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Amino Acid based Schiff Bases and its Zn (II) Complexes

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Research Article

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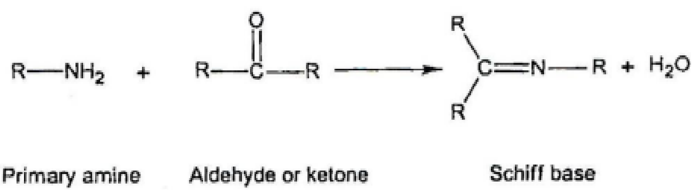
ABSTRACT

Metal chelates of Schiff base prepared by combining salicylaldehyde and amino acids could be effectively used in understanding the mechanism of transamination reaction. They can act as biomimetic species. The current article focused on the syntheses, characterization, complexation behaviour and antimicrobial studies of some novel Schiff bases formed from salicylaldehyde with 3-amino benzoic acid and Glycine and Alanine using sodium hydroxide as a catalyst. The synthesized Schiff base ligands have been successfully complexed with the metal Zn (II) and studied by their spectral data. Morphological studies were carried out using SEM. The impact of complexation on the antimicrobial activity of Schiff bases and its Zn (II) complexes has also been studied.

INTRODUCTION

Schiff bases are compounds containing azimethine group (-CH=N-). They are the condensation products of ketones or aldehydes with primary amines **(Scheme 1).** It was first investigated by Hugo Schiff [1]. Formation of Schiff base generally takes place under acid or base catalysis or with heat. Bases obtained from amines and aldehydes have applications in various disciplines of chemistry [2,3]. Several of these biomimetic Schiff bases are gifted with antimicrobial and antitumor properties and could be used against HIV [4,5]. Schiff base metal complexes obtained from salicylaldehyde and amino acid could be effectively used in explaining transamination reactions in living systems [6,7]. Schiff bases derived from amino acid are highly unstable and are generated on site [8-11]. Thus a few number of crystalline Schiff bases could be isolated from amino acids and aldehydes. Here we report the syntheses, characterization, antimicrobial studies and complexation behaviour of three Schiff bases obtained from salicylaldehyde with 3-amino benzoic acid, Glycine and D-Alanine [12]. Schiff bases are very good chelating ligands and transition metals could form highly efficient Schiff base complexes [13,14]. Atoms like N, O and S present at the active site of biomolecules play a key role in the coordination of transition metals [15,16]. Schiff base metal complexes with biomolecules have been widely studied because they have a wide range of activities including industrial, anticancer, antiviral and herbicidal applications [17-19]. They could perform as models for many biological species and find applications in many biomimetic catalytic reactions [20].



Scheme 1. General structure of synthesis of Schiff base.

EXPERIMENTAL

Materials

Chemicals like Ethanol, Sodium hydroxide, Glycine, D-Alanine, 3- Amino benzoic acid, Salicylaldehyde were provided by

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Sigma Aldrich Company and they were used as supplied. Metal salt used was zinc chloride. The UV-Vis spectra were taken on a Shimadzu 160-A spectrometer. The FTIR spectra were recorded on a Bruker IFS-55 spectrometer using KBr pellets. SEM photographs were taken using a Hitachi S-2400 instrument.

Methods

Preparation of amino acid based Schiff bases using Salicylaldehyde and glycine and alanine [21]: In a 50 ml conical flask, prepare a separate 10^{-2} mole solutions by dissolving (1.2 g) of Salicylaldehyde, (1.5 g) of Glycine, (0.89 g) of D-Alanine and (0.4 g) of sodium hydroxide, in 15 ml of ethanol. Mix the Salicylaldehyde solution with proper amino acid solution and mixture is stirred. By gradual addition, add sodium hydroxide solution to each mixture during a period of 30 minutes. The final mixture is left for about 15 minutes, filtered, washed with cold ethanol.

Preparation of Schiff base from Salicylaldehyde and 3-amino benzoic acid [22]: Prepared by adding 25 ml of salicylaldehyde in ethanol (1.22 g, 0.01 mol) to same volume of 2-amino benzoic acid also in ethanol (1.37 g, 0.01 mol). The solution was refluxed for 2 hours and the product is filtered, washed with ethanol and recrystallized from hot ethanol.

Preparation of metal complexes using Schiff base [22]: These were prepared by adding 25 ml of a solution of metal chloride in ethanol (0.01 mol) with preformed Schiff base in ethanol (0.01 mol) and aqueous ammonia is added drop wise. This was refluxed for two hours and the complex formed as a precipitate. It was filtered and washed several times with hot ethanol until washings were colourless and dried.

Antimicrobial activity: Antimicrobial substance kills or prevents the growth of microorganisms and metal complexes showed very good antimicrobial activity. E. coli is a gram-negative bacterium found in the lower intestine of humans. In the present work antimicrobial activity of synthesised Schiff base ligands and its metal complexes were studied against E. coli bacterium.

The antimicrobial studies were done by agar disc diffusion method, where the bacterial culture is incubated at 30 ± 0.1°C for 24 hours by injecting into nutrient agar [23,24]. Schiff bases were kept at room temperature in dry conditions and they were dissolved 20 mg/ml in double distilled water and complexes were dissolved in DMSO. It was then poured into the plates and allowed to solidify. The plates (9 cm) were incubated with 50 µL of normal saline solution of above culture media (105-106 bacteria per ml). Discs injected with preformed Schiff bases (50 µL) were applied on the solid agar medium by pressing tightly. The plates were kept at 37°C for 24 hours. After 24 hours the inhibition zones formed on media were measured with a zone reader in millimetres.

RESULTS AND DISCUSSION

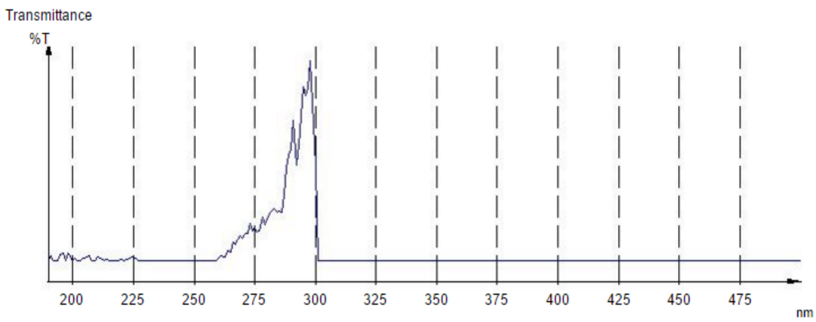
The present work describes the syntheses of amino acid based Schiff bases from salicylaldehyde with amino acids Glycine, D-Alanine and 3-Amino benzoic acid. Here we report the use of NaOH catalyst during the synthesis of Schiff base under study. The characterizations were done by IR, UV and SEM analysis. Antimicrobial studies were also carryout. The physical characteristics of the Schiff bases were recorded on **Table 1.**

Table 1. Physical properties of amino acid based Schiff base ligands.

No	Nomenclature	M. P.	Colour	Solubility
1	Glycine Salicylidimine	180°C	Yellow	Soluble in water and not soluble in organic solvents
2	Alanine Salicylidimine	120°C	Faint yellow	Soluble in water and insoluble in organic solvents
3	3-nitro benzoic acid Salicylidimine	162°C	Orange	Soluble in organic solvents and insoluble in water

Characterization

UV-Visible spectroscopy:



Transmittance range: 190-500 nm
Transmittance max: 298 nm (0.4897)

Figure 1. UV-visible spectra of salicylidene-glycine-Schiff base-Zn complex.

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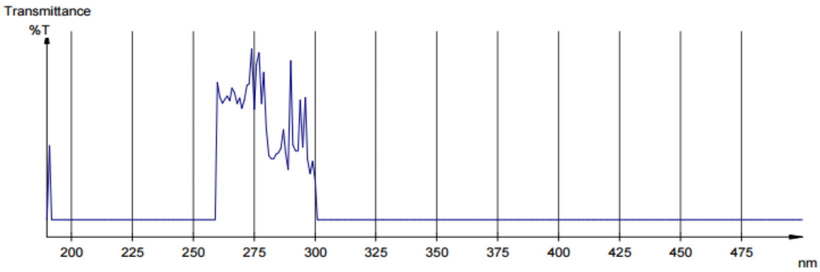
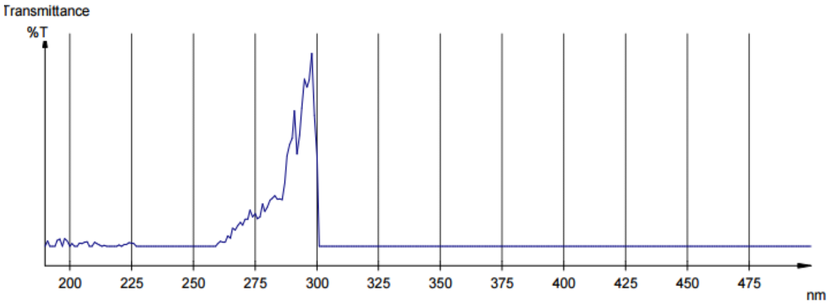


Transmittance range: 190-500 nm
Transmittance max: 275 nm (0.5678)

Figure 2. UV-visible spectrum of 3-amino benzoic acid-Zn-schiff base complex



Transmittance range: 190-500 nm
Transmittance max: 291 nm (2.8251)

Figure 3. UV-visible spectrum of alanine-schiff base-Zn complex

The UV-Vis transmittance spectra of metal complexes in DMSO were recorded at room temperature **(Figures 1-3).** The UV-Visible spectra of complexes show a peak in the region of 275–300 nm. This is due to the complex formation by Zn (II) ion. The transmittance max observed minimum in the case of Salicylaldehyde Glycine Zn (II) complex indicating the maximum attachment of Zn (II) ion to this schiff base ligand.

IR spectral studies of Schiff bases and their Zn complexes:

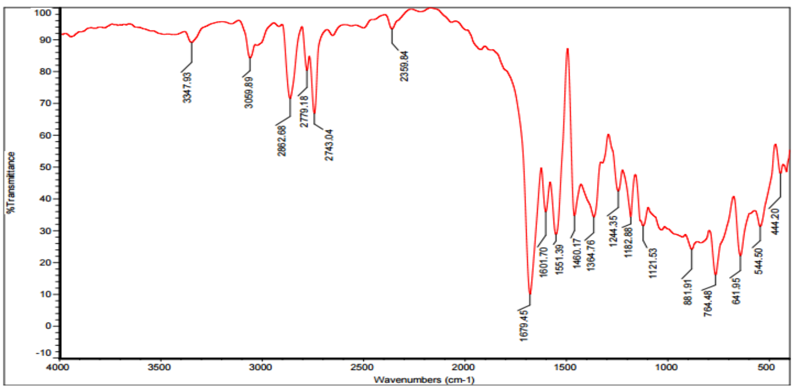


Figure 4. IR spectra of salicylidene-glycine-schiff base.

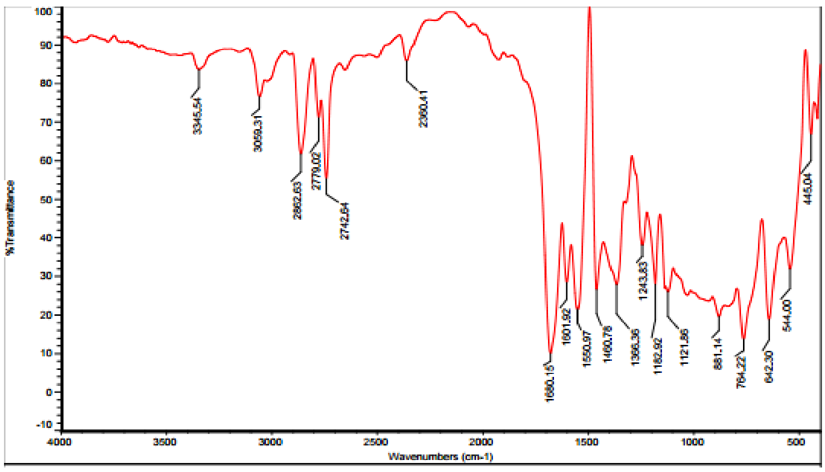


Figure 5. IR spectra of salicylidene-3-amino benzoic acid-schiff base.

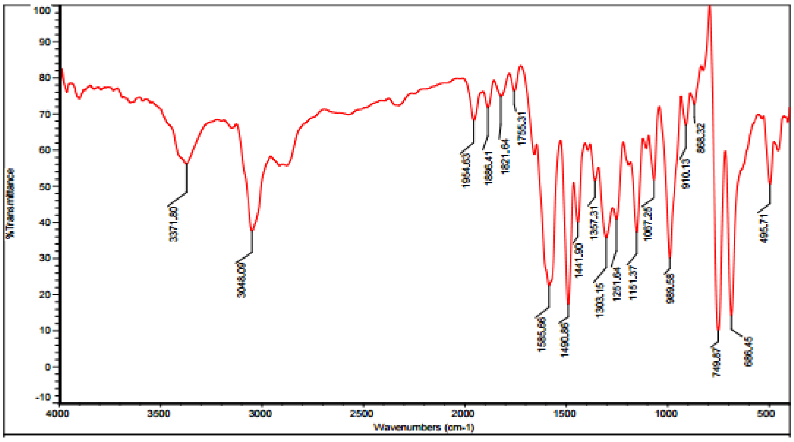


Figure 6. IR spectra of salicylidene-alanine-schiff base.

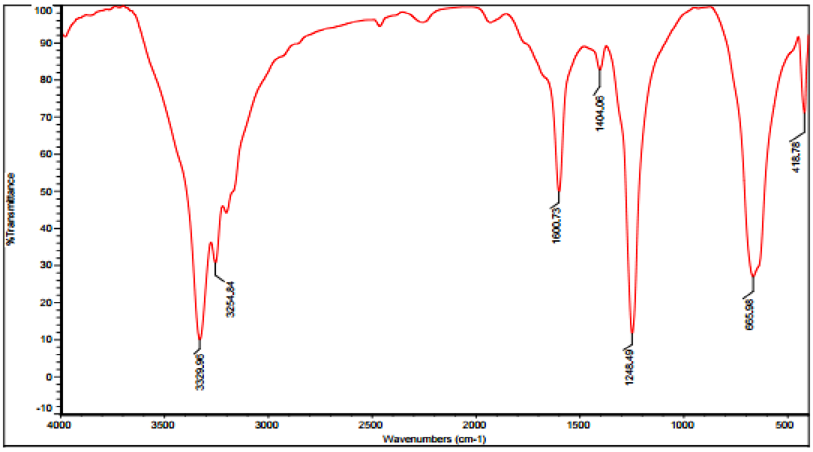


Figure 7. IR spectra of salicylidene-glycine-Zn complex.

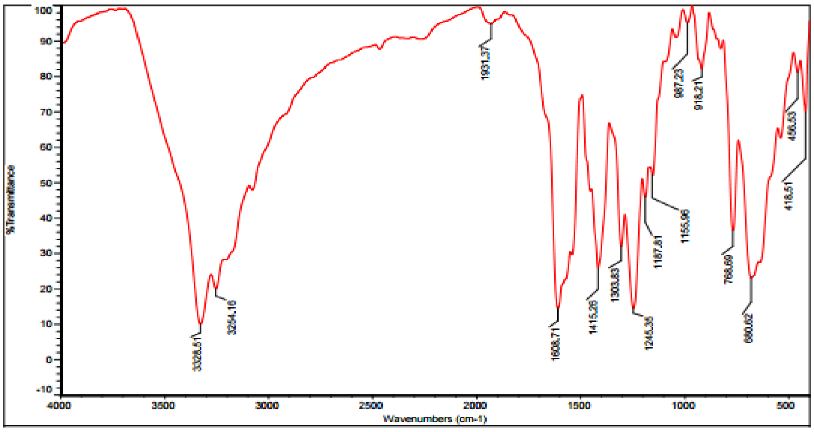


Figure 8. IR spectra of salicylidene–3-amino benzoic acid-schiff base-Zn complex.

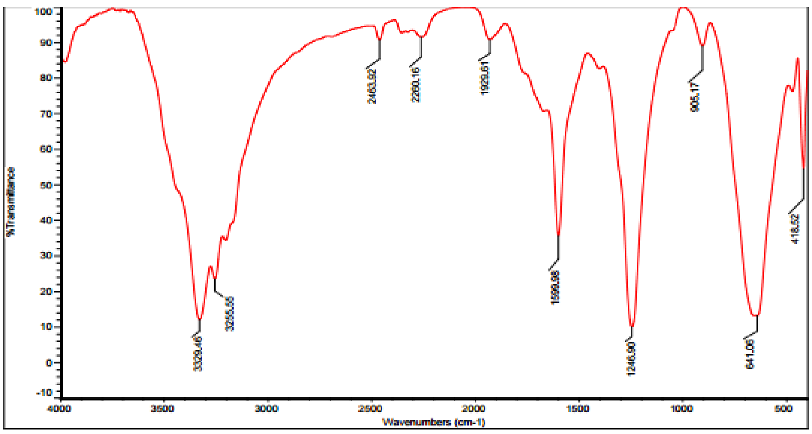


Figure 9. IR spectra of salicylidene-alanine-schiff base-Zn complex.

Table 2. IR spectra analysis of Schiff bases and corresponding ligands.

Compound	v (C=N) $c.m^{-1}$	v (C=O) $c.m^{-1}$	v (O-H) $c.m^{-1}$	v (M-O) $c.m^{-1}$	v (M-N) $c.m^{-1}$
Salicylidene Alanine Schiff base	1680.15	-	3345.15	-	-
Salicylidene Glycine Schiff base	1679.45	-	3347.93	-	-
Salicylidene – 3- Amino benzoic acid Schiff base	1585.66	-	3371.8	-	-
Salicylidene Alanine Schiff base Zn complex	1599.98	-	3329.46	641.06	418.52
Salicylidene Glycine Schiff base Zn complex	1600.73	-	3329.96	665.98	418.78
Salicylidene – 3- Amino benzoic acid Schiff base and Zn complex	1608.71	-	3328.51	680.62	563.53-418.51

The IR spectrum of ligands showed a band at a region of 1580-1680, **(Figures 4-6)**, which is due to C=N stretching frequency, a key feature of Schiff base. The same band is obtained for complexes also, **(Figures 7-9)** suggesting that ligands have combined with the metal through coordination. In the case of complexes, the bands in the region 640-660 cm^{-1} and 418 cm^{-1}, **(Figures7-9)** are attributed to v(M-O) and v(M-N) stretching vibrations respectively, conforming coordination of Schiff base to zinc ion.

SEM analyses:

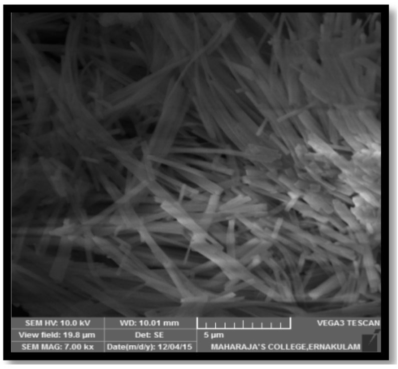


Image 1. SEM image of Salicylidene-Glycine-Schiff base.

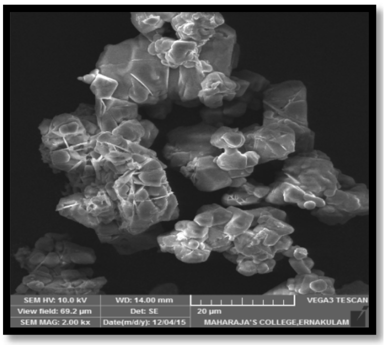


Image 2. SEM image of Salicylidene-Glycine-Schiff base-Zn complex.

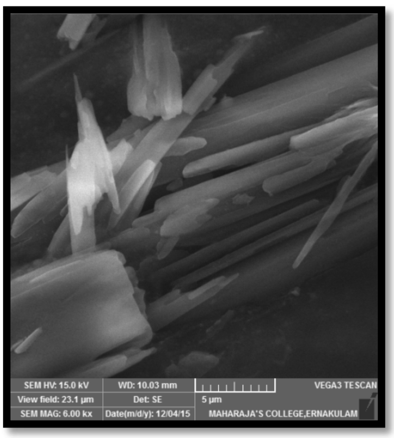


Image 3. SEM image of Salicylidene-Alanine-Schiff base.

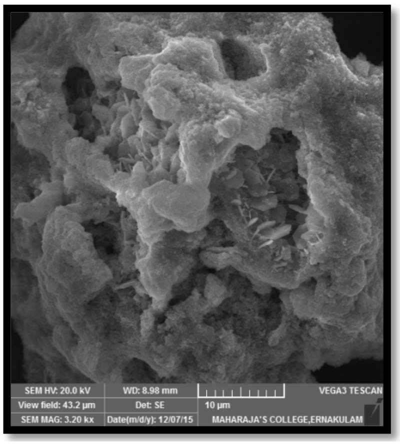


Image 4. SEM image of Salicylidene-Alanine-Schiff base-Zn complex.

The scanning Electron Micrographs (SEM) of Glycine and Alanine Schiff base and their corresponding Zn complex are given above **(Images 1-4).** From the figure, the Schiff base ligand shows a micro porous and fibre like appearance, with lots of voids in between. SEM analysis revealed that metal complexes have more crystalline appearance compared to their parent ligand which may be due to the contraction of the voids on the surface by complexation of the ligand with metal ions. This is another evidence for the metal complexation**.**

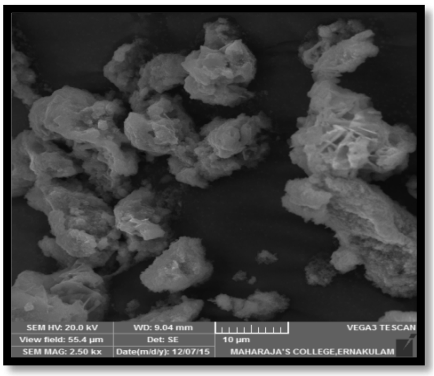


Image 5. SEM image of Salicylidene-3-Amino benzoic acid-Schiff base.

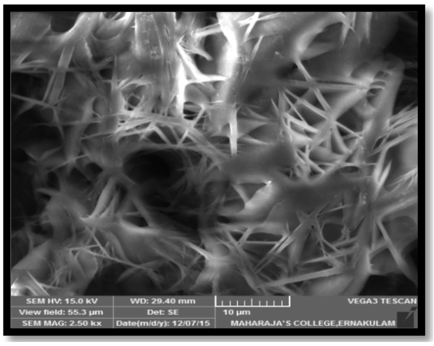


Image 6. SEM image of Salicylidene-3-Amino benzoic acid-Schiff base-Zn complex.

The scanning electron micrographs of 3-amino benzoic acid Schiff base and its complex are given above **(Images 5 and 6).** The particle size is about 10 µm. The Schiff base show a cloudy like appearance and have lots of micro voids. while the complex have more compact structure. It may be due to the cooperative contribution of ligands towards the complexation. The SEM studies show that the Schiff base ligand surfaces contain a micro porous structure with lots of voids in between. On the other hand there are contractions of voids on the surface of complex, which may due to the cooperative contribution of ligands for complexation with the metal ion [25]. This is another evidence for complexation of 3-amino benzoic acid with zinc.

Antimicrobial studies: The susceptibility of the gram negative bacteria *E. coli*, towards the ligands and their Zn complexes were analysed by measuring the size of their zone of inhibition. The antimicrobial studies were shown in **Images 7 and 8** and the results were given in **Table 3.** The effect against *E. coli* of complexes was found to be close to that of Amoxicillin. But there was no positive inhibitory activity by the Schiff base ligands. It is possible that ligand may be activated by the Zn (II) ion. The Glycine Schiff base complex show more antimicrobial activity than other two. The coordination of metal ion with bulky Schiff base ligand through chelation decreases the polarity of the metal ion. This is due to the overlap of ligand and metal orbitals and this leads to a delocalization of positive charge. Thus the lipophilic character of the metal chelates increases and this allows its penetration through the bacterial lipoid layer. Thus increases the inhibition activity. This may be the reason why zinc complex has more anti-microbial activity than the corresponding ligand or metal ion. E. coli are gram negative bacteria which cause several diseases in human and they are covered by an outer membrane of lipoglycan (LPS). The synthesized metal complexes could be able to combine with the lipophilic layer and thus intensify the membrane permeability of the gram negative bacteria. The lipid membrane surrounding the cell favours only the lipophilic materials to move through. Thus lipophilic character plays a key role in controlling the antimicrobial activity and this character of amino acid Schiff base might be greater than that of 3-amino benzoic acid. That will be the reason why it could show more antimicrobial activity. The reason for the increased inhibitory action of metal complexes compared with the parent ligand under experimental conditions is due to chelation during complexation. In the present work Glycine-Schiff's base-Zinc complex show an enhanced antimicrobial activity. This could make these complexes find application in medicinal chemistry.

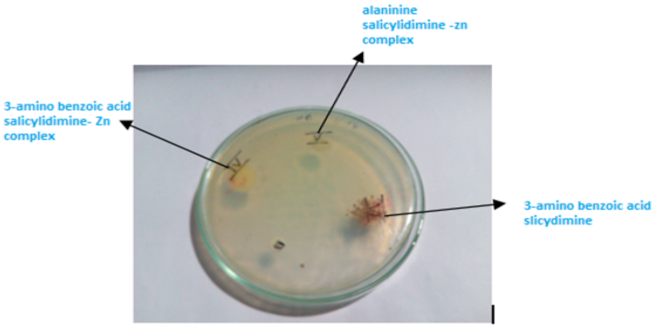


Image 7. Zone inhibition against *E. coli* bacteria.

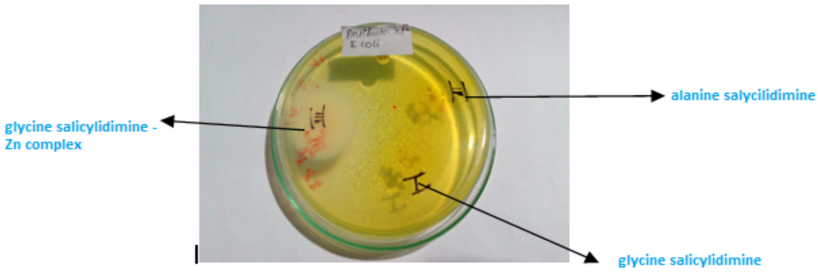


Image 8. Zone inhibition against *E. coli* bacteria.

Table 3. Results of antimicrobial studies.

	Salicylidene-Glycine-Schiff base	Salicylidene-Alanine- Schiff base	Salicylidene-Glycine-Schiff base-Zn complex	Salicylidene-3-amino benzoic acid-Zn complex	Salicylidene-Alanine-Schiff base-Zn complex	Salicylidene-3-amino benzoic acid-Schiff base	Control
Diameter of the zone	-	-	36	21	19	-	23

CONCLUSION

Schiff bases are common ligands in coordination chemistry and they are involved in many catalytic activities. Schiff bases which are formed from amino acids are biocompatible. So their metal complexes can be used as models for biologically important species and thus they play a key role in biomimetic catalytic reactions. In the present study Schiff bases were prepared using salicylaldehyde as the carbonyl part with 3-amino benzoic acid and amino acids like Glycine and Alanine using NaOH as a catalyst. The synthesized ligands have been successfully complexed with the metal ion Zn (II). Spectroscopic analysis has indicated the successful formation of amino acid based Schiff bases and their complex formation. Antibacterial studies revealed the effect of complexes against E. coli and are found to be close to that of Amoxicillin. But there is no positive inhibitory activity by the Schiff base ligands and this may be due to that the ligand is activated by the metal ion. The Glycine Salicylaldehyde schiff base Zn (II) complex show more antimicrobial activity than other two indicating the maximum attachment of Zn (II) ion to these schiff base ligands. This could make these complexes find application in water purification. The increased inhibitory action of metal complexes than the parent ligand under experimental conditions could be explained on the basis of chelation.

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