Acta Crystallographica Section E
**Structure Reports Online**
ISSN 1600-5368

# Bis(2-methoxyphenolato-$\kappa^2O,O'$)-copper(II)

**Guo-Zhu Mao,[a] Xiu-Lian Nong[b] and Shu Hua Zhang[c]***

[a]School of Environmental Science and Technology, Tianjin University, Tianjin 300072, People's Republic of China, [b]Department of Chemistry and Chemical Engineering, Guangxi Normal University, Guilin 541004, People's Republic of China, and [c]School of Chemistry and Bioengineering, Guilin University of Technology, Guilin 541004, People's Republic of China
Correspondence e-mail: zsh720108@163.com

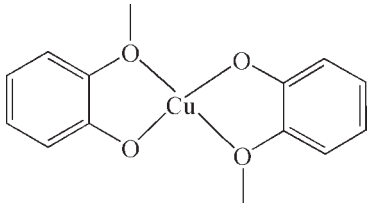
Received 2 July 2009; accepted 4 September 2009

Key indicators: single-crystal X-ray study; $T$ = 293 K; mean $\sigma$(C–C) = 0.007 Å; $R$ factor = 0.051; $wR$ factor = 0.129; data-to-parameter ratio = 14.4.

In the title compound, $[Cu(C_7H_7O_2)_2]$, the asymmetric unit contains one and a half molecules with the central Cu(II) atoms situated on a general position and on a centre of inversion, respectively. Both Cu(II) atoms show a similar slightly distorted square-planar coordination, resulting from four O atoms of two 2-methoxyphenolate anions.

## Related literature

For 2-methoxy-phenol compounds, see: Campello *et al.* (1997); Floriani *et al.* (1988); Minhas *et al.* (1993); Kuo *et al.* (1999); Schumann *et al.* (1996); Sobota *et al.* (2001).




## Experimental

### Crystal data

$[Cu(C_7H_7O_2)_2]$
$M_r$ = 333.82
Triclinic, $P\overline{1}$
$a$ = 9.5190 (19) Å
$b$ = 11.540 (2) Å
$c$ = 12.488 (3) Å
$\alpha$ = 102.83 (3)°
$\beta$ = 103.93 (3)°
$\gamma$ = 111.20 (3)°
$V$ = 1166.7 (6) Å$^3$
$Z$ = 3
Mo $K\alpha$ radiation
$\mu$ = 1.42 mm$^{-1}$
$T$ = 293 K
0.23 × 0.12 × 0.08 mm

### Data collection

Bruker P4 diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 1996)
$T_{min}$ = 0.656, $T_{max}$ = 0.857
6930 measured reflections
4164 independent reflections
3466 reflections with $I > 2\sigma(I)$
$R_{int}$ = 0.037

### Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.051
$wR(F^2)$ = 0.129
$S$ = 0.93
4164 reflections
289 parameters
4 restraints
H-atom parameters constrained
$\Delta\rho_{max}$ = 0.70 e Å$^{-3}$
$\Delta\rho_{min}$ = −0.63 e Å$^{-3}$

Data collection: *XSCANS* (Bruker, 1997); cell refinement: *XSCANS*; data reduction: *SHELXTL* (Sheldrick, 2008); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *SHELXTL*; software used to prepare material for publication: *SHELXTL*.

We acknowledge financial support by Guangxi Key Laboratory for Advanced Materials and New Preparation Technology (No. 0842003–25) and the Young Science Foundation of Guangxi Province (No. 0832085).

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: GW2068).

## References

Bruker (1997). *XSCANS*. Bruker AXS Inc., Madison, Wisconsin, USA.
Campello, M. P. C., Calhorda, M. J., Domingos, A., Galvao, A., Leal, J. P., Pires de Matos, A. & Santos, I. (1997). *J. Organomet. Chem.* **538**, 223–239.
Floriani, C., Mazzanti, M., Chiesi-Villa, A. & Guastini, C. (1988). *Angew. Chem. Int. Ed. Engl.* **27**, 576–578.
Kuo, C. N., Huang, T. Y., Shao, M. Y. & Gau, H. M. (1999). *Inorg. Chim. Acta*, **293**, 12–19.
Minhas, R. K., Edema, J. J. H., Gambarotta, S. & Meetsma, A. (1993). *J. Am. Chem. Soc.* **115**, 6710–6717.
Schumann, H., Frick, M., Heymer, B. & Girgsdies, F. (1996). *J. Organomet. Chem.* **512**, 117–126.
Sheldrick, G. M. (1996). *SADABS*. University of Göttingen, Germany.
Sheldrick, G. M. (2008). *Acta Cryst.* A**64**, 112–122.
Sobota, P., Przybylak, K., Utko, J., Jerzykiewicz, L. B., Pombeiro, A. J. L., Guedes da Silva, M. F. C. & Szczegot, K. (2001). *Chem. Eur. J.* **7**, 951–958.

# supporting information

*Acta Cryst.* (2009). E**65**, m1208 [doi:10.1107/S160053680903582X]

## Bis(2-methoxyphenolato-$\kappa^2O,O'$)copper(II)

**Guo-Zhu Mao, Xiu-Lian Nong and Shu Hua Zhang**

### S1. Comment

2-Methoxy-phenol ligand can act as either mondentate ligand (Campello, *et al.*, 1997), or didentate ligand (Sobota, *et al.*, 2001), or $mu_2$-o ligand or $mu_3$:$eta^1$:$eta^2$-O ligand (Schumann, *et al.* 1996) or $mu_4$:$eta^1$:$eta^3$-O ligand (Floriani, *et al.* 1988). However, copper compound with 2-Methoxy-phenol have not been reported till today (http://www.ccdc.cam.ac.uk/). The title compound, (I), is a new $Cu^{II}$ complex prepared by reaction of 2-Methoxy-phenol and Copper(II) nitrate using solvothermal technique.

There are one CuÎI^ atom and two $L^-$ ligand in the asymetric unit. The $Cu^{II}$ atom has a slightly distorted square-planar environment, formed by four O atoms from two different $L^-$ ligands. The $L^-$ ligand binds to copper in a didentate mode, through two O atoms. In the title complex, the two copper lied in the different position that the Cu2 is at the center of symmetry (010) plane and the Cu1 is at a general position (Fig. 2). The complex further constructed a 3-D network through very weak C–H···O hydrogen bond (C21–H21···$O1^{i}$, 3.426 (1) Å, symmetry code: (i) 1 - *y*,2 - *y*,1 - *z*) and C–H···p hydrogen bond (C16···$P^{ii}$, 3.652 (1) Å, symmetry code: (ii) 1 + *x*, *y*, *z*).

### S2. Experimental

A solution of (0.124 g, 1 mmol) 2-Methoxy-phenol and (0.056 g, 1 mmol) potassium hydroxide in 8 ml absolute methanol was added ((0.125 g, 0.5 mmol) Copper nitrate tetrahydrate. The solution was placed in a 15-ml Tetlon-lined stainless steel parr bomb. The bomd was heated at 363 k for 96 h. The cooled mixture yielded blue block-shaped crystal of (1) in about 71% yield. The crystals were washed with methanol and then dried in air.

### S3. Refinement

H atoms were positioned geometrically and refined with a riding model, with distances 0.96 Å($CH_3$) or 0.93 Å(aromatic ring). and with $U_{iso}$(H) = 1.2 $U_{eq}$(aromatic ring) or $U_{iso}$(H) = 1.5 $U_{eq}$(($CH_3$).

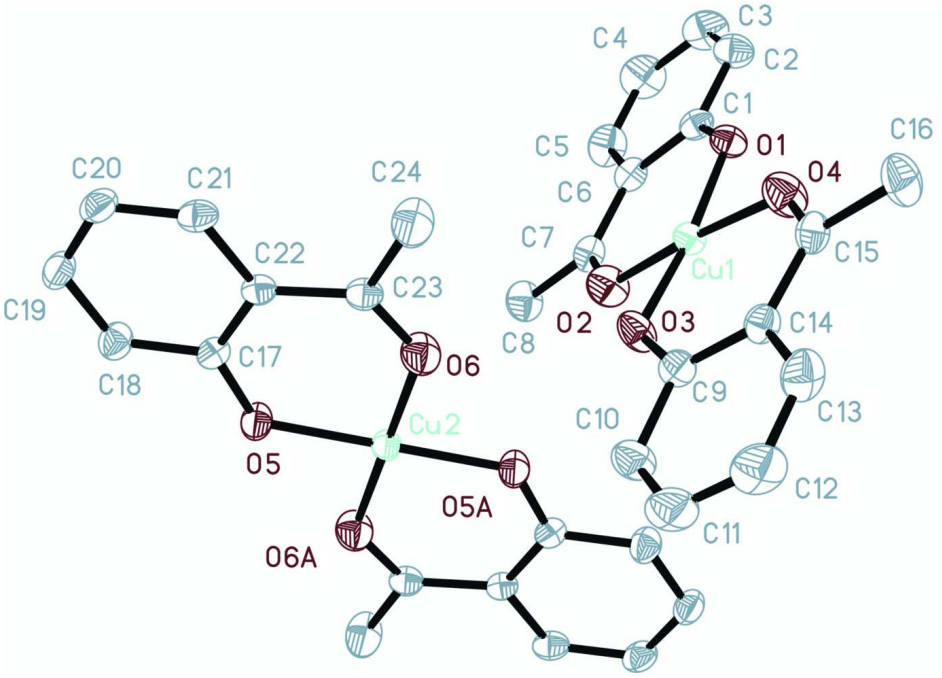



**Figure 1**

The molecular structure of (I), showing 30% probability displacement ellipsoids. Symmetry codes: (A) -*x* + 1, -*y* + 2, -*z* + 1.

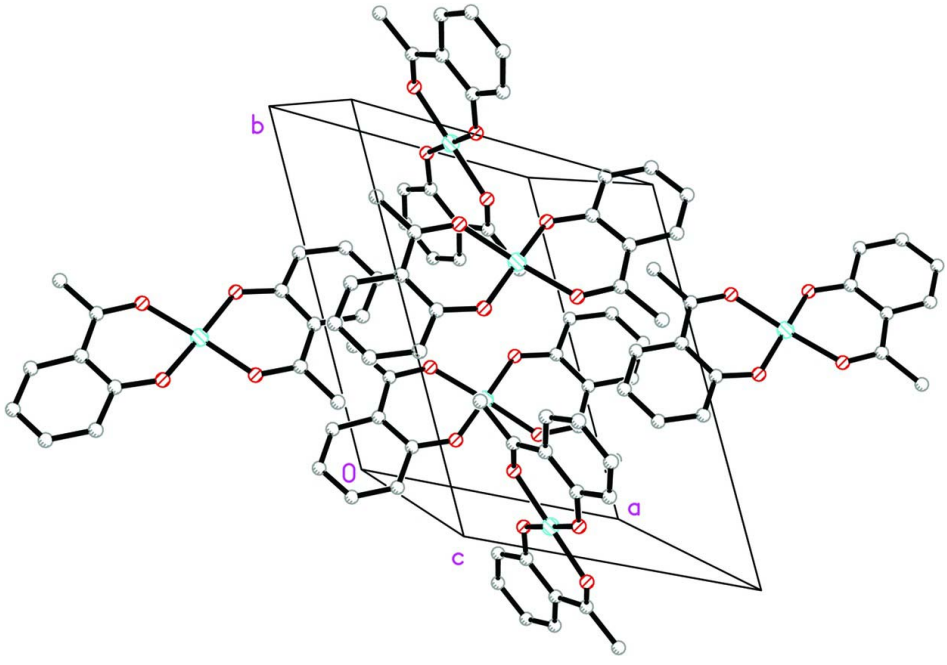



**Figure 2**

Packing diagram of title complex,hydrogen atoms were omitted.

**Bis(2-methoxyphenolato-$\kappa^2O,O'$)copper(II)**

*Crystal data*

$[Cu(C_7H_7O_2)_2]$
$M_r = 333.82$
Triclinic, $P\overline{1}$
Hall symbol: -P 1
$a = 9.5190$ (19) Å
$b = 11.540$ (2) Å
$c = 12.488$ (3) Å
$\alpha = 102.83$ (3)°
$\beta = 103.93$ (3)°
$\gamma = 111.20$ (3)°
$V = 1166.7$ (6) Å$^3$
$Z = 3$
$F(000) = 513$
$D_x = 1.425$ Mg m$^{-3}$
Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Cell parameters from 4216 reflections
$\theta = 3.1$–25.3°
$\mu = 1.42$ mm$^{-1}$
$T = 293$ K
Block, blue
0.23 × 0.12 × 0.08 mm

*Data collection*

Bruker P4 diffractometer
Radiation source: fine-focus sealed tube
Graphite monochromator
$\omega$ scans
Absorption correction: multi-scan (*SADABS*; Sheldrick, 1996)
$T_{min} = 0.656$, $T_{max} = 0.857$
6930 measured reflections
4164 independent reflections
3466 reflections with $I > 2\sigma(I)$
$R_{int} = 0.037$
$\theta_{max} = 25.3°$, $\theta_{min} = 3.1°$
$h = -11 \rightarrow 11$
$k = -13 \rightarrow 13$
$l = -14 \rightarrow 12$

*Refinement*

Refinement on $F^2$
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)] = 0.051$
$wR(F^2) = 0.129$
$S = 0.93$
4164 reflections
289 parameters
4 restraints
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map
Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0653P)^2 + 1.5P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.001$
$\Delta\rho_{max} = 0.70$ e Å$^{-3}$
$\Delta\rho_{min} = -0.63$ e Å$^{-3}$

*Special details*

**Geometry**. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

**Refinement**. Refinement of $F^2$ against ALL reflections. The weighted $R$-factor $wR$ and goodness of fit $S$ are based on $F^2$, conventional $R$-factors $R$ are based on $F$, with $F$ set to zero for negative $F^2$. The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating $R$-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. $R$-factors based on $F^2$ are statistically about twice as large as those based on $F$, and $R$- factors based on ALL data will be even larger.

*Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å$^2$)*

| | $x$ | $y$ | $z$ | $U_{iso}$*/$U_{eq}$ |
|---|---|---|---|---|
| Cu1 | 0.52201 (5) | 0.70662 (4) | 0.76824 (4) | 0.03605 (16) |
| Cu2 | 0.5000 | 1.0000 | 0.5000 | 0.03477 (19) |
| C1 | 0.1962 (4) | 0.5274 (4) | 0.7391 (3) | 0.0393 (9) |

| | | | | |
|---|---|---|---|---|
| C2 | 0.0931 (5) | 0.4117 (4) | 0.7551 (4) | 0.0544 (11) |
| H2 | 0.1388 | 0.3665 | 0.7934 | 0.065* |
| C3 | −0.0719 (6) | 0.3655 (5) | 0.7154 (5) | 0.0700 (14) |
| H3 | −0.1355 | 0.2901 | 0.7273 | 0.084* |
| C4 | −0.1437 (6) | 0.4304 (6) | 0.6579 (5) | 0.0746 (15) |
| H4 | −0.2552 | 0.3979 | 0.6298 | 0.090* |
| C5 | −0.0486 (5) | 0.5435 (5) | 0.6426 (4) | 0.0628 (13) |
| H5 | −0.0982 | 0.5867 | 0.6046 | 0.075* |
| C6 | 0.1233 (4) | 0.5970 (4) | 0.6827 (3) | 0.0418 (9) |
| C7 | 0.2162 (4) | 0.7193 (4) | 0.6650 (3) | 0.0419 (9) |
| C8 | 0.1304 (5) | 0.7895 (5) | 0.6067 (4) | 0.0573 (12) |
| H8A | 0.2086 | 0.8694 | 0.6053 | 0.086* |
| H8B | 0.0672 | 0.8107 | 0.6502 | 0.086* |
| H8C | 0.0613 | 0.7328 | 0.5278 | 0.086* |
| C9 | 0.8449 (4) | 0.8867 (4) | 0.7933 (4) | 0.0414 (9) |
| C10 | 0.9435 (5) | 1.0056 (4) | 0.7786 (4) | 0.0559 (11) |
| H10 | 0.8951 | 1.0450 | 0.7342 | 0.067* |
| C11 | 1.1084 (6) | 1.0620 (5) | 0.8293 (5) | 0.0699 (14) |
| H11 | 1.1699 | 1.1386 | 0.8180 | 0.084* |
| C12 | 1.1844 (5) | 1.0075 (5) | 0.8966 (5) | 0.0727 (15) |
| H12 | 1.2960 | 1.0477 | 0.9315 | 0.087* |
| C13 | 1.0938 (5) | 0.8930 (5) | 0.9118 (4) | 0.0605 (12) |
| H13 | 1.1464 | 0.8563 | 0.9565 | 0.073* |
| C14 | 0.9226 (4) | 0.8284 (4) | 0.8617 (3) | 0.0410 (9) |
| C15 | 0.8344 (4) | 0.7091 (4) | 0.8844 (3) | 0.0425 (9) |
| C16 | 0.9244 (6) | 0.6458 (5) | 0.9492 (5) | 0.0648 (13) |
| H16A | 0.8485 | 0.5657 | 0.9520 | 0.097* |
| H16B | 0.9902 | 0.7058 | 1.0277 | 0.097* |
| H16C | 0.9915 | 0.6259 | 0.9089 | 0.097* |
| C17 | 0.4664 (4) | 0.8676 (4) | 0.2612 (3) | 0.0362 (8) |
| C18 | 0.4051 (5) | 0.8508 (4) | 0.1408 (3) | 0.0453 (9) |
| H18 | 0.3634 | 0.9074 | 0.1197 | 0.054* |
| C19 | 0.4051 (5) | 0.7535 (4) | 0.0537 (4) | 0.0472 (10) |
| H19 | 0.3619 | 0.7437 | −0.0247 | 0.057* |
| C20 | 0.4707 (5) | 0.6694 (4) | 0.0840 (4) | 0.0465 (10) |
| H20 | 0.4724 | 0.6042 | 0.0259 | 0.056* |
| C21 | 0.5329 (4) | 0.6839 (4) | 0.2007 (4) | 0.0423 (9) |
| H21 | 0.5776 | 0.6283 | 0.2197 | 0.051* |
| C22 | 0.5311 (4) | 0.7810 (3) | 0.2934 (3) | 0.0336 (8) |
| C23 | 0.5920 (4) | 0.7872 (4) | 0.4156 (3) | 0.0378 (8) |
| C24 | 0.6642 (7) | 0.6950 (5) | 0.4440 (4) | 0.0690 (14) |
| H24A | 0.6945 | 0.7098 | 0.5267 | 0.104* |
| H24B | 0.7576 | 0.7121 | 0.4218 | 0.104* |
| H24C | 0.5861 | 0.6049 | 0.4013 | 0.104* |
| O1 | 0.3522 (3) | 0.5619 (2) | 0.7790 (2) | 0.0421 (6) |
| O2 | 0.3737 (4) | 0.7706 (3) | 0.6987 (3) | 0.0619 (8) |
| O3 | 0.6876 (3) | 0.8377 (3) | 0.7402 (3) | 0.0506 (7) |
| O4 | 0.6767 (4) | 0.6530 (3) | 0.8491 (3) | 0.0633 (9) |

| | | | | |
|---|---|---|---|---|
| O5 | 0.4601 (4) | 0.9650 (3) | 0.3363 (2) | 0.0488 (7) |
| O6 | 0.5830 (4) | 0.8684 (3) | 0.5029 (3) | 0.0571 (8) |

*Atomic displacement parameters (Å²)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| Cu1 | 0.0312 (3) | 0.0370 (3) | 0.0406 (3) | 0.0157 (2) | 0.0112 (2) | 0.0147 (2) |
| Cu2 | 0.0444 (4) | 0.0352 (3) | 0.0314 (4) | 0.0241 (3) | 0.0137 (3) | 0.0117 (3) |
| C1 | 0.038 (2) | 0.039 (2) | 0.039 (2) | 0.0164 (16) | 0.0172 (17) | 0.0062 (17) |
| C2 | 0.051 (2) | 0.046 (2) | 0.066 (3) | 0.017 (2) | 0.027 (2) | 0.020 (2) |
| C3 | 0.049 (3) | 0.062 (3) | 0.087 (4) | 0.007 (2) | 0.034 (3) | 0.021 (3) |
| C4 | 0.034 (2) | 0.080 (4) | 0.093 (4) | 0.011 (2) | 0.020 (2) | 0.026 (3) |
| C5 | 0.038 (2) | 0.078 (3) | 0.064 (3) | 0.023 (2) | 0.012 (2) | 0.021 (3) |
| C6 | 0.0350 (19) | 0.048 (2) | 0.039 (2) | 0.0179 (17) | 0.0128 (17) | 0.0089 (18) |
| C7 | 0.0368 (18) | 0.053 (2) | 0.037 (2) | 0.0237 (18) | 0.0122 (16) | 0.0116 (19) |
| C8 | 0.052 (2) | 0.070 (3) | 0.061 (3) | 0.037 (2) | 0.016 (2) | 0.027 (3) |
| C9 | 0.036 (2) | 0.043 (2) | 0.043 (2) | 0.0142 (17) | 0.0169 (17) | 0.0146 (19) |
| C10 | 0.052 (3) | 0.050 (3) | 0.066 (3) | 0.017 (2) | 0.023 (2) | 0.027 (2) |
| C11 | 0.056 (3) | 0.056 (3) | 0.079 (4) | 0.003 (2) | 0.029 (3) | 0.022 (3) |
| C12 | 0.035 (2) | 0.073 (3) | 0.084 (4) | 0.003 (2) | 0.016 (2) | 0.020 (3) |
| C13 | 0.037 (2) | 0.078 (3) | 0.057 (3) | 0.021 (2) | 0.008 (2) | 0.023 (3) |
| C14 | 0.0334 (19) | 0.047 (2) | 0.038 (2) | 0.0156 (17) | 0.0107 (16) | 0.0122 (18) |
| C15 | 0.037 (2) | 0.055 (2) | 0.037 (2) | 0.0239 (18) | 0.0115 (17) | 0.0163 (19) |
| C16 | 0.057 (3) | 0.081 (3) | 0.066 (3) | 0.038 (3) | 0.014 (2) | 0.040 (3) |
| C17 | 0.0349 (18) | 0.0349 (19) | 0.035 (2) | 0.0156 (16) | 0.0097 (16) | 0.0073 (17) |
| C18 | 0.048 (2) | 0.050 (2) | 0.038 (2) | 0.0260 (19) | 0.0090 (18) | 0.0129 (19) |
| C19 | 0.052 (2) | 0.049 (2) | 0.031 (2) | 0.0178 (19) | 0.0122 (18) | 0.0062 (19) |
| C20 | 0.054 (2) | 0.039 (2) | 0.041 (2) | 0.0181 (18) | 0.0202 (19) | 0.0031 (18) |
| C21 | 0.043 (2) | 0.034 (2) | 0.052 (3) | 0.0194 (17) | 0.0206 (19) | 0.0093 (18) |
| C22 | 0.0306 (17) | 0.0305 (18) | 0.039 (2) | 0.0132 (14) | 0.0133 (15) | 0.0089 (16) |
| C23 | 0.0389 (19) | 0.0342 (19) | 0.046 (2) | 0.0214 (16) | 0.0170 (17) | 0.0123 (17) |
| C24 | 0.100 (4) | 0.081 (3) | 0.055 (3) | 0.071 (3) | 0.024 (3) | 0.023 (3) |
| O1 | 0.0376 (14) | 0.0390 (14) | 0.0541 (17) | 0.0187 (11) | 0.0173 (12) | 0.0189 (13) |
| O2 | 0.0529 (17) | 0.065 (2) | 0.074 (2) | 0.0300 (15) | 0.0214 (16) | 0.0286 (18) |
| O3 | 0.0351 (14) | 0.0563 (17) | 0.065 (2) | 0.0183 (13) | 0.0134 (13) | 0.0364 (16) |
| O4 | 0.0519 (18) | 0.065 (2) | 0.079 (2) | 0.0271 (16) | 0.0203 (16) | 0.0362 (18) |
| O5 | 0.079 (2) | 0.0494 (16) | 0.0350 (15) | 0.0463 (15) | 0.0201 (14) | 0.0154 (13) |
| O6 | 0.0668 (19) | 0.0625 (19) | 0.0566 (19) | 0.0401 (16) | 0.0235 (16) | 0.0246 (16) |

*Geometric parameters (Å, º)*

| | | | |
|---|---|---|---|
| Cu1—O1 | 1.916 (3) | C11—C12 | 1.378 (7) |
| Cu1—O3 | 1.916 (3) | C11—H11 | 0.9300 |
| Cu1—O2 | 1.934 (3) | C12—C13 | 1.375 (7) |
| Cu1—O4 | 1.947 (3) | C12—H12 | 0.9300 |
| Cu2—O5$^{i}$ | 1.906 (3) | C13—C14 | 1.423 (5) |
| Cu2—O5 | 1.906 (3) | C13—H13 | 0.9300 |
| Cu2—O6$^{i}$ | 1.952 (3) | C14—C15 | 1.460 (6) |

| | | | |
|---|---|---|---|
| Cu2—O6 | 1.952 (3) | C15—O4 | 1.311 (5) |
| C1—O1 | 1.319 (4) | C15—C16 | 1.518 (5) |
| C1—C6 | 1.430 (5) | C16—H16A | 0.9600 |
| C1—C2 | 1.432 (6) | C16—H16B | 0.9600 |
| C2—C3 | 1.379 (6) | C16—H16C | 0.9600 |
| C2—H2 | 0.9300 | C17—O5 | 1.325 (4) |
| C3—C4 | 1.384 (7) | C17—C18 | 1.417 (5) |
| C3—H3 | 0.9300 | C17—C22 | 1.429 (5) |
| C4—C5 | 1.378 (7) | C18—C19 | 1.380 (6) |
| C4—H4 | 0.9300 | C18—H18 | 0.9300 |
| C5—C6 | 1.431 (5) | C19—C20 | 1.401 (6) |
| C5—H5 | 0.9300 | C19—H19 | 0.9300 |
| C6—C7 | 1.467 (6) | C20—C21 | 1.380 (6) |
| C7—O2 | 1.311 (5) | C20—H20 | 0.9300 |
| C7—C8 | 1.519 (5) | C21—C22 | 1.430 (5) |
| C8—H8A | 0.9600 | C21—H21 | 0.9300 |
| C8—H8B | 0.9600 | C22—C23 | 1.471 (5) |
| C8—H8C | 0.9600 | C23—O6 | 1.313 (5) |
| C9—O3 | 1.321 (4) | C23—C24 | 1.520 (5) |
| C9—C14 | 1.428 (5) | C24—H24A | 0.9600 |
| C9—C10 | 1.436 (6) | C24—H24B | 0.9600 |
| C10—C11 | 1.374 (7) | C24—H24C | 0.9600 |
| C10—H10 | 0.9300 | | |

| | | | |
|---|---|---|---|
| O1—Cu1—O3 | 173.38 (12) | C13—C12—H12 | 120.3 |
| O1—Cu1—O2 | 91.92 (12) | C12—C13—C14 | 122.6 (4) |
| O3—Cu1—O2 | 88.35 (12) | C12—C13—H13 | 118.7 |
| O1—Cu1—O4 | 89.17 (12) | C14—C13—H13 | 118.7 |
| O3—Cu1—O4 | 91.05 (12) | C13—C14—C9 | 117.6 (4) |
| O2—Cu1—O4 | 175.72 (15) | C13—C14—C15 | 119.4 (4) |
| O5$^{i}$—Cu2—O5 | 180.000 (1) | C9—C14—C15 | 123.0 (3) |
| O5$^{i}$—Cu2—O6$^{i}$ | 92.29 (12) | O4—C15—C14 | 121.6 (3) |
| O5—Cu2—O6$^{i}$ | 87.71 (12) | O4—C15—C16 | 118.1 (4) |
| O5$^{i}$—Cu2—O6 | 87.71 (12) | C14—C15—C16 | 120.3 (3) |
| O5—Cu2—O6 | 92.29 (12) | C15—C16—H16A | 109.5 |
| O6$^{i}$—Cu2—O6 | 180.000 (1) | C15—C16—H16B | 109.5 |
| O1—C1—C6 | 125.1 (3) | H16A—C16—H16B | 109.5 |
| O1—C1—C2 | 116.9 (4) | C15—C16—H16C | 109.5 |
| C6—C1—C2 | 118.0 (3) | H16A—C16—H16C | 109.5 |
| C3—C2—C1 | 121.9 (4) | H16B—C16—H16C | 109.5 |
| C3—C2—H2 | 119.1 | O5—C17—C18 | 116.4 (3) |
| C1—C2—H2 | 119.1 | O5—C17—C22 | 124.8 (3) |
| C2—C3—C4 | 120.5 (5) | C18—C17—C22 | 118.8 (3) |
| C2—C3—H3 | 119.8 | C19—C18—C17 | 122.2 (4) |
| C4—C3—H3 | 119.8 | C19—C18—H18 | 118.9 |
| C3—C4—C5 | 119.5 (4) | C17—C18—H18 | 118.9 |
| C3—C4—H4 | 120.3 | C18—C19—C20 | 119.6 (4) |
| C5—C4—H4 | 120.3 | C18—C19—H19 | 120.2 |

| | | | |
|---|---|---|---|
| C4—C5—C6 | 122.7 (5) | C20—C19—H19 | 120.2 |
| C4—C5—H5 | 118.7 | C21—C20—C19 | 119.7 (4) |
| C6—C5—H5 | 118.7 | C21—C20—H20 | 120.2 |
| C1—C6—C5 | 117.5 (4) | C19—C20—H20 | 120.2 |
| C1—C6—C7 | 123.1 (3) | C20—C21—C22 | 122.5 (4) |
| C5—C6—C7 | 119.4 (4) | C20—C21—H21 | 118.7 |
| O2—C7—C6 | 121.4 (3) | C22—C21—H21 | 118.7 |
| O2—C7—C8 | 118.5 (4) | C17—C22—C21 | 117.2 (3) |
| C6—C7—C8 | 120.1 (3) | C17—C22—C23 | 122.9 (3) |
| C7—C8—H8A | 109.5 | C21—C22—C23 | 119.9 (3) |
| C7—C8—H8B | 109.5 | O6—C23—C22 | 122.3 (3) |
| H8A—C8—H8B | 109.5 | O6—C23—C24 | 117.6 (4) |
| C7—C8—H8C | 109.5 | C22—C23—C24 | 120.1 (3) |
| H8A—C8—H8C | 109.5 | C23—C24—H24A | 109.5 |
| H8B—C8—H8C | 109.5 | C23—C24—H24B | 109.5 |
| O3—C9—C14 | 124.7 (3) | H24A—C24—H24B | 109.5 |
| O3—C9—C10 | 117.0 (4) | C23—C24—H24C | 109.5 |
| C14—C9—C10 | 118.3 (4) | H24A—C24—H24C | 109.5 |
| C11—C10—C9 | 120.8 (4) | H24B—C24—H24C | 109.5 |
| C11—C10—H10 | 119.6 | C1—O1—Cu1 | 127.9 (2) |
| C9—C10—H10 | 119.6 | C7—O2—Cu1 | 130.4 (3) |
| C10—C11—C12 | 121.3 (4) | C9—O3—Cu1 | 127.4 (2) |
| C10—C11—H11 | 119.3 | C15—O4—Cu1 | 130.0 (3) |
| C12—C11—H11 | 119.3 | C17—O5—Cu2 | 127.9 (2) |
| C11—C12—C13 | 119.4 (4) | C23—O6—Cu2 | 129.0 (3) |
| C11—C12—H12 | 120.3 | | |

Symmetry code: (i) $-x+1, -y+2, -z+1$.