Supporting Information

of

A Facile and Practical Preparation for P-Chiral Phosphine Oxides

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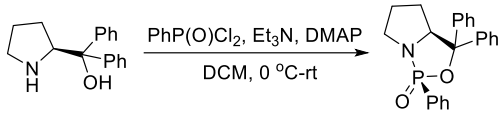
1. General Considerations.

All reactions were carried out under the designated conditions. Unless otherwise noted, commercialized reagents were used without further purifications. Toluene and hexafluorobenzene were purchased from Sigma-Aldrich Chemical Co. All other solvents were purified and dried according to standard methods prior to use.

^{1}H NMR, ^{19}F NMR and ^{13}C NMR data were recorded on a Bruker-Ultrashield PLUS 400 or 500 NMR Agilent spectrometer with Chloroform-d as the solvent. ^{1}H chemical shifts were referenced to Chloroform-d at 7.26 ppm. ^{13}C chemical shifts were referenced to Chloroform-d at 77.16 ppm and obtained with ^{1}H decoupling. Multiplicities are abbreviated as follows: singlet (s), doublet (d), triplet (t), quartet (q), doublet-doublet (dd), quintet (quint), sextet (sextet), septet (septet), multiplet (m), and broad (br). MS was measured on Agilent 7890A/5975C Series GC/MSD mass spectrometer. HPLC yield were determined on Agilent 1200 Infinity Series.

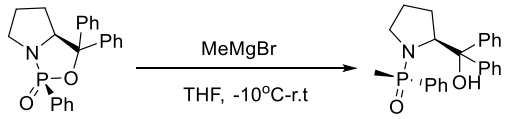
2. General procedures for Substrates 2



1 **2a**

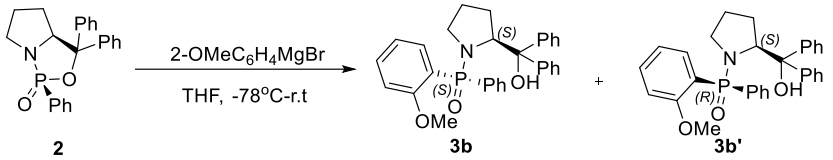
2a [1]**:** A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** to a stirred solution of *S*-Diphenylprolinol (**1**, 1 equiv) in dry DCM was added triethylamine (3 equiv) followed by 4-Dimethylaminopyridine (DMAP, 0.3 equiv). To the mixture at 0 ℃ was added Phenylphosphonic dichloride (1.5 equiv) and the mixture remained at 0 ℃. After adding the Phenylphosphonic dichloride, the cooling bath was removed and the solution was stirred at r.t. overnight (20 h). The mixture was carefully quenched with sat. $NaHCO_3$. The water layer was washed with DCM for three times. The organic layer was washed with sat. $NaHCO_3$ for three times, dried over sodium sulfate, and concentrated. The residue was slurried by EA and the crude product was recrystallized with hexane: DCM= 1:3 to give the substrate **2a** as yellow solid.

3. General procedures for Substrates 3



2 **3a**

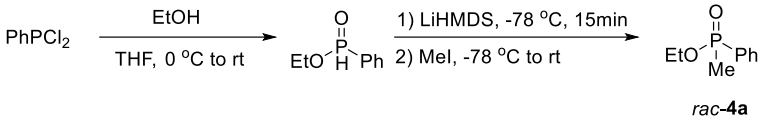
3a [2]**:** A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** (1*S*,3α*S*)-1,3,3-triphenyltetrahydro-3H-pyrrolo[1,2-c][1,3,2]oxazaphosphole 1-oxide (**2a**, 1 equiv) was solved in dry THF. To the mixture at -10 ℃ was added Methyl magnesium bromide (1 equiv) and the mixture remained at -10 ℃. After adding the Methyl magnesium bromide, the cooling bath was removed and the solution was stirred at rt overnight (12 h). The mixture was carefully quenched with sat. NH_4Cl at 0℃. The organic layer was separated and the aqueous layer was washed with EA (once) and DCM (twice), dried over sodium sulfate, and concentrated. The residue was slurried by EA to give the substrate **3a** as pale yellow solid.



3b [3]**:** Step A： A 1L-Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, Mg turnings (1.1 equiv.), iodine (a few grains) and THF (20 mL) were added. In a separate flask under N_2 atmosphere, a solution of 2-methoxy bromobenzene (5.0 equiv.) in THF (20 mL) was prepared. A few drops of the aryl bromide solution in THF was added to the tube containing Mg, and the mixture was gently heated with a heat gun until the solution color changed from brown to colorless. The remaining aryl bromide solution was then slowly added. Upon complete addition, the mixture was stirred for 1-2 hr.

Step B: A 1L-Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** (1*S*,3α*S*)-1,3,3-triphenyltetrahydro-3H-pyrrolo[1,2-c][1,3,2]oxazaphosphole 1-oxide (**2a**, 1 equiv) was solved in dry THF. To the mixture at -10 ℃ was added 2-Methoxyphenyl Magnesium Bromide (1 equiv) and the mixture remained at 0 ℃. After adding the 2-Methoxyphenyl Magnesium Bromide, the cooling bath was removed and the solution was stirred at r.t. overnight (12 h). The mixture was carefully quenched with sat. NH_4Cl at 0℃. The organic layer was separated and the aqueous layer was washed with EA (once) and DCM (twice), dried over sodium sulfate, and concentrated. The residue was purified by silica gel column chromatography and the crude product was slurried by hexane: DCM= 1:3 to give the substrate **3b** and **3b'** as a white solid.

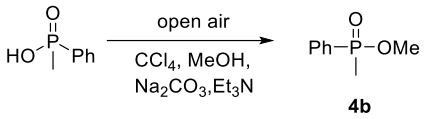
4. General procedures for racemic Substrates 4



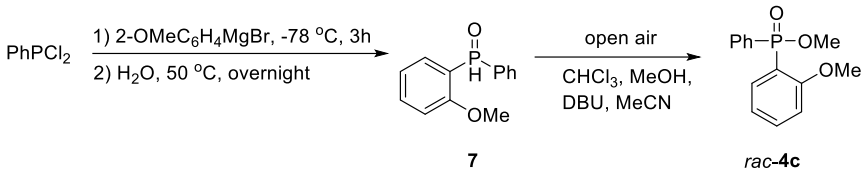
rac-**4a**

Ethyl Phenylphosphinate [4]**:** A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** Phenyl Phosphorus Dichloride (**7a**, 1 equiv) was solved in dry THF. To the mixture at 0 ℃ was added dry ethanol (1 equiv) and the mixture remained at 0 ℃. After adding the dry ethanol, the cooling bath was removed and the solution was stirred at rt overnight (12 h). The mixture was concentrated to give the substrate **7a** as colorless oil. It showed characterization data in full agreement with previously reported data[4].

rac-**4a** [5]: A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** ethyl phenylphosphinate (1 equiv) was solved in dry THF. To the mixture at -78 ℃ was added dropwise LiHMDS (Lithium bis(trimethylsilyl)amide，1 equiv) and the mixture remained at -78 ℃. After adding the Ethanol, the cooling bath was remained for 15 minutes and the MeI（Iodomethane，1 equiv）was added dropwise，then the cooling bath was removed and the mixture stirred at rt overnight (12 h). The organic layer was separated and the aqueous layer was washed with EA (once) and DCM (twice), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to provide the to give the substrate *rac*-**4a** as light yellow oil.



rac-**4b** [6]**:** A mixture of methyl(phenyl)phosphinic acid (1 mmol), Na_2CO_3 (2 mmol), CCl_4 (3 mmol), Et_3N (1 mmol) and CuI (0.1 mmol) in MeOH (1 ml) was stirred at 80 ºC under air atmosphere for 12 h. Removal of the solvent under a reduced pressure gave the crude product; pure product was obtained by passing the crude product through a short silica gel column using EtOAc as eluent to give the substrate *rac*-**4b** as light yellow oil and *rac*-**4c** as dark brown liquid.



7 *rac*-**4c**

7: A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere**,** Phenyl Phosphorus Dichloride (1 equiv) was solved in dry THF. To the mixture at -78 ℃ was added 2-$OMeC_6H_4MgBr$ (1 equiv) and the mixture remained at -78 ℃. After adding the 2-$OMeC_6H_4MgBr$, the cooling bath was removed and the solution was stirred at rt for 3h. After ^{31}P-NMR showed that the reaction was over， water (10 equiv) was added. The mixture was heated to 50℃ overnight. After ^{31}P-NMR showed that the reaction was over，the mixture was washed with EA (once) and DCM (twice), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to provide the to give the substrate **7** as light yellow oil.

rac-**4d** [7]: A Schlenk tube was dried under vacuum. Under an air atmosphere**,** To a solution of (2-methoxyphenyl)(phenyl)phosphine oxide (**7b**, 40 mg, 0.2 mmol) and methanol (46mg, 1 mmol) in CH_3CN (2 mL) were added $CHCl_3$ (24 mg, 0.2 mmol) and DBU (46mg, 0.3 mmol). The mixture was stirred at 80 ℃ under air atmosphere for 3 h. The reaction mixture was then concentrated under reduced pressure. The crude product was purified by flash column chromatography on silica gel with petrol /ethyl acetate (2:1) to afford substrate *rac*-**4d** (48 mg, 98%) as a colorless oil.

5. General procedures for optimization of acidic alcoholysis of 3[8]

A Schlenk tube was dried under vacuum. After cooling, the flask was placed under N_2 atmosphere. Under a N_2 atmosphere**,** ((*S*)-2-(hydroxydiphenylmethyl)pyrrolidin-1-yl)(methyl)(phenyl)phosphine oxide (**3**, 1 mmol, 1 equiv) was solved in ROH (2 mL). The resulting mixture was cooled to T ℃. A solution of H_2SO_4(x mmol, x eq) in EtOH (2 mL) was added dropwise into the mixture (**Caution:** A lot of heat will be released when preparing the corresponding alcohol solution of concentrated sulfuric acid. It can be dropped after cooling to room temperature. The rate of dropping must be slow enough to avoid the mixture from heating). The mixture was stirred at T ℃ for t h. After t h, the mixture was quenched with sat. $NaHCO_3$ to adjust pH to 7. The mixture was washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give the yield of **4a**. The enantiomeric purity of **4a** was determined by chiral HPLC.

6. General procedures for chiral Substrates 4

A Schlenk tube was dried under vacuum. After cooling, the flask was placed under N_2 atmosphere. Under a N_2 atmosphere**,** ((*S*)-2-(hydroxydiphenylmethyl)pyrrolidin-1-yl)(methyl)(phenyl)phosphine oxide (**3**, 1 mmol, 1 equiv) was charged EtOH (2 mL). The resulting mixture was cooled to -78℃. A solution of H_2SO_4(1 mmol, 1 eq) in EtOH (2 mL) was added dropwise into the mixture (**Caution:** A lot of heat will be released when preparing the ethanol solution of concentrated sulfuric acid. It can be dropped after cooling to room temperature. The rate of dropping must be slow enough to avoid the mixture from heating). The mixture was stirred at -78 ℃ for 2h. After 2h, the mixture was quenched with sat. $NaHCO_3$ to adjust pH to 7. The mixture was washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give yield of **4a**. The enantiomeric purity of **4a** was determined by chiral HPLC.

7. General procedures for racemic substrates 5

All Grignard reagents were prepared from aryl bromides via Mg insertion in the presence of iodium or purchased from commercial sources.

Step A： A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, Mg turnings (5.5 mmol, 5.5 equiv.), iodine (a few grains) and THF (2 mL) were added. In a separate flask under Ar atmosphere, a solution of aryl bromide (5 mmol, 5.0 equiv.) in THF (2 mL) was prepared. A few drops of the aryl bromide solution in THF was added to the tube containing Mg, and the mixture was gently heated with a heat gun until the solution color changed from brown to colorless. The remaining aryl bromide solution was then slowly added. Upon complete addition, the mixture was stirred for 1-2 hr.

Step B: A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, ethyl methyl (phenyl) phosphinate (*rac*-**4a** or *rac*-**4b**, 1 mmol, 1 equiv) was solved in THF (3 mL). Grignard reagents (5 mmol, 5 eq) was added dropwise into the mixture at room temperature. The mixture was stirred at 70℃overnight. After TLC showed the reaction was over, the mixture was cooled to 0 ℃ and quenched with sat. NH_4Cl. The mixture was washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give yield of *rac*-**5**.

8. General procedures for chiral substrates 5[9]

All Grignard reagents were prepared from aryl bromides via Mg insertion in the presence of iodium or purchased from commercial sources.

Step A： A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, Mg turnings (5.5 mmol, 5.5 equiv.), iodine (a few grains) and THF (2 mL) were added. In a separate flask under N_2 atmosphere, a solution of aryl bromide (5 mmol, 5.0 equiv.) in THF (2 mL) was prepared. A few drops of the aryl bromide solution in THF was added to the tube containing Mg, and the mixture was gently heated with a heat gun until the solution color changed from brown to colorless. The remaining aryl bromide solution was then slowly added. Upon complete addition, the mixture was stirred for 1-2 hr.

Step B: A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, ethyl methyl (phenyl) phosphinate (**4a** or **4b**, 1 mmol, 1 equiv) was solved in THF (3 mL). Grignard reagents (5 mmol, 5 equiv) was added dropwise into the mixture at room temperature. The mixture was stirred at room temperature overnight. After TLC showed the reaction was over, the mixture was cooled to 0 ℃ and quenched with sat. NH_4Cl. The mixture was washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give yield of **5**. The enantiomeric purity of **5** was determined by chiral HPLC.

9. Gram-scale synthesis of 5b.

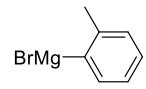
Step A：A 1L-Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, Mg turnings (597.63 mmol, 5.5 equiv.), iodine (a few grains) and THF (200 mL) were added. In a separate flask under N_2 atmosphere, a solution of 2-methoxy bromobenzene (543.30 mmol, 5.0 equiv.) in THF (2 mL) was prepared. A few drops of the aryl bromide solution in THF was added to the tube containing Mg, and the mixture was gently heated with a heat gun until the solution color changed from brown to colorless. The remaining aryl bromide solution was then slowly added. Upon complete addition, the mixture was stirred for 1-2 hr.

Step B: A 1L-Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, ethyl methyl (phenyl) phosphinate (**4a**, 108.66 mmol, 1 equiv) was solved in THF (3 mL). 2-Methoxyphenyl Magnesium Bromide (543.30 mmol, 5 equiv) in was added dropwise into the mixture at room temperature. The mixture was stirred at room temperature overnight. After TLC showed the reaction was over, the mixture was cooled to 0 ℃ and quenched with sat. NH_4Cl. The mixture was washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give yield of **5b**. The enantiomeric purity of **5b** was determined by chiral HPLC.

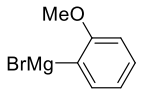
10. Synthesis of substrate 6z[10]

A Schlenk tube was dried under vacuum. After cooling, the tube was placed under N_2 atmosphere. Under a N_2 atmosphere, to a stirred solution of (R)-cyclopropyl(methyl)(phenyl)phosphine oxide (**5z**, 1 mmol, 1 equiv) in dry THF was added triethylamine (5 mmol，5 equiv). Trichlorosilane (5 mmol, 5 equiv) in was added dropwise into the mixture at room temperature. The mixture was stirred at 80 ℃ for 5h. After ^{31}P-NMR showed the reaction was over, sulfur was added. The mixture was stirred for overnight. After TLC showed the reaction was over, the mixture was cooled to 0 ℃ and quenched with NaOH. The mixture was heated at 60 ℃ for 30 mintues，and cooled to room room temperature，washed with DCM (3 times), dried over sodium sulfate, concentrated, and purified by silica gel column chromatography to give crude **6z**. The crude product was recrystallized with methanol to give the product **6z** as colorless crystal. It showed characterization data in full agreement with previously reported data[11].

The following Grignard reagents which were used above were synthesized using the above procedures (step A)



5a



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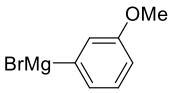

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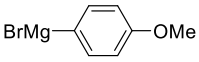

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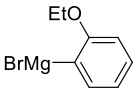

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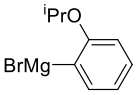

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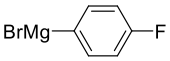

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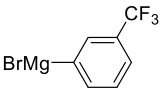

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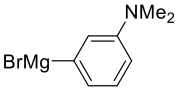

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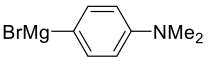

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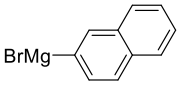

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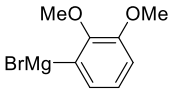

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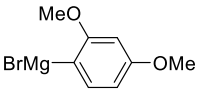

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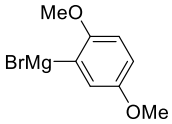

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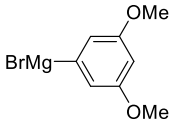

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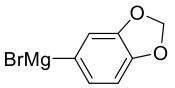

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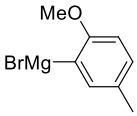

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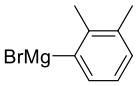

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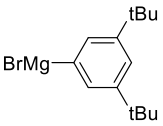

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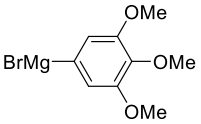

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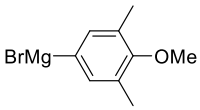

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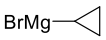
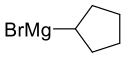
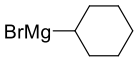


5aa



5ab

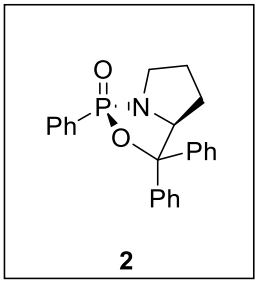


5ac

The following Grignard reagents which were purchased by Sigma-Aldrich

MeMgBr	EtMgBr	nPrMgBr	iPrMgBr	nBuMgBr	sBuMgBr
3.0 M in THF	3.4 M in THF	1.0 M in THF	1.3 M in THF	2 M in THF	2 M in THF
3'	**5v**	**5w**	**5x**	**5y**	**5z**

11. Analytical data of Substrates 2-7



2

Name:(1*R*,3*αS*)-1,3,3-triphenyltetrahydro-3H-pyrrolo[1,2-c][1,3,2]oxazaphosphole 1-oxide

Physical State: pale yellow solid

Yield:80% yield

^{1}H NMR (400 MHz, Chloroform-d): δ 1.50 – 1.60 (m, 1H), 1.60 – 1.69 (m, 1H), 1.69 – 1.78 (m, 2H), 1.78 – 1.88 (m, 1H), 3.00 (ddt, *J* = 12.5, 10.2, 7.1 Hz, 1H), 3.73 (tdd, *J* = 10.4, 7.9, 4.6 Hz, 1H), 4.70 (dt, *J* = 12.9, 6.5 Hz, 1H), 7.25 (d, *J* = 7.8 Hz, 1H), 7.27 – 7.37 (m, 7H), 7.38 – 7.48 (m, 3H), 7.50 – 7.60 (m, 4H).

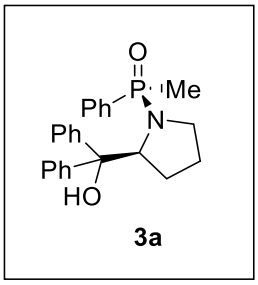
^{13}C NMR (101 MHz, Chloroform-d): δ 26.37 (d, *J* = 2.4 Hz, 1C), 30.25 (d, *J* = 3.3 Hz, 1C), 44.85, 71.37 (d, *J* = 7.4 Hz, 1C), 88.75, 126.72 (d, *J* = 17.8 Hz, 1C), 127.46, 128.02, 128.18, 128.34, 130.37, 131.72 (d, *J* = 10.7 Hz, 1C), 132.18, 141.24 (d, *J* = 2.9 Hz, 1C), 143.72 (d, *J* = 4.7 Hz, 1C).

^{31}P NMR (162 MHz, Chloroform-d) δ 35.21

ESI-MS: m/z 376.35 $[M+H]^+$, 398.30 $[M+Na]^+$

HRMS (ESI) calculated for [M+Na, $C_{23}H_{22}O_2NaNP]^+$: 398.1280; found: 398.1274.

$[\alpha]_D^{25}$: -52.0240 (c = 1.3720g/100 ml , $CHCl_3$).



3a

Name:(*R*)-((*S*)-2-(hydroxydiphenylmethyl)pyrrolidin-1-yl)(methyl)(phenyl)phosphine oxide

Physical State: pale yellow solid，

Yield: 65% yield，

^{1}H NMR (500 MHz, Chloroform-d) δ 1.00 (ddd, *J* = 12.9, 8.0, 5.5 Hz, 1H), 1.43 (dddd, *J* = 14.9, 12.7, 8.4, 6.1 Hz, 1H), 1.61 (d, *J* = 13.9 Hz, 3H), 1.95 – 2.10 (m, 2H), 2.63 (dq, *J* = 9.6, 7.0 Hz, 1H), 2.97 (dd, *J* = 8.9, 5.5 Hz, 1H), 4.69 (td, *J* = 8.7, 4.0 Hz, 1H), 6.40 (s, 1H), 7.21 – 7.33 (m, 6H), 7.41 (d, *J* = 7.7 Hz, 2H), 7.45 – 7.56 (m, 5H), 7.70 (dd, *J* = 11.7, 7.4 Hz, 2H).

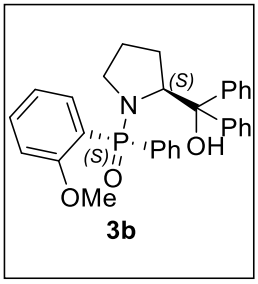
^{13}C NMR (126 MHz, Chloroform-d) δ 14.68, 15.43, 24.83 (d, *J* = 5.2 Hz, 1C), 30.75 (d, *J* = 4.5 Hz, 1C), 48.71 (d, *J* = 3.5 Hz, 1C), 66.59, 106.57, 126.96 (d, *J* = 17.8 Hz, 1C), 127.29, 127.91 (d, *J* = 12.3 Hz, 1C), 128.54, 128.65, 128.75, 130.43 (d, *J* = 9.8 Hz, 1C), 131.80 (d, *J* = 3.2 Hz, 1C), 133.04 (d, *J* = 116.3 Hz, 1C), 145.53 (d, *J* = 213.7 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 39.55.,

ESI-MS: m/z 414.45 $[M+Na]^+$;

HRMS (ESI) calculated for $[M+Na, C_{24}H_{26}O_2NaNP]^+$: 414.1593; found: 414.1599.

$[\alpha]_D^{25}$: -200.9557 (c = 1.7320g/100ml, $CHCl_3$).



3b

Name:(*S*)-((*S*)-2-(hydroxydiphenylmethyl)pyrrolidin-1-yl)(2-methoxyphenyl)(phenyl)phosphine oxide (3b):

Physical State: white solid

Yield: 35% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 0.97 – 1.08 (m, 1H), 1.33 – 1.46 (m, 1H), 2.00 – 2.05 (m, 1H), 2.06 – 2.21 (m, 2H), 3.00 (qd, *J* = 9.5, 4.1 Hz, 1H), 3.73 (s, 3H), 4.68 (td, *J* = 8.6, 4.7 Hz, 1H), 6.99 (dd, *J* = 8.4, 5.5 Hz, 1H), 7.09 – 7.14 (m, 1H), 7.19 – 7.25 (m, 2H), 7.27 – 7.33 (m, 4H), 7.36 – 7.42 (m, 4H), 7.46 – 7.60 (m, 7H), 7.94 (ddd, *J* = 13.2, 7.5, 1.8 Hz, 1H).

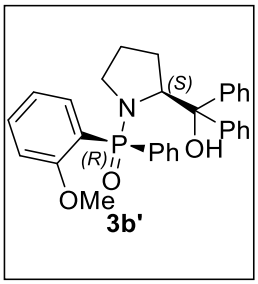
^{13}C NMR (126 MHz, Chloroform-d) δ 24.75 (d, *J* = 4.9 Hz, 1C), 31.00 (d, *J* = 5.3 Hz, 1C), 50.06 (d, *J* = 5.6 Hz, 1C), 55.10, 67.62 (d, *J* = 3.4 Hz,1C), 80.08, 110.64 (d, *J* = 7.8 Hz,1C), 117.72, 118.65, 121.13 (d, *J* = 12.2 Hz, 1C), 126.72, 126.89, 127.02, 127.80, 128.02 – 128.49 (m), 129.08, 131.23 (d, *J* = 10.4 Hz), 131.64 – 131.98 (m), 132.75, 134.22, 137.01 (d, *J* = 6.7 Hz, 1C), 145.38 (d, *J* = 219.2 Hz).

^{31}P NMR (202 MHz, Chloroform-d) δ 32.60.,

ESI-MS: m/z 484.35 $[M+H]^+$, 506.35 $[M+Na]^+$;

HRMS (ESI) calculated for$[M+H, C_{30}H_{31}O_3NP]^+$: 484.2036; found: 484.2036 $[M+Na, C_{30}H_{30}O_3NaNP]^+$: 506.1856; found: 506.1860.

$[\alpha]_D^{25}$: -48.4027 (c = 0.4760g/100 ml, $CHCl_3$).



3b'

Name:(*R*)-((*S*)-2-(hydroxydiphenylmethyl)pyrrolidin-1-yl)(2-methoxyphenyl)(phenyl)phosphine oxide (3b')

Physical State: pale yellow solid

Yield: 45% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.14 (ddd, *J* = 17.0, 8.2, 4.4 Hz, 1H), 1.23 – 1.43 (m, 2H), 1.98 (dtd, *J* = 13.1, 7.8, 5.0 Hz, 1H), 2.14 (ddt, *J* = 14.2, 9.0, 4.5 Hz, 1H), 2.45 (ddt, *J* = 10.3, 8.4, 7.0 Hz, 1H), 2.94 (dtd, *J* = 10.0, 8.4, 3.8 Hz, 1H), 3.71 (s, 3H), 4.96 (td, *J* = 8.2, 5.0 Hz, 1H), 6.64 (s, 1H), 6.86 – 6.92 (m, 1H), 6.96 (tdd, *J* = 7.5, 2.5, 0.9 Hz, 1H), 7.12 – 7.25 (m, 6H), 7.36 – 7.45 (m, 4H), 7.45 – 7.52 (m, 5H), 7.62 – 7.69 (m, 2H).

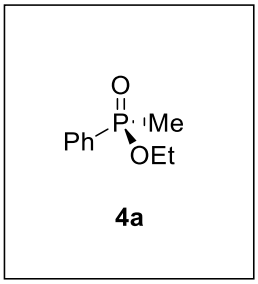
^{13}C NMR (126 MHz, Chloroform-d) δ 25.19 (d, *J* = 5.5 Hz, 1C), 30.73 (d, *J* = 5.5 Hz, 1C), 49.81 (d, *J* = 4.6 Hz, 1C), 55.32, 67.10 (d, *J* = 3.2 Hz, 1C), 80.18, 110.93 (d, *J* = 7.7 Hz, 1C), 118.89, 119.92, 120.83 (d, *J* = 12.5 Hz, 1C), 126.53, 126.82, 127.10, 127.73, 127.87, 128.27 (d, *J* = 13.4 Hz, 1C), 128.49, 131.32 (d, *J* = 10.2 Hz, 1C), 131.42, 132.16, 133.15, 134.10, 134.91 (d, *J* = 7.0 Hz, 1C), 145.50 (d, *J* = 184.2 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 31.18.,

ESI-MS: m/z 506.25 $[M+Na]^+$;

HRMS (ESI) calculated for$[M+H, C_{30}H_{31}O_3NP]^+$: 484.2036; found: 484.2036 $[M+Na, C_{30}H_{30}O_3NaNP]^+$: 506.1856; found: 506.1853

$[\alpha]_D^{25}$: -72.7482 (c = 05480g/100 ml, $CHCl_3$).



4a

Name: ethyl (*S*)-methyl(phenyl)phosphinate

Physical State: yellow oil

Yield: 95% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.12 (t, *J* = 7.1 Hz, 3H), 1.50 (d, *J* = 14.6 Hz, 3H), 3.66 (dp, *J* = 10.1, 7.2 Hz, 1H), 3.87 – 3.93 (m, 1H), 7.32 (ddd, *J* = 8.5, 6.8, 3.3 Hz, 2H), 7.39 (td, *J* = 7.3, 1.5 Hz, 1H), 7.64 (ddd, *J* = 12.0, 8.2, 1.5 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 15.35, 16.29 (d, *J* = 6.6 Hz, 1C), 60.32 (d, *J* = 6.7 Hz, 1C), 128.51 (d, *J* = 13.1 Hz, 2C), 131.07 (d, *J* = 10.1 Hz, 2C), 132.12, 170.86

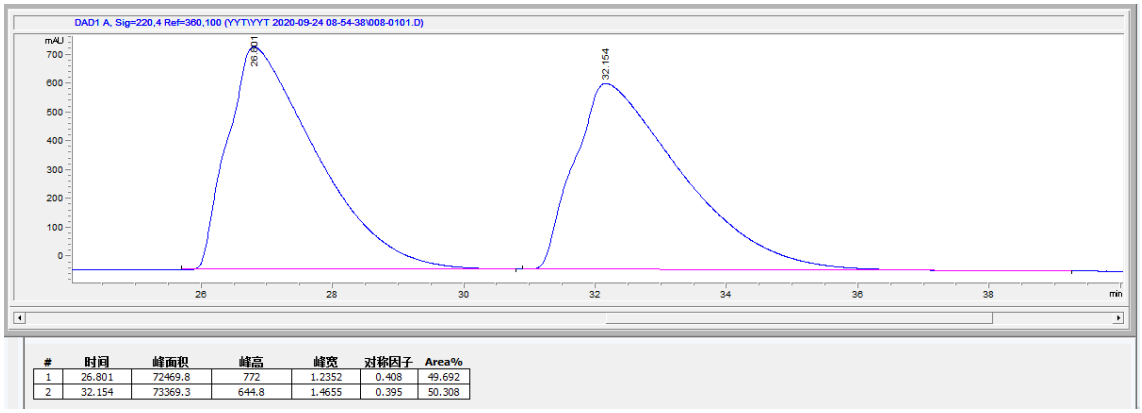
^{31}P NMR (202 MHz, Chloroform-d) δ 42.67..,

ESI-MS: m/z 369.15 $[2M+H]^+$, 391.30 $[2M+Na]^+$

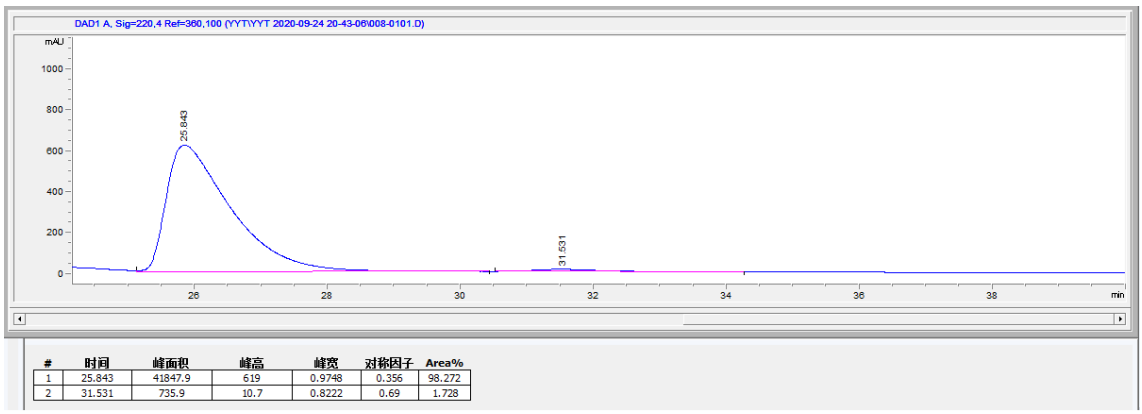
HRMS (ESI) calculated for $[M+H, C_{19}H_{13}O_2NaP]^+$: 207.0545; found: 207.0548.

$[\alpha]_D^{25}$: -4.3518 (c = 1.0560g/100ml, $CHCl_3$).

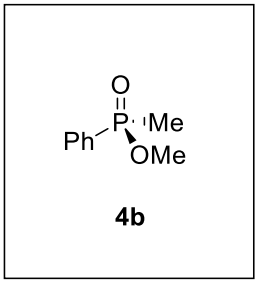
Chiral HPLC conditions: OD-H, *i*-PrOH-hexane 2.5/97.5, flow rate 0.8 mL/min, 220 nm. t_1 = 26 min, t_2 =32 min . 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	26.801	72469.8	772	1.2352	0.408	49.692
2	32.154	73369.3	644.8	1.4655	0.395	50.308



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	25.843	41847.9	619	0.9748	0.356	98.272
2	31.531	735.9	10.7	0.8222	0.69	1.728



4b

Name: methyl (*S*)-methyl(phenyl)phosphinate

Physical State: yellow oil

Yield: 90% yield

^{1}H NMR (500 MHz, Chloroform-d) δ1.66 (d, *J* = 14.6 Hz, 3H), 3.59 (d, *J* = 11.3 Hz, 3H), 7.46 – 7.51 (m, 2H), 7.53 – 7.58 (m, 1H), 7.77 (ddt, *J* = 12.0, 6.9, 1.4 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 15.54 (d, *J* = 102.5 Hz, 1C), 50.97 – 51.15 (m, 1C), 128.72 (d, *J* = 12.5 Hz, 2C), 131.33 (d, *J* = 10.2 Hz, 2C), 132.37, 170.86.

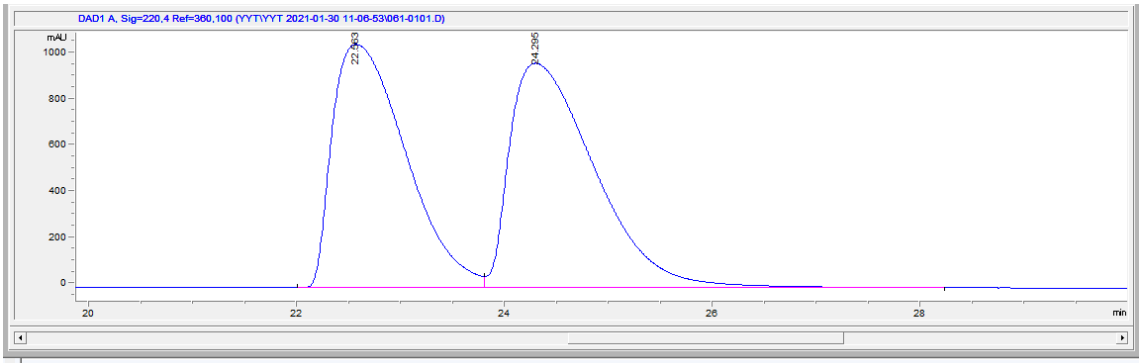
^{31}P NMR (202 MHz, Chloroform-d) δ 43.10

ESI-MS: m/z 170.85 $[M+H]^+$, 192.90 $[M+Na]^+$

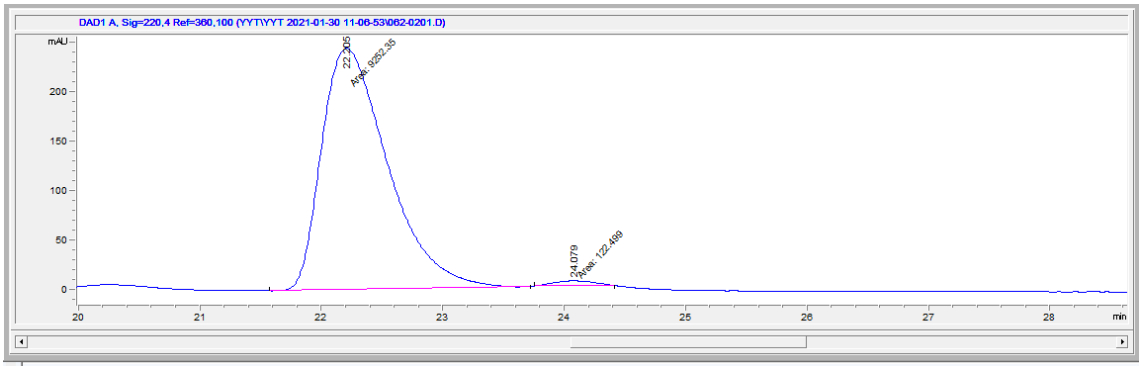
HRMS (ESI) calculated for [M+H, $C_8H_{12}O_2P]^+$: 171.0569; found: 171.0573. calculated for [M+Na, $C_8H_{11}O_2PNa]^+$: 193.0389; found: 193.0394.

$[\alpha]_D^{25}$:-4.9510 (c = 0.8240g/100 ml, $CHCl_3$).

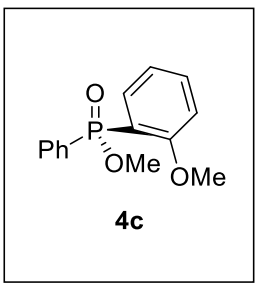
Chiral HPLC conditions: OD-H, *i*-PrOH-hexane 5/95, flow rate 0.8 mL/min, 220 nm. t_1 = 22.363 min (*S*), t_2 =24.295 min (*R*). 98% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	22.563	51749.1	1054.9	0.7743	0.443	48.333
2	24.295	55319.1	973.1	0.7793	0.409	51.667



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	22.205	9252.4	244.3	0.6313	0.587	98.693
2	24.079	122.5	5.1	0.3987	0.872	1.307



4c

Name: methyl (*S*)-(2-methoxyphenyl)(phenyl)phosphinate

Physical State: yellow oil

Yield: 80% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 3.70 (s, 3H), 3.74 (d, *J* = 11.4 Hz, 3H), 6.86 (dd, *J* = 8.3, 6.0 Hz, 1H), 7.06 (tdd, *J* = 7.5, 2.6, 0.9 Hz, 1H), 7.38 – 7.46 (m, 2H), 7.47 – 7.56 (m, 2H), 7.80 – 7.89 (m, 2H), 7.97 (ddd, *J* = 13.3, 7.6, 1.8 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 51.43 (d, *J* = 5.7 Hz, 1C), 55.53, 111.24 (d, *J* = 7.9 Hz, 2C), 118.85 (d, *J* = 135.6 Hz, 2C), 120.65 (d, *J* = 12.4 Hz, 2C), 128.05 (d, *J* = 13.6 Hz, 1C), 131.40, 131.81 (d, *J* = 10.2 Hz, 1C), 132.52, 133.93 – 136.36 (m).

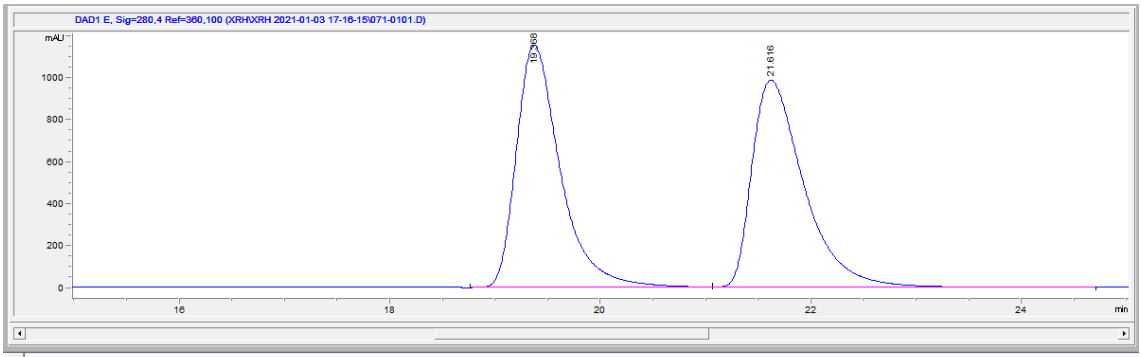
^{31}P NMR (202 MHz, Chloroform-d) δ 30.73..,

ESI-MS: m/z 263.15 $[M+H]^+$, 285.15 $[M+Na]^+$;

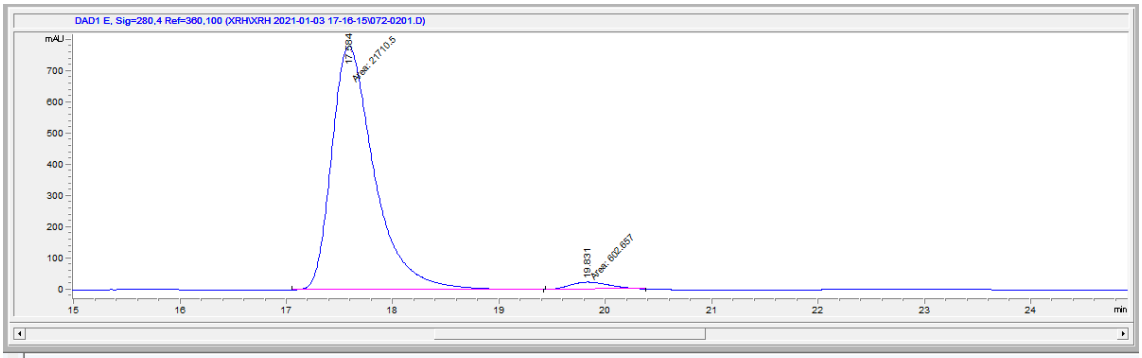
HRMS (ESI) calculated for $[M+H, C_{14}H_{16}O_3P]^+$: 263.0832; found: 263.0835. calculated for $[M+Na, C_{14}H_{15}O_3PNa]^+$: 285.0561; found: 285.0654.

$[\alpha]_D^{25}$: -25.0713 (c = 0.13g/100ml, $CHCl_3$).

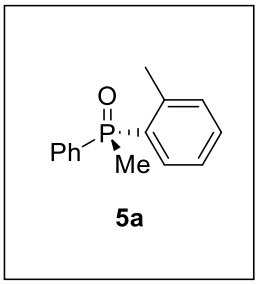
Chiral HPLC conditions: AD-3, *i*-PrOH-hexane 12.5/87.5, flow rate 0.8 mL/min, 280 nm. t_1 = 19.363 min (*S*), t_2 =19 min (*R*). 21.626% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	19.368	33596.7	1153.5	0.4418	0.629	49.769
2	21.616	33908.4	986.6	0.523	0.528	50.231



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	17.584	21710.5	780.6	0.4635	0.642	97.299
2	19.831	602.7	23.1	0.435	0.775	2.701



5a

Name: (S)-methyl(phenyl)(o-tolyl)phosphine oxide

Physical State: yellow oil

Yield: 60% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.06 (d, *J* = 12.9 Hz, 3H), 2.38 (s, 3H), 7.21 – 7.25 (m, 1H), 7.31 (t, *J* = 7.6 Hz, 1H), 7.42 – 7.48 (m, 3H), 7.52 (t, *J* = 7.3 Hz, 1H), 7.66 (td, *J* = 12.4, 11.8, 7.4 Hz, 3H).

^{13}C NMR (126 MHz, Chloroform-d) δ 17.14 (d, *J* = 73.7 Hz, 1C), 21.37 (d, *J* = 4.6 Hz, 1C), 125.64 (d, *J* = 12.3 Hz, 1C), 128.71 (d, *J* = 11.8 Hz, 1C), 130.44 (d, *J* = 9.9 Hz, 1C), 131.53 (d, *J* = 11.3 Hz, 1C), 131.68, 132.00, 132.25, 134.32 (d, *J* = 99.8 Hz, 1C), 142.17 (d, *J* = 8.1 Hz, 1C).

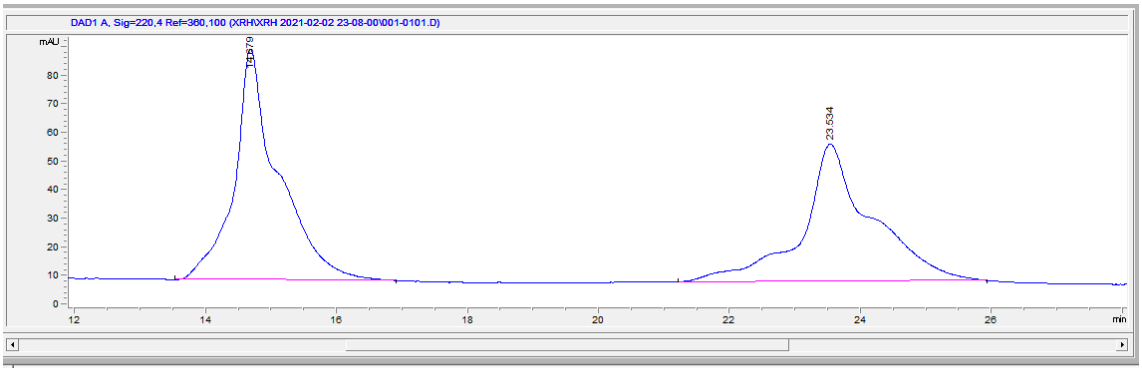
^{31}P NMR (202 MHz, Chloroform-d) δ 33.33.

ESI-MS: m/z 253.15 $[M+Na]^+$

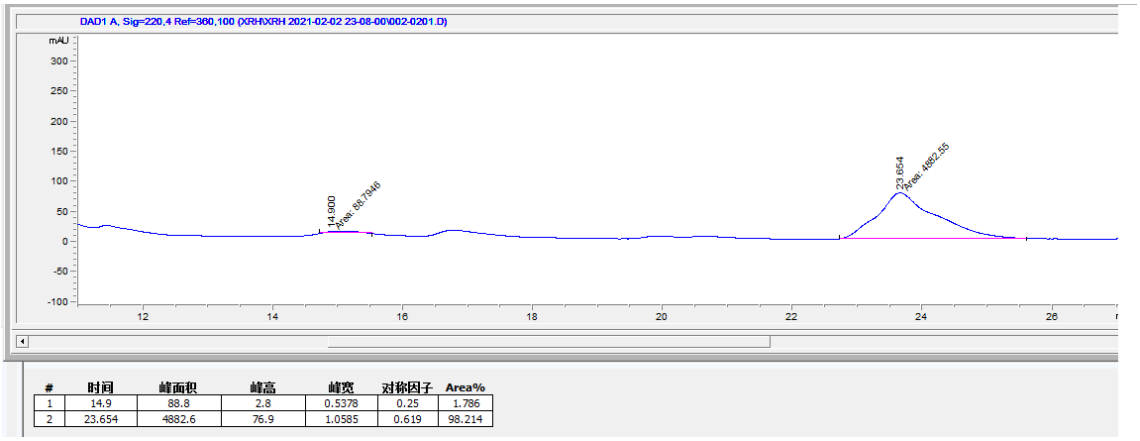
HRMS (ESI) calculated for $[M+Na, C_{14}H_{15}OPNa]^+$: 253.0753; found:253.0746.

$[\alpha]_D^{25}$: 9.1285 (c = 1.0667g/100ml, $CHCl_3$).

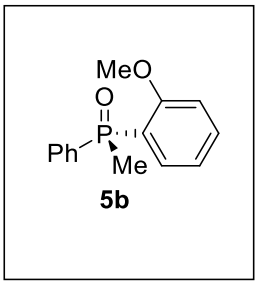
Chiral HPLC conditions: AD-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 14.679 min, t_2 =23.534 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	14.679	3795.1	80.8	0.6221	0.583	51.791
2	23.534	3532.6	48.1	0.9534	0.708	48.209



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	14.9	88.8	2.8	0.5378	0.25	1.786
2	23.654	4882.6	76.9	1.0585	0.619	98.214



5b

Name：(*S*)-(2-methoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical State: colorless solid

Yield: 70% yield

^{1}H NMR (400 MHz, Chloroform-d) δ 7.95 (ddd, *J* = 13.0, 7.5, 1.4 Hz, 1H), 7.79 – 7.66 (m, 2H), 7.52 – 7.37 (m, 4H), 7.17 – 7.05 (m, 1H), 6.88 (dd, *J* = 8.2, 5.4 Hz, 1H), 3.71 (s, 3H), 2.07 (d, *J* = 14.0 Hz, 3H).

^{13}C NMR (101 MHz, Chloroform-d) δ160.01, 134.00, 131.36, 131.74 – 129.07 (m, 3C), 128.30 (d, *J* = 12.2 Hz, 2C), 121.15 (d, *J* = 11.3 Hz, 2C), 110.99 (d, *J* = 6.5 Hz, 2C), 55.39, 16.26 (d, *J* = 75.3 Hz, 1C).

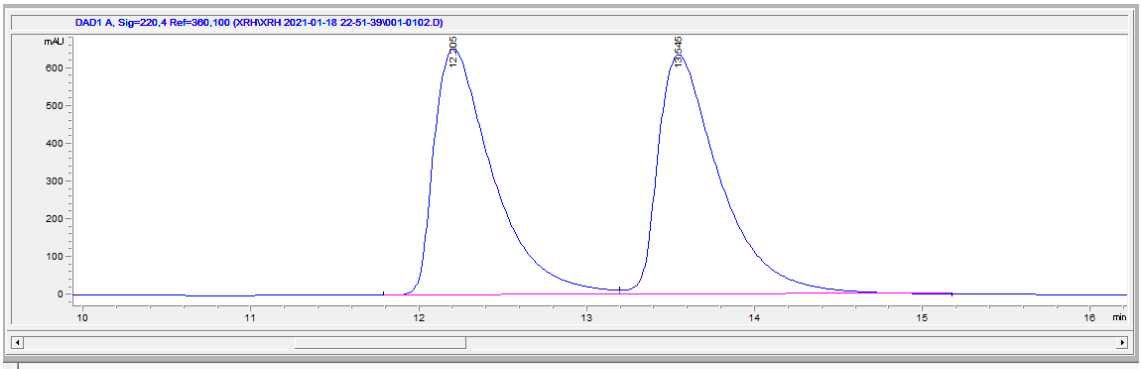
^{31}P NMR (162 MHz, Chloroform-d) δ 25.09 ,

ESI-MS: m/z 247.00 $[M+H]^+$, 269.10 $[M+Na]^+$

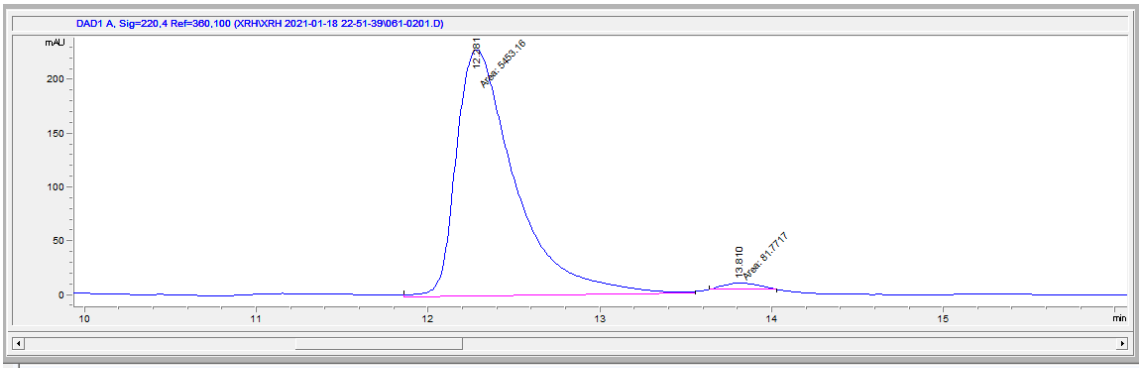
HRMS (ESI)calculated for [M+Na, $C_{14}H_{15}O_2PNa]^+$: 269.0702; found: 269.0704.

$[\alpha]_D^{25}$: 15.1150 (c = 2.5400g/100ml, $CHCl_3$).

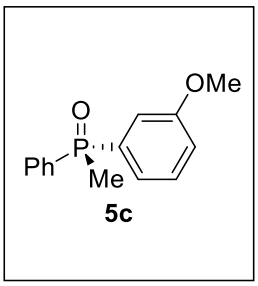
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 15/85, flow rate 1.00 mL/min, 220 nm. t_1 = 12.205 min, t_2 =13.545 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.205	16012.6	653.3	0.3679	0.452	49.460
2	13.545	16362.2	635.5	0.3844	0.454	50.540



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.281	5453.2	229.1	0.3968	0.512	98.523
2	13.81	81.8	5.8	0.233	0.79	1.477



5c

Name: (*S*)-(3-methoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: yellow oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ7.74 (ddd, *J* = 8.4, 3.4, 1.7 Hz, 1H), 7.54 – 7.49 (m, 1H), 7.47 (dd, *J* = 4.2, 2.9 Hz, 1H), 7.38 (dd, *J* = 13.7, 9.9 Hz, 1H), 7.33 – 7.28 (m, 1H), 7.25 – 7.19 (m, 1H), 7.06 (d, *J* = 2.3 Hz, 1H), 3.84 (s, 3H), 2.06 – 1.98 (m, 3H).

^{13}C NMR (126 MHz, Chloroform-d) δ159.67 (d, *J* = 14.7 Hz, 1C), 131.85, 130.50 (d, *J* = 10.0 Hz, 1C), 129.87, 128.69 (d, *J* = 11.7 Hz, 1C), 122.56 (d, *J* = 10.1 Hz, 1C), 117.90 (d, *J* = 1.4 Hz, 1C), 115.53 (d, *J* = 10.8 Hz, 1C), 55.49, 16.59 (d, *J* = 73.8 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 31.26 (d, J = 21.6 Hz).

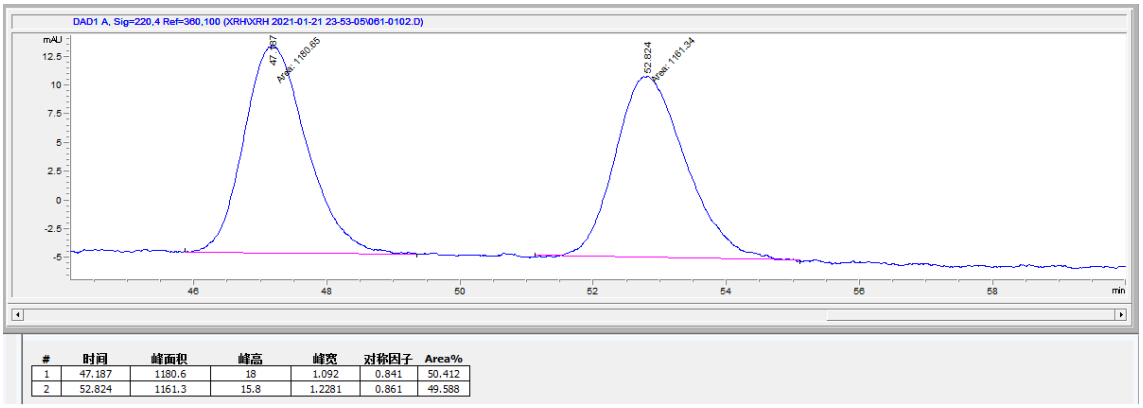
ESI-MS: m/z 247.35 $[M+H]^+$

HRMS (ESI) calculated for [M+H, $C_{14}H_{16}O_2P]^+$:247.0882; found:247.0884,calculated for [M+Na, $C_{14}H_{15}O_2PNa]^+$: 269.0702; found: 269.0706.

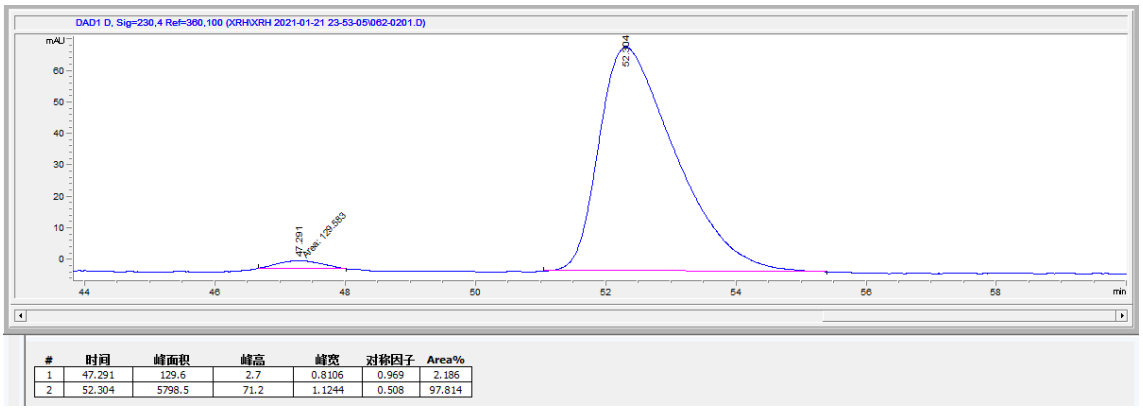
$[\alpha]_D^{25}$: -13.7510 (c = 0.2933g/100ml, $CHCl_3$)..

Chiral HPLC conditions: ID-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.

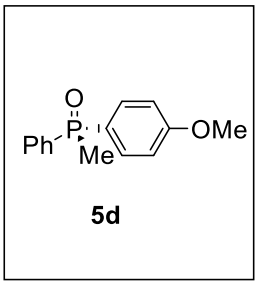
t_1 =47.187 min, t_2 =52.824 min 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	47.187	1180.6	18	1.092	0.841	50.412
2	52.824	1161.3	15.8	1.2281	0.861	49.588



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	47.291	129.6	2.7	0.8106	0.969	2.186
2	52.304	5798.5	71.2	1.1244	0.508	97.814



5d

Name: (*S*)-(4-methoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: yellow oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ7.74 – 7.61 (m, 4H), 7.54 – 7.41 (m, 3H), 7.00 – 6.94 (m, 2H), 3.83 (d, *J* = 0.9 Hz, 3H), 1.98 (dd, *J* = 13.1, 0.9 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ162.37 (d, *J* = 3.1 Hz, 2C), 132.42 (d, *J* = 11.3 Hz,2C), 131.67 (d, *J* = 3.1 Hz, 2C), 130.48 (d, *J* = 10.1 Hz, 2C), 128.62 (d, *J* = 11.3 Hz, 2C), 114.23 (d, *J* = 12.5 Hz, 2C), 55.37, 16.78 (d, *J* = 73.6 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 30.95 (d, J = 7.8 Hz).

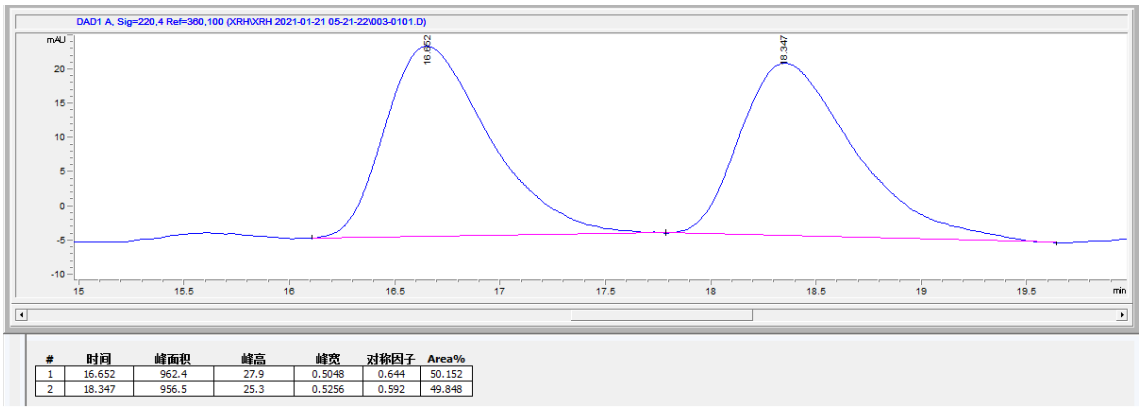
ESI-MS: m/z 247.35 $[M+H]^+$;

HRMS (ESI) calculated for [M+H, $C_{14}H_{16}O_2P]^+$:247.0882; found:247.0881,calculated for [M+Na, $C_{14}H_{15}O_2PNa]^+$: 269.0702; found: 269.0702

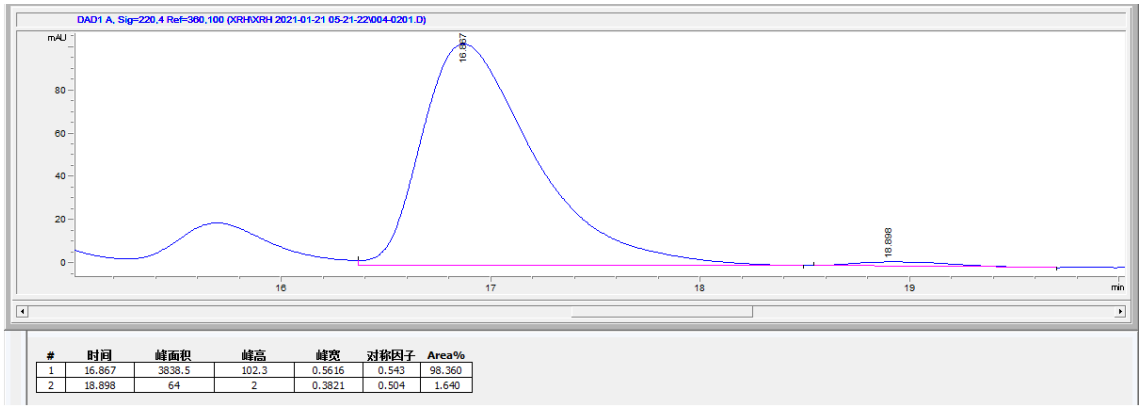
$[\alpha]_D^{25}$: -1.1764 (c = 0.3400g/100ml, $CHCl_3$).

Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 10/90, flow rate 1.00mL/min, 220 nm.

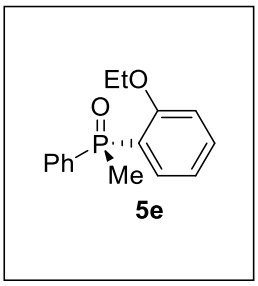
t_1 = 16.652 min, t_2 =18.347 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	16.652	962.4	27.9	0.5048	0.644	50.152
2	18.347	956.5	25.3	0.5256	0.592	49.848



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	16.867	3838.5	102.3	0.5616	0.543	98.360
2	18.898	64	2	0.3821	0.504	1.640



5e

Name: (*S*)-(2-ethoxyphenyl)(methyl)(phenyl)phosphine oxide (5g)

Physical States: colorless solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 8.02 (ddd, *J* = 13.0, 7.5, 1.5 Hz, 1H), 7.71 (dt, *J* = 36.9, 18.4 Hz, 2H), 7.54 – 7.35 (m, 4H), 7.08 (dd, *J* = 18.0, 10.6 Hz, 1H), 6.83 (dd, *J* = 8.2, 5.4 Hz, 1H), 4.08 – 3.97 (m, 1H), 3.91 – 3.83 (m, 1H), 2.09 (d, *J* = 14.0 Hz, 3H), 1.19 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (126 MHz, Chloroform-d) δ 159.11 (d, *J* = 4.5 Hz, 1C), 134.28 – 133.81 (m, 1C), 131.25, 130.24 (d, *J* = 10.1 Hz, 1C), 128.16 (d, *J* = 12.4 Hz, 1C), 120.80 (d, *J* = 11.1 Hz, 1C), 111.27 (d, *J* = 6.7 Hz, 1C), 63.76, 16.21, 15.61, 14.35.

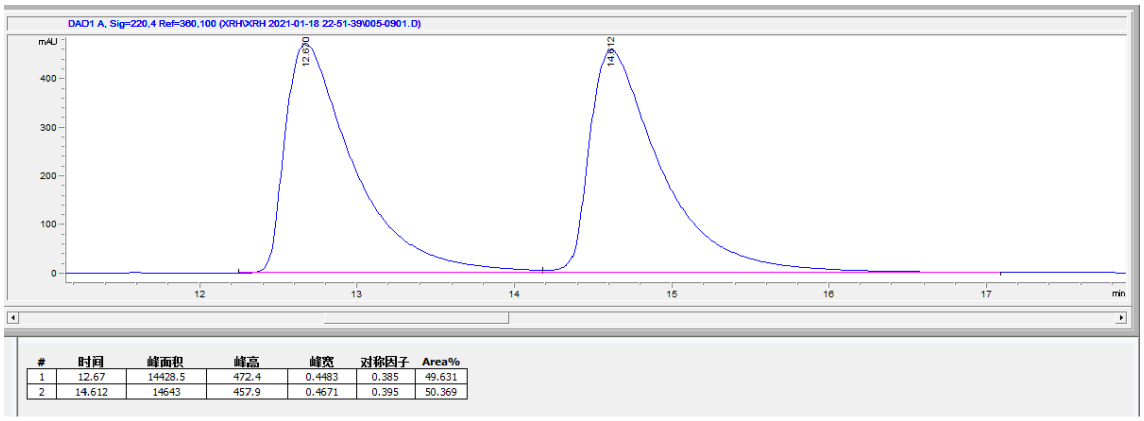
^{31}P NMR (202 MHz, Chloroform-d) δ 29.48.

ESI-MS: m/z 283.35 $[M+Na]^+$

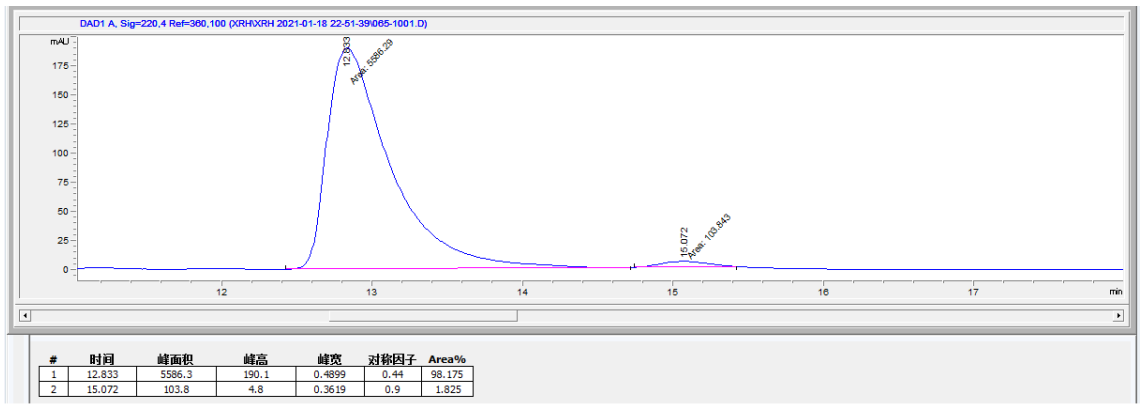
HRMS (ESI) calculated for $[M+H, C_{15}H_{18}O_2P]^+$: 261.1039; found:261.1033. calculated for $[M+Na, C_{15}H_{17}O_2PNa]^+$: 283.0858; found:283.0855

$[\alpha]_D^{25}$: 8.6349 (c =0.2800g/100ml, $CHCl_3$).

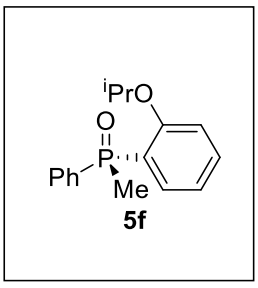
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 15/85, flow rate 1.00 mL/min, 220 nm. t_1 = 12.670 min, t_2 =14.612 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.67	14428.5	472.4	0.4483	0.385	49.631
2	14.612	14643	457.9	0.4671	0.395	50.369



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.833	5586.3	190.1	0.4899	0.44	98.175
2	15.072	103.8	4.8	0.3619	0.9	1.825



5f

Name: (*S*)-(2-isopropoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: yellow oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 0.91 (d, *J* = 6.1 Hz, 3H), 1.24 (d, *J* = 6.0 Hz, 3H), 2.10 (d, *J* = 14.1 Hz, 3H), 4.54 (p, *J* = 6.0 Hz, 1H), 6.81 (dd, *J* = 8.4, 5.4 Hz, 1H), 7.04 – 7.11 (m, 1H), 7.39 (td, *J* = 7.5, 2.9 Hz, 2H), 7.43 – 7.51 (m, 2H), 7.67 – 7.74 (m, 2H), 8.07 (ddd, *J* = 13.1, 7.5, 1.9 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 15.53 (d, *J* = 75.5 Hz, 1C), 21.42 (d, *J* = 93.8 Hz, 1C), 69.64, 111.75 (d, *J* = 6.7 Hz, 1C), 120.35 (d, *J* = 11.1 Hz, 1C), 128.12 (d, *J* = 12.4 Hz, 1C), 130.25 (d, *J* = 10.2 Hz, 1C), 131.23 (d, *J* = 3.1 Hz, 1C), 133.77, 134.36 (d, *J* = 5.6 Hz, 1C), 157.83 (d, *J* = 4.5 Hz, 1C).

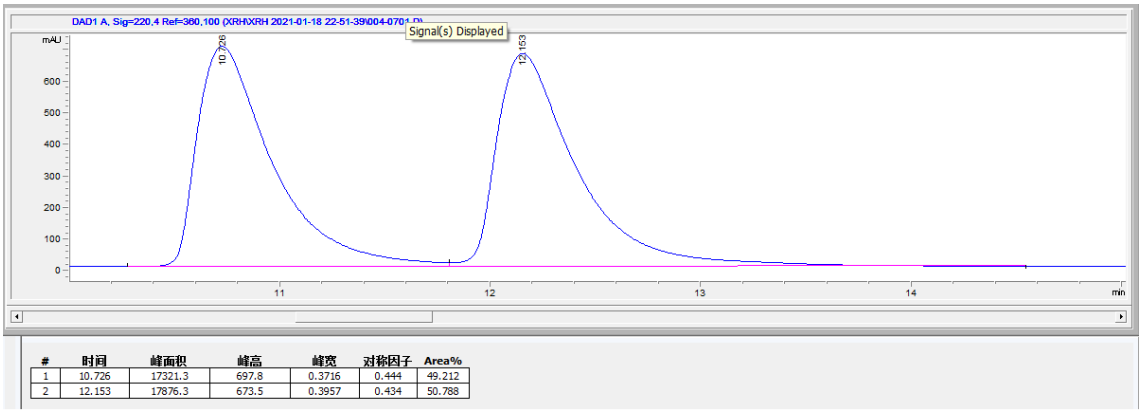
^{31}P NMR (202 MHz, Chloroform-d) δ 29.81 (d, J = 7.5 Hz)

ESI-MS: m/z 275.35 $[M+H]^+$, 297.35 $[M+Na]^+$

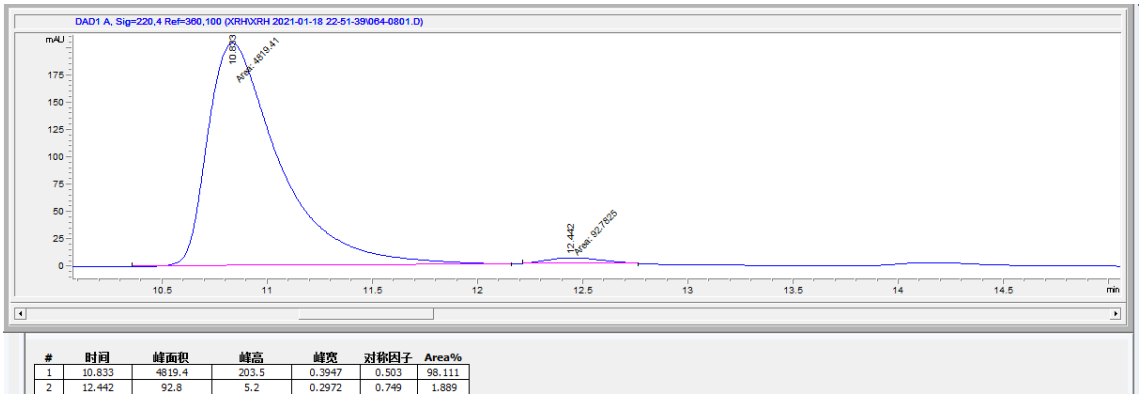
HRMS (ESI) calculated for $[M+H, C_{16}H_{20}O_2P]^+$: 275.1195 found 275.1196; calculated for $[M+Na, C_{16}H_{19}O_2PNa]^+$: 297.1015 found: 297.1016.

$[\alpha]_D^{25}$: 3.7337 (c = 0.3133g/100ml, $CHCl_3$).

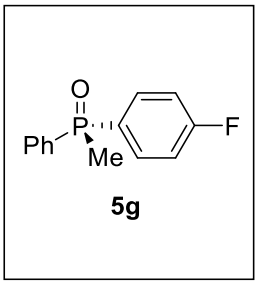
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 10.726 min, t_2 =12.153 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	10.726	17321.3	697.8	0.3716	0.444	49.212
2	12.153	17876.3	673.5	0.3957	0.434	50.788



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	10.833	4819.4	203.5	0.3947	0.503	98.111
2	12.442	92.8	5.2	0.2972	0.749	1.889



5g

Name: (S)-(4-fluorophenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield:70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ2.02 (dd, *J* = 13.0, 4.1 Hz, 3H), 7.15 (td, *J* = 8.7, 2.0 Hz, 1H), 7.43 – 7.56 (m, 4H), 7.66 – 7.76 (m, 4H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.72 (d, *J* = 74.4 Hz, 1C), 116.07 (dd, *J* = 21.4, 13.4 Hz, 1C), 128.74 (t, *J* = 11.5 Hz, 1C), 130.51 (t, *J* = 10.0 Hz, 1C), 131.83 (d, *J* = 2.5 Hz, 1C), 131.98, 133.04 (dd, *J* = 11.2, 8.2 Hz, 1C), 161.11 – 173.11 (m, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 30.53 (d, J = 148.1 Hz).

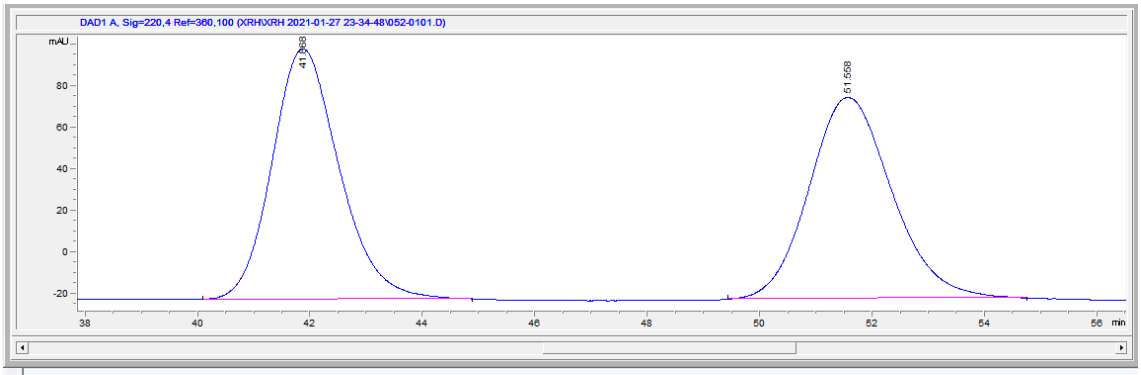
^{19}F NMR (471 MHz, Chloroform-d) δ -106.97 (t, J = 8.1 Hz).

ESI-MS: m/z 275.35 $[M+H]^+$, 297.35 $[M+Na]^+$;

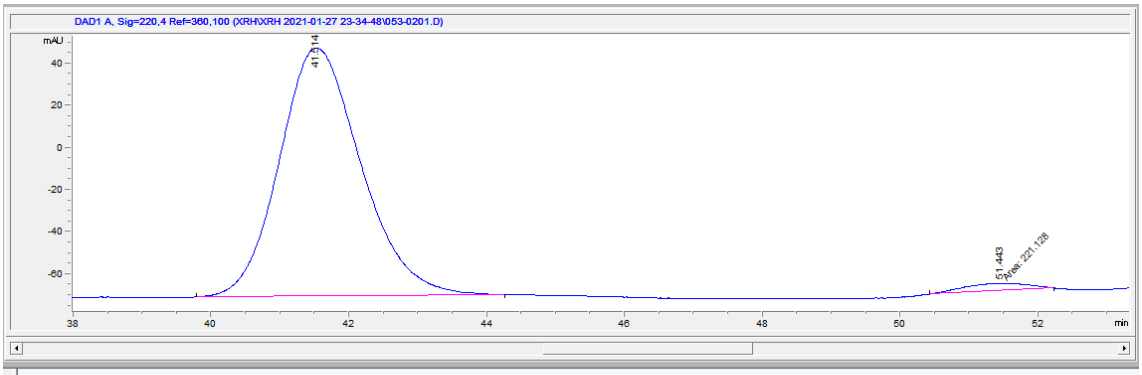
HRMS (ESI) calculated for $[M+H, C_{16}H_{20}O_2P]^+$: 275.1195 found 275.1196; calculated for $[M+Na, C_{16}H_{19}O_2PNa]^+$: 297.1015 found: 297.1016.

$[\alpha]_D^{25}$: -8.3305 (c = 6g/100ml, $CHCl_3$)..

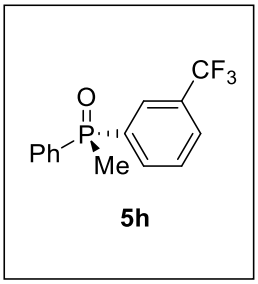
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 42.152 min, t_2 =51.899 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	41.868	10013.5	120.5	1.1717	0.812	50.199
2	51.558	9934.1	96.9	1.2158	0.852	49.801



#	时间	峰面积	峰高	峰宽	对称因子	峰面积 %	Area%
1	41.514	9705.6	117.9	1.0462	0.767	97.772	97.772
2	51.443	221.1	3.5	1.0633	1.353	2.228	2.228



5h

Name: (S)-methyl(phenyl)(3-(trifluoromethyl)phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.06 (dd, J = 13.3, 1.2 Hz, 3H), 7.49 (dddd, J = 8.4, 6.9, 3.2, 1.5 Hz, 2H), 7.53 – 7.63 (m, 2H), 7.69 – 7.79 (m, 3H), 7.86 – 7.91 (m, 1H), 8.00 (d, J = 11.8 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.48 (d, *J* = 74.5 Hz, 1C), 127.13 – 127.55 (m, 1C), 128.40 – 128.61 (m, 1C), 128.92 (d, *J* = 12.3 Hz, 1C), 129.28 (d, *J* = 11.3 Hz, 1C), 130.45 (d, *J* = 10.1 Hz, 1C), 132.24, 132.61, 133.43, 133.82 (d, *J* = 9.4 Hz, 1C), 135.74 (d, *J* = 98.9 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) δ 29.61 ,

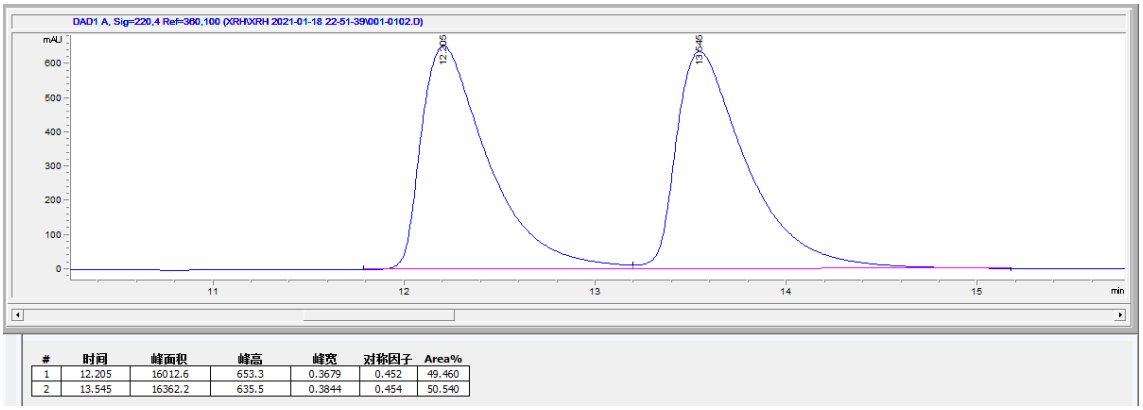
^{19}F NMR (471 MHz, Chloroform-d) δ -62.76

ESI-MS: m/z 285.15 $[M+H]^+$, 307.15 $[M+Na]^+$;

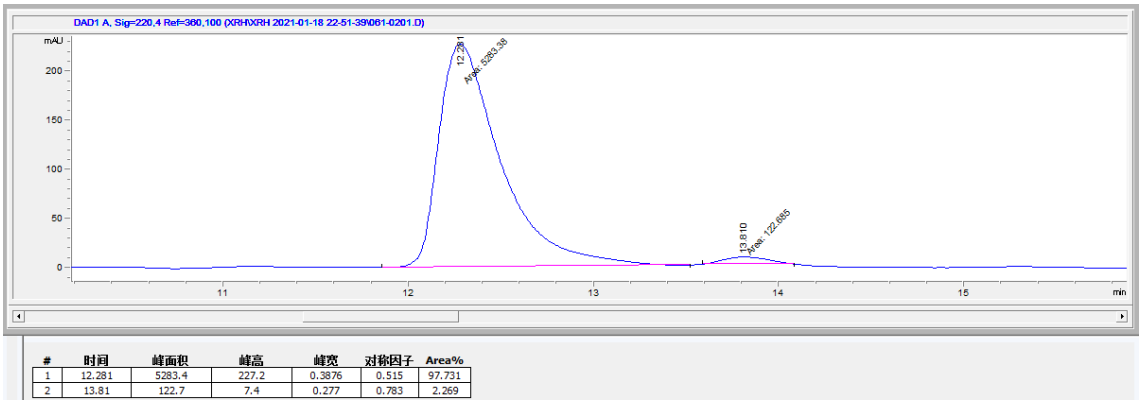
HRMS (ESI) calculated for $[M+H, C_{14}H_{13}F_3OP]^+$: 285.0651 found 285.0653; calculated for $[M+Na, C_{14}H_{12}F_3OPNa]^+$: 307.0470 found: 307.0473.

$[\alpha]_D^{25}$: -23.1499 (c = 0.4600g/100ml, $CHCl_3$).

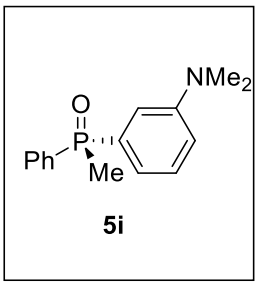
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 12.205 min, t_2 =13.81 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.205	16012.6	653.3	0.3679	0.452	49.460
2	13.545	16362.2	635.5	0.3844	0.454	50.540



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.281	5283.4	227.2	0.3876	0.515	97.731
2	13.81	122.7	7.4	0.277	0.783	2.269



5i

Name: (*S*)-(3-(dimethylamino)phenyl)(methyl)(phenyl)phosphine oxide

Physical States: white soild

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.99 (d, J = 13.1 Hz, 3H), 2.96 (d, J = 1.1 Hz, 6H), 6.80 – 6.92 (m, 2H), 7.13 – 7.18 (m, 1H), 7.28 (td, J = 7.8, 3.9 Hz, 1H), 7.40 – 7.52 (m, 3H), 7.72 (ddt, J = 11.8, 6.9, 1.4 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.67 (d, *J* = 73.5 Hz, 1C), 40.46, 114.13 (d, *J* = 10.8 Hz, 1C), 115.37, 117.86, 128.60, 129.32 (d, *J* = 14.7 Hz, 1C), 130.49 (d, *J* = 9.2 Hz, 1C), 131.60, 133.96 (d, *J* = 31.8 Hz, 1C), 134.76 (d, *J* = 30.7 Hz, 1C), 150.32 (d, *J* = 13.3 Hz, 1C).

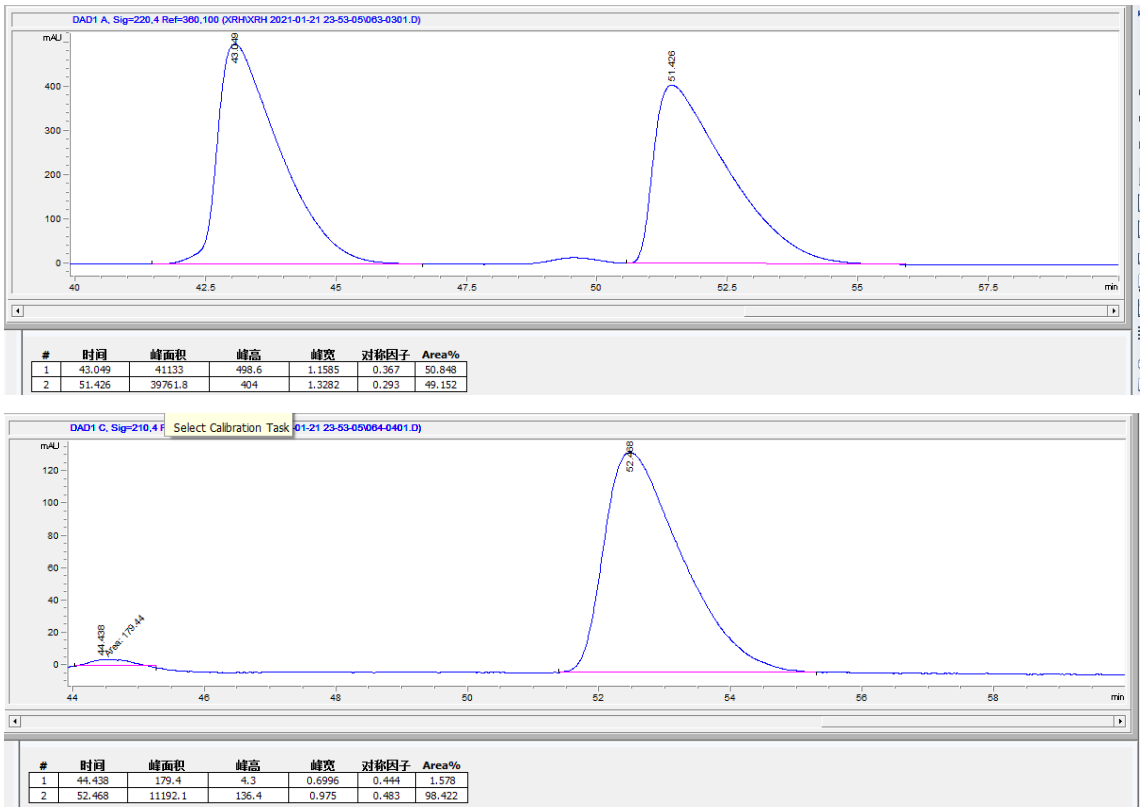
^{31}P NMR (202 MHz, Chloroform-d) δ 31.48.

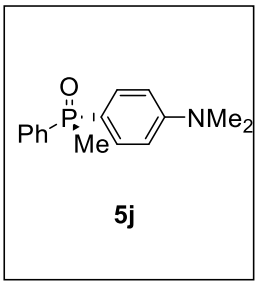
ESI-MS: m/z 260.10 $[M+H]^+$, 282.05 $[M+Na]^+$

HRMS (ESI) calculated for $[M+H, C_{15}H_{19}NOP]^+$: 260.1199 found 260.1205; calculated for $[M+Na, C_{15}H_{18}NOPNa]^+$: 282.1018 found: 282.1024.

$[\alpha]_D^{25}$: -48.4142 (c = 0.1667g/100ml, $CHCl_3$).

Chiral HPLC conditions: ID-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 43.049 min, t_2 =51.426 min. 97% ee.





5j

Name: (S)-(4-(dimethylamino)phenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.89 (dd, J = 13.1, 1.3 Hz, 3H), 2.94 (d, J = 1.2 Hz, 6H), 6.67 (dd, J = 8.2, 2.8 Hz, 2H), 7.32 – 7.51 (m, 5H), 7.59 – 7.67 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ16.86 (d, *J* = 73.9 Hz, 1C), 40.13, 111.59 (d, *J* = 12.4 Hz, 1C), 128.48 (d, *J* = 11.4 Hz, 1C), 130.50 (d, *J* = 9.2 Hz, 1C), 131.33 (d, *J* = 3.2 Hz, 1C), 131.96 (d, *J* = 11.2 Hz, 1C), 152.25,

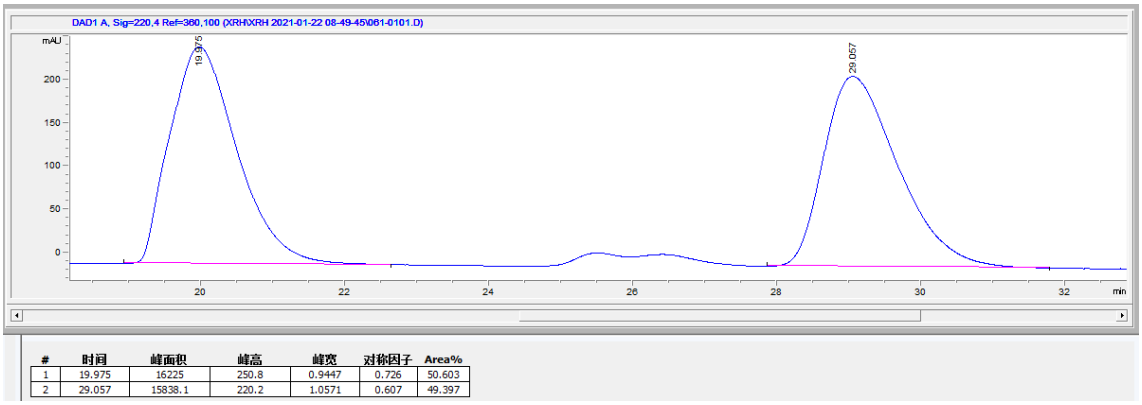
^{31}P NMR (202 MHz, Chloroform-d) δ 30.89.

ESI-MS: m/z 260.10 $[M+H]^+$, 282.10 $[M+Na]^+$;

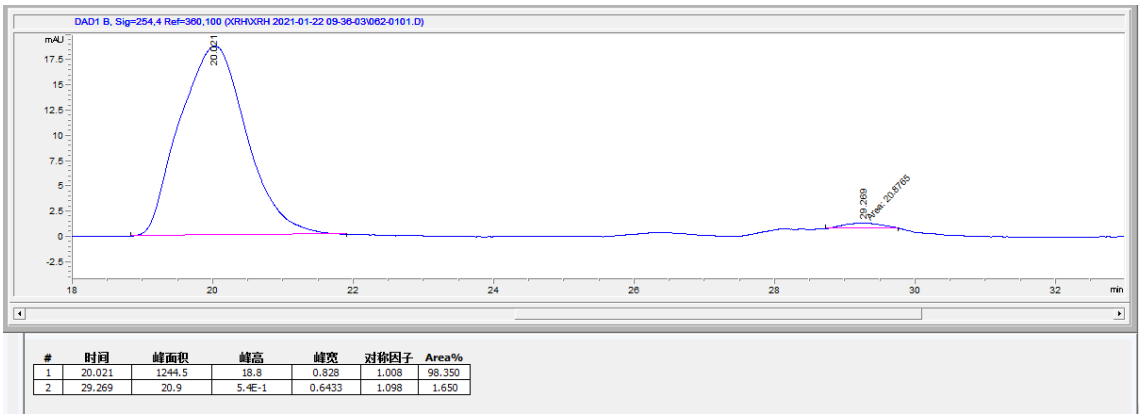
HRMS (ESI) calculated for [M+H, $C_{15}H_{19}NOP]^+$: 260.1199 found 260.1200; calculated for [M+Na, $C_{15}H_{18}NOPNa]^+$: 282.1018 found: 282.1021.

$[\alpha]_D^{25}$: 5.9894 (c =0.2000g/100ml, $CHCl_3$).

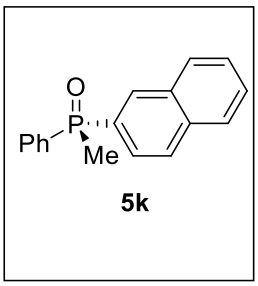
Chiral HPLC conditions: OJ-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 19.075 min, t_2 =29.057 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	19.975	16225	250.8	0.9447	0.726	50.603
2	29.057	15838.1	220.2	1.0571	0.607	49.397



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	20.021	1244.5	18.8	0.828	1.008	98.350
2	29.269	20.9	5.4E-1	0.6433	1.098	1.650



5k

Name: (S)-methyl(naphthalen-2-yl)(phenyl)phosphine oxide (5q)

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.11 (dd, J = 13.2, 1.8 Hz, 3H), 7.43 – 7.67 (m, 6H), 7.72 – 7.81 (m, 2H), 7.84 – 7.95 (m, 3H), 8.37 (d, J = 13.6 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.57 (d, *J* = 73.6 Hz, 1C), 127.07, 127.86, 128.20, 128.55, 128.64, 128.69, 128.79, 128.89, 130.57 (d, *J* = 10.0 Hz, 1C), 131.87, 132.36, 132.45 (d, *J* = 3.5 Hz, 1C), 132.57, 134.63

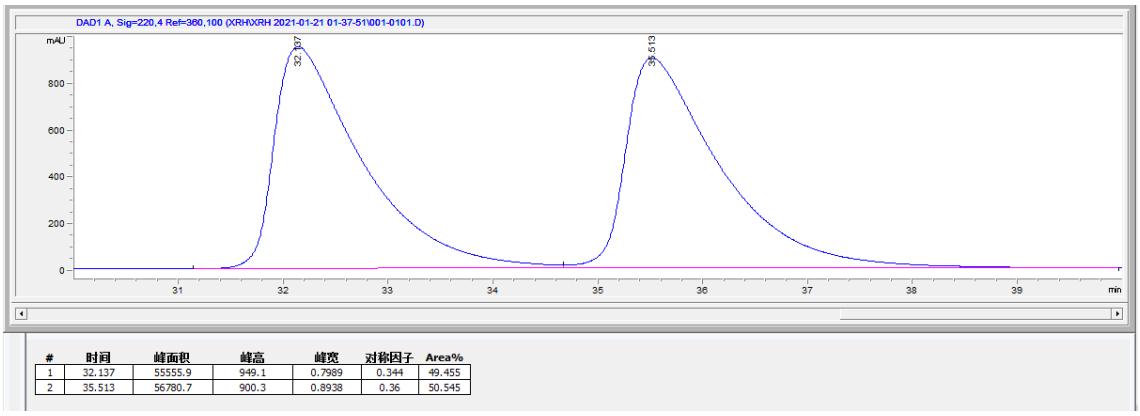
^{31}P NMR (202 MHz, Chloroform-d) δ 30.86

ESI-MS: m/z 267.10 $[M+H]^+$, 289.05 $[M+Na]^+$

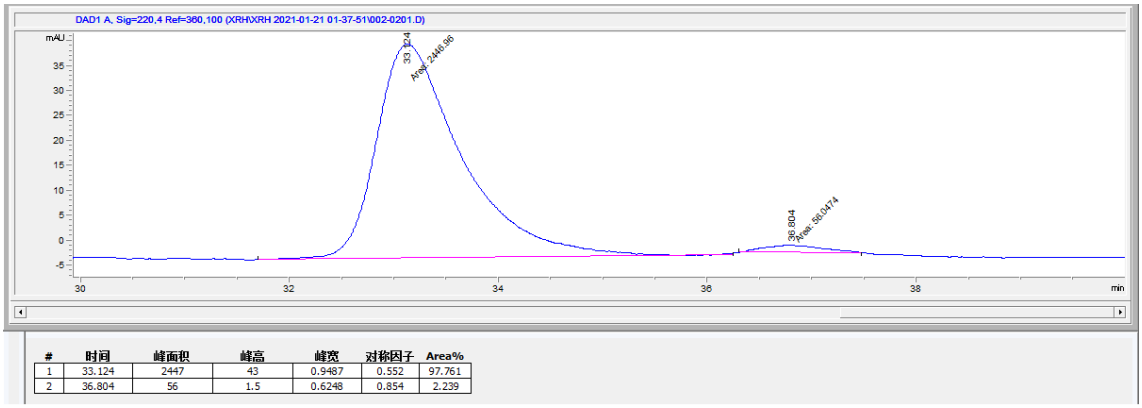
HRMS (ESI) calculated for [M+H, $C_{17}H_{16}OP]^+$: 267.0933 found 267.0939; calculated for [M+Na, $C_{17}H_{15}OPNa]^+$: 289.0753 found: 289.0759.

$[\alpha]_D^{25}$: 11.6679 (c = 0.1267g/100ml, $CHCl_3$).

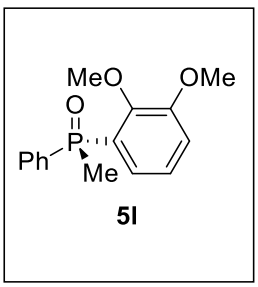
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 32.137min, t_2 =35.123 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	32.137	55555.9	949.1	0.7989	0.344	49.455
2	35.513	56780.7	900.3	0.8938	0.36	50.545



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	33.124	2447	43	0.9487	0.552	97.761
2	36.804	56	1.5	0.6248	0.854	2.239



5l

Name: (*S*)-(2,3-dimethoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.09 (d, J = 14.0 Hz, 3H), 3.45 (s, 3H), 3.84 (s, 3H), 7.09 (dd, J = 8.1, 1.5 Hz, 1H), 7.17 (td, J = 7.9, 2.8 Hz, 1H), 7.42 – 7.51 (m, 4H), 7.71 – 7.77 (m, 2H)

^{13}C NMR (126 MHz, Chloroform-d) δ 16.04 (d, *J* = 75.7 Hz, 1C), 55.84, 60.18, 116.71, 124.09 (d, *J* = 13.1 Hz, 1C), 124.42 (d, *J* = 6.5 Hz, 1C), 126.91, 127.70, 128.39 (d, *J* = 12.4 Hz, 1C), 130.32 (d, *J* = 10.3 Hz, 1C), 131.45 (d, *J* = 2.5 Hz, 1C), 134.80, 135.62, 149.65 (d, *J* = 4.5 Hz, 1C), 152.28 (d, *J* = 10.1 Hz, 1C).

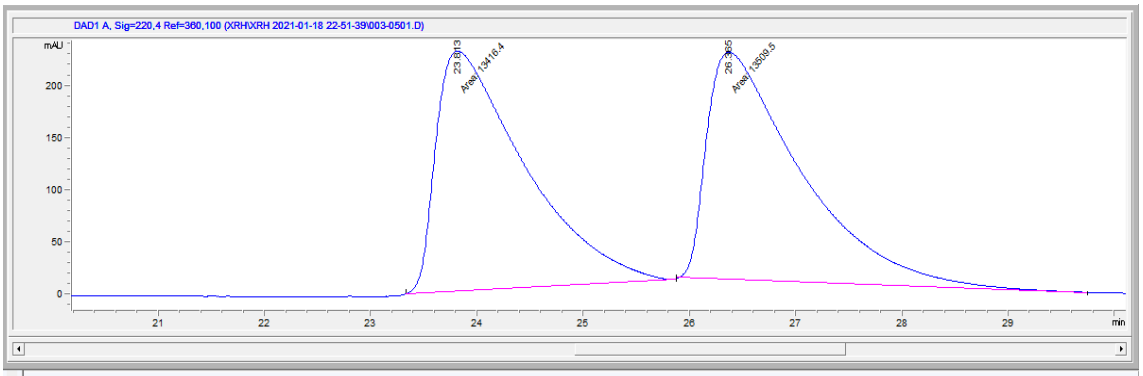
^{31}P NMR (202 MHz, Chloroform-d) δ 29.30.

ESI-MS: m/z 277.05 $[M+H]^+$,

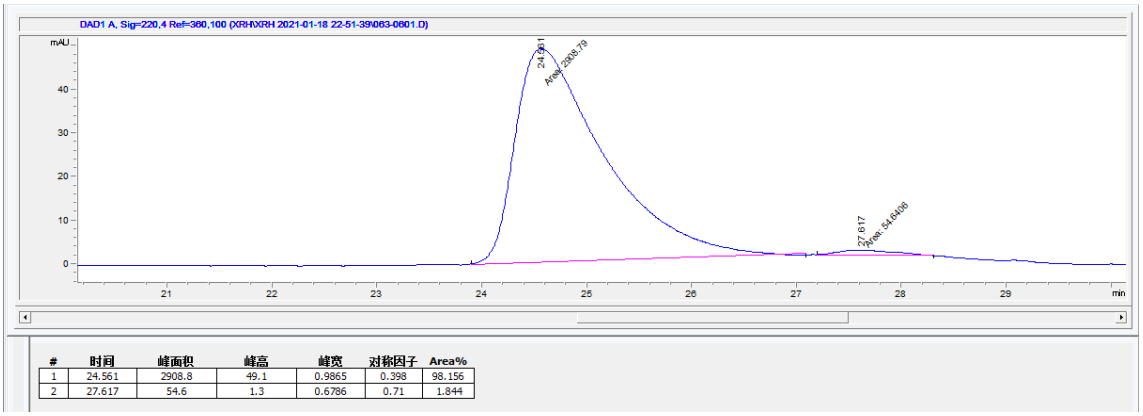
HRMS (ESI) calculated for [M+H, $C_{15}H_{18}O_3P]^+$: 277.0988 found 277.0991; calculated for [M+Na, $C_{15}H_{17}O_3PNa]^+$: 299.0808 found: 299.0811.

$[\alpha]_D^{25}$: -12.1588 (c = 0.1000g/100ml, $CHCl_3$).

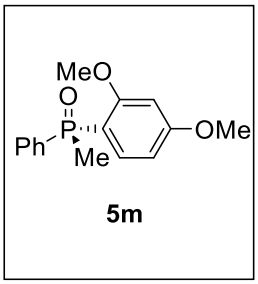
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 23.813 min, t_2 =26.365 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	23.813	13416.4	230.5	0.9703	0.316	49.827
2	26.365	13509.5	218	1.0327	0.293	50.173



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	24.561	2908.8	49.1	0.9865	0.398	98.156
2	27.617	54.6	1.3	0.6786	0.71	1.844



5m

Name: (*S*)-(2,4-dimethoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.03 (dd, J = 14.1, 0.8 Hz, 3H), 3.69 (s, 3H), 3.83 (s, 3H), 6.41 (dd, J = 4.8, 2.2 Hz, 1H), 6.60 (dt, J = 8.5, 1.7 Hz, 1H), 7.37 – 7.49 (m, 3H), 7.71 (ddt, J = 12.1, 6.9, 1.5 Hz, 2H), 7.85 (dd, J = 12.9, 8.5 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.38 (d, *J* = 75.7 Hz, 1C), 55.43 (d, *J* = 28.3 H, 1C z), 98.70, 104.97 (d, *J* = 11.4 Hz, 1C), 128.21 (d, *J* = 12.4 Hz, 1C), 130.16 (d, *J* = 10.1 Hz, 1C), 131.19 (d, *J* = 3.2 Hz, 1C), 135.37 (d, *J* = 6.7 Hz, 1C), 163.04 (d, *J* = 415.4 Hz, 1C)

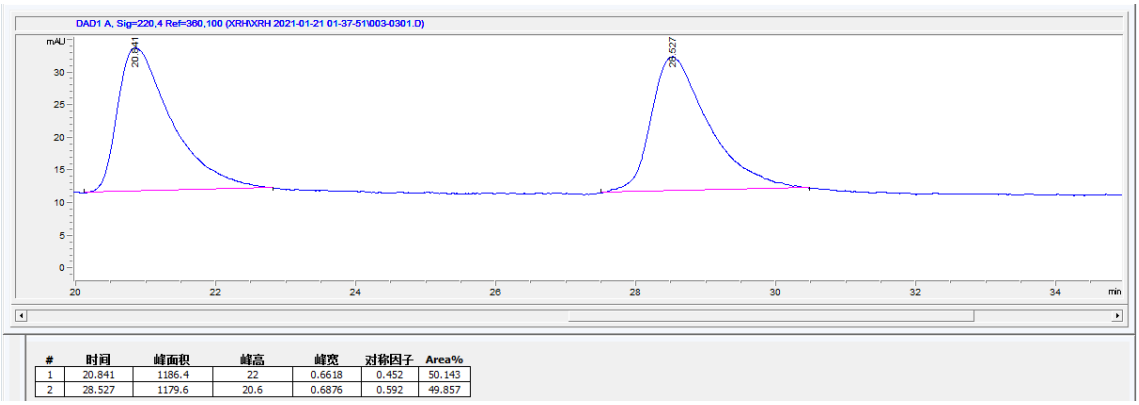
^{31}P NMR (202 MHz, Chloroform-d) δ 29.77 (d, J = 8.6 Hz)

ESI-MS: m/z 299.30 $[M+Na]^+$

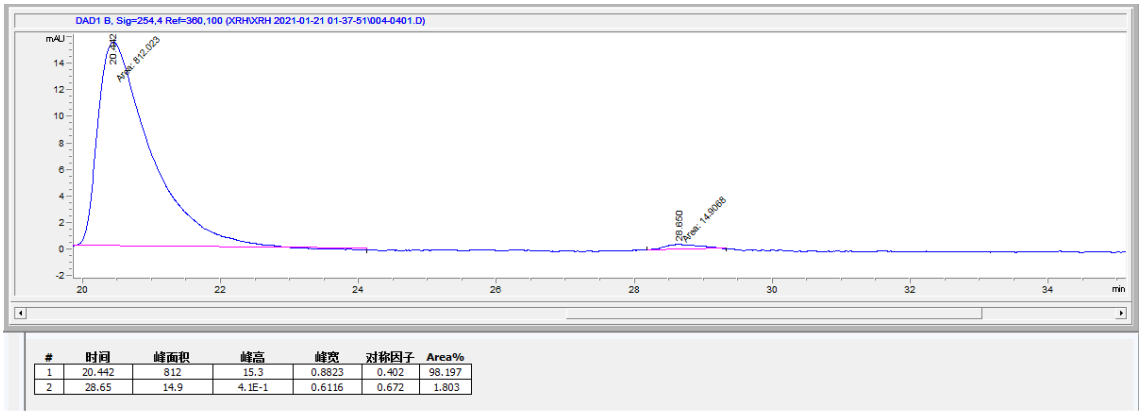
HRMS (ESI) calculated for $[M+H, C_{15}H_{18}O_3P]^+$: 277.0988 found 277.0987; calculated for $[M+Na, C_{15}H_{17}O_3PNa]^+$: 299.0808 found: 299.0809.

$[\alpha]_D^{25}$:-1.6675 (c = 0.2267g/100ml, $CHCl_3$).

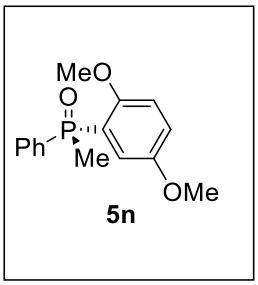
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 15/85, flow rate 1.00 mL/min, 220 nm. t_1 = 20.841 min, t_2 =28.527 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	20.841	1186.4	22	0.6618	0.452	50.143
2	28.527	1179.6	20.6	0.6876	0.592	49.857



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	20.442	812	15.3	0.8823	0.402	98.197
2	28.65	14.9	4.1E-1	0.6116	0.672	1.803



5n

Name: (S)-(2,5-dimethoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.03 (dd, J = 14.1, 0.8 Hz, 3H), 3.69 (s, 3H), 3.83 (s, 3H), 6.41 (dd, J = 4.8, 2.2 Hz, 1H), 6.60 (dt, J = 8.5, 1.7 Hz, 1H), 7.37 – 7.49 (m, 3H), 7.71 (ddt, J = 12.1, 6.9, 1.5 Hz, 2H), 7.85 (dd, J = 12.9, 8.5 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.00 (d, *J* = 75.0 Hz, 1C), 55.80, 56.01, 112.47 (d, *J* = 8.6 Hz, 1C), 117.67 (d, *J* = 6.5 Hz, 1C), 120.14, 128.25 (d, *J* = 12.3 Hz, 1C), 130.24 (d, *J* = 10.2 Hz, 1C), 131.39 (d, *J* = 3.2 Hz, 1C), 150.87 – 155.38 (m, 1C).

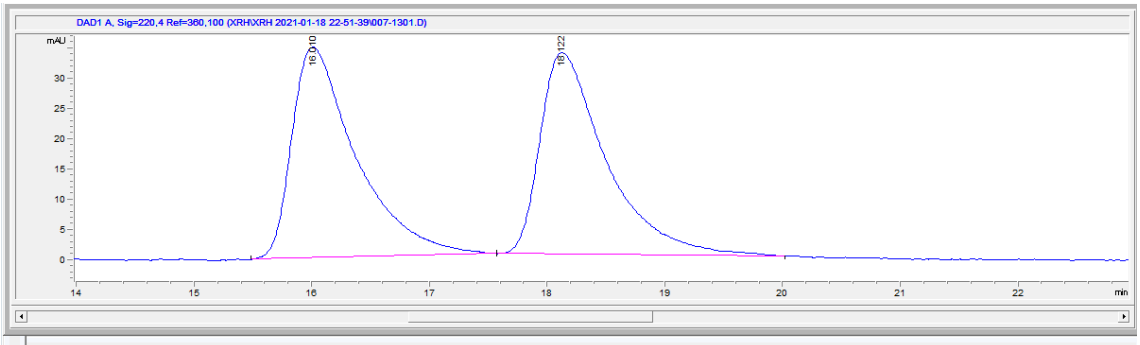
^{31}P NMR (202 MHz, Chloroform-d) δ 29.77 (d, J = 8.6 Hz)

ESI-MS: m/z 299.30 $[M+Na]^+$

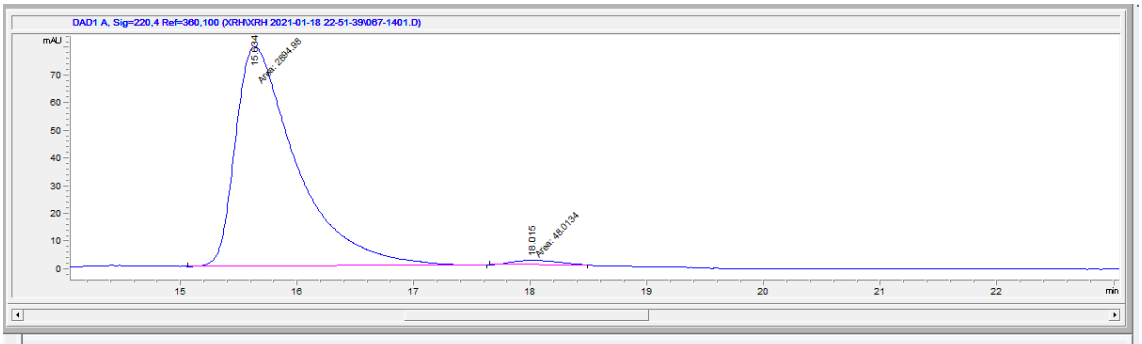
HRMS (ESI) calculated for $[M+H, C_{15}H_{18}O_3P]^+$: 277.0988 found 277.0990; calculated for $[M+Na, C_{15}H_{17}O_3PNa]^+$: 299.0808 found: 299.0811.

$[\alpha]_D^{25}$: -16.4232 (c =0.0944g/100ml, $CHCl_3$).

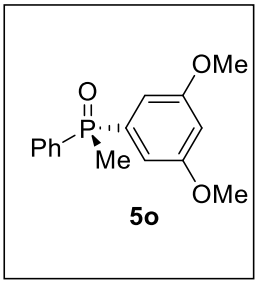
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 15/85, flow rate 1.00 mL/min, 220 nm. t_1 = 16.01 min (*S*), t_2 =18.122 min (*R*). 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	16.01	1320.7	34.8	0.5502	0.461	50.363
2	18.122	1301.6	33.3	0.5659	0.46	49.637



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	15.634	2895	79.4	0.6079	0.444	98.369
2	18.015	48	1.8	0.4526	0.752	1.631



5o

Name: (*S*)-(3,5-dimethoxyphenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.95 – 2.02 (m, 3H), 3.76 – 3.81 (m, 6H), 6.56 (q, J = 2.1 Hz, 1H), 6.83 (dd, J = 13.1, 2.2 Hz, 2H), 7.41 – 7.54 (m, 3H), 7.71 (ddt, J = 11.9, 6.9, 1.5 Hz, 2H)

^{13}C NMR (126 MHz, Chloroform-d) δ16.55 (d, *J* = 74.4 Hz, 1C), 55.61, 103.77, 108.18 (d, *J* = 11.2 Hz, 1C), 128.68 (d, *J* = 12.3 Hz, 1C), 130.45 (d, *J* = 9.3 Hz, 1C), 131.85 (d, *J* = 3.3 Hz, 1C), 133.78 (d, *J* = 101.7 Hz, 1C), 135.93 (d, *J* = 100.6 Hz, 1C), 160.98 (d, *J* = 18.0 Hz, 1C)

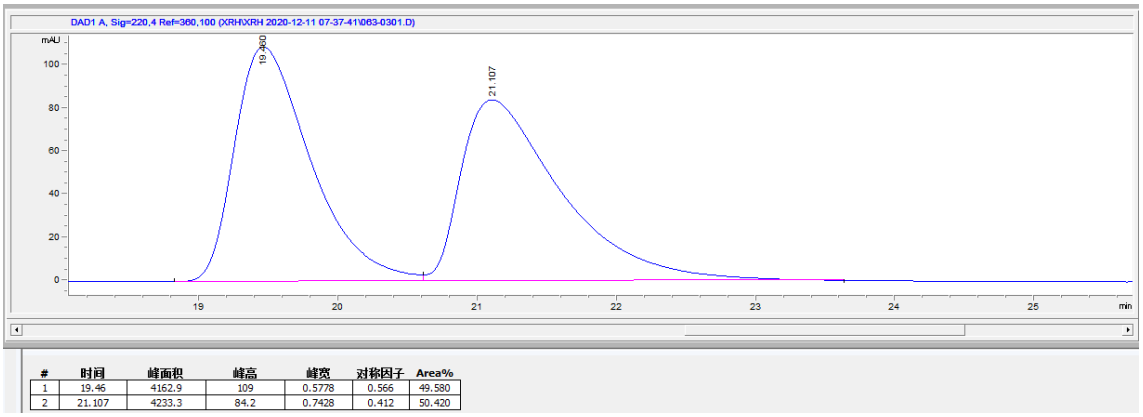
^{31}P NMR (202 MHz, Chloroform-d) δ 31.62 (d, J = 8.1 Hz)

ESI-MS: m/z 277.35 $[M+H]^+$,

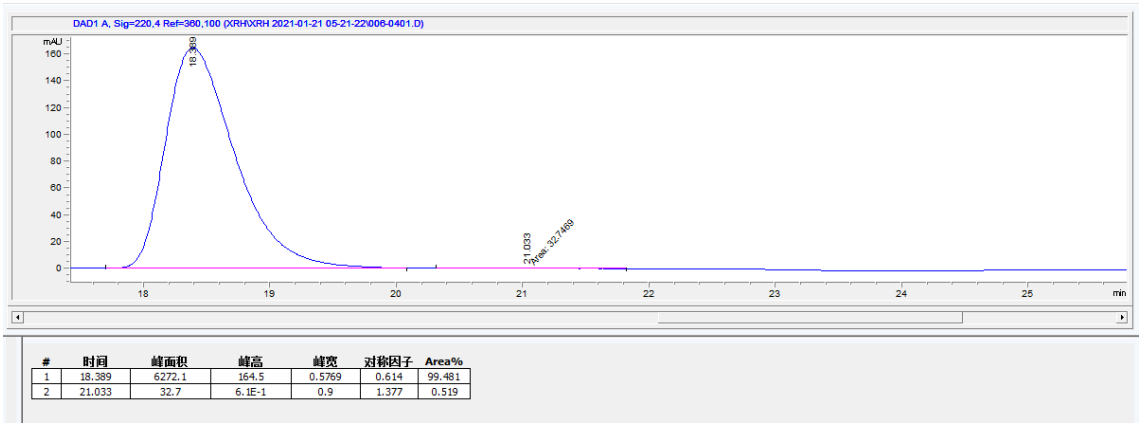
HRMS (ESI) calculated for $[M+H, C_{15}H_{18}O_3P]^+$: 277.0988 found 277.0988; calculated for $[M+Na, C_{15}H_{17}O_3PNa]^+$: 299.0808 found: 299.0810.

$[\alpha]_D^{25}$: -4.4995 (c = 0.2200g/100ml, $CHCl_3$).

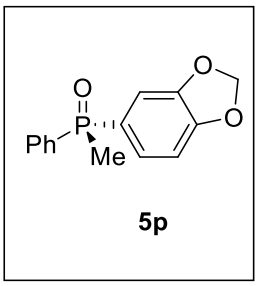
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 19.46 min, t_2 =21.107 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	19.46	4162.9	109	0.5778	0.566	49.580
2	21.107	4233.3	84.2	0.7428	0.412	50.420



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	18.389	6272.1	164.5	0.5769	0.614	99.481
2	21.033	32.7	6.1E-1	0.9	1.377	0.519



5p

Name: (*S*)-benzo[d][1,3]dioxol-5-yl(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.97 (dd, J = 13.1, 1.0 Hz, 3H), 5.99 (d, J = 1.1 Hz, 2H), 6.88 (dd, J = 7.9, 2.3 Hz, 1H), 7.09 (dd, J = 11.4, 1.4 Hz, 1H), 7.21 – 7.25 (m, 1H), 7.42 – 7.53 (m, 3H), 7.66 – 7.73 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.71 (d, *J* = 74.5 Hz, 1C), 101.64, 108.80 (d, *J* = 14.8 Hz, 1C), 110.15 (d, *J* = 12.4 Hz, 1C), 125.78 (d, *J* = 11.2 Hz, 1C), 128.68 (d, *J* = 12.3 Hz, 1C), 130.45 (d, *J* = 10.1 Hz, 1C), 131.79 (d, *J* = 3.2 Hz, 1C), 148.10 (d, *J* = 18.1 Hz, 1C), 150.70 (d, *J* = 2.9 Hz, 1C).

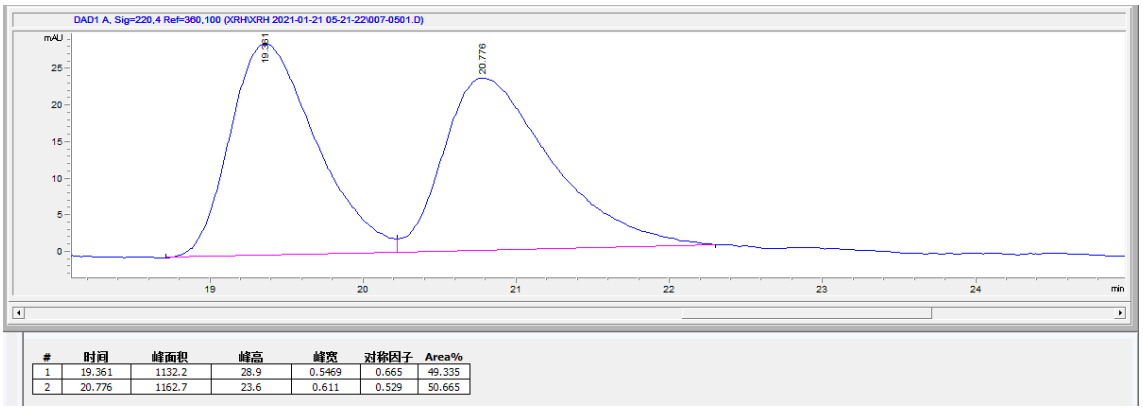
^{31}P NMR (202 MHz, Chloroform-d) δ 31.20.

ESI-MS: m/z 261.35 $[M+H]^+$, 283.30 $[M+Na]^+$

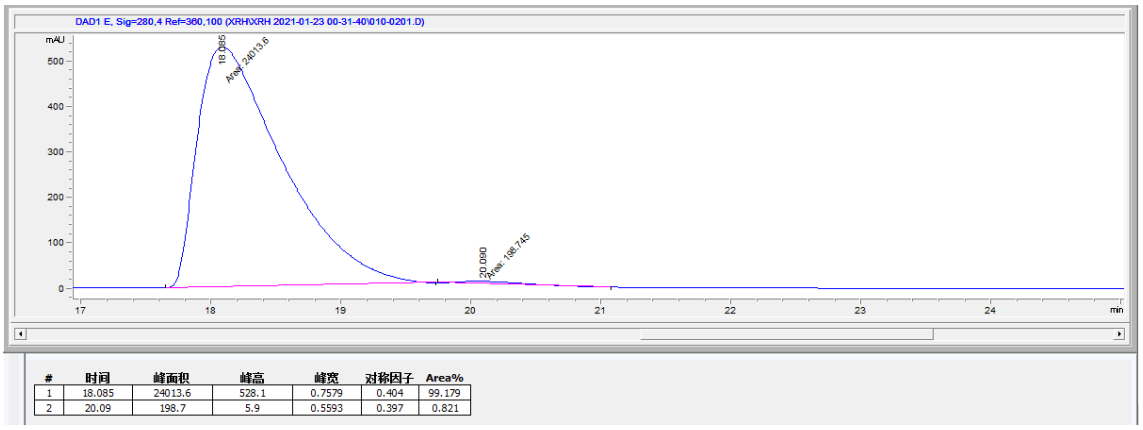
HRMS (ESI) calculated for [M+H, $C_{14}H_{14}O_3P]^+$: 261.0675 found 261.0675; calculated for [M+Na, $C_{14}H_{13}O_3PNa]^+$: 283.0495 found: 283.0496.

$[\alpha]_D^{25}$: -0.8189 (c = 0.6667g/100ml, $CHCl_3$)

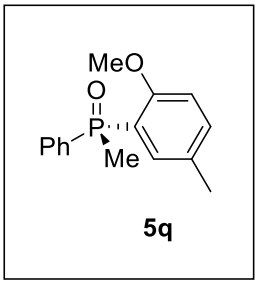
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 19.361 min, t_2 =20.776 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	19.361	1132.2	28.9	0.5469	0.665	49.335
2	20.776	1162.7	23.6	0.611	0.529	50.665



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	18.085	24013.6	528.1	0.7579	0.404	99.179
2	20.09	198.7	5.9	0.5593	0.397	0.821



5q

Name: (*S*)-(2-methoxy-5-methylphenyl)(methyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield:70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.07 (dd, J = 14.0, 1.2 Hz, 3H), 2.32 (s, 3H), 3.68 (d, J = 0.9 Hz, 3H), 6.78 (dd, J = 8.3, 5.6 Hz, 1H), 7.27 – 7.31 (m, 1H), 7.40 (ddd, J = 8.2, 6.7, 2.8 Hz, 2H), 7.43 – 7.49 (m, 1H), 7.73 (ddd, J = 12.2, 8.0, 1.4 Hz, 2H), 7.81 (dd, J = 13.4, 2.3 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 16.14 (d, *J* = 74.7 Hz, 1C), 20.38, 55.36, 110.87 (d, *J* = 7.7 Hz, 1C), 128.21 (d, *J* = 12.4 Hz, 1C), 130.23 (d, *J* = 10.2 Hz, 1C), 130.54 (d, *J* = 11.2 Hz, 1C), 131.29, 134.20 (d, *J* = 5.6 Hz, 1C), 134.34, 157.77

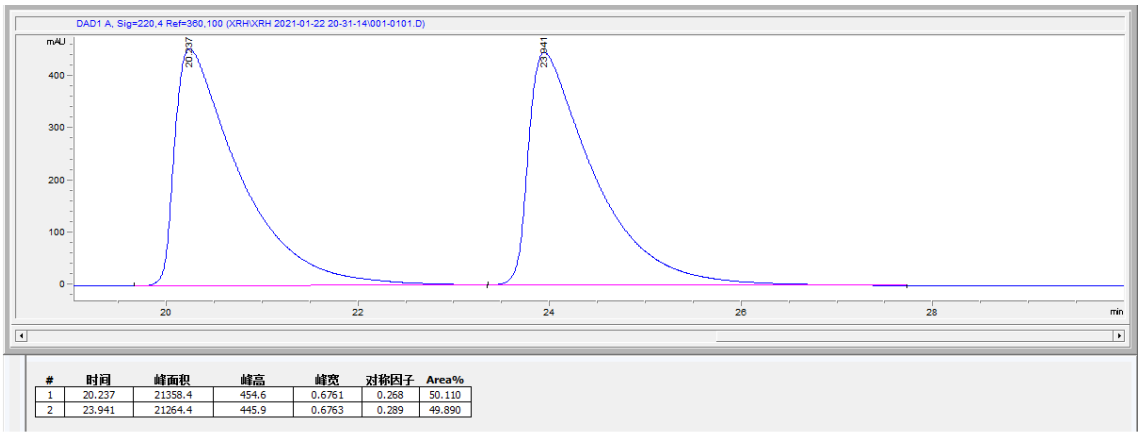
^{31}P NMR (202 MHz, Chloroform-d) δ 29.58.

ESI-MS: m/z 261.15 $[M+H]^+$, 283.05 $[M+Na]^+$

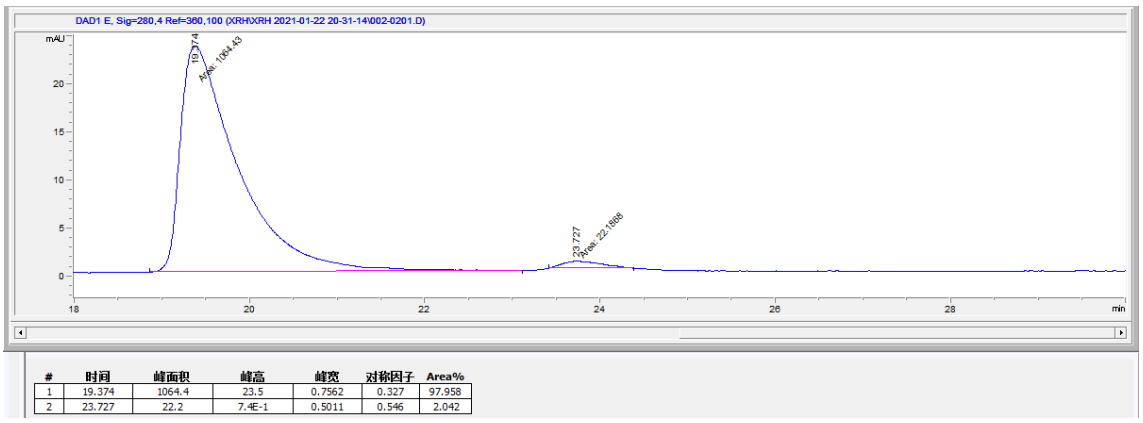
HRMS (ESI) calculated for $[M+H, C_{15}H_{18}O_2P]^+$: 261.1039 found 261.1045; calculated for $[M+Na, C_{15}H_{17}O_2PNa]^+$: 283.0858 found: 283.0866.

$[\alpha]_D^{25}$: -12.6854 (c = 0.3000g/100ml, $CHCl_3$).

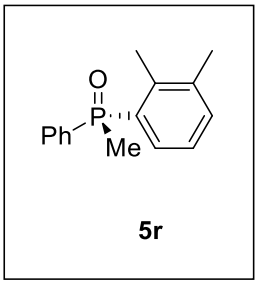
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 20.237 min, t_2 =23.727 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	20.237	21358.4	454.6	0.6761	0.268	50.110
2	23.941	21264.4	445.9	0.6763	0.289	49.890



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	19.374	1064.4	23.5	0.7562	0.327	97.958
2	23.727	22.2	7.4E-1	0.5011	0.546	2.042



5r

Name: (*S*)-(2,3-dimethylphenyl)(methyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.04 (d, J = 13.0 Hz, 3H), 2.25 (s, 3H), 2.30 (s, 3H), 7.18 – 7.24 (m, 1H), 7.34 (d, J = 7.5 Hz, 1H), 7.45 (td, J = 7.5, 2.8 Hz, 2H), 7.48 – 7.55 (m, 2H), 7.65 (ddt, J = 11.9, 6.8, 1.4 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 17.62 (d, *J* = 74.6 Hz, 1C), 18.02 (d, *J* = 5.6 Hz, 1C), 20.34, 125.43 (d, *J* = 13.3 Hz, 1C), 128.65 (d, *J* = 12.1 Hz, 1C), 129.44 (d, *J* = 11.6 Hz, 1C), 130.34 (d, *J* = 10.0 Hz, 1C), 131.49, 133.87, 138.77 (d, *J* = 10.2 Hz, 1C), 140.63 (d, *J* = 8.2 Hz, 1C).

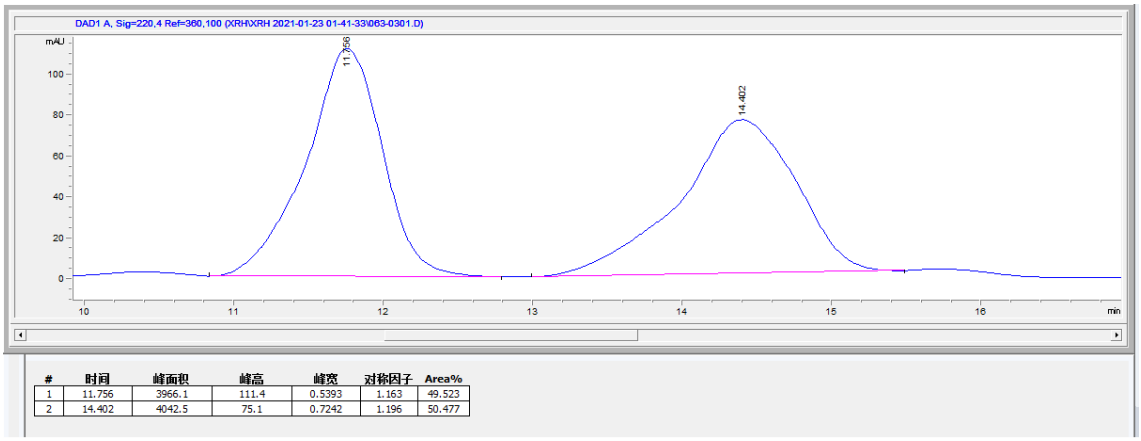
^{31}P NMR (202 MHz, Chloroform-d) δ33.87,

ESI-MS: m/z 245.20 $[M+H]^+$, 266.90 $[M+Na]^+$

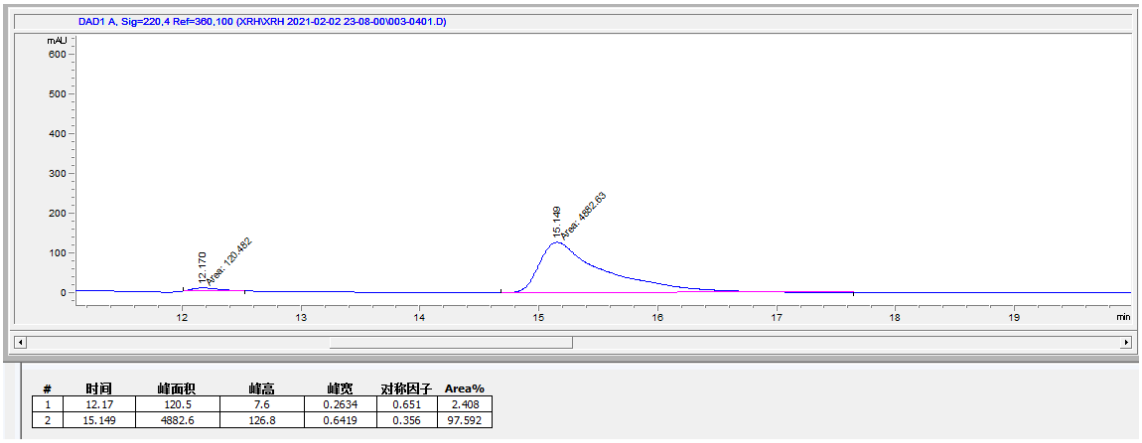
HRMS (ESI) calculated for [M+H, $C_{15}H_{18}OP]^+$: 245.1090 found 245.1082; calculated for [M+Na, $C_{15}H_{17}OPNa]^+$: 267.0909 found: 267.0904.

$[\alpha]_D^{25}$: -39.0011 (c = 0.4000g/100ml, $CHCl_3$).

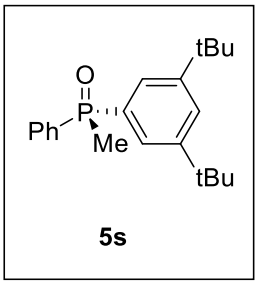
Chiral HPLC conditions: AD-3, *i*-PrOH-hexane 10/90, flow rate 1.00mL/min, 220 nm. t_1 = 11.746 min, t_2 =14.402 min (*R*). 95% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	11.756	3966.1	111.4	0.5393	1.163	49.523
2	14.402	4042.5	75.1	0.7242	1.196	50.477



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	12.17	120.5	7.6	0.2634	0.651	2.408
2	15.149	4882.6	126.8	0.6419	0.356	97.592



5s

Name: (*S*)-(3,5-di-tert-butylphenyl)(methyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.29 (d, J = 2.2 Hz, 18H), 2.00 (dd, J = 13.0, 1.8 Hz, 3H), 7.42 – 7.58 (m, 6H), 7.70 – 7.76 (m, 2H)

^{13}C NMR (126 MHz, Chloroform-d) δ 16.93 (d, *J* = 73.4 Hz, 1C), 31.31, 35.03, 124.60 (d, *J* = 10.3 Hz, 1C), 126.02 (d, *J* = 3.1 Hz, 1C), 128.52 (d, *J* = 11.3 Hz, 1C), 130.54 (d, *J* = 10.1 Hz, 1C), 131.58 (d, *J* = 2.8 Hz, 1C), 151.16 (d, *J* = 11.4 Hz, 1C).

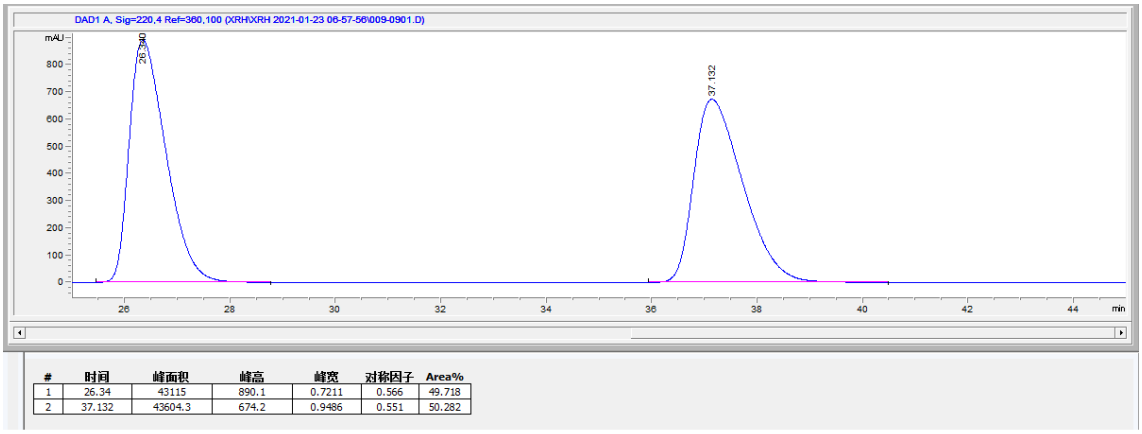
^{31}P NMR (202 MHz, Chloroform-d) 31.60

ESI-MS: m/z 329.25 $[M+H]^+$,

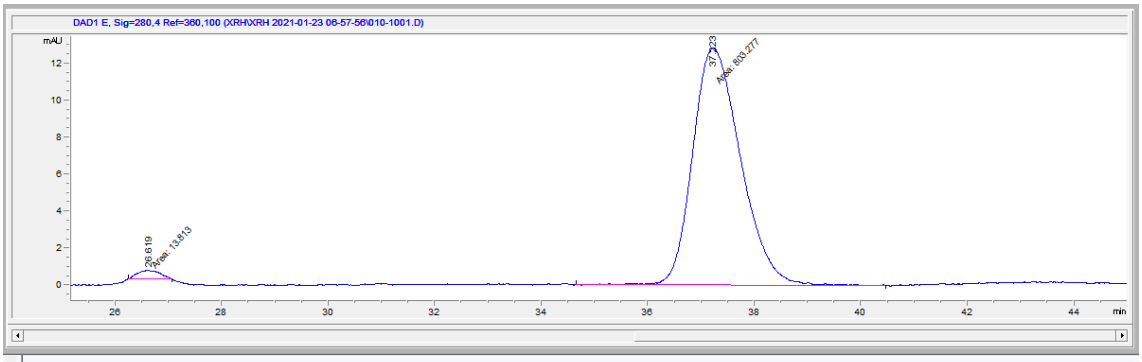
HRMS (ESI) calculated for [M+H, $C_{21}H_{30}OP]^+$: 329.2029 found 329.2032; calculated for [M+Na, $C_{21}H_{29}OPNa]^+$: 351.1848 found: 351.1850.

$[\alpha]_D^{25}$: -11.2894 (c = 0.9769g/100ml, $CHCl_3$)

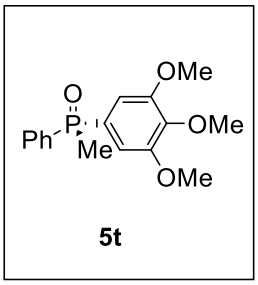
Chiral HPLC conditions: IC-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 26.34 min, t_2 =37.132 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	26.34	43115	890.1	0.7211	0.566	49.718
2	37.132	43604.3	674.2	0.9486	0.551	50.282



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	26.619	13.8	4.6E-1	0.4988	0.897	1.691
2	37.223	803.3	12.8	1.0432	0.732	98.309



5t

Name: (S)-methyl(phenyl)(3,4,5-trimethoxyphenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 2.01 (d, J = 13.2 Hz, 3H), 3.86 (s, 6H), 3.88 (s, 3H), 6.91 (d, J = 13.0 Hz, 2H), 7.45 – 7.56 (m, 3H), 7.69 – 7.76 (m, 2H).

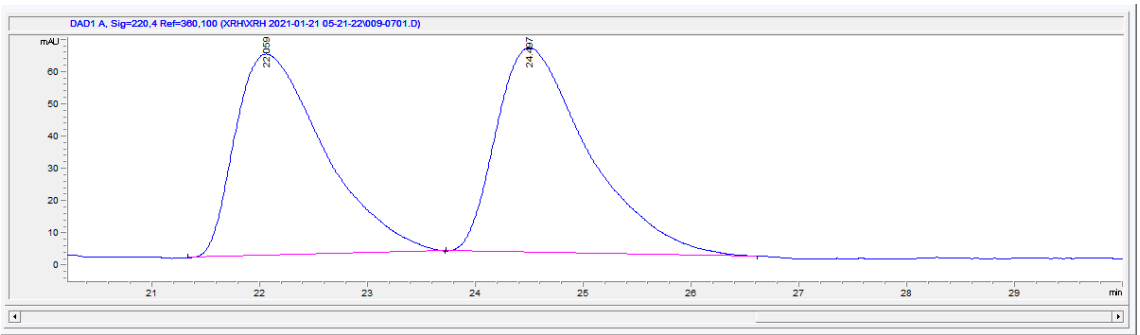
^{13}C NMR (126 MHz, Chloroform-d) δ 16.68 (d, *J* = 74.3 Hz, 1C), 56.37, 60.89, 107.62 (d, *J* = 11.4 Hz, 1C), 128.69 (d, *J* = 11.4 Hz, 1C), 130.42 (d, *J* = 9.3 Hz, 1C), 131.86, 133.97 (d, *J* = 101.7 Hz, 1C), 140.97, 153.47 (d, *J* = 17.8 Hz, 1C).

^{31}P NMR (202 MHz, Chloroform-d) 31.23

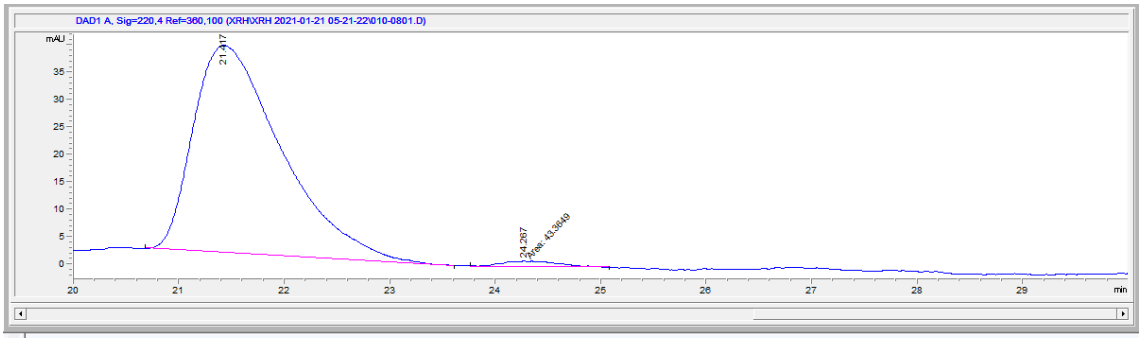
ESI-MS: m/z 307.20 $[M+H]^+$

HRMS (ESI) calculated for $[M+Na, C_{16}H_{19}O_4PNa]^+$: 329.0913 found: 329.0912. $[\alpha]_D^{25}$: -7.4990 (c = 0.0867g/100ml, $CHCl_3$)

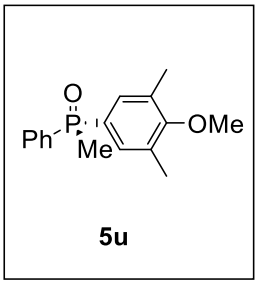
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 22.059 min, t_2 =24.497 min. 97% ee.



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	22.059	3580.3	62.6	0.7838	0.5	48.638
2	24.497	3780.8	63.5	0.817	0.526	51.362



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	21.417	2202	37.8	0.7893	0.482	98.069
2	24.267	43.4	1.1	0.6568	0.756	1.931



5u

Name: (*S*)-(4-methoxy-3,5-dimethylphenyl)(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.91 (dd, J = 13.1, 1.2 Hz, 3H), 2.22 (s, 6H), 3.66 (d, J = 1.2 Hz, 3H), 7.29 (d, J = 11.9 Hz, 2H), 7.37 – 7.47 (m, 3H), 7.62 – 7.69 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ16.21, 16.69 (d, *J* = 73.6 Hz, 1C), 59.68, 128.62 (d, *J* = 12.3 Hz, 1C), 130.48 (d, *J* = 10.1 Hz, 1C), 131.25 (d, *J* = 10.3 Hz, 1C), 131.60, 131.67 (t, *J* = 3.9 Hz, 1C), 160.05

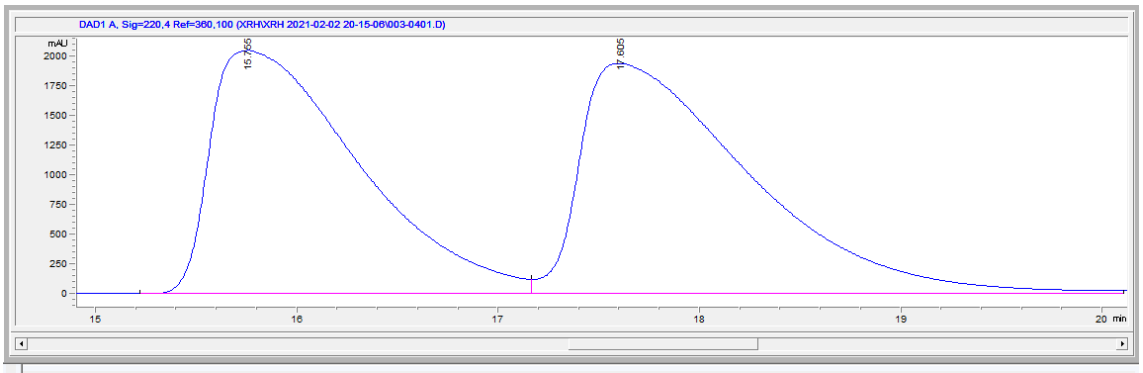
^{31}P NMR (202 MHz, Chloroform-d) 30.58

ESI-MS: m/z 275.35 $[M+H]^+$, 297.35 $[M+Na]^+$

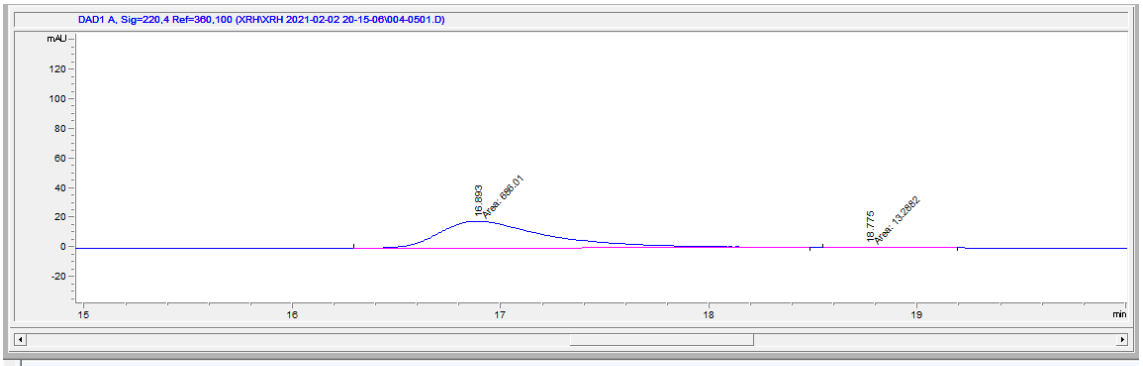
HRMS (ESI) calculated for $[M+H, C_{16}H_{20}O_2P]^+$: 274.2741 found 274.2748; calculated for $[M+Na, C_{16}H_{19}O_2PNa]^+$: 297.1015 found: 297.1021.

$[\alpha]_D^{25}$: 5.8794 (c =0.1000g/100ml, $CHCl_3$).

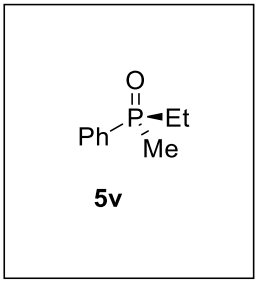
Chiral HPLC conditions: IA-3, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 16.192 min, t_2 =18.126 min. 96% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	15.755	104861.4	2051.4	0.6084	0.33	48.018
2	17.605	113518.3	1936.5	0.6879	0.304	51.982



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	16.893	686	18.5	0.6193	0.542	98.100
2	18.775	13.3	5.7E-1	0.3862	0.456	1.900



5v

Name: (*S*)-ethyl(methyl)(phenyl)phosphine oxide

Physical States: white solid

Yield: 70% yield，

^{1}H NMR (500 MHz, Chloroform-d) δ 1.08 (dt, J = 17.5, 7.6 Hz, 3H), 1.65 (d, J = 12.7 Hz, 3H), 1.89 (dddt, J = 26.3, 15.1, 11.0, 7.5 Hz, 2H), 7.41 – 7.51 (m, 3H), 7.66 (ddt, J = 11.3, 6.7, 1.5 Hz, 2H)..

^{13}C NMR (126 MHz, Chloroform-d) δ 5.74 (d, *J* = 5.2 Hz, 1C), 15.41 (d, *J* = 69.1 Hz, 1C), 24.63 (d, *J* = 71.2 Hz, 1C), 128.65 (d, *J* = 12.4 Hz, 1C), 130.07 (d, *J* = 10.0 Hz, 1C), 131.63 (d, *J* = 2.9 Hz, 1C), 133.21 (d, *J* = 95.1 Hz, 1C).

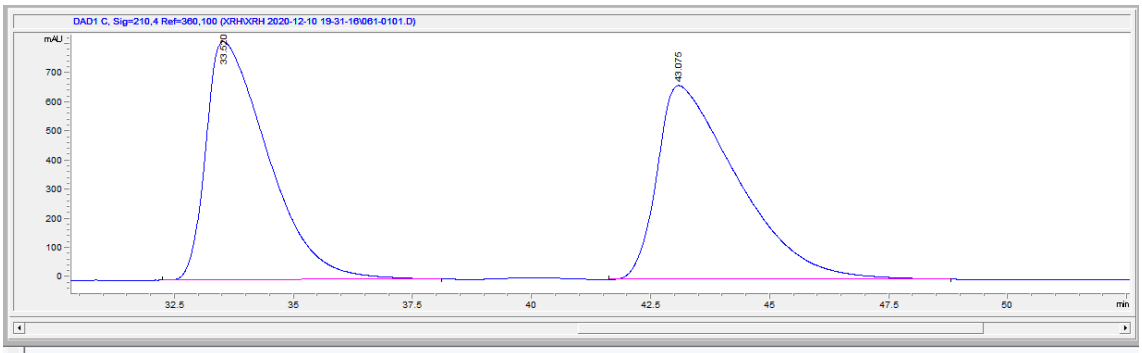
^{31}P NMR (202 MHz, Chloroform-d) 39.58

ESI-MS: m/z 169.00 $[M+H]^+$,

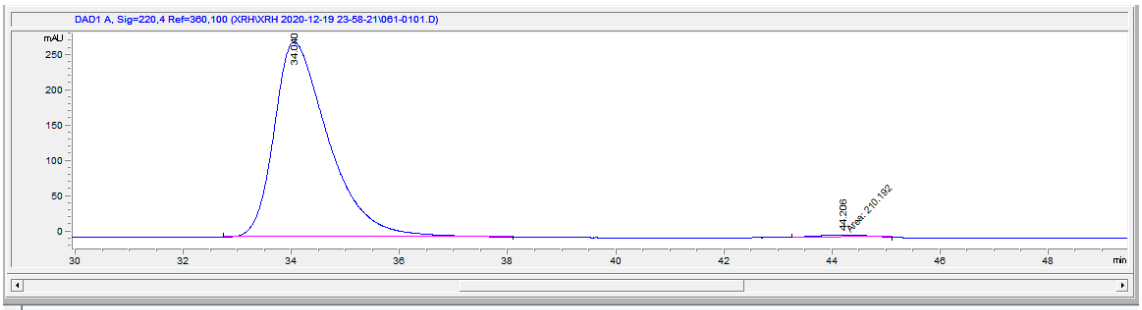
HRMS (ESI) calculated for $[M+H, C_9H_{14}OP]^+$: 169.0777 found 169.0784; calculated for $[M+Na, C_9H_{13}OPNa]^+$: 191.0596 found: 191.0604

$[\alpha]_D^{25}$: -11.0239(c =0.8000g/100ml, $CHCl_3$).

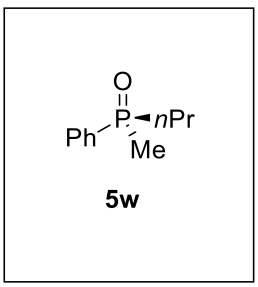
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm. t_1 = 32.52 min, t_2 =43.075 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	33.52	73987.3	818.8	1.1682	0.369	48.545
2	43.075	78423	666.1	1.4895	0.338	51.455



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	34.04	19342.6	276.3	0.9947	0.554	98.925
2	44.206	210.2	3.4	1.0198	1.134	1.075



5w

Name: (S)-methyl(phenyl)(propyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 0.98 (td, J = 7.3, 1.0 Hz, 3H), 1.45 – 1.66 (m, 2H), 1.69 (d, J = 12.7 Hz, 3H), 1.80 – 2.00 (m, 2H), 7.45 – 7.56 (m, 3H), 7.70 (ddt, J = 11.3, 6.7, 1.5 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ15.42 (d, *J* = 3.5 Hz, 1C), 15.62 (d, *J* = 15.8 Hz, 1C), 16.02 (d, *J* = 69.9 Hz, 1C), 33.88 (d, *J* = 70.1 Hz, 1C), 128.65 (d, *J* = 11.3 Hz, 1C), 130.01 (d, *J* = 9.5 Hz, 1C), 131.57, 133.70 (d, *J* = 95.0 Hz, 1C)

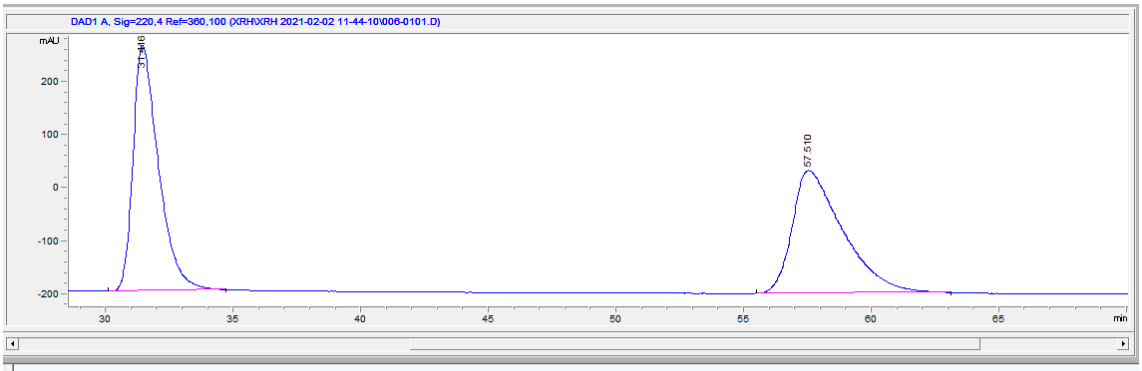
^{31}P NMR (202 MHz, Chloroform-d) 37.90 ,

ESI-MS: m/z 183.00 $[M+H]^+$, 205.00 $[M+Na]^+$

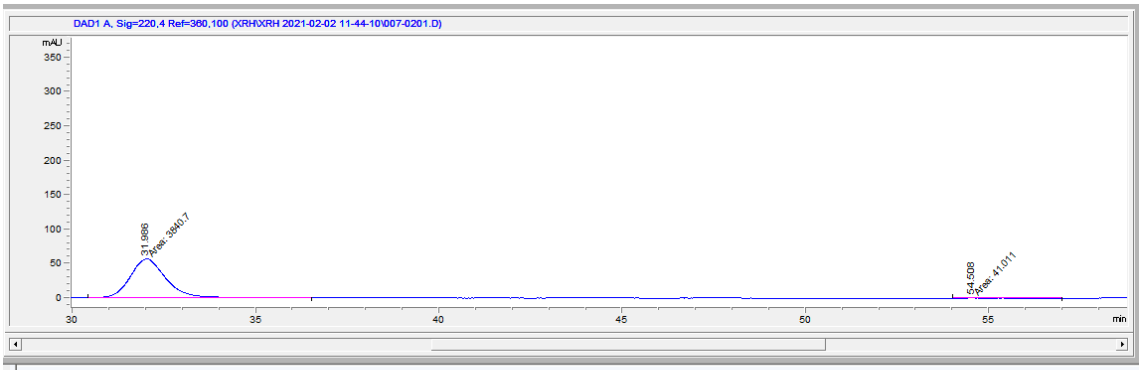
HRMS (ESI) calculated for [M+H, $C_{10}H_{16}OP]^+$: 183.0933 found 183.0937; calculated for [M+Na, $C_{10}H_{15}OPNa]^+$: 205.0753 found: 205.0757

$[\alpha]_D^{25}$: -17.8696 (c = 0.1400g/100ml, $CHCl_3$).

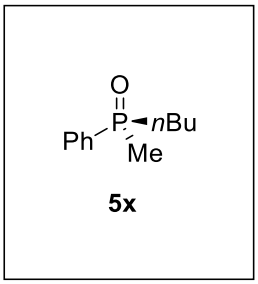
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 25.011 min, t_2 =37.728 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	31.416	32073.5	463	0.9963	0.539	50.205
2	57.51	31812.2	230.8	1.6344	0.454	49.795



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	31.986	3840.7	56.2	1.1383	0.739	98.943
2	54.508	41	4.6E-1	1.4807	0.201	1.057



5x

Name: (*S*)-butyl(methyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 0.80 (t, J = 7.2 Hz, 3H), 1.31 (h, J = 7.1 Hz, 2H), 1.36 – 1.58 (m, 2H), 1.62 (s, 3H), 1.76 – 1.95 (m, 2H), 7.43 (tdd, J = 8.6, 6.5, 4.8 Hz, 3H), 7.61 – 7.69 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ13.55, 16.00 (d, *J* = 69.3 Hz, 1C), 22.67 – 25.03 (m, 1C), 31.46 (d, *J* = 70.8 Hz, 1C), 128.62 (d, *J* = 11.3 Hz, 1C), 129.97 (d, *J* = 9.0 Hz, 1C), 131.54, 133.65 (d, *J* = 95.2 Hz, 1C).

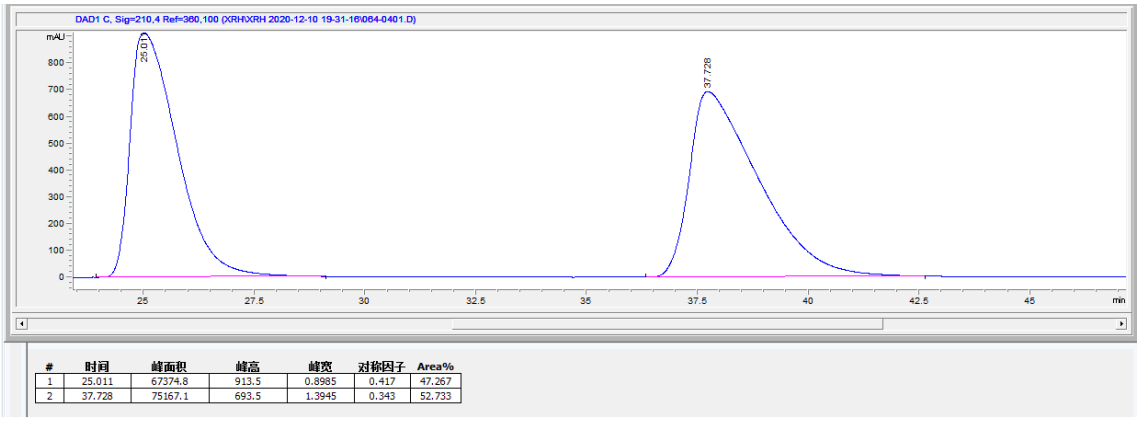
^{31}P NMR (202 MHz, Chloroform-d) 38.18

ESI-MS: m/z 197.05 $[M+H]^+$, 219.05 $[M+Na]^+$

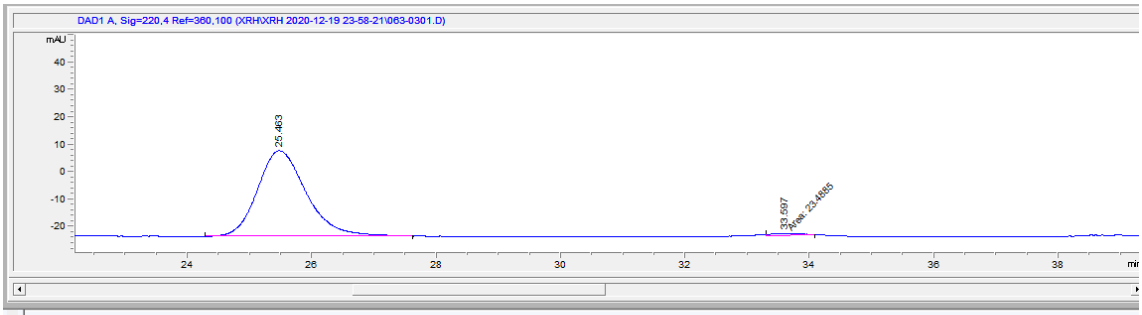
HRMS (ESI) calculated for $[M+H, C_{11}H_{18}OP]^+$: 197.1090 found 197.1091; calculated for $[M+Na, C_{11}H_{17}OPNa]^+$: 219.0909 found: 219.0912.

$[\alpha]_D^{25}$: -0.0197(c = 1.1200g/100ml, $CHCl_3$).

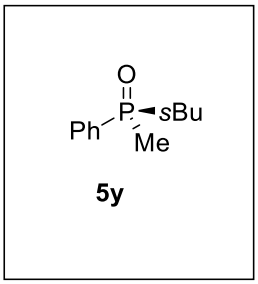
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 25.011 min, t_2 =37.728 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	25.011	67374.8	913.5	0.8985	0.417	47.267
2	37.728	75167.1	693.5	1.3945	0.343	52.733



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	25.463	1702.8	31.3	0.7932	0.751	98.639
2	33.597	23.5	7.4E-1	0.5256	0.852	1.361



5y

Name: (*S*)-(methyl)(phenyl)(sec-butyl)phosphine oxide

Physical States: colorless oil，

Yield: 70% yield，

^{1}H NMR (500 MHz, Chloroform-d) δ 0.91 (t, J = 7.4 Hz, 1H), 0.96 – 1.10 (m, 3H), 1.17 (dd, J = 16.9, 7.1 Hz, 2H), 1.22 – 1.38 (m, 1H), 1.66 – 1.72 (m, 3H), 1.73 – 1.93 (m, 2H), 7.44 – 7.55 (m, 3H), 7.69 (dddt, J = 9.7, 6.7, 2.9, 1.5 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-*d*) δ 11.72 (d, *J* = 11.5 Hz, 1C), 12.21 (d, *J* = 5.5 Hz, 1C), 12.31 (d, *J* = 4.6 Hz, 1C), 22.20 (d, *J* = 19.2 Hz, 1C), 36.10 (d, *J* = 3.6 Hz, 1C), 36.67 (d, *J* = 3.5 Hz, 1C), 128.21 – 129.78 (m, 1C), 130.06 – 130.92 (m, 1C), 131.52, 132.54 (d, *J* = 21.6 Hz, 1C), 133.27 (d, *J* = 21.8 Hz, 1C).

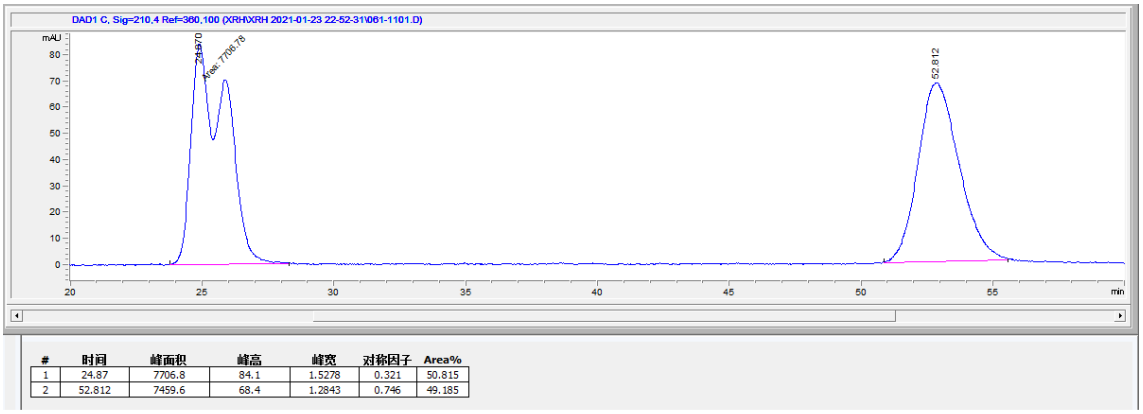
^{31}P NMR (202 MHz, Chloroform-d) 43.61

ESI-MS: m/z 196.90 $[M+H]^+$,

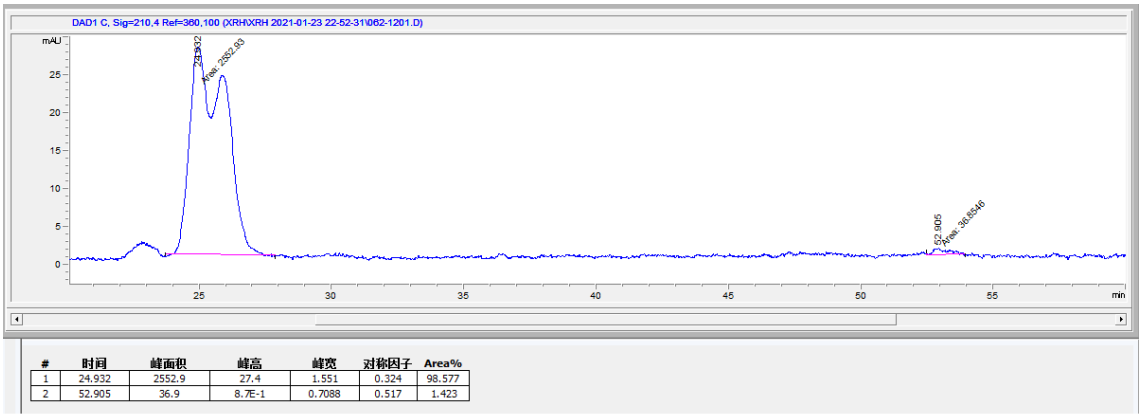
HRMS (ESI) calculated for [M+H, $C_{11}H_{18}OP]^+$: 197.1090 found 197.1091; calculated for [M+Na, $C_{11}H_{17}OPNa]^+$: 219.0909 found: 219.0914.

$[\alpha]_D^{25}$: -3.2184(c = 0.4480g/100ml, $CHCl_3$).

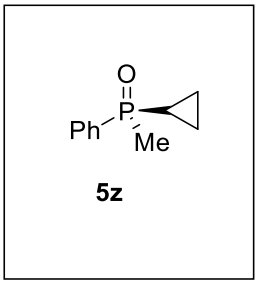
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 24.870 min, t_2 =52.812 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	24.87	7706.8	84.1	1.5278	0.321	50.815
2	52.812	7459.6	68.4	1.2843	0.746	49.185



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	24.932	2552.9	27.4	1.551	0.324	98.577
2	52.905	36.9	8.7E-1	0.7088	0.517	1.423



5z

Name: (*S*)-cyclopropyl(methyl)(phenyl)phosphine oxide

Physical States: colorless oil，

Yield: 70% yield，

^{1}H NMR (500 MHz, Chloroform-d) δ 0.70 – 0.78 (m, 1H), 0.79 – 0.88 (m, 2H), 0.88 – 0.98 (m, 2H), 1.66 (d, J = 13.0 Hz, 3H), 7.38 – 7.48 (m, 3H), 7.65 – 7.72 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ2.55 (d, *J* = 4.5 Hz, 1C), 2.76 (d, *J* = 3.4 Hz, 1C), 8.47 (d, *J* = 101.6 Hz, 1C), 16.19 (d, *J* = 73.8 Hz, 1C), 128.58 (d, *J* = 11.4 Hz, 1C), 129.89 (d, *J* = 9.0 Hz, 1C), 131.58 (d, *J* = 3.2 Hz, 1C), 134.22 (d, *J* = 100.6 Hz, 1C).

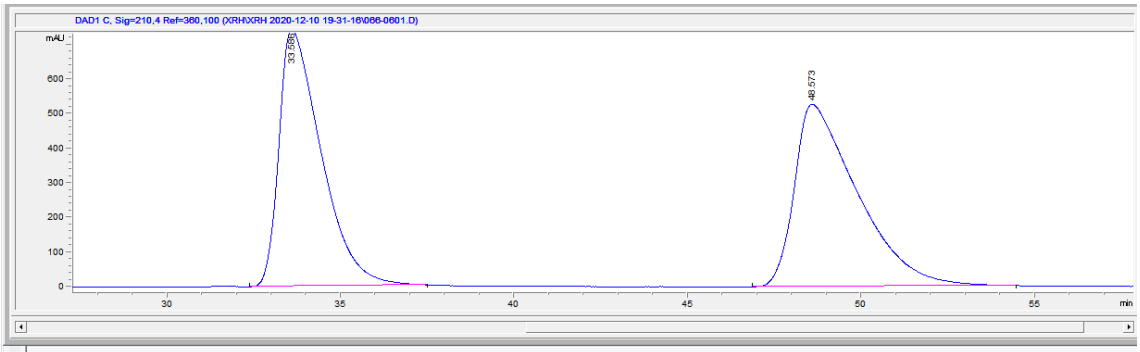
^{31}P NMR (202 MHz, Chloroform-d) 36.71

ESI-MS: m/z 180.95 $[M+H]^+$, 203.00 $[M+Na]^+$

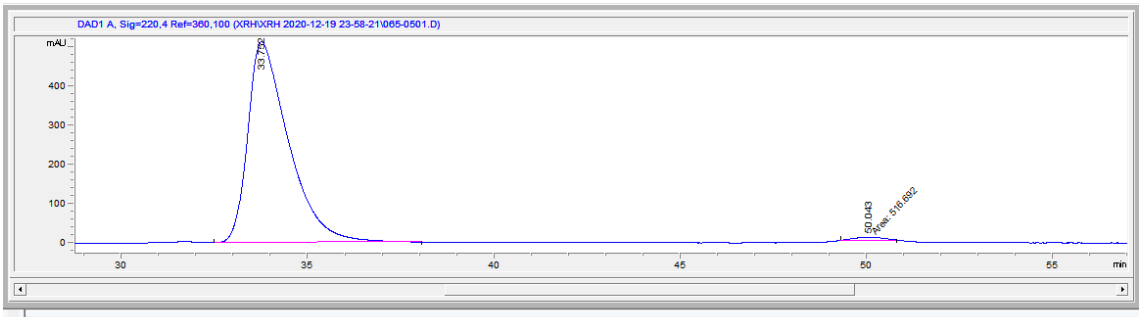
HRMS (ESI) calculated for [M+H, $C_{10}H_{14}OP]^+$: 181.0777 found 181.0782; calculated for [M+Na, $C_{10}H_{13}OPNa]^+$: 203.0596 found: 203.0600.

$[\alpha]_D^{25}$: -46.5436 (c = 0.9520g/100ml, $CHCl_3$).

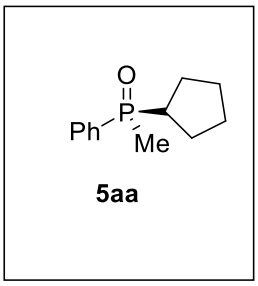
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 33.752 min, t_2 =50.043 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	33.586	62635.9	741.3	1.1218	0.417	48.509
2	48.573	66486.6	527.3	1.4992	0.389	51.491



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	33.752	38822.9	511.3	1.0959	0.477	98.687
2	50.043	516.7	8.6	1.0049	0.982	1.313



5aa

Name: (*S*)-cyclopentyl(methyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield:70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.50 – 1.64 (m, 4H), 1.67 (d, J = 12.4 Hz, 4H), 1.70 – 1.73 (m, 1H), 1.76 – 1.99 (m, 2H), 2.21 (pt, J = 8.8, 5.2 Hz, 2H), 7.43 – 7.53 (m, 3H), 7.70 (ddd, J = 10.9, 8.1, 1.6 Hz, 2H)

^{13}C NMR (126 MHz, Chloroform-d) δ14.78 (d, *J* = 69.0 Hz, 1C), 26.30 (d, *J* = 9.0 Hz, 1C), 26.48 (d, *J* = 9.1 Hz, 1C), 26.72 (d, *J* = 10.9 Hz, 1C), 39.59 (d, *J* = 74.6 Hz, 1C), 128.53 (d, *J* = 11.2 Hz, 1C), 130.28 (d, *J* = 9.0 Hz, 1C), 131.43 (d, *J* = 3.2 Hz, 1C), 133.73 (d, *J* = 93.9 Hz, 1C).

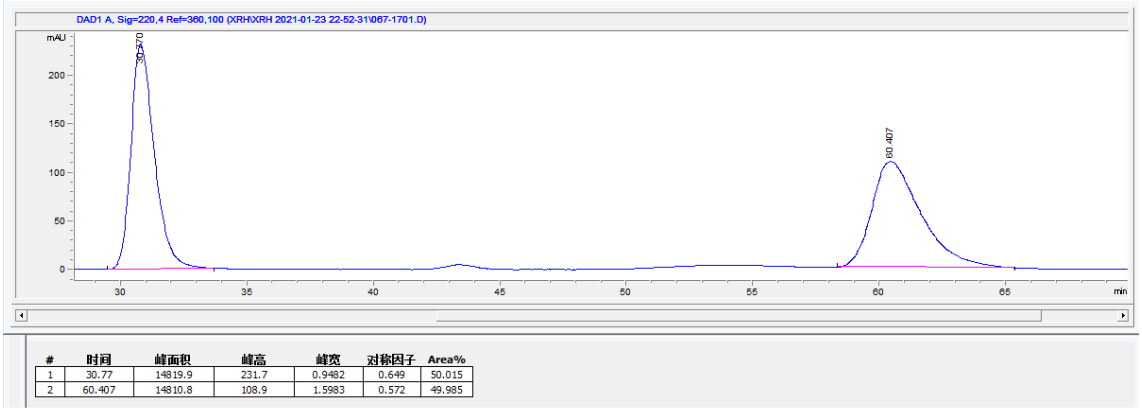
^{31}P NMR (202 MHz, Chloroform-d) δ 40.69.. ,

ESI-MSm/z 197.00 $[M+H]^+$, 205.00 $[M+Na]^+$;

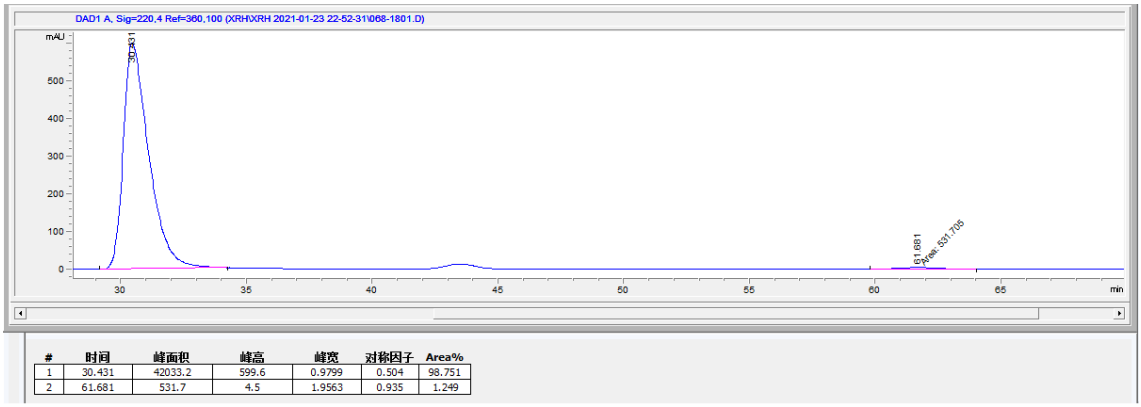
HRMS (ESI) calculated for [M+H, $C_{10}H_{16}OP]^+$: 183.0933 found 183.0937; calculated for [M+Na, $C_{10}H_{15}OPNa]^+$: 205.0753 found: 205.0757.

$[\alpha]_D^{25}$:-15.3021 (c = 0.8960g/100ml, $CHCl_3$)..

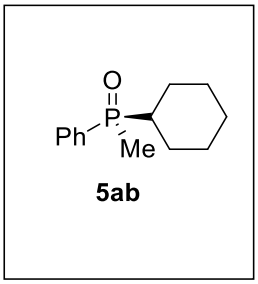
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 30.401 min, t_2 =50.407 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	30.77	14819.9	231.7	0.9482	0.649	50.015
2	60.407	14810.8	108.9	1.5983	0.572	49.985



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	30.431	42033.2	599.6	0.9799	0.504	98.751
2	61.681	531.7	4.5	1.9563	0.935	1.249



5ab

Name: (*S*)-cyclohexyl(methyl)(phenyl)phosphine oxide (5ap):

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 1.09 – 1.41 (m, 6H), 1.63 – 1.70 (m, 5H), 1.74 (tp, J = 9.2, 3.1 Hz, 2H), 1.80 (s, 1H), 1.89 – 1.97 (m, 1H), 7.43 – 7.53 (m, 3H), 7.66 (ddt, J = 10.8, 6.7, 1.5 Hz, 2H).

^{13}C NMR (126 MHz, Chloroform-d) δ 12.93 (d, *J* = 67.7 Hz, 1C), 25.02, 25.74, 26.19 (d, *J* = 3.4 Hz, 1C), 26.30 (d, *J* = 3.5 Hz, 1C), 39.69 (d, *J* = 72.2 Hz, 1C), 128.49 (d, *J* = 11.3 Hz, 1C), 130.49 (d, *J* = 9.0 Hz, 1C), 131.48, 132.67 (d, *J* = 92.8 Hz, 1C).

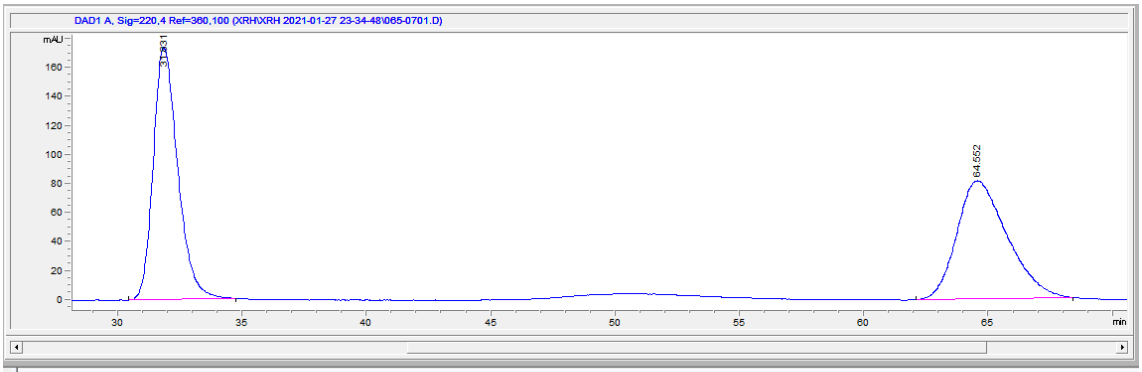
^{31}P NMR (202 MHz, Chloroform-d) δ 41.31.

ESI-MS: m/z 223.05 $[M+H]^+$,

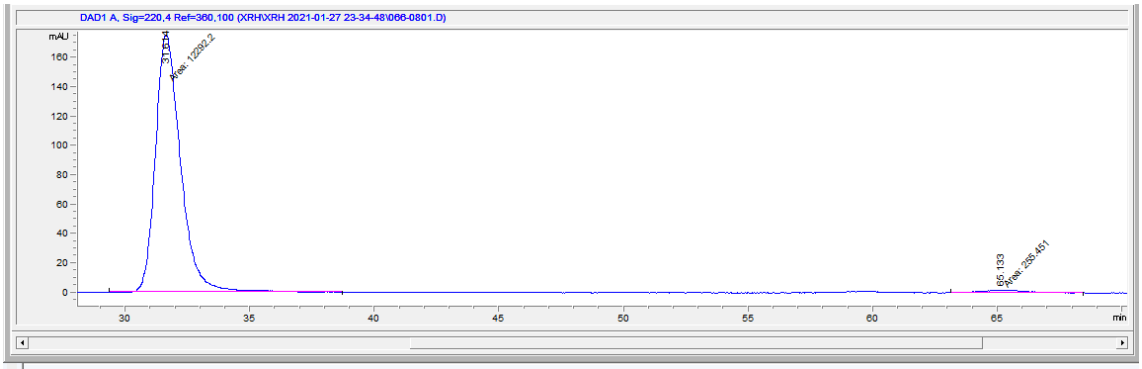
HRMS (ESI) calculated for [M+H, $C_{13}H_{20}OP]^+$: 223.1246 found 223.1247; calculated for [M+Na, $C_{13}H_{19}OPNa]^+$: 245.1066 found: 245.1067.

$[\alpha]_D^{25}$: --10.8112 (c = 0.6533g/100ml, $CHCl_3$).

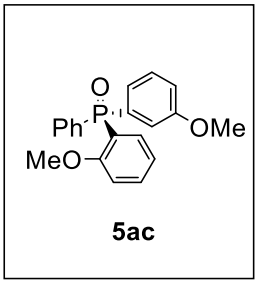
Chiral HPLC conditions: Celluose-2, *i*-PrOH-hexane 10/90, flow rate 1.00 mL/min, 220 nm.t_1 = 31.031 min, t_2 =64.552 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	31.831	11951.9	174.1	1.0047	0.708	51.067
2	64.552	11452.3	81.5	1.6541	0.689	48.933



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	31.614	12292.2	175.2	1.1693	0.692	97.964
2	65.133	255.5	1.8	2.3235	0.854	2.036



5ac

Name: (S)-(2-methoxyphenyl)(3-methoxyphenyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 3.57 (s, 3H), 3.78 (s, 3H), 6.91 (dd, J = 8.3, 5.2 Hz, 1H), 7.00 – 7.08 (m, 2H), 7.21 (ddt, J = 12.1, 7.5, 1.2 Hz, 1H), 7.29 – 7.36 (m, 2H), 7.42 (ddd, J = 8.5, 6.8, 3.0 Hz, 2H), 7.47 – 7.56 (m, 2H), 7.66 – 7.72 (m, 3H)

^{13}C NMR (126 MHz, Chloroform-d) δ 55.34, 55.42, 111.46 (d, *J* = 6.7 Hz, 1C), 116.58 (d, *J* = 11.3 Hz, 1C), 117.71 (d, *J* = 3.2 Hz, 1C), 120.91 (d, *J* = 12.2 Hz, 1C), 124.15 (d, *J* = 10.2 Hz, 1C), 128.14 (d, *J* = 12.4 Hz, 1C), 129.30 (d, *J* = 14.0 Hz, 1C), 131.48 (d, *J* = 3.2 Hz, 1C), 131.78 (d, *J* = 10.2 Hz, 1C), 133.17 (d, *J* = 107.4 Hz, 1C), 134.09, 134.32, 134.98 (d, *J* = 7.9 Hz, 1C), 159.31 (d, *J* = 14.8 Hz, 1C), 161.01 (d, *J* = 3.4 Hz, 1C).

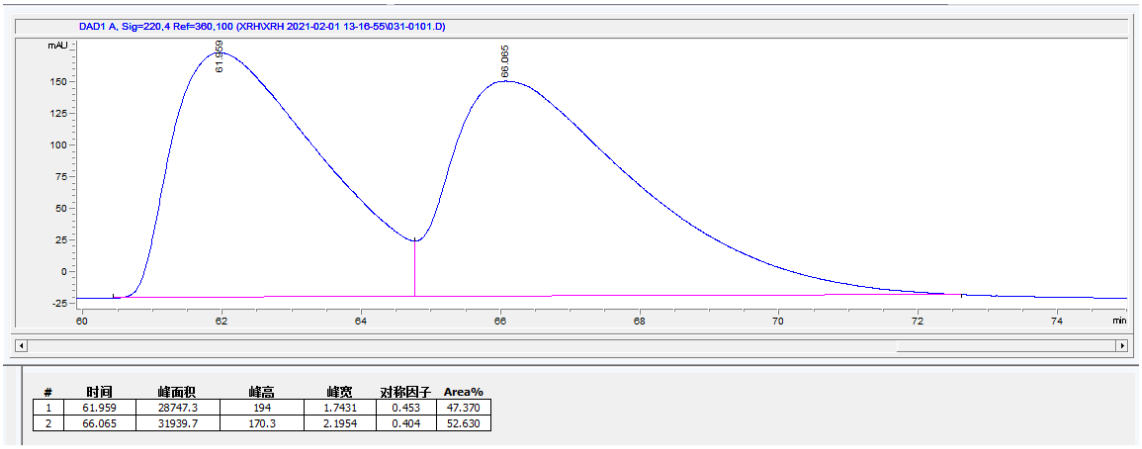
^{31}P NMR (202 MHz, Chloroform-d) δ 26.59.. ,

ESI-MS: m/z 339.10 $[M+H]^+$, 360.70 $[M+Na]^+$

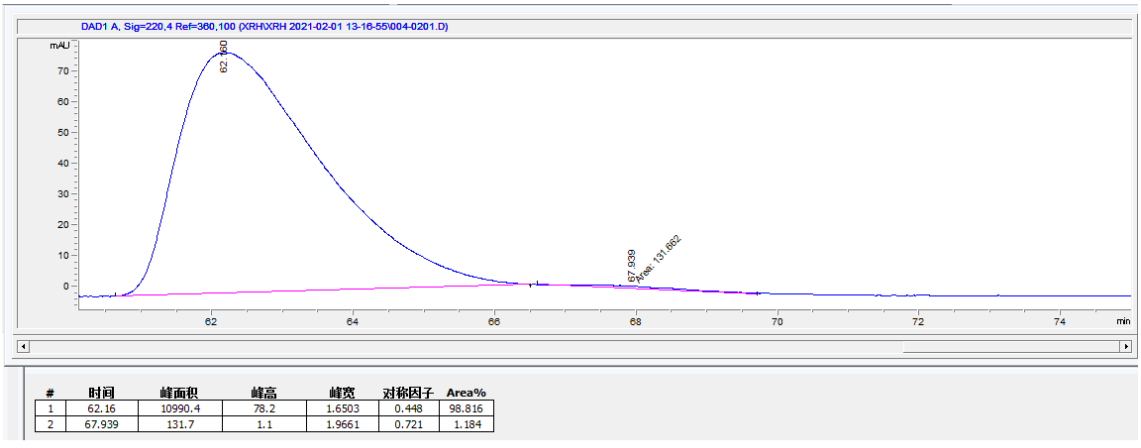
HRMS (ESI) calculated for $[M+H, C_{20}H_{20}O_3P]^+$: 339.1145 found 339.1148; calculated for $[M+Na, C_{20}H_{19}O_3PNa]^+$: 361.0964 found: 361.0968.

$[\alpha]_D^{25}$: -10.1390 (c = 0.3333g/100ml, $CHCl_3$)

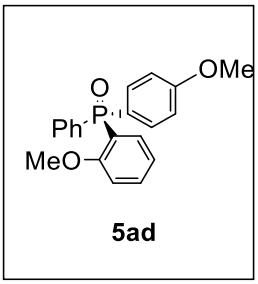
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 3/97, flow rate 1.00 mL/min, 220 nm. t_1 = 61.959 min (*S*), t_2 =68.065 min (*R*). 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	61.959	28747.3	194	1.7431	0.453	47.370
2	66.065	31939.7	170.3	2.1954	0.404	52.630



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	62.16	10990.4	78.2	1.6503	0.448	98.816
2	67.939	131.7	1.1	1.9661	0.721	1.184



5ad

Name: (S)-(2-methoxyphenyl)(4-methoxyphenyl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 3.59 (s, 3H), 3.86 (s, 3H), 6.91 – 6.98 (m, 3H), 7.09 (tdd, J = 7.5, 2.0, 0.9 Hz, 1H), 7.43 (tdd, J = 8.2, 2.9, 1.3 Hz, 2H), 7.49 – 7.58 (m, 2H), 7.68 (dddd, J = 18.6, 11.9, 7.5, 1.6 Hz, 4H), 7.79 (ddd, J = 13.4, 7.5, 1.8 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-*d*) δ 55.31, 111.35 (d, *J* = 6.3 Hz, 1C), 113.68 (d, *J* = 13.4 Hz, 1C), 120.23, 120.54 – 121.42 (m, 1C), 124.23 (d, *J* = 114.0 Hz, 1C), 128.08 (d, *J* = 12.5 Hz, 1C), 131.32, 131.75 (d, *J* = 10.7 Hz, 1C), 133.35, 133.78 (d, *J* = 12.2 Hz, 1C), 133.94 (d, *J* = 11.2 Hz, 1C), 134.15, 134.20, 134.98 (d, *J* = 7.0 Hz, 1C), 160.82 (d, *J* = 3.4 Hz, 1C), 162.13

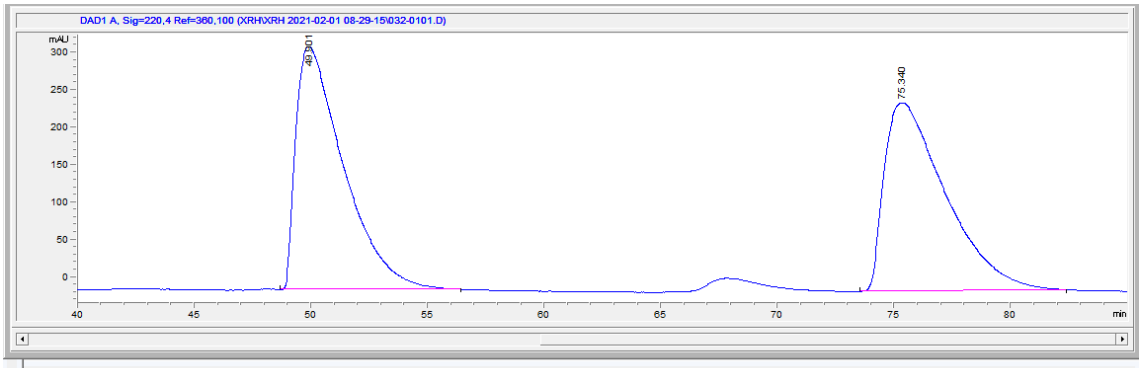
^{31}P NMR (202 MHz, Chloroform-d) δ 26.07.

ESI-MS: m/z 339.15 $[M+H]^+$, 361.10 $[M+Na]^+$

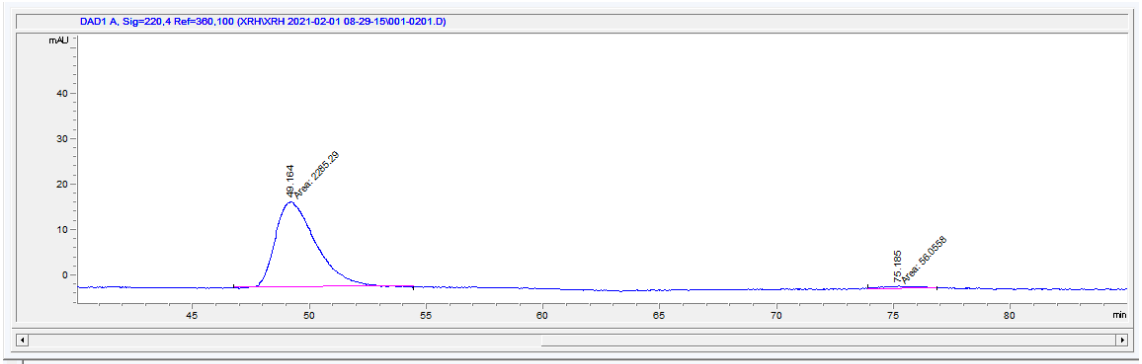
HRMS (ESI) calculated for $[M+H, C_{10}H_{16}OP]^+$: 339.1145 found 339.1152;.

$[\alpha]_D^{25}$: 1.5619 (c = 0.1933g/100ml, $CHCl_3$)..

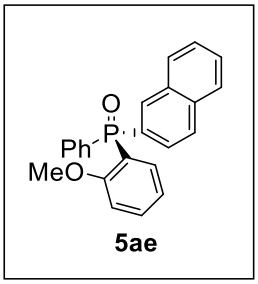
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 5/95, flow rate 0.8 mL/min, 220 nm. t_1 = 49.901 min, t_2 =75.34 min. 95% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	49.901	46031.9	324.8	1.6815	0.362	50.053
2	75.34	45935.3	251.7	2.1428	0.403	49.947



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	49.164	2285.3	18.8	2.0255	0.568	97.606
2	75.185	56.1	5.5E-1	1.6999	0.886	2.394



5ae

Name: (*S*)-(2-methoxyphenyl)(naphthalen-2-yl)(phenyl)phosphine oxide

Physical States: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 3.59 (s, 3H), 6.94 (dd, J = 8.3, 5.3 Hz, 1H), 7.10 (tdd, J = 7.5, 2.1, 0.9 Hz, 1H), 7.35 – 7.41 (m, 1H), 7.42 – 7.48 (m, 4H), 7.49 – 7.58 (m, 2H), 7.59 – 7.63 (m, 2H), 7.66 (dd, J = 8.4, 2.6 Hz, 2H), 7.71 – 7.85 (m, 5H).

^{13}C NMR (126 MHz, Chloroform-*d*) δ 55.32, 111.42 (d, *J* = 6.7 Hz, 1C), 120.68, 121.02 (d, *J* = 12.0 Hz, 1C), 126.82 (d, *J* = 12.5 Hz, 1C), 127.27, 127.93 – 128.39 (m, 1C), 128.94, 131.51 (d, *J* = 3.3 Hz, 1C), 131.83 (d, *J* = 10.4 Hz, 1C), 132.39 (d, *J* = 10.3 Hz, 1C), 134.34, 135.04 (d, *J* = 6.8 Hz, 1C), 140.16, 144.15, 160.87

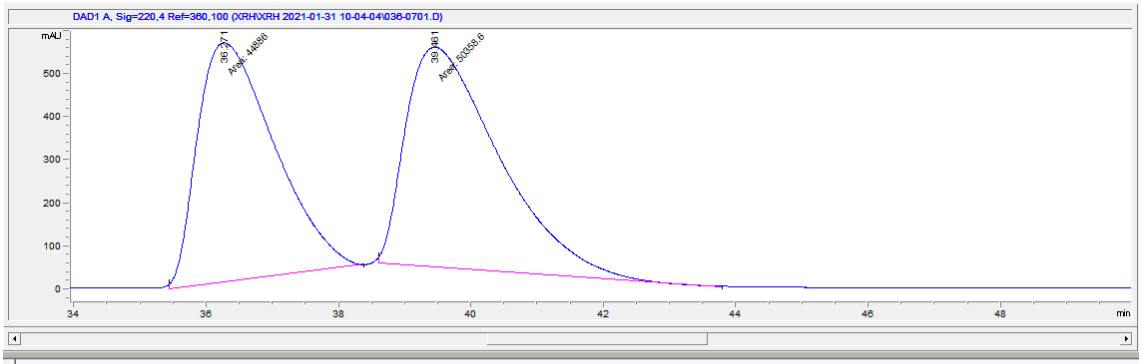
^{31}P NMR (202 MHz, Chloroform-d) δ 26.22.

ESI-MS: m/z 359.15 $[M+H]^+$, 381.15 $[M+Na]^+$

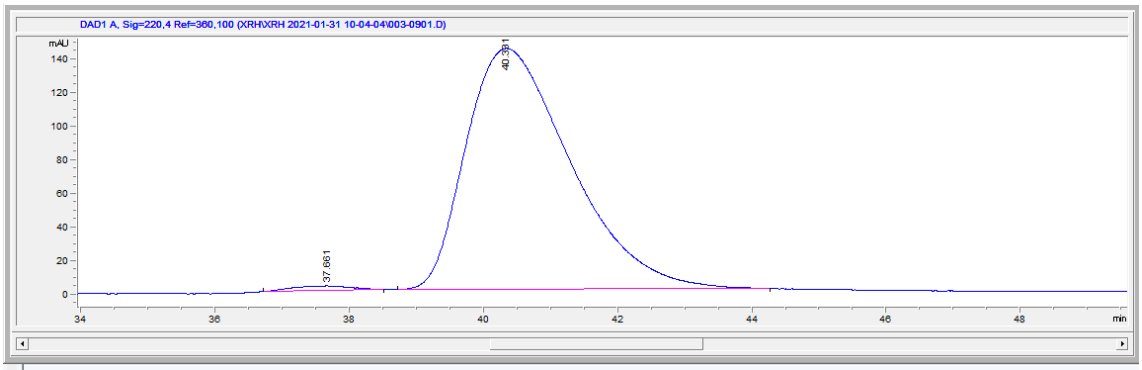
HRMS (ESI) calculated for [M+H, $C_{23}H_{20}O_2P]^+$: 359.1195 found 359.1200; calculated for [M+Na, $C_{23}H_{19}O_2PNa]^+$: 381.1015 found:381.1021.

$[\alpha]_D^{25}$: -9.7485 (c = 0.0667g/100ml, $CHCl_3$).

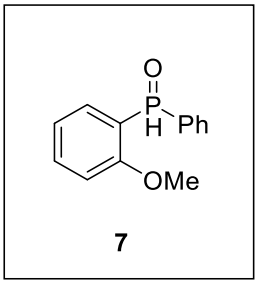
Chiral HPLC conditions: OD-3, *i*-PrOH-hexane 5/95, flow rate 1.00 mL/min, 220 nm. t_1 = 36.271 min, t_2 =39.461 min. 97% ee



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	36.271	44886	556	1.3456	0.532	47.127
2	39.461	50358.6	512.2	1.6385	0.452	52.873



#	时间	峰面积	峰高	峰宽	对称因子	Area%
1	37.661	174.7	2.8	0.7426	1.53	1.114
2	40.331	15504.4	143.3	1.2826	0.594	98.886



7

Name: (2-methoxyphenyl)(phenyl)phosphine oxide

Physical State: colorless oil

Yield: 70% yield

^{1}H NMR (500 MHz, Chloroform-d) δ 3.76 (s, 3H), 6.90 (dd, *J* = 8.4, 5.6 Hz, 1H), 7.06 – 7.12 (m, 1H), 7.44 (ddd, *J* = 8.5, 6.7, 3.0 Hz, 2H), 7.49 – 7.56 (m, 2H), 7.66 (s, 0H), 7.69 – 7.84 (m, 3H), 8.66 (s, 0H).

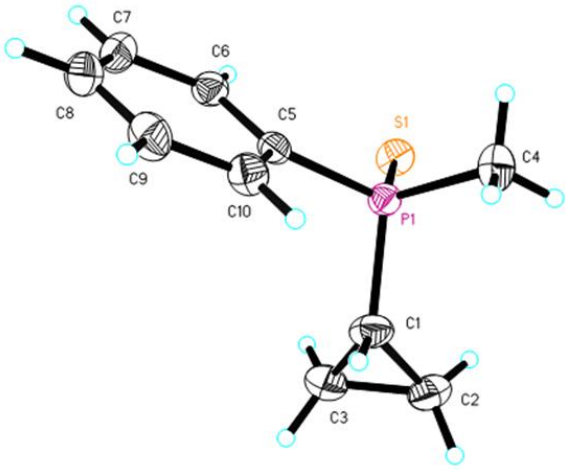
^{13}C NMR (126 MHz, Chloroform-d) δ 55.56, 110.80 (d, *J* = 6.6 Hz, 1C), 119.33 (d, *J* = 101.8 Hz, 1C), 121.15 (d, *J* = 12.4 Hz, 1C), 128.54 (d, *J* = 13.5 Hz, 1C), 130.47 (d, *J* = 11.3 Hz) , 1C, 131.68, 132.06 (d, *J* = 2.7 Hz, 1C), 132.51, 133.04 (d, *J* = 6.8 Hz, 1C), 134.46

^{31}P NMR (202 MHz, Chloroform-d) δ 13.43.

ESI-MS: m/z 233.00 $[M+H]^+$, 255.05 $[M+Na]^+$

HRMS (ESI) calculated for [M+Na, $C_{13}H_{13}O_2PNa]^+$: 255.0545 found:255.0553.

12. X-ray structural data of 6 am



Crystal data and structure refinement for mo_d8v20731_0m.

Identification code	mo_d8v20731_0m	
Empirical formula	C10 H13 P S	
Formula weight	196.23	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P 21 21 21	
Unit cell dimensions	a = 9.1461(3) Å	α= 90 °.
	b = 9.6810(3) Å	β= 90 °.
	c = 11.8702(3) Å	γ = 90 °.
Volume	1051.03(5) $Å^3$	
Z	4	
Density (calculated)	1.240 Mg/m^3	
Absorption coefficient	0.405 mm^{-1}	
F(000)	416	
Crystal size	0.170 x 0.140 x 0.120 mm^3	
Theta range for data collection	2.715 to 25.995 °.	
Index ranges	-11<=h<=11, -11<=k<=11, -14<=l<=14	
Reflections collected	9523	
Independent reflections	2054 [R(int) = 0.0318]	
Completeness to theta = 25.242 °	99.1 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.6532	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2054 / 0 / 111	
Goodness-of-fit on F^2	1.054	

Final R indices [I>2sigma(I)]	R1 = 0.0238, wR2 = 0.0656
R indices (all data)	R1 = 0.0247, wR2 = 0.0668
Absolute structure parameter	0.00(3)
Extinction coefficient	0.188(15)
Largest diff. peak and hole	0.253 and -0.170 e.Å^{-3}

13. References

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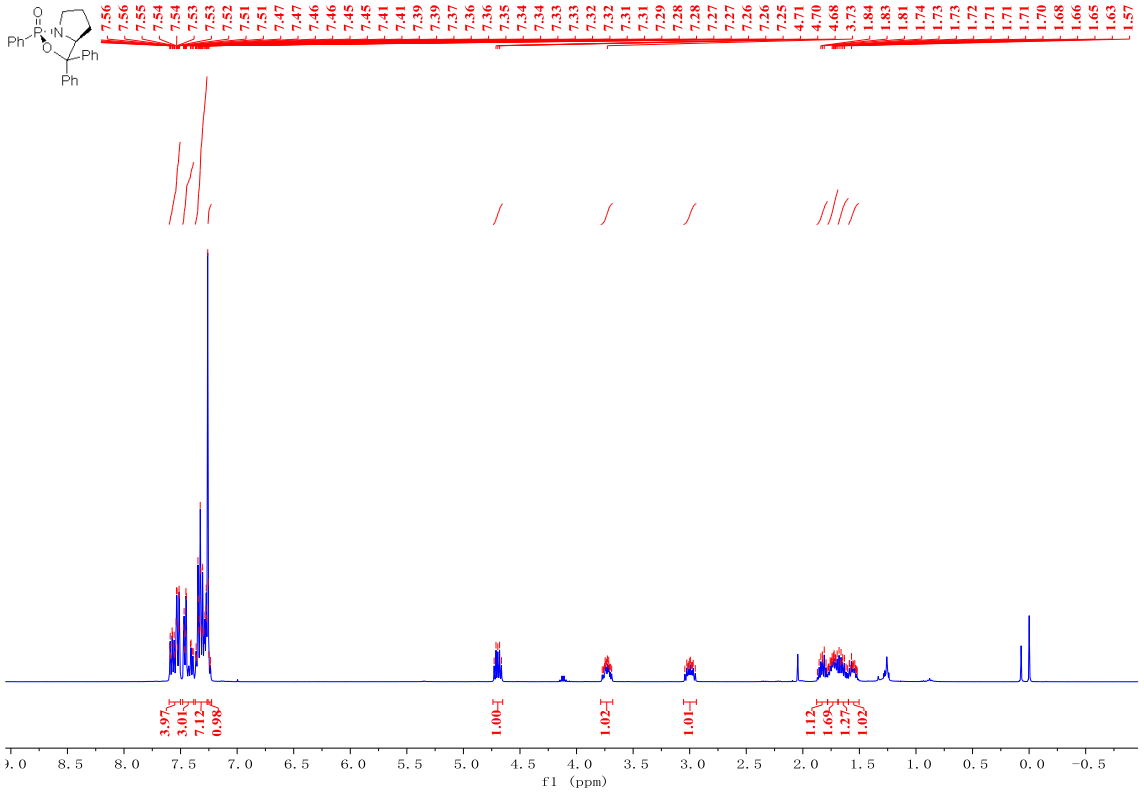
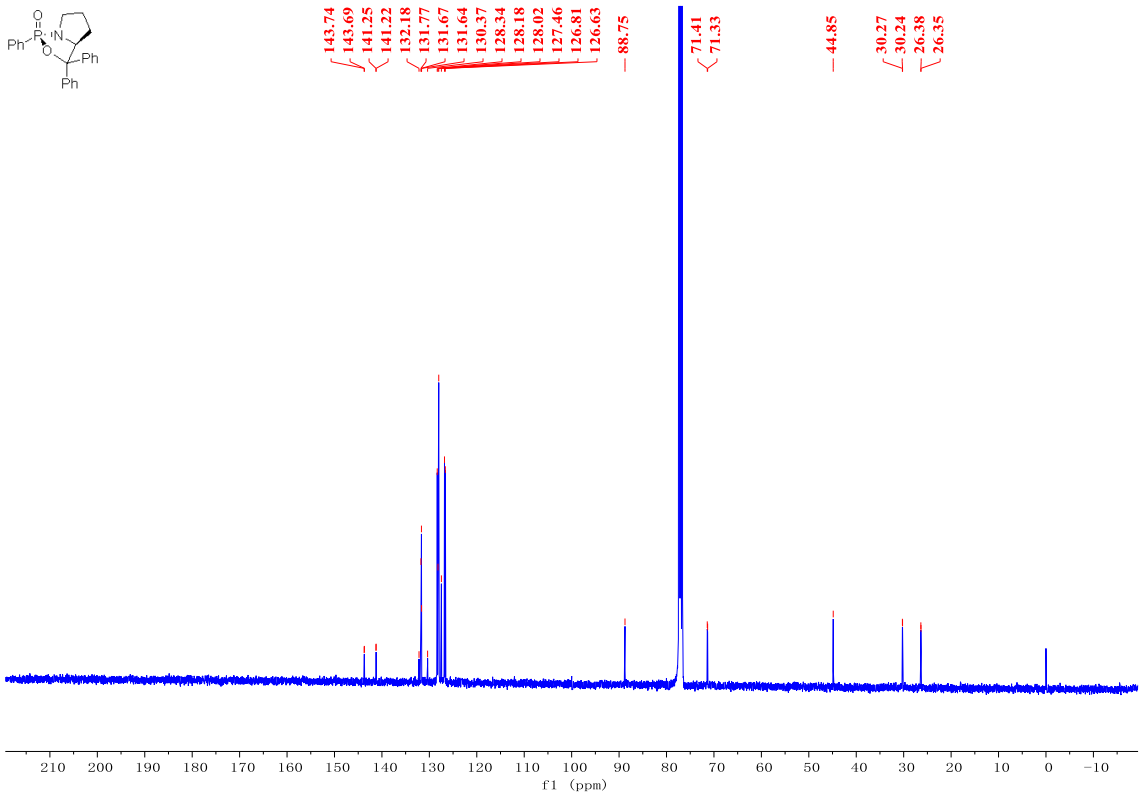
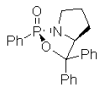
14. NMR spectra (Note: The order of the spectrum of each compound is ^{1}H NMR, ^{13}C NMR, ^{31}P NMR, ^{19}F NMR (if the compound contains fluorine))



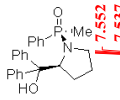




35.21

190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40

f1 (ppm)

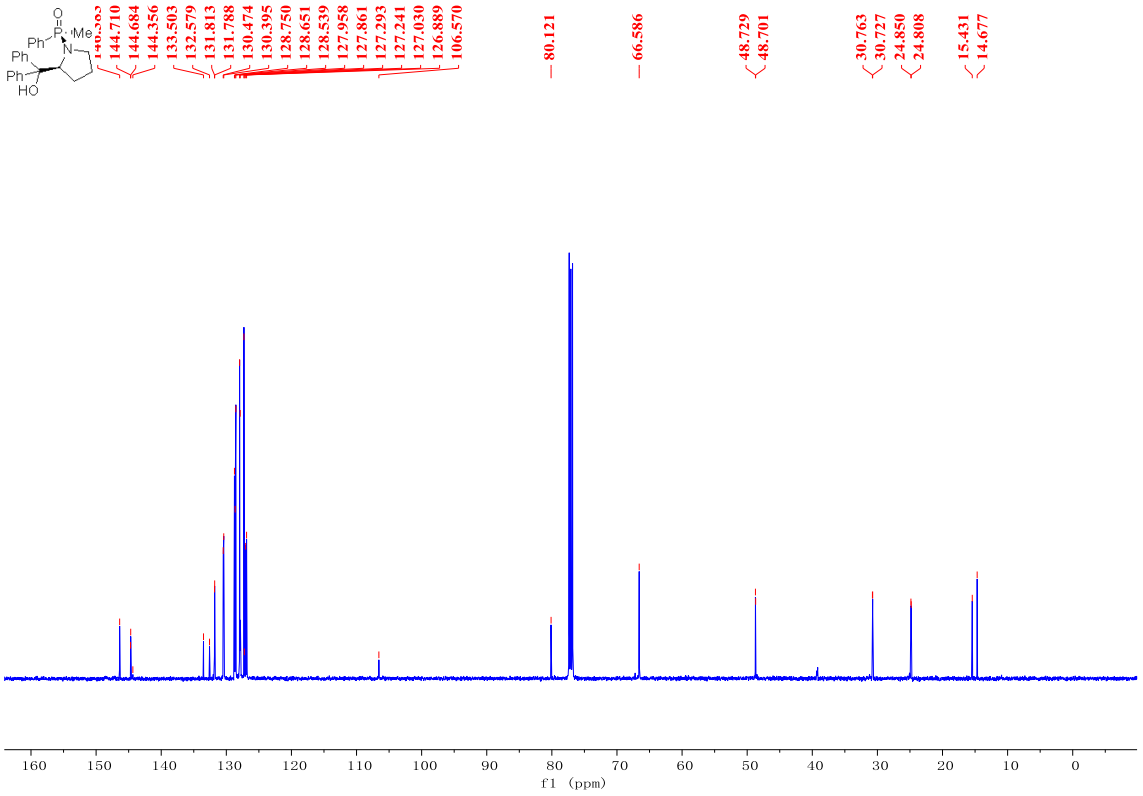


7.552 7.537 7.523 7.511 7.508 7.493 7.480 7.474 7.465 7.459 7.421 7.406 7.328 7.324 7.311 7.307 7.293 7.277 7.261 7.250 7.235 7.221 2.985 2.974 2.967 2.956 2.646 2.642 2.632 2.627 2.618 2.613 2.048 2.042 2.031 2.015 2.005 1.998 1.988 1.978 1.626 1.598 1.446 1.441 1.434 1.428 1.422 1.416 1.411 1.026 1.015 1.010 1.000 0.990 0.985

1.99 5.30 2.01 6.38 0.70 1.03 1.05 1.03 2.13 3.00 1.10 1.08

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.

f1 (ppm)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Ph
Ph
HO
O
P
Me
N
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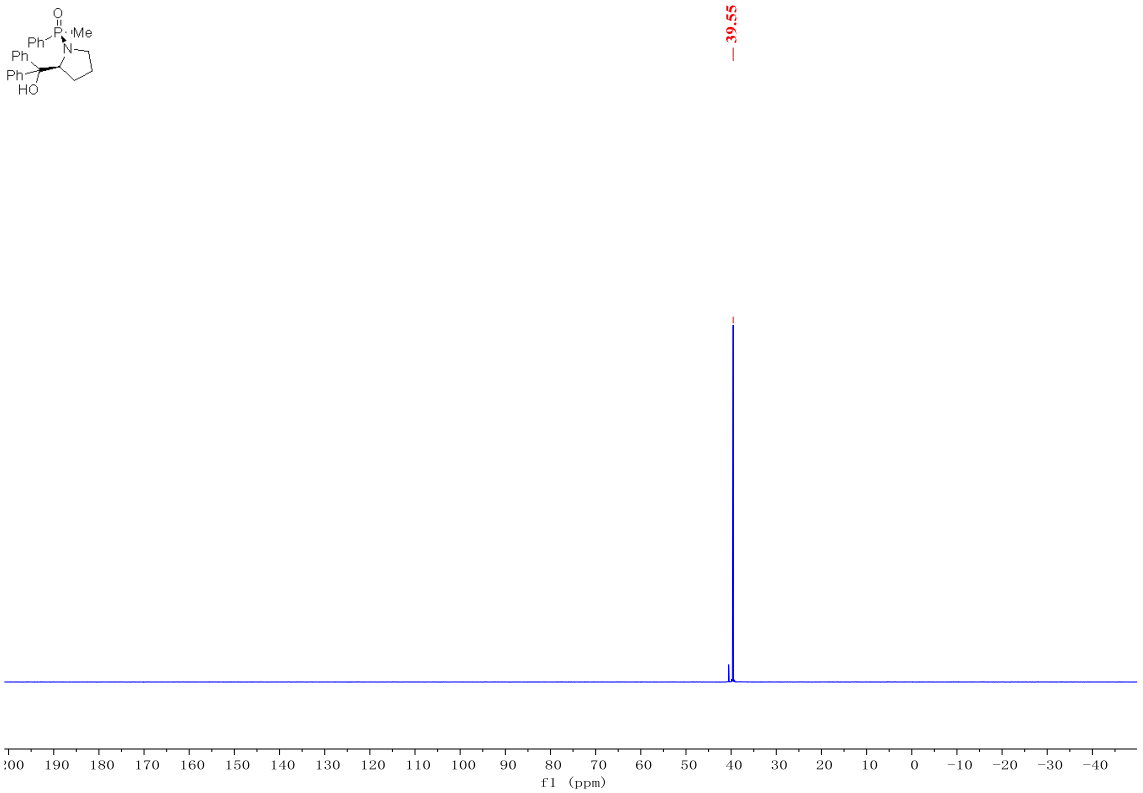
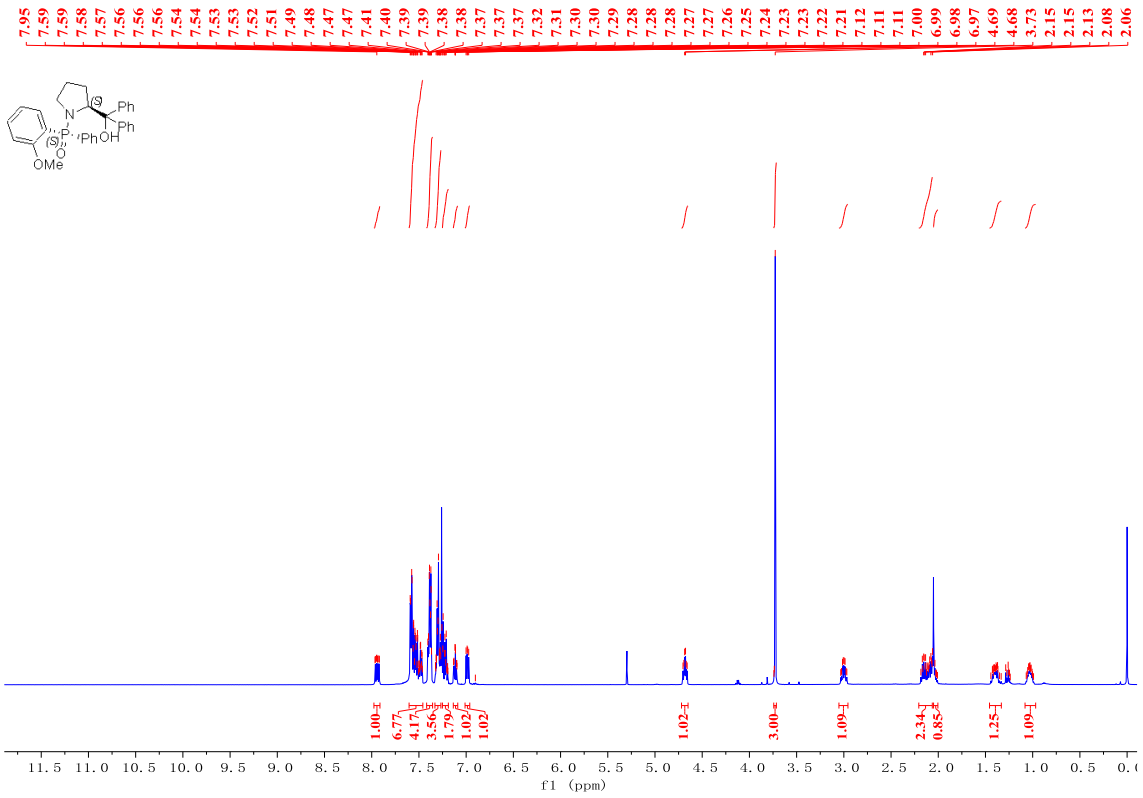
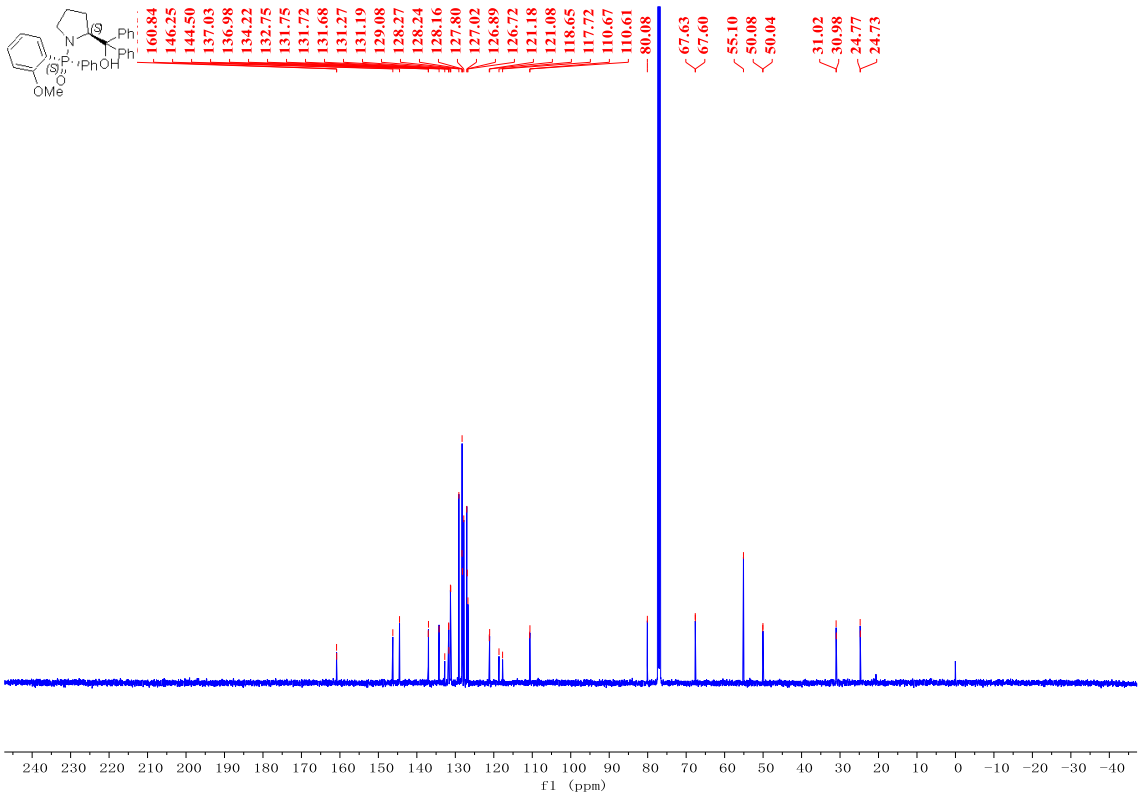
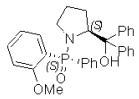
144.684
144.356
133.503
132.579
131.813
131.788
130.474
130.395
128.750
128.651
128.539
127.958
127.861
127.293
127.241
127.030
126.889
106.570
80.121
66.586
48.729
48.701
30.763
30.727
24.850
24.808
15.431
14.677
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

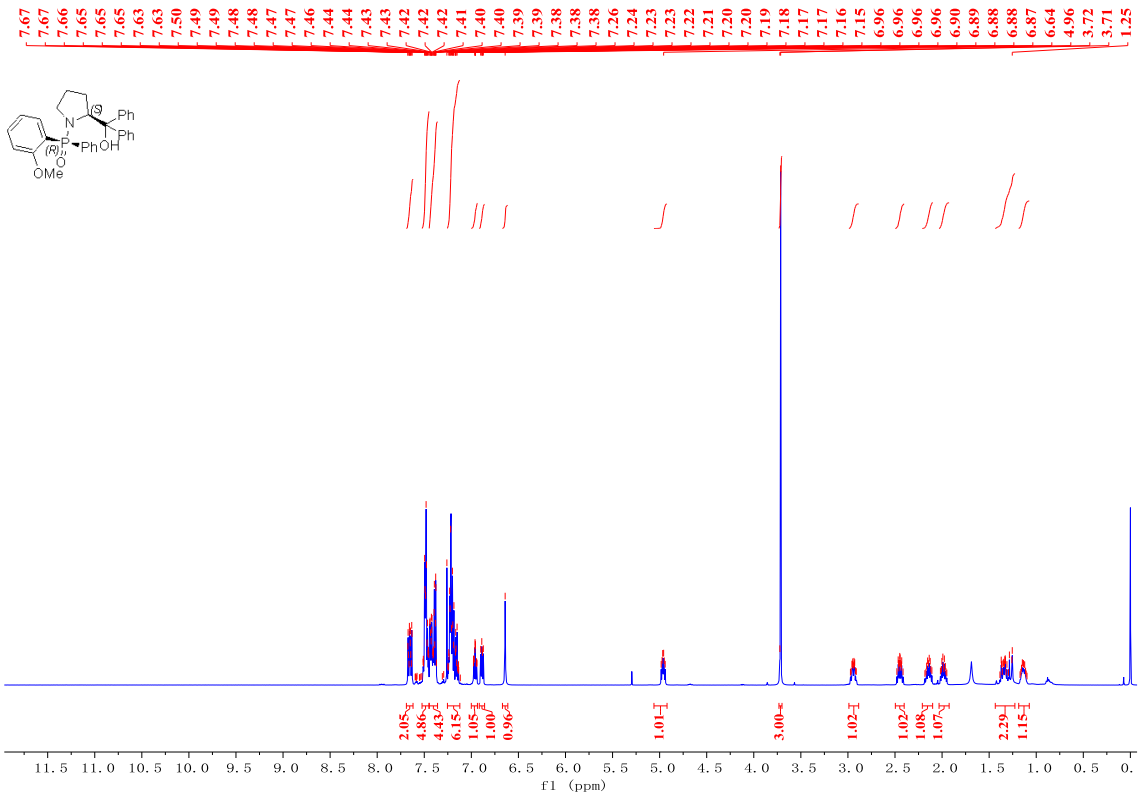

Ph
Ph
Ph
HO
O
P
Me
N
39.55
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40
f1 (ppm)

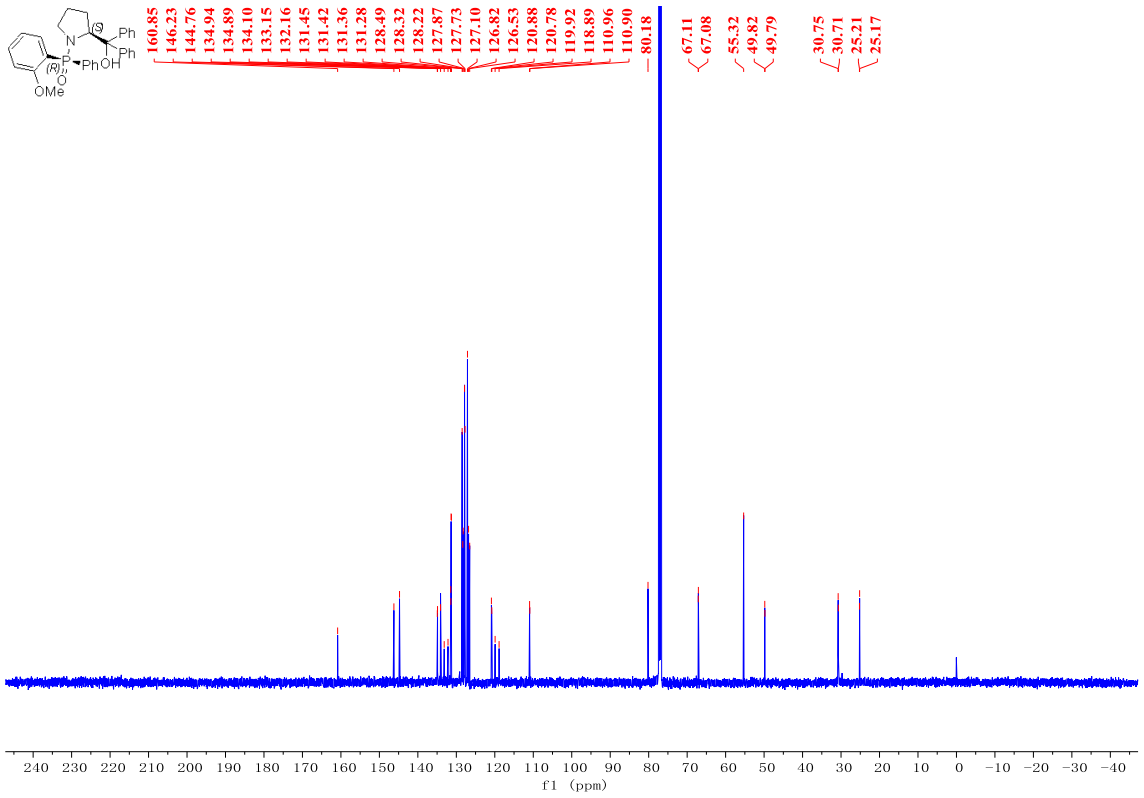

7.95 7.59 7.59 7.58 7.57 7.56 7.56 7.56 7.54 7.54 7.53 7.53 7.52 7.51 7.49 7.48 7.47 7.47 7.41 7.40 7.39 7.39 7.38 7.38 7.37 7.37 7.37 7.32 7.31 7.30 7.30 7.29 7.28 7.28 7.28 7.27 7.27 7.26 7.25 7.24 7.23 7.23 7.22 7.21 7.12 7.11 7.11 7.00 6.99 6.98 6.97 4.69 4.68 3.73 2.15 2.15 2.13 2.08 2.06
Ph
Ph
OH
Ph
O
P
N
OMe
1.00 6.77 4.17 3.56 1.79 1.02 1.02 1.02 3.00 1.09 2.34 0.85 1.25 1.09
f1 (ppm)


160.84 146.25 144.50 137.03 136.98 134.22 132.75 131.75 131.72 131.68 131.27 131.19 129.08 128.27 128.24 128.16 127.80 127.02 126.89 126.72 121.18 121.08 118.65 117.72 110.67 110.61 80.08 67.63 67.60 55.10 50.08 50.04 31.02 30.98 24.77 24.73
Ph
Ph
OH
Ph
O
P
N
OMe
f1 (ppm)


Ph
Ph
PhOH
OMe

32.60
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90
f1 (ppm)


7.67 7.67 7.66 7.65 7.65 7.65 7.63 7.63 7.50 7.49 7.49 7.48 7.48 7.47 7.47 7.46 7.44 7.44 7.44 7.43 7.43 7.42 7.42 7.42 7.41 7.40 7.40 7.39 7.39 7.38 7.38 7.26 7.24 7.23 7.23 7.22 7.21 7.20 7.20 7.19 7.18 7.17 7.17 7.16 7.15 6.96 6.96 6.96 6.90 6.89 6.88 6.88 6.87 6.64 4.96 3.72 3.71 1.25
Ph
Ph
PhOH
OMe
2.05 4.86 4.43 6.15 1.05 1.00 0.96 1.01 3.00 1.02 1.02 1.08 1.07 2.29 1.15
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.
f1 (ppm)


160.85
146.23
144.76
134.94
134.89
134.10
133.15
132.16
131.45
131.42
131.36
131.28
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128.32
128.22
127.87
127.73
127.10
126.82
126.53
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118.89
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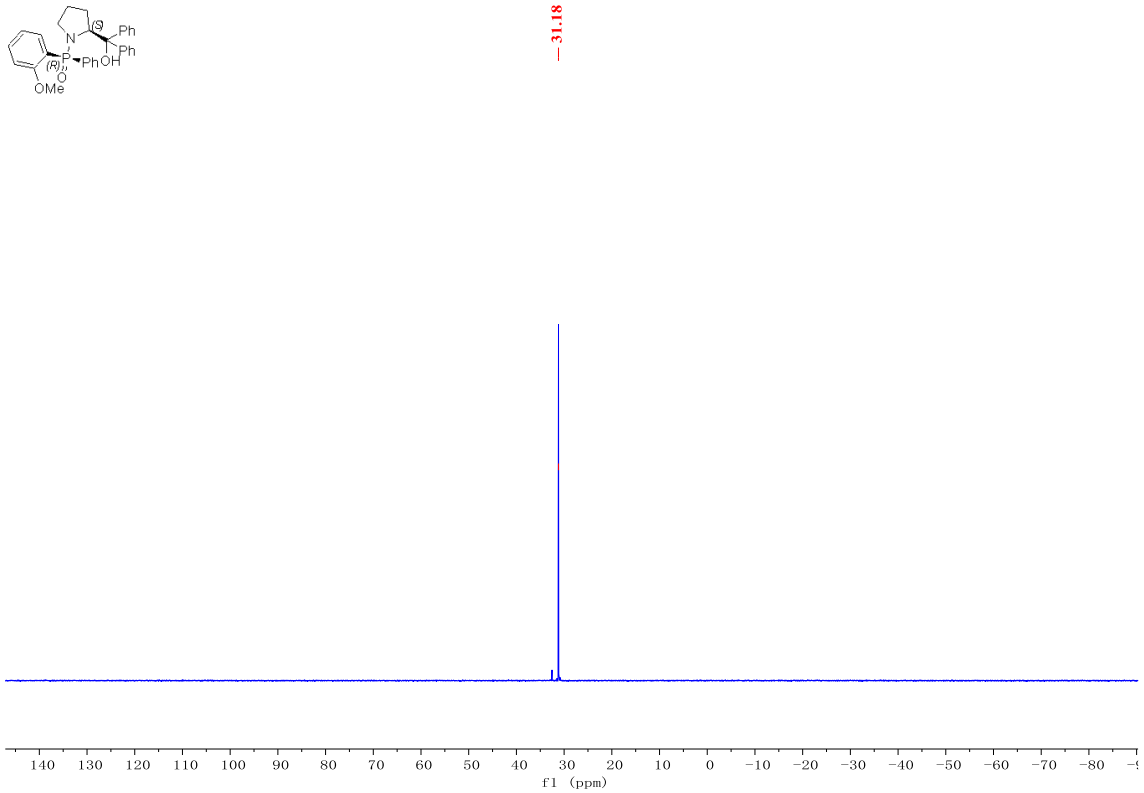
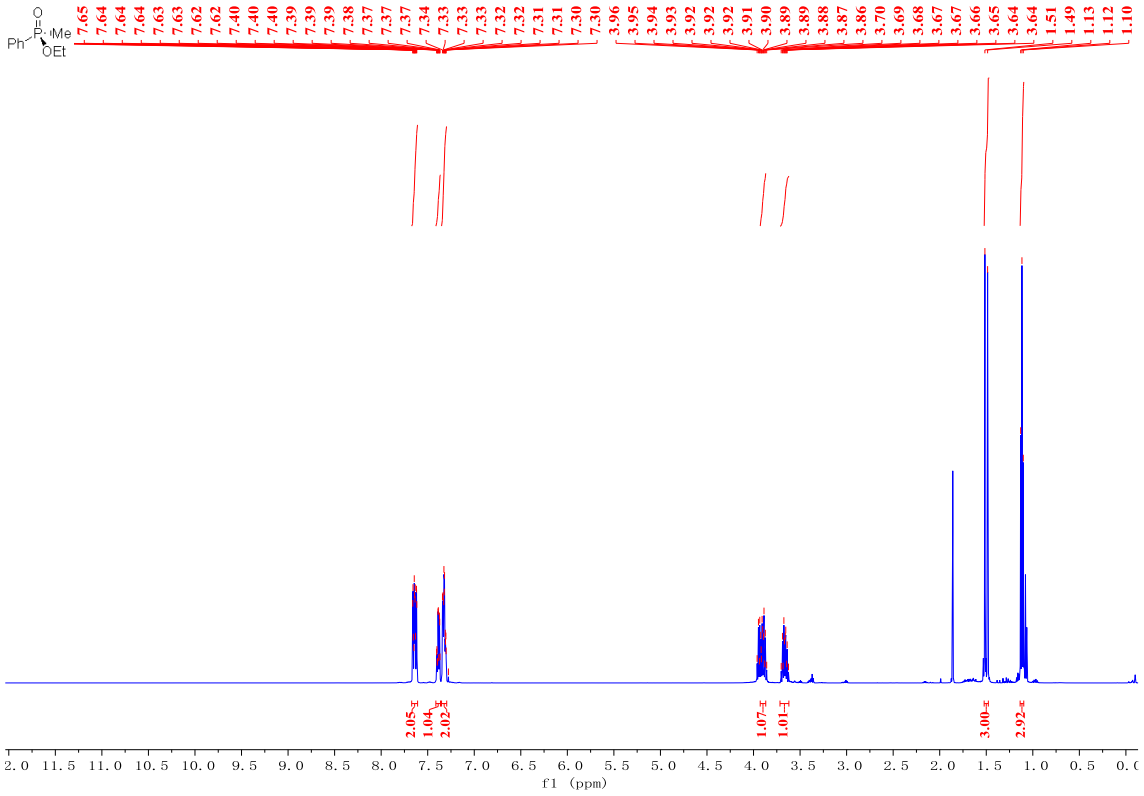
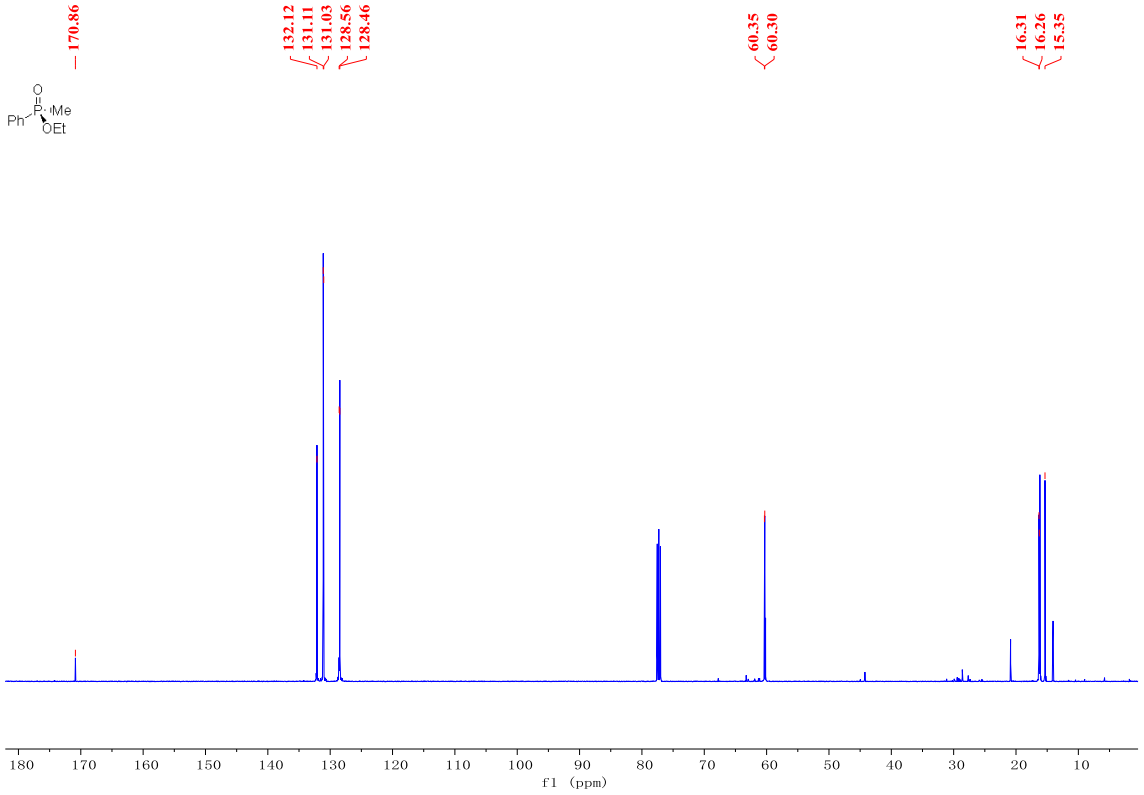
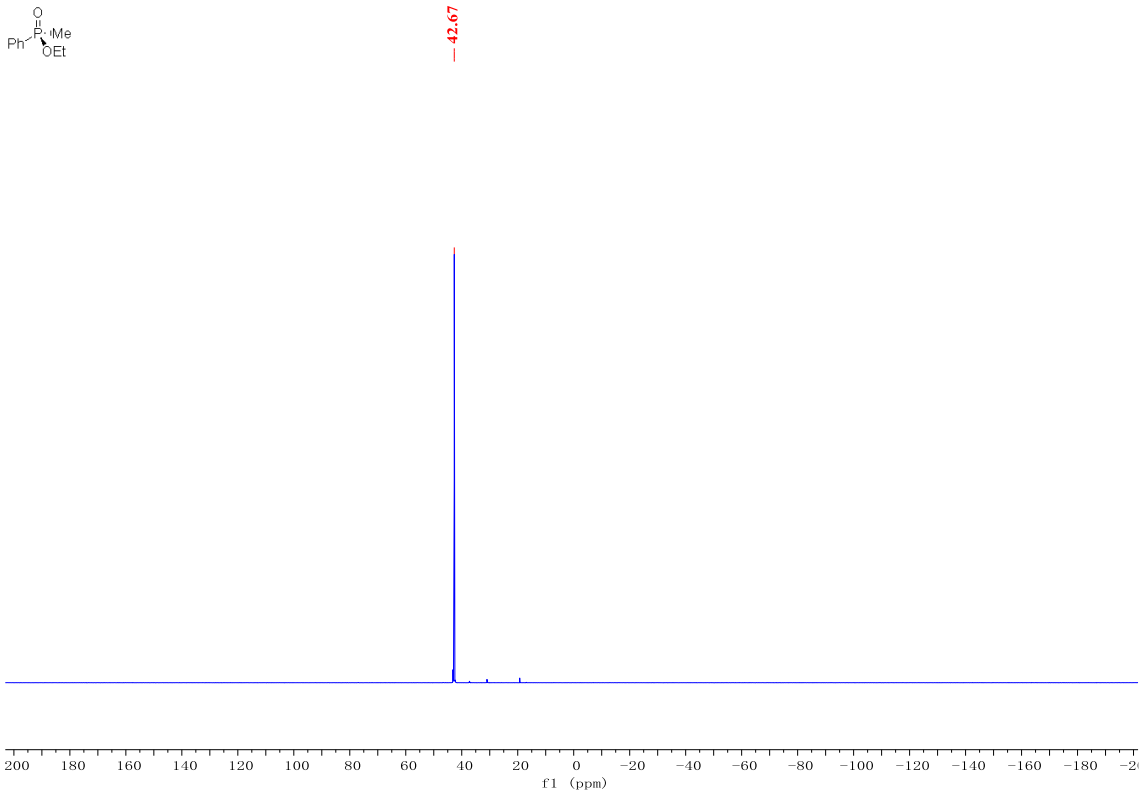
30.71
25.21
25.17
f1 (ppm)


31.18
f1 (ppm)


7.65 7.64 7.64 7.64 7.63 7.63 7.62 7.62 7.40 7.40 7.39 7.39 7.39 7.38 7.37 7.37 7.37 7.34 7.33 7.33 7.33 7.32 7.32 7.31 7.31 7.30 7.30
3.96 3.95 3.94 3.93 3.92 3.92 3.92 3.91 3.90 3.89 3.89 3.88 3.87 3.86 3.70 3.69 3.68 3.67 3.67 3.66 3.65 3.64 3.64 1.51 1.49 1.13 1.12 1.10
2.05 1.04 2.02 1.07 1.01 3.00 2.92
f1 (ppm)


170.86
132.12 131.11 131.03 128.56 128.46
60.35 60.30
16.31 16.26 15.35
f1 (ppm)


Ph
P
O
Me
OEt
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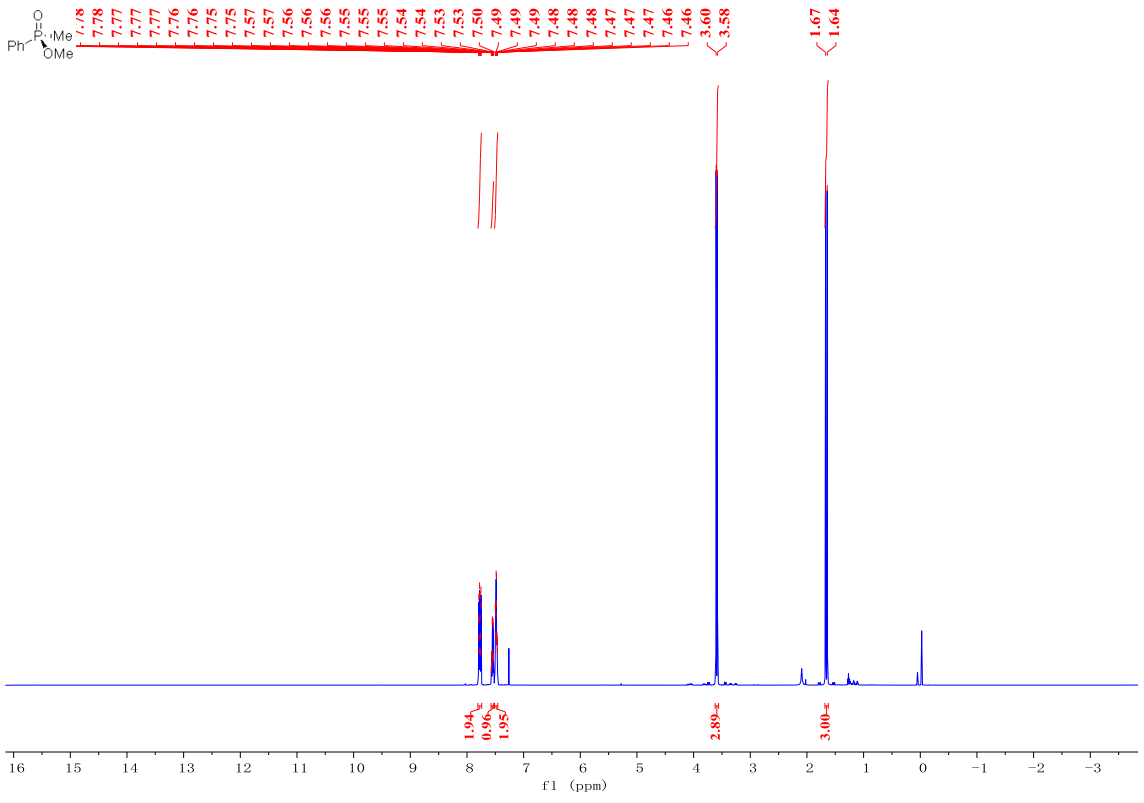
f1 (ppm)


Ph
P
O
Me
OMe
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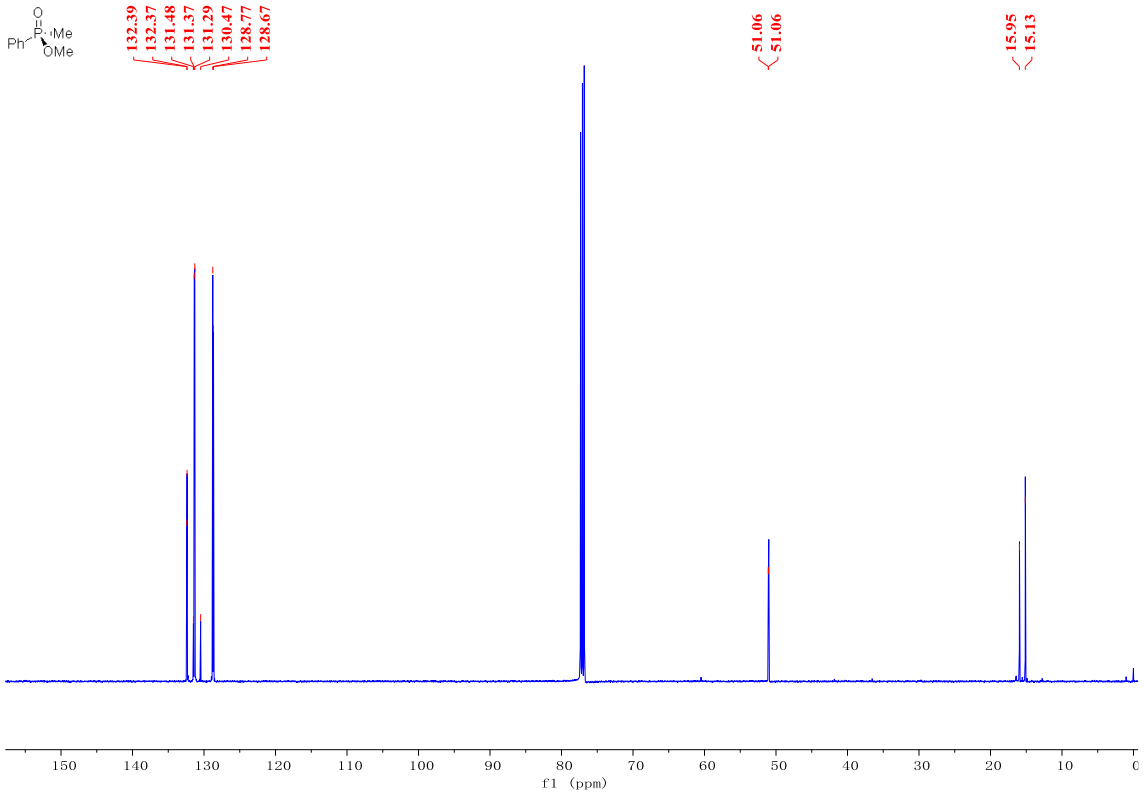
3.60 3.58
1.67 1.64
1.94 0.96 1.95
2.89
3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)


O
P
Me
OMe
Ph
132.39
132.37
131.48
131.37
131.29
130.47
128.77
128.67
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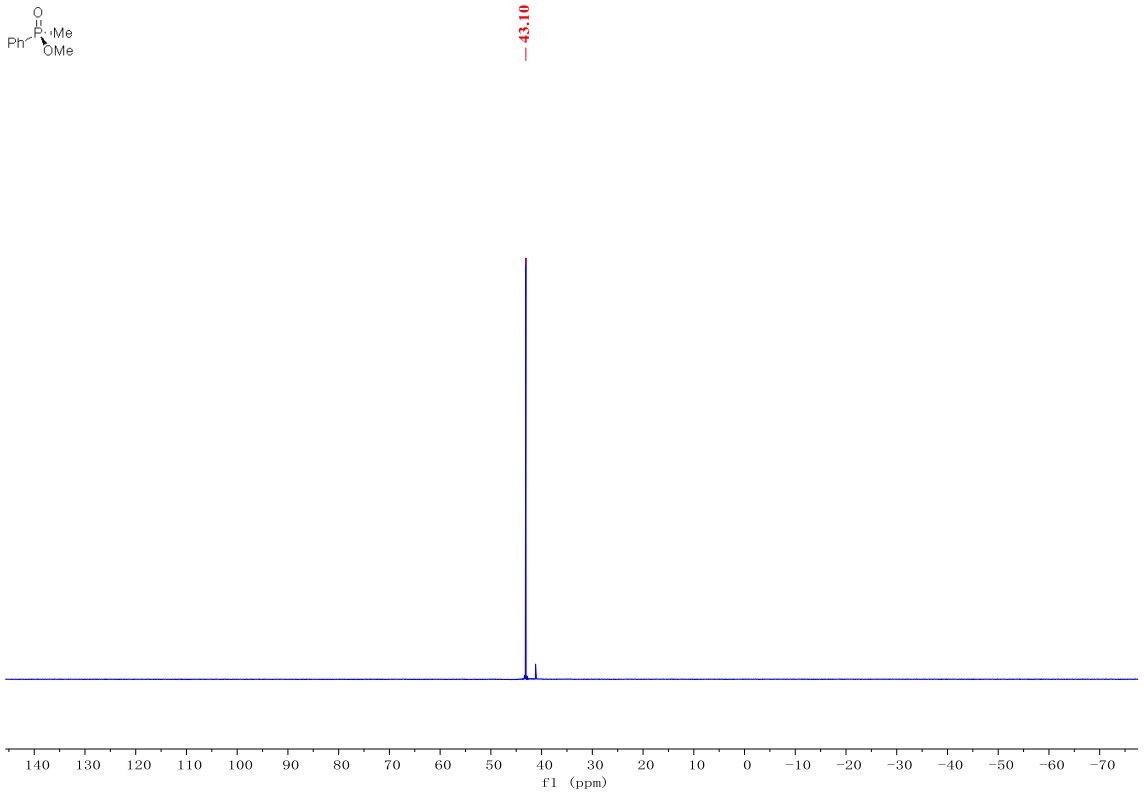
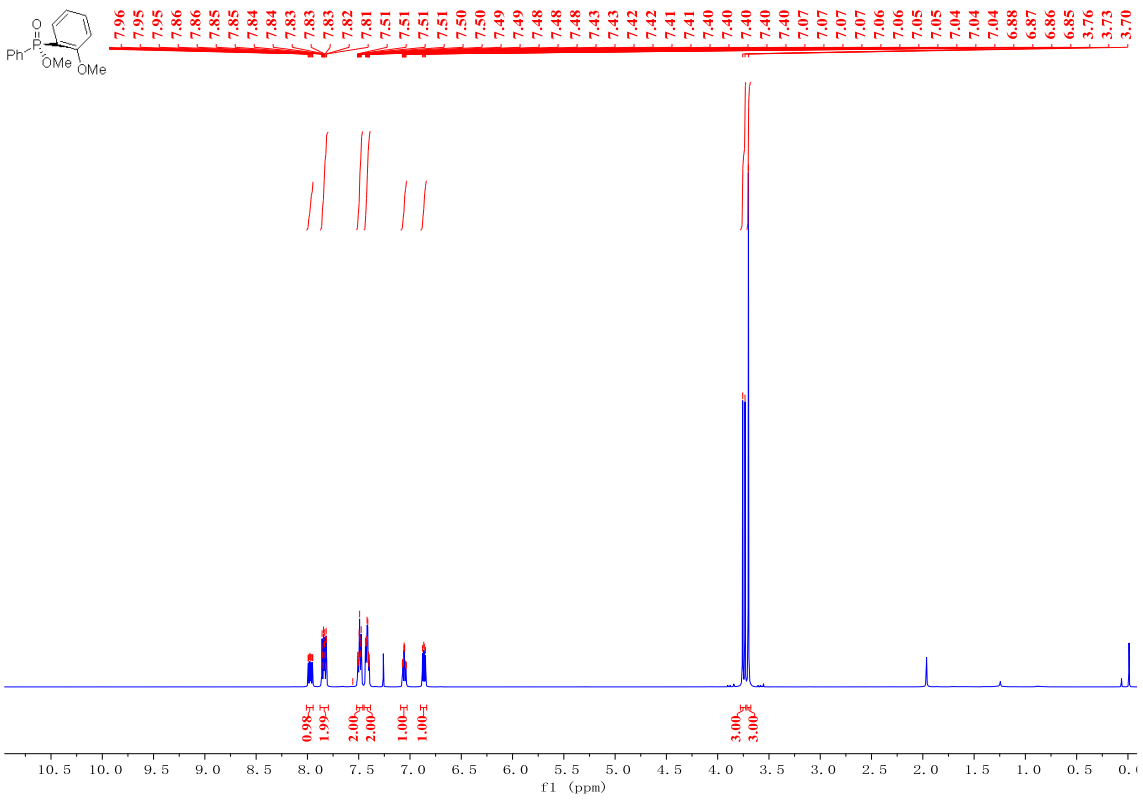
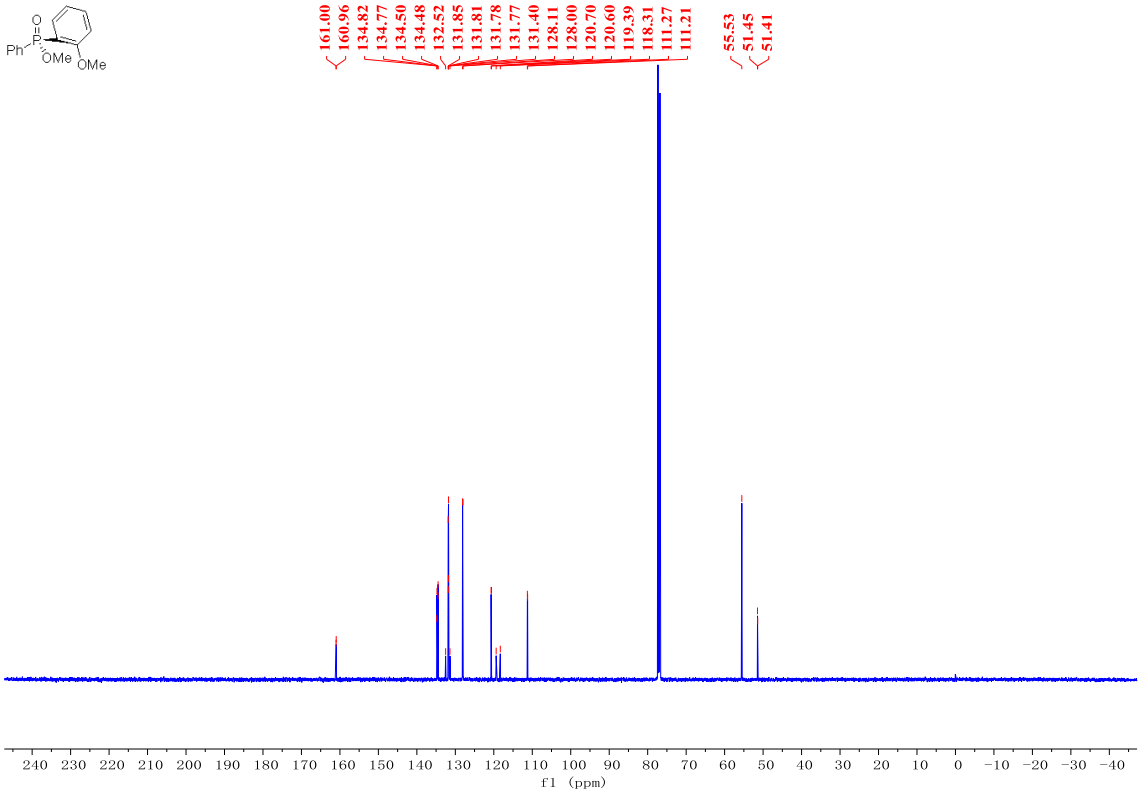
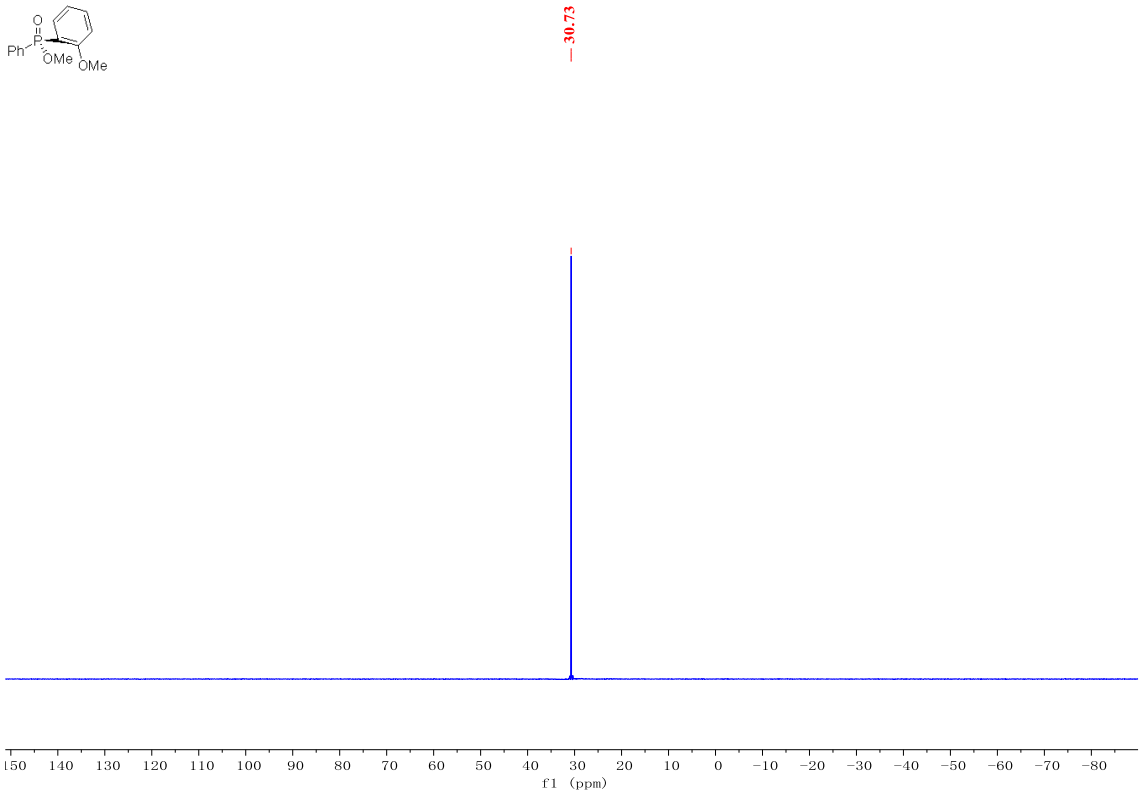
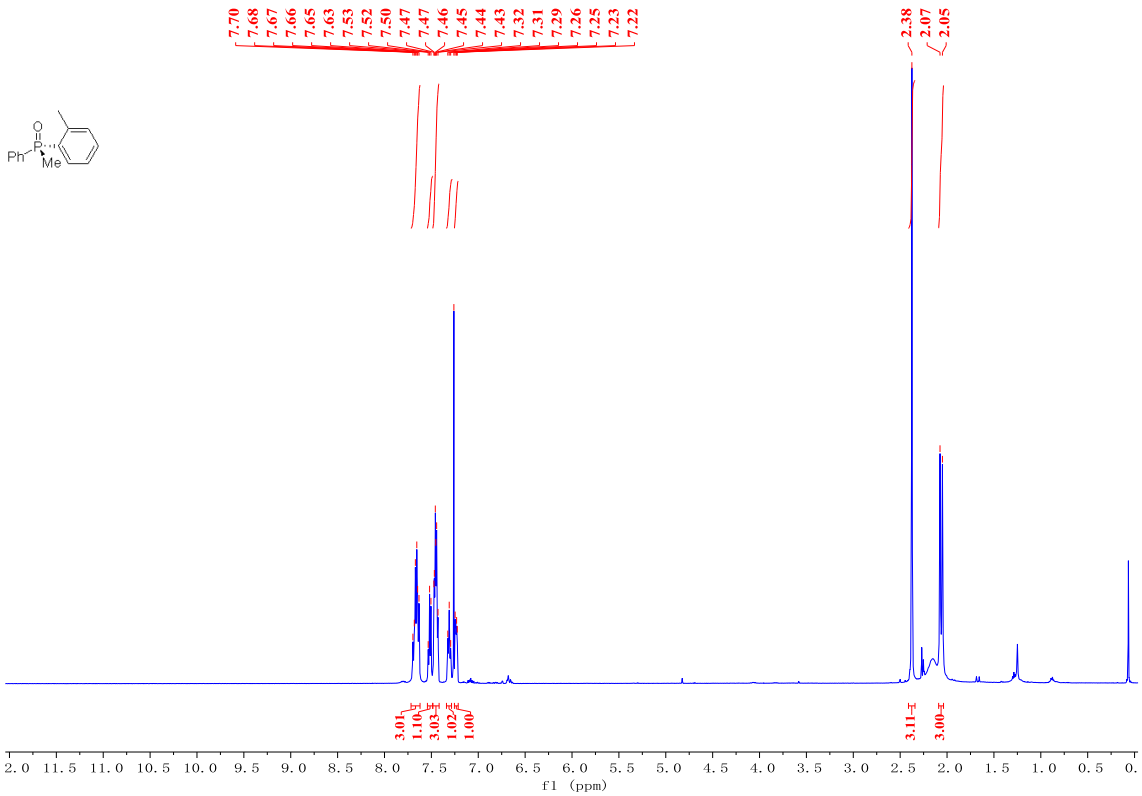
51.06
15.95
15.13
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

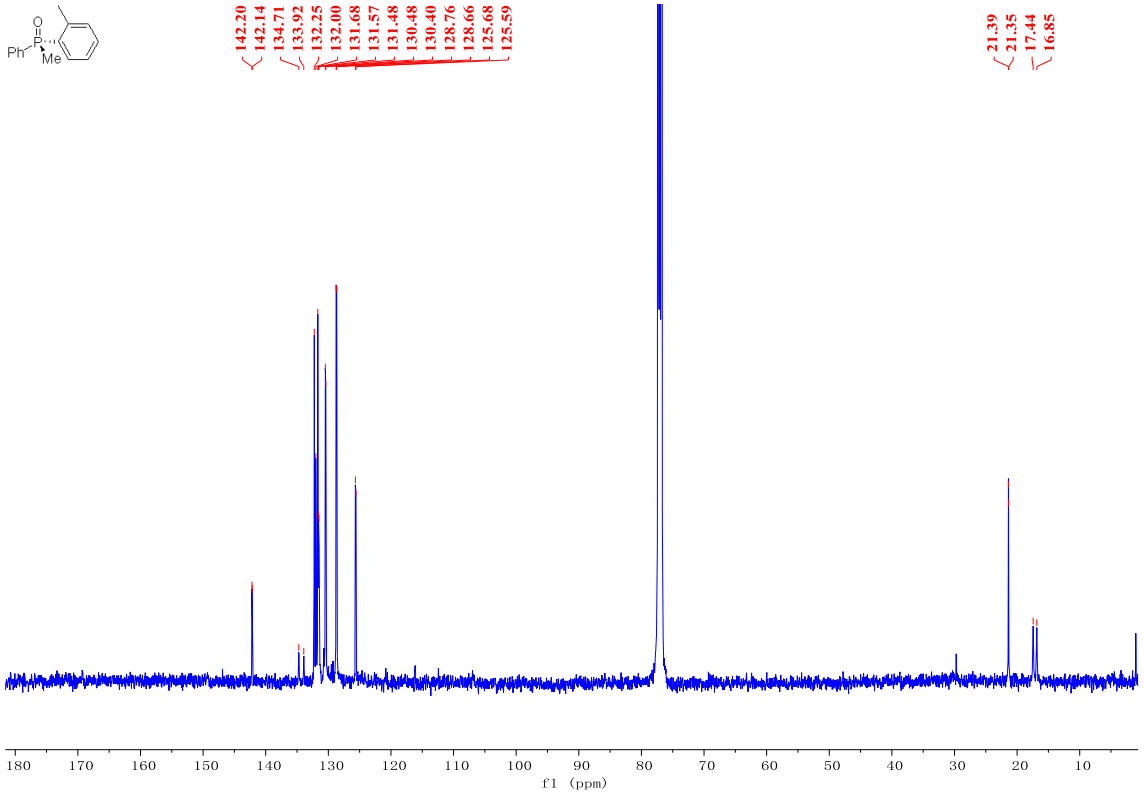

O
P
Me
OMe
Ph
43.10
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
f1 (ppm)

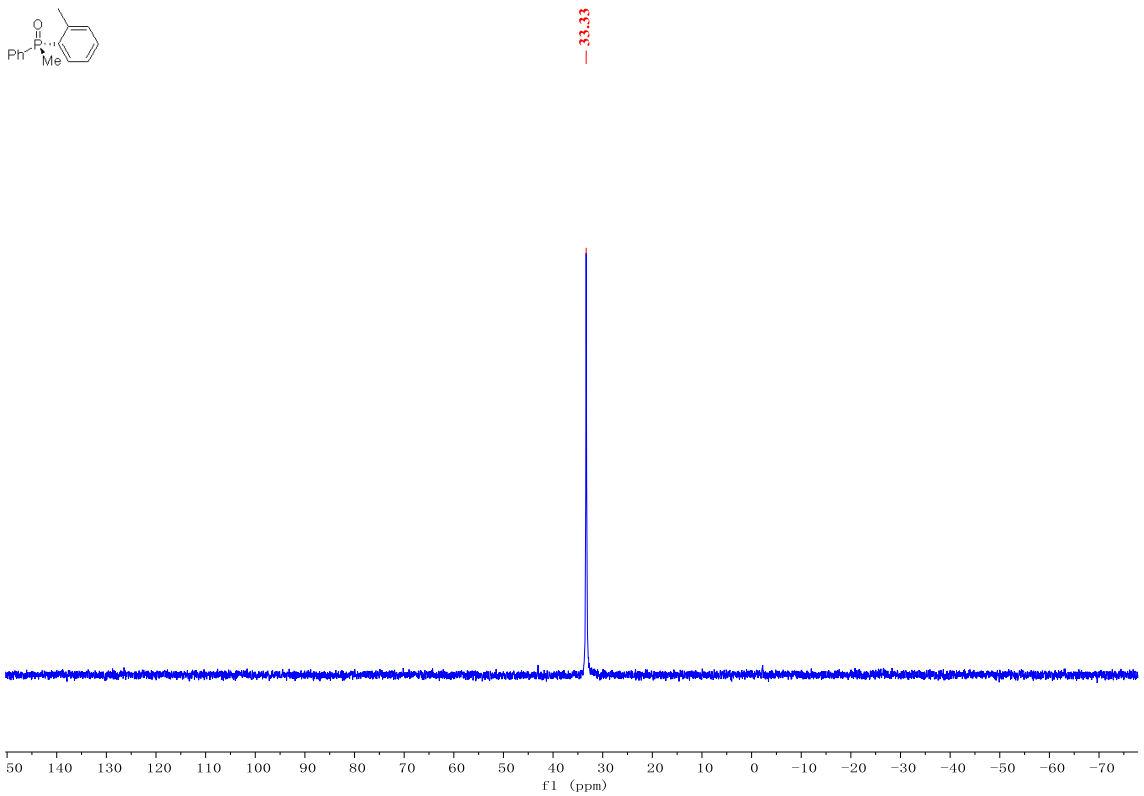

7.96 7.95 7.95 7.86 7.86 7.85 7.85 7.84 7.84 7.83 7.83 7.83 7.82 7.81 7.51 7.51 7.51 7.51 7.50 7.50 7.49 7.49 7.48 7.48 7.48 7.43 7.43 7.42 7.42 7.41 7.41 7.40 7.40 7.40 7.40 7.40 7.07 7.07 7.07 7.06 7.06 7.05 7.05 7.04 7.04 7.04 6.88 6.87 6.86 6.85 3.76 3.73 3.70
0.98 1.99 2.00 2.00 1.00 1.00 3.00 3.00
f1 (ppm)

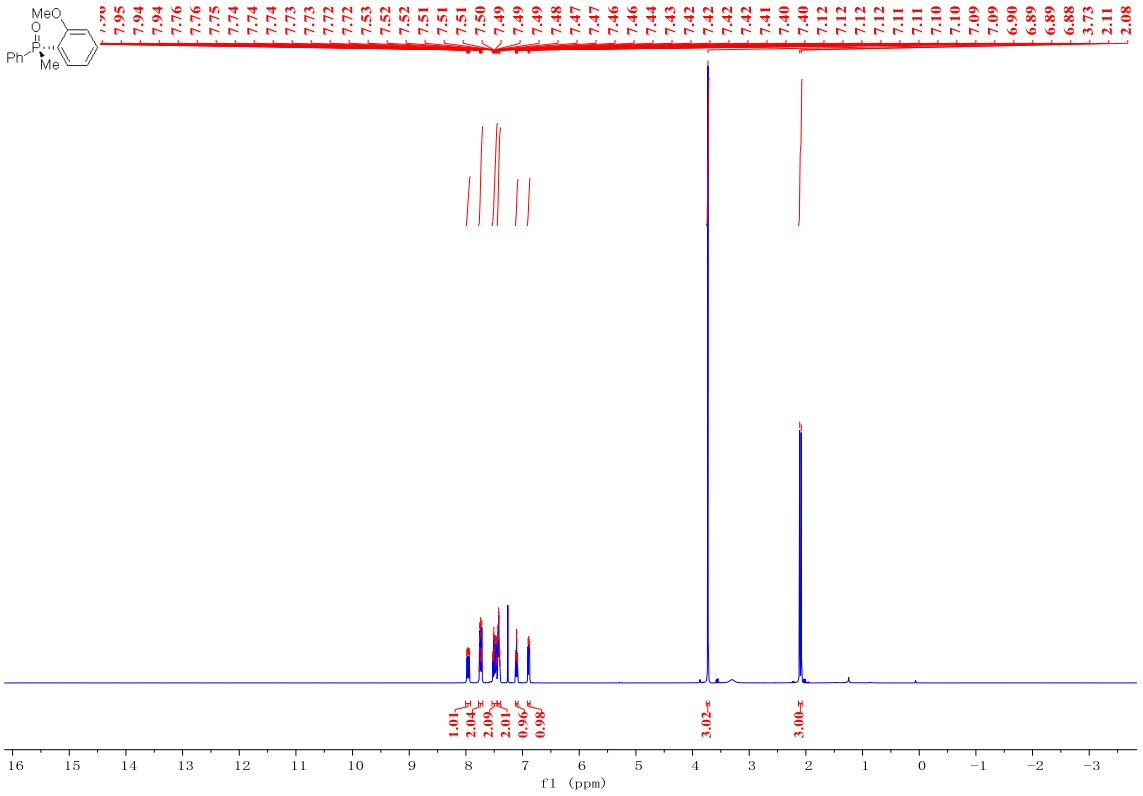

161.00 160.96 134.82 134.77 134.50 134.48 132.52 131.85 131.81 131.78 131.77 131.40 128.11 128.00 120.70 120.60 119.39 118.31 111.27 111.21 55.53 51.45 51.41
f1 (ppm)

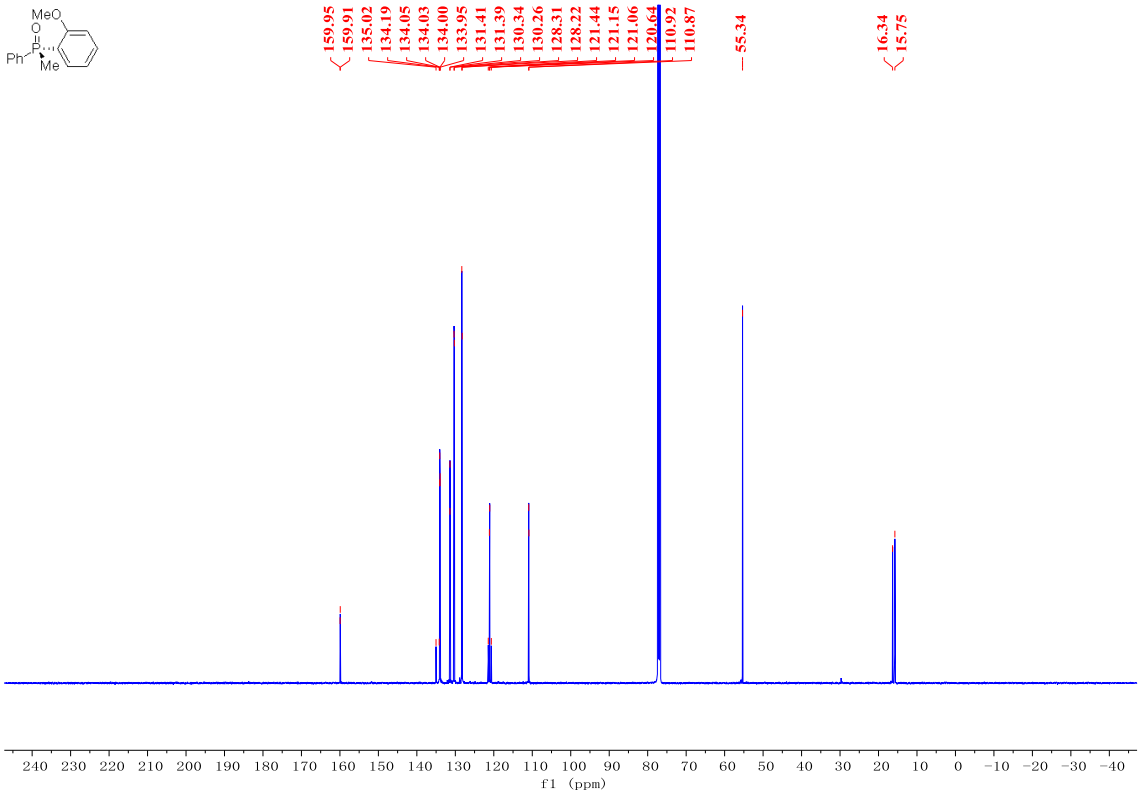

30.73
f1 (ppm)

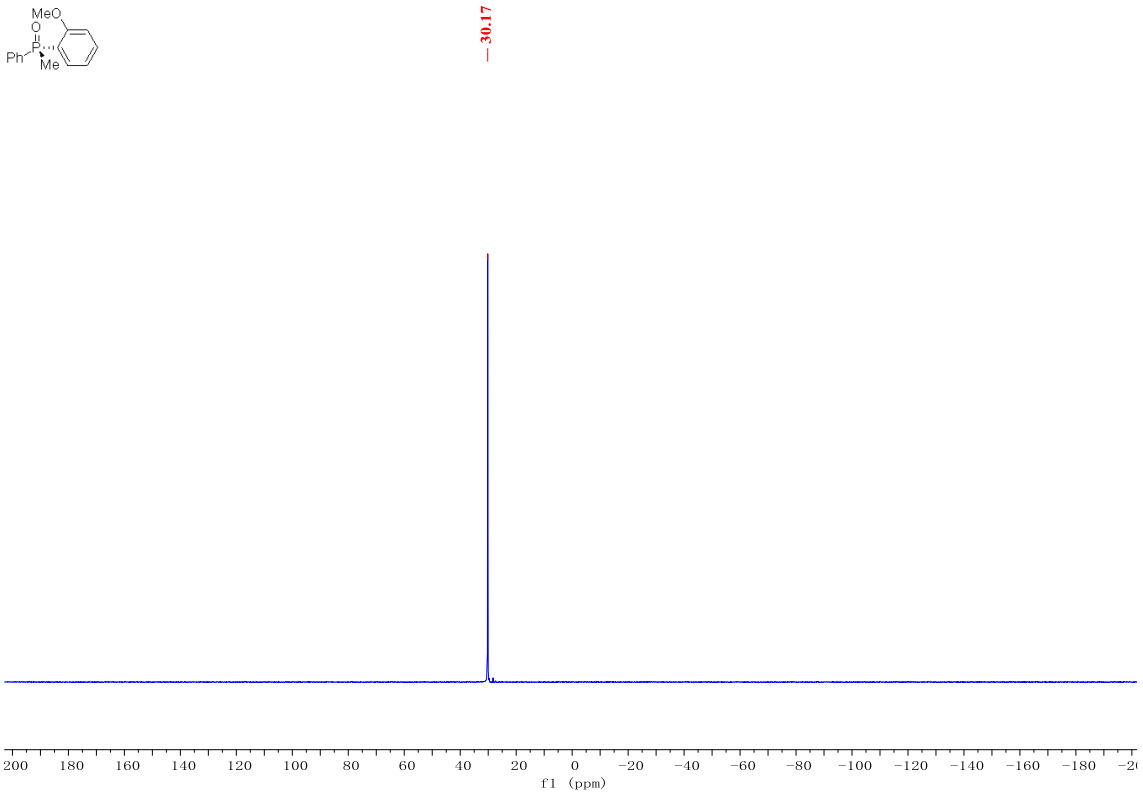

7.70
7.68
7.67
7.66
7.65
7.63
7.53
7.52
7.50
7.47
7.47
7.46
7.45
7.44
7.43
7.32
7.31
7.29
7.26
7.25
7.23
7.22
2.38
2.07
2.05
3.01
1.10
3.03
1.02
1.00
3.11
3.00
f1 (ppm)

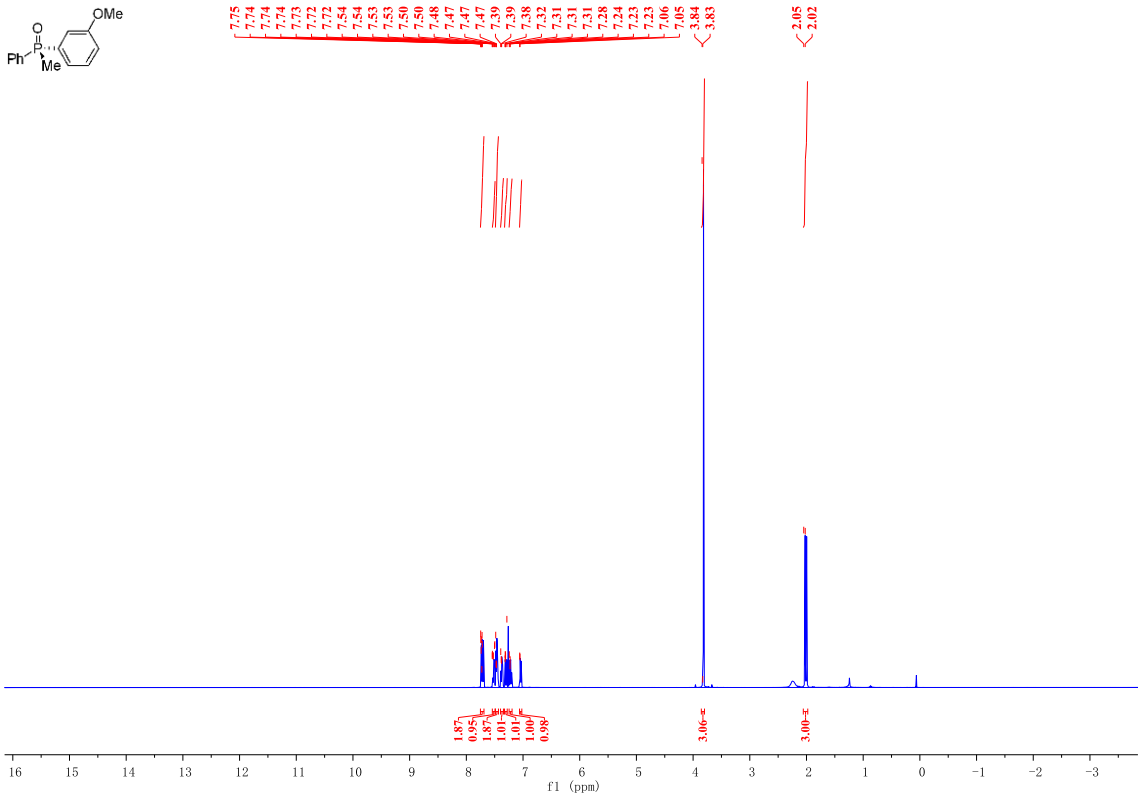

142.20
142.14
134.71
133.92
132.25
132.00
131.68
131.57
131.48
130.48
130.40
128.76
128.66
125.68
125.59
21.39
21.35
17.44
16.85
f1 (ppm)

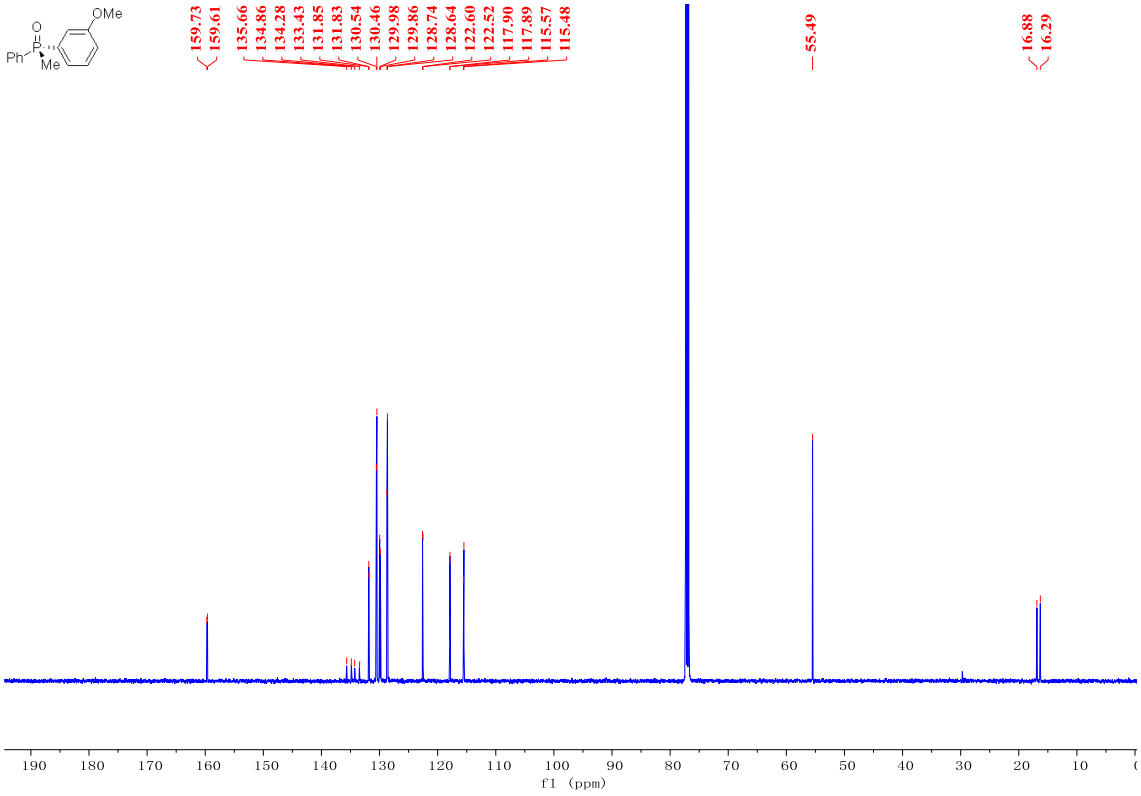

33.33
f1 (ppm)

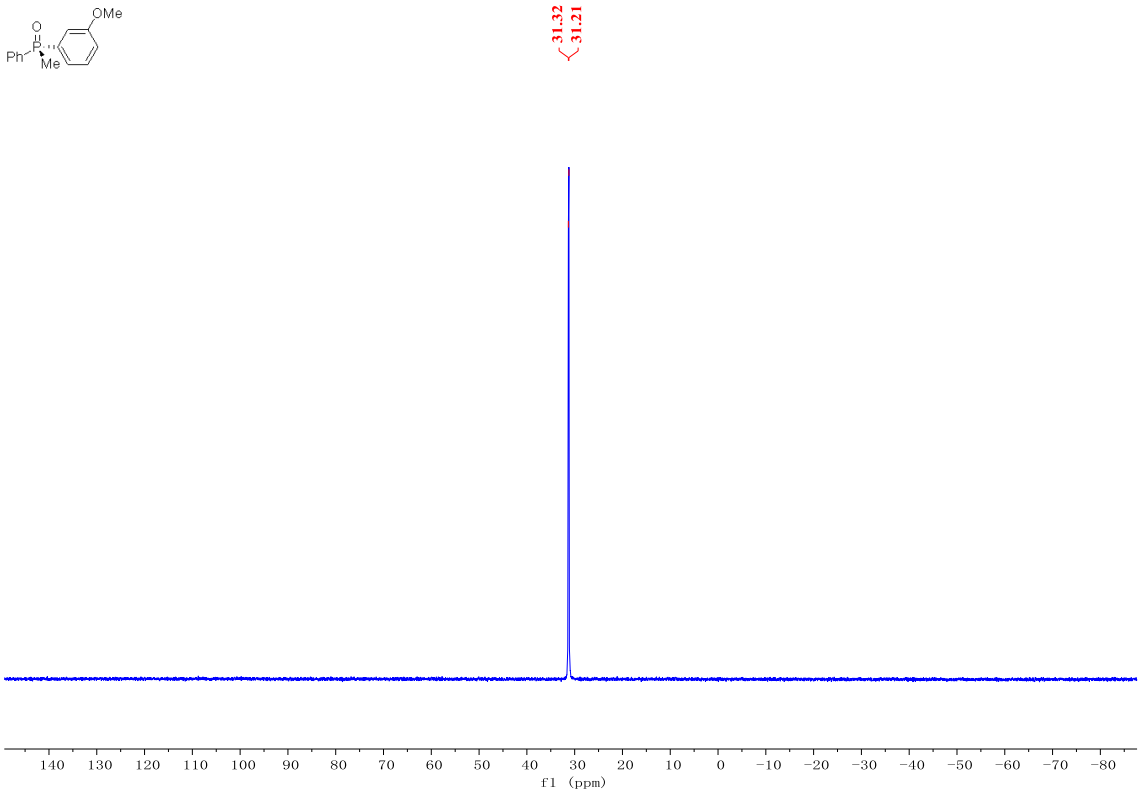

MeO
O
P
Ph
Me
7.95
7.94
7.94
7.76
7.76
7.75
7.74
7.74
7.74
7.73
7.73
7.72
7.72
7.53
7.52
7.52
7.51
7.51
7.51
7.50
7.49
7.49
7.49
7.48
7.47
7.47
7.46
7.46
7.44
7.43
7.42
7.42
7.42
7.42
7.41
7.40
7.40
7.12
7.12
7.12
7.11
7.11
7.10
7.09
7.09
6.90
6.89
6.89
6.88
3.73
2.11
2.08
1.01
2.04
2.09
2.01
0.96
0.98
3.02
3.00
f1 (ppm)

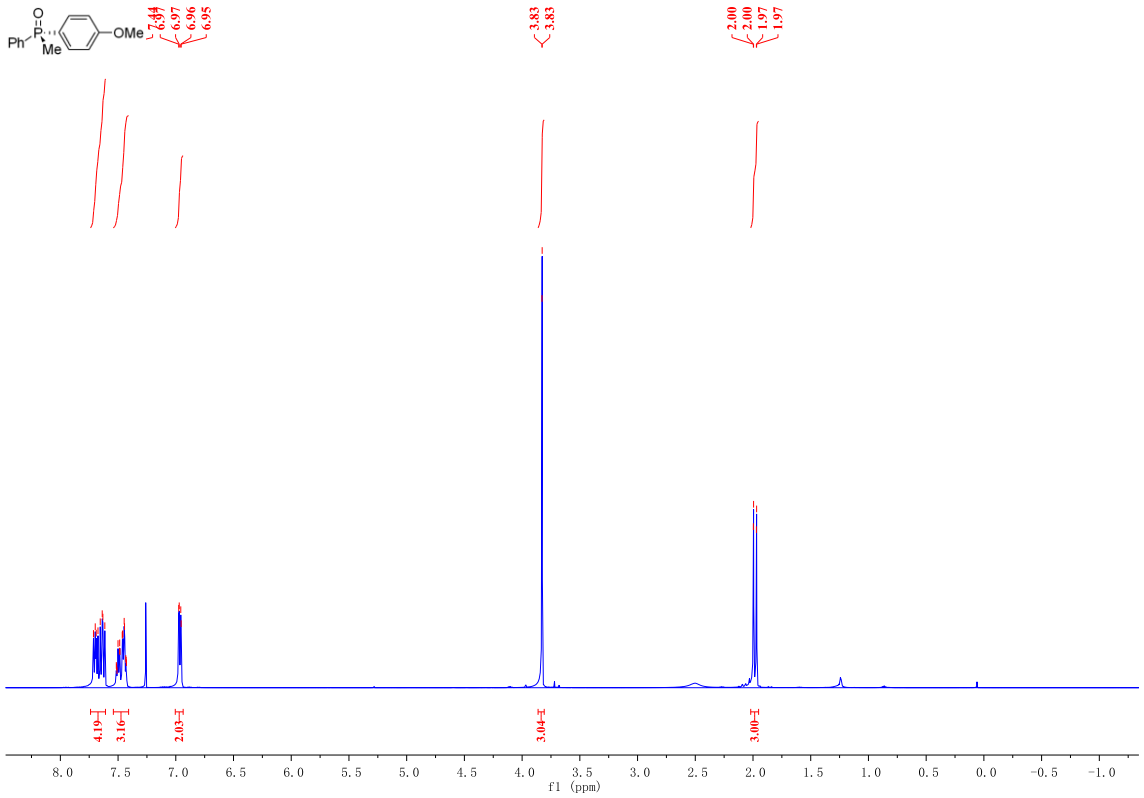

MeO
O
P
Ph
Me
159.95
159.91
135.02
134.19
134.05
134.03
134.00
133.95
131.41
131.39
130.34
130.26
128.31
128.22
121.44
121.15
121.06
120.64
110.92
110.87
55.34
16.34
15.75
f1 (ppm)

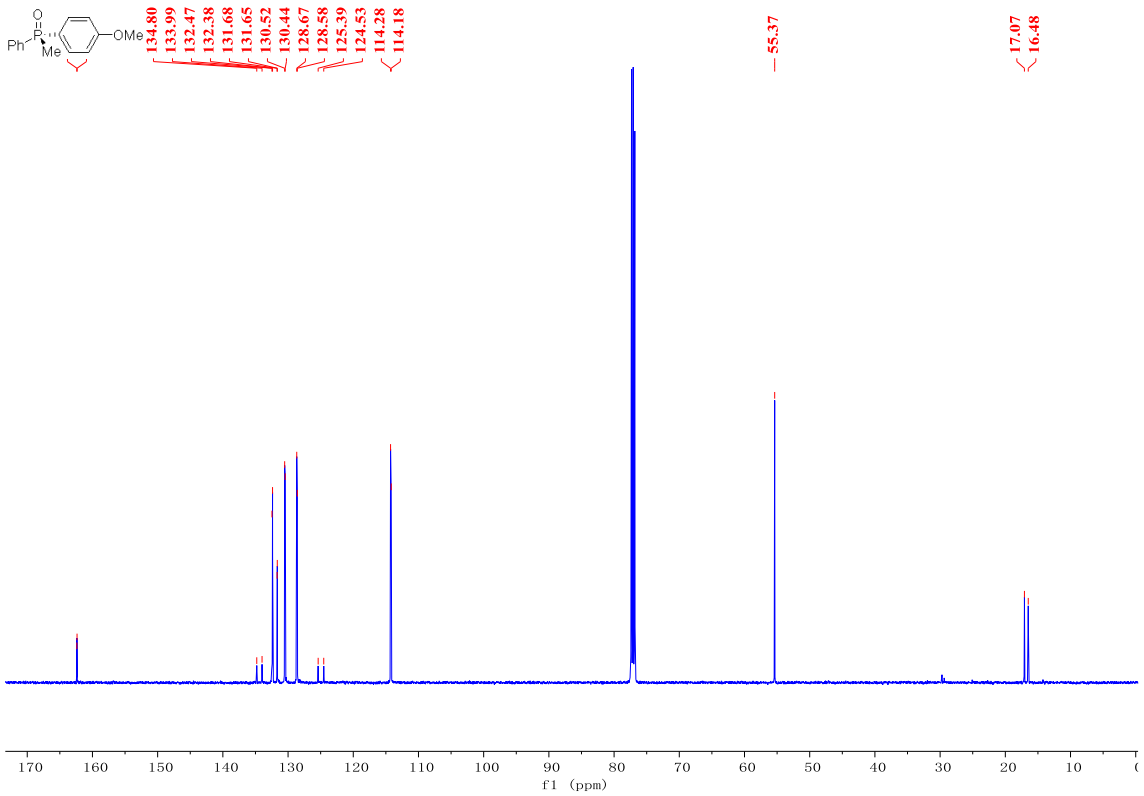

MeO
O
P
Ph
Me
30.17
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)


OMe
O
P
Ph
Me
7.75 7.74 7.74 7.74 7.73 7.72 7.72 7.54 7.54 7.53 7.53 7.50 7.50 7.48 7.47 7.47 7.47 7.39 7.39 7.38 7.32 7.31 7.31 7.31 7.28 7.24 7.23 7.23 7.06 7.05 3.84 3.83
2.05 2.02
1.87 0.95 1.87 1.01 1.01 1.00 0.98
3.06
3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)


OMe
O
P
Ph
Me
159.73
159.61
135.66
134.86
134.28
133.43
131.85
131.83
130.54
130.46
129.98
129.86
128.74
128.64
122.60
122.52
117.90
117.89
115.57
115.48
55.49
16.88
16.29
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


OMe
O
P
Ph
Me
31.32
31.21
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80
f1 (ppm)


Ph
P
O
Me
OMe
7.44
6.97
6.96
6.95
3.83
3.83
2.00
2.00
1.97
1.97
4.19
3.16
2.03
3.04
3.00
f1 (ppm)


Ph
P
O
Me
OMe
134.80
133.99
132.47
132.38
131.68
131.65
130.52
130.44
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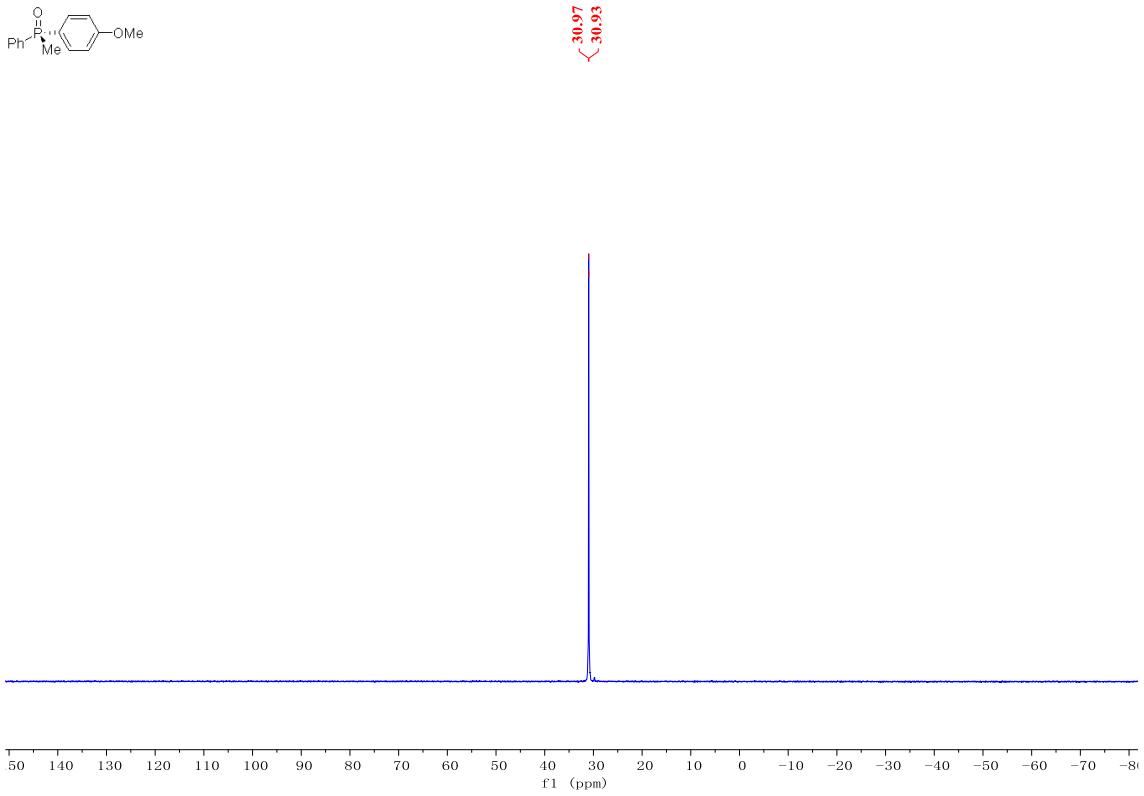
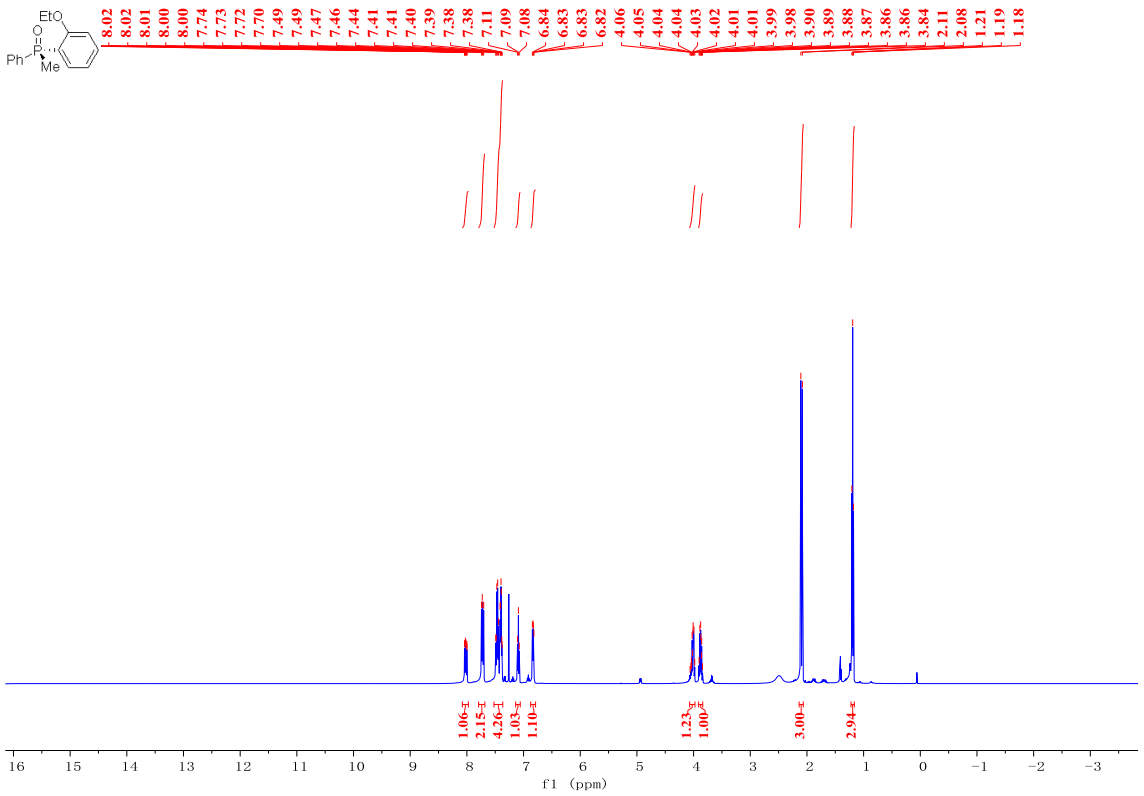
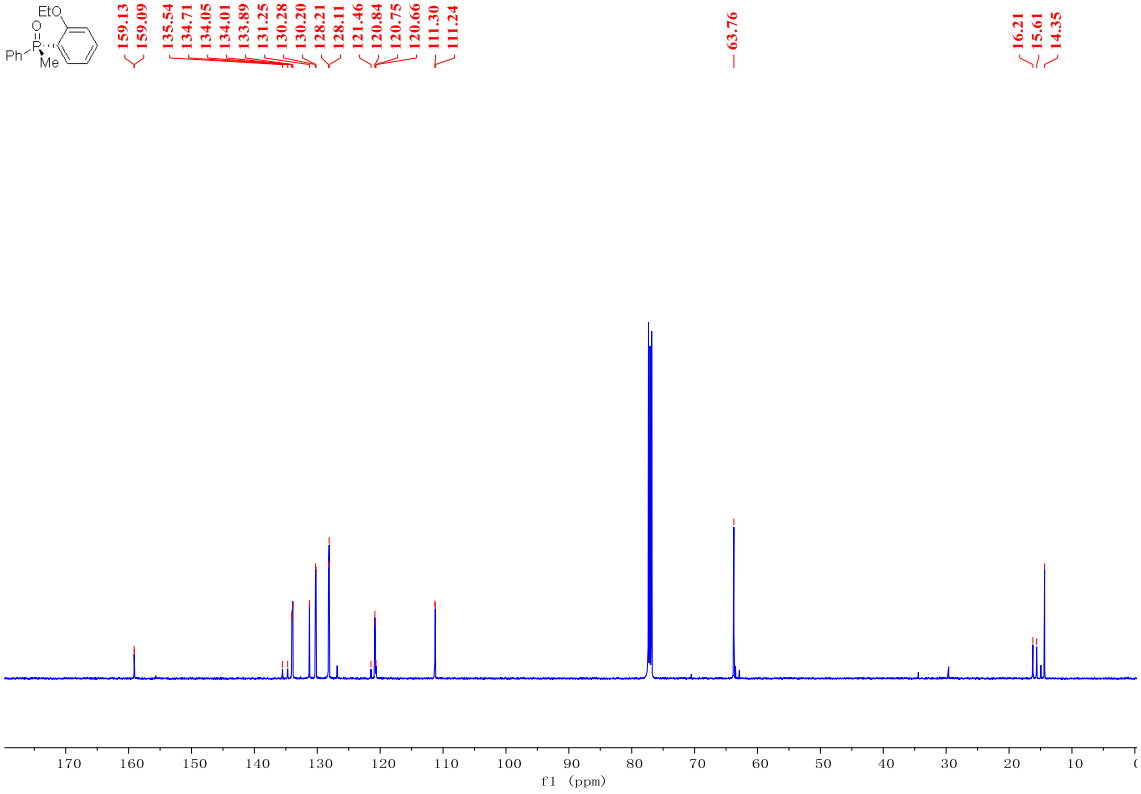
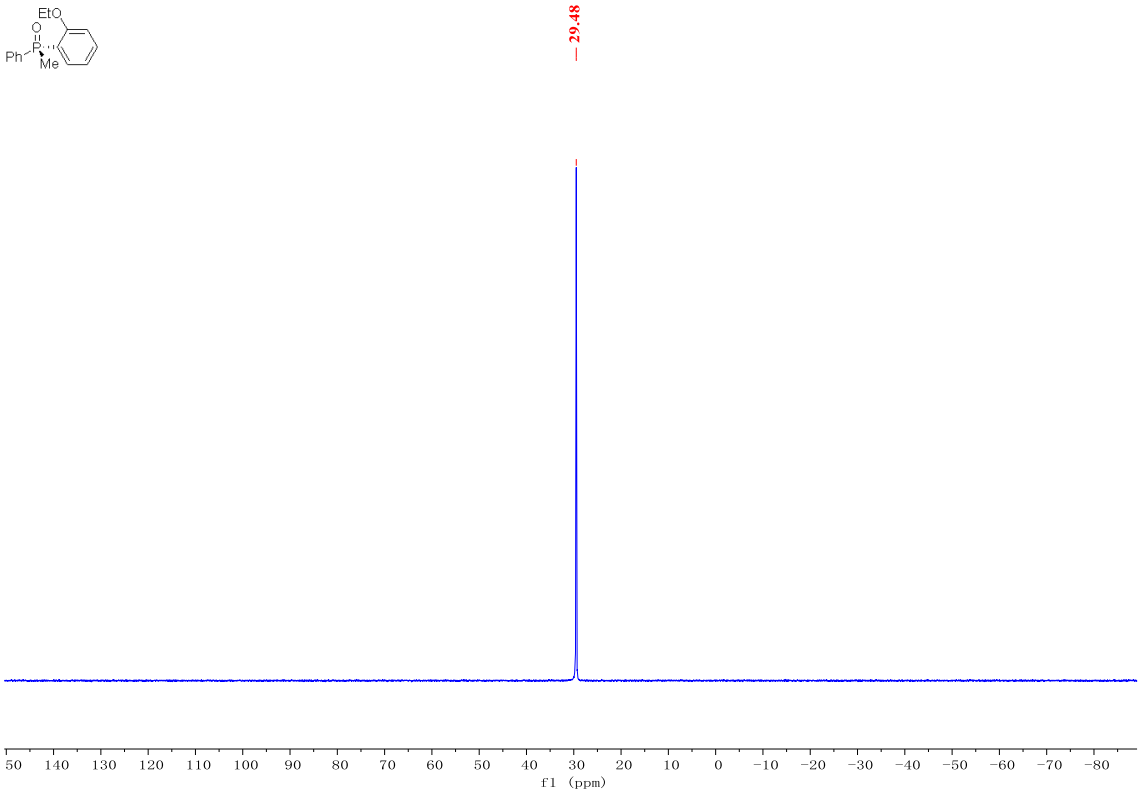
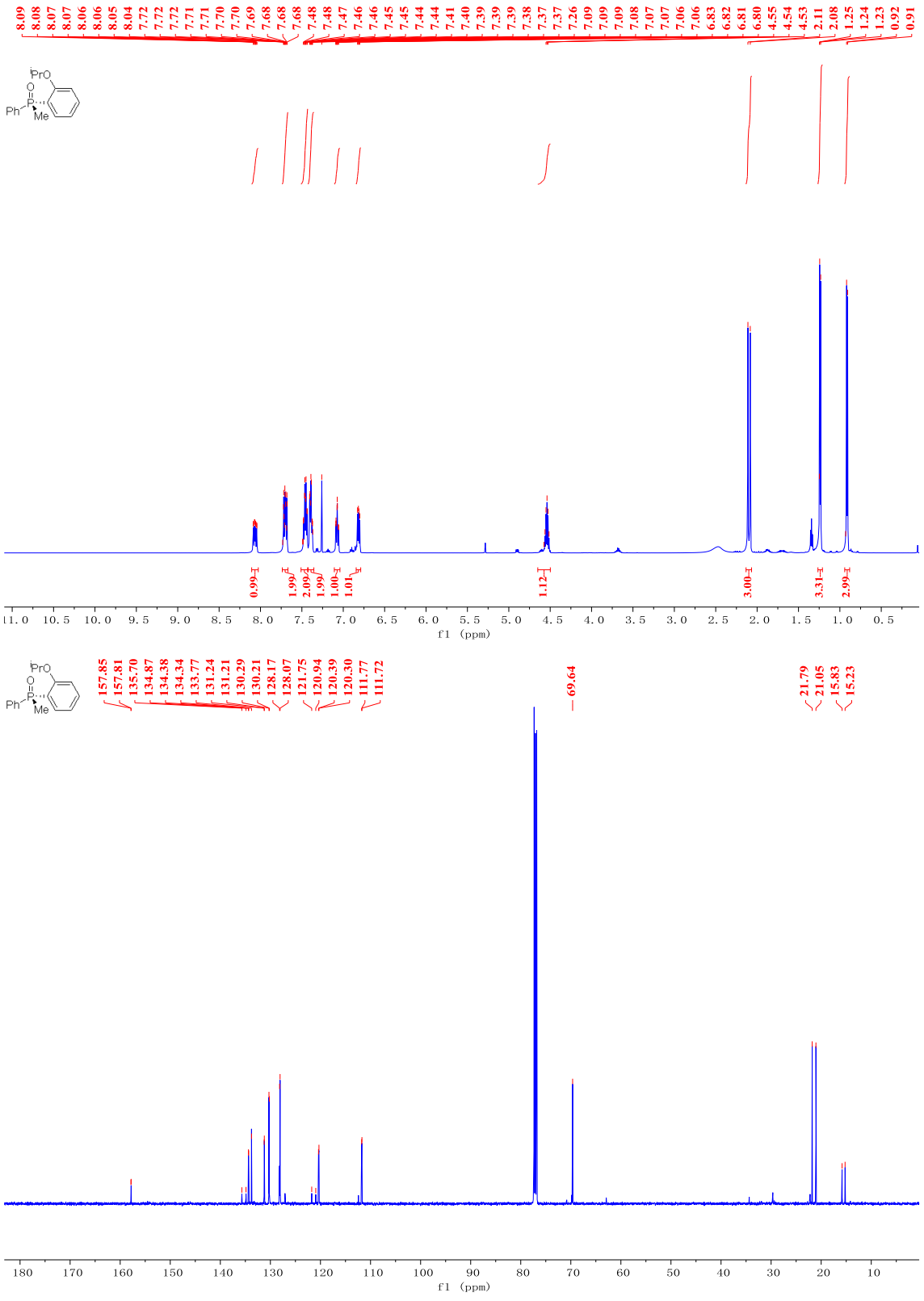
128.58
125.39
124.53
114.28
114.18
55.37
17.07
16.48
f1 (ppm)

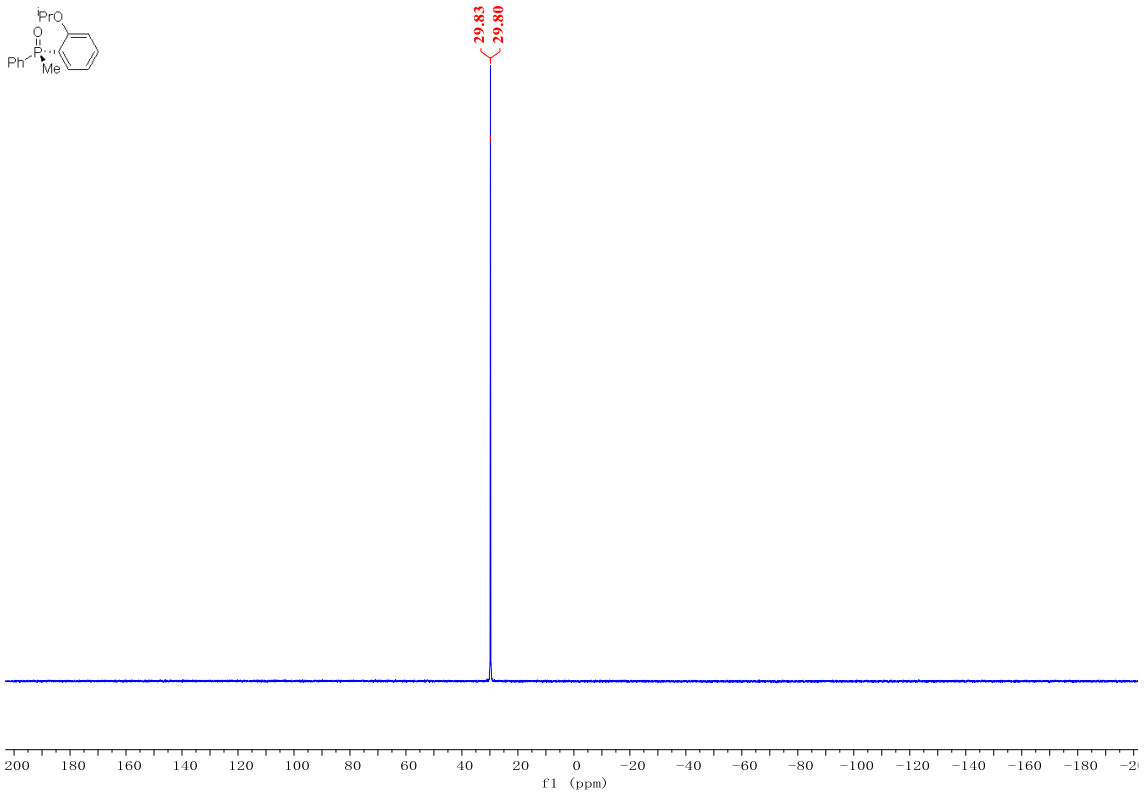

30.97
30.93
f1 (ppm)

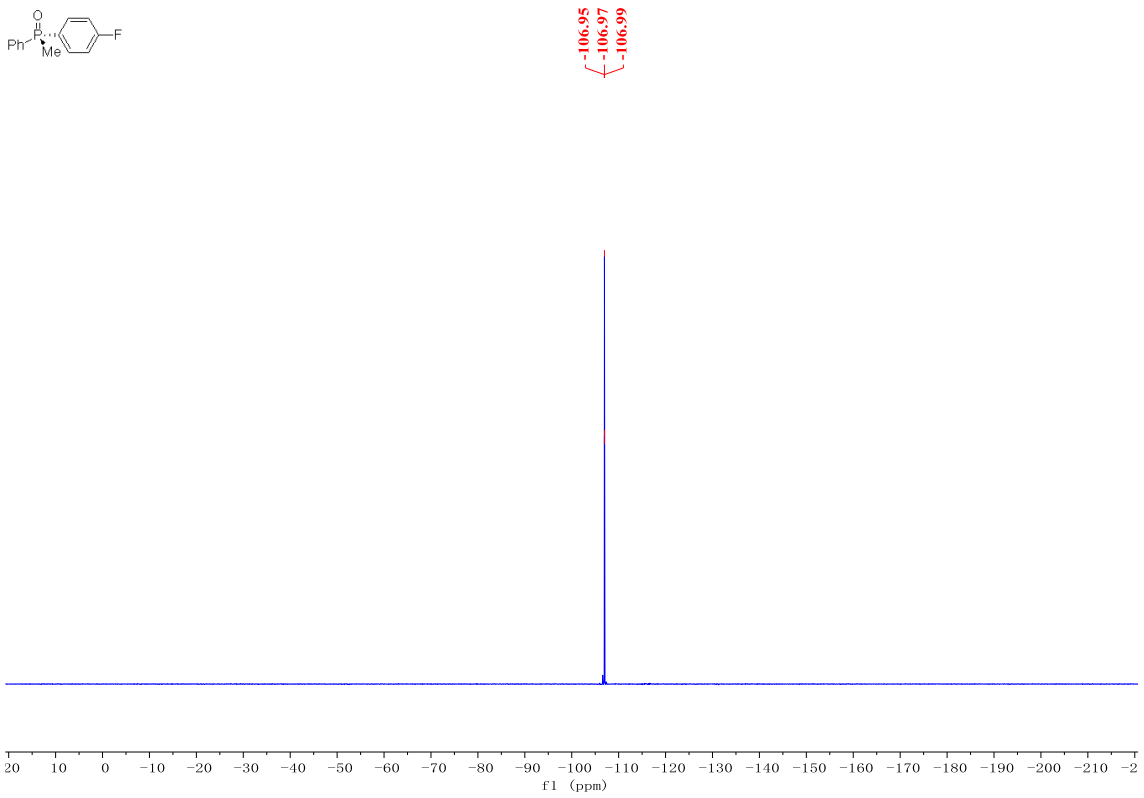

8.02
8.02
8.01
8.00
8.00
7.74
7.73
7.72
7.70
7.49
7.49
7.47
7.46
7.44
7.41
7.41
7.40
7.39
7.38
7.38
7.11
7.09
7.08
6.84
6.83
6.83
6.82
4.06
4.05
4.04
4.04
4.03
4.02
4.01
4.01
3.99
3.98
3.90
3.89
3.88
3.87
3.86
3.86
3.84
2.11
2.08
1.21
1.19
1.18
1.06
2.15
4.26
1.03
1.10
1.23
1.00
3.00
2.94
f1 (ppm)

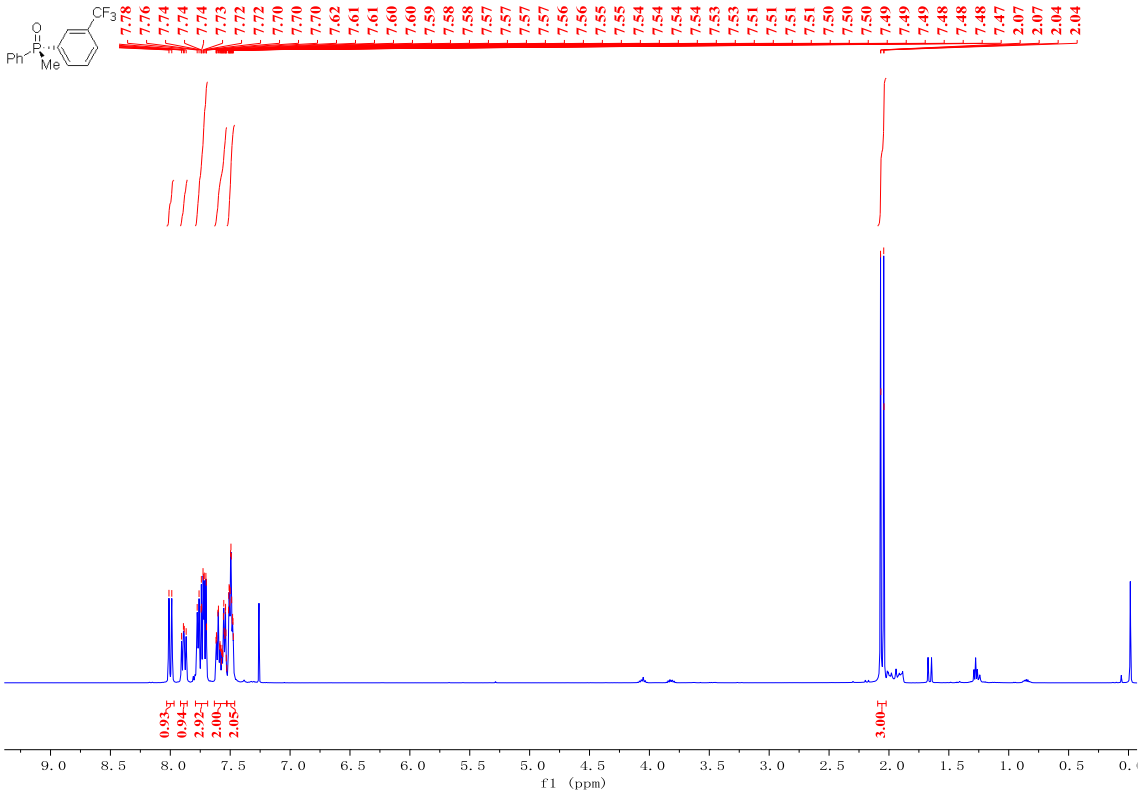

EtO
O
P
Ph
Me
159.13
159.09
135.54
134.71
134.05
134.01
133.89
131.25
130.28
130.20
128.21
128.11
121.46
120.84
120.75
120.66
111.30
111.24
63.76
16.21
15.61
14.35
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

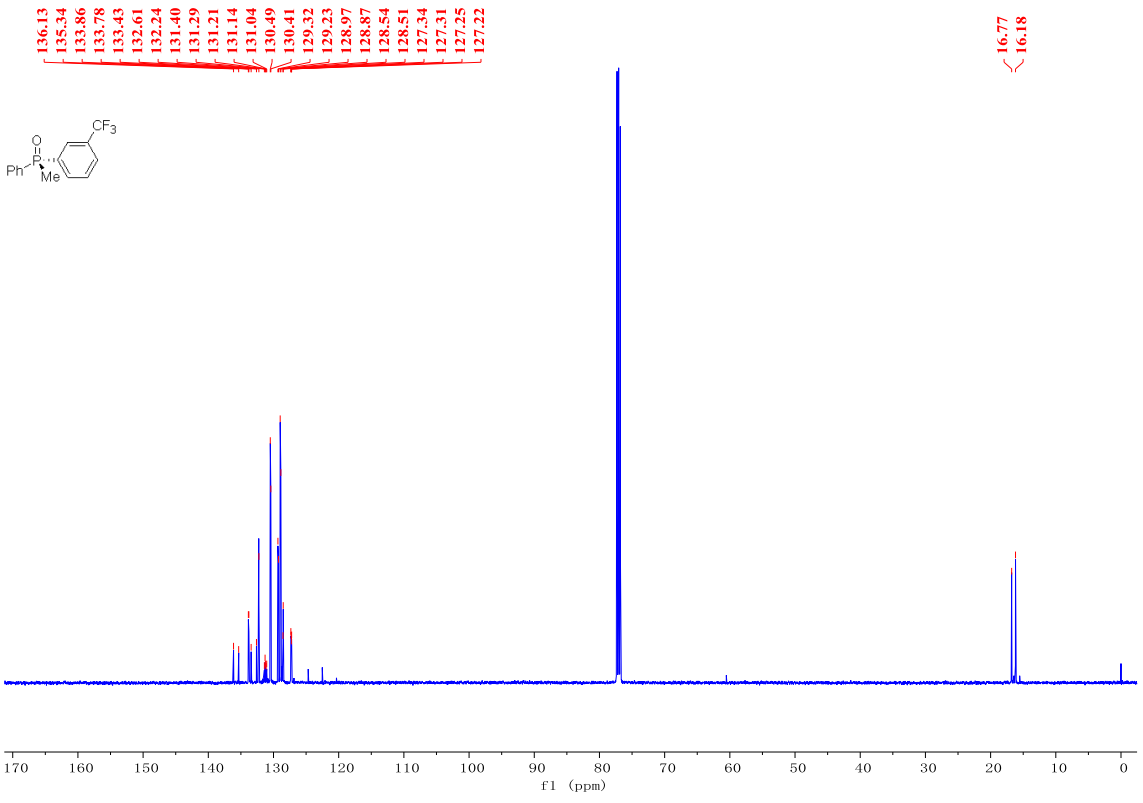

EtO
O
P
Ph
Me
29.48
50 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80
f1 (ppm)

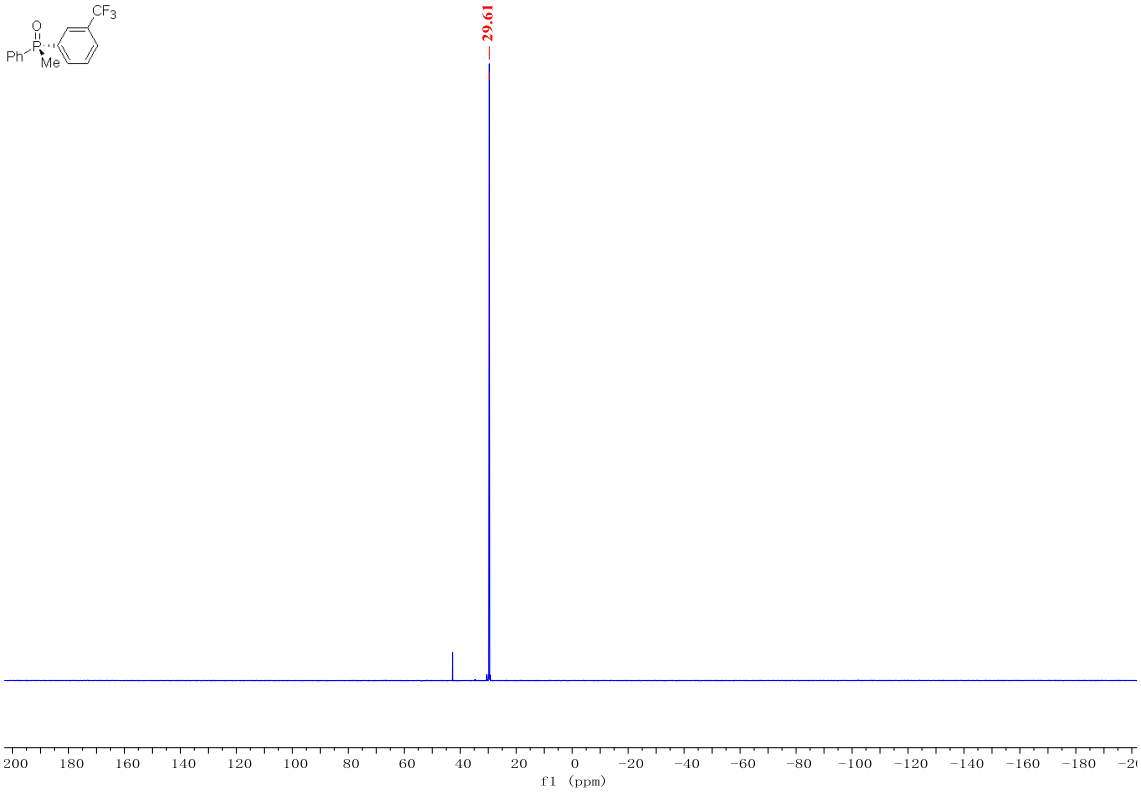

8.09 8.08 8.07 8.07 8.06 8.06 8.05 8.04 7.72 7.72 7.72 7.71 7.71 7.70 7.70 7.69 7.68 7.68 7.68 7.48 7.48 7.47 7.46 7.46 7.45 7.45 7.44 7.44 7.41 7.40 7.39 7.39 7.39 7.38 7.37 7.37 7.26 7.09 7.09 7.09 7.08 7.07 7.07 7.06 7.06 6.83 6.82 6.81 6.80 4.55 4.54 4.53 2.11 2.08 1.25 1.24 1.23 0.92 0.91
iPrO
Ph
Me
0.99 1.99 2.09 1.99 1.00 1.01 1.12 3.00 3.31 2.99
f1 (ppm)
157.85 157.81 135.70 134.87 134.38 134.34 133.77 131.24 131.21 130.29 130.21 128.17 128.07 121.75 120.94 120.39 120.30 111.77 111.72
69.64
21.79 21.05 15.83 15.23
f1 (ppm)

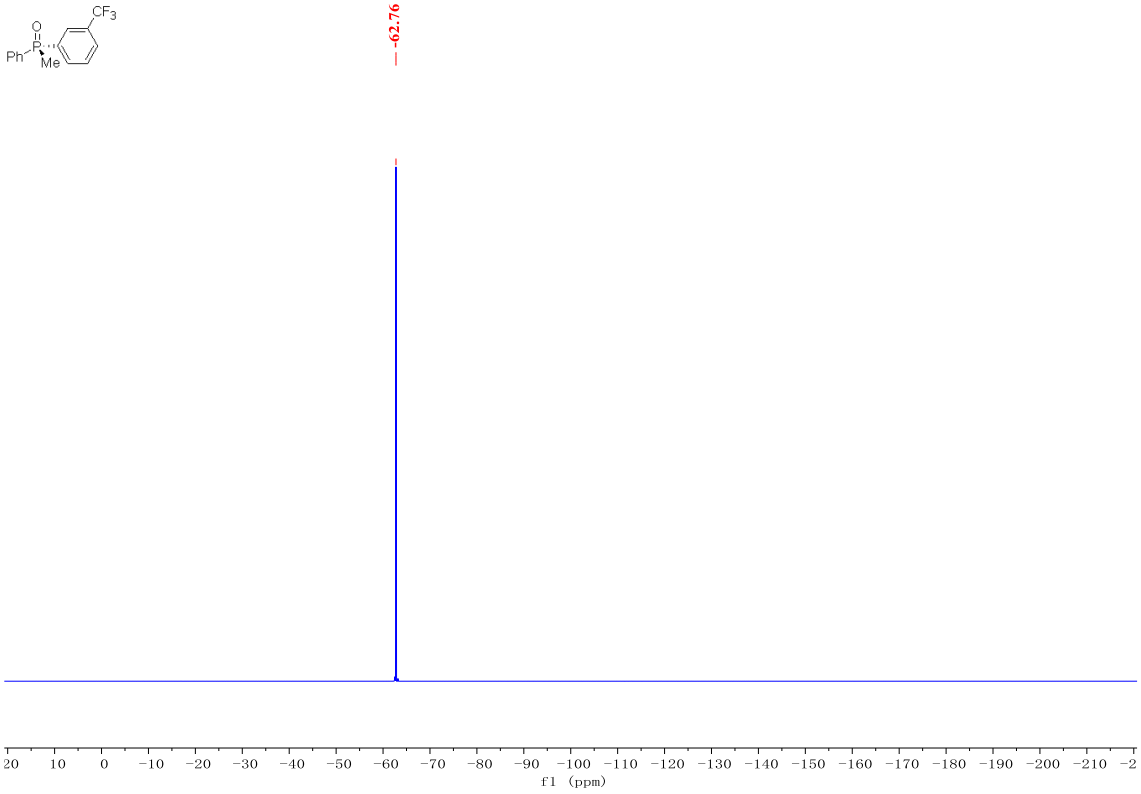

iPrO
O
Ph
P
Me
29.83
29.80
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

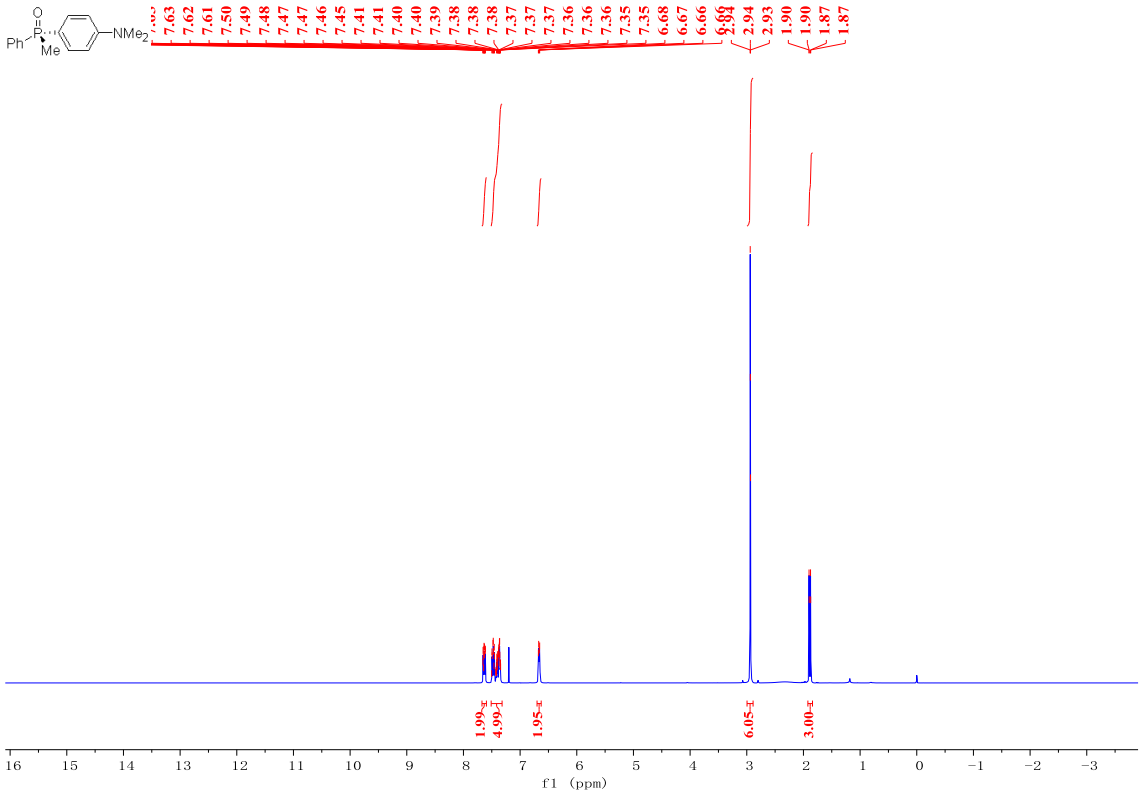

O
Ph
P
Me
F
-106.95
-106.97
-106.99
20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)


7.78 7.76 7.74 7.74 7.74 7.73 7.72 7.72 7.70 7.70 7.70 7.62 7.61 7.61 7.60 7.60 7.59 7.58 7.58 7.57 7.57 7.57 7.57 7.56 7.56 7.55 7.55 7.54 7.54 7.54 7.54 7.53 7.53 7.51 7.51 7.51 7.51 7.50 7.50 7.50 7.49 7.49 7.49 7.48 7.48 7.48 7.47 2.07 2.04 2.04
0.93 0.94 2.92 2.00 2.05
3.00
f1 (ppm)


136.13 135.34 133.86 133.78 133.43 132.61 132.24 131.40 131.29 131.21 131.14 131.04 130.49 130.41 129.32 129.23 128.97 128.87 128.54 128.51 127.34 127.31 127.25 127.22
16.77 16.18
f1 (ppm)


29.61
f1 (ppm)


-62.76
f1 (ppm)


Ph
O
P
Me
NMe2
7.63
7.62
7.61
7.50
7.49
7.48
7.47
7.47
7.46
7.45
7.41
7.41
7.40
7.40
7.39
7.38
7.38
7.38
7.37
7.37
7.37
7.36
7.36
7.36
7.35
7.35
6.68
6.67
6.66
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2.93
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1.90
1.87
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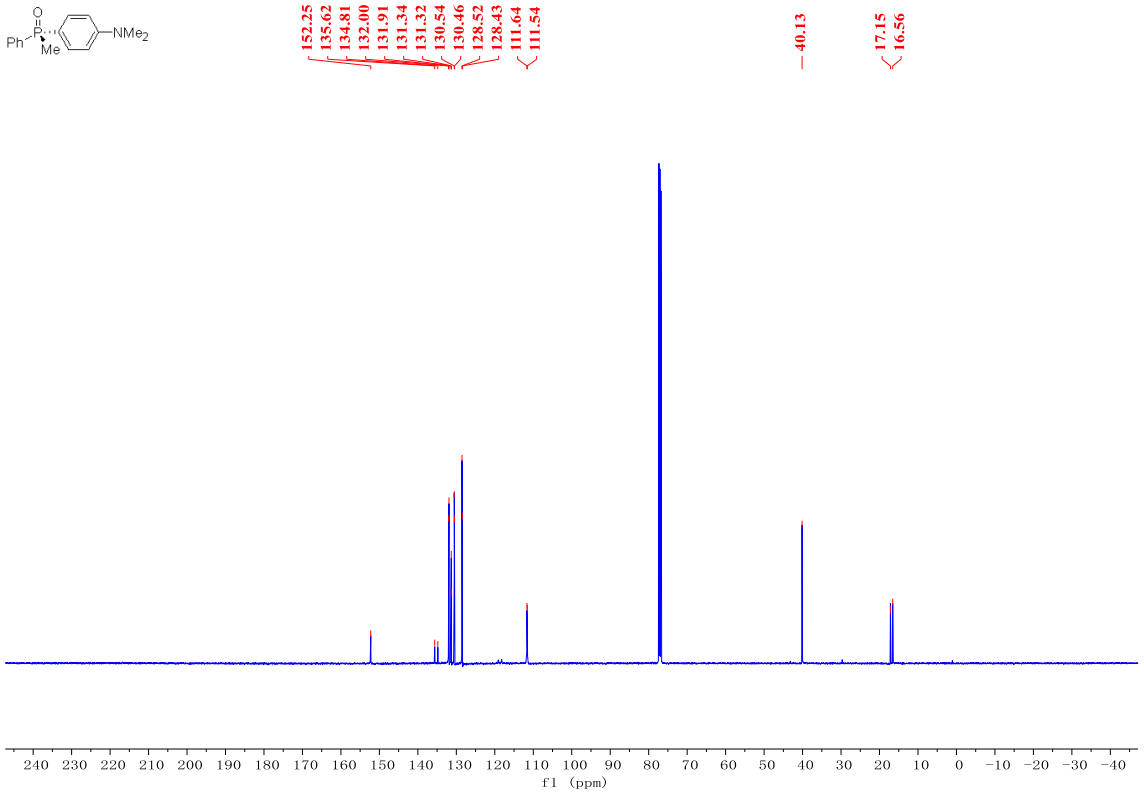
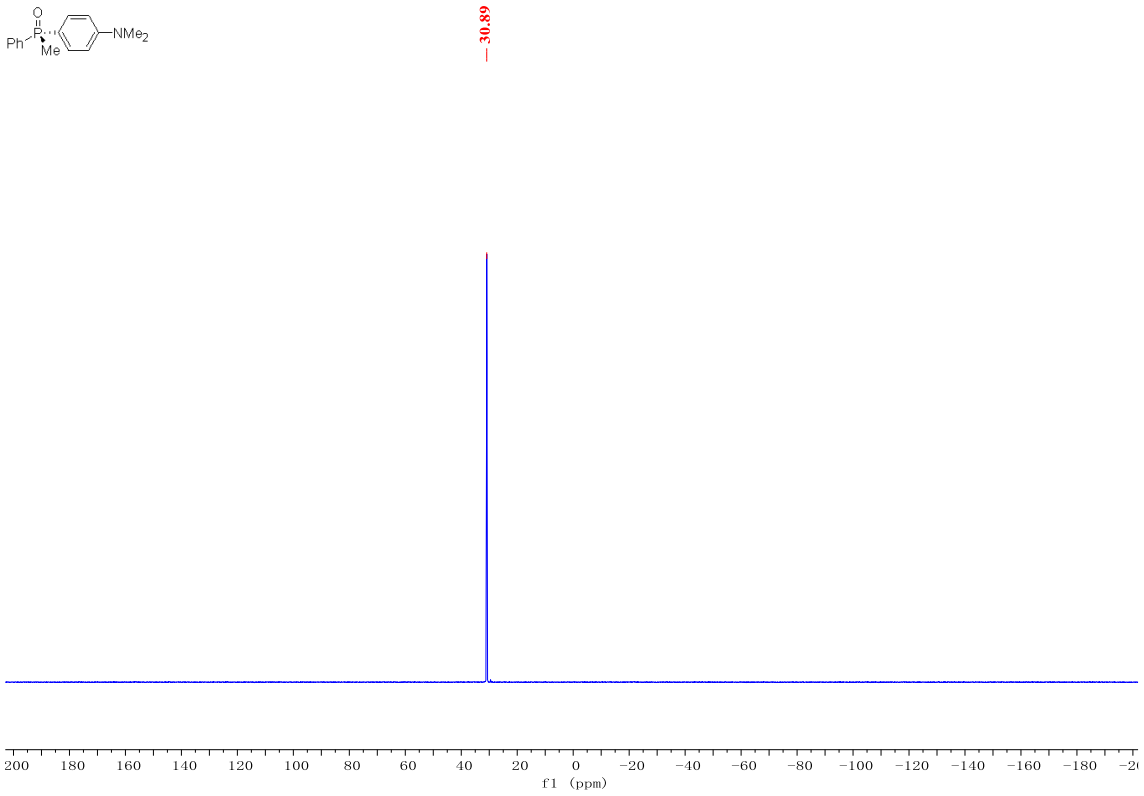
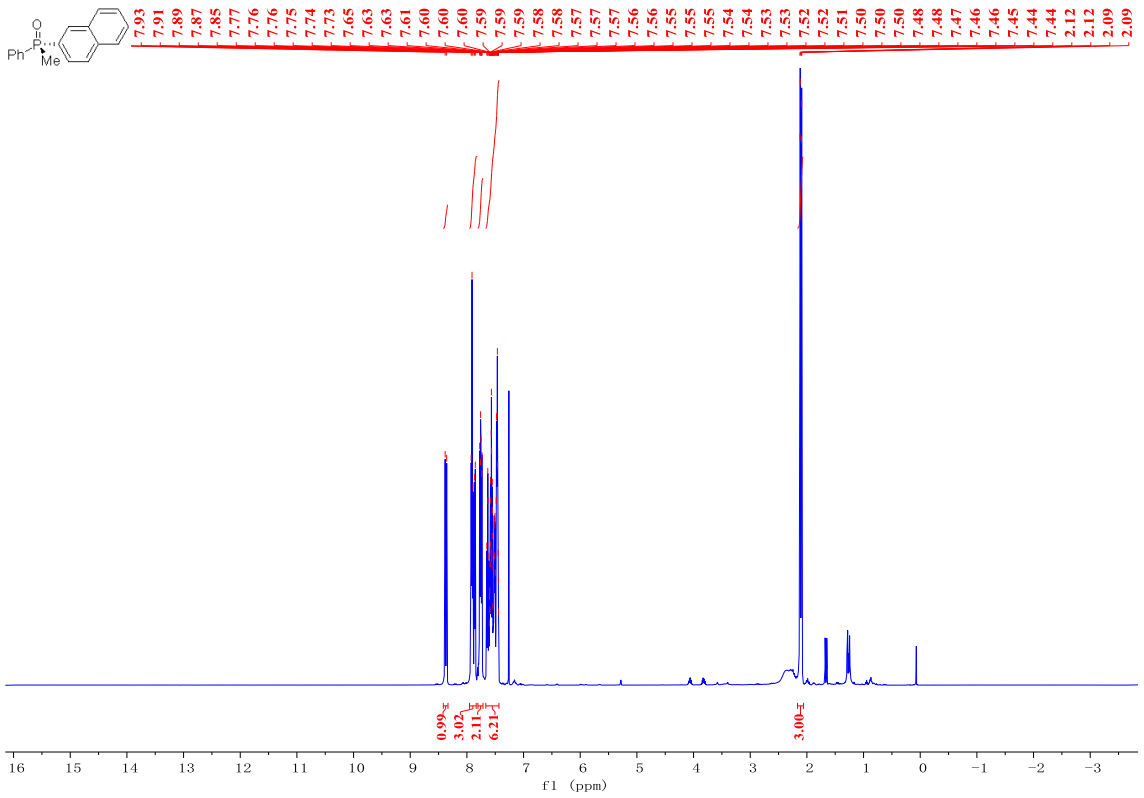
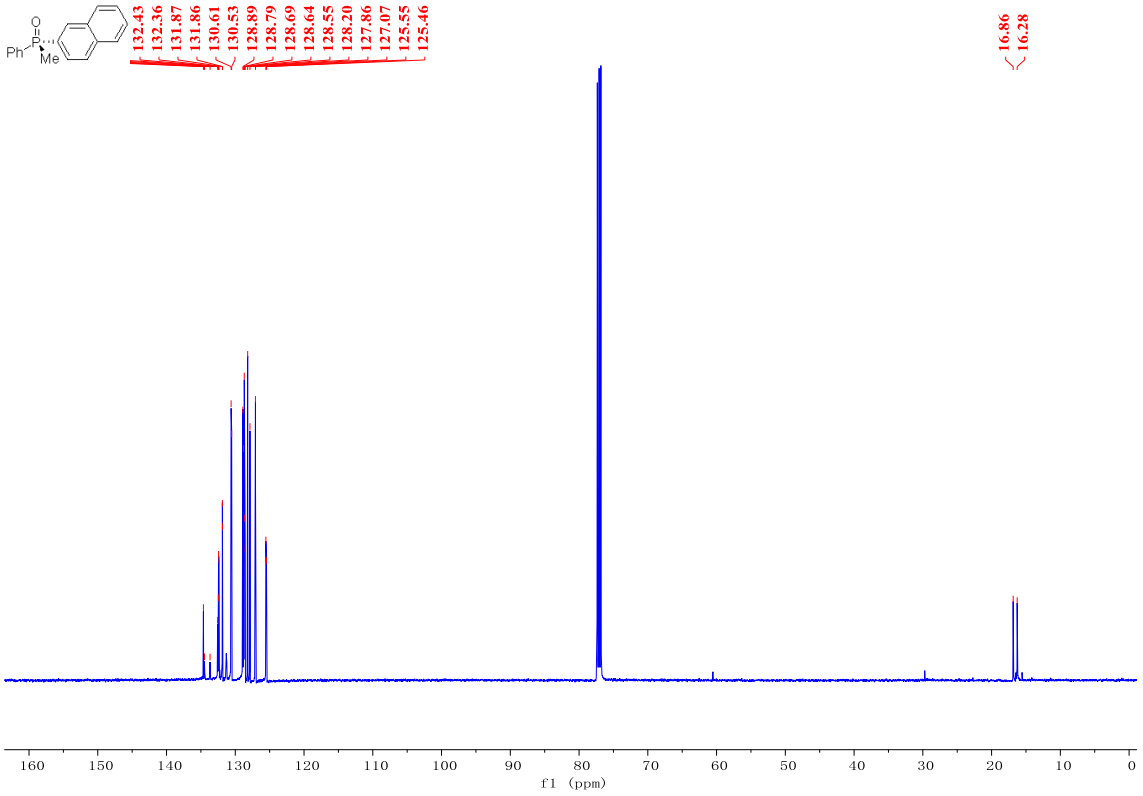
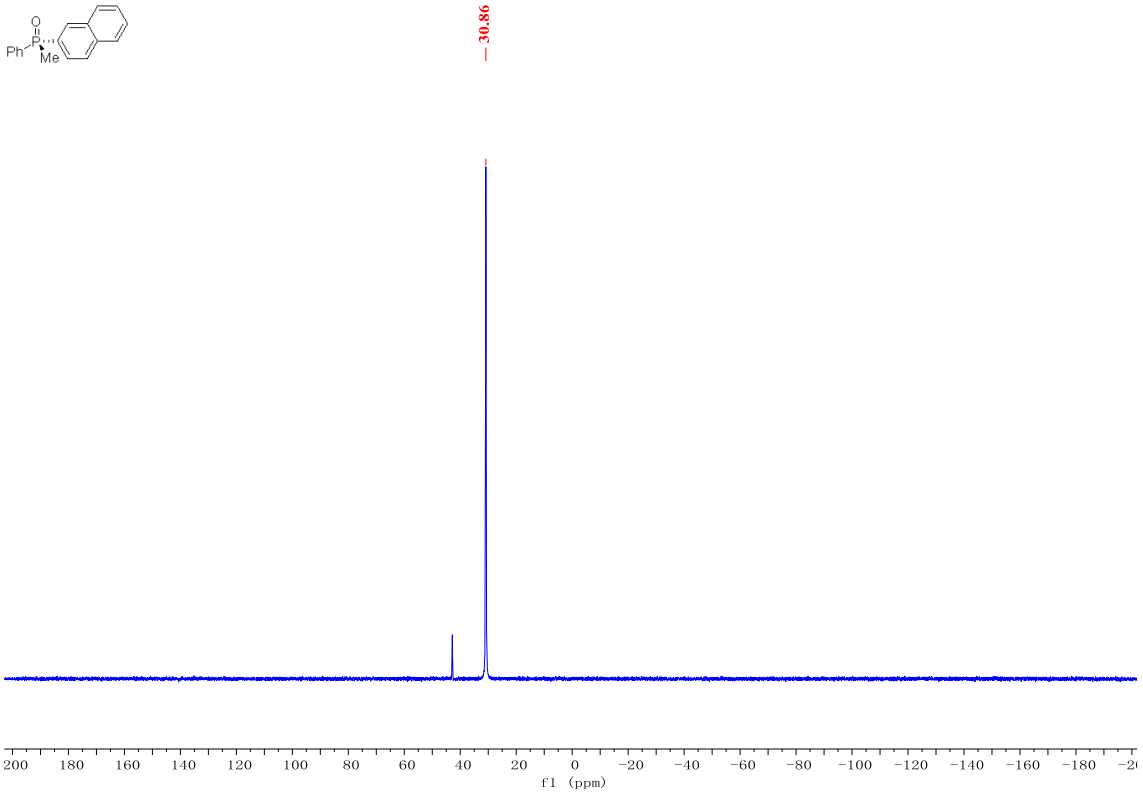
1.99
4.99
1.95
6.05
3.00
f1 (ppm)

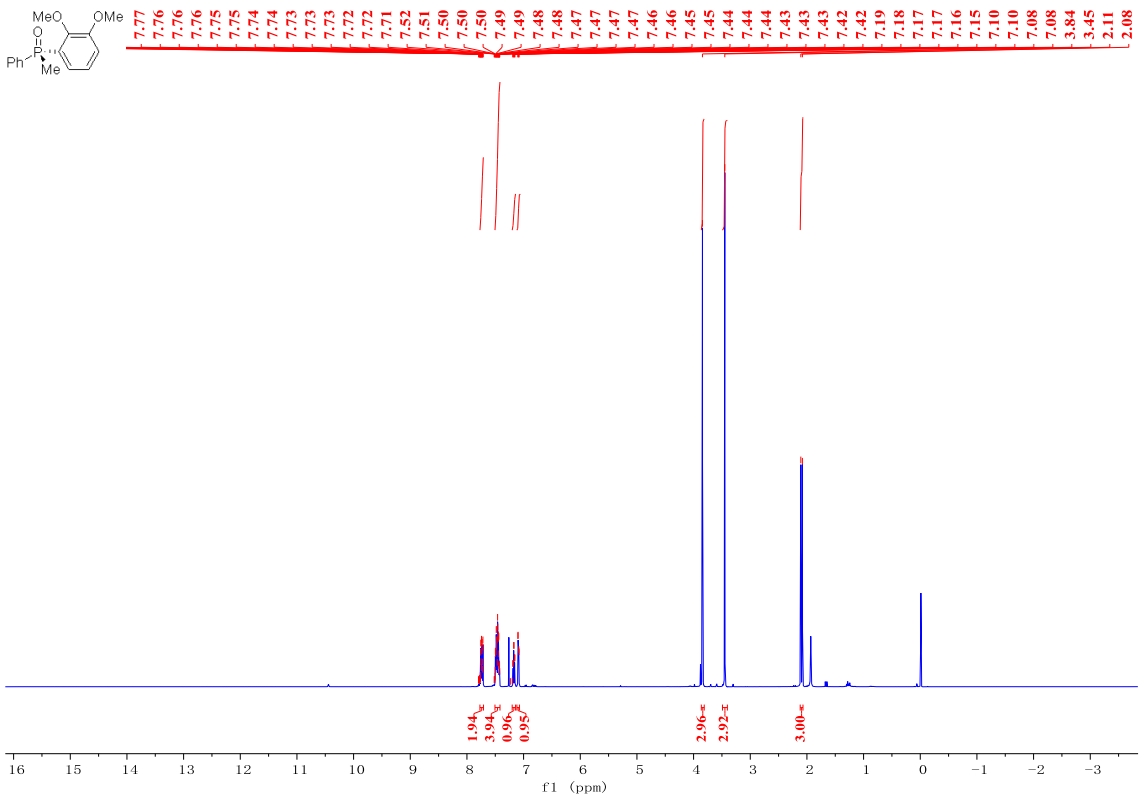

Ph
O
P
Me
NMe2
152.25
135.62
134.81
132.00
131.91
131.34
131.32
130.54
130.46
128.52
128.43
111.64
111.54
40.13
17.15
16.56
f1 (ppm)

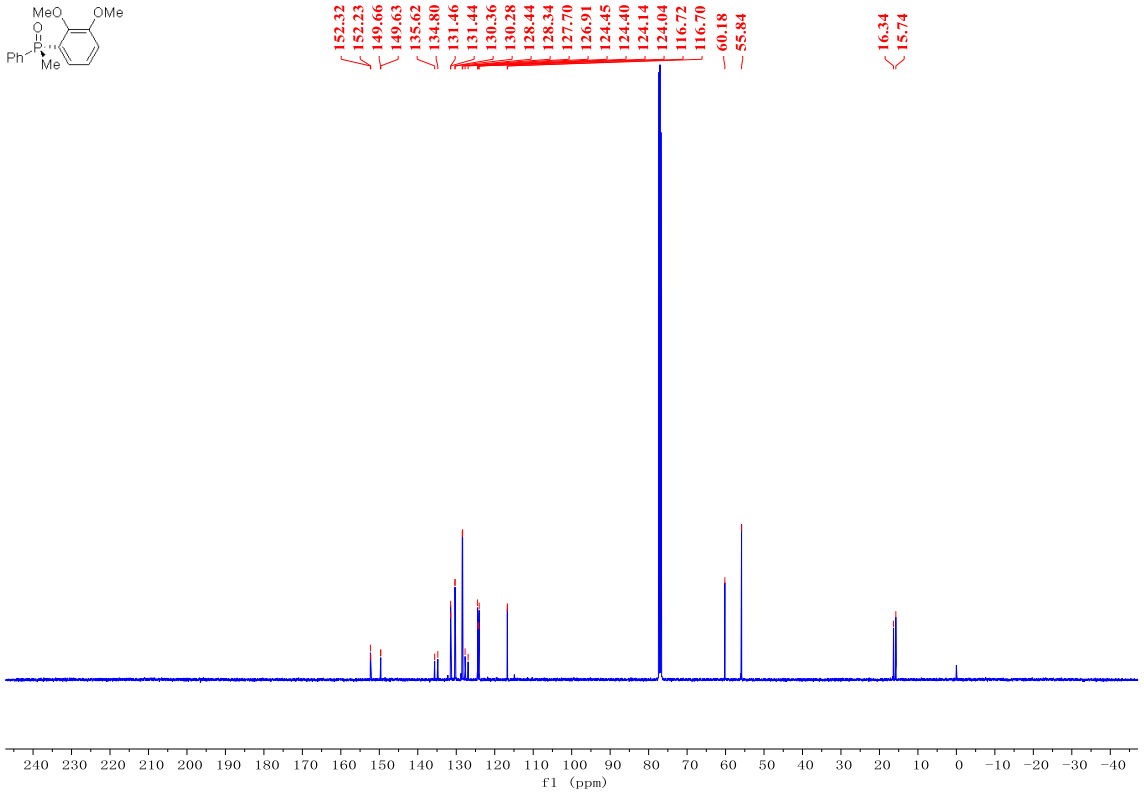

Ph
O
P
Me
NMe2
30.89
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

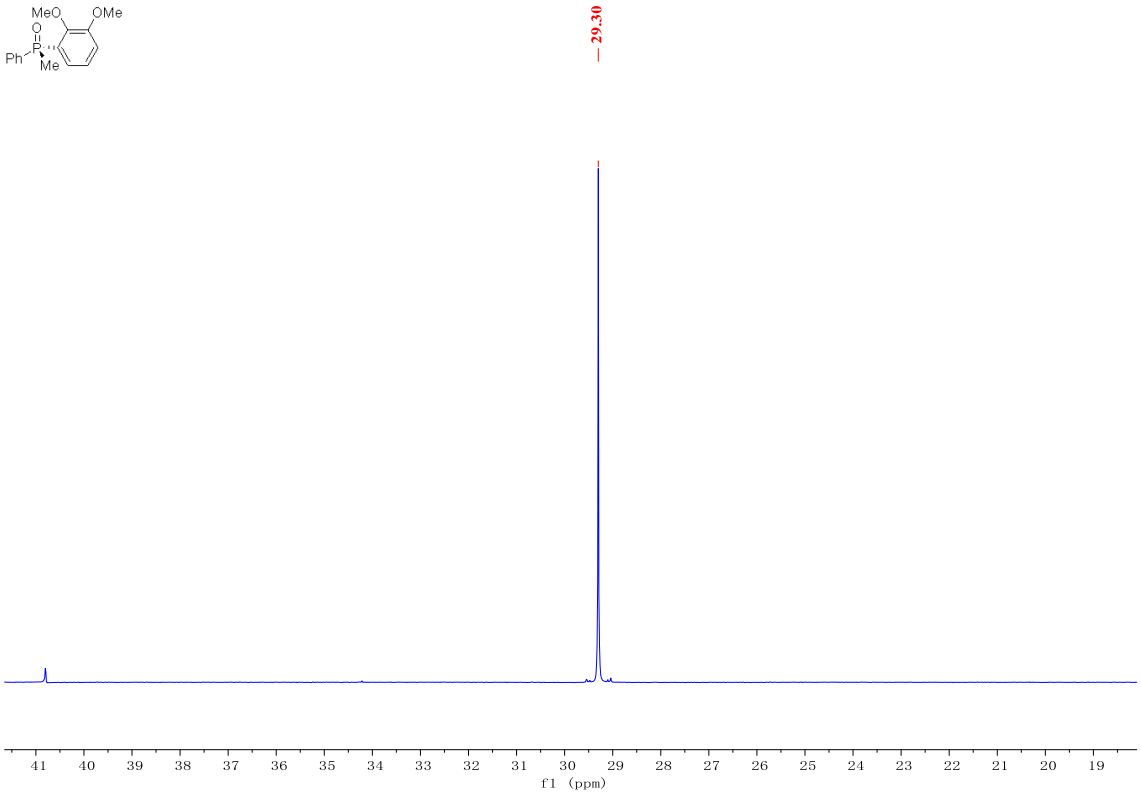

Ph
O
P
Me
7.93 7.91 7.89 7.87 7.85 7.77 7.76 7.76 7.75 7.74 7.73 7.65 7.63 7.63 7.61 7.60 7.60 7.60 7.59 7.59 7.59 7.58 7.58 7.57 7.57 7.57 7.56 7.56 7.55 7.55 7.55 7.54 7.54 7.53 7.53 7.52 7.52 7.51 7.50 7.50 7.50 7.48 7.48 7.47 7.46 7.46 7.45 7.44 7.44 2.12 2.12 2.09 2.09
0.99
3.02
2.11
6.21
3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

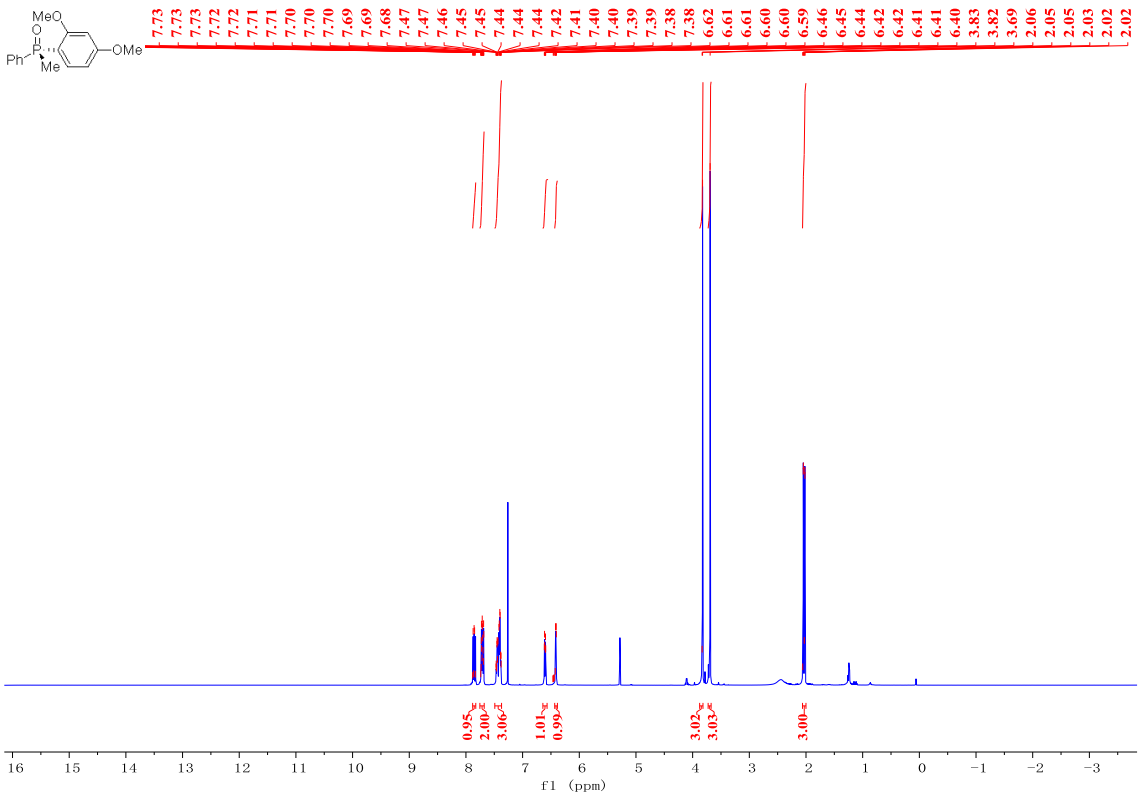

Ph
P
O
Me
132.43
132.36
131.87
131.86
130.61
130.53
128.89
128.79
128.69
128.64
128.55
128.20
127.86
127.07
125.55
125.46
16.86
16.28
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

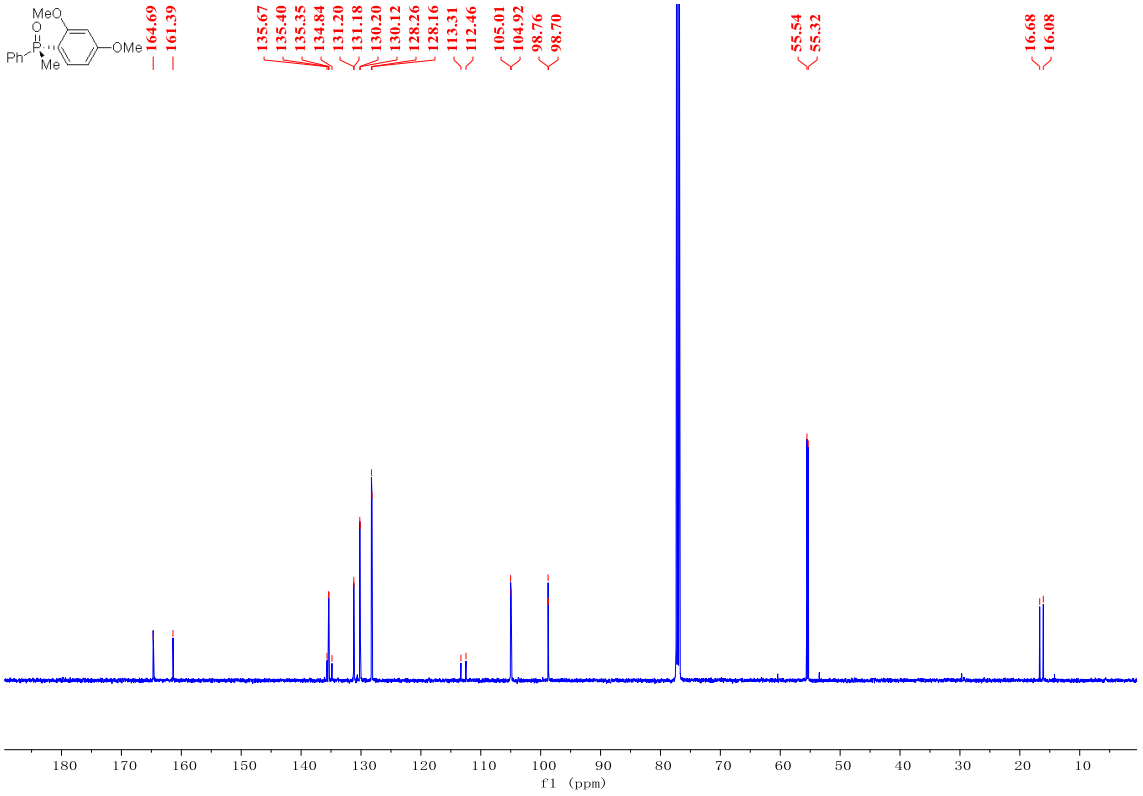

Ph
P
O
Me
30.86
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

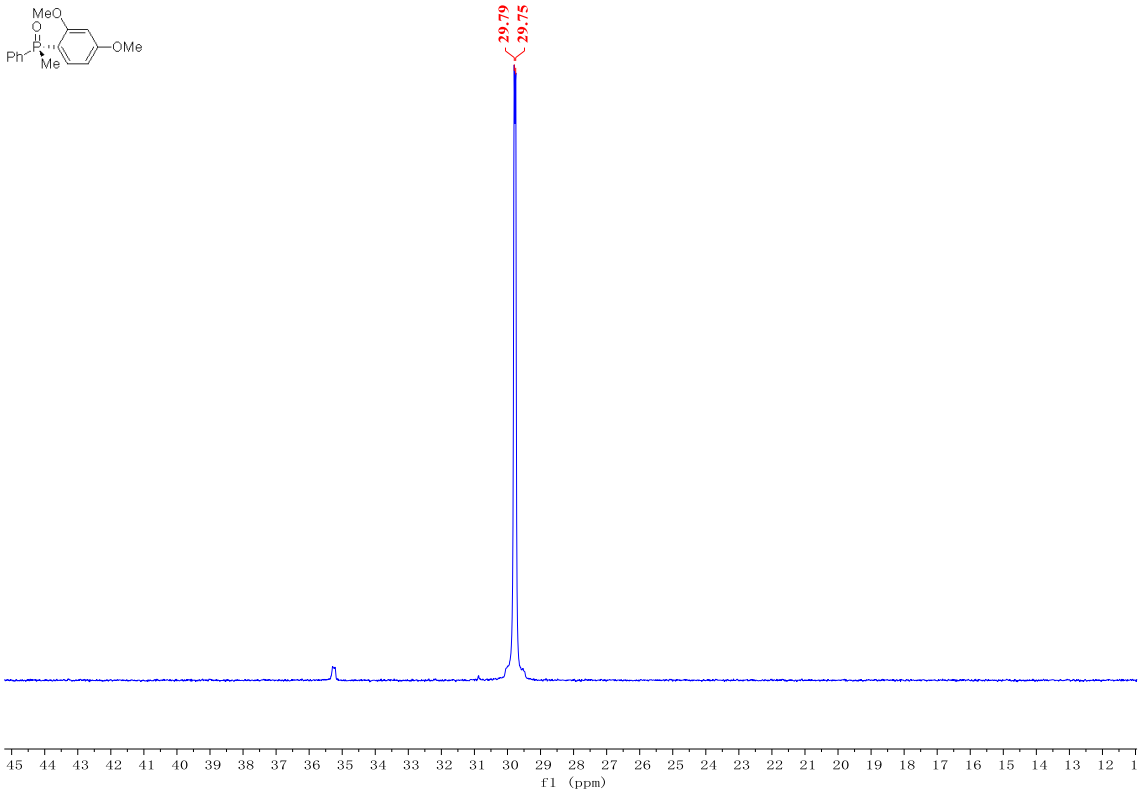

MeO
OMe
O
P
Ph
Me
7.77 7.76 7.76 7.76 7.75 7.75 7.74 7.74 7.73 7.73 7.73 7.72 7.72 7.71 7.52 7.51 7.50 7.50 7.50 7.49 7.49 7.48 7.48 7.47 7.47 7.47 7.47 7.46 7.46 7.45 7.45 7.44 7.44 7.44 7.44 7.43 7.43 7.43 7.42 7.42 7.19 7.18 7.17 7.17 7.16 7.15 7.10 7.10 7.08 7.08 3.84 3.45 2.11 2.08
1.94 3.94 0.96 0.95 2.96 2.92 3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)


MeO
OMe
O
P
Ph
Me
152.32 152.23 149.66 149.63 135.62 134.80 131.46 131.44 130.36 130.28 128.44 128.34 127.70 126.91 124.45 124.40 124.14 124.04 116.72 116.70 60.18 55.84 16.34 15.74
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40
f1 (ppm)


MeO
OMe
O
P
Ph
Me
29.30
f1 (ppm)


MeO
OMe
O
P
Ph
Me
7.73 7.73 7.73 7.72 7.72 7.71 7.71 7.70 7.70 7.70 7.69 7.69 7.68 7.47 7.47 7.46 7.45 7.45 7.44 7.44 7.44 7.42 7.41 7.40 7.40 7.39 7.39 7.38 7.38 6.62 6.61 6.61 6.60 6.60 6.59 6.46 6.45 6.44 6.42 6.42 6.41 6.41 6.40 3.83 3.82 3.69 2.06 2.05 2.03 2.02 2.02
0.95 2.00 3.06 1.01 0.99 3.02 3.03 3.00
f1 (ppm)


MeO
O
P
Ph
Me
OMe
164.69
161.39
135.67
135.40
135.35
134.84
131.20
131.18
130.20
130.12
128.26
128.16
113.31
112.46
105.01
104.92
98.76
98.70
55.54
55.32
16.68
16.08
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)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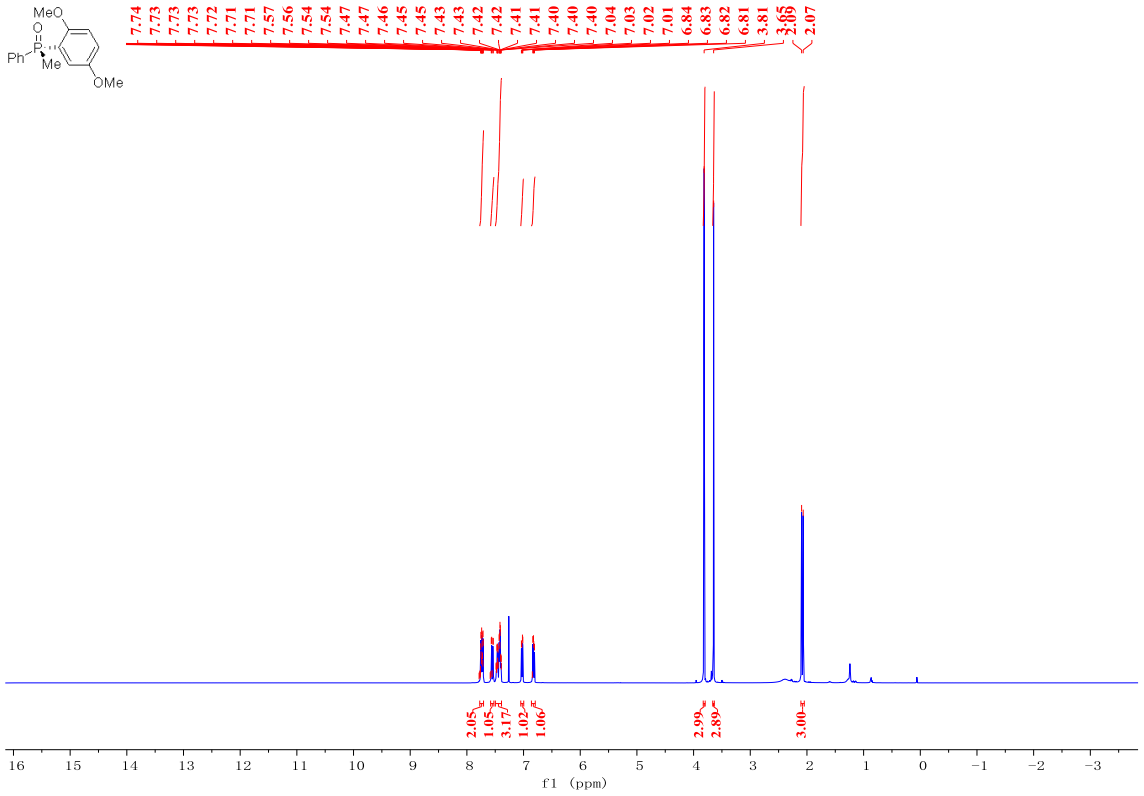
O
P
Ph
Me
OMe
29.79
29.75
45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 1
f1 (ppm)


MeO
O
P
Ph
Me
OMe
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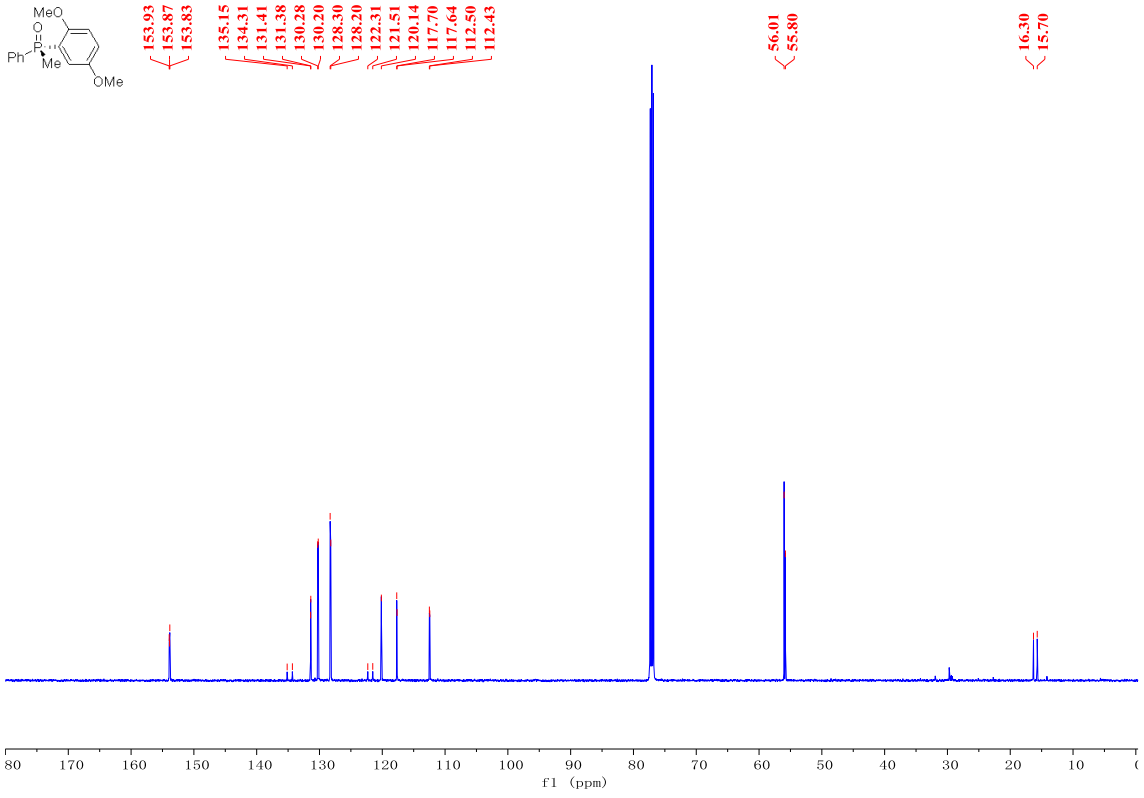
7.73
7.73
7.73
7.72
7.71
7.71
7.57
7.56
7.54
7.54
7.47
7.47
7.46
7.45
7.45
7.43
7.43
7.42
7.42
7.41
7.41
7.40
7.40
7.40
7.04
7.03
7.02
7.01
6.84
6.83
6.82
6.81
3.81
3.65
2.07
2.05
1.05
3.17
1.02
1.06
2.99
2.89
3.00
f1 (ppm)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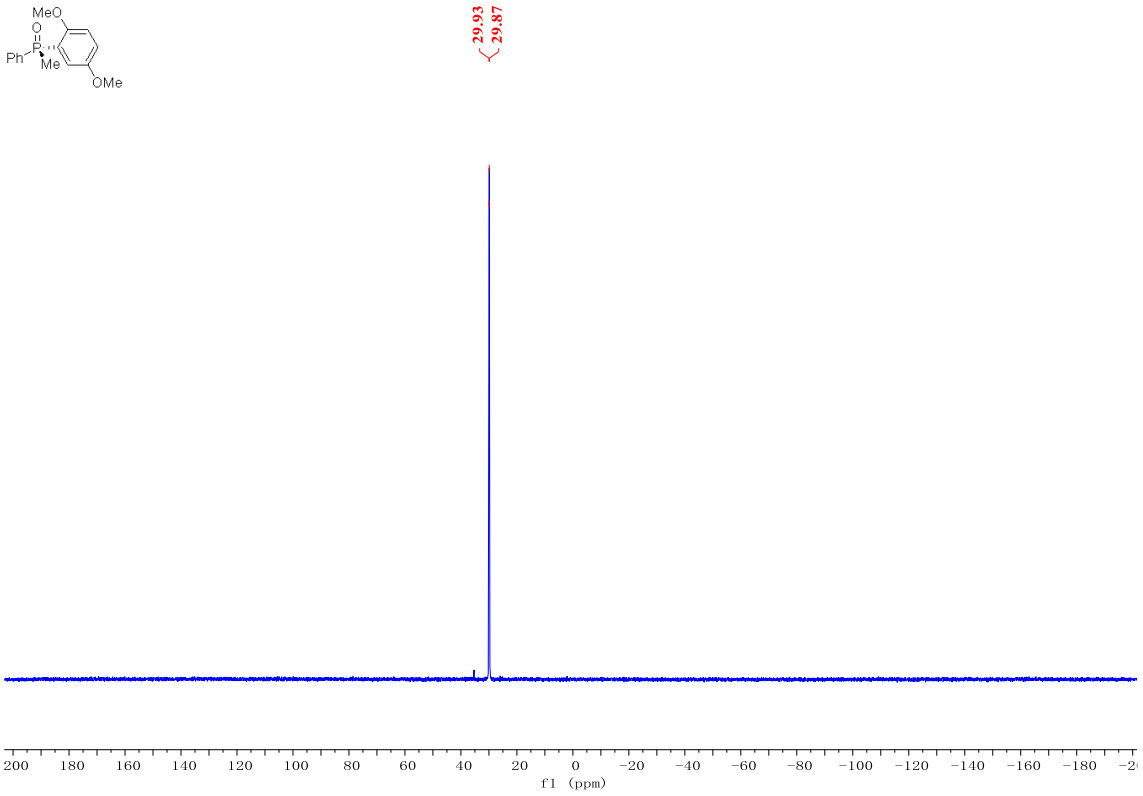
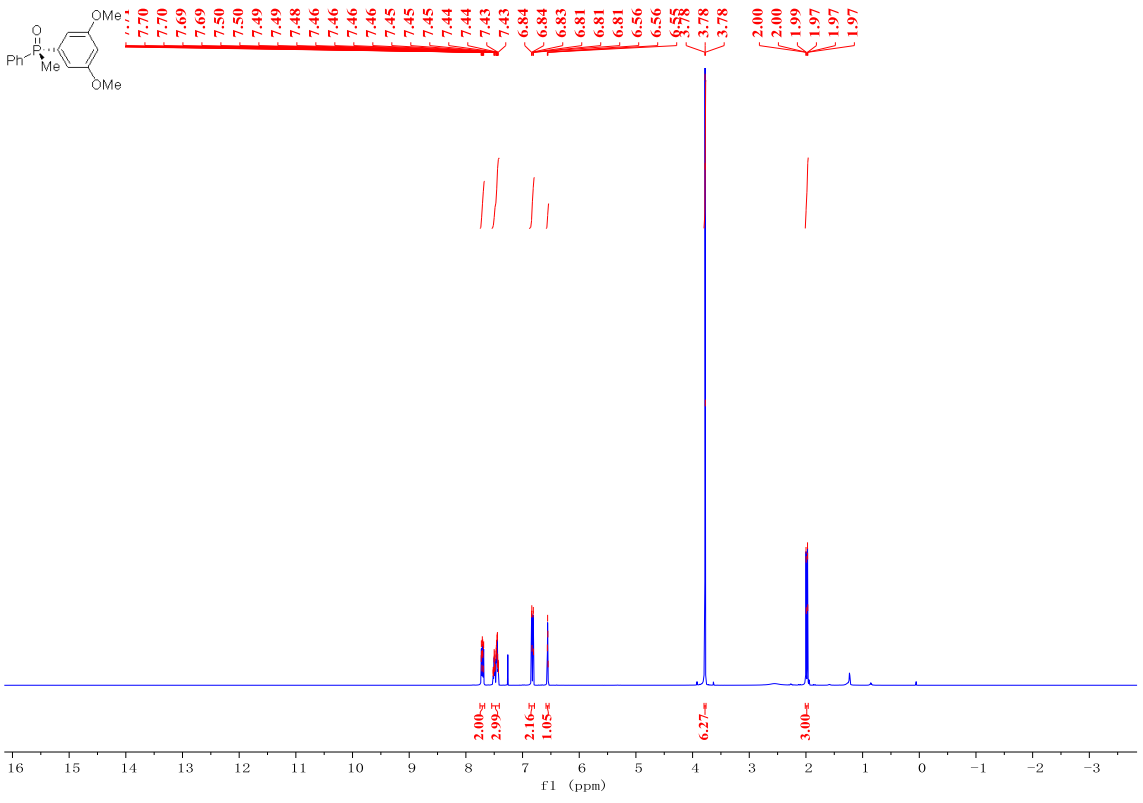
O
P
Ph
Me
OMe
153.93
153.87
153.83
135.15
134.31
131.41
131.38
130.28
130.20
128.30
128.20
122.31
121.51
120.14
117.70
117.64
112.50
112.43
56.01
55.80
16.30
15.70
f1 (ppm)


MeO
O
P
Ph
Me
OMe
29.93
29.87
f1 (ppm)


OMe
O
P
Ph
Me
OMe
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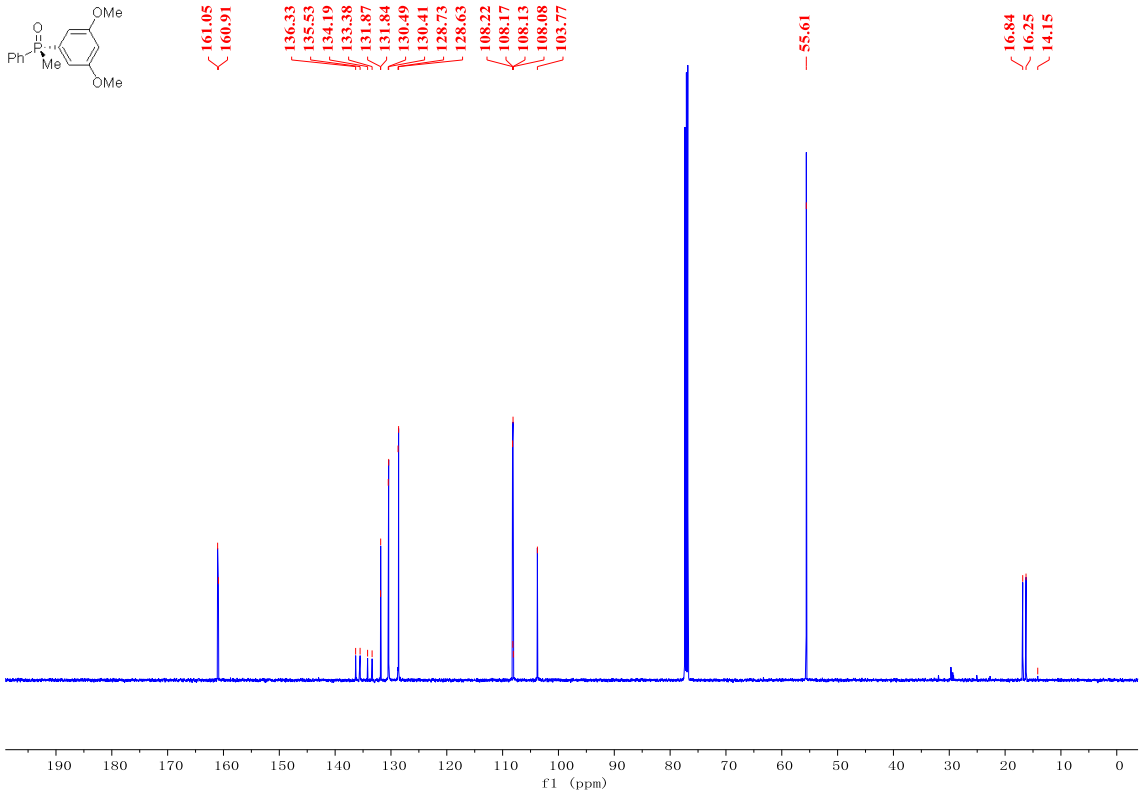
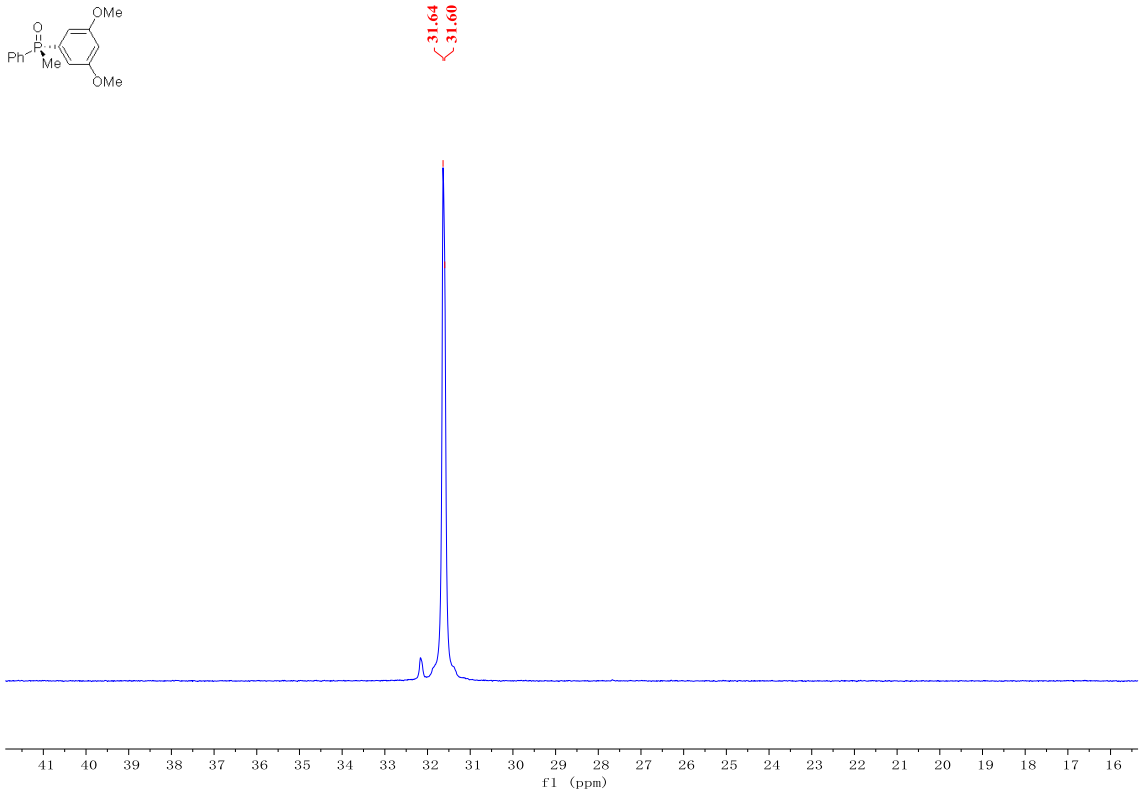
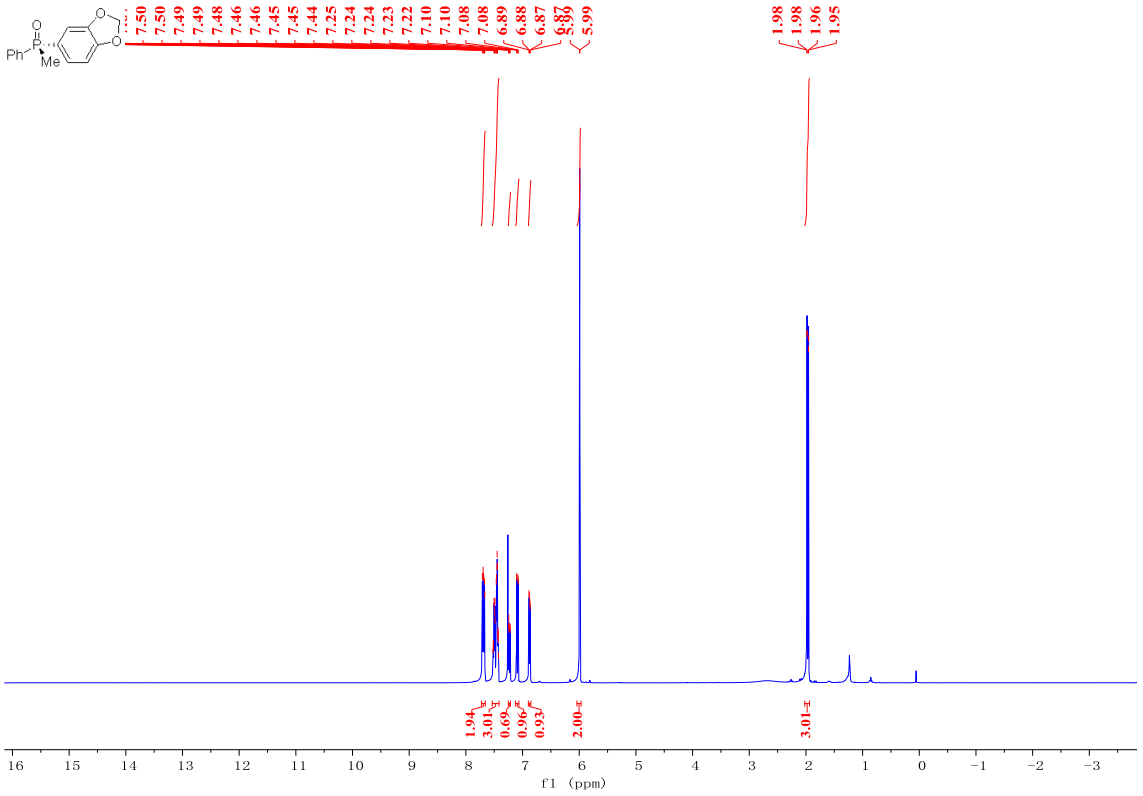
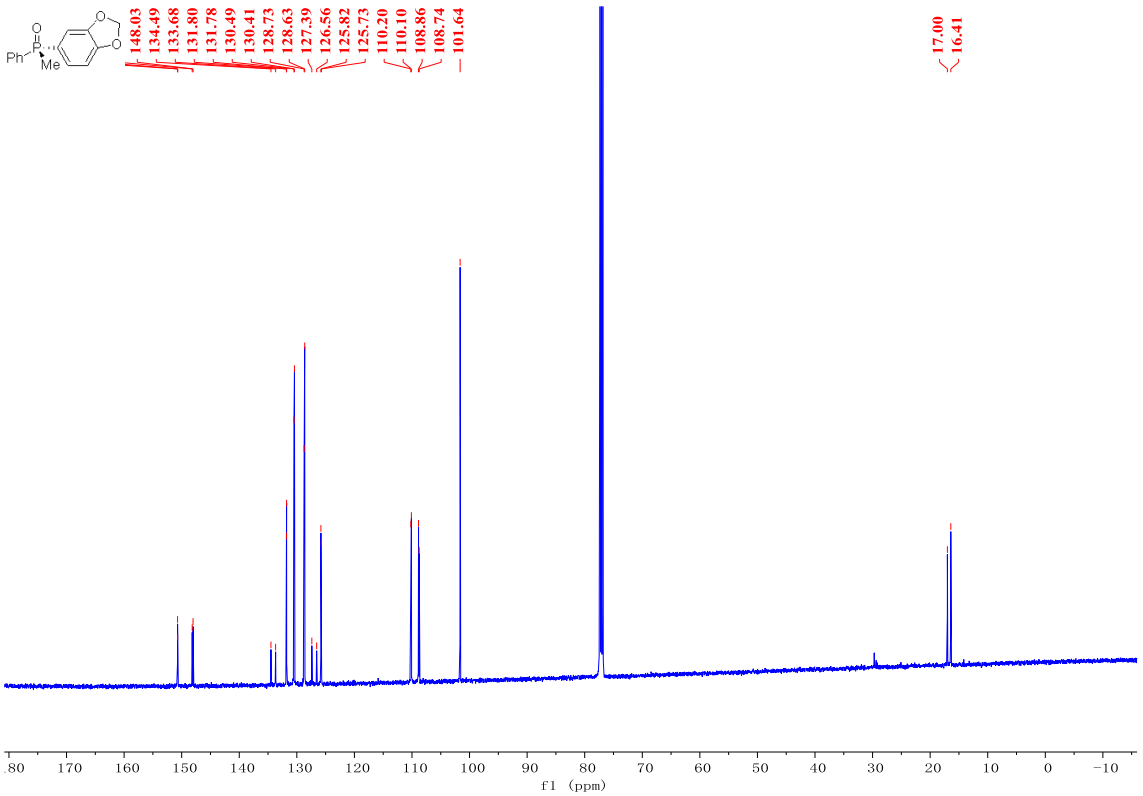
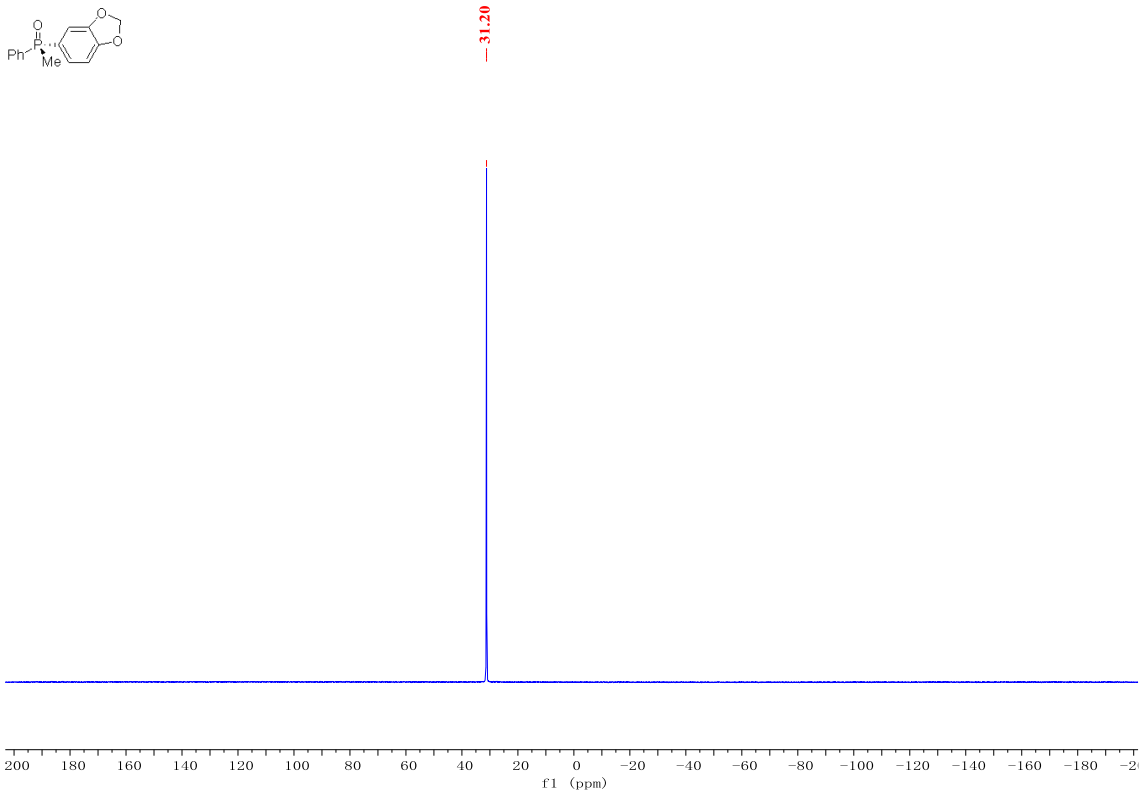
7.70
7.69
7.69
7.50
7.50
7.49
7.49
7.48
7.46
7.46
7.46
7.46
7.45
7.45
7.45
7.44
7.44
7.43
7.43
6.84
6.84
6.83
6.81
6.81
6.81
6.56
6.56
3.78
3.78
2.00
2.00
1.99
1.97
1.97
1.97
2.00
2.99
2.16
1.05
6.27
3.00
f1 (ppm)

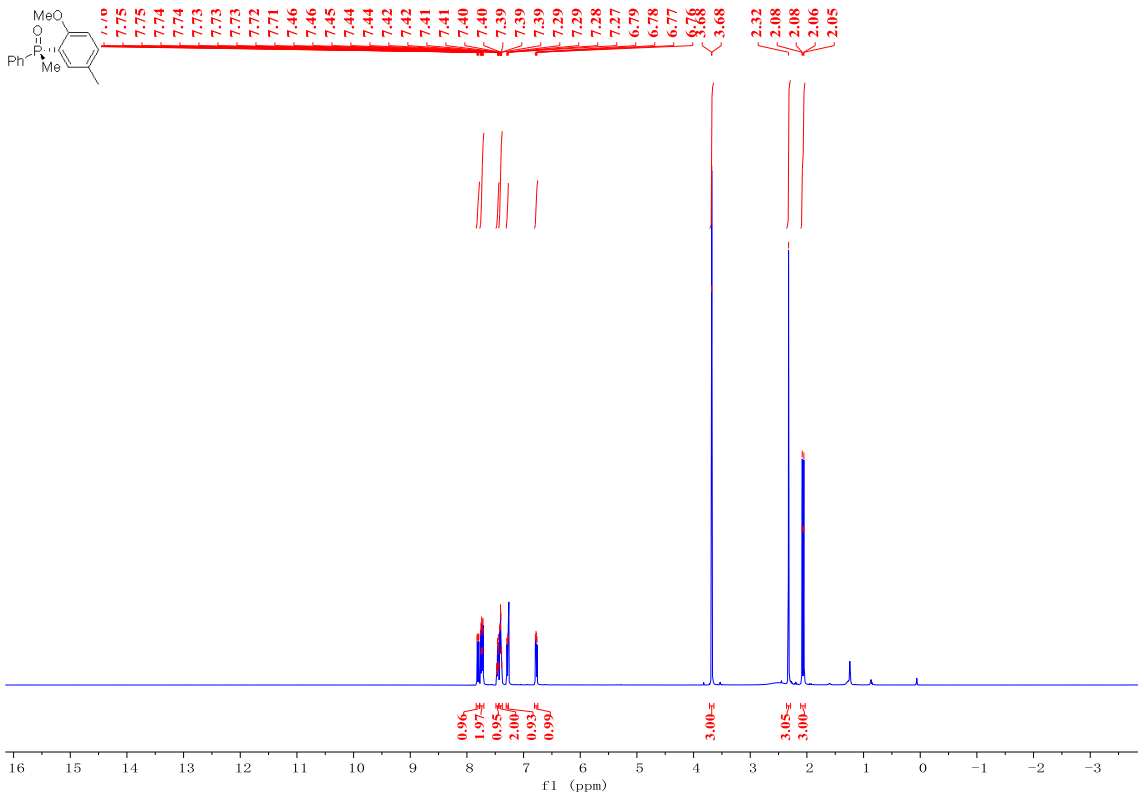

OMe
O
Ph
P
Me
OMe
161.05
160.91
136.33
135.53
134.19
133.38
131.87
131.84
130.49
130.41
128.73
128.63
108.22
108.17
108.13
108.08
103.77
55.61
16.84
16.25
14.15
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

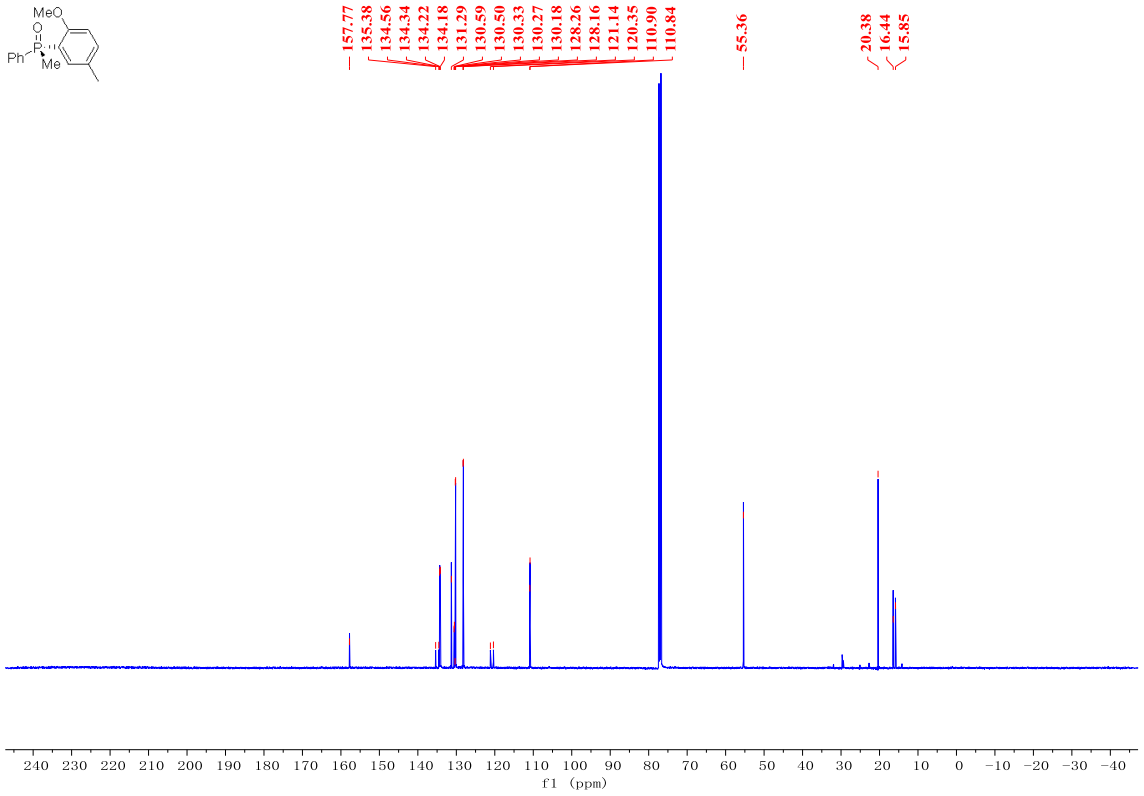

OMe
O
Ph
P
Me
OMe
31.64
31.60
41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16
f1 (ppm)

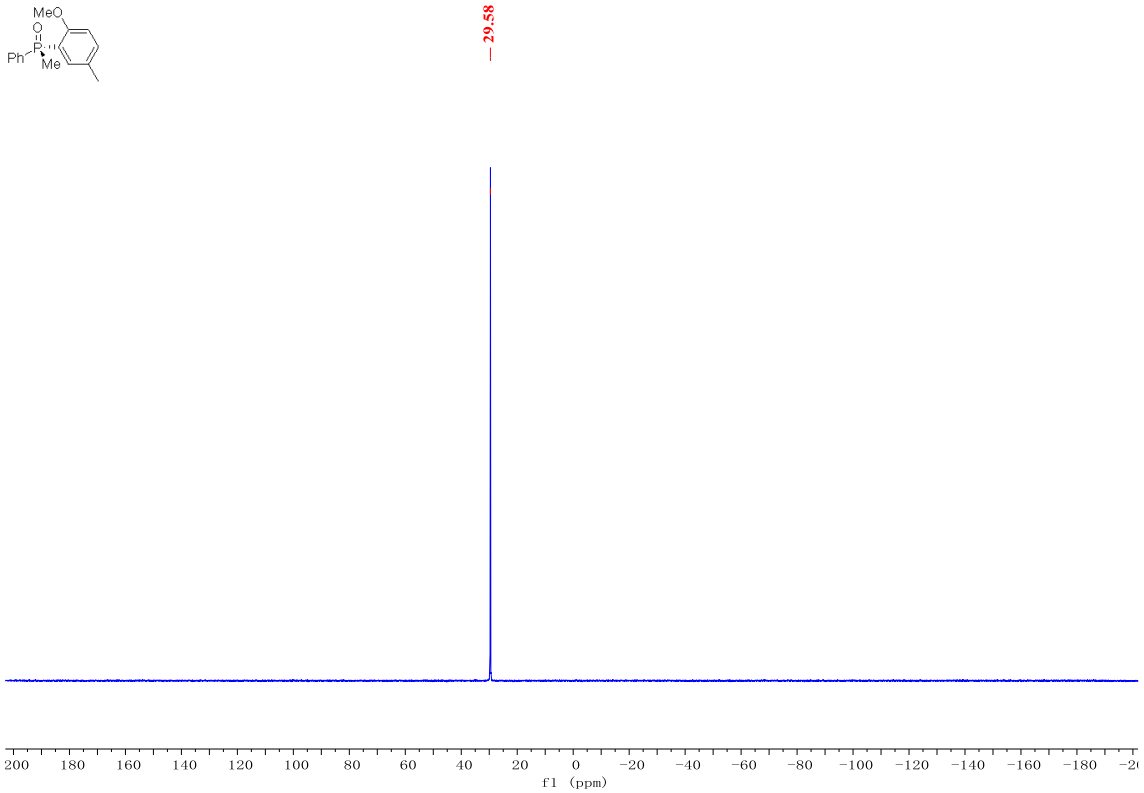

7.50
7.50
7.49
7.49
7.48
7.46
7.46
7.45
7.45
7.44
7.25
7.24
7.24
7.23
7.22
7.10
7.10
7.08
7.08
6.89
6.88
6.87
6.87
5.99
1.98
1.98
1.96
1.95
1.94
3.01
0.69
0.96
0.93
2.00
3.01
f1 (ppm)

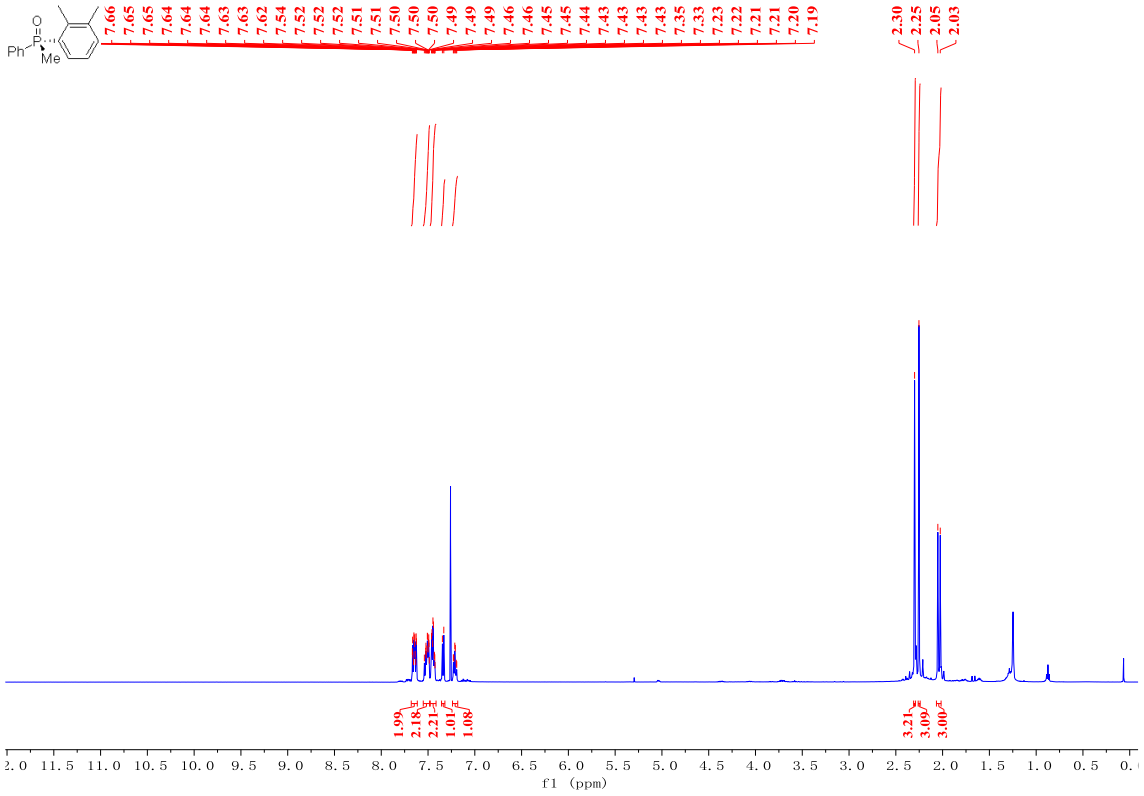

148.03
134.49
133.68
131.80
131.78
130.49
130.41
128.73
128.63
127.39
126.56
125.82
125.73
110.20
110.10
108.86
108.74
101.64
17.00
16.41
f1 (ppm)

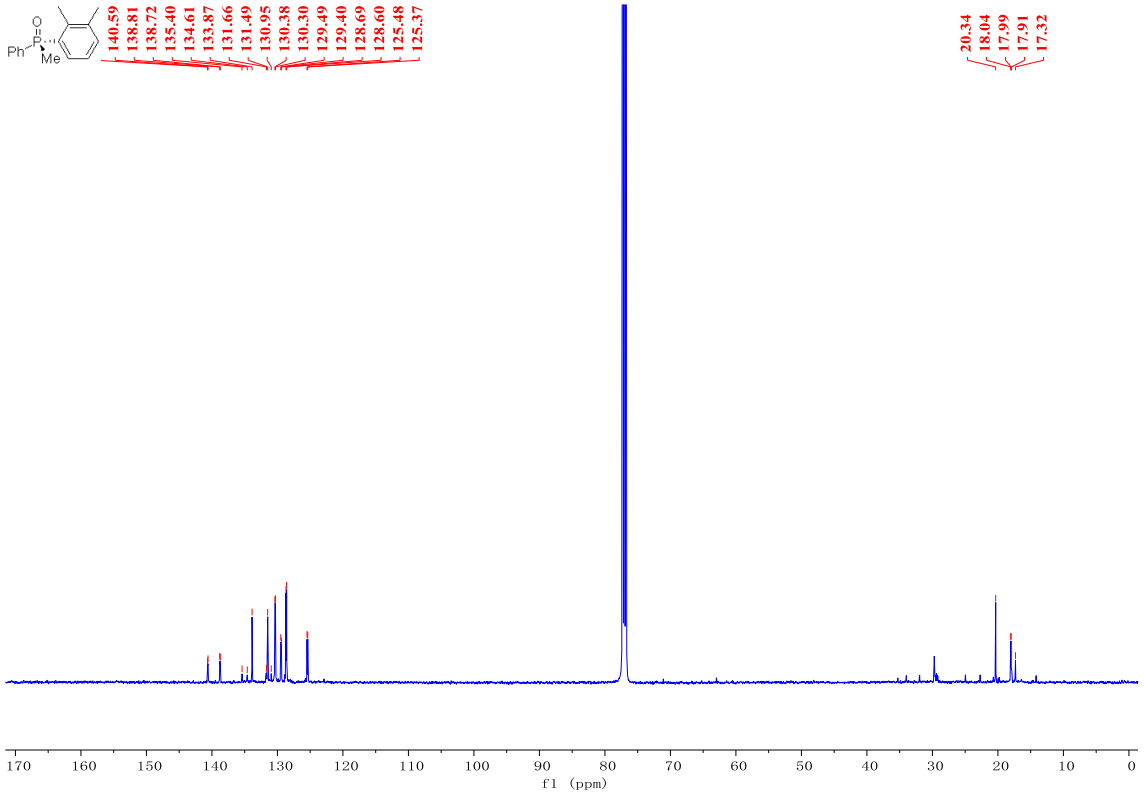

31.20
f1 (ppm)

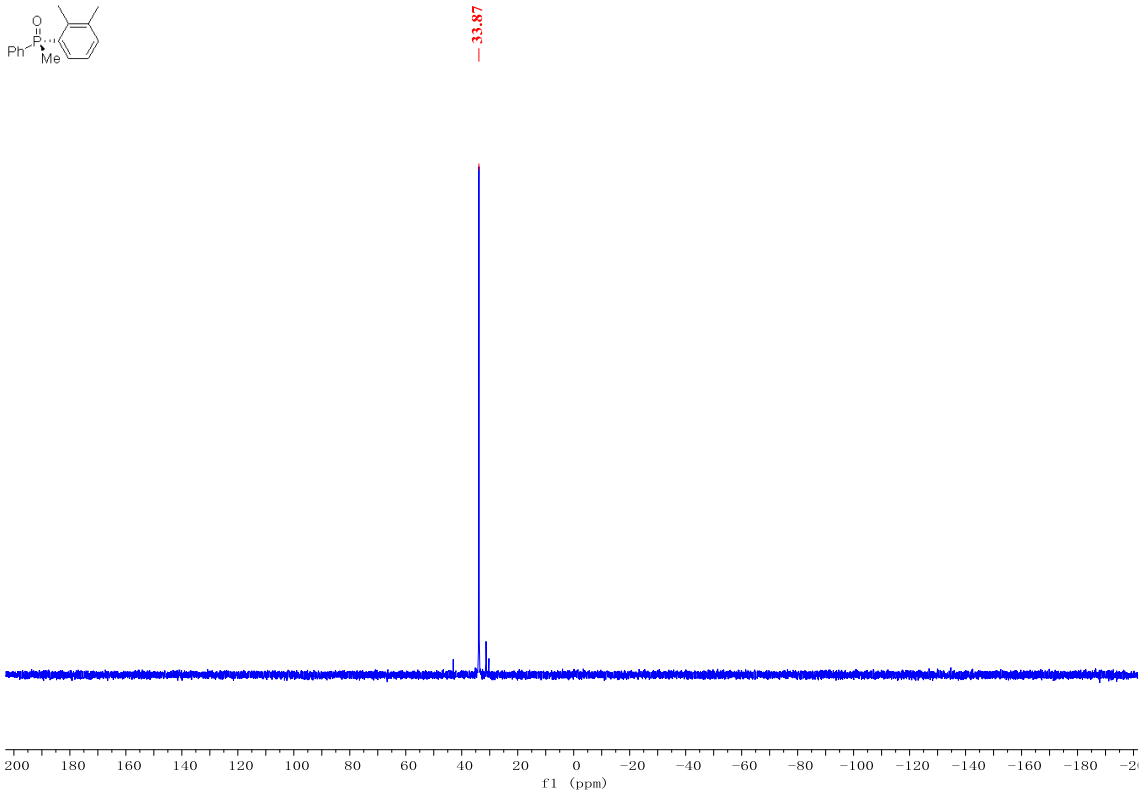

7.75
7.74
7.73
7.72
7.71
7.46
7.45
7.44
7.42
7.41
7.40
7.39
7.29
7.28
7.27
6.79
6.78
6.77
3.68
2.32
2.08
2.06
2.05
0.96
1.97
0.95
2.00
0.93
0.99
3.00
3.05
3.00
f1 (ppm)

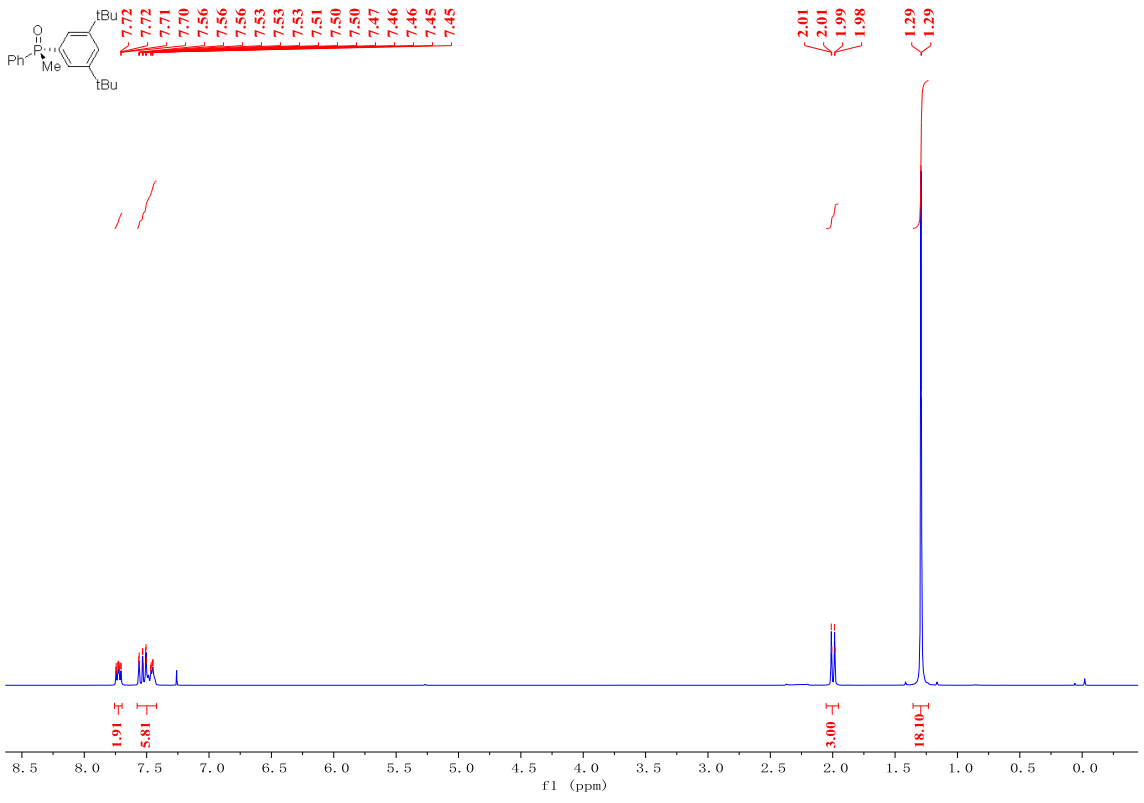

MeO
O
Ph
P
Me
157.77
135.38
134.56
134.34
134.22
134.18
131.29
130.59
130.50
130.33
130.27
130.18
128.26
128.16
121.14
120.35
110.90
110.84
55.36
20.38
16.44
15.85
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40
f1 (ppm)

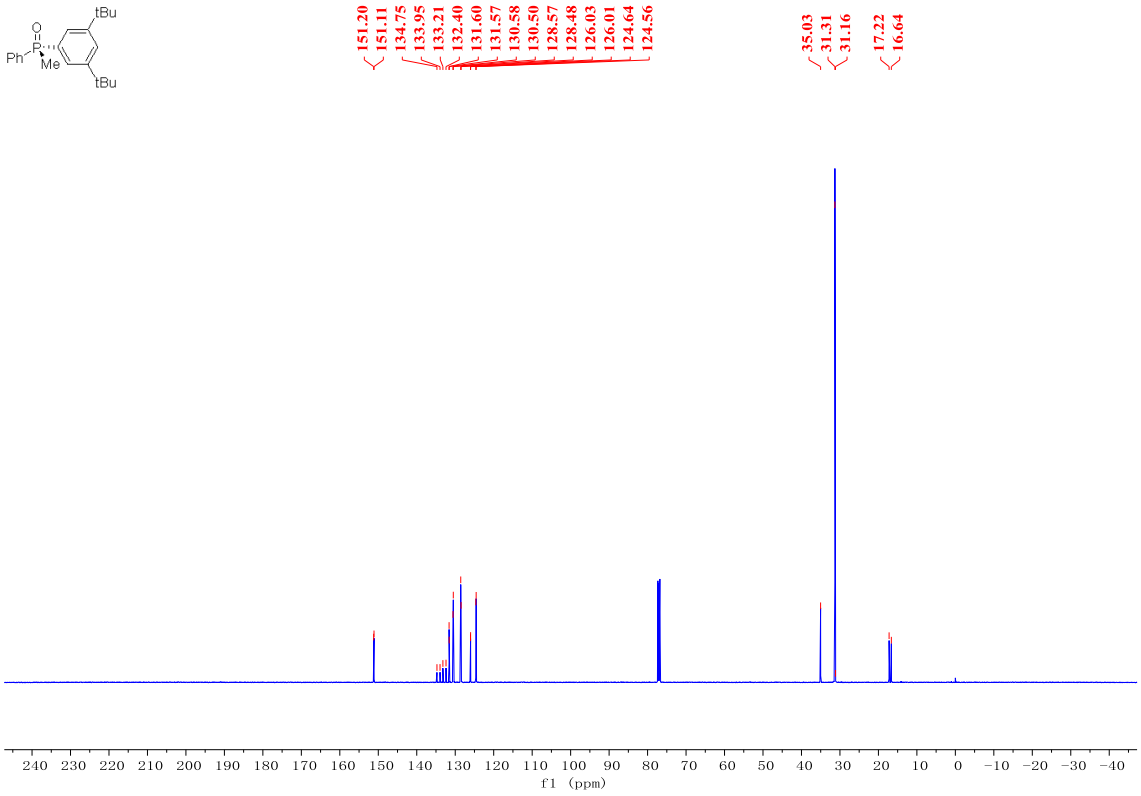

MeO
O
Ph
P
Me
29.58
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

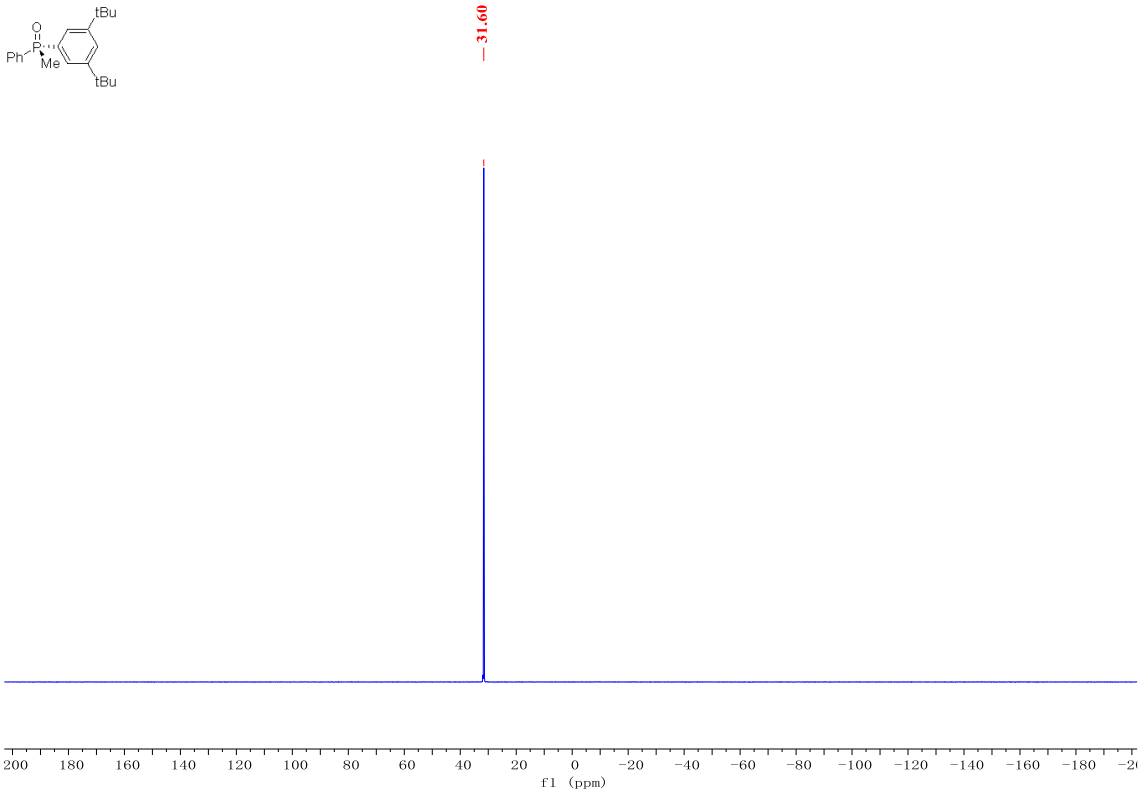

7.66 7.65 7.65 7.64 7.64 7.64 7.63 7.63 7.62 7.54 7.52 7.52 7.52 7.51 7.51 7.50 7.50 7.50 7.49 7.49 7.49 7.46 7.46 7.45 7.45 7.44 7.43 7.43 7.43 7.43 7.35 7.33 7.23 7.22 7.21 7.21 7.20 7.19
2.30 2.25 2.05 2.03
1.99 2.18 2.21 1.01 1.08
3.21 3.09 3.00
f1 (ppm)

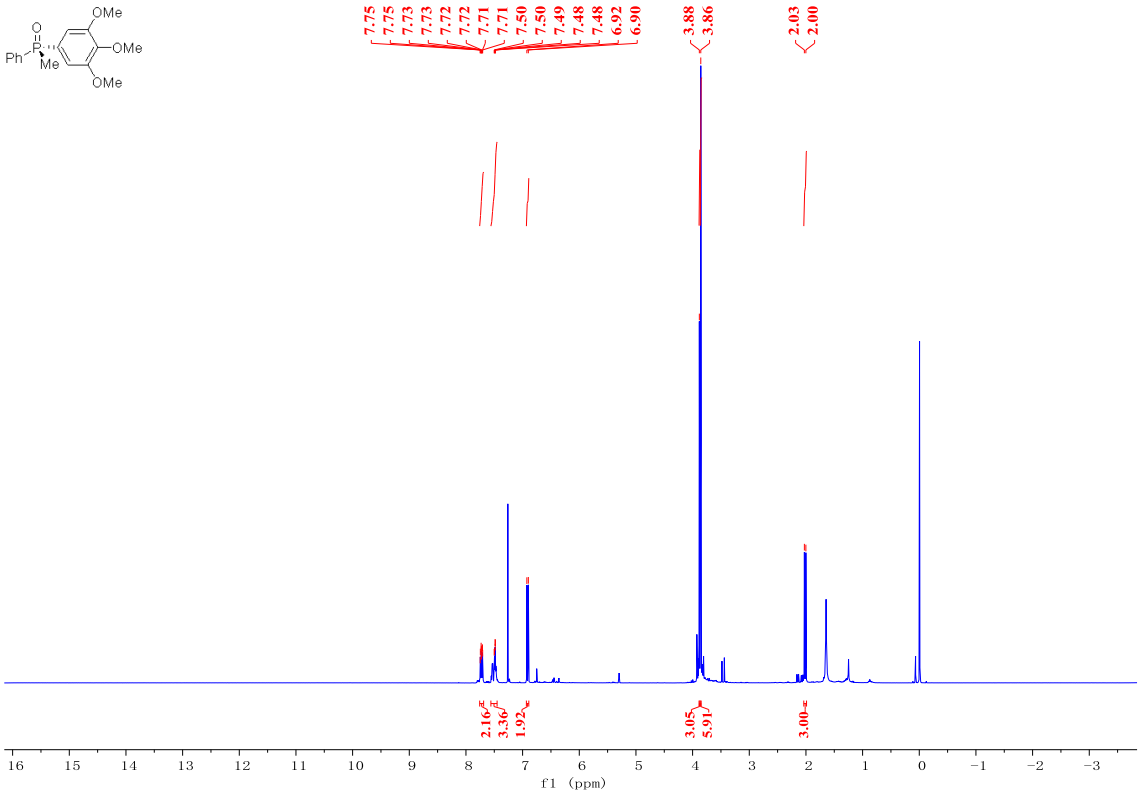

140.59 138.81 138.72 135.40 134.61 133.87 131.66 131.49 130.95 130.38 130.30 129.49 129.40 128.69 128.60 125.48 125.37
20.34 18.04 17.99 17.91 17.32
f1 (ppm)

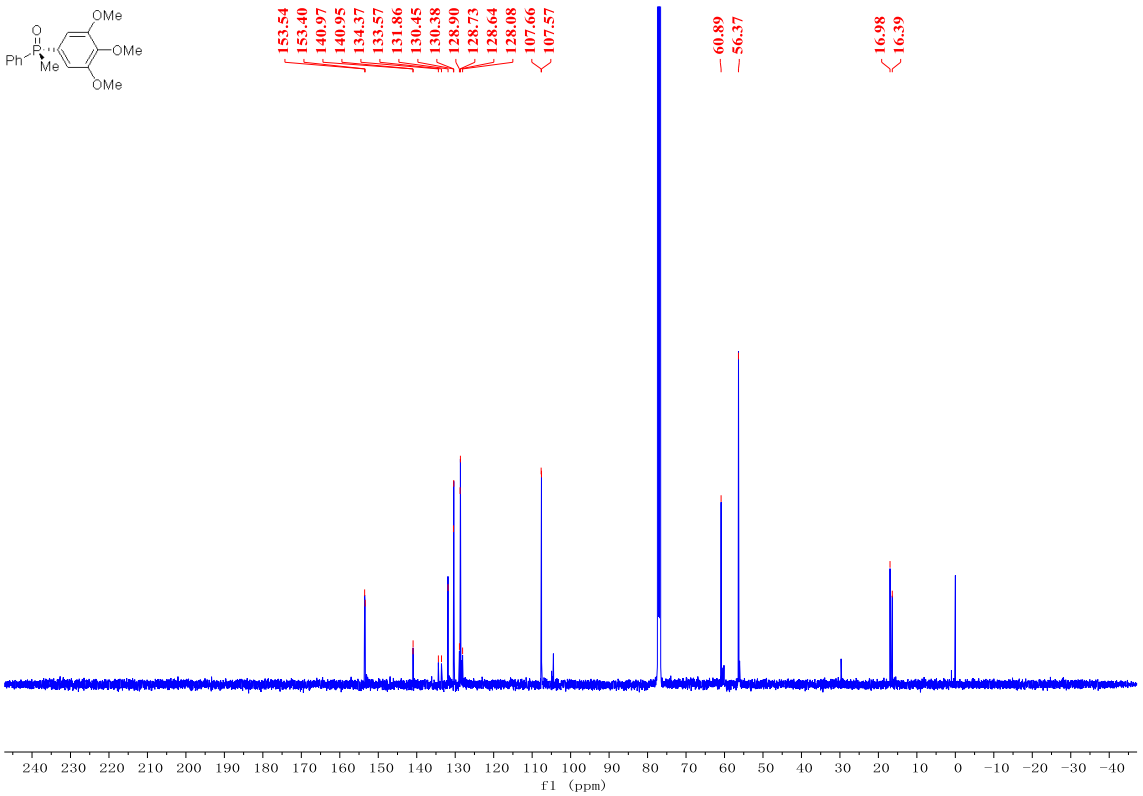

Ph
O
P
Me
33.87
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

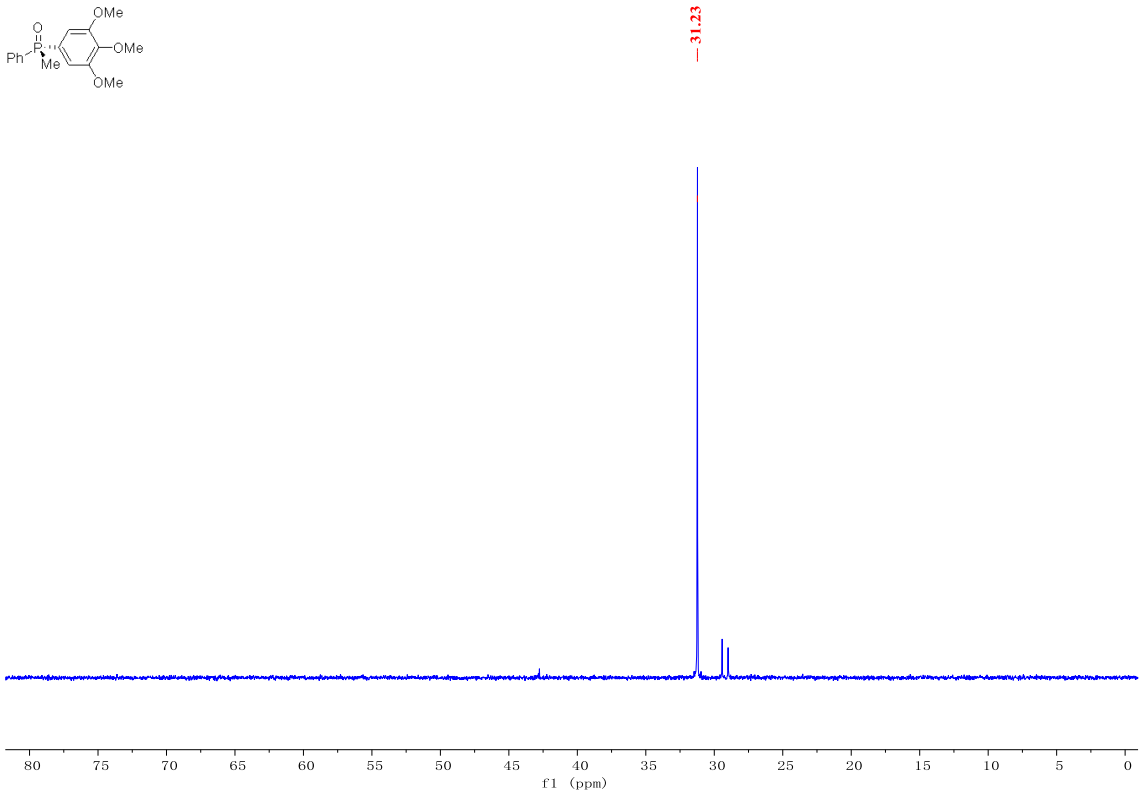

Ph
O
P
Me
tBu
tBu
7.72
7.72
7.71
7.70
7.56
7.56
7.53
7.53
7.53
7.51
7.50
7.50
7.47
7.46
7.46
7.45
7.45
2.01
2.01
1.99
1.98
1.29
1.29
1.91
5.81
3.00
18.10
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

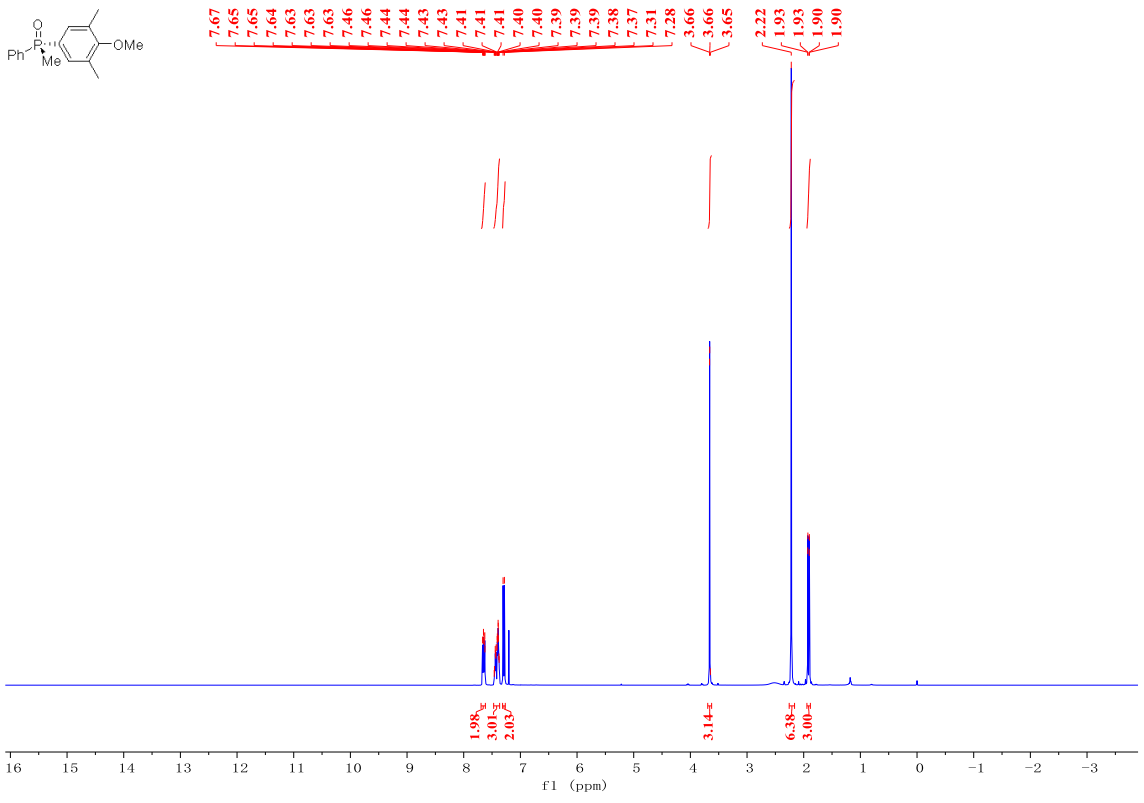

tBu
O
Ph
P
Me
tBu
151.20
151.11
134.75
133.95
133.21
132.40
131.60
131.57
130.58
130.50
128.57
128.48
126.03
126.01
124.64
124.56
35.03
31.31
31.16
17.22
16.64
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40
f1 (ppm)

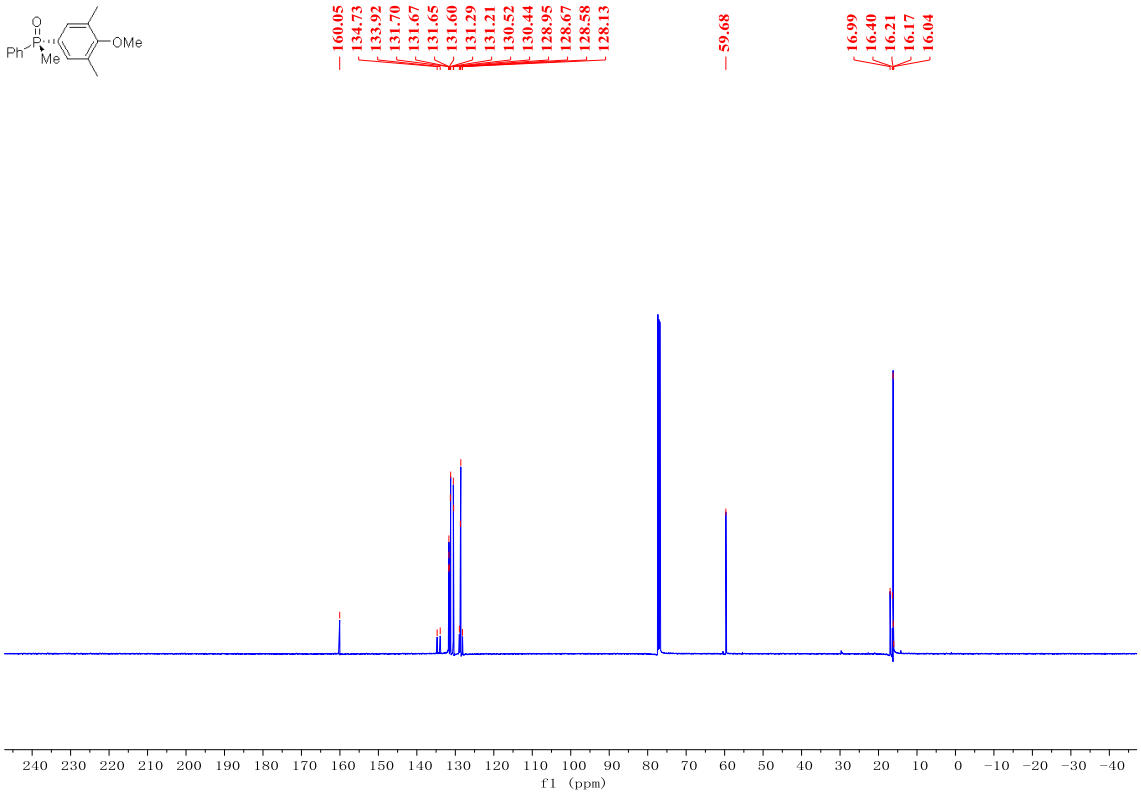

tBu
O
Ph
P
Me
tBu
31.60
200 180 160 140 120 100 80 60 40 20 0 −20 −40 −60 −80 −100 −120 −140 −160 −180
f1 (ppm)

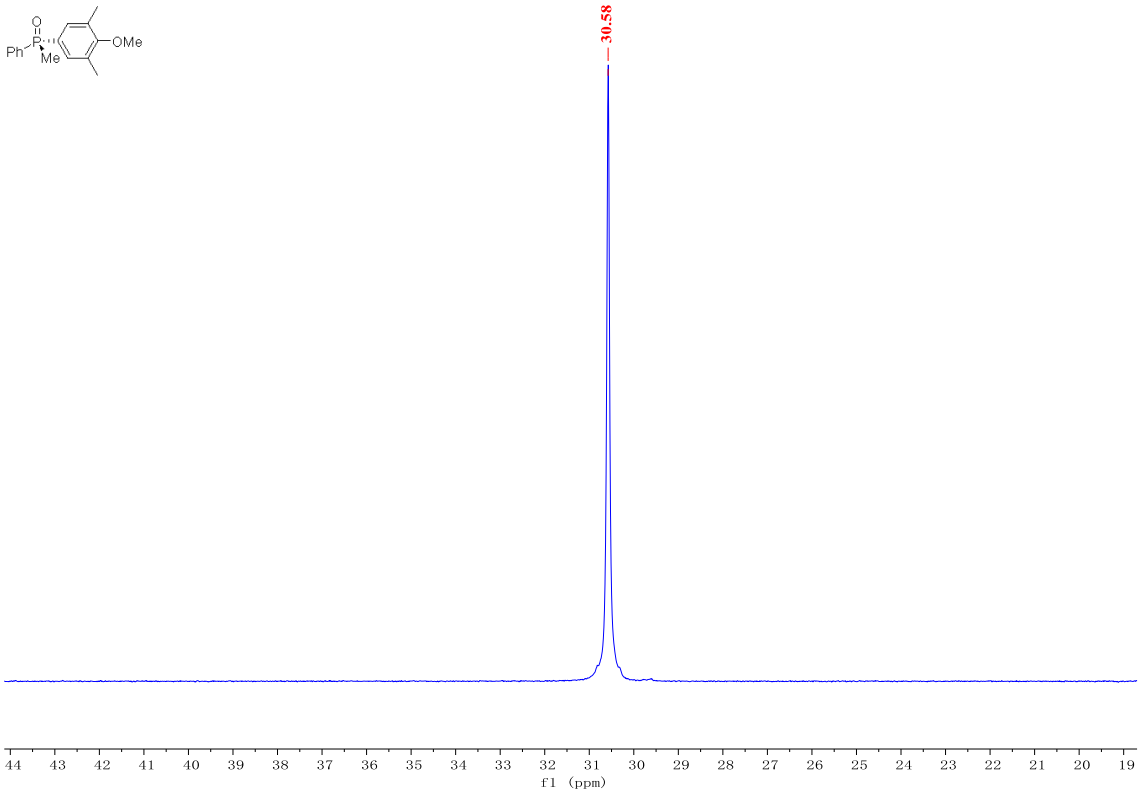

OMe
OMe
OMe
O
Ph
P
Me
7.75
7.75
7.73
7.73
7.72
7.72
7.71
7.71
7.50
7.50
7.49
7.48
7.48
6.92
6.90
3.88
3.86
2.03
2.00
2.16
3.36
1.92
3.05
5.91
3.00
f1 (ppm)

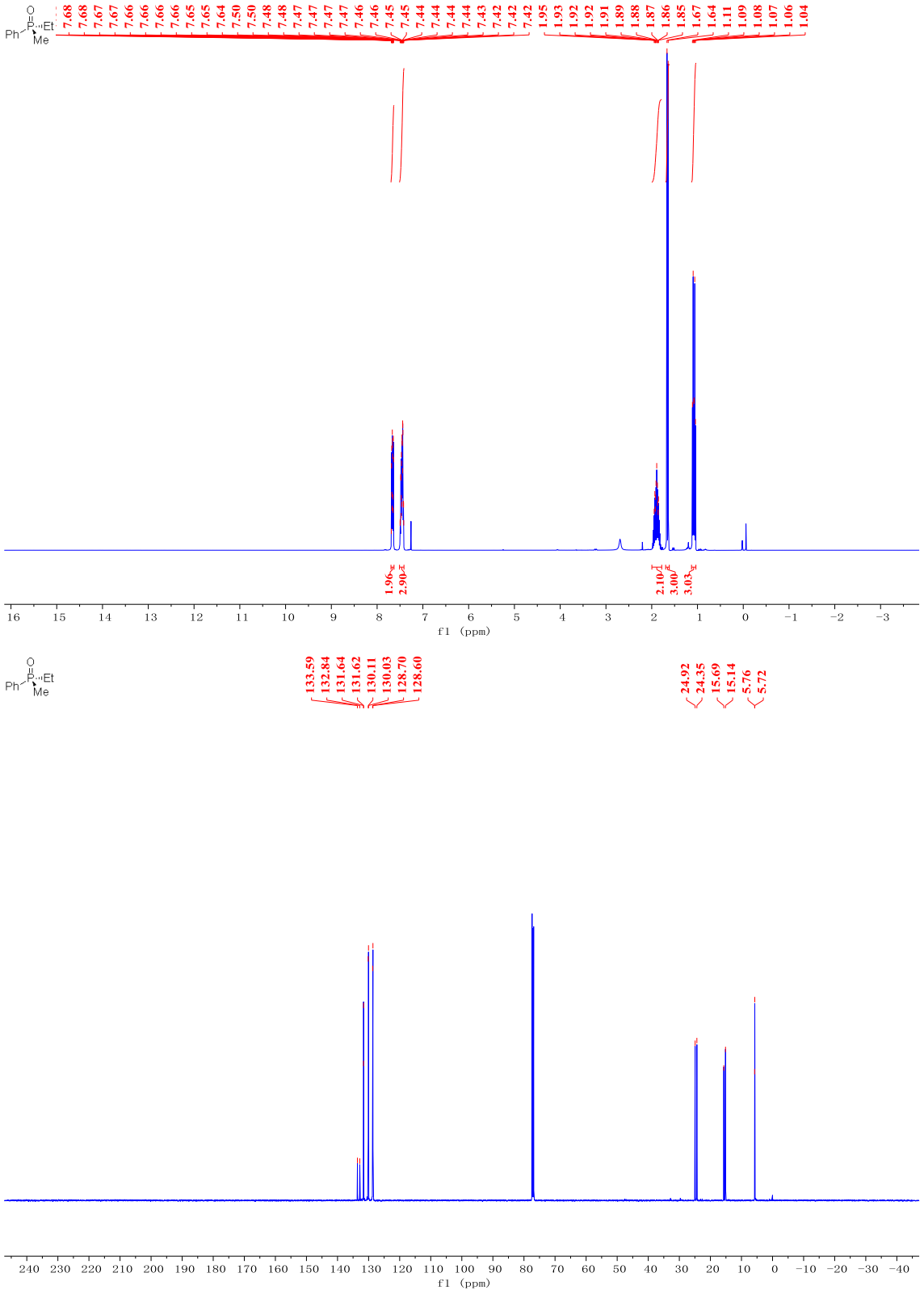

OMe
OMe
OMe
O
Ph
P
Me
153.54
153.40
140.97
140.95
134.37
133.57
131.86
130.45
130.38
128.90
128.73
128.64
128.08
107.66
107.57
60.89
56.37
16.98
16.39
f1 (ppm)

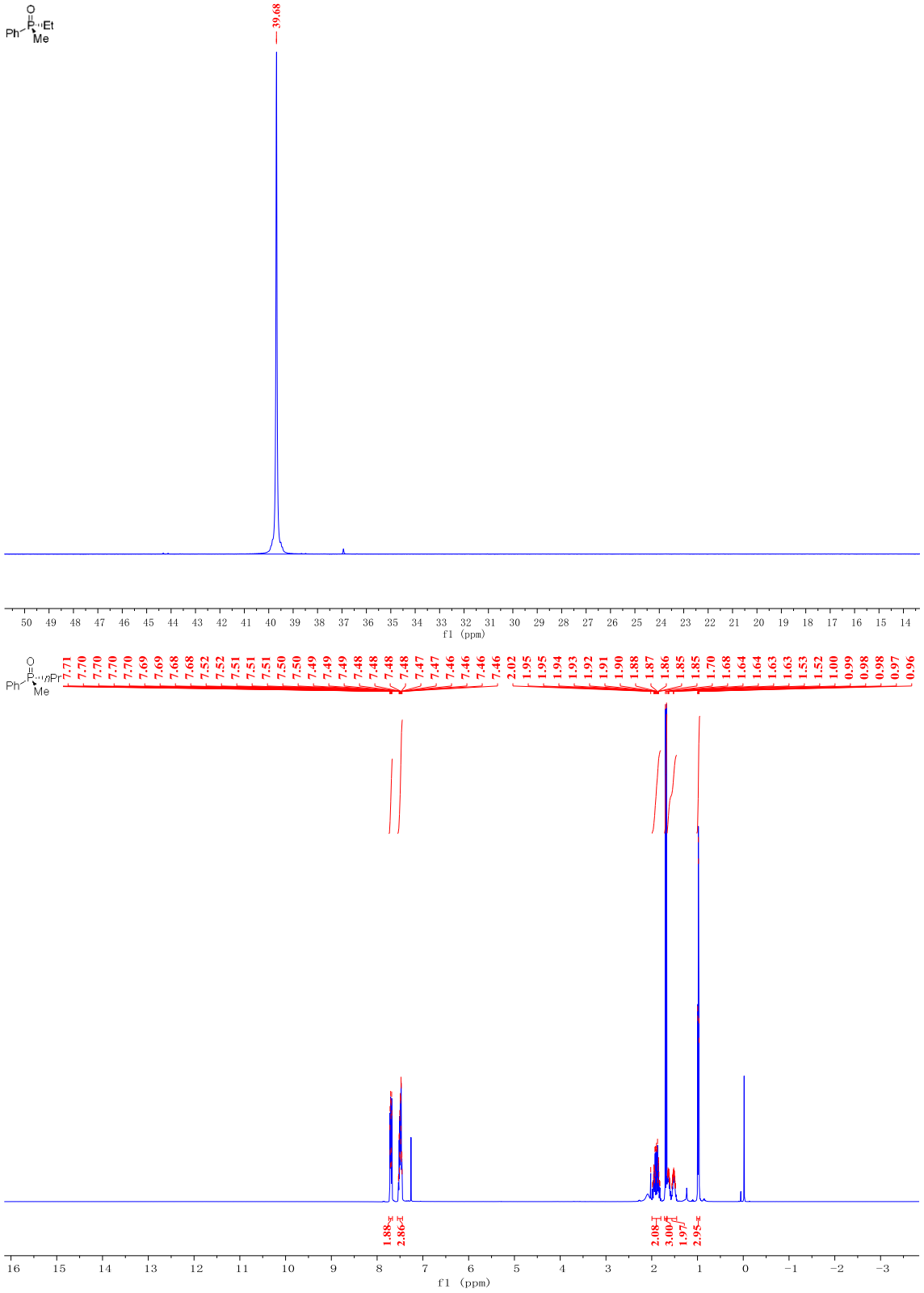

OMe
OMe
OMe
O
Ph
P
Me
31.23
80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

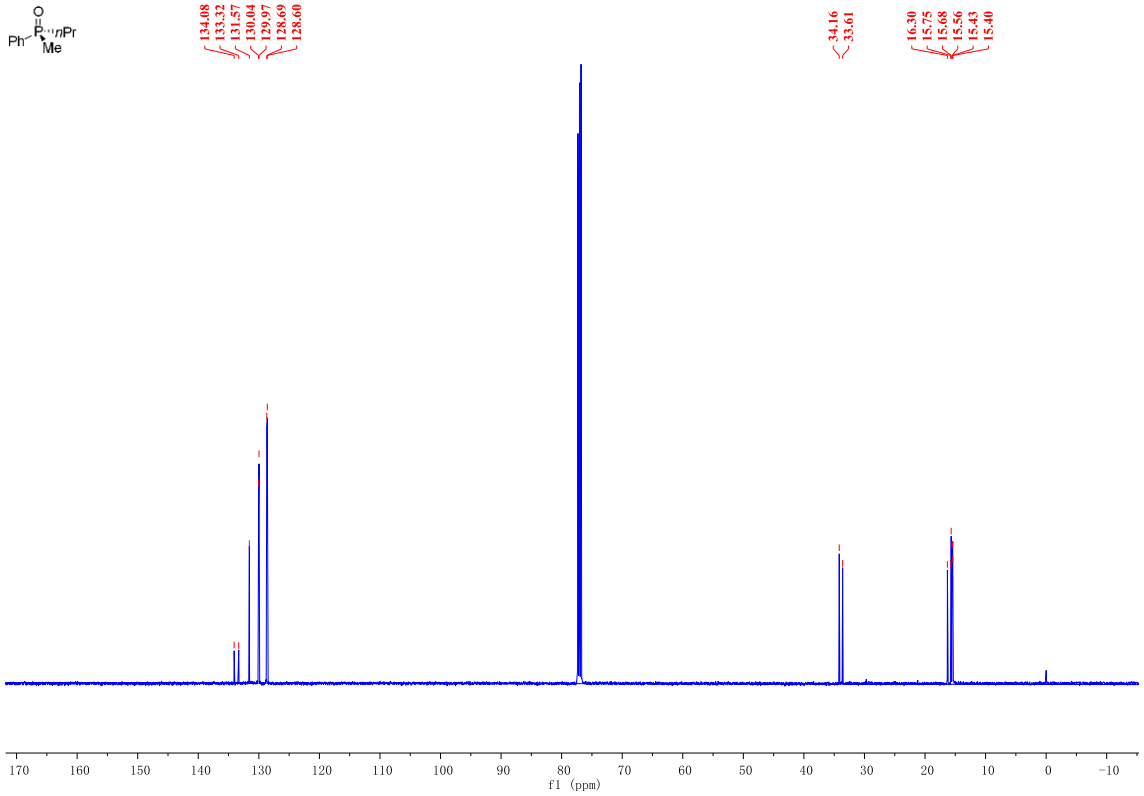

OMe
O
Ph
P
Me
7.67 7.65 7.65 7.64 7.63 7.63 7.63 7.46 7.46 7.44 7.44 7.43 7.43 7.41 7.41 7.41 7.40 7.40 7.39 7.39 7.39 7.38 7.37 7.31 7.28
3.66 3.65
2.22 1.93 1.93 1.90 1.90
1.98 3.01 2.03 3.14 6.38 3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

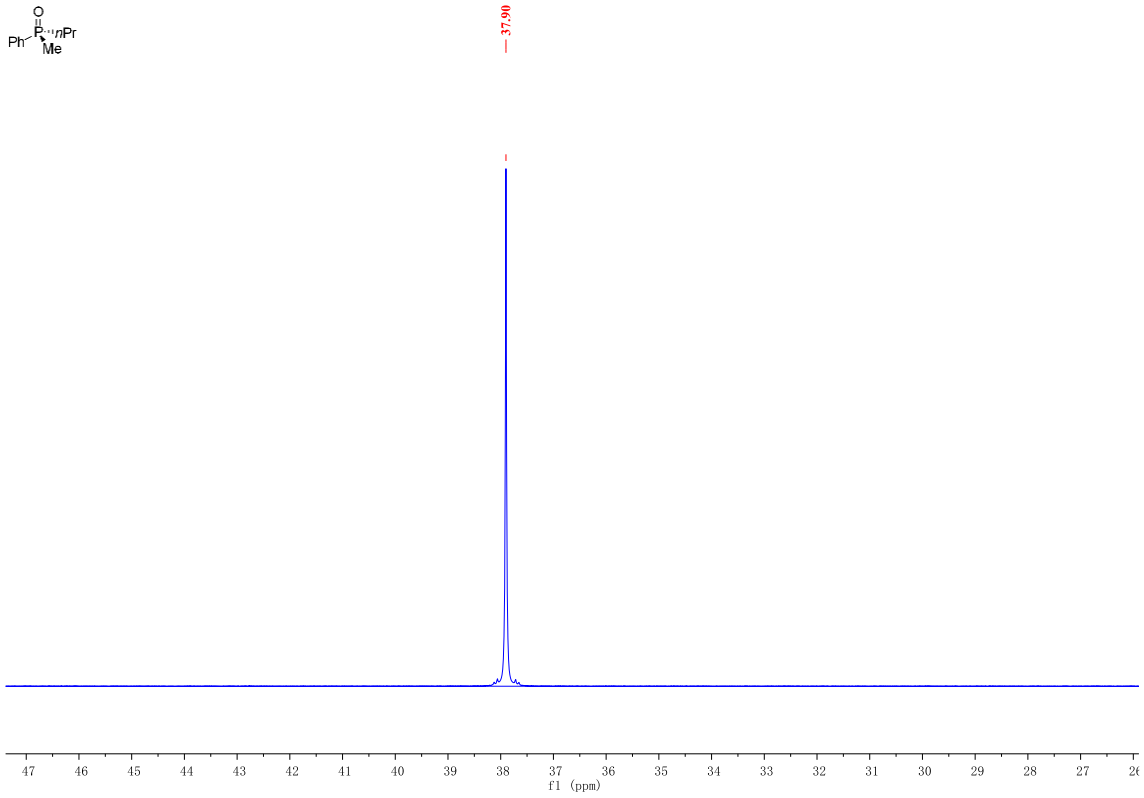

Ph
P
O
Me
OMe
160.05
134.73
133.92
131.70
131.67
131.65
131.60
131.29
131.21
130.52
130.44
128.95
128.67
128.58
128.13
59.68
16.99
16.40
16.21
16.17
16.04
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40
f1 (ppm)

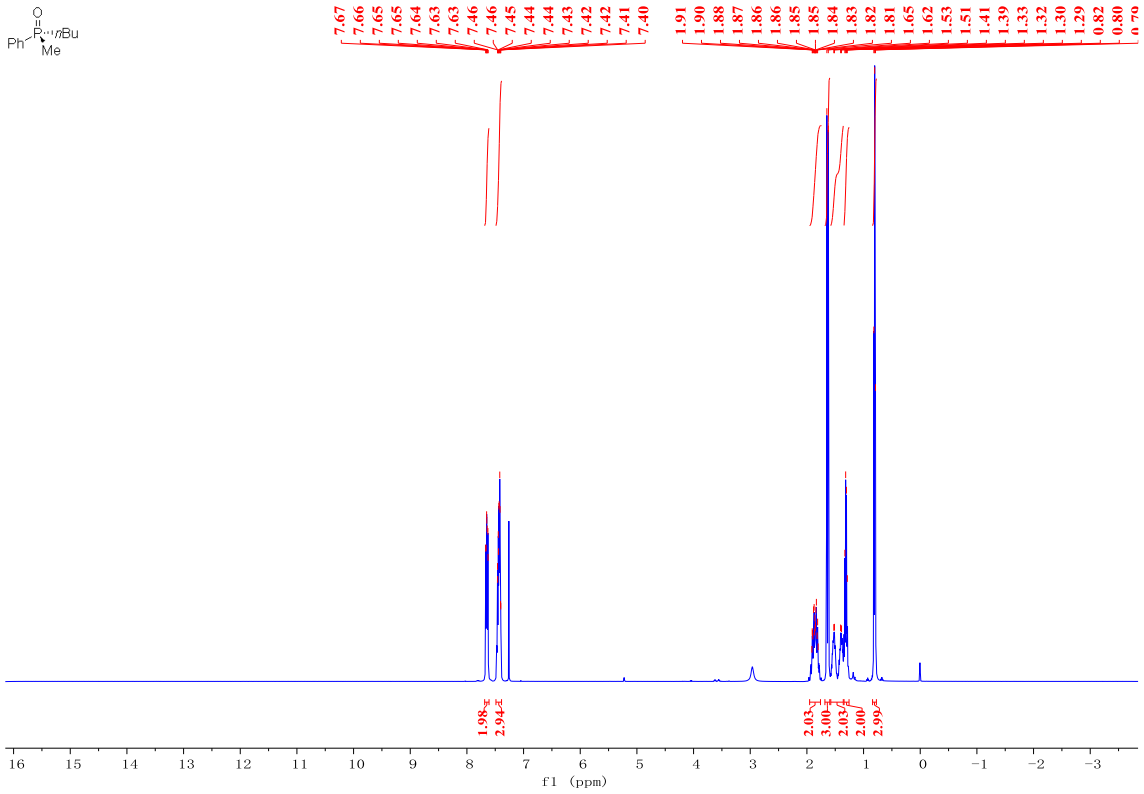

Ph
P
O
Me
OMe
30.58
44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19
f1 (ppm)

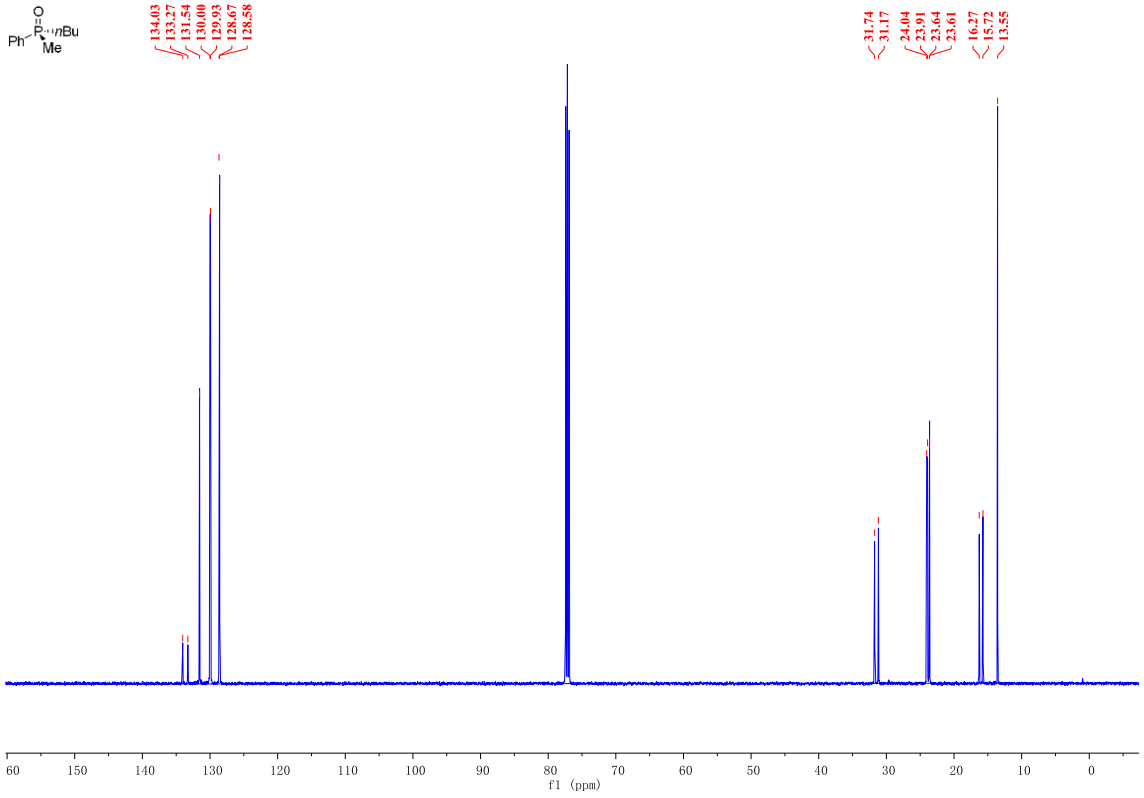

7.68 7.68 7.67 7.67 7.66 7.66 7.66 7.66 7.65 7.64 7.50 7.48 7.48 7.47 7.47 7.47 7.47 7.46 7.46 7.45 7.45 7.44 7.44 7.44 7.44 7.43 7.42 7.42 7.42
1.95 1.93 1.92 1.92 1.91 1.89 1.88 1.87 1.86 1.85 1.67 1.64 1.11 1.09 1.08 1.07 1.06 1.04
1.96 2.90
2.10 3.00 3.03
f1 (ppm)
133.59 132.84 131.64 131.62 130.11 130.03 128.70 128.60
24.92 24.35 15.69 15.14 5.76 5.72
f1 (ppm)

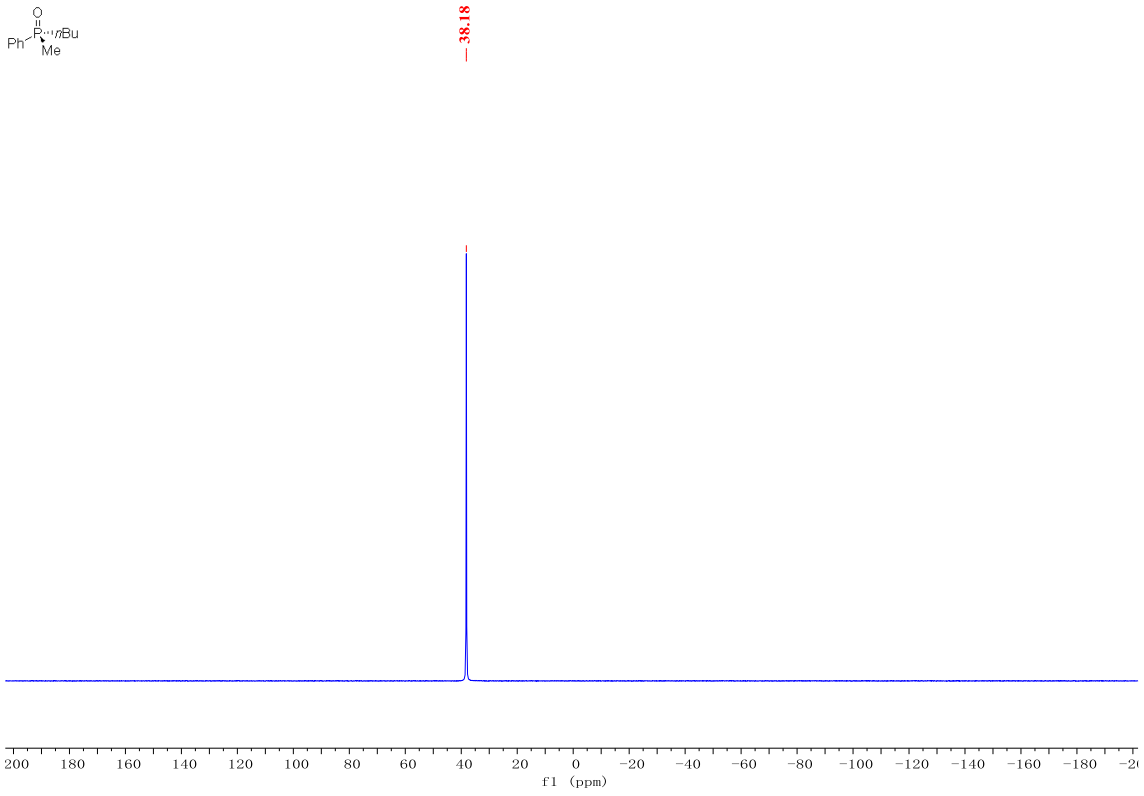

Ph
O
P
Et
Me
39.68
f1 (ppm)
7.71 7.70 7.70 7.70 7.69 7.68 7.68 7.52 7.52 7.51 7.51 7.51 7.50 7.50 7.49 7.49 7.49 7.48 7.48 7.48 7.47 7.47 7.46 7.46 7.46 7.46
2.02 1.95 1.95 1.94 1.93 1.92 1.91 1.90 1.88 1.87 1.86 1.85 1.85 1.70 1.68 1.64 1.64 1.63 1.63 1.53 1.52 1.00 0.99 0.98 0.98 0.97 0.96
1.88
2.86
2.08
3.00
1.97
2.95
f1 (ppm)

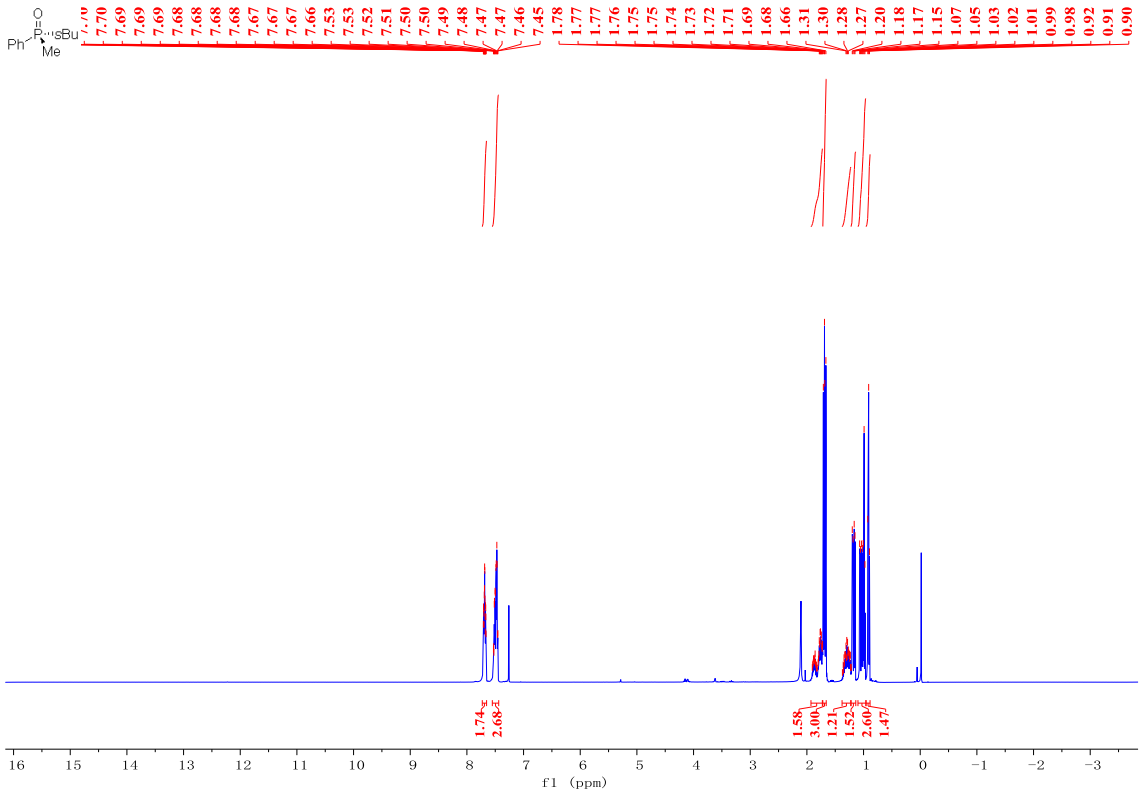

O
Ph
P
nPr
Me
134.08
133.32
131.57
130.04
129.97
128.69
128.60
34.16
33.61
16.30
15.75
15.68
15.56
15.43
15.40
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

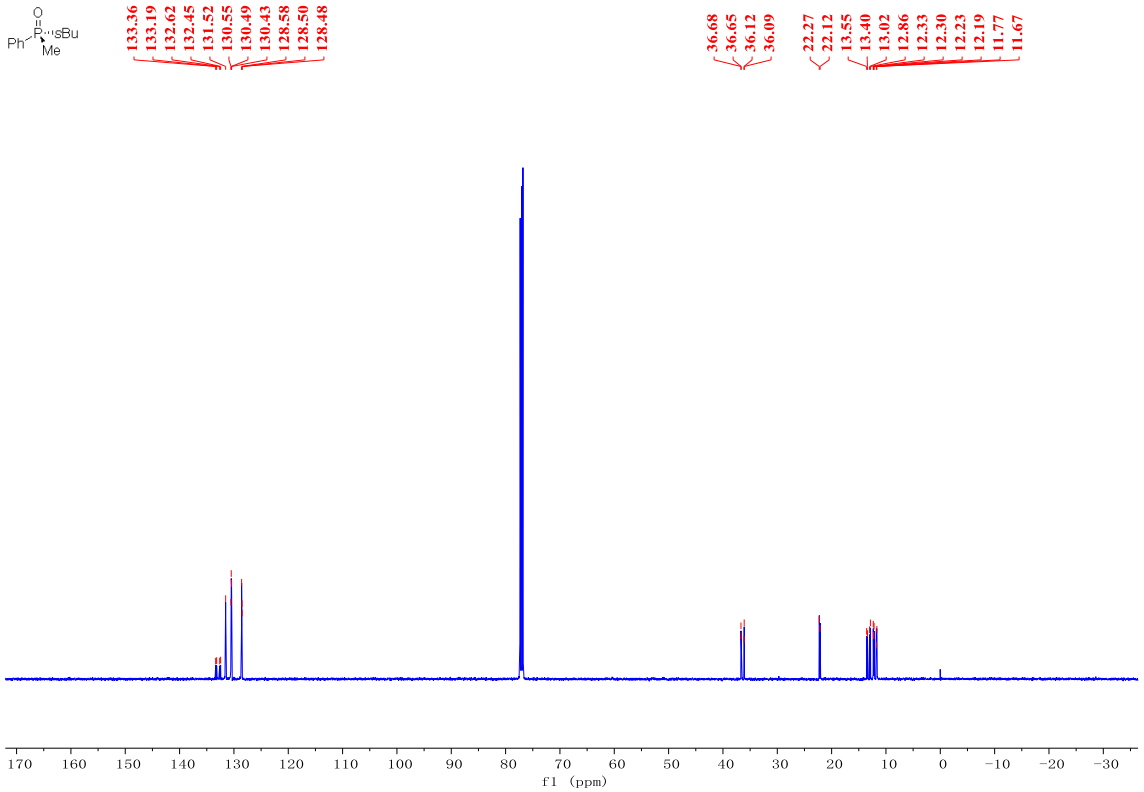

O
Ph
P
nPr
Me
37.90
47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27
f1 (ppm)

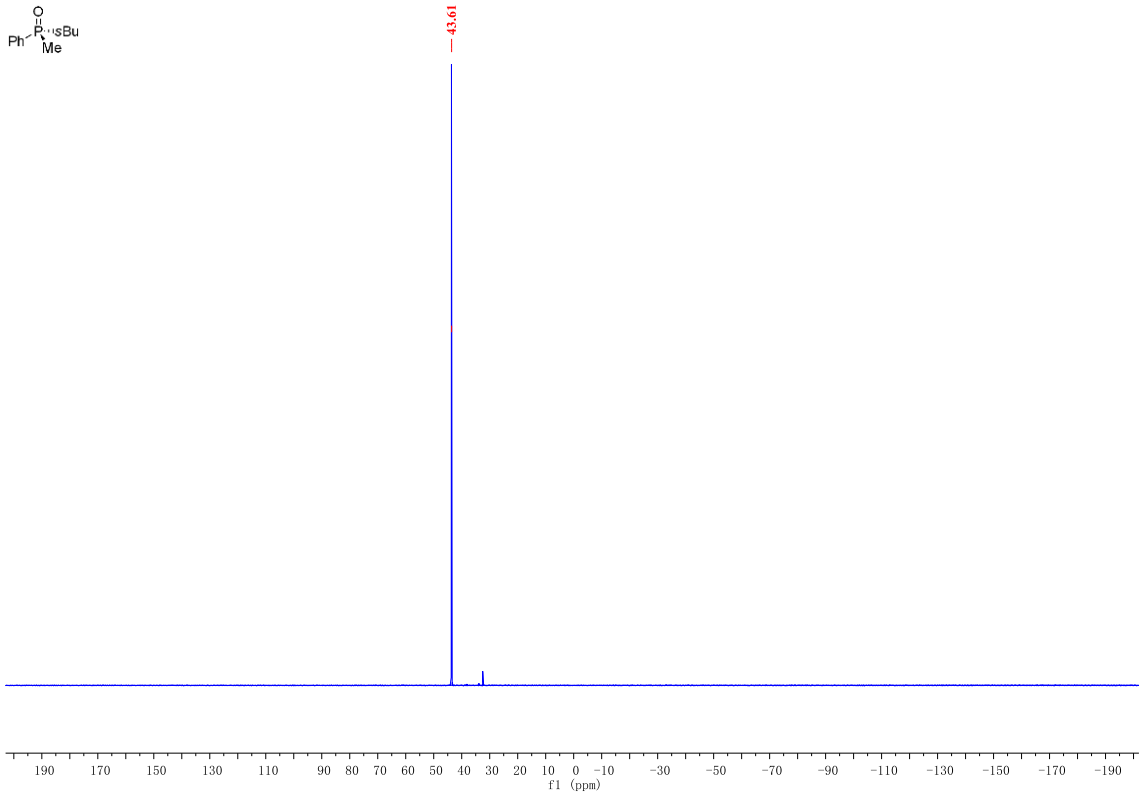

Ph
P
O
nBu
Me
7.67 7.66 7.65 7.65 7.64 7.63 7.63 7.46 7.46 7.45 7.44 7.44 7.43 7.42 7.42 7.41 7.40
1.91 1.90 1.88 1.87 1.86 1.86 1.85 1.85 1.84 1.83 1.82 1.81 1.65 1.62 1.53 1.51 1.41 1.39 1.33 1.32 1.30 1.29 0.82 0.80
1.98 2.94 2.03 3.00 2.03 2.00 2.99
f1 (ppm)

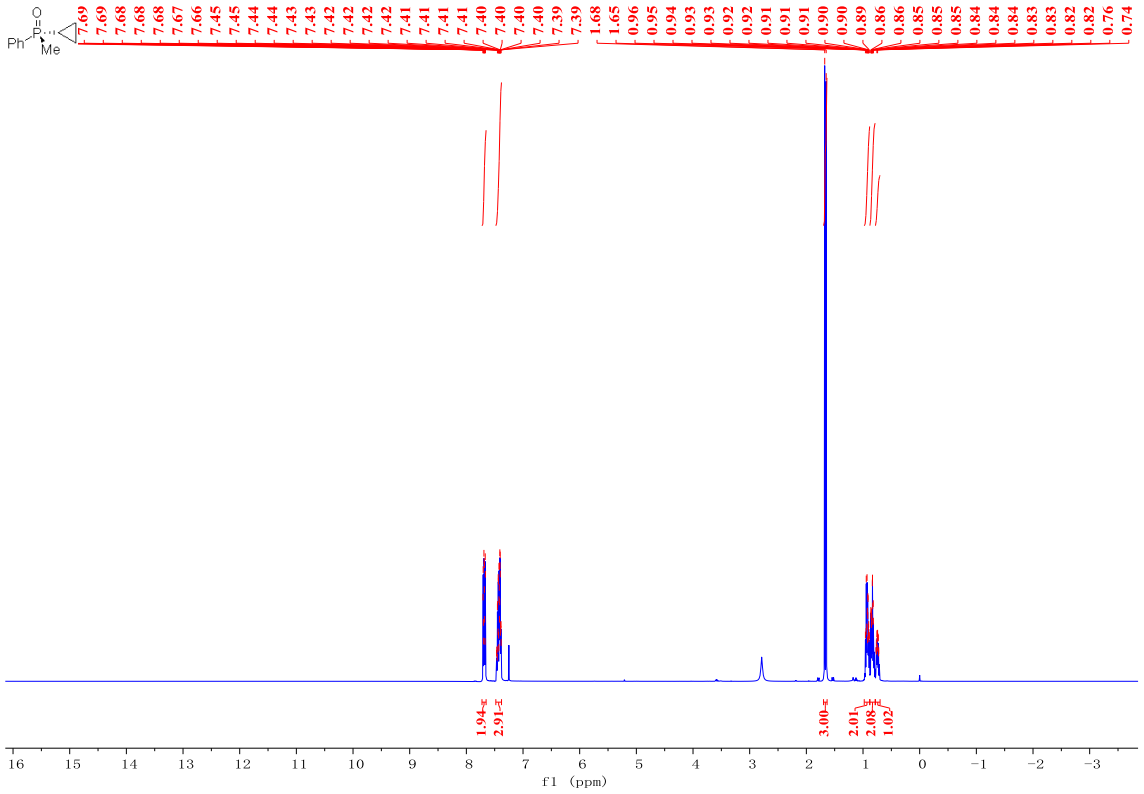

Ph
P
O
nBu
Me
134.03 133.27 131.54 130.00 129.93 128.67 128.58
31.74 31.17 24.04 23.91 23.64 23.61 16.27 15.72 13.55
f1 (ppm)

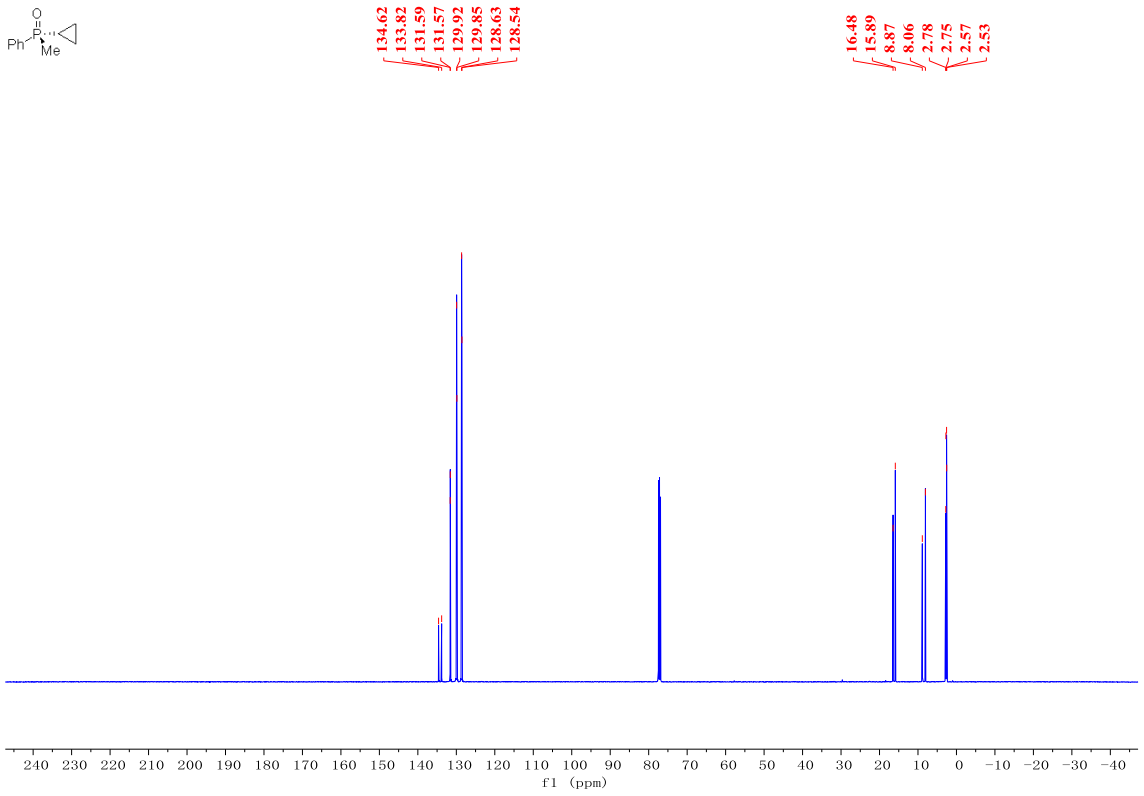

Ph
P
nBu
Me
38.18
f1 (ppm)

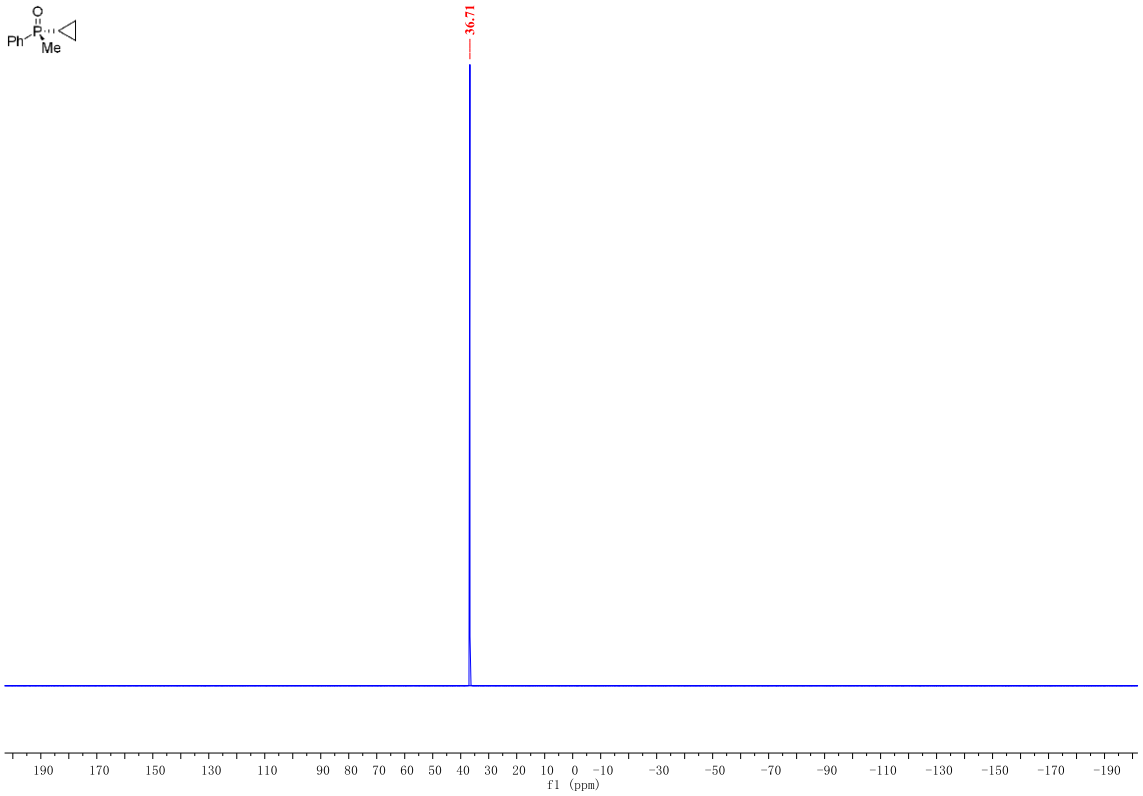

Ph
P
sBu
Me
7.70 7.69 7.69 7.69 7.68 7.68 7.68 7.68 7.67 7.67 7.67 7.67 7.66 7.53 7.53 7.52 7.51 7.50 7.50 7.49 7.48 7.47 7.47 7.46 7.45
1.78 1.77 1.77 1.76 1.75 1.75 1.74 1.73 1.72 1.71 1.69 1.68 1.66 1.31 1.30 1.28 1.27 1.20 1.18 1.17 1.15 1.07 1.05 1.03 1.02 1.01 0.99 0.98 0.92 0.91 0.90
1.74
2.68
1.58
3.00
1.21
1.52
2.60
1.47
f1 (ppm)

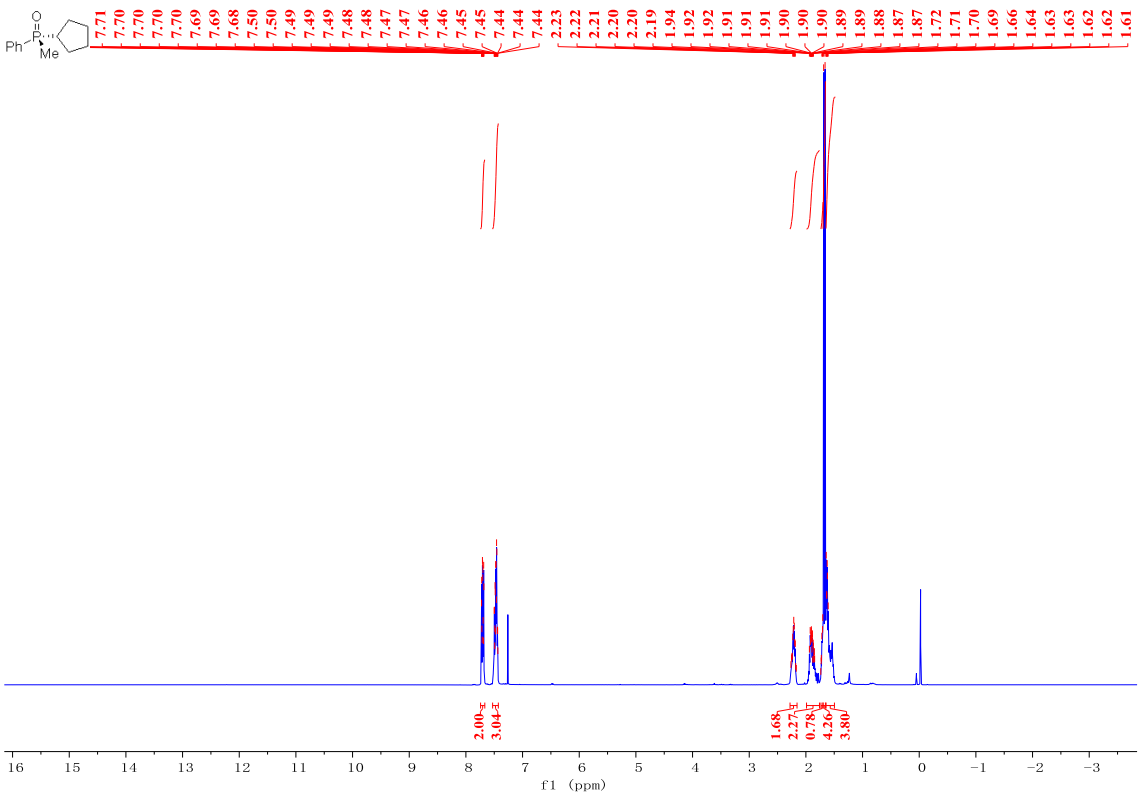

Ph
P
O
sBu
Me
133.36
133.19
132.62
132.45
131.52
130.55
130.49
130.43
128.58
128.50
128.48
36.68
36.65
36.12
36.09
22.27
22.12
13.55
13.40
13.02
12.86
12.33
12.30
12.23
12.19
11.77
11.67
f1 (ppm)

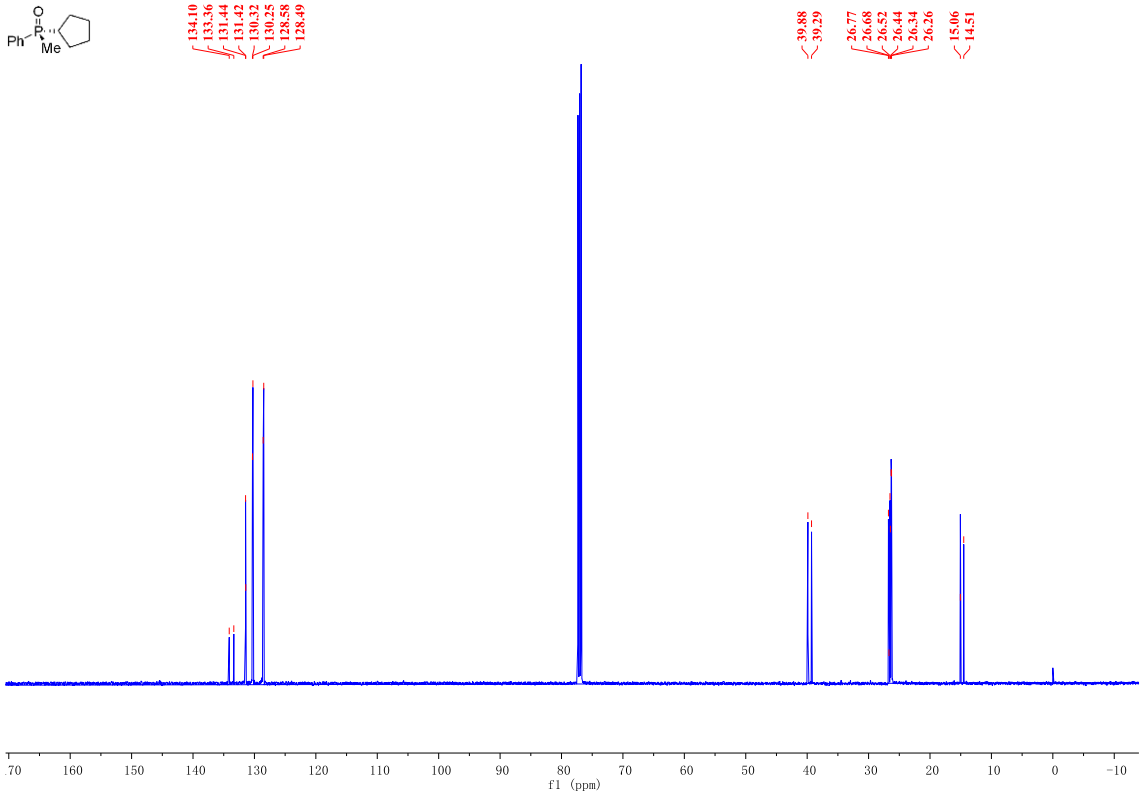

Ph
P
O
sBu
Me
43.61
f1 (ppm)

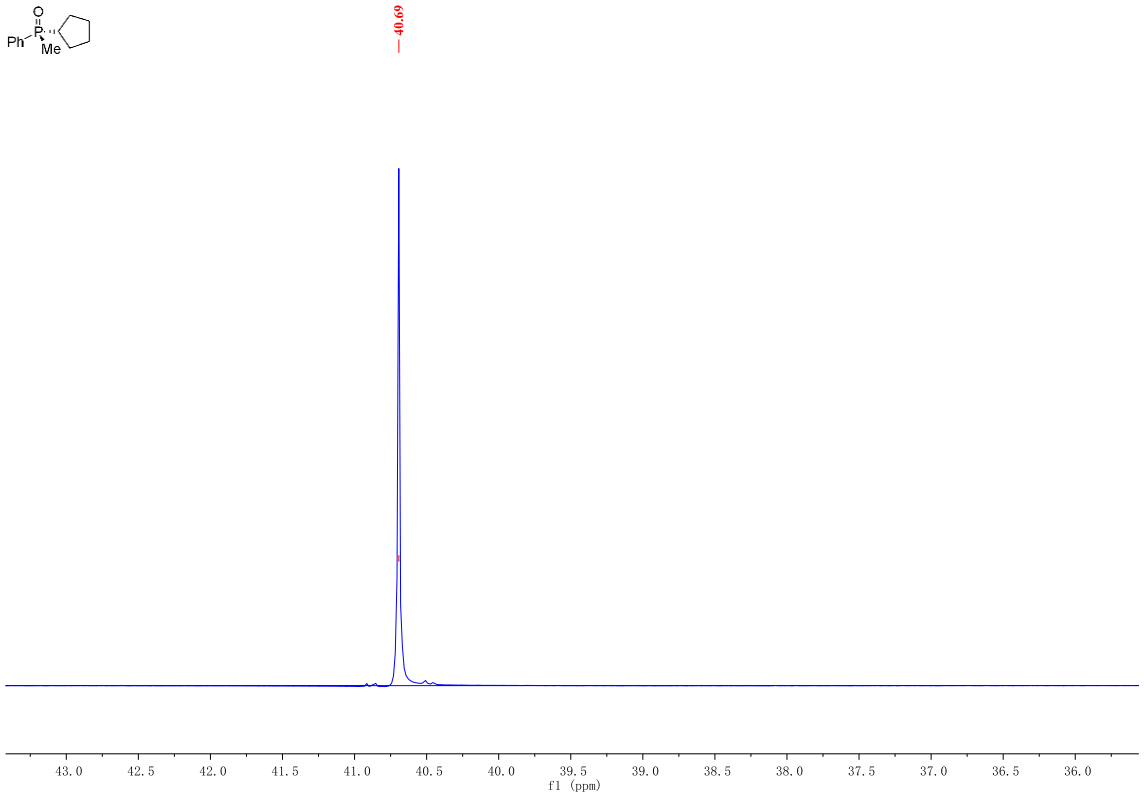

7.69 7.69 7.68 7.68 7.68 7.67 7.66 7.45 7.45 7.44 7.44 7.43 7.43 7.42 7.42 7.42 7.42 7.41 7.41 7.41 7.41 7.40 7.40 7.40 7.40 7.39 7.39 1.68 1.65 0.96 0.95 0.94 0.93 0.93 0.92 0.92 0.91 0.91 0.91 0.90 0.90 0.89 0.86 0.86 0.85 0.85 0.85 0.84 0.84 0.84 0.83 0.83 0.82 0.82 0.76 0.74
1.94 2.91 3.00 2.01 2.08 1.02
f1 (ppm)

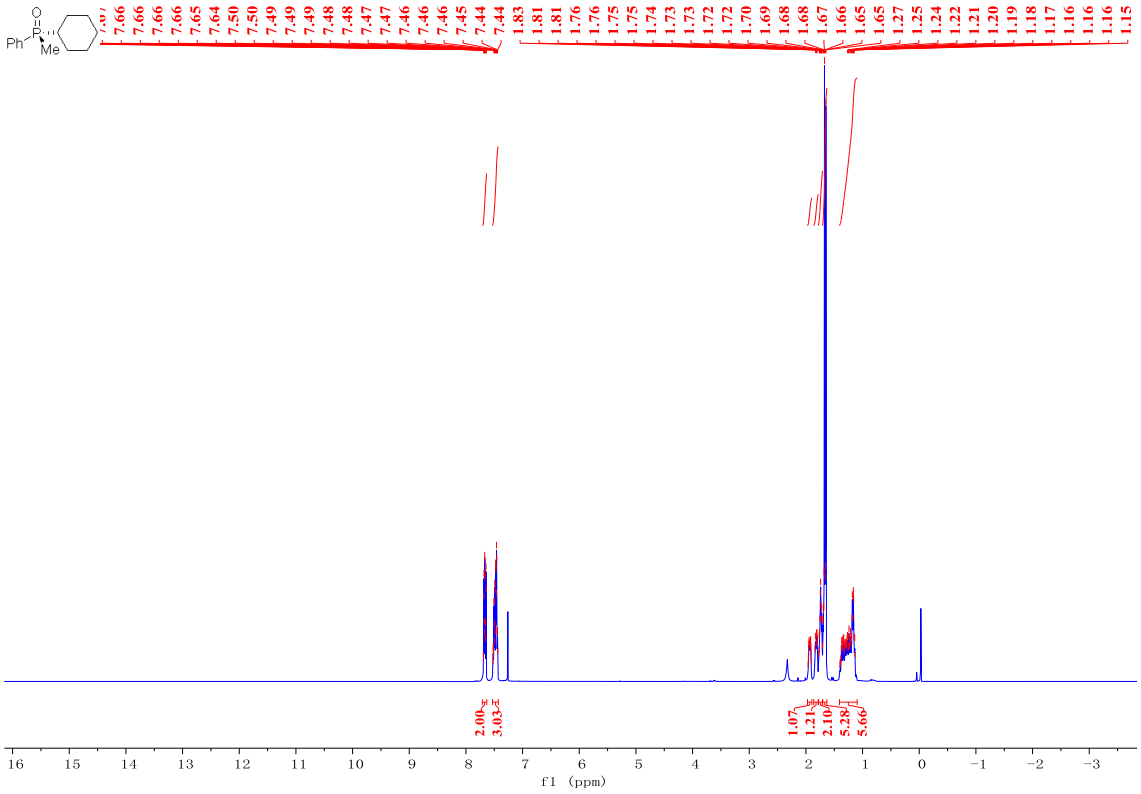

134.62 133.82 131.59 131.57 129.92 129.85 128.63 128.54
16.48 15.89 8.87 8.06 2.78 2.75 2.57 2.53
f1 (ppm)

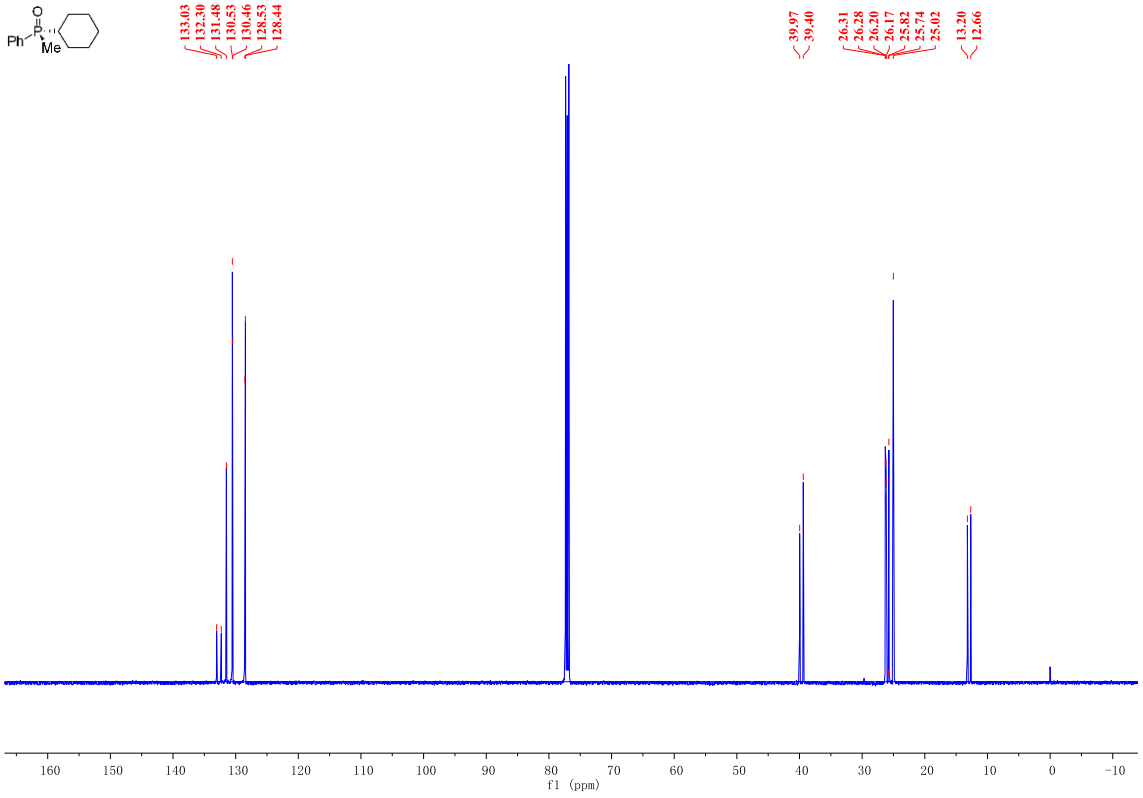

Ph
P
O
Me
36.71
190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190
f1 (ppm)

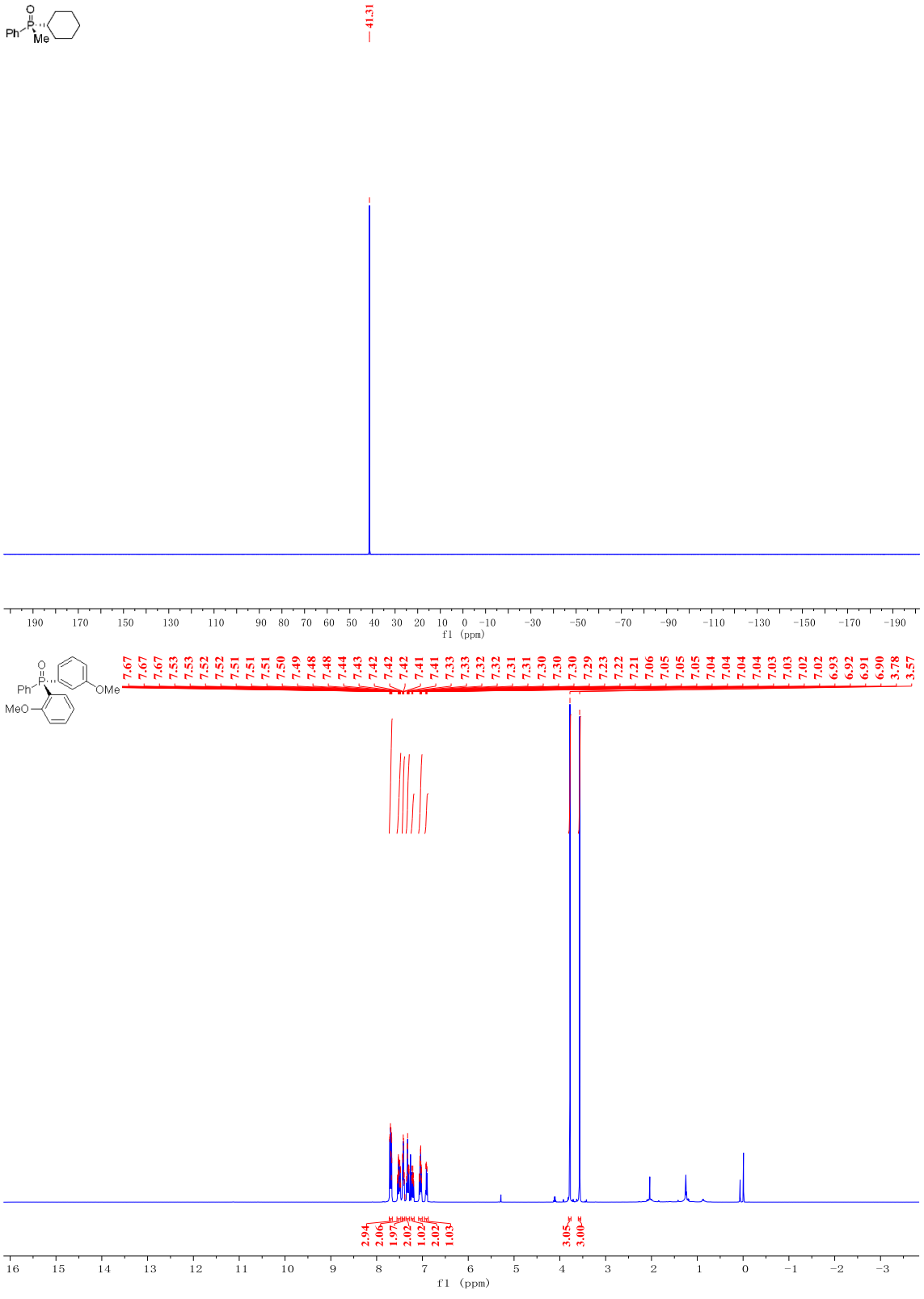

Ph
P
O
Me
7.71 7.70 7.70 7.70 7.70 7.69 7.69 7.68 7.50 7.50 7.49 7.49 7.49 7.48 7.48 7.47 7.47 7.46 7.46 7.45 7.45 7.44 7.44 7.44
2.23 2.22 2.21 2.20 2.20 2.19 1.94 1.92 1.92 1.91 1.91 1.91 1.90 1.90 1.90 1.89 1.89 1.88 1.87 1.87 1.72 1.71 1.70 1.69 1.66 1.64 1.63 1.63 1.62 1.62 1.61
2.00
3.04
1.68
2.27
0.78
4.26
3.80
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

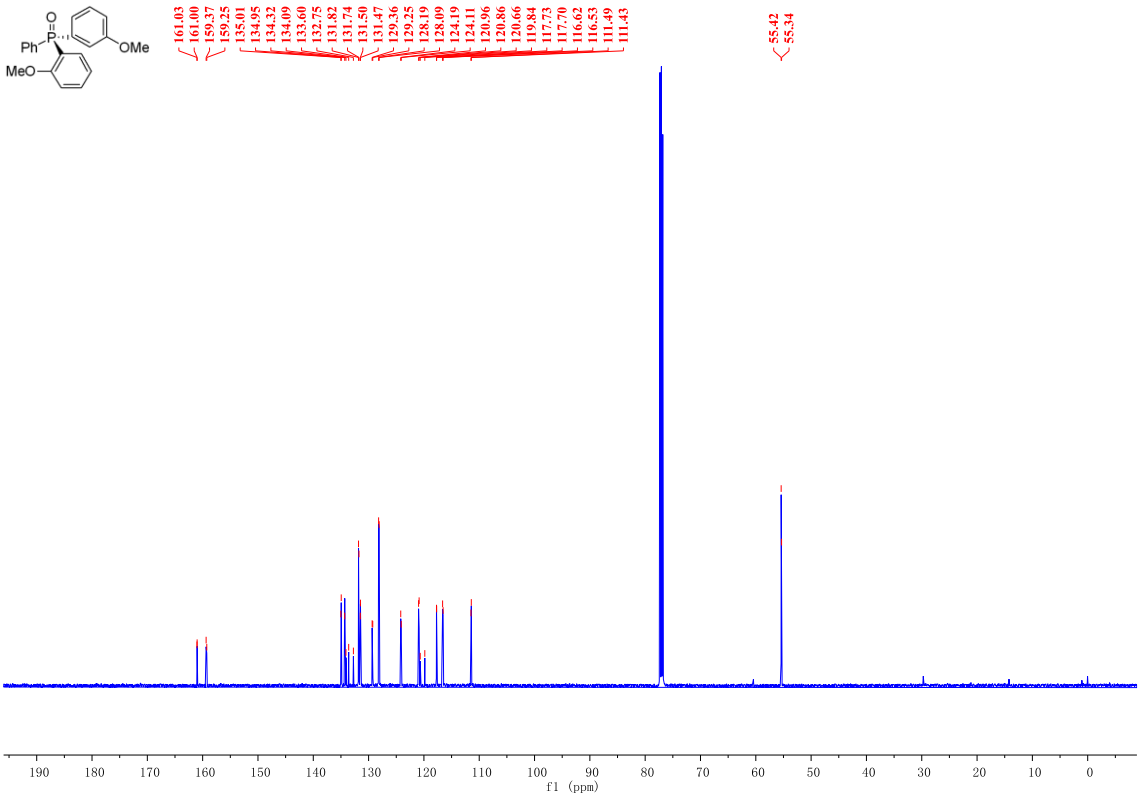

Ph
O
P
Me
134.10
133.36
131.44
131.42
130.32
130.25
128.58
128.49
39.88
39.29
26.77
26.68
26.52
26.44
26.34
26.26
15.06
14.51
f1 (ppm)

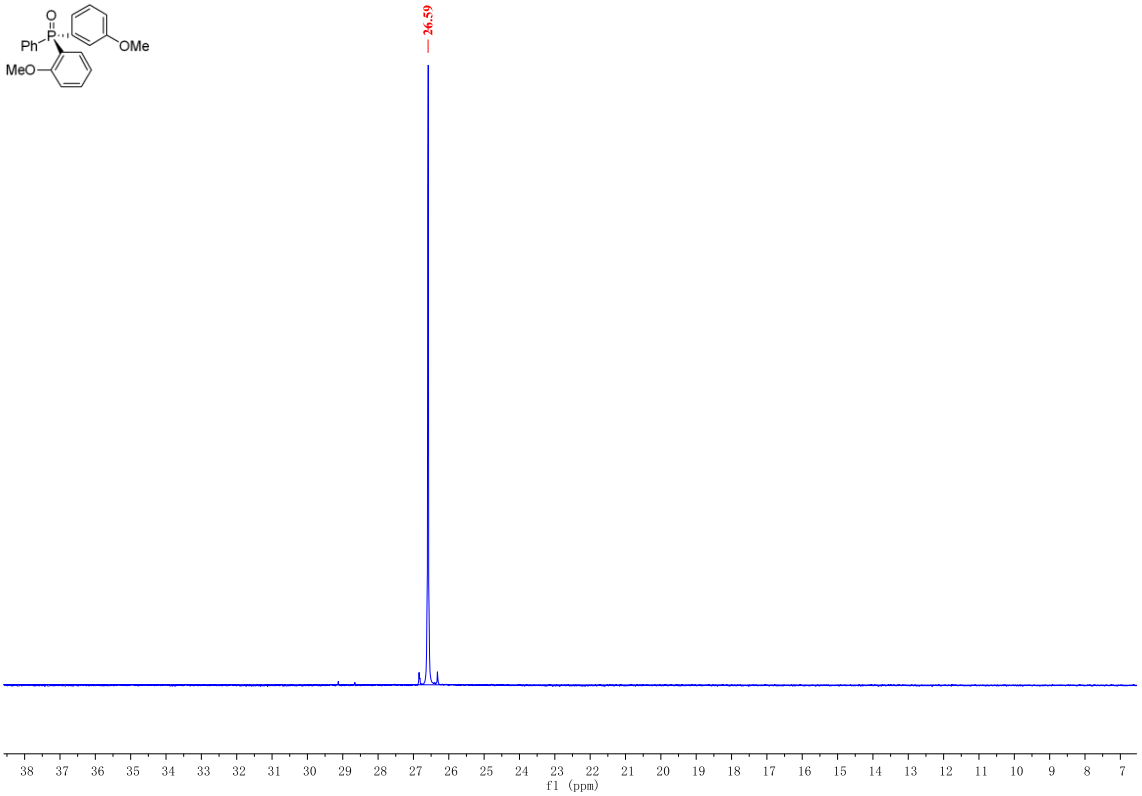

Ph
O
P
Me
40.69
f1 (ppm)

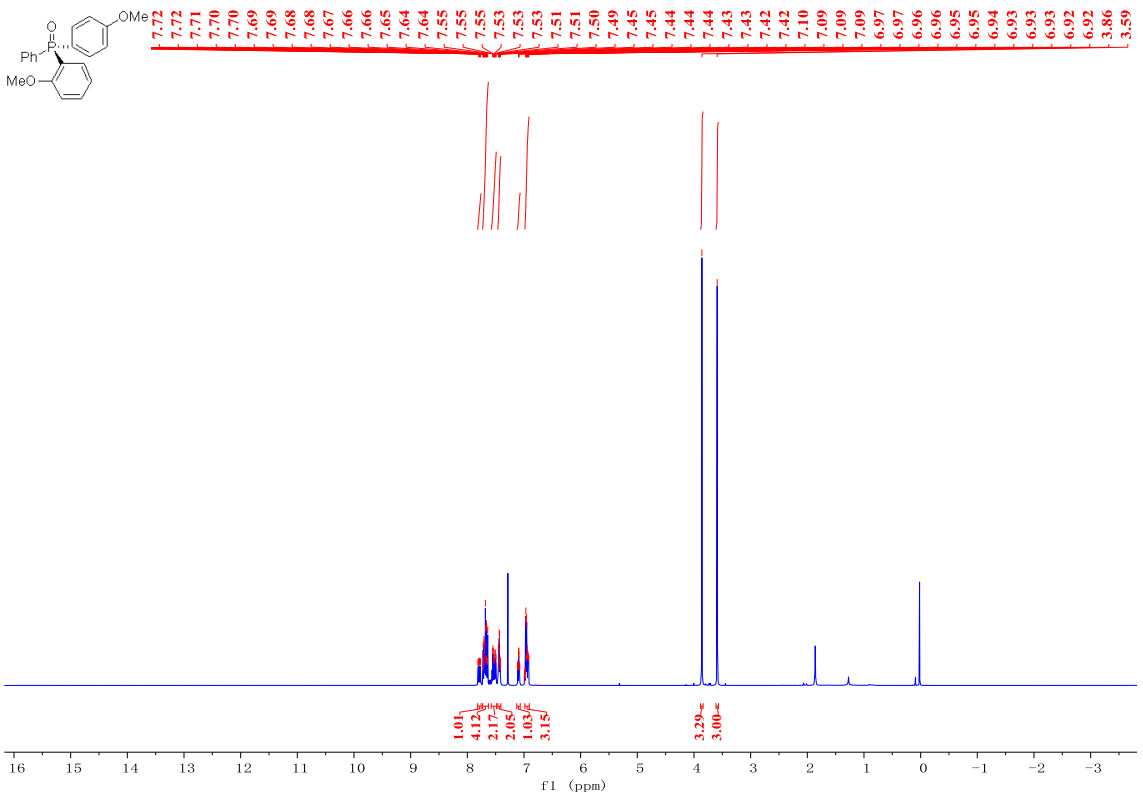

Ph
P
O
Me
7.66 7.66 7.66 7.66 7.65 7.64 7.50 7.50 7.49 7.49 7.49 7.48 7.48 7.47 7.47 7.46 7.46 7.46 7.45 7.44 7.44
1.83 1.81 1.81 1.76 1.76 1.75 1.75 1.74 1.73 1.73 1.72 1.72 1.70 1.69 1.68 1.68 1.67 1.66 1.65 1.65 1.27 1.25 1.24 1.22 1.21 1.20 1.19 1.18 1.17 1.16 1.16 1.16 1.15
2.00
3.03
1.07
1.21
2.10
5.28
5.66
f1 (ppm)

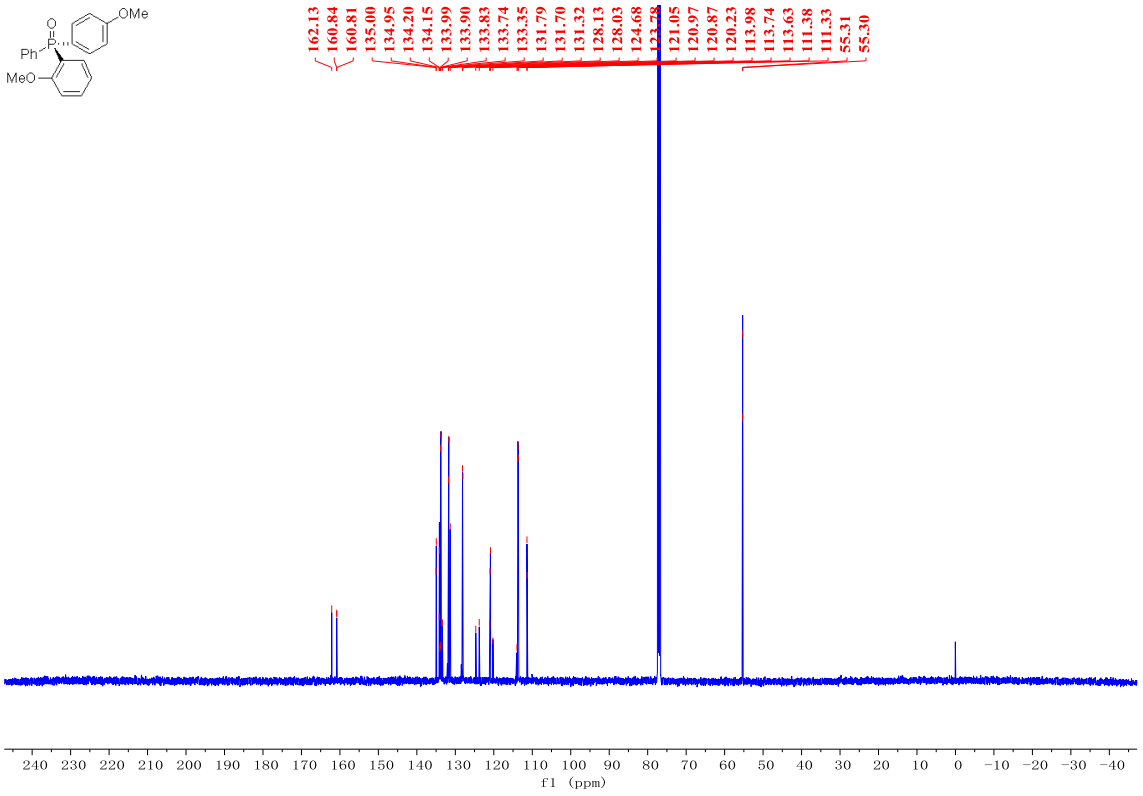

Ph
P
O
Me
133.03 132.30 131.48 130.53 130.46 128.53 128.44
39.97 39.40 26.31 26.28 26.20 26.17 25.82 25.74 25.02 13.20 12.66
f1 (ppm)

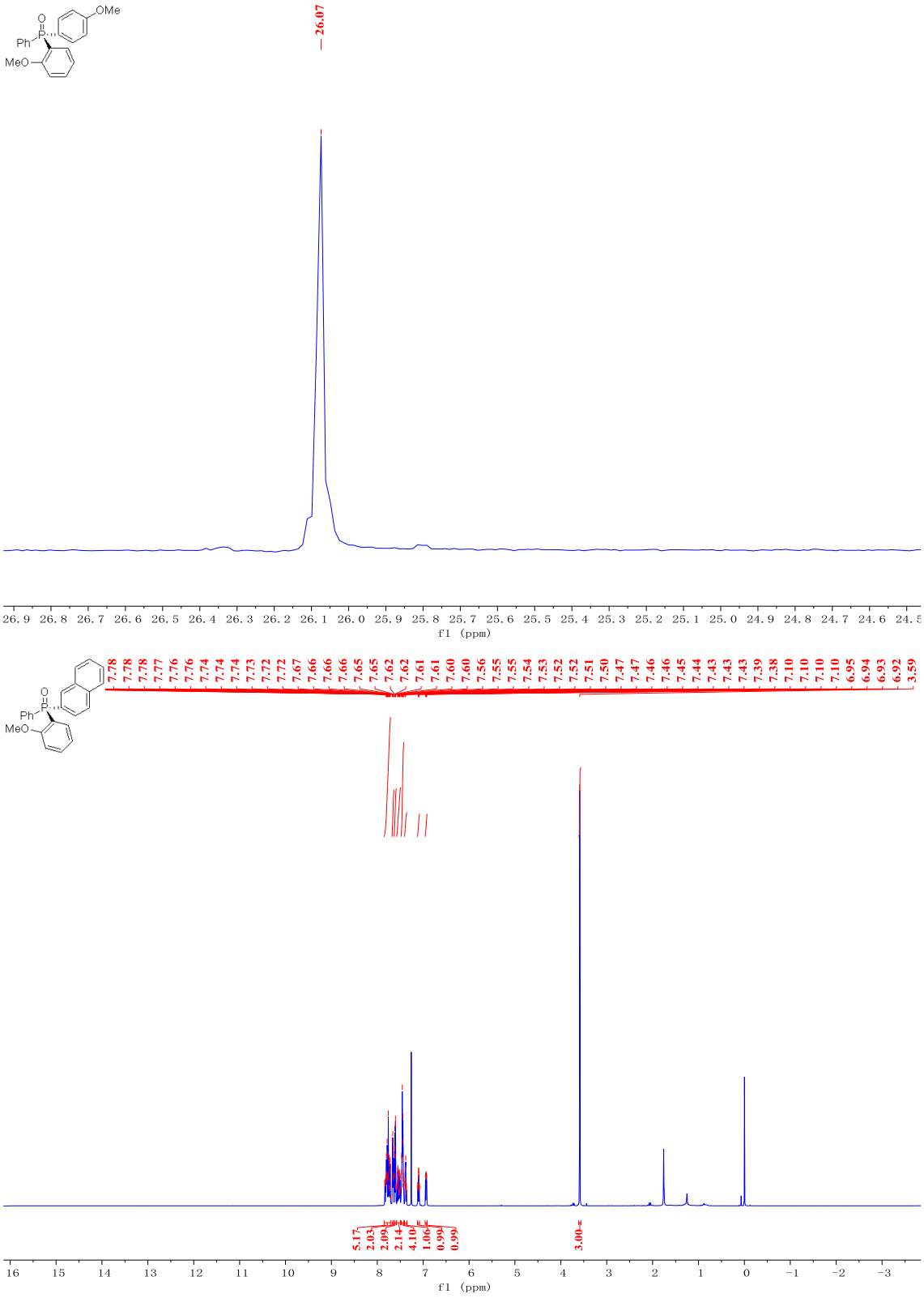

Ph
Me
41.31
f1 (ppm)
MeO
OMe
7.67 7.67 7.67 7.53 7.53 7.52 7.52 7.51 7.51 7.51 7.50 7.49 7.48 7.48 7.44 7.43 7.42 7.42 7.42 7.41 7.41 7.33 7.33 7.32 7.32 7.31 7.31 7.30 7.30 7.30 7.29 7.23 7.22 7.21 7.06 7.05 7.05 7.05 7.04 7.04 7.04 7.04 7.03 7.03 7.02 7.02 6.93 6.92 6.91 6.90 3.78 3.57
2.94 2.06 1.97 2.02 1.02 2.02 1.03 3.05 3.00
f1 (ppm)


Ph
MeO
OMe
161.03
161.00
159.37
159.25
135.01
134.95
134.32
134.09
133.60
132.75
131.82
131.74
131.50
131.47
129.36
129.25
128.19
128.09
124.19
124.11
120.96
120.86
120.66
119.84
117.73
117.70
116.62
116.53
111.49
111.43
55.42
55.34
f1 (ppm)


Ph
MeO
OMe
26.59
f1 (ppm)


OMe
Ph
MeO
7.72 7.72 7.71 7.70 7.70 7.69 7.69 7.68 7.68 7.67 7.66 7.66 7.65 7.64 7.64 7.55 7.55 7.55 7.53 7.53 7.53 7.51 7.51 7.50 7.49 7.45 7.45 7.44 7.44 7.44 7.43 7.43 7.42 7.42 7.10 7.09 7.09 7.09 6.97 6.97 6.96 6.96 6.95 6.95 6.94 6.93 6.93 6.93 6.92 6.92 3.86 3.59
1.01 4.12 2.17 2.05 1.03 3.15
3.29 3.00
f1 (ppm)


OMe
Ph
MeO
162.13 160.84 160.81 135.00 134.95 134.20 134.15 133.99 133.90 133.83 133.74 133.35 131.79 131.70 131.32 128.13 128.03 124.68 123.78 121.05 120.97 120.87 120.23 113.98 113.74 113.63 111.38 111.33 55.31 55.30
f1 (ppm)


OMe
Ph
MeO
26.07
f1 (ppm)
7.78
7.78
7.78
7.77
7.76
7.76
7.74
7.74
7.74
7.73
7.72
7.72
7.67
7.66
7.66
7.66
7.65
7.65
7.62
7.62
7.61
7.61
7.60
7.60
7.56
7.55
7.55
7.54
7.53
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7.50
7.47
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7.46
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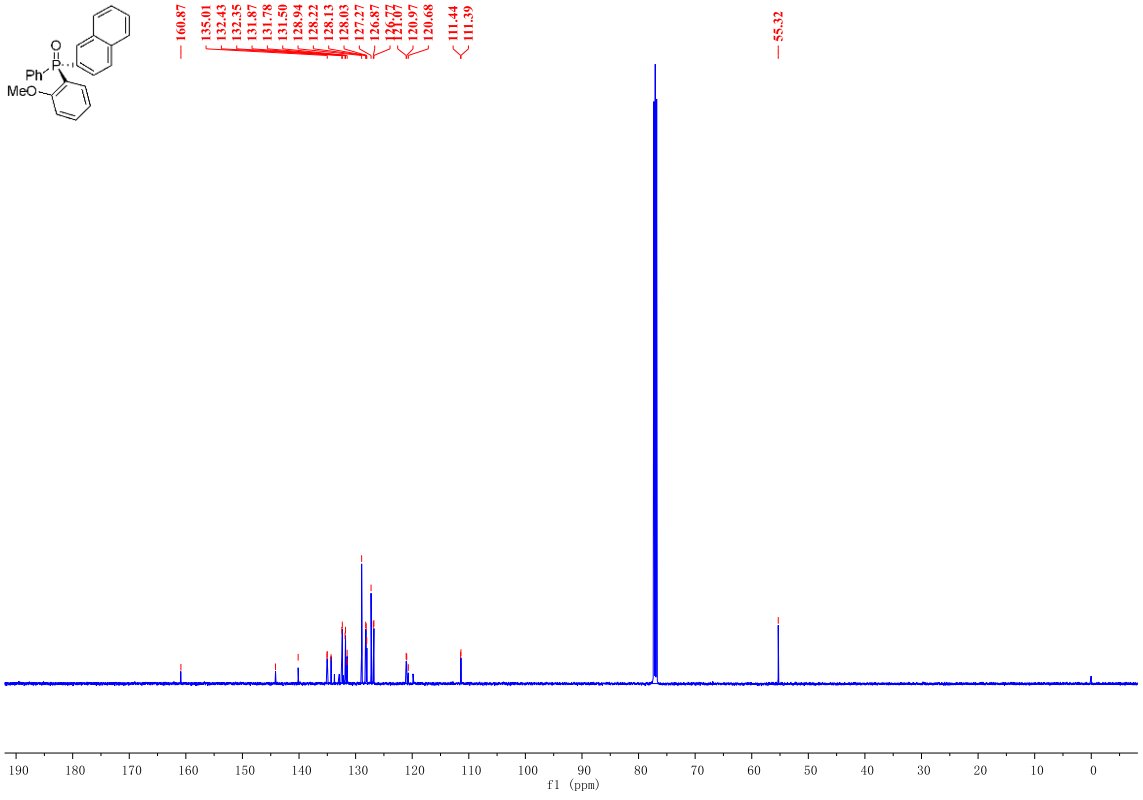
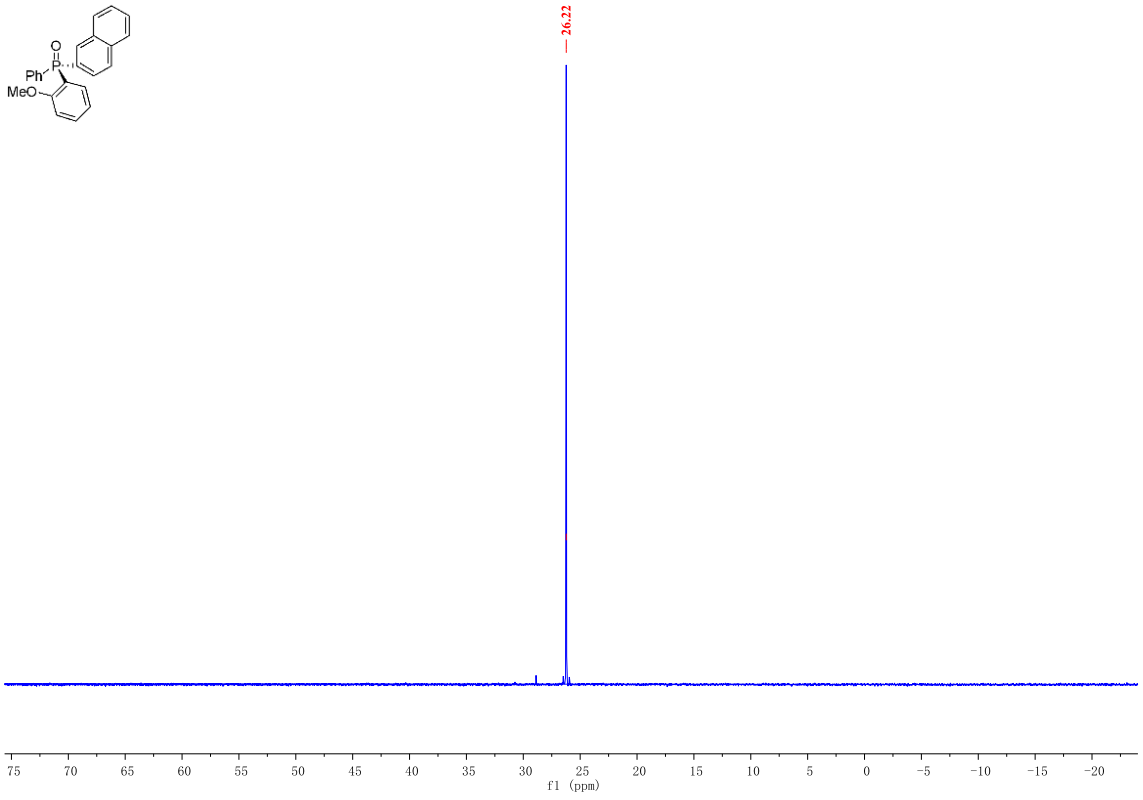
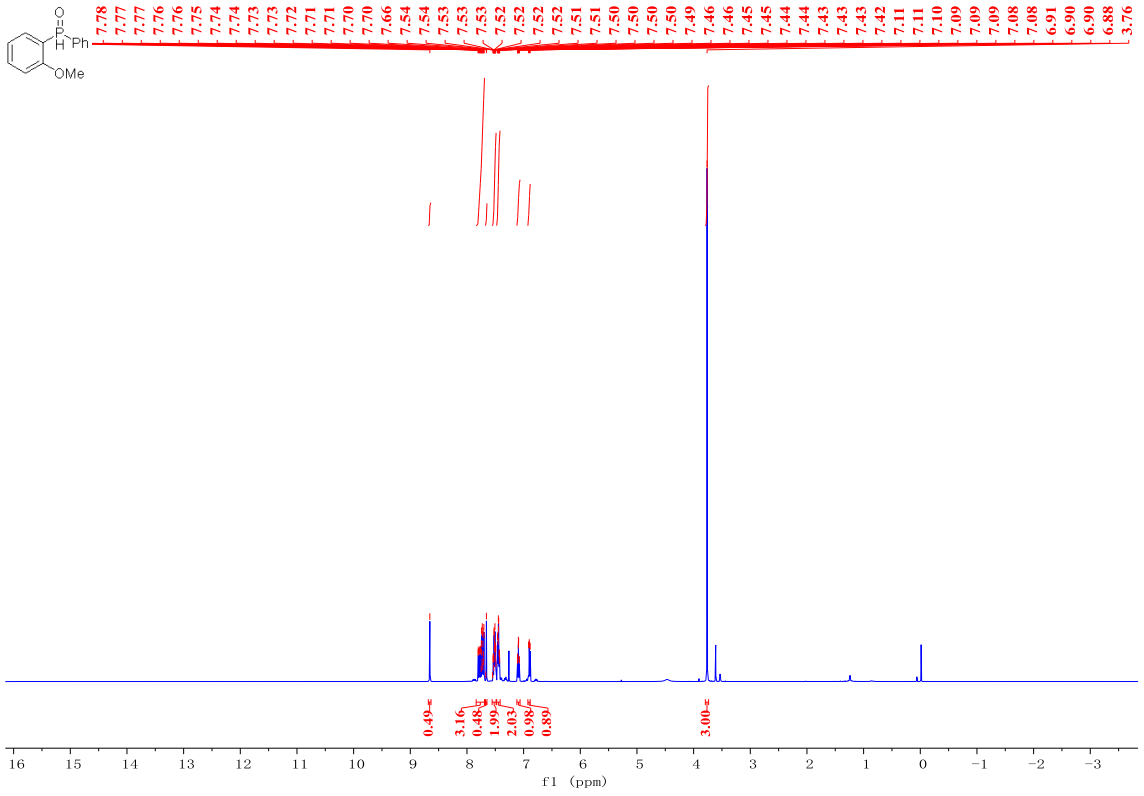
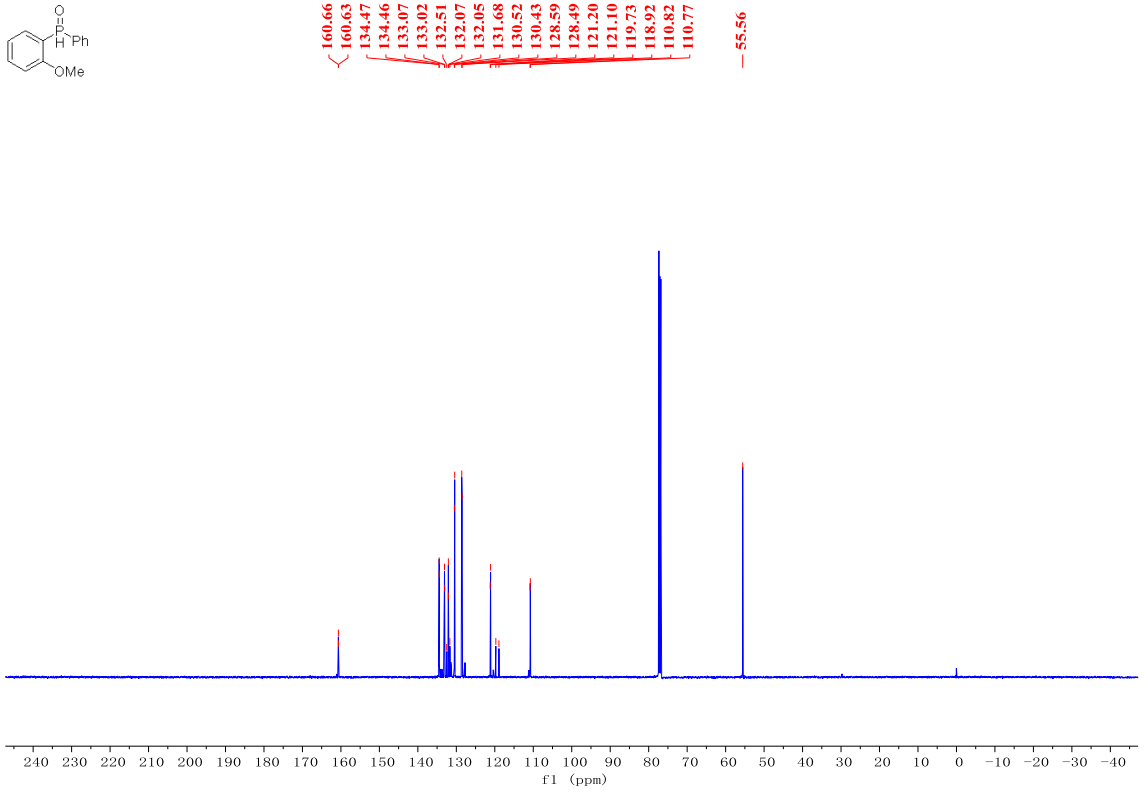
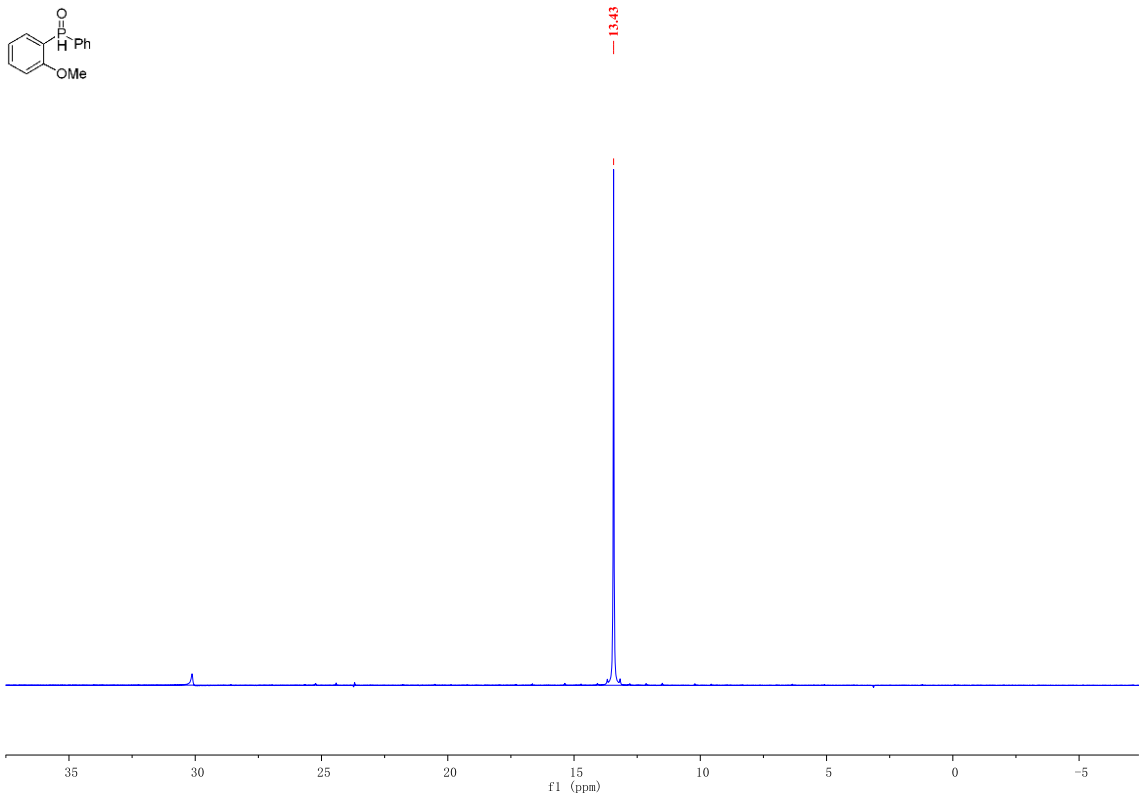
7.45
7.44
7.43
7.43
7.43
7.39
7.38
7.10
7.10
7.10
7.10
6.95
6.94
6.93
6.92
3.59
5.17
2.03
2.09
2.14
4.10
1.06
0.99
0.99
3.00
f1 (ppm)


O
Ph
MeO
160.87
135.01
132.43
132.35
131.87
131.78
131.50
128.94
128.22
128.13
128.03
127.27
126.87
126.72
121.07
120.97
120.68
111.44
111.39
55.32
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


O
Ph
MeO
26.22
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20
f1 (ppm)


7.78 7.77 7.77 7.76 7.76 7.75 7.74 7.74 7.73 7.73 7.72 7.71 7.71 7.70 7.70 7.66 7.54 7.54 7.53 7.53 7.53 7.52 7.52 7.52 7.52 7.51 7.51 7.50 7.50 7.50 7.50 7.49 7.46 7.46 7.45 7.45 7.44 7.44 7.43 7.43 7.43 7.42 7.11 7.11 7.10 7.09 7.09 7.09 7.08 7.08 6.91 6.90 6.90 6.88 3.76
Ph
OMe
0.49 3.16 0.48 1.99 2.03 0.98 0.89 3.00
f1 (ppm)


160.66 160.63 134.47 134.46 133.07 133.02 132.51 132.07 132.05 131.68 130.52 130.43 128.59 128.49 121.20 121.10 119.73 118.92 110.82 110.77 55.56
Ph
OMe
f1 (ppm)


O
P
H
Ph
OMe
13.43
35
30
25
20
15
10
5
0
-5
f1 (ppm)