African Journal of Pure and Applied Chemistry Vol. 3 (11), pp. 212-217, November, 2009
Available online at http://www.academicjournals.org/ajpac
ISSN 1996 - 0840

Full Length Research Paper

The inhibition of corrosion of zinc in 2.0 M hydrochloric acid solution with acetone extract of red onion skin

A. O. James* and O. Akaranta

Department of Pure and Industrial Chemistry, University of Port Harcourt, P. M. B. 5323, Port Harcourt, Nigeria.

Accepted 18 September, 2009

The inhibition of the corrosion of zinc by acetone extract of red onion skin in hydrochloric acid solutions has been studied using weight loss method. The results of the study reveal that different concentrations of the extract inhibit zinc corrosion. Inhibition efficiency of the extract is found to vary with concentration and temperature. The active component in red onion skin is Quercetin. Acetone extract of red onion skin could serve as an effective and non-toxic inhibitor of the corrosion of zinc in hydrochloric acid solution.

Key words: Corrosion inhibition, zinc, weight loss, red onion skin, hydrochloric acid.

INTRODUCTION

In an attempt to find corrosion inhibitors which are environmentally safe and readily available, there has been a growing trend in the use of natural products such as leaves or plant extracts as corrosion inhibitors for metals in acid cleaning process (Orubite and Oforka, 2004). A lot of works have been reported using economic plants such as *Vernonia Amydalina* (bitter leaf) extracts (Loto, 1998), *Nypa fruticans* Wurmb. leaf extracts (Orubite and Oforka, 2004), Zenthoxylum alatum plant (Chauhara and Gunasekara, 2006) and the juice of *Cocos nucifera* (Abiola et al., 2004) for the acid corrosion of mild steel.

In this study, the inhibitory action of *Aloe vera* on the corrosion of zinc in 2M hydrochloric acid solution has been investigated at three different temperatures (30, 40 and 50°C) using weight loss method.

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

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

Where; ΔW_B and ΔW_i are the weight loss data of the metal coupons in the absence and presence of the additives respectively (Orubite and Oforka, 2004).

EXPERIMENTAL

The weight loss corrosion test method was used for this study.

Material preparation

The zinc sheet of thickness 0.1 cm used for this study was purchased at Mile one steel market, Port-Harcourt. It was mechanically press-cut into 4 × 3 cm coupons. These coupons were used as supplied, without further polishing. However, surface treatment of the coupon involved degreasing in absolute ethanol and drying in acetone (Ita and Edem, 2000). The coupons were then stored in a moisture-free dessicator to avoid contamination before their use in the corrosion studies.

The inhibitor used was *Aloe vera* gel. The leaves of the *Aloe vera* plant were obtained from a garden and sliced open along their length. The gel was squeezed out of the leaves and sieved in order to obtain a clear, concentrated semi-liquid. No water was added. The semi-liquid was transferred into a clean glass bottle, and was labelled "*Aloe vera* gel". Six different concentrations (1, 2, 3, 4, 5 and 10%) of *Aloe vera* gel were prepared with the 2 M hydrochloric acid solution. The prepared *Aloe vera* - acid solutions were used for all measurements.

Weight loss measurements

Weight loss study using hydrochloric acid solution only

Fifteen 250 ml beakers, which separately contained 1.0, 2.0, 3.0,

*Corresponding author. E-mail: bidean2002@yahoo.com. Tel: 08057314332.

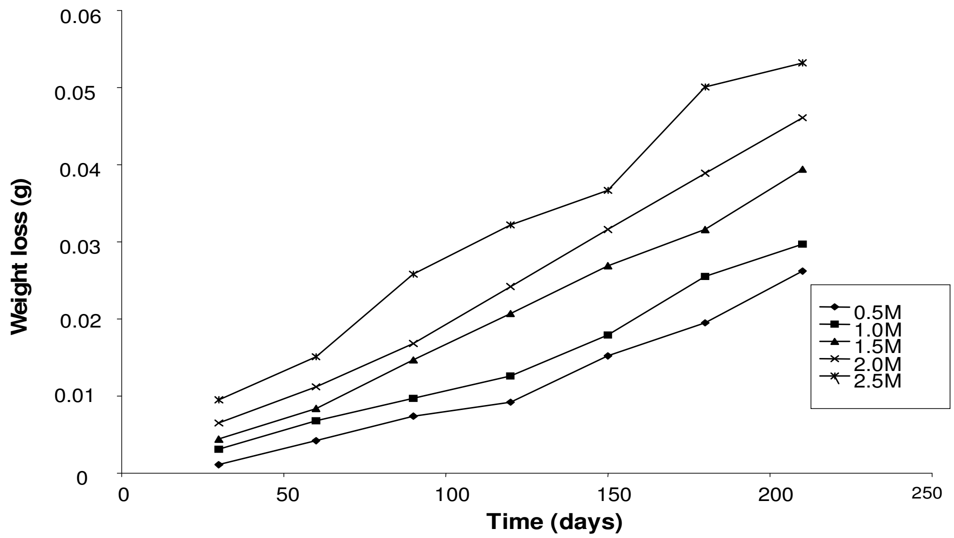

Figure 1. Variation of weight loss (grams) of zinc with time (days) for different concentrations of HCl solution at 30°C.

4.0 and 5.0 M HCl solutions were maintained at 30, 40 and 50°C constituting three sets of experiments. Previously weighed metal coupons were each suspended in each beaker through a 0.1 cm hole in diameter. The zinc coupons at 30, 40 and 50°C were retrieved at 24 h interval progressively for 168 h (7 days).

Each retrieved coupon was immersed in a solution of 20% sodium hydroxide containing 200 g/l of Zn dust to terminate the corrosion reaction, scrubbed with brittle brush several times inside water to remove corrosion product, dried in acetone and then re-weighed. The weight loss was calculated in grams as the difference between the initial weight prior to immersion, and weight after removal of the corrosion product.

Each reading reported is an average of two readings recorded to the nearest 0.0001 g on a mettler AE 166 Delta range analytical balance.

Weight loss study using the red onion skin acetone extract

Further work involved the introduction of already prepared concentrations (0.01, 0.02, 0.03, 0.04, 0.05 and 0.10 g/dm^3) of the extract into 7 separate beakers maintained at 30, 40 and 50°C. The 7th beaker contained only 2.0 M hydrochloric acid solution (without any additive); this was to be used for the blank (control) experiment. Previously weighed coupons were then placed in the test solutions containing one zinc coupon. As before, each coupon was retrieved from the test solutions at 24 h intervals progressively for 168 h (7 days) for the experiments at 30, 40 and 50°C. The difference in weight of the coupons was again taken as the weight loss.

RESULTS AND DISCUSSION

Effect of hydrochloric acid (HCL) concentration on zinc corrosion

Zinc corrodes in different concentrations of HCl solutions, since there was a decrease in the original weight of zinc as seen in Figure 1. The corrosion is attributed to the presence of water, air and H^+, which accelerate the corrosion process.

The corrosion of the zinc in HCl increases with the concentration of the acid and time. Similar results were obtained at 313 and 323 K. This observation is attributed to the fact that the rate of chemical reaction increases with increasing concentration. This observation has been reported by several authors (Ita and Edem, 2000; James et al., 2007).

Effect of temperature on the corrosion of zinc

There is a progressive increase in weight loss as the temperature is increased from 30 - 50°C (Figure 2). This signifies that the dissolution of the metal coupons increased at higher temperatures. This observation is attributed to the general rule guiding the rate of chemical reaction, which says that chemical reaction increases with increasing temperatures. Also an increased temperature favors the formation of activated molecules, which may be doubled in number, with 10°C rise in temperature, thereby increasing the reaction rate. This is because the reactant molecules gain more energy and are able to overcome the energy barrier more rapidly. An increase in temperature may also increase the solubility of the protective films on the metals, thus increasing the susceptibility of the metal to corrosion (James and Etela, 2008).

Inhibitory action of *Aloe vera* gel on the corrosion of zinc

Figures 3, 4 and 5 show that *Aloe vera* is indeed a corrosion inhibitor for zinc in hydrochloric acid solution since

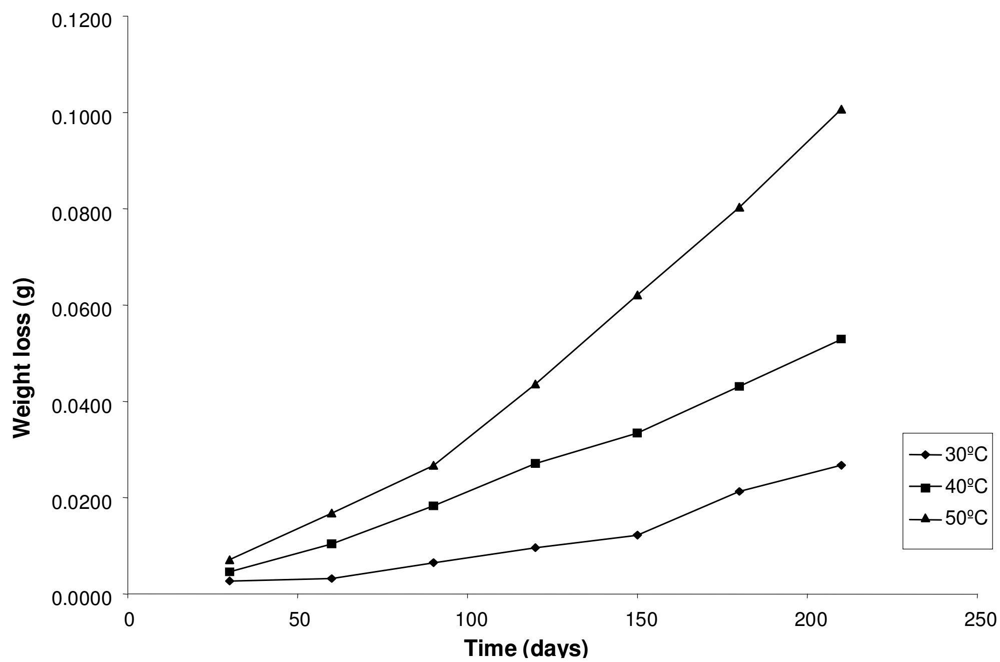

Figure 2. Variation of weight loss with time for zinc coupons in 2.0 M hydrochloric acid solution at three different temperatures Without *Aloe vera*.

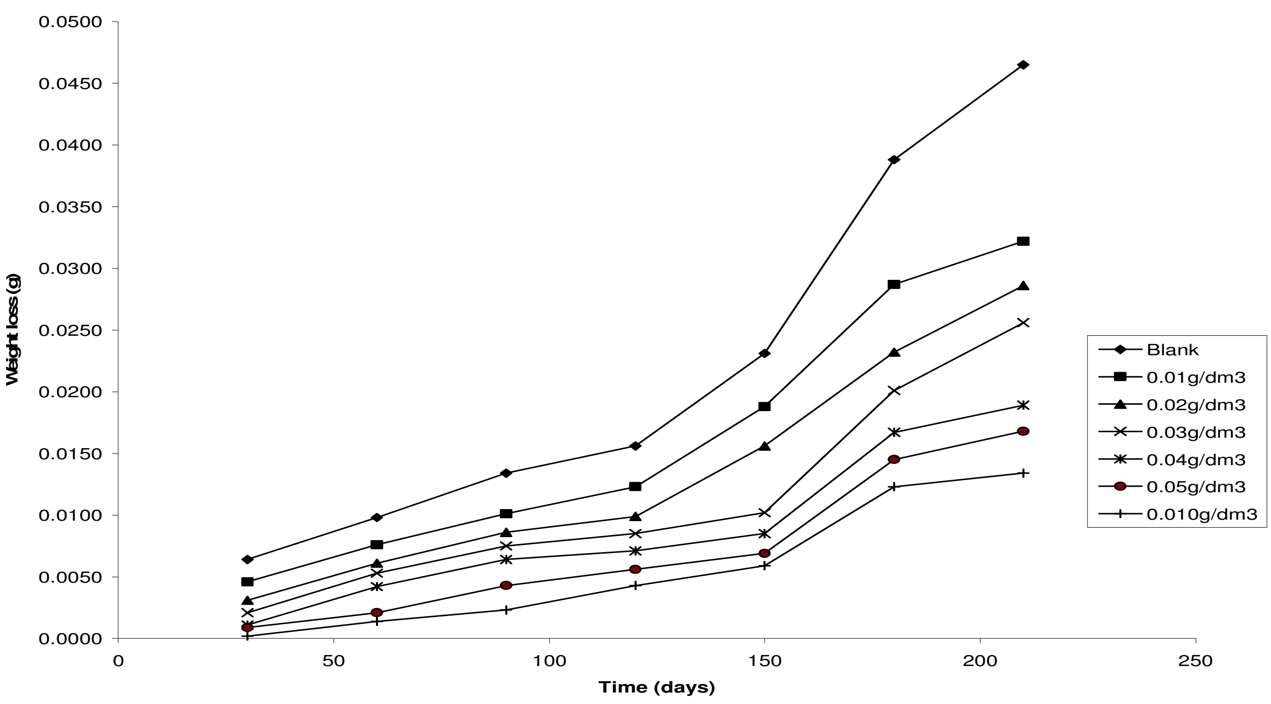

Figure 3. Variation of weight loss with time for zinc coupons in 2.0 M HCl solution containing different concentrations of *Aloe vera* at 30℃.

there was a general decrease in weight loss at the end of the corrosion-monitoring process at the temperature studied. From the variation of weight loss with time of exposure of zinc in 2 M hydrochloric acid (blank) at 30℃ (Figure 3) compared with those containing the additives, there is a remarkable decrease in weight loss signifying

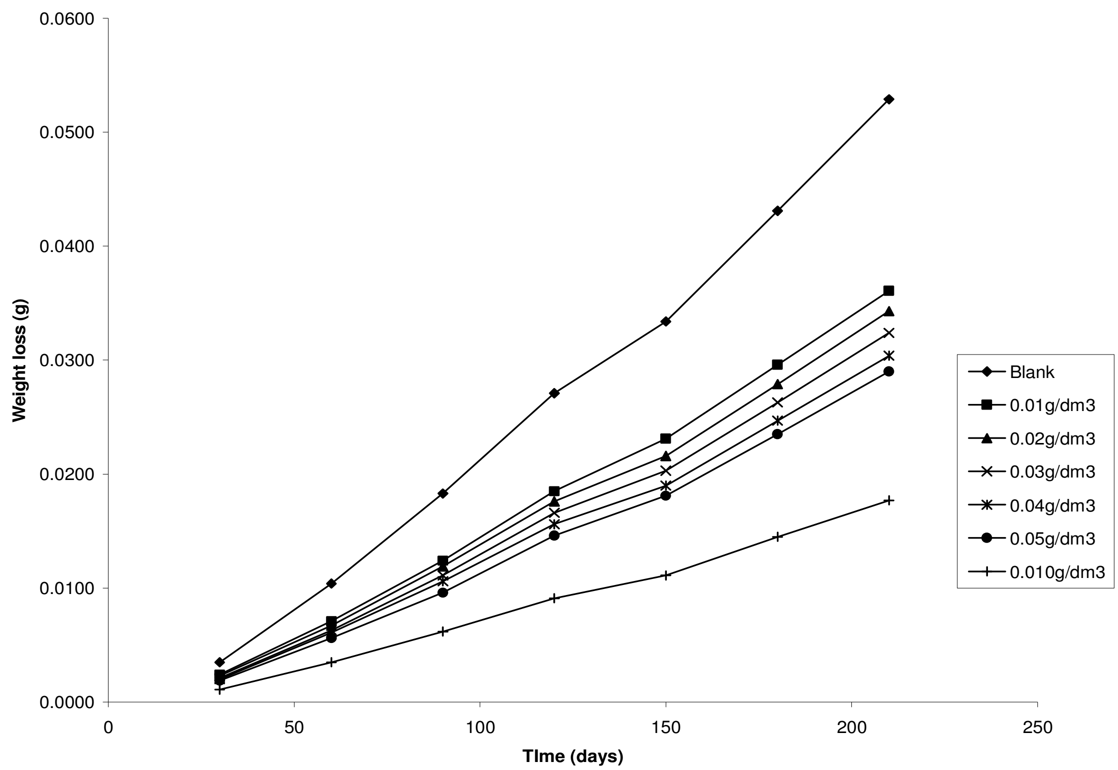

Figure 4. Variation of weight loss with time for zinc coupons in 2.0 M HCl solution containing different concentrations of *Aloe vera* at 40℃.

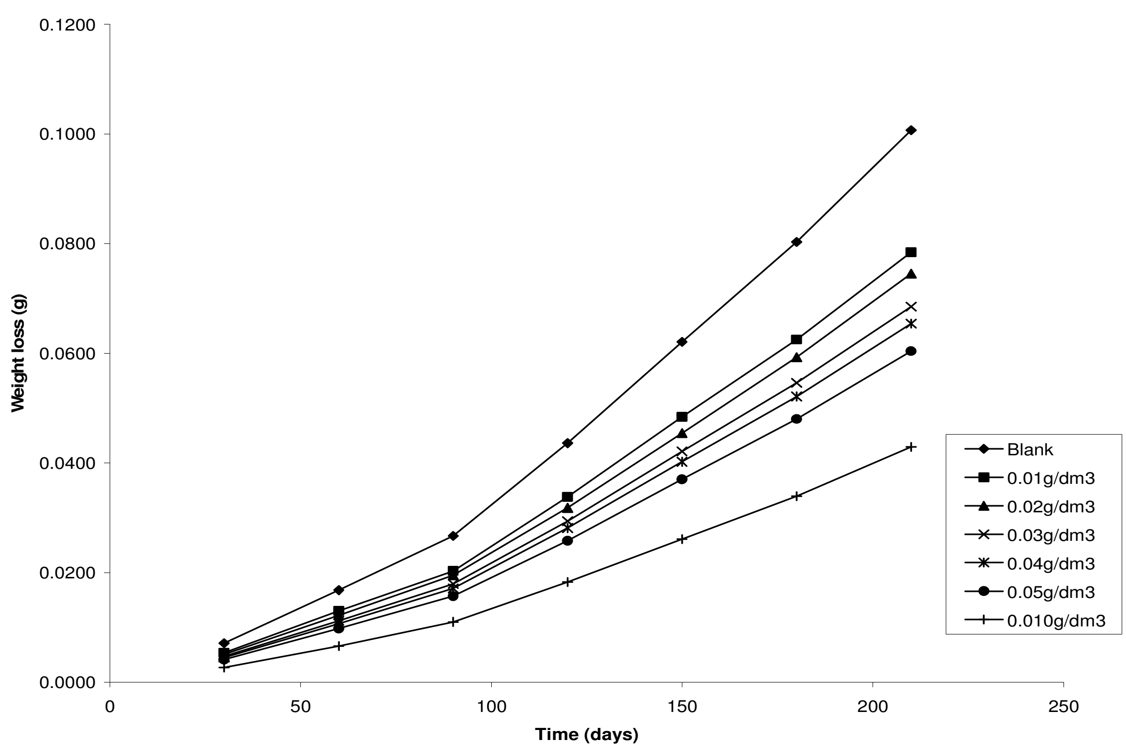

Figure 5. Variation of weight loss with time for zinc coupons in 2.0 M HCl solution containing different concentrations of *Aloe vera* at 50℃.

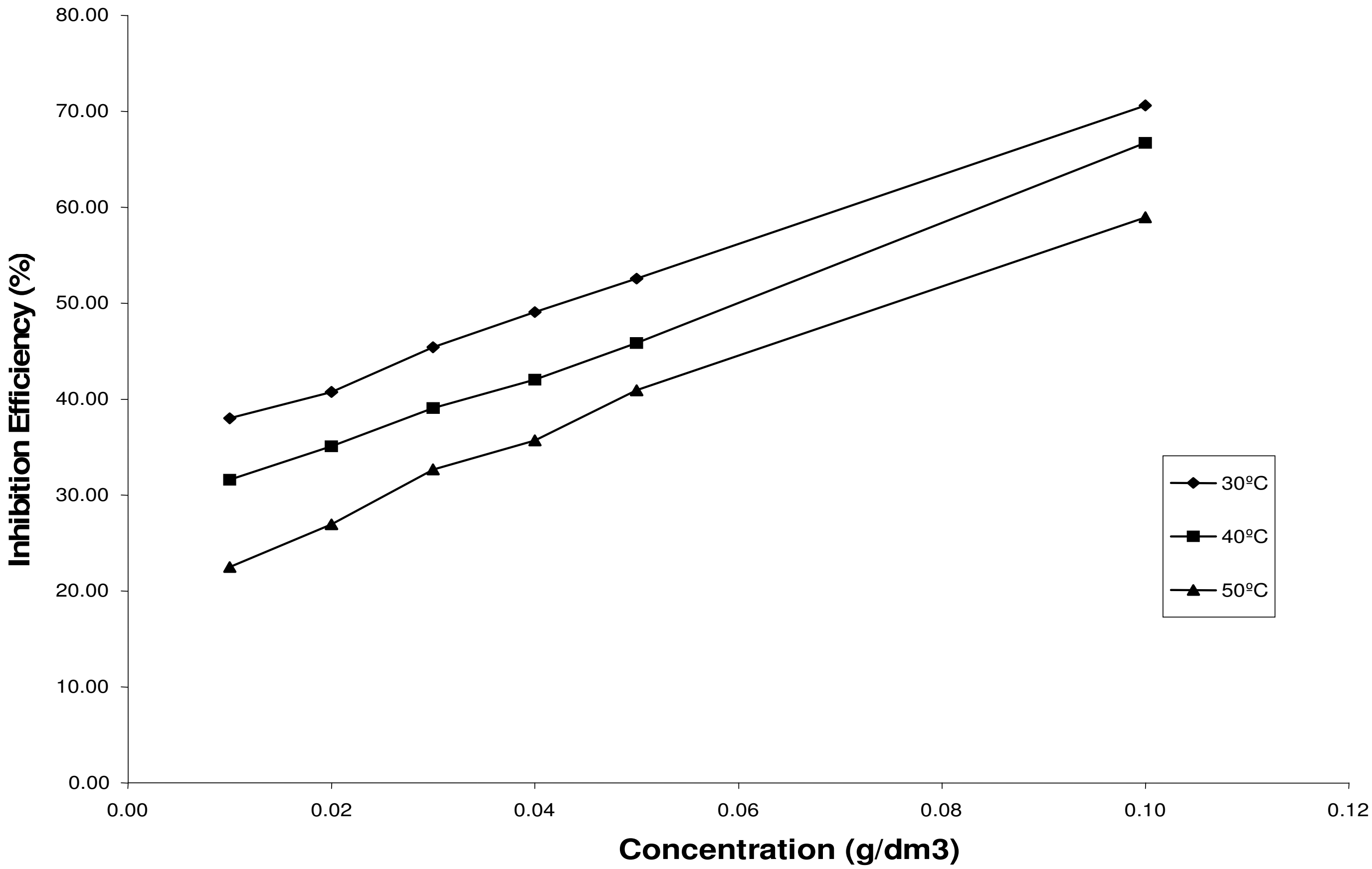

Figure 6. Variation of inhibition efficiency with inhibitor concentration for zinc coupons in 2.0 M HCl solution containing *Aloe vera* gel at three different temperatures.

corrosion inhibition.

At 40℃, as the concentration of *Aloe vera* increases from 1 - 10%, the weight losses of the zinc coupons reduce as shown by Figure 4. This shows us that *Aloe vera* gel is still effective in inhibiting the corrosion of zinc at 40℃.

The weight loss of the zinc coupons still reduced with increasing *Aloe vera* concentration as seen in Figure 5. This depicts that, even at 50℃, *Aloe vera* inhibits the corrosion of zinc in hydrochloric acid solution.

Effect of temperature on the inhibition efficiency of *Aloe vera*

The effect of increase in temperature on the inhibition efficiency of *Aloe vera* gel is displayed graphically in Figure 6.

We can observe from the graph that, as the reaction temperature is increased from 30 to 40℃ and to 50℃, the inhibition efficiency increases.

Thus it is appropriate to say that increase in temperature favours the inhibition efficiency of *Aloe vera* gel on zinc in hydrochloric acid.

Effect of concentration increase on the inhibtion efficiency of *Aloe vera*

Figure 6 also portrays an increase in inhibition efficiency of *Aloe vera* gel as the concentration of the gel increases in the acid solution. This can be observed from the upward progression of all three temperatures.

The active component responsible for the inhibitory action of red onion skin

The inhibitory action of red onion skin was due to the presence of Quercetin (Figure 7). Quercetin is one of the flavonoid compounds present in red onion skin. It is a compound with conjugated system and contains hetero atoms and carbonyl groups that are electron rich which can serve as a good adsorption site onto the metal surface thereby inhibiting the corrosion of the zinc.

Conclusion

From the results of this study, we can conclude that *Aloe vera* gel is an effective inhibitor of the corrosion of zinc in

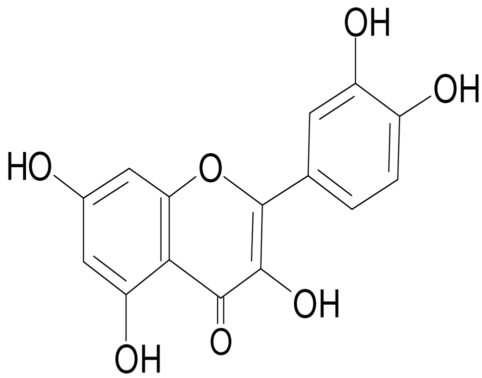

Figure 7. The structure of quercetin (red onion skin).

2 M hydrochloric acid solution at 30, 40 and 50℃. The inhibitor efficiency was found to increase with increased inhibitor concentration and temperature.

REFERENCES

Abiola OK, Oforka NC, Ebenso EE (2004). A potential corrosion inhibition for acid corrosion of mild steel. Electrochemistry 20(9): 409-413.

Chauhara LR, Gunasekara G (2006). Corrosion inhibition of mild steel in hydrochloric acid solution by *Zenthoxylum alatum* plant extracts. J. Corros. Sci. 17: 1016.

Ita BI, Edem CA (2000). Inhibition of steel corrosion in hydrochloric acid solutions by green A and erythrosine dyes. Global J. Pure Appl. Sci. 6(2): 239-242.

James AO, Etela AO (2008). *Aloe vera*: An inhibitor of aluminium corrosion in Hydrochloric acid. International J. Pure Appl. Chem. 3(3): 159-163.

James AO, Oforka NC, Abiola OK (2007). Inhibition of acid corrosion of mild steel by pyridoxal and pyridoxol hydrochloride. Int. J. Electrochem. Sci. 2: 278-284.

Loto CA (1998). The effect of *Vernomia amygdalina* (bitter leaf) solution extract on the corrosion inhibition of mild steel. Niger. Corros. J. 19(1): 20-28.

Orubite KO, Oforka NC (2004). Corrrosion inhibition of zinc in HCl using *Nypa Fruticans* Wurmb extracts. J. Appl. Sci. Environ. Manage. 8(1): 56 -61.