

ASSESSMENT OF THE INHIBITIVE EFFECT OF COCONUT WATER (*COCOS NUCIFERA LINN*) ON THE CORROSION OF ALUMINIUM IN ACIDIC MEDIUM

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Abstract: The corrosion inhibitive effect of Coconut (*Cocos nucifera linn*) juice on the acid corrosion of aluminium in 1M HCl solution was studied by a weight loss technique which is regarded as the best method for this analysis. The analyses were carried out using 5-30ml of the *Cocos nucifera linn*. Aluminum sheets of purity 99.8% were used in this study. Each sheet was 0.12cm thick and was cut into square like shaped coupons of dimension 4 cm x 5 cm. However, surface treatment of the coupon involved degreasing in absolute ethanol and drying in acetone. The pre-weighted aluminum coupons were totally immersed in a beaker containing the corroding acidic medium of various concentration of the inhibitor at the time intervals of 1-5 hours. The inhibitor exhibited highest inhibition efficiency of 84.0% at the highest inhibitor concentration of 60% v/v. The corrosion rate was found to decrease. It was found that the extracts of *Cocos nucifera* inhibited the corrosion of aluminium in this acid medium. The inhibitor (coconut water) efficiency increased with increasing concentration of the *Cocos nucifera* juice at 30⁰C. This research showed that coconut juice possesses inhibiting properties for reducing the corrosion of aluminium in the 1M HCl.

Keywords: Cocos Nucifera Linn, inhibitive effect, aluminium, HCl, corrosion rate.

I. INTRODUCTION

Corrosion is defined as the physical interaction between a metal and its environment which results in changes of the metal's properties and which may lead to significant functional impairment of the metal, the environment or the technical system of which they form a part. Or Corrosion can be also defined as the deterioration of material by reaction to its environment. Corrosion occurs because of the natural tendency for most metals to return to their natural state (reverse of metallurgy); For instance, iron is made from hematite (common ore of iron) by heating with carbon. Iron corrodes and reverts to rust. The hematite and rust have the same composition. Despite different definitions, it can be observed that corrosion is basically the result of interaction between materials and their environment. Corrosion is an enemy to mankind because it causes destruction of properties worth billions of dollars all round the world annually. The use of inhibitor is one of the most suitable and cheapest methods employed to tackle corrosion especially in acidic media (Touir *et al.*, 2008). Inhibitors naturally react physically or chemically with metals by adsorbing on its surface. The adsorption may form a layer on the metal and function as a barrier protecting the metal. The adsorption process depends on the nature and surface area of the metal, the chemical structure of the organic molecule, distribution of the charge in the molecule and the aggressive medium. The efficiency of inhibitor may depend on the nature of environment, nature of metal surface, electrochemical potential at the interface the structural feature of inhibitor, which includes number of adsorption centers in the molecule, their charge density, the molecular size and mode of adsorption (Ahamed *et al.*, 2009). The adsorption

phenomenon could take place via electrostatic attraction between the charged metal and charged inhibitors molecules and Pi (π) – electron interaction with the metals (Abdel – Gaber *et al.*, 2009). A good inhibitor should be easily prepared from low cost raw materials and the organic compound has to contain electronegative atoms such as O, N, P, and S. Inhibition increases in the sequence: $O < N < S < P$ Musa *et al.* (2009). These organic compounds function by forming a protective adsorption layer on aluminium surface which isolates the corroding metal from action of corrodent. The use of corrosion inhibitor is most economical and practical method to reduce electrochemical corrosion. Organic compounds have been widely used as corrosion inhibitor for aluminium in acid media. Several inhibitors in use is either synthesized from cheap raw materials or chosen from compounds having heteroatoms in their aromatic or long chain carbon system. The influence of such organic compounds on the corrosion of aluminium in acidic solution has been investigated by several researchers (Ebenso, 2004; Oguzie, 2008). The inhibition property of these compounds is attributed to their molecular structure (Mora-Mendoza *et al.*, 2002). The organic inhibitors decrease corrosion rate by adsorbing on the metal surface and blocking the active sites by displacing water molecules and form a compact barrier film on the metal surface.

In recent years, natural products such as plant extracts have become important as an environmentally acceptable, readily available and renewable source of materials for wide range of corrosion control. Attention has been focused on the corrosion inhibiting properties of plant extracts because plant extracts serve as incredibly rich sources of naturally synthesized chemical compounds that are environmentally being, inexpensive, readily available and renewable sources of materials and can be extracted by simple procedures. Naturally occurring substances have been used successfully as corrosion inhibitor for metals in corrosive environment (Eddy and Ebenso, 2008; Okafor *et al.*, 2005, 2007; Okafor and Ebenso, 2007; Abiola *et al.*, 2007; Umoren and Ebenso, 2008; Rajendran *et al.*, 2005; Oguzie, 2005; Oguzie *et al.*, 2006, 2007; Bendahou *et al.*, 2005). A lot of works have been reported on the inhibition of acid corrosion of metals using economic plants such as *Vernonia Amydalina* (bitter leaf) extracts (Loto, 1998), *Zenthoxylum alatum* plant (Chauhara and Gunasekara, 2006), seeds extract of *Strychnos nuxvomica* (Ambrish Singh *et al.*, 2010), *Gossipium hirsutum* Liquid extract (Abiola *et al.*, 2009), *Areca catechu* (Vinod Kumar *et al.*, 2011).

The aim of this study is to investigate the inhibitive effect of *Cocos nucifera* juice and its efficiency as a natural corrosion inhibitor on aluminium in 1 M HCl solution using the weight loss technique. Several laboratory techniques have been used to investigate the relative resistance of metals in various corrosive environments. The weight loss technique is considered the best though long and tedious is by far more informative than other laboratory techniques.

Coconut plant (*cocos nucifera* linn) has long been used as a valuable source of various commodities for human life. It provides varieties of uses. For example is used in cooking food, making juice, sugar, vinegar, fibers, thatching, oil, and brooms among many others. However, studies have shown that coconut plants can yield over two tons of oil per hectare. Coconut water has been studied since 1940s. In its natural state, it is nutritious beverage which is widely consumed due to its beneficial properties to health. Research has also shown that coconut water could be used as an alternative for oral rehydration and intravenous hydration of patients in remote regions. Also, a study has shown that regular consumption of either coconut water or a liquid extracted from the bark of the mauby tree (*Colubrina arborescens*), or a mixture of both, is effective in bringing about the control of hypertension.

Aluminium is a hard, strong, white metal. It is highly electropositive and resistant to corrosion because a hard, tough film of oxide is formed on the surface. Aluminium have very regular and diversified uses in domestic appliances, chemical reactions and storage bottles, vessels and containers, buildings, bridges, packaging foils, automobiles, aircrafts, ships and many others. It is used for variety of applications due to its light weight, very high strength, good thermal and electrical conductivities, good heat and light reflectivity, its non-rusty nature, non-toxicity and attractive appearance. It is highly electropositive and has the capability to resist corrosion to a certain level because it is hard, tough film of oxide is formed on the surface.

II. MATERIALS AND METHODOLOGY

MATERIALS:

The experimental materials and reagents include: 1M HCl, Coconut water, ethanol, acetone, beaker, desiccator, analytical weighing balance, bristle brush and aluminium coupon.



Graph I: Corrosion attack on an old ship

Stock Solution of *Cocos Nucifera*

Stock solution of *Cocos nucifera* was prepared by mixing 100 ml of it with 100ml of 1M HCl in a round bottomed flask. The blank corrodent was 1M HCl solution.



Graph II: samples of matured coconut with water

III. METHODOLOGY

Aluminum sheets of purity 98.8% were used in this study. Each sheet was 0.14cm thick and was mechanically cut into rectangular coupons of dimension 4 cm x 5 cm. The total surface area of the coupon used was 20 cm². These coupons were used without further polishing. However, surface treatment of the coupon involved degreasing in absolute ethanol and drying in acetone. The coupons were then stored in moisture – free desiccator to avoid contamination before using them for corrosion studies. The initial weight of each sample was taken and recorded. All reagents used were BDH analytical grade. They were used as sourced without further purification. The used acid solutions were made from 37% HCl. An aqueous solution of 1M HCl was used as a blank solution. The inhibitor used was *Cocos nucifera* juice. Different concentrations (from 10% v/v to 60% v/v) were prepared with 1M hydrochloric acid solution and were used for all measurement. The temperature of the reaction was monitored at 30⁰C. This work involved the introduction of already prepared concentrations of the inhibitor into separate beakers maintained at 30⁰C. A total of eight beakers labeled B₁ – B₈ were used; with B₁ and B₂ containing 50 ml of 1M HCl solution only (without *Cocos nucifera* juice); these were used as the blank (control) experiment. The other beakers labeled B₃ to B₈ contain different volumes of stock solution and 1M HCl as follows:

- B₃ - 45 ml of 1 M HCl + 5 ml of stock solution
- B₄ - 40 ml of 1 M HCl + 10 ml of stock solution
- B₅ - 35 ml of 1 M HCl + 15 ml of stock solution
- B₆ - 30 ml of 1 M HCl + 20 ml of stock solution
- B₇ - 25 ml of 1 M HCl + 25 ml of stock solution
- B₈ - 20 ml of 1 M HCl + 30 ml of stock solution

Previously weighed aluminium coupons were then placed in the test solutions. Each Coupon was retrieved from the test solutions at 1 hour intervals progressively for 5 hours. After the immersion test, the specimens were carefully rinsed in distilled water, dried and then weighed. Rinsing removed loose segments of the film of the corroded samples. The difference in weight of the coupons was again taken as the weight loss. From the initial and final weights of the aluminium coupons, the weight loss, the corrosion rate (CR) ($\text{gcm}^{-2}/\text{hr}$) and inhibition efficiency were determined using equations 1 and 2 respectively (Wabane and Okafor, 2001).

$$CR = \frac{W}{AT} \dots\dots\dots (1)$$

W is the weight loss of the aluminium coupon after time t (grams), A is the area of the aluminium coupon (cm^2) and t is the time of immersion (hours)

$$I.E (\%) = \frac{CR_{(blank)} - CR_{(inhibited)}}{CR_{(blank)}} \dots\dots\dots (2)$$

Where $CR_{(blank)}$ and $CR_{(inhibited)}$ are the corrosion rates of the aluminium coupons in the absence and presence of the inhibitors respectively. All the experiment were performed in duplicate

IV. RESULTS

The experimental results are presented in table 1 below.

Immersion time	Samples	$W_i(\text{g})$	$W_f(\text{g})$	$W_i - W_f(\text{g})$
1 hour	B ₁	1.3670	0.9200	0.4470
	B ₂	1.3580	0.9120	0.4460
	B ₃	1.3570	0.9730	0.3840
	B ₄	1.3620	1.0920	0.2700
	B ₅	1.3630	1.1420	0.2210
	B ₆	1.3610	1.1710	0.1900
	B ₇	1.3600	1.2350	0.1250
	B ₈	1.3600	1.2870	0.0730
2 hours	B ₁	1.3670	0.9174	0.4496
	B ₂	1.3580	0.9110	0.4470
	B ₃	1.3570	0.9484	0.4086
	B ₄	1.3620	1.0070	0.3550
	B ₅	1.3630	1.0498	0.3132
	B ₆	1.3610	1.0695	0.2915
	B ₇	1.3600	1.1172	0.2428
	B ₈	1.3600	1.1653	0.1947
3 hours	B ₁	1.3670	0.9143	0.4527
	B ₂	1.3580	0.9063	0.4517
	B ₃	1.3570	0.9377	0.4193
	B ₄	1.3620	0.9811	0.3809
	B ₅	1.3630	1.0200	0.3430
	B ₆	1.3610	1.0361	0.3249
	B ₇	1.3600	1.0638	0.2962
	B ₈	1.3600	1.0960	0.2640

4 hours	B ₁	1.3670	0.9132	0.4538
	B ₂	1.3580	0.9054	0.4526
	B ₃	1.3570	0.9343	0.4227
	B ₄	1.3620	0.9436	0.4184
	B ₅	1.3630	1.0103	0.3527
	B ₆	1.3610	1.0246	0.3364
	B ₇	1.3600	1.0474	0.3126
	B ₈	1.3600	1.0754	0.2846

Where:

W_i = Initial weight

W_f = Final weight

Weight loss = $W_i - W_f$

Effect of concentration on inhibition efficiency

The concentration of the inhibitor and its efficiency exhibit a direct proportionality. As the concentration increases, inhibition efficiency increases. This is clearly shown in Figure 1 to figure 5.

Table 2: Weight loss and inhibition efficiency after 1 hour

Sample	Inhibitor Concentration (% v/v)	Weight Loss (g)	Inhibition Efficiency (%)
B ₃	10	0.3840	14.1
B ₄	20	0.2700	40.0
B ₅	30	0.2210	50.5
B ₆	40	0.1900	57.5
B ₇	50	0.1250	72.0
B ₈	60	0.0730	84.0

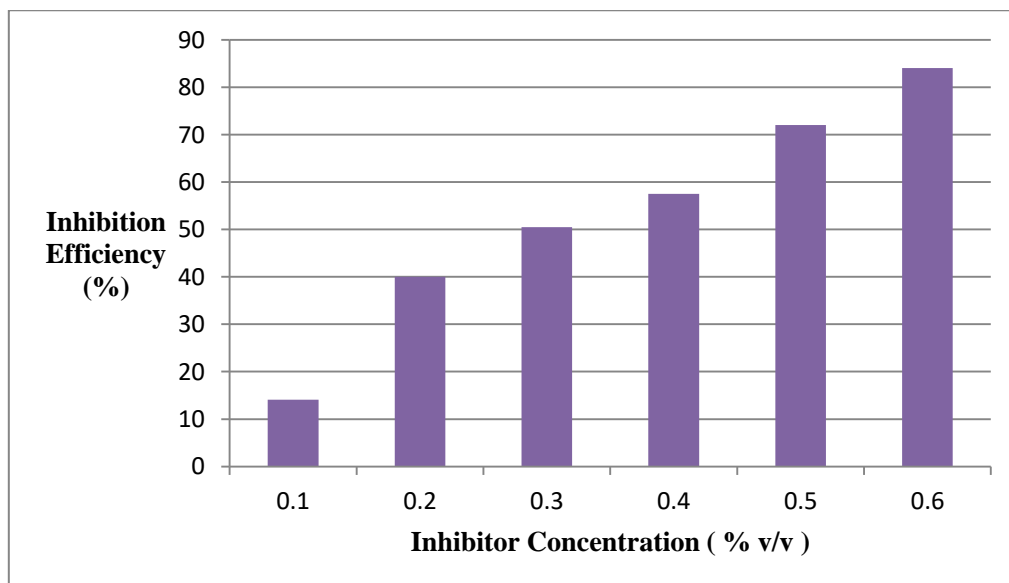


Figure 1: Effect of concentration on inhibition efficiency after 1 hour

Table 3: Weight loss and inhibition efficiency after 2 hours

Sample	Inhibitor Concentration (% v/v)	Weight Loss (g)	Inhibition Efficiency (%)
B ₃	10	0.4086	9.0
B ₄	20	0.3550	21.0
B ₅	30	0.3132	30.3
B ₆	40	0.2915	35.1
B ₇	50	0.2428	45.9
B ₈	60	0.1947	56.6

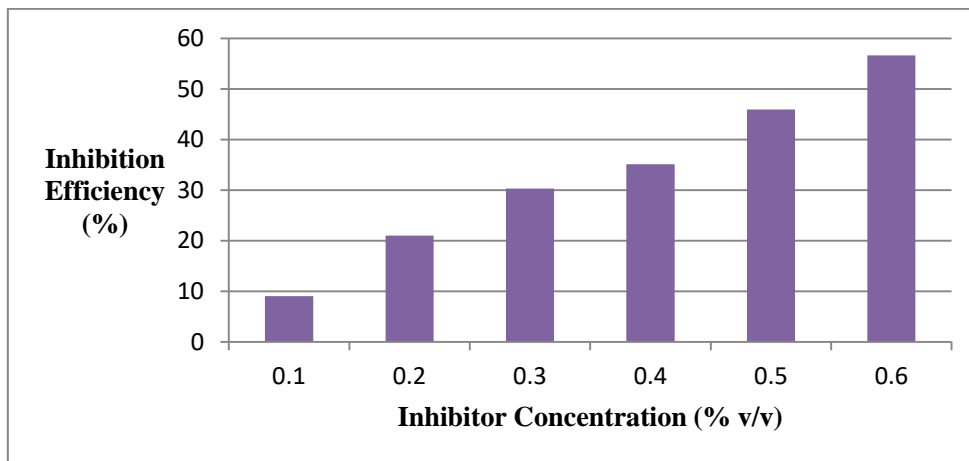


Figure 2: Effect of concentration on inhibition efficiency after 2 hours

Table 4: Weight loss and inhibition efficiency after 3 hours

Sample	Inhibitor Concentration (% v/v)	Weight Loss (g)	Inhibition Efficiency (%)
B ₃	10	0.4193	7.3
B ₄	20	0.3809	15.8
B ₅	30	0.3430	24.2
B ₆	40	0.3249	28.2
B ₇	50	0.2962	34.6
B ₈	60	0.2640	41.7

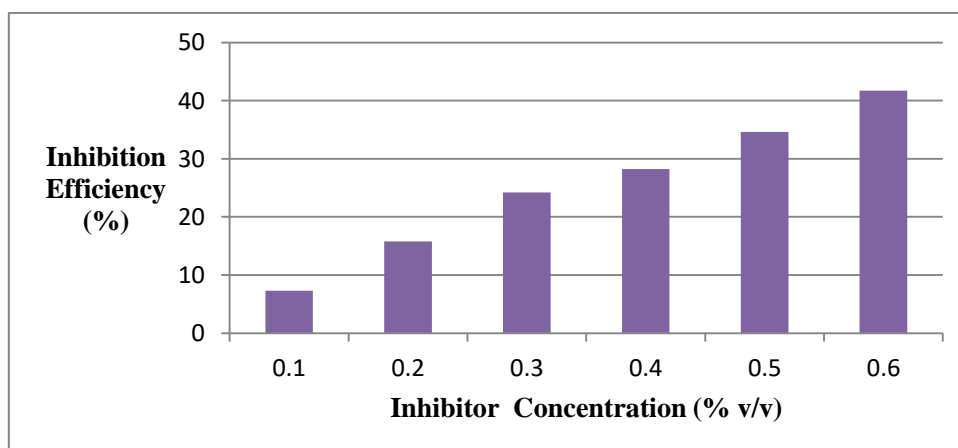


Figure 3: Effect of concentration on inhibition efficiency after 3 hours

Table 5: Weight loss and inhibition efficiency after 4 hours

Sample	Inhibitor Concentration (% v/v)	Weight Loss (g)	Inhibition Efficiency (%)
B ₃	10	0.4227	6.9
B ₄	20	0.4184	7.8
B ₅	30	0.3527	22.3
B ₅	40	0.3364	25.9
B ₆	50	0.3126	31.1
B ₇	60	0.2846	37.3

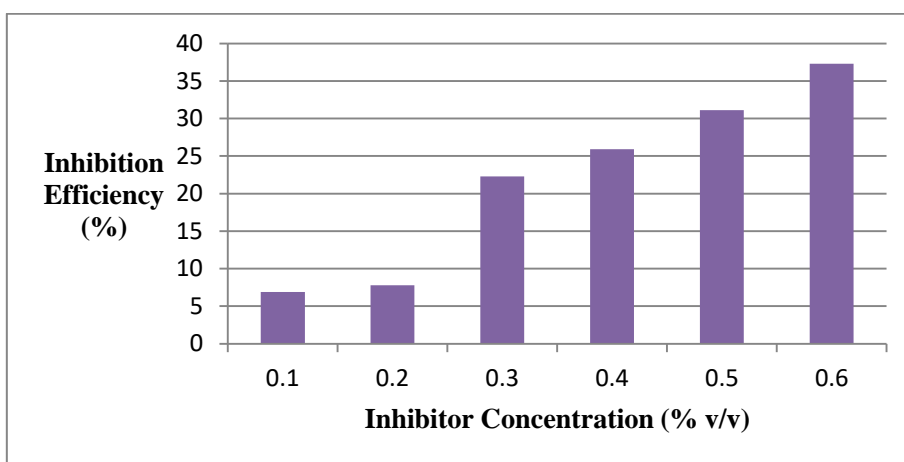


Figure 4: Effect of concentration on inhibition efficiency after 4 hours

Table 6: Weight loss and inhibition efficiency after 5 hours

Sample	Inhibitor Concentration (% v/v)	Weight Loss (g)	Inhibition Efficiency (%)
B ₃	10	0.4272	5.9
B ₄	20	0.4228	6.9
B ₅	30	0.3543	22.0
B ₆	40	0.3372	25.8
B ₇	50	0.3134	31.0
B ₈	60	0.2862	37.0

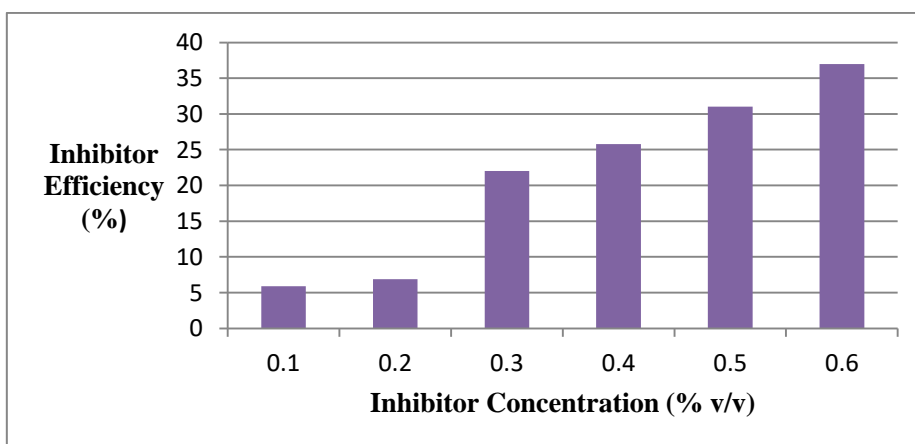


Figure 5: Effect of concentration on inhibition efficiency after 5 Hours

V. CONCLUSION

The rate of corrosion decreases significantly with increasing concentration of *Cocos nucifera* juice. The addition of the inhibitor resulted in noticeable reduction in the amount of material loss from the aluminium surface in comparison with that of control (1M HCl) at 30°C. The inhibition efficiency increases with increasing concentration of *Cocos nucifera* and the percentage inhibition efficiency was relatively high in 1M HCl solution (84.0%) at 60% v/v of *Cocos nucifera* juice.

The present study shows that *Cocos nucifera* juice inhibits the corrosion of aluminium in 1M HCl solution at a concentration of 60% v/v. The inhibitive action of *Cocos nucifera* juice is ascribed to the adsorption of its molecules on the aluminium surface.

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