Corrosion Inhibition of Stainless Steel Using Plant Extract *Vernonia amygdalina* and *Azadirachta indica*.

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ABSTRACT

The corrosion inhibition of stainless steel, coated with *Vernonia amygdalina* (Bitter Leaf) and *Azadirachta indica* (Dogoyaro) and immersed in hydrochloric acid solution, tetraoxosulphate (IV) acid solution, trioxonitrate (v) acid solution, and exposed to the atmosphere, was investigated in a laboratory scale experiment. The results showed that the *Azadirachta indica* had a better effect with an inhibitive efficiency of 85% for stainless steel compared to an efficiency of 69% for stainless steel smeared with *Vernonia amydgalina.*

(Keywords: corrosion inhibition, stainless steel, bitter leaf, dogoyaro, Vernonia amygdalina, Azadirachta indica)

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 this 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 (Roberge, 2000).

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. Inhibitors are widely used in the corrosion protection of metals in several environments. 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 decreases or eliminates anodic dissolution. In recent years, most researchers are focusing on natural products as corrosion inhibitors *viz*, G*ossipium hirsutum L (*Arukalam and Obidiegwu. 2011), *Cola Acuminata* and *Camellia Sinensis* (Loto and Popoola 2012), *Andrographis paniculata, Jatropha curcas* (Deepa Rani and Selvaraj. 2012), *Hibiscus sabdariffa* calyx (Nnabuk, et al., 2012). In this present investigation, we study corrosion inhibition of stainless steel in different inhibitive media and efficiencies of *Vernonia amygdalina* (Bitter leaf) and *Azadirachta indica* (Dogoyaro) to the reactive environments. 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. Most proposed inhibitors fall into one of the following categories; natural plant or animal products, dyes, industrial by -products or pure chemical compounds.

MATERIALS AND METHODS

Preparation of Specimens

The percentage composition of that of stainless steel used was 0.08%C, 2%Mn, 0.045%P, 0.030%S, 18%Cr, 0.75%Si, 8%Ni, 0.10%N, and finally 80%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.

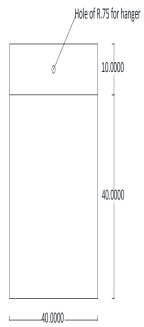

Figure 1: Coupon Dimension.

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.

Preparation of Leaf Extracts

The inhibitor used are *Vernonia amydgalina* (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.

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 50^0C. The dried coupons where tagged using a white cello tape as follows;

1. Eighteen (18) stainless steel coupons smeared with *Vernonia amydgalina* were tagged **BS_1-BS_{18}**
2. Eighteen (18) stainless steel coupons smeared with *Azadirachta indica* were tagged **DS_1-DS_{18}**
3. Eighteen (18) stainless coupons not smeared were tagged **NS_1-NS_{18}**

The prepared specimens were all weighed on an electronic mass balance and readings for the initial weight of the specimens were recorded. The experiment was arranged in two (2) series, viz:

Series A- Acid test on specimen

Series B- Exposure to the atmosphere

In the series A setup, 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, ($HN0_3$) 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 the test of HCl on stainless steel,
   BS_1-BS_6 ....1^{ST} Column
   DS_1-DS_6 ....2^{ND} Column
   NS_1-NS_6 ....3^{RD} Column

2. For the test of H_2SO_4 on stainless steel,
   BS_7-BS_{12} ....1^{ST} Column
   DS_7-DS_{12} ....2^{ND} Column
   NS_7-NS_{12} ....3^{RD} Column

3. For the test of HNO_3 on stainless steel,
   BS_{13}-BS_{18} ....1^{ST} Column
   DS_{13}-DS_{18} ....2^{ND} Column
   NS_{13}-NS_{18} ....3^{RD} Column

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

The series B test was carried out by exposing the specimens to the atmospheric conditions. The test was timed at seven (7) days interval for a period of forty-two (42) days.

Measurements

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

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, after which they 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 were then weighted on an electronic mass balance and the weights obtained were compared with the initial values to obtain the weight losses in grams.

$W_L = W_I - W_F$ [4] **(1)**

W_L=weight loss
W_I= initial weight
W_F = final weight

Corrosion Rate Measurement

A typical corrosion rate expressing weight loss per Area per unit time is given below as corrosion rate (Nwoko and Lakeman, 2009).

$$C.R = \frac{\text{Weight loss}}{\text{Area x Time}} \quad \text{Or} \quad \frac{W}{A \times T}$$

(2)

A = total surface area in (Cm^2) = $2lw + 4lt - \pi r^2$ **(3)**

(Where L= length, W= width, t = thickness, r = radius). T= exposure time in hours.

Inhibitive Efficiency of Inhibitors

The percentage inhibitive efficiency, EI was calculated from relationship [4]:

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

(4)

Where EI = inhibitor efficiency
R_{inh} = corrosion rate with inhibitor
R_{free} = corrosion rate without inhibitor

RESULTS AND DISCUSSIONS

Weight Loss of Stainless Steel in HCL

The corrosion rate for three coupons was progressive up to 20 hours after which the coupons smeared with *Vernonia amygdalina* and the un-smeared begins to have a rapid corrosion rate (weight loss). From the graph in Figure 2, there is minute loss in weight between point 16-20 in both the control (un-smeared) and the *Vernonia amygdalina*.

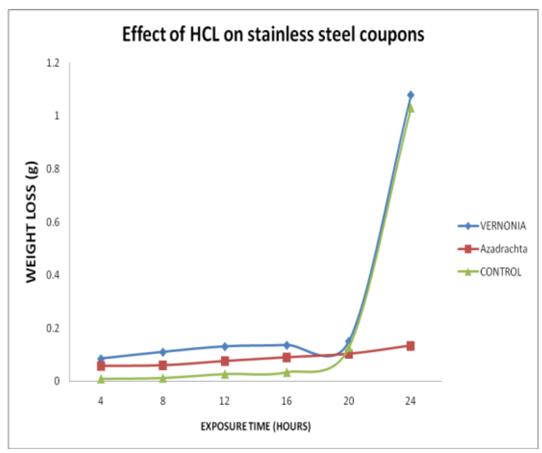

Figure 2: Weight Loss of Stainless Steel in HCL.

Corrosion Rate of Stainless Steel Coupons in HCl

The graph in Figure 3 indicates the corrosion rate of stainless steel coupons deep in HCL. It was found to almost the same rate for the two inhibitors.

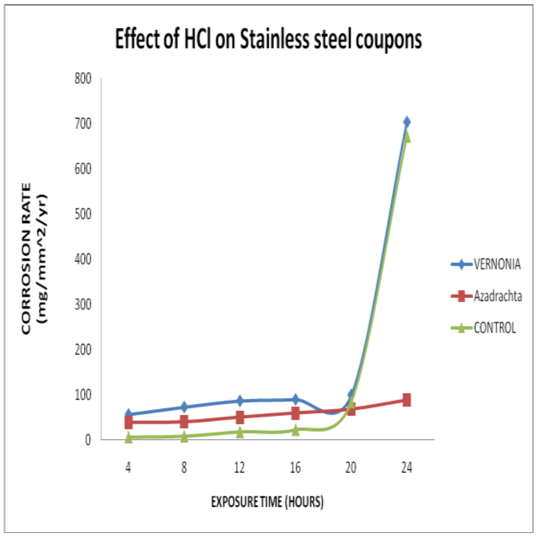

Figure 3: Graph of Corrosion Rate of Stainless Steel Coupons in HCl.

Weight Loss in Stainless Steel Coupons in H_2SO_4

From the graph in Figure 4, the three coupons were found to have a progressive corrosion rate up to 16hours while the un-smeared coupon (control) experienced a rapid increase in weight loss. The smeared coupons (Azadrachhta indica and *Vernonia amygdalina*) were observed to have almost the same corrosion rate up to 16 hours but *Vernonia amygdalina* had higher weight loss than the *Azadirachta indica*.

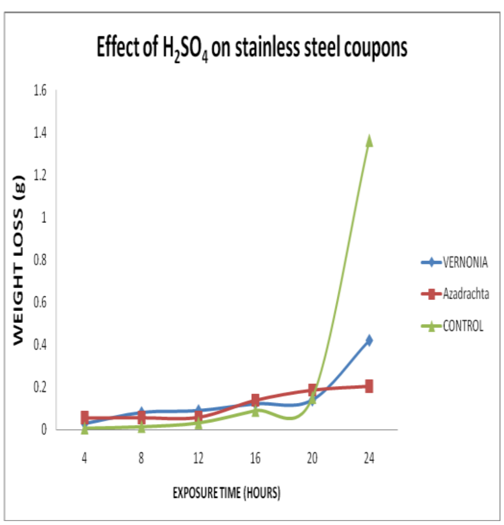

Figure 4: Weight Loss of Stainless Steel in H_2SO_4.

Corrosion Rate of Stainless Steel in H_2SO_4

From the graph in Figure 5, the observations proved to be the same, which means that the corrosion rate of stainless steel was proportional to weight loss in H_2SO_4 solution.

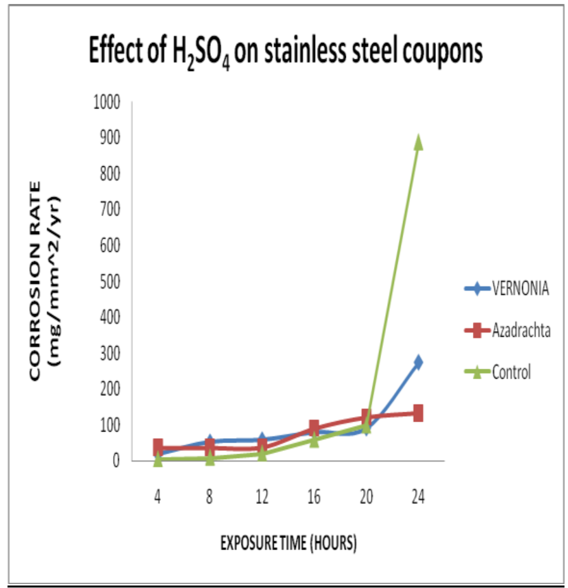

Figure 5: Graph of Corrosion Rate of Stainless Steel in H_2SO_4

Efficiency of Inhibition on Stainless Steel in H_2SO_4

The graph in Figure 6 indicates that although the two smeared coupons were observed to have almost the same efficiency, the *Azadirachta indica* was slightly higher in efficiency than the *Vernonia amygdalina*.

CONCLUSION

The research was carried out to investigate the Corrosion Inhibition of Stainless Steel Using Plant Extract. The results were found that the leave extract for *Azardirachta indica and Vernonia amygdalina* inhibits the corrosion of stainless steel to a reasonable extent depending on the medium.

The juice extracted from *Azadirachta indica* and *Vernonia amydgalina* smeared on Stainless steel proved to be inhibitive while immersed in HCl.

Figure 6: Graph Showing Efficiency of Stainless Steel in H_2SO_4.

The juice extracted from *Azadirchta indica* and *Vernonia amydgalina* smeared on stainless steel also proved to be inhibitive while immersed in H_2SO_4. But *Azadirachta indica* also had a better effect with an inhibitive efficiency of 85% for stainless steel compared to an efficiency of 69% for stainless steel, respectively, smeared with *Vernonia amydgalina*.

Juice extracted from *Azadirachta indica* inhibited much more effectively than *Vernonia amydgalina* under the atmospheric environment with an efficiency of 83%. However this inhibitive effect was noticed after thirty-five days.

The test on HNO_3 was unsuccessful at any concentration due to the corrosive nature of the acid.

Stainless steel did not corrode under atmospheric environment within the limit of experiment. Likely, this might be because of the presence of chromium (Cr) and nickel (Ni) in the material, which form protective oxide films on the material.

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SUGGESTED CITATION

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