CHAPTER IX

Concluding Remarks

The main aim of this research work presented in this thesis was to synthesize transition metal complexes from amine functionalized ionic liquid-supported Schiff bases (mainly imidazolium based), their physico-chemical characterization and exploration of their antibacterial and antimicrobial activities against some naturally available gram positive and gram negative bacteria. Chapter I deals with the general idea about ionic liquids, their fascinating characteristics and their applications in different fields. It also contains a brief literature review as a back ground for the object and application of the research work undertaken. Chapter II deals with the experimental sections giving the details of the reagents and solvents used to synthesize various ionic liquids-supported Schiff bases and their transition metal complexes as well as a brief note on the spectroscopic and analytical techniques utilized to characterize the synthesized compounds.

In chapter III the synthesis, characterization and antibacterial activities of the Mn(II) and Co(II) complexes of an ionic liquid-supported Schiff base, [1-{2-(2-hydroxybenzylideneamino)ethyl}-3-methyl-1*H*imidazolium] bromide were discussed. It was found that the Schiff base acted as a bidentate ligand and formed tetrahedral 1:2 (M:L) complexes with Mn^{2+} and Co^{2+} ions. The Schiff base and its complexes were hygroscopic in nature. The synthesized compounds were tested for their antibacterial activities against two commonly known bacteria, *viz*., *Escherichia coli* and *Bacillus subtilis*. The observed minimum inhibition (MIC) concentrations revealed that the synthesized complexes have slight antibacterial activities against the bacteria *Escherichia coli* and *Bacillus subtilis*. In chapter IV the investigation on the Mn(II), Co(II) and Cu(II) complexes derived from a Schiff base, [1-{2-(2-hydroxybenzylideneamino)ethyl}-3-methyl imidazolium hexafluorophosphate was described. The complexes were formed in 1:2 (M:L) ratio as confirmed by the various analytical and spectral analyses. The complexes are soluble in *N,N*-dimethylformamide, dimethylsulphoxide and methanol but immiscible in water. The ligand and synthesized complexes were screened against the bacteria *Bacillus subtilis* and *Escherichia coli.* The Cu(II) complex exhibited no antibacterial activities where as the Mn(II) and Co(II) complexes showed minimum activities against the selected

bacteria. In chapter V the physico-chemical characterization and antibacterial activities of the Co(II), Ni(II) and Cu(II) complexes derived from an ionic liquid-supported Schiff base, 1-{2-(2-hydroxy-5-nitrobenzylideneamino)ethyl}-3-ethylimidazolium tetrafluoroborate were described. It was observed that the Schiff base has square planner geometry around the metal ions in the metal complexes. The antibacterial studies of the synthesized compounds were performed and the metal complexes exhibited significant activities against the selected gram negative bacteria (*Escherichia coli, Pseudomonas aeruginosa, Proteus vulgaris* and *Enterobacter aerogenes*) and gram positive bacteria (*Staphylococcus aureus* and *Bacillus cereus*). The observation suggested that the chelation might have facilitated the capability of the complexes to penetrate bacterial cell membrane, *i.e*., such a chelation could have enhanced the lipophilic property of the corresponding metal ions that favours permeation through the lipid layer of cell membrane. Such activities for both the complexes and ligand were found to enhance as their concentration in the assay analyses increased due to enhanced degree of inhibition against the respective bacteria.

In chapter VI the syntheses and physico-chemical characterization of Co(II), Ni(II) and Cu(II) complexes of the Schiff base, 1-{2-[(2-hydroxy-5-bromobenzylidene)amino]ethyl}-3-ethylimidazolium tetrafluoroborate were described. It was found that the bidentate ligand coordinates to the metal ions through the azomethine nitrogen (-HC=N-) and phenolic O-atoms and formed square planar complexes. The synthesized complexes showed reasonable antibacterial activities against the selected four gram negative bacteria (*E. coli, P. aeruginosa, P. vulgaris* and *E. aerogenes*) and two gram positive bacteria (*S. aureus* and *B. cereus*). From the inhibitory zones, it is clear that the Schiff base is most effective against the five organisms except *E. aerogenes*. The Co(II) complex is most effective against *P. vulgaris* and *E. aerogens*. The Ni(II) complex was observed to be very active against *E. coli, S. aereus, P. aeruginosa* and *E. aerogenes*. It was found that the Cu(II) complex is most active against *E. coli, S. aereus, B. Cereus, P. aeruginosa* and *P. Vulgaris.*

In chapter VII, an ionic liquid-supported Schiff base, 1-{2-(2-hydroxy-5-bromobenzylamine)ethyl}-3-ethylimidazolium tetrafluoroborate and its Fe(III) and

Cr(III) complexes were synthesized and characterized by different spectroscopic and analytical techniques. These data suggested distorted octahedral geometries for both the metal complexes. The Schiff base coordinates to the metal ions through the azomethine nitrogen (-HC=N-) and phenolic O-atom and thus formed 1:2 (M:L) complexes with Fe(III) and Cr(III) ions. The synthesized complexes along with the ligand were tested for their *in vitro* antibacterial activities. A detectable antibacterial activity was observed for the Cr(III) complex against the bacteria *Escherichia coli* and *Staphylococcus aureus.* Chapter VIII described the synthesis, physico-chemical characterization and potential biological applications of some transition metal complexes of the Schiff base, 1-{2-(2-hydroxy-5-chloro-benzylideneamino)ethyl}-3-methylimidazolium tetrafluoroborate. Interestingly the ligand was observed to form square planner complexes with Co(II), Ni(II) and Cu(II) ions but it formed octahedral complexes with Mn(III), Fe(III) and Cr(III) ions. Overnight broth culture grown for the four bacterial strains (two gram positive bacteria, *viz.*, *Staphylococcus aureus* and *Bacillus cereus* and two gram negative bacteria, *viz.*, *Escherichia coli* and *Klebsiella pneumoniae*) revealed that all the synthesized compounds except the Mn(III) complex have positive responses. Maximum inhibition zone was produced by the Cu(II) complex in plates of *Klebsiella pneumoniae* and the minimum inhibition zone was produced in case of *Bacillus cereus.*

Anyway, the most of the synthesized ionic liquid-supported Schiff bases and their transition metal complexes were air and moisture stable and biologically active. There are so many scopes to alter the cation or anion part and turn them for a specific applications but the major problem in dealing with their synthesis is poor yield and cumbersome purification process. Another concern regarding these ionic liquids or ionic liquid-supported Schiff bases may be environment issues, *i.e.*, their toxicity and biodegradibilty. However, the lucrative aspect of the so-called ionic liquid-supported Schiff bases and their transition metal complexes is that they are often suitable materials for various catalyses and a variety of pharmaceutical applications. Therefore, further investigation on their easy way of preparation, purification and potential applications as well as their toxicity and bio-degradability is required and some works targeting these issues are underway in our laboratory.