Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Organocatalytic 1,6-hydrophosphination of *para*-quinone methides: enantioselective access to phosphorus-substituted quaternary carbon stereocenters

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Contents:

General remarks and materials

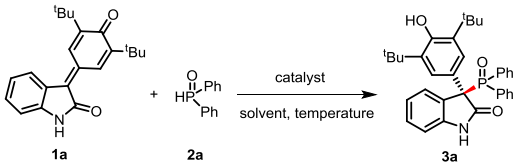
NMR spectra were recorded with a BrukerAvance III HD600 (500) spectrometer at 600 MHz or 500 MHz for ^{1}H NMR, 151 MHz or 126 MHz for ^{13}C NMR, 243 MHz or 202 MHz for ^{31}P NMR and 565 MHz or 471 MHz for ^{19}F NMR. Tetramethylsilane (TMS) signals or residual solvent signals were used [TMS $\delta = 0.00$ (^{1}H NMR), $CDCl_3$ $\delta = 77.00$ (^{13}C NMR), DMSO-d_6 $\delta = 2.50$ (^{1}H NMR), 39.52 (^{13}C NMR)] as internal standards. Date for ^{1}H NMR are reported in parts per million as follows: chemical shift, multiplicity (s =singlet, d = doublet, t = triplet, q = quartet, dd = double doublet, m = multiplet, hept = heptet). Data for ^{13}C NMR, ^{31}P NMR and ^{19}F NMR are reported in terms of chemical shift in parts per million. HRMS (ESI) Mass spectra were recorded on Waters Xevo G2 Q-TOF MS with Acquity UPLC. Column chromatography was carried out on silica gel (particle size 300-400 mesh). HPLC analysis was performed on Shanghai Wufeng LC-P100 equipped with Daicel chiralpak IC, OD-H and AD-H. The racemic standards used in HPLC studies were prepared according to the general procedure by using DABCO. Unless stated otherwise, all the solvents and reagents were purchased from commercial suppliers and used without further purification. We used the commercial available powdered molecular sieves in the reaction. Molecular sieves were flame-dried under vacuum. Substrates **1** were synthesized according to the published procedures.[1] Substrates **2** were prepared according to the literature method.[2] Substrate **4** was prepared according to the literature method.[3] Catalysts **Q-5** was prepared according to the literature method.[4]

General Procedures

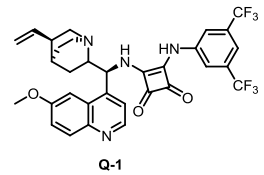
General Procedure for Optimization of Reaction Conditions (Table 1 and Table S1):

The solvent was added to the mixture of **1a** (33.5 mg, 0.1 mmol), **2a** (40.4 mg, 0.2 mmol) and catalyst under the indicated temperature in Table 1. Upon completion (monitored by TLC), the mixture was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 2/1) to give the product **3a**.

Table S1. Optimization of the catalysts [a]



1a 2a 3a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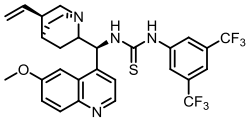
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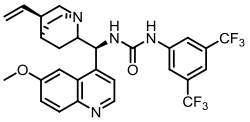
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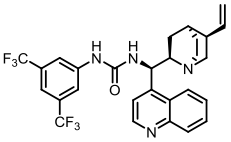
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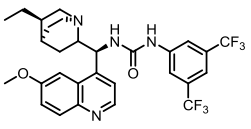
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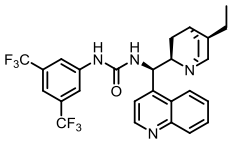
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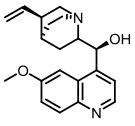
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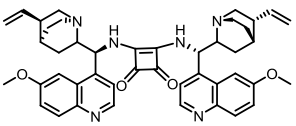
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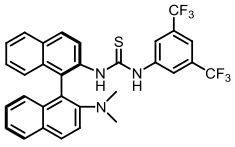
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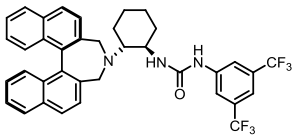
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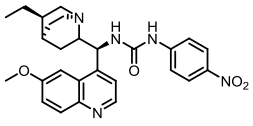
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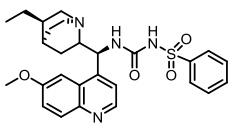
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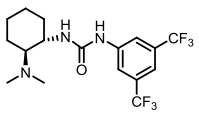
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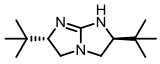
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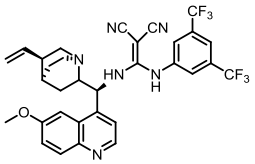
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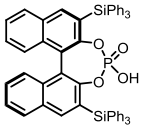

Q-16

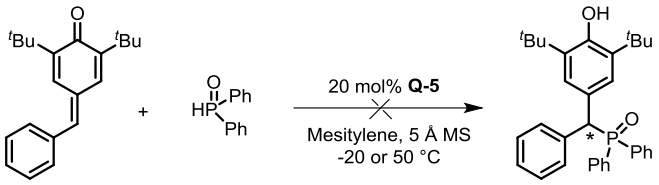
entry	catalyst	solvent	temp. (°C)	yield (%)[b]	er[c]
1	**Q-1**	toluene	rt	55	75:25
2	**Q-2**	toluene	rt	74	75:25
3	**Q-3**	toluene	rt	84	83:17
4	**Q-4**	toluene	rt	83	28:72
5	**Q-5**	toluene	rt	75	84.5:15.5
6	**Q-6**	toluene	rt	65	21:79
7	**Q-7**	toluene	rt	35	59:41
8	**Q-8**	toluene	rt	26	55:45
9	**Q-9**	toluene	rt	46	52:48
10	**Q-10**	toluene	rt	37	50:50
11	**Q-11**	toluene	rt	74	60:40
12	**Q-12**	toluene	rt	52	73:27
13	**Q-13**	toluene	rt	89	68:32
14	**Q-14**	toluene	rt	NR	-
15	**Q-15**	toluene	rt	36	72.5:27.5
16	**Q-16**	toluene	rt	NR	-

[a]Reaction conditions: **1a** (0.10 mmol), **2a** (0.20 mmol), catalyst (10 mol %), solvent (2 mL), 36 h. [b]Isolated yield. [c]Determined by HPLC on a chiral stationary phase. NR = No Reaction.

General Procedure for asymmetric 1,6-hydrophosphination of *p*-QMs with H-phosphine oxides (Table 2, Table 3):

Mesitylene (4 mL) was added to the mixture of **1** (0.1 mmol), **2** (0.2 mmol), molecular sieves (50 mg, 5 Å) and catalyst **Q-5** (11.6 mg, 0.02 mmol) at -20 °C. Upon completion (monitored by TLC), the mixture was purified by column chromatography on silica gel (petroleum ether/ethyl acetate) to give the product.

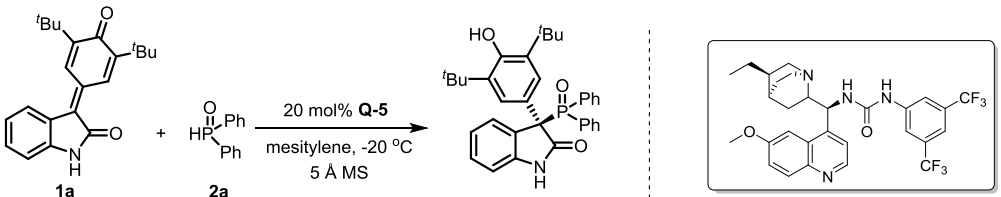
General Procedure for asymmetric 1,6-hydrophosphination of *p*-QMs derived from aldehyde with H-phosphine oxide:



1a' 2a 3a'

Mesitylene (4 mL) was added to the mixture of **1a'** (0.1 mmol), **2** (0.2 mmol), molecular sieves (50 mg, 5 Å) and catalyst **Q-5** (11.6 mg, 0.02 mmol) at -20 or 50 °C. The procedure was monitored by TLC. No desired product was found.

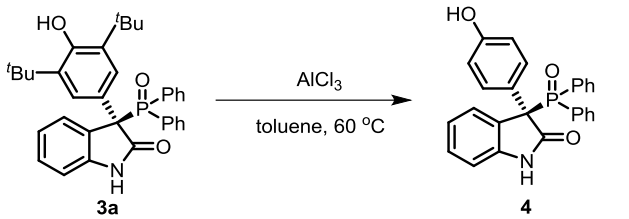
General procedure for scale-up reaction (Scheme 2a):



1a (1.0 mmol) 2a 3a 418 mg, 78% yield, 95:5 er Q-5

Mesitylene (40 mL) was added to the mixture of **1a** (335 mg, 1 mmol), **2a** (404 mg, 2 mmol), molecular sieves (500 mg, 5 Å) and catalyst **Q-5** (116 mg, 0.02 mmol) at -20 °C. The reaction was stirred at -20 °C for 72 h. Upon completion (monitored by TLC), the mixture was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 2/1) to give the product **3a** in 78% yield and 95:5 er. Then, the pure catalyst could be isolated and recovered in 89% yield (103.5 mg) by using CH_2Cl_2/MeOH/Et_3N 100:2:1 as eluent.

General procedure for the synthesis of compound 4 (Scheme 2b):

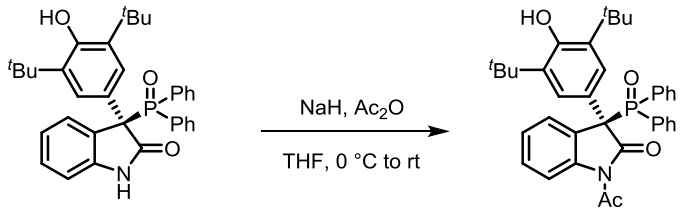


3a
95:5 er

4
82% yield, 92.5:7.5 er

To a solution of **3a** (161.3 mg, 0.3 mmol) in toluene (3 mL) at rt was added $AlCl_3$ (20 equiv) in one portion. Then the mixture was stirred at 60 °C for 2 h. Upon completion (monitored by TLC), the mixture was cooled to room temperature and poured into 10 mL ice water. The mixture was extracted 3x with 10 mL ethyl acetate and the combined organic layers are dried over Na_2SO_4, filtered, and concentrated *in vacuo*. And then the residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 1/2) to give the product **4** in 82% yield with 92.5:7.5 er.

General procedure for the synthesis of compound (*R*)-3l:



3a **3l**

To a solution of **3a** (161.3 mg, 0.3 mmol) in 3 mL anhydrous THF was added NaH (21.6 mg, 0.9 mmol) at 0 °C. After the mixture was stirred at 0 °C for 0.5 h, Ac_2O (36.8 mg, 0.36 mmol) was added at the same temperature. Then the mixture was stirred at room temperature for 3 h. Upon completion (monitored by TLC), water (5 mL) was added. The mixture was extracted 3x with 10 mL ethyl acetate and the combined organic layers are dried over Na_2SO_4, filtered, and concentrated *in vacuo*. And then the residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5/1) to give the product **3l** in 66% yield with 93.5:6.5 er.

References:

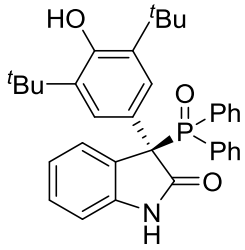
1. H. Wang, K. Wang, Y. Man, X. Gao, L. Yang, Y. Ren, N. Li, B. Tang, G. Zhao, *Adv. Synth. Catal.* 2017, **359**, 3934.

2. C. A. Busacca, J. C. Lorenz, N. Grinberg, N. Haddad, M. Hrapchak, B. Latli, H. Lee, P. Sabila, A. Saha, M. Sarvestani, S. Shen, R. Varsolona, X. Wei, C. H. Senanayake, *Org. Lett.* 2005, **7**, 4277.

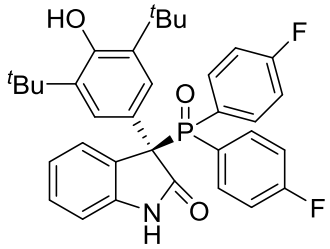
3. Z. Feng, Z. Yuan, X. Zhao, Y. Huang, H. Yao, *Org. Chem. Front.* 2019, **6**, 3535.

4. M. S. Manna, S. Mukherjee, *J. Am. Chem. Soc.* 2015, **137**, 130.

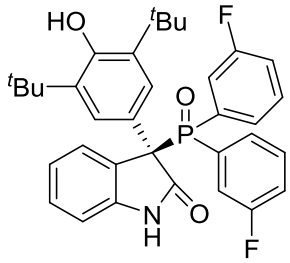
Analysis data for products



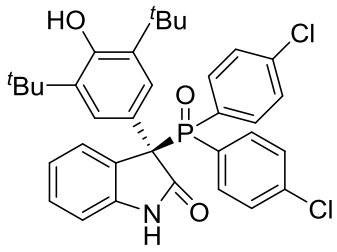
(*R*)-**3a**, white solid, 78% yield, 95:5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.34 (s, 1H), 7.87–7.78 (m, 2H), 7.57–7.46 (m, 6H), 7.39–7.33 (m, 3H), 7.23 (td, *J* = 7.8, 3.2 Hz, 2H), 7.18 (t, *J* = 7.7 Hz, 1H), 7.03 (t, *J* = 7.4 Hz, 1H), 6.68 (d, *J* = 7.7 Hz, 1H), 5.17 (s, 1H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.93, 153.37 (d, *J* = 2.5 Hz), 140.82 (d, *J* = 6.2 Hz), 135.30 (d, *J* = 1.7 Hz), 133.45 (d, *J* = 8.7 Hz), 132.27 (d, *J* = 9.0 Hz), 131.85 (d, *J* = 2.8 Hz), 131.79 (d, *J* = 2.7 Hz), 130.18 (d, *J* = 86.5 Hz), 129.39 (d, *J* = 88.6 Hz), 128.66 (d, *J* = 1.2 Hz), 128.63, 127.82 (d, *J* = 7.2 Hz), 127.73 (d, *J* = 7.0 Hz), 126.57 (d, *J* = 4.3 Hz), 125.62 (d, *J* = 4.8 Hz), 122.95 (d, *J* = 5.3 Hz), 122.08 (d, *J* = 2.0 Hz), 109.45, 62.03 (d, *J* = 56.5 Hz), 34.52, 30.11; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.80; **HRMS** (ESI) Calcd.for $C_{34}H_{36}NO_3PNa$ $(M+Na)^+$ 560.2325, Found: 560.2321; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R = 7.915 min, 20.448 min.



(*R*)-**3b**, white solid, 81% yield, 96:4 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.94 (ddd, *J* = 10.5, 8.7, 5.8 Hz, 2H), 7.70 (d, *J* = 9.3 Hz, 2H), 7.55 (d, *J* = 1.6 Hz, 2H), 7.47 (ddd, *J* = 10.7, 8.7, 5.7 Hz, 2H), 7.22 (t, *J* = 7.7 Hz, 1H), 7.12–7.03 (m, 3H), 6.94 (td, *J* = 8.7, 2.2 Hz, 2H), 6.69 (d, *J* = 7.8 Hz, 1H), 5.17 (s, 1H), 1.31 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.96, 166.05 (dd, *J* = 15.4, 3.2 Hz), 164.03 (dd, *J* = 15.4, 3.4 Hz), 153.43 (d, *J* = 2.3 Hz), 140.62 (d, *J* = 6.3 Hz), 135.94 (t, *J* = 9.4 Hz), 135.58 (d, *J* = 1.5 Hz), 134.69 (t, *J* = 9.5 Hz), 128.84 (d, *J* = 1.5 Hz), 128.56 (d, *J* = 2.6 Hz), 126.49 (d, *J* = 4.1 Hz), 126.00 (dd, *J* = 86.3, 3.0 Hz), 125.35 (d, *J* = 4.9 Hz), 125.19 (dd, *J* = 89.7, 3.5 Hz), 123.09 (d, *J* = 5.2 Hz), 122.34 (d, *J* = 1.6 Hz), 115.30 (dd, *J* = 13.4, 3.7 Hz), 115.13 (dd, *J* = 13.2, 3.7 Hz), 109.50, 62.18 (d, *J* = 58.1 Hz), 34.53, 30.11; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.15; **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -106.27 (d, *J* = 3.8 Hz), -106.51 (d, *J* = 4.6 Hz); **HRMS** (ESI) Calcd.for $C_{34}H_{34}F_2NO_3PNa$ $(M+Na)^+$ 596.2137, Found: 596.2137; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R = 14.015 min, 19.598 min.

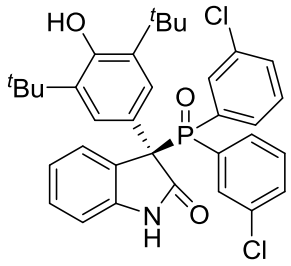


(*R*)-**3c**, white solid, 93% yield, 90:10 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.81 (s, 1H), 7.74–7.60 (m, 3H), 7.56 (d, *J* = 1.8 Hz, 2H), 7.41–7.34 (m, 1H), 7.34–7.27 (m, 1H), 7.26–7.15 (m, 4H), 7.10 (t, *J* = 7.9 Hz, 2H), 6.72 (d, *J* = 7.8 Hz, 1H), 5.18 (s, 1H), 1.32 (s, 18H). **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 174.30, 162.46 (t, *J* = 16.6 Hz), 160.49 (t, *J* = 16.8 Hz), 153.05 (d, *J* = 2.5 Hz), 141.41 (d, *J* = 6.5 Hz), 135.56, 132.42 (dd, *J* = 87.7, 5.4 Hz), 131.64 (dd, *J* = 91.4, 5.7 Hz), 129.44 (d, *J* = 7.5 Hz), 129.36, 129.27 (d, *J* = 7.4 Hz), 128.80 (dd, *J* = 8.3, 2.9 Hz), 128.55 (d, *J* = 1.5 Hz), 127.91 (d, *J* = 2.4 Hz), 127.49 (dd, *J* = 8.1, 2.9 Hz), 125.88 (d, *J* = 4.2 Hz), 124.98 (d, *J* = 5.0 Hz), 122.86 (d, *J* = 5.6 Hz), 121.51, 119.87 (dd, *J* = 23.4, 9.5 Hz), 118.68 (d, *J* = 21.3 Hz), 118.53 (dd, *J* = 22.8, 9.6 Hz), 109.46, 61.62 (d, *J* = 59.1 Hz), 34.21, 29.76; **^{31}P NMR** (202 MHz, Chloroform-*d*) δ 26.85 (t, *J* = 5.7 Hz); **^{19}F NMR** (471 MHz, Chloroform-*d*) δ -111.29 (d, *J* = 5.7 Hz), -111.51 (d, *J* = 5.9 Hz); **HRMS** (ESI) Calcd.for $C_{34}H_{34}F_2NO_3PNa$ $(M+Na)^+$ 596.2137, Found: 596.2138; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R = 7.357 min, 12.323 min.

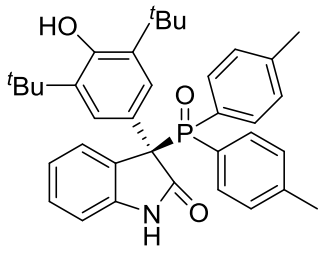


(*R*)-**3d**, white solid, 67% yield, 94:6 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 9.03 (s, 1H), 7.80 (dd, *J* = 10.5, 8.6 Hz, 2H), 7.65 (d, *J* = 7.4 Hz, 1H), 7.55 (d, *J* = 1.0 Hz, 2H), 7.44 (dd, *J* = 10.6, 8.5 Hz, 2H), 7.35 (dd, *J* = 8.5, 2.2 Hz, 2H), 7.20 (dd, *J* = 8.5, 2.2 Hz, 2H), 7.17 (t, *J* = 7.7 Hz, 1H), 7.05 (t, *J* = 7.6 Hz, 1H), 6.65 (d, *J* = 7.7 Hz, 1H), 5.23 (s, 1H), 1.31 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.86, 153.49 (d, *J* = 2.5 Hz), 140.88 (d, *J* = 6.3 Hz), 138.78 (d, *J* = 3.5 Hz), 138.69 (d, *J* = 3.4 Hz), 135.59 (d, *J* = 1.8 Hz), 134.72 (d, *J* = 9.7 Hz), 133.52 (d, *J* = 9.8 Hz), 128.91 (d, *J* = 1.7 Hz), 128.47 (d, *J* = 3.0 Hz), 128.41 (d, *J* = 64.5 Hz), 128.28 (d, *J* = 2.0 Hz), 128.18 (d, *J* = 2.4 Hz), 127.61 (d, *J* = 68.4 Hz), 126.25 (d, *J* = 4.3 Hz), 125.39 (d, *J* = 4.9 Hz), 122.70 (d, *J* = 5.4 Hz), 122.28 (d, *J* = 1.9 Hz), 109.72, 61.92 (d, *J* = 58.5 Hz), 34.52, 30.07; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 27.99; **HRMS** (ESI) Calcd.for $C_{34}H_{34}Cl_2NO_3PNa$ $(M+Na)^+$ 628.1546,

Found: 628.1551; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =11.981 min, 18.073 min.

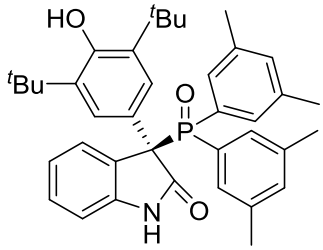


(*R*)-**3e**, white solid, 90% yield, 95:5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.17 (s, 1H), 7.87 (d, *J* = 11.3 Hz, 1H), 7.79 (t, *J* = 9.3 Hz, 1H), 7.66 (d, *J* = 7.5 Hz, 1H), 7.57 (d, *J* = 1.0 Hz, 2H), 7.48–7.35 (m, 4H), 7.33 (td, *J* = 7.9, 3.8 Hz, 1H), 7.25–7.17 (m, 2H), 7.11 (t, *J* = 7.6 Hz, 1H), 6.74 (d, *J* = 7.7 Hz, 1H), 5.20 (s, 1H), 1.33 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.82, 153.60 (d, *J* = 2.5 Hz), 140.95 (d, *J* = 6.4 Hz), 135.71 (d, *J* = 1.9 Hz), 134.41, 134.28, 133.11 (d, *J* = 9.7 Hz), 132.21 (d, *J* = 2.6 Hz), 132.18 (d, *J* = 2.6 Hz), 132.04 (d, *J* = 9.6 Hz), 131.95 (d, *J* = 78.4 Hz), 131.43 (d, *J* = 8.5 Hz), 131.18 (d, *J* = 81.5 Hz), 130.06 (d, *J* = 8.8 Hz), 129.33 (d, *J* = 9.5 Hz), 129.23 (d, *J* = 9.4 Hz), 129.11 (d, *J* = 1.7 Hz), 128.40 (d, *J* = 3.1 Hz), 125.91 (d, *J* = 4.3 Hz), 125.39 (d, *J* = 4.9 Hz), 122.43, 122.38, 109.84, 61.94 (d, *J* = 58.2 Hz), 34.54, 30.09; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 26.87; **HRMS** (ESI) Calcd.for $C_{34}H_{34}Cl_2NO_3PNa$ $(M+Na)^+$ 628.1546, Found: 628.1537; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =7.040 min, 11.007 min.

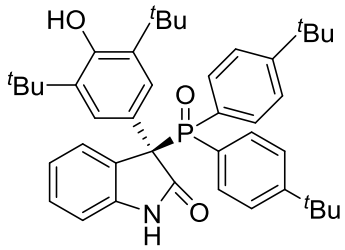


(*R*)-**3f**, white solid, 78% yield, 91:9 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.71 (s, 1H), 7.65 (dd, *J* = 10.4, 8.3 Hz, 2H), 7.55 (d, *J* = 0.8 Hz, 2H), 7.51 (d, *J* = 7.3 Hz, 1H), 7.41 (dd, *J* = 10.8, 8.1 Hz, 2H), 7.14 (t, *J* = 7.6 Hz, 3H), 7.05–6.97 (m, 3H), 6.66 (d, *J* = 7.7 Hz, 1H), 5.16 (s, 1H), 2.36 (s, 3H), 2.24 (s, 3H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 175.15, 153.24 (d, *J* = 2.4 Hz), 142.10 (d, *J* = 2.7 Hz), 142.04 (d, *J* = 2.6 Hz), 141.18 (d, *J* = 5.9 Hz), 135.08 (d, *J* = 1.6 Hz), 133.36 (d, *J* = 9.0 Hz), 132.30 (d, *J* = 9.2 Hz), 128.52 (d, *J* = 2.1 Hz), 128.48 (d, *J* = 1.8 Hz), 127.13 (d, *J* = 95.2 Hz), 126.78, 126.33 (d, *J* = 94.5 Hz), 125.68 (d, *J* = 4.5 Hz), 123.05 (d, *J* = 5.1 Hz), 121.77 (d, *J* = 1.6 Hz), 109.60, 61.87 (d, *J* = 56.6 Hz), 34.48, 30.08, 21.52, 21.43; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 29.32; **HRMS** (ESI) Calcd.for $C_{36}H_{40}NO_3PNa$ $(M+Na)^+$

588.2638, Found: 588.2645; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =13.973 min, 28.832 min.

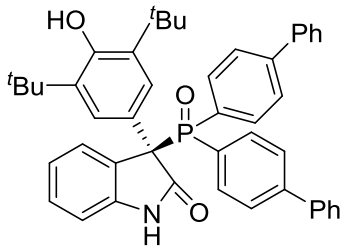


(*R*)-**3g**, white solid, 93% yield, 95:5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.16 (s, 1H), 7.61 (d, *J* = 1.6 Hz, 2H), 7.39 (d, *J* = 7.5 Hz, 1H), 7.33 (d, *J* = 11.2 Hz, 2H), 7.20 (t, *J* = 7.7 Hz, 1H), 7.09 (s, 1H), 7.06–7.01 (m, 3H), 7.00 (s, 1H), 6.70 (d, *J* = 7.7 Hz, 1H), 5.16 (s, 1H), 2.25 (s, 6H), 2.15 (s, 6H), 1.32 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.88, 153.30 (d, *J* = 2.4 Hz), 141.42 (d, *J* = 5.9 Hz), 137.23 (d, *J* = 9.2 Hz), 137.13 (d, *J* = 9.2 Hz), 135.20 (d, *J* = 1.7 Hz), 133.48 (d, *J* = 2.9 Hz), 133.38 (d, *J* = 2.9 Hz), 130.99 (d, *J* = 8.6 Hz), 130.07 (d, *J* = 97.4 Hz), 130.02 (d, *J* = 9.0 Hz), 128.86 (d, *J* = 98.4 Hz), 128.64 (d, *J* = 2.9 Hz), 128.52 (d, *J* = 1.8 Hz), 126.53 (d, *J* = 3.7 Hz), 125.73 (d, *J* = 4.5 Hz), 123.18 (d, *J* = 5.1 Hz), 121.76 (d, *J* = 1.4 Hz), 109.46, 61.94 (d, *J* = 55.4 Hz), 34.49, 30.17, 21.27, 21.17; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 29.76; **HRMS** (ESI) Calcd.for $C_{38}H_{44}NO_3PNa$ $(M+Na)^+$ 616.2951, Found: 616.2953; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =6.632 min, 10.982 min.

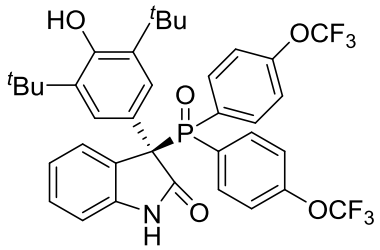


(*R*)-**3h**, white solid, 94% yield, 91:9 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.76 (s, 1H), 7.71 (dd, *J* = 10.1, 8.6 Hz, 2H), 7.52 (dd, *J* = 10.8, 8.5 Hz, 2H), 7.48 (d, *J* = 1.0 Hz, 2H), 7.44 (d, *J* = 6.9 Hz, 1H), 7.39 (dd, *J* = 8.4, 2.8 Hz, 2H), 7.28 (dd, *J* = 8.4, 2.6 Hz, 2H), 7.17 (t, *J* = 7.7 Hz, 1H), 7.01 (t, *J* = 7.6 Hz, 1H), 6.69 (d, *J* = 7.7 Hz, 1H), 5.14 (s, 1H), 1.31 (s, 9H), 1.27 (s, 18H), 1.25 (s, 9H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.84, 155.13 (d, *J* = 2.8 Hz), 154.96 (d, *J* = 2.7 Hz), 153.29 (d, *J* = 2.7 Hz), 141.11, 134.95 (d, *J* = 2.0 Hz), 133.37 (d, *J* = 8.8 Hz), 132.32 (d, *J* = 9.2 Hz), 128.65, 128.45 (d, *J* = 1.7 Hz), 127.14 (d, *J* = 90.0 Hz), 126.56 (d, *J* = 4.0 Hz), 126.33 (d, *J* = 92.0 Hz), 125.81 (d, *J* = 4.6 Hz), 124.80 (d, *J* = 2.8 Hz), 124.70 (d, *J* = 2.9 Hz), 122.66 (d, *J* = 5.0 Hz), 121.71, 109.46, 61.87 (d, *J* = 56.5 Hz), 34.91, 34.83, 34.50, 31.11, 31.01, 30.11; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.97; **HRMS** (ESI) Calcd.for $C_{42}H_{52}NO_3PNa$ $(M+Na)^+$

672.3577, Found: 672.3585; **HPLC** (Chiral IC, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =7.240 min, 21.123 min.

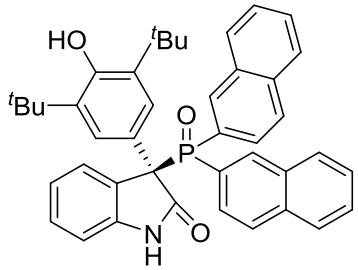


(*R*)-**3i**, white solid, 74% yield, 93:7 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.15 (s, 1H), 7.95 (dd, *J* = 10.5, 8.4 Hz, 2H), 7.70–7.55 (m, 9H), 7.52–7.42 (m, 6H), 7.42–7.37 (m, 3H), 7.34 (t, *J* = 7.3 Hz, 1H), 7.19 (t, *J* = 7.7 Hz, 1H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.71 (d, *J* = 7.7 Hz, 1H), 5.16 (s, 1H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 175.18, 153.36 (d, *J* = 2.5 Hz), 144.49 (d, *J* = 2.7 Hz), 144.30 (d, *J* = 2.8 Hz), 141.52 (d, *J* = 5.3 Hz), 139.95, 139.66, 135.26 (d, *J* = 1.4 Hz), 133.87 (d, *J* = 9.0 Hz), 132.82 (d, *J* = 9.1 Hz), 128.85 (d, *J* = 59.3 Hz), 128.83, 128.73, 128.65, 128.45 (d, *J* = 2.3 Hz), 128.05 (d, *J* = 62.7 Hz), 128.00, 127.92, 127.19, 127.06, 126.47 (d, *J* = 3.5 Hz), 126.42, 126.37 (d, *J* = 3.5 Hz), 125.72 (d, *J* = 4.5 Hz), 122.76 (d, *J* = 5.0 Hz), 121.83, 109.94, 61.99 (d, *J* = 57.4 Hz), 34.49, 30.06; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.98; **HRMS** (ESI) Calcd.for $C_{46}H_{44}NO_3PNa$ $(M+Na)^+$ 712.2951, Found: 712.2950; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =22.107 min, 46.023 min.

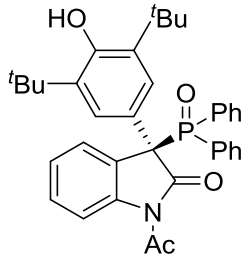


(*R*)-**3j**, white solid, 99% yield, 90.5:9.5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.80 (s, 1H), 7.74–7.61 (m, 3H), 7.56 (d, *J* = 1.8 Hz, 2H), 7.41–7.34 (m, 1H), 7.34–7.28 (m, 1H), 7.26–7.15 (m, 4H), 7.10 (t, *J* = 7.9 Hz, 2H), 6.72 (d, *J* = 7.8 Hz, 1H), 5.18 (s, 1H), 1.32 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.76, 153.56 (d, *J* = 2.5 Hz), 152.06 (dd, *J* = 3.6, 1.9 Hz), 151.96 (dd, *J* = 3.2, 1.6 Hz), 140.69 (d, *J* = 6.3 Hz), 135.68 (d, *J* = 1.8 Hz), 135.47 (d, *J* = 10.0 Hz), 134.21 (d, *J* = 10.0 Hz), 129.01 (d, *J* = 1.8 Hz), 128.54 (d, *J* = 2.9 Hz), 128.41 (d, *J* = 59.0 Hz), 127.61 (d, *J* = 62.4 Hz), 126.12 (d, *J* = 4.4 Hz), 125.38, 125.34, 122.60 (d, *J* = 5.4 Hz), 122.41 (d, *J* = 1.8 Hz), 120.26 (q, *J* = 259.2 Hz), 120.18 (q, *J* = 259.3 Hz), 119.82 (d, *J* = 25.3 Hz), 109.63, 62.07 (d, *J* = 58.7 Hz), 34.51, 30.01; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 27.36; **^{19}F NMR** (471 MHz, $CDCl_3$) δ -57.60, -57.63; **HRMS** (ESI) Calcd.for $C_{36}H_{34}F_6NO_5PNa$ $(M+Na)^+$ 728.1971,

Found: 728.1971; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =7.573 min, 10.248 min.

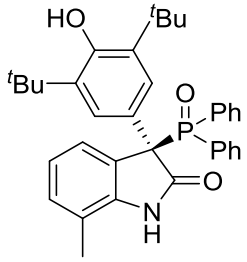


(*R*)-**3k**, white solid, 63% yield, 95:5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.46 (d, *J* = 13.2 Hz, 1H), 8.18 (s, 1H), 8.13 (d, *J* = 13.3 Hz, 1H), 7.90–7.78 (m, 4H), 7.73 (d, *J* = 8.2 Hz, 1H), 7.70–7.55 (m, 7H), 7.50 (t, *J* = 7.1 Hz, 2H), 7.40 (t, *J* = 7.4 Hz, 1H), 7.16 (t, *J* = 7.4 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.63 (d, *J* = 7.5 Hz, 1H), 5.14 (s, 1H), 1.23 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.80, 153.41 (d, *J* = 2.5 Hz), 141.00 (d, *J* = 6.2 Hz), 136.04 (d, *J* = 7.8 Hz), 135.36 (d, *J* = 1.8 Hz), 134.76 (d, *J* = 8.3 Hz), 134.65 (d, *J* = 2.4 Hz), 134.55 (d, *J* = 2.4 Hz), 132.24 (d, *J* = 13.2 Hz), 132.06 (d, *J* = 13.2 Hz), 129.19, 129.13, 128.69 (d, *J* = 1.8 Hz), 128.64 (d, *J* = 3.2 Hz), 128.18, 128.07, 127.99 (d, *J* = 9.9 Hz), 127.55, 127.49, 127.52 (d, *J* = 7.7 Hz), 127.35 (d, *J* = 11.8 Hz), 127.23, 127.14 (d, *J* = 2.5 Hz), 126.73 (d, *J* = 88.0 Hz), 126.61 (d, *J* = 4.1 Hz), 126.47, 126.45, 125.70 (d, *J* = 4.8 Hz), 123.06 (d, *J* = 5.2 Hz), 122.12 (d, *J* = 2.0 Hz), 109.59, 62.08 (d, *J* = 56.8 Hz), 34.47, 30.05; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 29.61; **HRMS** (ESI) Calcd.for $C_{42}H_{40}NO_3PNa$ $(M+Na)^+$ 660.2638, Found: 660.2638; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =20.182 min, 65.065 min.

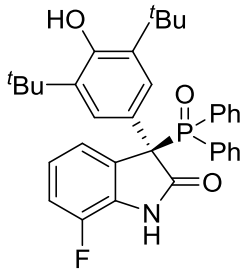


(*R*)-**3l**, white solid, 66% yield, 93.5:6.5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.07 (d, *J* = 8.2 Hz, 1H), 7.78 (dd, *J* = 10.8, 8.2 Hz, 2H), 7.54–7.41 (m, 5H), 7.41–7.31 (m, 5H), 7.29–7.27 (m, 1H), 7.25 (d, *J* = 3.4 Hz, 1H), 7.22 (t, *J* = 7.5 Hz, 1H), 5.27 (s, 1H), 2.46 (s, 3H), 1.31 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.72, 170.32, 153.58 (d, *J* = 1.9 Hz), 140.00 (d, *J* = 6.0 Hz), 135.71, 133.33 (d, *J* = 8.7 Hz), 132.30 (d, *J* = 2.8 Hz), 132.14 (d, *J* = 2.8 Hz), 131.90 (d, *J* = 9.1 Hz), 129.78 (d, *J* = 98.3 Hz), 129.04 (d, *J* = 2.1 Hz), 128.69 (d, *J* = 100.0 Hz), 127.99 (d, *J* = 3.5 Hz), 127.89 (d, *J* = 3.4 Hz), 125.47 (d, *J* = 4.9 Hz), 125.00 (d, *J* = 4.3 Hz), 124.61 (d, *J* = 2.2 Hz), 123.27 (d, *J* = 4.5 Hz), 116.03 (d, *J* = 0.6 Hz), 62.62 (d, *J* = 54.7 Hz), 34.51, 30.07, 26.60; **^{31}P NMR** (202 MHz, $CDCl_3$) δ

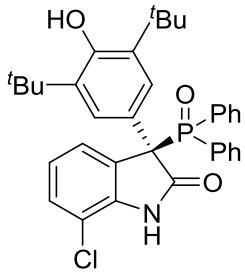
29.43; **HRMS** (ESI) Calcd.for $C_{36}H_{38}NO_4PNa$ $(M+Na)^+$ 602.2431, Found: 602.2435; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 10/1, Flow rate = 0.8 mL/min), t_R =12.640 min, 22.015 min.



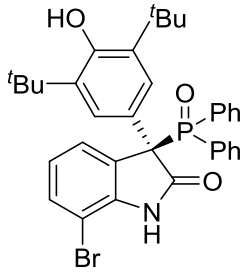
(*R*)-**3m**, white solid, 93% yield, 99:1 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 9.14 (s, 1H), 7.78 (t, *J* = 9.3 Hz, 2H), 7.58–7.46 (m, 5H), 7.36 (t, *J* = 7.0 Hz, 3H), 7.26–7.21 (m, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.95 (t, *J* = 7.6 Hz, 1H), 5.16 (s, 1H), 2.13 (s, 3H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 175.76, 153.41 (d, *J* = 2.6 Hz), 139.87 (d, *J* = 5.9 Hz), 135.22 (d, *J* = 1.9 Hz), 133.53 (d, *J* = 8.6 Hz), 132.41 (d, *J* = 8.8 Hz), 131.86 (d, *J* = 2.5 Hz), 131.77 (d, *J* = 2.4 Hz), 130.19 (d, *J* = 91.9 Hz), 129.90 (d, *J* = 1.6 Hz), 129.41 (d, *J* = 93.6 Hz), 127.76, 127.66, 127.57, 125.99 (d, *J* = 3.7 Hz), 125.77 (d, *J* = 4.6 Hz), 122.67 (d, *J* = 5.2 Hz), 122.02 (d, *J* = 1.8 Hz), 118.90, 62.44 (d, *J* = 56.3 Hz), 34.53, 30.11, 16.30; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.79; **HRMS** (ESI) Calcd.for $C_{35}H_{38}NO_3PNa$ $(M+Na)^+$ 574.2482, Found: 574.2487; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =9.623 min, 14.440 min.



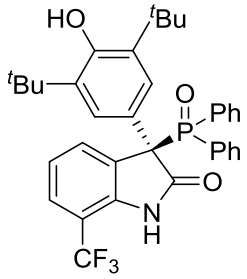
(*R*)-**3n**, white solid, 74% yield, 92:8 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.40–8.09 (m, 1H), 7.92–7.79 (m, 2H), 7.58–7.47 (m, 5H), 7.40–7.35 (m, 4H), 7.28–7.26 (m, 1H), 7.26–7.23 (m, 1H), 7.04–6.96 (m, 2H), 5.17 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.90, 153.43 (d, *J* = 2.4 Hz), 146.71 (d, *J* = 244.6 Hz), 135.38 (d, *J* = 1.8 Hz), 133.46 (d, *J* = 8.8 Hz), 132.11 (d, *J* = 9.0 Hz), 131.93 (d, *J* = 1.2 Hz), 129.90 (d, *J* = 76.6 Hz), 129.38 (d, *J* = 3.6 Hz), 129.11 (d, *J* = 79.5 Hz), 128.52 (dd, *J* = 12.7, 6.1 Hz), 127.83, 127.73, 125.48 (d, *J* = 4.7 Hz), 124.34 (d, *J* = 5.7 Hz), 124.34, 122.48 (d, *J* = 4.9 Hz), 122.43 (d, *J* = 5.5 Hz), 115.46 (dd, *J* = 16.6, 1.3 Hz), 62.66 (d, *J* = 57.8 Hz), 34.49, 30.04; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 28.63; **^{19}F NMR** (471 MHz, $CDCl_3$) δ -134.37; **HRMS** (ESI) Calcd.for $C_{34}H_{35}FNO_3PNa$ $(M+Na)^+$ 578.2231, Found: 574.2241; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =7.423 min, 14.515 min.



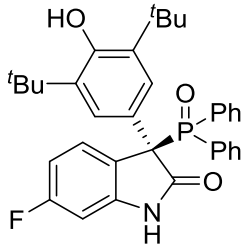
(*R*)-**3o**, white solid, 93% yield, 93.5:6.5 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.92–7.83 (m, 2H), 7.79 (s, 1H), 7.57–7.47 (m, 6H), 7.46–7.41 (m, 1H), 7.38 (td, *J* = 7.7, 3.4 Hz, 2H), 7.29 (td, *J* = 7.9, 3.3 Hz, 2H), 7.21 (dt, *J* = 8.2, 1.0 Hz, 1H), 7.03 (t, *J* = 7.9 Hz, 1H), 5.16 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.39, 153.49 (d, *J* = 2.4 Hz), 138.52 (d, *J* = 5.9 Hz), 135.45 (d, *J* = 1.8 Hz), 133.46 (d, *J* = 8.9 Hz), 132.14 (d, *J* = 9.0 Hz), 132.06 (d, *J* = 2.8 Hz), 131.99 (d, *J* = 2.8 Hz), 129.88 (d, *J* = 79.4 Hz), 129.10 (d, *J* = 82.4 Hz), 128.47 (d, *J* = 1.8 Hz), 128.15 (d, *J* = 4.1 Hz), 127.90 (d, *J* = 2.0 Hz), 127.80 (d, *J* = 2.3 Hz), 126.93 (d, *J* = 3.0 Hz), 125.44 (d, *J* = 4.8 Hz), 122.96 (d, *J* = 2.1 Hz), 122.47 (d, *J* = 5.2 Hz), 114.60, 63.34 (d, *J* = 55.4 Hz), 34.53, 30.08; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.67; **HRMS** (ESI) Calcd.for $C_{34}H_{35}ClNO_3PNa$ $(M+Na)^+$ 594.1935, Found: 594.1937; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 5/1, Flow rate = 0.6 mL/min), t_R =12.665 min, 33.915 min.



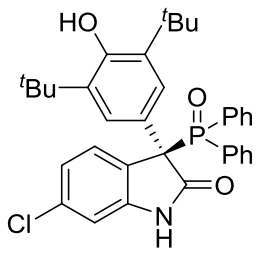
(*R*)-**3p**, white solid, 85% yield, 92:8 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.93–7.84 (m, 2H), 7.60–7.47 (m, 7H), 7.44 (t, *J* = 7.4 Hz, 1H), 7.38 (td, *J* = 7.6, 3.3 Hz, 2H), 7.34 (d, *J* = 8.1 Hz, 1H), 7.29 (td, *J* = 7.7, 3.0 Hz, 2H), 6.97 (t, *J* = 7.9 Hz, 1H), 5.16 (s, 1H), 1.30 (s, 18H); **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 173.84, 153.48 (d, *J* = 2.4 Hz), 139.89 (d, *J* = 5.6 Hz), 135.49, 133.45 (d, *J* = 8.9 Hz), 132.09 (d, *J* = 8.3 Hz), 132.09, 131.98 (d, *J* = 2.7 Hz), 131.23, 129.85 (d, *J* = 94.0 Hz), 129.19 (d, *J* = 97.3 Hz), 128.07 (d, *J* = 4.0 Hz), 127.91, 127.83, 127.55 (d, *J* = 3.1 Hz), 125.39 (d, *J* = 4.8 Hz), 123.40, 122.66 (d, *J* = 4.0 Hz), 102.26, 63.67 (d, *J* = 54.9 Hz), 34.53, 30.09; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.81; **HRMS** (ESI) Calcd.for $C_{34}H_{35}BrNO_3PNa$ $(M+Na)^+$ 638.1430, Found: 638.1425; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =10.265 min, 12.373 min.



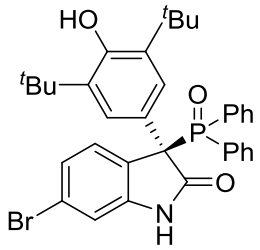
(*R*)-3q, white solid, 72% yield, 95:5 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.00–7.92 (m, 3H), 7.80 (s, 1H), 7.56–7.34 (m, 11H), 7.20 (t, *J* = 7.8 Hz, 1H), 5.16 (s, 1H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.95, 153.51 (d, *J* = 2.2 Hz), 137.84, 135.65 (d, *J* = 1.6 Hz), 133.44 (d, *J* = 9.1 Hz), 132.18, 132.14 (d, *J* = 2.9 Hz), 132.05 (d, *J* = 2.8 Hz), 131.81 (d, *J* = 8.9 Hz), 129.74 (d, *J* = 65.6 Hz), 128.95 (d, *J* = 69.5 Hz), 128.62, 128.59, 127.95 (d, *J* = 8.0 Hz), 127.85 (d, *J* = 7.7 Hz), 125.32 (d, *J* = 4.9 Hz), 123.64 (q, *J* = 272.2 Hz), 122.67 (d, *J* = 5.0 Hz), 122.05 (d, *J* = 2.0 Hz), 111.62 (q, *J* =30.0 Hz), 61.82 (d, *J* = 54.3 Hz), 34.52, 30.06; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.84; **^{19}F NMR** (471 MHz, $CDCl_3$) δ -61.01; **HRMS** (ESI) Calcd.for $C_{35}H_{35}F_3BrNO_3PNa$ $(M+Na)^+$ 628.2199, Found: 628.2189; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 5/1, Flow rate = 0.6 mL/min), t_R =8.657 min, 10.782 min.



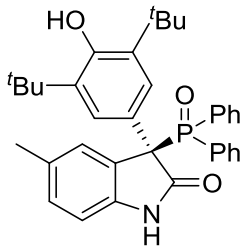
(*R*)-**3r**, white solid, 73% yield, 85.5:14.5 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.85 (dd, *J* = 11.2, 7.9 Hz, 2H), 7.76 (s, 1H), 7.56 (dd, *J* = 10.9, 8.1 Hz, 2H), 7.53–7.46 (m, 4H), 7.43 (t, *J* = 7.4 Hz, 1H), 7.39 (td, *J* = 7.5, 2.9 Hz, 2H), 7.29 (td, *J* = 7.7, 2.9 Hz, 2H), 6.74 (td, *J* = 9.0, 1.9 Hz, 1H), 6.43 (dd, *J* = 8.3, 1.7 Hz, 1H), 5.16 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 175.20, 163.09 (dd, *J* = 246.9, 2.1 Hz), 153.49 (d, *J* = 2.6 Hz), 142.78 (dd, *J* = 12.2, 6.1 Hz), 135.35 (d, *J* = 1.9 Hz), 133.34 (d, *J* = 8.6 Hz), 132.49 (d, *J* = 9.0 Hz), 132.05 (d, *J* = 2.7 Hz), 131.93 (d, *J* = 2.6 Hz), 129.90 (d, *J* = 73.7 Hz), 129.51 (d, *J* = 2.6 Hz), 129.12 (d, *J* = 75.8 Hz), 127.94 (d, *J* = 2.4 Hz), 127.84 (d, *J* = 2.4 Hz), 125.59 (d, *J* = 4.7 Hz), 122.49 (d, *J* = 4.6 Hz), 121.82 (dd, *J* = 3.6, 3.0 Hz), 108.36 (dd, *J* = 22.4, 2.0 Hz), 98.20 (d, *J* = 27.5 Hz), 61.61 (d, *J* = 56.9 Hz), 34.52, 30.07; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 29.39; **^{19}F NMR** (471 MHz, $CDCl_3$) δ -111.39 (d, *J* = 3.5 Hz); **HRMS** (ESI) Calcd.for $C_{34}H_{35}FNO_3PNa$ $(M+Na)^+$ 578.2231, Found: 574.2231; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =12.765 min, 28.232 min.



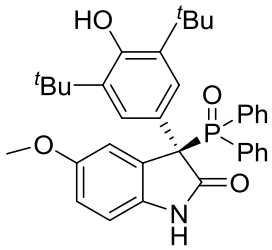
(*R*)-**3s**, white solid, 97% yield, 89.5:10.5 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.01 (s, 1H), 7.83 (dd, *J* = 10.3, 8.4 Hz, 2H), 7.58 (dd, *J* = 10.7, 7.4 Hz, 2H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.46 (d, *J* = 1.4 Hz, 2H), 7.45–7.36 (m, 4H), 7.30 (td, *J* = 7.7, 3.1 Hz, 2H), 7.01 (dd, *J* = 8.2, 1.7 Hz, 1H), 6.70 (d, *J* = 1.5 Hz, 1H), 5.17 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 174.44, 152.88 (d, *J* = 2.3 Hz), 142.82 (d, *J* = 5.9 Hz), 135.34, 133.76 (d, *J* = 2.4 Hz), 132.81 (d, *J* = 8.7 Hz), 132.81 (d, *J* = 8.9 Hz), 131.41, 129.77 (d, *J* = 97.4 Hz), 129.33 (d, *J* = 100.1 Hz), 128.62 (d, *J* = 3.0 Hz), 127.38 (d, *J* = 5.1 Hz), 127.29 (d, *J* = 5.3 Hz), 124.87 (d, *J* = 4.8 Hz), 124.73 (d, *J* = 4.1 Hz), 122.50 (d, *J* = 5.1 Hz), 120.86 (d, *J* = 2.0 Hz), 109.70, 61.28 (d, *J* = 57.4 Hz), 34.06, 29.62; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.95; **HRMS** (ESI) Calcd.for $C_{34}H_{35}ClNO_3PNa$ $(M+Na)^+$ 594.1935, Found: 594.1926; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =14.077 min, 34.832 min.



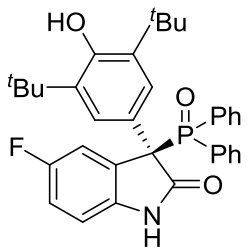
(*R*)-**3t**, white solid, 96% yield, 82.5:17.5 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.92 (s, 1H), 7.83 (dd, *J* = 10.7, 8.2 Hz, 2H), 7.58 (dd, *J* = 11.0, 8.0 Hz, 2H), 7.51 (t, *J* = 7.3 Hz, 1H), 7.46 (s, 2H), 7.43 (t, *J* = 7.5 Hz, 1H), 7.39 (td, *J* = 7.7, 3.2 Hz, 2H), 7.35 (d, *J* = 7.9 Hz, 1H), 7.30 (td, *J* = 7.7, 3.1 Hz, 2H), 7.17 (dd, *J* = 8.1, 1.1 Hz, 1H), 6.86 (s, 1H), 5.17 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 174.48, 153.00 (d, *J* = 1.8 Hz), 143.05 (d, *J* = 6.2 Hz), 135.32, 132.97 (d, *J* = 8.7 Hz), 131.84 (d, *J* = 8.9 Hz), 131.52 (d, *J* = 2.0 Hz), 129.91 (d, *J* = 97.4 Hz), 129.12, 129.10, 129.05 (d, *J* = 100.3 Hz), 127.51 (d, *J* = 6.1 Hz), 127.42 (d, *J* = 6.3 Hz), 125.45 (d, *J* = 4.0 Hz), 125.02 (d, *J* = 4.6 Hz), 123.96, 122.61 (d, *J* = 5.1 Hz), 121.94 (d, *J* = 1.8 Hz), 112.64, 61.53 (d, *J* = 57.3 Hz), 34.18, 29.76; **^{31}P NMR** (202 MHz, $CDCl_3$) δ 29.00; **HRMS** (ESI) Calcd.for $C_{34}H_{35}BrNO_3PNa$ $(M+Na)^+$ 638.1430, Found: 638.1436; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =9.523 min, 19.832 min.



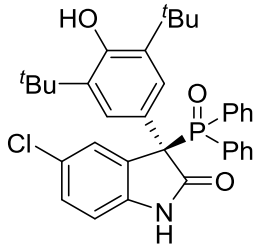
(*R*)-**3u**, white solid, 75% yield, 88:12 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.88 (t, *J* = 9.3 Hz, 2H), 7.57–7.45 (m, 6H), 7.42–7.34 (m, 4H), 7.26–7.23 (m, 2H), 7.01 (d, *J* = 7.8 Hz, 1H), 6.58 (d, *J* = 7.9 Hz, 1H), 5.13 (s, 1H), 2.31 (s, 3H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 174.34, 152.63 (d, *J* = 2.2 Hz), 138.98 (d, *J* = 6.1 Hz), 135.14 (*J* = 1.5 Hz), 132.86 (d, *J* = 8.6 Hz), 131.63 (d, *J* = 8.9 Hz), 131.11, 130.16 (d, *J* = 97.5 Hz), 130.06 (d, *J* = 2.0 Hz), 129.17 (d, *J* = 99.7 Hz), 128.54 (d, *J* = 2.6 Hz), 128.37, 127.15, 127.05, 126.05 (d, *J* = 3.9 Hz), 124.98 (d, *J* = 4.8 Hz), 123.10 (d, *J* = 5.2 Hz), 108.76, 61.46 (d, *J* = 57.5 Hz), 34.00, 29.58, 20.75; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.85; **HRMS** (ESI) Calcd.for $C_{35}H_{38}NO_3PNa$ $(M+Na)^+$ 574.2482, Found: 574.2484; **HPLC** (Chiral IC, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =8.248 min, 23.748 min.



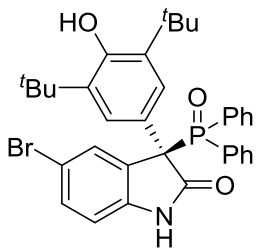
(*R*)-**3v**, white solid, 94% yield, 85:15 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.21 (s, 1H), 7.83 (dd, *J* = 10.7, 7.7 Hz, 2H), 7.61–7.52 (m, 4H), 7.49 (td, *J* = 7.5, 1.0 Hz, 1H), 7.38 (td, *J* = 7.7, 3.0 Hz, 3H), 7.24 (dd, *J* = 7.6, 3.1 Hz, 2H), 7.09 (s, 1H), 6.79–6.72 (m, 1H), 6.59 (d, *J* = 8.5 Hz, 1H), 5.17 (s, 1H), 3.70 (s, 3H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 175.07, 154.95 (d, *J* = 2.3 Hz), 153.37 (d, *J* = 2.5 Hz), 135.21 (d, *J* = 1.8 Hz), 134.80 (d, *J* = 6.2 Hz), 133.45 (d, *J* = 8.6 Hz), 132.34 (d, *J* = 9.0 Hz), 131.86 (d, *J* = 2.6 Hz), 131.77 (d, *J* = 2.6 Hz), 130.12 (d, *J* = 82.6 Hz), 129.34 (d, *J* = 84.2 Hz), 127.82 (d, *J* = 6.7 Hz), 127.73 (d, *J* = 6.7 Hz), 127.30 (d, *J* = 4.2 Hz), 125.65 (d, *J* = 4.7 Hz), 122.64 (d, *J* = 5.2 Hz), 115.34 (d, *J* = 1.7 Hz), 114.03 (d, *J* = 2.9 Hz), 110.22, 62.27 (d, *J* = 56.8 Hz), 55.67, 34.51, 30.10; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.78; **HRMS** (ESI) Calcd.for $C_{35}H_{38}NO_4PNa$ $(M+Na)^+$ 590.2431, Found: 590.2426; **HPLC** (Chiral IC, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =6.898 min, 14.348 min.



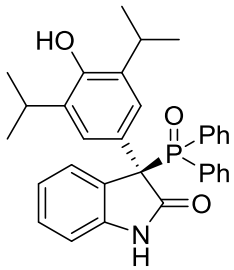
(*R*)-**3w**, white solid, 90% yield, 88.5:11.5 er; **^{1}H NMR** (500 MHz, DMSO-d_6) δ 10.83 (s, 1H), 7.88–7.80 (m, 2H), 7.61–7.54 (m, 1H), 7.53–7.48 (m, 1H), 7.48–7.40 (m, 4H), 7.40–7.34 (m, 4H), 7.20 (d, *J* = 8.9 Hz, 1H), 7.11–7.03 (m, 1H), 7.00 (s, 1H), 6.71 (dd, *J* = 8.6, 4.6 Hz, 1H), 1.21 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 174.80, 158.08 (dd, *J* = 239.6, 2.3 Hz), 153.16 (d, *J* = 2.3 Hz), 137.49 (d, *J* = 5.4 Hz), 135.41, 133.18 (d, *J* = 8.8 Hz), 131.99 (d, *J* = 9.0 Hz), 131.70, 131.68 (d, *J* = 4.6 Hz), 130.00 (d, *J* = 97.7 Hz), 129.16 (d, *J* = 100.8 Hz), 128.20 (dd, *J* = 8.2, 4.1 Hz), 127.68, 127.58, 125.15 (d, *J* = 4.9 Hz), 123.01 (d, *J* = 5.1 Hz), 115.92 (d, *J* = 26.5 Hz), 114.91 (d, *J* = 24.3 Hz), 109.74 (d, *J* = 7.6 Hz), 62.40 (d, *J* = 56.6 Hz), 34.33, 29.90; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 28.96; **^{19}F NMR** (565 MHz, $CDCl_3$) δ -119.86; **HRMS** (ESI) Calcd.for $C_{34}H_{35}FNO_3PNa$ $(M+Na)^+$ 578.2231, Found: 574.2239; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =14.640 min, 37.048 min.



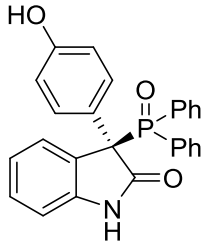
(*R*)-**3x**, white solid, 82% yield, 88:12 er; **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.90–7.81 (m, 3H), 7.58 (dd, *J* = 11.0, 8.0 Hz, 2H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.49–7.37 (m, 6H), 7.29 (td, *J* = 7.5, 2.7 Hz, 2H), 7.17 (d, *J* = 8.3 Hz, 1H), 6.61 (d, *J* = 8.3 Hz, 1H), 5.18 (s, 1H), 1.30 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 174.65, 153.52 (d, *J* = 2.4 Hz), 139.58 (d, *J* = 6.1 Hz), 135.49 (d, *J* = 1.8 Hz), 133.37 (d, *J* = 8.7 Hz), 132.46 (d, *J* = 9.0 Hz), 132.10 (d, *J* = 2.7 Hz), 132.02 (d, *J* = 2.6 Hz), 129.77 (d, *J* = 90.9 Hz), 128.97 (d, *J* = 94.7 Hz), 128.73 (d, *J* = 3.1 Hz), 128.61, 128.31 (d, *J* = 4.2 Hz), 127.96, 127.86, 127.32 (d, *J* = 2.7 Hz), 125.45 (d, *J* = 4.8 Hz), 122.48 (d, *J* = 4.7 Hz), 110.36, 62.45 (d, *J* = 55.9 Hz), 34.53, 30.06; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 29.09; **HRMS** (ESI) Calcd.for $C_{34}H_{35}ClNO_3PNa$ $(M+Na)^+$ 594.1935, Found: 594.1929; **HPLC** (Chiral AD-H, λ = 254 nm, hexane/ethanol = 5/1, Flow rate = 0.6 mL/min), t_R =13.132 min, 44.675 min.



(*R*)-**3y**, white solid, 87% yield, 81:19 er; **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.59 (s, 1H), 7.78 (dd, *J* = 10.7, 8.1 Hz, 2H), 7.60 (dd, *J* = 11.2, 7.9 Hz, 2H), 7.53 (t, *J* = 7.3 Hz, 1H), 7.45 (d, *J* = 1.0 Hz, 2H), 7.40 (m, 4H), 7.32–7.27 (m, 3H), 6.56 (d, *J* = 8.2 Hz, 1H), 5.20 (s, 1H), 1.29 (s, 18H); **^{13}C NMR** (126 MHz, Chloroform-*d* + DMSO-d_6) δ 173.82, 152.67 (d, *J* = 2.2 Hz), 140.49 (d, *J* = 6.0 Hz), 135.53 (d, *J* = 1.5 Hz), 132.53 (d, *J* = 8.7 Hz), 131.40 (d, *J* = 7.6 Hz), 131.25 (d, *J* = 10.5 Hz), 130.55 (d, *J* = 8.3 Hz), 130.37 (d, *J* = 9.2 Hz), 129.44 (d, *J* = 97.5 Hz), 128.55 (d, *J* = 96.9 Hz), 128.14, 127.07 (m), 124.54 (d, *J* = 4.9 Hz), 124.46 (d, *J* = 4.8 Hz), 122.31 (d, *J* = 5.0 Hz), 112.99 (d, *J* = 2.7 Hz), 110.41, 61.56 (d, *J* = 57.0 Hz), 33.85, 29.36; **^{31}P NMR** (243 MHz, $CDCl_3$) δ 29.10; **HRMS** (ESI) Calcd.for $C_{34}H_{35}BrNO_3PNa$ $(M+Na)^+$ 638.1430, Found: 638.1426; **HPLC** (Chiral IC, λ = 254 nm, hexane/ethanol = 3/1, Flow rate = 0.6 mL/min), t_R =6.182 min, 9.198 min.

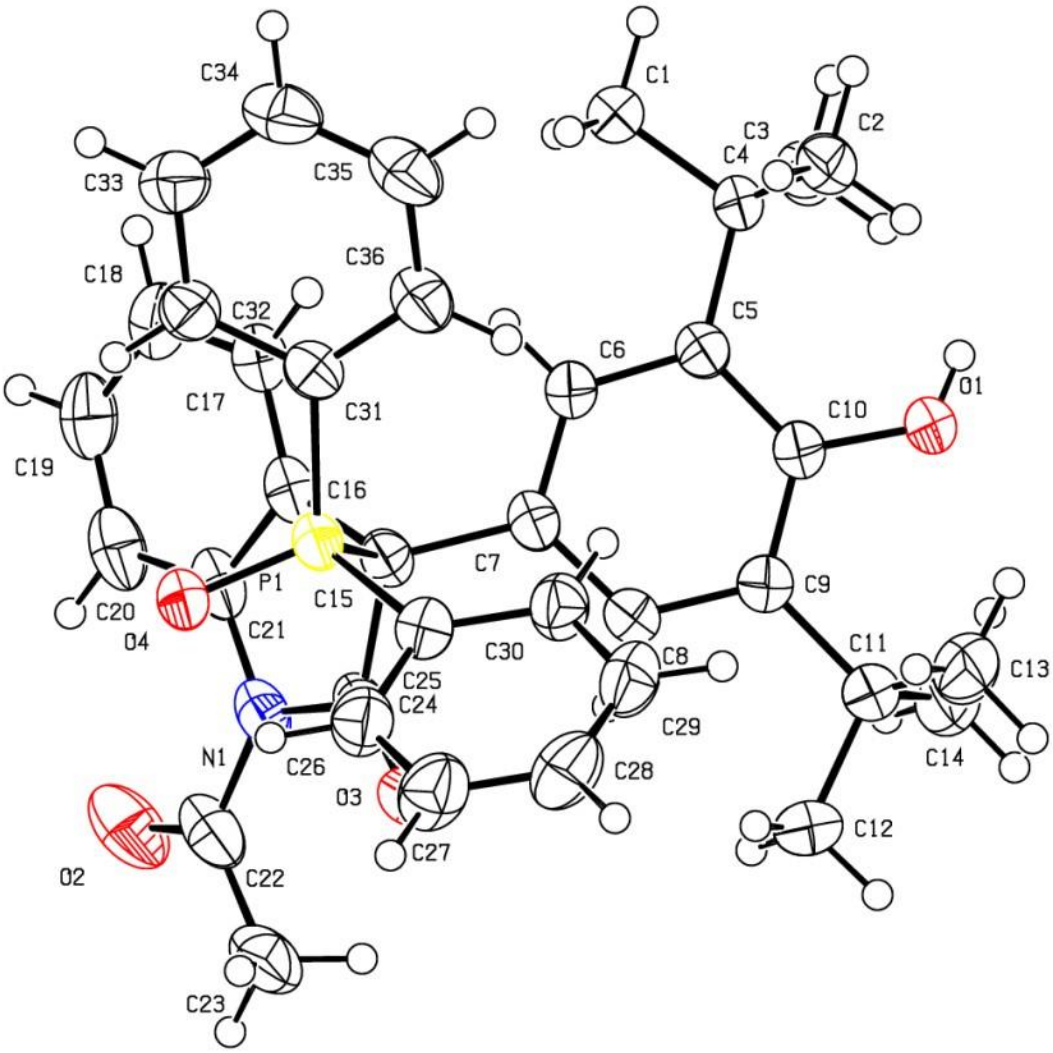


(*R*)-**3z**, white solid, 91% yield, 91:9 er; **^{1}H NMR** (500 MHz, DMSO-d_6) δ 10.73 (s, 1H), 8.09 (s, 1H), 7.88 (t, *J* = 8.5 Hz, 2H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.51–7.41 (m, 4H), 7.38–7.27 (m, 6H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.70 (d, *J* = 7.7 Hz, 1H), 3.17 (hept, *J* = 6.7 Hz, 2H), 0.97 (t, *J* = 6.2 Hz, 12H); **^{13}C NMR** (126 MHz, DMSO-d_6) δ 174.44, 149.97 (d, *J* = 1.6 Hz), 141.92 (d, *J* = 6.1 Hz), 134.67, 132.87 (d, *J* = 8.6 Hz), 131.88, 131.44 (d, *J* = 8.7 Hz), 130.86 (d, *J* = 76.6 Hz), 130.25 (d, *J* = 11.5 Hz), 130.08 (d, *J* = 79.0 Hz), 128.98 (d, *J* = 12.5 Hz), 128.74, 127.94 (d, *J* = 8.5 Hz), 127.85 (d, *J* = 8.0 Hz), 126.67 (d, *J* = 3.9 Hz), 124.64 (d, *J* = 5.0 Hz), 123.07 (d, *J* = 5.0 Hz), 121.14, 109.36, 61.76 (d, *J* = 56.9 Hz), 26.14, 22.84, 22.77; **^{31}P NMR** (202 MHz, DMSO-d_6) δ 27.57; **HRMS** (ESI) Calcd.for $C_{32}H_{32}NO_3PNa$ $(M+Na)^+$ 532.2012, Found: 532.2021; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =6.973 min, 19.290 min.



(*R*)-**4**, white solid, 82% yield, 92.5:7.5 er; **^{1}H NMR** (500 MHz, DMSO-d_6) δ 10.74 (s, 1H), 9.77 (s, 1H), 7.85–7.76 (m, 2H), 7.56–7.43 (m, 5H), 7.40 (td, *J* = 7.9, 3.2 Hz, 2H), 7.32–7.16 (m, 5H), 7.00 (t, *J* = 7.6, 0.7 Hz, 1H), 6.70–6.64 (m, 3H); **^{13}C NMR** (126 MHz, DMSO-d_6) δ 174.96, 157.13, 142.04 (d, *J* = 6.0 Hz), 133.35 (d, *J* = 9.0 Hz), 132.93 (d, *J* = 1.7 Hz), 132.85 (d, *J* = 2.0 Hz), 131.92 (d, *J* = 8.9 Hz), 130.44 (d, *J* = 71.9 Hz), 129.65 (d, *J* = 73.8 Hz), 129.65 (d, *J* = 5.0 Hz), 129.55, 128.64 (d, *J* = 12.0 Hz), 128.52 (d, *J* = 11.8 Hz), 128.23 (d, *J* = 2.4 Hz), 127.18 (d, *J* = 3.8 Hz), 125.21 (d, *J* = 5.0 Hz), 122.26, 115.82, 110.08, 61.74 (d, *J* = 57.7 Hz); **^{31}P NMR** (243 MHz, DMSO-d_6) δ 28.29; **HRMS** (ESI) Calcd.for $C_{26}H_{20}NO_3PNa$ $(M+Na)^+$ 448.1073, Found: 448.1072; **HPLC** (Chiral IC, λ = 254 nm, hexane/2-propanol = 3/1, Flow rate = 0.6 mL/min), t_R =14.023 min, 16.482 min.

Single Crystal X-ray Structure Determinations of Compound (*R*)-3l (CCDC: 2019323)



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	alpha=90	beta=90	gamma=90

Temperature: 150 K

	Calculated	Reported
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Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C36 H38 N O4 P	C36 H38 N O4 P
Sum formula	C36 H38 N O4 P	C36 H38 N O4 P
Mr	579.64	579.64
Dx,g cm-3	1.230	1.230
Z	4	4

Mu (mm-1)	1.090	1.090
F000	1232.0	1232.0
F000'	1236.55	
h,k,lmax	12,19,25	12,19,25
Nref	6414[3606]	6348
Tmin,Tmax	0.761,0.858	0.064,0.174
Tmin'	0.761	

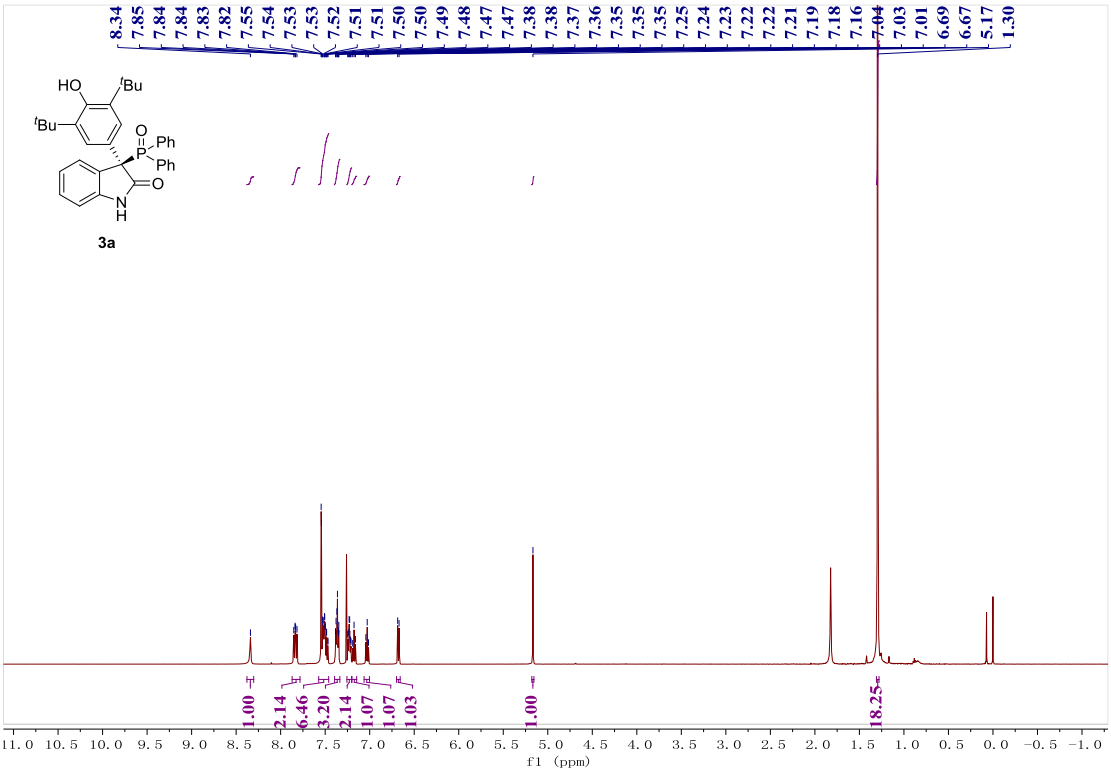
Correction method= # Reported T Limits: Tmin=0.064 Tmax=0.174 AbsCorr = MULTI-SCAN

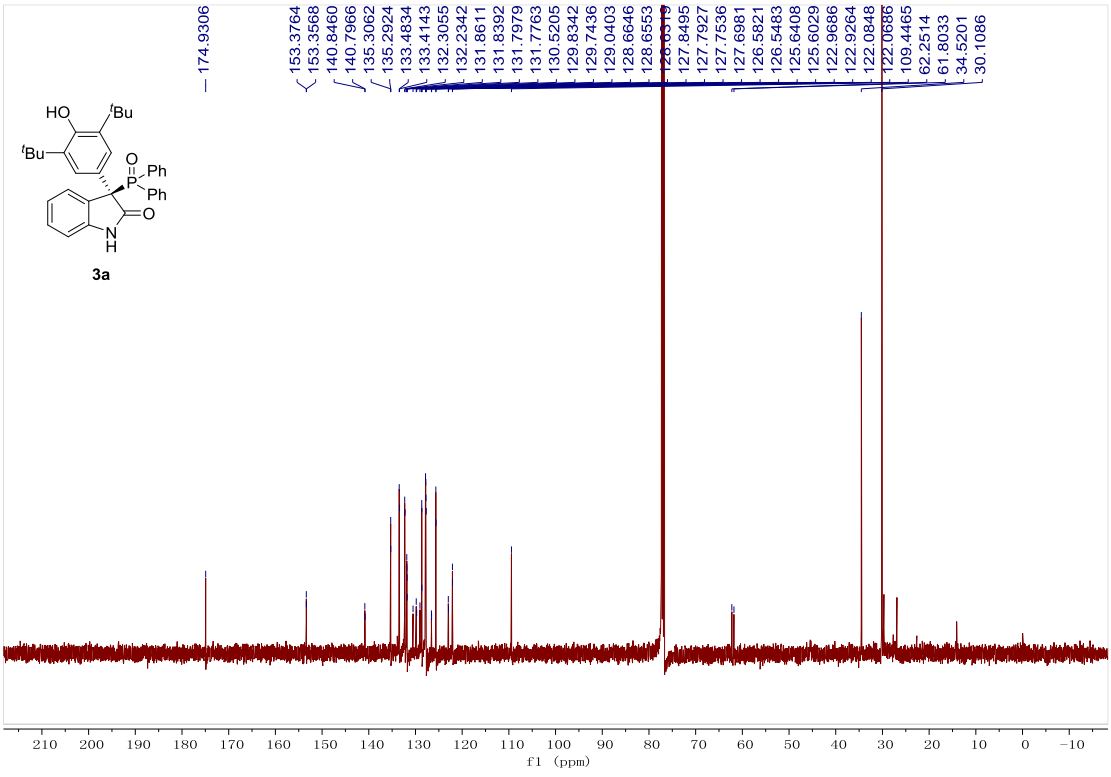
Data completeness= 1.76/0.99 Theta(max)= 74.502

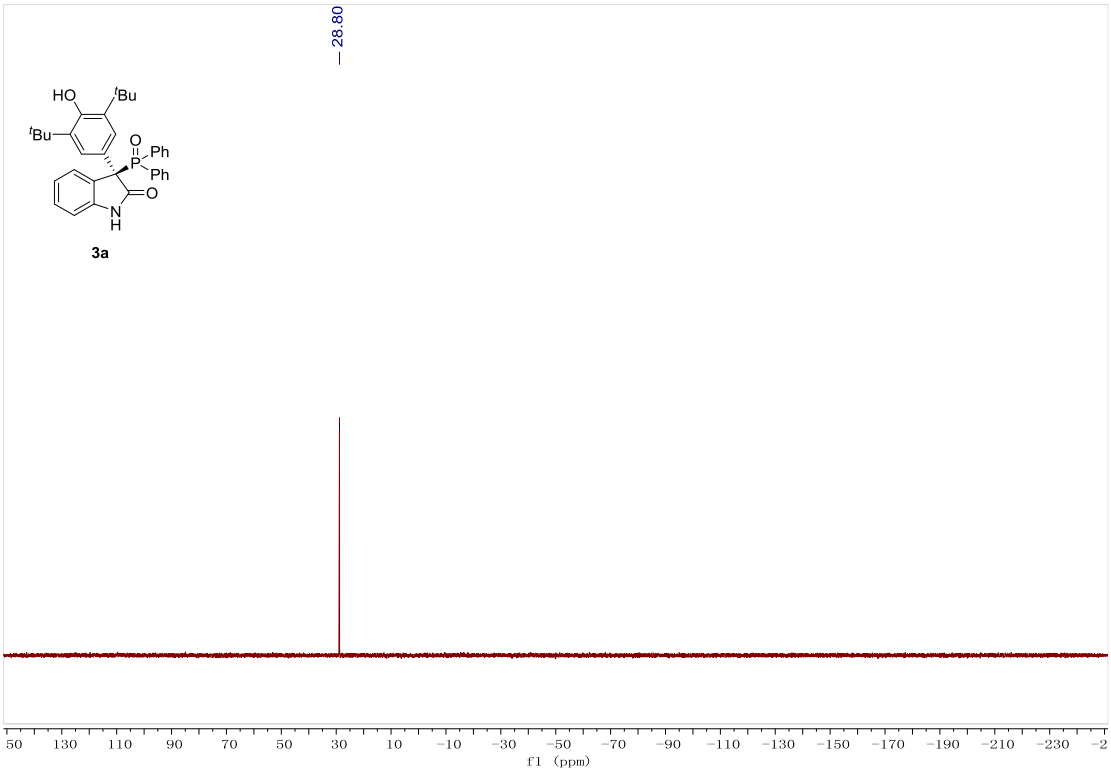
R(reflections)= 0.0307(6181) wR2(reflections)= 0.0858(6348)

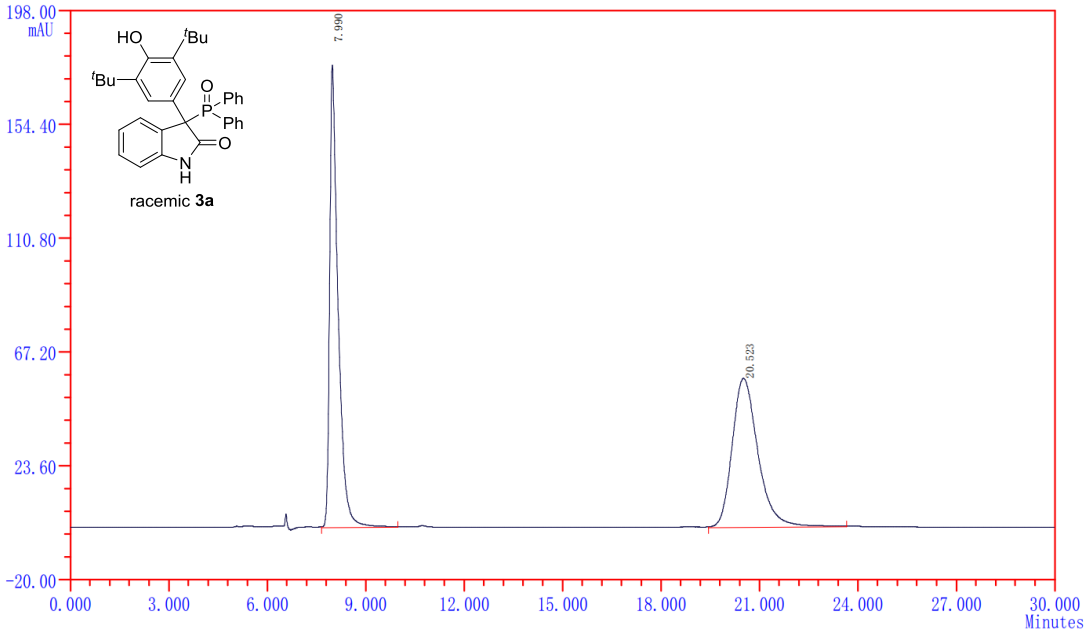
S = 1.050 Npar= 391

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









Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
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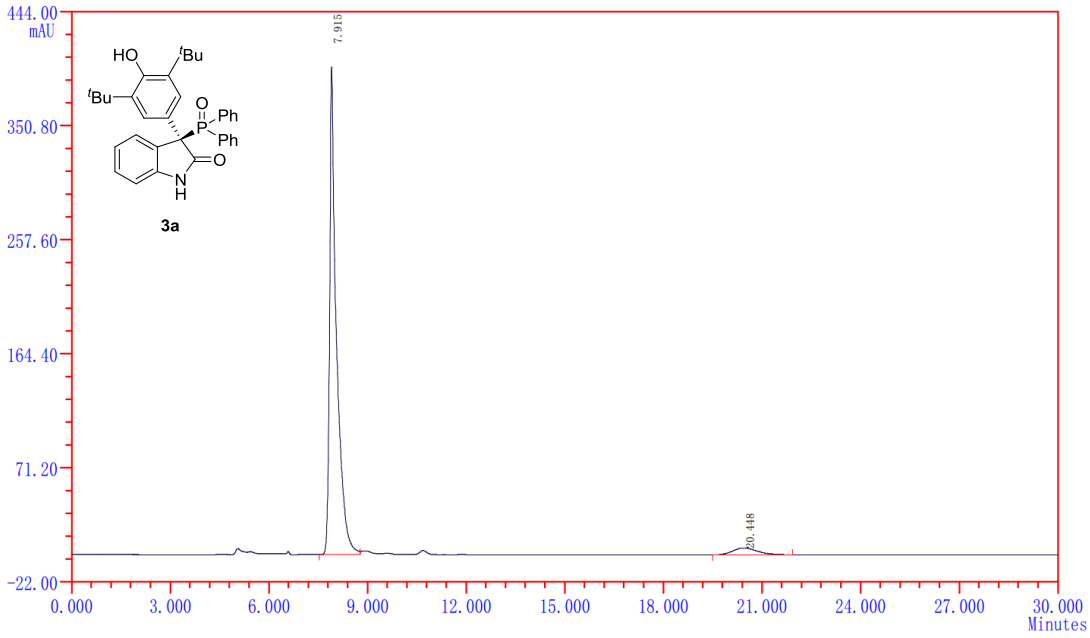

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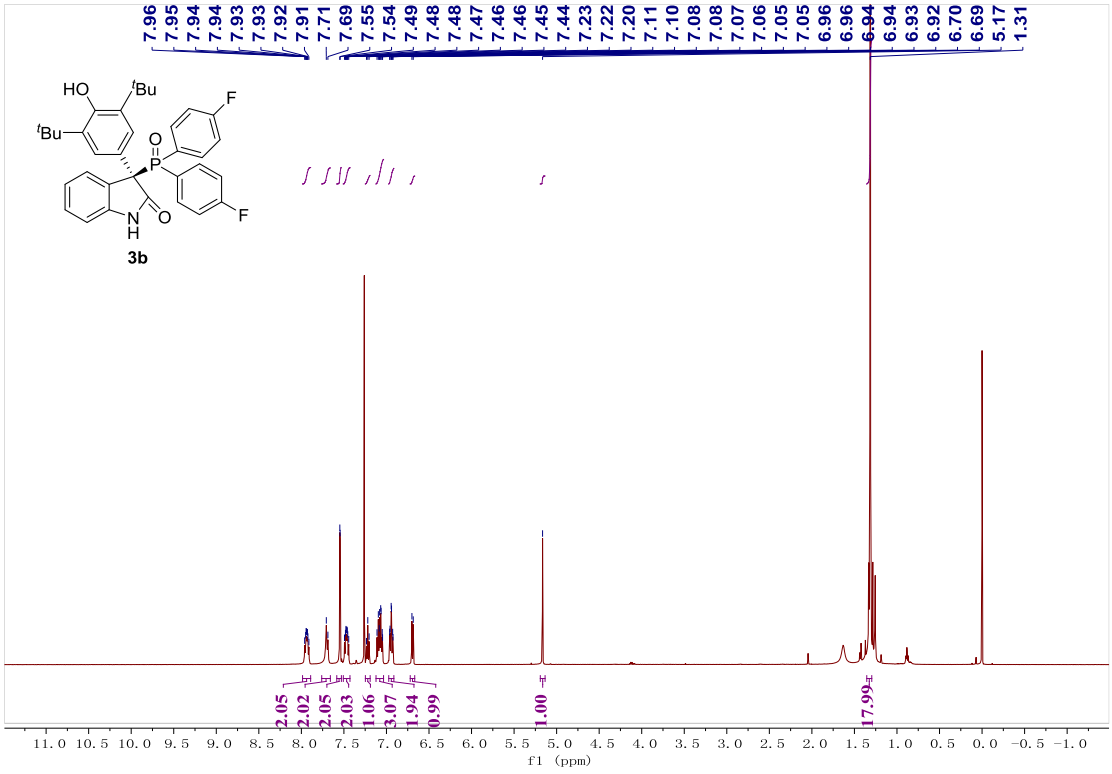

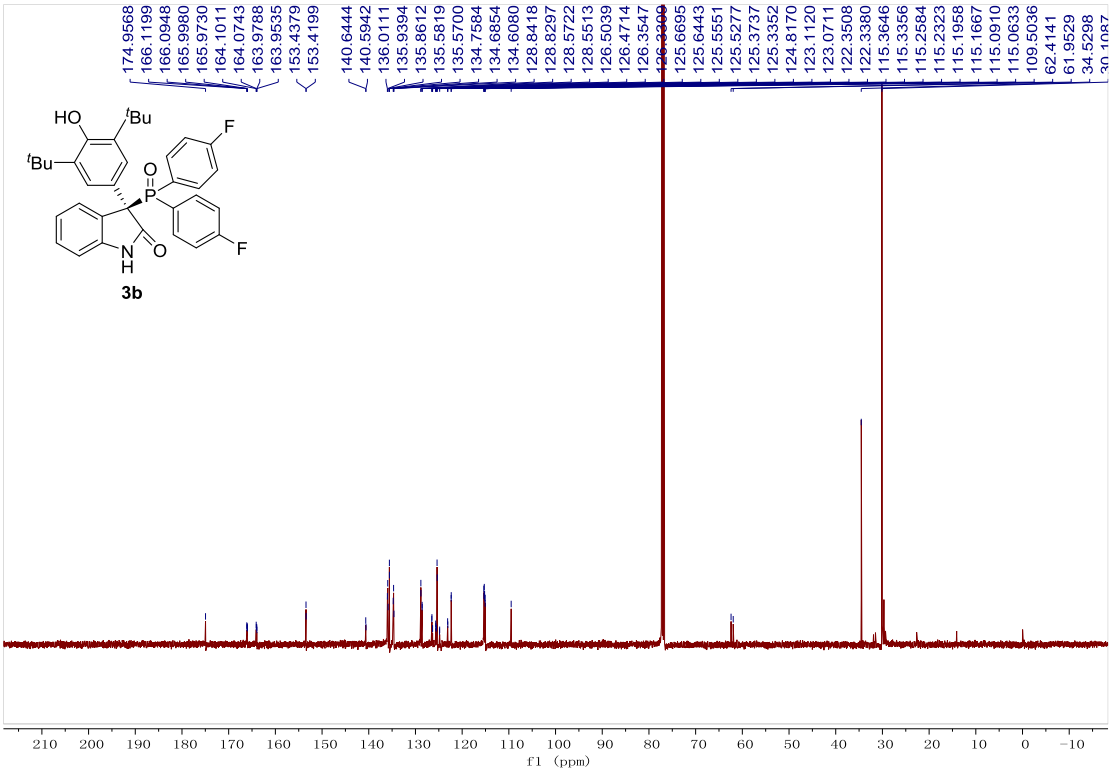
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115.2584
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F
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O
3b
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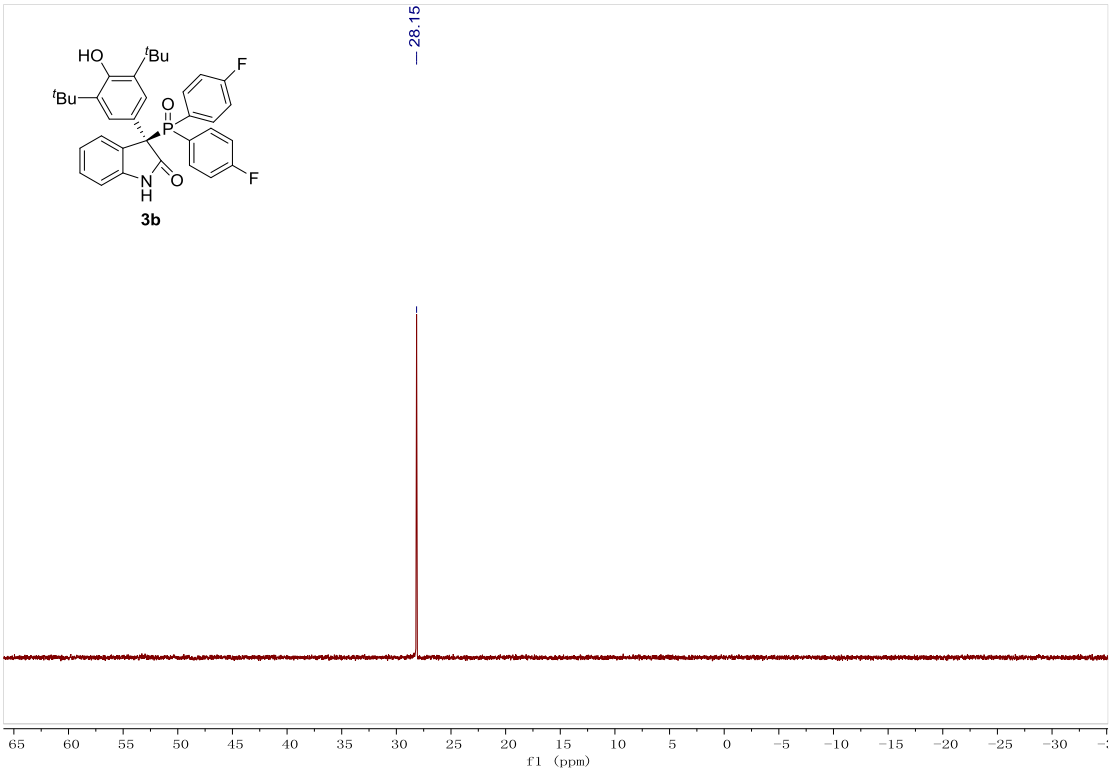
f1 (ppm)


28.15
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tBu
tBu
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P
F
F
N
H
O
3b
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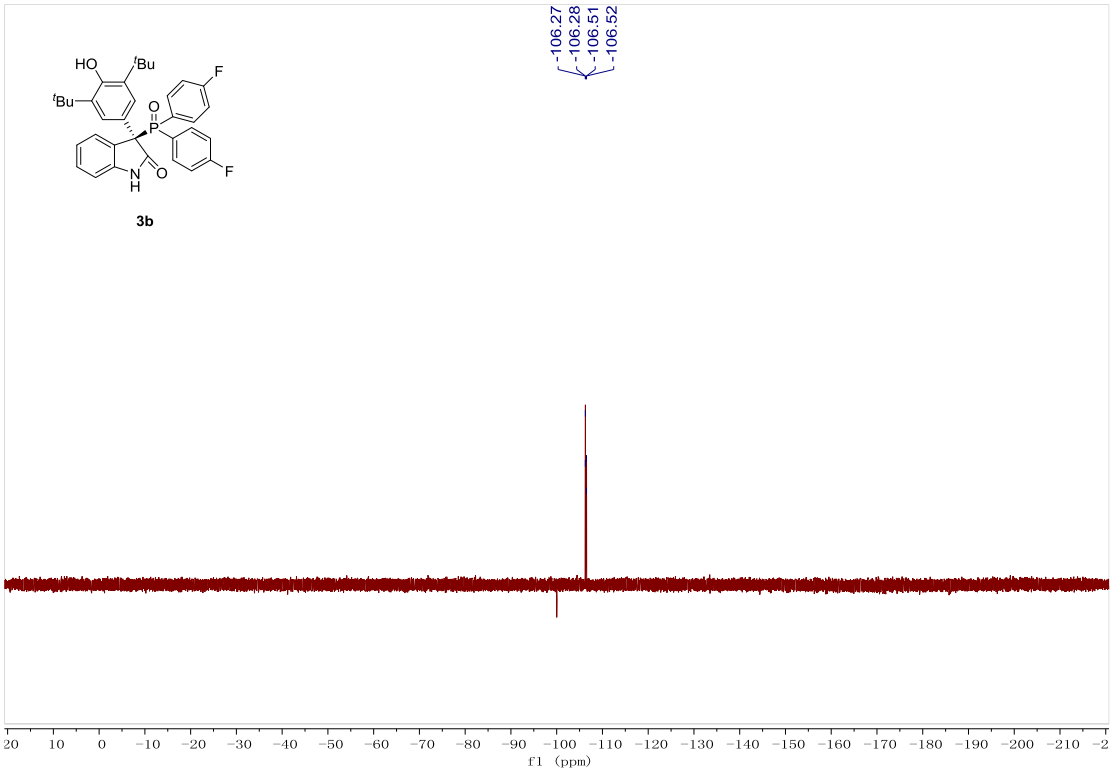
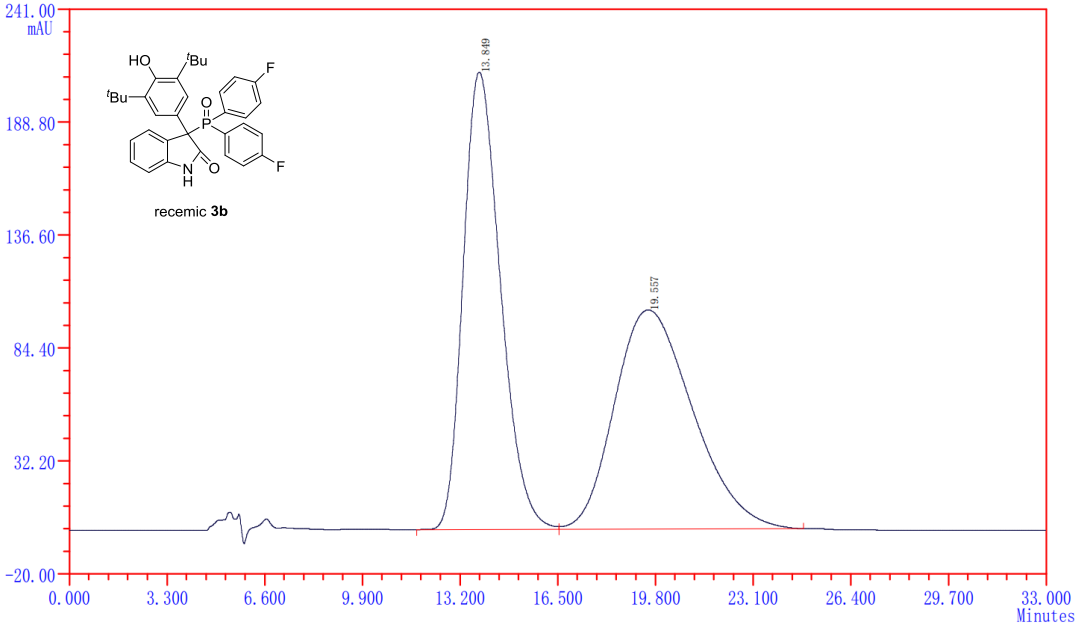
f1 (ppm)





Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
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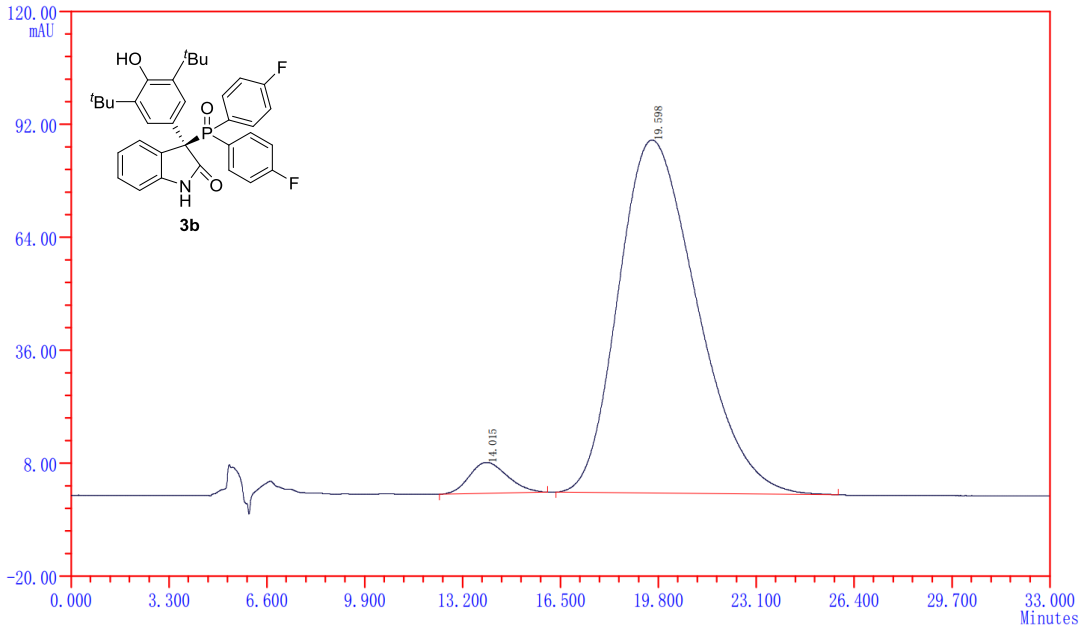

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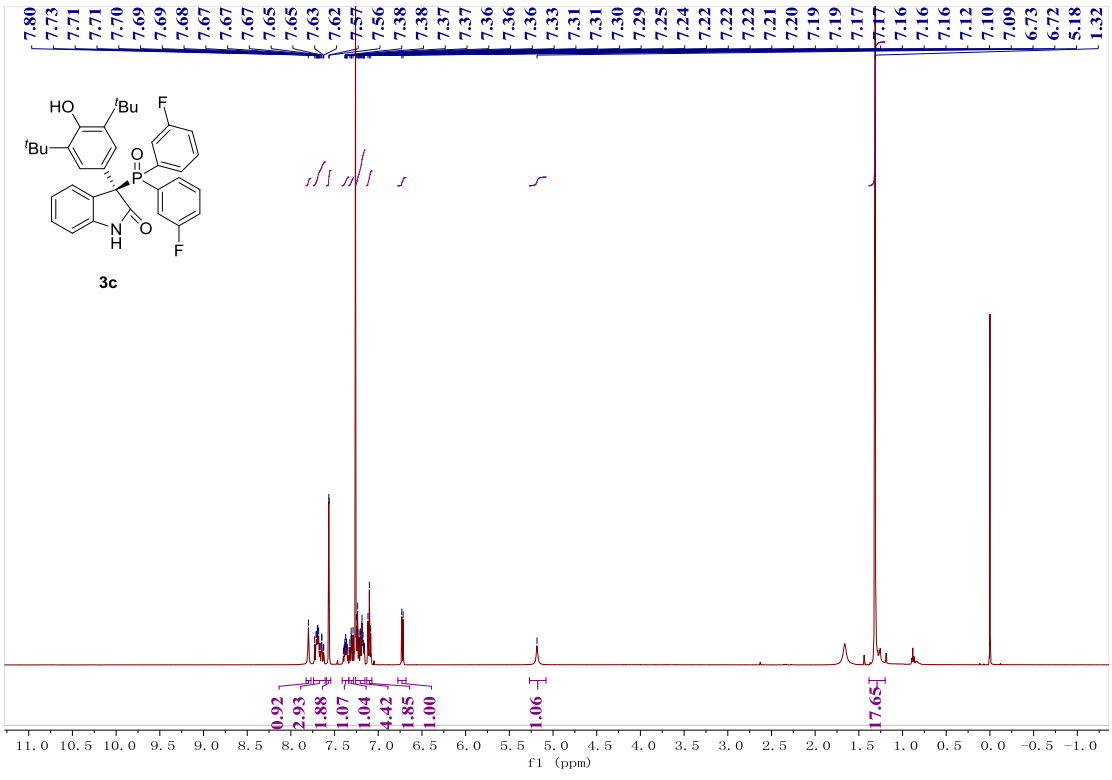

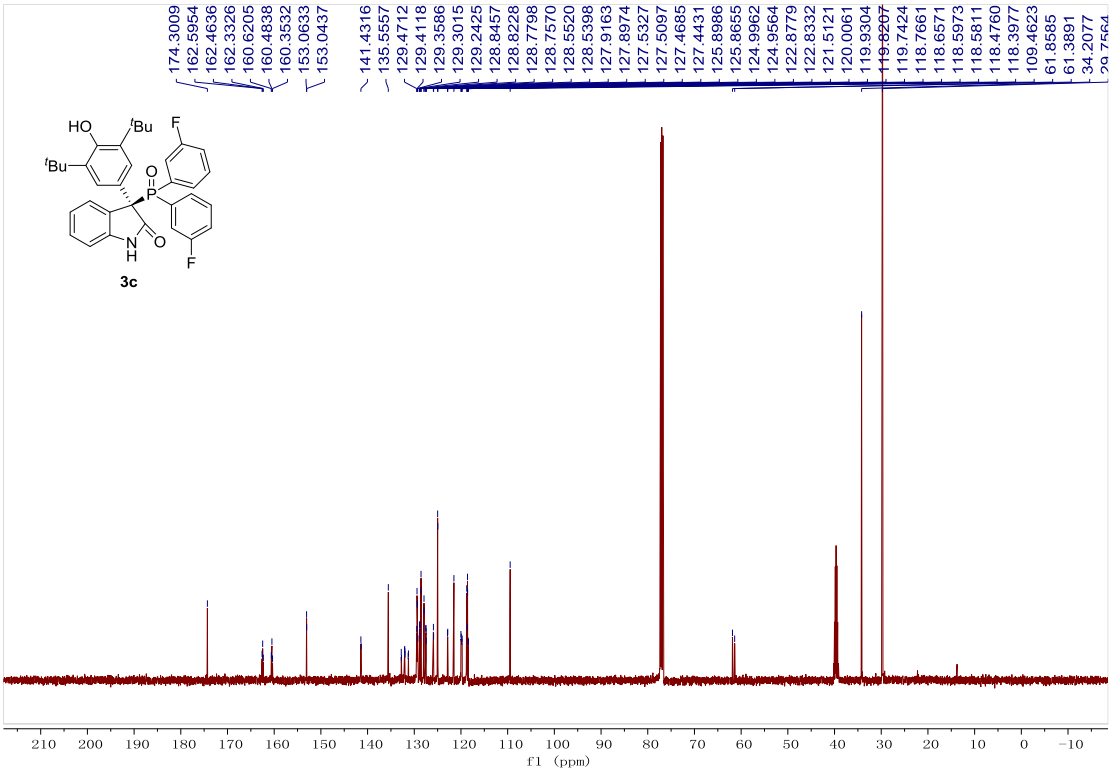
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F
3c
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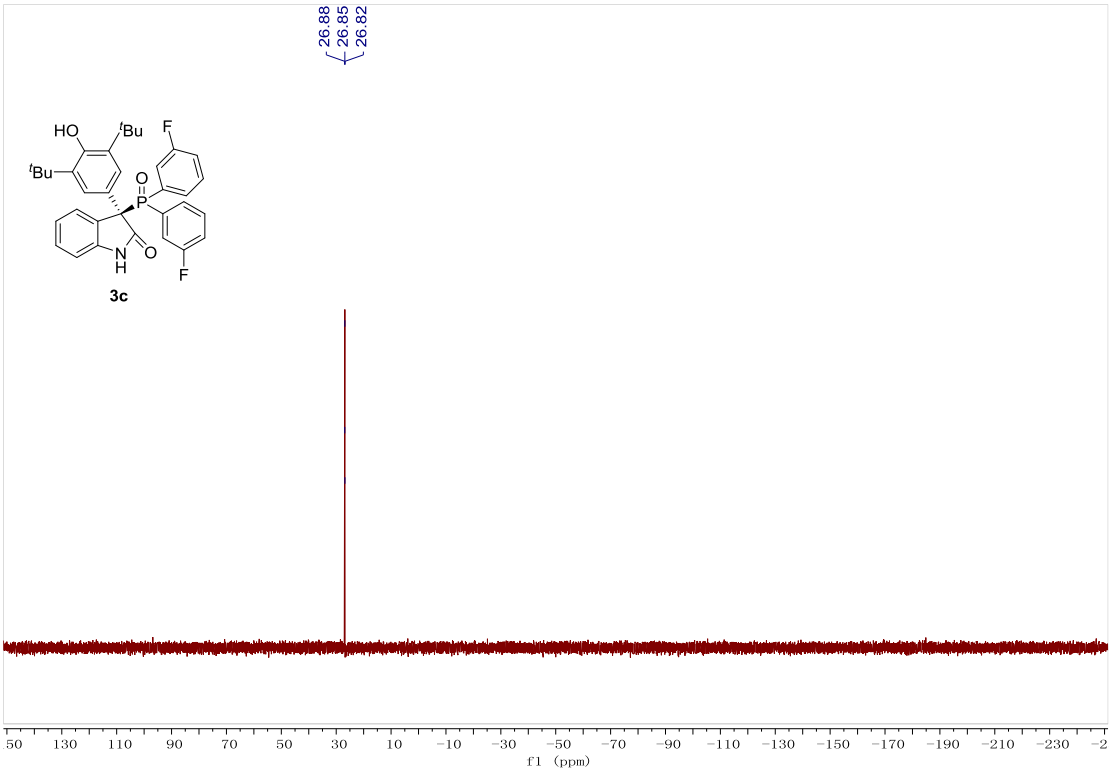
f1 (ppm)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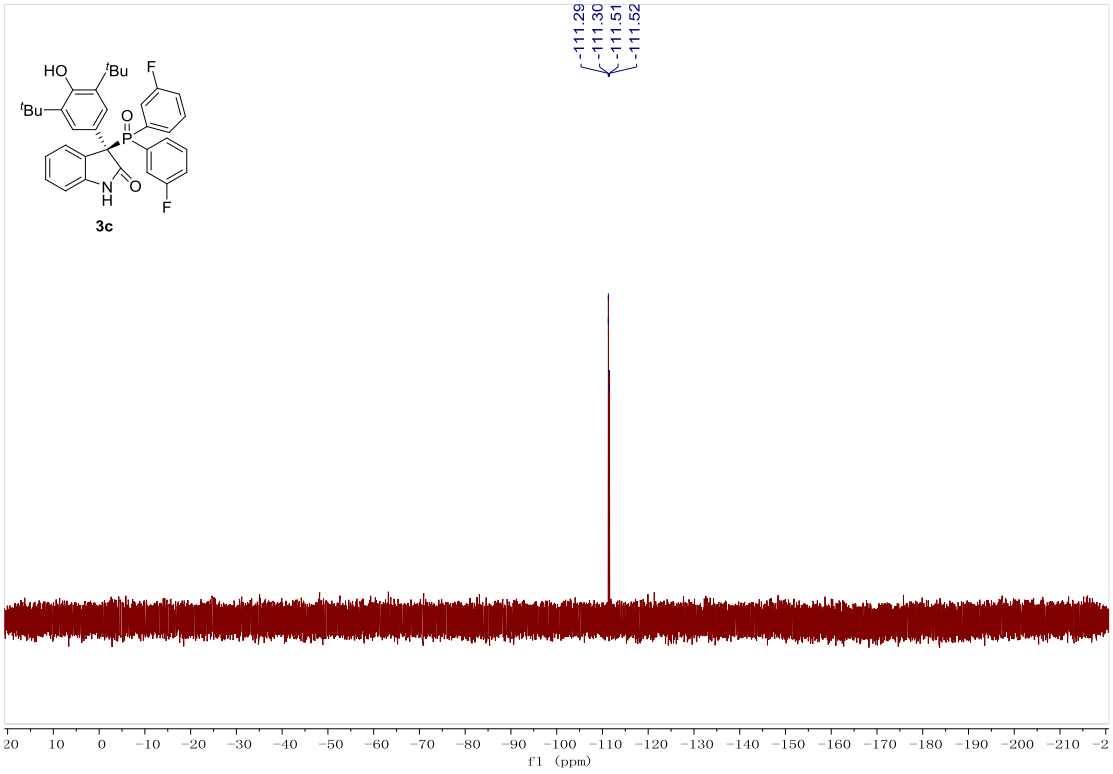
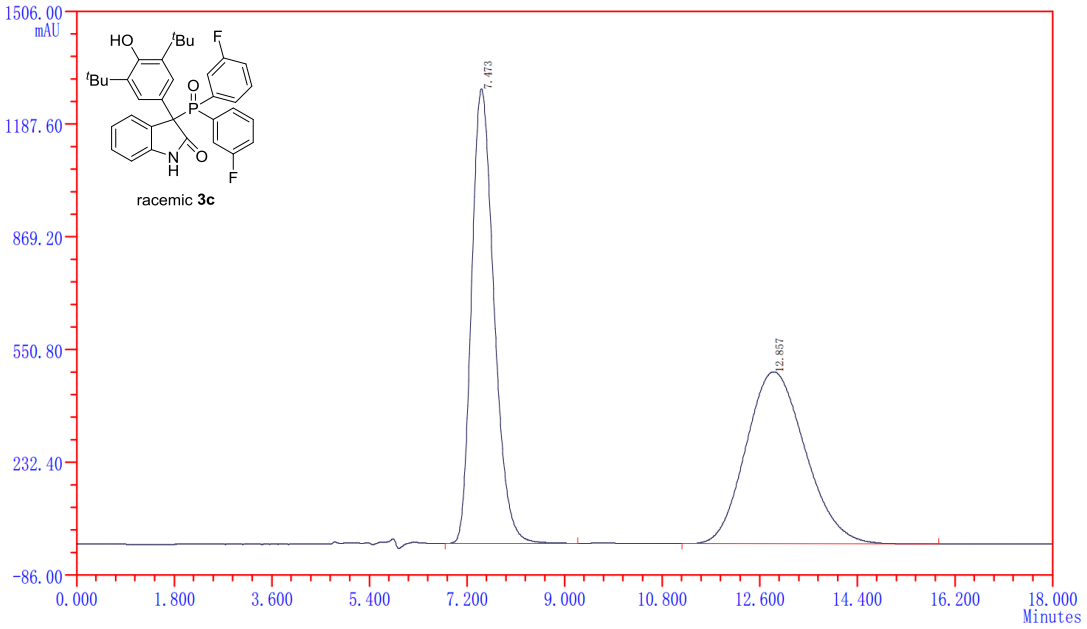
f1 (ppm)





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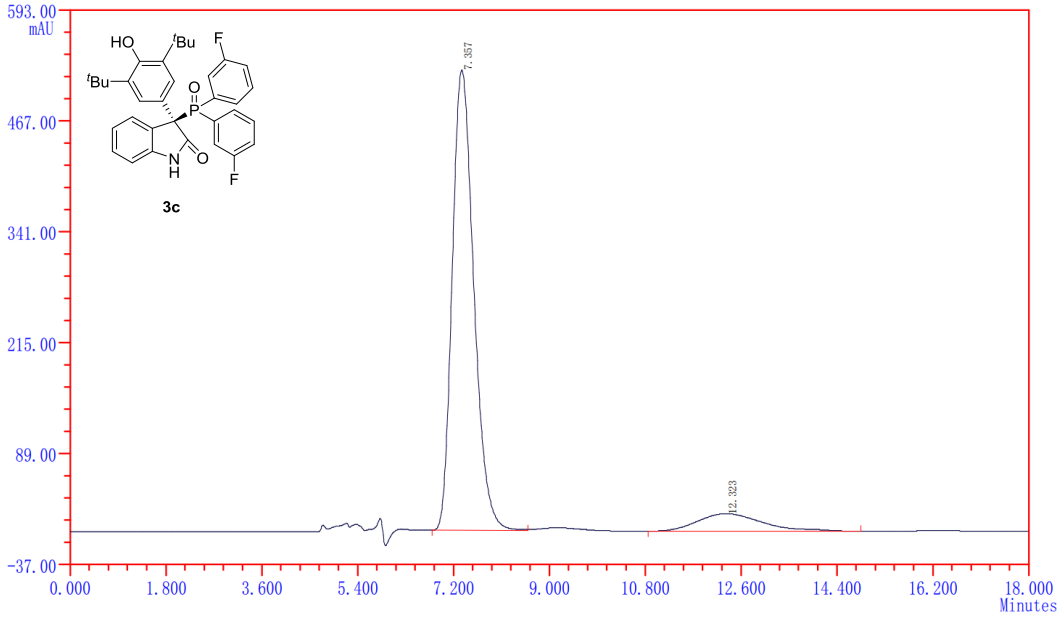

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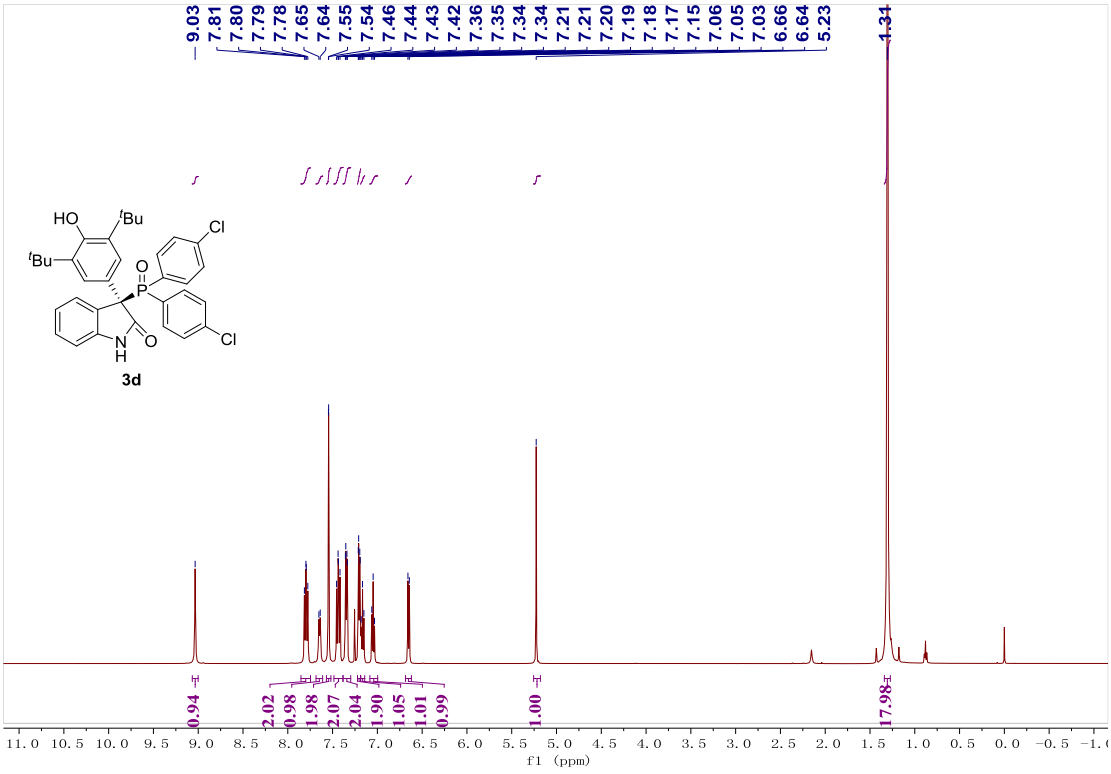

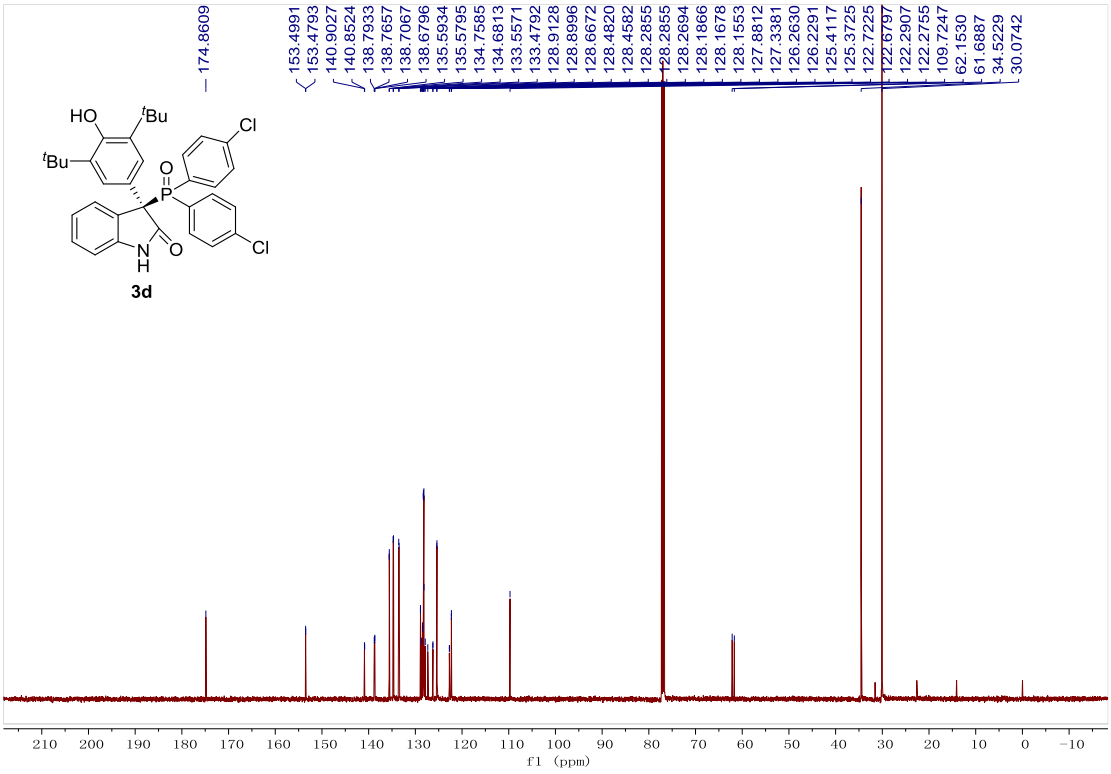
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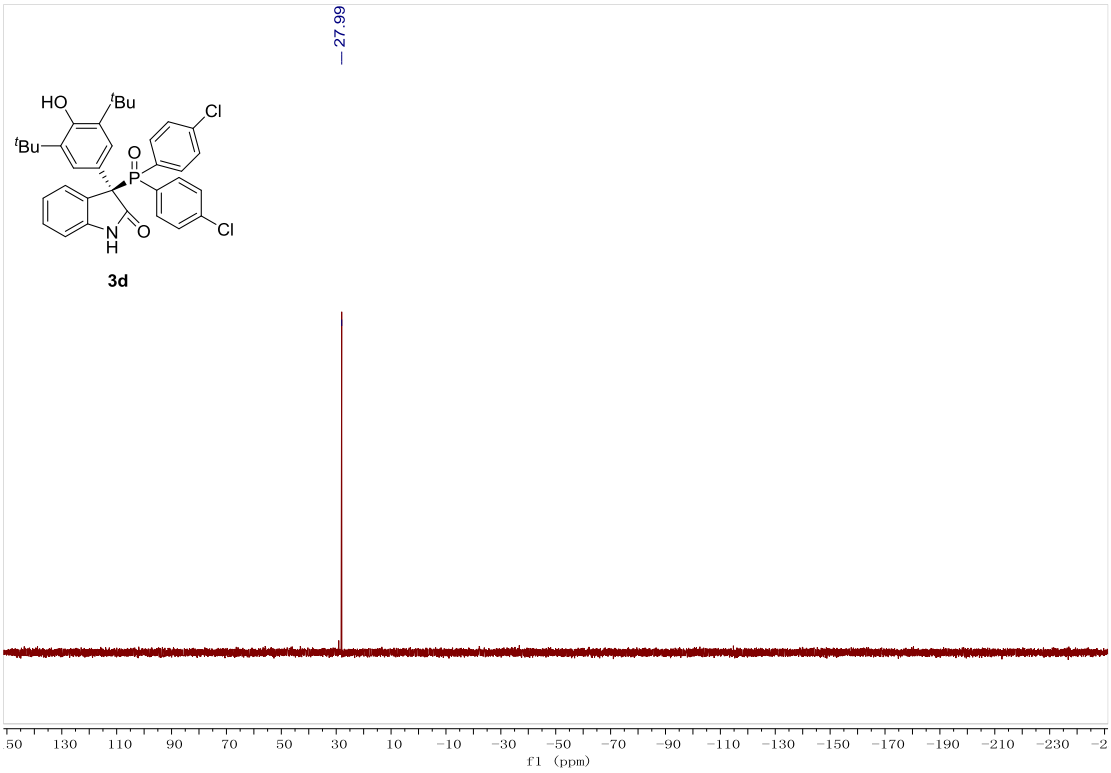
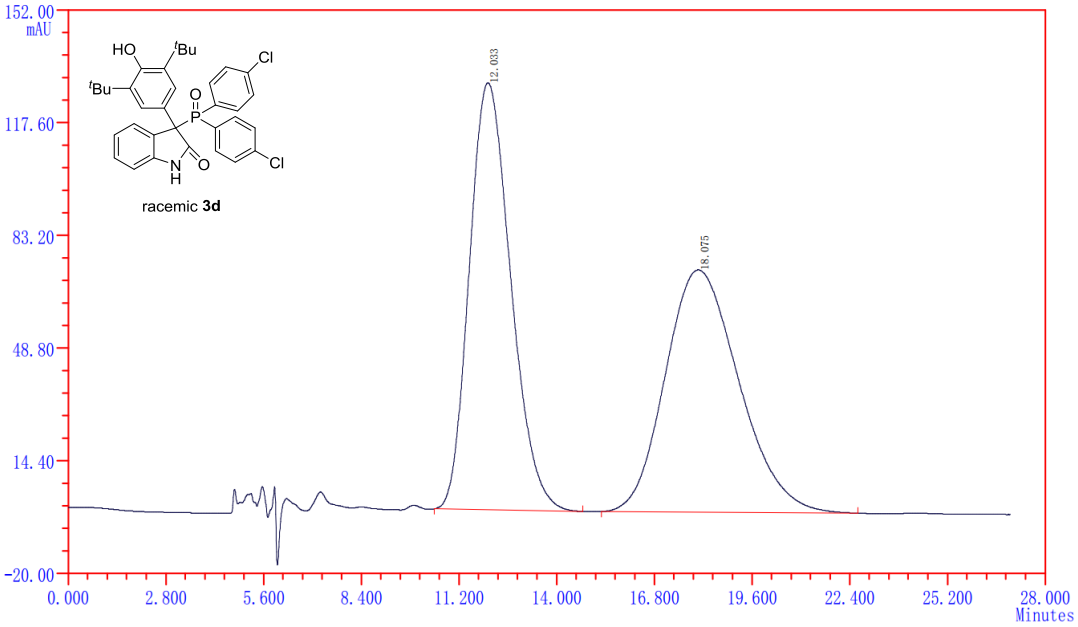
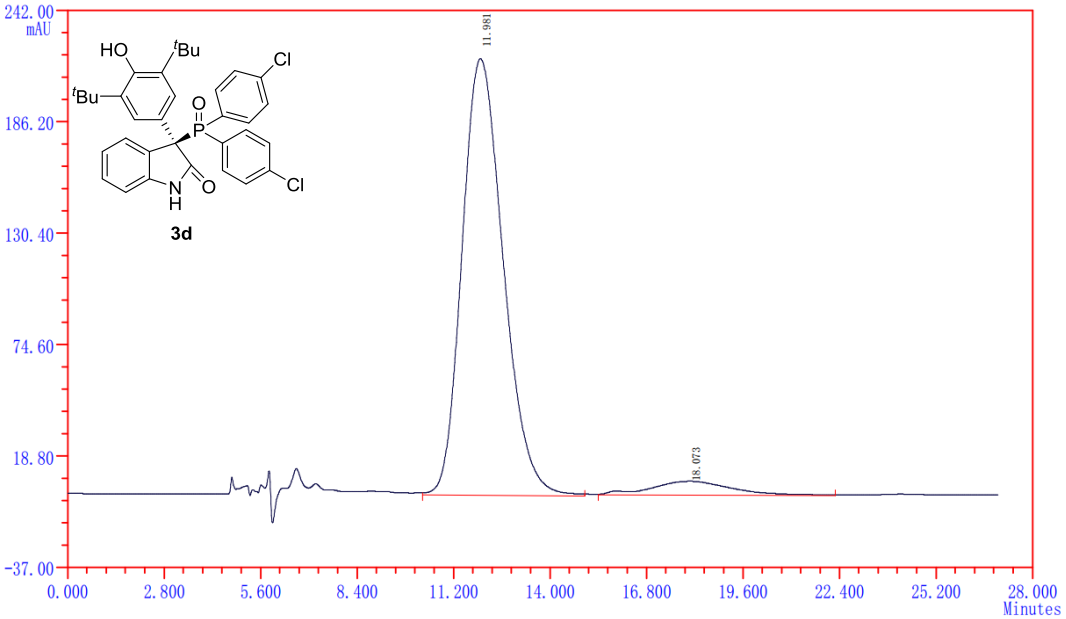
126.2630
126.2291
125.4117
125.3725
122.7225
122.6797
122.2907
122.2755
109.7247
62.1530
61.6887
34.5229
30.0742
HO
tBu
tBu
Cl
O
P
Cl
N
H
O
3d
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

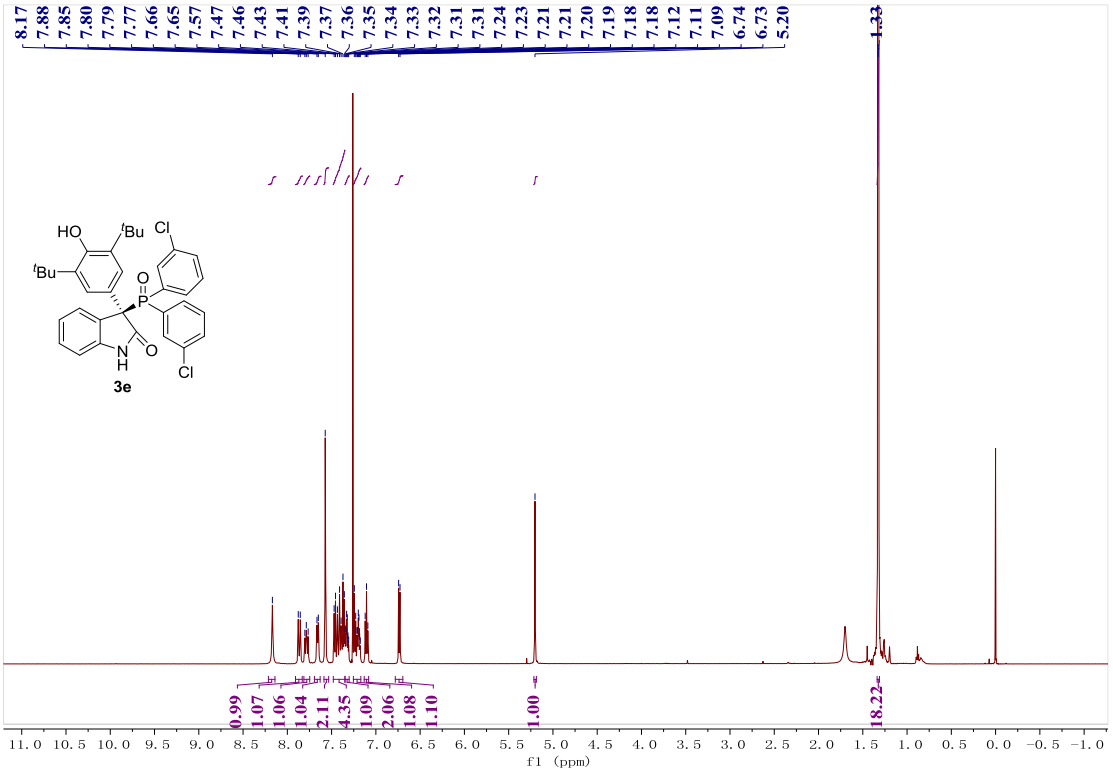

27.99
HO
tBu
tBu
Cl
O
P
Cl
N
H
O
3d
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

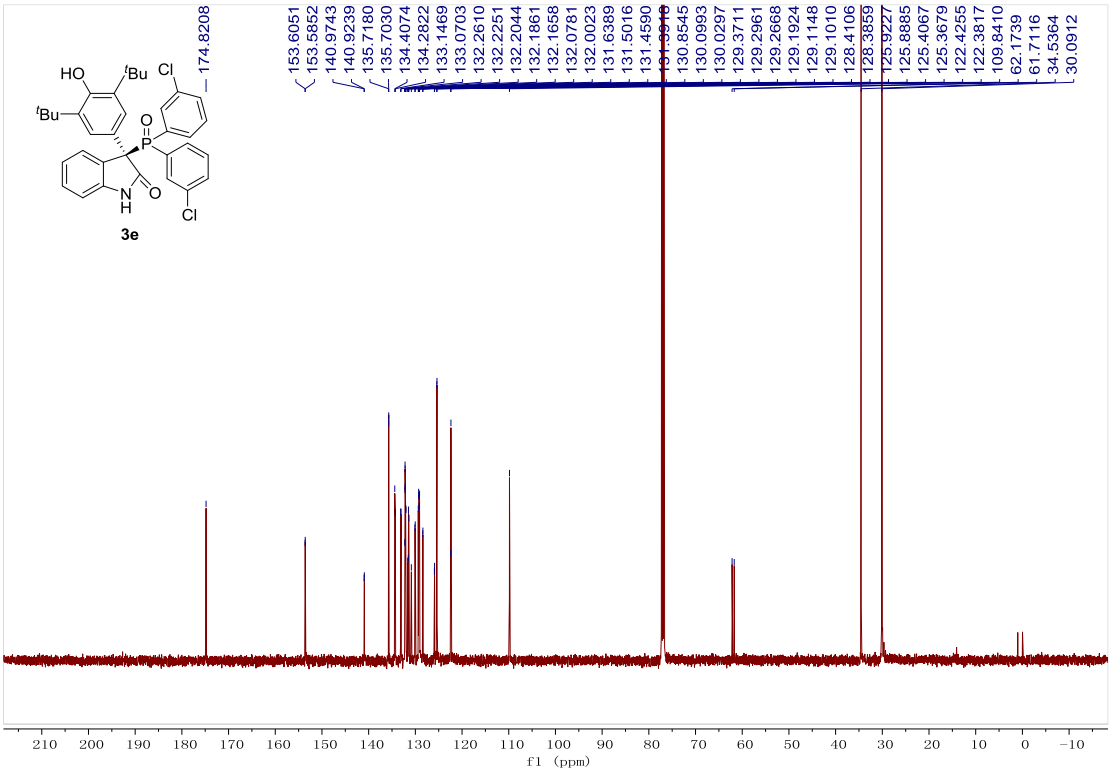


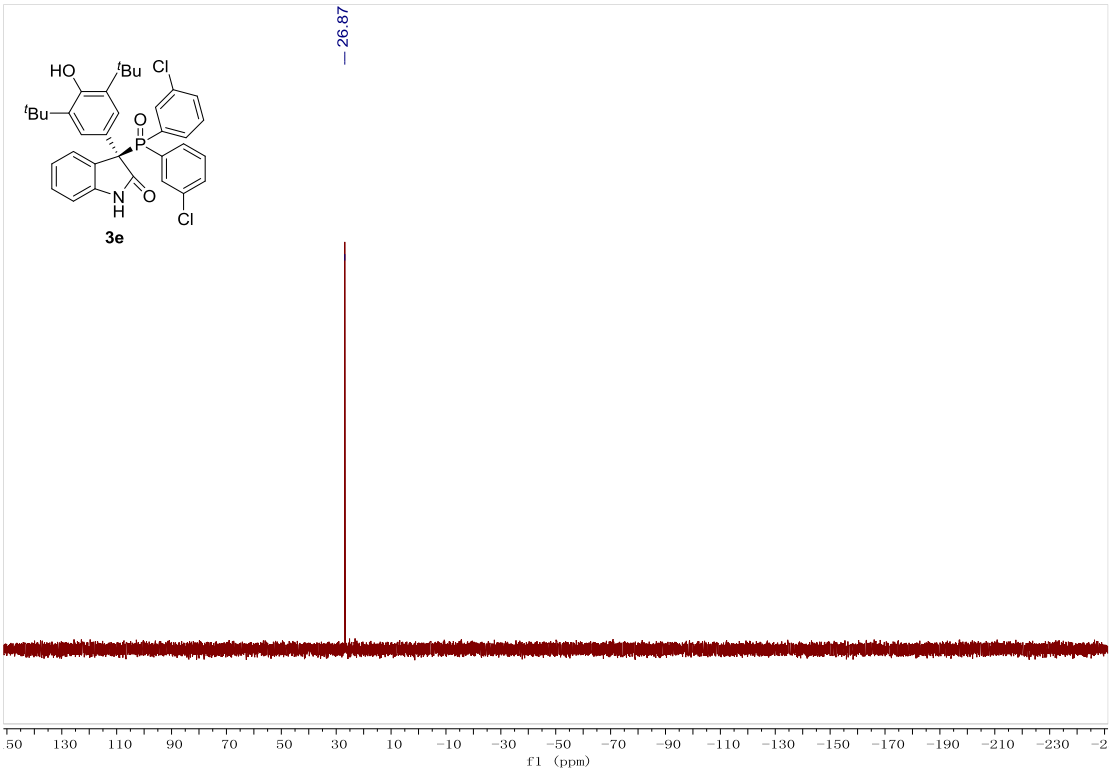
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.033	130.29	10764.277	49.827
2	18.075	73.93	10838.968	50.173
Total:		204.22	21603.245	100.0000

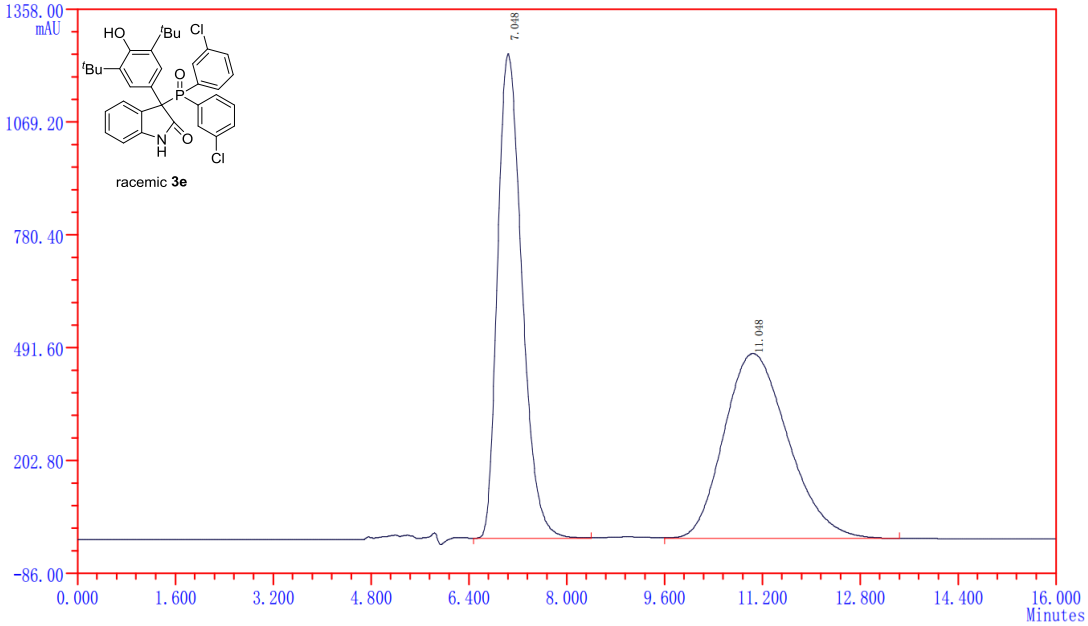


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	11.981	218.75	18217.192	94.135
2	18.073	6.92	1134.927	5.865
Total:		225.67	19352.118	100.0000

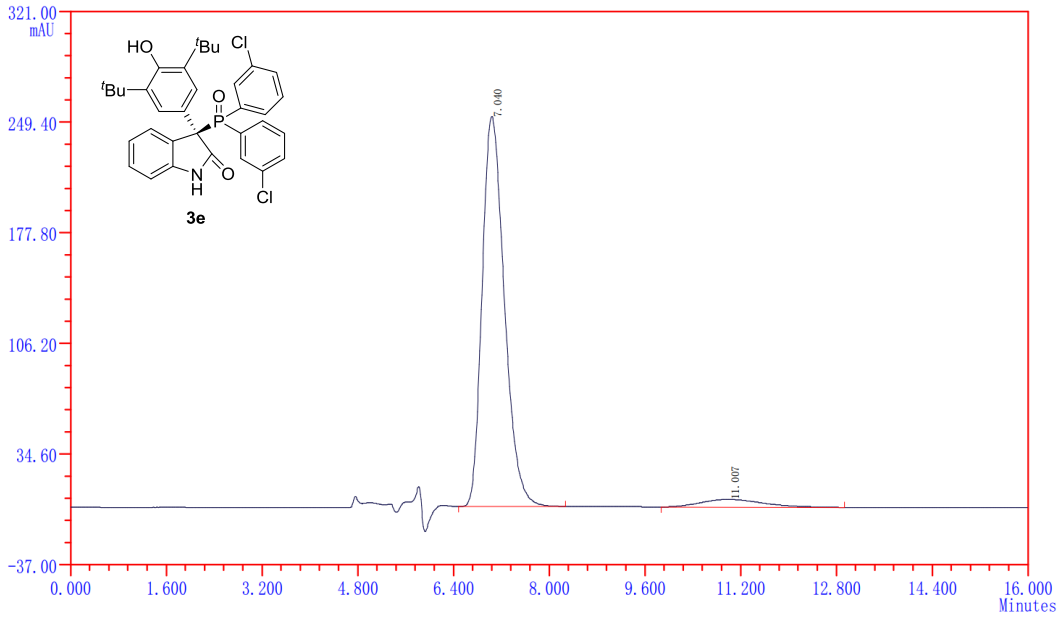

8.17 7.88 7.85 7.80 7.79 7.77 7.66 7.65 7.57 7.47 7.46 7.43 7.41 7.39 7.37 7.36 7.35 7.34 7.33 7.32 7.31 7.31 7.24 7.23 7.21 7.21 7.20 7.19 7.18 7.18 7.12 7.11 7.09 6.74 6.73 5.20
1.33
HO
tBu
tBu
Cl
O
P
N
H
O
Cl
3e
0.99 1.07 1.06 1.04 2.11 4.35 1.09 2.06 1.08 1.10
1.00
18.22
f1 (ppm)


174.8208
153.6051 153.5852 140.9743 140.9239 135.7180 135.7030 134.4074 134.2822 133.1469 133.0703 132.2610 132.2251 132.2044 132.1861 132.1658 132.0781 132.0023 131.6389 131.5016 131.4590 131.3916 130.8545 130.0993 130.0297 129.3711 129.2961 129.2668 129.1924 129.1148 129.1010 128.4106 128.3859 125.9227 125.8885 125.4067 125.3679 122.4255 122.3817 109.8410 62.1739 61.7116 34.5364 30.0912
HO
tBu
tBu
Cl
O
P
N
H
O
Cl
3e
f1 (ppm)

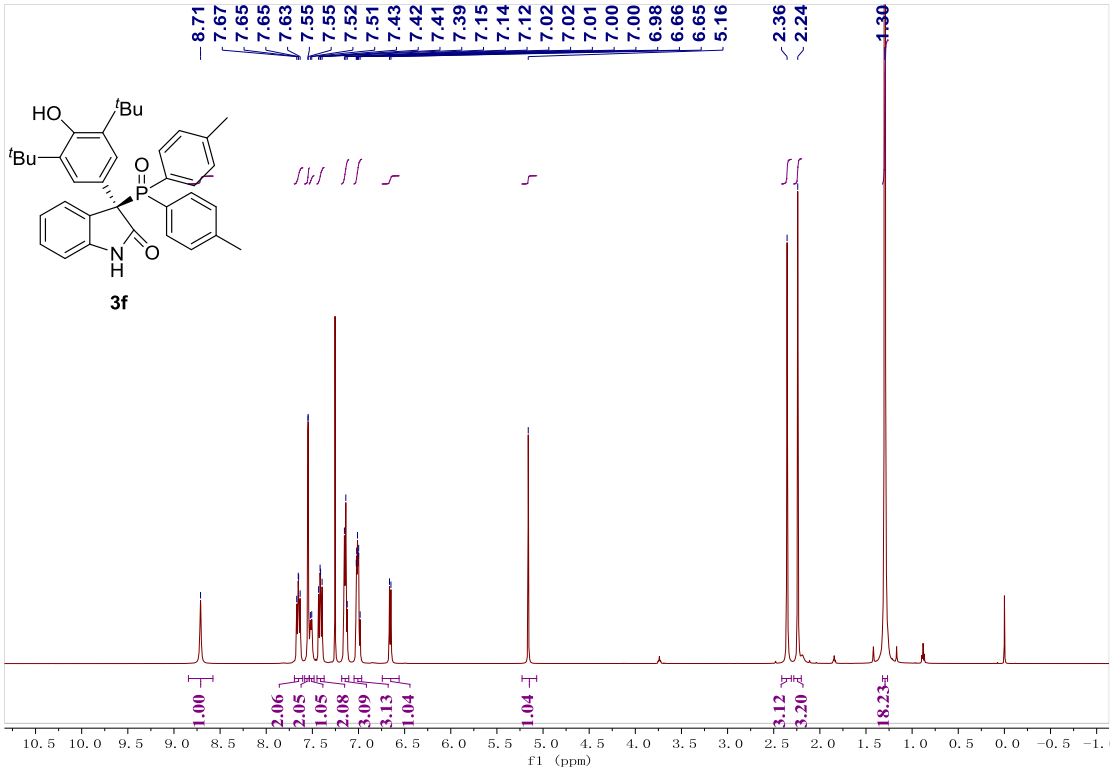


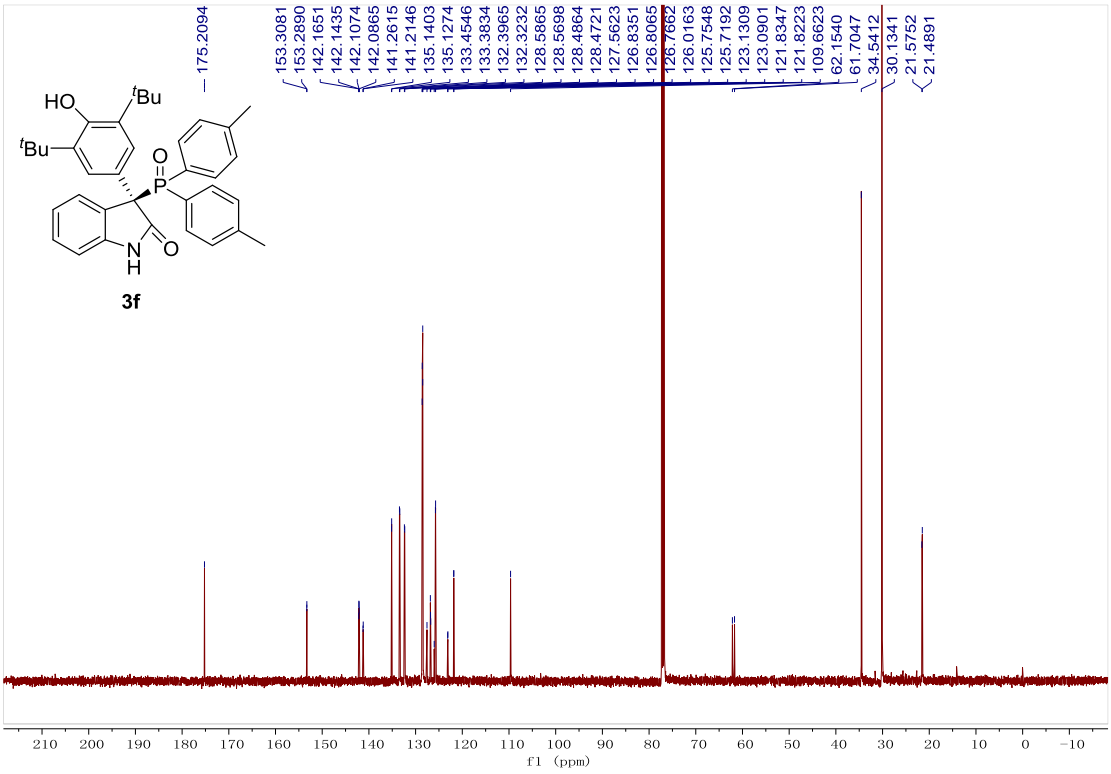


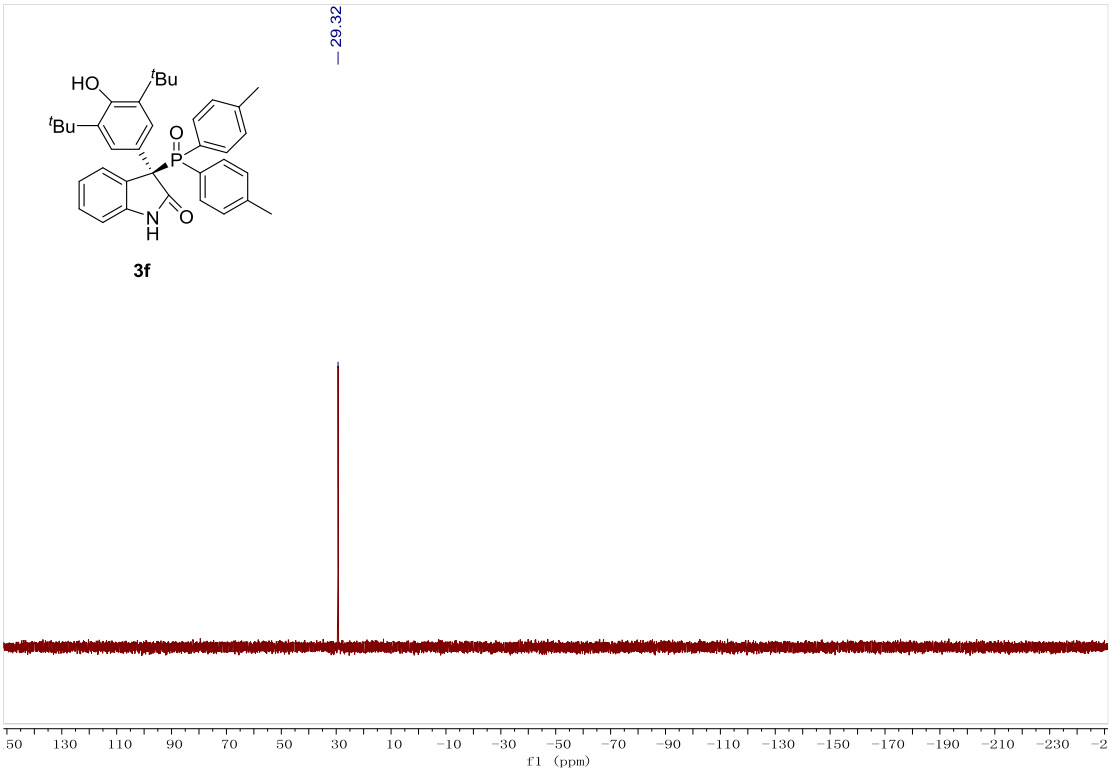
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.048	1239.77	34393.488	49.906
2	11.048	473.23	34523.367	50.094
Total:		1713.00	68916.854	100.0000

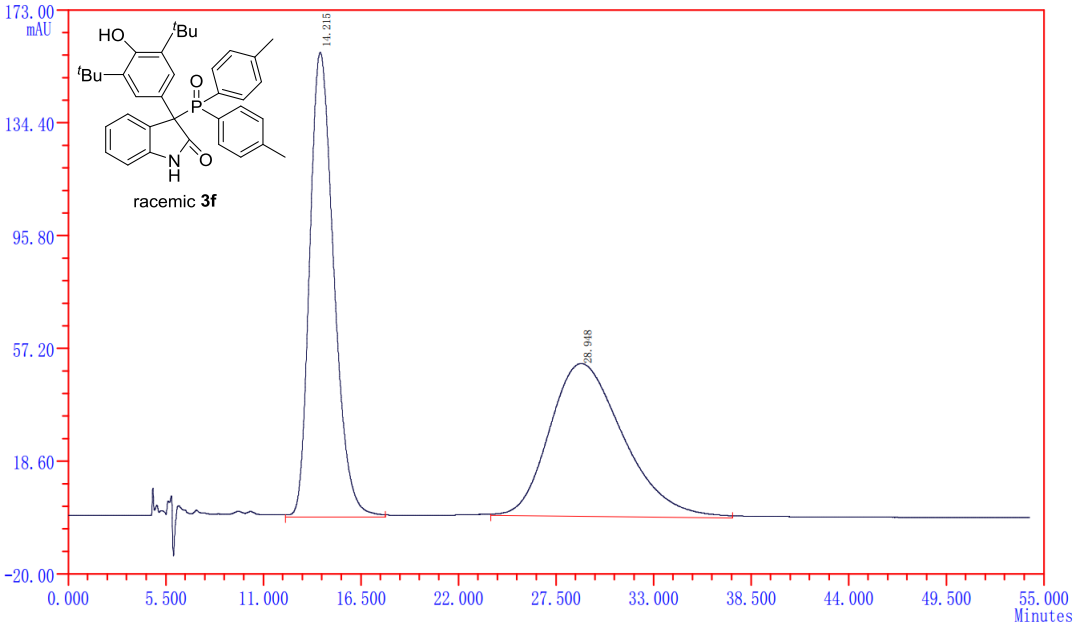


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.040	252.53	6531.458	94.749
2	11.007	5.01	361.975	5.251
Total:		257.54	6893.433	100.0000

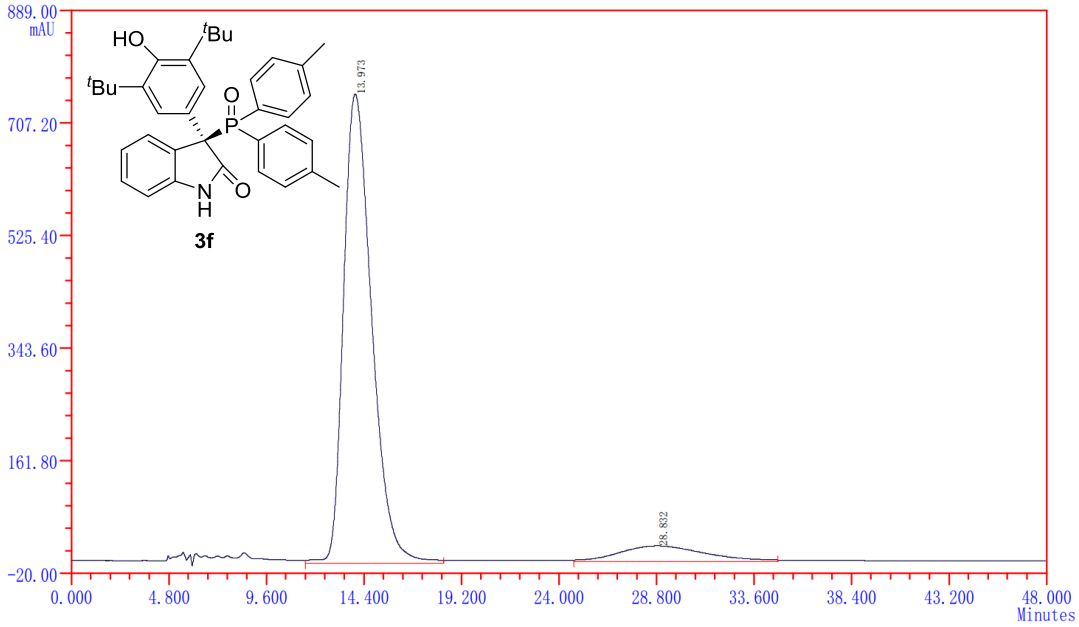



175.2094
153.3081
153.2890
142.1651
142.1435
142.1074
142.0865
141.2615
141.2146
135.1403
135.1274
133.4546
133.3834
132.3965
132.3232
128.5865
128.5698
128.4864
128.4721
127.5623
126.8351
126.8065
126.7662
126.0163
125.7548
125.7192
123.1309
123.0901
121.8347
121.8223
109.6623
62.1540
61.7047
34.5412
30.1341
21.5752
21.4891
HO
tBu
tBu
O
P
N
H
O
3f
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)

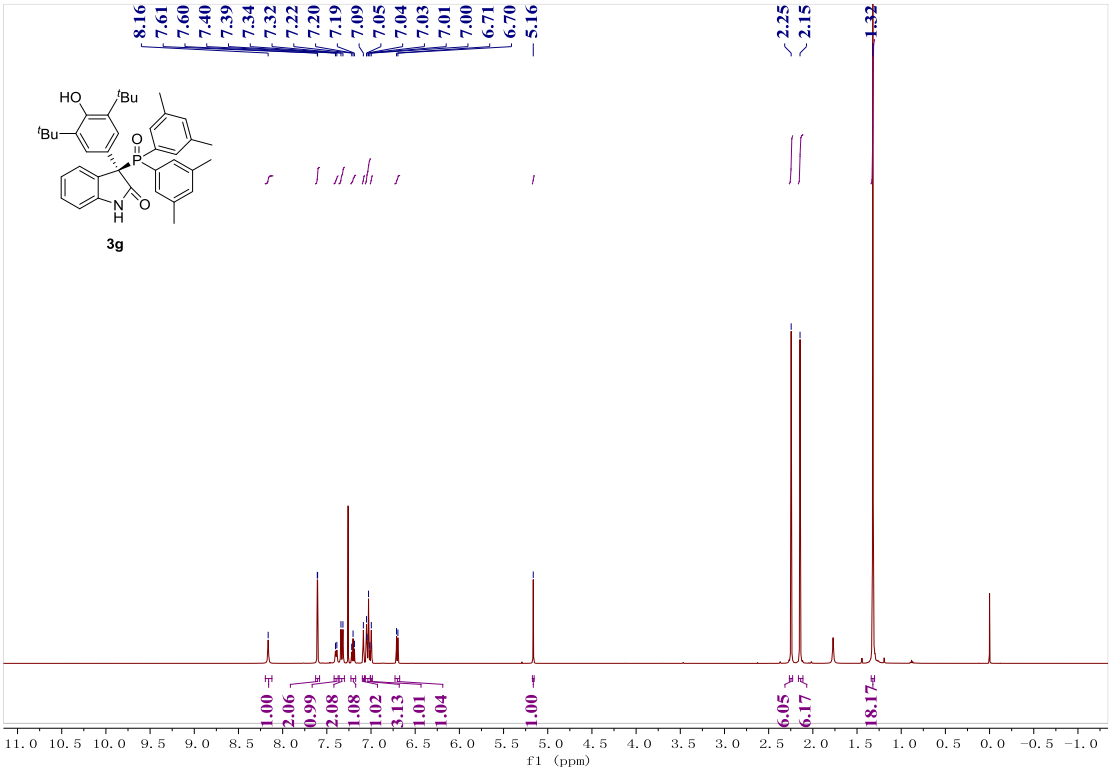

29.32
HO
tBu
tBu
O
P
N
H
O
3f
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

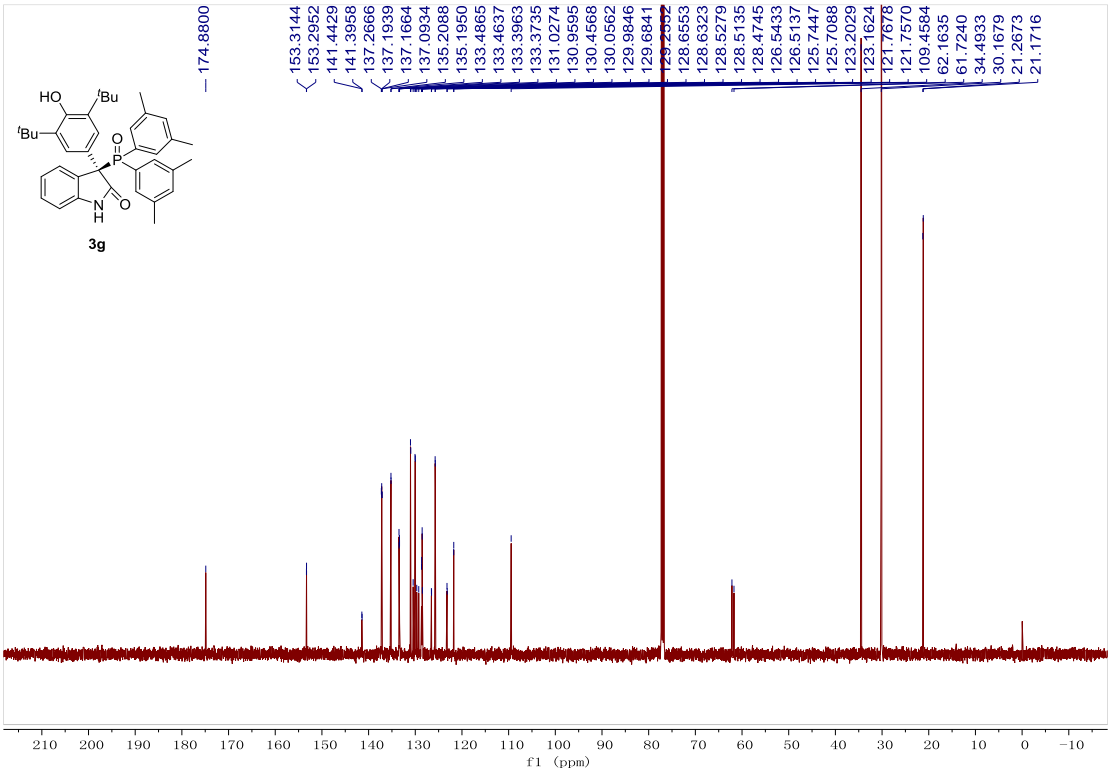


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.215	158.93	15066.674	49.855
2	28.948	52.30	15154.042	50.145
Total:		211.23	30220.716	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	13.973	757.34	72987.553	90.790
2	28.832	25.07	7404.335	9.210
Total:		782.41	80391.889	100.0000


8.16
7.61
7.60
7.40
7.39
7.34
7.32
7.22
7.20
7.19
7.09
7.05
7.04
7.03
7.01
7.00
6.71
6.70
5.16
2.25
2.15
1.32
HO
tBu
tBu
O
P
N
H
O
3g
1.00
2.06
0.99
2.08
1.08
1.02
3.13
1.01
1.04
1.00
6.05
6.17
18.17
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 −0.5 −1.0
f1 (ppm)


174.8800
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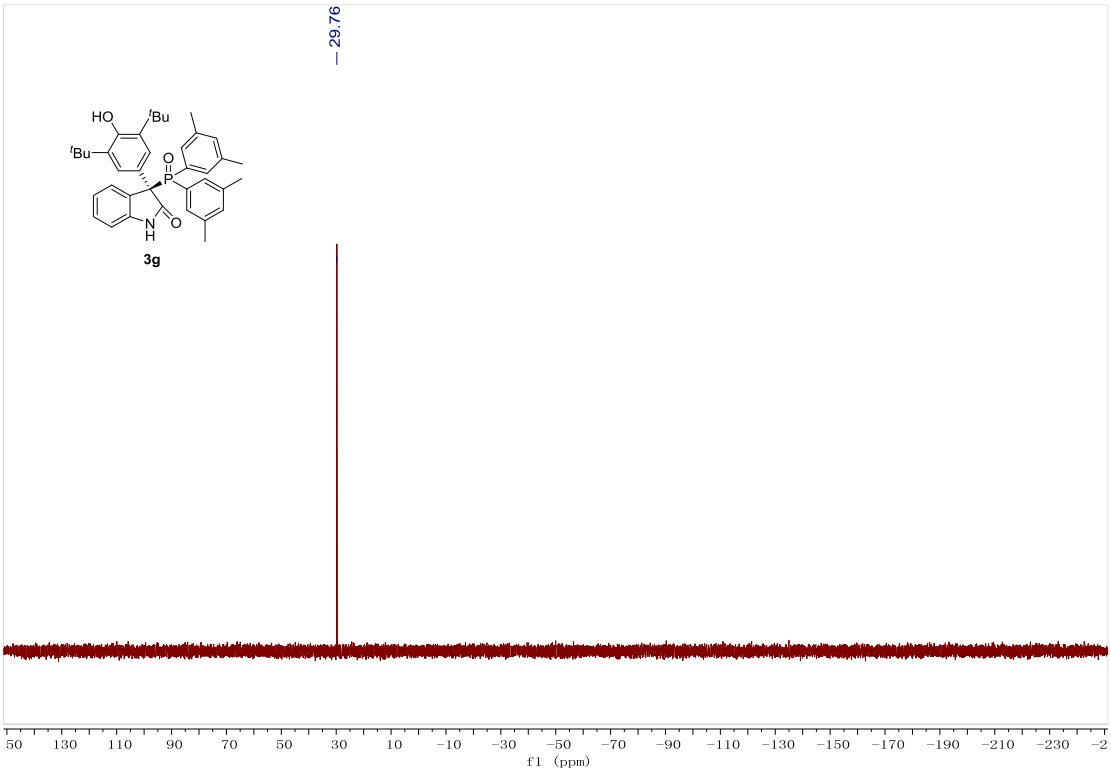
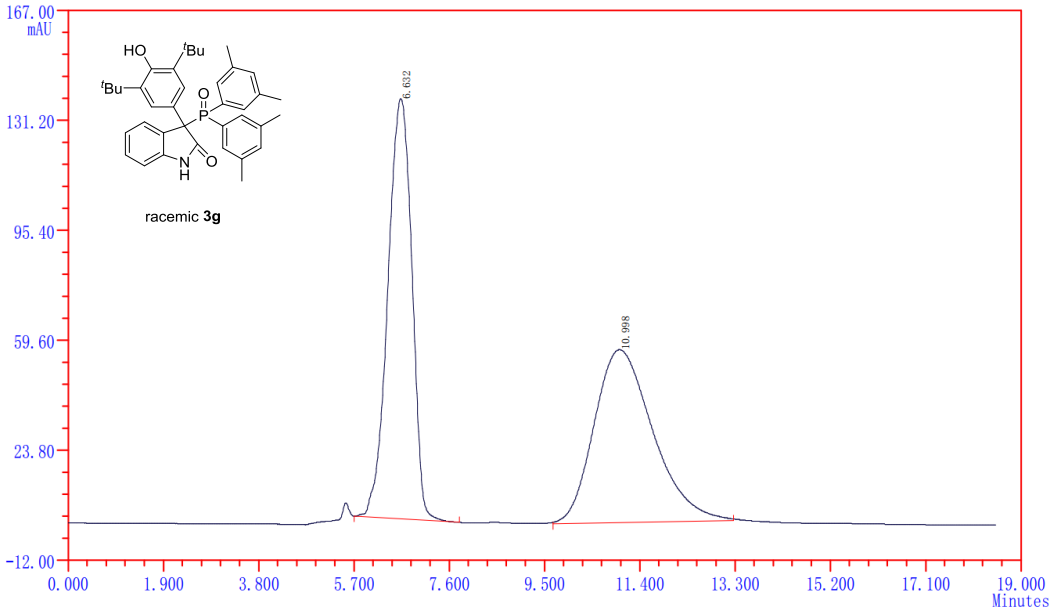
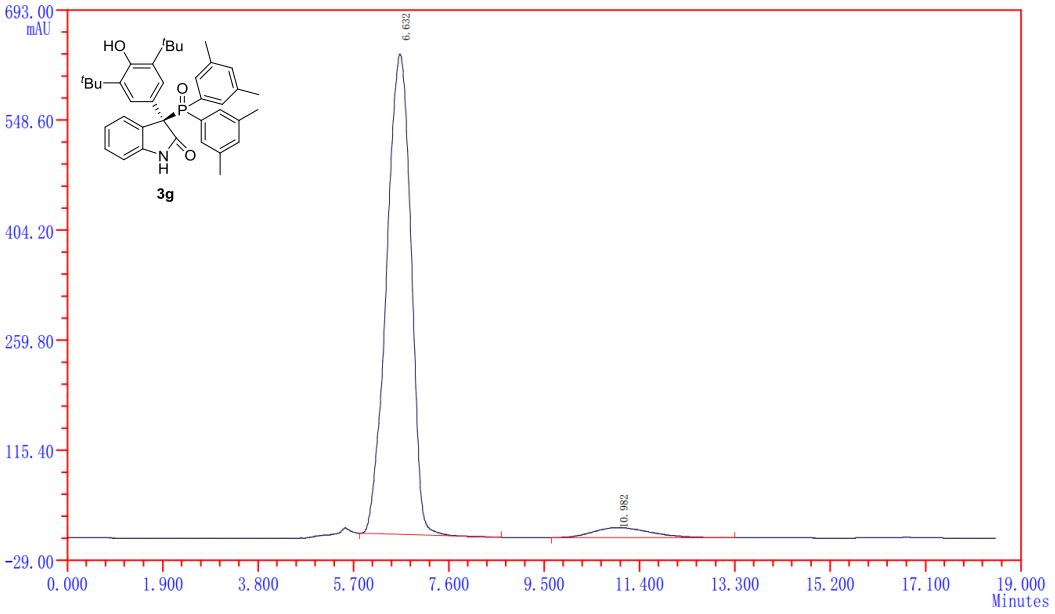
141.4429
141.3958
137.2666
137.1939
137.1664
137.0934
135.2088
135.1950
133.4865
133.4637
133.3963
133.3735
131.0274
130.9595
130.4568
130.0562
129.9846
129.6841
129.2352
128.6553
128.6323
128.5279
128.5135
128.4745
126.5433
126.5137
125.7447
125.7088
123.2029
123.1624
121.7678
121.7570
109.4584
62.1635
61.7240
34.4933
30.1679
21.2673
21.1716
HO
tBu
tBu
O
P
N
H
O
3g
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)

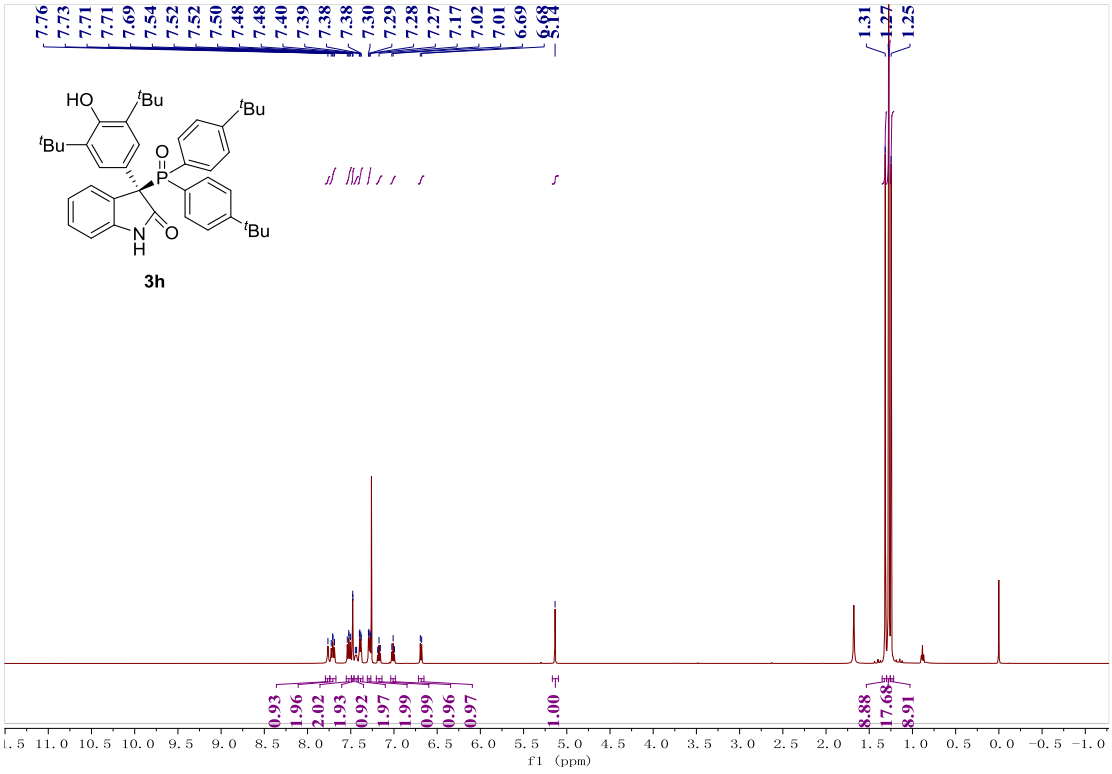


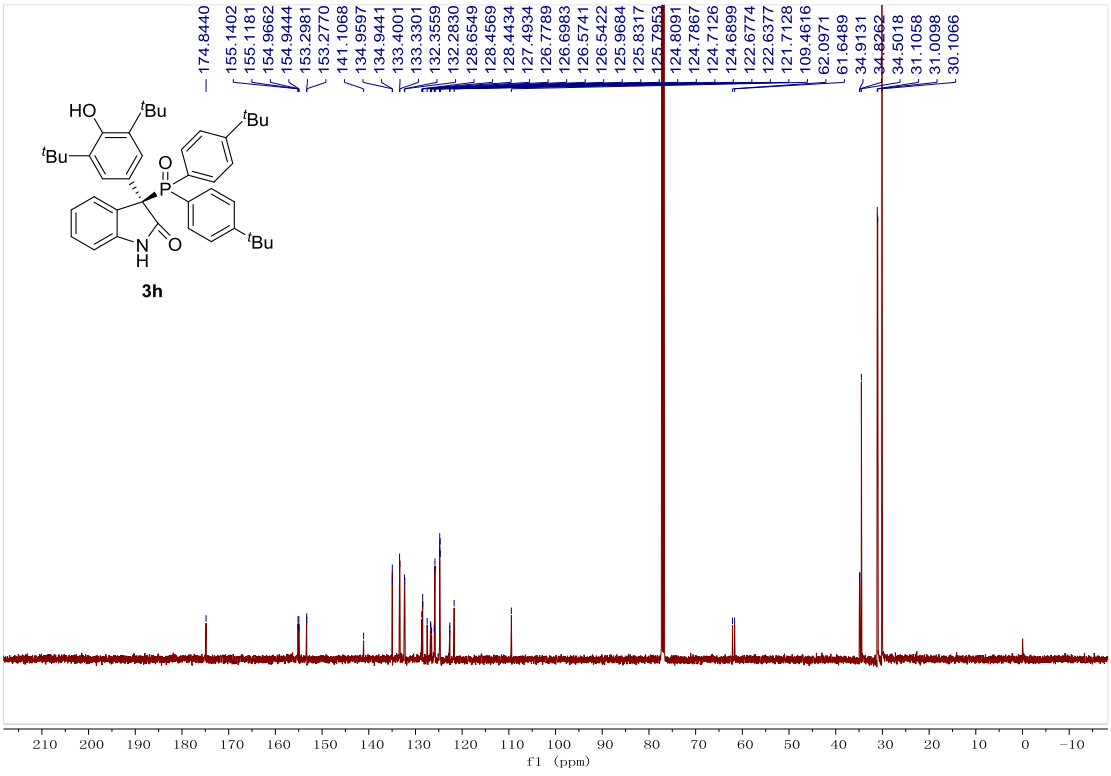


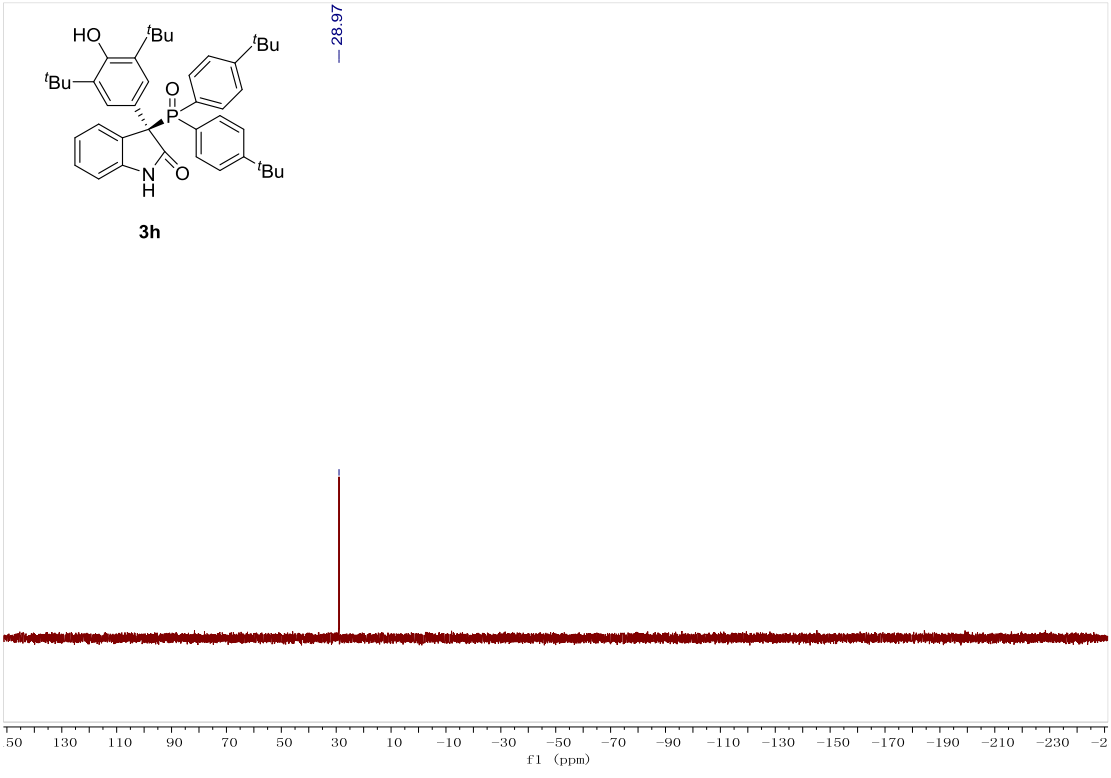
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.632	136.88	4570.464	49.860
2	10.998	56.29	4596.040	50.140
Total:		193.17	9166.504	100.0000

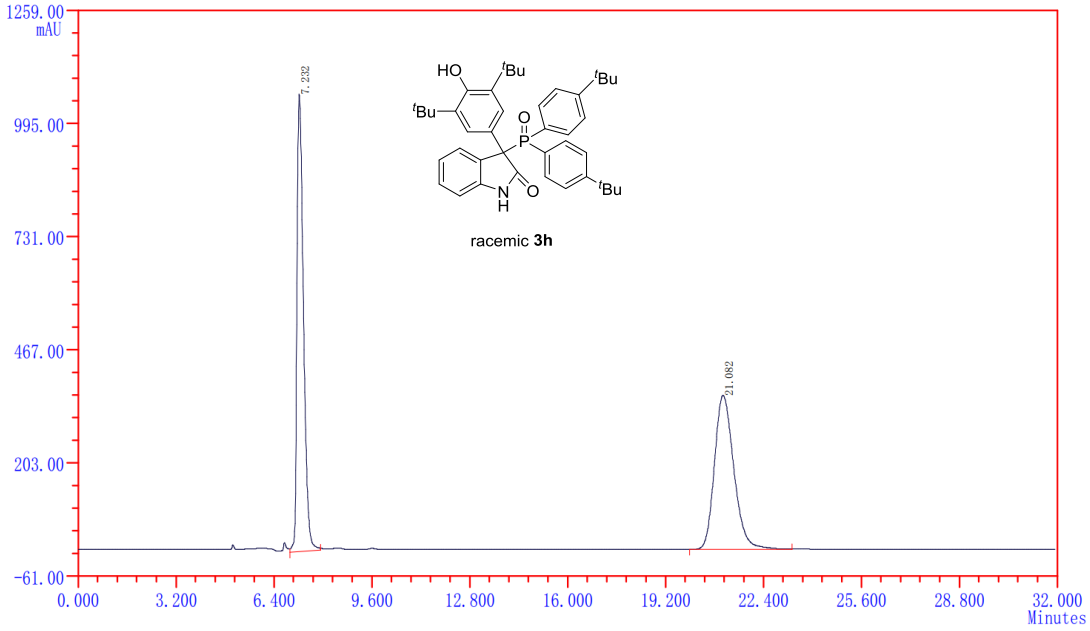


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.632	630.69	21392.947	95.210
2	10.982	13.38	1076.290	4.790
Total:		644.07	22469.238	100.0000

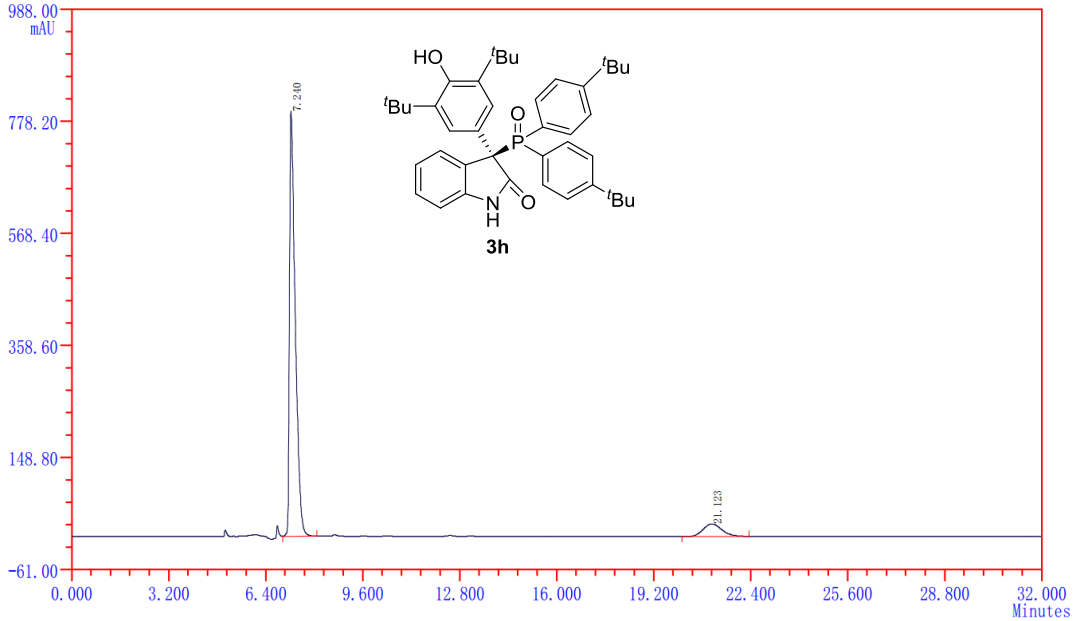



174.8440
155.1402
155.1181
154.9662
154.9444
153.2981
153.2770
141.1068
134.9597
134.9441
133.4001
133.3301
132.3559
132.2830
128.6549
128.4569
128.4434
127.4934
126.7789
126.6983
126.5741
126.5422
125.9684
125.8317
125.7953
124.8091
124.7867
124.7126
124.6899
122.6774
122.6377
121.7128
109.4616
62.0971
61.6489
34.9131
34.8262
34.5018
31.1058
31.0098
30.1066
HO
tBu
tBu
tBu
tBu
O
P
N
H
O
O
3h
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)

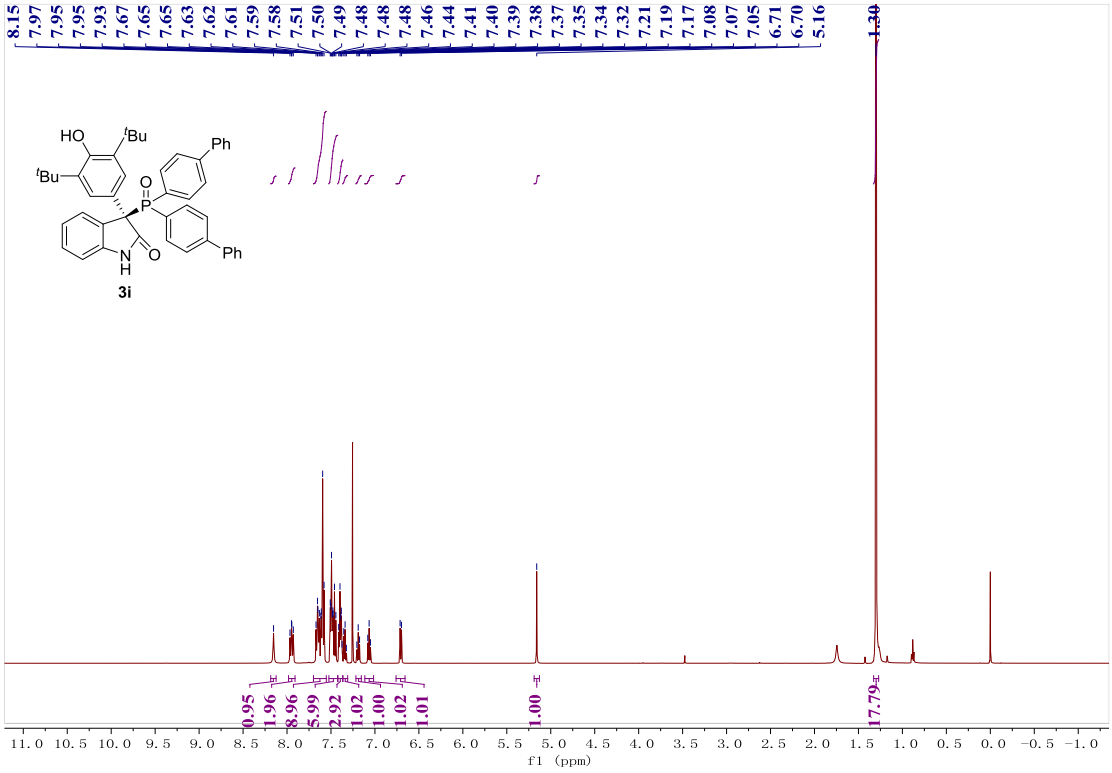

28.97
HO
tBu
tBu
tBu
tBu
O
P
N
H
O
O
3h
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

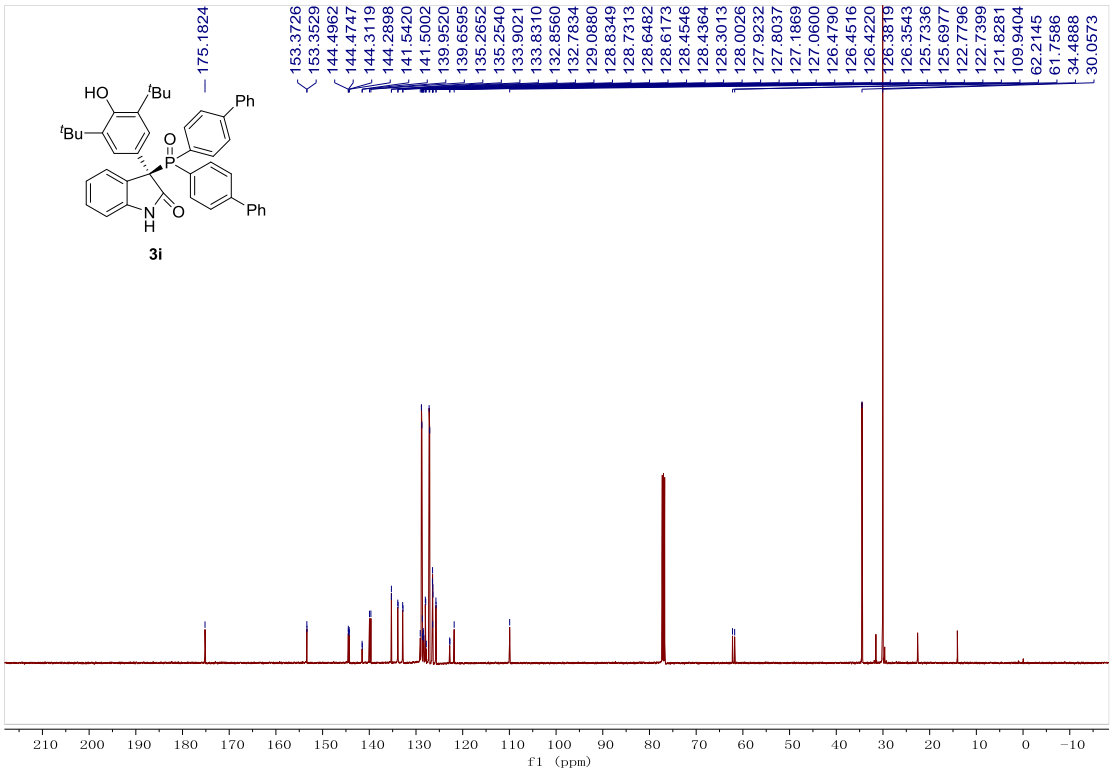


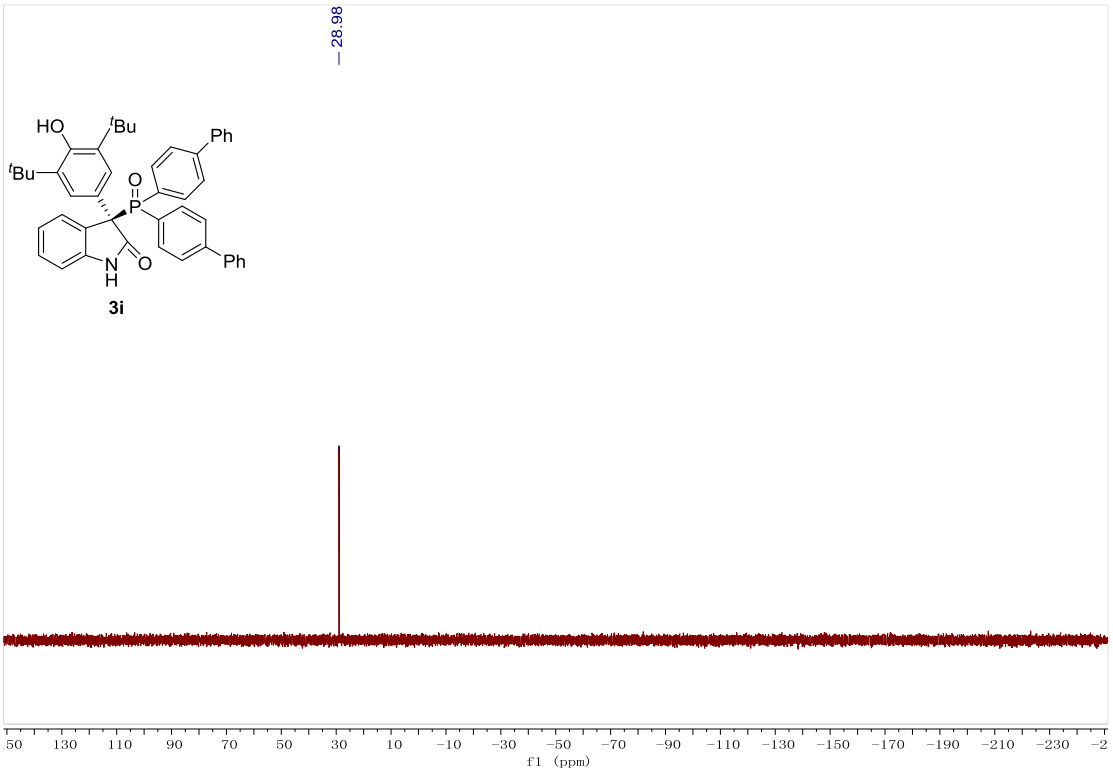
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.232	1068.08	15778.837	49.853
2	21.082	359.22	15871.861	50.147
Total:		1427.30	31650.697	100.0000

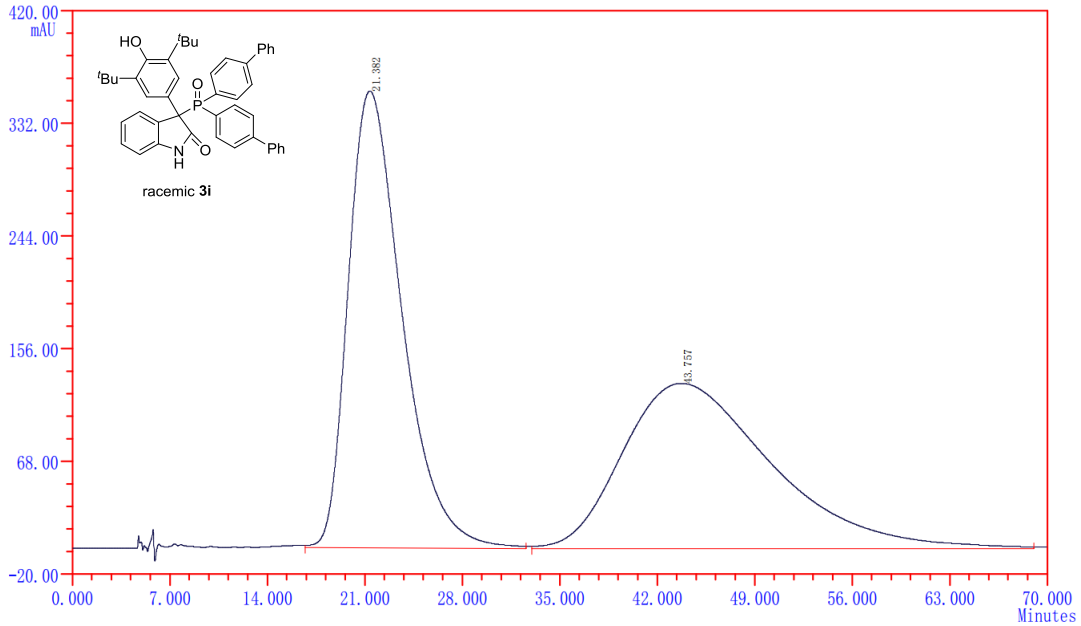


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.240	795.70	10523.326	91.186
2	21.123	23.63	1017.137	8.814
Total:		819.33	11540.463	100.0000

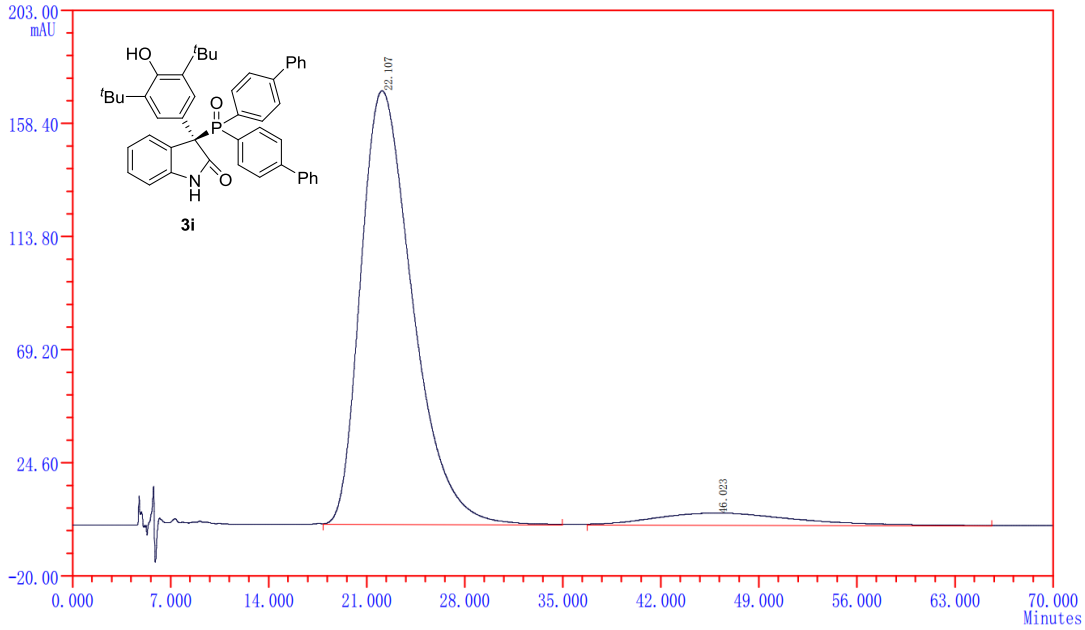

8.15 7.97 7.95 7.95 7.93 7.67 7.65 7.65 7.63 7.62 7.61 7.59 7.58 7.51 7.50 7.49 7.48 7.48 7.48 7.46 7.44 7.41 7.40 7.39 7.38 7.37 7.35 7.34 7.32 7.21 7.19 7.17 7.08 7.07 7.05 6.71 6.70 5.16 1.30
HO
tBu
tBu
O
P
Ph
Ph
N
H
O
3i
0.95 1.96 8.96 5.99 2.92 1.02 1.00 1.02 1.01 1.00 17.79
11.0 10.5 10.0 9.5 9.0 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 −0.5 −1.0
f1 (ppm)


175.1824
153.3726 153.3529 144.4962 144.4747 144.3119 144.2898 141.5420 141.5002 139.9520 139.6595 135.2652 135.2540 133.9021 133.8310 132.8560 132.7834 129.0880 128.8349 128.7313 128.6482 128.6173 128.4546 128.4364 128.3013 128.0026 127.9232 127.8037 127.1869 127.0600 126.4790 126.4516 126.4220 126.3819 126.3543 125.7336 125.6977 122.7796 122.7399 121.8281 109.9404 62.2145 61.7586 34.4888 30.0573
HO
tBu
tBu
O
P
Ph
Ph
N
H
O
3i
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)

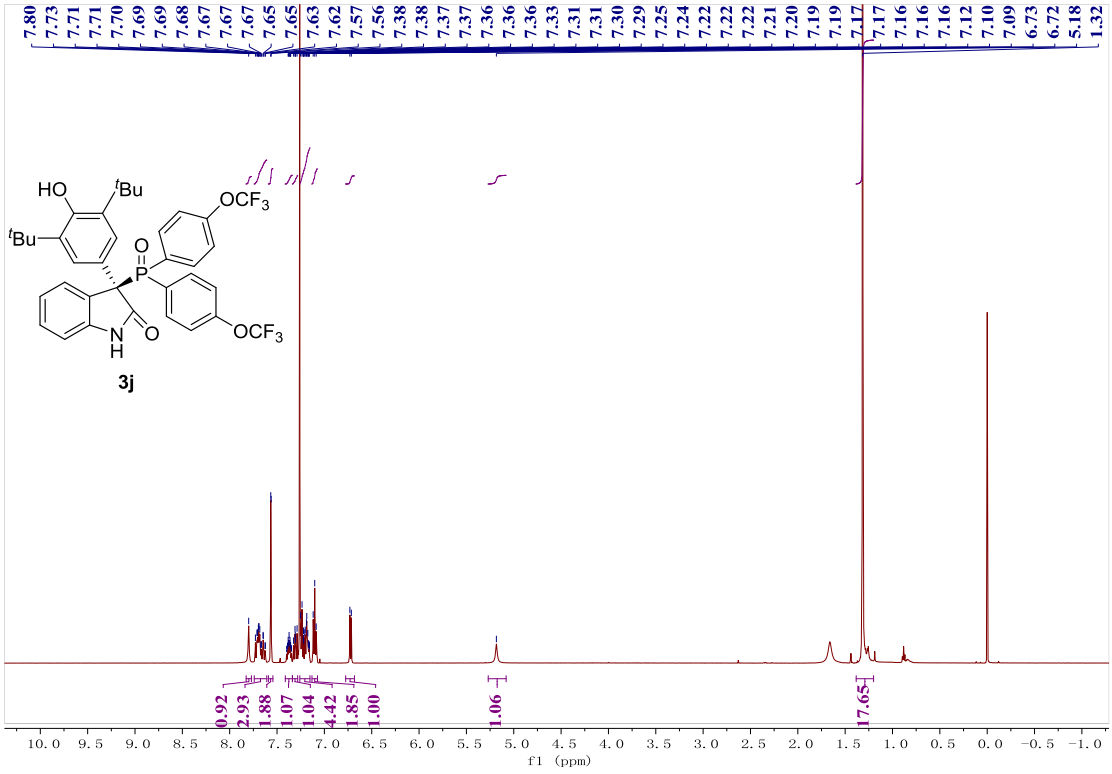


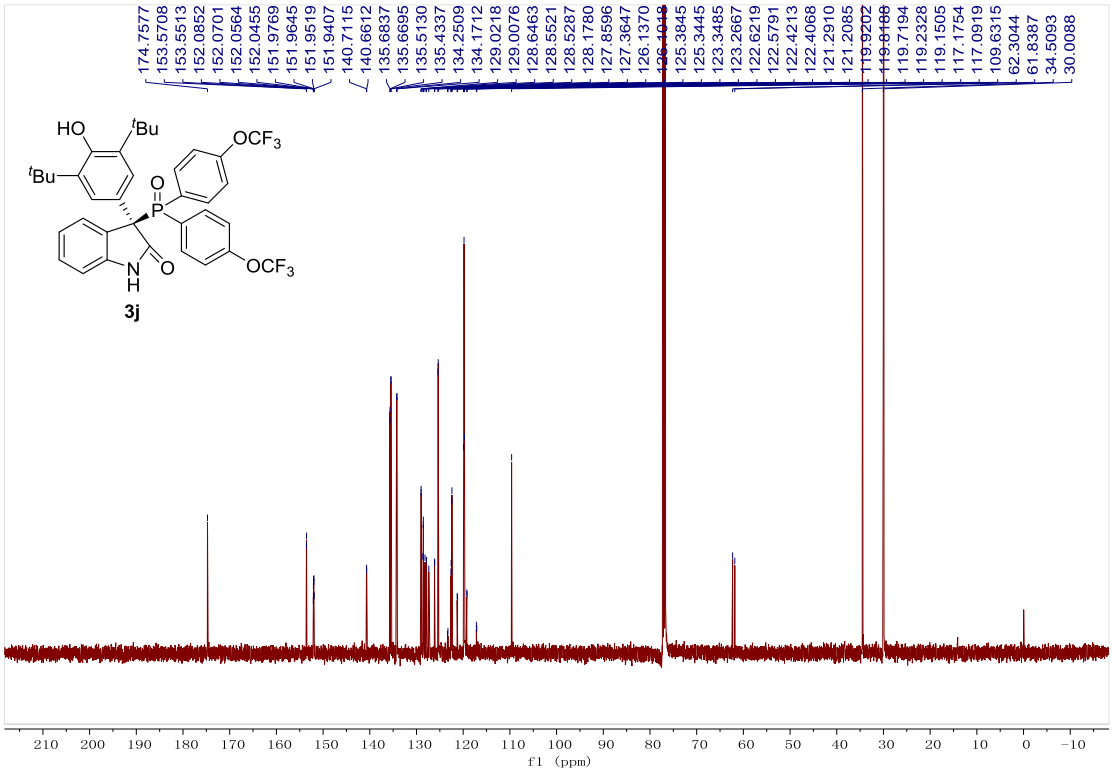


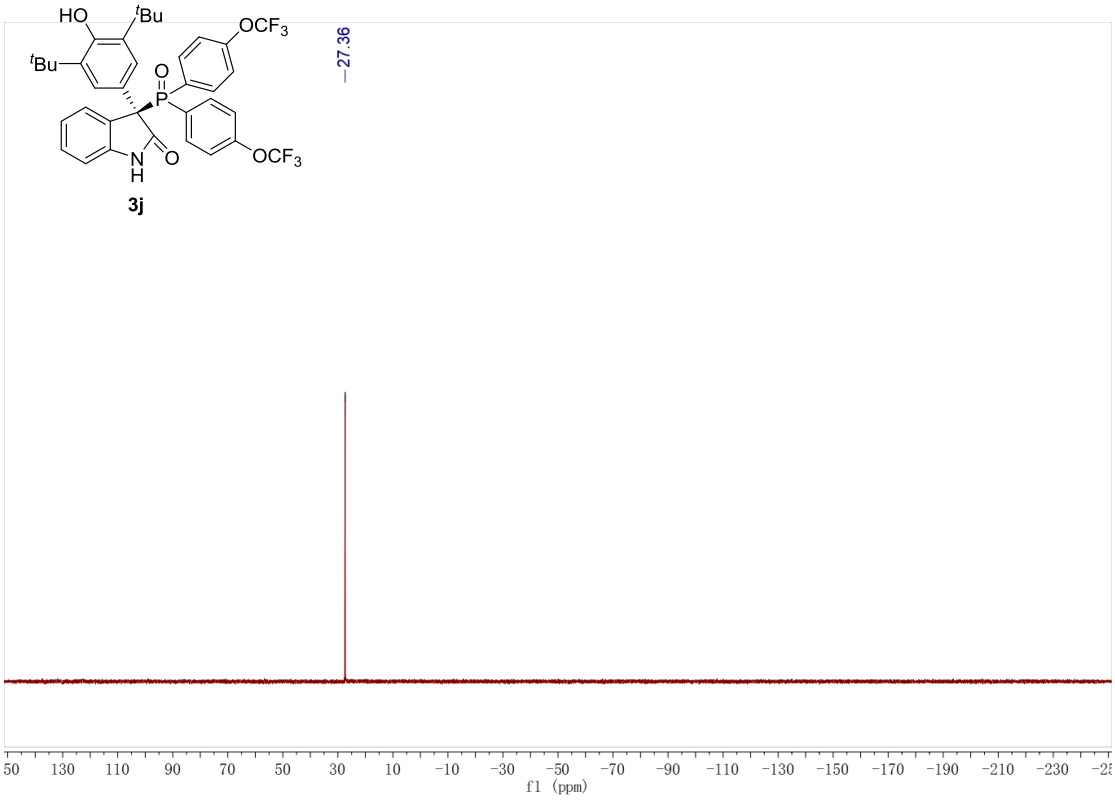
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	21.382	356.81	96274.194	49.924
2	43.757	129.22	96569.196	50.076
Total:		387.78	192843.390	100.0000

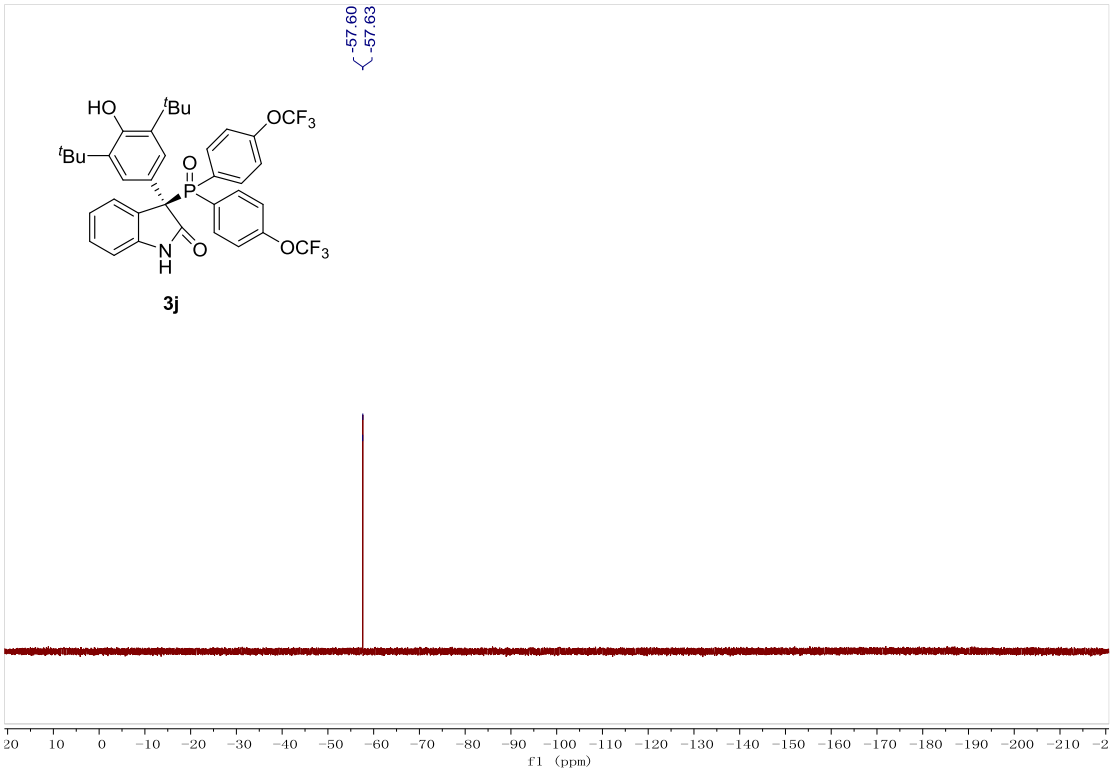


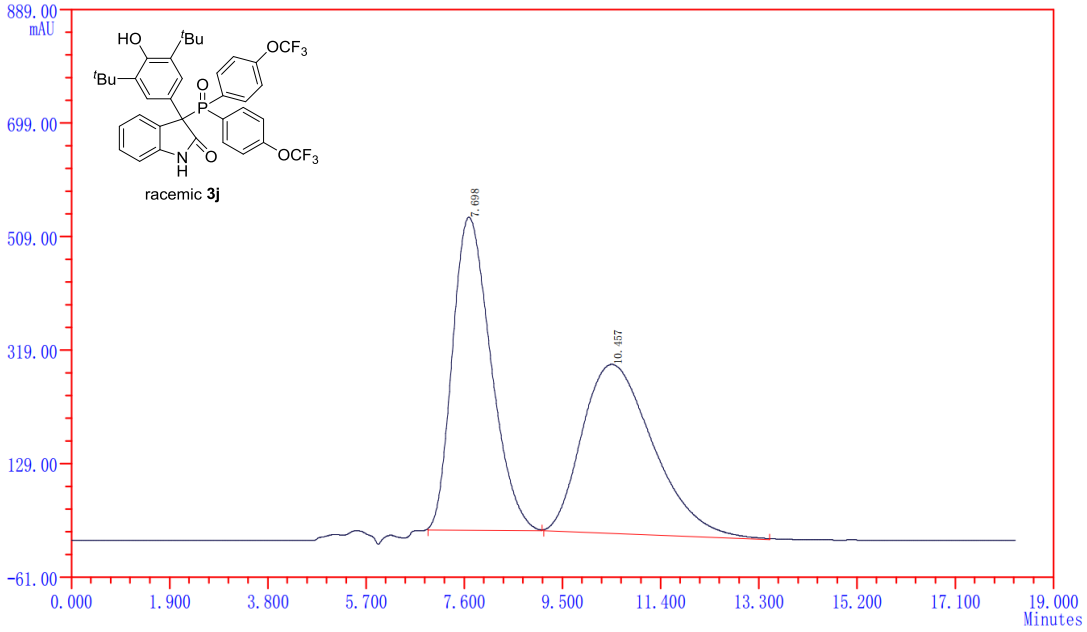
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	22.107	171.00	44075.641	92.714
2	46.023	4.86	3463.770	7.286
Total:		175.86	47539.411	100.0000



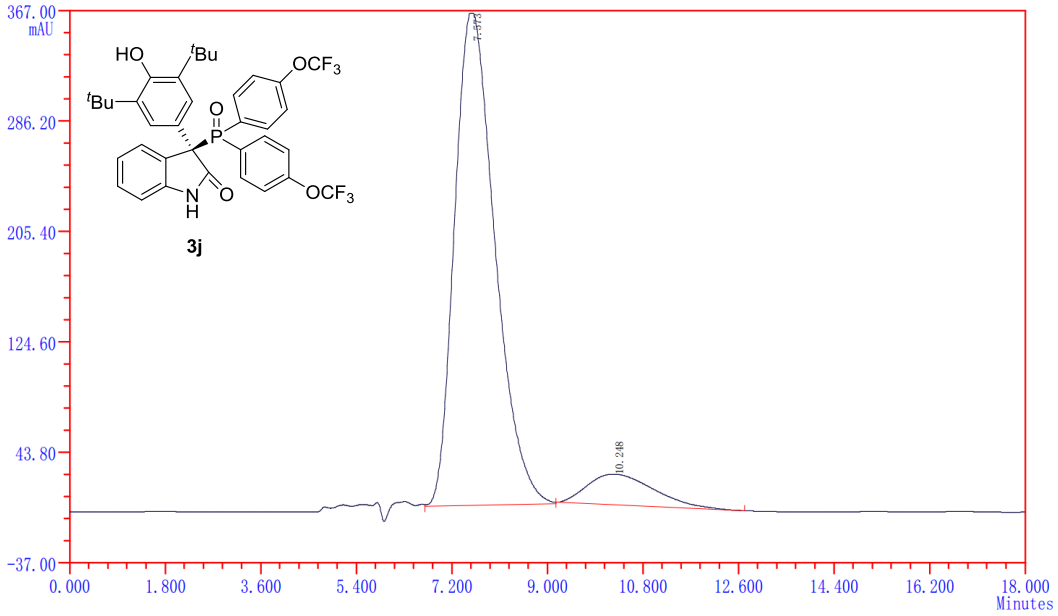

174.7577
153.5708
153.5513
152.0852
152.0701
152.0564
152.0455
151.9769
151.9645
151.9519
151.9407
140.7115
140.6612
135.6837
135.6695
135.5130
135.4337
134.2509
134.1712
129.0218
129.0076
128.6463
128.5521
128.5287
128.1780
127.8596
127.3647
126.1370
125.3845
125.3445
123.3485
123.2667
122.6219
122.5791
122.4213
122.4068
121.2910
121.2085
119.9202
119.8188
119.7194
119.2328
119.1505
117.1754
117.0919
109.6315
62.3044
61.8387
34.5093
30.0088
HO
tBu
tBu
OCF3
O
P
N
H
O
OCF3
3j
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)


HO
tBu
tBu
OCF3
O
P
N
H
O
OCF3
3j
27.36
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230
f1 (ppm)

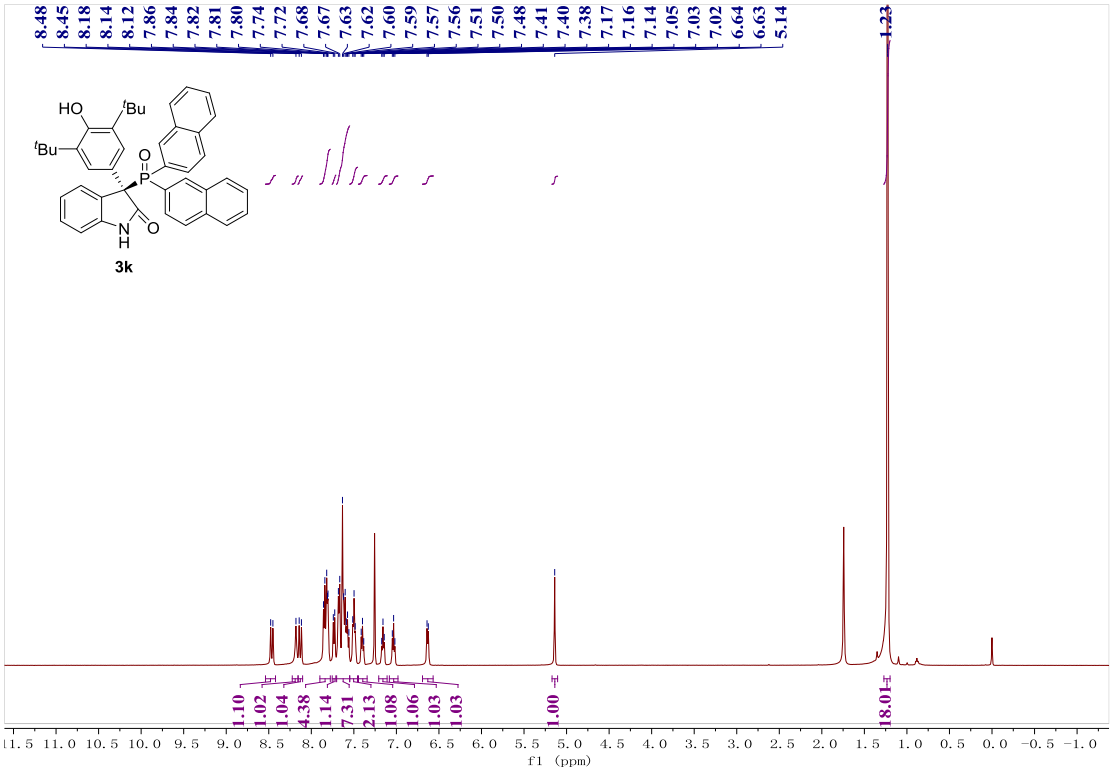


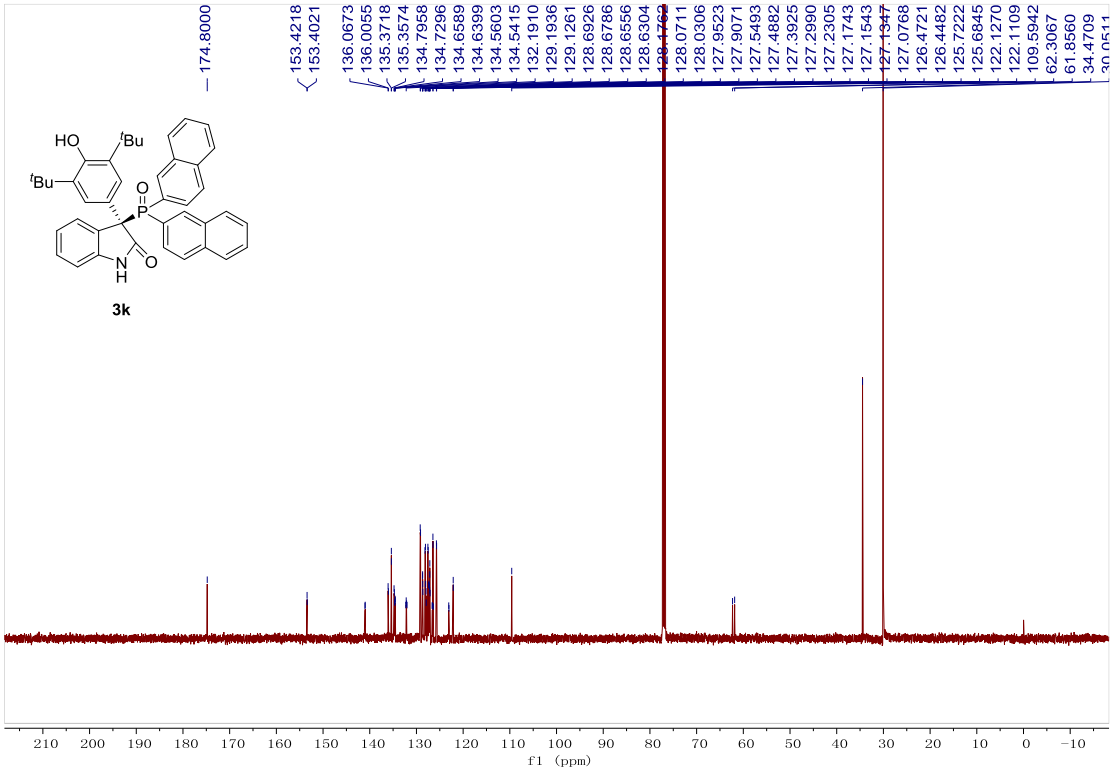


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.698	523.65	27121.834	50.008
2	10.457	282.84	27112.711	49.992
Total:		806.49	54234.545	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.573	362.25	19099.044	90.670
2	10.248	22.46	1965.257	9.330
Total:		384.71	21064.301	100.0000

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136.0055
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132.1910
129.1936
129.1261
128.6926
128.6786
128.6556
128.6304
128.0711
128.0306
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127.5493
127.4882
127.3925
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127.2305
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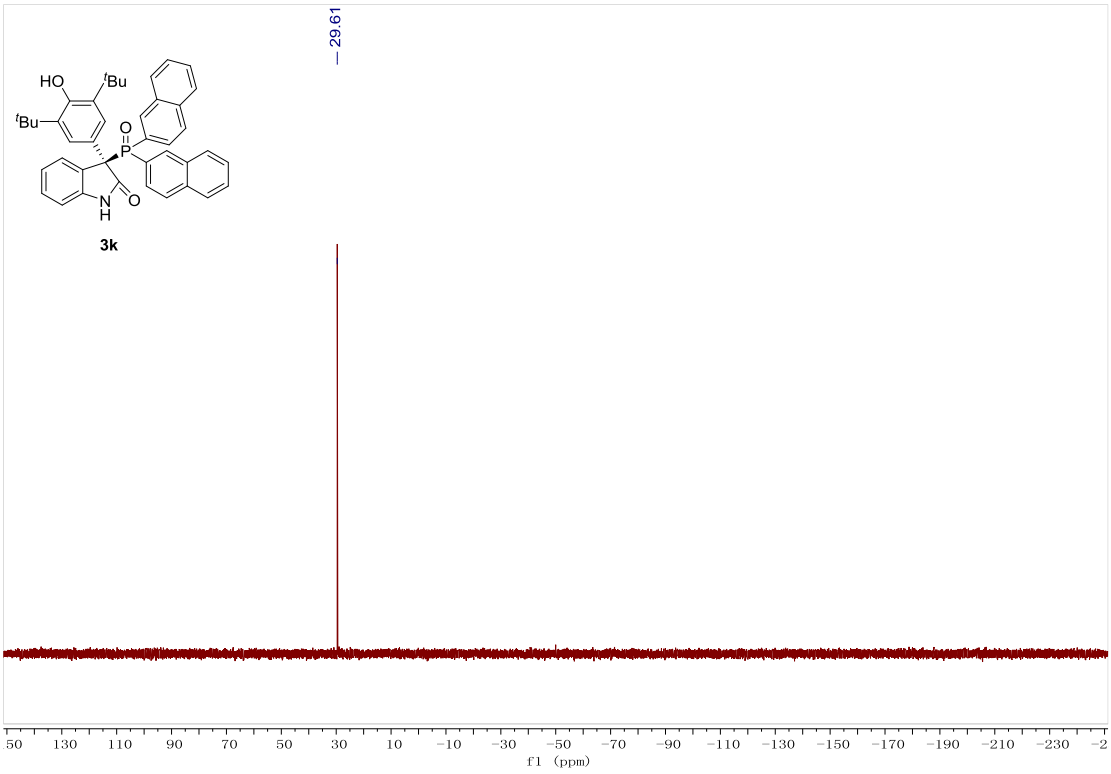
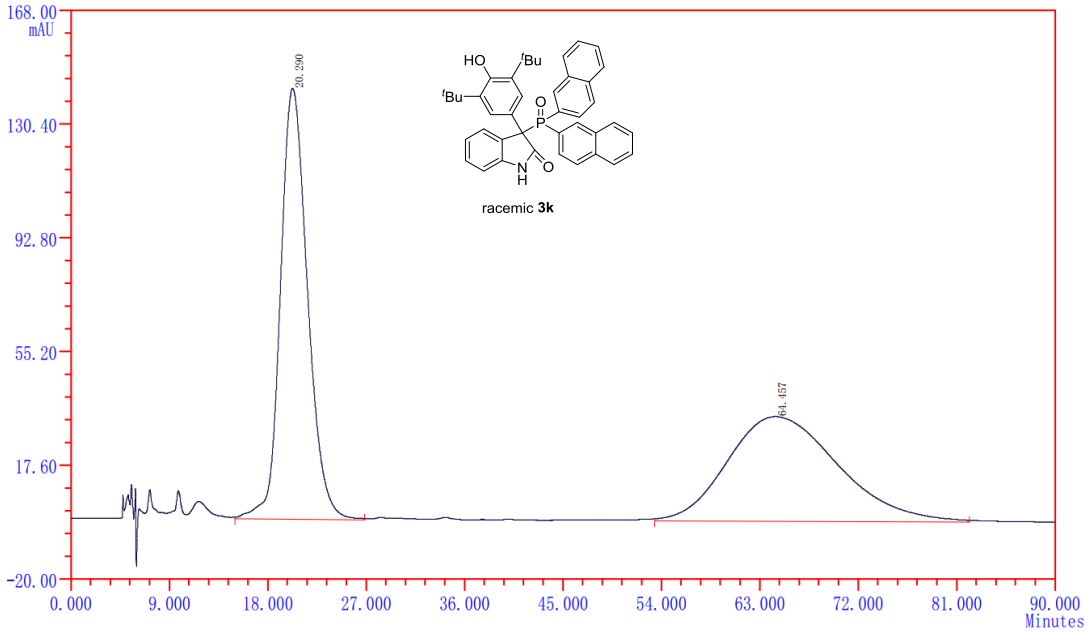
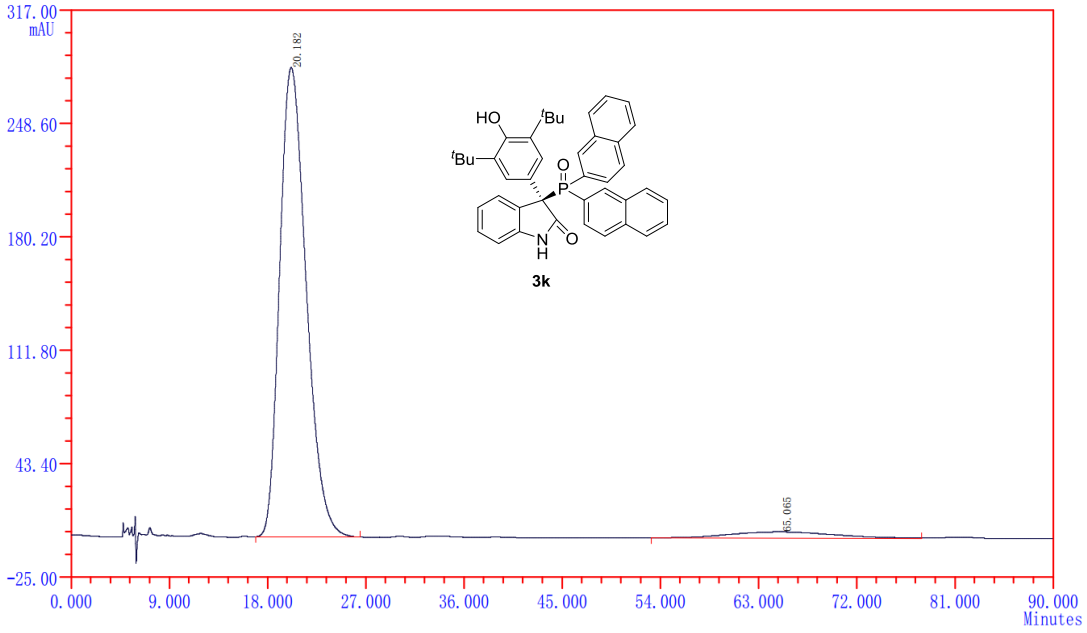
127.1543
127.1347
127.0768
126.4721
126.4482
125.7222
125.6845
122.1270
122.1109
109.5942
62.3067
61.8560
34.4709
30.0511
HO
tBu
tBu
O
P
N
H
O
3k
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

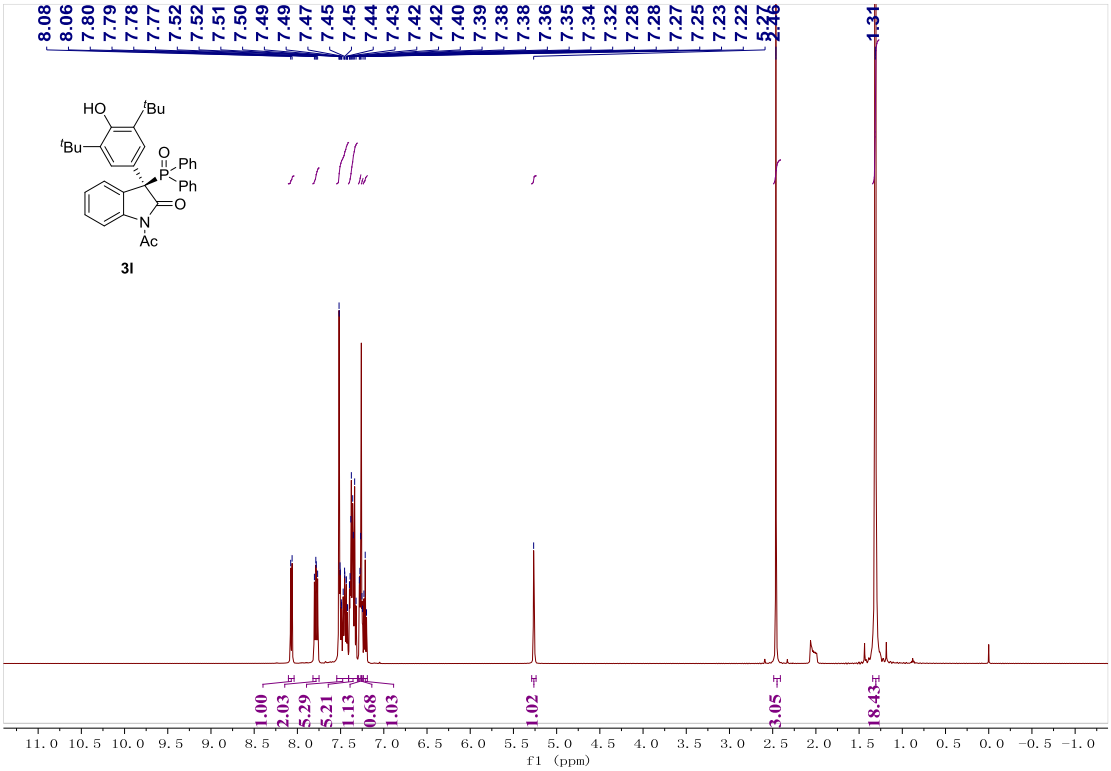


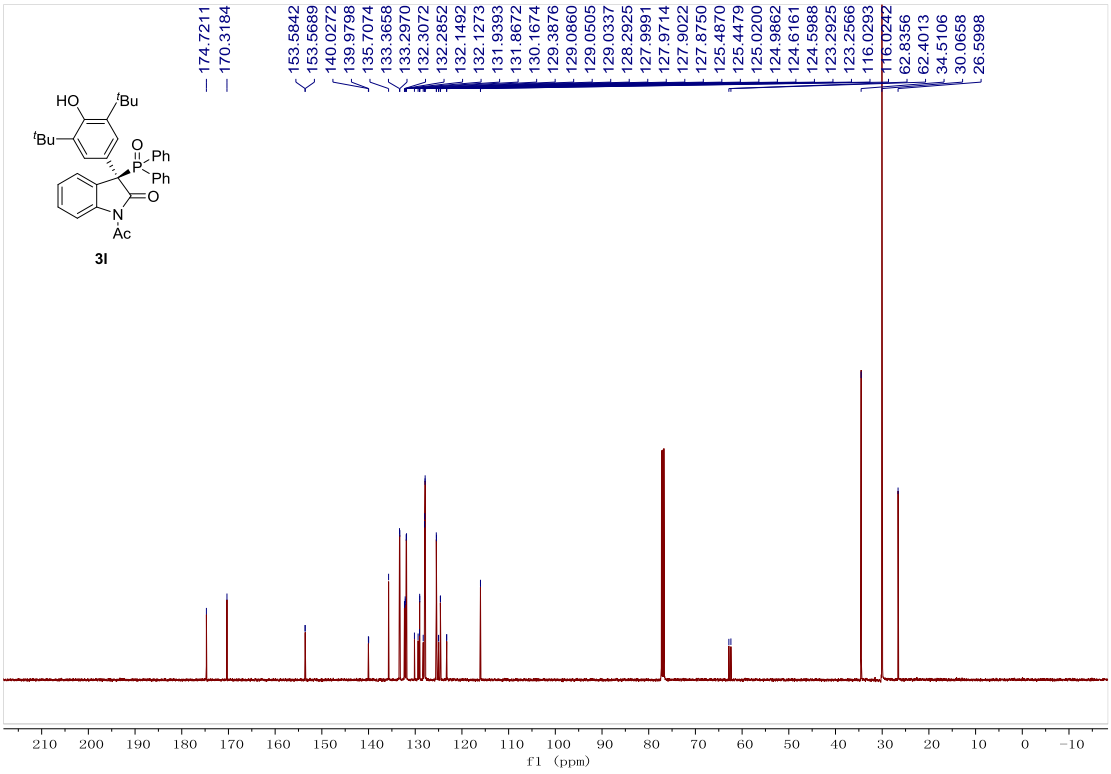


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	20.290	142.44	24619.352	50.119
2	64.457	34.66	24502.426	49.881
Total:		177.10	49121.778	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	20.182	283.03	47823.974	94.727
2	65.065	3.86	2662.263	5.273
Total:		286.89	50486.237	100.0000

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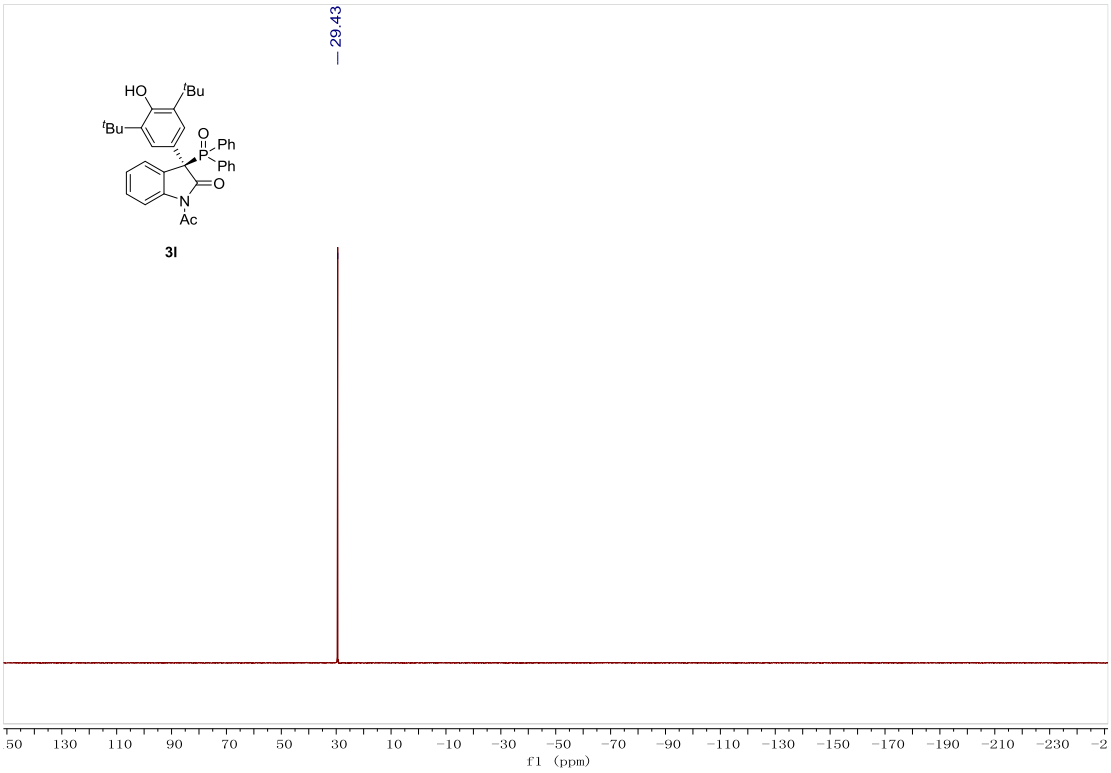
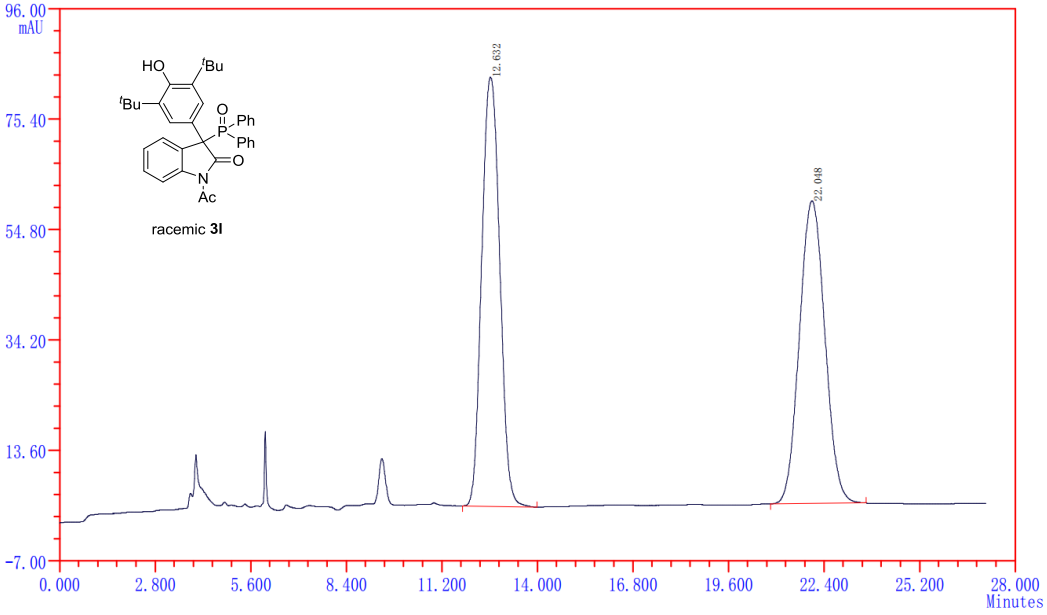
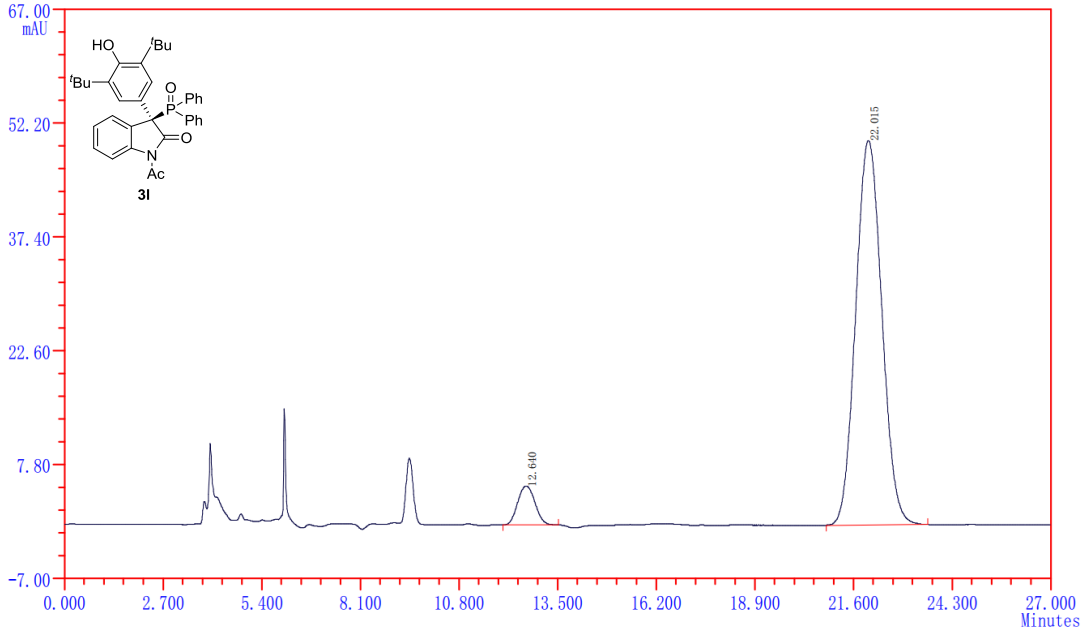
132.1492
132.1273
131.9393
131.8672
130.1674
129.3876
129.0860
129.0505
129.0337
128.2925
127.9991
127.9714
127.9022
127.8750
125.4870
125.4479
125.0200
124.9862
124.6161
124.5988
123.2925
123.2566
116.0293
116.0242
62.8356
62.4013
34.5106
30.0658
26.5998
HO
tBu
tBu
O
Ph
P
Ph
O
N
Ac
3l
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

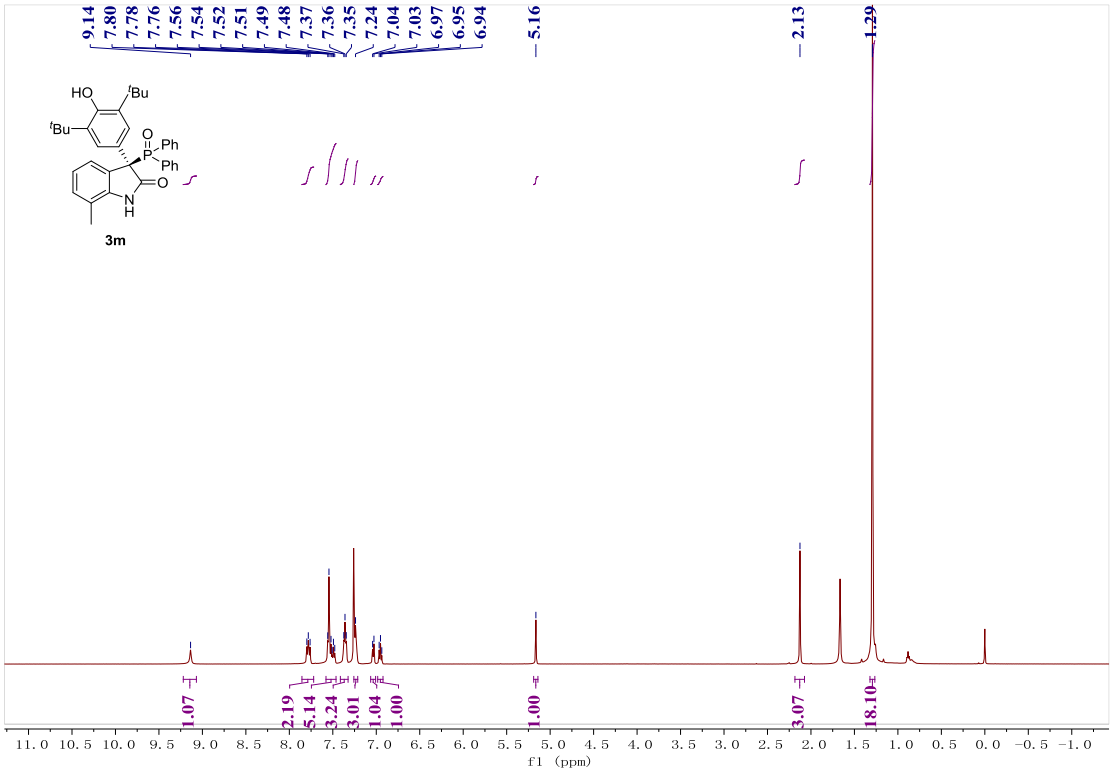

29.43
HO
tBu
tBu
O
Ph
P
Ph
O
N
Ac
3l
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.632	80.07	2940.826	50.087
2	22.048	56.48	2930.600	49.913
Total:		136.55	5871.426	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.640	5.08	167.576	6.311
2	22.015	49.98	2487.613	93.689
Total:		55.06	2655.189	100.0000


9.14
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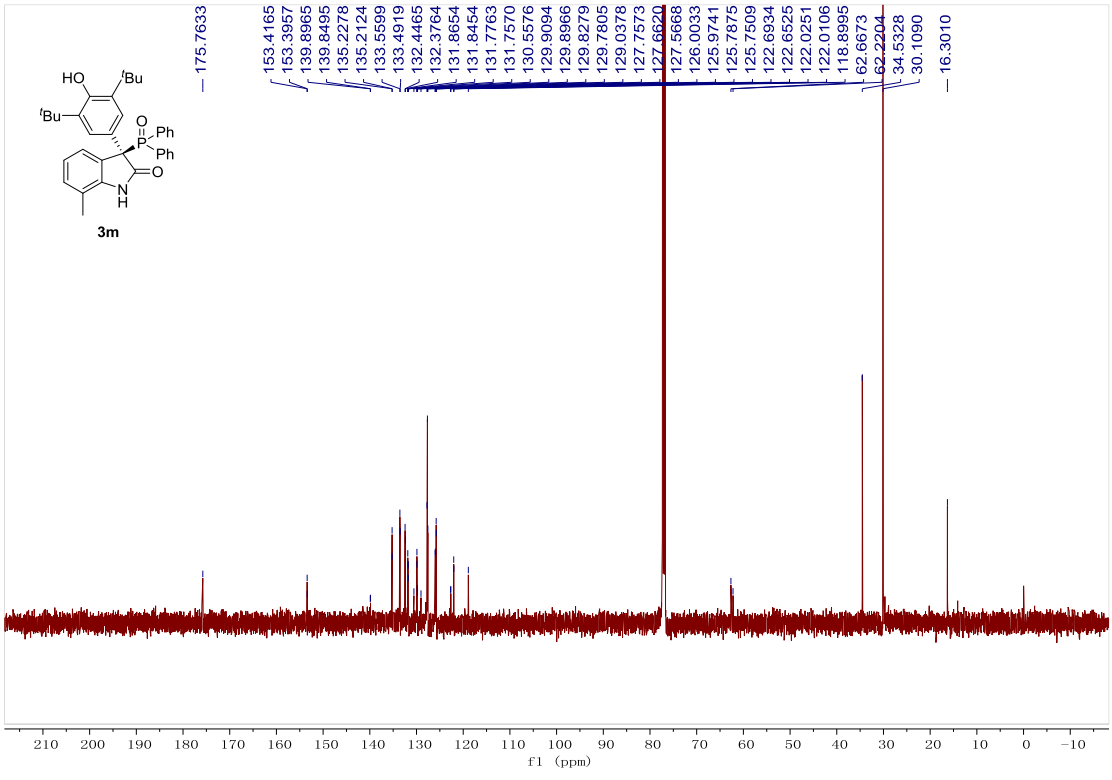
7.78
7.76
7.56
7.54
7.52
7.51
7.49
7.48
7.37
7.36
7.35
7.24
7.04
7.03
6.97
6.95
6.94
5.16
2.13
1.29
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
3m
1.07
2.19
5.14
3.24
3.01
1.04
1.00
1.00
3.07
18.10
f1 (ppm)


175.7633
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139.8495
135.2278
135.2124
133.5599
133.4919
132.4465
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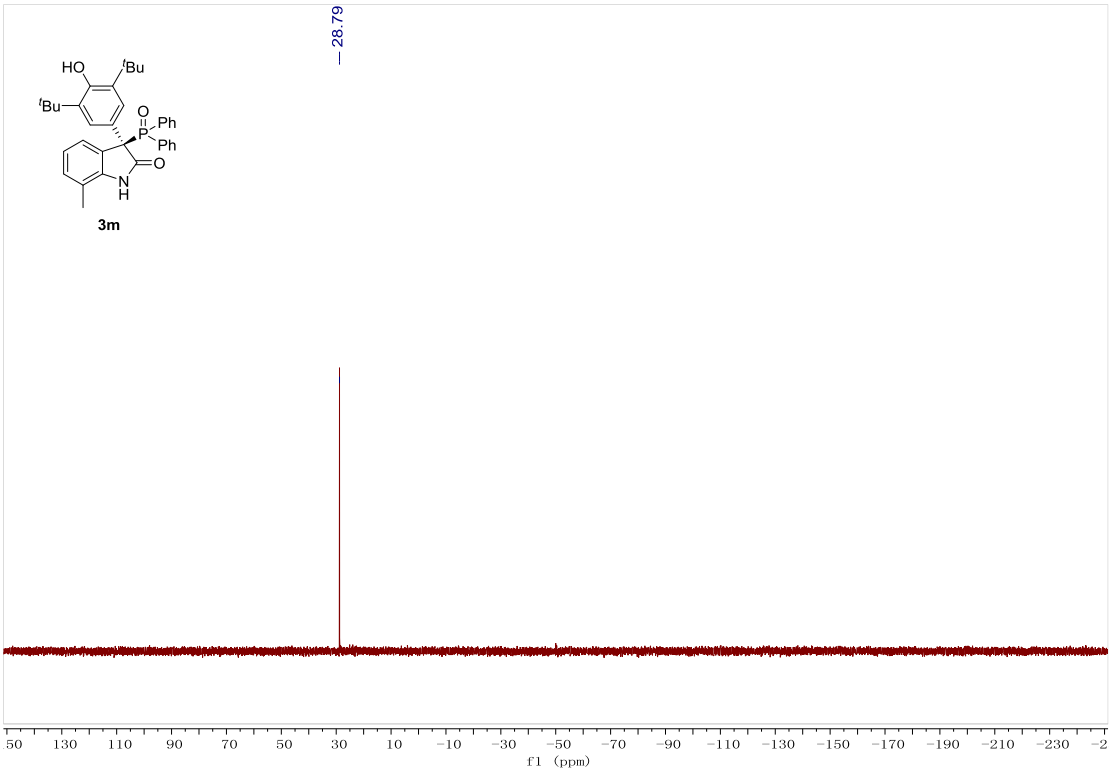
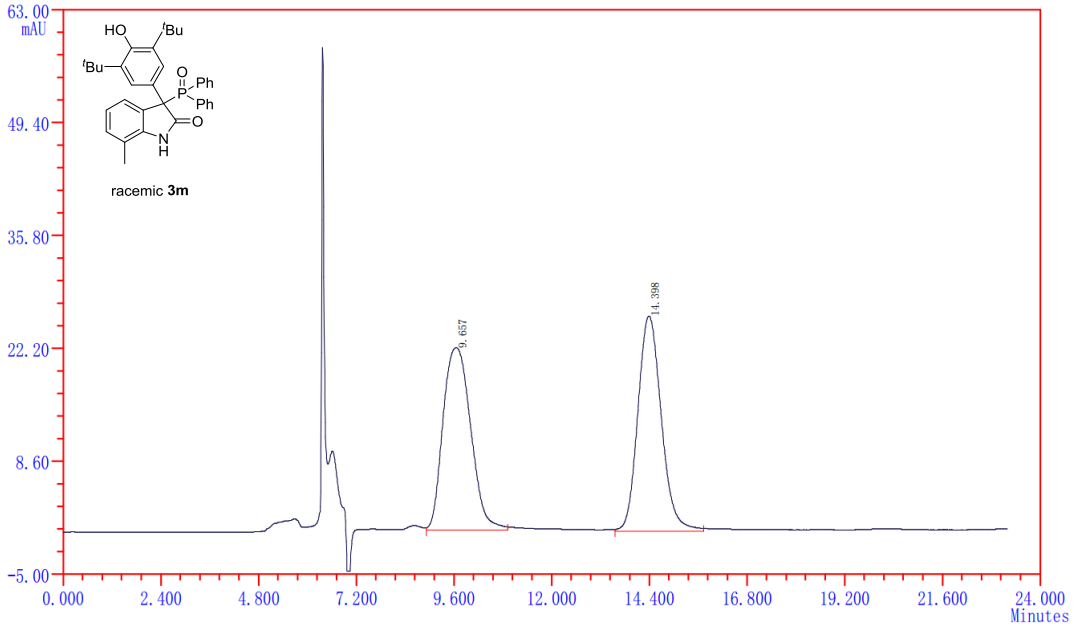
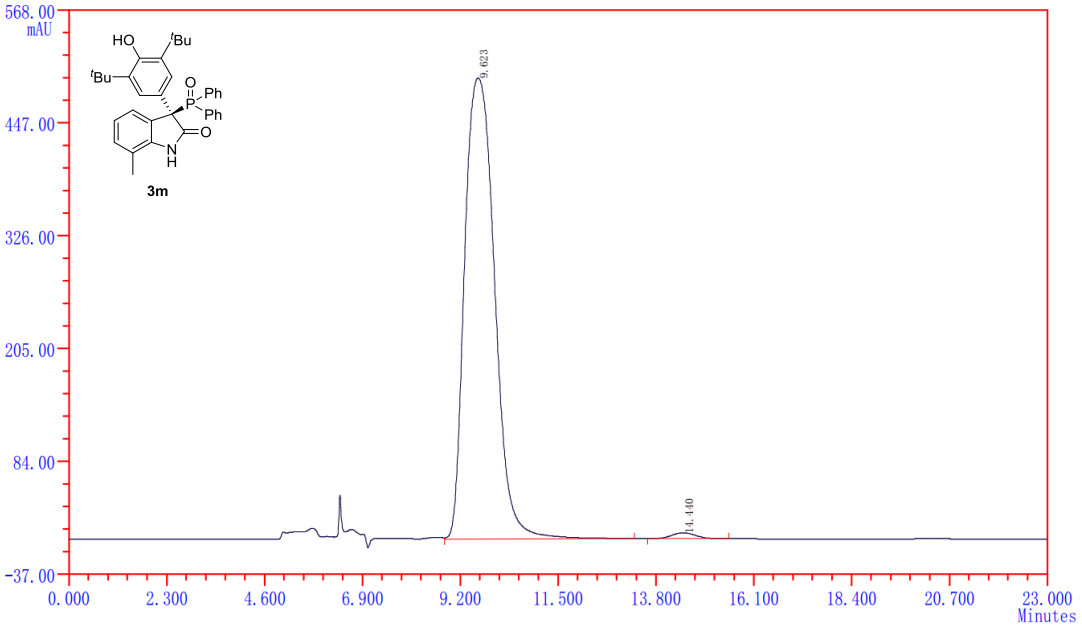
131.8654
131.8454
131.7763
131.7570
130.5576
129.9094
129.8966
129.8279
129.7805
129.0378
127.7573
127.6620
127.5668
126.0033
125.9741
125.7875
125.7509
122.6934
122.6525
122.0251
122.0106
118.8995
62.6673
62.2204
34.5328
30.1090
16.3010
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
3m
f1 (ppm)

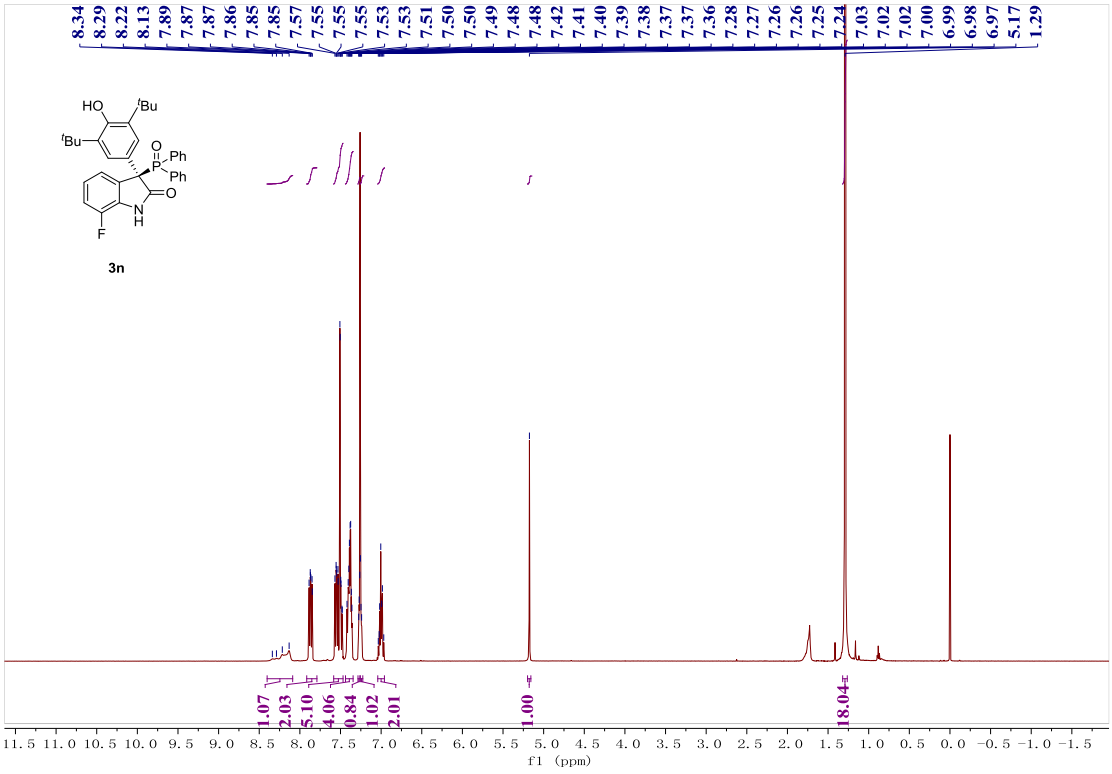


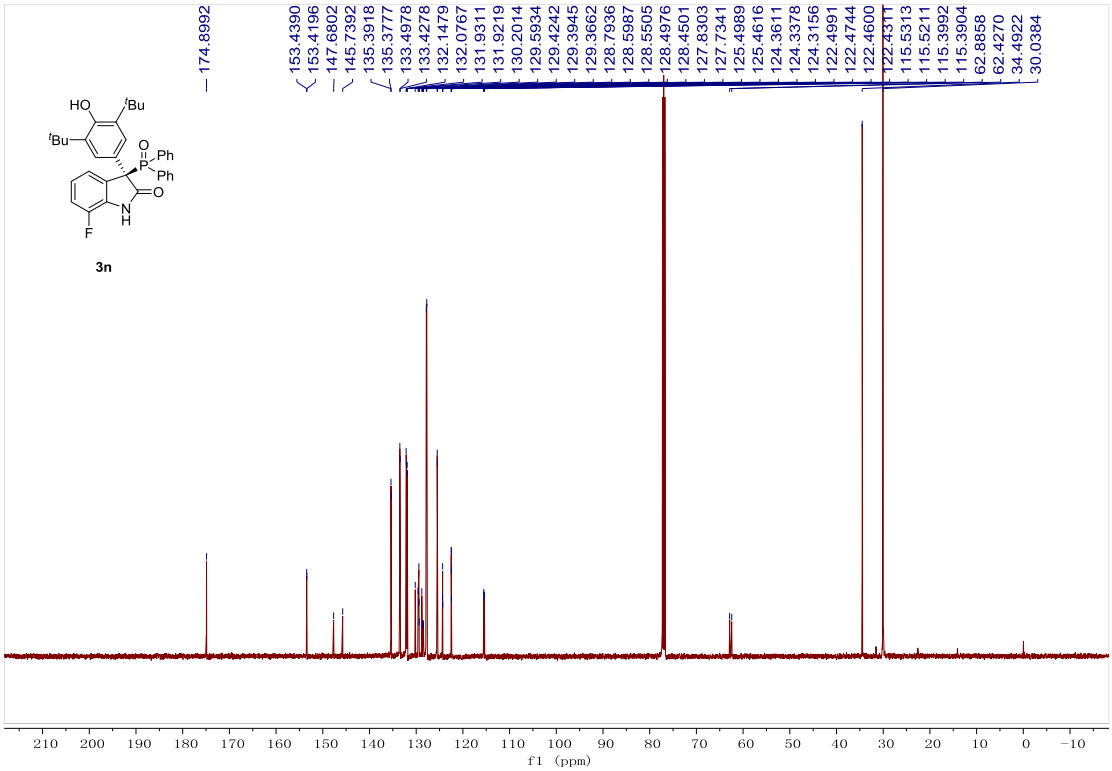


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	9.657	21.97	1041.091	49.905
2	14.398	25.95	1045.062	50.095
Total:		47.92	2086.153	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	9.623	494.25	24128.201	98.973
2	14.440	6.34	250.376	1.027
Total:		500.59	24378.576	100.0000

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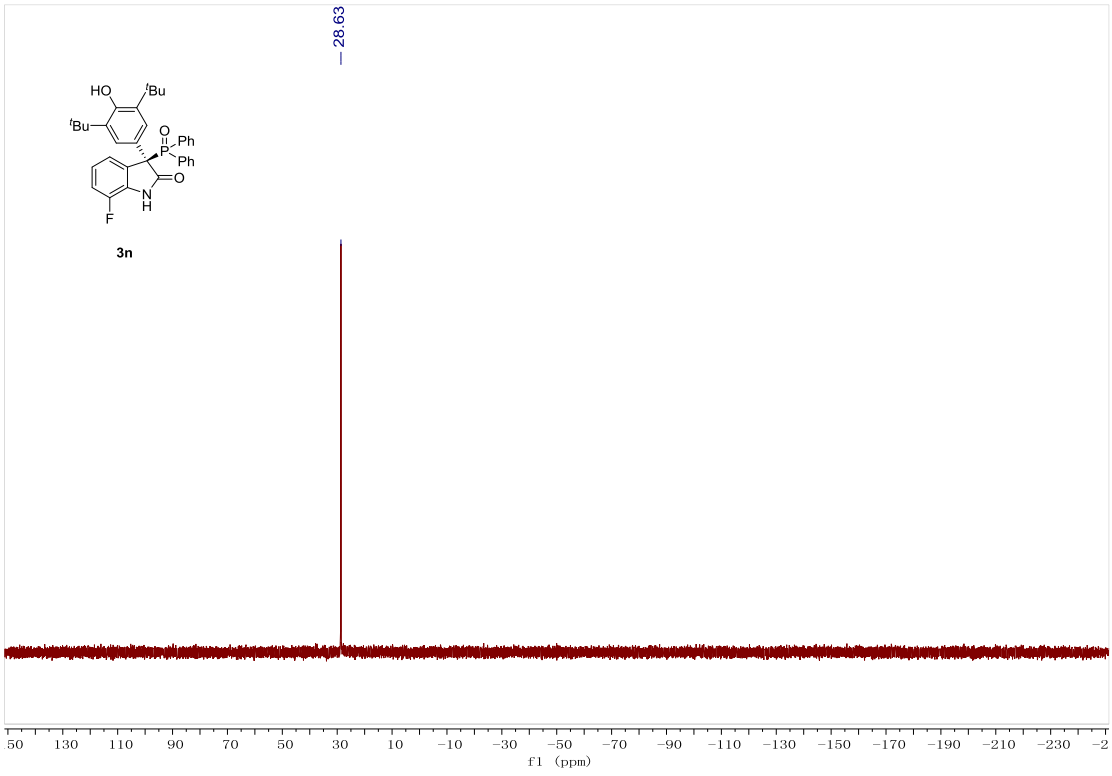
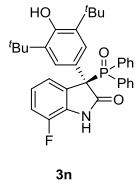
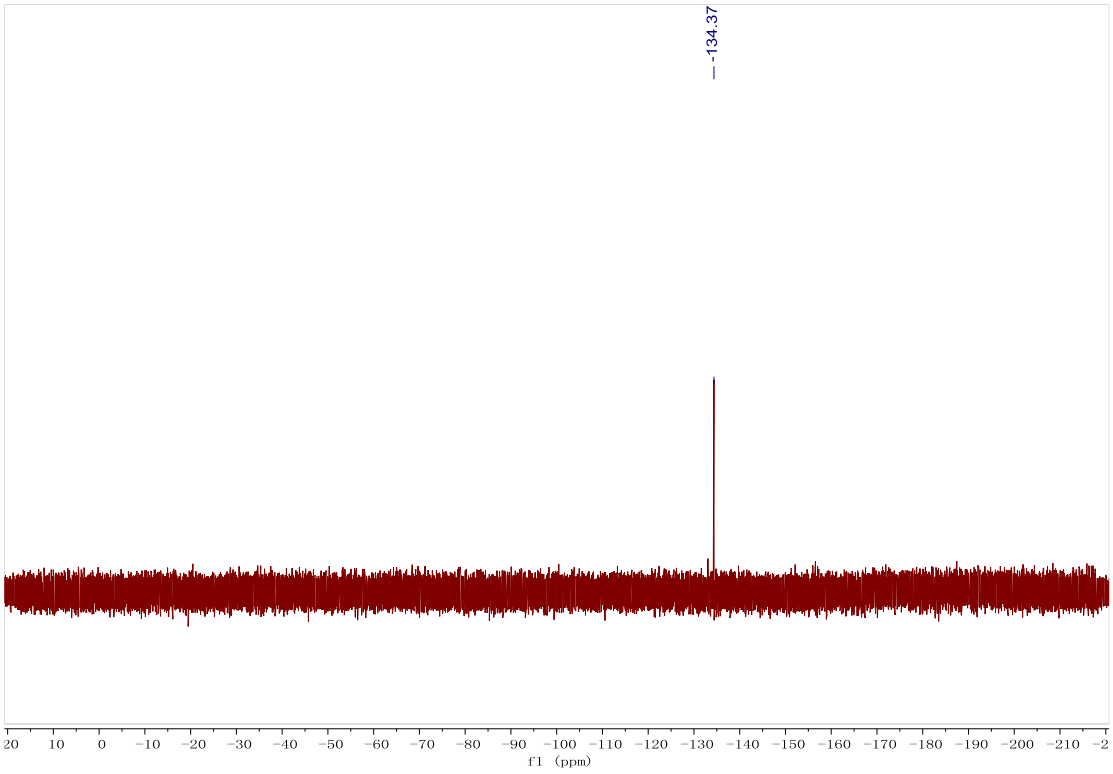
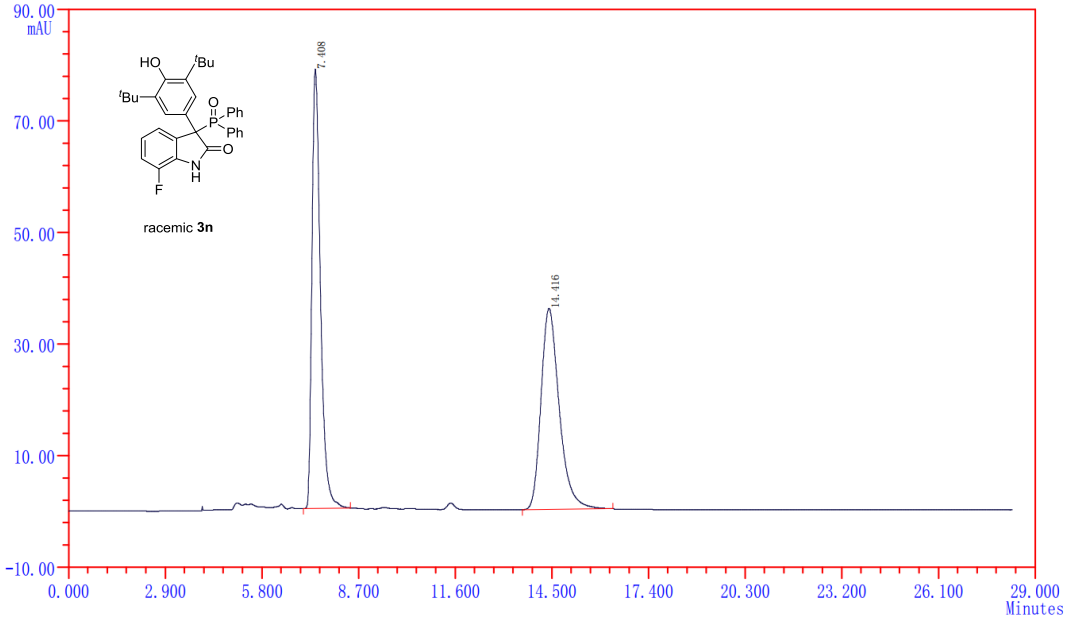
145.7392
135.3918
135.3777
133.4978
133.4278
132.1479
132.0767
131.9311
131.9219
130.2014
129.5934
129.4242
129.3945
129.3662
128.7936
128.5987
128.5505
128.4976
128.4501
127.8303
127.7341
125.4989
125.4616
124.3611
124.3378
124.3156
122.4991
122.4744
122.4600
122.4311
115.5313
115.5211
115.3992
115.3904
62.8858
62.4270
34.4922
30.0384
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
F
3n
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)

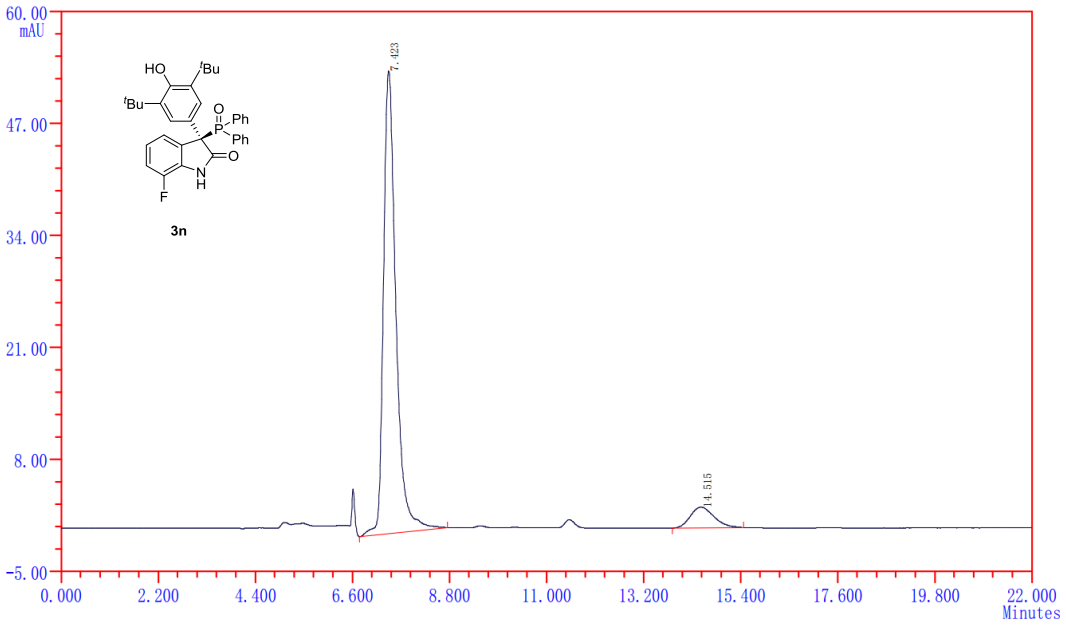

28.63
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
F
3n
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)


HO
tBu
tBu
O
P
Ph
Ph
O
N
H
F
3n

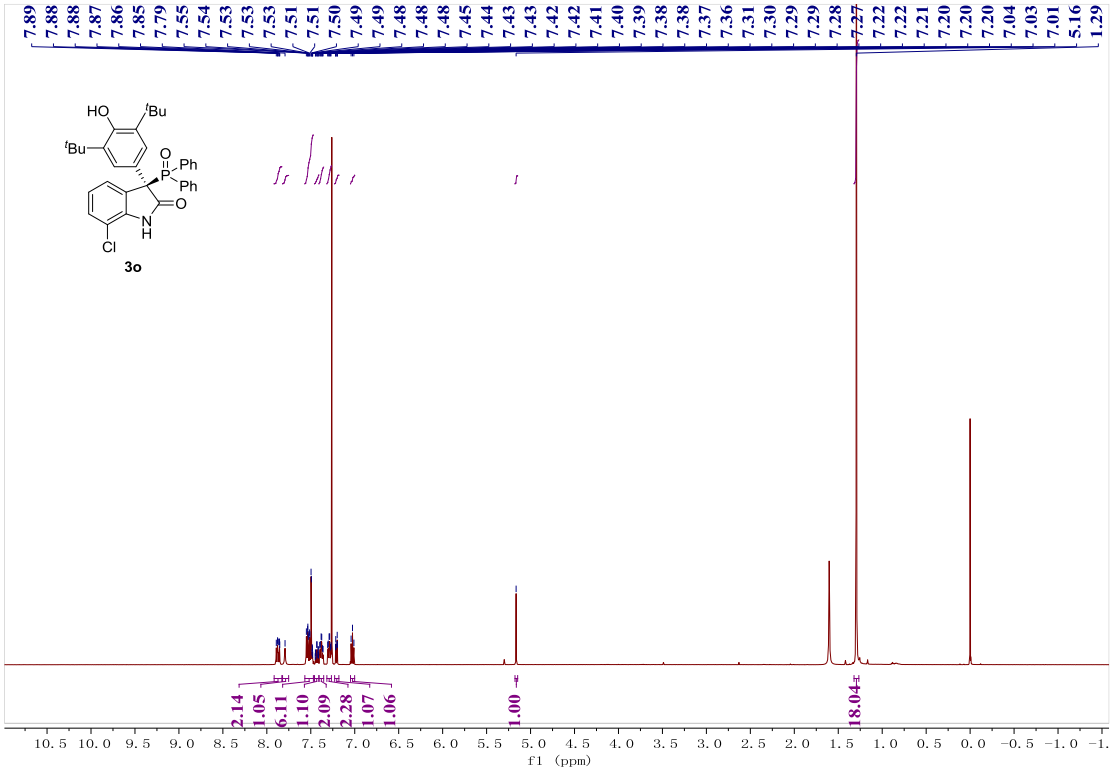


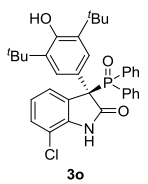


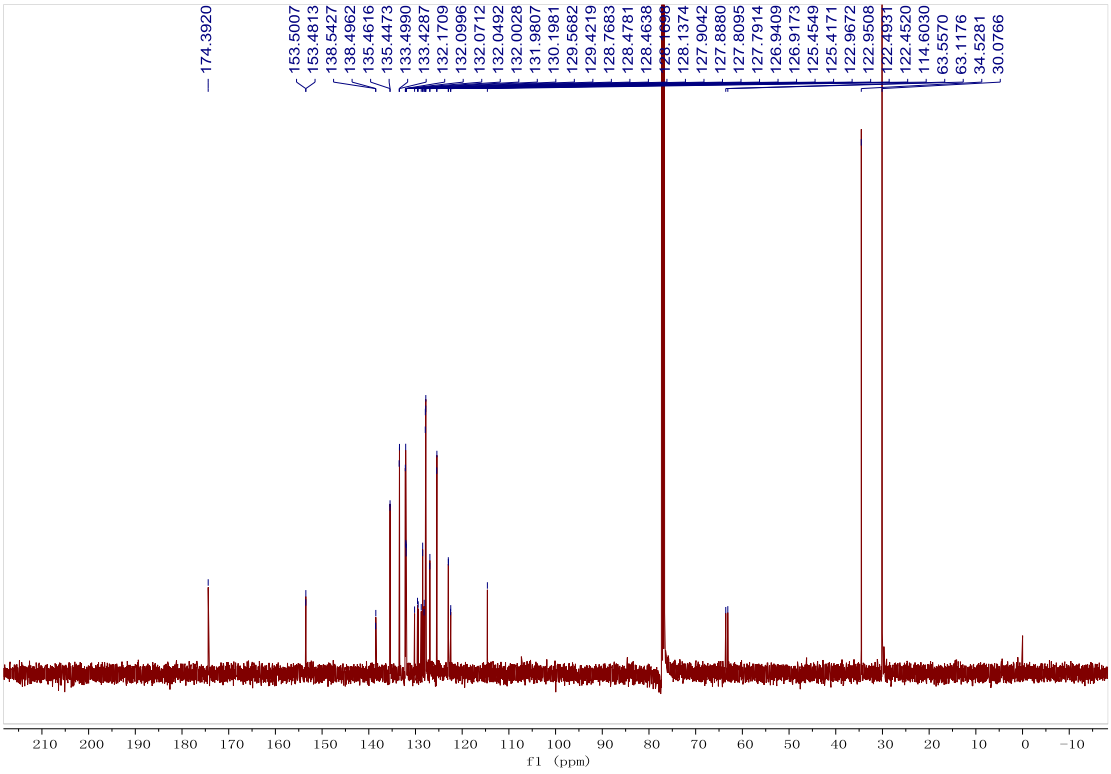
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.408	78.75	1393.744	50.152
2	14.416	36.04	1385.299	49.848
Total:		114.79	2779.043	100.0000

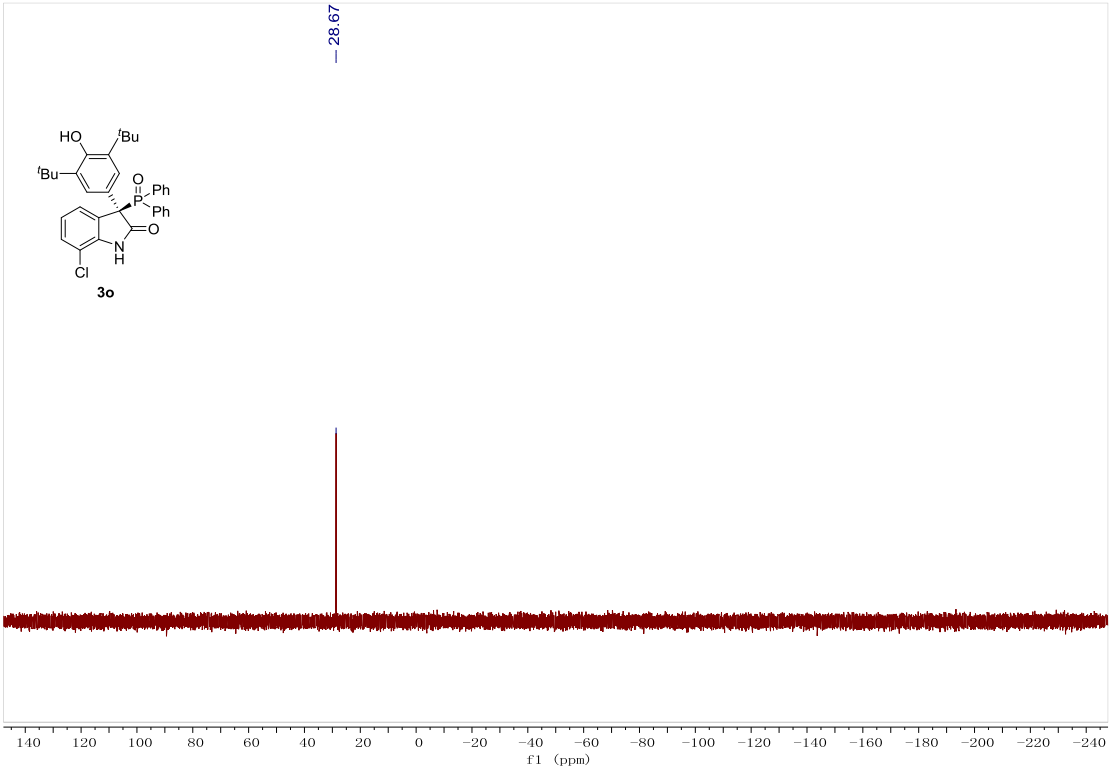


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	7.423	53.77	1053.744	92.140
2	14.515	2.41	89.885	7.860
Total:		56.18	1143.629	100.0000

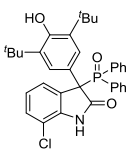




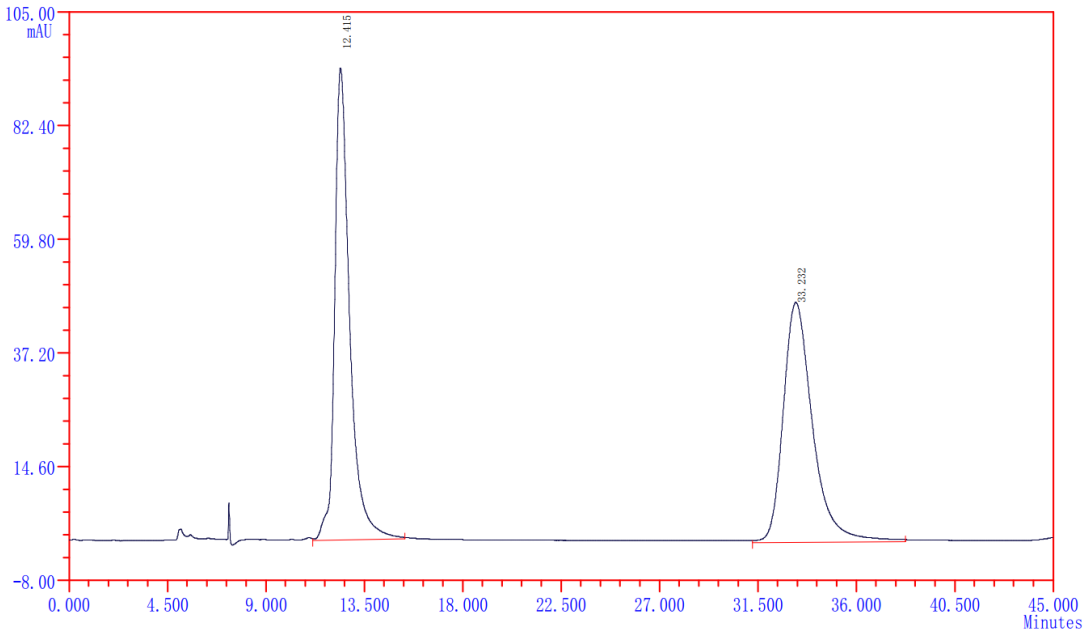




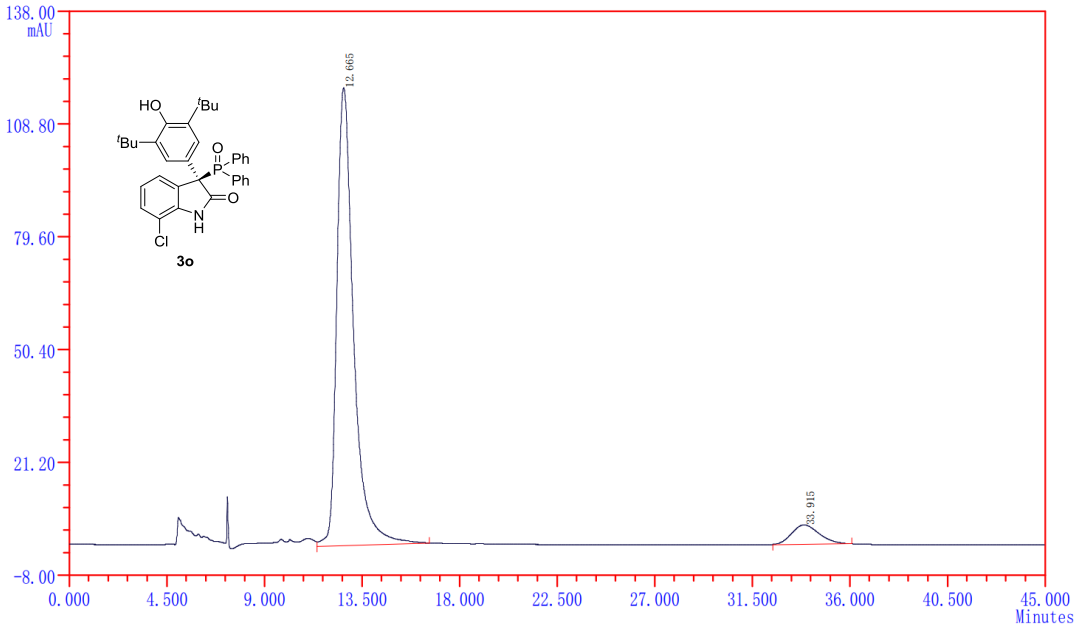
3o



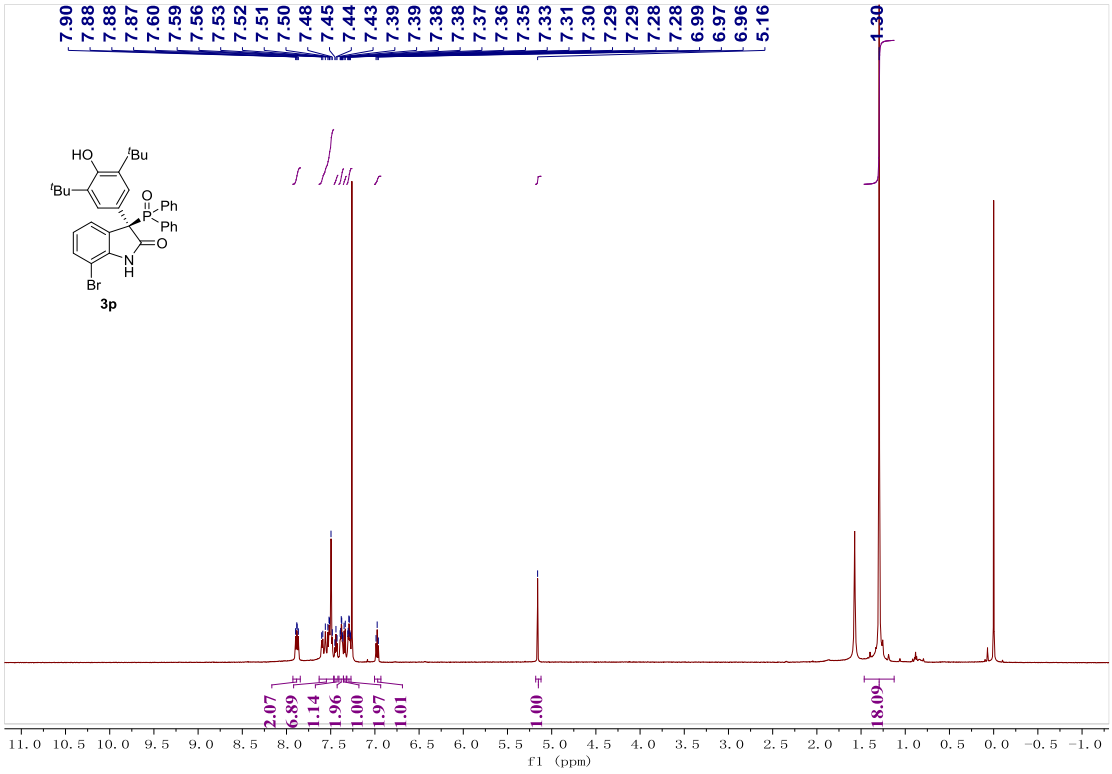
racemic **3o**



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.415	93.81	4482.293	49.966
2	33.232	47.72	4488.328	50.034
Total:		141.53	8970.621	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.665	118.52	6386.209	93.560
2	33.915	4.98	439.591	6.440
Total:		123.50	6825.800	100.0000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7.88
7.87
7.60
7.59
7.56
7.53
7.52
7.51
7.50
7.48
7.45
7.44
7.43
7.39
7.39
7.38
7.38
7.37
7.36
7.35
7.33
7.31
7.30
7.29
7.29
7.28
7.28
6.99
6.97
6.96
5.16
1.30
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
Br
3p
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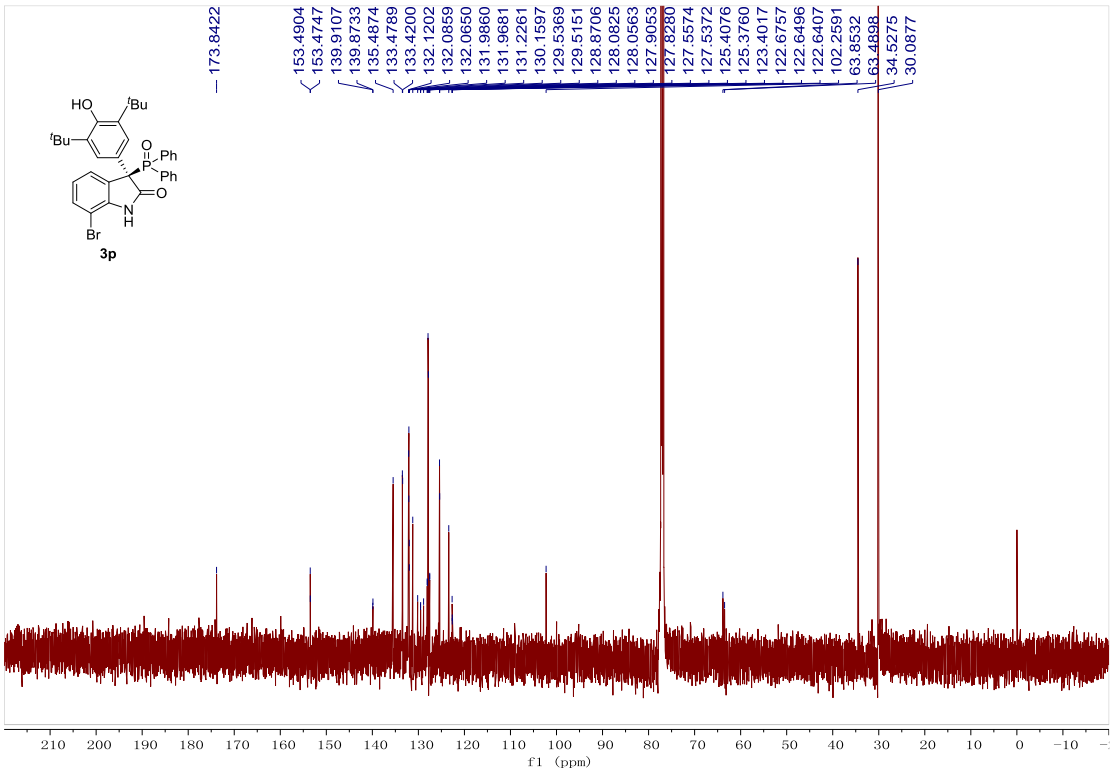
6.89
1.14
1.96
1.00
1.97
1.01
1.00
18.09
f1 (ppm)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139.8733
135.4874
133.4789
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102.2591
63.8532
63.4898
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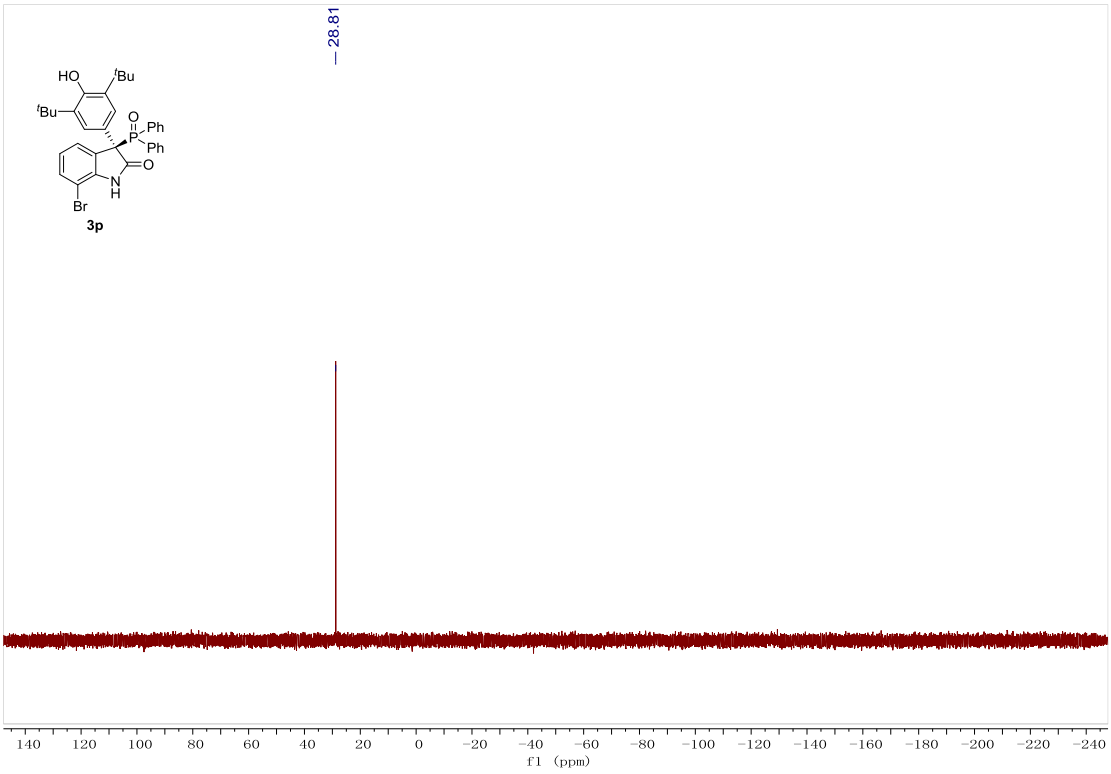
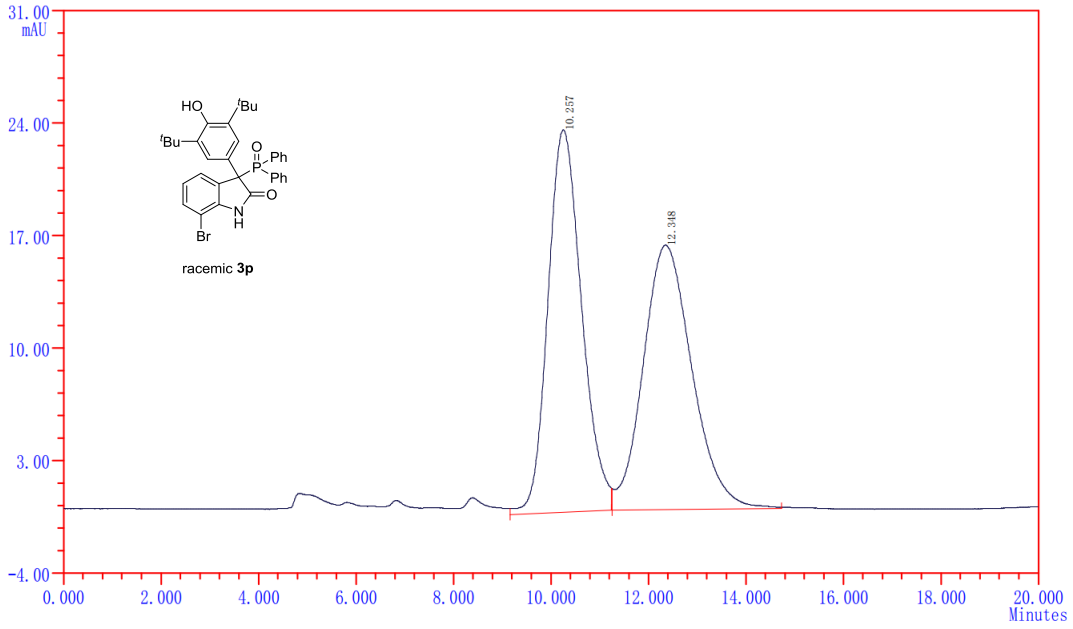
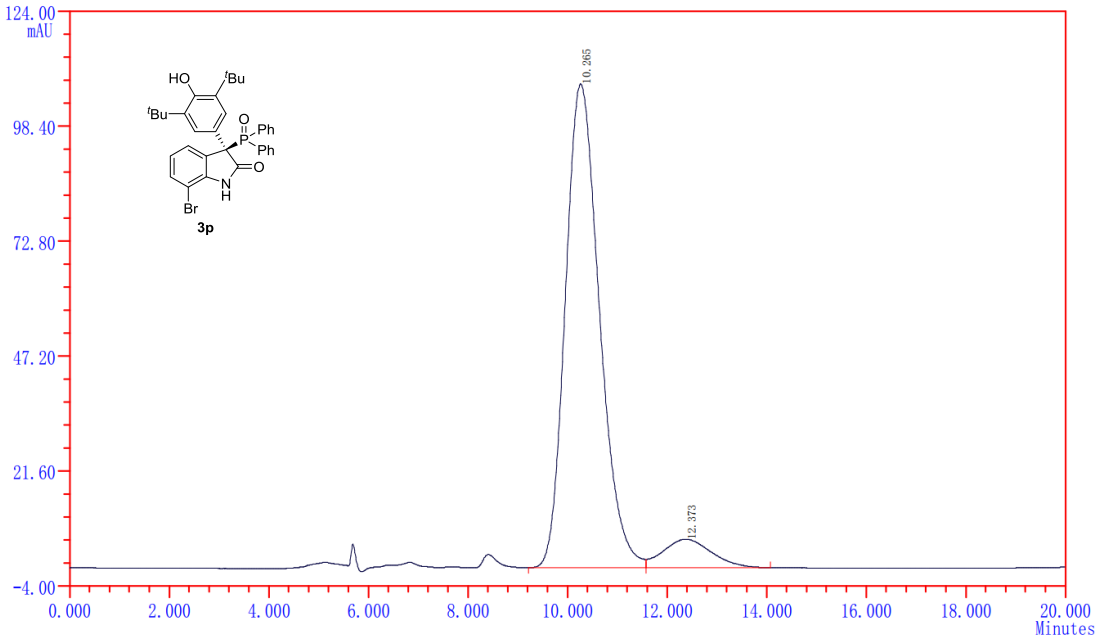
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
Br
3p
f1 (ppm)

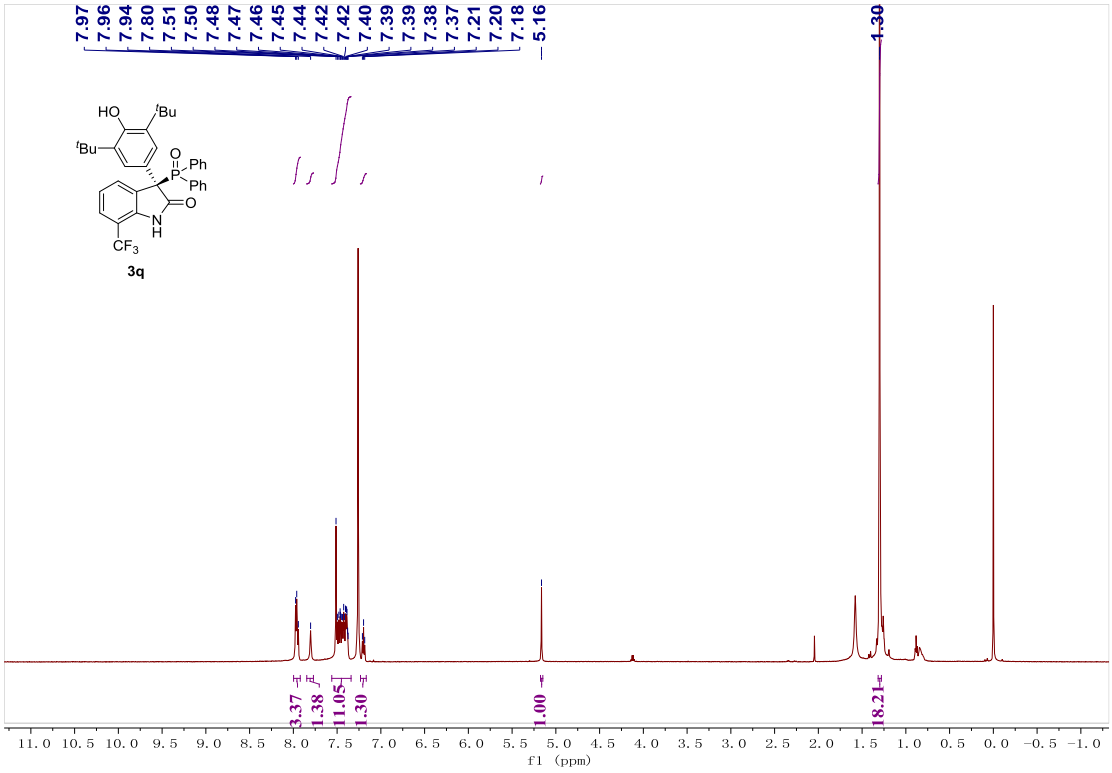


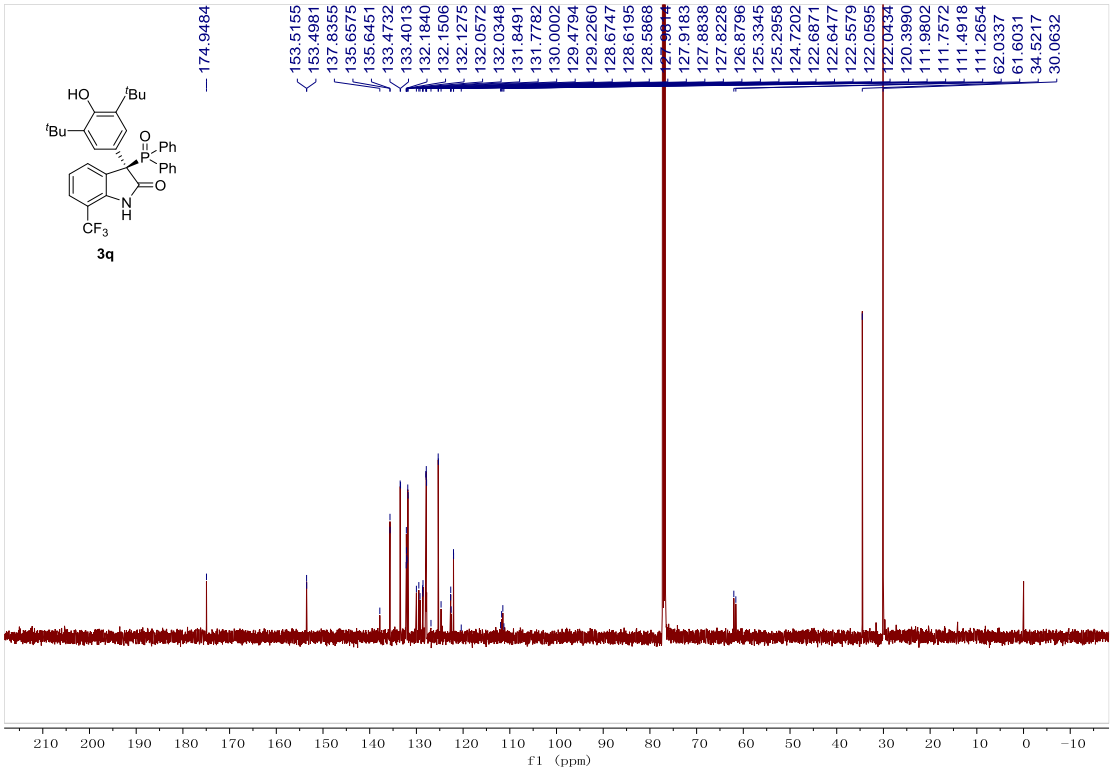


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	10.257	23.79	1145.604	49.959
2	12.348	16.44	1147.474	50.041
Total:		40.23	2293.079	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	10.265	107.75	5119.707	92.261
2	12.373	6.34	429.453	7.739
Total:		114.09	5549.160	100.0000

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153.4981
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135.6451
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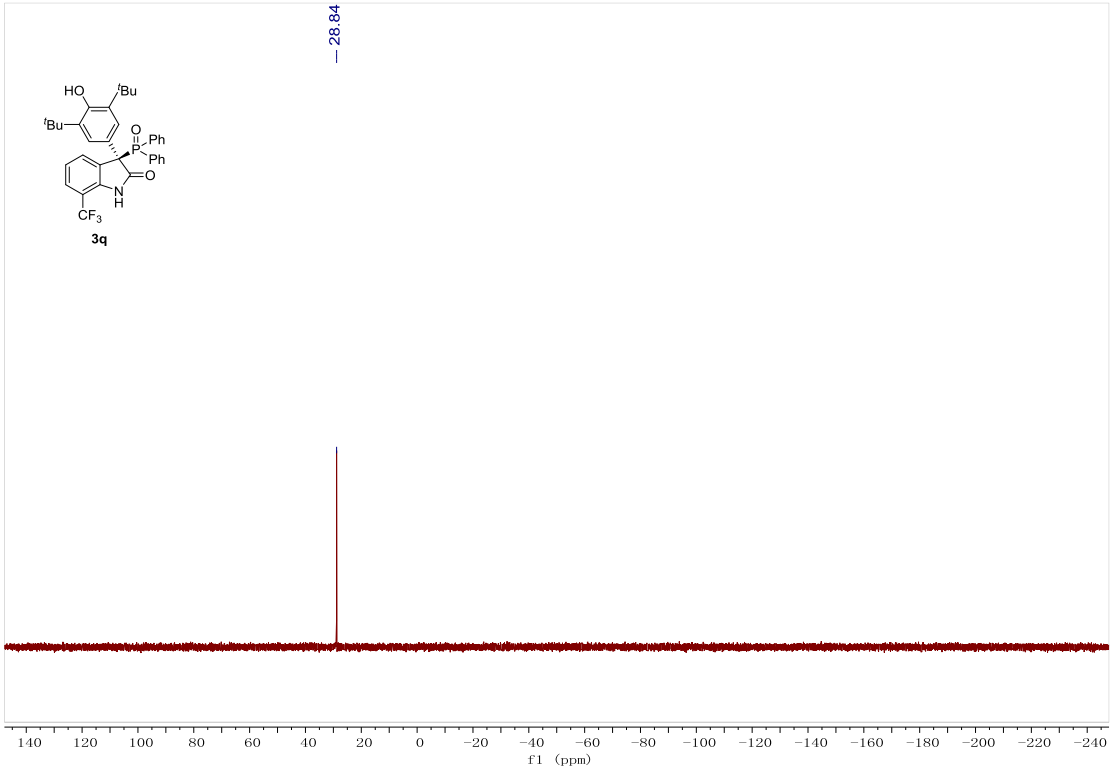
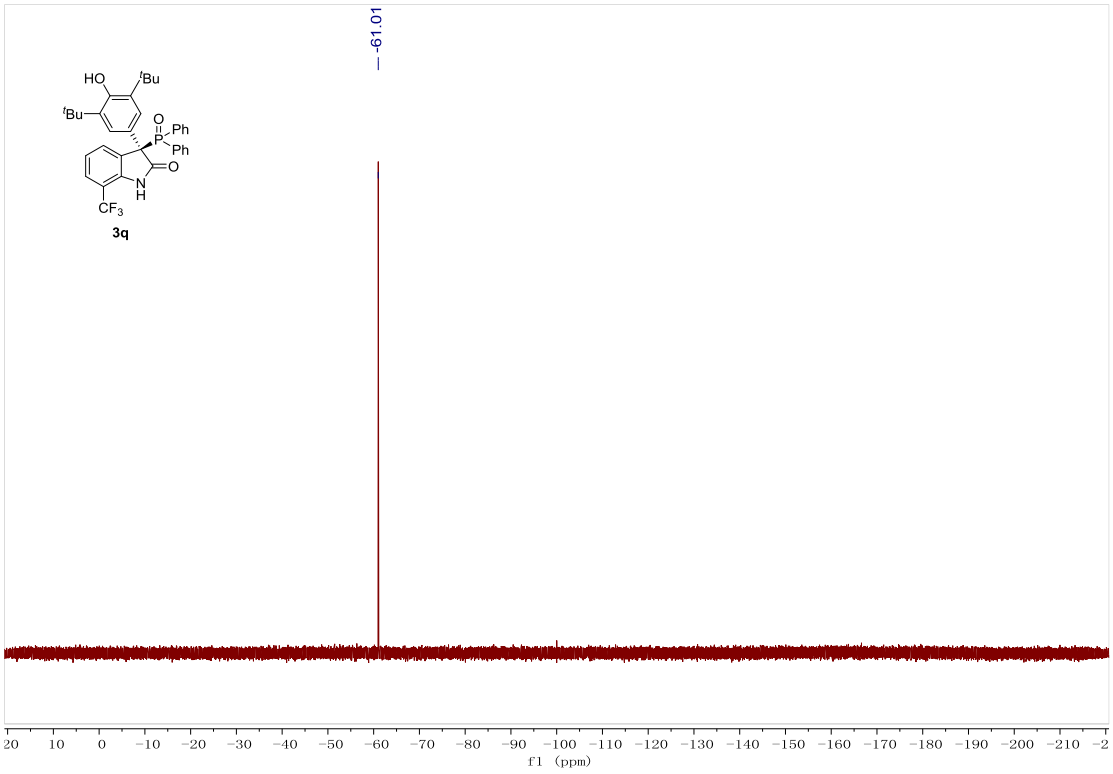
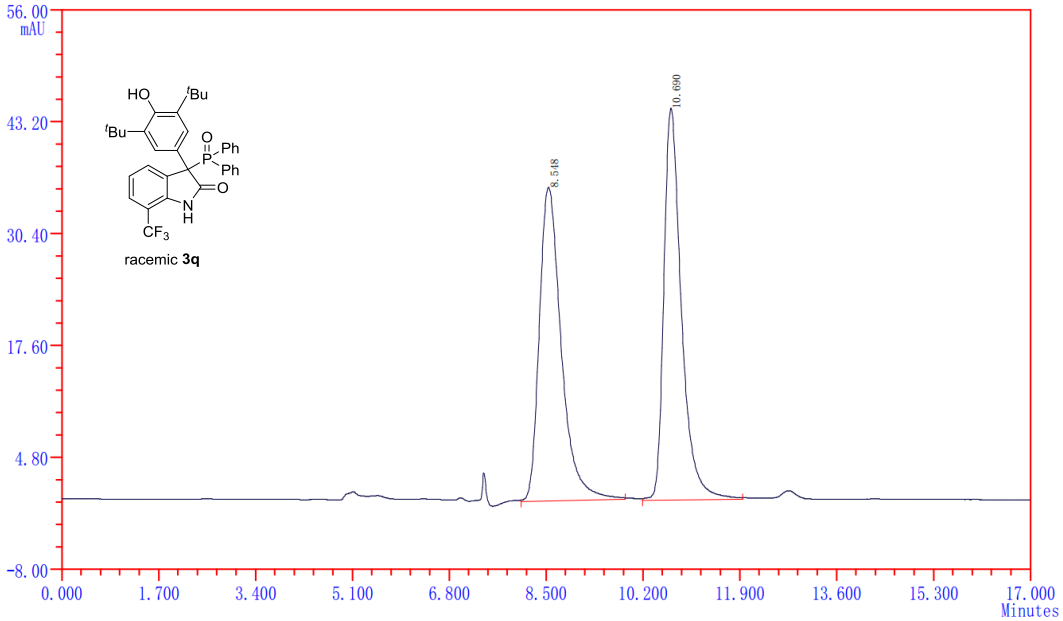
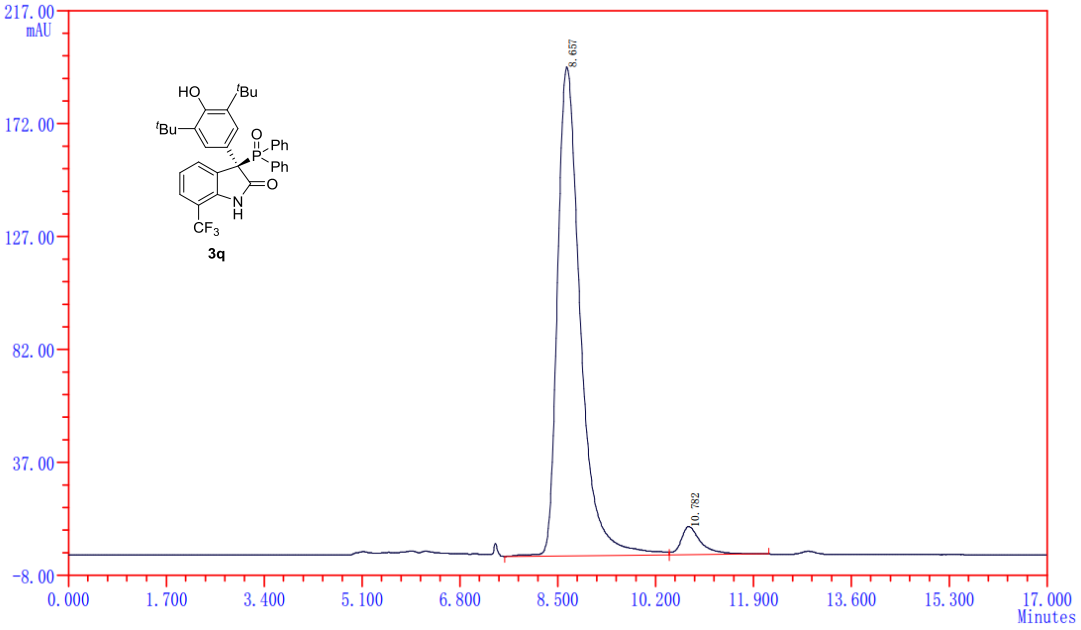
133.4013
132.1840
132.1506
132.1275
132.0572
132.0348
131.8491
131.7782
130.0002
129.4794
129.2260
128.6747
128.6195
128.5868
127.9183
127.8838
127.8228
126.8796
125.3345
125.2958
124.7202
122.6871
122.6477
122.5579
122.0595
122.0434
120.3990
111.9802
111.7572
111.4918
111.2654
62.0337
61.6031
34.5217
30.0632
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
CF3
3q
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)


28.84
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
CF3
3q
140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −220 −240
f1 (ppm)

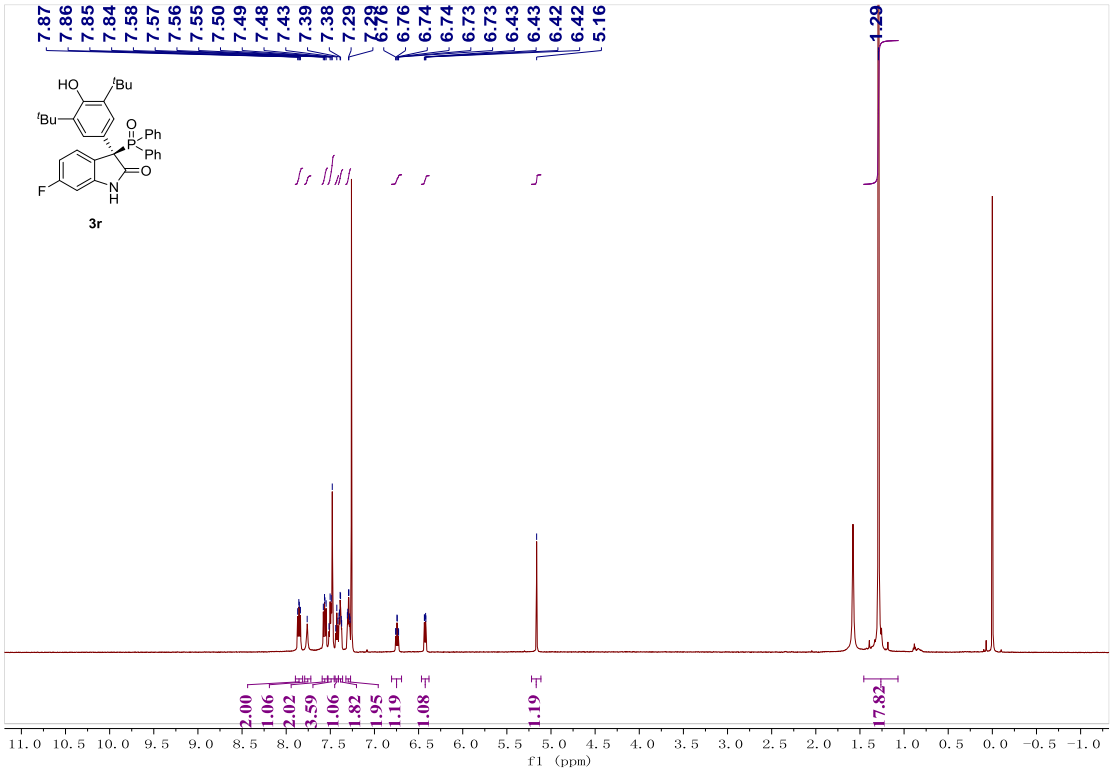


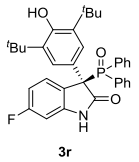


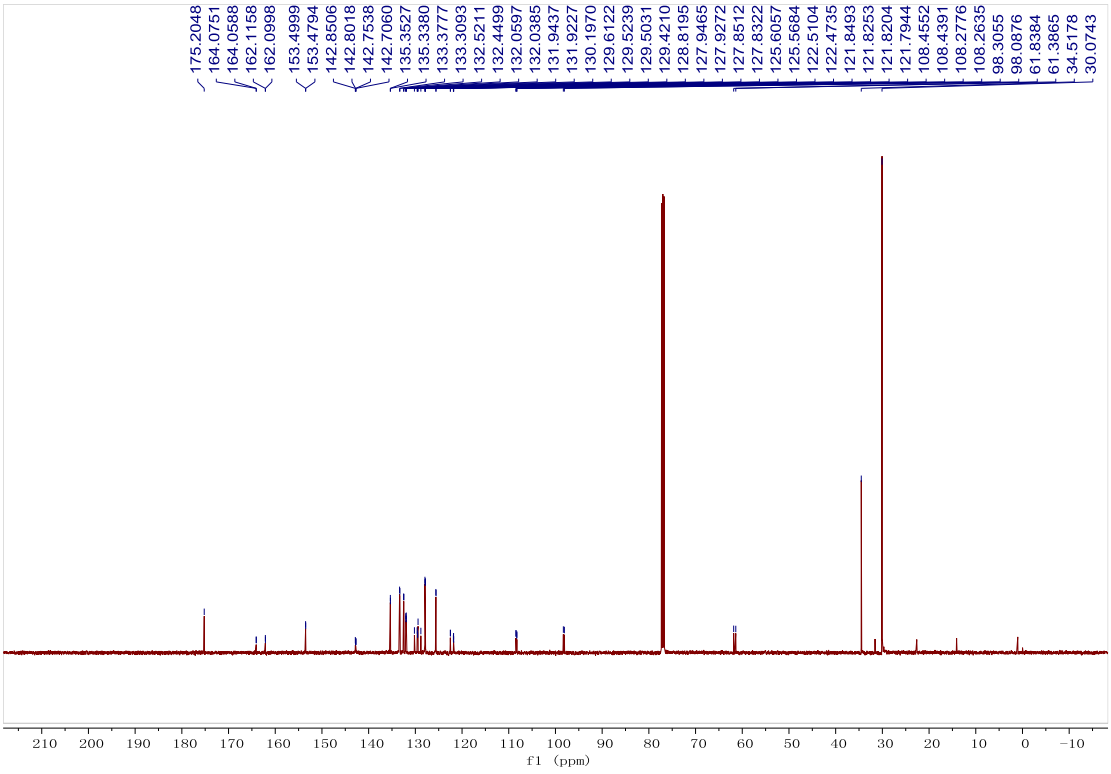
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	8.548	35.87	962.215	49.951
2	10.690	44.85	964.113	50.049
Total:		80.72	1926.328	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	8.657	194.80	5396.798	95.115
2	10.782	11.28	277.202	4.885
Total:		206.08	5674.000	100.0000



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132.4499
132.0597
132.0385
131.9437
131.9227
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129.5239
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121.8253
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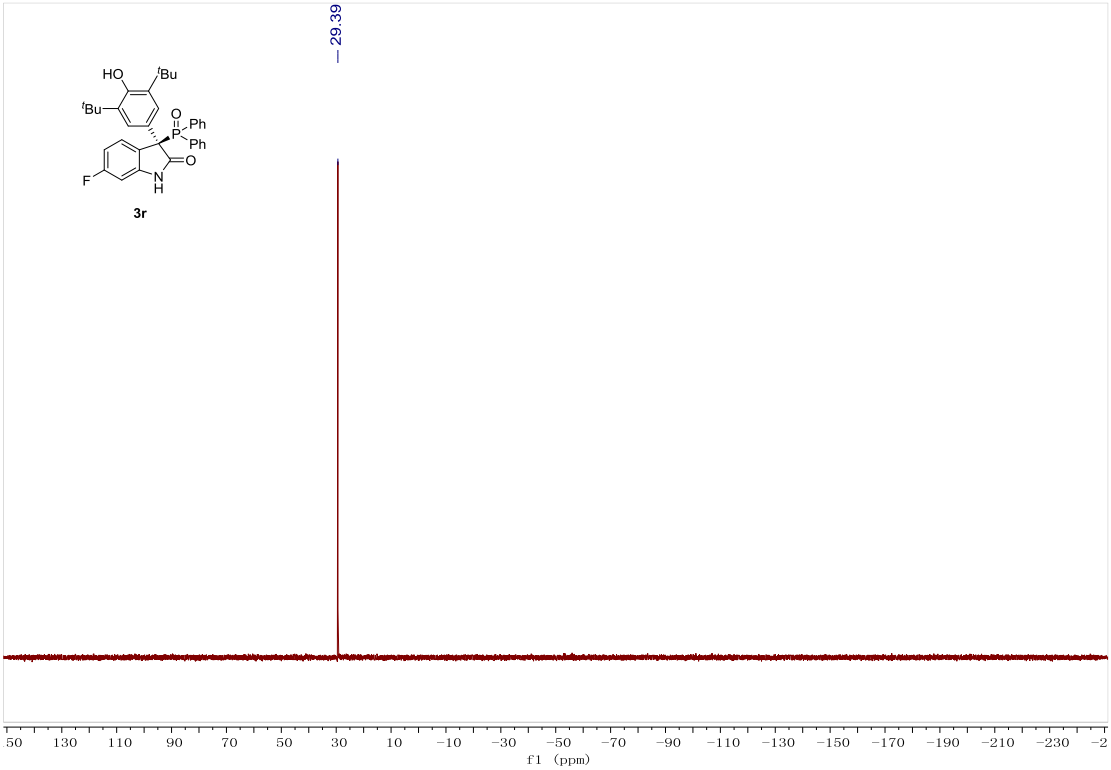
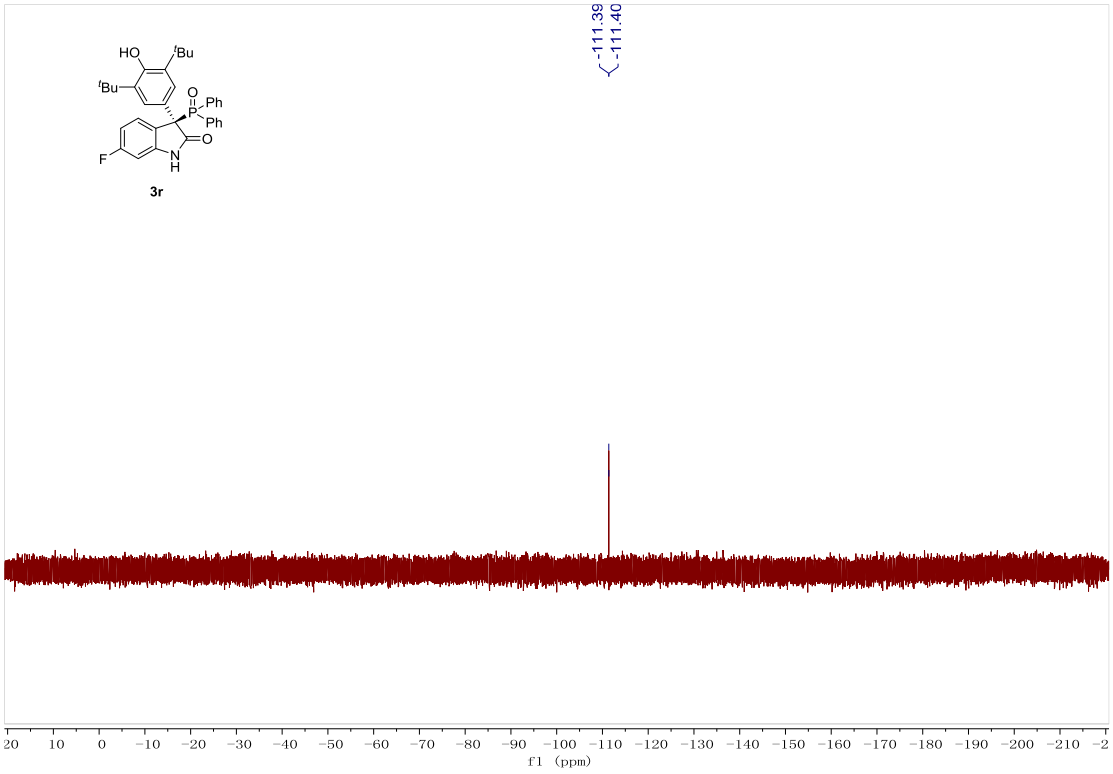
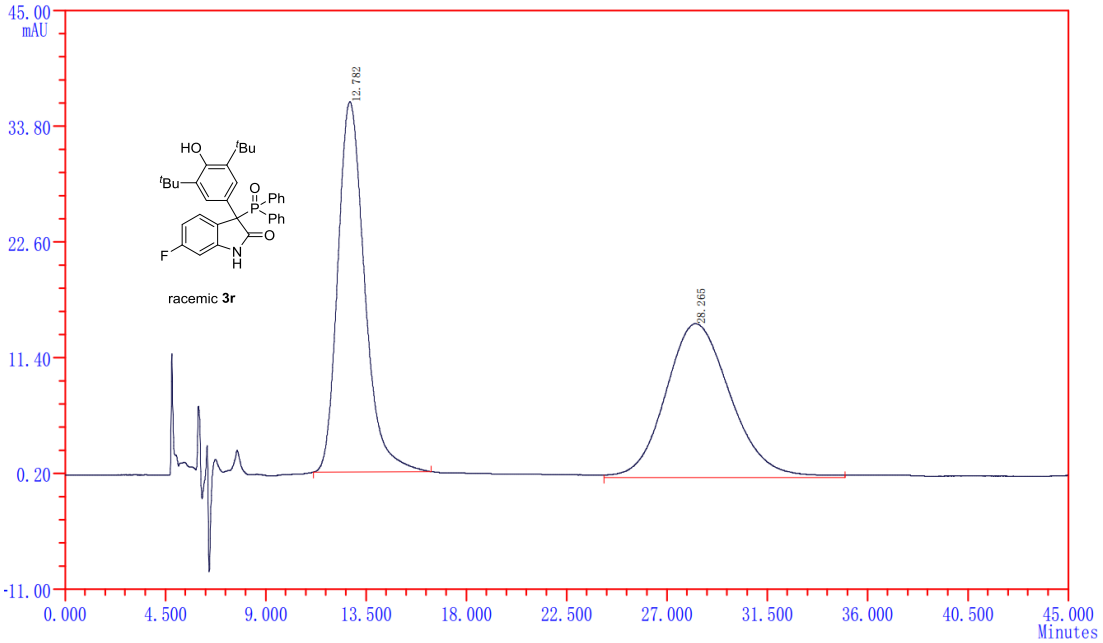
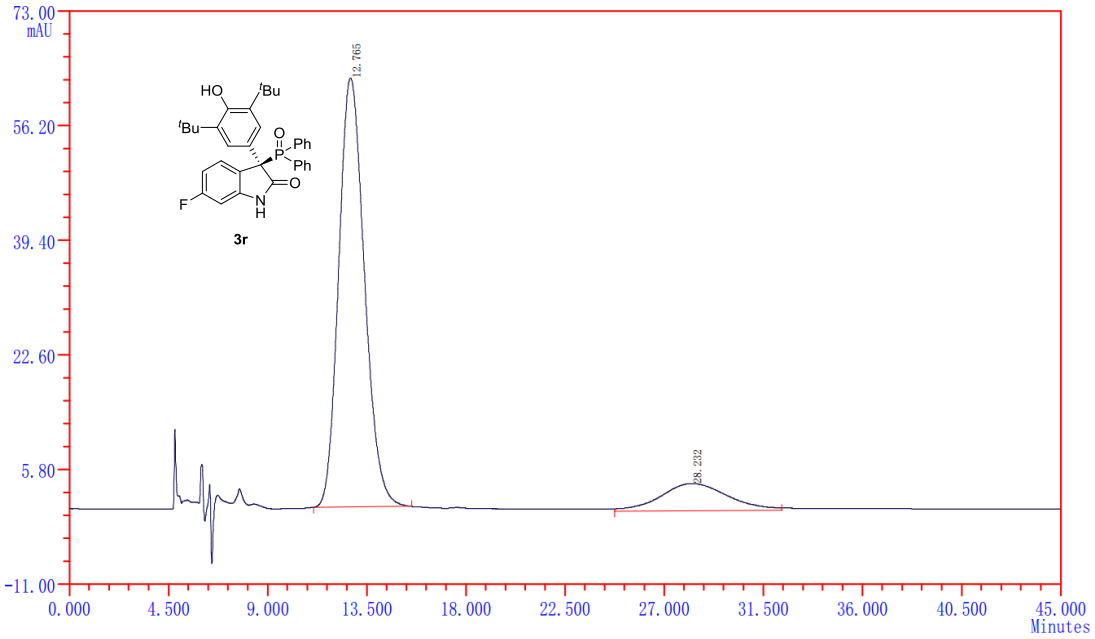
121.7944
108.4552
108.4391
108.2776
108.2635
98.3055
98.0876
61.8384
61.3865
34.5178
30.0743
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


29.39
HO
tBu
tBu
O
P
Ph
Ph
O
F
N
H
3r
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)

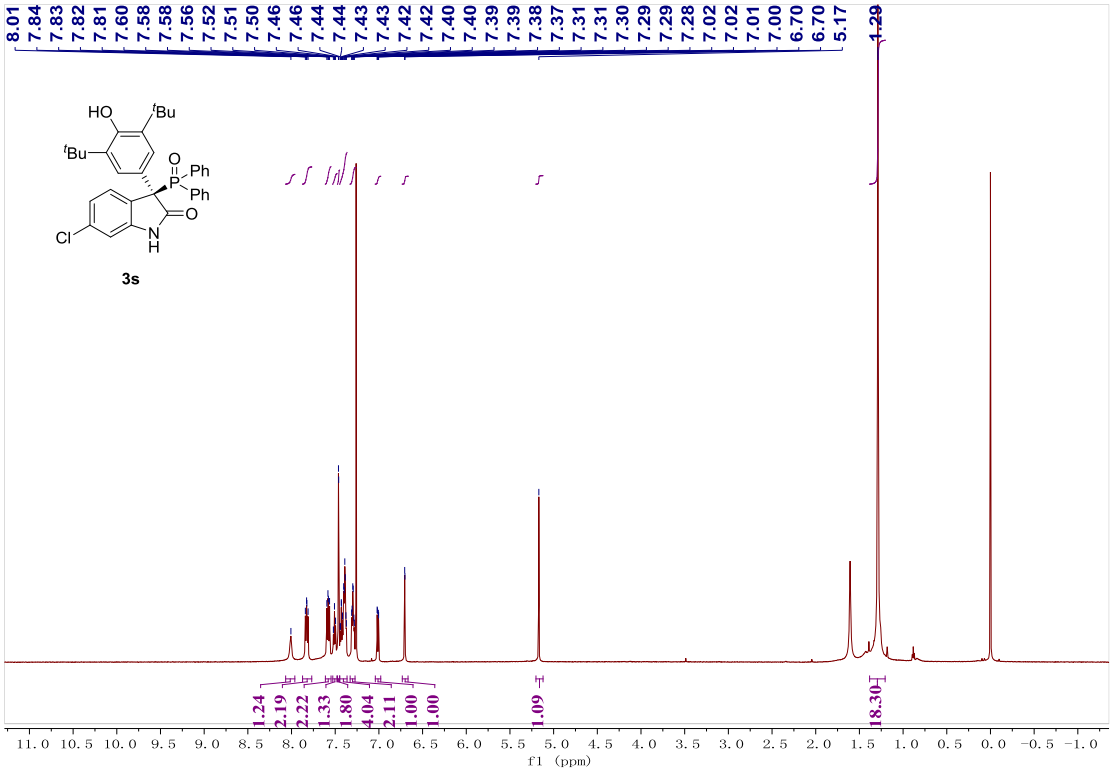


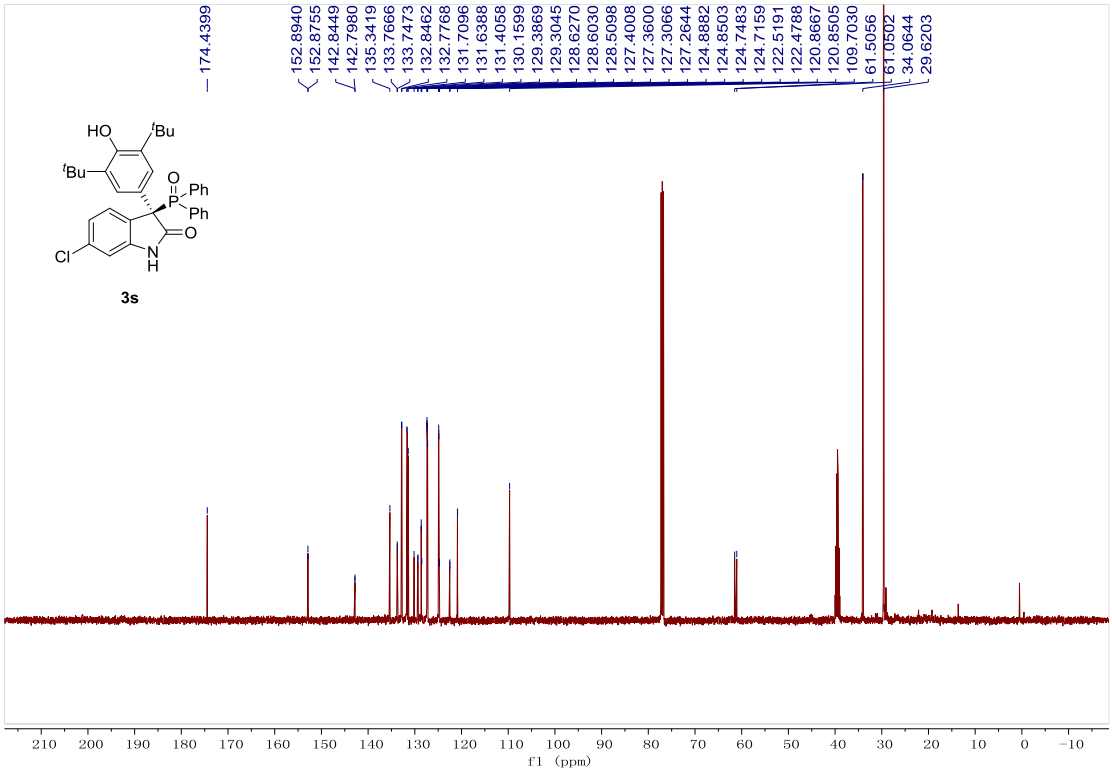


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.782	35.82	2998.913	49.903
2	28.265	14.86	3010.517	50.097
Total:		50.68	6009.429	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	12.765	62.90	5106.763	85.519
2	28.232	4.01	864.753	14.481
Total:		66.91	5971.517	100.0000

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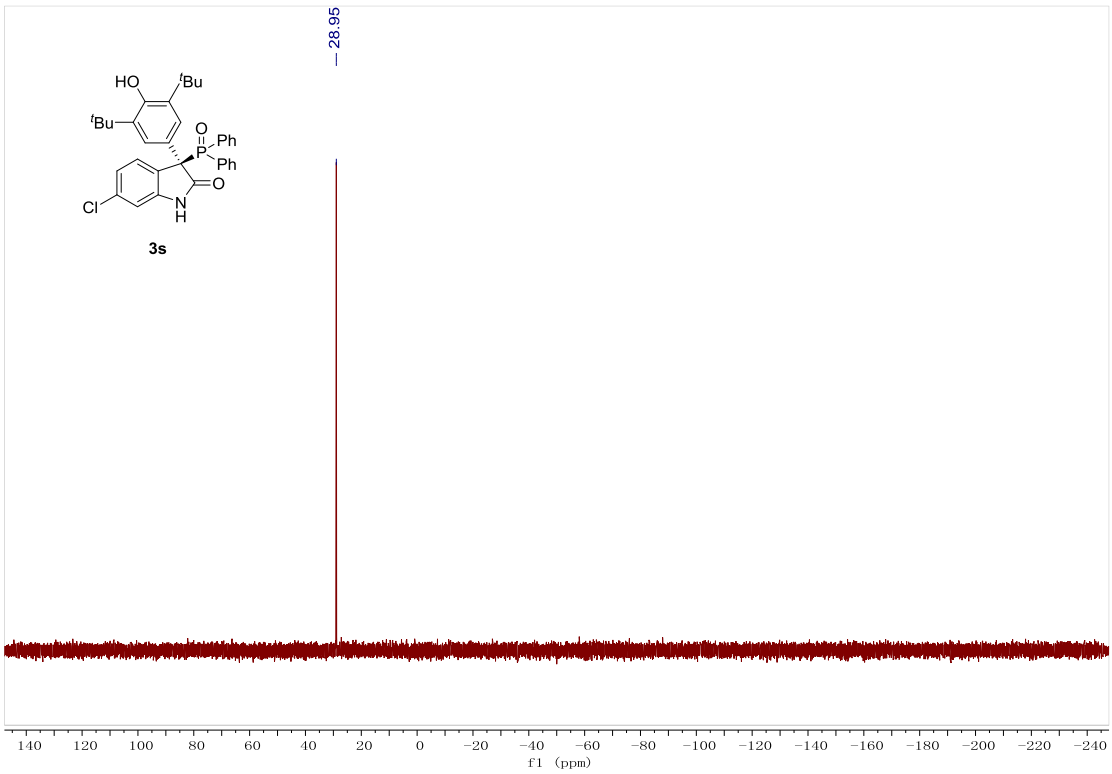
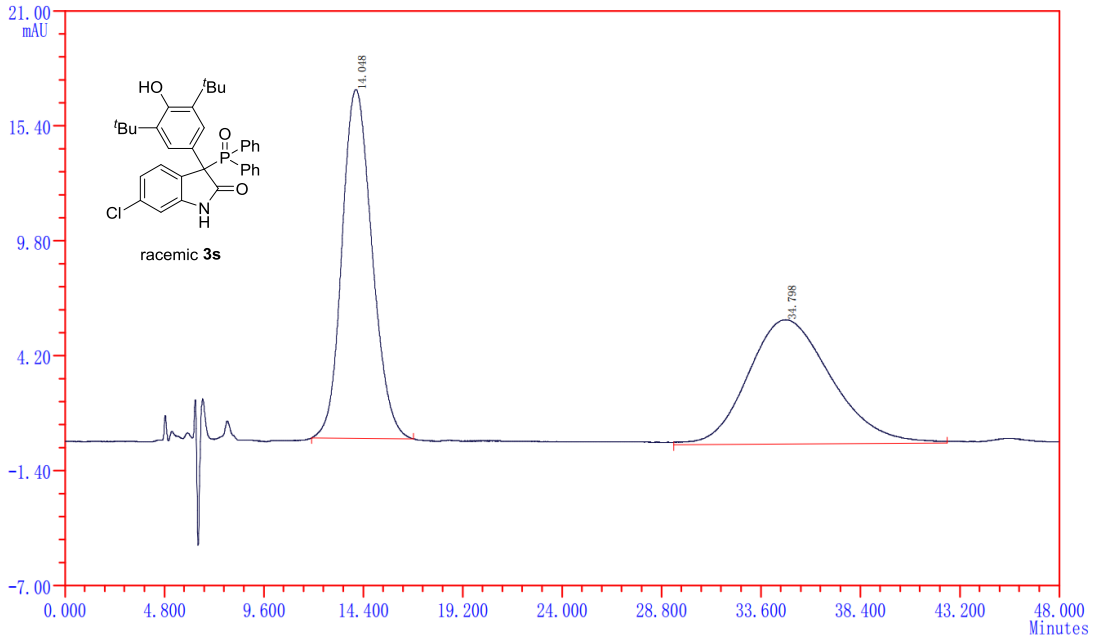
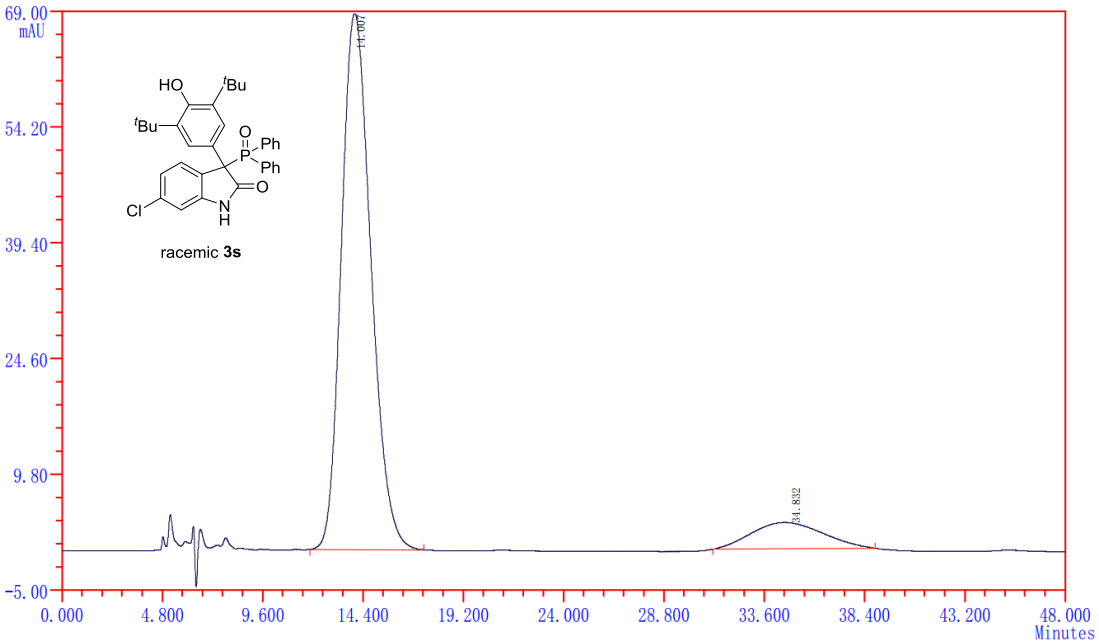
122.4788
120.8667
120.8505
109.7030
61.5056
61.0502
34.0644
29.6203
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
Cl
3s
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

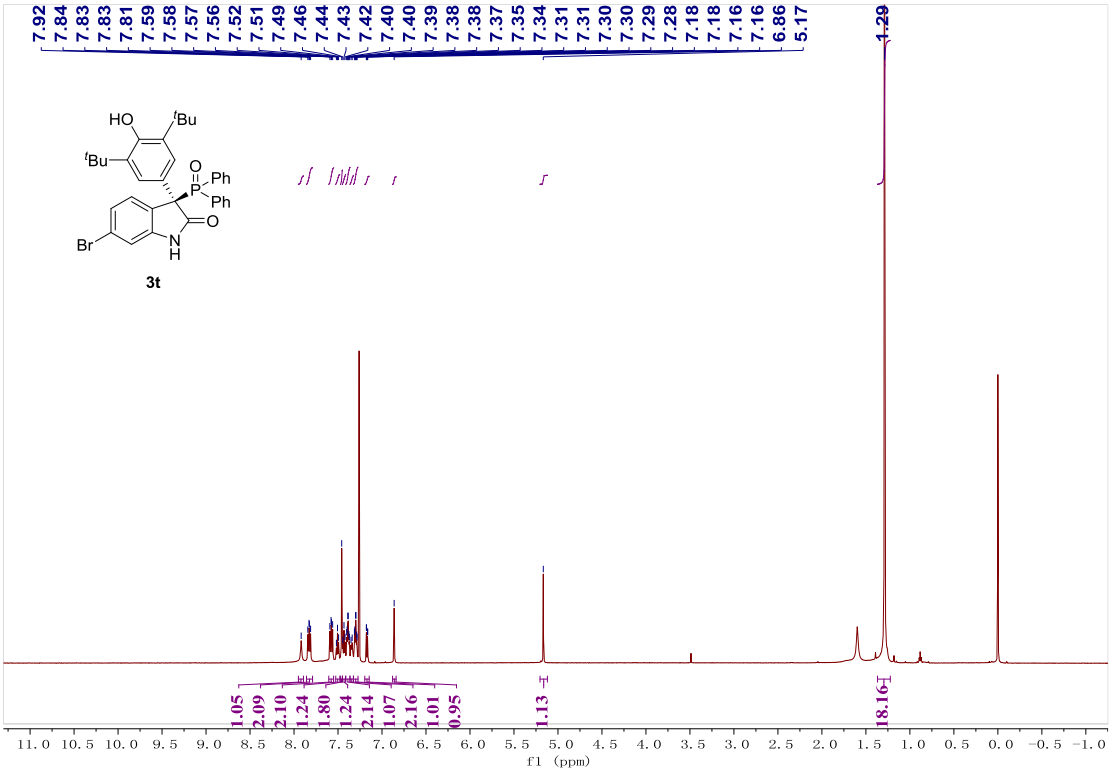

28.95
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
Cl
3s
140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −220 −240
f1 (ppm)

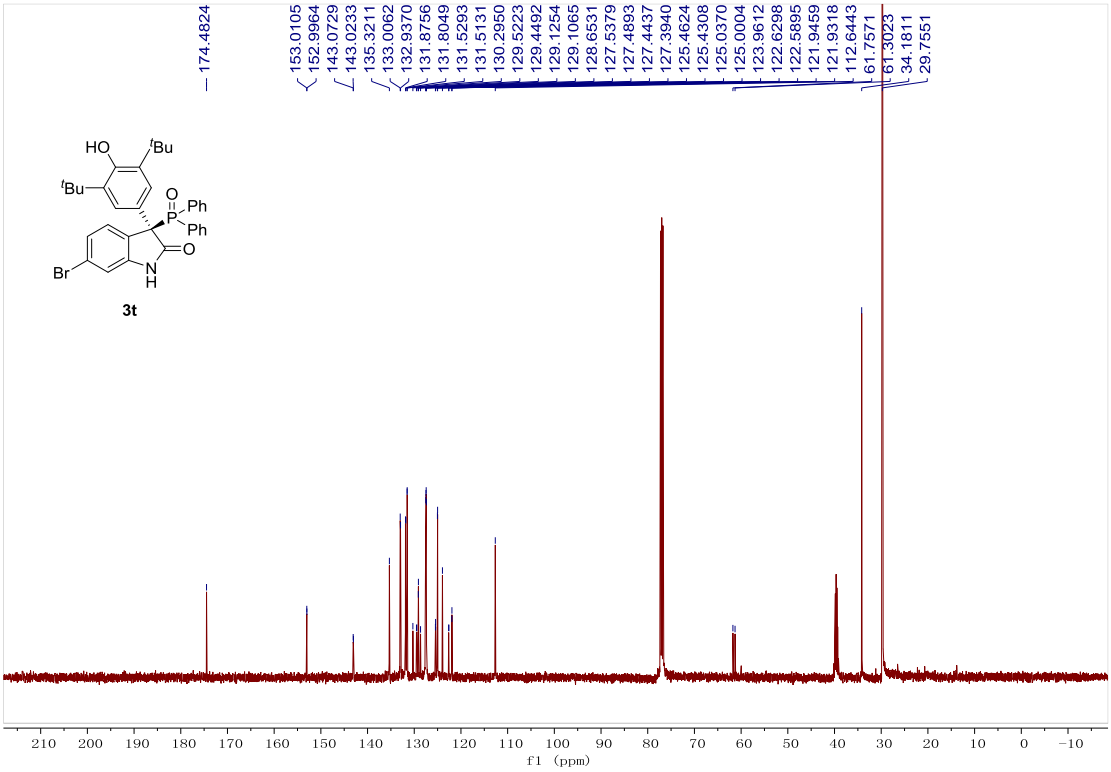


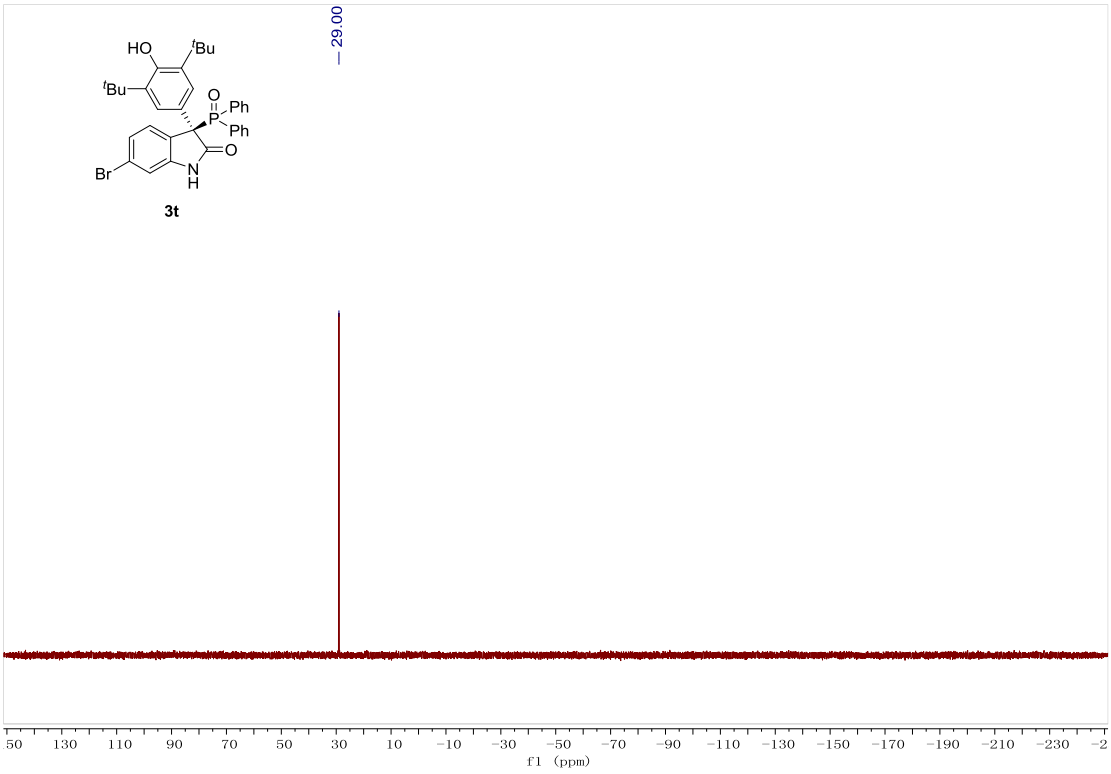
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.048	17.00	1714.971	50.191
2	34.798	6.06	1701.918	49.809
Total:		23.06	3416.889	100.0000

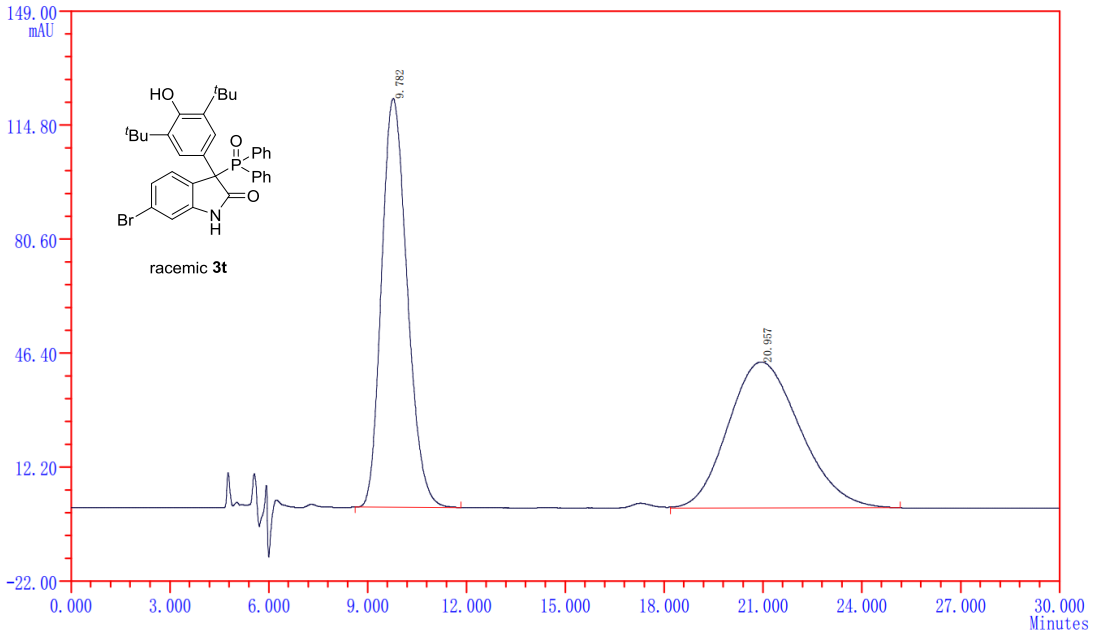


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.007	68.59	6770.425	89.404
2	34.832	3.36	802.411	10.596
Total:		71.95	7572.836	100.0000

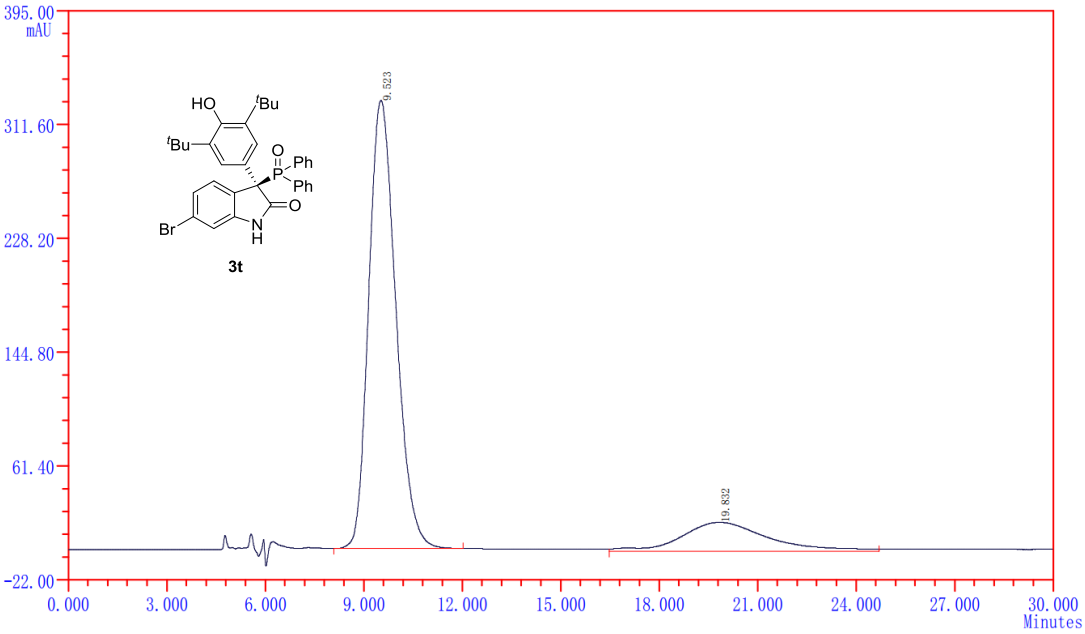

7.92 7.84 7.83 7.83 7.81 7.59 7.58 7.57 7.56 7.52 7.51 7.49 7.46 7.44 7.43 7.42 7.40 7.40 7.39 7.38 7.38 7.37 7.35 7.34 7.31 7.31 7.30 7.30 7.29 7.28 7.18 7.18 7.16 7.16 6.86 5.17
1.29
HO
tBu
tBu
O
P
Ph
Ph
O
Br
N
H
3t
1.05 2.09 2.10 1.24 1.80 1.24 2.14 1.07 2.16 1.01 0.95
1.13
18.16
11.0 10.5 10.0 9.5 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 -0.5 -1.0
f1 (ppm)


174.4824
153.0105 152.9964 143.0729 143.0233 135.3211 133.0062 132.9370 131.8756 131.8049 131.5293 131.5131 130.2950 129.5223 129.4492 129.1254 129.1065 128.6531 127.5379 127.4893 127.4437 127.3940 125.4624 125.4308 125.0370 125.0004 123.9612 122.6298 122.5895 121.9459 121.9318 112.6443 61.7571 61.3023 34.1811 29.7551
HO
tBu
tBu
O
P
Ph
Ph
O
Br
N
H
3t
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)

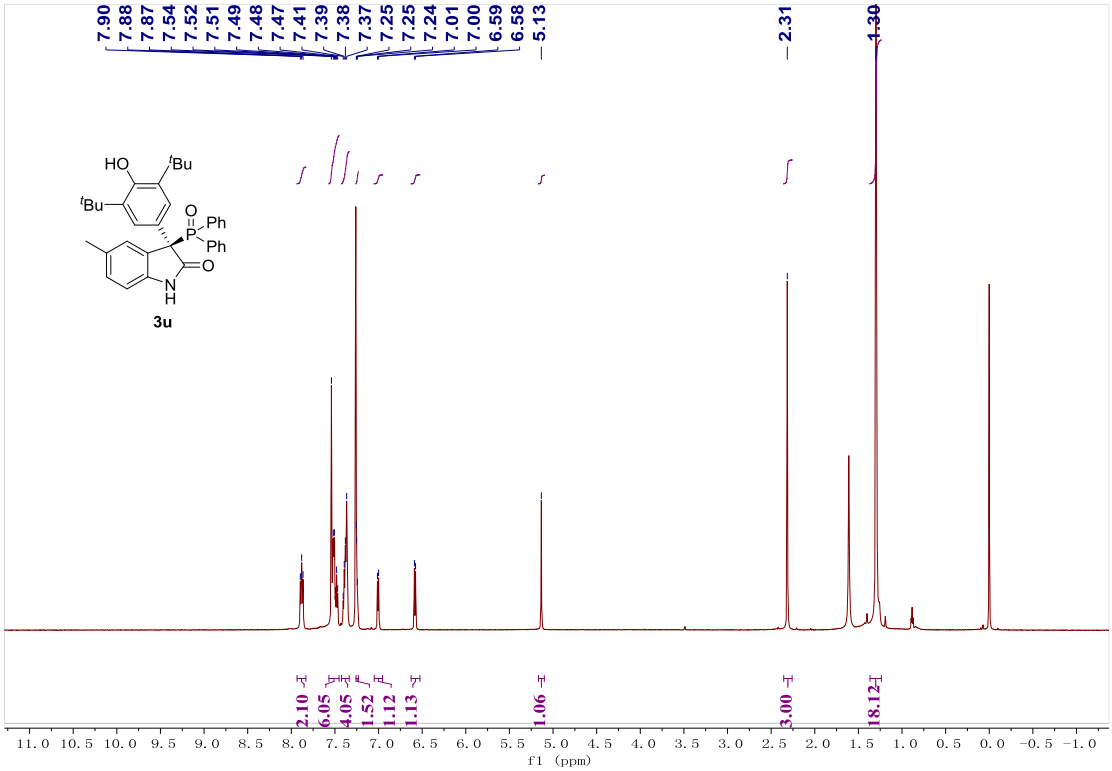


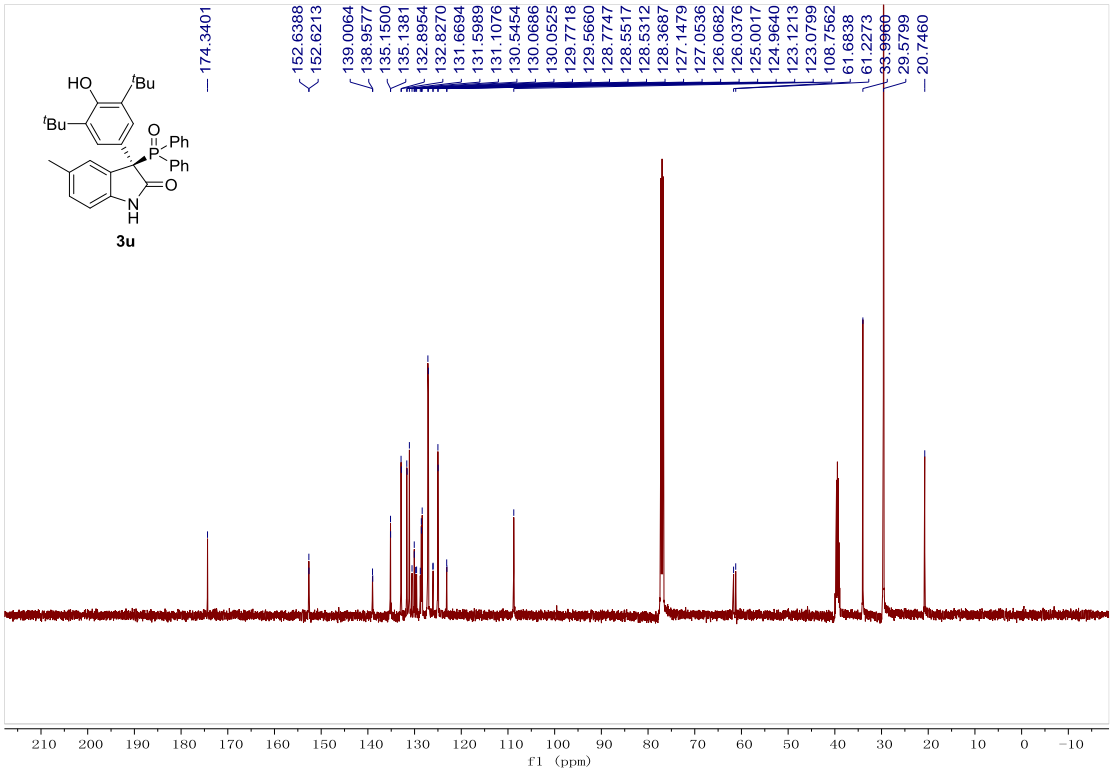


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	9.782	122.63	6652.943	50.050
2	20.957	43.75	6639.538	49.950
Total:		166.38	13292.481	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	9.523	328.39	18883.414	82.544
2	19.832	21.28	3993.449	17.456
Total:		349.67	22876.863	100.0000

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152.6213
139.0064
138.9577
135.1500
135.1381
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132.8270
131.6694
131.5989
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130.5454
130.0686
130.0525
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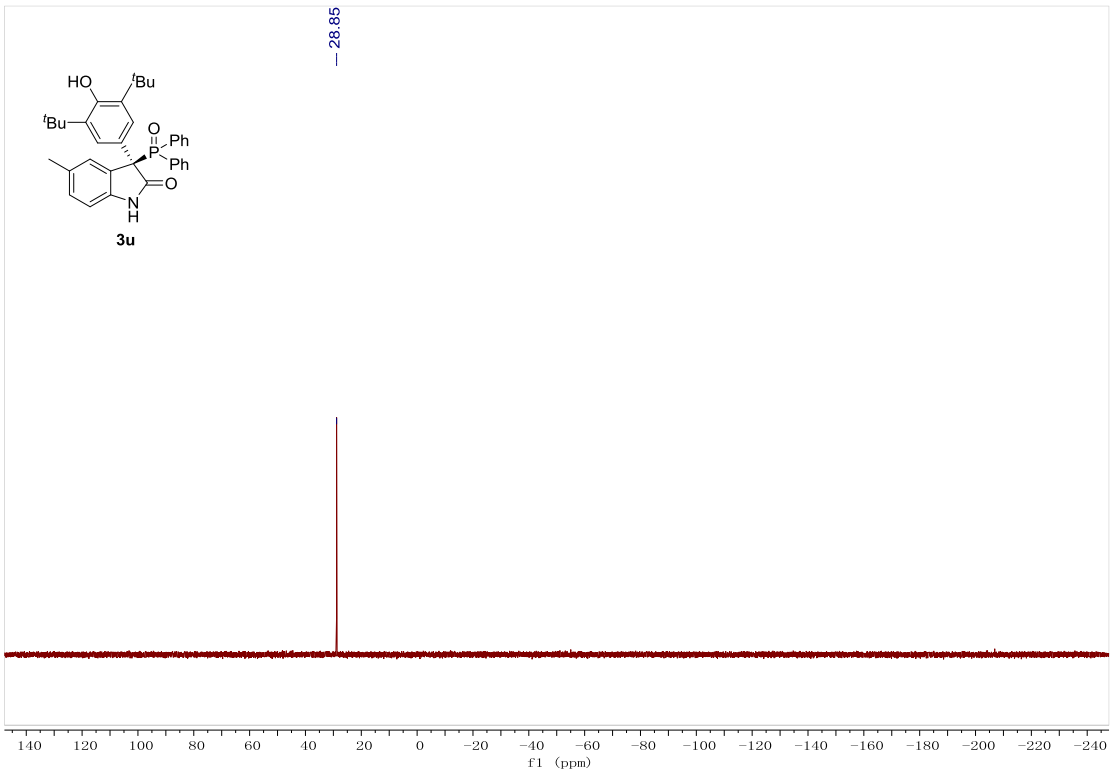
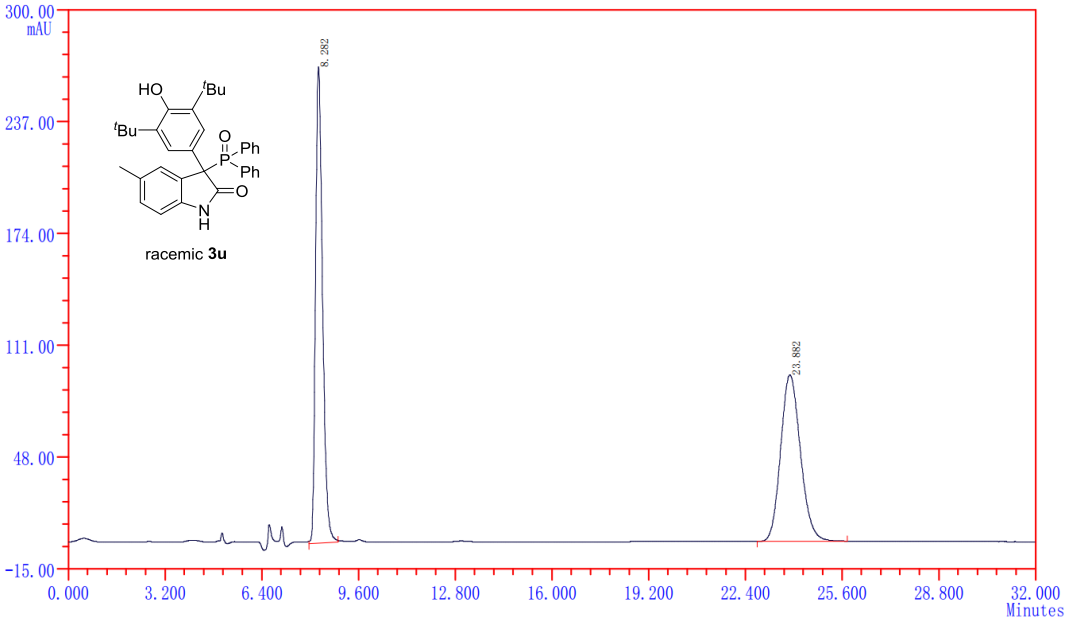
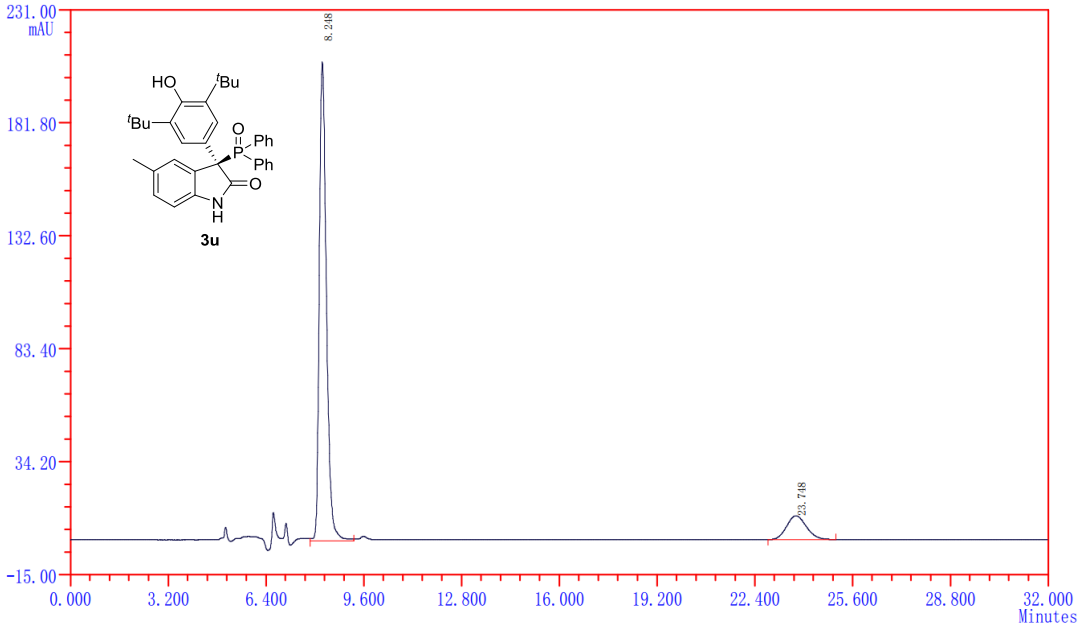
129.5660
128.7747
128.5517
128.5312
128.3687
127.1479
127.0536
126.0682
126.0376
125.0017
124.9640
123.1213
123.0799
108.7562
61.6838
61.2273
33.9960
29.5799
20.7460
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
3u
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

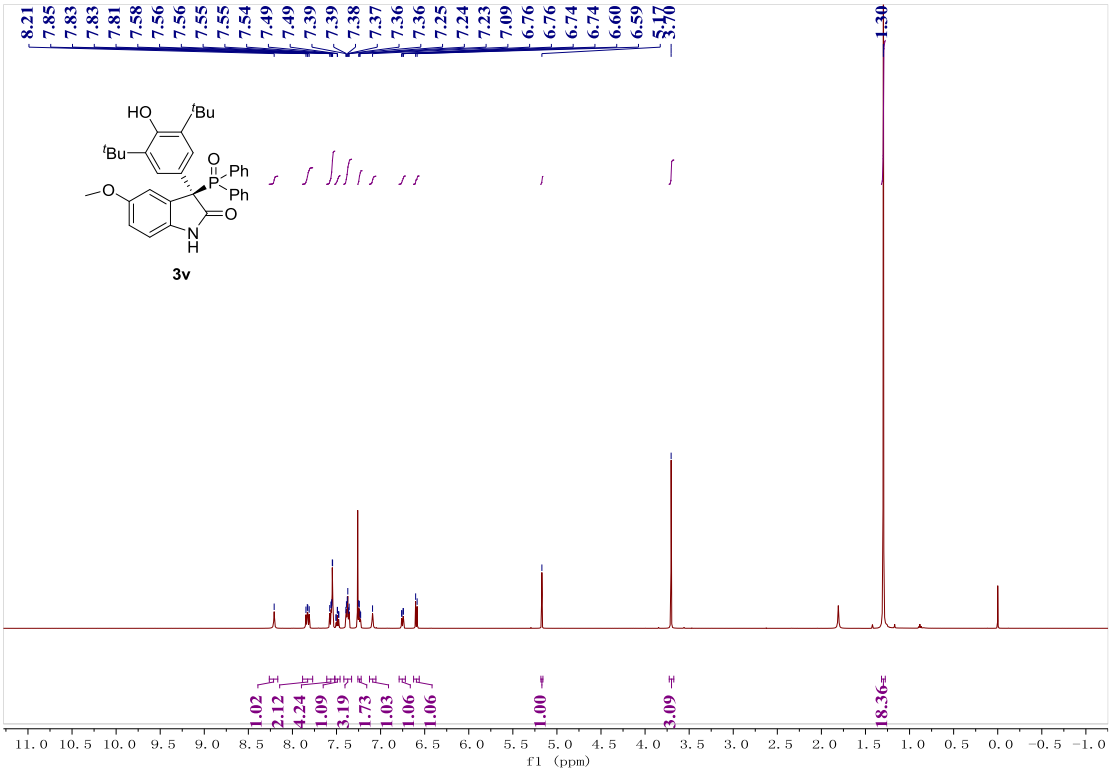

28.85
HO
tBu
tBu
O
P
Ph
Ph
O
N
H
3u
140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −220 −240
f1 (ppm)



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	8.282	268.21	4320.289	50.176
2	23.882	93.87	4289.950	49.824
Total:		362.08	8610.238	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	8.248	208.50	3371.057	87.761
2	23.748	10.40	470.105	12.239
Total:		362.08	3841.162	100.0000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7.83
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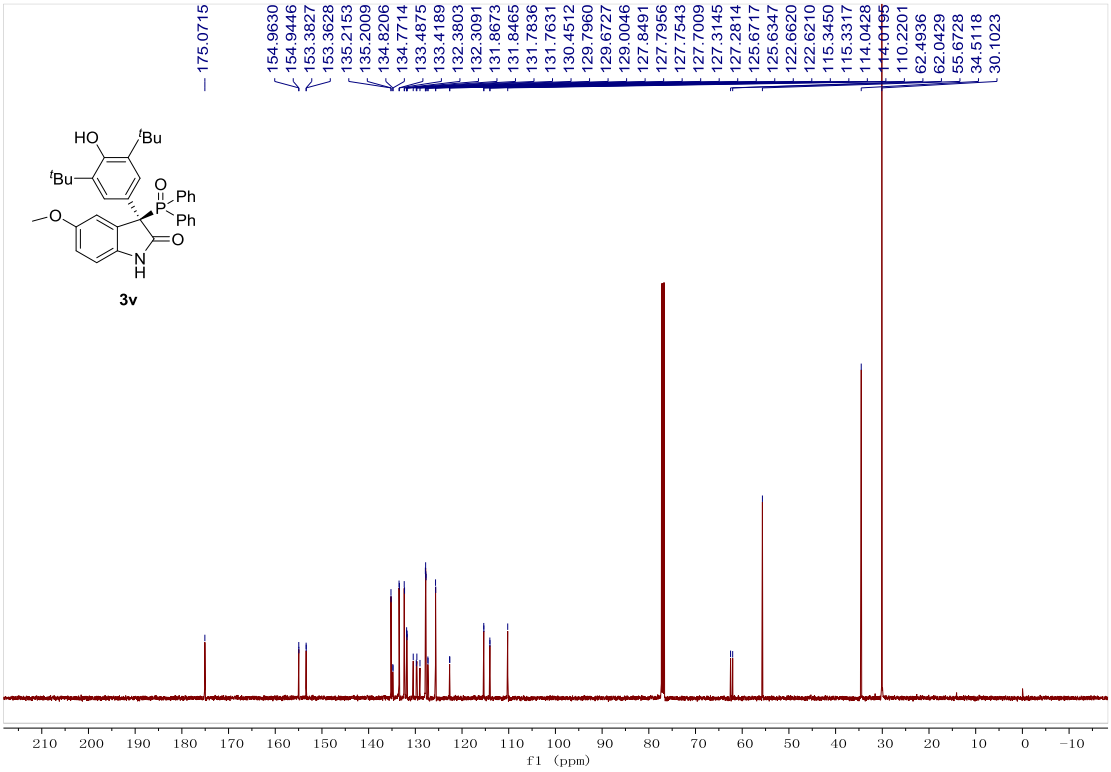
7.39
7.39
7.38
7.37
7.36
7.36
7.25
7.24
7.23
7.09
6.76
6.76
6.74
6.74
6.60
6.59
5.17
3.70
1.30
HO
tBu
tBu
O
P
Ph
Ph
O
O
N
H
3v
1.02
2.12
4.24
1.09
3.19
1.73
1.03
1.06
1.06
1.00
3.09
18.36
f1 (ppm)


175.0715
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133.4189
132.3803
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129.7960
129.6727
129.0046
127.8491
127.7956
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127.3145
127.2814
125.6717
125.6347
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122.6210
115.3450
115.3317
114.0428
114.0195
110.2201
62.4936
62.0429
55.6728
34.5118
30.1023
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tBu
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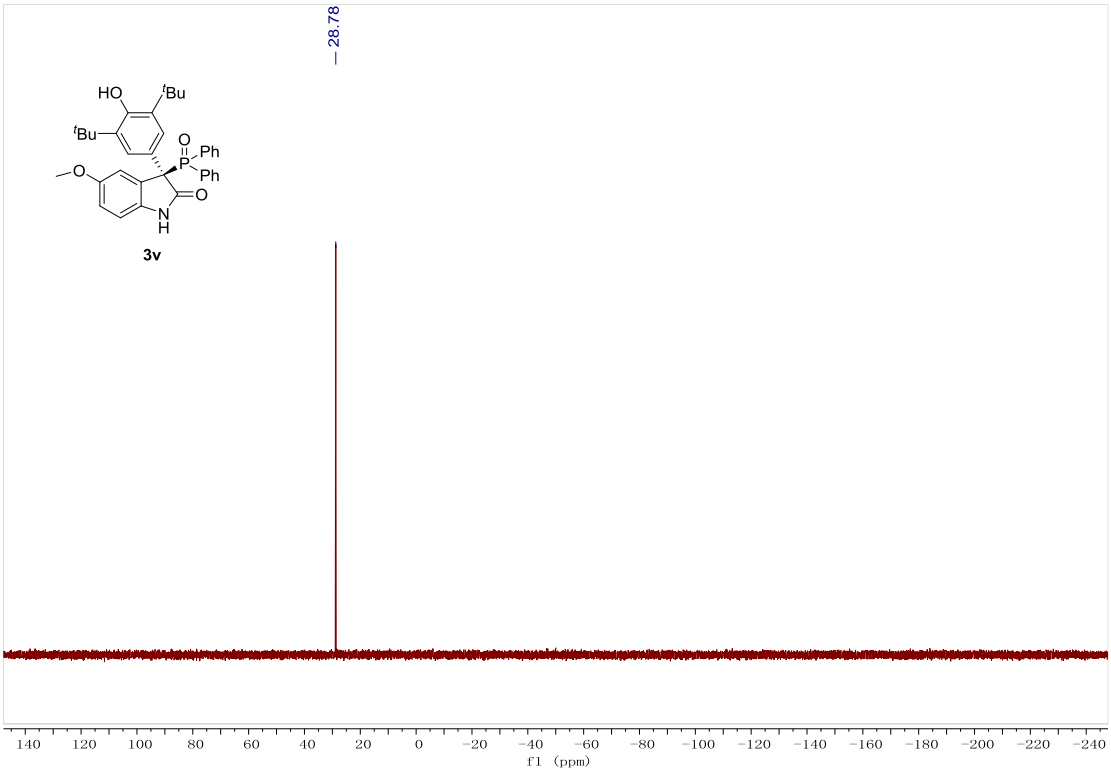
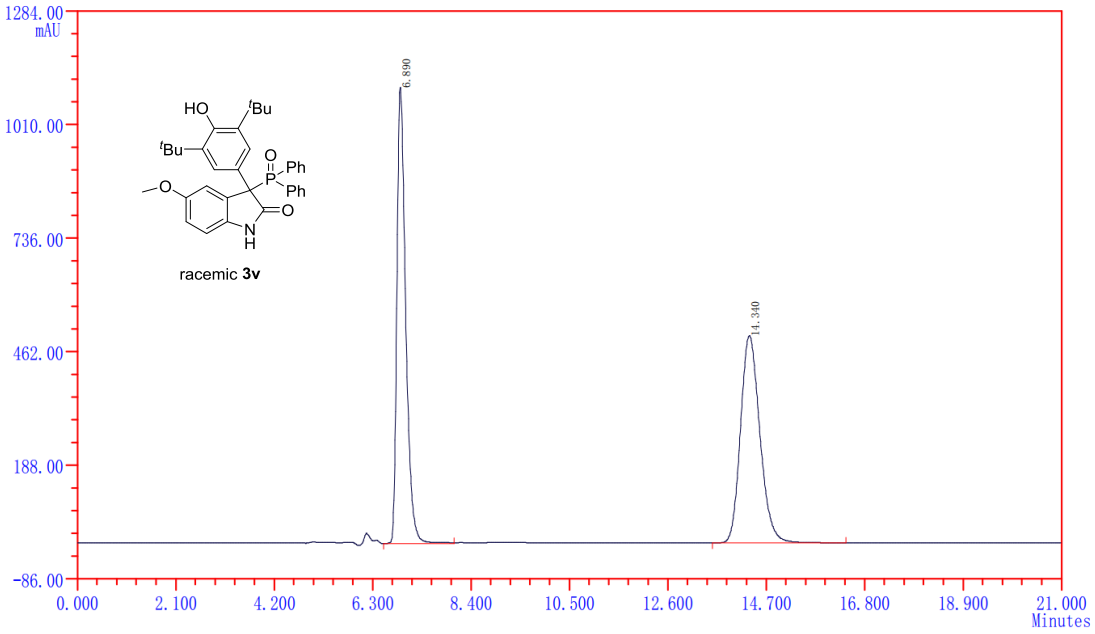
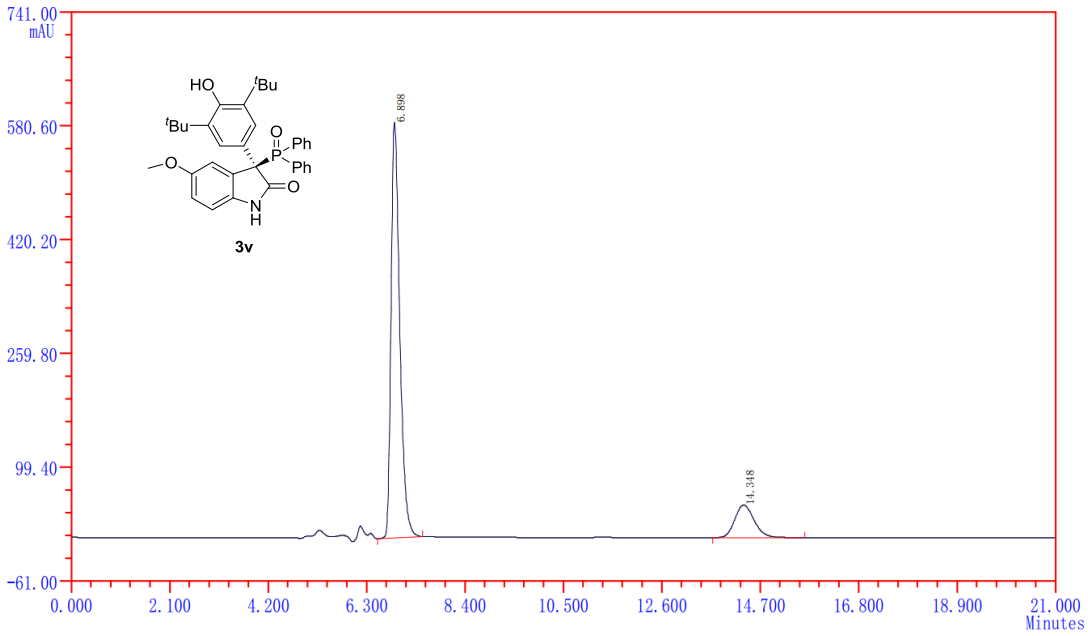
Ph
Ph
O
O
N
H
3v
f1 (ppm)

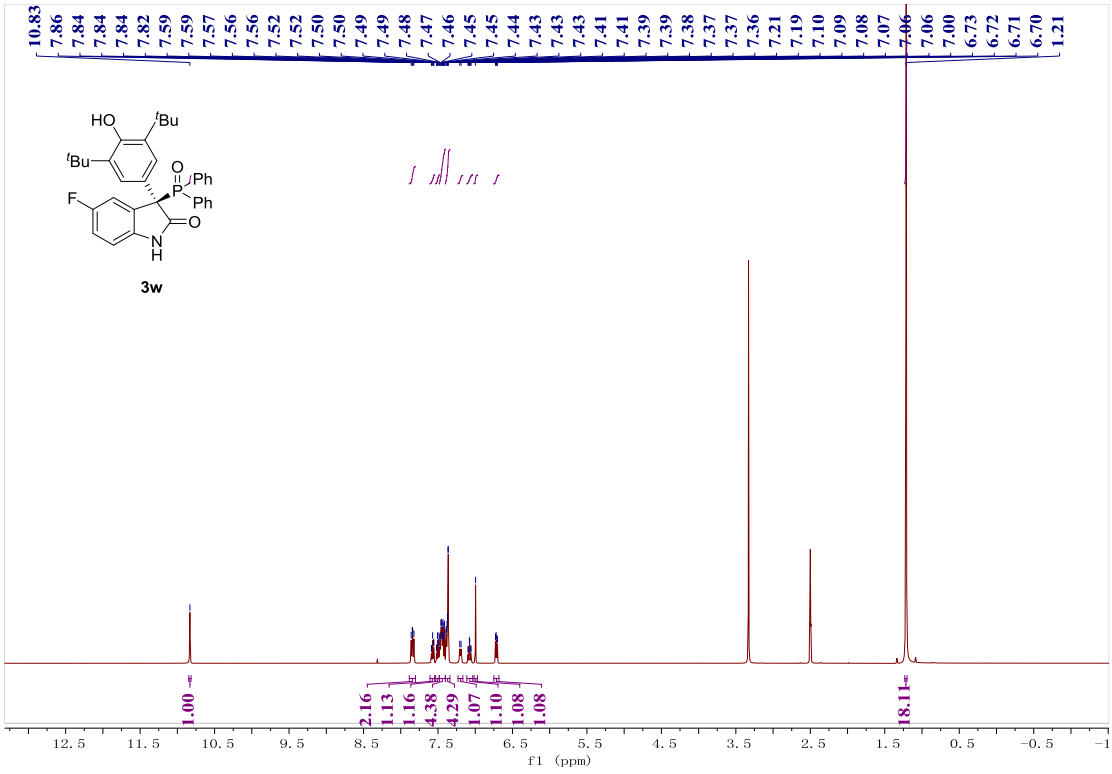


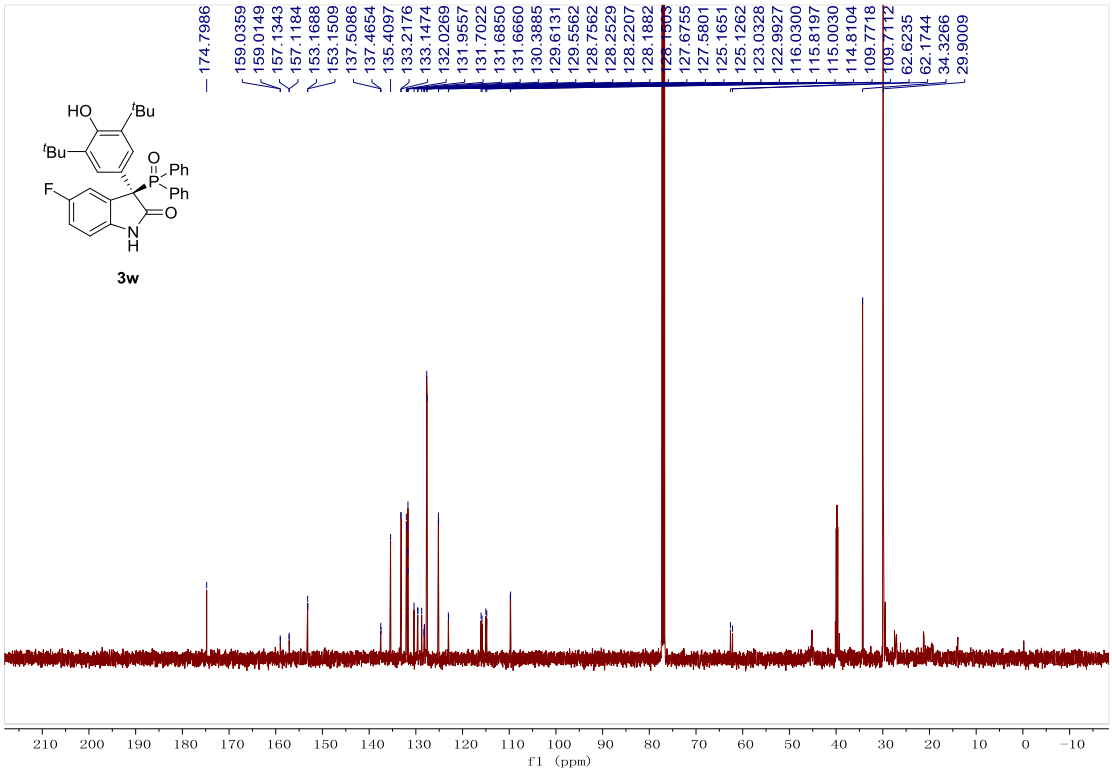


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.890	1100.23	14471.599	50.144
2	14.340	499.59	14388.358	49.856
Total:		1599.82	28859.957	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.898	586.25	7572.108	85.116
2	14.348	46.01	1324.138	14.884
Total:		632.26	8896.246	100.0000




174.7986
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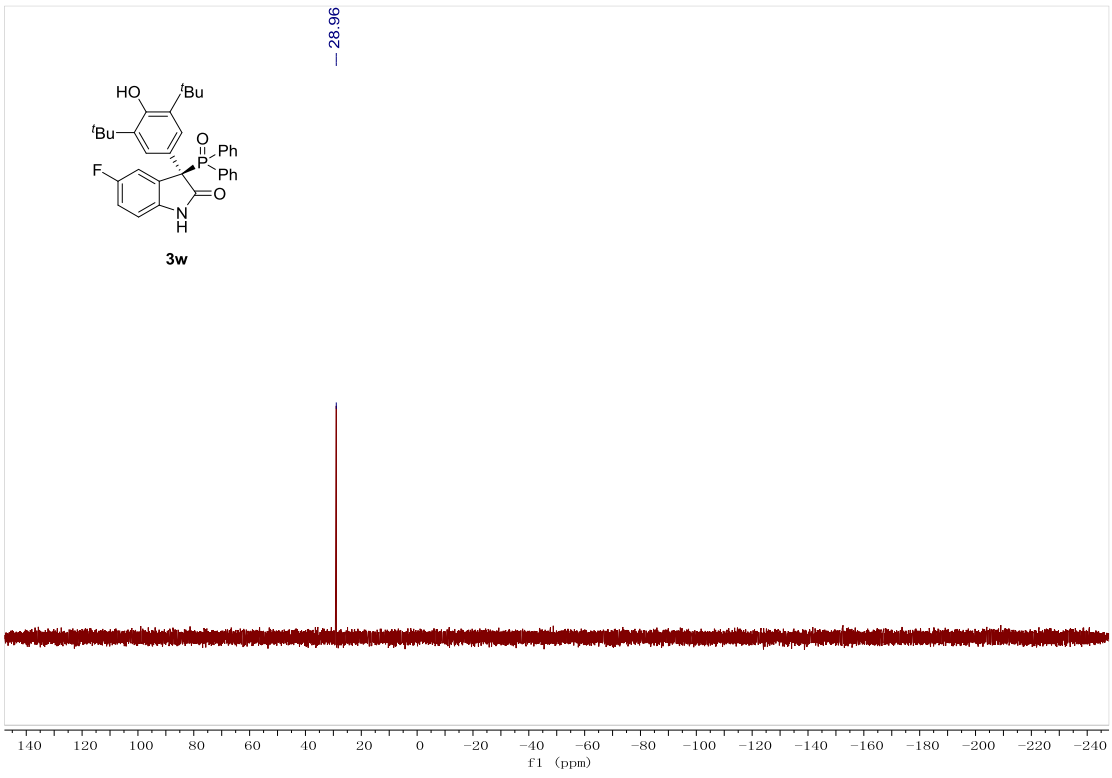
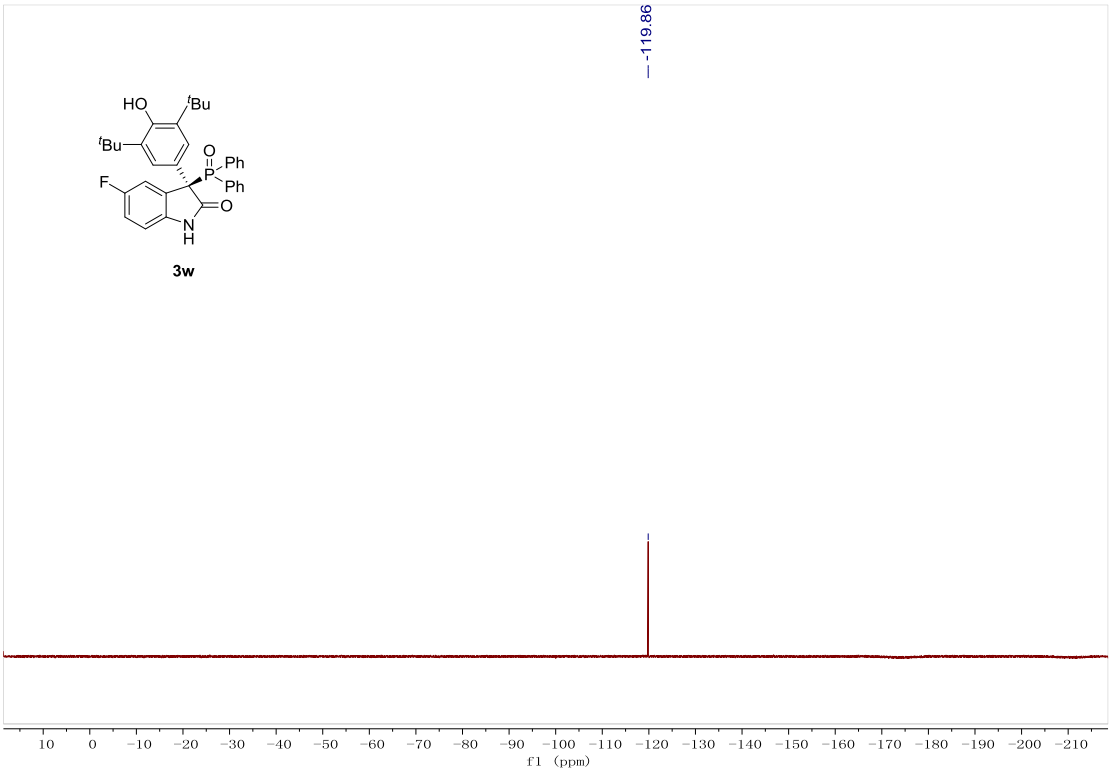
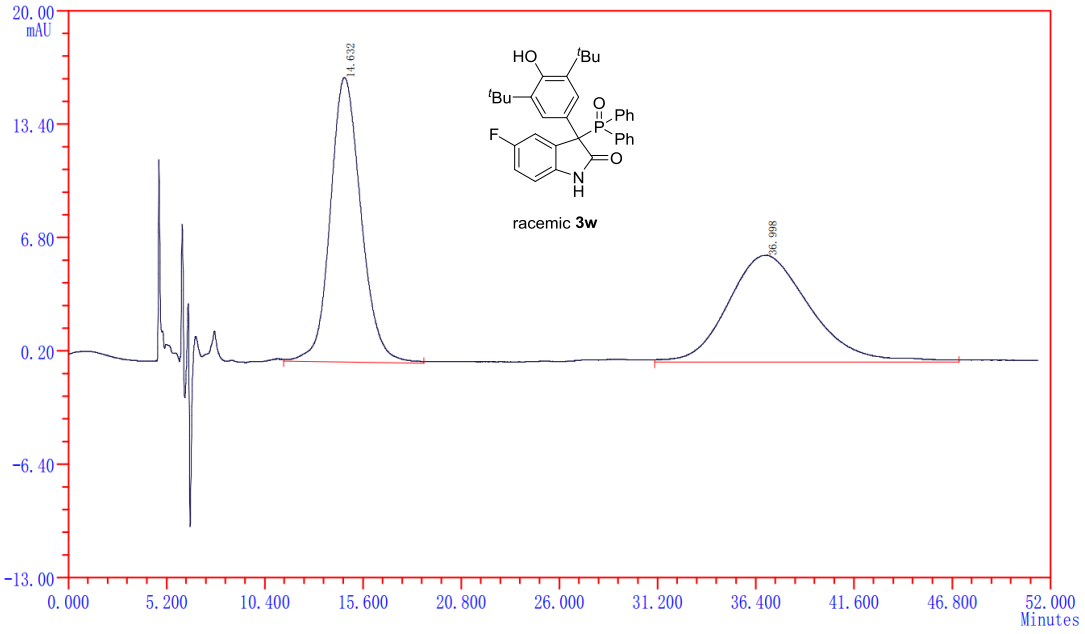
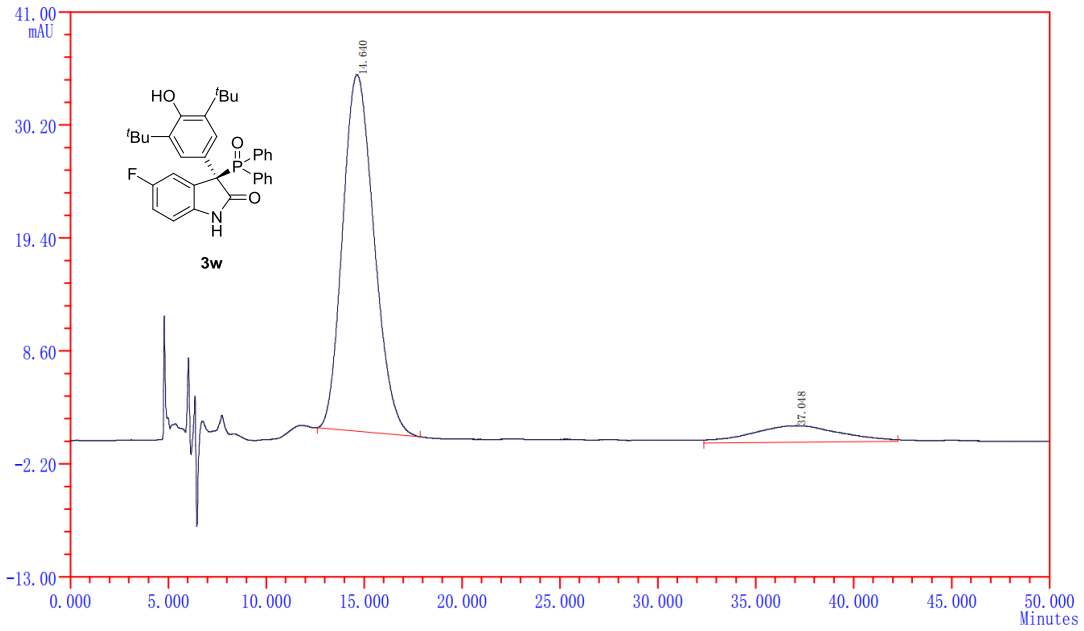
159.0149
157.1343
157.1184
153.1688
153.1509
137.5086
137.4654
135.4097
133.2176
133.1474
132.0269
131.9557
131.7022
131.6850
131.6660
130.3885
129.6131
129.5562
128.7562
128.2529
128.2207
128.1882
128.1503
127.6755
127.5801
125.1651
125.1262
123.0328
122.9927
116.0300
115.8197
115.0030
114.8104
109.7718
109.7112
62.6235
62.1744
34.3266
29.9009
HO
tBu
tBu
O
P
Ph
Ph
F
O
N
H
3w
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)


28.96
HO
tBu
tBu
O
P
Ph
Ph
F
O
N
H
3w
140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −220 −240
f1 (ppm)

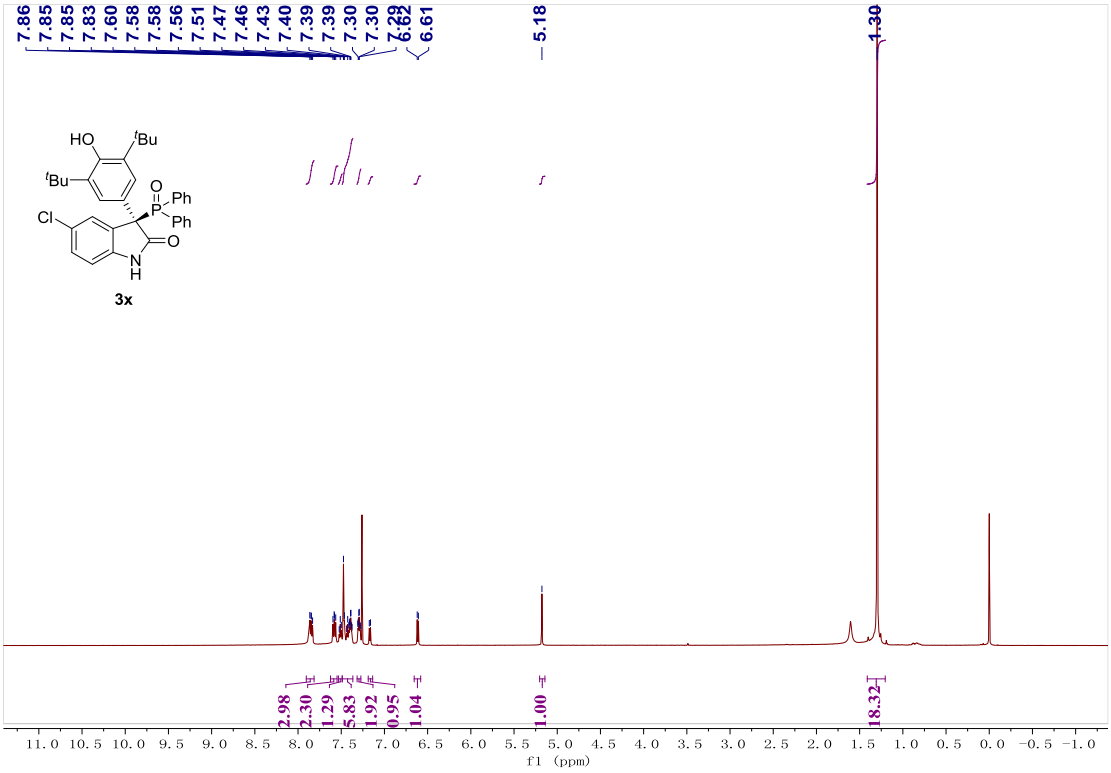


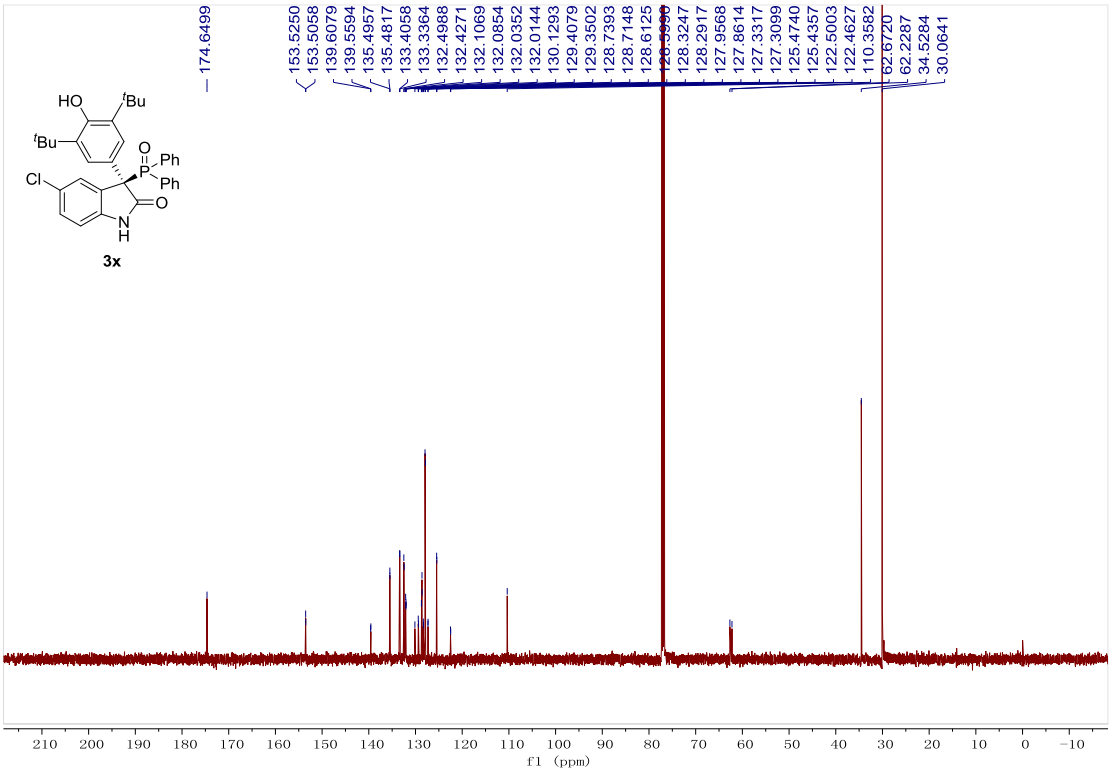


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.632	16.55	1871.109	49.939
2	36.998	6.21	1875.664	50.061
Total:		22.76	3746.772	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.640	34.08	3813.059	88.402
2	37.048	1.57	500.271	11.598
Total:		35.65	4313.329	100.0000

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139.6079
139.5594
135.4957
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133.3364
132.4988
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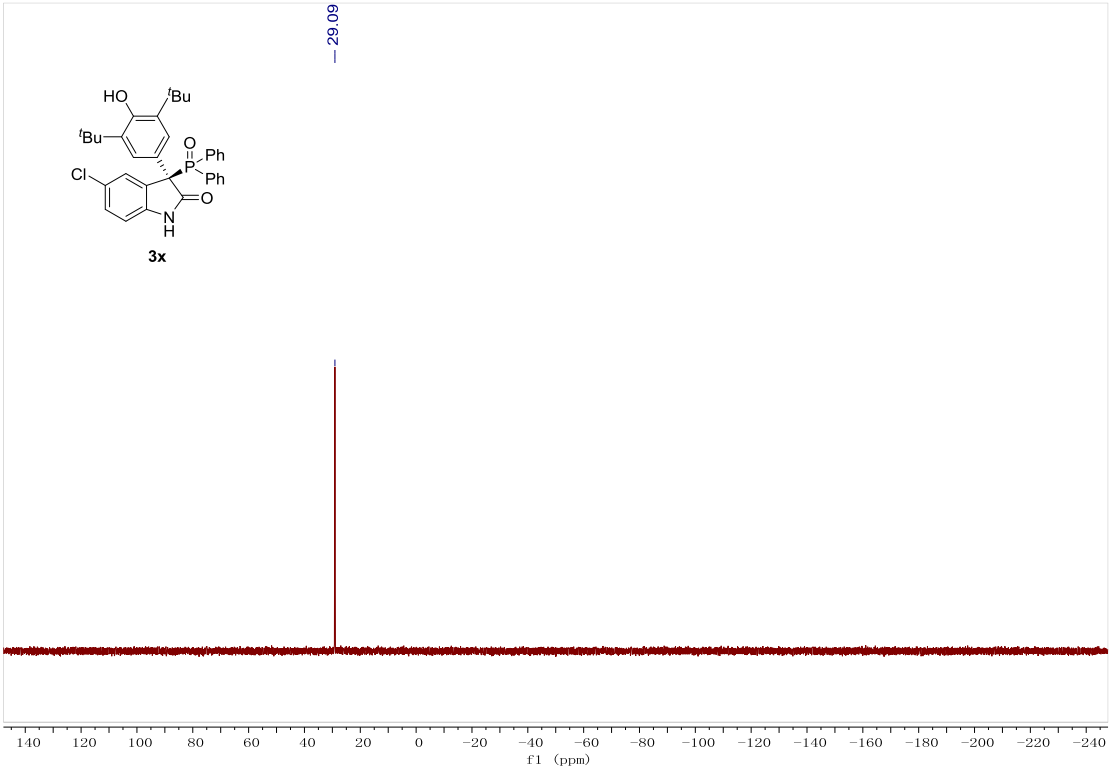
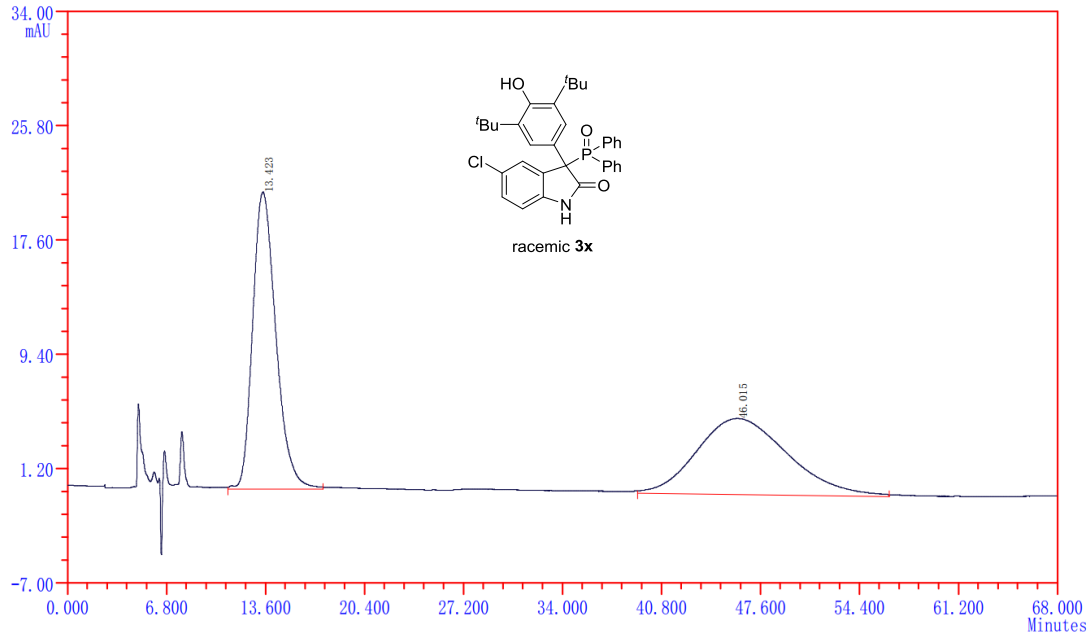
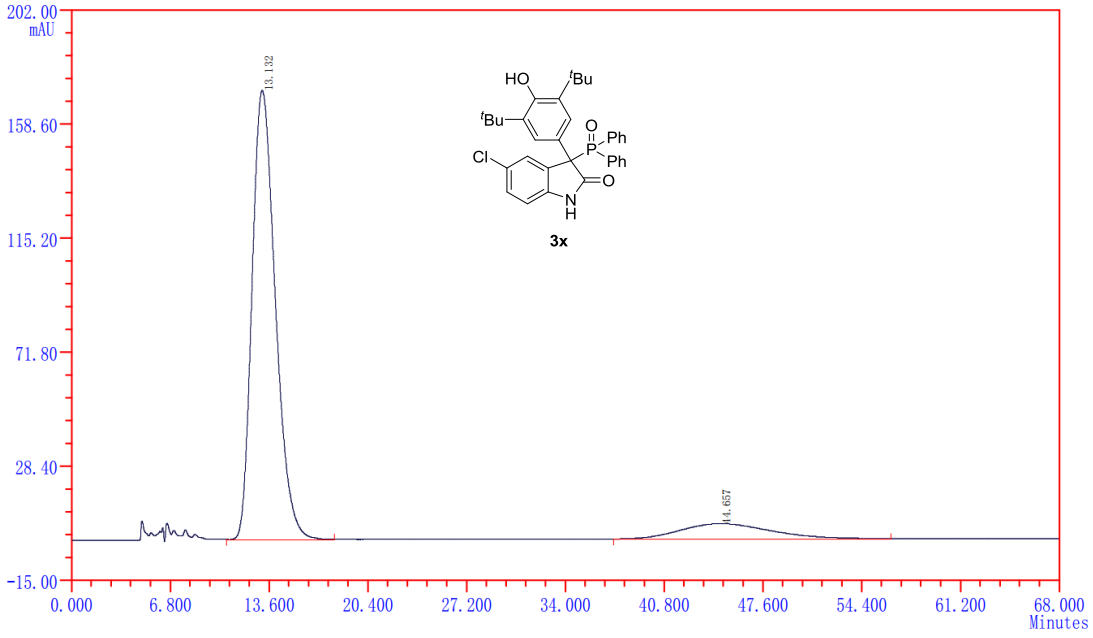
132.1069
132.0854
132.0352
132.0144
130.1293
129.4079
129.3502
128.7393
128.7148
128.6125
128.3247
128.2917
127.9568
127.8614
127.3317
127.3099
125.4740
125.4357
122.5003
122.4627
110.3582
62.6720
62.2287
34.5284
30.0641
HO
tBu
tBu
O
P
Ph
Ph
Cl
O
N
H
3x
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

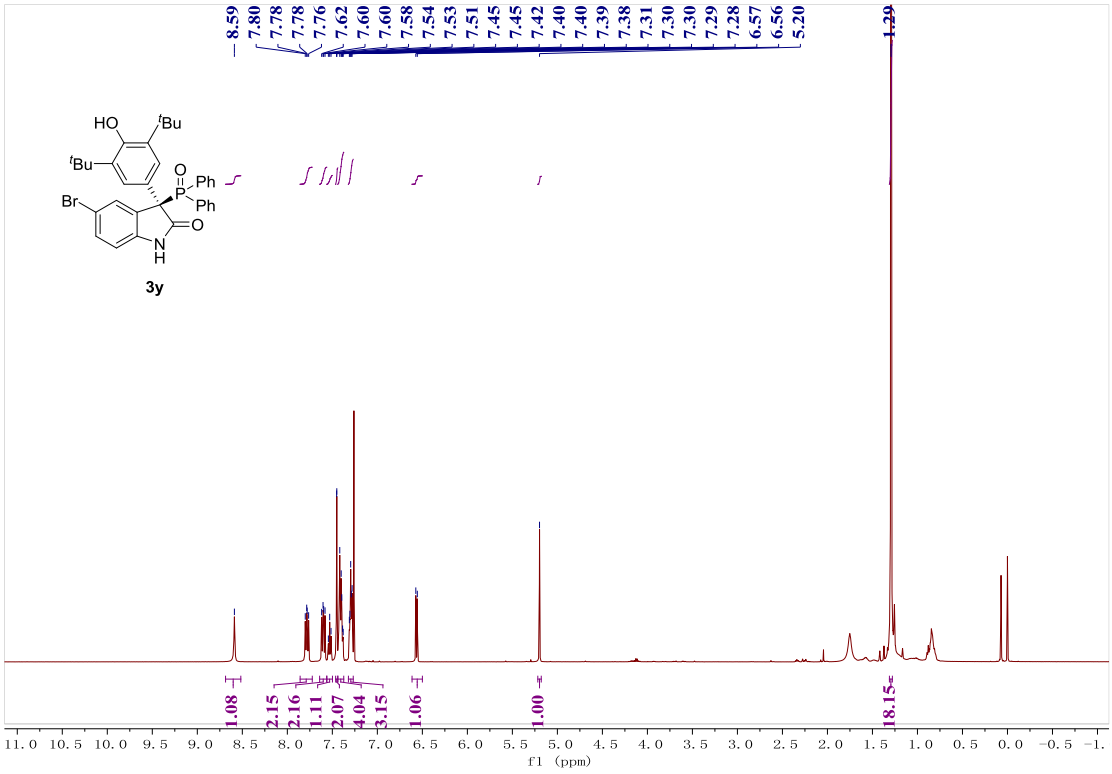

29.09
HO
tBu
tBu
O
P
Ph
Ph
Cl
O
N
H
3x
140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180 −200 −220 −240
f1 (ppm)

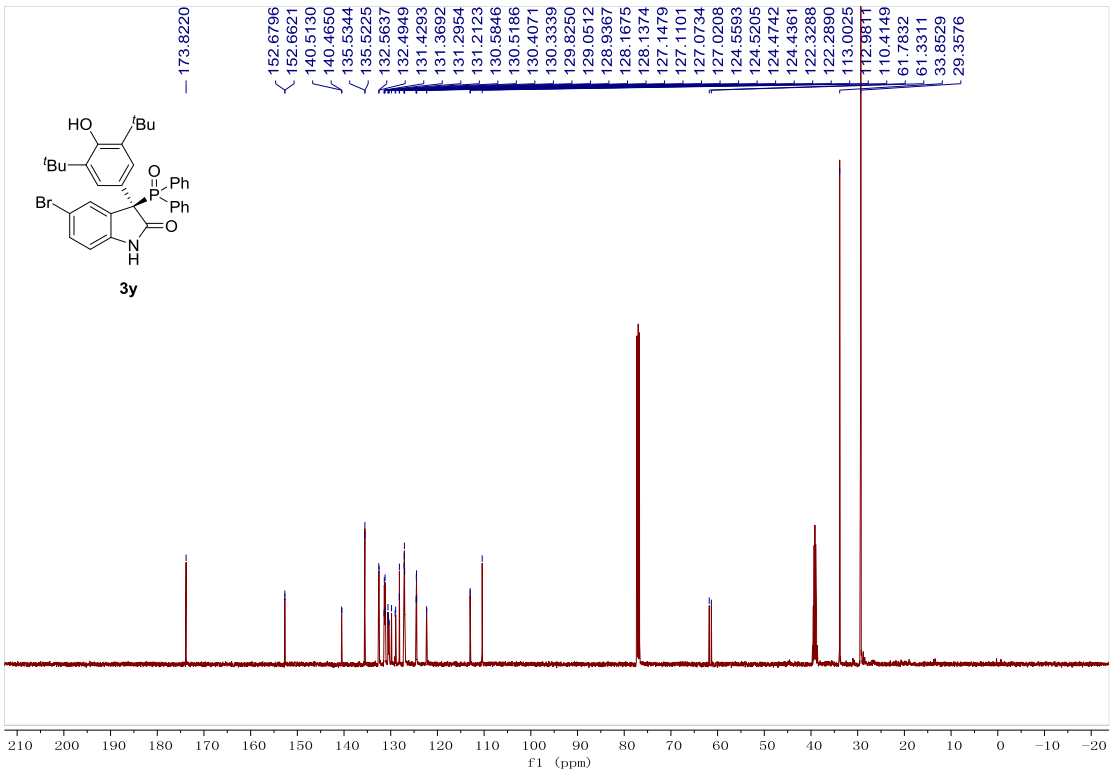


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	13.423	21.32	2370.528	49.863
2	46.015	5.46	2383.528	50.137
Total:		26.78	4754.056	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	13.132	171.10	19081.969	87.700
2	44.657	5.94	2676.285	12.300
Total:		177.04	21758.254	100.0000


8.59
7.80
7.78
7.78
7.76
7.62
7.60
7.60
7.58
7.54
7.53
7.51
7.45
7.45
7.42
7.40
7.40
7.39
7.38
7.31
7.30
7.30
7.29
7.28
6.57
6.56
5.20
1.29
HO
tBu
tBu
O
Ph
P
Ph
Br
O
N
H
3y
1.08
2.15
2.16
1.11
2.07
4.04
3.15
1.06
1.00
18.15
f1 (ppm)


173.8220
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152.6621
140.5130
140.4650
135.5344
135.5225
132.5637
132.4949
131.4293
131.3692
131.2954
131.2123
130.5846
130.5186
130.4071
130.3339
129.8250
129.0512
128.9367
128.1675
128.1374
127.1479
127.1101
127.0734
127.0208
124.5593
124.5205
124.4742
124.4361
122.3288
122.2890
113.0025
112.9811
110.4149
61.7832
61.3311
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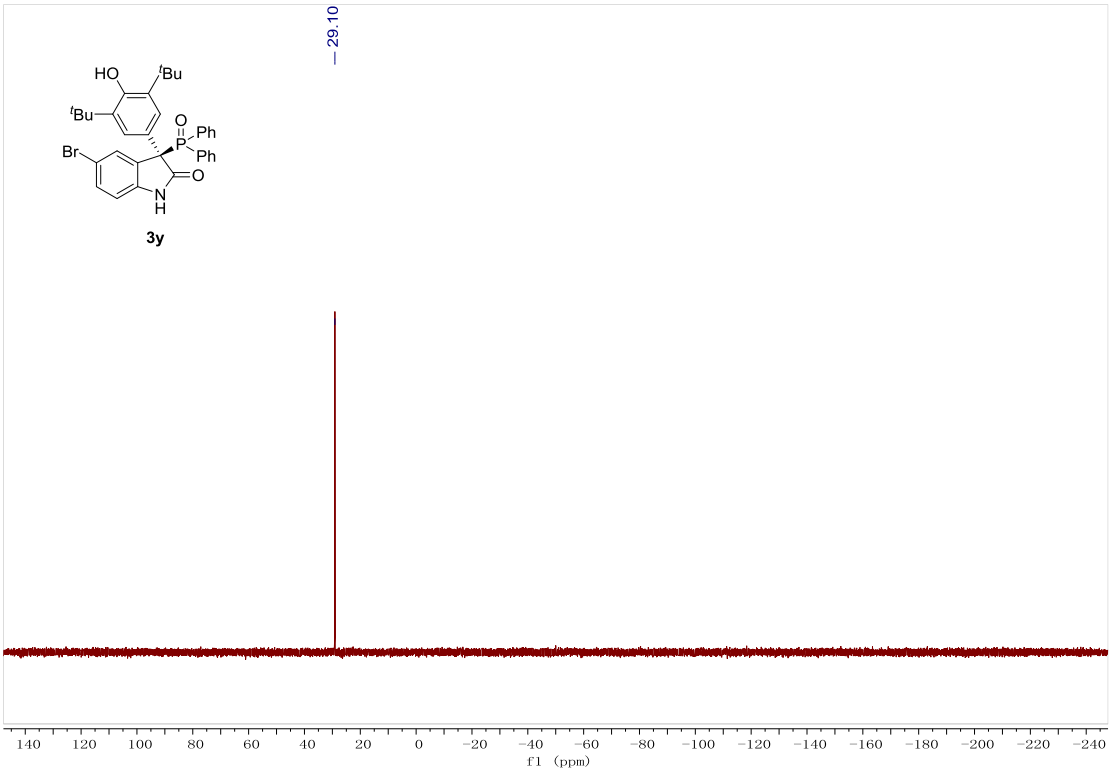
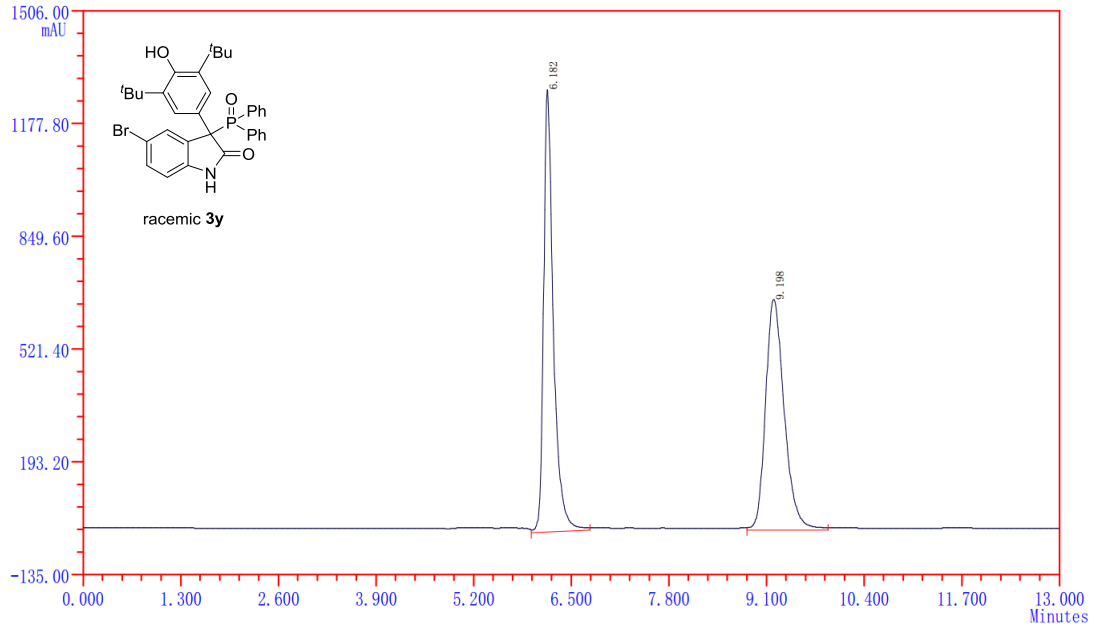
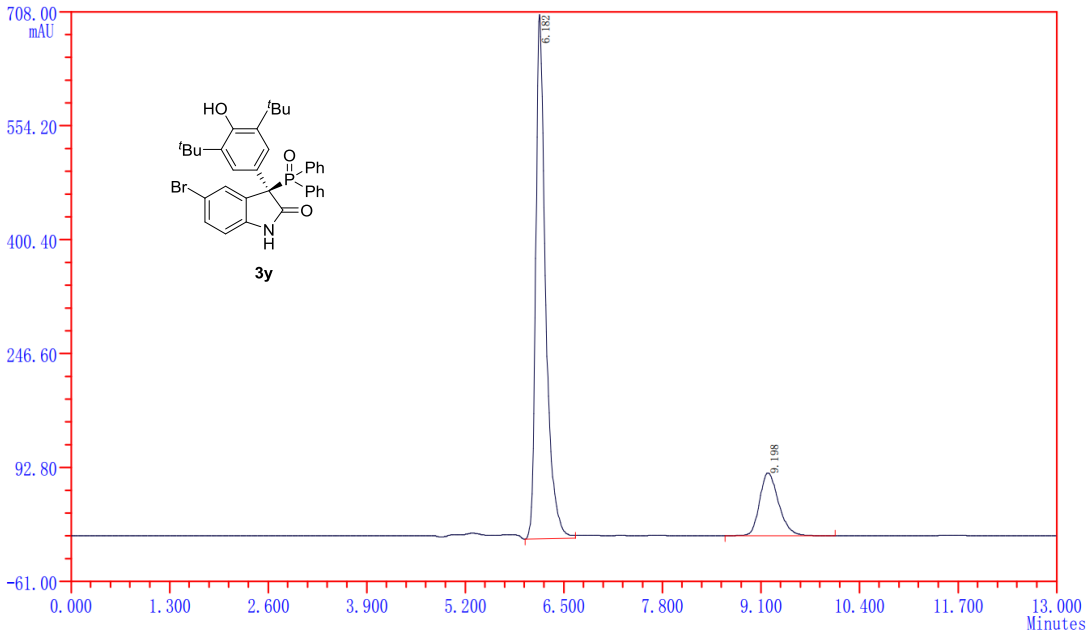
tBu
tBu
O
Ph
P
Ph
Br
O
N
H
3y
f1 (ppm)

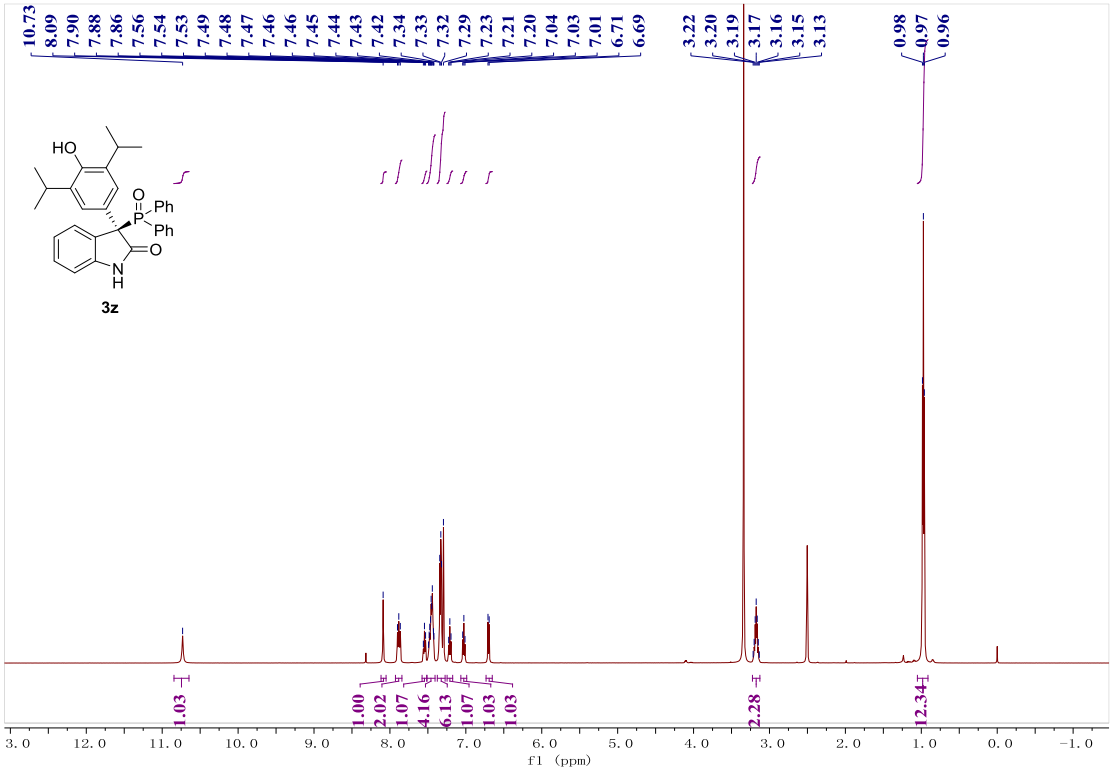


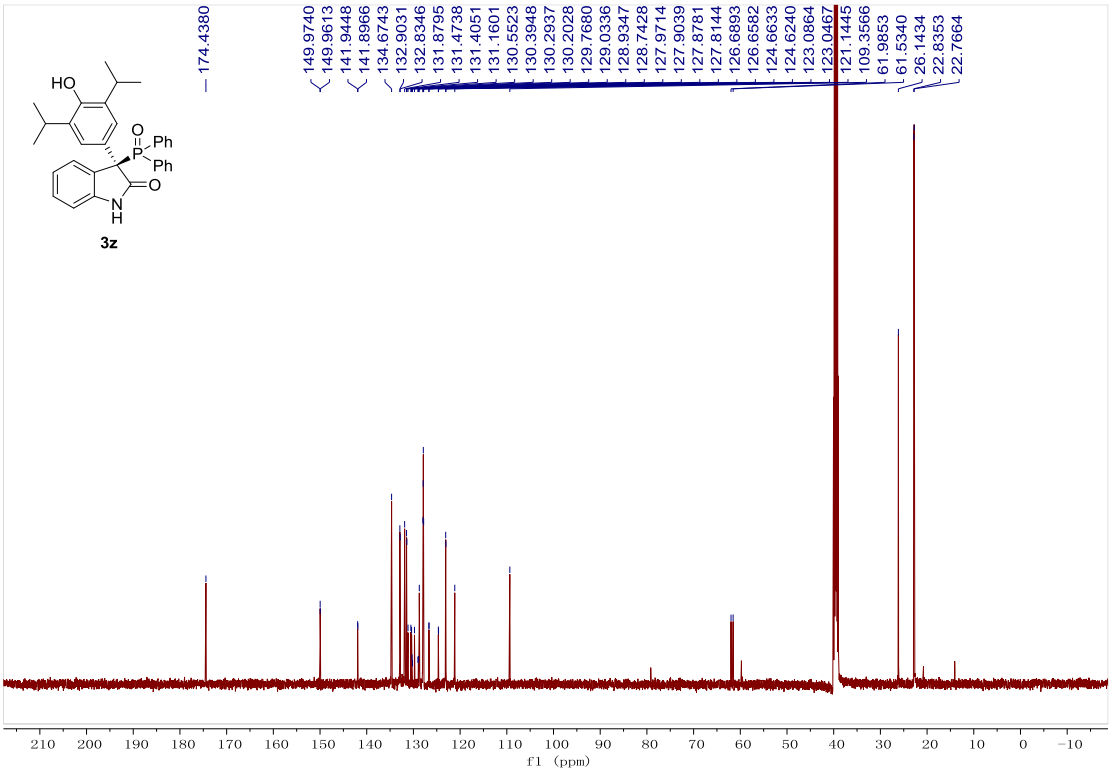


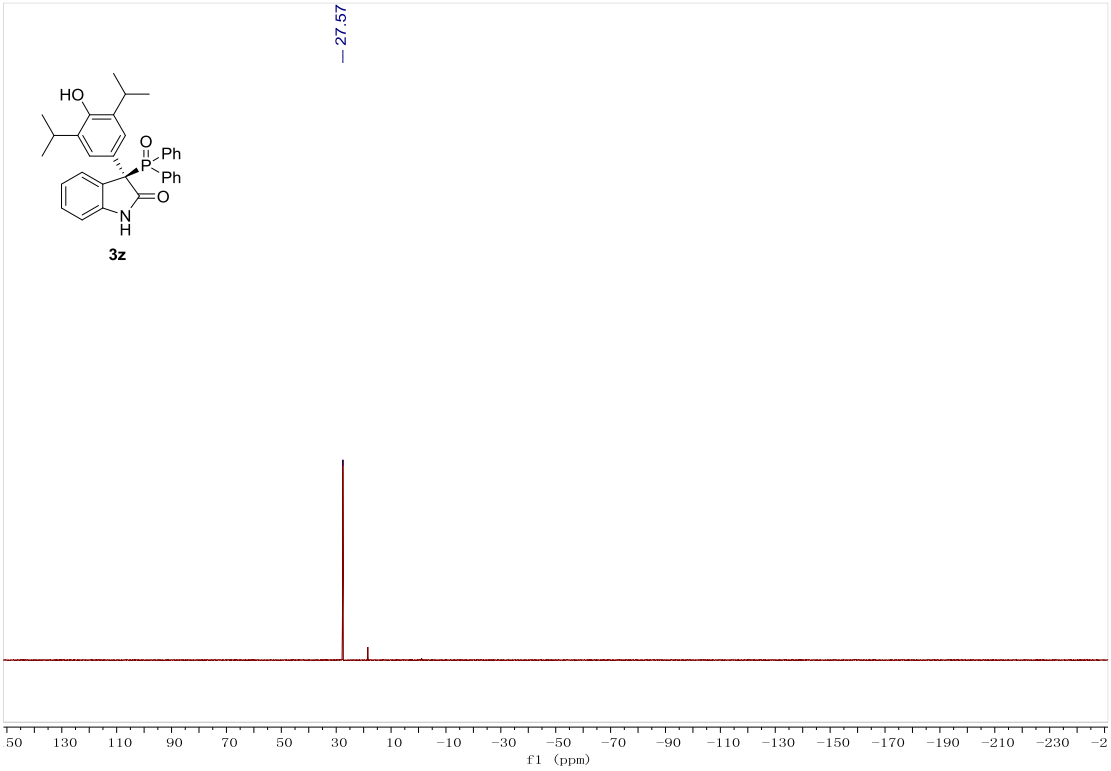
Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.182	1287.10	11642.276	49.993
2	9.198	669.89	11645.343	50.007
Total:		1956.99	23287.618	100.0000

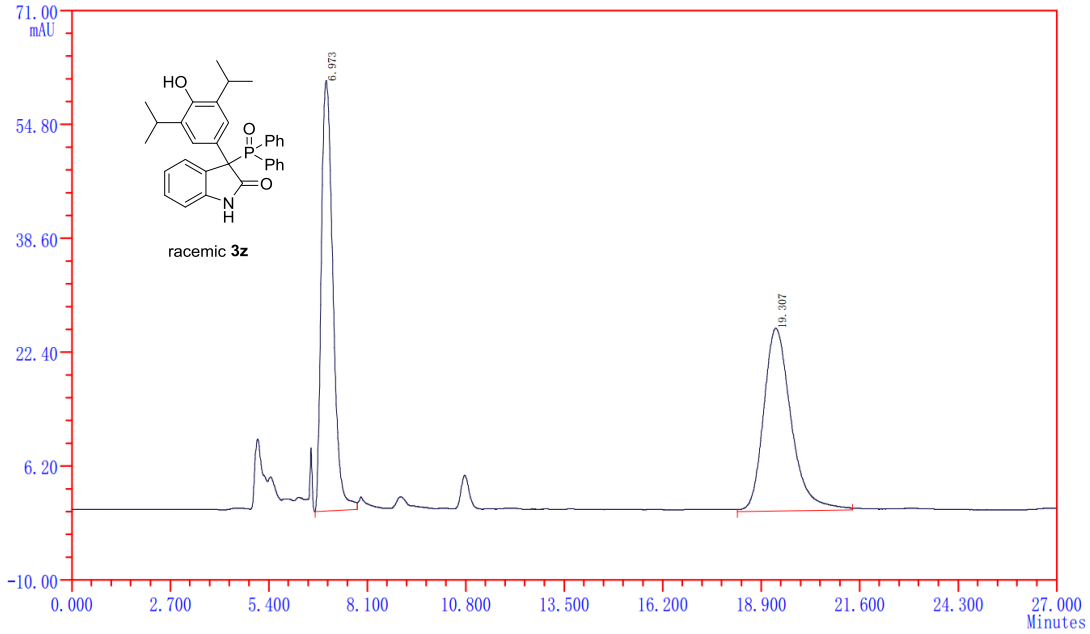


Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.182	710.37	6411.635	81.179
2	9.198	84.95	1486.527	18.821
Total:		795.32	7898.162	100.0000

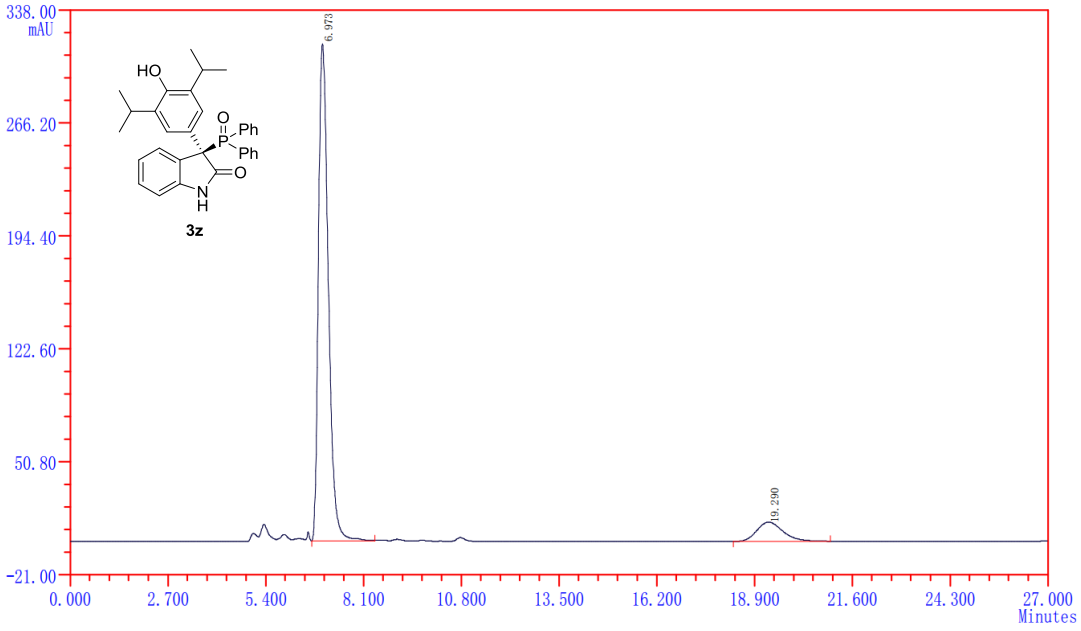



HO
O
P
Ph
Ph
O
N
H
3z
174.4380
149.9740
149.9613
141.9448
141.8966
134.6743
132.9031
132.8346
131.8795
131.4738
131.4051
131.1601
130.5523
130.3948
130.2937
130.2028
129.7680
129.0336
128.9347
128.7428
127.9714
127.9039
127.8781
127.8144
126.6893
126.6582
124.6633
124.6240
123.0864
123.0467
121.1445
109.3566
61.9853
61.5340
26.1434
22.8353
22.7664
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)

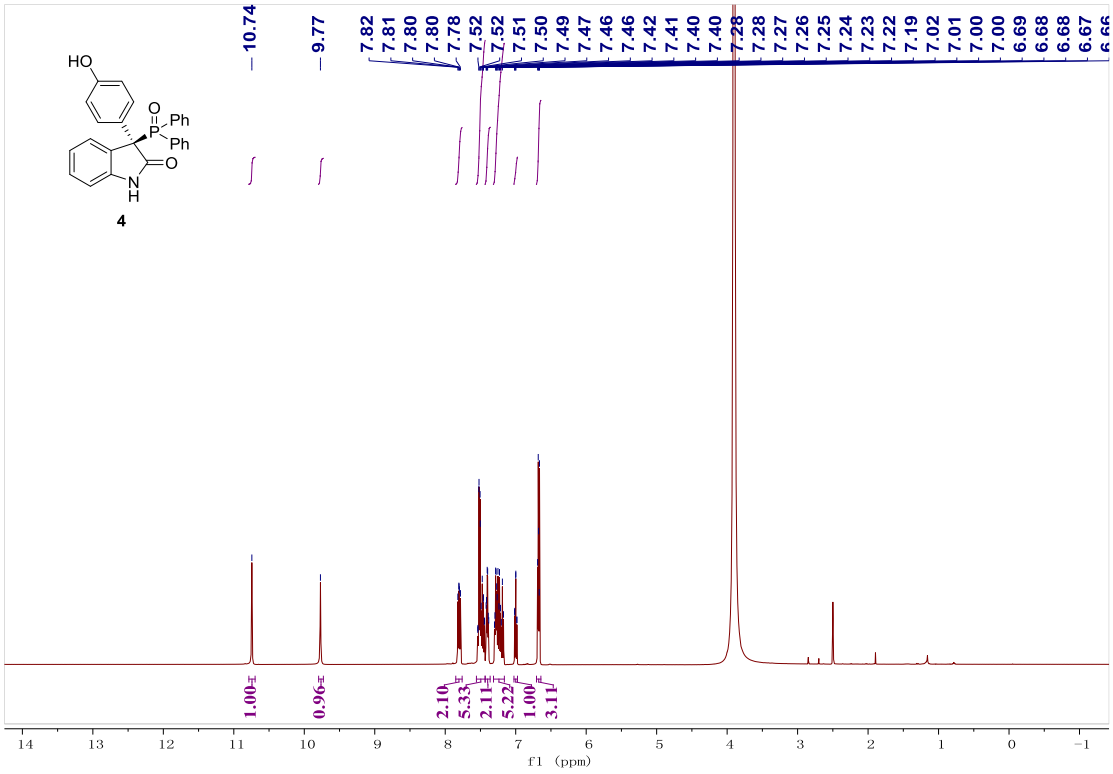

HO
O
P
Ph
Ph
O
N
H
3z
27.57
50 130 110 90 70 50 30 10 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230 −2
f1 (ppm)



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.973	61.25	1358.339	49.876
2	19.307	25.96	1365.105	50.124
Total:		87.21	2723.444	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	6.973	315.97	6010.459	90.754
2	19.290	12.21	612.331	9.246
Total:		328.18	6622.790	100.0000


HO
O
P
Ph
Ph
O
N
H
4
10.74
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7.82
7.81
7.80
7.80
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7.51
7.50
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7.47
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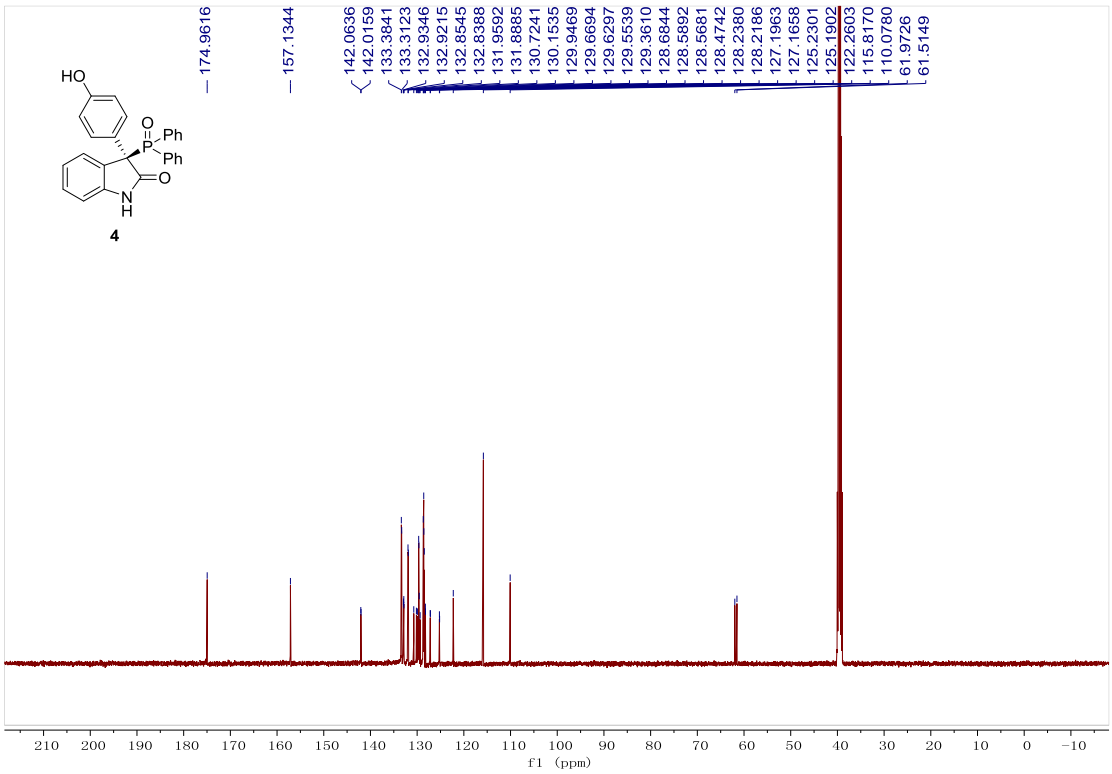
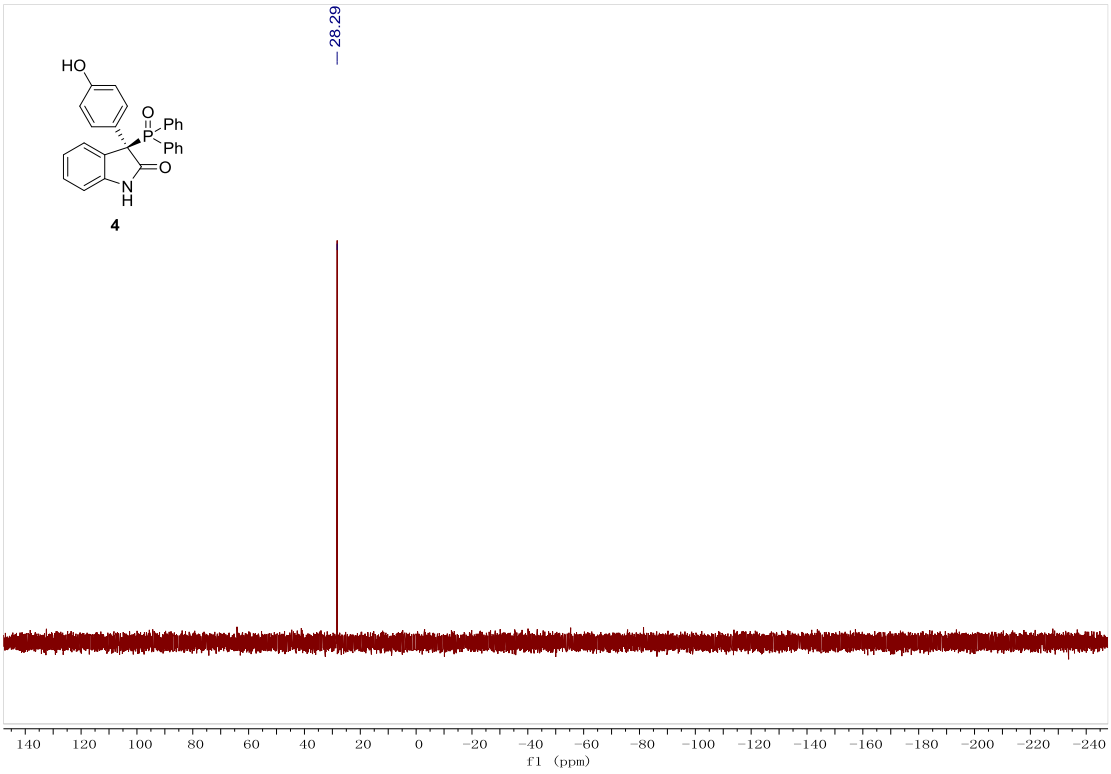
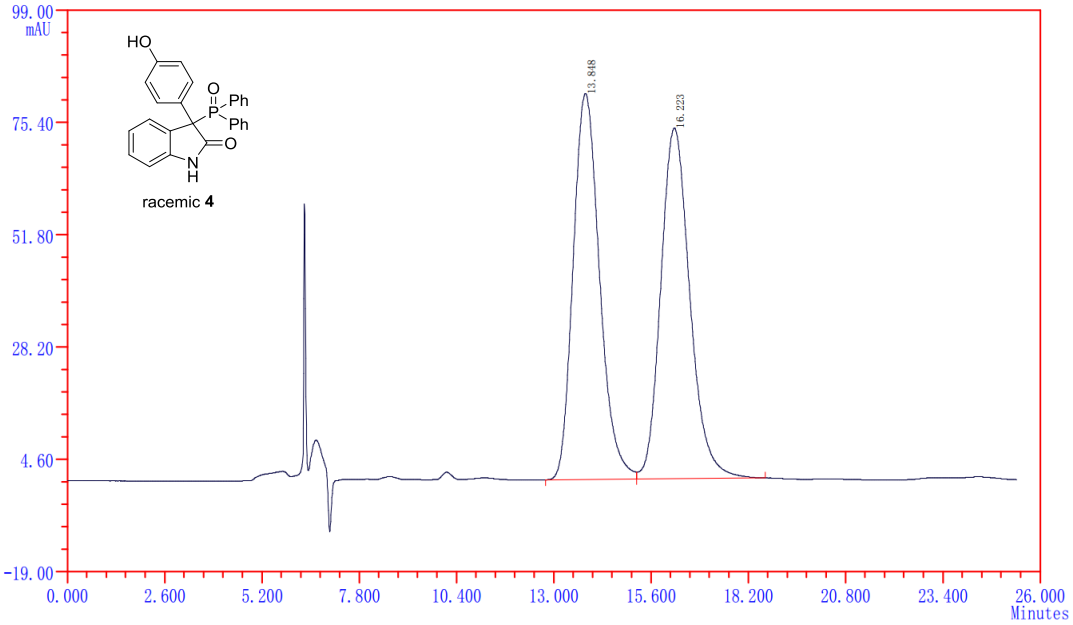
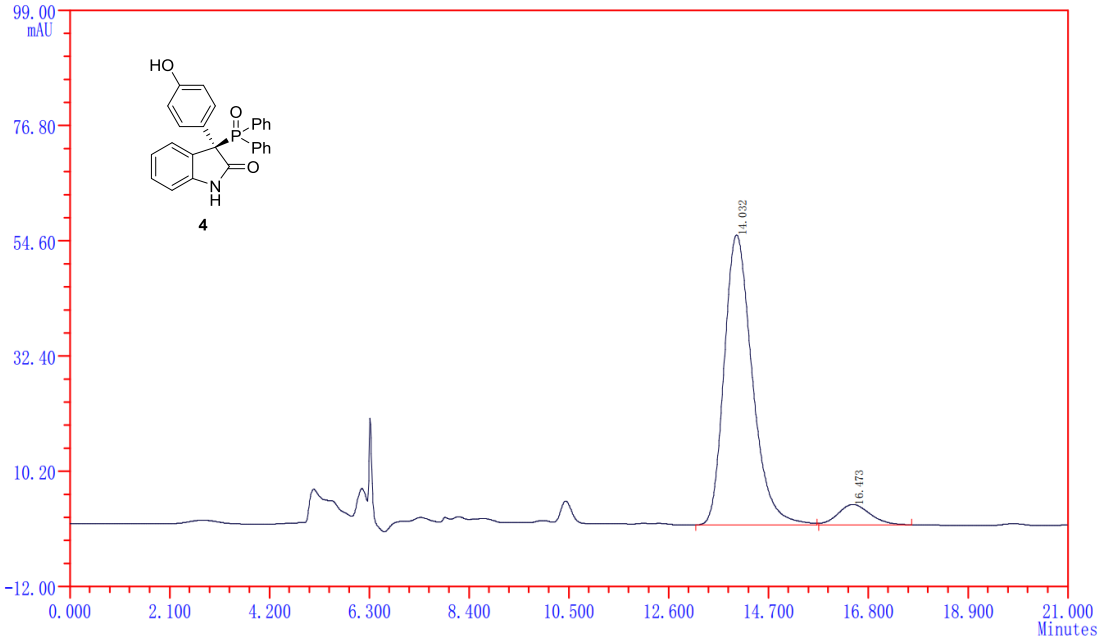
7.46
7.42
7.41
7.40
7.40
7.28
7.28
7.27
7.26
7.25
7.24
7.23
7.22
7.19
7.02
7.01
7.00
7.00
6.69
6.68
6.68
6.67
1.00
0.96
2.10
5.33
2.11
5.22
1.00
3.11
f1 (ppm)


HO
O
P
Ph
Ph
O
N
H
4
174.9616
157.1344
142.0636
142.0159
133.3841
133.3123
132.9346
132.9215
132.8545
132.8388
131.9592
131.8885
130.7241
130.1535
129.9469
129.6694
129.6297
129.5539
129.3610
128.6844
128.5892
128.5681
128.4742
128.2380
128.2186
127.1963
127.1658
125.2301
125.1902
122.2603
115.8170
110.0780
61.9726
61.5149
f1 (ppm)





Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	13.848	81.12	3985.562	49.910
2	16.223	73.69	3999.863	50.090
Total:		328.18	7985.425	100.0000



Peak #	RetTime [Min]	Height [mAu]	Area [mAu*s]	Area %
1	14.032	55.84	2293.949	92.587
2	16.473	3.91	183.670	7.413
Total:		59.75	2477.619	100.0000