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Research article

KINETIC STUDIES OF THECORROSION INHIBITION OF MILD STEEL IN 2M SULPHURIC ACID SOLUTION USING RED PEANUT SKIN EXTRACT AS INHIBITOR

A. O. James[1] and O. Akaranta[2]

[1&2]Department of Pure and Industrial Chemistry,
University of Port Harcourt, P.M.B. 5323, Port Harcourt.
[1]E-mail address: bidean2002@yahoo.com
[2]E-mail address: oakaranta@yahoo.com
Phone Number: 08057314332

ABSTRACT

It has been established from weight loss measurement that the different concentration of acetone extract of red peanut skin (RPSE) inhibits the corrosion of mild steel in sulphuric acid solution to a remarkable extent. Generally, inhibition was found to increase with an increase in inhibitor concentration and half life. A first order type mechanism has been deduced from the kinetic treatment of the result. The mechanism of physical adsorption has been proposed for the inhibitors on the basis of the temperature effect and the values of activation energy obtained. The corrosion is probably due to the adsorption of catechin in red peanut skin extract on the surface of the mild steel.

Keywords: MILD STEEL, SULPHURIC ACID, RED PEANUT SKIN, PHYSICAL ADSORPTION, WEIGHT LOSS, CORROSION

INTRODUCTION

Metals undergo chemical reactions with the environment to form products such as oxides, sulphates, sulphides and chlorides that no longer have the required physical and chemical properties of refined metals and are in a more stable state. This reaction of metal with the environment and the consequent wearing away of the metal surface is referred to as corrosion of metals (Ita, 2004). High losses are incurred due to high cost of replacement of materials and equipment such as pipes, rails, water heaters and other items subject to corrosion (Abiola and Oforka, 2002). Corrosion could also lead to total loss in production, loss of products due to leakage or life due to collapse of structures like bridges, houses, etc. (Kruger, 2001). Although there are numerous options for controlling the corrosion of metals, theuse of inhibitors is one of the best methods for protecting metals against corrosion (Eddy et. al, 2008). Many current corrosion inhibitors being employed for control of metallic corrosion in acidic environment are toxic and environmentally polluting chemicals. There is a great need to develop environmentally acceptable and non-toxic inhibitors that are compatible with the current industrial legislation (Bereez and Szita, 1993).

The high inhibition efficiency of acetone extract of red onion skin on mild steel (James and Akaranta, 2009a), aluminium (James and Akaranta, 2009b) and zinc (James and Akaranta, 2009c) in hydrochloric acid and sulphuric acid solutions, necessitated exploringthe acetone extract of red peanut skin (James et. al., 2011). In furtherance of the work on acetone extract of red peanut skin as potential corrosion inhibitors, this paper presents the kinetic studies of the inhibition of mild steel in sulphuric acid via the weight loss method at 30^{o}C, 40^{o}C and 50^{o}C in the presence of acetone extract of red peanut skin.

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

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

Where ΔW_B and ΔW_i are the weight loss data of the metal coupons in the absence and presence of an additive respectively (James and Oforka, 2010).

EXPERIMENTAL

MATERIAL PREPARATION

The mild steel 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 (James and Ekpe, 2008). The coupons were then stored in a moisture-free dessicator to avoid contamination before their use in the corrosion studies.

The inhibitor used was acetone extract of red peanut skin. The red peanut skin was obtained locally from a groundnut seller in a kiosk at the campus of university of Port-Harcourt, after roasting and peeling. The red peanut extract was obtained following the method used by sJames and Akaranta, 2009. The red peanut skin was boiled with 70ml acetone and 30ml water mixture. The resulting red solution, after the chaff of the red peanut skin has been filtered out of the boiled solution, was evaporated to dryness; the powder obtained was then scrapped out and stored

in a sample bottle. Five different concentrations (0.005g/250ml, 0.01g/250ml, 0.05g/250ml, 0.5g/250ml, 1.0g/250ml) of the extract were prepared with 2M sulphuric acid solution and were used for all measurement.

WEIGHT LOSS MEASUREMENTS

The various concentrations (0.005g/250ml, 0.01g/250ml, 0.05g/250ml, 0.5g/250ml, and 1.0g/250ml) of the acetone extract of red peanut skin were introduced into five out of six separate beakers maintained at 303K, 313K and 323K. The sixth beaker contained only 2M sulphuric acid solution, without additive and used for the control experiment. Previously weighed coupons were then placed in the corrodent-inhibitor solutions. Each coupon was retrieved from these solutions at 24hours intervals progressively for 168hours (7 days) for the experiments at the temperature studied. The difference in weight of the coupon was taken as the weight loss.

RESULTS AND DISCUSSIONS

INHIBITORY ACTION OF THE EXTRACT

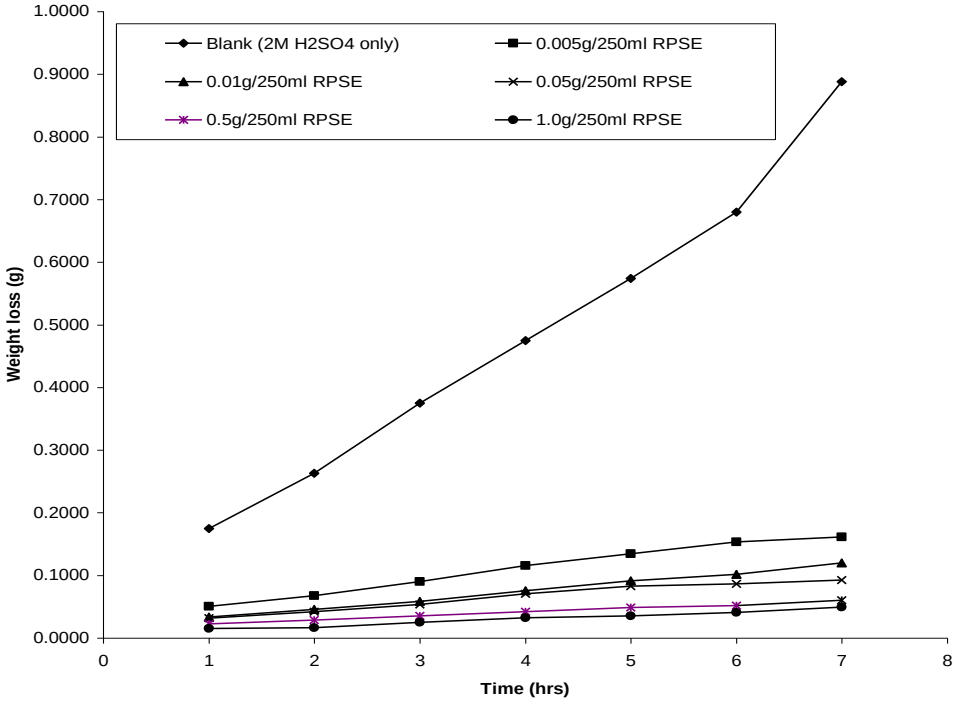

Figure 1: Variation of Weight Loss with Time for mild steel coupons in 2.0M H_2SO_4 Solution Containing Different Concentrations of acetone extract of red peanut skinat 303K.

From the variation of weight loss with time of exposure of mild steel in 2M sulphuric acid (blank) at 303K (fig. 1) compared with those containing the additives, there is a remarkable decrease in weight loss signifying corrosion inhibition.

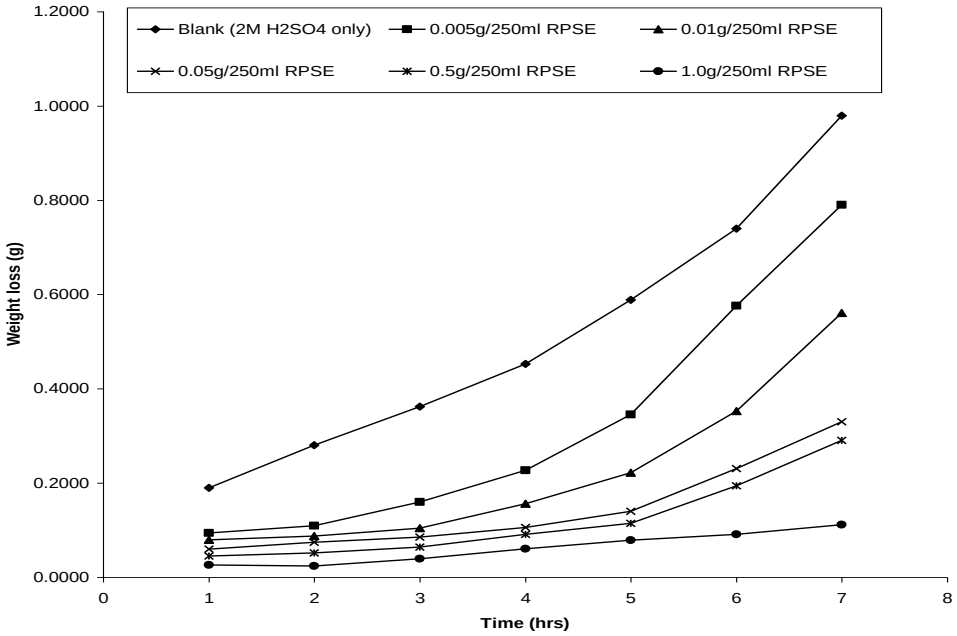

Figure 2: Variation of Weight Loss with Time for mild steel coupons in 2.0M H_2SO_4 SolutionContaining Different Concentrations of acetone extract of red peanut skin at 313K.

At 313K, as the concentration of acetone extract of red peanut skinincreases from 0.005g/250ml -1.0g/250ml, the weight losses of the mild steel coupons reduce as shown by fig. 2. This shows us that acetone extract of red peanut skinis still effective in inhibiting the corrosion of mild steel at 313K.

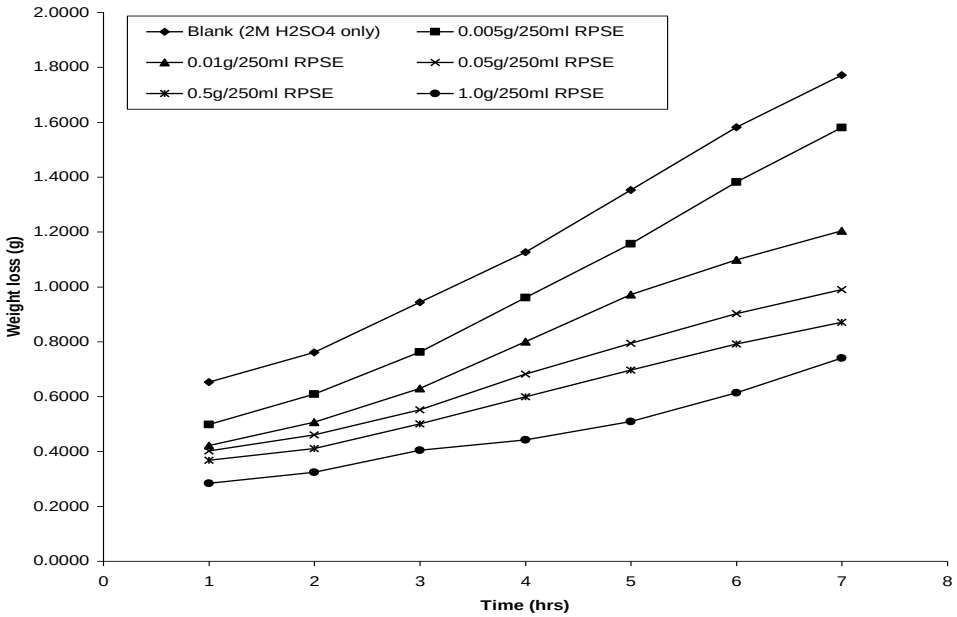

Figure 3: Variation of Weight Loss with Time for mild steel coupons in 2.0M H_2SO_4 Solution Containing Different Concentrations of acetone extract of red peanut skin at 323K.

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

EFFECT OF TEMPERATURE ON INHIBTION EFFICIENCY OF THE EXTRACT

The effect of increase in temperature on the inhibition efficiency of acetone extract of red peanut skin is displayed graphically in Fig. 4 below.

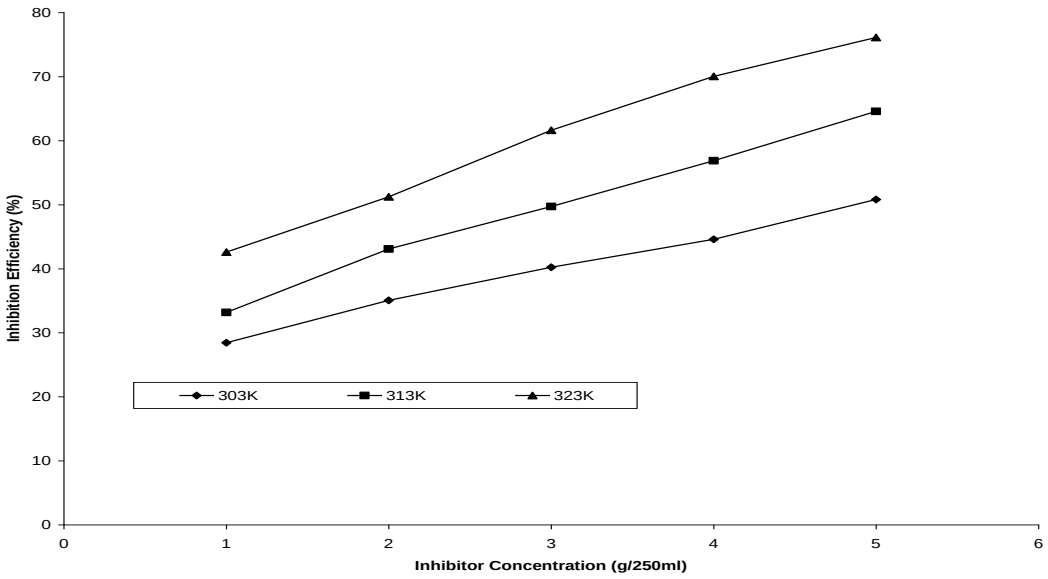

Figure 4: Variation of Inhibition Efficiency with Inhibitor Concentration for mild steel coupons in 2.0M H_2SO_4 Solution Containing acetone extract of red peanut skin at Three Different Temperatures.

We can observe from the graph that, as the reaction temperature is increased from 303K to 313K and to 323K, the inhibition efficiency increases. Thus it is appropriate to say that increase in temperature favours the inhibition efficiency of acetone extract of red peanut skin on mild steel in hydrochloric acid.

EFFECT OF CONCENTRATION ON INHIBTION EFFICIENCY OF THE EXTRACT

Figure 4 also portrays an increase in inhibition efficiency of acetone extract of red peanut skin as the concentration of the extract increases in the acid solution.

ACTIVE COMPONENT OF THE EXTRACT

The inhibitory action of red peanut skin was due to the presence of Catechin (fig. 5). 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 mild steel.

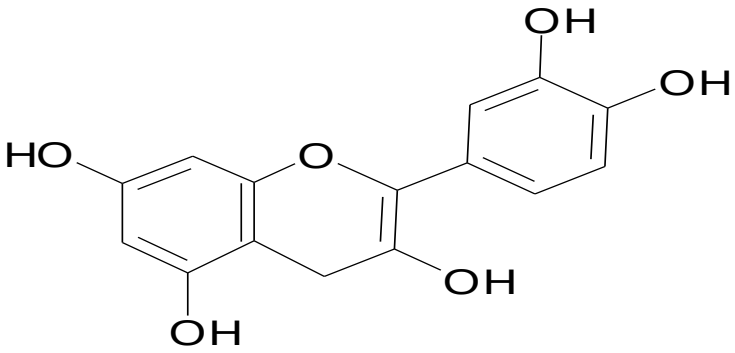

Figure 5: The structure of Catechin (Red Peanut skin)

KINETIC TREATMENT OF WEIGHT LOSS RESULTS

Corrosion reaction is a heterogeneous one, composed of anodic and cathodic reactionswith the same or different rate. It is on this basis that kinetic analysis of the data isconsidered necessary. The initial weight of mild steel coupon at time t, is designated Wi,the weight loss is ΔW and the weight change at time t, (Wi - ΔW). The plots of log (Wi-ΔW) against time (min) at 303K and other temperatures studied, showed a linear variationwhich confirms a first order reaction kinetics with respect to the corrosion of mild steel in H_2SO_4 solutions at 303K without inhibitor (Figure 6).

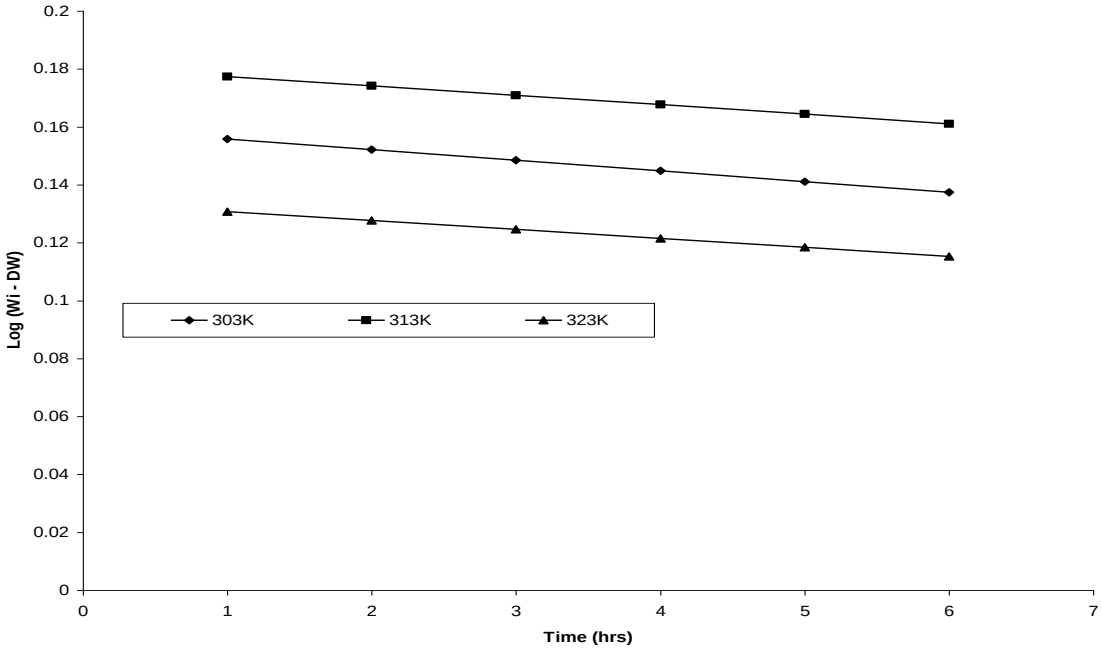

Figure 6: Variation of log (Wi - ΔW) with time (days) for mild steel coupons in 2M H_2SO_4solution at different temperatures without inhibitor.

Figure 7 also shows a linear plot, suggesting a first order reaction kinetics with respect to mild steel corrosion in 2M H_2SO_4 solutions in the presence of the red peanut skin acetone extract (RPSE).

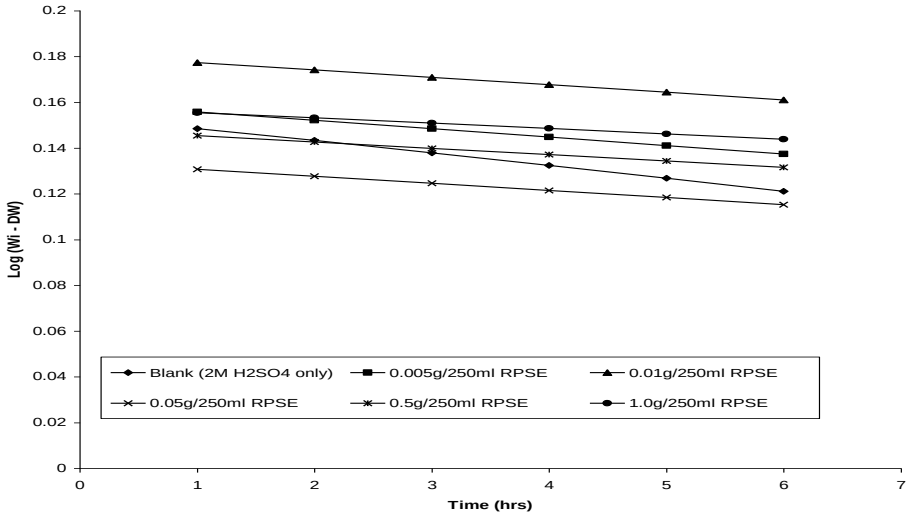

Figure 7: Variation of log (Wi - ΔW) with time (days) for mild steel coupons in 2M H_2SO_4solutions containing different concentration of acetone extract of red peanut skin at 303K.

Table 1: Kinetic data for mild steel in different concentrations of sulphuric acid solution without inhibitor

Sulphuric acid concentration (M)	Rate Constant, K (min^{-1}) x 10^{-4}			Half life, $t^1/_2$ (mins) x 10^3			**Average activation energy** $KJmol^{-1}$
	303K	313K	323K	303K	313K	323K	
0.5	1.08	1.19	2.01	6.42	5.82	3.45	32.58
1.0	2.19	2.29	3.74	3.16	3.03	1.85	
1.5	3.22	3.59	5.43	2.15	1.93	1.28	
2.0	4.29	4.79	6.76	1.62	1.45	1.03	
2.5	5.35	6.77	7.98	1.30	1.02	0.87	

Table 2: Kinetic data for mild steel in 2M H_2SO_4 containing red peanut skin acetone extract from weightloss measurement.

Inhibitor concentration (g/250ml)	% Inhibition Efficiency			Rate Constant, K (min^{-1}) x 10^{-4}			Half-life, $t^1/_2$ (mins)x 10^3			Activation energy $kJmol^{-1}$	Average activation energy $kJmol^{-1}$
	303K	313K	323K	303K	313K	323K	303K	313K	323K		
0.005	49.60	15.43	13.38	2.21	4.54	5.46	3.14	1.53	1.27	18.09	26.58
0.01	61.45	37.15	32.49	1.66	3.59	4.58	4.18	1.93	1.51	20.47	
0.05	67.65	46.65	42.69	1.43	2.87	4.03	4.85	2.42	1.72	28.54	
0.5	68.91	50.95	49.24	1.34	2.59	3.23	5.17	2.68	2.15	18.56	
1.0	75.41	67.26	54.38	1.05	1.75	3.07	6.60	3.96	2.26	47.25	

There is a general decrease in the rate constants from 303K - 323K with increasingconcentrations of the extract (Table 2). The increase in half-life ($t_{1/2}$) observed whenthe extract ispresent further supports the inhibition of mild steel in 2M H_2SO_4 by theextract. The increase in half life indicates more protection of the metal. The average activation energy of 26.58 kJ mol^{-1}obtained in the H_2SO_4 – RPSE system at 303 - 313K. On the basis of theseexperimentally determined activation energy values, the extract is a physically adsorbedon the aluminium coupons. Therefore, it is probable that a multilayer protective coverage on the entiremild steel surface was obtained.

CONCLUSION

The inhibition of the corrosion of mild steel coupons by acetone extract of red peanut skin increased with increased extract concentration and decreased temperature.Kinetic treatment of the results of the corrosion of mild steel in H_2SO_4 in both inhibited and uninhibited reactions confirm a first order type of mechanism.The values of activation energy obtained in the presence and absence of inhibitors are below 80KJmol^{-1}. The inhibition is probably due to the adsorption of the inhibitors on the metal surface by physical adsorption i.e the compounds were physically adsorbed on the surface of the metal.The inhibition is due to the adsorption of an active ingredient in the extract on the metal surface and blocking its active sites.The active component in the red onion skin extract responsible for the corrosion inhibition is catechin.

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