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Kinetics Study on Mild Steel Corrosion Inhibition by Ethyl Ester of Rubber Seed Oil

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ABSTRACT

The Kinetics of Mild steel Corrosion Inhibition by Ethyl Ester of Rubber Seed Oil was studied. This was motivated by the view of assessing the effects of kinetic energy on the corrosion and corrosion inhibition processes. Corrosion inhibition assessment was conducted using weight loss analysis at 40°C, at varying times (of 4, 8, 16, 24 and 32hours) and dozing rates (of 50%, 60% and 70% Strokes). The first-order kinetic rate constant (k_1) was found to be positive at all reaction conditions, indicating the continuous need for kinetic energy during the corrosion reaction. The time taken for the loaded inhibitor sample to be absorbed by the material by half (the half life), $t_{1/2}$ was observed to be higher at blank conditions than when inhibitor is present, at the various dozing rates; this indicates that adsorption of the corrosion medium by the material is higher in blank solution, thereby making the steel pipe more susceptible to corrosion effects in the absence of inhibitor. However, the values of coefficient of determination (R^2), at the various cases, range from 0.6611-0.9889, indicating a good fit of the data points.

Keywords: Kinetics, Mild steel, Corrosion Inhibition, Rubber Seed Oil

INTRODUCTION

Rubber seed, from which the rubber seed oil is extracted, is obtained in high yield as a by-product of Hevea Brasiliensis, cultivated primarily for its latex (Aigbodion et al, 2003; Kim, 1994; George et al,2014). Rubber seed is reported to be abundant in Nigeria, and is found to contain 42% of the oil (Aigbodion and Pillai, 2007). However, a number of researches have shown rubber seed to be a rich source of oil that is comparable in quality to dry oils, commonly used in surface coatings (Patel et al, 2010; Okieimen and Okieimen, 2000). The industrial value of vegetable oils

generally depends on their constituents' fatty acids and the ease at which it can be modified or combined with other chemicals.

Several physical and chemical modifications of rubber seed oil, to enhance its initial quality, have been evolved over the years. Chemical transformation of vegetable oil to fatty acid alkyl ester (esterification) is one of the methods of modifying the quality of vegetable oils. Raw vegetable oils are composed of glycerol, esters of fatty acids and various amounts of solubilized impurities, such as pigments, vitamins, sterols, phospholipids and so on; these impurities may compromise the quality of the finished alkyd resins, if not properly managed (Akintayo and Adebowale, 2004; Athawale and Joshi, 2012).

In the oil and gas industries, corrosion failures are prominent in the flowlines. Therefore, since flowlines form the major distribution network for gas, oil and water, corrosion can be considered as an important site for pipe failures. However, proper definition of material failure can be seen in terms of how well a material fulfills all aspects of the functional requirements of the application for which it was selected (Athawale and Joshi, 2012). When a material losses its integrity, failure occurs; and rehabilitation of such failed material is always capital intensive. Development of alternative means of preventing this menace is, thus, essential in order to appreciate effective productivity from our industries at an optimal production cost.

MATERIALS AND METHOD

Corrosion Inhibition Assessment

Corrosion inhibition assessment of the mild steel material by the Ethyl Ester of Rubber Seed Oil (EERSO) was conducted using weight loss analysis, at varying dozing rate (of 50%, 60% and 70% Strokes). Both ends of the mild steel pipe, of weight, W_1, were fused into different points of a fitting hose, connected to a dozing pump. The hose is held firmly in position by means retort stand. Another hose connects the

outlet of the dozing pump back to a plastic reservoir (recycle stream), from where 10g/L inhibitor (Rubber Seed Oil, RSO) concentration is fed through the mild steel pipe; the reservoir was securely placed in a thermostat water bath, containing about 4litres of water and set at 40°C. After 4hours of the medium circulation (through the system), the steel pipe was removed, washed gently (with distilled water), dried in an oven for 4minutes and reweighed, to obtain the weight, W_2. The same procedure was used for the blank. The procedure was repeated at different times of 8, 16, 24 and 32hours for the varying dozing rates, and the weight differences were evaluated and recorded accordingly as presented in Appendix 1.

Kinetics Study

The kinetics of the process was studied, to appreciate the impact of kinetic energy on the fluid activities. In this case, the relationship between negative logarithm of the **Weight Loss** and **Time** of equation 1, as specified by Eddy et al (2009), was applied.

$$-\log W = \frac{k_1 t}{2.303} = \qquad (1)$$

The negative logarithm of the weight loss, '-log W' was plotted against Time, 't' at various dozing rates, and the result is presented in Figure 1, while that of the blank (without inhibitors) is presented in Figure 2. The slope of each of the graph is equivalent to the factor: '$k_1/2.303$', as contained in equation 1, from which the first-order kinetic rate constant, k_1 was evaluated. Also, Eddy et al (2009) reported that k_1 is related with the time taken for the loaded inhibitor sample to be adsorbed by the material by half (the half life) as stated in equation 2.

$$t_{1/2} = \frac{0.693}{k_1} \qquad (2)$$

Thus, equation 2 was employed to evaluate the half life values for the cases under study, and the values of k_1 and the corresponding values of $t_{1/2}$ (for study sample) are presented in Table 1.

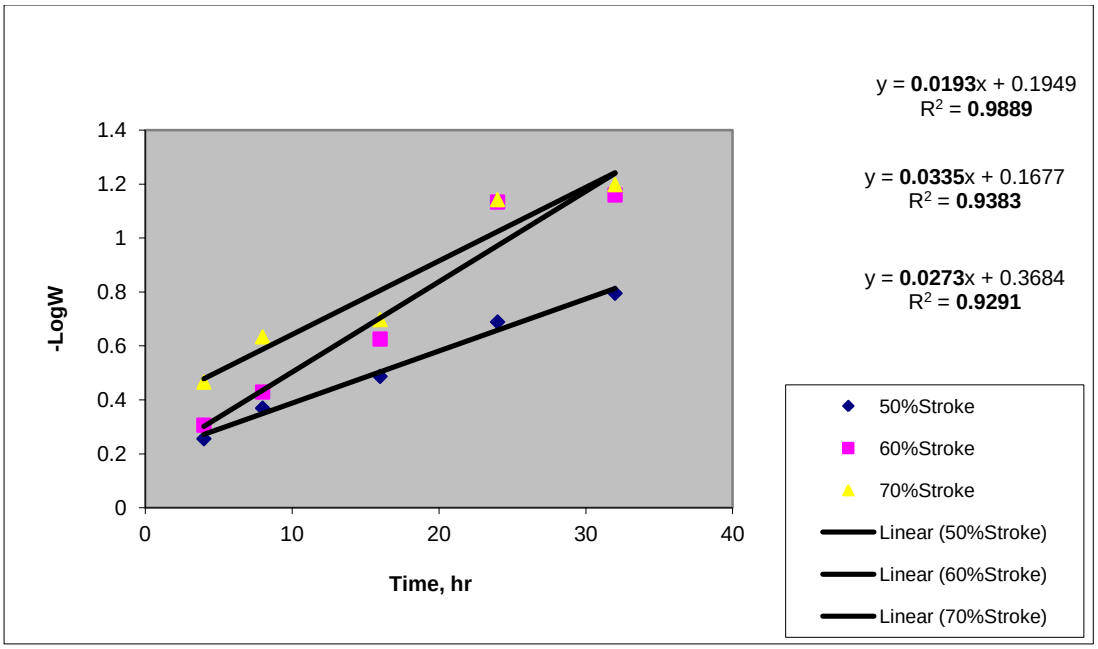

Fig. 1: Kinetic Plot at C_o = 10g/L, 40°C in the Presence of Inhibitor- EERSO

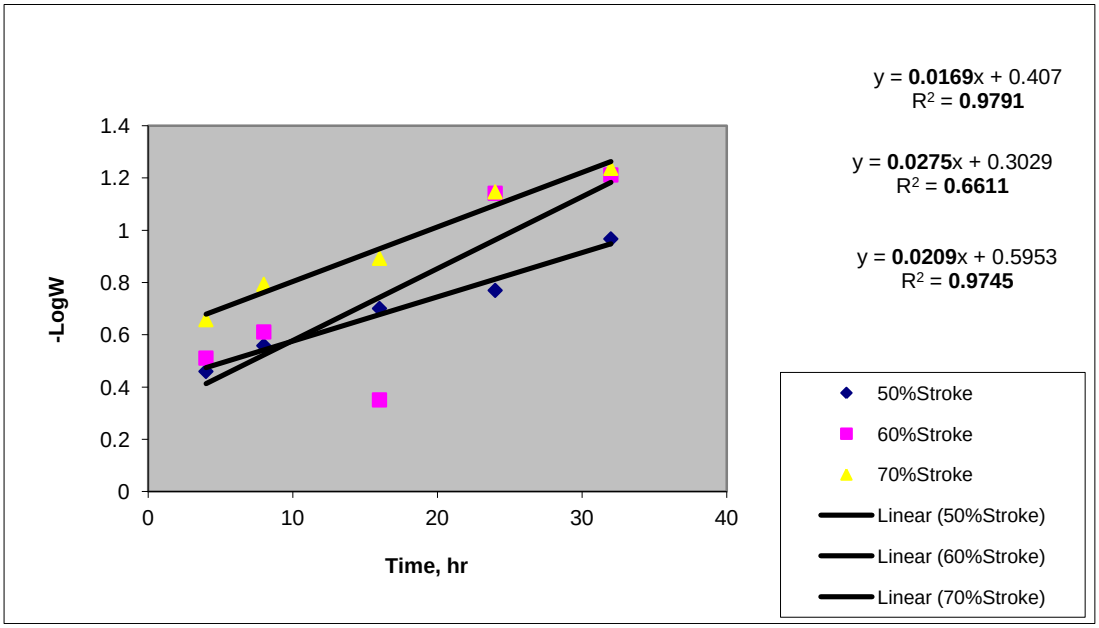

Fig. 2: Kinetic Plot at C_o = 10g/L, 40°C in the Absence of Inhibitor- EERSO

Table 1: Kinetic Parameters

Dozing Rate (% Stroke)	With Inhibitor			Without Inhibitor		
	K_1	$t_{1/2}$	R^2	K_1	$t_{1/2}$	R^2
50	0.044	15.750	0.9889	0.039	17.769	0.9791
60	0.077	9.000	0.9383	0.063	11.000	0.6611
70	0.063	11.000	0.9291	0.048	14.438	0.9745

The plots of the kinetic study, in Figures 1 and 2 have positive slopes, indicating a direct variation between the reduction (degradation) in the integrity of the material and time. In other words, weight loss (due to corrosion) increase with time in a given corrosion environment (Amadi, 2006). The values of first order kinetic rate constant (k_1) were all positive, indicating the continuous need for kinetic energy during the corrosion reaction. The values of the half life, $t_{1/2}$ could be observed to be higher at blank conditions than they are when inhibitor is present, at the various dozing rates. This indicates that adsorption of the corrosion medium by the material is higher in blank solution, which makes the steel pipe more susceptible to corrosion effects. However, the values of coefficient of determination (R^2), as presented in Tables 1, range from 0.6611-0.9889; this indicates a good fit of the data points.

CONCLUSION

Kinetic study helps us to further appreciate the impacts of kinetic energy in chemical processes. The present study affirms that the rate of corrosion of a given material, under given corrosion conditions, is directly proportional to the time taken for the corrosion reaction to occur. The kinetic rate constant (k_1) indicates the continuous need for kinetic energy during the corrosion reaction. The half life, $t_{1/2}$ indicates that the inhibitor sample was able to inhibit corrosion of the mild steel to a reasonable extent, under the study conditions.

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APPENDIX 1- Weight Difference at Various Time and Dozing Rate

A. 10g/L at 40°C, at 50% STROKE

S/N	Time, hr	WITH INHIBITOR		WITHOUT INHIBITOR	
		Weight Loss, g	-LogW	Weight Loss, g	-LogW
1	4	1.8024	0.2559	2.8841	0.4600
2	8	2.3412	0.3694	3.6182	0.5585
3	16	3.0681	0.4869	5.0213	0.7008
4	24	4.8853	0.6889	5.8898	0.7701
5	32	6.2418	0.7953	9.2673	0.9670

B. 10g/L at 40°C, at 60% STROKE

S/N	Time, hr	WITH INHIBITOR		WITHOUT INHIBITOR	
		Weight Loss, g	-LogW	Weight Loss, g	-LogW
1	4	2.0246	0.3063	3.2426	0.5109
2	8	2.8126	0.4291	4.0829	0.6110
3	16	4.2214	0.6255	2.2438	0.3510
4	24	13.6010	1.1336	13.8591	1.1417
5	32	14.4429	1.1597	16.2860	1.2118

C. 10g/L at 40°C, at 70% STROKE

S/N	Time, hr	WITH INHIBITOR		WITHOUT INHIBITOR	
		Weight Loss, g	-LogW	Weight Loss, g	-LogW
1	4	2.9221	0.4657	4.5502	0.6580
2	8	4.3012	0.6336	6.2133	0.7933
3	16	4.9844	0.6976	7.8132	0.8928
4	24	13.8692	1.1421	14.0234	1.1469
5	32	15.7724	1.1979	17.2582	1.2370