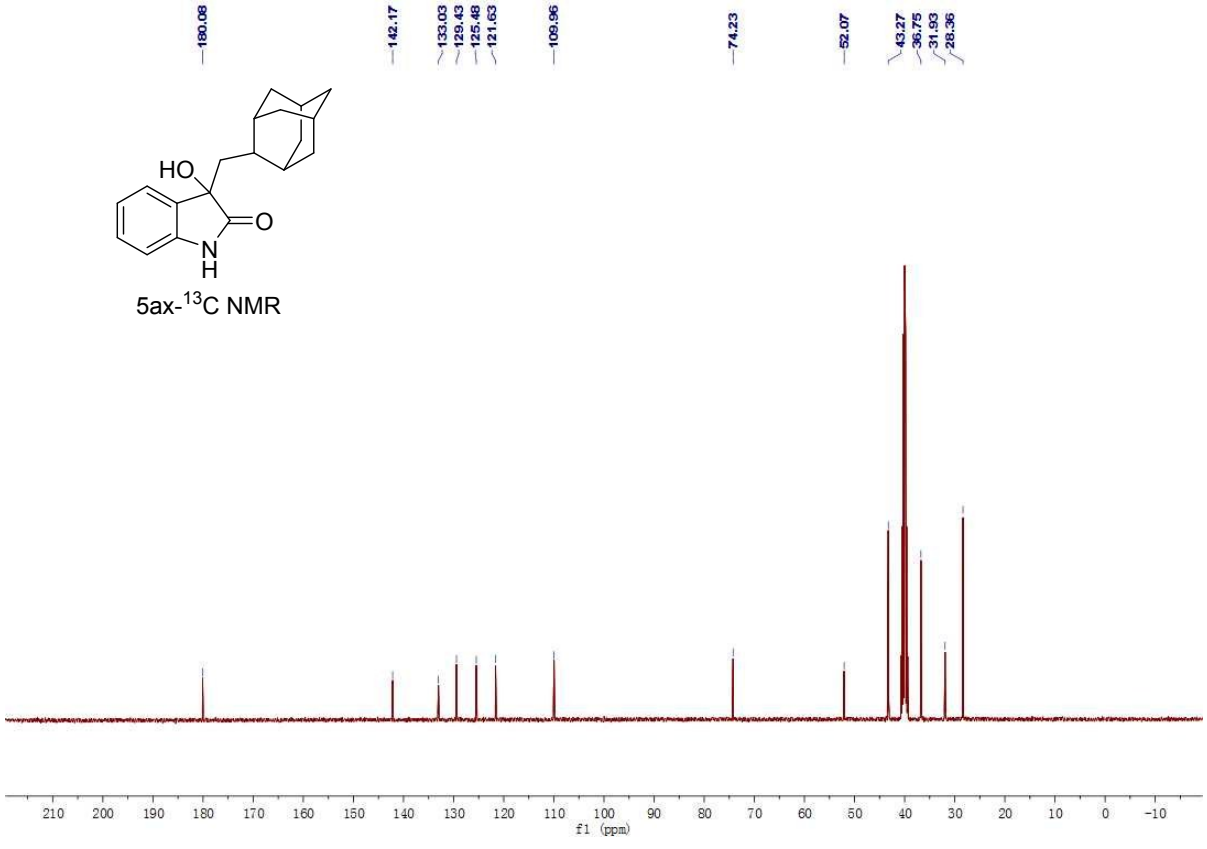


5aw-^{13}C NMR

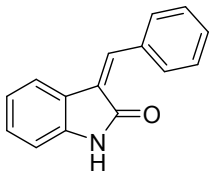




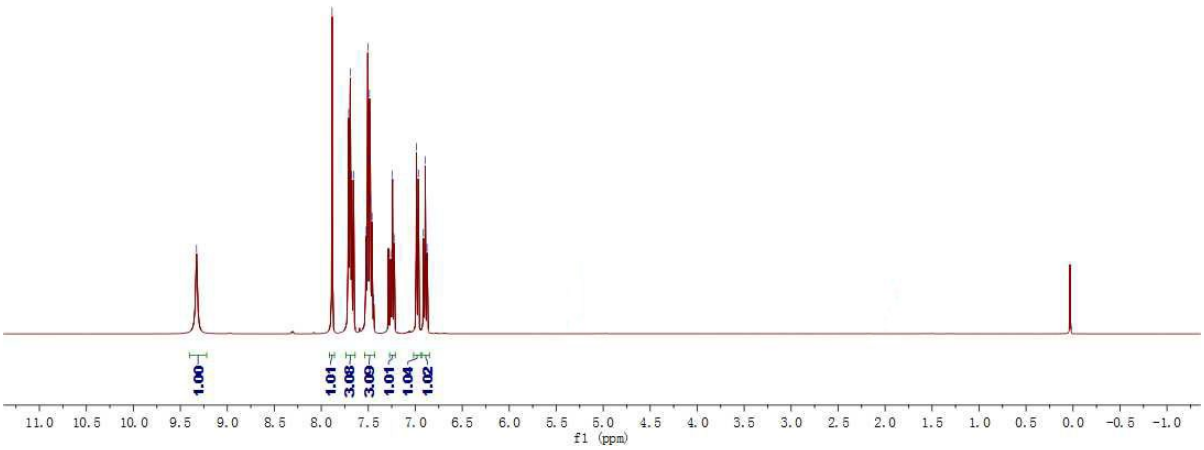
5ax-^{1}H NMR

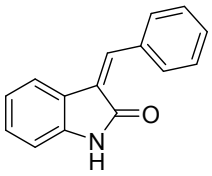


5ax-^{13}C NMR

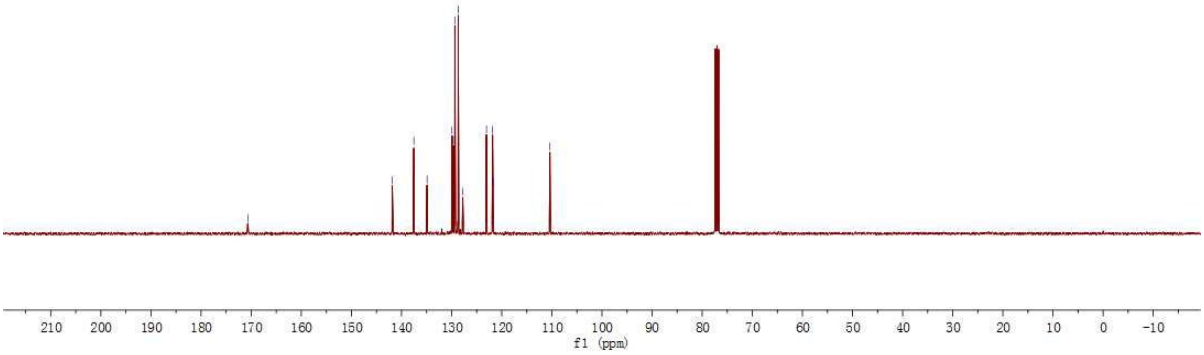


B-^{1}H NMR





B-^{13}C NMR



7. Reference

1. R. Huang, Y. Yang, D.-S. Wang, L. Zhang and D. Wang, Organic Chemistry Frontiers, 2018, 5, 203-209; Z. Xu, D.-S. Wang, X. Yu, Y. Yang and D. Wang, Advanced Synthesis & Catalysis, 2017, 359, 3332-3340.
2. A. E. Putra, Y. Oe and T. Ohta, European Journal of Organic Chemistry, 2015, 2015, 7799-7805; Thomas Jensen and Robert Madsen*, J. Org. Chem. 2009, 74, 3990–3992; C. Chaudhari, S. M. A. H. Siddiki, K. Kon, A. Tomita, Y. Tai and K.-i. Shimizu, Catal. Sci. Technol., 2014, 4, 1064-1069.