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INHIBITION OF ALUMINUM CORROSION IN 0.5 M SULPHURIC ACID SOLUTIONS BY VELVET TAMARIND – WATER EXTRACT.

< A.O.James >[1], < Eziaku Osarolube >[2]

[1]Department of Pure and Industrial Chemistry, University of Port Harcourt, Port Harcourt, Rivers State ,Nigeria.
[1]Email address: bidean2002@yahoo.com
[1]Phone Number: 0706986462

[2]Department of physics, University of Port Harcourt, Port Harcourt, Rivers State Nigeria.
[2]Email address: eziaku68@yahoo.com
[2]Phone Number: 08037590934

ABSTRACT: The corrosion inhibition of aluminum in 0.5M H_2S0_4 solution in the presence of velvet tamarind (VT) at various concentrations (0.5 - 0.25g/dm^3) was studied using weight loss technique at temperature range of 30^oC – 50^oC. It was found that VT-water extracts acts as a good inhibitor for aluminum corrosion in the sulphuric acid medium. The inhibition efficiency of VT increased with increase in temperature and concentration of the acid. The result shows that velvet tamarind serves as an effective and non-toxic inhibitor of the corrosion of aluminum in H_2SO_4 solution. The inhibition may be attributed to the adsorption of the active ingredients in VT on aluminum surface. The adsorption fits well into the Langmuir adsorption isotherm.

Keywords: Corrosion, Aluminium, Weight-loss, Sulphuric acid, Inhibitor, Adsorption, Langmuir.

1. INTRODUCTION

Aluminum has been known to be a soft, ductile, malleable and lightweight metal. It has a silvery or light gray colour appearance which is very attractive. It's low density, non-toxicity, high ductility; high thermal and electrical conductivity makes it applicable in aerospace, automobile, food, building, and electrical industries [1].

***Corresponding Author: [a]A.O. James**
Email address: bidean2002@yahoo.com
Tel: +234706986462**.**

Aluminum metal resists corrosion naturally because it forms a protective oxide film on its surface when exposed to air which prevents it from further reaction with the environment. However, when aluminium is exposed to acidic or alkaline conditions, corrosion may occur [2].

Corrosion of metals is a natural phenomenon, which can be considered to be either chemical or electrochemical in nature. It degrades the metallic properties of metal and alloys rendering them unfit for specific role [3]. It is also a major industrial problem that many investigators and researchers have worked on [4]-[7]. One of the best options recommended for protecting metals against corrosion is the use of corrosion inhibitors [8]. Organic chemicals were widely used as inhibitors in industry to reduce the corrosion rate of metals and alloys in aggressive media [9], [10]. The toxic nature and high cost of synthesizing these chemicals necessitates the development of environmentally acceptable and less expensive inhibitors [11].
There are so many organic compounds in natural products of plant origin with inhibitive action [11]. Studies have shown that such natural compounds contained in fruits, roots, leaves, husk and seed of plants have been successfully applied because they are biodegradable, renewable, non-toxic and eco-friendly [12], [13]. The trend of using natural products as corrosion inhibitors of metals is increasing daily [14].

Velvet tamarind is a tall, tropical, fruit-bearing tree, native to Southern Thailand and Malaysia. It belongs to the leguminous family, and has small typically grape-sized edible fruits with brown hard inedible shells. The fruit is used as a candy- like snack food in Thailand, often dried, sugar coated and spiced with chili. The dried fruit has a powdery texture, and is orange in colour with a tangy flower. The velvet tamarind can also be found in West African countries such as Sierra Leone, Senegal, and Nigeria. These trees are tolerant to poor soil condition and also tend to love shade in their seedling stage. In Nigeria, the tree flowers from September to October and it fruits from October to January [15].

VT has been previously established to be a green inhibitor of low carbon steel corrosion in HCl [16] and copper in sulphuric acid [15] using weight loss method. A thorough review of the literature revealed that VT has not yet been tested on aluminium corrosion in sulphuric acid.
The present work therefore reports the inhibitory action of Velvet Tamarind – water extract on the corrosion rate of aluminium in sulphuric acid medium.

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2. MATERIALS AND METHODS

2.1 Preparation of the Test specimen

Aluminum sheet of 0.5cm thickness were used in the study. The sheet was mechanically press cut into coupons of dimension, 4cm x 2cm. The coupons were polished using silicon carbide emery paper, then washed thoroughly with distilled water and degreased in ethanol, dried in acetone and stored in a desiccator prior to their use in corrosion studies.

2.2 Preparation of the Test solution

The Velvet Tamarind used as inhibitor was obtained from the local market. The back covers of the fruits were peeled off and the edible part separated from the seeds, ground and sieved to obtain fine powder**.** The sulphuric acid was of analytical grade and 0.5M solution of the acid was employed as the corrosive medium for this study. Different concentrations of VT (0.5 - 0.25g/ dm^3) were prepared with the 0.5M sulphuric acid as solutions for the tests.

2.3 Weight loss Measurements

The weight loss measurements were as described earlier [15]. The weight loss method of corrosion measurements is very simple and commonly used in determining the efficiency of corrosion inhibitors as well as the surface coverage of the inhibitor on the metal. The weight loss of a metal depends on the strength of the metal, the concentration of the corrodent and the reacting temperatures. The test specimens (pre-weighted aluminium metal coupons) were immersed in 250ml conical flasks which contained 100ml of 0.5M sulphuric acid (blank) and then the different concentrations of VT (0.5 - 0.25g/ dm^3). These test solutions were maintained at 30^oC, 40^oC and 50^oC in a water bath with thermometer to regulate the temperatures studied. The aluminium coupons were retrieved from the test solutions daily for 7 days. The coupons were washed in distilled water, oven-dried and re-weighed. Weight loss per unit area of the specimen, ΔW was recorded and inhibition efficiency ($\%\,\mathrm{In.Eff}$), surface coverage (ϴ) as well as the corrosion rates ($\mathrm{Corr.}_{rate}$) in millimeter per year were calculated using the following equations:

$$\% \text{ In.Eff.} = \frac{\Delta W\, l_{blank} - \Delta W\, l_{In}}{\Delta W\, l_{Blank}} \; x \; 100 \text{ ……… (1)}$$

$$\Theta = \frac{\% \, In.Eff.}{100} \text{ …………………………..…….. (2)}$$

$$\text{Corr.}_{rate} = \frac{87.6\, \Delta W}{\rho t} \text{ …………………………..… (3)}$$

Where $\Delta W\, l_{Blank}$ and $\Delta W\, l_{In}$ is the weight loss of aluminium coupon in blank and inhibited solution respectively, t is exposure time and ρ is the density of aluminium used.

3. RESULTS AND DISCUSSION

3.1 Results of the weight loss measurements.

Aluminium initially corroded at a very high rate but the introduction of various concentrations of VT reduced the corrosion rate (Fig. 1-3). It was also observed from the three figures that the corrosion rate decreases with increasing inhibitor concentration at all the temperature studied.

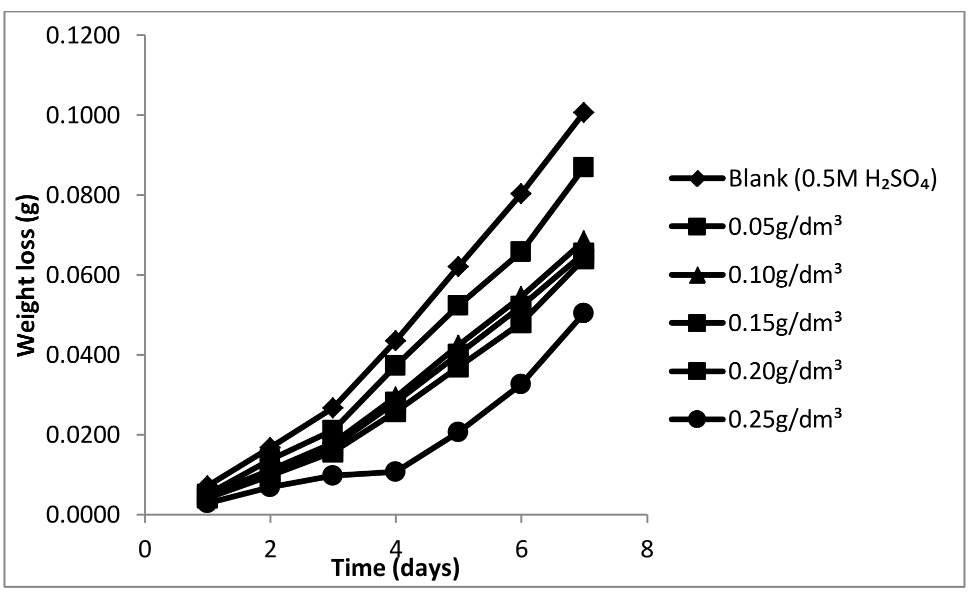

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Fig.1: Variation of weight loss (g) with time (days) of aluminium in VT-sulphuric acid medium at 30^0C

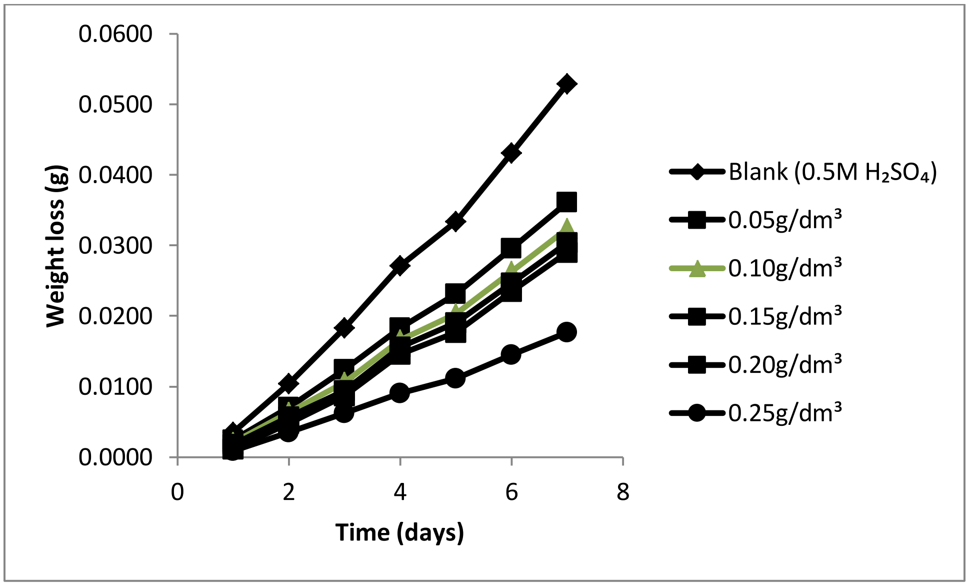

Fig.2: Variation of weight loss (g) with time (days) of aluminium in VT-sulphuric acid medium at 40^0C

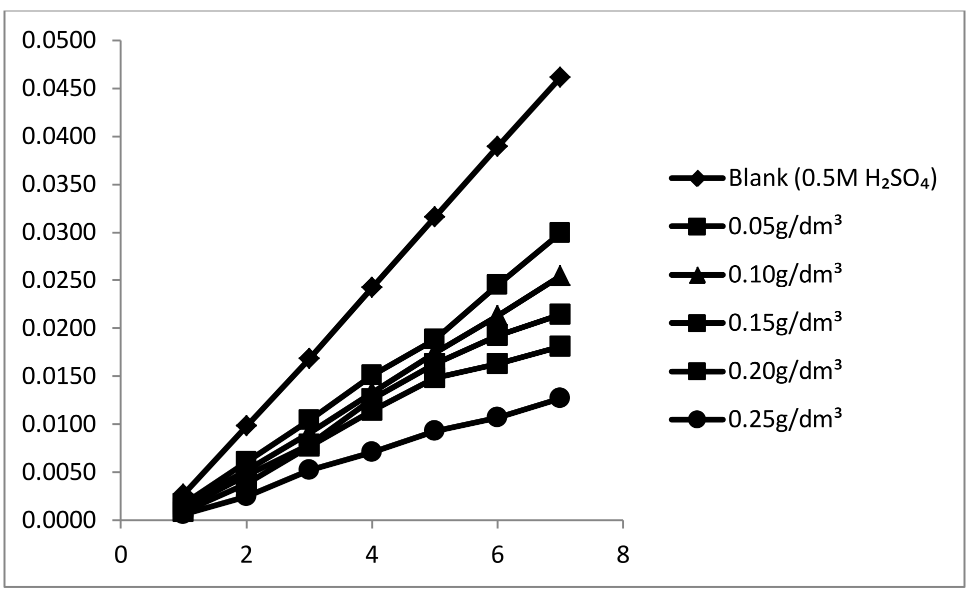

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Fig.3: Variation of weight loss (g) with time (days) of aluminium in VT-sulphuric acid medium at 50^{0}C.

3.2 Temperature Effects on the Inhibition Efficiency of Velvet Tamarind

Fig. 4 shows the effect of increase in temperature on the inhibition efficiency of VT. The Inhibition efficiency was found to increase with increase in temperature. Thus, Velvet Tamarind shows the highest inhibition efficiency at 50^{o}C. Increase in temperature therefore favours the inhibition efficiency of VT on aluminium in sulphuric acid solution.

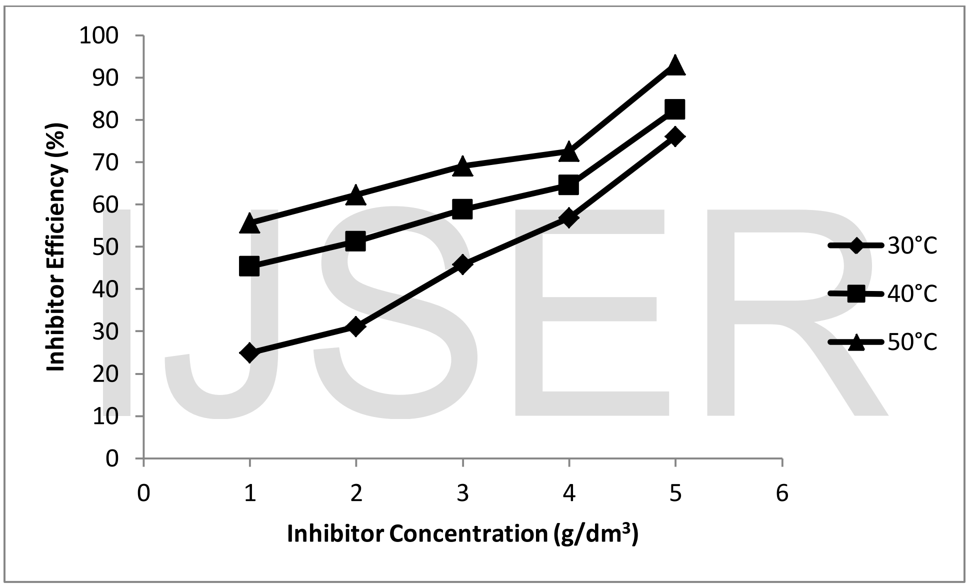

Fig. 4. Percentage Inhibition Efficiency of VT at three different Temperatures.

It is also shown in fig. 4 that there is an increase in inhibition efficiency of **VT** as its concentration increases in the acid solution. This can be observed from the upward progression of all three temperatures.

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3.3 The Active Ingredients responsible for the inhibitory property of Velvet Tamarind.

The inhibitory effect of the VT is ascribed to the presence of certain organic compounds (Fig. 6) present in the chemical constituent of VT. The VT contains several organic compounds of high molecular weight with heteroatoms, several carbonyl and phenyl groups.

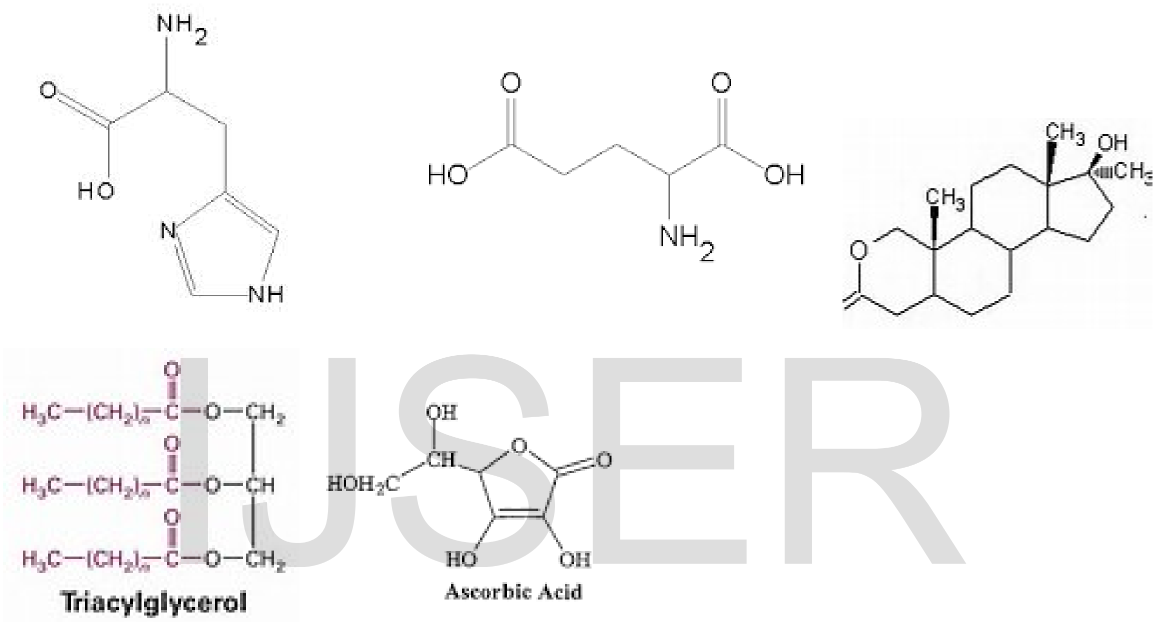

Fig. 6: Chemical structures of the compounds in African black velvet tamarind

These include glutamic acid (amino acid), histidine (crude protein), triacylglycerol, a high content of vitamin C (ascorbic acid) and sterols. These compounds must have been adsorbed onto the aluminium surface through the lone pair of electrons on the nitrogen and oxygen atoms and the pi electrons of the phenyl and the carbonyl groups. The adsorption of these compounds on aluminium surface reduces the surface area that is available for the attack by the aggressive ion from the sulphuric acid medium resulting in the inhibition of the metal corrosion. The decrease in weight loss of aluminium shown in figures 1-3 as the VT concentration increases confirmed the inhibitory effect of VT on aluminium metal.

3.4 Adsorption Isotherm.

The inhibition of the corrosion of aluminium in sulphuric acid solution occurs through the adsorption of the active components in VT onto the metal surface. This adsorption can be fitted into adsorption isotherm. There are many isotherm models used in describing adsorption phenonmenon, but Frumkin, Temkin, Freundlich, Flory-huggins and Langmuir are the common isotherms applied in explaining adsorption behavior of inhibitors. When the adsorption of VT on aluminium was fitted on these isotherms, the isotherm that has the highest regression coefficient was Langmuir (fig. 5) and this was taken as the most appropriate adsorption to describe the inhibition of aluminium corrosion by VT.

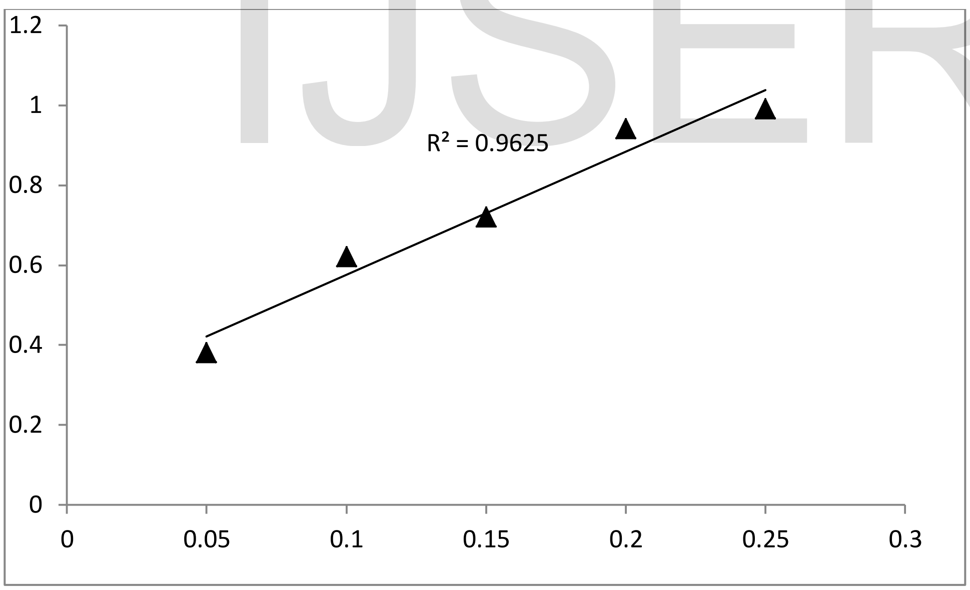

Fig. 5: Langmuir adsorption isotherm for aluminium in 0.5M H_2SO_4 containing different concentrations of Velvet Tamarind.

In the Langmuir isotherm, surface coverage θ is related to VT concentration C, through the equation (4) below:

$\frac{C}{\theta} = C + \frac{1}{K}$ ………….. (4)

and K is the aluminium – VT interaction adsorption coefficient..

4. CONCLUSION

Velvet tamarind – water extract was discovered to be a highly efficient inhibitor for aluminium in 0.5M sulphuric acid solution at all the concentrations and temperatures studied. The efficiency of VT as aluminium corrosion inhibitor increased with temperature and acid concentration. Its corrosion inhibition property was attributed to the adsorption of the organic compounds present in it on the aluminium surface. The adsorption of VT on the aluminium obeys Langmuir adsorption isotherm.

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