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Cocos nucifera L. water as green corrosion inhibitor for acid corrosion of aluminium in HCl solution

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Abstract

The ability of *Cocos nucifera* L. water (CW) as non-toxic corrosion inhibitor for acid corrosion of aluminium in 0.5 mol/L HCl has been studied using chemical technique. CW shows significant inhibition as corrosion inhibitor, with 93% efficiency at the highest concentration of the inhibitor. The inhibitive action is attributed to the adsorption of the inhibitor molecules on metal surface following Langmuir adsorption isotherm.

Keywords: *Cocos nucifera* L. water; Acid inhibition; Green inhibitor; Aluminium; Weight loss

HCl solution is the acid of choice for industrial chemical cleaning, pickling and electrochemical etching of aluminium and these processes result in substantial loss of base metal to acid corrosion. In order to minimize base metal loss and reduce acid consumption, organic and inorganic compounds [1] are usually added to HCl solution as corrosion inhibitors, but some of these inhibitor are toxic, non-biodegradable and costly to synthesize [1–5]. Consequently, as a result of environmental concern for these compounds, plant extracts are increasingly being tried as corrosion inhibitors of metals in acid environment to replace toxic chemicals currently in use.

Amongst others, extracts of some plants such as *Delonix regia* [6] *Opuntia* [7], *Vernonia amydalina* [8] and *Sansevieria trifasciata* [9] have been reported to inhibit the rate of acid corrosion of Al. Their inhibitive effect has been attributed to the presence of phytochemicals in their chemical constituents and the adsorption of the phytochemicals on the Al surface leads to slowing down of the electrochemical processes on the metal surface.

Cocos nucifera L. water (coconut liquid endosperm) contains several biodegradable non-toxic organic compounds and is one of the world's most versatile natural products because of its many applications [10,11]. In our previous report [11], CW has been established as a green corrosion inhibitor of acid corrosion of mild steel in HCl solution, using weight loss method. Presently, to the best of our knowledge, there is no reported work on the effect of CW on acid corrosion of Al in HCl solution.

The paper reports the inhibitive effect of CW on corrosion of Al in 0.5 mol/L HCl solution using weight loss method.

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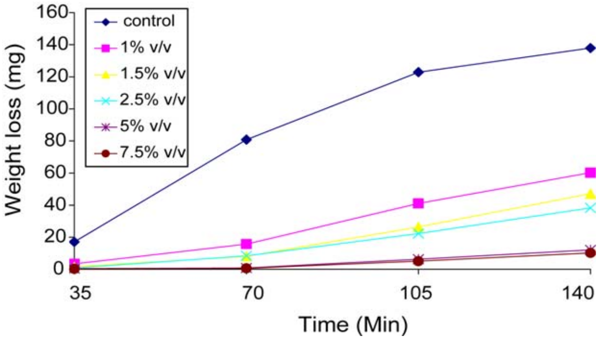

Fig. 1. The variation of weight loss of aluminium coupon with time in the absence and presence of *Cocos nucifera* L. water at 30 °C.

1. Experimental

The Al test specimens of dimensions 5 cm × 2 cm × 0.04 cm were cut from Al sheet of 0.04 cm in thickness and 98.8% purity. The Al samples were prepared, degreased and cleaned as described earlier [12].

HCl was of analytical grade and 0.5 mol/L HCl was employed as the aggressive solution for this study. The stock solution of CW was prepared as reported earlier [11]. The stock solution of the CW was diluted with appropriate quantity of 0.5 mol/L HCl solution to obtain inhibitor test solutions of 1–7.5% (v/v) concentrations. The procedure for weight loss determination was as previously reported [11,12]. Previously weighed Al coupons were immersed in 100 mL open beakers containing 80 mL of 0.5 mol/L HCl (blank) and then with addition of different CW concentrations to the 0.5 mol/L HCl (1–7.5%, v/v) at 30 °C. The weight losses of the coupons were monitored for 140 consecutive min at 35 min interval as presented in Fig. 1. Duplicate experiments were conducted at the same time and the average values were taken. Corrosion rate (mm/year), percentage inhibition efficiency ($n\%$) and surface coverage (θ) were calculated for 140 min immersion period using the following equations [1]:

$$\text{Corrosion rate (mm/year)} = \frac{87.6w}{DAt} \tag{1}$$

$$n\% = \frac{r_a - r_p}{r_a} \tag{2}$$

$$\theta = \frac{n\%}{100} \tag{3}$$

where w is the weight loss of aluminium (mg), D is the density of the aluminium (g cm^{-3}), A is the area of specimen (cm^2), and t is the immersion time (h).

2. Results and discussion

The correlation of weight loss of Al samples with time in free acid and in the presence of different concentrations of CW is shown in Fig. 1. This figure shows that the introduction of the CW at different concentrations to the acid solution decreased the value of material loss from the surface of Al and the decreased deflection of the weight loss rate with time for 1–7.5% (v/v) CW concentrations. This observation in Fig. 1 shows that CW acts as an inhibitor of Al corrosion in 0.5 mol/L HCl at the studied concentrations. It is evident in Table 1 that the corrosion rate decreased with increasing concentration of the CW in HCl solutions and the inhibition efficiencies increase with increasing CW concentration.

This behaviour indicates that the inhibition is due to the adsorption of inhibitor's molecule onto the Al surface and the CW acts as an adsorption inhibitor. Comparing this result (Table 1) with the prescribed efficiency limit of 87% for acid pickling inhibitors [13], CW is a good inhibitor of acid corrosion of Al in HCl solution with 93% inhibition at 7.5% (v/v) concentration. The inhibitory effect of the CW is ascribed to the presence of organic compounds (Fig. 2) in