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EFFECTS OF *ALCHORNEA CORDIFOLIA* LEAF EXTRACT ON THE MECHANICAL PROPERTIES OF MILD STEEL IN ACIDIC MEDIUM.

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ABSTRACT

The effect of Alchornea Cordifolia leaf extract on the mechanical properties of mild steel in acidic medium was studied using weight loss method. The first sample was not introduced to any medium. It served as the control[1] sample. The second sample was introduced to a medium containing 0.2M Sulphuric acid solution in the absence of the Alchornea Cordifolia leaves extract for 21 days, while the third sample was immersed in a vessel containing 0.2M sulphuric[2] acid and 0.5g/L of Alchornea Cordifolia leaves extract as an inhibitor for 21 days. Results obtained showed a substantial improvement on the mechanical properties of mild steel exposed to the medium with the inhibitor.

Keywords: Mechanical Properties, Corrosion, Inhibition, Alchornea Cordifolia, Sulphuric acid

INTRODUCTION

Corrosion damages both physical and mechanical properties of materials. Corrosion of metals is a major problem that must be confronted for safety, environmental, and economic reasons. The continued manifestation of corrosion and corrosion products on steel structures is still causing a lot of concern to corrosion scientists and engineers (Ita and Offiong, 2000). Corrosion can be prevented by using metals that have the capacity to naturally protect itself from corrosion through formation of film layers; however, such metallic alloys are either very exorbitant or poisonous, *James* et al.[3] *(2007)*. The toxicity of commercial inhibitors plus the rising strictness of the environmental standards have boosted intensive research into the existing or novel substances as potential inhibitors of corrosion. These factors have shifted the focus of study into non-toxic "green" inhibitors of corrosion. Green inhibitors include substances that protect metals from corrosion without having any negative effect on the environment and life forms.

The use of organic inhibitors is a method of protection that is flexible and cost effective because the layer formed is very thin such that small amounts are able to provide broad protection (Tems and Al-Zahrani (2006). Results of previous studies show that some extracts of natural materials can be used as corrosion inhibitors of some metals and alloys in different aggressive media, such as: oxandra asbeckii plant, *Lebrini* et al.[3] *(2011)*, musa paradica peel, *Gopal* et al.[3] *(2015)*, asteriscus graveolens, *Znini* et al.[3] (2012), spirulina pantesis, *Kamal & Sethuraman (2012)*, molasses, *Ghulamullah* et al.[3] *(2015)*, zizyphus spina

Christi, *Aisha* et al.[3] *(2010)*, sebasnian sesban *Hussein* et al.[3] *(2013)*, chlomolaena odorata L, *Obot* et al.[3] *(2012)*, Pongamia piñata seed, *Ambrish* et al.[3] *(2011)*, mymecodia pendans *Pradityana &Shahab (2016)*, and the obroma cacao peel, *Yetri* et al.[3] *(2015)*.

According to the estimations of the world experts in this field, corrosion of iron and its alloys in the world during a period of one year "eats" over thirty percent (30%) annual world production of iron. In our environment, corrosion of metals, especially mild steel, has resulted in many mechanical failures of structure. It implies that corrosion impacts on the mechanical features and structure of mild steel internally (Oparaku & Osarolube (2018).

Mild steel remains an important engineering material frequently applied in construction, chemical, power production, automobile and electrochemical industries due to its abundance at relatively low production cost. Above all, mild steel possesses unique and remarkable mechanical properties such as good strength, toughness, ductility, formability and weldability which confirm its suitability as a better construction material in comparison to other engineering materials *Vytautas* et al.[3] *(2010).*

Alchornea Cordifolia **(Figure 1)** belongs to the family of Euphorbiaceae, having a chromosome number of 36.

Figure 1: *Alchornea Cordifolia* Leaves

Vernacular names: Christmas bush dovewood (English). Arbre de djeman (French). Bugi-bugi, bunce, pô d'arco (Portuguese). Ububo (Igbo).The entire part of *Alchornea cordifolia* ranging from the fruit, leaf, stem, stem bark and root are all used for medicinal purposes, *Kamara* et al.[3] *(2000).*

The present work is undertaken to evaluate the inhibition efficiency of *Alchornea Cordifolia* Leaf Extract on the Mechanical Properties of Mild Steel in Sulphuric acid solution.

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MATERIALS AND METHODS

Weight Loss Technique at Room Temperature

The inhibited and non-inhibited mild steel[4] coupons were setup using 0.2M sulphuric[2] acid. The coupons were weighed using the electronic balance. One coupon was immersed in nine beakers each containing the acidic solution. Similarly, a coupon was also immersed in nine beakers each containing the acidic solution and with 0.5g/L concentrations of *Alchornea Cordifolia* leaf extract. After 24hours, a coupon was removed from both the non-inhibited and inhibited medium respectively. The two coupons removed were cleaned, dried, and reweighed. The same procedure was carried out after 7days, 14th day, and 21st day of immersion respectively. Parameters such as the corrosion rates and inhibitor efficiencies were determined from the weight loss values.

Tensile Test

Three specimen of mild steel were dimensioned to fit into the Tensile Testing Machine. The control, the sample exposed to the acidic environment without inhibitor and the sample exposed to the acidic environment with the presence of the inhibitor. The load or force applied on the sample and the extension created by the force were constantly measured and recorded till the sample failed. After failure, the final length and cross sectional area was recorded to obtain the stress - strain plot, indicating the reaction of the material throughout the tensile test. The developed data and plot was utilized in evaluating the mechanical properties of the material.

Hardness Test

Rockwell B Hardness test was used to determine the hardness of the samples. In the procedure, it is noted that the deeper the depth of indentation, the softer the material. Here, preload or preliminary force (load-10kg) was applied on the mild steel sample with the aid of diamond indenter. This minor load was applied specifically to create way for the major testing by breaking the surface finish on the sample. After a specified time, the indenter baseline depth was measured. The main load was then applied (90kg), to make the load applied and needed testing load to (100kg). This load was held constant on the material for a specified time (dwell time), before it was removed and the material allowed for elastic recovery, and return to the preload. The preload was held steady for a specified time, then released, before[5] the indentation depth (d) was measured.

The Rockwell Hardness value was evaluated, using equation (6) from the difference between baseline depth and final depth. This distance was converted to Hardness Number.

$$HRB = 130 - \frac{d}{0.002} \qquad (6)$$

RESULTS

Analysis of data from weight loss experiment

The calculated values of corrosion rate (mpy)[6] and inhibition efficiency (%) from the weight loss measurement are presented in Table 1.

Table 1[7]: Corrosion rate and inhibitor efficiency of mild steel with and without inhibitor in 0.2M sulphuric[2] acid for 21Days

Exposure Time (Day)	Corrosion Rate (mpy)		Inhibitor Efficiency (%)
	Without Inhibitor	With Inhibitor	
1	67.8	13.0	80.0
2	59.7	15.2	75.1
3	67.9	12.5	81.2
4	88.4	16.3	80.3
5	76.3	13.9	81.2
6	67.8	28.3	61.7
7	67.8	26.9	62.7
14	55.6	25.7	51.5
21	40.5	6.6	84.4

The table above reveals high corrosion rate of mild steel[4] in 0.2M sulphuric[2] acid solution in the absence of the inhibitor, then a decrease in the corrosion rate on introduction of the *Alchornea Cordifolia* leaves extract into the corrodent, indicating that *Alchornea Cordifolia* leaves extract actually inhibits the corrosion of Mild Steel in sulphuric[2] acid solution. The plot of variation of corrosion rate with time is as shown in figure 2 below.

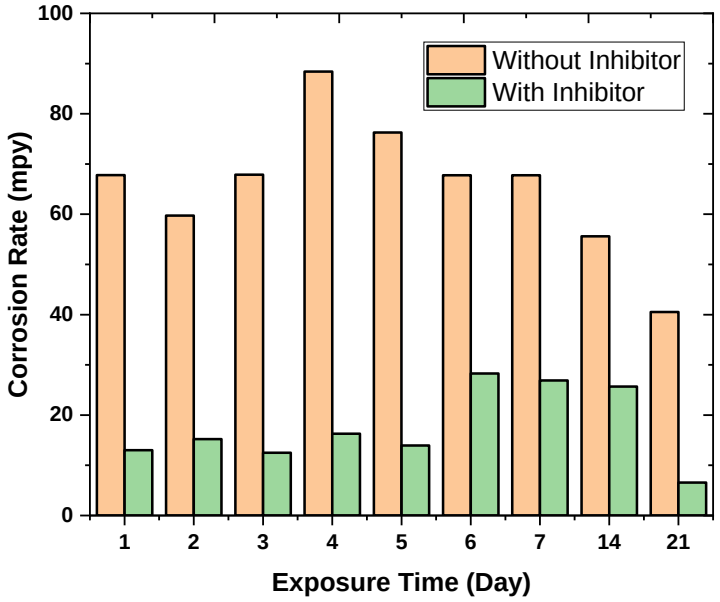

Figure 2: Variation of corrosion rate with time for 0.5g/L concentration of *Alchornea Cordifolia* leaf extract for mild steal in 0.2M Sulphuric acid for 21Days.

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Tensile Test

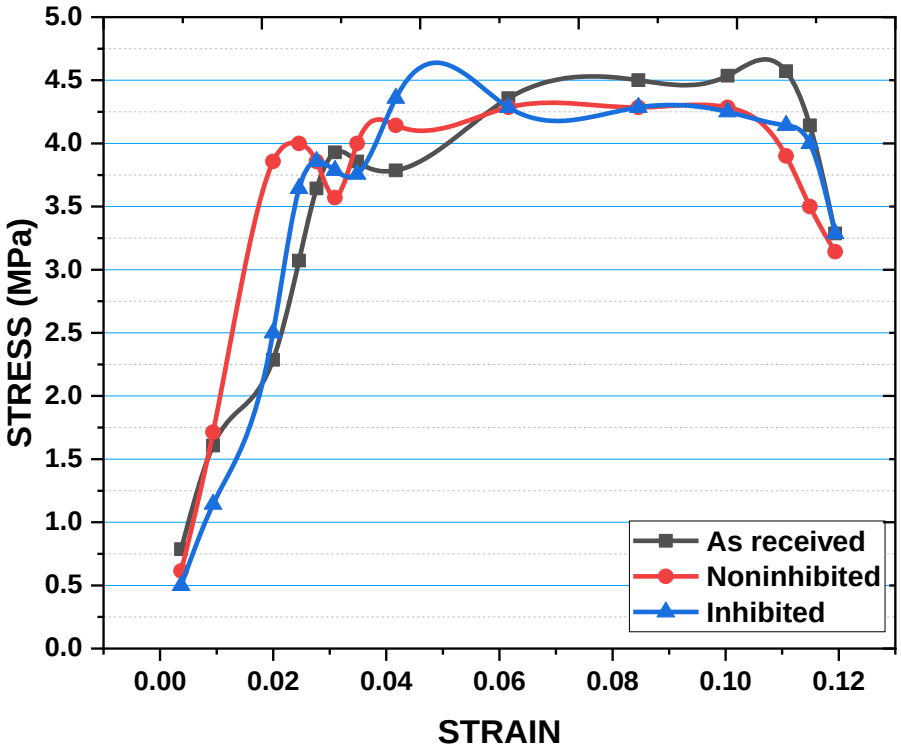

Figure 3: Stress-Strain Curve of Mild Steel in 0.2M Sulphuric Acid containing *Alchornea Cordifolia* Leaf Extract for 21 Days (For 'As received', Noninhibited, and Inhibited sample)

Table 4: Mechanical Properties from Tensile Test

Mechanical Properties	Sample 1 Without Medium (Control)	Sample 2 Without Inhibitor (Blank)	Sample 3 With Inhibitor
Ultimate Tensile Strength ($X10^8nm^{-2}$)	4.5714	4.2857	4.3571
Yield Strength ($X10^8nm^{-2}$)	3.8571	4.000	3.8571
Engineering Fracture Strength ($X10^8nm^{-2}$)	3.2857	3.1429	3.2857
Ductility (% Elongation) (%)	12.8571	7.1429	7.1438
Ductility (% Reduction In Area) (%)	64.6429	70.2857	66.6071
Young's Modulus (Nm^{-2})	1529.6730	1270.8030	1720.4719

The presence of *Alchornea Cordifolia* leaf extract as a corrosion inhibitor in the sulphuric[2] environment increased the ultimate tensile strength, stiffness and fracture strength of the mild

steel, while it caused a decrease in the yield strength and ductility of the material as seen on **Table 4.**

Hardness Tests

Table 5: Hardness Test Results

Tests	Test 1 (Control)	Test 2 (Without Inhibitor)	Test 3 (With Inhibitor)
Hardness	**30**	**32**	**34**

The above table shows that the presence of the acidic medium increased the hardness of the sample. With the presence of the inhibitor in the acidic medium, there was a further increase in the hardness of the sample.

DISCUSSION OF RESULTS

Analysis of results from Weight Loss Technique

Corrosion of mild[4] steel in an oxygenated 0.2M sulphuric[2] acid solution occurs by combination of the anodic mild steel dissolution and the cathodic oxygen reduction. However, in the presence of the extracts the reduction process is retarded by the adsorption of the active adsorbable species of the extract at the metal surface and becomes the rate determining step. High percentage of corrosion inhibition efficiency shown by *Alchornea Cordifolia* leaf extract shows good adsorption over the metal surface. Any inhibitor that retards the corrosion rate of a metal as found in this work is said to be an effective inhibitor. This result obtained is in agreement with that of several researchers like *Osarolube* et al. (2008), *Osarolube & James* (2015), *Osarolube & Nwosu* (2018).

Effects of corrosion on mechanical properties

Similar results as seen on Table 4 were obtained by Osarolube (2015) in her study on Inhibitory effect of 1-Phenyl – 3 – Methylpyrazol – 5 – One on the mechanical properties of copper in aqueous media. This implies that *Alchornea Cordifolia* leaf extract in the acidic environment increases the maximum strain mild steel can withstand. It therefore improves the maximum resistance of mild steel to being pulled apart due to tension load.

Yield Strength is the stress level at which plastic deformation starts. A reduction of the stress level at which mild steel transits from elastic plastic region as seen on table 4 is in agreement with the results obtained by *Rahbar Ranji & Zakeri* (2010)[8] in his work on Mechanical properties and corrosion resistance of normal strength and high strength steels in chloride solution. Generally yield stress decreases by corrosion, but there are some discrepancy in results. This is due to pitting and stress concentrations which cause local yielding. Local yielding forges ahead yielding strength and this is the reason of discrepancy of yield stress. Increase in the stress at which mild steel fails via fracture (fracture strength) as obtained in the result is also similar to results obtained by ***Rahbar Ranji and Zakeri*** (2010)[8]

The Corrosion process was found to decrease the ductility of the metal. This is the capacity of a material to undergo significant plastic deformation before

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fracture and may be presented as percentage elongation from tensile test.

Young's Modulus, (Elastic Modulus), measures the stiffness of solid material. A stiff material needs more force to deform compared to a soft material. Hence, using *Alchornea Cordifolia* leaf extract in the sulphuric^2 medium increased the stiffness of mild steel. This means that more force will now be needed to deform the mild steel.

Alchornea Cordifolia leaf extract in the acidic environment increased the materials resistance to plastic deformation. The material will also be resistant to various kinds of permanent shape change when compressive force is applied.

CONCLUSION

Having analyzed the results obtained from the study, the following conclusions were made:

- Alchornea Cordifolia leaf extract acts as a good and efficient inhibitor for the corrosion of mild steel^4 in sulphuric^2 acid medium.
- Alchornea Cordifolia leaf extract improves the ultimate tensile strength^9, stiffness, hardness and fracture strength of mild steel.
- The inhibitor decreases the yield strength and ductility of mild steel in sulphuric^2 acid medium.

Therefore, adequate considerations should be given to mechanical properties and corrosion resistance of materials while selecting them for service conditions.

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