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#### Key indicators

Single-crystal X-ray study

$T = 294\text{ K}$

Mean  $\sigma(\text{C}-\text{C}) = 0.007\text{ \AA}$

$R$  factor = 0.052

$wR$  factor = 0.116

Data-to-parameter ratio = 20.9

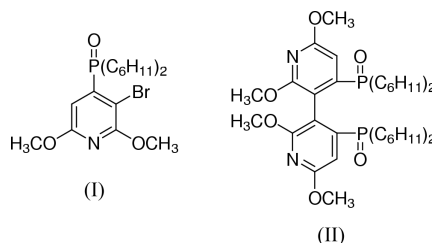
For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.

## 3-Bromo-4-(dicyclohexylphosphinoyl)-2,6-dimethoxypyridine

The crystal structure of the title compound,  $\text{C}_{19}\text{H}_{29}\text{BrNO}_3\text{P}$ , contains one pyridyl ring and two cyclohexyl rings in chair forms. There are two molecules per asymmetric unit, and the overall molecular organization is stabilized by well defined intermolecular weak interactions.

### Comment

The search for new chiral ligands is an ongoing process in the field of asymmetric synthesis. Over the past two decades, tremendous success has been achieved in the use of chiral arylphosphine ligands such as BINAP [2,2'-bis(diphenylphosphino)-1,1'-binaphthyl], BIPHEP [(6,6'-dimethyl-1,1'-biphenyl-2,2'-diyl)bis(diphenylphosphine)], DuPhos [1,2-bis(2,5-diethylphospholano)benzene], and so on, in Rh- or Ru-catalysed asymmetric hydrogenation reactions (Lin *et al.*, 2001). In an effort to expand the scope of the arylphosphine ligands and their application in homogeneous asymmetric catalysis, we have recently developed a class of novel dipyriddyphosphine ligands P-Phos [2,2',6,6'-tetramethoxy-4,4'-bis(diphenylphosphino)-3,3'-bipyridine; Pai *et al.*, 2000] and Tol-P-Phos [2,2',6,6'-tetramethoxy-4,4'-bis[bis(*p*-methylphenyl)phosphino]-3,3'-bipyridine; Wu *et al.*, 2001], and found their  $\text{Ru}^{\text{II}}$  complexes to be highly effective in the catalytic asymmetric hydrogenation of 2-(6-methoxy-2-naphthyl)propenoic acid and keto esters.



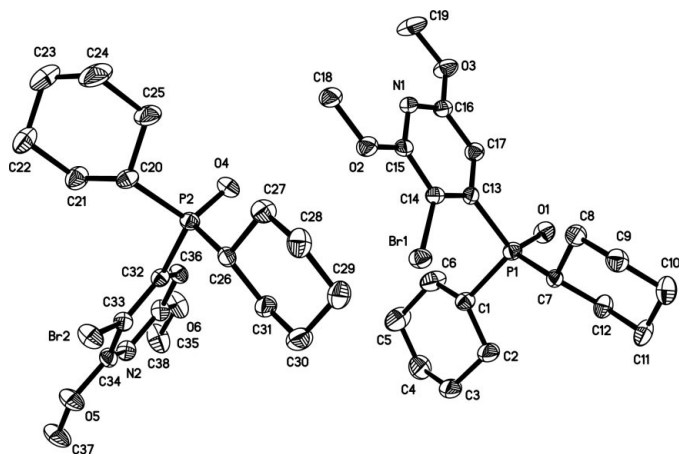
In this study, we attempted to synthesize another new P-Phos derivative, namely 2,2',6,6'-tetramethoxy-4,4'-bis(dicyclohexylphosphino)-3,3'-bipyridine, (II), by replacing the four phenyl rings in P-Phos with four cyclohexyl rings, as a means of tuning its electronic and steric properties. In the synthesis of the target product, the title compound, (I), is the important intermediate, and was obtained by the *ortho*-lithiation of 3-bromo-2,6-dimethoxypyridine with lithium diisopropylamide (LDA), followed by the addition of dicyclohexylphosphine chloride and then by oxidation of resulting phosphine with hydrogen peroxide.

Of these procedures, the *ortho*-lithiation reaction deserves further comment. Regioselective lithiation of halopyridines always involved lithium-halogen exchange, halogen-dancing reaction or deprotonation reaction. The choice of lithium

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**Figure 1**  
The molecular structure of the asymmetric unit of (I), showing ellipsoids at the 30% probability level (Siemens, 1995). H atoms have been omitted.

reagent, *viz.* *n*-Bu-Li or LDA, is also very important (Rocca *et al.*, 1993). The relative kinetic acidity of pyridine (C-4 > C-3 > C-2; Zoltewica & Grahe, 1969), combined with the greatly increased kinetic acidity of the *ortho* H atom in halobenzenes, suggested that it would be feasible to metalate regioselectively the C-4 position of 3-halopyridines. The X-ray crystallographic analysis of (I) showed unambiguously that the *ortho*-lithiation reaction proceeds with high chemo- and regioselectivity, almost avoiding the formation of by-products. By well defined intermolecular weak interactions, molecules of (I) (as building blocks) were finally assembled into a three-dimensional network. As part of our efforts investigating this topic, we present the crystal structure of (I). The synthesis of chiral ligand (II) and its application in the Ru- or Rh-catalysed asymmetric hydrogenation reactions are underway.

## Experimental

The title compound, (I), was prepared according to the following procedures under a nitrogen atmosphere unless otherwise stated. To a magnetically stirred solution of 2.26 ml (4.5 mmol) of LDA (2.0 M solution in THF) was added a solution of 3-bromo-2,6-dimethoxy-pyridine (0.988 g, 4.5 mmol) in dried THF (5 ml) at 195 K over a period of 15 min. The reaction mixture was stirred for another 15 min and to the resulting red-brown suspension was added a solution of dicyclohexylphosphine chloride in 10 ml dried THF. The reaction mixture was stirred and reached ambient temperature overnight. 25 ml water was added to the reaction mixture and the solvent was removed under reduced pressure. The organic product was extracted with dichloromethane. The combined extract was dried with anhydrous sodium sulfate and was concentrated *in vacuo* to give a crude product. To the crude product in acetone solution (20 ml), 35% hydrogen peroxide (10 ml) was added slowly and the reaction was monitored by thin-layer chromatography. The product was extracted with dichloromethane. The crude product was purified by column chromatography (silica gel, hexane-ethyl acetate 6:1) to give the pure

product (I) (50% yield). The crystal used for the data collection was obtained by slow evaporation from a hexane-dichloromethane (1:1) saturated solution at room temperature. Found: C 52.63, H 6.90, N 2.96%; calculated for C<sub>19</sub>H<sub>29</sub>BrNO<sub>3</sub>P: C 53.03, H 7.53, N 3.25%.

## Crystal data

C<sub>19</sub>H<sub>29</sub>BrNO<sub>3</sub>P  
*M<sub>r</sub>* = 430.31  
 Monoclinic, *P*2<sub>1</sub>/*n*  
*a* = 9.2025 (12) Å  
*b* = 18.759 (2) Å  
*c* = 23.761 (3) Å  
 $\beta$  = 92.009 (3)°  
*V* = 4099.3 (9) Å<sup>3</sup>  
*Z* = 8

*D<sub>x</sub>* = 1.394 Mg m<sup>-3</sup>  
 Mo *K*α radiation  
 Cell parameters from 8624 reflections  
 $\theta$  = 1–27.5°  
 $\mu$  = 2.10 mm<sup>-1</sup>  
*T* = 294 (2) K  
 Prism, colorless  
 0.30 × 0.26 × 0.24 mm

## Data collection

Siemens SMART CCD area-detector diffractometer  
 $\varphi$  and  $\omega$  scans  
 Absorption correction: multi-scan (SADABS; Sheldrick, 1996)  
*T<sub>min</sub>* = 0.571, *T<sub>max</sub>* = 0.633  
 27403 measured reflections

9427 independent reflections  
 3936 reflections with *I* > 2σ(*I*)  
*R<sub>int</sub>* = 0.061  
 $\theta_{\text{max}}$  = 27.5°  
*h* = −11 → 11  
*k* = −19 → 24  
*l* = −30 → 27

## Refinement

Refinement on *F*<sup>2</sup>  
*R*[*F*<sup>2</sup> > 2σ(*F*<sup>2</sup>)] = 0.052  
*wR*(*F*<sup>2</sup>) = 0.117  
*S* = 1.03  
 9427 reflections  
 451 parameters

H-atom parameters constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.035P)^2]$   
 where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\text{max}} = 0.002$   
 $\Delta\rho_{\text{max}} = 0.91 \text{ e \AA}^{-3}$   
 $\Delta\rho_{\text{min}} = -0.60 \text{ e \AA}^{-3}$

The C-bound H atoms were placed in geometrically calculated positions and included in the final refinement in the riding-model approximation.

Data collection: SMART (Siemens, 1995); cell refinement: SMART; data reduction: SAINT and SHELXTL-NT (Siemens, 1995); program(s) used to solve structure: SHELXS97 (Sheldrick, 1997); program(s) used to refine structure: SHELXL97 (Sheldrick, 1997); molecular graphics: SHELXTL-NT; software used to prepare material for publication: SHELXTL-NT.

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