Corrosion Inhibition of Mild Steel in Hydrochloric Acid by African Black Velvet Tamarind

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Abstract
The effect of the extract of African Black Velvet Tamarind on the corrosion of mild steel in 0.5M HCl solution was studied using weight loss technique at 30°C, 40°C and 50°C. Velvet Tamarind extract inhibited the corrosion of mild steel in 0.5M HCl solution and the inhibition efficiency increased with increasing concentration of the extract and temperature. The inhibition is attributed to the adsorption of the extract on the surface of the mild steel coupon. The high content of vitamin C (ascorbic acid) in the extract must have been responsible for the its corrosion inhibiting effect. The result showed that African Black Velvet Tamarind extract could serve as an effective, non-toxic and a temperature resistant corrosion inhibitor of mild steel in hydrochloric acid. Apart from being environmentally friendly and ecologically acceptable, Velvet Tamarind extract is inexpensive, readily available and renewable. It should therefore be recommended to corrosion engineers or scientists to replace the toxic organic inhibitors added to acid solutions, widely used in industrial acid cleaning, acid descaling, acid pickling and oil well acidizing, to restrain corrosion attack on metallic materials most especially, on mild steel.

Keywords: African black velvet tamarind; corrosion; inhibition; mild steel; vitamin C.

INTRODUCTION
Corrosion is the defined as the spontaneous deterioration of physical and chemical state of a material due to the reaction with its environment [Osarolube et al., 2004]. The uses of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment have been the accepted practice for decades [Talati and Daraji, 1991]. The corrosion inhibition potentials of large numbers of organic compounds have been studied in the past and are still been investigated [Udom and James, 2009]. All these studies revealed that organic compounds especially those containing oxygen, nitrogen and sulphur show significant inhibitor efficiency [Babu and Thangavel, 2005; Rahma et al., 2005 and James et al., 2006]. Though many synthetic compounds have shown good anticorrosive activity, most of them are highly toxic to human and environment. The safety and environmental issues of corrosion inhibitors arisen in industries has always been a global concern. Such inhibitors may cause reversible (temporary) or irreversible (permanent) damage to organ system viz; kidneys or liver or to disturb a biochemical process or to disturb an enzyme system at some site in the body. The toxicity may manifest either during synthesis of the compounds or during its application (Philip et al., 2002).

Recently, plant extracts have become important source of corrosion inhibitors because of its environmental friendliness and availability [Ekpe et al., 2010]. Several scientists have used natural products as corrosion inhibitors for various metals and alloys in aggressive media [Nkuzinna et al., 2011; Awiri and Osarolube, 2010; James and Akaranta, 2009].

Plant extracts like extracts from the leaves, seeds and bark of carica papaya (Pawpaw) [Ebenso and Ekpe, 1996]; black pepper extracts and its piperine [Dahmani et al., 2010]; Cocos Nucifera water[Abiola and Oforka, 2002]; Azadirachta Indica extracts [Ekpe et al., 2010]; to mention but a few, has been used to inhibit the corrosion of mild steel in hydrochloric acid:

The African black velvet tamarind called Awin in Yoruba language and Ucheka in Ibo is potentially a source for the inhibition of corrosion of mild steel due to its chemical composition. It has a high content of vitamin C (Ascorbic acid) and other micronutrients like crude fats, carbohydrates and proteins. [Achoba et al., 1992].

In this study, the inhibitory affect of African black velvet tamarind on the corrosion of mild steel in 0.5M hydrochloric acid solution has been investigated at three different temperatures (30°C, 40°C and 50°C) using weight loss method.
The inhibition efficiencies (% E) were calculated from the equation below:

$$\% E = \frac{\Delta W_B - \Delta W_i}{\Delta W_B} \times 100$$  

$$\therefore \quad \Delta W_B \quad \text{and} \quad \Delta W_i \text{are the weight loss data of the metal coupons in the absence and presence of the additives respectively (Abiola et. al, 2004).}$$

**EXPERIMENTAL**

Rectangular specimens of mild steel of dimension 4.0 x 4.0 x 3.0 cm containing a small hole of about 2mm diameter near the upper edge were taken. The chemical composition of the specimens was 0.12% C, 0.90% Mn, 0.066% S, 0.050% P, 0.10% Si and the remainder Fe. The specimens were cut out from a steel sheet and were cleaned to produce a spotless finish, degreased in ethanol and dried in acetone. The treated coupons were then stored over calcium chloride in moisture free desiccators to prevent contamination before use for corrosion studies.

**WEIGHT LOSS DETERMINATION**

The weight loss was determined following the methods reported earlier [Avwiri and Osarolube, 2010].

Three sets of experiments were carried out at 30°C, 40°C and 50°C, consisting of twenty five, 250ml beakers, which separately contained 0.05g/500ml, 0.10g/500ml, 0.15g/500ml, 0.20g/500ml and 0.25g/500ml of African black velvet tamarind concentrations in 0.5M HCl acid concentration respectively. Previously weighed mild steel coupons were each suspended in each beaker with the help of glass hooks.

The mild steel coupons were retrieved from the corrodent solutions at 24hours interval progressively for 168hours (7 days).

Each retrieved coupon was immersed in a solution of 20% sodium hydroxide containing 200g/litre of Zn dust, scrubbed with a bristle brush several times to remove the corrosion product, dried in acetone and then reweighed. The weight loss was calculated in grams as the difference between the initial weight prior to immersion, and weight after removal of the corrosion product (rust).

Each reading reported is an average of two readings recorded to the nearest 0.001g on an AB 54 AR digital analytical weighing balance.

**RESULT AND DISCUSSION**

<table>
<thead>
<tr>
<th>INHIBITOR CONCENTRATION (g/500ml)</th>
<th>AVERAGE INHIBITION EFFICIENCY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g)/500ml</td>
<td>30°C</td>
</tr>
<tr>
<td>0.05</td>
<td>36.92</td>
</tr>
<tr>
<td>0.10</td>
<td>38.12</td>
</tr>
<tr>
<td>0.15</td>
<td>41.02</td>
</tr>
<tr>
<td>0.20</td>
<td>44.94</td>
</tr>
<tr>
<td>0.25</td>
<td>51.02</td>
</tr>
</tbody>
</table>

*Table 1: Average percentage inhibition efficiency of different concentrations of the African black velvet tamarind extract in 0.5M HCl at different temperatures.*

*Figure 1:* Variation of weight loss (g) with time days for mild steel coupons in 0.5M HCL solution containing different concentrations of velvet tamarind extract at 30°C.
Figure 2: Variation of weight loss (g) with time (days) for mild steel coupons in 0.5M HCL solution containing different concentrations of velvet tamarind extract at 40°C.

Figure 3: Variation of weight loss (g) with time (days) for mild steel coupons in 0.5M HCL solution containing different concentrations of velvet tamarind extract at 50°C.
Figure 4: Variation of inhibition efficiency (%) with inhibitor concentration (g/500ml) for mild steel coupon in 0.5M HCL solution containing velvet tamarind at three different temperatures.

Fig 1 shows that weight loss of mild steel coupons decreased considerably with increase in the concentration of velvet tamarind at 30°C. This demonstrates that the Africa black velvet tamarind decreases the corrosion rate of mild steel in hydrochloric solution at room temperature.

We can see from the fig 2 that there is still a reduction in weight loss of mild steel as the concentration of velvet tamarind increases at 40°C.

Fig 3 shows that at higher temperature (50°C) the African velvet tamarind is still effective in inhibiting mild steel corrosion in hydrochloric acid solution.

Fig 4 compares the efficiency of Velvet tamarind at 3 different temperatures. From this fig, there is an increase in inhibition efficiency of Velvet tamarind as the concentration increases. This is evidenced in upward trend of all the temperature curves. It is observed that the inhibition efficiency increases as the temperature increases from 30°C to 50°C. The results show that irrespective of the acidic medium, inhibition efficiency of the African black velvet tamarind increases with increasing temperature.

CONCLUSION
From the results obtained in this study the following conclusions were made;
1. The African black velvet tamarind inhibits corrosion of mild steel in 0.5M Hydrochloric acid solution at 30°C, 40°C and 50°C.
2. Inhibition efficiency increases with increase in the concentration of the inhibitor and temperature.
3. The African black velvet tamarind, being a non-toxic, eco-friendly substance should be used in place of the toxic corrosion inhibitors commonly used in the metallurgical industry.

LIMITATION OF THE STUDY
Velvet Tamarind extract has not been tried as corrosion inhibitor of mild steel in hydrochloric acid at temperatures lower than 30°C and that higher than 50°C.

REFERENCES


