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Synthesis, Characterization and Antimicrobial Activities of Schiff Base Complexes of Co (II) and Cu (II) Derived from Salicyldehyde and Diphenylamine

Uba Bala[1*]

[1]Desert Research Monitoring and Control Center, Yobe State University, Damaturu-Nigeria

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***Corresponding author:** Uba Bala
Desert Research Monitoring and Control Center, Yobe State University, Damaturu-Nigeria

Abstract

This paper reports antibacterial and antifungal activities of Schiff base and that's of its metal (II) complexes (Co, Cu) derived from salicyldehyde and diphenylamine. The Schiff base and its metal (II) complexes were characterized using different analytical techniques like FTIR, melting point, solubility, and molar conductance, The Schiff base and its respective metals complexes were colored. The result from IR analysis revealed bands at 1614cm^{-1} indicating the formation of azomethine (C=N) confirming the formation of Schiff base. The band at 664cm^{-1}indicate the formation of complex which is assign toV(M-N) supporting coordination of Schiff base to respective metals. The solubility test result showed that both the Schiff base and complexes are soluble in most organic solvent and insoluble in water. Both the schiff base and complexes revealed sharp melting point and decomposition temperature. The molar conductance data of the complexes in Dimethylsulphoxide(DMSO) show low value of 9 and 10 Ohm^{-1}cm^{2} mol^{-1}) indicating the complexes are non-electrolytes. The entire compound was tested for their antibacterial and antifungal activities. The results indicated that the growth of the tested organism was inhibited by the compounds.

Key word: Schiff Base, Synthesis, Complexes.

INTRODUCTION

Drug resistance is a well-known phenomenon that results when diseases become tolerant to pharmaceutical treatments. Although several classes of antibacterial and antifungal compounds are presently available, the resistance of microorganisms to these drugs has been constantly emerging. In order to address this serious medical problem, there is an urgent need to discover new drugs with novel mechanisms of action, higher activity and improved selectivity to address the severe challenge of multidrug resistance in treating bacterial infections and fungal infections. In view of this, Schiff bases and their metal complexes are attractive candidates for consideration due to their broad biological application (kasabe *et al.,* 2010).

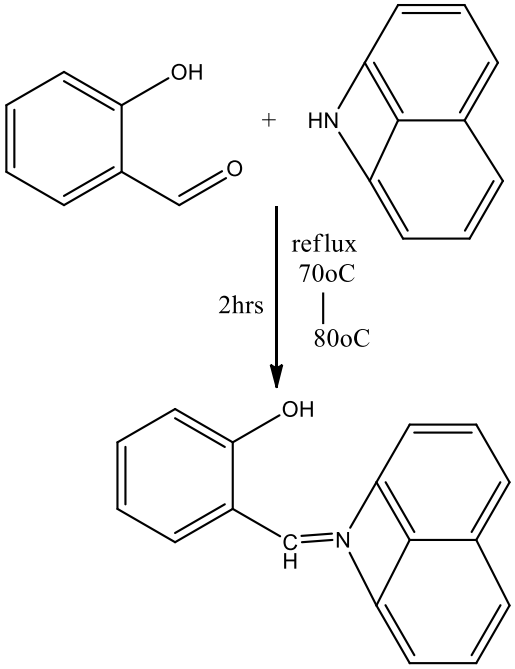
MATERIALS AND METHODS

All reagents and solvents used for this research were of analytical grade and were purchased from sigma Aldrich and Merck and were used without further purification the melting point was recorded on hot stage gallenkamp melting point apparatus. The infrared spectra was recorded using agilent carry 630 FTIR spectrometer in the frequency range of 400-4000cm^{-1}. The magnetic susceptibility was obtained at room temperature using magnetic susceptibility balance MK1 Sherwood. Conductivity measurement was carried out using Jan way conductivity meter 401.

METHODS

SYNTHESIS OF SCHIFF BASE

Exactly 0.05mol (6.106g) of salicylaldehyde was mixed with 0.05mol (8.46g) of diphenylamine in 25 cm^{3} of ethanol. The resulted mixture was heated under reflux for 2hours and the solid product formed was separated by filtration, purified by recrystallization from ethanol, washed with ethanol, and then dried in desiccators over phosphorus pentaoxide(P_2O_5) for 48hrs (Uba*et al., 2020).*



SYNTHESIS OF COBALT (II) COMPLEXES

An aqueous solution of a hydrated cobalt (II) chloride (0.01mol, 1.36g) in 10cm^3 ethanol was added to an ethanolic solution of the prepared Schiff base ligand (0.02mol, 2.73g) the mixture was refluxed for 2hours. The precipitated complex formed was separated by filtration recrystallized and washed with ethanol and dried in a desiccator over phosphorus pentaoxide (P_2O_5) for 48hrs (Alias *et al*., 2013).

SYNTHESIS OF COPPER (II) COMPLEXES

An aqueous solution of hydrated copper (II) chloride (0.01mol, 1.36g) in 10 cm3 of ethanol was added to an ethanolic solution of the prepared Schiff base ligand (0.02mol, 5.467g) the mixture was refluxed for 2hours. The precipitated complex formed was separated by filtrationrecrystallized and washed with ethanol and dried it in a desiccator over calcium chloride ($CaCl_2$) for 48 hours (Alias, *et al*., 2014).

Media Preparation and Sensitivity test (Antibacterial and Antifungal)

The sensitivity test was carried out by preparing sterile nutrient agar and P. D. A. media and carefully transferred into sterile petri-dishes to an appreciable amount. The media was allowed to cool and solidify at room temperature. The petri-dishes were marked to indicate fungi, bacteria and the positions of the three wells of different test concentrations (100ppm, 200ppm, 300ppm, 400ppm and 500ppm) for both the ligand and complexes. From the standardized inoculums of each isolate, uniform spreading (using a glass spreader) of 0.1 mL of bacteria and fungi(s) inoculums was done on the surface of dried nutrient agar and P.D. A. Each fraction of metals (II) complexes and Schiff base (ligand) petri-dishes were placed at the marked positions. For the fungi. The petri-dishes were kept in a cool dry place for 72 hours which the plate were observed for the presence for zones of inhibition as evidence of antifungal activities, while for bacteria the petri-dishes were kept in an incubator for 24 hours at 37^{o}C. The degree of sensitivity was determined by measuring the diameter of visible zones of inhibition to the nearest millimeters with respect to each isolate and test concentration and the result was recorded (Uba *et al., 2020).*

RESULT AND DISCUSSION

Table-1: Physical properties and analytical data of the schiff base ligand and its metal (ii) complexes

Ligand/complexes	Color	MP^{0}C	%Y	MP^{0}C
L	Light blue	190	46	190
[CuL_2]	Dark green	249	40	249
[CoL_2]	Brown	290	33	290

Key: L= ligand, CuL_2 = cupper complex, CoL_2 = cobalt complex, Mp^{0}c = Melting point
%y = Percentage yield

Table-2: Molar Conductance Measurement of the Complexes in Dmso Solution

Compound	Specific conductance	Molar conductance
Ohm^{-1} cm^{-1}	**Ohm^{-1} cm mol^{-1}**	
[CuL_2]	$9.83x10^{-6}$	9.83
[CoL2]	$11.20x10^{-6}$	11.20

Table-3: the infrared spectral data of schiff base ligand and its metal (ii) complexes

Compound	V(OH)	v(C=N) cm^{-1}	v(M-N) cm^{-1}
Ligand	**3022**	1577	-
[CuL_2]	**3048**	1536	664
[CoL_2]	**3164**	1540	679

Table-4: Solubility of Schiff Base and Its Metal (II) Complexes

Compound	Water H_2O	Ethanol CH_3CH_2OH	Methanol CH_3OH	DMSO $(CH_3)_2SO$	Chloroform $CHCl_3$	Acetone $CH3COCH3$
Ligand	IS	S	S	S	SS	SS
[CuL_2]	IS	S	SS	S	SS	SS
[CoL_2]	IS	S	SS	S	SS	SS

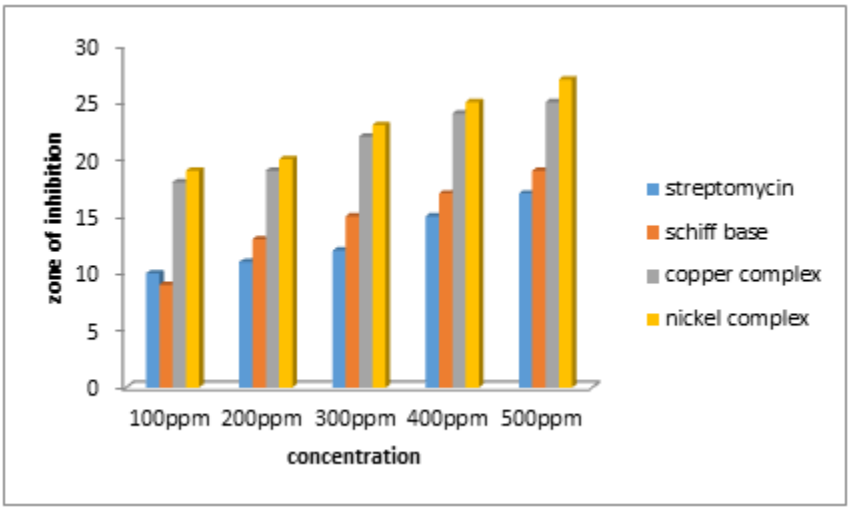


Fig-1: Sensitivity test for antibacterial activity of Schiff base and its Metal (II) Complexes against clinical isolate (*Staphylococcus aureus*) using Well diffusion method

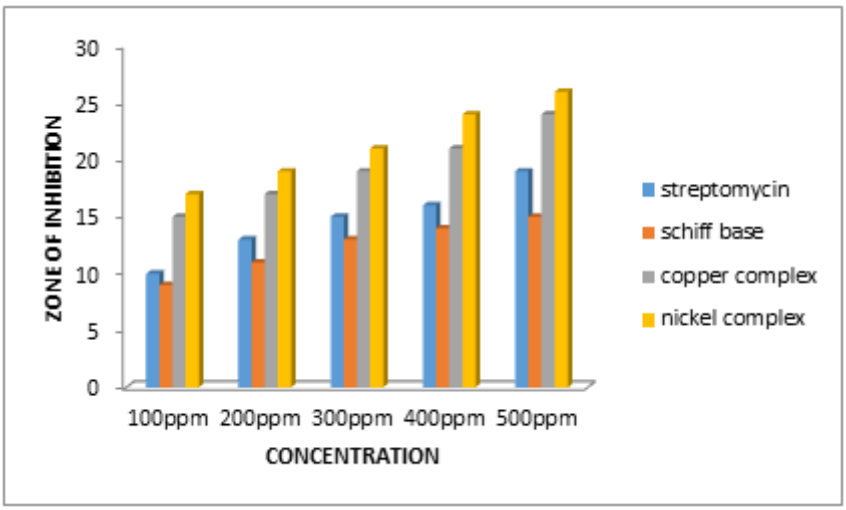


Fig-2: Sensitivity test for antibacterial activity of Schiff base and it's MetaComplexes against clinical isolate (*E. coli*) using Well diffusion method

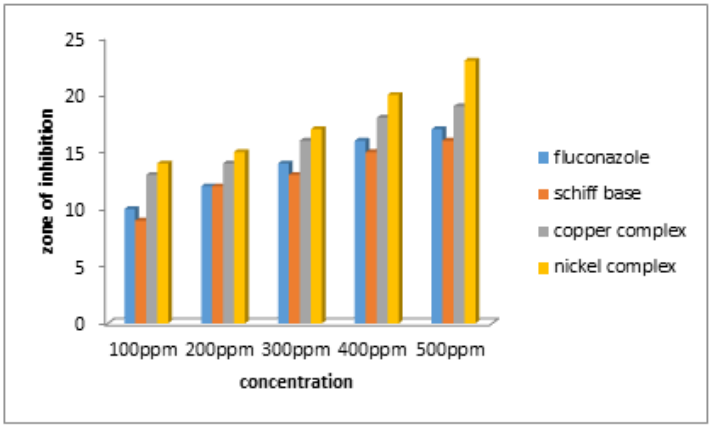


Fig-3: Sensitivity test for antifungal activity of Schiff base and its Metal (II) Complexes against clinical isolate (*Aspergillus Niger*) using Well diffusion method

DISCUSSION

The interaction between salicylaldehyde and Diphenylamine gives a light blue and its metal complexes of Co (II), and Cu (II) were found to be dark green and brown respectively. This is typical for transition metal complexes due to d-d electrons transition. They are non-hygroscopic solids and are air and photo stable. The purity of the Schiff base and metal complexes is established by the observance of sharp melting/decomposition temperature and for Schiff base and metal complexes were 190^{o}C, 249^{o}C and 290^{o}C respectively. The percentage yield of Schiff base and complexes were 46%, 40% and 33% respectively. As shown in Table 1.

Solubility of a compound in various solvents depends on the nature of the compound, type of bonding and solvent (satya *et al.*, 2006). The solubility test was carried out in methanol, ethanol dimethylsulphoxide, water, chlorofoam and acetone both the Schiff base and metals complexes were found to be soluble in some solvent such as dimethylsulphoxide and ethanol. This is due to the fact that polar solvents dissolve polar compounds due to similar attractive force between them. However, they are slightly soluble in acetone and chlorofoam probable because many non-polar solvents are able to dissolve compounds containing oxygen atom, which is used in forming a bond with polar hydrogen of the carbon-hydrogen in the solvent (satya *et al.*, 2006). Both are insoluble in water. The solubility test is significance because it gives information on the best solvent that will completely dissolved synthesized Schiff base and its metal complexes to be use for antimicrobial test and other research purposes as shown in Table 4.

Electrolytic conductivity is the measure of the mobility of ions present in the solution. The ionic mobility in turn depends on the charge and size of metal ions and interaction with solvent molecules. When a metal ion forms a complex with solvent molecule or some ligands, the conductivity reduced (David *et al.*, 1999). In this study the electrical conductivity of divalent metal ions (M^{2+}) in 10^{-3}M DMSO solution was studied. It is observed that molar conductance value of Co (II), and Cu (II) Schiff base complexes determined in 10^{-3}M DMSO solution at room temperature are (9 and 11 $Ohm^{-1}cm^{2}$ mol^{-1}) their molar conductance value are low, which may be due to the fact that the metal (II) ions form a stable complexes with DMSO solution, and therefore mobility and conductance of these metal (II) complexes is lowered (David *et al.*, 1999). And behave as non-electrolytes in DMSO. Which is similar to what Geary *et al*., (1971) reported. Thus it has been established that ionization is an important factor in the activity of synthetic drugs (lewis, 1954), as shown in the Table 2.

The infrared spectrophotometer analysis which carried out on the Schiff base ligand and their metal (II) complexes as indicated in Table 3. Above have shown the relative absorption band at 3022 cm^{-1} which attributed to v (OH) vibration frequency, the absorption band also shifted to different frequency of 3048 cm^{-1} and 3164 cm^{-1} for the Cu (II) and Co (II) of the Schiff base ligand respectively. This absorption band of such spectrum showed the coordination of the Schiff base to the respective metal (Asharaf *et al.*, 2011). The absorption band at 1577 cm^{-1} could be attributed due to v(C=N) i.e the azomethine group in the Schiff base ligand. Nearly this absorption band have appeared or shown in the spectra of the two complexes 1536 cm^{-1}, 1540 cm^{-1} respectively, which shows a coordination of Schiff base to the respective metal (sani and Iliyasu, 2018). The strong absorption band in the same region ranging from 679 cm^{-1} to 664 cm^{-1} could be due to v (M-N).

Antibacterial activity of schiff base and its metal (II) complexes showed activity on *Staphylococcus aureus*, *Escherichia coli* but the activity is higher on *Staphylococcus aureus* compared to that of *Escherichia coli with inhibitory zone of 9mm-20mm and 13mm-23mm ligand to metal complex respectively*. The metal complexes on the other hand showed higher activities compared to Schiff base because of chelation

and π-electron delocalization, which increase the lipophilic character, favoring its permeation into the bacterial membrane, causing the death of the organisms (Agwara *et al*., 2010). The activities of both Schiff base and its metal (II) complexes increase as the concentration increases as shown in figure.1 and 2. The Schiff base ligand did not show much efficacy on staphylococcus aureus as compare to the metal (II) complexes, the CU (II) complex show higher activity against *staphylococcus* aureus at both the concentrations with inhibitory zones of 10-23 mm, followed by CO (II) complex with zones of inhibition ranging from 9-16 mm. because of chelation and π-electron delocalization, which increase the lipophilic character, favoring its permeation into the bacterial membrane, causing the death of the organisms (Agwara *et al*., 2010).The Schiff base ligand show moderate activity against staphylococcus aureus but in the case of *Escherichia* coli, it shows modarate activity with zones of inhibition of 10-17 mm at both the concentrations. Co (II) complex against Escherichia Coli show higher activity at both the concentrations as well. The streptomycin which serve as the control show high activity in contrast with the Schiff base ligand. it is well known that some drugs have greater activity when administered as metal complexes than as free organic compounds (Tweedy,1964). The antifungal activity against *Aspergillus niger* using well diffusion method revealed that metals (II) Complexes have higher activity compared to Schiff base. The better activities of the metal complexes are attributed to the metal ions, since the metal-free ligand has low antifungal activity which is similar to that of Lawal *et al.,* (2014).

CONCLUSION

In conclusion, the synthesis, characterization and antimicrobial activities of a Schiff base derived from salicylaldehyde and Diphenylamine and its metal (II) complexes have been described. The Schiff base ligand coordinated through its azomethine nitrogen with metal ion. This is supported by infrared spectral data. The molar conductivity data of the complexes in DMSO indicated that they are non-electrolytes. All the complexes are air stable and soluble in some of the solvents used except petroleum ether. They also form moderate yield as their percentage yield required. The in vitro antimicrobial screening of schiff base and its metal complexes showed that they are potential antimicrobial agents against the tested microorganisms.

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