Austin Journal of Analytical and Pharmaceutical Chemistry

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Austin Publishing Group

Research Article

Synthesis and Anti-bacterial Application of Copper(II) Salicyldehyde Schiff Base Complex

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Received: November 24, 2016; **Accepted:** December 13, 2016; **Published:** December 15, 2016

Abstract

The coordination complex of Cu(II) with the Schiff base derived from salicyldehyde with 5-chloro aniline have been synthesized and characterized by micro analytical data; FT-IR, UV-vis, FAB-mass and X-ray diffraction. Furthermore, in an attempt to improve the antibacterial activity, synthetic analogues i.e. Copper complex has been designed based on the structural properties. Well diffusion method using Nutrient Agar as the medium, we determined the anti-bacterial activity and mechanism of action of these complexes. For antibacterial screening Gram-positive bacteria; *Bacillus subtilis, Staphylococcus aureus* and Gram-negative bacteria; *Escherichia coli, Pseudomonas aeruginosa* have been used. The synthesized Cu(II) Schiff base ligands show good or moderates antibacterial activity.

Keywords: Salicyldehyde; Bacillus subtilis; Staphylococcus aureus; Escherichia coli; Pseudomonas aeruginosa; Cu(II) complex

Introduction

Organo-metallic compounds have been used in medicine for centuries. Metal complexes play essential role in pharmaceuticals industry and in agriculture. The metallo elements present in trace quantities play vital roles at the molecular level in living system. The transition metal ions are responsible for proper functioning of different enzymes. The activity of biometals is attained through the formation of complexes with different bioligands and the mode of biological action for complexes depends upon the thermodynamic and kinetic properties. The lipophilicity of the drug is increased through the formation of chelates and drug action is significantly increased due to effective permeability of the drug into the site of action. Interaction of various metal ions with antibiotics may enhance their antimicrobial activity as compared to that of free ligands.

Reproducing complex biological reactivity within a simple synthetic molecule is a challenging endeavor with both intellectual and aesthetic goals. The sequence of examining biological reactivity, creating similar chemical architectures, and determining functional reaction conditions for model systems is a process that allows the biological code of reactivity to be deciphered. The coordination chemistry of Copper(II) attracts much attention because of its biological relevance and its own interesting coordination chemistry such as geometry, flexible redox property, and oxidation state [1-3]. Nowadays, coordination compounds have been known to be useful in constructing molecular information processing systems, particularly by biological self-organizing processes [4,5]. Especially for this purpose, synthesis, structural and anti-bacterial of Copper(II) complex has been attempted to mimic metalloenzyme [6-9]. Recently, we tried to prepared new anti-bacterial agents against to Gram-positive bacteria; *Bacillus subtilis, Staphylococcus aureus* and Gram-negative bacteria; *Escherichia coli, Pseudomonas aeruginosa*.

Experimental

Apparatus and reagent

All the used chemicals and solvents were of A.R. grade. Copper (II) chloride was obtained from Aldrich, Fluca, Loba and Merck chemie. Elemental analysis of the ligand and complexes were performed micro analytically on Elementar Vario EL III Carbo Erba 1108 model, microanalyzer. I.R. spectra of ligand and complex was recorded on Perkin Elmer RX-I spectrophotometer as KBr pellets and FAB-mass were recorded on JEOL SX_{102}/DA-6000 mass spectrometer/ data system using argon/xenon (accelerating voltage 10 KV) SAIF-CDRI, Lucknow. UV-vis. spectra were obtained in methanol by specord-200 spectrometer and Acuta 710 softwere.

Synthesis of schiff base

Schiff base has been synthesized by adding the methanolic solution of salicyldehyde (0.06/0.07mol) with methanolic solution of 5-chloro aniline (0.06/0.07mol) in 1:1 equimolar ratio. The reaction mixture was then refluxed on 5-8 hours. The volume of solvent was reduced until precipitation began, and the mixture was allowed to stand overnight, after which the colored solid was obtained. It was filtered off, recrystallized thrice with ethanol, finally washed with ether, and dried under reduced pressure over anhydrous $CaCl_2$ in desiccators. The purity of the synthesized compounds was monitored by TLC using silica gel-G. Schiff base CAS(R) in 90% yield as yellow crystalline solid and melting point is 110˚c. IR (cm^{-1}): 3421(Ph-OH), 1630(CH=N), 1310(S, CH); UV-vis. (λ_{max}): 220, 252, and 326 nm.

Synthesis of complex

The Cu(II) metal complex has been prepared by mixing the methanolic solution of $MCl_2.nH_2O$ (0.005/0.003mol) with the methanolic solution of Schiff base CAS-(R) (.005/.007mole) in 1:2 molar ratio. The resulting mixture was refluxed on water bath for 8-9 hours. The volume of solvent was reduced until precipitation began,

Citation: Shukla S. Synthesis and Anti-bacterial Application of Copper(II) Salicyldehyde Schiff Base Complex. Austin J Anal Pharm Chem. 2016; 3(4): 1077.

Table 1: Analytical and physical data of the Schiff base and Cu-(R) complex.

Comp.	Mol. Wt.	Colour	Yield %	Found (calcd.) %				Decompo. temp.˚c
				C	H	N	Metal	
R	270.37	Yellow	90	14.79 (14.76)	5.22 (5.21)	20.72 (20.70)	-	110
R_2Cu	508.3	Dusty Yellow	95	33.06 (33.06)	4.76 (4.75)	11.02 (11.01)	11.59 (11.54)	148

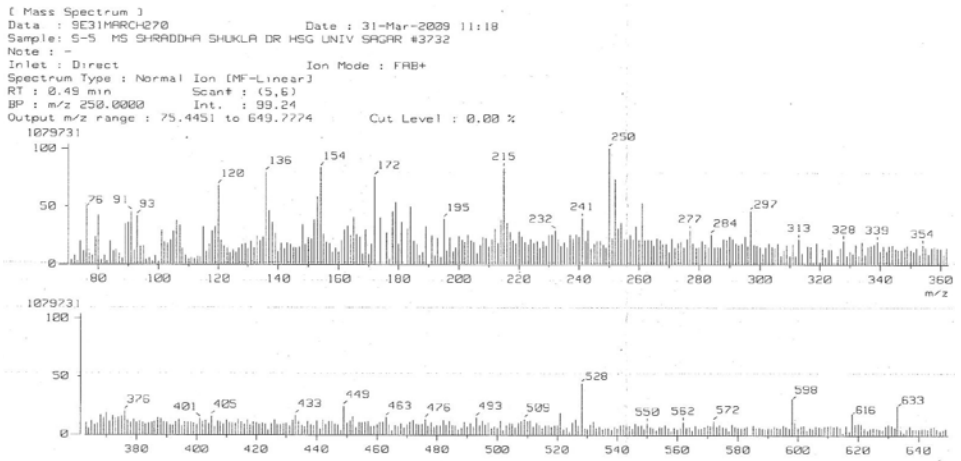

Figure 1: FAB-mass spectrum of Cu-(r) complex.

and the mixture was allowed to stand overnight, after which the colored solid was obtained. It was filtered off, recrystallized thrice with ethanol, finally washed with ether, and dried under reduced pressure over anhydrous $CaCl_2$ in desiccators. The purity of the synthesized compounds was monitored by TLC using silica gel-G. Metal complex in 95% yield as dusty yellow crystalline solid and decomposition temp. 148˚c. IR (cm^{-1}): 1380(M-O), 1620(CH=N), 550(M-N), 570(M-O); UV-vis. (λ_{max}): 208, 311, and 388 nm.

Evaluation of antibacterial screening

All the synthesized compounds were tested for their antibacterial activity against; Gram-positive bacteria; *Bacillus subtilis, Staphylococcus aureus* and Gram-negative bacteria; *Escherichia coli, Pseudomonas aeruginosa*. Antibacterial screening was performed by the Well diffusion method using Nutrient Agar as the medium. Two-eight hours old bacterial inoculums containing approximately 104-106 colony forming units (CFU)/mL were used in these screening. Streptomycin has been used as a standard drug. Recommended concentration (100µl) of the test sample (1mg/mL in DMSO) was introduced in the respective wells.

Results and Discussion

The complexes are stable in atmospheric conditions and soluble in ethanol, methanol, DMF and DMSO. Both the complexes were analyzed for elemental analysis. The colour change of the complex along with decomposition > 148°C shoes characteristic differences between the Schiff base and metal complex. Analytical data of Schiff base and Cu(II) complex are complies in Table 1.

FAB-mass spectra

The FAB-mass spectra suggested fragmentation pattern of the complex. These complexes show molecular ion peaks in good agreement with the empirical formula suggested by elemental analyses (Figure 1).

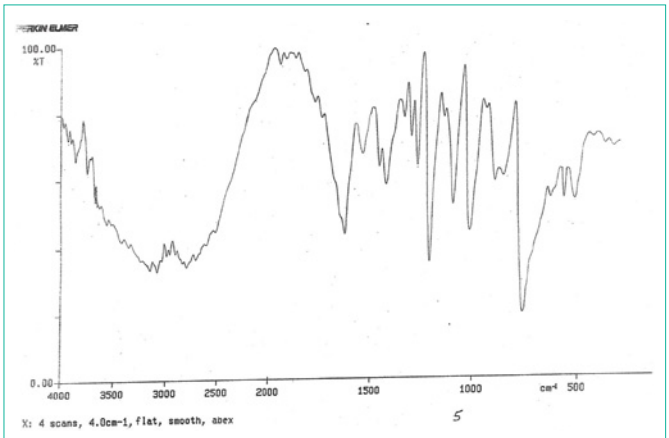

Figure 2: FT-IR spectrum of Cu-(r) complex.

The FAB-mass spectrum of the $[Cu(R)_2].2H_2O$ complex shows a characteristic molecular ion (M^+) peak at m/z = 633amu. The mass spectrum shows multiple peaks representing successive degradation of the complex molecule by the formation of different fragments. The spectrum of complex also shows series of peaks at 616, 598, 528, 297 and 120 corresponding to various fragments. The m/z value 633 corresponds to nearest composition of the $[Cu(R)_2].2H_2O$ and 120 corresponds to Cu(II) with chelated O and N donor as ligand moiety.

FT-ir spectra

The IR spectra show that the characteristics frequencies of these complex exhibit significant changes as compared with those of the parent ligand. The IR spectra of the ligand showed the absence of bands at ~ 1735 and 3315 cm^{-1} due to the carbonyl ν (C=O) and ν (NH_2) stretching vibrations and a strong new bands at ~ 1630 cm^{-1}

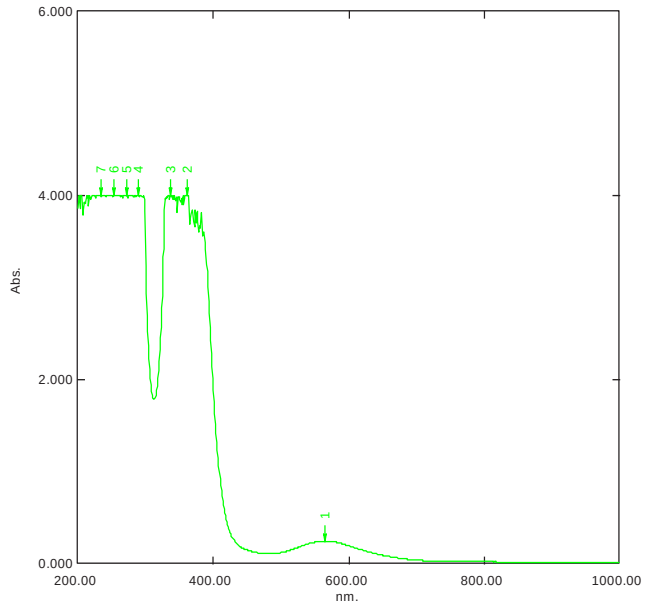

Figure 3: UV-Vis spectrum of Cu-(R) complex.

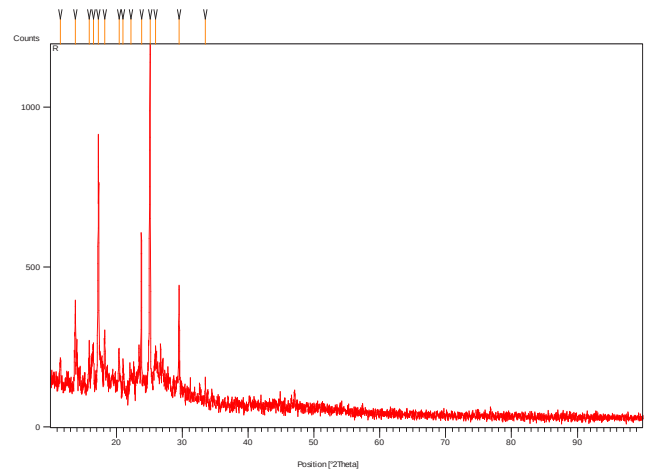

Figure 4: X-Ray diferactogram of Cu-(R) complex.

assigned to azomethene ν (HC=N) linkage, showing that amino and aldehyde moieties of the reactant are ~ absent and have been converted into the ligand, i.e. p-chlorosalicylidine aniline.

The comparison of IR spectra of the ligand and its Cu(II) complex (Figure 2) indicated that the ligand is principally coordinated to the metal ion is two ways, thus acting as a bidentate ligand. The band appearing at ~ 1630 cm^{-1} due to azomethene was shifted to a lower frequency by ~ 115 cm^{-1} in Cu complex, indicating participation of azomethene nitrogen in the interaction with the metal ion. A broad band appearing at 3415 cm^{-1} assigned to the ν (OH) in the ligand was no longer found in the spectra of the metal complex but instead a new band appeared at ~ 1380 cm^{-1}, indicated deportation and coordination of hydroxyl oxygen with the metal ion.

UV-vis spectra

The study of the electronic spectra in the ultraviolet and visible range for the metal complex (Figure 3) and ligand was carried out in a methanolic solution. The electronic spectrum of the ligand had a strong band at λ_{max} = 220nm, a medium band at λ_{max} = 252nm and a weak band at λ_{max} = 326nm. The Cu complex showed four bands, the two band at 220 and 326nm are shifted to 208 and 388 nm and a new band at 311nm appeared. These indicate that complex are formed.

Table 2: Antibacterial screening data of Schiff bases and Cu-(R) complex.

Compound	Antibacterial							
	B. cereus		*P. aeruginosa*		*E. coli*		*S. aureus*	
	50*	100*	50*	100*	50*	100*	50*	100*
R	18	21	15	19	10	12	13	13
Cu(R)	19	20	18	34	16	25	20	27
DMSO	-	-	-	-	-	-	-	-
Streptomycin	20	21	18	18	10	12	17	20

*Inhibition zone (diameter in mm); (-) Inactive/Not Measurable; *Concentration in ppm.*

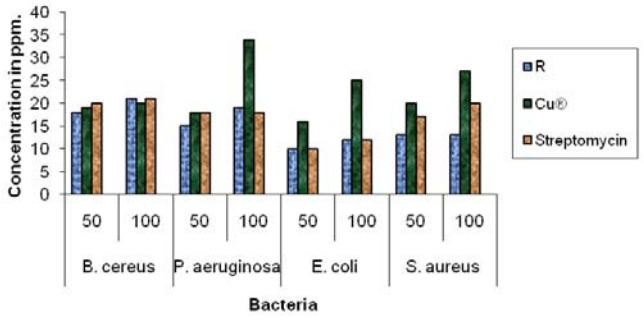

Figure 5: Anti-bacterial activity of schiff base and Cu-(R) complex.

XRD spectra

X-ray diffraction of Cu-(R) complex has been studied. The XRD patterns indicate crystalline nature of the complex (Figure 4).

Anti-bacterial activity

Some biologically active Schiff base ligands interacts via chelation, however little is known about how metal coordination influences their activity.

In general the synthesized metal complexes have higher biological activities compared to free ligands. The increased inhibition activity of metal complexes can be explained on the basis of Tweedy's chelation theory [12]. In metal complexes, on chelation the polarity of metal ion is reduced to a greater extent due to the overlap of the ligand orbital and partial sharing of the positive charge of the cobalt metal ion with donor ring. Further, it increases the delocalization of π-electrons over the whole chelate ring. The large ring size of attached two ligand moiety makes the complexes more lipophilic . This increased lipophillicity enhance the penetration of the metal complexes into lipid membranes and block the metal binding sites in the enzymes [13]. Metal complexes also disturb the respiration process of the cell and thus block the synthesis of proteins, which restricts further growth of the organisms. The azomethine linkage (-C=N-) in the synthesized complexes exhibit extensive biological activities [14-16] due to increased liposolubility of the molecules in crossing cell membrane of the microorganism. The presence of

electron donor group in the complexes also plays a role in enhancing the inhibition activity. The activity of complexes is higher than the ligand. The values of minimum inhibitory concentration (M.I.C., μg/ml) are presented in Table 2 and Figure 5. The antibacterial activity of Cu(II) complex against Gram-positive bacteria; *Bacillus subtilis* and *Staphylococcus aureus* is shown Figure 5; irrespective of standard streptomycin against *B. subtilis* .Cu-(R) complex against *S. aureus* showed considerably greater activity than other metal complexes. The antibacterial activity against the Gram-negative bacteria; *Escherichia coli* and *Pseudomonas aeruginosa* was inhibited by the Cu(II) complex shown Figure 5. The Cu-(R) complex showed greater activity against *P. aeruginosa* than other metal complexes.

Conclusion

The antibacterial activity of Schiff bases (R) and its Copper (II) complex may find a strong position in development of new pharmaceuticals especially as antibacterial agents. Moreover, it also plays a significant role in protein and enzymes biosynthesis. Ongoing researches will most likely result into novel uses in the future and good sublimates of market anti-bacterial agents; this may also assist to solve drug resistance problems. The synthesized compound shows a good activity against the Gram-positive bacteria; *B. subtilis, S.aureus* and Gram-negative bacteria; *E.coli, P.aeruginosa*. Mostly medicine restricted for *P.aeruginosa* but Cu(II) complex shows higher activity against this gram negative bacteria. It may be suggested that the chelated complexes deactivate various cellular enzymes, which play a vital role in various metabolic pathways of these microorganisms. It has also been proposed that the ultimate action of the toxicant is the denaturation of one or more protein of the cell, which as a result, impairs normal cellular process.

Acknowledgement

We acknowledge SAIF, CDRI, Lucknow for micro analysis and FAB-mass spectra. Thanks are also due to the Head, Department of Chemistry, Guru Ghasidas University (C.G.) for Laboratory facilities.

References

1. Murakmi T, Hatano M. Spectroscopic properties of copper(H) complexes with quadridentate derivatives of L-proline amide and L-proline methyl amide. Inorg. Chim. Acta. 1986; 125: 111-115.
2. Sigel H, Martin RB. Coordinating properties of the amide bond. Stability and structure of metal ion complexes of peptides and related ligands. Chem. Rev. 1982; 82: 385-426.
3. Braga D, Grepioni F, Desiraju GR. Crystal Engineering and Organometallic Architecture. Chem. Rev. 1998; 98: 1375-1406.
4. Petty MC, Bryce MR, Bloor D. Eds.: An Introduction to Molecular Electronic; Edward Arnold press: 1995, 348-376.
5. Dong Y, Layland RC, Smith MD, Pschirer NG, Bunz UHF, Loye H. Synthesis and structures of main group cage compounds containing boron, silicon, and phosphorus atoms. Inorg. Chem. 1999; 38: 3056-3067.
6. Lever ABP. "Inorganic Electronic Spectroscopy; 2nd ed.; Elsevier: New York, 1984, 26.
7. Cotton FA, Wilkinson G. ''Advanced Inorganic Chemistry; 4th ed.; Wiley-Interscience: New York, 1980, 800.
8. Linder MC. Biochemistry of copper, New York, Plenum Press. 1991.
9. Seven MJ. and Johnson LA., Metal Binding in Medic, 1960, 4th edn., Lippincott Co: Philadelphia, PA.
10. Walsh C. overview Enabling the chemistry of life. Scien. 2001; 409: 226-231.
11. McCleverty J. Prog. Inorg. Chem. 1968; 10: 49.
12. Tweedy BG. Plant extracts with metal ions as potential antimicrobial agents. Phytopathology. 1964; 55: 910-914.
13. Mazumeler UK, Gupta M, Bera A, Bhattacharya S, Karki S and Manikandan L. Indian J. Chem. 2003; 42: 313.
14. Vaghasia Y, Nair K, Soni M, Baluja S and Chandra S. Synthesis, structural determination and antibacterial activity of compounds derived from vanillin and 4-aminoantipyrine. J. Serb. Chem. Soc. 2004; 69: 991-998.
15. Neelakantan MA, Rusalraj F, Dharmaraja J, Johnsonraja S, Jeyakumar T and Sankarayana PM. Spectral characterization, cyclic voltammetry, morphology, biological activities and DNA cleaving studies of amino acid Schiff base metal(II) complexes. Spectrochim. Acta. 2008; A 71: 1599-1609.
16. Chauhan ZH. Antibacterial and antifungal ferrocene incorporated dithiothione and dithioketone compounds. Appl. Organamet. Chem. 2006; 20: 112-116.

Austin J Anal Pharm Chem - Volume 3 Issue 4 - 2016
ISSN : 2381-8913 | www.austinpublishinggroup.com

Citation: Shukla S. Synthesis and Anti-bacterial Application of Copper(II) Salicyldehyde Schiff Base Complex. Austin J Anal Pharm Chem. 2016; 3(4): 1077.