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The Effect of Corrosion of Mild Steel in the Presence of Anthocliesta Djalonensis Rootbark Extract in 1.0 M HCl

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Abstract:- The experimentally Studying of the corrosion of mild steel metal using methanonic root bark extract of Anthocleista djalonensis plant, in hash 1molar solution of hydrochloric acid by gravimetric method shows the folowing results. The result gotten shows, that the s concentration of Anthocleista djalonensis plant extract even in acidic media, inhibitsmild steel's corrosion rate.Furthermore, the Inhibitive efficiency of this sampled plant was found to defer with concentration, temperature and time ofimmersion.Thermodynamic studies reveals that adsorption of the metal coupon is spontaneous in accordance with Langmuir's adsorption isotherm. Synergistic consideration which is the presence of potassium iodide (KI) was carried out indicating an increase in the corrosion inhibition of Anthocleista djalonensis extract. There was a physical adsorption model of theory that was proposed as inhibition efficiency tarries with temperature change, concentration and other parameters as well.

Keywords:- *Spontaneous reactions, Gibbs free energy, iron oxide, biodegradable, inhibitor efficiency.*

I. INTRODUCTION

Corrosion in its term is defined as a gradually deteriorating process of metallic materials when they reacts with their environment. From thermodynamic studies, corrosion is found to be a **spontaneous**in which that**Gibbs energy** is denoted by a negative sign. This means that, corrosion occurs because of the natural tendency of any metal gearing towards an equilibrium state;For example unstable metallic iron oxidizing to a stable iron(iii) oxide. Since corrosion is a natural process, it therefore cannot be completely aameliorated but can be managed, regulated, and controlled.

The problem of corrosion is invariably present all over the world,in countries like U.S,England and in Australia where facilities are constituted with metal structures. Apparently, one-fifth of the iron and steel, produced annually in the world today is used to replace rusted metals. Ejikeme *2015.*This therefore gave rise to our concern about its effects and implications all around the world and how to put to good use all our findingsas to inhibit and make ineffective the problems of corrosion generally. It is not until recent that plants role as eco-friendly non-toxic source of material from which complex molecular structure pave the way for better studies of inhibitive process by so surface covering system. The choice of inhibitors can be considered in two folds; inhibitors obtained from living organismswhich are referred to as green inhibitors and also inhibiting compounds containing hetero atoms in their metal surfaces. The most common kind of acidic media form of organic compounds are those containing oxygens, phosphorus and nitrogen with heterocyclic nitrogenous compounds dominating.Oguzie *et al*. Many of the compounds are toxic. The trending thing in environmental regulation is to consciously replace toxic compounds with eco-friendly green plants. It is important to find non-toxic chemicals with high biodegradability and reduced bioaccumulation. Statistics proof that BOD should be at least 60%; BOD is the measure of how long inhibitors will persist in the environment (Matjaz et al,2014).

Some chemicals are great inhibitors, but yet toxic and are readily absorbed through the skin. To this effect there is a growing demand for corrosion inhibitors which arebiodegradable, and also less toxic, compared to those complex heterocyclic nitrogenous compounds.Green inhibitors have shown most efficiently improved environmental properties that are friendly to mankind. The advancement of technology as well as the need for environmental friendly ways of reducing problems encountered by corrosion are our prime focus for this laboratory work.The papers' report is on the inhibition effect of corrosion on mild-steel in a root bark extract of *Anthocleista djalonensis* plant in an acidic solution of 1M HCL.

II. EXPERIMENTAL

A. *Materials preparation*

Mild steel was purchase and cut into coupons of 2cm by 3cm, with thickness of 0.08cm .These coupons were each, with the use of emery cloth ,polished mechanically, washed thoroughly with distill water and ethanol , then dried with concentrated acetone and stored in a desiccator. There is a preparation of aggressive acid solution of 1.0 M HCL that was mixed with the root bark extract of *Anthocleista djalonensis*with concentration rang of 0.20gam/ltr , 0.40gram/ltr, 0.60gram/ltr ,0.80gram/ltr, and finally1.00gram/ltr, respectively. A blank sample of 1.0M HCL was prepared as well. This contains potassium iodide (KI) used as synergistic effect in 1.0 M HCL and a blank.

B. *Gravimetric experiment*

Seven samples of beakers, with five containing 0.2grams, 0.4grams, 0.6grams, 0.8grams and 1.0grams quantities of*Anthocliesta djalonensis* root bark extract respectively then two other beakers, one serving as control by lacking the extract and the other containing potassium iodide all in 1.0M HCL acid solution wereprepared.Pre-

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weighed mild steel coupon pairs of sizes 2 by3 cm each were immersed in 250ml beaker of acid solutions in containing the above mentioned concentration rage of the sample plant (0.2g/L – 1.0g/L) with the aid of a net thread each beaker has a duplicate without the sample plant extract for weight difference comparability. They were removed after 24 hours, cleaned, dried, reweighed and immersed again in the respective test solutionsfor five (5)consecutive days, with temperature at 303K. The weight loss measurement was carried out in duplicates in order to obtain reproducible results (N. Eddy *et al* 2008). Then temperature effect investigation was also done indicated by that which theknown masses of mild steel metal coupons were also immersed in 250cm^3 of the test solutions in a beaker in a water bath maintained that was maintained at 303K, 313K and 333K respectively. After three hours intervals, the corroded coupons were removed and washed each with distilled water and the help of a brush these coupons were rinsed in acetone, cleaned with a rag and air dried before reweighing (Momoh-Yahaya *et al, 2014*).

III. RESULT

A. Weight loss and corrosion rate

The result shows that the corrosion rate varies with change in concentration of the sample extract. This implies that as the concentration of *Anthocleista djanlonensis* extract increases, there is physical absorption of the complex molecules. In general there was an observed decrease in weight lossin each coupon provided the concentration of the extract in acidic media is constantly increasing as well.

Table 1: Effect of concentration for 24hrs

Conc.(g/l)	**Weight loss**	**I.E (%)**	**C.R ($gh^{-1}cm^{-2}$)**
0.0	0.055	-	0.000385
0.2	0.046	17	0.000319
0.4	0.029	47	0.00021
0.6	0.021	61	0.000145
0.8	0.027	50	0.000187
1.0	0.022	60	0.000152

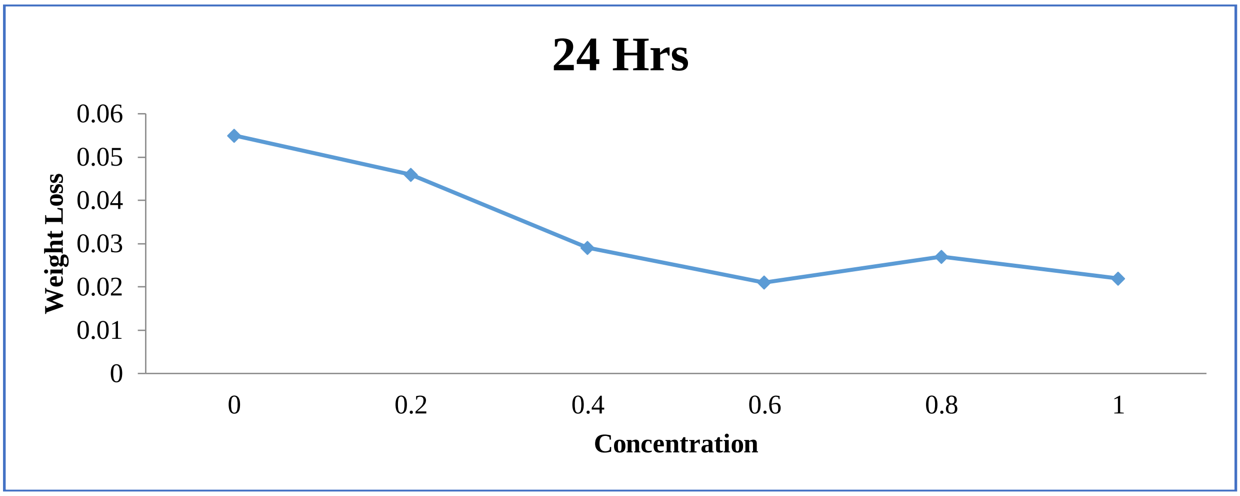

Fig. 1: Weight loss on concentration of Anthocleista djanlonensis root bark for 24hrs

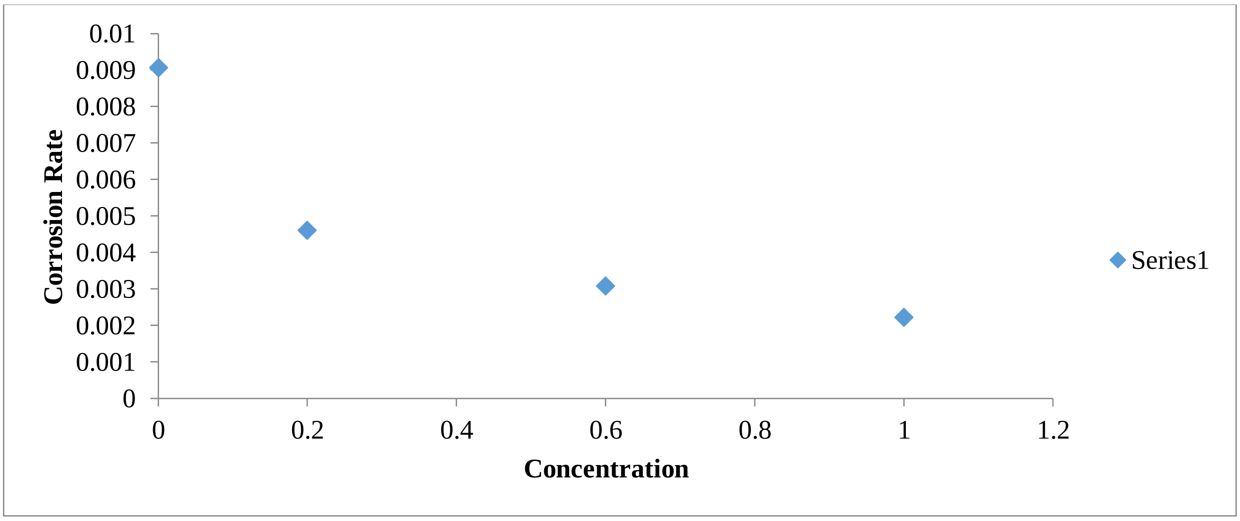

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Fig. 2: Concentration varies with corrosion rate

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B. *Inhibition efficiency*

The difference in weight for the period of three hours each, were taken as an average weight losses. Given the result of the weight loss gotten, the inhibition efficiency *(% IE)*, the degree of surface coverage (θ) and the corrosion rate *(CR)* of mild steel all were calculated using equations 1, 2 and 3 respectively.

$$IE_{exp} = \left(1 - \frac{W_1}{W_2}\right) X\ 100 \quad 1$$

$$\theta = 1 - \frac{W_1}{W_2} \quad 2$$

$$CR(gh^{-1}cm^{-2}) = \frac{\Delta W}{At} \quad 3$$

Where W_1 and W_2 are the weight losses (g) for metal in the presence and absence of the inhibitor respectively, θ is the degree of surface coverage of the inhibitor, A is the area of the metal coupon (cm3), t is the period of immersion (hours) and $\Delta W = W_2 - W_1$ is the weight loss of metal after time.

Table 2: Effect of concentrations on corrosion rate for 24hrs and 48hrs

Conc.(g/l)	I.E (%) 24hrs	I.E(%) 48hrs
0.0	-	
0.2	17	67
0.4	47	
0.6	61	68
0.8	50	
1.0	60	77

It has been observed that the longer the time of immersion the better the result of inhibition as shown in the table above.

C. *Temperature Effect*

Weight loss experiments were performed at temperature range between 303K and 333K with 10K intervals each. The concentration selected was chosen. The results gotten were for 3hrs period of immersion and the corrosion rates is for both the sample extract and controlled acid media and then for temperature change. Also from the plot below it is evident that inhibition efficiency in the acid medium decreased with increase in temperature for either concentrations. Indications proof that mild steel corrosion rate in hydrochloric acid media solution, increases with temperature in the presence of inhibitors, and decreases with increase in temperature in the absence of inhibitors.

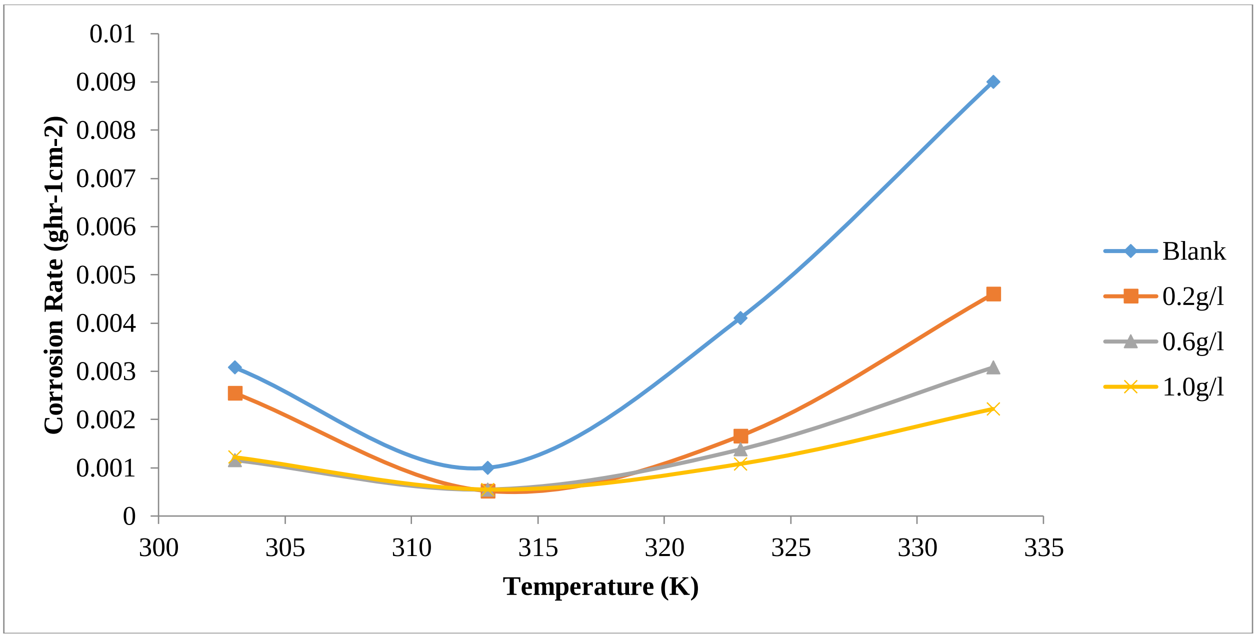

Fig. 3: Temperature on corrosion rates effect

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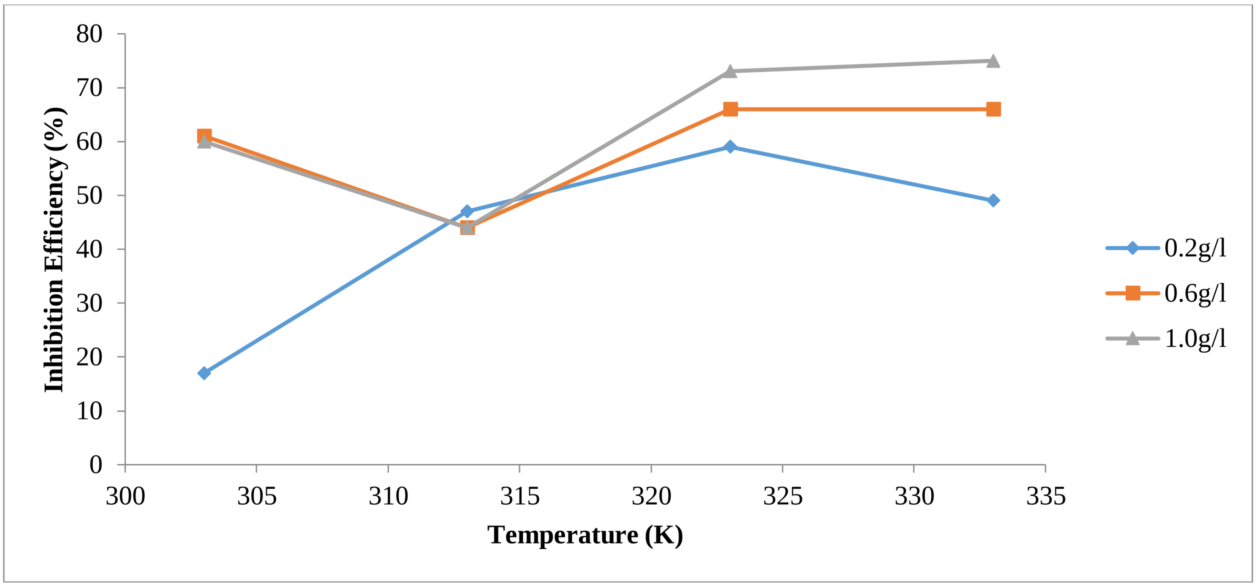

Fig. 4: Temperature on the inhibition efficiency effect

There was a barrier created between the corroding media and the metal surface by its rich complex molecules. Note that the inhibition efficiency increases with an increase in the metal surface action with the organic matter.This means that as the temperature increases for various concentrations, the inhibition efficiency decreases.

To calculate activation thermodynamic parameters of the corrosion process Arrhenius equation and the modified form of the equation were to be used (Lebrini*et al.* 2006.)

$$logCR = logA - \frac{E_a}{2.303RT} \qquad 4$$

$$log(CR_2/CR_1) = {}^{E_a}/_{2.303R}\left({}^{1}/_{T_1} - {}^{1}/_{T_2}\right) \qquad 5$$

The modified form of the equation is derived from Arrhenius equation (2.0) by taking logarithm of both side of the equation and considering CR_2 and CR_1 for both temperatures giving rise to the equation(2.1) above.

From the trend of temperature change with surface coverage the equation above was used to obtain the heat of adsorption(E Oguzie, 2008).

$$Q_{ads} = 2.303R\left[\log\left(\frac{\theta_2}{1-\theta_2}\right) - \log\left(\frac{\theta_1}{1-\theta_1}\right)\right]x\left(\frac{T_{1X}T_2}{T_2 - T_1}\right)kJmol^{-1}$$

Were θ_1 and θ_2 are the degrees of surface coverage at temperatures T_1 and T_2 respectively

Q_{ads} Is positive meaning that the reaction is an endothermic reaction this indicates that there is a chemical adsorption (chemisorption) process of the organic component of *Anthocliesta djalonensis* Extract on the steel metal surfaces.

Table 3: Thermodynamic Parameters

Sample	E_a ($kJmol^{-1}$)	Q_{ads} ($kJmol^{-1}$)
Blank	29.69	-
0.2g/L	16.95	43.24
0.6g/L	26.24	59.18
1.0g/L	16.59	19.38

The plant's degree of surface coverage from weight loss experiment is used to check the absorption characteristics at 303k such as for the Langmuir adsorption isotherm. According to Langmuir adsorption model, the degree of surface coverage is related to the concentration of the inhibitor (Oguzie, 2008).

$$\theta = K_{ads}C/(1 + K_{ads}C)$$

$$K_{ads}C = \theta(1 + K_{ads}C)$$

$$C/\theta = 1/K_{ads} + C$$

The plot of C/θ vs C is shown in figure below(Momoh-Yahaya,et al 2012)

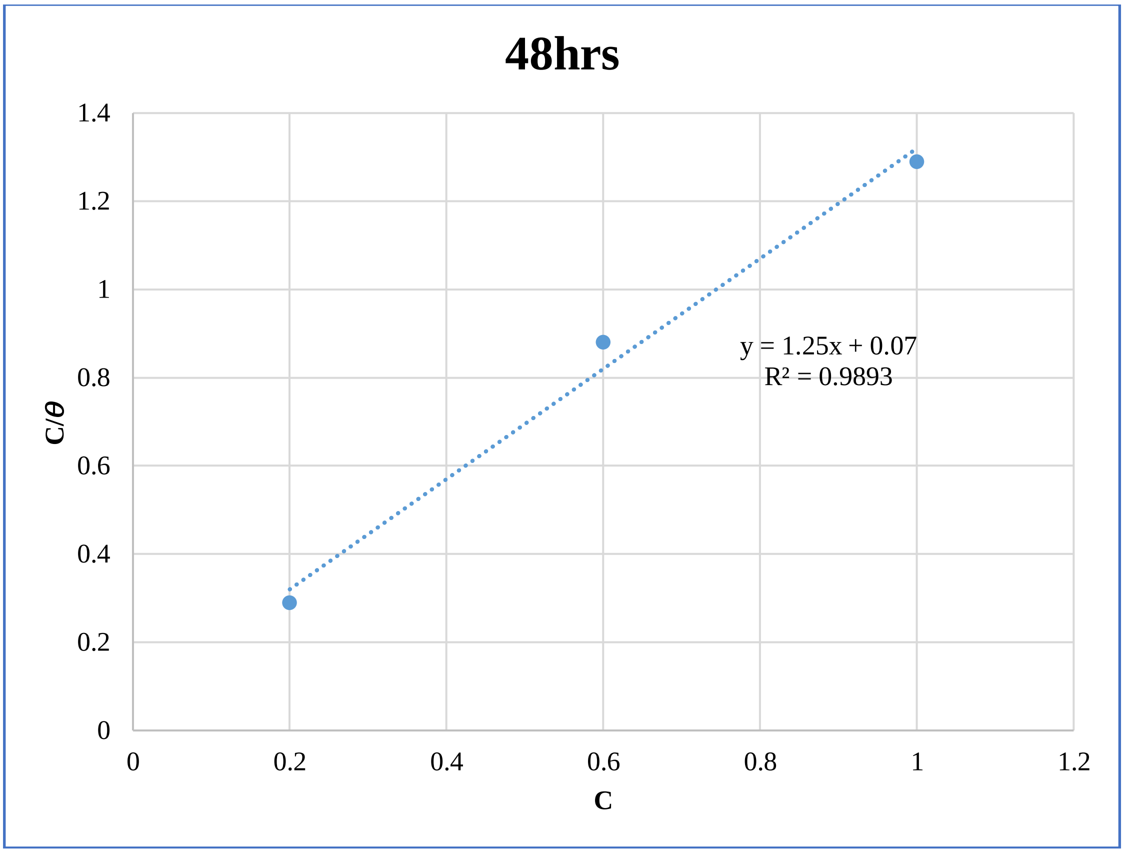

Fig. 5: Langmuir isotherms for the adsorption

The results obtained shows that the slope and r-square value for the isotherms are close to unity, which indicate the application of the Langmuir isotherm to the adsorption of the *Anthocleista djanlonensis* root back extract. This attribute indicate the interactions between absorbing species on the metal surface as well as changes in the adsorption and heat with increasing surface coverage factors which were not taken into consideration in derivation of the isotherm (Emeka *et al*).

It is important to state that the value of the equilibrium constant of adsorption (K_{ads}) above is related to free energy of adsorption according to the equation below,

$$\Delta G_{ads} = -2.303RT\log(55.5K_{ads})$$

The free energies of adsorption calculated from equation 4.8. From the results obtained, the free energies are negatively less than the threshold value of-40 kJ mol^{-1} required for the mechanism of chemical adsorption.

D. Determination of Enthalpy and entropy

The Entropiesand enthalpies are other thermodynamic features relating to adsorption isotherm and corrosion process may be evaluated from the effect of temperature .The enthalpy and entropy of activation of corrosion process was calculated with the equation above.

$$\text{Log}\frac{CR}{T} = \log\left(\frac{R}{nh}\right) + \frac{\Delta S}{2.303R} - \frac{\Delta H}{2.303RT} \quad 6$$

Were $CR$is corrosionrate at temperature T, Rmolar gas constant, and$n$ is Avogadros constant. A plot of $log\ CR/T$ and$1/T$ is a straight line graph with a slope of $\left(\frac{\nabla H}{2.303RT}\right)$And an intercept of ($log\ (R/nh)\ + \Delta S/2.303R$) from which the value of ΔH andΔH was calculated. (Olasehinde *et al.)*

Table 4: Enthalpy and entropy of the reaction with various concentration in 1.0 M HCl.

Concentration(g/l)	**Enthalpy (KJ/mol)**	**Entropy (KJ/mol)**
Blank	45.6	-1.029
0.2	19.79	-2.141
0.6	27.7	-1.09
1.0	16.22	-1.13

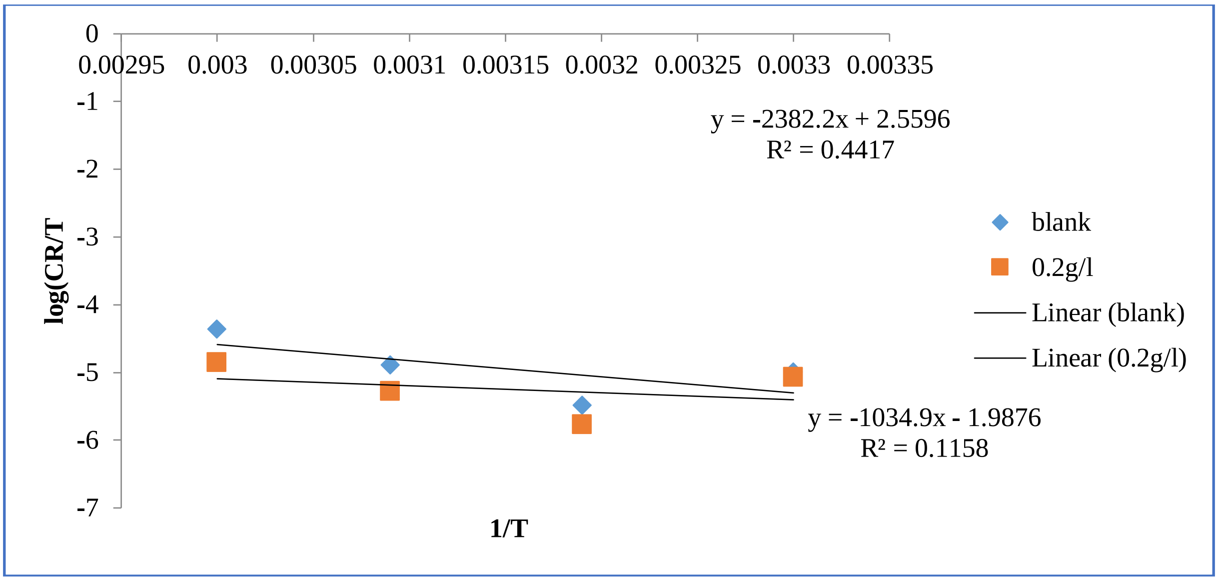

Fig. 6: Plot of log(CR/T) versus 1/T for enthalpy and entropy

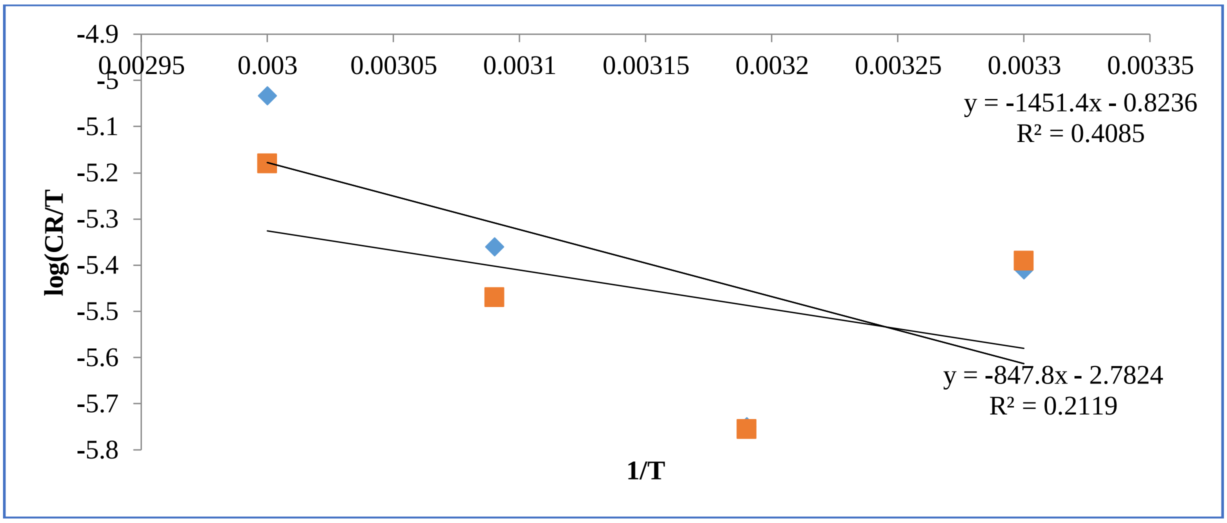

Fig. 7: Plot of log(CR/T) versus 1/T for enthalpy and entropy

The synergistic effect of iodide ion in acid media of Athocliesta djalonensis plant extract indicates that the iodide ions facilitates adsorptionof sample plants extracts during the mild steel corrosion process by forming intermediate bridges between the metal surfaces and the positive end of the organic inhibitor (E. E. Oguzie et al).

IV. CONCLUSIONS

- Anthocleista djanlonens is root back extract inhibited the corrosion of mild steel in 1M Hydrochloric acid.Chemical and physical adsorption processes following ,Langmuir model the inhibition efficiency increase as the concentration of the extract increases.
- The thermodynamic parameters were obtained which are; enthalpy changes, Gibbs free energy, entropy and the kinetic properties have been deduced. Understanding of temperature effects on inhibition efficiencies.
- Synergistic effect as in the presence of halides increased the efficiency of the extract making use to suggest chemisorption reaction took place.

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