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Corrosion Mitigation Potential of Editan Leaves Extract on Al-Si-Mg Alloy in Simulated Seawater Environment

Hafsat N.M[1], A. Tokan[1], M. A. Bawa[1]
[1]Department of Mechanical/Production Engineering,
Abubakar Tafawa Balewa University

Abstract:- Corrosion, which has become a menace to humans and the society is a subject of concern especially in the food and pharmaceutical industries. Research in mitigating corrosion has generated lots of interests especially in the development of organic inhibitors such as potato peels, siam weeds, harmal leaves, with promising results. This work investigated the potentials of the leaves of Editan (*Lasienthera Africanum*) extract for use in formulating inhibitor in corrosion prevention of Aluminum alloys. The leave was subjected to phytochemical screening, Characterization was done using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR) for the protective layer and the extracts respectively. Corrosion test using gravimetric measurement on Al-Si-Mg alloy coupon in 3.5% NaCl solution was investigated. The result obtained showed that *Lasienthera Africanum* contains phytochemical properties of terpenoids, saponin, alkaloids, glycosides, tannins. The inhibitor efficiency was found to improve with increase in inhibitor concentration. Inhibition efficiency for Editan was obtained to be 100% at high concentration of extract (5v/v%), obtained at a temperature of 303 K The results have confirmed that the leave extract of Editan is a good inhibitor against corrosion inaluminum alloys.

Keywords*:-Editan (Lasienthera Africanum) Al-Si-Mg, Gravimeric, Seawater.*

I. INTRODUCTION

The wholeness and strength of materials globally has been in doubt due to the rising rate of corrosion specifically in metallurgical, chemical, material, and oil industries. Through chemical and electrochemical reaction with the environment, metallic corrosion is a natural happening whereby the surface of metallic structure is subjugated to corrosion product such as lepidocrocite, greigite, paratacamite etc (Akpoborie et al.,2021; Liao et al, 2018; Buchweishaija, 2009). Over time, failure of these materials takes places when the metallic structure is attacked via the movement of ions away from the surface (Wan-Nik et al 2011). Breakdown of materials as a result of corrosion have posed serious economic effects in terms of substitution and fixing cost, alongside safety, and atmospheric pollution (Yingbo et al, 2016; Mohebbi and Li, 2011).

Researchers are unrelenting in the quest for more beneficial and productive methods of fighting the corrosion of metals. In a bid to forestall corrosion and the rate at which it spreads, several methods have been developed with the aim of improving the life time of metallic materials (Askari *et al*., 2021). The use of repellant metal alloys, application of protective coatings, cathodic and anodic protection, are spotlight measures in forestalling corrosion (Popoola *et al*, 2014; Rani and Basu, 2012. However, these methods demonstrated a secondary effect, and caused environmental hazard. Significant number of researches have been carried out with the aim of developing eco-friendly inhibitors using natural products such as plants extracts among which includes carica papaya, Cnidoscolus Aconitifolius, Salvia officinalis, Acacia Senegal etc, essential oils such as rose, lavender, roman chamomile, sunflower, myrrh etc, and purified compounds(i.e cowanin, cowanol amongst others) (Znini *et al*., 2012; Bochuan *et al*, 2020; Rosa *et al*., 2013). Plant extracts are viewed as an incredibly rich source with natural compounds that can be extracted by uncomplicated procedures with low cost (Rajendran & Sribharathy, 2012; Sasidharan *et al*., 2010). However, there is serious need to find plant extracts for suitable application in the food and chemical (pharmaceutical) industry. This work looked into the potentials of plant extracts of Editan leaf (*lasienthera Africanum*) and Atama leaf(*Heinsia Crinata*)in mitigating corrosion of Al-Si-Mg alloy in a simulated seawater environment.

II. MATERIALS AND METHODS

A. Materials and sample preparation

Al-Mg-Si alloyrod (3 mm thickness), Editan leaves, methanol, acetone, sodium chloride pellet, reagents (distilled water, Mayer's reagent, NaCl).

Al-Si-Mg alloy rod (as cast) sample was obtained in ATBU Center for Industrial Studies, Bauchi State. The alloy was cut into coupons of dimension (9.6x22) mm and 1420 mm^2 total surface area (Kolawole *et al*., 2019), which were used for the gravimetric analysis and surface examination studies. The surface preparation of mechanically polished specimens was carried out using different grades of emery paper (320 and 400 grit) and then degreased with acetone and air-dried.

B. Preparation of aggressive media

The aggressive media for corrosion employed in this research was a simulated seawater. The formula used (which is shown in table below) was reported by Kalada *et al*., 2016.

Table 1: 3.5% Artificial Seawater

SALT	**Concentration (mg/L)**
Sodium Chloride (NaCl)	55
Sodium sulphate (Na_2S0_4)	10
Potassium chloride (KCl)	4
Sodium bicarbonate ($NaHCO_3$)	1
Boric acid (H_3BO_3)	0.010
Magnesium chloride ($MgCl_2.6H_2O$)	32
Calcium chloride ($CaCl_2.2H_20$)	4

C. Plant extract preparation

The leaves of *Lasienthera Africanum* were collected at Eket-market, Akwa Ibom, Nigeria.They were properly cleaned, shade dried and ground into powder. From this,118 g of powdered samples were extracted using 500 ml of methanol using cold maceration technique. The flasks containing the leaves were shaken, corked and left to stay for 72 hrs at room temperature, with intermittent shaking. The mixture was filtered and concentrated using a rotary evaporator at a temperature of 50^0C to a semi-solid form. The sticky semi-solid substance obtained for both samples were stored in a container for further use (Shi*et al*., 2016; Pramudita *et al*., 2018).

D. Phytochemical screening of plant

The extracts were subjected to phytochemical screening to detect the presence of secondary metabolites such as alkaloids, flavonoids, tannins glycosides and steroids(Senguttuvan*et al*., 2014; Junaid & Patil, 2020).

- Determination of Alkaloids –four drops of Mayer‘s reagent was added to0.5 g of the extract sample in a test tube. The mixture was shaken thoroughly and, the creamy precipitate was then observed.
- Determination of Flavonoids – five drops of aqueous NaOH was added to 5ml of extract in a test tube, the change in colour from greenish/brownish solution to yellowish solution was then observed.
- Determination of Tannin **-** 0.1g of extract was dissolved in 1% $FeCl_3$ reagent and stirred. A blue-black coloration was then observed.
- Determination of Steroids – 10ml of acetic anhydride was added to 0.5g of extract. 1ml of concentrated sulphuric acid was added down side the tube. The blue/blue-green coloration was observed.
- Determination of Saponin – 0.5g of the extract was dissolved in 10ml of distilled water. This was shaken vigorously for 30 seconds and was allowed to stand for 30 minutes. The honey comb foam was then observed.
- Determination of Protein – five drops of copper sulphate solution were added into 0.5g extract in a test tube, four drops of caustic soda solution were added and the solution was shaken thoroughly. The color of the mixture was observed for violet coloration.

E. Weight loss measurement

The cleaned and pre-weighed Al-Si-Mg coupon was inserted into different beakers with various level of inhibitor concentration (1v/v% - 5v/v%), and a beaker was set aside, which was without inhibitor, serving as the control. The beakers were placed on a water bath, and subjected to various temperature, ranging from 303K, 313K, 323K and 333K, and the coupons were retrieved after a period of 24 hours.The difference between the present and the previous weighs were computed and recorded as weight loss. From the weight loss data collated, corrosion rate (CR), the inhibition efficiency (I.E %) of the inhibitor, and the degree of surface coverage (θ) were calculated using equations 1 to 3 respectively.

$$CR_{(mm/y)} = \frac{87600W}{A\rho t} \quad \ldots (1)$$

Where, CR is corrosion rate, w is weight loss (g), A is the area of the coupon in cm^2 and t is time (hr), ρ is the density (g/cm^3).

From corrosion rates, Inhibition efficiency was calculated using the formula 2 below,

$$\mathrm{I.E}\ (\%) = \left(1 - \frac{\mathrm{CR_{inh}}}{\mathrm{C_{blank}}}\right) \times 100 \quad \ldots (2)$$

Where, I.E is the Inhibition Efficiency, $\mathrm{CR_{inh}}$ and $\mathrm{CR_{blank}}$ correspond to the corrosion rates in the presence and absence of inhibitor respectively.

Degree of surface coverage,θ, at each concentration of inhibitor is computed using the expression

$$\theta = \left(1 - \frac{\mathrm{CR_{inh}}}{\mathrm{CR_{blank}}}\right) \quad \ldots (3)$$

where, θ is the surface coverage, $\mathrm{CR_{inh}}$ and $\mathrm{CR_{blank}}$ correspond to the corrosion rates in the presence and absence of inhibitor respectively.

F. Fourier Transform Infrared (FT-IR) Spectroscopy

The functional groups present in editan and the film formed on the metal surface were determined using the Cary-630 Agilent Fourier transform infra-red spectrophotometer. The analysis was carried out by scanning the sample through a wave number range of 500 to $4000cm^{-1}$.

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G. Surface Morphology

A scanning electron microscope (SEM) model JSM-5600 LV, was used to analyze the morphology of Al-Si-Mg surface without and with inhibitor added. One piece of Al-Si-Mg coupon was immersed in seawater solution while the second coupon was immersed in a solution of seawater and 5%v/v of editan for 24 hours. The coupons were rinsed dried, and subjected to SEM examination.

III. RESULTS AND DISCUSSION

A. Phytochemical results

Table 1 shows the phytochemical screening of editan (*Lasienthera Africanum*) extract. Phytochemical properties like alkaloids, terpernoids, glycosides and steroids are highly present indicated by triple plus (+++). Other properties present but in in high amount are saponin (++), tannin (+) and flavonoids (+). These properties are responsible for the corrosion inhibitory action of editan extract.

Table 2: Phytochemical screening

Substance in Editan	**Qualitative**	**Quantitative**
Tannins	+	4000mg/100g
Saponin	++	8%
Flavanoid	+	8%
Alkaloids	+++	34%
Terpenoids	+++	35%
Glycosides	+++	259.2mg/g
Steroids	+++	20mg/g

Note: +++ means Highly present, ++ Moderately present, + means slightly present

B. Weight loss results

The effect of temperature on the corrosion behavior of Al-Si-Mg alloy in the absence and presence of editan extract was investigated by performing weight loss experiments at 303, 313, 323, and 333K. The results as shown in Tables 2 demonstrate that the corrosion rates decreased and the inhibition efficiency increased at low temperature but at higher temperature, inhibition efficiency dropped. The decrease in inhibition efficiency with increasing temperature suggests weak adsorption interaction between the metal and the extract organic matter. Such behavior corresponds to physical adsorption, such that at higher temperatures, there is a possible shift of the adsorption-desorption equilibrium towards desorption of adsorbed inhibitor (Njoku et al., 2014).The experiment yielded best result with inhibition efficiency of 100% at a temperature of 303K. This recordis in line with the reports of Onuegbu *et al.*, 2013; Madu et al., 2019; Loto *et al*., 2011.

Table 3: Corrosion rate, inhibition efficiency and inhibitor concentration on Al-Si-Mg alloy using editan extract inhibitor

Aluminum alloy with Editan Inhibitor								
Inhibitor Concentration (v/v%)	Corrosion Rate (mm/yr) x10^3				Inhibition Efficiency (%)			
	303K	313K	323K	333K	303K	313K	323K	333K
0	0.03	0.62	0.80	0.65	0.00	0.00	0.00	0.00
1	0.02	0.03	0.39	0.30	40.00	95.08	52.86	55.41
2	0.02	0.02	0.26	0.21	53.33	97.01	68.63	70.05
3	0.01	0.01	0.22	0.17	66.67	98.07	74.98	75.96
4	0.00	0.01	0.13	0.10	93.33	99.12	84.50	84.78
5	-	0.00	0.06	0.05	100.00	99.82	92.84	92.51

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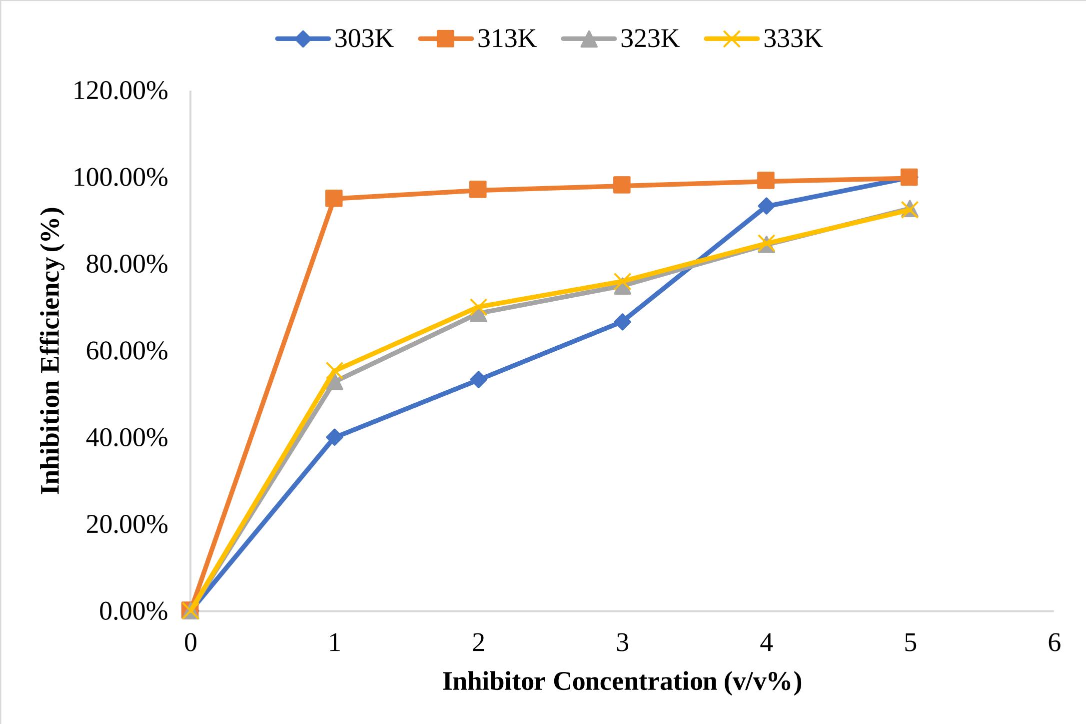

Fig. 1(a): Inhibition Efficiency (I.E %) versus inhibitor concentration for Al-Si-Mg alloy corrosion in seawater in the absence and presence of Editan (lasienthera africanum) leaf extract at different temperatures and varying concentration

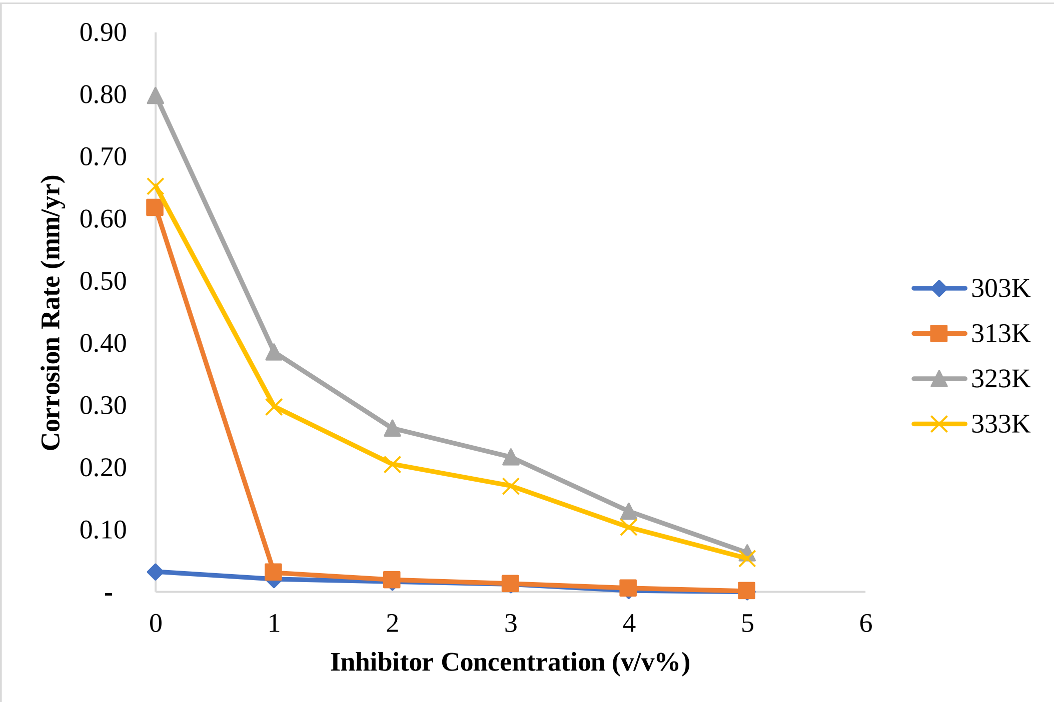

Fig. 1(b): Plot of corrosion rate against inhibitor concentration for Al-Si-Mg alloy corrosion in seawater in the absence and presence of Editan (lasienthera africanum) leaf extract at different temperatures and concentration

C. FTIR Analysis

Figure 2 shows the absorption spectrum for Editan leaf extract with frequency band at 736.01, 819.04, 1096.72, 1311.99, 1464.84, 1643.30, 2443.70, 2736.01, 2958.15, 3457.74. this indicates the presence of the following functional group C-I, C-F, C-OH stretch with strong intensities, this implies the extracts' ability to improve its reactivity against corrosion. C=C with weak intensity belonging to the alkene compound class, C≡N stretch, carboxylic acid OH stretch, OH stretch. Literature reports that plant extract with range values of 3200 – 3500cm^{-1}, have strong absorption, indicating the presence of polymeric hydroxyl derivative (Nikhan *et al.*, 2018; Al-Mhyawi *et al.*, 2019; Dakeshwar and Fahmida,2016).

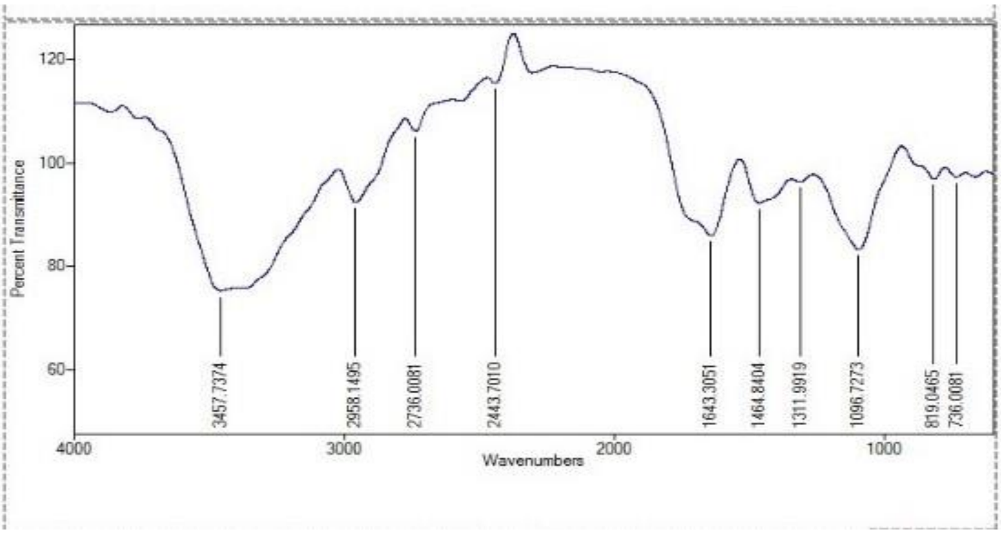

Fig. 2: FT-IR analysis of editan extract

D. Scanning Electron Microscopy

The surface morphology of Al-Si-Mg alloy was examined using the scanning electron microscopy. Figure 3a shows the exposed metal to the aggressive media, showing the metal has been seriously attacked. Figure 3b reveals corrosion inhibitive effect of editan extract at a concentration of 5v/v%.

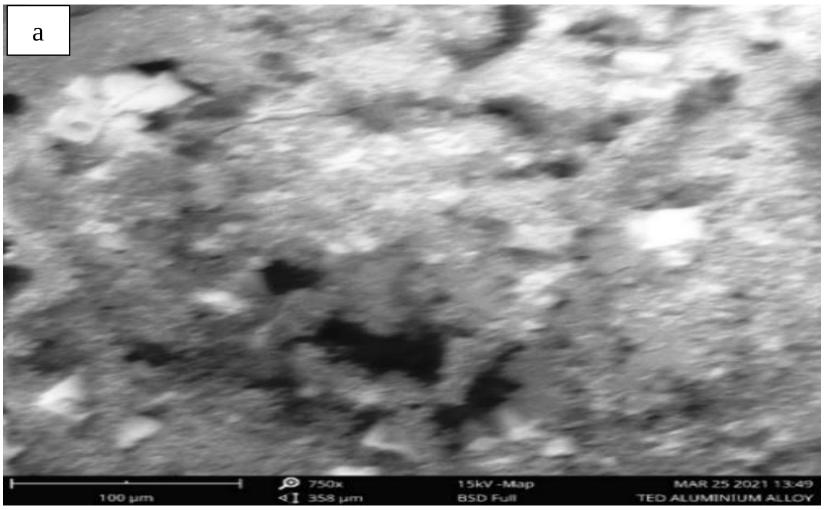

Fig. 3(a): SEM micrograph of corroded Al-Si-Mg

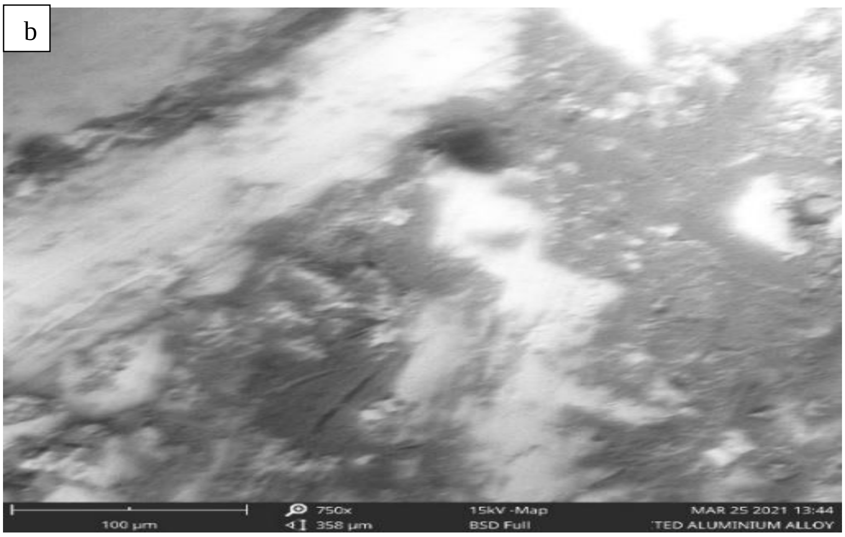

Fig. 3(b): SEM micrograph of Inhibited Al-Si-Mg

IV. CONCLUSION

The characterization of the plants extracts by qualitative and quantitative analysis showed phyto compounds present in Editan are quite high in terpenoids, glycosides, alkaloids and steroids. This shows that the plant extracts have good potential of being used as inhibitors for Al-Si-Mg alloy in an alkaline environment.

The evaluation analysis result proved that

- Corrosion rates values when exposed to the corrosive atmosphere had values as high as 0.62, 0.65, 0.80mmy^{-1} without editan extract inhibitor at temperatures of 313K, 323K and 333K. Corrosion rates in the Al-Si-Mg alloy reduced with the addition of inhibitors, higher concentration at 5v/v% of Editan inhibitor showed zero corrosion rate yielding 100% inhibition efficiency at low temperature (303K) over a period of 24 hours.
- SEM analysis revealed that the corrosion Al-Si-Mg alloy in alkaline environment was weakened by the protective surface of the film formed by addition of editan leaf extracts as inhibitors.

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