Research paper

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Multi-properties of a Cu(Ⅱ) complex : crystal structure, anion binding ability, bioactivity and cell cytotoxicity

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Abstract:

A new copper(Ⅱ) complex based on Schiff bases of 3-nitrosalicylaldehyde was synthesized and the crystal was also obtained fortunately. Its structure was well characterized by single-crystal X-ray diffraction and HRMS. The complex showed the strongest binding ability and high selectivity for hydrogen sulfide among other anions (AcO^-, $H_2PO_4^-$, F^-, Cl^-, Br^- and I^-) at neutral pH in organic-aqueous solutions. The possible mechanism was the copper ion was released and combined with hydrogen sulfide after the anion was added. In addition, the further application of the sensor was applied to hela cells cytotoxicity. The above results indicated the copper(Ⅱ) complex could be used as a sensor for the detection of HS^- in the sample of environment, pharmacy, and etc. More importantly, the copper(Ⅱ) complex also exhibited effective and wide antibacterial activity.

Key words: copper(Ⅱ) complex; crystal property; hydrogen sulfide; sensor; antibacterial activity

1. Introduction

Hydrogen sulfide (H_2S), notorious for the stink of rotten-eggs, was considered merely as a toxin with no beneficial physiological significance until the initial observations by Kimura's group suggesting its biological relevance as a signaling molecule [1]. Now hydrogen sulfide(H_2S) is found to be the third endogenous gasotransmitter after carbon monoxide and nitric oxide [2-6], which contributes to various physiological processes, including relaxation of vascular smooth muscles, mediation of neurotransmission, regulation of inflammation and O_2 sensing, and it can also protect against ischemia/reperfusion injury [7-11]. On the other hand, the abnormal H_2S level in cell is related to various diseases such as Alzheimer's disease, Down's syndrome, diabetes and liver cirrhosis [12-15]. Therefore, the selective recognition and detection of H_2S in living systems is significant for better understanding of its physiological and pathological function. And so, the detection of H_2S has become the important subject of chemical research. A variety of detection methods including colorimetric, electrochemical, chem-luminescence, chromatography, and methylene blue assay [16-21] are generally limited by their invasive and destructive nature to the living organisms. While, fluorescence is suitable for the study of H_2S in biological samples due to the high sensitivity and selectivity. What's more, the fluorescence detection method has been widely used in biological studies to research the physiological roles of H_2S and other small molecules because this technology provides real-time, easy-to-use, nondestructive detection in live cells or tissues [22-33]. Lippard reported a number of mental complexes for the fluorescent detection of NO by following the dis placement approach with a detection limit of 50-100mM [34]. Chang et al. synthesized a cyclopalladated derivative showed ppb level sensitivity towards CO [35].

Schiff bases have been attracted considerable attention for their wide range of

biological activities, such as antibacterial, antifungal, antitumor, antiflammatory, and cytotoxic [36]It was reported that Schiff bases bearing electron-withdrawing groups can improve their antimicrobial activities [37]. Antibacterial tests for schiff base and their copper complex reveal that the antibacterial activity of the schiff bases is enhanced when they are chelated with a copper(Ⅱ) ion [38].

Based on the above considerations, we synthesized a copper(Ⅱ) complex (scheme 1) to research the anion binding ability, especially for HS^-. Fortunately, the crystal of copper complex was also obtained. As expected, the complex showed the strongest binding ability for HS^- among the tested anions (HS^-, AcO^-, $H_2PO_4^-$, F^-, Cl^-, Br^- and I^-). In addition, the copper(Ⅱ) complex also exhibited stronger antibacterial activity in the bactericidal test.

Scheme 1

2. Experimental

All reagents and solvents used were of analytical grade. Sodium hydrosulfide hydrate, all anions in the form of tetrabutylammonium salts (such as $(n\text{-}C_4H_9)_4NCl$, $(n\text{-}C_4H_9)_4NBr$, $(n\text{-}C_4H_9)_4NI$, $(n\text{-}C_4H_9)_4NAcO$ and $(n\text{-}C_4H_9)_4NH_2PO_4$) were purchased from Aladdin Chemistry Co. Ltd (Shanghai, China). All anions were stored in a desiccator under vacuum, and used without any further purification. Dimethyl sulfoxide (DMSO) was distilled in vacuum after being dried with CaH_2. ^1H NMR spectra were recorded on a Unity Plus-400-MHz spectrometer. HRMS was performed with a Mariner apparatus. UV-vis titration experiments were made on a Shimadzu UV2550 Spectrophotometer at 298 K. The binding constant, K_s, was obtained by non-linear least squares calculation method for data fitting.

The copper(Ⅱ) complex was synthesized according to the route shown in Scheme 1. The condensation product of 3-nitrosalicylaldehyde and phenylamine was synthesized according to the literature [39]. 3-Nitrosalicylaldehyde (10 mmol) was resolved in ethanol solution (40 mL) and phenylamine (10 mmol) was added to the above solution. Then, the mixture was refluxed for 4 h and the red precipitate was obtained and recrystalled by ethanol, washed, dried under vacuum. Yield: 85%. mp.133-134□.^{1}H NMR (400 MHz, DMSO) δ 15.75 (s, 1H, -OH), 9.23 (s, 1H, -CH=N- C7-H), 8.12 (dd, J = 8.1, 1.7 Hz, 1H, C_4-H), 7.95 (dd, J = 7.7, 1.7 Hz, 1H, C_6-H), 7.59 (d, J = 8.0 Hz, 2H, C_9-H), 7.53 (t, J = 7.8 Hz, 2H, C_{10}-H), 7.40 (t, J = 7.2 Hz, 1H, C_{11}-H), 7.03 (t, J = 7.9 Hz, 1H, C_5-H)(**S1**). ^{13}C NMR (DMSO-d_6, δ, ppm): 163.10(C_7), 158.73(C_2), 144.50(C_8), 139.36(C_6), 138.94(C_3), 130.40(C_4), 130.17(C_{10}), 128.57(C_{11}), 121.75(C_9), 121.11(C_1), 117.17(C_5)(**S2**). Elemental analysis: Calc. for $C_{13}H_{10}N_2O_3$: C, 64.46; H, 4.16; N, 11.56; Found: C, 64.63; H, 4.08; N, 11.37. ESI-MS (*m/z*): 241.3 $(M\text{-H})^-$.

The copper(Ⅱ) complex was synthesized according to the above literature [37]. To a stirred ethanol solution (20 mL) of N-3-nitrosalicylaldehyde-aniline (242 mg, 1 mmol) copper nitrate trihydrate (121 mg, 0.5 mmol) was added. The mixture was refluxed for 8 h and then stood overnight at room temperature. Suitable brown single crystal for X-ray crystal structural analysis was obtained, separated by filtration, washed with petroleum ether. Elemental analysis: Calc. for $C_{26}H_{18}CuN_4O_6$: C, 57.19; H, 3.32; N, 10.26; Found: C, 57.45; H, 3.61; N, 10.52. ESI-HRMS in DMSO/methanol (1:20, v/v, 1×10^{-4} mol·L^{-1}) (*m/z*): 568.0408 $(M+\text{Na})^+$**(S5)**.

Antibacterial activity of Cu(Ⅱ) complex

The kinds of bacteria were Bacillus subtilis, Staphylococcus aureus, Staphylococcus albus, Escherichia coli, Salmonella typhi and Pseudomonas aeruginosa. Antibacterial activity was determined by filter paper method. The qualitative filter paper was made into small round pieces (d = 6 mm) which was used after high pressure sterilization. Under the sterile conditions, the appropriate culture medium (20 ~ 25 mL) was dished into the sterilized Petri and made into solid plate after solidifying. The prepared bacterial suspension (200 μL) was poured into the appropriate solid medium using coated rods liquid coating. The filter paper was pasted on bacterial plate. The essential oils (5 μL) were added in each piece of filter paper. Bacillus subtilis, Staphylococcus aureus, Staphylococcus albus, Escherichia coli, Salmonella typhi and Pseudomonas aeruginosa were stood in culture incubator (37 ℃) for 24 h. Then the clear the plate diameter size of inhibition zone was selected and the average value of repeat test results was obtained. Each test was carried out for eight times to minimize the error. In order to clarify any effect of DMSO in the biological screening, blank studies were carried out, and no activity was observed against any bacterial strain in pure DMSO.

Cell cytotoxicity of Cu(Ⅱ) complex

In the experiment, the cells used were Hela cell which were seeded into a 96-well plate at a density of 5×10^4 cells/well. After the cells form monolayer, the culture media were replaced by solutions of complex at concentration in a range of 5-200 $\mu g \cdot mL^{-1}$. After further 24 h incubation, complex solutions were then replaced with fresh media after several washing steps, and 20 μL MTT with concentration of 5 $mg \cdot mL^{-1}$ was added to each well and incubated for a further 4 h. After that, the culture media were removed and 150 μL of DMSO were then added. Finally, the absorbance of cells were detected at 490 nm using the microplate reader (Thermo

Multiscan MK3, Thermo Fisher Scientific, MA, USA) with the plain cell culture media as the control. Cell viability was expressed by the ratio between the absorbance of the cells incubated with complex to that of the cells incubated with blank culture media only.

3. Results and discussion

3.1 X-ray crystal structure

Single crystal for X-ray analysis was prepared fortunately in order to determine the structure of the copper(Ⅱ) complex. The measurement of X-ray structure was performed at room temperature using a BRUKER APEX Ⅱ. The structure were solved by SHELXL-97. Software packages APEX Ⅱ (data collection), saint(cell refinement and date reduction), SHELXTL (data reduction, molecular graphics and publication material) were also used [40-41] An ORTEP view of complex with the atoms numbering was shown in Fig. 1. A summary of the detailed crystal data, data collection and refinement details were all listed in Table 1. Selected bond lengths and bond angles were listed in Table 2. The crystallographic data revealed that the metal center was four-coordinated by two oxygen atoms in phenolate and two nitrogen atoms in imine of the ligand. Two ligands coordinated with the copper center in trans- orientation with respect to each other and the distance (Cu-O) was shorter than the distance (Cu-N). The geometry around the metal center was a distorted square-planar and space group of the unit cell is P21/c. There were also five-coordinated complexes with a distorted square pyramidal geometry in the central copper atom [42] and six-coordinated complexes which forming an octahedron geometry with copper atom [43]. Tri-dentate or tetra-dentate ligands were involved in the formation of the complexes. To the best of our knowledge, almost bi-dentate ligands was constructed to form four-coordinated complex due to the steric

hindrance [44]. Similarly, four-coordinated complex formed due to the bi-dentate ligand in this paper.

Fig.1

Table 1

Table 2

3.2 UV-vis titration

The binding ability of copper complex with anions was investigated using UV-vis absorption spectra in DMSO and DMSO/HEPES (pH=7.4) at 298 K. The UV-vis spectral responses of copper complex in DMSO were shown in Fig.2 during the titration with various anions. The free complex (8.0×10^{-5} mol·L^{-1} in DMSO) revealed a strong band with the maximum absorption peak at about 400 nm. The absorption peak was gradually turned into a valley with the stepwise addition of HS^- and a new absorption peak developed at about 487 nm. The red-shift phenomenon was observed which induced the color change of the copper complex solution from yellow to pink. In addition, four clear isosbestic points at 270, 325, 362 and 430 nm appeared which indicated the stable complex formed and had a certain stoichiometric ratio between the Cu(Ⅱ) complex and HS^-. Analogous investigations were carried out on other normal anions. The additions of $H_2PO_4^-$, AcO^- and F^- to Cu(Ⅱ) complex induced similar red shift of the peak, but only the addition of $H_2PO_4^-$ transformed the peak into valley with ten times the concentration compared with HS^- which indicated Cu(Ⅱ) complex also interacted with the above anions (Fig. 2). However, the additions of Cl^-, Br^- and I^- did not induce any spectral responses. The above results indicated that Cu(Ⅱ) complex showed almost no binding ability toward these anions (Fig. 3).

Fig. 2 Fig. 3

In order to further study the binding ability of Cu(Ⅱ) complex in aqueous solution, a solution of Cu(Ⅱ) complex (8.0×10^{-5} mol·L^{-1}) was prepared in DMSO/H_2O(6:4, v/v, 0.04mol·L^{-1} HEPES buffer at pH 7.4). The UV-vis absorption spectra of each solution were recorded after the investigated anions were added. As shown in the Fig. 4, the absorption peak shifted from 413 to 447 nm and the valley shifted from 327 to 386 nm with the concentration of NaHS increasing from 0 to 2.5×10^{-4} mol·L^{-1}. What's more, two isosbestic points at 369 and 423 nm were appeared which indicated the interaction of HS^- and complex. However other anions did not induce any spectral response and the anion binding ability could be ignored. The reason probably was the displacement reaction which the Cu^{2+} was captured by HS^- and free ligand was released from the complex. However, other anions could only coordinate with complex probe to form a six-coordinated complex. Besides, the HS^- selective sensor was not affected by the presence of other anions (Fig. 4c). The remarkable response of UV-vis absorption was fast enough to complete within seconds indicated the synthesized copper complex could be used as a sensor for the detection of HS^- in aqueous solution.

Fig. 4

3.3 Fluorescent response

The fluorescence properties of the copper(Ⅱ) complex were also investigated in DMSO. The free probe displayed weak fluorescence intensity upon excitation at 466 nm. As shown in Fig. 5, the fluorescence emission intensity was gradually strengthened at about 550 nm with the increasing concentration of HS^-. The interacted process completed within 20 min and very quick. The reason may be that the addition of HS^- could coordinate with Cu^{2+} and release the free ligand. A 4-fold fluorescence enhancement suggested that the probe could be a good candidate for the detection of

HS^- (Fig. 5). The fluorescence titration of the probe with various anions was conducted to examine the selectivity. As shown in Fig. 5(b), the addition of 100 equiv. of Cl^-, Br^- and I^- produced a nominal change in the fluorescence spectra of the sensor and AcO^-, $H_2PO_4^-$and F^- showed a decrease of fluorescence intensity. All these results suggested that the complex probe was a practical probe for detection of HS^- with high selectivity.

Fig. 5

3.4 HRMS titration of complex with NaHS

In order to study the mechanism of HS^- interact with complex, further insight into the interaction of HS^- with complex was investigated by performing HRMS titration in DMSO/methanol (1:20, v/v, 1×10^{-4} mol·L^{-1}). **Figure S5-7** illustrate the change in HRMS signal of complex upon addition of NaHS. The singlet 568.0408 (complex + $Na)^+$ gradually vanished from spectral window and a new signal at 265.0681 (ligand + $Na)^+$ appeared after addition of NaHS. The reason probably was the displacement reaction which the Cu^{2+} was captured by HS^- and free ligand was released from the complex.

3.5 Affinity constant

Affinity constants for the sensor with anionic species are calculated according to the equation (1) of 1:2 host-guest complexation [45-47].

$$X = X_0 + \Delta\varepsilon c_G c_H^2 \Big/ 1 + K_s c_H^2 \qquad (1)$$

where, c_G and c_H are the concentration of guest and host, respectively. X is the absorbance intensity at certain concentration of host and guest. X_0 is the absorbance intensity of the host alone. K_s is the affinity constant for the host-guest complexation. $\Delta\varepsilon$ is the change in molar extinction coefficient. According to the non-linear fitting

curves (Fig. 6), copper(Ⅱ) complex interacted with anions as the ratio of 1:2. The affinity constants could be obtained and listed in Table 3 based on the UV–vis data. Obviously, the affinity constants of copper(Ⅱ) complex were in the order: HS^- > AcO^- > $H_2PO_4^-$ > F^- >> Cl^- ~ Br^- ~ I^-. The copper(Ⅱ) complex showed the strongest binding ability for HS^- among anions tested. The reason probably was the displacement reaction that the Cu^{2+} was captured by HS^- and free ligand was released from the complex. However, other anions could only coordinate with complex probe to form a six-coordinated complex. In DMSO/H_2O (e, 6:4, v/v, 0.5mol·L^{-1}HEPES buffer at pH 7.4) solution, only the addition of HS^- could induce the spectral change of copper complex. The affinity constant was listed in Table 1 with a value of $6.07\pm0.1\times10^7$. The above results indicated the synthesized copper complex could be used as a sensor for the detection of HS^- in aqueous solution.

Fig. 6

Table 3

3.6 Mechanism

Many literatures have been reported on the anion recognition. However, a full understanding of the interacted principles has not yet been achieved. Similar to previously reported H_2S probe containing metal ion, the interacted mechanism of host-guest was linked with the red shift phenomenon in absorption spectra. The added NaHS could snatch the copper ions from the complex and the free ligand was released due to the much higher affinity constant between sulfide and copper ions (Scheme 2). However, other anions could only axial coordinate with complex probe to form a six-coordinated complex. The binding ratio and affinity constants also could illustrate it. As showed in Table 3, the copper complex interacted with HS^- as the ratio of 1:2 in DMSO solution and DMSO/H_2O (6:4, v/v, 0.04 mol·L^{-1} HEPES buffer at pH 7.4)

solution which indicated the copper atom was released from the host. In DMSO/H_2O (6:4, v/v, 0.04mol·L^{-1} HEPES buffer at pH 7.4) solution, the water molecule competed the interaction with copper complex and so the affinity constants was much lower and no coordination with other anions.

Scheme 2

3.7 Antibacterial activity

The antibacterial activity of the Cu(Ⅱ) complex was shown in Fig. 7. The complex was subjected to antibacterial activity tests against Bacillus subtilis, Staphylococcus aureus, Staphylococcus albus, Escherichia coli, Salmonella typhi and Pseudomonas aeruginosa. The experiment demonstrated that Cu(Ⅱ) complex exhibited effective and wide antibacterial activity. Staphylococcus aureus and Staphylococcus albus group were different from Bacillus subtilis (*$P < 0.05$, n = 8). Significant differences were founded in Escherichia coli, Salmonella typhi and Pseudonym aeruginosa group compared with Bacillus subtilis (**$P < 0.01$, n = 8).

Fig. 7

3.8 Cell cytotoxicity

For further biological application point of view, a quantitative in vitro cytotoxicity study of the complex was conducted using the MTT assay. In this experiment, we used Hela cell. Cell viability was expressed by the ratio between the absorbance of the cells incubated with complex to that of the cells incubated with blank culture media only. As shown in Fig. 8, the complex showed almost no cytotoxicity to Hela cell at a concentration of 100 μg·mL^{-1} indicating that the complex have the potential to detect H_2S outside the cells. Further in vivo studies are currently under way in our laboratory.

Fig. 8

4. Conclusion

In conclusion, we have successfully designed and synthesized a copper complex crystal. The copper complex prepared in 60% DMSO aqueous solution were relatively stable and showed high selective and sensitive for HS^- among various anions tested. The complex could be used as a new colorimetric sensor for the detection of H_2S at neutral pH in aqueous condition. The above method was advantage for the simplicity analysis and low cost of the starting material. Antimicrobial tests showed that copper(Ⅱ) complex exhibited wide antibacterial activity. In addition, the cell cytotoxicity of the sensor also conducted in hela cell. The complex holds a great potential for environmental analysis of HS^-, S^{2-}, H_2S and the application in bio-analysis is still challenging. Preparation of highly water soluble and highly fluorescent copper complex is under investigation.

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Supplementary Material

Crystallographic data as cif file for the structure reported in this paper have been deposited at the Cambridge Crystallographic Data Center with CCDC 1416108. Copies of the data can be obtained free of charge at www.ccdc.cam.ac.uk/conts/retrieving.html (or from the Cambridge Crystallographic Data Center, 12, Union Road, Cambridge CB2 1EZ, UK). Email:

deposit@ccdc.cam.ac.uk.

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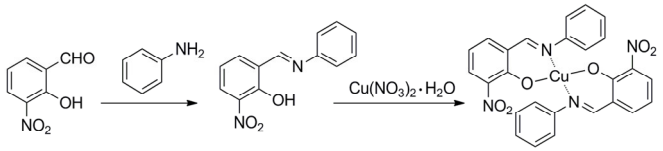


Scheme 1 Synthesis route for Copper(Ⅱ) Complex

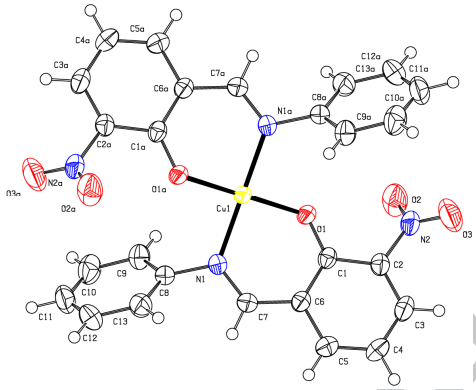
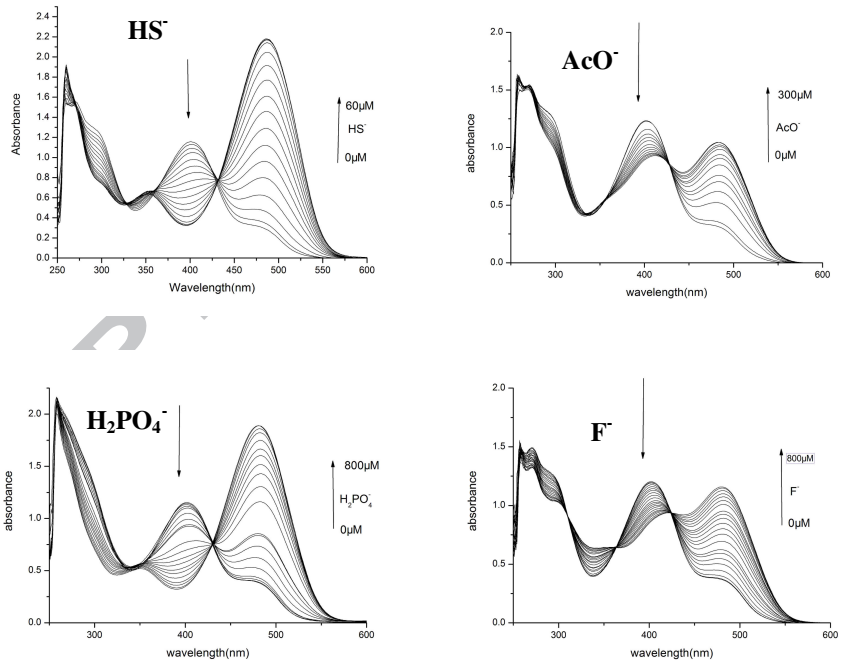


Fig.1 The molecular structure of copper complex



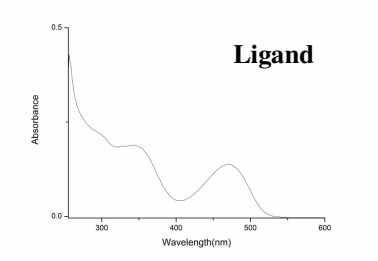


Fig. 2 UV-vis spectral changes of Cu(Ⅱ) complex upon the addition of various anions. [complex] = 8.0×10^{-5} mol·L^{-1} in DMSO. Arrows indicate the direction of increasing anions concentration. And the spectrum of free ligand (2.0×10^{-5} mol·L^{-1} in DMSO).

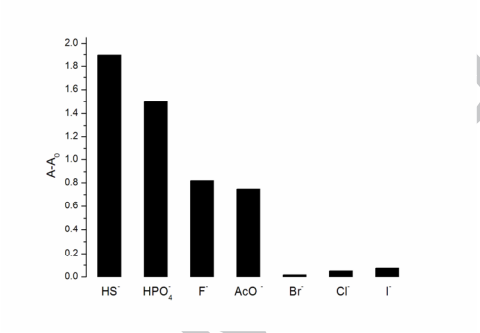
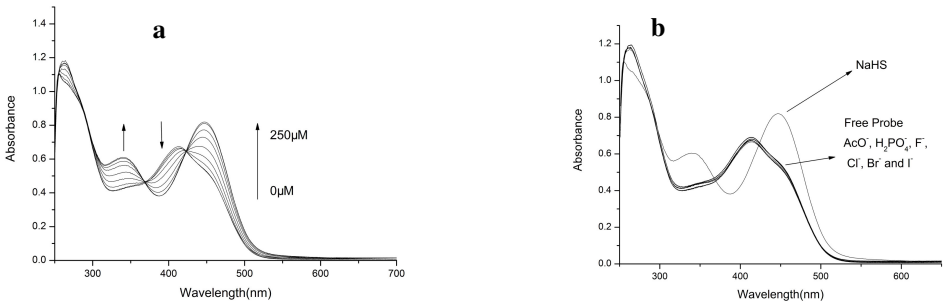


Fig. 3 UV-vis spectral changes of Cu(Ⅱ) complex (8×10^{-5} mol·L^{-1}) upon the additions of various anions.



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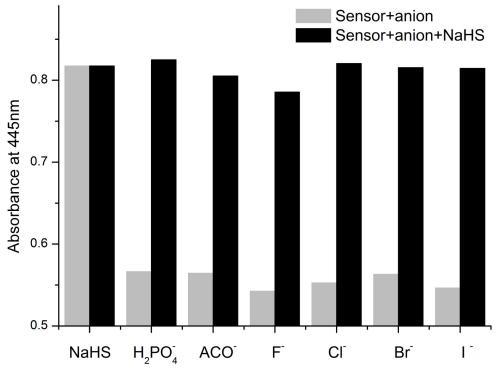


Fig. 4 UV-vis spectral of the complex solution [complex] = 8.0×10^{-5} mol·L^{-1} in DMSO/H_2O(6:4, v/v 0.04mol·L^{-1} HEPES buffer at pH 7.4) and the complex solution after addition of different anions. (a) HS^- (0 - 2.5×10^{-4} mol·L^{-1}), Arrows indicate the direction of increasing HS^- concentration. (b) the complex and the complex after the addition of different anions. (c) Change in absorbance at 445nm in the presence of anions and mixed with NaHS.

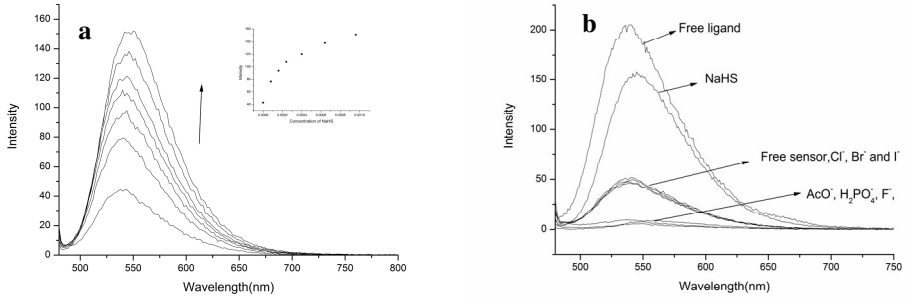


Fig. 5 (a) Fluorescence response ($\lambda_{ex,}$ 466nm) of copper probe (4.0×10^{-5} mol·L^{-1}, slit widths: 10 nm/10 nm) upon the addition of NaHS. Arrows indicate the increase direction of NaHS concentration. All the spectra were acquired after reaction of the probe with NaHS for 20 min. (b) Fluorescence spectra ($\lambda_{ex,}$ 466 nm, slit widths: 10 nm/10 nm) of probe (4.0×10^{-5} mol·L^{-1}in DMSO) upon the addition of NaHS (20

equiv.) and various anions (50 equiv.) and fluorescence spectra ($\lambda_{ex,}$ 466 nm, slit widths: 10 nm/10 nm) of free ligand (2.0×10^{-5} mol·L^{-1} in DMSO).

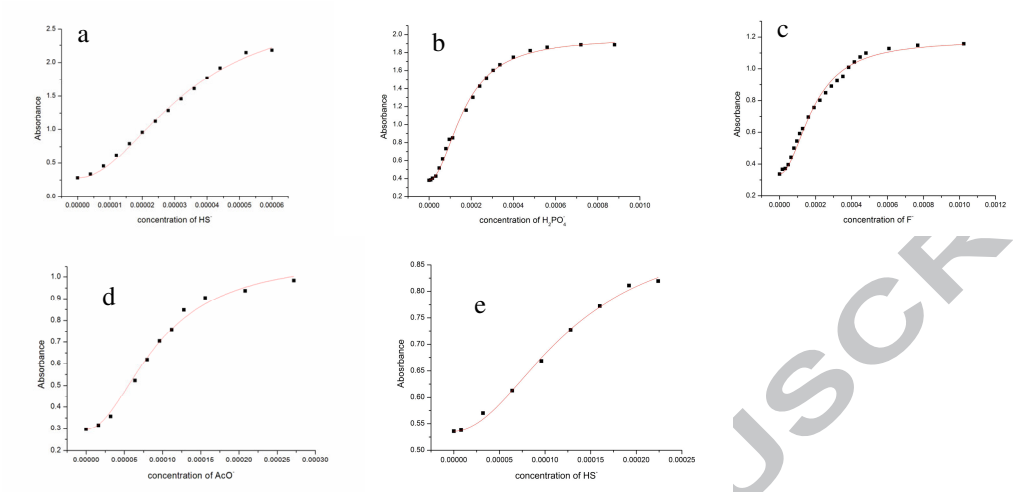
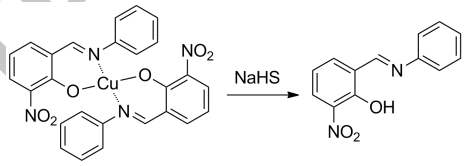


Fig. 6 Non-linear fitting curves of Cu(Ⅱ) complex in DMSO (a, b, c, d) or H_2O/DMSO(e, 6:4, v/v, 0.04 mol·L^{-1}HEPES buffer at pH 7.4) upon the addition of HS^-.



Scheme 2 The possible binding mode of complex with hydrogen sulfide ion

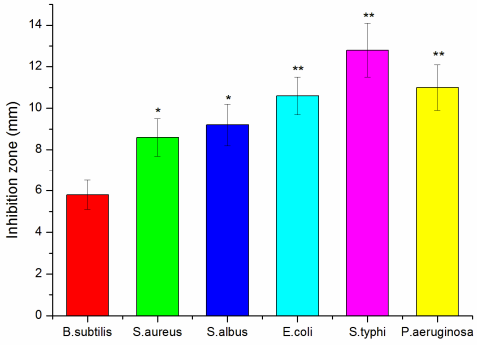


Fig. 7 Antimicrobial activity of Cu(Ⅱ) complex against bacteria. All the data were presented as means ± SDs (n =8), compared with that of B. subtilis *P<0.05; ** P<0.01.

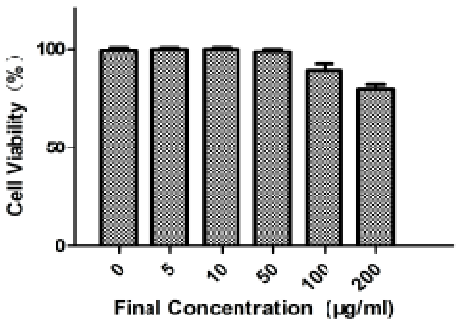


Fig. 8 Cell viability values (%) estimated by MTT proliferation test versus concentrations of complex after 24h incubation at 37℃. Hela cell was cultured in the 5-200 μg/mL complex solution at 37℃ for 24 h (n=6).

Table 1. Crystallographic and experimental data for the Cu(Ⅱ) Complex

Empirical formula	C26H18CuN4O6	
Formula weight	545.98	
Temperature	296(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 21/c	
Unit cell dimensions	a = 11.9215(11) Å	α= 90°
	b = 7.9662(8) Å	β= 112.269(3)°
	c = 12.1770(12) Å	γ = 90°
Volume	1156.42(7) $Å^3$	
Z	2	
Density (calculated)	1.568 Mg/m^3	
Absorption coefficient	0.997 mm^{-1}	
F(000)	558	
Crystal size	0.503 x 0.479 x 0.160 mm^3	
Theta range for data collection	3.112 to 27.570°.	
Index ranges	-10<=h<=11, -13<=k<=13, -16<=l<=17	
Reflections collected	17283	
Independent reflections	2656 [R(int) = 0.0736]	
Completeness to theta = 25.242°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.853 and 0.612	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2656 / 0 / 169	
Goodness-of-fit on F^2	1.016	
Final R indices [I>2sigma(I)]	R1 = 0.0372, wR2 = 0.1337	
R indices (all data)	R1 = 0.0424, wR2 = 0.1413	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.461 and -0.368 $e.Å^{-3}$	

Table 2. Selected bond lengths (Å) and angles (°) for the complex

Cu(1)-O(1)	1.8909(17)	Cu(1)-O(1)#1	1.8909(17)
Cu(1)-N(1)	1.9770(15)	Cu(1)-N(1)#1	1.9771(15)
O(1)#1-Cu(1)-O(1)	180.0	N(1)-Cu(1)-N(1)#1	180.0
O(1)#1-Cu(1)-N(1)	88.97(7)	O(1)-Cu(1)-N(1)#1	88.97(7)
O(1)-Cu(1)-N(1)	91.03(7)	O(1)#1-Cu(1)-N(1)#1	91.03(7)

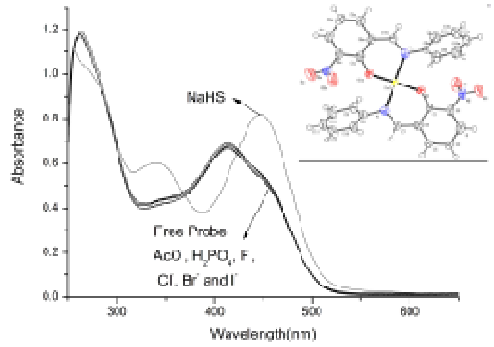
Symmetry transformations used to generate equivalent atoms: #1 -x+2,-y,-z+2

Table 3 Affinity constants of Cu(Ⅱ) complex with various anions

anions	K_s(DMSO)	K_s(DMSO/HEPES)
HS^-	$(8.85\pm0.5)\times10^{8}$[b]	$(6.07\pm0.07)\times10^{7}$[b]
HPO_4^-	$(3.55\pm0.06)\times10^{7}$[b]	ND
F^-	$(2.76\pm0.8)\times10^{7}$[b]	ND
AcO^-	$(1.13\pm0.1)\times10^{8}$[b]	ND
Br^-	ND[a]	ND
Cl^-	ND	ND
I^-	ND	ND

[a]The binding constant could not be determined
[b]The binding ratio of host-guest is 1:2

Graphical abstract



A new copper(Ⅱ) complex crystal based on Schiff bases of 3-nitrosalicylaldehyde was synthesized. The complex showed the strongest binding ability and high selectivity for hydrogen sulfide among other anions (AcO^-, $H_2PO_4^-$, F^-, Cl^-, Br^- and I^-). The above results indicated the copper(Ⅱ) complex could be used as a biosensor for the detection of HS^-. More importantly, the copper(Ⅱ) complex also exhibited effective and wide antibacterial activity and lower cytotoxicity.

Multi-properties of a Cu(Ⅱ) complex crystal: anion binding ability, bioactivity and cell cytotoxicity

Xuefang Shang*, Kui Ren, Jie Li, Wanli Li, Jiajia Fu, Xueli Zhang, Jinlian Zhang

Highlights

A new copper(Ⅱ) complex crystal based on Schiff bases of 3-nitrosalicylaldehyde was synthesized.

The complex showed the strongest binding ability and high selectivity for hydrogen sulfide among other anions.

The copper(Ⅱ) complex exhibited effective and wide antibacterial activity and lower cytotoxicity.