Effect Of Moringa Oleifara Leaves Extract as Inhibitor on The Corrosion Rate of Mild Steel.

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Abstract-* Corrosion is the gradual destruction of materials (usually metals) by chemical reaction with its environment whose impact is felt in economics, safety and environmental damages. To protect metal and alloys from corrosion, approaches such as isolating the structure from aggressive media (using coatings or film forming chemicals) or compensating for the loss of electrons from the corroded structure should be implemented. In recent times, research has been in the field of corrosion inhibitors using cheap effective materials of low or non-negative environmental impact to replace environmentally hazardous compounds. Corrosion inhibitors may include organic (green) or inorganic (synthetic) compounds that adsorb on the metallic structure to isolate it from its surrounding media in order to stop or slow down the rate of oxidation. In this research, the mild steel of geometric area of 1cm2 embedded in Moringa Oleifara resins was used as the working electrode; platinum electrode was used as counter electrode and saturated silver/silver chloride was used as reference electrode, while caustic soda was used as the electrolyte. This was done at different proportions of Moringa Oleifara extract to Caustic Soda. In conclusion, the ethanol extract of Moringa Oleifara leaves could slow down the corrosion rate of mild steel in caustic soda solution. Meanwhile, 7% of Moringa Oleifara leaves tends to be the most appropriate proportion to be used. Therefore, Moringa Oleifara leaves extract can serve as a good(green) inhibitor for preventing or slowing down the rate corrosion of mild steel.

***Index Terms-* Moringa Oleifara, Caustic Soda, Inhibitor, Corrosion and Mild steel**

I. INTRODUCTION

Corrosion is a gradual destruction of materials (usually metals) by chemical reaction with its environment (Shuaib-Babata, 2010). It is an electrochemical phenomenon by which metallic structures are damaged slowly through anodic dissolution (Abdulrahaman et al., 2015). It can also be defined as the damage or deterioration of metals and alloys due to chemical or electrochemical interaction with their surrounding environment (Kadhim et al., 2021; Vashi, 2025). Ibrahimi and Issai (2020), stated that corrosion is a natural phenomenon where metals and alloys try to revert to their more stable thermodynamics form due to reaction with the environment that surrounds them. It is more than just an inevitable natural phenomenon, its impact is felt in seemingly many sectors (Tanwer and Shukla, 2022). It is a serious problem contributing to massive economic losses globally, with cost estimated between 1 and 5 % of GDP in different countries (Rauta, et al., 2025). Corrosion is a serious problem in many industries and unfortunately, metallic structures are susceptible to the damage it can cause (Kadhim et al., 2021). The failure of mild steel as construction materials can be dangerous to both human health and economy. Mild steel is the most common type of metal used in large industries due to its acceptable material properties and low cost. However, a growing concern is that of being limited due to low resistance to corrosion, especially in acidic and alkaline environment in industries (Oyekunle et al., 2019; Obot, et al, 2011).

Corrosion Controls of metals is of technical, economical and aesthetical importance. Corrosion inhibitors are substances used to prevent or reduce metal surface corrosion in corrosive environments (Al - Miery et al., 2023). The use of corrosion inhibitors which may be green organic (natural) or inorganic (synthetic) is one of the most efficient methods of protecting metals against corrosion which affects many sectors including the world economy (Souza Morais et al., 2023). Corrosion inhibitors have been encouraged by various researchers as a means of slowing down the rate of corrosion and thus reducing monetary losses (Oyekunle et al., 2019). The use of inhibitors is one of the best options of protecting metals and alloys against corrosion. Corrosion inhibition can be carried out using organic or inorganic approach (Martins et al., 2022). The environmental toxicity of inorganic corrosion inhibitors has prompted the search for green (organic) corrosion inhibitors as they are biodegradable, do not contain heavy metals or other toxic compounds. Green inhibitors are environmentally friendly and ecologically acceptable. Plant produce is inexpensive, readily available and renewable and; some of these can be used as inhibitors (Rani et. al., 2011).

II. MATERIALS AND METHODS

The commercially available mild steel sheet of thickness (gauge) 5mm was selected for this study due to its cost effectiveness, availability in the market and commonly used by most industries, engineers and fabricators in engineering firms. This was cut into size of 1cm by 1cm and a thickness of 5mm to produce the coupon as shown in plate 1 that was used to carry out the electrochemical corrosion test. Moringa oleifera leaves were sourced locally and dried at room temperature for two weeks and later pulverized to obtain fine grain (powdered form). 400 g of the pulverized Moringa leaves was weighed and soaked in 4000 ml of ethanol for 72 hours. After which the mixture was filtered, and the filtrate was further subjected to evaporation at room temperature to obtain the extract.

Plate 1 : The specimens used for electrochemical testing

A. The Process of Electrochemical Testing.

The potentiodynamic polarization and open circuit potential (OCP) measurements experiments were carried out using VersaSTAT 4 instrument shown in Figure 1. The electrochemical studies were carried out using a three-electrode cell assembly at room temperature. The mild steel of geometric area of 1cm^2 embedded in Moringa Oleifara resins was used as the working electrode; platinum electrode was used as counter electrode; and saturated silver/silver chloride was used as reference electrode, while caustic soda was used as the electrolyte. The working electrode was polished with different grades of emery paper. Prior to the potentiodynamic polarization measurement, the open-circuit corrosion potential (OCP) measurements were carried out from cathodic potential of −250 mV to an anodic potential of +250 mV with a scan rate 1.0 mVs^{-1} for 30 sec to determine the current density, corrosion rates.

Figure 1. VersaSTAT 4

Before immersion, the surface preparation of the specimen was carried out in accordance with ASTM standard. The coupons were weighed and recorded. The weighed coupons were immersed in closed containers containing Caustic Soda and Moringa Oleifara leaves extracts in different ratios while one of the containers was 100% caustic soda which stands as control for the experiment. This was observed for 30 days. The weights of the specimens after exposure were also measured.

These coupons were immersed fully into the bottles of different test environments (test media) which contains the followings:

- 100% of caustic soda.
- 99% of caustic soda and 1% of Moringa oleifera leaves extract.
- 98% of caustic soda and 2% of Moringa oleifera leaves extract.

- 97% of caustic soda and 3% of Moringa oleifera leaves extract.
- 96% of caustic soda and 4% of Moringa oleifera leaves extract.
- 95% of caustic soda and 5% of Moringa oleifera leaves extract.
- 94% of caustic soda and 6% of Moringa oleifera leaves extract.
- 93% of caustic soda and 7% of Moringa oleifera leaves extract.
- 92% of caustic soda and 8% of Moringa oleifera leaves extract.
- 91% of caustic soda and 9% of Moringa oleifera leaves extract.
- 90% of caustic soda and 10% of Moringa oleifera leaves extract.

This was done by hanging each specimen with an inelastic thread attached to the lid for the period of 30 days.

After the immersion, the specimens were thoroughly cleaned immediately after removal from the test media using chemical methods of cleaning test specimens as specified by ASTM (2007 and 1985). The cleaning solution contained 3.5 g Hexamethylenetetramine, 500ml Hydrochloric acid (HCl SP gr 1.19), and 500 ml Distilled Water to make 1000 ml. The coupons were cleaned in the solution for about 10 minutes, hot dried and weighed immediately.

III. RESULTS AND DISCUSSION

A. *Weight analysis of pre-immersion*

The results of the weight obtained before immersion into the inhibiting solutions are presented in Table 4.1

Table 1: Corrosion parameters for weight of the Specimen

Temperature	Percentage	Weight
Room temperature	100	188.2g
	99	192.2g
	98	189.9g
	97	192.2g
	96	189.6g
	95	192.8g
	94	191.2g
	93	192.5g
	92	188.3g
	91	197.2g
	90	188.2g

B. *Analysis of Potentiostat Polarization curve*

Table 2 shows the corresponding corrosion potentials (E_{corr}), Corrosion current density (I_{corr}), anodic Tafel slopes (B_A), cathodic Tafel slopes (B_C) and corrosion rate.

The value for the corrosion potential and corrosion densities were estimated from the intersection of the anodic and cathodic Tafel lines

Table 2: Results of electrochemical Parameters in Moringa leave extract Concentration

S/N	PERCENTAGE OF MONRIGA LEAVE EXTRACT (%)	E_{CORR}(mV)	I_{CORR}(μA)	B_A(mV)	B_C(mV)	CORROSION RATE (mmpy)
1	0	-403.607	-2.888	466.024	243.796	0.033267
2.	1	-379.827	-967.624	122.925	132.757	0.011145
3.	2	-467.155	-1.658	404.51	193.223	0.019108
4.	3	-935.503	-23.263	305.8	44.153	0.25795
5	4	-672.024	-2.08	949.409	87.97	0.02396
6	5	-526.115	-1.752	747.663	316.523	0.02018

7	6	-779.202	-2.232	238.16	106.514	0.025716
8	7	-671.641	-912.346	174.911	72.111	0.010508
9	8	-921.747	-8.534	512.775	186.192	0.098301
10	9	-1.094	-4.634	70.249	37.67	0.053378
11	10	-1.045	-9.629	220.419	51.033	0.11091

The result of the polarization curve is plotted in the chart shown in Figure 2.

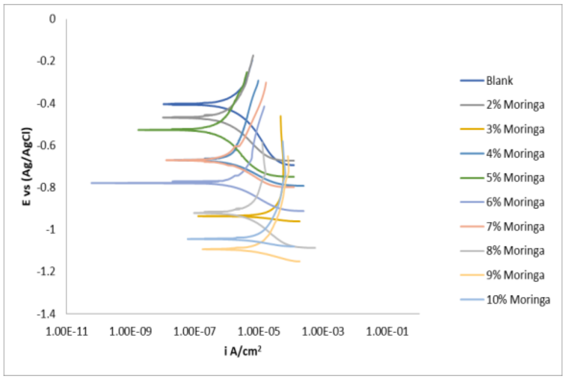

Figure 2. The result of polarization curve of mild carbon steel in various concentrations of moringa leaf extract.

The results from Table 2 and Figure 2 show the effectiveness of Moringa as an inhibitor in the Caustic Soda medium starting with the blank at 1% Moringa Oleifara extract specimen, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, and 10% respectively. From the result of cathodic and anodic current obtained, it shows that anodic reaction releases too much of electrons into the metal and this shifted the corrosion potential of the metal to negative curve at different points and minimized the anodic reaction while the cathodic reaction was speed up.

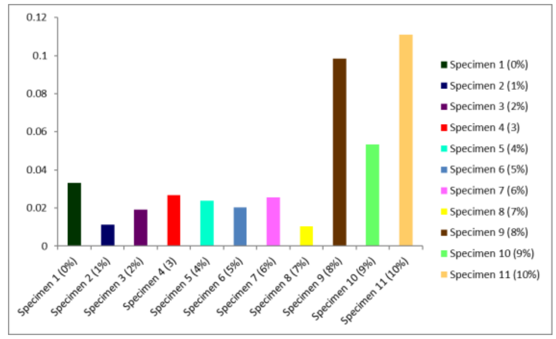

Figure 3: Corrosion rate of the specimen in moringa leaf extract concentration

From Figure 3 which shows the corrosion rate of the specimens using moringa leaves extracts as inhibitor, the corrosion rate of specimen 11 was the highest followed by specimen 9. The least corrosion rate is that of specimen 2 and specimen 8 which has 1 % and 7% proportion of moringa leaves extract respectively. This was followed by that of specimens 3 and 6. Specimen 5 corrosion rate was a bit higher than that of specimens 3 and 6. Specimens 4 and 7 have their corrosion rate a bit higher compared to that of specimens 2 and 8. The corrosion rate of specimens 9, 10 and 11 with moringa leaves extract proportions as 8%, 9% and 10% respectively are very high. This indicates that the smaller the proportion of the moringa leaves extract in the caustic soda concentration, the better it serves as an inhibitor.

CONCLUSION

From the research the following conclusion can be made:

(i) The ethanol extract of moringa oleifera leaves can minimize or slow down the corrosion rate of mild steel in caustic soda solution provided the percentage of the moringa extract does not exceed 7% in the caustic soda solution.
(ii) Moringa Oleifara leaves extract is a good inhibitor that can prevent the corrosion of mild steel in a caustic soda environment.

(iii) Also, industries and local fabricators are encouraged to use this process towards ensuring the longevity of the steel.
(iv) The choice of the type of inhibitor to be used will depend on the specific application, the severity of the corrosion environment and the desired level of efficiency.

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