Supplementary Information (SI) for ChemComm.
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Diastereoselective C(sp^3)–H Acetoxylation of Phosphoramidites

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Supporting Information

General information and instrumentation

Unless otherwise specified, all reagents were obtained from commercial sources and used without further purification. Dry solvents were obtained using a MBraun SPS 800 system and stored under N_2. For the C–H functionalisation reactions, dry DCE, AcOH, AC_2O, trifluoroacetic acid (TFA), trifluoroacetic anhydride (TFAA) and propionic acid were degassed through the freeze-pump-thaw method (4-6 cycles) and stored in a glovebox.

All reactions were carried out under N_2 atmosphere in oven-dried or heat gun-dried glassware with magnetic stirring. When specified, reactions were monitored by analytical thin layer chromatography on silica-coated aluminum plates (silica gel 60 F254 Merck) and components were visualized by UV light and $KMnO_4$ staining (1.5 g $KMnO_4$, 10 g K_2CO_3, 1.25 mL 10% NaOH, 200 mL H_2O). Flash column chromatography was performed on silica gel 60 (Merck, 230-400 mesh). Celite® 521 was used as filtering agent.

^{1}H-NMR, ^{13}C-NMR and ^{31}P{^{1}H}-NMR experiments were carried out using Varian AMX400, Varian Oxford AS 500 MHz and Bruker Innova 600 MHz spectrometers. Chemical shift values are reported in ppm with the residual solvent resonances as the internal standards. Coupling constants (*J*) are given in Hertz (Hz). Multiplicities are reported as follows: s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, m = multiplet, hep = heptet or as a combination of them.

High Resolution Mass spectrometry (HRMS) analysis was carried out using a LTQ Orbitrap XL (ESI+, ESI-).

X-ray diffraction analysis was performed Bruker APEX-II CCD diffractometer. The crystal was kept at 100.0 K during data collection. See below for further details.

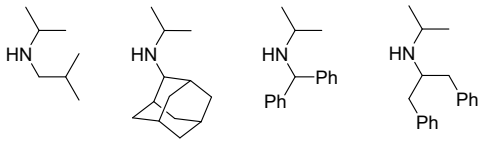
Purchased chemicals

The following chemicals were purchased at the corresponding supplier and used without further treatment:

(*R*)-BINOL (*Fluorochem*), *N*,*N*-diisopropylamine (*Fluorochem*), *N*-isopropylpentan-3-amine (*Fluorochem*), *N*-isopropylcyclohexylamine (*Fluorochem*), *N*-isopropylcycloheptanamine hydrochloride (*Fluorochem*), *N*-isopropylmethylamine (*Sigma Aldrich*), *N*-*tert*-butylisopropylamine (*Sigma Aldrich*), *N*-isopropylaniline (*Alfa Aesar* by *Thermo Fisher Scientific*), *N*-isopropyl-2-methyl-1-propanamine hydrochloride (*Sigma Aldrich*), palladium acetate (*Sigma Aldrich*), silver acetate (*Sigma Aldrich*), phenyl iododiacetate (*Sigma Aldrich*).

Compounds prepared following literature procedures

Amine **S1**[1], **S2**[1], **S3**[1] and **S4**[1,2] were prepared following previously described procedures.



S1 **S2** **S3** **S4**

S2: **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.90 (hep, *J* = 6.2 Hz, 1H), 2.78 (s, 1H), 1.92 – 1.65 (m, 12H), 1.61 – 1.46 (m, 3H), 1.04 (d, *J* = 6.3 Hz, 6H).

S3: **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.49 – 7.17 (m, 10H), 5.01 (s, 1H), 2.80 (hep, *J* = 6.3 Hz, 1H), 1.91 (s, 1H), 1.13 (d, *J* = 6.3 Hz, 6H).

S4: **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.33 – 7.25 (m, 4H), 7.24 – 7.14 (m, 6H), 3.11 (p, *J* = 6.6 Hz, 1H), 2.81 (h, *J* = 6.3 Hz, 1H), 2.68 (d, *J* = 6.6 Hz, 4H), 0.90 (d, *J* = 6.2 Hz, 6H).

Optimisation

General procedure

[1] a) N. Mistry, S. P. Fletcher, *Adv. Synth. Catal.* **2016**, *358*, 2489-2496; b) R. Ardkhean, P. M. C. Roth, R. M. Maksymowicz, A. Curran Q. Peng, R. S. Paton, S. P. Fletcher, *ACS Catal.* **2017**, *7*, 6729-6737.

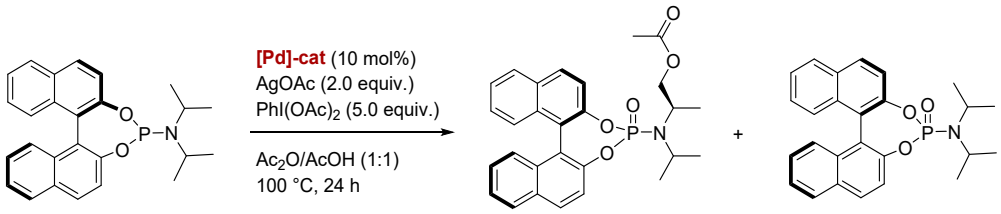
[2] Y.-X. Wang, F.-P. Zhang, H. Chen, Y. Li, J.-F. Li, M. Ye*, Angew. Chem. Int. Ed.* **2022**, *61*, e202209625.

In an oven-dried reaction tube, the phosphoramidite (*R*)-**1a** (0.1 mmol, 1.0 equiv.), appropriate amounts of specified catalyst, oxidant and additives were added and taken into the glove box. Deoxygenated solvent or solvent mixtures were added via a syringe. The reaction vessel was taken out of the glovebox and the mixture stirred at specified temperature for 24 h, cooled to room temperature and concentrated in vacuum. The internal standard, 1,3,5-trimethoxybenzene was added to the crude reaction material, which was subsequently dissolved in $CDCl_3$ (0.6 mL) and submitted for analysis.

Conversion was determined by GC-MS analysis. NMR yield was determined by introducing an internal standard (1,3,5-trimethoxybenzene). *d.r.* was determined by ^{31}P-NMR of the crude reaction mixture.

NOTE: Deoxygenated solvents and co-solvents were used to prevent pre-oxidation of the starting material, as the phosphoramidites were observed to undergo gradual oxidation when exposed to air in these solvents.

Table S1. Catalyst screening[a]

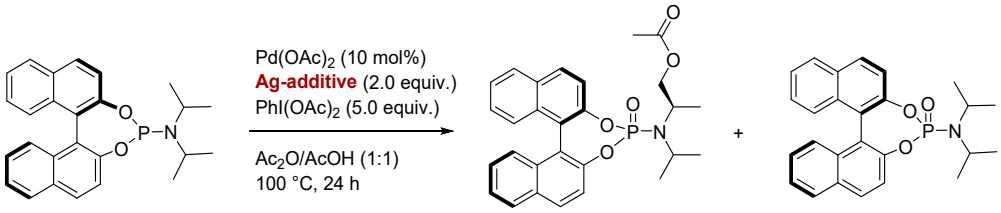


(*R*)-**1a** (*R*,*R*)-**2a** (*R*)-**1a-O**

Entry	[Pd]-catalyst (10 mol%)	Conversion to (*R*,*R*)-**2a** (%)[b]	*d.r.*[c]
1[d]	$Pd(OAc)_2$	<10	88:12
2	$Pd(OAc)_2$	26	88:12
3	$Pd(OPiv)_2$	N.R	-
4	$Pd_2(dba)_3$	<10	88:12
5	$PdCl_2$	N.R	-
6	$PdCl_2(CH_3CN)_2$	19	88:12
7	**$Pd(OAc)_2$ (15 mol%)**	**38**	**89:11**

[a] General procedure for optimization used: the indicated catalyst (10 mol% unless stated otherwise). [b] Determined by GC-MS analysis. [c] *d.r.* was determined by ^{31}P-NMR analysis of the crude reaction mixture. [d] No AgOAc was added.

Table S2. Ag-additive screening[a]

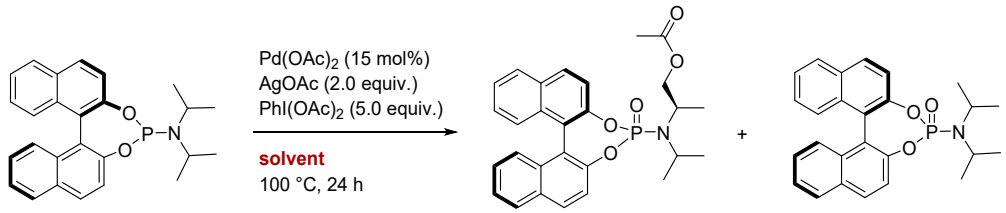


(*R*)-**1a** (*R*,*R*)-**2a** (*R*)-**1a-O**

Entry	Ag-additive (2.0 equiv.)	Conversion to (*R*,*R*)-**2a** (%)[b]	*d.r.*[c]
1	**AgOAc**	**26**	**88:12**
2	Ag_2CO_3	25	89:11
3	AgF	<10	-
4	AgTFA	<10	-
5	Ag_2O	<10	-
6	$AgSbF_6$	<10	-

[a] General procedure for optimization stated in section 6.8. [b] Determined by GC-MS analysis. [c] *d.r.* was determined by ^{31}P-NMR analysis of the crude reaction mixture.

Table S3. Solvent screening[a]

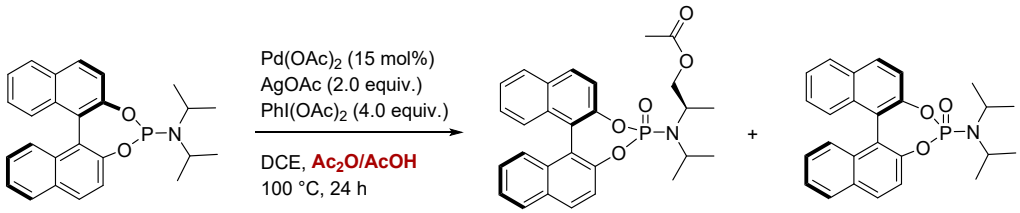


(*R*)-**1** (*R*,*R*)-**2a** (*R*)-**1-O**

Entry	Solvent	Conversion to (*R*,*R*)-**2a** (%)[b]	*d.r.*[c]
1	MeCN	<10	-
2	DCE	<10	-
3	dioxane	N.R	-
4	Ac_2O	<10	-
5	toluene	<10	-
6	HFIP	<10	-
7	PhMe	<10	-
8	AcOH/Ac_2O (1:1)	38	89:11
9	**DCE/AcOH/Ac_2O (4:1:1)**	**44**	**92:8**

[a] General procedure for optimization used. [b] Determined by GC-MS analysis. [c] *d.r.* was determined by ^{31}P-NMR analysis of the crude reaction mixture. [d]

Table S4. Effect of co-solvents[a]

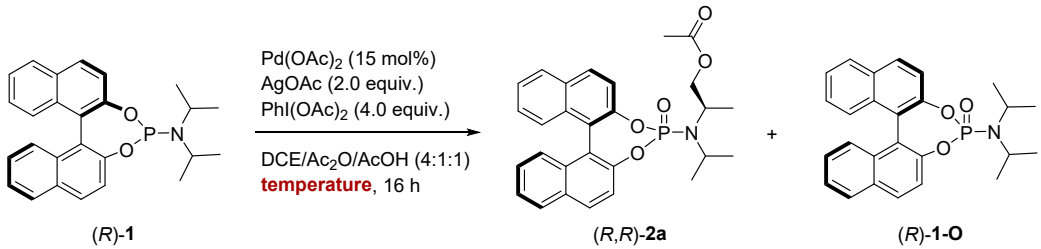


(*R*)-**1** (*R*,*R*)-**2a** (*R*)-**1-O**

Entry	Ac_2O (equiv.)	AcOH (equiv.)	Yield of (*R*,*R*)-**2a** (%)[b]	*d.r.*[c]
1[d]	**55**	**55**	**43**	**91:9**
2	55	-	-	-
3	-	55	27	89:11
4	0.25	0.5	22	90:10
5	0.5	0.5	22	91:9
6	1	1	25	90:10
7	10	10	42	91:9
8	10	10	41	93:7

[a] General procedure for optimization stated in section 6.8. [b] Yield determined by ^{1}H-NMR analysis using 1,3,5-trimethoxybenzene as an internal standard. [c] *d.r.* was determined by ^{31}P-NMR analysis of the crude reaction mixture. [d] Using 55 equiv. as an access of co-solvents comparable to the DCE/Ac_2O/AcOH-mixture (4:1:1).

Table S5. Screening of reaction temperature[a]

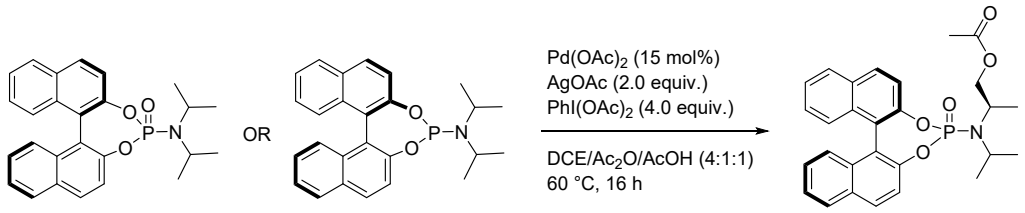


(*R*)-**1** (*R*,*R*)-**2a** (*R*)-**1-O**

Entry	Reaction temperature [°C]	Yield of (*R*,*R*)-**2a** (%)[b]	*d.r.*[c]
1	100	44	92:8
2	70	41	92:8
3	**60**	**56**	**92:8**
4	50	39	92:8

[a] General procedure for optimization used. [b] Yield determined by ^{1}H-NMR analysis using 1,3,5-trimethoxybenzene as an internal standard. [c] *d.r.* was determined by ^{31}P-NMR analysis of the crude reaction mixture.

Table S6. Control experiments for the developed C(sp^3)–H functionalization[a]

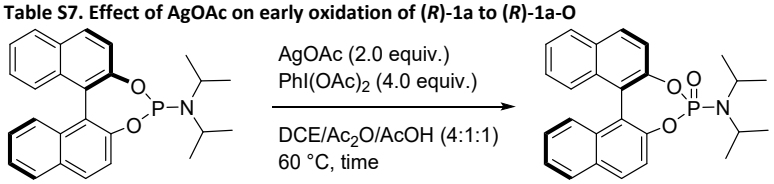


(*R*)-**1-O** (*R*)-**1** (*R*,*R*)-**2a**

Entry	Starting material	$Pd(OAc)_2$	AgOAc	Yield of (*R*,*R*)-**2a** [%][b]	*d.r.*[c]
1	(*R*)-**1a-O**	15 mol%	2.0 equiv.	-	-
2	(*R*)-**1a**	-	2.0 equiv.	<5	-
3	(*R*)-**1a**	15 mol%	-	16	84:16

[a] Optimised reaction conditions used with specified deviations. [b] Yield determined by ^{1}H-NMR analysis using 1,3,5-trimethoxybenzene as an internal standard. [c] Determined by ^{31}P-NMR analysis.

Table S7. Effect of AgOAc on early oxidation of (*R*)-1a to (*R*)-1a-O

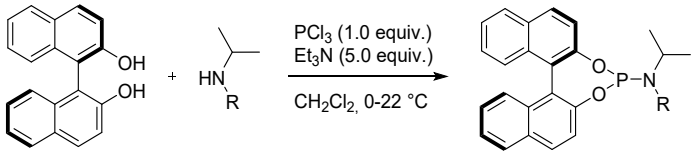


(*R*)-**1** (*R*)-**1-O**

Entry	$PhI(OAc)_2$	AgOAc	Time	Conversion to (*R*)-**1a-O** [%][b]
1	4.0 equiv.	2.0 equiv.	2 h	7
2	4.0 equiv.	-	2 h	100
3	-	2.0 equiv.	2 h	-
4	4.0 equiv.	2.0 equiv.	1 d	74
5	-	2.0 equiv.	1 d	31

[a] Optimised reaction conditions used with specified deviations. [b] Conversion determined by ^{31}P-NMR analysis.

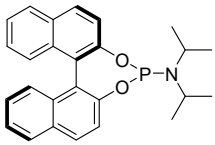
Preparation of phosphoramidites



Scheme S1 Preparation of phosphoramidites

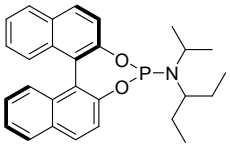
General procedure A (GP A)

All phosphoramidites were synthesized using known literature procedures.[1] For our previous reported procedures see also ref 3[3]. Anhydrous Et_3N (5.0 eq.) was added dropwise to a stirred ice-cooled solution of PCl_3 (1.0 eq.) in CH_2Cl_2 (7 mL / mmol amine). The ice bath was removed and the solution left to warm to room temperature before the desired amine (1.0 eq.) was added to the stirring solution. After 5 additional hours of stirring, BINOL (1.0 eq.) was added to the suspension and the subsequent mixture was left to stir overnight. The solution was then filtered on a small pad of silica and celite and rinsed with CH_2Cl_2 (20 mL). The resulting solution was concentrated under reduced pressure to afford a yellow residue. After flash column chromatography with Pentane/DCM (80:20, with 2% Et_3N) as eluent, the phosphoramidites were obtained as crystalline solids.



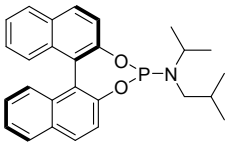
(*R*)-*N*,*N*-diisopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1a)

Prepared following **GP A** using (*R*)-BINOL (10.0 g, 34.9 mmol, 1.0 equiv.) and *N,N*-diisopropylamine (4.9 mL, 34.9 mmol, 1.0 equiv.). White solid, 71% yield (10.1 g, 24.3 mmol). **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.98 – 7.85 (m, 4H), 7.50 (dd, *J*=8.7, 1.0, 1H), 7.46 – 7.35 (m, 4H), 7.35 – 7.18 (m, 3H), 3.38 (m, 2H), 1.20 (dd, *J*=13.0, 6.8, 12H). **^{31}P NMR (121 MHz, $CDCl_3$)** δ 151.68. All the spectroscopic data are in accordance with the literature.[1]



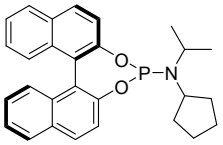
(*R*)-*N*-isopropyl-*N*-(pentan-3-yl)dinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1b)

Prepared following **GP A** using (*R*)-BINOL (1.1 g, 3.9 mmol, 1.0 equiv.) and *N*-isopropylpentan-3-amine (0.63 mL, 3.9 mmol, 1.0 equiv.). White solid, 60% yield (1.1 g, 2.4 mmol). **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.98 (d, *J*=8.7, 1H), 7.94 – 7.91 (m, 3H), 7.52 (dd, *J*=8.7, 0.9, 1H), 7.48 (d, *J*=8.8, 1H), 7.44 – 7.40 (m, 3H), 7.33 (dd, *J*=8.6, 1.2, 1H), 7.30 – 7.22 (m, 2H), 3.50 – 3.37 (m, 1H), 2.84 – 2.80 (m, 1H), 1.89 – 1.80 (m, 1H), 1.78 – 1.71 (m, 3H), 1.09 (d, *J*=6.7, 3H), 1.01-0.97 (m, 9H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.69, 150.65, 150.3, 133.0, 132.9, 131.5, 130.6, 130.3, 129.5, 128.4, 128.3, 127.3, 127.28, 126.1, 125.9, 124.8, 124.4, 124.2 (d, *J* = 5.4 Hz), 122.6, 122.0 (d, *J* = 2.5 Hz), 56.8 (d, *J* = 19.5 Hz), 45.3 (d, *J* = 2.0 Hz), 30.8 (d, *J* = 10.1 Hz), 28.5, 23.6, 23.3, 11.9, 11.8. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 151.04. **HRMS** (ESI+, m/z) calculated for $C_{28}H_{31}NO_2P$ $[M+H]^+$: 444.2096, found 444.2094.



(*R*)-*N*-isopropyl-*N*-(pentan-3-yl)dinaphtho[2,1-d:1',2'-f][1,3,2]dioxapho-sphepin-4-amine ((*R*)-1c)

Prepared following **GP A** using (*R*)-BINOL (1.9 g, 6.6 mmol, 1.0 equiv.) and *N*-isopropyl-2-methyl-1-propanamine hydrochloride (1.0 g, 6.6 mmol, 1.0 equiv.). White solid, 73% yield (2.1 g, 4.8 mmol). **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.98 (d, *J*=8.8, 1H), 7.92 (dd, *J*=8.9, 7.3, 3H), 7.52 (d, *J*=8.8, 1H), 7.43 (td, *J*=7.7, 6.8, 5.2, 4H), 7.35 (d, *J*=8.5, 1H), 7.31 – 7.23 (m, 2H), 3.46 – 3.35 (m, 1H), 2.83 – 2.68 (m, 2H), 1.83 (dq, *J*=8.3, 6.6, 1H), 1.12 (d, *J* = 6.3 Hz, 1H), 1.11 (d, *J* = 6.2 Hz, 1H), 0.93 (d, *J*=6.6, 3H), 0.85 (d, *J*=6.6, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.6 (d, *J* = 5.9 Hz), 150.0, 133.0, 132.8, 131.5, 130.7, 130.3, 129.7, 128.42, 128.35, 127.23, 127.18, 126.1, 126.0, 124.8, 124.5, 124.2 (d, *J* = 5.1 Hz), 122.4 (d, *J* = 2.0 Hz), 122.30, 122.26 (d, *J* = 2.1 Hz), 51.2 (d, *J* = 25.5 Hz), 47.1 (d, *J* = 8.2 Hz), 29.3 (d, *J* = 4.4 Hz), 23.1, 23.03, 23.00, 20.4 (d, *J* = 3.4 Hz). **^{31}P NMR (162 MHz, $CDCl_3$)** δ 148.12. **HRMS** (ESI+, m/z) calculated for $C_{27}H_{29}NO_2P$ $[M+H]^+$: 430.1930, found 430.1935.

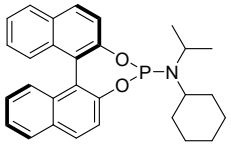


(*R*)-*N*-cyclopentyl-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1d)

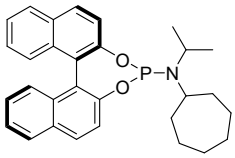
Prepared following **GP A** using (*R*)-BINOL (859 mg, 3.0 mmol, 1.0 equiv.) and *N*-isopropylcyclopentylamine (570 mg, 4.5 mmol, 1.5 equiv.). White solid, 55% yield (723 mg, 1.6 mmol) **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.96 (d, *J* = 8.8 Hz, 1H), 7.91 (dt, *J* = 8.8, 1.8 Hz, 3H), 7.52 (dd, *J* = 8.8, 1.0 Hz, 1H), 7.46 – 7.37 (m, 4H), 7.32 (dd, *J* = 8.6, 1.1 Hz, 1H), 7.29 – 7.20 (m, 2H), 3.53 – 3.40 (m, 1H), 3.36 (m, 1H), 1.90 – 1.60 (m, 6H), 1.37 (m, 2H), 1.18 (d, *J* = 6.8 Hz, 3H), 1.13 (d, *J* = 6.7 Hz, 3H). **^{13}C NMR (151 MHz,**

[3] A. Duursma, J.-G. Boiteau, L. Lefort, J. A. F. Boogers, A. H. M. de Vries, J. G. de Vries, A. J. Minnaard, B. L. Feringa*, J. Org. Chem.* **2004**, *69*, 8045-8052; b) X.-B. Chen, D. Padín, C. N. Stindt, B. L. Feringa, *Angew. Chem. Int. Ed.* **2023**, *62*, e2023074.

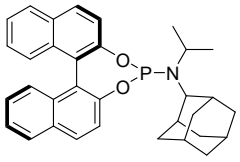
$CDCl_3$) δ 150.3, 150.24, 150.16, 132.8, 132.7, 131.3, 130.5, 130.1, 129.3, 128.24, 128.17, 127.1, 125.9, 125.8, 124.6, 124.2, 124.0 (d, *J* = 5.4 Hz), 122.5, 122.4 (d, *J* = 2.1 Hz), 121.9 (d, *J* = 2.2 Hz), 55.0 (d, *J* = 15.6 Hz), 45.3 (d, *J* = 8.5 Hz), 33.8 (g, *J* = 7.9 Hz), 24.1 (d, *J* = 7.0 Hz), 23.9, 23.8. **^{31}P NMR (121 MHz, $CDCl_3$)** δ 151.48. **HRMS** (ESI+, m/z) calculated for $C_{28}H_{29}NO_2P$ $[M+H]^+$: 442.1930, found 442.1927.



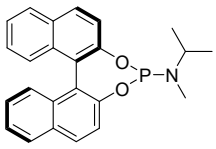
(*R*)-*N*-cyclohexyl-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphos- phepin-4-amine ((*R*)-1e)
Prepared following **GP A** using (*R*)-BINOL (1.5 g, 5.2 mmol, 1.0 equiv.) and *N*-isopropylcyclohexylamine (2.6 mL, 5.2 mmol, 1.0 equiv.). White solid, 62% yield (4.5 g, 9.8 mmol) **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.99 (d, *J*=8.8, 1H), 7.93 (t, *J*=7.8, 3H), 7.54 (dd, *J*=9.4, 3.9, 1H), 7.44 (td, *J*=15.7, 12.9, 6.8, 4H), 7.35 (d, *J*=8.5, 1H), 7.32 – 7.22 (m, 2H), 3.43 (dt, *J*=13.4, 6.8, 1H), 2.92 – 2.75 (m, 1H), 2.07 – 1.48 (m, 7H), 1.12 (td, *J*=25.8, 24.0, 8.5, 9H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.44, 150.39, 150.19, 132.8, 132.7, 131.3, 130.5, 130.1, 129.3, 128.2, 128.13, 127.07, 125.9, 125.8, 124.6, 124.2, 124.0 (d, *J* = 5.0 Hz), 122.39, 122.35, 121.8 (d, *J* = 2.2 Hz), 53.3 (d, *J* = 15.2 Hz), 45.3 (d, *J* = 6.8 Hz), 36.2, 35.6, 26.6 (d, *J* = 8.7 Hz), 25.4, 24.0, 23.7. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 151.76. **HRMS** (ESI+, m/z) calculated for $C_{29}H_{31}NO_2P$ $[M+H]^+$: 456.2096, found 456.2094.



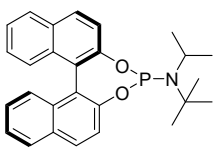
(*R*)-*N*-cycloheptyl-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1f)
Prepared following **GP A** using (*R*)-BINOL (1.5 g, 5.2 mmol, 1.0 equiv.) and *N*-isopropylcycloheptanamine hydrochloride (1 g, 5.2 mmol, 1.0 equiv.). White solid, 75% yield (1.8 g, 3.8 mmol). **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.99 (d, *J*=8.8, 1H), 7.94 – 7.92 (m, 3H), 7.54 (d, *J*=8.7, 1H), 7.49 – 7.39 (m, 4H), 7.35 (d, *J*=8.6, 1H), 7.31 – 7.24 (m, 2H), 3.45 – 3.42 (m, 1H), 3.07 – 3.04 (m, 1H), 2.07 (m, 1H), 2.00 – 1.85 (m, 3H), 1.74 – 1.61 (m, 2H), 1.48 (hept, *J*=8.7, 6.9, 4H), 1.29 – 1.08 (m, 8H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.42, 150.38, 150.2, 132.9, 132.7, 131.3, 130.5, 130.1, 129.4, 128.3, 128.2, 127.1, 125.9, 125.8, 124.6, 124.3, 124.0 (d, *J* = 5.3 Hz), 122.42 (d, *J* = 1.8 Hz), 122.39, 121.9 (d, *J* = 2.3 Hz), 55.6 (d, *J* = 14.7 Hz), 45.6 (d, *J* = 7.0 Hz), 38.2, 27.3, 27.2, 25.2 (d, *J* = 6.6 Hz), 24.0, 23.7. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 151.76. **HRMS** (ESI+, m/z) calculated for $C_{30}H_{33}NO_2P$ $[M+H]^+$: 470.2243, found 470.2240.



(*R*)-*N*-adamantan-2-yl-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1g)
Prepared following **GP A** using (*R*)-BINOL (666 mg, 2.3 mmol, 1.0 equiv.) and *N*-isopropylcyclohexylamine (450 mg, 2.3 mmol, 1.0 equiv.). White solid, 45% yield (527 mg, 1.0 mmol).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.7 Hz, 1H), 7.93 – 7.86 (m, 3H), 7.53 (dd, *J* = 8.7, 1.0 Hz, 1H), 7.45 – 7.35 (m, 4H), 7.31 (dd, *J* = 8.6, 1.1 Hz, 1H), 7.29 – 7.18 (m, 2H), 3.60 (m, 1H), 3.38 (d, *J* = 20.3 Hz, 1H), 2.63 (t, *J* = 13.8 Hz, 2H), 2.16 (s, 1H), 2.04 (s, 1H), 2.00 – 1.80 (m, 6H), 1.76 (d, *J* = 2.9 Hz, 2H), 1.65 (t, *J* = 14.3 Hz, 2H), 0.98 (d, *J* = 6.7 Hz, 3H), 0.93 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.9, 150.8, 150.1, 132.9, 132.8, 131.3, 130.3, 130.2, 129.3, 128.2, 128.1, 127.1 (d, *J* = 4.8 Hz), 125.9, 125.7, 124.6, 124.2 (d, *J* = 5.7 Hz), 124.1, 122.6 (d, *J* = 2.2 Hz), 122.5, 121.4 (d, *J* = 2.2 Hz), 59.5 (d, *J* = 16.9 Hz), 46.2 (d, *J* = 3.9 Hz), 39.5 (d, *J* = 16.8 Hz), 38.5 (d, *J* = 4.3 Hz), 35.5 (d, *J* = 3.3 Hz), 34.9 (d, *J* = 7.5 Hz), 31.9, 31.8, 31.6 (d, *J* = 17.0 Hz), 27.8, 27.6, 23.0, 21.7. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 146.24. **HRMS** (ESI+, m/z) calculated for $C_{33}H_{35}NO_2P$ $[M+H]^+$: 508.2399, found 508.2395. Data in accordance with the literature.[1b]

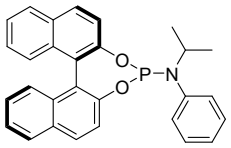


(*R*)-*N*-isopropyl-*N*-methyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphos-phepin-4-amine ((*R*)-1h)
Prepared following **GP A** using (*R*)-BINOL (7.4 g, 25.7 mmol, 1.0 equiv.) and *N*-isopropylmethylamine (2.7 mL, 25.7 mmol, 1.0 equiv.). White solid, 69% yield (6.8 g, 17.7 mmol). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.96 (d, *J* = 8.8 Hz, 1H), 7.94 – 7.87 (m, 3H), 7.51 (dd, *J* = 8.8, 0.9 Hz, 1H), 7.46 – 7.37 (m, 4H), 7.34 (dd, *J* = 8.6, 1.1 Hz, 1H), 7.31 – 7.21 (m, 2H), 3.91 – 3.69 (m, 1H), 2.22 (d, *J* = 5.6 Hz, 3H), 1.27 (d, *J* = 6.6 Hz, 3H), 1.17 (d, *J* = 6.7 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 150.4 (d, *J* = 5.0 Hz), 149.8, 132.9 (d, *J* = 1.7 Hz), 132.7, 131.4, 130.7, 130.3, 130.0, 128.4, 128.3, 127.1, 127.0, 126.1, 124.8, 124.6, 124.1 (d, *J* = 4.9 Hz), 122.7 (d, *J* = 2.3 Hz), 122.2 (d, *J* = 1.9 Hz), 122.1, 48.1 (d, *J* = 40.9 Hz), 25.7 (d, *J* = 3.9 Hz), 21.6 (d, *J* = 4.1 Hz), 21.3 (d, *J* = 7.0 Hz). **^{31}P NMR (162 MHz, $CDCl_3$)** δ 148.90. **HRMS** (ESI^+, m/z) calculated for $C_{24}H_{23}NO_2P$ $[M+H]^+$: 388.1461, found 388.1459.



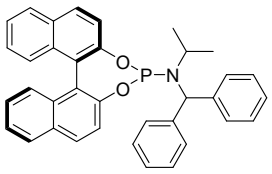
(*R*)-*N*-(tert-butyl)-N-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1i)
Prepared following **GP A** using (*R*)-BINOL (1.4 g, 5.0 mmol, 1.0 equiv.) and *N-tert*-butylisopropylamine (0.8 mL, 5.0 mmol, 1.0 equiv.). White solid, 69% yield (1.5 g, 3.5 mmol). **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.96 (d, *J* = 8.7 Hz, 1H), 7.93 – 7.86 (m, 3H), 7.50 (d, *J* = 8.4 Hz, 1H), 7.43 – 7.34

(m, 4H), 7.30 (d, *J* = 8.6 Hz, 1H), 7.26 – 7.18 (m, 2H), 3.50 (h, *J* = 7.0 Hz, 1H), 1.46 (s, 9H), 1.28 (d, *J* = 6.9 Hz, 3H), 0.85 (s, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 151.3, 151.2, 150.3, 133.08, 133.07, 131.5, 130.4, 129.4, 128.4, 128.2, 127.4, 127.2, 126.1, 125.9, 124.8, 124.6 (d, *J* = 6.0 Hz), 124.2, 123.1, 122.5 (d, *J* = 2.2 Hz), 121.8 (d, *J* = 2.2 Hz), 57.4 (d, *J* = 19.9 Hz), 48.0, 32.1, 25.7, 24.8. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 158.92. **HRMS** (ESI$^+$, m/z) calculated for $C_{27}H_{29}NO_2P$ [M+H]$^+$: 430.1930, found 430.1928.



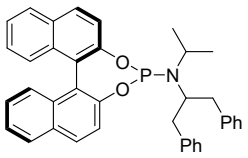
(*R*)-*N*-isopropyl-*N*-phenyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1j)

Prepared following **GP A** using (*R*)-BINOL (890 mg, 3.1 mmol, 1.0 equiv.) and *N*-isopropylaniline, (420 mg, 3.1 mmol, 1.0 equiv.). White solid, 70% yield (975 mg, 2.2 mmol). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.04 (d, *J* = 8.8 Hz, 1H), 8.00 – 7.89 (m, 3H), 7.65 (d, *J* = 8.8 Hz, 1H), 7.56 (d, *J* = 8.7 Hz, 1H), 7.53 – 7.40 (m, 4H), 7.40 – 7.26 (m, 7H), 3.92 – 3.63 (m, 1H), 1.13 (d, *J* = 6.6 Hz, 3H), 0.98 (d, *J* = 6.7 Hz, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.1, 150.0, 149.6, 139.4 (d, *J* = 21.8 Hz), 133.0, 132.8, 132.2, 132.1, 131.5, 130.7, 130.4, 129.5, 128.7, 128.4, 128.3, 127.2, 127.2, 126.9 (d, *J* = 2.1 Hz), 126.1, 126.0, 124.9, 124.2 (d, *J* = 5.1 Hz), 122.34 (d, *J* = 1.9 Hz), 122.29, 122.2 (d, *J* = 2.3 Hz), 48.1 (d, *J* = 4.4 Hz), 23.8 (d, *J* = 1.7 Hz), 22.5. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 141.76. **HRMS** (ESI$^+$, m/z) calculated for $C_{29}H_{25}NO_2P$ [M+H]$^+$: 450.1617, found 450.1610.



(*R*)-*N*-benzhydryl-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphos- phepin-4-amine ((*R*)-1k)

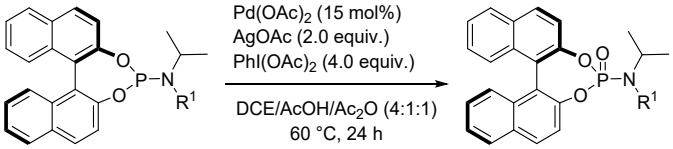
Prepared following **GP A** using (*R*)-BINOL (890 mg, 3.1 mmol, 1.0 equiv.) and *N*-benzhydrylpropan-2-amine **S3** (700 mg, 3.1 mmol, 1.0 equiv.). White solid, 50% yield (800 mg, 1.5 mmol). **^{1}H NMR (600 MHz, $CDCl_3$)** δ 7.94 (d, *J*=8.8, 1H), 7.90 (d, *J*=8.2, 2H), 7.81 (d, *J*=8.8, 1H), 7.51 (d, *J*=7.7, 2H), 7.46 – 7.41 (m, 5H), 7.41 – 7.33 (m, 6H), 7.32 – 7.26 (m, 4H), 7.23 (dd, *J*=8.4, 6.9, 1H), 5.74 (d, *J*=17.1, 1H), 3.61 (pd, *J*=6.6, 4.4, 1H), 1.12 (d, *J*=6.8, 3H), 1.00 (d, *J*=6.5, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.39, 150.35, 149.8, 143.5 (d, *J* = 5.5 Hz), 143.4 (d, *J* = 3.8 Hz), 132.8, 132.74, 132.65, 131.3, 130.5, 130.1, 129.3, 129.0 (d, *J* = 3.9 Hz), 128.8 (d, *J* = 3.5 Hz), 128.3, 128.22, 128.17, 128.1, 127.1, 127.03, 127.00, 126.97, 125.9, 125.8, 124.6, 124.3, 124.0 (d, *J* = 5.4 Hz), 122.4 (d, *J* = 2.1 Hz), 122.2, 121.7 (d, *J* = 2.2 Hz), 60.7 (d, *J* = 24.1 Hz), 46.8, 23.2, 23.0 (d, *J* = 3.5 Hz). **^{31}P NMR (162 MHz, $CDCl_3$)** δ 149.25. **HRMS** (ESI$^+$, m/z) calculated for $C_{36}H_{31}NO_2P$ [M+H]$^+$: 569.2433, found 569.2423. Data in accordance with the literature.[4]



(*R*)-*N*-(1,3-diphenylpropan-2-yl)-*N*-isopropyldinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-amine ((*R*)-1l)

Prepared following **GP A** using (*R*)-BINOL (452 mg, 1.6 mmol, 1.0 equiv.) and amine **S4** (400 mg, 1.6 mmol, 1.0 equiv.). White solid, 66% yield (600 mg, 1.1 mmol). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.03 (d, *J* = 8.7 Hz, 1H), 7.96 (d, *J* = 8.2 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.85 (d, *J* = 8.8 Hz, 1H), 7.58 (d, *J* = 8.7 Hz, 1H), 7.45 (dd, *J* = 8.4, 6.1 Hz, 3H), 7.42 – 7.19 (m, 14H), 3.62 – 3.44 (m, 1H), 3.37 – 3.18 (m, 3H), 3.13 – 2.96 (m, 2H), 0.67 (s, 6H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 150.6, 150.5, 150.2, 140.0, 139.9, 133.0, 132.8, 131.5, 130.6, 130.4, 130.0, 129.7, 129.6, 128.5, 128.4, 128.3, 127.3, 127.2, 126.5, 126.4, 126.1, 126.0, 125.9, 124.8, 124.5, 124.1 (d, *J* = 5.0 Hz), 122.40, 122.39, 122.3, 121.90, 121.89, 58.1 (d, *J* = 24.4 Hz), 45.7 (d, *J* = 2.0 Hz), 44.1, 22.5, 19.9. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 150.88. **HRMS** (ESI$^+$, m/z) calculated for $C_{38}H_{35}NO_2P$ [M+H]$^+$: 568.2400, found 568.2399.

Preparation of acetoxylated phosphoramidates



Scheme S2 Preparation of acetoxylated phosphoramidates

General procedure for Pd-catalysed enantioselective C(sp^3)–H acetoxylation (GP B)

In an oven-dried reaction tube, the corresponding phosphoramidite (*R*)-**1a-g** (0.3 mmol, 1.0 equiv.), $PhI(OAc)_2$ (386 mg, 1.2 mmol, 4.0 equiv.), AgOAc (100 mg, 0.6 mmol, 2.0 equiv.) and $Pd(OAc)_2$ (10.1 mg, 0.045 mmol, 15 mol%) were added and taken into the glove box. The deoxygenated DCE/AcOH/Ac_2O mixture (4:1:1, 3.75 mL) were added via a syringe. The reaction vessel was taken out of the glovebox and the mixture stirred at 60°C for 24 h, cooled to room temperature and concentrated

[4] M. Sidera, P. M. C. Roth, R. M. Maksymowicz, S. P. Fletcher, *Angew. Chem. Int. Ed.* **2013**, *52*, 7995-7999.

in vacuum. The residue was purified by silica gel column flash chromatography (eluent: pentane/EtOAc) to give compound (*R,R*)-**2a-g**.

NOTE: NMR-spectra of the major diastereomer are reported.

NOTE: To confirm that C–H activation occurred at the β-position of the amine, ^{1}H–^{1}H Total Correlation Spectroscopy (TOCSY) of (R,R)-2a was performed (Figure S 1). The TOCSY spectrum reveals a total correlation among the protons b, b', c, and e within the same spin system to confirm our assignment.

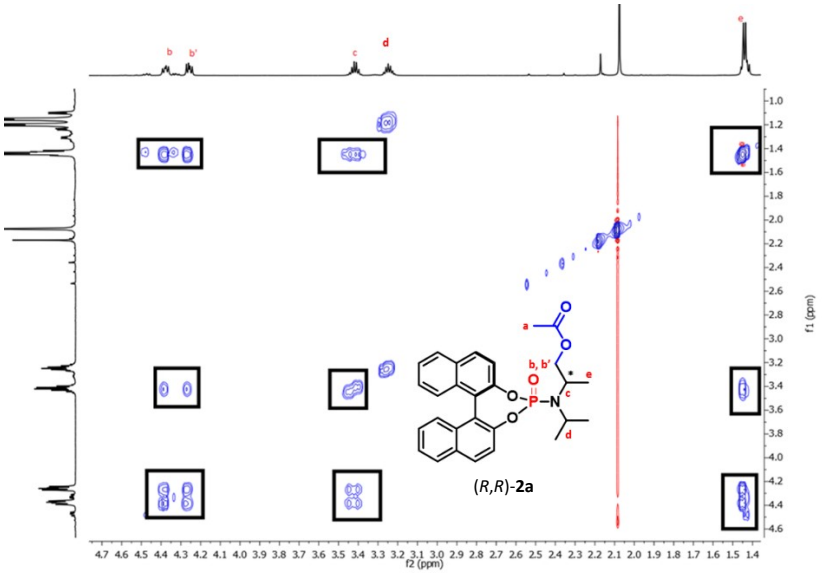
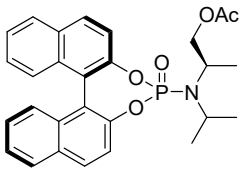
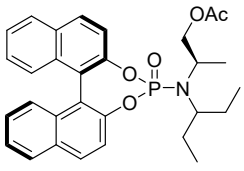


Figure S1 TOCSY NMR (600 MHz, $CDCl_3$) spectra of (*R,R*)-2a



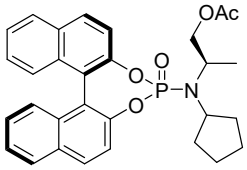
(2*R*)-2-(isopropyl((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-yl)amino)propyl acetate ((*R,R*)-2a)

Prepared following **GP B**. Purification by column chromatography with pentane/ethyl acetate (80:20) afforded (*R,R*)-**2a** (97:3 *d.r.;* crude 92:8 *d.r.*; 82 mg, 0.168 mmol, 56%) as a light yellow oil**.** **^{1}H NMR (600 MHz, $CDCl_3$)** δ 8.04 (d, *J* = 8.9 Hz, 1H), 8.01 (d, *J* = 8.8 Hz, 1H), 7.99 – 7.93 (m, 2H), 7.63 (dd, *J* = 8.8, 1.1 Hz, 1H), 7.55 – 7.49 (m, 2H), 7.49 – 7.45 (m, 1H), 7.44 (d, *J* = 8.6 Hz, 1H), 7.36 – 7.31 (m, 1H), 7.28 – 7.25 (m, 2H), 4.38 (dd, *J* = 11.0, 7.1 Hz, 1H), 4.26 (dd, *J* = 11.0, 7.0 Hz, 1H), 3.49 – 3.36 (m, 1H), 3.31 – 3.18 (m, 1H), 2.08 (s, 3H), 1.44 (d, *J* = 6.9 Hz, 3H), 1.20 (d, *J* = 6.7 Hz, 3H), 1.15 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 170.8, 148.6 (d, *J* = 11.4 Hz), 146.8 (d, *J* = 8.8 Hz), 132.6, 132.4 (d, *J* = 1.1 Hz), 131.8 (d, *J* = 1.1 Hz), 131.2, 130.5, 128.5, 128.4, 127.5, 127.0, 126.7, 126.5, 125.56, 125.55, 121.6 (d, *J* = 2.7 Hz), 121.4 (d, *J* = 2.3 Hz), 120.9 (d, *J* = 1.6 Hz), 120.7, 120.6, 66.8, 48.9 (d, *J* = 5.3 Hz), 48.4 (d, *J* = 3.7 Hz), 21.9 (d, *J* = 22.6 Hz), 21.0, 18.6, 18.5. **^{31}P NMR (162 MHz, $CDCl_3$)** δ 11.16. **HRMS** (ESI+, m/z) calculated for $C_{28}H_{29}NO_5P$ $[M+H]^+$: 490.1783, found 490.1764.



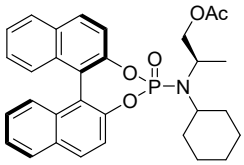
(2*R*)-2-(((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-yl)(pentan-3-yl)amino)propyl acetate ((*R,R*)-2b)

Prepared following **GP B**. Purification by MPLC with pentane/ ethyl acetate (70:30) afforded (*R,R*)-**2b** (93.5:6.5 *d.r.*, 44 mg, 0.085 mmol, 28%) as a light yellow oil. ^{1}H NMR (400 MHz, **$CDCl_3$**) δ 8.00 (t, *J* = 9.5 Hz, 2H), 7.94 (t, *J* = 7.7 Hz, 2H), 7.59 (dd, *J* = 8.8, 1.1 Hz, 1H), 7.55 – 7.37 (m, 4H), 7.33-7.29 (m, 1H), 7.24 – 7.19 (m, 2H), 4.30 (m, 1H), 4.23 (dd, *J* = 11.1, 7.1 Hz, 1H), 3.38-3.27 (m, 1H), 2.76 – 2.49 (m, 1H), 2.02 (s, 3H), 1.77 – 1.61 (m, 2H), 1.58-1.53 (m, 2H), 1.43 (d, *J* = 6.9 Hz, 3H), 0.92 (t, *J* = 7.4 Hz, 3H), 0.67 – 0.61 (m, 3H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 170.8, 148.5 (d, *J* = 11.1 Hz), 146.6 (d, *J* = 8.5 Hz), 132.6, 132.4, 131.8, 131.2, 131.1, 130.4, 128.5, 128.3, 127.4, 127.0, 126.6, 126.5, 125.6, 125.5, 121.5 (d, *J* = 2.7 Hz), 121.4 (d, *J* = 2.7 Hz), 120.9, 120.7 (d, *J* = 3.8 Hz), 67.0, 61.4, 49.7 (d, *J* = 4.6 Hz), 27.7, 25.7, 21.0, 18.5, 11.8, 11.7. **^{31}P NMR (243 MHz, $CDCl_3$)** δ 11.42. **HRMS** (ESI+, m/z) calculated for $C_{30}H_{33}NO_5P$ $[M+H]^+$: 518.2090, found 518.2090.



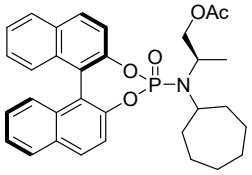
(2*R*)-2-(cyclopentyl((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-yl)amino)propyl acetate ((*R,R*)-2d)

Prepared following **GP B**. Purification by MPLC with pentane/ ethyl acetate (70:30) afforded (*R*,*R*)-**2d** (95:5 d.r., 43 mg, 0.083 mmol, 28%) as a light yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.00 (t, *J* = 9.2 Hz, 2H), 7.94 (t, *J* = 7.5 Hz, 2H), 7.59 (d, *J* = 8.9 Hz, 1H), 7.53 – 7.38 (m, 4H), 7.36 – 7.28 (m, 1H), 7.28 – 7.20 (m, 2H), 4.29 (dd, *J* = 11.0, 7.1 Hz, 1H), 4.18 (dd, *J* = 11.0, 7.1 Hz, 1H), 3.49 – 3.17 (m, 2H), 2.05 (s, 3H), 1.82 – 1.68 (m, 4H), 1.36 (d, *J* = 6.9 Hz, 3H), 1.32 – 1.16 (m, 4H). **^{13}C NMR (151 MHz, $CDCl_3$)** 170.7, 148.4, 148.4, 146.6, 146.6, 132.5, 132.3, 131.8, 131.2, 131.2, 130.4, 128.4, 128.3, 127.4, 127.0, 126.6, 126.5, 125.5, 121.5, 121.5, 121.4, 121.4, 121.0, 120.7, 120.7, 66.6, 58.1, 50.0, 50.0, 30.6, 23.7, 23.4, 20.9, 18.2. **^{31}P NMR (243 MHz, $CDCl_3$)** δ 11.42. **HRMS** (ESI+, m/z) calculated for $C_{30}H_{31}NO_5P$ $[M+H]^+$: 516.1934, found 516.1930.



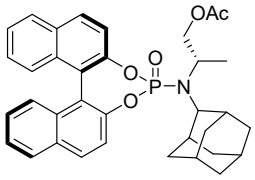
(2*R*)-2-(cyclohexyl((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-yl)amino)propyl acetate ((*R*,*R*)-2e)

Prepared following **GP B**. Purification by MPLC with pentane/ ethyl acetate (80:20) afforded (*R*,*R*)-**2e** (91:9 *d.r.*, 84 mg, 0.153 mmol, 51%) as a light yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ: 8.01 (d, *J* = 8.9 Hz, 1H), 7.98 (d, *J* = 8.8 Hz, 1H), 7.96 – 7.90 (m, 2H), 7.59 (dd, *J* = 8.9, 1.1 Hz, 1H), 7.53 – 7.42 (m, 3H), 7.41 (d, *J* = 8.5 Hz, 1H), 7.35 – 7.28 (m, 1H), 7.25 – 7.21 (m, 2H), 4.29-4.26 (m, 1H), 4.21-4.17 (m, 1H), 3.45 – 3.26 (m, 1H), 2.83 (dd, *J* = 10.6, 4.9 Hz, 1H), 2.04 (s, 3H), 1.97 – 1.76 (m, 4H), 1.72 – 1.48 (m, 2H), 1.44 – 1.33 (m, 3H), 1.34 – 1.20 (m, 4H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 170.7, 148.5 (d, *J* = 11.0 Hz), 146.7 (d, *J* = 8.8 Hz), 132.5, 132.3, 131.7, 131.1, 130.4, 128.4, 128.2, 127.3, 126.9, 126.6, 126.4, 125.5, 125.4, 121.5 (d, *J* = 2.7 Hz), 121.3 (d, *J* = 2.3 Hz), 120.8, 120.58, 120.55, 66.8, 59.2, 50.2 (d, *J* = 3.1 Hz), 35.0, 34.4, 26.8, 26.6, 24.9, 24.6, 20.9. **^{31}P NMR (243 MHz, $CDCl_3$)** δ 11.22. **HRMS** (ESI+, m/z) calculated for $C_{31}H_{33}NO_5P$ $[M+H]^+$: 530.2096, found 530.2080.



(2*R*)-2-(cycloheptyl((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2]dioxaphosphepin-4-yl)amino)propyl acetate ((*R*,*R*)-2f)

Prepared following **GP B**. Purification by MPLC with pentane/ ethyl acetate (70:30) afforded (*R*,*R*)-**2f** (90:10 *d.r.*, 55 mg, 0.101 mmol, 34%) as a light yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.05 – 7.99 (m, 2H), 7.98 – 7.91 (m, 2H), 7.63 – 7.56 (m, 1H), 7.53 – 7.38 (m, 4H), 7.31 (ddd, *J* = 8.5, 6.7, 1.4 Hz, 1H), 7.25 – 7.21 (m, 2H), 4.28 (m, 1H), 4.19 (m, 1H), 3.36 (dq, *J* = 24.7, 6.9 Hz, 1H), 2.94 – 2.72 (m, 1H), 2.04 (s, 3H), 1.97 – 1.73 (m, 4H), 1.64 – 1.45 (m, 2H), 1.37 (d, *J* = 6.8 Hz, 3H), 1.36 – 1.13 (m, 4H), 1.09 – 0.82 (m, 2H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 170.8, 148.6 (d, *J* = 11.1 Hz), 146.8 (d, *J* = 9.0 Hz), 132.6, 132.4, 131.8, 131.2, 130.5, 128.5, 128.3, 127.4, 127.0, 126.7, 126.5, 125.6, 125.51, 121.55 (d, *J* = 2.7 Hz), 121.38 (d, *J* = 2.5 Hz), 120.89, 120.67, 120.65, 66.89, 59.24, 50.28 (d, *J* = 4.1 Hz), 35.1, 34.4, 26.9, 26.7, 25.0, 24.7, 21.0, 18.4. **^{31}P NMR (243 MHz, $CDCl_3$)** δ 11.17. **HRMS** (ESI+, m/z) calculated for $C_{32}H_{35}NO_5P$ $[M+H]^+$: 544.2253, found 544.2238.



(2*R*)-2-((adamantan-2-yl)((*R*)-4-oxidodinaphtho[2,1-d:1',2'-f][1,3,2] dioxaphosphepin-4-yl)amino)propyl acetate ((*R*,*S*)-2g)

Prepared following **GP B**. Purification by MPLC with pentane/ ethyl acetate (70:30) afforded (*R*,*R*)-**2g** (98:2 *d.r.*, 38 mg, 0.066 mmol, 22%) as a light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.01 (d, *J* = 8.9 Hz, 1H), 7.98 (d, *J* = 8.8 Hz, 1H), 7.93 (d, *J* = 8.4 Hz, 2H), 7.59 (dd, *J* = 8.9, 1.1 Hz, 1H), 7.52 – 7.42 (m, 3H), 7.38 (d, *J* = 8.5 Hz, 1H), 7.33 – 7.27 (m, 1H), 7.25 – 7.17 (m, 2H), 4.52 (s, 1H), 4.35 (t, *J* = 9.2 Hz, 1H), 4.28 – 4.06 (m, 1H), 3.14 (d, *J* = 9.1 Hz, 1H), 2.23 – 2.10 (m, 2H), 2.04 (s, 5H), 1.90 (s, 1H), 1.72 – 1.42 (m, 10H), 1.10 – 0.82 (m, 2H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 170.6, 148.9, 148.9, 146.8, 146.8, 132.5, 132.4, 131.8, 131.2, 131.1, 130.6, 128.5, 128.2, 127.3, 127.0, 126.7, 126.5, 125.5, 125.5, 121.7, 121.7, 121.5, 121.4, 120.7, 120.5, 120.5, 67.3, 61.1, 50.6, 40.1, 40.0, 38.3, 34.4, 34.3, 33.5, 32.7, 31.1, 27.4, 26.8, 21.0, 19.3. **^{31}P NMR (243 MHz, $CDCl_3$)** δ 13.14. **HRMS** (ESI+, m/z) calculated for $C_{35}H_{37}NO_5P$ $[M+H]^+$: 582.2403, found 582.2401.

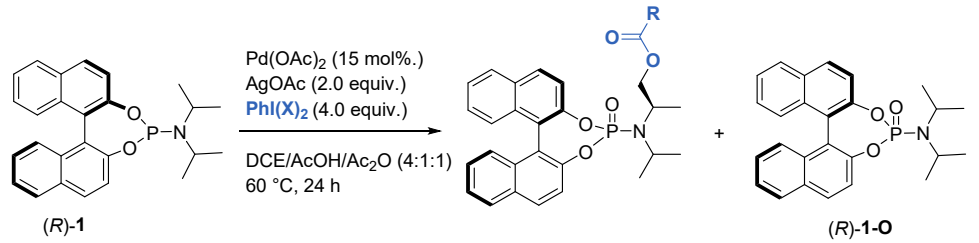
Limitations

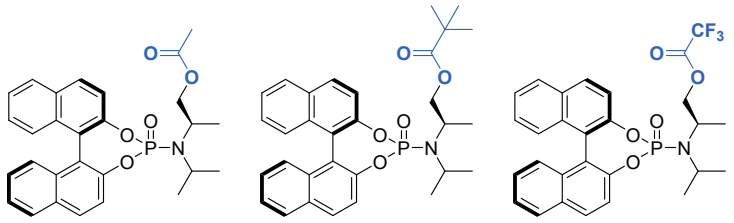
General procedure

In an oven dried reaction tube, the corresponding phosphoramidite (*R*)-**1** (0.1 mmol, 1.0 equiv.), $PhI(OAc)_2$ (4.0 equiv.), AgOAc (2.0 equiv.) and $Pd(OAc)_2$ (15 mol%) were added and taken in to the glove box. The deoxygenated solvent or solvent mixtures were added via a syringe. The reaction vessel was taken out of the glovebox and the mixture stirred at specified temperature for 24 h, cooled to room temperature and concentrated in vacuum. The internal standard, 1,3,5-trimethoxybenzene was added to the crude reaction material, which was subsequently dissolved in $CDCl_3$ (0.6 mL) and submitted for analysis.

NMR yield was determined by introducing an internal standard (1,3,5-trimethoxybenzene). *d.r.* was determined by ^{31}P-NMR of the crude reaction mixture.

Table S 8 Attempted C(sp^3)–H functionalizations of (*R*)-1a in the presence of various hypervalent iodine reagents $PhI(X)_2$[a]

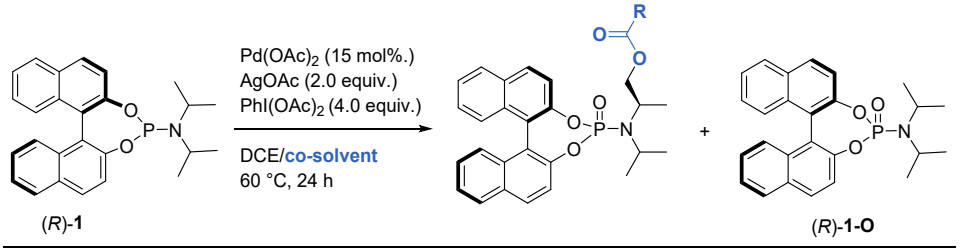


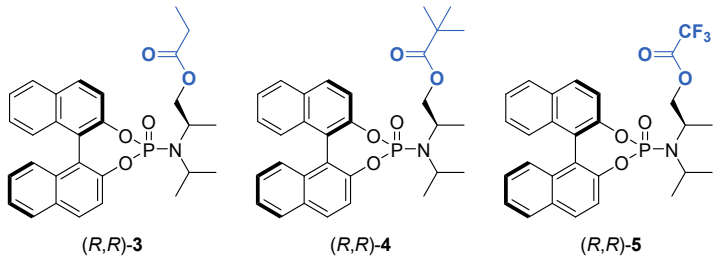


Entry	$PhI(X)_2$	Desired product	Observation
1[b]	$PhI(OPiv)_2$	(*R*,*R*)-**4**	No (*R*,*R*)-**4**, (*R*,*R*)-**2a** (36%, 92:8 *d.r.*)
2	$PhI(TFA)_2$	(*R*,*R*)-**5**	No (*R*,*R*)-**5**, only (*R*)-**1a-O**

[a] Optimized reaction conditions used with specified deviations. [b] Isolated yield reported, *d.r.* determined by ^{31}P NMR analysis.

Table S 9 Attempted various C(sp^3)–H functionalizations of (*R*)-1a[a]





Entry	Co-solvent (1:1)	Desired product	Yield of desired product [%]	*d.r.*
1[b]	$AcOH/Ac_2O$	(*R*,*R*)-**3**	27	92:8
2[c]	$PivOH/Piv_2O$	(*R*,*R*)-**4**	-	-
3[c]	TFA/TFAA	(*R*,*R*)-**5**	Not conclusive	-

[a] Optimized reaction conditions used with specified deviations. [b] Yield determined by ^1H NMR using 1,3,5-trimethoxybenzene as an internal standard, *d.r.* determined by ^{31}P NMR of crude reaction mixture. [c] Conducted at 60 °C and at 100 °C. TFAA = trifluoroacetic anhydride, TFA = trifluoroacetic acid.

X-ray crystal structure of (*R*,*S*)-2g

Single crystals of $C_{35}H_{36}NO_5P \cdot CH_2Cl_2$ of (*R*,*S*)-**2g** were grown from a saturated solution in CH_2Cl_2 at 7 °C. A suitable crystal was selected and mounted on a cryoloop and placed in the nitrogen stream (100 K) of a Bruker-AXS D8 Venture diffractometer. Data collection and processing was carried out using the Bruker APEX3 software suite. A multi-scan absorption correction was applied, based on the intensities of symmetry-related reflections measured at different angular settings (SADABS).[5] The

structure was solved using SHELXT[6] and refinement was performed using SHELXL[7] in the OLEX2 software package.[8] The hydrogen atoms were generated by geometrical considerations, constrained by idealized geometries and allowed to ride on their carrier atoms with an isotropic displacement parameter related to the equivalent displacement parameter of their carrier atoms. No A- or B-level alerts were raised by CheckCIF.

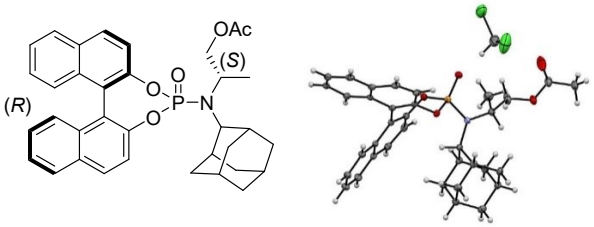


Figure S 2 : ORTEP representation of the single crystal structure of **(*R*,*S*)-2a**

Crystal data and structure refinement for (*R*,*S*)-2a (CCDC 2291901**).**

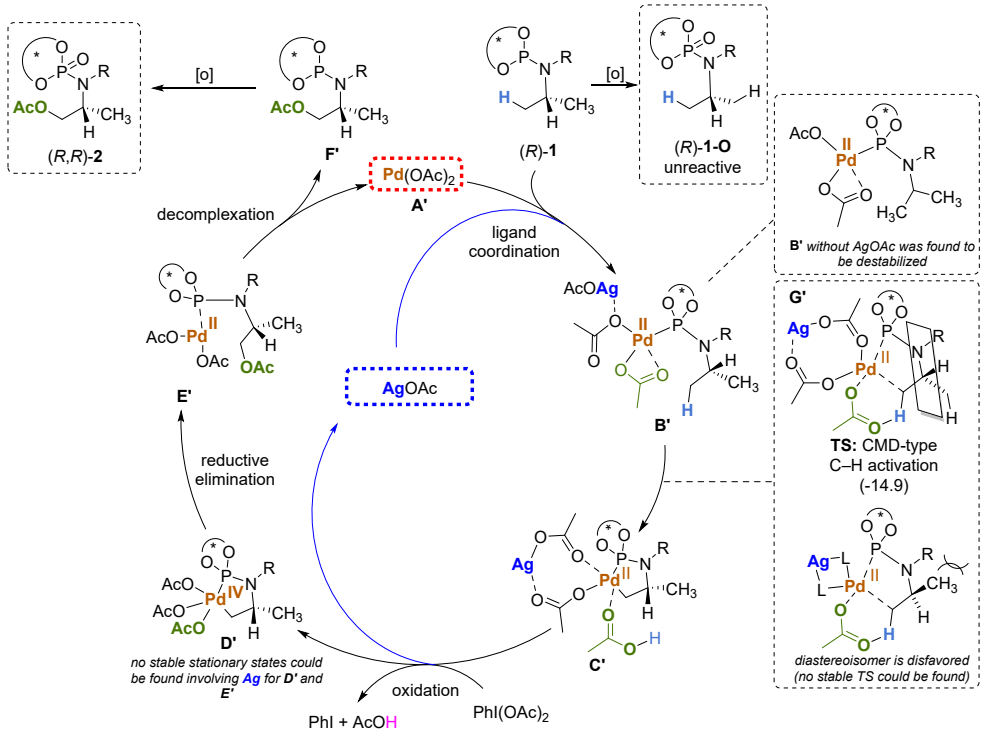
Identification code	**(*R*,*S*)-2a**
Empirical formula	$C_{36}H_{38}Cl_2NO_5P$
Formula weight	666.54
Temperature/K	100.00
Crystal system	monoclinic
Space group	$P2_1$
a/Å	12.6352(9)
b/Å	6.4448(4)
c/Å	20.9210(16)
α/°	90
β/°	106.627(3)
γ/°	90
Volume/Å^3	1632.4(2)
Z	2
ρ_{calc}g/cm^3	1.356
μ/mm^{-1}	0.292
F(000)	700.0
Crystal size/mm^3	0.203 × 0.037 × 0.026
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.972 to 58.496
Index ranges	-17 ≤ h ≤ 17, -8 ≤ k ≤ 8, -28 ≤ l ≤ 28
Reflections collected	107515
Independent reflections	8838 [R_{int} = 0.1007, R_{sigma} = 0.0442]
Data/restraints/parameters	8838/1/409
Goodness-of-fit on F^2	1.028
Final R indexes [I>=2σ (I)]	R_1 = 0.0456, wR_2 = 0.1008
Final R indexes [all data]	R_1 = 0.0601, wR_2 = 0.1088
Largest diff. peak/hole / e Å^{-3}	0.60/-0.69
Flack parameter	0.02(2)

DFT calculations

All computational input files were prepared in GaussView 6.0 on a local Windows 10 terminal. Input files were then transferred to the Rijksuniversiteit Groningen Peregrine HPC cluster where DFT calculations were carried out using the Gaussian 16 (g16) suite of programs.

[5] L. Krause, R. Herbst-Irmer, G. M. Sheldrick, D. Stalke, *J. Appl. Cryst.* **2015**, *48*, 3–10.
[6] G. M. Sheldrick, *Acta Cryst. A* **2015**, *71*, 3–8.
[7] G. M. Sheldrick, *Acta Cryst. A* **2008**, *64*, 112–122.
[8] O. V. Dolomanov, L. J. Bourhis, R. J. Gildea, J. A. K. Howard, H. Puschmann, *J. Appl. Cryst.* **2009**, *42*, 339–341.

The DFT thermochemistry of stationary points and the C-H activation step transition state of the catalytic cycle were examined. Geometry optimization of structures to stationary point minima or a transition states (TS) were done using the g16 opt command at the B3LYP functional and def2-SVP basis set level of theory with implicit solvation using the polarization continuum model (PCM) with dichloromethane as the implicit solvent. Transition state geometry inputs were the result of rational guess based on bond-breaking atomic distances, or were the result of potential energy surface relaxed coordinate scans using the g16 scan command at the B3LYP/def2-SVP/PCM=DCM level. Intrinsic reaction coordinate (IRC)iv calculations were carried out on the C-H activation transition state structure to verify that it is connected to the associated reactant and product minima structures. After optimization, frequency DFT calculations of the optimized structures were carried out using the g16 *freq* command at the B3LYP/def2-SVP/PCM=DCM level, to confirm that minima structures had zero imaginary frequencies and that transition states had a single imaginary frequency. All shown free energies (Figure S3 below) are ZPE and thermally corrected and were obtained from the frequency calculations. All shown free energies are reported in kcal/mol, at 298.15 K and 1 atm.



A proposed catalytic cycle of the investigated C(sp³)–H acetoxylation of (*R*)-1 to (*R,R*)-2, which is supported by Density Functional Theory calculations.

***(R)*-1** optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

EE + Thermal Free Energy Correction: -1244.760707

0 1

C	-1.81146500	1.10359100	0.11162500
C	-0.62632200	1.32953400	0.84843500
C	-0.09649100	2.61890200	0.97797700
C	-0.72527200	3.70376200	0.36566300
C	-1.89240800	3.50045700	-0.37981000
C	-2.42544300	2.21550300	-0.49560600
C	-2.41770700	-0.24794000	0.01726700
C	-1.62865100	-1.39253600	-0.23278500
C	-2.20787100	-2.66309200	-0.32471000
C	-3.58859300	-2.81571500	-0.18571700
C	-4.39107600	-1.69394300	0.05234100
C	-3.80701600	-0.42976900	0.15225100
H	0.80778600	2.74591200	1.57581100
H	-0.30233400	4.70611300	0.46875900
H	-2.38716700	4.34153000	-0.87099300
H	-3.33354300	2.05806500	-1.08245200
H	-1.55551000	-3.51624600	-0.52180600
H	-4.03638000	-3.80958500	-0.26230700
H	-5.47183600	-1.80422600	0.16815300
H	-4.43431800	0.44081000	0.35778600
O	-0.00454800	0.30401500	1.51357100
O	-0.28038600	-1.26383600	-0.46153500
P	0.80970600	-1.02162200	0.82398200
N	2.07109000	-0.41292400	-0.10415700
C	3.46127400	-0.79290000	0.26063000
H	4.09393900	-0.39189500	-0.54445000
C	3.67726500	-2.31151800	0.27355300
H	3.11286800	-2.79320100	1.08766400
H	3.35380300	-2.75663000	-0.67975600
H	4.74381900	-2.54362900	0.42308700
C	3.91106000	-0.13217400	1.56936900
H	4.97440700	-0.34159500	1.76881500
H	3.77367200	0.95849600	1.52155300
H	3.32629500	-0.51228000	2.42355600
C	1.87634800	0.45801900	-1.28875300
H	0.80818500	0.71140100	-1.30542500
C	2.18010300	-0.30230600	-2.58519300
H	1.97279900	0.33172900	-3.46216500
H	3.23792500	-0.60802600	-2.63775900
H	1.55360300	-1.20404100	-2.64836300
C	2.65470100	1.77405700	-1.18850600
H	3.74432400	1.61653200	-1.22296600
H	2.38898200	2.42771600	-2.03413500
H	2.41031900	2.30483600	-0.25773100

$Pd(OAc)_2$ (A') optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

EE + Thermal Free Energy Correction: -584.540974

0 1

O	-1.76694800	1.08237900	-0.01155700
O	-1.76688900	-1.08243600	-0.01154700
C	-2.44153000	-0.00005400	-0.00480600
C	-3.93272400	0.00001500	0.04284600
H	-4.24957100	0.00537500	1.09863000
H	-4.32767400	0.90251700	-0.44226900
H	-4.32771900	-0.90701100	-0.43363000
O	1.76694300	1.08238100	-0.01155600
C	2.44153300	-0.00004700	-0.00480700
O	1.76690400	-1.08243700	-0.01155000
C	3.93272800	0.00002500	0.04284700
H	4.24957300	0.00483400	1.09863400
H	4.32772800	-0.90676700	-0.43407500
H	4.32767500	0.90276400	-0.44182400
Pd	-0.00000300	-0.00000900	-0.01157100

AgOAc optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

EE + Thermal Free Energy Correction: -375.335423

0 1

C	-3.08243700	-0.01650200	-0.00004900
H	-3.43510200	-0.56707400	-0.88598100
H	-3.50650500	0.99562700	0.00098900
H	-3.43531000	-0.56909500	0.88452800
C	-1.55903400	0.01496700	0.00007000
O	-0.97202700	1.13087400	0.00005600
O	-0.95365900	-1.09616200	0.00006200
Ag	1.14109000	-0.00272200	-0.00001300

B' optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

EE + Thermal Free Energy Correction: -2204.690737 (-33.7 kcal/mol)

0 1

C	-2.84060700	1.79892700	-0.17842800
C	-1.44231100	1.94911500	-0.12133500
C	-0.80529700	3.16512700	-0.36792800
C	-1.57426800	4.27413500	-0.72660000
C	-2.96537800	4.15270900	-0.82902200
C	-3.58667300	2.93471400	-0.54787800
C	-3.51102800	0.52878200	0.20599700
C	-3.05087300	-0.73944600	-0.19871900
C	-3.68656300	-1.91936500	0.18273100
C	-4.82301100	-1.85988300	0.98833700
C	-5.31159200	-0.61666100	1.40555700
C	-4.66147200	0.55547900	1.01900600
H	0.27786400	3.22665500	-0.24095700
H	-1.08627400	5.23120100	-0.92407300
H	-3.57087700	5.01337400	-1.12170400
H	-4.67288100	2.85029300	-0.62327400
H	-3.27290800	-2.86860500	-0.16091000
H	-5.32173600	-2.78229000	1.29388300
H	-6.19616900	-0.55946700	2.04373500
H	-5.03494100	1.52054600	1.36787900
O	-0.65467800	0.87059500	0.26328400
O	-1.97777000	-0.85436800	-1.07689900
P	-0.44467900	-0.44572300	-0.70636700
N	0.15098800	-0.01397700	-2.18216000
C	-0.56852200	-0.07217100	-3.48927500
H	0.19252700	0.24957100	-4.21340200
C	-1.71809300	0.93467900	-3.57586600
H	-2.08967500	0.98203800	-4.61161000
H	-2.55744700	0.65095300	-2.92667200
H	-1.37987600	1.93922300	-3.28117100
C	-0.97548600	-1.49594000	-3.88257500
H	-1.31890300	-1.50718600	-4.92894800
H	-0.12059300	-2.18141600	-3.78749200
H	-1.79195200	-1.87110600	-3.25043700
C	1.60380000	0.33581400	-2.19730800
H	1.93170000	0.38274100	-1.14667800
C	1.83527800	1.73401500	-2.77293300
H	2.88953600	2.00371000	-2.62601000
H	1.60842800	1.78280000	-3.84939500
H	1.21485900	2.47805500	-2.25412600
C	2.44781000	-0.73640000	-2.88867500
H	2.21034500	-0.80964600	-3.96219000
H	3.51392300	-0.47802900	-2.79720200
H	2.27942900	-1.71915900	-2.42646200
Pd	0.70584100	-1.94798200	0.43342300
O	0.67985800	-0.78744900	2.14651200
O	-1.38404800	-1.53885400	2.57662800
O	1.88698100	-3.86583700	0.78185800

O	0.96225300	-3.28712900	-1.11641600
C	-0.43650700	-0.83239800	2.86717000
C	-0.44077000	0.09383500	4.06605500
H	-0.67109100	1.11485600	3.71923700
H	-1.21970900	-0.21991500	4.77216100
H	0.54017200	0.11648300	4.56154800
C	1.66490300	-4.12331200	-0.42907400
C	2.21210800	-5.33891700	-1.11293400
H	3.08982000	-5.03957600	-1.70859300
H	2.52057100	-6.08854200	-0.37325700
H	1.46471800	-5.75613600	-1.80228000
O	3.79240900	1.73274100	-0.21049000
C	3.35819500	2.83812500	0.14656600
O	2.49485200	3.02269800	1.08403200
C	3.80122100	4.10364700	-0.57883000
H	3.05270000	4.33706300	-1.35423100
H	3.84929100	4.96053100	0.10755700
H	4.77043100	3.94912200	-1.07175300
Ag	1.79777100	1.13097600	1.83016400

B' (without AgOAc) optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

EE + Thermal Free Energy Correction: -1829.334899 (-20.8 kcal/mol)

0 1

C	2.88088500	1.31242600	-0.11897700
C	2.55009500	0.16999200	0.64071400
C	3.53293300	-0.63668500	1.21780800
C	4.88153700	-0.32819600	1.03213100
C	5.23935300	0.78997400	0.27065100
C	4.24872900	1.59780200	-0.28980200
C	1.83714400	2.21131800	-0.67141200
C	0.68635500	1.70663400	-1.30426200
C	-0.32521800	2.53639000	-1.78796000
C	-0.18295800	3.92075700	-1.67534600
C	0.96277900	4.45664300	-1.07545800
C	1.95528200	3.61082800	-0.57775700
H	3.21775600	-1.49056400	1.81970300
H	5.64992000	-0.96102800	1.48199800
H	6.29218800	1.03453500	0.11341600
H	4.53234900	2.46808300	-0.88585700
H	-1.21022600	2.07680800	-2.23084100
H	-0.96973600	4.57945600	-2.05003300
H	1.07632200	5.53878300	-0.97929900
H	2.83070500	4.03457800	-0.08101800
O	1.22719300	-0.14104100	0.90898600
O	0.55888300	0.33249100	-1.49481200
P	0.11629900	-0.61080300	-0.22052300
N	0.45540600	-2.11885600	-0.79673000
C	-0.34362000	-3.30969100	-0.38004800
H	0.17358600	-4.15860600	-0.84690600
C	-1.76710500	-3.30155200	-0.94427300
H	-2.38646800	-2.51768900	-0.48192700
H	-1.75404900	-3.13005100	-2.03077000

H	-2.25099200	-4.27104500	-0.74819000
C	-0.29210700	-3.52389600	1.13612400
H	-0.82248700	-4.45001900	1.40745000
H	0.75163300	-3.61017800	1.47527400
H	-0.75891000	-2.69046000	1.68453300
C	1.63682900	-2.34035900	-1.68586600
H	2.14817100	-1.37151900	-1.76009300
C	1.18074400	-2.73041400	-3.09356800
H	2.05142200	-2.83087700	-3.76023200
H	0.64694800	-3.69425000	-3.09213600
H	0.51044300	-1.96191800	-3.50595000
C	2.63651400	-3.33434600	-1.08863400
H	2.23446200	-4.35812100	-1.04561500
H	3.54041000	-3.36155800	-1.71640800
H	2.93420900	-3.03326300	-0.07487600
Pd	-1.91807000	-0.07597300	0.47636400
O	-1.35120800	-0.42682400	2.37267200
O	-0.69547300	1.71126500	2.61928000
O	-3.99474000	0.65754900	0.47352400
O	-2.84140600	0.28548000	-1.34506700
C	-0.79476400	0.56286800	3.02849200
C	-0.23703700	0.12368300	4.37185800
H	0.67255800	-0.47054000	4.18707700
H	0.01864900	0.99970000	4.98169100
H	-0.95125800	-0.52082800	4.90447700
C	-3.92812200	0.68503800	-0.78736800
C	-5.05055100	1.19826700	-1.63596400
H	-5.14230500	0.59482700	-2.54980200
H	-5.99147600	1.19527400	-1.07108900
H	-4.81711900	2.23300600	-1.93553700

C-H Activation TS optimised geometry [# opt=(calcfc,ts,noeigen) freq=noraman b3lyp scrf=(solvent=dichloromethane) #empiricaldispersion=gd3 #p #pop=none def2svp gfinput integral=ultrafinegrid iop(6/7=3) scf=tight]

EE + Thermal Free Energy Correction: -2204.630968 (+3.8 kcal/mol)

0 1

C	-3.89396400	0.69969100	-0.74875600
C	-3.15332400	-0.45097300	-1.09406300
C	-3.77183900	-1.52763700	-1.74663300
C	-5.13894600	-1.50959100	-2.01126100
C	-5.90441500	-0.40361500	-1.62412000
C	-5.28129500	0.68087500	-1.01059600
C	-3.27905600	1.92575200	-0.18224900
C	-2.28857500	1.89696600	0.81995300
C	-1.85117900	3.07235300	1.44120300
C	-2.33899500	4.31103900	1.02886600
C	-3.27418100	4.37310400	-0.01047400
C	-3.73875300	3.19544200	-0.59371200
H	-3.15494700	-2.37638100	-2.04464200
H	-5.60590600	-2.36030400	-2.51338200
H	-6.98147000	-0.38332400	-1.80477400
H	-5.88118200	1.54365000	-0.71361000
H	-1.13291200	2.98694100	2.25536500
H	-1.98589300	5.22352900	1.51507500
H	-3.64923000	5.33754400	-0.36037300
H	-4.47593300	3.25095800	-1.39724100
O	-1.79693000	-0.52480100	-0.92255700
O	-1.79221300	0.70123500	1.29919300
P	-0.80399900	-0.34759900	0.44200100
N	-0.95858900	-1.85051200	1.14404700
C	-0.25429500	-1.85255400	2.43577500
H	0.37978700	-2.75269500	2.48895700
C	-1.20943300	-1.85125000	3.63422600
H	-1.87705800	-0.97652700	3.58661400
H	-1.82693700	-2.75988800	3.66851400
H	-0.63177100	-1.80306700	4.57103700
C	0.61484200	-0.59979400	2.38665400
H	0.67960400	-0.13979200	3.38715100
H	1.64315400	-0.85108200	2.06700200
H	0.67326300	0.83912000	1.96404400
C	-1.73377600	-2.99790700	0.63594900
H	-1.75422400	-2.87549600	-0.45469400
C	-3.18336100	-3.02880100	1.14399500
H	-3.77027100	-3.75810100	0.56368900
H	-3.23258700	-3.32184500	2.20267200
H	-3.66423300	-2.04734100	1.03724000
C	-1.01219400	-4.31747300	0.92914900
H	-1.04442100	-4.57009200	2.00041100
H	-1.50747700	-5.13426600	0.38216500
H	0.04057100	-4.27693400	0.61711400
Pd	0.95440000	0.32226400	-0.81545000
O	2.23405600	-2.65990500	-0.18711600
O	0.92394200	-1.55176500	-1.65484000
O	1.06772000	1.91881100	2.06017200

O	0.98897400	2.26995500	-0.15586100
C	1.47108900	-2.60406900	-1.17955800
C	1.13684900	-3.87645500	-1.93354500
H	1.60681700	-4.74726100	-1.46075400
H	0.04556500	-4.00824100	-1.97127700
H	1.49064800	-3.78095000	-2.97153500
C	1.24127300	2.63647600	1.01687300
C	1.79290500	4.01971000	1.21660600
H	1.73045200	4.32403600	2.26827300
H	2.84878000	4.00802800	0.90095400
H	1.25583900	4.72759500	0.57053800
O	2.61581000	0.99150200	-2.01297600
C	3.64996100	1.47542900	-1.45723100
O	4.10587800	1.13063500	-0.33124100
C	4.36318400	2.58581900	-2.20354200
H	5.38692800	2.72114900	-1.83204400
H	4.36507600	2.38378300	-3.28365600
H	3.79729900	3.51801600	-2.04097600
Ag	3.33079500	-0.80676300	0.41606900

C' optimised geometry [# opt=(calcfc) b3lyp scrf=(solvent=dichloromethane) guess=read pop=full geom=check #empiricaldispersion=gd3 #freq=noraman #p chkbasis gfinput integral=ultrafinegrid iop(6/7=3) scf=tight def2svp]

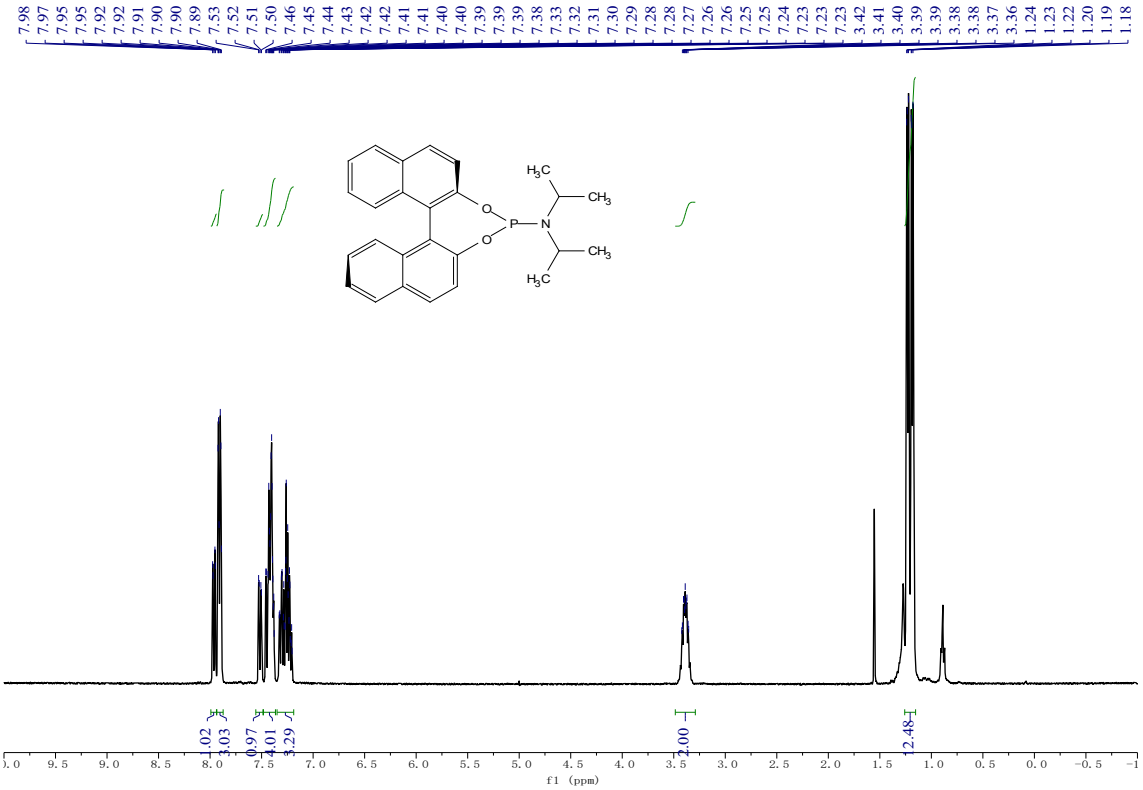
EE + Thermal Free Energy Correction: -2204.703146 (-41.5 kcal/mol)

0 1

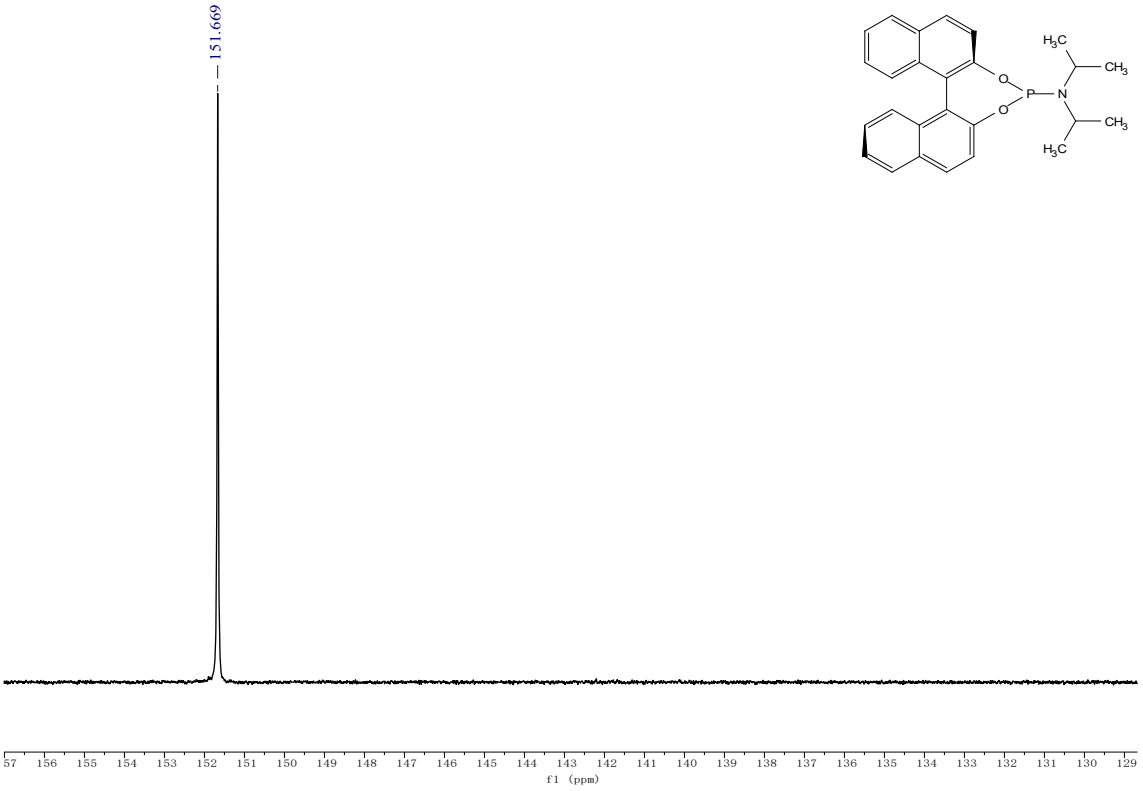
C	-3.64191800	1.33855700	-0.35504500
C	-3.00477900	0.44983900	-1.24361100
C	-3.64936200	-0.05766100	-2.37254600
C	-4.97169500	0.30479800	-2.63244400
C	-5.63665000	1.17501500	-1.76052100
C	-4.97583700	1.68575200	-0.64260200
C	-2.92260400	1.92559300	0.80063800
C	-2.07022400	1.15336500	1.61371800
C	-1.33329900	1.72011700	2.65494400
C	-1.45421900	3.08591700	2.91789300
C	-2.31775300	3.87288000	2.14648700
C	-3.04056100	3.29569500	1.10216200
H	-3.09865000	-0.73045800	-3.03181900
H	-5.48139400	-0.09419100	-3.51219000
H	-6.67472700	1.45586700	-1.95132700
H	-5.50153200	2.35959500	0.03732200
H	-0.65760400	1.08539200	3.22869400
H	-0.87018800	3.53356100	3.72510500
H	-2.41564500	4.94186300	2.34803900
H	-3.68432500	3.91986600	0.47870800
O	-1.67224400	0.09367500	-1.04421700
O	-1.99598300	-0.21864900	1.42652900
P	-1.13063600	-0.92480000	0.20694300
N	-1.84316300	-2.41027900	0.09634100
C	-0.85049200	-3.51853900	0.04241200
H	-1.26892000	-4.28997000	-0.62643000
C	-0.58222000	-4.14456100	1.41596900
H	-0.16834000	-3.38768900	2.10192200
H	-1.48800600	-4.56663900	1.86862700
H	0.15609100	-4.95547700	1.31583100
C	0.44044500	-2.97121200	-0.58058400
H	1.29032300	-3.64161200	-0.39175900
H	0.32342100	-2.83375200	-1.66979600
C	-3.30904000	-2.62090700	0.16081900
H	-3.74750600	-1.61918200	0.05267000
C	-3.79219200	-3.16458000	1.50998800
H	-3.52455300	-4.22269300	1.64633400
H	-3.36334600	-2.58112100	2.33746200
H	-4.88981900	-3.09070000	1.56332500
C	-3.80442700	-3.46336000	-1.01657200
H	-3.47386400	-4.51074300	-0.93548500
H	-4.90505400	-3.46280300	-1.03672700
H	-3.44113100	-3.05593200	-1.97160400
Pd	1.03053900	-1.15008300	0.18333000
O	1.60189100	0.85474400	0.74819700
O	1.66757100	0.39075900	2.94166400
C	1.83406500	1.15160400	1.98512800
C	2.32746100	2.58008500	2.19213700

H	1.57776200	3.28715800	1.80377500
H	2.50688600	2.78166500	3.25621500
H	3.25532400	2.74255600	1.62093700
O	3.03299800	-1.91118300	0.28700800
C	4.22498200	-1.60779700	0.00866600
O	4.62505500	-0.58596100	-0.61667600
C	5.29171000	-2.57452300	0.50072600
H	6.25549000	-2.38607700	0.01056200
H	5.41069400	-2.43804400	1.58800000
H	4.96978000	-3.61209500	0.33231900
Ag	3.38658300	1.07437300	-1.18945700
O	1.99009100	2.75590700	-1.73218400
C	0.82415300	2.37374000	-1.65807600
O	0.49504700	1.20618000	-2.18168300
H	-0.39503000	0.88790700	-1.89616900
C	-0.23620000	3.16316300	-0.95286200
H	-1.22161200	3.06101900	-1.42552100
H	-0.29838600	2.75662700	0.06886500
H	0.05991200	4.21668400	-0.89315900

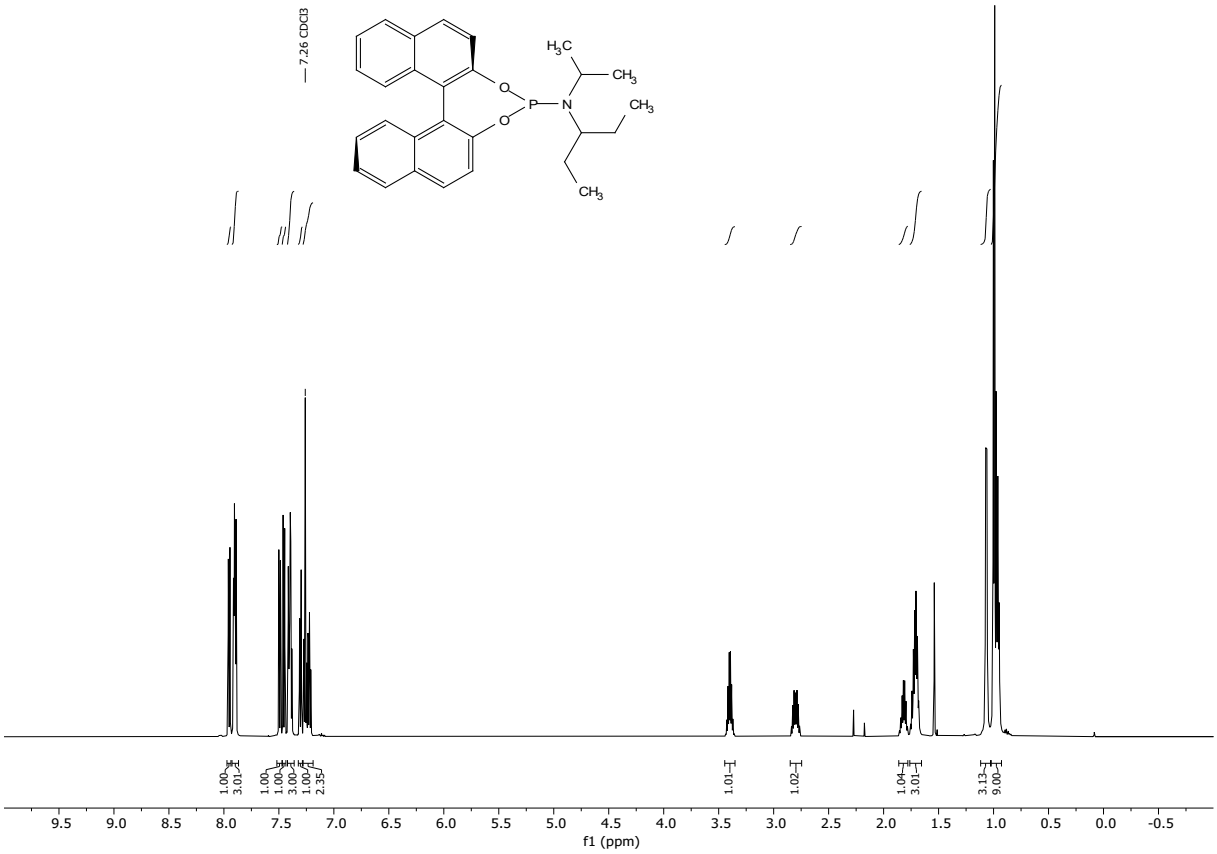
^{1}H NMR (300 MHz, $CDCl_3$)



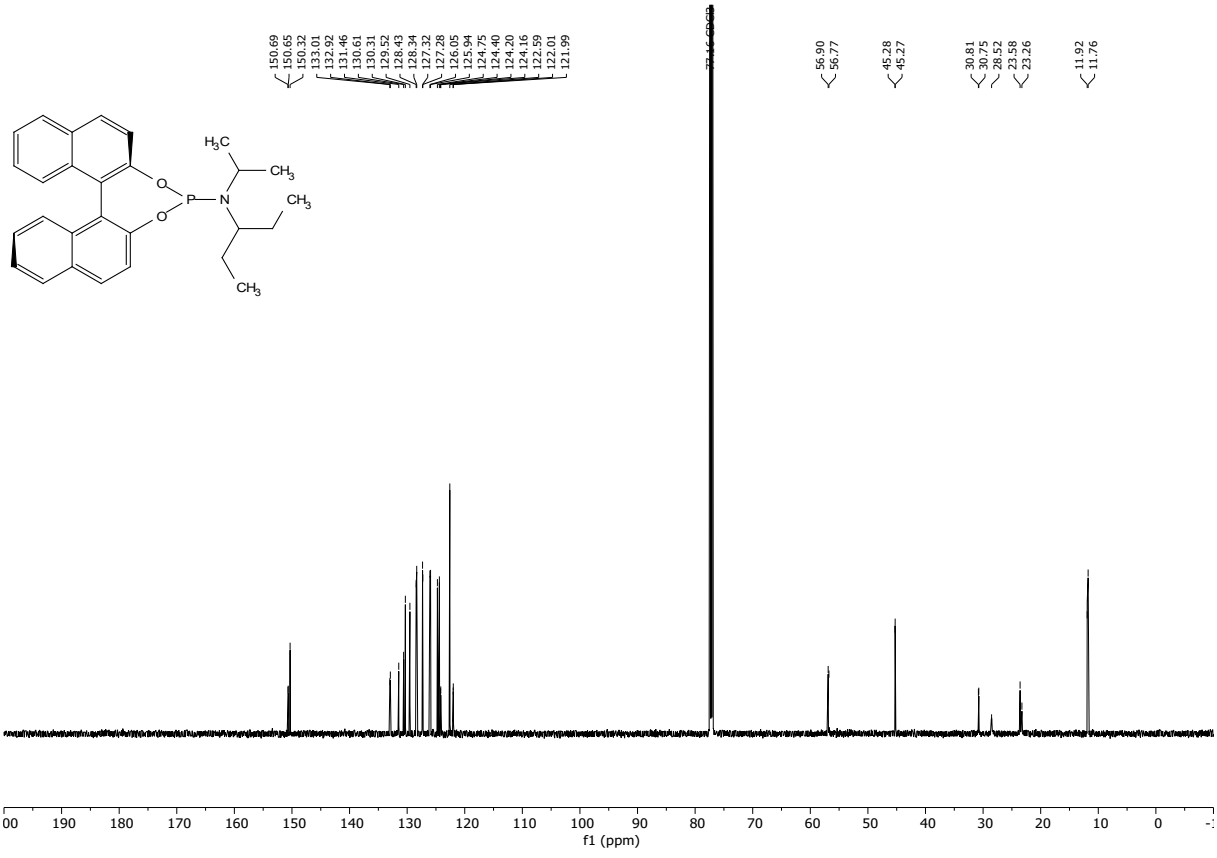
^{31}P NMR (121 MHz, $CDCl_3$)



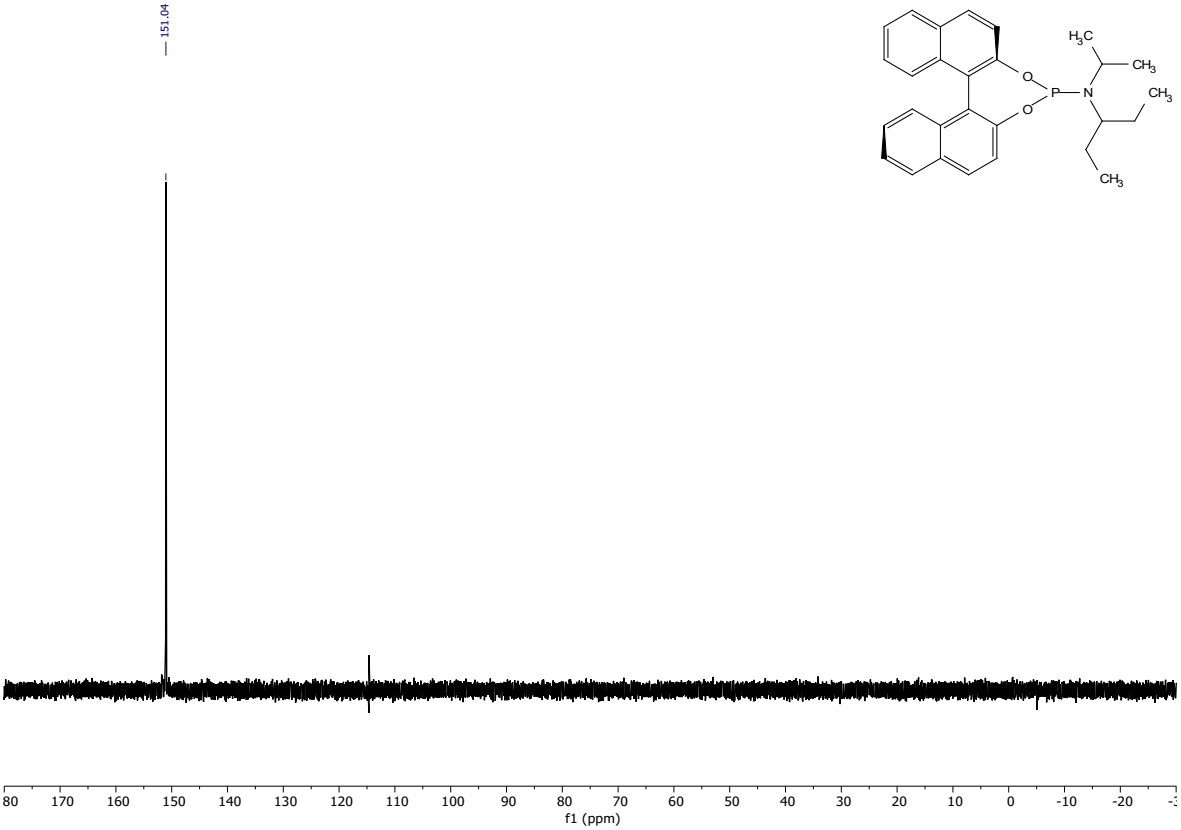
^{1}H NMR (600 MHz, $CDCl_3$)



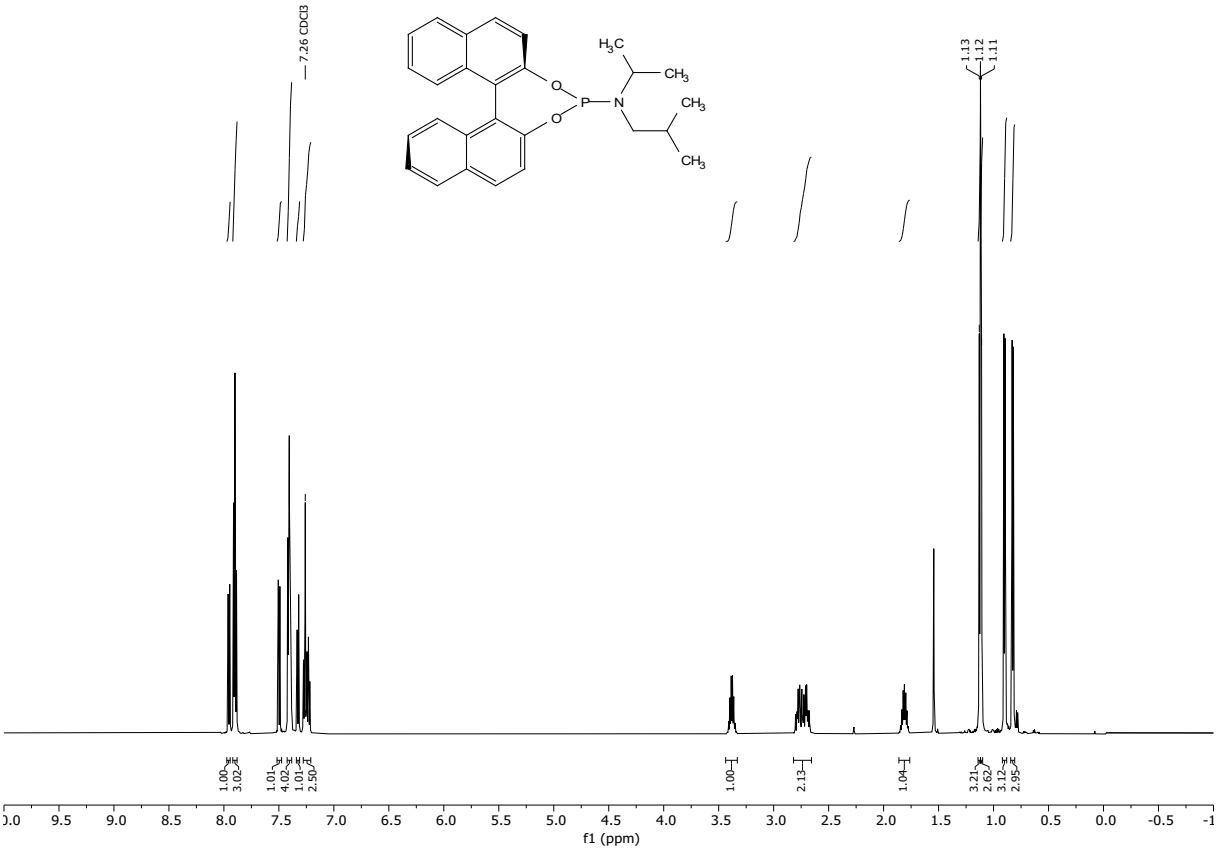
^{13}C NMR (151 MHz, $CDCl_3$)



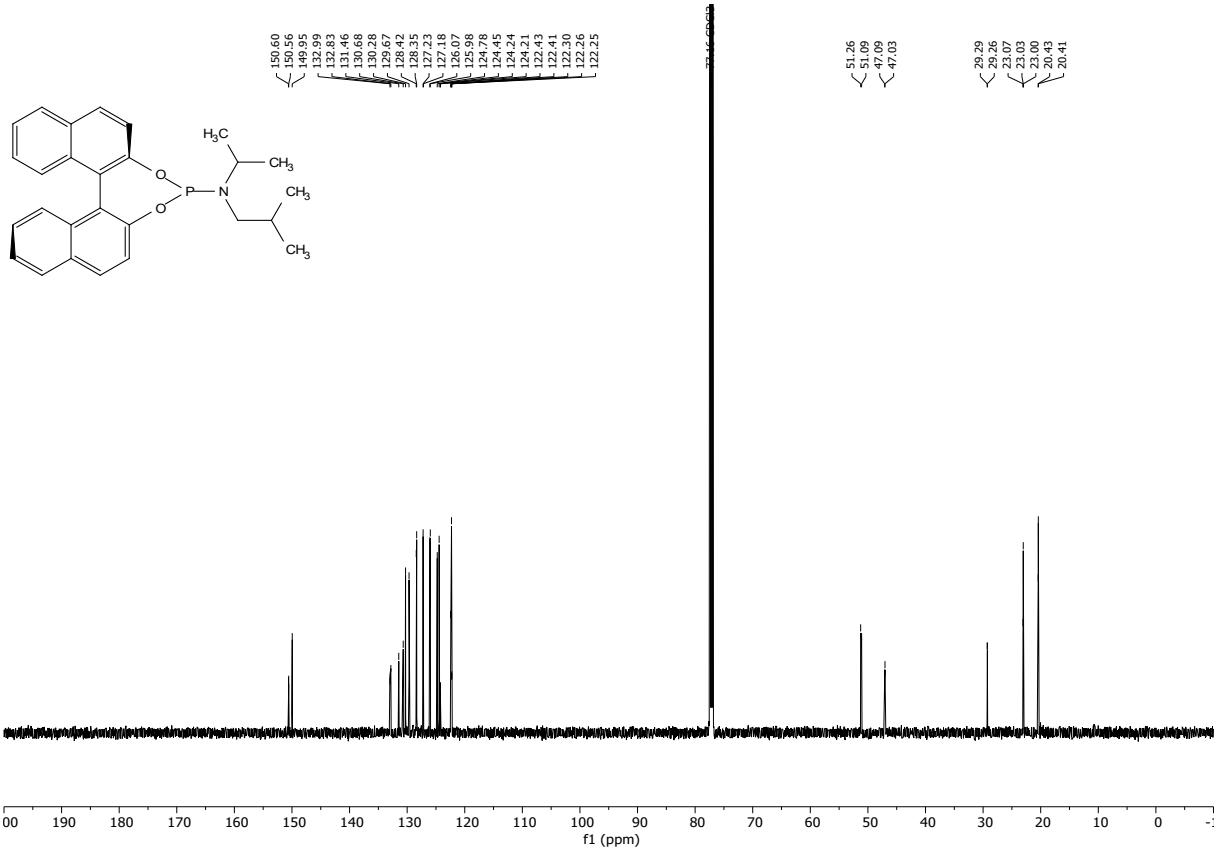
^{31}P NMR (162 MHz, $CDCl_3$)



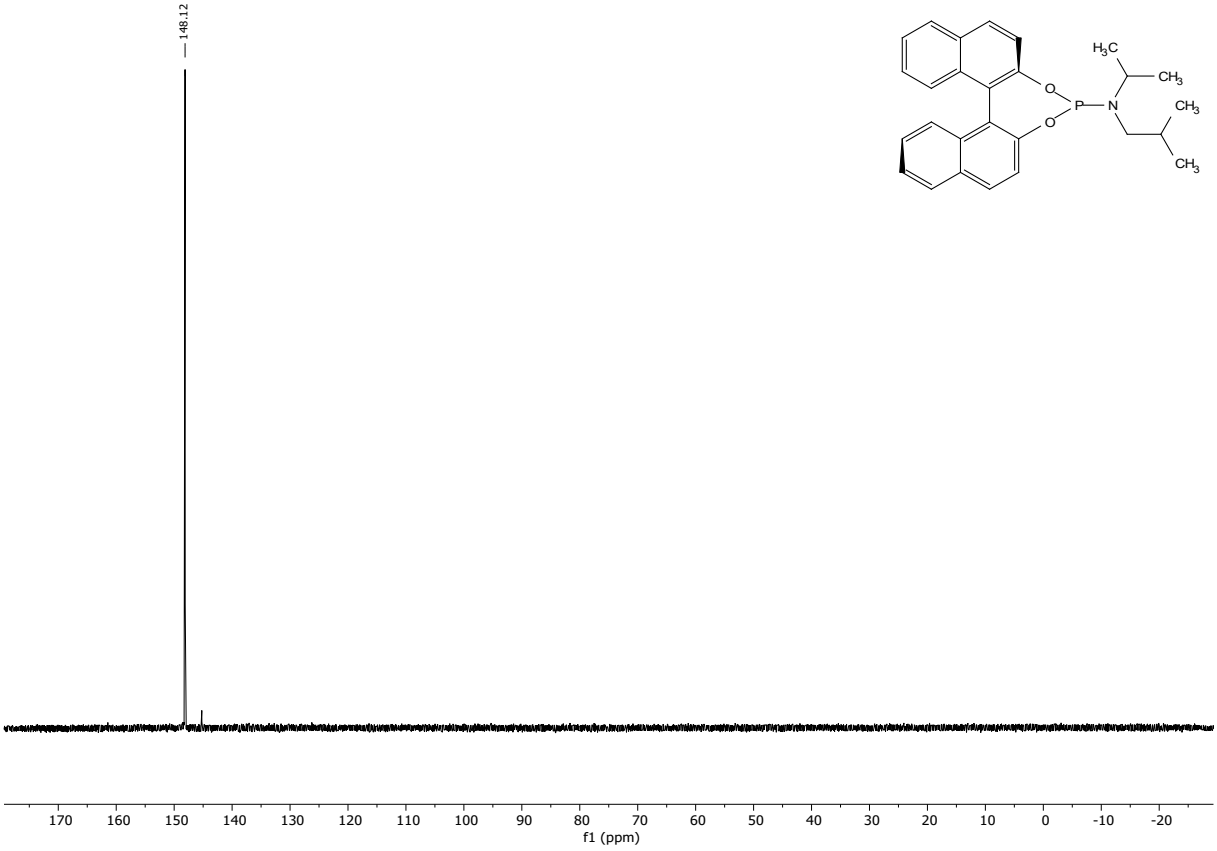
^{1}H NMR (600 MHz, $CDCl_3$)



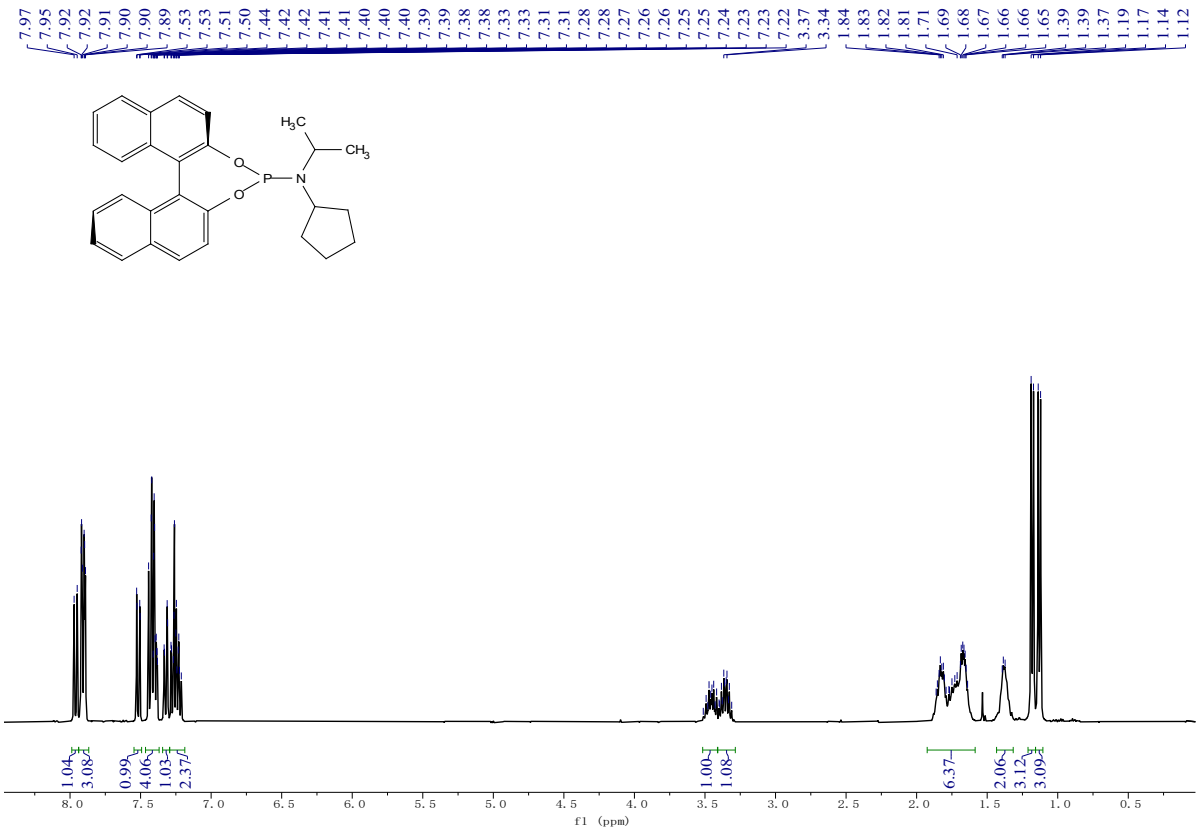
^{13}C NMR (151 MHz, $CDCl_3$)



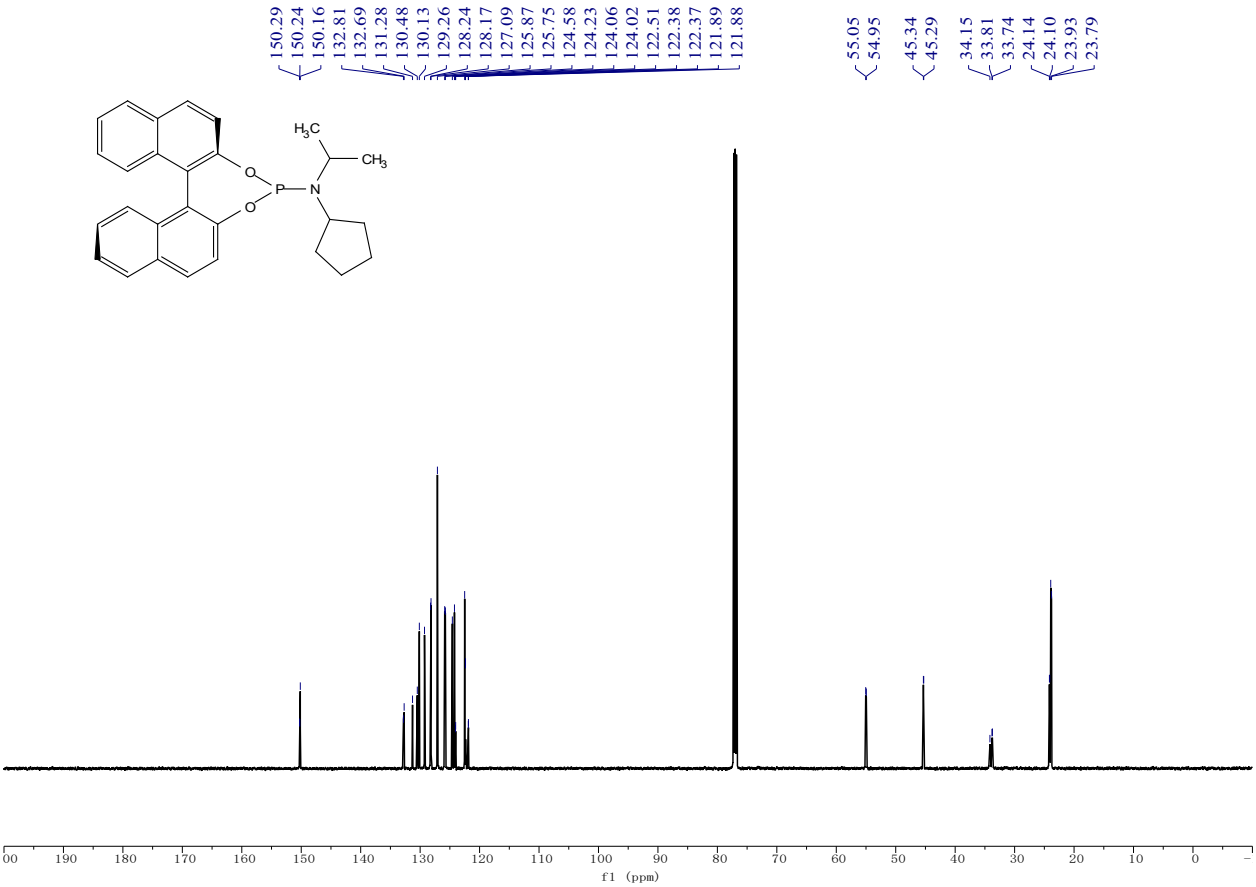
^{31}P NMR (162 MHz, $CDCl_3$)



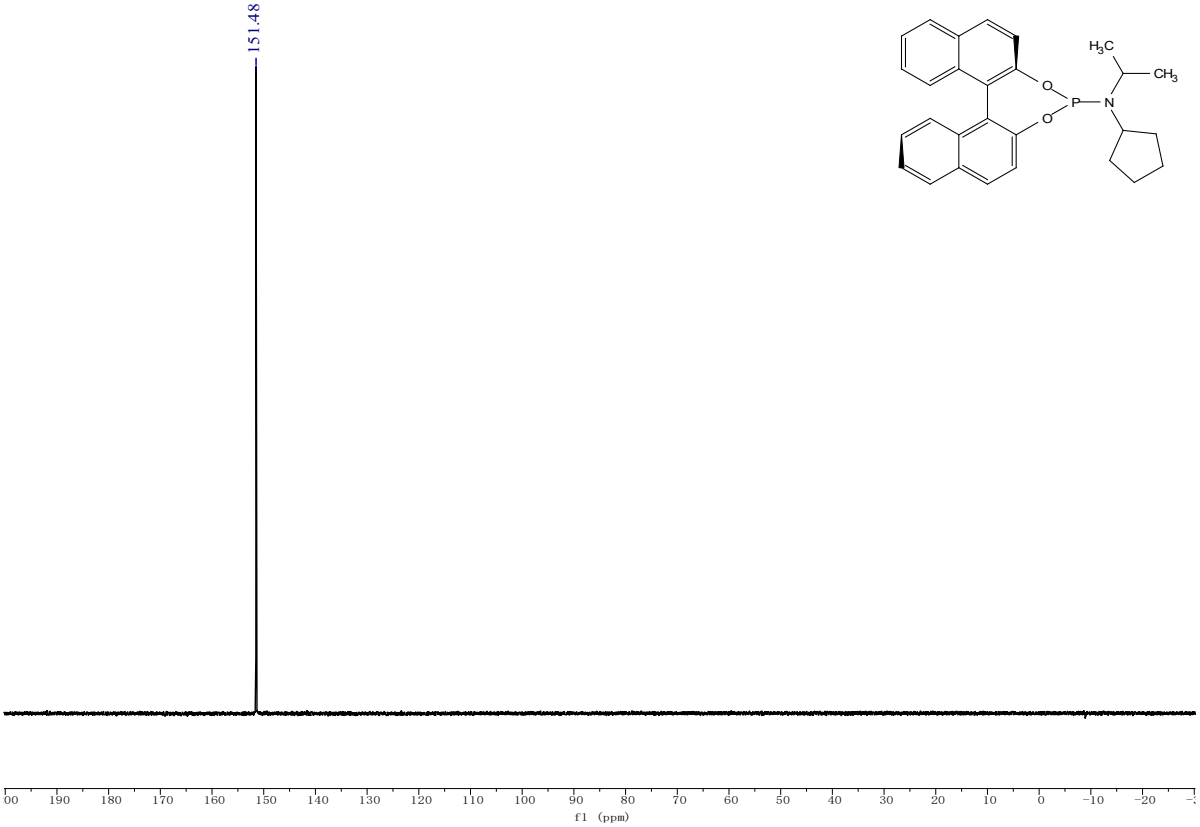
^{1}H NMR (300 MHz, $CDCl_3$)



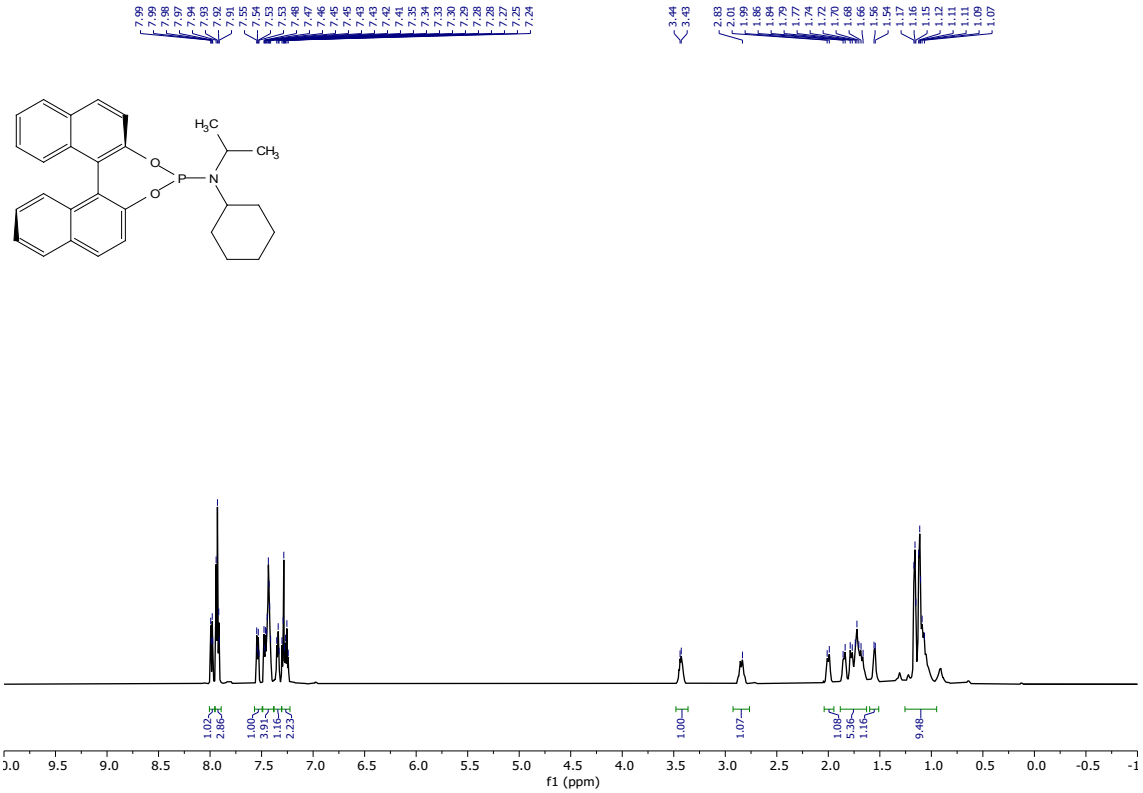
^{13}C NMR (151 MHz, $CDCl_3$)



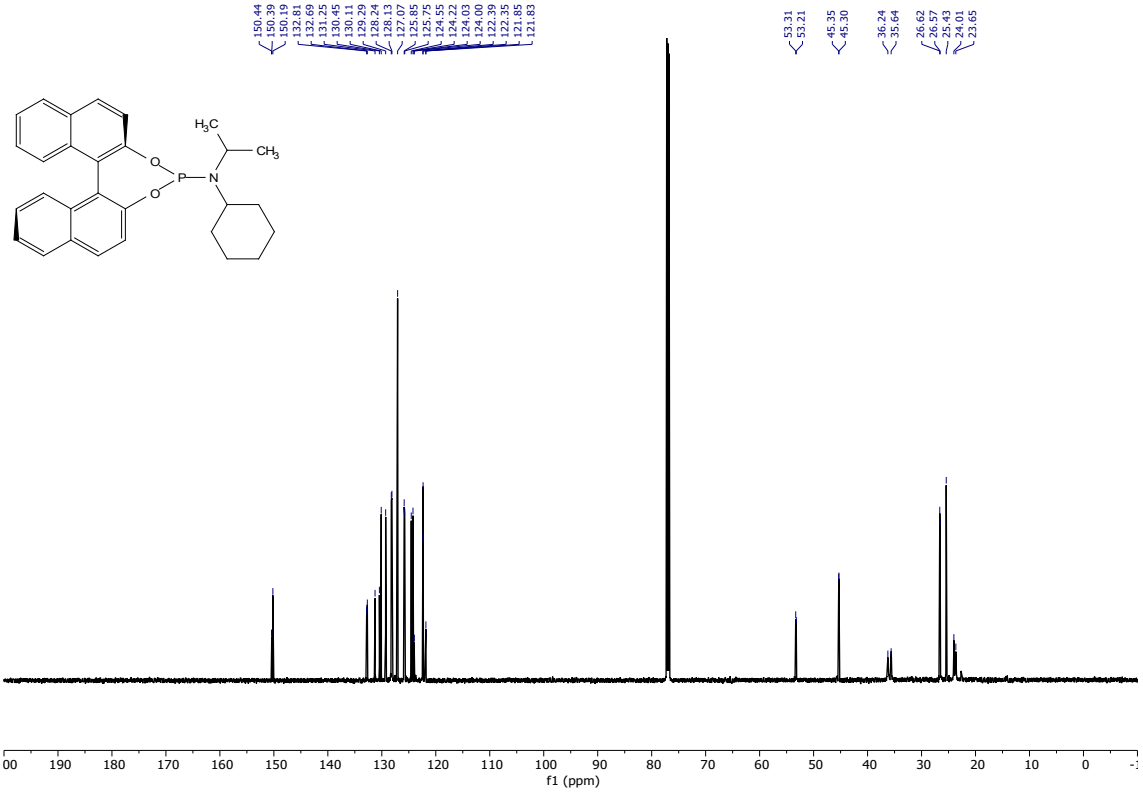
^{31}P NMR (162 MHz, $CDCl_3$)



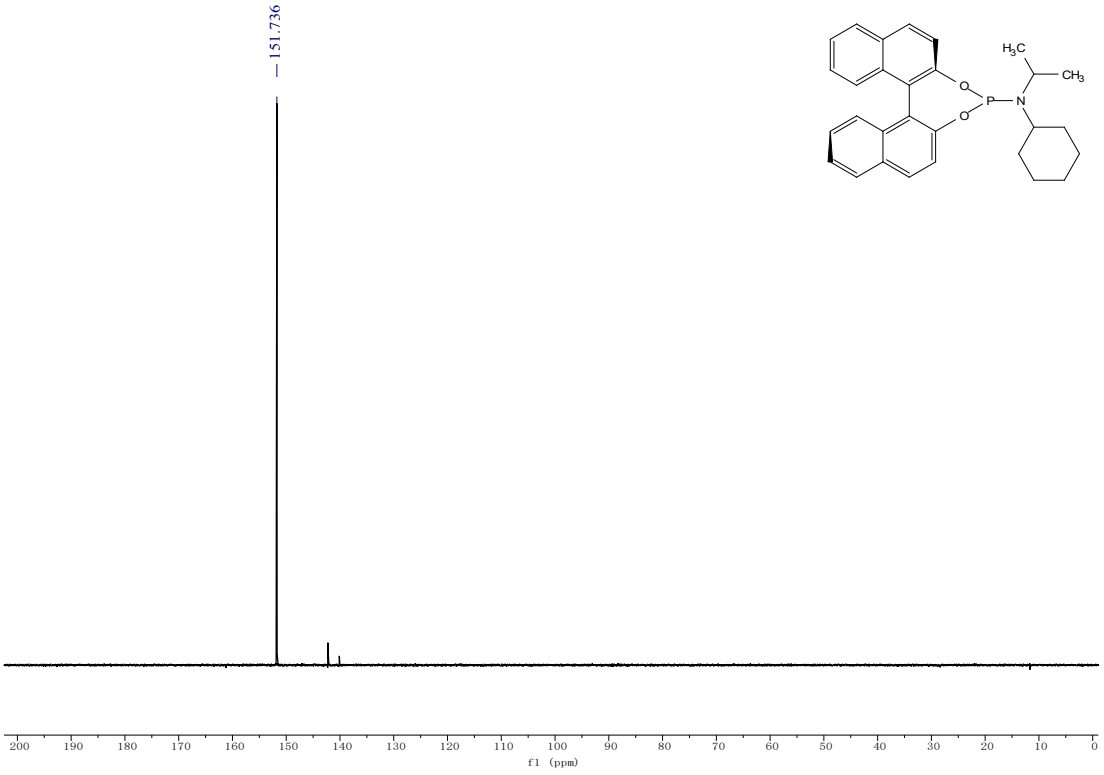
^{1}H NMR (600 MHz, $CDCl_3$)



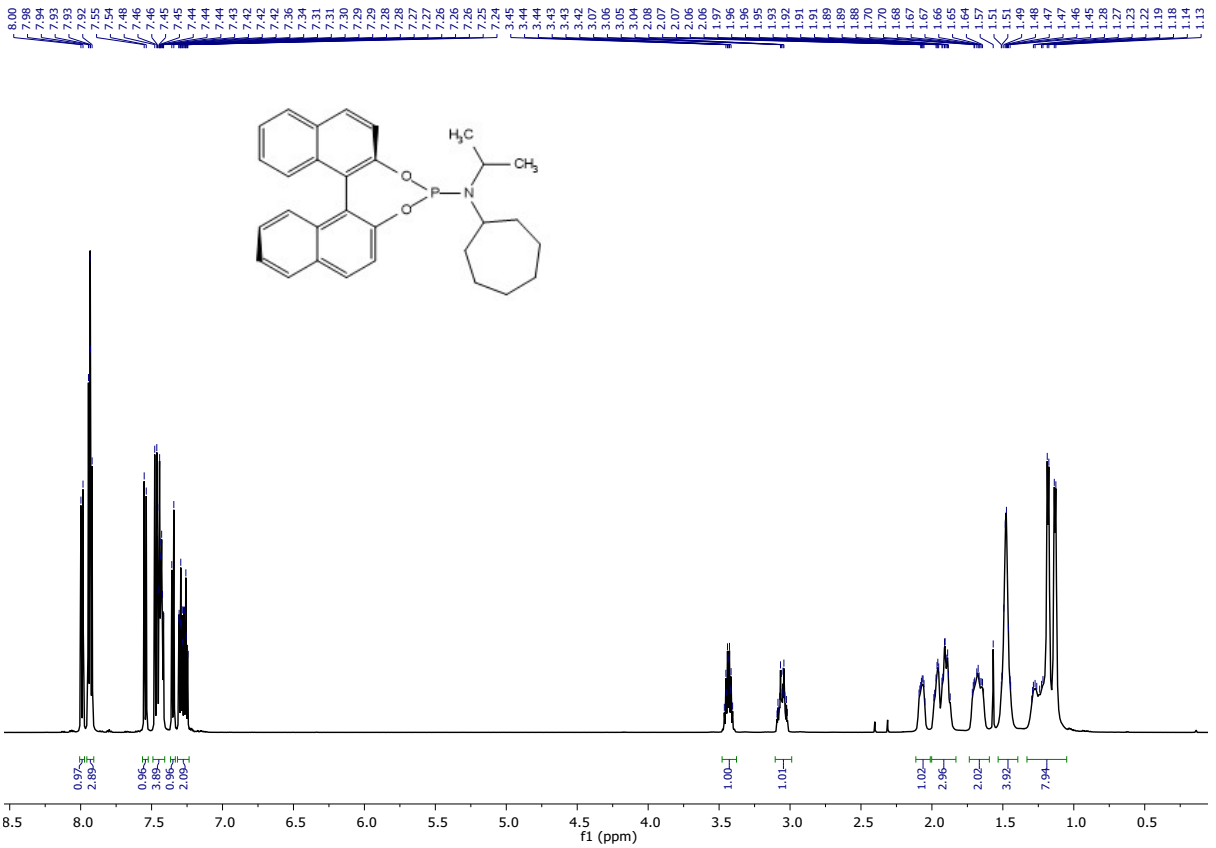
^{13}C NMR (151 MHz, $CDCl_3$)



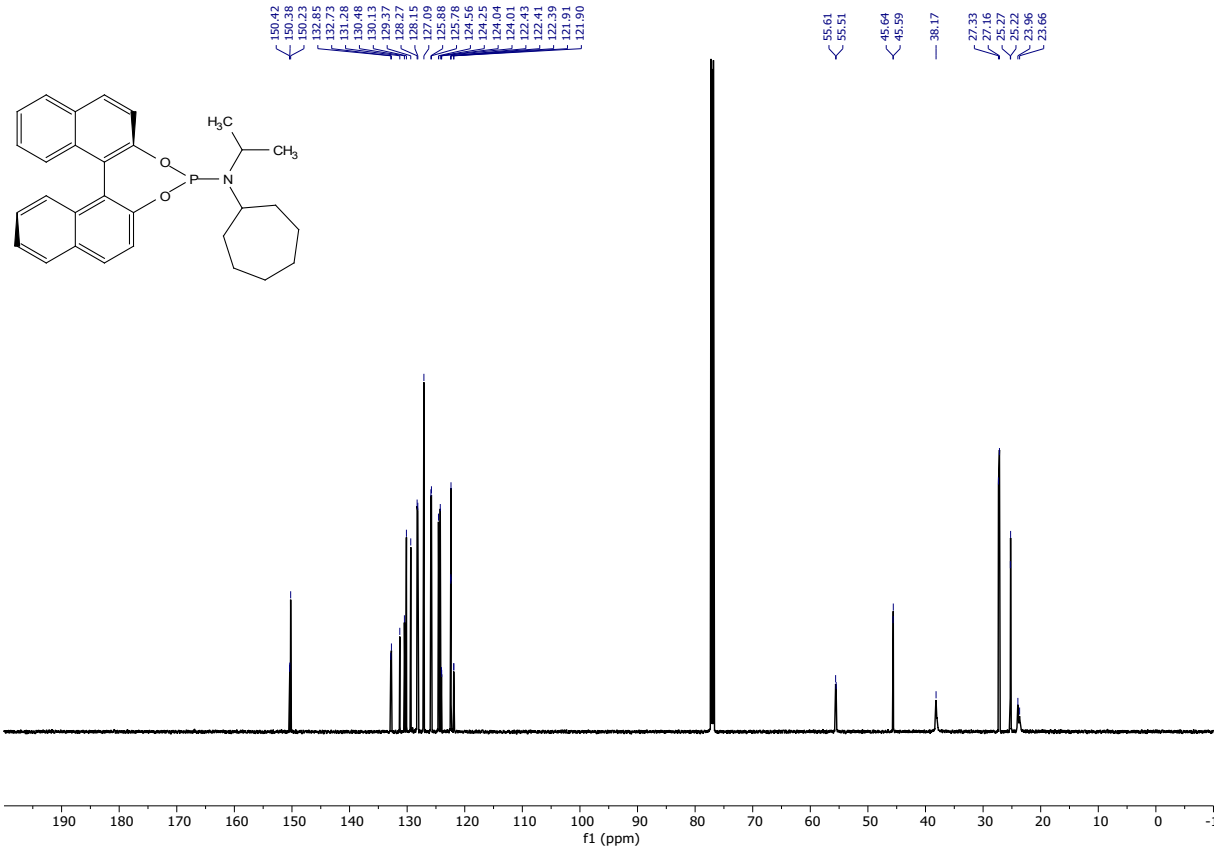
^{31}P NMR (162 MHz, $CDCl_3$)



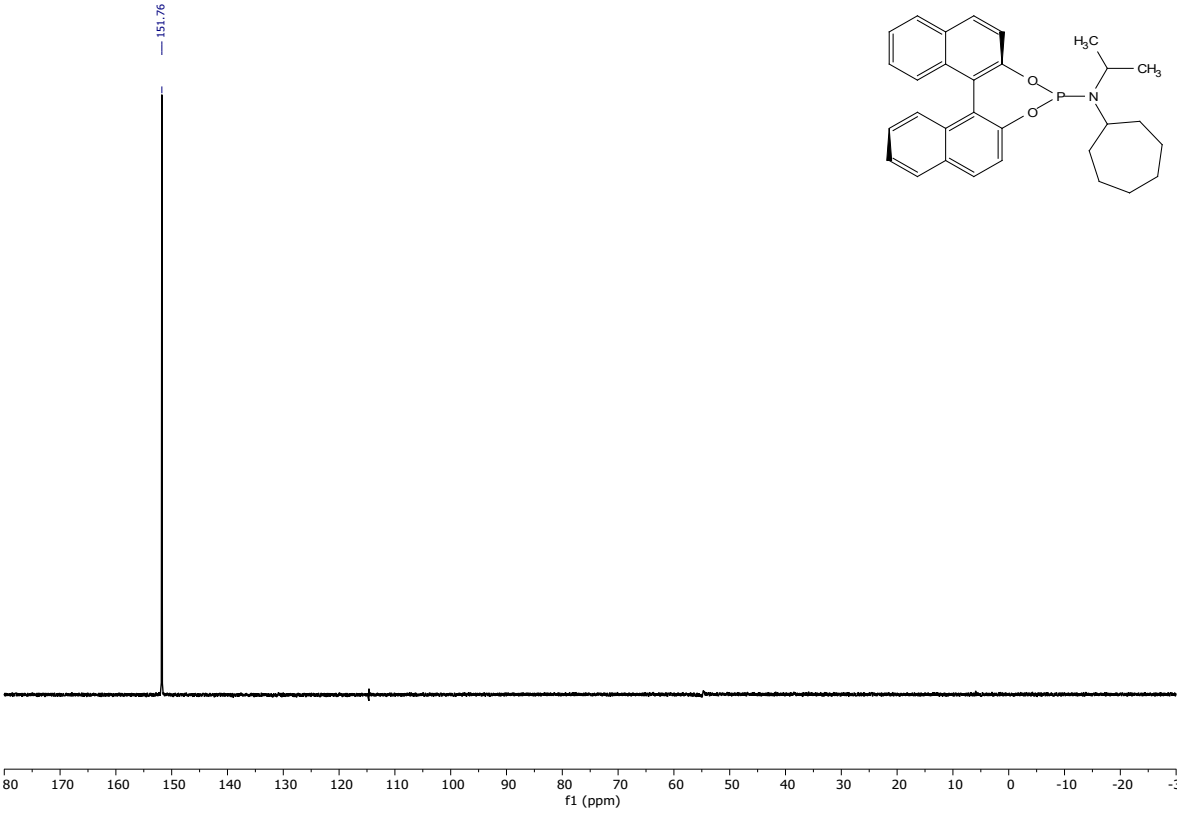
^{1}H NMR (600 MHz, $CDCl_3$)



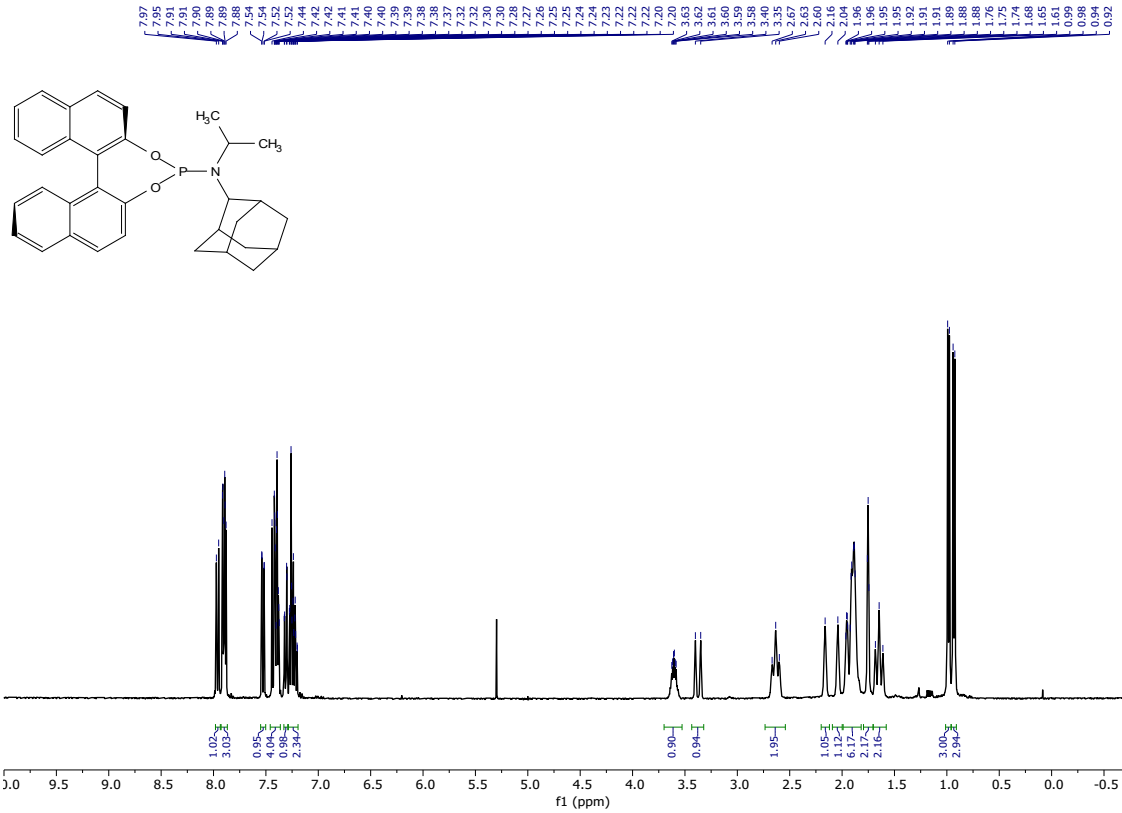
^{13}C NMR (151 MHz, $CDCl_3$)



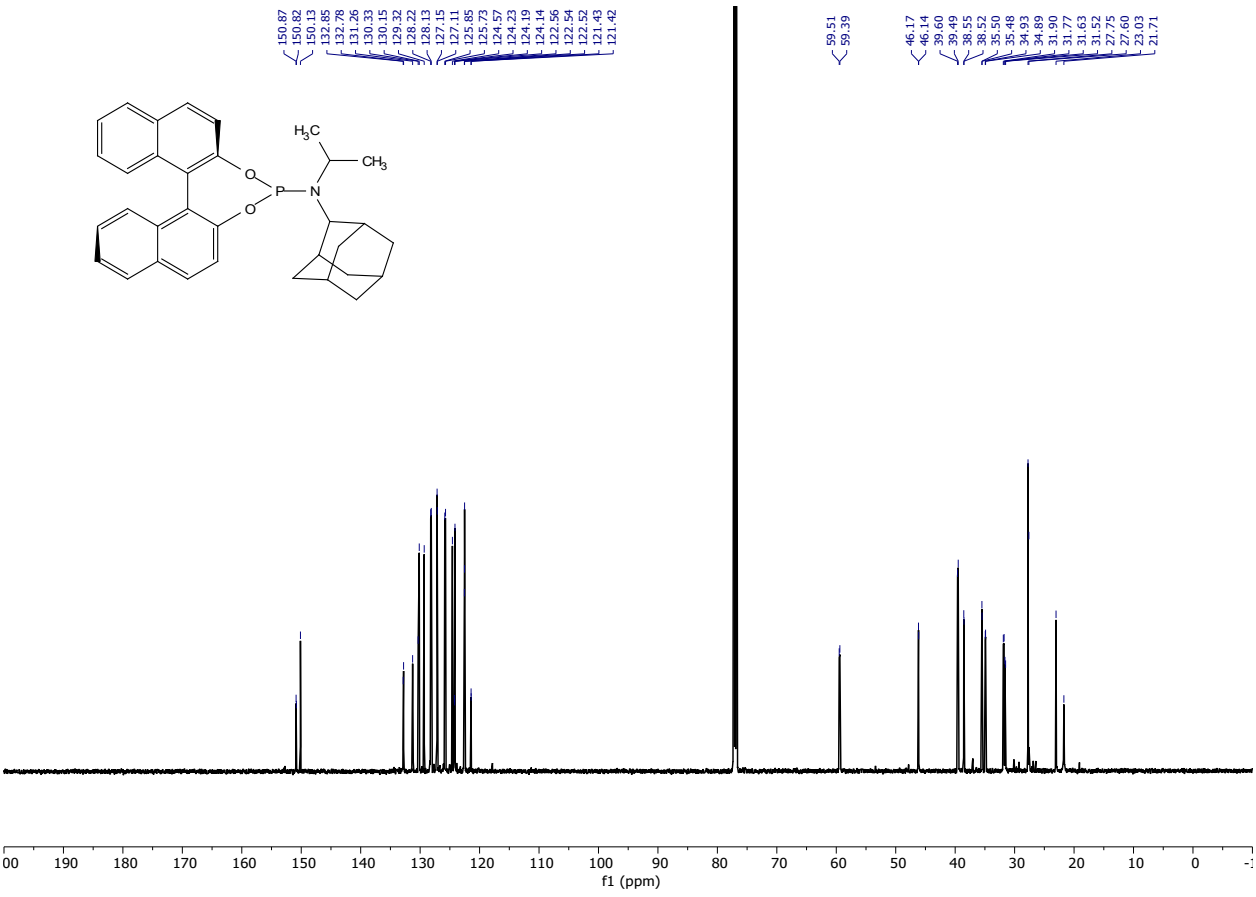
^{31}P NMR (162 MHz, $CDCl_3$)



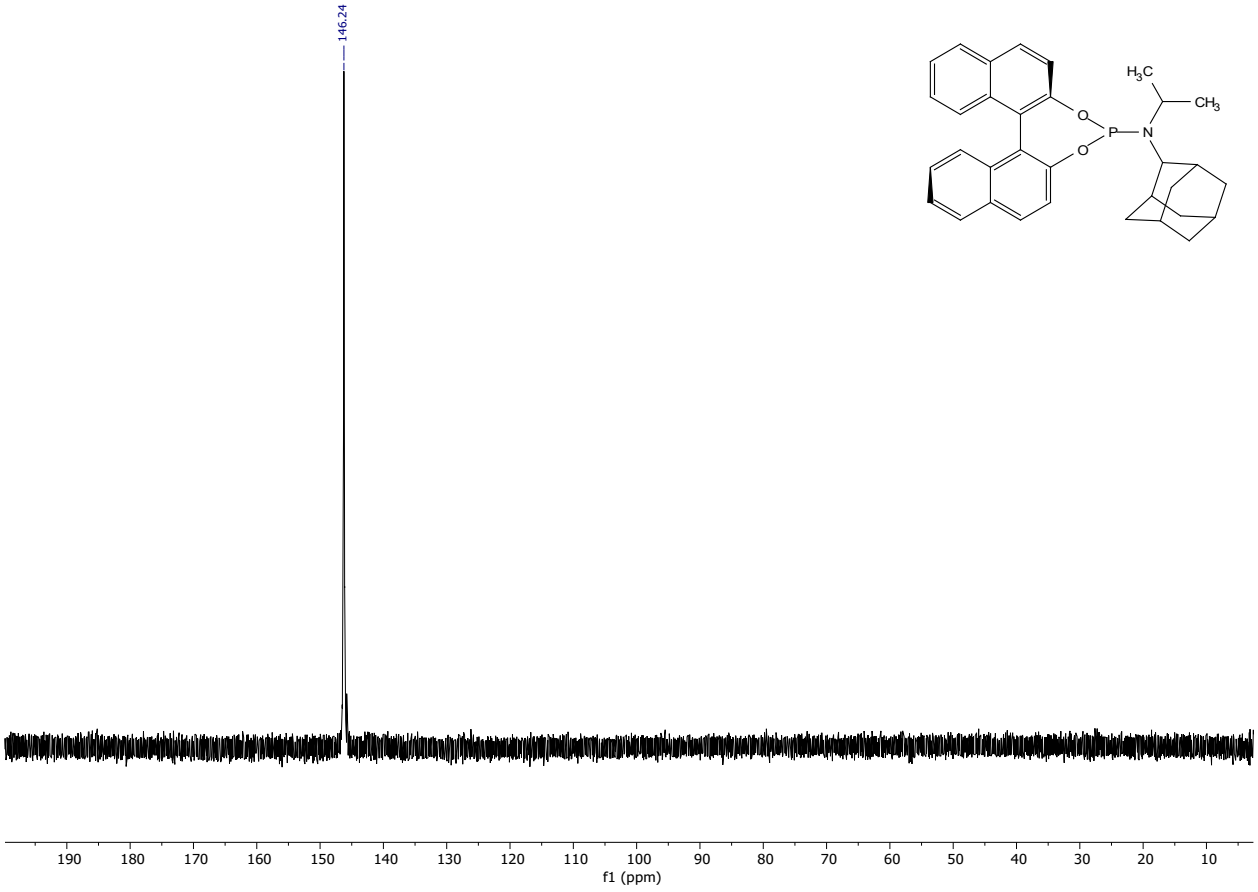
^{1}H NMR (400 MHz, $CDCl_3$)



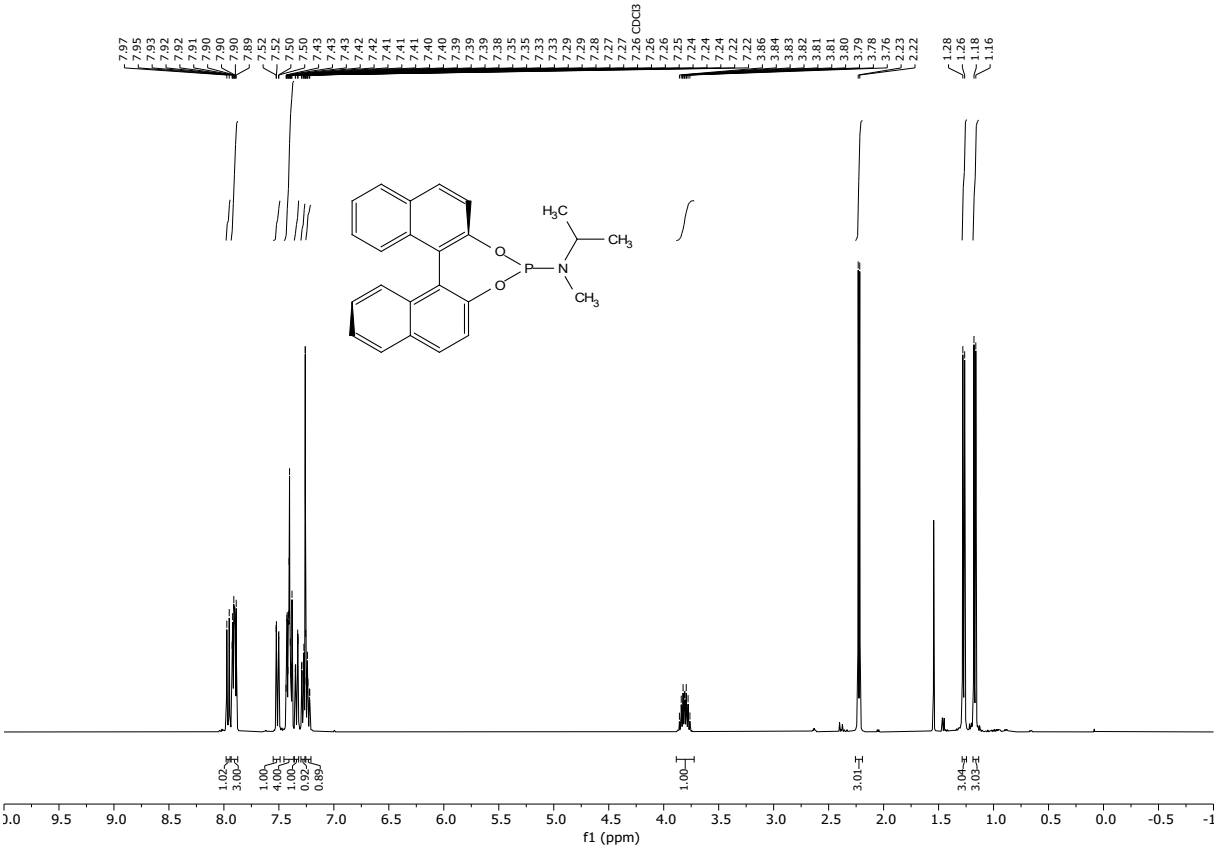
^{13}C NMR (151 MHz, $CDCl_3$)



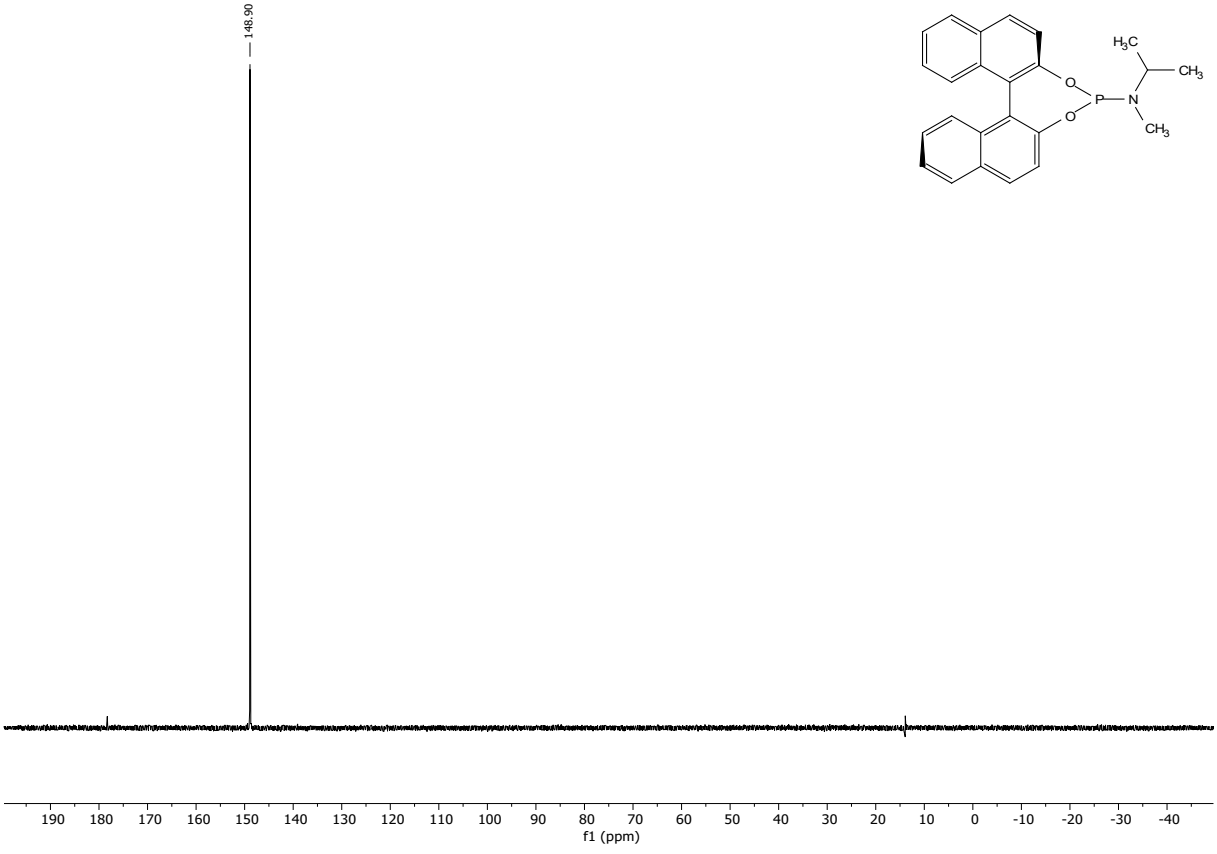
^{31}P NMR (162 MHz, $CDCl_3$)



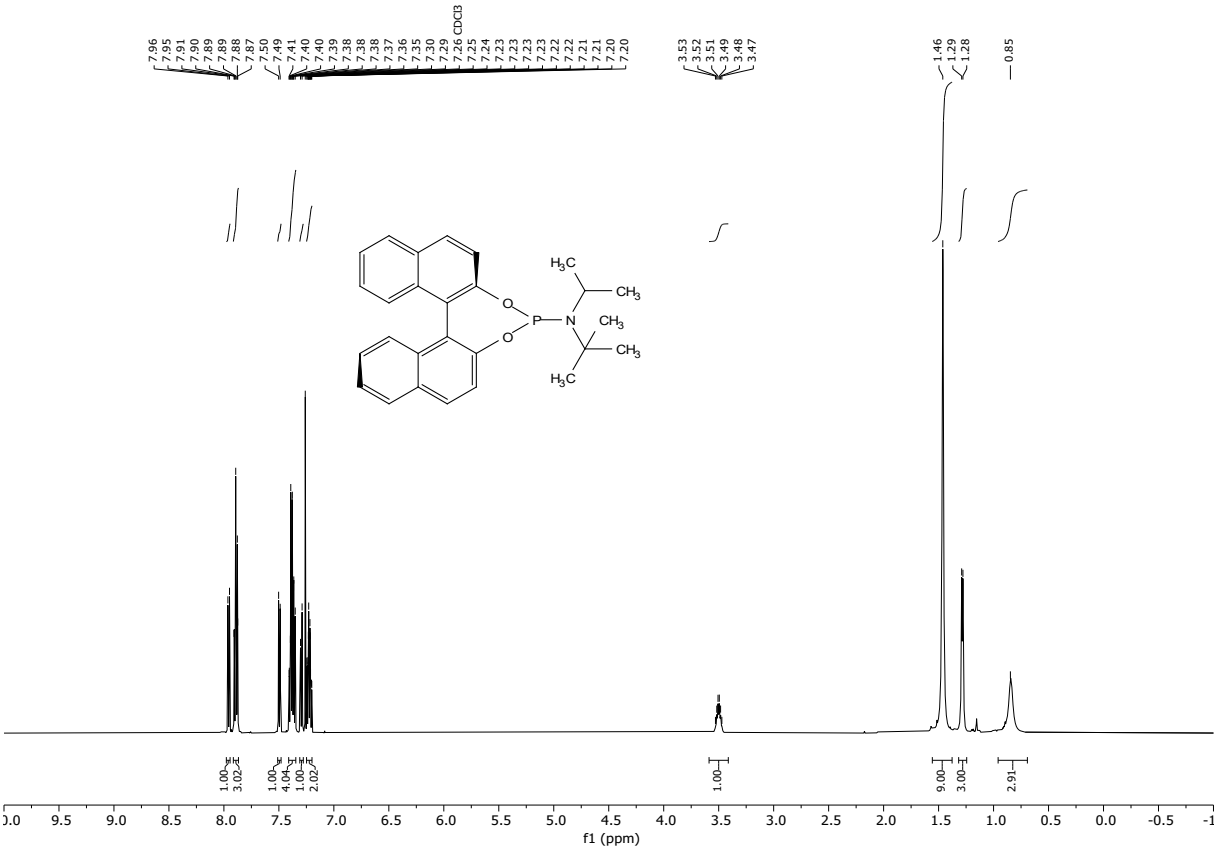
^{1}H NMR (400 MHz, $CDCl_3$)



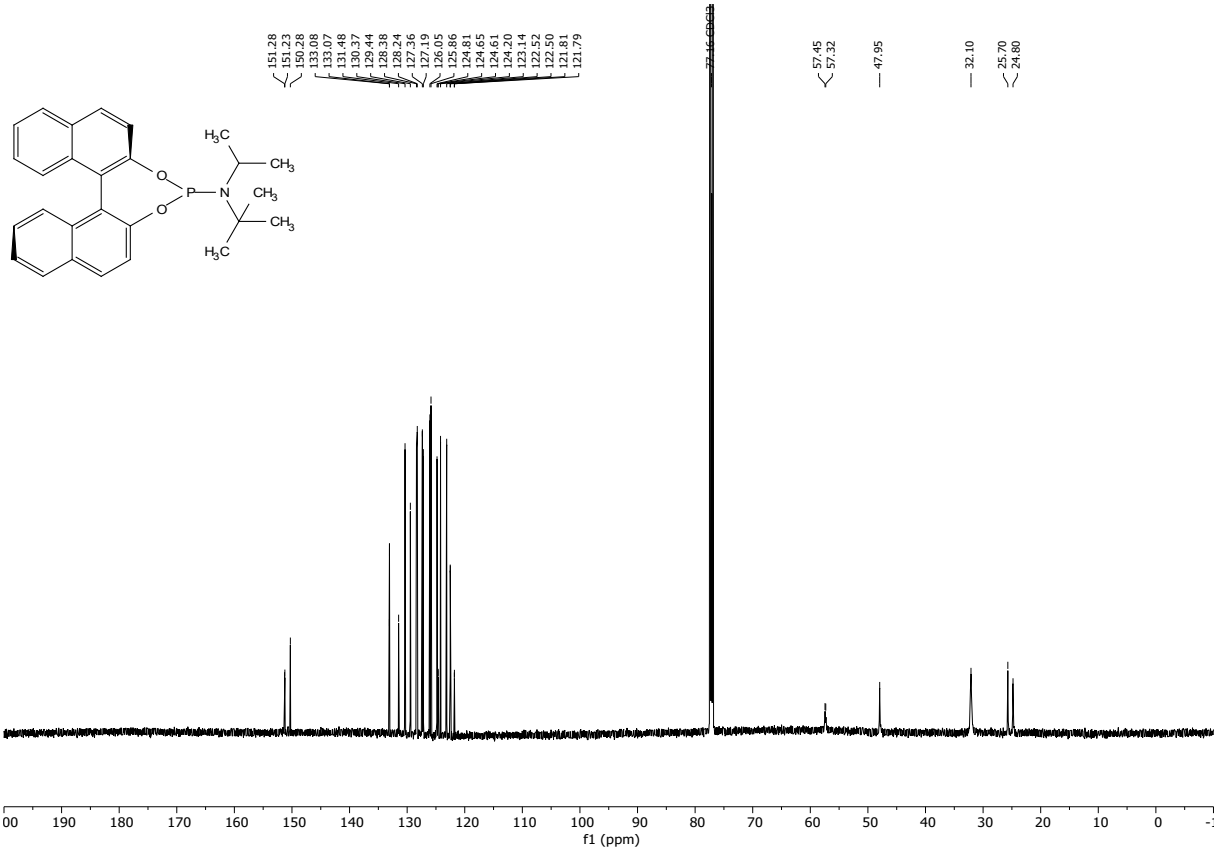
^{31}P NMR (162 MHz, $CDCl_3$)



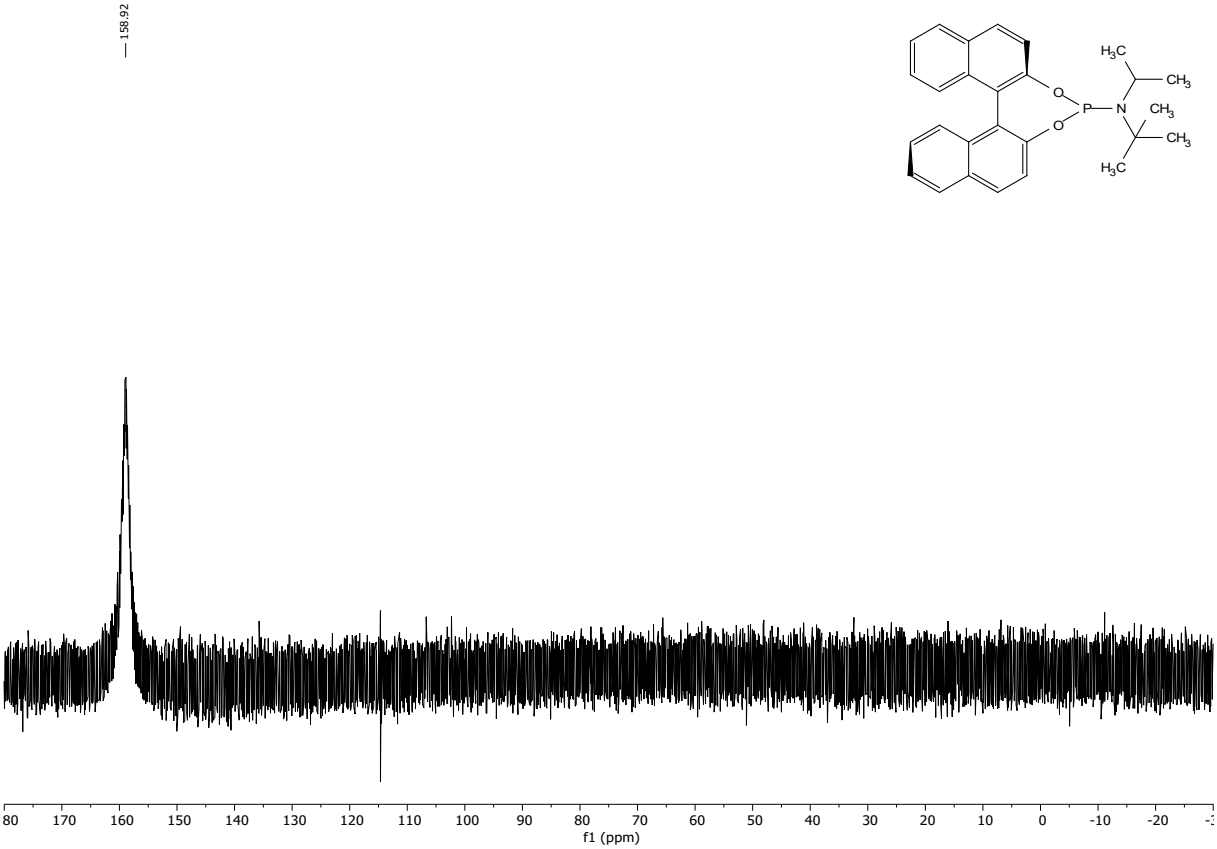
^{1}H NMR (600 MHz, $CDCl_3$)



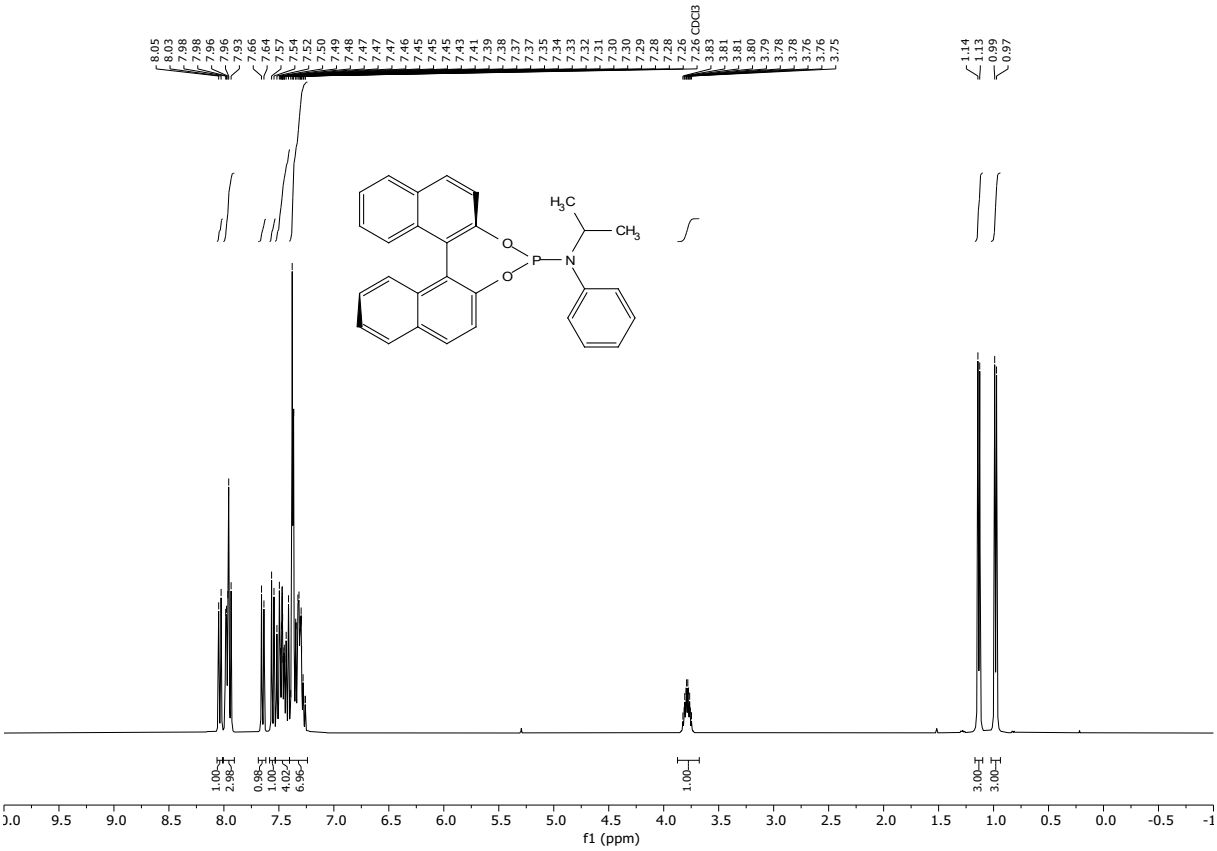
^{13}C NMR (151 MHz, $CDCl_3$)



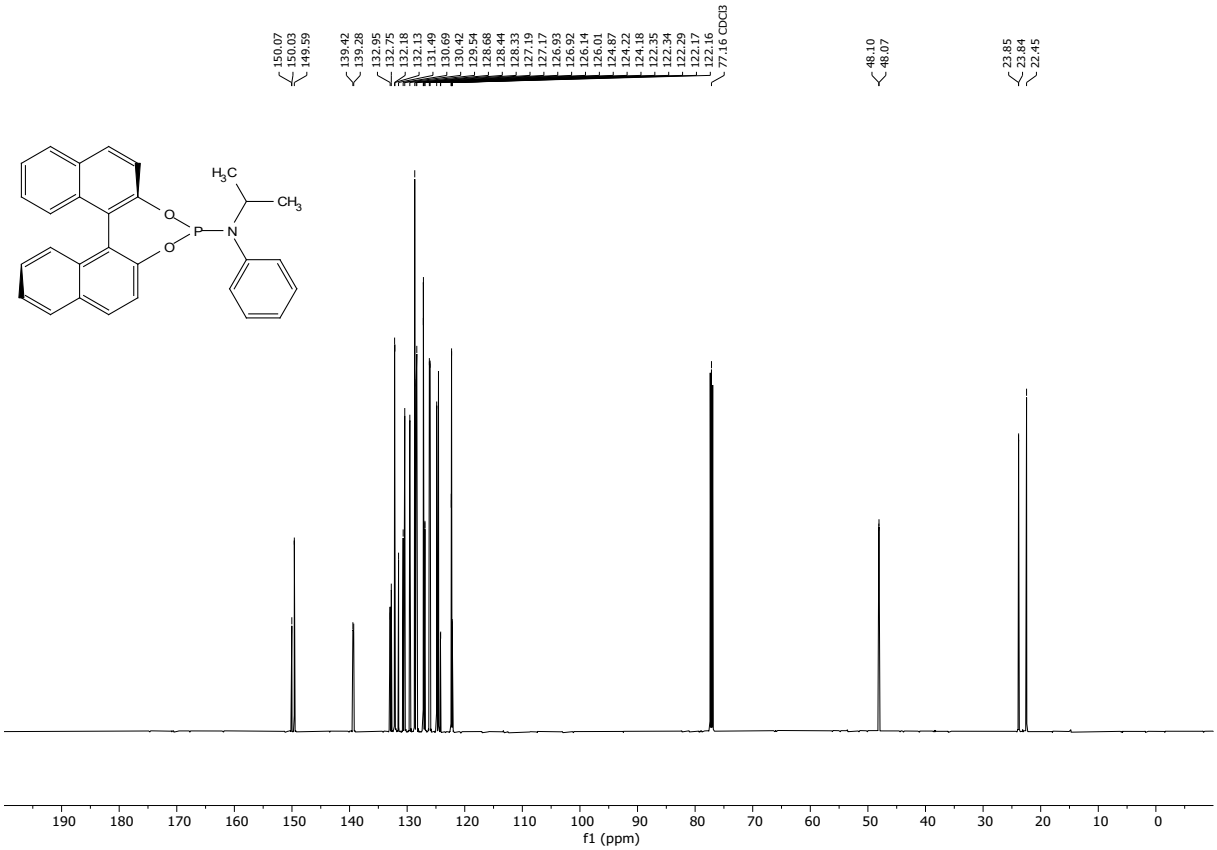
^{31}P NMR (162 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



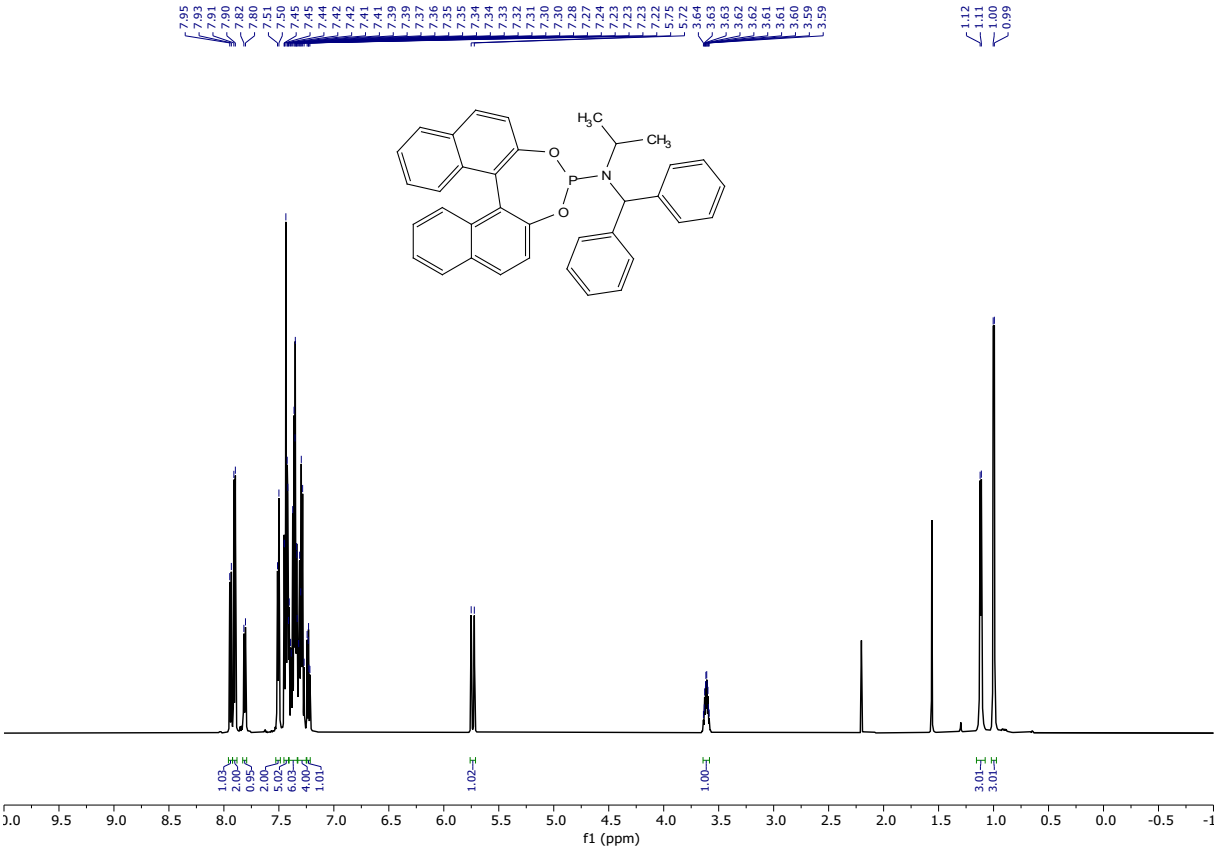
^{13}C NMR (151 MHz, $CDCl_3$)



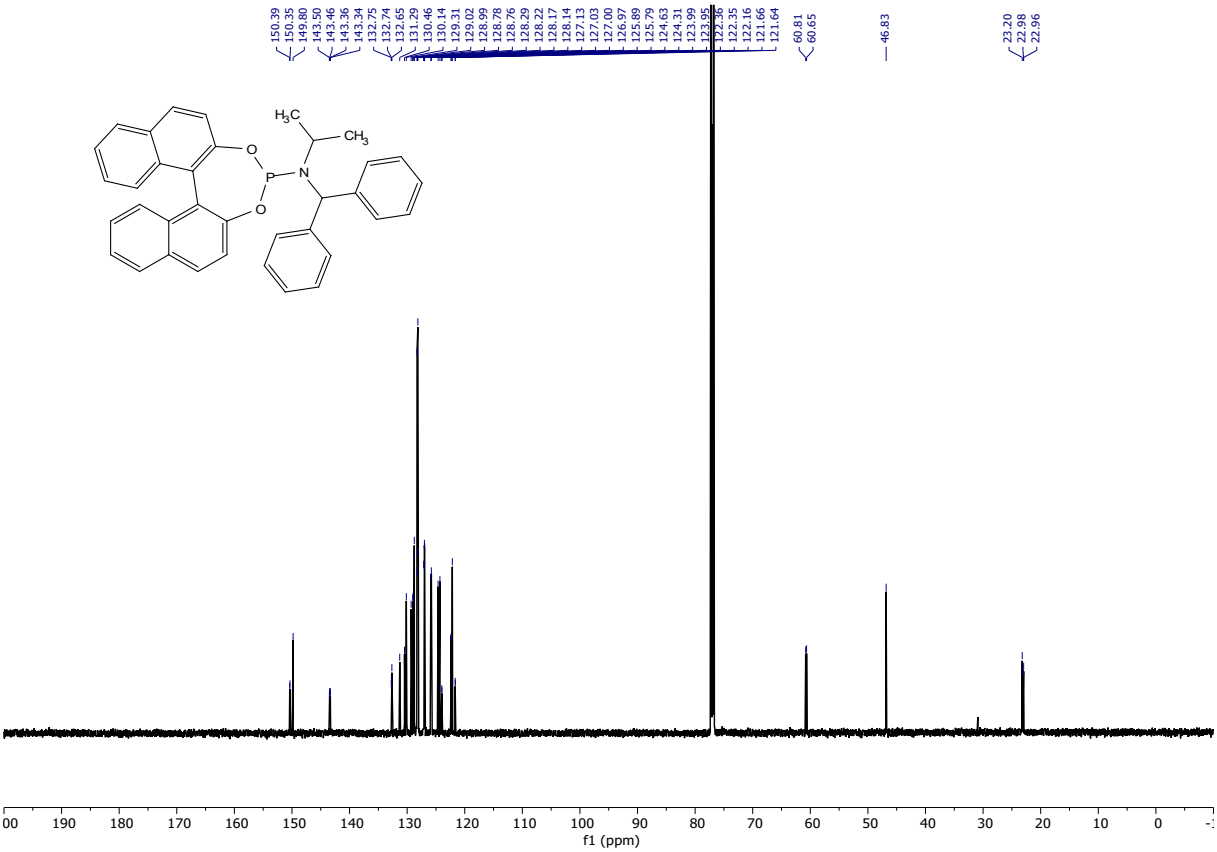
^{31}P NMR (162 MHz, $CDCl_3$)


141.76
H3C
CH3
O
P
N
O
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

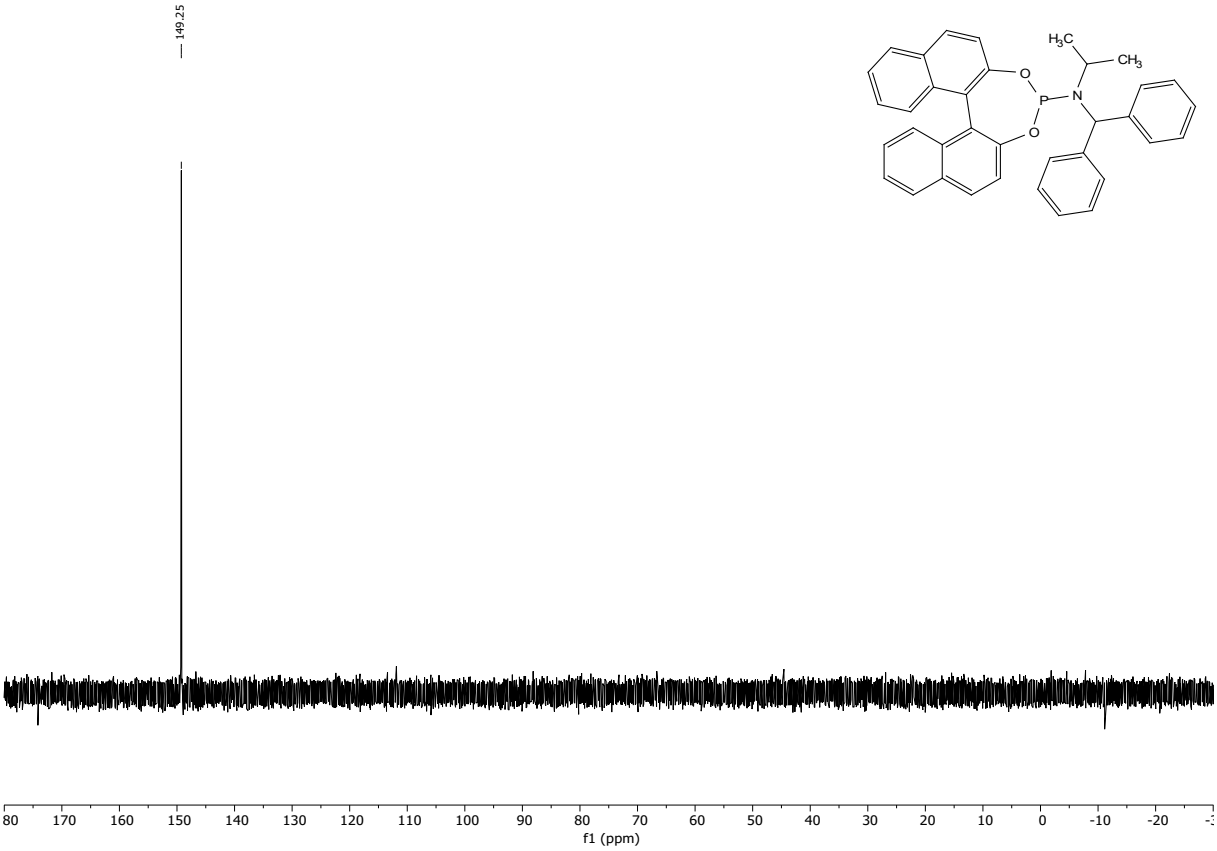
^{1}H NMR (600 MHz, $CDCl_3$)



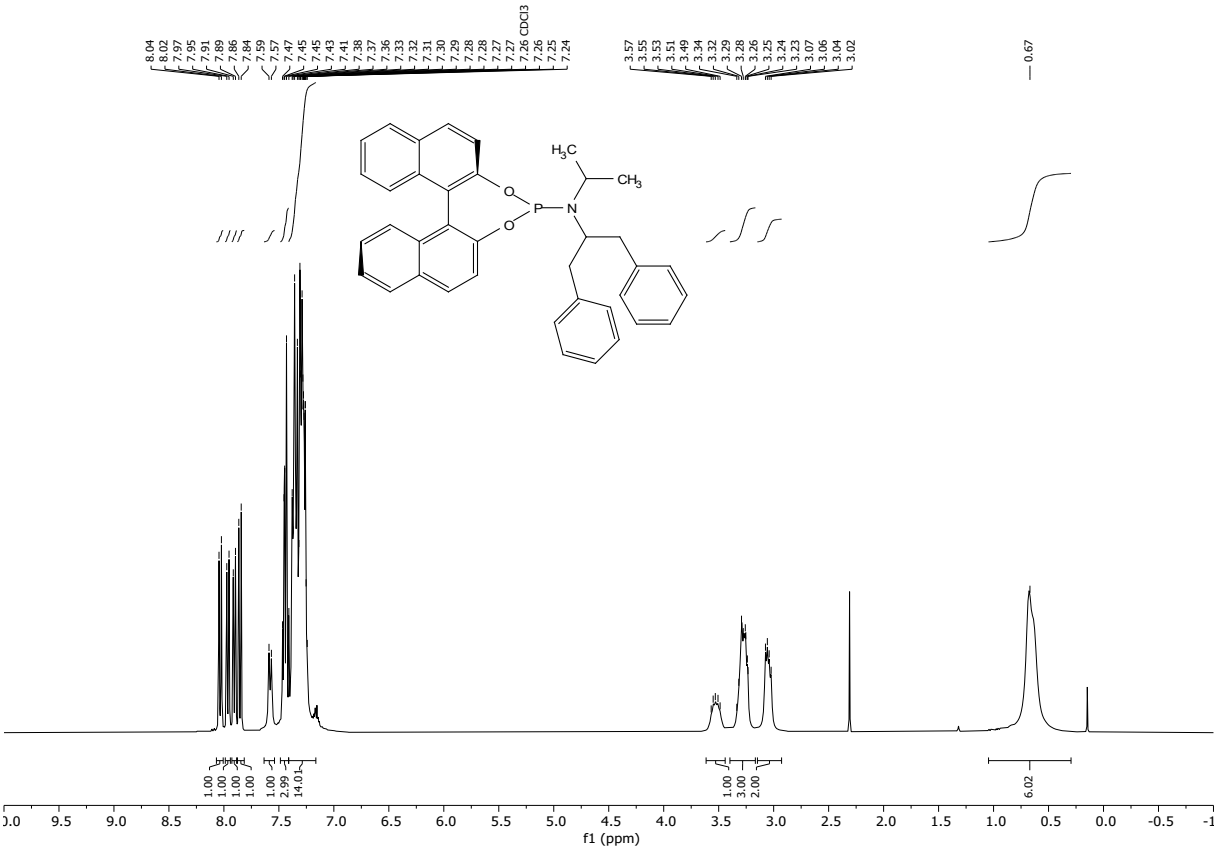
^{13}C NMR (151 MHz, $CDCl_3$)



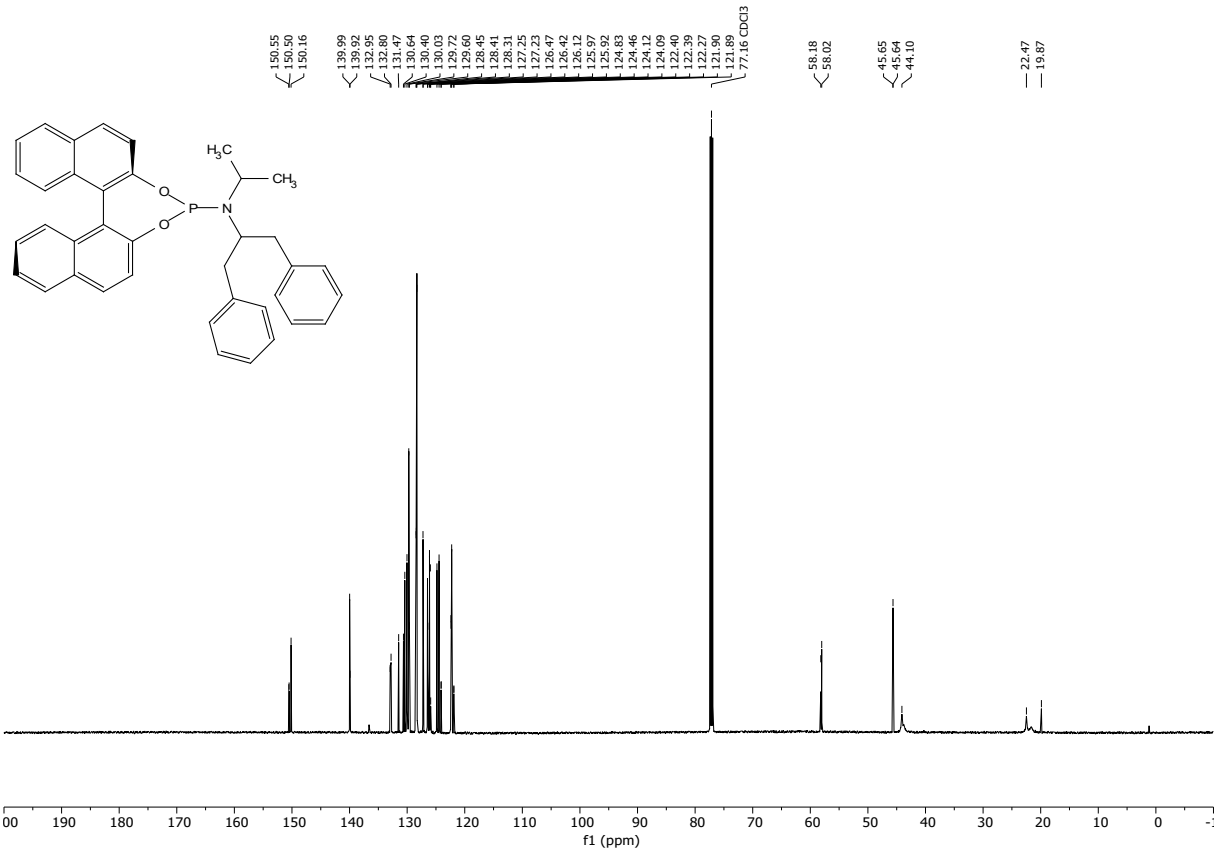
^{31}P NMR (162 MHz, $CDCl_3$)



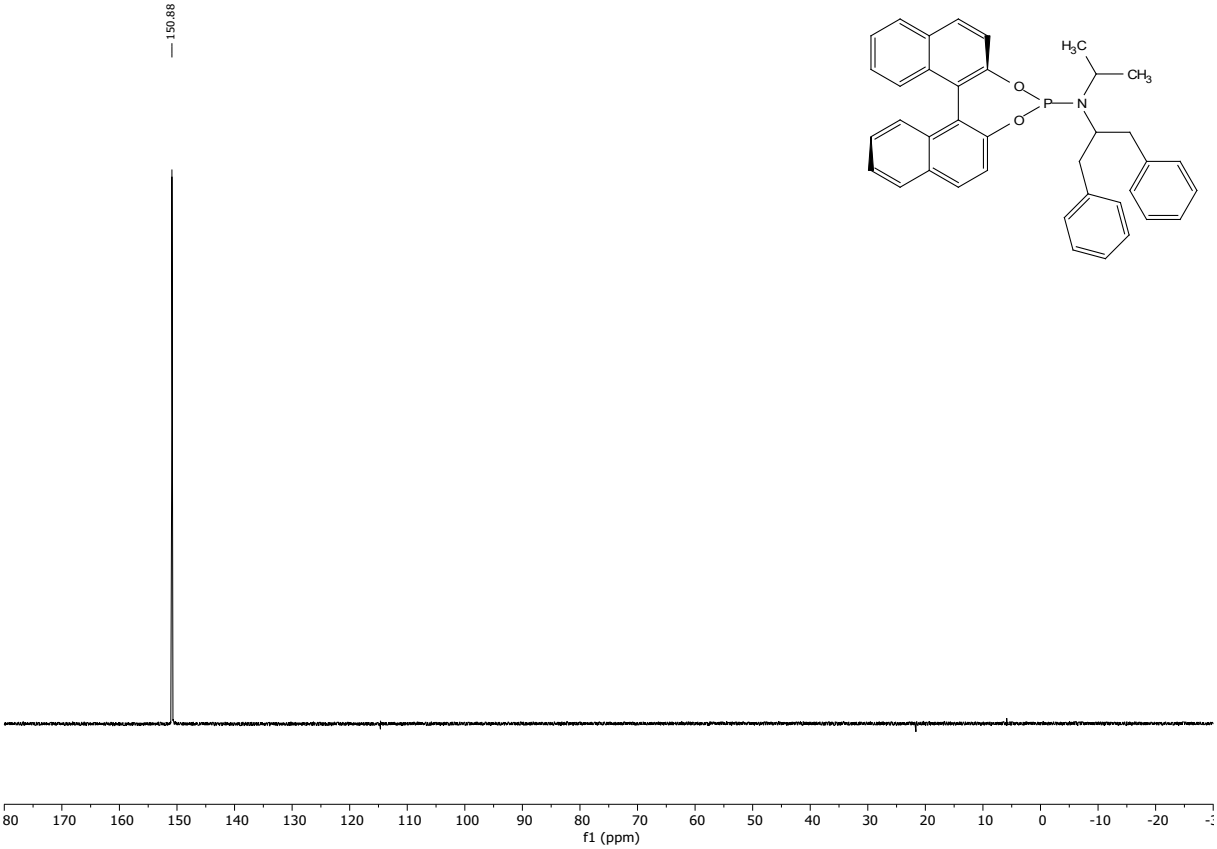
^{1}H NMR (400 MHz, $CDCl_3$)



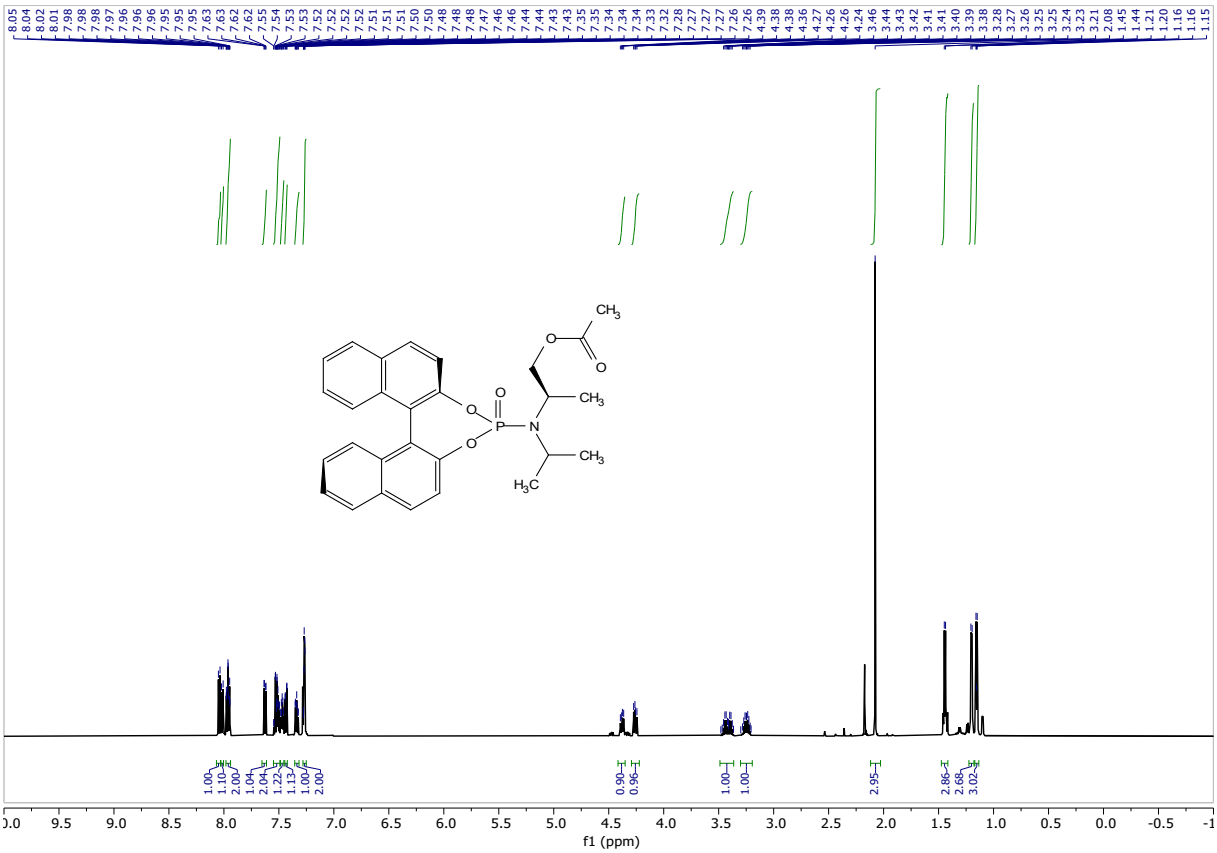
^{13}C NMR (151 MHz, $CDCl_3$)



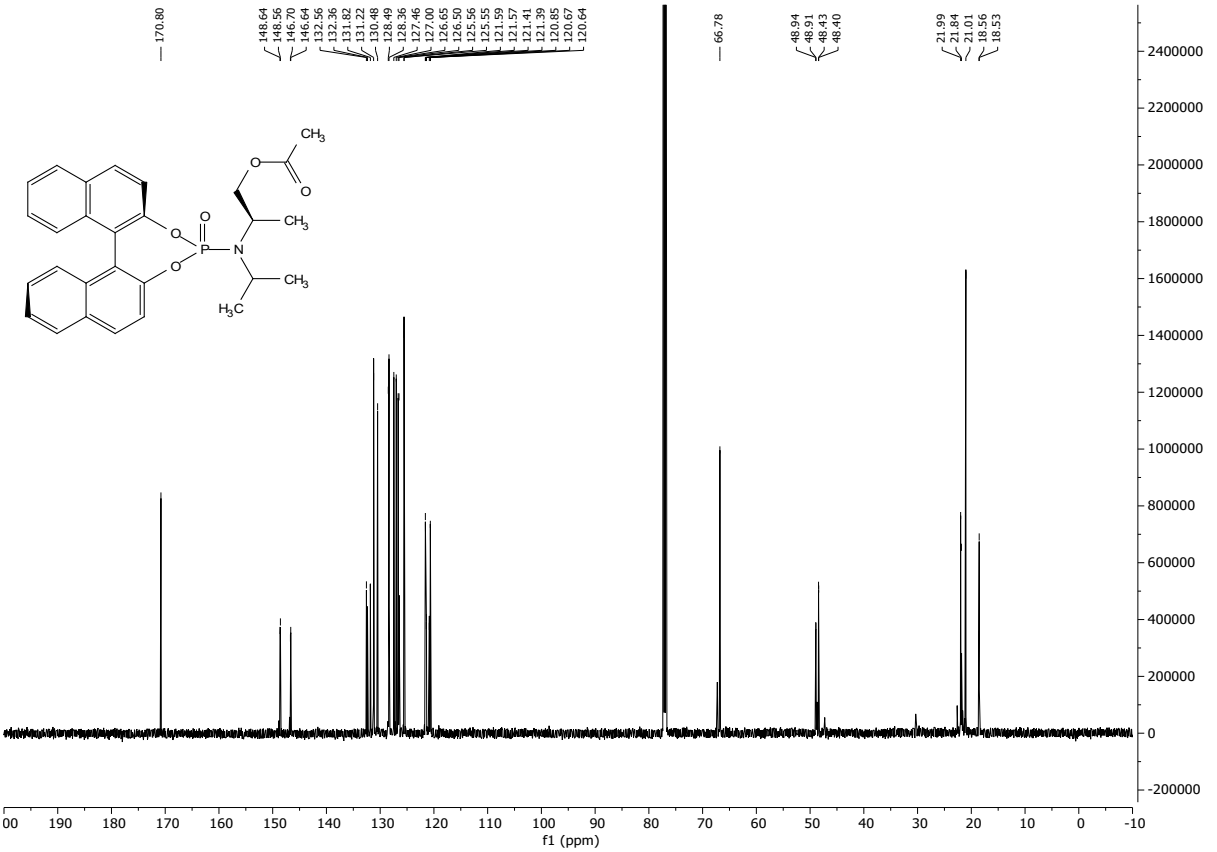
^{31}P NMR (162 MHz, $CDCl_3$)



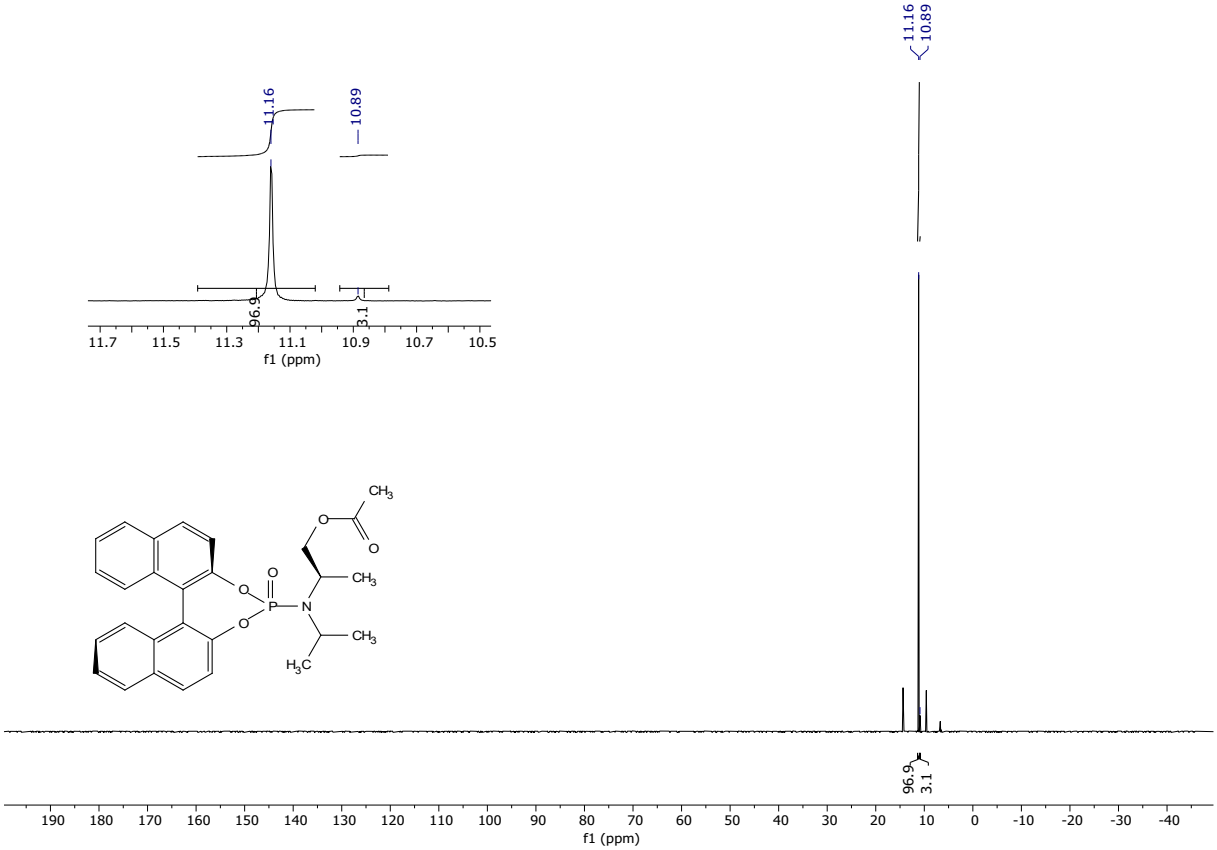
^{1}H NMR (600 MHz, $CDCl_3$)



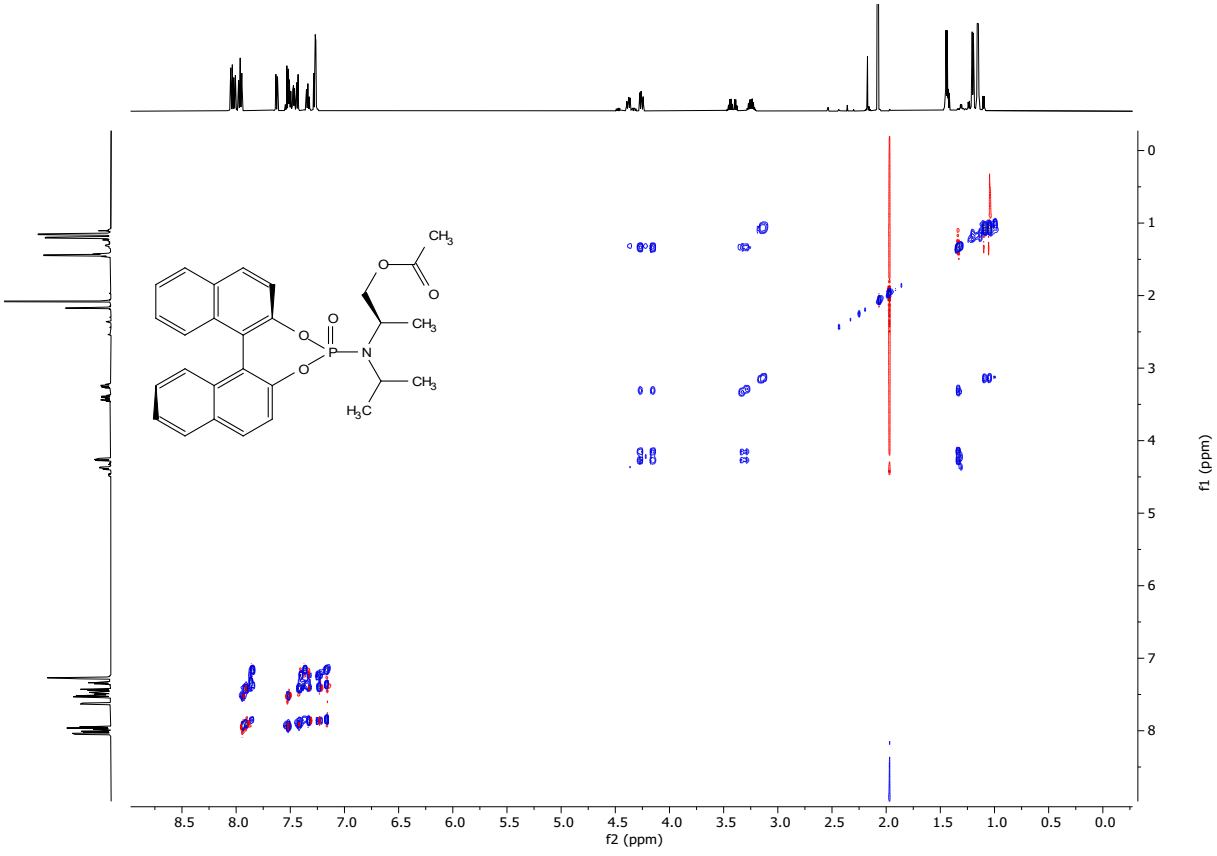
^{13}C NMR (151 MHz, $CDCl_3$)



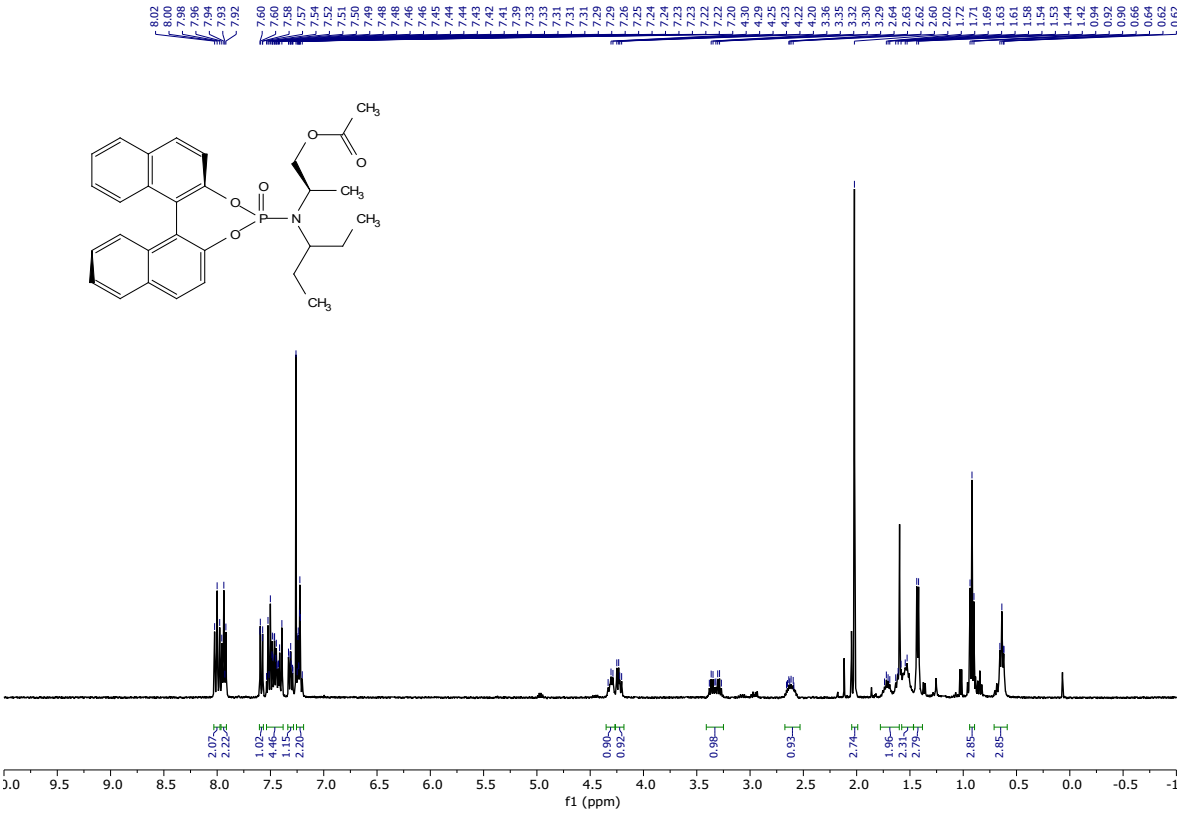
^{31}P NMR (162 MHz, $CDCl_3$)



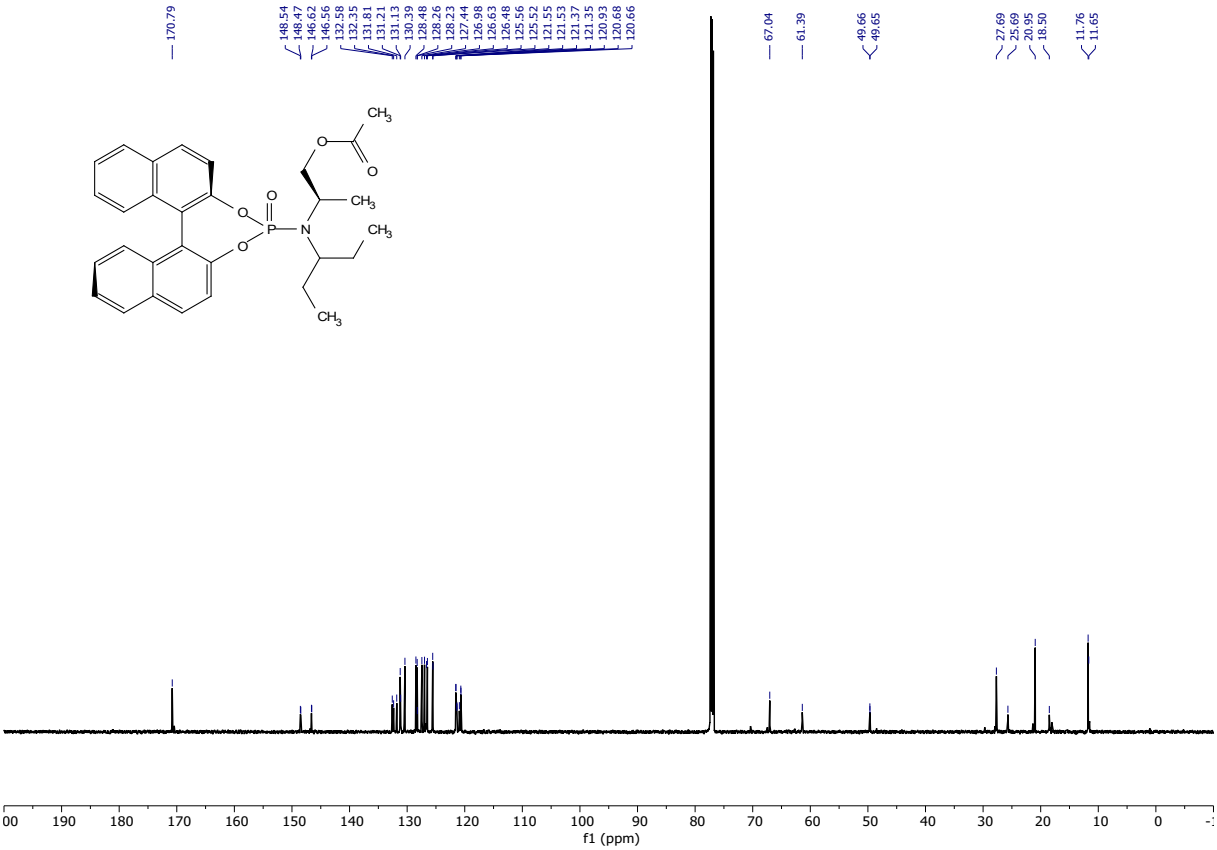
TOSCY NMR (600 MHz, $CDCl_3$)



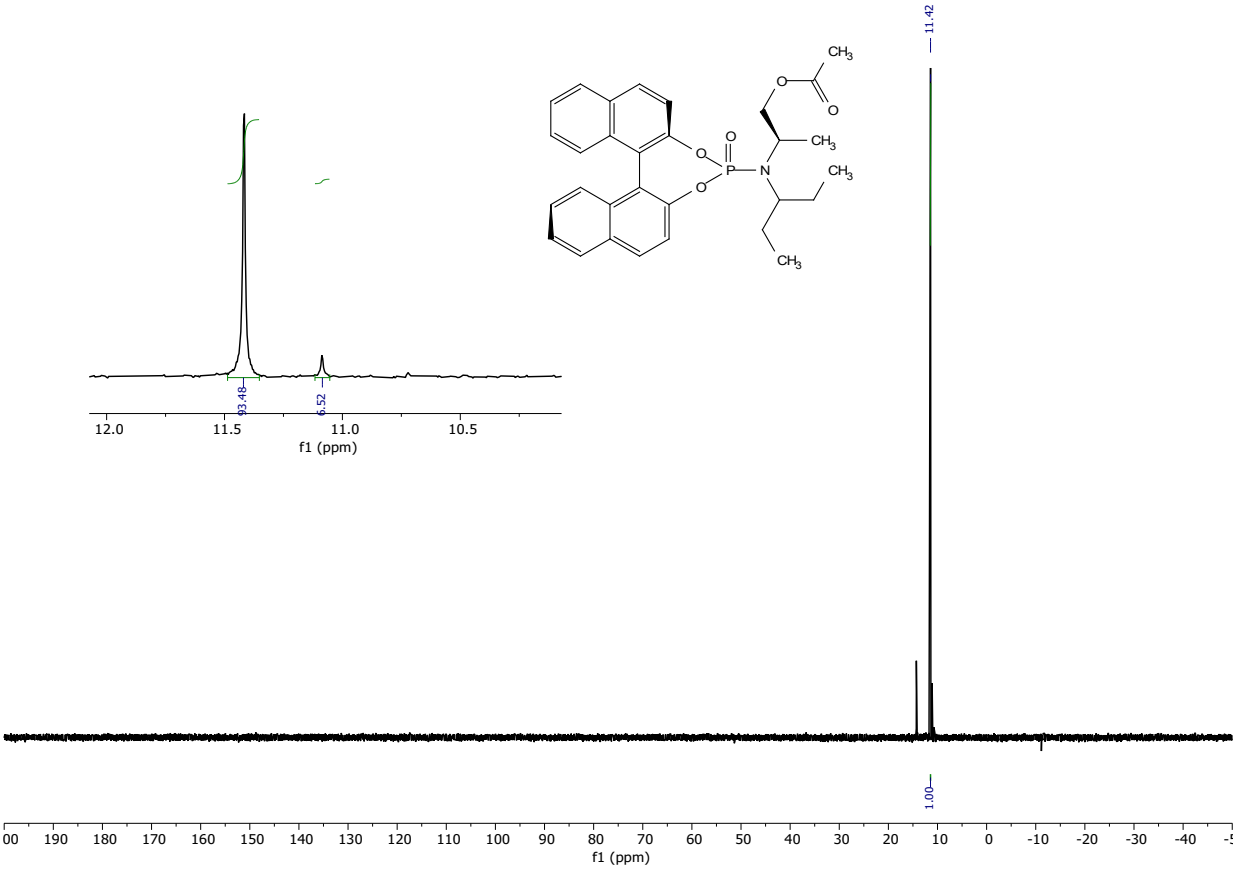
^{1}H NMR (400 MHz, $CDCl_3$)



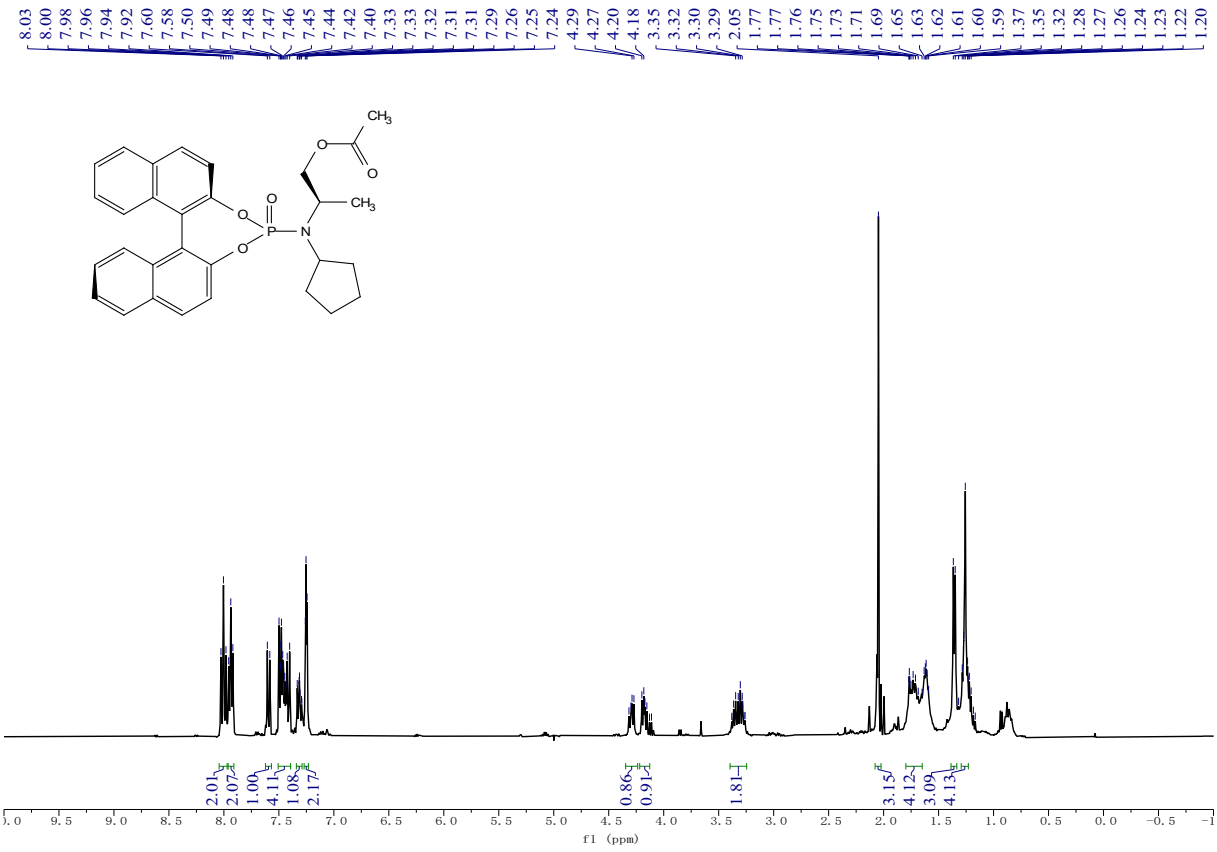
^{13}C NMR (151 MHz, $CDCl_3$)



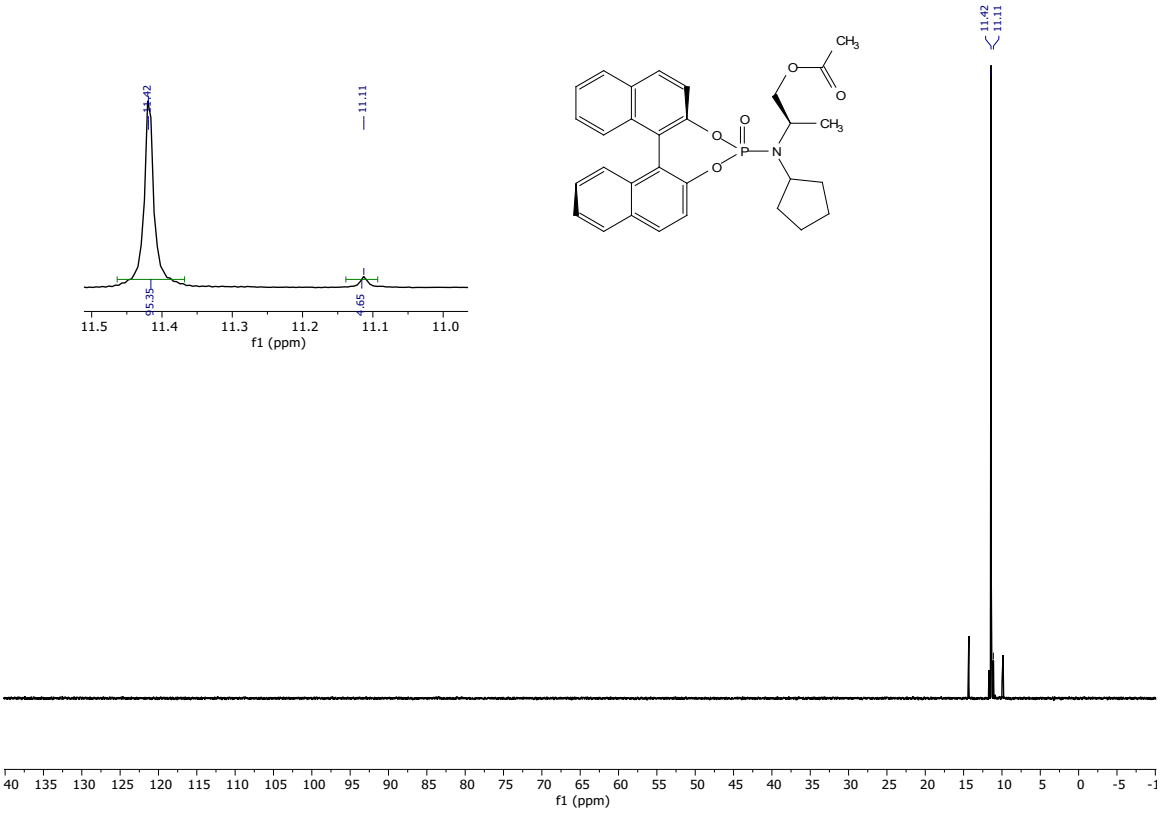
^{31}P NMR (162 MHz, $CDCl_3$)

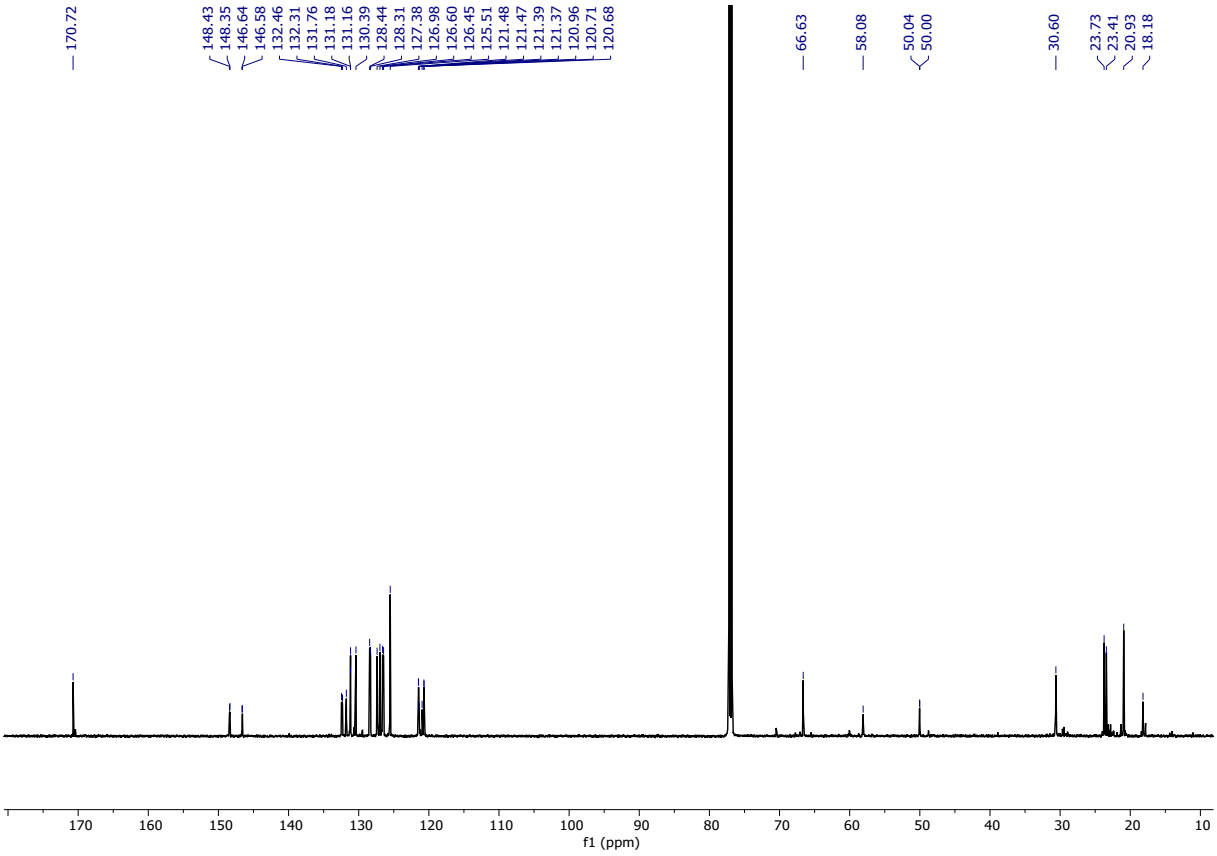


^{1}H NMR (400 MHz, $CDCl_3$)

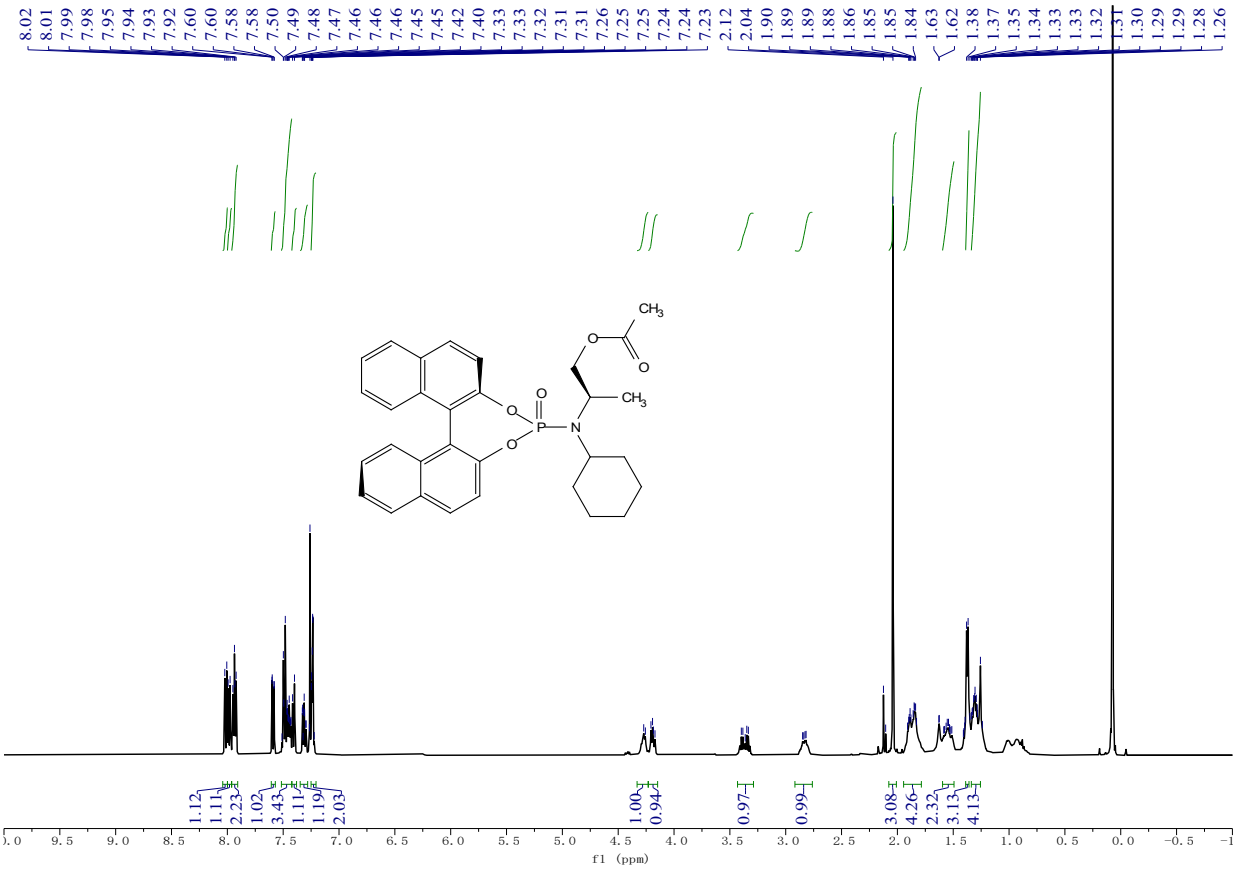


^{31}P NMR (162 MHz, $CDCl_3$)

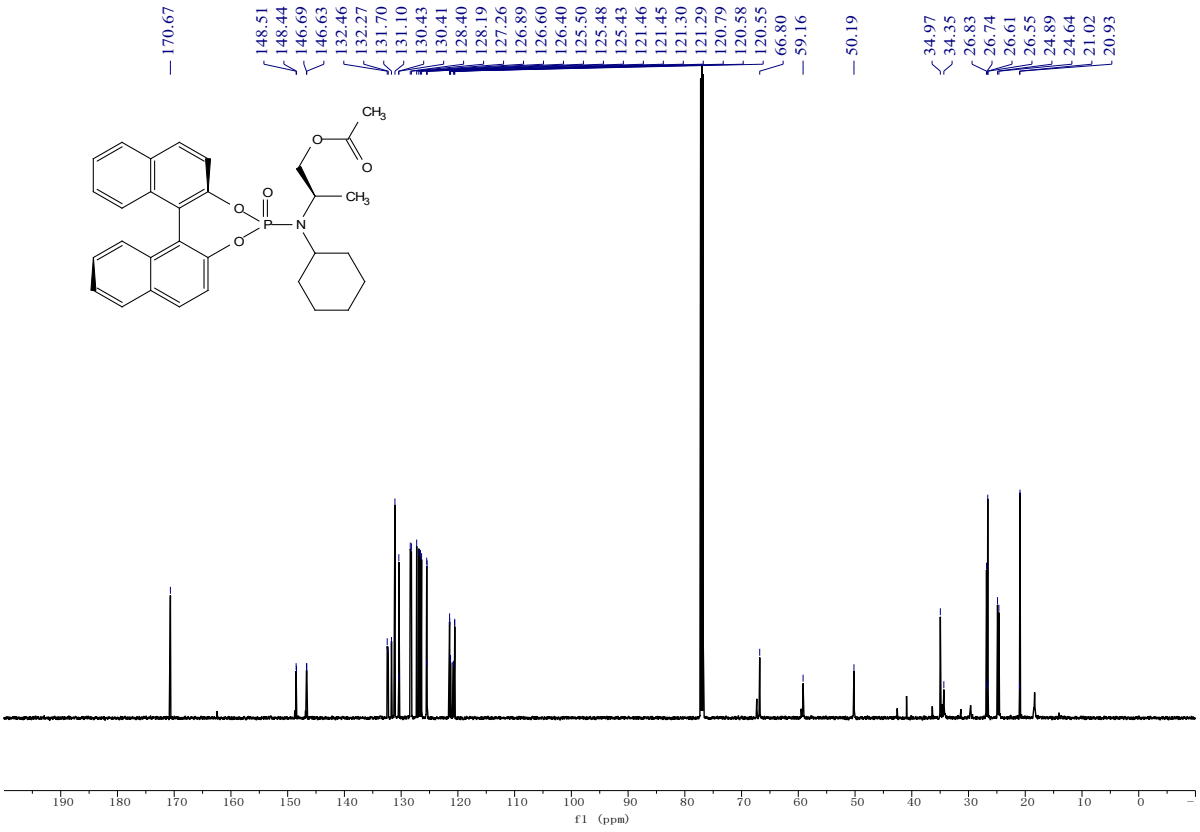



170.72
148.43
148.35
146.64
146.58
132.46
132.31
131.76
131.18
131.16
130.39
128.44
128.31
127.38
126.98
126.60
126.45
125.51
121.48
121.47
121.39
121.37
120.96
120.71
120.68
66.63
58.08
50.04
50.00
30.60
23.73
23.41
20.93
18.18
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

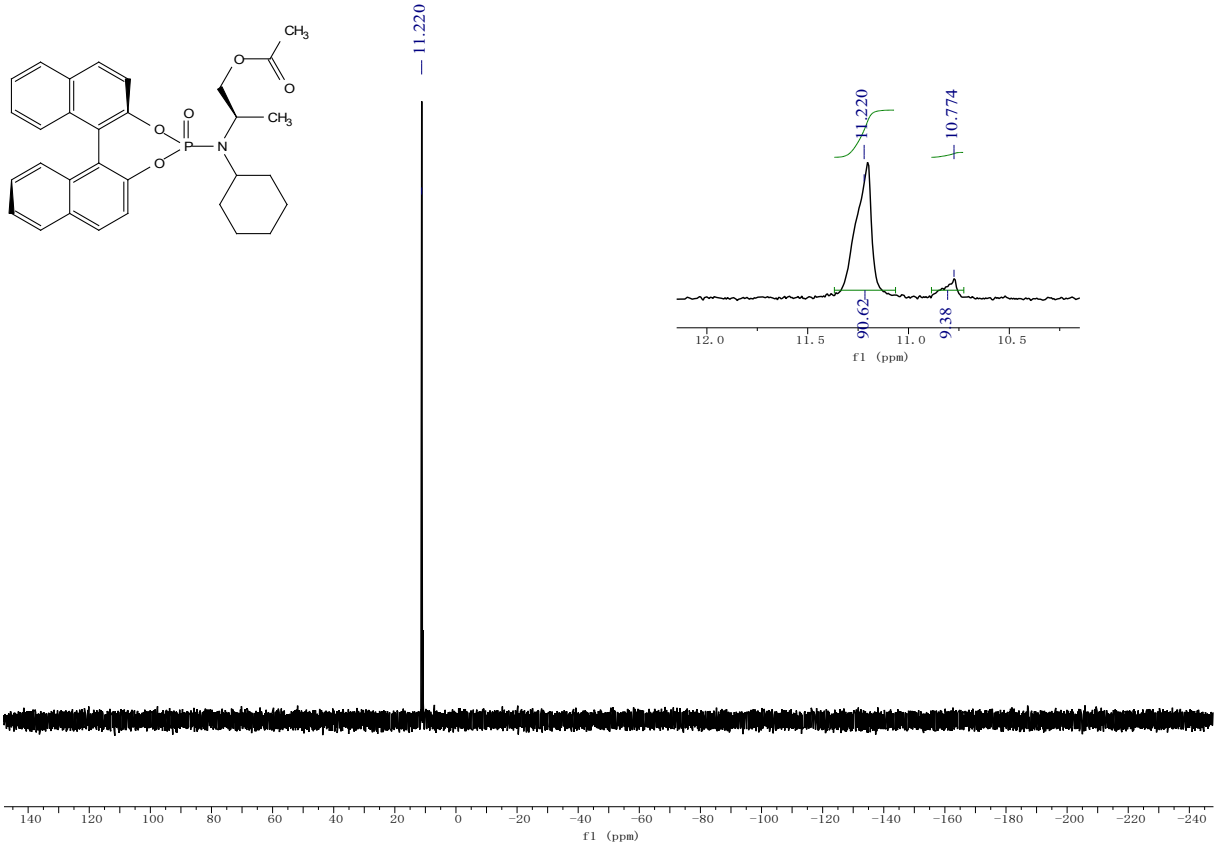
^{1}H NMR (500 MHz, $CDCl_3$)



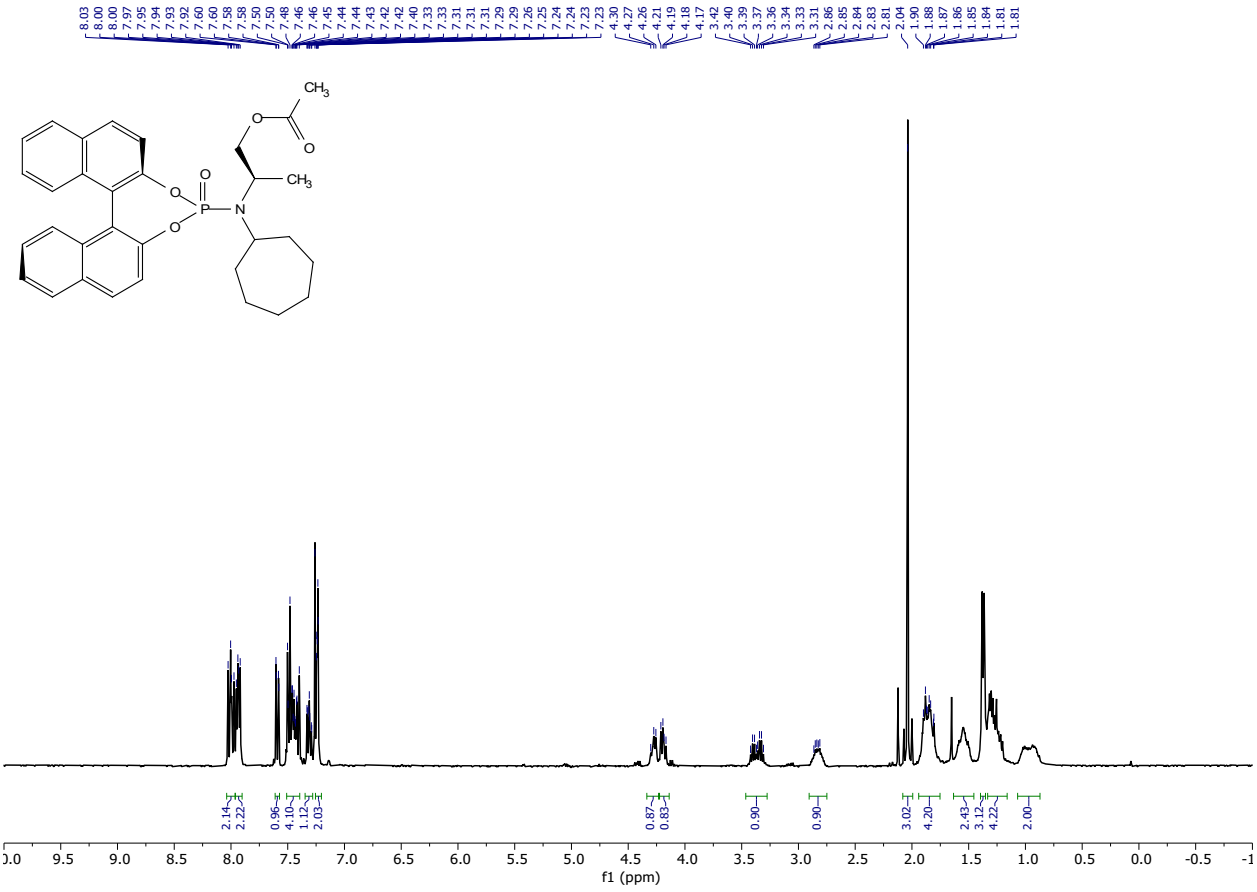
^{13}C NMR (151 MHz, $CDCl_3$)



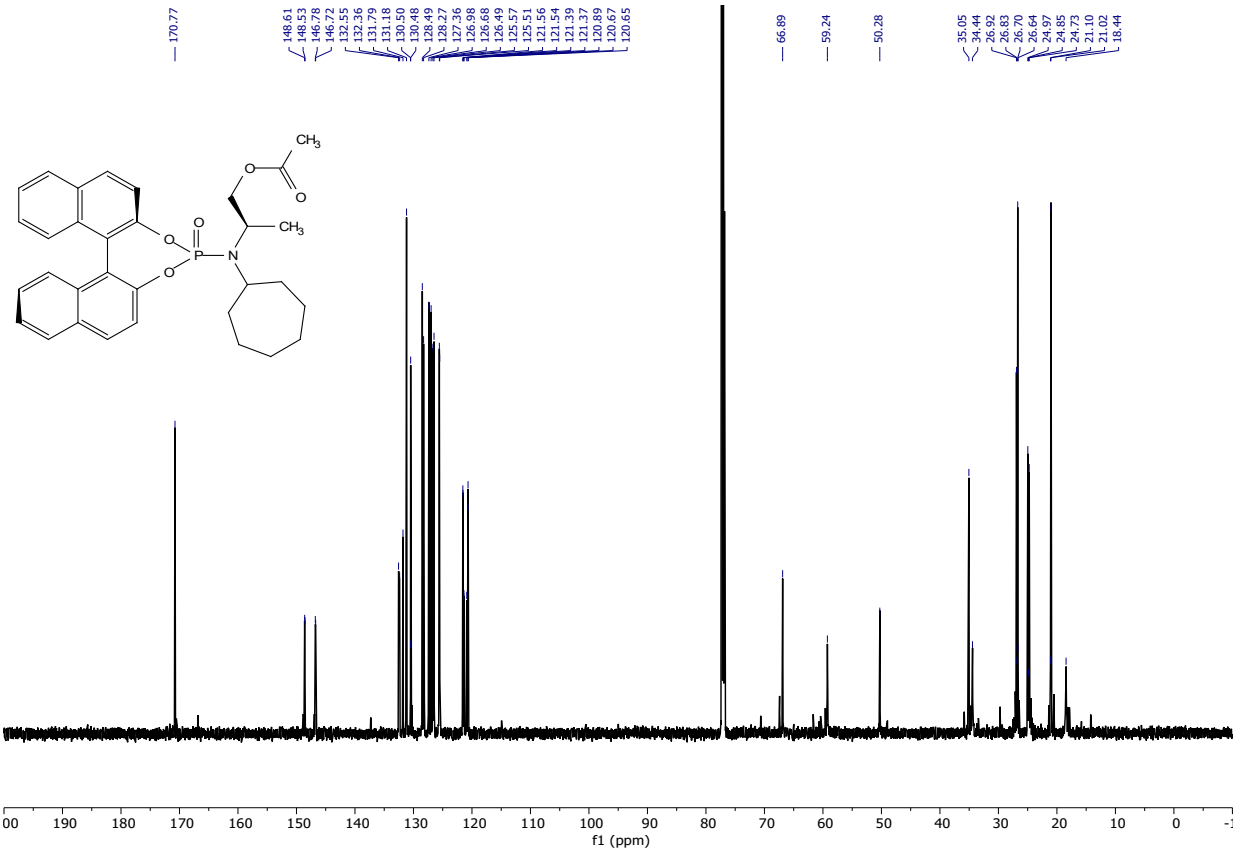
^{31}P NMR (243 MHz, $CDCl_3$)



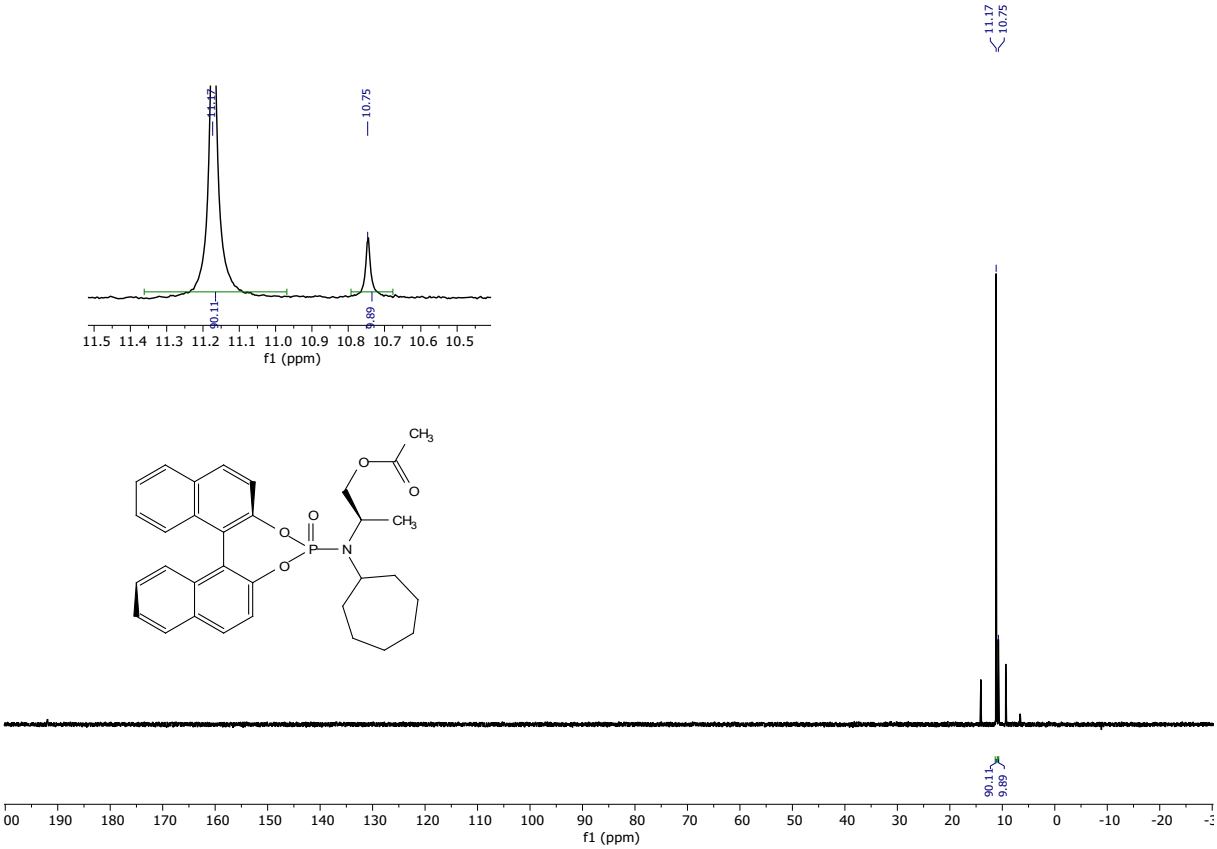
^{1}H NMR (400 MHz, $CDCl_3$)



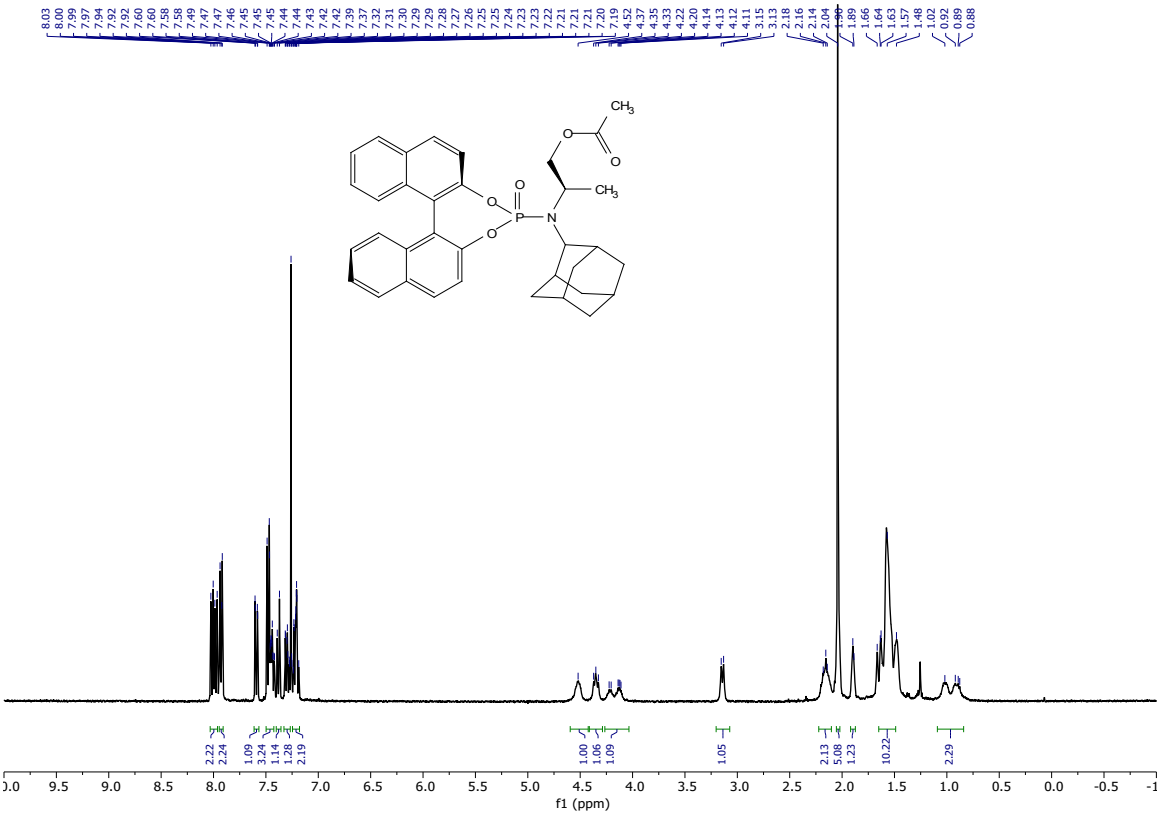
^{13}C NMR (151 MHz, $CDCl_3$)


170.77
148.61
148.53
146.78
146.72
132.55
132.36
131.79
131.18
130.50
130.48
128.49
128.27
127.36
126.98
126.68
126.49
125.57
125.51
121.56
121.54
121.39
121.37
120.89
120.67
120.65
66.89
59.24
50.28
35.05
34.44
26.92
26.83
26.70
26.64
24.97
24.85
24.73
21.10
21.02
18.44
CH3
O
O
CH3
O
O
P
N
f1 (ppm)

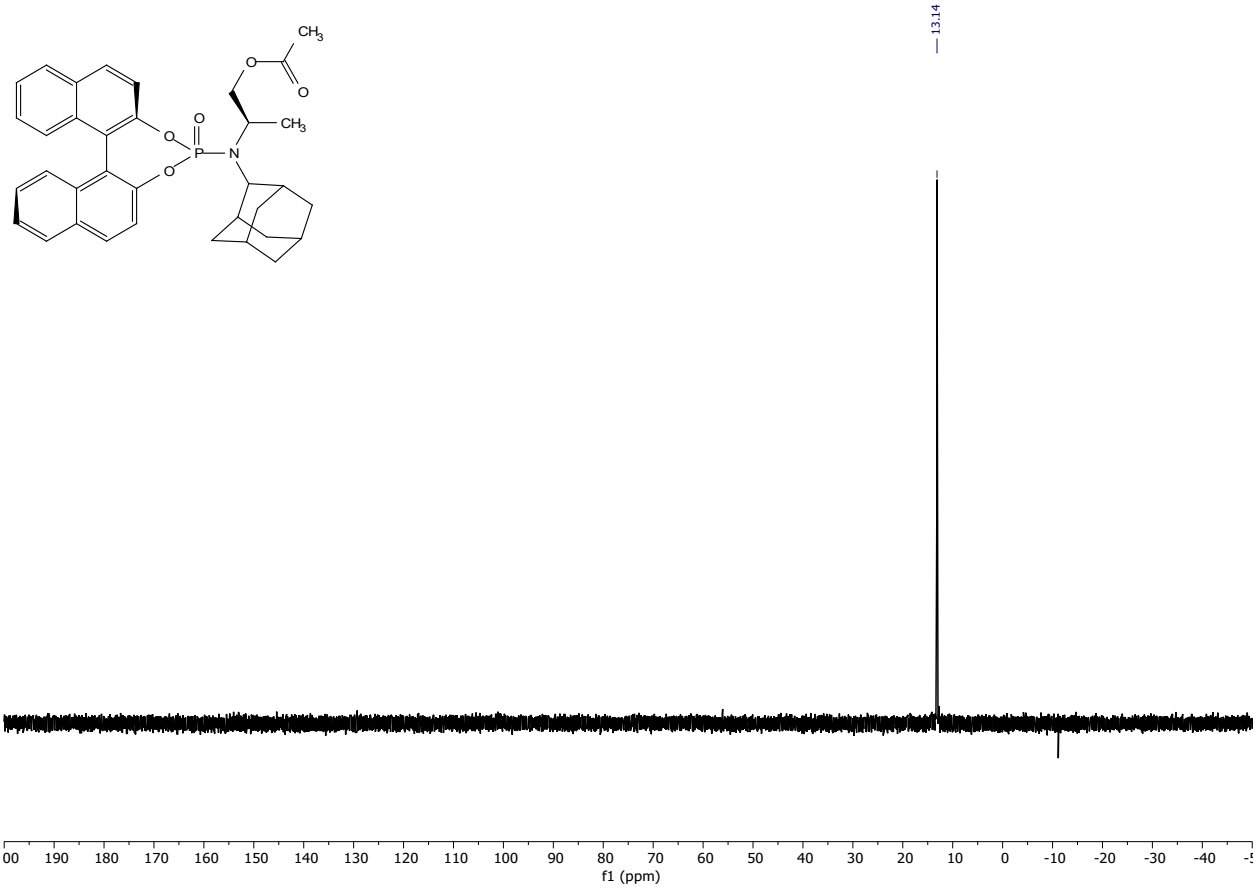
^{31}P NMR (162 MHz, $CDCl_3$)

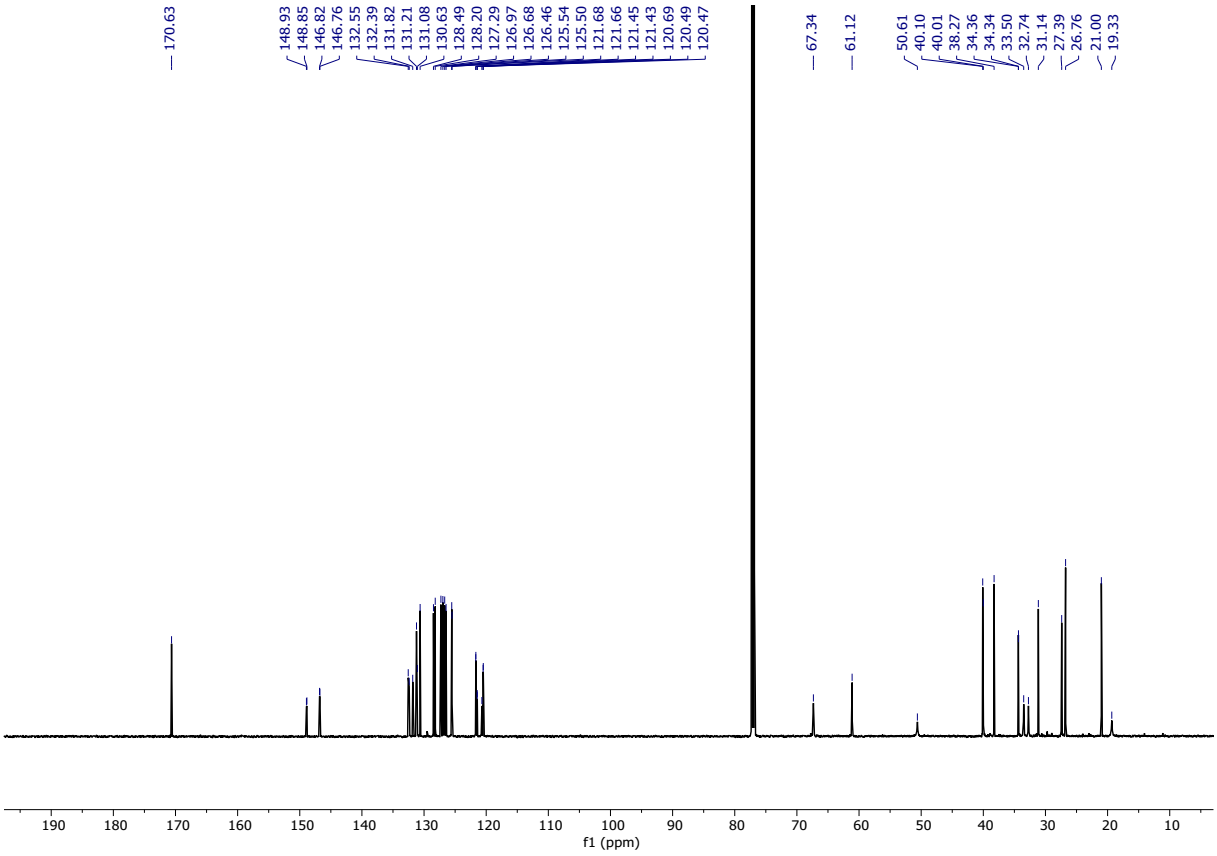


^{1}H NMR (400 MHz, $CDCl_3$)



^{31}P NMR (162 MHz, $CDCl_3$)




170.63
148.93
148.85
146.82
146.76
132.55
132.39
131.82
131.21
131.08
130.63
128.49
128.20
127.29
126.97
126.68
126.46
125.54
125.50
121.68
121.66
121.45
121.43
120.69
120.49
120.47
67.34
61.12
50.61
40.10
40.01
38.27
34.36
34.34
33.50
32.74
31.14
27.39
26.76
21.00
19.33
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)