Inhibition of Corrosion of Zinc in Hydrochloric Acid Solution by Red Onion Skin Acetone Extract

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Abstract

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.
Keywords: 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[1]. A lot of works have been reported using economic plants such as *Vernonia Amydalina* (bitter leaf) extracts[2], *Nypa Fruticans* Wurmb leaf extracts[1], Zenthoxylum alatum plant[3] and the juice of cocosnucifera[4] for the acid corrosion of mild steel.

In this study, the inhibitory action of **acetone extract of red onion skin** on the corrosion of zinc in 2M hydrochloric acid solution has been investigated at three different temperatures (30^{o}C, 40^{o}C and 50^{o}C) using weight loss method.

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

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

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

Material and Methods

The weight loss corrosion test method was used for this study

Material Preparation: The zinc sheet of thickness 0.1cm used for this study was purchased at Mile one steel market, Port-Harcourt. It was mechanically press-cut into 4 X 3cm 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[5]. The coupons were thesn stored in a moisture-free dessicator to avoid contamination before their use in the corrosion studies.

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 heated 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 hydrochloric acid solution and were used for all measurement.

Weight loss measurements:

Weight loss study using hydrochloric acid solution only.: Fifteen 250ml beakers, which separately contained 1.0M, 2.0M, 3.0M, 4.0M and 5.0M HCl solutions were maintained at 30°C, 40°C and 50°C constituting three sets of experiments. Previously weighed metal coupons were each suspended in each beaker through a 0.1cm hole in diameter. The zinc coupons at 30°C, 40°C and 50°C were retrieved at 24hours interval progressively for 168hours (7days).

Each retrieved coupon was immersed in a solution of 20% sodium hydroxide containing 200g / litre 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 reweighed. 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 0.0001g 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 (0.01g/dm^3, 0.02 g/dm^3, 0.03g/dm^3, 0.04g/dm^3, 0.05g/dm^3 and 0.10g/dm^3) of the extract into seven separate beakers maintained at 30°C, 40°C and 50°C. The seventh beaker contained only 2.0M 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 24hours intervals progressively for 168hours (7 days) for the experiments at 30°C, 40°C and 50°C. The difference in weight of the coupons was again taken as the weight loss.

Result and Discussion

Effect of hydrochloric acid 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 313K and 323K. 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[5-6].

Effect of temperature on the corrosion of zinc: There is a progressive increase in weight loss as the temperature is increased from 30°C to 50°C (fig. 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[7].

Inhibitory action of acetone extract of red onion skin on the corrosion of zinc: Figures 3, 4 & 5 show that acetone extract of red onion skin is indeed a corrosion inhibitor for zinc in hydrochloric acid solution since there was a general decrease in weight loss at the end of the corrosion-monitoring process at the temperatures studied.

From the variation of weight loss with time of exposure of zinc in 2M hydrochloric acid (blank) at 30°C (fig. 3) compared with those containing the additives, there is a remarkable decrease in weight loss signifying corrosion inhibition.

At 40°C, as the concentration of acetone extract of red onion skin increases from 0.01g/dm^3 to

0.10g/dm^3, the weight losses of the zinc coupons reduce as shown by fig. 4. This shows us that acetone extract of red onion skin is still effective in inhibiting the corrosion of zinc at 40^{o}C.

The weight loss of the zinc coupons still reduced with increasing acetone extract of red onion skin concentration as seen in fig. 5. This depicts that, even at 50^{o}C, acetone extract of red onion skin inhibits the corrosion of zinc in hydrochloric acid solution.

Effect of temperature on the inhibition efficiency of acetone extract of red onion skin: The effect of increase in temperature on the inhibition efficiency of acetone extract of red onion skin is displayed graphically in fig. 6 below.

We can observe from the graph that, as the reaction temperature is increased from 30^{o}c to 40^{o}c and to 50^{o}c, the inhibition efficiency increases. Thus it is appropriate to say that increase in temperature favours the inhibition efficiency of acetone extract of red onion skin on zinc in hydrochloric acid.

Effect of concentration increase on the inhibition efficiency of acetone extract of red onion skin: Fig. 6 also portrays an increase in inhibition efficiency of acetone extract of red onion skin as the concentration of the extract 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 (fig. 7). Quercetin is one of the flavonoid compounds present in red onion skin. It is a compound with conjugated system and contains heteroatoms 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.

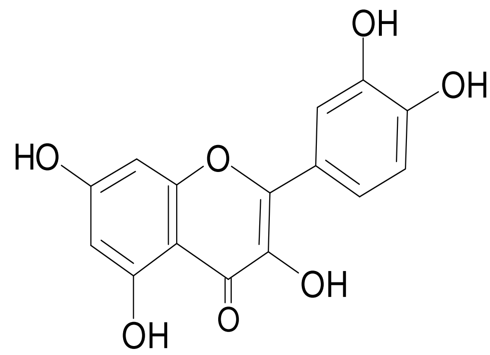

Figure 7: the structure of quercetin (red onion skin)

Conclusion

From the results of this study, we can conclude that acetone extract of red onion skin is an effective inhibitor of the corrosion of zinc in 2M hydrochloric acid solution at 30^{o}C, 40^{o}C and 50^{o}C. The inhibitor efficiency was found to increase with increased inhibitor concentration and temperature.

References

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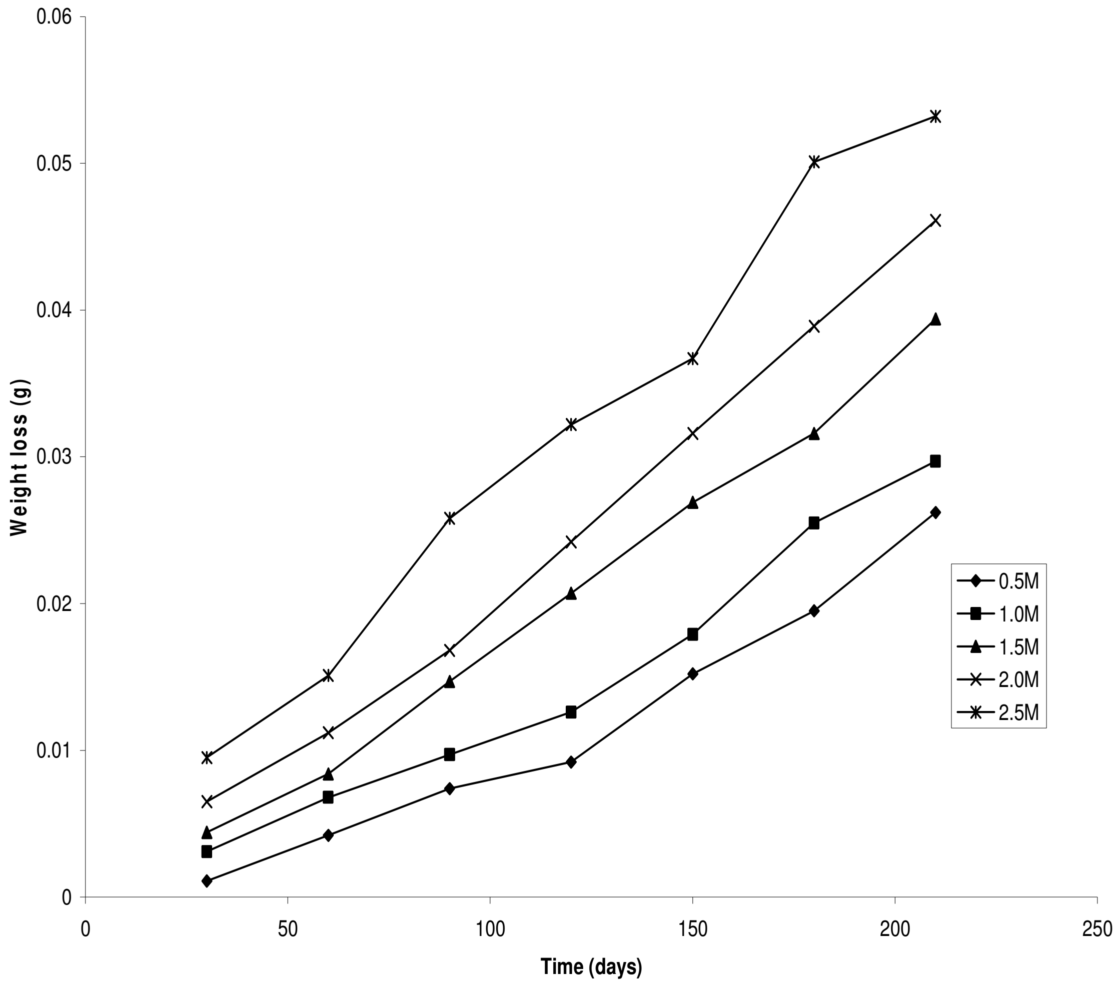

Figure 1: - Variation of weight loss (grams) of zinc with time (days) for different concentrations of HCl solution at 30^{o}C.

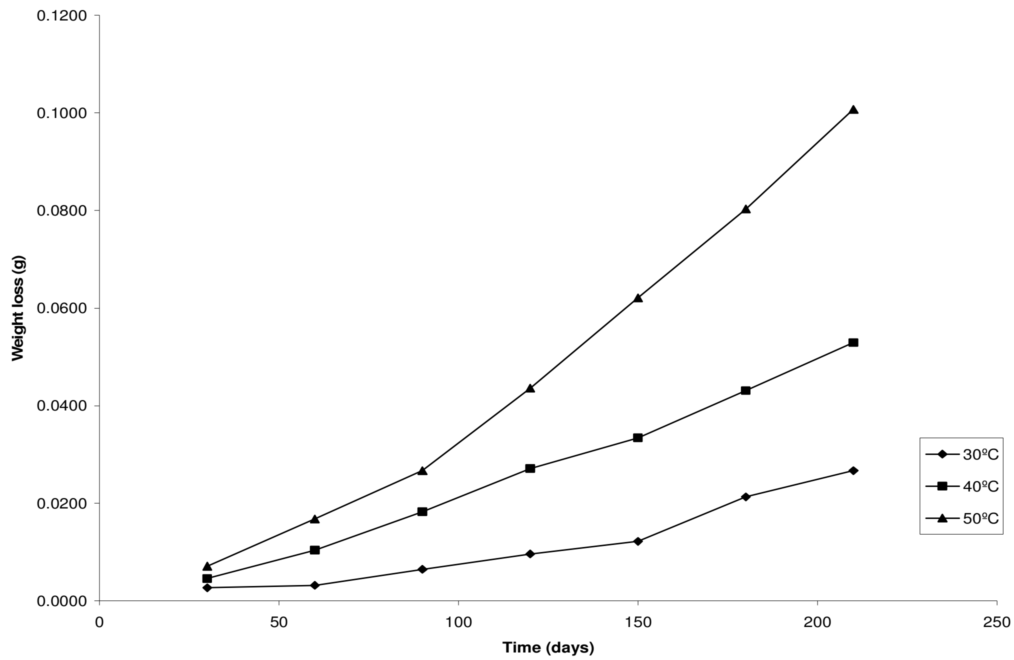

Figure 2: - Variation of Weight Loss with Time for zinc Coupons in 2.0M Hydrochloric Acid Solution at three different temperatures without **the extract**.

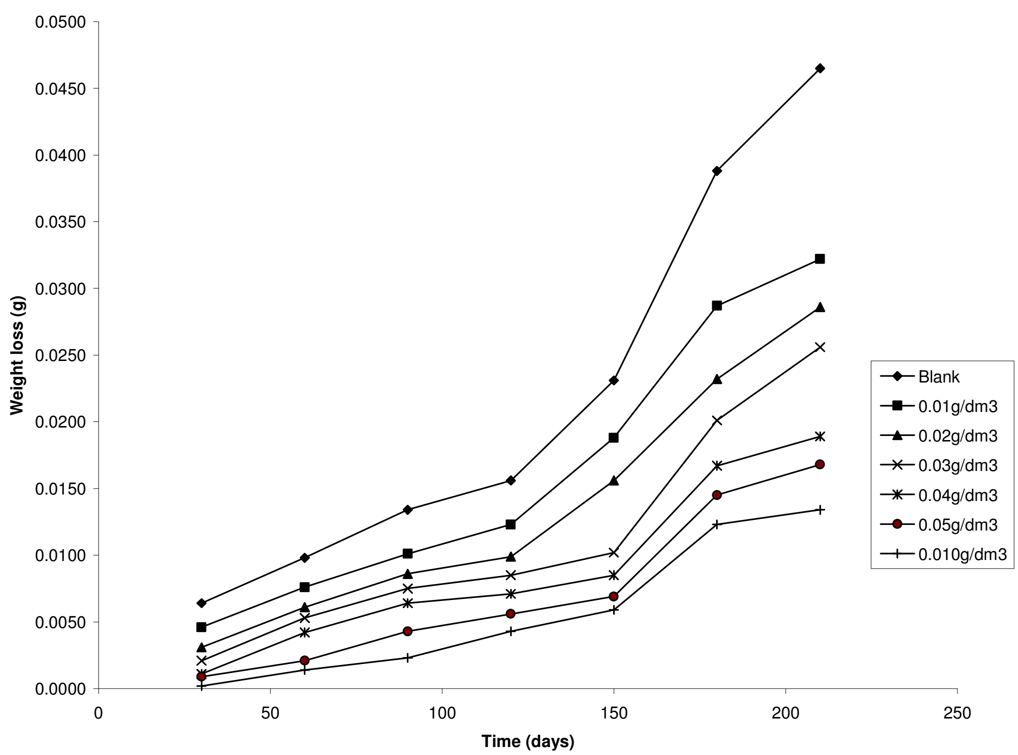

Figure 3: - Variation of Weight Loss with Time for zinc Coupons in 2.0M HCl Solution Containing Different Concentrations of **acetone extract of red onion skin** at 30 ºC

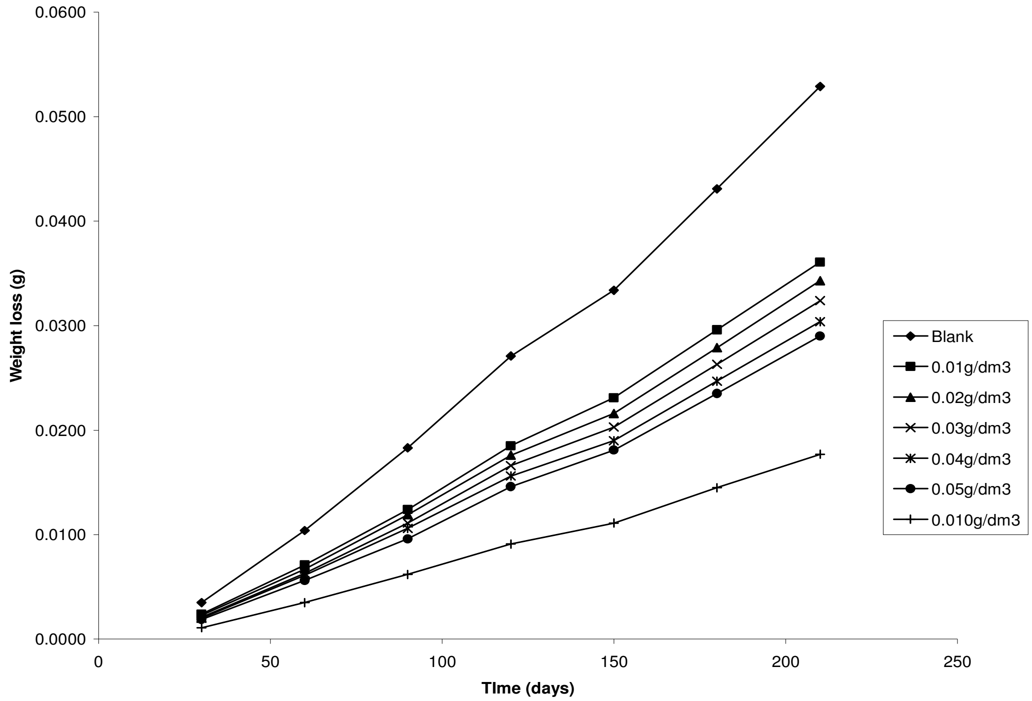

Figure 4: - Variation of Weight Loss with Time for zinc Coupons in 2.0M HCl Solution Containing Different Concentrations of **acetone extract of red onion skin** at 40 ºC

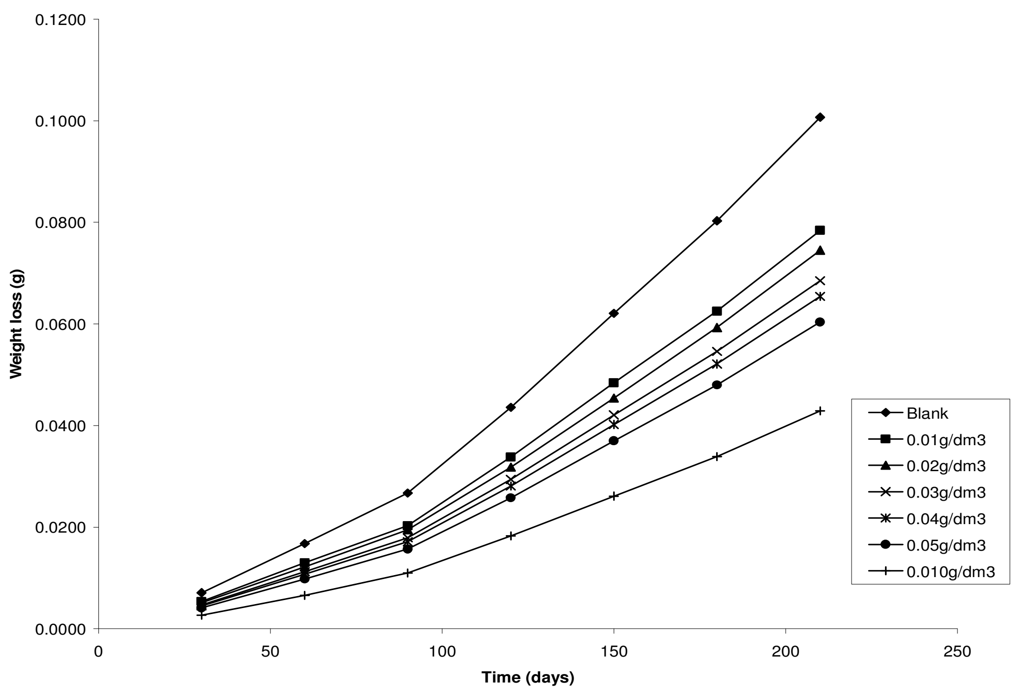

Figure 5: - Variation of Weight Loss with Time for zinc Coupons in 2.0M HCl Solution Containing Different Concentrations of **acetone extract of red onion skin** at 50 ºC

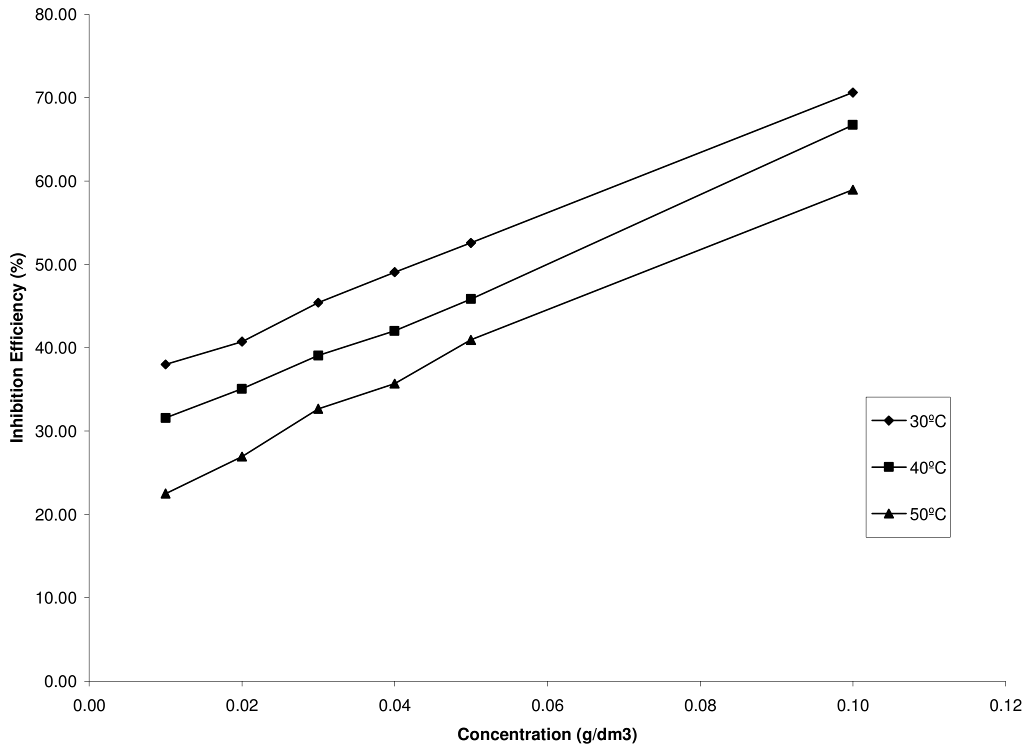

Figure 6: - Variation of Inhibition Efficiency with Inhibitor Concentration for zinc Coupons in 2.0M HCl Solution Containing **acetone extract of red onion skin** at Three Different Temperatures