The Corrosion Inhibition of Aluminium Metal In 0.5M Sulphuric Acid Using Extract Of Breadfruit Peels

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ABSTRACT

In the present work, corrosion inhibition of aluminium metal in 0.5M H_2SO_4 solution by extract from breadfruit peel was investigated using weight loss method. It has been found that the extract acts as an effective corrosion inhibitor of aluminum in sulphuric acid as a corrodent. The inhibition process is attributed to the formation of an adsorbed film of inhibition on the metal surface which protects the metal against corrosion. The inhibition efficiency and surface coverage (Θ) if extract from breadfruit peel increased with increase in inhibitor concentration, but decreased with increasing temperature. The adsorption of extract of breadfruit peel on aluminum metal surface was found to obey Langmuir's adsorption isotherm. The negative free energy value ($-\Delta G_{ads}$) indicates that the adsorption of inhibitor molecule was of physical adsorption and the reaction was spontaneous extract from breadfruit peel could serve as an excellent corrosion inhibitor owing to the nature that it is eco-friendly, cheap, biodegradable and highly acceptable by environmental regulation.

Keywords: *Adsorption, Breadfruit Peel, Corrosion Inhibition, Free Energy, Weight loss method.*

1.0INTRODUCTION

Aluminum is the second most used metal after iron. It is used in large number of application both as aluminum metal and wide range of alloys. Because of the low atomic mass (27g/mol) and the negative value of standard electrode potential (-eV), aluminum potentially is an anodic material for power sources with high energy densities [9,12]. The essential nature of aluminum makes it one of the metal that is heavily sort for in the industry. Aluminium protective films are stable in aqueous solution of pH range of 4.5-8.5, but not stable in strong acid and alkaline solutions. One of the most challenging and difficult task for industries is the protection of aluminum from corrosion [9,6,20].

Corrosion of aluminum has resulted to the following problems:

i. Passivation of the cathode active metal
ii. Solid products increase their electric resistance
iii. Soluble products contaminate the electrolyte and increase the self discharge rate
iv. Dissolved aluminum ion (Al^{3+}) migrate to the counter anode and reductively get deposited[19,24]

Acid media are always used in the study of corrosion of aluminum because acids (HCl, H_2SO_4, H_2PO_4, CH_3COOH, etc) are commonly used for pickling, industrial cleaning, descaling, etc, [7,11,17]. In the effort to reduce the menace of corrosion of aluminum, various method have been employed such as upgrading materials, blending of product fluid, process control, and chemical inhibition [7,9,16]. A number of chemical inhibitor as opine by researchers are known to be applicable as good corrosion inhibitor of aluminum[9,15,18]. Thus, the use of chemical inhibitor is depleting due to strict environmental regulation and toxic effect of the chemical compound on human and animal life.Examples of some chemical inhibitor are tetrachromate (VI) ion (CrO_4^{2-}), dinitrate (V) ion (NO_2^-), trimolybdinate (V)ion (MoO_3^-), hydrogen tetraphosphate (V) ion ($H_2PO_4^-$) and silicate [23,24].Owing to the toxicity of these chemical inhibitors, there is need to develop a new class of inhibitor called green inhibitor with low toxicity, eco-friendliness, improved efficiency, acceptability and cost-effectiveness.A lot of natural product were previously used as corrosion inhibitor of different metal in various environment [3,4,5,8,10,16,18,21,22]. And there optimum concentration was reported. There finding indicates that the plant extract could serves as effective corrosion inhibitors, they also establish that corrosion inhibition occur via adsorption of their molecule on the corroding metal surface and the efficiency of inhibition depends on the mechanical, structural and chemical adsorption layer form under particular condition.

Extractsof plant witha wide variety of organic compounds containing heteroatoms like phosphorus, nitrogen, sulphur and oxygen have been investigated on their green corrosion inhibition properties[1]. These atoms coordinate with the corroding metal atom (their ion) through their electron and prevent corrosion by formation of protective layer on the metal surface [2,13,14].

The purpose of the study is to reveal the use of extract from breadfruit peels to inhibit the corrosion of aluminum in sulphuric acid. Breadfruit peel has been analyze and found to contain highest level of ascorbic acid and the least level of total reducing sugar [1]. The ascorbic acid contains conjugated and electron rich compound that may likely inhibits the corrosion of metal. In the study, the inhibitory action of extract from breadfruit peel on the corrosion of aluminum in 0.5M H_2SO_4solution has been investigated at three different temperatures, using weight loss experiment.

2.0 METHOD

2.1 Material preparation

The commercial aluminum metal of thickness 1mm with dimension of 3cm X 4cm, used for the study was obtained at the world bank engineering workshop, university of Port-Harcourt, Choba Port Harcourt, the total geometric surface area of coupon expose is $24cm^2$, cleaning and degreasing was done by grade acetone followed by rinsing with distilled water. The inhibitor used was extract from breadfruit peel, the breadfruit peel was obtained locally from different location from Idu Ogba farm land in ONELGA Rivers State. The dry grindered breadfruit peel was boiled with 50ml of acetone and 50ml of water mixture. The resulting solution was heated to dryness, the powered obtained was then scrapped out and stored in a sample bottle. Five different concentration of 0.025g/dm^3 and 0.0075 g/dm^3, 0.0101 g/dm^3, 0.0125 g/dm^3 and 0.145 g/dm^3 of the extract were prepared with 0.5M H_2SO_4 acid solution was used for all measurement.

2.2 Weight loss method

The weight loss techniques are the conventional and simplest of all corrosion monitoring techniques. The method involves the exposing of the specimen of material (the coupon) to a process environment for a given period, then removing the specimen for measurement. The basic measurement which is determined from corrosion coupon, is weight loss, the weight loss taking place over the period of exposure being expressed as corrosion rate [6,18]. In the weight loss measurement; aluminum coupons were completely immersed in 100ml of the test solution of acidic environment (0.5M H_2SO_4) in the present and absence of the inhibitor at different temperature, the aluminum coupons were weight at interval of 30 minutes for 240 minutes of the experimental period. Corrosion rate is calculated assuming uniform corrosion over the entire surface of the coupon, corrosion rates (CR) are calculated from weight loss methods.

The formula used to calculate corrosion rates is

$$\text{Corrosion rate (mmpy)} = \frac{87.6xW}{DAT} \quad \text{Eq. 1}$$

Where: W = weight loss (g), D = density (g/cm^3) A = area of specimen (cm^2) and T= time (hr)

The inhibition efficiency (%IE) and degree of surface coverage (Θ) were calculated using

$$\% IE = \frac{W1-W2}{W1} \text{ x } 100\% \quad \text{Eq. 2}$$

$$\Theta = \frac{W1-W2}{W1} \text{ x } 100\% \quad \text{Eq. 3}$$

Where: $W_1$and W_2 are the corrosion rates in the absence and presence of the inhibitor respectively.

3.0 RESULT AND DISCUSSION

Table 1:Corrosion parameter of aluminum in 0.5M H_2SO_4 in different concentration of extract from breadfruit peels.

Inhibitor conc.	30⁰C			40⁰C			50⁰C		
	Surface coverage	Rate	% IE	Surface coverage	Rate	% IE	Surface coverage	Rate	% IE
0.0025	0.575	0.00487	57.5	0.56	0.00495	56.5	0.55	0.00506	55.5
0.0075	0.771	0.00270	77.1	0.712	0.00324	71.5	0.672	0.00379	67.2
0.0101	0.781	0.00143	78.1	0.752	0.00284	75.2	0.715	0.00324	71.5
0.0125	0.804	0.00216	80.4	0.784	0.00243	78.4	0.765	0.00270	76.5
0.0145	0.853	0.00162	85.3	0.832	0.00189	83.2	0.812	0.00216	81.2

Table 2: Mean % IE of Breadfruit Peel Extract Conc. on Aluminum in0.5M H_2SO_4 at different temperatures.

Inhibitors conc. (g/L)	30^0C	40^0C	50^0C
0.0025	57.5	56.5	55.5
0.0075	77.1	71.5	67.2
0.0101	78.1	75.2	71.5
0.0125	80.4	78.4	76.5
0.0145	85.3	83.2	81.2

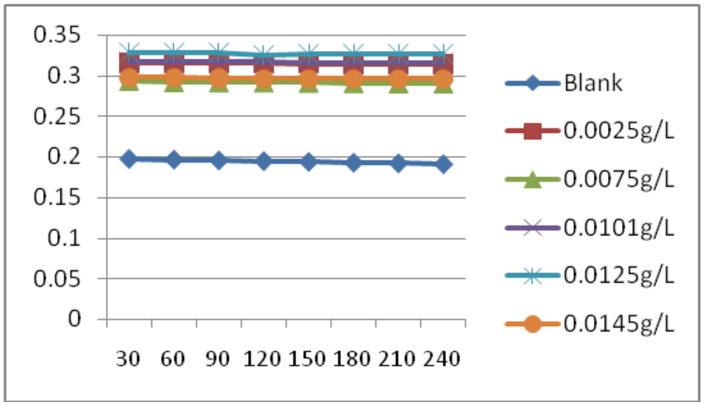
Table 3: Thermodynamic parameter of Aluminum Metalin absence and presence of different conc. of extract from breadfruit peelsin 0.5M H_2SO_4

Temperature (K)	K_{ads} (mol^{-1})	ΔG^0 (KJ/mol)
303	52.6	-20.104
313	125.0	-23.021
323	200	-25.018

3.1Weight loss measurement and effect of temperature

The effect of the addition of extract from breadfruit peel tested at different concentration on the corrosion of aluminum coupon in 0.5M H_2SO_4 solution was studied by weight loss measurement at 30^0C, 40^0C and 50^0C. for 240 minutes of immersion period. The value of percentage inhibition efficiency and corrosion rate obtained from weight loss method at different concentration of extract from breadfruit peel at different temperature are summarized in **Table 1.** it is observed that the decreasing corrosion rate is associated with increase in the inhibitors concentration, which indicates adsorption of inhibitor on the metal surface or at the solution interface, providing wide surface coverage. **Table 2,** demonstrates the effect of increase in temperature on percentage efficiency of inhibition. As the temperature increases from 30⁰C to 40⁰C to 50⁰C respectively, the inhibition efficiency decrease from 85.3% to 83.2% to 81.2% respectively, the data obtained suggest that extract from breadfruit peel adsorbed on the metal surface at different temperature of study in 0.5M H_2SO_4 solution, and the decrease in inhibition efficiency was probably due to decreasing strength of adsorption (Shifting the adsorption – desorption equilibrium toward desorption).

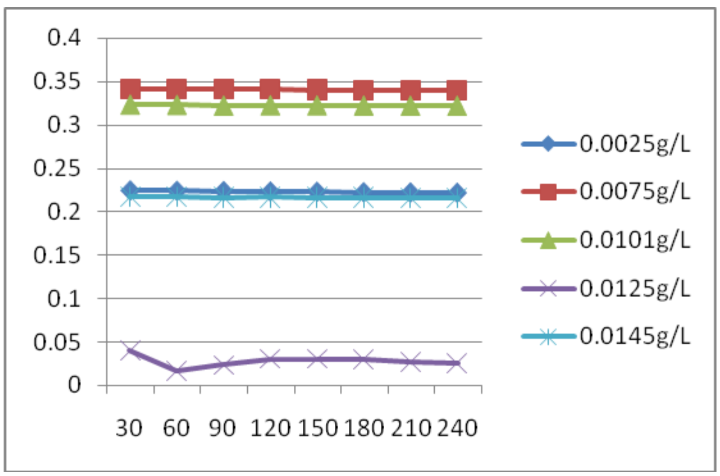
Log (W_1 - ΔW)



Time

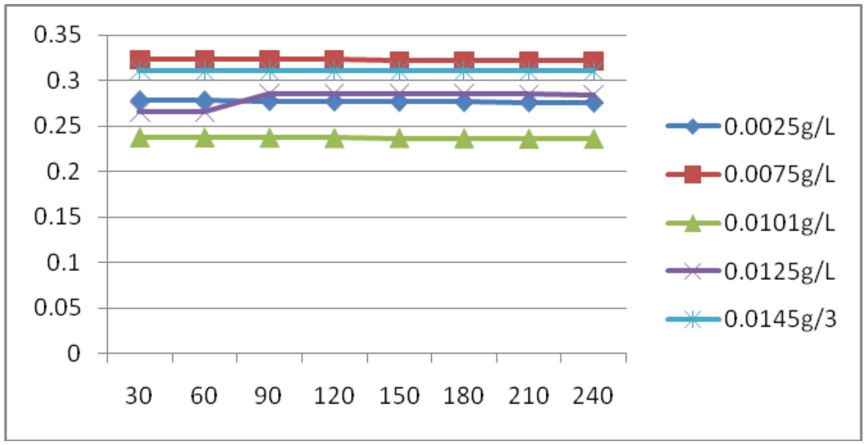
Figure 1:Variation of log (W_1 - ΔW) with time for aluminum metal in 0.5M H_2SO_4 solution containing different concentration of extract of breadfruit peel at 30⁰C

Log (W_1 - ΔW)



Time

Figure 2:Variation of log (W_1 - ΔW) with time for aluminum metal in 0.5M H_2SO_4 solution containing different concentration of extract of breadfruit peel at 40⁰C

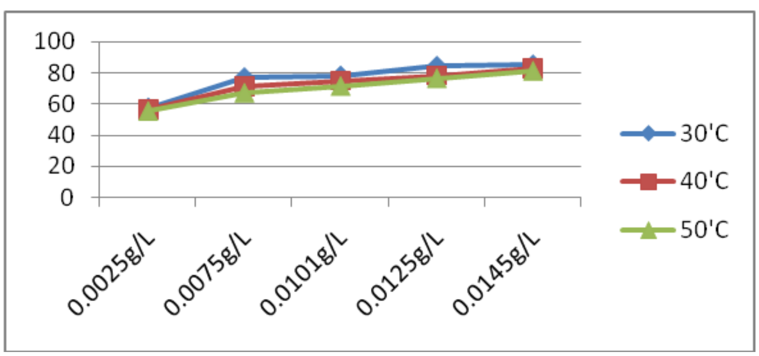


Log(W_1 -ΔW)

Time

Figure 3: Variation of log (W_1 - ΔW) with time for aluminum coupon in 0.5M H_2SO_4 solution containing different concentration of extract of breadfruit peel at 50^0C

Figures1-3 show the variation of log(W_1-ΔW) with time for aluminum metal in 0.5M H_2SO_4 solution containing different concentration of extract from breadfruit peels at 30^0C, 40^0C and 50^0C respectively. The plot of log(W_1- ΔW). Against time at 30^0C, 40^0Cand 50^0C temperature of studied showed a linear variation which confirms a first order reaction kineticswith respect to corrosion of aluminum in 0.5M H_2SO_4 in the presence of extract from breadfruit peel.



IE

Conc.

Figure 4: Variation of inhibitor efficiency with inhibitor concentration for aluminum metal in 0.5M H_2SO_4 solution containing extract from breadfruit peel at three different temperature.

These effects of temperature over inhibition efficiency are demonstrated graphically in Figure 4 shown above.

3.2 Adsorption isotherm analysis

The effectiveness of organic compounds as corrosion inhibitor can be ascribed to the adsorption of molecules of the inhibitors through their polar function on the metal [10,11].

The observed inhibitive action of extract from breadfruit peel could be due to the adsorption of its molecules on the aluminum surface making a barrier for charge and mass transfer between the metal and the environment.

Table I, show the data at all the studied temperature (30^0C, 40^0C, 50^0C), the finding indicates that as the concentration of inhibitor increased, the fraction of aluminum surface covered by adsorbed molecule (ϴ) increases leading to higher efficiency. Figure V shows a graphical relation between the inhibitor concentration C_{inh} and C_{inh}/Θ at different temperature of study.

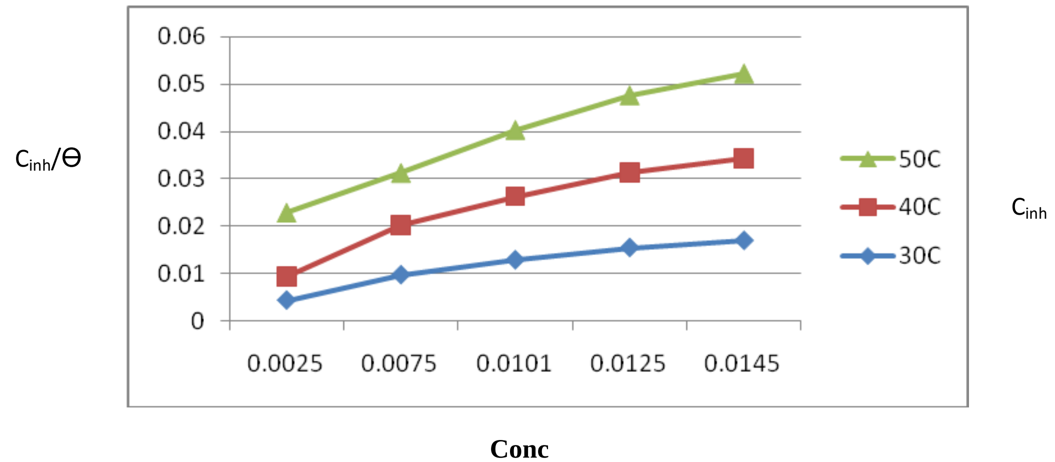


Figure 5: Linear variation of C_{inh}/Θ vs C_{inh} which indicates a Langmuir Isotherm.

The straight line relationship indicates that the adsorption of extract from breadfruit peel follows Langmuir adsorption isotherm.

$$\mathrm{Cinh}/\Theta = 1/Kads + \mathrm{Cinh} \qquad \text{Eq. 4}$$

Where: K_{ads} is adsorption constant, the K_{ads} value can be calculated from the intercept line on the C_{inh}/Θ axis, and is related to standard free energy of adsorption (ΔG) log ΔG = -2.303RT log(55.5K_{ads}).

3.3 Free energy determination

The free energies of adsorption ΔG_{ads} were calculated from the equilibrium constant of adsorption using the equation ΔG_{ads} = -2.303RT log(55.5K_{ads}).

Where 55.5 is the molar concentration of water in the solution, R is the universal gas constant and T is the absolution temperature. Generally, value of ΔG_{ads} around – 25KJ/mol or lower are consistent with the electrostatic interaction between the charged molecule and the metal surface (Physical adsorption), those around -40KJ/mol or higher involve charge sharing or transfer from organic molecule to the surface to form a coordinate type of bond [16,20].

From the finding in table III, the negative value of ΔG_{ads} indicates that extract from breadfruit peel undergoes physical adsorption on the surface of the metal spontaneously.

4.0 CONCLUSION

Extract of breadfruit peel acts as a good inhibitor for the corrosion of aluminum metal in 0.5M H_2SO_4 solution. The inhibition efficiency increases with increasing concentration, but decrease with increase in temperature.Adsorption of extract from breadfruit peel on aluminum follows the Langmuir Isotherm. The negative value of ΔG shows that adsorption of inhibitor on the surface of aluminum metal is spontaneous. Extract from breadfruit peel can be considered as a source of relatively cheap, eco-friendly, biodegradable and effective acid corrosion inhibition.

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