***Original Research Article***

**THE INHIBITIVE ACTION OF Ocimum gratissimum LEAF EXTRACT ON MILD STEEL CORROSION USING THE ULTRA VIOLET LIGHT**


## ABSTRACT

Addition of *Ocimum gratissimum* extract synergistically increased the efficiency of the inhibitor. UV radiation also increased the inhibitor efficiency and that corrosion activation energy increased in presence of the inhibitor. A mechanism of adsorption is proposed to explain inhibition behaviour.



*Keywords: Gravimetric technique, corrosion, uv radiation, inhibitor, leaf extract.*


**Commented [A1]:** The abstract succinctly summarizes the study's findings regarding the synergistic effect of Ocimum gratissimum extract and UV radiation on corrosion inhibition of mild steel. While it effectively highlights the key results, it lacks specific quantitative data to support the claims made. Additionally, it could benefit from providing a clearer statement of the study's objectives and implications.

## 1. INTRODUCTION

**Commented [A2]:** The introduction provides a comprehensive overview of corrosion and its significance, laying a strong foundation for the study. However, it could be more focused on directly addressing the research objectives and highlighting the novelty of the study within the existing literature. Incorporating specific references to previous studies on the inhibitive action of Ocimum gratissimum extract and UV radiation would enhance the introduction's credibility.

Corrosion is the gradual destruction of materials (usually metals) by chemical reaction with its environment. Corrosion occurs due to the natural tendency for most metals to return to their original state. Rusting, the formation of iron oxides is a well-known example of electrochemical corrosion. This type of damage typically produces oxides or salts of the original metal (Al-Otaibi *et al.,* 2014).

Many structural alloys corrode merely from exposure to moisture in air but the process can be strongly affected by exposure to certain substances. Corrosion can be concentrated locally from a pit or crack, or it can be extended across a wide area more or less uniformly corroding the surface (Arnand & Balasubiamanian, 2011).) The process of corrosion requires four elements; an anode, a cathode, an electrolyte and a metallic path. Corrosion cannot be prevented because it's a natural process but it can be controlled (Aliyu,*et al.,* 2022).

Corrosion destroys the useful properties of materials and structures including strength, appearance and permeability of liquids and gases.

Corrosion occurs in materials other than metals such as ceramics or polymers (Bethencourt, *et al.,* 2003)

As a result, methods to reduce the activity of the exposed surface such as passivation and chromate conversion can increase a material's corrosion resistance.

Electrochemical reaction is the fundamental reaction during the corrosion process, which the electron can flow from certain areas on the metal surface to other areas through a solution which can conduct electric current (Loto, *et al.,*2011)

Most corrosion reactions are electrochemical in nature, at anodic sites on the surface of iron goes into solution as ferrous ion, this leads to anodic reaction. As oxidation occurs in atoms , they release electrons whose negative charge would quickly build up in metals and prevent further anodic reaction (Alan and Araceli,2020).

The part of a metal surface which becomes the corroding area is called the anode, the other part which acts as the other electrode of the battery is called cathode, which does not corrode. At the cathodic site the electrons react with some reducible components of the electrolyte and they are removed from the metal. The corroding piece of the metal is known as “mixed electrode” since both cathodic and anodic processes occur on its surface (Talbot and Talbot, 2018)

Hydrogen ions form as a protective layer on the surface of the cathode, preventing or slowing down further corrosion. This effect is known as cathodic polarization. Salt water environments are exposed to atmospheric oxygen following reactions involving the hydrogen ion on the surface of the cathode being reduced to hydrogen and oxygen lend to the formation of water (Kumar *et al.,* 2022)

Corrosion takes place with pure water provided that oxygen is present. In such cases oxygen combines with the hydrogen generated at the cathode removing it and permitting the reaction to go on.

There are various types of corrosion which include Localized corrosion (Pitting corrosion) where the basic metal is eaten away and performed in places in the manner of holes, the rests of the surface being affected only slightly or not at all. This usually occurs in metals with passivation layers (Loto and Loto, 2011).

Inter granular corrosion usually occur from the outside within a grain structure of a metal. It is imperceptible or barely perceptible from outside since the corrosion proceeds at the grain boundaries. Stainless steel is an example (Loto and Loto, 2011).

Galvanic corrosionoccur when two different metals have physical contact with each other (Loto and Loto, 2011). It increases corrosion in crevices or cracks at contact surfaces.

Corrosion Inhibitors is a chemical compound that is added to a liquid or gas which decreases the corrosion rate of a material a metal or alloy (Chaubey *et al.,* 2015). The effectiveness of a corrosion inhibitor depends on fluid composition, quantity of water and flow regime. A common mechanism for inhibiting corrosion involves formation of a coating, often a passivation layer which prevents access of the corrosive substance of a metal They are also additives to the fluid that surrounds the metal. Permanent treatment such as chrome plating are not generally accepted inhibitors (Oguzie,2004).

ULTRA-VIOLET (UV) is an electromagnetic radiation with wavelength shorter than that of visible light but longer than x-rays. UV is found in sunlight and is emitted by electric arcs and specialized light such as black lights. It can cause chemical reactions and may cause many substances to glow (Oguzie *et al.,* 2007). UV rays are responsible for sunburn and also for the formation of vitamin D.

**1.2 STATEMENT OF PROBLEM**

Corrosion is a way of destroying materials, usually metals gradually through the chemical reaction process with the surrounding environment. This is caused by natural tendency for most metals to return to their original state. Rusting which is the formation of iron oxides, is a typical example of electrochemical corrosion. This damage results in the production of oxides or salts of the original metal (Al-Otaibi *et al.,*2014)

Corrosion be extended across a wide area or can be concentrated locally from a pit or crack. It can more or less uniformly corrode the surface (Arnand & Balasubiamanian, 2011).

The four elements required for the process of corrosion include; an anode, a cathode, an electrolyte and a metallic path. Corrosion cannot be prevented because it's a natural process but it can be controlled (Aliyu *et al.,*2022)

Corrosion occurs in materials other than metals such as ceramics or polymers (Bethencourt *et al.,* 2003). A primary cause of corrosion is due to an effect known as galvanic corrosion. All metals have different

natural electrical potentials. Metals are coupled together in a common environment which helps the steel corrode faster than normal.

Corrosion takes place with pure water provided that oxygen is present. In such cases oxygen combines with the hydrogen generated at the cathode removing it and permitting the reaction to go on.

Hydrogen ions form as a protective layer on the surface of the cathode, preventing or slowing down further corrosion. This effect is known as cathodic polarization. Salt water environments are exposed to atmospheric oxygen following reactions involving the hydrogen ion on the surface of the cathode being reduced to hydrogen and oxygen lend to the formation of water (Kumar *et al.,* 2022).

A corrosion inhibitor which is a chemical compound that is added to a liquid or gas which decreases the corrosion rate of a material usually a metal or alloy (Chaubey *et al.*,2015) can be used to prevent metal from rusting. One way to protect metal is by sacrificing a metal with a more active reduction potential through sacrificing coating. Developing a thick layer of corrosion in a process known as anodizing protects underlying metals from corrosion.

Other ways could include coating the metal with a thin layer of another metal by electrochemical means i.e. to electroplate, coating the metal surface with paint or ethanol provides a barrier between the metal surfaces and the moisture in the environment, thus removing the opportunity of oxygen and moisture to come in contact and to apply protective lubricants to metal to seal out moisture.

## 2. METHODOLOGY

**Commented [A3]:** The methodology section is well-structured and provides clear details on the experimental procedures. However, it lacks information on control variables and statistical analysis methods, which are essential for assessing the validity of the results. Including these details would improve the reproducibility and robustness of the study.

### 2.1 Study Area

This research was conducted at Owerri, a metropolitan center in Nigeria's Imo State. Imo State is a State in the South-East geopolitical zone of Nigeria, bordered by Anambra State to the North for 84km, Abia State to the East for about 104km and Rivers State to the South and West for about 122km. The state lies within latitudes 4º 45 N and 7º15'N and longitude 6º 50'E and 7º25'E, with an area of around 5,100 sq km.

The state has several natural resources which includes crude oil, natural gas, lead, Calcium Carbonate and zinc. Profitable flora including iroko, rubber tree and oil palm are also found in the state.

There are several institutions of higher learning including both State and Federal government run institutions such as Federal University of Technology, Owerri, Alvan Ikoku College of Education, Federal Polytechnic, Nekede, Imo State University, Owerri and an Airport called Sam Mbakwe International Cargo Airport.

**2.2 Research Design**

The experimental research design was used for this research.

**2.3 Sampling Technique**

The purposive sampling technique was used.

**2.4 Variables**

**2.4.1 Preparation of Specimen**

The mild steel was bought from the department of Material and Metallurgical Engineering in Federal University of Technology Owerri. The surface of the coupons was cleaned using smooth and rough emery paper from grit size 220 and above. The samples were neatly wiped with cotton wool, ethanol and dried with acetone and stored in a desiccator. Accurate weight of each coupon was taken and recorded as initial weight. The coupons were labeled to avoid mix up.

**2.4.2 Preparation of the extract**

The ethanol was added to the sample and leaf for 2days (48hrs). After 48hrs, the sample was squeezed using a sieve cloth and the chaff discarded. The volume of the inhibitor solution was measured out with a measuring cylinder.

**2.4.3 Preparation of Acid and Salt**

The acid used was Hydrochloric Acid and the salt was Sodium Chloride. The acid was prepared using the measuring cylinder (1000mg/dm$^3$) prior to that; the molar solution of HCl was gotten. 1dm$^3$ of the molar solution will contain 58.5g of HCl. Now, to get the volume of HCl that contains 58.5g.

$$Volume = \frac{Mass}{Density}$$

Where 3.14g is the weight of active sample

$$3.14g \longrightarrow 400ml$$

Amount in 1000ml

$$= \frac{3.14\ x\ 1000ml}{400ml} = 7.85g$$

Stock concentration = $7850mg/l$

**2.4.4 For The Salt**

29.25g of salt was added to 1000ml of distilled water until the desired quantity was gotten.

For the various concentrations used for dipping, the dilution formula was used i.e. $C_1V_1 = C_2V_2$

For 200 concentration = 7850 x ? = 200 x 200

$$= \frac{200\ x\ 200}{7850} = 5.1ml$$

For 400 concentration = $\frac{400\ x\ 200}{7850} = 10.2ml$

For 800 concentration = $\frac{800\ x\ 200}{7850} = 20.4ml$

For 1200 concentration $\frac{1200\ x\ 200}{7850} = 30.6ml$

**2.4.5 Experimental Method.**

**Ultra Violet Experiment (The UV Experiment)**

Two containers containing the highest concentration of each corrodent i.e. 1200mg/l of HCl and NaCl respectively were used.

Four well-polished coupons having mirror image were weighed and suspended over the corrodents HCl and NaCl respectively and placed in a dark cupboard over a UV light for one week.

After one week two coupons were removed weighed, snapped, discarded and the remaining two were sprayed for another one week and kept under the UV light, they were blow-dried and snapped for comparism. It was discovered that the HCl corroded more than the NaCl.

## 3. RESULTS AND DISCUSSION

Table 1 shows the weight of the coupons before and after the use of UV light in the acidic medium (HCl). The result shows that there was a reduction in the weight of the coupons, indicating that the UV light had had an effect on the coupons by reducing the corrosive effect.

Table 1: The weight of the coupons before and after the use of UV light.

| Before brushing | After brushing |
|---|---|
| 5.0403 | 4.7697 |

Table 2 shows the weight of the coupons before and after the use of UV light in the alkaline medium (NaCl). The result shows that there was a reduction in the weight of the coupons, indicating that the uv light had had an effect on the coupons by reducing the corrosive effect.

Table 2. Weight of the coupons before and after the use of UV light in the alkaline medium (NaCl).

| Before brushing | After brushing |
|---|---|
| 4.5647 | 4.5073 |

**Commented [A4]:** The results and discussion section presents experimental data effectively through tables and figures, demonstrating the effects of UV light on corrosion inhibition in both acidic and alkaline environments. However, the discussion lacks depth in interpreting the results within the context of existing literature and addressing potential limitations of the study. Incorporating a more thorough analysis of the implications of the findings and acknowledging any constraints or uncertainties would strengthen this section.

Table 3 shows the weight of the coupons before and after the use of UV light in the acidic medium (HCl) after a week. The result shows that there was a reduction in the weight of the coupons, indicating that the UV light had had an effect on the coupons by reducing the corrosive effect.

Table 3. The weight of the coupons before and after the use of UV light in the acidic medium (HCl)

| Before brushing | After brushing |
|---|---|
| 5.0938 | 4.6082 |

Table 4 shows the weight of the coupons before and after the use of UV light in the alkaline medium (NaCl) after a week. The result shows that there was a reduction in the weight of the coupons, indicating that the UV light had had an effect on the coupons by reducing the corrosive effect.

Table 4. The weight of the coupons before and after the use of UV light in the alkaline medium

| Before brushing | After brushing |
|---|---|
| 4.8786 | 4.7237 |

Figures 1 and 2 shows the effect of UV on NaCl before and after cleaning respectively. The result shows that the UV had an effect on the mild steel by reducing the corrosion.

**F**igure1. shows the effect of UV on NaCl before cleaning

**F**igure 2. shows the effect of UV on NaCl after cleaning

Figures 3 and 4 shows the effect of UV on HCl before cleaning and after cleaning respectively. The result shows that the UV had an effect on the coupons by reducing the corrosion.

**F**igure 3. shows the effect of UV on HCl before cleaning

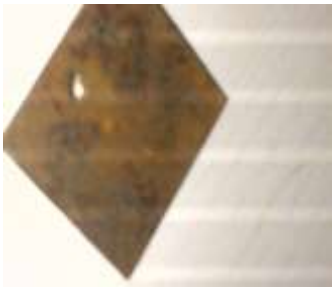
**F**igure 4. shows the effect of UV on HCl after cleaning all for the first week.

**F**igure 5. shows the effect of UV on NaCl after one week before cleaning

Figures 6 and 7 shows the effect of UV on HCl before cleaning and after cleaning respectively. The result shows that the UV had an effect on the coupons by reducing the corrosion.

**F**igure 6. shows the effect of UV on NaCl after one week after cleaning

Figure 7. shows the effect of UV on HCl after one week before cleaning



**F**igure 8. shows the effect of UV on HCl after one week after cleaning.

## 4. CONCLUSION AND RECOMMENDATION

The exposure of UV radiation showed that the extract was effective for both the acidic and the salt environment.

The following recommendations were made:

- With the results both graphically and pictorially, it is evident that *Ocimum gratissimum* is a good inhibitor and can be used both in an acidic and salt environment to reduce corrosion. I will hereby recommend it for further use to reduce corrosion.

**Commented [A5]:** The conclusion provides a concise summary of the study's findings and offers logical recommendations for further research. However, it could be strengthened by highlighting avenues for future research or practical applications of the findings. Additionally, providing a more nuanced discussion of the limitations and implications of the study's findings would enhance the conclusion's comprehensiveness.

## REFERENCES


1. Al-Otaibi, M.S., Al-Mayouf, A.M., Khan, M., Mousa, A.A., Mazroa, S.A and Alkhathlan, H.Z(2014). Corrosion inhibitory action of some plant extracts on the corrosion of mild steel in acidic media. *Arabian Journal of Chemistry* 7(3):340-346.
2. Arnand, B., and Balasubiamanian, V.(2011). Corrosion behaviour of mild steel in acidic medium in presence of aqueous extract of *Allamanda blanchetti*, *E-Journal of Chemistry* 8:226 – 230.
3. Aliyu, A.O., Awe, A.E., Faruruwa, M.D., and Abawua, T.E. (2022). Synthesis of some Schiff Bases and investigation of their corrosion inhibition efficiencies of Aluminium in acidic media, *Communication in Physical Sciences* 8(1): 42-57.

4. Bethencourt M., Botana F.J, Marcos M., Osuna R.M., and Sanchez – Amaya J.M. (2003) Inhibitor properties of “green” pigments for paints progress in organic coatings 46 280 – 287.
5. Loto, C.A., Loto, R.T and Popoola,A.P.I (2011). Corrosion and plants extracts inhibition of mild steel in HCl. *International Journal of the Physical Sciences* 6(15): 3616-3623.
6. Alan, M., and Araceli, E.V. (2020). Plant extracts as green corrosion inhibitors for different metal surfaces and corrosive media. *Processes* 8(8):942.
7. David Talbot and Jane Talbot (2018) Corrosion Science and Technology,CRC Press. London pp 596.
8. Kumar, H., Yadav, V and Kumari, A. (2022). Adsorption, corrosion inhibition mechanism and computational studies of *Azadirachta indica* extract for protecting mild steel: Sustainable and green approach. Journal of Physics and Chemistry 165: 110690.
9. Loto, C.A., Loto., R.T. (2011) Popoola, A.P. Effect of Neem leaf, Azarichita indica extract on the corrosion inhibition of mild steel in dilute acid, 6: 2249 – 2257.
10. Loto, C.A., Loto., R.T. (2011) Popoola, A.P. Effect of Neem leaf, Azarichita indica extract on the corrosion inhibition of mild steel in dilute acid, 6 2249 – 2257.
11. Chaubey, N., Singh,V.K., Savita., Quraishi, M.A., and Ebenso,E.(2015). Corrosion inhibition of Aluminum alloy in Alkaline media by Neolamaarkia cadamba bark extract as a green inhibitor. *International Journal ofElectrochemical Science*
12. Oguzie, E.E (2004). Influence of halide ions on the inhibitive effect of Congo red dye on the corrosion of mild steel in sulphuric acid solution, *Material Chemistry and Physics* 87 :212 – 217.
13. Oguzie E.E, Onuoha G.N.,and Ejike E.N [2007] effect of *gongronema latifolium* extract on aluminum corrosion in acidic and alkaline media, *Pigment and Resin Technology* 36(1)44 – 49.