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SCHIFF BASE COMPLEXES OF MANGANESE (II) AND COPPER (II) METALS : SYNTHESIS, SPECTROSCOPIC AND BIOLOGICAL ASPECTS

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ABSTRACT

New Schiff base complexes of Mn (II) and Cu (II) have been synthesized by the interaction of Mn (II) chloride and Cu (II) chloride with the semicarbazone and thiosemicarbazone of heterocyclic ketone 1,3–dihydro–3–[2–(phenyl)–2–oxo–ethylidene]–2H–indol–2–one in 1 : 1 and 1 : 2 molar ratios and their biochemical properties were studied. The complexes have been characterised by elemental analysis, electron spin resonance, infrared and electronic spectral studies. They have the composition $[MCl(L)H_2O]$ and $[M(L)_2]$ (where M = Mn (II) and Cu (II) for which a tetrahedral structure has been tentatively proposed.

Key words : Copper (II) complexes, Manganese (II) complexes, Schiff base, Biological activity, Spectral studies.

INTRODUCTION

Schiff bases constitute one of the most important class of biologically active ligands providing potential binding sites through nitrogen and sulfur/oxygen donor atoms. The case of formation of a variety of metal complexes from these ligands speak for their spectacular progress in coordination and bioinorganic chemistry. The metal thiosemicarbazone compounds are emerging as a new class of experimental anticancer chemotherapeutic agents[1–3], which exhibit inhibitory activities against most of the cancers through inhibition of a crucial enzyme obligatory for DNA biosynthesis and cell division[4,5]. The innovative work of the forerunners gives on inkling of the uses of transition metal derivatives as model compounds[6,7] in enzymatic mechanism[7,8], novel stoichiometric and catalytic oxygen transfer systems[9,10]. Schiff bases and their metal complexes play a key role in our understanding of the coordination chemistry of transition metal ions. They have evoked much interest due to their inherent biopotency[11], striking structural aspects and unique stereo–and magneto–chemistry[12]. The complexes of manganese play important role in photochemical reactions[13]. There is currently a resurgency of interest in the biochemistry as well as the coordination chemistry of bivalent manganese and copper due to their biological importance. Their complexes with Schiff bases have been found to exhibit fungicidal, bactericidal, antiviral and antitubercular activity. In view of this and our

interest in biologically active coordination compounds of Mn (II) and Cu (II), we report herein the reactions of $MnCl_2.4H_2O$ and $CuCl_2.2H_2O$ with various imines.

EXPERIMENTAL

All the chemicals and solvents used were dried and purified by standard methods. The reactions were carried out under anhydrous conditions.

Preparation of the ligands

The ligands were prepared by the condensation of heterocyclic ketone 1,3–dihydro–3–[2–(phenyl)–2–oxo–ethylidene]–2H–indol–2–one with hydrazinecarboxamide in the presence of sodium acetate in 1 : 1 (L_1H) and with hydrazinecarbothioamide in 1 : 1 molar ratio (L_2H) in absolute ethanol. These were purified by recrystallization from the same solvent and analysed before use.

Preparation of the metal complexes

The complexes were prepared by refluxing $MnCl_2.4H_2O$ and $CuCl_2.2H_2O$ with imines in 1 : 1 and 1 : 2 molar ratios in dry methanol (60 mL). The reaction mixture was refluxed for 12–24 hours on a fractionating column. After completion of the reaction, the excess of the solvent was distilled off and the product was dried *in vacuo*. It was repeatedly washed with dry n–hexane and again dried for 2 hours to obtain the purified product. The physical and analytical data of the compounds are enlisted in Table 1.

Table 1–Analytical and physical data of manganese (II) and copper (II) complexes

S.No.	Empirical formula	M.P. (°C)	Colour	Analysis (%)			Molecular weight Found (Calcd.)
				N found (Calcd.)	Cl Found (Calcd.)	M Found (Calcd.)	
1.	L_1H	180	Red solid	18.08 (18.31)	–		339 (306)
2.	L_2H	175	Red solid	17.11 (17.40)	–		296 (322)
3.	$C_{17}H_{15}O_3N_4ClMn$	230	Red	13.12 (13.54)	8.11 (8.56)	12.37 (13.27)	446 (414)
4.	$C_{17}H_{15}O_2SN_4ClMn$	210	Orange	12.85 (13.04)	7.94 (8.24)	12.24 (12.78)	402 (430)
5.	$C_{34}H_{26}O_4N_8Mn$	205	Red	16.17 (16.84)	–	8.07 (8.26)	638 (665)
6.	$C_{34}H_{26}O_2S_2N_8Mn$	198	Orange	17.26 (16.06)	–	7.46 (7.87)	676 (698)
7.	$C_{17}H_{15}O_3N_4ClCu$	215	Light brown	12.98 (13.27)	8.12 (8.40)	14.68 (15.06)	410 (422)
8.	$C_{17}H_{15}O_2SN_4ClCu$	204	Brown	12.16 (12.78)	7.88 (8.09)	14.26 (14.51)	420 (438)
9.	$C_{34}H_{26}O_4N_8Cu$	208	Mustard	16.41 (16.62)	–	9.08 (9.43)	646 (674)
10.	$C_{34}H_{26}O_2S_2N_8Cu$	195	Mustard	15.36 (15.86)	–	8.74 (9.00)	682 (706)

Nitrogen and sulphur were estimated by the Kjeldahl's and Messenger's methods, respectively. Molecular weights were determined by the Rast camphor method. Electronic spectra of the complexes were recorded in chloroform on a UV–160A Shimadzu spectrophotometer in the range 200–600 nm and conductivity was measured with a Systronics conductivity bridge (type 305). IR spectra were recorded on a Perkin Elmer 577 Grating spectrophotometer. EPR spectra got recorded from I.I.T Chennai.

RESULTS AND DISCUSSION

Manganese (II) chloride and copper (II) chloride react with monofunctional bidentate ketimines (L_1H and L_2H) having N and S/O coordinating site. The reaction proceeds by the successive replacement of chloride by ligand molecule as shown below –

$$MnCl_2.4H_2O + \widehat{NX}H \xrightarrow{MeOH} [MnCl(\widehat{NX})H_2O] + 3\ H_2O + HCl$$

$$MnCl_2.4H_2O + 2\ \widehat{NX}H \xrightarrow{MeOH} [Mn(\widehat{NX})_2] + 4\ H_2O + 2\ HCl$$

$$CuCl_2.2H_2O + \widehat{NX}H \xrightarrow{MeOH} [CuCl(\widehat{NX})H_2O] + H_2O + HCl$$

$$CuCl_2.2H_2O + 2\ \widehat{NX}H \xrightarrow{MeOH} [Cu(\widehat{NX})_2] + 2\ H_2O + 2\ HCl$$

$\widehat{NX}$ = donor group of the ligand and X = S/O

The resulting products are coloured, solids, monomeric and are soluble in methanol, DMSO and DMF.

The electronic spectra of the ligands display two maxima at ~ 270 and ~ 315 nm, which are due to π - π^* electronic transitions and remain almost unchanged in the spectra of the metal complexes. The band around 350 nm, due to n - π^* transition of the >C=N chromophore[14] shows a bathochromic shift of 25–35 nm in the complexes. This shift is due to the metal–ligand electronic interaction during the chelation.

In the IR spectra of the ligands the bands observed at ~ 3500 and ~ 3350 cm^{-1} are due to asymmetric and symmetric NH_2 vibrations[15], respectively. These bands are observed at almost the same position in the spectra of the metal complexes, suggesting the non–involvement of this group in chelation. A broad band in the region ~ 3150 cm^{-1} due to νNH vibrations in the spectra of ligands disappears in the spectra of the complexes suggesting the deprotonation of the α–nitrogen[16] after complexation with metal atom. The strong and sharp band at ~ 1610 cm^{-1} may be attributed to the νC=N vibrations. This band is shifted to lower frequency by 10–25 cm^{-1} in the spectra of the corresponding metal complexes. Another strong bands at 1695 cm^{-1} and ~ 1040 cm^{-1} in the spectra of ligands are due to νC=O and νC=S vibrations, respectively. These bands disappear in the spectra of the complexes indicatng the coordination of the ligand through the oxygen and sulphur. The new bands in the regions 840–690, 420–375 and 460–425

cm^{-1} are probably due to the coordinated water molecule and the formation of νM–N and νM–O bonds, respectively[17].

Table 2. IR spectral data of Mn (II) and Cu (II) complexes

Complexes	νNH_2	νC=N	νM–N	νM–O
$[MnCl(L_1)H_2O]$	3470–3358	1590	380	445
$[Mn(L_1)_2]$	3465–3362	1600	385	460
$[MnCl(L_2)H_2O]$	3485–3356	1585	395,	
$[Mn(L_2)]$	3460–3350	1580	420,	
$[CuCl(L_1)H_2O]$	3465–3350	1595	370	425
$[Cu(L_1)_2]$	3462–3356	1610	375	440
$[CuCl(L_2)H_2O]$	3464–3352	1587	380,	
$[Cu(L_2)_2]$	3462–3358	1585	395,	

The EPR spectra of the manganese complexes were recorded at room temperature. The 'g' values lie in the range 2.00–2.2 in the present complexes, which are in accordance with the values reported for tetracoordinated manganese complexes[18]. EPR spectra of $[Cu^{II}L_2]$ complexes shows anisotrophy in g values. The $g_{\|}$ value at 2.392 and $g_{\perp}$ value at 2.093 indicates that copper complexes are also tetracoordinated[19].

Biological aspects

The ligands and their metal complexes were tested for their growth inhibitory activity against pathogenic fungi, viz. *Fusarium oxysporum* and *Aspergillus niger* and bacteria viz. *Staphylococcus aureus* and *Escherichia coli.* Aseptic techniques were employed to prepare the culture of fungi and bacteria. The radial growth and paper disc plate methods were used to evaluate the antimycotic and antibacterial activities[20].

Antifungal and antibacterial activities of the ligands and their corresponding complexes are recorded in Table–3. The results show that bioactivity enhances on undergoing chelation. This can be well understood by considering the chelation theory. The chelation reduces the polarity of the central metal ion mainly because of the partial sharing of its positive charge with donor groups and possible π–electron delocalisation over the whole chelate ring. Such chelation increases the lipophilic character of the central atom, which subsequently favours its permeation through the lipid layer of the membrane[21].

Table 3. Antibacterial and antifungal activity of the ligands and their complexes

Complex	Antibacterial Diameter of inhibition zone (mm)				Antifungal Average (%) inhibition after 96 hrs.					
	Staphylococcus aureus		Escherichia coli		F. oxysporum			A. niger		+
	500 ppm	1000 ppm	500 ppm	1000 ppm	50 ppm	100 ppm	200 ppm	50 ppm	100 ppm	200 ppm
L_1H	5	6	3	4	32	50	68	34	52	69
L_2H	5	7	5	6	36	53	71	38	56	74
$[MnCl(L_1)H_2O]$	5	6	5	6	42	59	76	43	60	76
$[Mn(L_1)_2]$	6	8	6	7	54	64	87	56	66	90
$[MnCl(L_2)H_2O]$	6	7	6	7	45	62	79	48	63	82
$[Mn(L_2)]$	7	9	7	8	58	67	92	60	69	96
$[CuCl(L_1)H_2O]$	6	7	5	7	43	61	77	46	65	79
$[Cu(L_1)_2]$	7	8	6	8	55	64	89	56	67	90
$[CuCl(L_2)H_2O]$	7	8	6	7	47	63	81	49	65	84
$[Cu(L_2)_2]$	8	10	7	9	60	73	96	62	75	98

REFERENCES

1. W. K. Subezynski, W. E. Antholine, J. E. Hyde and D. H. Petering, J. Am. Chem. Soc., **109**, 46 (1987).
2. A. Murugkar, B. Unnikrishnan, S. B. Padhye, R. Bhonde, S. Teat, E. Triantafullan and E. Sinn, Metal Based Drugs, **6**, 177 (1999).
3. A. Murugkar, S. B. Padhye, S. Guha–Roy and U. Wagh, Inorg. Chem. Commun., **2**, 545 (1999).
4. K. C. Agrawal and A. C. Sartorelli, Prog. Med. Chem., **15**, 351 (1978).
5. L. R. Saryam, E. Anker, C. Krishnamurthi and D. H. Petering, J. Med. Chem., **22**, 1218 (1979).
6. S. Ozawa, Y. Watrnabe, S. Nakashima, T. Kitogawa and I. Morishima, J. Am. Chem. Soc., **116**, 634 (1994).
7. P. I. Persiki, S. V. Khangulor, D. M. Ho and G. C. Dismukes, J. Am. Chem. Soc., **16**, 891 (1999).
8. K. Weighardt, Angew. Chem. Int. Ed. Engl., **28**, 1153 (1990).
9. A. S. Goldstein, R. H. Beer and R. S. Drago, J. Am. Chem. Soc., **116**, 2424 (1994).

10. C. G. Young, A. G. Wedd, In "Encyclopedia of Inorganic Chemistry", R. B. King, Ed. Wiley, New York (1994) p. 2330.
11. I. Haiduc, Coord. Chem. Rev., **99**, 253 (1990) and references therein.
12. B. Singh, R. N. Singh and K. C. Agarwal, Polyhedron. **4**, 401 (1985).
13. Taozhang–Hai and T. L. Brown, J. Am. Chem. Soc., **115**, 107 (1993).
14. S. Belwal, Seema, N. Fahmi and R. V. Singh, Indian J. Chem., **38A**, 597 (1999).
15. D. Singh and R. V. Singh, Main Group Met. Chem., **13**, 309 (1990).
16. A. Garg and J. P. Tandon, Synth. React. Inorg. Met Org. Chem., **18**, 705 (1988).
17. A. K. Panda, D. C. Dash, P. Mishra and H. Mahanthy, Indian J. Chem., **35A**, 376 (1996).
18. L. Mishra, Synth. React. Inorg. Met.–Org. Chem., **16**, 831 (1986).
19. G. S. Reddy, B. Sireesha, Ch. Sarla Devi, R. Mohiuddin, C. Gyana Kumari and M. G. Ram Reddy, J. Indian Chem. Soc., **75**, 290 (1998).
20. C. Saxena, D. K. Sharma and R. V. Singh, Phosphorus, Sulfur and Silicon, **85**, 9 (1993).
21. B. G. Tweedy, Phytopathology, **55**, 910 (1964).

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