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Biological activity of imidazole-based Schiff bases: A review

Iman Noori Mahmood Mahdi [1,*], Maryam Najdat Masood [2] and Shahad Amer Abdulkareem [2]

[1] *Department of Chemistry, College of Science, University of Kirkuk, Kirkuk, Iraq.*
[2] *Department of Biochemistry, College of Medicine, University of Kirkuk, Kirkuk, Iraq.*

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Abstract

An azole heterocycle that is frequently added to both synthetic and natural compounds is imidazole. It is made up of two nitrogen atoms that are not contiguous. Imidazole derivatives need to have a planar ring structure connected to electron-rich nitrogen donors in order to interact weakly with various bio receptors and enzymes. It is employed as a solution for aqueous solubility, bioavailability, and toxicity characteristics because, as a polar chemical, it improves the pharmacokinetic properties of the pilot molecules. A long-term home has been established for an organic compound comprising imidazole derivatives in the therapeutic and medical fields Consolidating the imidazole unit is a crucial synthetic technique in the drug development process. Due to the enormous therapeutic potential of imidazole-based Schiff bases, scientists are currently focusing on newly produced novel chemotherapeutic medicines, such as anticancer, antibacterial, antioxidant, antiviral, and antileishmanial. In clinical medicine, the extent to which imidazole medications may treat different dispositions has grown. This page covers the design, synthesis, and significance of imidazoles as well as their structural properties. An overview of the documented imidazole-based Schiff bases and their derivatives, which have a great deal of potential applications in medicinal chemistry, is what this research aims to present.

Keywords: Imidazole; Schiff bases; biological activity; Antifungal; Antibacterial

1. Introduction

The Azoles are five membered aromatic nitrogen heterocycles that are fundamental building blocks of various chemicals that find wide application in industry, medicine, agriculture and coordination chemistry. The sp2 N-donors in azoles and pyridines exhibit almost the same coordination characteristics. azoles may be deprotonated to generate the corresponding azolate (or azolide) anions, despite the fact that they are most frequently thought of as bases (the protonated form is an azolium cation). Some of them include imidazole (Him), pyrazole (Hpz), 1,2,4-triazole (Htz), 1,2,3-triazole (v-trizole, Hvtz), and tetrazole (Httz) as illustrated in Fig.1 [1,2].

In Figure 2, imidazole is a heterocyclic ring of five members that is planar with three carbon and two nitrogen atoms. N is present in rings I and III. A few notable natural compounds that include the imidazole ring are purine, histamine, histidine and nucleic acid. Being a polar, ionisable aromatic chemical, it enhances pharmacokinetic characteristics of lead molecules, and is therefore employed as a remedial measure to maximize the solubility and bioavailability characteristics of lead molecules which are proposed to be insoluble. The imidazole derivatives have played a special role in the field of medicinal chemistry. The imidazole nucleus is one of the important synthesis methods used in drug development. medicine therapeutic imidazoles-associated drugs have a tremendous treatment potential, and thus have encouraged medicinal chemists to develop an extensive variety of novel chemotherapy therapies. The use of imidazole medications to treat different conditions in clinical medicine has expanded. The topic of medicinal chemistry has vast opportunities due to the variety of techniques available for the synthesis of imidazoles and their diverse structural reactions. This article attempts to examine the research that has been done in the past on the chemical and biological activity of imidazole [2, 3]. Derivatives of imidazoles are a significant family of heterocycles that provide the basis of many natural products and biological systems. Their strong biological activity gives them a special place in the field of

* Corresponding author: Iman Noori Mahmood Mahdi

medicinal chemistry [4]. They are widely recognized for having a wide range of pharmacological characteristics and for being crucial to a variety of metabolic processes [2, 5]. Medicinal chemistry is focused on the identification, development, interpretation and discovery of the mechanisms of action of physiologically active substances on a molecular level. Some of the synthetic substances which are physiologically active include a nitrogen containing heterocyclic ring of five members in their chemistry structure [6,7]. There are assertions that structural frameworks are desirable structures and that polycyclic structure containing N, in particular, have an association with many biological activities. Among the five membered heterocyclic structures, the imidazole nucleus exhibits a variety of characteristics. The great therapeutic potential of medications related to imidazoles has inspired medicinal chemists to create a wide range of innovative chemotherapy treatments. In clinical medicine, the usage of imidazole drugs to treat various illnesses has increased. Imidazole used as a drug has many pharmaceutical uses: anticancer, 20-HETE (20-Hydroxy-5,8,11,14-eicosatetraenoic acid) synthase, hemeoxygenase, b-lactamase, antiaging, anticoagulant, antifungal, antiviral, antitubercular, antidiabetic[2, 8-15]. This class of compounds is known for its antifungal azoles, which prevent methylated sterols from building up and alter the lipid bilayer of membranes. At high dosages, some imidazole medications may directly block membranes without interfering with sterols and sterol esters [16, 17]. The global problem of infectious microbial diseases arises from the fact that bacteria have a longer resistance to treatment or prevention than any other living form. Multidrug-resistant microbe issues have gotten alarmingly worse in several nations worldwide in recent decades. An increasing number of significant worldwide issues are brought about by anti-microbial agent resistance to various bacterial species and β-lactam antibiotics, macrolides, quinolones, and vancomycin, among others [18].

Schiff bases, named after Hugo Schiff [19-21] are created when certain circumstances are met by any primary amine and an aldehyde or ketone. In terms of structure, an aldehyde or ketone's nitrogen analogue is an imine or azomethine group that has taken the place of the carbonyl group (C-O) in a Schiff base, sometimes referred to as an imine or azomethine, as seen in **Fig 3.** Some of the most utilized organic compound compounds are Schiff bases They function as catalysts, pigments and dyes, polymer stabilisers, and intermediates in the production of organic compounds [22]. Many biological activities of Schiff bases have also been reported, including antifungal, antibacterial, anti-malarial, antiprolliferative, anti-inflammatory, antiviral and antipyretic properties [22, 23]. Imine or azomethine groups (see Fig. 2) are commonly found in many natural, naturally occurring, and non-natural chemicals. The imine group of these substances has been shown to be necessary to their biological functions [24-26]. Numerous biological effects, such as antimalarial, antiproliferative, anti-inflammatory, antiviral, and antipyretic qualities, are conferred by the imine group [27].

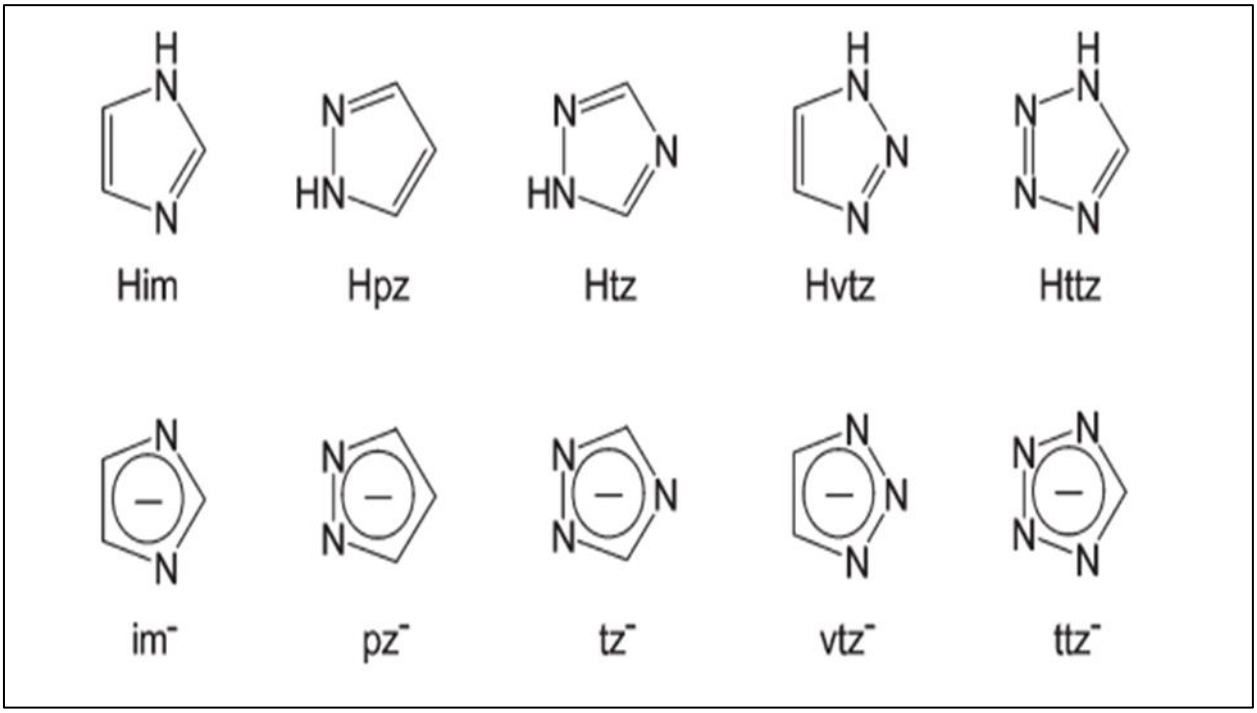


Figure 1 Prototypical Azole Structures and Associated Azolates [1]

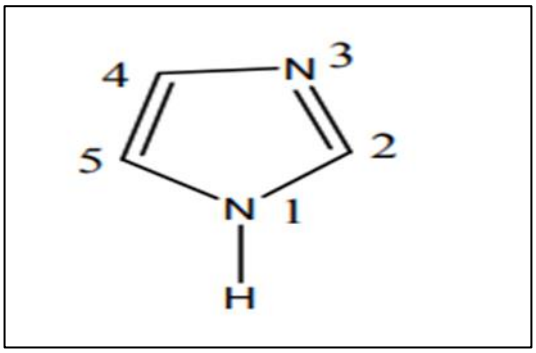


Figure 2 General imidazol structure [28].

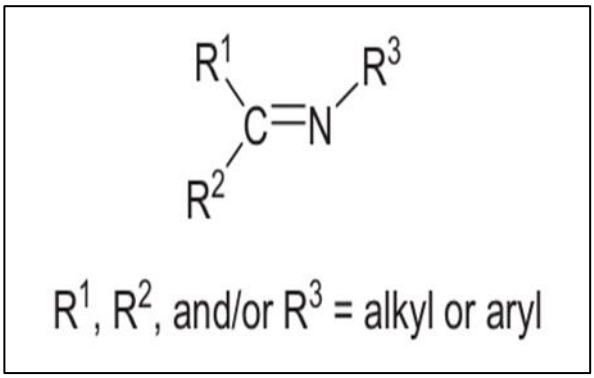


Figure 3 General structure of a Schiff base[20]

1.1. Imidazole Synthesis

TosMIC and aldimine participate in a base-induced cycloaddition process in a proton solvent, as Van Leusen et al. first described in 1977. Meanwhile, the influence of R1 and R2 on the synthesis of 17 was examined qualitatively. They found that 1,4,5-trisubstituted imidazoles (19) may be formed by α-tosylbenzyl isocyanate and α-tosylethyl isocyanate 18. Figure 4 This reaction is commonly referred to as the van Leusen imidazole synthesis due to its many benefits [29].

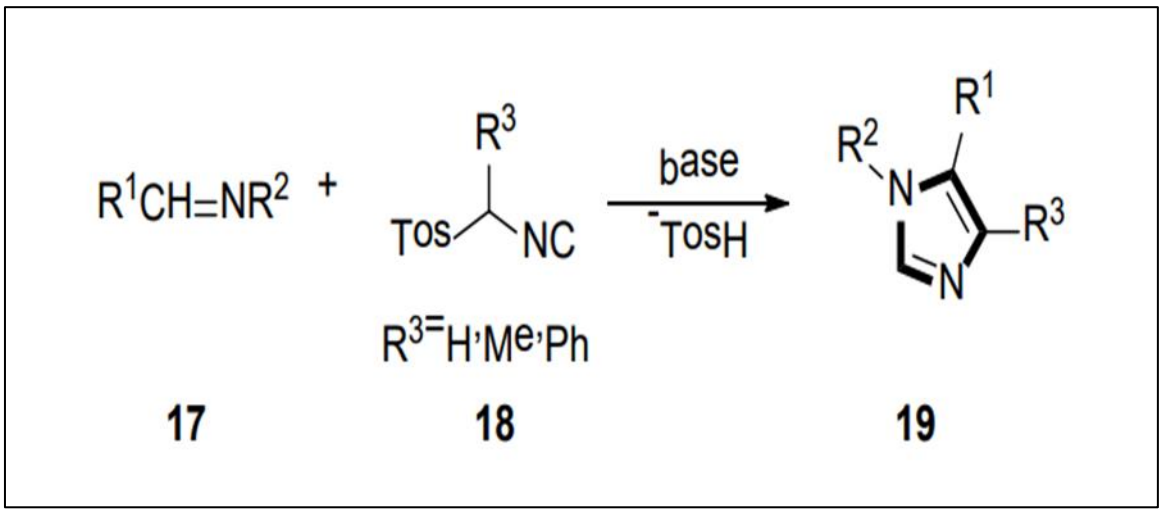


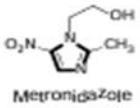
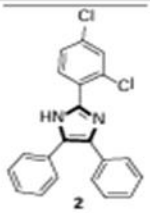
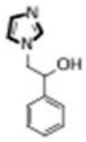
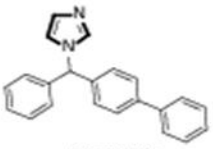
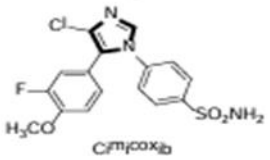
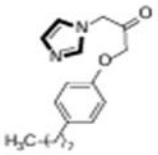
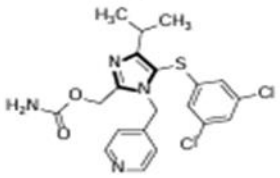
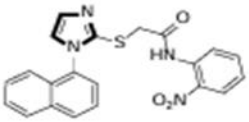
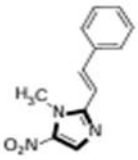
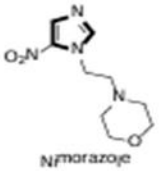
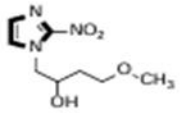
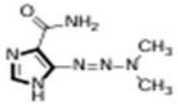
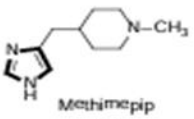
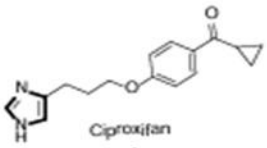
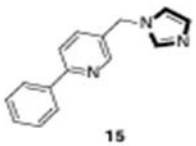
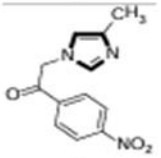
Figure 4 The first instance of imidazole synthesis by van Leusen [29]

1.2. Biology actvity of imidazol

The imidazole ring is found in many different forms in nature, and it is essential to the functioning of numerous bodily systems, including histamine and histadine. Imidazoles have a variety of biophysical interactions, including as the capacity to form hydrogen bonds with proteins and medications [30]. Additionally, imidazole-based heterocyclic compounds which have a crucial place in medicinal chemistry have proven essential in the treatment of a wide range of illnesses, and there is a global push to produce novel derivatives for these applications [31-34]. Imidazole salts possess a special structural characteristic that makes them valuable due to their electron-rich nature, which makes it desirable for imidazole groups to interact with various receptors and enzymes in biological systems through discrete weak connections, hence presenting a diversity of biological activities.Many imidazole-containing substances with great therapeutic promise are currently in widespread use to treat a variety of diseases, including antimicrobial [34, 35],antifungal [36, 37],anti-inflammatory [38, 39], antiviral[40, 41],anti-parasitic[42, 43],anticancer[44, 45]antihistaminic[46, 47],Andenzymeinhibitio [48, 49].

Table 1 below illustrates the wide range of medicinal applications for imidazole and its derivatives [34].

Table 1 Different chemical structures and pharmacological actions of compounds based on imidazole [34]

Pharmacological Activities	Chemical Structures	
Antibacterial	 Metronidazole 1	 2
Antifungal	 Phenethylimidazole 3	 Bifonazole 4
Anti-inflammatory	 Celecoxib 5	 6
Antiviral	 Capravirine 7	 8
Antiparasitic	 9	 Nimorazole 10
Anticancer	 Misonidazole 11	 Dacarbazine 12
Antihistaminic	 Methimepip 13	 Ciproxifan 14
Enzyme inhibitor	 15	 16

1.3. Schiff base Synthesis

Schiff (1864) documented the first imine production in the 19th century. Since then, several techniques for producing imines have been documented [50]. Azeotropic distillation is used in the conventional synthesis that Schiff outlines to condense an amine and a carboxylic product [51]. The water that has developed in the system is subsequently totally

removed using molecular sieves. [52]. An in situ technique for eliminating water was created in the 1990s, employing dehydrating solvents like trimethyl orthoformate or tetramethyl orthosilicate [53, 54]. The effectiveness of these techniques is reliant on the employment of strongly nucleophilic amines and highly electrophilic carbonyl compounds, as Chakraborti et al. (2004) shown. As an alternative, they suggested using substances that behave as Lewis or Bronsted-Lowry acids to catalyze the amines' nucleophilic assault, activate the carbonyl group of aldehydes, and dehydrate the system until water is removed [55]. It is usually made in a Dean Stark apparatus by taking out a water molecule and condensing an aldehyde or ketone 5 with a primary amine 6. The reversible reaction that forms a Schiff base 8 is followed by the typical catalysis of an acid or base, or heating, to cause the dehydration of carbinolamine 7. The water that has developed in the system is subsequently totally removed using molecular sieves [52, 56] as showed in **Fig.6**

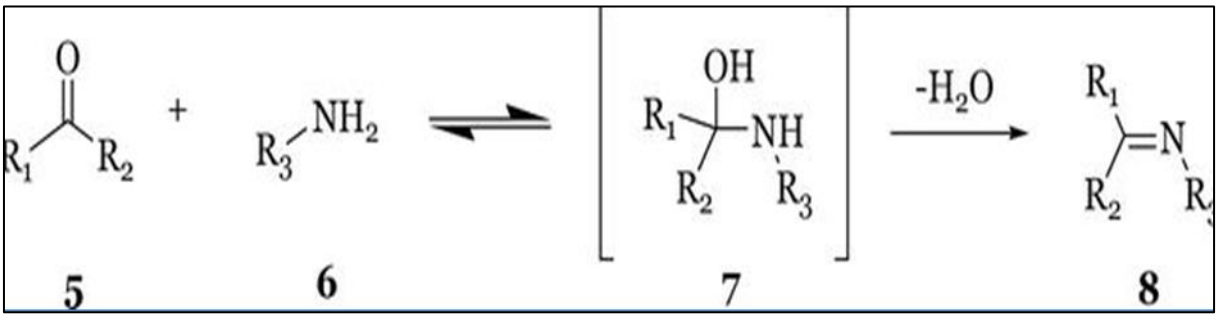


Figure 5 Schiff reaction for the preparation of imines [56]

1.4. Biology actvity of Schiff base

Vitamin B6 is a coenzyme that forms an imine when it reacts with an amino acid. The coenzyme that is connected to the enzyme performs the transamination process, which is the transfer of an amino group from one amino acid to another and is essential to amino acid metabolism and biosynthesis. An enzyme-mediated process of hydrolysis converts the imine into pyridoxal and the modified amino acid at the final stage. Biological characteristics of Schiff bases, including antibacterial and antifungal activity, have been documented [57-61]. Due to their herbicidal and anticancer effects of their metal complexes, they have been widely studied [62, 63]. They serve as modals of species that are important to biology. O-phenylenediamine Clinical characteristics are indicated via Schiff bases [64, 65]. It is reported that isatin Schiff bases have antiviral, anti-HIV, anthelmintic and antiprotozoal effects [66].Apart from their various pharmacological properties, they have significant anticonvulsant activity [67]. Several cobalt Schiff base complexes have potent antiviral characteristics [49]. Schiff bases made from 4-dimethylamine benzaldehyde have been demonstrated to possess antibacterial properties. In drugs that have anti-inflammatory and immunological properties [66, 68-71] O-phenylenediamine Schiff bases are used to indicate clinical features [64, 65]. Isatin Schiff bases have been shown to possess anthelmintic, antiviral, anti-HIV, and antiprotozoal activities[66]. Apart from their various pharmacological properties, they also have significant anticonvulsant activity[72]. Schiff bases of 4-dimethylamine benzaldehyde have been demonstrated to have antibacterial activity. In drugs which act as anti-inflammatory and antibody [66, 68-71] some example of drug was in Fig.7[73].

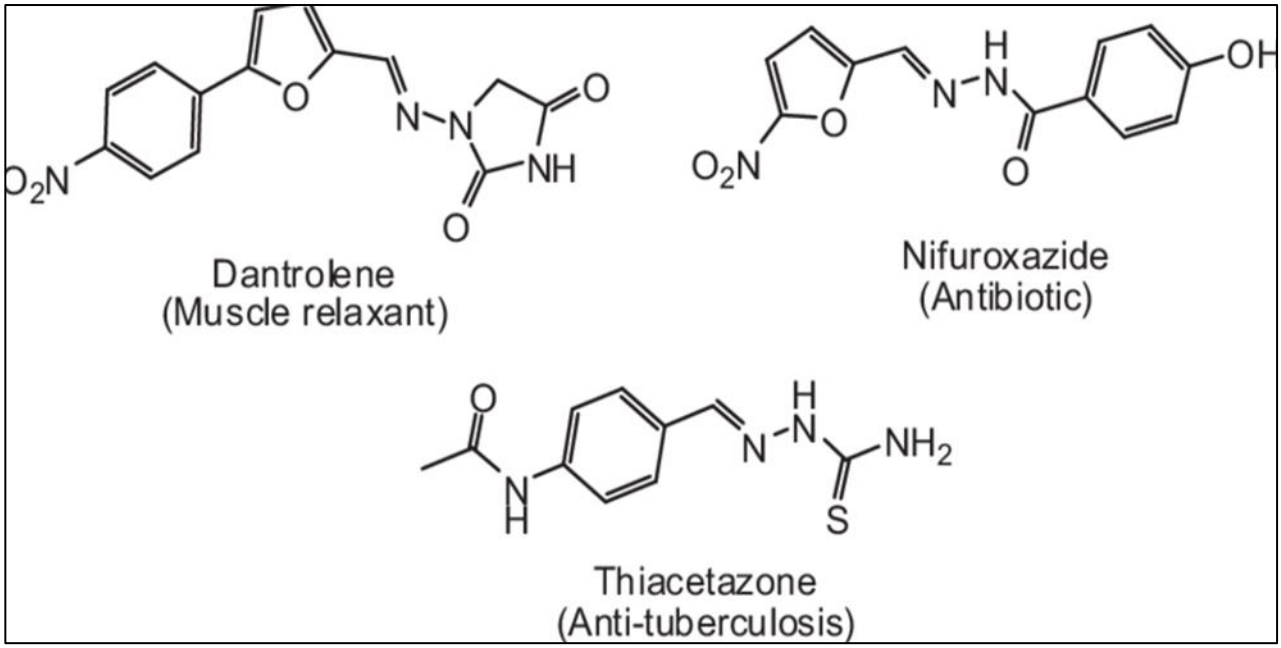


Figure 6 The structures of some drugs bearing Schiff base group [73]

2. Imidazole-centered Schiff base metal complexes

Imidazole-2-carboxaldehyde was equimolarly condensation-bonded to L-histidine to create a novel Schiff base. The generated Schiff base was examined using methods for elemental analysis and spectrum characterisation. It was subsequently complexed with many 3-d metal(II) ions, such as manganese, iron, cobalt, nickel, copper, and zinc. The stability, coordination properties, and type of bonding of the complexes were deduced using elemental analysis, IR, UV-vis, 1 H NMR, mass, electronic spectra, magnetic, conductivity, and thermogravimetric tests.Through the imidazole ring nitrogen atoms of histidine, deprotonated carboxylic oxygen, and azomethine nitrogen, the Schiff base exhibits tridentate behavior, which is corroborated by infrared studies. The magnetic moments and electronic spectra have shown that the complexes are of octahedral geometry with an exception of the zinc complex which is tetrahedral. Experiments conducted in vitro have shown that the chemicals generated had potent antibacterial and antifungal characteristics. The possibility of the generated Schiff base to act as an antibacterial agent was also substantiated by a docking study of the target proteins in the antibacterial process. [74]. Recent studies in the field of bioinorganic chemistry have yielded a substantial amount of useful substances that are currently employed as antimicrobial mediators [75, 76]. Schiff bases are a significant subclass of these chemicals since they have demonstrated a wide range of biological functions and showed significant promise for the pharmaceutical industry [77, 78]. But the question of more active chemicals arises when microbial resistance becomes increasingly common. The exceptional interaction of heterocycles, particularly those containing imidazole derivatives. The compounds' remarkable pharmacological properties resulted from weak interactions with enzymes, proteins, and receptors in biological systems, including hydrogen bonds, π–π stacking, van der Waals forces, and cation–π interactions [79]. It is discovered that the activity of metal complexes is increased by the presence of heteroatoms acting as ligands, especially in compounds with donor sites for nitrogen and oxygen. According to reports, the majority of physiologically necessary metal ions that are important for biological activity include an anchoring moiety called imidazole [80]. Schiff base metal complexes based on histidine are an example of these complexes, and their biological actions have been well studied. This is due to the fact that histidine's imidazole side chain frequently serves as an essential catalytic component in enzyme active sites and can function as a coordinating ligand in metalloproteins. Newly, we have studied and investigated many Schiff base metal complexes that are important to biology [81-84].

2.1. Biological activity

The imal–L-his (**Fig.8**) showed variable degrees of inhibitory properties, and their metal multiplexes moderately to dramatically reduced the development of the different tested bacterial strains. Compared to the Schiff base, the metal complexes are often more active against all species. This can be explained by the chelation effect, which disrupts the homeostasis of microbial cells and hence inhibits the action of metal-dependent proteins, thereby preventing microbial feeding, growth, and development [85, 86]. The active pharmacophore found in the synthetic chemicals' molecular structures may disrupt the process of cell division, preventing bacteria from growing further [87] The [Cu(II)-(imal–

Lhis)(H2O)2Cl] combination had the highest activity among the produced metal complexes, and its activity against two species surpasses that of the common medication ciprofloxacin. Other complexes have shown good to moderate effectiveness against E. Coli, a Gram-negative bacterium. The compounds' promising activity against Gram-negative bacteria provides insight into their potential future use as anti-tumor agents, as these bacteria are considered a valuable and important tool for testing important and beneficial drugs in both clinical and experimental tumor chemotherapy [88].

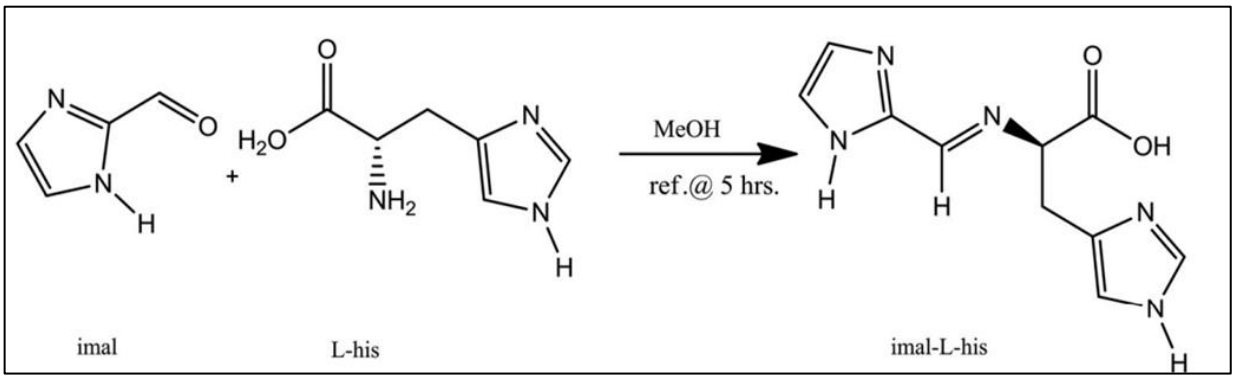


Figure 7 Synthetic route of imal–L-his [89]

3. Aromatic Sulfonamide's Schiff Base Including Imidazole

One of the many medicinal uses for sulfonamides is the suppression of different carbonic anhydrase (CA) isoforms. Of the several CA isoforms, CA IX is the one that regulates the pH of the surrounding tissue and is overexpressed in malignancies. We current here five novel ruthenium (II) p-cymene complexes (1–5) of Schiff base ligands (L1–L4) of 4-(2-aminoethyl) benzenesulfonamide by variable the aldehyde, with the goal of improving the selective cytotoxicity against cancer cells. Every complex is stable to aquation for the whole 24 hours that were observed, with the exception of one that equaled to less than an hour; still, the monoaquated species does not change. Both the human pancreatic cancer cell line MIA PaCa-2 and the MDA-MB-231 cell line, which were isolated at MD Anderson from a patient's pleural effusion due to invasive ductal carcinoma, are susceptible to cytotoxicity from the two imidazole derivatives, 1 and 2, but not from the noncancerous cells CHO and MDCK [90].

3.1. Biological activity

Research into effective metal-based anticancer medicines that have lower side effects and more selectivity is a difficult task [91, 92]. Because Pt medications work well as cancer chemotherapy, metals have a major role in anticancer therapies [91, 93-96]. Platinum(II) compounds are advantageous for several cancer treatments, including testicular, ovarian, bladder, head and neck, and non-small cell lung cancer [97]. But Pt medications also experience acquired or innate resistance. in addition to harmful side effects. Consequently, diverse Ru and Ga complexes are emerging as feasible alternatives for addressing CDDP resistance, exhibiting a unique mechanism of action due to the pursuit of alternative metal-based anticancer agents [98-100]. The inaugural metal-based anticancer drug to undergo clinical trials as a prospective photodynamic therapy for high-risk invasive bladder cancer resistant to BCG is the Ru(II) complex TLD-1433[101]. In therapeutic studies, Ru(III) complexes NAMI-A and NKP1339 have demonstrated potential. NKP1339 has effectively passed phase I studies, notwithstanding NAMI-A's lack of efficacy and subsequent withdrawal from clinical trials [92, 102-105]. NKP1339 causes endoplasmic reticulum stress and inhibits GRP78, which results in cell death [106]. Other than this, excellent antiproliferative activity has been shown by organometallic Ru(II) complexes, with several opportunities to modify their biological and pharmacological characteristics [92, 107-109]. Because the complex's steric and electrical properties change when the right ligands and attached halide are used, Ru(II) complexes' target selectivity, stability, and mechanism of action may all be changed [110-119]. The ability to use a ligand as an organic-directing molecule (ODM) to give greater efficacy owing to target selectivity is a significant attribute, in addition to manipulation of the electronic properties [114, 120]. ODMs known as sulfonamides have a wide range of biological activity, including antibacterial, anti-inflammatory, and anticancer properties because they recognize different protein targets dependent on their structure [121]. Dihydropteroate synthase (DHPS) and cyclooxygenase-2 (COX-2) are among their targets [122-125], and various isoforms of carbonic anhydrase (CA). CAs are inhibited by the small molecules acetazolamide, methazolamide, ethoxzolamide, saccharin, brinzolamide and dorzolamide [126, 127]. CA IX and CA XII (two terminal membrane-bound isoforms from the multiple CA isoforms) are now known to play a role in promoting cancer cell pH regulation under hypoxic cell conditions (12). Consequently, the expression of hypoxia-induced CA IX

appears to be a promising therapeutic target in anticancer treatment as it is overexpressed in many cancer cells but relatively low levels were detected in normal cell lines. [128-130]. When CA targets sulfonamides, their activity can be altered and enhanced by attaching to transitionmetal ions [127, 131-136]. Recent research has demonstrated that gold nanoparticles attached to 4-(2-aminoethyl)benzenesulfonamide (AEBS) selectively target CA IX over CA I and CA II.49 [137]. Thus, sulfonamides can selectively target cancer cells than normal cells. Given this as depicted in Fig. 9, we developed ruthenium(II)p-cymene complexes of four different Schiff bases derived from AEBS and aldehydes: pyridine, 1-methyl-2-imidazole, imidazole and 4-methylthiazole. The Ru(II) complexes are stabilized by these N,N-donor ligands, however there is a wide range in their cytotoxicity. This article presents the stability, cytotoxicity, and mode of action of these complexes, highlighting the importance of the imidazole motif in enhancing cytotoxicity.On the other hand, cancer cells expressing CA IX are more selectively targeted by the AEBS motif [138]

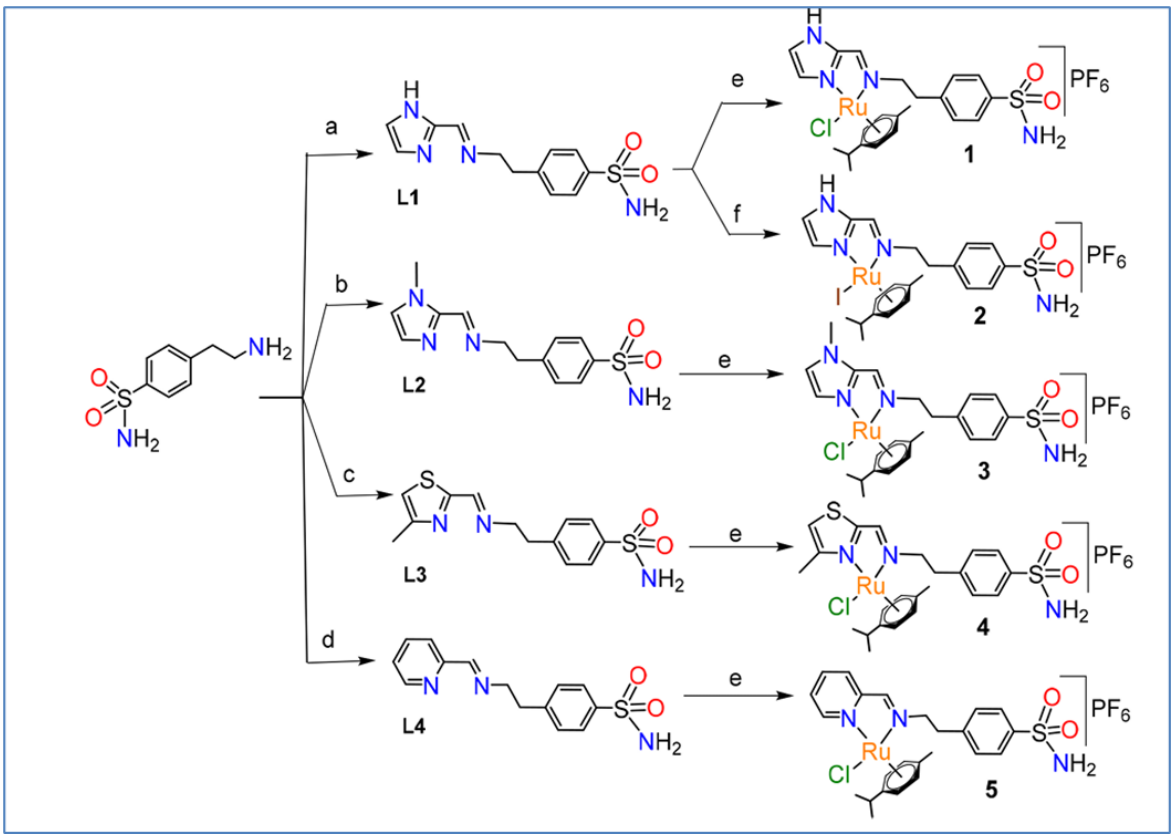


Figure 8 Synthetic Methods for the Creation of p-Cymene Complexes with Ruthenium(II)

4. Ligands Comprising Imidazole and Azo-Based Schiff Bases

Here, we discuss the synthesis, detailed description, and visual belongings of four unalike ligands (L1–L4) that connect a Schif base fragment, an azo group, and an imidazole unit. UV-visible absorption bands, which also involve an extra responsibility transference among the azobenzene mediety and the imino group, are what define the π→ π∗ and n→ π∗ transitions. Finally, the MIC80 values were ascertained for a variety of pathogenic fungus, for example *S. apiospermum*, A. fumigatus, and *Candida albicans*. The findings demonstrated the potency of these ligands as antifungal agents, with the azole-based ligands L1–L3 exhibiting the highest antifungal activity (MIC80) against Candida albicans. The investigated ligands' capacity to scavenge DPPH radicals was put to the test [139]. Derivatives of imidazoles are a significant family of heterocycles that provide the basis of many natural products and biological systems. Their strong biological activity makes them stand out in the field of medicinal chemistry [4]. They are widely recognized for having a wide range of pharmacological characteristics and for being crucial to a number of different metabolic processes [2, 5]. Numerous substituted imidazoles have a broad spectrum of biological activities, including antifungal, antiprotozoal, and antihypertensive properties [140-142].

Additionally, azo compounds exhibit a wide range of biological properties,such as antibacterial [143]antifungal, [144]pesticidal, [144] anti-inflammatory and antiviral properties [145]. It has been established that chelating Schif bases ligands are preferred ligands for forming constant developments through a wide range of evolution metallic

element[146]. They have produced discrete supramolecular assemblies like metallosupramolecular helicates, for instance, by the application of metallo-ligand self-assembly [147-149] cages [150], and capsules,[151] and have furthermore been employed in catalysis with a range of transition metals[152, 153] Moreover, Schif base derivatives demonstrated a range of pharmacological and biological properties as antimicrobials, [154]antidepressant, [155]cytotoxic, [156]analgesic,[157] anti-HIV, [41] antileishmanial, [158] anticonvulsant, [158] fungicides, [159] anti-infammatory [160],

and anticancer [161]. The combination of azo group, imidazole unit and Schif base fragment are of interest to us in this present inquiry job. Nevertheless, the synthesis, description, and optical properties of four different Schif bases ligands, L1–L4', are discussed in this study (Fig. 10).We also discuss the potential biological uses of these systems, particularly in light of their antioxidant and antifungal capabilities [162].

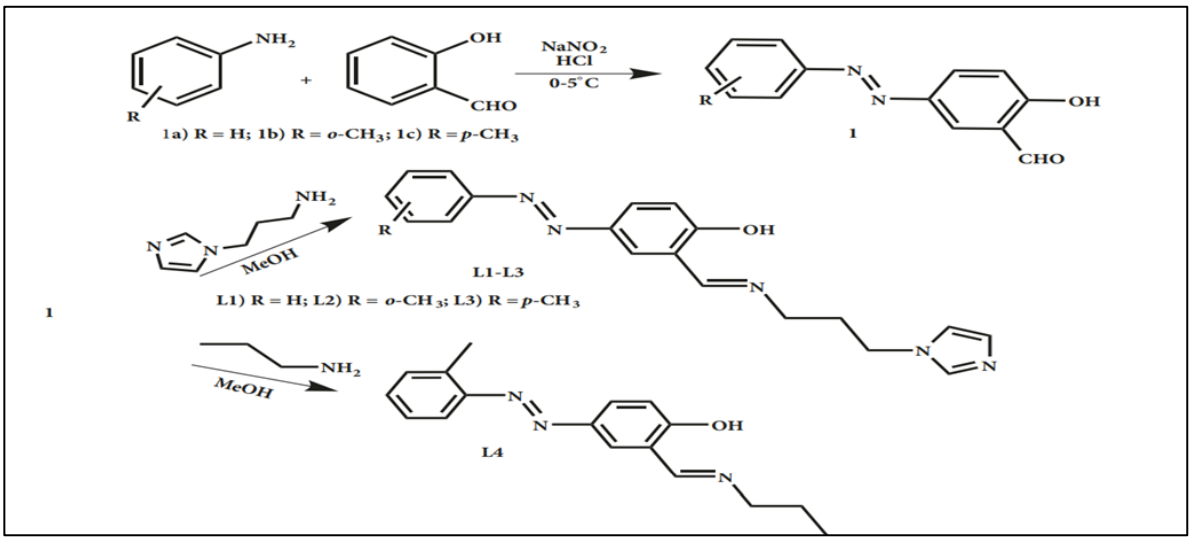


Figure 9 Creation of the ligands (L1-L4) and the azo-based salicylaldehydes (1a-c)

4.1. Antifungal Activity

We employed Aspergillus fumigatus, Candida albicans, and Scedosporium apiospermum, three important human pathogenic fungus species, to investigate the antifungal activities of ligands L1 through L4. Cystic fibrosis sufferers are especially connected to these microbes [163]. Initially, a solid medium disc difusion method was utilized to conduct a prompt antifungal screening. Regarding C. albicans, the results in Table 2. show that ligands "L2, L3, and L4 have lower antifungal activity" than the reference antifungal miconazole, but the antifungal activity of ligand L1 is similar to that of miconazole.Every ligand exhibited action against S. apiospermum; three of them shown activity lower than miconazole, but nonetheless displayed an ascending sequence of L4 < L2 < L3 [164].

Table 2 Antifungal activity assessed on a solid medium and indicated by the growth inhibition zone's diameter (mm) [164].

Compounds tested	Fungi		
	S. apiospermum	*A. fumigatus*	*C. albicans*
L1	32	28	17
L2	19	13	14.5
L3	21	33	14.5
L4	16.5	12	12.5
Miconazole	28.5	18.5	18.5

4.2. Antioxidant Function

Because they have the ability to absorb free radicals, which are the cause of many illnesses including cancer, antioxidants are significant bioactive species [165]. Due to a proton's (OH, NH,...) mobility within their structure, they function by directly scavenging reactive oxygen species (ROS). The ability of the Schif bases L1-L4 to scavenge "DPPH (2,2 Dipheny-1-picrylhydrazyl) radicals at various concentrations was examined and compared to the ability of the established antioxidant ascorbic acid Table 3 using UV- visible spectroscopy. The data summarizes antioxidant activity of all the compounds that were studied even though to a lesser extent compared to ascorbic acid. The most probable reason behind this encouraging behavior is the hydroxyl group which is well known to be the active group in the scavenging of DPPH" [166].

Table 3 L1–L4's antioxidant activity in DPPH [164].

Compound	Concentration (μg/ml)						
	10	50	100	200	400	600	IC50
L1	39,12	44,48	51,62	64,28	76,29	88,63	**95,98**
L2	41,07	43,83	51,13	63,14	77,75	91,07	**94,48**
L3	35,87	46,1	51,13	64,61	83,44	91,55	**96,01**
L4	33,60	37,01	49,83	71,42	83,27	88,31	**116,39**
Ascorbic Acid	49,18	52,07	55,31	65,04	82,34	98,73	**25,88**
Blank	-	-	-	-	-	-	-

5. Conclusion

The exploration of Imidazole-Based Schiff Bases has emerged as a captivating and dynamic field within the realm of bioorganic chemistry. This review article has meticulously navigated through the vast landscape of these compounds, shedding light on their diverse biological activities and the underlying molecular mechanisms that govern their interactions with biological systems and as we delved into the literature, it became evident that Imidazole-Based Schiff Bases exhibit a remarkable spectrum of biological properties, ranging from antibacterial and antifungal to anticancer and antioxidant activities. The structural versatility of these compounds, coupled with the flexibility in their synthetic routes, has paved the way for a myriad of derivatives with distinct biological profiles. This diversity underscores the potential of Imidazole-Based Schiff Bases as versatile candidates for drug development and therapeutic interventions,.one of the significant aspects highlighted in this review is the antimicrobial activity exhibited by Imidazole-Based Schiff Bases. The ability of these compounds to inhibit the growth of various bacteria and fungi underscores their potential as antimicrobial agents. The structure-activity relationship studies presented in the literature offer valuable insights into the molecular features crucial for enhancing their efficacy against specific pathogens. Such understanding is pivotal for the rational design of more potent and selective antimicrobial agents and moreover, the anticancer potential of Imidazole-Based Schiff Bases has been a focal point of interest. The reviewed studies collectively emphasize the promising role of these compounds in inhibiting cancer cell proliferation, inducing apoptosis, and interfering with key cellular pathways. The diverse mechanisms of action, including DNA binding and interference with cell cycle progression, contribute to their potential as candidates for the development of novel anticancer drugs. However, further investigations are warranted to elucidate the specific pathways targeted by different derivatives and to optimize their pharmacological properties for clinical applications the antioxidant properties of Imidazole-Based Schiff Bases have also been scrutinized in this review, unveiling their ability to scavenge free radicals and mitigate oxidative stress. Given the implications of oxidative stress in various pathological conditions, the antioxidant potential of these compounds positions them as promising candidates for therapeutic interventions in diseases associated with oxidative damage. Understanding the molecular mechanisms underlying their antioxidant activity will be instrumental in harnessing their full therapeutic potential.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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