

# Synthesis Characterization and Biological Applications of Schiff Base Complexes Containing Acetophenone or Resemblance Compounds

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## Abstract

In this review we report some literature survey on the synthesis, characterization and applications of Schiff bases and their complexes which synthesized from 2-hydroxyacetophenone (C=O) compound and primary amines (-NH<sub>2</sub>). Including applications of Schiff's bases and their complexes in qualitative analysis, biological activity and sample preparation for chemical analysis have. The variation of chemicals used in the synthesis to produce Schiff bases and complexes with remarkable stability lead to summarize as much of these important compounds in the field of chemistry. The uses of Schiff bases and their complexes as biological activity reagents open door for significant research to be consider among the chemists to enroll important factors in solving the recent problems in the living aspects.

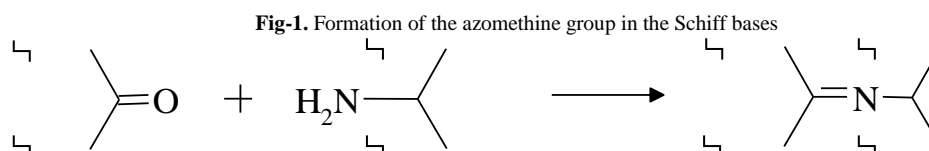
**Keywords:** Schiff base; Complexes; Quantitative analysis; Azomethine; Acetophenone; Resemblance; Biological activity.



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## 1. Introduction

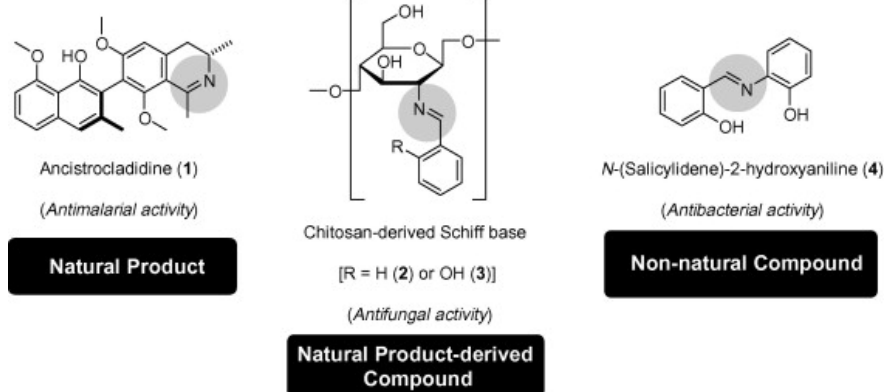
Schiff base is a nitrogen analog of an aldehyde or ketone in which the C=O group is converted to C=N-R group. It is usually formed by condensation of an aldehydes or ketones with a primary amine according to the following reaction. Where, R can be an alkyl or an aryl group. Schiff bases that contain aryl substituents are substantially more stable and more readily synthesized, while, those which contain alkyl substituents are relatively unstable. Schiff bases of aliphatic aldehydes are readily polymerizable, meanwhile, those of aromatic aldehydes having effective conjugation are more stable as shown in Fig.-1



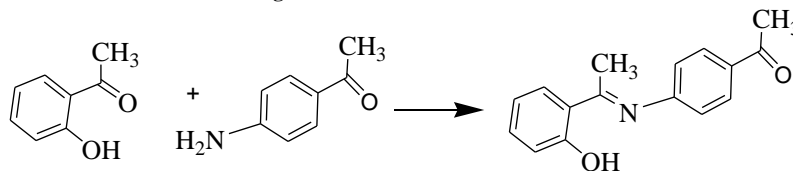
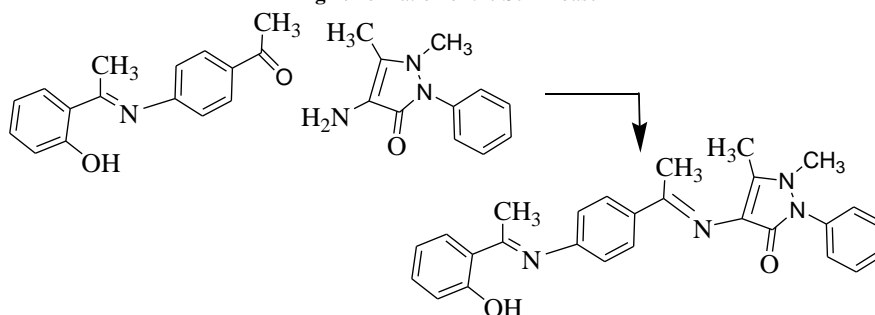
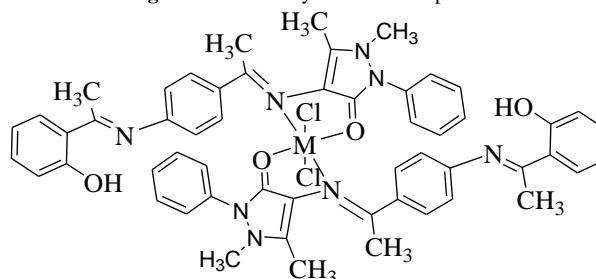
Azomethine (-C=N) group of the Schiff base compounds play an important role in many aspects, such as biochemical reactions because some of the enzymes use the amino group of an amino acid to react with carbonyl (C=O) to form an azomethine linkage. compound such as s 2-hydroxyacetophenone has several chemical intermediates with significant commercial applications [1, 2].

The so-called Salen compounds, when four coordinating sites and two axial sites open to ancillary ligands. That occur when a appropriate diamine combined with two equivalents salicylaldehyde to produce particular chelating Schiff base . Although the term Salen was used originally only to describe the tetradentate Schiff bases derived from ethylenediamine or phenylenediamine derivatives with salicylaldehyde or 2-hydroxyacetophenone or other resemblance molecules, which classified as Salophens Schiff bases that synthesized from aromatic moieties species which quite stable with non-toxic properties and are an effective substitute for salicylaldehyde or derivatives. The more general naming terms of Schiff bases type are used in literature to describe the class of [O,N,N,O] tetradentate Schiff base ligands donor. Almost all such compounds are insoluble in aqueous solutions mainly the aliphatic kinds are decompose easily in acidic solutions, limiting their use to basic condition.

Schiff base compounds are the most widely used organic compounds. They are used as polymer stabilizers, catalysts, dyes, pigments and intermediates in organic synthesis. Also, they have been shown to exhibit a broad range of biological activities, including antimicrobial, antiviral, antiproliferative, antimalarial, anti-inflammatory and antipyretic properties [3, 4]. Azomethine (-C=N) groups are presented in various natural, non-natural and natural product derived compounds as shown in Fig.-2. The azomethine group presented in such compounds has been analogous to be critical to their biological activities [5, 6].

**Fig-2.** Examples of bioactive Schiff bases, where, the azomethine group ( $-\text{C}=\text{N}-$ ) present in each molecular structure as shaded

Co(II), Ni(II) and Cu(II) complexes were formed from the reaction of Schiff base resulted from the reaction of p-aminoacetophenone with salicylaldehyde ( $\text{L}^1$ ) and 4-aminoantipyrine ( $\text{L}^2$ ) to produce Schiff base; 4-(1-(4-(2-hydroxybenzylideneamino)phenyl)ethylideneamino)-1,5-dimethyl-2-phenyl-1H-pyrazol-3(2H)-one. The elucidation of the structure and other phenomenal properties of the Schiff bases and their complexes have been carried out by several physical technique. Some of the obtained results exhibited the complexation sites for the Schiff base with the metal ion were to be via the nitrogen of the azomethine ( $\text{C}=\text{N}$ ) and oxygen of the hydroxyl groups or other groups which can involve coordination. Some of the obtained data, confirmed the existence of octahedral geometrical structures for all complexes [7], and the obtained products as shown in Figs. 3,4,5.

**Fig-3.** Formation of the Schiff base**Fig-4.** Formation of the Schiff base**Fig-5.** Structure of synthesized complexes

Schiff base ligands are easily prepared by the condensation between aldehydes and amines. These compounds are also known as anils, imines or azomethines. Lone pair of nitrogen atom of the azomethine group is of considerable chemical and biological importance. Schiff base ligands are able to coordinate with various transition metal and to stabilize them in various oxidation states [8].

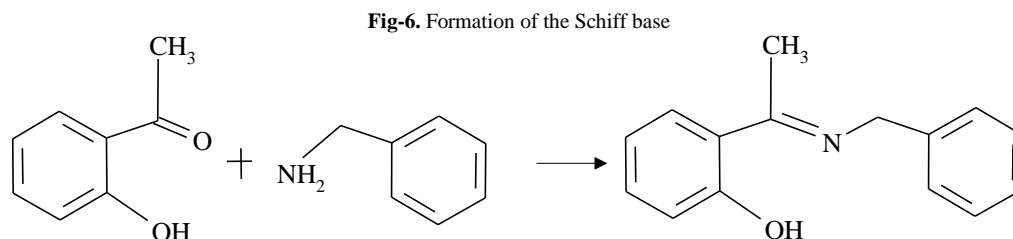
Schiff bases and their complexes are versatile compounds synthesized from the condensation of an amino compound with carbonyl compounds and widely used for industrial purposes and also exhibited a broad range of biological activities including antifungal, antibacterial, antimalarial, antiproliferative, anti-inflammatory, antiviral, and antipyretic properties. Many Schiff base complexes showed excellent catalytic activity in various reactions and in the presence of moisture. Over the past few years, there have been many reports on their applications in homogeneous and heterogeneous catalysis. The high thermal and moisture stabilities of many Schiff base complexes

were useful attributes for their application as catalysts in reactions involving at high temperatures. The activity is usually increased by complexation therefore to understand the properties of both ligands and metal can lead to the synthesis of highly active compound [9-11].

## 2. Experimental Synthesis of Schiff Bases and Their Complexes

### 2.1. Synthesis Of A Schiff Base and Its Pd(II) Complex Derived From 2-Hydroxyacetophenone and Benzylamine [12]

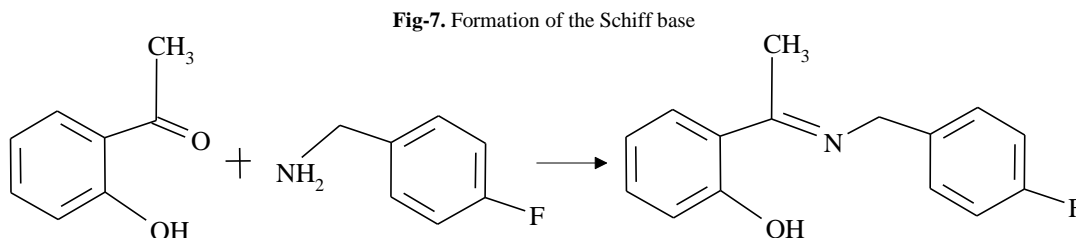
In 60 ml ethanolic solution of 2-hydroxyacetophenone and benzyl amine were mixed in a round-bottomed flask to give a bright yellow solution. The obtained mixture was refluxed for 1hr. A yellow precipitate was appeared when the solution was allowed to cool slowly to room temperature. The precipitate was filtered, washed with ice-cold ethanol and dried at room temperature to yield 76.3% and the obtained product as shown in Fig.-6.



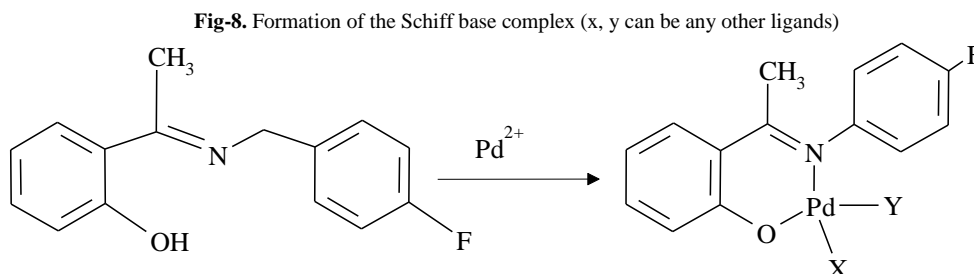
The palladium(II) acetate (2.5mmol) was dissolved in hot absolute ethanol (40ml) and added to the Schiff base solution. The mixture reaction was refluxed for 5hrs, and a green product was formed. It was separated by washed with ice-cold ethanol and dried at room temperature. The obtained product was recrystallized from chloroform yielding yellow crystals with 87.8% yield.

### 2.2. Synthesis of Schiff Base and Its Pd(II) Complex Derived From 2-Hydroxyl Acetophenone and 4-Fluorobenzylamine [12]

This Schiff base was synthesized from the reaction of 2-hydroxyacetophenone and 4-fluorobenzylamine in 60 ml of ethanol. The bright yellow solution. Upon cooling, bright yellow solid was appeared without condensation. The obtained product was filtered, washed with ice-cold ethanol and dried at room temperature with 82.7% yield and the obtained product as shown in Fig.-7.



In 20 ml of acetonitrile, 1mmol of Palladium(II) acetate was added to 2mmol of ligand solution. The mixture was refluxed for 5hrs and a yellow precipitate was obtained. The yellow precipitate was separated by filtration, washed with ice-cold acetonitrile, dried and yield 48.5%. The obtained Schiff base as shown in Fig.-8.

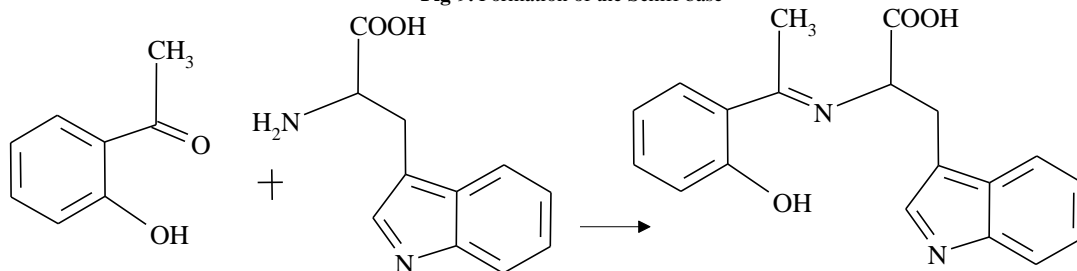


### 2.3. Synthesis of Schiff Base and Its Complexes Derived From 2-Hydroxy Acetophenone and L-Tryptophane [13]

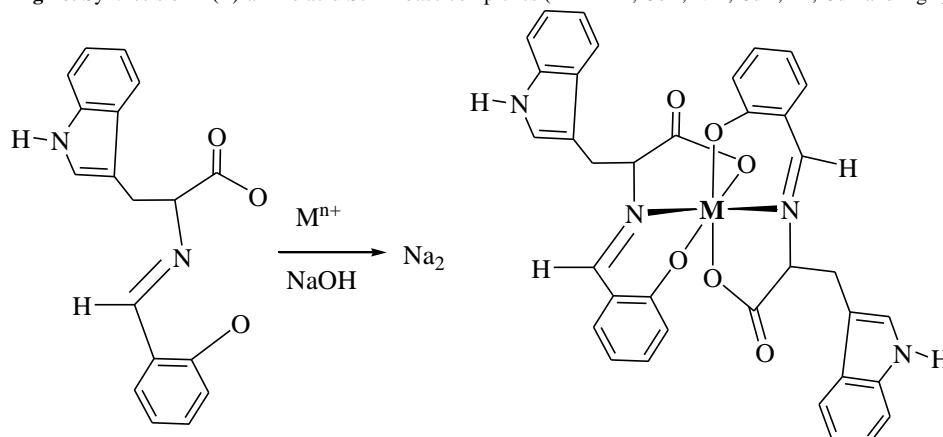
The following Schiff base complexes have synthesized by the following procedure: 2mmol of KOH solution was dissolved in 5ml of distilled water. To an ethanolic solution, 1mmol of *l*-tryptophan was added slowly with constant stirring. Then, the same mmols of 2-hydroxyacetophenone was added and the reaction mixture was stirred for 1hr at 60°C. The obtained precipitate turned to yellow color and finally the precipitate was filtered, washed and dried under vacuum over CaCl<sub>2</sub>. To the above solution, 1mmol of divalent metal ions salts [Mn, Co, Ni, Cu, Zn, Hg

and Cd] in the form of acetate monohydrate can be added in the presence of 1mmol of N,N,N',N'tetramethylethylenediamine (TMEN) and the mixtures were refluxed for 3hrs. The obtained mixtures were filtered, washed with ethanol and dried. The products are shown in Figs.-9,10.

**Fig-9.** Formation of the Schiff base



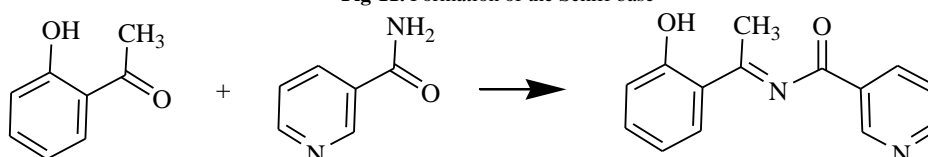
**Fig-10.** Synthesis of M(II)-amino acid Schiff base complexes (M=  $Mn^{2+}$ ,  $Co^{2+}$ ,  $Ni^{2+}$ ,  $Cu^{2+}$ , Zn,  $Cd^{2+}$  and  $Hg^{2+}$ )



## 2.4. Synthesis of Schiff Base and Its Complexes Derived From 2-Hydroxyl Acetophenone and Nicotinamide [14]

Schiff bases of nicotinamide and an isoniazided with 2-hydroxy- acetophenone have been synthesized by refluxing the methanolic solution of 0.8mol of 2-hydroxyacetophenone with nicotinamide. The obtained product was filtered, washed with ethanol and ether, recrystallized with ethanol and dried under vacuum over  $CaCl_2$  and the obtained product as shown in Fig.-11.

**Fig-11.** Formation of the Schiff base



## 2.5. Synthesis of Schiff base and its complexes derived from 2-hydroxyacetophenone and Isoniazid [14]

The following Schiff base was synthesized by the reaction of 0.8mol of 2-hydroxyacetophenone with the same ratio of isoniazid. The obtained mixture was filtered, washed with ethanol and ether, recrystallized with ethanol and dried under vacuum over  $CaCl_2$ . The methanolic solutions of 0.16 mol of the above Schiff bases were add to 0.08 mole of VO(II) and Co(II) salts in the same solvent. The mixtures were refluxed for 10-12hrs to form in 1:2 [M:L] ratio. The obtained mixtures were filtered and recrystallized twice with ethanol, finally washed with petroleum ether (60-80°C) and dried under vacuum over  $CaCl_2$  and the obtained products as shown in Figs.12,14.

**Fig-12.** Formation of the Schiff base

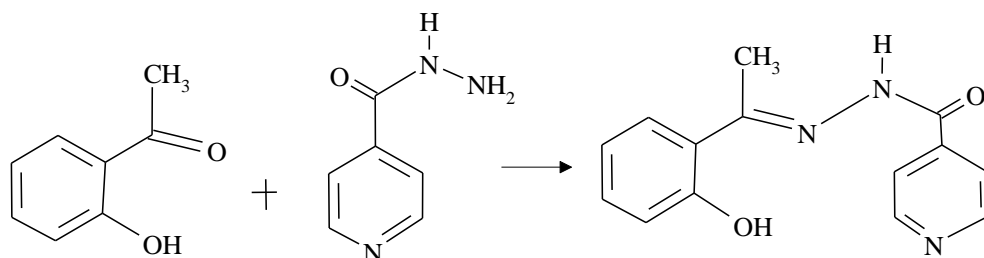


Fig-13. Formation of the Schiff base VO(II) complex

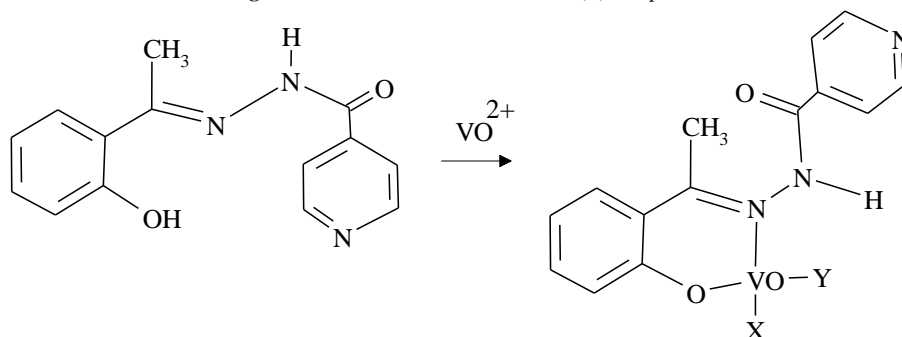
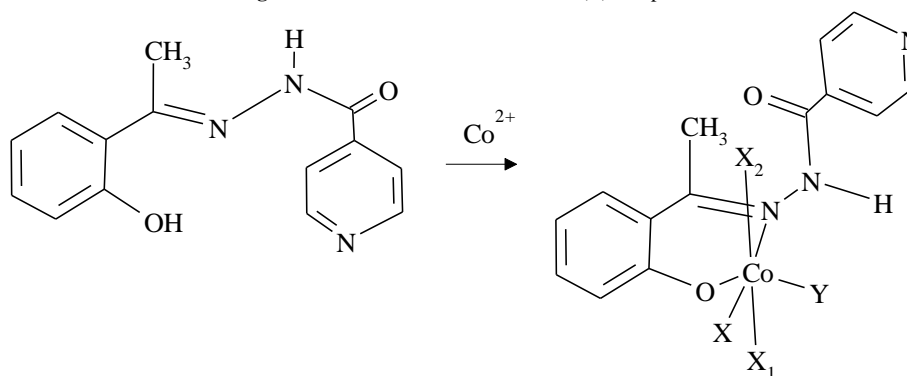


Fig-14. Formation of the Schiff base Co(II) complex



## 2.6. Synthesis of Schiff Base and Its Complexes Derived From 2-Hydroxyl Acetophenone and 1, 8-Naphthalenedamine [15]

An ethanolic solution of 2mmol of 2-hydroxyacetophenone was added to 1mmol of 1,8-diaminonaphthalene in ratio [2:1] in the same solvent. The reaction mixture was condensed for 8hrs. The mixture solution was allowed to evaporate at room temperature, upon which a precipitate was obtained. The product was filtered, washed with cold ethanol and vacuum dried. As well, its Cu(II) complex has been synthesized. And because the geometrical effect , the probability of having either structures as shown in Figs.-15,16.

Fig-15. Formation of the Schiff base

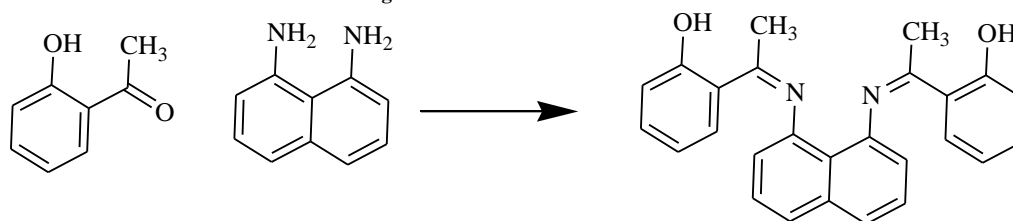
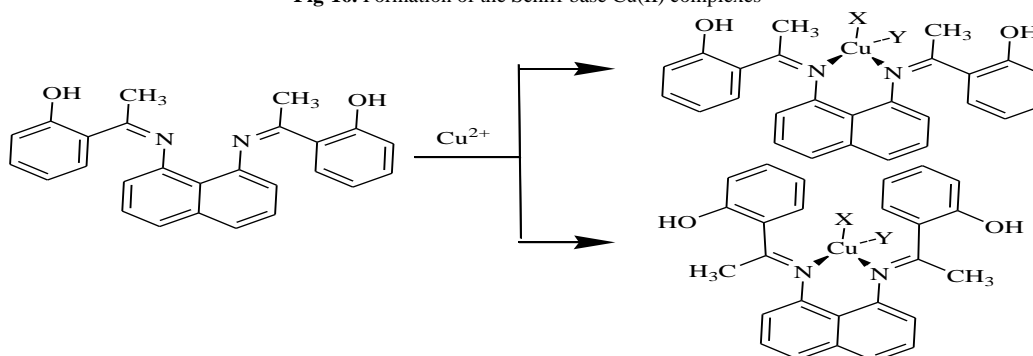
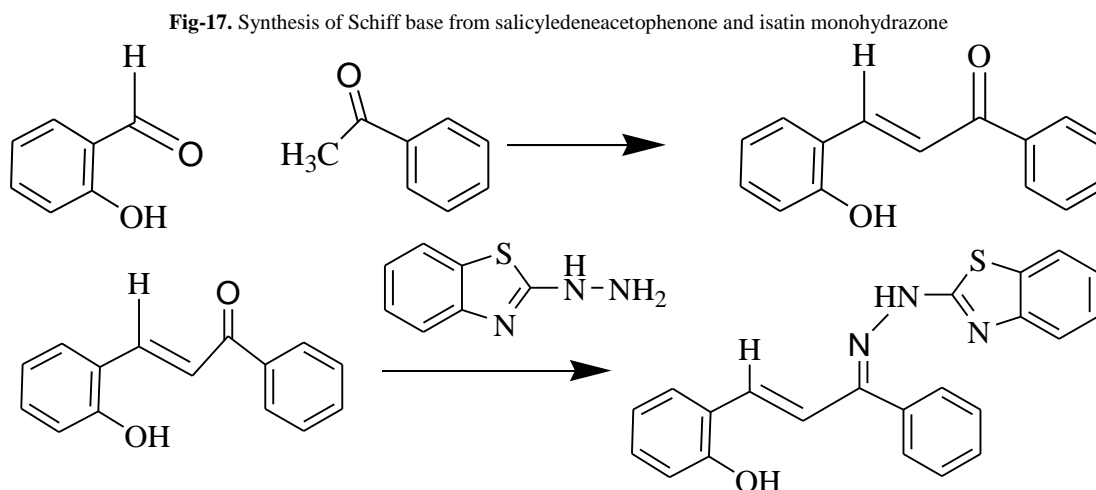


Fig-16. Formation of the Schiff base Cu(II) complexes



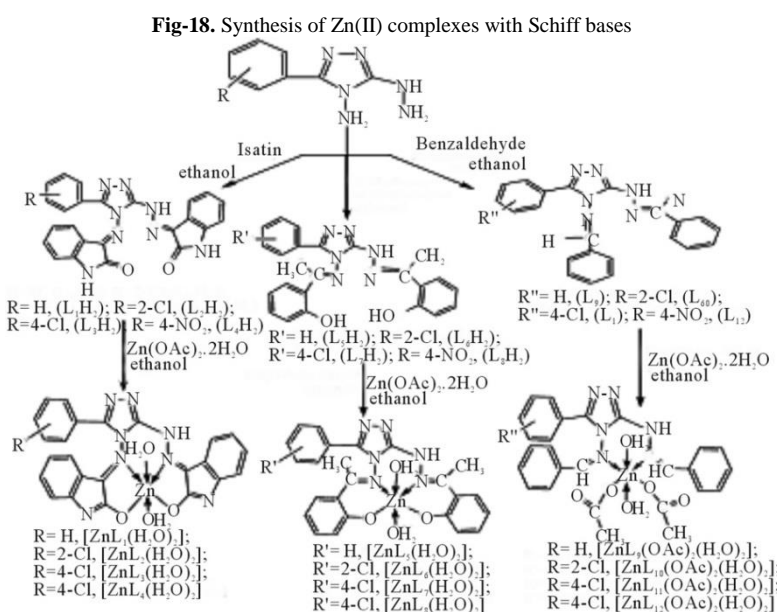
## 2.7. Synthesis of Schiff Base Derived From Salicylaldehydeacetophenone and Amines [16]

This reaction mixture was synthesized by mixing 0.1mol of salicylaldehyde and same ratio of acetophenone, half of the mixture was added to a solution of 10g of NaOH in mixture of 100ml water and 80 ml ethanol). The solution was maintained at room temperature with constant stirring. A deep brown colored product was formed in 2-3mins. The remaining part of mixture was added with stirring for 30 mins. The product was filtered, washed with cold water to eliminate un reacted NaOH and then dried. It was recrystallized from hot rectified spirit. Then the Schiff base was synthesized by warming ethanolic solution of 0.1mol of 2-hydrazinobenzothiazole which then added to the same solvent of the same ratio of salicylaldeneacetophenone and refluxed for 3-4hrs where a grey colored product was obtained. It was filtered, washed and recrystallized from ethanol and the obtained products are shown in Fig.-17.



## 3. Biological Activities (Antibacterial and Antifungal Activities)

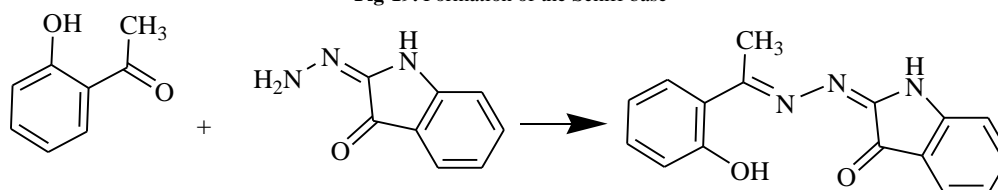
Zn(II) complexes have been carried out by the reactions of zinc(II) acetate with Schiff bases formed from different carbonyl groups [2- hydroxyacetophenone, indoline-2,3-dione and benzaldehyde] with 3-substituted phenyl-4-amino-5-hydrazino-1,2,4-triazole and the obtained products as shown in Fig.-18. All Zn(II) complexes were soluble in DMSO and DMF solvents; The molar conductance values revealed that the synthesized complexes were non-electrolyte in nature. All the Schiff bases and their Zn(II) complexes have also been tested for their antimicrobial activities against two kinds of pathogenic bacteria [*B. subtilis*, *E. coli*] and four pathogenic fungi [*C. falcatum*, *A. niger*, *F. oxysporium* and *C. pallascence*] [17].



A series of complexes with divalent metal ions [Mn, Co, Ni, Cu and Zn] have been synthesized by refluxing of 2-hydroxyacetophenone with isatin monohydrazone and studied by using several physical techniques [18]. The Schiff base and its complexes were examined for their antimicrobial activities against some pathogenic bacteria and fungal strains by the agar disc diffusion method. A comparative investigation of the MIC values of the free Schiff base and its complexes exhibited that the Cu(II) complex indicated a higher antimicrobial activity than the free Schiff base and the obtained product as shown in Fig.-19.



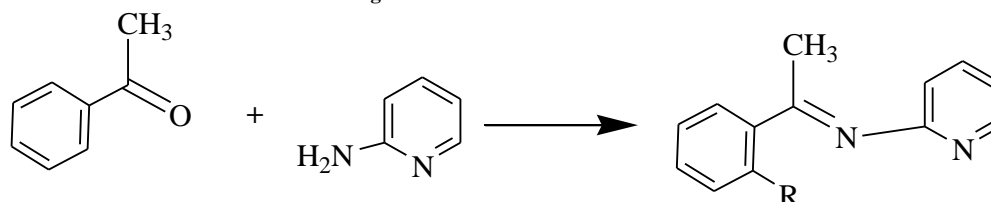
Fig-19. Formation of the Schiff base



Two complexes of Ni(II) and Cu(II) ions of a Schiff base derived from 2-hydroxyacetophenone and *N,N',O*-donor have been synthesized and investigated by applying several physiochemical techniques. The synthesized complexes also exhibited a moderate zone inhibition against *S. aureus*, *M. resistant*, *P. aeruginosa* and *A. baumannii*. No biological activity showed for the complexes with *K. pneumonia*. In addition, the Schiff base was tested against the emerging multi-drug resistance nosocomial bacterial extracted from the hospital settings, namely, MRSA, *P. aeruginosa*, *A. baumannii* and *K. pneumonia*. In the first level antibacterial examining with disc diffusion assay. The Schiff base and its complexes have been screened against eight clinical strains, with two from each bacterial species. Inhibition zones have been observed in metal-coupled Schiff base. However, no inhibition zone was observed in any of the compounds tested against *K. pneumonia*. All of the Cu(II) and Ni(II) coupled Schiff base were moderately inhibitive against MRSA, meanwhile, revealed a weak antibacterial activity against *P. aeruginosa* and *A. baumannii*. The test displayed that all of the Cu and Ni compounds were active against MRSA. Both *P. aeruginosa* and *A. baumannii* were resistant to the examined Schiff base and its complexes. It was concluded that the Schiff base and its complexes inhibitive only against the gram positive bacterium (MRSA). A comparative study of minimum inhibitory concentration (MIC) values of the Schiff bases and their complexes, with Cu(II) and Ni(II) indicated that they have better activity than the free Schiff base. This may be assigned to the change in structure as a result of complexation and chelating tends to make complexes acted more powerful and potent bacteriostatic agents, thus inhibiting the growth of the microorganisms. On chelation, the polarity of the metal ions will be reduced to a greater extent due to the overlap of the ligand orbital and partial sharing of positive charge of the metal ions with donor atoms [19, 20].

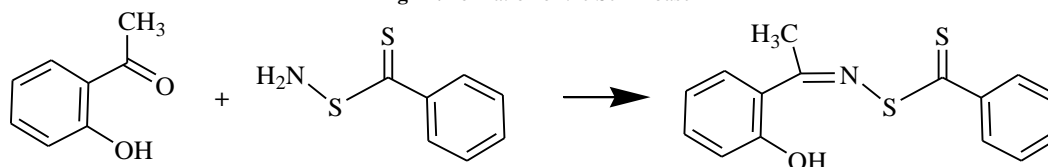
The synthesis, characterization and biological activity of thorium(IV) and uranium(VI) complexes of Schiff base formed from the refluxing of 2-aminopyridine and acetophenone compounds have been reported [21], and the obtained product as shown in Fig.-20.

Fig-20. Formation of the Schiff base



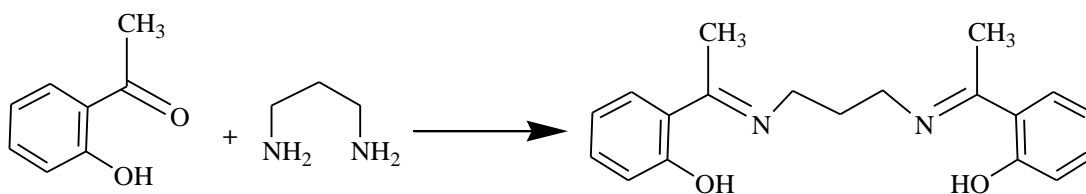
A series of the divalent transition metal ions [Ni, Cu and Zn] complexes of Schiff base derived from the condensation of 2-hydroxyacetophenone and *S*-benzylthiocarbamate were prepared and investigated by using several physiochemical tools [22]. The antimicrobial activities (Antibacterial and antifungal) of the Schiff base and its complexes were tested against some pathogenic bacteria and fungi species [*S. dysenteriae*, *S. typhi*, *B. cereus*] and [*F. equiseti*, *M. phaseolina*, *B. theobromae* and *A. alternate*]. The activity was found to be potential antimicrobial agents. An attempt is also made to correlate the geometry of the synthesized complexes and their biological activities. The obtained product as shown in Figs.-21.

Fig-21. Formation of the Schiff base



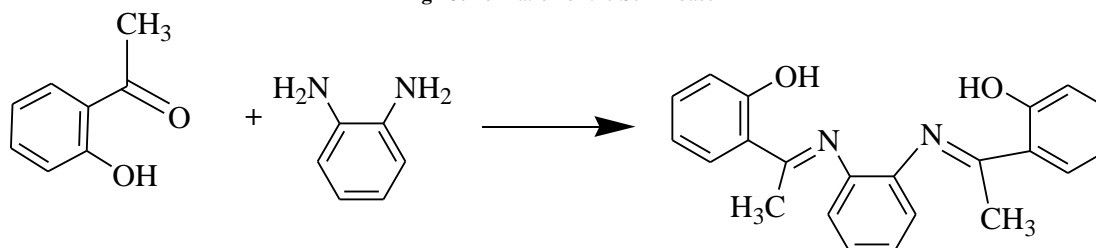
The synthesized Schiff base which formed from the condensation of 2-hydroxyacetophenone and 1,3-diaminopropane in ratio[1:2] has been reported [23]. The Schiff base (fig.22) used in preparation of complexes with Pd(II) ion in ratios of 1:1 or 1:2[M:L]. Its complexes were screened for their antibacterial activity against two different bacteria species [*E. coli* and *S. aureus*]. It was found that the activity of the complexes were more active than free Schiff base, this may be due to the chelation process.

Fig-22. Formation of the Schiff base



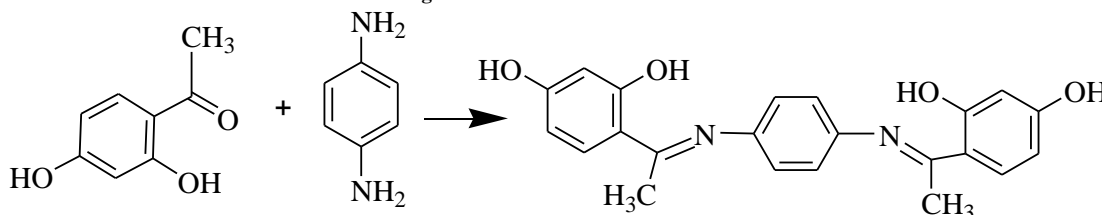
The complexes of divalent transition metal ions [Co and Cu] with Schiff base formed by the refluxing of 2-acetophenone and 1,2-phenylenediamine have been prepared and characterized by several physiochemical tools; in terms; elemental analysis and spectroscopic techniques [24]. The obtained results showed a square planar structure for both two complexes. The antibacterial activity of the Schiff base and its complexes were screened against three types of pathogenic bacteria species. The data displayed that the complexes have more antibacterial activity than the free Schiff base and the obtained product presented in Fig.-23.

Fig-23. Formation of the Schiff base



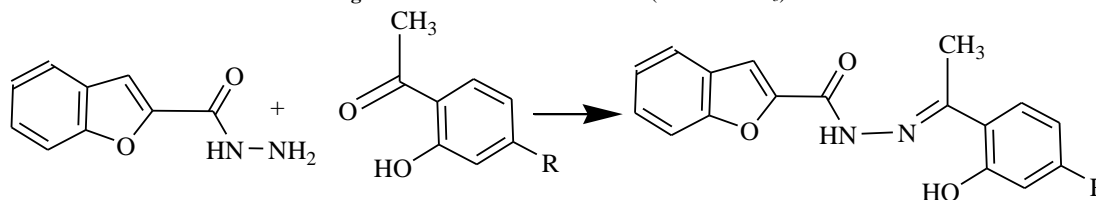
Preparation and investigation of five polymeric complexes of Mn(II), Co(II), Ni(II), Cu(II) and Zn(II) ions with Schiff base resulted from the reaction of 2,4-dihydroxyacetophenone and 1,4-phenylene diamine were done [25]. As well the antimicrobial activity of these compounds were tested against some pathogenic bacteria species. It was found that the polymeric complexes have a higher activity than the free Schiff base and the obtained product is shown in Fig.-24.

Fig-24. Formation of the Schiff base



Six complexes of Co(II), Ni(II), Cu(II), Zn(II), Cd(II) and UO<sub>2</sub>(II) ions with Schiff base resulted from 2-hydroxy-4-chloroacetophenone, 2-hydroxy-4-methylacetophenone and carbohydrazide were prepared and characterized using several physical techniques [26]. The antimicrobial activity of the Schiff base and its complexes have been examined against various types of microorganisms. The results exhibited different activities against those microorganisms used. Also the complexes showed a higher activity than free Schiff base, this is due to the effect of chelation process which occurred between the metal ions and the active groups in the Schiff base and the obtained product is shown in Fig.-25.

Fig-25. Formation of the Schiff base (R = Cl or CH<sub>3</sub>)

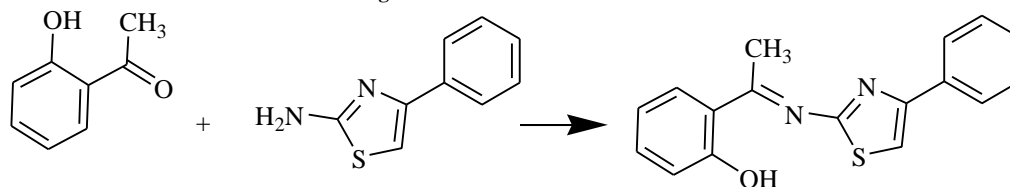


The prepared and the characterized Schiff base derived from 2-hydroxyacetophenone and nicotinamide were done and used to form complexes with Ni(II) and Cu(II) ions in ratio [1:2; M:L]. The Schiff base and their complexes have been tested for their antibacterial activity against Gram negative and positive bacteria species. The results showed good activity [27].

The synthesize and investigation of four divalent metal ions complexes [Co, Ni, Cu and Zn] with Schiff base resulted from the condensation of 2-hydroxy-5-chloroacetophenone with 2-amino-4-phenylthiazole have been reported [28]. The Schiff base and its complexes were examined for their antimicrobial activity against some pathogenic bacteria strains [*B.subtilis*, *P.vulgaris*, *S.aureus*, *E.coli*, *P. fluore scen*, *A.aerogenes*, *B. megatherium*] and the obtained Schiff base is shown in Fig.-26.

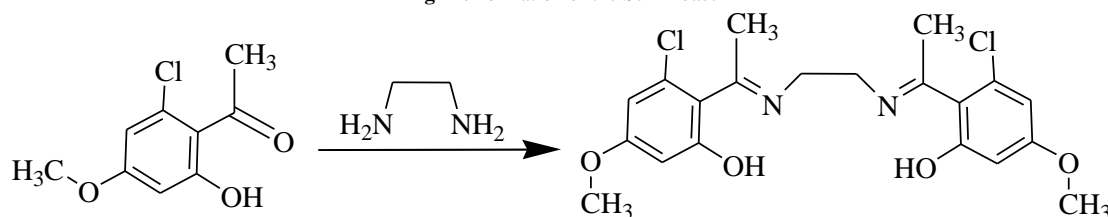


Fig-26. Formation of the Schiff base



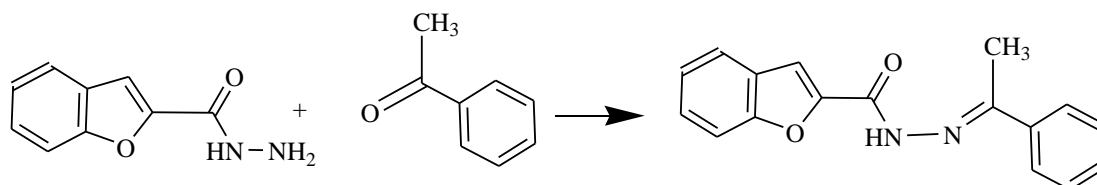
Cu(II), Co(II), Ni(II) and VO(II) complexes with Schiff base formed from the reaction of 2-hydroxy-4-methoxyacetophenone and ethylenediamine in ratio [2:1], were synthesized and the obtained product is shown in Fig.-27. The Schiff base and its complexes have been investigated using several physiochemical techniques. It was found that the Schiff base behaved as tetradentate ligand and coordinated to the metal ions via nitrogen atom of the azomethine and oxygen atoms of the hydroxyl group. According to the spectroscopic analysis, a tetragonal pyramidal geometry was suggested for VO(II) complex, tetrahedral for Co(II) complex and square planar structure for both Ni(II) and Cu(II) complexes [29].

Fig-27. Formation of the Schiff base



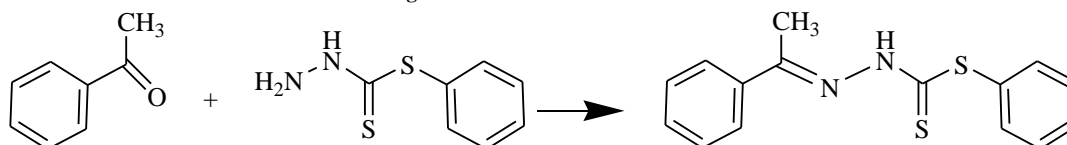
Complexes of divalent metal ions [Cu, Co, Ni, Zn, Cd and Hg] with a Schiff base (Fig.28) derived from acetophenone and 2-carbohydrazide have been prepared and studied by using several physical tools. The spectral study showed that the Schiff base acts as bidentate ligand. The Schiff base and its complexes were screened for their antimicrobial activity against some pathogenic bacteria and fungi [*A. niger*, *C. albicans*, *E. coli* and *S. aureus*]. It was found that Co(II), Cu(II) and Zn(II) complexes have moderate activity against *E. coli*, meanwhile Hg(II) complex exhibited a high activity against the same bacteria, but Ni(II), Co(II) and Zn(II) complexes showed a high activity against *S. aureus* bacteria. The results showed higher activity for complexes than the free Schiff base. Also, the complexes revealed high antifungal activity compared to the free Schiff base [30].

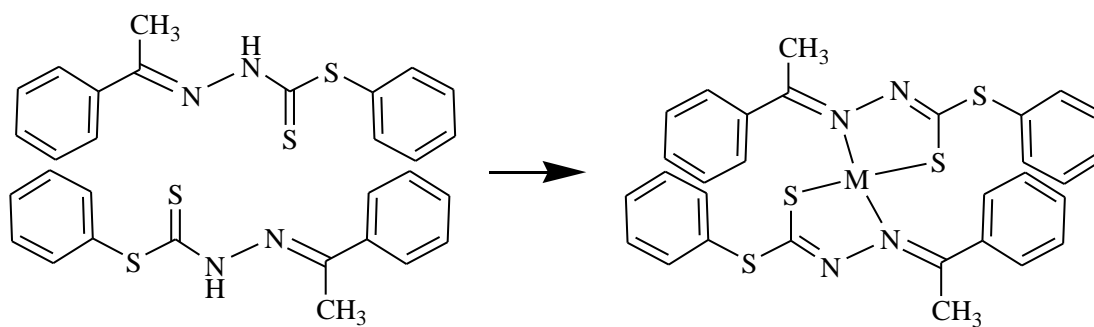
Fig-28. Formation of the Schiff base



The preparation of Schiff base [(SBDTC)<sub>2</sub>AP] (Fig.-29) was derived from the condensation of *S*-benzylthiocarbamate and acetophenone in 2:1 ratio and the mechanism have been given as cited in the reference. This Schiff base was engaged to form five complexes with Cu(II), Cd(II), Zn(II), Ni(II) and Co(II) ions, fig.-30. The Schiff base and its complexes were investigated by using several physical techniques [31]. The Schiff base and its complexes have been tested for their biological activities against some pathogenic bacteria species. The Schiff base exhibited a moderate activity against *S. aureus*, *S. Typhi* M.H. and *Aeromonas sp.* All complexes were inactive against *S. Typhi* M.H.

Fig-29. Formation of the Schiff base

Fig-30. Structures of complexes (M = Co<sup>2+</sup>, Ni<sup>2+</sup>, Cu<sup>2+</sup>, Zn<sup>2+</sup> or Cd<sup>2+</sup> ions)



A Schiff base from p-Toullic hydrazone and resacetophenone (RAPPTH) as ligand used to prepare four Mn(II), Co(II), Ni(II) and Cu(II) complexes Figs. 32, 33 were synthesized and characterized by some physical methods, such as; microanalysis, molar conductivity, magnetic properties, IR,  $^1\text{H}$ NMR, UV-Visible, ESR, VSM and XRD. The resulted data showed the formation of the complexes in 1:2[M:L] ratio and an octahedral structure was confirmed for all complexes.

Fig-31. Formation of the Schiff base

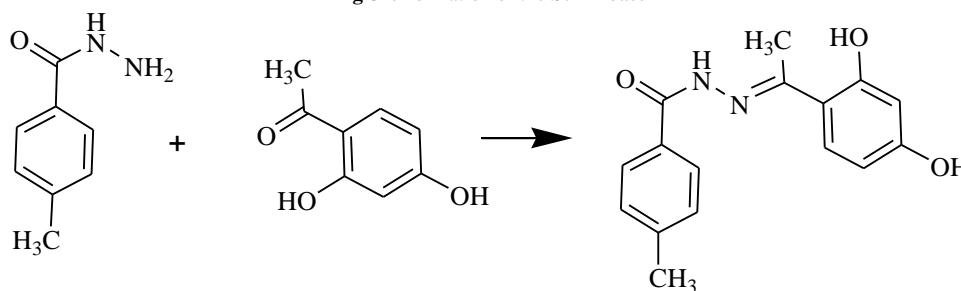
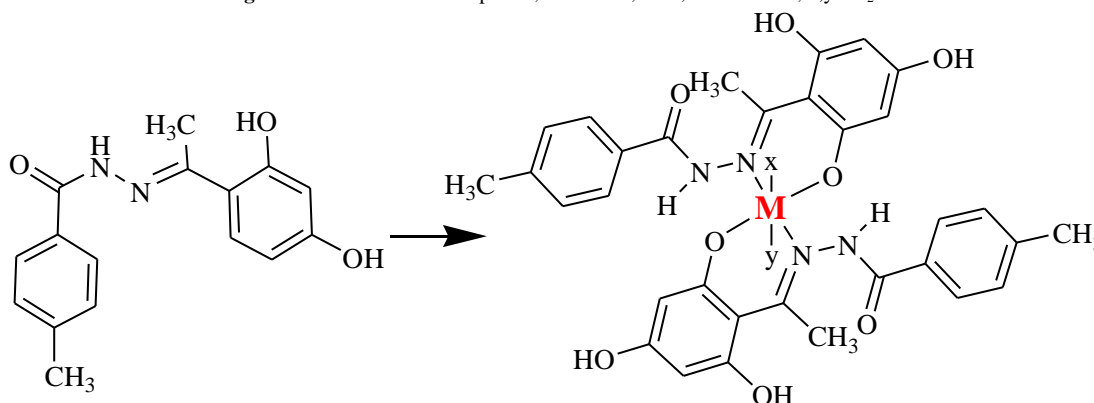


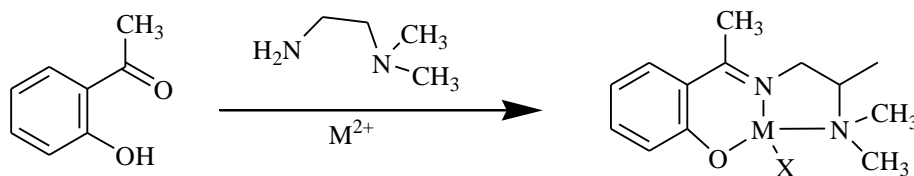
Fig-32. Formation of the complexes;  $M = \text{Mn}^{2+}, \text{Co}^{2+}, \text{Ni}^{2+}$  or  $\text{Zn}^{2+}$ ;  $x, y = \text{H}_2\text{O}$



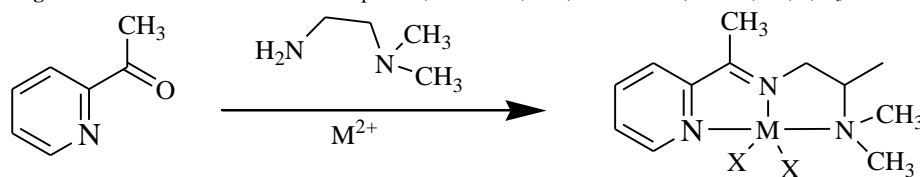
The biological activity studies of the Schiff base; RAPPTH ligand and their complexes were examined against some pathogenic bacteria species. All the compounds have been engaged in biological activity and their antibacterial activity studies estimated against four bacteria's namely, *E. coli*, *S. aureus*, *P. aeruginosa* and *B. subtilis*. The antibacterial activity studies suggested that the most of the complexes are of a good antibacterial activity when compared to streptomycin. RAPPTH with Cu(II) complex exhibited a higher activity compared to the other remaining compounds [32].

Series of complexes involved *N,N',O*-donor Schiff base resulted from the condensation reaction of 2-hydroxyacetophenone with *N,N*-dimethylethylenediamine were synthesized. as well as resemblance compounds were also synthesized to justify the chemical behavior of the complexes. The Schiff bases were used to form complexes with Mn(II), Ni(II), Cu(II), Zn(II) and Cd(II) ions (Fig.34-36). Such Schiff bases and their complexes have been studied by using several physiochemical techniques. The Schiff bases and their complexes displayed a moderate zone inhibition against Gram positive bacterium [*Methicillin-resistant Staphylococcus aureus*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*]. No antimicrobial activity observed with *Klebsiella pneumonia* [33].

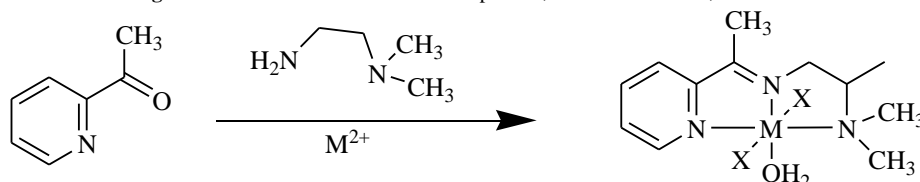
Fig-33. Formation and structures of compounds;  $M = \text{Mn}^{2+}, \text{Ni}^{2+}, \text{Cu}^{2+}$  or  $\text{Zn}^{2+}$ ;  $X = \text{Cl}^-$  or  $\text{Br}^-$



**Fig-34.** Formation and structures of compounds;  $M = \text{Mn}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Cu}^{2+}$  or  $\text{Zn}^{2+}$ ;  $X = \text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{N}_3^-$  or  $\text{NCS}^-$

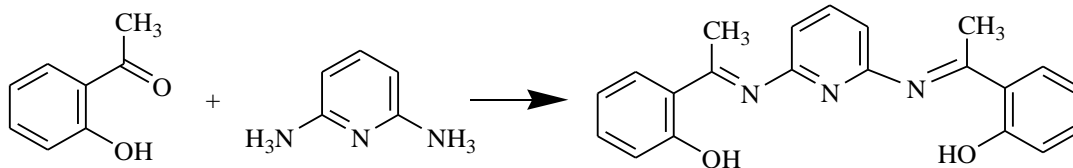


**Fig-35.** Formation and structures of compounds;  $M = \text{Mn}^{2+}$  or  $\text{Ni}^{2+}$ ;  $X = \text{NCS}^-$

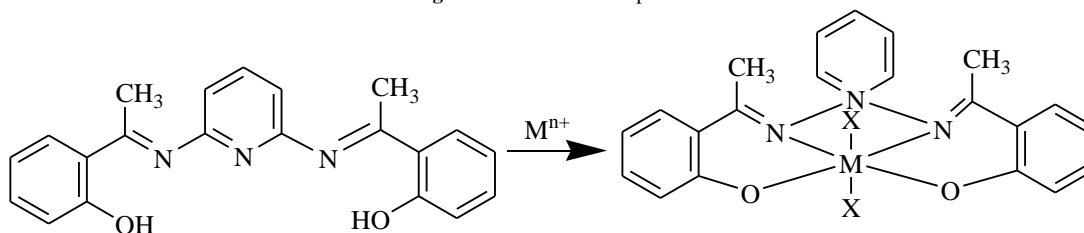


Schiff base from 2,2'-(1E,1'E)-1,1'-(6-chloropyrimidine-2,4-diyl)bis (azan-1-yl-1-ylidene)bis(ethan-1-yl-1-ylidene)diphenol were prepared by the condensation of 4-chloro-2,6-diaminopyrimidine and 2-hydroxyacetophenone [34]. Five Mn(II), Co(II), Ni(II), Cu(II) and VO(IV) complexes of this Schiff base were introduced to the biological activity study. The Schiff base has been evaluated against four pathogenic bacteria Gram-positive (*S. aureus*, *B. subtilis*) and Gram negative (*E. coli* and *K. pneumonia*) bacteria strains. All the complexes exhibited higher antibacterial activity than the free Schiff base. Whereas, cobalt(II) and nickel(II) complexes have higher bacterial activity than the other complexes. The obtained products are shown in Figs.-37,38.

**Fig-36.** Formation of the Schiff base



**Fig-37.** Formation of complexes



The Schiff base formed from the reaction of hydrazine and 2-hydroxyacetophenone was synthesized and investigated by using several physical techniques, in particular; CHN elemental analysis, infrared, ultra violet and mass spectra. Only one product was formed from the reaction of the carbonyl and primary amine. The purity of the isolated Schiff base was confirmed by melting points and TLC technique. The Schiff base under investigation forms complexes with Co(II), Ni(II), Cu(II), Cr(III) and La(III) ions. The synthesized complexes were confirmed by elemental analysis, molar conductivity, thermogravimetric analysis (TGA) analysis and spectral (IR, electronic and ESR) measurements. The analytical data showed the formation of 1:1 (M:L) complexes. The molar conductance measurements of the complexes revealed a non-electrolytic nature. The thermogravimetric analysis data of some complexes exhibited the presence of coordinated and hydrated water molecules. The infrared spectral data displayed the chelation behavior of the Schiff base towards the metal ions. The electronic spectral results of the Schiff base and its complexes showed  $\pi \rightarrow \pi^*$  (phenyl ring),  $n \rightarrow \pi^*$  ( $\text{HC}=\text{N}$ ) and the expected geometrical structures for the synthesized complexes. Basis on the electron paramagnetic resonance spectral data, an octahedral structure was suggested for all complexes. The synthesized Schiff base and its complexes were tested against some pathogenic bacteria [*Escherichia coli*, *Proteus* Sp, *Pseudomonas aeruginosa* and *Staphylococcus aureus*] [35].

The prepared and characterized series of chelates of Zr(IV), La(III) and Ce(IV) with bidentate Schiff base; 2-(2-[(2-hydroxyphenyl)-ethanimidoyl]phenylethanimidoyl)phenol were introduced in research studies [36]. On the basis of several physical tools, specially, the elemental analysis data, the chelates have been found to be in the 1:1 [M:L] ratio as cited in the reference. According to the data, also an octahedral geometry was suggested for all the chelates.

The Schiff base and its metal chelates were screened for their biological activities against some pathogenic antimicrobial activity two Gram-negative (*Escherichia coli*, *Salmonella kentucky*), two Gram-positive (*Lactobacillus fermentum*, *Streptococcus faecalis*) bacterial strains and fungi unicellular (*Fusarium solani*) and filamentous fungi (*Aspergillus niger*). The data showed that the metal chelates have antibacterial and antifungal activities more than the parent free Schiff base against one or more bacterial or fungal species. The obtained products are shown in Figs.39-42.

Fig-38. Formation of Schiff base

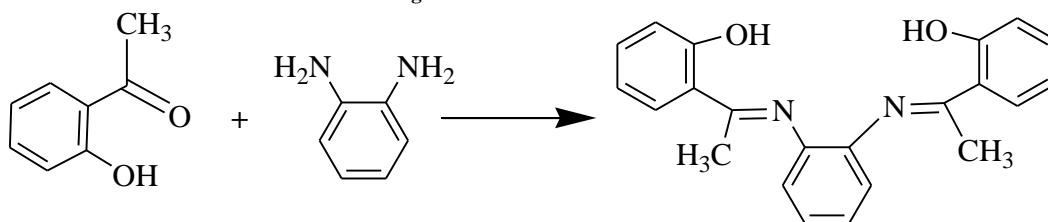


Fig-39. Formation of ZrO(II) complex

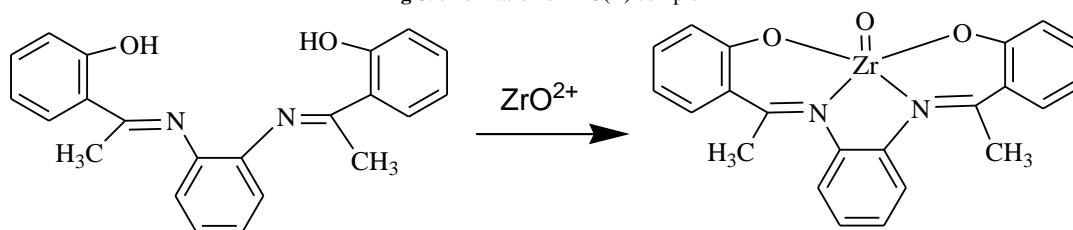


Fig-40. Formation of La(III) complex

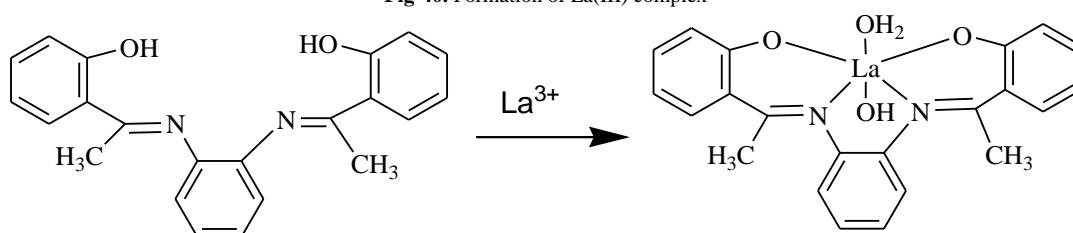
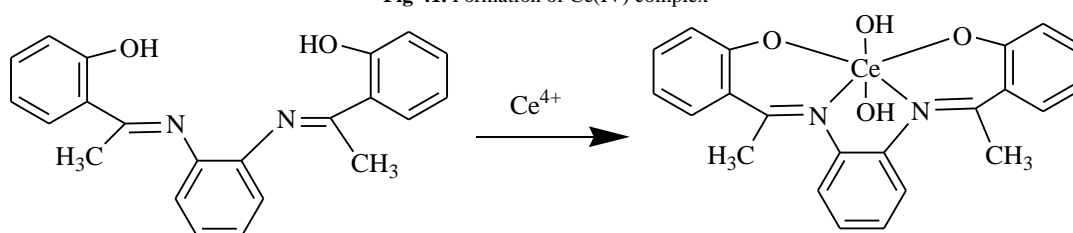


Fig-41. Formation of Ce(IV) complex



## 4. Conclusion

As we mentioned in very conservative lines and descriptions. And has been illustrated in many occasions, both in the literature and in this review, Schiff's bases in the form of salens or salophens have clear advantages in term of easy to prepare and in complexes formation, and versatility. Recently the promised application of Schiff's bases in analytical chemistry, medical, and in the other fields such as, sensors. The development of Schiff's bases based sensors and to be considered in many fields of research planes. Many published papers emphasizing the impotence of such simple chemical compounds as research aspects and/or applications, which are under continuous investigations and considered for publication yearly..

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