BAJOPAS Volume 15 Number 1, June, 2022

http://dx.doi.org/10.4314/bajopas.v15i1.15

Bayero Journal of Pure and Applied Sciences, 15(1): 114 - 118
Received: April, 2022
Accepted: May, 2022
ISSN 2006 – 6996

SYNTHESIS, CHARACTERIZATION AND ANTIMICROBIAL ACTIVITIES OF SCHIFF BASE COMPLEXES DERIVED FROM SALICYLALDEHYDE AND AMINO ACID (ISOLEUCINE)

*** Abdullahi, B.L. and Siraj, I.T.**
Department of Pure and Industrial Chemistry, Bayero University, P.M.B 3011 Kano, Nigeria
Correspondence author: Blabdullahi59@gmail.com

ABSTRACT

Complexes of Fe(II), Co(II), Cu(II), and Zn(II) with a Schiff base derived from salicylaldehyde and isoleucine were successfully synthesized. All complexes were distinctly colored and were characterized by molar conductance, magnetic susceptibility, infrared and UV spectroscopy. Infrared spectroscopy shows the Schiff base ligand is coordinated to the central metal ion in a tridentate manner through the N-atom of the azomethine and two oxygen of the phenol and carboxylate. All complexes contain two ligands molecules per metal ion (ML_2). An octahedral geometry is proposed for the metal complexes. Antimicrobial study of the complexes was undertaken against five pathogenic bacteria strains and two fungi, mucus species and Aspergillus fumigates. The result reveal that most of the complexes and particularly Co (II) and Zn (II) have a much enhanced activity against Staphyllococcus aureus, Escherichia coli and Klebsiella pneumoniae.

Keywords: Schiff base, salicylaldehyde, isoleucine, antimicrobial activity, synthesis.

INTRODUCTION

Schiff bases are the compounds carrying imine or azomethine (-C=N) functional group which are condensation products of primary amines with carbonyl compounds (aldehyde/ketone) and were first reported by Hugo Schiff (Cimerman *et al.*, 2000). These compounds are also known as anils, imines or azomethines. Schiff base form an important class of the most widely used organic compounds and have a wide variety of application in various fields including analytical, biological and inorganic chemistry and have also gained importance in medicinal and pharmacological fields due to a broad spectrum of biological activities like anti-inflammatory (Chandramouli *et al.*, 2012), analgesic (Sondhi *et al.*, 2006), antimicrobial (Venkatesh, 2011), antioxidant(Wei *et al.,*2006) and so on. It is believed that the biological activity is related partly to the hydrogen bonding through the imino group of Schiff base with the active centers of the cell constituents (Sujapon *et al.*, 2016). Studies have also shown that the metal complexes show greater biological activity than the free organic compounds (Chohan *et al.*, 1997). Amino acid Schiff bases tend to act as good chelating agents owing to the presence of the amine and the carboxylate functional groups. Metal amino acid chelates resemble compounds which allow the metals to be carried in with the amino acid during adsorption and once released from the metal the amino acid is released can be used to build protein or provide energy (Abu-Dief and Mohammed, 2015.).

Here in, we report the synthesis, characterization and antimicrobial activities of Schiff base derived from salicylaldehyde and isoleucine and their Fe (II), Co (II), Cu (II) and Zn (II) complexes. The work also explore the biological activities of the Schiff base and the respective metal complexes.

MATERIALS AND METHODS

All the chemicals including the metal salts used in this work were of analytical grade and were used without further purification. The glass wares used were washed with detergent, rinsed with distilled water and dried in Gallenkamp Hot box oven at 110ºC before used. All weighing were carried out on electric metler Toledo B154 weighing balance. Magnetic susceptibility balance Sherwood MK1 was used to measure the magnetic susceptibility of the complexes. Melting point of the Schiff base as well as the decomposition temperature of the complexes were determined using Gallenkamp melting point apparatus. Infrared spectral analyses were recorded using Happ Genzel in the range 650-4000cm^{-1}. Molar conductances of the complexes were measured using Jenway 4010 conductivity meter. Absorbance measurement was carried out using Jenway 6305 Spectrophotometer.

Antimicrobial activity studies were carried out at the department of microbiology, Bayero University Kano. The isolates used were obtained and identified at the same department.

Preparation of the Schiff base

The Schiff base was prepared by adding an ethanolic solution (10ml) of salicylaldehyde (0.01mol) to ethanolic solution (20ml) of the amino acid (0.0lmol) with stirring. Concentrated sulphuric acid (2-3 drops) were added and the mixture was refluxed for 1hr. The reaction mixture was then collected and cooled in an ice-bath which immediately gave a precipitate. The precipitated product obtained was filtered, washed severally with ethanol, then with ether and dried (Zahid *et al.,* 1997).

Preparation of the Schiff base complexes

The complexes were prepared by refluxing a mixture of hot ethanolic solution (20ml) of the ligand (0.02mol) with an aqueous solution (10ml) of the metal (II) chloride (0.01mol) salt for 2hrs. The mixture obtained was then reduced to nearly half its volume and left over night which resulted in the formation of a solid precipitate. The colored precipitate obtained was then filtered, washed with cold ethanol and dried (Zahid *et al.,* 1997).

Determination of metal to ligand ratio

The number of ligand coordinated to the metal was determined using Job's method of continuous variation (Angelici, 1971). A 3mmol aqueous solution of the ligand and the metal chlorides were prepared. The following ligand to metal ratio (ml); 0:16, 1:15, 3:13, 5:11, 7:9, 9:7, 11:5, 13:3, 15:1 were taken from the ligand solution and each of the metal chloride solutions respectively. A total volume of 16ml was maintained throughout the process and the mole fraction of the ligand was calculated in each mixture. The solutions of the metal chlorides were scanned so as to find the wavelength of maximum absorption (λ_{max}) for that particular metal ion (Angelici, 1971). The spectrometer was fixed at (λ_{max}) before taking the absorbance values. The absorbance values were extrapolated against mole fraction of the ligand and the number of coordinated ligand (coordination number) was determined using the relation below:

$n = x_l / (1 - x_l)$

Where n= number of coordinated ligand and

x_l= mole fraction at maximum absorbance.

Antibacterial Activity Studies

The synthesized ligand and its corresponding metal complexes were screened for antibacterial activity against bacterial species; *Staphylococcus aureus*, *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia* and *Proteus mirabilis* and anti fungal activity against *Aspergillus fumigates and Mucor species*. The complexes and ligand were dissolved in DMSO to produce three different concentrations 60, 30 and 15 µg per disc. A sterilized forcep was then used to place the prepared disc of the ligand and complexes on the already inoculated agar plates at various intervals and then incubated at 37◦c for 24hrs (Yusha'u 2011). The inhibition zone of the ligand and complexes were then measured (in diameter) around the disc (NCCLS, 2008) and compared.

Antifungal Activity Studies

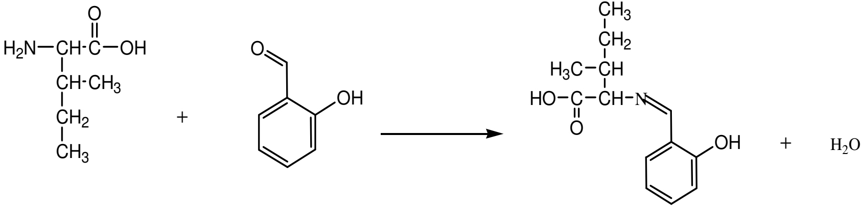
The ligand and the complexes were dissolved separately in DMSO to have three different concentrations (60, 30 and 15 µg) per disc. They were placed on the surface of the culture media (sabouraud dextrose agar) and incubated at room temperature for 48hrs. Then *in vitro* antifungal activity against *Aspergillus fumigates* and mucor species of the ligand and complexes respectively were carried out by disc diffusion method. The diameter of zone of inhibition produced by the ligand and complexes respectively were recorded (Hassan *et al*., 2006).

RESULTS AND DISCUSSION

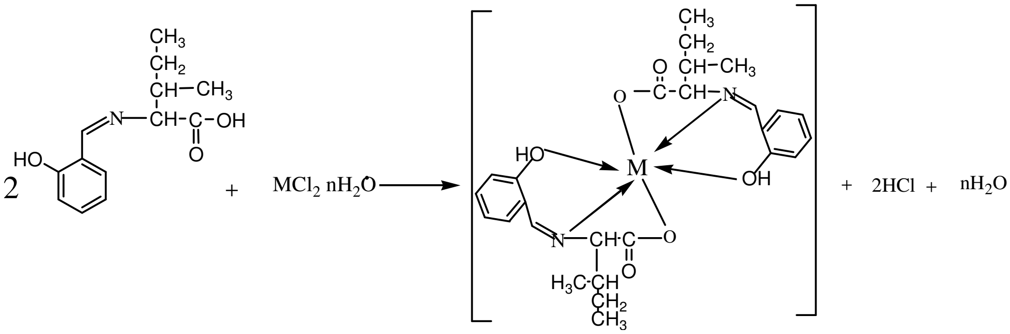
Physicochemical studies

The Schiff base was prepared according to an improved procedure reported by Zahid *et al*., (1997), isoleucine and salicylaldehyde were refluxed in ethanol (scheme 1**)**. The physical data of the yellow precipitated Schiff base with a percentage yield of 80% is presented in Table 1**.** Fe (II), Co(II), Cu(II), and Zn (II) complexes of the synthesized Schiff base were prepared by refluxing the respective metal salts with the Schiff base as shown in scheme 2**.** This gave the corresponding complexes in appreciable yield whose properties are also given in Table 1**.** The complexes were found to be thermally stable with decomposing temperature within the range of 238-258°C (Table 1). This decomposition temperature was found to be significantly higher than the synthesised schiff base which support the formation of the complexes and in agreement with values of similar metal(II) complexes reported by Chohan et al., (1997).

The magnetic moment values (Table 1) of the Co(II), Cu(II) and Fe (II) complexes were found to be 4.4 BM, 1.8 BM and 5.8 BM respectively suggesting the presence of unpaired electrons while Zn (II) complex was found to be diamagnetic. These values were found to be consistent with octahedral geometry around the central metal ion (Zahid *et al*., 1997).



Scheme 1:Isoleucine Schiff base Formation



M = Fe(II), Co(II), Cu(II), or Zn(II)
Scheme 2: Synthesis of Isoleucine Schiff base-Metal Complexes

The complexes were found to be soluble in water and DMSO but insoluble in hexane, ether and1,4-dioxane (Table 2). Molar conductance measurements values in 10^{-3}M DMSO solution are relatively low(Table 3) when compared with molar conductance values of strong electrolytes like NaCl (123.7 ohm^{-1} cm^{2} mol^{-1}) which indicated non-electrolytic nature of the complexes(Gupta, 2012).

Table 1: Physical Properties of the Ligand and its metal (II) Complexes

Compound	Colour	μ_{eff} (BM)	Decpt. Temp. (°C)	Melting Point (°C)	Percentage Yield(%)
$C_{13}H_{17}NO_3$	Yellow	–	–	208	80.04
$[Fe(C_{13}H_{16}NO_3)_2]$	Reddish brown	5.8	238	–	68.90
$[Co(C_{13}H_{16}NO_3)_2]$	Light blue	4.4	240	–	53.00
$[Cu(C_{13}H_{16}NO_3)_2]$	Deep blue	1.8	248	–	61.50
$[Zn(C_{13}H_{16}NO_3)_2]$	White	Dia	258	–	59.00

Table 2: Solubility test of the Ligand and its metal (II) complexes

Compound	Water	Ethanol	Methanol	DMSO	DMF	Hexane	Acetonitrile	Ether
$C_{13}H_{17}NO_3$	S	S	S	S	S	IS	IS	IS
$[Fe(C_{13}H_{16}NO_3)_2]$	S	SS	SS	S	S	IS	IS	IS
$[Co(C_{13}H_{16}NO_3)_2]$	S	SS	SS	S	SS	IS	IS	IS
$[Cu(C_{13}H_{16}NO_3)_2]$	S	SS	SS	S	SS	IS	IS	IS
$[Zn(C_{13}H_{16}NO_3)_2]$	S	SS	S	S	S	IS	IS	IS

KEY: S-Soluble, SS-Sparingly soluble, IS-Insoluble

Table 3: Conductivity measurement of complexes in 1×10^{-3} DMSO

Complex	Concentration (Moldm^{-3})	Specific conductance (Ohm^{-1}cm^{-1})	Molar conductance (Ohm^{-1} cm^{2} mol^{-1})
$[Fe(C_{13}H_{16}NO_3)_2]$	1×10^{-3}	15.0×10^{-6}	15.0
$[Co(C_{13}H_{16}NO_3)_2]$	1×10^{-3}	14.69×10^{-6}	14.69
$[Cu(C_{13}H_{16}NO_3)_2]$	1×10^{-3}	17.49×10^{-6}	17.49
$[Zn(C_{13}H_{16}NO_3)_2]$	1×10^{-3}	9.0×10^{-6}	9.0

Infrared spectral studies

Comparison of the IR spectra of the salicylaldehyde and isoleucine to that of the Schiff base indicated a significant change which is a good indication of the Schiff base formation. A new peak was observed at 1594cm^{-1} assigned to (C=N) azomethine bond which was absent in both starting materials. On complexation, this band has shifted to 1611, 1622 and 1606 and cm^{-1} in the spectra of the respective complexes (Table 4) which shows the participation of the azomethine nitrogen (C=N) in coordination to the metal ion which is in agreement with similar reported literature(Ahmed and Aktar, 1983). Also in the spectral of the Schiff base ν(OH) vibrational peak at 3174cm^{-1} has shifted towards higher frequency side an indication of the participation of –OH group in bond formation. Absorption bands at 722-774 and 536-544 support the formation of M-N and M-O bonds. This spectral information suggested that the azomethine –N, phenolic –O and the O from the carboxylato were involved in coordination with the metal ion.

Table 4: Infrared spectral data of the Ligand and their metal (II) complexes

Compound	**C=N v(cm^{-1})**	**(-OH) v (cm^{-1})**	**(M – N) v (cm^{-1})**	**(M-O) v (cm^{-1})**
$C_{13}H_{17}NO_3$	1594	3177	–	–
$[Fe(C_{13}H_{16}NO_3)_2]$	1611	3176	776	536
$[Co(C_{13}H_{16}NO_3)_2]$	1611	3170	750	541
$[Cu(C_{13}H_{16}NO_3)_2]$	1622	3178	758	544
$[Zn(C_{13}H_{16}NO_3)_2]$	1606	3173	774	541

The estimation of the ligand to metal ratio was carried out by Job's method of continuous variation. The plot of absorbance against mole fraction in each case at maximum absorbance corresponding to the ligand mole fraction suggest 1:2 metal-ligand ratio for all the complexes, indicating ML_2 (M= Co (II), Cu (II), Fe (II) and Zn (II), L= ligand) molecular formula for the compounds.

Antimicrobial studies

The antibacterial activity of the Schiff base and its metal (II) complexes were determined using disc diffusion method. The diameters of zone of inhibition (mm) were measured for each treatment. The ligand showed little or no activity against all the tested organisms at all concentrations (Table 5). However, the synthesized metal complexes were all found to be active against all the tested organisms with Fe (II) complex having the highest activity as shown from the zone of inhibition.

The antifungal activity studies of the compounds showed isoleucine Schiff base to be less active but a slight activity was recorded at higher concentration, while the metal complexes exhibited appreciable activity even at lower concentration (Table 6). The fungal species *Aspergillus fumigatus* was found to be more prone to attack by the complexes when compared with the *Mucor* species isolate.

Table 5: Antibacterial activities of the Schiff base and its complexes against some bacterial species

Test organisms	**Compound**	**Zone of inhibition(mm)/Concentration (µg/disc)**		
		60	**30**	**15**
	$C_{13}H_{17}NO_3$	08	06	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	16	14	10
S. aureus	$[Co(C_{13}H_{16}NO_3)_2]$	15	11	09
	$[Cu(C_{13}H_{16}NO_3)_2]$	11	09	07
	$[Zn(C_{13}H_{16}NO_3)_2]$	12	06	06
	$C_{13}H_{17}NO_3$	09	08	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	10	06	06
E. coli	$[Co(C_{13}H_{16}NO_3)_2]$	15	11	09
	$[Cu(C_{13}H_{16}NO_3)_2]$	18	16	06
	$[Zn(C_{13}H_{16}NO_3)_2]$	17	10	07
	$C_{13}H_{17}NO_3$	06	06	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	14	09	07
P. aeruginosa	$[Co(C_{13}H_{16}NO_3)_2]$	06	06	06
	$[Cu(C_{13}H_{16}NO_3)_2]$	13	08	06
	$[Zn(C_{13}H_{16}NO_3)_2]$	12	09	07
	$C_{13}H_{17}NO_3$	06	06	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	06	06	06
K. pneumonia	$[Co(C_{13}H_{16}NO_3)_2]$	11	09	08
	$[Cu(C_{13}H_{16}NO_3)_2]$	13	10	06
	$[Zn(C_{13}H_{16}NO_3)_2]$	10	08	06
	$C_{13}H_{17}NO_3$	06	06	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	13	11	08
Proteus mirabilis	$[Co(C_{13}H_{16}NO_3)_2]$	14	10	08
	$[Cu(C_{13}H_{16}NO_3)_2]$	13	10	06
	$[Zn(C_{13}H_{16}NO_3)_2]$	09	06	06

Table 6: Antifungal activity of the metal complexes against some fungal species

Test organisms	**Compound**	**Zone of inhibition(mm)/Concentration (µg/disc)**		
		60	**30**	**15**
Aspergillus fumigatus	$C_{13}H_{17}NO_3$	09	07	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	14	11	08
	$[Co(C_{13}H_{16}NO_3)_2]$	13	10	09
	$[Cu(C_{13}H_{16}NO_3)_2]$	16	15	13
	$[Zn(C_{13}H_{16}NO_3)_2]$	06	06	06
Mucor species	$C_{13}H_{17}NO_3$	08	06	06
	$[Fe(C_{13}H_{16}NO_3)_2]$	10	08	06
	$[Co(C_{13}H_{16}NO_3)_2]$	09	07	06
	$[Cu(C_{13}H_{16}NO_3)_2]$	13	09	07
	$[Zn(C_{13}H_{16}NO_3)_2]$	10	08	06

CONCLUSION

The Schiff base was prepared by condensation of salicylaldehyde with Isoleucine. Its corresponding Co (II), Cu (II), Fe (II) and Zn (II) complexes were also successfully prepared from the reaction of ethanolic solution of the Schiff bases and metal (II) chloride. Characterization showed the complexes to be non electrolyte. The decomposition temperature of the metal Schiff base complexes revealed high values which is an indication of high stability. The solubility test carried out in various solvents showed they are all soluble in DMSO. IR spectroscopy shows the Schiff base ligand is coordinated to the central metal ion in a tridentate manner through the N- atom of the azomethine and two oxygen of the phenol and carboxylate. Further analysis such as Job's method of continuous variation established 1:2 metal to ligand ratio in all the complexes. The anti-microbial activity of the ligands and their metal complexes indicated that the metal (II) complexes were more active than the free Schiff base on one or more isolates.

REFERENCES

Ahmed, A. and Aktar, F. (1983). Cu(II) and Ni(II) Complexes with Tetradentate Schiff Base derived from 2-hydroxy-1-naphthaldehyde and ethylenediamine. *Indian Journal of Chemistry,* 20(A): 737-758.

Abu –Dief, A.M,and Mohammed, I.M.A, (2015): A review on versatile applications of transition metal complexes incorporating Schiff bases, *Beni-Suef University Journal of Basic and Applied Science,* 4(2) 119-133.

Chandramouli, C., Shivanand, M. R. Nayanbhai, T.,B.Bheemachari, B and Udupi, R. H (2012.) "Synthesis and biological screening of certain new triazole schiff bases and theirderivatives bearing substituted benzothiazole moiety," *Journal of Chemical and Pharmaceutical Research*, 4(2): 1151–1159.

Chohan, Z.H., Praveen, M., and Abdul-Ghaffar, A (1997). Structural and Biological Behaviour of Co(II) and Cu(II) Amino acid derived Schiff bases. *Met-Based Drugs,* 4:267-272.

Cimerman,Z., Miljani´c,S and Gali´c,N.(2000) "Schiff bases derived from aminopyridines as spectrofluorimetric analytical reagents,"*Croatica Chemica Acta*, 73(1):81–95.

Gupta, V. Singh, S. and Gupta, Y.K. (2013). Synthesis and Antimicrobial Activity of some salicylaldehyde Schiff bases of 2-aminopyridine .*Research Journal of Chemical Sciences*, 3(9): 26-29.

Hassan, S., Umar, R.A., Lawal, N.,Bilbis, L.S., Mohammed, B.Y.(2006). Evaluation of Antifungal activity of ficussycomones L. (moracaeae.s),.*Best Journal* 3(2): 18-25.

National Committee for Clinical Laboratory Standards (NCCLS) (2008). Performance standards for Antimicrobial susceptibility testing , 9th informational supplements. *National committee for clinical laboratory standards.* Wayne P.A. M 100-59.

Sondhi, S. M., Singh, N., Kumar, A., Lozach, O. and Meijer L (2006),"Synthesis, anti-inflammatory, analgesic and kinase (CDK-1,CDK-5 and GSK-3) inhibition activity evaluation of benzimidazole/benzoxazole derivatives and some Schiff 's bases,"*Bioorganic and Medicinal Chemistry*, 14(11):3758–3765.

Sujapon,P.S., Mini, S., Theodore David Manickan, R., Anthony, S. , Muthupoogodi and Magala Sathyasheeli, S (2016), New class of Copper(II) complex derived from Isatin and Thiosemicarbazide. Synthesis, Spectral Characterization and Biological activity, *Der Pharma Chemica* , 8(4): 67-76 .

Venkatesh, P.,(2011) "Synthesis, characterization and antimicrobial activity of various schiff bases complexes of Zn(II) and Cu(II) ions," *Asian Journal of Pharmaceutical and Health Sciences*, 1(1):8–11.

Wei, D.. Li, N. Lu, G and. Yao, K (2006.) "Synthesis, catalytic and biological activity of novel dinuclear copper complex with Schiff base," *Science in China B*, 49(3): 225–229.

Yushau, M. and Salisu F.U., (2011), Inhibitory activity of detariummicrocarpum extracts on some clinical bacterial isolates. Biological and Environmental Science *Journal for the tropics.* 8(4): 113-117