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Corrosion Inhibitor by Leaves Extract of *Launaea taraxacifolia* (Wild Lettuce) for Mild Steel in 1M Hydrochloric Acid (HCl) Solution

Titilayo Jesusina[1] & Iyabode Adejumobi[2]

[1]Science Laboratory Technology Department, The Federal Polytechnic, Ilaro
[2]Department of Chemistry, Federal University of Technology, Akure
Email; titilayo.jesusina@federalpolyilaro.edu.ng; abright14@gmail.com

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Abstract

Corrosion is the destructive attack on metals or alloys in our environment. The corrosion inhibition potentials of Launaea taraxacifolia Leaves Extract (LTLE) were assessed using weight loss techniques. The influence of extract concentrations (0.2, 0.4, 0.6, 0.8 & 1.0g/l) and temperatures (303, 313, 323, and 333 K) on corrosion and corrosion inhibition was analyzed. The inhibitory effect of ethanol extract of Launaea taraxacifolia Leaves (LTL) on the corrosion of mild steel in an acidic medium was investigated by gravimetric and electrochemical techniques. Investigation carried out on inhibition efficiency on mild steel shows that 94.6% was achieved at 303K. The findings demonstrated that the corrosion rate decreases as LTLE concentration rises and inhibitory efficacy was explained in terms of adsorption and the creation of protective films. With longer exposure times and higher inhibitor concentrations, the inhibition process interacts with the mild steel surface and reduces the rate of corrosion. The procedures employed yielded consistent findings, indicating the extract's potential to suppress mild steel corrosion in 1M HCl. Because of the phytochemicals—saponin, flavonoids, glycosides, and tannins—found in the leaf extract, the LTE effectively inhibits mild steel corrosion. L. taraxacifolia is a renewable and biodegradable source of material that is environmentally benign and does not harm the environment. The inhibitor may find use in surfaces of metals or alloys.

Keywords: Corrosion, inhibition, photochemical, wild lettuce, mild steel

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Introduction

Corrosion is described as a hazardous effect of substances interacting with their environment, especially attacks on metals. The consequences of material corrosion on the structural integrity of materials have long been a topic of interest in the technological community. Harsimran et al., (2021) described corrosion to be a result of a chemical attack or contact with their environment. Ogunleye et al., (2020) argued that this effect happens to metals every time two distinct electrochemical reactions interact on their surface, which then often leads to the gradual destruction of the material. Each year, corrosion claims around 10% of the production of iron, steel, aluminum, and their alloys (Fayomi et al., 2019 and Onen, 2010). The majority of alcoholic and alcohol-free beverage bottle tops, food carriers, machine parts used in the industry, etc., are known to corrode quickly, posing a health risk to consumers (Deshwal & Panjagari, 2020). In the mechanical engineering and transportation industries, in particular, metallic materials continue to be the most often used class of materials (Ashby & Jones, 2012). Metals are also frequently utilized in electrons and are being utilized more and more in the building sector (Buchweishaija, 2009). Because of its affordable pricing and good material qualities for a variety of applications, mild steel which is also referred to as plain carbon steel has become the most popular type of steel (Villalobos et al., 2018). A popular choice for engineering materials, mild steel is prized for its excellent mechanical properties and is well-known for being inexpensive, strong, and stiff. It is especially important for use as an outdoor structural material and performs well in acidic situations, where corrosion is a significantly greater challenge (Fekry et al., 2010).

In Nigeria and other West African nations, *Launea taraxacifolia* (LT) is known by several names. The Yoruba people refer to it as "EfoYanrin and OdundunOdo" in Nigeria, whereas the Hausa people refer to it as "Namijindayii, Nomenbarewa, and NonanBarya" (Morakinyo & Olubode, 2015). It grows wild in fields, rocky soil, waste places, banks, and in groups or alone (Bello, Abiodun & Uduma, 2018). In addition to being a popular vegetable, it can also be cooked in soups and sauces, or eaten as a salad. In certain regions of Nigeria, nursing cows are given the leaves of this herbaceous plant to boost their milk supply; it also helps ruminant animals, such as sheep and goats, achieve multiple gestation rates (Di Meo et al., 2023; Sani et al., 2019). This work aims to prepare different amounts of *L. taraxacifolia* leaf extract, using 100% ethanol, and conduct corrosion studies at varying temperatures and time of exposure exploring the gravimetric method. Clarifying the protective mechanism at play and examining the impact of various environmental factors, like temperature and extract concentration, were also part of this.

Materials and methods

In Ilaro, Ogun State, fresh leaves of L. *taraxacifolia* were gathered in the Gbogidi and Ilu-ata regions. Following leaf plucking, distilled water was used to wash, rinse, and air-dry the leaves for seven days. Using an analytical balance, the leaves were pulverized into a fine powder and weighed. For two days, 1000 g of powdered leaves were steeped in 1.5 L of 99% pure ethanol solution. A rotary evaporator was used to condense the filtrate sample into leaf extract after it had been filtered through Whatman No. 1 filter paper. The mild steel coupons measured 15 mm x 15 mm and had a 2 mm thickness. After being cleaned with distilled water, acetone was used to quickly dry the coupons after they had been degreased with 100% ethanol. This helped to separate milled scales from the coupons (Abiola et al., 2007; Onyeije et al., 2023).

Preparation of mild steel coupons

The investigation used mild steel (MS) specimens with the following compositions: C=0.01%, Mn=0.34%, P=0.08%, and Fe=99.51%. The coupons made of mild steel have dimensions of 15 x 15 x 2 mm. A stiff brush was used to clean the coupons with ethanol and distilled water. When it was ready for further analysis, it was stored in a desiccator to prevent contamination and quickly dried in acetone. A serial solution was prepared from the inhibitor stock solution by applying the following equation to produce various test concentrations of the inhibitor: 0.2, 0.4, 0.6, 0.8, and 1.0g/l.

$C_1V_1 = C_2V_2$

Where:

C_1 = concentration of the stock solutions
C_2 = concentration of the inhibitor to be prepared
V_1 = volume of stock solution needed to be taken
V_2 = volume of the inhibitor to be prepared

3.7.1 Calculation of 0.2 g/l

C_1=12g/l

C_2=0.2g/l

V_1=?

V_2=250ml

$C_1V_1 = C_2V_2$

$\frac{\not{12}\times V_1}{} = \frac{0.2\times 250}{\not{12}}$

V_1 = 4.2ml

An analytical weighing balance was used throughout the entire process of weighing the metal coupon, both before and after immersion. 40ml of each of the test solutions—0.2, 0.4, 0.6, 0.8, and 1.0 g/l—prepared in 100 ml beakers with 1M HCl concentrations submerged a previously weighed metal coupon entirely. The beakers were placed in a water bath that was kept at various temperatures—303, 313, 323, and 333 Kelvin—for a duration of one to five hours. The corrosion product was taken out of the test solution,brushed to remove the corroded part, washed in distilled water and dried in acetone, allowed to air dry before being weighed again once every hour. The equation was used to calculate corrosion rates based on the weight loss numbers.

$$CR = \frac{\Delta w}{At}$$

Where:
CR = corrosion rate
Δw = change in weight (g)
t = exposure time (hour)
A = sectional area of coupon (m^2)
$\Delta w = IW - FW$

Weight loss = Initial weight – final weight after time (t).

The inhibition efficiency (%) of the *L.taraxacifolia* extracts was evaluated from the following equation

$$\%I.E = \frac{V_{(blank)} - V_{(inh)}}{V_{(blank)}} \times 100$$

Result

The weight loss variation for mild steel corrosion in 1M HCl at 303K, 313K, 323K, and 333K, respectively, is displayed in Figure 3.1.1-3.1.4. The graphs demonstrate that weight loss rose as exposure time and temperature increased.

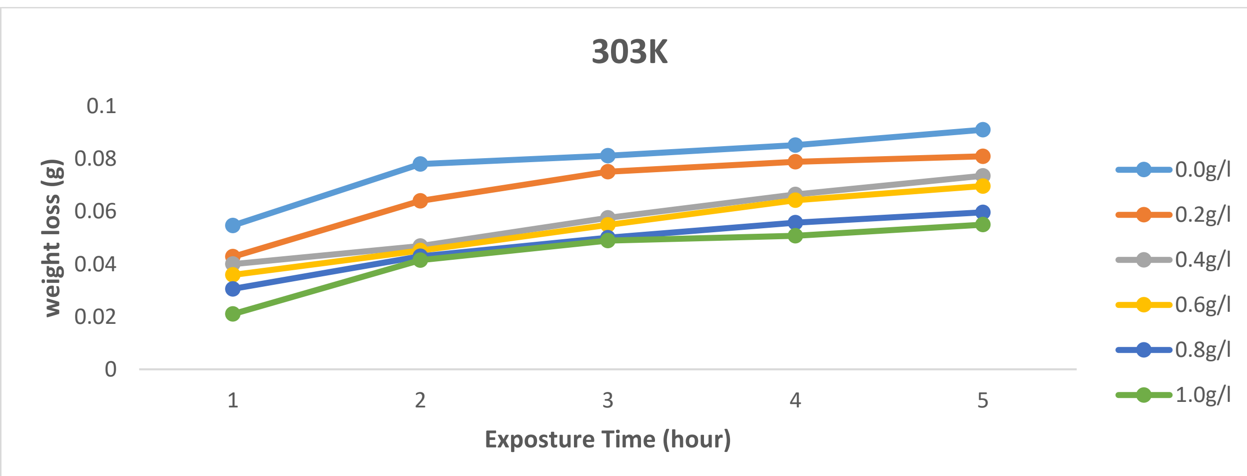

Figure .1.1: Plot of weight loss against exposure time for different concentrations at 303K

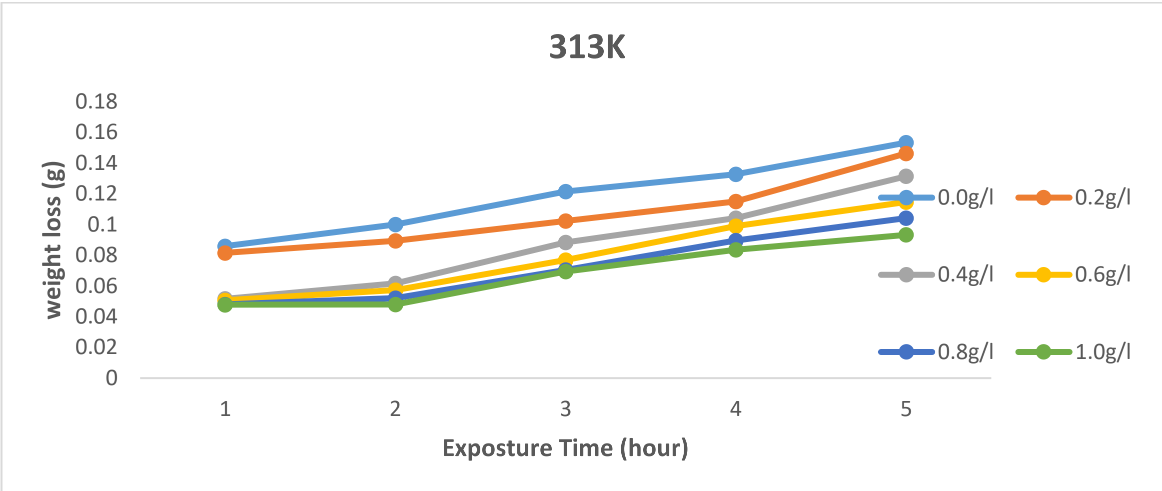

Figure 2: Plot of weight loss against exposure for different concentrations at concentrations at 313K

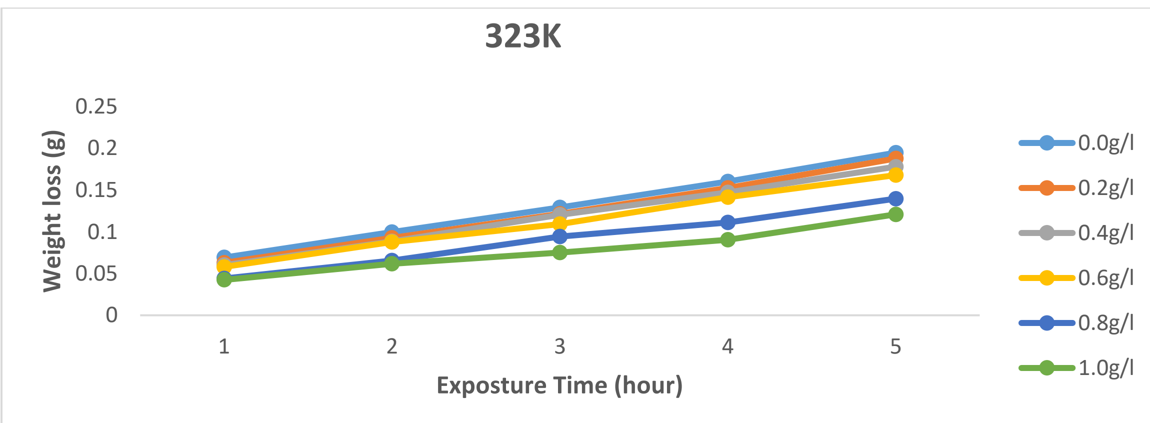

Figure 3: Plot of weight loss against exposure time for different concentrations at 323K

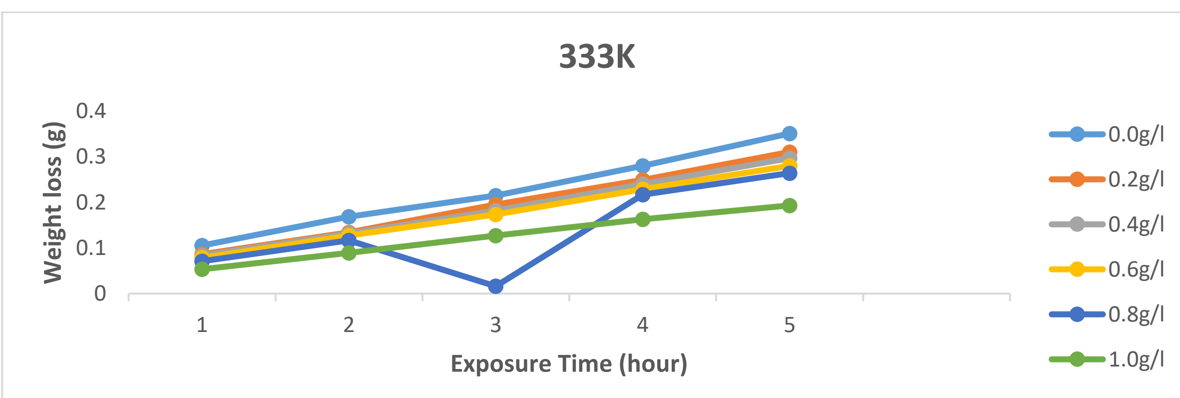

Figure 4: Plot of weight loss against exposure time for different concentrations at 333K

Concentration for mild steel corrosion at different Temperatures

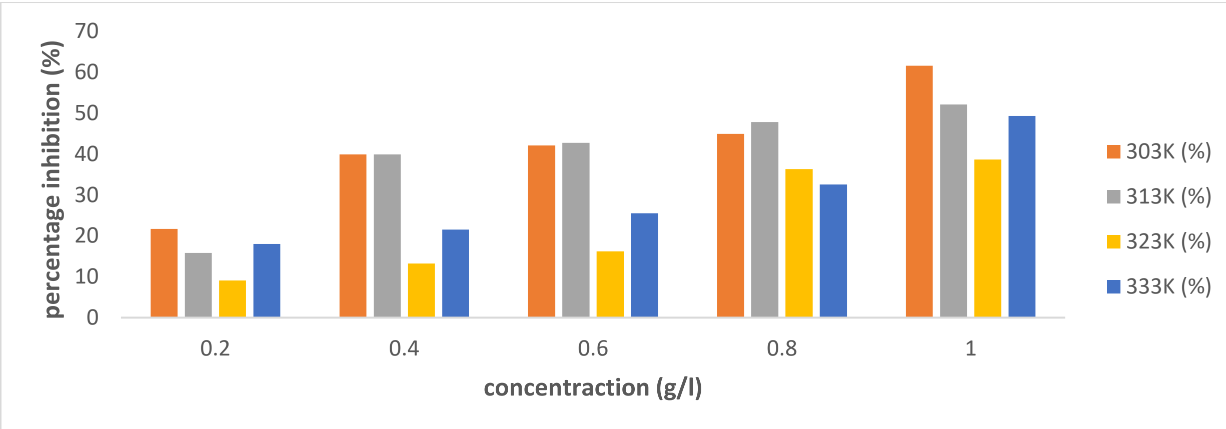

Figure 5: Plot of % I.E. versus inhibitor concentration

Discussion

L. taraxacifolia concentrations of 0.2g/l, 0.4g/l, 0.6g/l, 0.8g/l, and 1.0g/l at 303K, 313K, 323K, and 333K exhibited reduced weight loss when compared to the variation in exposure duration (hour) for mild steel corrosion in 1M HCl (depicted in Figure 1- 4). According to the plots, the weight loss on mild steel was lowest at 303K at 1.0g/l, the maximum inhibitor concentration examined. *L. taraxacifolia* appears to have prevented mild steel from corroding, nevertheless.

According to the research, mild steel's weight loss trended upward with increasing temperatures but declined with higher inhibitor extract concentrations. The corrosion process's increased oxidation rates and the spread of active species are the most likely reasons for this behaviour. This consistent trend was observed across all temperatures, signifying the influential role of inhibitor concentration in modulating corrosion. Parallel observations in prior studies investigating metal corrosion in 1M H_2SO_4 and HCl solutions support these results, affirming that inhibition tends to rise with inhibitor concentration while diminishing with elevated temperatures (Alamieri et al., 2021; Zubairu, Gimba, & Waziri, 2021).

The results show that there is a clear link between LTLE content, temperature, and mild steel corrosion inhibition efficacy in 1M HCl. Figure 5 depicts the percentage inhibition efficiency at temperatures 303K, 313K, 323K, and 333K. Notably, the inhibition efficiency was optimal at 1.0g/l concentration and 303K, decreasing with lower concentrations and higher temperatures, as observed at 0.2g/l concentration and 333K. This observed trend aligns with the work of Teymouri et al., (2021) who reported that there is a well-established dependency of corrosion rate and inhibition efficiency on the concentration of the inhibitor, as noted in the weight loss experiments. This results also are consistent with previous studies on the corrosion of metals in acidic solutions, where inhibition was found to increase with inhibitor concentration and decrease with rising temperatures (Khadom et al., 2020; Alamieri et al., 2021;).

Conclusion

The solvent extract from LTL is a potent green corrosion inhibitor that inhibits mild steel corrosion in 1M HCl solution under room conditions. The plant extract adsorbs on the steel surface, creating a thin film coating that protects the steel from corrodent attack. The corrosion inhibition efficiency moderately increases with the amount of extract, reaching nearly 61.6% after four days. However, the increase becomes gradual and plateaus over time as the steel surface is coated with the adsorbent plant extract.

Recommendation

LTLE is a cost-effective, environmentally friendly, and biodegradable corrosion inhibitor recommended for practical applications in industries like metals and alloy surface anodizing, cathodizing, and surface coating. Its advantageous properties contribute to sustainable and eco-friendly practices, enhancing corrosion protection measures. Further research and development can optimize the inhibitor's effectiveness in diverse industrial applications, enhancing its potential for practical applications.

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