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Biological Advances in Mixed Ligand Complexes with Schiff Base

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Abstract

This research focuses on the multifunctional character of Schiff bases and therefore has a paramount role. Schiff bases are the structural isomers of ketones and imines. They may include secondary aldimines or ketoimines depending on the second carbonyl compound. Schiff bases are synthesized through the reactions of nucleophilic aromatic or aliphatic amines with carbonyl compounds, the intermediate hemiaminals that expel the water molecule. The reaction mainly takes place in the acidic layer of the system. They have the R-CH=NR formula in common. However, if R' is not H. The azomethine chemistry of the Schiff base linkages makes them suitable for the conglomeration of a variety of transition and non-transition metal ions. These compounds are associated with a wide range of evidence, including their antibacterial and antifungal activities. The paper provides a superficial overview of the synthesis techniques and biological activities concerning different mixed ligand complexes comprising Schiff base moieties.

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1. Introduction

Mixed-ligand coordination complexes are widely recognized for their substantial influence on biological systems [1]. Wide research has been carried out over many decades in the field of metal complexation, focusing on inter- and intra-transition elements. For this time, more data has shown that mixed-ligand complexes are more stable than their superficial counterparts. These complexes are significant in biological systems where they have essential functions [2–3]. Researchers have studied the synthesis of mixed ligand complexes in great detail, and their results have shown how vital biological activities such as antimicrobial, antibacterial, antifungal, and antidiabetic properties are profoundly affected [4-8]. A mixed-ligand complex is a particular type of coordination compound characterized by two or more ligands of different kinds covalently bound to a similar metal ion. A complex that contains many ligand types is more likely to have distinct properties than would be expected for the complex. Consequently, researchers have focused on generating mixed ligand groups with diverse properties [9–10]. Some biological activities of complexes of mixed-ligand have been reported [11-12]. This research centers on the multifunctional character of Schiff bases and, therefore, has a paramount role. Schiff bases are the structural isomers of ketones and imines. They may include antimicrobial activity: In this study, mixed-ligand complexes were screened against various bacteria and fungi, which revealed significant suppressive effects. The antimicrobial efficacy of the complexes surpassed that of the individual ligands or metal salt. The antimicrobial properties, ligand proportions, and structural configuration of the complex were directly influenced by the specific metal ion used.

1.1. Mixed Ligand Complexes:

The following mixed-ligand complexes were produced and characterized: Cu(II), Zn (II), Cd (II), Au (III), Ni (II), and Fe(III). Fig. 1, [13] also demonstrates the development of a Schiff base from 4-(dimethylamine)-2-hydroxybenzaldehyde and 4-amino-3-hydroxybenzene sulfonamide, as well as a new azo ligand from the combination of 4-methylimidazole and sulfadiazine.

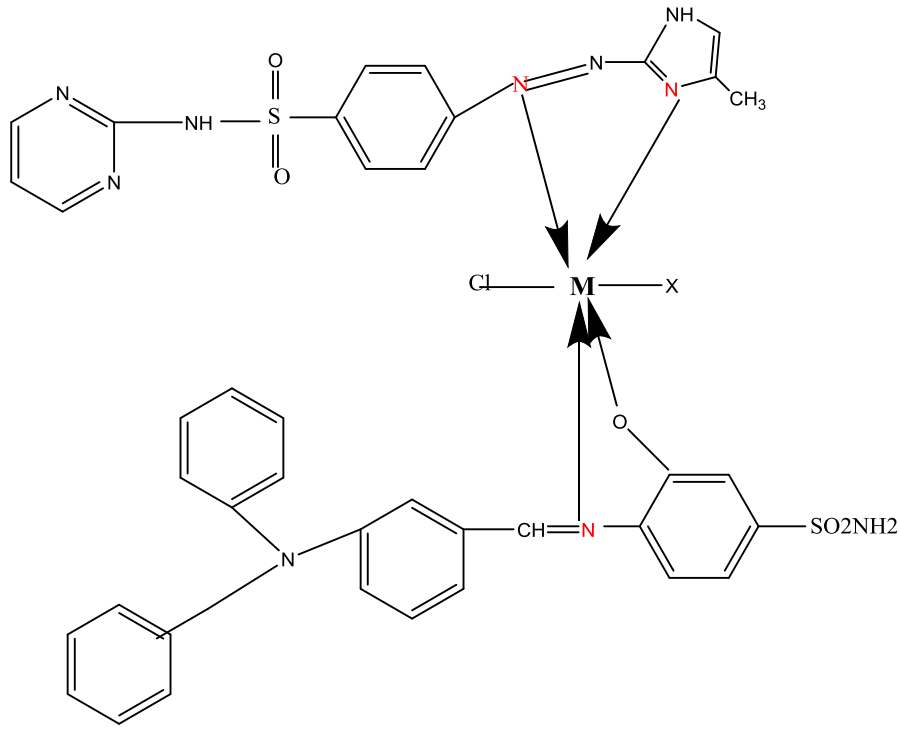


Fig.1: The structural formulae for mixed-ligand complex [13]. Where M= Co (II), Ni (II), Cu (II), Zn (II), Cd (II), X=H_2O

Using two different complexes of Schiff bases, including Cu(II), Co(II), Ni(II), Fe(III), and Zn(II) were created. 2-((2-hydroxy-1-phenylethylidene)amino)-3-(4-hydroxyphenyl)propanoic acid is the first Schiff base, or HL1, and 4-((2-(2,4-dinitrophenyl)hydrazono)methyl)-N,N-dimethylaniline is the second Schiff base, or HL2). Tyrosine and 2-hydroxyacetophenone reacted to make the former (HL1), whereas 4-dimethylaminobenzadehyde and 2,4-dinitrophenylhydrazine reacted with the solvent to form the latter (HL2). Numerous analytical methods, such as CHN examination analysis, conductivity measurements, electronic, mass, and electron paramagnetic resonance spectra, IR spectroscopy, and p-NMR analysis were utilized to assess the Schiff bases of the synthesized compounds and their complexes. According to the molar conductivity measurements, the mixed Schiff base complexes of Cu(II), Ni(II), Zn(II), and Co(II)exhibited sodium ions and operated as electrolytes, as shown in Fig.2. The Fe(III)mixed Schiff base complex, on the other hand, was discovered to be neutral, which is consistent with the non-electrolytic nature traits listed in Fig3,[14].

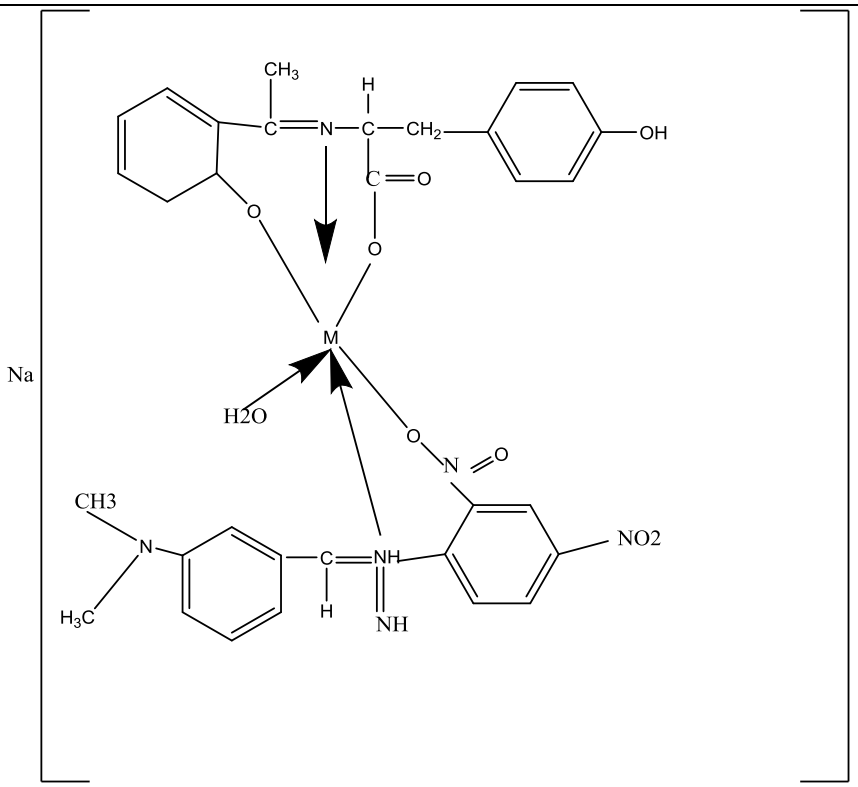


Fig.2. Mixed ligand complexes involving metal ions such as zinc (II), cobalt (II), copper (II), and nickel (II), have been extensively studied.

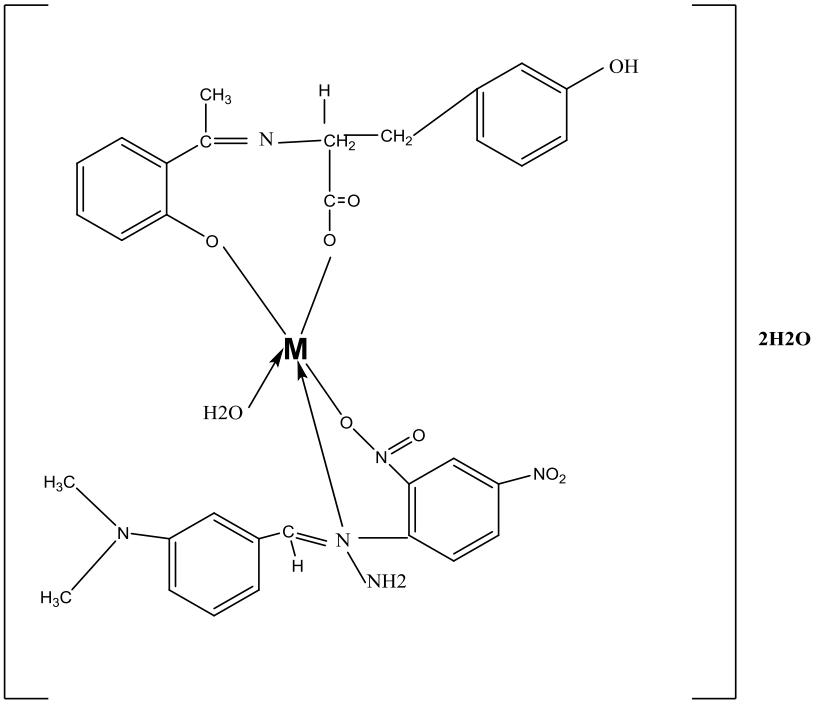


Fig3, Mixed ligand complexes, M= Fe (III) [14].

Shatha et al. produced mixed ligand complexes combining Ni (II), Cr (III), Mn (II), Co (II), Cu (II) and Zn (II). According to Obaid et al. [15], o-phenylenediamine, oxalic acid dihydrate, and 8-hydroxyquinoline were used to create these mixed ligands. The ligands, along with their related metal complexes, underwent evaluation for antibacterial and antifungal activities. The results reveal a notable

development in the antimicrobial efficacy of the complexes of the metals in comparison to the ligands, as illustrated in Fig. 4. Furthermore, the findings underscore a significant improvement in the effectiveness of these metal complexes [16-17] relative to the ligands, as depicted in Fig. 4.

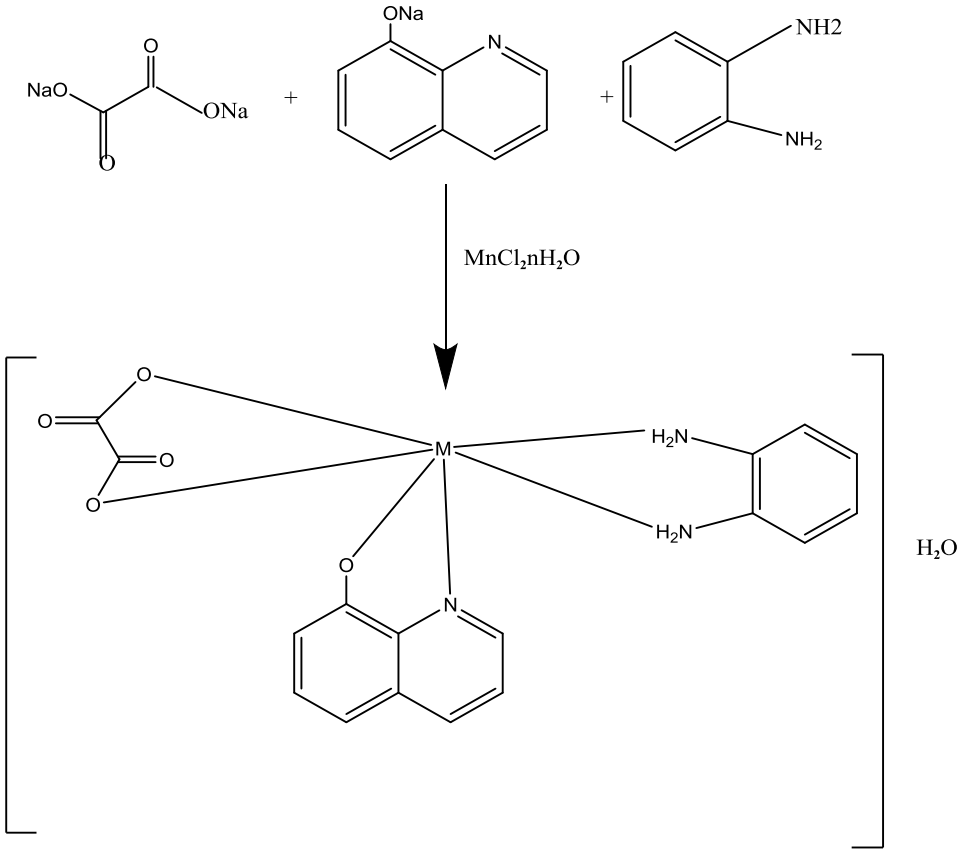
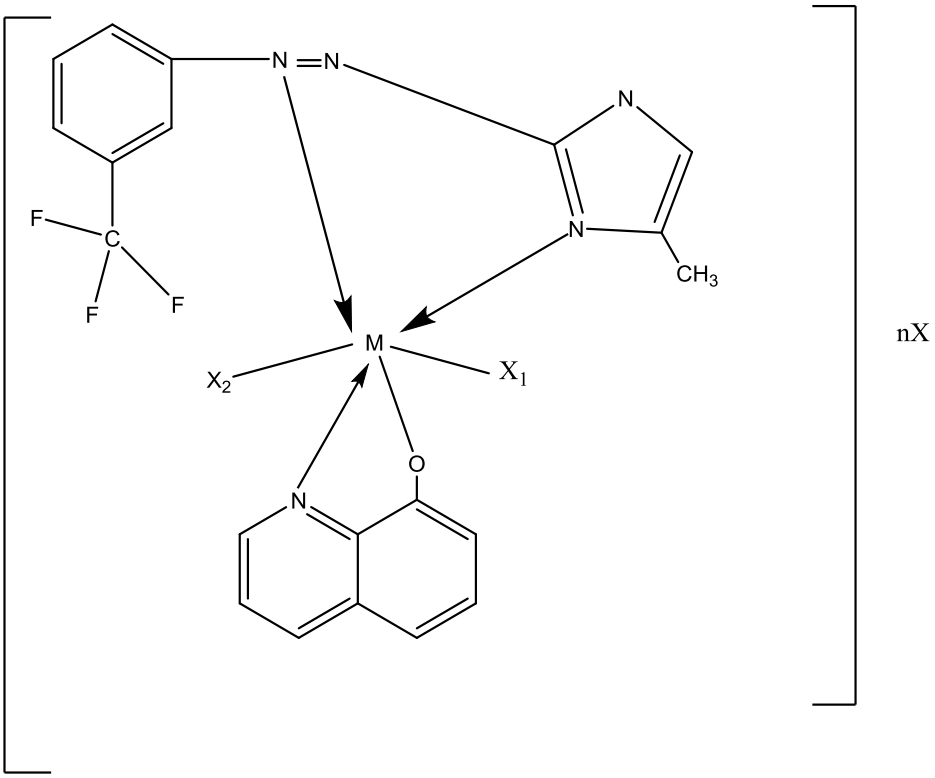


Fig.4 Formation of mixed-ligand complexes [15].

Using an azo ligand made from 5-methyl-imidazole and 8-hydroxyquinoline, Widad I. Yahya and associates [18] synthesised and characterised a unique family of mixed ligand complexes. According to the results, these complexes were expressed as [ML(8-HQ) Cl2] H2O, where M stands for Pd and M represents Zn+2, Cu+2, Co+2, X=0, Ni+2, X=1, and [ML(8-HQ)] Cl. All complexes, out of Pd+2 complexes, which have a planar-square geometry as shown in Fig. 5, mostly display octahedral geometry, according to the examination of magnetic susceptibility and electronic spectrum data.



Scheme -5, Proposed geometry of mixed-ligand complexes, [18].

Inhibition of cell growth induced by different concentrations of [Pd((MFPAI) (8-HQ)] Cl2 in CP3 prostate cancer cells with or without healthy cells. (WRL-68) exhibited a percentage of viable cells following treatment with the Pd(II) complex at a specified concentration. It will be 93.60% for 100µg/ml and 97.15 percent for WRL-68 cells at the same dose. Following the addition of Pd (II) complex, the highest percentage of the 6.3% inhibition ratio by CP3 at a concentration of 100 µg/ml, while the same concentration of WRL displayed maximum inhibition ratio which is 2.85%. The research revealed that a concentration of 100µg/ml of Pd((MFPAI) (8-HQ)] Cl2 effectively eliminated over 50% of compromised cells while sparing a larger proportion of healthy cells. This finding suggests that the Pd (II) complex could serve as a potential treatment for prostate cancer.

Table 1. The impact of [Pd (MFPAI)) (8-HQ)] Cl2 on the viability of a human prostate cancer cell line (PC3) was evaluated in comparison to healthy cells (WRL-68) under identical conditions. This assessment was conducted using a 24-hour MTT assay at 370C, [18].

Con. (µg.mL-1)	Means of cell line/ (%)			
	(PC-3)		(WRL-68)	
	(PC-3) Cancerous line cells		(WRL-68) regular line cells	
	Cell Viability	Cell Inhibition	Cell Viability	Cell Inhibition
6.25	95.95	4.05	96.03	3.97
12.5	95.9	4.1	96.84	3.16
25	95.22	4.78	96.95	3.05
50	95.33	4.67	96.45	3.55
100	93.6	6.4	97.15	2.85
200	84.8	15.2	77.97	22.03
400	71.95	20.05	61.31	38.69

Researchers examined the formation of transition metal-based mixed-ligand complexes. They used isoniazid and p-anisaldehyde to create a Schiff base (L1), which served as the main ligand. In addition,

the secondary ligand was 2,2′-bipyridine (L2). Using a variety of analytical approaches, such as molar conductance, magnetic susceptibility tests, and spectroscopic techniques including infrared and ultraviolet/visible, the researchers investigated the ligand and its metal complexes. The hybrid ligands mentioned above are of the form [M-(L1) (L2)]2+ (M = Cu(II) and Ni(II)). A comparative study of the collected data indicated the presence of square-planar structures in the metal and the electrolytic nature of the complexes. The compounds' antibacterial activities were checked versus Escherichia coli (E. coli) and Bacillus cereus (B. cereus), and it was revealed that free complexes are more active against microbes than the free ligand [19].

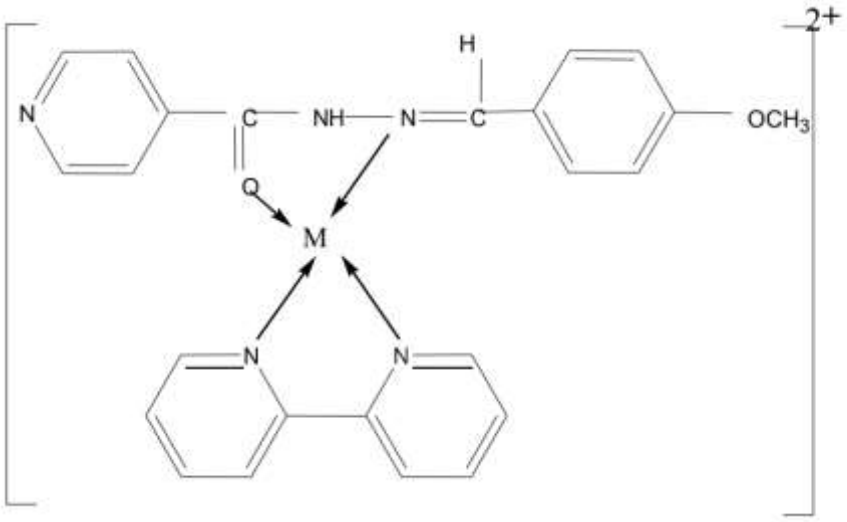


Fig. 6 Proposed geometry of mixed ligand complexes [19].

The antibacterial activity of the Schiff base ligand and its mixed ligand complexes against Bacillus cereus and Escherichia coli was assessed. The millimeters were used to measure the zone inhibition levels. Table 2 provides information on the ligand's and its mixed-ligand complexes' antibacterial properties.

Table .2 Antibacterial screening results of ligands and their mixed ligand complexes [19].

Compounds	Zone of Inhibition for Antibacterials (in mm)	
	Gram (-ve)	Gram (+ve)
	Escherichia-coli	Bacillus-cereus
Kanamycin	32	35
Ligand (L1)	4	4
$[Cu[L1](L2)](NO_3)_2$	20	2
$[Ni(L1)(L2)](NO_3)_2$	18	15

2. Conclusions

Schiff bases' biological activity and their mixed ligand-metal complexes are discussed here; hence, much of the work treated here has only recently been published. Schiff-based compounds also play a significant role in enzymatic reactions and catalysis. With their accessible synthetic preparation methodologies and varied applications, Chemists find great interest in complexes with multiple ligands that include a Schiff base component due to their potential applications as antifungal and antibacterial agents. However, a brief overview will undoubtedly facilitate the design of novel mixed-ligand complexes with transition metals, leading to enhanced applications in this field.

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Conflict of Interest: This study does not contain any conflicts of interest.

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