Supporting Information

Gold-catalyzed redox cycloisomerization/nucleophilic addition/ reduction: direct access to 2-phosphoryl indolin-3-ones

Xingcui Zhou, Ting Xiong and Jun Jiang*

School of Chemistry and Chemical Engineering, Guangxi Key Laboratory of Electrochemical Energy Materials, Guangxi University, Nanning, 530004, P. R. China.
E-mail: jiangjun@gxu.edu.cn

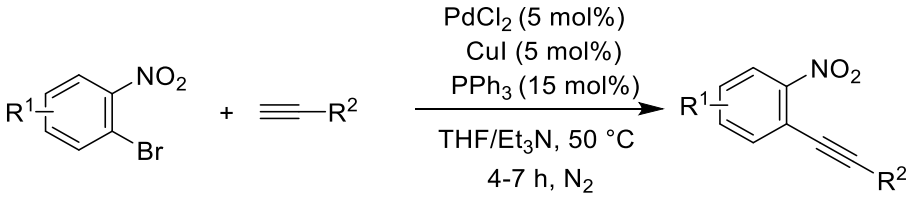
Contents

1. General Information

All reactions were carried out under an atmosphere of N_2 unless otherwise noted. All the reactions were monitored by thin layer chromatography (TLC), carried out on 0.25 mm silica gel plates using UV light as visualizing agent. Column chromatography was carried out on silica gel (particle size 300-400 mesh). Unless stated otherwise, all the yields refer to isolated products after flash column chromatography. The solvent mixtures employed in flash column chromatography purifications are reported as volume by volume and in percentages. NMR spectra were recorded with BrukerAvance III HD500 and BrukerAvance III HD400 spectrometer at 500 MHz or 400 MHz. All ^{13}C, ^{1}H, ^{31}P and ^{19}F NMR spectra were recorded using $CDCl_3$, DMSO-d_6 or MeOD-d_4 as solvent. Tetramethylsilane (TMS) signals or residual solvent signals were used [TMS δ=0.00(^{1}H NMR), $CDCl_3$=7.26 ppm (^{1}H NMR), 77.16 ppm (^{13}C NMR), DMSO-d_6=2.50 ppm (^{1}H NMR), 39.52 ppm (^{13}C NMR), MeOD-d_4=4.88 ppm (^{1}H NMR), 47.60 ppm (^{13}C NMR)] as internal standards. Coupling constants (*J*) are reported in Hz. The following abbreviations were used to describe peak splitting patterns when appropriate: s = singlet, d = doublet, dd = double doublet, t = triplet, q = quartet, m = multiplet, td = triplet doublet, qd = quartet doublet, ddq = doublet doublet quartet. High-resolution mass spectra were recorded on Agilent 6545 Q-TOF LC/MS. There lative configuration of **3s** was determined by NMR Data, molecular weight compared and X-ray single crystal diffraction.

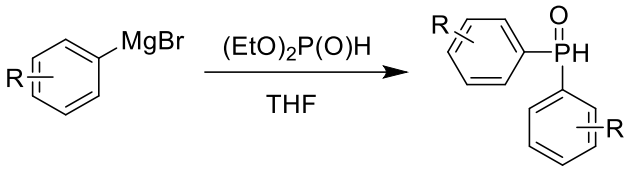
2. Experiment Section

2.1. Preparation for the synthesis of *o*-nitroalkynes[1],[2]



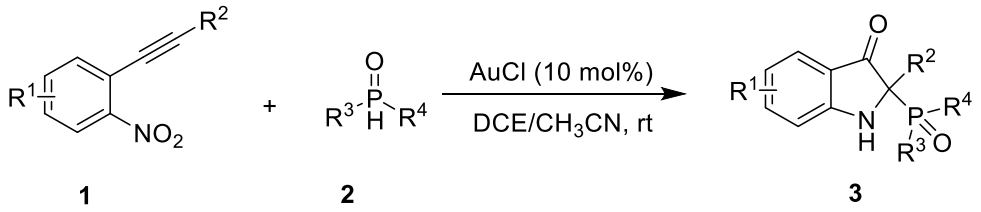
Under N_2 atmosphere, a 100 mL three-necked round-bottomed flask equipped with an egg-shaped Teflon-coated magnetic stir bar was charged with the 1-bromo-2-nitrobenzene (2.0 mmol, 1.0 equiv.), $PdCl_2$ (0.1 mol, 17.7 mg), CuI (0.1 mol, 19.0 mg), PPh_3 (0.3 mol, 78.7 mg) and anhydrous THF/Et_3N (20 mL, v/v = 1:1). The mixture was stirred at 50 °C for 30 min by placement onto a pre-heated oil bath (50 °C, oil bath temperature) and then terminal alkyne (4 mmol, 2.0 equiv.) was slowly added by syringe. The resultant mixture was further stirred at the same temperature for 4 – 7 h. Upon cooling to room temperature, water (60 mL) was added, and the mixture was extracted with ethyl acetate (3 x 40 mL). The combined organic layers were combined, washed by brine, dried over anhydrous $MgSO_4$, and filtered. The filtrate was concentrated with a rotary evaporator under reduced pressure. The crude residue was purified by column chromatography on silica gel to afford *o*-nitroalkynes.

2.2. Preparation for the synthesis of *H*-phosphine oxides[3]



To a solution of arylmagnesium bromide (0.1 mol) in THF (100 mL), diethyl phosphate (0.03 mol, 4.1 g) in THF (20 mL) was added dropwise with vigorous stirring under the cooling of ice-water bath. Then the resulting mixture stirred at rt for 3 h. After the reaction, the resulting reaction mixture was cooled to 0 ℃, and sat. aq. NH_4Cl solution was added slowly upon stirring. The solution was then evaporated under reduced pressure. The residue was extracted with dichloromethane (150 mL). The organic layer was dried over anhydrous sodium sulfate and concentrated in vacuo. The crude product was purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 3:1) to give the product *H*-phosphine oxide as a white solid.

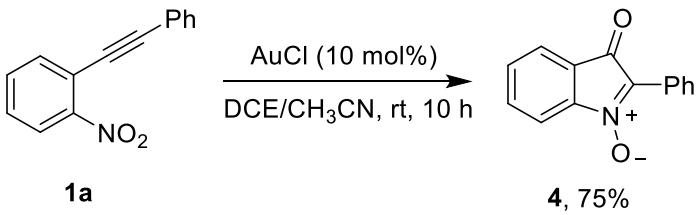
3. General Procedure for the Synthesis of 2-Phosphoryl Indolin-3-ones



1 **2** **3**

Under N_2 atmosphere, a 10 mL oven-dried reaction vessel was charged with AuCl (10 mol%), *o*-nitroalkyne **1** (0.1 mmol) with anhydrous DCE (0.5 mL). Shaking the reaction vessel to make the catalyst dissolve in the solution as much as possible. Then the resultant mixture was added *H*-phosphine oxides **2** (0.16 mmol, 1.6 equiv.) with anhydrous CH_3CN (0.5 mL). The reaction vessel was stirred at rt for 24 h. After the reaction is completed, the solution was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1 – 1.5:1) to give the pure product **3** as a yellow solid.

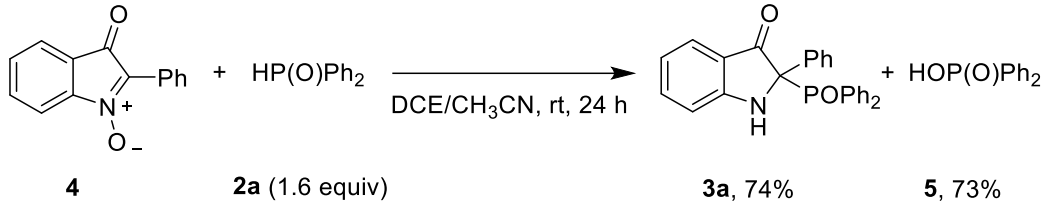
4. Control Reactions (Scheme 4)



1a **4**, 75%

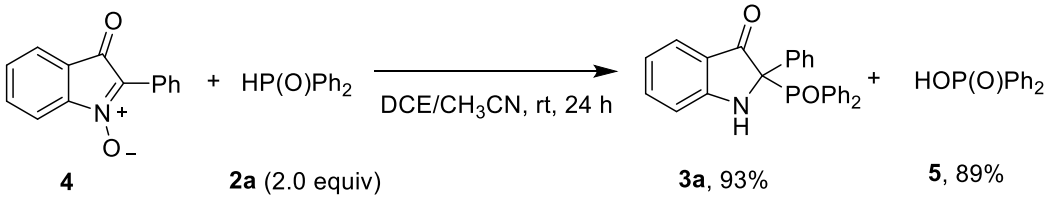
Under N_2 atmosphere, a 10 mL oven-dried flask was charged with AuCl (10 mol%, 4.64 mg), *o*-nitroalkynes **1** (0.2 mmol, 44.6 mg) with anhydrous DCE (1.0 mL) and anhydrous CH_3CN (1.0 mL). Then the reaction vessel was stirred at rt for 10 h. After the reaction is completed, the solution was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 50:1) to give a red solid **4** in 75% yield (**4** was detected by **^{1}H NMR** and **HRMS**).

3-oxo-2-phenyl-3*H*-indole 1-oxide (4). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.67 – 8.61 (m, 2H), 7.69 – 7.67 (m, 2H), 7.64 – 7.62 (m, 1H), 7.55 – 7.44 (m, 4H). **HRMS** (ESI) m/z calcd for $C_{14}H_{10}NO_2$ $[M+H]^+$: 224.0712, found: 224.0704.



Under N_2 atmosphere, a solution of **4** (0.1 mmol, 22.3 mg) with anhydrous DCE (0.5 mL) was added **2a** (1.6 mmol, 32.3 mg) with anhydrous CH_3CN (0.5 mL). The reaction vessel was stirred at rt for 24 h, **3a** and **5** were isolated in yields of 74% and 73%.

Diphenylphosphinic acid (5): ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.79 (dd, J = 11.6, 7.3 Hz, 4H), 7.40 – 7.35 (m, 2H), 7.34 – 7.31 (m, 4H). **HRMS** (ESI) m/z calcd for $C_{12}H_{11}O_2PNa$ $[M+Na]^+$: 241.0389, found: 241.0392.



Under N_2 atmosphere, a solution of **4** (0.1 mmol, 22.3 mg) with anhydrous DCE (0.5 mL) was added **2a** (2.0 mmol, 40.4 mg) with anhydrous CH_3CN (0.5 mL). The reaction vessel was stirred at rt for 24 h, giving the product **3a** in 93% yield and **5** in 89% yield.

5. Reference

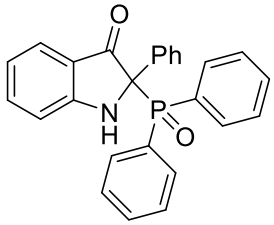
[1] Meng, H.; Xu, Z.; Qu, Z.; Huang, H.; Deng, G. Copper(0)/PPh3-Mediated Bisheteroannulations of *o*-Nitroalkynes with Methylketoximes Accessing Pyrazo-Fused Pseu-doindoxyls. Org. Lett. 2020, 22, 6117−6121.

[2] Liu, R.; Ye, S.; Lu, C.; Zhuang, G.; Gao, J.; Jia, Y. 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.

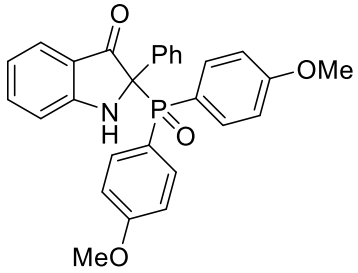
[3] Wang, J.; Deng, G.; Liu, C.; Chen, Z.; Yu, K.; Chen, W.; Zhang, H.; Yang, X. Transition Metal-Free Synthesis of α-Aminophosphine Oxides through C(sp^3)−P Coupling of 2-Azaallyls. Adv. Synth. Catal. 2020, 362, 2268−2273.

6. Characterization Data for Compounds

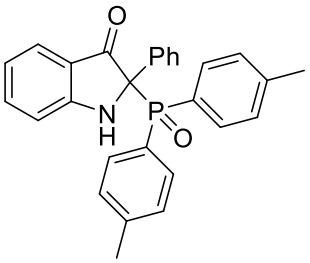
2-(diphenylphosphoryl)-2-phenylindolin-3-one (3a). Yellow solid, 30.7 mg, 75% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.02 (t, *J* = 9.5 Hz, 2H), 7.90 – 7.81 (m, 2H), 7.76 – 7.73 (m, 2H), 7.53 – 7.49 (m, 1H), 7.43 (m, 3H), 7.43 – 7.39 (t, *J* = 7.5 Hz, 1H), 7.32 – 7.29 (m, 1H), 7.27 – 7.15 (m, 5H), 6.87 (d, *J* = 8.2 Hz, 1H), 6.67 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.73 (d, *J* = 1.0 Hz), 159.84 (d, *J* = 3.7 Hz), 137.35 , 133.23 (d, *J* = 102.4 Hz), 133.13 (d, *J* = 2.5 Hz), 133.01 (d, *J* = 9.2 Hz), 132.38 (d, *J* = 2.7 Hz), 132.20 (d, *J* = 2.7 Hz), 132.19 (d, *J* = 101.8 Hz), 132.12 (d, *J* = 9.0 Hz), 128.15, 128.07 (d, *J* = 1.3Hz), 128.03 (d, *J* = 3.8 Hz), 127.99 (d, *J* = 3.8 Hz), 127.44 (d, *J* = 4.0 Hz), 124.60, 121.54, 119.13, 112.21, 74.83 (d, *J* = 60.8 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 29.43. **HRMS** (ESI) m/z calcd for $C_{26}H_{20}NO_2PNa$ $[M+Na]^+$: 432.1124, found: 432.1126.

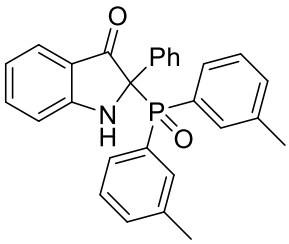


2-(bis(4-methoxyphenyl)phosphoryl)-2-phenylindolin-3-one (3b). Yellow solid, 28.6 mg, 61% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.57 (s, 1H), 7.81 – 7.73 (m, 2H), 7.70 (t, *J* = 9.3 Hz, 2H), 7.49 (dd, *J* = 10.5, 8.5 Hz, 2H), 7.42 – 7.34 (m, 1H), 7.30 (d, *J* = 6.7 Hz, 3H), 7.23 (d, *J* = 7.7 Hz, 1H), 6.97 (d, *J* = 8.3 Hz, 1H), 6.93 (m, 4H), 6.61 (t, *J* = 7.4 Hz, 1H), 3.75 (s, 3H), 3.74 (s, 3H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 195.78, 162.54 (d, *J* = 2.7 Hz), 162.38 (d, *J* = 2.7 Hz), 160.81 (d, *J* = 4.7 Hz), 137.65, 134.93 (d, *J* = 9.5 Hz), 134.21, 133.98 (d, *J* = 10.0 Hz), 128.23, 128.20, 127.17 (d, *J* = 3.4 Hz), 124.30, 122.20 (d, *J* = 104.4 Hz), 120.51 (d, *J* = 104.0 Hz), 119.85, 118.48, 114.19 (d, *J* = 12.6 Hz), 114.05 (d, *J* = 12.3 Hz), 112.76, 74.68 (d, *J* = 68.4 Hz), 55.76, 55.75. **^{31}P NMR** (202 MHz, Chloroform-*d*) δ25.86. **HRMS** (ESI) m/z calcd for $C_{28}H_{25}NO_4P$ $[M+H]^+$: 470.1516, found: 470.1519.

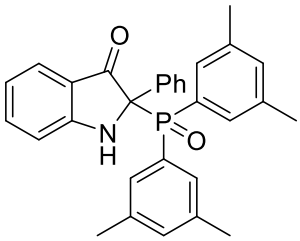


2-(di-*p*-tolylphosphoryl)-2-phenylindolin-3-one (3c). Yellow solid, 32.3 mg, 74% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.87 – 7.80 (m, 2H), 7.80 – 7.76 (m, 2H), 7.76 – 7.70 (m, 2H), 7.58 (s, 1H), 7.45 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.32 – 7.25 (m, 1H), 7.26 – 7.16 (m, 5H), 7.04 (dd, *J* = 8.1, 2.9 Hz, 2H), 6.85 (dd, *J* = 8.3, 0.9 Hz, 1H), 6.66 (t, *J* = 7.4 Hz, 1H), 2.39 (s, 3H), 2.27 (s, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.97, 160.15 (d, *J* = 3.8 Hz), 142.76 (d, *J* = 2.8 Hz), 142.53 (d, *J* = 2.9 Hz), 137.18, 133.36 (d, *J* = 2.1 Hz), 133.00 (d, *J* = 9.5 Hz), 132.13 (d, *J* = 9.4 Hz), 128.83 (d, *J* = 5.5 Hz), 128.73 (d, *J* = 5.2 Hz), 127.87, 127.86 (d, *J* = 2.1 Hz), 127.57 (d, *J* = 3.9 Hz), 125.97 (d, *J* = 99.3 Hz), 125.54 (d, *J* = 101.4 Hz), 124.51, 121.38, 118.66, 112.32, 75.04 (d, *J* = 61.9 Hz), 21.67 (d, *J* = 1.0 Hz), 21.47 (d, *J* = 1.0 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 30.23. **HRMS** (ESI) m/z calcd for $C_{28}H_{25}NO_2P$ $[M+H]^+$: 438.1617, found: 438.1617.

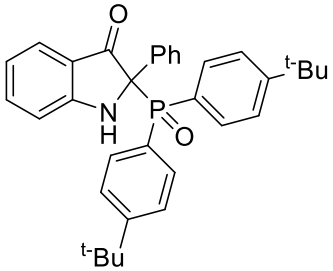


2-(di-*m*-tolylphosphoryl)-2-phenylindolin-3-one (3d). Yellow solid, 31.9 mg, 73% yield. 

^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79 (s, 1H), 7.75 (d, *J* = 7.7 Hz, 2H), 7.68 (t, *J* = 10.7 Hz, 2H), 7.63 – 7.51 (m, 2H), 7.43 (d, *J* = 7.8 Hz, 1H), 7.28 (d, *J* = 18.0 Hz, 3H), 7.16 (dt, *J* = 18.7, 6.8 Hz, 5H), 6.83 (d, *J* = 8.3 Hz, 1H), 6.64 (t, *J* = 7.5 Hz, 1H), 2.31 (s, 3H), 2.15 (s, 3H). **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 196.78, 160.08 (d, *J* = 2.7 Hz), 138.36 (d, *J* = 92.9 Hz), 137.93 (d, *J* = 2.4 Hz), 137.81 (d, *J* = 2.7 Hz), 137.18, 133.61 (d, *J* = 8.3 Hz), 133.16, 133.13 (d, *J* = 1.8 Hz), 132.90 (d, *J* = 1.8 Hz), 132.82 (d, *J* = 8.3 Hz), 130.09 (d, *J* = 9.5 Hz), 129.17 (d, *J* = 9.3 Hz), 128.78 (d, *J* = 95.1 Hz), 128.29 (d, *J* = 96.4 Hz), 127.95, 127.60 (d, *J* = 3.0 Hz), 124.46, 121.56, 118.83, 112.30, 75.00 (d, *J* = 61.7 Hz), 21.41, 21.23. **^{31}P NMR** (162 MHz, Chloroform-*d*) δ 30.33. **HRMS** (ESI) m/z calcd for $C_{28}H_{25}NO_2P$ $[M+H]^+$: 438.1617, found: 438.1625.

2-(bis(3,5-dimethylphenyl)phosphoryl)-2-phenylindolin-3-one (3e). Yellow solid, 32.6 mg, 70% yield. 

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.78 – 7.72 (m, 2H), 7.47 (dd, *J* = 9.8, 2.5 Hz, 3H), 7.40 (dd, *J* = 11.6, 1.5 Hz, 2H), 7.34 – 7.29 (m, 1H), 7.22 (q, *J* = 7.0, 6.3 Hz, 3H), 7.14 (s, 1H), 7.06 (d, *J* = 4.1 Hz, 1H), 6.97 (s, 1H), 6.85 (d, *J* = 8.2 Hz, 1H), 6.69 (t, *J* = 7.4 Hz, 1H), 2.30 (s, 6H), 2.16 (s, 6H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.53, 159.81 (d, *J* = 3.3 Hz), 137.68 (d, *J* = 9.2 Hz), 137.54, 137.03, 134.07 (d, *J* = 2.9 Hz), 133.81 (d, *J* = 2.9 Hz), 133.21 (d, *J* = 1.8 Hz), 130.61 (d, *J* = 9.2 Hz), 129.81 (d, *J* = 9.1 Hz), 128.43 (d, *J* = 95.8 Hz), 127.90 (d, *J* = 2.5 Hz), 127.89 (d, *J* = 97.7 Hz), 127.76 (d, *J* = 2.1 Hz), 127.57 (d, *J* = 3.8 Hz), 124.37, 121.88, 118.99, 112.26, 74.81 (d, *J* = 59.9 Hz), 21.29, 21.13. **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 31.20. **HRMS** (ESI) m/z calcd for $C_{30}H_{29}NO_2P$ $[M+H]^+$: 466.1930, found: 466.1928.

2-(bis(4-(tert-butyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3f). Pale yellow solid, 27.1 mg, 52% yield. 

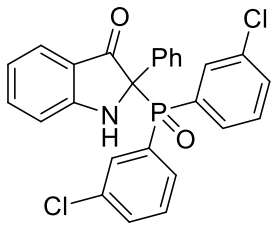
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.89 (t, *J* = 9.5 Hz, 2H), 7.76 (d, *J* = 6.6 Hz, 4H), 7.62 (s, 2H), 7.42 (d, *J* = 7.8 Hz, 3H), 7.37 (d, *J* = 7.9 Hz, 1H), 7.21 (d, *J* = 7.5 Hz, 3H), 7.15 (s, 1H), 6.81 (d, *J* = 8.2 Hz, 1H), 6.59 (t, *J* = 7.4 Hz, 1H), 1.31 (s, 9H), 1.18 (s, 9H). **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 196.90, 160.23, 155.81 (d, *J* = 2.7 Hz), 155.52 (d, *J* = 2.3 Hz), 136.98, 133.39 (d, *J* =1.3 Hz), 132.96 (d, *J* = 9.5 Hz), 132.16 (d, *J* = 9.4 Hz), 127.87 (d, *J* = 1.6 Hz), 127.81 (d, *J* = 1.9 Hz), 127.61 (d, *J* = 3.7 Hz), 125.71 (d, *J* = 99.7 Hz), 125.44 (d, *J* = 101.0 Hz), 125.08 (d, *J* = 12.4 Hz), 124.91 (d, *J* = 12.1 Hz), 124.48, 121.44, 118.60, 112.40, 75.18 (d, *J* = 60.8 Hz), 35.02, 34.85, 31.09, 30.92. **^{31}P NMR** (162 MHz, Chloroform-*d*) δ 30.03. HRMS (ESI) m/z calcd for $C_{34}H_{37}NO_2P$ $[M+H]^+$: 522.2556, found: 522.2555.

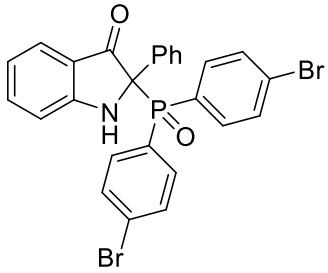
2-(bis(4-fluorophenyl)phosphoryl)-2-phenylindolin-3-one (3g). Yellow solid, 19.6 mg, 44% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.04 (td, *J* = 9.5, 5.5 Hz, 2H), 7.86 (td, *J* = 9.7, 9.3, 5.3 Hz, 2H), 7.77 (d, *J* = 7.2 Hz, 3H), 7.45 (d, *J* = 7.8 Hz, 1H), 7.33 (t, *J* = 7.7 Hz, 1H), 7.22 (dt, *J* = 14.8, 7.1 Hz, 2H), 7.17 – 7.10 (m, 2H), 6.94 (t, *J* = 8.4 Hz, 2H), 6.86 (d, *J* = 8.3 Hz, 1H), 6.70 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.99, 166.30 (dd, *J* = 29.6, 3.4 Hz), 164.27 (dd, *J* = 29.2, 3.9 Hz), 160.18 (d, *J* = 3.9 Hz), 137.73, 135.60 (dd, *J* =11.3, 8.8 Hz), 134.69 (dd, *J* =11.3, 10.0 Hz), 132.82 (d, *J* = 2.0 Hz), 128.27 (d, *J* = 2.6 Hz), 128.13 (d, *J* = 2.2 Hz), 127.47 (d, *J* = 4.1 Hz), 124.78 (dd, *J* = 99.8, 3.0 Hz), 124.59, 124.35 (dd, *J* = 102.6, 3.3 Hz), 121.11, 119.12, 115.69 (dd, *J* =16.4, 5.0 Hz), 115.49 (dd, *J* =16.4, 5.0 Hz), 112.22, 75.03 (d, *J* = 64.1 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 28.40. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -105.31, -105.53. **HRMS** (ESI) m/z calcd for $C_{26}H_{18}F_2NO_2PNa$ $[M+Na]^+$: 468.0935, found: 468.0936.

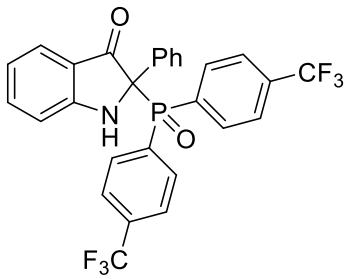
2-(bis(3-fluoro-4-methylphenyl)phosphoryl)-2-phenylindolin-3-one (3h). Yellow solid, 34.1 mg, 72% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.82 – 7.71 (m, 3H), 7.70 – 7.62 (m, 2H), 7.46 (q, *J* = 8.7, 7.2 Hz, 3H), 7.36 – 7.15 (m, 5H), 7.06 (d, *J* = 8.3 Hz, 1H), 6.85 (d, *J* = 8.3 Hz, 1H), 6.67 (t, *J* = 7.5 Hz, 1H), 2.30 (s, 3H), 2.18 (s, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.70, 161.76 (dd, *J* = 13.6, 2.6 Hz), 160.18 (d, *J* = 3.8 Hz), 159.80 (dd, *J* = 17.2, 2.8 Hz), 137.58 , 132.79 (d, *J* = 1.0 Hz), 131.57 (dd, *J* = 10.0, 5.0 Hz), 131.42 (dd, *J* = 7.6, 3.8 Hz), 130.19 (dd, *J* = 17.0, 2.5 Hz), 129.99 (dd, *J* = 14.5, 2.6 Hz), 128.52 (dd, *J* = 8.7, 3.5 Hz), 128.24, 128.10, 128.01 (dd, *J* = 88.0, 7.6 Hz), 127.57 (dd, *J* = 86.0, 6.1 Hz), 127.55 (dd, *J* = 8.8, 3.8 Hz), 127.47 (d, *J* = 3.6 Hz), 124.61, 121.13, 119.44 (dd, *J* = 24.1, 10.1 Hz), 118.97, 118.72 (dd, *J* = 23.8, 10.4 Hz), 112.32, 74.93 (d, *J* = 64.7 Hz), 14.83 (d, *J* = 3.3 Hz), 14.63 (d, *J* = 3.1 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.61. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -115.65, -115.73. **HRMS** (ESI) m/z calcd for $C_{28}H_{23}F_2NO_2P$ $[M+H]^+$: 474.1429, found: 474.1424.

2-(bis(4-chlorophenyl)phosphoryl)-2-phenylindolin-3-one (3i). Yellow solid, 31.1 mg, 65% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.92 (t, *J* = 9.3 Hz, 2H), 7.74 (d, *J* = 7.0 Hz, 5H), 7.42 (dd, *J* = 16.5, 7.9 Hz, 3H), 7.32 (t, *J* = 7.7 Hz, 1H), 7.18 – 7.25 (m, 5H), 6.84 (d, *J* = 8.3 Hz, 1H), 6.70 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.80, 160.15 (d, *J* = 4.1 Hz), 139.33 (d, *J* = 3.2 Hz), 139.13 (d, *J* = 3.5 Hz), 137.84, 134.34 (d, *J* = 10.1 Hz), 133.42 (d, *J* = 10.0 Hz), 132.65, 128.62 (d, *J* = 13.4 Hz), 128.51 (d, *J* = 13.2 Hz), 128.39 (d, *J* = 1.0 Hz), 128.21(d, *J* = 2.5 Hz), 127.46 (d, *J* = 4.0 Hz), 127.26 (d, *J* = 97.3 Hz), 126.88 (d, *J* = 100.3 Hz), 124.65, 121.05, 119.23, 112.26, 74.93 (d, *J* = 63.9 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 28.55. **HRMS** (ESI) m/z calcd for $C_{26}H_{18}Cl_2NO_2PNa$ $[M+Na]^+$:

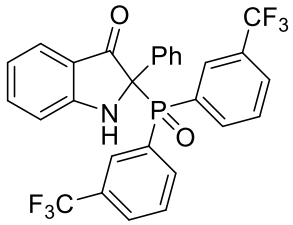
500.0344, found: 500.0341.

2-(bis(3-chlorophenyl)phosphoryl)-2-phenylindolin-3-one (3j). Yellow solid, 28.7 mg, 60% yield.  **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.98 – 7.90 (m, 2H), 7.88 – 7.85 (m, 1H), 7.80 – 7.75 (m, 2H), 7.73 (s, 1H), 7.68 – 7.64 (m, 1H), 7.52 – 7.48 (m, 1H), 7.46 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.39 (td, *J* = 7.8, 3.9 Hz, 1H), 7.36 – 7.30 (m, 2H), 7.26 – 7.16 (m, 4H), 6.88 – 6.83 (m, 1H), 6.69 (t, *J* = 7.5 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.52 , 160.10 (d, *J* = 4.1 Hz), 137.83, 134.83 (d, *J* = 5.5 Hz), 134.70 (d, *J* = 6.0 Hz), 132.88 (d, *J* = 9.7 Hz), 132.76 (d, *J* = 2.8 Hz), 132.58 (d, *J* = 2.7 Hz), 132.37 (d, *J* = 2.1 Hz), 132.15 (d, *J* = 9.5 Hz), 130.97 (d, *J* = 9.3 Hz), 130.84 (d, *J* = 94.5 Hz), 130.42 (d, *J* = 96.9 Hz), 129.95 (d, *J* = 9.2 Hz), 129.62 (d, *J* = 4.9 Hz), 129.52 (d, *J* = 4.5 Hz), 128.46 (d, *J* = 2.5 Hz), 128.24 (d, *J* = 2.1 Hz), 127.43 (d, *J* = 4.2 Hz), 124.64, 121.14, 119.31, 112.33, 74.89 (d, *J* = 64.1 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.36. **HRMS** (ESI) m/z calcd for $C_{26}H_{18}Cl_2NO_2PNa$ $[M+Na]^+$: 500.0344, found: 500.0344.

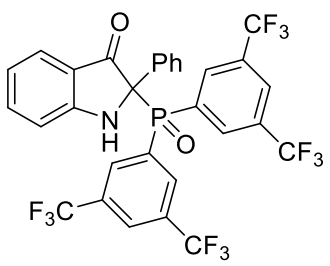
2-(bis(4-bromophenyl)phosphoryl)-2-phenylindolin-3-one (3k). Yellow solid, 28.4 mg, 50% yield.  **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.88 (s, 1H), 7.87 – 7.81 (m, 2H), 7.74 (d, *J* = 7.8 Hz, 2H), 7.66 (d, *J* = 7.8 Hz, 2H), 7.57 (d, *J* = 7.8 Hz, 2H), 7.44 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 2H), 7.35 – 7.28 (m, 1H), 7.24 (d, *J* = 7.1 Hz, 1H), 7.19 (t, *J* = 7.4 Hz, 2H), 6.84 (d, *J* = 8.3 Hz, 1H), 6.70 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.76, 160.23, 137.88, 134.46 (d, *J* = 8.2 Hz), 133.49 (d, *J* = 8.5 Hz), 132.54, 132.43 (d, *J* = 13.0 Hz), 132.17 (d, *J* = 11.7 Hz), 131.58 (d, *J* = 11.2 Hz), 131.48 (d, *J* = 11.8 Hz), 128.43, 128.22, 127.76 (d, *J* = 95.6 Hz), 127.49, 127.32 (d, *J* = 96.6 Hz), 124.65, 120.98, 119.21, 112.32, 74.95 (d, *J* = 64.9 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 28.90. **HRMS** (ESI) m/z calcd for $C_{26}H_{18}Br_2NO_2PNa$ $[M+Na]^+$: 587.9334, found: 587.9326.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3l). Yellow solid, 40.9 mg, 75% yield.  **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.33 (s, 1H), 8.25 – 8.21 (m, 2H), 8.05 – 8.00 (m, 2H), 7.86 – 7.78 (m, 2H), 7.74 (dd, *J* = 8.4, 2.7 Hz, 2H), 7.57 – 7.44 (m, 3H), 7.35 – 7.32 (m, 1H), 7.31 – 7.26 (m, 1H), 7.20 (t, *J* = 7.7 Hz, 2H), 6.88 (dd, *J* = 8.3, 2.1 Hz, 1H), 6.72 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.64 (d, *J* = 1.6 Hz), 160.39 (d, *J* = 4.5 Hz), 138.06, 134.26 (qdd, *J* = 32.5, 15.2, 2.7 Hz), 133.56 (d, *J* = 9.7 Hz), 132.91 (d, *J* = 94.6 Hz), 132.70 (d, *J* = 96.4 Hz), 132.63 (d, *J* = 9.5 Hz), 132.27 (d, *J* = 2.0 Hz), 128.64 (d, *J* = 2.3 Hz), 128.31 (d, *J* = 1.5 Hz), 127.52 (d, *J* = 4.1 Hz), 125.04 (tq, *J* = 12.4, 3.4 Hz), 124.69, 123.34 (qd, *J* = 272.7, 29.2 Hz), 120.81, 119.31, 112.28, 74.97 (d, *J* = 65.5 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.67. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.34, -63.54. **HRMS** (ESI) m/z calcd for $C_{28}H_{18}F_6NO_2PNa$ $[M+Na]^+$: 568.0872, found:568.0872.

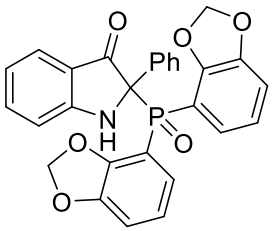
2-(bis(3-(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3m). Yellow solid, 39.2mg, 72% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.32 – 8.23 (m, 2H), 8.19 (d, J = 11.3 Hz, 1H), 7.97 – 7.90 (m, 1H), 7.81 (d, J = 7.8 Hz, 1H), 7.76 – 7.72 (m, 2H), 7.66 – 7.61 (m, 2H), 7.45 (s, 1H), 7.44– 7.41 (m, 2H), 7.36 – 7.33 (m, 1H), 7.27 – 7.19 (m, 3H), 6.86 (d, J = 8.3 Hz, 1H), 6.71 (t, J = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-d) δ 196.46 (d, J = 1.3 Hz), 159.89 (d, J = 4.2 Hz), 138.01 , 136.11 (d, J = 9.6 Hz), 135.12 (d, J = 9.0 Hz), 132.09 (d, J = 2.2 Hz), 131.36 – 130.40 (m), 130.19 – 129.99 (m), 129.85 (d, J = 96.1 Hz), 129.41 – 129.26 (m), 129.31 (d, J = 99.0 Hz), 129.26 – 129.14 (m), 129.15 – 129.01 (m), 128.86 (d, J = 4.3 Hz), 128.77 (d, J = 3.9 Hz), 128.63 (d, J = 2.5 Hz), 128.36 (d, J = 2.1 Hz), 127.28 (d, J = 4.2 Hz), 124.65, 121.15, 119.62, 112.26, 74.78 (d, J = 64.5 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.50. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -62.94, -62.99. **HRMS** (ESI) m/z calcd for $C_{28}H_{18}F_6NO_2PNa$ $[M+Na]^+$: 568.0872, found:568.0871.

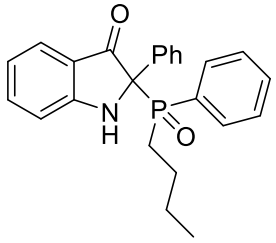


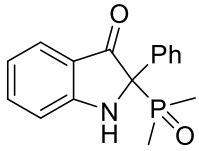
2-(bis(3,5-bis(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3n). Yellow solid, 37.5 mg, 55% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.51 (dd, *J* = 11.1, 1.6 Hz, 2H), 8.29 (dd, *J* = 11.0, 1.5 Hz, 2H), 8.07 (s, 1H), 7.90 (s, 1H), 7.89 (s, 1H), 7.78 – 7.71 (m, 2H), 7.51 – 7.45 (m, 1H), 7.39 – 7.35 (m, 1H), 7.27 (d, *J* = 1.8 Hz, 1H), 7.20 (t, *J* = 7.7 Hz, 2H), 6.85 (d, *J* = 8.3 Hz, 1H), 6.75 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.17 (d, *J* = 1.9 Hz), 160.07 (d, *J* = 4.8 Hz), 138.62, 133.36 – 131.58 (m), 132.36 – 131.83 (m), 131.13 (d, *J* = 95.1 Hz), 131.06 (d, *J* = 2.3 Hz), 130.59 (d, *J* = 98.0 Hz), 129.21 (d, *J* = 2.6 Hz), 128.69 (d, *J* = 2.2 Hz), 127.16 (d, *J* = 4.5 Hz), 126.68-126.44 (m), 124.82, 122.52 (qd, *J* = 273.5, 33.1 Hz), 120.81, 120.16, 112.32, 74.79 (d, *J* = 68.0 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 25.84. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.14, -63.21. **HRMS** (ESI) m/z calcd for $C_{30}H_{16}F_{12}NO_2PNa$ $[M+Na]^+$: 704.0619, found: 704.0607.

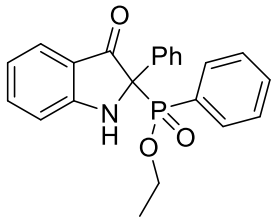


2-(bis(benzo[d][1,3]dioxol-4-yl)phosphoryl)-2-phenylindolin-3-one (3o). Yellow solid, 26.3 mg, 53% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.79 – 7.73 (m, 2H), 7.53 – 7.46 (m, 1H), 7.46 – 7.40 (m, 2H), 7.35 – 7.29 (m, 2H), 7.25 – 7.18 (m, 4H), 7.15 (s, 1H), 6.87 (d, *J* = 8.3 Hz, 1H), 6.82 (dd, *J* = 8.0, 2.3 Hz, 1H), 6.72 – 6.61 (m, 2H), 6.02 – 5.98 (m, 2H), 5.90 – 5.87 (m, 2H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.91, 160.00 (d, *J* = 2.8 Hz), 151.14 (d, *J* = 2.0 Hz), 150.90 (d, *J* = 2.0 Hz), 147.62 (d, *J* = 12.6 Hz), 147.48 (d, *J* = 11.9 Hz), 137.40, 133.29, 128.81 (d, *J* = 9.8 Hz), 128.09, 128.06, 127.84 (d, *J* = 10.1 Hz), 127.47 (d, *J* = 3.4 Hz), 124.64, 121.93 (d, *J* = 102.6 Hz), 121.43, 120.00 (d, *J* = 102.5 Hz), 119.04, 112.40 (d, *J* = 12.2 Hz), 112.30, 111.67 (d, *J* = 11.9 Hz), 108.45 (d, *J* = 15.3 Hz), 108.26 (d, *J* = 15.0 Hz), 101.57, 101.48, 75.18 (d, *J* = 62.8 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 30.07. **HRMS** (ESI) m/z calcd for $C_{28}H_{21}NO_6P$ $[M+H]^+$: 498.1101, found: 498.1101.



2-(butyl(phenyl)phosphoryl)-2-phenylindolin-3-one (3p). Yellow solid, 20.6 mg, 53% yield.  **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.13 – 8.06 (m, 2H), 7.98 (s, 1H), 7.88 (s, 1H), 7.77 – 7.69 (m, 2H), 7.67 – 7.59 (m, 3H), 7.58 – 7.51 (m, 3H), 7.50 – 7.37 (m, 6H), 7.35 – 7.30 (m, 2H), 7.22 (td, *J* = 7.7, 2.8 Hz, 2H), 7.19 – 7.15 (m, 2H), 7.12 (dd, *J* = 8.3, 6.6 Hz, 2H), 7.07 (d, *J* = 8.3 Hz, 1H), 6.87 – 6.81 (m, 1H), 6.73 (d, *J* = 8.3 Hz, 1H), 6.53 – 6.50 (m, 1H), 2.72 – 2.57 (m, 1H), 2.08 – 1.92 (m, 3H), 1.66 – 1.53 (m, 1H), 1.37 (h, *J* = 7.1 Hz, 3H), 1.32 – 1.23 (m, 4H), 0.83 (t, *J* = 7.1 Hz, 3H), 0.76 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.83 (d, *J* = 1.8 Hz), 196.75 (d, *J* = 1.3 Hz), 160.36 (d, *J* = 3.6 Hz), 160.15 (d, *J* = 3.3 Hz), 137.65, 137.06, 132.96 (d, *J* = 2.4 Hz), 132.77 (d, *J* = 2.3 Hz), 132.55 (d, *J* = 8.9 Hz), 132.36 (d, *J* = 2.6 Hz), 132.16 (d, *J* = 8.7 Hz), 132.02 (d, *J* = 2.6 Hz), 128.49 (d, *J* = 1.9 Hz), 128.24 (d, *J* = 2.1 Hz), 128.01 (d, *J* = 11.8 Hz), 127.93 (d, *J* = 94.0 Hz), 127.86 (d, *J* = 11.4 Hz), 127.68 (d, *J* = 2.3 Hz), 127.63 (d, *J* = 1.9 Hz), 127.55 (d, *J* = 94.5 Hz) 127.40 (d, *J* = 3.4 Hz), 126.81 (d, *J* = 3.8 Hz), 124.77, 124.20, 121.14, 120.81, 118.92, 118.37, 112.78, 112.11, 74.37 (d, *J* = 18.4 Hz), 73.91 (d, *J* = 20.3 Hz), 24.09 (d, *J* = 6.3 Hz), 23.98 (d, *J* = 5.3 Hz), 23.93 (d, *J* = 65.5 Hz), 23.45 (d, *J* = 4.7 Hz), 22.87 (d, *J* = 4.7 Hz), 22.73 (d, *J* = 65.7 Hz), 13.58 , 13.56 . **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 42.55, 41.68. **HRMS** (ESI) m/z calcd for $C_{24}H_{25}NO_2P$ $[M+H]^+$: 390.1617, found: 390.1617.

2-(dimethyl phosphoryl)-2-phenylindolin-3-one (3q). Yellow solid, 18.8 mg, 66% yield.  **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.85 (s, 1H), 7.86 – 7.80 (m, 2H), 7.57 – 7.51 (m, 1H), 7.49 (d, *J* = 7.8 Hz, 1H), 7.42 (dd, *J* = 8.5, 6.8 Hz, 2H), 7.35 (m, 1H), 7.09 (d, *J* = 8.3 Hz, 1H), 6.78 (t, *J* = 7.4 Hz, 1H), 1.35 (d, *J* = 12.9 Hz, 3H), 1.26 (d, *J* = 12.4 Hz, 3H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 195.97 , 160.88 (d, *J* = 3.8 Hz), 138.23, 133.80 (d, *J* = 1.0 Hz), 128.58 (d, *J* = 1.9 Hz), 128.34 (d, *J* = 2.1 Hz), 126.83 (d, *J* = 3.4 Hz), 124.62, 119.73, 118.66, 112.72, 73.76 (d, *J* = 60.9 Hz), 12.91 (d, *J* = 90.1 Hz), 12.38 (d, *J* = 89.1 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 44.51. **HRMS** (ESI) m/z calcd for $C_{16}H_{16}NO_2PNa$ $[M+Na]^+$: 308.0811, found: 308.0813.

ethyl ((S)-3-oxo-2-phenylindolin-2-yl) (phenyl)phosphinate (3r). Yellow solid, 15.1 mg, 40% yield.  **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.01 (dt, *J* = 8.2, 1.7 Hz, 2H), 7.71 (dd, *J* = 11.4, 7.6 Hz, 2H), 7.62 – 7.56 (m, 6H), 7.53 (td, *J* = 7.5, 1.2 Hz, 1H), 7.46 – 7.43 (m, 1H), 7.40 – 7.30 (m, 6H), 7.25 – 7.15 (m, 6H), 6.98 (d, *J* = 8.2 Hz, 1H), 6.86 (s, 1H), 6.84 – 6.76 (m, 2H), 6.73 (s, 1H), 6.59 (t, *J* = 7.3 Hz, 1H), 4.07 – 3.97 (m, 4H), 1.29 (t, *J* = 7.0 Hz, 3H), 1.08 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 195.49, 195.08, 159.84 (d, *J* = 3.3 Hz), 159.63 (d, *J* = 3.9 Hz), 137.09, 136.97, 133.66 (d, *J* = 9.4 Hz), 133.18 (d, *J* = 9.4 Hz), 133.02 (d, *J* = 2.7 Hz), 132.87, 132.83, 132.73 (d, *J* = 2.6 Hz), 128.21 (d, *J* = 2.1 Hz), 128.15 (d, *J* = 2.4 Hz), 128.01 (d, *J* = 1.8 Hz), 127.93 (d, *J* = 3.1 Hz), 127.90 (d, *J* = 1.8 Hz), 127.88 (d, *J* = 2.3 Hz), 127.43 (d, *J* = 85.4 Hz), 127.31 (d, *J* = 3.7 Hz), 126.90 (d, *J* = 4.2 Hz), 126.41 (d, *J* = 83.5 Hz), 124.90, 124.59, 121.24, 120.87, 119.24,

118.93, 112.44, 112.07, 73.49 (d, *J* = 94.8 Hz), 73.29 (d, *J* = 91.8 Hz), 63.05 (d, *J* = 7.6 Hz), 62.65 (d, *J* = 7.3 Hz), 16.44 (d, *J* = 5.4 Hz), 16.30 (d, *J* = 5.7 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 36.21, 30.45. **HRMS** (ESI) m/z calcd for $C_{22}H_{21}NO_3P$ $[M+H]^+$: 378.1254, found: 378.1257.

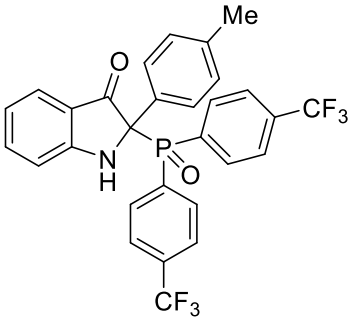
diethyl-(3-oxo-2-phenylindolin-2-yl)phosphonate (3s). Yellow solid, 9.3 mg, 27% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.98-7.96 (m, 2H), 7.64 – 7.59 (m, 1H), 7.48 – 7.41 (m, 1H), 7.37 – 7.34 (m, 2H), 7.32 – 7.29 (m, 1H), 7.06 – 6.92 (m, 1H), 6.82 (t, *J* = 7.4 Hz, 1H), 6.47 (s, 1H), 4.15 – 4.03 (m, 2H), 4.01 – 3.90 (m, 2H), 1.21 (t, *J* = 7.1 Hz, 3H), 1.07 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 194.73 (d, *J* = 3.6 Hz), 159.94 (d, *J* = 4.6 Hz), 137.28, 133.41 (d, *J* = 2.9 Hz), 128.32 (d, *J* = 2.5 Hz), 128.22 (d, *J* = 2.8 Hz), 126.80 (d, *J* = 4.9 Hz), 125.14, 120.43, 119.35, 112.51, 71.51 (d, *J* = 145.2 Hz), 64.62 (d, *J* = 7.7 Hz), 64.38 (d, *J* = 7.4 Hz), 16.25 (d, *J* = 5.7 Hz), 16.18 (d, *J* = 5.7 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 15.83. **HRMS** (ESI) m/z calcd for $C_{18}H_{21}NO_4P$ $[M+H]^+$: 346.1203, found: 346.1203.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl-2-(4-methoxyphenyl)indolin-3-one (3t). Yellow solid, 35.1 mg, 61% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.22 (t, *J* = 9.4 Hz, 2H), 7.96 (dd, *J* = 10.8, 8.1 Hz, 2H), 7.87 (s, *J* = 8.8 Hz, 1H), 7.74 – 7.69 (m, 4H), 7.47 (dd, *J* = 15.5, 8.3 Hz, 3H), 7.36 – 7.28 (m, 1H), 6.86 (d, *J* = 8.3 Hz, 1H), 6.71 (t, *J* = 7.5 Hz, 3H), 3.74 (s, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.83(d, *J* = 1.3 Hz), 160.07 (d, *J* = 4.4 Hz), 159.76 (d, *J* = 2.0 Hz), 138.01, 134.71 – 131.88 (m), 133.66 (d, *J* = 94.3 Hz), 133.53 (d, *J* = 9.6 Hz), 132.71 (d, *J* = 96.3 Hz), 132.59 (d, *J* = 9.4 Hz), 128.76 (d, *J* = 4.1 Hz), 125.19 – 124.84 (m), 124.70, 124.11 (d, *J* = 1.3 Hz), 123.38 (qd, *J* = 273.4 Hz, 29.0 Hz), 120.97, 119.45, 113.76 (d, *J* = 1.4 Hz), 112.28, 74.45 (d, *J* = 66.1 Hz), 55.19. **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.63. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.31, -63.53. **HRMS** (ESI) m/z calcd for $C_{29}H_{21}F_6NO_3P$ $[M+H]^+$: 576.1158, found: 576.1156.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl-2-(3-methoxyphenyl)indolin-3-one (3u). Yellow solid, 23.6 mg, 41% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.23 (dd, *J* = 11.0, 8.0 Hz, 2H), 8.07 (s, 1H), 7.99 (dd, *J* = 10.9, 8.1 Hz, 2H), 7.78 – 7.69 (m, 2H), 7.54 – 7.39 (m, 3H), 7.32 (q, *J* = 8.4 Hz, 3H), 7.08 (t, *J* = 8.0 Hz, 1H), 6.83 (d, *J* = 8.3 Hz, 1H), 6.78 (d, *J* = 8.3 Hz, 1H), 6.69 (t, *J* = 7.4 Hz, 1H), 3.54 (s, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.49 (d, *J* = 1.3 Hz), 160.30 (d, *J* = 4.3 Hz), 159.37 (d, *J* = 1.9 Hz), 138.01, 134.84 – 132.35 (m), 133.73 (d, *J* = 97.3 Hz), 133.62 (d, *J* = 9.6 Hz), 133.20 (d, *J* = 2.0 Hz), 132.65 (d, *J* = 9.4 Hz), 132.51 (d, *J* = 94.9 Hz), 129.31, 125.23 – 124.88 (m), 124.68, 123.79 (qd, *J* = 272.2 Hz, 26.5 Hz), 120.76, 119.84 (d, *J*

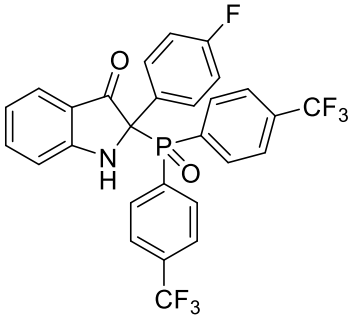
= 4.3 Hz), 119.37, 114.44 (d, *J* = 2.5 Hz), 112.97 (d, *J* = 4.1 Hz), 112.30, 74.91 (d, *J* = 65.6 Hz), 54.94. **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.33. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.34, -63.54. **HRMS** (ESI) m/z calcd for $C_{29}H_{21}F_6NO_3P$ $[M+H]^+$: 576.1158, found: 576.1154.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(p-tolyl)indolin-3-one (3v).



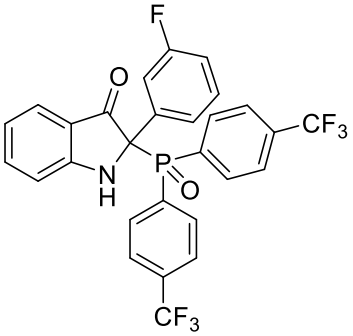
Yellow solid, 31.9 mg, 57% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.73 (s, 1H), 8.03 (dd, *J* = 10.2, 8.2 Hz, 2H), 7.87 – 7.78 (m, 6H), 7.66 (dd, *J* = 8.4, 2.0 Hz, 2H), 7.42 – 7.39 (m, 1H), 7.27 – 7.22 (m, 1H), 7.17 (d, *J* = 8.1 Hz, 2H), 6.96 (d, *J* = 8.3 Hz, 1H), 6.65 (t, *J* = 7.4 Hz, 1H), 2.27 (s, 3H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 195.25, 160.86 (d, *J* = 5.3 Hz), 138.21 (d, *J* = 2.3 Hz), 138.15, 134.78 (d, *J* = 95.2 Hz), 134.02 (d, *J* = 8.7 Hz), 133.70(d, *J* = 96.4 Hz), 133.14 (d, *J* = 9.1 Hz), 132.96 – 131.81 (m), 130.02, 129.27, 126.98 (d, *J* = 3.7 Hz), 125.66 (dq, *J* = 11.5, 3.7 Hz), 125.44 (dq, *J* = 11.0, 3.8 Hz), 124.44 , 124.02 (qd, *J* = 272.5, 3.6 Hz), 119.68, 119.14, 112.98, 73.91 (d, *J* = 71.3 Hz), 21.05. **^{31}P NMR** (202 MHz, DMSO-d_6) δ 23.81. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.31, -63.53. **HRMS** (ESI) m/z calcd for $C_{29}H_{21}F_6NO_2P$ $[M+H]^+$: 560.1209, found: 560.1200.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(4-fluorophenyl)indolin-3-one (3w).



Yellow solid, 42.2 mg, 75% yield. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.18 (dd, *J* = 10.9, 8.1 Hz, 2H), 8.03 (s, 1H), 7.97 (dd, *J* = 10.9, 8.1 Hz, 2H), 7.77 – 7.73 (m, 4H), 7.50 – 7.45 (m, 3H), 7.35 – 7.32 (m, 1H), 6.91 – 6.80 (m, 3H), 6.72 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 196.45, 162.79 (dd, *J* = 249.3, 2.3 Hz), 160.12 (d, *J* = 3.9 Hz), 138.26, 135.03 – 133.90 (m), 133.49 (d, *J* = 9.5 Hz), 132.55 (d, *J* = 95.2 Hz), 132.52 (d, *J* = 9.4 Hz), 132.35 (d, *J* = 96.1 Hz), 129.37 (dd, *J* = 8.1, 3.8 Hz), 127.99 (d, *J* = 2.5 Hz), 125.32 – 124.95 (m), 124.78, 123.26 (qd, *J* = 273.1, 30.0 Hz), 120.8, 119.65, 115.26 (d, *J* = 22.7 Hz), 112.20, 74.28 (d, *J* = 64.6 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 23.90. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.34, -63.59, -112.57. **HRMS** (ESI) m/z calcd for $C_{28}H_{18}F_7NO_2P$ $[M+H]^+$: 564.0958, found: 564.0952.

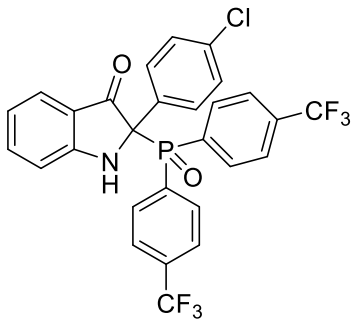
2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(3-fluorophenyl)indolin-3-one (3x).



Yellow solid, 33.8 mg, 60% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.81 (s, 1H), 8.02 (t, *J* = 9.2 Hz, 2H), 7.85 (d, *J* = 6.7 Hz, 4H), 7.83 – 7.78 (m, 2H), 7.68 – 7.61 (m, 1H), 7.59 (d, *J* = 8.0 Hz, 1H), 7.48 – 7.39 (m, 2H), 7.26 (d, *J* = 7.8 Hz, 1H), 7.24 – 7.18 (m, 1H), 6.98 (d, *J* = 8.3 Hz, 1H), 6.68 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 194.35, 162.20 (dd, *J* = 244.0 Hz), 160.82 (d, *J* = 5.0 Hz), 138.43, 135.60 (d, *J* = 7.8 Hz), 134.30 (d, *J* =

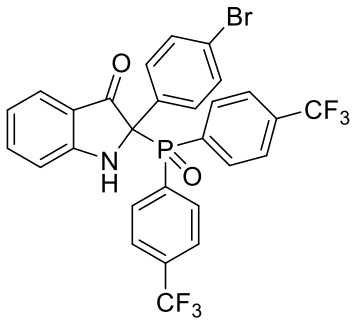
96.6 Hz), 134.07 (d, *J* = 8.6 Hz), 133.11 (d, *J* = 9.1 Hz), 133.88 – 131.72 (m), 132.95 (d, *J* = 95.2 Hz), 130.64 (d, *J* = 8.6 Hz), 125.84 (dq, *J* = 12.0, 4.5 Hz), 125.52 (dq, *J* = 10.1, 3.5, 2.9 Hz), 124.56, 123.45 (qd, *J* = 273.2 Hz, 2.5 Hz), 122.94 (d, *J* = 2.5 Hz), 119.46, 119.42, 115.77 (d, *J* = 21.2 Hz), 114.17 (dd, *J* = 24.4, 3.4 Hz), 113.04, 73.60 (d, *J* = 70.6 Hz). **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 27.64. **^{19}F NMR** (471 MHz, DMSO-d_6) δ -61.91, -61.93, -112.39. **HRMS**(ESI) m/z calcd for $C_{28}H_{18}F_7NO_2P$ $[M+H]^+$: 564.0958, found: 564.0953.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl-2-(4-chlorophenyl)indolin-3-one



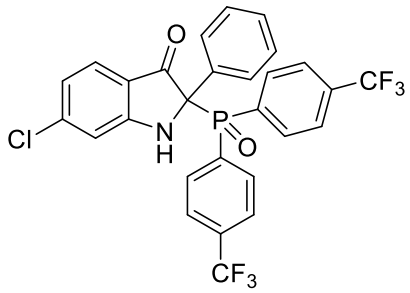
(3y). Yellow oil, 33.6 mg, 58% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.82 (s, 1H), 8.02 (dd, *J* = 10.3, 8.1 Hz, 2H), 7.87 – 7.78 (m, 8H), 7.50 – 7.45 (m, 2H), 7.46 – 7.39 (m, 1H), 7.25 (d, *J* = 7.9 Hz, 1H), 6.97 (d, *J* = 8.3 Hz, 1H), 6.67 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 194.57, 160.81 (d, *J* = 5.0 Hz), 138.38, 134.75, 134.05 (d, *J* = 8.7 Hz), 133.88 (d, *J* = 2.7 Hz), 134.90 – 132.60 (m), 134.37 (d, *J* = 95.8 Hz), 133.60 (d, *J* = 97.0 Hz), 133.11 (d, *J* = 9.3 Hz), 132.00, 128.82 (d, *J* = 3.6 Hz), 128.73 (d, *J* = 1.3 Hz), 125.82 (dq, *J* = 11.6, 3.4 Hz), 125.51 (dq, *J* = 11.3, 3.6 Hz), 124.53, 123.99 (qd, *J* = 273.3, 2.5 Hz), 119.45, 119.40, 113.02, 73.54 (d, *J* = 70.2 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 23.88. **^{19}F NMR** (471 MHz, DMSO-d_6) δ -61.92, -61.93. **HRMS** (ESI) m/z calcd for $C_{28}H_{17}ClF_6NO_2PNa$ $[M+Na]^+$: 602.0482, found: 602.0485.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl-2-(4-bromophenyl)indolin-3-one



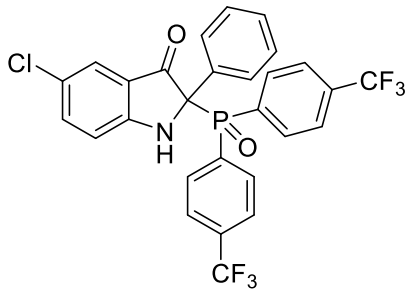
(3z). Yellow solid, 46.2 mg, 74% yield. **^{1}H NMR** (500 MHz, DMSO-d6) δ 8.81 (s, 1H), 8.02 (dd, J = 10.3, 8.1 Hz, 2H), 7.88 – 7.82 (m, 4H), 7.80 (dd, J = 8.4, 2.4 Hz, 2H), 7.75 (dd, J = 8.7, 1.9 Hz, 2H), 7.65 – 7.56 (m, 2H), 7.44 – 7.41 (m, 1H), 7.28 – 7.22 (m, 1H), 7.00 – 6.93 (m, 1H), 6.68 – 6.65 (m, 1H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 194.51, 160.81 (d, *J* = 5.1 Hz), 138.37 , 134.37 (d, *J* = 98.3 Hz), 134.05 (d, *J* = 8.8 Hz), 133.83 (d, *J* = 94.5 Hz), 133.10 (d, *J* = 9.2 Hz), 133.60 – 132.11 (m), 132.69(d, *J* = 2.5 Hz), 132.48, 131.65, 129.11 (d, *J* = 3.8 Hz), 125.83 (dq, *J* = 11.1, 3.2 Hz), 125.52 (dq, *J* = 11.4, 3.6 Hz), 125.07 (qd, *J* =273.4, 1.3), 124.53, 122.60 (d, *J* = 2.8 Hz), 119.42 (d, *J* = 4.8 Hz), 113.03, 73.60 (d, *J* = 70.2 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 23.76. **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -63.35, -63.59. **HRMS** (ESI) m/z calcd for $C_{28}H_{17}BrF_6NO_2PNa$ $[M+Na]^+$: 645.9977, found: 645.9974.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-6-chloro-2-phenylindolin-3-one



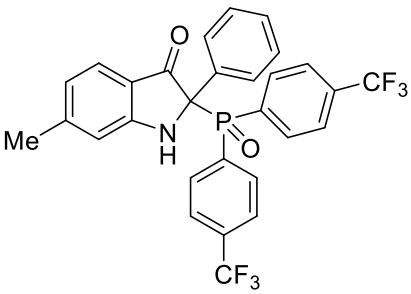
(3aa). Yellow solid, 34.7 mg, 60% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 9.05 (s, 1H), 8.02 (dd, J = 10.4, 8.1 Hz, 2H), 7.84 (t, J = 6.2 Hz, 6H), 7.78 – 7.69 (m, 2H), 7.43 – 7.33 (m, 3H), 7.28 (d, J = 8.3 Hz, 1H), 6.95 (d, J = 1.7 Hz, 1H), 6.68 (dd, J = 8.3, 1.7 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 193.79, 160.98 (d, J = 4.9 Hz), 143.09, 134.25 (d, J = 96.0 Hz), 134.05 (d, J = 8.8 Hz), 133.17 (d, J = 94.4 Hz), 133.16 (d, J = 9.2 Hz), 133.79 – 132.02 (m), 132.59, 129.02, 128.78, 126.96 (d, J = 3.7 Hz), 126.21, 125.83 – 125.50 (m), 123.99 (qd, J = 272.8, 7.1 Hz), 119.64, 118.48, 112.26, 74.70 (d, J = 69.1 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 24.07. **^{19}F NMR** (471 MHz, DMSO-d_6) δ -61.88, -61.90. **HRMS** (ESI) m/z calcd for $C_{28}H_{18}ClF_6NO_2P$ $[M+H]^+$: 580.0662, found:580.0656.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-5-chloro-2-phenylindolin-3-one



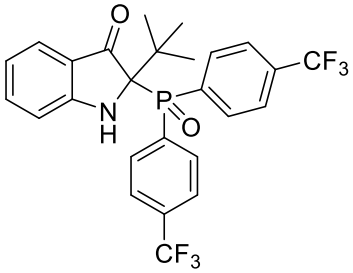
(3bb). Yellow oil, 29.0 mg, 50% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 9.05 (s, 1H), 8.02 (dd, J = 10.4, 8.1 Hz, 2H), 7.84 (t, J = 6.2 Hz, 6H), 7.78 – 7.69 (m, 2H), 7.43 – 7.33 (m, 3H), 7.28 (d, J = 8.3 Hz, 1H), 6.95 (d, J = 1.7 Hz, 1H), 6.68 (dd, J = 8.3, 1.7 Hz, 1H). **^{13}C NMR** (126 MHz, Methanol-d_4) δ 194.17, 158.93 (d, J = 5.2 Hz), 137.55, 135.60 – 132.88 (m), 133.59 (d, J = 8.9 Hz), 132.76 (d, J = 96.1 Hz), 132.74 (d, J = 9.3 Hz), 131.73 (d, J = 97.7 Hz), 131.71 (d, J = 2.5 Hz), 128.59 (d, J = 2.4 Hz), 128.22 (d, J = 2.1 Hz), 126.50 (d, J = 4.0 Hz), 125.12 – 124.75 (m), 124.30, 126.94 – 119.98 (m), 122.99, 120.93, 113.75, 74.53 (d, J = 71.7 Hz). **^{31}P NMR** (202 MHz, DMSO-d_6) δ 24.07. **^{19}F NMR** (471 MHz, DMSO-d_6) δ -61.88, -61.90. **HRMS** (ESI) m/z calcd for $C_{28}H_{18}ClF_6NO_2P$ $[M+H]^+$: 580.0662, found:580.0654.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-6-methyl-2-phenylindolin-3-one



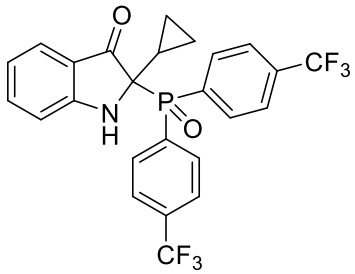
(3cc). Yellow solid, 40.2 mg, 72% yield. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.69 (s, 1H), 8.01 (dd, J = 10.3, 8.1 Hz, 2H), 7.82 (q, J = 3.8 Hz, 6H), 7.75 (dt, J = 7.4, 1.9 Hz, 2H), 7.35 (dd, J = 5.6, 1.9 Hz, 3H), 7.15 (d, J = 8.0 Hz, 1H), 6.74 (dt, J = 1.5, 0.9 Hz, 1H), 6.50 (dd, J = 8.0, 1.3 Hz, 1H), 2.24 (s, 3H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 194.17, 161.29 (d, J = 5.3 Hz), 149.48, 134.71 (d, J = 95.7 Hz), 134.07, 133.98 (d, J = 8.7 Hz), 133.71 (d, J = 95.8 Hz), 133.12 (d, J = 9.7 Hz), 135.66 – 130.04 (m), 128.79 (d, J = 2.5 Hz), 128.59 (d, J = 1.3 Hz), 127.07 (d, J = 3.8 Hz), 125.75 – 124.36 (m), 125.12 (qd, J = 273.4 Hz, 6.3 Hz), 124.26, 121.06, 117.62, 112.62, 74.28 (d, J = 71.2 Hz), 22.41. **^{31}P NMR** (202 MHz, DMSO-d_6) δ 24.16. **^{19}F NMR** (471 MHz, DMSO-d_6) δ -61.83, -61.84. **HRMS** (ESI) m/z calcd for $C_{29}H_{21}F_6NO_2P$ $[M+H]^+$: 560.1209, found:560.1206.

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(tert-butyl)indolin-3-one (3dd).



Yellow solid, 26.3 mg, 50% yield. **^{1}H NMR** (500 MHz, Methanol-d_4) δ 8.38 (dd, J = 10.4, 8.2 Hz, 2H), 8.22 (dd, J = 10.5, 8.2 Hz, 2H), 7.74 (dd, J = 8.5, 2.5 Hz, 2H), 7.67 (dd, J = 8.5, 2.5 Hz, 2H), 7.38 – 7.31 (m, 1H), 7.22 (d, J = 7.8 Hz, 1H), 6.92 (d, J = 8.3 Hz, 1H), 6.63 (t, J = 7.4 Hz, 1H), 1.12 (s, 9H). **^{13}C NMR** (126 MHz, Methanol-d_4) δ 199.10 (d, J = 2.5 Hz), 161.42 (d, J = 5.3 Hz), 137.36, 135.87 (d, J = 90.6 Hz), 135.05 (d, J = 95.5 Hz), 133.96 – 132.98 (m), 133.29 (d, J = 8.9 Hz), 132.77 (d, J = 8.8 Hz), 124.81 – 124.49 (m), 123.55 (qd, J = 272.0, 7.2 Hz), 123.20, 122.36, 118.70, 112.10, 78.06 (d, J = 71.4 Hz), 40.08 (d, J = 1.1 Hz), 25.79 (d, J = 4.8 Hz). **^{31}P NMR** (202 MHz, Methanol-d_4) δ 21.13. **^{19}F NMR** (471 MHz, Methanol-d_4) δ -64.81, -64.86. **HRMS** (ESI) m/z calcd for $C_{26}H_{23}F_6NO_2P$ $[M+H]^+$: 526.1365, found: 526.1361.

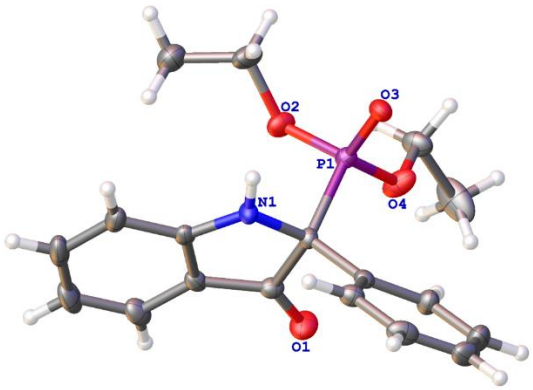
2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-cyclopropylindolin-3-one (3ee).



Yellow solid, 18.3 mg, 36% yield. **^{1}H NMR** (500 MHz, Chloroform-d) δ 8.65 (dd, J = 11.1, 8.1 Hz, 2H), 7.89 (dd, J = 8.4, 2.5 Hz, 2H), 7.83 (dd, J = 10.9, 8.1 Hz, 2H), 7.44 (dd, J = 8.4, 2.5 Hz, 2H), 7.35 – 7.32 (m, 2H), 6.90 – 6.84 (m, 1H), 6.77 (s, 1H), 6.68 (dd, J = 7.9, 6.9 Hz, 1H), 1.50 – 1.46 (m, 1H), 0.82 – 0.74 (m, 1H), 0.51 (dd, J = 9.9, 4.7 Hz, 1H), 0.47 – 0.40 (m, 1H), 0.36 – 0.27 (m, 1H). **^{13}C NMR** (126 MHz, Chloroform-d) δ 199.42 (d, J = 2.5 Hz), 161.04 (d, J = 3.8 Hz), 137.88, 135.40 – 133.27 (m), 133.60 (d, J = 92.5 Hz), 133.43 (d, J = 10.1 Hz), 133.26 (d, J = 94.2 Hz), 131.97 (d, J = 9.6 Hz), 125.56 (dq, J = 11.9, 3.5 Hz), 124.93 (dq, J = 11.5, 3.6 Hz), 124.62 , 123.04 (qd, J = 272.2, 41.6 Hz), 120.95 (d, J = 1.2 Hz), 119.49, 112.31, 72.19 (d, J = 67.7 Hz), 13.43 (d, J = 2.9 Hz), 1.49 (d, J = 3.3 Hz), -0.85 (d, J = 7.5 Hz). **^{31}P NMR** (202 MHz, Chloroform-d) δ 26.41. **^{19}F NMR** (471 MHz, Chloroform-d) δ -63.29, -63.58. **HRMS** (ESI) m/z calcd for $C_{25}H_{19}F_6NO_2P$ $[M+H]^+$: 510.1052, found: 510.1049.

7. Single Crystal X-ray Structure Determinations of Compounds

Single crystal X-ray structure determinations of compound 3s (CCDC: 2160338)



Bond precision:	C-C = 0.0041 A	Wavelength = 0.71073	
Cell:	A = 9.8117(8)	B = 9.8216(7)	C = 10.5478(8)
	Alpha = 76.027(6)	Beta = 74.128(7)	Gamma = 60.531(8)
Temperature:	150 K		
	Calculated	Reported	
Volume	844.24(13)	844.24(13)	
Space group	P -1	P -1	
Hall group	-P 1	-P 1	
Moiety formula	C18 H20 N O4 P	C18 H20 N O4 P	
Sum formula	C18 H20 N O4 P	C18 H20 N O4 P	
Mr	345.32	345.32	
Dx,g cm-3	1.358	1.358	
Z	2	2	
Mu (mm-1)	0.185	0.185	
F000	364.0	364.0	
F000’	364.37		
h,k,lmax	11,11,12	11,11,12	
Nref	2976	2975	
Tmin,Tmax	0.973,0.980	0.784,1.000	
Tmin’	0.973		

Correction method = # Reported T Limits: Tmin = 0.784 Tmax = 1.000

AbsCorr = MULTI-SCAN

Data completeness = 1.000 Theta(max) = 24.997

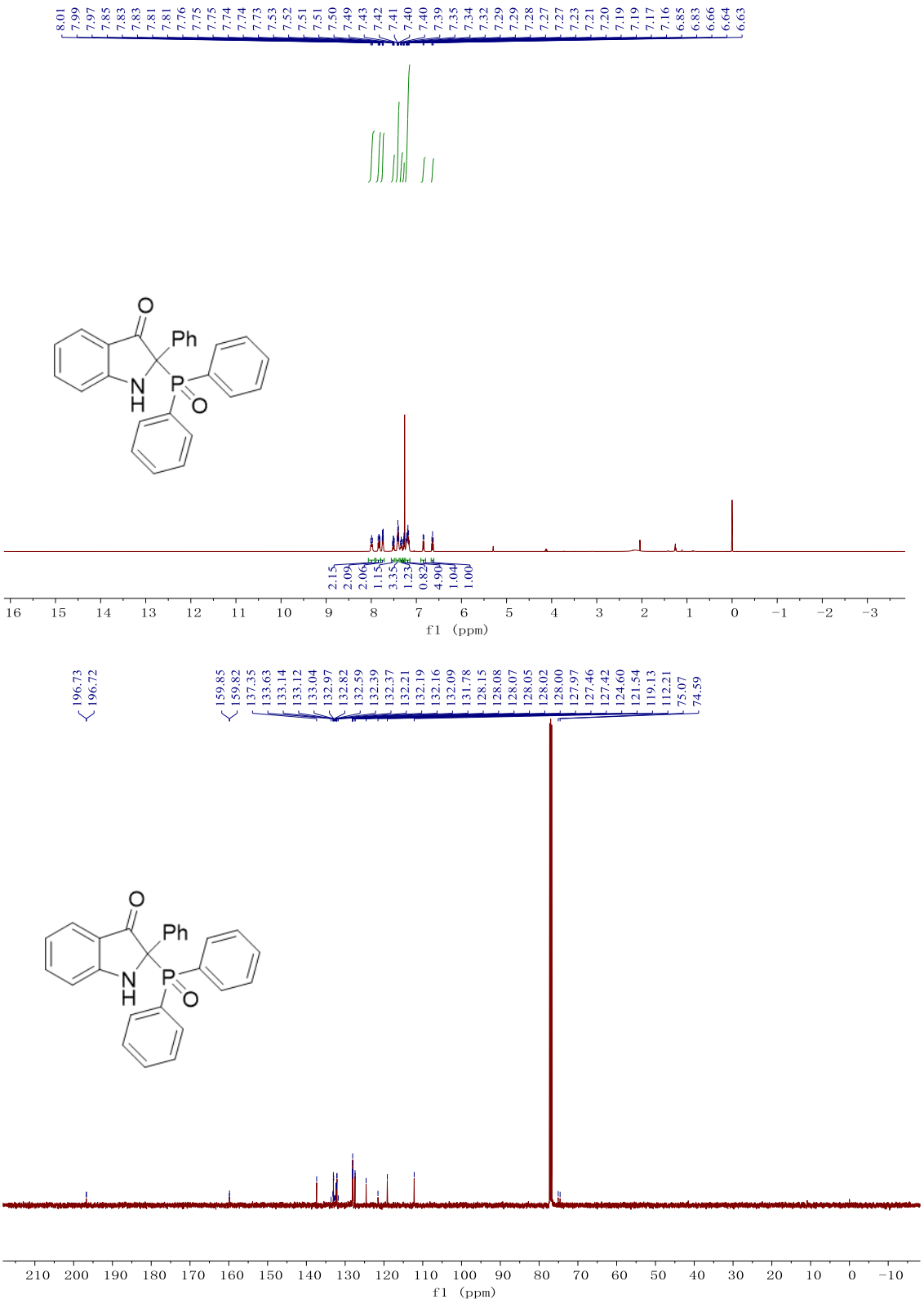
R(reflections) = 0.0483(2565) wR2(reflections)= 0.1239(2975)

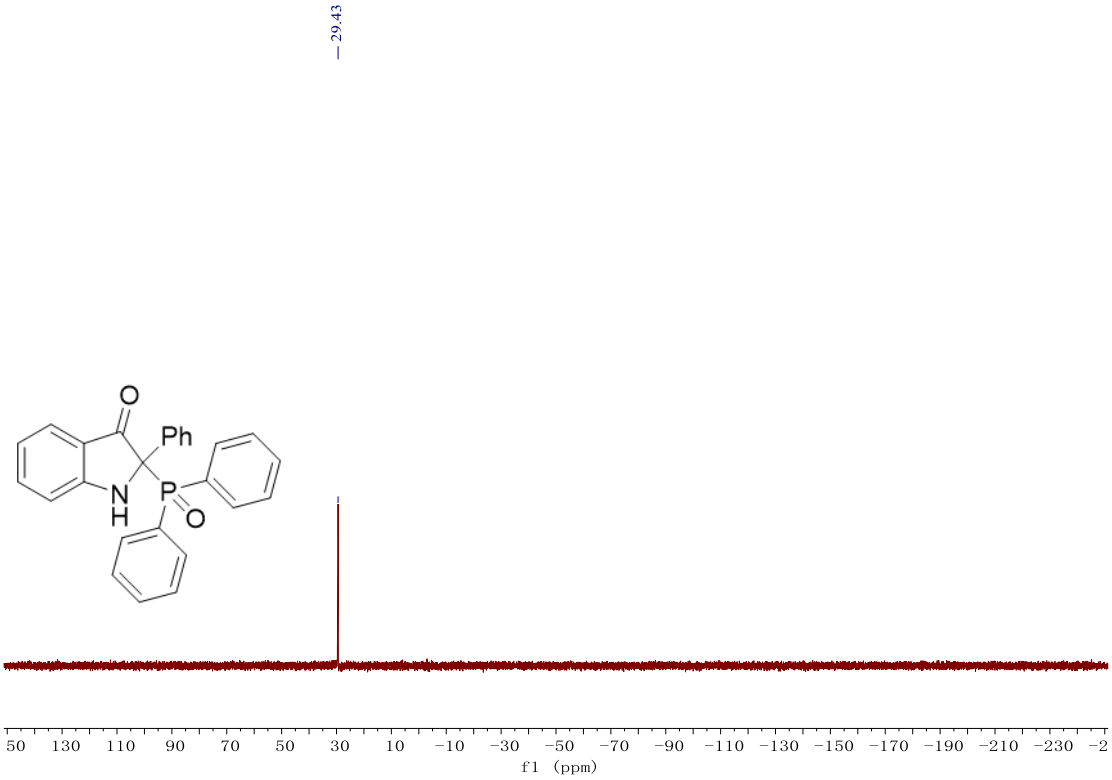
S = 1.063 Npar = 233

8. Copies of NMR Spectra

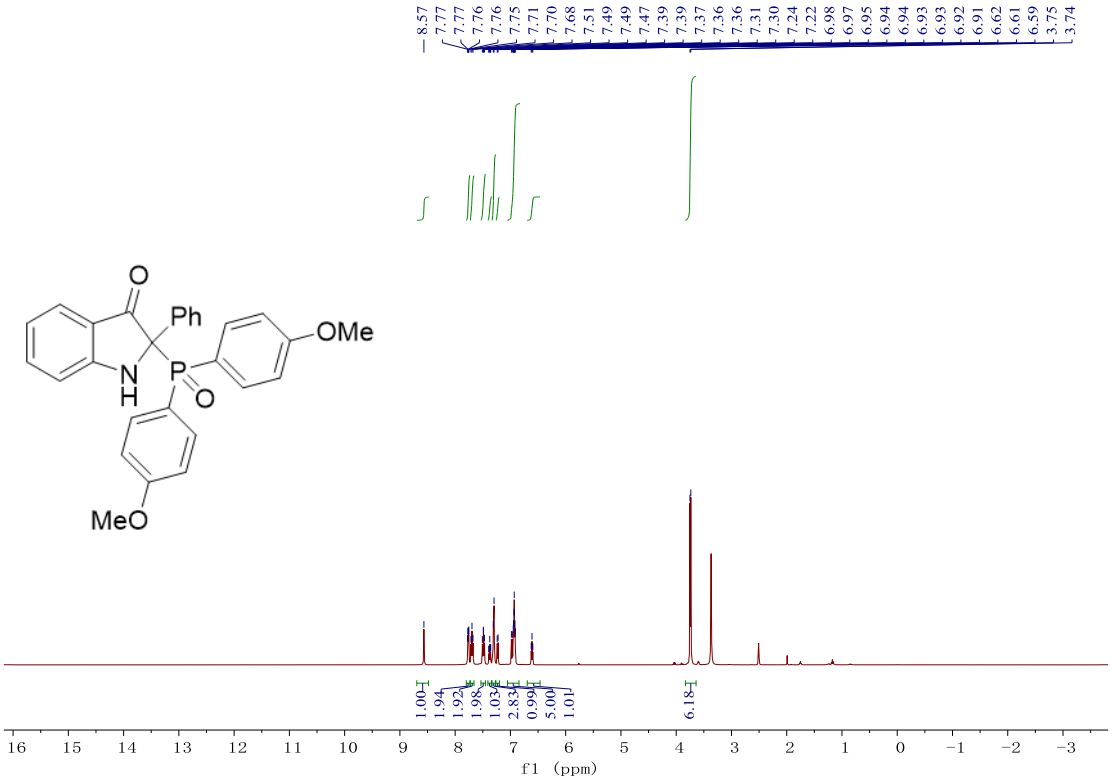
^{1}H NMR, ^{13}C NMR, ^{31}P NMR and ^{19}F NMR spectra for compounds

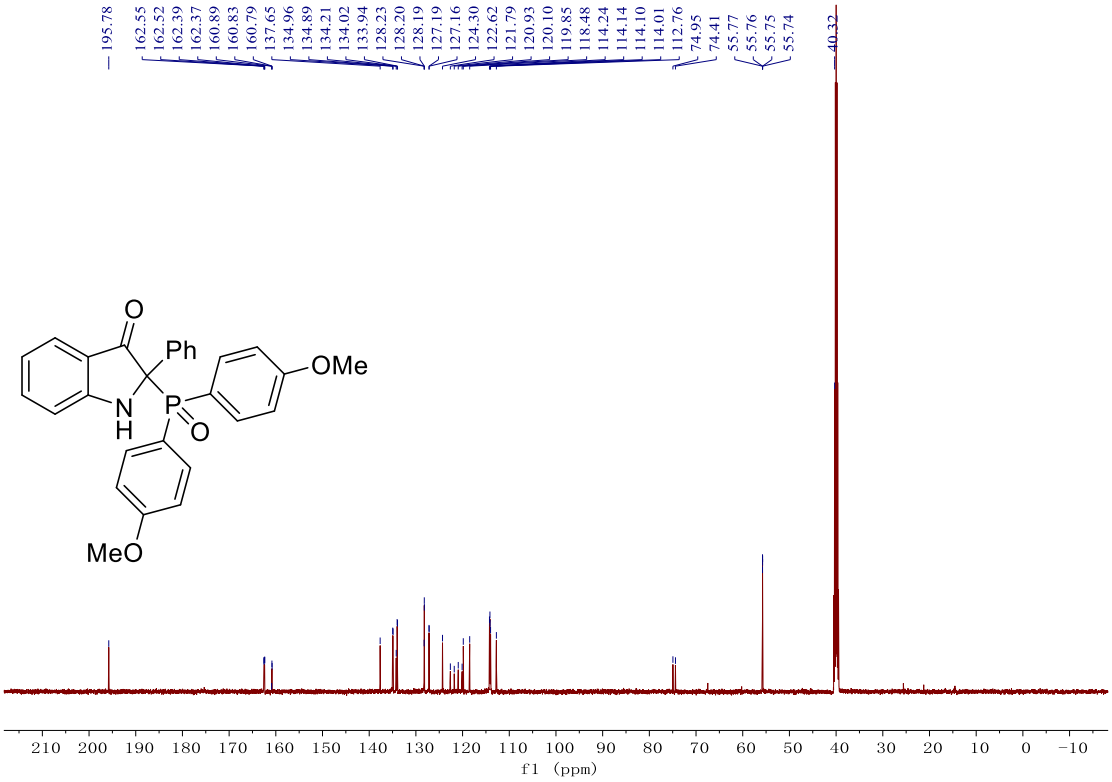
henylphosphoryl)-2-phenylindolin-3-one (3a)

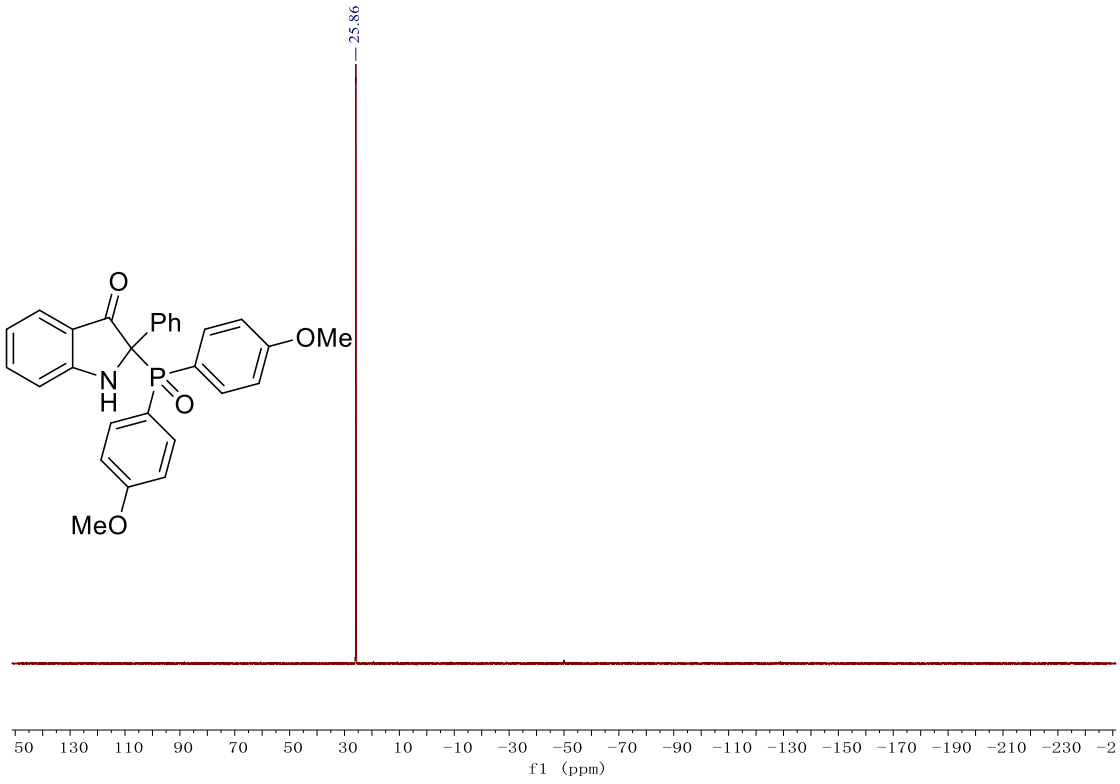




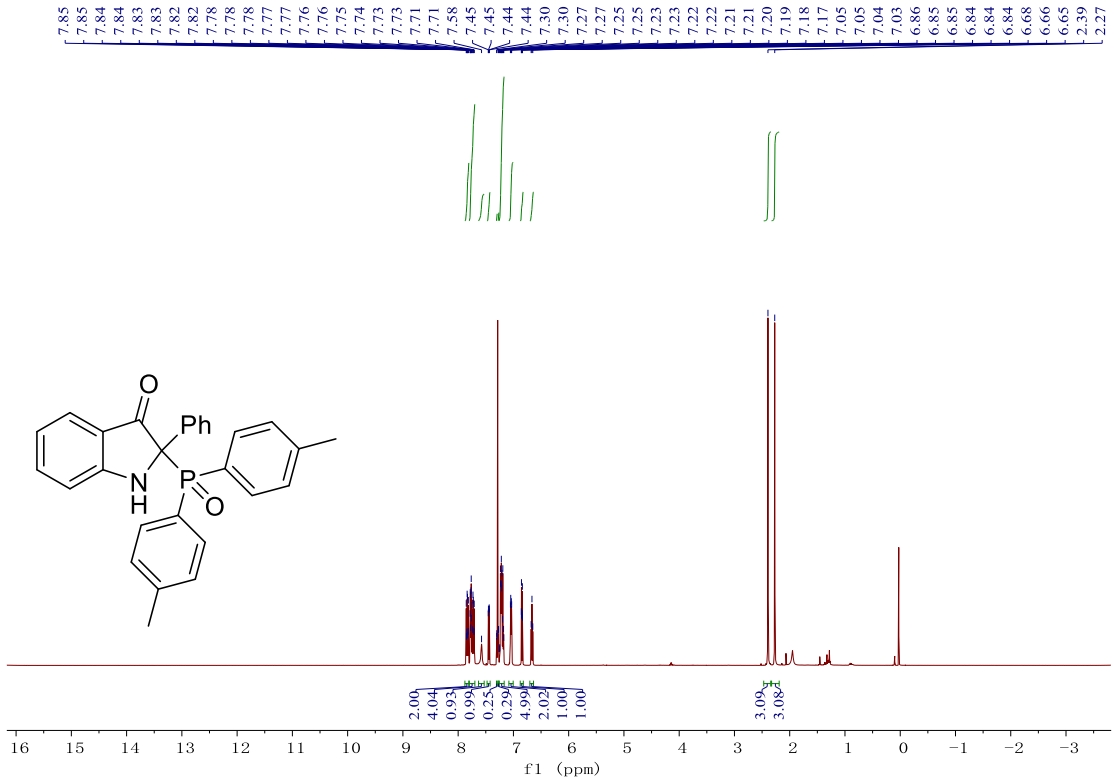
2-(bis(4-methoxyphenyl)phosphoryl)-2-phenylindolin-3-one (3b)

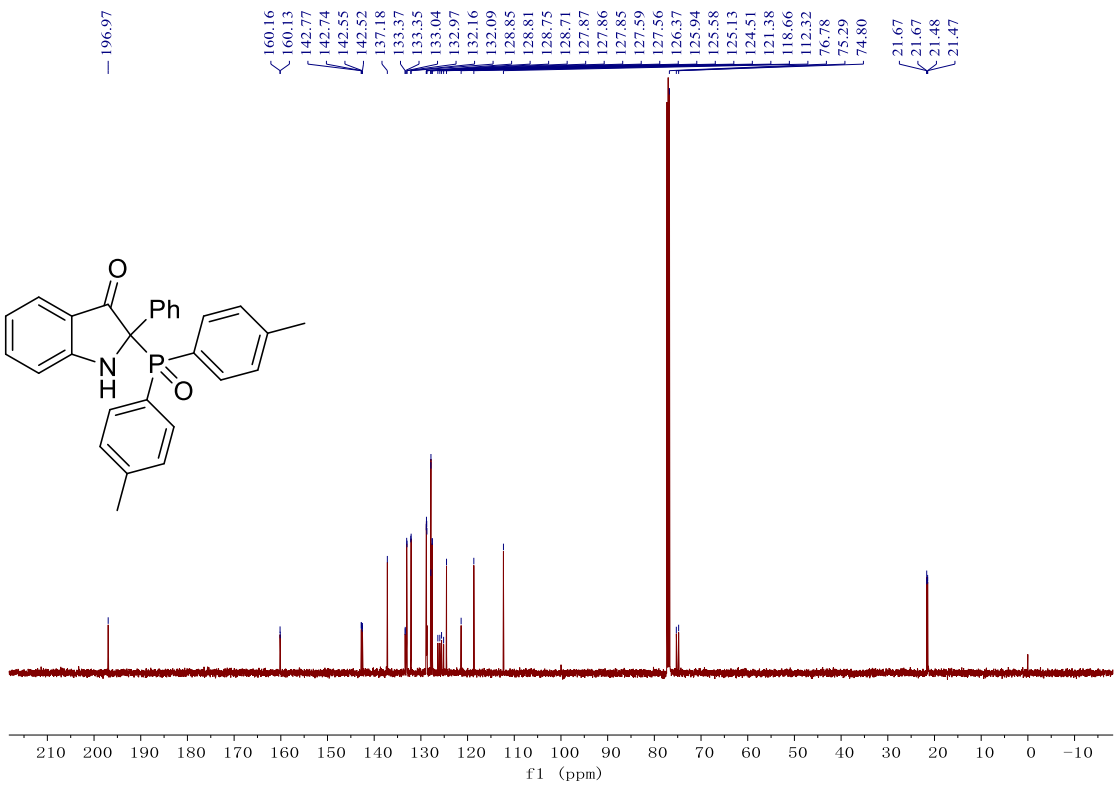


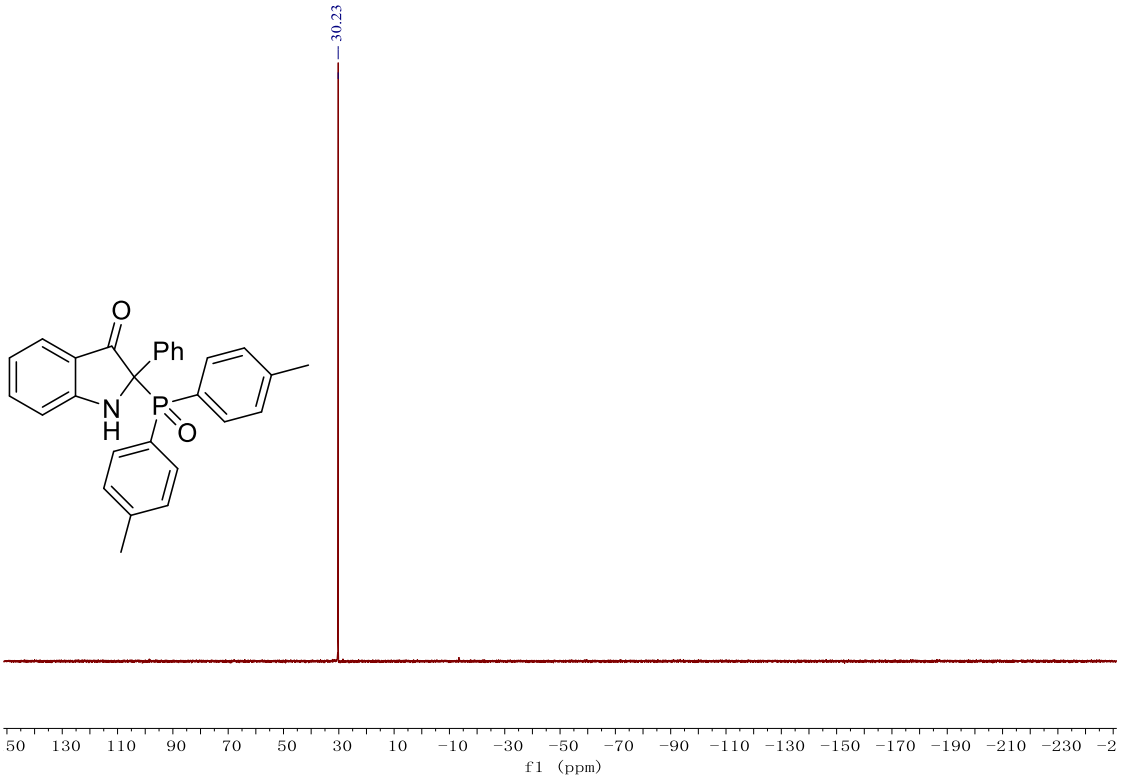

195.78
162.55
162.52
162.39
162.37
160.89
160.83
160.79
137.65
134.96
134.89
134.21
134.02
133.94
128.23
128.20
128.19
127.19
127.16
124.30
122.62
121.79
120.93
120.10
119.85
118.48
114.24
114.14
114.10
114.01
112.76
74.95
74.41
55.77
55.76
55.75
55.74
40.32
O
Ph
OMe
N
H
P
O
MeO
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


25.86
O
Ph
OMe
N
H
P
O
MeO
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

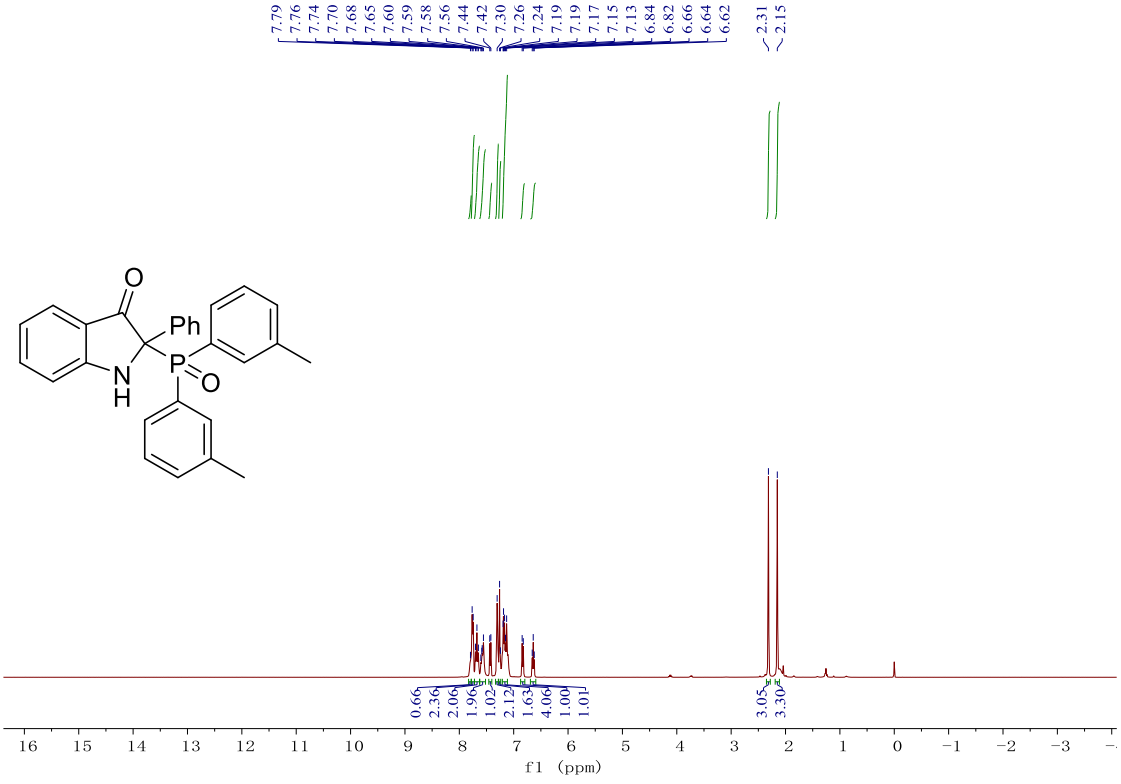
2-(di-p-tolylphosphoryl)-2-phenylindolin-3-one (3c)

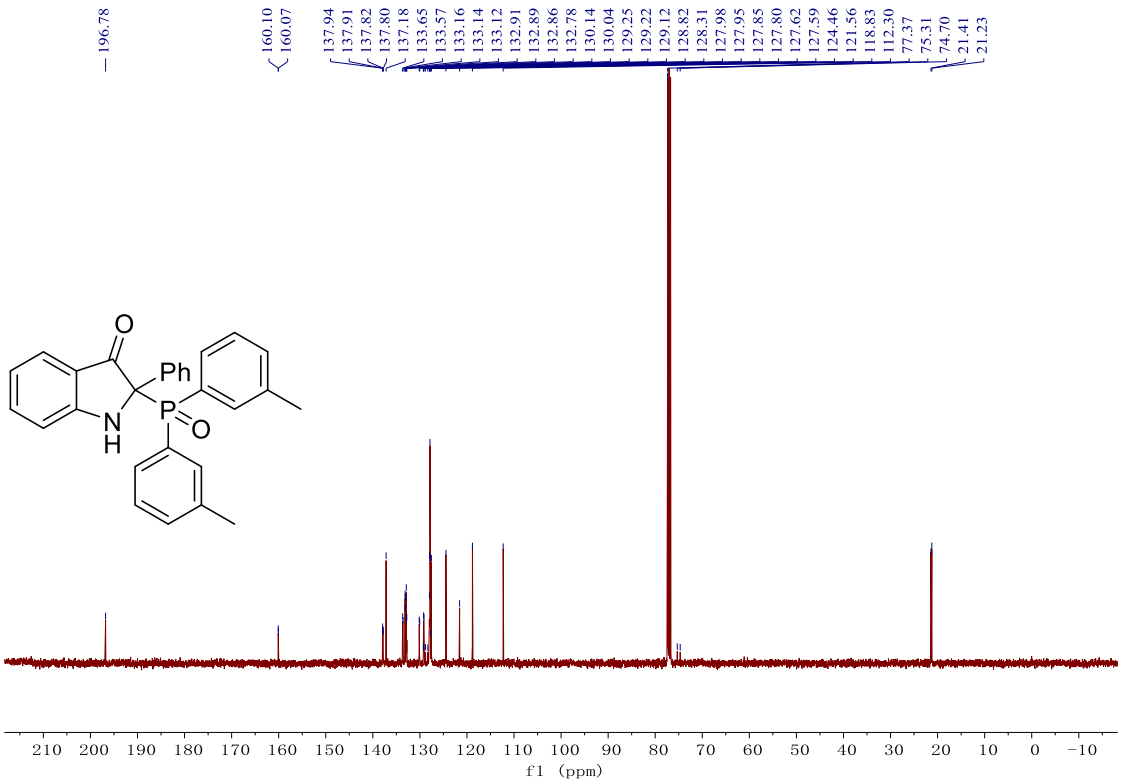


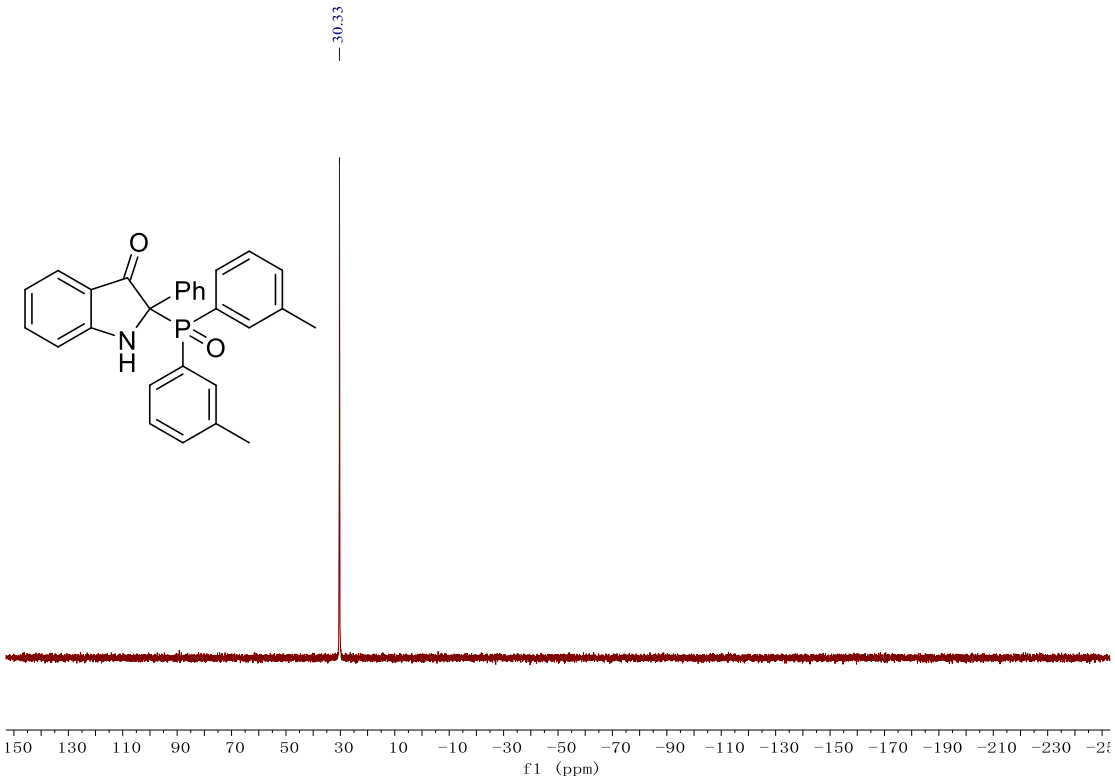




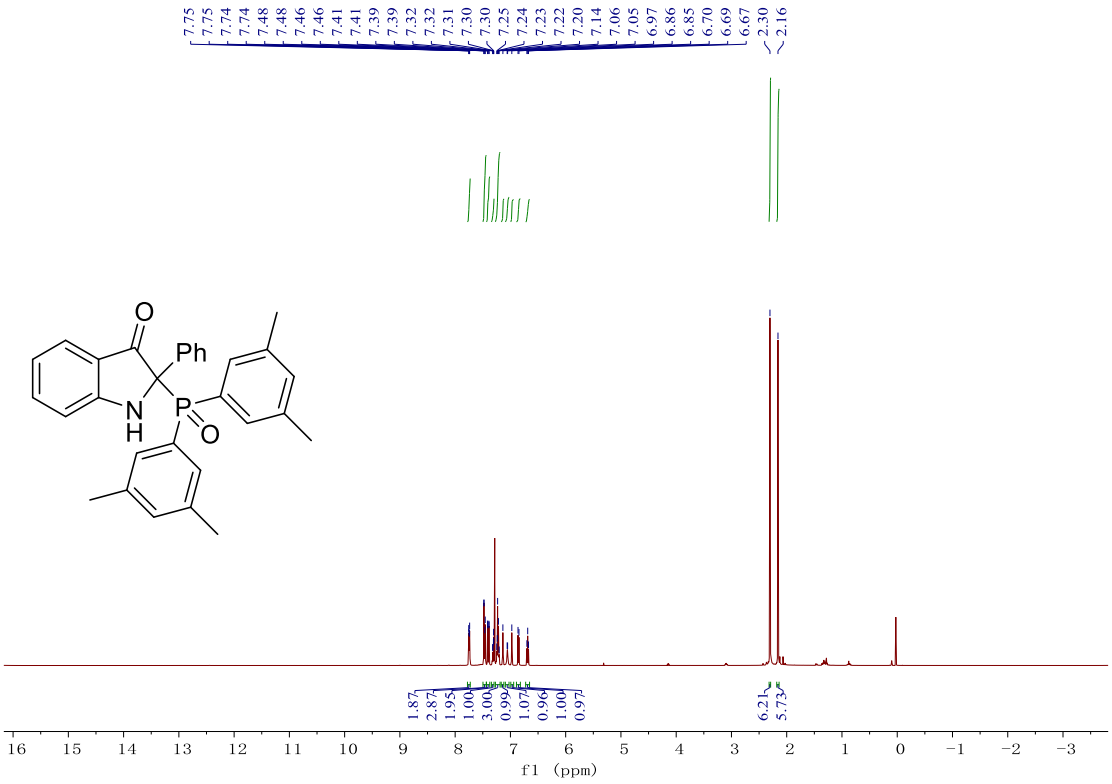
2-(di-m-tolylphosphoryl)-2-phenylindolin-3-one (3d)

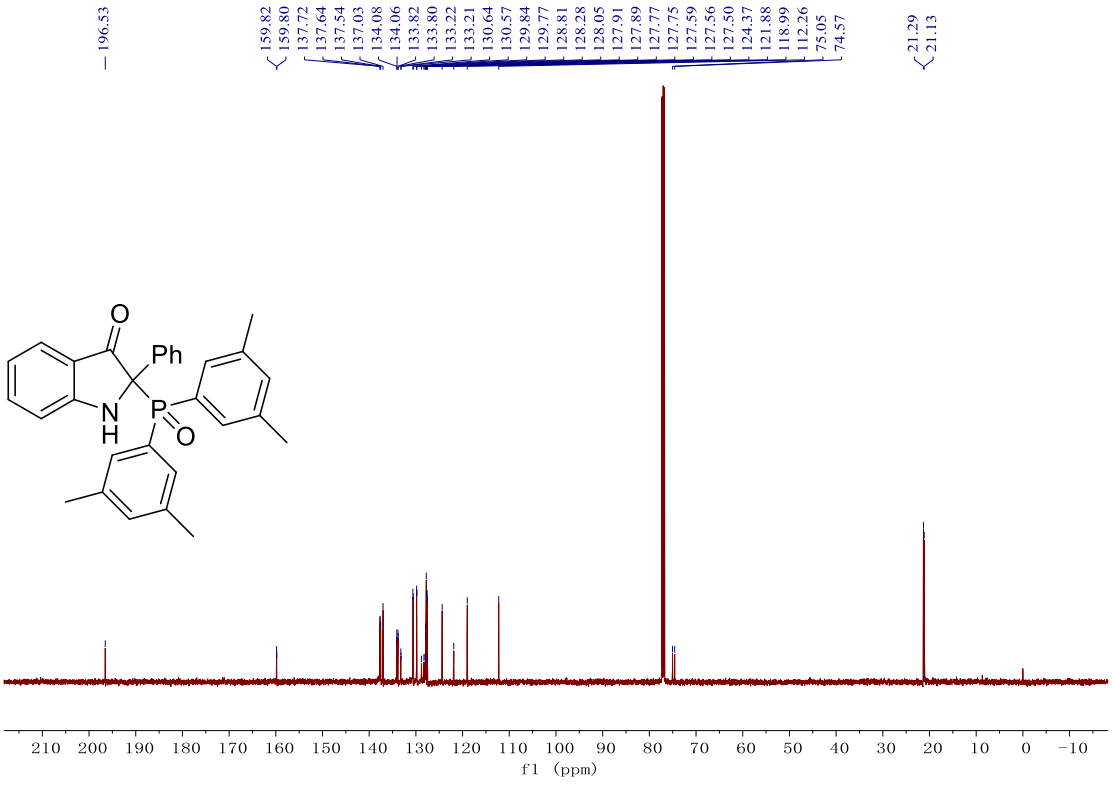


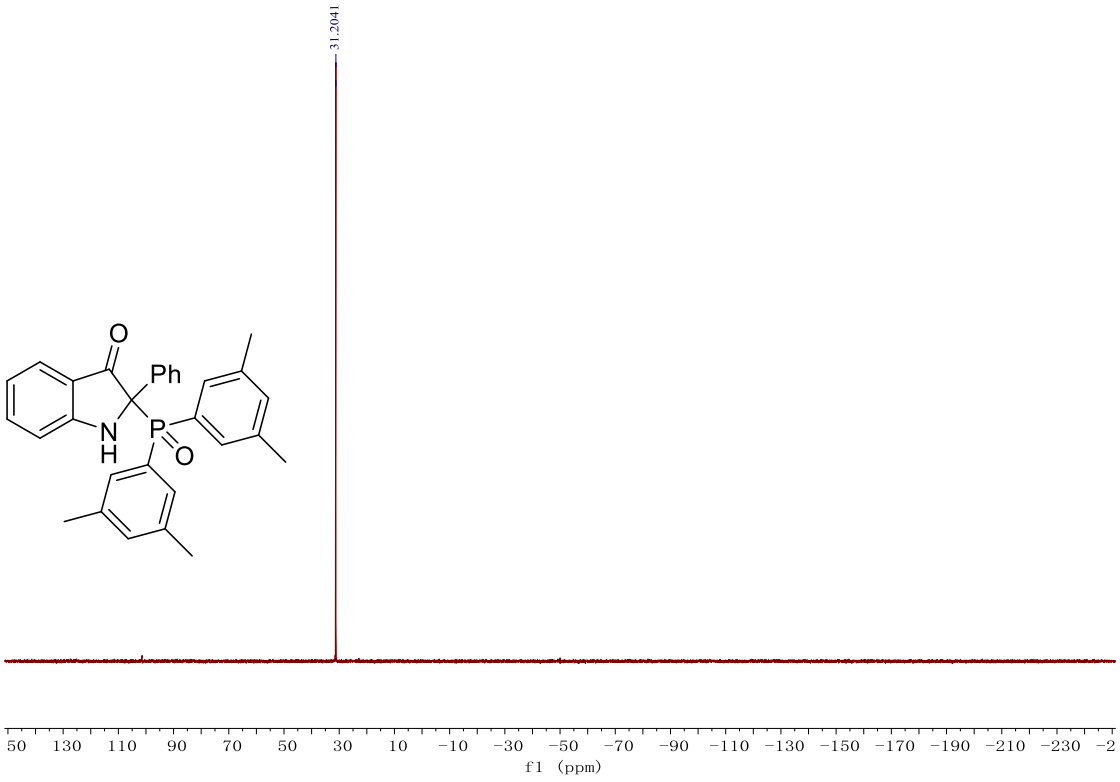

196.78
160.10
160.07
137.94
137.91
137.82
137.80
137.18
133.65
133.57
133.16
133.14
133.12
132.91
132.89
132.86
132.78
130.14
130.04
129.25
129.22
129.12
128.82
128.31
127.98
127.95
127.85
127.80
127.62
127.59
124.46
121.56
118.83
112.30
77.37
75.31
74.70
21.41
21.23
O
Ph
P
O
N
H
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


30.33
O
Ph
P
O
N
H
150 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230
f1 (ppm)

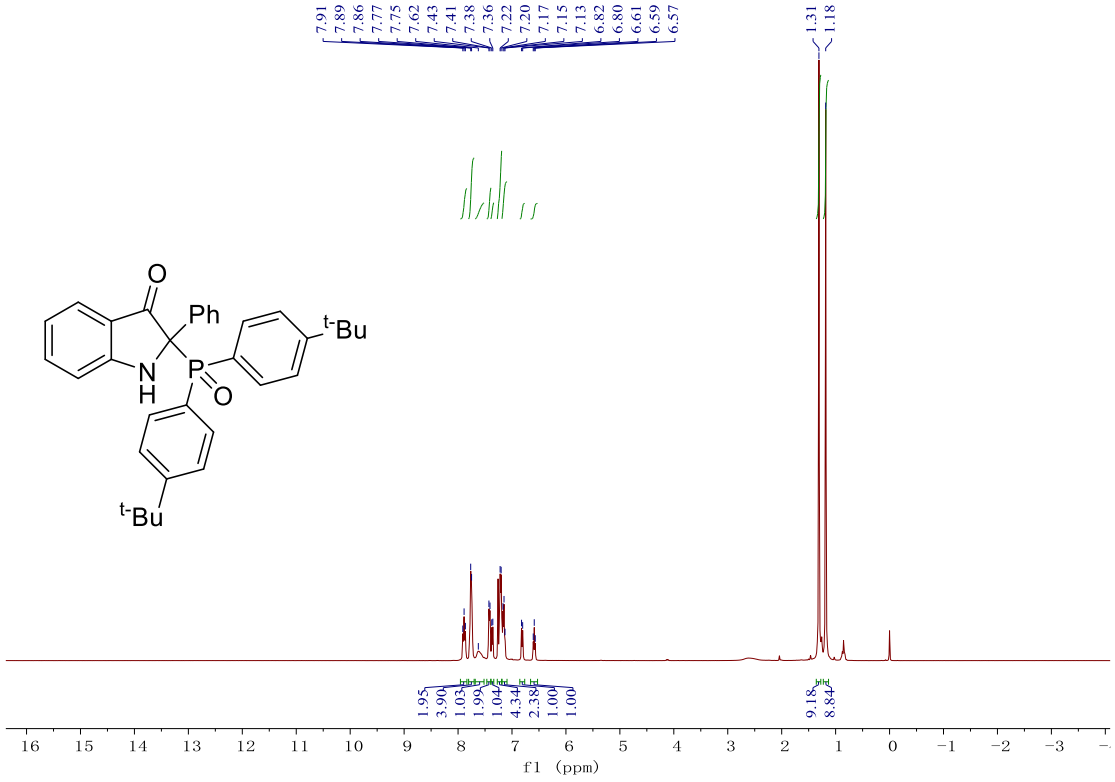
2-(bis(3,5-dimethylphenyl)phosphoryl)-2-phenylindolin-3-one (3e)

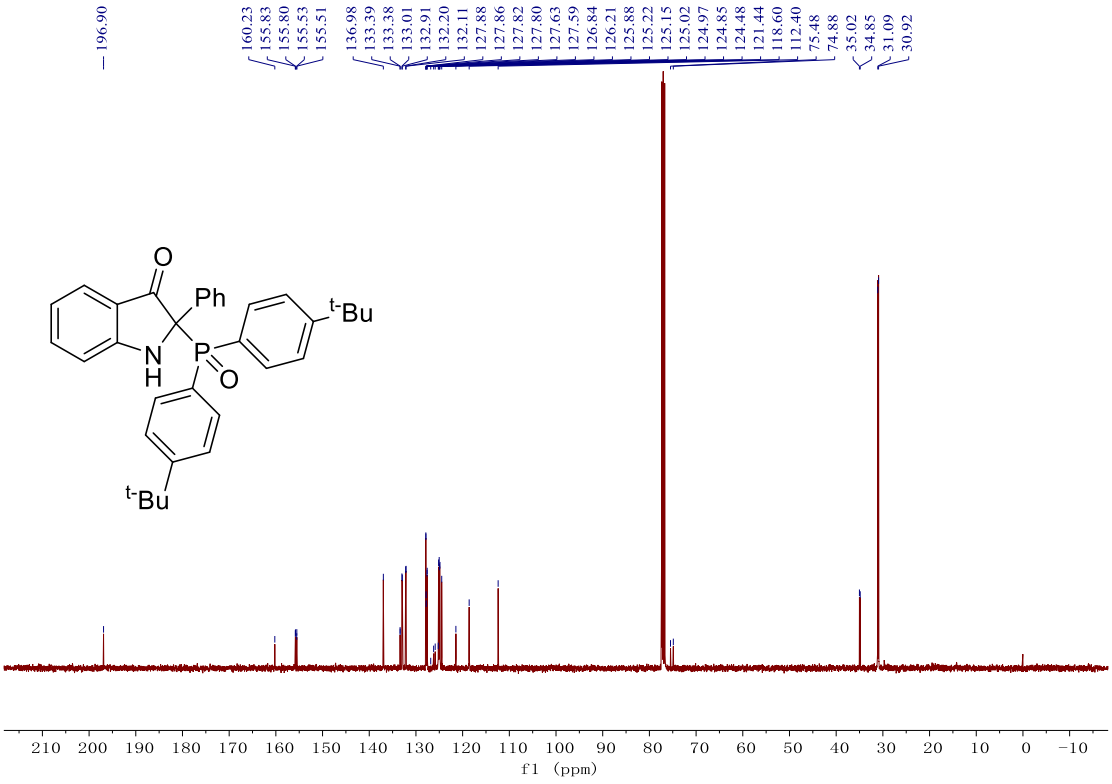


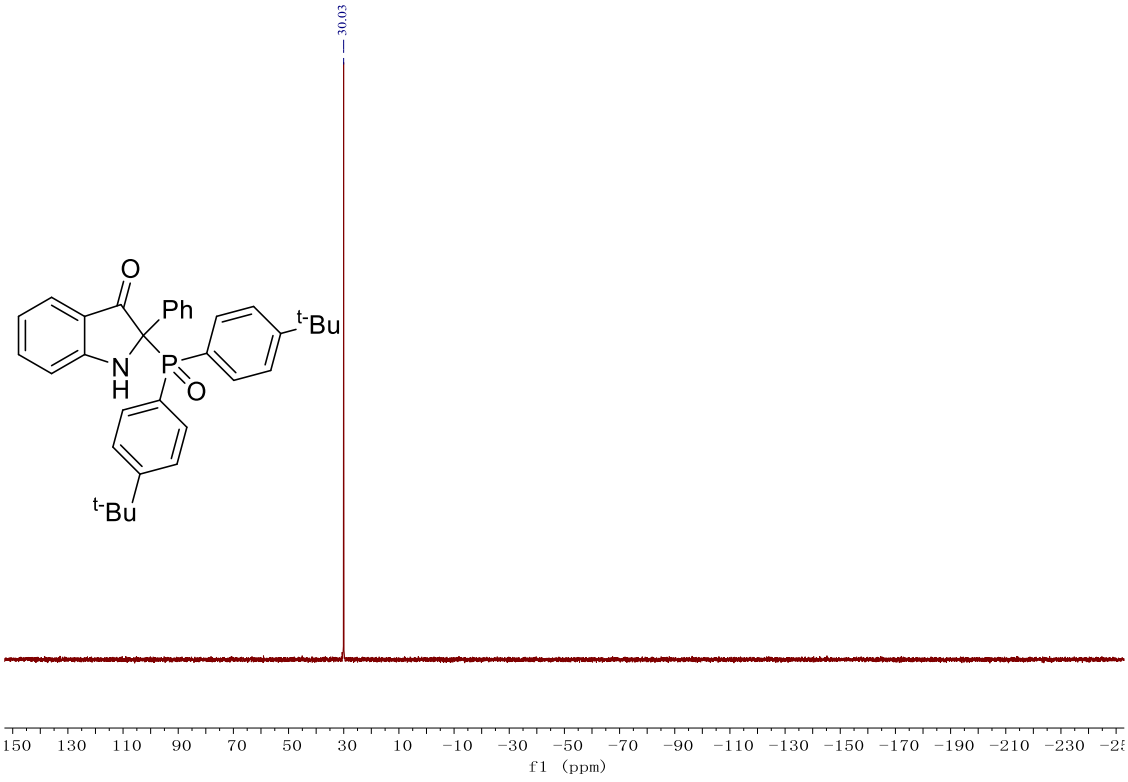




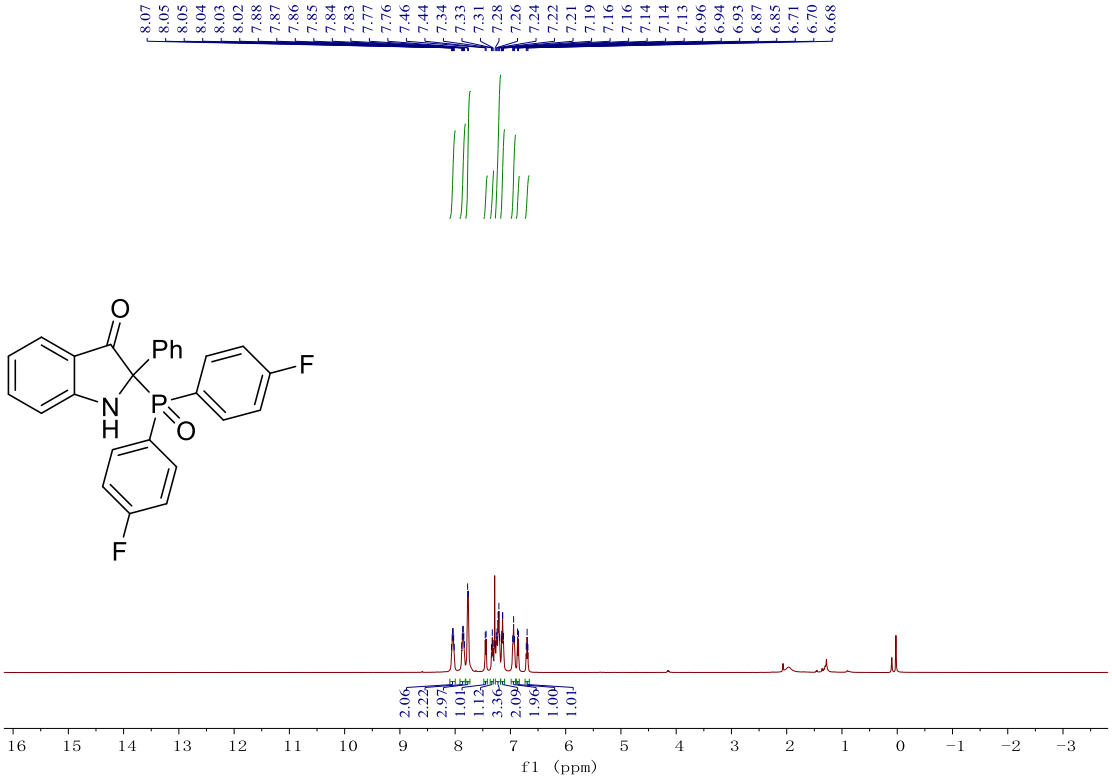
2-(bis(4-(tert-butyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3f)

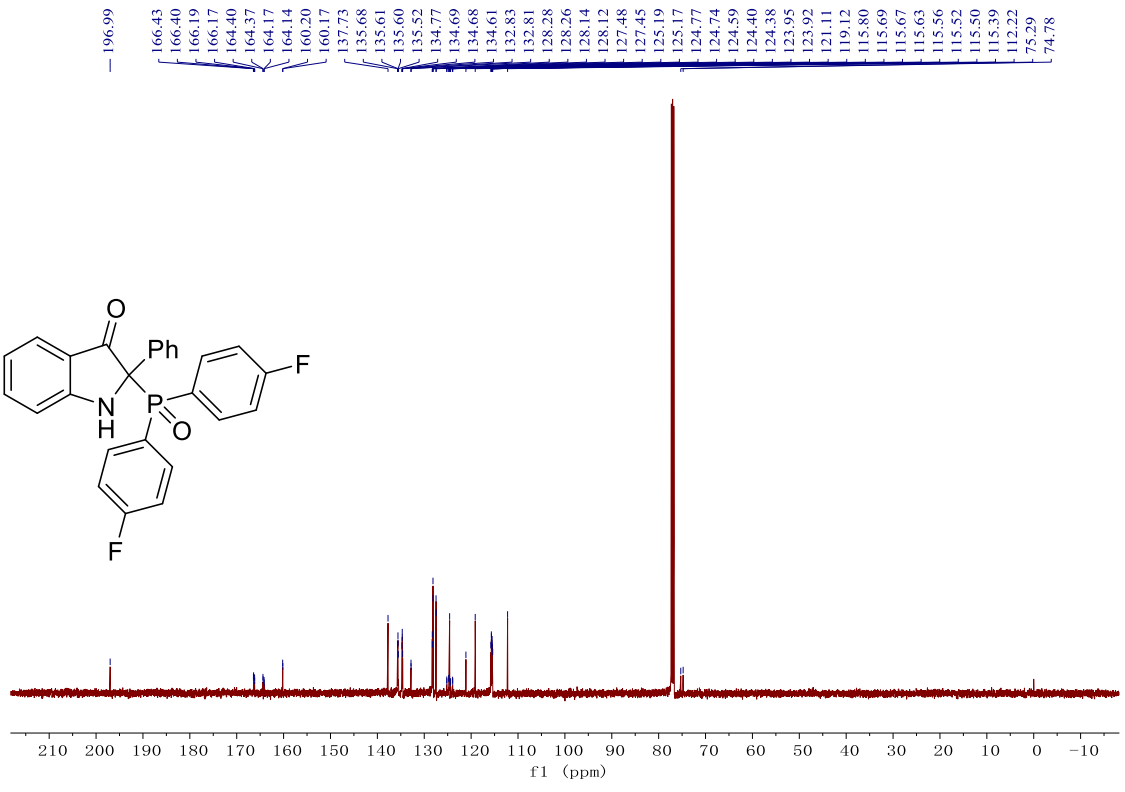


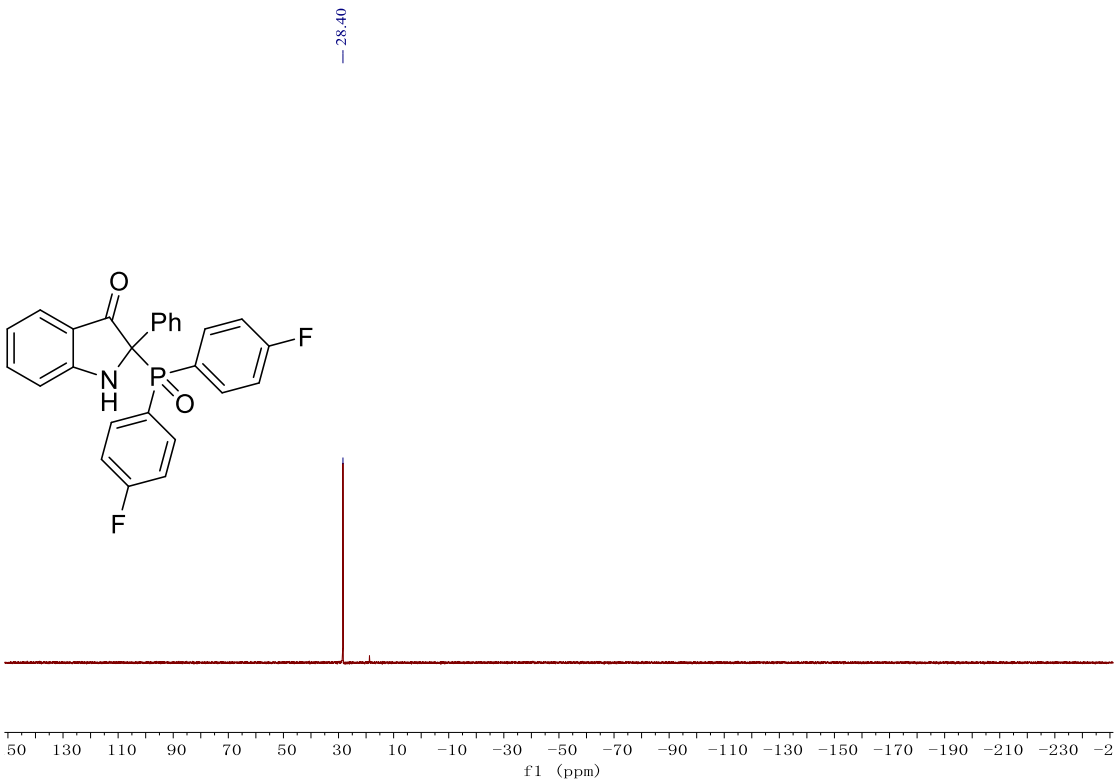

196.90
160.23
155.83
155.80
155.53
155.51
136.98
133.39
133.38
133.01
132.91
132.20
132.11
127.88
127.86
127.82
127.80
127.63
127.59
126.84
126.21
125.88
125.22
125.15
125.02
124.97
124.85
124.48
121.44
118.60
112.40
75.48
74.88
35.02
34.85
31.09
30.92
O
Ph
t-Bu
N
H
P
O
t-Bu
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

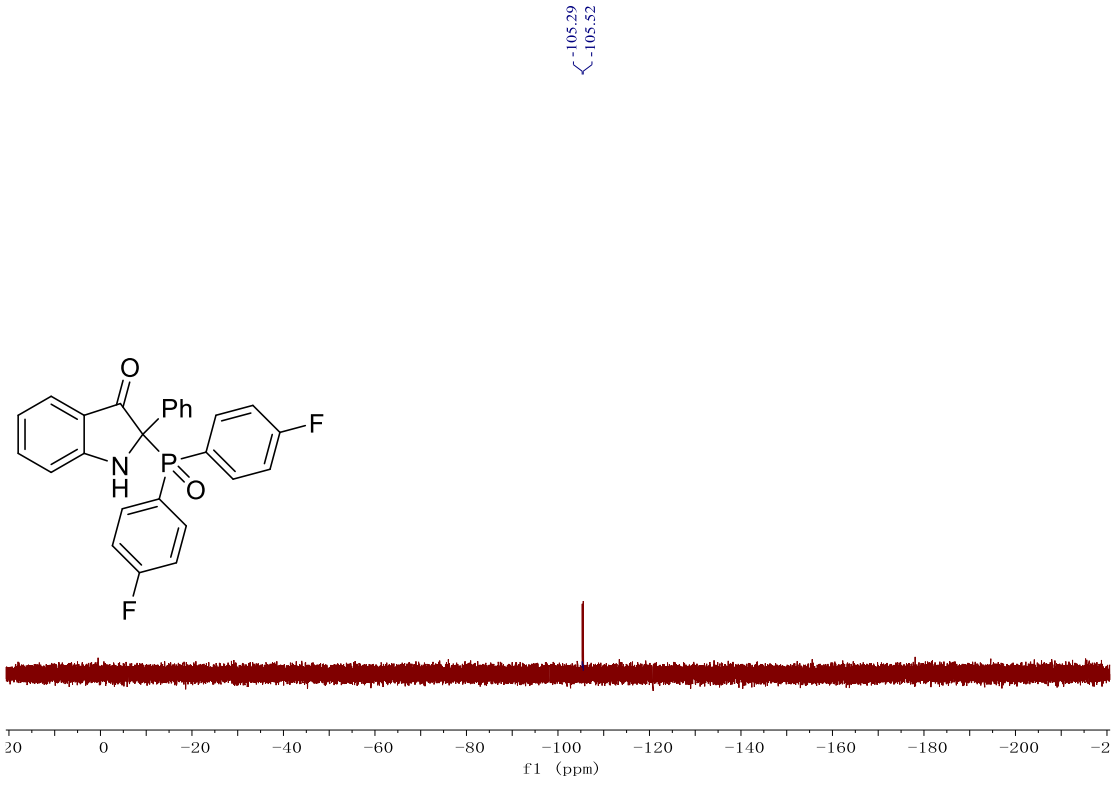

30.03
O
Ph
t-Bu
N
H
P
O
t-Bu
150 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230
f1 (ppm)

2-(bis(4-fluorophenyl)phosphoryl)-2-phenylindolin-3-one (3g)

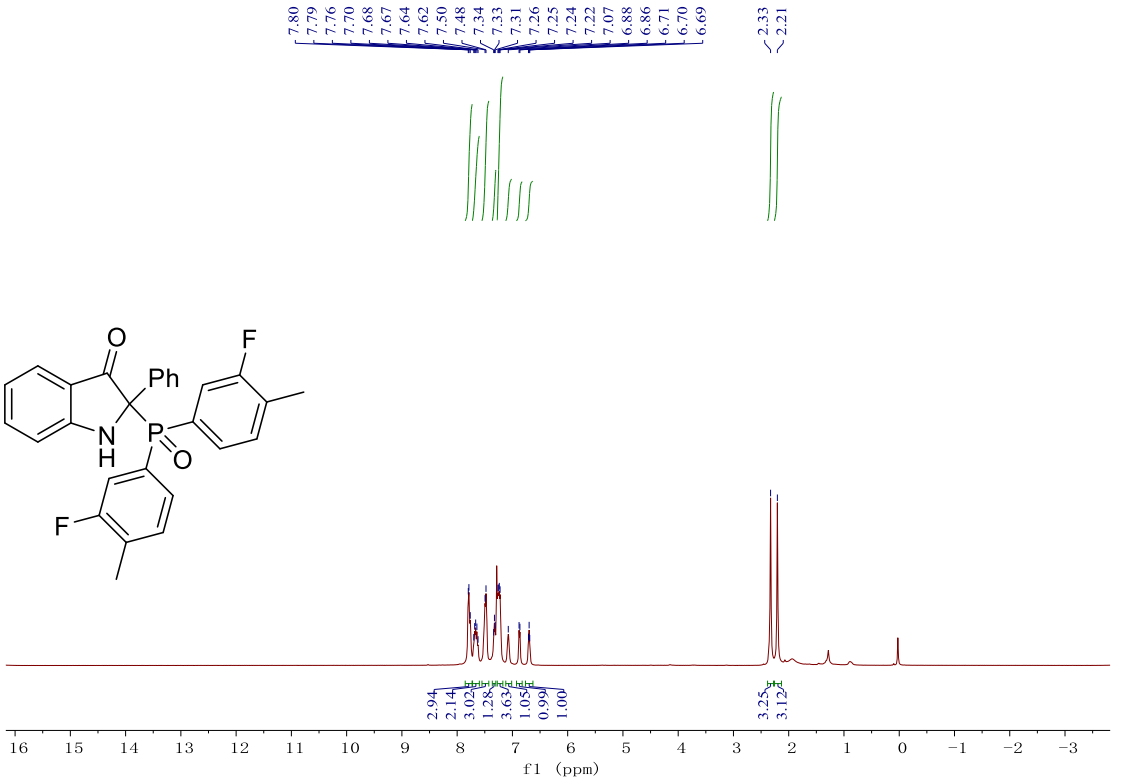


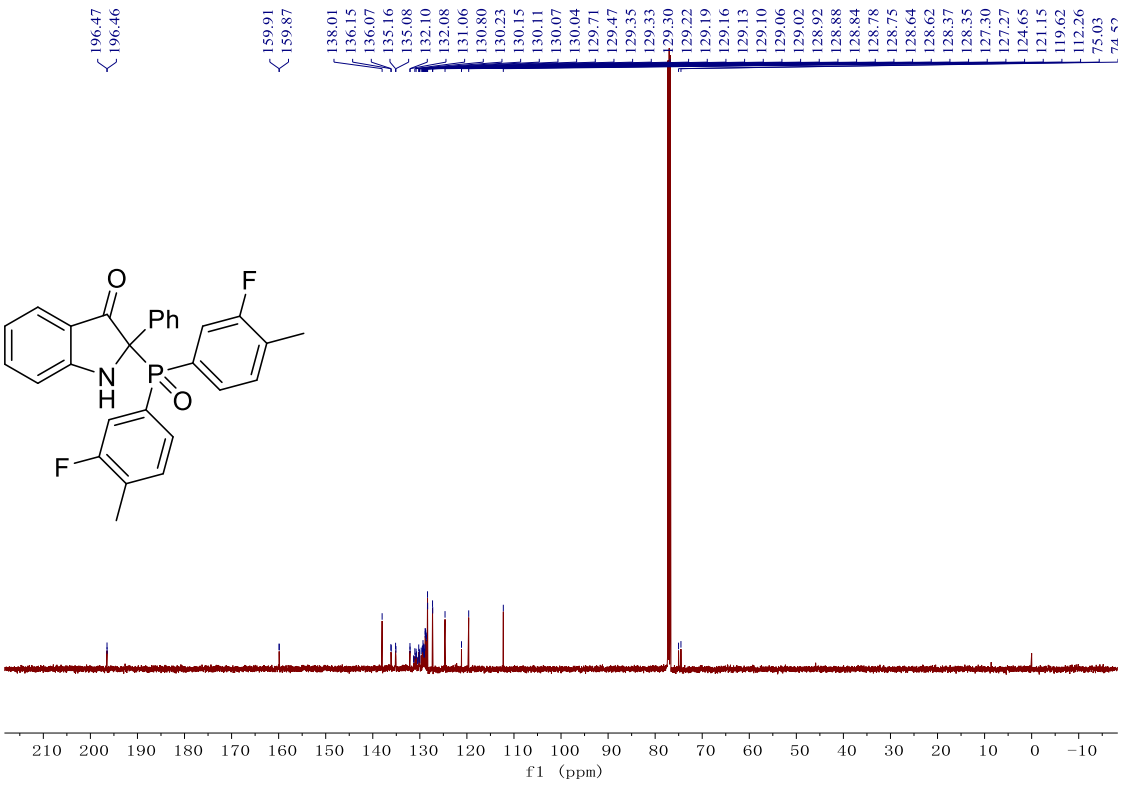


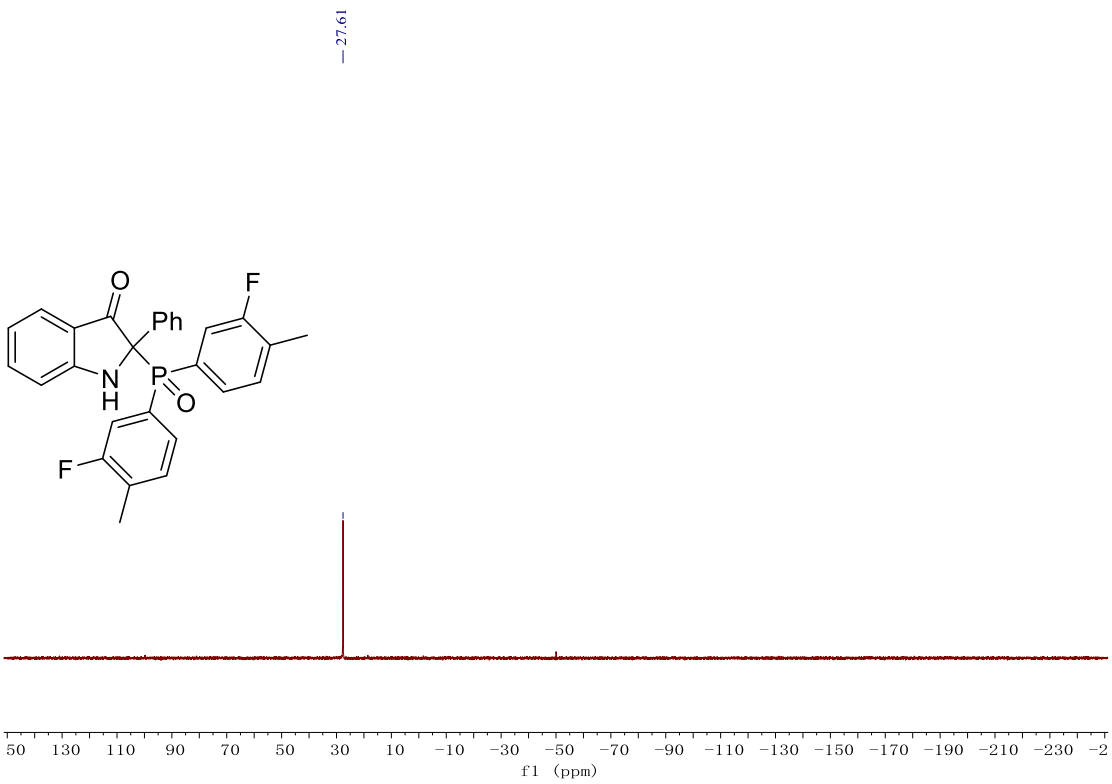

28.40
O
Ph
F
N
H
P
O
F
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

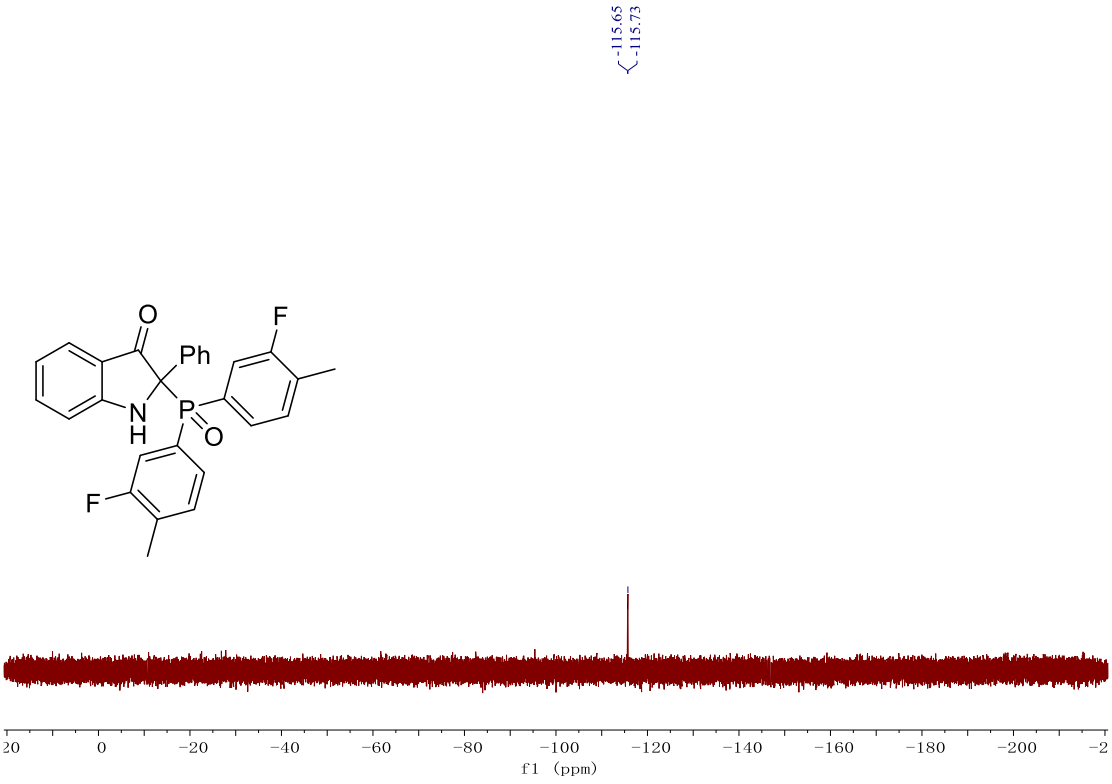

-105.29
-105.52
O
Ph
F
N
H
P
O
F
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(3-fluoro-4-methylphenyl)phosphoryl)-2-phenylindolin-3-one (3h).

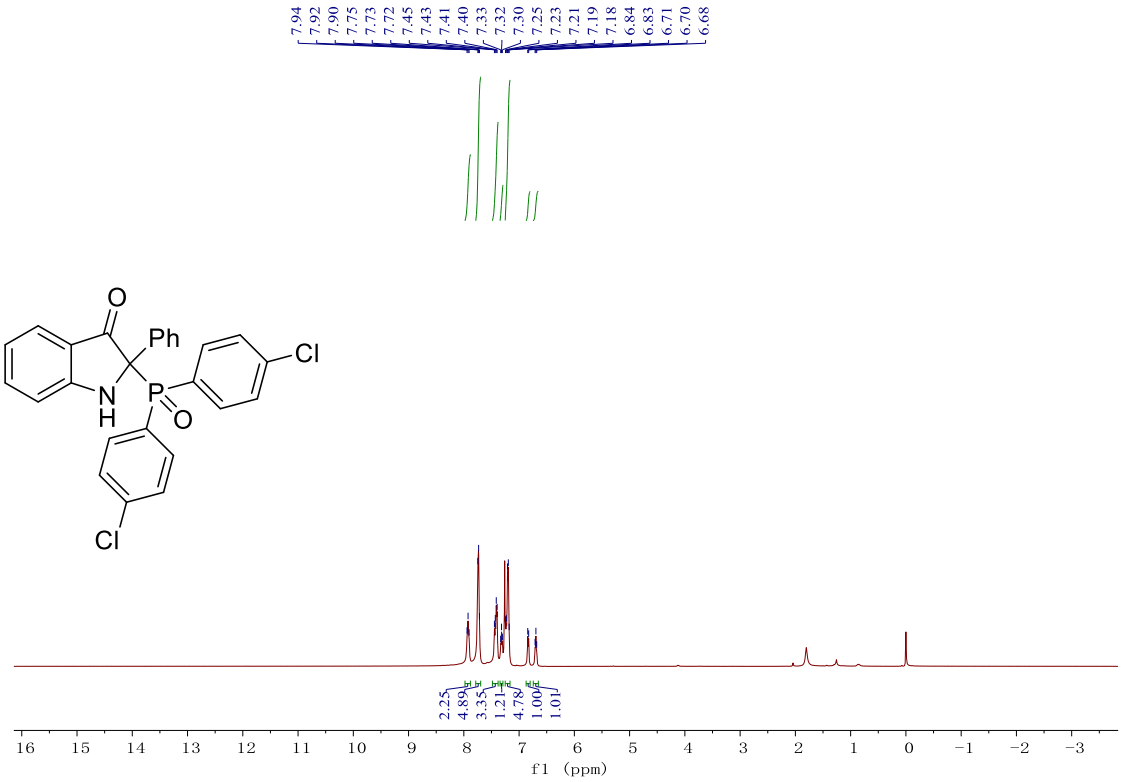


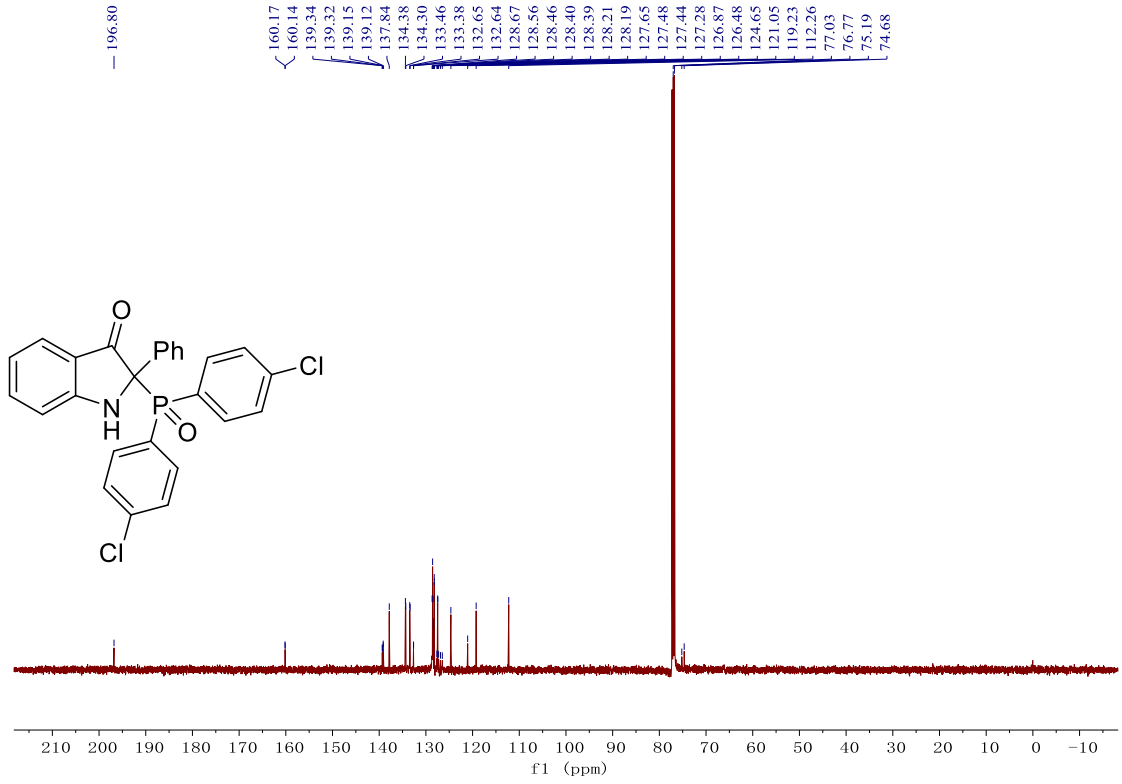


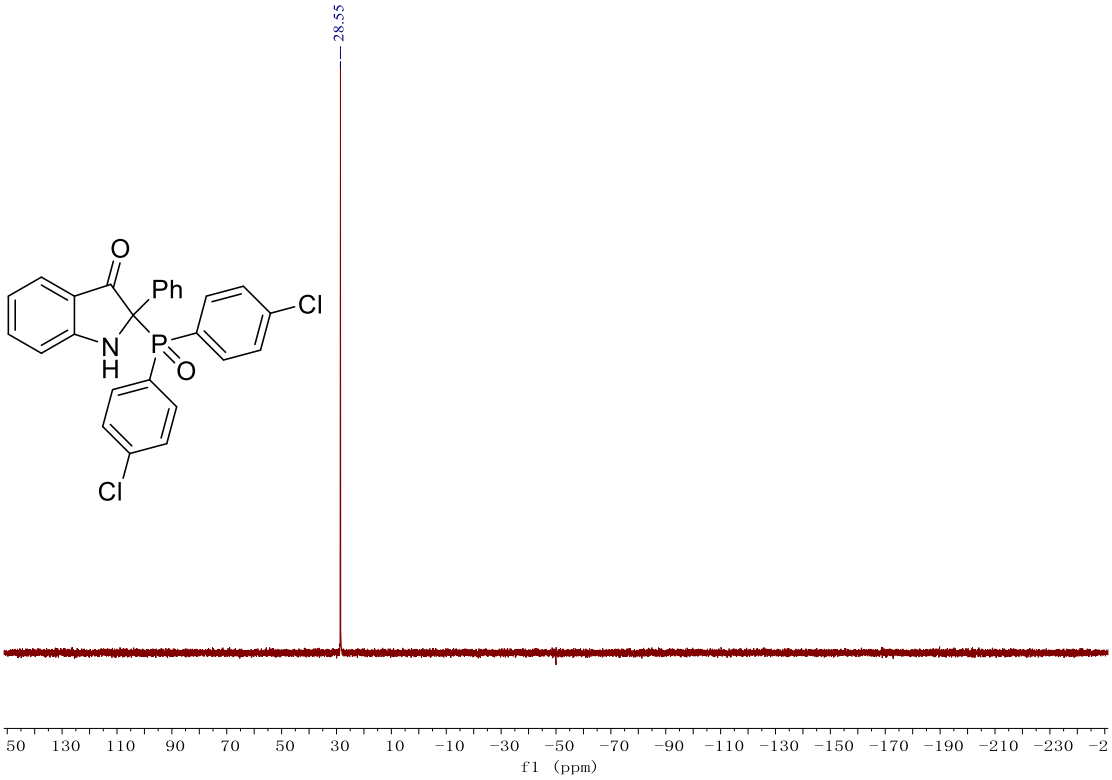

27.61
O
Ph
F
N
H
P
O
F
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)


115.65
115.73
O
Ph
F
N
H
P
O
F
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

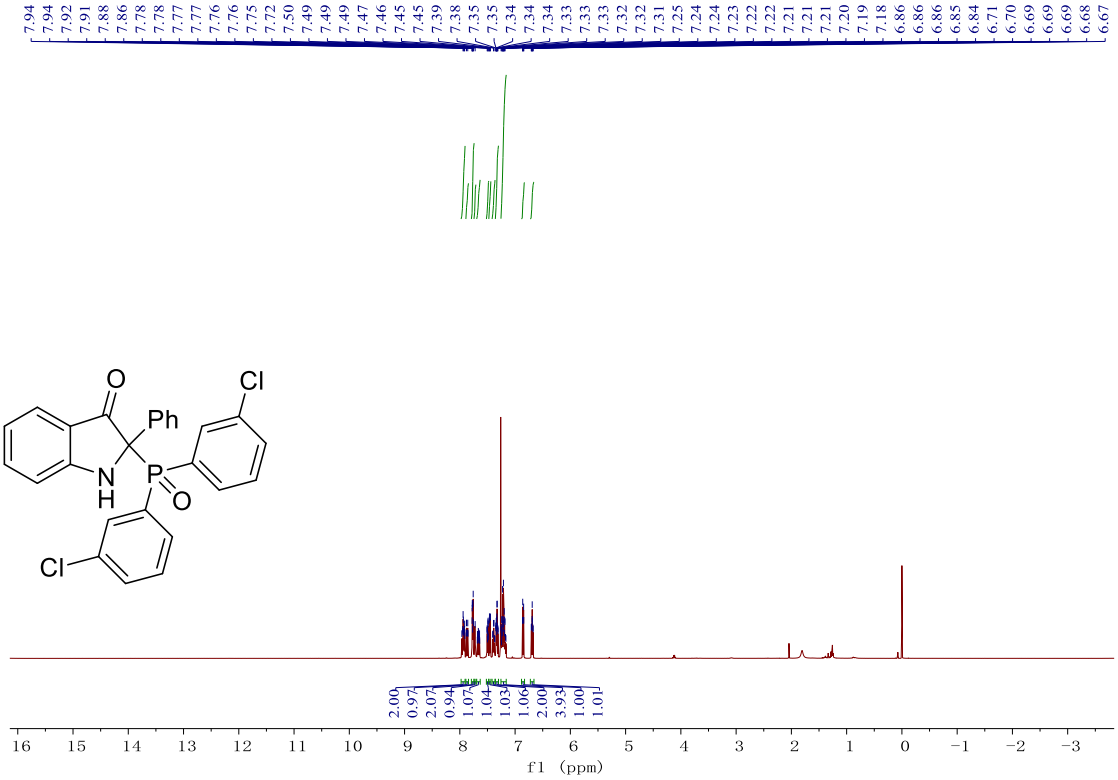
2-(bis(4-chlorophenyl)phosphoryl)-2-phenylindolin-3-one (3i)

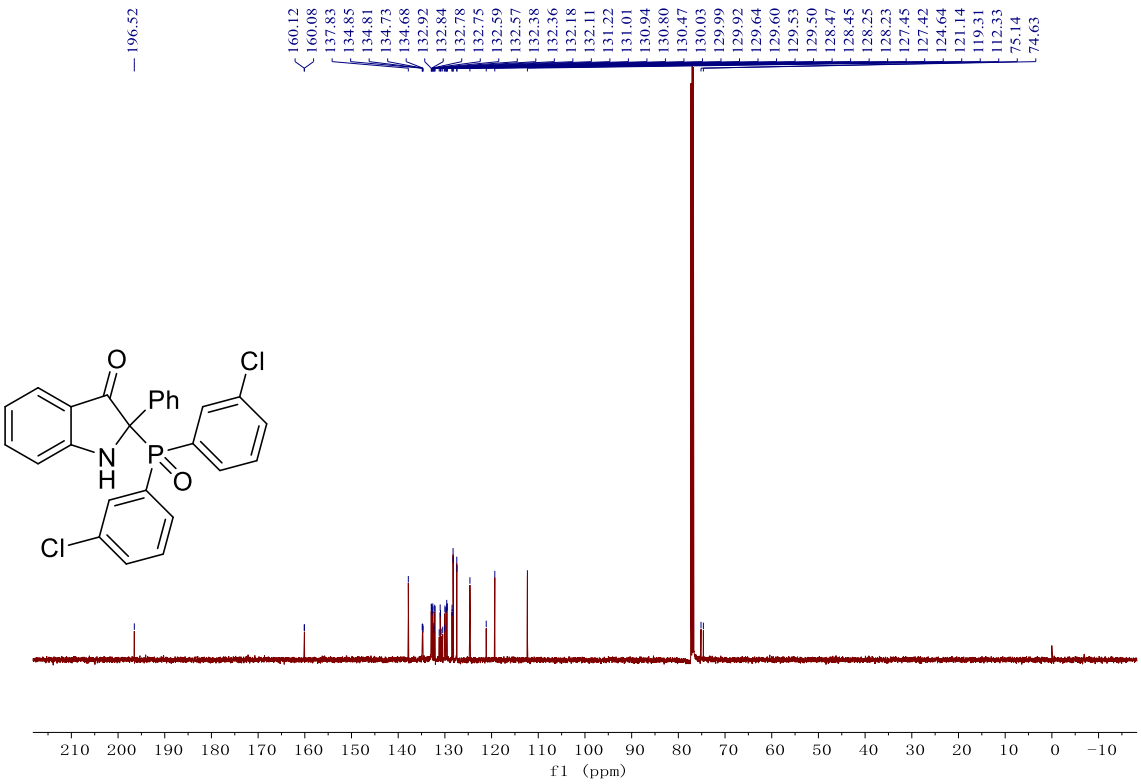


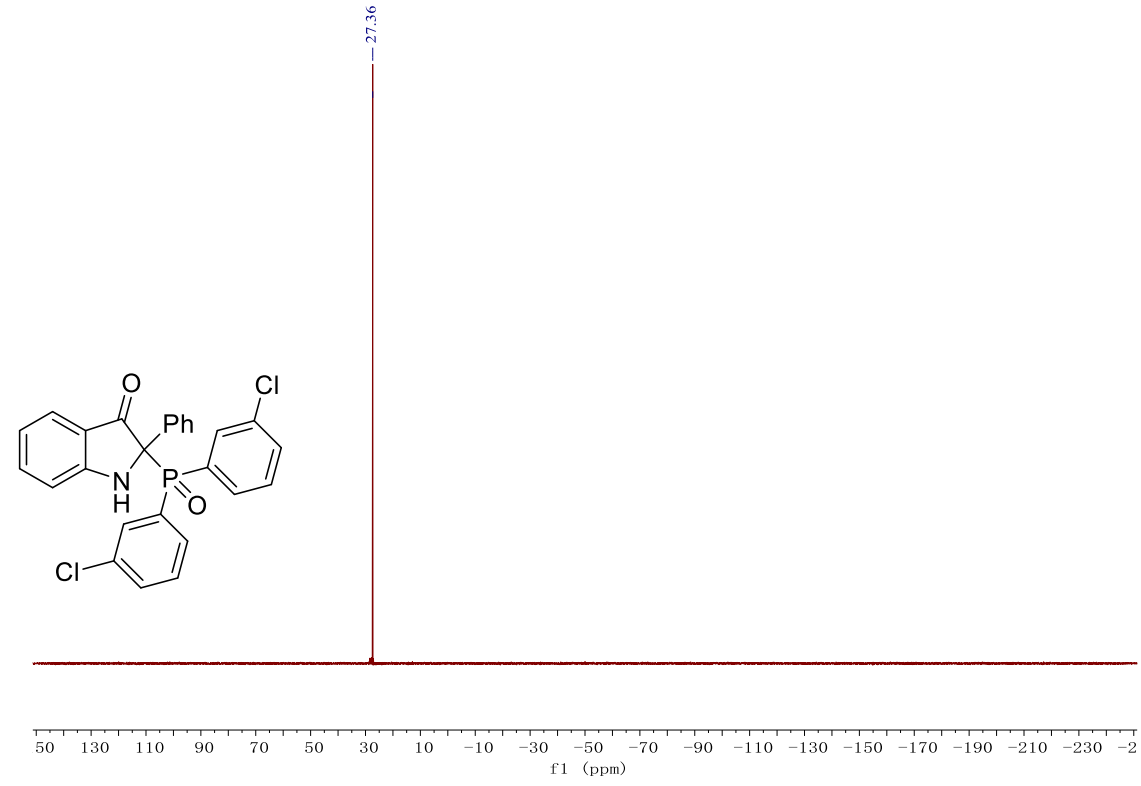




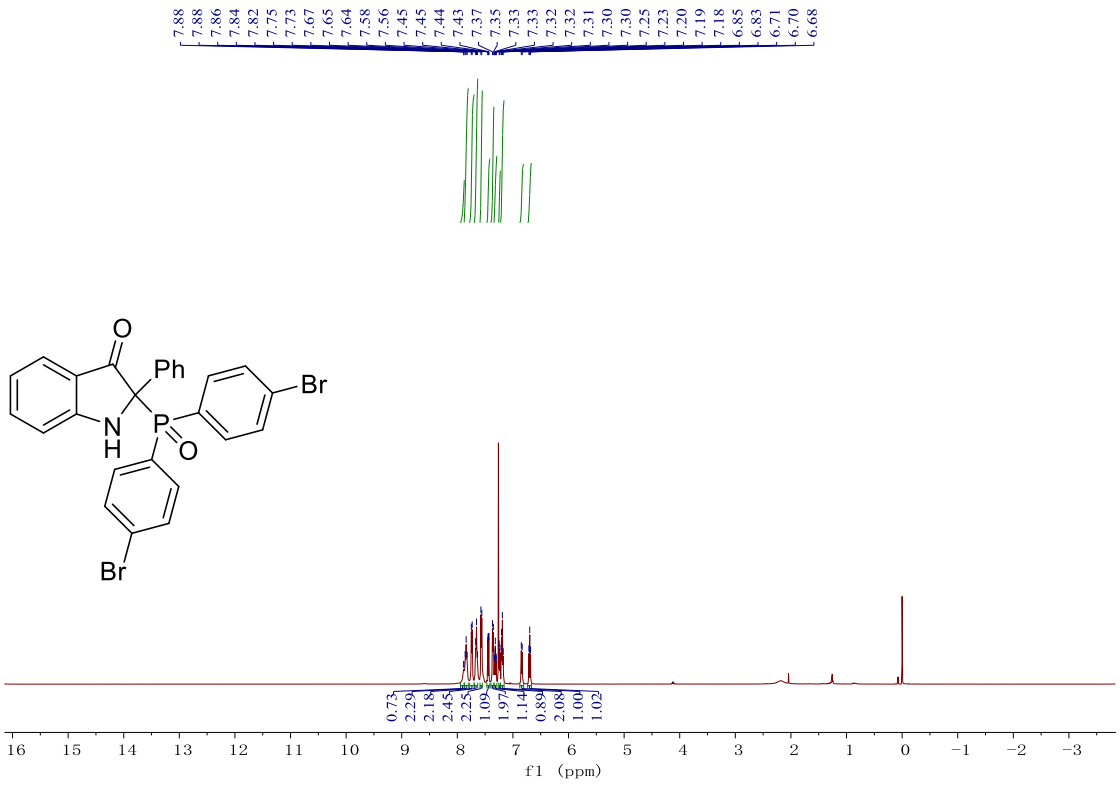
2-(bis(3-chlorophenyl)phosphoryl)-2-phenylindolin-3-one (3j)

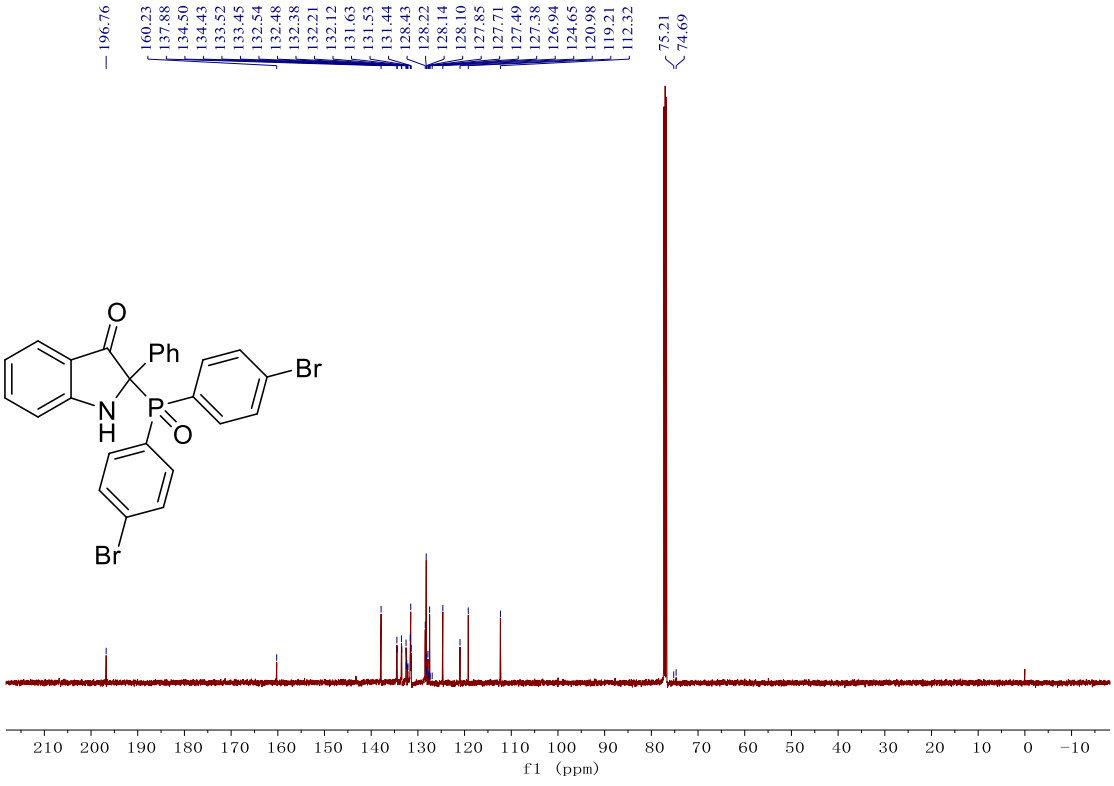


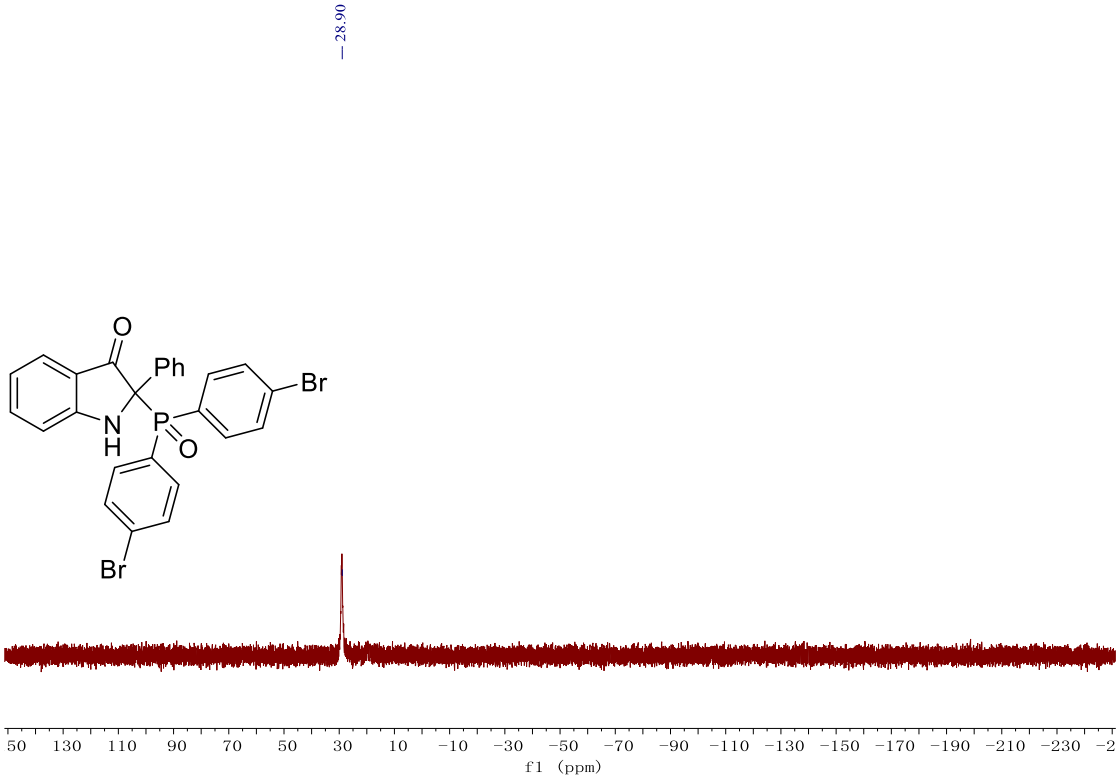

196.52
160.12
160.08
137.83
134.85
134.81
134.73
134.68
132.92
132.84
132.78
132.75
132.59
132.57
132.38
132.36
132.18
132.11
131.22
131.01
130.94
130.80
130.47
130.03
129.99
129.92
129.64
129.60
129.53
129.50
128.47
128.45
128.25
128.23
127.45
127.42
124.64
121.14
119.31
112.33
75.14
74.63
O
Ph
Cl
N
H
P
O
Cl
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


27.36
O
Ph
Cl
N
H
P
O
Cl
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

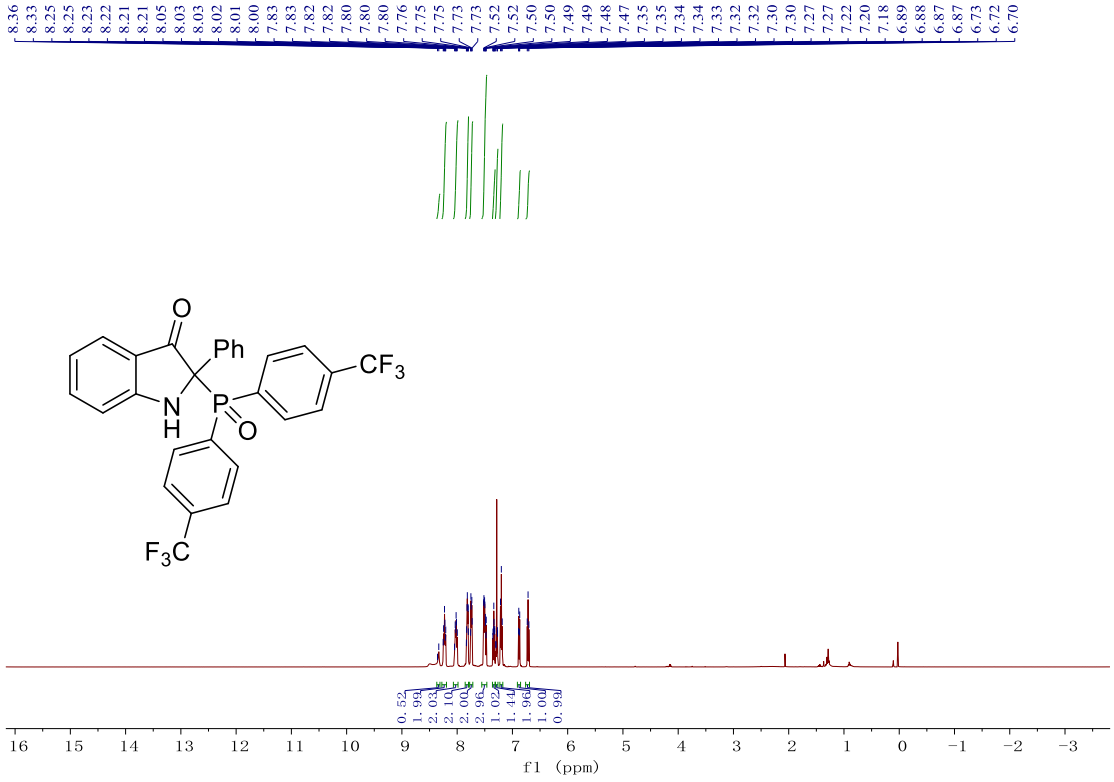
2-(bis(4-bromophenyl)phosphoryl)-2-phenylindolin-3-one (3k)

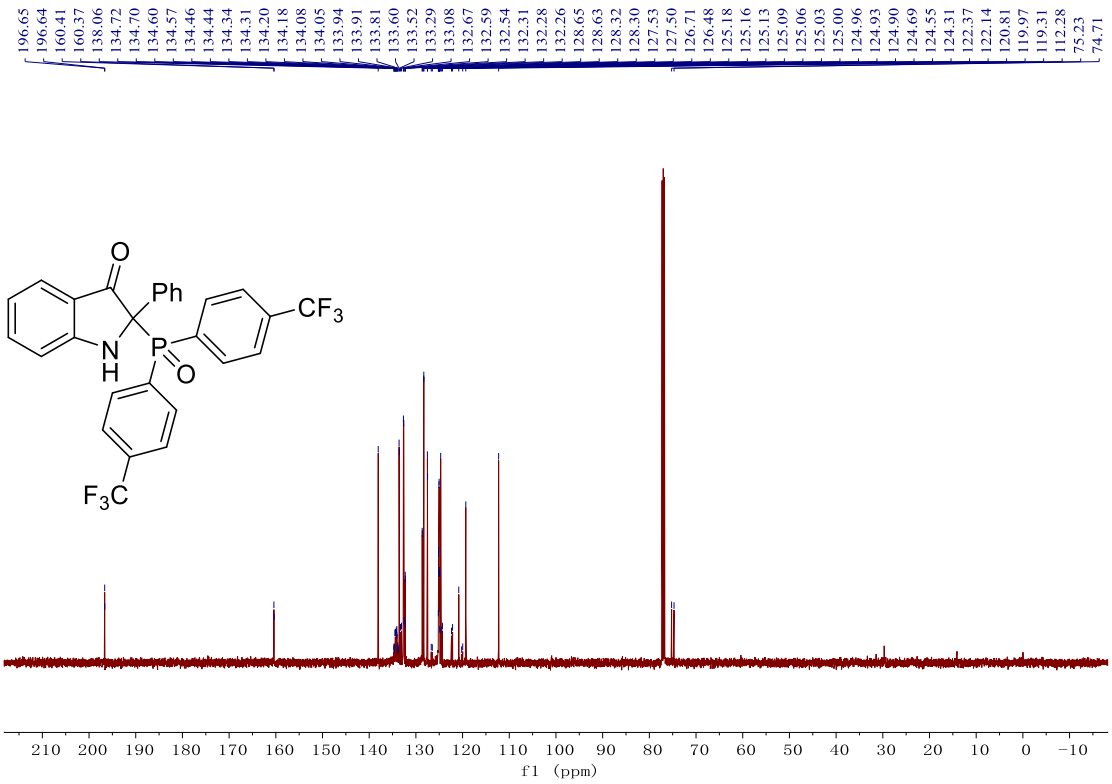


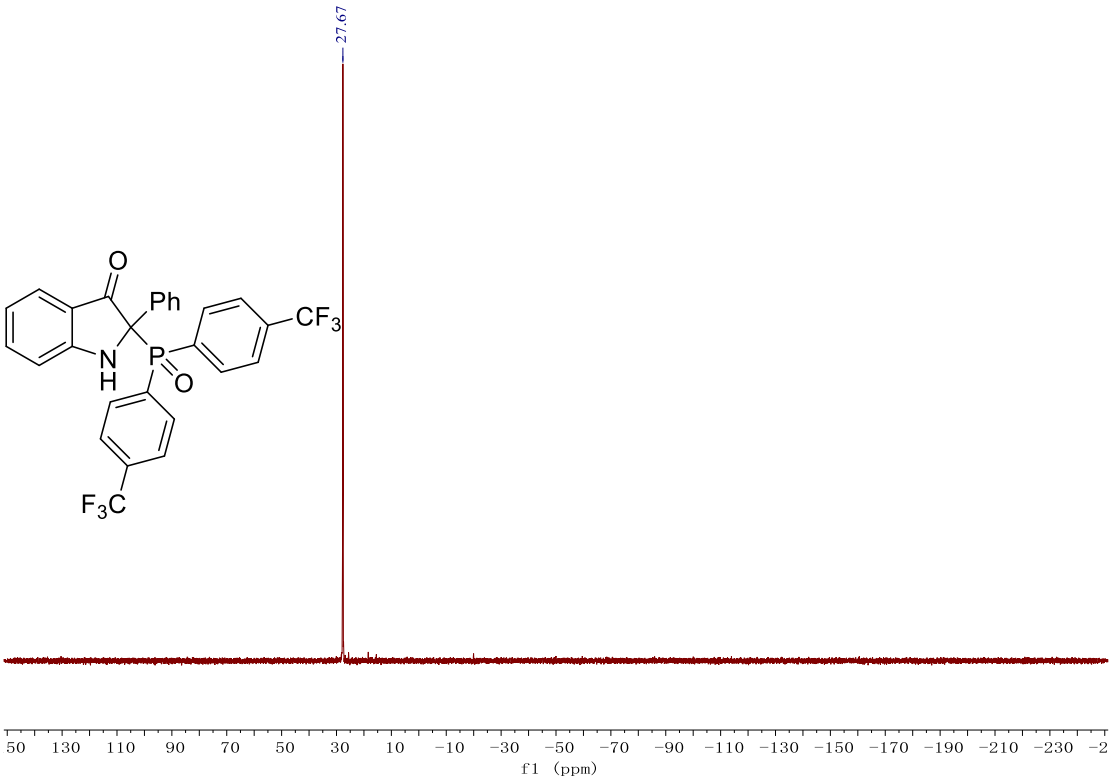


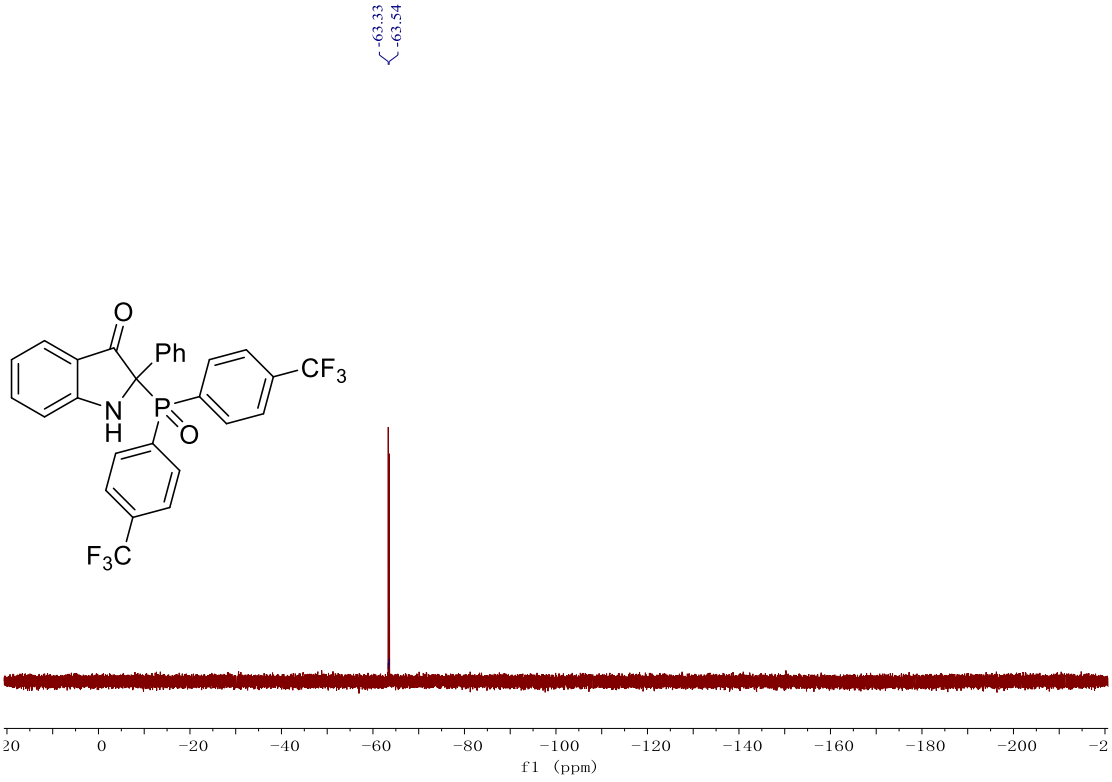


2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3l)

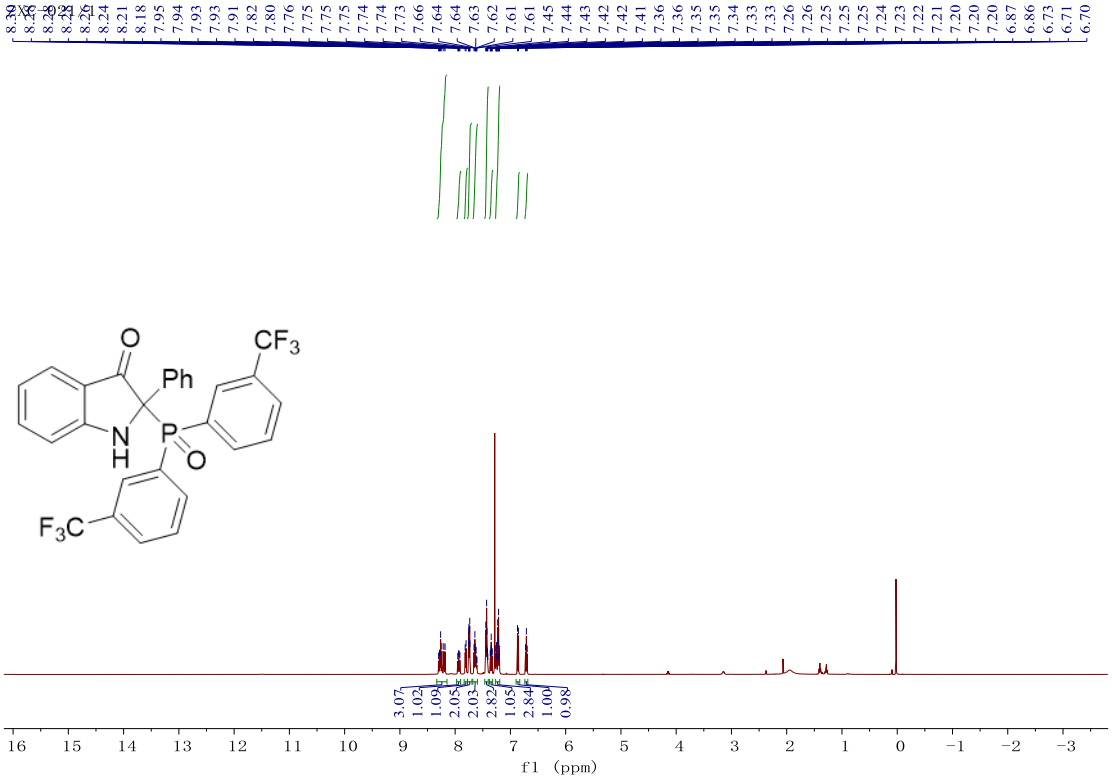


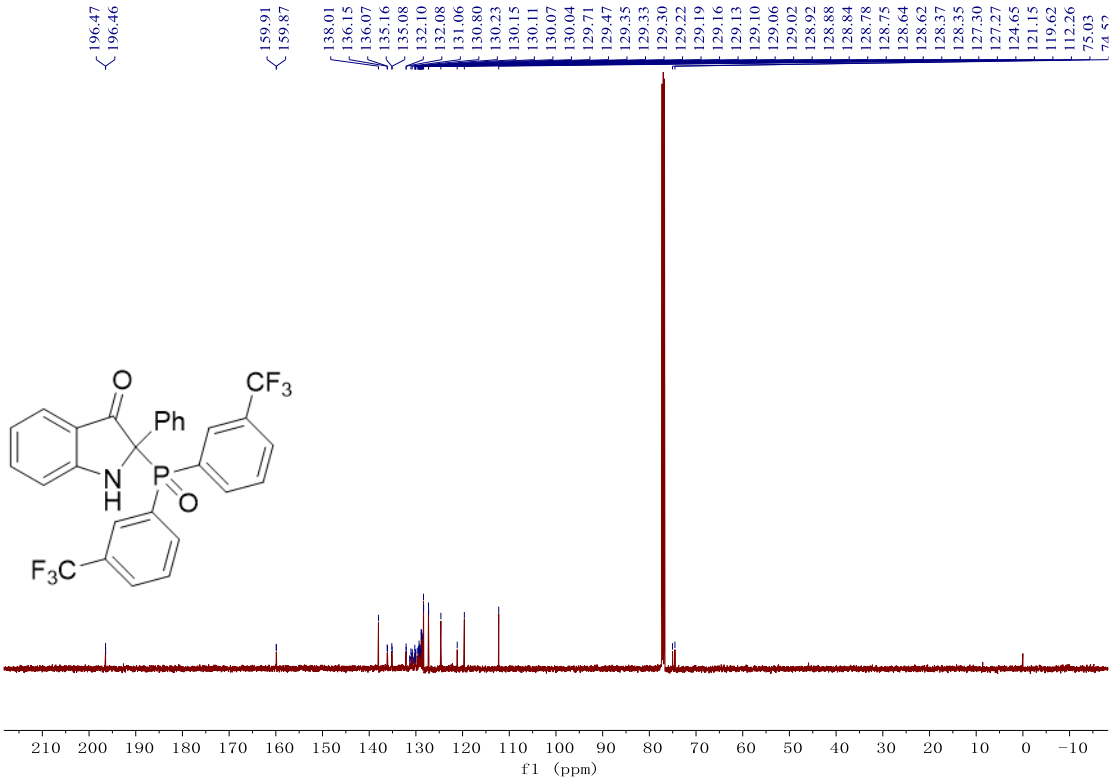

196.65
196.64
160.41
160.37
138.06
134.72
134.70
134.60
134.57
134.46
134.44
134.34
134.31
134.20
134.18
134.08
134.05
133.94
133.91
133.81
133.60
133.52
133.29
133.08
132.67
132.59
132.54
132.31
132.28
132.26
128.65
128.63
128.32
128.30
127.53
127.50
126.71
126.48
125.18
125.16
125.13
125.09
125.06
125.03
125.00
124.96
124.93
124.90
124.69
124.55
124.31
122.37
122.14
120.81
119.97
119.31
112.28
75.23
74.71
O
Ph
CF3
N
H
P
O
F3C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

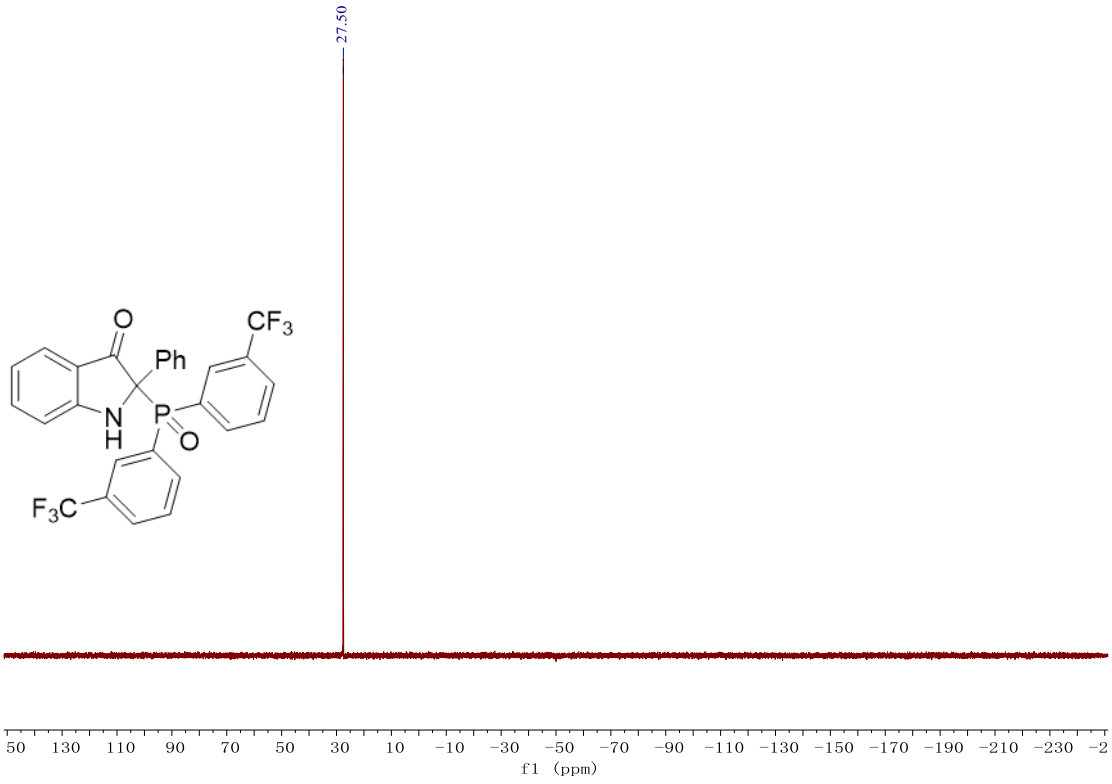

27.67
O
Ph
CF3
N
H
P
O
F3C
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

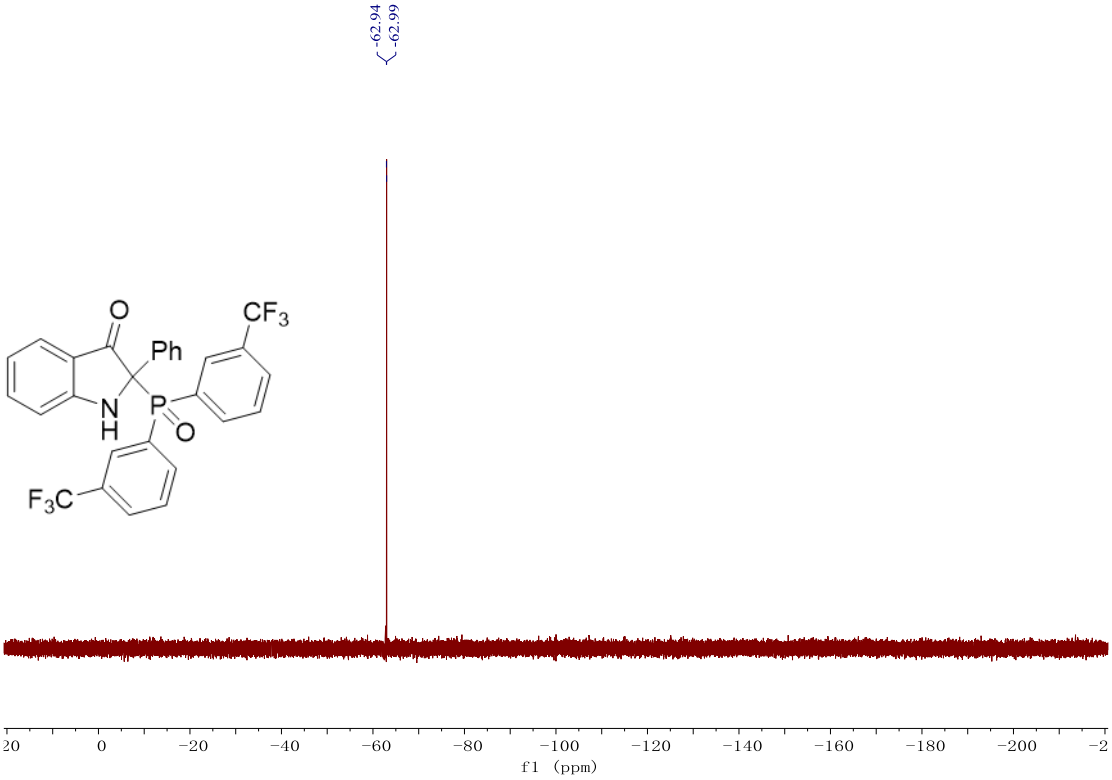


2-(bis(3-(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3m)

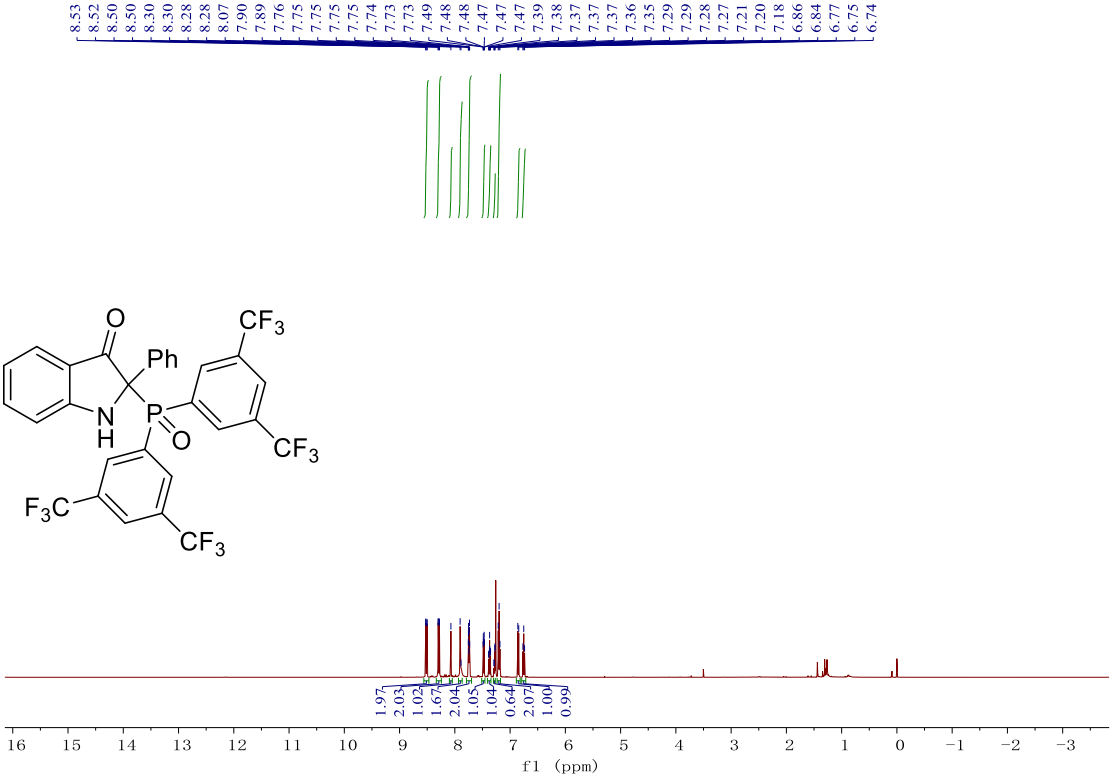


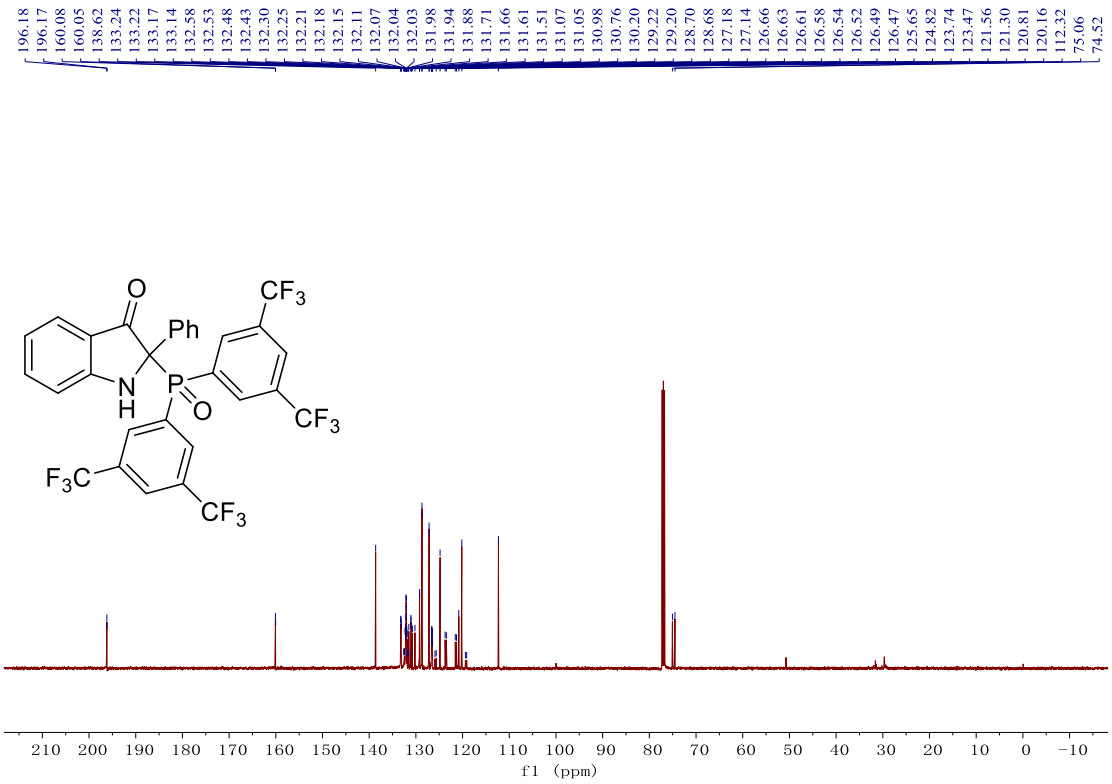

196.47
196.46
159.91
159.87
138.01
136.15
136.07
135.16
135.08
132.10
132.08
131.06
130.80
130.23
130.15
130.11
130.07
130.04
129.71
129.47
129.35
129.33
129.30
129.22
129.19
129.16
129.13
129.10
129.06
129.02
128.92
128.88
128.84
128.78
128.75
128.64
128.62
128.37
128.35
127.30
127.27
124.65
121.15
119.62
112.26
75.03
O
Ph
CF3
N
H
P
O
F3C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

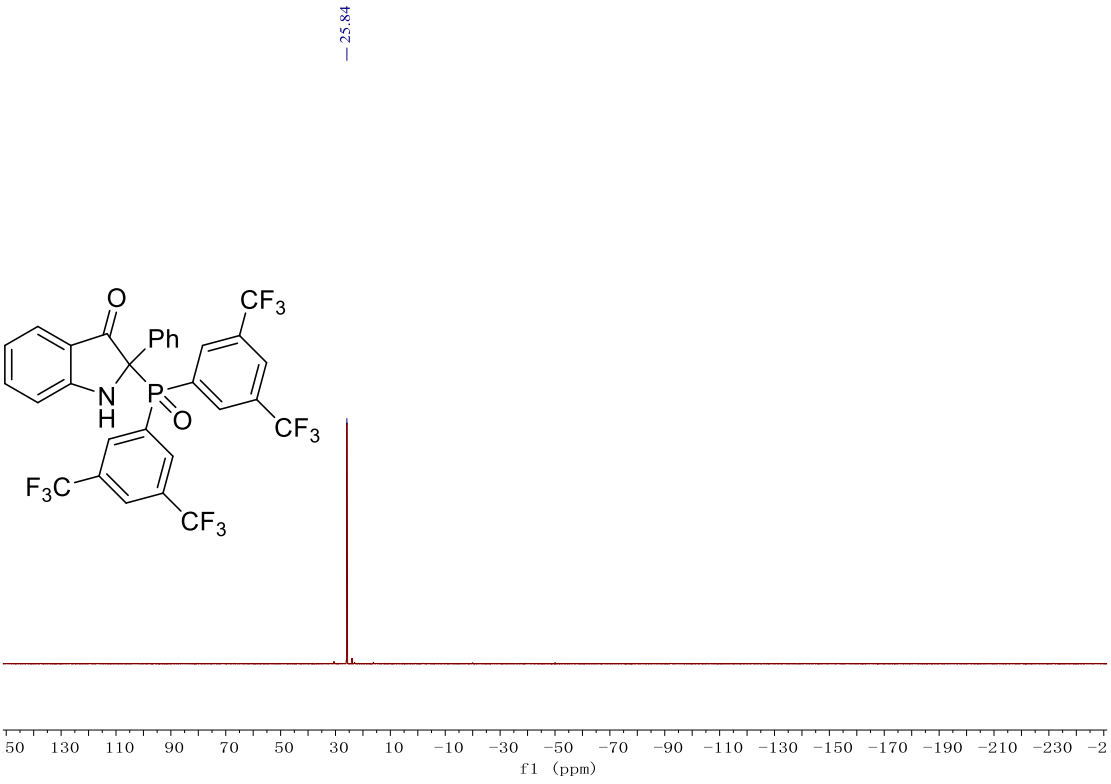

27.50
O
Ph
CF3
N
H
P
O
F3C
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

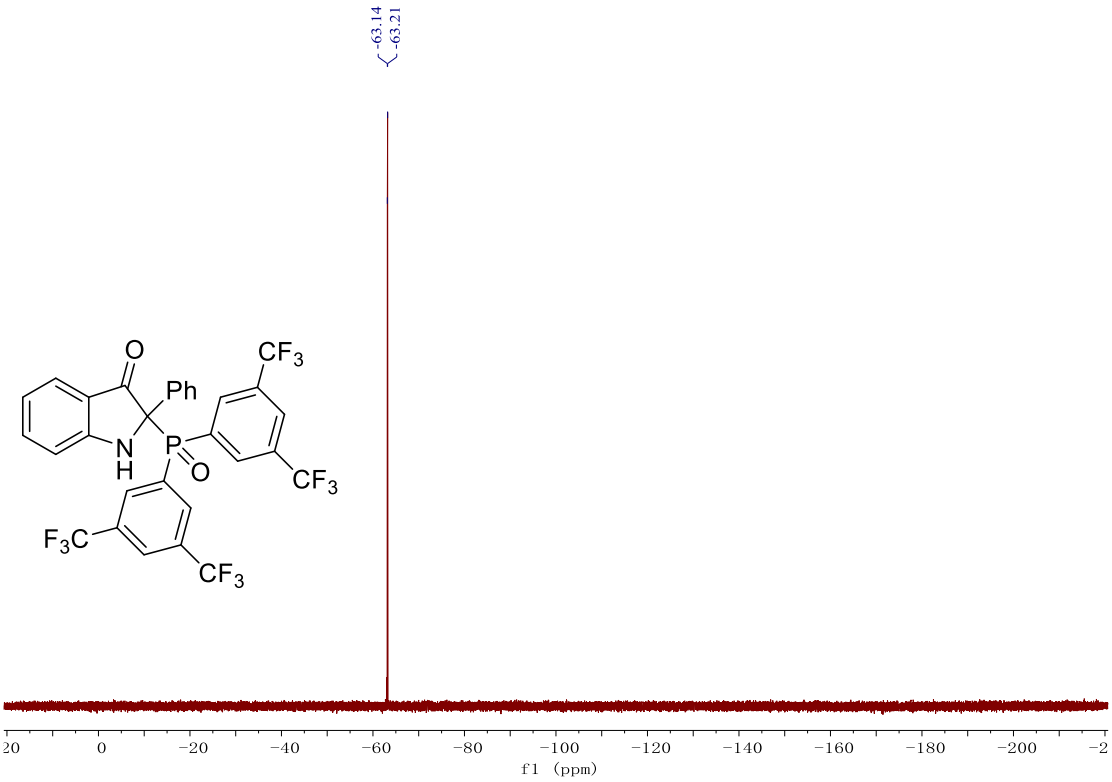


2-(bis(3-(trifluoromethyl)phenyl)phosphoryl)-2-phenylindolin-3-one (3n).

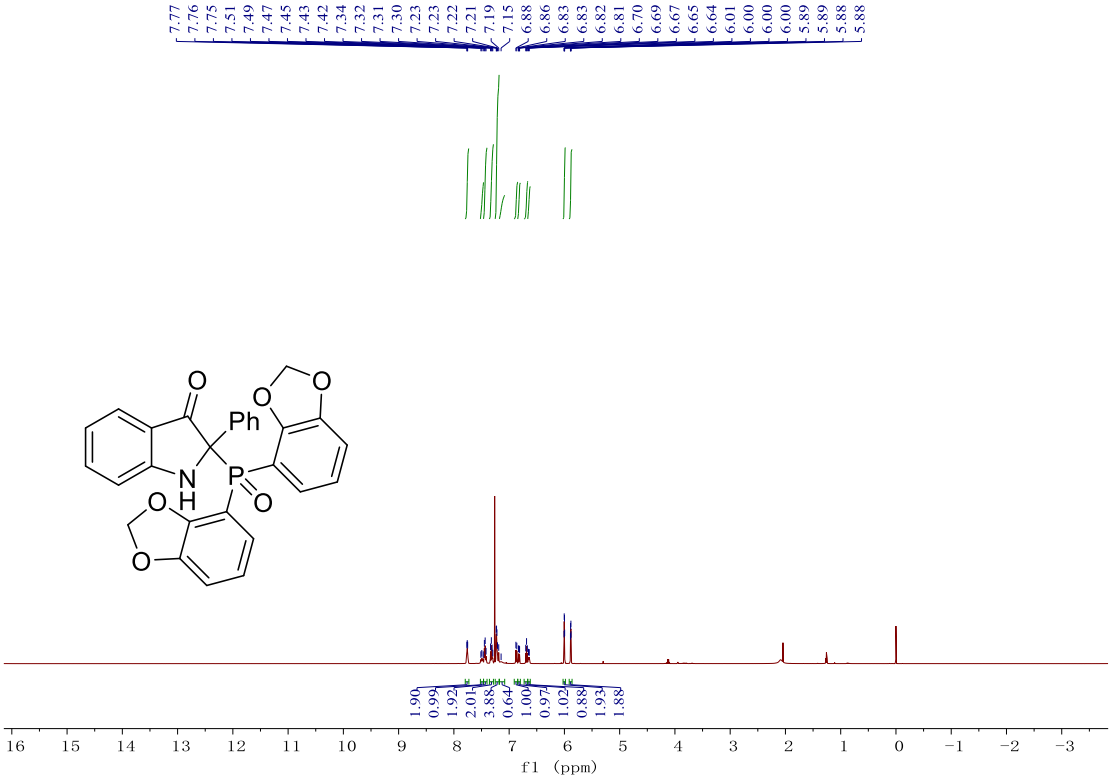


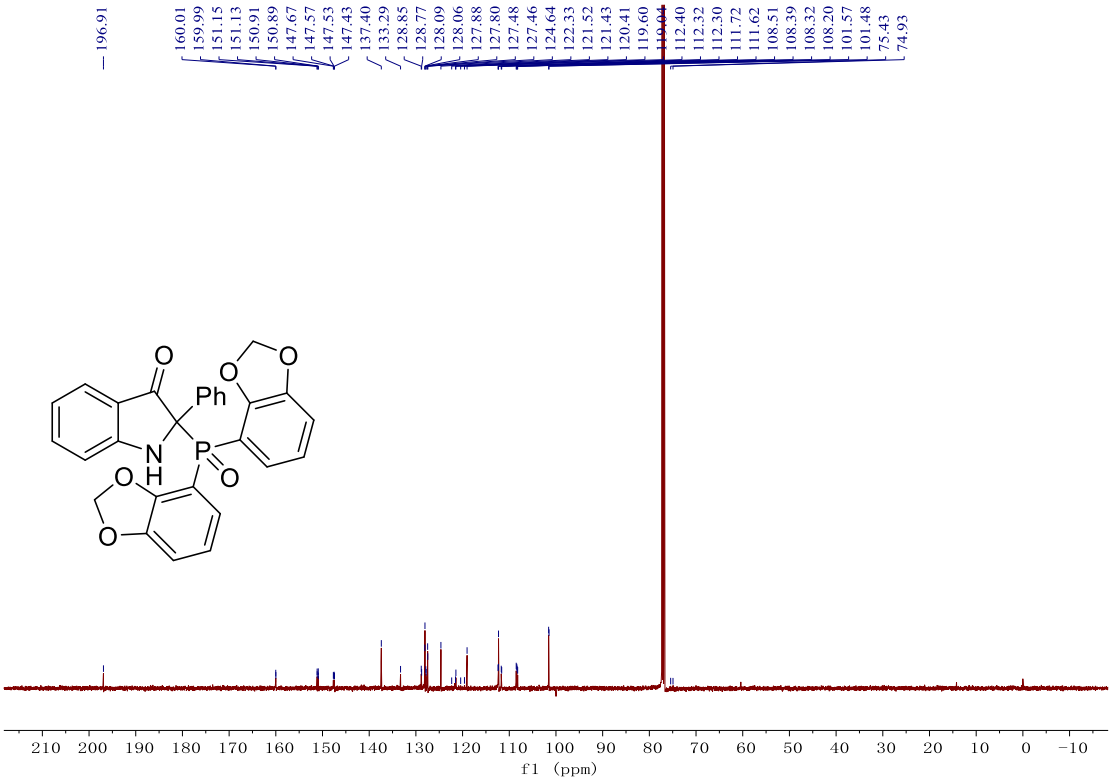

196.18
196.17
160.08
160.05
138.62
133.24
133.22
133.17
133.14
132.58
132.53
132.48
132.43
132.30
132.25
132.21
132.18
132.15
132.11
132.07
132.04
132.03
131.98
131.94
131.88
131.71
131.66
131.61
131.51
131.07
131.05
130.98
130.76
130.20
129.22
129.20
128.70
128.68
127.18
127.14
126.66
126.63
126.61
126.58
126.54
126.52
126.49
126.47
125.65
124.82
123.74
123.47
121.56
121.30
120.81
120.16
112.32
75.06
74.52
O
Ph
N
H
P
O
CF3
CF3
F3C
CF3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

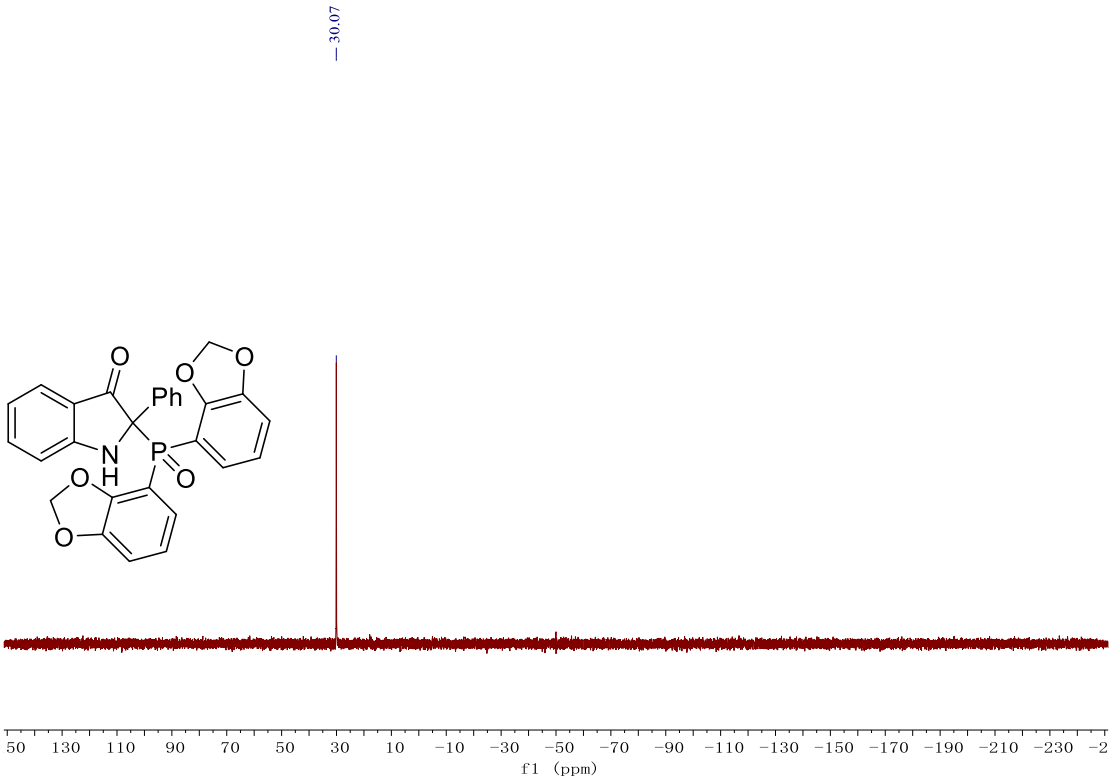

25.84
O
Ph
N
H
P
O
CF3
CF3
F3C
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)



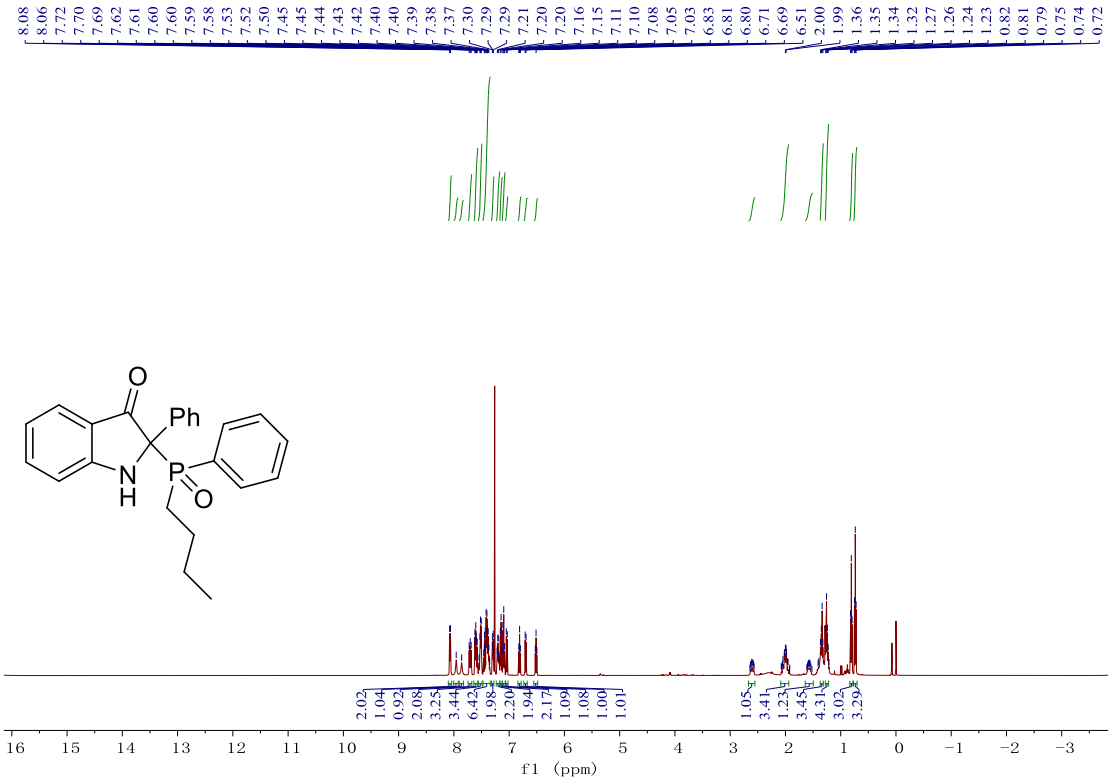
2-(bis(benzo[d][1,3]dioxol-4-yl)phosphoryl)-2-phenylindolin-3-one (3o)

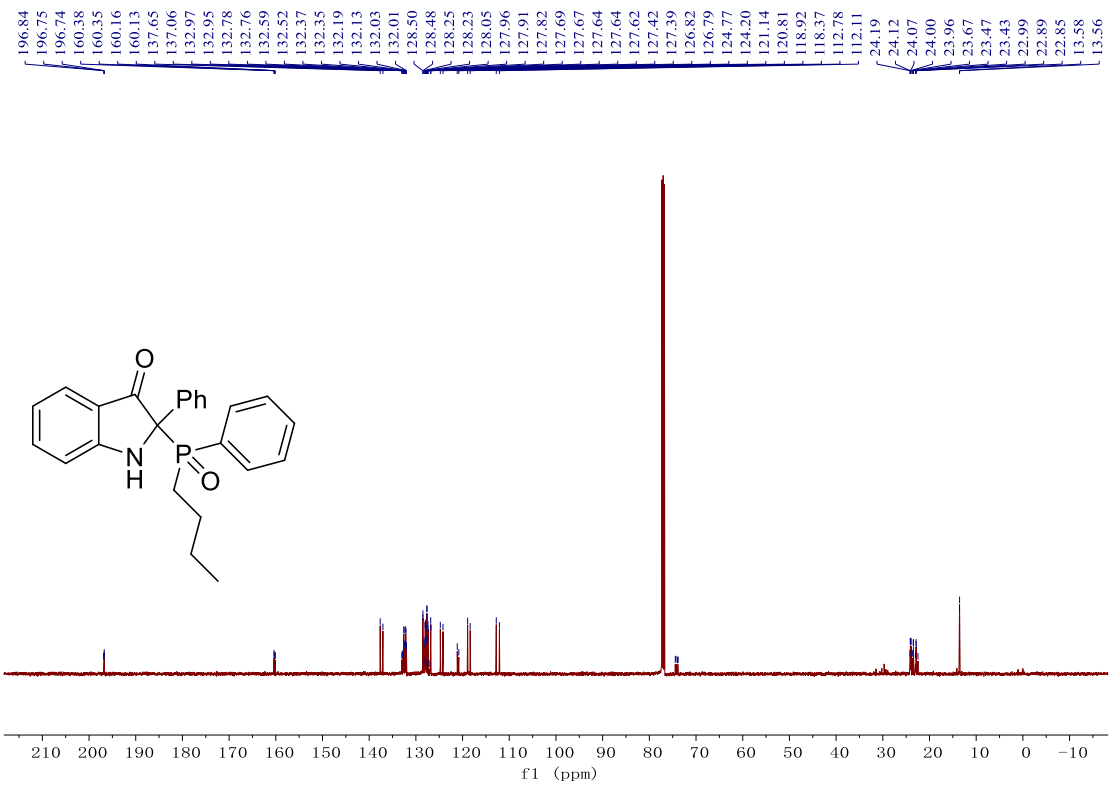


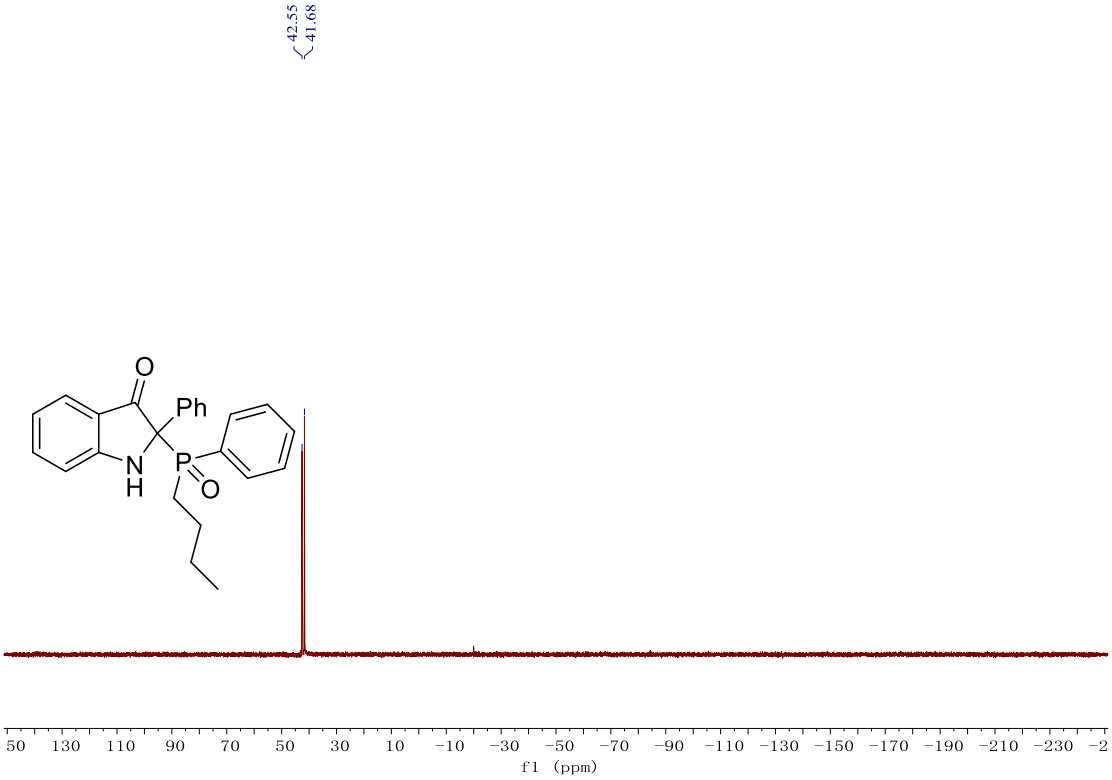

196.91
160.01
159.99
151.15
151.13
150.91
150.89
147.67
147.57
147.53
147.43
137.40
133.29
128.85
128.77
128.09
128.06
127.88
127.80
127.48
127.46
124.64
122.33
121.52
121.43
120.41
119.60
119.04
112.40
112.32
112.30
111.72
111.62
108.51
108.39
108.32
108.20
101.57
101.48
75.43
74.93
O
O
O
Ph
N
H
P
O
O
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


30.07
O
O
O
Ph
N
H
P
O
O
O
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

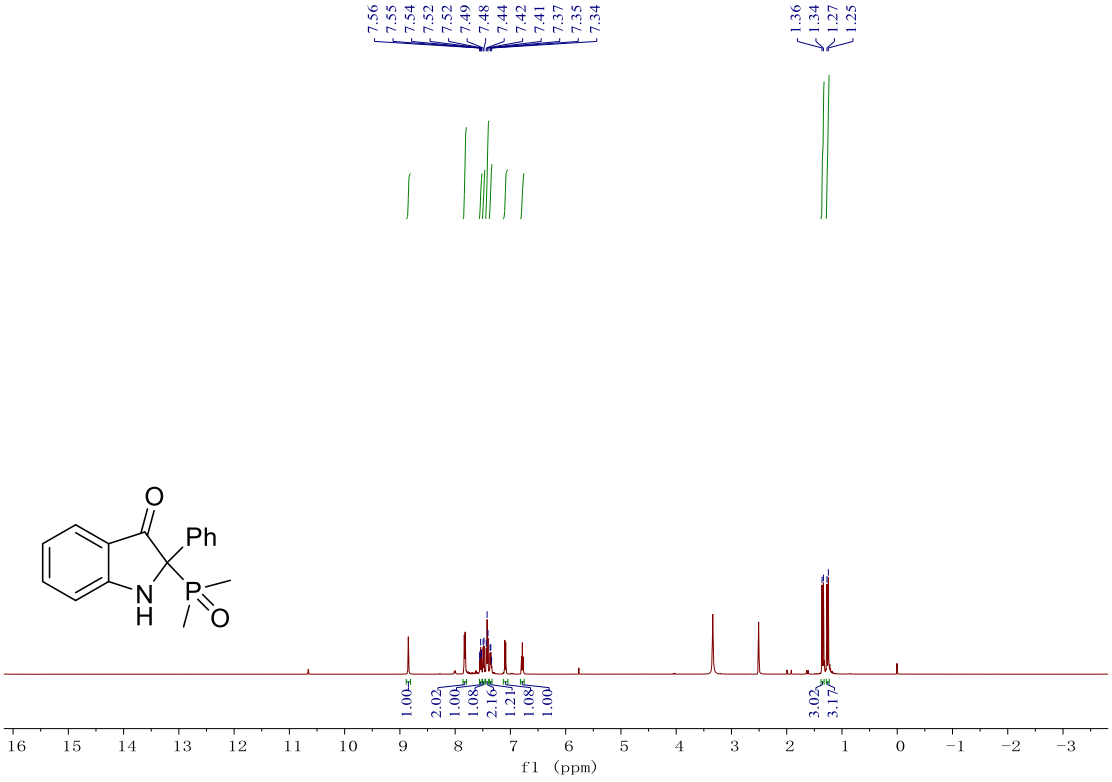
2-(butyl(phenyl)phosphoryl)-2-phenylindolin-3-one (3P)

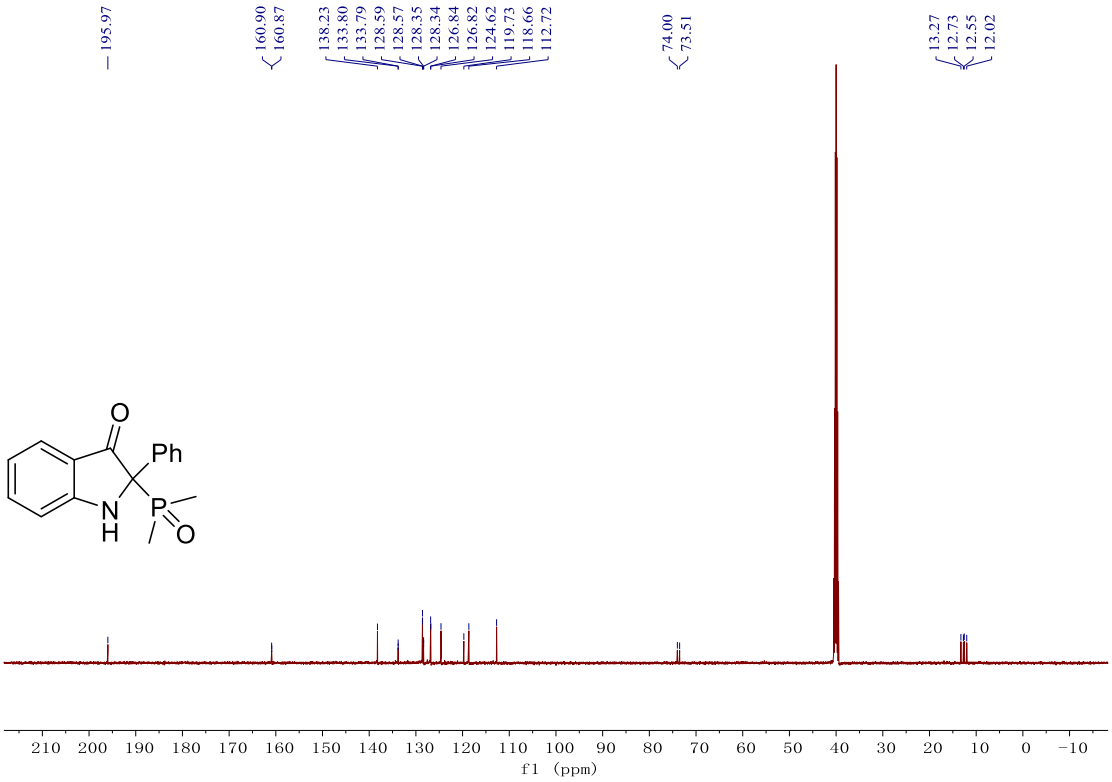


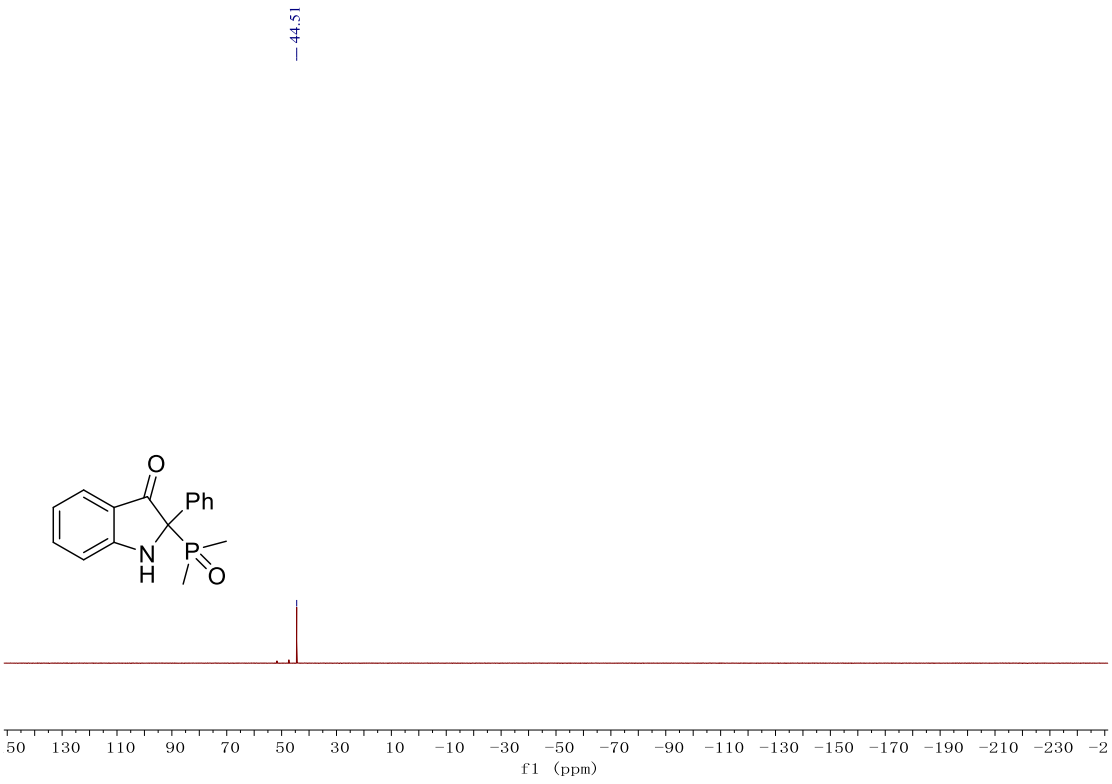




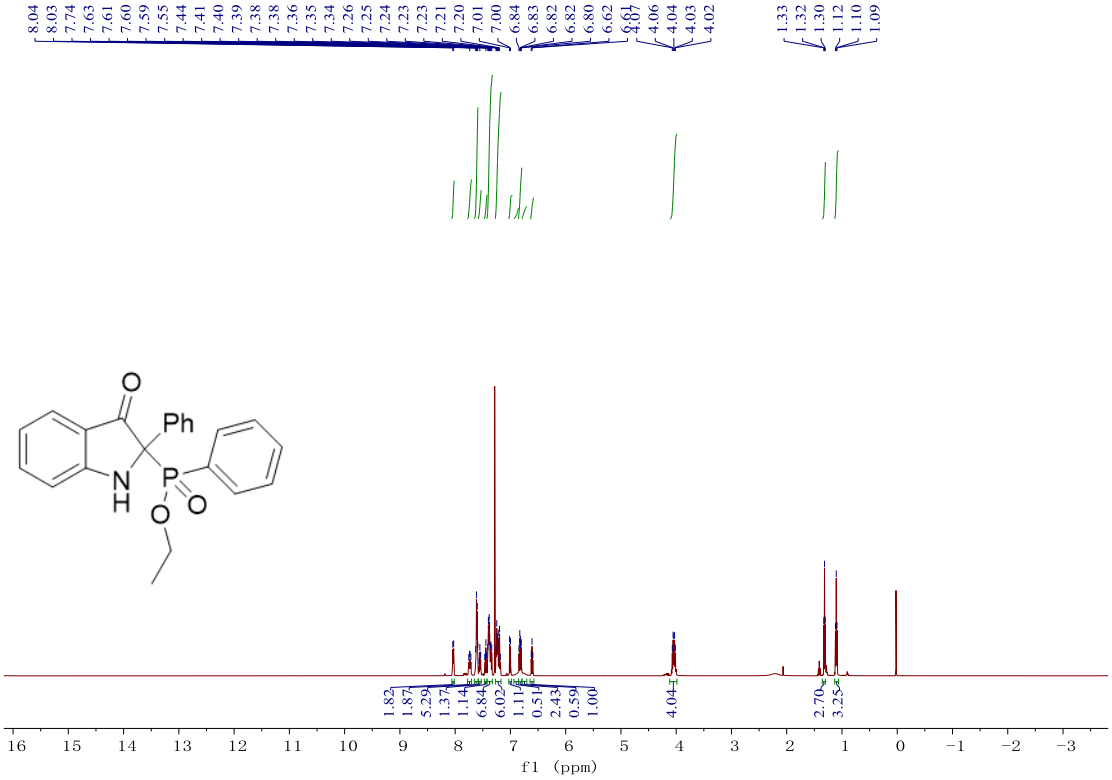
2-(dimethylphosphoryl)-2-phenylindolin-3-one (3q).

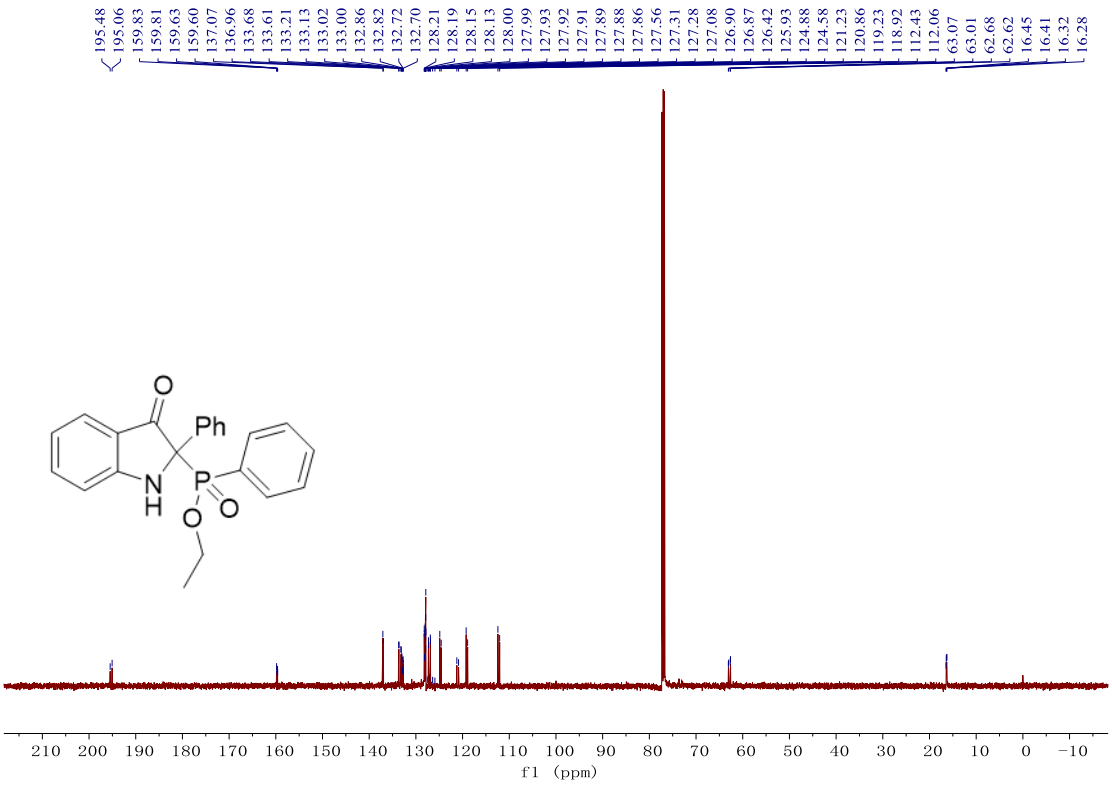


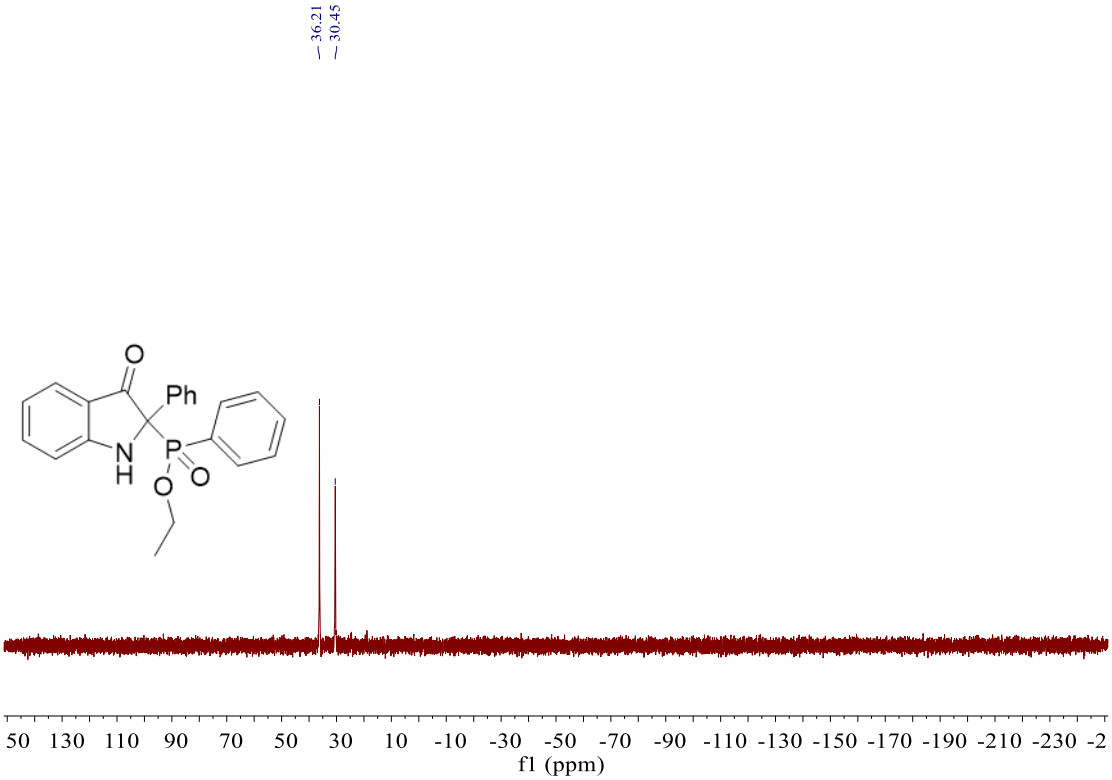

195.97
160.90
160.87
138.23
133.80
133.79
128.59
128.57
128.35
128.34
126.84
126.82
124.62
119.73
118.66
112.72
74.00
73.51
13.27
12.73
12.55
12.02
O
Ph
N
H
P
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


44.51
O
Ph
N
H
P
O
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

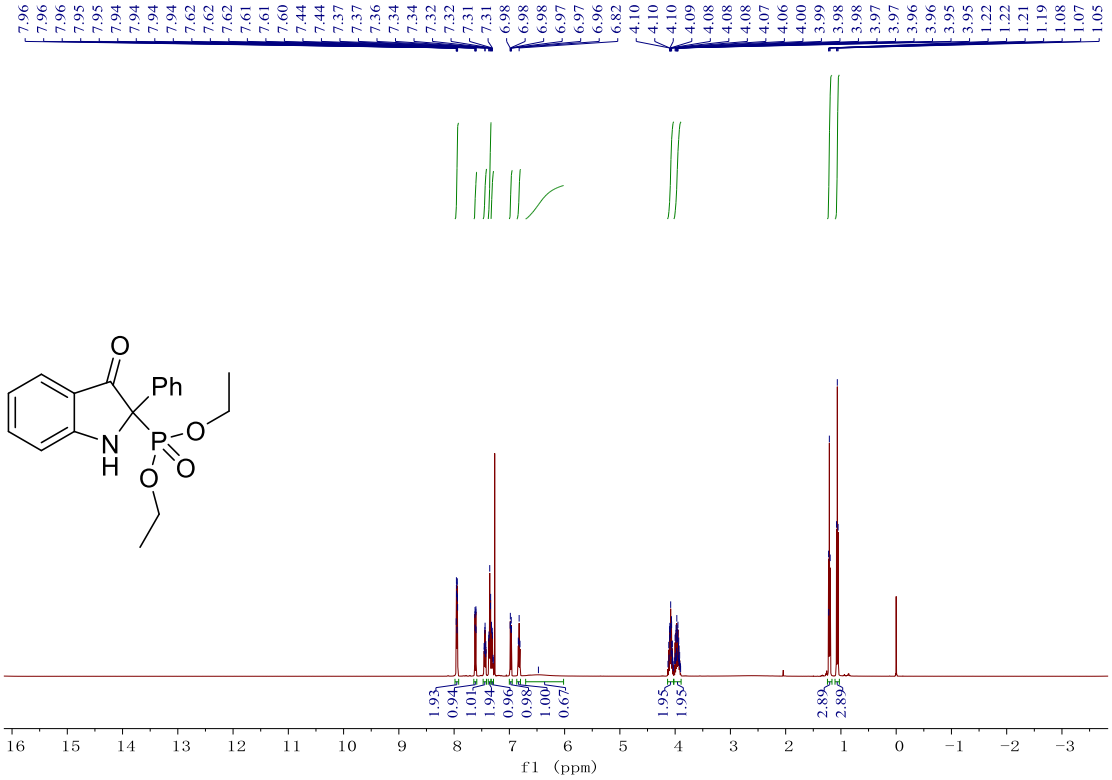
ethyl ((S)-3-oxo-2-phenylindolin-2-yl)(phenyl)phosphinate (3r).

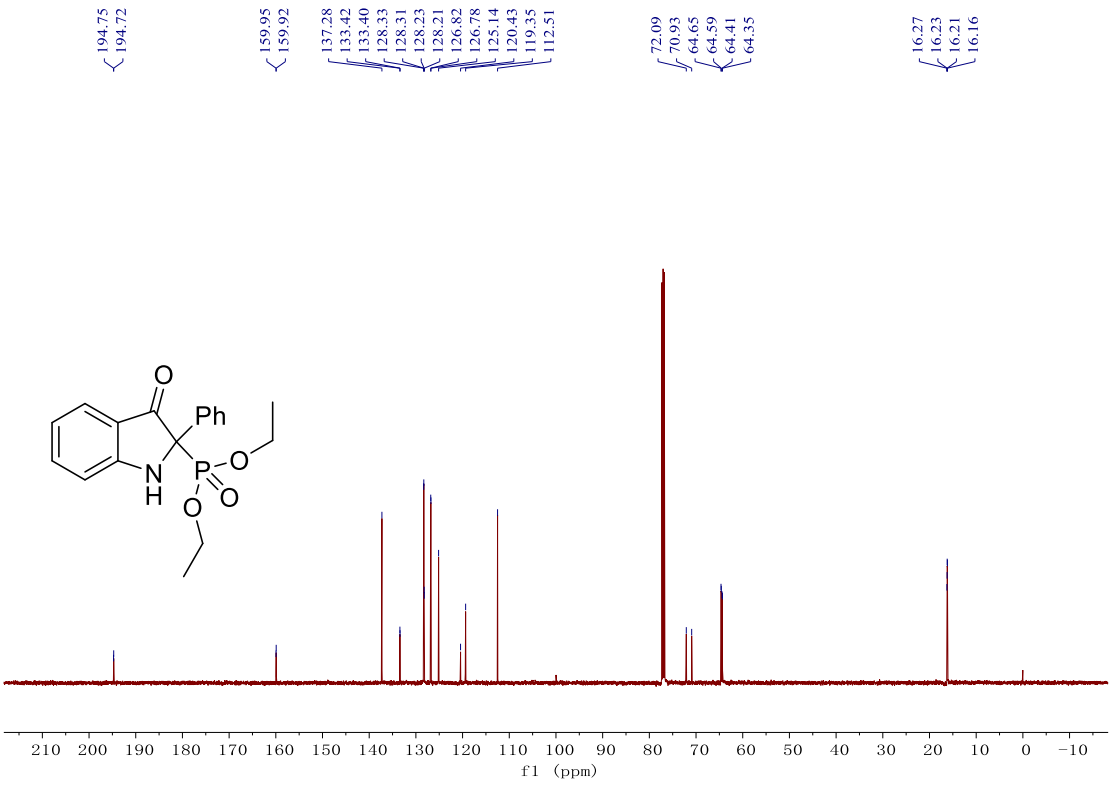


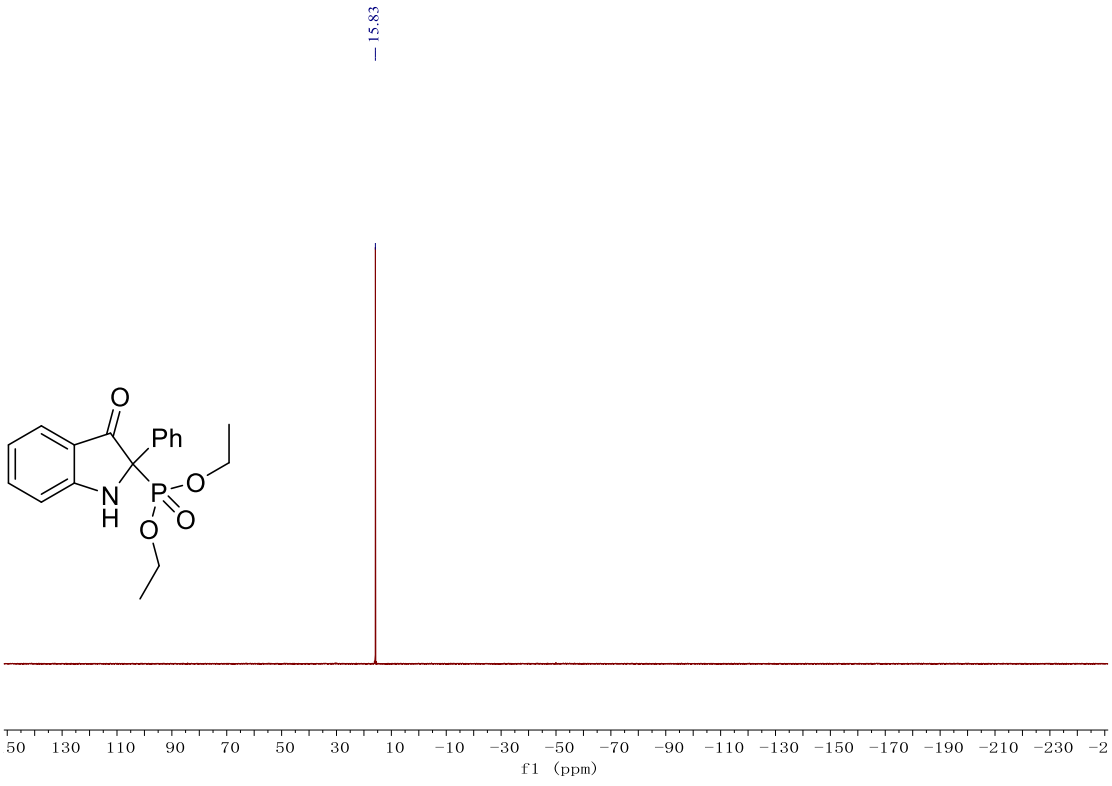




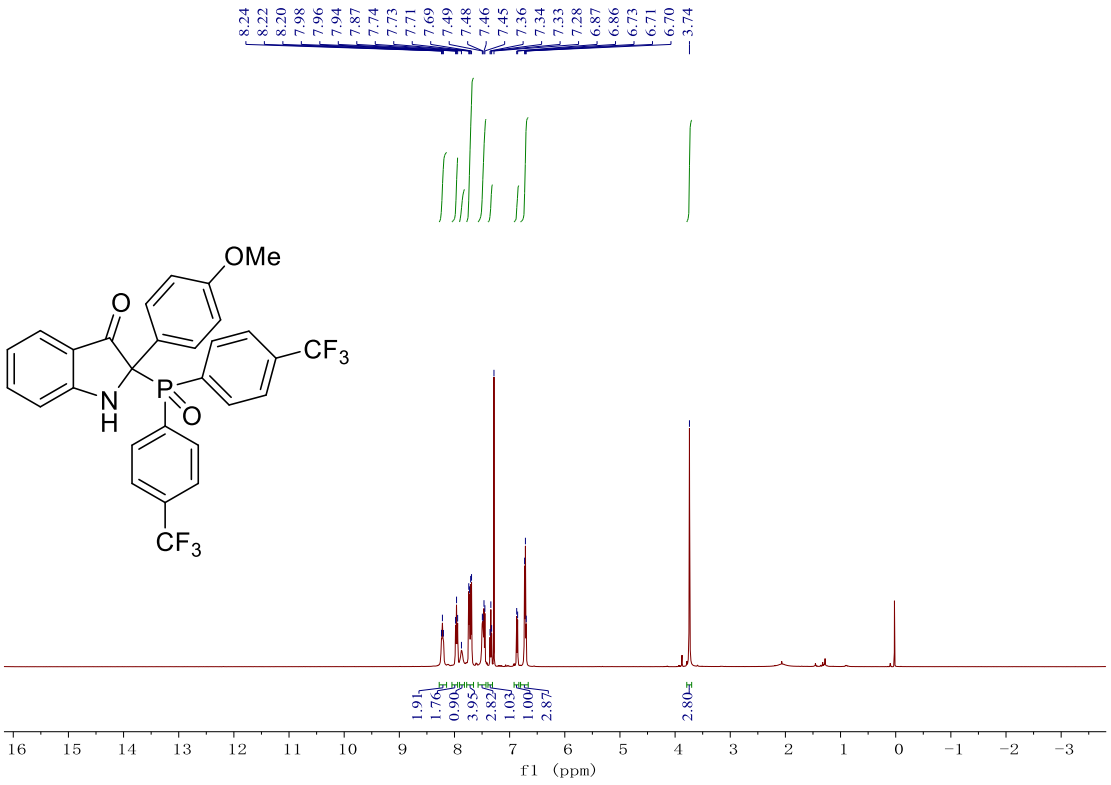
diethyl-(3-oxo-2-phenylindolin-2-yl)phosphonate (3s)

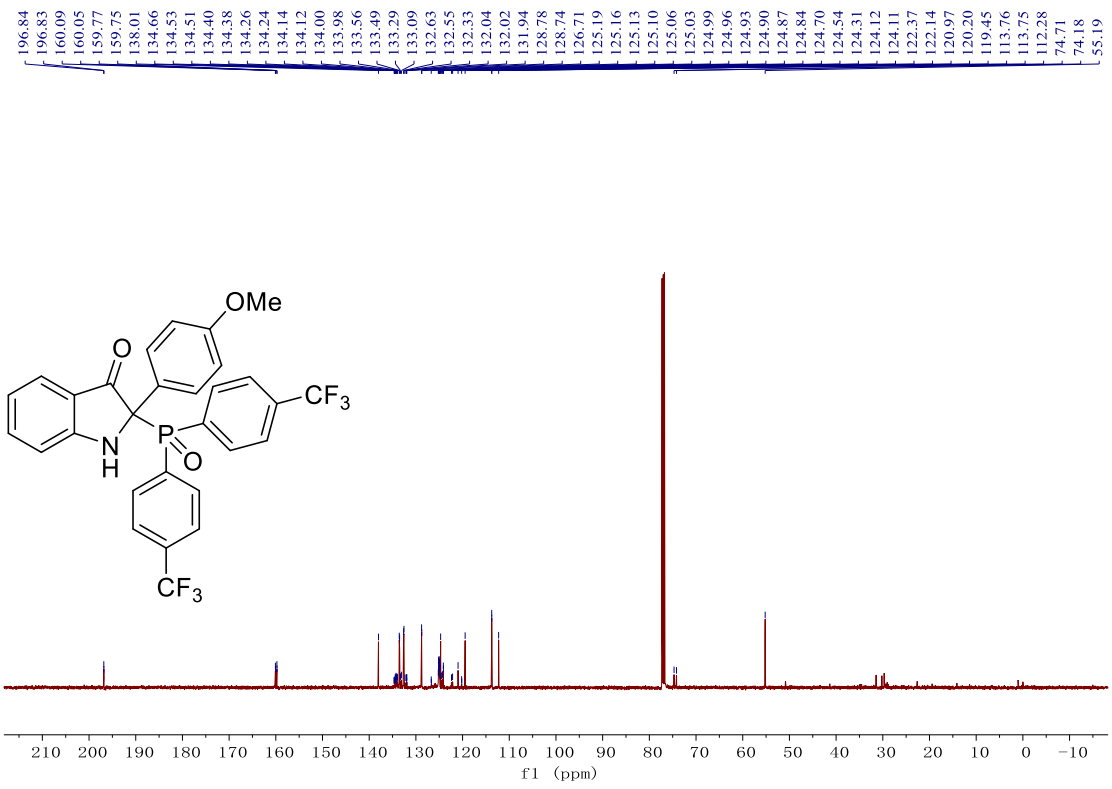


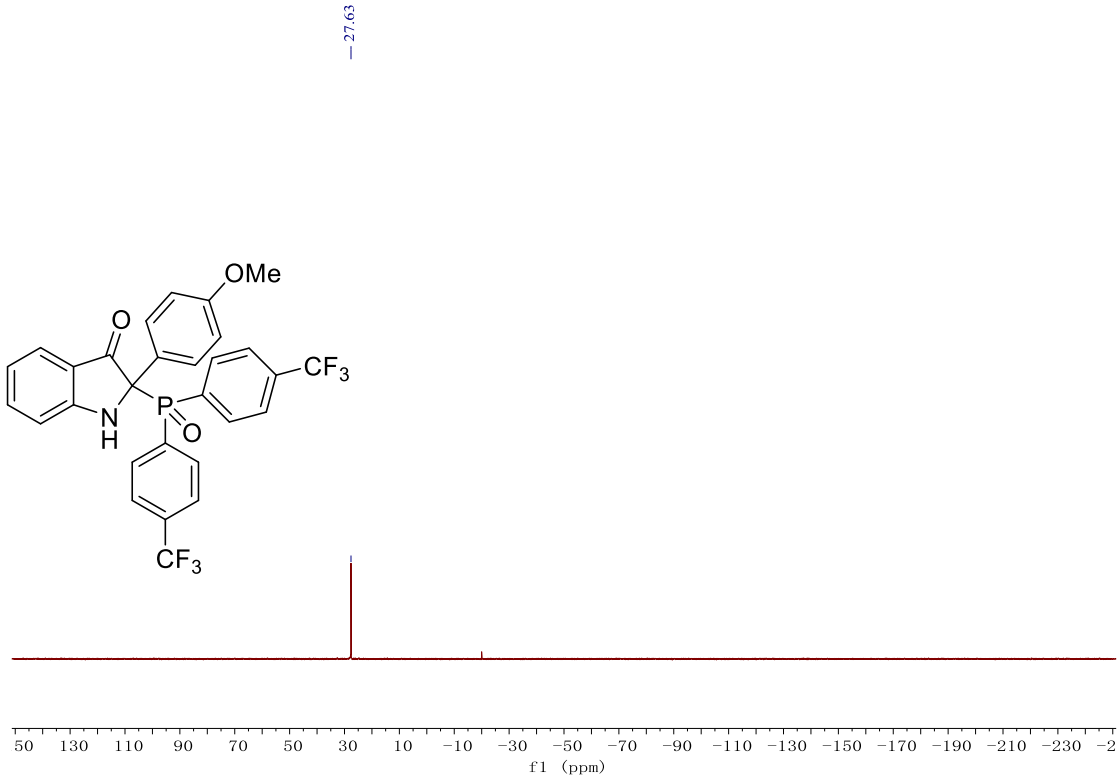

194.75
194.72
159.95
159.92
137.28
133.42
133.40
128.33
128.31
128.23
128.21
126.82
126.78
125.14
120.43
119.35
112.51
72.09
70.93
64.65
64.59
64.41
64.35
16.27
16.23
16.21
16.16
O
Ph
N
H
P
O
O
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

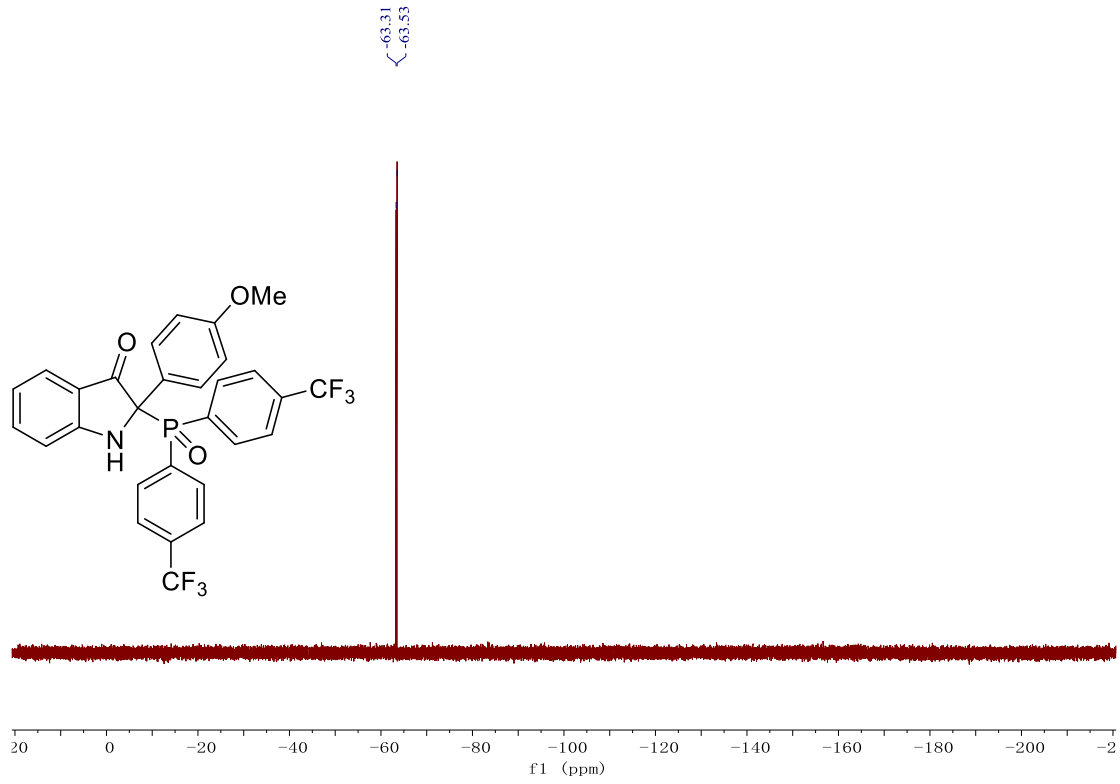

15.83
O
Ph
N
H
P
O
O
O
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(4-methoxyphenyl)indolin-3-one(3t)

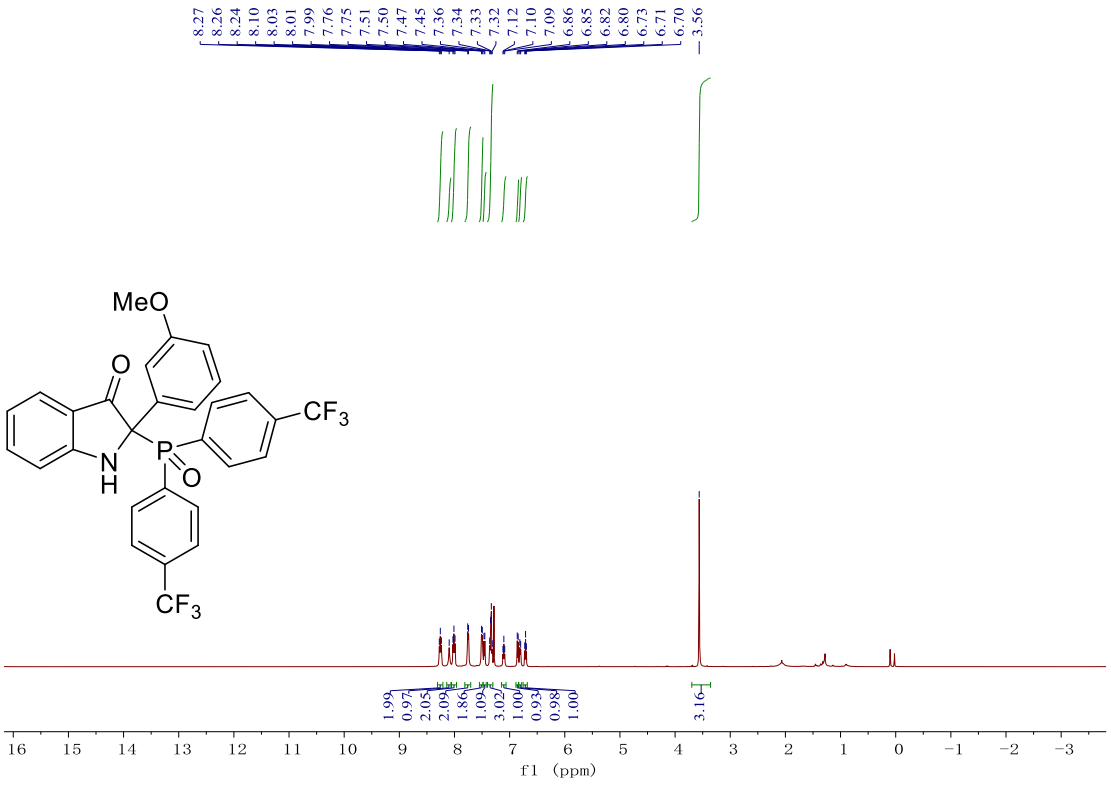


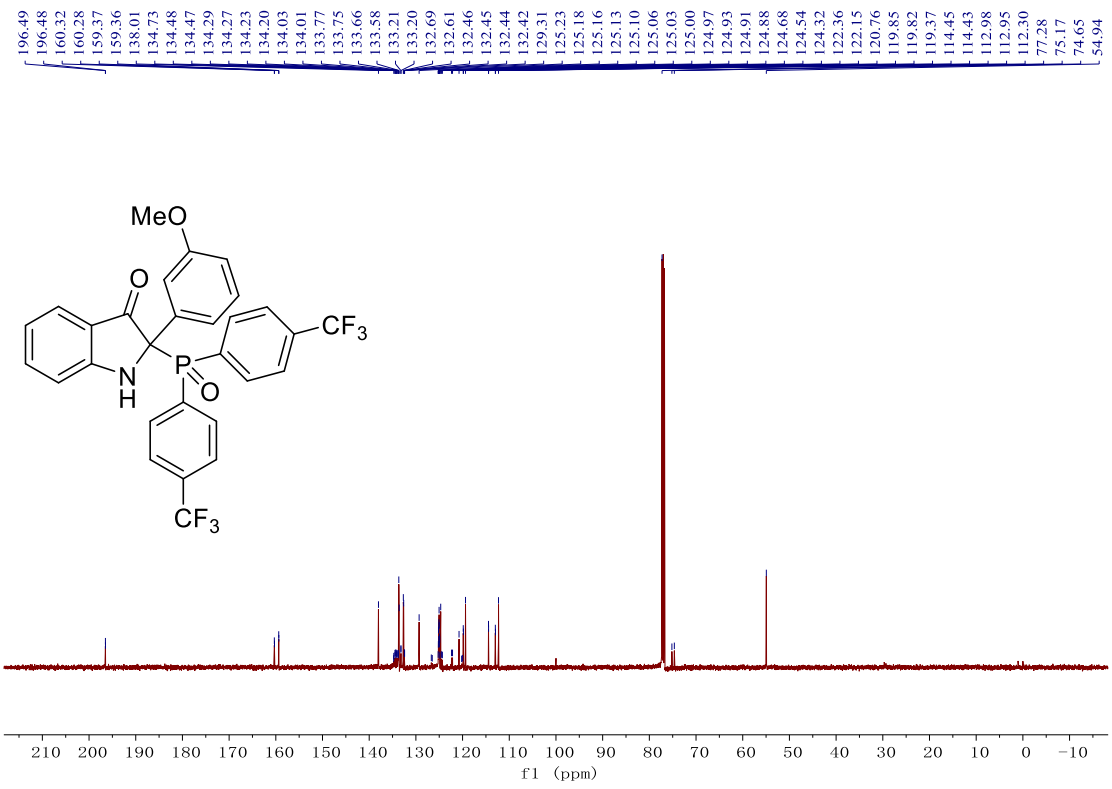


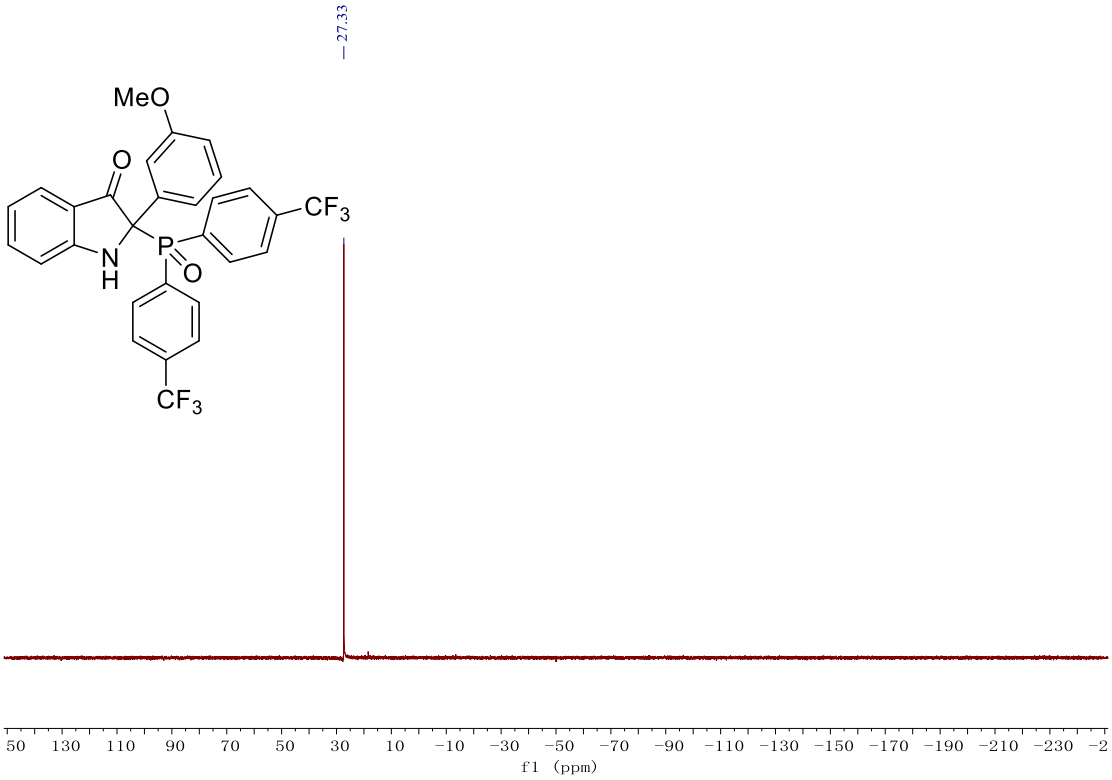

27.63
OMe
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

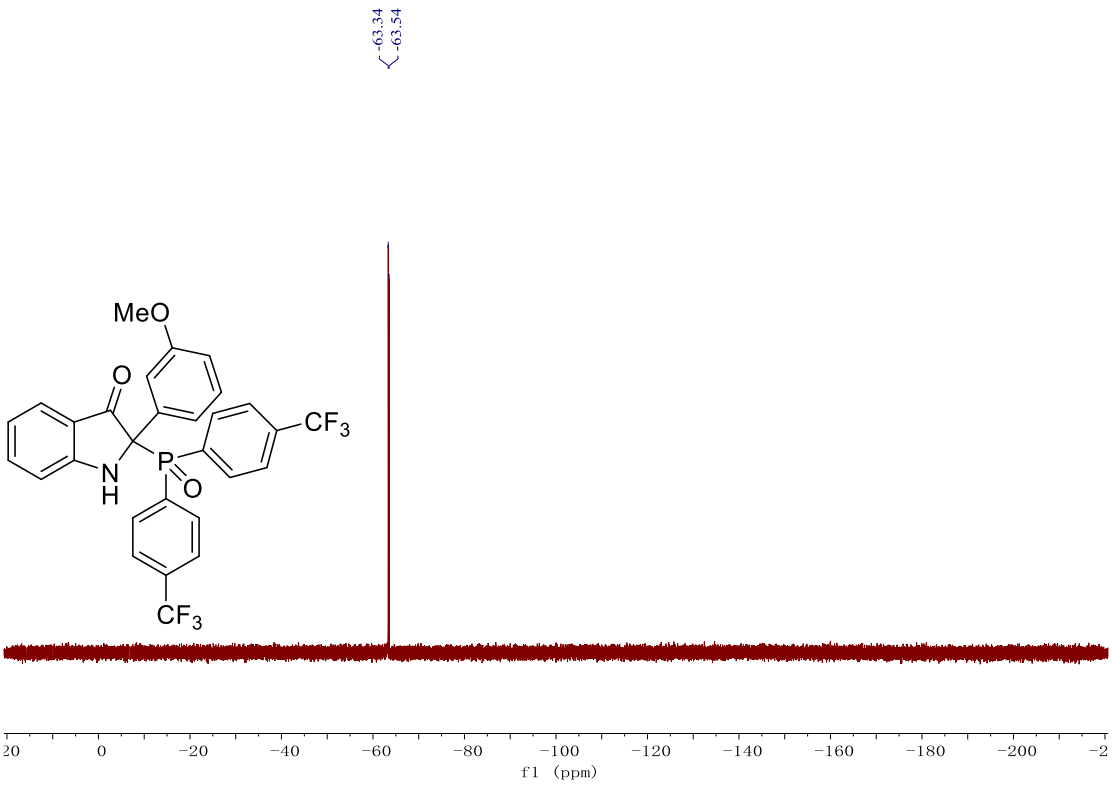

-63.31
-63.53
OMe
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(3-methoxyphenyl)indolin-3-one(3u)

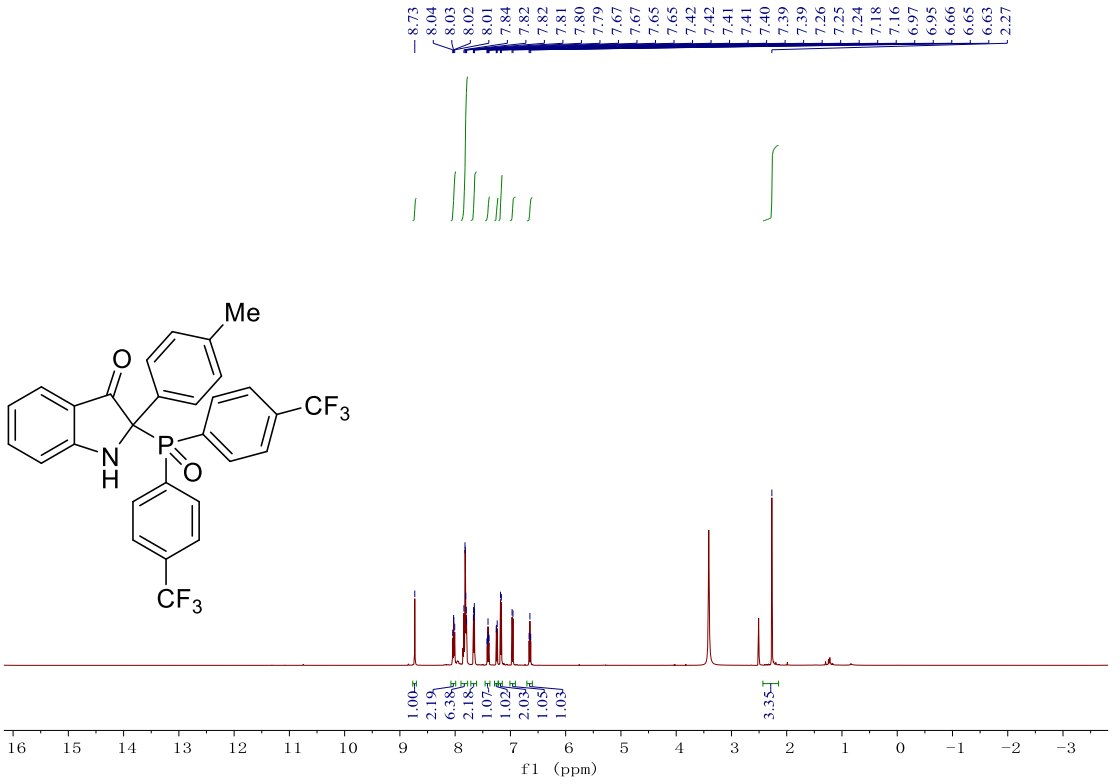


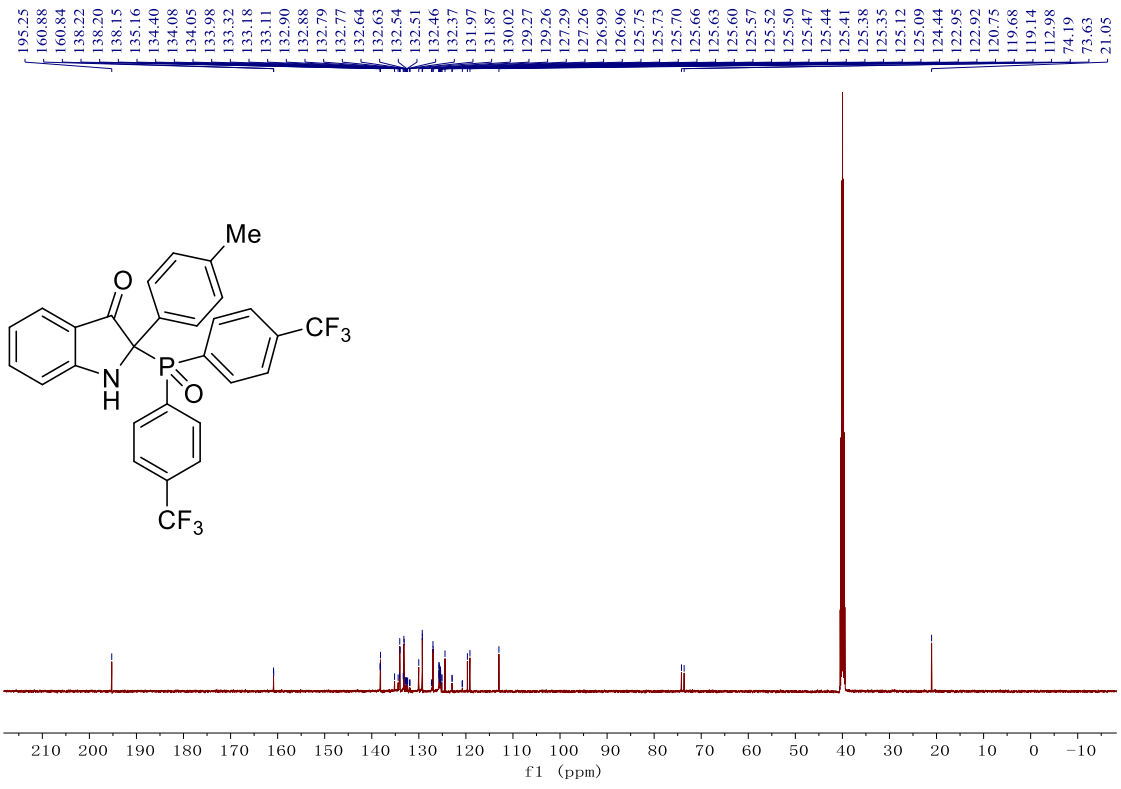


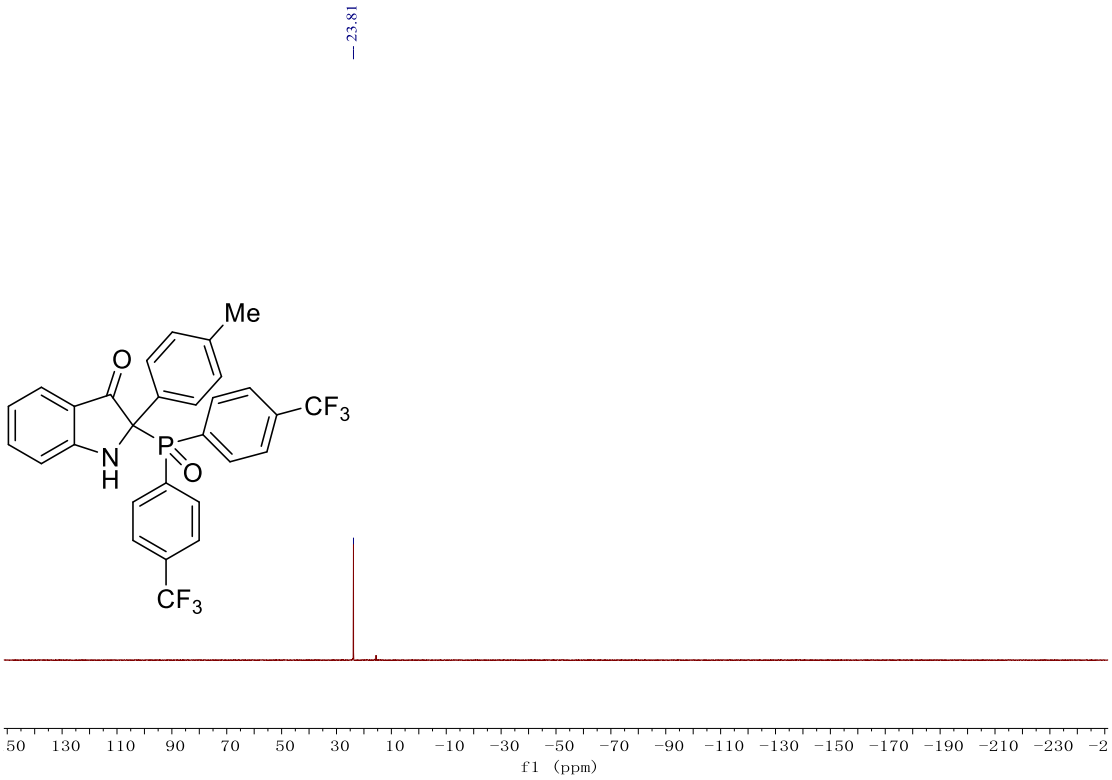

27.33
MeO
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

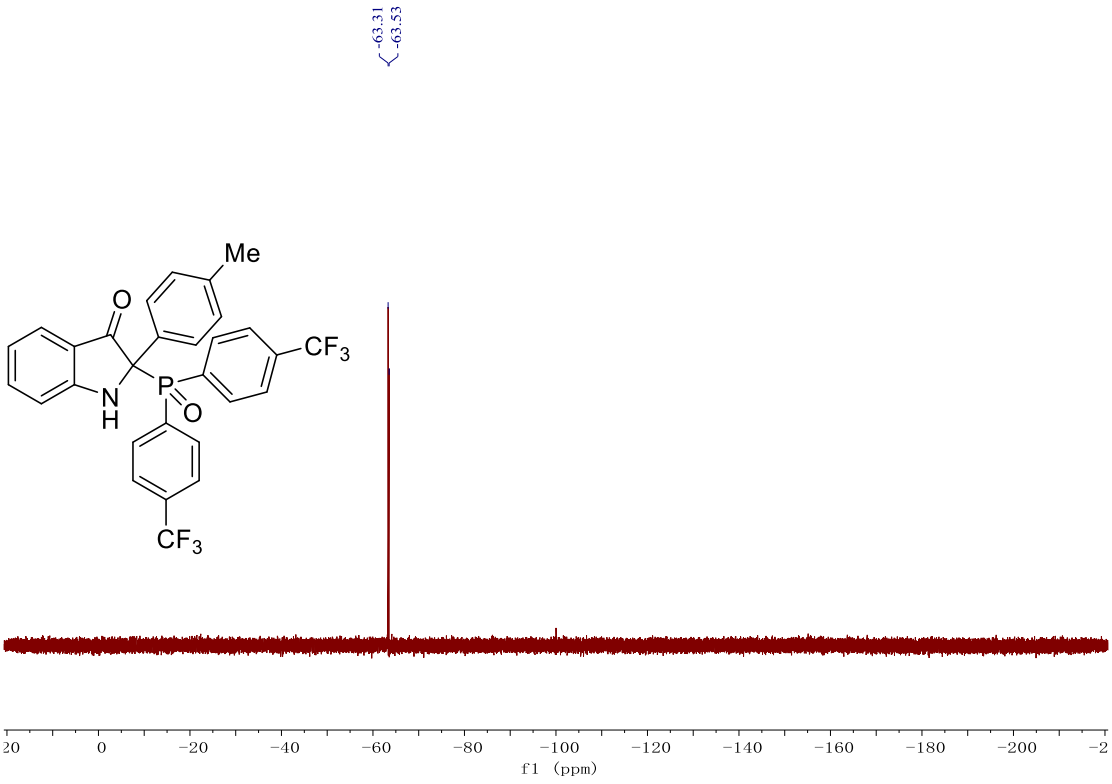

-63.34
-63.54
MeO
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(p-tolyl)indolin-3-one (3v).

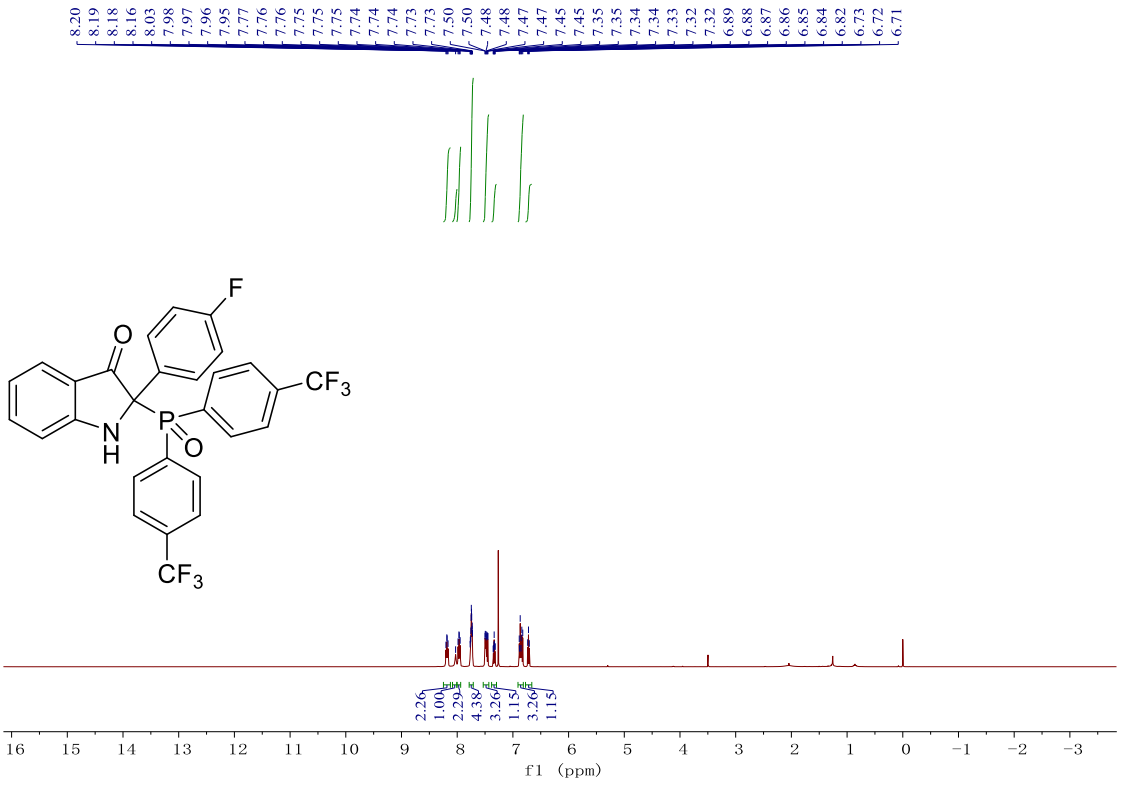


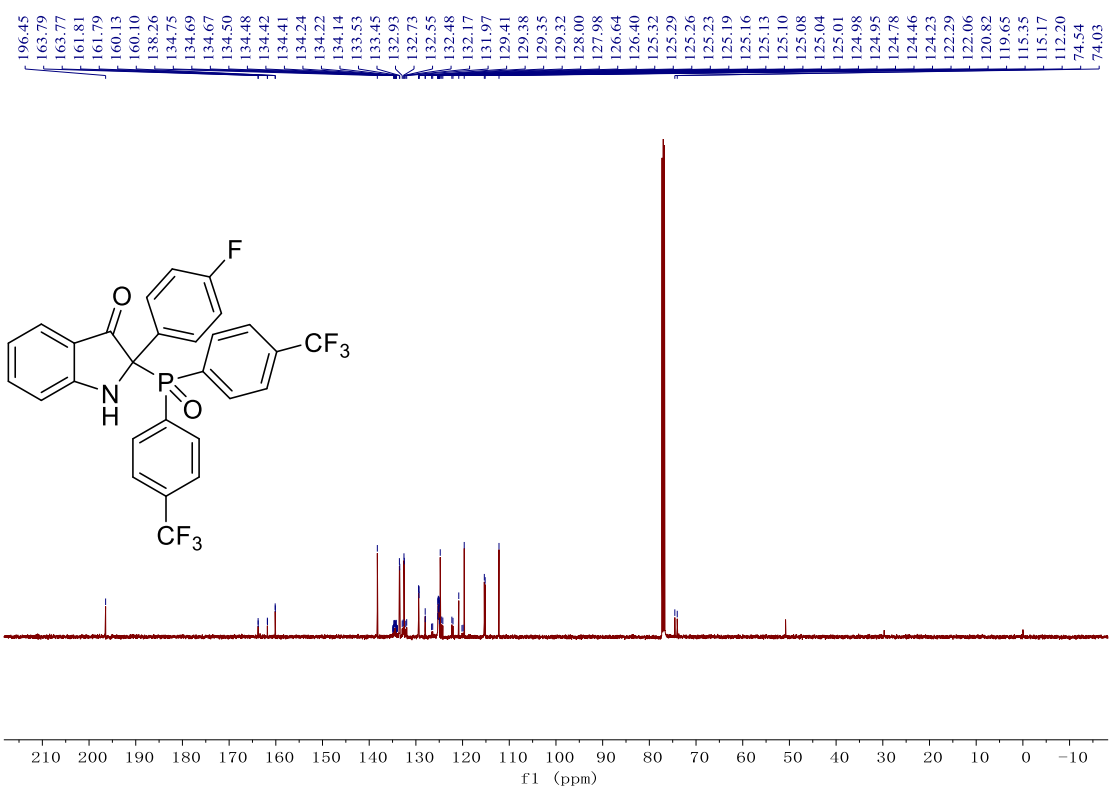


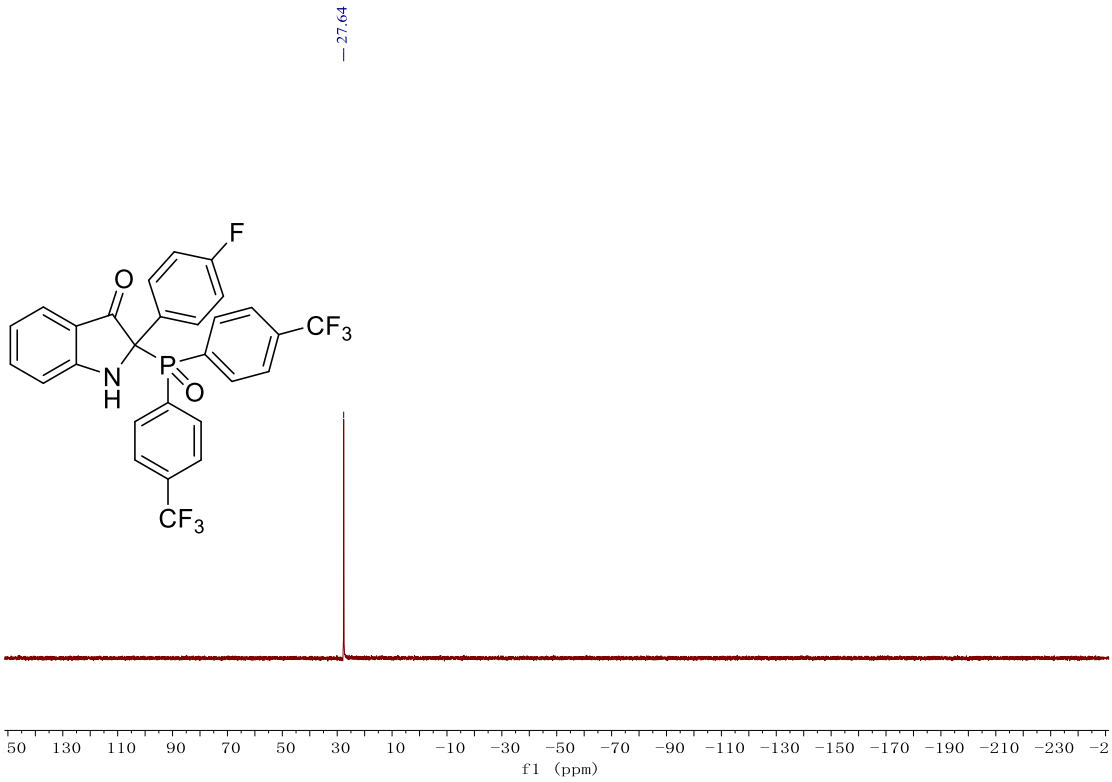

23.81
Me
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

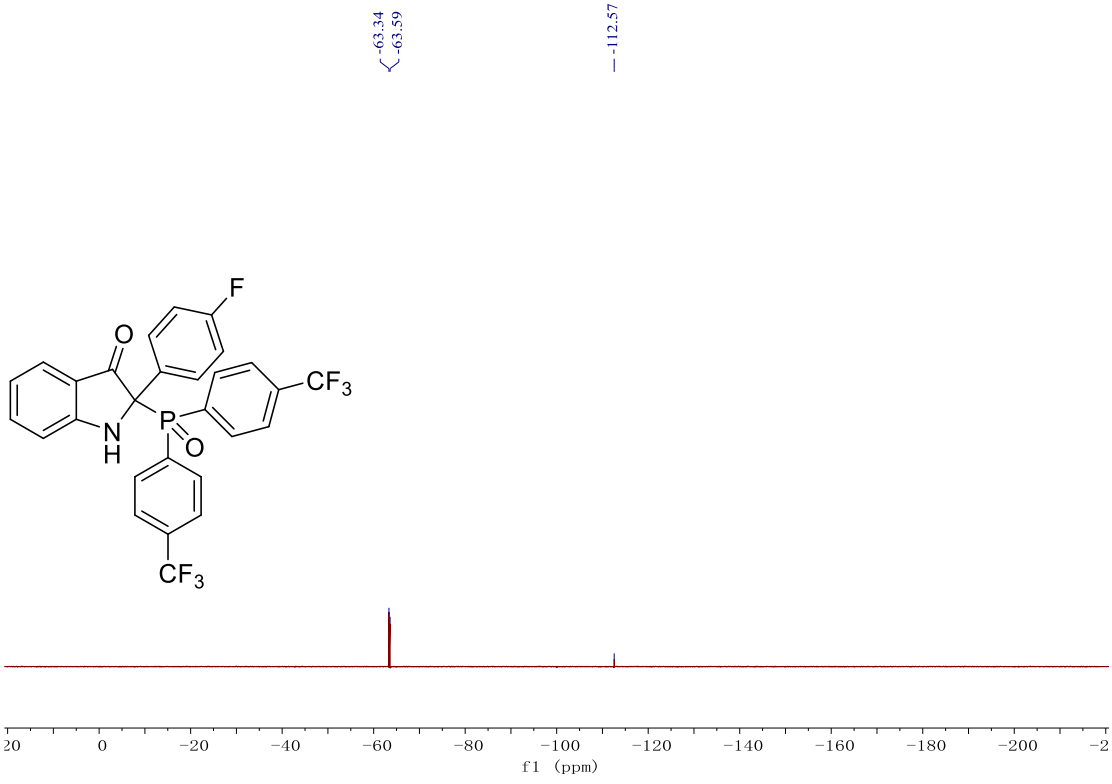

-63.31
-63.53
Me
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(4-fluorophenyl)indolin-3-one (3w)

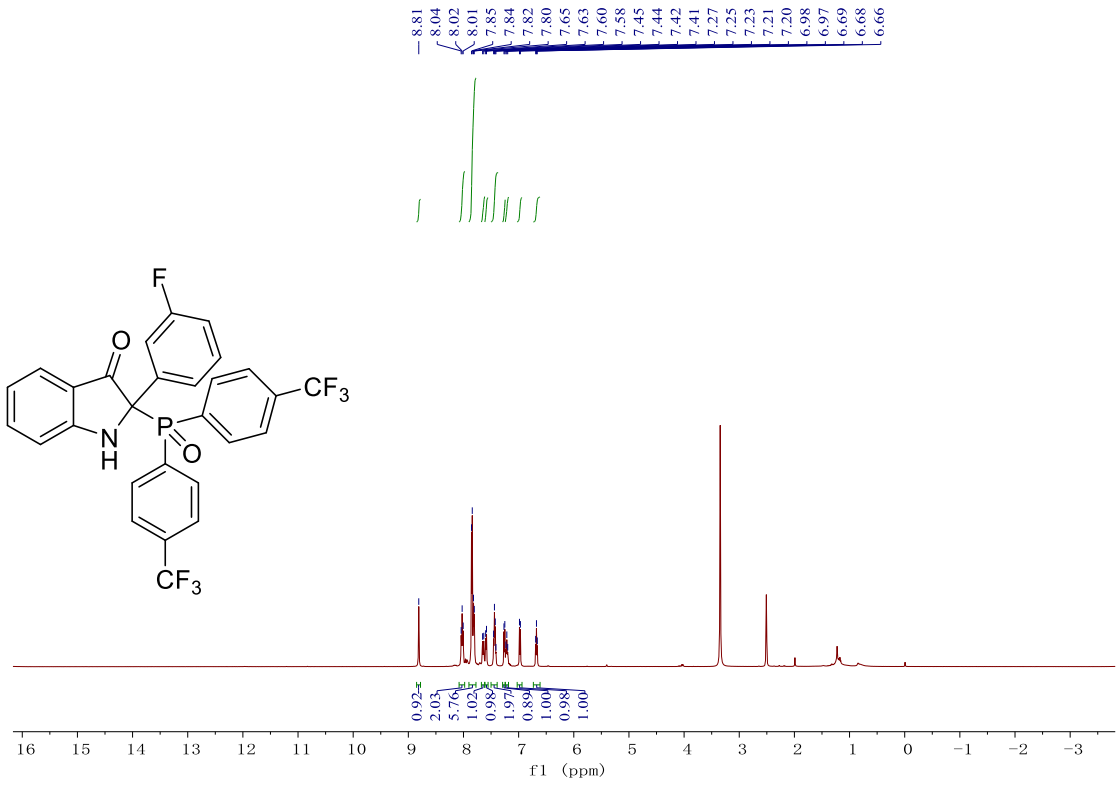


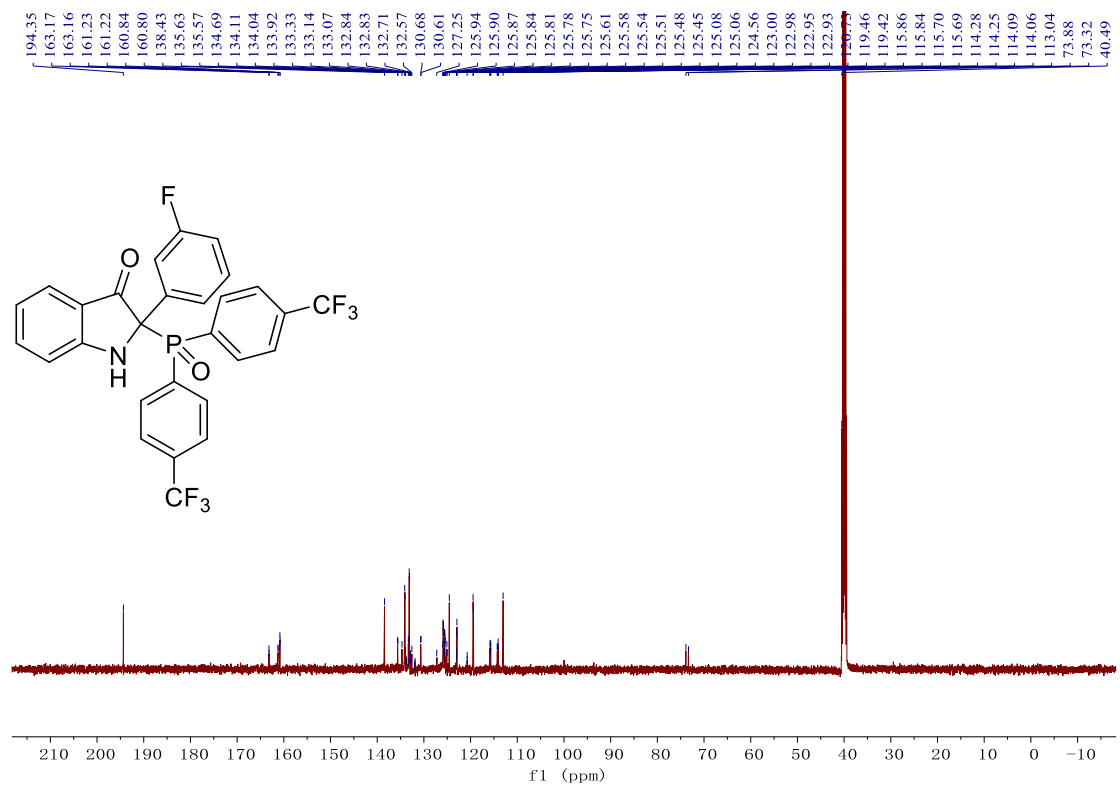


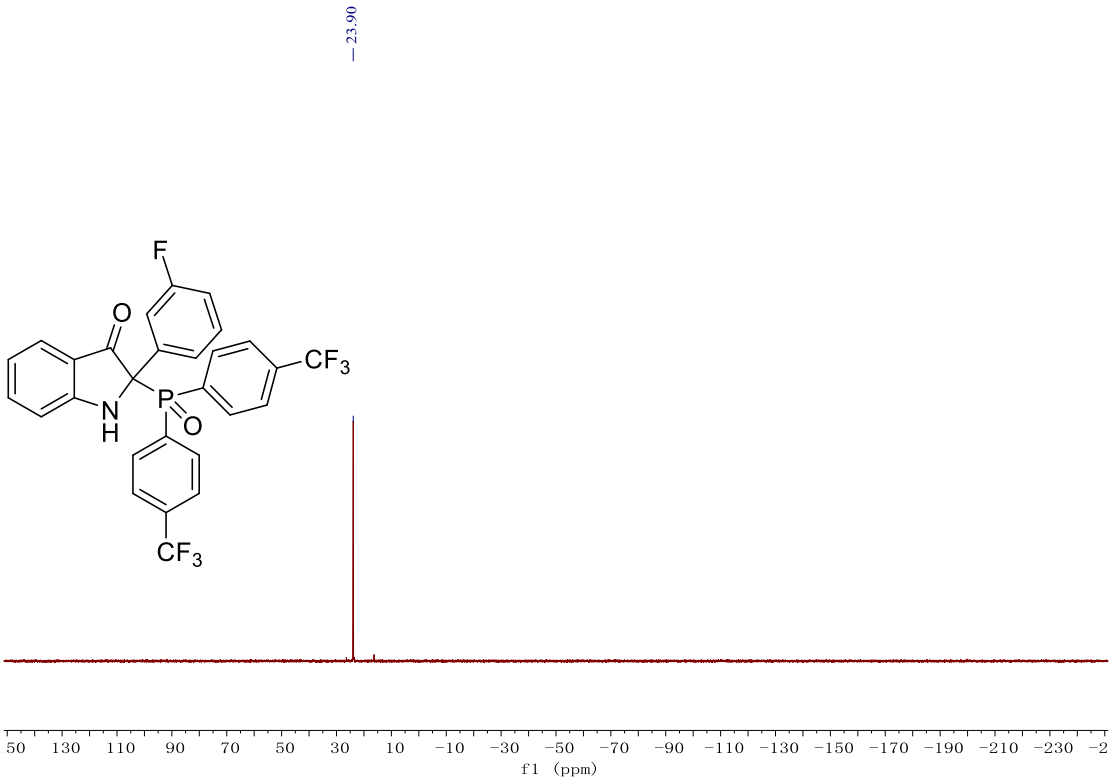

27.64
F
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

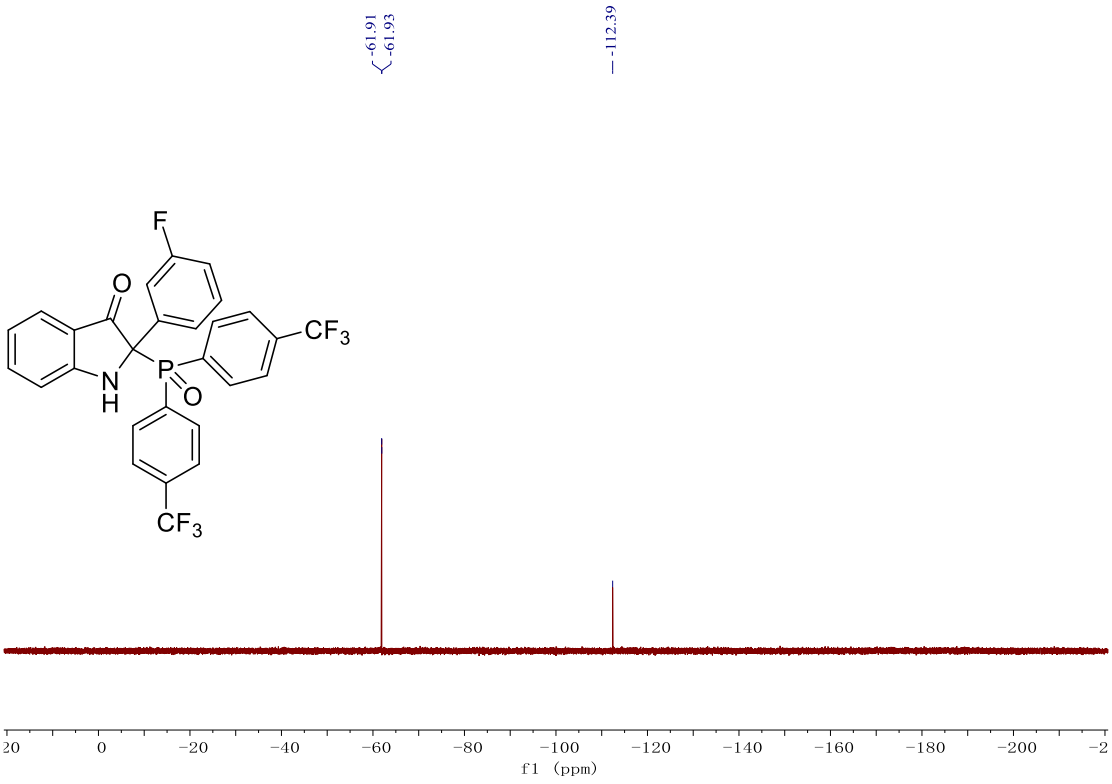

63.34
63.59
112.57
F
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(3-fluorophenyl)indolin-3-one (3x).

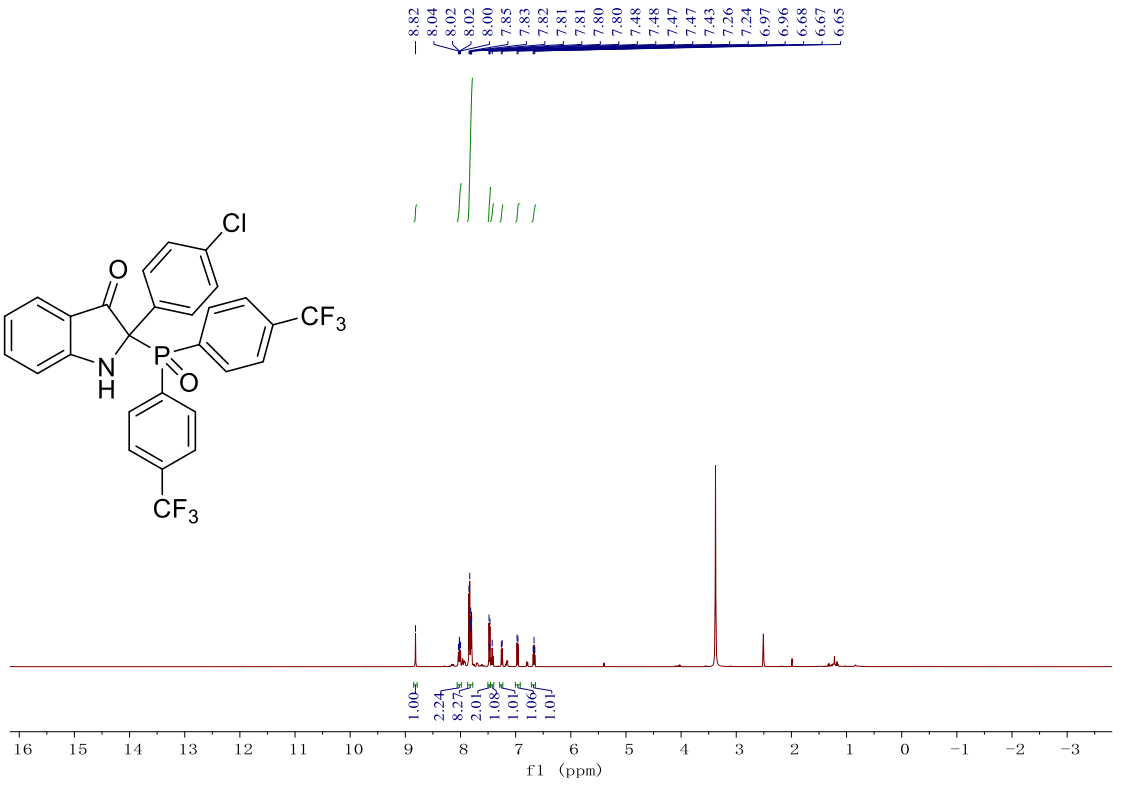


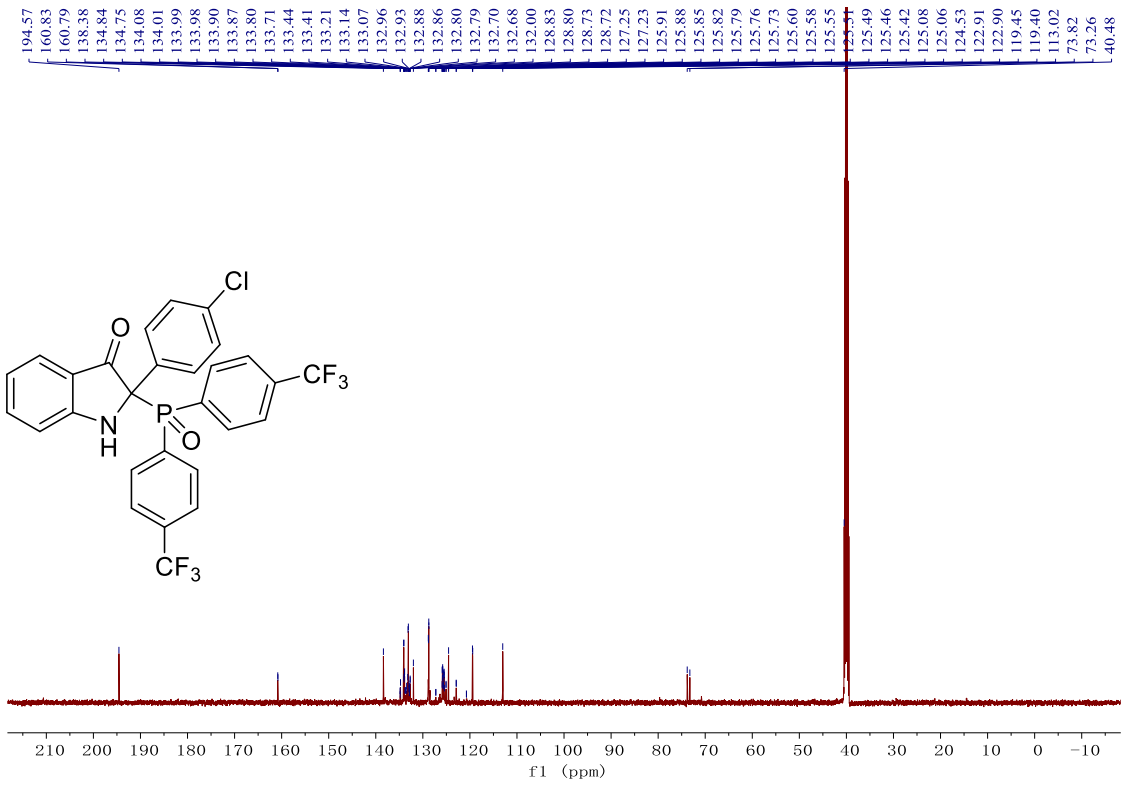


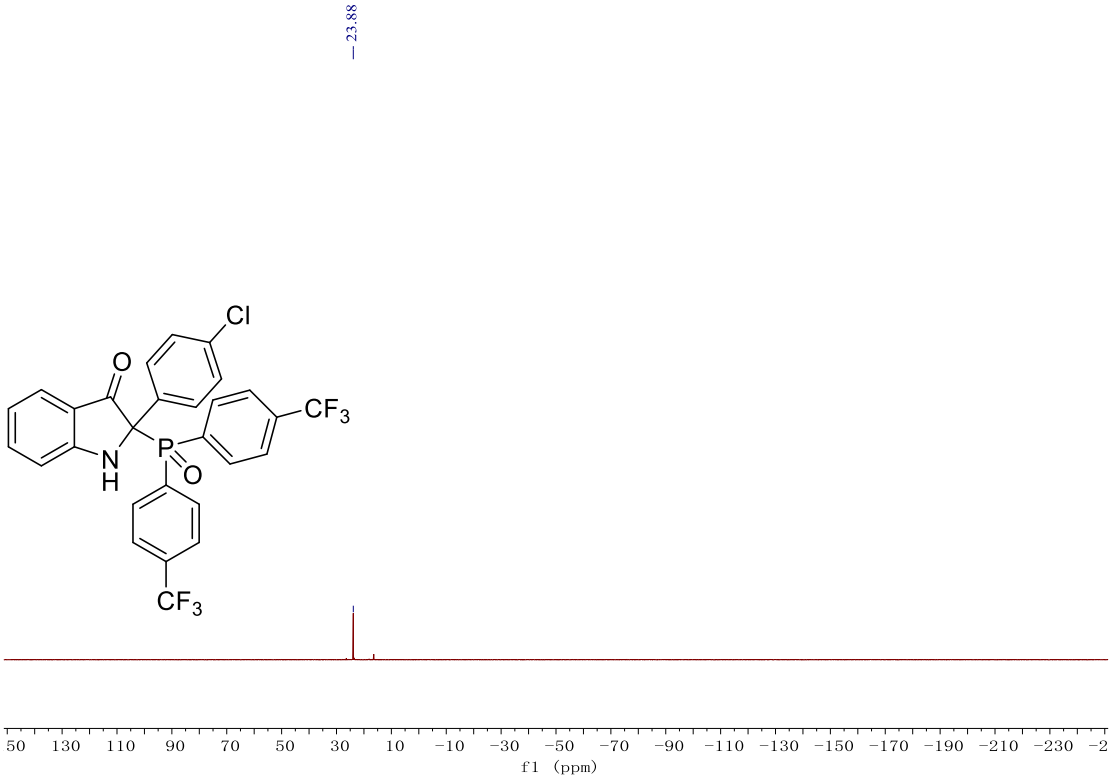

23.90
F
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

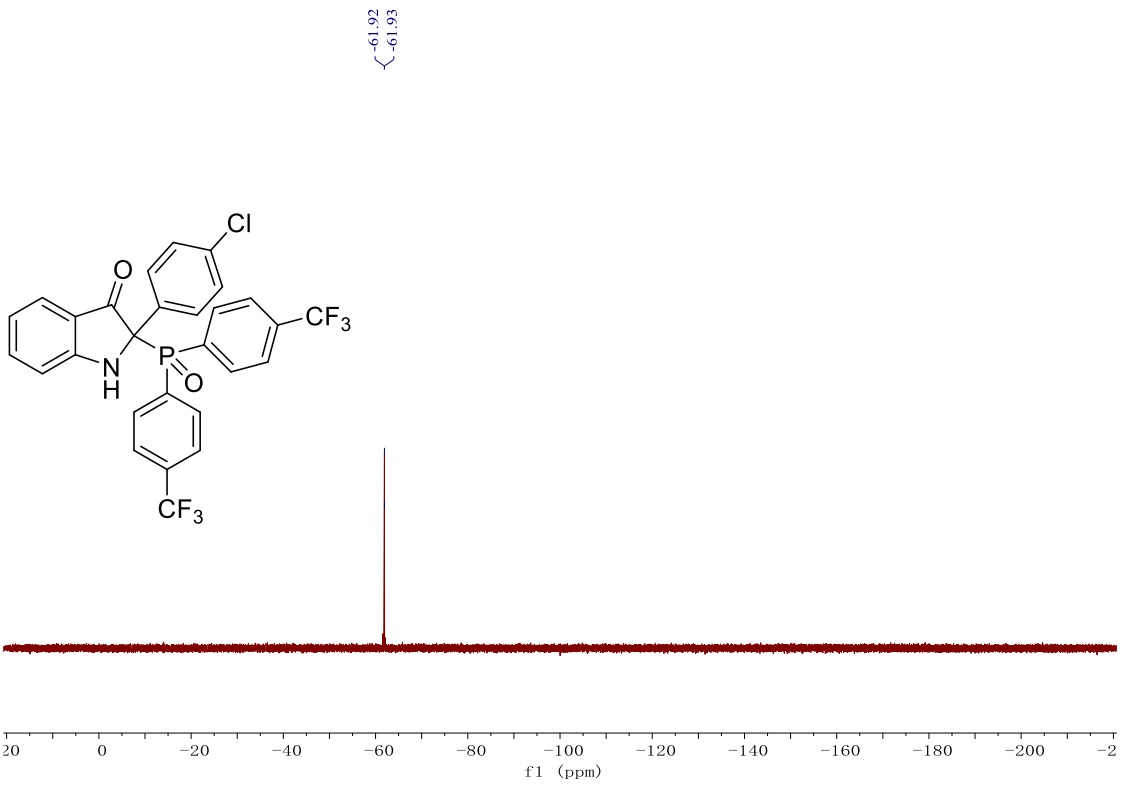

61.91
61.93
112.39
F
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(4-chlorophenyl)indolin-3-one (3y)

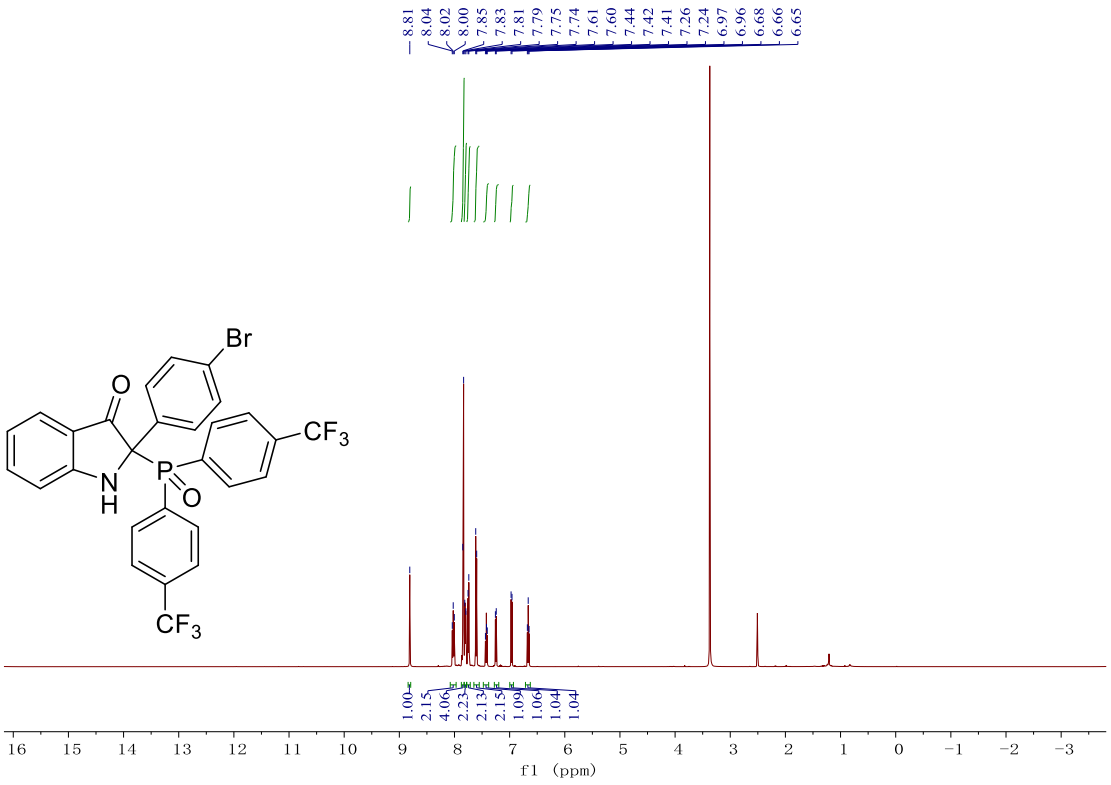


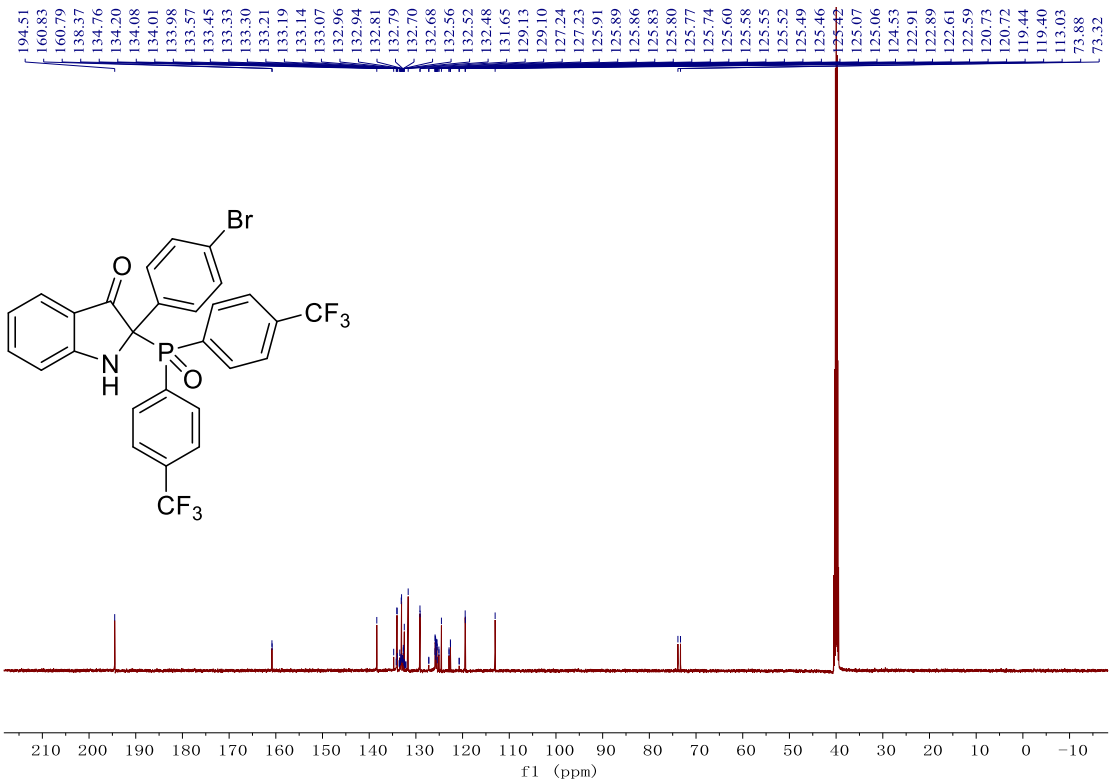


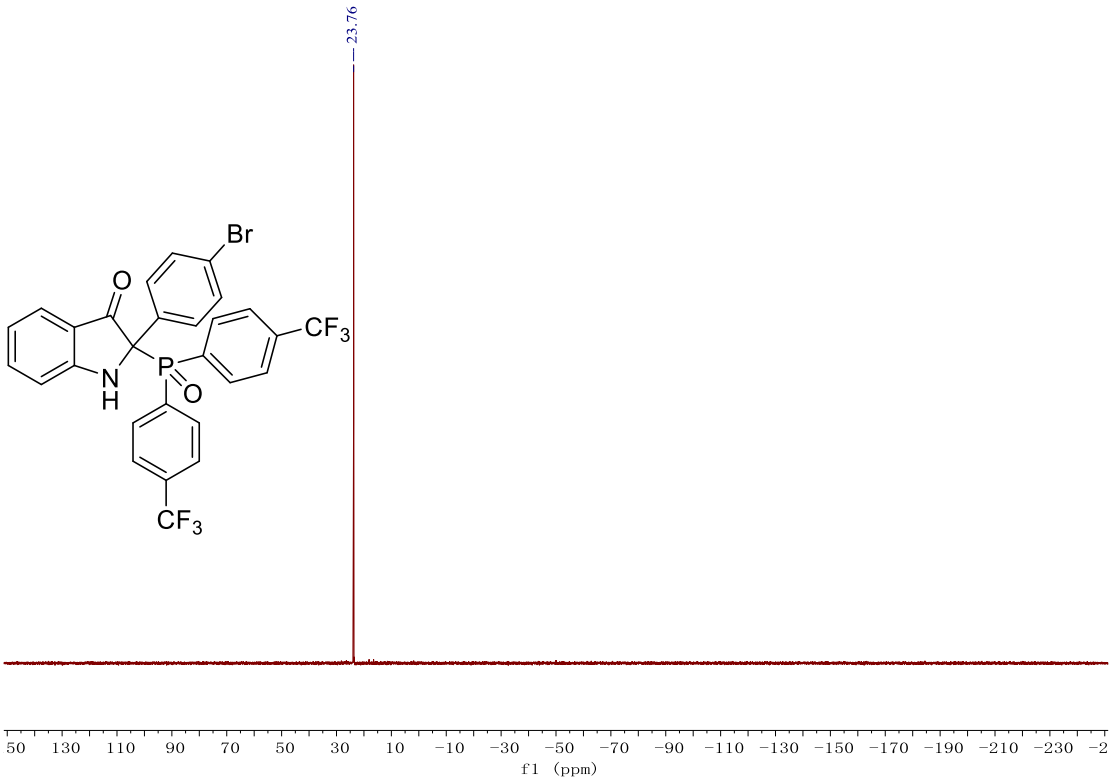

23.88
Cl
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

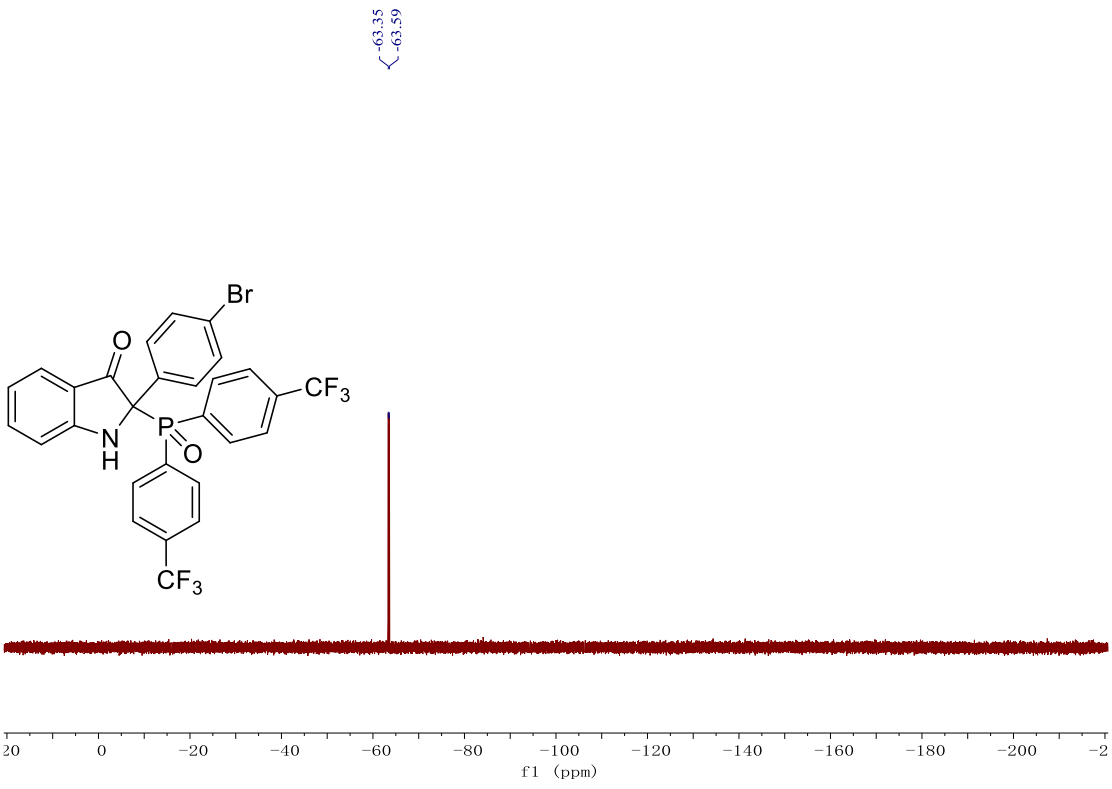

-61.92
-61.93
Cl
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(4-bromophenyl)indolin-3-one (3z)

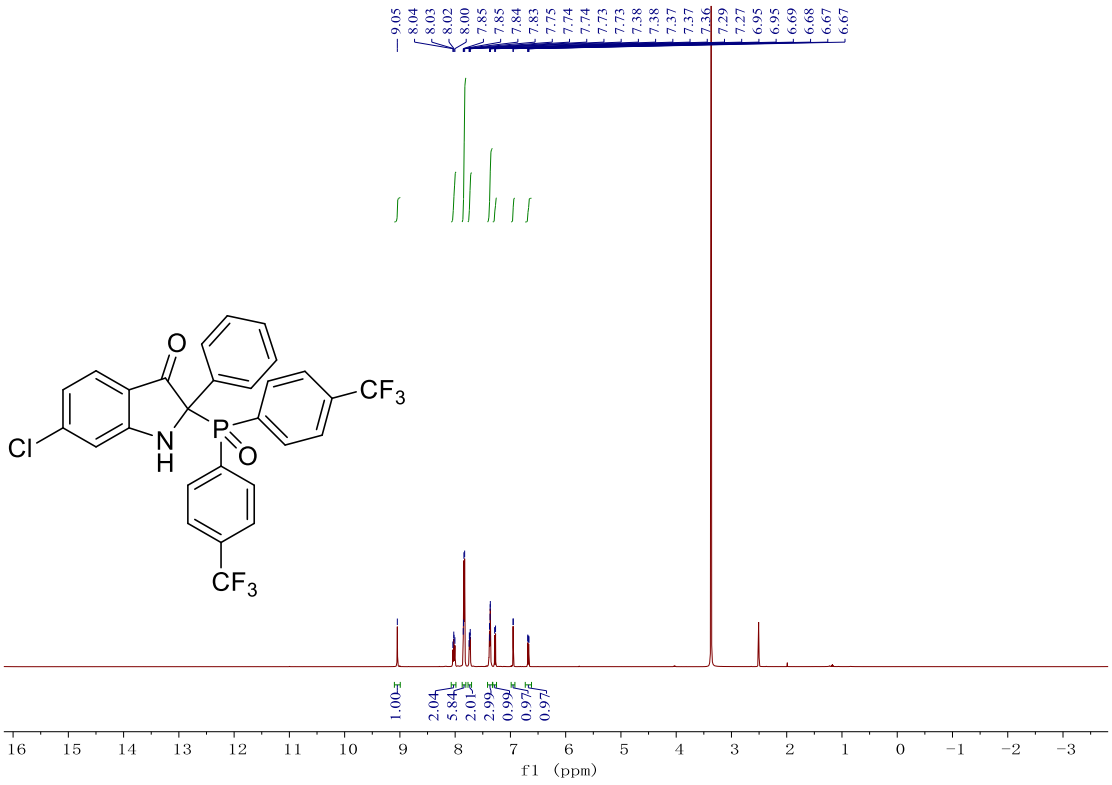


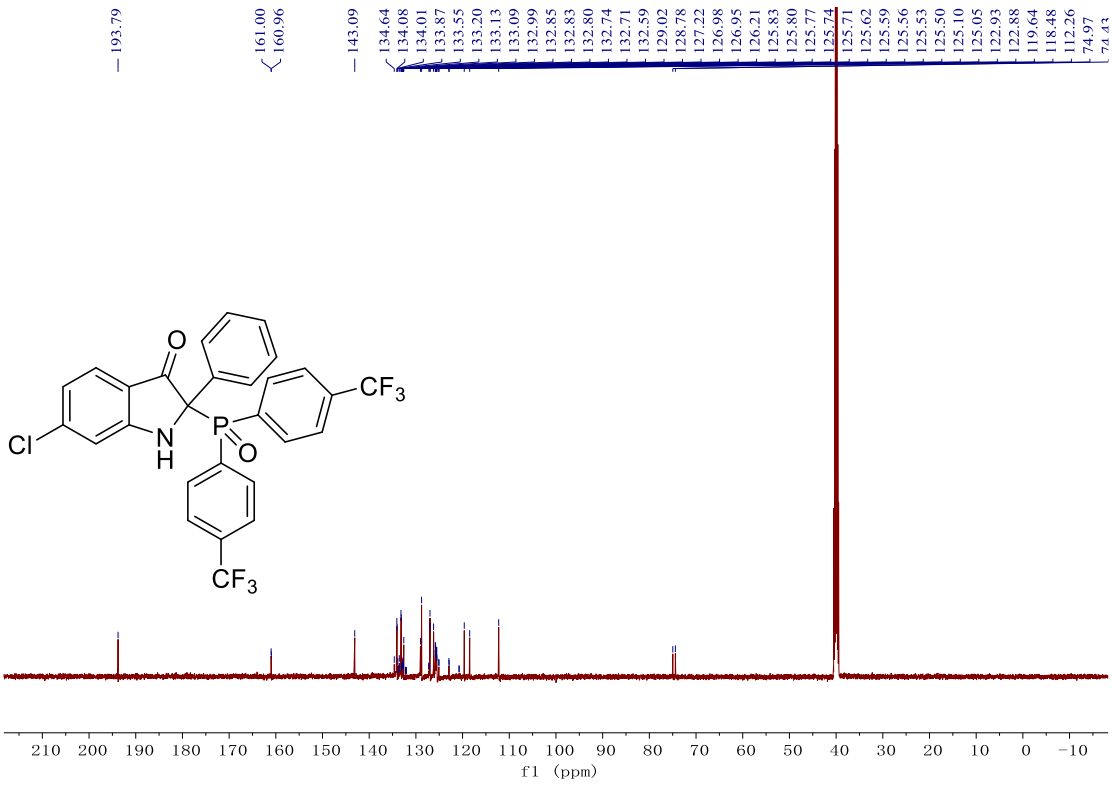


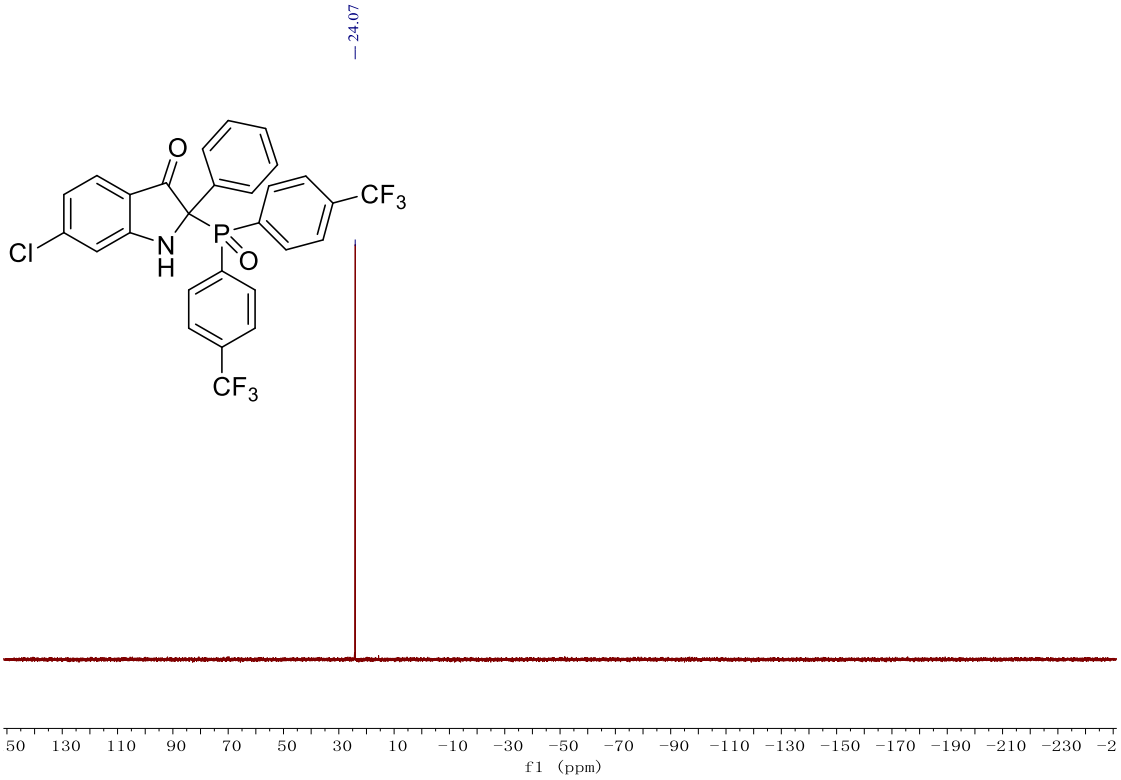

23.76
Br
O
CF3
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

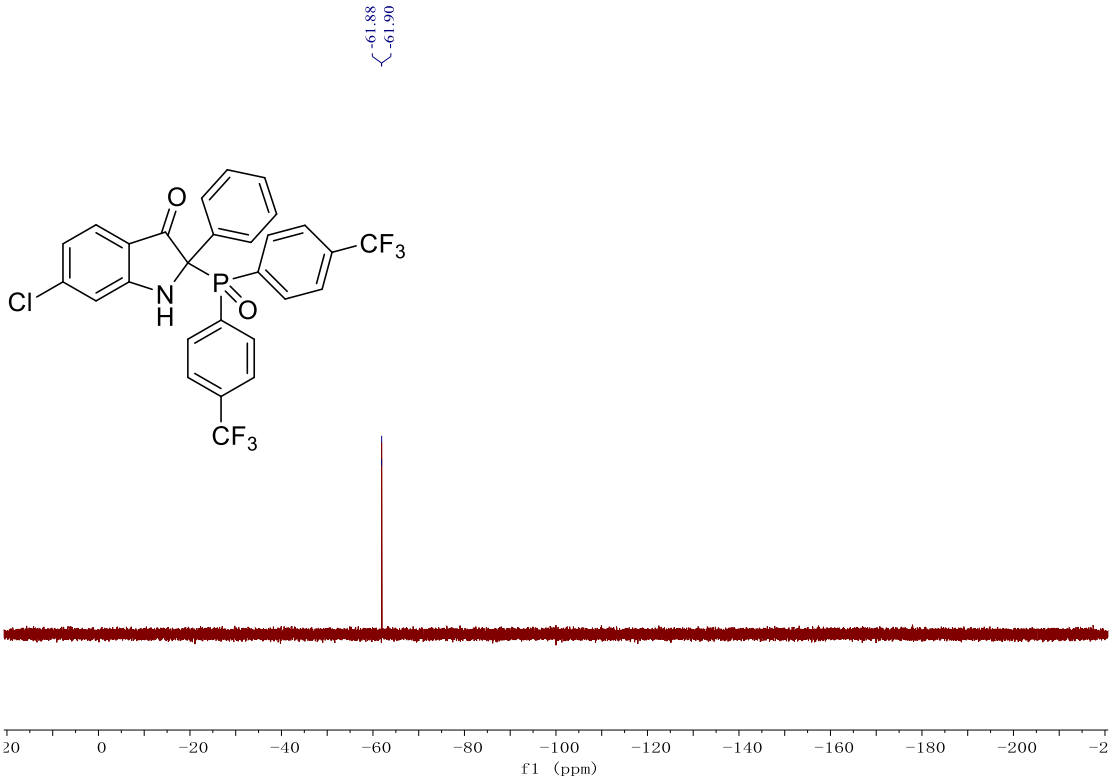

-63.35
-63.59
Br
O
CF3
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-6-chloro-2-phenylindolin-3-one (3aa)

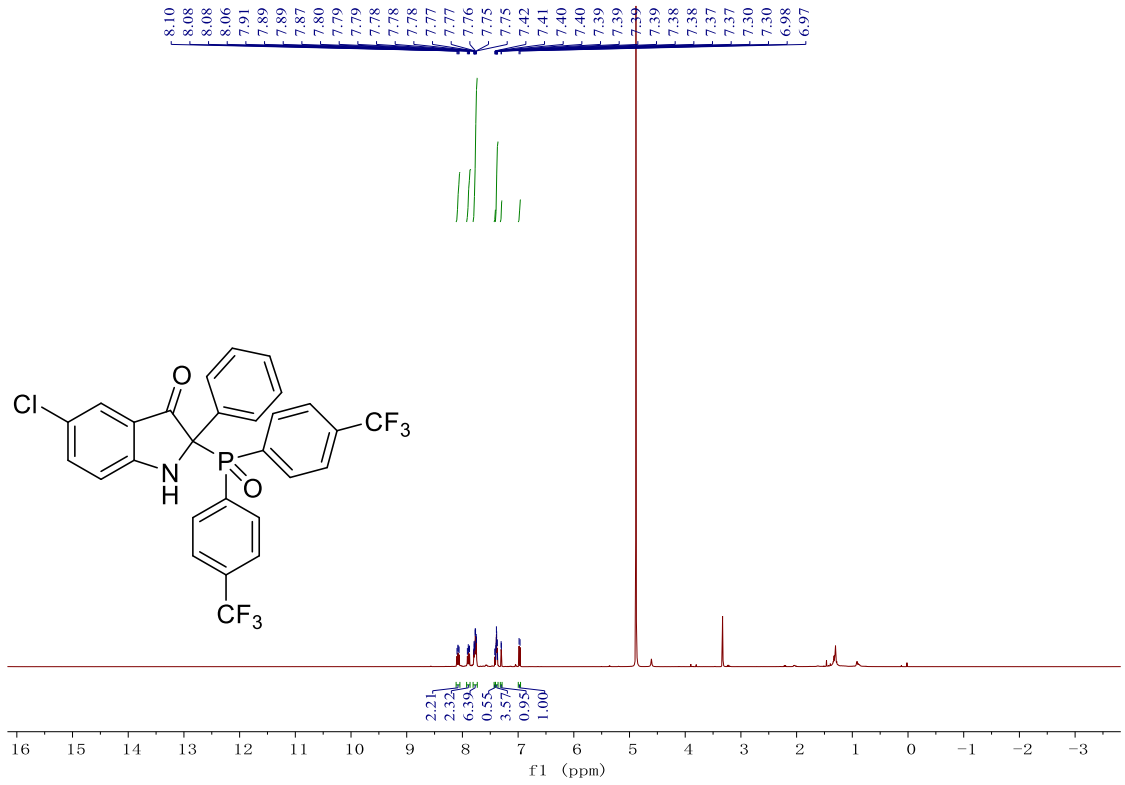


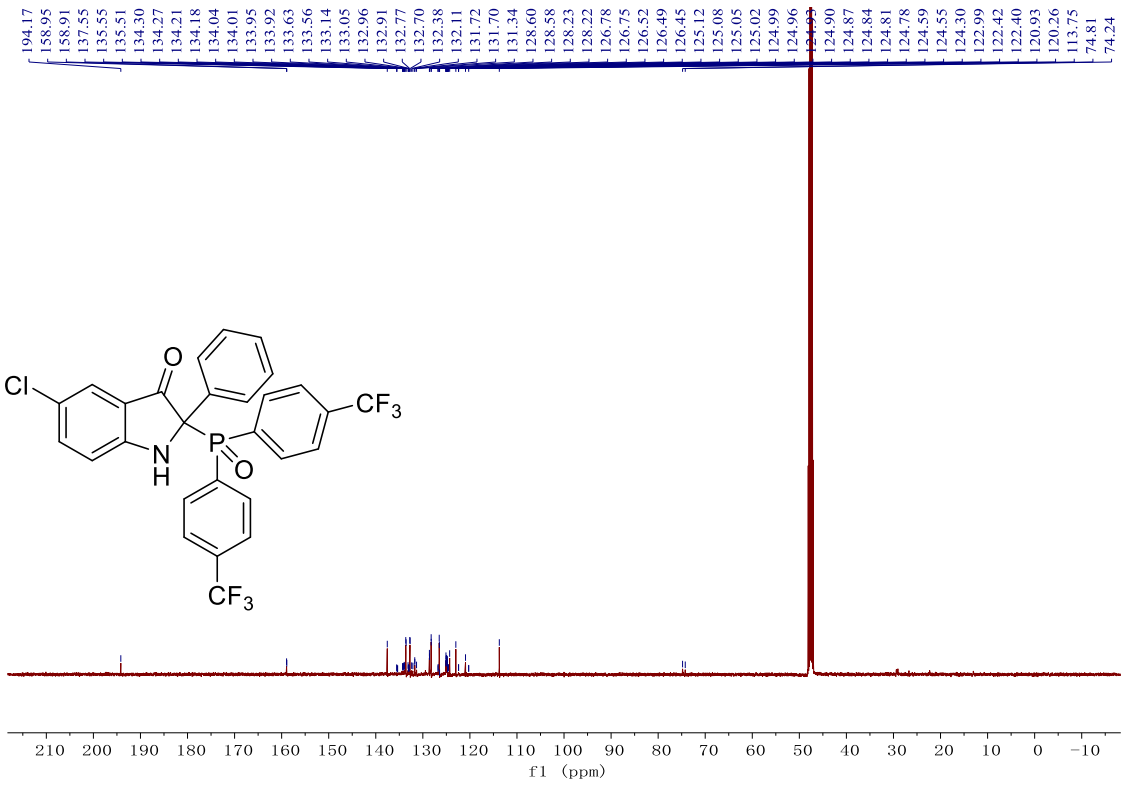


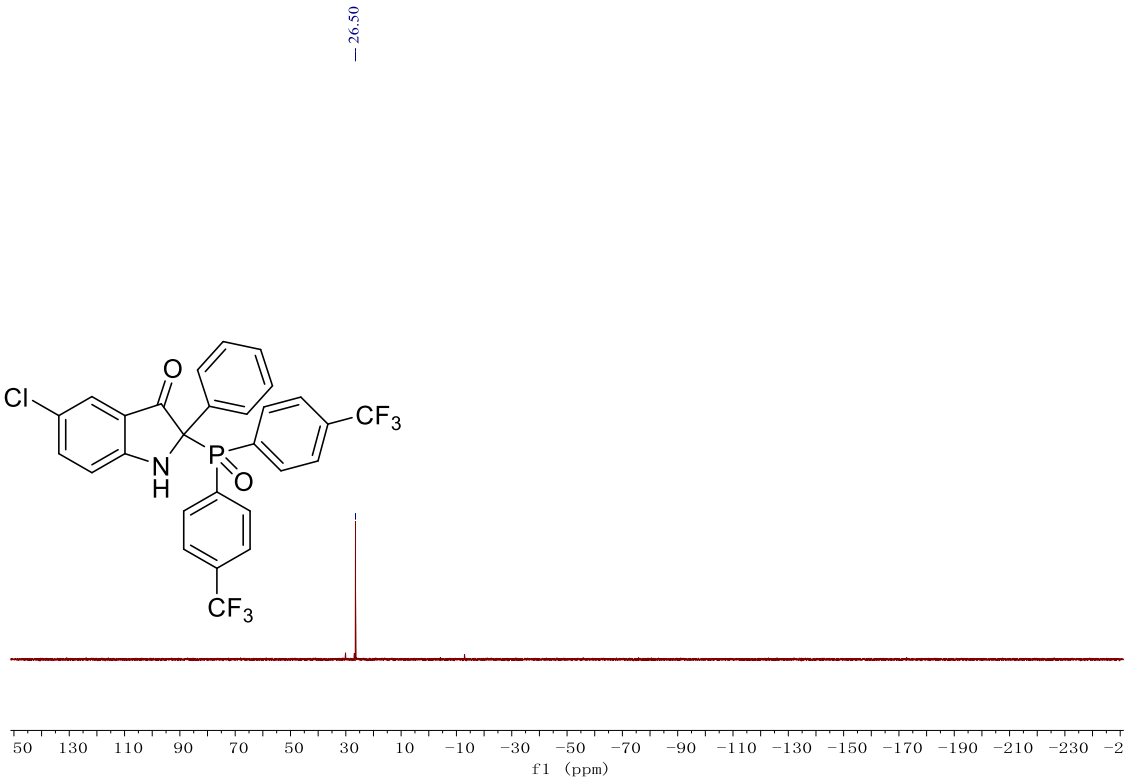

-24.07
O
CF3
Cl
N
H
P
O
CF3
50 130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230 -2
f1 (ppm)

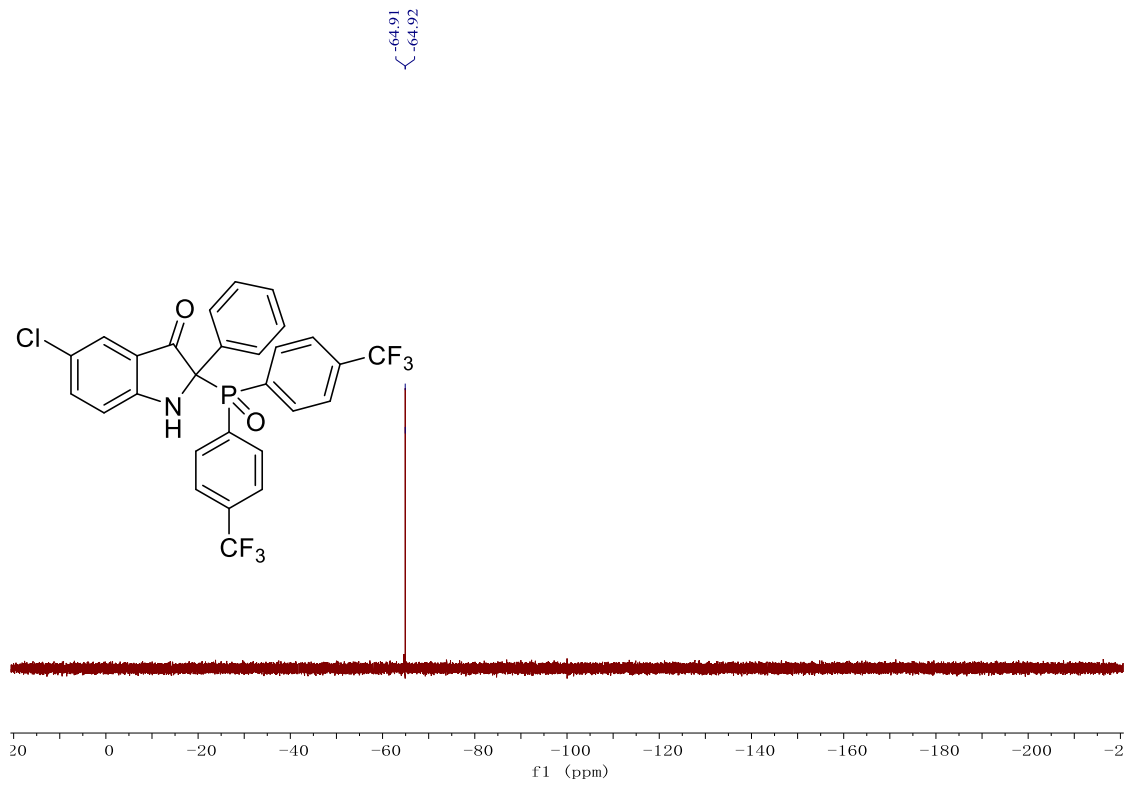

-61.88
-61.90
O
CF3
Cl
N
H
P
O
CF3
20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-5-chloro-2-phenylindolin-3-one (3bb).

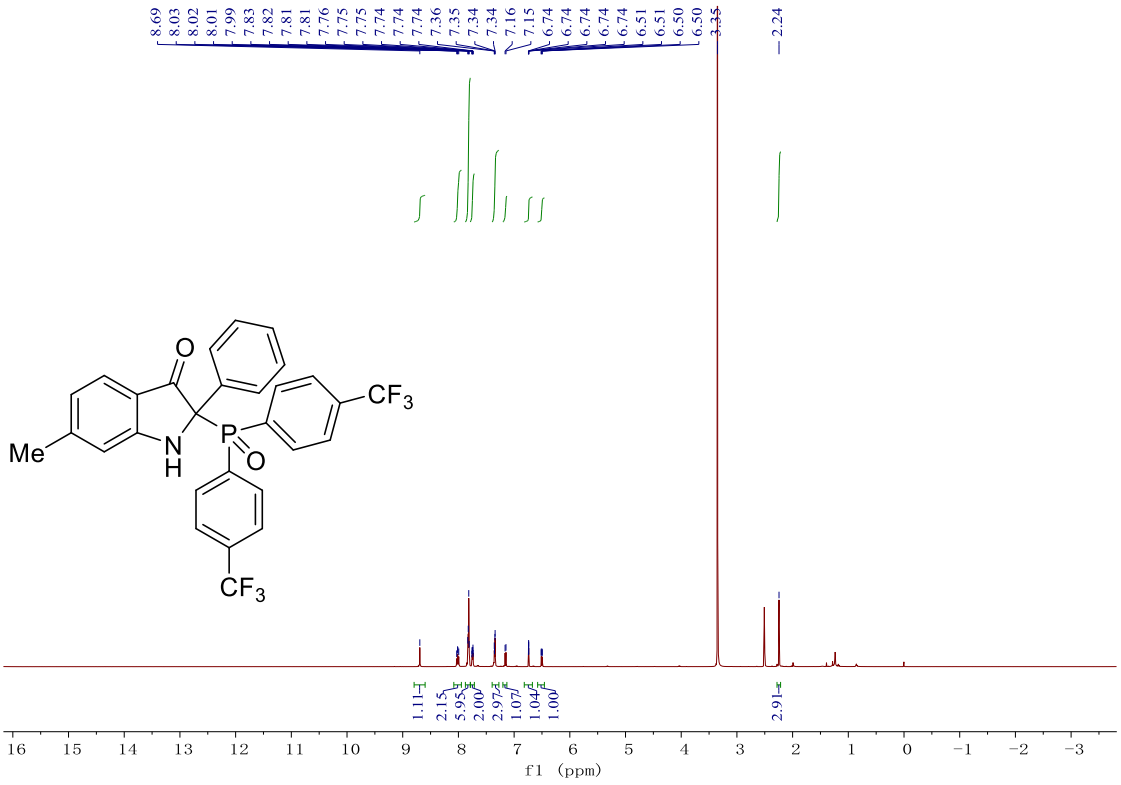


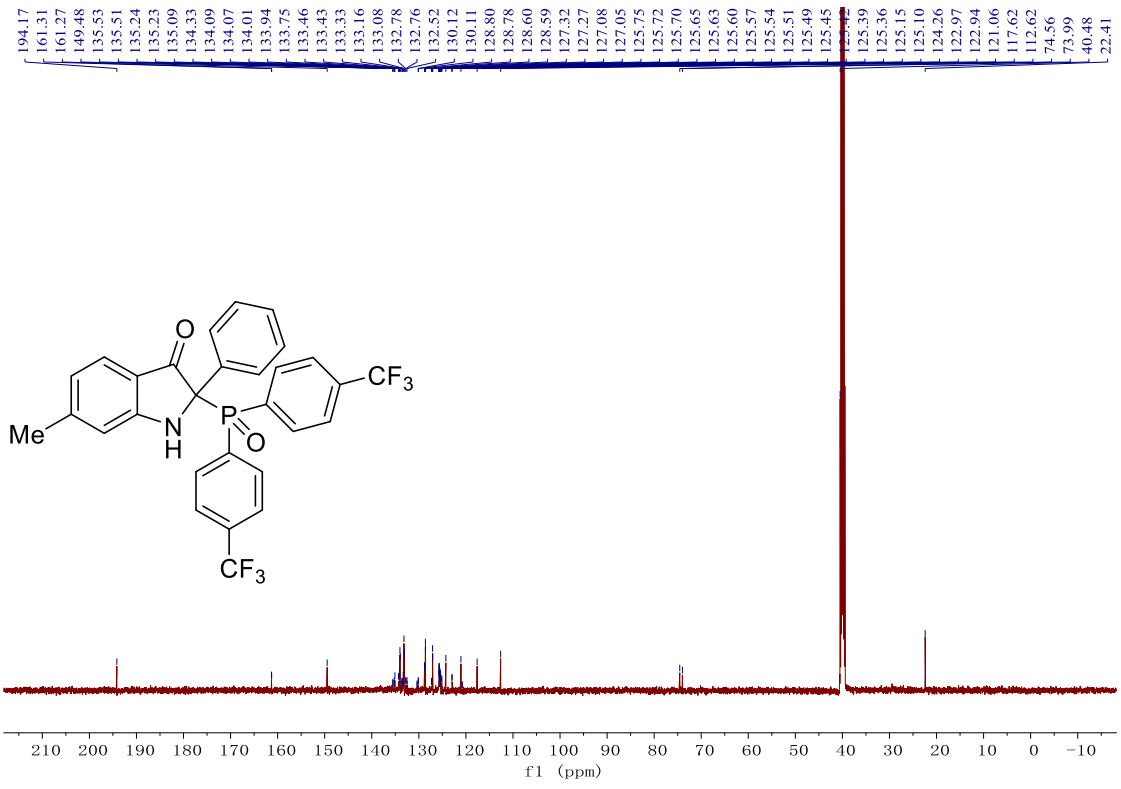


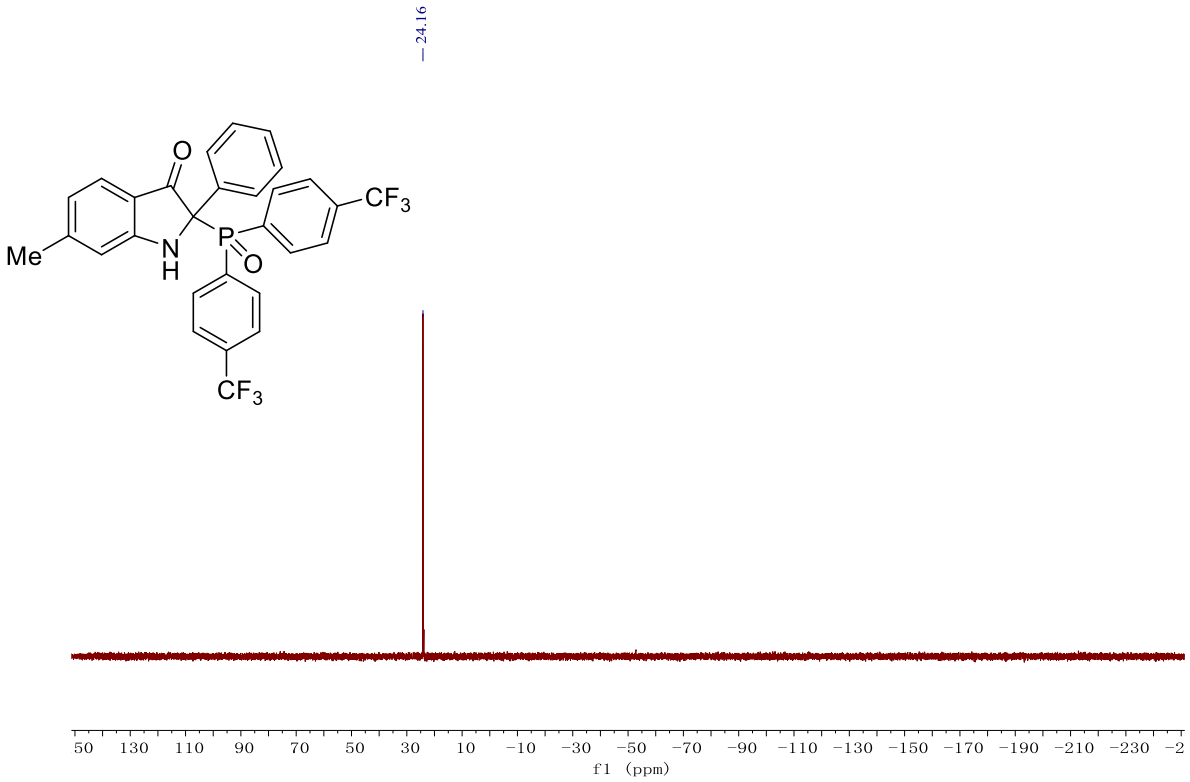

26.50
Cl
O
N
H
P
O
CF3
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

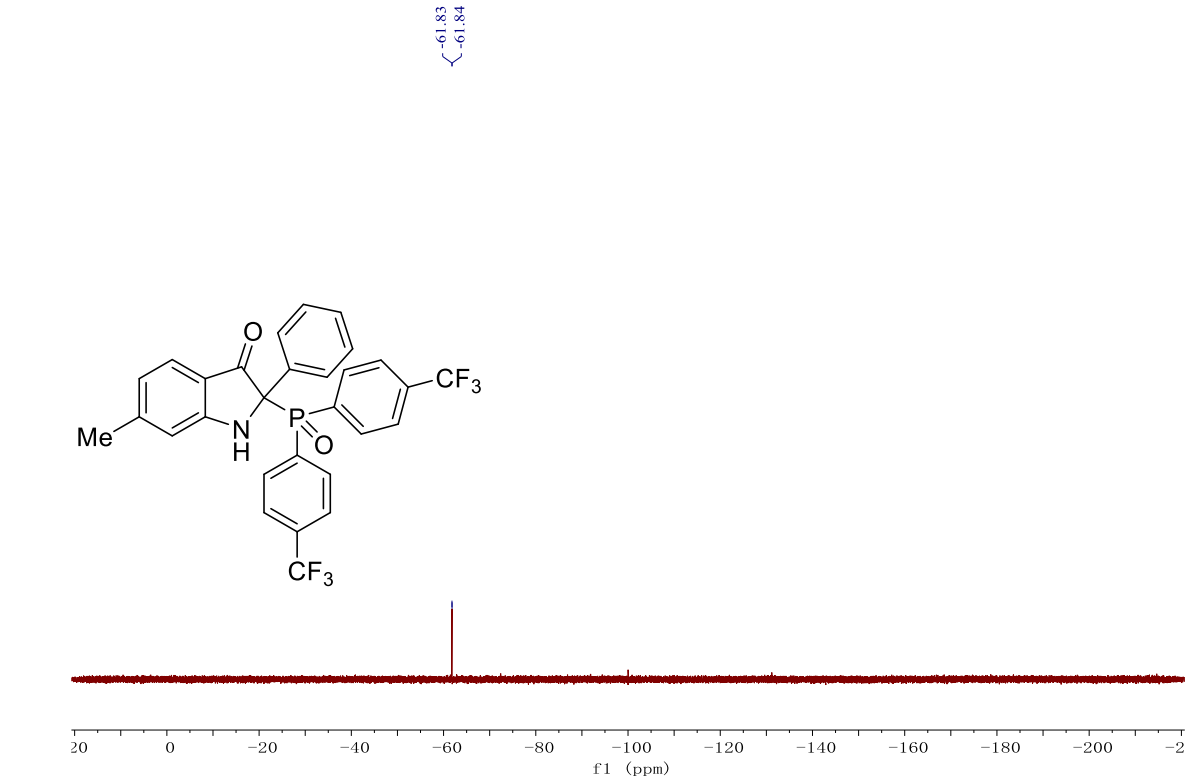

-64.91
-64.92
Cl
O
N
H
P
O
CF3
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-6-methyl-2-phenylindolin-3-one (3cc)

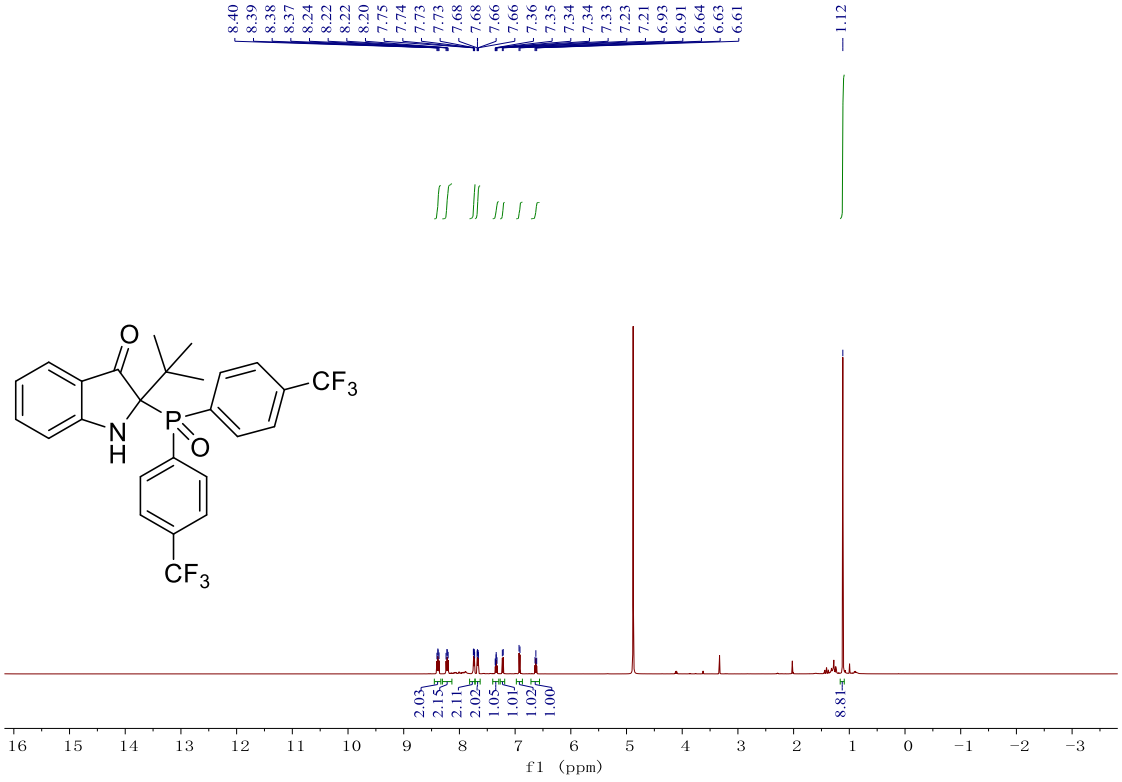


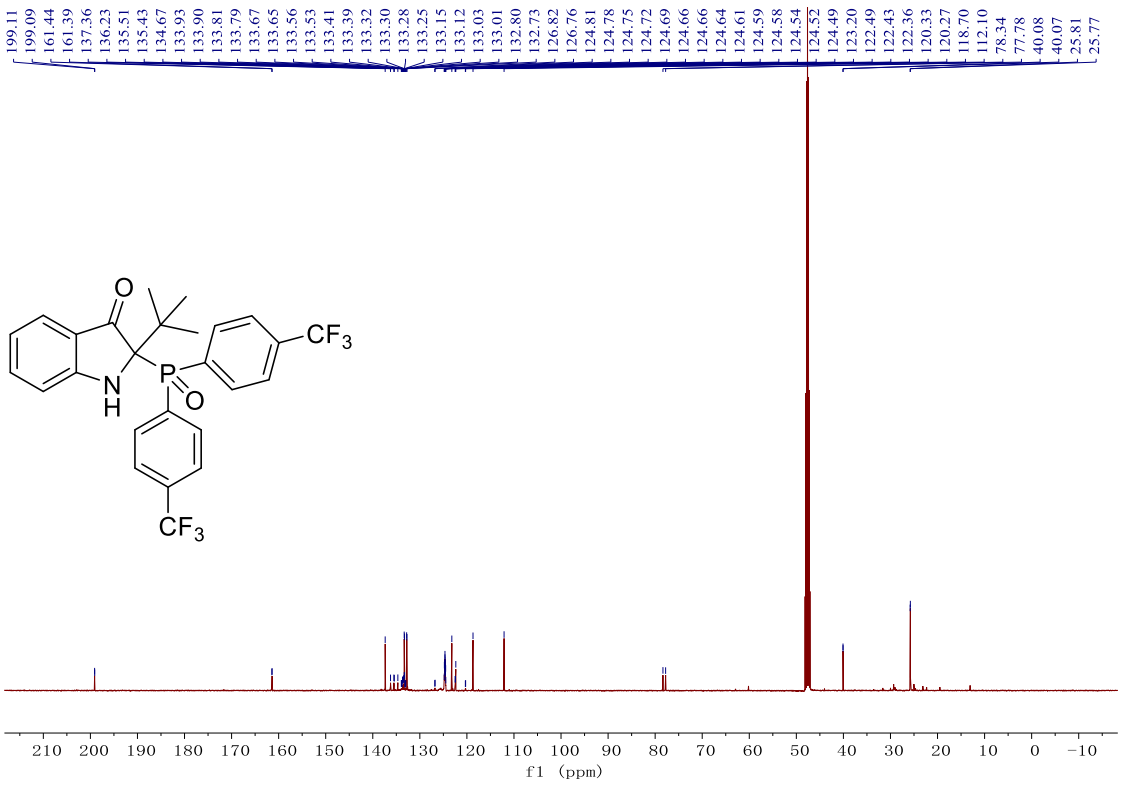


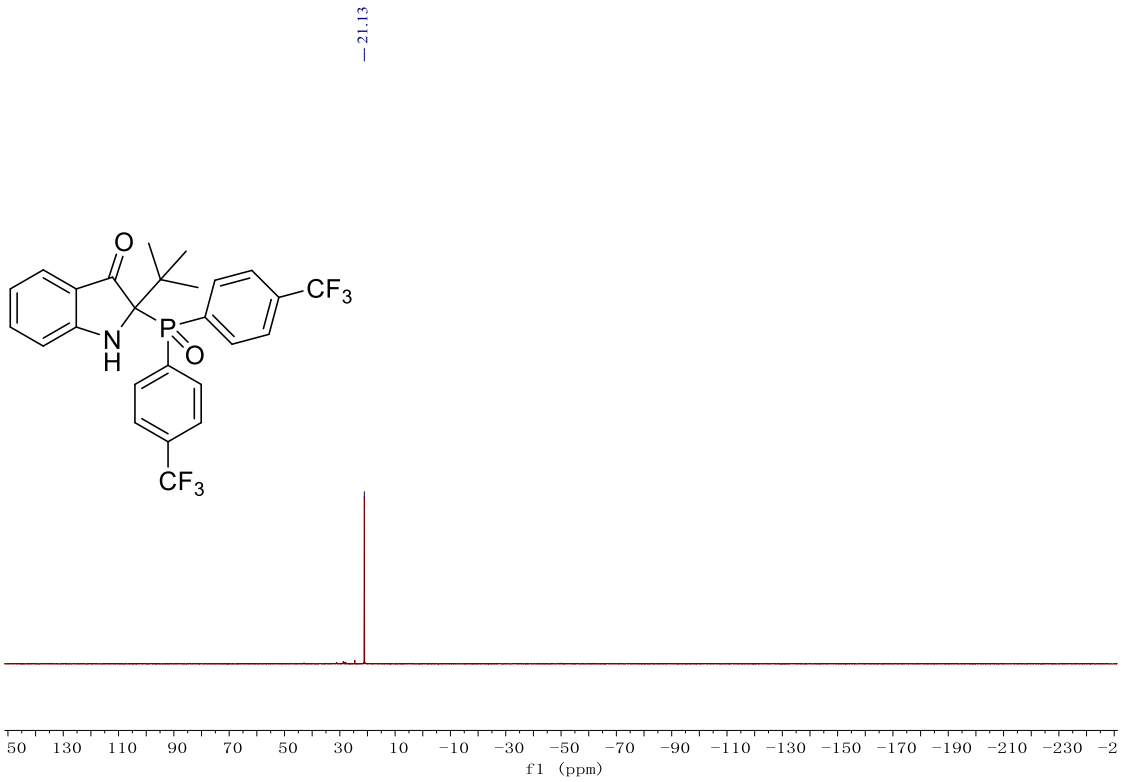

24.16
O
CF3
Me
N
H
P
O
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

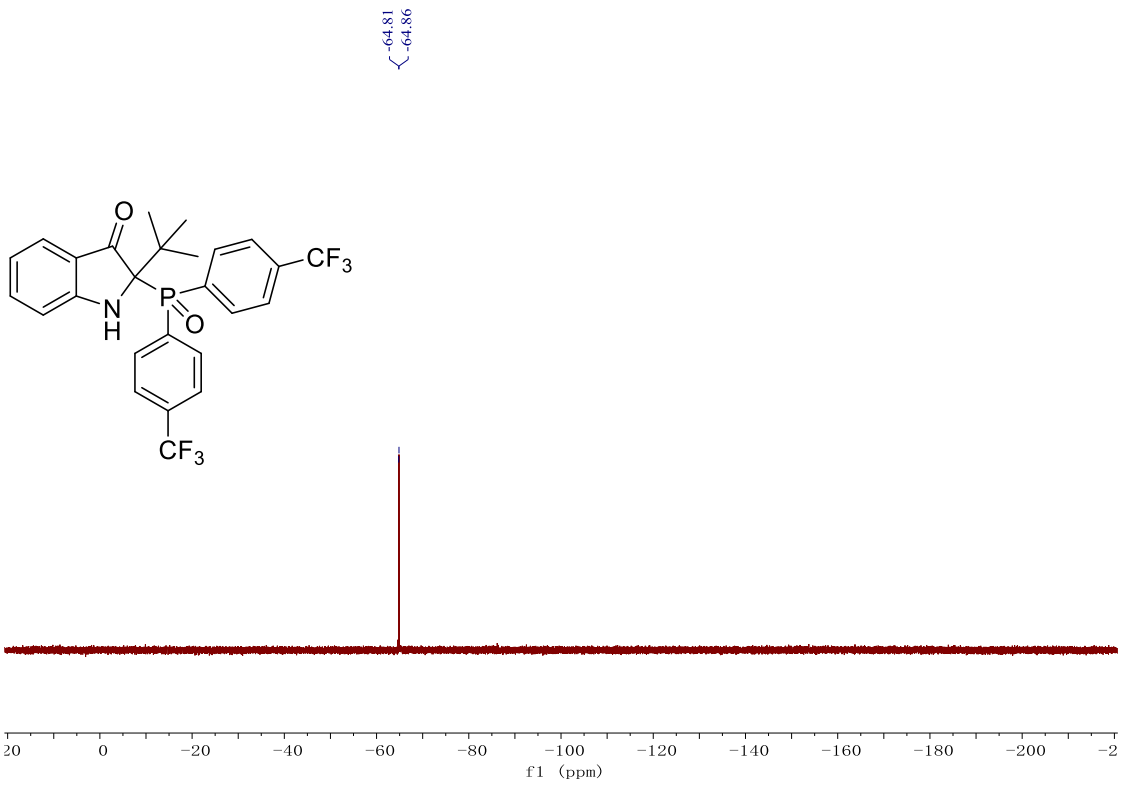

61.83
61.84
O
CF3
Me
N
H
P
O
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-(tert-butyl)indolin-3-one (3dd)

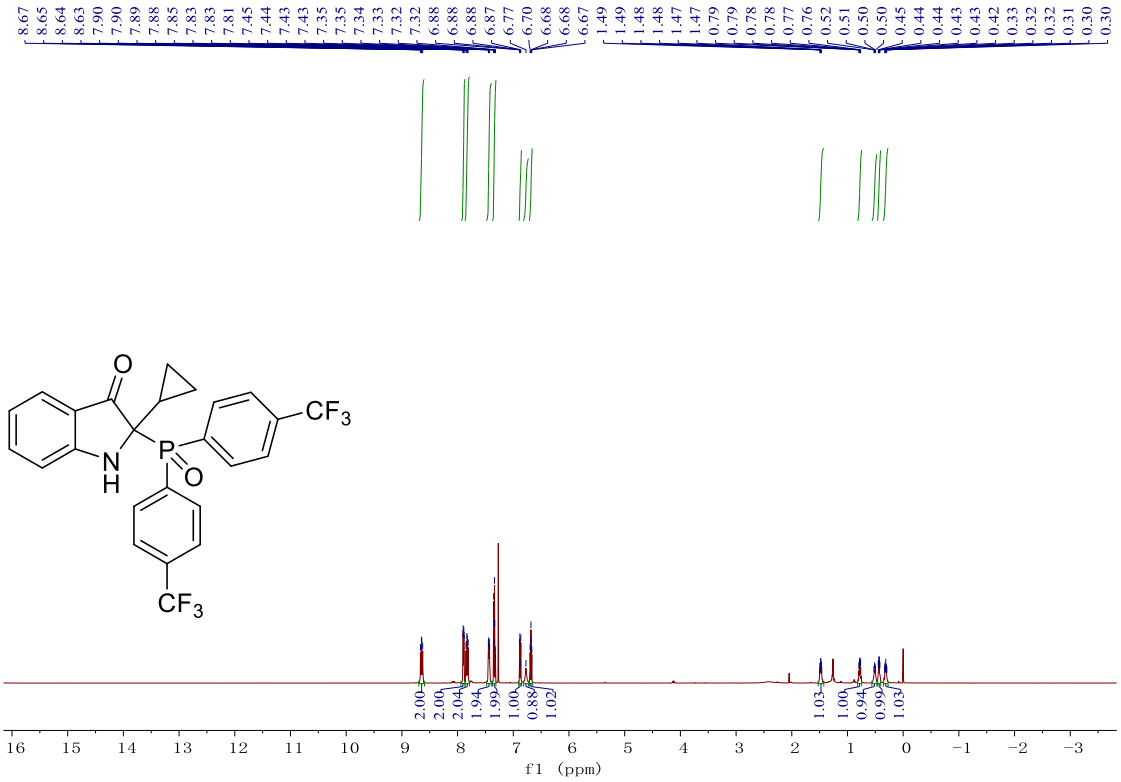


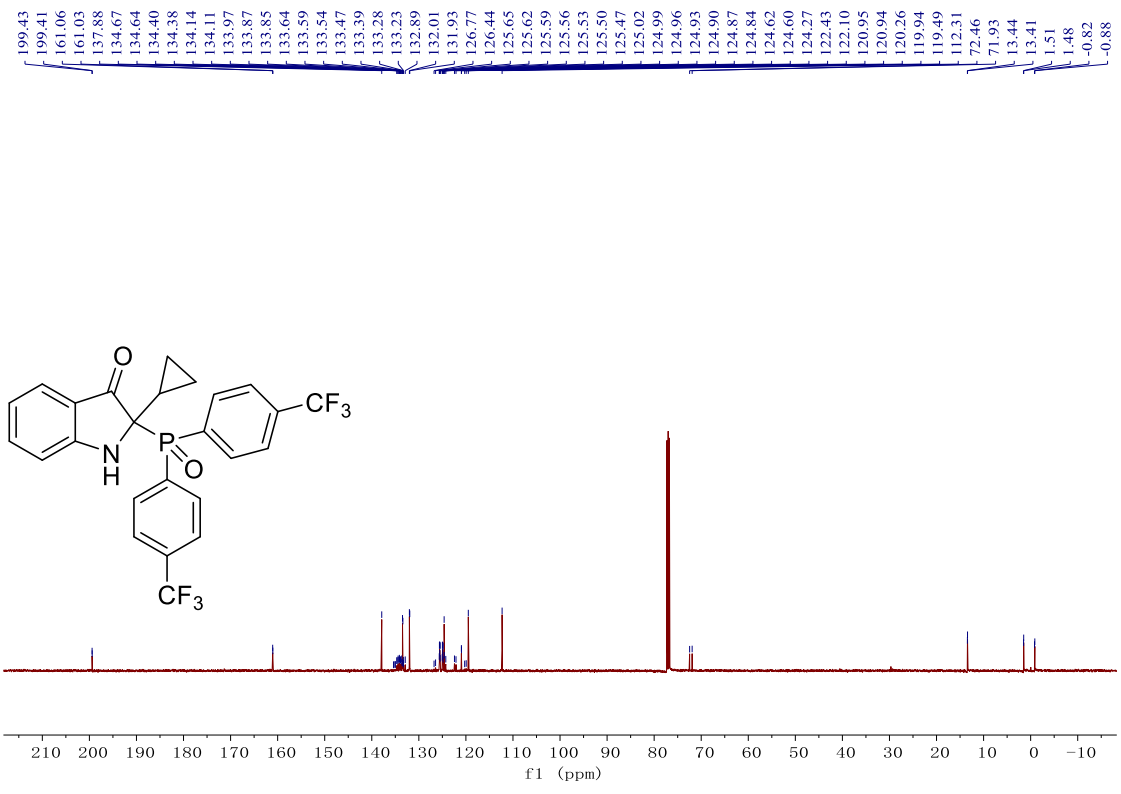


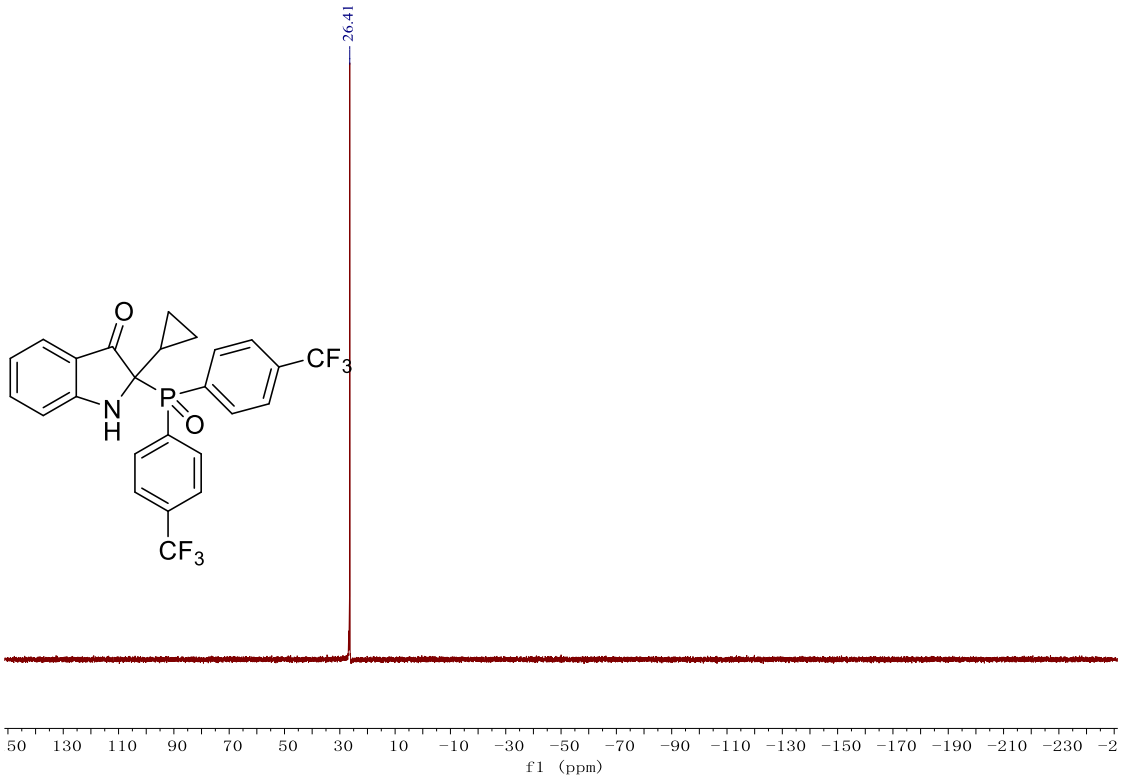

21.13
O
N
H
P
O
CF3
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

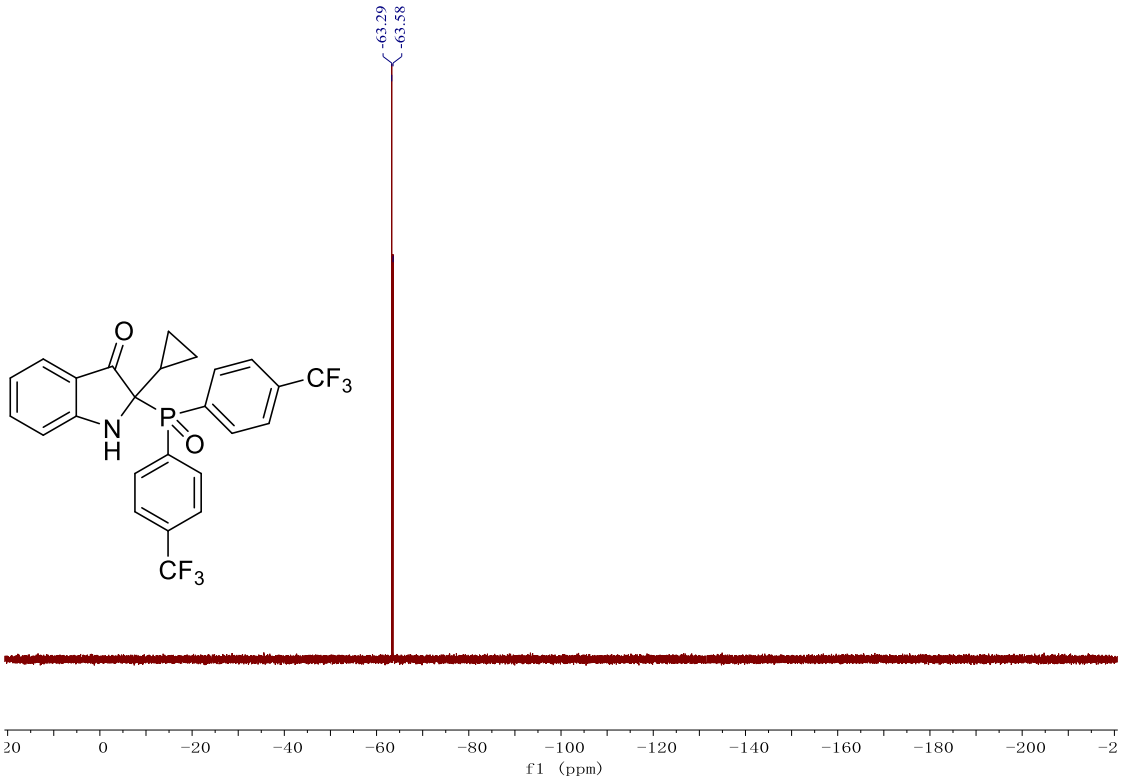

-64.81
-64.86
O
N
H
P
O
CF3
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

2-(bis(4-(trifluoromethyl)phenyl)phosphoryl)-2-cyclopropylindolin-3-one (3ee)

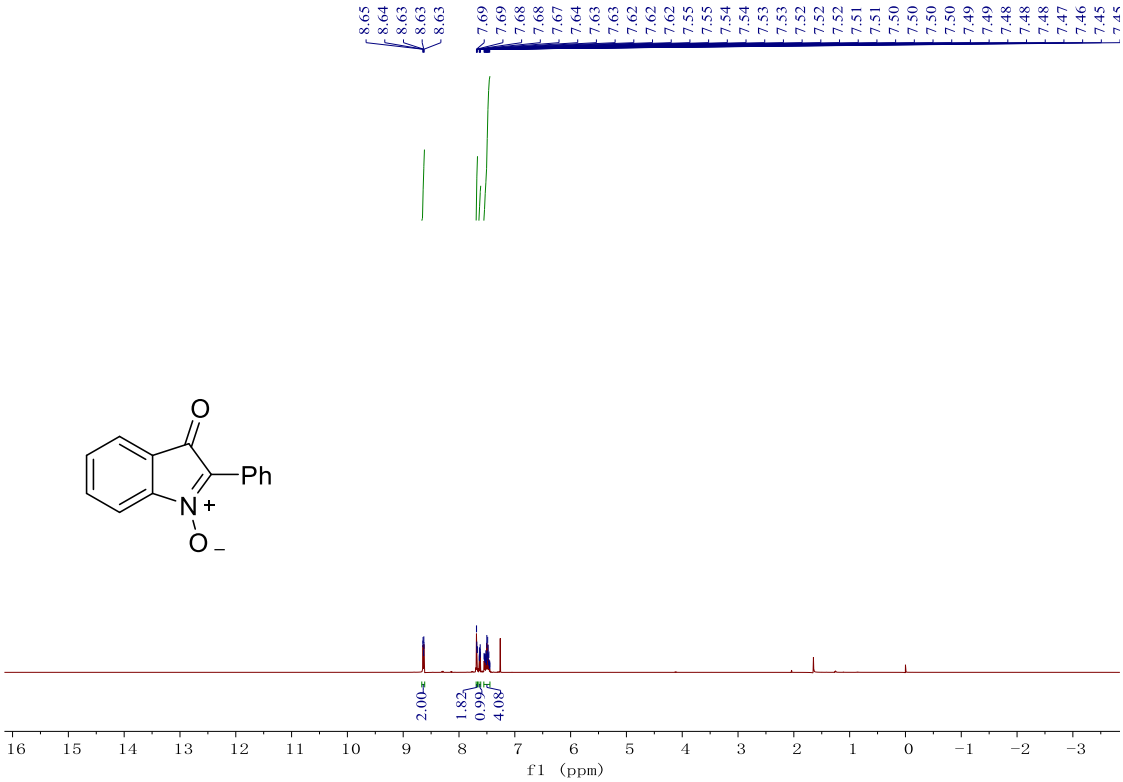





26.41
O
N
H
P
O
CF3
CF3
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)


-63.29
-63.58
O
N
H
P
O
CF3
CF3
20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −2
f1 (ppm)

3-oxo-2-phenyl-3*H*-indole 1-oxide (4)



Diphenylphosphinic acid (5)