SUPPORTING INFORMATION

Gold(I)-catalyzed redox transformation of *o*-nitroalkynes with indoles for the synthesis of 2,3'-biindole derivatives

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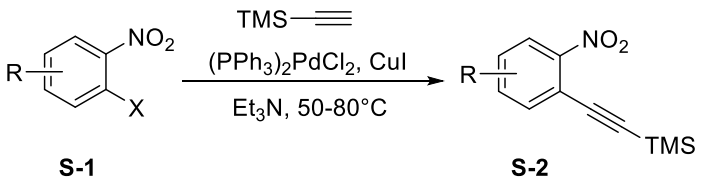
General Information

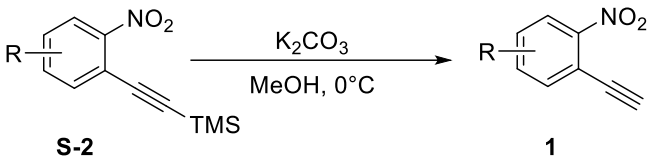
All reactions were carried out in oven-dried glassware. Solvents were dried by the standard methods. Flash column chromatography was performed using silica gel (300-400 mesh). Analytical thin-layer chromatography was performed using glass plates pre-coated with 200-300 mesh silica gel impregnated with a fluorescent indicator (254 nm). ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ on a 400 or 500 MHz spectrometer; chemical shifts were reported in ppm with the solvent signal as reference, and coupling constants (*J*) were given in Hertz. The peak information was described as: br = broad, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, comp = composite. High-resolution mass spectra (HRMS) were recorded on a commercial apparatus (ESI or CI Source).

General Procedure for the Preparation of *o*-nitroalkynes 1.



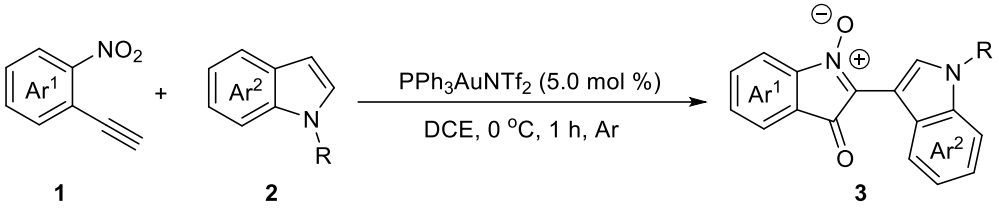
S-1 **S-2**

Synthesis of S-2:[1] To a 50-mL oven-dried flask containing a magnetic stirring bar, **S-1** (10 mmol, 1.0 equiv), trimethylsilylacetylene (15 mmol, 1.5 equiv), $(PPh_3)_2PdCl_2$ (70.1 mg, 0.01 equiv), CuI (19.0 mg, 0.01 equiv), and Et_3N (25 mL) were added in sequence under argon atmosphere at room temperature. The reaction mixture was stirred at 50 - 80 ^{o}C for 2.0 hours. Upon completion (monitored by TLC), the reaction mixture was filtered through a short pad of Celite and the solid was washed with EtOAc (20 mL). The combined organic phase was concentrated under reduced pressure, and the residue was purified by column chromatography on silica gel (Hexanes : EtOAc = 50:1) to afford pure products **S-2** in >80% yields.

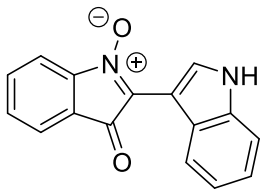


Synthesis of 1: To a 50-mL oven-dried flask containing a magnetic stirring bar, **S-2** (8.0 mmol, 1.0 equiv), K_2CO_3 (12 mmol, 1.5 equiv), and MeOH (20 mL) were added in sequence at 0 ^oC. The reaction mixture was stirred at 0 ^oC for 10 minutes. Upon completion (monitored by TLC), H_2O (10 mL) was added to quench the reaction, and the aqueous layer was extracted with DCM (3×10 mL). The combined organic phase was washed with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated in vacuo after filtration, and the residue was purified by column chromatography on silica gel (Hexanes : EtOAc = 50:1) to afford pure products **1** in >90% yields. The physical and spectral properties identical to the earlier reported.[1]

General Procedure for the Gold-Catalyzed Cascade Reaction.

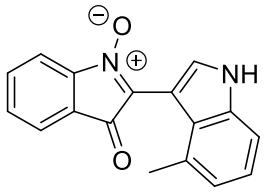


To a 10-mL oven-dried vial containing a magnetic stirring bar, o-nitroalkyne **1** (0.3 mmol), indole **2** (0.2 mmol), PPh_3AuNTf_2 (7.4 mg, 5.0 mol%), and anhydrous DCE (4.0 mL) were added in sequence under atmosphere of argon at 0 ^oC, and the reaction mixture was stirred at 0 ^oC for 1.0 hour (or at indicated time in Scheme 3 for the synthesis of **4**). When the reaction was completed (monitored by TLC), the crude reaction mixture was quenched with saturated aqueous sodium bicarbonate (10 mL) and extracted with EtOAc (15 mL). The organic layer was washed with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated in *vacuo* after filtration. The residue was purified by flash column chromatography on silica gel (Hexanes : EtOAc = 10:1 to 4:1) to give the pure products **3** or **4** in moderate to high yields.



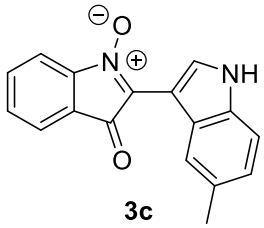
3a

3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3a). 47.7 mg, 91% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 12.11 (s, 1H), 8.94 (s, 1H), 8.58 (d, *J* = 8.0 Hz, 1H), 7.76 (t, *J* = 7.6 Hz, 1H), 7.65 (d, *J* = 7.0 Hz, 1H), 7.60 (d, *J* = 7.6 Hz, 1H), 7.54 (comp, 2H), 7.25 (t, *J* = 7.1 Hz, 1H), 7.19 (t, *J* = 7.5 Hz, 1H). ^{13}C NMR (100 MHz, DMSO) δ 187.3, 148.3, 136.7, 135.8, 133.3, 131.1, 130.6, 124.6, 124.0, 123.4, 123.3, 121.9, 121.2, 113.4, 112.7, 103.1. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{11}N_2O_2$ $[M+H]^{+}$: 263.0815, found 263.0815.



3b

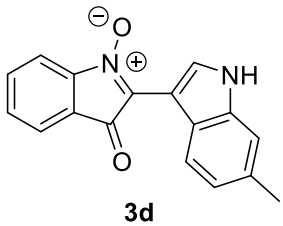
4'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3b). 40.3 mg, 73% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 11.84 (s, 1H), 7.83 (t, *J* = 7.6 Hz, 1H), 7.75 – 7.64 (comp, 4H), 7.33 (d, *J* = 8.1 Hz, 1H), 7.09 (t, *J* = 7.6 Hz, 1H), 6.86 (d, *J* = 7.1 Hz, 1H), 2.38 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 187.6, 147.7, 137.0, 135.6, 134.0, 131.6, 130.6, 129.6, 126.3, 122.7, 122.1, 121.9, 114.1, 110.3, 98.9, 19.3. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^{+}$: 277.0972, found 277.0966.



3c

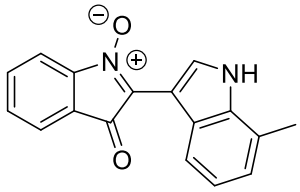
5'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3c). 45.2 mg, 82% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 11.99 (s, 1H), 8.87 (d, *J* = 3.0 Hz, 1H), 8.37 (s, 1H), 7.77 (t, *J* = 7.6 Hz, 1H), 7.64 (d, *J* = 7.1 Hz, 1H), 7.60 – 7.54 (comp, 2H), 7.40

(d, *J* = 8.2 Hz, 1H), 7.08 (d, *J* = 9.0 Hz, 1H), 2.44 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 187.3, 148.3, 135.8, 135.1, 133.3, 131.1, 130.5, 130.1, 129.8, 124.9, 123.7, 123.3, 121.9, 113.4, 112.3, 102.7, 22.1. HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^+$: 277.0972, found 277.0988.



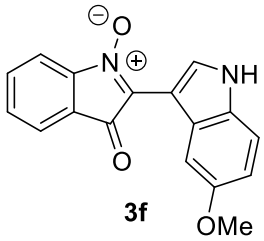
3d

6'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3d). 44.1 mg, 80% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 11.98 (s, 1H), 8.89 (s, 1H), 8.46 (d, *J* = 8.3 Hz, 1H), 7.75 (t, *J* = 8.0 Hz, 1H), 7.63 (d, *J* = 6.9 Hz, 1H), 7.59 – 7.51 (comp, 2H), 7.30 (s, 1H), 7.01 (dd, *J* = 8.4, 1.2 Hz, 1H), 2.42 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 187.3, 148.3, 137.2, 135.7, 133.2, 132.7, 130.7, 130.5, 123.8, 123.2, 122.9, 122.4, 121.9, 113.3, 112.4, 103.1, 21.7. HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^+$: 277.0972, found 277.0975.



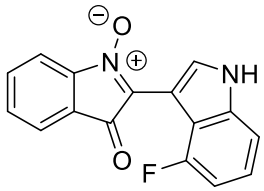
3e

7'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3e). 43.0 mg, 78% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 11.98 (s, 1H), 8.89 (s, 1H), 8.46 (d, *J* = 8.3 Hz, 1H), 7.75 (t, *J* = 8.0 Hz, 1H), 7.63 (d, *J* = 6.9 Hz, 1H), 7.59 – 7.51 (comp, 2H), 7.30 (s, 1H), 7.01 (dd, *J* = 8.4, 1.2 Hz, 1H), 2.42 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 187.3, 148.3, 137.2, 135.7, 133.2, 132.7, 130.7, 130.5, 123.8, 123.2, 122.9, 122.4, 121.9, 113.3, 112.4, 103.1, 21.7. HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^+$: 277.0972, found 277.0963.



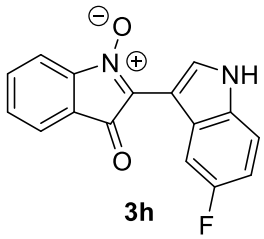
3f

5'-methoxy-3-oxo-1′*H*,3*H*-[2,3'-biindole] 1-oxide (3f). 40.9 mg, 70% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 11.98 (s, 1H), 8.91 (d, *J* = 3.0 Hz, 1H), 8.19 (d, *J* = 2.1 Hz, 1H), 7.76 (t, *J* = 7.6 Hz, 1H), 7.65 (d, *J* = 7.1 Hz, 1H), 7.60 – 7.52 (comp, 2H), 7.41 (d, *J* = 8.8 Hz, 1H), 6.94 – 6.85 (m, 1H), 3.83 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 187.5, 154.8, 148.3, 135.8, 133.3, 131.7, 131.4, 130.4, 125.3, 123.2, 121.9, 113.3, 113.2, 113.2, 106.1, 103.1, 55.7. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_3$ $[M+H]^{+}$: 293.0921, found 293.0927.



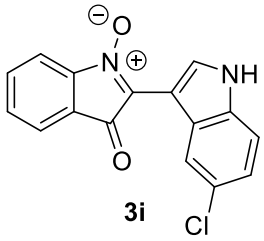
3g

4'-fluoro-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3g). 47.6 mg, 85% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 12.27 (s, 1H), 8.07 (s, 1H), 7.81 (t, *J* = 7.6 Hz, 1H), 7.69 (t, *J* = 6.1 Hz, 2H), 7.64 (t, *J* = 7.4 Hz, 1H), 7.37 (d, *J* = 8.1 Hz, 1H), 7.25 – 7.16 (comp, 1H), 6.92 – 6.86 (m, 1H). ^{13}C NMR (125 MHz, DMSO) δ 185.9, 157.1 (d, *J* = 248.0 Hz), 147.7, 139.4 (d, *J* = 10.1 Hz), 135.6, 132.0, 131.5, 130.7, 123.7 (d, *J* = 7.8 Hz), 123.1, 121.9, 114.6 (d, *J* = 20.0 Hz), 114.0, 109.1 (d, *J* = 3.5 Hz), 106.4 (d, *J* = 20.0 Hz), 97.1. ^{19}F NMR (471 MHz, DMSO) δ -116.5. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{10}FN_2O_2$ $[M+H]^{+}$: 281.0721, found 281.0718.



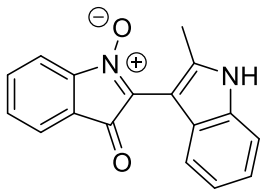
3h

5'-fluoro-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3h). 37.5 mg, 67% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 12.23 (s, 1H), 8.95 (s, 1H), 8.31 (dd, *J* = 11.3, 2.4 Hz, 1H), 7.75 (t, *J* = 7.6 Hz, 1H), 7.63 (d, *J* = 7.0 Hz, 1H), 7.60 – 7.49 (m, 3H), 7.10 (td, *J* = 8.9, 2.4 Hz, 1H). ^{13}C NMR (125 MHz, DMSO) δ 187.3, 158.0 (d, *J* = 232.5 Hz), 148.2, 135.8, 133.4, 132.5, 130.7, 130.1, 125.0 (d, *J* = 11.1 Hz), 123.25, 121.95, 113.1 (d, *J* = 10.1 Hz), 113.4, 111.5 (d, *J* = 20.0 Hz), 109.1, 108.9, 103.4 (d, *J* = 4.3 Hz). ^{19}F NMR (376 MHz, DMSO) δ -122.3. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{10}FN_2O_2$ $[M+H]^{+}$: 281.0721, found 281.0718.



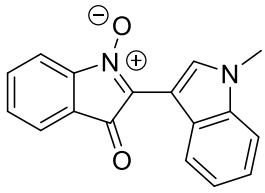
3i

5'-chloro-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3i). 40.2 mg, 68% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 12.26 (s, 1H), 8.93 (s, 1H), 8.62 (d, *J* = 1.8 Hz, 1H), 7.77 (t, *J* = 7.5 Hz, 1H), 7.65 (d, *J* = 7.0 Hz, 1H), 7.61 – 7.53 (comp, 3H), 7.26 (dd, *J* = 8.6, 1.9 Hz, 1H). ^{13}C NMR (125 MHz, DMSO) δ 187.2, 148.2, 135.8, 135.3, 132.8, 132.2, 130.7, 125.7, 125.6, 123.4, 123.31, 123.27, 122.0, 114.2, 113.5, 102.9. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{10}ClN_2O_2$ $[M+H]^{+}$: 297.0425, found 297.0429.



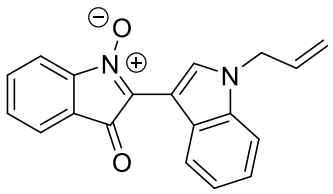
3j

2'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3j). 39.2 mg, 71% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 11.76 (s, 1H), 7.79 (t, *J* = 7.2 Hz, 1H), 7.68 – 7.65 (comp, 2H), 7.61 (t, *J* = 7.3 Hz, 1H), 7.45 (d, *J* = 7.9 Hz, 1H), 7.36 (d, *J* = 8.0 Hz, 1H), 7.11 (t, *J* = 7.1 Hz, 1H), 7.02 (t, *J* = 7.5 Hz, 1H), 2.49 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 186.7, 148.2, 140.6, 136.1, 135.4, 134.2, 131.2, 127.0, 123.9, 121.9, 121.8, 121.3, 120.2, 113.9, 111.5, 97.9, 14.7. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^{+}$: 277.0972, found 277.0963.



3k

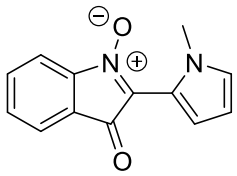
1'-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3k). 40.8 mg, 74% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 8.95 (s, 1H), 8.59 (d, *J* = 8.1 Hz, 1H), 7.77 - 7.73 (comp, 1H), 7.65 (d, *J* = 7.1 Hz, 1H), 7.60 – 7.53 (comp, 3H), 7.34 – 7.31 (comp, 1H), 7.25 – 7.22 (comp, 1H), 3.93 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 187.2, 148.2, 137.3, 135.8, 134.6, 132.9, 130.6, 125.1, 124.3, 123.5, 123.2, 121.9, 121.4, 113.4, 111.0, 102.1, 33.8. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^{+}$: 277.0972, found 277.0973.



3l

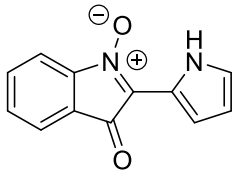
1'-allyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3l). 47.1 mg, 78% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 8.99 (s, 1H), 8.60 (d, *J* = 8.0 Hz, 1H), 7.76 (d, *J* = 7.6

Hz, 1H), 7.65 (d, *J* = 7.1 Hz, 1H), 7.62 - 7.50 (comp, 3H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.23 (t, *J* = 7.5 Hz, 1H), 6.12 – 5.99 (comp, 1H), 5.23 (d, *J* = 10.3 Hz, 1H), 5.14 (d, *J* = 17.0 Hz, 1H), 5.00 (d, *J* = 5.3 Hz, 2H). ^{13}C NMR (100 MHz, DMSO) δ 187.1, 148.2, 136.5, 135.8, 134.0, 133.7, 132.9, 130.6, 125.2, 1244, 123.5, 123.2, 121.9, 121.5, 118.1, 113.4, 111.3, 102.6, 49.1. HRMS (TOF MS ESI$^+$) calculated for $C_{19}H_{15}N_2O_2$ $[M+H]^+$: 303.1128, found 303.1126.



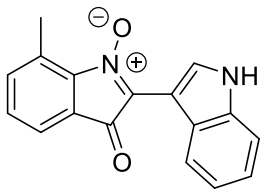
3m

2-(1-methyl-1*H*-pyrrol-2-yl)-3-oxo-3*H*-indole 1-oxide (3m). 39.8 mg, 88% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 7.81 - 7.74 (comp, 1H), 7.69 - 7.57 (comp, 3H), 7.15 – 7.10 (comp, 1H), 6.85 - 6.80 (comp, 1H), 6.28 – 6.24 (comp, 1H), 3.78 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 185.8, 147.9, 135.6, 131.4, 128.9, 123.4, 129.9, 122.0, 118.8, 116.6, 114.1, 109.7, 37.4. HRMS (TOF MS ESI$^+$) calculated for $C_{13}H_{11}N_2O_2$ $[M+H]^+$: 227.0815, found 227.0817.



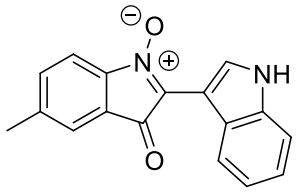
3n

3-oxo-2-(1*H*-pyrrol-2-yl)-3*H*-indole 1-oxide (3n). 35.2 mg, 83% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 11.73 (s, 1H), 7.78 - 7.71 (comp, 1H), 7.63 – 7.50 (comp, 3H), 7.32 - 7.28 (comp, 1H), 7.21 - 7.15 (comp, 1H), 6.40 - 6.32 (comp, 1H). ^{13}C NMR (100 MHz, DMSO) δ 186.2, 148.3, 135.9, 130.7, 124.8, 123.4, 122.2, 118.9, 114.6, 113.6, 111.2. HRMS (TOF MS ESI$^+$) calculated for $C_{12}H_9N_2O_2$ $[M+H]^+$: 213.0659, found 213.0656.



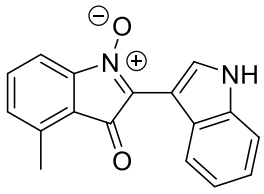
3o

7-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3o). 41.4 mg, 75% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 12.05 (s, 1H), 8.92 (d, *J* = 3.0 Hz, 1H), 8.55 (d, *J* = 8.1 Hz, 1H), 7.54 – 7.46 (comp, 3H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.26 – 7.21 (comp, 1H), 7.19 – 7.15 (comp, 1H), 2.72 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 187.3, 143.8, 139.7, 136.7, 133.7, 130.5, 130.2, 127.0, 124.6, 124.1, 124.0, 123.3, 121.0, 120.1, 112.6, 103.0, 17.0. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^{+}$: 277.0972, found 277.0977.



3p

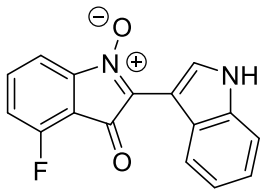
5-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3p). 38.6 mg, 70% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 12.06 (s, 1H), 8.90 (s, 1H), 8.55 (d, *J* = 8.1 Hz, 1H), 7.55 (d, *J* = 7.6 Hz, 1H), 7.51 (d, *J* = 8.0 Hz, 1H), 7.49 – 7.43 (m, 2H), 7.24 (t, *J* = 7.5 Hz, 1H), 7.17 (t, *J* = 7.5 Hz, 1H), 2.43 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 187.4, 146.2, 140.8, 136.7, 135.5, 133.0, 130.8, 124.6, 124.0, 123.4, 123.3, 122.6, 121.1, 113.2, 112.6, 103.1, 21.3. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^{+}$: 277.0972, found 277.0971.



3q

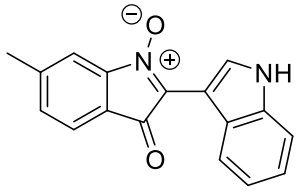
4-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3q). 44.2 mg, 80% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 12.05 (s, 1H), 8.92 (d, *J* = 2.9 Hz, 1H), 8.55 (d,

J = 8.0 Hz, 1H), 7.56 - 7.44 (comp, 3H), 7.40 (t, *J* = 7.4 Hz, 1H), 7.27 - 7.23 (comp, 1H), 7.20 – 7.14 (comp, 1H), 2.71 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 187.3, 143.7, 139.7, 136.7, 133.7 130.6, 130.5, 130.2, 127.0, 124.6, 124.0, 123.2, 121.0, 120.0, 112.5, 103.0, 17.0. HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^+$: 277.0972, found 277.0976.



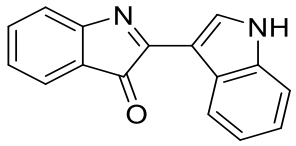
3r

4-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3r). 42.6 mg, 76% yield. Purple solid. ^{1}H NMR (400 MHz, DMSO) δ 12.12 (s, 1H), 8.94 (d, *J* = 2.8 Hz, 1H), 8.54 (d, *J* = 8.0 Hz, 1H), 7.84 - 7.76 (comp, 1H), 7.52 (d, *J* = 8.0 Hz, 1H), 7.45 (d, *J* = 7.6 Hz, 1H), 7.38 (t, *J* = 8.7 Hz, 1H), 7.25 (t, *J* = 7.4 Hz, 1H), 7.18 (t, *J* = 7.5 Hz, 1H). ^{13}C NMR (125 MHz, DMSO) δ 183.61, 155.2 (d, *J* = 261.7 Hz), 149.2 (d, *J* = 4.6 Hz), 138.2 (d, *J* = 8.7 Hz), 136.8, 133.4, 131.4, 124.5, 124.1, 123.5, 121.3, 119.2, 119.1, 112.7, 110.1, 103.0, 79.7. ^{19}F NMR (376 MHz, DMSO) δ -115.4. HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{10}FN_2O_2$ $[M+H]^+$: 281.0721, found 281.0726.



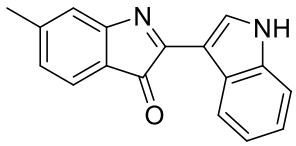
3s

6-methyl-3-oxo-1'*H*,3*H*-[2,3'-biindole] 1-oxide (3s). 30.4 mg, 55% yield. Purple solid. ^{1}H NMR (500 MHz, DMSO) δ 12.10 (s, 1H), 8.94 (s, 1H), 8.57 (d, *J* = 7.6 Hz, 1H), 7.52 (d, *J* = 7.1 Hz, 2H), 7.43 (s, 1H), 7.33 (d, *J* = 6.4 Hz, 1H), 7.25 (t, *J* = 6.9 Hz, 1H), 7.18 (t, *J* = 6.9 Hz, 1H), 2.47 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 186.9, 148.7, 147.1, 136.7, 131.0, 130.5, 124.6, 124.1, 123.4, 121.9, 121.1, 120.8, 114.2, 112.6, 103.2, 22.3. HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{13}N_2O_2$ $[M+H]^+$: 277.0972, found 277.0967.



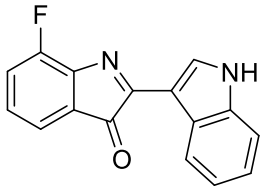
4a

1'*H*,3*H*-[2,3'-biindol]-3-one (4a). Deep red solid. ^{1}H NMR (500 MHz, DMSO) δ ^{1}H NMR (500 MHz, DMSO) δ 12.16 (s, 1H), 8.52 (s, 1H), 8.41 (d, *J* = 7.1 Hz, 1H), 7.62 - 7.56 (comp, 3H), 7.36 (d, *J* = 6.8 Hz, 1H), 7.31 – 7.24 (comp, 2H), 7.19 (t, *J* = 6.3 Hz, 1H). ^{113}C NMR (125 MHz, DMSO) δ 195.7, 163.4, 158.5, 137.8, 137.3, 133.8, 126.8, 126.4, 124.9, 124.0, 123.0, 122.9, 122.3, 121.1, 113.0, 106.9. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{11}N_2O$ [M+H]$^{+}$: 247.0871, found 247.0863.



4s

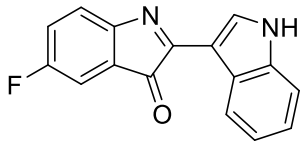
6-methyl-1'*H*,3*H*-[2,3'-biindol]-3-one (4s). 31.7 mg, 61% yield. Deep red solid. ^{1}H NMR (400 MHz, DMSO) δ 12.13 (s, 1H), 8.51 (s, 1H), 8.42 – 8.37 (comp, 1H), 7.57 – 7.52 (comp, 1H), 7.42 (d, *J* = 7.3 Hz, 1H), 7.31 – 7.24 (comp, 2H), 7.20 (s, 1H), 7.00 (d, *J* = 7.3 Hz, 1H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, DMSO) δ 195.1, 164.0, 159.2, 149.2, 137.2, 133.7, 127.0, 126.4, 124.9, 123.9, 122.9, 122.2, 122.1, 120.6, 113.0, 107.0, 22.4. HRMS (TOF MS ESI^{+}) calculated for $C_{17}H_{13}N_2O$ [M+H]$^{+}$: 261.1022, found 261.1028.



4t

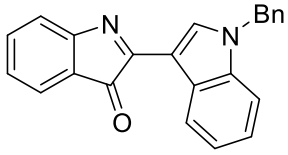
7-fluoro-1'*H*,3*H*-[2,3'-biindol]-3-one (4t). 37.0 mg, 70% yield. Deep red solid. ^{1}H NMR (400 MHz, DMSO) δ 12.23 (s, 1H), 8.55 (d, *J* = 3.0 Hz, 1H), 8.47 - 8.22 (comp, 1H), 7.61 – 7.53 (comp, 1H), 7.52 – 7.45 (comp, 1H), 7.40 (d, *J* = 7.0 Hz, 1H), 7.36 – 7.26 (comp, 2H), 7.25 – 7.18 (comp, 1H). ^{13}C NMR (100 MHz, DMSO) δ 194.5,

158.6, 153.2 (d, *J* = 254.4 Hz), 148.7 (d, *J* = 12.3 Hz), 137.33, 134.36, 128.4 (d, *J* = 5.8 Hz), 126.31, 126.0 (d, *J* = 3.7 Hz), 125.5 (d, *J* = 19.7 Hz), 124.15, 122.97, 122.52, 121.1(d, *J* = 2.5 Hz), 113.1, 107.1. ^{19}F NMR (376 MHz, DMSO) δ -130.0. HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{10}FN_2O$ [M+H]$^+$: 265.0772, found 265.0770.



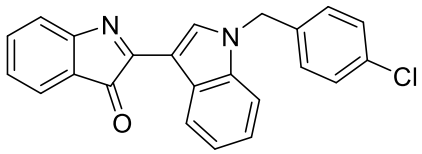
4u

5-fluoro-1'*H*,3*H*-[2,3'-biindol]-3-one (4u). 35.9 mg, 68% yield. Deep red solid. ^{1}H NMR (400 MHz, DMSO) δ 12.14 (s, 1H), 8.48 (d, *J* = 2.4 Hz, 1H), 8.43 – 8.34 (comp, 1H), 7.57 - 7.50 (comp, 1H), 7.42 – 7.34 (comp, 3H), 7.33 – 7.21 (comp, 2H). ^{13}C NMR (125 MHz, DMSO) δ 194.7, 161.2 (d, *J* = 244.2 Hz), 159.3, 158.9 (d, *J* = 3.8 Hz), 137.2, 133.7, 126.2, 124.3 (d, *J* = 7.9 Hz), 124.0, 123.1 (d, *J* = 23.6 Hz), 122.9, 122.3, 122.1 (d, *J* = 7.5 Hz), 113.1, 112.6 (d, *J* = 25.4 Hz), 106.9. ^{19}F NMR (376 MHz, DMSO) δ -116.5. HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{10}FN_2O$ [M+H]$^+$: 265.0772, found 265.0768.



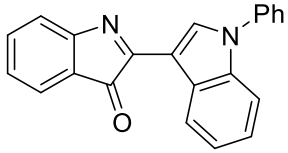
4v

1'-benzyl-1'*H*,3*H*-[2,3'-biindol]-3-one (4v). 47.7 mg, 71% yield. Deep red solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.61 (d, *J* = 7.8 Hz, 1H), 8.49 (d, *J* = 3.5 Hz, 1H), 7.52 - 7.47 (comp, 2H), 7.37 – 7.27 (comp, 7H), 7.18 (d, *J* = 6.6 Hz, 2H), 7.12 – 7.09 (comp, 1H), 5.40 (s, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.9, 163.6, 158.3, 137.1, 137.0, 135.9, 135.6, 129.0, 128.2, 127.3, 126.9, 126.2, 124.5, 123.9, 123.6, 122.9, 122.6, 121.2, 110.5, 107.3, 51.01. HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{17}N_2O$ [M+H]$^+$: 337.1335, found 337.1340.



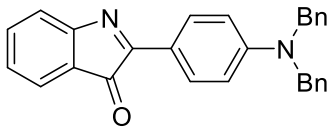
4w

1'-(4-chlorobenzyl)-1'*H*,3*H*-[2,3'-biindol]-3-one (4w). 56.3 mg, 76% yield. Deep red solid. ^{1}H NMR (400 MHz, DMSO) δ 8.72 (s, 1H), 8.58 - 8.42 (comp, 1H), 7.62 - 7.56 (comp, 2H), 7.53 (d, *J* = 6.9 Hz, 1H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.37 (d, *J* = 7.5 Hz, 1H), 7.35 – 7.25 (comp, 4H), 7.20 (t, *J* = 7.3 Hz, 1H), 5.62 (s, 2H). ^{13}C NMR (100 MHz, DMSO) δ 195.4, 163.2, 158.3, 137.8, 137.1, 136.6, 136.5, 132.8, 130.1, 129.7, 129.2, 127.1, 127.0, 125.0, 124.3, 124.2, 123.3, 122.9, 122.7, 121.3, 111.9, 106.6, 49.4. HRMS (TOF MS ESI^{+}) calculated for $C_{23}H_{16}ClN_2O$ [M+H]$^{+}$: 371.0946, found 371.0948.



4x

1'-phenyl-1'*H*,3*H*-[2,3'-biindol]-3-one (4x). 42.5 mg, 66% yield. Deep red solid. ^{1}H NMR (400 MHz, DMSO) δ 8.60 (s, 1H), 8.58 – 8.49 (m, 1H), 7.73 – 7.65 (m, 4H), 7.60 – 7.52 (m, 4H), 7.45 – 7.36 (m, 3H), 7.23 (dd, *J* = 14.3, 7.0 Hz, 1H). ^{13}C NMR (125 MHz, DMSO) δ 195.0, 162.8, 158.3, 138.2, 137.9, 136.8, 135.0, 130.6, 130.1, 128.6, 127.4, 127.3, 125.1, 125.0, 123.5, 123.4, 122.9, 121.6, 111.9, 108.3. HRMS (TOF MS ESI^{+}) calculated for $C_{22}H_{15}N_2O$ [M+H]$^{+}$: 323.1179, found 323.1185.

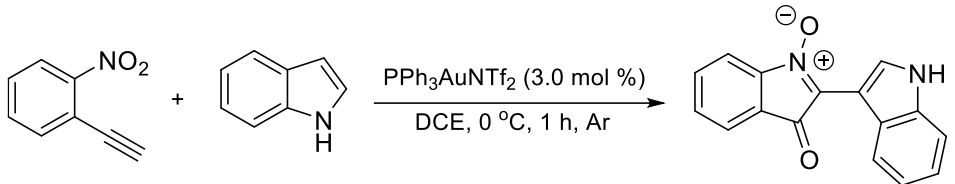


4y

2-(4-(dibenzylamino)phenyl)-3*H*-indol-3-one (4y). 26.5 mg, 33% yield. Purple solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32 (d, *J* = 9.2 Hz, 2H), 7.50 (d, *J* = 7.3 Hz, 2H), 7.40 - 7.36 (comp, 4H), 7.35 - 7.30 (d, *J* = 4.7 Hz, 4H), 7.25 (d, *J* = 6.9 Hz, 4H), 6.85 (d, *J* = 9.2 Hz, 2H), 4.77 (s, 4H). ^{13}C NMR (100 MHz, DMSO) δ 195.2, 161.2, 159.7,

152.0, 138.4, 137.5, 131.2, 129.1, 127.5, 127.1, 127.0, 124.8, 123.5, 121.2, 117.7, 112.9, 54.3. HRMS (TOF MS ESI$^+$) calculated for $C_{28}H_{23}N_2O$ $[M+H]^+$: 403.1824, found 403.1805.

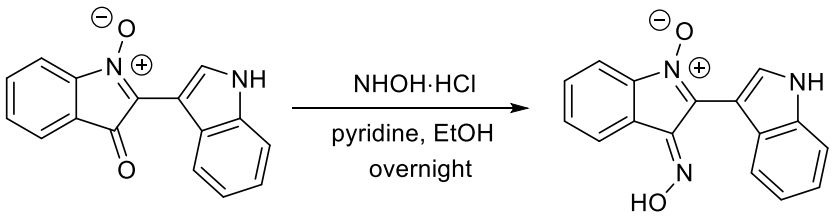
General Procedure for Scale up.



1a 6.0 mmol, 1.05 g **2a** 4.0 mmol, 0.468 g **3a** 0.89 g, 85% yield

To a 100-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **1a** (6.0 mmol), indole **2a** (4.0 mmol), PPh_3AuNTf_2 (88.6 mg, 3.0 mol%), and anhydrous DCE (50 mL) were added in sequence under atmosphere of argon at 0 °C, and the reaction mixture was stirred at 0 °C for 1.0 hours. When the reaction was completed (monitored by TLC), the crude reaction mixture was quenched with saturated aqueous sodium bicarbonate (30 mL) and extracted with EtOAc (30 mL). The organic layer was washed with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated in *vacuo* after filtration. The residue was purified by flash column chromatography on silica gel (Hexanes : EtOAc = 6:1 to 4:1) to give 0.89 g pure **3a** in 85% yield.

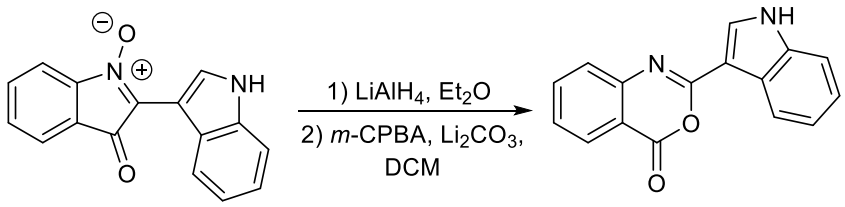
Derivatizations.



3a **5**, 60%

Synthesis of 5:[2] To a 10-mL oven-dried round-bottom flask containing a magnetic stirring bar, **3a** (26.2 mg, 0.1 mmol) in EtOH (2.0 mL), was added NHOH·HCl (10.4 mg, 0.3 mmol, 3.0 equiv) and pydrine (12.0 mg, 0.3 mmol, 3.0 equiv) under stirring at

room temperature. And the reaction mixture was stirred for 24 h under these conditions. When the reaction was completed (monitored by TLC), the solvent was evaporated under vacuum after filtering through a pad of Celite. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc = 2:1) to give 16.6 mg of the product **5** as orange solid, 60% yield. ^{1}H NMR (500 MHz, DMSO) δ 13.53 (s, 1H), 11.95 (s, 1H), 8.77 (s, 1H), 8.40 (d, *J* = 8.1 Hz, 1H), 8.24 (d, *J* = 7.3 Hz, 1H), 7.66 (d, *J* = 3.9 Hz, 2H), 7.56 – 7.53 (comp, 1H), 7.51 (d, *J* = 8.0 Hz, 1H), 7.22 (t, *J* = 7.5 Hz, 1H), 7.14 – 7.10 (comp, 1H). ^{13}C NMR (125 MHz, DMSO) δ 148.5, 145.7, 136.6, 135.0, 131.9, 131.1, 129.7, 126.9, 125.2, 124.2, 122.8, 120.5, 118.7, 113.3, 112.4, 103.3. HRMS (TOF MS ESI^{+}) calculated for $C_{16}H_{11}N_3O_2$ $[M+H]^{+}$: 278.0924, found 278.0922.



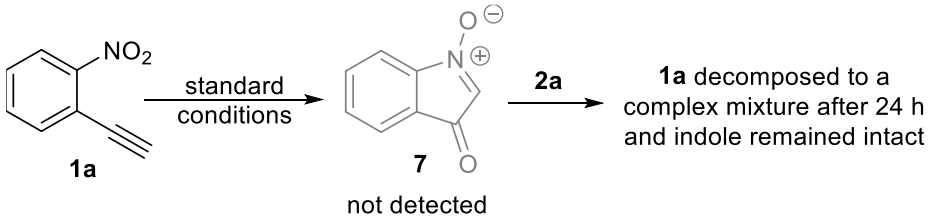
3a **6**, 66% over 2 steps

Synthesis of 6:[3] To a 10-mL oven-dried round-bottom flask containing a magnetic stirring bar, and **3a** (26.2 mg, 0.1 mmol) in Et_2O (2.0 mL), was added $LiAlH_4$ (3.8 mg, 0.1 mmol, 1.0 equiv) under stirring at 0 °C, and the reaction mixture was stirred at room temperature for additional 1.0 hour. When the reaction was completed (monitored by TLC), the solvent was evaporated under vacuum after filtering through a pad of Celite. The residue was purified by column chromatography on silica gel (Hexanes : EtOAc = 6:1) to give 20.9 mg of the reduction product as deep-red solid, 85% yield.

Then to another 10-mL oven-dried round-bottom flask containing a magnetic stirring bar, the above obtained product (20.9 mg, 0.085 mmol), and Li_2CO_3 (1.9 mg, 30 mol %), in DCM (1.0 mL), was added a solution of *m*-CPBA (29.2 mg, 0.17 mmol 2.0 equiv) in DCM (1.0 mL) under stirring at 0 °C, and the reaction mixture was stirred at room temperature for 5 minutes. Then, the reaction mixture was quenched

with aqueous Na_2SO_3, and extracted with ether, washed with cold aqueous $NaHCO_3$ and aqueous NaCl in sequence. Then the organic phase was dried over anhydrous $MgSO_4$. After evaporating the solvent after filtration, the crude product was purified by flash chromatography on silica gel (Hexanes : EtOAc = 15:1) to give 17.1 mg of pure product **6** as white solid, 66% yield over 2 steps. ^{1}H NMR (400 MHz, DMSO) δ 12.13 (s, 1H), 8.44 (comp, 1H), 8.30 (s, 1H), 8.12 (d, *J* = 7.8 Hz, 1H), 7.91 (t, *J* = 7.5 Hz, 1H), 7.68 (d, *J* = 8.0 Hz, 1H), 7.56 - 7.46 (comp, 2H), 7.33 - 7.22 (comp, 2H). ^{13}C NMR (125 MHz, DMSO) δ 159.2, 155.6, 147.5, 136.9, 136.7, 131.5, 127.9, 126.8, 126.1, 124.8, 122.8, 121.4, 121.2, 116.2, 112.4, 106.3. HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{10}N_2O_2$ $[M+H]^+$: 263.0815, found 263.0815.

Control Experiment.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **1a** (14.7 mg, 0.1 mmol), PPh_3AuNTf_2 (3.7 mg, 5.0 mol%), and anhydrous DCE (2.0 mL) were added in sequence under atmosphere of argon at 0 ^{o}C. Then the reaction mixture was subjected to proton NMR analysis after 24 hours under these conditions. All the material **1a** was consumed and decomposed in to a complex mixture after 24 hours (see Figure S1, the third spectrum). Then, indole **2a** (7.8 mg, 0.07 mmol) was added to the above reaction mixture, leading to no further reaction at all (see Figure S1, the fourth spectrum).

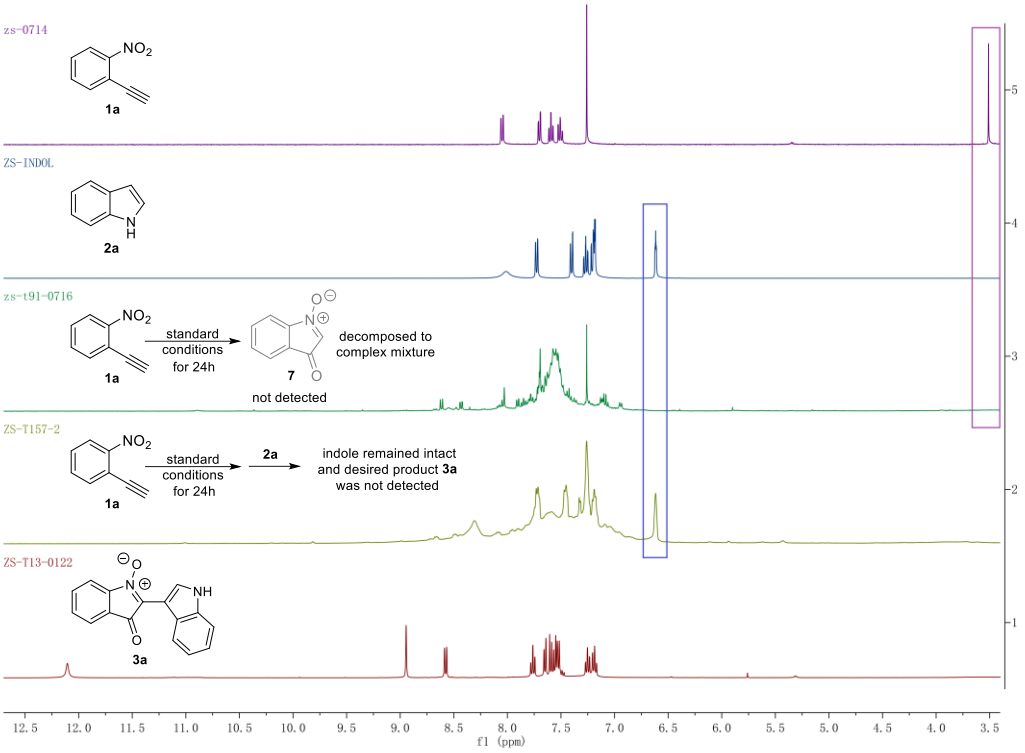
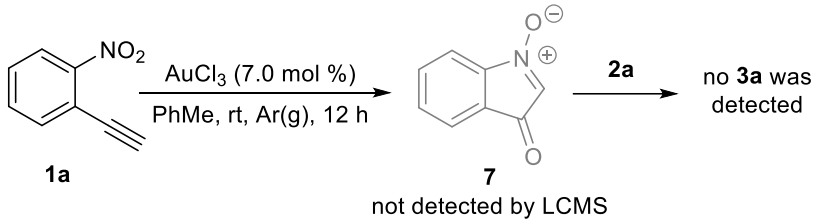
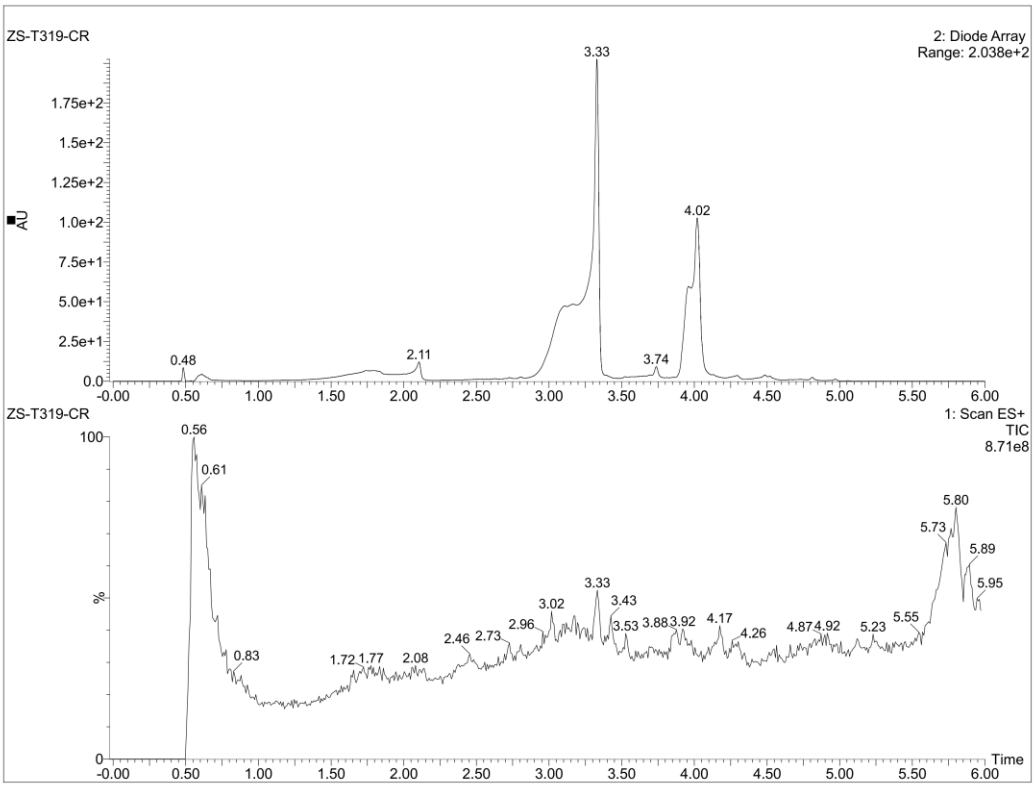


Figure S1. Proton NMR spectra of crude reaction mixture of **1a**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **1a** (14.7 mg, 0.1 mmol), $AuCl_3$ (4.6 mg, 7.0 mol%), and PhMe (1.0 mL) were added in sequence under atmosphere of argon at room temperature. Then the reaction was monitored by TLC and LCMS. All the material **1a** was consumed and decomposed in to a complex mixture after 12 hours (see Figure S2, the MS signal 293.09 might be the dimer product of **1a**). Then, indole **2a** (7.8 mg, 0.07 mmol) was added shortly to the above reaction mixture, leading to no further reaction at all.



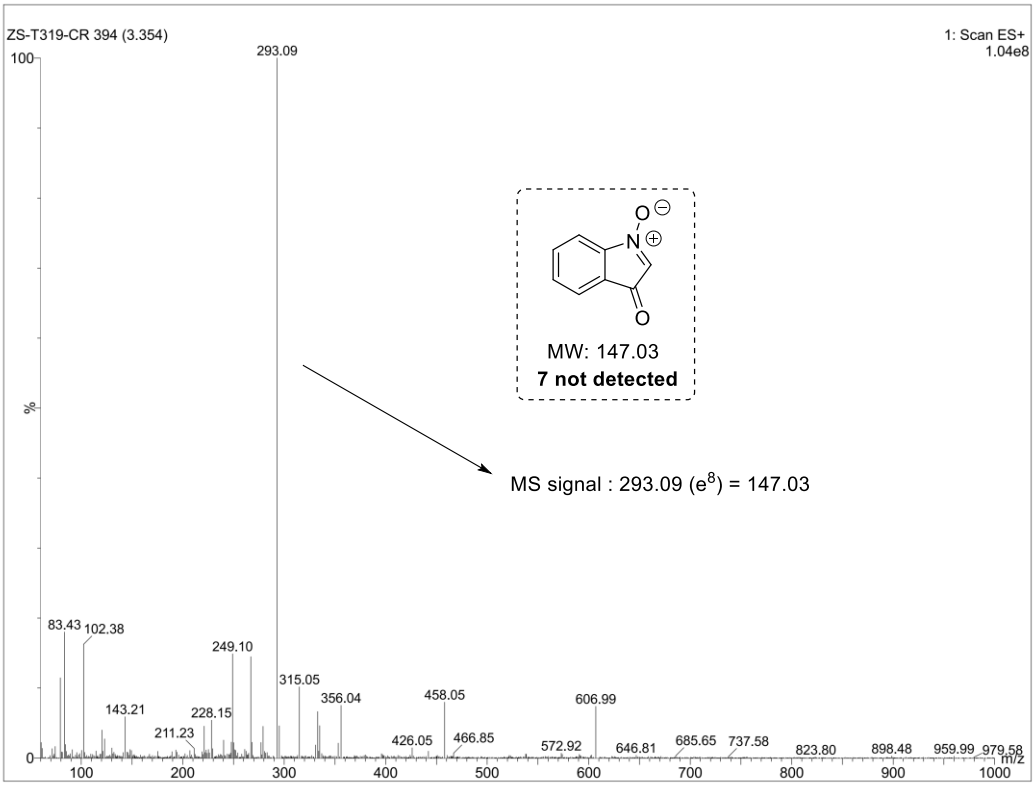
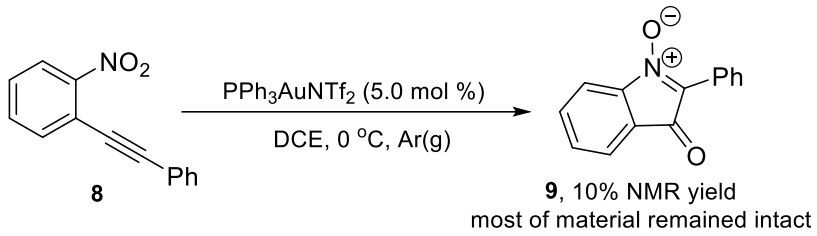


Figure S2. LCMS monitoring of the crude reaction of **1a** with **2a**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **8** (22.3 mg, 0.1 mmol), PPh_3AuNTf_2 (3.7 mg, 5.0 mol%), and anhydrous DCE (2.0 mL) were added in sequence under atmosphere of argon at 0 °C. Then the reaction mixture was subjected to proton NMR analysis after 1.0 hour under these conditions. Most of **8** remained intact, and minor amount of **9** was detected by proton NMR (10%, see Figure S3).

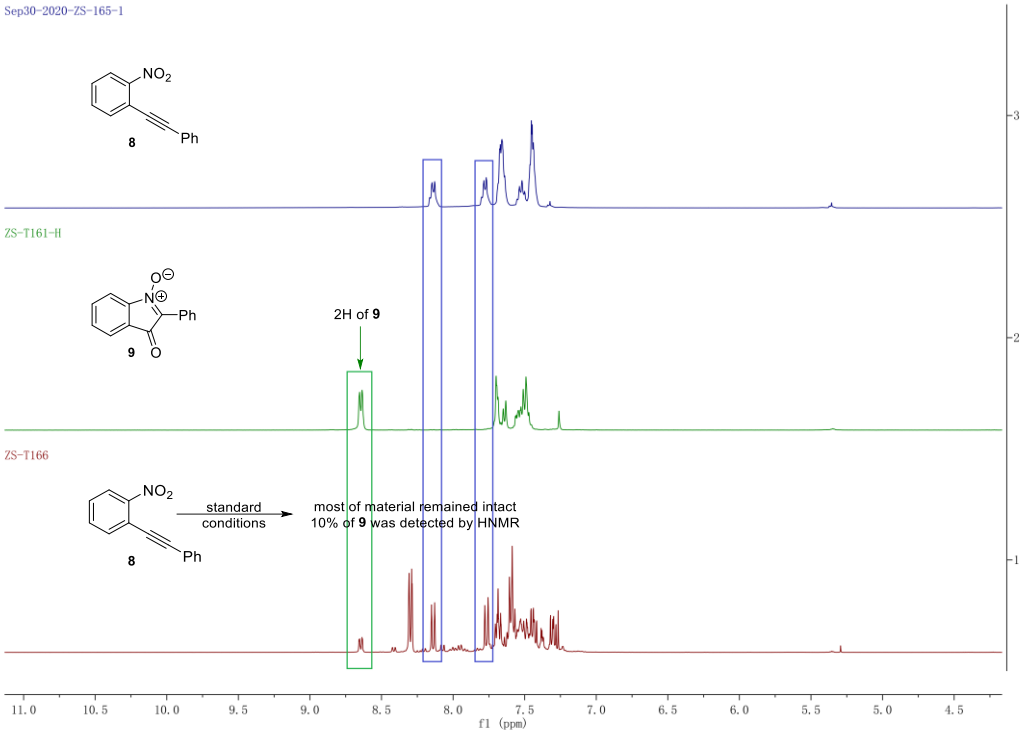
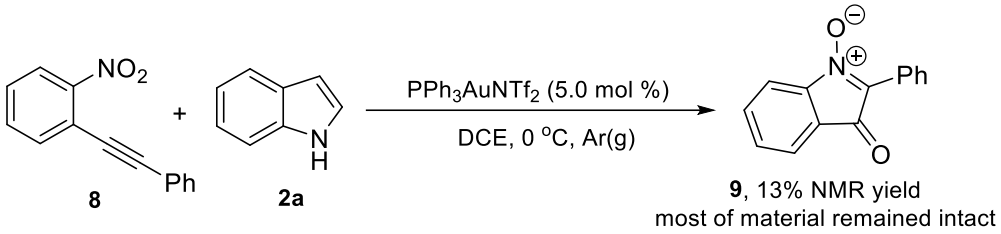


Figure S3. Proton NMR spectra of crude reaction mixture of **8**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **8** (33.5 mg, 0.15 mmol), indole **2a** (11.7 mg, 0.1 mmol), PPh_3AuNTf_2 (3.7 mg, 5.0 mol%), and anhydrous DCE (2.0 mL) were added in sequence under atmosphere of argon at 0 ^oC. Then the reaction mixture was subjected to proton NMR analysis after 1.0 hour under these conditions. Most of **8** and indole remained intact, and minor amount of **9** was detected by proton NMR (13%, see Figure S4).

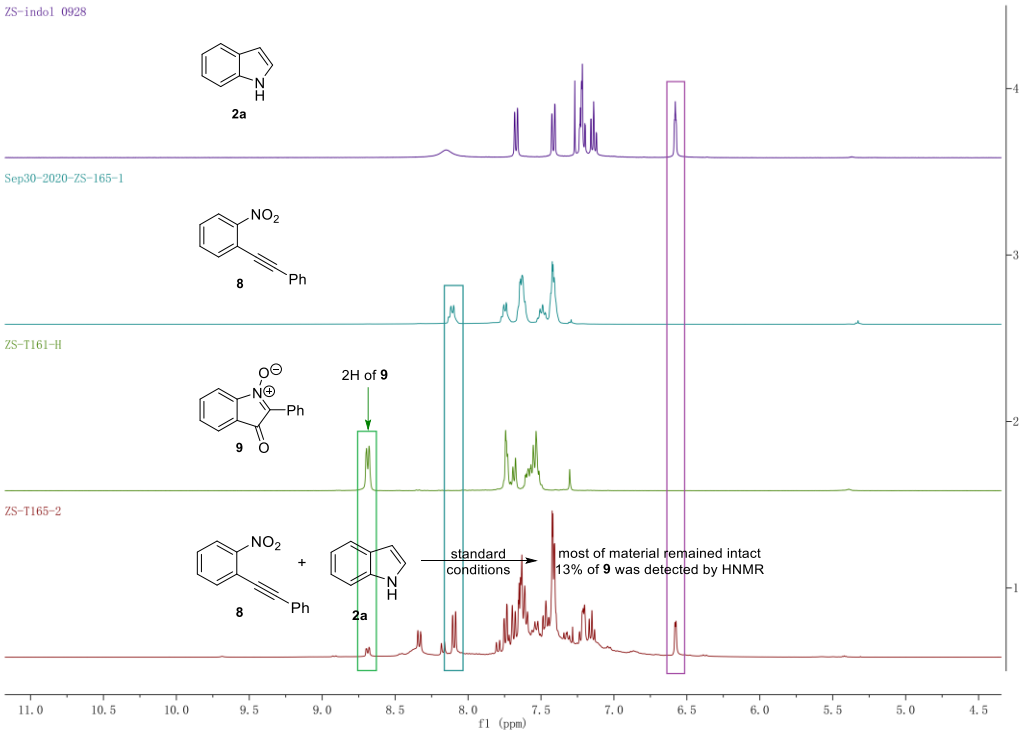
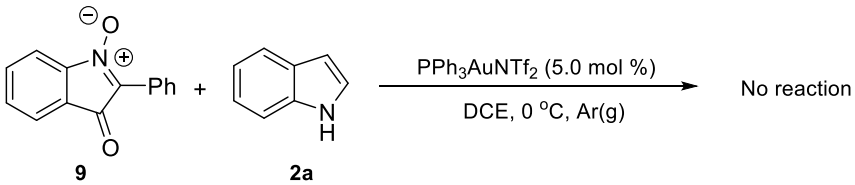


Figure S4. Proton NMR spectra of crude reaction mixture of **8** with indole **2a**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, **9** (22.3 mg, 0.1 mmol), indole **2a** (11.7 mg, 0.1 mmol), PPh_3AuNTf_2 (3.7 mg, 5.0 mol%), and anhydrous DCE

(2.0 mL) were added in sequence under atmosphere of argon at 0 °C. Then the reaction mixture was subjected to proton NMR analysis after 1.0 hour under these conditions. Most of **9** and indole **2a** remained intact, and the desired product **10** reported by Jia was not detected (see Figure S5).[4]

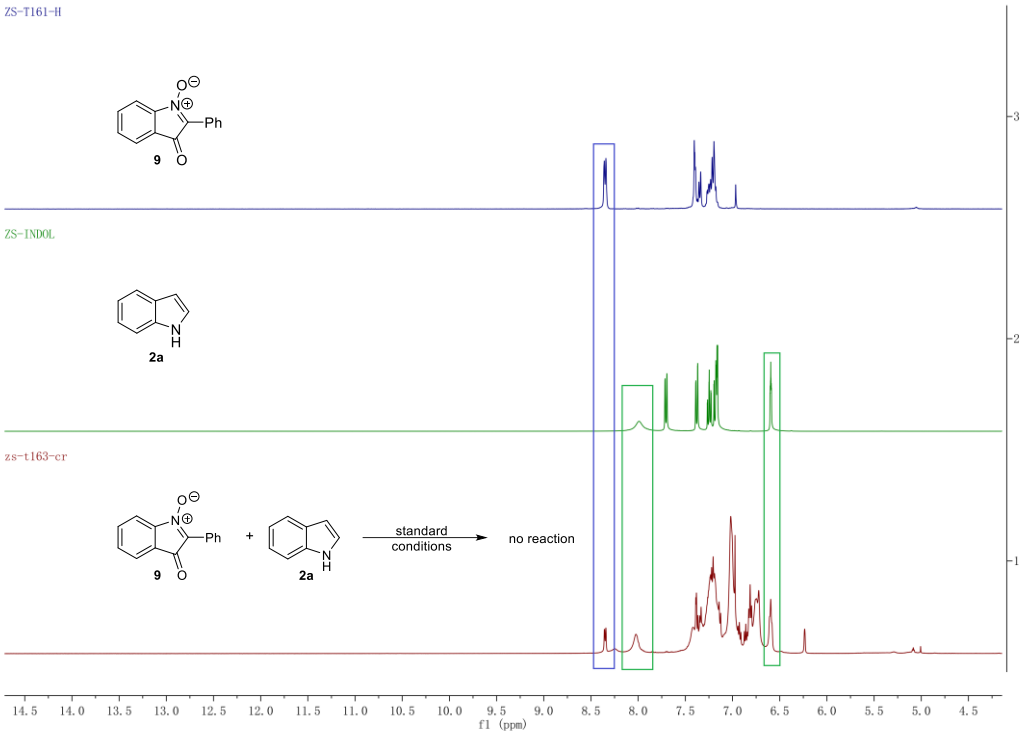
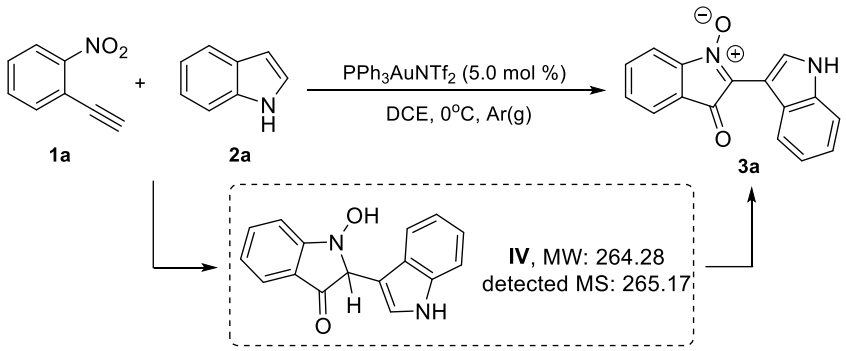


Figure S5. Proton NMR spectra of crude reaction mixture of **9** with indole **2a**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **1a** (44.1 mg, 0.3 mmol), indole **2a** (23.4 mg, 0.2 mmol), PPh_3AuNTf_2 (7.4 mg, 5.0 mol%), and anhydrous DCE (4.0 mL) were added in sequence under atmosphere of argon at 0 °C, and the reaction mixture was stirred at 0 °C for 1.0 hours. The the reaction was subjected to the LCMS analysis. MS signal for intermediate **IV** was observed (see Figure S6).

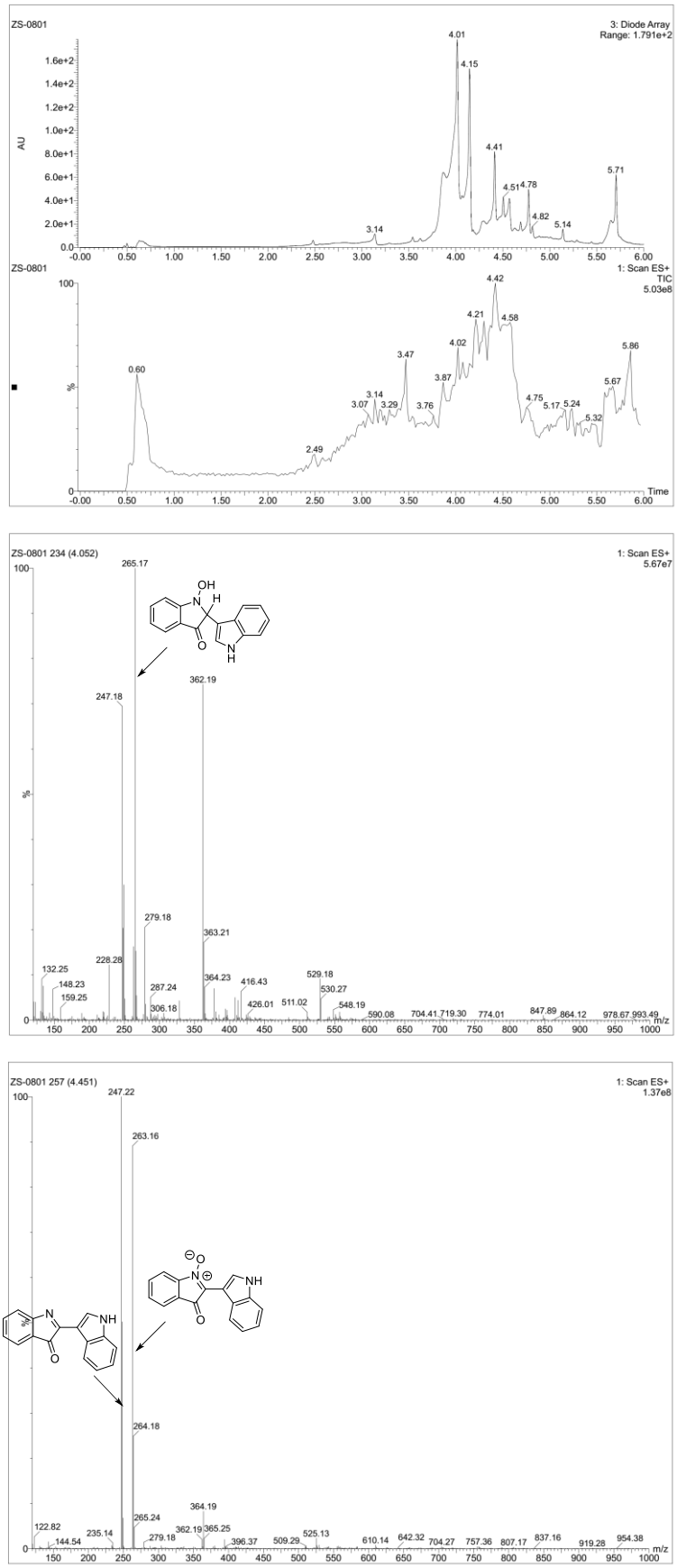
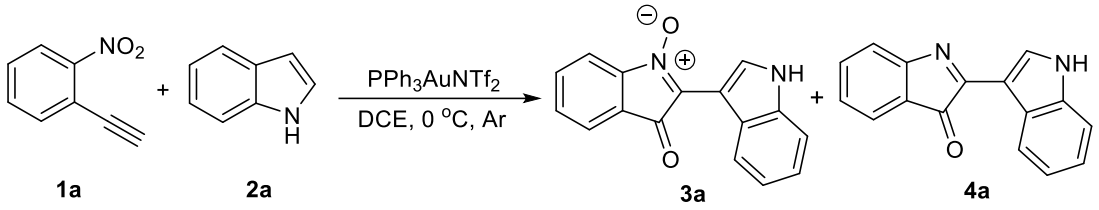


Figure S6. LCMS monitoring of the crude reaction of **1a** with **2a**.



To a 10-mL oven-dried vial containing a magnetic stirring bar, *o*-nitroalkyne **1a** (44.1 mg, 0.3 mmol), indole **2a** (23.4 mg, 0.2 mmol), PPh_3AuNTf_2 (7.4 mg, 5.0 mol%), and anhydrous DCE (4.0 mL) were added in sequence under atmosphere of argon at 0 °C, and the reaction mixture was stirred at 0 °C for several hours. The reaction mixture was monitored by crude proton NMR after 2 and 6 hours, the ratio of **3a**:**4a** was decreased from 10:1.4 to 10:2.9, and this ratio could reach to 10:5.3 by adding additional 5 mol% of gold catalyst to the reaction mixture and stirring for 2 hours. (see Figure S7).

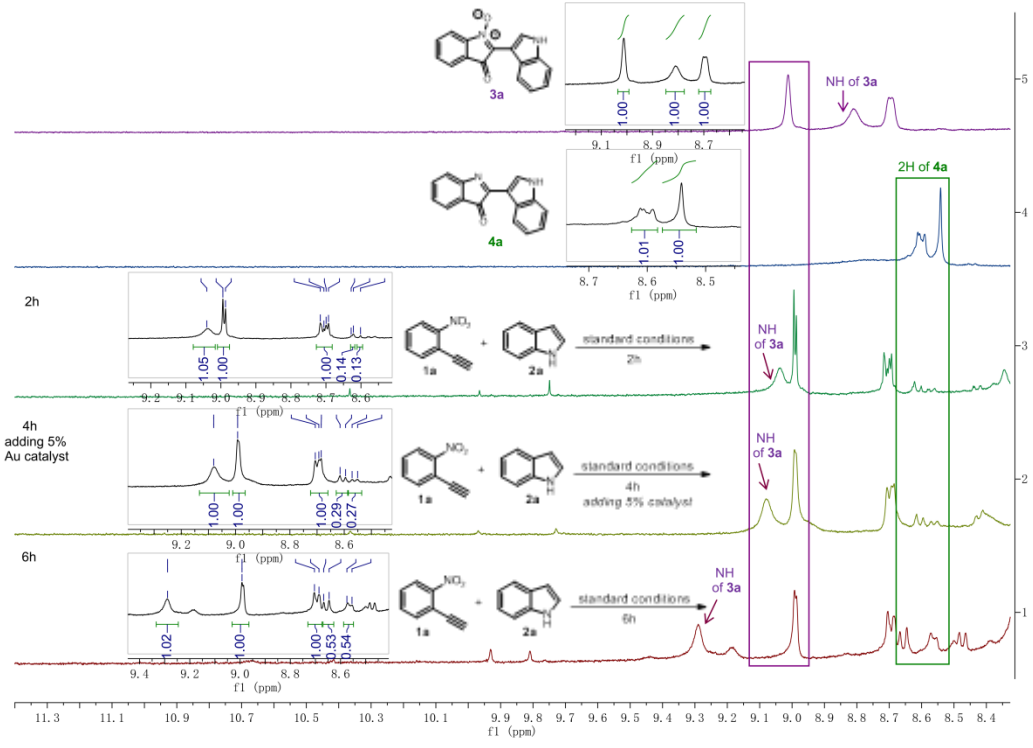
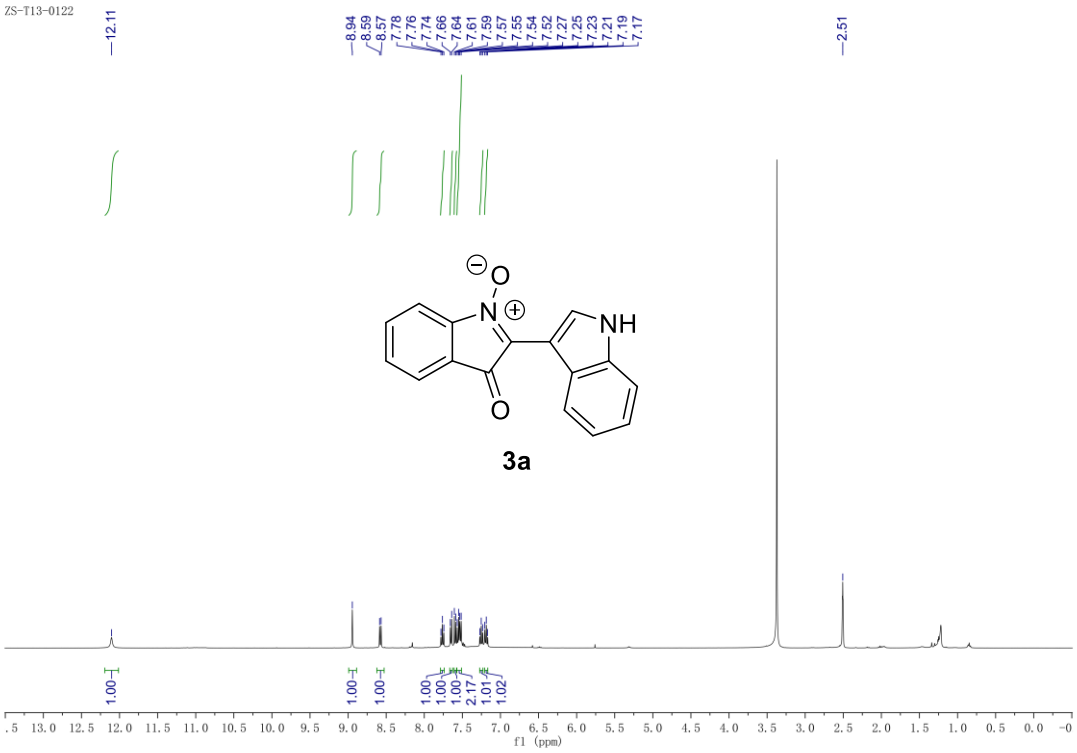


Figure S7. Proton NMR monitoring of the model reaction at different reaction times.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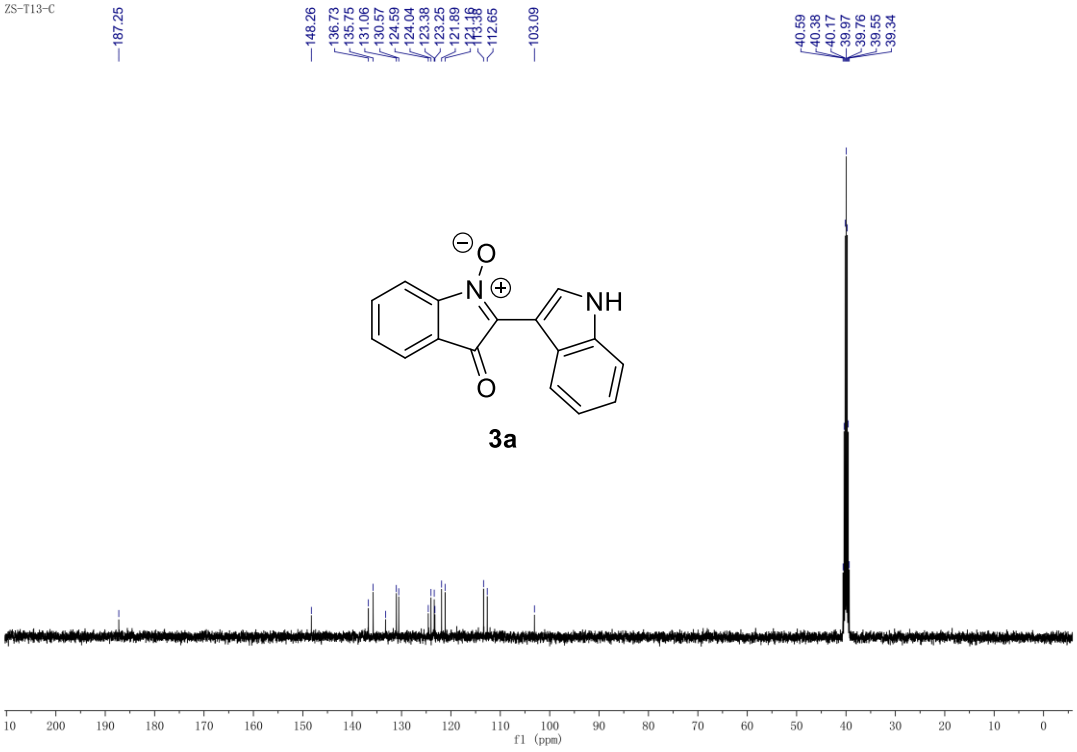
8.57
7.78
7.76
7.74
7.66
7.64
7.61
7.59
7.57
7.55
7.54
7.52
7.27
7.25
7.23
7.21
7.19
7.17
2.51
O
N
NH
O
3a
1.00
1.00
1.00
1.00
1.00
1.00
2.17
1.01
1.02
f1 (ppm)


ZS-T13-C
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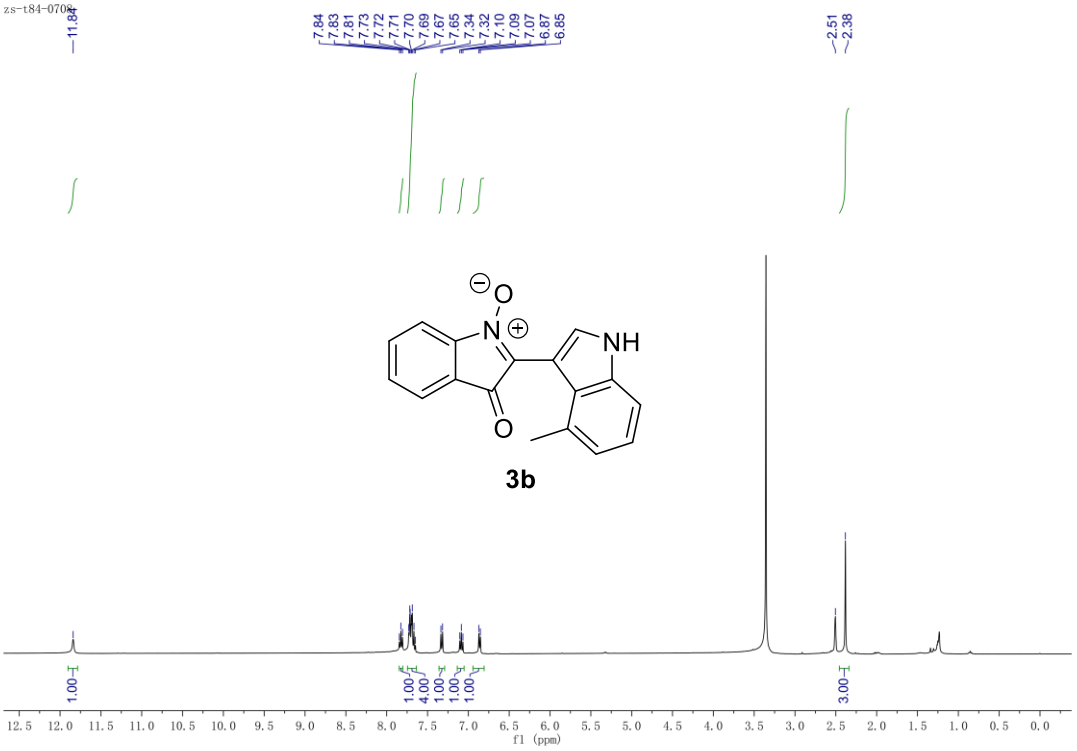
148.26
136.73
135.75
131.06
130.57
124.59
124.04
123.38
123.25
121.89
121.16
113.38
112.65
103.09
40.59
40.38
40.17
39.97
39.76
39.55
39.34
O
N
NH
O
3a
f1 (ppm)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7.84
7.83
7.81
7.73
7.72
7.71
7.70
7.69
7.67
7.65
7.34
7.32
7.10
7.09
7.07
6.87
6.85
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2.38
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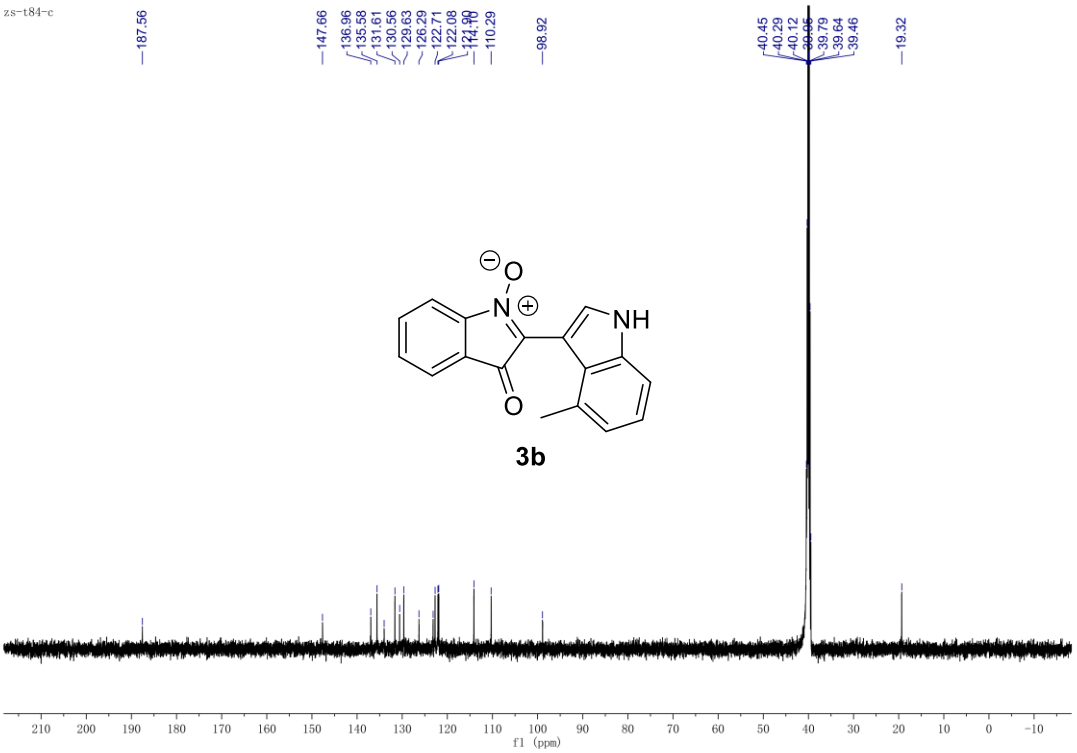
1.00
4.00
1.00
1.00
3.00
f1 (ppm)

3b


zs-t84-c
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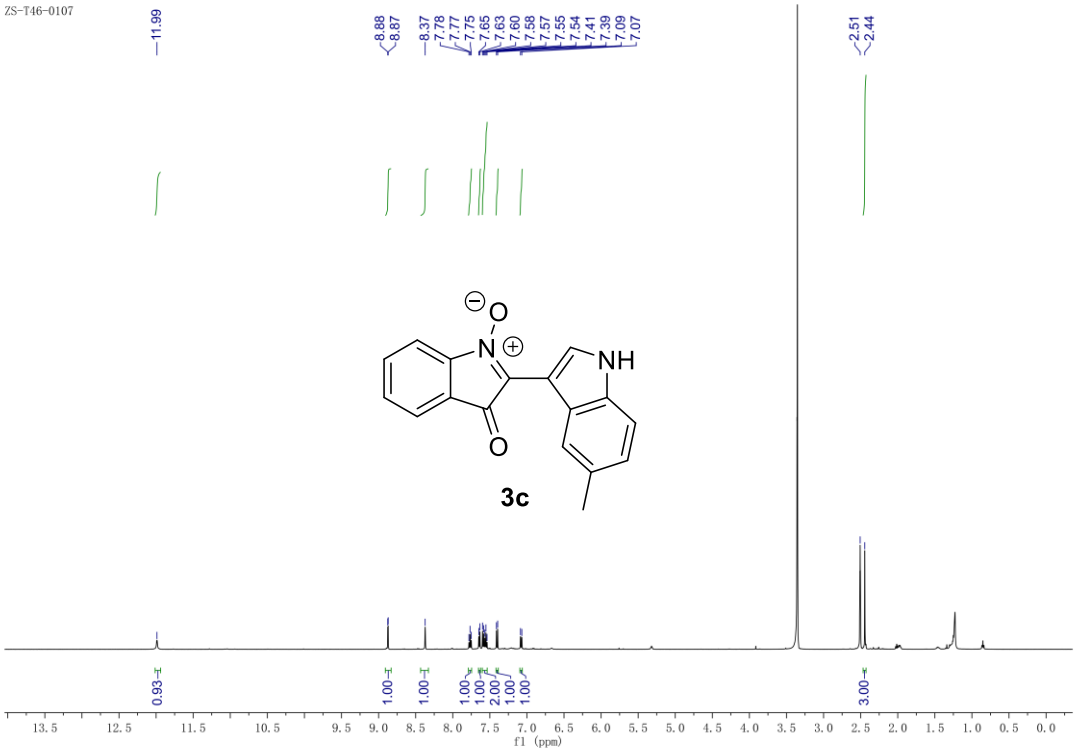
135.58
131.61
130.56
129.63
126.29
122.71
122.08
114.10
110.29
98.92
40.45
40.29
40.12
39.79
39.64
39.46
19.32
f1 (ppm)

3b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8.37
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7.77
7.75
7.65
7.63
7.60
7.58
7.57
7.55
7.54
7.41
7.39
7.09
7.07
2.51
2.44
O
N
NH
O
3c
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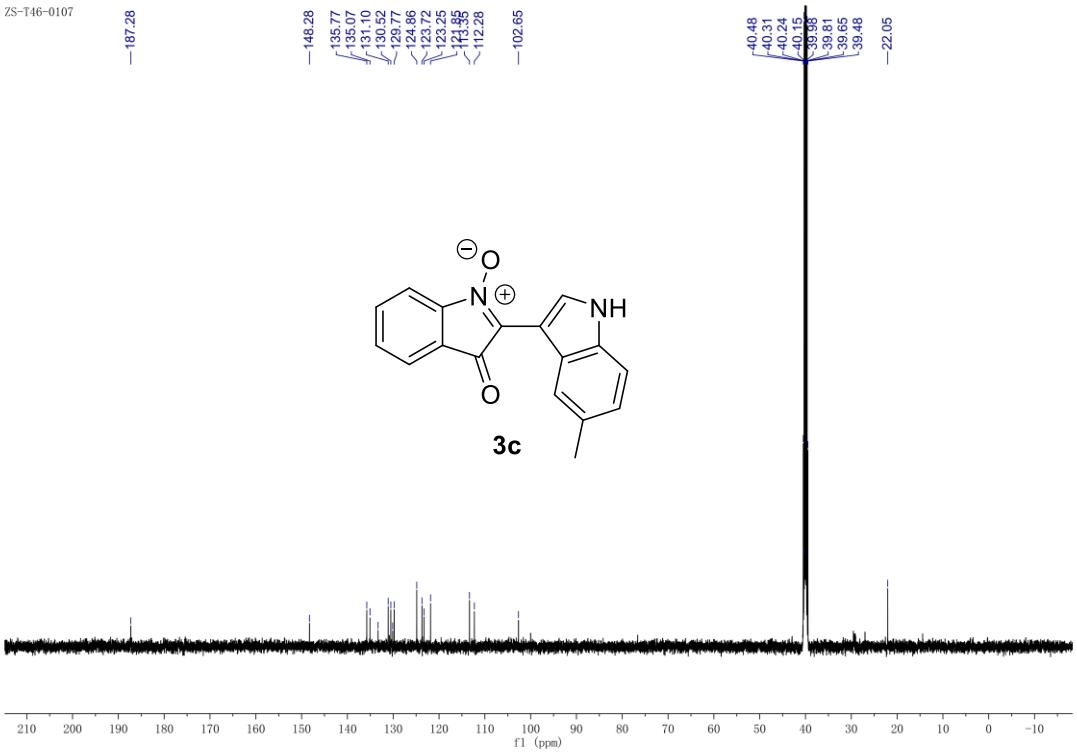
1.00
1.00
1.00
1.00
2.00
1.00
1.00
3.00
f1 (ppm)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148.28
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121.85
113.35
112.28
102.65
40.48
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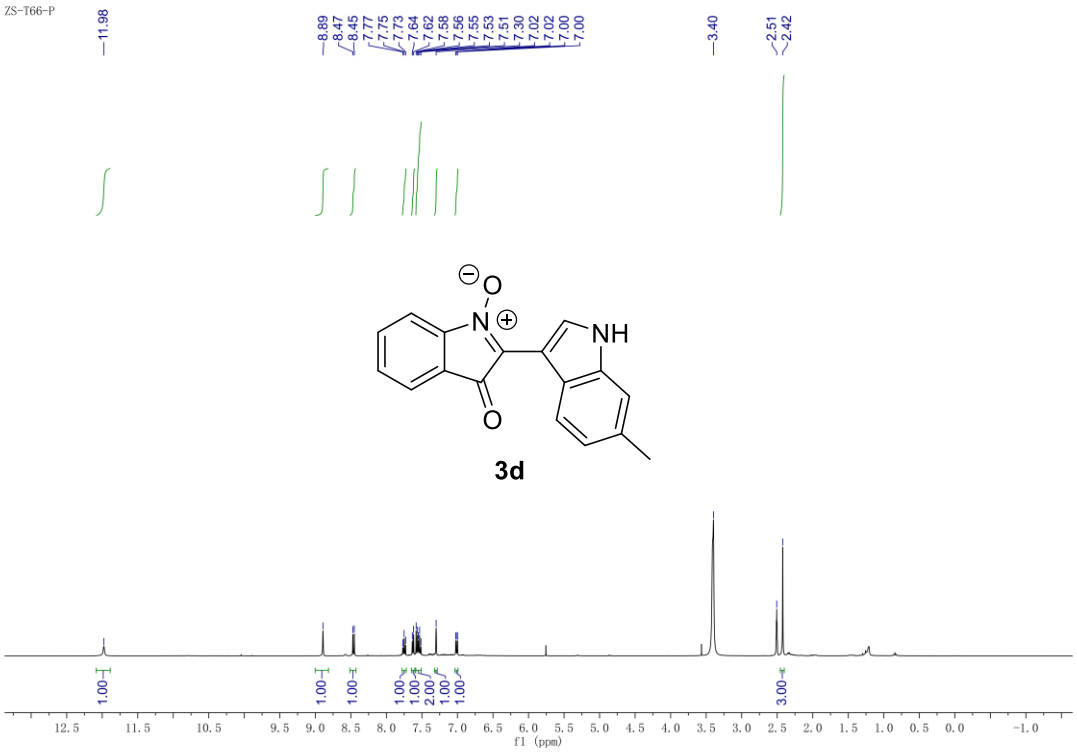
40.24
40.15
39.98
39.81
39.65
39.48
22.05
O
N
NH
O
3c
f1 (ppm)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7.73
7.64
7.62
7.58
7.56
7.55
7.53
7.51
7.30
7.02
7.02
7.00
7.00
3.40
2.51
2.42
NH
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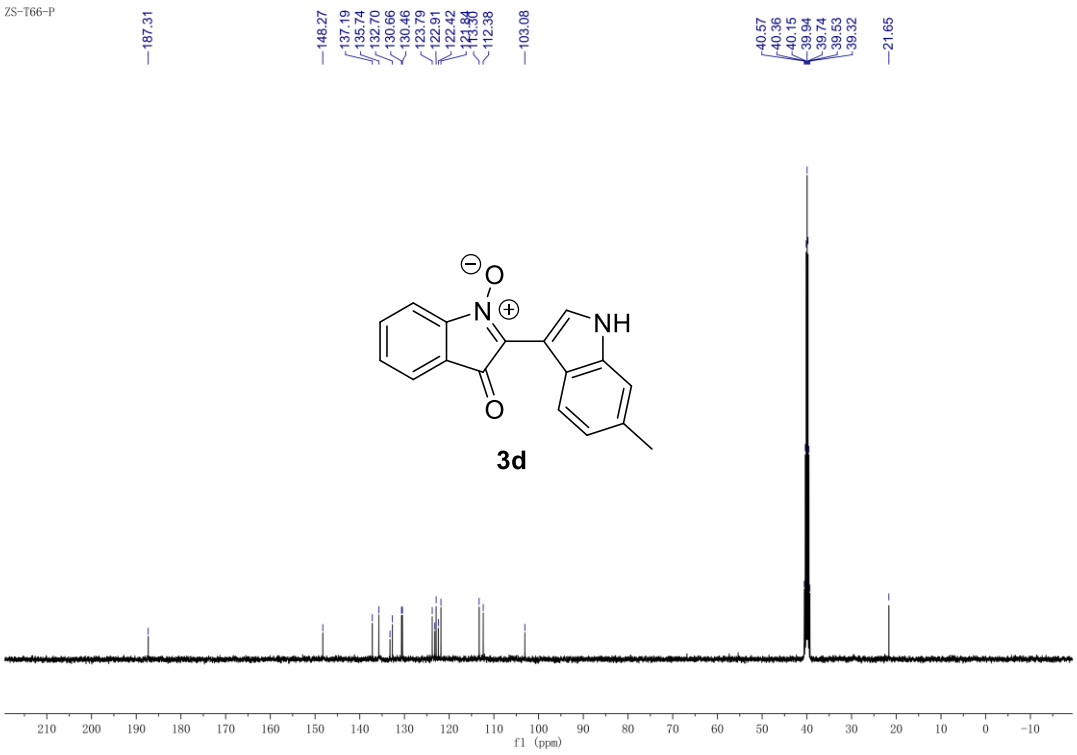
1.00
1.00
1.00
2.00
1.00
1.00
3.00
f1 (ppm)

3d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132.70
130.66
130.46
123.79
122.91
122.42
112.38
103.08
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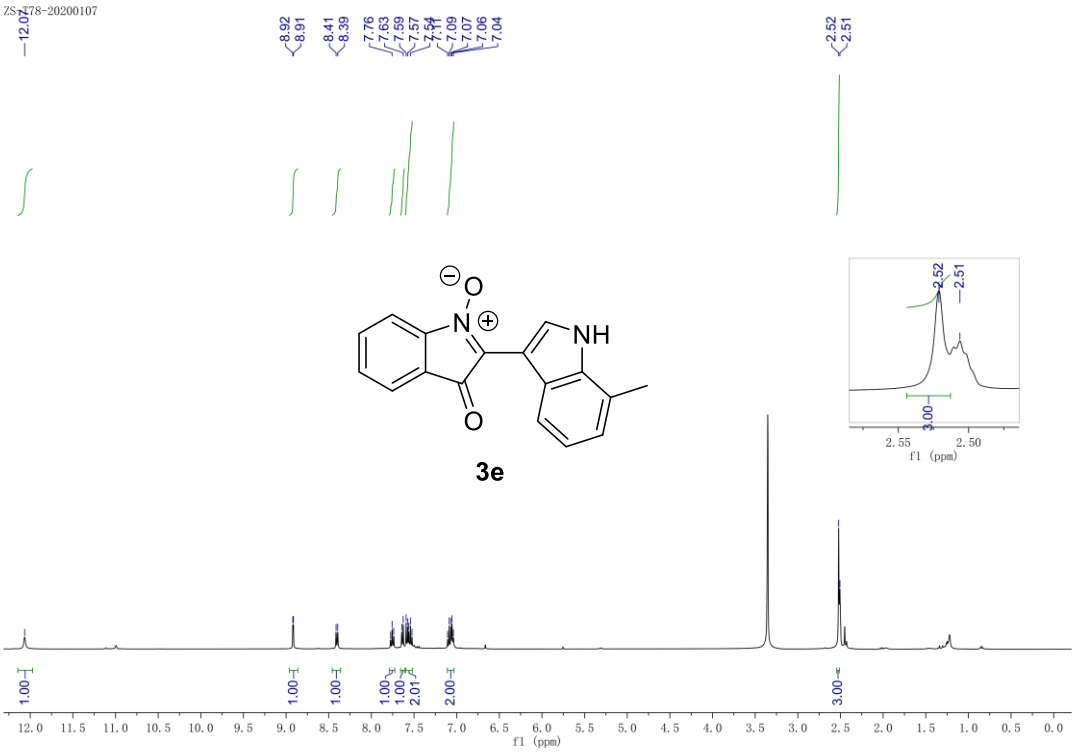
40.36
40.15
39.94
39.74
39.53
39.32
21.65
NH
f1 (ppm)

3d


ZS-T78-20200107
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8.91
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8.39
7.76
7.63
7.59
7.57
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7.11
7.09
7.07
7.06
7.04
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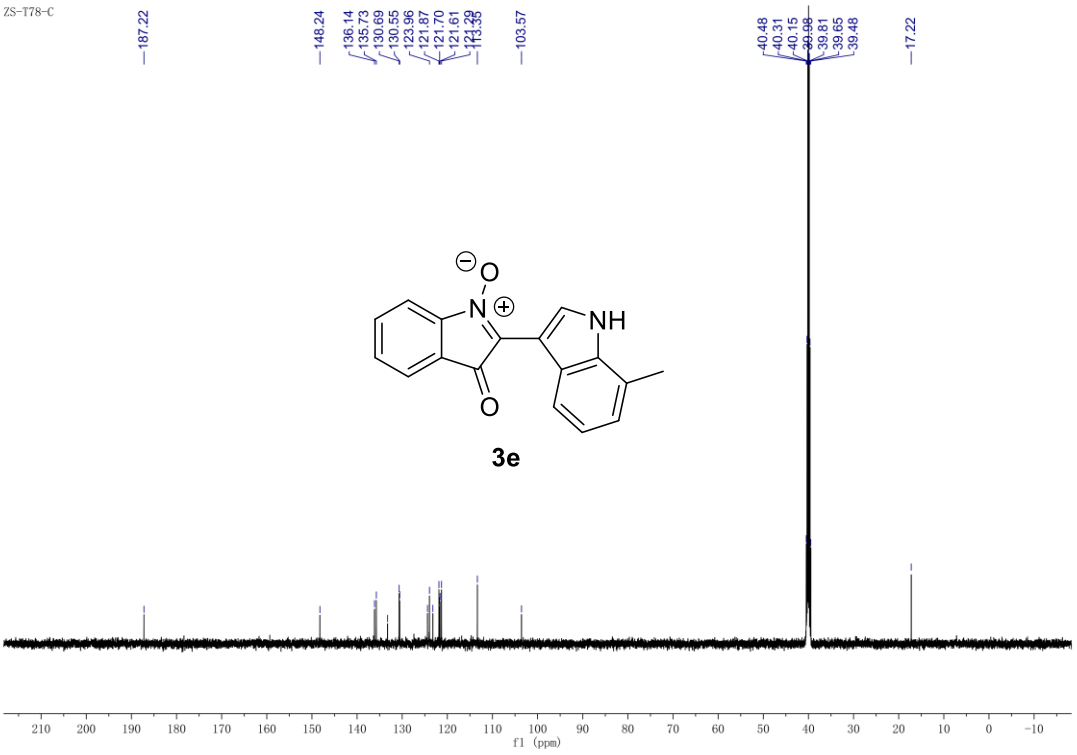
1.00
1.00
2.01
2.00
3.00
f1 (ppm)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121.87
121.70
121.61
121.29
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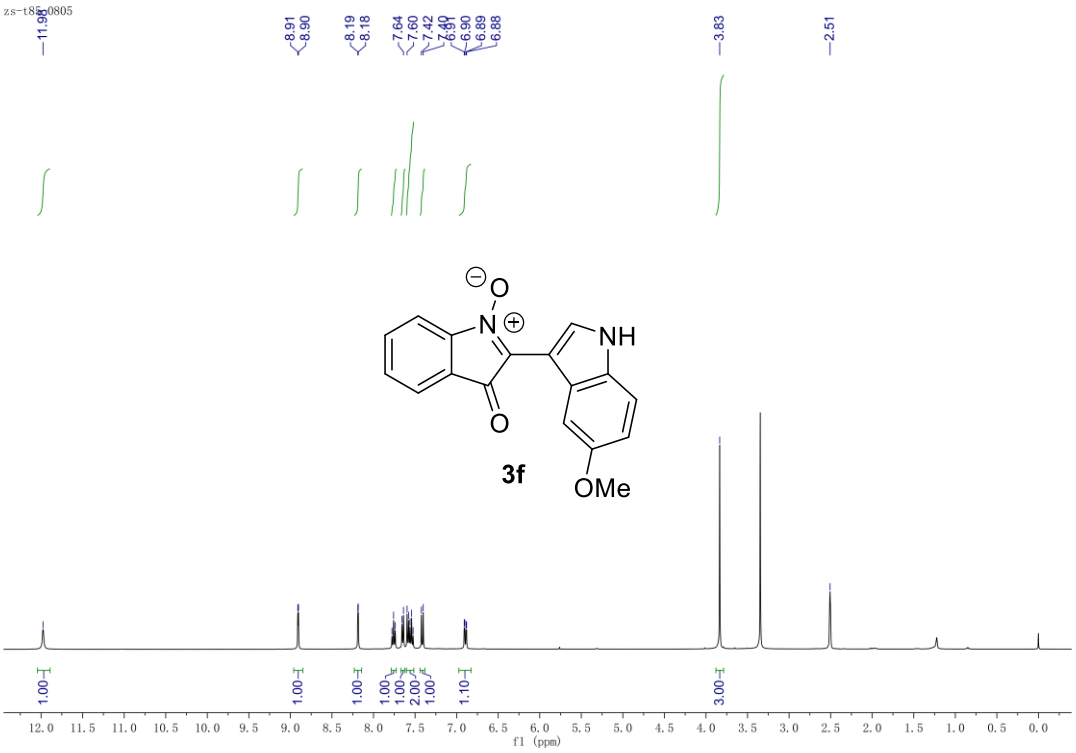
40.31
40.15
40.08
39.81
39.65
39.48
17.22
3e
f1 (ppm)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8.90
8.19
8.18
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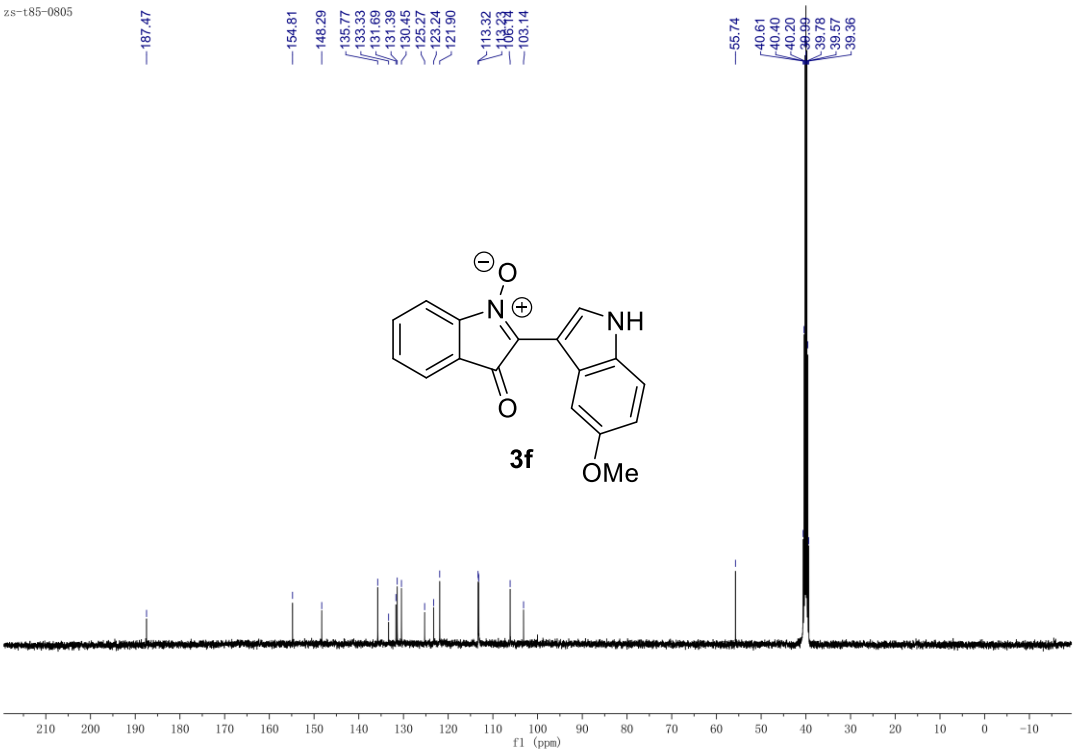
7.60
7.42
7.40
6.91
6.90
6.89
6.88
3.83
2.51
O
N
NH
O
3f
OMe
1.00
1.00
1.00
1.00
1.00
2.00
1.00
1.10
3.00
f1 (ppm)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148.29
135.77
133.33
131.69
131.39
130.45
125.27
123.24
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113.32
103.14
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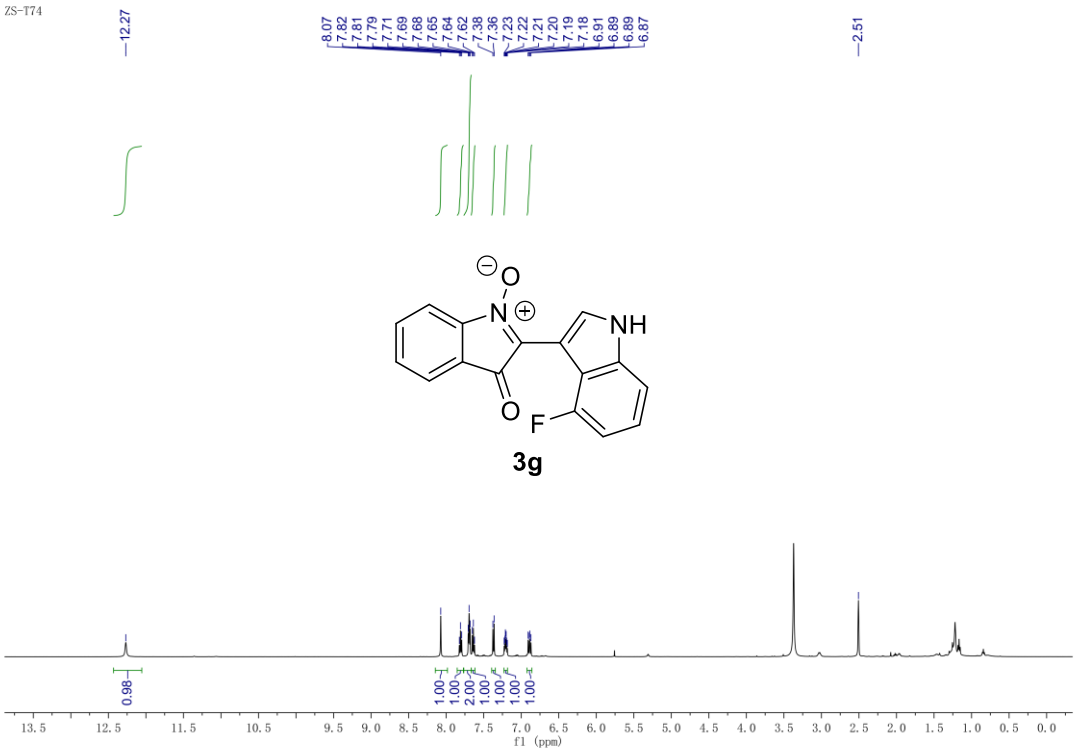
O
N
NH
O
3f
OMe
f1 (ppm)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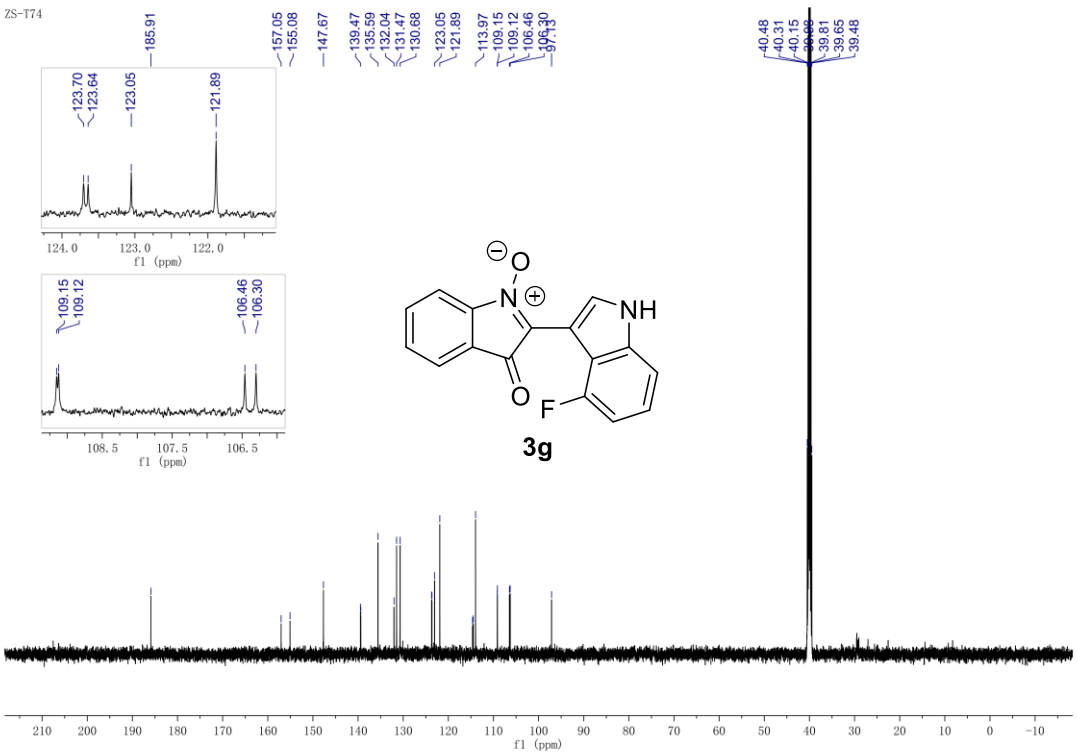
7.65
7.64
7.62
7.38
7.36
7.23
7.22
7.21
7.20
7.19
7.18
6.91
6.89
6.89
6.87
2.51
O
N
NH
O
F
3g
0.98
1.00
1.00
2.00
1.00
1.00
1.00
1.00
f1 (ppm)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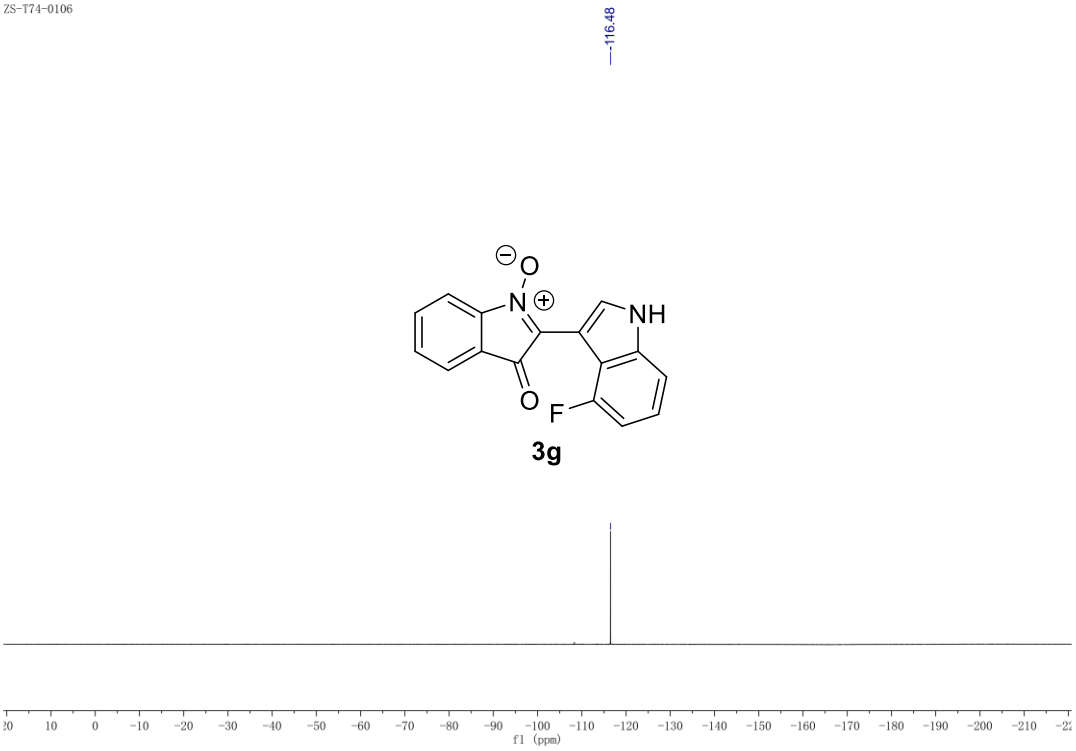
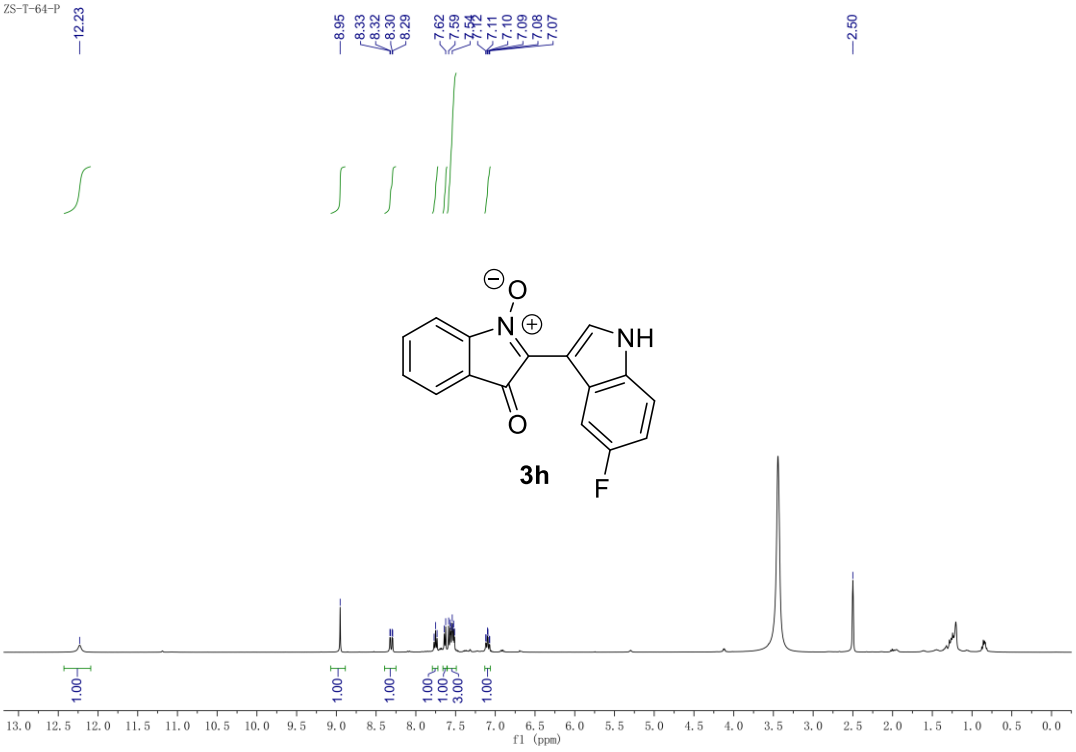
139.47
135.59
132.04
131.47
130.68
123.05
121.89
113.97
109.15
109.12
106.46
106.30
97.43
40.48
40.31
40.15
39.81
39.65
39.48
123.70
123.64
123.05
121.89
f1 (ppm)
109.15
109.12
106.46
106.30
f1 (ppm)
O
N
NH
O
F
3g
f1 (ppm)

ZS-T74-0106

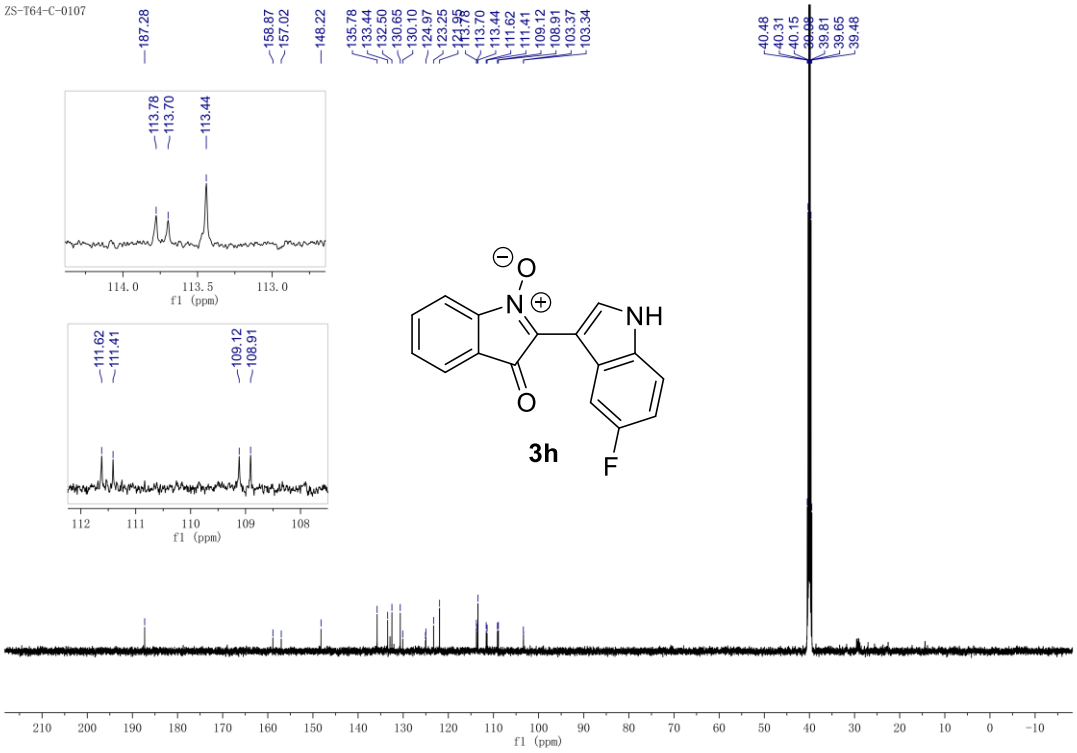


3g

ZS-T-64-P



3h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157.02
148.22
135.78
133.44
132.50
130.65
130.10
124.97
123.25
121.95
113.78
113.70
113.44
111.62
111.41
109.12
108.91
103.37
103.34
40.48
40.31
40.15
39.81
39.65
39.48
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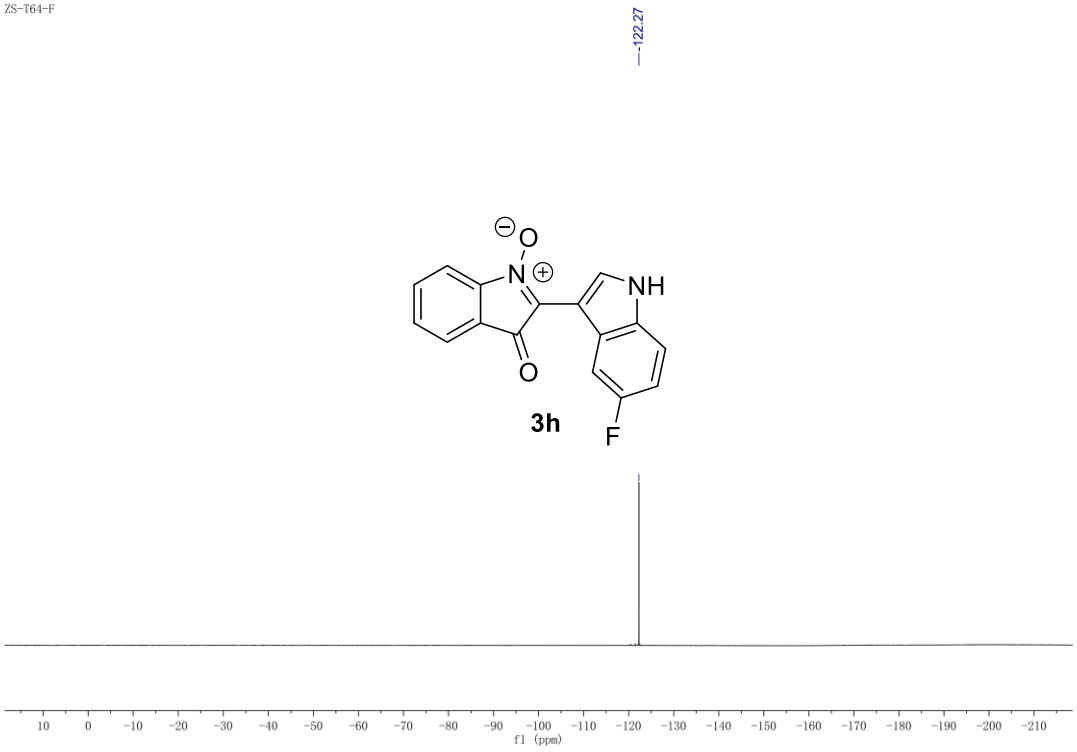
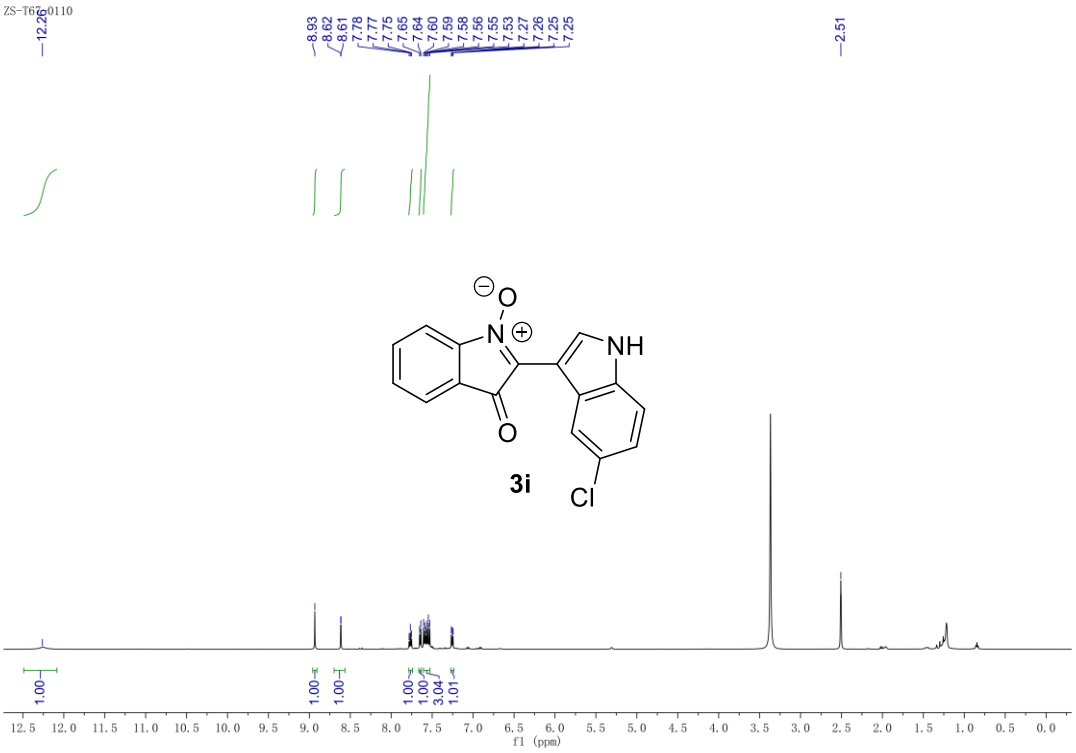
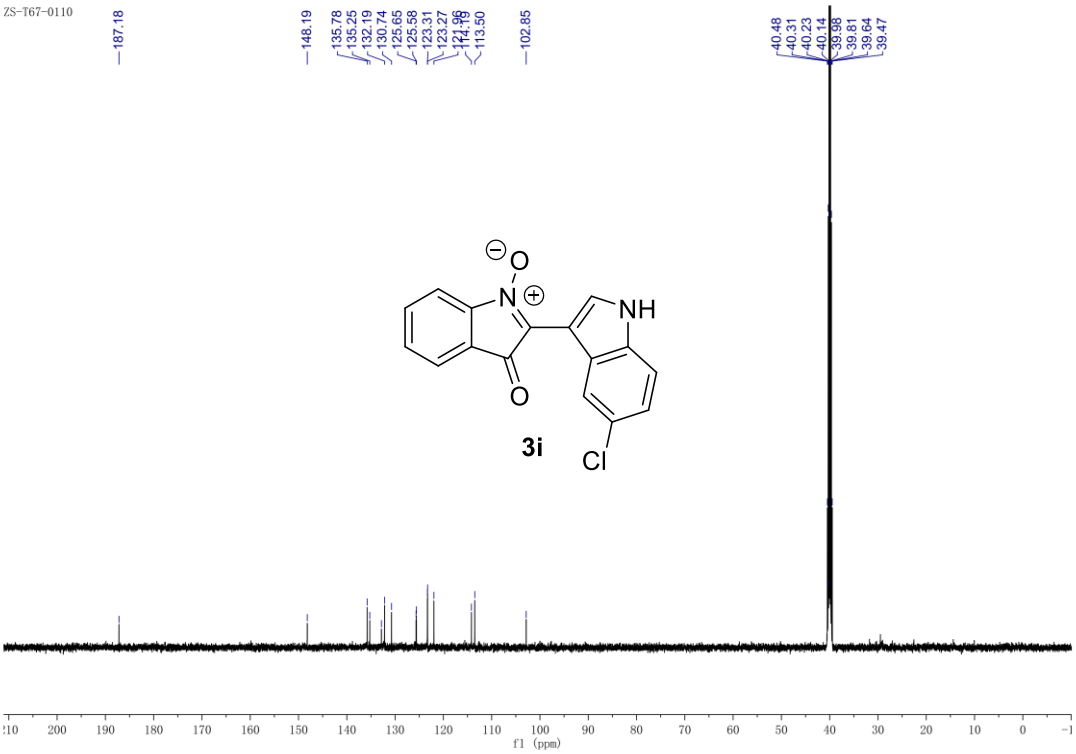
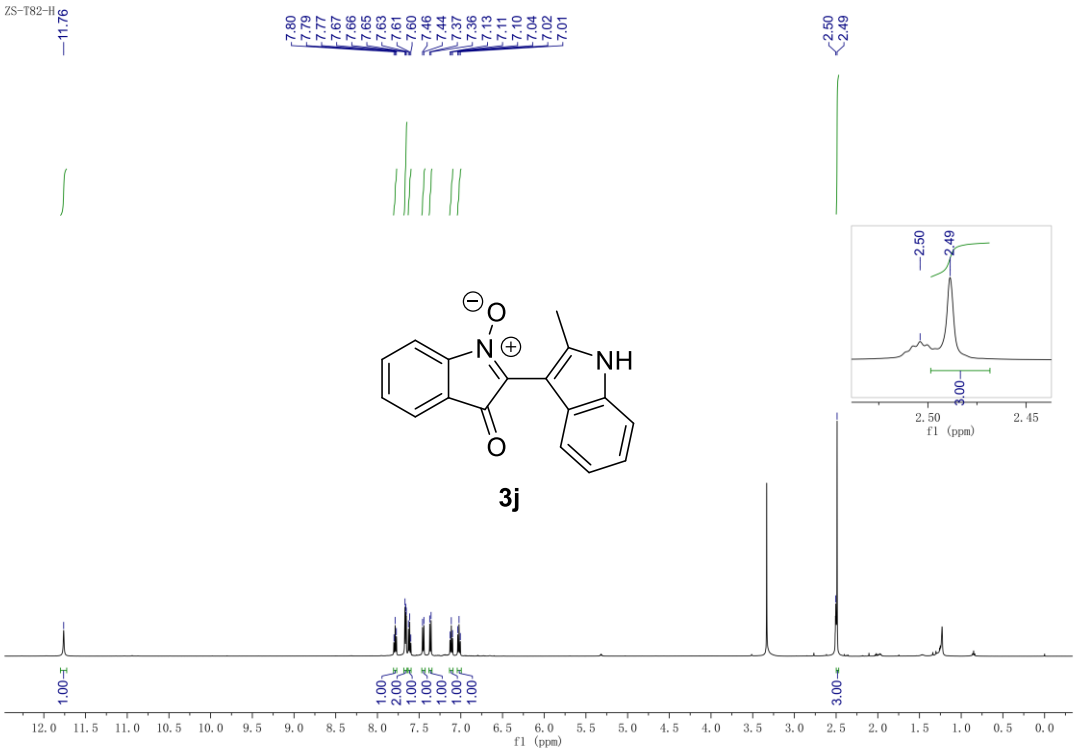
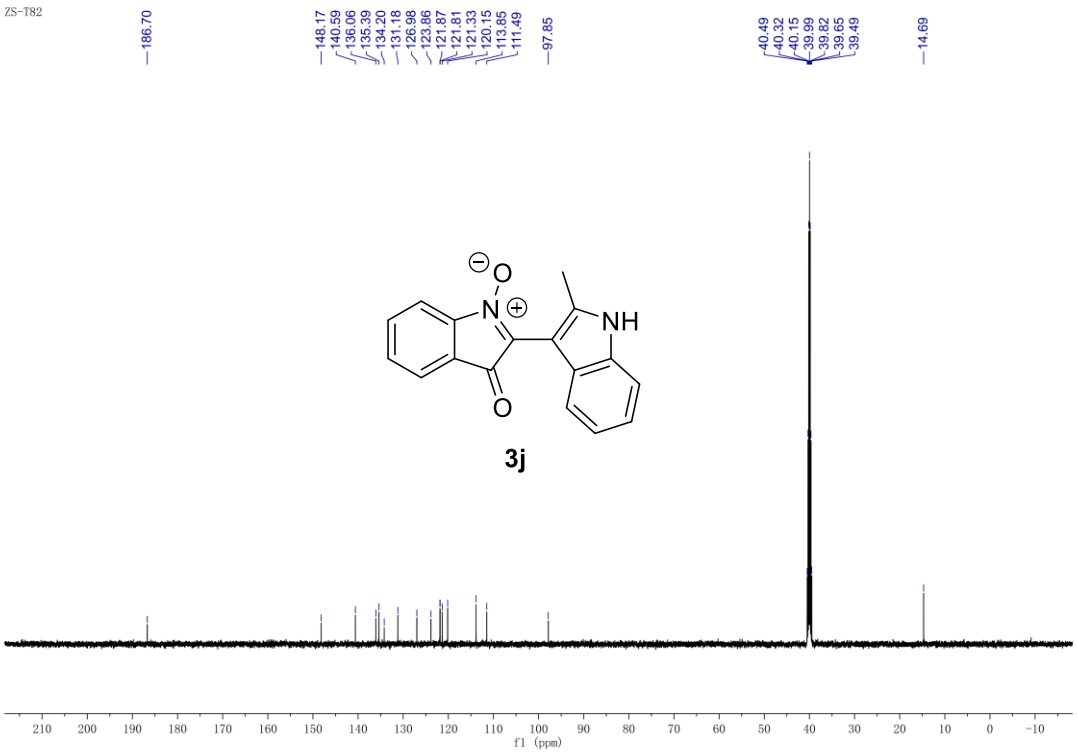
O
N
NH
O
F
3h
f1 (ppm)

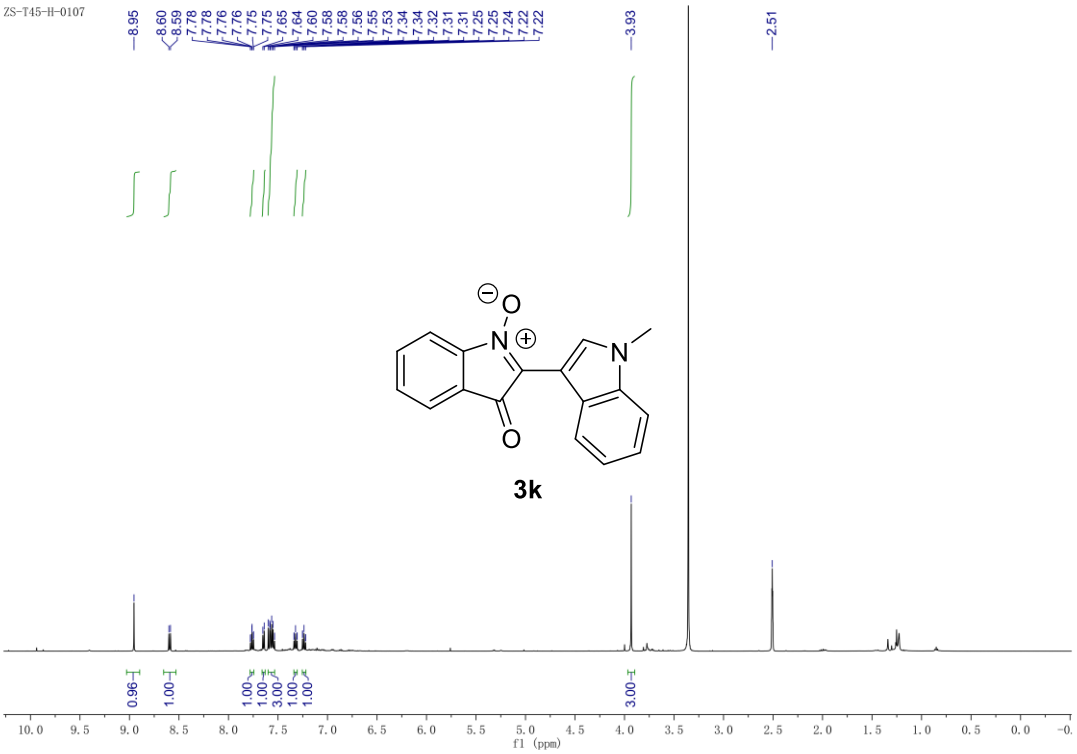

ZS-T64-F
-122.27
O
N
NH
O
F
3h
f1 (ppm)

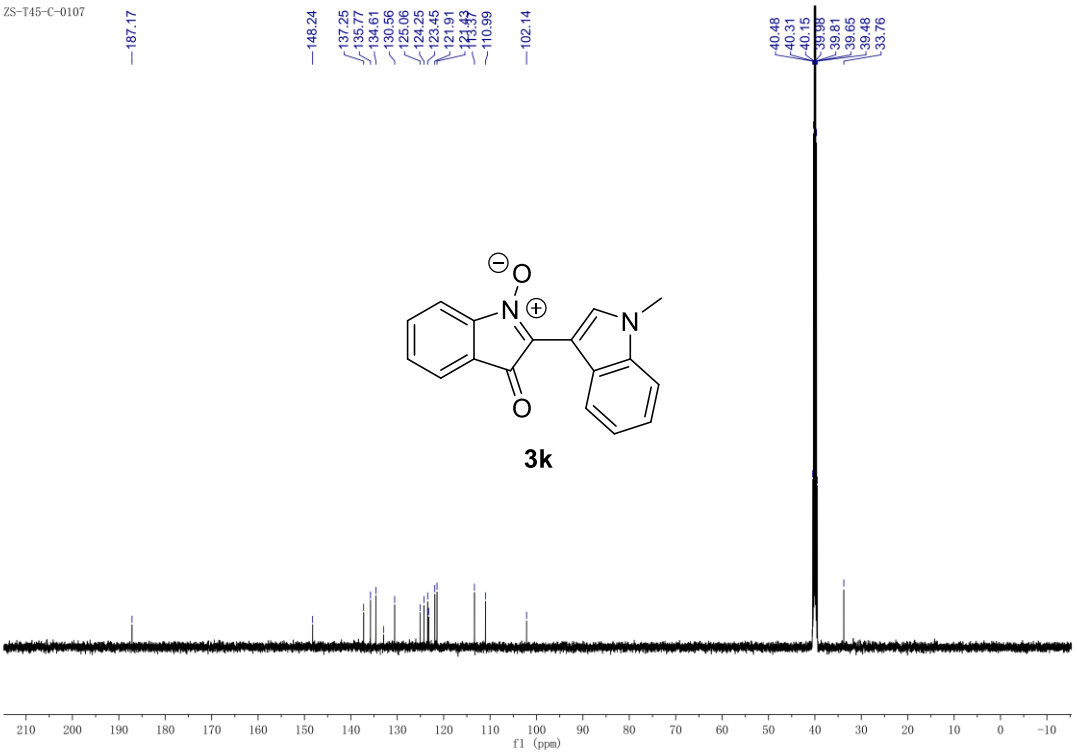

ZS-T67-0110
12.26
8.93
8.62
8.61
7.78
7.77
7.75
7.65
7.64
7.60
7.59
7.58
7.56
7.55
7.53
7.27
7.26
7.25
7.25
2.51
O
N
NH
O
3i
Cl
1.00
1.00
1.00
1.00
3.04
1.01
f1 (ppm)

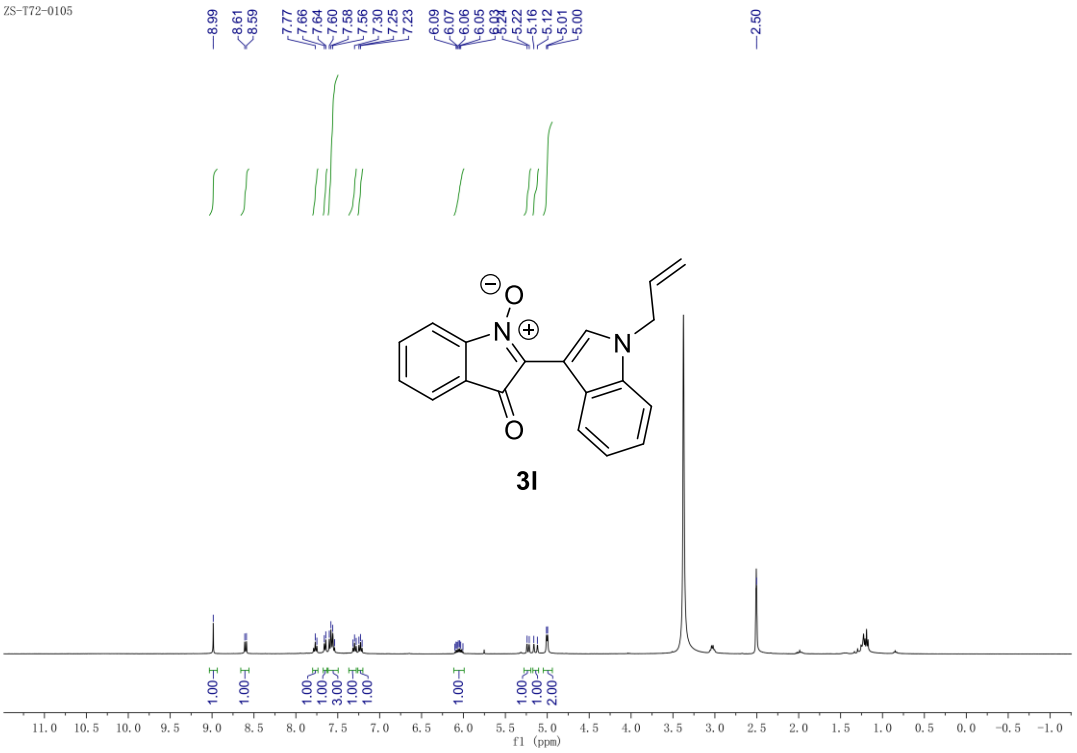

ZS-T67-0110
187.18
148.19
135.78
135.25
132.19
130.74
125.65
125.58
123.31
123.27
121.96
114.19
113.50
102.85
40.48
40.31
40.23
40.14
39.98
39.81
39.64
39.47
O
N
NH
O
3i
Cl
f1 (ppm)

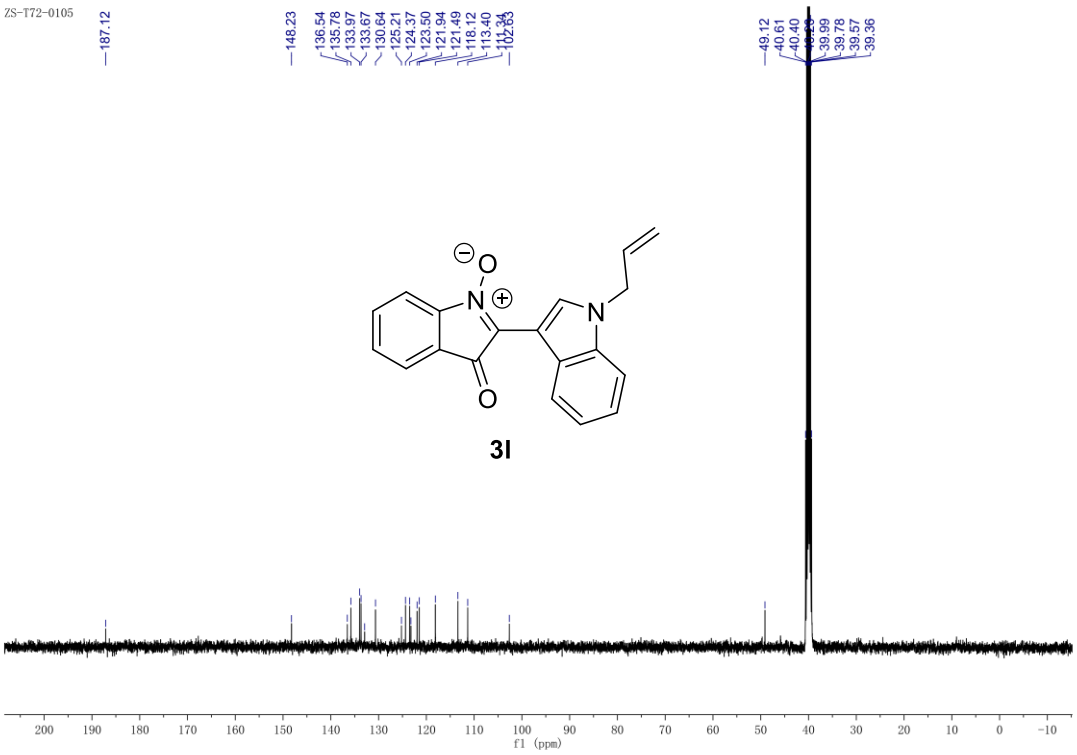

ZS-T82-H
11.76
7.80
7.79
7.77
7.67
7.66
7.65
7.63
7.61
7.60
7.46
7.44
7.37
7.36
7.13
7.11
7.10
7.04
7.02
7.01
2.50
2.49
3j
1.00
2.00
1.00
1.00
1.00
1.00
3.00
f1 (ppm)

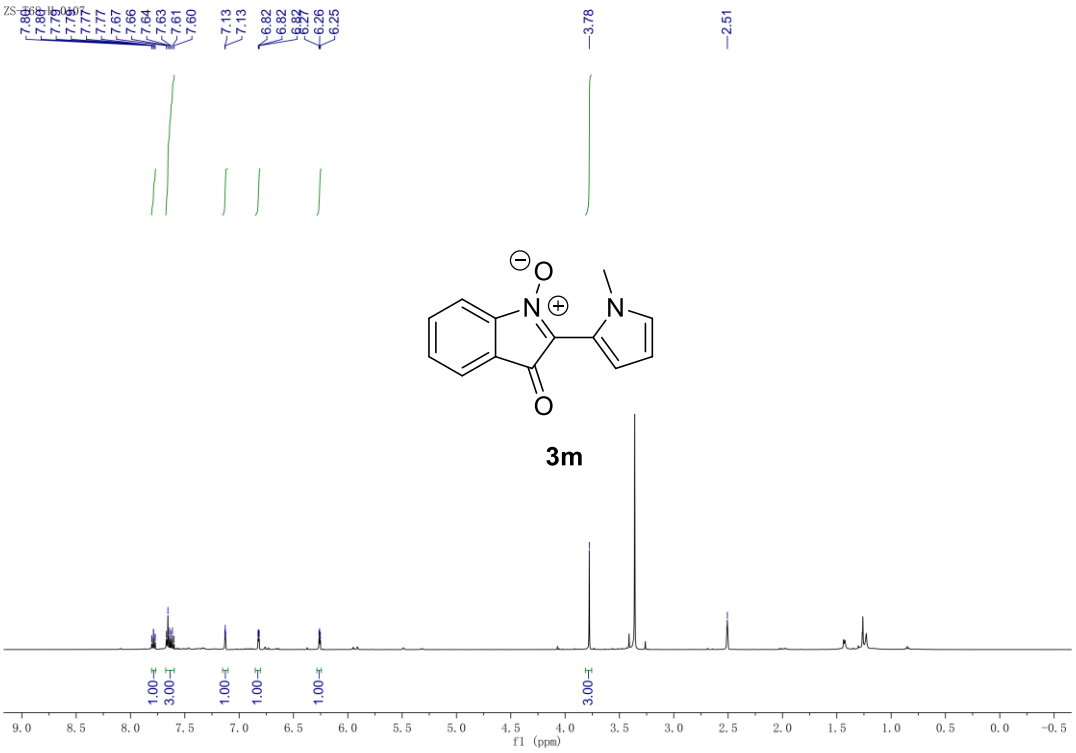

ZS-T82
186.70
148.17
140.59
136.06
135.39
134.20
131.18
126.98
123.86
121.87
121.81
121.33
120.15
113.85
111.49
97.85
40.49
40.32
40.15
39.99
39.82
39.65
39.49
14.69
3j
f1 (ppm)

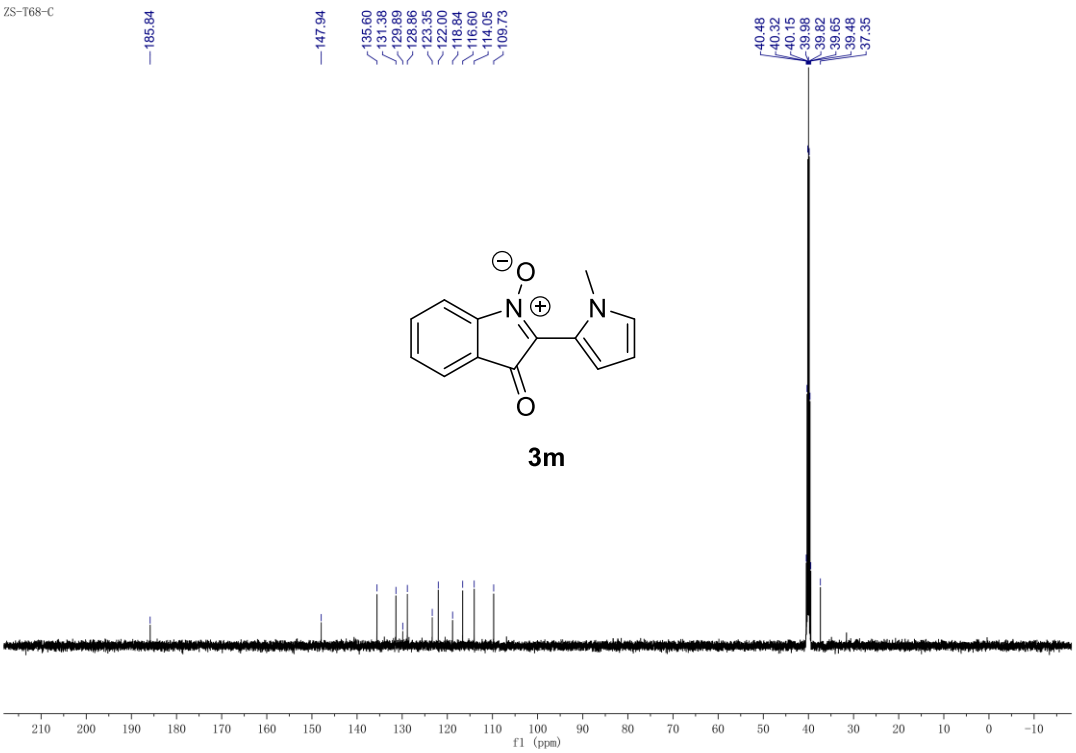

ZS-T45-H-0107
8.95
8.60
8.59
7.78
7.78
7.76
7.76
7.75
7.75
7.65
7.64
7.60
7.58
7.58
7.56
7.55
7.53
7.34
7.34
7.32
7.31
7.31
7.25
7.25
7.24
7.22
7.22
3.93
2.51
3k
0.96
1.00
1.00
1.00
3.00
1.00
1.00
3.00
f1 (ppm)

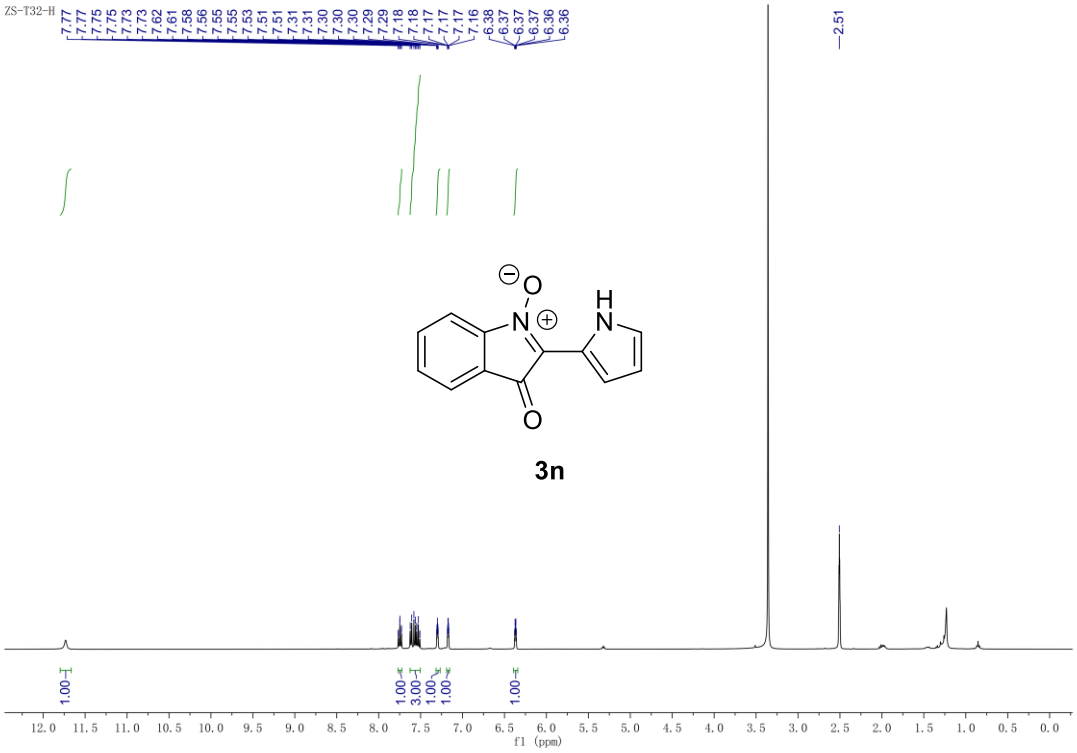

ZS-T45-C-0107
187.17
148.24
137.25
135.77
134.61
130.56
125.06
124.25
123.45
121.91
121.43
121.37
110.99
102.14
40.48
40.31
40.15
39.98
39.81
39.65
39.48
33.76
3k
f1 (ppm)


ZS-T72-0105
8.99
8.61
8.59
7.77
7.66
7.64
7.60
7.58
7.56
7.30
7.25
7.23
6.09
6.07
6.06
6.05
5.24
5.22
5.16
5.12
5.01
5.00
2.50
3I
1.00
1.00
1.00
1.00
3.00
1.00
1.00
1.00
1.00
2.00
f1 (ppm)

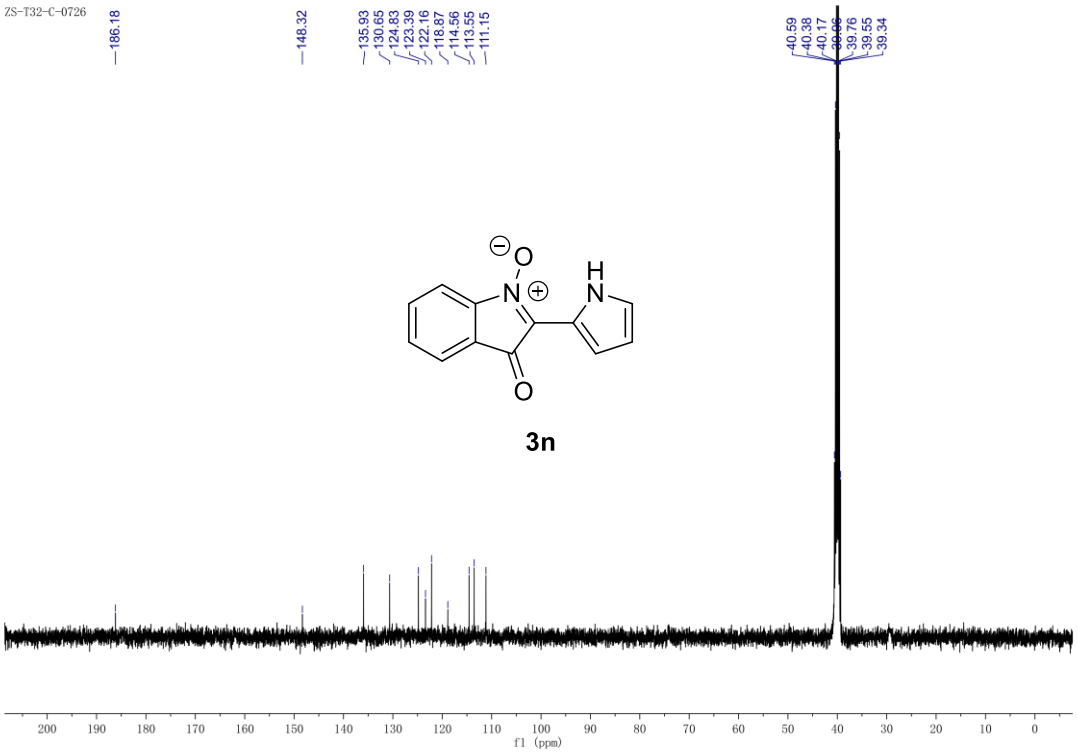

ZS-T72-0105
187.12
148.23
136.54
135.78
133.97
133.67
130.64
125.21
124.37
123.50
121.94
121.49
118.12
113.40
111.34
102.83
49.12
40.61
40.40
39.99
39.78
39.57
39.36
3I
f1 (ppm)


7.86
7.79
7.77
7.67
7.66
7.64
7.63
7.61
7.60
7.13
7.13
6.82
6.82
6.26
6.25
3.78
2.51
3m
1.00
3.00
1.00
1.00
1.00
3.00
f1 (ppm)

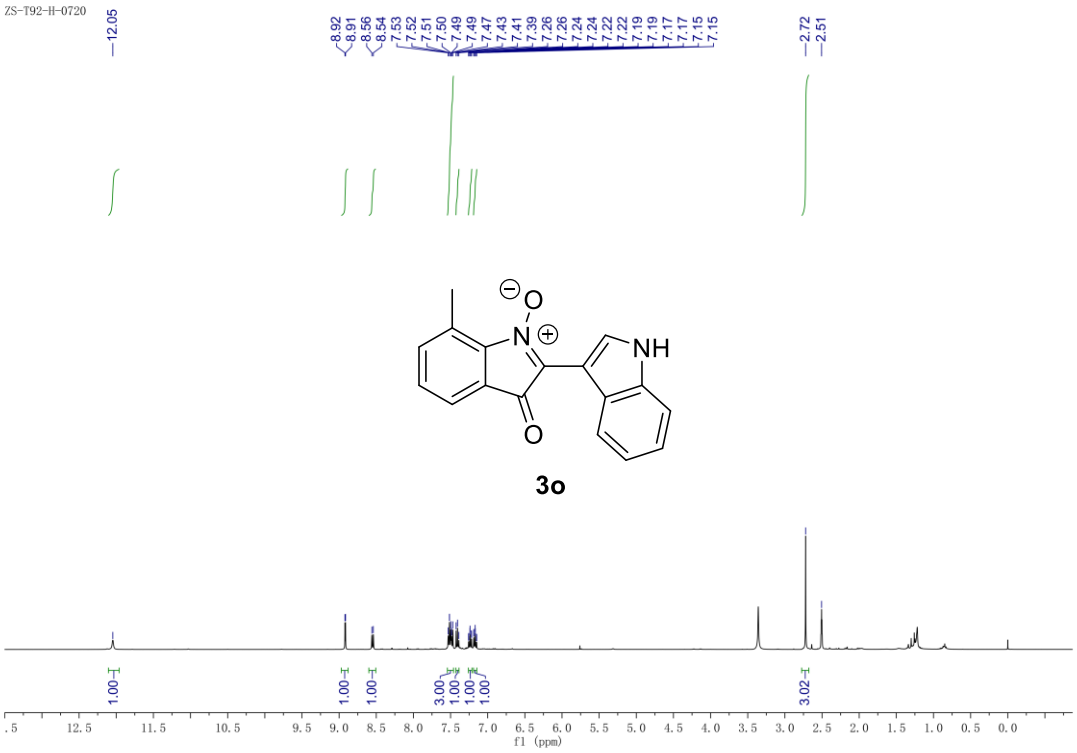

ZS-T68-C
185.84
147.94
135.60
131.38
129.89
128.86
123.35
122.00
118.84
116.60
114.05
109.73
40.48
40.32
40.15
39.98
39.82
39.65
39.48
37.35
3m
f1 (ppm)


ZS-T32-H
7.77
7.77
7.75
7.75
7.73
7.73
7.62
7.61
7.58
7.56
7.55
7.55
7.53
7.51
7.51
7.31
7.31
7.30
7.30
7.30
7.29
7.29
7.18
7.18
7.17
7.17
7.17
7.16
6.38
6.37
6.37
6.37
6.36
6.36
2.51
O
N
H
N
O
1.00
1.00
3.00
1.00
1.00
1.00
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

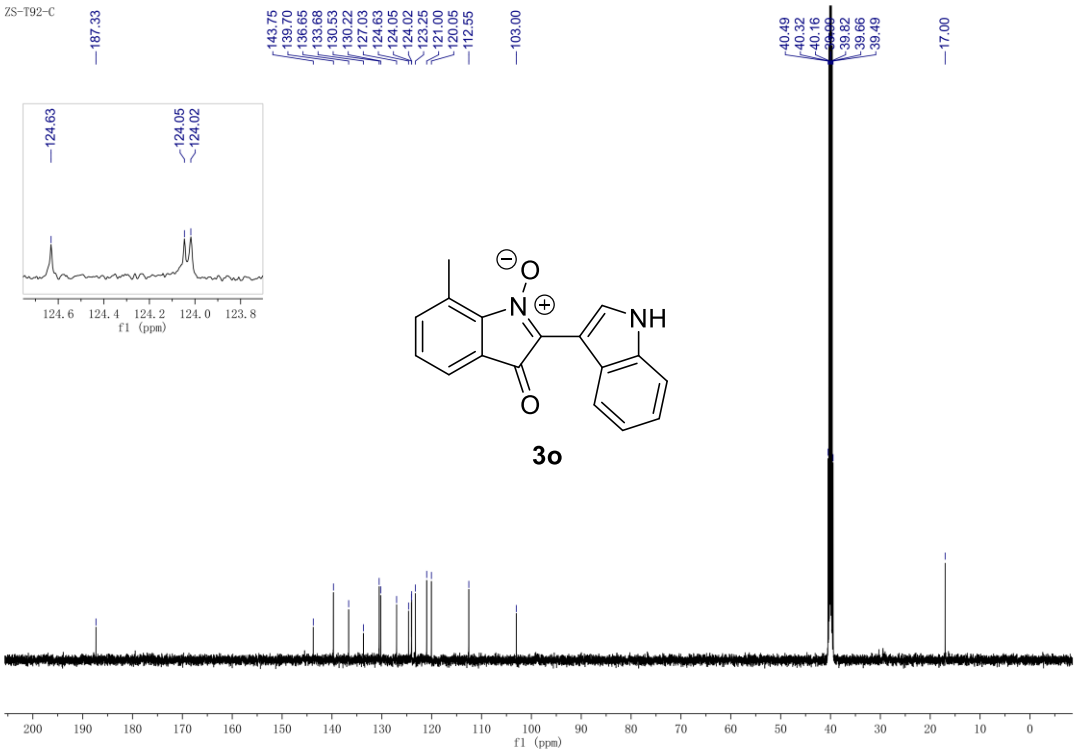
3n


ZS-T32-C-0726
186.18
148.32
135.93
130.65
124.83
123.39
122.16
118.87
114.56
113.55
111.15
40.59
40.38
40.17
39.76
39.55
39.34
O
N
H
N
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

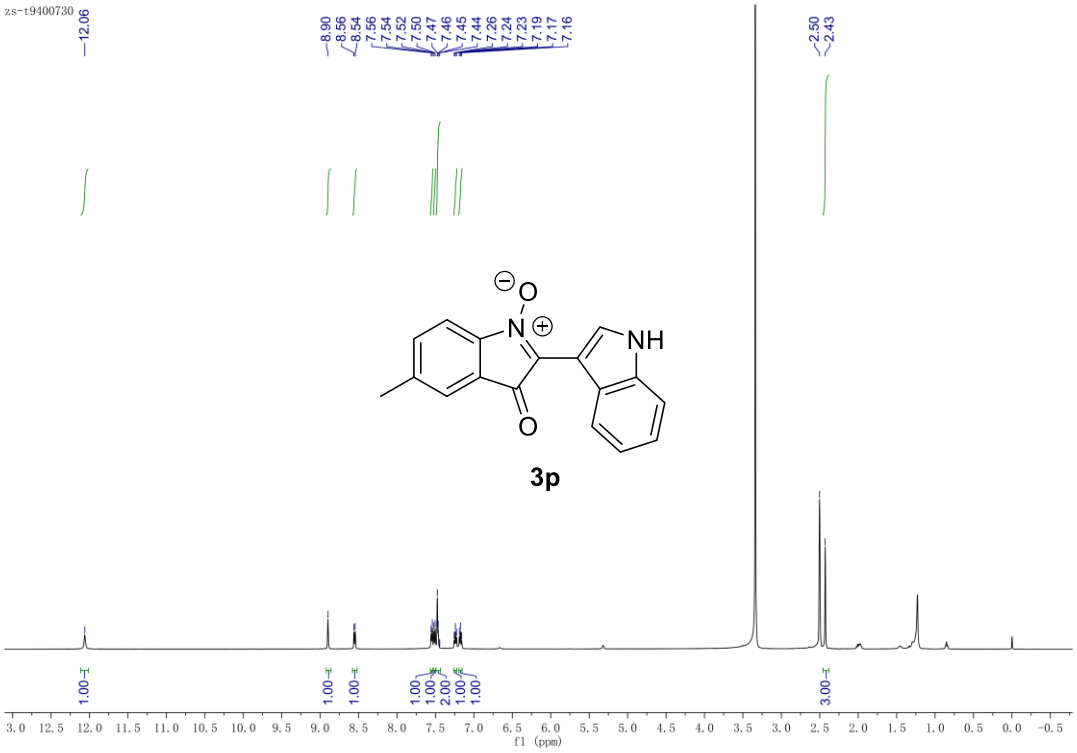
3n

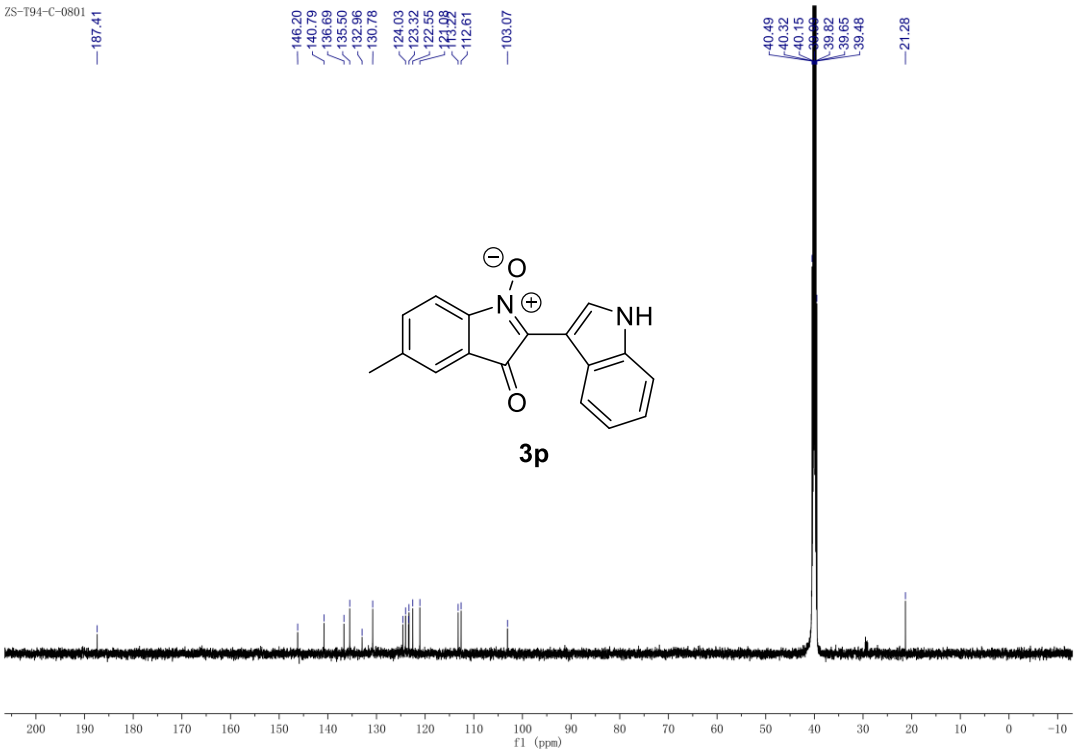

ZS-T92-H-0720
12.05
8.92
8.91
8.56
8.54
7.53
7.52
7.51
7.50
7.49
7.49
7.47
7.43
7.41
7.39
7.26
7.26
7.24
7.24
7.22
7.22
7.19
7.19
7.17
7.17
7.15
7.15
2.72
2.51
O
N
NH
O
1.00
1.00
1.00
3.00
1.00
1.00
3.02
f1 (ppm)

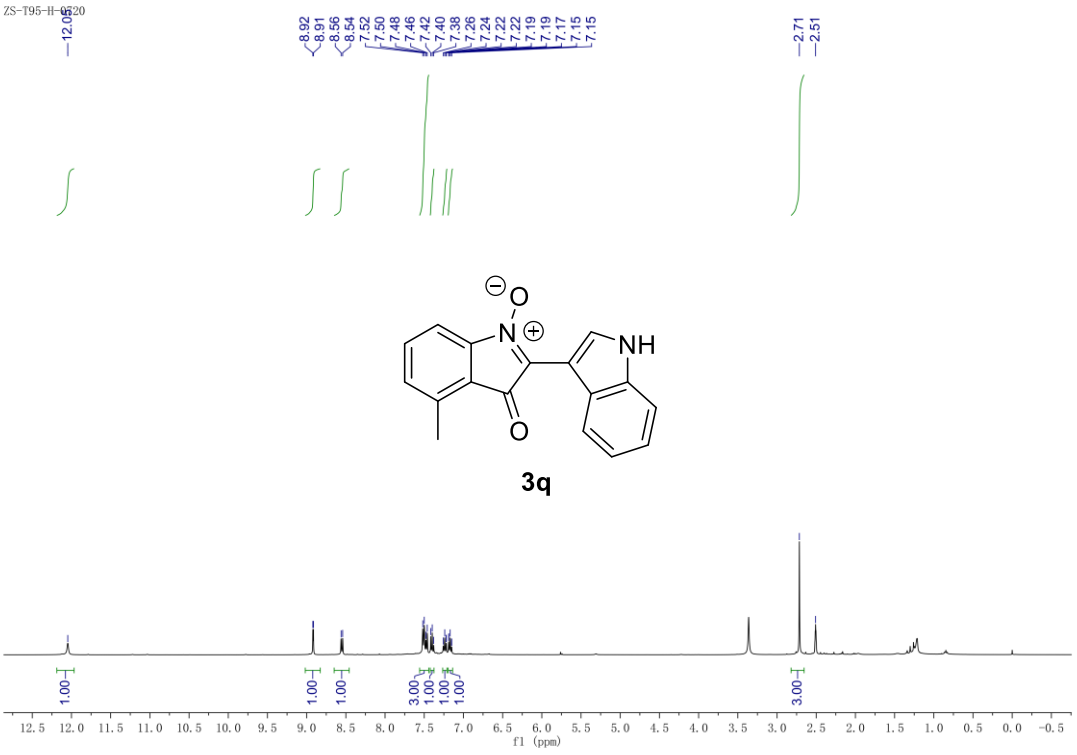
3o


ZS-T92-C
187.33
143.75
139.70
136.65
133.68
130.53
130.22
127.03
124.63
124.05
124.02
123.25
121.00
120.05
112.55
103.00
40.49
40.32
40.16
39.82
39.66
39.49
17.00
124.63
124.05
124.02
O
N
NH
O
f1 (ppm)

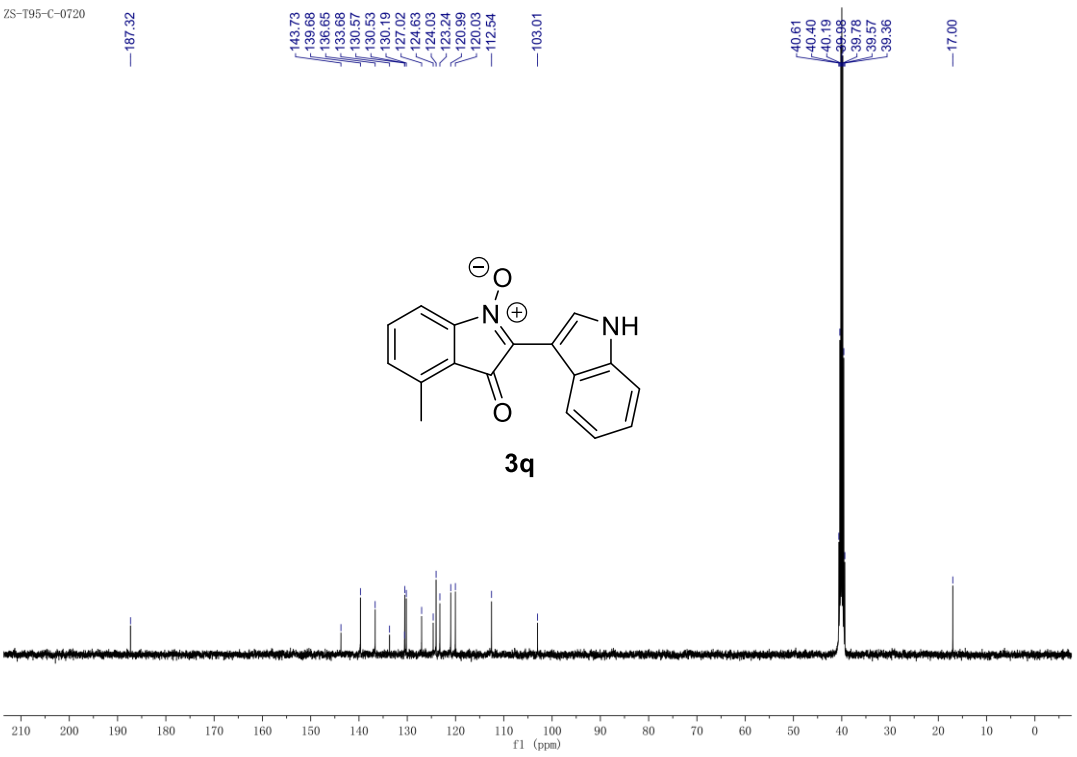
3o


zs-t9400730
12.06
8.90
8.56
8.54
7.56
7.54
7.52
7.50
7.47
7.46
7.45
7.44
7.26
7.24
7.23
7.19
7.17
7.16
2.50
2.43
O
N
NH
O
3p
1.00
1.00
1.00
1.00
2.00
1.00
1.00
3.00
f1 (ppm)

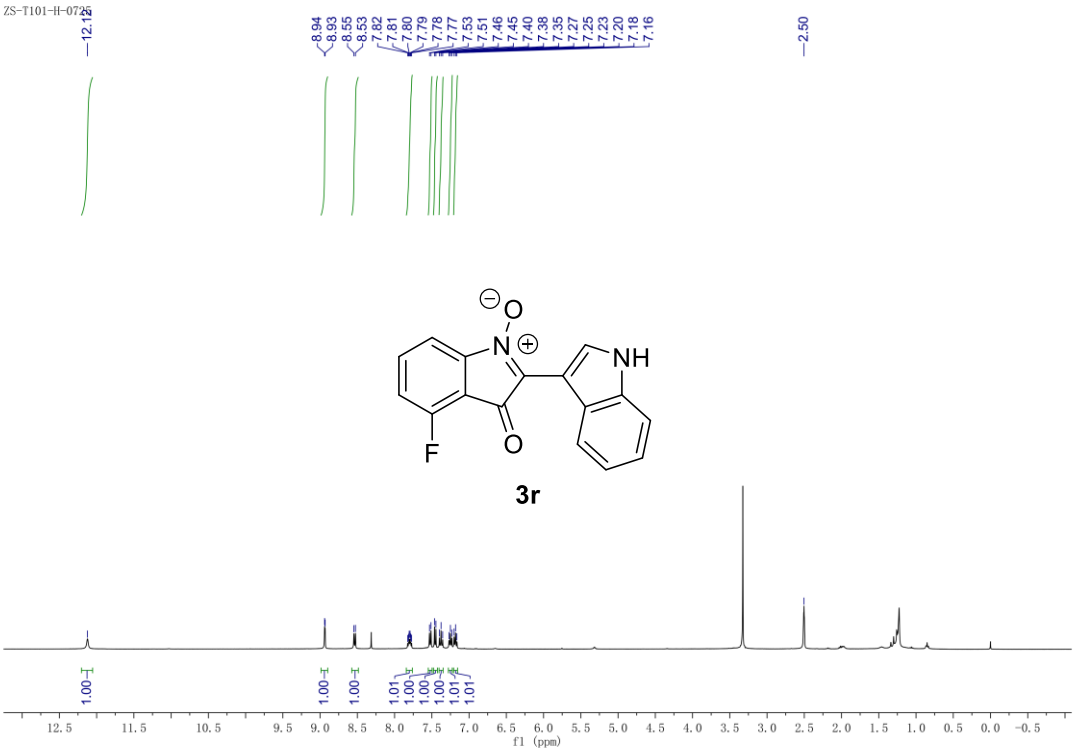

ZS-T94-C-0801
187.41
146.20
140.79
136.69
135.50
132.96
130.78
124.03
123.32
122.55
112.61
103.07
40.49
40.32
40.15
39.82
39.65
39.48
21.28
O
N
NH
O
3p
f1 (ppm)

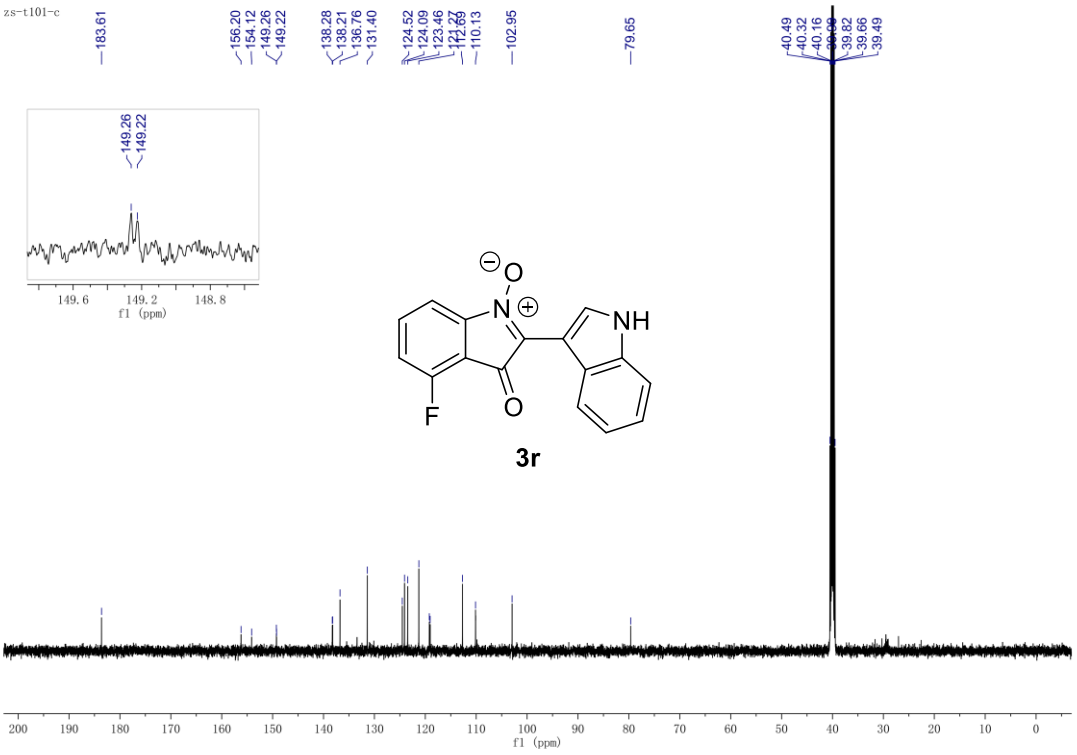

ZS-T95-H-0520
12.05
8.92
8.91
8.56
8.54
7.52
7.50
7.48
7.46
7.42
7.40
7.38
7.26
7.24
7.22
7.22
7.19
7.19
7.17
7.15
7.15
2.71
2.51
O
N
NH
O
1.00
1.00
1.00
3.00
1.00
1.00
3.00
f1 (ppm)

3q

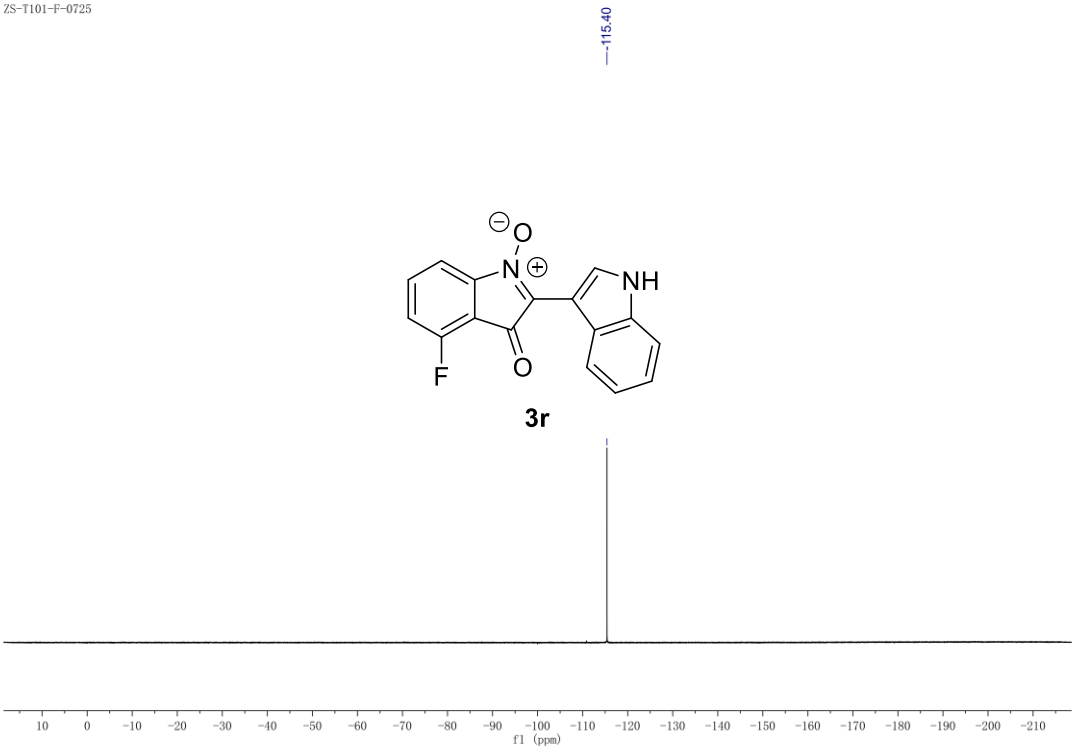

ZS-T95-C-0720
187.32
143.73
139.68
136.65
133.68
130.57
130.53
130.19
127.02
124.63
124.03
123.24
120.99
120.03
112.54
103.01
40.61
40.40
40.19
39.98
39.78
39.57
39.36
17.00
O
N
NH
O
f1 (ppm)

3q


ZS-T101-H-0725
12.12
8.94
8.93
8.55
8.53
7.82
7.81
7.80
7.79
7.78
7.77
7.53
7.51
7.46
7.45
7.40
7.38
7.35
7.27
7.25
7.23
7.20
7.18
7.16
2.50
O
N
NH
F
O
3r
1.00
1.00
1.00
1.01
1.00
1.00
1.00
1.01
1.01
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

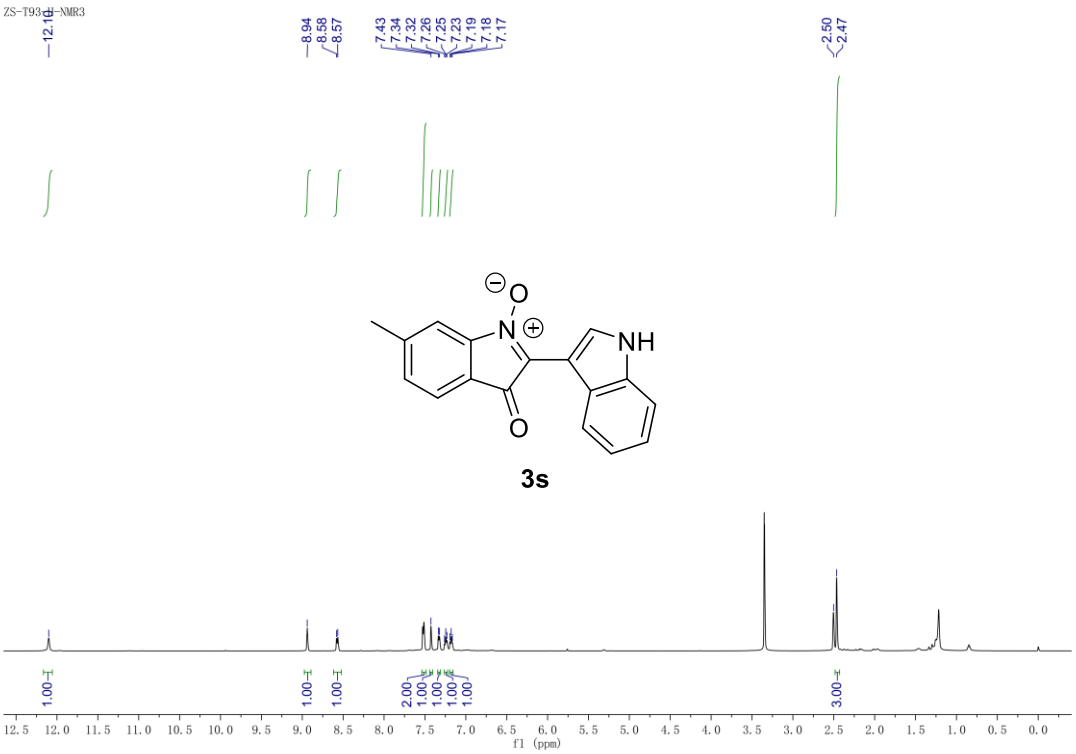

zs-t101-c
183.61
156.20
154.12
149.26
149.22
138.28
138.21
136.76
131.40
124.52
124.09
123.46
121.27
112.69
110.13
102.95
79.65
40.49
40.32
40.16
39.82
39.66
39.49
149.26
149.22
149.6
149.2
148.8
f1 (ppm)
O
N
NH
F
O
3r
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

ZS-T101-F-0725

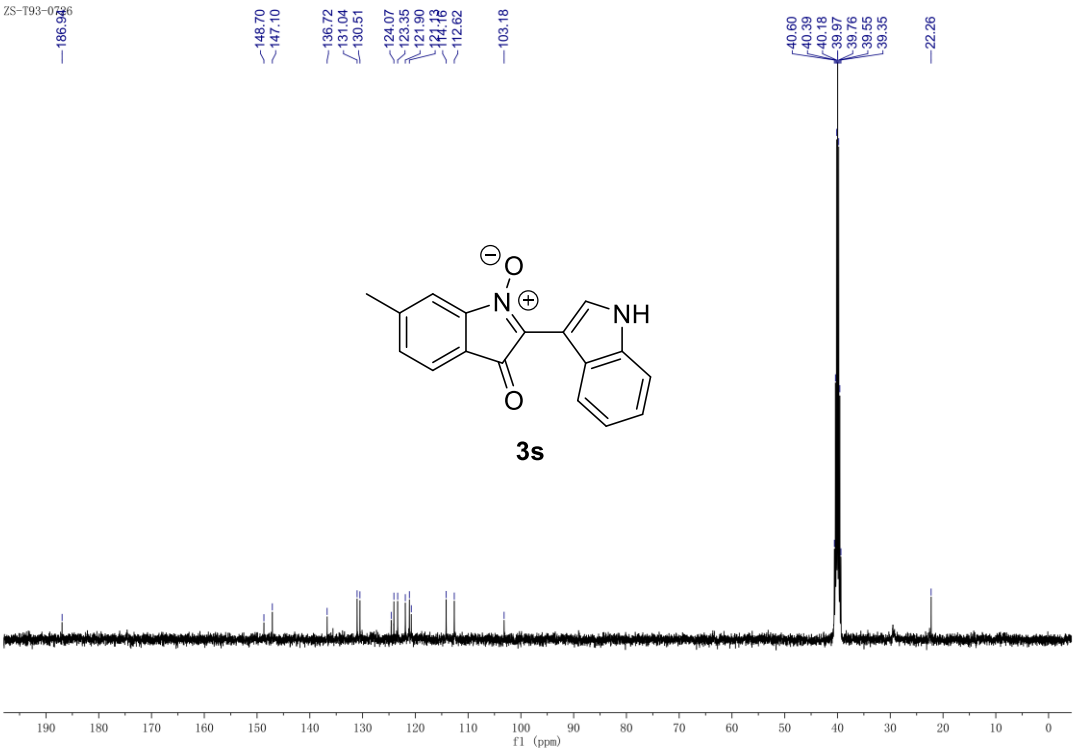


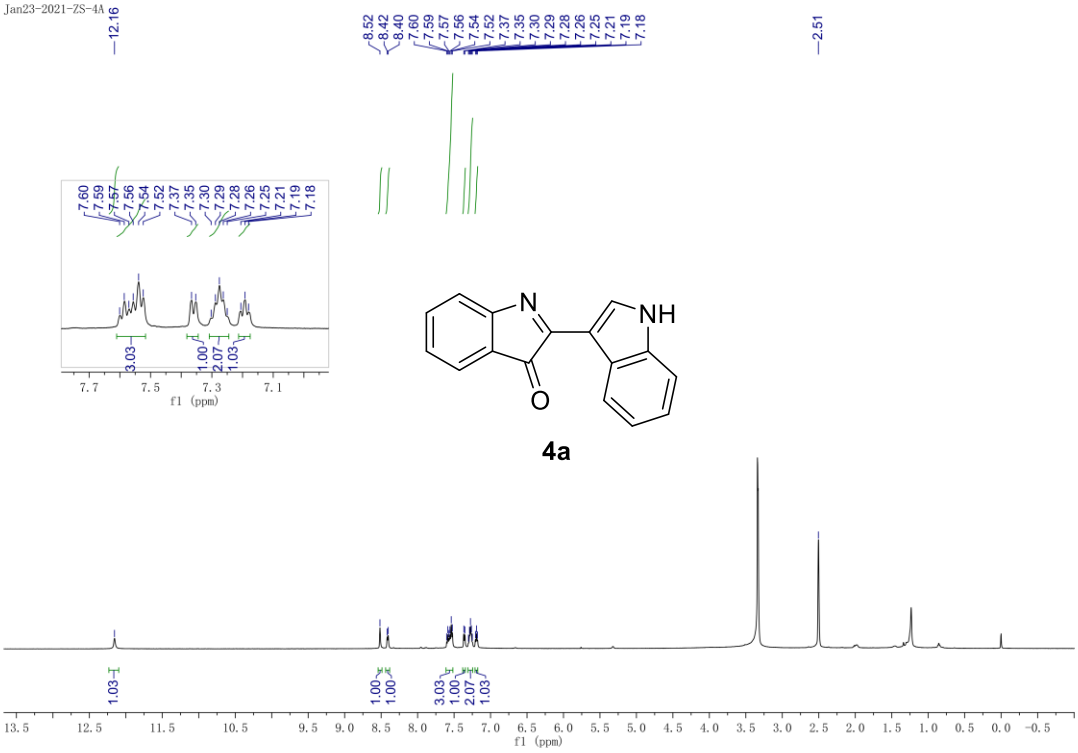
3r

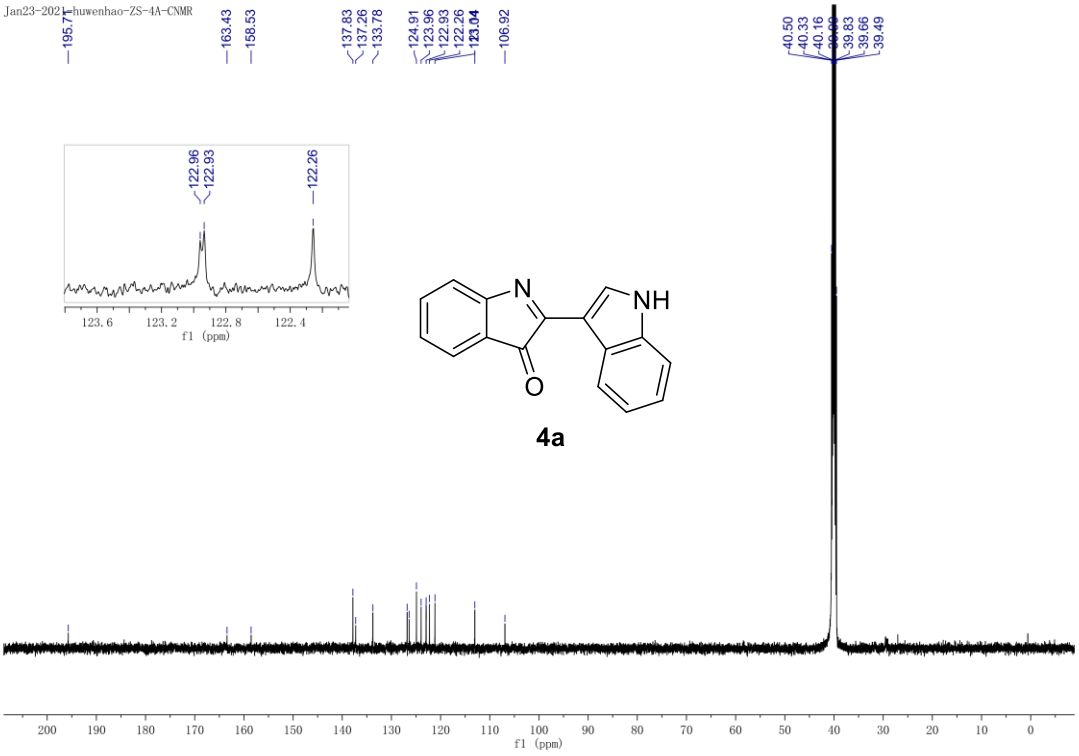
ZS-T93-H-NMR3

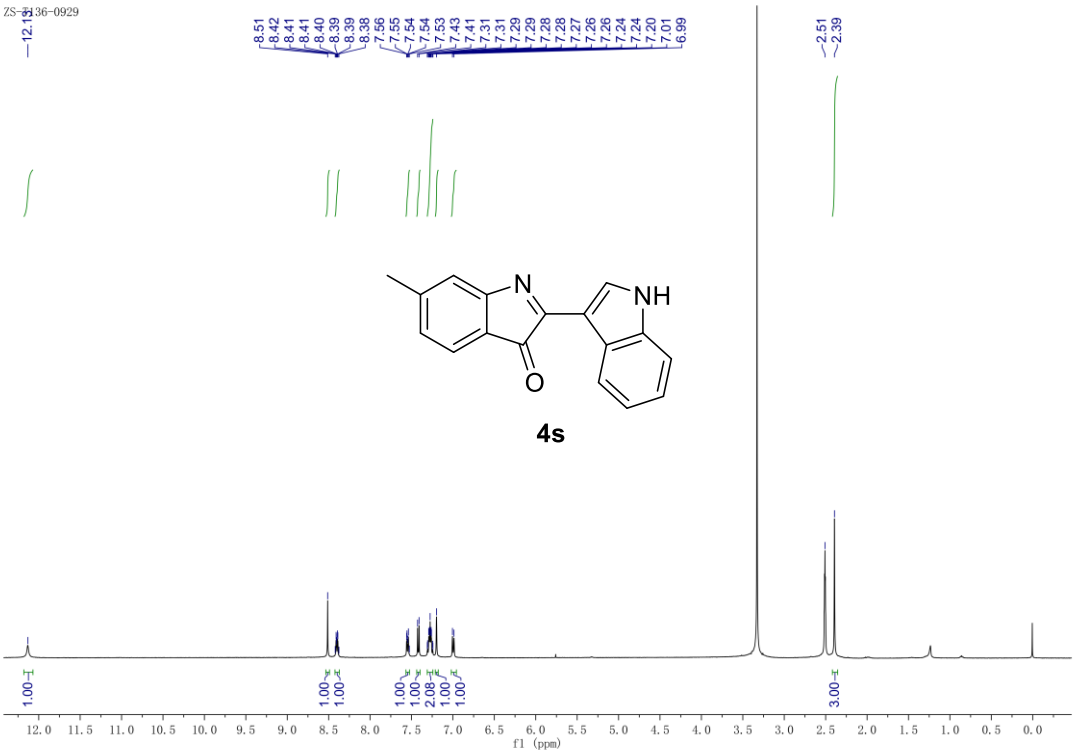


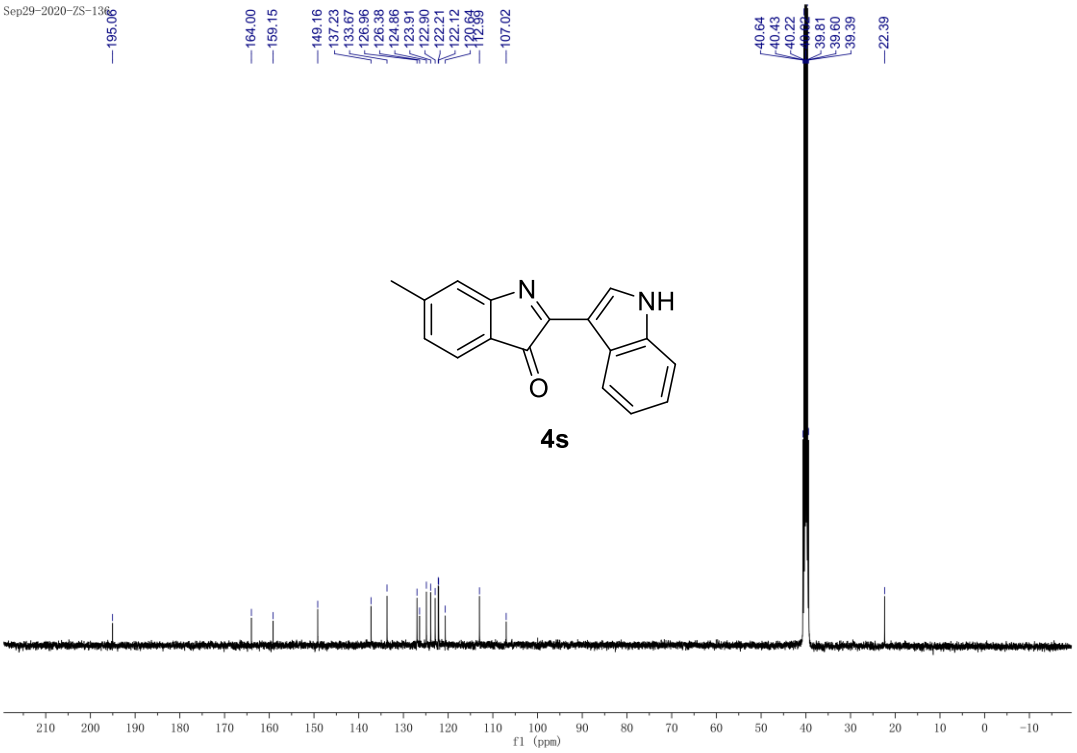
3s

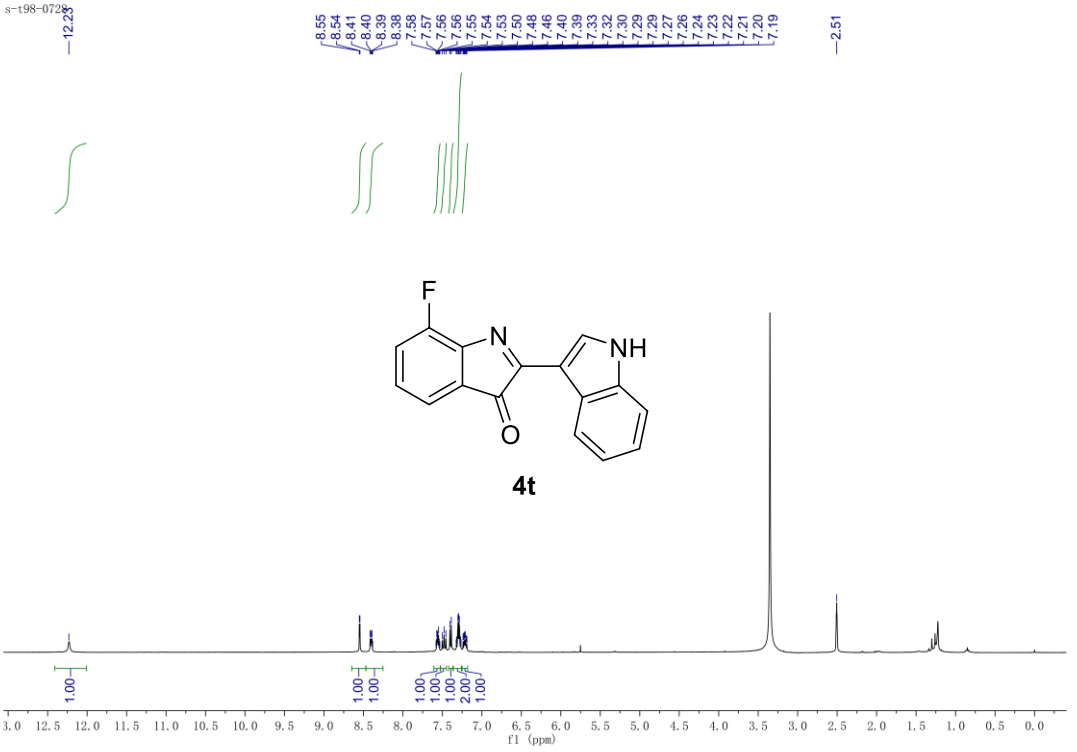

ZS-T93-0726
186.94
148.70
147.10
136.72
131.04
130.51
124.07
123.35
121.90
112.62
103.18
40.60
40.39
40.18
39.97
39.76
39.55
39.35
22.26
O
N
NH
O
3s
f1 (ppm)


Jan23-2021-ZS-4A
12.16
8.52
8.42
8.40
7.60
7.59
7.57
7.56
7.54
7.52
7.37
7.35
7.30
7.29
7.28
7.26
7.25
7.21
7.19
7.18
2.51
3.03
1.00
2.07
1.03
f1 (ppm)
N
NH
O
4a
1.03
1.00
1.00
3.03
1.00
2.07
1.03
f1 (ppm)


Jan23-2021-huwenhao-ZS-4A-CNMR
195.71
163.43
158.53
137.83
137.26
133.78
124.91
123.96
122.93
122.26
123.04
106.92
40.50
40.33
40.16
39.83
39.66
39.49
122.96
122.93
122.26
123.6
123.2
122.8
122.4
f1 (ppm)
N
NH
O
4a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


ZS-4136-0929
12.12
8.51
8.42
8.41
8.41
8.40
8.39
8.39
8.38
7.56
7.55
7.54
7.54
7.53
7.43
7.41
7.31
7.31
7.29
7.29
7.28
7.28
7.27
7.26
7.26
7.24
7.24
7.20
7.01
6.99
2.51
2.39
N
NH
O
4s
1.00
1.00
1.00
1.00
1.00
2.08
1.00
1.00
3.00
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


Sep29-2020-ZS-13C
195.06
164.00
159.15
149.16
137.23
133.67
126.96
126.38
124.86
123.91
122.90
122.21
122.12
120.64
112.99
107.02
40.64
40.43
40.22
39.81
39.60
39.39
22.39
N
NH
O
4s
f1 (ppm)


s-t98-0728
12.23
8.55
8.54
8.41
8.40
8.39
8.38
7.58
7.57
7.56
7.56
7.55
7.54
7.53
7.50
7.48
7.46
7.40
7.39
7.33
7.32
7.30
7.29
7.29
7.27
7.26
7.24
7.23
7.22
7.21
7.20
7.19
2.51
F
N
NH
O
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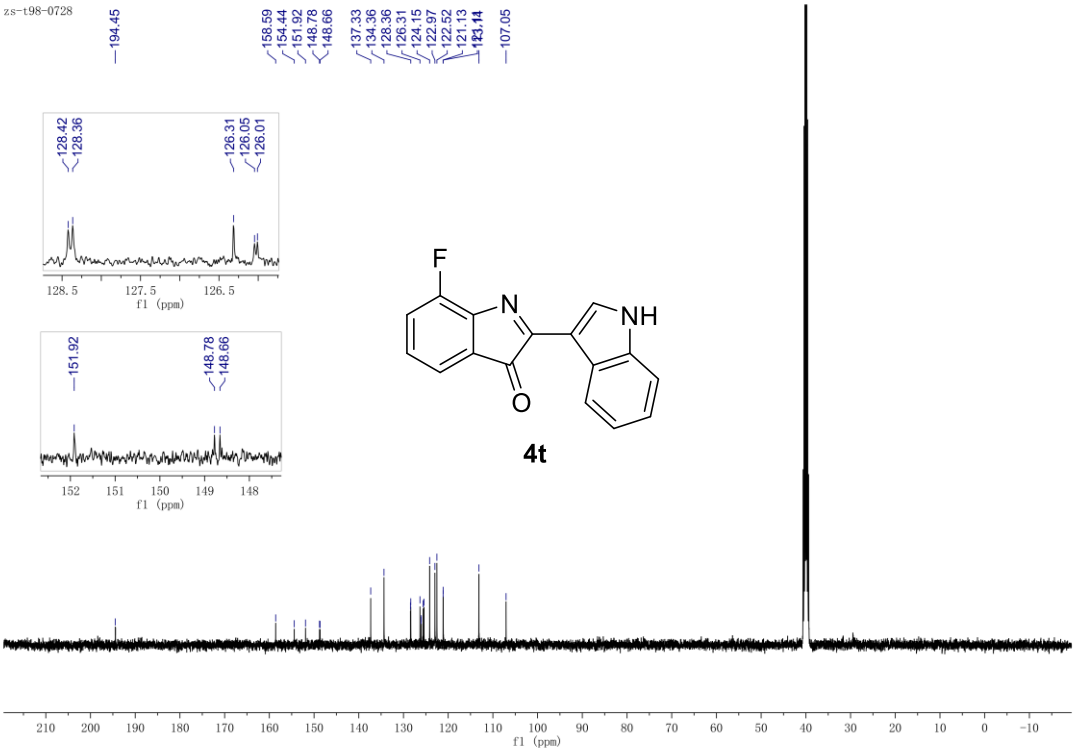
1.00
1.00
1.00
1.00
2.00
1.00
f1 (ppm)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122.97
122.52
121.13
113.14
107.05
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126.01
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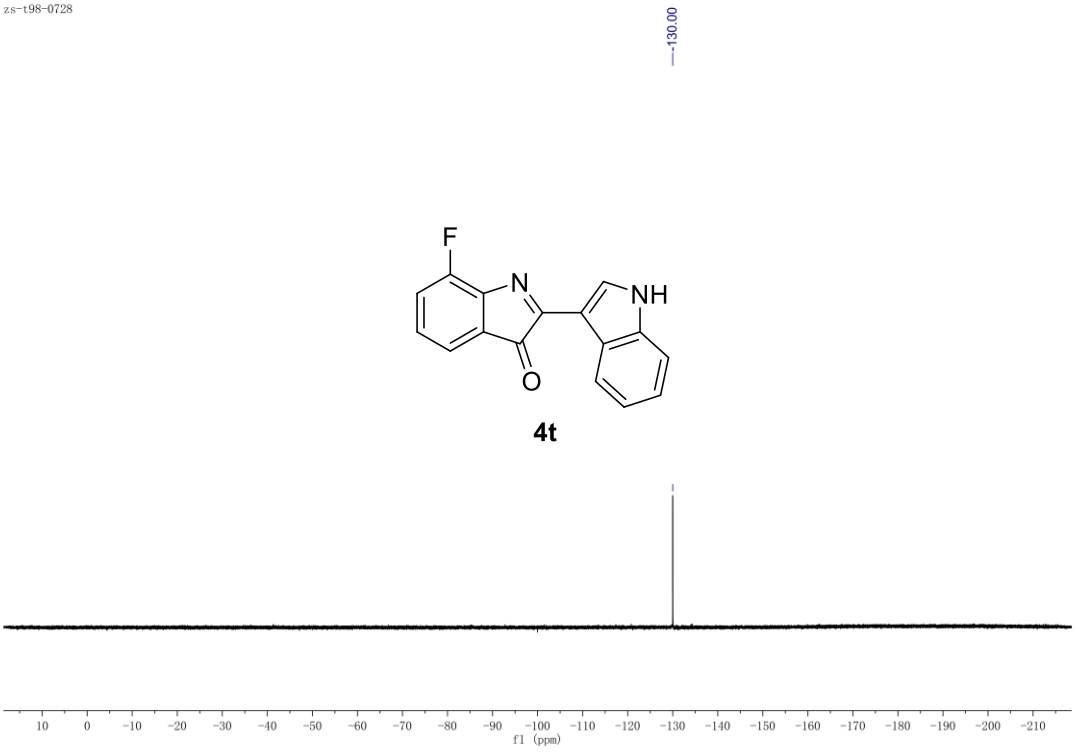
148.66
F
N
NH
O
4t
f1 (ppm)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F
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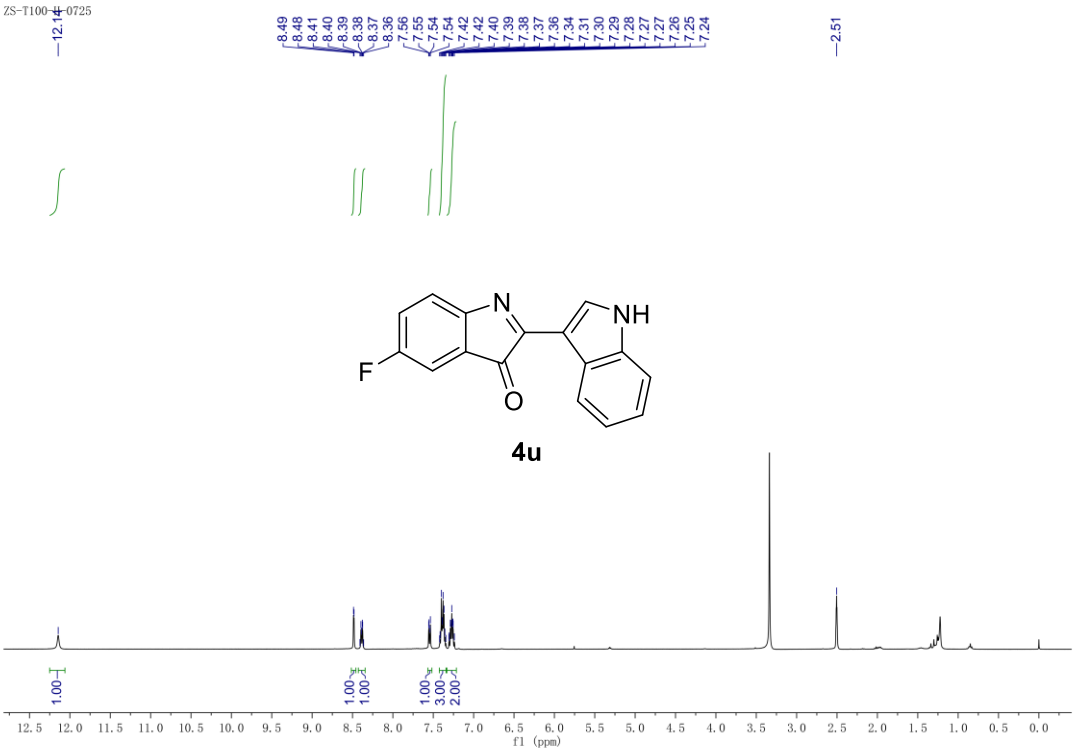
NH
O
4t
f1 (ppm)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7.55
7.54
7.54
7.42
7.42
7.40
7.39
7.38
7.37
7.36
7.34
7.31
7.30
7.29
7.28
7.27
7.27
7.26
7.25
7.24
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N
NH
F
O
4u
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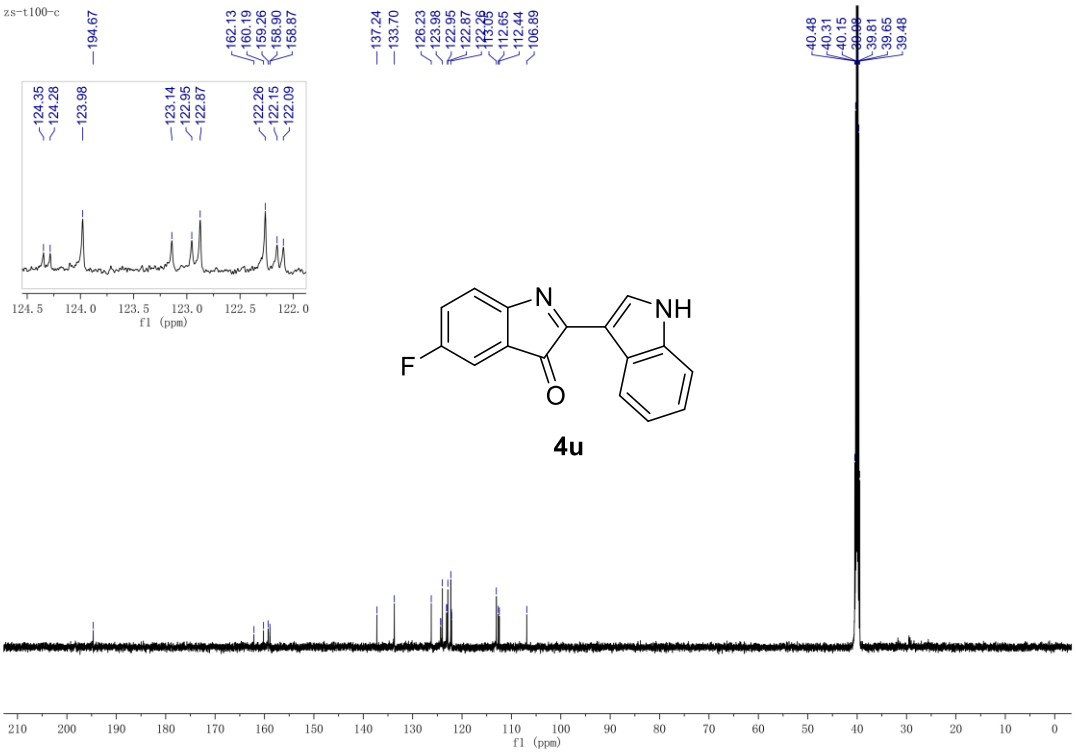
1.00
1.00
1.00
3.00
2.00
f1 (ppm)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162.13
160.19
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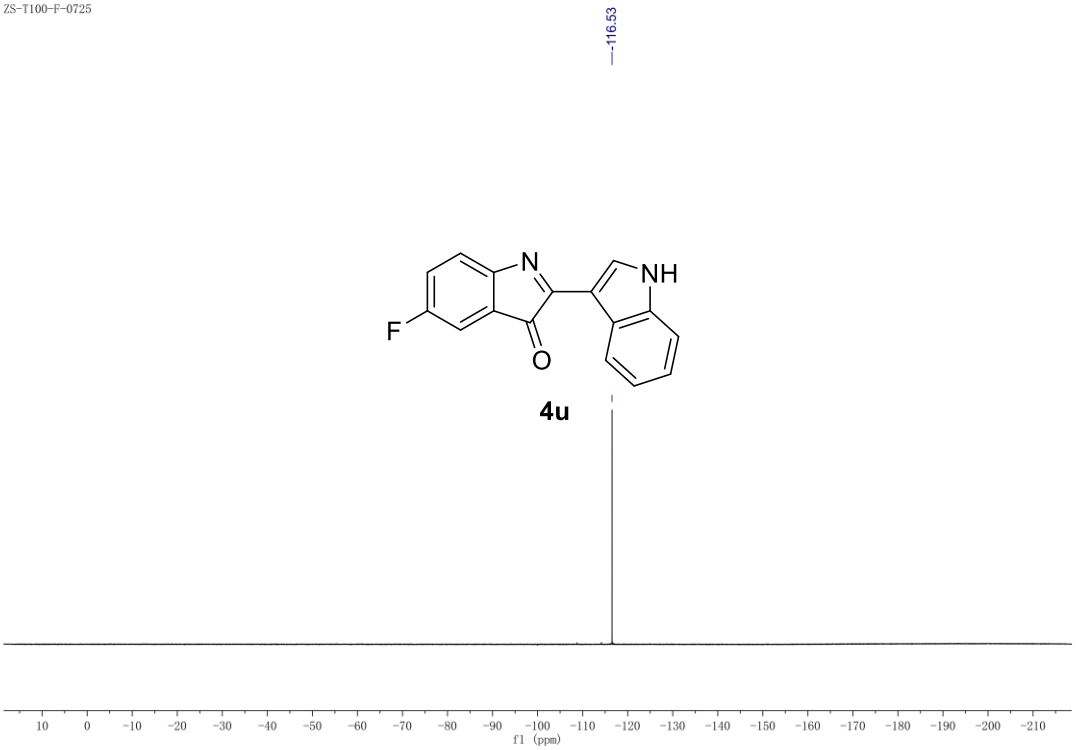
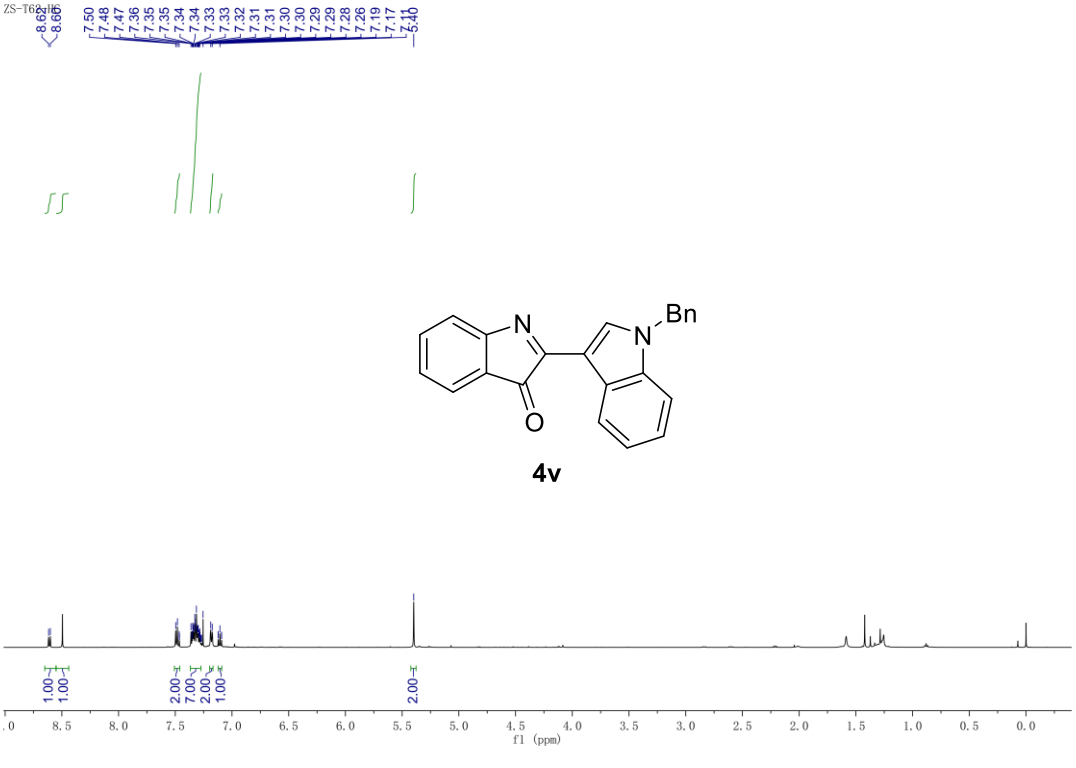
122.95
122.87
122.26
113.05
112.65
112.44
106.89
40.48
40.31
40.15
39.81
39.65
39.48
124.35
124.28
123.98
123.14
122.95
122.87
122.26
122.15
122.09
f1 (ppm)
N
NH
F
O
4u
f1 (ppm)

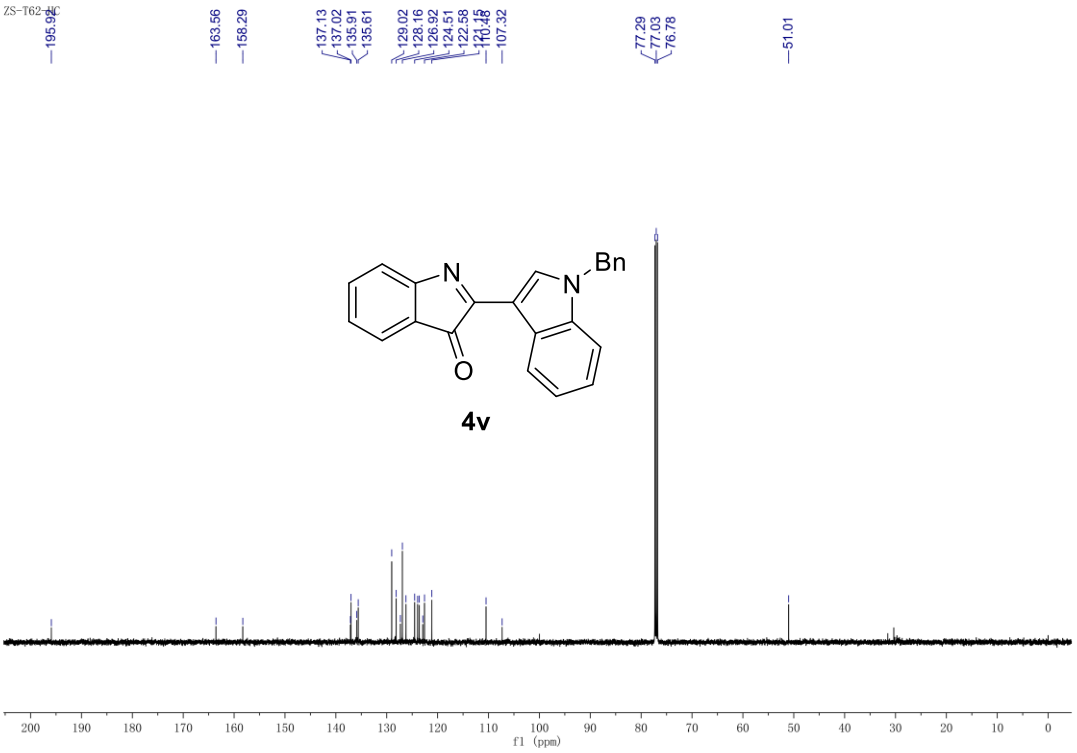
ZS-T100-F-0725



4u



4v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158.29
137.13
137.02
135.91
135.61
129.02
128.16
126.92
124.51
122.58
111.45
111.18
107.32
77.29
77.03
76.78
51.01
N
N
Bn
O
4v
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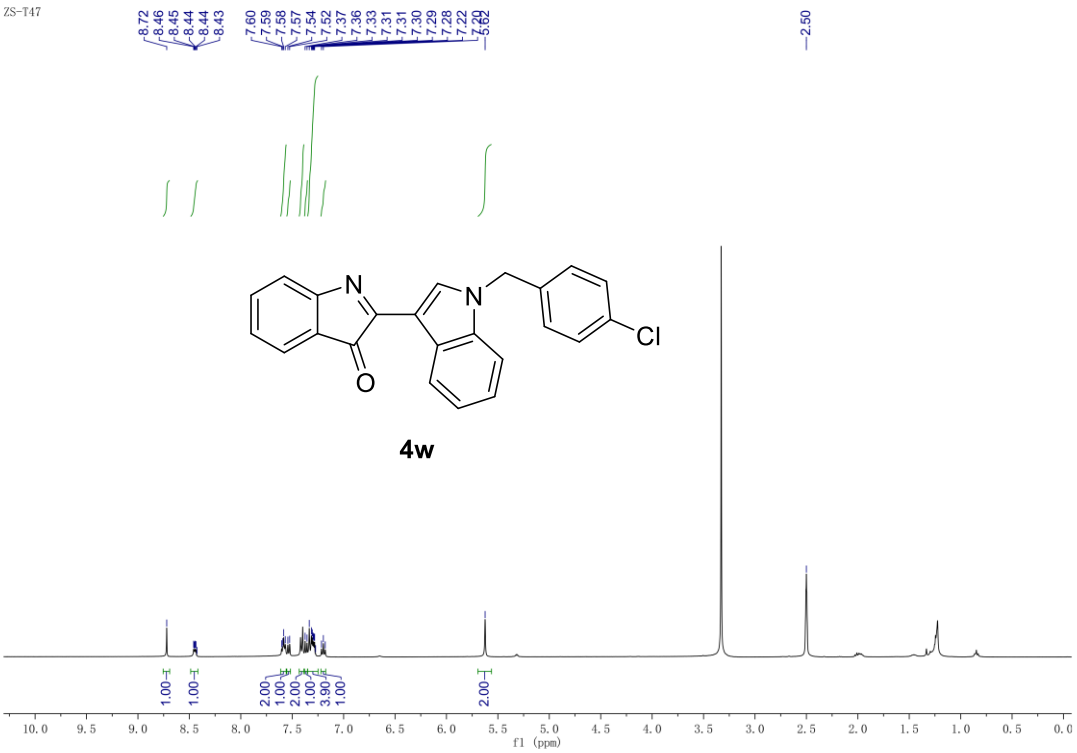
f1 (ppm)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8.72
8.46
8.45
8.44
8.44
8.43
7.60
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7.58
7.57
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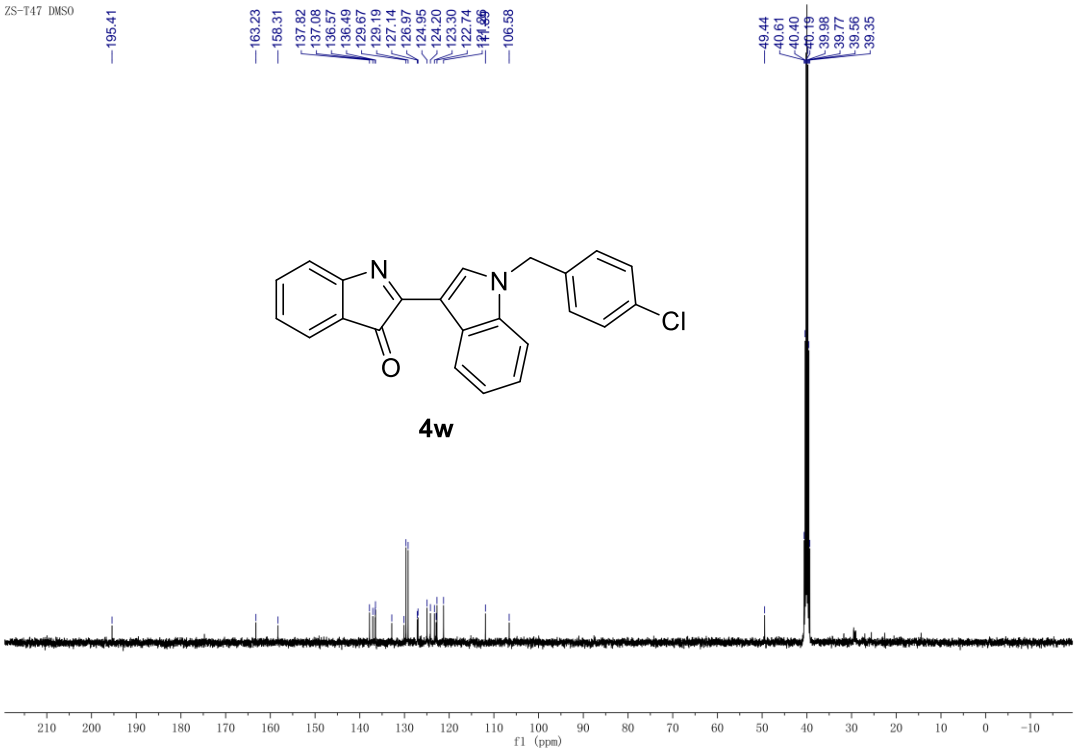
7.52
7.37
7.36
7.33
7.31
7.31
7.30
7.29
7.28
7.22
5.82
2.50
N
N
Cl
O
4w
1.00
1.00
2.00
1.00
2.00
1.00
3.90
1.00
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


ZS-T47 DMSO
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163.23
158.31
137.82
137.08
136.57
136.49
129.67
129.19
127.14
126.97
124.95
124.20
123.30
122.74
106.58
49.44
40.61
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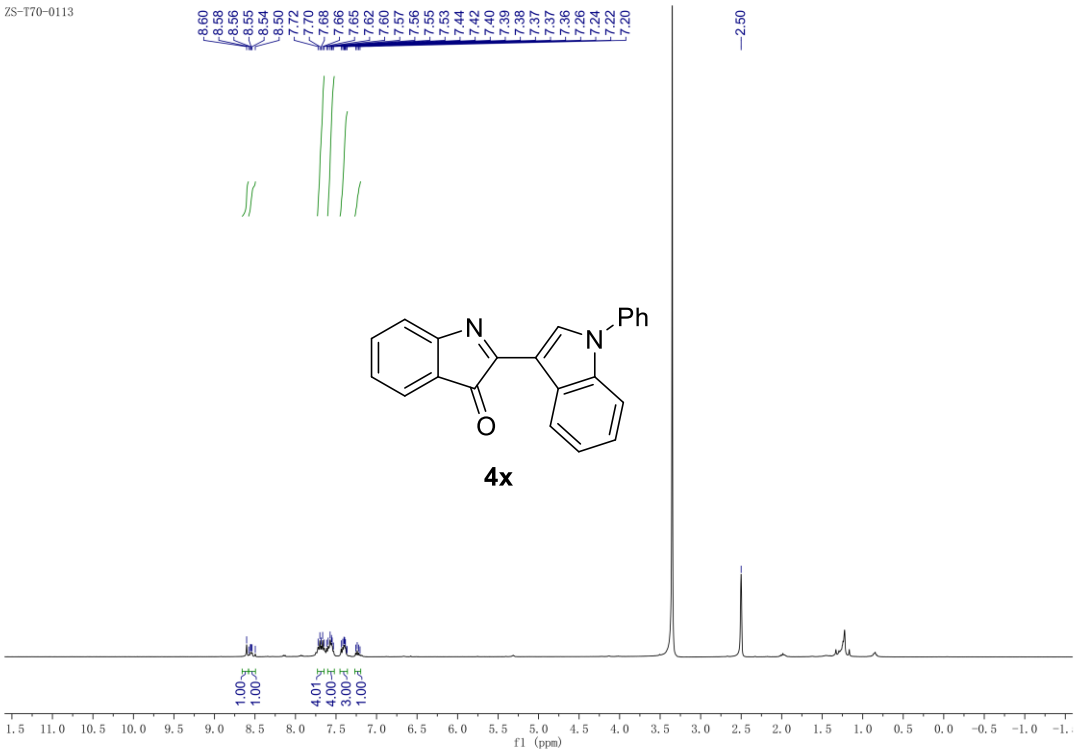
40.19
39.98
39.77
39.56
39.35
N
N
O
Cl
4w
f1 (ppm)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8.56
8.55
8.54
8.50
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7.66
7.65
7.62
7.60
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7.56
7.55
7.53
7.44
7.42
7.40
7.39
7.38
7.37
7.37
7.36
7.26
7.24
7.22
7.20
2.50
N
N
Ph
O
4x
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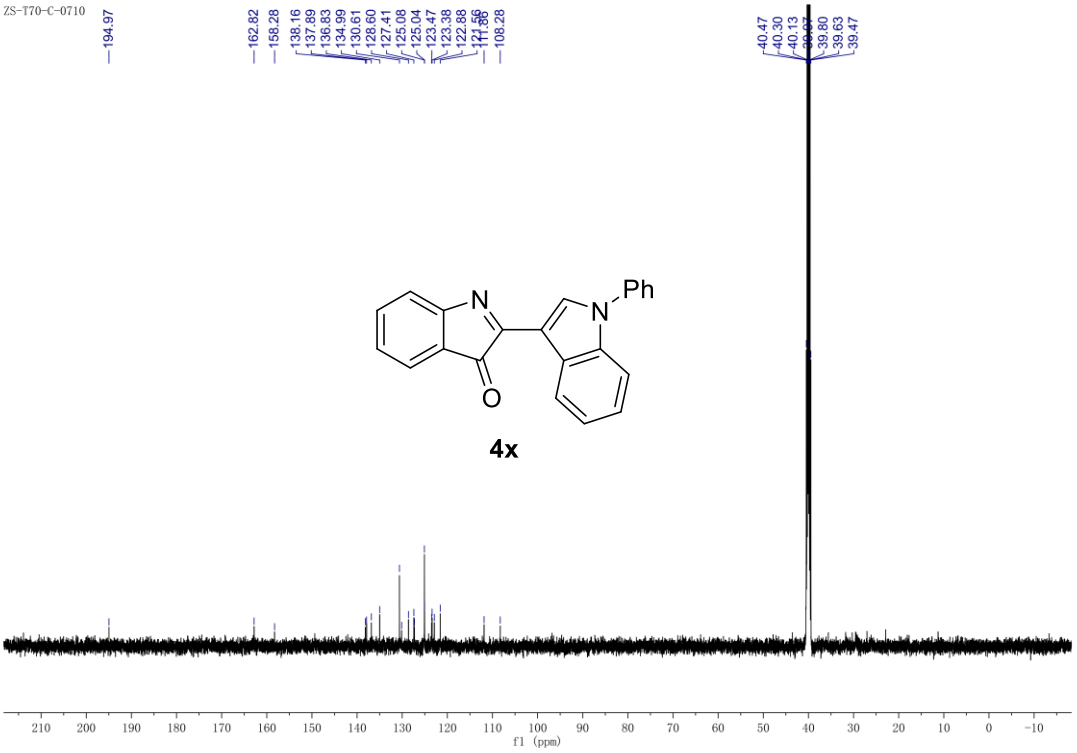
1.00
4.01
4.00
3.00
1.00
f1 (ppm)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137.89
136.83
134.99
130.61
128.60
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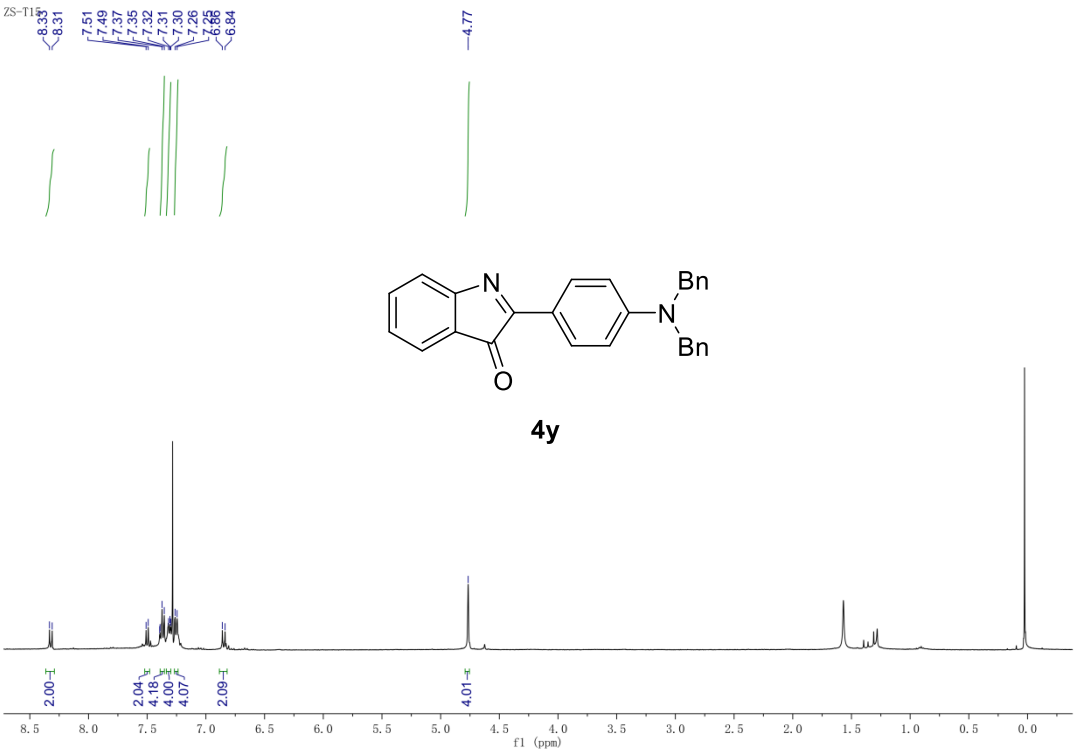
125.08
125.04
123.47
123.38
122.88
108.28
40.47
40.30
40.13
39.80
39.63
39.47
N
N
Ph
O
f1 (ppm)

4x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8.31
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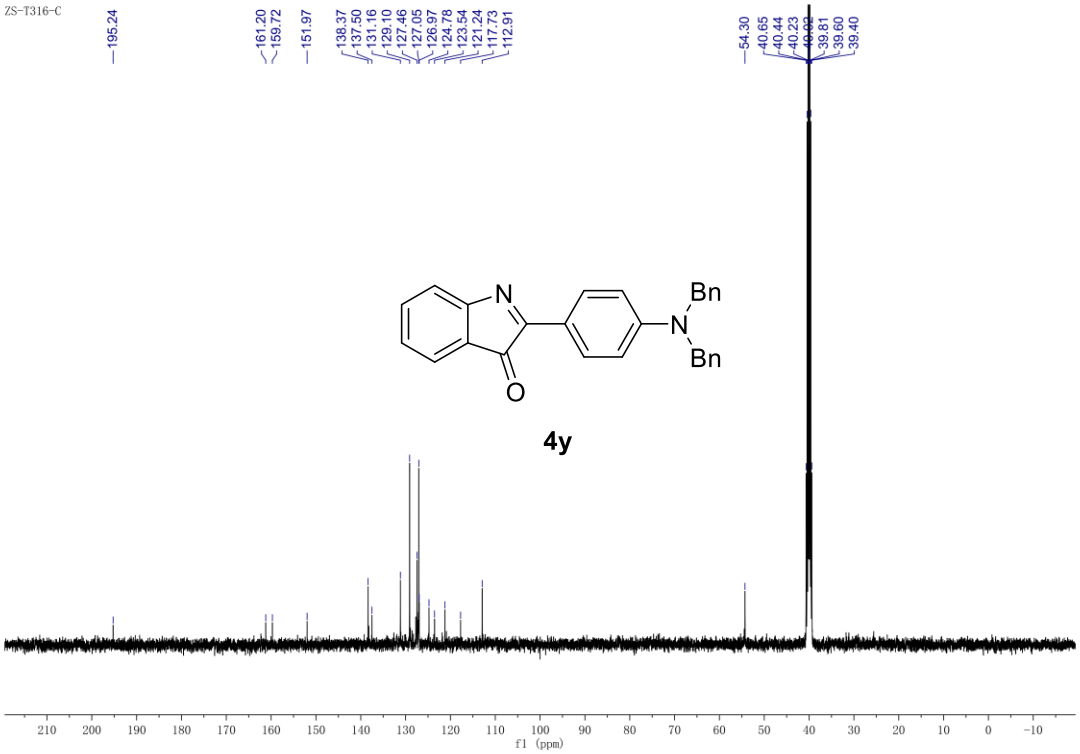
7.49
7.37
7.35
7.32
7.31
7.30
7.26
6.86
6.84
4.77
N
N
Bn
Bn
O
2.00
2.04
4.18
4.00
4.07
2.09
4.01
f1 (ppm)

4y


ZS-T316-C
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161.20
159.72
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138.37
137.50
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129.10
127.46
127.05
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124.78
123.54
121.24
117.73
112.91
54.30
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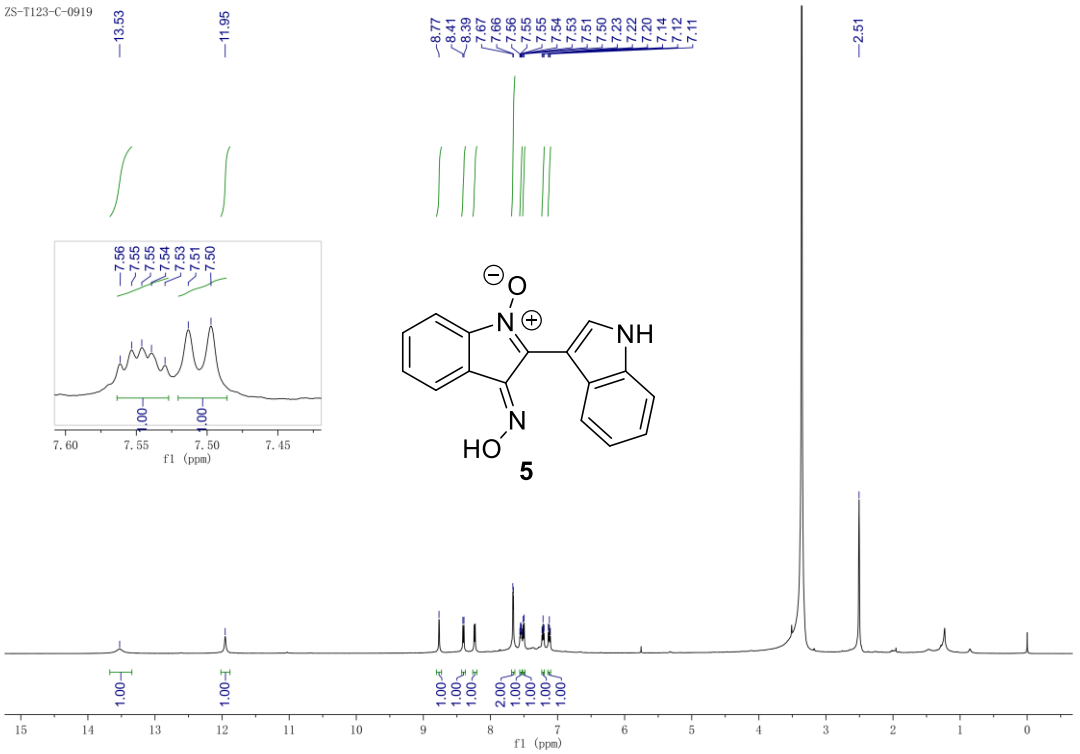
40.23
40.02
39.81
39.60
39.40
N
Bn
N
Bn
O
4y
f1 (ppm)


ZS-T123-C-0919
13.53
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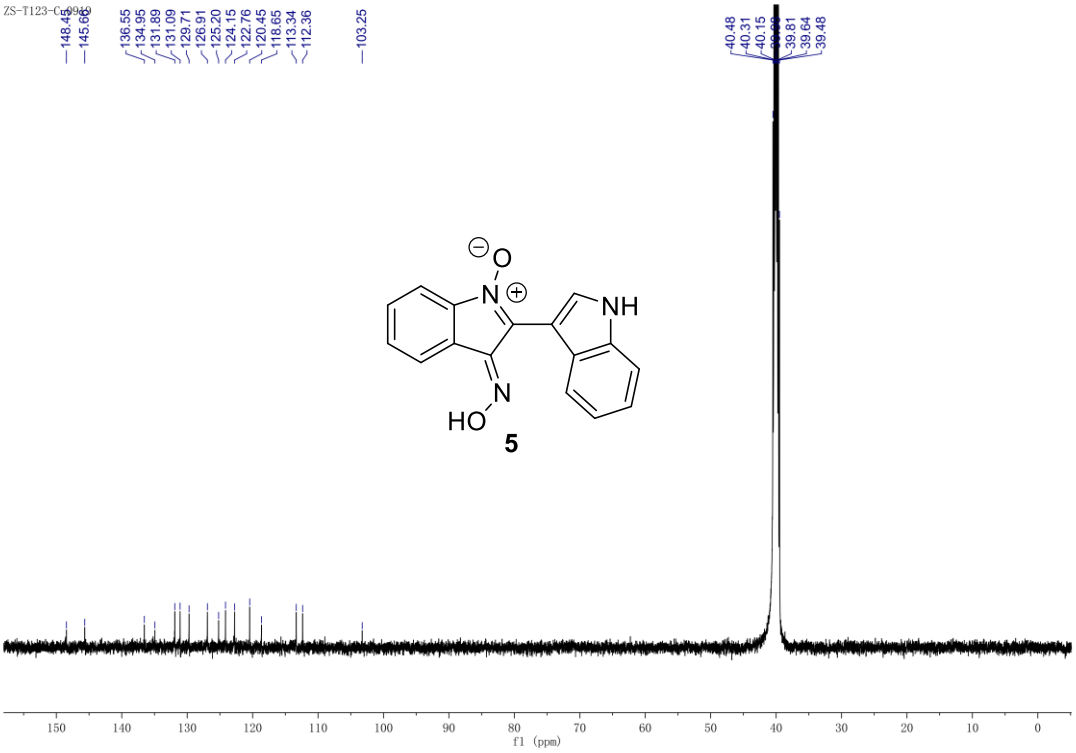
8.77
8.41
8.39
7.67
7.66
7.56
7.55
7.55
7.54
7.53
7.51
7.50
7.23
7.22
7.20
7.14
7.12
7.11
2.51
7.56
7.55
7.55
7.54
7.53
7.51
7.50
1.00
1.00
f1 (ppm)
O
N
NH
N
HO
5
1.00
1.00
1.00
1.00
2.00
1.00
1.00
1.00
f1 (ppm)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145.66
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129.71
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120.45
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112.36
103.25
40.48
40.31
40.15
39.81
39.64
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O
N
NH
N
HO
5
150
140
130
120
110
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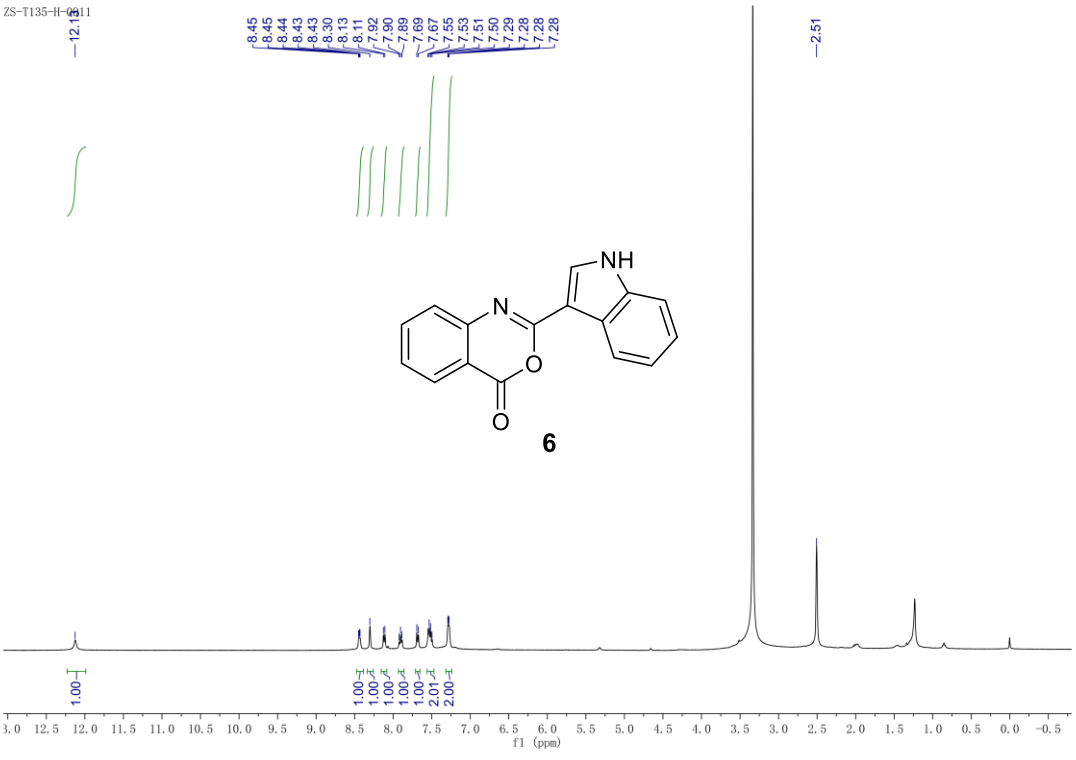
80
70
60
50
40
30
20
10
0
f1 (ppm)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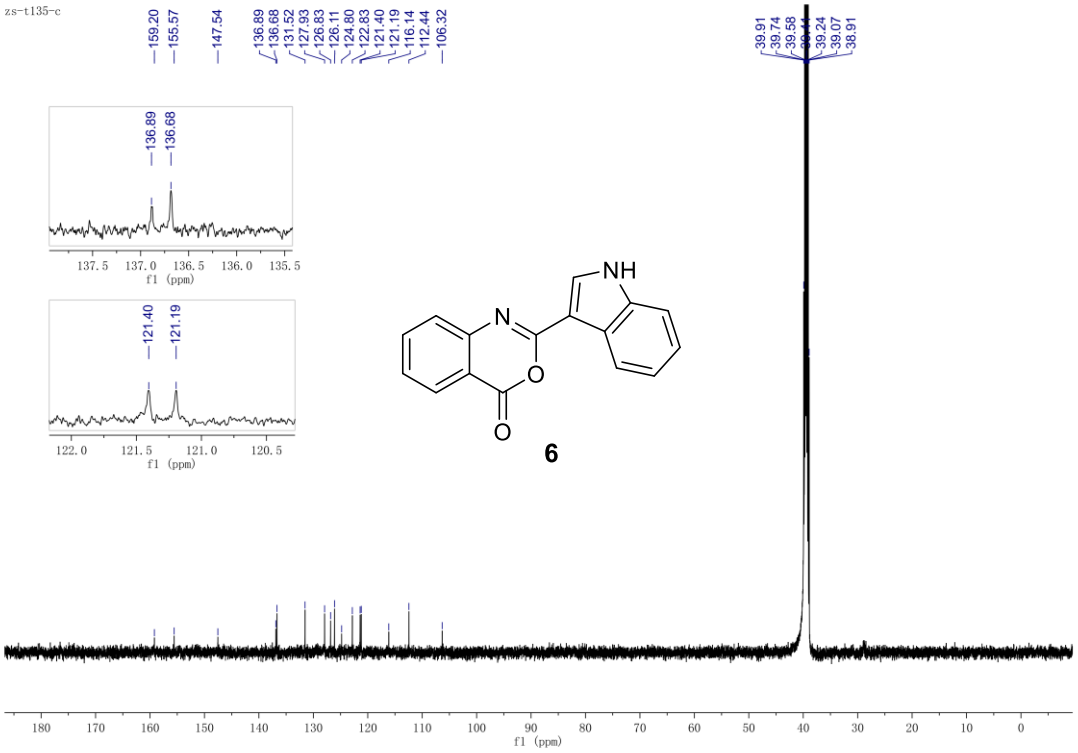
8.11
7.92
7.90
7.89
7.69
7.67
7.55
7.53
7.51
7.50
7.29
7.28
7.28
7.28
2.51
NH
N
O
O
6
1.00
1.00
1.00
1.00
1.00
2.01
2.00
f1 (ppm)


zs-t135-c
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155.57
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131.52
127.93
126.83
126.11
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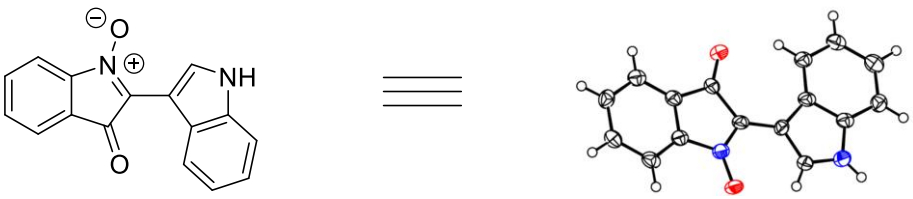
122.83
121.40
121.19
116.14
112.44
106.32
39.91
39.74
39.58
39.24
39.07
38.91
136.89
136.68
137.5 137.0 136.5 136.0 135.5
f1 (ppm)
121.40
121.19
122.0 121.5 121.0 120.5
f1 (ppm)
NH
N
O
O
6
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

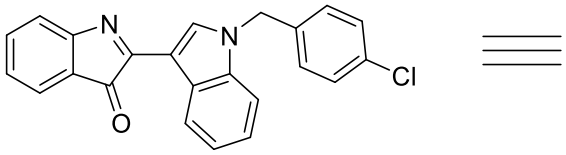
Crystallographic Data for Compound 3a

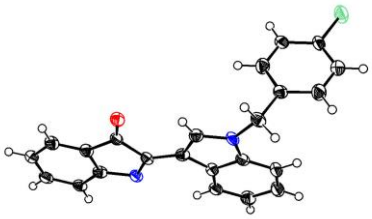


CCDC: 2022220

```
Bond precision:  C-C = 0.0048 A          Wavelength=1.54184

Cell:            a=15.0020(3)     b=7.4177(2)        c=42.7748(8)
                 alpha=90         beta=99.813(2)     gamma=90
Temperature:     100 K

                 Calculated                Reported
Volume           4690.35(18)               4690.35(18)
Space group      P 21/c                    P 1 21/c 1
Hall group       -P 2ybc                   -P 2ybc
Moiety formula   C16 H10 N2 O2             C16 H10 N2 O2
Sum formula      C16 H10 N2 O2             C16 H10 N2 O2
Mr               262.26                    262.26
Dx,g cm-3        1.486                     1.486
Z                16                        16
Mu (mm-1)        0.818                     0.818
F000             2176.0                    2176.0
F000'            2182.80
h,k,lmax         18,9,54                   18,9,53
Nref             9939                      9707
Tmin,Tmax        0.921,0.921               0.839,1.000
Tmin'            0.921

Correction method= # Reported T Limits: Tmin=0.839 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.977          Theta(max)= 77.186

R(reflections)= 0.0945( 4707)     wR2(reflections)= 0.3277( 9707)

S = 1.034                 Npar= 722
```

Crystallographic Data for Compound 4w





CCDC: 2022225

Bond precision: C-C = 0.0082 A Wavelength=1.54184

Cell: a=8.3666(3) b=15.6359(10) c=16.4108(8)
alpha=113.858(5) beta=92.451(4) gamma=103.993(5)
Temperature: 100 K

	Calculated	Reported
Volume	1881.09(19)	1881.08(18)
Space group	P -1	P -1
Hall group	-P 1	-P 1
Moiety formula	2(C23 H15 Cl N2 O), C H2 Cl2	2(C23 H15 Cl N2 O), C H2 Cl2
Sum formula	C47 H32 Cl4 N4 O2	C47 H32 Cl4 N4 O2
Mr	826.57	826.56
Dx,g cm-3	1.459	1.459
Z	2	2
Mu (mm-1)	3.243	3.243
F000	852.0	852.0
F000'	856.96	
h,k,lmax	10,19,20	10,19,20
Nref	7876	7466
Tmin,Tmax	0.759,0.723	0.747,1.000
Tmin'	0.689	

Correction method= # Reported T Limits: Tmin=0.747 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.948 Theta(max)= 76.178

R(reflections)= 0.1241(5798) wR2(reflections)= 0.3400(7466)

S = 1.318 Npar= 514

General Procedure for the *in vitro* Anti-tumor Activity Study

Cell viability was measured by CCK-8 assay

Human small cell lung cancer cell lines H446 and H128 were obtained from American Type Culture Collection (ATCC). Cells were cultured in RPMI1640 medium containing 10% fetal bovine serum and 1% penicillin/ streptomycin (Gibco) in a humidified incubator containing 5% CO_2 at 37 °C. For cell viability, cells were seeded in 96-well plates at 1000 cells per well. After 24 hours, serially diluted compounds were added and cells were cultured for another 96 hours. Cell viability was measured using a Cell Counting Kit-8 (CCK-8) assay according to the manufacturer's instructions (Beyotime Biotechnology, China). The results were presented as percentages and vehicle-treated cells set at 100 (Figure S7).

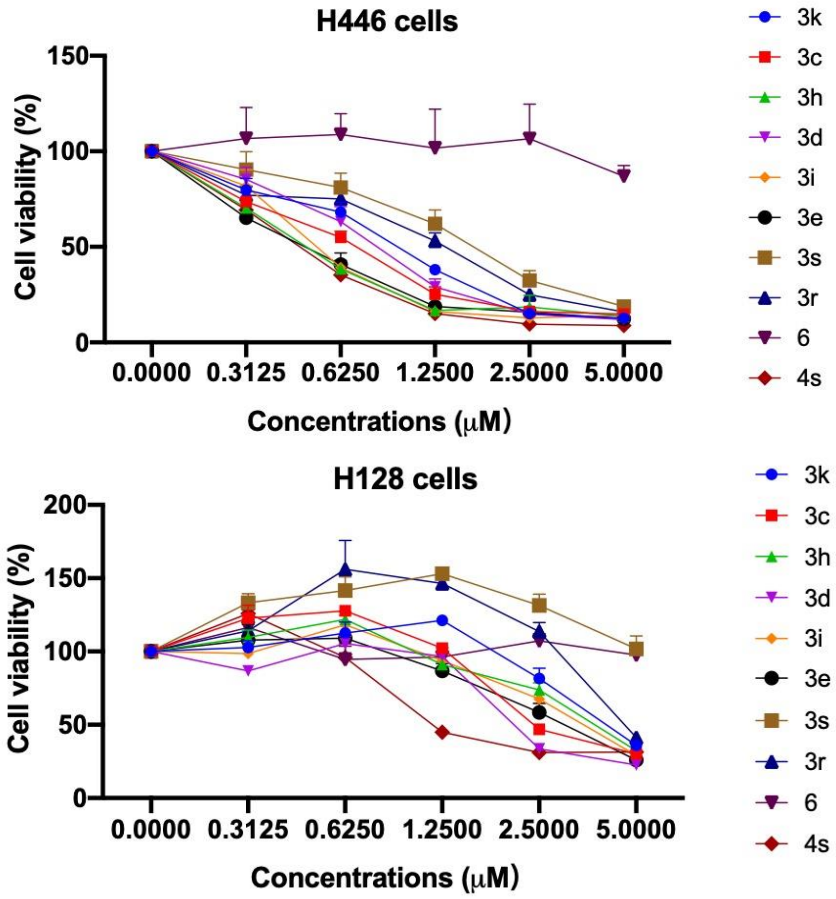


Figure S8. Compounds **3c-6** on the viability of H446 and H128 cells.

These representative products **3c-3d**, **3h**, **3i**, **3k**, **3r**, **3s**, **4s**, and **6** on cell viability was evaluated *via* CCK8 assay in SCLC cells (H446 and H128), and the *in vitro* anti-tumor activity results are listed in Table S1. Most of these 2,3'-biindole derivatives showed significant anti-cancer activity in comparison to the reported 2-aryl analogous, compounds **3d** and **4s** were more potent than other compounds.

Moreover, the substitutions of the left benzene ring on isatogens might affect the activity and showed lower cytotoxicity (the following order of potency: **3c**, **3d**, **3e**, **3h**, **3i** > **3k**, **3r**, **3s**). The structural differences between **3s** and **4s** showed that the reduction product **4s** without the *N*-oxide part was more effective. Whereas, the B-V oxidation product **6** was less potent than the other tested compounds in SCLC cells.

Table S1 Anti-tumor activities of compounds **3c-6** (IC_{50}, μM)[a]

Compound	H446	H128
3c	0.68	2.84
3d	0.83	2.25
3e	0.48	3.01
3h	0.50	3.74
3i	0.56	3.46
3k	0.93	4.19
3r	1.24	4.94
3s	1.66	>10
4s	0.47	1.67
6	>10	>10

[a]IC_{50} is the half maximal inhibitory concentration.

References:

(1) A. M. Jadhav, S. Bhunia, H. Y. Liao and R. S. Liu, Gold-catalyzed stereoselective synthesis of azacyclic compounds through a redox/[2+2+1] cycloaddition cascade of nitroalkyne substrates. *J. Am. Chem. Soc.*, 2011, **133**, 1769–1771.

(2) H. S. Yeom, Y. Lee, J. E. Leeb and S. Shin, Geometry-dependent divergence in the gold-catalyzed redox cascade cyclization of o-alkynylaryl ketoximes and nitrones leading to isoindoles. *Org. Biomol. Chem.*, 2009, **7**, 4744–4752.

(3) H. L. Wei, M. Bao, K. Y. Dong, L. H. Qiu, B. Wu, W. H. Hu and X. F. Xu, Enantioselective oxidative cyclization/mannich addition enabled by gold(I)/chiral phosphoric acid cooperative catalysis. *Angew. Chem., Int. Ed.*, 2018, **57**, 17200−17204.

(4) R. R. Liu, S. C. Ye, C. J. Lu, G. L. Zhuang, J. R. Gao and Y. X. Jia, Dual catalysis for the redox annulation of nitroalkynes with indoles: enantioselective construction of indolin-3-ones bearing quaternary stereocenters. *Angew. Chem., Int. Ed.*, 2015, **54**, 11205−11208.