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Original Research Article

Effect of *Leptania hastata* (Yadiya) Leaves Extract as Corrosion Inhibition of Mild Steel in Acidic Media

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ABSTRACT

The inhibiting effect of Leptadenia hastata (Yadiya) leaves extract on the corrosion of mild steel in 1 M HCl and 1 M H_2SO_4 *was studied by weight loss measurement. Different concentrations of Leptadenia hastata leaves extract were prepared ranging from 0 to 1000 ppm for the inhibition of mild steel corrosion at room temperature. The prepared samples of mild steel were exposed to the corrosive media and the corresponding weight loss subsequently obtained was recorded at intervals of 72 hours. The inhibition efficiency increased with increasing inhibitor concentration, while it decreased with increase in time. Likewise, inhibition efficiency (IE) from the findings revealed an increased (with at least 12.48 % in HCl, and 0.78% in* H_2SO_4*) with increase in the inhibitor concentration from 0-1000 ppm. The results indicate that the extract could be used as inhibitor.*

1. INTRODUCTION

The history of corrosion is as old as the history of metals and it has been looked on as a menace which destroys metals and structures and turns beauty into a beast (Jeffrey and Melchers, 2009). Corrosion may be defined broadly as the destruction or deterioration of metal by direct chemical and electro-chemical reaction with its environment (Buchweishaija, 2009a). Human civilization cannot exist without metals and yet corrosion has become a problem (Ahmad, 2006).

Metallic corrosion occurs because in many environments most metals are not inherently stable and tend to revert to some more stable combination of which the metallic ores as found in nature are familiar with (Uzorh, 2013). These environments ranging from dry ambient condition to highly acidifying conditions has set the steps for the 'destructive set back' of corrosion most alarming in acidic environment. Inorganic acids like HCl and H_2SO_4

are used in the industries for many purposes like drilling, fracturing and acid stimulations at various stages in oil exploration, production and/or descaling operations. Wet acidic gases such as CO_2, H_2S and weak acetic and formic acids cause significant amount of corrosion for steel pipelines and storage processing facilities used in the oil and gas production networks (Ibrahim *et al.,* 2011).

The most important of alloys is steel, an alloy of iron and carbon, which has low carbon content especially mild steel is the most commonly, used metal due to its cheapness, availability and excellent mechanical properties. Although familiarity with corrosion is ancient, it has been taken very passively by scientists and engineers in the past. The impact of corrosion has been concluded as an unusual especially in industrialized countries. Financial losses have been assessed in several studies which come to a final conclusion that premature materials degradation costs the industrialized nations approximately 3 % of their gross domestic product (GDP) (Angst, 2018). In spite of this, estimate shows that 25-30 % of this could be avoided if corrosion prevention technologies are put in place (NACE, 2002).

Several different methods can be employed to slow or prevent corrosion of metallic erections. The most commonly used methods are protective coatings on metals using organic molecules, plastics, polymers; cathodic and or anodic protection using organic or inorganic inhibitors (Aliofkhazrael, 2018). Inhibitors are chemicals that directly or indirectly coat a film on a metal surface to protect it from its environment. Most inhibitors are absorbed by the metal surface from a solution or dispersed, but some are applied directly as coatings. Generally, the dissolution of metal can be suppressed by the action of adsorptive inhibitors which may prevent the adsorption of the aggressive ions, and by the formation of a more resistant film on the metallic surface (El Maghraby, 2009). The initial report of corrosion inhibition by organic inhibitors was conducted on scaled water pipes in HCl (Kesavan, *et al.*, 2012). Since then, many organic and inorganic compounds that are added to the corrosive fluids have been investigated for this purpose due to their excellent anti-corrosive proprieties (Kesavan, *et al.*, 2012).

The secondary environmental effect of severe hazard inflicted on the ecosystem due to the carcinogenic and non-biodegradable nature of synthetic inorganic inhibitors has made the scientific community begin a search for eco-friendly inhibitors like the green organic inhibitors, which are biodegradable and poses no advance environmental effect (Abdel-Gaber, *et al.*, 2011). Green organic inhibitors of corrosion are those derived from some plants extract or biodegradable material and cause the reduction of dissolved metal, reducing its corrosion rate. The natural plants extract contains a variety of organic compounds, for example amino acids, alkaloids, steroids, flavonoids, proteins and tannins as a green alternative for toxic and hazardous compounds (Anbarasi and Vasudha. 2014). Moreover, the use of organic inhibitors is specifically interesting due to their cheapness, availability, non-toxic, renewability and eco-friendliness.

Leptadenia hastata is edible non-domesticated vegetable and it is collected in wild throughout Africa. *Leptadenia hastata* is a voluble herb with creeping latex stems, glabescent leaves, glomerulus and racemes flowers as well as follicle fruits. It is typically grown in tropical dry lands in sandy soil. Vernacular names for *Leptadenia hastata* include: *hagalhadjar* (Arabic) in Chad, *yadiya* (Hausa) in Nigeria and Niger, *hayla* (Kusume) Ethiopia, (Thomas, 2012*)*. A phytochemical screening conducted by Bello *et al.* (2011) on *Leptadenia hastata* leaves indicate the presence of phenolic glycosides, tannins, flavonoids, proanthocyanidins, alkaloids and saponins which are active anti-oxidants. The presence of these anti-oxidants in *Leptadenia hastata* leaves confirm that the extract from this plant can serve as green corrosion inhibitor (Yahaya *et al.*, 2013). Plant such as *Leptadenia hastata* can be found in abundant quantity in the northern part of Nigeria but was never used as corrosion inhibitor. Therefore, this present research is focused on the use of bio-extract from *Leptadenia hastata* leaves as corrosion inhibitor on mild steel in 1 M HCl and 1 M H_2SO_4 solution using weight loss techniques.

2. MATERIALS AND METHODS

2.1. Materials

The materials used for this study include: The low carbon steel obtained from Bola opposite Maiduguri Monday market, *Leptadenia hastata* leaves obtained from Ramat Polytechnic Agric farm. Masking tapes, cotton wool, burette, dropper, hand gloves, thread, plastic container and abrasive papers obtained from Emmicon scientific supplies chemical store, adjacent Mara-Zain Hotel Bama road Maiduguri was used.

2.2. Chemicals, Solvents and Reagents

The chemicals used were 1 M HCl and 1 M H_2SO_4 for preparation of media needed for the corrosion process. Distilled Water, Ethanol and Acetone were the solvents used for extract preparation were obtained from Emmicon scientific supplies chemical store, Adjacent Mara-Zain Hotel Bama road Maiduguri.

2.3. Equipment

Bench vice, hack saw, metal scraper: used to cut and prepare the steel bar into required dimension (coupons). Xenemetrix XRF Machine (Model: Genius IF) for determining the elemental composition of the steel bar. Analytical mass balance (Newacalox: Mode 8068, 100×0.001g): for measuring the mass of samples. Desiccator: used for drying and keeping the prepared samples air tight. Soxhlet extractor: for preparation of extracts. Separating funnel and filter paper: for filtration of mixture of ethanol and leave or from their chaff.

2.4. Methods

2.4.1. Preparation of *Leptadenia hastata* leaves extracts

The *Leptadenia hastata* leaves collected from Ramat Polytechnic School Farm were washed with tap water to remove dirt, shade dried to remove the moisture content. The leaves were then pulverized into fine powder using pestle and mortar and weighed on the analytical mass balance to 700 g (Loto *et al.*, 2012).

2.4.2. Extraction

The powdered sample was placed inside a thimble made from filter paper, which was loaded into the extraction chamber of a Soxhlet apparatus, further attached to a round bottom flask containing a solvent (methanol) and a condenser. The solvent was heated causing it to evaporate. The hot solvent vapor travels up to the condenser, where it cools and drips down onto the dry powder. The chamber containing the powder slowly fills with warm solvent until, when it almost full, which was emptied by siphon action, back down to the flask. This cycle was allowed to repeat many times. During each cycle, a portion of the material dissolves in the solvent until the entire leaching is carried out. Concentrate and excess solvent was removed using a vacuum rotary evaporator, leaving behind only the crude extracts material and scrap with the use of metal scraper into a beaker, covered with Aluminum foil and stored in desiccator for further use.

2.4.3. Preparation of mild steel specimen

The low carbon steel used for this research was obtained from Maiduguri Monday Market opposite NEPA Headquarters. The steel was sectioned for elemental analysis using X-Ray fluorescence. However, the steel material was obtained in form of pipe, sectioned by cutting machine and mechanically pressed into flat bar and later cut into straight square rods, which was further turned into cylindrical cross section for further processing. Samples for weight loss analysis were prepared according to ASTM G1-03 as adopted by Ibrahim and Habbab (2011). Low carbon steel rods mechanically cut into cylindrical shape with a diameter of 10 mm and a thickness of 10 mm were polished to mirror like surface with abrasive papers of 80 to 800 grades. The specimens were first washed with water, then degreased in ethanol, followed by water and finally in acetone. The samples were allowed to dry in the air before preservation in desiccator to avoid re-oxidation.

2.4.4. Experimental procedure

The simple standard weight loss method as described in Zubairu et al. (2021) was adopted. Five (5) glass containers were cleaned thoroughly, dried and labeled respectively. Hundred milliliters (100 ml) of 1 M HCl and 1 M H_2SO_4 were measured and poured into each container. Similarly, 250 ppm, 500 ppm, 750 ppm and 1000 ppm of the *Leptadenia hastata* leaves extract solution was pipetted and added into the four containers respectively. No extract solution was added to the fifth container and therefore left as control. One hundred and fifty (150) mild steel coupons (with dimension specified earlier) were individually cleaned with distilled water, and then washed with acetone, dried and weighed. The coupons were each tied with a string to the cover of the container that will enable them to suspend in the solution. The experiment was carried out at room temperature. The first set of the coupons were retrieved from the acid corrodent after 72 hours. Similarly, the second set retrieved after 192 hours, the third set after 312 hours, the fourth set after 432 hours, the fifth set after 504 hours and finally the last after 576 hours. Each coupon was individually cleaned with distilled water, and then with acetone, dried and weighed. The weight loss, Δm (g) was calculated using Equation (1) (Zubairu, et al., 2021).

$$\Delta \mathrm{m} = m\mathrm{b} - ma \tag{1}$$

Where mb (g) and ma (g) are the weights before and after immersion in the test solutions respectively.

2.4.5. Corrosion rate

The corrosion rate was calculated from weight loss of the coupons at room temperature for various concentrations and immersion times using Equation (2) (Sheeba et al., 2014).

$$CR = \frac{\Delta \mathrm{m}}{\mathrm{st}} \tag{2}$$

Where s = surface area of the coupon (cm^2), t = immersion time (h), CR = corrosion rate ($mg/cm^2.h$).

2.4.6. Inhibition efficiency

The inhibition efficiency of the green inhibitor was calculated from weight loss measured for different inhibitor concentrations using Equation (3) as reported by Vasudha and Shanmuga, (2013).

$$IE = \left[1 - \left(\frac{CRinh}{CRcorr}\right)\right] \times 100 \tag{3}$$

Where IE = Inhibition efficiency (%), CRinh = Corrosion rate in the presence of extract ($mg/cm^2.h$) and CRcorr = Corrosion rate without extract ($mg/cm^2.h$)

3. RESULTS AND DISCUSSION

3.1. Corrosion Rate

Figure 1 illustrates the effect of amount of *Leptadenia hastata* leaves extract on the corrosion rate of low carbon steel in 1 M HCl solution. From the result, the rate of corrosion increased with an increase in all concentrations except for 500 ppm which decreases indicating that at this ppm the extract was able to be absorbed by the surface of the low carbon steel at 192 hrs of the experiment.

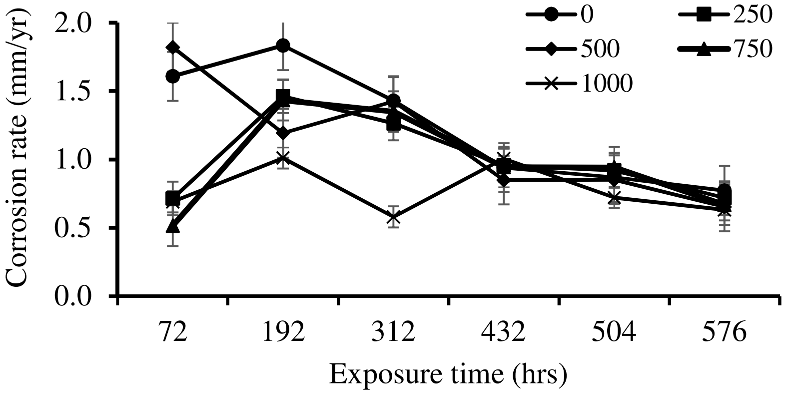

Figure 1: Variation of corrosion rate against exposure time of low carbon steel in 1 M HCI at different concentration of leaves extracts

Generally, it can be observed that the corrosion rate is significantly decreased after 192 hrs except for 500 ppm which later decreased at 312 ppm. Moreover, it could be observed that the corrosion rate was gradual for all level of the concentration used. Equally, the un-inhibited low carbon steel specimen demonstrated to be the least protected expectedly. On the other hand, the corrosion rate decreased with an increase in inhibitor concentration as observed Figure 1. Similar trends were also reported by Zubairu *et al.* (2021).

Figure 2 shows the effect of amount of *Leptadenia hastata* leaves extract on the corrosion rate of low carbon steel in 1 M H_2SO_4 solution The results indicated that corrosion rate was reduced in the presence of *Leptadenia hastata*, and this effect became more noticeable with increased of extract concentration indicating that more inhibitor molecules were absorbed on the low carbon steel surface that led to the formation of a protective film thus inhibiting the dissolution of the low carbon steel. The behavior implies that *Leptadenia hastata* inhibited low carbon steel corrosion in 1 M H_2SO_4, in a concentration-dependent manner. It was also observed in Figure 2 that corrosion rate decreased with an increase in exposure time which was similarly observed by Zubairu *et al.* (2021).

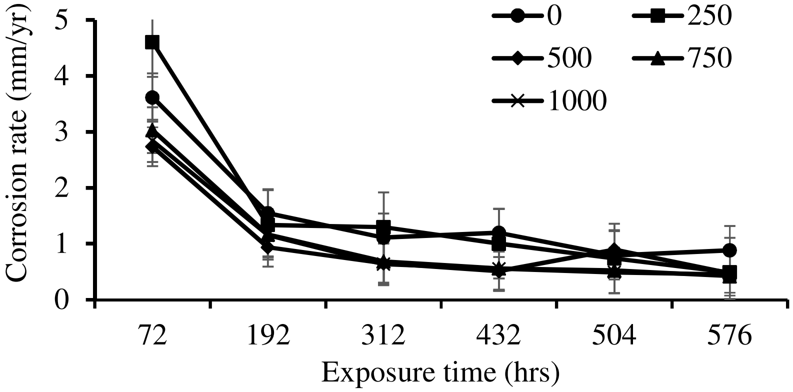

Figure 2: Variation of corrosion rate with exposure time of low carbon steel in 1M H_2SO_4 at different concentration of leaves extracts

3.2. Inhibition Efficiency

Figure 3 shows the inhibitive efficiency of the leaves extract of *leptadinia hastata* in 1 M HCI against time. The results show that the inhibition efficiency decreased with time but increased with increase in the amount of the extract concentration. For instance, at 72 hrs all concentration achieved inhibition efficiency of about 85 % at 72 hrs except for 500 ppm which achieved 61 % which is likely because at the beginning of the experiment, the mild steel surface was exposed to the acid corrodent which was similarly observed by Zubairu *et al.* (2021).

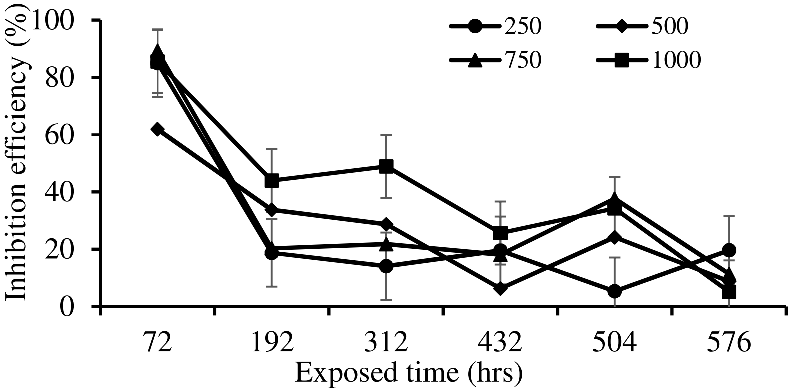

Figure 3: Variation of percentage of inhibition efficiency against concentration for leaves extract in 1 M HCl

Similarly, Figure 4 shows the variation of the inhibition efficiency of the *Leptadenia hastata* leaves extract with time for various level of the extract concentration in 1 M H_2SO_4. It could be noted that the inhibition efficiency generally increases with increase in the amount of extract concentration. The results show a little increase in efficiency of 4 % at 72 hrs to 18 % at 576 hrs for 250 ppm indicating that the extract was able to absorb on the surface of the low carbon steel. However, a decrease in inhibition efficiency was observed in 500 ppm, 750 ppm and 1000 ppm extract concentration as the immersion time increases. The decrease in inhibition efficiency with the prolonged immersion of low carbon steel may be due to the instability of adsorbed layer on the metal surface, as a result of desorption of active constituents present in the *Leptadenia hastata* extract and / or diffusion process through the interface protective layer Chung *et al.* (2010).

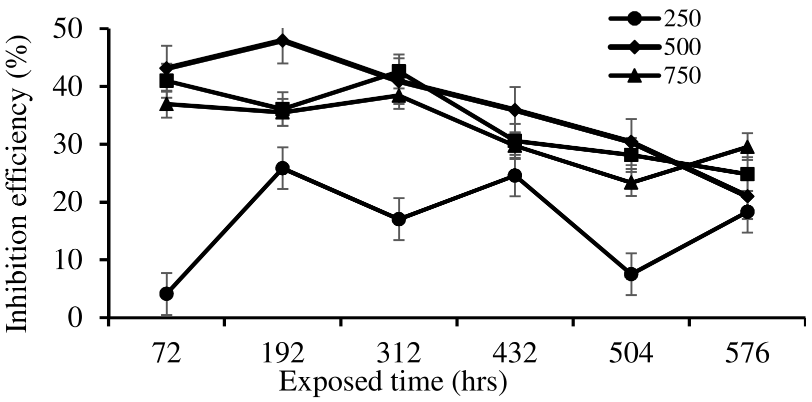

Figure 4: Variation of percentage of inhibition efficiency against concentration at different extract in 1 M H_2SO_4

4. CONCLUSION

The inhibitive property of the *Leptadenia hastata* leaves extract was investigated on prevention of corrosion of low carbon steel in 1M HCl and 1M H_2SO_4. It was found that the extract acted as inhibitor and reduced the corrosion of the low carbon steel. It was also observed that inhibition efficiency of the leaves extract increases with increase in concentration but decreases with time which shows that inhibition efficiency is time dependent. It was therefore, concluded that *Leptadenia hastata* leaves extract can be used as inhibitor for the prevention of mild steel corrosion.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Abdel-Gaber, A. M., Abd-FI-Nabey, B. A., Khamis, E. and Abd-El-Khalek, D. R. A. (2011). Natural Extract; is Scale and Corrosion Inhibitor for Steel Surface in Brine Solution. *Desalination*, 278 (1-2), pp. 337-342.

Ahmad, Z. (2006). *Principle of Corrosion Engineering and Corrosion Control*, 1(1), pp 1

Alamgir, A. N. M. (2018). Therapeutic Use of Medicinal Plants and their Extracts: Phytochemistry and Bioactive Compounds. 74(1), p. 785.

Aliofkhazrael, M. (2018). Corrosion Inhibitors, Principle and Recent Applications. 1, pp 262

Amitha, R. B. E. and Basu, B. B. J. (2012). Green Inhibitors for Corrosion Protection of Metals and Allots- An Overview. *International Journal of Corrosion*, 1(1), pp. 1-15

Anbarasi, K. and Vasudha, V. G. (2014). Mild Steel Corrosion Inhibition by Cucurbita maxima Plant Extract in Hydrochloric Acid Solution. *Journal of Environmental Technology*, 3(1), pp. 16-22

Angst, U. M. (2018). Challenges and opportunities in corrosion of steel in concrete. *Materials and Structures*, 51(4), pp. 1-30.

Bello, A., Aliero, A. A., Saidu, Y. and Muhammad, S. (2011). Phythochemical Screening, Polyphenolic Content and Alpha-Glucosidase Inhibitory Potential of Leptadenia hastata (pers.) Decne. *Nigerian Journal of Basic and Applied Science.* 19(1), pp. 181-186.

Buchweishaija, J. (2009). Phytochemicals as Green Corrosion Inhibitors in Various Corrosive Media. *Tanzania Journal of Science*, 35 (1), pp. 77-92.

Chung, I., Hemapriya. V., Ponnusami, K., Arunadevi, N., Chitra, S., Hee-yun, C., Kim, S. and Prabakaran, M. (2018). Assessment of Low Carbon Steel Corrosion Inhibition by Eco-friendly Green *Chaenomeles Sinesis* Extract in Acid Medium. *Journal of Electrochemical. Science. Technology,* 9(3), pp. 238-249.

EL Maghraby, A. A. (2009). Corrosion Inhibition of Aluminium in Hydrochloric Acid Solution using Potassium Iodate Inhibitor. *The Open Corrosion Journal* 3 (2), pp. 2318-9315Ibrahim, H. T., Chehade, Y. and Mohamed, A. Z. (2011).

Corrosion Inhibition of Mild Steel using Potato Peel Extract in 2M HCI Solution. *International Journal of Electrochemical Science*, 6(1), pp. 6542– 6556.

Ibrahim, T. and Habbab, M. (2011) Corrosion Inhibition of Mild Steel in 2 M HCI using Aqueous Extract of Eggplant Peel. *International. Journal of Electrochemical Science*, 6(1), pp. 5357-5371.

Jeffrey, R. and Melchers, R. E. (2009). Corrosion of vertical mild steel strips in seawater. *Corrosion Science*, 51(10), pp. 2291-2297.Kesavan, D., Mayakrishnan, G. and Nagarajan, S. (2012). Green Inhibitors for Corrosion of Metals: A Review. *Chemical Science Review Letter*, 1(1), pp. 1-8.

Loto, R. T., Loto, C. A. and Popoola, A. P. I. (2012). Corrosion inhibition of thiourea and thiadiazole derivatives: A Review. *Journal of Material Environment,* 3(5), pp. 885-894

NACE. (2002). Corrosion Costs and Preventive Strategies in the United States. NACE International. Available at: http:www.nace.org. Sourced

Sheeba, R. S., Raja, A. S., Sathiabama, J. and Prathipa, V. (2014). Green Approach to Corrosion Inhibition of Carbon Steel in Well Water by the Extract of *Polyalthia Longifolia*. *Journal of Applicable Chemistry*, 3(5), pp. 2055-2065.

Thomas, S, D. (2012). Leptadenia hastata: A Review of its Traditional uses and its Pharmacological Activity. *Journal of Medicinal Chemistry,* 2(7), pp 148-150

Uzorh, A. C. (2013) Corrosion Properties of Plain Carbon Steels. *The International Journal of Engineering and Science*, 2(11), pp. 18-24.

Vasudha, V. G. and Shanmuga, P. K. (2014). Corrosion Inhibition of Mild Steel in H_2SO_4 Media using *Polyalthia Longifolia* Leaves. *Chemical Science Review and Letters*, 3(1), pp. 21-26

Yahaya, I. A., Nok, A. J. and Bonire, J. J. (2013). Chemical Studies of the Peel of *Xanthosoma sagittifolium* (Tannia Cocoyam). *Pakistan Journal of Nutrition*, 12 (I), pp. 40-44.

Zubairu, A., Gimba A. S. B. and Waziri, A. B. (2021). Corrosion Inhibition of *Polyalthia Longifolia* Leaves Extract in 1 M HCl Solution on Mild Steel. *Arid Zone Journal of Engineering, Technology and Environment*, 17(2), pp. 103-110.