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Synthesis, characterization and antimicrobial activity of Co(II), Cu(II), and Mn(II) metal complexes of Schiff base ligand derived from cinnamaldehyde and ethylenediamine

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Abstract
Transition metal complexes of Co(II), Cu(II) and Mn(II) Containing Bidentate Schiff base, derived from the condensation of ethylenediamine and cinnamaldehyde were synthesized and characterized by IR, UV- Vis., and some physical measurements. IR spectral studies show the binding sites of the Schiff base ligand with the metal ion. Molar conductance data and magnetic susceptibility measurements give evidence for monomeric and electrolytic nature of the complexes. The complexes have been found to have moderate antimicrobial activity against the tested bacteria.

Keywords: Transition metal complex, Antimicrobial activity, Schiff base

1. Introduction
Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Hugo Schiff in 1864. These compounds containing a general formula RHC=N-R' where R and R' are alkyl, aryl, cyclo alkyl or heterocyclic groups are also known as anils, imines or azomethines [1]. Several studies showed that the presence of a lone pair of electrons in sp^2 hybridized orbital of nitrogen atom of the azomethine group is of considerable chemical and biological importance. Because of the relative easiness of preparation, synthetic flexibility, and the special property of C=N group, Schiff bases are generally excellent chelating agents, especially when a functional group like –OH or –SH is present close to the azomethine group so as to form a five or six membered ring with the metal ion [2, 3]. Schiff bases are well known for their biological applications as antibacterial, antifungal, anticancer and antiviral agents [4, 5]. Also, Schiff base metal complexes have been widely studied because they have industrial, antifungal, antibacterial, anticancer herbicidal applications [6], antitubercular activities [7] and chelating abilities which give it attracted remarkable attention [8].

Recently, we studied few transition metal complexes and studied their antimicrobial properties [11-20]. In the present work, Transition metal complexes of Co(II), Cu(II) and Mn(II) Containing Bidentate Schiff base, derived from the condensation of ethylenediamine and cinnamaldehyde were synthesized, characterized and also studied their antibacterial properties.

2. Experimental
2.1 *Reagents and Chemicals*
All the reagents used were of analar or chemically pure grade. Solvents were purified and dried according to standard procedures.

2.2 *Physical Measurements*
The melting or decomposition temperatures of all the prepared metal complexes were observed in an electro thermal melting point apparatus model No.AZ6512. The SHERWOOD SCIENTIFIC Magnetic Susceptibility Balance was used for the present investigation. Infrared spectra as KBr disc were recorded in a SIMADZU FTIR-8400 (Japan) infrared spectrophotometer, from 4000-400 cm^{-1}. The absorbances of the complexes were recorded on SHIMUDZU Spectrophotometer.

3. General method for the preparation of the complexes

Preparation of $[Cu(C_{11}H_{14}N_2)_2](NO_3)_2$: 0.240g (4 mmol) of ethylenediamine was dissolved in 10 mL ethanol and 0.529 g (4 mmol) of cinnamaldehyde was dissolved in 10 mL of ethanol. The solution of ethylenediamine and cinnamaldehyde were mixed. Then the mixed solution was poured in the canonical flask containing 0.483 g (2 mmol) of $Cu(NO_3)_2.3H_2O$ ethanol solution and stirred for 4 hours at ambient temperature and allowed to stand for half an hour. An ash precipitate was filtrate off and dried in a vacuum desiccator over anhydrous $CaCl_2$. Co(II) and Mn(II) metal complexes were prepared following the same procedure stated above.

4. Results and Discussion

4.1. *Physical Properties*

The conductance values of the complexes are shown in the Table-1. All three complexes are electrolytic in nature. The structural assignment of the complexes were based on the elemental analysis which are in good agreement with the proposed structures (Figure 1) Table-2.

4.2. *IR spectra*

Selected Infrared spectral data of the complexes are shown in the Table-3. The spectral data of the complexes showed a strong absorption band at (1580-1620) cm^{-1} due to ν (C=N) stretching, band at (3045-3065) cm^{-1} is due to aromatic ν(C-H) stretching and also the band at (740-800) cm^{-1} is due to ν (M-N) stretching which indicated the coordination through N atom to the metal. A band at (3300-3500) cm^{-1} was found is due to ν(N-H) stretching of ν(NH_2) modes.

4.3. *Magnetic moment and electronic spectra.*

Significant UV-visible spectral bands of the complexes in dimethyl sulfoxide (DMSO) have presented in the Table-1. The observed absorption bands in the region 200-400 nm are due to the charge transfer. The observed magnetic moment of the complexes at room temperature is also given in Table-1. The magnetic moment values of the complexes indicated that these complexes are high spin paramagnetic with tetrahedral geometry.

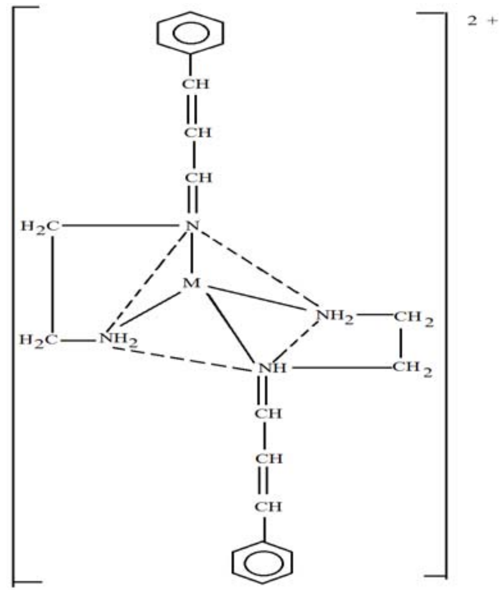

Fig 1: Proposed Tetrahedral structure of the complexes.

Here, M = Co(II), Cu(II) and Mn(II)

Therefore, on the basis of the elemental analysis, magnetic moment, conductance measurements, IR spectra, UV-visible spectra and other physical properties, the suggested structures of the complexes are tetrahedral as shown in Figure-1.

Table 1: Physical properties of the complexes.

Complexes	Colour	Melting point (±5°C)	% Yield	Molar conductance ($ohm^{-2}cm^2mol^{-1}$)	μ_{eff} (B.M)	λ_{max} (nm)
$[Cu(C_{11}H_{14}N_2)_2](NO_3)_2$	Ash	190 (d)	63	108	1.78	332
$[Co(C_{11}H_{14}N_2)_2](NO_3)_2$	Orange	180 (d)	60	104	3.93	363
$[Mn(C_{11}H_{14}N_2)_2](SO_4)$	Gray	110 (d)	62	62	5.88	320

Table 2: Elemental analysis data of the complexes.

Complexes	% Carbon		% Hydrogen		% Nitrogen	
	Calculated	Found	Calculated	Found	Calculated	Found
$[Cu(C_{11}H_{14}N_2)_2](NO_3)_2$	49.29	49.27	5.26	5.13	15.68	15.55
$[Co(C_{11}H_{14}N_2)_2](NO_3)_2$	49.72	49.62	5.31	5.19	15.81	15.74
$[Mn(C_{11}H_{14}N_2)_2](SO_4)$	52.90	52.75	5.65	5.56	11.22	11.15

Table 3: Selected infrared spectral bands of the complexes.

Complexes	ν(C=N) (cm^{-1})	ν(C-H) aromatic (cm^{-1})	ν(NH_2) (cm^{-1})	ν(M-N) (cm^{-1})
$[Cu(C_{11}H_{14}N_2)_2](NO_3)_2$	1593	3040	3454	761
$[Co(C_{11}H_{14}N_2)_2](NO_3)_2$	1610	3020	3417	753
$[Mn(C_{11}H_{14}N_2)_2](SO_4)$	1614	3050	3450	750

5. Antibacterial Activity of the Metal Complexes

The microorganisms adsorb metal ions on their cell walls and as a result respiration processes of cells are disturbed and protein synthesis is blocked which is the requirement for further growth of organisms. The growth inhibition effects of metal ions are considerable. The susceptibility of microorganism to antimicrobial agents can be determined *in vitro* by a number of methods. The disc diffusion technique is widely acceptable for preliminary investigations of compounds, which are suspected to possess antimicrobial properties. Antimicrobial activities of the test samples are expressed by measuring the zone of inhibition observed around the area.

The present results revealed that the complexes are more microbial toxic than the free metal ions or ligands. The Schiff base complexes (Table 4) showed moderate activity against both Gram positive and Gram negative bacteria compared to standard Kanamycine.

Table 4: antibacterial activity of the complexes.

Bacteria	Gram Staining	Diameter of zone inhibition (in mm)		
		$[Cu(C_{11}H_{14}N_2)_2](NO_3)_2$ μg/disc	$[Co(C_{11}H_{14}N_2)_2](NO_3)_2$μg/disc	K- 30 μg/disc
Bacillus subtilis	Positive	10	09	28
Streptococcus aureus	Positive	10	09	31
Streptococcus -β-haemolyticus	Positive	13	10	25
Escherichia coli	Negative	11	13	29
Shigella dysenteriae	Negative	12	11	31
Shigella sonnei	Negative	09	11	28

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