

Juan Mo,<sup>a\*</sup> Heng-Yu Qian,<sup>b</sup>  
 Xiang-Dang Du<sup>a</sup> and Wen Chen<sup>a</sup>

<sup>a</sup>College of Animal Husbandry and  
 Veterinary Studies, Henan Agricultural  
 University, Zhengzhou, Henan Province  
 450002, People's Republic of China, and

<sup>b</sup>School of Materials and Chemical Engineering,  
 Zhengzhou University of Light Industry,  
 Zhengzhou, Henan Province 450002, People's  
 Republic of China

Correspondence e-mail: mojuan52@126.com

**Key indicators**

Single-crystal X-ray study  
 T = 292 K  
 Mean  $\sigma(\text{C}-\text{C}) = 0.014 \text{ \AA}$   
 Disorder in solvent or counterion  
 R factor = 0.066  
 wR factor = 0.216  
 Data-to-parameter ratio = 12.2

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

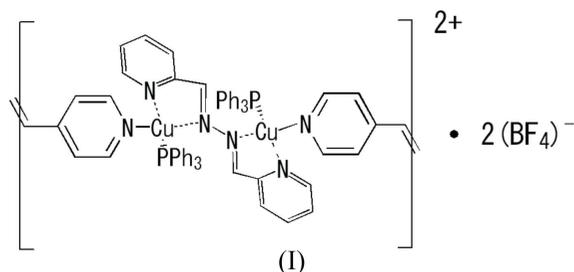
**catena-Poly[[ $\mu$ -pyridine-2-carbaldehyde azine- $\kappa^4\text{N},\text{N}':\text{N}'',\text{N}'''$ -bis[(triphenylphosphine- $\kappa\text{P}$ )-copper(I)]]- $\mu$ -1,2-bis(4-pyridyl)ethene- $\kappa^2\text{N}:\text{N}'$ ] bis(tetrafluoroborate)]**

In the title complex,  $\{[\text{Cu}_2(\text{C}_{12}\text{H}_{10}\text{N}_2)(\text{C}_{12}\text{H}_{10}\text{N}_4)(\text{C}_{18}\text{H}_{15}\text{P})_2](\text{BF}_4)_2\}_n$ , the cations form a linear chain, and are bridged by 1,2-bis(4-pyridyl)ethene and pyridine-2-carbaldehyde azine. Each  $\text{Cu}^{\text{I}}$  atom is coordinated by one P atom of a  $\text{PPh}_3$  ligand, two N atoms of a pyridine-2-carbaldehyde azine bridging ligand and one N atom of a bridging 1,2-bis(4-pyridyl)ethene ligand. There is a crystallographic centre of symmetry at the mid-point of the N—N bond.

Received 27 February 2006  
 Accepted 6 March 2006

**Comment**

Neutral 4-pyridyl ring ligands, such as 4,4-bipyridine (bpy), pyrazine or 1,2-bis(4-pyridyl)ethene, are excellent bridging ligands (Yaghi *et al.*, 1997). Yu *et al.* (2004) have reported a new linear chain bridged by 4,4'-azobispyridine and pyridine-2-carbaldehyde azine. We describe here the synthesis and structure of a new copper(I) compound, (I).



The crystal structure of (I) is depicted in Fig. 1 and the molecular stacking along the *b* axis is shown in Fig. 2. Selected bond lengths and angles are listed in Table 1. There is a crystallographic centre of symmetry at the mid-point of the N—N bond. The structure consists of one-dimensional cationic polymers [ $\mu$ -pyridine-2-carbaldehyde azine-bis-[(triphenylphosphine)copper(I)]]- $\mu$ -1,2-bis(4-pyridyl)ethene and free tetrafluoroborate anions. The  $\text{Cu}^{\text{I}}$  atom is coordinated by one P atom of a  $\text{PPh}_3$  ligand, two N atoms of the bridging pyridine-2-carbaldehyde azine ligand and one N atom of the bridging 1,2-bis(4-pyridyl)ethene ligand. The coordination geometry of the  $\text{Cu}^{\text{I}}$  atom is distorted tetrahedral. The Cu—N3 bond length is similar to that in  $[\text{Cu}^{\text{I}}(4\text{-cyanopyridine})_2(\text{SCN})]_n$  [2.1038 (13) Å; Lin *et al.*, 2004]. The Cu···Cu distance in (I), bridged by 1,2-bis(4-pyridyl)ethene, is 13.325 (5) Å, and the Cu···Cu distance bridged by pyridine-2-carbaldehyde azine is 5.452 (5) Å.

**Experimental**

Hydrazine (1 ml, 11 mmol) was added dropwise to a solution of pyridine-2-carboxaldehyde (2.2 ml, 22 mmol) dissolved in ethanol (15 ml). Two drops of formic acid were added and the mixture was stirred at room temperature for 24 h. The yellow solid that formed

was filtered off and washed several times with ethanol–ether (1:1) (yield 91%).  $[\text{Cu}(\text{MeCN})_4]\text{BF}_4$  (62.9 mg 0.2 mmol) was added to a dichloromethane solution (15 ml) of pyridine-2-carbaldehyde azine (21.0 mg, 0.1 mmol) under a nitrogen atmosphere at room temperature. The mixture was stirred for 20 min to give a yellow solution. 1,2-Bis(4-pyridyl)ethene (18.2 mg 0.1 mmol) and  $\text{PPh}_3$  (52.4 mg, 0.2 mmol) were added to this solution. The mixture was stirred for 2 d. The filtrate was kept in a diethyl ether atmosphere for two weeks, during which time yellow block-shaped crystals were formed. Chemical analysis found: C 59.07, H 4.05, N 7.03%; calculated for  $\text{C}_{30}\text{H}_{25}\text{BCuF}_4\text{N}_3\text{P}$ : C 59.20, H 4.14, N 6.91%.

#### Crystal data

$[\text{Cu}_2(\text{C}_{12}\text{H}_{10}\text{N}_2)(\text{C}_{12}\text{H}_{10}\text{N}_4)-(\text{C}_{18}\text{H}_{15}\text{P})_2](\text{BF}_4)_2$   
 $M_r = 1217.70$   
 Triclinic,  $P\bar{1}$   
 $a = 10.196$  (5) Å  
 $b = 10.710$  (6) Å  
 $c = 13.590$  (7) Å  
 $\alpha = 82.447$  (12)°  
 $\beta = 84.181$  (12)°  
 $\gamma = 84.620$  (13)°  
 $V = 1458.8$  (14) Å<sup>3</sup>

$Z = 1$   
 $D_x = 1.386$  Mg m<sup>-3</sup>  
 Mo  $K\alpha$  radiation  
 Cell parameters from 777 reflections  
 $\theta = 3.2$ – $23.8$ °  
 $\mu = 0.85$  mm<sup>-1</sup>  
 $T = 292$  (3) K  
 Block, yellow  
 $0.20 \times 0.18 \times 0.16$  mm

#### Data collection

Bruker SMART CCD area-detector diffractometer  
 $\varphi$  and  $\omega$  scans  
 Absorption correction: multi-scan (SADABS; Sheldrick, 1996)  
 $T_{\min} = 0.845$ ,  $T_{\max} = 0.876$   
 7124 measured reflections

4985 independent reflections  
 2554 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.068$   
 $\theta_{\text{max}} = 25.0$ °  
 $h = -11 \rightarrow 12$   
 $k = -12 \rightarrow 12$   
 $l = -11 \rightarrow 16$

#### Refinement

Refinement on  $F^2$   
 $R[F^2 > 2\sigma(F^2)] = 0.066$   
 $wR(F^2) = 0.216$   
 $S = 0.96$   
 4985 reflections  
 407 parameters

H-atom parameters constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.1091P)^2]$   
 where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\text{max}} < 0.001$   
 $\Delta\rho_{\text{max}} = 0.80$  e Å<sup>-3</sup>  
 $\Delta\rho_{\text{min}} = -1.17$  e Å<sup>-3</sup>

**Table 1**

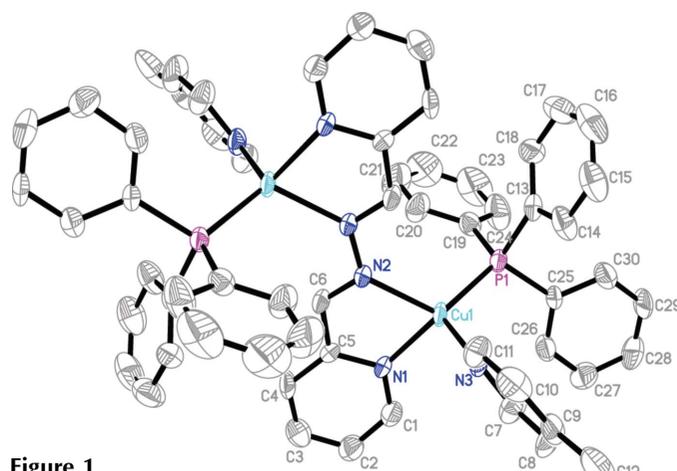
Selected geometric parameters (Å, °).

Cu1–N3	2.024 (6)	Cu1–P1	2.182 (2)
Cu1–N1	2.052 (6)	N2–N2 <sup>i</sup>	1.396 (10)
Cu1–N2	2.118 (5)	C12–C12 <sup>ii</sup>	1.09 (2)
N3–Cu1–N1	104.0 (2)	N1–Cu1–P1	128.12 (17)
N3–Cu1–N2	112.4 (2)	C6–N2–N2 <sup>i</sup>	114.0 (6)
N1–Cu1–N2	78.7 (2)	N2 <sup>i</sup> –N2–Cu1	133.4 (5)
N3–Cu1–P1	112.28 (17)	C12 <sup>ii</sup> –C12–C9	135 (2)
N2 <sup>i</sup> –N2–C6–C5	−179.2 (6)	C10–C9–C12–C12 <sup>ii</sup>	−11 (2)
C8–C9–C12–C12 <sup>ii</sup>	170.4 (19)		

Symmetry codes: (i)  $-x + 1, -y + 2, -z + 2$ ; (ii)  $-x + 2, -y + 2, -z + 1$ .

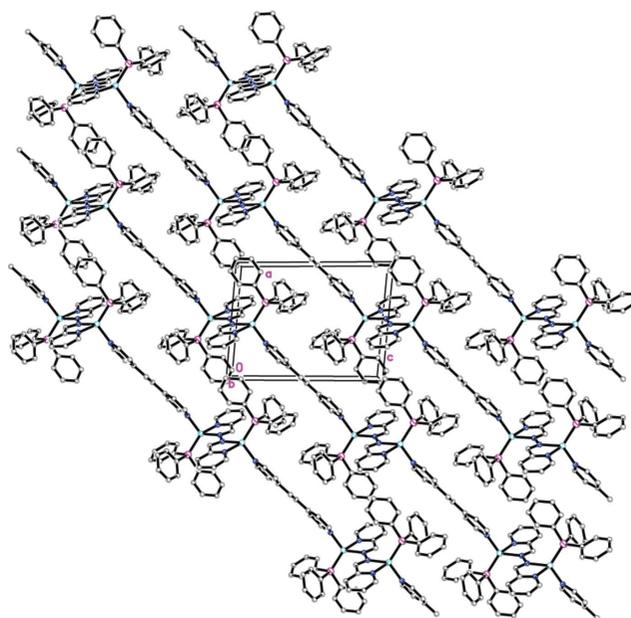
All H atoms were positioned geometrically (C–H bond lengths fixed at 0.93 Å) and refined as riding, with  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$ . The maximum electron-density peak was located 1.19 Å from atom Cu1.

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



**Figure 1**

The molecular structure of the title compound, showing the atom-numbering scheme and displacement ellipsoids drawn at the 40% probability level. Free tetrafluoroborate anions are not shown. The symmetry code for the unlabelled atoms is  $(1 - x, 2 - y, 2 - z)$ .



**Figure 2**

A view of the packing in the title compound, along the  $b$  axis.

The authors thank Henan Agricultural University and Zhengzhou University of Light Industry for the generous support of this study.

#### References

- Bruker (1997). SMART (Version 5.044) and SAINT (Version 5.01). Bruker AXS Inc., Madison, Wisconsin, USA.  
 Lin, P., Henderson, R. A., Harrington, R. W., Clegg, W., Wu, C.-D. & Wu, X.-T. (2004). *Inorg. Chem.* **43**, 181–188.  
 Sheldrick, G. M. (1996). SADABS. University of Göttingen, Germany.  
 Sheldrick, G. M. (1997). SHELXL97. and SHELXS97. University of Göttingen, Germany.  
 Sheldrick, G. M. (1998). SHELXTL. Version 5.10. Bruker AXS Inc., Madison, Wisconsin, USA.  
 Yaghi, O. M., Davis, C. E., Li, G. & Li, H. (1997). *J. Am. Chem. Soc.* **119**, 2861–2868.  
 Yu, M.-M., Fu, W.-F., Li, Z.-X., Yao, Z.-F. & Jia, L.-F. (2004). *Acta Cryst. E* **60**, m1897–m1899.