

Synthesis, characterization, antimicrobial, anti-diabetic, anti-inflammatory and anti-cancer studies of Schiff base metal(II) complexes derived from mixed Schiff base ligands

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A new Schiff base with ligands (L^1 and L^2) has been prepared from cinnamaldehyde with aniline (L^1) and 4-hydroxy-3-methoxybenzaldehyde with *o*-nitroaniline in 1:1 molar ratio. The mononuclear metal(II) complexes $[(ML^1L^2)]$ [$M = Co(II), Ni(II), Cu(II)$ and $Zn(II)$] have been synthesized and characterized. ML^1L^2 synthesized from ligand (L^1), metal salts and ligand (L^2) molar ratio is 1:1:1. Elemental analyses, IR, NMR, Electronic spectra, SEM and molar conductivity have been obtained to clarify the structure of synthesized metal(II) complexes. Square planar geometry is proposed for CoL^1L^2 , NiL^1L^2 and ZnL^1L^2 , and distorted square planar geometry for CuL^1L^2 complex. Antibacterial activity of metal(II) complexes, ML^1L^2 have been tested against Gram(+) and Gram(-) bacteria and fungi. The anti-inflammatory and anti-diabetic actions of the L^1 , L^2 , CuL^1L^2 complexes have been studied. The anticancer activity of L^1 , L^2 and CuL^1L^2 have been studied as opposed to MCF-7 using MTT assay method.

Keywords: Mixed ligand complexes, Anti-diabetic, Anti-cancer, Anti-inflammatory

The chemistry of coordination compounds with Schiff base ligand which contains azomethine group $RCH=N-R^1$, framed by the build-up of the condensation of primary amines with aldehyde and ketones, was first pronounced by Hugo Schiff in 1864 (Ref. 1). Schiff bases played an important role as ligands even a century after their discovery in coordination chemistry^{2,3}.

A Schiff base reaction is a reversible, acid-catalysed condensation between a primary amine (not ammonia) and either an aromatic/aliphatic aldehyde or ketone. A Schiff base is the nitrogen analogue of an aldehyde or ketone, where the carbonyl group is replaced by an imine group ($C=N-R$), which is shown in Scheme 1, where R may be an alkyl or an aryl group⁴.

Especially in the previous years, first-row transition metals are more interested in chemistry, because of the critical it is the subject of catalyses like hydroformylation, carboxylation, oxidation, reduction, hydrolysis and epoxidation⁵. Cobalt, nickel, copper, and zinc are life-essential metallic elements and exhibit greater biological activity when associated with certain

metal protein complexes, participating in oxygen transport, electronic transfer reactions or the storage of ions⁶.

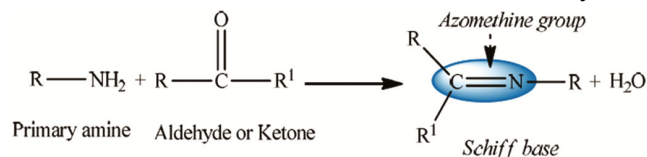
Schiff bases and their metal complexes are promising leads for both synthetic and structural research due to their relatively simple synthesis and structural diversity and have been widely investigated due to their incredible chemical properties and applications in various areas^{7,8}. The chelating ability and biological applications of metal complexes have attracted remarkable attention and they can work as models for biologically important species^{9,10}. Many Schiff base metal complexes have a diverse spectrum of biological and pharmaceutical activities. For instance, transition metal complexes of Schiff base ligands bearing "O" and "N" donor atoms are very important because of their biological properties such as antibacterial, antifungal, anti-inflammatory, analgesic¹¹, anticonvulsant, anti tubercular¹², antioxidant¹³ and anthelmintic¹⁴.

The Schiff base transition metal complexes have also been used as biological models to understand the structure of biomolecules and biological processes¹⁵.

It is believed that the biological activity is related to the hydrogen bonding through the imino group of Schiff bases with the active centers of the cell constituents¹⁶. One of the major areas of research on the Schiff base metal complexes is their biological activity with the main aim being the discovery of safe and effective therapeutic agents for the treatment of bacterial infections and cancer.

Metal complexes have been widely applied in clinics for centuries, although their molecular mechanism has not yet been entirely understood¹⁷. The great successes achieved with platinum-based antitumor agents, mainly including cisplatin, carboplatin and oxaliplatin, have promoted the development of metal-based drugs. However, all these Pt-based drugs are associated with severe side effects and evolution of drug resistance during therapy processes, which has stimulated inorganic chemists to seek and develop more effective, less toxic and target-specific metal-based anticancer drugs.

Platinum is not the only transition metal used in the treatment of cancer, various other transition metals have been used in anticancer drugs. Titanium complexes such as Titanocene dichloride have been recognized as active anticancer drug against breast and gastrointestinal carcinomas. Gold complexes also show anticancer activity. These complexes act through a different mechanism as compared with cisplatin. The 2-[(dimethylamino) methyl] phenyl gold (III) complex has also been proved to be anti-tumor agent against human cancer. Gold nanoparticles when used in combination with radio therapy or chemotherapy enhance DNA damage and make the treatment target specific¹⁸. Copper as an essential element for human with its bioessential activity and



oxidative nature has attracted numerous inorganic chemists to address Cu(II) complexes with the aim of medical applications¹⁹.

In the present work, a series of mononuclear Cu(II), Ni(II), Co(II) and Zn(II) complexes with Schiff base ligands (L^1 and L^2) were synthesized. All the prepared complexes have been characterized by physicochemical properties and *in-vitro* antimicrobial activity, anti-inflammatory, anti-diabetic and anti-cancer activities of metal complexes were also studied.

Experimental Section

The Cinnamaldehyde with aniline and 4-Hydroxy-3-methoxybenzaldehyde with O-Nitro aniline used for the preparation of Schiff base ligands were purchased from TCI chemicals. The metal acetate salts like $M(CH_3COO)_2 \cdot nH_2O$ ($M=Co$ and $Ni, (n=4)$; $Cu, (n=1)$; $Zn, (n=2)$) were purchased from Sigma Aldrich. All the solvents were purchased from Loba and used without further purification.

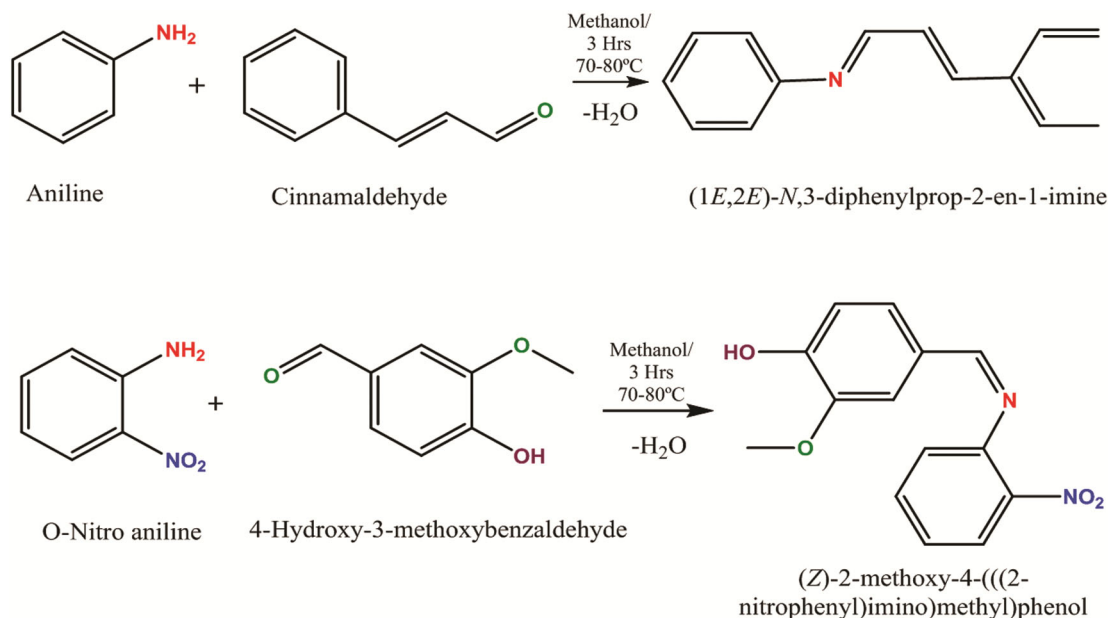
The percentage of C, N, O, and metal was determined by a FEI Quanta-250 FEG elemental analysis apparatus (Table 1). Electronic spectra of the ligand and their metal complexes dissolved in DMF were recorded on the JASCO V 650 in the range of 200 – 800 nm. Vibrational spectra of the compounds was recorded in Bruker Tensor 27 in the range of 4000 – 400 cm^{-1} . 1H and ^{13}C NMR spectra were recorded on the Bruker 300 Hz spectrometer using DMSO- d_6 as a solvent. The surface natures of the compounds were determined by CAREL ZEISS EVO 18 Scanning electron microscope.

Synthesis of Schiff Base Ligands(L^1 and L^2)

L^1 was prepared by the addition of methanolic solution of cinnamaldehyde (1 mmol) drop wise into the methanolic solution of aniline (1 mmol) taken in a round bottom flask at RT. The mixture was carefully mixed on a magnetic stirred for 4 hours which was followed by refluxing for 8 hours resulting in the light brown colored solid precipitate (Scheme 2). The

Table 1 — Analytical data of Schiff base ligands and its complexes

| Compd | Mol. Formula | Mol. Wt. | Nitrogen % | | Metal % | | Colour |
|------------------------------------|-----------------------------|----------|------------|--------|---------|--------|-------------|
| | | | C | H | N | M | |
| Ligand 1 | $C_{15}H_{13}N$ | 207 | (86.91) | (6.32) | (6.76) | – | Orange |
| Ligand 2 | $C_{14}H_{12}N_2O_4$ | 272 | (61.76) | (4.44) | (10.29) | – | Light brown |
| [CoL ₁ L ₂] | $Co[C_{33}H_{38}N_3O_{12}]$ | 727.17 | (54.45) | (5.26) | (5.77) | (9.45) | Red brown |
| [NiL ₁ L ₂] | $Ni[C_{33}H_{38}N_3O_{12}]$ | 726.18 | (54.53) | (5.27) | (5.78) | (7.97) | Black |
| [CuL ₁ L ₂] | $Cu[C_{33}H_{38}N_3O_{12}]$ | 677.14 | (58.48) | (4.76) | (6.20) | (9.29) | Greenish |
| [ZnL ₁ L ₂] | $Zn[C_{33}H_{38}N_3O_{12}]$ | 696.15 | (56.82) | (4.90) | (6.03) | (9.18) | Brown |

Scheme 2 — Synthesis of Schiff base ligands (L^1 and L^2)

product was filtered, rinsed a number of times with methanol and finally dried in a vacuum over anhydrous calcium chloride.

A methanolic solution of 4-Hydroxy-3-methoxybenzaldehyde (1mmol) was added drop wise into a methanolic solution of O-Nitro aniline (1mmol) taken in a round bottom flask at RT. The mixture was thoroughly mixed on a magnetic stirrer for 3-5 hours which was followed by refluxing for 6 hours resulting in the isolation of brown colored solid product (Scheme 2). The product (L^2) was filtered, washed several times with methanol and finally dried in vacuum over anhydrous calcium chloride (Yield-80%).

Synthesis of Schiff base mixed ligand complexes

A methanolic solution of the metal acetate salts of Cobalt(II), Nickel(II), Copper(II) and Zinc(II) (1mmol) was added slowly with constant stirring to the methanolic solution of Schiff base ligand (L^1), it is then followed by addition of (L^2)ligand in the ratio 1:1:1. The mixture was then refluxed for 3hrs on a water bath and the solution is cooled to RT. The obtained different colour product was filtered, washed several times with methanol lastly dried in vacuum over anhydrous calcium chloride (Fig. 1).

Molar conductance

The stability and stoichiometry of the metal complexes were confirmed by conductometric

measurement. The molar conductance of the synthesized ligand complexes were measured using 10^{-3} M DMF solvent. The conductance values are in the range of $0.6-10 \text{ ohm}^{-1}\text{mol}^{-1}\text{cm}^2$. These values are too low to account for any dissociation of the complexes in DMF. Hence these complexes can be regarded as non-electrolyte.

Infrared spectra

The IR spectra provide valuable information regarding the nature of functional group attached to the metal atom. The most valuable IR bands of the Schiff base ligands and their metal complexes were listed in Table 2 and as shown in Fig. S1-Fig. S6. The $\nu(\text{OCH}_3)$ appeared in the range $3283-3280 \text{ cm}^{-1}$ as observed in ligand(L^2) and all the complexes indicates the non-involvement of methoxy oxygen in coordination. The appearance of a broad strong band in the IR spectra of the complexes at $3470-3200 \text{ cm}^{-1}$ may be due to $\nu(\text{-OH})$ of water suggests the presence of coordinated water or lattice water in these complexes. Further, water molecules coordination are confirmed by occurrence of additional strong and sharp band at $890-740 \text{ cm}^{-1}$ arising due to -OH rocking vibration.

The band in the range $1645-1649 \text{ cm}^{-1}$ observed in the free ligands (L^1 and L^2) are due to $\nu(\text{-CH=N-})$ which has been shifted towards lower region at around $1570-1627 \text{ cm}^{-1}$ in the complexes indicating the participation of the azomethine groups in the

complexes formation this shift is also due to reduction of double bond character of carbon-nitrogen bond of azomethine group. In addition, a strong band around 1740 cm^{-1} have been assigned to $\nu(\text{OCH}_3)$ in 1:1 all metal complexes.

Further, the absorptions corresponding to asymmetric and symmetric stretching of the acetate groups at ~ 1610 and ~ 1455 cm^{-1} , respectively confirms the monodentate nature of the acetate ion in all the complexes. In the low frequency region, all the complexes exhibit new bands around at 421-422 cm^{-1} and 520 – 600 cm^{-1} are due to $\nu(\text{M-N})$ and $\nu(\text{M-O})$ respectively.

Electronic spectra

The electronic spectra of the ligand and their complexes have been measured in DMF solution between 200-800 nm at RT. The spectral data of the ligand and its complexes are tabulated in Table 3 and

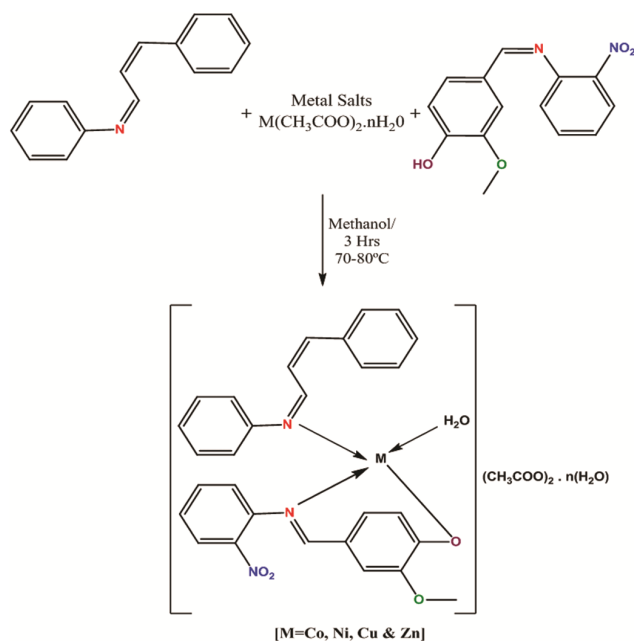


Fig. 1 — Synthesis of Schiff base mixed ligand complexes

as shown in Fig. S7. In the spectra of the Schiff base ligands, the absorption band observed in the region 230- 232 nm and were assigned to benzene $\pi \rightarrow \pi^*$ transition and the band 301-310 nm were assigned due to $n \rightarrow \pi^*$ transition associated with the azomethine chromophore ($-\text{CH}=\text{N}-$). However, the positions of these bands are found to be shifted to lower wavelengths in the spectra of metal complexes suggesting the coordination of ligand to the metal ions.

The electronic spectrum of Co(II) complex showed three intense peak, one peak at 413 nm due to charge transfer transition and another two peaks exhibited d-d transition at the visible region at 527 nm and 763 nm. These peaks are assign to ${}^4T_{1g}(\text{F}) \rightarrow {}^4T_{1g}(\text{P})$ and ${}^4T_{1g}(\text{F}) \rightarrow {}^4A_{2g}(\text{F})$ respectively. The magnetic moment value of 4.20 BM indicated the square planar geometry for the Co(II) ion.

The electronic spectrum of the nickel complex shows three intense bands, one band at 372 nm due to charge transfer transition and another two peaks exhibited d-d transition at the visible region at 456 nm and 546 nm indicating square planar geometry. This complex shows the diamagnetic behavior square planar environment around the Ni(II) ion.

The absorption spectrum of copper complex exhibits two intense peaks at the region 400 nm corresponding to charge transfer and another band in the region 667 nm assign to ${}^2B_{1g} \rightarrow {}^2A_{1g}$ characteristic of square planar geometry which is further confirmed by its magnetic moment value of 1.81 BM.

The electronic spectrum of Zn(II) complex, a strong band observed at 416 nm is assignable to the $L \rightarrow M$ charge transfer transition which is compatible with this complex having square planar geometry.

${}^1\text{H}$ NMR Spectral studies

In ${}^1\text{H}$ NMR spectra the chemical value for the shift aromatic protons are observed in the range 6.0 -7.0

Table 2 — IR Spectral data (cm^{-1}) of Schiff base ligands and its metal(II) complexes

| Compd | $\nu(\text{OCH}_3)$ cm^{-1} | $\nu(\text{CH}=\text{N})$ (cm^{-1}) | $\nu(\text{C}=\text{C})$ cm^{-1} | $\nu(\text{H}_2\text{O})$ | $\nu(\text{M-O})$ | $\nu(\text{M-N})$ cm^{-1} |
|------------------------------------|---|---|--|---------------------------|-------------------|---------------------------------------|
| Ligand(L ₁) | — | 1645 | 1441 | — | — | — |
| Ligand(L ₂) | 3283 | 1649 | — | — | — | — |
| [CoL ₁ L ₂] | 3144 | 1614 1567 | 1459 | 750 | 521 | 439 421 |
| [NiL ₁ L ₂] | 2974 | 1627 1599 | 1435 | 748 | 528 | 437 465 |
| [CuL ₁ L ₂] | 2976 | 1631 1574 | 1449 | 746 | 601 | 438 472 |
| [ZnL ₁ L ₂] | 2975 | 1610 1593 | 1451 | 774 | 630 | 439 458 |

Table 3 — Electronic Spectral data (nm) of Schiff base ligands and its metal(II) complexes

| Compd | Absorption (nm) | Band assignment | Geometry | Magnetic moment (BM) |
|-------------------------------------|-----------------|---|-------------------------|----------------------|
| Ligand (L ¹) | 230 | INCT | — | — |
| | 301 | INCT | | |
| Ligand (L ²) | 232 | INCT | — | — |
| | 310 | INCT | | |
| | 235 | INCT | | |
| | 273 | INCT | | |
| [Co L ¹ L ²] | 413 | LMCT | Square planar | 4.20 |
| | 527 | ⁴ T _{1g} (F)— ⁴ T _{1g} (P) | | |
| | 763 | ⁴ T _{1g} (F)— ⁴ A _{2g} (F) | | |
| | 233 | INCT | | |
| | 286 | INCT | | |
| | 372 | LMCT | | |
| [Ni L ¹ L ²] | 465 | ³ A _{2g} (F)— ³ T _{1g} (P) ³ A _{2g} (F)-- | Square planar | Diamagnetic |
| | 546 | ³ T _{1g} (F) | | |
| | 233 | INCT | | |
| | 279 | INCT | | |
| [Cu L ¹ L ²] | 400 | LMCT | distorted Square planar | 1.80 |
| | 667 | ² B _{1g} — ² A _{1g} | | |
| | 230 | INCT | | |
| [Zn L ¹ L ²] | 295 | INCT | Square planar | Diamagnetic |
| | 416 | LMCT | | |

Table 4 — Inhibition indices of Schiff base ligands and its metal(II) complexes against *S. aureus*, *E. coli* and *Candida albicans*

| Sample | Sample concentration (mg/mL) | Zone of inhibition (mm) | | Sample concentration (mg/mL) | Fungai <i>Candida albicans</i> |
|----------|------------------------------|------------------------------|-------------------------|------------------------------|--------------------------------|
| | | Gram positive | Gram negative | | |
| | | <i>Staphylococcus aureus</i> | <i>Escherichia coli</i> | | |
| A | 100 | 3 | 4 | 100 | 5 |
| B | | 4 | 5 | | 6 |
| C | | 8 | 7 | | 8 |
| D | | 9 | 8 | | 9 |
| E | | 8 | 7 | | 6 |
| F | | 10 | 12 | | 11 |
| Standard | Tetracyclin | 12 | 12 | Fluconazole | 14 |

ppm for ligands (L¹ and L²). The azomethine protons showed the chemical shift in the range 8.5- 9.0 ppm for ligands. The -OH proton showed the chemical shift in the range 9.4 ppm for ligand (L²) and methyl proton showed the chemical shift in the range 2.49 ppm for ligand (L²).

SEM

The surface morphology of the complexes has been examined using a scanning electron microscope. The SEM images showed (Fig. 2) all the complexes are microcrystalline in nature. All the complexes showed a uniform matrix which gives an indication of the existence of complexes in a homogeneous phase. From SEM images it was clear that there was a strong change in morphology of Schiff base complexation²¹.

Antibacterial Activity

In the present study, the synthesized ligands complexes showed maximum efficacy against the bacterial pathogens than the parent ligands. Among the 4 synthesized ligand complexes, Cu complex showed maximum inhibition against *E. coli* and Zn complex exhibited maximum inhibition against *S. aureus* (Table 4 and Fig. 3). Furthermore, the increase in the concentration of metal complexes increases the bacterial inhibition activity²². Similar to our findings, previous studies have also reported that the complexes showed improved antibacterial activities as compared with parent Schiff base ligands^{23,24}. In general, the coordination of metals with ligands will increase the efficacy of the compound against microbes. This enhanced activity of the complexes is due to their affinity and

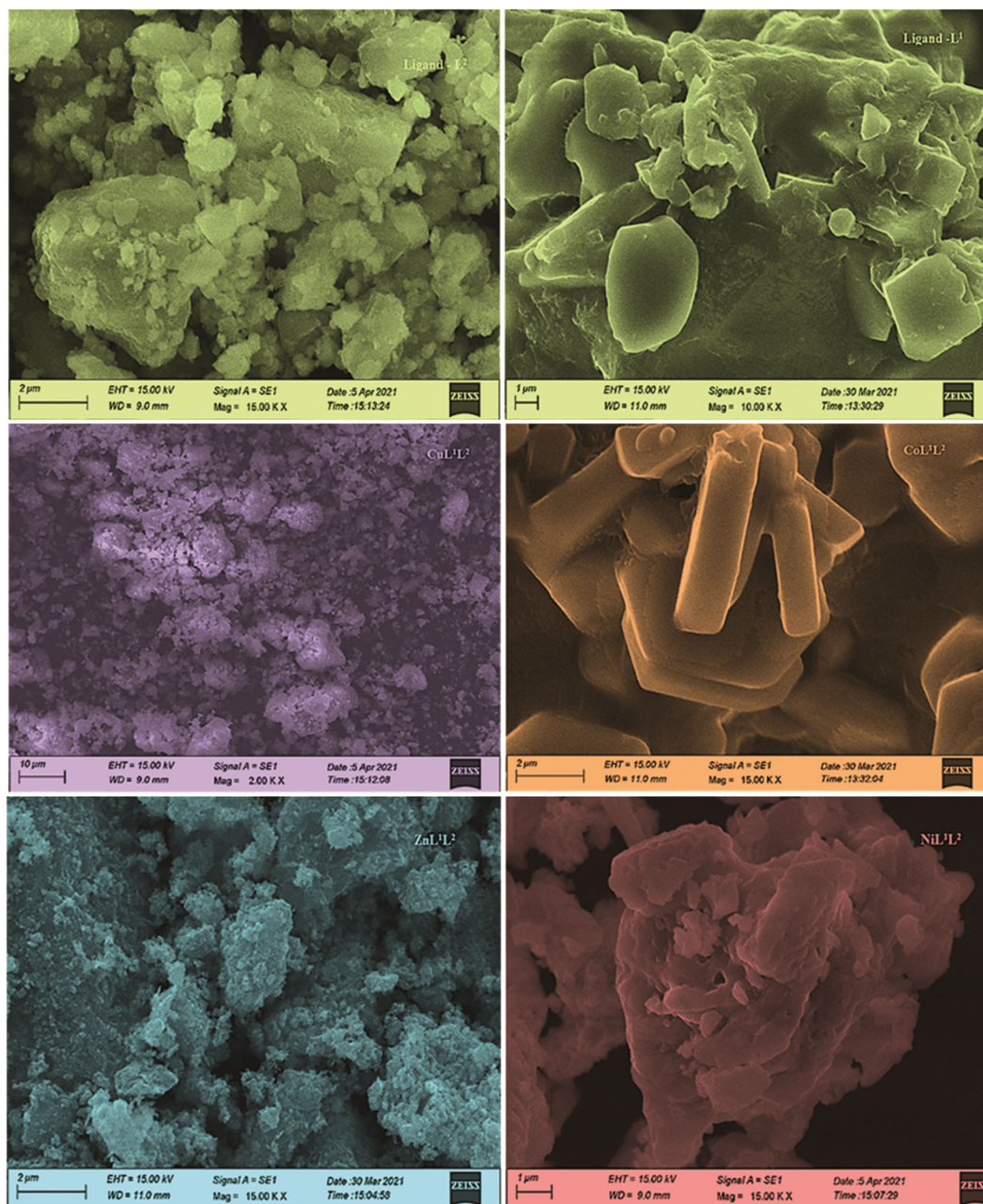


Fig. 2 — SEM analysis of Schiff base ligands and its metal(II) complexes

permeability nature and it could be elucidated on the basis of Ligand Field Theory, Overtone's concept and Tweedy's chelation theory. According to Overtone's concept, the lipophilic nature of the complexes is a major factor that determines the degree of antibacterial activity. The coordination metals with ligand decrease the polarity of the complex and increase the lipophilicity by delocalization of electrons from ligand to metal. Therefore it will increase the permeability of the metal complexes

across the selectively permeable lipid layer and inhibit the growth of the microorganism²⁵. Furthermore, the chelation between the complexes and the microbial cell wall might disintegrate the cell wall structure and result in the loss of cellular ingredients, which eventually kill the bacteria.

Anti-fungal activity

The antifungal activities of the compounds are summarized in Table 4. *In vitro* antifungal activity of

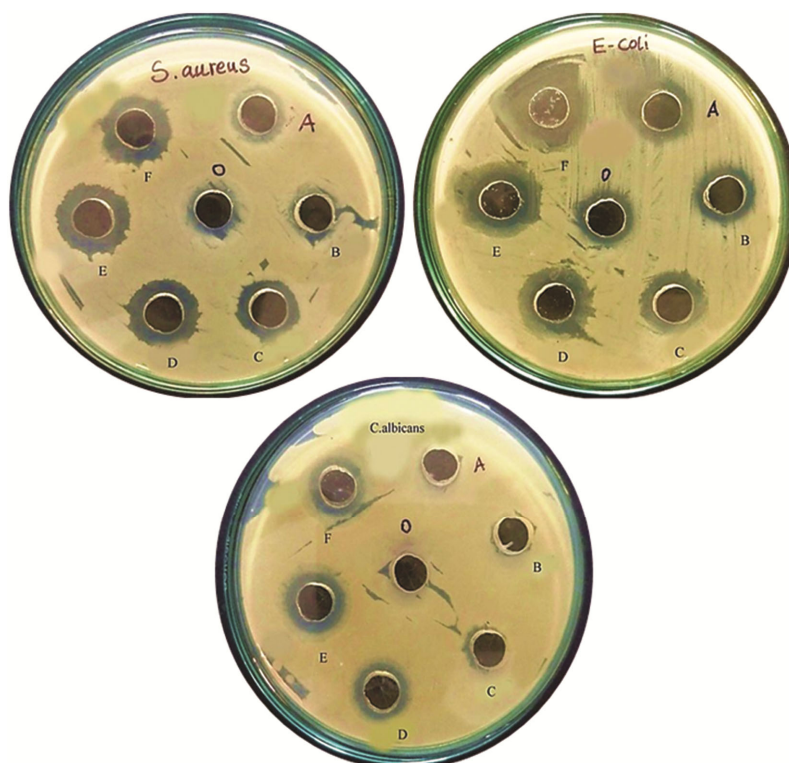


Fig. 3 — Anti-microbial activity of Schiff base ligands and its metal(II) complexes

Table 5 — Anti-inflammatory activity of Schiff base ligands and its Copper(II) complex

| Concentration ($\mu\text{g/mL}$) | % Inhibition of hemolysis | | | | | | | |
|---------------------------------------|---------------------------|----------------|-----------------------|----------------|-----------------------|----------------|-------------------|-------------|
| | Standard | IC50 values | Ligand L ¹ | IC50 values | Ligand L ² | IC50 values | Cu(II) complex | IC50 values |
| 20 | 56.28 | | 32.15 | | 36.62 | | 45.24 | |
| 40 | 60.14 | | 45.67 | | 44.18 | | 48.78 | |
| 60 | 67.49 | 0.592 | 51.23 | 55.17 | 56.76 | 49.68 | 57.50 | 37.82 |
| 80 | 72.78 | | 62.24 | | 64.43 | | 66.46 | |
| 100 | 78.69 | | 70.15 | | 71.25 | | 75.46 | |

all the synthesized compounds was carried out against *C. albicans*. Cu(II) complex exhibited good activity with inhibition zone 11 mm. Co(II), Ni(II), Zn(II) and the ligands has moderate activity compared to the standard drug tetracycline. The metal coordination converted the ligand from an inactive form to active ones as the presence of metal enhanced the antifungal action. In addition, many other factors like the nature of the ligand, solubility, dipole moment, conductivity and geometry may be responsible for the higher activity.

Anti-inflammatory activity

Anti-inflammatory activity of the ligand and metal complexes has been done by using the HRBC stabilization method. Diclofenac sodium was used as

standard and distilled water was used as control. The percentage of membrane stabilization for synthesized ligand, complexes and standard were done at 20, 40, 60, 80 & 100 $\mu\text{g/mL}$. The percentage of hemolysis by diclofenac sodium, ligands and their metal complexes by HRBC membrane stabilization method which increases with increase in concentration²⁶. The percentage inhibition hemolysis by ligand and complexes showing a concentration-dependent manner (Table 5). The copper complex shows the high inhibition of hemolysis (75.46%) at 100 $\mu\text{g/mL}$ compared to the free ligands.

Anti-diabetic activity

The anti-diabetic activities of synthesized compounds were examined by the standard amylase inhibition test. The inhibition activity of the ligand

Table 6 — Anti-diabetic effects of Schiff base ligands and its Copper complex

| Compd | Concentration ($\mu\text{g/mL}$) | | | | | IC_{50} ($\mu\text{g/mL}$) |
|-------------------------|------------------------------------|-------|-------|-------|-------|---------------------------------------|
| | 10 | 20 | 30 | 40 | 50 | |
| | % of inhibition at 540 nm | | | | | |
| Ligand(L ¹) | 23.67 | 26.78 | 34.72 | 42.89 | 51.64 | 49.55 |
| Ligand(L ²) | 26.73 | 29.90 | 36.24 | 43.51 | 52.78 | 46.86 |
| Copper(II) Complex | 30.25 | 34.76 | 47.59 | 56.52 | 65.78 | 33.26 |

Table 7 — Anti-Cancer effects of Schiff base ligands and its Copper complex

| Concentration ($\mu\text{g/mL}$) | Ligand-1 | | Ligand-2 | | CuL^1L^2 | |
|------------------------------------|------------------|---------------------------------------|------------------|---------------------------------------|--------------------------|---------------------------------------|
| | Cell Viability % | IC_{50} ($\mu\text{g/mL}$) | Cell Viability % | IC_{50} ($\mu\text{g/mL}$) | Cell Viability % | IC_{50} ($\mu\text{g/mL}$) |
| 3.125 | 98.74 | | 97.53 | | 95.65 | |
| 6.25 | 94.63 | | 94.52 | | 87.85 | |
| 12.5 | 82.27 | 43.51 | 78.43 | 34.18 | 76.52 | 24.05 |
| 25 | 66.93 | | 56.31 | | 48.00 | |
| 50 | 43.75 | | 47.95 | | 28.93 | |

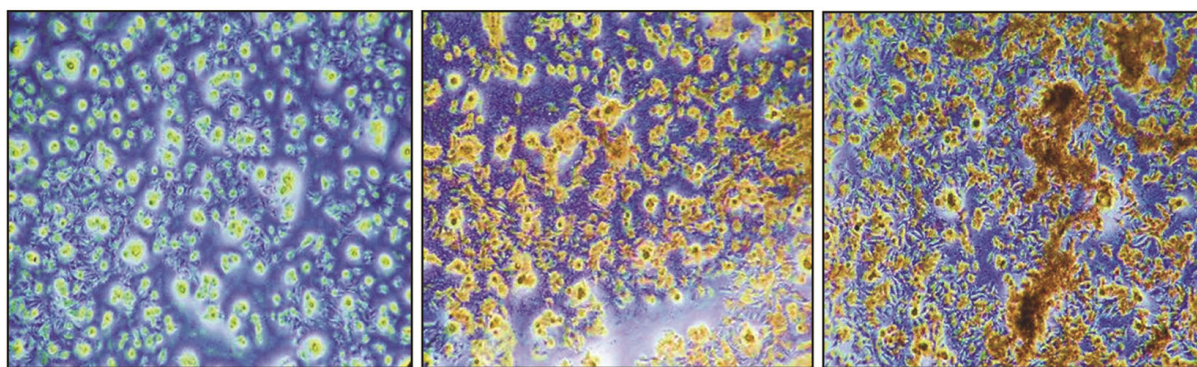


Fig. 4 — Anti-cancer activities of Schiff base ligands and its Copper(II) complex

and its Cu(II) complex against α -amylase is shown in Table 6. The Cu(II) complex exhibits more inhibition efficiency than the free ligands. The Cu(II) complex has higher inhibition effectiveness against α -amylase with IC_{50} value is $33.26 \mu\text{g/mL}$. The therapeutic approach may reduce the postprandial glucose level in blood by the inhibition of α -amylase enzymes, which can be used as an important strategy in the management of blood glucose levels.

Anti-Cancer activity

The anticancer activities of Schiff base ligands and its copper(II) complex were determined by MTT assay on human breast cancer cell line MCF7. The absorbance of the samples at 570 nm, at various concentrations (3.125 - $50 \mu\text{g/mL}$), the percentage of cell inhibition and IC_{50} values are found and reported in Table 7 and Fig. 4. The % cell inhibition and IC_{50} values indicated that the copper complex has valuable features for potential anticancer agents.

Conclusion

Schiffbase transition metal complexes Co(II), Ni(II), Cu(II), and Zn(II) were synthesized from mixed Schiff base ligand was clearly described and characterized on the basis of analytical and spectral data. Elemental analysis shows the metal and ligands ratio is 1:1:1. The physico-chemical methods suggest Square-planar geometry for Co(II), Ni(II), and Zn(II) complexes and distorted Square-planar geometry for Cu(II) complex. The SEM analysis clearly indicated the morphology of the synthesized compounds. The Schiff base ligands and its metal complexes (A-F) were screened against gram positive (*Staphylococcus aureus*), gram negative (*Escherichia coli*) bacteria and one fungal (*Candida albicans*). The anti-microbial study revealed that Cu(II) complexes have higher potential and all other complexes were more active than the free ligand. The anti-inflammatory activity of the ligands and complexes was done in different concentrations at the HRBC membrane method. The

percentage inhibition haemolysis by ligands and complexes increases with increasing concentration. The Cu(II) complex has higher inhibition haemolysis compared to Schiff base ligands. Anti-diabetic activity of the Cu(II) complex has shown 65.78% inhibition of amylase at 50 µg, while ligand has induced alpha amylase activity.

Supplementary Information

Supplementary information is available in the website
<http://nopr.niscpr.res.in/handle/123456789/58776>.

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