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## Key indicators

Single-crystal X-ray study  
 $T = 293\text{ K}$   
Mean  $\sigma(\text{C}-\text{C}) = 0.006\text{ \AA}$   
 $R$  factor = 0.047  
 $wR$  factor = 0.131  
Data-to-parameter ratio = 17.0For details of how these key indicators were  
automatically derived from the article, see  
<http://journals.iucr.org/e>. $\mu$ -1,4-Bis(diphenylphosphino)butane- $\kappa^2$ P:P'-bis[(2,2'-bipyridyl)silver(I)] ditetrafluoroborate

Pink crystals of the title dinuclear complex,  $[\text{Ag}_2(\text{C}_{10}\text{H}_8\text{N}_2)_2(\text{C}_{28}\text{H}_{28}\text{P}_2)](\text{BF}_4)_2$ , were obtained from a methanol solution of equivalent amounts of  $\text{AgBF}_4$ , 2,2'-bipyridyl (bipy) and 1,4-bis(diphenylphosphino)butane (dppb). The  $[\text{Ag}_2(\text{bipy})_2(\text{dppb})]^{2+}$  cation lies across a crystallographic inversion centre and the coordination environment around  $\text{Ag}^{\text{I}}$  is distorted trigonal.

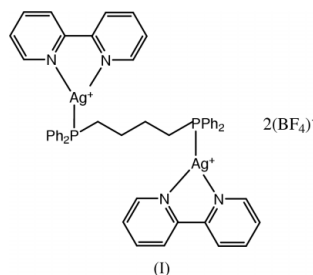
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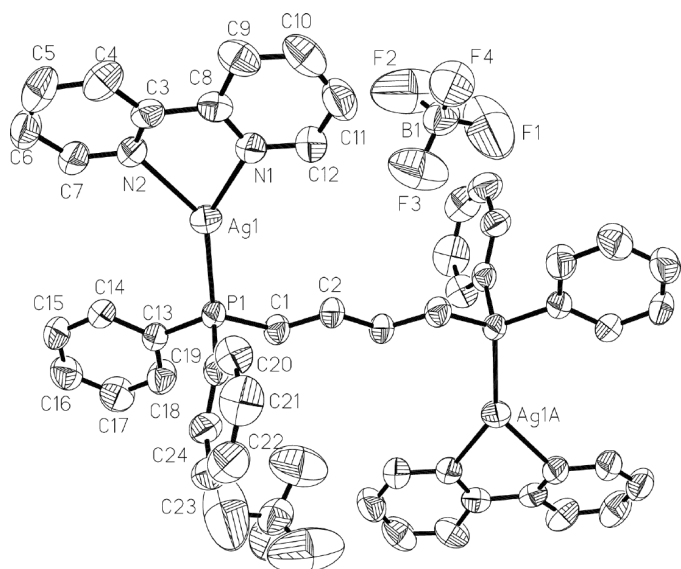
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## Comment

Diphosphine ligands  $\text{Ph}_2\text{P}(\text{CH}_2)_n\text{PPh}_2$  have been widely applied in coordination chemistry because of their versatile coordination modes, such as chelating (McLauchlan & Ibers, 2000),  $\mu_2$ -bridging (Yam *et al.*, 2002) or a combination of both coordination modes (Zhuravel & Glueck, 1999). Among  $\text{Ph}_2\text{P}(\text{CH}_2)_n\text{PPh}_2$  ligands, bis(diphenylphosphino)methane ( $n = 1$ ) is widely used owing to its rigid backbone with the shortest spacer. Recently, diphosphine ligands have been applied to synthesize macrocyclic and two-dimensional network structures, with the participation of another bridging ligand (Puddephatt, 2001). In the past, we have obtained a series of  $\text{Ag}^{\text{I}}$  complexes containing both diphosphine and thiolate ligands (Deng *et al.*, 2000; Kang *et al.*, 2002; Zhang *et al.*, 2003), from which we found that the backbone length of the diphosphine ligands is critical for the formation of the complexes. We also discovered that, the higher the value of  $n$  for the  $(\text{CH}_2)_n$  backbone, the more difficult it is to obtain single crystals of the complex. Here we report the crystal and molecular structure of  $[\text{Ag}_2(\text{bipy})_2(\text{dppb})](\text{BF}_4)_2$ , (I), which was prepared with the flexible dppb ligand. This work complements and extends our structural characterization of compounds of highly flexible diphosphine ligands.



The asymmetric unit of (I) consists of one-half of the  $[\text{Ag}_2(\text{bipy})_2(\text{dppb})]^{2+}$  cation and a  $\text{BF}_4^-$  anion. The other half of the cation is generated by a crystallographic inversion centre (Fig. 1). The mid-point of the  $\text{C}2-\text{C}2^{\text{i}}$  bond [symmetry code: (i)  $2 - x, 2 - y, -z$ ] is found to coincide with the crystallographic inversion centre. The  $\text{Ag}^{\text{I}}$  atom has a distorted



**Figure 1**  
View of (I), showing 50% probability displacement ellipsoids and atom-numbering scheme for the contents of the asymmetric unit.

trigonal coordination environment which is made up of two N atoms from the bipy ligand and a P atom from the dppb ligand. The bipy ligand chelates the  $\text{Ag}^{\text{I}}$  atom to form a five-membered ring with an angle  $\text{N1}-\text{Ag1}-\text{N2}$  of  $72.08(10)^\circ$ . The dppb ligand acts as a  $\mu_2$ -bridge linking two  $\text{Ag}^{\text{I}}$  atoms. The  $\text{BF}_4^-$  anion is linked to the cation only through  $\text{C}-\text{H}\cdots\text{F}$  hydrogen bonds (Table 2). The other short contacts observed in the structure are  $\text{Ag1}\cdots\text{N2}(1-x, 2-y, -z)$  of  $3.320(5)\text{ \AA}$  and  $\text{Ag1}\cdots\text{Ag1}(1-x, 2-y, -z)$  of  $3.5227(8)\text{ \AA}$ .

## Experimental

The synthesis of (I) was carried out by the reaction of  $\text{AgBF}_4$  (0.019 g, 0.1 mmol), 2,2'-dipyridyl (0.016 g, 0.1 mmol) and 1,4-bis(diphosphino)butane (0.043 g, 0.1 mmol) in MeOH solution (10 ml) at room temperature for 0.5 h. The solution was then filtered. Pink crystals of (I) were obtained by evaporation of the pale-red solution.

### Crystal data

$[\text{Ag}_2(\text{C}_{10}\text{H}_8\text{N}_2)_2(\text{C}_{28}\text{H}_{28}\text{P}_2)](\text{BF}_4)_2$	$D_x = 1.601\text{ Mg m}^{-3}$
$M_r = 1128.17$	Mo $K\alpha$ radiation
Monoclinic, $P2_1/c$	Cell parameters from 7492 reflections
$a = 10.7951(19)\text{ \AA}$	$\theta = 1.9\text{--}27.1^\circ$
$b = 14.402(3)\text{ \AA}$	$\mu = 0.98\text{ mm}^{-1}$
$c = 15.118(3)\text{ \AA}$	$T = 293(2)\text{ K}$
$\beta = 95.274(3)^\circ$	Block, pink
$V = 2340.5(8)\text{ \AA}^3$	$0.50 \times 0.46 \times 0.44\text{ mm}$
$Z = 2$	

### Data collection

Bruker SMART CCD diffractometer	4318 reflections with $I > 2\sigma(I)$
$\omega$ scans	$R_{\text{int}} = 0.024$
Absorption correction: none	$\theta_{\text{max}} = 27.1^\circ$
12917 measured reflections	$h = -12 \rightarrow 13$
5086 independent reflections	$k = -18 \rightarrow 13$
	$l = -19 \rightarrow 19$

### Refinement

Refinement on $F^2$	$w = 1/[\sigma^2(F_o^2) + (0.0851P)^2 + 0.6154P]$
$R[F^2 > 2\sigma(F^2)] = 0.047$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.131$	$(\Delta/\sigma)_{\text{max}} = 0.001$
$S = 1.07$	$\Delta\rho_{\text{max}} = 0.53\text{ e \AA}^{-3}$
5086 reflections	$\Delta\rho_{\text{min}} = -1.40\text{ e \AA}^{-3}$
299 parameters	Extinction correction: <i>SHELXL97</i>
H-atom parameters constrained	Extinction coefficient: $1.45(3)$

**Table 1**

Selected geometric parameters ( $\text{\AA}$ ,  $^\circ$ ).

$\text{Ag1}-\text{N1}$	2.277(3)	$\text{Ag1}-\text{P1}$	2.3579(8)
$\text{Ag1}-\text{N2}$	2.334(3)		
$\text{N1}-\text{Ag1}-\text{N2}$	72.08(10)	$\text{C19}-\text{P1}-\text{C1}$	102.65(13)
$\text{N1}-\text{Ag1}-\text{P1}$	144.12(7)	$\text{C13}-\text{P1}-\text{Ag1}$	115.68(10)
$\text{N2}-\text{Ag1}-\text{P1}$	139.32(7)	$\text{C19}-\text{P1}-\text{Ag1}$	111.26(10)
$\text{C13}-\text{P1}-\text{C19}$	103.80(14)	$\text{C1}-\text{P1}-\text{Ag1}$	116.56(11)
$\text{C13}-\text{P1}-\text{C1}$	105.37(14)		

**Table 2**

Hydrogen-bonding geometry ( $\text{\AA}$ ,  $^\circ$ ).

$D-\text{H}\cdots A$	$D-\text{H}$	$\text{H}\cdots A$	$D\cdots A$	$D-\text{H}\cdots A$
$\text{C1}-\text{H1A}\cdots\text{F3}^{\text{i}}$	0.97	2.50	3.460(5)	170
$\text{C24}-\text{H24}\cdots\text{F1}^{\text{i}}$	0.93	2.38	3.042(8)	128
$\text{C21}-\text{H21}\cdots\text{F1}^{\text{ii}}$	0.93	2.44	3.111(8)	129

Symmetry codes: (i)  $2-x, 2-y, -z$ ; (ii)  $x, \frac{5}{2}-y, \frac{1}{2}+z$ .

The H atoms were geometrically positioned and were treated as riding atoms on the parent C atoms, with C–H distances in the range 0.93–0.97  $\text{\AA}$ . H atoms were placed in calculated positions and refined using a riding model.

Data collection: *SMART* (Bruker, 1998); cell refinement: *SMART*; data reduction: *SAINTE* (Bruker, 1999); program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *SHELXTL* (Bruker, 1998); software used to prepare material for publication: *SHELXTL*.

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