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Corrosion Inhibition Effect of *Anthocleista Djalonensis* on Mild Steel in 1.0 M HCL

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Abstract: **Corrosion inhibition effect of *Anthocleista djalonensis* on mild steel was studied using gravimetric method for 1.0 M of HCl at different temperatures – ambient and 333K. The mild steel were immersed in the uninhibited corrosive media and those containing 0.1 g/l, 0.2 g/l, 0.3 g/l, 0.4 g/l, 0.5 g/l and 0.6 g/l of the extract for both the ambient temperature and 333K. The inhibition efficiency of the extract was determined, after weight losses were calculated and optimum value was gotten as 97.23% for ambient and 84.62% for 333K. The adsorption studies revealed Langmuir isotherm as the best model for the isotherm (r^2=0.9998 for ambient temperature and r^2=0.9966 for 333K) on the mild steel surface. This shows that *Anthoclesista djalonensis* is a good green inhibitor, obeying the strict environmental legislations for the "green" alternative of mitigating corrosion.**

***Keywords: Anthoclesista djalonensis*, Inhibition, Mild steel, Weight loss, Adsorption.**

I. INTRODUCTION

In the industries, mild steel is one of the most valued metals because of its high ductility and malleability. It is used in different constructions and industrial processes, making it prone to corrosion especially during industrial processes like etching, pickling, acid washing, etc. When they corrode, they raise safety concerns. This has aroused researchers to work to find suitable inhibitors that would not only mitigate the corrosion of mild steel but also not affect the environment negatively. Most of the inhibitors used there are synthesized, showing good anti-corrosive activities while on the other hand causing both temporary and permanent damages to human's existence on planet earth. Therefore, the study of new non-toxic corrosion inhibitors is essential to overcome this problem. The research in the field of eco-friendly corrosion inhibitors has been addressed toward the goal of using cheap, effective compounds at low or "zero" environmental impact (Lebe et al., 2013). *Anthocleista djalonensis* (commonly known as Cabbage tree), the inhibitor used in this research work, is a medicinal plant. Scientists and modern researchers have shown that medicinal plants have relatively small amount of constituents called "the active ingredient or principle" produced by the plants. These ingredients include Alkaloids, tannins, Saponins, Terpernoids, Phlobatanins, etc. (Luter et al., 2012; Peter and Des Met, 2002). Therefore, phytochemical study is the study of substances isolated or extracted from medicinal plants which occur naturally. This is accomplished by simple chemical tests (phytochemical screening) to detect their presence, isolate and purify them and determine their chemical structure and biosynthesis (metabolic and non-metabolic processes). The result of the phytochemical screening of the methanol, petroleum ether and hot water leaf extracts of *Anthocleista djalonensis* shows the presence of tannins, saponins, flavonoids, steroid, terpenoid and cardiac glycosides (Akinyemi and Ogundare, 2014). Inhibition performance of plant extracts have been normally ascribed to the presence of these complex organic species as well as conjugated double bonds in their molecular structure (Nnanna et al., 2011; Ulaeto et al., 2012; Atanda et al., 2012; Okafor et al., 2008). For this reason, the anticorrosive effect of *Anthocleista djalonensis* was studied in this work to know its efficiency in ambient (room) temperature and in an elevated temperature (333K).

II. MATERIALS AND METHODS

A. Materials Preparation:

Mild steel sheet used for this study was gotten at Aba South Local Government of Abia State and were mechanically cut in to coupons of dimension 2 cm × 2 cm. The thickness of the mild steel was 1.32 mm. These coupons were mechanically polished to remove coatings with Sic papers of different grades to obtain smooth surfaces that have no coatings on it. They were then degreased in ethanol, dried with acetone and stored in moisture free desiccators before being used for the studies. The percentage composition of the mild steel used (wt. %) is: C = 0.05, Mn = 1.13, Si = 0.05, P = 0.91, S = 0.85, Cu = 0.09, Pb = 0.15, Ve = 0.13, Mo = 0.08 and Fe = 96.56.

B. Preparation of the leaf extracts of Anthocleista djalonensis:

The procedure for the preparation of the leaf extracts is similar to that reported by Lebe et al. (2013) and Okafor et al. (2008). *Anthocleista djalonensis* were gotten from a farm in Aba North, Abia State. The leaves were washed thoroughly for dirt and were air-dried. The air-dried leaves were then pulverized. 10 g of the powder was refluxed in 240 ml of 1.0 M HCl solution the resultant mixture was filtered to get a stock solution. From this stock solution, a concentration range of 0.1 – 0.6 g/L was prepared using excess 1.0 M HCl as the solvent. These were prepared for the room temperature and for 333K.

C. Gravimetric experiment:

All coupons prepared and stored were weighed using the electronic weighing balance which had an accuracy of ±0.005. These initial weights were recorded and the coupons were immersed into the corrosive environment. Of the seven environments, one was purely the 1.0 M HCl while the other six had 0.1 – 0.6 g/L of the inhibitor present in them. At the end of the test, the coupons were carefully brought out of the environment, nitric acid was used to quench further corrosion and then washed in ethanol. They were then dried in acetone and their new weights recorded. Water bath was used to repeat this experiment for the elevated temperature (333 K) using the same set of procedures. These tests were repeated in duplicates and values reported are the mean values of the experiment.

III. RESULTS AND DISCUSSION

A. Gravimetric technique and corrosion rates:

The weight loss method is one of the most popularly used methods of determining corrosion rates of metals in corrosive media. The weight loss of mild steel in 1.0 M HCl was determined after 10 hours of exposure and the corrosion rates were determined from the equation shown below:

$$CR = \frac{k\Delta w}{\rho A t} \quad (1)$$

Where $CR =$ Corrosion rate in mm/yr

$k =$ Corrosion rate constant (534 mpy; mils per year).

$\Delta w =$ Weight loss in grams

$\rho =$ Density of the steel (g/cm^3)

$A =$ The exposed area of the coupon (cm^2)

$t =$ Immersion time (hrs)

Results show that the weight loss as reduced to a great percentage as the inhibitor was added to the corrosive media. Apart from the second concentration (0.2 g/l) of the extract in the environment, the weight loss of the metal reduced as the concentration increased. The corrosion rates of the mild steel were determined for room temperature and 333 K in the presence and absence of the inhibitor using calculations from the weight loss. Figure 2a and 2b shows the graph of corrosion rates against the concentration for ambient temperature and 333K respectively - it revealed that the corrosion rate of the metal decreased as the concentration of the extract in the medium increased. This showed that the inhibitor was really effective as its increase in the environment would reduce corrosion.

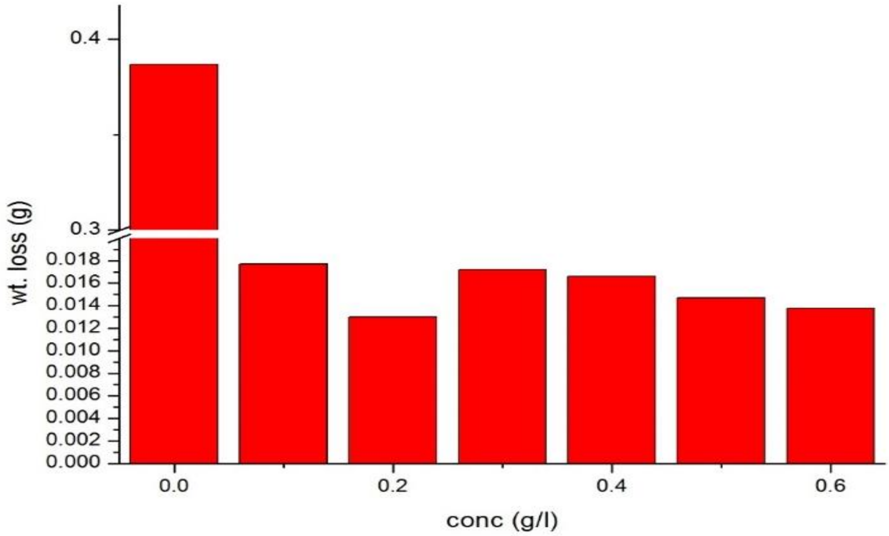

Figure 1a: Weight loss of mild steel in different concentrations of *A. djalonesis* after ten hours of exposure (ambient temperature)

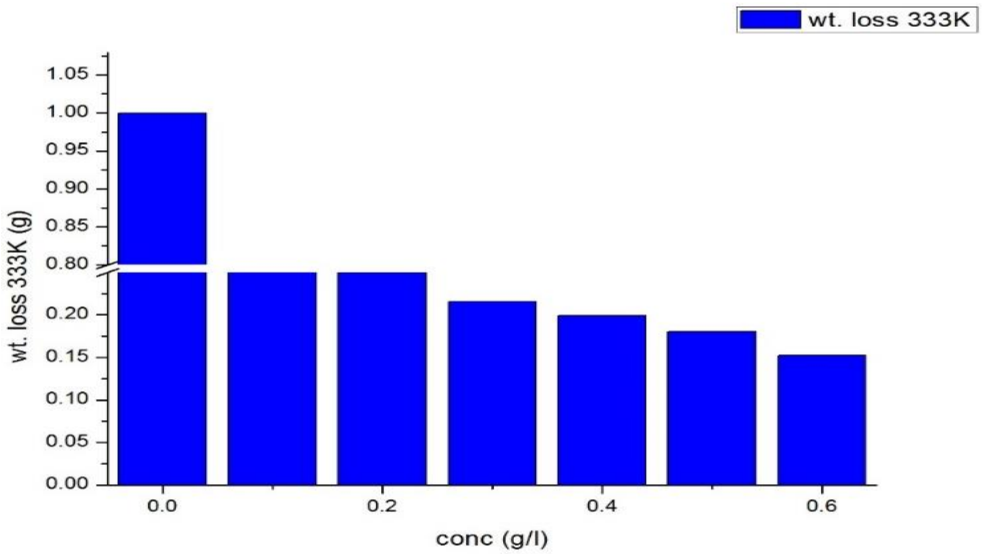

Figure 1b: Weight loss of mild steel in different concentrations of *A. djalonesis* after ten hours of exposure (333K)

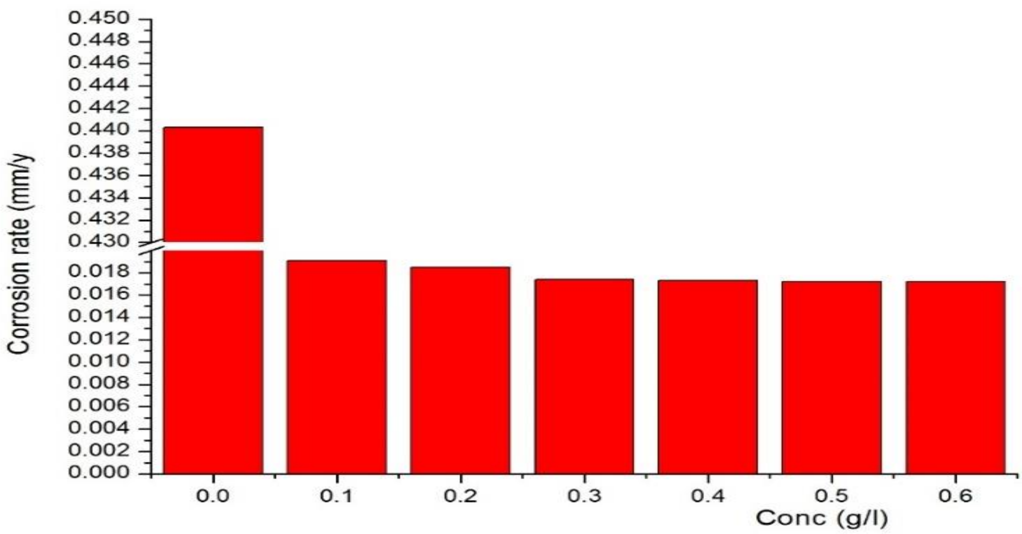

Figure 2: Corrosion rate of various concentrations of *A. djalonesis* in 1.0 M HCl on mild steel (ambient temperature)

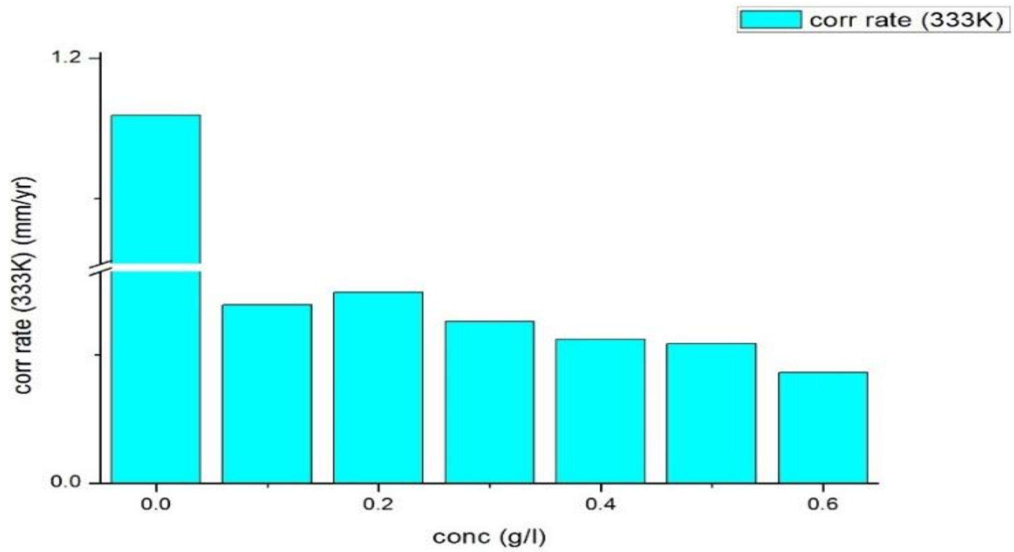

Figure 2b: Corrosion rate of various concentrations of *A. djalonesis* in 1.0 M HCl on mild steel (333K)

B. Inhibition Efficiencies:

Anthocleista djalonensis leaves are extensively used to treat diarrhoea, wound, abdominal pain, boils on skin and fungal skin infection. Phytochemical screening of the leaf extracts of *Anthocleista djalonensis* (Methanoic, petroleum ether and hot water) showed the presence of tannins, saponins, flavonoids, steroid, terpenoid and cardiac glycosides (Akinyemi and Ogundare, 2014) which are good solvents and are reported to be inhibitors of corrosion (Lebe et al., 2013; Umoren et al., 2008; Bouklah et al., 2006; Chetouani et al., 2005; Olabiyi et al., 2003), making it almost impossible to attribute the inhibiting act of the leave to just one constituent. The inhibition efficiency was calculated using the formula:

$$I\% = 1 - \frac{\rho_{inh}}{\rho_{blank}} \qquad (2)$$

where I% represents the inhibition efficiency expressed in percentage,

ρ_{inh} is the corrosion rate in the presence of the inhibitor while

ρ_{blank} is the corrosion rate in the absence of inhibitor.

Its inhibiting efficiency is way high starting at 95.66% for the 0.1 g/L concentration of the extract and peaking up at the 0.6 g/L giving a very interesting and excellent inhibiting efficiency (97.23%) for the ambient temperature. At increased temperature (333K), the aggressiveness of the environment could not necessarily stop the effectiveness of the inhibitor in stopping the attack on the metal as we got an optimum of 84.61% at 0.6 g/L from 75.14% at 0.1 g/L. This result goes along with the fact that an increase in the concentration of the inhibitor in the medium reduces the corrosion rate and increases the inhibition efficiency.

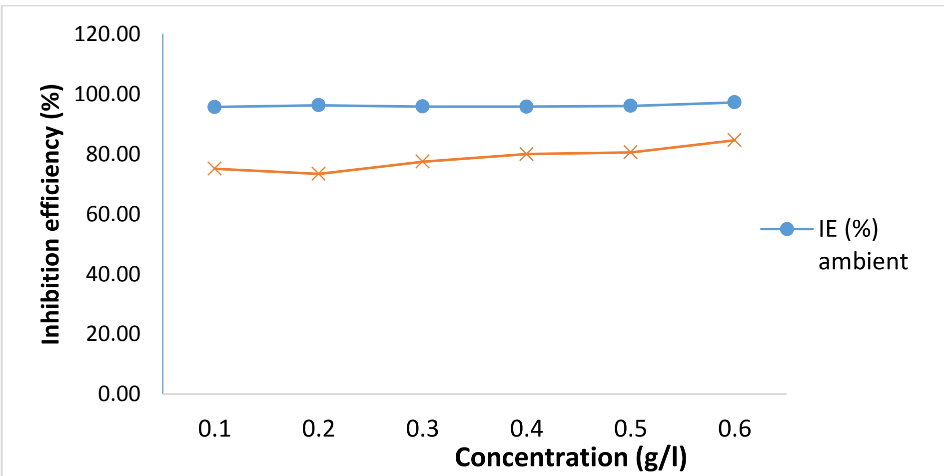

Figure 3: Inhibition efficiencies of different concentrations of *A. djalonesis* in 1.0 M HCl

C. Adsorption Isotherm studies:

The plot of the ratio of concentration to surface coverage (C/θ) against concentration (g/L) displayed a straight line for the tested inhibitor in the acidic media for both temperatures (Figure 4 and 5). The linear plots, with high correlation coefficient (r^2 = 0.9998 for the ambient temperature and r^2=0.9966 for the elevated temperature) clearly reveals that the surface adsorption process of *A. djalonesis* on mild steel surface obeys the Langmuir adsorption isotherm. The plot supports the assertion that the mechanism of corrosion inhibition is due to the formation and maintenance of a protective film on the metal surface and that the additive cover both the anodic and cathodic sites through uniform adsorption following Langmuir isotherm. This implies that chemisorptions and physiosorption processes were employed while the leaves in the media were in contact with the metal (James et al., 2007; Lebe et al., 2013; Nnanna et al., 2014), hence protecting it from further corrosion activities.

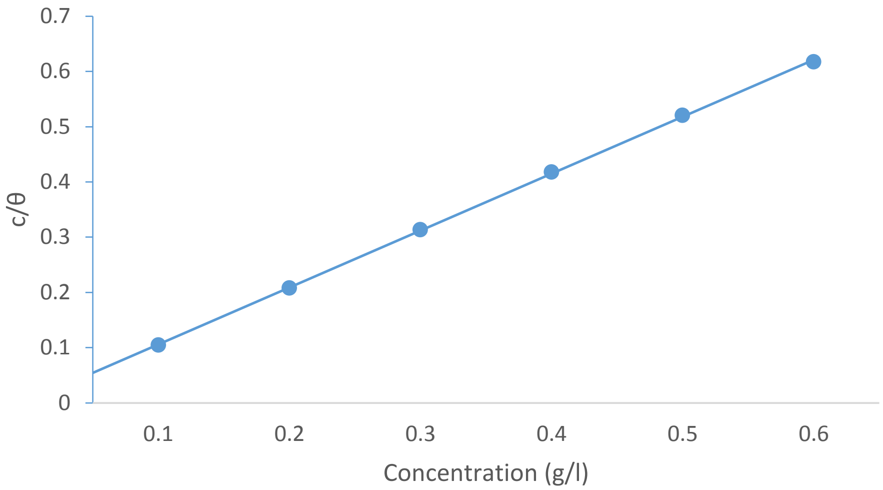

Figure 4: Langmuir isotherm for *A. djalonesis* adsorption on mild steel in 1.0 M HCl (ambient temperature)

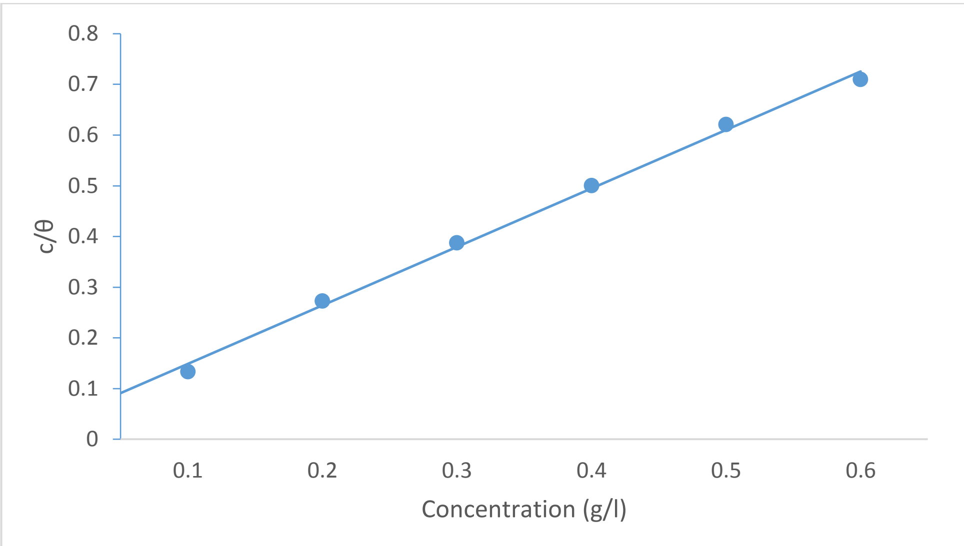

Figure 5: Langmuir isotherm for *A. djalonesis* adsorption on mild steel in 1.0 M HCl (333K)

IV. CONCLUSION

After the experiments and analysis, the following conclusions were made: *A. djalonesis* is a good "green" inhibitor for mild steel in 1.0 M HCl solution having its inhibition efficiency increasing as the concentration increased for both ambient temperature and 333 K. The maximum efficiency obtained was 97.23% for ambient and 84.62% for 333K. The adsorption of *A. djalonesis* on steel surface obeys the Langmuir adsorption isotherm having a coefficient of correlation as 0.9998 for ambient temperature and 0.9966 for 333K.

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