



Investigating the Efficacy of Azadirachta Indica (Neem) Leaf on Mild Steel Corrosion in 1M Sulphuric Acid (H₂SO₄)

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Abstract: Numerous failures and losses in the manufacturing and chemical industries have been attributed to corrosion processes. Chemical inhibitors can be used to combat failures brought on by metals that can no longer support the designed load due to corrosion problems. Synthetic inhibitors work well, but they come with drawbacks, including toxicity, disposal issues, lawsuits, and exorbitant costs. To safeguard people, the environment, and money, green inhibitors have gained popularity as partial and full replacements for chemical inhibitors. However, more investigation into the metal-inhibitor-media combination that yields the best results is needed because inhibitors are environment-specific. There are many effects of corrosion, and they are frequently more severe than a mere loss of metal mass when it comes to the equipment's or a structure's ability to work safely, dependably, and efficiently. The purpose of this study is to evaluate the Neem leaf's anticorrosion capacity against mild steel corrosion. The experimental work was done using the weight loss method. According to the weight loss values obtained, the corrosion rates drastically increased for the controlled experiment (acidic media without leaf extract), but there was a corresponding drop in corrosion rates when different doses of the leaf extract were added to the acidic medium, indicating that the neem leaf extract was protecting the metal. Corrosion rates tend to decrease as inhibitor concentration rises, with a dose of 0.5g/L achieving the highest level of 86% inhibitory efficiency. The Azadirachta Indica Leaf Extract showed favorable inhibitory effects on mild steel, demonstrating that when used in the proper proportion, it will increase the service life of mild steel in sulphuric acid environments.

Keywords: Weight Loss, Green Inhibitor, Efficiency, Newbouldia Laevis Leaf, Azadirachta Indica Leaf, Corrosion Rate

1. Introduction

Metallic deterioration caused by a chemical attack or reaction of a metal with its surroundings is known as corrosion. It's a never-ending problem that's difficult to completely eradicate. Rather than total eradication, deterrence would be more practical and achievable. Following the disintegration or penetration of the passive barrier, a series of reactions occur that modify the components and behavior of both the superficial metal surface and the immediate surroundings, resulting in rapid metallic deterioration. This can be seen in the production of oxides, metal cation transport into the coating matrix, local pH changes, and electrochemical potential, among other things. The study of metallic corrosion is a topic that is both conceptually and practically important, and it has sparked a

lot of attention. Acid solutions are commonly used on metal substrates in industrial acid cleaning, pickling, descaling, and oil well acidizing operations to achieve the required goal [4]. However, in order to prevent acid damage to metallic components, these operations necessitate the application of corrosion inhibitors.

Metallic degradation is one of the key issues determining the dependability of systems in the chemical, manufacturing, oil, gas, vehicle, and transportation industries. However, because the vast majority of these systems and their components are comprised of carbon steel and aluminum alloys, they will certainly corrode or degrade. Most of the time, these damages result in product spillage, which is invariably harmful to society because it poses a safety risk, an environmental danger, and a significant loss of production time and money. It's also terrible because it could lead to issues like

compensation and litigation. As a result, the monitoring and inspection of these facilities receives a lot of attention. However, by adopting sound corrosion protection measures, the length or duration at which these components are inspected can be extended or eliminated. Furthermore, these procedures will reduce corrosion rates and, as a result, will extend inspection or monitoring times, lowering operational costs.

A Natural phenomenon in which metals and alloys react with their surroundings in order to recover to a stable state. It occurs in practically every environment and is exacerbated by water, oils, liquid chemicals, humidity, and pollution [47]. Organic and inorganic compounds that adsorb on metals and isolate them from their surrounding medium, reducing the oxidation-reduction process, can be used to prevent corrosion. Organic inhibitors reduce corrosion by producing a protective coating on metal surfaces, whereas inorganic inhibitors improve corrosion resistance by functioning as anodic inhibitors. The most sought-after and explored corrosion inhibitors have been reported to be hazardous, resulting in safety issues and environmental hazard, limiting their use due to environmental constraints. As a result, the hunt for environmentally friendly/green inhibitors with exceptional efficiency is an ongoing area of research that plays a key role in corrosion prevention.

Natural/green inhibitors have piqued the curiosity of researchers, who have studied and investigated them. According to studies, the aerial parts of plants, as well as other plant parts, can be employed as corrosion inhibitors. Leaves [2, 3, 9, 8, 12, 14, 27, 28, 31, 34, 40, 46, 48], seeds [2, 38, 39], the entire plant [8, 12, 16, 22, 30], seed husk [3, 5], grasses [11], oil from seed [21, 13], flowers [7, 15], grains [42], fruit peels [20], bark [25, 23, 45], along with the organic waste from agriculture [33], fruit and seed outer shell [19, 44], roots [36, 51].

Green inhibitors have a long shelf life, increase metal life, improve corrosion resistance by forming a protected blockade on the metal's surface, provide more excellent corrosion resistance due to their inherent photochemical properties, are cost effective, have a strong chemical bond with the metal, and do not harm the environment. In accordance with the foregoing rationale, the purpose of this study is to evaluate the efficiency of neem leaf extracts as green inhibitors in acidic medium.

1.1. Green Inhibitors

Corrosion is the gradual deterioration of metals and alloys caused by the action of air gases, moisture, and other chemicals. The pace at which a corrosion inhibitor spreads in a little volume of water extends the life of metallic and alloy materials, effectively increasing the life of the metal exposed to that water. Plant extracts, commonly referred to as green corrosion inhibitors, can be used as corrosion inhibitors to keep metal from corroding. Plants create compounds that are naturally produced.

Because they are environmentally acceptable, financially effective, and easily available, the bulk of naturally occurring compounds are used. Some have complex molecular structures in addition to chemical, biological, and physical

properties. Low-concentration inhibitors are added to corrosive media to delay the reaction between the metal and the corrosive components in the medium.

1.2. Inhibition Mechanism

Plant extracts are used as corrosion inhibitors because their inhibitory action is linked to inhibitor molecule adsorption on the metal surface. Physical, electrostatic, and chemisorption techniques are used to adsorb organic molecules [24]. Adsorption inhibitors function by lowering the geometric size of the reaction region on the metal surface. They can also limit corrosion through the electrocatalytic effect or the products of their reaction when the rate of activation energy barriers varies for anodic and cathodic reactions [1]. The occurrence of electrical attraction between inhibitor molecules containing electron donor atoms such as (O, N, S, P), heterocyclic rings, and metal atom orbitals, as well as an increase in temperature, causes the adsorption of inhibitor molecules to increase, is known as physical adsorption [18].

The inhibitory mechanism of metal surfaces is triggered by the adsorption of inhibitor molecules. The adsorption phenomena are influenced by the type of metal, its surface, the medium charge, and the chemical makeup of the inhibitor [49]. As a result, the adsorption of inhibitor compounds may be due to the formation of bonds between the orbitals of metal atoms and the π - electron pairs that exist on the nitrogen and oxygen atoms of heterocyclic rings. Electrostatic interactions between the positively charged nitrogen atom and the negatively charged metal surface, for example may promote inhibitor adsorption when water molecules are pushed off metal surfaces. The corrosion inhibitory qualities of some inhibitors may be due to ring stability via resonance or ring removal from specific sub-inhibitors (acidic or alkaline) resulting from materials' oxidation resistance [41]. It takes only a small amount of inhibitors to stop their adsorption at specified concentrations.

2. Review of Related Work

The studies listed below are connected to various plant extracts as corrosion inhibitors on steels and alloys, and they demonstrate the research efforts aimed at developing long-term green inhibitors.

The efficacy of an aqueous extract of Thyme leaves as a mild steel corrosion inhibitor in 2M HCl was evaluated utilizing weight loss measurements and several electrochemical techniques. The efficiency of corrosion inhibition improves with the content of Thyme leaves extract, according to the results of the experiments. In 2M HCl, 84 percent corrosion inhibition efficiency was attained. Thyme leaves extract serves as a mixed inhibitor, according to polarization experiments, the adsorption of Thyme leaves extract on the steel surface follows the Langmuir adsorption isotherm, according to the results [26].

The effect of Black tea extract (BTE) as a green inhibitor on the corrosion behavior of mild steel in 1.0M HCl, 1.0M H_2SO_4 and 35g/l NaCl was investigated using potentiodynamic

polarization techniques such as open-circuit potential, linear polarization resistance, and Tafel plots polarization. It was discovered that BTE inhibits both anodic and cathodic slopes in Tafel polarization, indicating that the inhibitor used is a mixed type inhibitor. Scanning electron microscopy was also used to investigate the surface morphology of MS samples without and with the inhibitor [32].

Potentiodynamic polarization was used to study the corrosion inhibition effectiveness of tobacco root extract (TRE) for Q235 steel corrosion in artificial saltwater. The experimental results show that TRE has good corrosion inhibition properties, and that the inhibition efficiency rose when the TRE concentration was increased. The corrosion inhibition is attributed to the creation of a chemisorbed coating on the steel, according to scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). Static scale tests were used to investigate the anti-scale property of TRE in artificial seawater, and the scale deposits were investigated using X-ray diffraction (XRD) and scanning electron microscopy (SEM), respectively. The surface morphology and size of scale deposits were altered in the presence of TRE, according to the findings. The corrosion and scale inhibition results suggested that TRE might be used in artificial seawater as an effective corrosion and scale inhibitor [50].

The weight loss method, electrochemical measurements, and scanning electron microscopy were used to evaluate the inhibitory performance and mechanism of loquat leaf extract (LLE) for mild steel corrosion in 0.5 M H_2SO_4 (SEM). The results demonstrated that LLE operated as a mild cathodic inhibitor, with an inhibitory efficiency that rose with LLE concentration and peaked at 96 percent, but dropped with increasing temperature. Furthermore, it was discovered that LLE adsorption on steel surfaces followed the Langmuir adsorption isotherm, and the thermodynamic and kinetic parameters were calculated appropriately. Furthermore, the synergistic inhibition between the isolates was studied after LLE was preliminarily isolated by pH-gradient sedimentation [52].

In the presence and absence of *Xanthium Strumarium* leaves (XSL) extracts as a friendly corrosion inhibitor, corrosion inhibition of low carbon steel in 1M HCl was examined. Weight loss was used to investigate the effects of temperature and inhibitor concentration. The findings revealed that *Xanthium Strumarium* leaf extracts function as a corrosion inhibitor for low carbon steel in HCl and minimize the rate of corrosion. The efficiency of inhibition was observed to rise as the inhibitor concentration and temperature were increased. At higher levels of inhibitor concentration and temperature, the inhibition efficiency was 94.82 percent. The Langmuir adsorption isotherm model was discovered to govern the adsorption of *Xanthium Strumarium* leaf extracts. Adsorption free energy values were greater than -20 kJ/mol, indicating a mixed mechanism of physical and chemical adsorption [29].

The purpose of this research is to see if *Glycyrrhiza glabra* extract, also known as licorice, may suppress mild steel corrosion in a 1 M HCl solution. In a 1 M HCl solution, a

Glycyrrhiza glabra extract was employed to inhibit mild steel. The corrosion inhibition performance was assessed using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS), while the surface properties were assessed using atomic force microscopy (AFM) and contact angle testing. The *Glycyrrhiza glabra* leaves extract performed as a mixed type inhibitor, slowing both anodic and cathodic reactions rates, according to the results of the polarization test. The corrosion current density of mild steel fell dramatically when *Glycyrrhiza glabra* leaves extract was added, from 260 A/cm² for the sample without inhibitor to 40.2 A/cm² for the sample with 800 ppm inhibitor.

Furthermore, it was discovered that while the hydrogen evolution mechanism did not change in the presence of *Glycyrrhiza glabra* leaves extract, the anodic dissolution mechanism of iron was modified in the presence of inhibitors. The Electrochemical Impedance Spectroscopy (EIS) findings revealed that increasing the content of *Glycyrrhiza glabra* leaves extract and immersion time increased corrosion inhibition efficiency. After 24 hours of immersion in the presence of 800 ppm *Glycyrrhiza glabra* leaves extract, the maximum corrosion inhibition efficiency (about 88%) and surface coverage (around 72%) were attained. The mild steel surface deterioration was reduced in the HCl solution with 800 ppm *Glycyrrhiza glabra* leaves extract, according to atomic force microscopy data. The adsorption of organic molecules of inhibitors such as Glycyrrhizin (GL), 18-Glycyrrhetic acid (GA), Liquiritigenin (LTG), Licochalcone A (LCA), Licochalcone E (LCE), and Glabridin (GLD) on the active sites of mild steel was also confirmed by the decrease in surface hydrophilicity in the presence of *Glycyrrhiza glabra* leaves. Furthermore, modeling investigations using conventional molecular dynamics (MD), Monte Carlo (MC), and quantum mechanics (QM) methodologies demonstrated that all corrosion inhibitory elements present in *Glycyrrhiza glabra* adsorbed to steel surfaces, forming a corrosion-protective coating [6].

Using electrochemical techniques such as potentiodynamic polarization and electrochemical impedance spectroscopy, the inhibitive behavior of olive (*Olea europaea* L.) leaf extracts against mild steel corrosion in 1M H_2SO_4 media was investigated (EIS). The influence of temperature on mild steel corrosion behavior was also explored. Using the collected results, the adsorption properties of olive leaf extracts were determined. Scanning electron microscopy was used to analyze the surface morphology of mild steel after it was exposed to 1M H_2SO_4 free and containing 50 g L⁻¹ OLE solutions (SEM Surface characterization was also performed using Fourier transform infrared spectroscopy on mild steel subjected to 1 M H_2SO_4 solution with 50 g L⁻¹ OLE (FT-IR). OLE was found to be an effective inhibitor based on the results of different measurement techniques [17].

Gravimetric, depth of attack, and surface analysis techniques were used to examine the corrosion inhibition of *Luffa cylindrica* Leaf Extract (LCLE). On the Inhibition Efficiency (IE) of the extract on Mild Steel (MS) immersed in a 0.5 M HCl solution, the effect of inhibitor

concentrations (0.50–1.00 g/l), temperatures (30–60°C), and immersion time (4–12 h) was investigated. A GC-MS was used to identify the ingredients of the putative inhibitor. FTIR Spectrophotometer was used to characterize the media solutions and adsorbed film on MS. Surface morphology and depth of attack profile were studied using a SEM microgram and a surface tester. The ideal IE was found to be 87.89 percent. The Langmuir isotherm and pseudo-second-order adsorption kinetics of LCLE on MS were followed. Exothermic process and physical adsorption mechanism are shown by activation energy (28.71 kJ/mol), entropy (-0.15 kJ/mol. K), average enthalpy (-28.00 kJ/mol), and Gibbs free energy (-11.43 kJ/mol) found at optimum conditions. The results of this investigation were comparable to numerous previously reported green inhibitors for mild steel corrosion [37].

The investigation of the use of local wastes which are organic in nature for the production of green corrosion inhibitor is no doubt the trend of the day, the evaluation of corrosion inhibitor properties from *Musa Sapientum* peels extract with a view of determining the effectiveness of the corrosion inhibitor? *Musa Sapientum* peels extract produced was used as a corrosion inhibitor on mild steel in concentrated tetraoxosulphate (VI) acid using weight loss method. The results of the study showed that as the concentration of the produced inhibitor increases, the rate of corrosion decreases. It also showed that as the concentration of the inhibitor increases, the inhibitor efficiency also increases up to an optimum of approximately 71% for 0.8 g/l extract in 1.0M H_2SO_4 which is encouraging [43].

3. Materials and Method

3.1. *Azadirachta Indica* Leaf Preparations

In October 2021, *Azadirachta indica* leaves were collected in Aba, Abia State, in eastern Nigeria. The leaves were air-dried for 30 days at room temperature in the laboratory before being used to make the extract. The extraction was performed using the reflux technique for 3 hours at continuous heat (70°C) with ethanol as the extraction solvent. According to previous research, the extract is then diluted into a range of concentrations: 0.1, 0.2, 0.3, 0.4, and 0.5 g/L using 1M H_2SO_4 solution as the corrosive media [35].

3.2. Metal Preparations

A mild steel (MS) sample of grade (C-1026) was employed in the experiment, and its chemical make-up was as follows: C = 0.26 percent, Mn = 0.71 percent, Cr = 0.21 percent, Ti = 0.15 percent, Co = 0.55 percent, and Fe = 98.39 percent. The metal sheets were cut into 20 x 20 x 4mm coupons, abraded with 120, 600, and 1200 grit emery paper, cleaned with soap and ethanol to remove any grease, and allowed to dry on the air before being weighed.

3.3. Weight Loss Method

The pre-weighed coupons were treated with various test solutions. The experiment used various inhibitor concentrations of *Azadirachta Indica* leaf extracts (0.1g/L to 0.5g/L) and was conducted at room temperature. After being exposed for 4 to 20 hours, the coupons were removed at intervals of 4 hours, and the corrosion reaction was stopped by dipping the test piece in nitric acid, washing it off with water, removing the water with ethanol, and then quickly drying it with acetone so that corrosion wouldn't start before it could be reweighed. The weight loss was decided. The technique was repeated, and an average result was calculated.

4. Results and Discussion

The pre-weighed coupons were treated with various test solutions. The experiment used various inhibitor concentrations of *Azadirachta Indica* leaf extracts (0.1g/L to 0.5g/L) and was conducted at room temperature. After being exposed for 4 to 20 hours, the coupons were removed at intervals of 4 hours, and the corrosion reaction was stopped by dipping the test piece in nitric acid, washing it off with water, removing the water with ethanol, and then quickly drying it with acetone so that corrosion wouldn't start before it could be reweighed. The weight loss was decided. The technique was repeated, and an average result was calculated. This study led to the development of corrosion inhibitor formulations for use in sulphuric acid solutions to lessen corrosion of mild steel. These formulations were derived from *Azadirachta Indica* plant leaf extracts.

Below are the results of the weight loss experiment.

Table 1. Weight loss measurements for mild steel in 1 M sulphuric acid in the absence and presence of *Azadirachta Indica* leaves extract.

S/N	Exposure Time (Hrs)	Weight loss at Different Concentration for Mild Steel					
		Control (0.0g/L)	0.1g/L	0.2g/L	0.3g/L	0.4g/L	0.5g/L
1	4	0.0388	0.0255	0.0232	0.0213	0.0116	0.021
2	8	0.0864	0.0348	0.0311	0.0268	0.0207	0.0199
3	12	0.1227	0.0533	0.0412	0.0331	0.0258	0.0221
4	16	0.1825	0.0728	0.0565	0.0438	0.042	0.0274
5	20	0.2130	0.0755	0.0628	0.049	0.0362	0.0298

Table 1 shows the weight loss measurements for mild steel as it corrodes in the presence of an inhibitor and as it degrades in 1M sulphuric acid in the absence of an inhibitor

(*Azadirachta Indica* leaves extracts). Figure 1 displays the weight loss vs exposure time for mild steel corrosion in 1.0M H_2SO_4 in the presence and absence of varying concentrations

of AZI leaf extract.

In Figure 1, the weight loss for MS corrosion in 1.0M H₂SO₄ with various doses of AZI leaf extract is shown against exposure time in both the absence and presence of the compound. The rate of weight loss was monitored for 20 hours at 4-hour intervals in the controlled environment (1.0M H₂SO₄), as shown in the graphs. However, different leaf

extract doses considerably reduced weight loss in accordance with the inhibitor concentrations, indicating that AZI leaf extract might be a good inhibitor. The weight loss was slowed down in the presence of the inhibitor due to the components in the extract adhering to the surface of the test piece made of mild steel. For information on weight loss and exposure time, see table 1.

Table 2. Corrosion rate values for mild steel in 1 M sulphuric acid in the absence and presence of Azadirachta Indica leaves extract.

Time (t) of exposure (Hrs)	Corrosion rates (mm/yr.) for control experiment and different concentration of Azadirachta Indica leaf extraction in corrosive media.					
	Control (0.0g/L)	0.1g/L	0.2g/L	0.3g/L	0.4g/L	0.5g/L
4	0.3085	0.3420	0.3112	0.2857	0.1556	0.2817
8	0.4292	0.2334	0.2086	0.1797	0.1388	0.1335
12	0.4203	0.2383	0.1842	0.1480	0.1153	0.0988
16	0.4024	0.2441	0.1895	0.1469	0.1408	0.0919
20	0.4319	0.2025	0.1685	0.1314	0.0971	0.0799

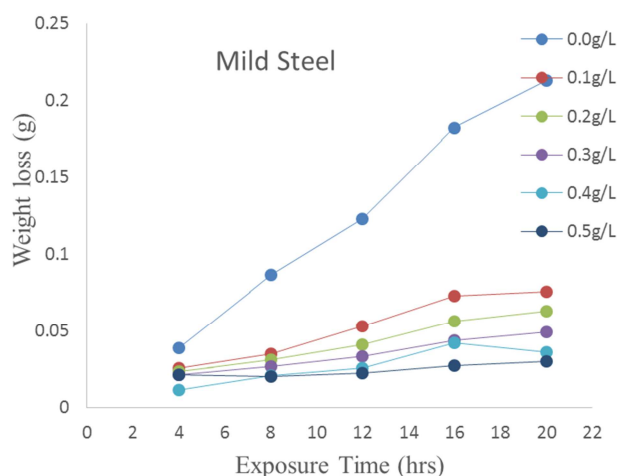


Figure 1. Plot of Weight Loss (g) versus Exposure Time (t).

When there was no inhibitor present, Table 2 shows that the corrosion rate values increased as the exposure duration increased; however, when leaf extract was added, the corrosion rate significantly decreased. The weight loss, corrosion rate, was calculated by Equations below

$$\Delta W = W_1 - W_2 \quad (1)$$

Where W_1 and W_2 are samples weight before and after immersion in the electrolyte solution for time (t), respectively [10]. ΔW is represented in grams.

Based on obtained results, the corrosion rate will be estimated in Equation (2).

$$CR = \frac{K\Delta W}{At\rho} \quad (2)$$

where K is a constant (8.76×10^4) which allows representing CR in mm/year;

A is the surface of the metal sample (cm²);

t is the immersion time (hours);

ρ is the density of the metal (g/cm³) (ASTM International, 2004).

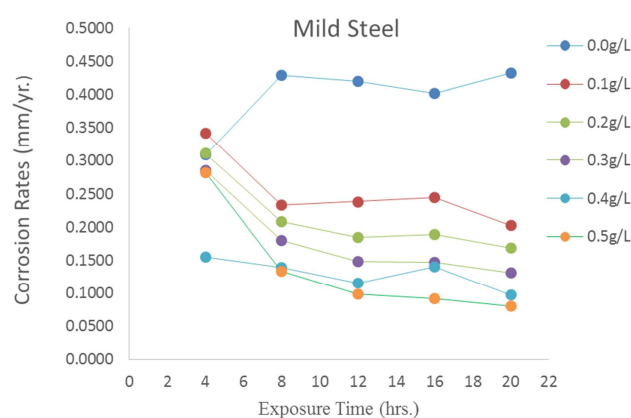


Figure 2. Plot of Corrosion Rate (mm/yr.) (for control + various concentrations) versus Exposure Time (t).

Figure 2 illustrates the behavior of mild steel corrosion rate over time in the absence of AZI leaf extract (control experiment). The control curve shows that passivation took place within the first four hours of metal exposure, followed by metal resistance to passivation. Corrosion resistance was observed between hours 8 and 16 as a result of the development of coatings on the test piece's surface; this does not imply that corrosion has stopped, merely that it has been postponed. After 16 hours, the films succumbed to further erosion due to the environment's extreme corrosiveness. Although there is no visible pattern in the corrosion rate figures from the control experiment, it decreases consistently over time in samples that have been blocked. According to the study, mild steel deteriorates gradually over time. See table 2 above for values of corrosion rates (for control + various concentrations) vs. exposure time.

It's also important to note that the corrosion rate decreased from 0 to 8 hours at a concentration of 0.1 g/L, increased slightly between 8 and 16 hours, and then decreased once more. This indicates that the leaf has formed a protective layer on the test piece's surface, preventing mass charge transfer in the corrosive environment. The best corrosion rate value was obtained at 20 hours with a leaf extract

concentration of 0.1g/L. The corrosion rate decreased between 16 and 20 hours from 0.2441 to 0.2025 mm/year, showing that the leaf extract concentration of 0.1g/L was still active and further shielding the test item. Similar patterns were observed for leaf extract concentrations of 0.2 to 0.3g/L, and 0.4g/L demonstrated a downward trend from 4 to 12 hours, followed by a sharp increase from 12 to 16 hours, possibly due to localized corrosion. From 16 to 20 hours later, the corrosion rate continued to decline, demonstrating the leaf extract's continued activity.

The corrosion rate decreased as the extract concentration increased, as shown by the continuous downward sliding at a concentration of 0.5 g/L. The graph demonstrates the significant influence of AZI leaf extract on acidic MS corrosion, with the MS exhibiting the highest inhibitory efficacy at dosages of 0.4 to 0.5g/L extract.

Table 3. Efficiencies (%) at concentrations (g/L) for Gravimetric Method.

Efficiencies (%) at concentrations (g/L) for Gravimetric Method.					
Exposure Time (hr.)	Efficiencies at various concentrations (g/L)				
	0.1	0.2	0.3	0.4	0.5
4	34%	40%	45%	70%	46%
8	60%	64%	69%	76%	77%
12	57%	66%	73%	79%	82%
16	60%	69%	76%	77%	85%
20	65%	71%	77%	83%	86%

Table 3 Elucidates how efficiency increased with an increase in concentrations of inhibitor. The efficiencies was calculated using the formula.

The inhibition efficiency for the gravimetric method will be calculated using Equation.

$$\eta_{\text{gravimetric}} = \left(1 - \frac{w_i}{w_o}\right) \times 100\%, \quad (3)$$

where w_i is the weight loss when inhibited and w_o is weight loss without being inhibited

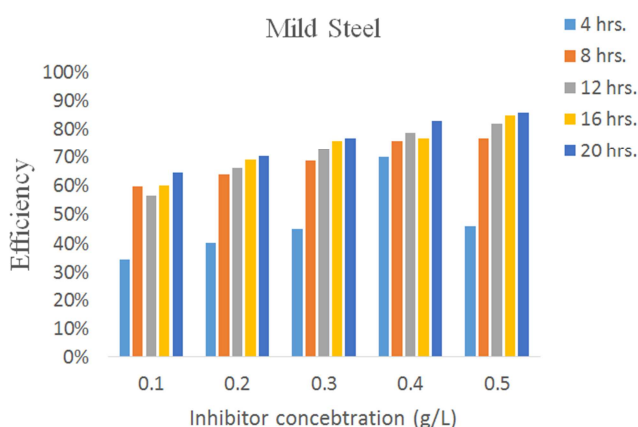


Figure 3. Efficiency (%) versus Concentration of inhibitor (g/L).

The effectiveness of the inhibitor's inhibition is displayed versus the concentration of the plant extract in Figure 3. It is clear that Azadirachta Indica leaf extract prevents mild steel from corroding when exposed to sulphuric acid. As the concentration of the inhibitor rose, the effectiveness of the

inhibition rose as well. Table 3 further shows that as the content of the plant extract increased, the rate of corrosion decreased.

5. Conclusion and Recommendations

5.1. Conclusion

The following conclusion can be made in light of the data amassed while researching the inhibitive activities of Azadirachta Indica Leaf extract on the Corrosion of Mild Steel in Sulphuric Acid:

- Azadirachta indica leaf ethanolic extract is a suitable environmentally benign green inhibitor for mild steel and can be used in place of dangerous chemicals.
- The gravimetric approach demonstrates aggressive degradation of the mild steel coupon immersed in the corrosive environment in the absence of Azadirachta Indica leaves extract in 1M of H₂SO₄ solution, the corrosion rate and weight loss rise dramatically, demonstrating that the test piece's active site was vulnerable to acid assault.
- The weight loss measurement demonstrates that adding Azadirachta Indica leaf extract to a 1M H₂SO₄ solution lowers the rate at which mild steel corrodes in the acid. The maximal inhibitory efficacy was 86%, and it will continue to improve as plant extract concentrations are increased.
- When the plant extract was added, mild steel was protected from corrosion by the compound of the extracts adhering to the metal surface, providing a barrier for charge and mass transfer and making the metal less sensitive to corrosion reaction.
- The results demonstrate that Azadirachta Indica leaf extract is an excellent mild steel corrosion inhibitor in sulphuric acid (H₂SO₄).

5.2. Recommendations

In view of the experienced gained on this research, the following are recommended for further research.

- To determine the active species in the adsorption layer, more research is needed to access the corrosion morphology.
- Since Azadirachta Indica trees are extremely effective inhibitors, the researcher advises encouraging their commercial growth. They can slow down corrosion since they are effective inhibitors. Additionally, they are both environmentally responsible and humane.
- To Investigate the inhibitive properties of Azadirachta Indica leaf extracts on mild steel in saline environment.
- Finding the ideal conditions for the plant extract preparation processes especially the drying and dehydration steps, which take the longest period requires a thorough examination. In addition, various solvent types are used in the solvent extraction process. Powerful acidic or alkaline solvents, which are categorized as being dangerous to human health and to increase the formation of hazardous waste, are occasionally utilized.

This demonstrates how crucial it is to adhere to industry standards while creating Green Corrosion Inhibitors in order to prevent the discharge of potentially hazardous substances into the environment. It is important to note that the bulk of studies do not take into account looking into Green Corrosion Inhibitors' toxicity.

- e) The findings of Green Corrosion Inhibitors' performance evaluation might be done better. For example, standard deviation calculation, which calls for repeatability testing, can be highly useful in identifying flaws and inaccuracies in the research. Additionally, comparing various outcomes that have been published in the literature using statistical analysis yields useful information.

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