

Mathematical Modeling of Corrosion Inhibition Efficiency of *Acalypha Wilkesiana* Leaves

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Abstract: *Acalypha wilkesiana* leaves were collected at Adeyemi College of Education, Ondo. Cleaned leaves were subjected to sun-dry and air-dry processes. Sun-dried and air-dried leaves were powdered, sieved and stored in desiccators at room temperature. A known mass of the powdered leaves was soaked in ethanol in different containers for 72 hours to obtain inhibitor extracts. Extracts were used as inhibitor for mild steel of known composition. Weight loss, inhibition efficiency (IE) and corrosion rate were studied using standard methods. Models that relate concentration of inhibitor and temperature to IE were proposed, established and evaluated using statistical methods. The inhibition efficiency increases with increasing extracts concentration to 88.89 % and 80.51 % at 333K of 1.0 g/l of extracts for the air and sun-dried extracts, respectively. The inhibition efficiency also increases with increasing temperature of the reaction system suggesting a chemical adsorption mechanism. The best models for sun and air dried extracts were $IE = -31.71 + 7.07X_1 + 0.25X_2 + 0.09X_1X_2$ and $IE = 0.21X_1^{0.23}X_2^{1.04}$ with MSC (4.3 and 4.1), AIC (69.3 and 67.9) and SC (72.3 and 70.8) and CD (0.990 and 0.988), respectively. The worst models for sun and air dried extracts were

$Log(IE) = 1.91 + 0.27Log(X_1) + 0.002Log(X_2) + 0.0007Log(X_1X_2)$ and

$Log(IE) = 1.92 + 0.26Log(X_1) + 0.002Log(X_2)$ with MSC (1.7 and 2.1), AIC (120.4 and 111.6), SC (123.4 and 108.6) and CD (0.887 and 0.910) respectively. It was concluded that these two extracts of the present study can serve as effective green corrosion inhibitors for mild steel in acidic media.

Keywords: Inhibition efficiency, weight loss measurement, Corrosion, Plant extracts, Mild steel, Statistical analysis.

I. INTRODUCTION

Iron and its alloys are widely used in engineering works such as constructions of overhead tanks, general and petroleum refineries equipment, pipes and valves. The main setback of using iron and alloys of iron is its aggressive reactions in acidic media. Acid media are generally used in the removal of unwanted scale and rust on iron and its alloys in many industrial processes (Anees *et al.*, 2018). There are many commercially available acids. Out of all these commercially available acids, HCl and H₂SO₄ are the most frequently used. It has been well documented that inhibitors are generally used materials in these processes to control iron and iron alloys dissolution as well as in the utilization of acid

(Ameer and Fekry, 2010; Musa *et al.*, 2010). Inhibitor studies cover a variety of activities, researches and actions. These researches range from protection mechanisms and kinetics, discovery and synthesis of new inhibition aid compounds and the assessment of competitive commercial inhibitors with evaluation of industrial processes in which inhibitors are being used (Khaled, 2011). Inhibitors can alter the reaction rate of metals in acidic media; affect the kinetics of the electrochemical reactions that support the corrosion process.

Previous studies provide descriptions of corrosion processes and list some of synthetic chemical compounds that exhibit inhibitive properties for metals in acidic media. Some of the chemical compounds are aminopyrimidines, fluconazole, clotrimazole, 2,3-diaminonaphthalene, tetrazole derivatives and purine (Obi-Egbedi *et al.*, 2012). Out of these only a few synthetic chemical compounds are actually used in practice. This is partly due to the fact that desirable properties of an inhibitor usually extend beyond those simply related to metal protection, but rather cost synthetic chemical compounds, biodegradability, toxicity; availability and environmental friendliness are of considerable prominence (Obi-Egbedi *et al.*, 2012).

With reference to effects of chemical and synthetic inhibitors on the environment, there exists the need to develop a new class of corrosion inhibitors with low toxicity, good efficiency and model of factors that influence performance of the inhibitors. Investigation of natural products of plant origin as inexpensive and environmental friendly corrosion inhibitors is an indispensable research. Apart from environmentally friendly and ecologically acceptable, plant products are cheap, readily available and are renewable sources of materials (Obi-Egbedi *et al.*, 2012). The extracts from their leaves, barks, seeds, fruits and roots comprise mixtures of organic compounds containing nitrogen, sulphur, and oxygen atoms and some essential elements (Obi-Egbedi *et al.*, 2012). It has been reported that some plants function as effective inhibitors of selected metal corrosion in different aggressive environments (Obi-Egbedi *et al.*, 2012). It has been shown that plant materials, such as opuntia extract, *Telferia occidentalis* extract, limonene, *Prosopis cineraria* zallouh root, olives leaves, *Datura stramonium*, *Gossypium hirsutum* extract and *Phyllanthus amarus* extract are effective inhibitors for metal in aggressive solutions (Obi-Egbedi *et al.*, 2012). Obi-

Egbedi *et al.* (2012) has recently reported on the corrosion inhibitive effectiveness of metals by *Dacryodes edulis*, *Pachylobus edulis*, *Vigna unguiculata*, Gum Arabic, *Raphia hookeri* and *Ipomoea invulcrata*. Despite the high availability and many varieties of plant materials, only relatively few (nearly 300,000 plant species that exist on the earth, less than 1%, Al-Otaibi *et al.*, 2014) have been thoroughly investigated and reports on the detailed mathematical models of the inhibition efficiencies are still scarce. More on corrosion and corrosion inhibitors can be found in literature such as Yaro (2013, 2014), Khadom and Abdul- Hadi (2014), Sanjay *et al.* (2015), Alaneme *et al.* (2015), Khadom *et al.* (2015), Ghulamullah *et al.* (2015), Hassan *et al.* (2016), Fouda *et al.* (2016), Nathiya and Vairamuthu (2017). The present study focuses on the broadening application of plant extracts of *Acalypha wilkesiana* leaves for metallic corrosion control and reports on mathematical models of the inhibiting effect of extracts of *Acalypha wilkesiana* leaves on mild steel corrosion in acidic medium.

II. MATERIALS AND METHOD

The leaves of *Acalypha wilkesiana* were collected at Adeyemi College of Education, Ondo (07°04'24.6"N, 004°49'26.1"E and elevation 256.2 m) Ondo State, Nigeria. The leaves were rinsed with distilled water to reduce necessary impurities to the lowest level. Cleaned leaves were subjected to sun-dry and air-dry processes. Initial and final moisture contents of the leaves (air and sun dried) were determined using standard methods (APHA, 2012). Percentage moisture content (%) was computed as follows:

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

Where; M_c is the moisture content (%), W_1 and W_2 are the initial and final weight of the leaves.

A known mass (2 kg) of these sun-dried and air-dried leaves were powdered, sieved using British Standard sieve size and stored in desiccators at room temperature. A known mass of the powdered leaves were then soaked in ethanol in different containers for 72 hours to obtain inhibitor from ethanol extracts. These ethanol extracts were concentrated using rotary evaporator and finally evaporated to dryness using a water bath (APHA, 2012). Solid residue extracts without ethanol were obtained. The obtained solid residues were used to prepare different concentrations (0.2 – 1.0 g/l) of inhibitors at intervals of 0.2. Commercial iron alloys (mild-steel) was purchased from commercial centre in Akure, Nigeria. Its chemical compositions were determined using Standard methods at the Mechanical Engineering Department of Federal University of Technology Akure, Ondo state, Nigeria. These alloys were cut into 18 x 16 x 4 mm, polished with emery papers (400 – 1000 grades), washed with distilled water, degreased with absolute ethanol, dried with acetone before storage in desiccators. Prepared iron alloys were subjected to acidic media of 2.0 M HCl solution with various

concentrations (0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 g/l) of ethanol extracts of *Acalypha wilkesiana* leaves as inhibitor at various temperature to ascertain effects of temperature on the performance of the inhibitor, 2.0 M of HCl was selected based on literature (Al-Otaibi *et al.*, 2014, Alaneme *et al.*, 2015, Hassan *et al.*, 2016, Fouda *et al.*, 2016, Nathiya and Vairamuthu, 2017). Mass loss and Inhibition Efficiency (IE) were computed as follows:

$$CR = \frac{\Delta w}{AT} \quad (2)$$

Where; Δw is the weight loss (g), A is the surface area of the mild steel and T is the exposure time of the mild steel

$$IE(\%) = 100 \left(\frac{CR_0 - CR_1}{CR_0} \right) \quad (3)$$

CR_0 is the corrosion rate of the mild steel in the absence of inhibitor (blank) and CR_1 is the corrosion rate of mild steel in the presence of inhibitor

A general mathematical model (Linear, interaction and polynomial) that relates IE, temperature and concentration of the inhibitor was proposed. Constants in the model were determined using MES method. These models were selected based on literature (Anees *et al.*, 2018). The models were evaluated statistically (Akaike Information Criterion, (AIC), Schwartz Criterion (SC), Coefficient of Determination (CD) and Model of Selection Criterion (MSC)) using expected IE as reference data). The model equations are as follows:

$$\text{Linear model: } IE = A + bX_1 + CX_2 \quad (4)$$

Where; IE is the inhibition efficiency (%), X_1 is the concentration of extract, X_2 is the temperature of the solution and A , b , c and d are model's constants.

Linear with interaction:

$$IE = A + bX_1 + CX_2 + dX_1X_2 \quad (5)$$

$$\text{Polynomial: Non-linear; } IE = AX_1^bX_2^c \quad (6)$$

Linear:

$$\text{Log}(IE) = \text{Log}(A) + b\text{Log}(X_1) + c\text{Log}(X_2) \quad (7)$$

Polynomial with interaction: Non-linear:

$$IE = AX_1^bX_2^c(X_1X_2)^d \quad (8)$$

$$\text{Linear: } \text{Log}(IE) = \text{Log}(A) + b\text{Log}(X_1) + c\text{Log}(X_2) + d\text{Log}(X_1X_2) \quad (9)$$

Procedures employed in the computations of model constants using Microsoft Excel Solver (MES) are as follows (Oke *et al.*, 2017):

- Microsoft Excel Solver was added in on the toolbar of Microsoft Excel;
- Target (limit) value of the iteration was set for the software based on square of difference as;

$$\sum_{i=1}^n (IE - (A + bX_1 + CX_2))^2 \quad (10)$$

- Changing cells of the iterations were selected, number of iterations, degree of accuracy and maximum time for the iteration were set for the software to meet the target; and
- The iteration started through Microsoft Excel Solver (Figure 1).

More on MES can be found in literature such as Oke *et al.* (2016; 2017), Barati (2013); Tay *et al.* (2014) and Hui *et al.* (2018). The Model of Selection Criterion (MSC) is interpreted as the proportion of expected weight of the mild steel and observed weight of the mild steel variation that can be explained by the obtained weight of the mild steel. Higher value of MSC indicates higher accuracy, validity and the good fitness of the method. MSC was computed using equation (11) as follows:

$$MSC = \ln \frac{\sum_{i=1}^n (Y_{obsi} - \bar{Y}_{obs})^2}{\sum_{i=1}^n (Y_{obsi} - Y_{cali})^2} - \frac{2p}{n} \quad (11)$$

where, Y_{obsi} is the observed weight of the mild steel; \bar{Y}_{obs} is the average of observed weight of the mild steel; p is the total number of fixed parameters to be estimated in the

equation; n is the total number of concentration, and Y_{cali} is the expected weight of the mild steel.

The Information Criterion of Akaike (AIC) was derived from the Information Criterion of Akaike (1976). It allows a direct comparison among models with a different number of parameters. The AIC presents the information on a given set of parameter estimates by relating the coefficient of determination to the number of parameters. The AIC values were computed using equation (12) as follows:

$$AIC = n \left(\ln \sum_{i=1}^n (Y_{obsi} - Y_{cali})^2 \right) + 2p \quad (12)$$

The Schwartz Criterion (SC) is defined by the formula in equation (13). SC was computed as follows:

$$SC = n \ln \left(\sum_{i=1}^n (Y_{obsi} - Y_{cali})^2 \right) + p \ln(n) \quad (13)$$

The more appropriate model is the one with the smaller SC value. Coefficient of determination (CD) can be interpreted as the proportion of expected data variation that can be explained by the obtained data. Higher values of CD indicate higher accuracy, validity and good fitness of the method. CD can be expressed as follows:

$$CD = \frac{\sum_{i=1}^n (Y_{obsi} - \bar{Y}_{cali})^2 - \sum_{i=1}^n (Y_{obsi} - Y_{cali})^2}{\sum_{i=1}^n (Y_{obsi} - \bar{Y}_{cali})^2} \quad (14)$$

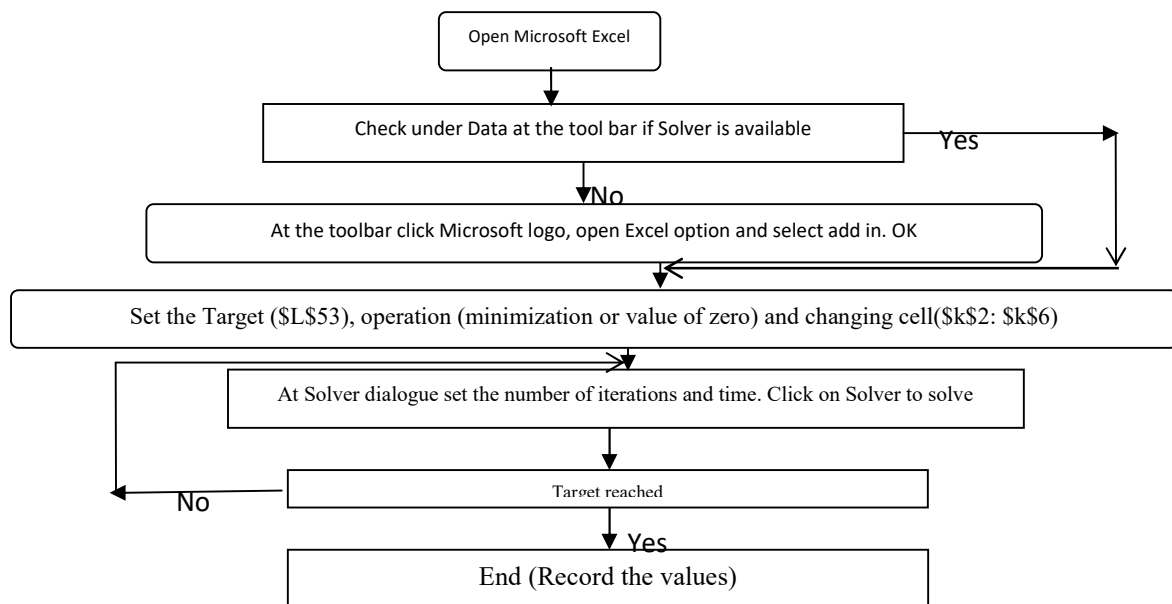


Figure 1: Flow chart of Microsoft Excel Solver in the computation of the constants in the model

III. RESULTS AND DISCUSSION

The study revealed that the mild-steel used for this study have the following compositions: Carbon (0.122 %), Si (0.172 %), Mn (0.56 %), P (0.021 %), S (0.032 %), Cr (0.085 %), Ni (0.114 %), Mo (0.006 %), Zn (0.0022 %), Al (0.0009 %), Cu (0.280 %), Co (0.0069 %), Ti (0.0008 %) and Fe (98.5 %). In a similar studies, Rajendran *et al* (2011) documented that mild steel chemical composition can be summarised as follows: S (.026 %), P (0.06 %), Mn (0.4 %), C (0.1%) and Fe(99.41 %). Al-Otaibi *et al.* (2014) reported that mild steel has chemical composition as follows; Fe (99.14 %), C (0.15 %), Mn (0.6 %), P(0.04 %), S (0.04 %) and Si (0.03 %). This result revealed mild steel is an alloy of iron. The result showed that the major composition of mild steel is iron with percentage composition between 98.5 and 99.41 %. It can then be confirmed that the mild steel used was similar to mild steel in other studies, which indicates that the steel was standard steel.

Umoren *et al.*, (2016) stated that the weight loss technique as scientific assessment have found broad practical application in corrosion evaluations. The rate of corrosion can be defined as the ratio of the loss in weight of the mild steel to its area and the time length over which the evaluation was conducted. A major advantage of this technique is its relative simplicity and availability. In addition, the technique uses a direct parameter for the quantitative evaluation of corrosion (the loss in weight of the mild steel). The weight loss and corrosion rate obtained for the corrosion behaviour of mild steel in 2.0 M HCl solution containing leaves extracts of *Acalypha wilkesiana* within the concentration range of 0.2 to 1.0 g/L are presented in Figures 1 and 2, respectively.

Figure 1 shows the weight loss–time curves for mild steel in 2 M HCl without and with different concentrations of leaves of *Acalypha wilkesiana* extract (air and sun dried) at different temperatures. Similar figure for the corrosion rate of the leaves extract (air and sun dried) are depicted in Figures 2 and 3 at the various temperature and at same temperature, respectively. It is seen from the figures that the amount of material loss decreases significantly in the presence of the extracts compared to the blank acid solution and was also found to be dependent on the concentration of the extracts (air and sun dried). This indicates that the additives inhibit the corrosion of mild steel in 2 M HCl solution. Also, the amount of mild steel loss increases with increase in temperature and greater loss in mass of the mild steel specimen was recorded at 333 K both in the absence and presence of the studied leaves extracts. The values of corrosion rate in the absence and presence of different extract concentrations are presented in Figure 2. Results in the Figure indicate that the extracts (air and sun dried) act as good corrosion inhibitor for mild steel in 2 M HCl solution given that the corrosion rate was reduced in the presence of the extracts (air and sun dried) compared to their absence. Further assessment of the Figure reveals that corrosion rate increases with increase in temperature with the highest values obtained at 333K for all the systems

investigated probably due to increase in the average kinetic energy of the system. Figures 4 and 5 present inhibition efficiencies of the extracts (air and sun dried) against temperature and the concentration, respectively. The inhibition efficiency increases with increasing extracts concentration and is more pronounced for the air-dried compared to the sun-dried extract. The inhibition efficiency values of 88.89 % and 80.51 % were observed at 333K of 1.0 g/l of extracts each. Evaluation of the figures revealed that an increasing trend in inhibition efficiency with increasing experimental temperatures for all the system studied was observed. This observation suggests increasing adsorption of some of the phytochemicals on the surface of the metal at higher temperatures. Such behaviour shows that the additives were chemically adsorbed on the metal surface (Oguzie, 2007). In a similar study, Al-Otaibi *et al.*(2014) observed maximum inhibition efficiency for alcoholic extract of *Artemisia sieberi*. and *Tripleurospermum auriculatum* (90.9%) followed by *Carthamus tinctorius*. (89.0%), *Lycium shawii*. (85.4%), and *Ochradenus baccatus* (84.7%) suggesting that these plant extracts could serve as effective green corrosion inhibitors.

It is a known fact that adsorption of the inhibitors is the main process affecting the corrosion rate of metals. Inhibitors can affect the corrosion rate in two possible ways (Al-Otaibi *et al.*(2014). In the first way, inhibitors decrease the available reaction area through adsorption on the metal which is called geometric blocking effect. In second way, inhibitors modify the activation energy of the cathodic and/or anodic reactions occurring in the inhibitor-free metal in the course of the inhibited corrosion process which is called energy effect. It is a difficult task to determine which aspects of the inhibiting effect are connected to the geometric blocking action and which are connected to the energy effect.

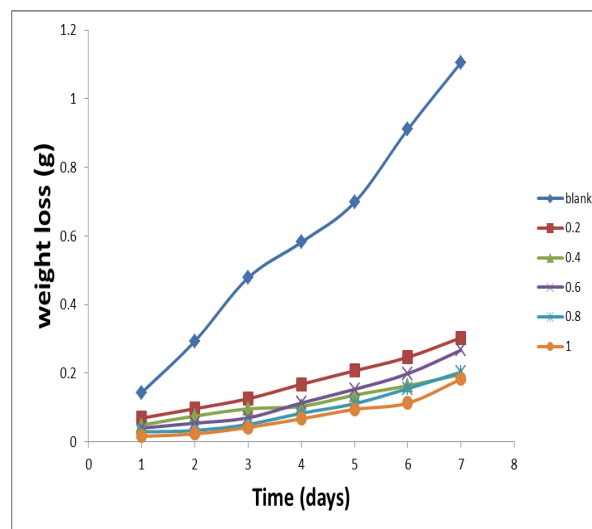


Figure 1a: Weight loss of the mild steel in sun-dried leaves *Acalypha wilkesiana* extract

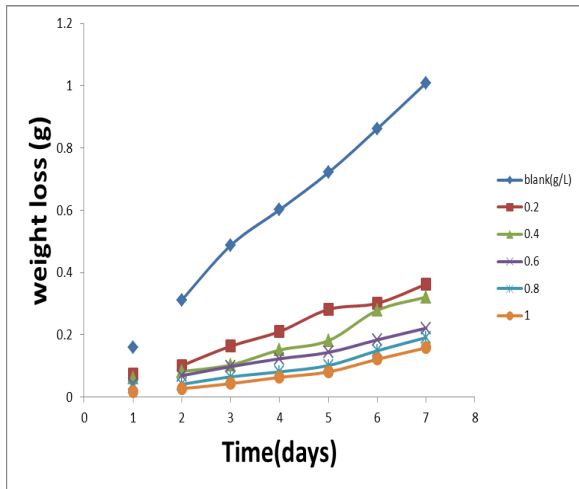


Figure 1b: Weight loss of the mild steel in air-dried leaves *Acalypha wilkesiana* extract

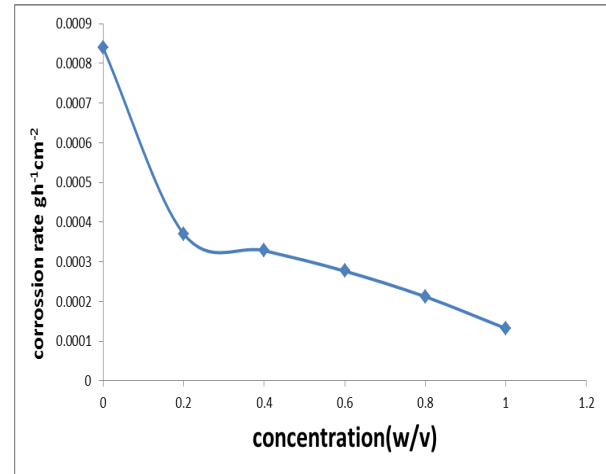


Figure 3a: Corrosion rate of the mild steel in sun-dried leaves *Acalypha wilkesiana* extract at constant temperature

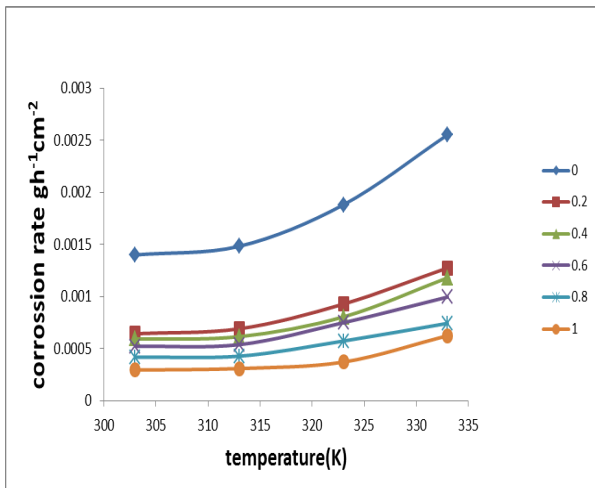


Figure 2a: Corrosion rate of the mild steel in sun-dried leaves *Acalypha wilkesiana* extract

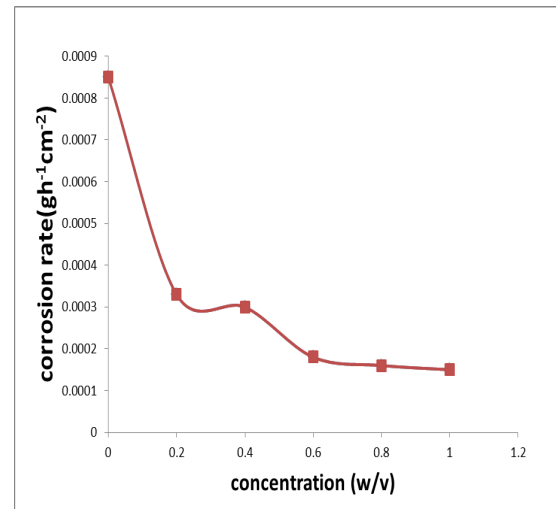


Figure 3b: Corrosion rate of the mild steel in air-dried leaves *Acalypha wilkesiana* extract at constant temperature

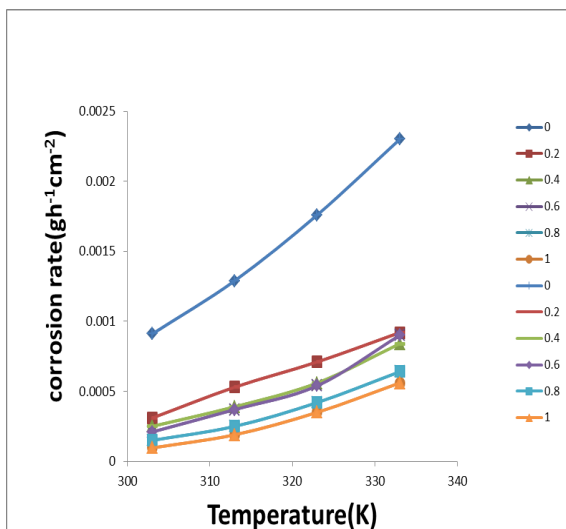


Figure 2b: Corrosion rates of the mild steel in air-dried leaves *Acalypha wilkesiana* extract

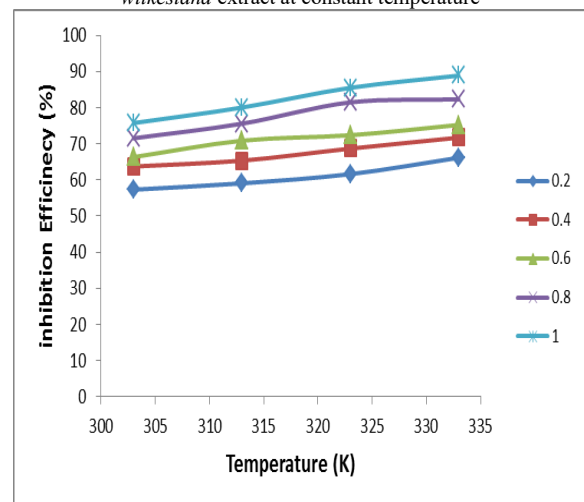


Figure 4a: Inhibition Efficiencies of sun-dried leaves *Acalypha wilkesiana* extract

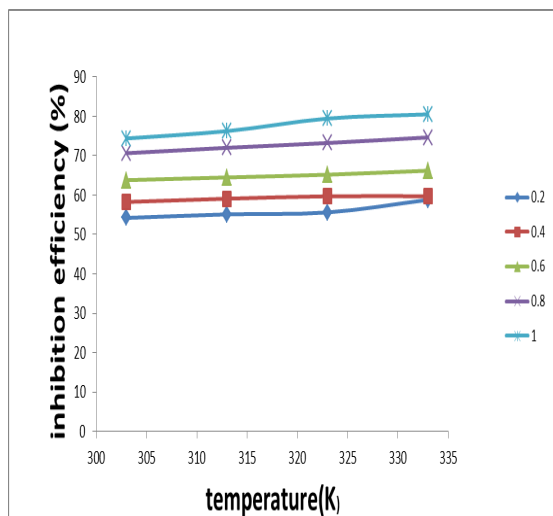


Figure 4b: Inhibition Efficiencies of air-dried leaves *Acalypha wilkesiana* extract

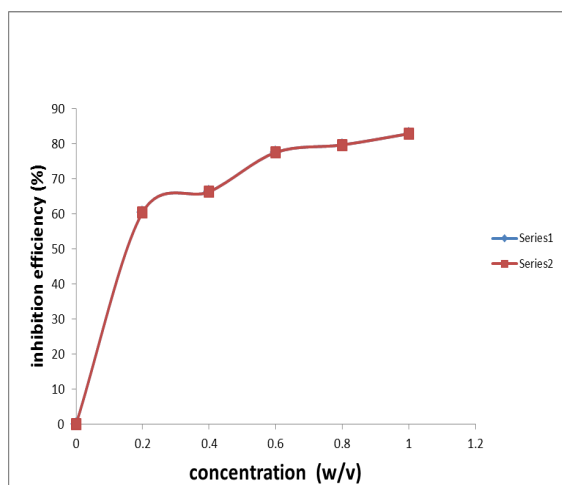


Figure 5a: Inhibition Efficiencies of sun-dried leaves *Acalypha wilkesiana* extract at constant temperature

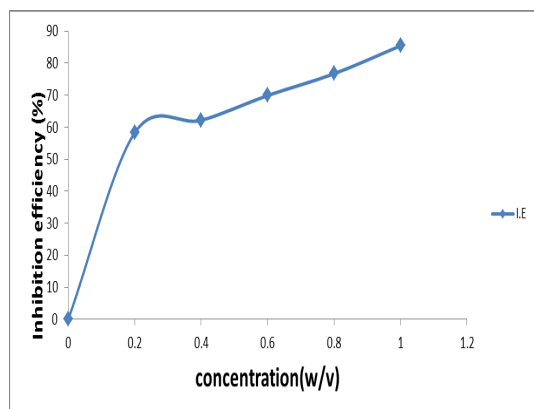


Figure 5b: Inhibition Efficiencies of air-dried leaves *Acalypha wilkesiana* extract at constant temperature

Theoretically, no shifts in the corrosion potential should be observed after addition of the corrosion inhibitor if the geometric blocking effect is stronger than the energy

effect. Al-Otaibi *et al.* (2014) documented that Gas chromatography–mass spectrometry (GC–MS) analysis of plant extracts led to the identification of 26 components from all the studied plants. It is interesting to see here that all the identified compounds from plant extracts contained oxygen and/or p-electrons in their molecules. Moreover, from the previous studies on the phytochemical constituents of the plant extracts it was established that the plant extracts used in this study also contain a mixture of organic compounds containing O, N or p-electrons in their molecules. Hence, the corrosion inhibition of mild steel through these studied plants may be attributed to the adsorption of the phytochemicals containing O, N or p-electrons in their molecules as these atoms are regarded as centres of adsorption onto the metal surface. The highly complex chemical compositions of the plant extracts make it rather difficult to assign the inhibitive effect to a particular compound present in plants extracts. Having confirmed the corrosion inhibition effectiveness of these plants extracts, further detailed investigation for each plant extract through inhibitive assay guided isolation using surface analytical techniques will enable the characterization of the active compounds in the adsorbed layer and assist in identifying the most active phytochemicals.

The model equations for the air dried inhibitor are as follows:

$$IE = -24.57 + 36.20X_1 + 0.25X_2 \quad (4)$$

$$IE = -42.01 + 61.04X_1 + 0.30X_2 - 0.09X_1X_2 \quad (5)$$

$$IE = 0.21X_1^{0.23}X_2^{1.04} \quad (6)$$

$$\text{Log}(IE) = 1.92 + 0.23\text{Log}(X_1) + 0.001\text{Log}(X_2) \quad (7)$$

$$IE = 0.18X_1^{0.12}X_2^{0.95}(X_1X_2)^{0.11} \quad (8)$$

$$\text{Log}(IE) = 1.92 + 0.25\text{Log}(X_1) + 0.002\text{Log}(X_2) + 0.0007\text{Log}(X_1X_2) \quad (9)$$

The model equations for the sun dried inhibitor are as follows:

$$IE = -49.25 + 36.25X_1 + 0.31X_2 \quad (4)$$

$$IE = -31.71 + 7.07X_1 + 0.25X_2 + 0.09X_1X_2 \quad (5)$$

$$IE = 0.03X_1^{0.27}X_2^{1.35} \quad (6)$$

$$\text{Log}(IE) = 1.92 + 0.26\text{Log}(X_1) + 0.002\text{Log}(X_2) \quad (7)$$

$$IE = 0.03X_1^{0.12}X_2^{1.24}(X_1X_2)^{0.16} \quad (8)$$

$$\text{Log}(IE) = 1.91 + 0.27\text{Log}(X_1) + 0.002\text{Log}(X_2) + 0.0007\text{Log}(X_1X_2) \quad (9)$$

These linear equations revealed that there was a decrease (negative constants) in the amount of dissolved iron in the presence of the inhibitors (leaves extracts) compared to the blank solution. In the blank acid solution (2 M HCl) the concentration of dissolved Fe will be found to be 24.57 and 42.01 mg/L, 49.25 and 31.71 mg/l for linear and interaction equations, and for air and sun- dried respectively. It can be explained further that atoms of the metal are reduced and passed into the solution as ions. The amount of ions in the solution will increase with the concentration of the acid media and with temperature, in the absence of inhibiting species. Inhibitors are commonly used to reduce acid attack on the substrate metal and then, reduce the amount of metal ions being passed into the solution. The model equations (linear, non- linear and interactions) revealed that inhibition efficiencies depends more on the concentration of the inhibitor than the temperature of the solution. Hence the adsorption of ethanol extract of *Acalypha wilkesiana* leaves on mild steel surface is consistent with the mechanism of chemical adsorption. Higher coefficient of concentration in IE model equation than temperature may be attributed to the adsorption of components of the extracts on the steel surface at lower temperature, producing a barrier, which isolates the surface from the corrosion environment. Table 1 presents detail of statistical evaluation of the model equations. From the table it was revealed that CD, MSC, AIC and SC were in the range of 0.910 to 0.988, 2.3 to 4.1, 67.9 to 104.6 and 70.8 to 107.6, 0.872 to 0.990, 1.7 to 4.2, 69.3 to 120.4 and 72.3 to 123.4 for air and sun dried extract respectively. The table revealed that the best models for sun and air dried extracts were

$$IE = -31.71 + 7.07X_1 + 0.25X_2 + 0.09X_1X_2 \quad \text{and}$$

$$IE = 0.21X_1^{0.23}X_2^{1.04} \quad \text{with MSC (4.3 and 4.1), AIC (69.3 and 67.9) and SC (72.3 and 70.8) and CD (0.990 and 0.988), respectively. The worst models for sun and air dried extracts were}$$

$$\text{Log}(IE) = 1.91 + 0.27\text{Log}(X_1) + 0.002\text{Log}(X_2) + 0.0007\text{Log}(X_1X_2)$$

and

$$\text{Log}(IE) = 1.92 + 0.26\text{Log}(X_1) + 0.002\text{Log}(X_2)$$

with MSC (1.7 and 2.1), AIC (120.4 and 111.6), SC (123.4 and 108.6) and CD (0.887 and 0.910) respectively. Figure 6 presents relationship between calculated IE and experimental IE for all the models. The figures revealed that

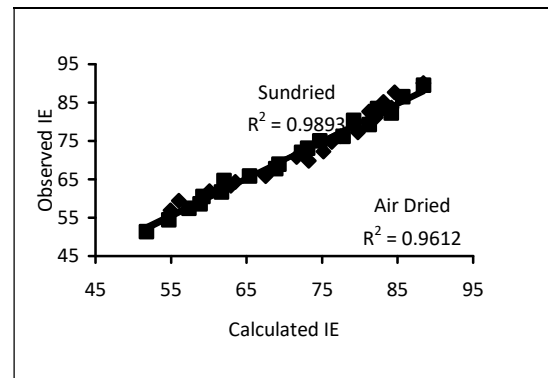


Figure 6a Linear model without interaction

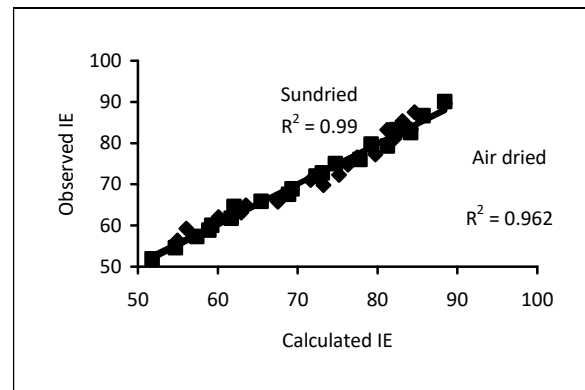


Figure 6b Linear with Interaction model

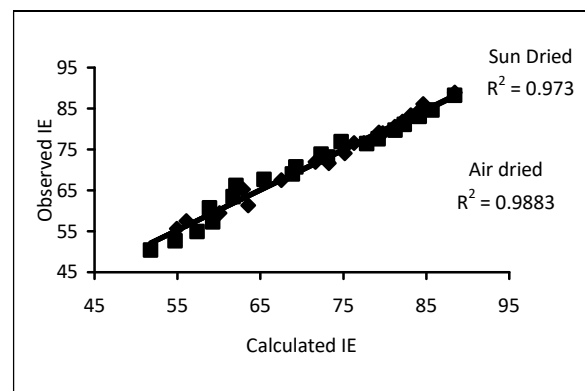


Figure 6a Linear model without interaction

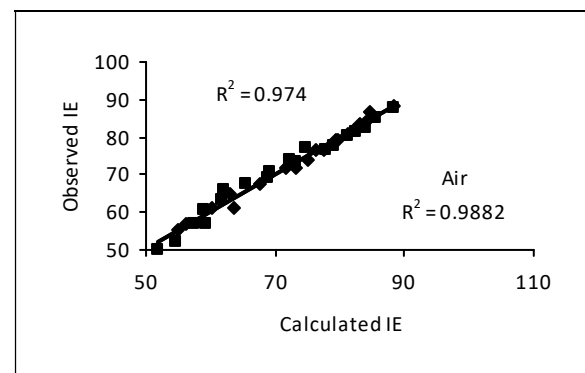


Figure 6d: Polynomial with interaction model

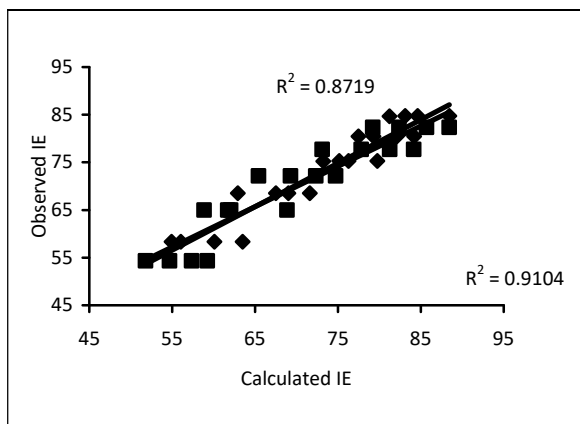


Figure 6e: Log- linear without interaction model

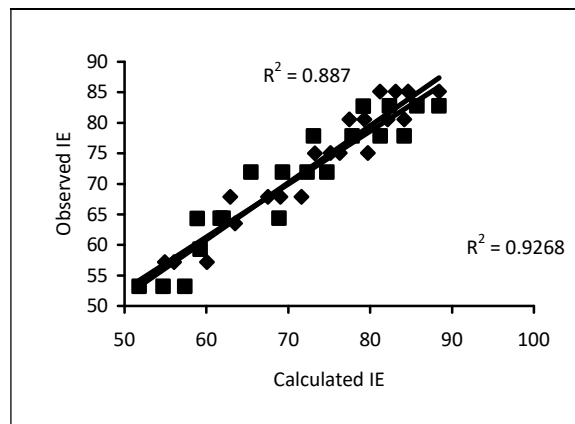


Figure 6f: Log-linear with interaction model

Table 1 presents statistical evaluation of the models

| | | Information Criterion of Akaike (AIC) | Schwartz Criterion (SC) | Model of Selection Criterion (MSC) | CD | |
|----------------------|---------------------|---------------------------------------|-------------------------|------------------------------------|-------|-----------|
| Linear equation | without interaction | 91.9 | 94.9 | 2.9 | 0.961 | Air dried |
| | | 70.7 | 73.7 | 4.2 | 0.989 | Sun Dried |
| | with interaction | 91.4 | 94.4 | 3.0 | 0.962 | Air dried |
| | | 69.3 | 72.3 | 4.3 | 0.990 | Sun Dried |
| Non- Linear equation | without interaction | 67.9 | 70.8 | 4.1 | 0.988 | Air dried |
| | | 89.2 | 92.2 | 3.3 | 0.973 | Sun Dried |
| | with interaction | 68.1 | 71.1 | 4.1 | 0.988 | Air dried |
| | | 88.4 | 91.4 | 3.3 | 0.974 | Sun Dried |
| Log-Linear equation | without interaction | 108.6 | 111.6 | 2.1 | 0.910 | Air dried |
| | | 120.4 | 123.4 | 1.7 | 0.872 | Sun Dried |
| | with interaction | 104.6 | 107.6 | 2.3 | 0.927 | Air dried |
| | | 117.9 | 120.9 | 1.9 | 0.887 | Sun Dried |

IV. CONCLUSION

The alcoholic extracts of the sun-dried and air-dried leaves *Acalypha wilkesiana* extracts revealed that the inhibition efficiency increases with increasing extracts concentration to 88.89 % and 80.51 % at 333K of 1.0 g/l of extracts for the air and sun-dried extracts, respectively. The inhibition efficiency also increases with increasing temperature of the reaction system suggesting a chemical adsorption mechanism. The best models for sun and air dried extracts were $IE = -31.71 + 7.07X_1 + 0.25X_2 + 0.09X_1X_2$ and $IE = 0.21X_1^{0.23}X_2^{1.04}$ with MSC (4.3 and 4.1), AIC (69.3 and 67.9) and SC (72.3 and 70.8) and CD (0.990 and 0.988), respectively. It can be concluded that the extracts under study can serve as effective green corrosion inhibitors for mild steel in acidic media.

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