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Research Article

SYNTHESIS, CHARACTERIZATION AND ANTIMICROBIAL STUDIES OF SOME TRANSITION METAL COMPLEXES OF SCHIFF BASES

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Abstract

A series of transition metal complexes of Cu (II), Ni (II) and Co (II) were prepared from bidentate Schiff base. The Schiff base ligand synthesized from the condensation of P-Hydroxybenzaldehyde and 2-amino -4,6 dihydroxypyrimidine (L₃) in alcohol medium. These metal complexes were characterized on the basis of their micro analytical data, molar conductance, magnetic susceptibility, IR, UV-Vis, ¹H NMR, X-ray diffraction, thermogravimetric analysis. The ligand and their metal complexes were screened for fungicidal activity against various fungi like *Aspergillus niger*, *Penicillium chrysogenum*, *Fusarium moneliforme* and *Aspergillus flavus*. and antibacterial activity against various bacteria like *Escherichia coli*, *Salmonellatyphi*, *Staphylococcus aurious*, *B.subtilis*. The result indicated that the complexes exhibited good antifungal and antibacterial activities.

Keywords: Schiff bases, Transition metal complexes, Thermal analysis, Powder X-ray diffraction, Antimicrobial activity.

Introduction

Pyrimidine and their derivatives are considered to be important for drugs and agricultural chemicals. Pyrimidine derivatives possess several interesting biological activities such as antimicrobial [1-3], antitumour [4-6], and antifungal [7-9]. Many pyrimidine compounds are used for thyroid drugs and leukemia [10]. Antibacterial, antifungal, antitumor, anticancer [11-15] and insecticidal [16] activities of some Schiff bases have been reported and they are found to be active against a wide range of organisms [17].

In coordination chemistry, Schiff bases have a significant role as ligands still a century after their discovery [18, 19]. The importance of Schiff bases and their metal complexes are important as biochemical [20], electrochemical [21], analytical [22], antifungal and antibacterial activities[23-26], redox catalysts[27,28]. Schiff bases and their metal complexes have been used as carries in the preparation of potentiometric sensors of

determining cations and anions, catalysts in several industrial redox process, oxidation reaction, vitamin B₆, Metal alkoxides. It's important and diversified roles in biological systems. The role of chlorophyll, hemoglobin, carbonic anhydrase, vitamin B₁₂, xanthine oxides and haemocyanin, illustrates the intimate linkage between inorganic chemistry and biology[29-35]. A search of literature reveals that no work has been done on the transition metal complexes of the Schiff bases derived from 2-amino -4,6 dihydroxypyrimidine and P-hydroxybenzaldehyde. In this communication we report the synthesis of bidentate Schiff bases formed by the condensation of 2-amino -4,6 dihydroxypyrimidine and P-hydroxybenzaldehyde (Fig.1). The solid complexes of Cu (II), Ni (II), Co (II), Mn (II) and Fe (III) with these ligands have been prepared and characterized by different physico-chemical methods.

Materials and Methods

Reagents and solvents

2-amino-4,6 dihydroxypyrimidine (Aldrich sigma), P-hydroxybenzaldehyde, metal nitrate of AR grade was used for synthesis of ligand and metal complex .

Synthesis of ligand

The ligand was prepared by a modification of the reported methods [36-38]. The Schiff base ligand has been synthesized by refluxing a mixture of 0.01 mol (1.2212g) of P- hydroxybenzaldehyde and 0.01 mol (1.2710 g) of 2-amino-4, 6-dihydroxypyrimidine in 50 ml super dry ethanol refluxed for about 4h. Schiff base thus formed was cooled to room temperature and collected by filtration, followed by recrystallization in ethanol and dried *in vacuo* over anhydrous calcium chloride (Yield:70%).

Synthesis of metal complexes

To a hot ethanol solution (25ml) of the ligand (2 mol) and (25ml) of metal Nitrate (1mol) was added with constant stirring. The pH of reaction mixture was adjusted to 7-8 by adding 10% alcoholic ammonia solution and refluxed for about 3 h. The precipitated solid metal complex was filtered off in hot condition and washed with hot ethanol and dried over calcium chloride in vacuum desiccators. (Yield: 65%)

Physical Measurement

IR spectra were recorded on FTIR(ATR)-BRUKER - TENSOR37 spectrometer using KBr pellets in the range of 4000-400 cm^{-1} . ^1H - NMR Varian mercury 300MHZ spectra of ligand were measured in CDCl_3

using TMS as internal standard. X-RD were recorded on BRUKER D8 Advance. TGA- DTA were recorded on Shimadzu. The carbon, hydrogen and nitrogen contents were determined on Elementar model vario EL-III. The UV-visible spectra of the complexes were recorded on model UV-1800, SHIMADZU spectrometer. Molar conductance of complexes was measured on Elico CM 180 conductivity meter using 10^{-4} M solution in DMSO. Magnetic susceptibility measurements of the metal chelates were done on a Guoy balance at room temperature using $\text{Hg}[\text{Co}(\text{SCN})_4]$ as a calibrant.

Results and Discussion

Schiff bases of 2-amino- 4,6 dihydroxypyrimidine and its complexes have a variety of applications including biological, clinical and analytical. The coordinating possibility of 2-amino- 4,6 dihydroxypyrimidine has been improved by condensing with a variety of carbonyl compounds. An attempt has been made to synthesize Schiff bases from 2-amino- 4,6 dihydroxypyrimidine with P-hydroxybenzaldehyde. Physical characteristics, micro analytical, and molar conductance data of ligand and metal complexes are given in (Table 1 and 2).The analytical data of complexes reveals 2:1 molar ratio (ligand: metal) and corresponds well with the general formula $[\text{ML}(\text{H}_2\text{O})_2]$ (where M= Cu Cu(II) ,Ni(II) and Co(II)). The magnetic susceptibilities of Cu(II) ,Ni(II) and Co(II) complexes at room temperature are consistent with high spin octahedral structure with two water molecules coordinated to metal ion. The presence of two coordinated water molecules was confirmed by TG-DTA analysis. The metal chelate solutions in DMSO show low conductance and supports their non-electrolyte nature (Table 1).

Table 1. Physical characterization, analytical and molar conductance data of compounds

Compound Molecular formula	Mol.Wt.	M.P. Decomp temp. $^{\circ}\text{C}$	Colour	Molar Conduc. Mho $\text{Cm}^2\text{mol}^{-1}$
L_3	231.21	175	Yellow	----
Cu L_3	561.99	>300	Dark Brown	27.96
Ni L_3	557.13	>300	Faint Brown	27.56
Co L_3	557.44	>300	Dark Brown	25.15

^1H -NMR spectra of ligand

The ^1H -NMR. spectra of free ligand at room temperature shows the following signals. 4.88 (s, 2H, Phenolic (OH) hydrogen of pyrimidine ring), 4.88

(s, 1H, Phenolic (OH) hydrogen of phenyl ring), 5.83 (s, 1H, Hydrogen bonded to pyrimidine ring), 7.77 (s, 1H, hydrogen bonded to azomethine carbon), 6.70-6.94 (D,4H, Aromatic Ha, Hb, protons of phenyl ring).

IR Spectra

The IR spectra of the complexes are compared with that of the ligand to determine the changes that might have taken place during the complexation. The bands at 3336, 1643, 1585, 1267, and 1215 cm^{-1} assignable to ν OH (intramolecular hydrogen bonded), ν C=C (aromatic), ν C=N (azomethine), ν C-N (aryl azomethine) and ν C-O (phenolic) stretching modes respectively [37-39]. The absence of a weak broad band in the 3200-3400 cm^{-1} region, in the spectra of the metal complexes suggests deprotonation of the intramolecular hydrogen bonded OH group on complexation and subsequent coordination of phenolic oxygen to the metal ion. This is further supported by downward shift in C-O (phenolic) [40] with respect to free ligand. On complexation, the ν (C=N) [41] band is shifted to lower wave number with respect to free ligand, denoting that the nitrogen of azomethine group is coordinated to the metal ion. The ν C-N band is shifted to lower wave number with respect to free ligand. The IR spectra of metal chelates showed new bands in between the 500-800 and 400-500 cm^{-1} regions which can be assigned to ν M-O and M-N [42] vibrations respectively. The IR spectra of Cu (II), Ni (II) and Co (II) show a strong band in the 3050-3600 cm^{-1} region, suggesting the presence of coordinated water in these metal complexes. The presence of coordinated water is further confirmed by the appearance of non-ligand band in 830-840 cm^{-1} region, assignable to the rocking mode of water. The presence of coordinated water is also established and supported by TGA/DTA analysis of these complexes. Hence it is concluded that the coordination takes place via phenolic oxygen and azomethine nitrogen of ligand molecule.

Thermogravimetric analysis

The dynamic TGA with the percentage mass loss at different steps have been recorded. The simultaneous TGA/DTA analysis of Cu(II) was studied from ambient temperature to 1000 $^{\circ}\text{C}$ in nitrogen atmosphere using $-\text{Al}_2\text{O}_3$ as reference. An analysis of the thermogram of the complexes indicated that Cu(II) complexes shows two step decomposition. The first weight loss 6.40%, in between temp. 50-220 $^{\circ}\text{C}$ could be correlated with the loss of two coordinated water (calculated 6.41 %). The anhydrous compound does not remain stable at higher temperature, it undergoes

rapid decomposition in the range 220-640 $^{\circ}\text{C}$, with 78.45 % mass loss corresponds to decomposition of the complex (calcd. 79.43%) in second step. The decomposition is completed leading to the formation of stable residue of metal oxide CuO obs. 13.80 % (calcd. 14.15 %). Kinetic and thermodynamic viz the energy of activation (E_a), frequency factor (Z), entropy change ($-\Delta S$) and free energy change (ΔG) for the non-isothermal decomposition of complexes have been determined by employing Horowitz-Metzger method [43] values are given in Table 3. The Calculated values of the given activation energy of the complexes are relatively low, indicating the autocatalysis effect of metal ion on the thermal decomposition of the complex. The negative value of activation entropy indicate that the activated complexes were more ordered than the reaction were slow. The more ordered nature may be due to the polarization of bonds in the activated state, which might occur through charge transfer transitions [44].

Magnetic measurements and electronic absorption spectra

The electronic spectral studies of metal complexes of Cu (II), Ni (II) and Co (II) with Schiff bases were carried out in DMSO solution. The absorption spectrum of the Cu(II) complex shows bands at 36231 cm^{-1} attributed to charge transfer respectively in an octahedral field [45]. Ni(II) complexes shows bands at 13477 cm^{-1} and 24875 cm^{-1} are assigned to ${}^1A_{1g}$ ${}^1T_{2g}$ and charge transfer transitions. The absence of band below 10,000 cm^{-1} and All Ni(II) complexes were diamagnetic in nature indicates octahedral geometry [46]. The absorption spectrum of the Co(II) complex shows bands at 19920 and 30864 cm^{-1} attributed to ${}^4T_{1g}$ ${}^4A_{2g}(F)$ and charge transfer in an octahedral field [47].

Molar Conductivity Measurements

The metal(II) complexes were dissolved in DMSO and the molar conductivity of 10^{-4}M of their solution at room temperature were measured. The lower conductance values of the complexes support their non-electrolytic nature of the compounds.

Table 2. Elemental Analysis of Co(II) Complex

Compound	Found (Calculated)			
	C	H	N	M
L_3	57.14 (46.94)	3.92 (3.92)	18.17 (17.50)	-
CuL_3	47.01 (47.00)	3.94 (3.80)	14.95 (14.80)	11.30 (11.15)
NiL_3	47.42 (47.32)	3.97 (3.84)	15.08 (15.00)	10.53 (10.41)
CoL_3	47.40 (47.36)	3.97 (3.75)	15.07 (15.00)	10.58 (10.46)

Powder x-ray diffraction

The x-ray diffractogram of Cu (II), Ni (II) and Co (II) complexes of L₃ was scanned in the range 20-80° at wavelength 1.540 Å. The diffractogram and associated data depict the 2θ value for each peak, relative intensity and inter-planar spacing (d-values). The diffractogram of Cu(II) complex of L₃ had eleven reflections with maxima at 2θ = 6.58° corresponding to d value 6.75Å. The diffractogram of Ni(II) complex of L₃ had thirteen reflections with maxima at 2θ = 6.67° corresponding to d value 6.63Å. The diffractogram of Co(II) complex of L₃ had eleven reflections with maxima at 2θ = 6.65° corresponding to d value 6.67Å. The x-ray diffraction pattern of these complexes with respect to major peaks of relative intensity greater than 10% has been indexed by using computer programmed [48] The above indexing method also yields Miller indices (hkl), unit cell parameters and unit cell volume. The unit cell of Cu(II) complex of L₃ yielded values of lattice constants, a= 9.123Å, b=7.789 Å, c = 19.567 Å and unit cell volume V=1208.78599 Å³. In concurrence with these cell parameters, the condition such as a ≠ b ≠ c and α = β = γ ≠ 90° required for sample to be Monoclinic were tested and found to be satisfactory. Hence it can be concluded that Cu(II) complex has Monoclinic crystal system. The unit cell

of Ni(II) complex of L₃ yielded values of lattice constants, a=8.567 Å, b=9.789Å, c = 14.789Å and unit cell volume V=1074.07974 Å³. In concurrence with these cell parameters, the condition such as a ≠ b ≠ c and α = β = γ = 90° required for sample to be monoclinic. The unit cell of Co(II) complex of L₃ yielded values of lattice constants, a=8.789 Å, b=9.234 Å, c = 13.345Å and unit cell volume V=937.94752Å³. In concurrence with these cell parameters, the condition such as a ≠ b ≠ c and α = β = γ = 90° required for sample to be monoclinic. Hence it can be concluded Cu (II), Ni (II) and Co (II) complex of L has monoclinic crystal system. The experimental density values of the complexes were determined by using specific gravity method [47] and found to be 1.0896, 1.2554 and 1.1000 gcm⁻³ for Cu (II), Ni (II) and Co (II) complexes respectively. By using experimental density values, molecular weight of complexes, Avogadro's number and volume of the unit cell were calculated. Number of molecules per unit cell were calculated by using equation $n = nM/NV$ and was found Cu (II), Ni (II) and Co (II) complexes respectively. With these values, theoretical density were computed and found to be 1.0786, 1.2444 and 1.0890 gcm⁻³ for respective complexes. Comparison of experimental and theoretical density shows good agreement within the limits of experimental error [49].

Table: 3 The kinetic and thermodynamic parameters for decomposition of metal complexes

Complex	Step	Decomp. Temp. (°C)	n	Ea (kJmole ⁻¹)	Z (S ⁻¹)	US (JK ⁻¹ mole ⁻¹)	UG (kJmole ⁻¹)	Correlation coefficient
Cu-L ₃	I	450	0.1	15.01	2.86 × 10 ⁴	-167.00	29.53	0.948

Table 4 Antifungal activity of ligands

Test Compound	Antifungal growth								
	Aspergillus niger		Penicillium chrysogenum		Fusarium moneliforme		Aspergillus flavus		
	1%	2%	1%	2%	1%	2%	1%	2%	
L ₃	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Cu- L ₃	+ve	-ve	-ve	-ve	-ve	-ve	+ve	RG	
Ni- L ₃	-ve	RG	RG	-ve	-ve	RG	+ve	RG	
Co- L ₃	-ve	-ve	-ve	-ve	-ve	-ve	RG	+ve	
+ve control	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	
-ve control (Griseofulvin)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	

Ligand& Metal : +ve – Growth (Antifungal Activity absent)

-ve - Growth (Antifungal Activity present)

RG - Reduced Growth (More than 50% reduction in growth observed)

Table 5 Antibacterial activity of ligands and their metal complexes

Test Compound	Diameter of inhibition zone (mm)							
	E. Coli		Salmonella typhi		Staphylococcus aureus		Bacillus subtilis	
	1%	2%	1%	2%	1%	2%	1%	2%
L ₃	13mm	13mm	13mm	16mm	17mm	21mm	12mm	16mm
Cu- L ₃	11mm	14mm	12mm	14mm	17mm	18mm	15mm	18mm
Ni- L ₃	10mm	13mm	-ve	12mm	-ve	17mm	-ve	11mm
Co- L ₃	12mm	13mm	12mm	14mm	18mm	20mm	11mm	14mm
DMSO	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Penicillin	14mm	14mm	17mm	17mm	30mm	30mm	19mm	19mm

L ligand & Metal: -ve - No Antibacterial Activity
 Zone of inhibition - --mm

Antibacterial activity

Antifungal activity and Antibacterial activity of ligand and metal complexes were tested *in vitro* against fungal such as *Aspergillus niger*, *Penicillium chrysogenum*, *Fusarium moneliforme*, *Aspergillus flavus* and bacteria such as *E. Coli*, *B.Subtilis*, *S. aurious* and *Bacillus subtilis* by paper disc plate

method [50-53] The compounds were tested at the concentrations 1% and 2% in DMSO and compared with known antibiotics *viz* *Griseofulvin* and *Penicilin*. (Table 4 and 5)., it is found that the inhibition by metal chelates is higher than that of a ligand and results are in good agreement with previous findings with respect to comparative activity of free ligand and its complexes [54]

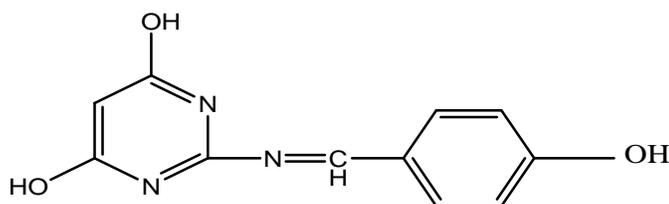


Figure 1. Structure of ligand

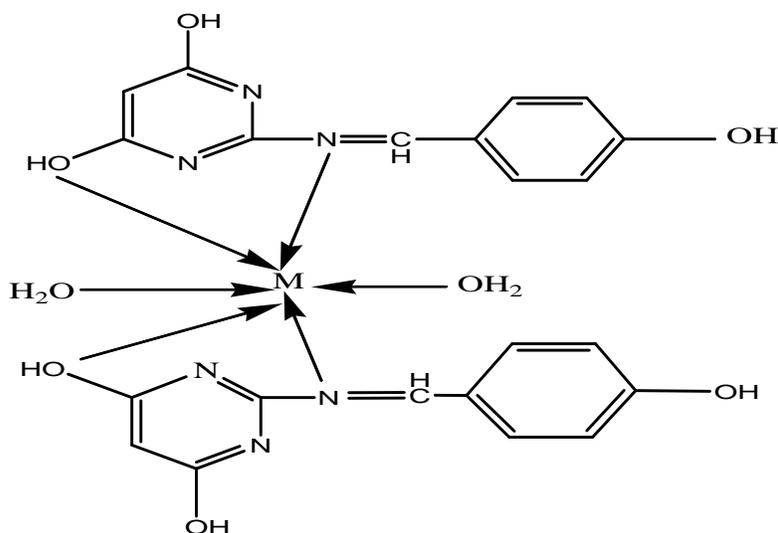


Figure 2. The proposed Structure of the complexes

When M= Cu (II), Ni (II) and Co (II).

Conclusion

In the light of above discussion we have proposed octahedral geometry for Cu (II), Ni (II) and Co (II) complexes. On the basis of the physico-chemical and spectral data discussed above, one can assume that the ligand behave as dibasic, NNO bidentate, coordinating via phenolic oxygen and imino nitrogen as illustrated in Fig.2. The complexes are biologically active and show enhanced antimicrobial activities compared to free ligand. Thermal study reveals thermal stability of complexes. The X-ray study suggests monoclinic crystal system for Cu (II), Ni (II) and Co (II) complexes.

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