



## **A Study on Gallic acid-derived Schiff's base and their efficacies as Mild Steel Corrosion Inhibitors under H<sub>2</sub>SO<sub>4</sub> medium**

**Ankit Sharma<sup>1</sup>, Dr. S.K. Arora<sup>2</sup>, Dr. Manoj Kumar Batra<sup>3</sup>, Rohtash Kumar<sup>4</sup>**

**Department of Chemistry, S.P.C Government P.G. College, Ajmer, (Rajasthan)**

**Email id- [ankitjaipuria@gmail.com](mailto:ankitjaipuria@gmail.com)**

---

### **Abstract:**

Organic, environmentally beneficial, and economically advantageous chemicals known as Schiff Bases are frequently used as corrosion inhibitors for metal alloy surfaces. One such widely used alloy is mild steel, which often exhibits poor corrosion resistance when exposed to acidic conditions like H<sub>2</sub>SO<sub>4</sub>. The most recent advancement in this process is using green technologies in applying Schiff Bases. These well-known sustainable methods work well for reducing toxicity, conserving energy, and many other things. This study is an expansion of a previously published study that uses the same methodology to create a Schiff Base from gallic acid hydrazide, which is created using a different aldehyde (than used in the previous work). Microwave irradiation is utilized for heating as a green technology strategy. Then, NMR, IR, SEM, and XRD approaches are used to describe the Green Schiff base. The Schiff Base is then applied to confirm their effectiveness as metal corrosion inhibitors. To assess their ability to suppress corrosion, three methods—the mass loss technique, SEM, and potentiodynamic polarization method—are applied. The study is thought to be a step forward in the adoption of environmentally friendly inhibitors with the aim of preventing corrosion on metal surfaces.

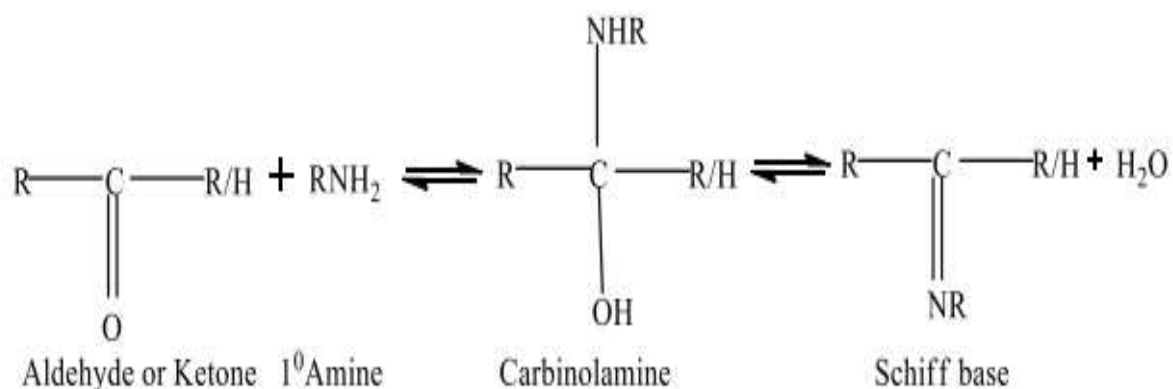
**Keywords:** Schiff base corrosion inhibitor, green steel corrosion inhibitor, schiff base variants, green techniques, eco-friendly Schiff bases

---

### **1. Introduction**

Steel and other iron alloys have many different industrial uses. Iron alloy utilisation is hampered by the materials' poor acidic corrosion resistance. One of the biggest issues facing corrosion researchers is the discovery of novel materials that can stop or lessen corrosion. By adsorbing to a metal surface, organic molecules with numerous bonds and electron-donating centres like O, N, S, and P can create a protective coating that inhibits corrosion [1]. The Schiff's bases have become more and more popular in the field of corrosion inhibition science due to their simplicity of

preparation and environmental friendliness.



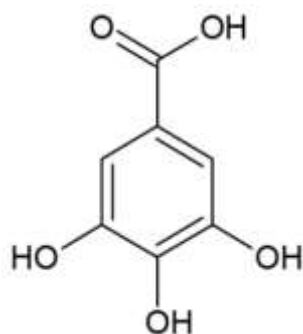
**Figure 1:** General Reaction of Formation of a Schiff Base [21]

Corrosion inhibitors are substances that regulate, restrict, or completely stop the corrosion of metals in corrosive conditions. An organic compound with sulphur, nitrogen, and oxygen atoms that can prevent metallic corrosion would be a good inhibitor. A damaging issue involving corroded metal coming into contact with its surroundings is corrosion. Chemical corrosion appears to be the uncontrolled deterioration of metals brought on by heterogeneous chemical reactions and occurs when oxygen and humidity are present on the metal surfaces.

Several researchers studied  $N_2$  and  $O_2$  donor atom-containing heterocyclic Schiff bases and their chelates [2]. Due to their numerous binding and structural possibilities, as well as their applicability in numerous domains, the metal chelates including (monodentate, bidentate, and polydentate) Schiff base ligands have been established and have increased in popularity in metal complexes.

The presence of the azomethine group ( $>C=N-$ ) which occurs from the condensation of a primary amine and a ketone or aldehyde, in the molecules explains why Schiff bases display stronger inhibitory performance than their building blocks (i.e., aldehydes and amines). Recent studies have looked into the effectiveness of many Schiff base compounds as acid corrosion inhibitors. Due to their low toxicity and simplicity of synthesis from affordable ingredients, these compounds are widely used as corrosion inhibitors [3].

Due to the global adoption of green chemistry, it is now more crucial than ever to protect both our environment and our health. The preparation and development of ecologically safe and safe technologies are the primary tasks, according to the 12 principles of green chemistry. In this situation, Schiff bases are frequently made using natural amines [5].



**Figure 2:** Gallic Acid Molecule Structure [5]

One such non-toxic amine with corrosion-inhibiting qualities for steel structures is gallic acid, also known as 3,4,5-trihydroxybenzoic acid, which is present in many plants and foods, including tea [4, 5].

Once more, the use of the microwave (MW) technology in analytical, polymer, medicinal, and inorganic chemistry has grown quickly. Recent advances in synthetic chemistry have been credited to microwave-assisted synthesis. This method has eliminated some of the drawbacks of conventional approaches, including longer reaction times, lower yields and purity, and slower reaction rates.

As mentioned in the section on Related Works, microwave synthesis offers organic chemists new chances to broaden their synthetic options by using microwave irradiation to better the outcomes of a range of organic reactions [6].

In this study, following the procedure of a previously published work, a Schiff Base is derived from Gallic Acid Hydrazide that is synthesized with the help of a different aldehyde (than used in the previous work) using microwave irradiation method. Then, the Green Schiff base is characterized by using NMR, FTIR, SEM and XRD schemes. Afterwards, the Schiff Base is used to ensure their efficacy as corrosion inhibitor for metals. Three approaches are used, namely, Mass loss method, SEM and Potentiodynamic polarization method to evaluate their corrosion inhibition potency.

The research is believed to be a progress step towards adoption of green inhibitors for the purpose of corrosion preventions on metal surfaces. The study emphasizes on the sustainability, resource availability and eco-friendly aspects of the chosen green inhibitor (Gallic Acid) that are felt beneficial in the sustainable manufacturing practices that are currently highly demanded worldwide.

## **2. Related Work**

This section is composed with the systematic review on the current scholarly works done in the applications of schiff bases as corrosion inhibitors. The section particularly stresses on the

convenience and effectiveness of schiff base applications as corrosion inhibitors and importance of green techniques to incorporate sustainability and eco-friendly procedure of corrosion protection for metal surfaces.

### **2.1 Importance of Schiff Bases as Corrosion Inhibitors**

In their experiment, [10] discovered that the adherent sorption process of the inhibitor molecules on the metal surface, which is spontaneous, exothermic, and supported by a lowering in the system's entropy from a thermodynamic point of view and abides the Temkin isotherm, was responsible for the high inhibition efficiency of Schiff Base (PSCs).

In this study, the inhibitive impact of Schiff bases was correlated to data from quantum chemical calculations using DFT at the B3LYP/6-311++G\*\* level of theory (PSCs). The DFT approach was used to calculate the correlations between the E HOMO, E LUMO-E HOMO, and N of PSCs and the inhibitory efficiency of iron in aerated 2.0 M HNO<sub>3</sub> and/or 2.0 M NaOH.

Polarization curves showed that the investigated Schiff bases behaved as mixed type corrosion inhibitors in HNO<sub>3</sub> by preventing both cathodic hydrogen evolution processes and anodic metal dissolution. With an increase in E HOMO and a drop in E LUMO E HOMO, the inhibition efficiency rose. Since PSC 1 had the highest HOMO energy, N values, and ability to supply electrons, it had the best inhibition efficiency.

It was discovered that the electron density and the length of the aminic nitrogen-containing carbon bonechain correlated positively, increasing the inhibitory potency. The regions with N and O atoms are the most likely candidates for adhering the metal's iron surface by supplying the metal with electrons. Chemical and electrochemical approaches yielded similar inhibitory efficiency, which are in good accord with one another. Both concentration and immersion time affect how well it inhibits.

[11] investigated the novel Schiff bases 1-(2-[(5-methylfuran-2-yl)methylene] hydrazono) phthalazine (MFHPZ) (2), 1-(phthalazin-1(2H)-one) [(pyridin-2-yl) ethylidene] hydrazono (ACPHPZ) (3) and (2-acetylthiophene hydrazono) phthalazine (ACTHPZ) (4) that were synthesised in succession and characterised using various spectroscopic techniques. These Schiff bases were produced from hydralazine hydrochloride 1. The inhibitory effect of the Schiff bases on the corrosion of mild steel in 1 M HCl solution was investigated using weight loss, potentiodynamic, and electrochemical impedance spectroscopy (EIS) techniques. As mixed-typed inhibitors, the compounds demonstrated outstanding inhibitory performance. The weight loss-related chemical and electrochemical measurements' inhibitory efficiencies were in good agreement. The order of the inhibition efficiencies is 4 > 3 > 1 > 2.

Three Schiff bases—benzylidene-pyridine-2-yl-amine (BPA), (4-methylbenzylidene)-pyridine-2-yl-amine (4CH<sub>3</sub>-BPA), and (4-chloro-benzylidene)-pyridine-2-yl-amine—were studied for their ability to suppress corrosion (4Cl-BPA) by [9]. Using density functional theory (DFT) to analyse the connection between electronic factors and corrosion inhibition activity, they looked into the process. In order to investigate the possibility for a novel Schiff base with an OH functional group (OH-BPA) to operate as an anti-corrosive material, complete theoretical calculations were carried out. Investigated was how differing OH functional group placements affected the ability to inhibit corrosion. Schiff bases with OH functional groups at the para position have the best corrosion prevention efficacy.

The performance of several Schiff bases as corrosion inhibitors in an acidic medium (HCl/H<sub>2</sub>SO<sub>4</sub>) was emphasised by [18], highlighting the role of Schiff bases in the production of novel compounds with the potential for anti-corrosive activity. According to earlier research, Schiff bases mostly functioned as mixed-type inhibitors, influencing both cathodic and anodic processes, and they shown an increase in efficiency with increase in concentration. The Langmuir adsorption isotherm was followed by the bulk of inhibitors. Due to the usage of standard harmful amines, the study predicted that typical Schiff bases could not be used as eco-friendly corrosion inhibitors, which is why the benefit of natural amines like chitosan is particularly advised.

[17] made investigation of corrosion inhibition behaviour of 2,2'-((1Z,1'Z)-(((propane-1,3-diylbis(oxy))bis(2,1-phenylene))bis(methanylylidene)) bis (azanylylidene)) diethanol (2-PPM) on the mild steel surface in 1N H<sub>2</sub>SO<sub>4</sub> solution by application of weight loss, Tafel plot and impedance spectroscopy techniques. Following a similar methodology to that of [11], this study also carried out weight loss studies that demonstrated that the 2-PPM inhibitor's ability to inhibit corrosion on mild steel samples' external surfaces in 1N H<sub>2</sub>SO<sub>4</sub> solutions is primarily dependent on the inhibitor's concentration and immersion time.

Polarization tests showed that the inhibitor functioned as a mixed type corrosion inhibitor by repressing both cathodic hydrogen development and anodic metal breakdown. Impedance experiments showed that the double-layer capacitance (Cdl) decreased while the polarisation resistance (Rct) rose in the presence of an inhibitor. The addition of inhibitors to the strong solutions reduced the corrosion of steel, as evidenced by the high resolution micrographs, which revealed that the corrosion of steel in acidic condition was indicated by corrosion attack.

## **2.2 Schiff Base and Their Efficacies**

In the experiment conducted by [13], mononuclear complexes were created by allowing the Schiff base ligand to react with metal ions in a 2:1 molar ratio (ligand:metal ion). The azomethine nitrogen

atoms and phenolic oxygen atoms, respectively, served as the binding sites. Spectral investigations including UV-Visible, FT-IR, NMR, Mass, ESR, and conductance measurements supported the attachment of the ligand to the metal ion. The complexes' non-electrolytic character was implied by the lower molar conductance values.

Both of the copper(II) complexes were demonstrated to exhibit a square planar geometry based on the analytical and spectral data. Studies of the ligand and its complexes' antibacterial and antifungal effects were also conducted as a sustainable strategy, and they showed that chelation increases activity.

The substances have an inhibitory effect, according to experimental data on the inhibition efficiency of the under investigation metal complexes and Schiff base ligands. They might prevent metal from oxidising in an acidic media. According to the researchers, the adsorption of the ligand and metal chelates may be the cause of the metal corrosion's suppression.

Environmentally friendly three chitosan Schiff bases (CSBs) that were produced for the first time under microwave irradiation by the reaction of chitosan and aldehydes (benzaldehyde (CSB-1), 4-(dimethylamino)benzaldehyde (CSB-2), and 4-hydroxy-3-methoxybenzaldehyde (CSB-3)) were used by [14]. To evaluate the synthetic inhibitors' ability to prevent corrosion, potentiodynamic polarisation and electrochemical impedance spectroscopy (EIS) were performed (PDP). The outcomes demonstrated that all of the Schiff bases (CSBs) were capable of effectively preventing mild steel in a 1 M HCl solution from corroding. At a very low concentration of 50 ppm, the synthesised Schiff base CSB-3 demonstrated the highest inhibitory efficiency of 90.65%. According to the EIS findings, CSBs prevent corrosion through an adsorption mechanism. All three of the Schiff bases are mixed-type inhibitors, according to the PDP data. Methods for scanning electron microscopy/energy dispersive X-ray analysis and Fourier-transform infrared spectroscopy provided evidence that inhibitor films were forming on the mild steel surface. The Langmuir adsorption isotherm was followed by the adsorption of CSBs on the mild steel surface. [15] conducted comparative assessments of the bis-Schiff bases produced from thiadiazoles for mild steel in 1 M HCl. The anticorrosion activity of bis-Schiff bases as inhibitors was investigated using a variety of electrochemical tests (electrochemical impedance spectroscopy and potentiodynamic polarisation), as well as weight loss assays. For all inhibitors, the best inhibition efficiency was attained at a concentration of 125 ppm. Studies on potentiodynamic polarisation provide an explanation for all inhibitors' mixed type, but primarily cathodic, character. The Langmuir adsorption isotherm was employed to characterise the mechanism of adsorption in this analysis as it did in [14]. The mixed form of interaction between the inhibitor and metallic

surface is reflected in the change in activation energy value upon the addition of inhibitors. X-ray diffraction, X-ray photoelectron spectroscopy, and scanning electron microscopy with energy-dispersive spectroscopy investigations supported the adsorption of bis-Schiff bases on the metal surface and the resulting corrosion protection.

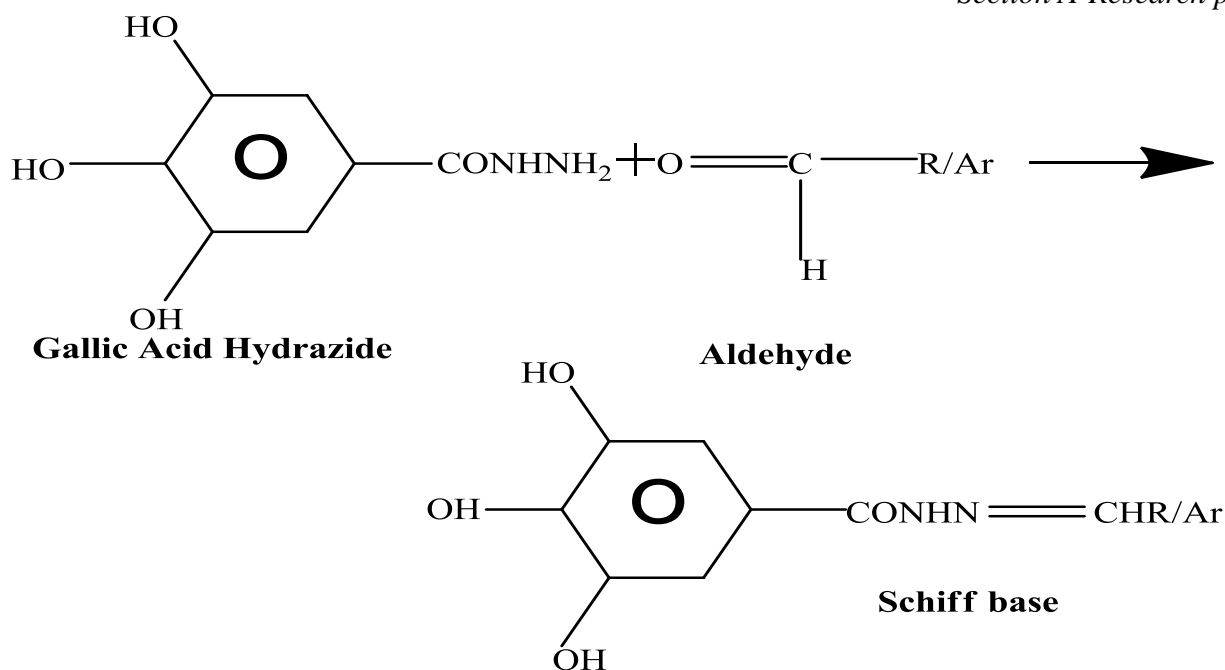
A tridentate Schiff base ligand (E)-1-(2-hydroxy-3-methoxybenzylidene)-3-phenylurea was employed by [16]. It was made from o-vanillin and phenyl urea in a 1:1 molar ratio. Moreover, both conventional techniques and microwave-assisted irradiation were used to create the metal complexes of Mn (II), Co (II), Ni (II), Cu (II), Zn (II), and Zr (IV). The ligand and its complexes 1-6 were characterised by thermogravimetric analysis, elemental analysis, FT-IR, UV-vis, <sup>1</sup>HNMR, and mass spectroscopy (TGA).

Electron spin resonance (ESR), magnetic moments, and electronic spectra were used to corroborate the geometrical structures of the complexes. The Coats-Redfern and Horowitz Metzger equation was used to study the thermal dehydration and breakdown of the Co (II), Ni (II), and Zn (II) complexes using the integral technique. The antibacterial activity of the ligand and its metal complexes was tested against gram-positive, gram-negative, and fungal microorganisms. Also, two cell lines—human colon carcinoma (HCT-116) and breast carcinoma cells—were used to test the cytotoxic activity (MCF-7).

By synthesising the triazole Schiff base derivatives N-(furan-2-ylmethylene)-1H-1,2,4-triazol-3-amine (FTA), and N-(thiophen-2-ylmethylene)-1H-1,2,4-triazol-3-amine (TTA) under ultrasonic irradiation, [12] explored three triazole Schiff base derivatives as corrosion inhibitors. The chemical structure of the produced inhibitors was clarified using FT-IR, NMR, and elemental analyses. Using three distinct methods, the inhibitive properties of these inhibitors on C-steel corrosion in 1.0 M HCl were investigated. The methods included potentiodynamic polarisation profiles, electrochemical frequency response, and electrochemical impedance spectroscopy. The data collected through the lab procedures demonstrated that the ideal concentration for TMN, FTA, and TTA is 1.0 10<sup>3</sup> mol/L, and the inhibitory efficiency for TMN, TTA, and FTA, respectively, progressively increased to 91.68%, 88.44%, and 87.29%. Additionally, experiments showed that these chemicals function as mixed-type inhibitors, and their concentration directly correlates to the effectiveness of the inhibition. Density functional theory (DFT) quantum measurements demonstrated good agreement between experimental and computational findings.

### **3. Research Strategy and Tools**

To produce the Schiff Base, the following general condensation reaction between Gallic Acid Hydrazide and Aldehyde is followed:



In this experiment, a new aldehyde - 4-(Dimethylamino) benzaldehyde is combined with gallic acid hydrazone to form two Schiff bases (in previous work, 4-Hydroxy-3-Methoxybenzaldehyde was used). This preparation uses the literature method. The Schiff Base under inquiry has been homogenised, finely powdered, and the bulk composition has been estimated using a standard scale. The compound's purity was examined using TLC and silica Gel-G as an adsorbent; visibility was made possible using iodine or UV light. All of the chemicals used to prepare the Schiff base are AR grade (MERCK) [19].

When a household microwave oven (LG, MS-194A) running at 2450MHz (40% power, 320 W) is used for heating purposes in the reaction, this is known as "green synthesis." The acidic medium selected to examine the effectiveness of the produced Schiff Bases in preventing corrosion is sulphuric acid ( $H_2SO_4$ ). The metal surface for testing the effectiveness of the schiff base's corrosion prevention is Mild Steel.

Fourier-transform infrared (FTIR), nuclear magnetic resonance (NMR), scanning electron microscopy (SEM), and X-ray diffraction (XRD) techniques are used to characterise Schiff bases. FTIR spectra ( $\nu_{max}$   $cm^{-1}$ ) are recorded on a Perkin Elmer 557 grating infrared spectrophotometer in KBr pallets. Using SEM examination, the potentiodynamic method, and the mass loss method, the effectiveness of Schiff Base's corrosion inhibition is assessed.

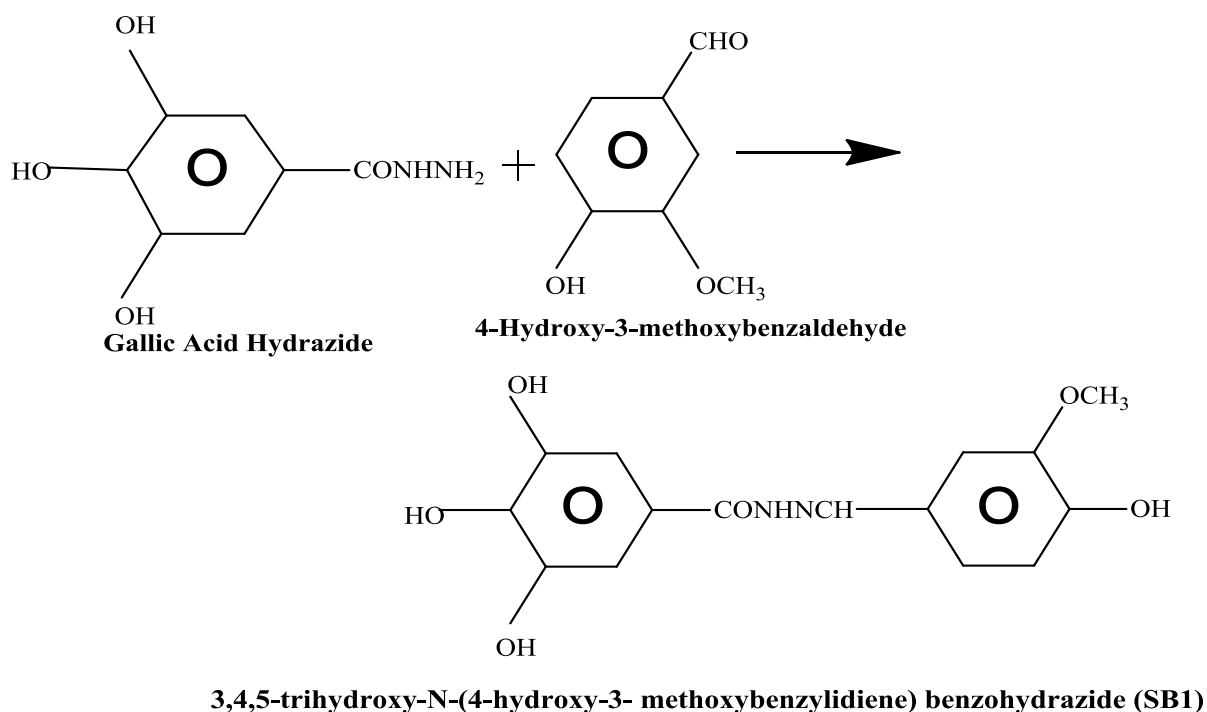
#### 4. Experimental Observation

##### 4.1 Schiff Base Synthesis

(a) Schiff Base 1 (Previously Published)



To create the required Schiff Base 1 (3,4,5-trihydroxy-N-(4-hydroxy-3-methoxy benzylidene) benzo hydrazide, 3,4,5-trihydroxy benzohydrazide and water are mixed in a reaction mixture [21]. Below is the condensation reaction:



The physical and analytical data of Schiff Base 1 is shown in Table 1.

| Molecular Formula   | Exact Mass    | Molecular Weight | M.P (°C)   | Yield         | Elemental Analysis Found (Calculated) % |             |             |              |
|---|---------------|------------------|------------|---------------|---|-------------|-------------|--------------|
|   |               |                  |            |               | C                                       | H           | N           | O            |
| <b>C<sub>15</sub>H<sub>14</sub>N<sub>2</sub>O<sub>6</sub></b> | <b>318.09</b> | <b>318.29</b>    | <b>254</b> | <b>89.36%</b> | <b>56.60</b>                            | <b>4.43</b> | <b>8.80</b> | <b>30.16</b> |

**Table 1:** The Physical and Molecular Composition of Schiff Base 1

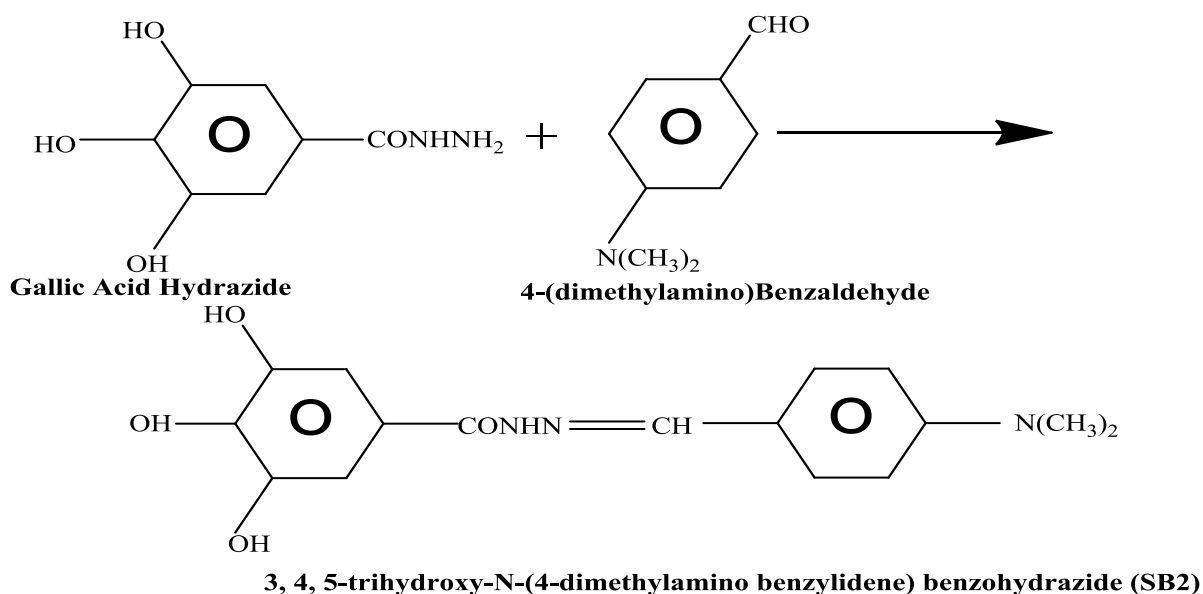
Two drops of concentrated H<sub>2</sub>SO<sub>4</sub> and 0.01 Mole of 4-hydroxy-3-methoxy benzaldehyde are incubated for 7-8 minutes at 160 W in a microwave. The reaction mixture is put into water and allowed to cool to room temperature once the necessary amount of time has passed. A solid is

created, and it starts to recrystallize.

Every two minutes, TLC monitors the reaction's development. TLC eventually revealed a total conversion. UV light at 254 nm is used to identify the TLC spots, and H<sub>2</sub>SO<sub>4</sub> in ethanolic solution (5%, v/v) was sprayed on the surface before being heated to 100 °C [20].

(b) Schiff Base 2 (New)

Similar approach as mentioned above is used to prepare the Schiff Base 2. The chemical equation of the condensation reaction is given below:



The physical and analytical data of Schiff Base 2 is shown in Table 2.

| Molecular Formula   | Exact Mass | Molecular Weight | M.P (°C) | Yield  | Elemental Analysis Found (Calculated) % |      |       |       |
|---|------------|------------------|----------|--------|---|------|-------|-------|
|   |            |                  |          |        | C                                       | H    | N     | O     |
| C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> | 315.12     | 315.33           | 223      | 91.47% | 60.94                                   | 5.43 | 13.33 | 20.29 |

**Table 2:** The Physical and Molecular Composition of Schiff Base 2

### 4.2 Schiff Base Characterization

#### (a) NMR Analysis

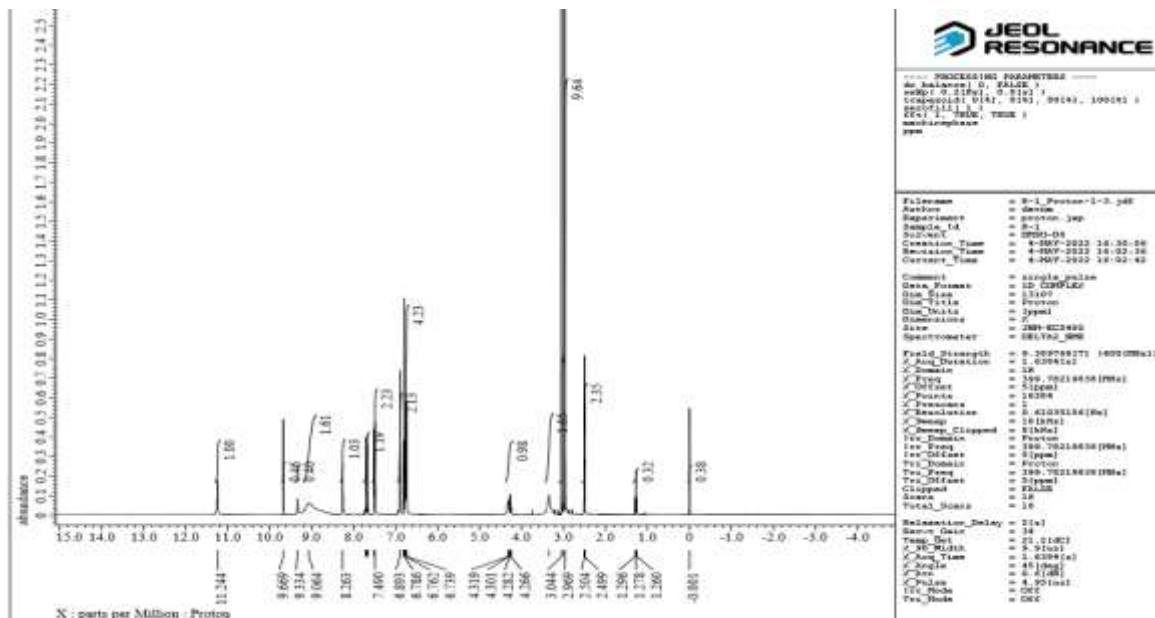


Figure 3: NMR Analysis for Schiff Base 1 Characterization

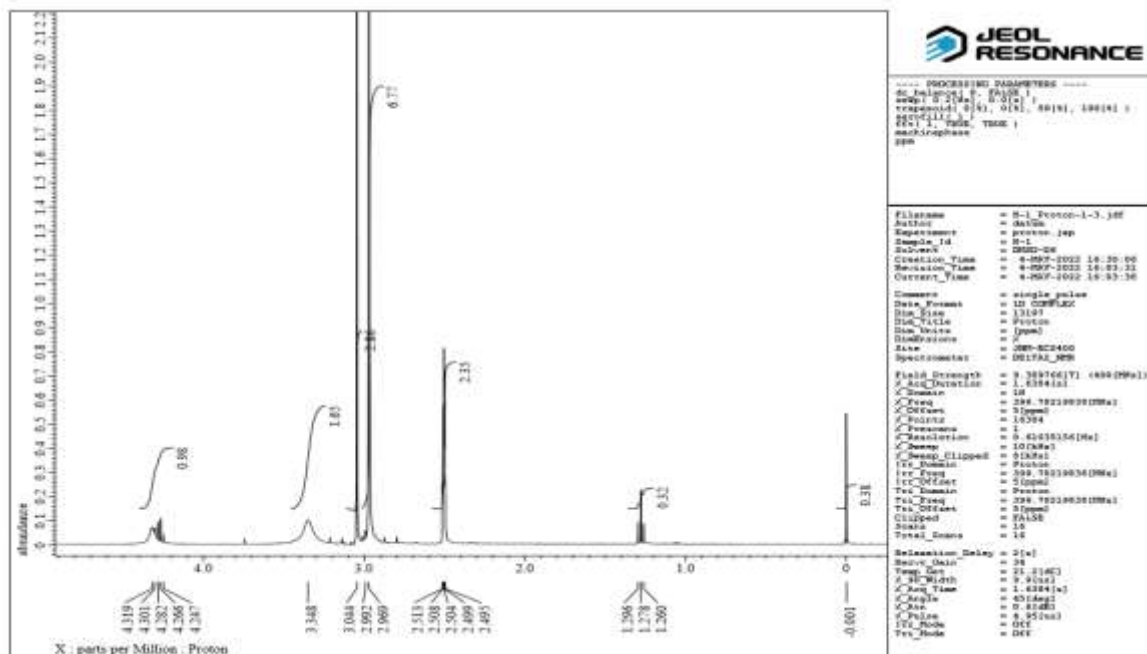


Figure 4: NMR Analysis for Schiff Base 2 Characterization

The NMR investigations for the confirmation of the Schiff Bases Characterization are displayed in the graphs above (Figures 3 and 4). The  $-CH=N$  proton resonance signal is observed to be a crisp

singlet at 8.2 ppm. The transformation of the formyl group (-CHO) into the imino group (-CH=N-) is confirmed by this up field. At 7.2–7.5 ppm, aromatic proton signals appear as multiplates. The rapid atomic bombardment (FAB) mass spectra as  $M^+$  at 422 that matches to their molecular mass provide the final confirmation.

(b) FTIR Analysis

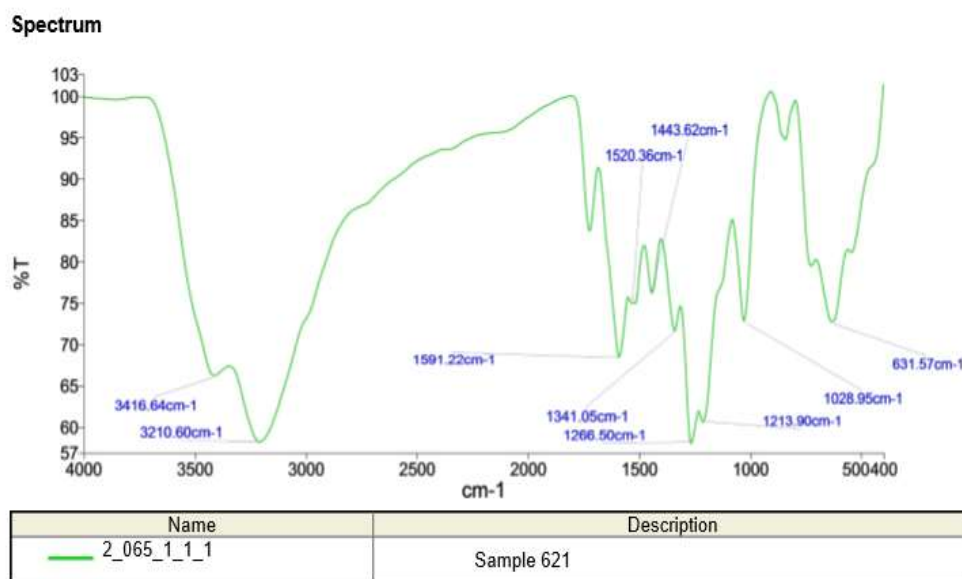


Figure 5: FTIR Analysis for Schiff Base 1 Characterization

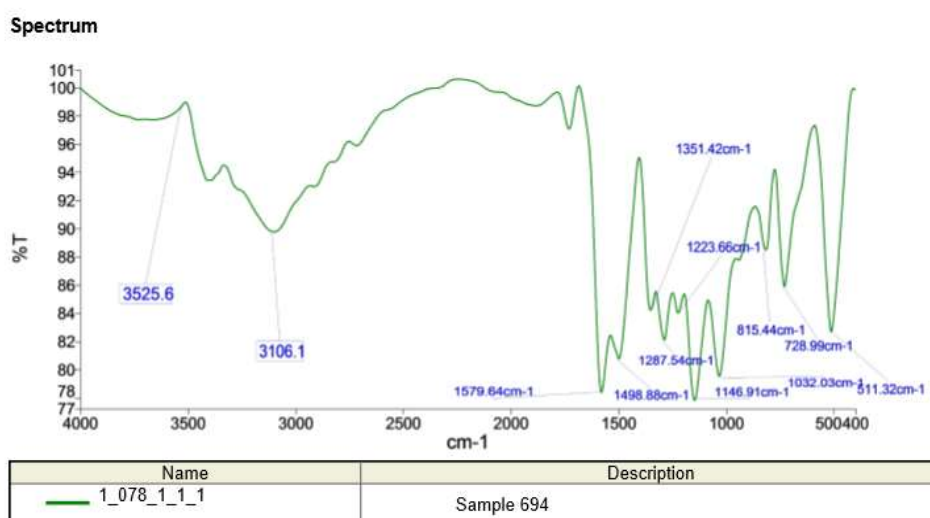
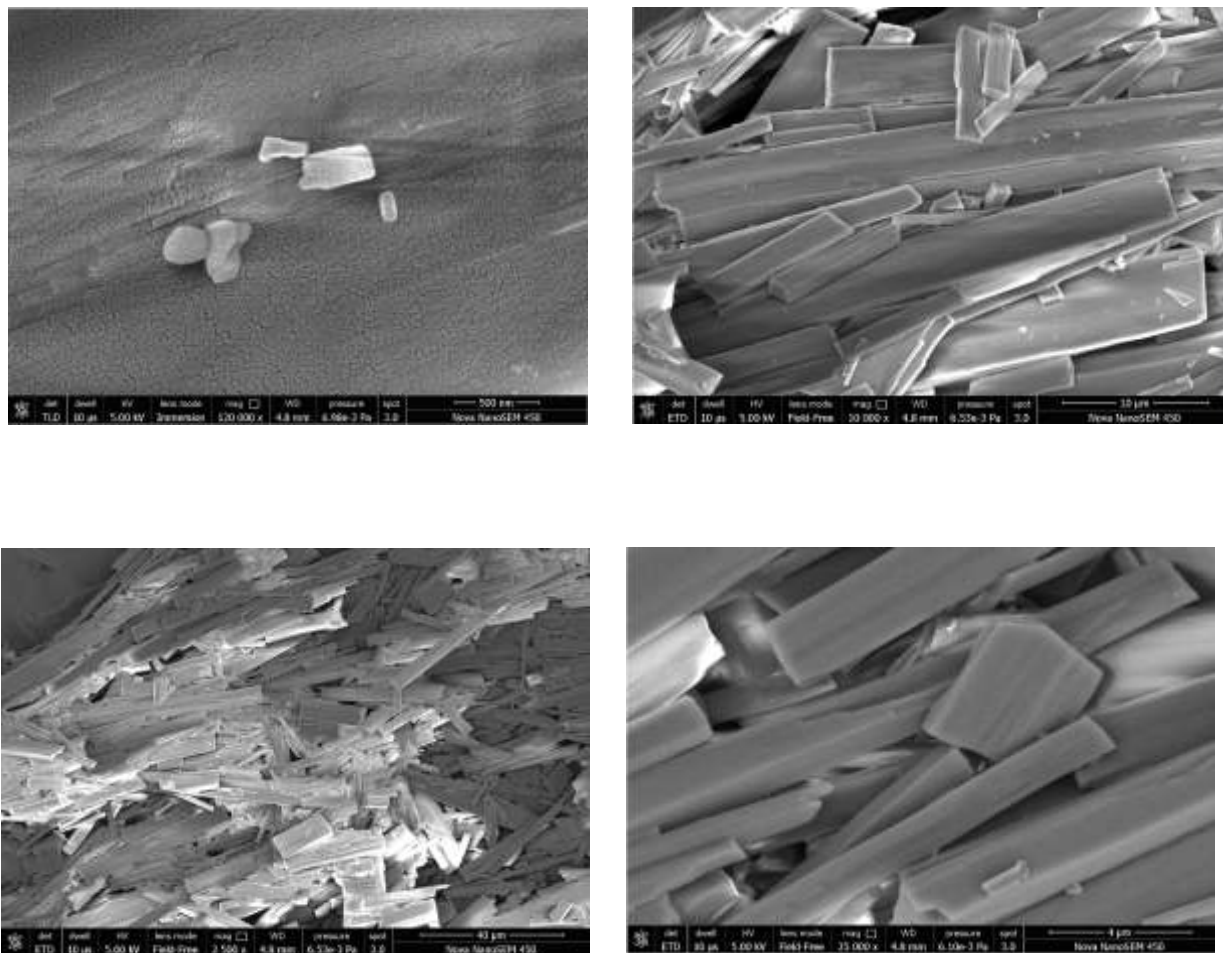


Figure 6: FTIR Analysis for Schiff Base 2 Characterization

*Section A-Research paper*

The FTIR Analysis results for the characterisation of Schiff Bases are displayed in the graphs above. The typical >C=N- group absorption can be seen in the FTIR spectra at 1630–1620 cm<sup>-1</sup>. The broad band of -NH- absorption ranges from 3250 to 3180 cm<sup>-1</sup>. The existence of an aromatic ring in the produced Schiff bases is indicated by the vibration bands at 1500–1400, 1100–1050, and 900–700 cm<sup>-1</sup>.

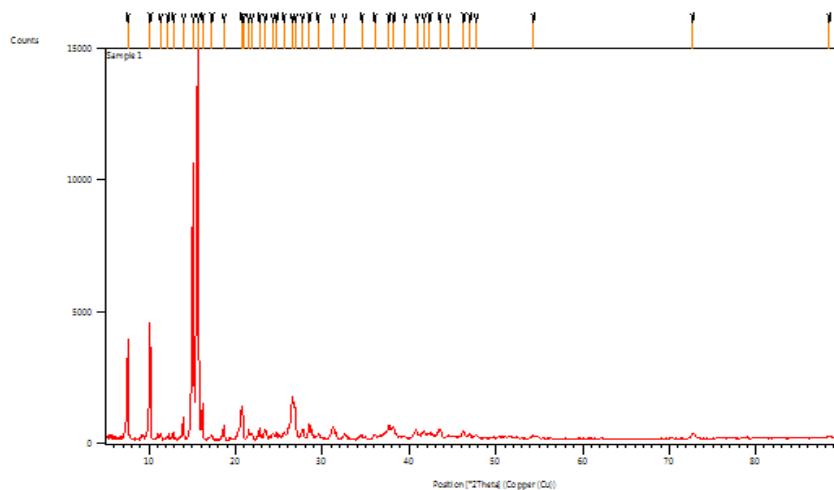
**(c) SEM Analysis**



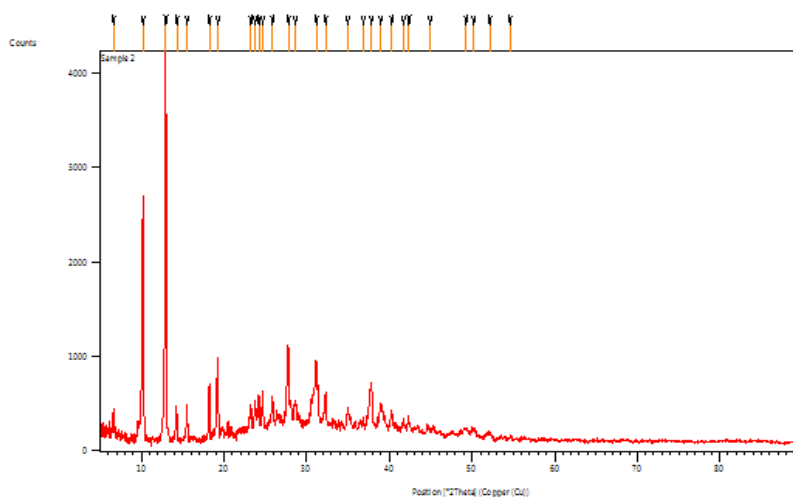
**Figure 7:** SEM Analysis for Schiff Base 2 Characterization

A synthetic base's SEM picture revealed the presence of tiny grains with controlled morphological aggregation and non-uniform size.

(d) XRD Analysis



**Figure 8:** XRD Analysis for Schiff Base 1 Characterization



**Figure 9:** XRD Analysis for Schiff Base 2 Characterization

The XRD analyses for characterising the Schiff base are shown in the graph above (Figures 8 and 9). The synthetic Schiff base's crystalline nature and typical grain size of 37–58 nm were revealed by X-ray powder diffraction.

### 4.3 Corrosion Inhibition Evaluation

#### (a) Mass Loss

Mass loss results of mild steel surface with the presence of Schiff Base corrosion inhibitor under variant acidic medium portions are given below in the tables:

| Inhibitor Concentration (%) | Mass Loss(ΔM)mg |     |      | Inhibition Efficacy(n %) |       |       | Corosion Rate(mmpy) |         |         | Surface Corage(θ) |        |        | log(θ/1-θ) |        |        | (θ/1-θ)  |          |          |
|-----------------------------|-----------------|-----|------|--------------------------|-------|-------|---------------------|---------|---------|-------------------|--------|--------|------------|--------|--------|----------|----------|----------|
|                             | 1h              | 6h  | 24 h | 1h                       | 6 h   | 24 h  | 1 h                 | 6 h     | 24 h    | 1 h               | 6h     | 24 h   | 1h         | 6h     | 24 h   | 1h       | 6 h      | 24 h     |
| Blank                       | 92              | 134 | 185  | 0                        | 0     | 0     | 22.0785             | 32.1578 | 44.397  | 0                 | 0      | 0      | 0          | 0      | 0      | 0        | 0        | 0        |
| 0.1                         | 39              | 66  | 43   | 57.6                     | 50.75 | 76.76 | 9.3594              | 15.8389 | 10.3193 | 0.5761            | 0.5075 | 0.7676 | 0.1332     | 0.013  | 0.5188 | 1.358974 | 1.030303 | 3.302356 |
| 0.2                         | 25              | 59  | 29   | 72.83                    | 55.97 | 84.32 | 5.99                | 14.159  | 6.9595  | 0.7283            | 0.5597 | 0.8432 | 0.4281     | 0.1042 | 0.7307 | 2.68     | 1.271186 | 5.37931  |
| 0.3                         | 21              | 31  | 28   | 77.17                    | 76.87 | 84.86 | 5.0397              | 7.4395  | 6.7195  | 0.7717            | 0.7687 | 0.8486 | 0.529      | 0.5215 | 0.7487 | 3.380952 | 3.322581 | 5.607143 |
| 0.5                         | 16              | 26  | 26   | 82.6                     | 80.6  | 85.95 | 3.8397              | 6.2396  | 6.2396  | 0.8261            | 0.806  | 0.8595 | 0.6767     | 0.6185 | 0.7864 | 4.75     | 4.153846 | 6.115385 |

**Table 3:** Corrosion data for different concentration of Schiff's bases for mild steel in 0.5N H<sub>2</sub>SO<sub>4</sub> at 298+ 0.1 K (Area of exposure - 7.75cm<sup>2</sup>)

| Inhibitor Concentration (%) | Mass Loss(M) mg |     |      | Inhibition Efficacy(n%) |       |       | Corrosion Rat(mmpy) |         |         | Surface Coverage(?) |        |        | log(θ/1-θ) |        |        | (θ/1-θ)  |          |          |
|-----------------------------|-----------------|-----|------|-------------------------|-------|-------|---------------------|---------|---------|---------------------|--------|--------|------------|--------|--------|----------|----------|----------|
|                             | 1h              | 6h  | 24 h | 1h                      | 6h    | 24 h  | 1h                  | 6 h     | 24 h    | 1h                  | 6 h    | 24 h   | 1h         | 6h     | 24 h   | 1h       | 6h       | 24 h     |
| Blank                       | 86              | 104 | 173  | 0                       | 0     | 0     | 20.6386             | 24.9583 | 41.5172 | 0                   | 0.00   | 0      | 0          | 0      | 0      | 0        | 0        | 0        |
| 0.1                         | 40              | 35  | 63   | 53.49                   | 66.35 | 63.58 | 9.5993              | 8.3994  | 15.119  | 0.5349              | 0.6635 | 0.6358 | 0.0607     | 0.2948 | 0.2421 | 1.15     | 1.971429 | 1.746032 |
| 2                           | 36              | 26  | 61   | 58.14                   | 75    | 64.74 | 8.6394              | 6.2396  | 14.639  | 0.5814              | 0.75   | 0.6474 | 0.1427     | 0.4771 | 0.2639 | 1.38889  | 3        | 1.836066 |
| 0.3                         | 29              | 25  | 47   | 66.28                   | 75.96 | 72.83 | 6.9595              | 5.996   | 11.2792 | 0.6628              | 0.7596 | 0.7283 | 0.2935     | 0.4997 | 0.4283 | 1.965517 | 3.16     | 2.680851 |
| 0.5                         | 22              | 22  | 31   | 74.42                   | 78.85 | 82.08 | 527.96%             | 5.2796  | 7.4395  | 0.7442              | 0.7885 | 0.8208 | 0.4638     | 0.5714 | 0.6609 | 2.909091 | 3.727273 | 4.580645 |

**Table 4:** Corrosion data for different concentration of Schiff's bases for mild steel in 1.0 N H<sub>2</sub>SO<sub>4</sub> at 298+ 0.1 K (Area of exposure - 7.75cm<sup>2</sup>)

| Inhibitor Concentration (%) | Mass Loss(M)mg |     |      | Inhibition Efficacy(n%) |       |       | Corrosion Rate(mmps) |         |         | Surface Coverage(θ) |        |        | log(θ/1-θ) |        |        | (θ/1-θ)  |          |          |
|-----------------------------|----------------|-----|------|-------------------------|-------|-------|----------------------|---------|---------|---------------------|--------|--------|------------|--------|--------|----------|----------|----------|
|                             | 1h             | 6h  | 24 h | 1 h                     | 6h    | 24 h  | 1h                   | 6 h     | 24 h    | 1h                  | 6 h    | 24 h   | 1h         | 6h     | 24h    | 1h       | 6h       | 24 h     |
| Blank                       | 243            | 315 | 409  | 0                       | 0     | 0     | 58.316               | 75.5948 | 98.153  | 0                   | 0      | 0      | 0          | 0      | 0      | 0        | 0        | 0        |
| 0.1                         | 139            | 131 | 164  | 42.8                    | 58.41 | 59.9  | 33.3577              | 31.4378 | 39.3573 | 0.428               | 0.5841 | 0.599  | -0.126     | 0.1475 | 0.1743 | 0.748201 | 1.40458  | 1.493902 |
| 0.2                         | 114            | 104 | 136  | 53                      | 66.98 | 66.75 | 27.3581              | 24.9583 | 32.6378 | 0.5309              | 0.6698 | 0.675  | 0.0537     | 0.3072 | 0.3026 | 1.131579 | 2.028846 | 2.007353 |
| 0.3                         | 94             | 78  | 103  | 61.32                   | 75.24 | 74.82 | 22.5585              | 18.7187 | 24.7183 | 0.6132              | 0.7524 | 0.7482 | 0.2001     | 0.4827 | 0.4729 | 1.585106 | 3.038462 | 2.970874 |
| 0.5                         | 69             | 68  | 85   | 71.6                    | 78.41 | 79.22 | 16.589               | 16.3189 | 20.3986 | 0.716               | 0.7841 | 0.7922 | 0.4017     | 0.5602 | 0.5811 | 2.521739 | 3.632353 | 3.811765 |

**Table 5:** Corrosion data for different concentration of Schiff's bases for mild steel in 2.0 N H<sub>2</sub>SO<sub>4</sub> at 298+ 0.1 K (Area of exposure - 7.75cm<sup>2</sup>)

Figures 3 to 5 display the weight loss method-derived percentage of inhibition efficiency and surface coverage for the corrosion of Schiff base in 0.5N, 1N, and 2N H<sub>2</sub>SO<sub>4</sub> for immersion times of 1 hour, 6 hours, and 24 hours at 298+0.1K, with an exposure area of 7.75 cm<sup>2</sup>. The results demonstrate that the inhibitor actually prevented mild steel corrosion in 0.5N, 1N, and 2N H<sub>2</sub>SO<sub>4</sub> at constant temperature (298+0.1K). The inhibitor effectiveness percentage also improves with increasing inhibitor concentration. Increased inhibitor adsorption on the food surface is the cause of this behaviour.

Using these equations (I) & (II), one can compute the inhibition efficiency (IE%) and level of surface coverage (θ), respectively [22].

$$IE (\%) = (W_u - W_i) / W_u \times 100 \dots\dots\dots(I)$$

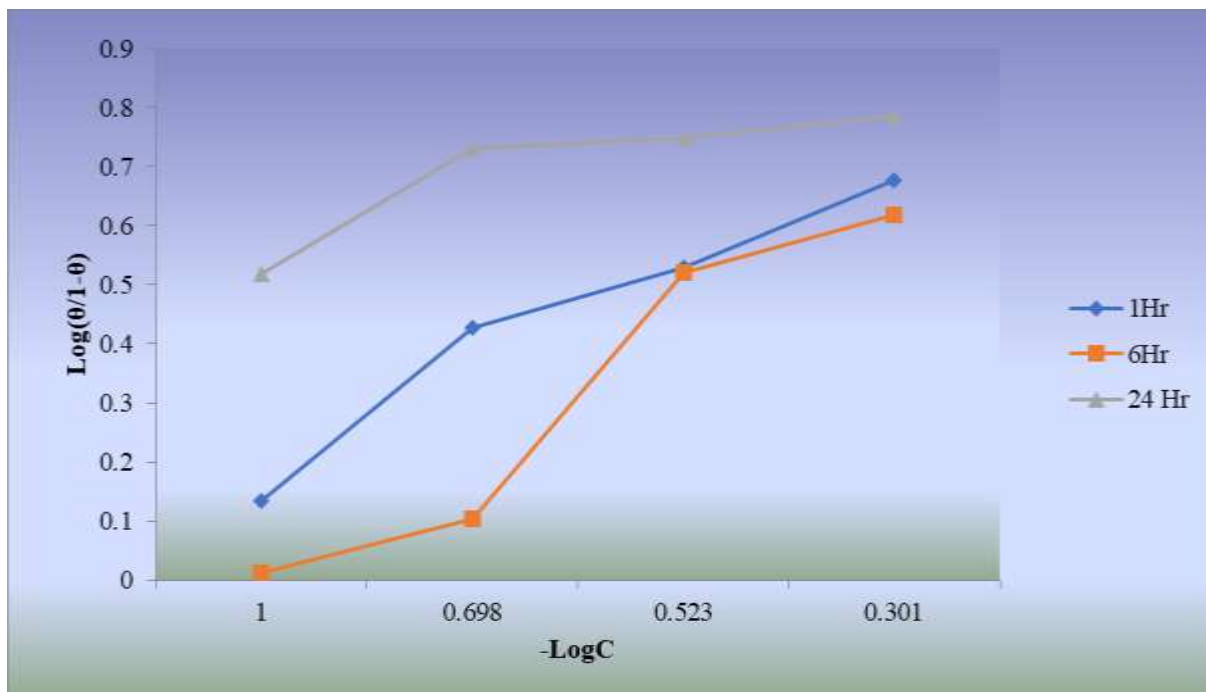
$$\theta = (W_u - W_i) / W_u \dots\dots\dots(II)$$

Where W<sub>u</sub> and W<sub>i</sub> represent the weight loss of mild steel in 0.5N, 1N, and 2N H<sub>2</sub>SO<sub>4</sub> when Schiff base is present and absent, respectively. how much of the surface is covered according to the Langmuir adsorption isotherm. Equation can be used to express the Langmuir adsorption isotherm assumption (III)

$$C / \theta = 1/k + C \dots\dots\dots(III)$$

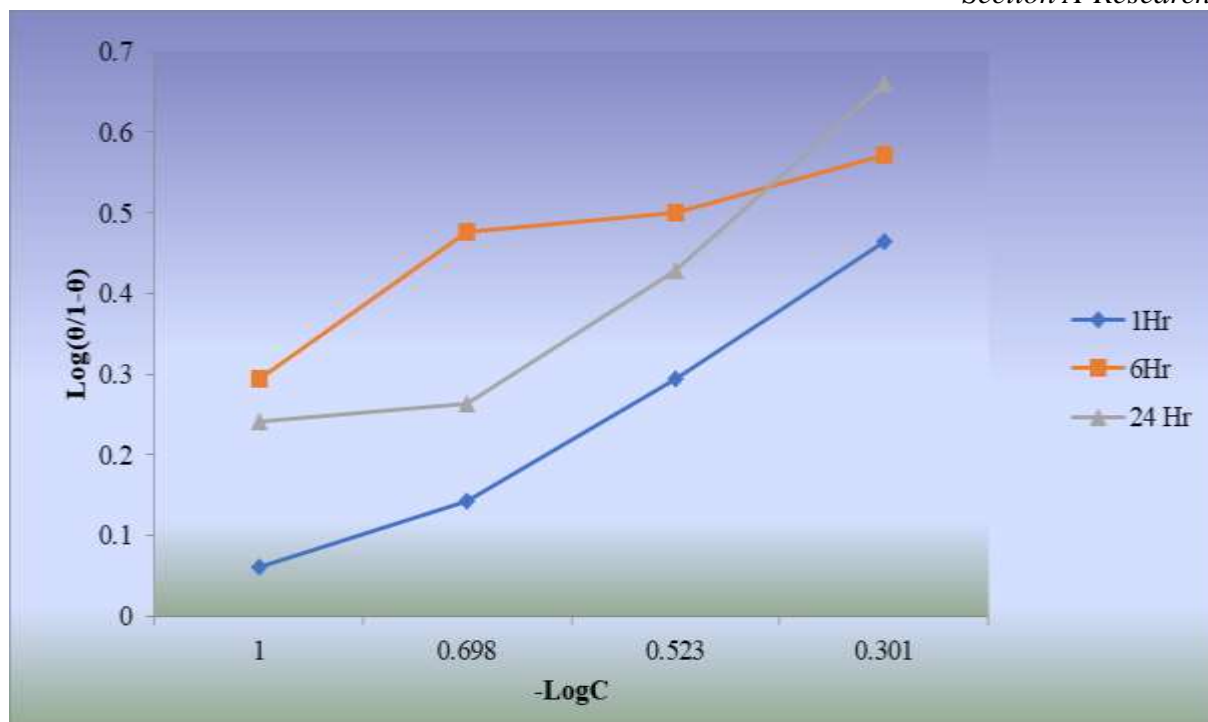
Where C is the inhibitor concentration, is the inhibitor Schiff Base 2's surface coverage, and k is the adsorption equilibrium constant. Taking the equation's logarithm (III).

$$\log C / \theta = \log C - \log k \dots\dots\dots(IV)$$

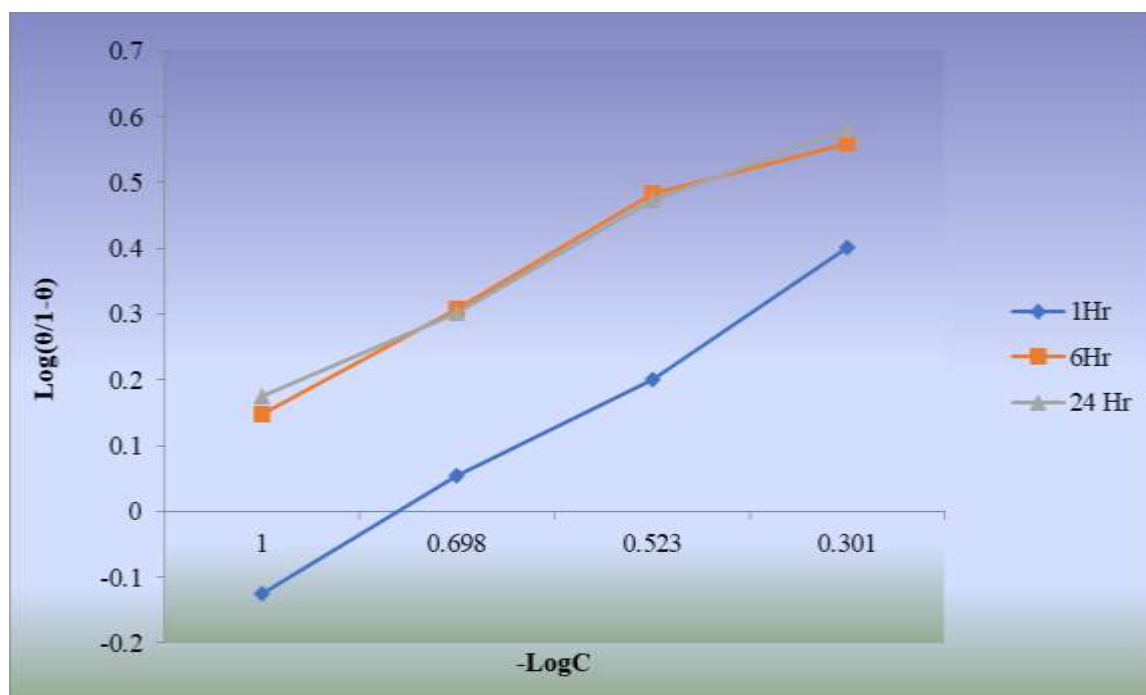


**Figure 10:** Variation of log (θ /1-θ) with log C for Schiff's bases inhibitors for mild steel in 0.5 N H<sub>2</sub>SO<sub>4</sub> at 298+ 0.1K, Time at 1h,6h,24h, Area of exposure - 7.75cm<sup>2</sup>



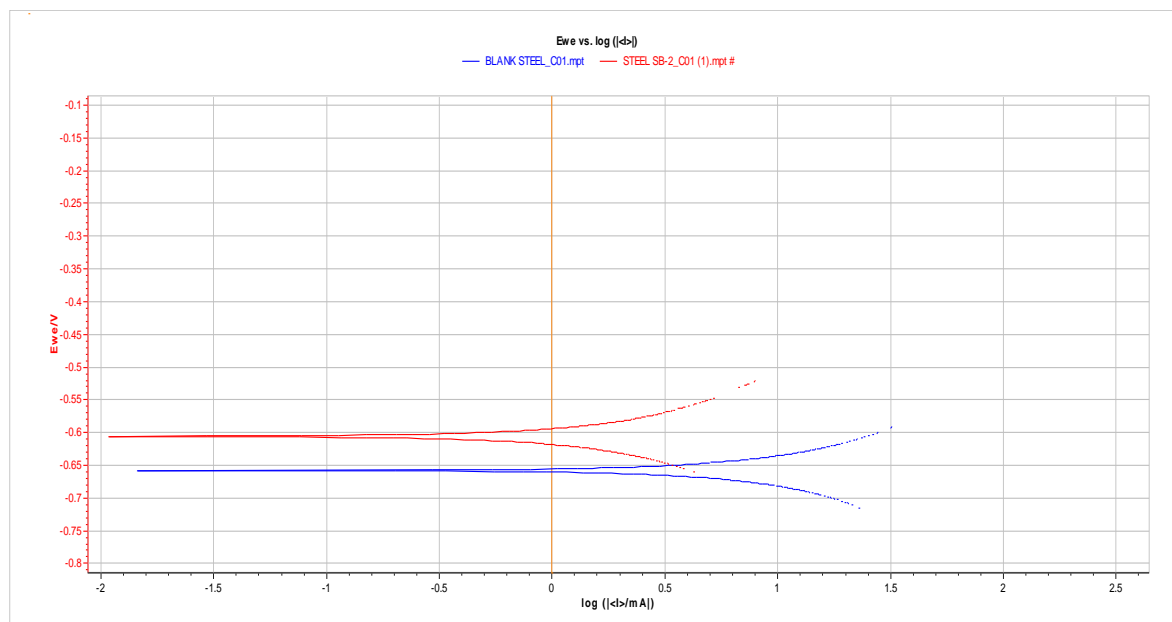


**Figure 11:** Variation of  $\log(\theta/1-\theta)$  with  $\log C$  for Schiff's bases inhibitors for mild steel in 1.0 N  $H_2SO_4$  at 298+ 0.1K, Time at 1h,6h,24h, Area of exposure - 7.75cm<sup>2</sup>



**Figure 11:** Variation of  $\log(\theta/1-\theta)$  with  $\log C$  for Schiff's bases inhibitors for mild steel in 2.0 N  $H_2SO_4$  at 298+ 0.1K, Time at 1h,6h,24h, Area of exposure - 7.75cm<sup>2</sup>

(b) Potentiodynamic Polarisation Method



**Figure 12:** Potentiodynamic Analysis for Schiff Base 2 Corrosion Inhibition Evaluation

The corrosion current density ( $i_{\text{mcorr}}$ ), corrosion potential ( $E$ ), corrosion rate, and anodic and cathodic Tafel slope ( $\beta_a$  and  $\beta_c$ ) that are determined through Tafel line extrapolation. The following formula is used to calculate inhibition efficiency (IE):

$$\text{IE (in \%)} = (i_{\text{mcorr}}^{\circ} - i_{\text{mcorr}}) / i_{\text{mcorr}}^{\circ} \times 100$$

where the corrosion current density values without and with the corrosion inhibitor, respectively, are  $i_{\text{mcorr}}^{\circ}$  and  $i_{\text{mcorr}}$  [7].

Faraday's law may be utilized to convert corrosion strength into a rate of penetration or weight loss on the premise that corrosion is uniform [8].

Figure 12 demonstrates how adding Schiff Base 2 to the corrosive solution delays the cathodic reaction and slows the anodic dissolving of steel. The inhibitory efficacy was raised as the corrosion rate decreased with increasing Schiff Base 2 concentration.

With the addition of the Schiff base, a decrease in anodic and cathodic current concentrations is seen. The decrease in cathodic current densities is, however, noticeably more pronounced than it is for anodic ones. As a result, it was hypothesised that the Schiff Base functions as a mixed-type inhibitor. In order to prevent the dissolution of Fe and the conversion of  $H^+$  ions to  $H_2$  gas, the

inhibitor molecules are adsorbed onto the surface of the mild steel sample.

## **5. Findings and Discussion**

Characterization of the Schiff base is confirmed by the performed tests, namely, NMR, FTIR, SEM and XRD, thereby proving the feasibility of the Schiff base synthesis scheme. The corrosion inhibition evaluation as done by using mass loss and potentiodynamic analysis confirms the inhibition efficacy of the prepared Schiff base as:

(a) The Schiff Base 2 inhibits mild steel corrosion in different concentrations of H<sub>2</sub>SO<sub>4</sub> solutions with inhibition efficiencies of 84.95% (0.5N H<sub>2</sub>SO<sub>4</sub>), 82.08% (1N H<sub>2</sub>SO<sub>4</sub>), and 79.22% (2N H<sub>2</sub>SO<sub>4</sub>) of 0.5% v/v of Schiff base concentration for 24-hour exposure time, which are efficient in reducing mild steel strip corrosion at temperature of 298±0.1K.

(b) Schiff Base 2 operates as mixed-type inhibitors, according to a potentiodynamic research. With an increase in concentration, it demonstrates Schiff base's ability to prevent corrosion.

## **6. Conclusion and Future Scope**

It is proven by the results of the experiment that the synthesised Schiff base formed from gallic acid hydrazide can function well as a mixed-type inhibitor. As seen, the addition of a suitable concentration decreased the acidic corrosion of mild steel. At increasing inhibitor concentration, the efficiency of inhibition increased. On a mild steel surface, the inhibitor effectively inhibits corrosion while adhering to the Langmuir adsorption isotherm. Other metal alloys' corrosion inhibition might be analysed as part of the experiment. Additionally, the technique can be applied to create Schiff bases using other powerful natural primary amines for comparative research, using the current experiment as a foundation for further analysis.

## **References**

1. Sliem, M. H., El Basiony, N. M., Zaki, E. G., Sharaf, M. A., & Abdullah, A. M. (2020). Corrosion inhibition of mild steel in sulfuric acid by a newly synthesized Schiff base: An electrochemical, DFT, and Monte Carlo Simulation Study. *Electroanalysis*, 32(12), 3145–3158. <https://doi.org/10.1002/elan.202060461>
2. El-Lateef, H. M., El-Dabea, T., Khalaf, M. M., & Abu-Dief, A. M. (2022). Innovation of imine metal chelates as corrosion inhibitors at different media: A collective study.

*International Journal of Molecular Sciences*, 23(16), 9360.  
<https://doi.org/10.3390/ijms23169360>

3. EL Basiony, N. M., Elgendy, A., Nady, H., Migahed, M. A., & Zaki, E. G. (2019). Adsorption characteristics and inhibition effect of two Schiff base compounds on corrosion of mild steel in 0.5 m hcl solution: Experimental, DFT studies, and Monte Carlo Simulation. *RSC Advances*, 9(19), 10473–10485. <https://doi.org/10.1039/c9ra00397e>
4. Ghazi, I., Zefzoufi, M., Siniti, M., Fdil, R., & Elattari, H. (2022). Corrosion inhibition of carob pod pulp (*Ceratonia siliqua* L.) on carbon steel surface C38 in hydrochloric acid. *Journal of Bio- and Tribo-Corrosion*, 8(1). <https://doi.org/10.1007/s40735-022-00630-y>
5. Kwolek, P., Dychtoń, K., Kościelniak, B., Obłój, A., Podborska, A., & Wojnicki, M. (2022). Gallic acid as a potential green corrosion inhibitor for aluminum in acidic solution. *Metals*, 12(2), 250. <https://doi.org/10.3390/met12020250>
6. MM, A. (2019). Green synthesis, spectral, thermal characterization and biological activity of Schiff base ligand derived from 3-amino-1,2,4-triazol and its metal complexes. *Organic & Medicinal Chemistry International Journal*, 8(03). <https://doi.org/10.19080/omcij.2019.08.555736>
7. Al-Amiery, A., Kadhum, A., Kadhum, A., Mohamad, A., How, C., & Junaedi, S. (2014). Inhibition of mild steel corrosion in sulfuric acid solution by New Schiff Base. *Materials*, 7(2), 787–804. <https://doi.org/10.3390/ma7020787>
8. Al-Amiery, A. A., Al-Azzawi, W. K., & Isahak, W. N. (2022). Isatin Schiff base is an effective corrosion inhibitor for mild steel in hydrochloric acid solution: Gravimetric, electrochemical, and computational investigation. *Scientific Reports*, 12(1). <https://doi.org/10.1038/s41598-022-22611-4>
9. Kaur, M., Kaur, K., & Kaur, H. (2021). Quest of schiff bases as corrosion inhibitors: A first principle approach. *Journal of Physical Organic Chemistry*, 34(11). <https://doi.org/10.1002/poc.4260>
10. Madkour, L. H., & SK, E. (2014). Correlation between corrosion inhibitive effect and quantum molecular structure of Schiff bases for iron in acidic and alkaline media. *Standard Scientific Research and Essays*, 2(13).
11. Njong, R. N., Ndosiri, B. N., Nfor, E. N., & Offiong, O. E. (2018). Corrosion inhibitory studies of novel Schiff bases derived from hydralazine hydrochloride on mild steel in acidic media. *Open Journal of Physical Chemistry*, 08(01), 15–32.  
2351

<https://doi.org/10.4236/ojpc.2018.81002>

12. Abdelsalam, M. M., Bedair, M. A., Hassan, A. M., Heakal, B. H., Younis, A., Elbially, Z. I., Badawy, M. A., Fawzy, H. E.-D., & Fareed, S. A. (2022). Green synthesis, electrochemical, and DFT studies on the corrosion inhibition of steel by some novel triazole Schiff base derivatives in hydrochloric acid solution. *Arabian Journal of Chemistry*, 15(1), 103491. <https://doi.org/10.1016/j.arabjc.2021.103491>
13. Veni, K., Karthik, A. D., Geetha, K., & Shakila, D. (2017). Green Synthesis, Characterisation, Corrosion Inhibition and Biological Applications of Schiff Base Transition Metal Complexes. *IOSR Journal Of Pharmacy* [www.iosrphr.org](http://www.iosrphr.org), 62–68.
14. Haque, J., Srivastava, V., Chauhan, D. S., Lgaz, H., & Quraishi, M. A. (2018). Microwave-induced synthesis of Chitosan Schiff bases and their application as novel and Green Corrosion Inhibitors: Experimental and Theoretical Approach. *ACS Omega*, 3(5), 5654–5668. <https://doi.org/10.1021/acsomega.8b00455>
15. Chugh, B., Singh, A. K., Thakur, S., Pani, B., Lgaz, H., Chung, I.-M., Jha, R., & Ebenso, E. E. (2020). Comparative investigation of corrosion-mitigating behavior of thiadiazole-derived bis-schiff bases for mild steel in acid medium: Experimental, theoretical, and Surface Study. *ACS Omega*, 5(23), 13503–13520. <https://doi.org/10.1021/acsomega.9b04274>
16. Hassan, A. M., Said, A. O., Heakal, B. H., Younis, A., Abdelmoaz, M. A., & Abdrabou, M. M. (2020). Conventional and Microwave-Assisted Synthesis, Antimicrobial and Antitumor Studies of Tridentate Schiff Base Derived from O-vanillin and Phenyl Urea and its Complexes. *Advanced Journal of Chemistry-Section*, 2645–2654. <https://doi.org/10.33945/SAMI/AJCA.2020.5.7>
17. Jafari, H., Ameri, E., Rezaeivala, M., & Vakili, M. H. (2022). Synthesized Schiff base acted as eco-friendly inhibitor for mild steel in 1N H<sub>2</sub>SO<sub>4</sub>. *Chemical Review and Letters*, 5, 119–126.
18. Afshari, F., Ghomi, E. R., Dinari, M., & Ramakrishna, S. (2023). Recent advances on the corrosion inhibition behavior of Schiff base compounds on mild steel in acidic media. *ChemistrySelect*, 8(9). <https://doi.org/10.1002/slct.202203231>
19. Shntaif AH, Rashid ZM. The Synthesis of Schiff bases under microwave Irradiation: Review. *J. Chem. Pharm. Sci.* 2016; 9(3):1066-1068.
20. Ay E. Synthesis and Characterization of Schiff Base 1-Amino-4-methylpiperazine  
2352

Derivatives.CBÜFenBil.Dergi.Cilt.2016;12(3):375–392

21. Sharma A., Arora, S. K., Batra, M. K., & Khandelwal, R. (2022). One-Pot, Eco Sustainable Synthesis, Spectral Studies and Corrosion Inhibition of Mild Steel in different concentrations of H<sub>2</sub>SO<sub>4</sub> solution by 3,4,5-trihydroxy-N-(4-hydroxy-3-methoxy benzylidene) benzo hydrazide Schiff Base. *Journal of Pharmaceutical Negative Results*, 13. <https://doi.org/10.47750/pnr.2022.13.S09.299>
22. Tang, L, Li, X, Li,L, Mu , G.Lu , G. Surf. Coat Technol. 2006; 201:384