

## Feature article

# Bio active mixed ligand complexes of Cu(II), Ni(II) and Zn(II): Synthesis, spectral, XRD, DNA binding and cleavage properties



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## ABSTRACT

The paper presents the synthesis of complex combinations of Cu(II), Zn(II) and Ni(II) with Schiff bases obtained by the condensation reaction of diphenylglyoxal with 1-amino-4-nitrobenzene ( $L^1$ )/1-amino-4-chlorobenzene ( $L^2$ )/*p*-anisidine ( $L^3$ ) as the main ligand and 1,10-phenanthroline as the co-ligand respectively. The characterization of newly formed complexes has been done by spectral and molar conductivity studies. The bioefficacy of the ligands and their complexes have been examined against the growth of bacteria and fungi in vitro to evaluate their antimicrobial potential. The in vitro antibacterial and antifungal assay indicates that these complexes are good antimicrobial agents against various pathogens. X-ray powder diffraction illustrates that the complexes have crystalline nature. The effect of the metal complexes on DNA is carried out by pUC19 DNA agarose gel electrophoresis at 50 V for 2 h. The results indicate that the complexes bind to DNA through intercalation and act as efficient cleaving agents.

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Progress of a new chemotherapeutic Schiff bases is now attracting the attention of medicinal chemist [1]. The area of inorganic chemistry, which most widely developed in the last few decades is mainly due to coordination chemistry and applies very particularly to the coordination compounds of transition metals. The chemistry of coordination compounds has always been a challenge to the inorganic chemists. Metal ion dependent processes are found throughout the life science and vary tremendously in their function and complexity. In literature, several reports linked the significance of biological activity of metal complexes with the metal ions rather than with the ligands [2]. Transition metals are involved in numerous biological processes. The identification of metal complex–DNA interaction is of fundamental importance to the understanding of the molecular basis of therapeutic activity.

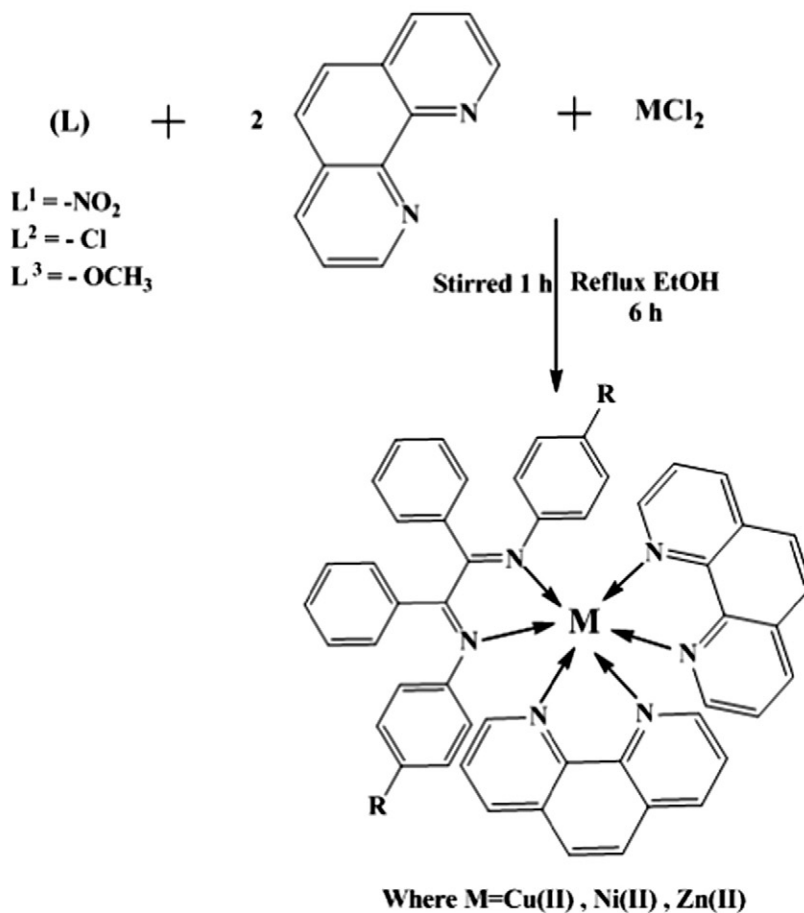
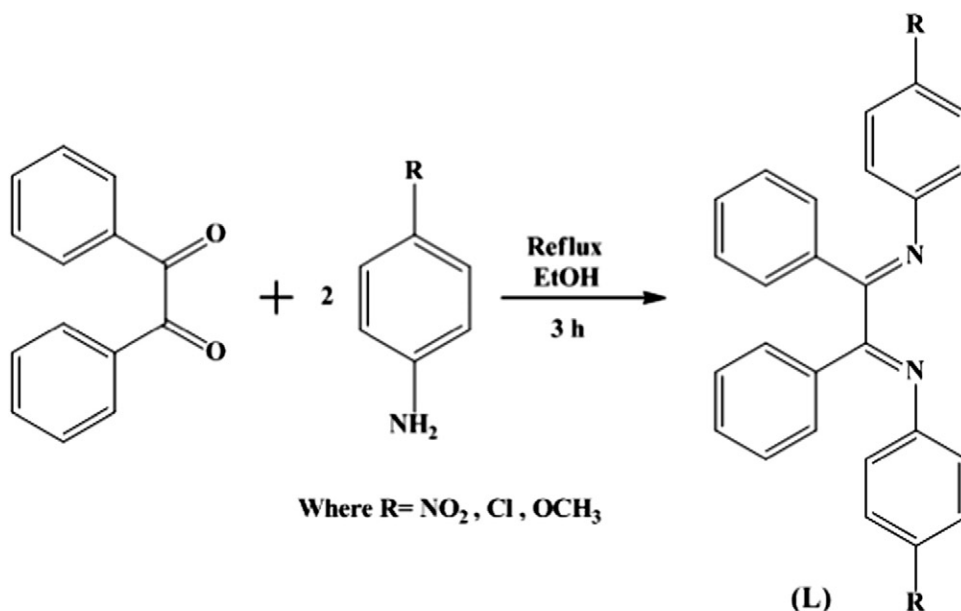
Metal complexes are well known to accelerate the drug action and the efficiency of a therapeutic agent can often be enhanced upon coordination with metal ions [3]. The pharmacological activity has also been found to be highly dependent on the nature of the metal ion and

the donor sequence of the ligands as different ligands exhibit different biological properties [4].

Diphenylglyoxal (benzil) is a diketone compound. Benzil and its related compounds have been extensively used as biologically active complexing agents and analytical reagents [5]. 1,10-Phenanthroline (phen) is a classic chelating bidentate ligand for transition metal ions that has played an important role in the development of coordination chemistry [6]. DNA binding of mixed ligand polypyridyl complexes (the ligands employed include: 2,2-bipyridine (bpy), 1,10-phenanthroline (phen), 4,7-diphenylphenanthroline (DIP), 5-nitrophenanthroline (5-NO<sub>2</sub>-phen) and 9,10-phenanthrenequinonediimine (phi)) and the factors (geometry, size, hydrophobicity, and hydrogen-bonding ability) contribute to DNA binding affinity [7]. Taking advantages of these structural features (planarity, rigidity and hydrophobicity) phen derivatives and their metal complexes have been used, for example, as intercalating or groove binding agents for DNA [8,9]. Keeping the above facts in our mind, we herein report the synthesis and structural characterization, binding, cleavage and biological studies of few novel mixed ligand Cu(II), Ni(II) and Zn(II) complexes with diphenylglyoxal and 1-amino-4-nitrobenzene/1-amino-4-chlorobenzene/*p*-anisidine as the main ligand and 1,10-phenanthroline as the co-ligand (Scheme 1).

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**Scheme 1.** Schematic route for synthesis of Schiff base ligands and their mixed ligand metal complexes.

The metal ion is coordinated by six atoms, two nitrogen C=N from diphenylglyoxal and 4N from co-ligand to form N<sub>6</sub> type metal(II) complexes.

The Schiff base ligand and its mixed ligand complexes were prepared by a typical procedure [10–23]. The nature of bonding and geometry of the transition metal complexes as well as ligands have been deduced from elemental analysis, FT-IR, UV-vis, <sup>1</sup>H NMR, EPR spectral studies, magnetic susceptibility and molar conductance

measurements. All the instrumental details and their EPR spectral characterization are given in Supplementary file. The analytical and physical data of Schiff base ligands and its complexes are given in Supplementary file (Table S3).

The mode and propensity for binding of the complexes to calf thymus DNA (CT-DNA) have been studied with the assist of different techniques, like electronic absorption, viscosity and electrochemical methods. DNA binding activities of metal complexes have been

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