# CORROSION PROTECTION OF MILD STEEL IN SIMULATED OFFSHORE ENVIRONMENT USING *Ocimum gratissimum* LEAF EXTRACT

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## ABSTRACT

The inhibitive action of *Ocimum gratissimum* leaf extracts on mild steel corrosion in 1M HCl and 0.5 NaCl solutions was studied using the Gravimetric technique. Four weighed well-polished coupons suspended into sample bottles labeled 200mg/l, 400mg/l, 800mg/l, 1200mg/l and the blank respectively was used. The results shown in Tables 1 to 5 is the weight loss data of mild steel in 0.1 M HCl and the effects of *Ocimum gratissimum* introduction and how the mild steel corroded progressively thereby increasing the weight loss value over immersion time as seen in Figure 1. Figure 2 shows the effects of *Ocimum gratissimum* extract concentration on the corrosion rate of mild steel in HCl, it is evident that increase in the concentration of the extract led to the decrease in the value of weight loss leading to appreciable inhibition efficiency. The plot in Figure 3 showed that the values of the inhibition efficiency increased with the concentration of *Ocimum gratissimum* extract in the acidic environment except the value for 9 days which decreased with concentration. These results led to decrease in the values of inhibition efficiency over time as shown in Figure 4. Tables 6 to 10 shows the weight loss data for the corrosion of mild steel in 0.5 M NaCl and the effects of *Ocimum gratissimum* introduction. The result showed that mild steel corroded, leading to fluctuations in the inhibition efficiency. Figures 5-8 showed the variations of efficiency with time with different concentrations of *Ocimum gratissimum* in 0.5 M NaCl. Addition of *Ocimum gratissimum* extract synergistically increased the efficiency of the inhibitor and helped reduce the corrosion rate. A mechanism of adsorption is proposed to explain inhibition behaviour.

*Keywords: Gravimetric technique; corrosion; UV radiation; inhibitor; leaf extract; Hydrochloric acid; Sodium Chloride.*

## 1. INTRODUCTION

### Corrosion

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)

Corrosion is a natural process. The primary aim of corrosion is to change iron from its natural state to steel (Oguzie *et al.,* 2007). Steel is an unstable state of iron. 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.

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 ions, 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 & 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 & 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.

Finally, subsequent reaction of the product of both anode and cathode form the visible products of corrosion which is known as rust.

A corrosion inhibitor 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). 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 (Loto *et al.,* 2011).

The use of plant extracts has become one of the methods to reduce corrosion/protecting metals from corrosion, especially in acidic media. They are more environmentally friendly compared to the likes of silicate, chromate and organic amines that are expensive, toxic and non-environmental friendly.

The inhibition performances of these extracts are usually attributed to the presence of tannin, alkanoids and nitrogen bases, amino acids and proteins. These organic compounds contain polar functions with nitrogen, Sulphur, oxygen atoms as well as conjugated double bonds or atomic rays in their molecular structures which are the major adsorption centers.

*Ocimum gratissimum* is also known as Clove Basil, African Basil or in the island of Hawaii as Wild Basil. It belongs to the plant family of Lamiaceae, Genus of *Ocimum* and is binomially referred to as *Ocimum* *gratissimum* or *O. gratissimum* for short. Locally, it is called scent leaf or Nnchawu. The plant is used traditionally to treat gastrointestinal disorders, diabetes, sexual disorders, and fertility problems (Kirk *et al.,* 2021)

This research records and discusses the results of experiments carried out by the author to verify the inhibitive effects of *Ocimum gratissimum* on metals in both salt and acidic environment. Sufficient quantity of ethanol was added to the extract and its effect on the inhibition efficiency was observed throughout the experiments.

## 1.1 STATEMENT OF PROBLEM

Corrosion is the process of destroying materials, mostly metals gradually by chemical reaction with the surrounding environment. It is as a result of the natural tendency for most metals to return to their original state. The formation of iron oxides mostly referred to as rusting, is a typical example of electrochemical corrosion. This damage produces oxides or salts of the original metal (Al-Otaibi *et al.,*2014)

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 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

### 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 (Chukwu *et al.,* 2011). and Rivers State to the South and West for about 122km. The state lies within latitudes $4^{o}$ 45 N and $7^{o}$15’N and longitude $6^{o}$ 50’E and $7^{o}$25’E, with an area of around 5,100 sq km (Chukwu *et al.,* 2011).

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 (Jacobsen, 2018).

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 (Chukwu *et al.,* 2011).

## 2.2 Research Design

The experimental research design was used for this research. Two containers containing 1200mg/l concentration of each corrodent, that is 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. The process was repeated after one week interval for the remaining two coupons.

## 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 Collection of Sample and Preparation of Extract (Inhibitor)

**Sourcing:**

The leaves of the scent leaf used for this experiment were bought in the market. The leaves were dried for at least seven days. The leaves after being removed from their stem were put in the grinding machine and ground dry without adding water. A bowl was kept at the lower end of the grinder to collect the ground leaves. The ground sample was stored in a container to avoid water touching it. 40g of the sample was weighed out after grinding.

### Preparation of the extract

The ethanol was added to the sample and was soaked for 2days (48hrs). After 48hrs, the sample was squeezed using a sieve cloth and the chaff was left to dry for 5 days, reweighed and discarded.

The volume of the inhibitor solution was measured out with a measuring cylinder.

### 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 = $7850mg/l$

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

After measuring the concentrations into the sample bottles, the coupons were reweighed again to make sure there was no addition of weight and are ready for immersion.

### 2.4.3 Experimental Materials / Method

This research involved the use of many materials and equipment which include distilled water, acid (Distilled) – HCl, ethanol, salt – sodium chloride (NaCl), beakers, measuring cylinder (100mg/l), thread, sticks (Dry and Clean) used to suspend the coupons, emery paper (Smooth and Rough), funnel, sample bottles, sample (Scent leaf), Sample Extract, weighing balance for weighing, generator to ensure steady power during weighing, 20 metal coupons (The Specimen), sieve cloth – for squeezing out inhibitor extract, grinder and bench for mounting the grinder, water (hot distilled) – for washing materials before and after use, baths and buckets – for washing, soap and detergent – for washing, rags, cotton wool, stabilizer and extension plug, watch, syringes, masking tape, stirrer, spray pump (two) and water blower for drying the coupons.

**There are two methods that can be used for this experiment.**

a. **The Immersion/Weight loss measurement**

The prepared sodium chloride and Hydrochloric acid in IM HCl and 0.5M NaCl respectively are stored in a gallon each.

The sample bottles were labeled according to concentrations i.e. blank, 200mg/l, 400mg/l, 800mg/l and 1200mg/l. The volume was calculated using the dilution formula

Each concentration was measured from the sample extract with a syringe or a measuring cylinder into a beaker respectively.

The coupons were polished with emery paper of grit size 220 (both rough and smooth) and clean up the coupon with a cotton wool immersed in ethanol and dry with acetone.

Weighed coupons were suspended into beakers containing the test solution using wooden cross bars and twine. The starting time was recorded and left for 3days (72hrs). The weights of the coupons were noted before immersion. After every immersion time (72hrs), the coupons were removed, polished with a brush, washed in distilled water and ethanol, degreased with acetone and dried in warm air and reweighed.

From the initial and final weight of the coupons, the weight loss was calculated and the corrosion rate efficiency of the inhibitor was computed.

### b. Splash method/Spray method

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 a mirror image were weighed and dipped in the extract (inhibitor) for 48hrs then they were blow dried and reweighed.

The four coupons were suspended with four other untreated coupons in the corrodents (HCl and NaCl respectively).

They were sprayed for 1 week using the different corrodents on each of the containers.

After one week, 2 coupons were removed from each container/corrodent, pictures of the coupons were taken. The remaining coupons were sprayed for another one week, blow dried and snapped for comparism.

## 3. RESULTS AND DISCUSSION

### 3.1 Weight Loss

Table 1 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* in an acidic medium after 3 days. The result showed that the inhibition efficiency increased and the rate of corrosion was most in 200mg/dm$^3$ concentration compared to the blank.

**TABLE 1. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 3days in an acidic medium (HCl).**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9876 | 4.8703 | 0.1173 | 0.115 | - |
| B | 5.1372 | 5.0246 | 0.1127 | | |
| 200 A | 4.6013 | 4.5712 | 0.0301 | 0.0297 | 74.2 |
| B | 4.6091 | 4.5799 | 0.0292 | | |
| 400 A | 4.8439 | 4.8188 | 0.0251 | 0.0216 | 81.2 |
| B | 5.1936 | 5.1756 | 0.018 | | |
| 800 A | 5.0222 | 5.0091 | 0.0131 | 0.01475 | 86.96 |
| B | 4.6321 | 4.6157 | 0.0164 | | |
| 1200 A | 5.0413 | 5.0233 | 0.018 | 0.0172 | 85.22 |
| B | 4.8826 | 4.8662 | 0.0164 | | |

Table 2 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* in an Acidic medium after 6 days. The result showed that the inhibition efficiency increased and the rate of corrosion increased most in 800mg/dm$^3$ concentration compared to the blank.

**TABLE 2. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 6days in as acidic medium (HCl).**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9876 | 4.8396 | 0.146 | 0.1606 | - |
| B | 5.1372 | 4.9640 | 0.1732 | | |
| 200 A | 4.6013 | 4.5467 | 0.0546 | 0.05265 | 67.22 |
| B | 4.6091 | 4.5584 | 0.0507 | | |
| 400 A | 4.8439 | 4.7948 | 0.0491 | 0.0446 | 72.23 |
| B | 5.1936 | 5.1532 | 0.0401 | | |
| 800 A | 5.0222 | 4.9916 | 0.0306 | 0.0347 | 78 |
| B | 4.6321 | 4.5933 | 0.0388 | | |
| 1200 A | 5.0413 | 5.0074 | 0.0339 | 0.035 | 78.2 |
| B | 4.8826 | 4.8465 | 0.0361 | | |

Table 3 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* in an Acidic medium after 9 days. The result showed that there was a decrease in the inhibition efficiency and the metals corroded more in 800mg/dm$^3$ concentration.

**TABLE 3. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 9days in an acidic medium (HCl)**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9876 | 4.8133 | 0.1743 | 0.1898 | - |
| B | 5.1372 | 4.9319 | 0.2053 | | |
| 200 A | 4.6013 | 4.5303 | 0.071 | 0.0674 | 64.5 |
| B | 4.6091 | 4.5381 | 0.0638 | | |
| 400 A | 4.8439 | 4.7814 | 0.0625 | 0.1245 | 34.5 |
| B | 5.1936 | 5.1316 | 0.062 | | |
| 800 A | 5.0222 | 4.9750 | 0.0472 | 0.1041 | 45.2 |
| B | 4.6321 | 4.5752 | 0.0569 | | |
| 1200 A | 5.0413 | 4.9991 | 0.0422 | 0.124 | 34.67 |
| B | 4.8826 | 4.8206 | 0.062 | | |

Table 4. The weight loss and inhibition efficiency of *Ocimum gratissimum* in an acidic medium after 12 days. The result showed that the inhibition efficiency decreased.

**TABLE 4. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 12days in an acidic medium (HCl)**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9876 | 4.7867 | 0.2009 | 0.216 | - |
| B | 5.1372 | 4.9061 | 0.2311 | | |
| 200 A | 4.6013 | 4.5138 | 0.0875 | 0.08885 | 58.9 |
| B | 4.6091 | 4.5189 | 0.0902 | | |
| 400 A | 4.8439 | 4.7563 | 0.0876 | 0.08215 | 62 |
| B | 5.1936 | 5.1169 | 0.0767 | | |
| 800 A | 5.0222 | 4.9584 | 0.0638 | 0.06685 | 69.1 |
| B | 4.6321 | 4.5622 | 0.0699 | | |
| 1200 A | 5.0413 | 4.9835 | 0.0578 | 0.0697 | 67.7 |
| B | 4.8826 | 4.8010 | 0.0816 | | |

Table 5 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* in an Acidic medium after 15 days. The result showed that there was an increase in the inhibition efficiency and the rate of corrosion was more in 1200mg/dm$^3$ of the concentration.

**TABLE 5. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 15days in an acidic medium (HCl)**

| System $mg/dm^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9876 | 4.7549 | 0.2327 | 0.25635 | - |
| B | 5.1372 | 4.8572 | 0.28 | | |
| 200 A | 4.6013 | 4.4859 | 0.1154 | 0.11315 | 55.9 |
| B | 4.6091 | 4.4982 | 0.1109 | | |
| 400 A | 4.8439 | 4.7334 | 0.1105 | 0.1145 | 57 |
| B | 5.1936 | 5.0812 | 0.1124 | | |
| 800 A | 5.0222 | 4.9380 | 0.0842 | 0.08445 | 67 |
| B | 4.6321 | 4.5474 | 0.0847 | | |
| 1200 A | 5.0413 | 4.9684 | 0.0729 | 0.0895 | 65 |
| B | 4.8826 | 4.7765 | 0.1061 | | |

Table 6 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* after 3 days in an alkaline medium. The result showed that 800mg/dm$^3$ corroded more than the blank.

**TABLE 6. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 3days in a salt medium (NaCl)**

Table 6 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* after 6 days. The result showed that the 400mg/dm$^3$ concentration corroded more than the blank.

| System $mg/dm^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9396 | 4.7803 | 0.1593 | 0.0841 | - |
| B | 5.1249 | 5.1160 | 0.0089 | | |
| 200 A | 5.2674 | 5.2557 | 0.0117 | 0.0109 | 87.0 |
| B | 4.7327 | 4.7226 | 0.0101 | | |
| 400 A | 5.0134 | 4.9953 | 0.0181 | 0.0148 | 82.4 |
| B | 4.7849 | 4.7734 | 0.0115 | | |
| 800 A | 5.0846 | 5.0743 | 0.0103 | 0.0141 | 83.7 |
| B | 4.9780 | 4.9601 | 0.0179 | | |
| 1200 A | 5.0797 | 5.0697 | 0.01 | 0.01375 | 83.7 |
| B | 4.9929 | 4.9754 | 0.0175 | | |

**TABLE 7. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 6days in a salt medium (NaCl)**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9396 | 4.7741 | 0.1655 | 0.09335 | - |
| B | 5.1249 | 5.1037 | 0.0212 | | |
| 200 A | 5.2674 | 5.2448 | 0.0226 | 0.0231 | 75.3 |
| B | 4.7327 | 4.7091 | 0.0236 | | |
| 400 A | 5.0134 | 4.9826 | 0.0308 | 0.02605 | 72.0 |
| B | 4.7849 | 4.7636 | 0.0213 | | |
| 800 A | 5.0846 | 5.0662 | 0.0184 | 0.02905 | 68.9 |
| B | 4.9780 | 4.9383 | 0.0397 | | |
| 1200 A | 5.0797 | 5.0588 | 0.0209 | 0.0263 | 72.0 |
| B | 4.9929 | 4.9612 | 0.0317 | | |

Table 8 and 9 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* after 9 days. The result showed that there was a decrease in the inhibition efficiency.

**TABLE 8. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 9days in a salt medium (NaCl)**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9396 | 4.7633 | 0.1763 | 0.1016 | - |
| B | 5.1249 | 5.0980 | 0.0269 | | |
| 200 A | 5.2674 | 5.2281 | 0.0393 | 0.03435 | 66.0 |
| B | 4.7327 | 4.7033 | 0.0294 | | |
| 400 A | 5.0134 | 4.9706 | 0.0428 | 0.03865 | 62.0 |
| B | 4.7849 | 4.7504 | 0.0345 | | |
| 800 A | 5.0846 | 5.0554 | 0.0292 | 0.0411 | 59.5 |
| B | 4.9780 | 4.9250 | 0.053 | | |
| 1200 A | 5.0797 | 5.0340 | 0.0457 | 0.04185 | 58.81 |
| B | 4.9929 | 4.9549 | 0.038 | | |

**TABLE 9 The weight loss and inhibition efficiency of *Ocimum gratissimum* after 12days in a salt medium**

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9396 | 4.7556 | 0.184 | 0.1102 | - |
| B | 5.1249 | 5.0885 | 0.0364 | | |
| 200 A | 5.2674 | 5.2231 | 0.0443 | 0.0391 | 64.5 |
| B | 4.7327 | 4.6988 | 0.0339 | | |
| 400 A | 5.0134 | 4.9551 | 0.0583 | 0.05155 | 55 |
| B | 4.7849 | 4.7401 | 0.0448 | | |
| 800 A | 5.0846 | 5.0496 | 0.035 | 0.0501 | 54.6 |
| B | 4.9780 | 4.9128 | 0.0652 | | |
| 1200 A | 5.0797 | 5.0162 | 0.0635 | 0.05685 | 48.4 |
| B | 4.9929 | 4.9427 | 0.0502 | | |

Table 10 shows the weight loss and inhibition efficiency of *Ocimum gratissimum* after 12 days. The result showed a decrease in the inhibition efficiency. In this case *Ocimum gratissimum* acts as a good inhibitor of corrosion of mild steel both in Acidic and Salt environment.

| System mg/dm$^3$ | Initial reading | Final reading | Weight loss | Average weight loss | % IE |
|---|---|---|---|---|---|
| Blank A | 4.9396 | 4.7272 | 0.2119 | 0.1303 | - |
| B | 5.1249 | 5.0762 | 0.0487 | | |
| 200 A | 5.2674 | 5.2674 | 5.2063 | 0.0611 | 60.2 |
| B | 4.7327 | 4.7327 | 4.6899 | 0.0428 | |
| 400 A | 5.0134 | 4.9433 | 0.0701 | 0.0625 | 52 |
| B | 4.7849 | 4.7300 | 0.0549 | | |
| 800 A | 5.0846 | 5.0412 | 0.0434 | 0.0605 | 54 |
| B | 4.9780 | 4.9004 | 0.0776 | | |
| 1200 A | 5.0797 | 5.0043 | 0.0754 | 0.07425 | 43 |
| B | 4.9929 | 4.9198 | 0.0731 | | |

**TABLE 10. The weight loss and inhibition efficiency of *Ocimum gratissimum* after 15days in a salt medium (NaCl**

### 3.2 Mild Steel Corrosion in HCl and The Inhibition with *Ocimum gratissimum.*

**Tables 1 to 5** shows the weight loss data for the corrosion of mild steel in 0.1 M HCl and the effects of *Ocimum gratissimum* introduction.

The results showed that mild steel corroded progressively with time in the acidic environment thereby increasing the weight loss value over immersion time as shown in Figure1.

Secondly, from the plot in Figure 1, addition of *Ocimum gratissimum* extract actually reduced the values of weight loss or corrosion rate of the mild steel in the acidic environment.

Figure 2 shows the effects of *Ocimum gratissimum* extract concentration on the corrosion rate retardation of mild steel in the studied medium. From the results in tables 1- 5 and Figure 2, it is evident that increase in the concentration of the extract leads to the decrease in the value of weight loss or corrosion rate leading to appreciable inhibition efficiency.

Then the inhibition efficiency values were estimated using the equation

$$\%IE = 1- \frac{W\ blank}{W\ Inhibitor} \times \frac{100}{1}$$

From the tables 1 -5 and the plot in Figure 3, it showed that the values of the inhibition efficiency increased with the concentration of *Ocimum gratissimum* extract in the acidic environment except the value for 9 days which decreased with concentration. These results led to decrease in the values of inhibition efficiency over time as shown in Figure 4.

Tables 6 to 10 shows the weight loss data for the corrosion of mild steel in 0.5 M NaCl and the effects of *Ocimum gratissimum* introduction.

The result showed that mild steel corroded there was fluctuations in the inhibition efficiency. The introduction of the extract helped reduce the corrosion rate.

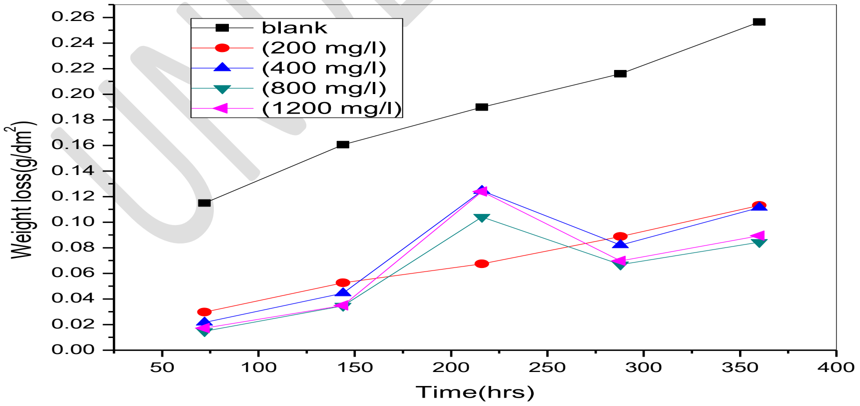

Figure 1: Variation of weight loss with time without and with different concentrations of *Ocimum gratissimum* in 1 M HCl.

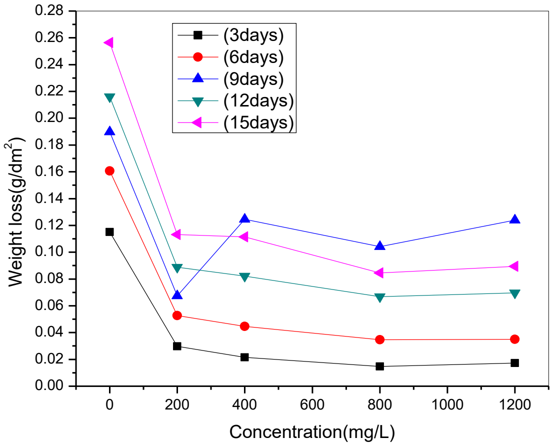

Figure 2: Variation of weight loss with different concentrations of *Ocimum gratissimum* in 1 M HCl.

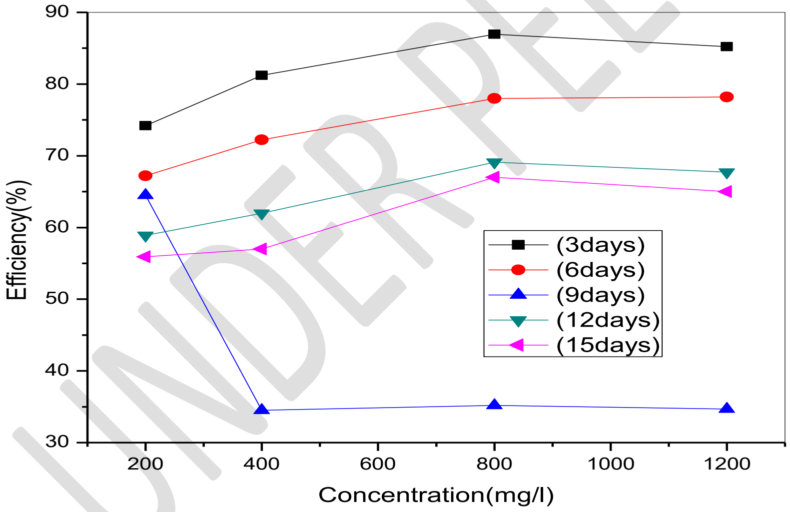

Figure 3: Variation of efficiency with different concentrations of *Ocimum gratissimum* in 1 M HCl.

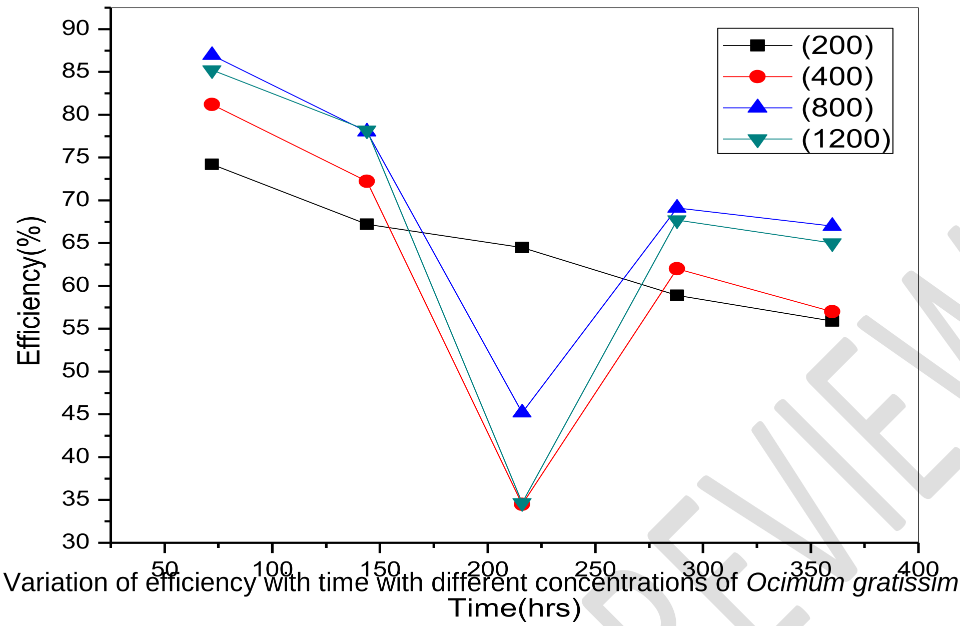

Figure 4: Variation of efficiency with time with different concentrations of *Ocimum gratissimum*in 1 M HCl.

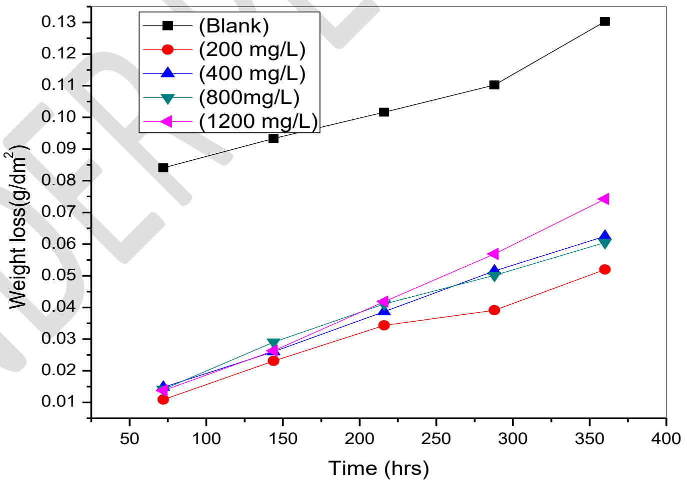

Figure 5: Variation of weight loss with time without and with different concentrations of *Ocimum gratissimum* 0.5 M NaCl

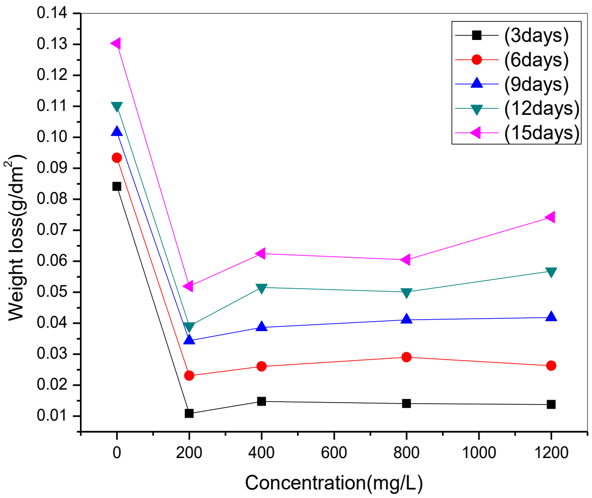

Figure 6: Variation of weight loss with different concentrations of *Ocimum gratissimum* in 0.5 M NaCl

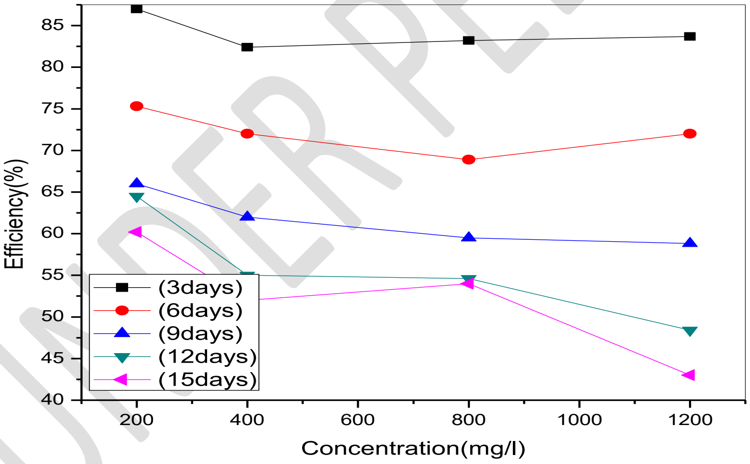

Figure 7: Variation of efficiency with different concentrations of *Ocimum gratissimum*in 0.5 M NaCl.

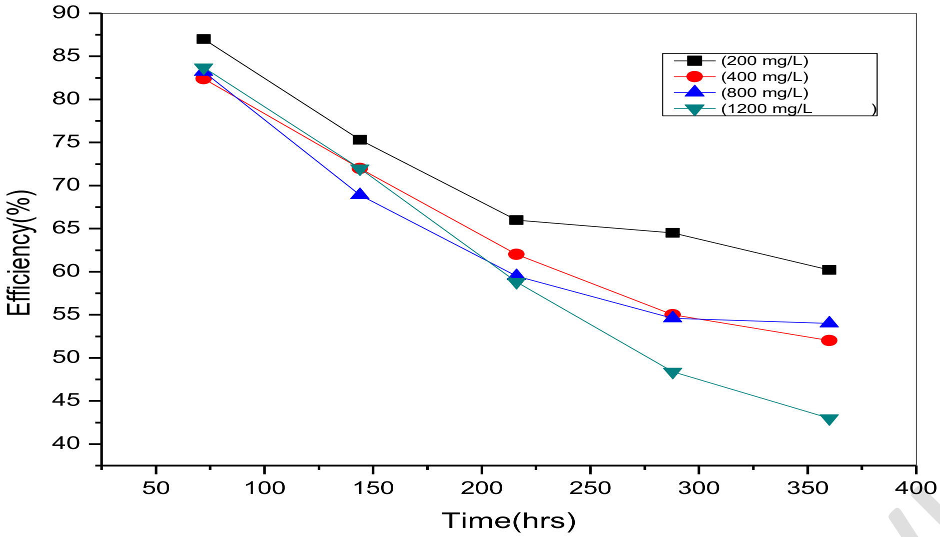

Figure 8: Variation of efficiency with time with different concentrations of *Ocimum gratissimum* in 0.5 M NaCl.

## 4. CONCLUSION AND RECOMMENDATION

- The gravimetric results showed that mild steel corrodes indefinitely in acidic environment and thus loses weight with exposure time.
- The gravimetric results showed that mild steel corroded uniformly in the salt environment except for the ones for weight loss against time and efficiency against concentration.
- The introduction of *Ocimum gratissimum* extract into the acidic environment improved the corrosion inhibition of mild steel or retarded the corrosion rate. The inhibition efficiency increases with *Ocimum gratissimum* extract concentration but decreased with immersion time.
- The introduction of the extract into the salt environment decreased the inhibiton
- Therefore, from the experimental data, *Ocimum gratissimum* extract is a good inhibitor for mild steel in both acidic and salt environment.

Following the findings of this research, the following recommendations were made:

- Given the graphical and pictorial representations of the research findings, it is evident that *Ocimum gratissimum* extract serves as a reliable corrosion inhibitor in both acidic and salt environments. It is recommended for further exploration and potential application to mitigate corrosion effectively.

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