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*MANGIFERA INDICA (*MANGO*)* SEED EXTRACT AS A POTENTIAL INHIBITOR ON CARBON STEEL METAL ALLOY CORROSION IN ACID ENVIRONMENT

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Abstract— **The inhibitive effect of the ethanolic extract of *Mangifera indica* seed on the corrosion of carbon steel metal alloy in 0.5 M HCl acidic medium at room temperature was investigated using the gravimetric method. The results showed that, for a given concentration of the extract, the inhibition efficiency decreased with time. The adsorption behavior of the constituents present in *Mangifera Indica* seed extract onto the carbon steel metal surface was investigated as well. Results indicated that the mode of adsorption of the seed extract on carbon steel metal alloy was best modeled by Langmuir adsorption isotherm with R^2 = 0.9604. Again, as the concentration of the inhibitor produced increased, the corrosion rate decreased. Results obtained are therefore indicative of the fact that *Mangifera indica* seed extract is a good corrosion inhibitor for carbon steel metal alloy in 0.5M HCl acidic medium, though its effect reduced with time under the conditions studied in the present report. And for this reason, it can be used in synergism with another good inhibitor to produce a stronger corrosion inhibitor for the alloy.**

Keywords— **Inhibition, *Mangifera Indica*, Corrosion, Carbon Steel**

I. INTRODUCTION

A good number of process industries utilize carbon steel for so many purposes owing to its excellent mechanical properties and cheapness. However, a major drawback in the use of carbon steel is its poor resistance to corrosion in acid medium; acids are mainly used for chemical cleaning, descaling, pickling and oil-well acidizing in industries [1].
Corrosion is often referred to as a metallic deterioration by chemical attack or reaction of a metal with its environment. It can be controlled by suitable modification of the environment which in turn stifle, retard or completely stop the anodic or cathodic reactions or both. This is achieved by the use of proper inhibitors. Inhibitors which prevent corrosion, are substances, which when added to solutions in small concentrations can decrease or prevent the reaction of the metal with the solution [2, 3].
Two major classifications of inhibitors include organic green corrosion inhibitors and inorganic green corrosion inhibitors [4]. The former are nontoxic to the environment [5] while the later are utilized in aqueous systems due to their high yield [6]. Examples of organic green inhibitors include iron liquids, biopolymers, surfactants, drugs, amino acids and plants while the inorganic green inhibitors include rare earth metals [7]. Among these, plants and their parts have been the more researched in the past two decades to assess their potentials as excellent inhibitors. This is because they are eco-friendly, cheap and readily available. Few of such published research articles include [8 – 14].
Many organic green inhibitors are applied extensively to protect metals from corrosion in many aggressive acidic solutions (e.g., in the acid pickling and cleaning processes of metals). Most of these organic inhibitors are nitrogen, phosphorus, sulphur or oxygen containing compounds [15 - 16]. The first stage, in the action mechanisms of these organic inhibitors in aggressive acid solution is their adsorption on the metal surface. The thin layer of inhibitor then acts as a barrier to any substance that may try to cause corrosion of the metal.
In this work, corrosion inhibition of *Mangifera indica* (mango) seed extract in 0.5M hydrochloric acid solutions on carbon steel metal alloy is discussed.

II. EXPERIMENTS AND RESULTS

A. Preparation of Coupon

The low carbon steel sheet coupons used for this research work were obtained from the Center for Industrial Studies (CIS)/Materials/Metallurgy Engineering Department workshop of the Federal University of Technology, Owerri (FUTO), Imo State, Nigeria. The dimension of the carbon steel sheets was 30mm x 30mm x 2mm, with a perforated hole of 2mm diameter. The coupons were abraded with 120 – 150 mesh abrasive for a smoother surface, degreased with acetone, dried in air and kept in a desiccator. The coupons were further

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cleaned with a brush, dried with a piece of cloth and then weighed before being dipped into the acidic medium.

B. Extraction of Plants Extracts

The seeds of *Mangifera Indica* were obtained from Federal University of Technology Owerri. The shells were removed, and the inner parts of the seeds were broken into bits and eventually dried using an oven for three days. The dried seeds were further ground into powder using a mechanical grinder. 200g of the powder were dissolved in 200ml of ethanol (extraction solvent), and the solution placed in a reflux setup. The setup was allowed to run for two (2) hours. This procedure was carried out five times, extracting all the powdered mango seed and producing an extract of 1g/L concentration. More concentrations (0.2g/L, 0.4g/L, 0.6g/L, and 0.8g/L) were also prepared. Five inhibitor test samples were then prepared by dissolving 0.2g/L, 0.4g/L, 0.6g/L, 0.8g/L and 1.0g/L of the extract in 400ml of 0.5M HCl respectively.

C. Gravimetric (Weight Loss) Measurement Method

The gravimetric process was carried out for the metal samples of dimension 30mm x 30mm x 2mm. The initial weights of the metal coupons were taken. Two pieces of the metal alloy were immersed into each test acid medium containing a given inhibitor concentration. A blank or uninhibited acid medium was also set up and used as control.

The experiment was carried out at total immersion and conducted at an ambient temperature of 30^0C. The coupons were retrieved at intervals of 2 days, for 21 days. After each retrieval, they were washed with running water to remove any corroded product(s), dipped in acetone, dried and re-weighed. The weight loss (W) was taken as the difference between initial weight of the test coupon and the weight at any given time. The weight loss data obtained were then used to determine the corrosion rates and inhibition efficiencies.

Equations 1, 2, 3, 4 and 5 were used to calculate weight losses, corrosion rates and inhibition efficiencies [3].

$$Wight\ loss = Initial\ weight - Final\ weight \quad 1$$

$$\text{or } W_L = W_I - W_F \quad 2$$

$$CR = \frac{weight\ lost\ by\ metal}{surface\ area\ of\ metal * time\ of\ immersion} \quad 3$$

$$CR = \frac{W_l}{A*t} \quad 4$$

$$IE = \frac{CR_0 - CR_I}{CR_0} * 100 \quad 5$$

where

$CR_0 = corrosion\ rate\ of\ coupon\ before\ inhibition\ g/cm^2 day$

$CR_I = corrosion\ rate\ of\ coupon\ after\ inhibition\ g/cm^2 day$

Surface coverage was calculated according to the following equation:

$$\theta = \frac{IE}{100} \quad 6$$

D. Results and discussion

Results of experiments are presented in Table 1, Fig. 1, Fig. 2 and Fig. 3 respectively.

Table 1: Average weight losses of the coupons at different times

Time (day)	CONCENTRATION OF INHIBITOR (g/L)					
	0.2	0.4	0.6	0.8	1.0	Control
1	-	-	-	-	-	-
3	0.176	0.159	0.062	0.012	0.034	0.448
5	0.379	0.279	0.350	0.260	0.189	1.036
7	0.715	0.500	0.628	0.464	0.398	1.531
9	1.059	0.843	0.950	0.676	0.609	2.086
11	1.406	1.194	1.289	0.988	0.855	2.421
12	1.676	1.456	1.511	1.182	1.123	2.588
15	1.778	1.619	1.695	1.281	1.233	2.826
17	1.919	1.794	1.906	1.508	1.385	3.011
19	2.034	1.991	2.015	1.780	1.562	3.154
21	2.211	2.118	2.126	1.936	1.930	3.356

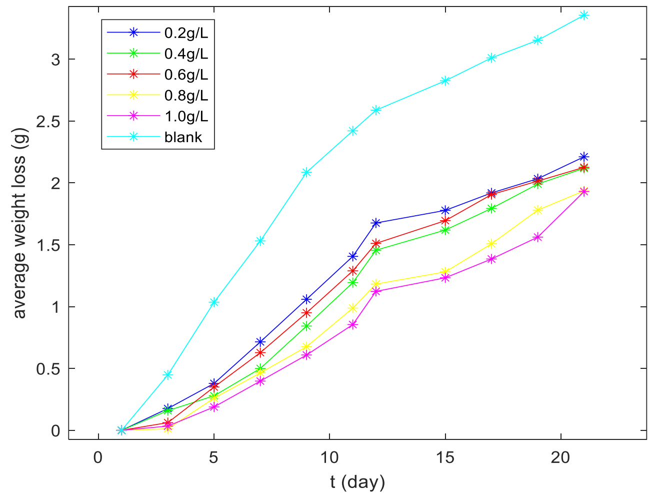

Fig. 1: Average weight loss of coupons against time at different concentrations of extract

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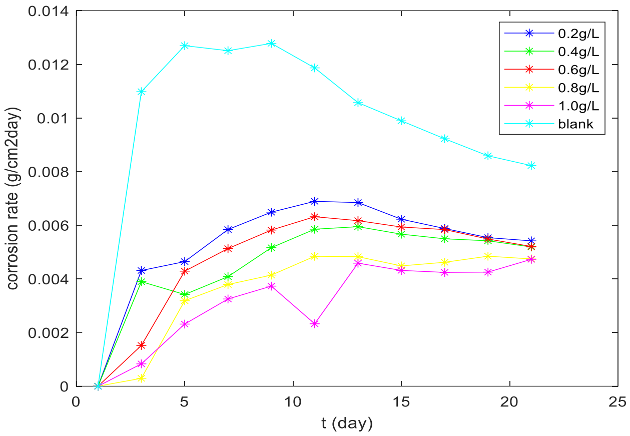

Fig. 2: Corrosion rate of coupons against time at different concentrations of extract

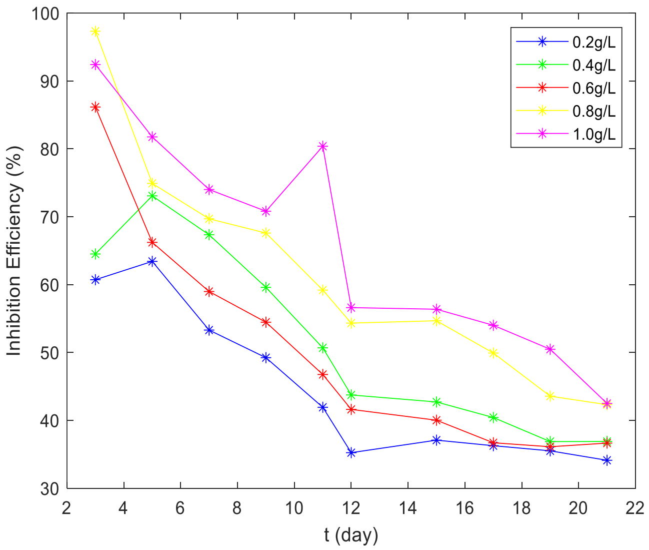

Fig. 3: Corrosion inhibition efficiency against time interval for different concentrations of extract

Examination of Figure 1 shows that, for a given extract concentration, the weight loss of the carbon steel metal alloy increased with time, signifying that as time elapsed, the acidic medium was able to penetrate and attack the metal for the inhibited samples but at a very low degree compared to that of the uninhibited sample. For the uninhibited corrosion process, the intense increase in the weight loss of the samples in acid medium in the first 13 days of exposure with marginal increase thereafter can be attributed to the initial aggression of the acid on the surface of the carbon steel which later decreased because of the dissolution of the carbon steel coupons in the acid media. This is also in agreement with a finding made by [17]. The plot also shows that the weight loss of the uninhibited sample is higher than that of the inhibited (with different extract concentrations). This confirms the inhibitive effect of the *Mangifera indica* seed extract.

Figure 2 indicates an inverse relationship between corrosion rate of the metal alloy and the time of exposure for the extract concentrations studied. This decrease in corrosion rate with time could be traced to two factors: formation of passive layers of corrosion products or the blocking of the surface of the carbon steel metal alloy by the molecules of the inhibitor via adsorption mechanism [18]. Additionally, a closer examination of Figure 2 shows that the values of corrosion rates in the blank medium were higher than those of the inhibited samples. Therefore, the reduction in corrosion rate of the specimen with time is traced to the adsorption and consequently the inhibitive effect of the seed extract.

Examination of Figure 3 shows that at a given extract concentration, the inhibition efficiency decreased with time. It can be inferred that the adsorbed inhibitor molecules were desorbed over time thereby exposing the initially protected metal surface to the corrodent. This agrees with results reported in some literature such as [19]. Again, the plot depicts that relatively higher values of inhibition efficiency were obtained with the 0.8g/L and 1.0g/L extract concentrations than with the other concentrations.

Four adsorption isotherms, Langmuir, Freundlich, Temkin and Florry-Huggins adsorption isotherms, were used to study the mode of adsorption of the extract on the alloy. The isotherm with the highest coefficient of determination, (R^2) of 0.9604 was selected as the best isotherm. This isotherm is the Langmuir adsorption isotherm. Langmuir isotherm is indicative of physisorption. Langmuir assumes monolayer adsorption, localization of the adsorbed extract molecules and formation of a layer of insoluble complex on the metal surface which acts as a barrier between the metal surface and the corrodent [20].

III. CONCLUSION

Ethanol extract of *Mangifera indica* seed extract was investigated as a potential corrosion inhibitor for carbon steel metal alloy. Higher values of inhibition efficiency were obtained with the 0.8g/L and 1.0g/L extract concentrations than with the other concentrations. Inhibition efficiency, however, generally decreased with time for all concentrations. It is therefore suggested that the inhibitive effect of the seed extract of this plant can be improved by a synergistic action with a strong inhibitor.

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