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Inhibitory Effect of Moringa Oleifera Seed Extract on The Corrosion of Mild Steel In 1m H_2so_4

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ABSTRACT

Mild steel which is a very important metal in the manufacturing industry is highly vulnerable to corrosion which has resulted in huge economic losses. This has led to research on the discovery of diverse means of mitigating or completely eliminating this phenomenal occurrence. Among the various means discovered, the use of organic (green) inhibitors is popular. In this study, the inhibitive and adsorption properties of the seed extract of *Moringa oleifera* in the corrosion of mild steel in 1M H_2SO_4 was investigated using weight loss method of monitoring corrosion. Ethanol was used to extract the *Moringa oleifera* seed by crushing the seed and soaking it in ethanol for 48hrs after which the ethanol was evaporated to obtain a pure concentrate. 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0g of the concentrate was added to 300ml of 1M H_2SO_4 as inhibitor. Inhibition efficiency of 83% for an exposure time of 12hours was obtained at 25^{o}C. Thermodynamic considerations indicate that the adsorption of the extract is exothermic and spontaneous. Also, the adsorption characteristic of the inhibitor is consistent with the assumptions of the Langmuir adsorption isotherm. From the result and findings of this study, ethanol extract of *Moringa oleifera* is a good inhibitor for the corrosion of mild steel in H_2SO_4, and a physical adsorption mechanism is proposed for the adsorption of the ethanol extract of *Moringa oleifera* on mild steel surface.

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INTRODUCTION

Inhibitors are frequently used for controlling corrosion of metals and alloys in acidic media for removing scales and rusts in metal finishing industries, cleaning of boilers and heat exchangers. Use of inhibitors is one of the most practical methods for protection against corrosion especially in acid solutions to prevent unexpected metal dissolution and acid consumption (Eyu *et al*., 2013; Ismail *et al*., 2011; Abdulrahman *et al*., 2011a; Abdulrahman and Ismail, 2011a,b). The known hazardous effect of most synthetic corrosion inhibitors have motivated scientists to use naturally occurring products as corrosion inhibitors as they are inexpensive, readily available and renewable sources of materials, environmentally friendly and ecologically acceptable (Asipita *et al*., 2014; Abdel-Gaber *et al*., 2009; Abdulrahman and Ismail, 2014).

Abdulrahman *et al*., (2011b) studied the inhibitive properties of solid waste (Genus Musa, Genus Saccharum and Citrullus Lanatus) on the corrosion of mild steel strip in 1M HCl using weight loss technique and recorded inhibition efficiencies of 69.60%, 68.41% and 58.15% for 72 hours exposure time for Genus Musa, Genus Saccharum and Citrullus Lanatus respectively. The inhibition efficiency was found to increase with increasing inhibition concentration and the adsorption of the inhibitor molecules were consistent with the Langmuir adsorption isotherm.

Eddy, (2009) studied the effect of ethanol extract of Phyllanthus amarus for the corrosion of mild steel in H_2SO_4 using gravimetric, thermometric and gasometric methods and found out that the extract of the Phyllanthus amarus leaves was a good adsorption inhibitor and that thermodynamic considerations showed that the adsorption of the extract was exothermic and spontaneous and was consistent with the assumptions of the Langmuir adsorption isotherm.

Singh *et al*., (2010) studied inhibition of the corrosion of mild steel by the fruit extracts of Moringa oleifera, Piper longum and Citrus aurantium using weight loss, electrochemical impedance spectroscopy, potentiodynamic polarization and linear polarization techniques of monitoring corrosion. Inhibition efficiency of the extracts was

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found to vary with acid concentration, temperature and period of immersion. Adsorption of the extract on mild steel surface obeyed the Langmuir adsorption isotherm and the values of the inhibition efficiency calculated from the various techniques were in good agreement.

Several researchers had worked on performance of green inhibitors against corrosion of metals, among which are: (Ajani *et al*., 2014; Abdulrahman and Ismail, 2014a,b; Abdulrahman, 2014; Abdulrahman, 2012a,b), but moringa oleifera seed extract has not been used.

Consequently, in continuation of the development of green corrosion inhibitors, this present study focuses on the use of the extract of Moringa oleifera seeds on the corrosion of mild steel in acidic media, using weight loss method of monitoring corrosion.

MATERIALS AND METHODS

Methodology:

The experiment is carried out using the extract of moringa oleifera seed to inhibit the corrosion of mild steel in sulphuric acid (H_2SO_4). The weight loss due to the corrosion of mild steel in sulphuric acid in the absence of the inhibitor (w_0) and the weight loss in the presence of the inhibitor (w_1) under different concentrations and temperatures were obtained to compute the corrosion rate and the inhibition efficiency.

Mild Steel Preparation:

The mild steel strip used for this study was mechanically cut to form different samples each of dimension 4 × 2.4 × 0.2cm and holes of 0.4cm diameter were drilled on each sample so as to facilitate easy suspension of the steel samples in the corroding media using a thread. The surfaces of each of the samples were then polished using emery paper and degreased by washing with ethanol. The washed samples are then rinsed with acetone, removed and allowed to dry in air before use. All reagents used for the study are analytical grade and distilled water was used for their preparation.

Preparation of the seed extract:

Moringa oleifera seeds obtained by drying completely under a shade were peeled to remove the outer shell. The whitish seeds obtained were then pulverised using a mortar and pestle and soaked in a solution of ethanol for 48 hours in accordance with method used by Abdulrahman (2012). After 48 hours, the solution was filtered using a filter paper. The filtrate so obtained was then subjected to evaporation (in order to leave the filtrate free of the ethanol) using a rotary evaporator set at 75^{o}C. The stock solution of the extract so obtained were used in preparing different concentrations of the test solution by dissolving 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0g of the extract in a 300ml solution of 1M H_2SO_4 acid for use in weight loss analysis.

Weight Loss Method:

The mild steel samples were first weighed to determine their initial weights using a digital weighing balance and were labelled and recorded accordingly. Threads were then tied via the drilled holes on each sample and labelled. With time being noted, three samples were dipped into each of the beakers containing the different concentrations of the test solutions at 25, 50 and 75^{o}C with and without the presence of aqueous moringa oleifera seed extract. The temperature was controlled using a water bath. The samples were removed after 4, 8 and 12hrs respectively, rinsed with acetone and dried in air. Weight loss was determined by gravimetric tests (taken as the difference in the weight of the mild steel strip samples before and after immersion in different test solutions) using a digital weighing balance.

The inhibition efficiency (%I), the corrosion rate (ρ) (g/cm^{2}h) in the absence and presence of inhibitors and degree of surface coverage (θ) were obtained using the following equations;

$$\%I = \frac{Wo - W}{Wo} \times 100 \quad (1)$$

$$\rho = \frac{\Delta W}{At} \quad (2)$$

$$\theta = \frac{\%I}{100} \quad (3)$$

Where ΔW is the weight loss of the metal (in grams), w_o is the weight loss of the metal in the absence of inhibitor, w is the weight loss in the presence of inhibitor, A is the area of the specimen (in cm$^{2)}$, and t is the period of immersion (in hours).

RESULT AND DISCUSSIONS

From Figure 1, it can be seen that the weight loss of the mild steel samples at 25^{o}C was constant for the varying concentrations of the extract at 4hrs of exposure, hence increasing the concentration of the extract will be unnecessary. Figure 2 shows that the weight loss of the mild steel sample at 50^{o}C increased with decreasing concentration of the extract. With increasing exposure time, there is a corresponding increase in the weight loss of the mild steel sample. From Figure 3, it can be seen that at 75^{o}C, weight loss increased with increasing concentration of the inhibitor and the progression is almost consistent with the passage of time.

From Figure 4, all the concentrations of the extract experienced corrosion at almost the same rate at 4hrs of exposure time. This is to say that at room temperature, irrespective of the concentration of the extract the mild steel experienced the same rate of corrosion. From Figure 5, it can be observed that at 50^{o}C, there was a decrease in the corrosion rate with increasing concentration of the extract. From Figure

6, it can be observed that at 75°C, there was an increase in corrosion rate with increasing concentration of the inhibitor, but this rate happen to reduce with the passage of time. This is due to the fact that as the reaction proceeds, there was a loss in the concentration of hydrogen ions in the acidic test solution thereby resulting in enrichment of the extract in the test solution, thereby promoting inhibition. For the test solution without inhibition, we do experience a continual rise in the corrosion rate.

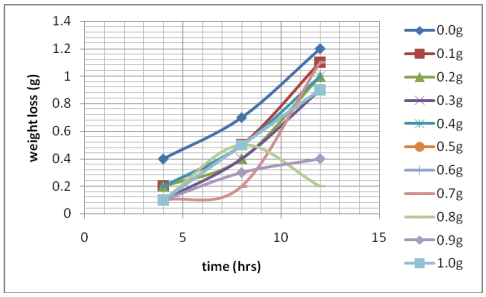

Fig. 1: Variation of weight loss with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 25°C.

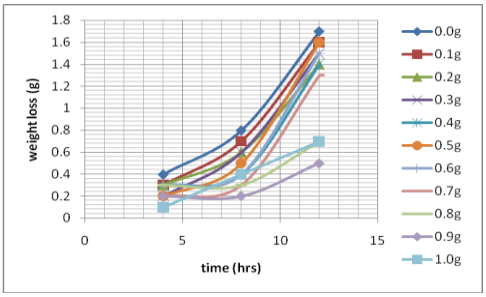

Fig. 2: Variation of weight loss with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 50°C.

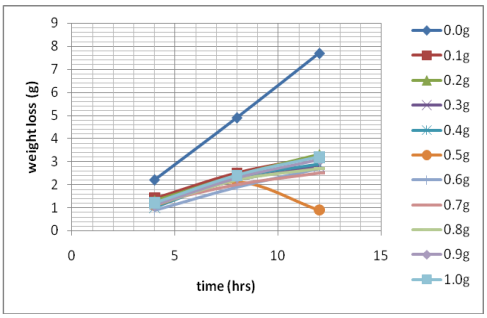

Fig. 3: Variation of weight loss with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 75°C.

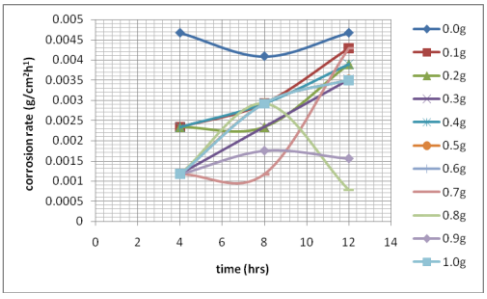

Fig. 4: Variation of corrosion rate with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 25°C.

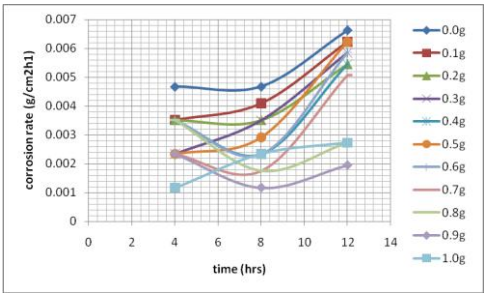

Fig. 5: Variation of corrosion rate with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 50^{o}C.

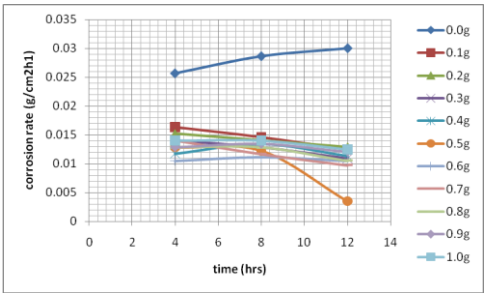

Fig. 6: Variation of corrosion rate with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 75^{o}C.

From Figure 7, the various concentrations of the extract at 25^{o}C exhibited the same efficiency at 4hrs of exposure time. There was decline in inhibition efficiency with prolonged exposure time. Both 1.0 and 0.6g concentration exhibited the same inhibitive property throughout. 0.8g showed excellent inhibitory efficiency with passage of time. Figure 8 shows that the inhibition efficiency of the extract at 50^{o}C increased with increasing concentration at 4hrs of exposure time and all concentrations continued to rise consistently except for the 1.0g concentration. After 8hrs, inhibition efficiency began to fall for all the concentrations except for the 1.0g concentration that increased. Although after 12hrs, 0.3g still exhibited the best inhibitory properties even though it was decreasing. From Figure 9, it can be observed that the inhibition efficiency of the extract at 75^{o}C decreased with increasing concentration and increased with time. 0.6g exhibited the best inhibition at 4hrs and 8hrs of exposure time and 0.5g excelled at 12hrs exposure time.

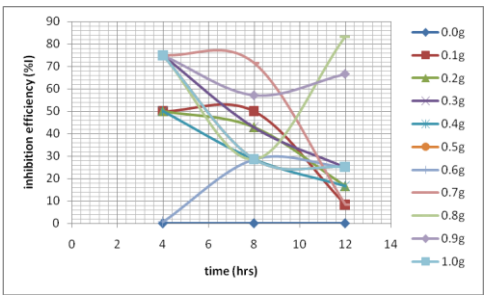

Fig. 7: Variation of inhibition efficiency with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 25^{o}C.

Adsorption Considerations:

The adsorption characteristics of ethanol extract of Moringa oleifera was investigated by fitting data obtained for the degree of surface coverage into the Langmuir adsorption isotherm as shown in Figure 10. The test indicated that Langmuir adsorption isotherm well describes the adsorption behaviour of ethanol extract of Moringa oleifera. The assumptions of Langmuir adsorption isotherm can be expressed as follows (Abdulrahman 2012):

$$\frac{C}{\theta} = \frac{1}{k} + C \qquad \text{(i)}$$

Where:

C is the concentration of the inhibitor

θ is degree of surface coverage of the inhibitor, and

K is the adsorption equilibrium constant.

Taking logarithm of equation (i) yields:

Log (C/θ) = log C – log K

The slope of the above graph is 0.9708 which is equal to the value of the adsorption equilibrium constant was used to calculate the free energy of adsorption of the Moringa oleifera seed extract on mild steel surface using equation (iii) below:

ΔG_{ads} = -2.303 RTlog (18.4K)

Where: ΔG_{ads} is the Free energy of adsorption, R is the gas constant, T is the temperature in Kelvin, 18.4 is the Molar concentration of the acid in the solution and K is the Langmuir isotherm slope.

The calculated value for ΔG_{ads} was -8.373KJ/mol for adsorption at 348K (75^{o}C). This value is negative and less than the threshold value of -40KJ/mol required for chemical adsorption, negative sign indicates that the adsorption of the plant constituents on to the metal surface is a spontaneous process hence the action of the Moringa oleifera seed extract on mild steel surface is spontaneous and is consistent with the mechanism of physical adsorption which collaborate with FTIR and GCMS results in Figures 11 and 12. (ii)

Effect of Temperature:

The effect of temperature on the corrosion of mild steel in the absence and presence of ethanol extract of Moringa oleifera was studied using the Arhenius equation as follows:

$$\log \frac{CR_2}{CR_1} = \frac{E_a}{2.303R}\left(\frac{1}{T1} - \frac{1}{T2}\right) \quad \text{(iv)}$$

Where; CR_1 and CR_2 are the corrosion rates after 12 hours of mild steel exposure at temperatures T_1 and T_2 respectively, E_a is the activation energy and R is the gas constant. Values of E_a calculated for different concentrations of the extract ranged from 63.43 to 78.19KJ/mol. These values are less than the threshold value of 80KJ/mol required for chemical adsorption; hence the adsorption of Moringa oleifera seed extract on mild steel supports the mechanism of physical adsorption. (iii)

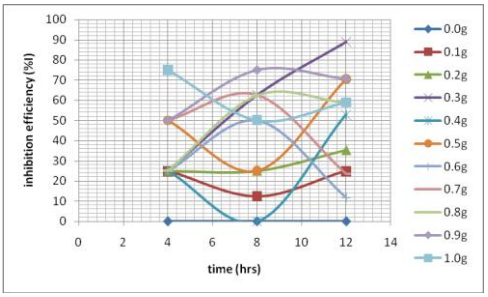

Fig. 8: Variation of inhibition efficiency with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 50^{o}C.

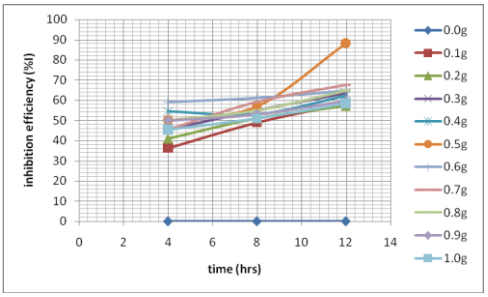

Fig. 9: Variation of inhibition efficiency with time for the corrosion of mild steel in H_2SO_4 containing various concentrations of Moringa oleifera seed extract at 75^{o}C.

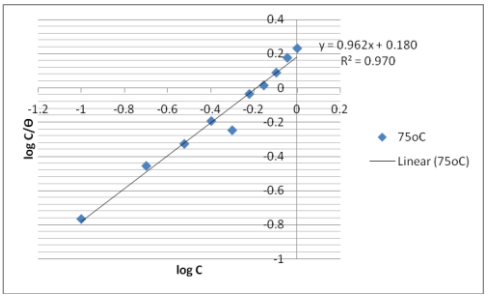

Fig. 10: Langmuir isotherms for the adsorption of Moringa oleifera seed extract on the surface of mild steel.

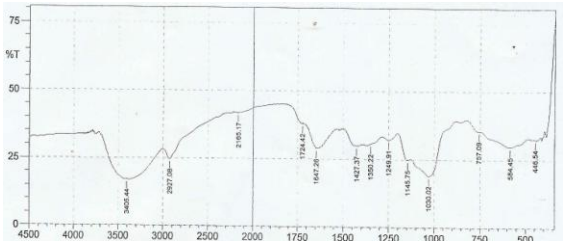

Fig. 11: Infra Ray analysis results of *Moringa oleifera* extract.

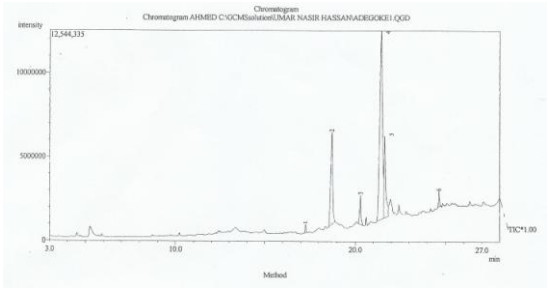

Fig. 12: GCMS Analysis Result.

Conclusion:

Ethanol extract of Moringa oleifera seed is a good inhibitor for the corrosion of mild steel in H_2SO_4. The inhibition efficiency increased with increasing concentration of the extract. The adsorption of the inhibitor on mild steel surface obeyed the Langmuir absorption isotherm, being spontaneous and consistent with the mechanism of physical adsorption. Hence this work advocates to the use of Moringa oleifera extract as a corrosion inhibitor for mild steel in acidic media.

REFERENCES

Abdulrahman, A.S. and Mohammad Ismail, 2014a. Electrochemical assessment of concrete ternary inhibitors used in retarding corrosion of steel reinforcement. ARPN Journal of Engineering and Applied Sciences, 9(5): 750-756.

Abdulrahman, A.S. and M. Ismail, 2014b. Assessment of green inhibitor on the crystal structures of carbonated concrete. Jurnal Teknologi , 69(3): 1-9.

Abdulrahman, A.S., 2013. The effect of green inhibitor on strength and water permeability of concrete. Nigerian Journal of Technological Research, 8: 41-44.

Abdulrahman, A.S., 2012. Performance of bambusa arundinacea as green inhibitor for corrosion of steel reinforcement in concrete. PhD Thesis, Faculty of Civil Engineering, Universiti Teknologi Malaysia.

Abdulrahman, A.S. and M. Ismail, 2012. Evaluation of corrosion inhibiting admixtures for steel reinforcement in concrete. International Journal of the Physical Sciences, 7(1): 139-143 DOI: 10.5897/IJPS11.966

Abdulrahman, A.S., M. Ismail, M.S. Hussain, 2011a. Inhibition of Corrosion of Mild Steel in Hydrochloric Acid by Bambusa Arundinacea. International Review of Mechanical Engineering, 5(1): 59-63.

Abdulrahman, A.S., M. Ismail, M.S. Hussain, 2011b. Corrosion inhibitors for steel reinforcement in Concrete- A Review. Scientific Research and Essays, 6(16).

Abdulrahman A.S., M. Ismail, M.S. Hussain, 2011c. Inhibiting Sulphate Attack in Concrete by Hydrophobic Green Plant Extract, Advanced Materials Research Vols, 250-253: 3837-3843.

Abdulrahman, A.S. and Mohammad Ismail, 2011a. Eco-friendly green inhibitor to improve the strength of concrete contaminated by chloride and sulphate. International Journal of Research and Reviews in Applied Sciences, 9(3): 355-360.

Abdulrahman, A.S. and M. Ismail, 2011b. Green plant Extract as a passivation-promoting Inhibitor for Reinforced concrete. International Journal of Engineering Science and Technology (IJEST), 3(8): 6484-6490.

Ajani, K.C., A.S. Abdulrahman and E. Mudiare, 2014. Inhibitory action of Aqueous *Citrus aurantifolia* seed extract on the corrosion of mild Steel in H_2SO_4 solution. World Applied Sciences Journal, 13(2): 2141-2147.

Asipita,*S.A.*, Mohammad Ismail, Muhd Zaimi Abd Majid, Zaiton Abdul Majid, CheSobry Abdullah, Jahangir Mirza, 2014. Green *Bambusa Arundinacea* leaves extract as a sustainable corrosion inhibitor in steel reinforced concrete. Journal of Cleaner Production, 67: 139-146.

Eddy, N.O., 2009. Ethanol extract of Phyllanthus Amarus as a green inhibitor for the

corrosion of mild steel in H_2SO_4. Portugaliae Electrochimica Acta, 27(5): 579-589.

Eyu Debi Gaius, Esah Hamzah, Mohammad Ismail, Asipita Salawu Abdulrahman, Aminu Mohammad, 2013. Effect of Vernonia Amygdalina Extract on Corrosion Inhibition of Mild Steel in Simulated Seawater. Australian Journal of Basic and Applied Sciences. 7(14): 257-263.

Ismail, M., A.S. Abdulrahman, M.S. Hussain, 2011. Solid waste as environmental benign corrosion inhibitors in acid medium. International Journal of Engineering Science and Technology (IJEST), 3(2): 1742-1748.

Singh Ambrish, Ahamad I. Singh, Vinod Kumar, M.A. Quraishi, 2010. Effect of fruit extracts of some environmentally benign green corrosion Inhibitors on corrosion of mild steel in hydrochloric acid solution Journal of Material Environmental Science, 1(3): 162-174.