Synthesis and Characterization of a Schiff base derived from 6-methylcoumarin and 2-aminophenol and its complexes using Cobalt (II) ,Copper (II) .

Abstract

Schiff bases and their metal complexes has been a subject of research for along period till date. Various researchers are focusing on synthesis of various Schiff bases with different metal salts to form complexes ~~and~~their unique properties tried to be identified. The coumarin possess a lot of medicinal values and it was reported that incorporating of metal ion into its structure increases its activity compared to the coumarin based ligandas reported in literature.Such an attempt made here to synthesize a Schiff base from 6-methylcoumarin and 2-aminophenol and its two metal complexes using cobalt and copper (II) chloride salts. Synthesis was confirmed by FTIR and antimicrobial activity of the ligand (Schiff base) and the metal complex weredetermined by agar well diffusion method against some bacterial and fungal strains. The result from activity revealed an enhanced antimicrobial activity of the metal complexes over their corresponding Schiff bases.

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Keywords: Schiff base, Ligand , Metal complex , Anti microbial

1: Introduction

Coumarins belong to a family of large and extensively studied compounds containing2H-1- benzopyran-2-one core structure, which consist of fused benzene and alpha-pyrone rings. This heterocyclic system is also known as 1,2-benzopyrone, 2H-chromen-2-one, 2-oxo-1,2-benzopyran or o-hydroxycinnamic acid lactone. The coumarin nucleus is a recurring motif in both natural and synthetic compounds that exhibit a broad spectrum of biological properties including anticoagulant, anti-inflammatory, antioxidant,antiviral, antimicrobial and anticancer agents as well as enzyme inhibitors.[1]. The history of coumarins can be traced back to 1820 when H.A. Vogel first isolated the simplest member of this family –coumarin from the *tonka beans.* Later on , this compound was first synthesized by W.M. Perkin in 1868 ,and discovered both natural and synthetic coumarins are endowed with a great therapeutic potential due to the wide spectrum of biological properties including anticancer, antimicrobial, antiviral, anti-inflammatory, neuroprotective and antioxidant activities.Hence, the coumarin skeleton can be foresighted as a privileged scaffold for the design and synthesis of pharmacologically active compounds.[2—8].Additionally, physicochemical properties and biological activities of coumarins might be enhanced by combining coumarin moiety with other chemical species such as, for example , metal ions. The literature survey reveals that several properties of the organometallic complexes offer great opportunities in the development of new compounds with specific and new modes of action. Infact,incorporation of metals such as cobalt, copper, zinc, silver, platinum, palladium, or iridium, into ligand molecules with biological activity has been implemented in the development of novel coumarin-based complexes with better pharmacological

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activity. As a consequence, a large number of coumarin –based metal complexes have been synthesized in order to obtain more potent molecules.[9---13]

2 :Experimental :

2,1 Materials

All chemicals reagents and solvents used were of analytical grade and were used without further purification. The metal (II) salts used are Cobalt (II) Chloride ~~ihexahydrate~~and Copper(II)Chloride dihydrate.All glasswares used were thoroughly washed with detergent and repeatedly rinsed with tap water and distilled water was finally used and then dried in an oven at 110^{0}C.The melting points were determined using aGallenkamp Melting Point Apparatus, the infrared (IR)spectra of the compounds were recorded using Cary 630 FTIR Spectrometer, conductivity and magnetic susceptibility values all determined using theJenway 4010 conductivity meter andSherwood Scientific MSB –MKI Magnetic susceptibility balance respectively.The Sensitive Balanceused was a Labtech electronic scale BL 3002 Japan, used in all measurements involving weight or mass.

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2.2 Method

2.2.1 Synthesis of the Schiff base(ligand) :

3.2g (0.02mole) of 6-metyhlcoumarin in 20cm^3 ethanol was added to 2.18g (0.02mole) of 2-aminophenol in 30cm^3 ethanol, the mixture refluxed for 5 hours while stirring , the volume reduced to one-half its original volume by heating on a water bath. The heated mixture was allowed to cool at room temperature and a light-brown crystals obtained which were filtered, recrystallizedusing ethanol and then dried in a desiccators over anhydrous calcium chloride for 48 hours.

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2.2.2 Synthesis of the metal (II) complexes :

The cobalt(II) and copper (II) complexes were synthesized by mixing 0.75g (0.003mole) of each of the metal salts and 1.5g (0.006mole) of the Schiff base, (that is in a ratio of 1:2) in ethanol the mixture heated at reflux for 5hours in each case the complex formed was filtered ,washed several times with hot ethanol and then dried

3. Characterization techniques :

3.1Solubility Test.

The solubility test was carried out for both the Schiff base and the two complexes , the test was done using ethanol, methanol ,petroleum ether, benzene ,water , chloroform and dimethyl sulphoxide(DMSO). From each of the three samples 20mg was taken and dissolved into about 4cm^3 of the corresponding solvent in a test tube.

3.2 Melting point:

The melting point of the synthesized ligand as well as the decomposition temperature of the metal complexes were recorded usinga GallenkampMelting Point Apparatus with a thermometer range of 0-360^{0}C

3.3 Molar conductance

The molar conductance of each of the two metal complexes was determined using aJenway 4010 conductivity meter at a concentration of 10^{-3} M in DMSO. The measurement is usedto determine whether a given compound is an electrolyte or non-electrolyte when in solution. Molar conductance is the conductivity of an electrolytic solution divided by by the molar concentration of the electrolyte, and therefore measures the efficiency with which a given electrolyte conducts electric current in solution.

3.4 Magnetic Susceptibility Measurements

Magnetic susceptibility measurements are widely used to study the magnetic properties of transition metal complexes. The magnetic properties are due to the presence of paired or unpaired electrons in the filled or partially filled d-orbitals in the outer shell of these compounds.

3.5 Infrared (IR)

The IR spectra of the ligand and complexes were recorded on FT-IR-91184 (FTIR Spectrum II) model in the range 450—4000 cm^{-1} using KBr pellets.This spectra is use to determine the coordinating atoms and the relative strength of the bonds.

3.6 Antibacterial studies :

The Antibacterial studies of the Schiff base and the metal complexes were carried out using *Staphylococcusaureus,Salmonella typhi*as and *Escherichia coli* test organisms and Gentamicin as control and three fungal strains *Aspergillus fumigates, Candida albican and Mucor sps*and Ketoconazole as control for the fungi. Using Agar-well diffusion method, the test organisms were prepared by dissolving them in peptone water and they were smeared over the surface of Muller Hilton Agar for the bacterial strain and potato dextrose agar for the fungal ~~strains.the~~tests were carried out in triplicates i.e..theligand and the complex were dissolved separately in DMSO.Three different concentrations(15mg/ml, 30mg/ml, and 60mg/ml).Awell was made on the agar medium inoculated with test organisms. The well was filled with the test solution using a micropipette and the plate was incubated 24 hours for the bacteria and 72 hours for fungi at 37 ^{0}C. The results were obtained by measuring the diameter (in mm) of the zone of inhibition of the activities of the Schiff base and metal complexes against the test organisms.[14]

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4. Results and Discussions:

The results of the physical properties and the infrared of the ligand and that of the complexes are given in the following tables and discussed as follows.

4.1 Physical properties of ligand and its metal complexes

The reaction ~~brtween~~ 6-methyl coumarin with 2-aminophenol in a molar ratio of 1:1 produced the Schiff base ligand a pale brown coloured substance with percentage yield of 60.60 % (scheme 1). The interaction between the Schiff base ligand and the metal (II) ions in ratio of 2:1 (L_2:M) giving a reddish-brown cobalt complex with percentage yield of 71.80 % and a black coloured copper complex with a yield of 79.20% (scheme 2)The melting point of the ligand and the decomposition temperature of the cobalt and copper metal complexes found to be 158^0C and 230^0C and 264^0C respectively (table 1). The high melting point indicates that the compounds are stable and not easily decomposed.[15]. The higher melting points of the complexes also suggest the chelating effect of the ligand, as chelating ligands form more stable complexes. In another finding as~~quoated~~ by Daniel and Kiremine [16,17] that the difference in melting point between ligand and their complexes proved that the new compounds form are different from the parental ligands.Moreover, lower melting point of ligand than their respective complexes shows that complexation increases the intra-atomic bonding effect of particles of the compounds.

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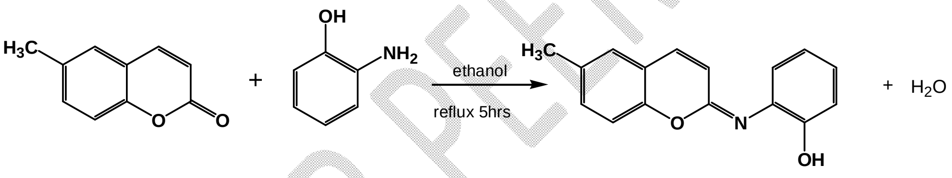

Scheme 1: ~~Synthesis~~of the Schiff base ligand.

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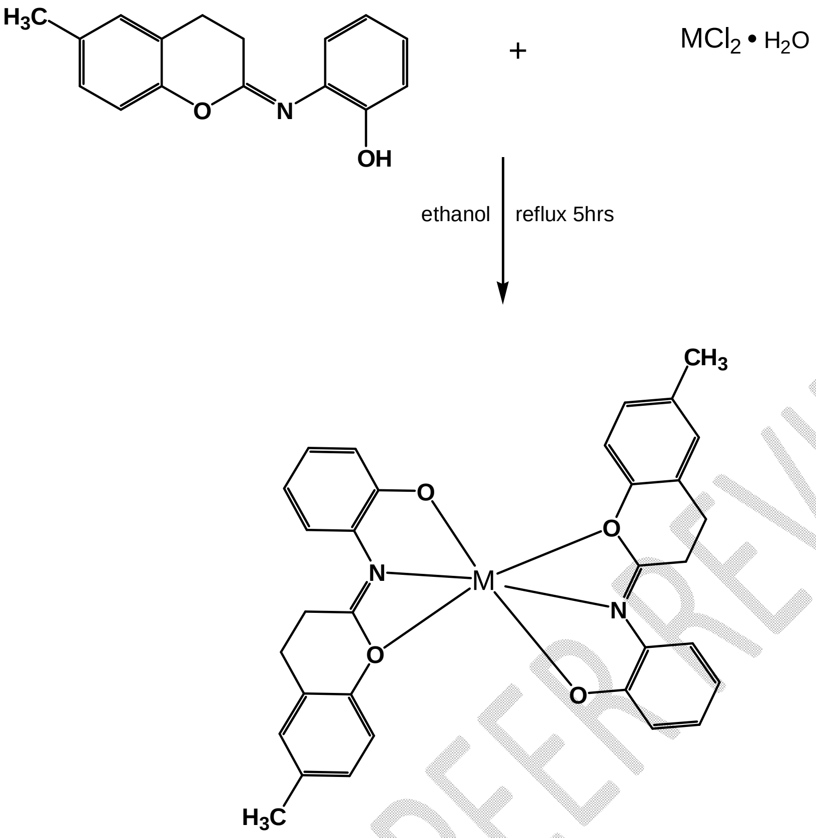

Scheme 2: Synthesis of the Schiff base metal complexes. [M = Co , Cu]

Table 1: Some physical properties of the ligand and their complexes

Compound	Colour	M. P. (^{0}C)	Yield (%)	Conductivity(S cm^{2}mol^{-1})
Ligand	pale-brown	158	60.60	--
Co complex	Reddish-brown	230	71.80	15.04
Cu complex	Black	264	79.20	12.76

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4.2 Solubility test of ligand and its metal complexes

For the solubility the result in table 2 revealed the ligand and the two complexes were tested in different solvents ,the result shows none of the complexes nor the ligand was soluble in water this indicating all have low polarity. Ethanol and methanol dissolved the ligand and the two complexes ,also the ligand and the complexes are all soluble in DMSO.Generally, transition metal complexes with organic ligands are relatively non-polar. As a result they are soluble in organic solvents but not in polar like the water. At molecular level, solubility is controlled by intermolecular forces. However , a simple empirical rule Likes dissolves like and is based on the polarity of the systems that is polar solvents and non-polar molecules in non-polar solvents.[18]

Table 2: Solubility of the ligand and their complexes

Compound	Ethanol	Methanol	Pet. Ether	Benzene	Water	Chloroform	DMSO
Schiff base	S	S	IS	SS	IS	SS	S
Co(L_2)	S	S	ISISISIS			S	
Cu(L_2)	S	S	IS	S	IS	S	S

Key : S=soluble SS=slightly soluble IS=insoluble

4.3 Conductivity measurement of metal complexes in 10^{-3} DMSO

The molar conductivity values of the complexes in 10^{-3} M DMSO solution (Table 1) showed that of cobalt as 15.04µ Scm^{-1} and 12.76µScm^{-1} for the copper complex , the low values suggest the complexes are non-electrolytes [19 20] therefore occurs as a neutral solution. In 2006, Deligonul and Tumer[21] also ascertained that low value of molar conductance indicates non-electrolytic nature of a complex. The conductance of a solution is a measure of the ability of that solution to conduct a current. The use of conductivity enables the determination of ions in solution. The results obtained from magnetic susceptibility measurement (table 3) revealed that the two complexes are all paramagnetic, which is due to the presence of unpaired electrons in the d-orbital of the metal ions , as such this make the complexes to also be less stable.

Table 3 : Magnetic susceptibility test result of the complexes

Complex	Co (L_2)	Cu (L_2)
Magnetic Susceptibility	13720×10^{-9}	666.67×10^{-9}

4.4 IR Spectra of the Schiff base and its metal complexes

Fourier Transform Infrared Spectroscopy(FT-IR),an instrumental method of analysis based on the fundamental principles of molecular spectroscopy, the FT-IR was utilized in order to identify the presence of certain functional groups in the synthesized compounds, and as an approach to confirm the identity of the compounds through the collection of absorption frequencies.The principle behind the usage is that the stretching modes of a ligand changes upon complexation due to subsequent changes in the positions of the bands appearing in the spectrum [22]. The IR spectra, were assigned by comparing the spectra of the ligand with that of the metal complexes and also with literature reports on similar systems.[23--25]. In the IR spectra of the ligand as shown in (table 4) revealed a medium sharp band at 1599cm^{-1} ,which was assigned to $_v$C=N stretching of azomethine group [26]. In the complexes these bands has shifted to a lower region 1547cm^{-1} and 1592cm^{-1} for Cu (II) and Co (II) complexes respectively, these bands has suggested the coordination of azomethine nitrogen to the respective metal atoms due to complexation.) [27, 28] The shift of the wavenumber is expected as a result of the coordination of the nitrogen atom of the azomethine group to the metal ions, which causes reducition in electron density in the azomethine link. [29] IR spectrum of the ligand shows a strong band at 3376 cm^{-1} due to v(OH) ligand stretching vibrations. This band is absent in the spectra of the complexes indicating the dissociation of the phenolic proton on complexation and involvement of phenolic anionic oxygen in coordination, [26].A stretching vibration due to v(C-O) at 1268cm^{-1} was observed in the free ligand, [30, 19] and shifted to higher frequencies of 1275cm^{-1} in copper and 1286cm^{-1} for the cobalt complexes; this shifts proved that there is coordination of the phenolic oxygen leading to the formation of C-O-M bond].The ligand showed a strong absorption band due to C-N- which occurred at 1462cm^{-1} and shifted to a new position of 1487cm^{-1} in both complexes. This new value ascertained the nitrogen atom of the aminophenol has been involved in complexation [25].From the IR results it may be understood that the Schiff base ligand coordinated to the metal ions through the azomethine nitrogen , hydroxyl group and the ~~hetro~~oxygen of the ligand.

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Table 4: Relevant infrared bands of the ligand and their complexes

Compound	v(O-H)	v(C=N)	v(C=O)	v(C=C)	v(C-N)	v(M-N)	v(M-O) /cm^{-1}
Ligand	3376	1599	1268	1514	1462	--	--
Co(L_2)	--	1592	1286	1487	1487	739	437
Cu(L_2)	--	1547	1275	1577	1487	757	448

4.6 Antimicrobial activity

The Schiff base ligand and the two metal complexes were screened for antibacterial activity(*in vitro)* by agar well diffusion method against three bacterial strains and three fungal strains. Gram-positive bacteria such as *Staphylococcus aureus,* Gram-negative bacteria such as *Escherichia coli,Salmonella typhi* and three fungal strains *Aspergillus fumigates,Candidaalbican,*and *Mucor sps*were used for the test. The results of the biological activity indicated that the compounds are active against both gram (-) and (+) bacteria.The Schiff base ligand alone is slightly effective against all strains of the micro-organisms.The Cu(II) complex showed moderate activity against all bacterial and fungal strains compared to the control antibiotics used, and it was observed the effectiveness increases as with concentration ,except against *Aspergillus fumigates* and *Mucor sps* in which the complex showed no action at a concentration of 15µg/mLThe cobalt complex showed high activity against *Aspergillus fumigillus Salmonella typhi* and moderate activity against *Escherichia coli,* and *Mucor sps*but no activity against *Candida albican,* Conclusively the value for the minimum inhibition concentration (MIC) shows the Schiff base is more active against the unicellular fungus *(Candida albicans)* and Gram negative bacteria *Escherichia coli* this is because lower MIC value indicates higher drug activity, the compounds are therefore promising antimicrobials subject to *in vivo* study outcome.

Table 5: Antimicrobial sensitivity test of Schiff base ligand and metal complexes against bacterial and fungal isolates at various concentrations (µg/ML) using agar well diffusion method.

Test organism used and inhibition zone	concentration of ligand /complex			Control antibiotics used	
	$Co(L_2)$	$Cu(L_2)$	Ligand	Gentamycin	Ketoconazole
	60 30 15	60 30 15	60 30 15	80mg	200mg
Staphylococcus a.	20 16 12	19 17 12	14 11 9	26mm	--
Escherichia coli	1412 11	15 13 10	16 14 12	21mm	
Salmonella typhi	20 16 14	1816 14	11 10 -	17mm	
Candida albican	- - -	18 15 13	18 16 12		19mm
Aspergillus fumigates	*12 10 -*	*13 10-*	14 11 9		*25mm*
Mucor spp	*11 9 8*	*16 13 -*	1512 10		*25mm*

KEY:

µg/Ml—micro unit per millilitermm—millimeter

gentamycin---antibacteriaketaconazole—antifungal

5. Conclusion

The synthesized Schiff base ligand and the metal (II) complexes and also their biological potentials investigated aiming at contributing towards search for novel metal complexes that exhibit various biological activities. The coordination through phenolic oxygen and imino nitrogen atom of the tridentate Schiff base ligand to the metal ions confirmed using the FTIR. The insolubility of the ligand and the two complexes in water may be due to their non-polar nature. The low molar conductance values of the metal (II) complexes showed their non-electrolytic nature.The infrared spectral data of the ligand when compared to those of the metal (II)complexes showed that coordination of the metal ion to the ligand is via the azomethine nitrogen, hydroxyl group of the ligand and the ~~hetro~~ -oxygen in the coumarin.Their antimicrobial action has shown that theligand is effective against the tested organisms but the complexes were observed to exhibit higher antibacterial action.

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