Synthesis, characterization and antimicrobial activity of transition metal complexes of pyrrole-2-carboxaldehyde with glycine

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Abstract

The schiffbase ligand was prepared by condensation of pyrrole-2-carboxaldehyde with glycine. Cu(II), Co(II), Mn(II), Zn(II) and Ni(II) complexes of above ligand was synthesised as well. The synthesised ligand and complexes have characterized by Powder XRD, SEM and EDAX. The antimicrobial activity of the synthesized ligand and its complexes have been tested for their antibacterial activity against bacterial species Basillus subtilis, Bacillus cereus, Escherichia coli, Klebsiella pneumoniae , Pseudomonaos aeruginosa, Staphylococcus aureus and fungal species Candida albicans and Aspergillus niger. The result found that the metal complexes were more active than the ligand. Antioxidant and SOD activites of metal complexes have also been studied.

Keywords : Pyrrole-2- carboxaldehyde, Glycine, Transition metal complex, Antimicrobial activity.

1. INTRODUCTION

Schiff base complexes of transition metals have played prominent role in the development of coordination chemistry[1]. Schiff base complexes derived from heterocyclic compounds have increased interest in the field of bioinorganic chemistry. Heterocyclic systems containing mainly nitrogen, sulphur and oxygen atom constitute a large class of compounds of biological and medicinal interest [2] .Now-a-days Schiff bases and their coordination compounds have been gained importance as they are useful in biochemical[3], anti-cancer[4], anti-inflammatory[5], and antipyretic [6], activities. Some of the Schiff base compounds have been used as complexing agent [7, 8] and powerful corrosion inhibitors[9]. In this paper the metal complexes of Cu(II), Co(II), Mn(II), Zn(II) and Ni(II) with the Schiff base derived from pyrrole-2-carboxaldehyde with glycine have been synthesized. The ligand and the metal complexes have been characterized by powder XRD and SEM. The ligand and their metal complexes have been screened for their antimicrobial activities using the well diffusion method against the selected bacteria and fungai.

2.EXPERIMENTAL

2.1 Materials

All the chemicals and solvents used in the present work were of analytical grade. Pyrrole-2-carboxaldehyde, L-glycine were purchased from sigma aldrich. Cu(II), Co(II), Mn(II), Zn(II) and Ni(II) chlorides and the solvents were purchased from Merck.

2.2 synthesis of Schiff base ligand Potassium(E) -2-(((1HPyrrol-2-yl) methylene) amino) acetate (M1)

Pyrrole-2-carboxaldehyde (0.01 mol) is dissolved in 20 ml MeOH and added 20 ml methonic solution of L-Glycine (0.01 mol) containing KOH (0.01 mol). The solution obtained was heated at 60℃ for 9 hours. Brownish yellow solution was formed. The volume of the solution is reduced to half. Filtered the precipitate, washed with ether followed by ethanol and dried in desiccator.

2.3 Synthesis of Schiff base metal complexes

To the hot methanolic solution of Schiff base ligand (0.01 mol), and the methanolic solution of metal ions ($CoCl_2.6H_2O$, $CuCl_2.2H_2O$, $NiCl_2.2H_2O$, $MnCl_2.2H_2O$, $ZnCl_2$) was added drop by drop at 60℃ in 1:2 (metal:ligand) molar ratio. The mixture was then refluxed for 1 hour the intensity of the colour becomes translucent. The resulting mixture was filtered out,washed repeatedly with ether and dried in desiccator.

2.4 Antimicrobial activity:

2.4.1. Test organisms:

Bacterial species Bacillus subtilis, Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Pseudomonos aeruginosa, Staphylococcus aureus and fungal species Candida albicans and Aspergillus niger were used as test organisms.

The Schiff base ligand and its metal complexes were screened against bacterial species such as Bacillus subtilis, Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Pseudomonos aeruginosa , Staphylococcus aureus and fungal species like Candida albicans and Aspergillus niger in agar well diffusion method. The Solvent used for dissolving the synthesised compounds was DMSO.

2.4.2.Experimental methods:

Muller hinton agar medium (20ml) was poured into each petri plate, and plates were swabbed with 100 µl inoculated of the test microorganisms and kept for 15 minutes for adsorption . Using sterile cork borer of 8mm diameter, wells were bored into the seeded agar plates, and these were located with a 100µl solution of each compound in DMSO. All the plates were incubated 37℃ for 24 hrs .After

incubation , the inhibition growth was analysed and the results were recorded.

2.5 Superoxide dismutase activity

Superoxide dismutase (SOD) activities were evaluated using the following methods. The invitro SOD activity was measured using alkaline DMSO as a source of superoxide radical ($O_{2^{-}}$) and nitrobluetetrazolium chloride (NBT) as $O_{2^{-}}$ scavenger [10]. In general, 400µl sample to be assayed was added to a solution containing 2.1 ml of 0.2 M potassium phosphate buffer (pH 8.6) and 1ml of 56 µM of alkaline DMSO solution was added while stirring. The absorbance was then monitored at 540 nm against a sample prepared under similar condition except NaOH was absent in DMSO. A unit of superoxide dismutase (SOD) activity is concentration of complex, which causes 50% inhibition of alkaline DMSO mediated reduction of nitrobluetetrazolium chloride (NBT).

2.6. Antioxidant assay (Free radical scavenging activity)

The free radical scavenging activity of the Schiff base ligand M1 and its Cu(II), Co(II), Mn(II) Zn(II) and Ni(II) test samples were determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) method[12].The different concentrations of test compound (200, 400, 800, 1000 µg) and standard vitamin-C were taken in different test tubes, and volume of each test tube was adjusted to 100 µl by adding DMSO. To the sample solutions in DMSO. Methanolic solution of DPPH was added to these tubes. The tubes were allowed to stand for 15 minutes. The control experiment was carried out the same but without the any test samples. The absorbance was measured at 515 nm. Radical scavenging activity was calculated by the following formula.

% Radical scavenging activity

$$= \left[\frac{\text{Absorbance of control OD - Absorbance of sample OD}}{\text{Absorbance of control OD}} \right] \text{x } 100$$

3.RESULTS AND DISCUSSION

The condensation of Pyrrole-2-carboxaldehyde with glycine give the schiffbase ligand Potassium (E)-2-(((1HPyrrol-2-yl) methylene) amino) acetate (M1). The ligand was coordinated with Cu^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+} and Ni^{2+} ions separately to give colored complexes respectively M2(Cu), M3(Co), M4(Mn), M5(Zn) and M6(Ni). All the metal complexes were found to be stable at room temperature and insoluble in common solvents such as EtOH, MeOH but soluble in DMSO and DMF.

3.1 XRD

The powder XRD patterns of ligand M1 and Cu(II) complexes are recorded in the range 2θ = 0-80 Å were shown in Fig 1. The diffraction pattern revals the crystalline nature of the copper complex. The crystalline size of the copper complex was calculated from Scherre's formula [11].

$d_{XRD} = 0.9\lambda/\beta \cos\theta$

Where λ is the wavelength, β is the full-width half maximum of the characteristic peak and θ is the diffraction angle for the h k l plane. From the observed XRD patterns, the average crystalline size for the ligand M1 and Cu(II) complex M2(Cu) are found to be 26.38 nm and 29.61 nm respectively. This suggests that the ligand and the complex are in a nanocrystalline phase.

3.2 SEM and EDAX studies

The morphology of the ligand and the metal complex have been illustrated by the Scanning Electron Microscope (SEM). The SEM images of ligand M1 and Cu(II) complex were shown in Fig 2. SEM picture of the metal complexes show that the particles are agglomerated with controlled morphological structure and the presence of small grains in non-uniform size . The SEM image of Ligand exhibit stone like morphology whereas Cu(II) complex exhibit needle shaped species. The average grain size (~ 68.64,84.33 nm) respectively. The EDAX images of ligand M1 and Cu(II) complex were shown in Fig.3. The results by Energy Dispersive X-ray Analysis (EDAX) data indicated that ligand M1 obtained O, K and Sn peaks, which shows presence of tin contamination. Cu(II) complex exhibit copper and oxygen peaks, which shows presence of copper oxides.

3.3 Antioxidant activity

The synthesized Schiff base and it's metal complexes were screened for free radical Scavenging activity by the DPPH method[12]. The results of the free radical scavenging activity of the ligand and it complexes at different concentrations are shown in Fig 4. Mn(II),Zn(II) complexes have exhibited a good free radical scavenging activity. Whereas Co(II),Ni(II), Cu(II) complexes have shown moderate activity. Ligand M1 showed less activity. The metal complexes were exhibited higher scavenging activity than the Schiff base ligand. The synthesized compounds scavenged the DPPH radical in a concentration dependent manner.

3.4 SOD activity

SOD activity of the ligand and metal complexes are given in Table 1. The observed SOD values (IC_{50}) of metal complexes are in the order of Mn(II) > Cu(II) > M1 > Zn(II) > Co(II) > Ni(II). From this trend it appears that inclusion of nitrogen donors reduces the SOD activity. The SOD activity studies shows that Cu(II), Mn(II) (note the smaller IC_{50} value,

the higher the SOD activity) showed good activity. The greater SOD activity is mainly because of the distorted geometry exhibited by the complexes. The presence of electron withdrawing group in the complex lead to an enhancement in SOD activity. The redox property of the metals such as Cu(II), Mn(II) is also responsible for higher SOD activity.

3.5 Antimicrobial activity

The antibacterial and antifungal activity results of the Schiff base ligand and their Cu(II),Co(II), Mn(II), Zn(II) and Ni(II) Zn(II) complexes were given in table 1.The presence of clear zones noted that the compounds were active. The zone of inhibition was measured in millimetres. The antimicrobial activities of ligands and its metal complexes are shown in Fig 5-6.

The Schiff base ligand and its metal complexes were screened against bacterial species Bacillus subtilis, Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Pseudomonos aeruginosa , and Staphylococcus aureus and fungal species Candida albicans and Aspergillus niger. M2(Cu) complex showed good activity against all the bacterial species .The M2(Cu) complex showed 32 mm, And 20mm zone of inhibition against Pseudomonos aeruginosa and Staphylococcus aureus. These values are greater than the control Amikacin. M3(Co)complex showed high activity against Pseudomonas aeruginosa and moderate activity against Bacillus subtilis, Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa but no activity against Bacillus cereus. M4(Mn) complex showed moderate activity against Bacillus cereus, Klebsiella pneumoniae, and Pseudomonas aeruginosa and no activity against the other bacterial species.M5(Zn) complexes showed high activity against Klebsiella pneumoniae, and Pseudomonas aeruginosa and moderate activity against other bacterial species and no activity against Staphylococcus aureus. M6(Ni) complex only moderate activity against Bacillus subtilis and Pseudomonos aeruginosa but no activity against the other bacterial species. It is found that metal complexes have higher antibacterial activity than the schiffbase ligand[13]. Such increased activity of the metal complexes can be explained on the basis of overtone's concept and chelation theory[14, 15]. On chelation the polarity of the metal ion will be reduced due to the overlapping of the ligand orbital and partial sharing of positive charge of the metal with donor groups[16]. It increases the delocalization of π-electrons over the whole chelate ring and enchances the lipoplicity of the complexes. This increased lipoplicity enchances the penetration of the complexes into lipid membranes and block the metal binding sites in the enzymes of microorganisms.

M2(Cu), M3(Co) and M6(Ni) complexes showed moderate antifungal activity against the Candida albicans and Aspergillus niger. M4(Mn), M5(Zn) complexes have no antifungal activity. Antifungal activity of these complexes is obtained to be increased as the stability of the complex increased . But ligand M1 exhibits moderate antifungal activity for all the species screened. From the result, it was concluded that M2(Cu) complex showed higher antimicrobial activity than other metal complexes. M6(Ni) complex showed lower antibacterial activity and M4(Mn) complex showed lower antifungal activity. M2(Cu) compound can be tested for invivo studies and can further used as drugs for Pseudomonos aeruginosa. The antimicrobial activity depends on the molecular structure of the compound, the solvent used [17] and the species screened under consideration[18].

TABLE 1 : SUPEROXIDE DISMUTASE ACTIVITY OF M1 AND THEIR COMPLEXES

S.No	Ligand (Complex	IC_{50} (μ mol dm^{-1})
1	M1	60
2	M2 (Cu)	51
3	M3 (Co)	94
4	M4 (Mn)	50
5	M5 (Zn)	62
6	M6 (Ni)	100

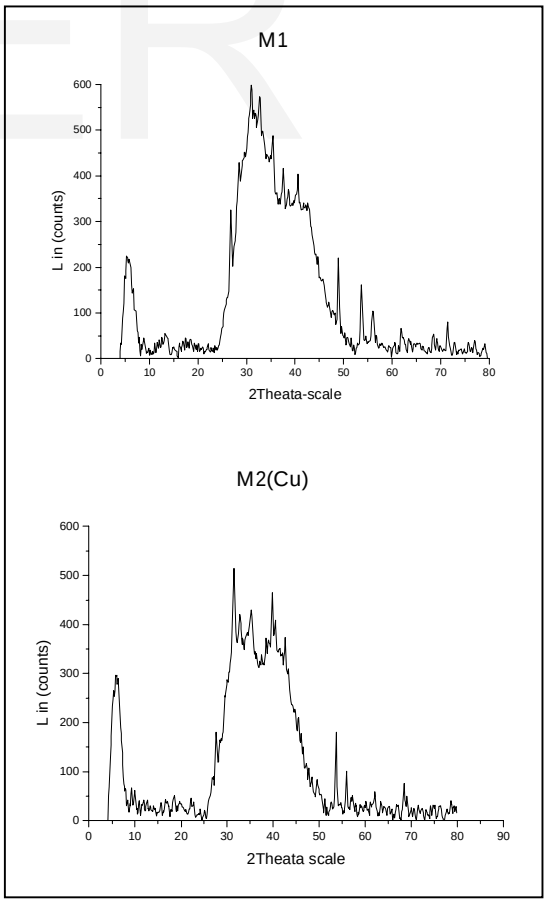
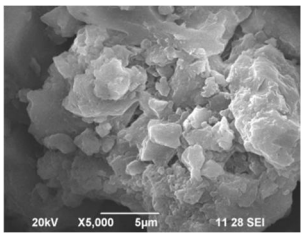
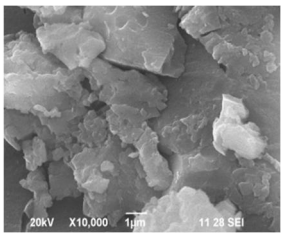


Fig 1 : Powder XRD pattern of ligand M1 and M2(Cu) Complex

TABLE 2: ANTIMICROBIAL ACTIVITY OF M1 AND THEIR METAL COMPLEXES

Ligand/ Complexes	Antibacterial activity						Antifungal activity	
	B. subtilis	*B. cereus*	*E. coli*	*K.pneumoniae*	*P.aeruginosa*	*S. aureus*	*C.albicans*	*A.niger*
M1	7	4	7	8	8	7	9	5
M2 (Cu)	10	6	10	24	32	20	7	-
M3 (Co)	6	-	4	6	20	7	7	4
M4 (Mn)	-	5	-	5	6	-	-	-
M5 (Zn)	5	5	5	25	20	-	-	-
M6 (Ni)	5	-	-	-	-	7	5	6
Amikacin	30	33	12	34	31	18		
Nystatin							18	13





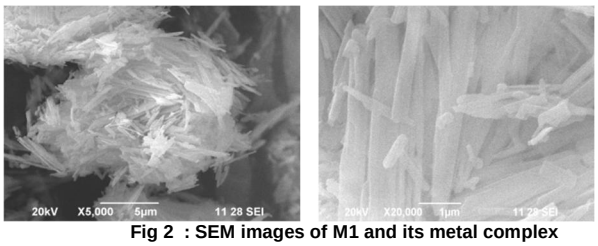


Fig 2 : SEM images of M1 and its metal complex

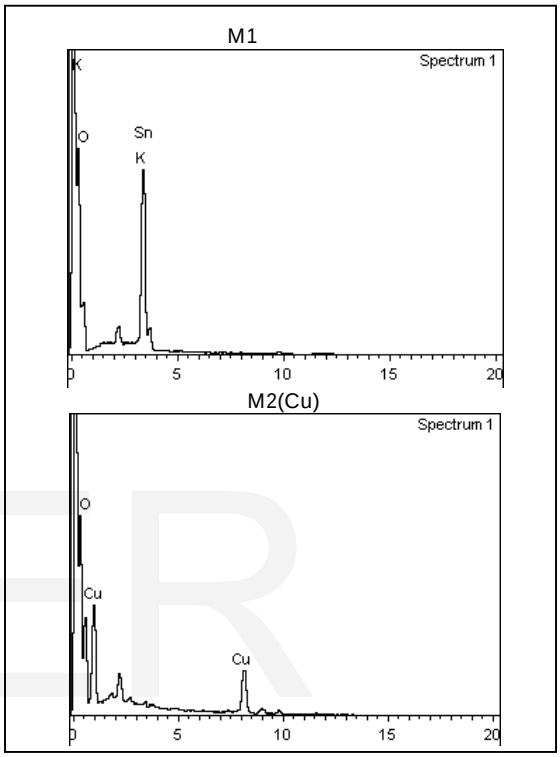


Fig 3 : EDAX spectrum of M1 and their metal complex

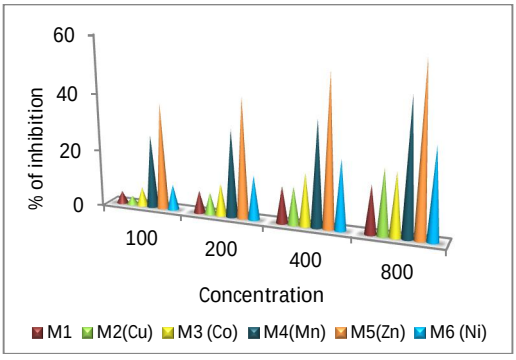


Fig 4 : Antioxidant activity of M1 and their metal complexes

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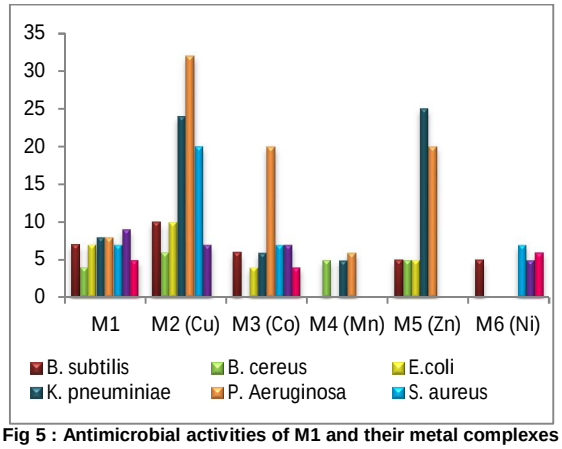

Fig 5 : Antimicrobial activities of M1 and their metal complexes

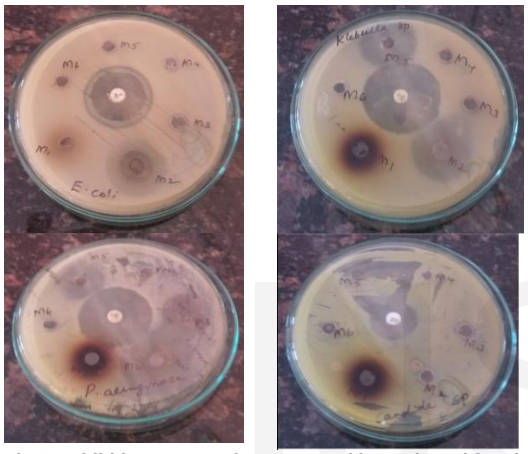

Fig.6 : Inhibition zone against screened bacteria and fungi by the ligand and complexes

4. CONCLUSION

The Schiff base ligands and it's M2(Cu), M3(Co), M4(Mn), M5(Zn) and M6(Ni) complexes were synthesized. The synthesized complexes were characterised by XRD , SEM. They were tested for SOD and Antioxidant activity. The XRD, SEM and EDAX analysis explains the crystalline and morphological structure of the ligand and complexes. EDAX studies gave information about metal and elemental composition. The SOD and Antioxidant activities indicate that the complexes show higher activity than the ligand. The antimicrobial studies showed that the Schiff base ligand possesses mild activity and metal (II) complexes possesses higher activities against different bacterial and fungal strains. From the results it was concluded that copper complex M2(Cu) exhibits higher antimicrobial activity than ligand and other metal complexes. M2 (Cu) compound can be used as drugs after invivo studies.

5. REFERENCES

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