Science World Journal Vol. 18(No 3) 2023
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

DOI: https://dx.doi.org/10.4314/swj.v18i3.3

SYNTHESIS, SPECTROSCOPIC DETERMINATION AND *IN VITRO* ANTIMICROBIAL STUDIES OF COBALT(II) AND NICKEL(II) COMPLEXES OF A SCHIFF BASE DERIVED FROM 1H-INDOLE-2,3-DIONE WITH HYDRAZINECARBOTHIOAMIDE

Isyaku S.[1]*, Bello J.[2], Aliyu H.N.[3], Abubakar T.[1] and Imam M.[1]

[1]Department of Chemistry, Ahmadu Bello University, Zaria
[2]Department of Applied Chemistry, Federal University Dutsin-ma
[3]Department of Pure and Industrial Chemistry, Bayero University, Kano

*Corresponding Author Email Address: isyaku.sulaiman@yahoo.com

ABSTRACT
Condensation of H-Indole-2,3-dione with Hydrazinecarbothioamide produced a Schiff base (2Z)-2-(2-Hydroxy-3H-indol-3-ylidinehydrzinE-1-Carbothioamide. Cobalt(II) and Nickel(II) complexes, were prepared by the interaction of the metal(II) salts with the synthesized Schiff base. The prepared compounds were analysed by magnetic susceptibility, molar conductance, FTIR, AAS, solubility absorbance and empirical formula. The complexes showed moderate values of decomposition temperatures. Infrared spectral data of the Schiff base and the complexes, indicated coordination of the Schiff base to the metal(II) ions via azomethine nitrogen, indole oxygen and thione sulphur. The effective magnetic moment of the complexes suggested an octahedral geometry. The molar conductivities indicated a non-electrolytic nature of these complexes. The results of the absorbance and the empirical formula showed that, the Schiff base is monobasic and tridentate in nature towards the metal ions. Both the ligand and the complexes were screened for antimicrobial activity against *Staphylococcus aureus*, *Salmonella typhimurium*, *Escherichia coli* (bacteria); *Aspergillus flavus, Aspergillus fumigatus* and *Mucor (indicus species)* (fungi). Amoxicillin and Ketoconazole were used as positive control for the bacteria and fungi isolates respectively. The results showed that the complexes are more active than the free ligand but less active when compared with the standards.

Keywords: Schiff base, Thiosemicarbazide, Isatin, molar conductivity, magnetic susceptibility, Empirical Formula.

INTRODUCTION

Schiff base is a condensation product of an amine and carbonyl compounds, and are important class of ligand that coordinate to metal ions through N, O and S donor atoms. (Chaudhary, 2013). Formation of Schiff base therefore involves chemistry of C=N functional group. (Devesh *et al*., 2014). The nitrogen of the carbon-nitrogen double bond is connected to an aryl or alkyl groups but not hydrogen, which provides a binding site for metal ions through its lone pair of electrons (Aliyu and Zayyan, 2013). Schiff base compounds are well employed in coordination chemistry due to their versatility, easy in preparation and ability to form stable complexes (Ignat, 2012). They are also useful in catalysis and in medicine as antibiotics and antitumor agents (Achut *et al*., 2010). Thiosemicarbazone are special class of sulphur containing Schiff base that are reported to have significant activity against tumor, tuberculosis and leprosis (Ainscough *et al*., 2007). Both clinical and experimental studies of these compounds revealed their activities against cancer (Marina *et al*., 2007). Schiff base derived from 2-acetylthiophene with 4-phenylthiosemicarbazide was found to be active on *Staphylococcus aureus, Salmonella typhii, and Escherichia coli bacteria specie* (Isyaku *et al*., 2020). N-methyl derivatives of isatin1-β-thiosemicarbazone (methisazone) were found active against small pox (Sau *et al*., 2003). Schiff bases of indoline-2,3-dione (isatin) was found to have antiproliferative activity against K562 chronic myelogenous leukemia cells (Aboul-Fadl *et al*., 2012). Isatin Schiff base derivative of the type 3-(4-(4-hydroxy-3- methoxylbenzylideneamino)phenylimino)indoline-2-one (Rajaram *et al*., 2010).

MATERIALS AND METHODS

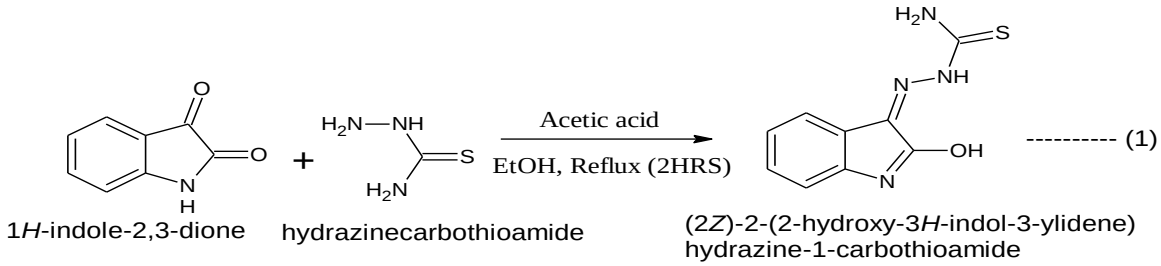
All the chemicals used in this work were of Analar Grade and were used without further purification. Glass wares used for the preparation of reagents were thoroughly washed with detergent, rinsed with distilled water and dried in an oven. Thiosemicarbazide and isatin, were purchased from Sigma Aldrich U. K.

All weighing was carried out using Electrical Meter Balance AB 54. Magnetic susceptibility measurements of the complexes were determined using Sherwood Scientific MSB MK1 Magnetic Susceptibility Balance. Melting point/decomposition temperatures were determined using a digital WRS-IB Microprocessor Melting Point Apparatus. Infrared spectral analyses were conducted using Shimadzu FTIR-8400S Fourier Transform Infrared Spectrophotometer in the range 4500-250 cm^{-1}. Molar conductivity measurements were carried out using George Kent model 5003 conductivity meter. Water of crystallization was obtained by heating a crucible containing the complex in an oven at 110^{o}C until constant weight was obtained. The metal contents in the complexes were determined using AAS Buck Scientific 210 VGP. All the microbial isolates used in this study were obtained from the Department of Medical Microbiology, Aminu Kano Teaching Hospital Kano, and identified at the Department of Microbiology. The fungal sample was sub-cultured at 25^{o}C on prepared Potato Dextrose Agar for 72 hours to obtain the pure culture of. While the Bacterial sample was isolated by inoculating the colony of on prepared Nutrient agar and incubated at 35^{o}C for 4 hours. The antimicrobial screening was conducted in the Department of Microbiology, Bayero University Kano. Standard drugs; Amoxicillin for bacteria and Ketoconozole for fungi as reference standards were obtained from Department of Microbiology, Bayero University, Kano. Mueller Hinton agar and Potato dextrose agar were used as growth media for the microbes.

Science World Journal Vol. 18(No 3) 2023
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University
DOI: https://dx.doi.org/10.4314/swj.v18i3.3

Preparation of Isatin-thiosemicarbazone

An ethanolic solution obtained by dissolving 0.147 g (10 mmol) of isatin in 10cm^3 of ethanol was added to a hot solution of thiosemicarbazide containing 0.105 g, (10 mmol) of the compound in 10cm^3 ethanol in a conical flask, followed by addition of 0.5cm^3 of acetic acid. The mixture was heated under reflux at 70^{o}C for 2 hours. The yellow precipitate formed was filtered using whatsman No. 1 paper, washed with ice-cold ethanol and dried in a desiccator over P_2O_{10}. (Nur *et al.,* 2015). The equation for the preparation of the ligand is presented in equation 1.



Equation for the Preparation of Thiosemicarbazone

Preparation of the Co(II) and Ni(II) complexes of the Schiff base

A solution of NaOH (0.16g, 4mmol) was added to an ethanolic solution (30 cm^3) of isatin-thiosemicarbazone (0.8810, 4 mmol) followed by the addition of an ethanolic solution (10cm^3) of hydrated M(II) chloride (2mmol). The resulting solution was refluxed for three hours and the precipitate formed was filtered, rinsed with hot ethanol and dried in a desiccator over P_2O_{10} (Nur *et al.,* 2015).

Estimation of the metal content in the complexes

Solutions for the determination of metal content in the complexes were prepared by digesting 0.0100g of each metal complex with 15 cm^3 of 33% aqueous HCl solution and the volume was made to 100 cm^3 with distilled water. The working solutions were prepared by serial dilution of this stock solution with distilled water and the amount of metals was measured against bank solution using AAS machine (Hassan *et al.,* 2013).

Determination of water of crystallization

0.2g of each complex was placed in a cleaned crucible of known weight. The crucible containing the complex was kept in an oven at 110 ^{o}C until constant weight was obtained (Vogel, 1972). The percentage of water in the complexes was calculated using the following equation

$$\%\ of\ water = \frac{loss\ in\ mass}{Mass\ complex\ taken} \times 100\% \quad ---- \quad (2)$$

Solubility Test

To determine the solubility of the ligand and the complexes, little amount of each compound were taken in a clean and dried test tube and about 1cm3 of the solvent was added, and the solubility was recorded.

Molar Conductance Measurement

0.001M solution of the complexes were prepared by dissolving appropriate gram of each complex in DMSO and the molar conductance was determined using Janway 4010 conductivity meter.

RESULTS

Table 1: Physical Characteristics of the Schiff base and Metal complexes

Ligand/Complexes	Colour	M.P/DT (^{o}C)	Yield (%)
$C_9H_8N_4OS$	Yellow	200	83.23
$[Co(C_9H_7N_4OS)_2].3H_2O$	Purple	270	82.65
$[Ni(C_9H_7N_4OS)_2].4H_2O$	Brown	280	76.55

Key : M.P = Melting point, D.T = Decomposition temperature

Table 2: Solubility test of the ligand and its Metal (II) complexes

Solvent/ Compound	Distilled water	Acetone	Acetonitrile	Carbontetrachloride	Chloroform	DMF	DMSO	Ethanol	Methanol	n-Hexane	Nitrobenzene	Petroleumether
$C_9H_8N_4OS$	IS	S	S	IS	SS	S	S	S	S	IS	S	IS
$[CoL_2].4H_2O$	IS	S	SS	IS	SS	S	S	SS	S	IS	SS	IS
$[NiL_2].3H_2O$	IS	SS	S	IS	IS	S	S	SS	S	IS	S	IS

Key: S=Soluble, IS= Insoluble, SS= slightly soluble L= $C_9H_8N_4OS$

Science World Journal Vol. 18(No 3) 2023 DOI: https://dx.doi.org/10.4314/swj.v18i3.3
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

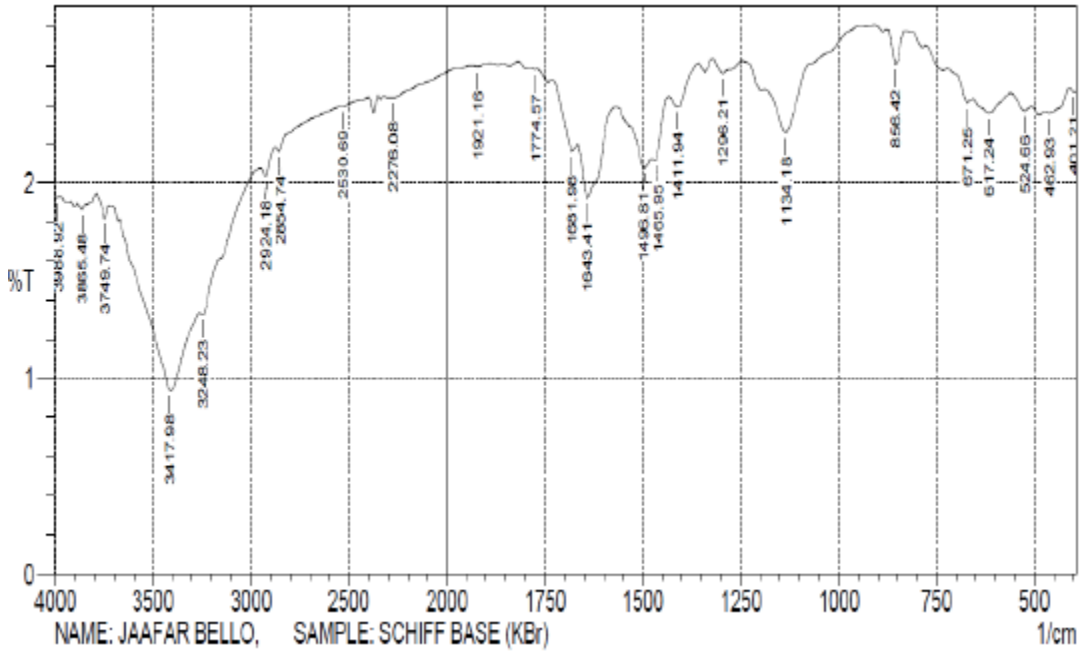


Fig 1: FTIR Spectrum of Isatin-Thiosemicarbazone Schiff Base

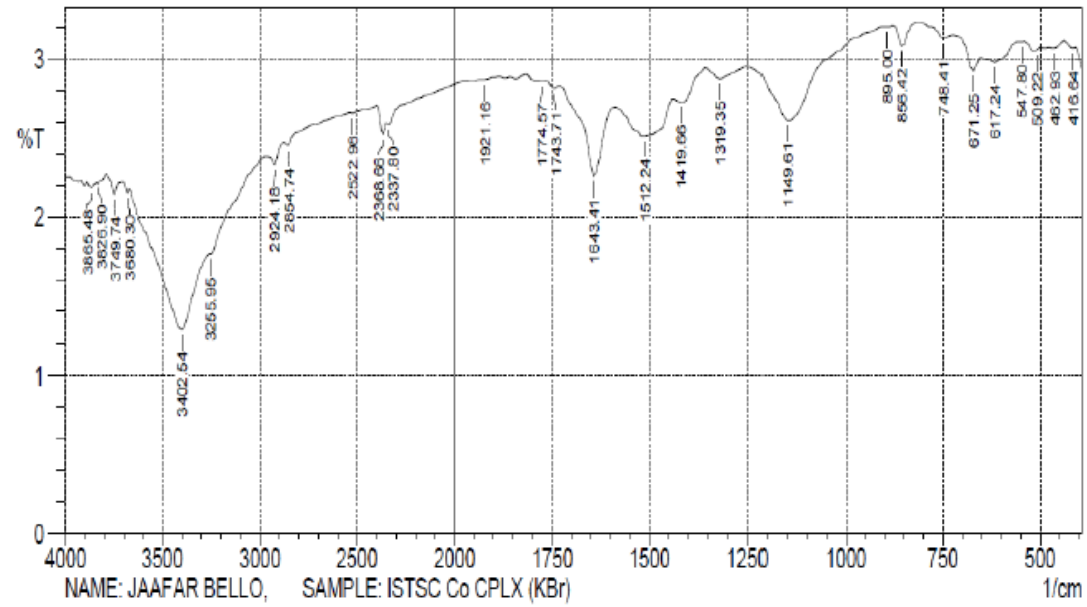


Fig 2: FTIR Spectrum of ISTSC-Co(II) Complex

Science World Journal Vol. 18(No 3) 2023 DOI: https://dx.doi.org/10.4314/swj.v18i3.3
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

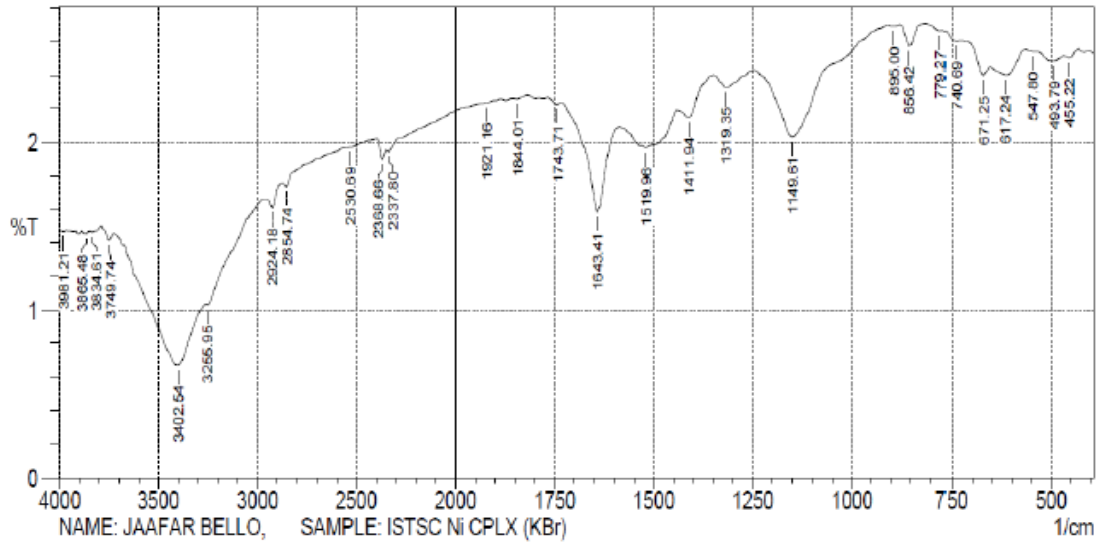


Fig 3: FTIR Spectrum of ISTSC-Ni(II) Complex

Table 3: Infrared spectral data of the ligand and its complexes

Schiff base & Complexes	v (O-H/H_2O) (cm^{-1})	v (C=N) (cm^{-1})	v (C=N) (Ring) (cm^{-1})	v (C=S) (cm^{-1})	v (C-O) (cm^{-1})	v (M-O) (cm^{-1})	v (M-N) (cm^{-1})
$C_9H_8N_4OS$	3417	1681	1643	858	1233		-
$[CoL_2].3H_2O$	3402	1512	1643	855	1298	509	416
$[Ni(L)_2].4H_2O$	3402	1519	1643	856	1298	547	455

L=$C_9H_7N_4O$

Table 4: Magnetic Susceptibility Measurement

Complexes	ψ_g (g^{-1}) × 10^{-7}	X_m × 10^{-2}	X_p × 10^{-4}	μ_{eff} (BM)
$[CoL_2]$	133.48	0.6640	68.36	4.11
$[NiL_2]$	88.71	1.0050	102.47	5.03

L=$C_9H_7N_4OS$

Table 5: Molar conductance measurement

Complexes	Spec. cond. (× 10^{-6} ($\Omega^{-1}cm^2$)	Λ_M ($\Omega^{-1}cm^2mol^{-1}$)
$[Co(C_9H_7N_4OS)_2]$	47.1	47.1
$[Ni(C_9H_7N_4OS)_2]$	9.1	9.1

Table 6: Determination of metals in the complexes

Complexes	Absorbance	Conc. (ppm)	% of metal (%)
$[Co(C_9H_7N_4OS)_2]$	0.015	10.45	10.45
$[Ni(C_9H_7N_4OS)_2]$	0.002	10.52	10.52

Table 7: Determination of water of crystallization in the complexes

Complexes	Intial mass (g)	Final mass (g)	Loss in mass (g)	% of water
$[Co(C_9H_7N_4OS)_2]$	0.2006	0.1780	0.0226	11.27
$[Ni(C_9H_7N_4OS)_2]$	0.2018	0.1804	0.0214	10.60

Table 8: Determination of empirical formulae of the complexes

Species	Co	L	H_2O	Ni	L	H_2O
%by mass	10.45	78.28	11.27	10.52	78.88	10.60
Moles	0.1773	0.3554	0.6256	0.1792	0.3581	0.5884
Mole ratio	1.0	2.0	3.5	1.0	2.0	3.2
Empirical Formula	$[CoL_2].3.5H_2O$			$[NiL_2].3H_2O$		

L= $C_9H_7N_4OS$, = Ligand

Table 9: Zone of inhibition (mm) for Antibacterial assay of the ligand and its metal (II) complexes

Isolate	*Escherichia coli*				*Salmonella typhirium*				*Staphylococcus aureus*			
Compd/Conc. (µg/disc)	100	200	300	400	100	200	300	400	100	200	300	400
Ligand	6	10	13	14	36	12	13	15	6	9	10	12
$[CoL_2].3H_2O$	7	10	10	11	8	12	15	18	7	9	11	13
$[NiL_2].3H_2O$	7	13	15	16	6	13	14	15	7	12	10	12
Amoxicillin	16	21	29	30	17	20	25	29	14	17	24	31

Science World Journal Vol. 18(No 3) 2023 DOI: https://dx.doi.org/10.4314/swj.v18i3.3
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

Table 10: Zone of inhibition (mm) for Antifungal assay of the ligand and its metal (II) complexes

Isolate	*Mucus(indicus specie)*				*Aspergillus flavus*				*Aspergilus Niger*			
Compd/Conc. (µg/disc)	100	200	300	400	100	200	300	400	100	200	300	400
Ligand	6	8	9	11	6	6	6	6	6	12	13	15
$[CoL_2].3H_2O$	13	15	18	19	6	7	8	9	6	6	6	6
$[NiL_2].3H_2O$	14	15	18	18	8	9	11	12	9	10	11	13
Ketoconazole	15	20	26	32	16	18	27	30	13	19	23	28

DISCUSSION

Schiff base obtained from ethanolic solutions of H-Indole-2,3-dione with Hydrazinecarbothioamide in 1:1 molar ratio was synthesized. Interaction of the Schiff base (2Z)-2-(2-Hydroxy-3H-indol-3-ylidinehydrzine-1-Carbothioamide ($L=C_9H_7N_4OS$) with cobalt (II) and nickel(II) salts produced Co(II) and Ni(II) complexes. The Schiff base together with the metal(II) complexes were analyzed through melting point/decomposition temperature, solubility, magnetic susceptibility, infrared (IR) spectra, molar conductance measurements, Atomic Absorption Spectroscopy (AAS) and gravimetric analyses.

Physico-Chemical Properties of the Schiff Base and its Metal (II) Complexes.

The colour of the Schiff base was flaky yellow with a yield of 83.23% and melting point of 200^{o}C. The Co(II) and Ni(II) complexes were purple and brown with decomposition temperatures of 270^{o}C and 280^{o}C respectively, indicating good stability (Table 1). Both the ligand and the complexes were soluble in DMF, DMSO and methanol. The ligand is further soluble in acetone, acetonitrile, nitrobenzene and ethanol. The cobalt (II) complex is soluble in acetone but slightly soluble in acetonitrile, nitrobenzene and ethanol. The Ni (II) complex on the other hand is soluble in acetonitrile and nitrobenzene but slightly in acetone and ethanol. These compounds are insoluble in distilled water, carbontetrachloride, petroleum ether and n-hexane (Tables 2). The solubility of the compounds in these common solvents with low polarities, can be used to determine the suitable solvents that could be utilized for subsequent spectroscopic analysis, (Jones and Fleming, 2010).

A band at 1681 cm^{-1} and 858 cm^{-1} for the Schiff base is assignable to v(C=N) and v(C=S) stretching frequencies respectively. The band assigned to v(C=N) shifted downward in the spectra of the complexes in the range of 1519 cm^{-1} and 1512 cm^{-1}, indicating participation of the azomethine nitrogen in the coordination of the ligand with the metal ions. This shift to lower frequencies can be attributed to the donation of electrons by the azomethine nitrogen to the empty orbital of the metal ions (Ceyhan *et al.,* 2015). Another evidence that support the participation azomethine nitrogen in the coordination with the metal ion is the appearance of new peaks in the spectra of the Co (II) and Ni (II) complexes at 509 cm^{-1} and 547 cm^{-1} which are assigned to Co – M and Ni – M bonds respectively (Mokhles *et al*, 2016).

The v(C=S) stretching vibration of the Schiff base also shifted downward to 855 cm^{-1} and 856 cm^{-1} in the spectrum of the Co (II) and Ni (II) complexes respectively upon complexation; indicating the coordination of the thionine sulpur to the metal ion (Ingale, 2014). The broad band at 3417 cm^{-1} in the spectrum of the ligand was assigned to v(-OH) of the indole ring. This band disappeared in the spectra of the complexes, which indicated the participation of the oxygen in bond formation with the metal ion after deprotonation (Tawfiq, 2011; Ceyhan *et al.,* 2015). The stretching vibration of the Schiff base at 1296 cm^{-1} was assignable to v(C-O) bond, this shifted 1319 cm^{-1} in the spectra of the metal (II) complexes, which is another evidence for the coordination of indolic oxygen to the metal ions (Khan *et al.*, 2015). The vibrations in the region of 3402 cm^{-1} in the spectra of the complexes was assigned to the v(OH) of water of crystallization (Mishra and Pandey, 2005). The frequency at 1643 cm^{-1} in the spectrum of the ligand was assigned to the v(C=N) of the indole ring. This band remained intact in the spectra of the complexes. This is due to none participation of the indolic oxygen in the coordination with the metal (II) ions, as presented in Table 3.

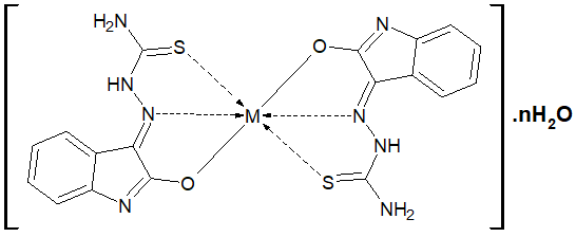
The magnetic susceptibility of the complexes at room temperature were found to be 4.11 BM and 5.03 BM, revealing a paramagnetic octahedral geometry (Table 4). The molar conductance of the Co(II) and Ni(II) complexes obtained were 47.1 $ohm^{-1}cm^2mol^{-1}$ and 9.1 $ohm^{-1}cm^2mol^{-1}$, indicating their non-electrolytic nature (Spînu, *et al.,* 2008) (Table 5). The metal contents in the complexes were determined using atomic absorption spectroscopy. The absorbance of the metal (II) complexes were 0.015 and 0.002, respectively. The absorbance values were used to obtain the respective metal concentrations. The percentage compositions of the metal ions were determined as a product (conc. obtained/conc. Prepared) x 100%. The percentages of the Co (II) and Ni (II), complexes were found to be 11.45% and 10.52%, (Table 6). The percentage water of crystallization for both the Co (II) and Ni (II) complexes were 11.27% and 10.60%, respectively (Table 7). The empirical formula is used to determine the total composition of the metal (II) complexes. This can be obtained from the percentage compositions of the metal (II) ions, water of crystallization and the ligand. The results obtained suggested the general formula $[ML_2].nH_2O$ where M = Co^{2+} and Ni^{2+} (Table 8).

The *in vitro* antibacterial studies of the ligand and its Co(II) and Ni(II)complexes were carried out against *Escherichia coli, Salmonella typhirium* and *Staphylococcus aureus* using amoxicillin as standard. The compounds were also evaluated against *Mucor (indicus), Aspergillus flavus and Aspergillus niger* fungal species while Ketoconazole was used as standard. The Schiff base and its Metal(II) complexes showed activities in one way or the other against all the bacterial and fungal isolates used. The complexes were more active than the ligand against the bacteria species excepts at 300 µg/disc and 400 µg/disc, where the ligand shows higher activity against *Escherichia coli* than Co(II) complex. Co(II) and Ni(II) complexes were more active than the Schiff base against *Mucus(indicus specie)* and *Aspergillus flavus* fungal isolates at all concentrations except the activity against *Aspergillus niger,* where the Schiff base was more active than the metal(II) complexes. The Schiff base shows no activity against *Aspergillus flavus* likewise Co(II) complex against *Aspergillus niger* at all concentrations respectively. Generally, study of the Schiff base and its metal(II) complexes reveals that; the metal chelates exhibited higher antimicrobial activity than the free ligand but lower activity than the standard. The studies shows further that, the activities of the tested compounds increase as their concentrations increased. The

Science World Journal Vol. 18(No 3) 2023 DOI: https://dx.doi.org/10.4314/swj.v18i3.3
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

increased activities of the complexes can be explained on the basis of chelation theory, which states that; the chelation tends to make the complex acts as a more powerful and potent bactericidal or bacteriostatic agent than the ligand. (Nair and Joseyphus, 2010; Ahmed *et al.,* 2011and Kothari, 2015)

From the results of the analyses of the synthesized complexes and available literature reviewed, the general molecular structure of the complexes is proposed below:



M = Co^{2+} or Ni^{2+}

Fig 4: The proposed structure of the complexes

Conclusion

Schiff base derived from H-Indole-2,3-dione with Hydrazinecarbothioamide has been synthesized from Isatin and thiosemicarbazide. Co(II) and Ni(II) complexes were prepared from the Schiff base and were both characterized. The decomposition temperature of the complexes indicated their good stability. The IR values assignable to ν(C=N), ν(C=S) and ν(OH) stretching vibrations revealed coordination of the ligand to the metal ion through azomethine nitrogen, thionine sulphur and indolic oxygen. The magnetic susceptibility of the complexes shows their paramagnetic properties and their octerhedral geometry. The molar conductance of the metal (II) complexes, suggested their non-electrolytic nature. The empirical formulae of the metal (II) complexes indicated a 2:1 metal ligand ratio with formula $[ML_2].nH_2O$. The antimicrobial screening shows that the Schiff base has enhanced activity against the isolates used but less than those of the complexes and finally, a structure for the complexes was proposed.

REFERENCES

Aboul-Fadl, T., Radwan, A. A., Attia, M. I., Al-Dhfyan, A., & Abdel-Aziz, H. A. (2012). Schiff bases of indoline-2, 3-dione (isatin) with potential antiproliferative activity. *Chemistry Central Journal*, *6*(1), 1-11.

Achut, S.M., Amarnath, N.J., Sarika, M.J. and Trimbak, K.C (2010). Synthesis, Characterization and thermal study of some Transition Metal Complexes of an asymmetrical tetradentate Schiff base Ligand. *Journal. Search. Chem.Soc*. 0(0): 1-11.

Ahmed A. A., Yasmien K. A., Haziem A., and Hussain A., (2011), Synthesis, Characterization, Theoretical Crystal Structure, and Antibacterial Activities of Some transitionmetal Complexes of Thiosemicarbazone (Z)-2-(pyrrolidin-2-ylidene)hydrazinecarbothioamide. *Bioinorganic Chemistry and Applications 2011, 1-7*

Ahmed A.A, B. S.-H. (2007). Synthesis and Characterization of Divalent Transition Metals Complexes of Schif Bases Derived From O-Phenylenediamine and Benzoylacetone and related species. *Journal of Science and Its Applications*, 21: 79-90.

Ainscough, E. W., Brodie, A. M., Ranford, J. A. and Waters, J. M. (2007). Reaction of anionic oxygen donors which the antitumor copper(II)-pyridine-2-carbodehyde thiosemicarbazone (HL) system and the crystal structure of[{ Cu(HL)(H_2PO_4)}2][H_2PO_4]2.2H_3PO_4.2H_2O. *Journal of Chemi cal Society* 37:1251-1255.

Aliyu, H.N and Zayyan, R.S (2013). Synthesis and characterization of biologically active N,N-Bis(4-bezene azosalicylidene-o-phenylenediiminato cobalt(II) complex. *Bayero journal of pure and applied science* 6(2): 127-131.

Ceyhan G., Kose M., McKee V., Urus S., Gölcü A. and Tumer M., (2012) Tetradentate Schiff base ligands and their complexes: Synthesis, structural characterization, thermal, electrochemical and alkane oxidation *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 95 382–398*

Chaudhary, N. K.(2013). *In vitro* antibacterial studies of some transition metal complexes of Schiff base derived from 2-aminophenol and furan-2-carbaldehyde. *Arc. App Sci. Res*., 5 (6):227-231. *Chem Abstr.,* 103:1062.

Dervesh Kumar et al., (2014). Review on biological important mixed ligand Complexes and their Application. *Asian journal of Biochemical and Pharmaceutical Research issue.*1 (4): 22-135

Ignat, L. (2012), Complexes of some Transition Metal with Ketone and azomethinic derivatives of Ketones. *PhD Thesis, University of Bucharest Romania*. 2(1): 256-285.

Ingale A. P., (2014) 'Synthesis and characterization of some novel thiosemicarbazone derivatives containing the tetrazole moiety' *J. Chem. Pharm. Res., 6(11):460-464*

Jones, M. and Fleming, S. A. (2010). Organic Chemistry (4th ed) USA: Nortown company Inc., pp14-16.

Khan S. A., Asiri A. M., Kumar S., and Sharma K., (2014), 'Green synthesis, Antibacterial activity and computational study of pyrazoline and pyrimidine derivatives from3-(3, 4-dimethoxyphenyl- 1-(2, 5-dimethylthiophen-3-yl)-propenone,' *European Journal of Chemistry*, 5, 85–90.

Kothari R., Sharma B., Sahawal S., Neha K., Mandal Kr. S., Birthare S. and Shivhare V., (2015), 'Synthesis, characterization and antimicrobial Evaluation of copper (ii) complex with ciprofloxacin Antibiotic', *World Journal of Pharmacy and Pharmaceutical Sciences, 4(6), 696-707*

Marina C., Mirta R., Ivica D., Gerald G., Boris K., (2007): Oxovanadium(V) coplexes of salicylaldehyde and 3-methoxysalicylaldehyde 4-phenylthiosemicarbazone: Formation of two new thiazoline compounds. *Journal of Croatica Chemical society*, 80 (3) 583-590.

Nair M. S., Joseyphus R. S., (2010) Synthesis, characterization and biological studies of some Co(II), Ni(II) and Cu(II) complexes derived from indole-3-carboxaldehyde and glycylglycine as Schiff base ligand, *Arabian Journal of Chemistry, 3: 195–204*

Nur N. D. Farina Y. Yamin B.M., (2015), Dysprosium (III) Isatin 2-Methyl-3-thiosemicarbazone: Synthesis and structural characterization, *Malaysian Journal of Analytical Sciences, 19(3): 541 – 549*

DOI: https://dx.doi.org/10.4314/swj.v18i3.3

Isyaku S., Aliyu H.N Abubakar T and Bello J. (2020). Synthesis, Characterization and Antimicrobial Studies of Iron(II) and Cobalt(II) Complexes of a Schiff Base Derived from 2-acetylthiophene with 4-phenylthiosemicarbazide *J. Chem Soc. Nigeria,* Vol. 45(1): 29 -37

Sau, D.K., Butcher, R.J., Chaudhuri, S. and Saha, N. (2003). Spectroscopic, structural and antibacterial properties of copper(II) complexes with bio-relevant 5-methyl-3-formylpyrazoneN(4)-benzyl-N(4)-methylthiosemicarbazone. *Journal of Molecular Cell biochemistry,* 25:21-29.

Spînu C., Pleniceanu M., Tigae C. (2008) Biologically Active Transition Metal Chelates with a 2-Thiophenecarboxaldehyde-Derived Schiff Base: Synthesis, Characterization, and Antibacterial Properties *Turk J Chem* 32:487 – 493

Tawfiq A.A. (2011); 'Synthesis and Characterization of some divalent transition metal complexes of Schiff bases derived from salicylaldehyde and diamine derivatives' *Almustansiriyya journal of Science, 21(2): 101-108*