

Evaluation of the Corrosion inhibition Effects of *Chrysophyllum albidum* Extracts on Mild Steel

Offurum F. C. & Offurum J. C.

Department of Environmental Technology, Federal University of Technology, Owerri
Department of Chemical Engineering, Imo State Polytechnic, Umuagwo-Ohaji

Email: jullyengine@yahoo.com

Corresponding Author: Offurum J. C.

ABSTRACT

The inhibiting action of the *Chrysophyllum albidum* (CA) extract (leave and bark) on mild steel corrosion in 1M HCl and 0.5M H₂SO₄ solution was studied using gravimetric, and potentiodynamic polarization (PDP), techniques. The experimental results showed that CA leave and bark functioned as an inhibitor in the acidic corrodent and inhibition efficiency increased with increase in extract concentration. The CA leaf extract showed higher inhibition efficiency in 0.5M H₂SO₄ (94%) than in 0.5M H₂SO₄ (73%) bark extract; also, 92% efficiency was observed in 1M HCl for CA bark extract, while 84% in 1M HCl leaf extract. Also, during the gravimetric chart, inhibition efficiency increased when metals are not withdrawn than in solutions with daily withdrawal of metal specimens. This was traceable to the fact that the metal surface already formed a thick film with the inhibitor, blocking the active corrosion sites on the surface, thereby reducing the corrosion rate (adsorption). Cathodic and anodic polarization curves showed that CA bark and leaf functioned as a mixed-type inhibitor. The study generally, indicates clearly that *Chrysophyllum albidum* extract has potentials of inhibiting corrosion of mild steel in acidic environment.

Keywords: Evaluation, Corrosion Inhibition, Effects, *Chrysophyllum albidum*, Mild Steel

INTRODUCTION

Iron and steel are among the most widely metals used in structures that are exposed to the atmosphere and, often, to the aggressive environment in industrial application, due to their availability and low cost. In these environments, acidic solutions are greatly used in cleaning services, picking and decaling processes, as well as in drilling operations in the oil

and gas sector. So, iron and steel, subjected to these environments usually encounter corrosion, though a huge effort has been deployed in cutting down corroding surfaces by various means as it affects both toxic and non toxic environmentally accepted ways. The use of corrosion inhibitors has, thus, been proven as the most practical and economical mode of protecting and preventing unexpected/unwanted metal dissolution in the environment. (Akalezi *et al*, 2012).

The most common form of corrosion (in recent discussions) is aqueous metallic corrosion, in which the material is a metal or metal alloy, and the corrosion environment is an aqueous solution. In daily life, such corrosion is present in various forms: corroded nails, tools, reddish-orange spots in car bodies, leaking hot-water tanks and murky portable water are common examples.

The economic cost of corrosion is enormous and has been estimated to be in the range of 2-4% of an industrialized country's gross national product (Al-Juaid, 2007). In addition to these direct costs, there are also indirect costs associated with plant shutdown, lower efficiency of equipment, contamination and overdesign. Parts and labour to replace corroded equipment are often minor, compared to the loss of production while the plant is non-operational. Thus leaks in pipelines and tanks result in loss of costly products, and the leaks can also pose serious environmental problems. Accumulation of undesirable corrosion products on heat exchanger tubing and pipelines decreases the efficiency of heat transfer and reduces pumping capacity (Eddy, 2008).

Mild Steel has been extensively used, under different conditions, in chemical and allied industries in handling alkaline, acid and salt solutions. One way of protecting this metal from corrosion is to use corrosion inhibitors. The known hazardous effects of most synthetic corrosion inhibitors are the motivation for the use of some natural products. The recent trend is geared towards environmental-friendly

inhibitors. Most of the natural products are non-toxic, biodegradable and readily available in plenty. The report of an investigation conducted by Akalezi (2012) shows that using such naturally-occurring substances pays off environmentally. According to the report, the use of chemical inhibitors to prevent corrosion in metals is accompanied by great concerns due to its toxicity, which affects living organisms and at the same time poison the environment. These features, in green inhibitors, are attractive and desirable for later generation's corrosion inhibitors.

MATERIALS AND METHODS

Metal specimen

Mild steel (MS) specimens containing Carbon, Manganese, Phosphorus and Iron (of the following percentages: C = 0.01%, Mn = 0.34%, P = 0.08% and Fe = 99.51%) were used for the study. Each sheet (of 0.1cm thickness) was mechanically pressed-cut into coupons of dimension: 3cm x 3cm. These coupons were cleaned with different grades of emery paper, degreased in absolute ethanol, dried in acetone, weighed and stored in moisture-free desiccators, prior to use.

Reagents Used

All reagents during the course of this study were of JHD analytical grade, and used as sourced (without further purification). Distilled water was used for the preparation of all the solutions used. 1M HCl and 0.5M H₂SO₄ solutions were employed as coreagents. The concentration of the plant solution used was varied for 50mg/l, 200mg/l, 400mg/l, 600mg/l, 800mg/l and 1000mg/l.

Plant Powder Preparation

The aqueous extracts from the leave and bark of *Chrysophyllum albidum* that were used as inhibitors were obtained directly from the tree at Obinze in Owerri West L.G.A. of Imo State, Nigeria. They were both thoroughly washed with clean water and sun-dried for 8 days. The dried leaves and shredded bark were ground into powder by means of

electronic grinder, and were separately stored in closed containers, prior to use at room temperature.

Extraction Process

40g of the ground leave and bark were added into 200ml of ethanol, each contained in a 500ml round-bottom flask. The resulting solution was heated under reflux for 3hrs, allowed to cool to room temperature and then filtered, using a 'Whatman 14' filter paper. The filtrate obtained from each sample was measured, stored in air tight container and kept away from the sun. The residue obtained was, also, dry-weighted. Thereafter, the residue was used in the determination of the amount of dissolved plant material in the ethanol. The concentrations of the stock solutions are 50mg/l, 200mg/l, 400mg/l, 600mg/l, 800mg/l and 1000mg/l. The extracts of CA leaf and bark were then used for the study.

Electrochemical Studies

When a metal specimen is immersed in a corrosive medium, redox reaction (reduction and oxidation) occurs on its surface (Amin *et al*, 2008). Typically, the specimen oxidizes (corrodes) and the medium (solvent) is reduced. In acidic media, hydrogen ions are reduced. The specimen functions as both anode and cathode, in which both anodic and cathodic currents occur on the specimen's surface. Experimentally, polarization characteristics could be measured by plotting the current response as a function of the applied potential.

In line with this analogy, the electrochemical experiments were conducted in a Model 'K004' corrosion cell, using a *VERSASTAT-400* Complete DC Voltammeter and Corrosion System (with V-3 Studio software). The data obtained in a three-electrode mode. Platinum, sheet and saturated calomel electrodes were used as counter and reference electrodes respectively. The material used for constructing the working electrode was mild steel.

Potential-dynamic polarization studies were carried out in a potential range of +250mV, at a scan rate of 0.333mV/S. The mild steel was encapsulated in epoxy resin in such a way that only one surface was left uncovered. The exposed area (1cm²) was mechanically abraded with emery papers of variable grades. The samples were then washed thoroughly with distilled water, followed by washing with Acetone and drying. It was finally washed with water, just before insertion in the cell. Each test was run in triplicate to verify the reproducibility of the system.

RESULT AND DISCUSSION

The result of the potentiodynamic polarization for mild steel in 0.5M H₂SO₄ and 1M HCl, in the presence and absence of CA leaf and bark, at the concentration of 1000mg/l is presented in figure 1, while figures 2 and 3 show the variation of weight loss (in gram) within a given time (in days) in the presence and absence of CA leaf and bark for both 0.5M H₂SO₄ and 1M HCL. Also, figures 4 and 5 show the variation of inhibition efficiency, within a given time, for both environment, using CA leaf and bark.

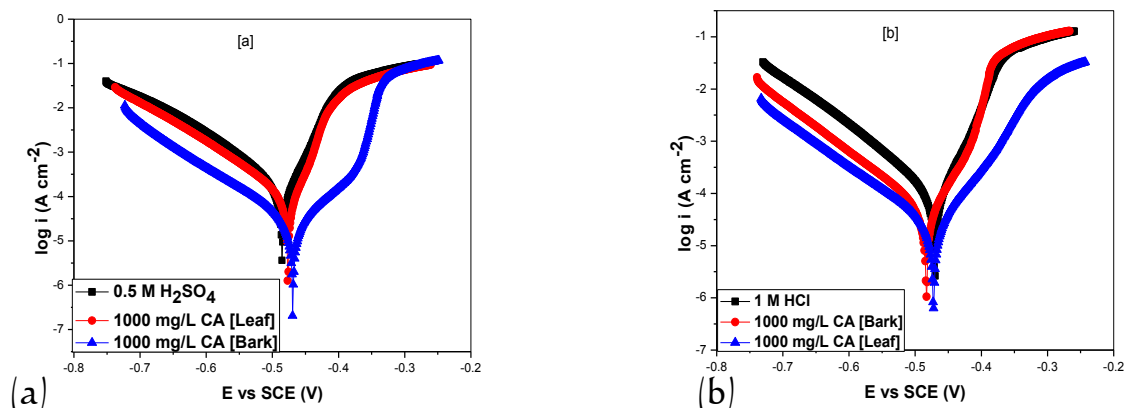
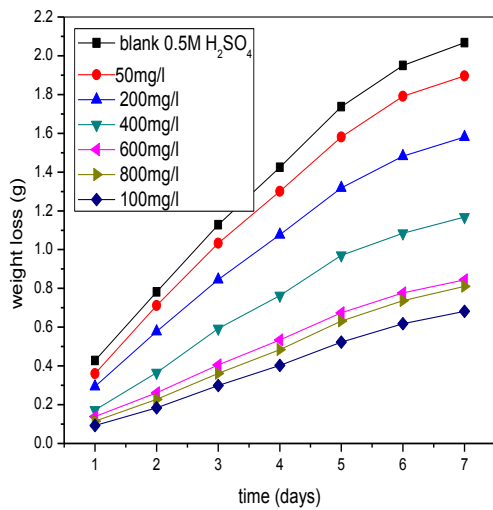
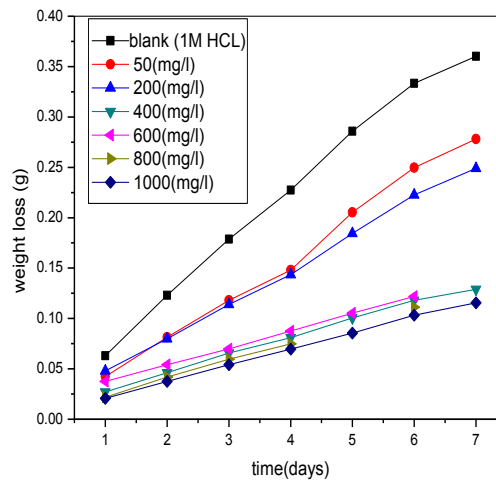


Fig. 1: Potentiodynamic polarization curves for mild steel in (a) 0.5 M H₂SO₄ and (b) 1 M HCl in the presence and absence of CA leaf and bark extract at highest and lowest concentration.

Evaluation of the Corrosion inhibition Effects of *Chrysophyllum albidum* Extracts on Mild Steel

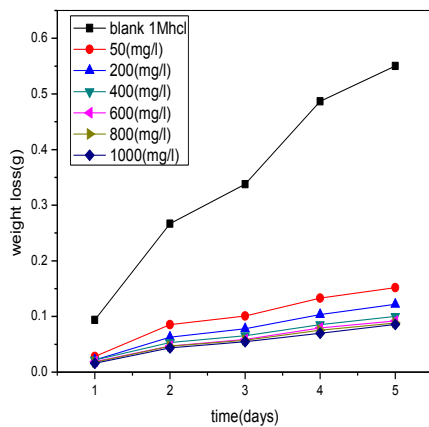


(a)

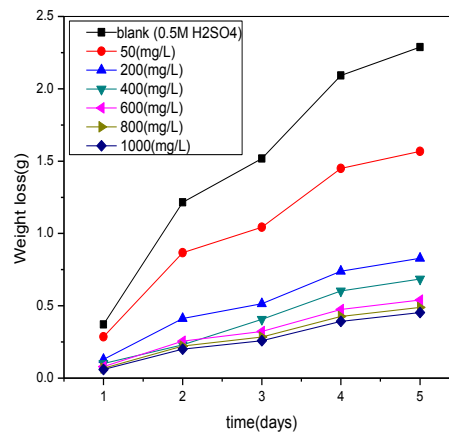


(b)

Fig. 2: Variation of weight loss with exposure time for mild steel corrosion in (a) 0.5M H₂SO₄ and (b) 1 M HCl in the presence and absence of CA bark extract.



(a)



(b)

Fig. 3: Variation of weight loss with exposure time for mild steel corrosion in (a) 0.5M H₂SO₄ and (b) 1 M HCl in the presence and absence of CA leaf extract.

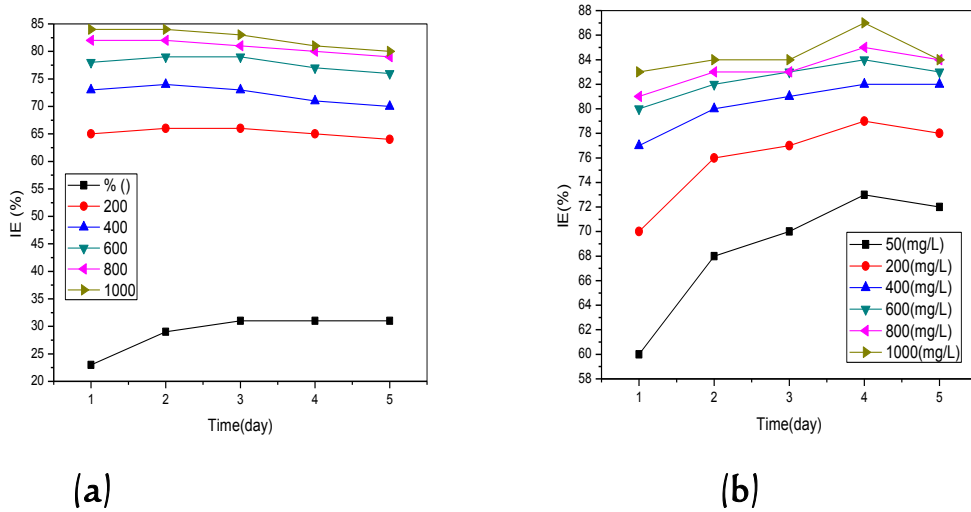


Fig. 4: Variation of inhibition efficiency with immersion time in CA leaf extract (a) 0.5M H₂SO₄ and (b) 1M HCl.

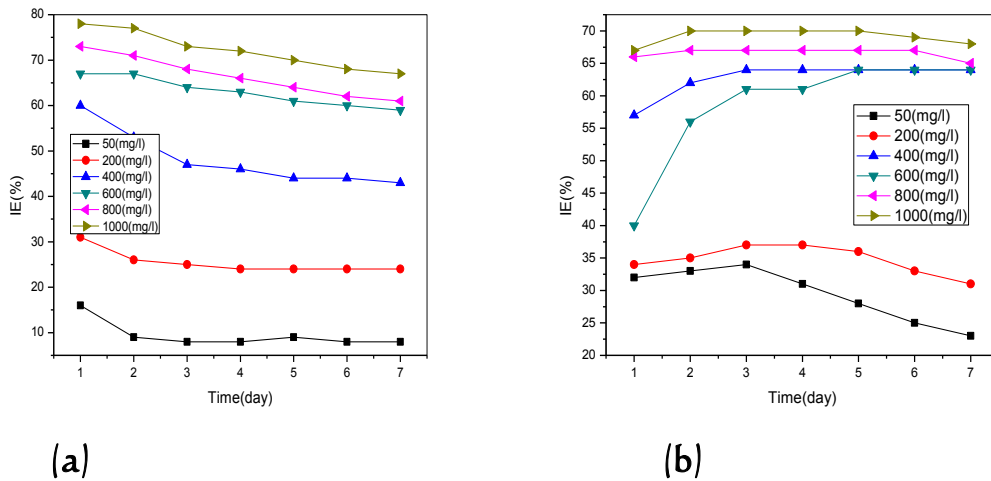


Fig. 5: Variation of inhibition efficiency with immersion time in CA bark extract (a) 0.5M H₂SO₄ and (b) 1M HCl.

The potentiodynamic polarization curves of *Figure 1* indicate that the mild steel specimen in both environments displayed active dissolution with no distinctive transition to passivation within the studied potential range. In agreement with the documentation of Ashassi-sorkhabi *et al*;

(2006), weight loss increases with time for both samples (*Leaf and Bark*) as indicated in *Figures 2 and 3*.

Figures 4 and 5 showed the variation of inhibition efficiency with *Chrysophyllum albidum* (CA) concentration and immersion time (*in 0.5M H₂SO₄ and 1M HCl*) for Leaf and Bark samples respectively. The low values observed at low CA concentrations (<50 mg/l) in 0.5M H₂SO₄ correspond to stimulation of the corrosion process. Nonetheless, inhibition efficiency in 1.0 M HCL increased steadily with increasing concentration, up to an optimum value of 92% (*at 1000 mg/l CA*) but reduced thereafter; whereas in 0.5M H₂SO₄, inhibition efficiency increased at 1000mg/l (84%) and reduced afterwards. But Ashassi-Sorkhabi and Nabavi-Amri (2000) reviewed that inhibition efficiency is more or less independent of immersion time and maintains steady values going within the first seven (7) days of the study. This clearly highlights the stability of the protective effect of CA at high concentrations. Such properties have been found particularly useful in corrosion protection of the material by the study samples (*Leaf and Bark of the CA*).

CONCLUSION

The present study, no doubt, provides new information on the inhibition characteristics of *Chrysophyllum albidum* leaf and bark extracts under the specified conditions. *Chrysophyllum albidum* leaf and bark extracts act as reliable inhibitors for mild steel corrosion in 0.5M H₂SO₄ and 1M HCL solutions respectively. The inhibition efficiency increased with increase in inhibitor concentration on both study samples (*CA Leaf and Bark extracts*), but decreased with time in the absence of an inhibitor. The inhibiting effect of the *Chrysophyllum albidum* leaf and bark extracts was attributable to the presence of the inherent phytochemical constituents (such as Tanins, Saponins and Cardiac Glycosides), which could be regularly adsorbed to the surface of the metal. The inhibitor could be easily sourced; it is very economical, environmental-friendly, non-toxic, renewable, readily and abundantly available. Though it is

biodegradable, it could be used in the elongation of service life of mild steel that is deployed into services in any aggressive environment.

It is, therefore, important to regularly encourage the use of plant extract in large-scale corrosion control activities; it is reliable and very dependable.

REFERENCES

- Al-Juaid S. S. (2007). Mono Azo Dyes Compounds as Corrosion Inhibitors for Dissolution of Aluminium in Sodium Hydroxide Solutions. *Portugaliae Electrochimica Acta*; 2(5): 363-373.
- Amin M. A., El-Rehim S. S., El-Sherbini E. E. and Bayoumi R. S.(2008). Chemical and Electrochemical (AC and DC) Studies on the Corrosion Inhibition of Low Carbon Steel in 1.0 M HCl Solution by Succinic Acid - Temperature Effect, Activation Energies and Thermodynamics of Adsorption. *Int. J. Electrochem. Sci.*;7(3): 199 – 215.
- Ashassi-Sorkhabi H. and Nabavi-Amri S. A.(2000). Corrosion Inhibition of Carbon Steel in Petroleum /Water Mixtures By N-Containing Compounds. *Acta Chim. Slov*; 4(7): 507-517.
- Chauhan J. S. and Gupta D. K. (2009). Corrosion Inhibition of Titanium in Acidic Media Containing Fluoride with Bixin; *E-Journal of Chemistry*; 6(4): 975-978.
- Eddy N. O., Odoemelam S. A. and Odiongenyi A. O. (2008). Ethanol Extract of *Musa acuminata* peel as an eco-friendly inhibitor for the corrosion of mild steel in H₂SO₄. *Advances in Natural and Applied Science*; 2(1): 35-42

- Kinani L. and Chtaini, A. (2007). Corrosion Inhibition of Titanium in Artificial Saliva Containing Fluoride. *Leonardo Journal of Sciences*; 4(6): 33-40.
- Mahmoud S. S. (2008). Hydrochloric Acid Corrosion Inhibition of Zn-Al-Cu Alloy by Methyl-Substituted Piperidines. *Portugaliae Electrochimica Acta*, 26, 245-256.
- Oguzie E .E (2005). Adsorption and corrosion inhibitive properties of *Azadirachta indica* in acid solutions. *Pigment and Resin Technology*; 35:334–340.
- Oguzie E .E (2008). Corrosion Inhibitive Effect and Adsorption Behaviour of Hibiscus Sabdariffa Extract on Mild Steel in Acidic Media. *Portuges Electrochem Acta* 26:303–314
- Oguzie E .E, Iyeh K. I, Onuchukwu A. I (2006). Inhibition of mild steel corrosion in acidic media by aqueous extract from *Garcinia kola* seed. *Bull Electrochem* 22:63
- Prabhu R. A., Venkatesha T. V. and Shanbhag A. V. (2009). Carmine and Fast Green as Corrosion Inhibitors for Mild Steel in Hydrochloric Acid Solution. *J. Iran. Chem. Soc.*,6(2), 353-363.
- Yordanov, D. and Petkov, P. (2008). Synthesis of Oxygenated Ethyl Esters of Tall Oil Fatty Esters and Characterization of their Properties as Corrosion Inhibitor to Mild Steel. *Journal of the University of Chemical Technology and Metallurgy*; 43(4), 399-404.