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Comparative Analysis of *Jatropha Curcas* and Neem Leaves Extracts as Corrosion Inhibitors on Mild Steel

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Abstract
Corrosion is a natural process which reverts metal and their alloys to their stable form, that is why it is also called extractive metallurgy in reverse. It causes a gradual deterioration of physical properties of the metals. This study compares the corrosion inhibition efficiency of an abundant and eco-friendly plant extracts of Neem (*Azadirachta Indica*) and Jatropha Curcas in acidic media. Gravimetric technique was used to study the corrosion inhibition behavior of the two plant extracts on mild steel in 2M H_2SO_4 solution for a period of 21 days. The results show that all the varieties under study are good corrosion inhibitors, among which leaves extract of Neem as the most effective. The phytochemical analysis shows that the constituent of the ethanol extracts of Neem and Jatropha Curcas contains cardiac glycosides, saponins and tannins, while flavonoids were found in Jatropha Curcas leave extract alone. The average inhibition efficiency of Neem was 80.31%, while that of Jatropha Curcas was found to be 72.45%.

Keywords: Adsorption; Inhibition, Hybridization, Phytochemical Analyses, Gravimetric technique

1.0 Introduction

Metals and their alloys exhibit a natural tendency of spontaneously reacting with their environment and this produces a destructive effect on their mechanical and physical properties. The degradation of materials as a result of its chemical or electrochemical interactions with the surrounding environment is generally understood as corrosion. This is as a result of the natural tendency for metals to return back to more stable mineral form in its natural state (Ajanaku *et al*., 2014). Corrosion can cause catastrophic damage to metal and their alloyed structures causing economic consequences in terms of repair, replacement, product losses, safety, and environmental pollution. Sumita and Kumar (2013) reported that the annual total costs of floods, hurricanes, tornadoes, fires, lightning and earthquakes are less than the costs of corrosion alone. Due to these harmful effects, corrosion is termed an undesirable phenomenon and needs to be controlled(Patni *et al*., 2013).

Research has shown that the use of inorganic compounds as corrosion inhibitors constitute environmental hazards because of their toxicities, that is why plant extracts has continued to gain lots of interest. Leaves extracts are found to contain some phytochemical constituents like tannins, saponins and flavonoids which are responsible for corrosion inhibition (Jothi *et al*., 2016).

Neem (plate 1) is a member of the mahogany family while *Jatropha Curcas* (plate 2) is a specie of a flowering plant in the spurge family, *Euphorbiaceae* (Alwi and Sukardi, 2013).

Plate 1: **Neem Plant**

Plate 2: ***Jatropha Curcas* Plant**

The by-product of *Jatropha Curcas* trans-etherification process can be used to make a wide range of products including high-quality paper, energy pellets, soap, cosmetics, toothpaste, embalming fluid, cough medicine and a moistening agent in tobacco, (Warra and Abubakar, 2015).

(Okafor *et al.* 2010) studied the inhibitive action of leaves (LV), root (RT) and seeds (SD) extracts of Neem on mild steel corrosion in H_2SO_4 solutions using gravimetric and gasometric techniques. They discovered that the inhibition efficiency increase with increase in extracts concentration and temperature, and followed the trend: SD > RT > LV. They also reported that the corrosion inhibition efficiency of *Neem* leaves extract in 2 M H_2SO_4, inhibitor concentration of 0.5 gdm^{-3} exhibit an inhibition efficiency of 32.5 %. They concluded that the leaves, root and seeds extracts from *Neem* inhibit the corrosion of mild steel in H_2SO_4 solutions to a reasonable extent and the corrosion inhibition is attributed to chemical adsorption of the phytochemical components of the plant on the surface of the mild steel. Similarly, Sharma *et al*. (2009), investigated the inhibitory efficacy of an ethanolic extract of Neem fruit at the room temperature as well as at elevated temperatures and they observed the inhibition efficiency to be significantly high (92.37%) at room temperature at concentration 1.052g/L. The experimentations have been carried out on acid corrosion of Aluminium using weight loss measurement. They found out that the high inhibitive effect is attributed due to the photochemical present in the extract, and the efficiency of the inhibitor increases with the increasing concentration of inhibitor. The thermodynamic parameters for Neem fruit extract indicate that the process was spontaneous and the active constituents have been physically adsorbed onto the metal surface. The adsorptive behavior of the inhibitor at room and higher temperatures has been further endorsed by carrying out FT-IR spectroscopy. From the study, it was concluded that ethanol extract of Neem fruit has a good adsorptive propensity for the Aluminium surface. Mokhtari *et al*. (2014) studied the effects of natural *Jatropha Curcas* oil on the corrosion of steel in 1M HCL using gravimetric method, electrochemical and EIS polarization techniques. The results obtained revealed that *Jatropha Curcas* oil reduced the rate of corrosion. The corrosion inhibition efficiency increased with the increase of inhibitor concentration. Potentiodynamic polarization studies clearly revealed that the presence of the natural *Jatropha Curcas* oil did not alter the mechanism of the hydrogen evolution reaction and acted a mixed inhibitor. The adsorption of *Jatropha Curcas* oil on the steel surface in hydrochloric acid obey the Fruwmkin adsorption isotherm model.

This study compares the corrosion inhibition efficiency of an abundant and eco-friendly plant extracts of Neem (*Azadirachta Indica*) and *Jatropha Curcas* in acidic media.

2.0 Materials and Methods

2.1 Materials

The equipment and materials used for this research are as follows: Beakers, which contain the acid solution and the sea water into which the mild steel samples were immersed; Palm scale 8.0 - Digital analytical mass balance for weight measurements (Capacity: 300g X 0.01G); Desiccators for preserving the test coupons to prevent any reaction with the environment or formation of a passivation layer which might interfere with the result of the experiment; Mild Steel coupons samples of dimension of 30 x 20 x 1 mm, with chemical composition shown in Table 1; Neem leaves collected from the University of Maiduguri Campus from which the inhibitor was extracted; *Jatropha Curcas* leaves collected from a garden cultivated for the purpose of the research; Abrasive papers of different grit size used for polishing the test coupons before the tests were carried out; Analytical grade Sulfuric acid (H_2SO_4) used in preparing 2M H_2SO_4 used as one of the test media; Acetone which was used to rinse the test coupons after washing with distilled water and before storing in the desiccators; Ethanol used in soaking the powdered inhibitors; Distillation equipment for distilling the extracts in order to leave the samples ethanol free; Pepper grinding machine for grinding the leaves.

2.2 Preparation of Acid Solution

The acid solution of 2 M H_2SO_4 was prepared from a standard concentration of Sulfuric acid having a density of 1.84 g/cm^3 and percentage purity of 98%.

2.3 Extraction of the Neem and Jatropha Curcas leaves extracts

The inhibitors used are *Azadirachta Indica* leaves and *Jatropha Curcas* leaves extracts. The leaves were air dried in a shade. The dried leaves were then machine-ground into powdered form and known weights placed in different containers. Ethanol was added to each container and the powdered leaves were allowed to soak according to the method of Loto *et al*., (2013). The samples were filtered and the filtrates were distilled using distillation equipment in order to reduce the ethanol content to barest minimum.

2.4 Preparation of Coupons

Mild steel sheet used was analyzed using a handheld TITAN XRF metal analyzer for its elemental chemical composition as shown in the Table 1.

Table 1: Elemental Composition of Mild Steel

Element (wt%)	C	Mn	Si	Cu	Cr	P	S	Fe
Average Content	0.14	0.48	0.18	0.03	0.79	0.17	0.005	Balance

The Mild steel sheet was mechanically cut into rectangular coupon samples of dimension of 30 x 20 x 1 mm. A small hole was drilled near the edge of the coupon and a thread tied for handling. The coupon samples were polished using abrasive papers of different grades and washed with ethanol to remove any form of grease or oxide. The coupons were rinsed with acetone and preserved in desiccators to prevent any reaction with the environment or formation of a passivation layer which might interfere with the experiment.

2.5 Area and Density of Specimen

For this work, flat mild steel sheet was cut into rectangular coupons of area (A) = 1300 mm^2 and density of 7.87 g/cm^3.

2.6 Gravimetric Method

The inhibitive properties of the extracts were evaluated using weight loss method. The method involves totally immersing pre-weighed test coupons in each of the test media for 21 days. The test specimens were taken out of the corrosive media (one each) after every 24 hours for the sulfuric acid test media, while for the test done in sea water media each of the tests' specimens were taken out every three days (72 hours). This was done so as to have an appreciable weight loss because rate of corrosion in seawater takes longer time to be detected. This was followed by washing with distilled water, rinse with acetone and dried to remove corrosion products. The coupon sample was re-weighed according to the method described by Yawas (2005).

The corrosion rate (CR) was calculated from the relationship provided by Loto and Popoola (2012):

$$\boldsymbol{CR} = \frac{\mathbf{87.8\ \Delta W}}{\boldsymbol{\rho}\mathbf{AT}} - - - - - - - - - - - -\mathbf{1}$$

where, W is the weight loss in milligrams, ρ is the density in g/cm^2, A is the area in cm^2, and T is the time of exposure in hours.

The percentage inhibitor efficiency, (%IE) was calculated from the relationship provided by Yawas, (2005):

$$\%\boldsymbol{IE} = \left[\frac{\mathbf{R_{blank}} - \mathbf{R_{inh}}}{\mathbf{R_{blank}}}\right] \mathbf{X\ 100} - - - - - - - - -\mathbf{2}$$

where, R_{blank} and R_{inh} are the corrosion rates in the absence and presence of a predetermined concentration of inhibitor respectively. The %IE was calculated for all the inhibitors after the final experiment.

From the corrosion rate, the surface coverage (Θ) as a result of adsorption of inhibitor molecules was determined using the equation provided by Khaled (2003):

$$\theta = \frac{R_{blank} - R_{inh}}{R_{blank}} - - - - - - - - - - 3$$

2.7 Chemical Analysis of the Leaves Extracts

Phytochemical analysis of the plant extracts was done at the faculty of Pharmacy, University of Maiduguri following the standard procedure described by Khan and Nasreen (2010) to determine the presence of tannins, carbohydrates, cardiac glycosides, saponins, glycosides, and lavonoids. PH of the two extracts was conducted at the Faculty of Agriculture, University of Maiduguri (Pathology Laboratory) using a Lida instrument (PHS-25 precision PH/m Vmeter). The electrical conductivity charges (ECC) was also conducted at the same Laboratory using an X10 model DOS-307 conductivity meter.

3.0 Results and Discussion

3.1 Phytochemical Constituent of the Ethanol Extracts of Neem and Jatropha Curcas leaves

The phytochemical constituent of the ethanol extracts of Neem and *Jatropha Curcas* are shown in Table 2. It indicates that cardiac glycosides, saponins, and tannins are all present in both Neem and *Jatropha Curcas* leave extracts, while flavonoids are found only in *Jatropha Curcas* leave extract. These complex organic species attributed to the inhibitive properties of the extract which enhances the adsorption of the inhibitor on the mild steel surface. This is in agreement with the work of Eddy *et al*. (2009). According to Iloamaeke *et al*. (2013), these compounds contains nitrogen and oxygen which are the center for chemical adsorption on the metal surface. Furthermore, tannins, saponins, alkaloid, glycoside, anthraquinone, and flavonoids aid corrosion inhibition of mild steel in an aggressive environment. Since, Saponins, flavonoids, glycosides and Tannins makes corrosion inhibition possible and they are found in different concentrations within the two plant extracts (i.e. Saponins concentration in Jatropha Curcas leaves was found to be three times what was found in Neem; Tannin is found only in Neem leaves extracts).

Table 2: Phytochemical Constituents of the Plant Extracts

Phytochemicals	*Azadirachta Indica* (Neem)	*Jatropha Curcas*
Carbohydrates	+	+
Cardiac glycosides	+	+
Keller Kilani	+	+++
Kedde	+	+
Borntragers	-	+
Monosaccharide	++	++
Reducing Sugar	++	+
Saponins	+	+++
Falvonoids	-	+
Tannins	++	-

+ and - indicates the presence and absence of phytochemicals respectively

3.2 Weight lost, Corrosion Rate and Inhibition Efficiencies of the Leaves Extracts in 2M Sulfuric Acid Medium.

The two plant extracts have proved to retard the corrosion rate, the weight loss in the presence of the plant extracts was appreciably lower than that without inhibitor. Although, the Jatropha leaves extract shows a lower weight loss within the first 270th hours, it can be noticed that the *Azadirachta Indica* leaves extract exhibits almost the same weight loss from then. These reductions in weight loss is accredited to the phytochemical constituents. TUN, T100A and T100J represents control for *Azadirachta* and Jatropha respectively. As the material is being consumed with time, the rate of corrosion drastically dropped to the level of the inhibited solution. This is an indication of the complete destruction of the material.

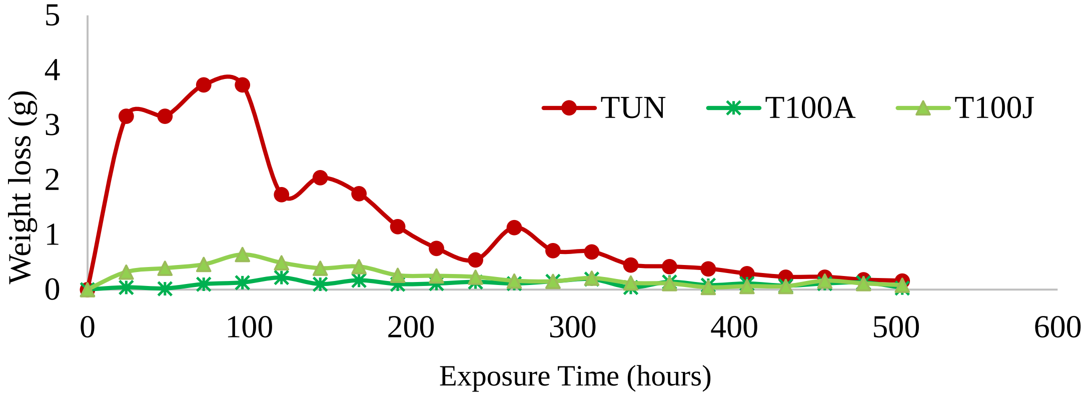

Fig. 1: Weight loss versus exposure time of mild steel in 2 M H_2SO_4

Corrosion rate to exposure time graph of mild steel exposed to 2 M sulfuric acid solution is presented in Figure 1. The result shows the same trend as in the weight loss versus exposure time graph with the uninhibited showing the highest corrosion rate, followed by *Jatropha Curcas* leaves extract. Furthermore, results displayed in Table 3 indicates that the corrosion rate of the mild steel coupon exposed to *Jatropha Curcas* leaves extract shows a corrosion rate of about 5.23 times less than the uninhibited sample, while the coupon exposed to Neem leaves extract shows a corrosion rate of about 11.73 times less than the uninhibited sample. Tannins has shown greater tendency to inhibit corrosion when the result of the phytochemical test is compared to the trend observed in Figure 1. It can therefore be said that the efficacy of Neem leave extract in reducing corrosion, especially at the initial days of the experiment is very clear. However, the two leaves extracts have proved to be good corrosion inhibitors for mild steel, with *Azadirachta Indica* having an average inhibitor efficiency of 80.31%, while *Jatropha Curcas* has average inhibition efficiency of 72.45%.

Table 3. Average Corrosion Rate of Mild Steel in 2M H2SO4 After 21 Days

Composition of Inhibitors Per Sample	Average Weight Weight Loss (g)	Average Corrosion Rate (mm/yr)	Average Inhibitor Efficiency (%)
Uninhibited	26.61	0.0528	-
100% Neem	2.29	0.0045	80.31
100% Jatropha Curcus	5.11	0.0101	72.45

4.0 Conclusion

Corrosion Inhibitors were successfully extracted from the leaves of *Azadirachta Indica* and *Jatropha Curcas* and have shown to inhibit corrosion. Phytochemical analysis shows that tannins has greater effect in combating corrosion when compared to other compounds like cardiac glycosides, saponins and flavonoids. It is clear that Neem leave has a higher corrosion inhibition efficiency than *Jatropha Curcas* Leave extracts with Neem leave extract having an average inhibitor efficiency of 80.31%, while Jatropha Curcas has average inhibition efficiency of 72.45%.

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