



RESEARCH ARTICLE

Synthesis, characterization and antimicrobial activities of Schiff base ligands derived from amino acids- alanine and phenylalanine and their metal complexes - A review

M. Bencela, S. Sudha Kumarai*

Department of Chemistry, South Travancore Hindu College, Nagercoil-629002, Tamil Nadu, India

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Abstract

Schiff base complexes of amino acids have gained importance because of their physiological and pharmacological activities. The complexes of amino acid Schiff bases are considered to constitute new kinds of potential antimicrobial reagents due to the presence of azomethine functional group. This review summarizes the synthesis, characterization and anti-microbial activities of amino acid Schiff base ligands derived from L- α alanine and L-Phenylalanine and their metal complexes.

Keywords

Schiff bases
Alanine
Phenylalanine
Metal complexes
Antimicrobial Activity

Introduction

Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Schiff in 1864 [13,26]. The mode of coordination of ligand to metal ion *via* azomethine group ($R-C=N$). Several studies showed that the presence of a lone pair of electrons in a sp^2 hybridized orbital of nitrogen atom of the azomethine group is of considerable chemical and biological importance. Because of synthetic flexibility and the special property of $C=N$, Schiff bases are generally act as excellent chelating agents. They also have other hetro-elements like oxygen, sulphur and nitrogen donors which provide

binding sites to the metal ion [1.26]. In recent years, Schiff bases and their metal complexes have been extensively examined due to their wide applications in various fields such as antifungal, antibacterial, analgesic, sedative, antipyretic, anti-inflammatory agents and DNA binding properties. Modern tentative research shows promising results with regard to their anti-tumor actions [2,4]. There are many interesting studies on the Schiff bases compounds derived from amino acids and their metal complexes. Amino acids play central roles both as building blocks of proteins and as intermediates in metabolism [5]. Amino acids ($H_2NCH(R)COOH$) are molecules containing an amine group, a carboxylic acid group and a side chain that varies between different amino acids. Recent reports have also shown that amino acid based metal(II) complexes show efficient DNA cleavage activity and antimicrobial activity [3-8]. Both, the Schiff bases and

*Corresponding author: Tel: +91- 9445434893.
Fax: + 91 044 27475166.
E-mail: rajeshp@ssn.edu.in

their complexes were characterized by FT-IR, ^1H NMR, ^{13}C NMR, EPR, XRD, UV-Vis, magnetic, molar conductance and their biological activities also studied [1-26]. This review summarizes the synthesis, characterization and antimicrobial activities of Schiff base ligands derived from L- α alanine and L-phenylalanine and their metal complexes.

Synthesis of new Schiff base ligands

The general procedure for synthesis of Schiff bases includes heating of a mixture of equimolar concentration of salicylaldehyde and amino acid at an appropriate temperature for 30 min with continuous stirring in an oil bath. The resultant product washed with hot alcohol or ether to yield orange solid crystal [1].

Al-Shaheen et.al were prepared the new Schiff base ligand called Sodium vanillinphenylalanineimine by taking L-phenylalanine 0.01 mol in 20 ml (25% distilled water + 75% ethanol) was mixed with vanillin (1.5 g, 0.01mol) in 20 ml ethanol in presence of sodium acetate (0.01mol). The mixture was then heated at 50 °C in water bath for an hour, the mixture was cooled and measured the pH. Then the solution was evaporated about its half volume and left for overnight to complete precipitation, the precipitate was collected by filtration, washed with 1:1 ethanol – water mixture and diethylether and it was dried over anhydrous over anhydrous CaCl_2 [6].

Robina Aman et. al prepared new Schiff base ligand by condensation of hot aqueous (25 ml) solution of alanine (.013 mole) and 2-hydroxy1-naphthaldehyde (.013 mole), dissolved in ethanol (50 ml). The reaction mixture was refluxed for about 2 h, and yellow brown polycrystalline precipitate was obtained after standing overnight. It was purified by repeated washing with aqueous-ethanol (1: 2) and dried in vacuum over fused CaCl_2 [8].

Aziz prepared the ligand using two steps. In the first step L-phenylalanine (6.0 mmol), was added to (10 ml), (6.0 mmol) sodium hydroxide-methanol solution, the mixture was stirred until a clear solution was obtained. A solution of (0.74 g, 6.0 mmol) 2-hydroxybenzaldehyde in (10 ml) methanol was added to reaction mixture, which was catalyzed with (5 drops) of glacial acetic acid and stirred for (3 h). yellow precipitate was formed, filtered, washed with ethanol and recrystallized from hot methanol to give yellow crystals of the precursor sodium 2-(2-hydroxybenzylideneamino)-3-phenyl-propanoate, [NaHL], yield (67%), mp (225-232°C).

In the second step a solution of the precursor [NaHL] (2.35g, 8.08 mmol) in (10 ml) methanol was added to (10 ml), (8.08 mmol) potassiumhydroxidemethanol solution, then a solution of (4.04 mmol) of 1,2-dichloroethane in (10 ml) methanol was added to reaction mixture was refluxed with stirring for 3 h. Orange precipitate was formed, filtered, washed with ethanol, and recrystallized from hot methanol to give orange crystals of the ligand called sodium2,2'-(2,2'-(ethane-1,2diylbis(oxy))bis(2,1-phenylene))bis(methan-1-yl-1-ylidene)bis(azan-1-yl-1-ylidene)bis(3-phenylpropanoate) which used as the Schiff base ligand for complexation [9].

New Schiff base ligand called benzylidene DL-alanine was prepared by refluxing the mixture of 0.06 g of benzaldehyde, (0.89 g) of DL-alanine and (0.4 g) of sodium hydroxide in 20 ml ethanol. The refluxing time was 2 h for preparing the ligand. Finally mixture was cooled and filtered. Product obtained was washed well with cold ethanol and dried [10].

Another new procedure was adopted by *Mehabaw et. al* that Schiff base ligand of ninhydrin and alanine was prepared in the presence of metal ion in the reaction mixture. 0.01 mole (1.78 g) of ninhydrin was dissolved in the minimum possible amount of ethanol and 0.01 mol of a metal chloride was added to the resulting solution, which was shaken and/or heated until all of it dissolved. This mixture was refluxed for about half an hour, followed by addition of 0.01 mol 0.89 g α ,L-alanine to the hot mixture and the mixture was refluxed for a further 2 h. The resulting colored precipitate was then filtered off while hot through a Whatman filter paper by suction, washed with distilled water, ethanol and finally with a 50:50 mixture of ethanol and petroleum ether (50 – 80 °C). The product was then dried and stored in desiccators. Here ninhydrin and α ,L-alanine form a deep purple colored compound known as Ruhemann's purple called ketimine Schiff base (indane-1,3-dione-2-imine-N-2-propionicacid), which complexes with metal to form complexes [7].

Hassan et. al prepared Schiff base ligand from amino acid (phenylalanine and alanine) and isatin using commercial condensation procedure. It shows O, N, O donor sight for complexation with metal. Schiff base

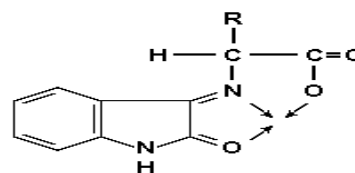


Fig 1 Mode of coordination sites to metal ion

derivative of isatin with amino acids, R represents $-\text{CH}_3$ (α -alan), $-\text{CH}_2-\text{C}_6\text{H}_5$ (β -ph- α -alan). Arrow shows the sights for co-ordination [11].

Muayed *et.al* prepared Schiff base ligand from 5 mmol of leucylalanine was taken in 20 ml water which added to 15 ml of an ethanol solution containing (5 mmol) of KOH. The resulting solution was stirred on a water bath at 25°C for half an hour and then filtered. The filtrate was added drop wise to 20 ml of an ethanol solution of salicylaldehyde (0.61 gm, 5 mmol) with stirring on a water bath at 25°C for one hour. The volume of the solution was reduced by distillation to 5 ml and then ethanol (10 ml) was added. The yellowish precipitate formed was separated by filtration. The precipitate was recrystallized from methanol [12]. Schiff base derived from the condensation of benzaldehyde or acetone and the amino acid phenylalanine in basic media using sodium hydroxide as a catalyst have been synthesized. The mixture was gradually stirred for 30 min. which were followed by 5-6 h refluxing. After cooling, the product was obtained, washed with ethanol [13].

Wilson *et. al* was synthesised 3-((2-hydroxybenzylidene)amino)-3-(ptolyl)propanoic acid using following procedure. 1.22 g of 2-hydroxybenzaldehyde in ethanol (1 mol) was added dropwise to 1.79 g of 3-amino-3-(p-tolyl)propanoic acid or β - tolyl alanine (1 mol) dissolved in water with continuous stirring. The mixture was refluxed for 6 h, was reduced to a minimum volume. The yellow coloured precipitate obtained was filtered washed with ethanol and dried in vacuum desiccator [14].

Another interesting method was adopted to prepare the Schiff base from 1-phenyl-3-methyl-4-phenylacetyl-5-pyrazolone (PMPAP) and L-phenylalanine methyl ester. A solution of L-phenylalanine methyl ester hydrochloride (10 mmol) in 50 ml ethylether was stirred. The solvent was allowed to evaporate. To this product obtained added PMPAP in 50 ml anhydrous ethanol and refluxed for 10 h. After the solvent was evaporated completely, recrystallization was carried out by mixing the solvents of acetonitrile and methanol in volume ratio 5:1. Yellow powder was obtained [17]. N-salicylidene- β -alanine new Schiff base ligand was synthesized in basic medium (KOH) using commercial method [15]. NaOH dissolved in ethanol which added to amino acid (alanine) in water which encourages forming Schiff base solution. Followed by adding acetic acid yield solid product of Schiff base [16].

Metal complexes of amino acid Schiff bases and their characterization

Recently, considerable attention has been paid to the

chemistry of metal complexes of amino acids of Schiff bases containing oxygen, nitrogen and other donors for their physiological reasons, since amino acids are absorbed well from intestinal lumen by specific active transport mechanisms, amino acids containing imines display significant biologically, they easily form stable complexes with most transition and other metal ions [1, 6]. Schiff base ligand derived from L-Alanine, D,L-Phenylalanine and their vanadyl complexes were reported recently.

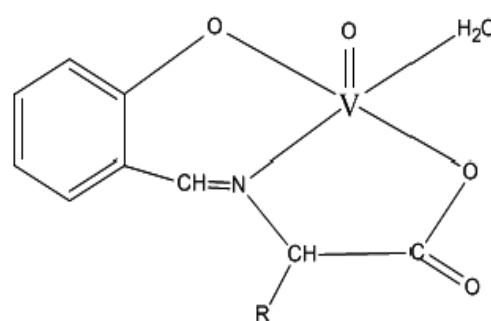


Fig 2 Tetrahedrally coordinated vanadyl complex

The complexes were prepared by mixing of aqueous solution of vanadyl sulphate with alcoholic solution of Schiff base. Pale blue complex was precipitated from solution. The low molar conductivities indicate that these complexes were neutral. The IR spectra of the prepared Schiff bases show distinct vibrational frequency $\nu\text{CH}=\text{N}$ at 1633 cm^{-1} for isomethine group, with the disappearance of νNH for amino group of the amino acid. On complexation of Schiff bases with vanadyl ion, $\nu\text{CH}=\text{N}$ were shifted to lower frequency due to the bonding between the donor nitrogen atom and the metal ion in the complexes. Moreover, the carboxylic and phenolic νOH disappeared as the oxygen atoms of these groups act as donor ligands to the vanadyl ion. The complexes were soluble in DMSO and DMF [1].

Schiff base derived from vanillin and amino acid (L-phenylalanine) and its complexes with Fe(III) have been reported. The IR spectra of the Schiff bases showed a strong band in the region ($1672\text{--}1650\text{ cm}^{-1}$) for $\nu\text{CH}=\text{N}$ stretching. In complex band slightly shifted to lower region which proves the involvement of azomethine nitrogen in complex. New bands were observed at $410\text{--}518$ and $524\text{--}590\text{ cm}^{-1}$, these bands assigned to the stretching modes of M-N and M-O, respectively. The Schiff base ligand of phenylalanine coordinated through tridentate phenoxy oxygen, carboxy oxygen and azomethine nitrogen atom. The electronic spectra indicate that Fe(III) complex may high spin octahedral geometry [6].

Complexes of Mn(II), Fe(III), Co(II), Ni(II) and Zn(II) with an intermediate Schiff base derived from ninhydrin and a L-alanine were reported in the year 2002. Schiff base ligand was prepared in the presence of corresponding metal ion. Metal ion was added to ninhydrin in the ethanolic medium, to this L-alanine was added and refluxed to get the corresponding complexes. First ninhydrin form schiff base with L-alanine called Ruhemann's purple, which forms distinctly colored complexes with the metal ions Mn(II), Fe(III), Co(II), Ni(II) and Zn(II). IR data of the complexes shows 1713-1733 cm^{-1} for (ν C=O), 1630-1661 cm^{-1} very strong band ($\nu_{\text{as}}\text{COO}$), 1588-1598 cm^{-1} strong band for ($\nu\text{C}=\text{C}_{\text{arom}}$), 1503-1516 cm^{-1} very strong band (ν C=N), bands at 544-715 cm^{-1} proves (ν M-N, M-O, M-Cl), N, O, Cl ligand coordinated to metal ions. Schiff base ligand was tridentate ligand According to magnetic susceptibility and electronic spectral studies shows all the complexes were octahedral geometry. Complexes of M = Co(II), Ni(II) and Zn(II) coordinated through two molecules of Schiff base ligand O,N,O. Complexes of M = Mn(II) co-ordinated through one molecule of Schiff base ligand and three molecules of water. Complexes of M=Fe(III) co-ordinated through one molecule of Schiff base ligand, two molecules of water and Cl ligand [7].

A new series of tin(IV) complexes were reported on 2014. The Schiff bases were derived from the condensation of 2-hydroxy-1-naphthaldehyde with and L β -alanine. The complexes were prepared by refluxing tin(IV) tetraisopropoxide (3.528 g, 0.0095 mol) and ligand (2.372 g, 0.01 mol) in benzene for 8–10 h. The structure was confirmed by IR and ^1H NMR. The IR data shows 1655 ($\nu_{\text{as}}\text{COO}$), 1390 ($\nu_{\text{s}}\text{COO}$), 535 (Sn–O), and 432 cm^{-1} (N \rightarrow Sn). ^1H NMR spectra of complexes shows 8.30 (s, 2H) for azomethine proton, 3.56 (s, 4H) for Methylene proton, 6.92–7.90 (m, 12H) for naphthylidene group proton. The studies revealed that two types of complexes were formed, one shows metal ion was coordinated through one Schiff base ligand (O,N,O donor) and two Monodentate isopropoxide ligand. The other coordinated through two Schiff base ligand (N,O donor) and two Monodentate isopropoxide ligand penta- and octahedral coordination around tin(IV) has been proposed [8].

The another tin(IV) complexes and their Schiff base derived from phenylalanine and 1*H*-indole-2,3-dione, 5-chloro-1*H*-indole-2,3-dione was reported. The complex was characterized by elemental analyses, molar conductance measurements, and molecular weight determinations. Bonding of this complex is discussed in terms of their UV-Vis., infrared and nuclear magnetic resonance (^1H , ^{13}C , and ^{119}Sn NMR) spectral studies. The ^{13}C NMR spectra shows corresponding peaks for COOH (185.4), CH (65.7), C=N (155.2),

CH_2/CH_3 (39.4), for aromatic carbons (150.0, 136.1, 132.6, 128.2, 127.1, 126.5, 124.4, 123.3, 120.2). IR spectra shows corresponding peaks for 1610 ($\nu\text{C}=\text{N}$), 1722 (ν C=O), 1590 ($\nu_{\text{as}}\text{COO}$), 1325 ($\nu_{\text{s}}\text{COO}$), 540 ($\nu\text{Sn}\leftarrow\text{N}$), 430 ($\nu\text{Sn}\leftarrow\text{O}$), 622 cm^{-1} ($\nu\text{Sn}\leftarrow\text{C}$). The results suggest that Schiff bases behave as monobasic bidentate ligands (N,O) and coordinate with dibutyltin(IV) in octahedral geometry according to the general formula $[\text{Bu}_2\text{Sn}(\text{L})_2]$. Elemental analyses and NMR spectral data of the ligands with their dibutyltin(IV) complexes agree with their proposed distorted octahedral structure [18].

The another report shows that L-phenylalanine amino acid that condensed with 2-hydroxybenzaldehyde to give the precursor for Schiff base which reacted with 1,2-dichloroethane to give the Schiff base called sodium 2,2'-(2,2'-(ethane-1,2-diylbis(oxy))bis(2,1-phenylene))bis(methan-1-yl-1-ylidene)bis(azan-1-yl-1-ylidene)bis(3-phenylproponate) which was used as a ligand $[\text{Na}_2\text{L}]$, in complexation with some metal ions $[\text{M} = \text{Co(II), Ni(II), Cu(II) and Zn(II)}]$ to give $[\text{M(L)}]$ complexes. λ max values showed by UV-Vis spectra of cobalt complexes were 245, 268, 382, 491, 531 and 622.3 nm which assigned as ligand field, ligand field, C.T, $^4\text{T}_{1\text{g}} \rightarrow ^4\text{T}_{2\text{g}}$, $^4\text{A}_{2\text{g}} \rightarrow ^4\text{T}_{1\text{g}}$ and $^4\text{T}_{1\text{g}} \rightarrow ^4\text{T}_{1\text{g}}$ (p) respectively. $[\text{Ni(L)}]$ complex shows 245, 364, 450, 510 and 642 nm which assigned as ligand field, C.T, $^3\text{A}_{2\text{g}} \rightarrow ^3\text{T}_{2\text{g}}$, $^3\text{A}_{2\text{g}} \rightarrow ^3\text{T}_{1\text{g}}$ and $^3\text{A}_{2\text{g}} \rightarrow ^3\text{T}_{1\text{g}}$ (p) respectively. $[\text{Cu(L)}]$ complex shows 243, 272, 369 and 660 nm which assigned as ligand field, ligand field, CT and $^2\text{E} \rightarrow ^2\text{T}_2$. Using electronic spectra and magnetic susceptibility values studies revealed that all the complexes shows octahedral geometry [9]. Another interesting work was reported that Schiff base called N-salicylidene- β -alanine prepared from salicylaldehyde and β -alanine and complexes with $\text{M} = \text{Cd(II), Zn(II), Ni(II), Cu(II)}$ in the presence of caffeine, which act as the extra ligand for complex. Schiff base was prepared using commercial method. The complexes were prepared by adding metal solution to the Schiff base in ethanol and of the caffeine. According to the spectral date it was concluded that Schiff base ligand act as a tridentate ligand whereas caffeine coordinated through nitrogen in 9th position. Thus metal complexes shows distorted octahedral geometry [19].

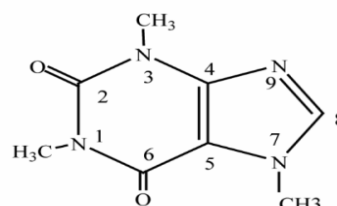


Fig 3 Structure of the caffeine

Synthesis of tetradentate Schiff base ligand from dibenzoylmethane and alanine and their Oxovanadium(IV) complex was reported. The magnetic moment of the complex found in the range 1.65 – 1.74 B.M which agrees with oxovanadium(IV) complex with one unpaired electron. The electronic spectra of vanadyl complex in the region 11425 – 11780, 15112 – 15856 and 21230 – 22500 cm^{-1} show that complex was five coordinate with tetradentate ligand. The measured ESR value of g_{\parallel} , g_{\perp} , A_{\parallel} , A_{\perp} (1.935, 1.973, 190.75 and 66.40) were in good agreement for a square pyramidal structure [20].

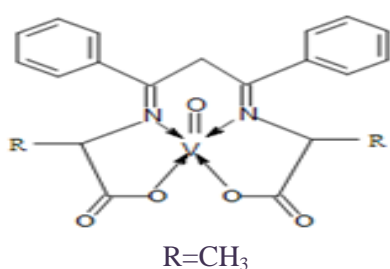


Fig 4 Oxovanadium (IV) complex with tetradentate ligand

The nickel complex of Schiff base ligand was synthesised from 1-phenyl-3-methyl-4-phenylacetyl-5-pyrazolone with L-phenylalanine methyl ester. Single-crystal X-ray diffraction was carried out to prove the structure of complex. According to the data it was concluded that the complex crystallizes in the $P2_1$ space group ($a = 21.4076(18)$, $b = 9.4792(8)$ and $c = 25.287(2)$ Å), which consists of a nickel six-coordinated compound. Every fragment is a distorted octahedron with four oxygen and two nitrogen atoms [17].

Not only Schiff base (amino acids) metal complexes were synthesised but also amino acids were directly connected to metal to yield another type of complexes also reported. Metal(II) [Mn, Co, Ni, and Cu] coordination compounds of phenylalanine were synthesised. According to the spectral data the Cu(II) ion in an octahedral environment, which subject to Jahn Teller distortion. Its magnetic moment value of 1.73 B.M suggested a dinuclear square pyramidal complex. Bands at 496, 481 and 526 nm, assignable to the ${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)$, ${}^3A_{2g}(F) \rightarrow {}^1T_g(F)$ and ${}^3A_{2g}(F) \rightarrow {}^1E_g$ transitions, respectively, observed with the Ni(II) complex, suggested a distorted octahedral geometry. The Co(II) complex showed $d-d$ transition bands at 499 and 526 nm and were assigned to ${}^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$ and ${}^4T_{1g}(F) \rightarrow {}^4A_{2g}(F)$ transitions, respectively typical of an octahedral geometry [21]. Most of the Schiff base ligands were tridentates

(O, N, and O) in nature. The molar conductance studies revealed that complexes were non-electrolyte in nature.

Anti-microbial activities

The generally synthesized compounds were screened for their antibacterial activity against gram positive and gram negative bacteria at different concentration by the agar Well Diffusion method. The test organisms after 24 h. of incubation were spread onto separate agar plates. The chemical compounds were dissolved in DMSO were poured into appropriately labelled holes using a pipette in aseptic conditions. A hole containing DMSO served as a control. Triplicate plate of each bacterial strain was prepared. The plates were incubated aerobically at 37 °C antimicrobial for 24 h. The activity was determined by measuring the diameter of the zone (mm) showing complete inhibition with respect to control (DMSO).

Dibutyltin(IV) complexes of Schiff base derived from 5-chloroindoline-2,3-dione, indoline-2,3-dione with amino acid (alanine) for antimicrobial screening against *Bacillus cereus* and *Enterobacter aerogenes* in 25, 50 and 100 μg concentration. Complex shows more activity when compared with Schiff base ligand. This is due that coordination enhances the properties of complex. While comparing bacteria shows more activity against Gram positive than negative [23]. Ti(III) complexes of alanine indole-3-aldehyde, L-alanine 2,4-dihydroxybenzaldehyde were screened against bacteria revealed that the metal complexes are more potent antibacterial as compared to corresponding ligands [16]. Nickel(II) complex was subjected against *E. Coli* and *B. Subtilis*. Complex shows better activity than ligand. Even though better activity against *Bacillus subtilis* (gram positive) [17]. Schiff base derived from 3-formyl-2H-pyrido[1,2-a]pyrimidine-2, 4(3H)-dione with alanine was tested against *P. Aurginos*, *S. Aureus*, *B. Subtilis*, *C. Albicans* and *E. Coli* showed good to moderate antibacterial activity against the test microbes [22]. The metal complexes of Ni(II), Co(II), Cu(II), Mn(II) and Cd(II) with amino acid phenylalanine without formation of Schiff base subjected toward antimicrobial activity against gram positive bacteria *B. Subtilis*, *S. Aureus*, *M. Resistant* and gram negative bacteria *Escherichia coli*, *Proteus vulgaris* *Pseudomonas aeruginosa* and fungi *Candida albicans* the results revealed that nickel complexes show no activity against any bacteria whereas show potent activity against fungi. The cadmium complex shows high activity against gram positive particularly *S. Aures* and medium activity against gram negative bacteria.

Good activity against fungi too. The cobalt complex shows potent activity against *P. Aeruginosa*. The cadmium complex shows higher activity against fungi than bacteria [21]. The cobalt complexes from Schiff base of 2-amino-4-nitrophenol-N-salicylidene with alanine and phenylalanine as extra ligand were subjected to antimicrobial activity demonstrate that complexes shows better activity than Schiff base due to contribution of metal and amino acid in the complexes [24]. Co(II), Ni(II), Cu(II) and Zn(II) complexes of Schiff base derived from phenylalanine and 2-hydroxybenzaldehyde screened for antibacterial activity against gram-positive bacteria like *S. Aureus*, and *A. Baumannii*. This study showed an effective inhibition of gram positive bacteria *A. Baumannii* [9].

Zinc(II) complexes derived from Salicylaldehyde and Leucylalanine screened against *Staphylococcus aureus*, *E. Coli*, *K. Pneumoniae*, *P. Vulgaris* and *P. Aeruginosa* by the disc diffusion method. The ligand shows moderate activity whereas complex shows very highly activity against *S. Aureus* (gram+ve) and *E. Coli*, *P. Aeruginosa* (gram-ve) [25]. A series of Schiff base complexes of Cu, Ni, Co, Zn and Cd derived from 3(amino)-3-p-tolylpropanoic acid and 2-hydroxybenzaldehyde. The antibacterial activity of the ligand and the complexes were screened against five bacteria viz., *E. coli*, *P. Vulgaris*, *P. Aeruginosa*, *S. Aureus* and *B. Subtilis*. The minimum inhibitory concentration (MIC) data revealed that most of the complexes are more potent than the ligand against the bacterial species. This is explained on the basis of Overtone's concept and the Tweedy's Chelation theory.

According to Overtone's concept of cell permeability, the lipid membrane surrounding the cell favours the passage of only the lipid-soluble materials and so liposolubility becomes an important factor, which controls the antimicrobial activity. On chelation, the polarity of the metal ion is reduced to a greater extent due to the overlap of the ligand orbital and partial sharing of the positive charge of the metal ion with donor groups. It further increases the delocalization of π -electrons over the whole chelate ring and enhances the lipophilicity of the complexes. This increased lipophilicity enhances the penetration of the complexes into lipid membranes and block the metal binding sites in the enzymes of the microorganisms. These complexes also disturb the respiration process of the cell and thus block the synthesis of the proteins that restricts further growth of the organism [14]. Although the exact mechanism hasn't been understood biochemically, mode of action of antimicrobials may involve various

targets in microorganisms.

(i) Interference with the cell wall synthesis, damage as a result of which cell permeability may be altered (or) they may disorganize the lipoprotein leading to the cell death.

(ii) Deactivate various cellular enzymes, which play a vital role in different metabolic pathways of these microorganisms.

(iii) Formation of a hydrogen bond through the azomethine group with the active centre of cell constituents, resulting in interference with the normal process [25,26].

Conclusions

The metal complexes prepared using alanine or phenylalanine Schiff base ligands shows excellent antimicrobial activity. Maximum number of above complexes shows good activity against gram positive bacteria, only little shows better activity against gram negative bacteria. The Schiff base may act as tridentate or bidentate donor. The complexes highly adopted distorted octahedral geometry. Only less number adopted square pyramidal and tetrahedral geometry. The molar conductance study reveals that all complexes are nonelectrolytic in nature. The Schiff bases and complexes mostly dissolve in DMSO and DMF solvent.

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