A Review on Chemistry of Schiff Base Complexes and Its Versatile Applications with Transition Metals

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Abstract
Schiff bases and their complexes are useful chemicals that can be made by combining an amino molecule with a co_2 compound. Schiff bases may also be made from complexes of Schiff base complexes. These compounds can be used in many different ways in industry, and they can also be used in many different ways in biological activities. Some examples of these activities include antifungal, antibacterial, and antimalarial properties. Other examples include antiproliferative, antiinflammatory, antiviral, and antipyretic qualities. Even when there is water around, many Schiff base complexes have a lot of catalytic activity in a wide range of processes. There are many Schiff base complexes, and many of them have excellent catalytic activity. These complexes could withstand the high temperatures of the method without becoming unstable. This made them useful as catalysts in methods that involved high temperatures. Several Schiff base complexes worked well as catalysts in high-temperature processes because they were resistant to heat and moisture. In this article, we discuss the chemistry of Schiff bases and their many applications involving transition metals.
Keywords: Schiff bases, versatile, transition metals, biological activities

1. INTRODUCTION

Schiff bases and the complexes that are formed from them are a special type of compound due to the fact that they can be produced via biochemistry, analyzed via electrochemistry, have properties that are antifungal, antiviral and antimalarial, as well as anti-inflammatory and catalytic. Schiff bases are utilized in the manufacturing companies to avoid corrosion, create materials that don't break when heated and make strong ligands for making coordination compounds. Using different amines as starting materials, making Schiff bases and their complexes and looking at their structures. These substances are bactericidal, which means that it is hard for any kind of bacteria, whether Gram-positive or Gram-negative, to live in them and continue to grow. Schiff bases continue to be significant contributors to the field of metal coordination chemistry, despite the fact that they were not identified until almost a century ago. It was still believed that Schiff's bases were one of the most promising groups of organic compounds due to the fact that they made it simple to produce metallo-organic hybrid materials and because of the role they play in organic synthesis. People are still interested in synthesizing macrocyclic ligands because these compounds have the potential to be applied in a wide variety of fields. Schiff bases are chemicals or metal complexes that have widespread application in the medical and pharmaceutical fields, as well as in industry.

An amino molecule and a carbonyl compound are combined in a certain manner in order to produce Schiff bases, which are also known as imines or azomethine, as well as the

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complexes containing these Schiff bases. They cure fever because in addition to being anti-fungal, anti-bacterial, anti-malarial and anti-inflammatory they also possess anti-pyretic activities. They are also used a lot in business [1]. Scientists have found that a few different Schiff base complexes have very high levels of catalytic properties in a diverse range of chemical processes, such as both heterogeneous and homogeneous catalysis. Figure 1 shows that a Schiff base is N_2 based version of CHO or =O in which the CO group has been altered into an imine or azo-methane [9, 12]. In other words, an imine or azo-methine has replaced the carbonyl group in a Schiff base.

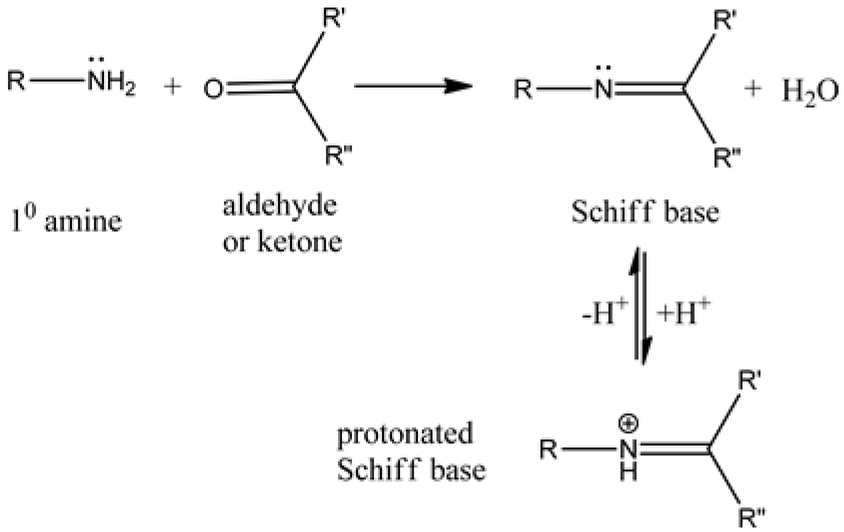

Fig. 1: Formation of Schiff bases ***(Source: https://www.scirp.org/journal/paperinformation.aspx?paperid=83501)***

2. Biological Activities of Schiff Bases

Paola et al. reported on how they made a sequence of hydrazones (Scheme 1) from cyclic as well as acyclic 1.2-benzis.othiazole parent hydrazides and their cyclic as well as acyclic 1.2-benziso.thiazole parent hydrazides. They then tested these hydrazones to see how effective they were as antibacterial and antifungal agents. These hydrazones were found to be more effective than the parent hydrazides against bacterial and fungal growth. It was discovered that these hydrazones were superior to their parent hydrazides in terms of their ability to combat bacterial and fungal diseases. All series I and IV of 2-amino-1.2-benziso.thiazol-3(2H)-one derivative products killed Gram-positive bacteria well when they were tested. The vast majority of them have demonstrated efficacy against yeasts as well. Compound II and chemicals 1 and 4 were reported to be the most effective chemicals after a lot of research. [13].

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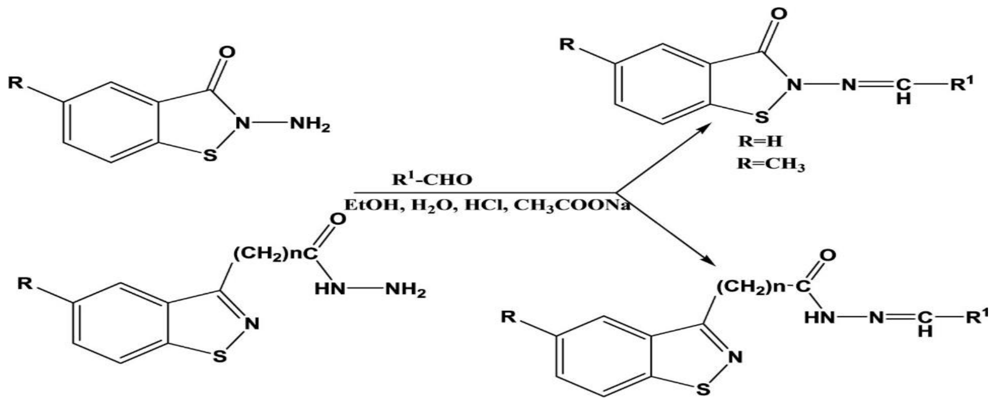
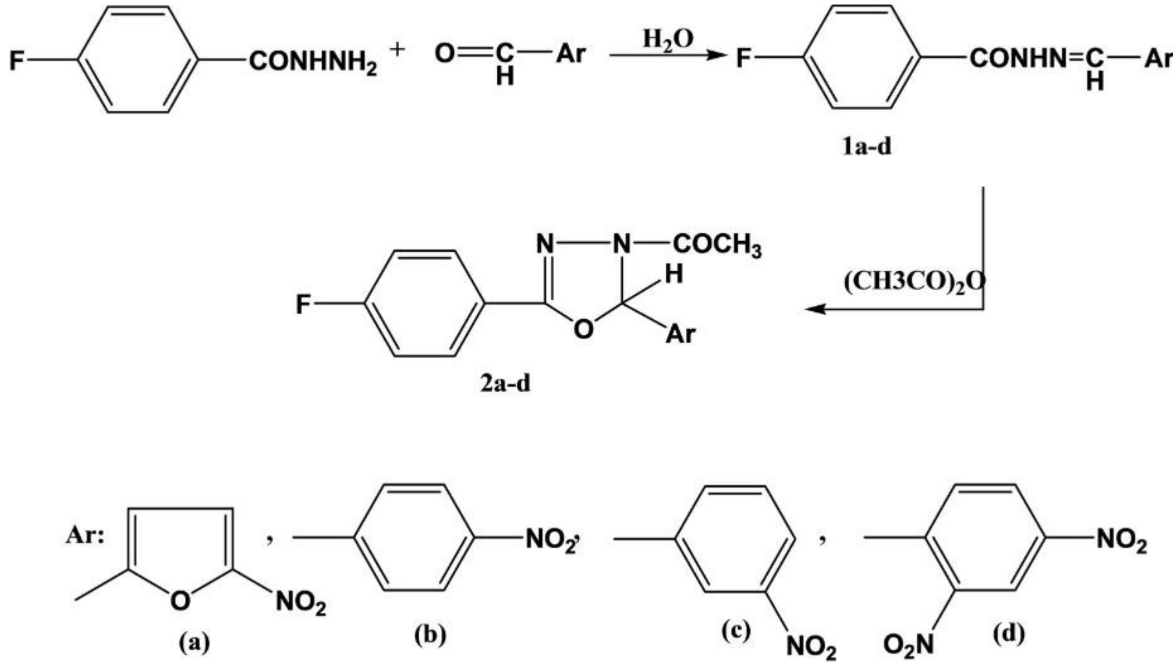


Scheme 1: synthesis of 1.2-benziosthiazole hydrazones

Sevim and his coworkers have made a number of 4-fluorobenzoic and hydrazide hydrazones and 1,3,4-oxadiazolines. This could be a medicine to kill germs (Scheme 2). They also checked how well these chemicals did what they were made to do. *S. aureus, E. coli, P. aeruginosa* & *Candida alb* were used to test how well these compounds kill bacteria and fungi. Hydride have antibacterial effect on *S. aureus* as *ceftriaxone* [14].



Scheme 2: Synthesis a sequence of hydrazide hydrazones

The Schiff bases were utilized by Natarajan and his coworkers in order to produce neutral chelate complexes of copper (II), nickel (II), cobalt (II), manganese (II), zinc (II), and vanadium (II) in ethyl acetate (Scheme 3). Spectral methods such as micro analytical data, magnetic susceptibility, infrared, ultraviolet light, nuclear magnetic resonance (NMR) and electron spin resonance were used to check the structures of the chelates (ESR). The compounds under study were tested against a wide variety of microorganisms to find out how effective they were at killing microorganisms in a lab setting. Some of the bacteria found

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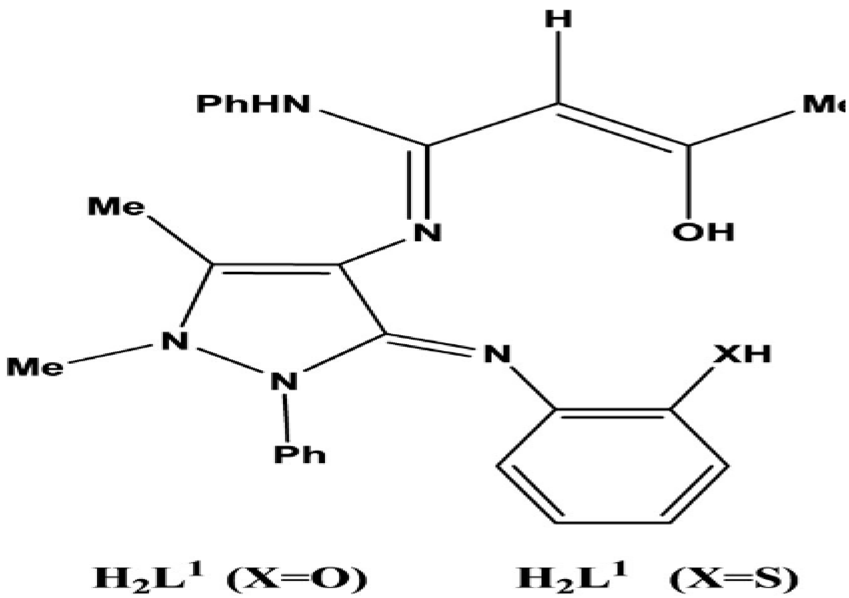
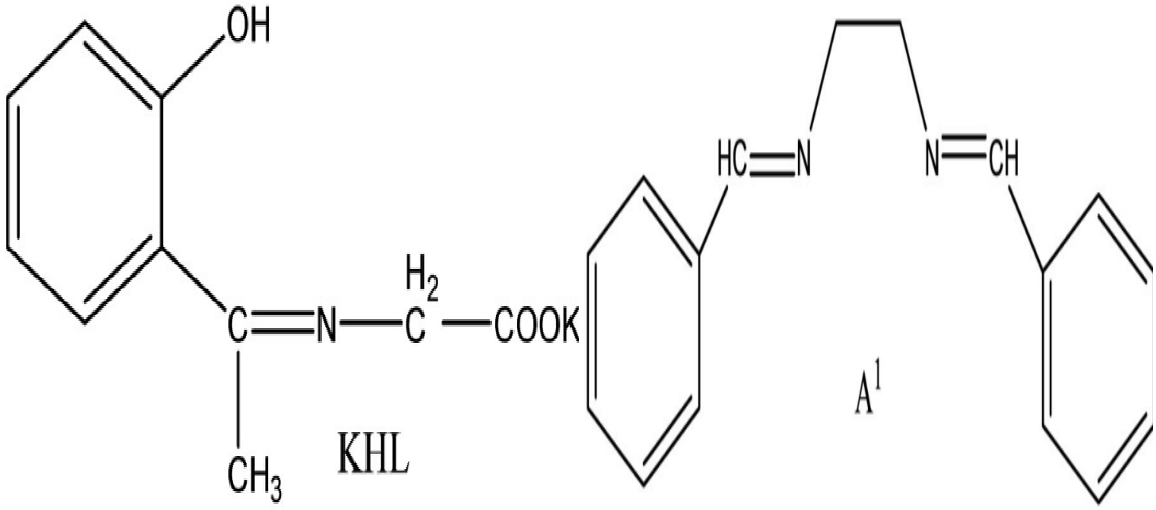
were *S. typhi, S. aureus, K. pneumoniae, B. subtilis, P. aeruginosa and Rhizoctonia bataicola*. When comparison to the antibacterial properties of free ligands, the antibacterial activity of most metal chelates is orders of magnitude stronger. [15].



Scheme 3: Synthesis Schiff bases derived from acetoacetanilido-4-aminoantipyrine and 2-aminophenol/2-aminothiophenol

Hitesh et al. demonstrates that bioactive Schiff bases can be used to make complexes with mixed ligands of Mn(II), Ni(II), Cu(II) and Zn(II) (Scheme 4). O-hydroxyacetophenoneglycine potassium salt and either bis(benzylidene) ethylenediamine or thiophene Mixed-ligand complexes kill fungi much better than free ligands, metal salts, or dimethylsulfoxide, which is used as a control. But the mixed ligand complexes are not as good as traditional fungicides like bavistin [16].



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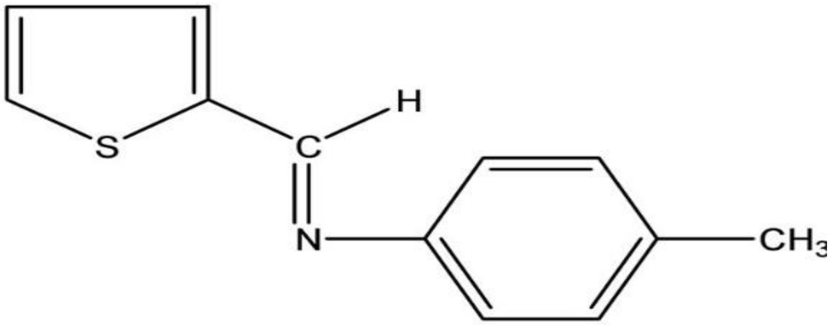
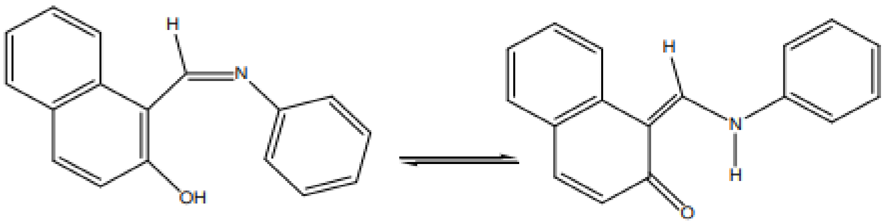


A²

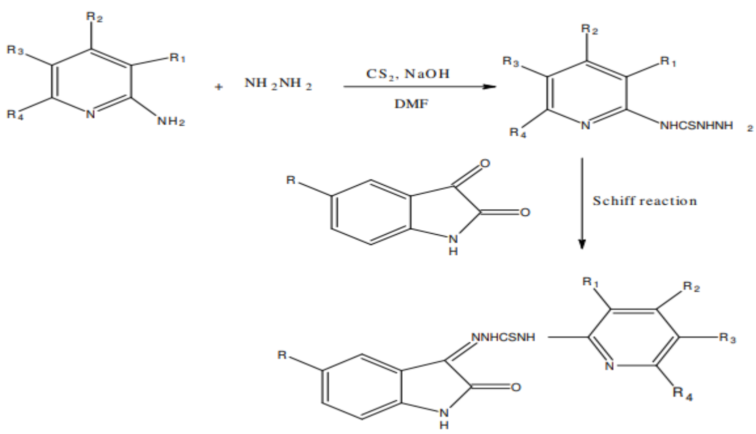
Scheme 4: Structures of the Schiff bases

Acetonitrile and toluene were utilized in order to perform an investigation into the ultraviolet and visible spectra of Schiff bases that were produced by reacting 2-aminopyridine and 2-aminopyrazine. Both polar and non-polar solvents showed evidence of the chemicals being in a state of tautomeric equilibrium. Asiri et al. came up with this idea. [17]



Scheme-5

According to Vijey Aanandhi et al. [36], several thiosemicarbazide derivatives have been manufactured. In a test tube, the bacterial and fungal *B. subtilis, S. aureus, E. coli, C. albicans* and *A. niger* were employed to determine the bactericidal efficacy of these compounds against bacteria and fungi. According to the reports, each of the substances had some level of activity against bacteria and fungi.



Scheme- 6

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2.1 Schiff base complexes' antibacterial properties:

Metal complexes of Schiff bases, which were produced by combining 2-thiophene carboxaldehyde and 2-aminobenzoic acids with Fe (III), Co (II), Ni (II), or UO_2 (II), were effective at killing *E. coli, P. aeruginosa* pyogones. Complexes made of Fe (III), copper (II), zinc (II) and uranium dioxide were what stopped *Escherichia coli* from growing (II). The main reason this is important is because these complexes might be able to be used in the right way to treat a number of common illnesses produced by *Escherichia coli.* On the other hand hand, iron (III), cobalt (II), copper (II), zinc (II) and uranium (II) complexes were particularly good at stopping Gram-positive bacteria strains from growing (Staphylococcus Pyogones and Pseudomonas aeruginosa). This was a unique thing about the Schiff complexes that were looked at. It's important because any of these strains could be used to treat infections without risk [18].

4 Platinum (II) Schiff base complexes with salicylaldehyde, 2-furaldehyde, o- and para-phenylenediamine, *E. coli, B. subtilis, P. aeruginosa* and *S. aureus* are able to kill these bacteria. These complexes were found to work effectively against the bacteria. Activity data suggest that Platinum (II) complexes are much better anti-bacterial agents than their parent Schiff base ligands against such a number of the species that were tested. [19].

By mixing sulphametrole and varelaldehyde, the metal complexes of a new Schiff base were created. The metal complexes were then tried out on different types of bacteria *(Escherichia coli and Staphylococcus aureus)*. Both gram-negative bacteria such as *E. coli* and gram-positive bacteria like S. aureus were discovered to be particularly sensitive to the antimicrobial effect of the newly synthesize Schiff base and its transition metals [20].

Using the disc diffusion method, Co(II), Ni(II) and Zn(II) Schiff base complexes were tested with indole3-carboxaldehyde and m-aminobenzoic acid. In the following, you will find a list of the activities of the compounds in the sequence in which they were synthesized: Copper (II) has a higher degree of stability compared to other ions such as cobalt (II), nickel (II), zinc(II) and ligand. The impact that metal ions have on normal cell membrane is probably why transition metals are so much more active. This is something that may be investigated further. As a result of the fact that metal chelates have both polar and nonpolar properties, it is possible for them to move freely across both cellular structures and connective tissue without being stopped. In addition, the metabolic potential of bioactive organic molecules can be altered by chelation in either an upward or downward direction [21].

Different kinds of Fe(II) Schiff base amino acid complexes were produced by reacting amino acids with sodium 2-hydroxybenzaldehyde-5-sulfonate. These complexes were made by the reaction. Conductance dimensions and elemental, electrical and infra-red spectral analysis methods were done to describe the complexes. After the compounds were made, they were put through a variety of tests to see how stable they were and how easily they dissolved. Bacillus cereus, Pseudomonas aeruginosa and Micrococcus have been used to see if the complexes made have antibacterial properties [22].

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2.2 Anti-fungal activity of Schiff base complexes:

Schiff bases are made from orthophthalaldehyde and amino acids including glycine, L-alanine, and L-phenylalanine. They are used to make copper (II), cobalt (II), nickel (II) and Mn (II) metal complexes. After that, three different kinds of fungus are used to test them. All of the micro - organisms that were evaluated stopped growing when Cu (II) and Ni(II) complexes were added. On the other hand, Co (II) and Mn(II) complexes have less of an effect on microorganisms, while VO(II) complexes have no effect [23].

In a methanolic medium, metal salts formed complexe with a Schiff base ligand produced of chromene-2,3-dione and 1,4-dicarbonyl-phenyl-.dihydrazide. After that, the antibacterial capabilities of these complexes were investigated to determine how well they could inhibit the growth of bacteria. The antifungal effects of the compounds were tested at the same concentration and especially in comparison to those of miconazole, which is the gold standard in the field. All of the metal complexes were superior to one another in terms of their ability to eradicate Aspergillus species. Miconazole is the conventional treatment for Rizoctonia spp., but these alternatives are not as effective against this pathogen as miconazole is. The Cromium and iron complexes are better than the usual medication for getting rid of Penicillium sp. According to the results, the activity also based on the type of metal ion, with Cr being more active than Fe and Mn [24].This ranking was arrived at by analyzing the data.

2.3 Schiff base complexes' anti-cancer properties:

The term "cancer" refers to a category of disorders in which a cluster of cells develops and spreads uncontrollably. Another name for cancer is "malignant neoplasm". It is still the diagnosis that people are most afraid of receiving and a major concern for public health all across the world. It is the 2nd most common reason for death in both developing and developed countries, after cardiovascular disease [25]. At the moment, the most common approaches of treating cancer are surgical removal of the tumor and chemotherapy. On the other hand, the currently available chemotherapeutic medications do not operate as effectively as necessary to cure cancer, and they cause a great deal of unpleasant side effects. For the past half-century, the primary objective has been to develop new medications with the intention of improving the efficacy of cancer treatment. In recent years, it has come to light that a significant number of Schiff bases and derivatives of these bases possess anticancer characteristics.

Five distinct ternary complexes of rare earth ions, such as ortho-phenanthroline, Schiff base salicylaldehyde and L-phenylalanine, were looked at and evaluted for their ability to treat cancer. Methyl thiazolyl tetrazolium colorimetric method and flow cytometry have been used to see if the complexes had an impact on K562 tumor cells that was anti-cancer. According to the studies, the complexes could make K562 tumor cells commit suicide and stop them from growing and making more cells. It was found that there was a positive significant link between the inhibition ratio and the dose and that this link got stronger as the dose went up. After being tested for their potential to fight cancer, all of these complexes were found to be extremely effective at eliminating K562 tumor cells [26].

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Coordination complexes of transition metals are three different configurations. The ligand (C18H16N3O2) of 2-acetylpyridine and L-tryptophan $(C_{18}H_{16}N_3O_2)_2.2CH_3OH$ are used to make Cu. The same ligand is used to make all 3 of these compounds. Then, MDA-MB-231 breast cancer cells have been used to see how well these 3 complexes stopped cancer from expanding. According to the research, that each of the 3 complexes can stop new cells from being made. Also, compared to the other two complexes, $Cd(C_{18}H_{16}N3O_2)_2.2CH_3OH$ has the strongest effect against cell growth. Human breast cancer cells can go through apoptosis when complex 3 is present. Complex 3 can also stop the proteasomal activity that is related to chymotrypsin. Complex has the potential to be either an inhibitor of proteasomes or an anticancer medication. [27].

2.4 Antioxidant activity of Schiff bases:

Chitosan and carboxymethyl chitosan (CMCTS) were evaluated on their capacity to fight free radicals using a tried-and-true method that involved getting rid of superoxide and hydroxyl radicals. Because of the work, five different Schiff bases of chitosan and CMCTS were made. Both chitosan and CMCTS had very different Schiff bases. This may have happened because each polymer chain had a different amount of active OH and amino groups. As the amount of Schiff bases in the solution increases, the scavenging effect becomes more pronounced. [28].

Schiff-base metal complexes made up of glutamic acid and salicylaldehyde can bind to bovine serum albumin (BSA). This caused Schiff-base metal complexes to form, which hold BSA together (BSA-SalGluM, where M represents copper, cobalt, nickel, or zinc). After amino acids were used to make Schiff-bases metal complexes, the outcomes revealed that the structure of the proteins in BSA did not change. The researchers investigated how the antioxidant activity would have its effect. More than a tenfold increase in the ability of BSA to combat free radicals was seen after attaching Schiff-base metal complexes to the protein. [29].

2.5 Anti-inflammatory activity of Schiff bases:

The effects of a Schiff base made from 4-aminoantipyrine (4-amino1,5-dimethyl-2-phenylpyrazole-3-one) and benzaldehyde derivative on decreasing inflammation were studied. The findings suggested that the medicine in question possessed anti-inflammatory qualities, which could make it useful in the treatment of conditions that trigger inflammation. The findings of this research may one day pave the way for the development of a novel anti-inflammatory medication that can cure conditions brought on by oxidative stress and inflammation. [30].

3. The oxygen affinity of Schiff base complexes

For square planar Mn(II), Co(II) and Nickel(II) complexes of Schiff ligands, the processes of oxygen desorption and absorption were studied. In DMF and chloroform solvents, ethylenediamine reacted with salicyladehyde, o-hydroxyacetophenone, or acetyl acetone to make these complexes. The sorption processes were done both with and without the axial-base pyridine. Complexes that have been dissolved in DMF are more attracted to oxygen than

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complexes that have been dissolved in chloroform. Complexes of cobalt(II) exhibited a greater degree of sorption than complexes of manganese(II) and nickel(II), respectively. It is abundantly obvious that oxygen affinity increases when pyridine axial base is present; this is the case. In organic chemistry and petrochemistry, oxidative addition processes might benefit from the presence of this kind of substance, which acts as a catalyst for those reactions. It is recyclable and has a positive impact on the natural world [31]. It is possible to make the product over and over again.

4. Uranium (VI) removal from aqueous solutions:

It was shown that uranium (VI) ions could be taken out of water solutions with a magnetic Schiff base made of a mixture of ferroferric oxide and Schiff base. It was made into this magnetic Schiff base. During this study, the effects of adsorption factors were looked at and changed. These factors included ph levels, adsorbent dose and temp. The purpose of the research was to look at these things and figure out how to use them most effectively. When pH = 6.0, adsorbent dose = 0.02 g, contact time = 6 hours and temp = 25 °C the magnetic composite can soak upto 94.30 mg.g-1 of uranium (VI). This was found out by putting the magnetic composite through these tests. Using 0.1 M NaOH, uranium (VI) that has adsorbed can be removed effectively (to the tune of about 98.57%), and the adsorption capacity doesn't change much even after three cycles. People considered that this magnetic Schiff base might be able to absorb uranium (VI). Also, it has been said that utilizing magnetic Schiff base as a way to separate uranium (VI) ions from such an aqueous phase could be a simple and quick method [27].

5. Schiff base metal complexes' urease-inhibitory actions:

Synthesis and analysis of transition metal Schiff base complexes formed from metal acetate Mn(II) or Nickel(II) or Cobalt(II) or Cadmium(II)). It was looked into to see if these chemicals could stop urease from working. When they were put up against the urease in jack bean, three of them stopped it from working very well. With an IC50 of 8.30.93 M, the Mn(II) complex was more effective at stopping jbU from working than the similar ligand and the control ion. This value was a huge improvement over the two previous values. Based on the constant stability and structural-activity connections of the complexe, researchers found that the entire complex, not just the free ions, interacted with enzymes [32].

6. Catalytic function of schiff base complexes

Schiff base complexes with transition metals are a group of important oxidizing catalysts that can be used on a diverse range of organic substrates. This is due to the fact that their synthesis is both simple and inexpensive, as well as the fact that they are chemically and thermally stable. Some significant oxidation reactions also include change of alcohols into CO2 compounds or COOH acids, change of sulfides into sulfoxides, change of alkenes into epoxides and diols, activation of hydrocarbons etc. People have said that Mn(II), Fe(III) and Cu(II) etc. complexes speed up the process of phenol hydroxylation. Every complex has enough physical activity to be healthy. These cobalt complexes are just a little bit less active

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than the copper(II), iron(II) and Mg(II) Schiff bases that were tested [33,34]. It was determined that catechol was the most significant result of the reaction [35]. The production of dimers may be to blame for the inactivity observed in the cobalt (II) complex. In such a way that it is unable to form the intermediate by binding with the oxygen, this is required for its formation. It was discovered that the copper complex was the most effective catalyst.

Conclusion

Schiff bases are a category of organic compounds that are very important. They can combine with transition metal ions to make complexes, and they have characteristics that make them useful in medicine. In the past few years, there has been a lot of interest in Schiff bases with complexes of transition metals. This is mostly because they are involved in many biological processes and could be used to make new medicines. But the bioactivity of the transition metal complexes that have already been made still need to be investigated, and new complexes with more properties need to be made.

Schiff bases have been investigated extensively for use in a wide variety of commercial applications as well as organic chemical reactions. Nevertheless, the biological activity of this family of chemicals ought to be the subject of additional research. This becomes plainly clear when plant pathogens are taken into consideration. There have recently been a growing number of studies that detail the impact that schiff bases have on the pathogens that are of therapeutic value. This is despite the fact that study on this subject has only recently begun. The use of Schiff base compounds as potential starting points for the development of more effective antibacterial drugs has demonstrated to have positive results. To advance in this area of research, it will be critical to do research on the schiff bases' structure-activity connections as well as the compounds' actual mechanisms of action.

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