

Comparative Investigation of Inhibitive Properties of *Newbouldia Laevis* (NL) and *Azadirachta Indica* (AZI) Leaf Extracts on Corrosion of High Carbon Steel in Sulphuric Acid.

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ABSTRACT

In this study, the effectiveness of the two extracts in preventing corrosion on high carbon steel using *Newbouldia Laevis* and *Azadirachta Indica* leaf extracts in sulphuric acid medium was evaluated. In order to calculate the weight loss of the high carbon steel while submerged in the corroding solution with and without the leaf extracts, respectively, the corrosion of high carbon steel was studied using the gravimetric method. Due to the relationship between weight loss and corrosion rate, the test piece weight loss serves as a gauge for the severity of corrosion. In general, the weight loss decreased when the extracts were present, proving that they were good corrosion inhibitors. In contrast, when the extracts were absent, there was a rapid weight loss that led to a high rate of high-carbon steel degradation in the acidic medium. Comparatively, the effectiveness of *Newbouldia Laevis* Leaf Extract as a corrosion inhibitor for high carbon steel in sulphuric acid peaked at an average efficiency of 88% at a concentration of 0.5g/L while *Azadirachta Indica* for the same conditions achieved an efficiency of 71%. This showed that *Newbouldia Laevis* Leaf Extract is a better corrosion inhibitor than *Azadirachta Indica* Leaf Extract.

Keywords: Corrosion, High Carbon Steel, Sulphuric Acid, Gravimetric, Inhibition.

1 INTRODUCTION

According to the American Society of Testing and Materials (ASTM) International, corrosion is the result of a chemical or electrochemical reaction between a substance, typically a metal, and its surroundings that accelerates the loss of the substance's qualities (Brycki et al., 2018). The International Organization for Standardization (ISO) also describes it as the physiochemical interaction between a metal and its surroundings that alters the metal's characteristics and may seriously affect the metal, the environment, or the technical system's ability to function (ISO 8044, 2015). Metal atoms are found in chemical compounds in nature, and variations in the electrolyte can cause corrosion. The oxygen, concentrations, moisture content, and different ionic concentrations are examples of such discrepancies (Papavinasam, 2011).

Metal corrosion control has been crucial, especially in the production industry (Rani and Basu, 2012). Corrosion inhibitors have historically been regarded as the first line of defense against internal corrosion in the oil and gas production and processing industries. Corrosion can cause structural and equipment failures in plants, which are often expensive to fix, expensive in terms of lost or polluted output, expensive in terms of environmental damage, and possibly expensive in terms of human safety. A precise evaluation of the factors influencing a structure's corrosion and rate of degradation is necessary before making decisions about the future integrity of the structure or its parts. With this knowledge, a wise choice can be made regarding the nature, expense, and urgency of potential corrective actions (Roberge, 2008).

Total corrosion costs include design, manufacture, maintenance, repair, and rehabilitation costs as well as depreciation or replacement costs for structures that have lost their usefulness due to corrosion (Koch, 2017). The main causes of corrosion are chemical and electrochemical reactions. Chemical corrosion occurs in non-conductive liquids and dry gases without current or electron flow. An oxide layer that develops as a result of oxidation in the air is the primary result of chemical corrosion. According to McCafferty (2010), redox reactions and the differing potentials on the surface of the corroded metal cause electrochemical corrosion to occur in solution between metallic materials and electrolytes. A portion of the metal is used as an anode, where it oxidizes and transforms into an ion. The cathode is another component, where depolarization, primarily the reduction of oxygen and hydrogen cation, takes place (Hou et al., 2017; Stewart et al., 2012).

Corrosive assault on mild steel will start at imperfections in the oxide film if it is exposed to a corrosive environment, such as sulfuric acid. These flaws could be caused by natural film discontinuities, such as inclusions, grain boundaries, or dislocation networks at the steel's surface, or they could be the result of mechanical dents like scratches.

1.1 Material and energy

The impact of corrosion on the equipment and its surroundings deserves careful attention when a sector of the economy is being developed. Corrosion is one of the hardest challenges to overcome for the majority of wealthy countries. A nation may experience major material and monetary losses as a result of corrosion of tanks, pipes, metal components of machinery, bridges, ships, etc. In addition, failure brought on by corrosion may jeopardize the security of operational equipment like boilers, pressure vessels, steel storage containers for hazardous chemicals, bridges, turbine blades and rotors, vehicle steering systems, and aircraft components. Additionally, water, electricity, and the production of metal frames are all susceptible to corrosion's harmful impacts (Li, and Trost, 2008). The energy needed to make one ton of steel is about similar to the energy used by a typical household over the period of three months, despite the fact that one ton of steel is believed to rust every 90 seconds. Nearly half of every ton of steel produced worldwide is used to replace corroded steel (Höfer and Bigorra, 2008).

1.2 Corrosion Implication on Human life and safety

Corrosion can have an inconceivable influence on human life and safety. As a result of liability concerns or simply because the evidence disappeared during the catastrophic event, this destructive phenomena has gone unrecognized as the main cause of many fatal occurrences. The Silver Bridge collapse is among the riskiest and most well-known corrosion accidents (Fiori-Bimbi et al., 2015). One of West Virginia's darkest days in history was December 15, 1967. It was sadly just the first of many terrible days that West Virginians would endure. In 1928, the Silver Bridge, which connected Point Pleasant with Gallipolis, Ohio, was made public. It was the first bridge in the country to use a cutting-edge eyebar-link suspension technology rather than a conventional wire-cable suspension. However, one of those eyebars had a minute, undetectable flaw. Out of sight from the general public or bridge inspectors, the defective eyebar ultimately broke and started to rust.

The bridge collapsed on December 15 about 5 p.m. after a string of failures that started with the eyebar. The bridge was crowded with vehicles because it was rush hour. Thirty-one trucks slid into the Ohio River's frigid waters. Although 21 people did not perish, 46 people did. National reforms in bridge inspection procedures were brought about after the Silver Bridge catastrophe. Another 40-year-old bridge of the same kind that was located at St. Marys, almost 100 miles upstream from Point Pleasant, was promptly closed and ultimately destroyed (Public broadcasting in West Virginia. Encyclopedia of West Virginia. published at 7:51 AM EST on December 15, 2020).

One of the deadliest industrial mishaps in terms of the number of persons killed and injured occurred the night of December 2-3, 1984, in Bhopal, India. At Union Carbide India Limited, an unfortunate seepage of water (500 liters) brought on by corrosion of pipelines, valves, and other safety systems led to the release of methylisocyanate (MIC) and other dangerous reaction products into the surrounding environs, there were 3000 fatalities and an estimated 500,000 injuries as a result of this tragedy (Aljourani et al., 2010). The Swimming Pool Roof Collapse in Uster, Switzerland in 1985 is another notable corrosion disaster, when the stainless steel rods supporting this swimming pool's ceiling snapped from stress crack corrosion, twelve people were killed (Jingrong and Yongming, 2012).

2 Review of Related Work

According to some research teams, the use of naturally occurring compounds to stop metal corrosion in both acidic and alkaline conditions is on the rise. Using the weight loss method, the effect of extract from breadfruit peel on the ability of aluminum metal to resist corrosion in 0.5M H₂SO₄ solution was studied. It has been discovered that the extract effectively inhibits the corrosion of aluminum when used as a corroder in sulphuric acid. The creation of an adsorbed inhibition film that shields the metal surface from corrosion is thought to be the cause of the inhibition process. With an increase in inhibitor concentration, but a decrease in surface coverage (θ), extract from breadfruit peel showed improved inhibitory efficacy. It was discovered that the adsorption of breadfruit peel extract on aluminum metal surface complied with Langmuir's adsorption isotherm. The extract from breadfruit peel may be a good corrosion inhibitor because of the negative free energy value ($-\Delta G_{ads}$), which shows that the inhibitor molecule was physically adsorbed and that the reaction was spontaneous. (Orie and

Mathew, 2015). Okra mucilage, a naturally occurring polysaccharide, is used as a cathodic type corrosion inhibitor for mild steel in 0.5 M H₂SO₄ (Amar et al., 2017).

A *Schinopsis lorentzii* extract's cathodic inhibition effectiveness was reported by Gerengi et al. (2012) to be "marginally" effective. Nevertheless, an inhibitor may be anodic, cathodic, or mixed. Depending on the environment, a guanidine derivative behaves differently, behaving cathodically in 1 M HCl and mixed-type in 0.5 M H₂SO₄, according to a report (Khaled, 2008).

As safe corrosion inhibitors for iron in aerated stagnant 1.0 M HCl solutions, Amin et al. (2010) evaluated the effectiveness of three chosen amino acids, namely alanine, cysteine, and S-methyl cysteine. The three amino acids were adsorbed to the electrode surface by various methods, including physical, chemical, and H-bonding adsorption. The study employed computational analyses to evaluate the HOMO (Highest Occupied Molecular Orbital)-LUMO (Lowest Unoccupied Molecular Orbital) orbitals.

Other papers were able to speculatively describe the adsorption mechanism and, by extension, the inhibitory mechanism, but they lacked more thorough arguments backed by theoretical and/or experimental evidence. The investigation of the Henna extract's ability to prevent corrosion produced a plausible explanation for the observed inhibition activity that did not include any solid data support and offered a theory on the development of complexes rather than an adsorption process (Chaudhari and Vashi, 2016).

Ostovari et al. (2009) highlighted the importance of examining the mechanism beyond the corrosion inhibition effect in another study on henna extract. To support the theory that insoluble complex compounds were formed when metal cations and adsorbed Lawsone molecules were mixed, conductimetric titration was utilized as a reliable approach.

They also determined the individual inhibitory potencies of the extract's components and the extract itself. Among the other henna components, including gallic acid, glucose, and tannic acid, lawsone demonstrated the highest inhibition efficiency. It also had a higher inhibition efficiency than the henna extract itself. Streptomycin was used as an inhibitor as well, and the authors of the study claimed to have obtained an inhibition effect that happens during the drug's adsorption on a metal surface without changing the way corrosion works. However, even in this instance, the process was not examined; instead, only a few ideas were provided (Shukla et al., 2009).

NL has been studied for its ability to prevent metal corrosion. According to Nnanna et al. (2011), both the content of the plant extract and the length of time the aluminum samples were exposed to the extract-containing H₂SO₄ solutions affected the effectiveness of the inhibition. The effect of hydrochloric acid corrosion on mild steel was revealed by Nwosu et al. (2018). The weight loss was substantially slower and the rate of chemical attack on the aluminum alloy was also slowed down by the presence of the *Newbouldia leavis* leaf extract. The effectiveness of the inhibitor's inhibition increases with concentration while decreasing with temperature. The addition of leaf extract modifies the metal's electrochemical behavior in an acidic environment.

Utilizing a gravimetric approach, the inhibitory effectiveness of an extract of NL leaves for the corrosion of mild steel was studied. The leaves were gathered, dried, and powdered to a micron size for gravimetric analysis. Using the ethanol reflux method, the leaf extract was obtained, and the weight of the extracted leaves was calculated. The quantities for various extract concentrations were likewise calculated, put to the acidic medium, and the mild steel coupons submerged throughout the course of four hours. The inhibitory efficiency was estimated after obtaining the weight loss values for each metal coupon.

Results for weight loss and corrosion rate showed that the plant extract from NL leaves functioned as an effective inhibitor, with weight loss reducing with increase in concentration (from 0.0g/L to 0.5g/L) and corrosion rate dropping (from 43mm/yr to 4.2mm/yr). With an increasing inhibition efficiency from 72% to 90% as inhibitor concentration increases, from the gravimetric approach employed to test the extract from *Newbouldia leavis* leaves, the inhibitor was found to be an effective mild steel corrosion inhibitor. Plant extracts are an excellent alternative to corrosion inhibitors due to their availability, biodegradability, low cost, and reduced risk to humans and the environment. This study has demonstrated that NL leaf extracts, when used in the proper concentration, can increase the service life of mild steel. (Yusuf et al., 2020).

The molecular and biological characteristics of AZI are noteworthy. It is one among the most effective producers of secondary metabolites in nature. To date, more than 300 natural products have been extracted from diverse tree parts, and the number

of substances added to the list each year is growing. The current work attempts to increase the usability of plant extracts for metallic corrosion inhibition as a contribution to the current interest in green corrosion inhibitors by specifically examining the inhibitory capacities of AZI for mild steel, aluminum, and tin. The current paper discusses the potential of AZI extract as a corrosion inhibitor on metal surfaces, in particular those formed of carbon steel and its alloys, aluminum, and tin. There has been extensive research on the chemical composition of AZI, the effect of temperature on inhibitory effectiveness, and the computational studies related to AZI adsorption on metals. This effort would enhance our comprehension of the adsorption process and the subsequent inhibitory effect of plant extract on metal corrosion (Sanjay et al., 2015).

The gravimetric method was used to assess the effectiveness of AZI gum as a mild steel corrosion inhibitor in 1.0M nitric acid (HNO_3), sulphuric acid (H_2SO_4), and hydrochloric acid (HCl) solutions at 298K and 313K. Weight loss was observed at various inhibitor doses (0.50, 1.00, 1.50, 2.00, and 2.50% w/v). The weight measurements were used to determine the extent of surface coverage and the efficiency of the inhibitor. The Gibbs free energy and heat of adsorption were calculated along with the activation energy using the Arrhenius equation in order to examine the spontaneity and enthalpy of the corrosion process. Langmuir, Temkin, and Freundlich adsorption isotherms were employed to shed light on a probable adsorption mechanism (Abdulmudallib et al., 2018).

This study investigated the ability of two biological elements, AZI and an enzyme, to inhibit mild steel corrosion. Using the weight loss analysis method, the corrosion rates, inhibitors' effectiveness, and surface coverage of mild steel exposed to saline solutions with or without inhibitors for a period of 576 days were assessed. The results showed that the rate of mild steel corrosion generally did not vary significantly after 400 days of continuous exposure to the same solution. The rate of mild steel corrosion was significantly reduced when enzyme was added to low and high saline solutions as opposed to when saline solutions were used alone. It was found that the enzyme's effective concentration was 2 wt.% in both low and high saline solutions, and application of the enzyme produced high corrosion inhibition efficacy. The corrosion inhibition of AZI, however, was shown to be more effective in low saline solutions, and in this environment, an optimum concentration of 2 wt.% was effective. However, a greater concentration of 10% is needed in high saline solution for efficient corrosion inhibition (Udoh et al., 2022).

For a very long time, there have been significant losses at high costs due to the corrosion and damage it creates in most industrial operations, particularly in the oil and gas industries. Erosion calls for long-term solutions due to the disastrous impact it has on the ecosystem and the serious threat it poses to both people and animals. As a result, the subject of corrosion is covered in a ton of literature. Thus, there is a need for organic corrosion inhibitors, whether they be natural or manufactured. These inhibitors are frequently accessible and secure because they decompose, as shown by previous studies. By using organic molecules with several heterogeneous atoms and double and triple bonds in their molecular structures, metals can be shielded from corrosion under a variety of corrosive situations. Each year, a large amount of research on the production or extraction of corrosion inhibitors, as well as on the classification and inhibitory mechanisms, is published by a large number of academics. The current study evaluates the efficacy of various extracted or synthesized coumarins used as corrosion inhibitors, as well as the various forms of corrosion, inhibitors, methods of action, and assessing corrosion inhibitor efficiency (Kadhim et al., 2021).

The ability of AZI leaf extracts to lessen corrosion in sea water was investigated using chemical methods. Mild steel didn't corrode in sea water because to AZI extracts. The extract of AZI leaves has been studied using linear polarization, electrochemical impedance spectroscopy (EIS), potentiodynamic polarization, and weight loss. The Nyquist plots showed that double layer capacitance reduced as AZI concentration increased while charge transfer resistance increased. The efficiency of the inhibition grew as the concentration of extract did. Higher 98% inhibitory efficiency of AZI's leaf extract was shown to exist (Sribharathy et al., 2018).

The effect of AZI seed extract in 0.5M, 1.0M, and 1.5M H_2SO_4 on the prevention of corrosion of mild steel and copper was investigated using the gasometric method. Zero order, half order, and first order models were fitted to the data based on the amount of hydrogen evolved. These results show that inhibition decreases the instantaneous volume of hydrogen evolved (V_0) and kinetic rate constant, and a zero order kinetic model may be utilized to approximate the volume of hydrogen evolved during the corrosion of mild steel and copper in an H_2SO_4 environment (k). The results of the gasometric approach also revealed that mild steel-based solutions rusted more quickly than copper-based ones (Ekeke et al., 2019).

3 Materials AND Method

3.1 Extraction of NL and AZI leaves.

In Aba, Nigeria, the NL and AZI plants' leaves were collected, dried, and ground. As the corrosive medium, H_2SO_4 (1.0 M) was used, by boiling weighed amounts of dried and powdered NL and AZI leaves in H_2SO_4 at a low, constant boil for three hours, stock solutions of plant extracts were created. Once the solutions had cooled to room temperature, they were filtered. To calculate the quantity of plant materials extracted into the solutions, the weight of the dried residues was compared to the weight of the powdered plant material before extraction. Inhibitor test solutions containing 0.1 to 0.5g/L of excess corrodent were made by diluting the stock solutions.

3.2 Metal Preparations

The experiment employed a high carbon steel (HCS) sample of grade (C-1345) with the following chemical composition: C = 0.85%, Mn = 1.71%, Si = 3.94%, Cr = 0.88%, Ti = 0.29%, Co = 0.68%, Cu = 0.07%, Mo = 0.68%, and Fe = 91.76%. 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 Gravimetric Method

The gravimetric experiment was conducted in accordance with the guidelines (American Society for Testing and Materials (ASTM) International, 2004). HCS samples with measurements of 2 cm x 2 cm x 4 cm were abraded with different grades of emery paper (120, 600, and 1200), and then rinsed with distilled water, ethanol, and acetone. A Mettler weighing balance was then used to precisely weigh the test samples. After that, HCS samples were dipped into a 100 ml beaker that contained 50 ml of 1.0 M H_2SO_4 solution in various doses of the inhibitor (0.0 g/L, control, 0.1 g/L, 0.2 g/L, 0.3 g/L, 0.4 g/L, and 0.5 g/L). The experiment was performed at each inhibitor concentration.

The test setup was exposed to air for a variety of exposure intervals (4hrs, 8hrs, 12hrs, 16hrs, and 20 hrs.). The test component was removed every four hours until the final piece was removed after twenty hours. The test piece was dipped in nitric acid to stop the corrosion reaction, washed in water to remove the acid, dipped in ethanol to remove the water, and then dried entirely in acetone to prevent corrosion before it could be reweighed.

The weight loss, corrosion rate, and Inhibition efficiency ($\eta_{\text{gravimetric}}$ %) will be calculated by Equation

$$\Delta W = W_1 - W_2 \quad (3.1)$$

Where W_1 and W_2 are samples weight before and after immersion in the test solution for time (t), respectively (ASTM International, 2014). ΔW is the weight loss represented in grams.

Based on obtained results, the corrosion rate will be estimated in Equation (3.2).

$$\text{Corrosion Rate (CR)} = K\Delta W / Atp \quad (3.2)$$

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

of the metal sample (cm^2); t is the immersion time (hours); ρ is the density of the metal (g/cm^3) (ASTM International, 2004).

The inhibition efficiency for the gravimetric method will be calculated using Equation (3.3).

$$(\eta_{\text{gravimetric}} \%) = (1 - W_i / W_o) \times 100 \%, \quad (3.3)$$

where W_i is the weight loss when inhibited and W_o is weight loss without being inhibited.

4. Results and Discussion

Below are the results of the weight loss experiment

4.1 Test Results for NL leaf extract as Corrosion Inhibitor for HCS in H₂SO₄

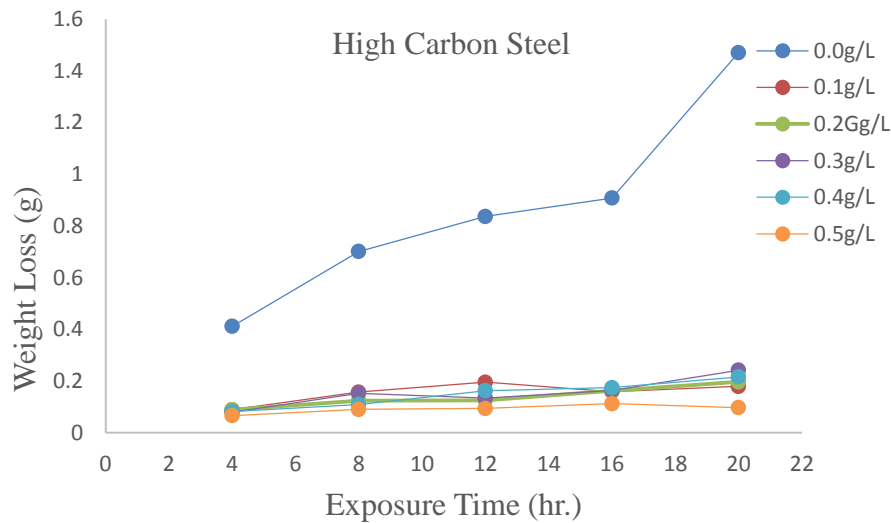


Figure 4.1: Plot of Weight Loss (g) versus Exposure Time (t) for HCS with NL leaf extract as inhibitor.

The corrosion of HCS in 1.0M H₂SO₄ in the absence and presence of various doses of NL leaf extract is presented as a function of weight loss versus exposure time in Figure 4.1, which depicts the outcomes of the gravimetric experiment using NL leaf as an inhibitor for high carbon steel. As can be observed from the plots, the rate of weight loss in the controlled environment (1.0M H₂SO₄) increased consistently over time; however, there was a large weight loss between 16 and 20 hours, showing that the HCS was succumbing to corrosion. When the leaf extract inhibitors were administered, the weight loss dropped and stayed the same until around 16 hours, at which point there was a slight increase, indicating that the inhibitor concentration was dwindling.

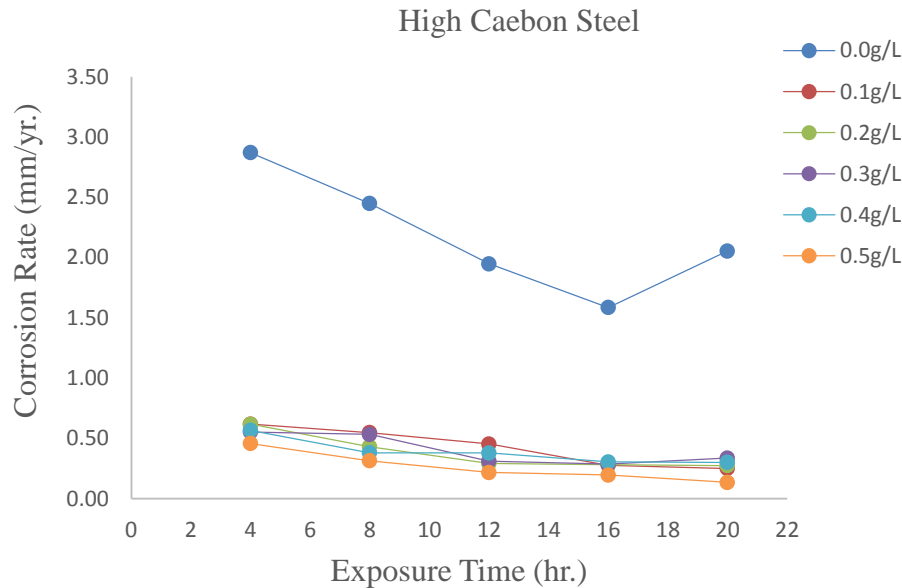


Figure 4.2: Plot of CR (mm/yr.) (For control + various concentrations) versus Exposure Time (hr.) foe HCS with NL leaf extract as inhibitor.

A graph showing the trend of high carbon steel CR over time in the presence (control experiment) and absence of NL leaf extract is shown in figure 4.2. The formation of a protective layer of film on the test piece's surface, which reduced the rate of corrosion, is what caused corrosion resistance to exist during the first 16 hours, as shown by the control curve. After 16 to 20 hours, the test piece succumbed to further corrosion, proving that the protective covering had completely worn off. After the addition of various concentrations of NL Leaf extracts, the corrosion decreased significantly and maintained a lower trend for all the concentrations (0.1 to 0.5g/L), proving that the test piece was protected against deterioration. CR values (for control + different concentrations) versus exposure time.

The inhibited corrosion curves also show that at 0.1 g/L, the CR fell continuously from 0 to 16 hours, indicating that the leaf has formed a protective layer on the test piece's surface and prevented the mass transfer of charges in the corrosive environment. The leaf extract concentration that produced the best CR value at 16 hours was 0.1g/L. between 16 and 20 hours, there was a little rise, indicating that the 0.1g/L concentration is deteriorating and starting to succumb to corrosion.

Although there was a slight increase between 16 and 20 hours, the corrosion rate of 0.2g/L decreased gradually from 0 to 16 hours, indicating that the amount of leaf extract in the corrosive media was diminishing. At a concentration of 0.3g/L, CR increased between 8 and 12 hours but declined from 0 to 16 hours. Concentrations of 0.4g/L behaved similarly to those of 0.3g/L. The concentration of 0.5g/L showed a consistent downward trend from 0 to 20 hours, demonstrating that the leaf extract is still active. The graph shows how NL leaf extract inhibits acidic corrosion of HCS.

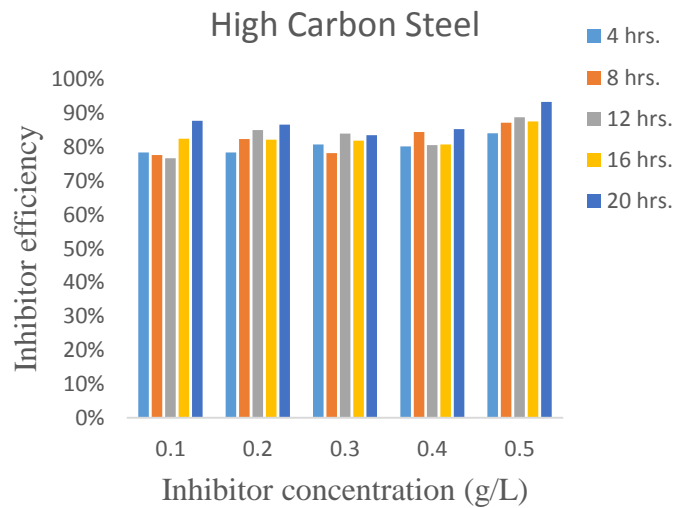


Figure 4.3: Efficiency (%) versus Concentration of inhibitor (g/L) for HCS with NL

In Figure 4.3, the inhibitor's inhibitory effectiveness is plotted against the concentration of the plant extract, demonstrating that NL leaf extract is a potent inhibitor of sulphuric acid corrosion of HCS. As the concentration of the inhibitor was increased, the effectiveness of inhibition increased.

4.2 Test Results for AZI leaf extract as Corrosion Inhibitor for HCS in H₂SO₄

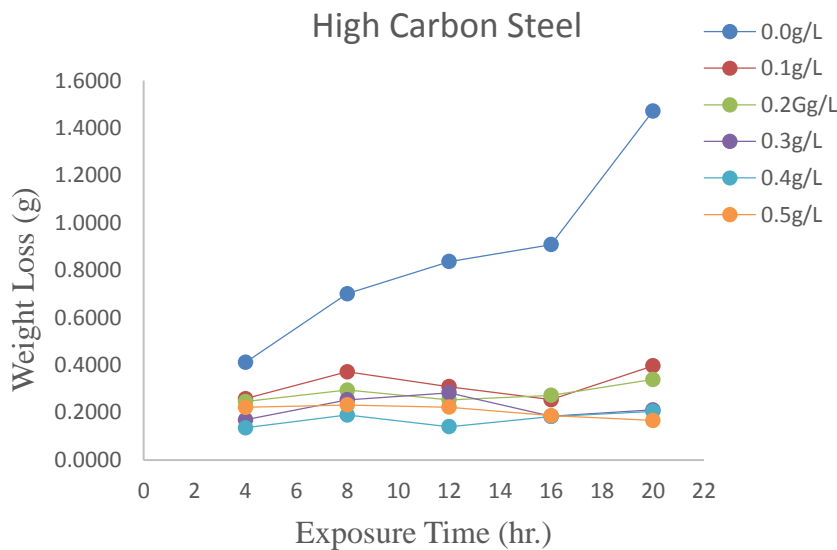


Figure 4.4: Plot of Weight Loss (g) versus Exposure Time (t) for MCS with AZI leaf extract as inhibitor

The gravimetric experiment using AZI leaf as an HCS inhibitor yields the findings shown in Figure 4.4. According to the graphs showing the corrosion of HCS in 1.0M H₂SO₄ in the absence and presence of varying concentrations of AZI leaf extract, the rate of weight loss in the controlled environment (1M H₂SO₄) increased steadily over time, though there was a significant loss

between 16 and 20 hours, indicating that the HCS will not survive for very long. Weight loss dropped after administration of the inhibitor leaf extracts and stayed steady for almost 16 hours before it slightly increased, indicating that the inhibitor concentration was declining.

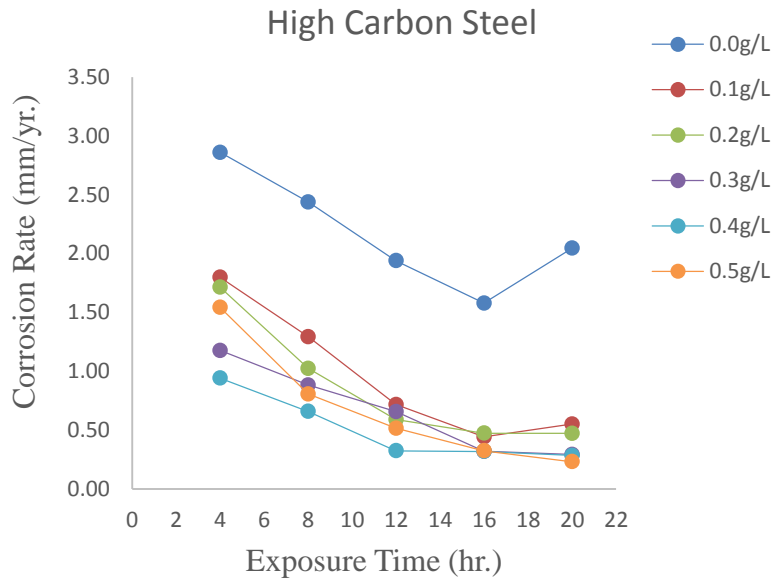


Figure 4.5: Plot of Corrosion Rate (mm/yr.) (for control + various concentrations) versus Exposure Time (hr.) for HCS with AZI leaf extract as inhibitor

The graph depicts the trend of high carbon steel CR over time in the presence and absence of AZI leaf extract (control experiment) (figure 4.5). The creation of a protective layer of film on the test piece's surface during the first 16 hours prevented corrosion, as shown by the control curve, which also showed a delay in the rate of corrosion. The test piece succumbed to further corrosion after 16 to 20 hours, indicating that the protective layer had totally disappeared. The corrosion significantly decreased and maintained a lower trend with the addition of different concentrations of AZI Leaf extracts (0.1 to 0.5g/L), indicating that the test pieces were shielded against deterioration.

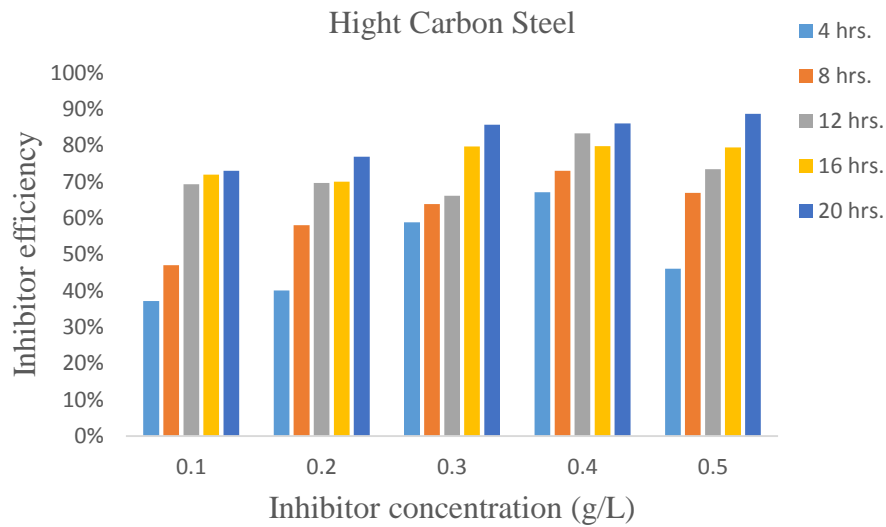


Figure 4.6: Efficiency (%) versus Concentration of inhibitor (g/L) for HCS with AZI leaf extract as inhibitor

The relationship between the inhibitory effectiveness and the concentration of the plant extract is shown in Figure 4.6. It is clear that AZI leaf extract works wonders to prevent HCS from corroding in sulphuric acid with an increase in inhibitor concentration.

4.3 Comparison of Inhibitive potencies of NL and AZI

Table 4.1: Values of Inhibition Efficiencies for NL and AZI leaf extracts at varying Inhibitor Concentrations for HCS.

Comparison of NL and AZI Leaf Extracts Efficacy on Inhibition Efficiency of HCS in H ₂ SO ₄						
Conc. (g/L)	Exposure Time (hr.)					Average Inhibition Efficiency
	4	8	12	16	20	
0.1g/L - NL	78%	78%	77%	83%	88%	81%
0.1g/L - AZI	37%	47%	69%	72%	73%	60%
Difference	41%	31%	7%	11%	15%	
0.2g/L - NL	78%	82%	85%	82%	87%	83%
0.2g/L - AZI	40%	58%	70%	70%	77%	63%
Difference	38%	24%	15%	12%	10%	
0.3g/L - NL	81%	78%	84%	82%	84%	82%
0.3g/L - AZI	59%	64%	66%	80%	86%	71%
Difference	22%	14%	18%	2%	-2%	
0.4g/L - NL	80%	84%	81%	81%	85%	82%
0.4g/L - AZI	67%	73%	83%	80%	86%	78%

Difference	13%	11%	-3%	1%	-1%	
0.5g/L - NL	84%	87%	89%	88%	93%	88%
0.5g/L - AZI	46%	67%	73%	79%	89%	71%
Difference	38%	20%	15%	8%	5%	

Table 4.1 displays the effectiveness of the leaf extracts from the NL and AZI on the preservation of HCS in H₂SO₄. The results show that the NL leaf extract significantly increased the fortification against degradation while the AZI extract protected HCS from corrosion. According to the study of efficiency in Table 4.1, a positive difference demonstrates that NL inhibited well, whereas a negative difference reveals that AZI inhibited best.

Table 4.1: Average Inhibition Efficiency (%) at various Concentration (g/L)

Concentration (g/L)	Inhibition Efficiency (%)	
	NL	AZI
0.1	81	60
0.2	83	63
0,3	82	71
0.4	82	78
0.5	88	71

The average inhibitive efficacy of NL and AZI at various concentrations is shown in Table 4.1, which further supports the conclusion that NL performed better than AZI.

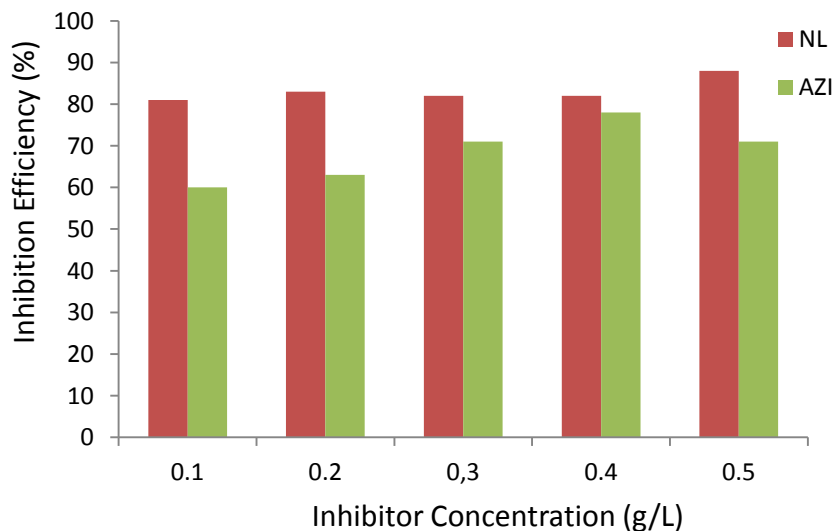


Figure 4.7: Efficiency (%) versus Concentration of inhibitor (g/L) for HCS with NL and AZI leaf extracts as inhibitor

NL leaf extract inhibited most effectively at 0.5 g/L with an efficacy of 88%, whereas AZI had its maximum efficiency at 0.4 g/L with a 78% efficiency. Figure 3.7 illustrates the pattern of how efficiency was improving as inhibitor concentration increased.

5 Conclusions

The findings of this study demonstrate that the extracts of *Newbouldia Laevis* and *Azadirachta Indica* leaves significantly reduce the corrosion of high carbon steel in H_2SO_4 solutions. With an increase in extract concentration, plant extracts' inhibitory potencies improved. The higher concentration of phytoconstituents identified in the *Newbouldia Laevis* extracts than in the *Azadirachta Indica* extracts may explain why the *Newbouldia Laevis* is found to be a more effective inhibitor than the *Azadirachta Indica*.

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