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Investigation of the Inhibition Efficiency of Irish Potatoes Leaves Extract on Aluminium Sheet in Acidic Medium

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Abstract
Aluminium is the most widely used non-ferrous metal, hence there is need to protect it from corrosion. This research work, investigated the inhibitive property of the ethanol extract obtained from Irish potato leaves (Solamun tuberosum) for aluminium corrosion using 2M H_2SO_4 *as a medium. The inhibitive effect of the extract against the corrosion of aluminium was investigated using gravimetric technique at* various *concentrations of the extract* (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 *g/L*). *The results* revealed *that with increase in concentrations of the extract, the corrosion rate decreases and the highest inhibition efficiency was* found *to be 77.78% at 4.0 g/L of the extract. Additionally, the adsorption of the extract on the aluminium surface was found to obey Langmuir's adsorption isotherm. However, the plant extract proved to be effective inhibitor on the corrosion of aluminium in the acid medium and can be used as green inhibitor.*

Keywords: Aluminium, corrosion, inhibition, extraction, irish potato, adsorption isotherm.

INTRODUCTION
Corrosion is the deterioration of metals by chemical attack or reaction with their environment. However, it is a constant and continuous problem, often difficult to eliminate completely. Therefore, prevention would be more practical and achievable than complete elimination (Bouklah *et al.,* 2005). The process of corrosion of metals tends to develop faster when the metal surface is disrupted by a number of reactions that change the properties and compositions of both the metal surface and its environment. For instance, local change in pH, oxides formation, diffusion of metal cations into the coating matrix and electrochemical potential (Fouda *et al.,* 2006).

Furthermore, corrosion of metals is a major problem for the application of metals in many services. According to the World Corrosion Organization (WCO) reported by Rajendran *et al.*

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(2009), corrosion causes waste of valuable resources, shutdown of plant, contamination of product, and decrease in productivity. However, to protect lives and preserve the valuable resources, there is need to investigate the causes and the mechanisms involved on how the resources are being destroyed by corrosion and how possible they can be protected by applying different corrosion technologies (Loto, 2005). However, a proper understanding of the environmental conditions and metal properties aids in designing an effective prevention system for the corrosion process (Adejo *et al.,* 2013).

Aluminium has many industrial applications and economic usage therefore; several attempts have been made to find methods of reducing its corrosion. Among these methods, inhibitors were found to be one of the most important and effective methods of corrosion prevention of aluminium (Patel and Šnita, 2014).

However, over the years, the use of inhibitors to protect materials especially metals, against the destructive effects of corrosion has been established (Adejo *et al.,* 2013). A corrosion inhibitor is defined as a chemical substance which effectively prevents or reduces corrosion when added in a very low concentration without significant reaction with the components of the corrosive environment (Garai *et al.,* 2012). Additionally, inhibitors could be natural or synthetic, organic or inorganic. Examples of inorganic inhibitors include carbonates, nitrites, silicates, chromates, and phosphates while organic inhibitors include heterocyclic nitrogen compounds, amines, sulphur compounds such as thioalcohols, thiourea and hydrazine (Atkins, 1998).

However, due to toxic effects of inorganic inhibitors to humans and the environment, their applications to inhibit corrosion have been restricted despites their excellent inhibitive properties (Adejo *et al.,* 2013). Therefore, attention has shifted to the use of plant extracts which are found to be eco-friendly, non-toxic, low cost, bio-degradable and coupled with simple procedures for their extraction (Nnanna *et al.,* 2010). So far, no work has been published on the inhibitive property of irish potato leaves. Therefore, this study aimed at evaluating the inhibitive potential of ethanol extract obtained from Irish potato leaves (Solamun tuberosum) as green inhibitor for the corrosion of Aluminium in acidic medium.

MATERIALS AND METHODS

Sample Collection and Preparation

Fresh leaves sample of Irish potato were obtained from Vom in Jos, Plateau State, Nigeria. The leaves were thoroughly washed with clean water to remove sand and other impurities and then air dried. After, drying, the leaves were pounded into powder using motar and pestle. While the aluminium sheet was purchased from building materials market in Suleja, Niger State.

Preparation of the Extract

The extract was obtained through solvent extraction method. Thus, 50 g of the prepared sample was transferred into a clean thimble and inserted into the soxhlet extractor. Ethanol (250 cm^3) was poured into 500 cm^3 round bottom flask containing the sample and a little boiling chip was added (to prevent uneven boiling). The round bottom flask was carefully placed on a heating mantle and the soxhlet extractor was carefully connected to the round bottom flask. The temperature of the heating mantle was set to about 78 ^oC and the extraction was done for 8 hours. The extract was heated to dryness under low pressure in a rotary evaporator (Adejo *et al.* 2013). The extract was further prepared at various concentrations (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 g/L) using serial dilution of the stock solution of the extract.

Preparation of Metal Coupons

Aluminium sheet was cut into coupons of size 3 x 2 x 1 cm using the method described by Nnanna *et al.* (2011). The coupons were degreased with solutions of ethanol and acetone to remove some organic impurities, followed by washing with deionized water, dried in an oven at 46 ^oC and polished with sand paper to obtain a clean shiny surface.

Inhibition Study of the Extract

Weight loss method was adopted to study the inhibitive property of the extract. Thus, nine test coupons (with a control) were weighed using electronic weighing balance and the weights were recorded. The coupons were completely immersed in separate beakers containing 250 cm^3 solution of 2 M H_2SO_4 in the absence and presence of the inhibitor with different concentrations. The coupons were removed from the solution and washed thoroughly with 500 $cm^3$of acetone to avoid further corrosion, followed by distilled water, dried and reweighed. The immersion time was 24 hours at room temperature. Weight loss was computed as the difference in weight of the coupons before immersion and after removal from the solution using equation (1) (Nnanna *et al.*, 2010)

$$W = (W_1 - W_2) \tag{1}$$

where, W = weight loss of coupon.
W_1= initial weight of metal
W_2 = final weight of metal

The corrosion rate (CR), percentage inhibition efficiency (I. E%) and surface coverage (θ) were calculated using equations (2), (3) and (4) respectively.

$$CR = W/A(T/365) \text{ (Daniel } et\ al.\text{, 2012)} \tag{2}$$

where CR = rate of corrosion (mg/mm^2 /year)
W = weight loss
A = surface area of the coupon (mm^2)
T/365 = time of exposure in days extended to year

$$I.E\% = \frac{(CR_{uninhibited} - CR_{inhibited})}{CR_{uninhibited}} \times 100 \tag{3}$$

where
CR = corrosion rate
CR = corrosion rate

$$\theta = \frac{W_0 - W}{W_0} \tag{4}$$

where
W_0= weight loss in the absence inhibitor
W= weight loss in the presence inhibitor (Orubite *et al.*, 2004)

RESULTS

Table 1 and 2 show the results for the corrosion rate of Aluminuim and inhibition efficiency of the extract at various concentrations in acidic medium and the degree of surface coverage for Aluminium respectively. Figure 1 represents the plot of Langmuir adsorption isotherm for the anticorrosion process.

Table 1: Effect of Concentrations of the Extract on Corrosion Rate of Aluminium and Inhibition Efficiency in 2M H_2SO_4 for 24 Hours

Conc. of Leaf Extract (g/L)	Initial Weight of Metal (g)	Final Weight of Metal (g)	Weight Loss of Metal (g)	Corrosion Rate (mg/mm²/yr)	Inhibition Efficiency (%)
Blank	3.4922	3.4877	0.0045	4.69	*
0.5	3.4768	3.4730	0.0038	3.96	15.56
1.0	3.4496	3.4462	0.0034	3.54	24.44
1.5	3.4878	3.4847	0.0031	3.23	31.11
2.0	3.4930	3.4900	0.0027	3.81	40.00
2.5	3.4477	3.4454	0.0023	2.40	48.89
3.0	3.4573	3.4556	0.0017	1.77	62.22
3.5	3.4689	3.4675	0.0014	1.46	68.89
4.0	3.4439	3.4429	0.0010	1.04	77.78

*= uninhibited system or Control

Table 2: Degree of surface coverage (θ) of Aluminium immersed for 24 Hours in 2 M H_2SO_4 in the presence of the extract as inhibitor

Conc. of Leaf Extract (g/L)	θ	C/ θ
Blank	-	-
0.5	0.1458	3.4294
1.0	0.2444	4.0917
1.5	0.3111	4.8216
2.0	0.4000	5.0000
2.5	0.4889	5.1135
3.0	0.6222	4.8216
3.5	0.6889	5.0806
4.0	0.7778	5.1427

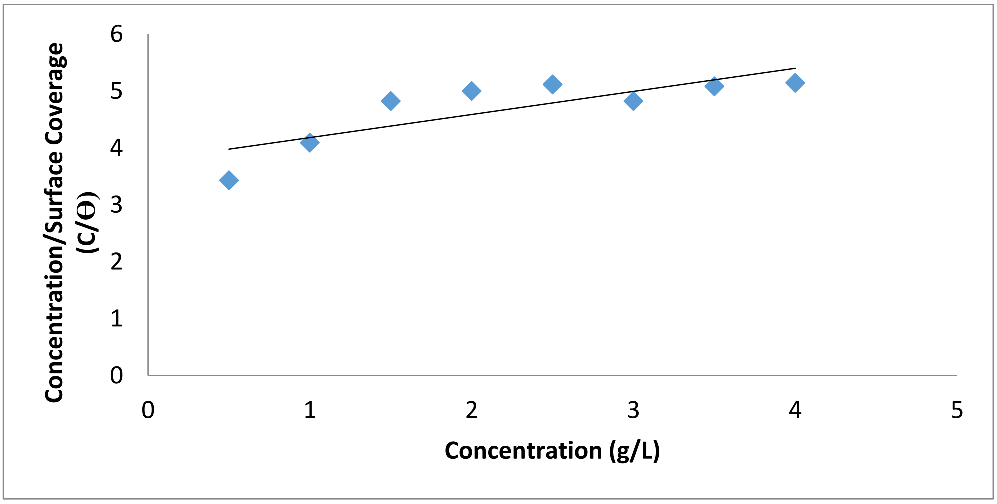

Figure 1: Langmuir Adsorption Isotherm for the Anticorrosion of Aluminium in presence of the Inhibitor.

DISCUSSION

The result indicates that for the blank medium (uninhibited system or control), an exceptional higher corrosion rate value (4.69 $mg/m^2/yr$) was observed, which was due to absence of inhibitor. However, it was observed that in the presence of the inhibitor, the corrosion rate decreases with increase in the concentrations of the inhibitor. The result revealed highest corrosion rate of 3.96$mg/mm^2/yr$ at 0.5 g/ L and lowest corrosion rate of 1.04 $mg/mm^2/yr$ at 4.0 g/L of the inhibitor.

The loss in weight of the Aluminium after immersion in 2 mol./dm^3 H_2SO_4 solution indicates the susceptibility of the metal to corrosion in an acidic environment as reported by Mistry *et al.,* (2011). This suggests that the presence of the inhibitor reduced the rate of corrosion on the Aluminum in 2 mol./dm^3 H_2SO_4 solution.

The efficiency of an inhibitor is the measure of its tendency to reduce the corrosion process in a given medium (Fiala *et al.,* 2007). From the result, it was revealed that the percentage inhibition efficiency of the extract increased with increase in concentrations of the extract in the system. However, the extract in the medium showed excellent inhibition efficiency with the highest value of 77.78% at 4.0 g/L concentration and the lowest inhibition efficiency value of 15.56% at 0.5 g/L concentration. This agreed with the results obtained by some researchers (Ebenso *et al.,* 2014; El-Etre, 2003; Abiola *et al.,* 2007; Umoren *et al.,* 2008), who equally reported the successful use of different naturally occurring substances to inhibit the corrosion of metals in acidic medium at various concentrations of the extract.

From the results, the values obtained for the degree of surface coverage (θ) were found to increase with increase in the inhibitor concentration as shown in Table 2. However, Langmuir adsorption isotherm equation describes the relationship between the concentration, the degree of surface coverage and the equilibrium constant (Mistry *et al.,* 2011).

Figure 1 showed the plot of Langmuir adsoption isotherm for aluminum in 2 mol./dm^3 H_2SO_4 in presence of the extract at various concentrations. The plot of C/θ versus C indicates that there is a good correlation between inhibition efficiency and surface coverage as both increase with increase in concentration of the extract (Inemesit *et al.,* 2013). This suggests that the inhibition process obeyed Langmuir adsorption isotherm.

CONCLUSION

The extract from the leaf material was found to be an excellent inhibitor on the corrosion of aluminium in 2 mol./dm^3 H_2SO_4.The corrosion rate of Aluminium decreased on addition of the extract and the inhibition efficiency increased with increase in the concentration of the extract. The inhibition process also obeyed Langmuir adsorption isotherm.

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