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Synthesis, Characterization And Antimicrobial Activity of Schiff Base Metal Complexes

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ABSTRACT

Co(II), Fe(III) and Cu (II) metal complexes of Schiff base derived from ethylenediamine, succinic acid and formaldehyde. The newly synthesized Schiff base complexes were characterized by elemental analysis, Melting point, conductivity, IR and UV-VIS spectral methods. The complexes have been tested for their antimicrobial activity against bacteria and fungi. The anti- microbial activity was determined in Mueller Hinton media (M H Media).

Keywords: Schiff base complex synthesis, characterization, antimicrobial activity.

INTRODUCTION

Schiff bases are versatile ligands that are synthesized from the condensation of primary amines with carbonyl groups. Schiff bases are an important class of ligands that co-ordinate with metal ions via azomethine (-CH=N-) nitrogen and have been studied extensively. The azomethine linkage is essential for biological activity and several azomethines were reported to possess antibacterial, antifungal, anticancer and diuretic activities [1]. Schiff bases are generally bi,tri or tetradentate ligands capable of forming very stable co-ordination compounds with transition metal ions. Schiff base reactions are useful in making carbon- nitrogen bonds in organic synthesis. Schiff bases appear to be an important intermediate in various enzymatic reactions [2].

A large number of Schiff bases and their coordination compounds have been extensively studied for their important properties e.g. their ability to bind reversibly with oxygen, catalytic activity in hydrogenation of olefin , transfer of an amino group and complexing ability towards some toxic metals [3]. Schiff base derived from aromatic aldehydes or their metal coordination compounds catalyze reactions like oxygenation, hydrolysis, electroreduction and decomposition [4]. Schiff bases have also been shown to exhibit a broad range of biological activities, including antifungal, antibacterial, antimalarial, antiproliferative, anti-inflammatory, antiviral, and antipyretic properties [5,6]. Imine or azomethine groups are present in various natural, natural-derived, and non-natural compounds. The imine group present in

such compounds has been shown to be critical to their biological activities [7-9].The chemotherapeutic Schiff bases are attracted the attention of biochemists [10].

MATERIALS AND METHODS

All chemicals used were of analytical grade (AR) reagents and of the highest purity available. They included ferric chloride anhydrous (fisher scientific), cobalt(II) chloride hexahydrate (RANKEM), cupric(II) chloride dihydrate (fisher scientific), ethylenediamine(MERCK), succinic acid (Sd.Fine. chem ltd.) and formaldehyde (MERCK).

Elemental analyses were performed using an elemental analyser. The conductance of the complexes was measured on a Conductometer at 25^0C. The IR spectra were recorded in a spectrometer (4000-400 cm^{-1}). The UV –VIS electronic spectra (200-800 nm) were recorded using double beam spectrophotometer. The geometries of the metal complexes were evaluated using the molecular calculation.

Template synthesis of Schiff base metal complexes: An ethanolic solution of MXn (0.00105 mols) [M=Co(II),Fe(III) and Cu(II)] is added slowly to an ethanolic solution of ethylenediamine (0.0021 mols) with constant stirring. The mixture is refluxed for one hour at 80^0C. Then an ethanolic solution of succinic acid (0.00105 mols) is added drop wise and the mixture is refluxed for about 6 hours at 80^0C. Finally an ethanolic solution of formaldehyde (0.0021 mols) is added drop wise and the reaction mixture is refluxed for about 3 h at 80^0C.The mixture is then filtered, washed with ethanol and dried the residue.

RESULTS AND DISCUSSION

Elemental analysis and molar conductance: The metal complexes CoSAF and CuSAF are soluble in water while FeSAF is insoluble in water but soluble in DMSO. The analytical data and physical properties of the complexes are presented in the table 1. The data are consistent with the calculated results from the empirical formula of each compound.

Table1: Elemental analysis, specific conductivity and melting points of the complexes.

Compounds	Emperical formula	mol.wt., g/mol	Elemental analysis found(calculated)%			Specific conductance mS/cm	Melting point ^{0}C
			C	H	N		
Co-complex	$C_{10}H_{18}O_2N_4CoCl_2$	356	32.36 (33.71)	4.81 (5.056)	14.94 (15.73)	0.30	292
Fe- complex	$C_{10}H_{18}O_2N_4FeCl_2$	353	32.42 (33.99)	4.91 (5.14)	24.31 (25.86)	0.18	282
Cu- complex	$C_{10}H_{18}O_2N_4Cu$	289.5	39.07 (41.45)	5.85 (6.22)	18.42 (19.34)	0.36	171

Specific conductance of Co-complex=0.30mS cm^{-1} at 25^0C,Specific conductance of Cu-complex=0.36mS cm^{-1} at 25^0C, Specific conductance of Fe-complex =0.18mS cm^{-1} at 25^0C. The above conductance values indicates that the complexes are electrolytes [11]

IR Spectra: The significant IR bands for the complexes are complied and presented in table 2. The IR spectrum of the complexes, a sharp band observed at 1616 cm^{-1} is assigned to the (C=N) mode of the azomethine group. This shifts to lower wave number 1606- 1609 cm^{-1} in all the complexes suggesting the co-ordination of the azomethine nitrogen to the metal centers. A strong band observed at 1640-1690 cm^{-1} is assigned to (C=O, amide) of the ligand.

Table 2. FT-IR spectral data for the metal complexes

Componds	V(C=O), cm^{-1}	V(C=N), cm^{-1}	V(M-N), cm^{-1}	V(C-N), cm^{-1}	V(N-H), cm^{-1}
Co-complex	1640-1690	1600-1620	457-464	1080-1360	3100-3500
Fe- complex	1640-1690	1600-1620	457-464	1080-1360	3100-3500
Cu- complex	1640-1690	1600-1620	457-464	1080-1360	3100-3500

UV-Vis Electronic spectra: The UV-VIS spectral data of the complexes are presented in table3. The electronic absorption spectra of the complexes of Cobalt and Copper were recorded in double distilled water while that of Fe-complex was recorded in DMSO in the range 200-700 nm. For the complex of Cobalt absorption peak was found at 478 nm and 413 nm and for the complex of iron absorption peak was found at 644.5 nm, 463.0 nm, 446.5 nm, 363.5 nm and209.0 nm. For the complex of Copper absorption peak was found at 236.4 nm and 213.0 nm.

APPLICATIONS

Antimicrobial Studies: The free Schiff base and its complexes had been tested for their antibacterial activity against Pseudomonas aeruginosa, Proteus vulgaris, Proteus mirabilis, Klebsiella pneumonia and Staphylococcus aureus. Fe(III)complexes with Schiff base ligands derived by the condensation of o-phenylenediamine, salicylaldehyde and isatin/2-hydroxyl naphthaldehyde/acetylacetone were synthesized by A.Nagajothi and his co-workers [12].The complexes were screened for antimicrobial activities against the bacteria Staphylococcus aureus, Escherichia coli and fungi Candida albicans. The in vitro biological screening effects of the investigated compounds were tested against the bacteria, Klebsiella pneumonia and salmonella typhi and fungi. Stock solutions of 2 mg of the complexes were dissolved in 1ml distilled water while 2 mg of the compound Fe-complex was dissolved in1ml DMSO. Serial dilution of the compounds were prepared in sterile distilled water to determine the minimum inhibitory concentration (MIC) .Different dilution of the stock solution were applied on the 10mm diameter sterile disc .The discs were placed on a incubator for 3 days .Antibacterial and antifungal potential of the complexes were assessed in terms of zone of inhibition of bacterial and fungal growth in figures 1-3.

The minimum inhibitory concentration (MIC)were calculated as the highest dilution showing complete inhibition of the tested bacterial and fungal strains and are reported in Table 4-7. The complexes were effective against both bacteria and fungi. It is evident from the table 7 that the MIC values for the complexes of Fe- and Cu- were 1.0mg ml^{-1} while that of Co-complex was 1.2mg ml^{-1} [12].

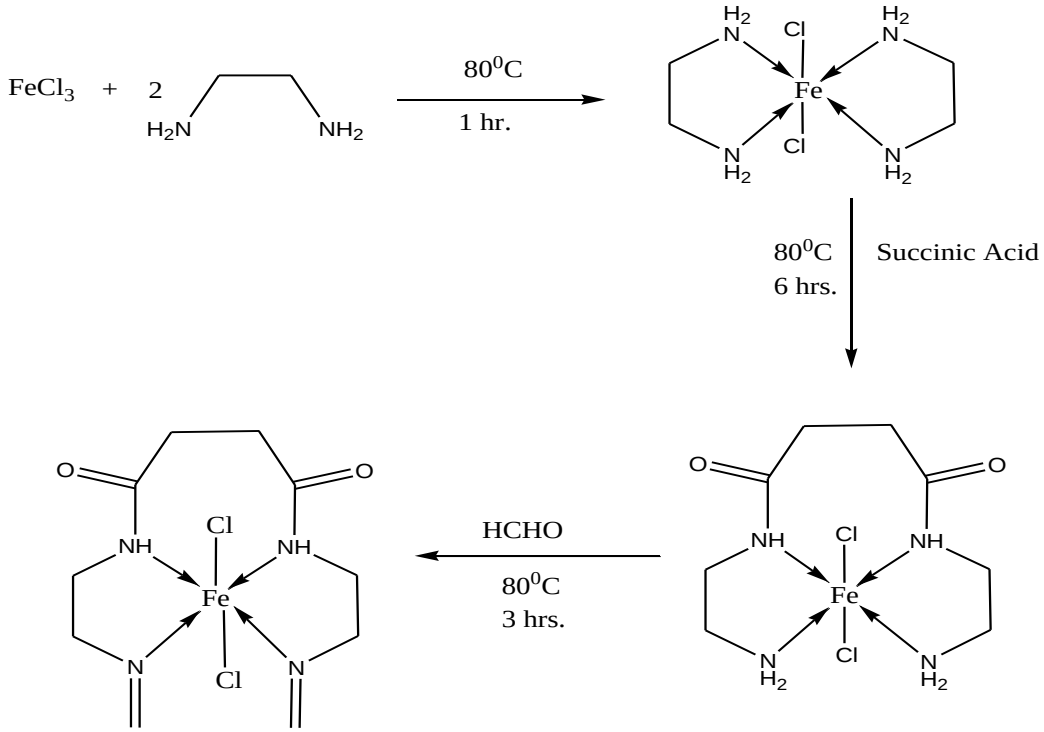

Fig.1: Synthetic reaction of Fe-complex

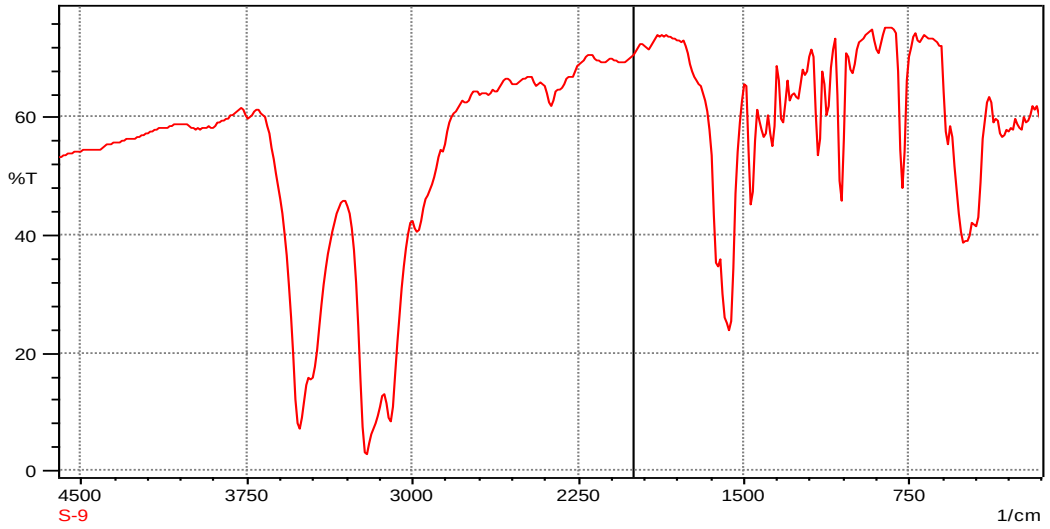

Fig.2: FT-IR spectra of metal complex

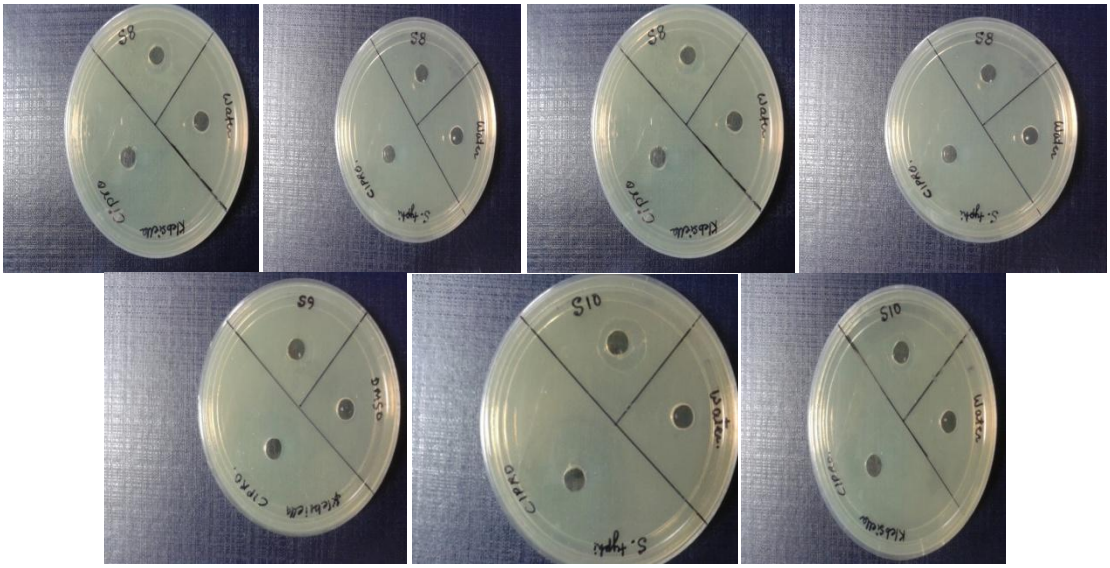

Fig.3: Disk diffusion assay showing zones of inhibition in the presence of compounds.

Table 4: Determination of MIC for antibacterial and antifungal activity of the Fe-complex

Micro-organism	2.0 mg/ml	1.7 mg/ml	1.5 mg/ml	1.2 mg/ml	1.0 mg/ml	0.7 mg/ml	0.5 mg/ml	0.1 mg/mg
S. typhi	-	-	-	-	-	+	+	+
K. pneu- monie	-	-	-	-	-	+	+	+
Fungi	-	-	-	-	-	+	+	+

Table-5: Determination of MIC for antibacterial and antifungal activity of the Co-complex

Micro-organism	2.0 mg/ml	1.7 mg/ml	1.5 mg/ml	1.2 mg/ml	1.0 mg/ml	0.7 mg/ml	0.5 mg/ml	0.1 mg/ml
S. typhi	-	-	-	-	+	+	+	+
K. pneu- monie	-	-	-	-	+	+	+	+
Fungi	-	-	-	-	+	+	+	+

Table 6: Determination of MIC for antibacterial and antifungal activity of the Cu-complex

Micro-organism	2.0 mg/ml	1.7 mg/ml	1.5 mg/ml	1.2 mg/ml	1.0 mg/ml	0.7 mg/ml	0.5 mg/ml	0.1 mg/ml
S. typhi	-	-	-	-	-	+	+	+
K. pneu-monie	-	-	-	-	-	+	+	+
Fungi	-	-	-	-	-	+	+	+

Table 7: Antibacterial and antifungal activity of the complexes: MIC values

Micro-organism	Complex	MIC value
Bacteria	Fe-complex	1.0mg/ml
Fungi	Do	1.0mg/ml
Bacteria	Co-complex	1.2mg/ml
Fungi	Do	1.2mg/ml
Bacteria	Cu-complex	1.0mg/ml
Fungi	Do	1.0mg/ml

CONCLUSIONS

In this paper, we have reported the synthesis of Co(II), Fe(III) and Cu(II) metal complexes of Schiff base derived from ethylenediamine, succinic acid and formaldehyde .The complexes were characterized by spectral methods and analytical data . Based on these an octahedral geometry has been assigned for Co(II) and Fe(III) complexes while Cu(II) complex has square planner geometry . The antimicrobial studies carried out with the complexes confirm that they are good antibacterial and antifungal agents with their MIC values.

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