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**Corrosion Inhibition of Mild Steel Using Plant Extract (*Vernonia amygdalina* (Bitter leaf) and *Azadirachta indica* (Dogoyaro)).**

**National Conference on Infrastructural Development and Maintenance in the Nigerian Environment. Nnamdi Azikiwe University, Awka**

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**ABSTRACT**

The corrosion inhibition of mild steel, coated with *Vernonia amygdalina* (Bitter Leaf) and *Azadirachta indica* (Dogoyaro) and immersed in hydrochloric acid (HCl) solution, tetraoxosulphate (IV) acid (H<sub>2</sub>SO<sub>4</sub>) solution, trioxonitrate (v) acid (HNO<sub>3</sub>) solution, distilled water, sea water and exposed to the atmosphere, was investigated in a laboratory scale experiment. The concentration of the acids used was 2.5M for each acid. The weight loss method, corrosion rate and inhibitive efficiency was used to carry out the experiment, at intervals of four (4) hours for twenty-four (24) hours for the acid test and seven (7) days interval for a period of forty-two (42) days for the other test with sea water, distilled water and exposure to the atmosphere and the results were obtained and recorded accordingly. The results obtained showed that the *Vernonia amygdalina* (Bitter leaf) and *Azadirachta indica* have inhibitive efficiencies of 91% and 69% respectively in acid solutions . *Azadirachta indica* proved to be a better inhibitor at the early stage of immersion in HCl with efficiency of 43% and was the best inhibitor in H<sub>2</sub>SO<sub>4</sub> with an efficiency of 91% at the early stage of immersion in the acid. The test on HNO<sub>3</sub> was not successful due to corrosive nature of the acid even when the concentration was reduced.

**Keywords: Corrosion Inhibition, Mild Steel, *Vernonia Amygdalina* (Bitter Leaf), *Azadirachta Indica* (Dogoyaro).**

**1. INTRODUCTION**

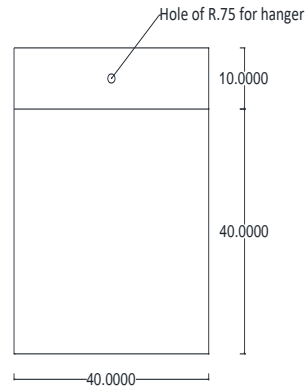
Corrosion of metal is a serious environmental problem that has been given adequate attention in the oil and gas industries, because during industrial processes in all these industries such as acid cleaning and etching, metal surfaces are often made to come into contact with the acid medium and these metals corrode due to the attack of the acid on the metal. Corrosion is an inevitable phenomenon and the only way to avoid corrosion totally is to operate in a vacuum but conditions make it impossible [1]. Acid solutions are extensively used in industry, the most important of which are acid pickling, industrial acid cleaning, acid decaling and oil well acidizing. The commonly used acids are hydrochloric acid, sulphuric acid, nitric acid, etc. Since acids are aggressive, inhibitors are usually used to minimize the corrosive attack on metallic materials [3]. Inhibitors are widely used in the corrosion protection of metals in several environments [1]. Lowering the aggressiveness of an environment towards a metal can reduce corrosion rate. This is usually done by the addition of inhibitors. Corrosion inhibitors are substances which, when added to a corrosion system decrease or eliminate anodic dissolution. This may be achieved by lowering anodic or cathodic reaction rates or both simultaneously [2]. This study on corrosion inhibition of mild steel and stainless steel in different media investigates the different inhibitive efficiencies of *Vernonia amygdalina* (Bitter leaf) and *Azadirachta indica* (Dogoyaro) in reactive environments. The findings will provide solutions to corrosion problems by creating means for reducing the effect of these environments on the metals. Corrosion inhibitors are added in little concentration to enhance performance, usually to acids, cooling water, steam and other environments continuously or intermittently, to prevent serious corrosion. Inhibitors cover a wide field of anti-corrosion measures, although a lot of work on the subject is concerned with preventing the attack of specific chemicals on certain metals during manufacturing, transport or storage [2]. Most proposed inhibitors fall into one of the following categories; natural plant or animal products, dyes, industrial by-products or pure chemical compounds.

## **2. Experimental procedure**

### **2.1 PREPARATION OF SPECIMENS.**

Mild steel from universal steel co. Lagos were used. The percentage composition of mild steel was 0.0292% C, 0.0062% Si, 0.0152% S, 0.2529% Mn, 0.0096% P, 0.0261% Ni, 0.0125% Cr, 0.0869% Cu, 0.0047% Mo, 0.1006% As, 0.0101% Sn, 0.003% Co, 0.0071% Al, 0.0005% Zn and finally 99.535% Fe.

The steel was cut into various pieces of the same measured dimensions of 1mm x 50mm x 40mm. holes were drilled in the coupons to enable the insertion of a hanger for ease of access of the coupons during removal.



**Fig 2.1: coupon dimension**

The coupons were ground with different grades of emery or abrasive paper; 160, 220, 320, 600, 1000 and 1500 grits i.e. from coarser to finer.

The specimens were thoroughly cleaned in acetone, dried and kept in a local desiccator for further test.

## **2.2 PREPARATION OF LEAF EXTRACTS**

The inhibitor used are *vernonia amygdalina* (bitter leaf) and *Azadirachta indica* (*Dogoyaro*). The leaves were obtained from a farmyard at School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The liquid extracts used as the inhibitor was obtained by squeezing in a juice extractor to extract the liquid in it.

## **2.3 EXPERIMENTAL SET-UP**

After cutting and preparing the steel specimens and the extract, the steel specimens were smeared with the extracts and dried in a dryer at a temperature of 50°C. The dried coupons were tagged using a white cello tape as follows;

1. Thirty-six (36) mild steel coupons smeared with *vernonia amygdalina* were tagged **BM<sub>1</sub> – BM<sub>36</sub>**

2. Thirty-six (36) mild steel coupons smeared with *azadirachta indica* were tagged **DM<sub>1</sub>-DM<sub>36</sub>**
3. Thirty-six (36) mild steel coupons not smeared tagged **NM<sub>1</sub>-NM<sub>36</sub>**

The prepared specimens were all weighed on an electronic mass balance at the Department of Materials and Metallurgical Engineering Laboratory, Federal University of Technology, Owerri. The readings for the initial weight of the specimens were recorded.

### 2.3 SET-UPS

In this series, the coupons or specimens were immersed in each of the acid solution used in this work. The acids used were; Hydrochloric acid, (HCl acid), trioxonitrate (V) acid, (HNO<sub>3</sub>) and tetraoxosulphate (VI) acid, each of a concentration of 2.5M.

Eighteen (18) coupons were arranged in each container in three rows and six columns. Two columns contained coupons smeared with a particular inhibitor and the last row with that of the unsmeared coupons.

The acids were poured into the containers with already placed coupons and the monitoring was done at intervals of four hours. This was carried out of about 24hours. The coupons were arranged for the various acid tests as follows;

1. For test of HCl on mild steel,

**BM<sub>1</sub>-BM<sub>6</sub> .....1<sup>ST</sup> Column**

**DM<sub>1</sub>-DM<sub>6</sub> .....2<sup>ND</sup> Column**

**NM<sub>1</sub>-NM<sub>6</sub> .....3<sup>RD</sup> Column**

2. For the test of H<sub>2</sub>SO<sub>4</sub> on Mild steel,

**BM<sub>7</sub>-BM<sub>12</sub> .....1<sup>ST</sup> Column**

**DM<sub>7</sub>-DM<sub>12</sub>.....2<sup>ND</sup> Column**

**NM<sub>7</sub>-NM<sub>12</sub> .....3<sup>RD</sup> Column**

3. For the test of HNO<sub>3</sub> on mild steel,

**BM<sub>13</sub>-BM<sub>18</sub> .....1<sup>ST</sup> Column**

**DM<sub>13</sub>-DM<sub>18</sub> .....2<sup>ND</sup> Column**

NM13-NM18 .....3<sup>RD</sup> Column

Each specimen was removed from the first row after four hours until the expiration of the 24hrs timing.

**1.4. MEASUREMENTS**

On any monitoring time, (four hours' interval for series A and seven days' interval for series B and series C, the initially weight specimens were now reweighed and subsequence the weight losses were calculated accordingly.

**1.4.1. WEIGHT LOSS MEASUREMENT**

The specimens were always removed at interval at intervals of four (4) hours for series A as indicated earlier and 7 days for series B and C respectively, after which were washed with water and subsequently a cork was used to scrub the corrosion products as well as other dirt clinging unto the coupons. The specimens now weighted on a suitable electronic mass balance hence the weight obtained were compared with the initial values to obtain the weight losses in grams.

Weight loss=initial weight- final weight.

$W_L = W_I - W_F$  (Nwoko et al 2005).....(3.1)

$W_L$ =weight loss

$W_I$ = initial weight

$W_F$ = final weight

**1.4.2. CORROSION RATE MEASUREMENT**

A typical corrosion rate expressing weight loss per Area per unit time is given below as corrosion rate.

$$C.R = \frac{\text{Weight loss}}{\text{Area} \times \text{Time}} \quad \text{Or} \quad \frac{W}{A \times T}$$
(Nwoko et al 2005) ..... 3.2

$A = \text{total surface area in (Cm}^2) = 2lw + 4lt - \pi r^2$ 
..... 3.3

(Where L= length, W= width, t= thickness, r= radius).

T= exposure time in hours.

### 1.4.3. INHIBITIVE EFFICIENCY OF INHIBITORS

The percentage inhibitive efficiency, EI was calculated from relationship

$$E.I = \left[ \frac{R_{free} - R_{inh}}{R_{free}} \right] \times 100$$

(Nwoko et al 2005)

3.4

Where EI = inhibitor efficiency

$R_{inh}$  = corrosion rate with inhibitor

$R_{free}$  = corrosion rate without inhibitor

## 3.3. DISCUSSION

### 3.3.1. SERIES A: ACID TEST ON COUPONS

#### 3.3.1.1. Weight LOSS (mild steel immersed in 2.5mol of HCL)

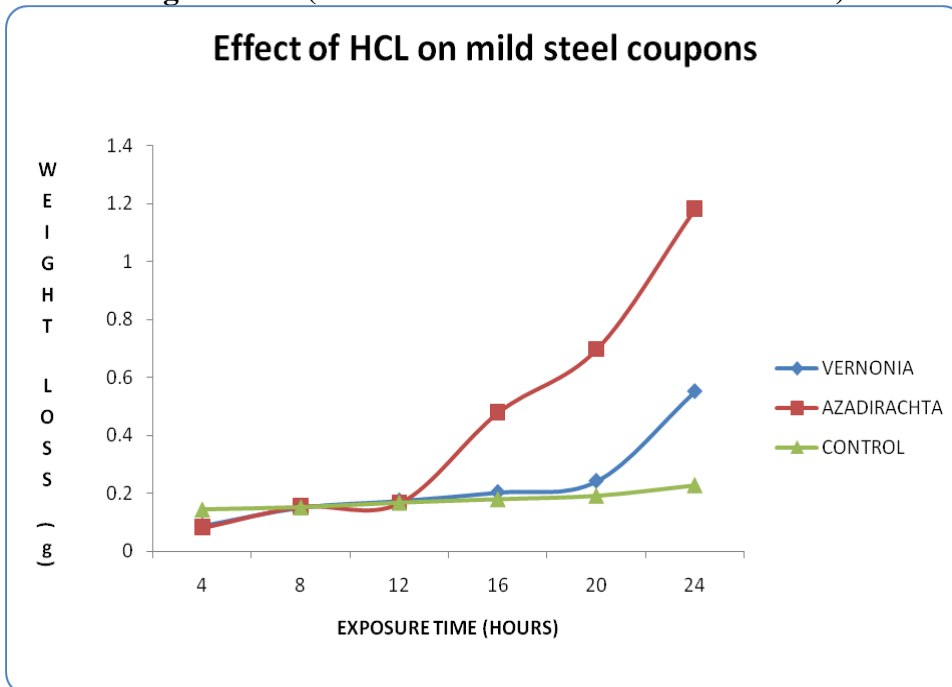
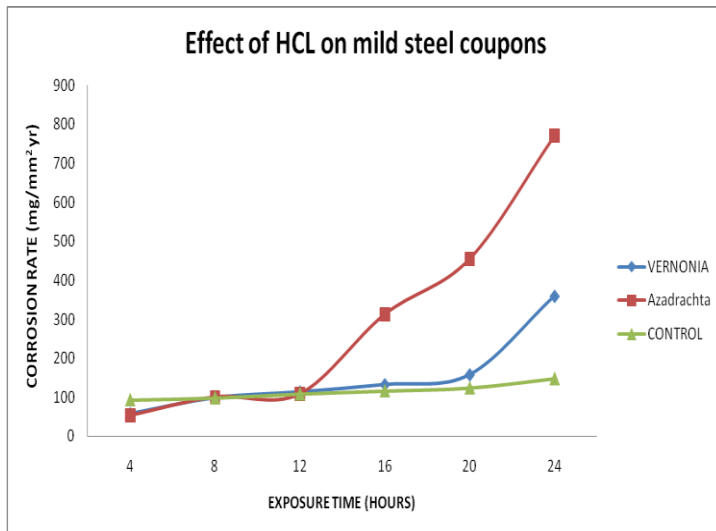


Fig. 3.1: Graph showing weight loss of mild steel coupons in HCL

The graph weight of loss with exposure time of the Coupons smeared with inhibitors, (*Azadirachta indica* and *vernonia amygdalina*), together with the unsmeared coupons. There is a progressive loss in weight observed in the three (3) coupon (both smeared and unsmeared) but the weight loss of *azadirachta indica* is the greatest followed by the control. But the coupons smeared with *Azadirachta indica* have the lowest weight loss at the first twelve hours.

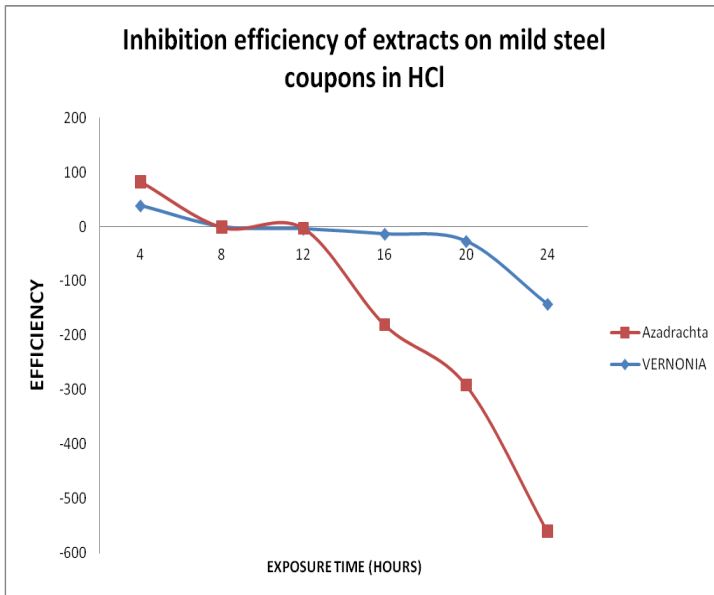
### 3.3.1.2. CORROSION RATE OF MILD STEEL IN HCL



**Fig 3.2: Corrosion Rate Of Mild Steel In HCL**

This is the same as the weight loss graph. The corrosion rate of the coupons smeared with *vernonia amygdalina* increased after eight (8) hours and had the same corrosion rate with the control at twelve (12) hours. But the corrosion rate of the *azadirachta indica* can be seen to be higher.

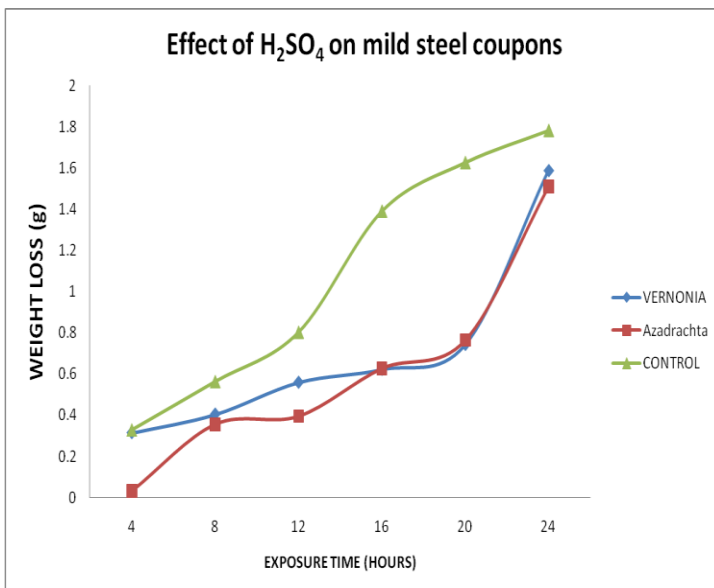
### 4.3.1.3. EFFICIENCY OF INHIBITION



**Fig 4.3: Efficiency Of Inhibition**

The efficiency of inhibition by extracts of *Azadirachta indica* has the highest efficiency of 43.36% while that of *Vernonia amygdalina* has an efficiency of 38.46% at the first four hours. The efficiency of inhibition by the two extracts decreased subsequently.

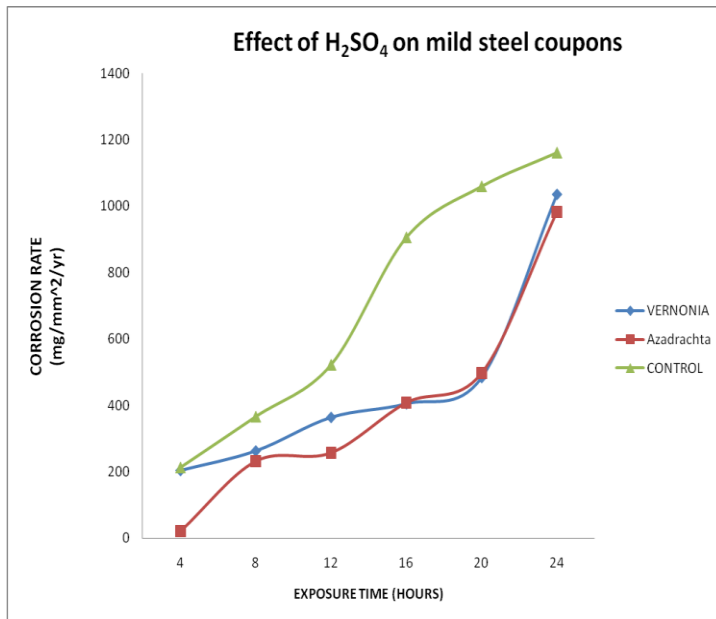
#### 4.3.1.4. WEIGHT LOSS OF MILD STEEL COUPONS IN H<sub>2</sub>SO<sub>4</sub>



**Fig 4.4: Graph showing the weight loss of mild steel coupons in H<sub>2</sub>SO<sub>4</sub>**

As we discover that the corrosion rate of the unsmeared coupons (control) with respect to exposed time coupons a progressive increase more than that of the smeared coupons. However, it was discovered that the coupons smeared with *vernonia amygdalina* corroded faster than smeared with *Azadirachta indica*. Also at point (16, 0.62), and (20, 0.76), the corrosion rate of the smeared/ inhibited coupons were equal.

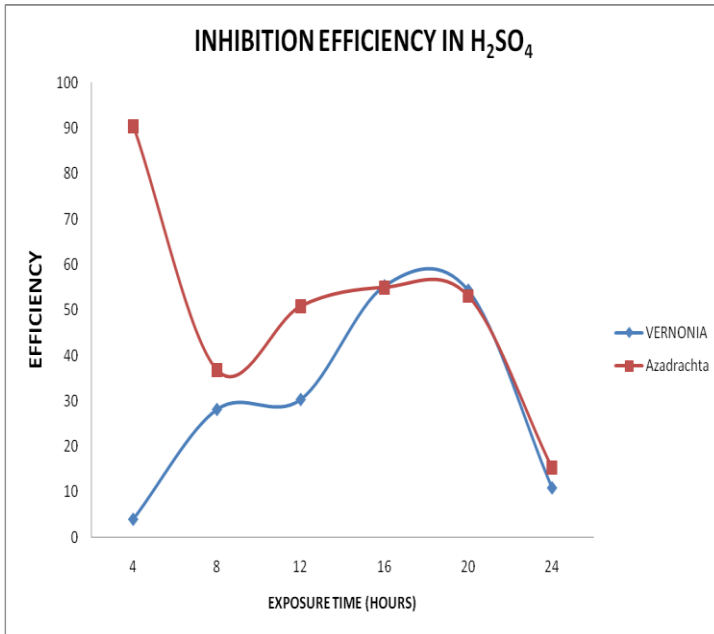
### 3.3.1.5 CORROSION RATE OF MILD STEEL COUPONS IN H<sub>2</sub>SO<sub>4</sub>



**Fig 4.5: Graph Showing The Corrosion Rate Of Mild Steel Coupons In H<sub>2</sub>SO<sub>4</sub>**

The corrosion rate of the mild steel coupons immersed in H<sub>2</sub>SO<sub>4</sub> were proportional to the weight losses as discovered in the previous graph.

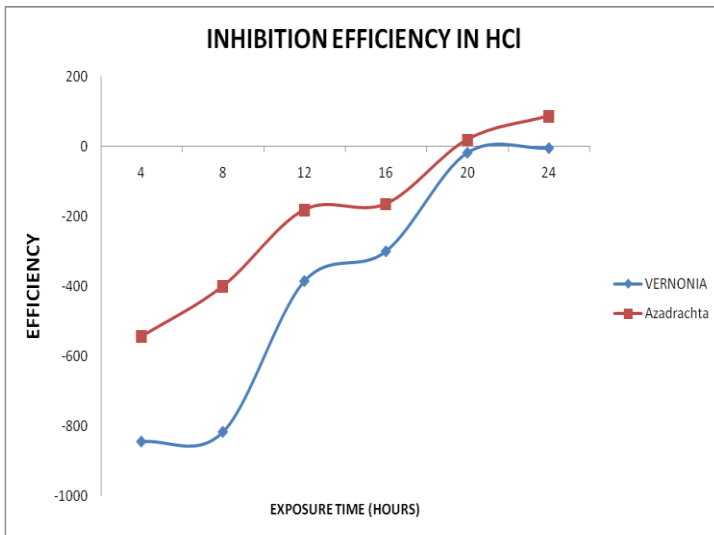
### 4.3.1.6. EFFICIENCY OF INHIBITION ON MILD STEEL COUPONS IMMERSED IN H<sub>2</sub>SO<sub>4</sub>



**Fig 4.6. Graph Showing Efficiency of Mild Steel Coupons Immersed In H<sub>2</sub>SO<sub>4</sub>**

From the graph of the efficiency, both inhibitors are effective in the medium but the *Azadirachta indica* was found to be more efficient with the value of 90.52 than the *Vernonia amygdalina* which has the value of 55.28.

### 3.3.1.9. EFFICIENCY OF INHIBITION ON MILD STEEL COUPONS IMMERSSED IN HCl



**Fig 3.9 The Graph Of Mild Steel Coupons Immersed In HCL**

The *azadirachta indica* with the highest efficiency of 87% is said to be more efficient than the *vernonia amygdalina* which has efficiency of 19.5% in HCL medium.

## 5.0. CONCLUSION

It can be deduced from the result presented in this paper that the leave extract for *azadirachta indica* and *vernonia amygdalina* inhibits the corrosion of mild steel a reasonable extent depending on the medium.

The juice extracted from *Azadirachta indica* and *vernonia amygdalina* smeared on mild steel proved to be inhibitive while immersed in HCl. But *Azadirachta indica* had a better effect with an inhibitive efficiency of 43% for mild steel while 38% for *vernonia amygdalina* smeared on mild steel. The juice extracted from *azadirachta indica* and *vernonia amygdalina* smeared on mild steel also proved to be inhibitive while immersed in H<sub>2</sub>SO<sub>4</sub>. But *azadirachta indica* also had a better effect with an inhibitive efficiency of 91% for mild steel compared to an efficiency of 55% for mild steel respectively smeared with *vernonia amygdalina*.

- [1] Roberge, P.R (ed) (2000), Handdook of Corrosion in Engineering (8 edition), New York: Mc-Graw-Hill, 1300pp
- [2] Harman M.,R W Coughlin. (1972): "inhibition of mild steel corrosion by organic polymers. Vol 11. Lehigh University press New York. 13pp
- [3] West , J.M. (1980), Basic Corrosion and Oxidation, London; Ellis Horwood Ltd,250Pp