

Synthesis, Characterization and Biological Properties of Mn(II), Co(II), Ni(II) and Cu(II) Chelates of Some Schiff Bases Containing N-S-O and N-O-O Moiety

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Metal chelates of bivalent transition metal ions have been synthesized by the reaction of *o*-(N- α -thiophene-2-aldimino)phenol (HTP), *o*-(N- α -furfuraldimino)phenol (HFP) and *o*-(N-benzofuran-2-yl methylimino) benzene sulphonic acid (HBB) with corresponding metal(II) acetate. The complexes have been characterized on the basis of their elemental analysis, potentiometric studies, conductance measurement and spectral analysis. The complexes have been screened for their biocidal activities against bacteria *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* and *Streptococcus pyogenes* and fungi *Aspergillus niger*, *Draschelera australiensis* and *Helminthosporium oryzae*. The metal chelates were found to be potent antimicrobial agents compared to the ligands.

Key Words: Synthesis, Biological, Mn(II), Co(II), Ni(II) and Cu(II), Chelates, Schiff bases.

INTRODUCTION

The Schiff bases have pronounced biological activities^{1,2} and form a class of important compounds in medicine and pharmaceutical field. Most of the common biologically active compounds have structures quite suitable for chelation with metal ions and studies on the chelation tendency of various organic compounds have supported the hypothesis that formation of strain free chelate rings enhances the biological activity. In the recent years immense interest has been developed in metal complexes with ligand containing N-S-O and N-O-O moieties³. In the light of our earlier observation^{4,5} we have extended work on the synthesis and characterisation of heterocyclic complexes of Mn(II), Co(II), Ni(II) and Cu(II) with *o*-(N- α -thiophene-2-aldimino)phenol (HTP), *o*-(N- α -furfuraldimino)phenol (HFP) and *o*-(N-benzofuran-2-yl methylimino) benzene sulphonic acid (HBB). In order to evaluate the micro-biological significance, their antibacterial and antifungal activity were also carried out.

EXPERIMENTAL

The ligand *o*-(N- α -thiophene-2-aldimino)phenol (HTP), *o*-(N- α -furfuraldimino) phenol (HFP) and *o*-(N-benzofuran-2-yl methylimino) benzene sulphonic acid (HBB) were synthesized by refluxing equimolar ethanolic solu-

tions of *o*-amino phenol with thiophene-2-aldehyde or furfuraldehyde in the presence of $\text{CH}_3\text{COONa} + \text{CH}_3\text{COOH}$ and benzofurane-2-yl methyl ketone with orthanilic acid using piperidine as condensing agent. The brownish yellow precipitate formed was filtered and dried in vacuum. The authenticity and purity of the ligands were established by elemental analysis, molecular mass and IR spectra.

The metal salt (BDH) and other solvents were reagent grade chemicals.

HTP, HFP or HBB (0.01 mole) was dissolved in 30–50 mL of 80% ethanol and mixed with solution of respective metal(II) acetate (0.005 mole) in 10–15 mL of 80% ethanol. The reacting solution was refluxed in nitrogen atmosphere on a steam bath for 2–3 h. The crystalline solid obtained was filtered, washed with ethanol and recrystallized from acetone. 80–87% yield was obtained.

The materials, apparatus and methods used were the same as described previously^{6,7}.

The bacterial activity of Schiff bases and their metal chelates was carried out against 24 h cultures of four selected bacteria. The organisms tested were *S. aureus*, *E. coli*, *B. subtilis* and *S. pyogenes*. The bacterial activity was performed by cup-plate technique. The agar cups were made by preceeded (12 mL) melted agar medium at 50°C by boring 1 cm thick broth culture on a plate by 10 mm cork borer. Two drops of the melted agar were pipetted into it, incubated for 24 h and zone of inhibition observed. Streptomycin was used as a standard. Three replicates were maintained for each treatment and the results obtained are presented in Table-1.

TABLE-1
ANTIBACTERIAL SCREENING HTP, HFP AND HBB AND THEIR BIVALENT METAL
CHELATES IN DMF

Compound	Diameter of zone of inhibition (mm)				
	Ligands/Metal-Chelates	<i>S. aureus</i>	<i>E. coli</i>	<i>B. subtilis</i>	<i>S. pyogenes</i>
HTP		8.9	7.9	9.7	8.7
Mn(II)		10.0	9.2	11.4	9.8
Co(II)		14.5	10.6	13.9	12.0
Ni(II)		15.2	11.0	15.5	13.0
Cu(II)		11.0	9.0	12.2	10.0
HFP		8.3	6.7	8.5	8.2
Mn(II)		9.2	7.0	10.1	8.8
Co(II)		13.2	8.5	12.1	10.0
Ni(II)		14.6	10.7	14.8	12.0
Cu(II)		10.0	8.0	11.7	9.1
HBB		8.6	7.3	9.0	8.5
Mn(II)		9.5	8.0	10.7	9.1
Co(II)		13.9	9.1	13.1	11.2
Ni(II)		15.0	10.9	14.9	12.3
Cu(II)		10.4	8.6	11.8	9.6

All the complexes have been screened for their antifungal activity by Vincent technique against fungi *A. niger*, *D. australiensis* and *H. oryzae*. A suspension of spores of the test organism was produced by shaking a three day old culture of the organism with 0.85% saline (10 mL) in a test tube (10.0 mL) and successive 9.0, 8.0, 7.0, 6.0 and 5.0 mL aliquots of the liquid medium were inoculated with one drop of the spore suspension applied by means of a pasture pipette. To the aliquot was added sufficient to an acetone solution of the compound being tested from a calibrated, sterile pasture pipette, to produce a final concentration of 10, 100 and 1000 ppm. The tubes were incubated at 28°C for 24 h and percentage growth inhibited was measured. A control test with no active gradient was also carried out. TBTO (tri-*n*-butyl tin oxide) was used as reference compound. Three replicates were maintained for each treatment. Inhibition of the fungus growth was determined as difference in growth between the control plate and those treated with the test compounds.

RESULTS AND DISCUSSION

The 1 : 2 (metal-ligand) stoichiometry is established on the basis of analytical results. Thus, they may be represented as $[M(TP)_2]$, $[M(FP)_2]$ or $[M(BB)_2]$ where M = Mn(II), Co(II), Ni(II), Cu(II) and HTP = $C_{11}H_9NSO$, HFP = $C_{11}H_9NO_2$ or HBB = $C_{16}H_{13}NSO_4$ which is also supported by elemental analysis, molecular mass and thermogravimetric data. The non-electrolytic character of the metal chelates is evident from the low molar conductance (3.1 to $10.2 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$) in DMSO.

Study of magnetic and electronic spectral data is quite informative in characterizing the octahedral geometry of the complexes. In case of Cu(II) chelates the observed magnetic moments and electronic spectra suggest a distorted octahedral geometry in terms of Jahn-Teller effect.

Spectral parameters like nephelauxetic ratio, Dq, Racha's interelectronic repulsion parameter (B), δ , F_2 , F_4 , C, β_0 , v_2/v_1 and LFSE were calculated using standard relationships. All these parameters also support the stereochemistry assigned to Mn(II), Co(II), Ni(II) and Cu(II) chelates under study and are in fairly good agreement with the results.

Comparison of the IR spectra of the ligand with those of their bivalent metal chelates indicated coordination of the ligand through azomethine nitrogen besides phenolic oxygen and thiophene ring sulphur in HTP; phenolic and furfural ring oxygen in HFP; sulphonic and benzofuran ring oxygen in HBB and supported by appearance of $\nu(M-N)$, $\nu(M-O)$ and $\nu(M-S)$ bands $425-400 \text{ cm}^{-1}$, $560-540 \text{ cm}^{-1}$ and $315-295 \text{ cm}^{-1}$ regions respectively.

The 1H NMR spectra findings stated that the signals due to —OH proton of the ligands HTP and HFP at δ 8.15 and 8.38 ppm, respectively and signals due to —SO₃H proton of the ligand HBB at δ 11.10 ppm, were absent in the spectra of the corresponding metal complexes, suggesting their replacement by the metal ions on chelation.

Antimicrobial screening data reveal that the toxicity of metal chelates has increased considerably as compared to their parent ligand against the same micro-

organism and under identical experimental conditions. HTP and HBB were found to possess better antibacterial property than HFP; this may be attributed to the presence of ring sulphur (HTP) and strong acidic (SO₂OH) group (HBB). While comparing the toxicity of metal chelates Ni(II) seems to display better antibacterial characteristics than those of Mn(II), Co(II), and Cu(II) chelates. All ligands were found less effective towards *E. coli*.

On the basis of average % inhibitions observed after 24 h all the compounds were found to display moderate to good level of toxicity against the fungi at 1000 ppm, but their toxicity decreased markedly on dilution at 100 and 10 ppm. They were, however more toxic against *H. oryzae*. Cu(II) chelates were found to be more fungi-toxic than rest of the metals used.

The increase in the activity of metal chelates may be due to the effect of metal ions on the normal cell process. The polarity of the metal ion is considerably reduced on chelation which is mainly because of partial sharing of its positive charge with the donor groups and possibly π -electron delocalization over the whole chelate ring⁸. Such chelation increases the lipophilic character of the metal complexes which probably leads to breakdown of permeability barrier of the cells resulting in interference with normal cell process.

REFERENCES

1. E.M. Hodnett and W.J. Dunn, *J. Med. Chem.*, **13**, 768 (1970).
2. A.Z. Halve and A. Goyal, *Oriental. J. Chem.*, **12**, 87 (1996).
3. K.C. Satapathy and G.C. Pradhan, *J. Indian Chem. Soc.*, **66**, 92 (1989).
4. V. Chowdhary, M. Parihar and R.K. Mehta, *Z. Phys. Chemie. Leipzig*, **271**, 413 (1990).
5. A.K. Gehlot, S. Sharma and R.K. Mehta, *Z. Phys. Chemie. Leipzig*, **268**, 315 (1987).
6. V. Choudhary, M. Parihar, B.R. Patel, S. Sharma and R.K. Mehta, *J. Indian Inst. Sci.*, **69**, 339 (1989).
7. V. Choudhary, B.R. Patel, R. Goyal, V. Gupta and R.K. Mehta, *Z. Prakt. Chemie Leipzig*, **4**, 573 (1990).
8. R.S. Srivastava, *Inorg. Chim. Acta*, **56**, 165 (1981).

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