Antimicrobial activity and corrosion inhibition property of Schiff bases derived from Imidazole

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Schiff base ligands such as methyl 4-[(2-butyl-4-chloro-5-formyl-1H-imidazol-1-yl)methyl]benzoate thiosemicarbazone (L₁) and 2-butyl-4-chloro-5-formylimidazole 2,4-dinitrophenylhydrazone (L₂) are designed and synthesized via the reaction between methyl 4-[(2-butyl-4-chloro-5-formyl-1H-imidazol-1-yl)methyl]benzoate & thiosemicarbazide for L₁ and 2-butyl-4-chloro-5-formylimidazole & 2,4-dinitrophenylhydrazine for L₂. Schiff bases are characterized by FT-IR, UV-visible, mass spectrometry, ¹H and ¹³C-NMR spectral studies. These ligands are individually tested for their antimicrobial activities for both gram positive and gram negative to examine their inhibition potential by well diffusion method. The corrosion inhibition property of all the three ligands L₁, L₂ & L₃ on mild steel in 0.5 N HCl solution has been investigated at different concentrations and different temperatures by weight loss method. The biological activity of L₂ has shown better activity against gram negative bacteria such as E.coli, Klebsiella pneumonia, Acinetobacter baumannii, Pseudomonas aeruginosa and gram positive bacteria Staphylococcus aureus when compared to standard ligand L₁. All the three ligands exhibit good corrosion inhibition property on mild steel in 0.5N HCl solution even at 0.1% concentration level and the rate of corrosion of mild steel is increased with increase of temperature of corrosion medium.

Keywords: Antibacterial activity, Butyl chloro formyl imidazole, Corrosion inhibition, Phenyl hydrazine, Schiff base ligand, Thiosemicarbazide.

The heterocyclic compounds are backbone of several biologically active compounds.¹² The design and study of Schiff base containing sulfur donor atom is interesting field of inorganic and bioinorganic chemistry.³⁴ Thiosemicarbazone are exhibit cytotoxic activity against a series of murine and human tumor cells in culture.⁶⁷ The chemistry of imidazole was reviewed in literature and found that the number of imidazole derivatives act as therapeutic agent such as antibacterial⁹, antimalarial,¹⁰ antihypertensive¹¹, antidepressant¹², antitubercular¹³, antiviral¹⁴, antiepileptic¹⁵, anti-inflammatory⁺, anticancer¹⁷ etc., Hydrazine derivatives exhibit physiological activities in the treatment of tuberculosis. They also exhibit as herbicides, insecticides, nematicicides, rodenticides, plant growth regulator.¹⁸ The nitro group is a strong electron withdrawing group and nitro Schiff bases play an important role in affecting the reactivity and enantioselectivities in synthesis as catalyst. Recently reported Schiff bases containing O, N or S atom possess an effective corrosion inhibition for mild steel¹⁹ and other metals.²⁰ The lone pair of electrons on heteroatoms in a compound has been reported to be an efficient corrosion inhibitor for metals and alloys. In an acidic environment, organic compounds with more than one heteroatom’s containing electrons exhibit high corrosion inhibiting properties by providing electrons to interact with metal surface.²¹ The efficient of corrosion inhibition property increases by the presence of either π-electrons of aromatic system or presence of electronegative groups (Nitro). The π-electrons facilitate the interaction with d-orbital electron of iron.²²

Losartan and Eprosartan are the antihypertensive drugs which contain buylchloroimidazole (Losartan, Allisartan) and buytimidazolechalcone (Eprosartan) skeleton illustrated in Fig. 1. 2-Butyl-4-chloro-5-formyl imidazole (BCFI) is an important intermediate used as precursors for designing a variety of antihypertensive drugs. It was reported that buylchloroimidazole derivatives are gained synthetic interest in recent years since it exhibits broad spectrum of biological properties.²³ Also butyl chloro imidazole chalcones and pyrazoles act as good inhibitors for angiotensin converting enzyme.²⁴ The nitro benzyl 2-butyl-4-chloroimidazole derivative act as anti-inflammatory and analgesic activity.²⁵ The nickel complex of Schiff base derived
from BCFI and ethylenediamine showed excellent activity against \textit{E. coli} bacteria.\textsuperscript{26}

By keeping all the above facts in mind, in the present work we made an effort to design and synthesis a new butyl chloro imidazole Schiff base ligands illustrated in Fig. 2. The synthesis of standard ligand $L_3$ has been described.\textsuperscript{27} The $L_1$ has been designed by protecting the imidazole $-NH$ group of

![Fig. 1 — Structure of drugs containing butylchloroimidazole skeleton.](image1)

![Fig. 2 — New Schiff base design strategy](image2)
Materials and methods

All chemicals and solvents used in the present work were of analytical grade. 2-butyl-4-chloro-5-formyl imidazole and methyl 4-[(2-butyl-4-chloro-5-formyl-1H-imidazol-1-yl)methyl]benzoate were purchased from sigma-Aldrich. Thiosemicarbazide, 2,4-dinitrophenylhydrazine, were purchased from SD fine chemicals. Acetic acid, concentrated hydrochloric acid, methanol, ethanol was purchased from Merck.

Synthesis of Ligand-1 (L₁)

Methyl 4-[(2-butyl-4-chloro-5-formyl-1H-imidazol-1-yl)methyl]benzoate(1)(10mmol;1g) in ethanol(10 ml) was added to thiosemicarbazide(2)(10mmol;0.27g) in ethanol(10ml). 5-10 drops of acetic acid was added. The reaction mixture was refluxed for about 1h. The progress of the reaction was monitored by TLC (1:1 ethylacetate-hexane system) and cooled to room temperature. The white precipitate formed was filtered and washed with ethanol. The solid was dried under vacuum at room temperature to yield the L₁ (3) and recrystallized from hot ethanol. The reaction scheme is shown in Scheme-1.

Yield : 85%, Description: white powder, HRMS(m/z): Calcd for [C₁₈H₂₂O₃N₆S₂Cl]⁺ is 407.9 Found: 407.89, IR(cm⁻¹): γ(N-H) 3398, γ(NH₂) 3248, γ(C=N) 1605, γ(C=S) 795, γ(N-N) 1102, γ(C=O, ester) 1727, γ(C=Cl) 843, γ(aliphatic, aromatic C-H) 2947, γ(aromatic C=C) 1532, 1542. ¹H NMR(d₆-DMSO)(ppm) : δ=0.81 (3H, t, butylCH₃), δ=1.22-1.28(2H, m, butylCH₂), δ=1.46-1.52(2H, m, butylCH₂), δ=2.6-2.63(2H, t, butylCH₂), δ=3.82(3H, s, esterCH₃), δ=5.7 (2H, s, N-CH₂), δ=8.02(1H, s, -NH₂), δ=9.09(1H, s, -NH), δ=6.91(1H, s, -CH), δ=7.10-7.12(2H, d, ArCH₃), δ=7.89-7.91(2H, d, ArCH), δ=11.27(1H, s, -NH). ¹³C NMR (d₆-DMSO) (ppm): δ=14.0, 22.0, 26.0, 29.4, 48.4, 52.5, 120.8, 126.4, 129.0, 130.0, 132.3, 133.3, 143.1, 152.1, 166.3, 177.6.

Synthesis of Ligand-2 (L₂)

2-Butyl-4-chloro-5-formylimidazole (4) (10m mol:1g) in methanol (10mL) was added to 2,4-dinitrophenylhydrazine (5) (10m mol:1.06 g) in methanol (10 mL) followed by the addition of 5-10 drops of concentrated hydrochloric acid. The reaction mixture was stirred at room temperature about 3-4 H. The progress of the reaction was monitored by TLC (20%Ethyl acetate in hexane system). The red precipitate obtained was filtered and washed with methanol and then dried the solid under vacuum at room temperature to yield the L₂ (6). The solid was recrystallized from hot ethanol. The reaction scheme is shown in Scheme 2.

Yield : 87%, Description: Red orange powder, HRMS(m/z): Calcd for[C₁₉H₂₃O₄N₆S₂Cl]⁺ is 366.7 Found: 366.69, IR(cm⁻¹): γ(N-H) 3276, γ(NO₂) 1511, γ(C=O) 1657, γ(C=S) 795, γ(C=N) 1605.

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Scheme 1 --- Preparation of L₁
γ(C=N) 1612, γ(N-N) 1138, γ(C-Cl) 839, γ(aliphatic, aromatic C-H) 3106 & 2960, γ(aromatic C=C) 1423.

1H NMR(CDCl₃) (ppm): δ=0.95-0.98(3H, t, butylCH₃), δ=1.38-1.48(2H, m, butylCH₂), δ=1.74-1.82(2H, m, butylCH₂), δ=2.76-2.79(2H, t, butylCH₂), δ=2.59-2.63(2H, t, butylCH₂), δ=7.2-8.3(2H, AroCH), δ=7.83(1H, s, CH), δ=9.15(1H, s, -CH), δ=9.46(1H, s, -NH), δ=11.3(1H, s, Imidazole-NH).

13C NMR(DMSO) (ppm): 14.0, 22.1, 28.1, 30.2, 79.6, 122.1, 129.1, 129.9, 150.4, 178.2.

**Synthesis of Ligand-3(L₃)**

2-Butyl-4-chloro-5-formylimidazole (7) (10mmol; 1g) in ethanol (10 mL) was added to thiosemicarbazide (8) (10mmol; 0.49g) in ethanol (10 mL) followed by 5-10 drops of acetic acid was added. The reaction mixture was refluxed for about 1h. The progress of the reaction was monitored by TLC (1:1 Ethylacetate+hexane system). The reaction mixture was cooled to room temperature and the white precipitate formed was filtered and washed with ethanol. The solid was dried under vacuum at room temperature to yield the L₃ (9). Then it was recrystallized from hot ethanol. The reaction scheme is shown in Scheme 3.

Yield : 84%, Description: white powder, HRMS (m/z): Calcd for[C₉H₁₄N₅S₁Cl₁]⁺ is 259.7 Found: 259.1, IR (cm⁻¹): γ(N-H) 3353, γ(NH₂) 3258, γ(C=N) 1606, γ(aliphatic, C-H) 3171 & 2925, γ(N-N) 1244, γ(C-Cl, C=S) 817, γ(aromatic C=C) 1477 & 1501.1H NMR (ppm): δ=0.88-0.91(3H, t, butylCH₃), δ=1.30-1.32 (2H, m, butylCH₂), δ=1.61-1.65(2H, m, butylCH₂), δ=2.59-2.63(2H, t, butylCH₂), δ=7.83(1H, s, -NH₂), 8.79(1H, s, -NH₂), δ=8.33(1H, s, -CH), δ=11.45(1H, s, N-NH).

**Antimicrobial activity**

The agar well diffusion method was used for examine the in vitro antimicrobial activity of synthesized ligands L₁, L₂ & L₃. The antimicrobial activity of synthesized ligands were screened against both gram positive organism such as *Staphylococcus aureus* and gram negative organisms such as *E-coli*, *Klebsiella pneumonia*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* with the quantity of 100µl of concentration of 1% solution (10 mg of testing ligand was dissolved in 1mL of dimethylsulfoxide).

The microorganisms were inoculated into the sterilized nutrient broth and it was maintained at 37°C about 24 h. On the day of testing, 100 µL of exponentially grown inocula of *E.coli*-ATCC 25922, *Staphylococcus aureus*-MTCC 1430, *Klebsiella pneumoniae*-MTCC 432, *Acinetobacter baumannii*-ATCC 19606, *Pseudomonas aeruginosa*-ATCC 27853 were uniformly spread with the help of L-rod on nutrient agar plates. After even spreading of all cultures, 6 mm diameter wells were cut on nutrient agar plates and 100 µL of ligands L₁, L₂ & L₃ were transferred into all the wells immediately. 100 µL DMSO is spotted separately to compare the effect of solvent on antimicrobial activity. The loaded plates were incubated at 37°C about 24h. The measurement of zone of inhibition was determined as radius of the clear zone with the help of antibiotic measuring zone scale (Himedia).
Corrosion study

The experiment was performed on mild steel with the chemical composition of iron-99.099% and carbon-0.084%. The size of rectangular mild steel specimens are 5cm × 2cm × 0.05cm (length × width × thickness) with a small hole at one end. The specimens were polished with 4/0,3/0,2/0 and 1/0 grade emery papers to remove dusts or other foreign matter followed by rinsing thoroughly with double distilled water degreased with acetone and dried.

The initial weight of the specimens was measured. A series of 200 mL 0.5N hydrochloric acid solutions were prepared using double distilled water. The prior weighed specimens are completely immersed into the solution through glass hook. The temperature was maintained 30±2°C about 24 h. The specimens were removed from the solution, washed with running water, dried and weighed to the accuracy of four decimal places. The weight loss of mild steel was calculated by the difference between the weight of mild steel before and after immersion. The experiment was repeated for the different concentrations of L₁, L₂ & L₃ with 0.1, 0.3, 0.5 and 0.7% respectively. To derive the effect of temperature on corrosion inhibition of mild steel, the above procedure was carried out at 40±2 and 50±2°C.

Result and Discussion

Mass spectra

The mass (m/z) is obtained for L₁, L₂& L₃ are 407.89, 366.69 & 259.1 respectively which are well supporting the proposed molecular mass calculated from molecular formula for these ligands. Along with molecular ion peak, the spectra exhibit some other peaks which are assignable to various possible fragments.[28]

Infra-Red spectra

The synthesized new ligands L₁ & L₂ and standard ligand L₃ shows a significant vibrational bands corresponding to the characteristic functional groups in the molecules. The strong evidence for the formation of imine(C=N) was found (the sharp and strong stretching vibrational band) at 1605 cm⁻¹ (for L₁), 1612 cm⁻¹ (for L₂) and 1606 cm⁻¹ (for L₃) and the absence of carbonyl (C=O) group stretching vibrational band at 1700cm⁻¹ for L₁, L₂ & L₃. Further, the stretching vibrational band at 1727cm⁻¹ and 3248 cm⁻¹ confirms the presence of ester(-COOCH₃) and amine(-NH₂) group in L₁. The stretching vibrational band at 1511 cm⁻¹ and 839 cm⁻¹ confirms the presence of nitro(-NO₂) and C-Cl bond in L₂[29]. The stretching vibrational band at 3258cm⁻¹ and 817 cm⁻¹ confirms the presence of amine(-NH₂) and C-Cl bond in L₃.

Ultraviolet-Visible spectra

The UV spectra of L₁, L₂ & L₃ is showed an intense broad peak at 335nm (for L₁ & L₂) and 418nm (for L₂) due to π → π* transition in azomethine group(C=N)[30]. The conjugation of double bond in the imidazole ring shifted the wavelength to lower region by the bathochromic shift. The probable forbidden n→π* is partially overlapped by the allowed π→π* for L₁ & L₃.

The short band at 305nm is due to n→π* transition azomethine group for L₂[31].

NMR spectra

The ¹H NMR spectrum of the synthesized ligands confirms the structure of the molecule. For L₁, the thiaoamide protons have shown the chemical shift values of δ=8.03 and 8.09 as two different singlet due to the involvement of one proton in hydrogen bonding with imine nitrogen. The secondary amine proton is observed as singlet (broad peak) at δ value of 11.2. The imine – CH and methylene (-CH₂) attached to imidazole ring is showed an intense singlet at δ value of 6.9 and 5.7 respectively[32]. The aliphatic protons on the n-butyl side chain attached to the imidazole ring are found at δ value of 0.81, 1.2, 1.4 and 2.6. The aromatic protons are observed as doublet at δ value between 7.1-7.9. For L₂, the imine – CH is found at δ of 9.15 as singlet. This is due to the deshielding effect of presence of dinitrophenyl group is shift to higher δ value. The imidazole – NH proton is appeared as singlet at δ value of 11.3[33]. The aliphatic protons on butyl side chain are observed at δ value of 0.95, 1.3, 1.7 and 2.7 respectively. The aromatic protons on phenyl ring are observed at δ value of 7.2-8.3. For L₃, the thiaoamide protons have shown the chemical shift values of δ=7.95 and 8.33 as two different singlet. The imine –NH is observed as singlet at δ value of 7.83. The imidazole –NH proton is appeared as singlet at δ value of 11.4. The aliphatic protons on butyl side chain are observed at δ value of 0.98, 1.3, 1.6 and 2.6 respectively.

The ¹³C NMR spectrum of L₁, L₂ & L₃ are further confirmed the formation of imine group in the molecule. The imine carbon was shown the peak at δ value of 130.0, 129.8 and 129.9 for L₁, L₂ & L₃ respectively[34]. The n-butyl side chain carbon atoms showed the peak at δ value of 14.0, 22.0, 26.0, 29.4 for L₁, 14.0, 22.1, 28.1, 30.2 for L₂ and 14.0, 22.1, 28.2, 30.2 for L₃.

Antimicrobial activity

The presence of nitro group (-NO₂), secondary amine group (-NH) or phenolic hydroxyl group (-OH)
in the compound which enhances the antimicrobial activity\(^\text{35}\). It can be seen from the data that the biological study of synthesized new ligand L\(_1\) (imidazole –NH of L\(_3\) is protected with aromatic substituent) has shown almost equal activity when compared to standard ligand L\(_3\) whereas the another new ligand L\(_2\) (amine part of L\(_3\) is replaced with 2,4-dinitrophenylhydrazine) has shown slightly better biological activity against gram negative bacteria such as Escherichia coli, Klebsiella pneumonia, Acinetobacter baumannii, Pseudomonas aeruginosa and gram positive bacteria Staphylococcus aureus when compared to standard ligand L\(_3\). The ligand bearing aromatic ring and hetero atom nitrogen has shown promising activity against all the tested fungi\(^\text{36}\). Hence, the presence of aromatic ring with hetero atom as key atom (nitro phenyl group) enhanced the antimicrobial activity than the standard ligand L\(_3\). The values of zone of inhibition of ligands L\(_1\), L\(_2\) & L\(_3\) is tabulated in Table 1.

**Corrosion Study**

The Schiff base containing the nitro group showed an effective corrosion inhibition property on mild steel in 0.5M HCl medium by weight loss method\(^\text{37}\). The present corrosion study at different concentration of ligands reveals that the corrosion inhibition property was increased or weight loss and corrosion rate are decreased drastically by doping with 0.1% of ligands with 0.5N hydrochloric acid solution. Further, by increasing the concentration of ligands from 0.1% to 0.7%, the corrosion inhibition efficiency is increased from 87.57 to 89.74% for L\(_1\), 89.71 to 91.76% for L\(_2\) and 86.22 to 88.64% for L\(_3\). This might be explained by the donor-acceptor interaction between the unshared pair of electrons of donor atom of the Schiff bases and metals in the steel. The higher corrosion inhibition property of Schiff base ligands L\(_1\), L\(_2\) was due to the increase of electron density in L\(_1\) by the presence of aromatic π-electrons and ester group, whereas in L\(_2\) by the presence of nitro group and aromatic π-electrons\(^\text{38}\). The observed values are tabulated in Table 2. The presence of heteroatoms such as N, O or S in the compound which enhances the corrosion inhibition property in an acidic environment and the corrosion inhibition efficiency is decreased with increase of temperature\(^\text{39}\). The corrosion study at different temperature with concentration of 0.1% of synthesized ligands reveals that the weight loss and corrosion rate are increased by increasing the temperature from 30±2 to 50±2°C and the corrosion inhibition efficiency is decreased from 87.6 to 86.9% for L\(_1\), 89.7 to 89.3% for L\(_2\) and 86.5 to 86.0% for L\(_3\) by increasing the temperature. The observed values are tabulated in Table 3.

From the weight loss measurements, the percentage of Inhibition efficiency (\(\eta\)), Corrosion rate (R) is calculated by the following formulae.

### Table 1 — Zone of inhibition values for ligands L\(_1\), L\(_2\) & L\(_3\)

<table>
<thead>
<tr>
<th>Human pathogens</th>
<th>Quantity (µL)</th>
<th>Zones of inhibition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blank</td>
<td>Lig-1</td>
</tr>
<tr>
<td>E.coli-ATCC 25922</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Staphylococcus aureus - MTCC 1430</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>Klebsiellapneumoniae -MTCC 432</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>Acinetobacterbaumannii- ATCC 19606</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa-ATCC 27853</td>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 2 — Corrosion Inhibition Efficiency and Corrosion rate of ligands in 0.5N HCl at 30±2°C

<table>
<thead>
<tr>
<th>Inhibitor</th>
<th>Concentration (%)</th>
<th>Weight loss (mg)</th>
<th>Inhibition efficiency (\eta) (%)</th>
<th>Corrosion rate R (mgcm(^{-2})h(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>-</td>
<td>82.9345</td>
<td>-</td>
<td>0.3456</td>
</tr>
<tr>
<td>Ligand-1</td>
<td>0.1</td>
<td>10.3123</td>
<td>87.57</td>
<td>0.0430</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>9.2535</td>
<td>88.84</td>
<td>0.0386</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>8.7321</td>
<td>89.47</td>
<td>0.0364</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>8.5122</td>
<td>89.74</td>
<td>0.0355</td>
</tr>
<tr>
<td>Ligand-2</td>
<td>0.1</td>
<td>8.5321</td>
<td>89.71</td>
<td>0.0356</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>7.6132</td>
<td>90.82</td>
<td>0.0317</td>
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<tr>
<td></td>
<td>0.5</td>
<td>7.0211</td>
<td>91.53</td>
<td>0.0293</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>6.8325</td>
<td>91.76</td>
<td>0.0285</td>
</tr>
<tr>
<td>Ligand-3</td>
<td>0.1</td>
<td>11.4321</td>
<td>86.22</td>
<td>0.0476</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>10.3652</td>
<td>87.50</td>
<td>0.0432</td>
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<td></td>
<td>0.5</td>
<td>9.8652</td>
<td>88.10</td>
<td>0.0411</td>
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<tr>
<td></td>
<td>0.7</td>
<td>9.4215</td>
<td>88.64</td>
<td>0.0393</td>
</tr>
</tbody>
</table>
Inhibitor & Temperature (°C) & Weight loss (mg) & Inhibition efficiency η (%) & Corrosion rate R (mg cm⁻² h⁻¹) \\
--- & --- & --- & --- & --- \\
Blank & 30±2 & 82.9345 & - & 0.3456 \\
& 40±2 & 163.2152 & - & 0.6801 \\
& 50±2 & 201.3524 & - & 0.8390 \\
Ligand-1 & 30±2 & 10.3123 & 87.57 & 0.0430 \\
& 40±2 & 21.1532 & 87.04 & 0.0881 \\
& 50±2 & 26.3581 & 86.91 & 0.1098 \\
Ligand-2 & 30±2 & 8.5321 & 89.71 & 0.0356 \\
& 40±2 & 17.0213 & 89.57 & 0.0709 \\
& 50±2 & 21.5310 & 89.31 & 0.0897 \\
Ligand-3 & 30±2 & 11.2325 & 86.46 & 0.0468 \\
& 40±2 & 22.5212 & 86.20 & 0.0938 \\
& 50±2 & 28.1321 & 86.03 & 0.1172 \\

1. Inhibition Efficiency η = [(W_{corr} - W_{inh})/W_{corr}] * 100
   Where, W_{corr} = Weight loss with inhibitor.
   W_{inh} = Weight loss without inhibitor.

2. Corrosion Rate (R) = Weight loss in mg / [Area of specimen (cm²) * Time (Hr)]

**Conclusion**
Schiff base L₁ & L₂, standard ligand L₃ are prepared and the structure was confirmed by UV-Visible, NMR, Mass and IR spectral studies. The new L₁ & L₂ are designed by protecting the imidazole – NH group of L₃ with benzyl-4-methylbenzoate (for L₁) and varying the amine part of L₃ with 2,4-dinitrophenyl hydrazine (for L₂).
The antimicrobial study by well diffusion method is performed for L₁, L₂ & L₃ and the results are compared with standard ligand L₁.
Corrosion inhibition property on mild steel in 0.5N HCl for L₁ & L₂ and standard ligand L₃ has been studied by weight loss method at different concentration and different temperature.

Similar biological activity is observed by protecting the imidazole –NH with ester substituted phenyl derivative (L₁) and little improvement in biological activity is observed by the amine part is replaced with nitro substituted phenyl hydrazine derivatives(L₂) when compared to standard ligand(L₃). All the ligands exhibit excellent antimicrobial activity against gram negative bacteria E-coli, Klebsiella pneumonia, Acinetobacter baumannii, Pseudomonas aeruginosa and gram positive bacteria Staphylococcus aureus.

All the ligands exhibit as good corrosion inhibitor on mild steel in 0.5N HCl medium. The corrosion inhibition efficiency (η) is increased gradually and corrosion rate (R) is decreased gradually by increasing the concentration of ligands from 0.1 to 0.7%. The corrosion study at elevated temperature reveals that, the corrosion inhibition efficiency (η) is decreased whereas corrosion rate (R) is increased by increasing the temperature from 30±2 to 50±2°C.

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