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Extracts from Leaves of Bamboo Tree and Gmelina Arborea Tree as Corrosion Inhibitors of Mild Steel in 1 M HCl

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Abstract
Eco-friendly inhibitors were prepared using bamboo leaves and gmelina leaves. These extracts were then used to inhibit the corrosion of mild steel in 1 M HCl. Using the weight loss method of measuring corrosion, the study shows that apart from increasing the half-life of mild steel from 2.89 days to 17.33 days (for the bamboo leaves' extract) and 11.55 days (for the gmelina leaves' extract), the inhibition efficiency increased with concentration of the extracts; reaching a maximum of 88% and 82% for the bamboo leaves extract and gmelina leaves extracts respectively.

Key words: *Bamboo leaves, Gmelina leaves, Extracts, Corrosion, half-life*

1. Introduction

As far as corrosion of mild steel and its prevention by use of inhibitors is concern, the literature is very rich. The interest of study on mild steel corrosion on various aggressive media may not be unconnected to the fact that it is the most preferred material for industrial use because of its easy availability and excellent physical properties (Sinnott and Towler, 2009). Mild steel has practical importance, for example in the acid pickling of iron and steel, chemical cleaning of the scale in metallurgy, oil recovery and petrochemical industry and other electrochemical systems (Undiandeye et al., 2014). Indeed, the susceptibility of mild steel to corrosion restricts its use in certain media like acidic environment and other corrosive mediums. These corrosive environments have also received a considerable amount of attention because of their attack on materials (Khadom, 2009). The use of corrosion inhibitors is one way of protecting mild steel from corrosion. The use of a suitable inhibitor for a given system can not only extend the life of a material in use, but could also enable the use of a less expensive inhibitor (Khadom et al, 2009).

Inorganic substances such as phosphates, chromates, dichromate and arsenates are often used in process industry applications as inhibitors to decrease the corrosion of various types of alloys, mostly mild steels. However, they suffer a major disadvantage because of their high toxicity, and as such their use has come under severe criticism. These toxicity effects have resulted in renewed interest in organic substances as anticorrosion agents. The development of new corrosion inhibitors of non-toxic type, which do not contain heavy metals and inorganic phosphates, is of considerable importance. Most corrosion inhibitors protect the corrosion of metals when they are adsorbed on the surface of the metal (Ashassi-Sorkhabi and Seifzadeh, 2008; Eddy and Odoemelam, 2008). Studies have also been conducted on the adsorptive and inhibitive properties of some natural products (Ashassi-Sorkhabi, and Nabavi-Amri, 2000). In most of these studies, these properties are found to be strongly influenced by the chemical structure of the compound, the corrosive medium, temperature, concentration of the inhibitor, period of contact, etc. Adsorption characteristics of an inhibitor can be studied by the use of adsorption isotherms and the application of the theory of thermodynamics (Ashassi-Sorkhabi, and Seifzadeh, 2008).

Due to the toxic nature of inorganic-based compounds and their associated high costs, efforts have been focused on the use of these plant extracts as potential agents to reduce corrosion in various typical industrial solutions. Plants have been recognized as sources of naturally occurring compounds, some with rather complex molecular structures and having varying physical, chemical and biological properties. These attributes have made plants become an important source of a wide range of eco-friendly (green) corrosion inhibitors. This paper seeks to study corrosion inhibition of mild steel in 1M HCl using extracts from plant leaves; those of bamboo tree and those of Gmelinaarborea tree. These two plants are chosen because they have been shown to contain a significant level of tannin (Daya and Patel, 2012; Offor, 2014; Coffie, 2014), an ingredient that has been shown to slow down the rate of corrosion of metals and alloys (Afidah et al., 2007; Afidah and Jain, 2008). The choice of the use of these extracts is because they are nontoxic, they are easily available, and they are not a threat to the environment.

2. Materials and methods

2.1. Extracts preparation

Healthy bamboo and gmelinaarborea leaves, looking green and fresh, were harvested from mature-looking bamboo stand and gmelinaarborea trees respectively in Port Harcourt. This harvesting was done around June. The reason for this period of harvesting was simply a matter of choice. These samples were washed carefully with distilled water to remove any form of dirt. The leaves were then dried under the sun until a constant weight was obtained. This was to ensure complete removal of water from the leaves. The dried leaves were then separately grounded using an industrial scale grinder to powdered form. The powdered leaves ware then run through a wire mesh sifter to obtain very fine powdered samples. The fine powdered samples were separately soaked in 100ml of ethanol solution for 96 hours, after which the mixture was stirred properly in order to have homogenous solution and then filtered. The filtrate was subjected to the evaporation process to remove the ethanol in the filtrate. The inhibitor was obtained in its pure form at the end of the evaporation process. The stock solutions of the extract obtained were used in preparing different concentrations of the extract by dissolving 0.1g/l, 0.2g/l, 0.3g/l and 0.4g/l of the extract in 1M of HCl respectively.

2.2. Preparation of coupons

Twenty-five mild steel coupons with initial weight of about 6.5 g were cut into rectangular shapes of 3cm by 4cm with thickness 2mm. These were then degreased with acetone to remove grease, oil and dust, washed with distilled water and dried. The coupons were then mechanically polished with 400 and 600 grade emery papers, cleaned and dried. The coupons were then attached to 5 pieces of stick in a set of 5 with the aid of thread passed through a drilled hole on the coupons. The prepared mild steel specimens were then weighed in a weigh balance and immersed in 5 different beakers containing 500 ml of 1M HCl for ten days with various concentrations of the extracts.

2.3. Measurement of corrosion rate

Weight loss measurements were carried out by weighing the specimens before and after immersion in the 500ml of 1M HCl acid solution in the absence and presence of inhibitors at various extract concentrations of 0.1g/l, 0.2g/l, 0.3g/l and 0.4g/l. Mild steel specimens were immersed in 500ml of 1M HCL with the various extract concentration for ten days at room temperature. One coupon from each of the solutions were taken out after 2,4,6,8 and 10 days respectively, washed, dried and reweighed accurately. The acid solution under investigation represents various real industrial environments including pickling acids, stimulation fluids, and/or cleaning solutions for inorganic carbonate scales. The inhibition efficiency (IE %) of the inhibitor, and corrosion rates (CR) were calculated using Equations 1and 2 respectively (Undiandeye et al., 2015).

$$\text{IE (\%)} = \frac{W_0 - W_1}{W_0} * 100 \qquad (1)$$

where W_0 = Weight loss in uninhibited medium and W_1 = Weight loss in inhibited medium.

$$\text{CR} = \frac{87.6W}{\rho A t} \qquad (2)$$

where ρ = density of coupons, A = area of the mild steel coupon (in cm^2), t = period of immersion (in days) and W = weight loss of mild steel after time, t.

3. Results and discussion

The effect of concentration of extracts on loss in weight of mild steel is shown in Figures 1 and 2 for each of the inhibitors. Many other authors (Undiandeye et al., 2014; Singh et al., 2012; Umoren and Ebenso, 2008; Okafor and Ebenso, 2007; Okafor et al., 2005) have reported this trend of a decrease in weight loss of mild steel as inhibitor concentration increases. For this study, extracts from the bamboo leaves resulted in a greater weight loss of mild steel than the extracts from the gmelina leaves. However, the weight of mild steel increased with time for both extracts. This increase of weight loss with time was also reported by Undiandeye et al. (2011), Chauhan and Gupta (2009), Yordanov and Petkov (2008), Umoren et al. (2008), Kinani, and Chtaini (2007), John et al. (2004), Mathur, and Vasudevan (1982).

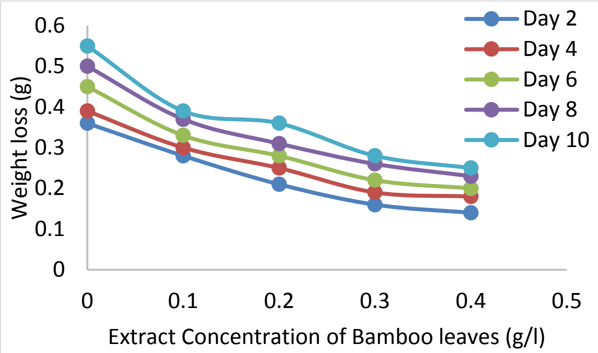

Fig. 1: Effect of Bamboo leaves extract concentration on weight loss of mild steel.

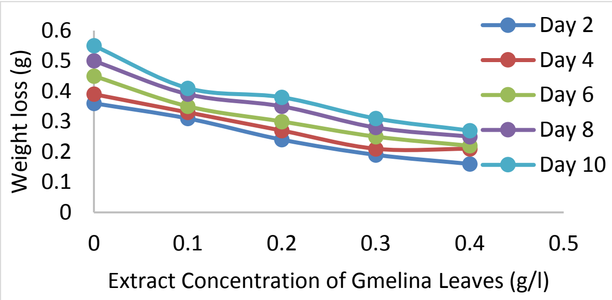

Fig. 2: Effect of Gmelina leaves extract concentration on weight loss of mild steel.

The inhibition efficiencies of both extracts were also seen to increase with extracts concentration for all days as reported by other authors and shown in Figures 3 and 4. The optimal inhibition efficiency for the bamboo leaves extract and Gmelina leaves extract was observed to be 88 % and 82 % respectively. This is considerably higher than the inhibition efficiency of unripe plantain peels extracts, Vegetal Tannins andMangrove tannins reported by Undiandeye et al. (2015), Afidah et al. (2008) and Afidah et al. (2007) respectively.

The kinetics of the corrosion of mild steel was studied by using the relation

$$-\log W = \frac{kt}{2.303} \qquad (3)$$

where W is the weight loss, k is the first order reaction rate constant and t is the time in days.

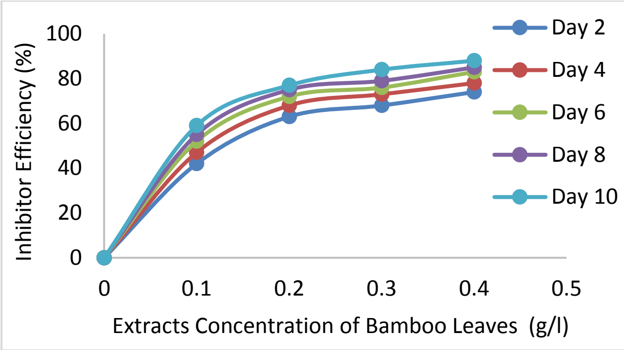

Fig. 3: Effect of Bamboo leaves extract concentration on inhibition efficiency.

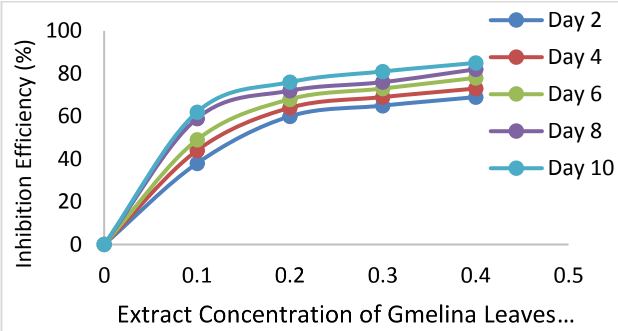

Fig. 4: Effect of Gmelina leaves extract concentration on inhibition efficiency.

Values of k were obtained from the slopes of the plots of –logW against time, at various concentrations of the inhibitors. These values of k were then used to find the half-life of the mild steel using the relation in equation 4 (Umoren et al., 2008).

$$t_{\frac{1}{2}} = \frac{0.693}{k} \qquad (4)$$

The values of K and $t_{\frac{1}{2}}$ are presented in Table 1. The table shows an increase in the half-life of mild steel as extract concentration increases. Similar findings of prolong half-life with increase in inhibitor concentration are given by Undiandeye et al. (2014), Umoren et al. (2008) and Eddy et al. (2008). At all concentrations, the bamboo leaves' extracts offered a better protection for mild steel than the extracts from the Gmelina leaves.

Table 1: Half-life of mild steel in 1M HCl

Extract Conc (g/l)	Values of K		Values of $t_{1/2}$ (days)	
	Bamboo	Gmelina	Bamboo	Gmelina
0	0.24	0.24	2.89	2.89
0.1	0.12	0.14	5.78	4.95
0.2	0.09	0.11	7.70	6.30
0.3	0.07	0.09	9.90	7.70
0.4	0.04	0.06	17.33	11.55

4. Conclusions

The following conclusions can be drawn based on the results obtained.

1. Extracts from Bamboo leaves and from Gmelina leaves are good corrosion inhibitors of mild steel in 1M HCl.
2. The inhibition of mild steel by both extracts approximates a first order reaction. Inhibition efficiency increased with increase in concentration of both extracts.
3. An increase in the concentration of both extracts brings about an increase in the half-life of mild steel in 1 M HCl.
4. Extracts from the Bamboo leaves offered a better protection for mild steel in 1 M HCl than extracts from Gmelina leaves.

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