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SYNTHESIS, CHARACTRIZATION AND ANTIMICROBIAL STUDIES OF CU (II) AND ZN (II) COMPLEXES WITH SCHIFF BASES

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ABSRACT

3-acetyl 4-Hydroxy quinolin-2-one and substituted pyridine containing Schiff bases were used to synthesize Cu (II) and Zn (II) complexes. The Schiff base ligands utilised for complex formations are 4-hydroxy-3-(1-(pyridin-2-ylimino)ethyl)quinolin-2(1*H*)-one (L_1), 4-hydroxy-3-(1-(pyridin-3-ylimino)ethyl)quinolin-2(1*H*)-one (L_2), 4-hydroxy-3-(1-(pyridin-4-ylimino)ethyl)quinolin-2(1*H*)-one (L_3) and 3-(1-((5-chloropyridin-2-yl)imino)ethyl)-4-hydroxy quino- lin-2(1H)-one (L_4). The synthesised metal complexes were characterized by their elemental analysis, magnetic moment, molar conductance along with electronic, thermal, infrared spectral analysis. Cu(II) and Zn (II) complexes of ligand (L_3) were subjected for their XRD Study. On the basis of magnetic, XRD and spectral studies octahedral geometry is assigned to Cu (II) Complexes while Zn (II) Complexes possess tetrahedral geometry. In vitro biological screening effects of the synthesized complexes were tested for their antibacterial activity by Agar well diffusion method and antifungal activity by the poison plate method. For antibacterial activity the bacterial species used were *Bacillus subtilis, Escherichia coli, Salmonella typhi*, and *Staphylococcus aureus* while fungal species used were *Aspergillus flavus, Penicillium chrysogenum, Aspergillus niger* and *Fusarium moneliforme*.

KEYWORDS: 3-acetyl 4-Hydroxy quinolin- 2-one, Schiff Bases, Metal Complexes, Spectral Analysis, XRD Studies, Antimicrobial Activity.

INTRODUCTION

Schiff's bases play a vital role in the overall progress of coordination chemistry. The major point of attraction is Schiff's base metal complexes. These are studied extensively due to their physical and chemical properties and also their broad spectrum of functions in various disciplines of Science. Many of these publications are focused on the catalytic properties of Schiff's base complexes particularly connected with homogeneous as well as heterogeneous reactions.[1] The catalytic function of Schiff base metal complexes are observed in various reactions such as polymerisation,[2] condensation,[3] epoxidation,[4] oxidation,[5] reduction,[6] and other reactions. Polydentate Schiff base transition metal complexes are important in environmental, chemical and biological fields.[7]

Quinoline is a naturally occurring heterocyclic moiety having significant pharmacological properties. The schiff base derived from quinoline derivatives also shows a wide range of application in medicine and industries.[8] The quinoline Schiff base moiety have a variety of biological activities such as antibacterial,[9] antifungal,[10] anticancer,[11] antioxidant,[12] antitubuerclosis,[13] anti-inflamatory[14] and many more. According to view of literature very few Schiff base metal complexes of quinoline with pyridine moiety were observed. Hence we undertake the synthesis of Cu (II) and Zn (II) metal complexes derived from condensation of schiff base derived from 3-acetyl 4-hydroxy quinolin-2-one and different amino pyridine. These synthesized metal complexes were characterized and further studied for their antibacterial and antifungal activity.

MATERIAL AND METHODS

All the chemicals used were of A.R. grade and solvents were purified by distillation before use. The C, H, N analysis of ligands and complexes were carried out by micro combustion method using CHNSO, EA1108, Elemental analyzer model-CARLO-ERBA Instruments. The Magnetic moment measurements were made on Gouy balance consisted of an electromagnet with a suitable power supply and a single pan semi-micro balance; E-mettler-Zurich, Swiss-make-H-16GD with maximum capacity 80gm and precision of ± 0.01mg.The solution conductivities of the metal complexes in DMSO were measured on a digital conductivity bridge at room temperature. The Electronic spectra of these complexes were recorded on SHIMADZU-UV-1601 UV/visible double beam spectrophotometer in the region 200-800

nm using quartz tubes of 1 cm path length. Infrared spectra of the ligands and metal complexes were taken as KBr pellets on Shimadzu spectrometer. X-ray diffraction patterns of the selected metal complexes in powder form were recorded on Philips PW 1050/70 X-ray diffraction machine attached with X-ray Diffractometer which is equipped with Cu-Ka target tube (A = 1.54056°A).

EXPERIMENTAL PROCEDURE

Preparation of Ligands (L_1-L_4)

The 3-Acetyl 4-hydroxy quinolin-2-one were prepared by refluxing methyl anthranilate with ethy acetoacetate in presence of situ. Sodium ethoxide. This synthesized 3-Acetyl 4-hydroxy quinolin-2-one on condensation with substituted amino pyridine provides the targeted ligands (L_1-L_4).

General procedure of synthesis of metal complexes

The synthesis of each complex is processed by taking 0.02 moles of ligand (L_1-L_4) in a round-bottomed flask containing 50ml of ethanol. The contents are heated for a few minutes followed by gradual addition of 0.01 moles of solution of metal salt dissolved in 20ml of ethanol and added gradually in a hot solution of ligand. The contents are refluxed for two hours and cooled. A freshly prepared 10% alcoholic ammonia solution is progressively added in a cold container with refluxed contents with constant stirring. At a particular pH, precipitation appears.

The precipitate of complex is digested for one hour. Any change in pH, if observed, is adjusted and further digested for an hour. The digested precipitate of a complex is filtered in hot, washed with alcohol (hot), followed by petroleum ether (40–60°C) and dried in vacuum desiccators over calcium chloride.

REACTION SCHEME

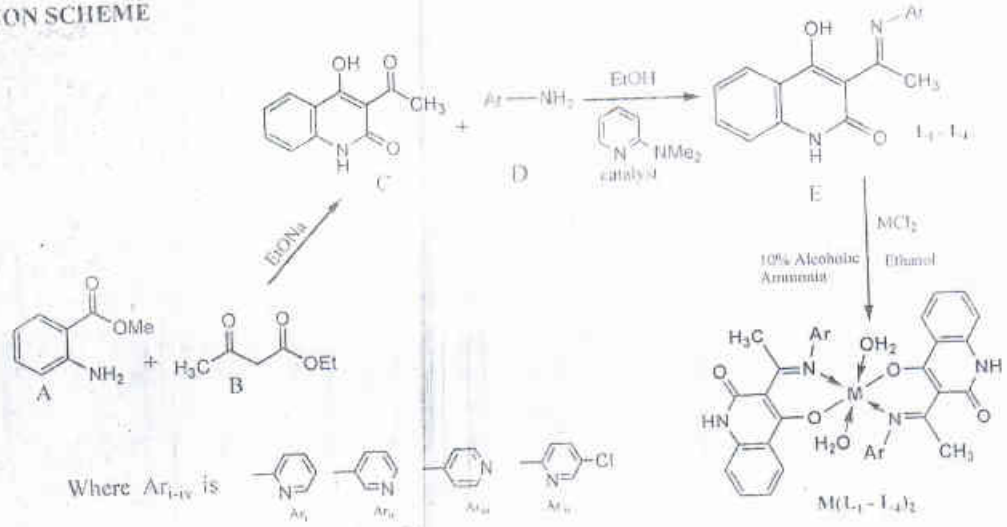

Fig. 1 Synthesis of Metal Complexes of Cu(II) and Zn (II)

RESULT AND DISCUSSION

All the Schiff base Cu(II) complexes prepared in the present work are greenish coloured. These complexes withstand moisture and air. None of the Cu(II) complexes is soluble in non-polar and polar solvents. Nevertheless, they are sparingly soluble in alcohol and chloroform. They are appreciably soluble in dimethyl sulphoxide (DMSO) and dimethylformamide (DMF). The colour, melting/decomposition temperature, conductivity measurement and elemental analysis of Cu(II), Zn(II) complexes synthesized from ligand L_1 - L_4 are presented in the table - 1.

The low solution conductivity values of the complexes in DMSO indicate their non-electrolytic nature. The elemental analysis data of metal complexes confirm the ligand to the metal ratio for copper complexes as 2:1, suggesting monomeric nature. The observed magnetic moment values (μ_{eff}) of all the Cu(II) complexes in the present investigation were seen to be in the range 1.72-1.86 B.M., consistent with one unpaired electron. The experimental μ_{eff}(B.M.) of Cu(II) complexes are shown in Table 2.The magnetic moments of Cu(II) complexes studied in the present investigation of ligand L_1 to L_4 suggest monomeric nature which is in agreement with literature.[15-16]

The electronic absorption spectra of each Cu(II) complexes showed broadband at (630nm) 15880 cm^{-1}, (890 to 860 nm) 11240-11627 cm^{-1} assigned to ($^2B_{1g} \rightarrow {}^2A_{1g}$) and ($^2B_{1g} \rightarrow {}^2B_{2g}$) transition respectively and charge transfer band at (360nm) 27777cm^{-1} for

($^2B_{1g} \rightarrow {}^2E_g$). These values fall within the range of many distorted octahedral Cu(II) complexes reported earlier.[17-20] The electronic spectral data of Cu(II) complexes are presented in Table - 3. Thus the electronic spectrum of the copper complex having distorted octahedral geometry displays three close bands in the visible and near IR region. In octahedral complexes having weak distortion, only the first and second of these transitions are displayed in the visible region and the third band is caused by $^2B_{1g} \rightarrow {}^2E_g$ transition and seen in the UV region and maybe oversight the band.

The EPR spectra $[Cu(L_3)_2]$ displayed g|| (2.244) > g⊥ (2.089) > 2.0023 indicate that the complex is axially symmetric and copper site has a dx^2-y^2 ground state characteristic of octahedral geometry.[21] The calculated G value for the present complexes appeared in the range 2.80 for $Cu(L_3)_2$, indicating the existence of negligible exchange interaction between copper, as G < 4.[22] The ESR spectrum data reconfirms the magnetic behavior of the copper (II) complexes as shown in Fig.2.

Zinc complexes Prepared in the present study are yellowish-white to pale yellow. They are stable in air and moisture. The Zn (II) complexes decompose at high temperatures. They are insoluble in non-polar and common polar solvents. At a very low concentration, solutions can be prepared in CH_3OH and DMSO. The molar conductance value of the complexes in DMSO (10^{-3}M) is very low (12.15 -13.44 mhos^{-1} cm^{2}mol^{-1}), indicating the non-electrolytic nature of complexes. The metal to ligand ratio was shown as 1:2, predicting a monomeric structure. All Zn (II) complexes are diamagnetic. These findings agree with the previously reported experimental work.[23-25]

The crystal lattice parameters of the Cu (II) and Zn (II) complexes were determined by the X-ray diffraction powder method. The X-ray diffraction patterns of complexes were recorded in the 2θ range from 10° to 80°. The significant reflections were measured, and the corresponding d values were obtained. The Miller indices (*hkl*) were calculated and refined using the Cheng Dong program by the computational method. All calculations were performed using the computerized software program *Powder-X* developed by Cheng Dong. The data obtained and reciprocal lattice (*h, k, l*) are listed in the Table - 5 &6.Fig.3 & 4.

Based on the results and the literature support, the complexes with ligands are crystalline due to sharp refluxes shown, and have been assigned monoclinic.[26-27]

The band assigned to the C=N stretching frequencies in the free ligand were observed around 1617-1600 cm^{-1}. In the IR spectra of the corresponding metal complexes, medium to weak bands appeared in the region 1595-1582 cm^{-1} were assigned to C=N stretching vibration mode. A decrease in a shift of this band by 10-13 cm^{-1} observed on complexation indicates that the imine group of each ligand is coordinated to metal ion via its nitrogen. The medium intensity absorption bands in the region 1278-1239 cm^{-1} in the spectra of metal complexes were predictable to enolic C–O stretching frequency. These bands in the corresponding free ligands spectra were observed in the range 1269-1224cm^{-1}. Thus the observed upward shift of this band by 18-22 cm^{-1} and the disappearance of broad absorption due to phenolic –OH in metal complexes confirms the participation of enolic oxygen bonded to ^{4}C of 4-hydroxyquinolin-2(1H)-one involved in the formation of the complex. The band assigned to the lactam C=O stretching frequencies in the corresponding free ligands were observed in the 1668-1655 cm^{-1}. In the complexes, the position of these bands is not changed significantly in complexes and is almost unaltered. This confirms the non-involvement of the lactam carbonyl group in complex formation. The spectra of copper complexes exhibit bands in the ranges 400–500 cm^{-1} These are assigned to ν(M–N) stretching frequencies. These bands are because of the formation of coordinate bonds between the nitrogen atom of the ligand and the central metal ion.[28] The spectra of complexes exhibit bands in the range 455–452 cm^{-1} assigned for ν(Cu–N) while 463-439 cm^{-1} assigned for ν(Zn–N) stretching freque- ncies.

In thermal studies, no weight loss was seen on constant heating for one h at 120°C, which is indicative of the presence of coordinated water. The TG analysis shows the percentage loss corresponding to two coordinated water molecules in Cu (II)complexes. The loss of water in these complexes was found to be a one-step process as only one endothermic peak was observed at200-220°C.[29]

The synthesized complexes of Cu(II)and Zn(II) were investigated for anti-bacterial with *Bacillus subtilis* and *Salmonella typhi*(gram positive bacteria) while *Staphylococcus aureus* and *Escherichia coli*(gram negative bacteria). The results are reported in Table 8. All compounds have displayed good antibacterial activity with all bacterial species in the range of 17-22 mm diameter of zone of inhibition. Metal complexes of Cu(II)and Zn(II) with ligands (L_1-L_3) shown lesser antibacterial activity than reference but greater than corresponding ligands. This indicates that metal chelation have enhanced the antibacterial activity. The enhanced activity observed in complexes of Cu(II)and Zn(II) with ligands (L_4) might be due to presence of chlorine atom in the moiety.[30] The screening test of metal complexes of Cu(II)and Zn(II) with ligands (L_1-L_3) for antifungal activity against *Aspergillus niger, Aspergillus flavus, Fusarium moneliforme; and Penicillium chrysogenum* fungi revealed that all complexes exhibit significant activity. Complexes with L_4 have shown lowest growth of all fungi as compare to complexes with other ligands.

Based on elemental analysis, conductivity measurement, magnetic moment values, electronic absorption spectral

data, copper complexes of the present investigation are ascribed monomeric stoichiometry and Cu (II) complexes possess distorted octahedral geometry while Zn (II) complexes have tetrahedral geometry.

ANTIMICROBIAL ACTIVITY

Antibacterial activity

The agar well diffusion method was used to test the antibacterial activity.[31] Mueller Hinton Agar for bacteria was used for all tests for antibacterial activity. For positive control of bacteria Ampicillin was used. The solvent and positive control used was DMSO. Antibiotics and dehydrated media powder were brought from Hi-Media, India. Using sterile wire-loop, test organisms were aseptically added to sterile MH broth before being incubated at 37°C for 18 hours. This suspension was utilized as an inoculant. Wells in the media plates with a 10mm diameter were made using a sterile cork borer for the addition of compound solutions and controls. With the aid of a micropipette, 100 µl of the compound solution was aseptically added to the wells to reach a final concentration of 10 g of compound in each well. As controls, the same quantity of DMSO and ampicillin solution were introduced. The plates were cooled for 30 minutes to allow solutions to diffuse through the agar substrate. Plates were then incubated for 24 hours at 37°C.*Bacillus subtilis* and *Salmonella typhi* were gram positive bacteria that were utilized as test organisms, whereas *Staphylococcus aureus* and *Escherichia coli* were gram negative microorganisms. The zone margin should be regarded as the region that does not clearly display any expansion that the unaided eye can see. With a measuring scale in millimetres, the clean zone was measured.

ANTIFUNGAL ACTIVITY

The poison plate approach was used to provide antifungal activity.[32] For the evaluation of antifungal activity *Aspergillus niger, Aspergillus flavus, Fusarium moneliforme, and Penicillium chrysogenum* were chosen to assess the antifungal activities. Potato Dextrose Agar (PDA) media was utilized as a culture. To sterilize the medium, it was autoclaved at 121°C for 25 minutes under 15 psi of pressure. 20 ml of sterilized, melted PDA was added to sterilized petri plates with 2 ml of each component, and the mixture was then gently stirred in a circular motion to get homogenized. With positive Neomycin and negative DMSO controls, the identical process was followed. The fungal spores from the slant culture were transferred to a test tube containing sterile saline and thoroughly mixed with a sterile wire loop. As an inoculant, this spore solution was employed. The plates were incubated for four days at room temperature. Afterincubation, the growth of the infected fungi was monitored on the plates. The outcomes were noted.

CONCLUSION

In conclusion we have described the synthesis of Cu (II) and Zn (II) Schiff base metal complexes.The Cu (II) complexes of ligands L_1-L_4 shows octahedral geometry while Zn (II) complexes of the same ligand shows tetragedral structure. All the synthesized Complexes were screened for antibacterial and antifungal activity. All complexes of the Cu (II) and Zn (II) series showed moderate to good biological activity. Hence, it is concluded that there is ample scope for further developing this field.

Table No. 1 Analysis Cu (II) & Zn (II) Complexes.

S. No.	Metal Complexes	Molecular formula	Colour	M.P Decom °C	Mol. Wt.	Soln. Con.μ_v	Elemental analysis Found(Calculated)				
							%C	%H	%N	Cl	%Cu
(1)	$[Cu(L_1)_2]$	$[Cu(C_{16}H_{12}N_3O_2)_2(H_2O)_2]$	Green	250	656.16	17.02	58.53 (58.58)	4.16 (4.30)	12.64 (12.81)	-	9.62 (9.68)
(2)	$[Cu(L_2)_2]$	$[Cu(C_{16}H_{12}N_3O_2)_2(H_2O)_2]$	Pale Green	240	656.16	16.91	58.52 (58.58)	4.18 (4.30)	12.78 (12.81)	-	9.65 (9.68)
(3)	$[Cu(L_3)_2]$	$[Cu(C_{16}H_{12}N_3O_2)_2(H_2O)_2]$	Greenish	244	656.16	16.90	58.54 (58.58)	4.22 (4.30)	12.74 (12.81)	-	9.61 (9.68)
(4)	$[Cu(L_4)_2]$	$[Cu(C_{16}H_{11}ClN_3O_2)_2(H_2O)_2]$	Dirty Green	260	725.04	17.44	52.94 (53.01)	3.60 (3.61)	11.50 (11.59)	9.62 (9.78)	9.62 (9.29)
(5)	$[Zn(L_1)_2]$	$[Zn(C_{16}H_{12}N_3O_2)_2]$	yellowish White	249	621.96	12.15	61.77 (61.80)	3.81 (3.89)	13.55 (13.51)	-	10.50 (10.51)
(6)	$[Zn(L_2)_2]$	$[Zn(C_{16}H_{12}N_2O_2)_2]$	yellowish White	258	621.96	12.31	61.73 (61.80)	(3.89) 3.82	(13.51) 13.47	-	(10.51) 10.44
(7)	$[Zn(L_3)_2]$	$[Zn(C_{16}H_{12}N_3O_2)_2]$	Pale yellow	264	621.96	12.73	61.67 (61.80)	(3.89) 3.85	(13.51) 13.44	-	(10.51) 10.37
(8)	$[Zn(L_4)_2]$	$[Zn(C_{16}H_{11}ClN_3O_2)_2]$	yellowish	>300	690.85	13.44	55.60 (55.63)	3.11 (3.21)	12.24 (12.17)	10.26 (10.23)	9.42 (9.46)

Table No. 2 Magnetic Susceptibility Data of Cu (II) Complexes at Room Temperature

Sr. No	Cu (II) Complexes of ligand	$\chi_M \times 10^6$ (CGS)	$\chi_A \times 10^6$ (CGS)	μ_{eff} (B.M.)
1	4-hydroxy-3-(1-(pyridin-2-ylimino)ethyl)quinolin-2(1*H*)-one (L_1)	963.50	1268.56	1.74
2	4-hydroxy-3-(1-(pyridin-3-ylimino)ethyl)quinolin-2(1*H*)-one (L_2)	983.90	1312.68	1.77
3	4-hydroxy-3-(1-(pyridin-4-ylimino)ethyl)quinolin-2(1*H*)-one(L_3)	887.06	1239.56	1.72
4	3-(1-((5-chloropyridin-2-yl)imino)ethyl)-4-hydroxy quinolin-2(1H)-one (L_4)	1111.56	1449.56	1.86

Table No. 3Electronic Absorption Spectral Data of Cu (II) complexes

Sr. No	Cu(II) Complexes of Ligand	Absorption Maxima cm^{-1} (nm)		
		V_1	V_2	V_3
1	4-hydroxy-3-(1-((pyridin-4-yl)imino)ethyl) quinolin-2(1H)-one (L_3)	11630 (860)	15880 (630)	27777 (360)
2	3-(1-((5-chloropyridin-2-yl)imino)ethyl)-4-hydroxy quinolin-2(1H)-one (L_4)	11240 (890)	15880 (630)	27777 (360)

Table 4: EPR data of the Cu(II) complexes of the ligand L_3.

Complex	$g_{\parallel}$	$g_{\perp}$	g_{av}	G	μ_{eff}
$Cu(L_3)_2$	2.244	2.089	2.14	2.80	1.61

Table: 5XRD Study of Cu (II) Complex with L_3.

Crystal system: Monoclinic Lattice Type: P						
Lattice Parameter: a= 4.7754 b= 4.9566 c= 5.4416						
Lattice Parameter: Alpha= 90 Beta= 102 Gama=90						
Radiation: Cu WaveLength: 1.540598						
2Theta Start= 10 2Theta End= 79.98						
H	K	L	d	2Theta	SinT	SinT^2
0	0	1	5.4416	16.276	0.141557	0.020039
0	1	0	4.20594	21.106	0.183146	0.033542
-1	1	0	4.17004	21.29	0.184722	0.034122
-1	0	0	4.13562	21.469	0.18626	0.034693
1	0	0	4.13562	21.469	0.18626	0.034693
0	1	1	3.32778	26.768	0.231475	0.053581
-1	1	1	3.30991	26.915	0.232725	0.054161
-1	0	1	3.29262	27.059	0.233947	0.054731
1	0	1	3.29262	27.059	0.233947	0.054731
0	0	2	2.7208	32.892	0.283115	0.080154
-1	2	0	2.42818	36.991	0.317233	0.100637
1	1	0	2.4078	37.316	0.319918	0.102348
-2	1	0	2.38759	37.644	0.322626	0.104088
0	1	2	2.28447	39.411	0.337189	0.113696
-1	1	2	2.27867	39.516	0.338048	0.114276
1	0	2	2.273	39.619	0.33889	0.114847
-1	0	2	2.273	39.619	0.33889	0.114847
-1	2	1	2.21743	40.655	0.347383	0.120675
1	1	1	2.20188	40.955	0.349837	0.122386
-2	1	1	2.18639	41.258	0.352316	0.124126
0	2	0	2.10297	42.974	0.366291	0.134169
-2	2	0	2.08502	43.363	0.369445	0.136489
-2	0	0	2.06781	43.742	0.372519	0.138771
2	0	0	2.06781	43.742	0.372519	0.138771
0	2	1	1.96158	46.244	0.392693	0.154208
-2	2	1	1.94699	46.611	0.395636	0.156528
-2	0	1	1.93295	46.97	0.398509	0.158809
2	0	1	1.93295	46.97	0.398509	0.158809
0	0	3	1.81387	50.26	0.424672	0.180347
-1	2	2	1.81164	[illegible]	0.425195	0.180791

1	1	2	1.80313	50.58	0.427202	0.182502
-2	1	2	1.79459	50.838	0.429234	0.184242

Table: 6 XRD study of Zn (II) Complex with L_3.

Lattice Parameter: a= 4.9168 b= 5.1168 c= 5.4089						
Lattice Parameter: Alpha= 90 Beta= 99.4 Gama=90						
Radiation: Cu WaveLength: 1.540598						
2Theta Start= 10 2Theta End= 60						
H	K	L	d	2Theta	SinT	SinT^2
0	0	1	5.4089	16.375	0.142413	0.020282
1	0	0	4.9168	18.027	0.156667	0.024544
1	0	1	3.63827	24.447	0.211722	0.044826
1	1	0	3.4767	25.601	0.22156	0.049089
1	1	1	2.92464	30.542	0.263383	0.06937
0	0	2	2.70445	33.097	0.284827	0.081126
2	0	0	2.4584	36.52	0.313333	0.098178
1	0	2	2.36964	37.94	0.32507	0.105671
2	0	1	2.23807	40.263	0.344179	0.118459
2	1	0	2.19886	41.013	0.350317	0.122722
1	1	2	2.13466	42.305	0.360853	0.130215
2	1	1	2.03697	44.439	0.378159	0.143004
2	0	2	1.81913	50.104	0.423443	0.179304
0	0	3	1.80297	50.585	0.42724	0.182534
2	2	0	1.73835	52.606	0.44312	0.196356
2	1	2	1.7061	53.679	0.451496	0.203848
1	0	3	1.69275	54.137	0.455059	0.207078
2	2	1	1.65498	55.478	0.465443	0.216637
3	0	0	1.63893	56.069	0.47	0.2209
1	1	3	1.60055	57.537	0.481272	0.231623
3	0	1	1.56851	58.826	0.491103	0.241182
3	1	0	1.55483	59.395	0.495424	0.245445

Table No. 7: Infrared Absorption Frquencie(cm^{-1}) of Cu (II)& Zn (II) complexes.

Sr. No.	Ligand / Complex	Bond vibrational modes (stretching – ν) in cm^{-1}					
		'Lactam	Pyridine	Azo-methine	Enolic	New Peaks	
		(C=O)	(C=N)	(C=N)	(C-O)	M-O	M-N
5	$Cu(L_1)_2$	1655	1610	1592	1248	560	455
6	$Cu(L_2)_2$	1660	1608	1595	1240	540	457
7	$Cu(L_3)_2$	1658	1606	1590	1239	562, 486	452
8	$Cu(L_4)_2$	1668	1602	1589	1265	. 507	457
9	$Zn(L_1)_2$	1662	1608	1585	1254	494	445
10	$Zn(L_2)_2$	1668	1610	1592	1243	478	439
11	$Zn(L_3)_2$	1660	1603	1588	1246	498	463
12	$Zn(L_4)_2$	1665	1609	1592	1278	452	439

Table No.8: Anti- Bacterial and Anti-Fungal Activity.

Synthesized Schiff base ligands	Zone of Inhibition(diameter in mm)				Growth of Fungi			
	Gram Positive		Gram Negative		*A. niger*	*A. flavus*	*F. moniliforme*	*P. chrysogenum*
	S. typhi	*B. subtilis*	*E. coli*	*S. aureus*				
Ampicillin (Reference)	19	16	18	17	Neomycin (Reference) -	-	-	-
$Cu(L_1)_2$	18	18	18	17	++	++	+	++
$Cu(L_2)_2$	19	19	18	17	+	+	++	++
$Cu(L_3)_2$	18	18	17	18	+	+	+	-
$Cu(L_4)_2$	22	22	21		-	-	-	-

$Zn(L_1)_2$	17	18	19	18	++	++	++	++
$Zn(L_2)_2$	18	18	18	19	+++	+++	++	++
$Zn(L_3)_2$	18	19	19	20	-	-	++	++
$Zn(L_4)_2$	20	20	19	20	-	-	+	+

Moderate growth (++), Reduced growth (+) and No growth (-) of fungi

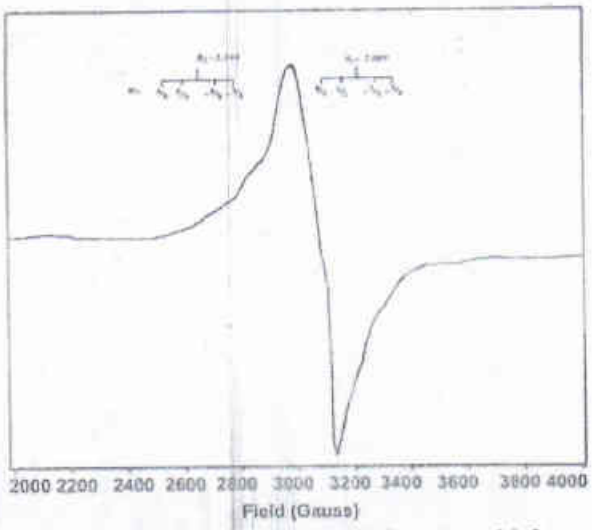

Fig. 2: ESR Spectrum of Cu (II) Complex with L_3.

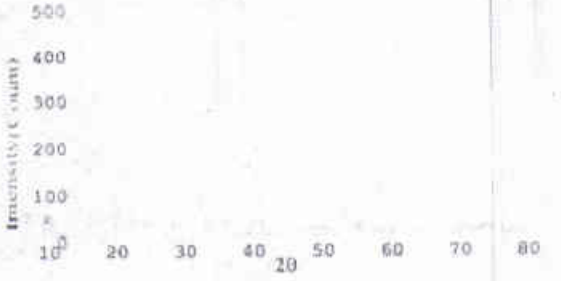

Fig.3 XRD Spectrum of Cu(II) Complex of Ligand L3

Fig.4 XRD Spectrum of Zn(II) Complex of Ligand L3

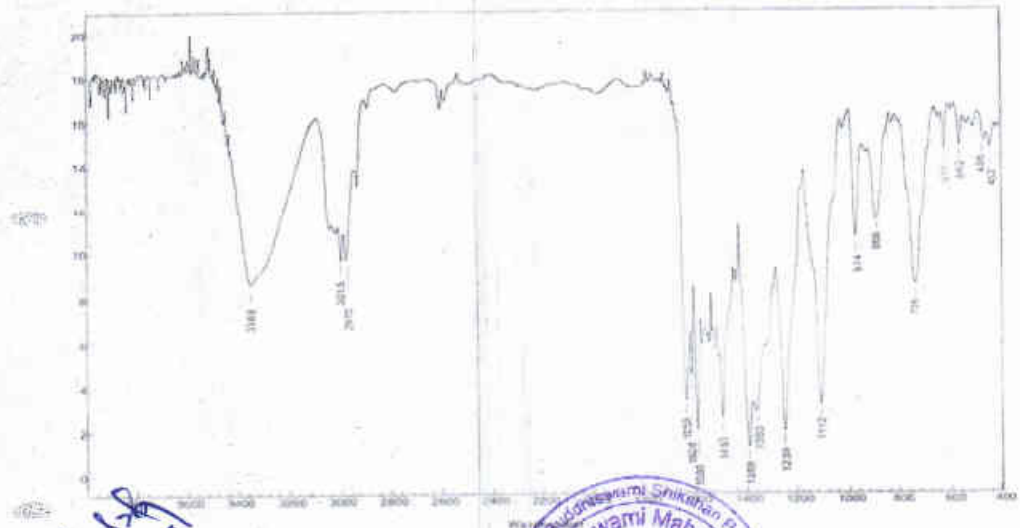

Fig. 5: IR Spectrum of Cu (II) o

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Purna (Jn) Dist. Parbhani - 431511 (M.S.)

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PRINCIPAL
Shri Guru Buddhiswami Mahavidyalaya
Purna (Jn.) Dist.Parbhani

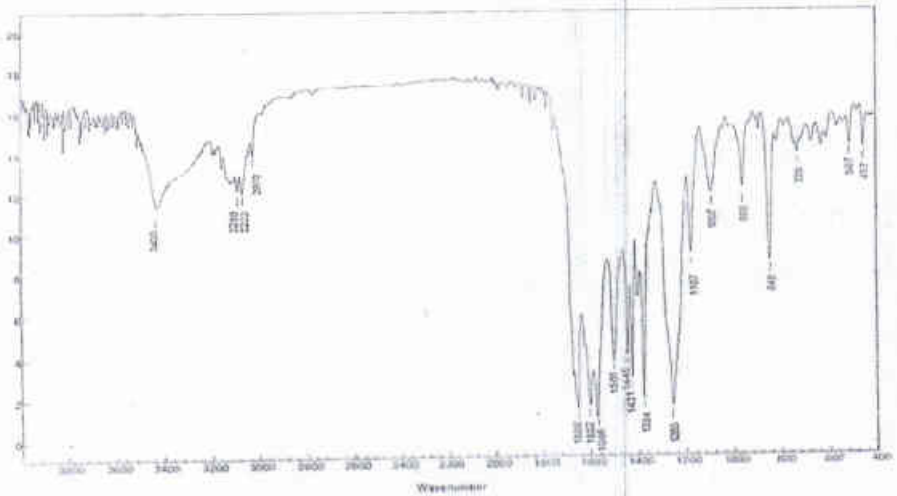


Fig. 6: IR Spectrum of Cu (II) Complex of L_4.

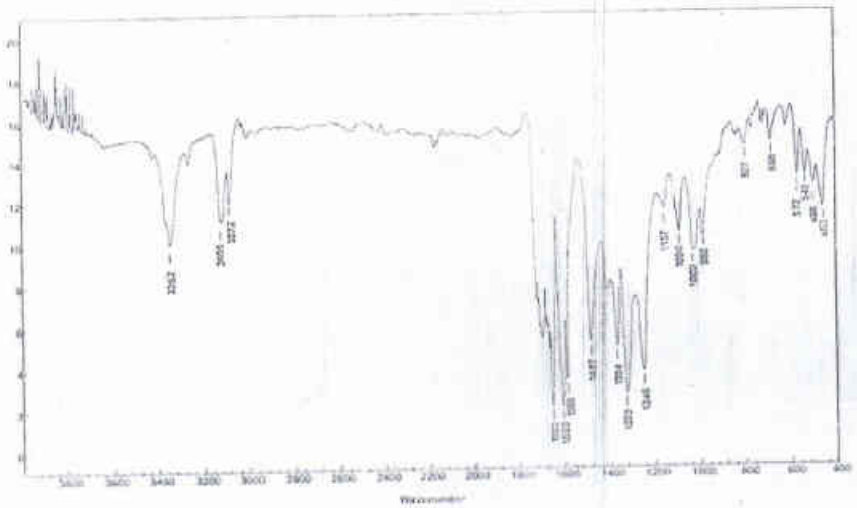


Fig. 7: IR Spectrum of Zn(II) complex of Ligand L_3.

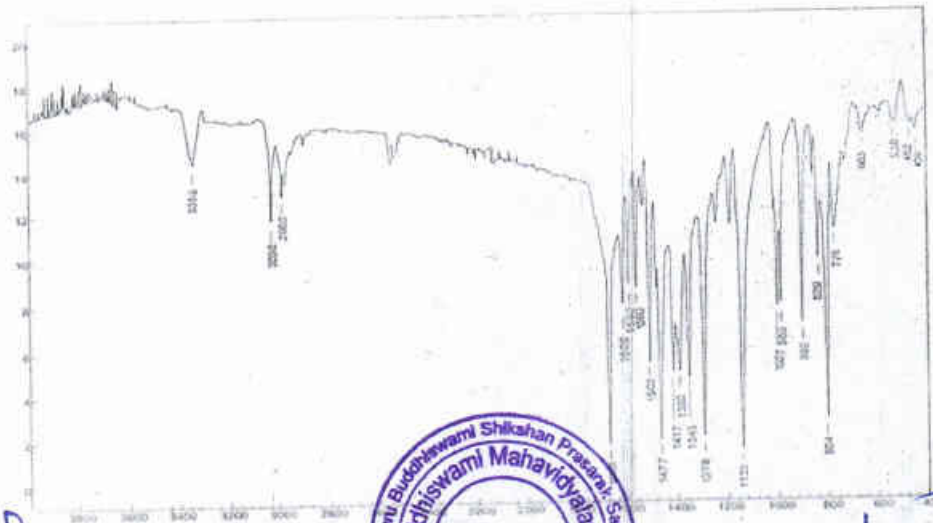
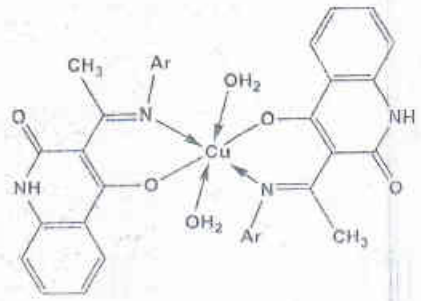
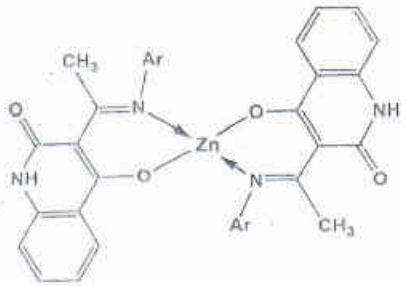


Fig. 8: IR Spectrum of Zn (II) Complex of L_4.



Structure I: Monomeric octahedral Structure of Cu(II)Complexes of Ligand L_1 to L_4



Structure II: Monomeric tetrahedral Structure of Zn(II) Complexes of Ligand L_1 to L_4

Fig. 9: Structure of Complexes.

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