

Synthesis Characterization And Biological Studies Of Cu(Ii) Complex With Schiff Base Ligand Derived From O-Vanillin And O-Phenylenediamine

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ABSTRACT

Copper metal with chelating ligands forms coordination complexes. Copper (II) exists $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ in an aqueous medium. Copper (II) complex

shows the fastest water exchange rate for any transition metal aqua complex. In this paper, we studied the biology of Schiff base and its copper complexes. In this paper, we presented the results of synthesis and

characterization studies for the Schiff's base transition metal complexes involving Schiff's ligands. The implemented methodologies for the synthesis of metal complexes are self-assembly method. The IR spectra reveal the existence of functional groups and anionic ligands such as O-H (water), C=C, C=N, and N₃ frequencies. The UV spectra confirm the complexation of metal and ligand with the increase in the absorbance value compared to the free ligand. The λ_{\max} values of the d-d band are observed to be in the range of 300 to 321 nm.

Keywords: Schiff base ligand, copper complexes, IR spectra, synthesis and characterization

INTRODUCTION

In recent years, a lot of research had been carried out to study the applications of copper containing coordination complexes in different fields like medicinal, bioinorganic chemistry, catalyst, analytical chemistry and many other industries.[1-2]

Copper metal complexes with three different ligands i.e, 4-phenyl-2,6-di(thiazole-2-yl)pyridine, 4-(anthracene-9-yl)-2,6-di(thiazole-2-yl)pyridine, 4-(benzofuran-2-yl)-2,6-di(thiazole-2-yl) had been prepared and analyzed. On the basis of elemental analysis and spectral studies, the metal complexes had broad composition [Cu(L)Cl₂]. The synthesized metal

complexes also screened for their biological activity. The metal complexes displayed activity against tested microorganism.[3]

A number of water soluble Cu (II) metal complexes of the general composition [Cu(L)Cl] and [Cu(L')Cl₂] had been synthesized, where L is 2-(2-(1H-benzimidazol-2-yl) ethyliminomethyl) phenol and 2-(2-(1H-benzimidazol-2-yl)-ethyliminomethyl)-4-methylphenol and L' is (2-pyridin-2ylethyl) pyridine -2 ylmethyleneamine, 2(1-benzimidazol2yl) ethylpyridin 2 ylmethyl eneamine, 2 (1-benzimidazol2yl) ethyl (1-imidazol2lmethylene) amine and 2-(1-benzimidazole-2-yl)ethyl-(4,4a-dihydroquinoline-2-ylmethylene)amine. All the complexes were found to have implausible cytotoxic properties against the HBL-100 human breast cancer cell line with potency more than that of the extensively used drug cisplatin and hence they had the potential to act as promising anticancer drugs. Interestingly, they were nontoxic to normal cell lymphocytes isolated from human blood samples, revealing that they were selective in killing only the cancer cells [4].

Schiff's base ligand is synthesized by the condensation of 4-aminoantipyrine with furfural and amino acid. Copper (II) complex of 4, 6 diacetylresorcinol with 3-hydrazino-5,6-diphenyl-1,2,4-triazine and isatinmonohydra zone metal complex of

synthesized Schiff's base ligand was also synthesized. Structural features of ligand and metal complex were obtained from the analytical and spectral techniques. The in vitro antibacterial and antifungal assay suggested that copper (II) complex was good antimicrobial agents against tested pathogens [5].

Schiff's base ligand containing 4-methoxy or 4-ethoxy thio semicarbazone moieties and their transition metal complexes with copper (II) complex of 4-methoxy thio semicarbazone were synthesized and the antimicrobial activity was also examined. Synthesized ligand and its metal complexes exhibit good inhibition against certain bacteria and yeasts. Some of them were comparatively higher or equipotent to the standard antibiotic and antifungal drugs. Some compounds showed reasonable antibacterial and antifungal activity [6].

Copper (II) complex of Schiff's base ligand had been synthesized, which was derived from o- hydroxybenzaldehyde and 2-aminopyridine. The ligand and the complex were the ligands and metal complexes had been screened for microbiological activity [7].

A series of four new mixed-ligand copper(II) complexes (1–4) of the type $[Cu(L)(diimine)](ClO_4)$ [where L is 2-((1H-imidazole-2-yl) methylene)-N-phenyl hydrazine carbothioamide and the diamines

are 1,10-phenanthroline (phen,1),2,20-bipyridine(bpy,2),4,40-dimethyl-2,20-bipyridyl(dmbpy,3) and 2,20-dipyridylamine (dpa,4)] have been successfully synthesized and characterized by various spectral techniques. Complexes showed efficient antibacterial activities against *Staphylococcus aureus* (gram positive) and *Pseudomonas aeruginosa* (gram negative). Furthermore, studies of their in vitro cytotoxicity against AGS cancer cells indicated promising antitumor activity with significant IC50 values [8]

The new metal complexes of copper (II), with the new ligand derived from isatine and 1,2-diaminocyclohexane were synthesized and biologically screened. The synthesized complexes and ligand were characterized. The ligand and complexes were screened for their antibacterial activities against three different strains, namely *E. coli*, *P. aeruginosa* and *S. aureus*. In particular, the copper complexes exhibited excellent antibacterial activities [9].

EXPERIMENTAL

REAGENTS

Chemicals are procured from renowned companies like sigma Aldrich, molychem, and used without further purification. Ethanol, methanol is used for amalgamation of metal complexes are A.R.grade and used as received for

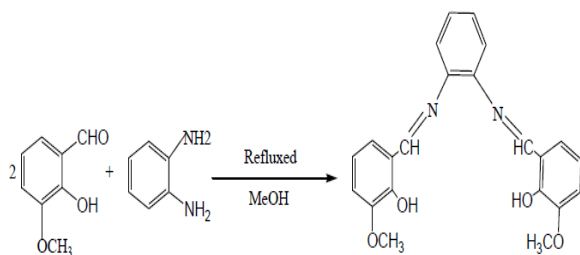
synthetic work.

Cu (ClO₄)₂.6H₂O is procured from Alfa aesar.

Caution: azides and per chlorates are explosive, handle with care.

SYNTHESIS OF SCHIFF BASE LIGAND

A solution of o-phenylenediamine (0.1mmol) in methanol is added to ortho vanillin (0.2mmol) in 20 ml methanol and water. The mixture is refluxed for about 30 minutes. The mixture is cooled. The resulting precipitate is then filtered, washed with methanol and dried.



Scheme 1.Synthetic route and proposed structure of Schiff base ligand

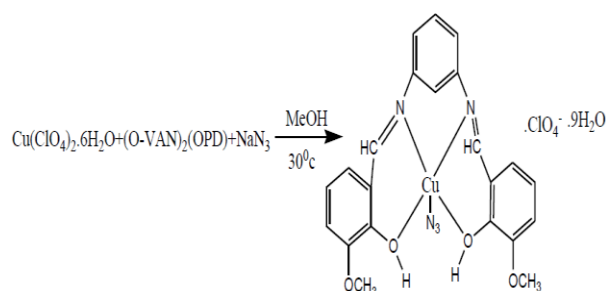
SYNTHESIS OF [(Cu)(O-VAN)₂(OPD)(N₃)].(ClO₄)₉H₂O

A solution of Schiff's base (0.5mmol, 0.188gms) is dissolved in 10ml of hot methanol added to a solution of copper per chlorate (0.5mmol, 0.185gms) is dissolved in 10ml of water, instantaneously a brown colored solution is appears. To this, a solution of sodium azide (0.5mmol, 0.032gms) is dissolved in 10ml of water is added, a green colored precipitate is

obtained after one hour on constant stirring at room temperature. Anal. Exptal. C₂₂H₄₄Cu ClO₁₇N₅(M.Wt.742) C, 45.62; H, 5.18; N, 12.46; O, 22.26; Found. C, 44.43 O, 21.28; H, 5.85; N, 11.28. Important IR absorptions (KBr disk,cm⁻¹). 3307,1236,1602,1109,424,533,.Mass peaks (m/z). 742,654,437,303,149.

M.P; 320⁰ C

Yield; 0.403gm (57%)



Scheme .2.Synthetic route and proposed structure of complex 1

PHYSICAL MEASUREMENTS

An IR spectrum is obtained with a Bruker-alpha-T FT-IR spectrophotometer. UV-spectra is recorded onsystronics 2700R UV spectrophotometer.LC-MS Spectra is recorded on AGILANT-Triple Quad (LC-MS/MS) mass spectrometer. TG-DTA Spectra is recorded using Shimadzu-DTG-60H.NMR spectrum was noted on Bruker-Ascend (400).

ELECTRONIC- SPECTRUM

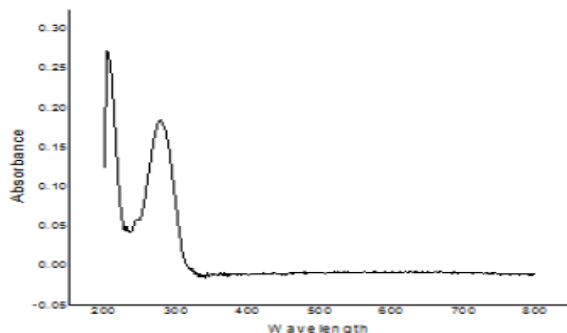


Figure 1 Electronic- spectrum of Schiff base ligand

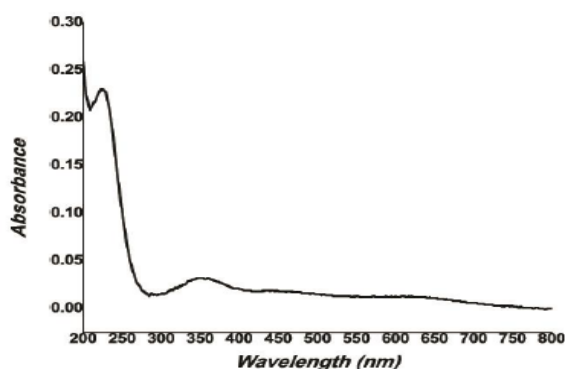


Figure 2 Electronic spectrum of complex [(Cu)(O-VAN)₂(OPD)(N₃). (ClO₄) 9H₂O

The electronic absorption spectra of metal complexes are recorded in DMF in the range 200 – 800 nm. The electronic spectrum of free Schiff base revealed three bands around 240, 350 and 450 nm characteristic of π - π^* and n - π^* transitions. In the metal complexes, this band is shifted to a longer wave length with increasing intensity. This shift may be attributed to the donation of lone pair of electrons of oxygen of Schiff base to metal ion. The copper complexes exhibits bands around 255-300 nm, 350- 355 nm and 477-498 nm. The broad intense and poorly resolved bands around 350-355

nm may be assigned to LMCT or MLCT. The high intensity band around 250 nm is of ligand cause assignable to n - π^* or π - π^* transition [10]. The complexes exposed shoulder broad bands in the range of 300-325 nm may be assigned to the d-d transition.

IR SPECTRUM

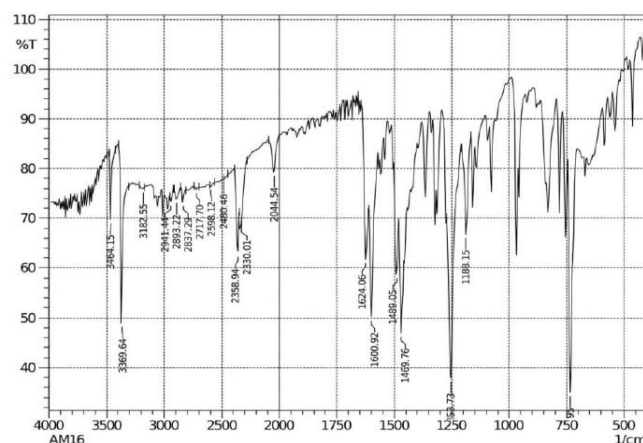


Figure 3 IR spectrum of free Schiff's base ligand

The solid state FT-IR spectrum of the complex is fully consistent with their structural data as revealed from X-ray studies. In the IR spectrum of the Schiff base ligand a sharp band observed at 1624cm^{-1} is dispersed to the $\nu(\text{C}=\text{N})$ mode of the azomethine group[11]. The characteristic phenolic $\nu(\text{O}-\text{H})$ mode due to presence of a hydroxyl group at ortho position in the ligand is observed around $3300\text{-}3500\text{ cm}^{-1}$. A band at 1253 cm^{-1} due to $\nu(\text{C}-\text{O})$ phenolic group is also observed in the ligand. A band at 2893 cm^{-1} due to $\nu(\text{O}-\text{CH}_3)$ group observed in the ligand.

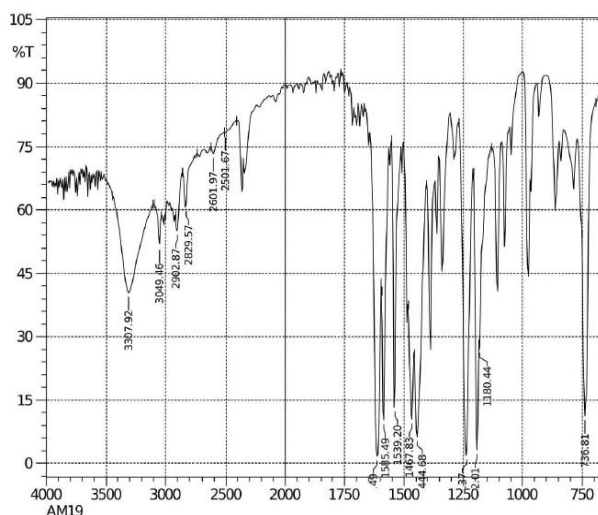


Figure 4. IR Spectrum of [Cu (O-VAN)₂ (OPD)]

In the IR spectrum of the free Schiff base ligand a sharp band observed at 1624 cm^{-1} is assigned to the $\nu(\text{C}=\text{N})$ mode of the azomethine group. This shift is altered in the complex 1600 cm^{-1} suggesting the co-ordination of the azomethine nitrogen to the metal centers [12]. The appearance of a new band around 503 cm^{-1} in the complexes due to $\nu(\text{M}-\text{O})$ bond formation [13]. The strong bond at 1253 cm^{-1} in the free ligand were due to phenolic $\nu(\text{C}-\text{O})$ stretching, on complex formation these bonds shifted to lower frequency 1237 cm^{-1} indicating coordination through the phenolic oxygen [14].

¹H-NMR SPECTRUM OF FREE SCHIFF'S BASE LIGAND AND [(Cu)(O-VAN)₂(OPD)(N₃)]·(ClO₄) 9H₂O

A review of the literature revealed that NMR spectroscopy has been proven to be useful in establishing the nature and

structure of many Schiff bases, as well as their complexes in solutions. The NMR spectra of Schiff bases are recorded in dimethylsulfoxide (DMSO) solution, using tetramethylsilane (TMS) as internal standard. The NMR spectra of the Schiff bases, the spectra of the complexes are examined in comparison with those of the parent Schiff bases upon examination it was found that the N-CH signal that appeared in the spectrum of the ligand at 10.2 ppm, signal shifts downfields in the spectrum of its Cu (II) complex, this also confirms co- ordination by azomethine nitrogen. Signal at 3.85 ppm signifying methoxy group, moreover, signal observed at 12.9 ppm indicating the phenolic OH in free Schiff base, the signal shifts down fields in the spectrum, this confirms the coordination of the phenolic (OH) proton.

ANTIMICROBIAL SCREENING OF FREE SCHIFF'S BASE LIGAND

The complex is screened in vitro for antibacterial activities against E.coli, S.aureus and antifungal activity against C.albicans by Agar-well diffusion method [19-22]. The antibacterial and antifungal activities of complex are listed in table. 1.



Figure 5 Inhibition zones for Schiff's base ligand against S.aureus and E.coli

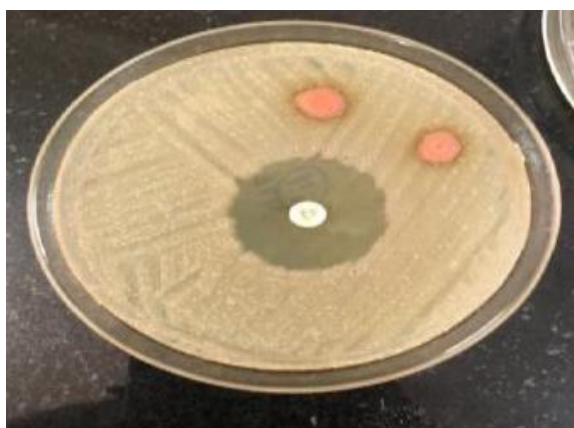


Figure 6 Inhibition zones for Schiff's base ligand against C.albicans

Table 1 Antimicrobial activities of Schiff's base ligand

Bacteria	Inhibition zone (mm)
E.coli	7
S.aureus	10
Fungi	Inhibition zone (mm)
C.albicans	5

According to above table the Schiff's base ligand showed antibacterial activity against E.coli and S.aureus. The obtained inhibition zones are 7 and 10 mm and antifungal activity against C.albicans gave inhibition zone is 5 mm.

POWDER X-RAY DIFFRACTOGRAM OF FREE SCHIFF'S BASE LIGAND

Since single crystal of the complex could not be obtained the exact crystal structure could not be determined. In order to provide a typical idea about the single phasic nature of the complexes, we have carried out powder x-ray diffraction pattern for the ligand and its complex, the diffractogram obtained for complex is given in Fig.7. With the help of the data obtained from the powder XRD, the crystallite size calculations are performed using Scherer equation [23-24].

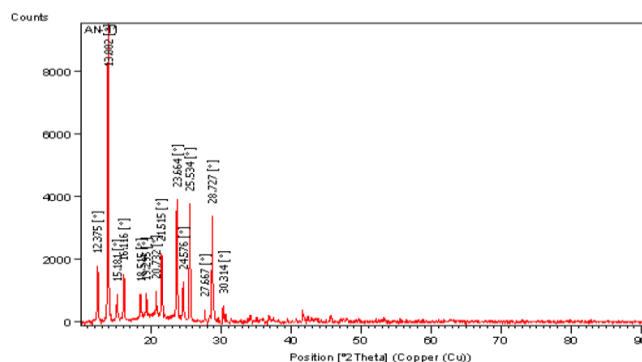


Figure 7 Powder X-ray diffractogram of free Schiff's base ligand

Table.2. crystallite size of Schiff's base

COMPLEX	2θ	Crystallite size
Schiff's Base ligand	13.002	79.37nm

POWDER X-RAY DIFFRACTOGRAM OF [(Cu)(O-VAN)2(OPD)(N3)].(ClO4)9H2O

Crystallite size is obtained using Scherer's equation, $D = K\lambda / (\beta \cos\theta)$, where D is the particle size in nm of the crystal grain has been calculated using maximum

intensity peak; K is the Scherer's constant; λ is the wavelength of target used; β is the full width at half maximum reflection height in terms of radian and θ is the Bragg diffraction angle at peak position in degree. In both the diffractogram we calculated crystallization about 79.37 nm and 79.52 nm by using crystallite size cell calculator.

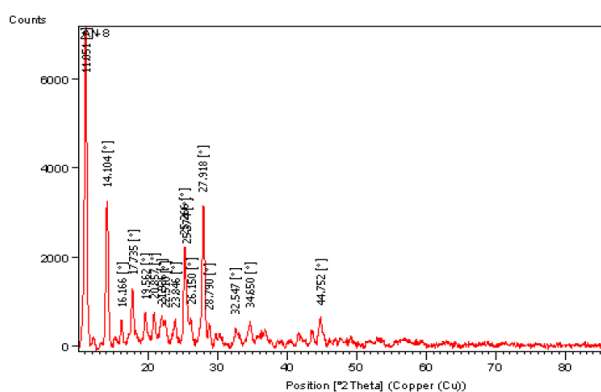


Figure 8 Powder X-ray diffractogram of [(Cu)(O-VAN)2(OPD)(N3)].(ClO4)9H2O

Table 3 Crystallitesize of Schiff's base [(Cu)(O-VAN)2(OPD)(N3)].(ClO4)9H2O

COMPLEX	2 θ	Crystallite size
[(Cu)(O-VAN)2(OPD)(N3)].(ClO4)9H2O	11.051	79.52nm

CONCLUSIONS

In this paper, we presented the results of synthesis and characterization studies for the Schiff's base transition metal complexes involving Schiff's ligands. The implemented methodologies for the synthesis of metal complexes are self-assembly method. The IR spectra

reveal the existence of functional groups and anionic ligands such as O-H (water), C=C, C=N, and N₃ frequencies. The UV spectra confirm the complexation of metal and ligand with the increase in the absorbance value compared to the free ligand. The λ_{\max} values of the d-d band are observed to be in the range of 300 to 321 nm. The LC- MS spectra predict the structures of the described complexes and the m/z values are reported for each fragment of the complex and they confirm the structure. The TGA determines the decomposition rates of ligands such as H₂O, Schiff's base and CuO. The results of thermochemistry are in arrangement with the structure of the complexes. From the Powder-X ray diffract gram, we obtained the crystallite sizes and purity of the compound.

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