**SYNTHESIS, CHARACTERIZATION AND PRELIMINARY ANTIMICROBIAL STUDIES OF SOME SCHIFF BASE LIGANDS AND THEIR Co(II), Mn(VII), Mo(VII) COMPLEXES**

**A PROJECT**

**BY**

**ENWEREM JESSICA**

**U14/NAS/ICH/013**

**SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE (B.Sc)**

**INDUSTRIAL CHEMISTRY**

**DEPARTMENT OF CHEMICAL SCIENCES**

**FACULTY OF NATURAL AND APPLIED SCIENCES,**

**GODFREY OKOYE UNIVERSITY UGWUOMU NIKE, ENUGU.**

**JULY 2018**

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**SUPERVISOR: MRS OKEKE CHINELO**

**JULY 2018**

**CERTIFICATION PAGE**

This is to certify that the research work “Synthesis**,** Characterization and Preliminary Antimicrobial Studies of some Schiff Base Ligands and their Co(II), Mn(VII), Mo(VII) complexes”submitted in partial fulfilment of the requirements for the degree of bachelor of science (B.Sc) in Industrial Chemistry, Godfrey Okoye University, Thinkers Corner Enugu was work carried out by ‘’Enwerem Jessica Daberechi’’ Reg No U14/NAS/ICH/013

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HEAD OF DEPARTMENT

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EXTERNAL EXAMINER DATE/SIGNATURE

**DEDICATION**

This work is dedicated to GOD Almighty who made it possible for me to attain this height during my research for His mercies endures forever and to my beloved mother Mrs.Enwerem .N. Norah for her special support.

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I owe my deep gratitude to God Almighty, the giver of all good things for his guidance and protection and above all, for his infinite goodness upon my life.

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**ABSTRACT**

The synthesis, characterization and preliminary antimicrobial studies of some novel Schiff base ligands; N,N/ - Bis(2-hydroxybenzylidene)-1,4-phenylenediimine(M) and N,N/ - Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine (N) were undertaken. It was prepared by the condensation reaction of 1,4-phenylenediamine with 4-dimethylaminobenzadehyde and 2-hydroxybenzaldehde .Their Co(II), Mn(VII), Mo(VII) metal complexes were synthesized by coupling them respectively with the individual formed ligands. These ligands and their complexes were characterized on the basis of their melting point, stoichiometry, electronic spectra, infrared spectra and antimicrobial their antimicrobial properties. Spectrophotometric analysis gave the stoichiometry to be 1:1 metals to ligand mole ratio for the Co(II) and Mn(VII) complexes of the N,N/ - Bis(2-hydroxybenzylidene)-1,4-phenylenediimine(M) ligand and a 1:2 metal to ligand mole ratio for its Mo(VII) complex. Secondly its N,N/ - Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine (N) ligand gave a 2:3 metal to ligand mole ratio for its Co(II) complex, a 1:4 ratio for its Mn(VII), and a 1:1 ratio for Mo(VII) complexes. Based on their spectral studies the ligandN,N/Bis(2-hydroxybenzylidene)-1,4-phenylenediimine(M) was observed to be bidentate through the participation of the oxygen from their hydroxyl endand N,N/ - Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine (N) was bidentate through the participation of their imine nitrogen end. The ligand and its complexes were tested against *Candida albicans , Escherichia coli,Salmonella typhi, Enterococcus feacalis and Staphylococcus aureus* with dimethylformamide (DMF) as the control. These screening were performed at different concentrations by the agar-well diffusion method and the gram negative organism showed activity that the metal complexes are more potent than the parent Schiff base ligand.

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**CHAPTER ONE**

**INTRODUCTION**

**1.1 SCHIFF BASES**

Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Schiff (*Cimerman et. al., 2000)*. The common structural feature of these compounds is the azomethine group with a general formula RHC=N-R1, where R and R1 are alkyl, aryl, cyclo alkyl or heterocyclic groups which may be variously substituted. The common structural feature of these compounds is the azomethine group with a general formula RHC=N-R1, where R and R1 are alkyl, aryl, cyclo alkyl or heterocyclic groups which may be variously substituted. These compounds are also known as anils, imines or azomethines. Several studies *(Singh et. al., 1975, Perry et. al., 1988, Elmali et. al., 2000, Patel et. al., 1999, Valcarcel et. al., 1994, Spichiger et. al., 1998, Lawrence et. al., 1976)*showed that the presence of a lone pair of electrons in an sp2 hybridized orbital of nitrogen atom of the azomethine group is of considerable chemical and biological importance.



R1,R2 and/or R3 **=** alkyl or arynl

Fig.1. General structure of Schiff bases (*Silva da. et al.,2011*)

A Schiff base is a nitrogen analog of an aldehyde or ketone in which the C=O group is replaced by C=N-R group. It is usually formed by condensation of an aldehyde or ketone with a primary amine.The formation of a schiff base from an aldehydes or ketone is a reversible reaction and generally takes place under acid or base catalysis, or upon heating.



Fig 2: formation of Schiff base upon heating

Schiff bases are generally bidentate (1), tridentate (2), tetradentate (3) or polydentate (4) ligands capable of forming very stable complexes with transition metals. They can only act as coordinating ligands if they bear a functional group, usually the hydroxyl, sufficiently near the site of condensation in such a way that a five or six membered ring can be formed when reacting with a metal ion.





Fig.3.Some classes of Schiff base ligands

Schiff bases derived from aromatic amines and aromatic aldehydes have a wide variety of applications in many fields, eg., biological, inorganic and analytical chemistry (*Cimerman et. al.,2000 and Elmali et. al.,2000*). Applications of many new analytical devices require the presence of organic reagents as essential compounds of the measuring system.

**1.2 SCHIFF BASE METAL COMPLEXES**

Transition metal complexes with Schiff bases have expanded enormously and embraced wide and diversified subjects comprising vast areas of organometallic compounds and various aspects of bio-coordination chemistry (*Anacona et. al., 1999*). The design and synthesis of symmetrical Schiff bases derived from the 1:2 step wise condensation of carbonyl compounds, with alkyl or aryl diamines and a wide range of aldehyde or ketone functionalities, as well as their metal(II) complexes have been of interest due to their preparative accessibility, structural variability and tunable electronic properties allowing to carry out systematic reactivity studies based ancillary ligand modifications. In recent years much effort has been put in synthesis and characterization of mono- and bi-nuclear transition metal complexes (*Trujillo et. al., 2008*).Schiff bases are used in optical and electrochemical sensors, as well as in various chromatographic methods to enable detection of enhanced selectivity and sensitivity (*Valcared et. al., 1994, spichiger et. al., 1998,Lawerence et. al., 1998*). Among the organic reagents actually used, Schiff bases possess excellent characteristics, structural similarities with natural biological substances, relatively simple preparation procedures and the synthetic flexibility that enables design of suitable structural properties *(Patai 1970*).

**1.3 APPLICATIONS OF SCHIFF BASES**

Schiff bases are widely applicable in analytical determination, using reactions of condensation of primary amines and carbonyl compounds in which the azomethine bond is formed (determination of compounds with an amino or carbonyl group) using complex forming reactions (determination of amines, carbonyl compounds and metal ions) or utilizing the variation in their spectroscopic characteristics following changes in pH and solvent (*Metzler et, al., 1980).* Schiff bases play important roles in coordination chemistry as they easily form stable complexes with most transition metal ions *(Clarke et. al., 1998*). In organic synthesis, Schiff base reactions are useful in making carbon-nitrogen bonds.

**1.3.1 Biological Importance of Schiff Bases**

Many biologically important Schiff bases have been reported in the literature possessing antimicrobial, antibacterial, antifungal, anti-inflammatory, anticonvulsant, antitumour and anti HIV activities (*Pandeya et. al., 1999, Singh et. al., 1988, Kelly et. al., 1995*). Another important role of Schiff base structure is in transamination (*Schmid 1996).* Transamination reactions are catalysed by a class of enzymes called transaminases. Transaminases are found in mitochondria and cytosal of eukaryotic cells. Schiff base formation is also involved in the chemistry of vision, where the reaction occurs between the aldehyde function of 11-cis-retinal and amino group of the protein (opsin) (*Carry 1992*).

**1.3.2 Anti-bacterial Activities**

Methicillin resistance staphylococcus aureus causes many problems as it has become resistance to almost currently available antibiotics. Two Antibiotics, vancomycin and Teicoplanin does not show resistance to s.aureus. But recently studies and data from many countries show that VISA(Vancomycin-intermediate s.aureus) and VRSA (Vancomycin-resistance s.aureus) increasing in many countries, as susceptibility toward Vancomycin has been decrease. The Schiff base derived from 2-furancarboxaldehyde and 2-aminobenzoic acid and its metal complexes with Cu (II), Ni (II), Co (II), and Fe (III) has biological activities against bacteria *staphylococcus*pyogenes, E.coli and pseudomonasaeruginosa (*Duca et. al.,1979 ,Zota et. al.,1985*).Taking streptomycin as a standard, using Mueller- Hinton agar as a medium with 2% glucose. The diameter of inhibition was visualized after 24 hous at 37oc and found to be effective against them.

**1.3.3 Antifungal Activities**

Studies have shown that some of the Schiff Base are very effective in prevention of fungal infection. As fungal infection is not only limited to superficial tissues but in some cases it is become life threatening (*Sundriyalet, al., 2006, Nucci et. al., 2005, Martin et. al., 2009*). Production of most of the cruciferous crops like cauliflower, cabbage, mustard, radish etc is effective by Fungi like Alterneriabrassicae and Alterneriabrassicicola (*Przybyiski et. al., 2009*). Schiff base N-(salicylidene)-2-hydroxyaniline inhibited the growth of both fungi by 67-68% at the concentration of 500 ppm *(Cleiton et. al., 2011).*

**1.3.4 Enzymatic Activities**

Schiff base linkage with pyridoxal 5’ phosphate (PLP) a derivative of pyridoxine commonly known as vitamin B6abolished the enzyme activities of Proteins. PLP binds to some number of specific enzymes and play a critical role in helping here these enzymes tocatalyze their reaction. Most enzymes that interact with PLP catalyzereactions involved in the metabolism of amino acids. In many PLP dependent enzymatic reactions, PLP forms a Schiff base link with Lysine residue on the enzyme. Another Schiff Base complex of 2-pyridine carboxyaldehyde and its derivative show high super oxide dismutase activities(*Sivasankaran et. al., 2000*). Ternary complex of Cu (II) containing NSO donar Schiff base showed DNA cleverage activities.

**1.4 STOICHIOMETRY**

Stoichiometry is the calculation of reactants and products in chemical reactions. Stoichiometry is founded on the law of conservation of mass where the total mass of the reactants equals the total mass of the products, leading to the insight that the relations among quantities of reactants and products typically form a ratio of positive integers. This means that if the amounts of the separate reactants are known, then the amount of the product can be calculated. Conversely, if one reactant has a known quantity and the quantity of the products can be empirically determined, then the amount of the other reactants can also be calculated.

This is illustrated in the image here, where the balanced equation is:

CH4 +2O2 → CO2 + 2H2O.

Here, one molecule of methane reacts with two molecules of oxygen gas to yield one molecule of carbon dioxide and two molecules of water. This particular chemical equation is +n example of complete combustion. Stoichiometry measures these quantitative relationships, and is used to determine the amount of products and reactants that are produced or needed in a given reaction. Describing the quantitative relationships among substances as they participate in chemical reactions is known as reaction stoichiometry. In the example above, reaction stoichiometry measures the relationship between the methane and oxygen as they react to form carbon dioxide and water.

**1.4.1 Uses of Stoichiometry**

Stoichiometry is also used to find the right amount of one reactant to "completely" react with the other reactant in a chemical reaction that is, the stoichiometric amounts that would result in no leftover reactants when the reaction takes place. A stoichiometric amount *(Carmen 2016*) or stoichiometric ratio of a reagent is the optimum amount or ratio where, assuming that the reaction proceeds to completion:

* All of the reagent is consumed
* There is no deficiency of the reagent
* There is no excess of the reagent.

Stoichiometry rests upon the very basic laws that help to understand it better, i.e., law of conservation of mass, the law of definite proportions (i.e., the law of constant composition), the law of multiple proportions and the law of reciprocal proportions. In general, chemical reactions combine in definite ratios of chemicals. Since chemical reactions can neither create nor destroy matter, nor transmute one element into another, the amount of each element must be the same throughout the overall reaction. For example, the number of atoms of a given element X on the reactant side must equal the number of atoms of that element on the product side, whether or not all of those atoms are actually involved in a reaction.

Chemical reactions, as macroscopic unit operations, consist of simply a very large number of elementary reactions, where a single molecule reacts with another molecule. As the reacting molecules (or moieties) consist of a definite set of atoms in an integer ratio, the ratio between reactants in a complete reaction is also in integer ratio. A reaction may consume more than one molecule, and the stoichiometric number counts this number, defined as positive for products (added) and negative for reactants. (*Carmen J.2016)*

Different elements have a different atomic mass, and as collections of single atoms, molecules have a definite molar mass, measured with the unit mole (6.02 × 1023 individual molecules, Avogadro's constant). By definition, carbon-12 has a molar mass of 12 g/mol. Thus, to calculate the stoichiometry by mass, the number of molecules required for each reactant is expressed in moles and multiplied by the molar mass of each to give the mass of each reactant per mole of reaction. The mass ratios can be calculated by dividing each by the total in the whole reaction.Elements in their natural state are mixtures of isotopes of differing mass, thus atomic masses and thus molar masses are not exactly integers. For instance, instead of an exact 14:3 proportion, 17.04 kg of ammonia consists of 14.01 kg of nitrogen and 3 × 1.01 kg of hydrogen, because natural nitrogen includes a small amount of nitrogen-15, and natural hydrogen includes hydrogen-2 (deuterium). A stoichiometric reactant is a reactant that is consumed in a reaction, as opposed to a catalytic reactant, which is not consumed in the overall reaction because it reacts in one step and is regenerated in another step.

**1.4.2 Stoichiometry as it relates to complexation reactions**

Complexationreactions of the form

:xM + yL ↔\_ MxLy

are based on the reaction of a metal cation (M) and a ligand (L). These reactions are widely used in analytical chemistry. Absorption spectroscopy is a powerful tool for exploring these complexation reactions. In this experiment, two general approaches to studying the composition of complexes are used to demonstrate the necessity of carefully evaluating theproperties of a particular chemical system in order to select the best method for determining the composition (metal to ligand ratio) of a complex by absorption measurements.

**Method of Continuous Variation (Job’s Method)**

In this method, metal cation and ligand solutions with identical concentrations are mixedin different amounts such that the total volume of the mixture solutions and the total moles of reactants in each mixture is constant. This procedure causes the mole ratio of reactants to be varied across the set of mixture solutions. The absorbance of each solution is then measuredand plotted vs. the volume fraction of one of the reactants (M or L). For example, the volume fraction of the metal is

VM/(VM + VL)

**Mole-Ratio Method (Yoe-Jones Method)**

In this method, a series of solutions is prepared in which the concentration of one reactant is held constant while that of the other is varied. The absorbance of each solution ismeasured and plotted against the mole ratio of the reactants. Assuming the complex absorbs more than the reactants, this plot will produce an increasing absorbance up to the combining ratio. At this point, further addition of reactant will produce less increase in absorbance. Thus a break in the slope of the curve occurs at the mole ratio corresponding to the combining ratio of the complex.

**1.5 AIM AND OBJECTIVES OF THE RESEARCH**

The relationship between metal ions and biological activity of certain systems is obvious and a subject of great interest. It has been demonstrated that biologically inactive compounds become active and less biologically active compounds become more active upon coordination with the metal ions (Okeke, 2018). The apparent role played by metal ions in the induction or enhancement of biological activity of the organic compounds is therefore definite, but how, is still not well understood.

In order to get an insight into this role, the behaviour of Schiff bases has gained a great deal of attraction. The imine linkage (– N = CH-) is a significant feature that makes Schiff base ligands interesting for biological activities as well as coordination with the metal ions. The interaction between these metal ions and such biologically active ligands should serve as a route in designing new metal-based drugs for bacteria, fungi, microbes, HIV, etc strains that have become resistant to the use of conventional drugs.

This study therefore is aimed at;

1. Synthesizing two new Schiff base ligands by capping the amine group in 1,4-phenylenediamine with 4-dimethylaminobenzadehyde and 2-hydroxylbenzadehyde.
2. Preparation of their metal complexes by refluxing in absolute ethanol using Co(II), Mo(VI), and Mn(VI) metal salts.
3. Characterizing the formed ligands and their different metal complexes on the basis of their;

i) Melting point

ii) Electronic Spectra

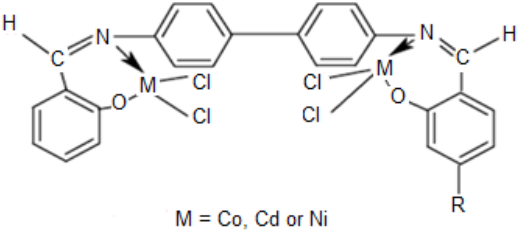
iii) Infrared spectra

iv)Microbial analysis

**CHAPTER TWO**

**LITERATURE REVIEW**

Sibous et al., (2013) synthesized, characterised and studied the electrochemical behaviour of Co(II), Ni(II) and Cd(II) complexes with N2O2 donor ligands derived from 4,4’-diaminobiphenyl and 2-hydroxybenzaldehyde or 2,4-dihydroxybenzaldehyde. The coordination of the metal ions is through nitrogen and oxygen atoms. The cobalt(II) and cadmium(II) compounds presented a distorted tetrahedral geometry while nickel(II) complexes exhibited a typical square planar structure.

****

**Figure 4:Structureof Co(II), Cd(II), and Ni(II) complexes**

Suresh et al.,(2010) synthesized a new series of transition metal complexes of Mn(II), Co(II), Ni(II), Cu(II) and Zn(II) from the Schiff base ligand derived from 4-aminoantipyrine, furfural and o-phenylenediamine. The structural features were derived from their elemental analyses, infrared, UV-visible spectroscopy, NMR spectroscopy, thermal gravimetric analyses, ESR spectral analyses and conductivity measurements. The data of the complexes suggested square planar geometry for the metals with primary valence of two. Antimicrobial screening tests were performed against bacteria. The comparative study of the MIC values of the Schiff base and its metal complexes indicated that the metal complexes exhibited greater antibacterial activity than the free ligand.

****

**Figure 5; Structure of the metal complex**

Abdunnaser et al.,(2013) studied the uptake properties of the Schiff bases derived from salicylaldehyde and 4-dimethylaminobenzaldehyde, 1,8-naphthalenediamine, or 2-aminobenzoyl alcohol. These Schiff bases were synthesised, characterized and subjected to complexation reactions. A series of transition and heavy metals such as Zinc (II), Cobalt (II), Lead (II), cadmium (II) formed stable complexes with the obtained Schiff bases. The Schiff bases and their complexes, for comparison, have been studied by simple conventional techniques. Various analytical parameters such as: Melting points, pH values, solubility in different solvents, infrared spectroscopy, electrical conductivity and atomic absorption spectroscopy were used. Moreover, the only Schiff base obtained from salicylaldehyde and 1,8-naphthalenediamine was considered and was subjected and evaluated for its influence on the metal ions uptake behaviour. The condition and coordination of the sites and metal ions properties agreed with the data obtained from the tools used in the analysis. To this end, a number of compounds were formulated, and such Schiff bases were found to possess the uptake properties. Attempts were made this to find out the best uptake properties.

****

**Figure 6; Schiff base 2-{(E)-[(8-aminonaphthalen-1- yl)imino]methyl}phenol**

Muneera F. M. et al.,(2012) synthesized a Schiff base ligand, (E)-3-(2-aminophenylimino)indolin-2-one (APIISA) via condensation reaction of o-phenylenediamine with isatin. Metal complex and lithium-schiff base of this ligand were prepared. Metal complex bis[(E)-3-(2-aminophenylimino)indolin-2-one]Co(II), [Co(APIISA)2] was synthesized from Schiff base ligand with Cobalt acetate tetrahydrate in 2:1 ratio. While lithium-schiff base was prepared by using Lithium acetate dihydrate produced lithium[(E)-3-(2-aminophenylimino)indolin-2-one], [Li(APIISA)]. All the synthesized compounds were characterized by variety of physicochemical techniques such as melting point, elemental analysis, infrared spectroscopy, 1H nuclear magnetic spectroscopy, magnetic susceptibility and X-ray diffraction. Conductivity studies of the ligand, metal complex and lithuim- Schiff base were investigated by impedance analyser in which the samples were prepared in the form of pellets. The electrical conductivities of the prepared compounds were measured by applying alternating current (ac) voltage. The conductivity values were calculated and lithium-schiff base showed higher conductivity value followed by Cobalt metal complex and Schiff base ligand. The schiff base behaved as a bidentate chelating ligand which binds through azomethine and imino nitrogen. 1H NMR spectrum of Schiff base indicates the structure of the compound. Magnetic moments show that cobalt(II) complex was tetrahedral environment. The Schiff base, its metal complex and lithium-schiff for their conductivity studies showed that lithium-schiff base has the highest conducted values followed by cobalt (II) metal complex and Schiff base ligand.

Abdulghani et al.,(2013) synthesized a series of new di-, tri-, and tetra nuclear Co(II) and Cu(II) complexes of three new dischiff base ligands by two different methods. The first method involved the synthesis of the three ligands from condensation reaction of 3,4- dihydroxybenzaldehyde (LH2) with ethylenediamine (en), o-phenylenediamine (o-PD), or 4,5-dimethyl-1,2-phenylendiamine (DMPD) in a mole ratio of 2:1 followed by the reaction of the resulting Schiff bases ligands with Cu(II) or Co(II) ions in the presence of 2,2-bipyridyl (L) to form the di and tri nuclear metal complexes. The second method involved the condensation of the copper complex LCu(II)L (L = 2,2-bipyridyl, L= 4-formylbenzene-1,2-bis(olate) with en, o-PD, or DMPD in a mole ratio of 2:1, respectively, followed by reaction with CuCl 2 orCu(ClO4)2 to form di, tri, and tetra nuclear copper(II)complexes, respectively. The structures of the ligands and metal complexes were characterized by elemental analyses, NMR, and FTIR spectra. The geometries of metal complexes were suggested according to elemental analysis, electronic spectra, thermal analyses, atomic absorption, and magnetic moments and conductivity measurements.



Abdulghani A.J. et al, (2007) synthesized two Schiff base derivatives of cefotaxime antibiotic (CFX) namely: [sodium3-(acetoxymethyl)-7-((Z)-2-(methoxyimino)-2-(2-((E)-2–oxoindolin-3-ylide-neamino) thiazol-4-yl)acetamido)-8-oxo-5-thia-1-azabicyclo[4.2.0]oct-2-ene-2-carboxylate]. (0.5) Methanol (LI) and [sodium3-(acetoxymethyl)-7-((2Z)-2-(2-(4-dimethylamino) benzylideneamino) thiazol-4- yl)-2-(methoxyimino)acetamido)-8-oxo-5-thia-1-azabicyclo [4.2.0] oct-2-ene-2-carboxylate]. (0.5) Methanol (LII) from the condensation reaction of the antibiotic with 1H-Indole-2,3-dione(isatin) and -N, N-dimethyl amino benzaldehyde respectively. Metal complexes of the two Schiff base li- gands with Co(II), Ni(II), Cu(II), Cd(II), Pd(II) and Pt(IV) ions were prepared by reacting each li- gand with the metal salts in refluxing ethanol. The chemical structures of the two ligands as well as the stereo-chemical structures and geometries of the studied metal complexes were suggested depending the results obtained from CHN and TG analysis, NMR, FTIR, and atomic absorption spectrophotometry, electronic spectra, magnetic moments and conductivity measurements. The mole ratio of the ligands to the metal ion was 1:1 with tridentate bonding behaviors of the coordinating ligands with the metal ions.

Two Schiff base derivatives of cefotaxime were successfully synthesized from the condensation reaction of the antibiotic with isatin (LI) and N-dimethylaminobenzaldehyde (LII) and their structures were characterized by elemental and thermal analysis, NMR and FTIR spectra. The coordination of the two ligands with Co(II), Cd(II), Ni(II), Cu(II), Pd(II), and Pt(IV) ions showed tridentate behaviour with M:L mole ratio of 1:1. All complexes were of octahedral geometries except the Pd(II) complexes which had square planar structures. The biological activity of the prepared compounds was controlled by type of bacteria, functional groups of ligands and type of metal ion.

Natarajan Raman *et al.,* (2015) have reported the synthesis of a novel 14-membered macrocyclic Schiff base derived from 3-cinnamalideneacetanalide and *o*-phenylenediamine which acts as a tetradentate and strongly conjugated ligand to form a cationic solid complex with Cu(II), Ni(II), Co(II) and Zn(II). The ligand and the complexes were characterized by the usual spectral and analytical techniques. The antimicrobial tests were also recorded and gave good results in the presence of metal ions in the ligand system.

Tofazzal H.,*et al*(2000) have reported the synthesis of complexes of a tridentate Schiff base from thecondensation of S-benzyldithiocarbazate with salicylaldehyde. These complexes have been characterized by elemental analysis and spectral analysis. Square planar structures are proposed for the Ni(II) and Cu(II) complexes. These authors have also studied the antimicrobial tests which indicate that Schiff base and five of the metal complexes of Cu(II), Ni(II), U(IV), Zr(II) and Sb(II) are strongly active against bacteria.

MukeshK.,*et al* (2008) have studied the synthesis of mono basic bidendate Schiff base complexes of palladium (II) and platinum (II) from 1H-indol-2,3-dione thiosemicarbazone. These complexes were characterized on the basis of elemental analysis, molecular weight determination, 1H NMR and UV spectral studies. Antimicrobial effects of both the ligands and their complexes on different species of pathogenic fungi and bacteria have been recorded and these are found to possess significant fungicidal and bactericidal properties

**CHAPTER 3**

**MATERIALS AND METHOD**

**3.1 MATERIALS/APPARATUS**

1. Mechanical stirrer
2. Glass wares
3. Pot
4. Boiling ring
5. Heating mantle
6. Aspirator bucket
7. Reflux condenser
8. Retort stand and clamp
9. Fridge
10. Nose mask
11. Sample analysis bottles
12. Fume cupboard
13. Water hose
14. Thermometer (0ᵒ-360ᵒc)
15. Filter paper
16. Hand gloves
17. Weighing balance

**3.2 REAGENTS**

The reagents used for the research include the following;

1. 1,4-phenylenediamine
2. 4- Dimethylaminobenzadehyde
3. Ammonium molybdate
4. Potassium tetraoxomanganate(IV)
5. Cobalt(II) chloridedihydrate
6. 2- hydroxybenzadehyde
7. Silica gel
8. Acetic acid
9. Ethanol
10. Methanol
11. Benzene
12. Butanol
13. Propan -2-one
14. Dimethyl sulfoxide
15. Nutrient agar
16. Distilled water

The Microorganisms used are *Candida albicans, Escherichia coli, Salmonella typhi, Enterococcus feacalis and Staphylococcus aureus*

**3.3 METHODS**

**3.3.1 Preparation of the Schiff base ligands**

**3.3.1a Synthesis of N,N/Bis(2-hydroxylbenzylidene-1,4-phenylenediimine)- M**

1,4-phenylenediimine (0.22g, 0.002mol) dissolved in 30ml of absolute ethanol was added to a mixture of 2-hydroxybenzylidene (0.50g, 0.005mol) in 30ml of ethanol. This was poured into a 2-neckedround bottom flask and a magnetic stirrer was then inserted into the mixture and this was refluxed with continuous stirring for 4hours within the range of 60ᵒ-70ᵒc. After 4hours, the refluxed mixture was allowed to cool and then the solvent was filtered out. The resulting brownish powdery compound was re-crystallized with ethanol and was later allowed to dry in a desiccator for further analysis.

**3.3.1b Synthesis of N,N/Bis(4-dimethylaminobenzylidene-1,4-phenylenediimine)- N**

1,4-phenylenediimine (0.18g, 0.0016mol) dissolved in 30ml of absolute ethanol and was added to a mixture of 4-Dimethylbenzylidene (0.50g, 0.005mol) in 30ml of ethanol, and poured into 2-neck round bottom flask and a magnetic stirrer was then inserted into the solution and was reflux with continuous stirring for 4hours within the range of 60ᵒ-70ᵒc. After 4hours, the refluxed mixture was allowed to cool and then solvent was filtered out. The resulting yellowish powdery compound was re-crystallized with ethanol and was later allowed to dry in a desiccator for further analysis.

**3.3.2 Preparation of complexes**

Here the metal compounds and the various Schiff base ligands were reacted together in a stoichiometric mole ratio of 1:2.

**3.3.2a Synthesis of N,N/Bis(2-hydroxylbenzylidene- 1,4-phenylenediimine)- M Co(II) complex**

A solution of Schiff base M (0.084g,0.00083mol) dissolved in 20ml ethanol was added to a solution of cobalt (II) chloride (0.2g, 0.00084mol) in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis.

**3.3.2b Synthesis of N,N/Bis(2-hydroxylbenzylidene- 1,4-phenylenediimine)- M Mn(VII) complex**

A solution of Schiff base M (0.126g, 0.00125mol) dissolved in 20ml ethanol was added to a solution of potassium permanganate (0.2g, 0.00126mol) in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis.

**3.3.2c Synthesis of N,N/Bis(2-hydroxylbenzylidene- 1,4-phenylenediimine)-M Mo(VII) complex**

A solution of Schiff base M (0.10g, 0.00099mol) dissolved in 20ml ethanol was added to a solution of ammonium molybdate (0.2g, 0.0010mol) in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis.

**3.3.2d Synthesis of N,N/Bis(4-dimethylaminobenzylidene- 1,4-phenylenediimine)-N Co(II) complex**

A solution of Schiff base N (0.01g,0.00026mol) dissolved in 20ml ethanol was added to a solution of cobalt(II) chloride (0.006g, 0.0000252mol)in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis

**3.3.2e Synthesis of N,N/Bis(4-dimethylaminobenzylidene- 1,4-phenylenediimine)-N Mn(VII) complex**

A solution of Schiff base N (0.01g,0.00026mol) dissolved in 20ml ethanol was added to a solution of potassium permanganate (0.004g, 0.0000253mol) in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis

**3.3.2f Synthesis of N,N/Bis(4-dimethylaminobenzylidene- 1,4-phenylenediimine)-N Mo(VII) complex**

A solution of Schiff base N (0.01g,0.00026mol) dissolved in 20ml ethanol was added to a solution of Ammonium molybdate(0.05g, 0.000255mol) in absolute ethanol of 20ml were mixed and poured into a 2- necked round bottom flask. The mixture was allowed to reflux for 2hours for further analysis.

**3.4. STOICHIOMETRY OF THE COMPLEXES**

In the stoichiometry of these complexes using the job continuous variation method, several reactant solutions were prepared in which the mole quantities of the metal ion and the ligands were varied but the sum of the mole quantities as kept constant. For each reactant performed, a total of nine (9) different mixtures were made.

4ml of absolute ethanol was then added into each mixture, these mixture were shaken and then allowed to react for 2 hour. Their absorbances were later read from the ultraviolet –spectrophotometer.

The net result of a reaction will identify the reactants and products as well as the ratios in which these species reactant are produced and that becomes the stoichiometry of the reaction.

**Table 3.4 Stoichiometry of the complexes**

|  |  |  |  |
| --- | --- | --- | --- |
| S/N | Metal | Ligand | Mole ratio (L/M) |
| 1 | 0.9 | 0.1 | 0.11 |
| 2 | 0.8 | 0.2 | 0.25 |
| 3 | 0.7 | 0.3 | 0.42 |
| 4 | 0.6 | 0.4 | 0.66 |
| 5 | 0.5 | 0.5 | 1.00 |
| 6 | 0.4 | 0.6 | 1.50 |
| 7 | 0.3 | 0.7 | 2.33 |
| 8 | 0.2 | 0.8 | 4.00 |
| 9 | 0.1 | 0.9 | 9.00 |

**3.5 CHARACTERIZATION OF THE SCHIFF BASE LIGANDS AND THEIR COMPLEXES**

The formed ligands and their complexes were characterized by the following techniques.

1. Melting/Decomposition Points

2. Ultraviolet-Visible Spectroscopy

3. Infrared Spectroscopy

4. Antimicrobial Analysis

**3.5.1 Melting / decomposition point**

Melting point apparatus with Microsoft X-4B was used for this determination. It’s below >400oc and it involves a capillary tube with a sample quantity in a plate container which gets heated up once the electrical source is switched on. Over the plate is a viewing lens, through which the sample is viewed as the temperature rises. As soon as the sample is viewed to melt or decompose, the temperature is recorded from the in-built thermometer connected to the apparatus.

**3.5.2 Ultraviolet- visible spectroscopy**

UV-5800pc spectrophotometer was used. And the electronic absorption spectra in the ultraviolet-visible range was recorded between 200nm and 800nm using ethanol as the solvent

**3.5.3 Infrared spectroscopy**

An infrared spectrum was recorded on a FTIR Thermo Scientific IS5 Nicolet. The important infrared bands, such as u(C=N), u(N=H), u(C=C), u(OH), u(C=O), u(COOH) stretches indicating the formation of the ligands and their complexes were studied.

**3.5.4 Antimicrobial Analysis**

The analysis was carried out to determine the antimicrobial effect and the minimum inhibitory concentration of the ligands and metal complexes. The screening effects of the investigated compounds were tested against *Candida albicans, Escherichia coli, Salmonella typhi, Enterococcus feacalis and Staphylococcus aureus.* The samples were dissolved in dimethylformamide to obtain a concentration of 10mg/ml and left overnight to dissolve considerably. Nutrient agar (NA) and Sabouraud Dextrose Agar (SDA) medium were prepared by autoclaving 2.8g and 6.5g respectively of the powdered medium dissolved in 100ml of distilled water at 121˚C under 15 pounds per square inch pressure for 15 minutes. The medium was allowed to cool to 45˚C and poured into 8 sterile 90 X 15mm petri-dishes, each plate containing 25ml, and allowed to gel at room temperature. Pure 18-hour old culture of the test microorganisms were dissolved in sterile distilled water and standardized to a concentration of 3.5 X 108cfu/ml by comparing the microbial suspension with the turbidity of McFarland 0.5. The SDA and NA plates were inoculated with 0.1ml each of *Candida albicans, Escherichia coli, Salmonella typhi, Enterococcus feacalis and Staphylococcus aureus* respectively by spreading the microbial inoculums with sterile wire loop. The ligand samples were further diluted, two- fold, and a drop of the 10mg/ml and 5mg/ml dilutions were dispensed with Pasteur pipette on the agar surfaces previously overlaid with microorganism, leaving some gap in between the drops. Each plate contained drops including DMF of a concentration of either 10mg/ml which served as a positive control. The plates were left on the bench for 1 hour for the agar to absorb the samples, and thereafter incubated aerobically in an inverted position for 24 hours at 37 ˚C in an incubator. After 24 hours incubation, the diameters of the inhibited zones of the microorganisms were measured with a ruler.

**CHAPTER FOUR**

**RESULTS AND DISCUSSION**

For clarity reasons these abbreviations were used

M → N,N/Bis(2-hydroxylbenzylidene) -1,4-phenylenediimine

N→ N,N/Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine

CoM→ Co(II) complex of N,N/Bis (2-hydroxylbenzylidene) -1,4-phenylenediimine

MnM →Mn(VII) complex of N,N/Bis (2-hydroxylbenzylidene) -1,4-phenylenediimine

Mo2M → Mo(VII) complex of N,N/Bis (2-hydroxylbenzylidene) -1,4-phenylenediimine

CoN → Co(II) complex of N,N/Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine

MnN→ Mn(VII) complex of N,N/Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine

Mo2N→Mo(VII) complex of N,N/Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine

**4.1 PHYSICAL PROPERTIES**

The physical properties of these ligands and their complexes are presented in Table 4.1.

Table 4.1: Physical properties of the ligand and its complexes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Compound | Colour | Texture | Melting point(oC) | Yield  (g) (%) | |
| M | Dark brown | Powdery | 228 | 0.30 | 46.15 |
| N | Yellow | Powdery | 300 | 0.39 | 62.90 |
| CoM | White | Crystal | 240 | 0.08 | 0.026 |
| MnM | Green | Powdery | >400 | 0.15 | 0.040 |
| Mo2M | Grey | Powdery | >400 | 0.30 | 0.015 |
| CoN | Dark brown | Powdery | 272 | 1.10 | 0.002 |
| MnN | Brown | Powdery | >400 | 1.10 | 0.002 |
| Mo2N | Reddish brown | Powdery | >400 | 1.14 | 740.99 |

Ligand M has been observed to be a powdery dark brown compound with melting point 219-228oc. Its Co(II) complex, CoM is white and its texture is crystal with melting point 0f 240oc. MnM i.e Mn(VII) complex is a green powdery compound and has the melting point of >400oc. Mo2M i.e Mo(VII) was a grey powdery compound with a melting point of >400oc.

Ligand N has been observed to be a powdery yellow compound with melting point 300oc. Its Co(II) complex ie CoN is dark brown with a melting point of 272oc. Its Mn(VII) complex is brown and powdery with melting point of above 400oc while Mo2N i.e the Mo(II) complex was observed to be reddish brown and powdery with melting point of >400oc

Generally, the percentage yields of these compounds were calculated to be high except some few compounds having low yields which might be due to insufficiency of the precursor reagents or error during analysis.

**4.2 SOLUBILITY ASSAY**

The solubility assay of the ligand M ie N,N/-Bis(2-Hydroxybenzylidene)-1,4-Phenylenediimine and N ie N,N/-Bis(4-Dimethylaminobenzylidene)-1,4-Phenylenediimine and their Co(II), Mn(VII), and Mo(VII) complexes showed results that are very much alike and was conducted using eight organic solvents to ascertain how soluble the compounds were under heat and when cold. This was reported in table 4.2.

**Table 4.2: Solubility Assay**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S/N** | **Solvent** | **Ligand (M&N)** | **Co(II) complex** | **Mn(VII)** | **Mo(VII)** |
| **1** | **PROPAN-2-ONE** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Partially soluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Insoluble | Partially soluble | Partially soluble |
|  |  |  |  |  |  |
| **2** | **DIETHYL ETHER** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Insoluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Soluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
| **3** | **BUTANOL** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Insoluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
| **4** | **BENZENE** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Partially soluble | Insoluble | Insoluble | Insoluble |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Partially soluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
| **5** | **ACETIC ACID** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Partially soluble | Insoluble | Insoluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Partially soluble | Partially soluble | Partially soluble |
|  |  |  |  |  |  |
| **6** | **DMSO** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Soluble | Partially soluble | Partially soluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Soluble | Partially soluble | Partially soluble | Insoluble |
|  |  |  |  |  |  |
| **7** | **ETHANOL** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Partially soluble | Insoluble | Partially soluble | Insoluble |
|  |  |  |  |  |  |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Insoluble | Partially soluble | Insoluble |
|  |  |  |  |  |  |
| **8** | **METHANOL** | **COLD** | **COLD** | **COLD** | **COLD** |
|  |  | Partially soluble | Partially soluble | Insoluble | Insoluble |
|  |  | **HEAT** | **HEAT** | **HEAT** | **HEAT** |
|  |  | Partially soluble | Partially soluble | Insoluble | Insoluble |

The ligand M and N in Propan -2-one solvent in cold and heat shows partially soluble. The Co(II) complex in cold and heat shows both insoluble. The Mn(VII) shows insoluble in cold and partially soluble in heat. The Mo(VII) complex shows insoluble in cold and partially insoluble in heat.

The ligand M and N in Diethyl ether solvent using cold and heat shows insoluble. The Co(II) complex for cold and heat shows both insoluble. The Mn(VII) shows insoluble for both cold and heat. The Mo(VII) complex shows insoluble in cold and in heat.

The ligand M and N in Butanol solvent in cold shows insoluble and heat shows partially soluble. The Co(II) complex for cold and heat shows both insoluble. The Mn(VII) shows insoluble in cold and in heat. The Mo(VII) complex shows insoluble for both cold and heat.

The ligand M and N using benzene solvent in cold and heat shows partially soluble. The Co(II) complex in cold shows insoluble and in heat shows partially soluble. The Mn(VII) shows insoluble for both cold and in heat. The Mo(VII) complex shows insoluble in cold and in heat.

The ligand M and N in Acetic Acid solvent in cold and heat shows to be partially soluble. The Co(II) complex in cold shows insoluble and in heat shows partially soluble. The Mn(VII) shows insoluble in cold and partially soluble in heat. The Mo(VII) complex shows insoluble in cold and partially insoluble in heat.

The ligand M and N in DMSO solvent in cold and heat shows soluble. The Co(II) complex for cold and heat shows both partially soluble. The Mn(VII) shows partially soluble in both cold and heat. The Mo(VII) complex shows insoluble in cold and in heat.

The ligand M and N in Ethanol solvent in cold and heat shows partially soluble. The Co(II) complex for cold and heat shows both insoluble. The Mn(VII) shows partially soluble in cold and in heat. The Mo(VII) complex shows insoluble in cold and in heat.

The ligand M and N in Methanol solvent in cold and heat shows partially soluble. The Co(II) complex for cold and heat shows both partially soluble. The Mn(VII) shows insoluble in cold and in heat. The Mo(VII) complex shows insoluble in cold and in heat.

**4.3 STOICHIOMETRY OF THE COMPLEXES**

## The Job’s continuous variation curves for these complexes, as presented in Figures 8 - 13 and summarized in Table 4.3 gives an over-view of each complexes’ metal to ligand mole ratio as contained in the complexes.

Absorbance

Mole ratio

**Figure 8: Job’ curve for CoM**

|  |  |
| --- | --- |
|  |  |
|  |  |
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**Absorbance**

**Mole ratio**

**Figure 9: Job’s curve for MnM**

|  |  |
| --- | --- |
|  |  |
|  | mole ratio | |

Absorbance

**Mole ratio**

**Figure 10: Job’s Curve For Mo2M**

Absorbance

**Figure 11: Job’s Curve For CoN**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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| Absorbance |  |  |  |  |  |  |  |  |  |
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Mole ratio

**Figure 12: Job’s curve for MnN**

Absorbance

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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**Figure 13: Job’s curve for Mo2N**

**TABLE 4.3. STOICHIOMETRY RESULTS**

|  |  |
| --- | --- |
| Complex | Metal to ligand mole ratio |
| CoM | 1:1 (ML) |
| MnM | 1:1 (ML) |
| Mo2M | 1:2 (ML2) |
| CoN | 2:3 (M2L3) |
| MnN | 1:4 (ML4) |
| Mo2N | 1:1 (ML) |

The M complexes especially CoM and MnM were found to have the same metal to ligand mole ratio of 1:1 while Mo2M mole ratio is 1:2.

Considering N complexes, CoN’s mole ratio was 2:3 metal to ligand mole ratio while MnN exhibited 1:4 mole ratio and Mo2N a 1:1 mole ratio.

These results generally, although quite tentative, would serve as a preliminary guide in establishing the structure for these complexes.

**4.4 REACTION SCHEME**

4.4.1 Reaction scheme for N,N/Bis(2-hydroxylbenzylidene-1,4-phenylenediimine (M)

synthesis. The synthesis for M is a condensation reaction between 1,4-phenylenediamine and 2-hydroxylbenzadehyde.





**Figure 14: The reaction scheme between 1,4-phenylenediimine and 2-hydroxylbenzylidene (M)**

4.4.2 Reaction scheme for N,N/Bis(4-dimethylaminobenzylidene-1,4-phenylenediimine (M) synthesis. The synthesis for M is a condensation reaction between 1,4-phenylenediamine and 4-dimethylaminobenzadehyde.

N,N/Bis(4-dimethylaminobenzylidene + 1,4-phenylenediimine ) N





**Figure 15: The reaction scheme between 1,4-phenylenediimine and 4-Dimethylaminobenzylidene (N)**

**4.5 ELECTRONIC SPECTRA**

The electronic spectral data of these ligands and complexes as obtained from ethanolic solution are presented in table 4.5. The various absorption bands for each ligand with its complexes are grouped for better clarity.

Table 4.5: Electronic Spectral Data showing Wavelength (nm), Wave-number, (cm-1) and Molar absorptivity (€)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Compounds** | **nm(cm-1)€** | **nm(cm-1)€** | **nm(cm-1)€** | **nm(cm-1)€** | **nm(cm-1)€** | **nm(cm-1)€** | **nm(cm-1)€** |
| M |  | 408m(24509.80)  1.009691 |  | 356sh(28089.88)  0.81582 |  |  | 326sh(30674.84)  0.76819 |
| CoM |  |  |  |  |  |  | 332sh(30120.48)  0.181407 |
| MnM |  |  |  | 360m(27777.77)  0.24792 | 380s(26315.78)  0.26749 | 330m(30303.03)  0.22659 |  |
| Mo2M | 796b(12562.81)  0.192475 |  |  |  |  | 336sh(29761.90)  0.192612 |  |
| N |  | 420s(23809.23)  1.280546 |  | 360sh(27777.77)  1.074571 | 380m(26315.78)  1.280540 | 330sh(30303.03)  1.025011 |  |
| CoN |  | 514s(19455.28)  1.2915277 | 488s(20491.80)  1.275462  420m(23809.52)  1.2666203 | 360s(27777.77)  0.93888  375s(26666.66)  1.074074 |  |  | 322sh(30120.48)  0.917129 |
| MnN |  |  |  | 382sh(26178.01)  0.8525 | 352m(28409.09)  0.9667592 |  |  |
| Mo2N | 796b(12562.81)  0.1860185 |  |  |  |  | 346m(28901.73)  0.578703 |  |

S= strong, br=broad, m=moderate, sh= shoulder band

**4.5.1 N,N/Bis(2-hydroxylbenzylidene-1,4-phenylenediimine)-M and their CoM, MnM, Mo2M complexes**

The electron spectra of M with it complex (table 4.4) with regards to band position and intensity are quite similar to each other. The spectra of M (appendix 1) show moderate band at 408nm and shoulder band at 356nm and 326nm. These absorption bands observed is attached to be mainly due to π→π\* transitions and n→ π\* transitions of the non-bonding in the ligand.

In the spectra of CoM (appendix 2), one absorption band ranging at 332nm shoulder band intensity was observed in the case of a d7 complex. The colour (which is yellow) can give an insight into the geometry of CoM. The value when compared to the ligand showed much difference.

In the spectrum of MnM three absorbance ranging between 360nm, 380nm, 330nm (appendix 3) moderate, shoulder band, moderate were observed. Their absorbance were calculated as 2777.77, 26315.78, 30303.03. It has been reported that this complex, which is a d5 complex would have most of its transitions to be spin-forbidden. Based on the Job’s continuous variation results, the transitions of this complex can be completed as an octahedral complex because its absorptions is centred around absorption bands of other octahedral Mn(II) complexes reportedthese display a bathochromic shift when compared to the ligand. The Mn complexes therefore corresponds to 6A1g→ 4T2g(D) and 6A1g→ 4Eg(D) transitions in the order of increasing energy.

Two absorbance band were observed in MoM (appendix 4) ranging from broad to shoulder band were observed at 796b, 336sh. It is a d5 configuration as it applies to octahedral complexes and therefore corresponds to 6A1g→ 4Eg (D). The complexes CoM, MnM, Mo2M when reported displays a bathochromic shift when compared to the ligand M.

**4.4.2. N,N/Bis(4-dimethylaminobenzylidene- 1,4-phenylenediimine)-N and their CoN, MnN, Mo2N complexes**

The electron spectra of N with its complex (appendix 5) is characterized by a total number of four bands ranging strong, shoulder band, moderate, shoulder band from 420nm, 380nm, 360nm, 330nm were observed as part of its absorption bands. It is attributed to be as a result of unreacted ligand (N) because of the same absorption band occurs for its ligand.

Six absorbance ranging from strong, strong, moderate, strong, shoulder band were observed in CoN (appendix 6) the peak at 19455.28cm-1, 2777,77cm-1of this complex experience a bathochromic shift from 19455.28cm-1 to 30120.48cm-1 and ligand from 23809.23 to 30120.48cm-1 respectively which serves as an evidence of complexation has occurred. The colour (which is dark brown) can give an insight into the geometry of CoN. The value when compared to the ligand showed much difference.

In the spectrum of MnN (appendix 7), two absorption bands (also including a doublet) ranging from shoulder band to moderate intensities was observed. This is in contrast to reports on other manganese (II) complexes revealing a d5configurationregardless of whether it is octahedral or tetrahedral in nature. Based on Job’s continuous variation result and some spectral data, MnN is an octahedral complex. Therefore, its absorption bands centered at 26178.01cm-1, 28409.09cm-1, can be interpreted to correspond to 6A1g→ 4T1g, 6A1g→ 4T2g and 6A1g→ 4T2g (D) transitions respectively. The second absorption peak corresponding to 6A1g→ 4Eg (D).All these transitions are likely due to charge transfer as well as d-d transition. A very minute shift showing evidence of complexation was observed in the ligands spectrum in relation to the complex’s spectrum

Two absorption peaks ranging between broad and moderate intensities were observed for Mo2N (appendix 8). Its absorption bands centered at 1256.81cm-1 and 28901.73cm-1 is attributed to be due to charge transfer. Considering the Job’s stoichiometric result, these absorption bands is in agreement with octahedral and tetrahedral complexes. Therefore 28901.73cm-1absorption bands correspondto6A1g→ 4Eg (D) transitions respectively.

**4.6 INFRARED SPECTRA**

Table 4.6: Infrared absorption frequencies (cm-1) of N,N/Bis(2-hydroxylbenzylidene-1,4-phenylenediimine)-M and their CoM, MnM, Mo2M complexes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **M** | **CoM** | **MnM** | **Mo2M** | **Assignments** |
| 3413.85br | **3420.32**br | 3400br | **3141.36b**r | ν(OH) |
| 1617.11s | **1647.14s** | **1690.10s** | **1639.94w** | ν(C=C) aromatic |
| **1636.32**w | **1636.27s** | **1636.38s** | **1639.94m** | ν(C=N) |
| **481.87w** | **419.10w** | **444.64w** | **481.94w** | γ(C–C) ring |

The infrared spectra of M and its complexes are presented in table 4.6. The spectrum of M (appendix 9) was much as expected. A strong bond formation were revealed by the presence of absorption band at 1617.11cm-1 region of the spectrum which is assigned to (C=C) aromatic stretching. Bands assignable to (C-C) ring absorption bands at 481.87cm-1.Bands assignable to (O-H) ring stretching were still observed to be 3413.85cm-1. Bond formations were revealed by the presence of absorption bands at 1636.32cm-1 region of the spectrum which is assigned to C=N stretching frequency. The spectrum for CoM ,MnM, Mo2M (appendix 10,11,12)

**Table: 4.7 Infrared absorption frequencies (cm-1) of N,N/Bis (4-dimethylaminobenzylidene -1,4-phenylenediimine)-N**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **N** | **CoN** | **MnN** | **Mo2N** | **Assignments** |
| 3415.87br | 3376.79br | 3447.53br | 3415.48br | ν (H20) |
| 1636.45m | 1647.10w | 1647.56s | 1604.14m | ν(C=C) aromatic |
| 2853.81w | - | - | 2925w | ρ(C–H) |
| 1595.71s | 1550.55s | 1522.25s | 1547.72s | ν(C=N) |
| - | - | - | 410.56w | γ(C–C) ring |

The infrared spectra of N and its complexes are represented in table 4.7. The spectrum of N(appendix 13) was much expected. The presence of moderate absorption bands at 1636.45cm-1 indicates a (C=C) aromatic stretching frequencies because the compound contains an aromatic ring. Also at 410.56cm-1(C-C) ring was observed. The presence of absorption band at 1595.71cm-1 indicated the formation of an imine linkage (C=N). The infrared spectrum for CoN was observed critically. (H2O) It was found that a broad band at 3376.79cm-1 similar to that of the ligand also shows/ indicates that moisture from the atmosphere entered the sample.

At 1595.71cm-1 a strong band assigned to imine stretching was observed. This frequency reveals a decrease from that of complexes suggesting the participation of the imine nitrogen in the coordination with the metal ion. Coordination of the imine nitrogen with the metal ion results to a reduction of bond order and an increment in the vibrational constant existing.

**4.8 PROPOSED STRUCTURES**

Following the results of the Job’s continuous variation, electronic, and infrared spectra the structures of these ligands and complexes can be tentatively put as the following;



**Figure 16 : N,N/Bis(2-hydroxylbenzylidene, 1,4-phenylenediimine) -(M)**



**Fig 17:N,N/Bis(2-hydroxylbenzylidene, 1,4-phenylenediimine) –Co(II) complex, CoM**



**Fig 18: N,N/Bis (2-hydroxylbenzylidene, 1,4-phenylenediimine)-Mn(VIII) complex, MnM**



**Fig 19: N,N/Bis (2-hydroxylbenzylidene, 1,4-phenylenediimine)-Mo(VIII) complex, Mo2M**



**Fig 20; N,N/Bis (4-dimethylaminobenzylidene, 1,4-phenylenediimine) (N)**



**Fig 21: N,N/Bis( 4-dimethylaminobenzylidene, 1,4-phenylenediimine)-Co(II) complexes, CoN**



**Fig 22: N,N/Bis(4-dimethylaminobenzylidene, 1,4-phenylenediimine)-Mn(VII) complexes, MnN**



**Fig 23: N,N/Bis (4-dimethylaminobenzylidene, 1,4-phenylenediimine-Mo(VII) complexes, Mo2N**

**4.9 ANTIMICROBIAL PROPERTIES**

The antimicrobial activity of the compounds was tested against the microorganisms *E.coli, S.typhi, S.aureus, E. feacalis, C.albicans*to 10mg/ml of the samples are shown in the table below. The ligand showed no activity against *E.coli, S.typhi, S.aureus, C.albicans* but there was activity against *E. feacalis.* The metal complexes showed activity against some organisms, both concentration of the positive and negative control (DMF) showed no activity on the different microorganisms. The antimicrobial result showed that there were higher activities on the gram negative organism than on the gram positive organism.

Table : 4.9 Antimicrobial activity of Schiff base ligand, L and their metal complexes (10mg mL-1) showing the various of zones of inhibition (mm)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ligand/complex** | ***S.aureus***  **Gram positive** | ***C.albicans***  **Gram positive** | ***S.typhi***  **Gram positive** | ***E.coli***  **Gram negative** | ***E.feacalis***  **Gram negative** |
| M | - | - | - | - | 18 |
| N | - | - | - | - | 15 |
| CoM | - | - | 26 | 20 | 21 |
| MnM | - | - | 13 | 13 | - |
| Mo2M | - | - | - | - | 15 |
| CoN | - | - | 12 | 12 | - |
| MnN | - | - | 11 | 17 | 19 |
| Mo2N | - | - | - | - | - |
| DMF | - | - | - | - | - |

**CHAPTER FIVE**

**CONCLUSION AND RECOMMENDATION**

The chemistry of Schiff bases is a field that is being noticed. Schiff base ligands are considered privileged ligands because they are easily prepared by a simple condensation of an aldehyde derivatives and primary amines. The synthesis and characterization of the ligands N,N/Bis (2-hydroxylbenzylidene) -1,4-phenylenediimine,(M) and N,N/Bis(4-dimethylaminobenzylidene)-1,4-phenylenediimine (N) with its Co(II), Mn(VII) and Mo(VII) complexes all obtained as powders were possible with respect to their various methods of preparations. Generally, these compounds have yellow and dark brown colours with high melting point and high molar absorptivity. The result of the electron spectra and infrared spectra shows that there was coordination between the ligands and metal complexes. The antimicrobial result showed that there were higher activities on the gram negative organism than on the gram positive organism.

It was observed from this preliminary study that these ligands are virgin and novel. Thus, they can serve as starting materials for some organic, coordination, kinetics, polymer and other branches of chemistry researches. These compounds and their metal complexes had a variety of applications including clinical, analytical, agrochemical industry they also play important roles in catalysis and corrosion inhibitor. Due to the high melting points of these ligands and complexes, they can be employed in high technology industries were high melting point are required. More conclusions concerning these structures in this work could be made with further studies involving elemental analysis, x-rays, electron spin resonance, crystallography, magnetic and conductivity measurements. This would be a good research starting point which would require variation of substituents on the same structural nucleus and elucidation of the mechanism of the variation in the microbial property of the ligands and their complexes.

**REFERENCE**

Abdulghani A.J., khaleel A.M., (2013). “A series of new di-, tri-, and tetranuclear Co(II) and Cu(II). *Bioinorg Chem Appl.*10: 155.

Carmen J.G.(2016).” Amount of Substance, Chemical Amount, and Stoichiometric Amount. ‘’ *International Journal of Science and Research (IJSR*): 3

Carry F. A.,(1992. Organic Chemistry, *International Journal of Science and Research (IJSR)* McGraw-Hil: 3.

Clarke B., Clarke N., Cunningham D., Higgins T., McArdle P., Ni Cholchu M., (1998). Application of Schiff bases. *J. Organomet. Chem*.55:559

Cleiton da Silva M., Daniel L., Modolo L.V., Rosemeire B., Maria A., Cleide V.B., Martins A.,(2011) .”Schiff bases: A short review of their antimicrobial activities”. *Journal of Advanced* Research 2:1–8

Cimerman Z., Miljanic S., Galic N. (2000). Croatica Chemical Acta*. International Journal of Science and Research (IJSR*). 73 (1): 81- 95.

Duca E., Duca M., (1979).“Microbiologie medical”, International Conference on Chemistry and Chemical Process IPCBEE *J. Mol. Struct:10* .

Elmali A., Kabak M., Elerman Y.,(2000). International Conference on Chemistry and Chemical Process IPCBEE.  *.* 477 :151.

Kelley J.L., J.A. Linn J.A,. Bankston D.D., C.J. Burchall C.J., Soroko F.E., Cooper B.R., (1995). *J. Med. Chem*., 38:3676.

Lawrence J.F., Frei R.W.(1976). *"*Chemical Derivatization in Chromatography", Elsevier, Amsterdam.

Martins C.V.B., Da Silva D.L., Neres A.T.M., Magalha˜es T.F.F., Watanabe G.A., Modolo L.V. (2009). Curcumin as a promising antifungal of clinical interest. *J Antimicrob Chemother* ;63(2):337–9.

Metzler C. M., Cahill A., Metzler D. E.,(1980).”Application of Schiff bases”. *J. Am. Chem. Soc.,* 102, 6075.

Mukesh K., Biyala K,. Sharma M., Swami., Fahmi N., Singh V.,(2008). Transition Metal Chemistry. *Chemical and Process Engineering Research* 33: 377

Muneera F. M., Karimah K., Mohd A.,(2012). “Synthesis, characterization and conductivity”. *The Malaysian Journal of Analytical science.* 16:318-324.

Natarajan. R., Thangaraja C.,(2005).Transition Metal Chemistry*.* *Chemical and Process Engineering Research* 30: 317

Nucci M., Marr K.A,. (2005). Emerging fungal diseases. *Clinical Infection Disease* ;41(4):521–6.

Patai S., Ed.(1970)."The Chemistry of the Carbon-Nitrogen Double Bond". *International Conference on Chemistry and Chemical Process IPCBEE :.(10*).

Okeke. C. (2018). “MSC Project’’.14

Patel P.R., Thaker P.T., Zele S.(1999). International Conference on Chemistry and Chemical Process IPCBEE. *Indian J. Chem.* 38 : 563.

Perry B.F., Beezer A.E., Mile R.J., Smith B.W., Miller J., Nascimento M.G., (1988). Microbois., , *International Conference on Chemistry and Chemical Process IPCB EE* 45: 181.

Przybylski P., Huczynski A., Pyta K., Brzezinski B., Bartl F.,(2009). Biological properties of schiff bases and azoderivatives of phenols. *Curr Org Chem* 2:124–48

Scheurer A., Maid H., Hampel F.,. Saalfrank R.W., Toupet L., Mosset P., Puchta R., Van N.J., Hommes E., (2005). *Eur. J. Org. Chem.,* 2566.

Schiff H.,(1869). Ann. Chem. Pharm., *International Conference on Chemistry and Chemical Process IPCBEE* 150 -193.

Schmid G.H., (1996). Organic Chemistry, *International Journal of Science and Research (IJSR*) New York, :3

Sibous L., Embarek B., Ahmed K., (2013). Synthesis, characteriation and electrochemical behaviour of Co(II), Ni(II)” . *journal of inorganic chemistry*.11.

Silva da C., Silva da D., Modolo L., Alves R. (2011). Schiff bases: A short review of their

Antimicrobial activities. J. Ad. Res., 2, pp 1–8.

Singh P., Goel R.L., (1975) . International Conference on Chemistry and Chemical Process IPCBEE. *Journal . Indian Chem*. Soc52: 958.

Sivasankaran N.M., Theodore D.S., (2000).Biological Applications of Schiff base and its Metal

Complexes. *J.IndianChem.Soc* .77- 220.

Skoog, D. A., West, D. M.; Holler, J. F. (1988). *Fundamentals of Analytical Chemistry, 5th Ed.* New York: Saunders.

Spichiger-Keller U.(1998)."Chemical Sesors and Biosensors for Medical and Biological Applications*"*, Weinheim.

Suresh M.S., Prakash V.(2010). Preparation and characteriation of Cr(II), Mn(II), Co(III). *Int. J.Phys.Sci*. 5(14):221-2203.

Sunatsuki Y., Motoda Y., Matsumoto N.,(2002). “Coordination Chemistry”. *International Conference on Chemistry and Chemical Process IPCBEE :10* : 199-226

Sundriyal S., Sharma R.K., Jain R.,(2006). Current advances in antifungal targets and drug development. *Curr MedChem* ;13(11):1321–35.

Tofazzal H., Tarafder M., Ali D., Wee K., Azahiri S., Silong K., Crouse A., (2000). “Transition Metal Chemistry”. *Chemical and Process Engineering Research* 25: 456.

Valcarcel M., Laque de Castro M.D.(1994). "Flow-Throgh Biochemical Sensors", *International Conference on Chemistry and Chemical Process IPCBEE* :10

Zotta V.,(1985). “Chimie farmaceutic” *International Conference on Chemistry and Chemical Process IPCBEE :10*, Ed. Medical, Bucureti,