COBALT(II), Ni(II), Cu(II), Zn(II), Cd(II), Hg(II), UO₂(VI) AND Th(IV) COMPLEXES FROM ONNN SCHIFF BASE LIGAND

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ABSTRACT

A new tetradentate Schiff base, 3-[(Z)-2-piperazin-1-yl-ethylimino]-1, 3-dihydro indol-2-one was synthesized by the condensation of isatin(Indole-2,3-dione) with 1-(2-aminoethyl)piperazine(AEP). Its complexes with Co(II), Ni(II), Cu(II), Zn(II), Cd(II), Hg(II), UO₂(VI) and Th(IV) have been synthesized and characterized by microanalysis, conductivity, UV-visible, FT-IR, ¹H NMR, TGA and magnetic susceptibility measurements. The complexes have 1:1 metal to ligand stoichiometry. The complexes of Cu(II) and Th(IV) are 1:1 electrolytes whereas the complexes of Co(II), Ni(II), Zn(II), Cd(II), Hg(II) and UO₂(VI) are nonelectrolytes. The spectral data revealed that the ligand acts as a neutral tetradentate, coordinating through the azomethine nitrogen, two piperazine nitrogen atoms and carbonyl oxygen. Octahedral geometry for Co(II), Ni(II), Cu(II), Zn(II), Cd(II) and Hg(II) complexes and a coordination number of 8 for UO₂(VI) and Th(IV) complexes are proposed. The ligand and its metal complexes were screened for antibacterial activity against *Bacillus subtilis*, *Staphylococcus aureus* (*S. aureus*), *Escherichia Coli* (*E. Coli*) and *Pseudomonas aeruginosa* and the complexes are more potent bactericides than the ligand. The anthelmintic activity of the ligand and its complexes against earthworms was also tested.

Key words: Isatin, Schiff base, 1-(2-aminoethyl)piperazine and complexes.

INTRODUCTION

Isatin thiosemicarbazone derivatives were found to exhibit interesting applications in physiological studies¹. Many isatin-derived compounds possess a wide spectrum of medicinal properties and thus, have been studied for activity against tuberculosis^{2,3}, leprosy⁴, fungal^{5,6}, viral⁷ and bacterial infections^{8,9}. Weinberger and coworkers¹⁰ synthesized a novel mixed valence copper(I)-copper(II)-bis(N,N'-antipyril-methyl)-piperazine complex and characterized by spectroscopic and X-ray diffraction technique. In this case the ligand acts as tetradentate in which the piperazine ring adopts a "boat"-confirmation. In this paper, the synthesis and characterization of a new Schiff base and its complexes with cobalt (II), nickel(II), copper (II), zinc(II), cadmium(II), mercury(II), dioxouranium(VI) and thorium(IV) are presented in which piperazine ring adopts boat confirmation. The ligand and its metal complexes were screened for antibacterial activity against *Bacillus subtilis*, *Staphylococcus aureus* (*S. aureus*), *Escherichia Coli* (*E. Coli*) and *Pseudomonas aeruginosa*. Anthelmintic activity of the compounds was tested on earthworms (*Peretima posthuma*).

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EXPERIMENTAL

The chemicals employed were of AR or LP grade. All the solvents were purified by standard methods. 1-(2-aminoethyl) piperazine (AEP) (Aldrich Chemicals) and isatin (S.D Fine chemicals) were used.

Preparation of Schiff base: The Schiff base was prepared by the reported method¹¹. Equimolar ethanolic solutions (50 ml each) of isatin and 1-(2-aminoethyl) piperazine were mixed and refluxed for about 1 hour. The reaction mixture was concentrated to a small volume and allowed to cool. The Schiff base ligand precipitated out. It was filtered, washed with ethanol and recrystallised from ethanol. The purity of the Schiff base ligand was monitored by TLC using eluants 1:1 ethyl acetate and petroleum ether and separated

by column chromatography (Yield 90%). The mass spectrum of the ligand (IsAEP, L) (Fig.1) shows the molecular ion peak at 259 u corresponding to the macrocyclic moiety [(C₁₄H₁₈N₄O)⁺ atomic mass 258].

Preparation of the complexes: The metal complexes were prepared by adding ethanolic solution (50 ml) of the metal salt to the ligand (100 ml) in 1:2 molar ratio and heating under reflux for about 3 hours. The reaction mixture was concentrated to a small volume. On cooling, the metal complexes precipitate out. They were filtered, washed with ethanol and dried in vacuo.

Antibacterial and anthelmintic activity measurements

The ligands and its complexes with Cu(II), Co(II), Ni(II), Zn(II), Cd(II) and Hg(II) were screened for antibacterial activity against *Bacillus subtilis*, *Staphylococcus aureus* (*S. aureus*), *Escherichia Coli* (*E. Coli*) and *Pseudomonas aeruginosa* at a concentration of 1mg/0.02ml in DMF by cup plate method¹². Anthelmintic activity of the compounds was measured on earthworms (*Peretima posthuma*) using 5mg/ml concentration by reported method¹³.

Analysis and physical measurements: The micro analysis of the samples was carried using Carlo Ebra analyser. The metal contents were estimated by standard methods¹⁴. The conductivity measurements were made using a Systronics Conductivity Meter 304 with a dip type conductivity cell with a cell constant 1 cm⁻¹. The magnetic susceptibility measurements were carried out at room temperature using Faraday balance. Electronic spectra were recorded in DMF in the range 900-350 nm using Shimadzu UV-3101 PC UV-VIS-NIR scanning spectrophotometer. ¹H NMR spectra of the ligand and its complexes were obtained using Bruker AMX 400MHz FT NMR spectrometer. IR spectra of samples in KBr pellets were recorded in the region 4000-600 cm⁻¹ on a Nicolet Impact 400-D FT-IR spectrometer. The far IR spectra of the complexes in the region 600-250 cm⁻¹ were recorded using a Perkin Elmer Instruments, Spectrum one FT-IR spectrometer. The mass Spectrum of the ligand was recorded using a ESI-MS Bruker Daltronics mass spectrometer. TGA studies of the complexes were carried out using Perkin-Elmer Thermo gravimetric analyser TGA 7 with a scan rate of 10°C per minute in nitrogen atmosphere.

RESULTS AND DISCUSSION

All the metal complexes are coloured solids and are stable towards air and have high melting points (above 250°C). The complexes have the general formula [MLCl₂] where M= Co(II) or Ni(II) while with Cu(II) salt, gives complex of the type [CuLCl(H₂O)]Cl.2H₂O, [MLCl₂].2H₂O where M = Zn(II), Cd(II) and Hg(II) and with UO₂(VI) and Th(IV) salts the complexes of the type [UO₂L(NO₃)₂] and [ThL(NO₃)₃.2H₂O]NO₃ respectively were obtained. The complexes are insoluble in water and common organic solvents but are partly soluble in DMF and DMSO. Hence the molecular weights could not be determined. Elemental analysis and analytical data of the complexes suggest that the metal to ligand ratio in all the complexes is 1:1 (Table1). The conductivity for 10⁻³M solution of the complexes in DMF show Cu(II) and

Th(IV) to be 1:1 electrolytes and the other complexes show non electrolytic behaviour (Table 1).

Table 1. Analytical and physical data of the complexes

Compound	Yield %	Colour	M.P °C	Elemental analysis (%) Found (Calcd)				Mol.cond S cm ² mol ⁻¹
				C	H	N	M	
IsAEP (L) (C ₁₄ H ₁₈ N ₄ O.H ₂ O)	90	Brown	220	60.65 (60.86)	7.21 (7.24)	20.25 (20.29)	--	--
[CuLH ₂ O.Cl]Cl.2H ₂ O	85	Light green	180	39.98 (39.16)	5.95 (5.13)	12.0 (13.05)	15.04 (14.90)	86
[CoLCl ₂]	80	Brown	>250	43.77 (43.29)	4.82 (4.64)	14.25 (14.43)	15.02 (15.20)	14
[NiLCl ₂]	80	Reddish brown	>250	43.01 (43.33)	4.84 (4.64)	14.26 (14.44)	14.98 (15.13)	33
[ZnLCl ₂].2H ₂ O	78	Brown	>250	39.05 (39.12)	4.90 (4.89)	13.00 (13.04)	15.23 (15.23)	12
[CdLCl ₂].2H ₂ O	80	Orange	>250	35.30 (35.26)	4.38 (4.40)	11.78 (11.75)	23.60 (23.59)	08
[HgLCl ₂].2H ₂ O	82	Whitish	>250	29.68 (29.75)	3.70 (3.72)	9.91 (9.92)	35.54 (35.53)	16
[UO ₂ L(NO ₃) ₂]	90	White	>250	25.80 (25.77)	2.78 (2.76)	8.62 (8.59)	36.78 (36.50)	32
[ThL(NO ₃) ₄].2H ₂ O	92	Cream red	>250	22.54 (21.70)	2.83 (2.84)	14.50 (14.47)	28.80 (29.97)	120

Table 2: Selected IR frequencies (cm⁻¹) and UV-visible spectral data (cm⁻¹) of the complexes.

Ligand/Complex	$\nu_{\text{O-H}}$ (H ₂ O)	ν_{NH} (isatin)	$\nu_{\text{C=O}}$	$\nu_{\text{C=N}}$	UO ₂ ⁺²	ν_{NO_3} (Coordinated)	$\nu_{\text{M-N}}$	$\nu_{\text{M-O}}$	$\nu_{\text{M-Cl}}$	λ_{max} cm ⁻¹
IsAEP (L)	3417	3240	1717	1618	---	---	---	---	---	---
[CuL(H ₂ O)Cl]Cl.H ₂ O	3447	3241	1709	1610	---	---	480	460	320	14388
[CoLCl ₂]	--	3241	1709	1610	---	---	493	420	326	15748,19230
[NiLCl ₂]	--	3249	1702	1612	---	---	490	450	326	10050,14925,23529
[ZnLCl ₂].2H ₂ O	3429	3241	1711	1610	---	---	504	425	306	---
[CdLCl ₂].2H ₂ O	3417	3241	1709	1610	---	---	455	418	310	---
[HgLCl ₂].2H ₂ O	3430	3242	1708	1609	---	---	537	437	280	---
[UO ₂ L(NO ₃) ₂]	--	3241	1705	1611	932, 759	1480,1290,1031	---	---	---	---
[ThL(NO ₃) ₃ .2H ₂ O]. NO ₃	3347	3241	1701	1611	---	1472,1303,1035	---	---	---	---

IR spectra: Selected IR spectral bands for the ligand and its complexes are given in Table 2. The IR spectrum of the free ligand is characterized mainly by the strong bands at 3221, 1717, and 1618 cm⁻¹ which are attributed to the stretching frequencies of NH (aromatic), C=O and C=N(azomethine) respectively^{15,16}. The band at 1717cm⁻¹ due to C=O stretching in the spectrum of the ligand shifts to lower wave numbers by 8-16 cm⁻¹ in the metal complexes indicating that the carbonyl oxygen atom is coordinated to the central metal ion^{16,17}. The band at 1618cm⁻¹ due to C=N stretching in the spectrum of the ligand shifts to lower wave numbers in all the metal complexes by 7-10 cm⁻¹ indicating that the azomethine nitrogen atom is coordinated to the metal ion^{16,17}. The band due to N-H (aliphatic) in the complexes appears at lower wave numbers relative to its position in the free ligand, thus clearly indicating the coordination of the ligand through the nitrogen atom of the N-H group.

The band due to the C-H stretching frequency of the N-CH₃ group in the complexes either disappears or shifts to lower wavelength region. In the case of disappearance, these bands probably shift to lower wave number region (2,900 cm⁻¹) and overlap with stretching vibrational bands of other C-H bonds of the complexes. This shift indicates that the nitrogen atom of the N-CH₃ group no longer has a lone pair of electrons and it acquired a partial positive charge due to its coordination with the metal ion. Similar observations were made by earlier authors^{10,26}. A broad band around the 3450-3340 cm⁻¹ is observed in the infrared spectra of the complexes of Cu(II), Zn(II), Cd(II), Hg(II) and Th(IV). This may be assigned to OH stretching frequencies of water molecule. Further the i.r spectra of the complexes of Cu(II), Co(II), Ni(II), Zn(II), Cd(II) and Hg(II) exhibit new bands at 480-540, 420-460 and 330-335cm⁻¹, which may be assigned to M-O, M-N and M-Cl (terminal) stretching modes respectively¹⁸.

The IR spectra of $\text{UO}_2(\text{VI})$ nitrate complex showed no absorption bands due to free nitrate groups, where as the spectra of $\text{Th}(\text{IV})$ nitrate complex showed an absorption band at 1382cm^{-1} , where the free nitrate is known to absorb¹⁹. Both the complexes exhibit bands around 1480, 1300, 1030cm^{-1} corresponding to monodentate nitrate groups¹⁹. The sharp bands at 932 and 759cm^{-1} observed in the case of the uranyl complex correspond to the asymmetric (ν_3) and symmetric (ν_1) stretching vibrations respectively. Thus the Schiff base ligand, is acting toward the central metal ions as neutral ONNN tetradentate ligand via carbonyl oxygen of isatin moiety, azomethine nitrogen and two piperazine nitrogen atoms forming three five-membered chelating rings.

¹H NMR Spectra

The ¹H NMR spectrum of the ligand and its diamagnetic $\text{Zn}(\text{II})$, $\text{Cd}(\text{II})$, $\text{Hg}(\text{II})$, $\text{U}(\text{VI})$ and $\text{Th}(\text{IV})$ complexes were recorded in $\text{DMSO}-d_6$ and the spectral data are reported in Table 3. The protons of the isatin moiety, methylene groups and piperazine ring were assigned according to Chohan et al²⁰. These protons shifted downfield due to the coordination to the metal ions²⁰. The number of protons calculated from the integration of ¹H NMR spectra is in accord with that expected from CHN analyses.

Table 3: ¹H NMR Chemical Shifts (δ ppm) of the Schiff base and its $\text{Zn}(\text{II})$, $\text{Cd}(\text{II})$, $\text{Hg}(\text{II})$, $\text{U}(\text{VI})$ and $\text{Th}(\text{IV})$ complexes.

Sl.No	Ligand/Complex	Isatin ring					Piperazine ring			
		N-H	H-5	H-4	H-6	H-7	H-1'	H-4'	H-2',3'	N-H
1	IsAEP (L) ($\text{C}_{14}\text{H}_{18}\text{N}_4\text{O}_2\cdot\text{H}_2\text{O}$)	10.5s,br	7.58t	7.49d	7.05t	6.90d	2.66t	2.59t	2.4m	2.6s,br
2	$[\text{ZnLCl}_2]\cdot 2\text{H}_2\text{O}$	11.0s,br	7.62t	7.53d	7.12t	6.98d	2.70t	2.61t	2.45m	2.9s,br
3	$[\text{CdLCl}_2]\cdot 2\text{H}_2\text{O}$	11.6s,br	7.60t	7.54d	7.15t	7.05d	2.75t	2.68t	2.51m	3.0s,br
4	$[\text{HgLCl}_2]\cdot 2\text{H}_2\text{O}$	11.5s,br	7.64t	7.55d	7.17t	7.09d	2.76t	2.70t	2.52t	2.93s,br
5	$[\text{UO}_2\text{L}(\text{NO}_3)_2]$	11.5s,br	7.62t	7.53d	7.12t	6.98d	2.70t	2.61t	2.45m	2.98s,br
6	$[\text{ThL}(\text{NO}_3)_3\cdot 2\text{H}_2\text{O}]\cdot \text{NO}_3$	11.1s,br	7.60t	7.54d	7.15t	7.05d	2.75t	2.68t	2.51m	3.1s,br

t- triplet, m-multiplet, s-singlet, br-broad

UV- visible and magnetic susceptibility measurements:

The cobalt(II), nickel(II) and copper(II) complexes show magnetic moments of 3.92, 3.15 and 1.92 B.M respectively which is characteristic of mononuclear, octahedral cobalt(II), nickel(II) and copper(II) complexes²¹. Zinc(II), cadmium(II), mercury(II), dioxouranium(VI) and thorium(IV) complexes are diamagnetic. The electronic spectral data of the complexes in DMF are presented in Table 2.

The broad band centered at 14390cm^{-1} appearing as an envelope in the copper (II) complex, assigned to the ${}^3\text{E}_g \rightarrow {}^2\text{T}_{2g}$ transitions indicates octahedral geometry²². The electronic spectrum of the cobalt (II) complex shows two bands at 15748 , 19230cm^{-1}

which are assigned to ${}^4\text{T}_{1g} \rightarrow {}^4\text{A}_{2g}(\text{F})$ (ν_2) and ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{1g}(\text{P})$ (ν_3) transitions, respectively, as expected for an octahedral cobalt(II) complex²². The electronic spectrum of the nickel (II) complex exhibits three bands at 10050 , 14925 and 23529cm^{-1} , attributable to ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{2g}(\text{F})$ (ν_1), ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{1g}(\text{F})$ (ν_2) and ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{1g}(\text{P})$ (ν_3) transitions, respectively, for an octahedral nickel(II) complex²³. The electronic spectra of the $\text{U}(\text{VI})$ and $\text{Th}(\text{IV})$ complexes in DMF solution exhibit no bands in the $450\text{-}750\text{nm}$ region. The absorption bands obtained below 450nm correspond to the ligand $\pi \rightarrow \pi^*$ transitions and are not of help in deciding the geometry around the central uranium and thorium ions.

Thermo gravimetric studies

TGA studies of the complexes were carried out in nitrogen atmosphere at the rate of 10° per minute up to 700°C . In the thermal decomposition studies of the complexes a general pattern is observed where the water of hydration is lost followed by the loss of uncoordinated chloride/nitrate, coordinated chloride/nitrate, ligand molecules and the decomposition of the complex to finally yield the respective metallic oxides at higher temperatures (Table 4).

Table 4: TGA data of the complexes

Sl.No	Complex	Stage	Temp. ($^\circ\text{C}$)	Weight loss % Found (%Calc.)	Species lost	Residue
1	$[\text{CuL}(\text{H}_2\text{OCl})\text{Cl}]\cdot\text{H}_2\text{O}$	1	100	4.5(4.19)	Lattice water	CuO
		2	180-250	21.0(20.74)	2Cl+Coordinated water	
		3	370	61.00(60.13)	L	
2	$[\text{CoLCl}_2]$	1	250-300	18.7(18.30)	2Cl (coordinated)	Co_2O_3
		2	370	66.8(66.49)	L	
3	$[\text{NiLCl}_2]$	1	240-290	18.0(18.32)	2Cl (coordinated)	NiO
		2	350	67.5(66.55)	L	
4	$[\text{ZnLCl}_2]\cdot 2\text{H}_2\text{O}$	1	110	8.5(8.38)	Lattice water	ZnO
		2	250	17.1(16.53)	2Cl (coordinated)	
		3	340	61.3(59.85)	L	
5	$[\text{CdLCl}_2]\cdot 2\text{H}_2\text{O}$	1	100	8.1(7.55)	Lattice water	CdO
		2	240	14.2(14.90)	2Cl (coordinated)	
		3	360	54.5(53.94)	L	
6	$[\text{HgLCl}_2]\cdot 2\text{H}_2\text{O}$	1	100	7.2(6.37)	Lattice water	HgO
		2	250	12.9(12.57)	2Cl (coordinated)	
		3	350	46.6(45.52)	L	
7	$[\text{UO}_2\text{L}(\text{NO}_3)_2]$	1	290	20.3(19.02)	Coordinated NO_3 .	U_3O_8
		2	360	41.0(39.57)	L	
8	$[\text{ThL}(\text{NO}_3)_3\cdot 2\text{H}_2\text{O}]\cdot \text{NO}_3$	1	200	8.9(8.01)	Uncoordinated NO_3	ThO_2
		2	300	29.8(28.68)	Coordinated $\text{H}_2\text{O} + \text{NO}_3$.	
		3	350	34.5(33.33)	L	

Table 5: Antibacterial activity of the Schiff base and its complexes.

Sl.No	Compound 1mg/0.02ml	Zone of inhibition (in mm)			
		Bacillus subtilis	S. aureus	E.Coli	Pseudomonas aeruginosa
1	DMF(control)*	-	-	-	-
2	IsAEP (L)	4	4	6	-
3	[CuL(H ₂ O)Cl]Cl.H ₂ O	22	8	8	8
4	[CoLCl ₂]	24	12	11	9
5	[NiLCl ₂]	17	8	8	12
6	[ZnLCl ₂].2H ₂ O	8	10	7	5
7	[CdLCl ₂].2H ₂ O	6	10	6	7
8	[HgLCl ₂].2H ₂ O	7	5	6	6

*No effect upto 24 hours.

Table 6: Anthelmintic activity of the Schiff base and its complexes.

S.No	Ligand/Complex	Time taken for paralysis and death of worms	
		Paralysis(min)	Death(min)
1	Blank(Normal saline)	No effect for 10 hours	
2	Standard(piperazine citrate)	10	16
3	IsAEP (L)	8	14
4	[CuL(H ₂ O)Cl]Cl.H ₂ O	7	10
5	[CoLCl ₂]	10	12
6	[NiLCl ₂]	14	18
7	[ZnLCl ₂].2H ₂ O	25	20
8	[CdLCl ₂].2H ₂ O	15	12
9	[HgLCl ₂].2H ₂ O	8	13

Antibacterial Activity

The ligand and its metal complexes have been screened for their antibacterial activity and the results are presented in Table 5. The complexes Cu(II) and Co(II) shows very good activity against bacillus subtilis, S. aureus and E. Coli and least activity against Pseudomonas aeruginosa. The Ni(II) complex shows moderate activity against Bacillus subtilis and Pseudomonas aeruginosa and least active against S. aureus and E. Coli. On the other hand the complexes of Zn(II), Cd(II) and Hg(II) have shown least to moderate activity against both gram positive and gram negative bacteria. The enhanced activity of the complexes over the Schiff base can be explained on the basis of chelation theory²⁴. Chelation reduces the polarity of the metal ion considerably, mainly because of the partial sharing of its positive charge with donor groups and possible π - electron delocalization on the whole chelate ring. The lipid and polysaccharides are some important constituents of cell walls and membranes, which are preferred for metal ion interaction. In addition to this, the cell wall also contains amino phosphates, carbonyl and cysteinyl ligands, which maintain the integrity of the membrane acting as a diffusion barrier and also provides suitable site for bonding. Chelation can reduce not only the polarity of the metal ion, but increases the lipophilic character of the chelate, and the interaction between the metal ion and the lipid is favoured. This may lead to breakdown of the permeability barrier of the cell, resulting in interference with the normal cell process. If the geometry and charge distribution around the molecule are incompatible with the geometry and the charge distribution around the pores of the bacterial cell wall, penetration through the wall by the toxic agent cannot takes place and this will prevent the toxic reaction within the pores. Chelation is not only criterion for antibacterial activity. Some important factors such as nature of the metal ion, nature of ligand, coordinating sites, hydrophilicity, lipophilicity and presence of co-ligands have considerable influence on antibacterial activity. Certainly, Steric and pharmacokinetic factors also play a decisive role in deciding the potency of an antimicrobial agent. The higher toxicity of the metal complex can attributed to the effect of metal

ion on the normal cell process. The widespread interaction of metal ions with cellular compounds is due to the fact that all these structures contain a variety of functional groups that can act as metal binding agents. The problem is how to obtain those interactions in cells and organisms where non-polar membrane exist to hinder the movement of charged metal ions into the cell, where myriad of metal binding sites exist to compete for the metal ion, and where specificity of cellular interaction must occur in order to obtain therapeutic value²⁵. The presence of lipophilic and polar substituents is expected to enhance antibacterial activity. Heterocyclic ligands with multifunctionality have a greater chance of interaction either with nucleoside bases (even after complexation with metal ion) or with biologically essential metal ions present in the biosystem can be promising candidates as bactericides since they always tend to interact especially with some enzymatic functional groups, in order to achieve higher coordination numbers^{25, 26}. Thus the antibacterial activity of metal complexes cannot be ascribed to chelation alone, but it is an intricate blend of all the above contributions.

Anthelmintic activity (in vitro)

The anthelmintic activity was tested on earthworms (Pheretima Posthuma). Amongst the complexes Cu(II), Co(II), Ni(II), Zn(II), Cd(II) and Hg(II) the complexes Cu(II), Co(II), Cd(II) and Hg(II) showed more activity than the standard and the remaining complexes are less active. Based on the above results, it may be stated that the activity of the Schiff base is enhanced on complexation with Cu(II), Co(II), Cd(II) and Hg(II) ions (Table 6).

CONCLUSION

As discussed above the Schiff base ligand acts as tetradentate with carbonyl oxygen, azomethine nitrogen and piperazine nitrogen atoms as donors. The probable structures are shown below, Fig 1-3. The antibacterial activity of the isatin Schiff base is enhanced upon complexation with metal ions particularly for Co(II). The anthelmintic activity of the Schiff base is also enhanced on

complexation with metal ions.

Fig.1

M=Cu(II), X=H₂O, Y=Cl and Z= Cl.2H₂O
 M=Co(II) and Ni(II), X=Y=Cl and Z= ---
 M=Zn(II), Cd(II) and Hg(II), X=Y= Cl and Z=2H₂O.

Fig.2

Fig.3

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