International Journal of Applied Chemical Sciences Research
Vol. 2, No. 1, March 2014, PP: 1 -10, ISSN: 2328 - 2827 (Online)
Available online at http://ijacsr.com/

Research article

CORROSION INHIBITION OF ALUMINIUM IN 2M SULPHURIC ACID USING ACETONE EXTRACT OF RED ONION SKIN.

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ABSTRACT

This work presents the results of corrosion inhibition of aluminium 3SR alloy in 2M sulphuric acid solution by acetone extract of red onion skin. Hydrogen gas evolution and weight loss techniques were used to determine the amount of aluminium dissolved from the alloy in the aggressive solution were and. The experiments were carried out at the temperatures of 30^{o}C, 40^{o}C & 50^{o}C. Inhibition was found to increase with increasing inhibitor concentration and decreasing temperature. The inhibition is attributed to the adsorption of red onion skin extract on the surface of the aluminium coupon and conforms to Langmuir adsorption isotherm. The results from the hydrogen evolution and weight loss techniques confirmed that acetone extract of red onion is effective in reducing the corrosion of aluminium in sulphuric acid medium. The active component in red onion skin is quercetin**.**

Key words: Acetone extract; Red onion skin; Corrosion; Inhibition; aluminium; adsorption; Langmuir; sulphuric acid.

1.0 INTRODUCTION

When metals are exposed to aggressive environments, such as, the use of acid solutions for pickling, chemical and electrochemical etching of metal, industrial acid cleaning, cleaning of oil refinery equipment, oil well acidizing and acid descaling, they usually lead to loss of the metal due to corrosion (Ating et.al, 2010). The problem of metallic corrosion has attained significant concerns. It has been estimated that approximately 5% of an industrialized nations income is spent on corrosion prevention, maintenance and replacement of products lost or contaminated as a result of corrosion reactions. Therefore corrosion poses one of the biggest problems to the economy of a nation (Abiola, 2002). Since corrosion is always a function of the acidic medium and the environmental conditions, control should be concentrated on preventing contact of the surroundings with the metals. This led to the use of corrosion inhibitors in the control metal corrosion (Vastag et.al., 2001).

Corrosion inhibition is a surface process which involves the adsorption of the inhibitor on the metal surface (Abiola and Oforka, 2002). Naturally occurring substances have continued to receive attention as inhibitors of acid cleaning processes and a replacement of the synthetic organic inhibitors which are sometimes toxic to the environment (Umoren et al., 2008 and Okafor.et.al., 2007). The growing interest on naturally occurring substances as inhibitors is attributed to the fact that they are cheap, readily available, renewable and ecologically friendly (Abiola et.al., 2004).

A thorough review of the literature revealed that plant materials such as Aloe plant extract (Al-Turkustani et.al., 2010), *sansaviera infasciata* extract (Oguzie, 2007), ethanol extract of Garcinia kola (Okafor et. al., 2007), natural occurring exudates gums (Umoren et.al., 2006), exudates gum from *pachylobus edulis* in the presence of halide ions, (Umoren et.al., 2008), to mention but few, have been used to inhibit the corrosion of aluminium in acid media in recent years.

Acetone extract of red onion skin has also been used to inhibit the corrosion of mild steel in hydrochloric acid and sulphuric acid solutions (James and Akaranta, 2009a), zinc (James and Akaranta, 2009b), and aluminium (James and Akaranta, 2009c) in 2M hydrochloric acid solution.

The objective of the present investigation is to assess the inhibiting effects of acetone extract of red onion skin on aluminium in 2M sulphuric acid solution using gasometric and gravimetric (weight loss) techniques.

EXPERIMENTAL

Material Preparation

Aluminium (3SR) sheets used in the present work were supplied by First Aluminium Plc, Port Harcourt, Nigeria. Chemical composition – (Si: 0.20960, Cu: 0.003443, Mn: 0.10245, Mg: 0.01191, Zn: 0.01520, Cr: 0.00780, Ni: 0.00292, V: 0.00422, Pb: 0.02521, Al: 98.7577) %. Every sheet was 0.53 mm in thickness and 98.76% in purity. The aluminium sheets were cut into 5 cm by 2 cm for weight loss determination and a hole of 2 mm were drilled on the centre of one end of all the coupons for suspension inside the corrodent solution. The coupons were used as supplied without further polishing but were degreased in absolute ethanol and dried in acetone.

Prior to the experimental work, these already prepared coupons were stored in moisture free desiccators to prevent contamination.

Reagents of Analar grade were used and doubly distilled water was used for the preparation of all solutions. The inhibitor used was acetone extract of red onion skin. The skin of red onion bulb was obtained locally from Choba market, Port-Harcourt. The red onion skin was boiled with 50ml acetone and 50ml water mixture. The resulting red solution was evaporated to dryness; the powder obtained was then scrapped out and stored in a sample bottle. Six different concentrations (0.01g/dm^3, 0.02g/dm^3, 0.03g/dm^3, 0.04g/dm^3, 0.05g/dm^3 and 0.10g/dm^3) of the extract were prepared with 2M sulphuric acid solution and used for all measurement. Weight loss and hydrogen gas evolution corrosion test methods were used for the study.

Weight Loss Determination

The already prepared different concentrations (0.01g/dm^3, 0.02g/dm^3, 0.03g/dm^3, 0.04g/dm^3, 0.05g/dm^3 and 0.10g/dm^3) of the extract were placed into six out of seven separate beakers maintained at 303, 313 and 323K. The seventh beaker contained only 2.0 M sulphuric acid solution (without any extract) and used for the blank (control) experiment. Previously weighed coupons were then placed in the test solutions. Each coupon was retrieved from the test solutions at 30 min intervals progressively for 210 min for the experiments at 303, 313 and 323 K. The difference in weight of the coupons was again taken as the weight loss and recorded.

The inhibitory efficiencies (%E) were calculated from the equation below:

$$\%\,\mathrm{E} = \frac{\Delta W_B - \Delta W_i}{\Delta W_B} \quad x \ \frac{100}{1} \ \ldots\ldots\ldots (1)$$

Where ΔW_B and ΔW_i are the weight loss data of the metal coupons in the absence and presence of the inhibitor respectively [James and Akaranta, 2009b].

Gasometric Technique

The corrosion rates of aluminium were investigated by the hydrogen evolution technique in 2M H_2SO_4 with and without the acetone extract of red onion skin. Variation in the volume of hydrogen evolved with time was recorded every 1 minute for 30 minutes. Aluminium coupons of dimension 1.0 cm by 0.5 cm were used. Each experiment was conducted on a fresh specimen of aluminium. The hydrogen evolved is a function of the corrosion reaction and it displaces the fluid in the gasometric setup, which is read directly. Experiments performed without inhibitors recorded the highest volume of hydrogen gas evolved.

3.0 RESULTS AND DISCUSSIONS

INHIBITORY EFFECT OF THE EXTRACT

The figures below (1, 2 & 3) show that acetone extract of red onion skin effectively reduced the corrosion of aluminium in sulphuric acid solution because there was a general decrease in weight loss at the end of the corrosion-monitoring process at the temperatures studied 30^{o}C, 40^{o}C and 50^{o}C. The weight loss of the aluminium coupon also decreases with increase in the concentration of the extract as seen in the figures.

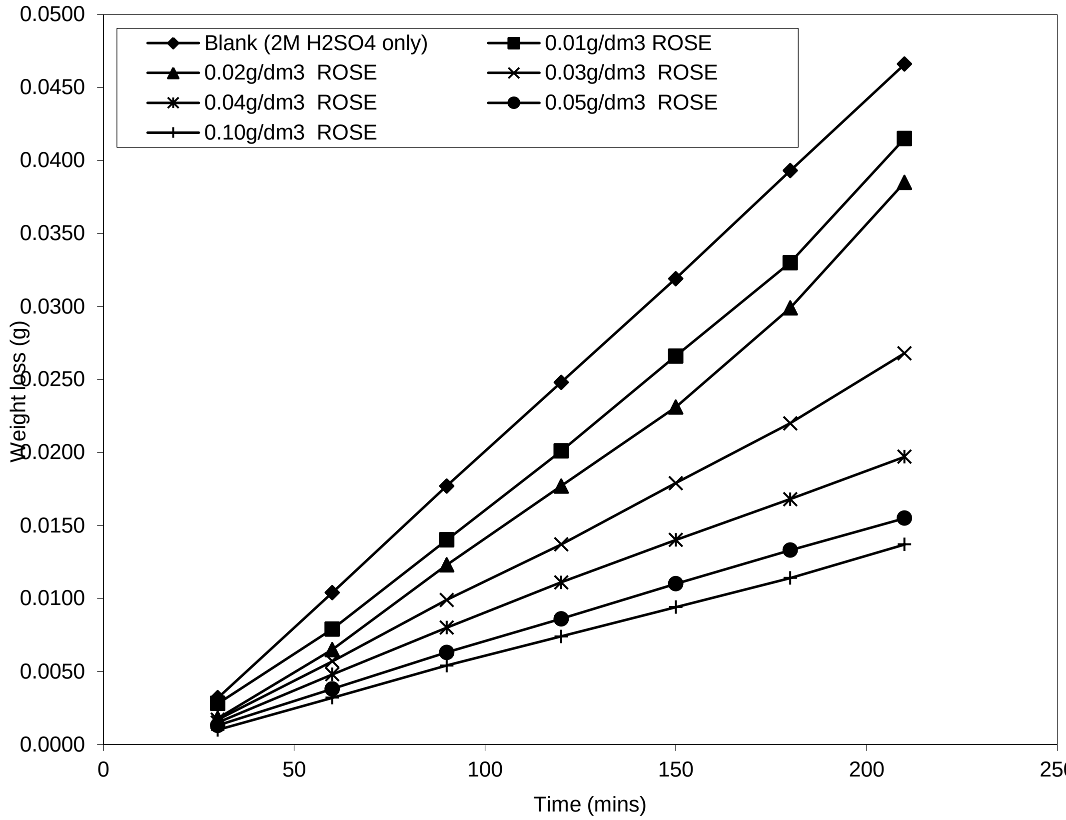

Figure 1: Variation of Weight Loss with Time for aluminium coupons in 2.0M H_2SO_4 Solution Containing Different Concentrations of acetone extract of red onion skin at 303K.

From the variation of weight loss with time of exposure of aluminium in 2M sulphuric acid (blank) at 303K (fig. 1) compared with those containing the extract, there is a remarkable decrease in weight loss signifying corrosion inhibition. Also at 303K, the weight loss of the aluminium coupons decreased considerably with increased concentration of Red Onion Skin extract over time. This graph (figure 1) demonstrates the effectiveness of red onion skin extract as a corrosion inhibitor of aluminium at 303K.

At 313K, the weight loss of aluminium coupons still decreased in the presence of the extract. As the concentration of the acetone extract of red onion skin increases from 0.01g/dm^3 -0.10g/dm^3, the weight losses of the aluminium coupons reduce as shown by fig. 2. This portrays that acetone extract of red onion skin is still effective in inhibiting the corrosion of aluminium at 313K.

The weight loss of the aluminium coupons still reduced with increasing acetone extract of red onion skin concentration as seen in fig. 3. This depicts that, even at 323K, acetone extract of red onion skin inhibits the corrosion of aluminium in sulphuric acid solution.

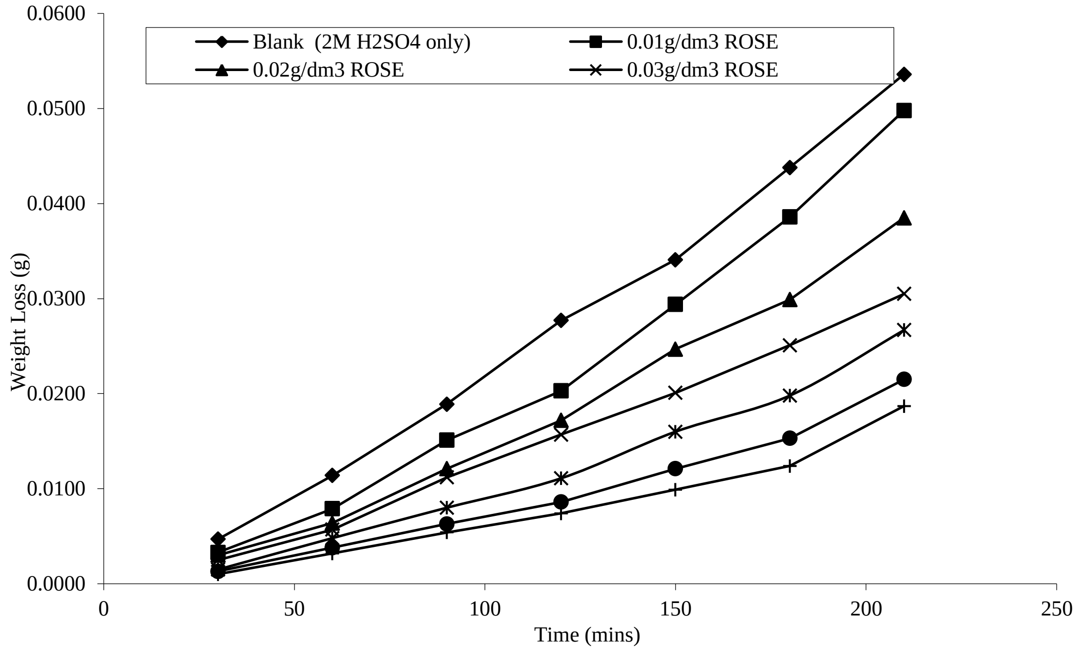

Figure 2: Variation of Weight Loss with Time for aluminium coupons in 2.0M H_2SO_4 Solution Containing Different Concentrations of acetone extract of red onion skin at 313K.

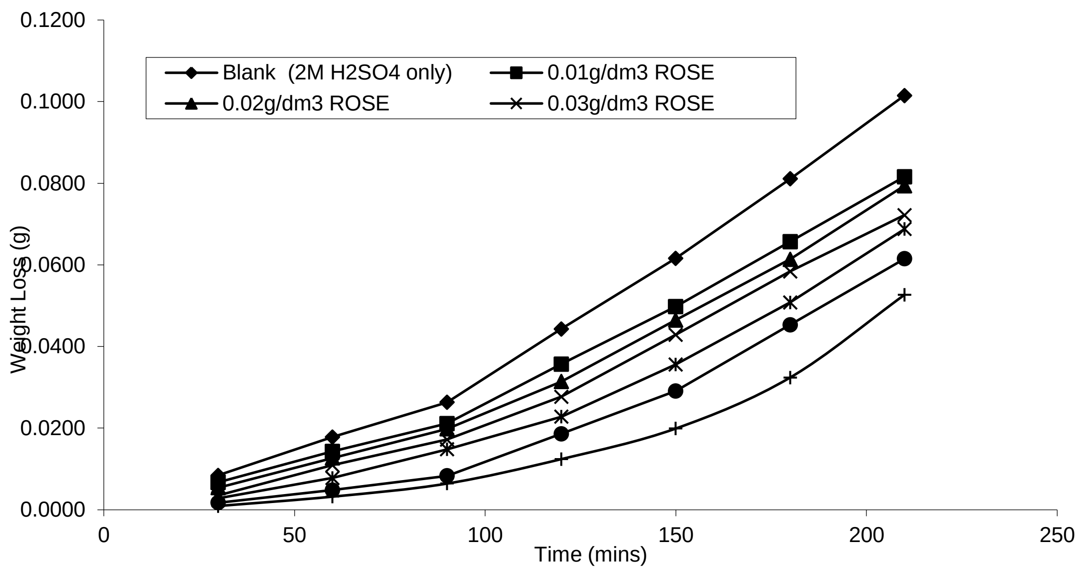

Figure 3: Variation of Weight Loss with Time for aluminium coupons in 2.0M H_2SO_4 Solution Containing Different Concentrations of acetone extract of red onion skin at 323K.

HYDROGEN GAS EVOLUTION RESULTS

The general decrease in hydrogen gas evolution with time as concentration of extract increased from 0.01g/dm^3 to 0.10g/dm^3 (Figure 4) compared with the uninhibited (2M H_2SO_4) confirm that acetone extract of red onion skin is indeed a corrosion inhibitor of aluminium in sulphuric acid and also that the inhibition efficiency of the extract increases with its concentration.

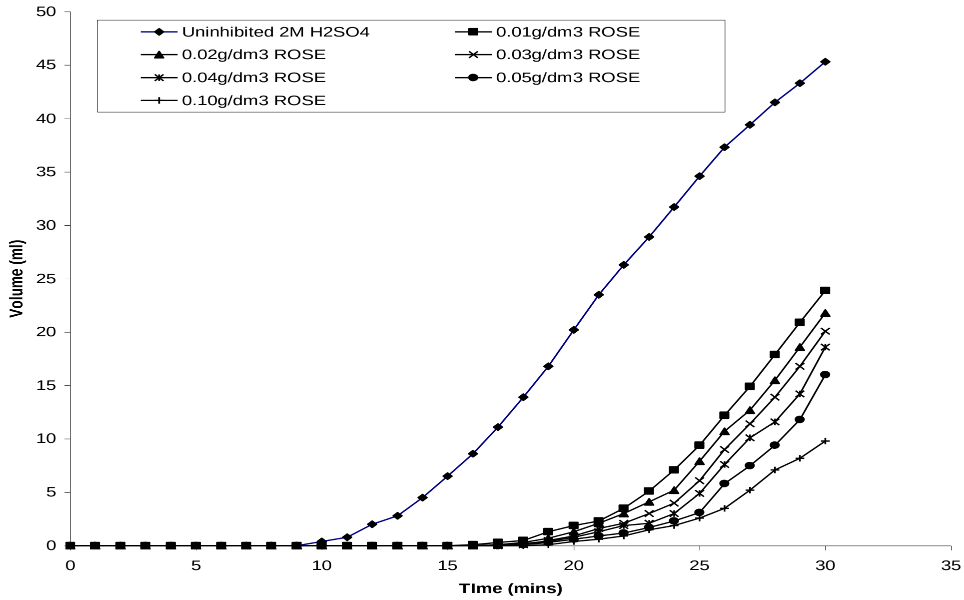

Figure 4: Variation of Inhibition Efficiency with Inhibitor Concentration for aluminium coupons in 2.0M H_2SO_4 solution containing acetone extract of red onion skin at Three Different Temperatures.

EFFECT OF TEMPERATURE ON THE INHIBTION EFFICIENCY

Fig. 5 shows that inhibition efficiency of acetone extract of red onion skin decreases with increasing temperature. This can also be seen in Table 1.

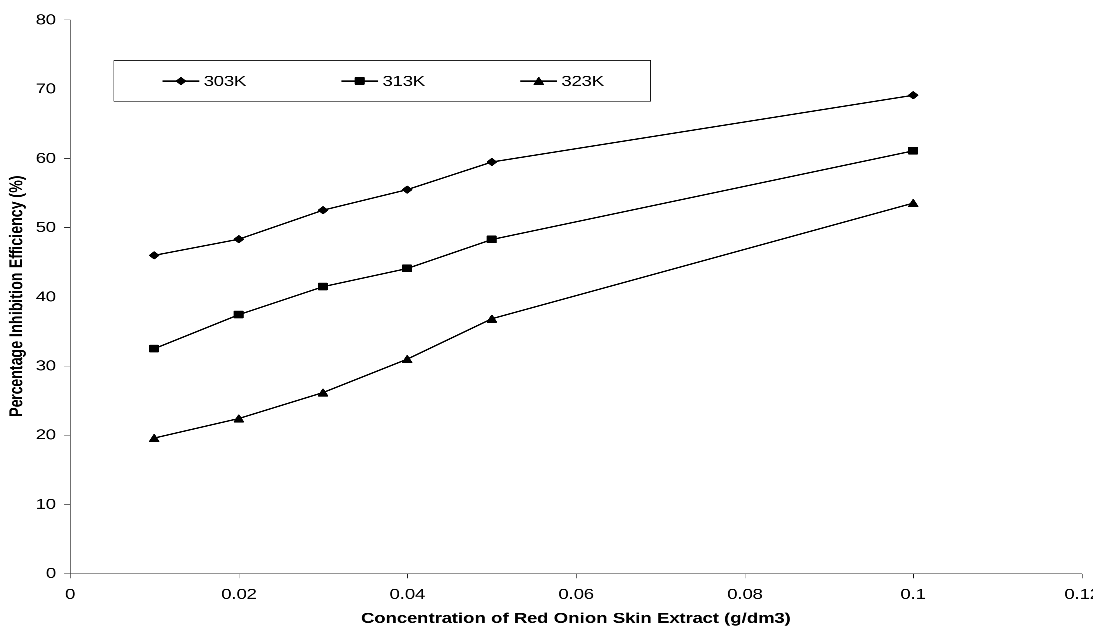

Figure 5: Variation of Inhibition Efficiency with Inhibitor Concentration for aluminium coupons in 2.0M H_2SO_4 solution containing acetone extract of red onion skin at Three Different Temperatures.

It is obvious from the graph that, as the reaction temperature is increased from 303K to 313K and to 323K, the inhibition efficiency increases. This is suggestive of a physical adsorption mechanism.

Table 1: The average percentage inhibition efficiency of different concentration of the Red Onion Skin Extract for the inhibition of aluminium corrosion in 2M H_2SO_4 at different temperature

THE ACETONE EXTRACT OR RED ONION SKIN (g/dm^3)	PERCENTAGE INHIBITION EFFICIENCY (%)		
	30^0C	40^0C	50^0C
0.05	66.92	59.32	55.65
0.10	78.12	68.79	64.70
0.15	81.02	73.77	66.84
0.20	94.94	80.36	73.96
0.25	95.02	87.09	76.03

EFFECT OF EXTRACT CONCENTRATION INHIBTION EFFICIENCY

It is also evident from Fig. 5 and Table 1 that inhibition efficiency of acetone extract of red onion skin increases as its concentration increases in the acid solution.

This is corroborated by figures 1, 2 and 3, where an increase in the concentration of the extract reduces the weight loss of the aluminium coupons.

ACTIVE COMPONENT OF THE EXTRACT

Quercetin is a component of the extract with conjugated system; has hydroxyl groups that have electron rich oxygen atoms which can serve as a good adsorption site onto the metal surface thereby inhibiting the corrosion of the aluminium.

It can therefore be deduced that the inhibitory action of red onion skin was due to the presence of Quercetin (fig. 6).

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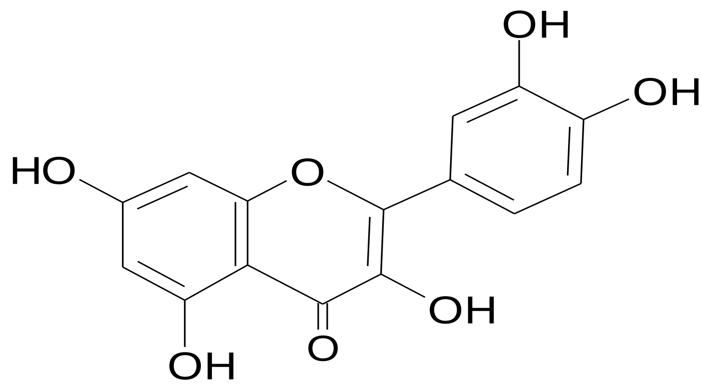

Figure 6: The structure of Quercetin (Red Onion Skin)

ADSORPTION CONSIDERATION

From the knowledge of the dependence of adsorption on temperature, it is clear that compounds which obey physical adsorption have plots of isotherms at the temperatures studied.

The interpretation of adsorbent type organic inhibitors performance data can however be enhanced by fitting the data from weight loss to the adsorption isotherms it obeys.

The Langmur Isotherm is given by

$$\frac{C}{\theta} = \frac{1}{d} + C \qquad \text{---} \quad (2)$$

Where C =Inhibitor concentration and

θ = Surface coverage

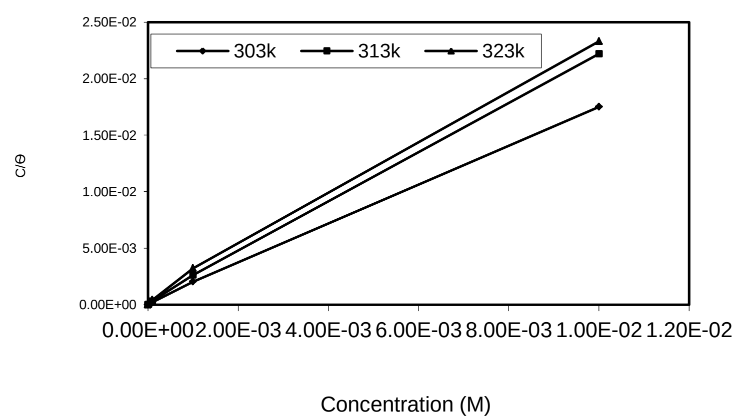

Figure 5: Langmuir adsorption isotherms plotted as C/Θ versus Concentration for inhibition of aluminium corrosion in 2M H_2SO_4 solution by acetone extract of red onion skin.

The plot of C/θ against C (M) that is linear (Fig. 5) shows that acetone extract of red onion skin obeys the Langmuir isotherm at the concentration and temperatures studied for the aluminium metal. The plots support 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 additives cover both the anodic and cathodic sites through uniform adsorption following Langmuir isotherm (Maayta 2002).

CONCLUSION

On the basis of this study, it can be concluded that the rate of corrosion of aluminium in sulphuric acid is a function of the concentration of the acetone extract of red onion skin. The inhibition of aluminium corrosion by this extract increased with increase in extract concentration and decreased temperature. The inhibition is due to physical adsorption of an active component in the extract onto the aluminium surface. The active component in the red onion skin extract responsible for the corrosion inhibition is Quercetin. The data obtained from this study fit well into the langmuir adsorption isotherm.

REFERENCES

[1] Ating E.I, Umoren S.A., Udousoro, L.I., Ebenso E.E. and Udoh, A.I. (2010); "Leaves extract of Ananas Sativum as green corrosion inhibitor for aluminium in hydrochloric acid solutions" Green Chemistry Letters and Reviews, 3 (2), 61-68.

[2] Abiola O.K. (2002); "Kinetic studies of corrosion inhibition of mild steel and aluminium by (4-Amino-2-5-Pyrimidinyl Methylthio) Acetic acid, 3-[4-amino-2-methyl-5-pyrimidyl methyl]-5-[2-hydroxylethyl]-4-methyl Thiazolium chloride hydrochloride and Thioglycolic acid in hydrochloric acid" Ph.D Thesis, University of Port-Harcourt, Port-Harcourt, Nigeria.

[3] Vastag, G.Y., SZOCS, E., Shaban, A and Kalman (2001); "New inhibitors for copper corrosion." IUPAC Pure and Applied Chemistry, 73 (12), 1861-1869.

[4] Abiola.O.K and Oforka.N.C. (2002).The corrosion inhibition of Azadirachta leaves extract on corrosion of mild steel in HCl solution. Material Chemistry and Physics, 70:241-268.

[5] Umoren S.A., Obot, I.B., Ebenso, E.E. (2008); Corrosion inhibition of aluminium using exudates gum from pachylobus edulis in the presence of halide ions. E-Journal of Chemistry 5: 355-364.

[6] Abiola, O.K., Oforka, N.C. and Ebenso, E.E. (2004); "A potential corrosion inhibition for acid corrosion of mild steel" Electrochemistry, 20 (9), 409-413.

[7] Al-Turkustani, A.M, Arab, S.T. and Aldahiri, R.H. (2010); "Aloe plant extract as an environmentally friendly inhibitor on the corrosion of aluminium in hydrochloric acid in absence and presence of iodide ions." Journal of Modern Applied Science, 4: 105-124.

[8] Oguzie, E.E. (2007); Corrosion inhibition of aluminium in acidic and alkaline media on sansaviera infasciata extract. Corrosion Science 49:1527-1539.

[9] Okafor P.C., Osabor V.I., Ebenso E.E. (2007); Eco friendly corrosion inhibitors: Inhibitive action of ethanol extract of Garcinia kola for the corrosion aluminium in acidic medium. Pigment and Resin Technology 36: 299-305.

[10] Umoren, S.A., Obot, I.B., Igwe, I.O., (2007).Synergetic inhibition between Poly vinyl pyrrolidone and iodide ions on corrosion of aluminium in HCl.The Open Corrosion Journal. 2:74-81.

[11] James A.O.* and Akaranta O., (2009). Studies on the corrosion inhibition properties of acetone extract of red onion skin on mild steel in hydrochloric and sulphuric acids solutions. Sciential Africana, 8 (1), 33-34.

[12] James A.O.* and Akaranta O., (2009). The inhibition of corrosion of zinc in 2.0M Hydrochloric acid solution with acetone extract of red onion skin. African Journal of Pure and Applied Chemistry, 3, (11), 212-217.

[13] James A.O.* and Akaranta O., (2009) Corrosion inhibition of aluminium in 2.0M hydrochloric acid solution by the acetone extract of red onion skin. African Journal of Pure and Applied Chemistry, 3, (11), 30-34.

[14] Maayta, A. K. (2002); "Organic Corrosion inhibitors for Aluminum in sodium hydroxide" Journal of Corrosion Science and Engineering 3, (4), 1 – 10.