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EFFECTS OF PROCESS PARAMETERS ON MILDSTEEL CORROSION INHIBITION BY ETHYL ESTER OF RUBBER SEED OIL

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Abstract: This research was anchored on the Effects of Process Parameters on Mildsteel Corrosion Inhibition by Ethyl Ester of Rubber Seed Oil. The research interest is traceable to the fact that rubber seed oil has recently gained a lot of attention in corrosion inhibition applications (probably due to its well established phytochemical characteristics). The seed oil was esterified after extraction and purification (degumming), in order to enhance its performance ability. Results of Corrosion Inhibition assessment showed that corrosion rate (with time) increased as concentration, temperature and dosage increased. For cases with inhibitors, the weight loss was least (*1.8024g*) at 10g/L concentration and temperature of 40°C, but was highest (*24.2275g*) at 20g/L concentration and temperature of 60°C; the same trend was found to apply in blank conditions as well. Similarly, the highest weight losses (at all reaction conditions) were witnessed at the highest dosage (70% stroke), within a given time, and vice versa. The R^2 values for all the cases fall between *0.7868* and *0.9922*, indicating strong fitness of the data points. Generally, corrosion rate could be observed to be higher at blank cases than in cases with inhibitors; this shows that the rubber seed oil was able to inhibit mildsteel corrosion within the stipulated experimental conditions. Generally, the results obtained in this study suggest that ethyl ester of rubber seed oil has the capacity to inhibit mildsteel corrosion.

Keywords: Effects, Process Parameters, Corrosion Inhibition, Mildsteel, Rubber Seed Oil

INTRODUCTION

Natural rubber, also called India rubber, (as initially produced) consists of polymers of the organic compound called isoprene, with minor impurities of other organic compounds plus water. It has vegetable origin, and is created by enzymatic process in many plants, belonging mainly to families of Euphorbiacea, Compositea, Moracea and Apocynacea (Kang *et al*, 2000; Xie *et al*, 2008). The rubber seed (from which the rubber seed oil is derived) is industrially achieved from the rubber tree-*Hevea Brasiliensis*, belonging to the Euphorbiacea family. It is grown in a plantation way in warm (average monthly temperature of 25-28°C) and humid (about 80% humidity) climate of South-Eastern Asia (*Malaysia, India,*

China, Sri Lanka and Vietnam), in Western Africa (*Nigeria and Cambodia*) and in Northern part of South America (*Brazil and Guatemala*). Rubber seed oil is also of commercial importance. Hitherto, rubber seed has, in the past, largely been allowed to waste, with very small quantity used for raising root stock seedlings for propagation purposes (Uzu *et al*, 1985; Thomas *et al*, 1998). The useful properties of the rubber seed oil makes it similar to well-known linseed and soyabean oil (Aigbodion, 1994; Achmad, *et al*, 2012). Rubber seed oil, also, could be used for the paint industry as semi-drying oil, in the manufacturing of soap, for production of linoleum and alkyd resin. It could also serve important medical purposes as antimalaria oil, in engineering as core binder for factice preparation, and the cake left after extraction of the oil could be used in fertilizer preparation and as feed for cattle and poultry (Uzu *et al*, 1985; Thomas *et al*, 1998). Sakhri *et al* (2011), also, documented that rubber seed oil has been, recently, widely utilized for inhibition of metallic corrosion through varying applications. The chemical enhancement of the oil properties, through acid esterification, gives it a larger disposition to inhibit metallic corrosion.

Theoretical Principles of Metallic Corrosion

The mixed potential theory consists of two simple hypotheses. The first hypothesis states that any electrochemical reaction can be divided into two or more partial oxidation and reduction (redox) reactions; the second is that there can be no net accumulation of electric charge during an electrochemical reaction. The second hypothesis is a restatement of the law of conservation of charge. It follows that during the corrosion of an electrically isolated metal sample, the total rate of oxidation must be equal to the total rate of reduction. Corrosion involves the destructive attack of metal material by chemical or electrochemical reaction with its environment. Usually, corrosion consists of a set of redox reactions that are electrochemical in nature. The metal is oxidized to corrosion products at anodic sites as shown in *equation 1*.

$$M \rightleftharpoons M^{2+} + 2e^{-} \qquad (1)$$

And hydrogen is reduced at the cathodic sites as shown in *equation 2*.

$$2H^{+} + 2e^{-} \rightleftharpoons H_2 \qquad (2)$$

Because of the electrochemical nature of most corrosion processes, electrochemical methods are used for studying corrosion. More specifically, electrochemical techniques can be used to measure the kinetics of electrochemical processes (such as corrosion rates) in specific environment, and also to measure and control the oxidizing power of the environment.

MATERIALS AND METHOD

Rubber Seed Oil Preparation

The rubber seeds used for this study were collected (picked) from the Imo Rubber Estate, Obiti-Ohaji in the Ohaji/Egbema L.G.A. of Imo State, Nigeria. The seeds were de-shelled and sun-dried for forty-eight (48) hours, after which they were collated and ground to finer forms. Then 1418.1818g of the ground rubber seed was impregnated in 2litres of petroleum ether solution for 18hours, after which the mixture was subjected to mechanical pressure. The solvent was sequentially recovered from the mixture (of oil and petroleum ether), through a controlled heat application (by means of a heating mantle) at the temperature of 60°C, using a soxhlet extractor; the oil was then collected as a reflux. Hot water method of degumming was used to remove any possible traces of the used solvent present in the mixture. In this regard, 1ml of the hot water was added to 50ml of the oil sample, and the mixture is placed in a water bath at 60°C for 10minutes. At the elapse of the time, the mixture was then placed under the action of a centrifuge at 80rpm for 5minutes. The process tactically separates the gums (formed) from the pure sample of the oil, which was isolated by simple decantation.

Acid Esterification of the Oil Sample

The oil sample was converted to esters to enhance its performance as inhibitor of mildsteel corrosion. The esterification of oil sample was performed according to the procedure reported in Offurum *et al* (2017). The esterification process of the sample was performed in 1litre size of beaker, using 50ml of the oil. The measured volume of the oil was poured in the flasks differently and heated up to 60°C. Then 45% volume per volume (v/v) methanol was added to the preheated samples and stirred for 3minutes by means of magnetic stirrer. 0.5% sulphuric acid was added to the mixture, while heating and stirring continued for about 45minutes at atmospheric pressure. After completion of the reaction (within this specified time), the mixture was poured into a separating funnel, to separate the excess alcohol, impurities and sulphuric acid. The alcohol, impurities and sulphuric acid settles at the top of the funnel, while the esterified oil (which is denser) settles below. The oil was then carefully collected from the funnel.

Corrosion Inhibition Assessment

The corrosion inhibition assessment of the mildsteel material by the Ethyl Ester of Rubber Seed Oil (EERSO) was conducted in accordance with the procedure reported by Offurum *et al* (2017). The process parameters considered are Temperature, Concentration and Dosage. A flow system, designed with a standard water bath and a dozing pump was used for the inhibition assessment. The two ends of a mildsteel pipe (of weight, W_i), were fitted into different points of a sizeable hose, connected to a dozing pump. The hose was held firmly in

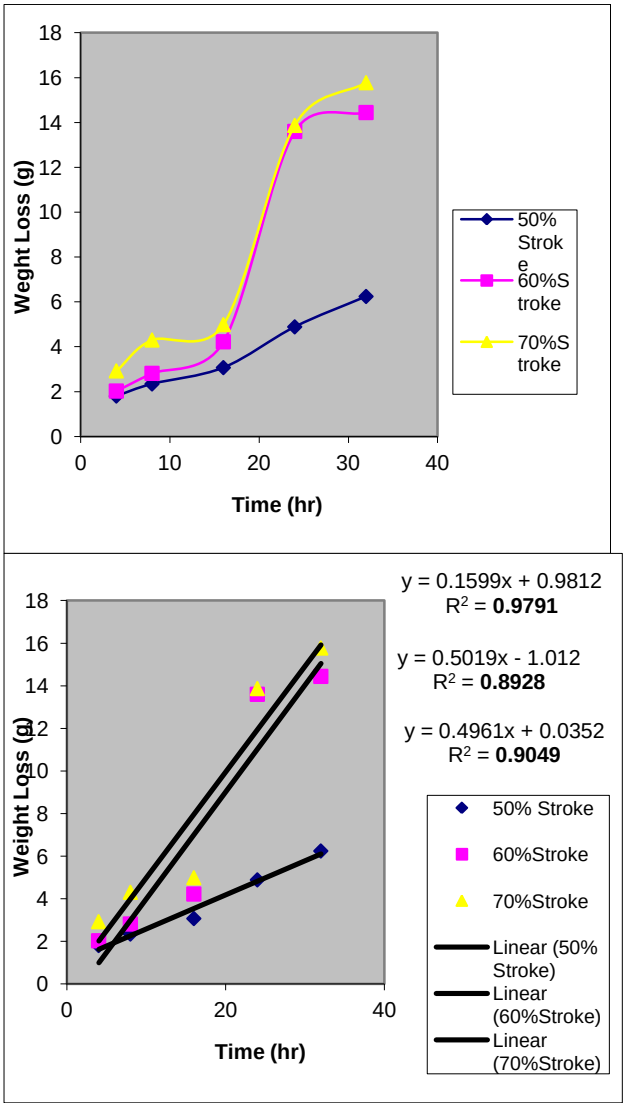
position by means retort stand. Another hose (that served as the recycle stream) was connected from the outlet of the dozing pump back to a reservoir (a plastic bowl), from where a given concentration (10g/L) of the inhibitor (EERSO) is fed through the mildsteel pipe; the reservoir was securely placed in a thermostat water bath, containing a reasonable quantity of water and set at 40°C. After 4hours of the acid medium circulation (through the system), the steel pipe was removed, rinsed (with distilled water), dried in an oven for about 3minutes and reweighed (to obtain the weight, W_2); the same procedure was used for the blank. The procedure was repeated for the inhibitor-in-acid concentrations of *15 and 20g/L* at different temperatures of *50, 60°C* and times of *8, 16, 24 and 32hours* for the varying dosages of *50, 60 and 70% strokes*, and the weight differences were evaluated and recorded accordingly as presented in *Appendix 1*.

Data Plots of the Relationships

For a better appreciation of the effects of the process variables on the response variable (*the weight loss*), curves of the weight differences against time were plotted, at different experimental conditions, using *MS-Excel software*. Also, linear forms of the graphs were plotted for due accentuations of possible similarities.

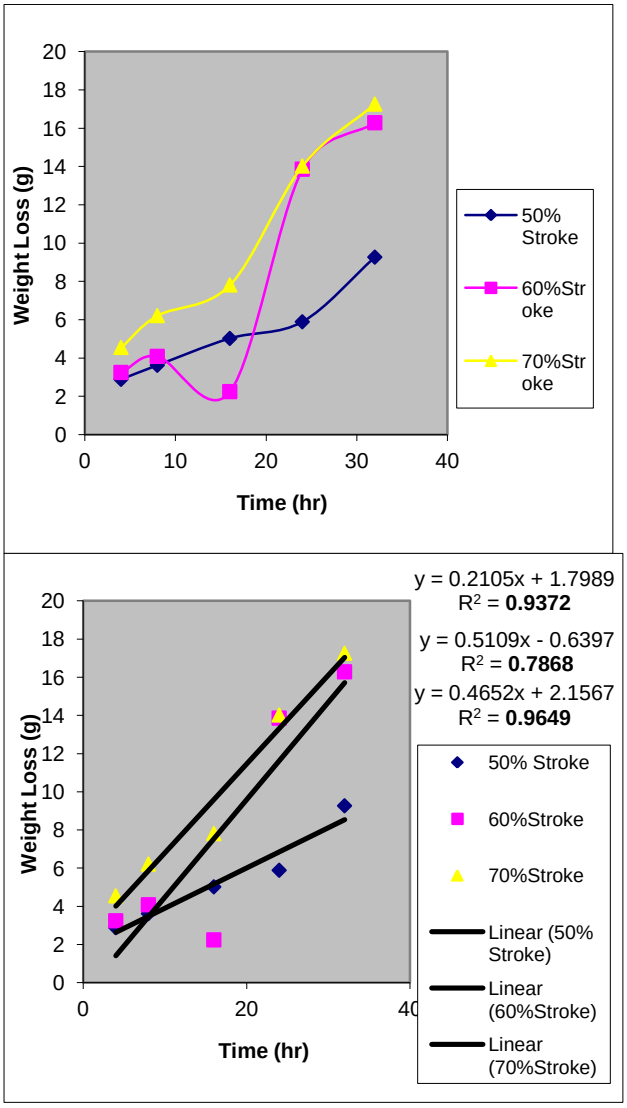
DISCUSSION

The results of the weight loss, in the presence and absence of the inhibitor (EERSO) for 10g/L concentration (40°C) at different dosages are presented in *Figures 1* and *2* respectively, while those for 15g/L (50°C) and 20g/L (60°C) are respectively presented in *Figures 3* and *4* (in the presence of inhibitor) and *Figures 4* and *6* (at blank). The linear plots (with trend lines) that display the equations of the lines and their corresponding coefficients of determination are placed side-by-side with the curves for necessary comparisons.



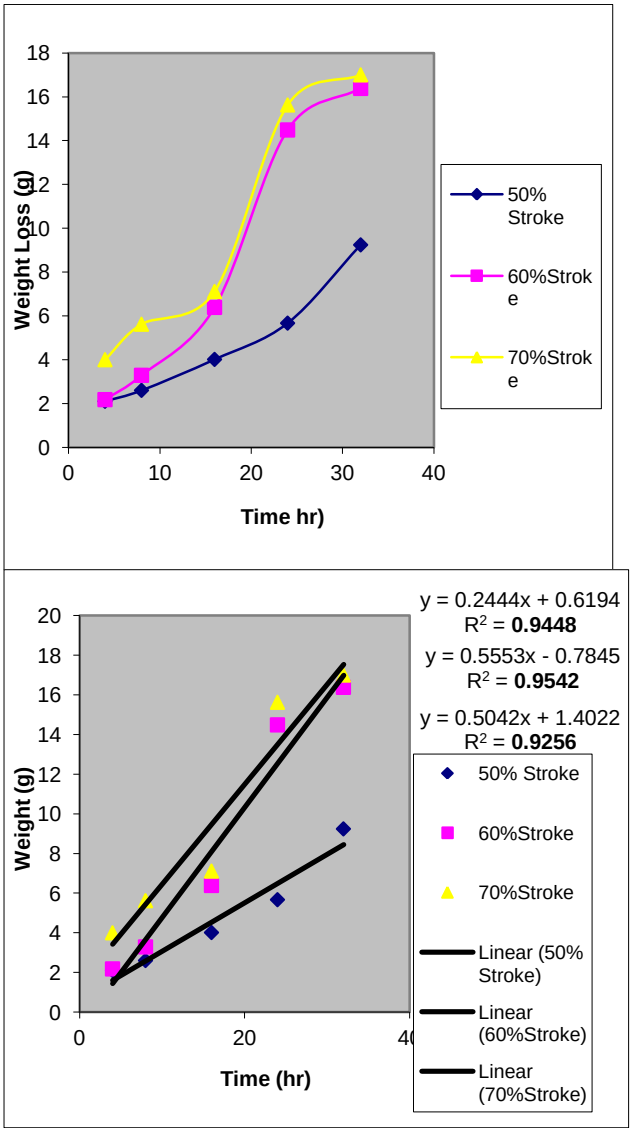
(a) Curve Fit *(b) Linear Fit*

Fig. 1: Weight Loss vs Time at Varying Dozing Rate, with Inhibitor *(for 10g/l and 40°C Conditions)*



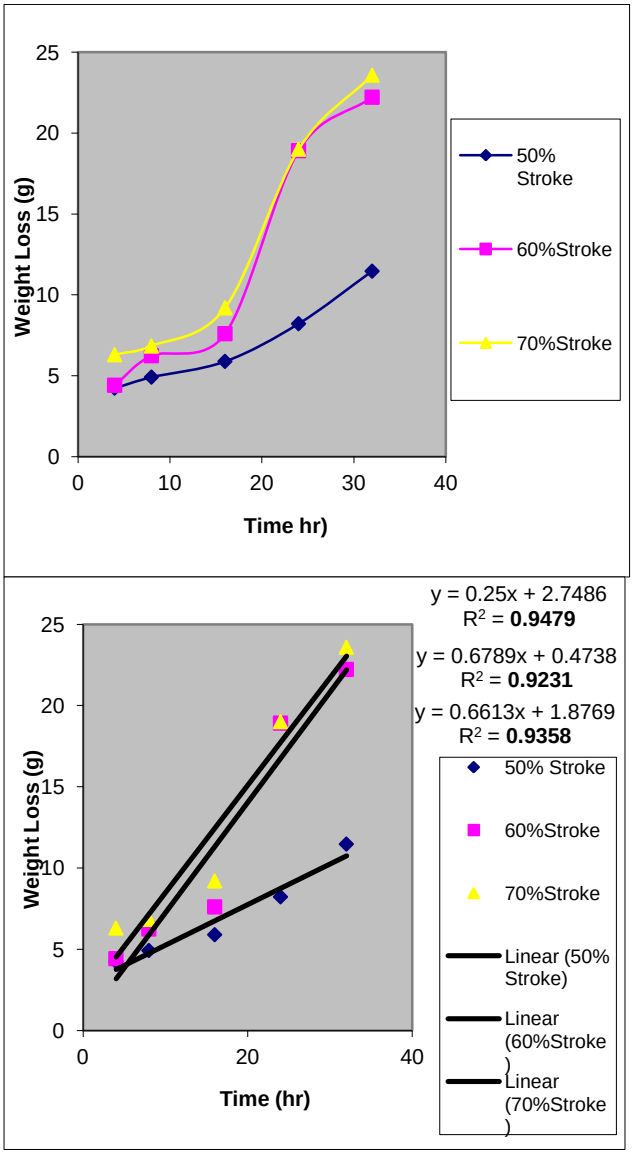
(a) Curve Fit *(b) Linear Fit*

Fig. 2: Weight Loss vs Time at Varying Dozing Rate, at Blank *(for 10g/l and 40°C Conditions)*



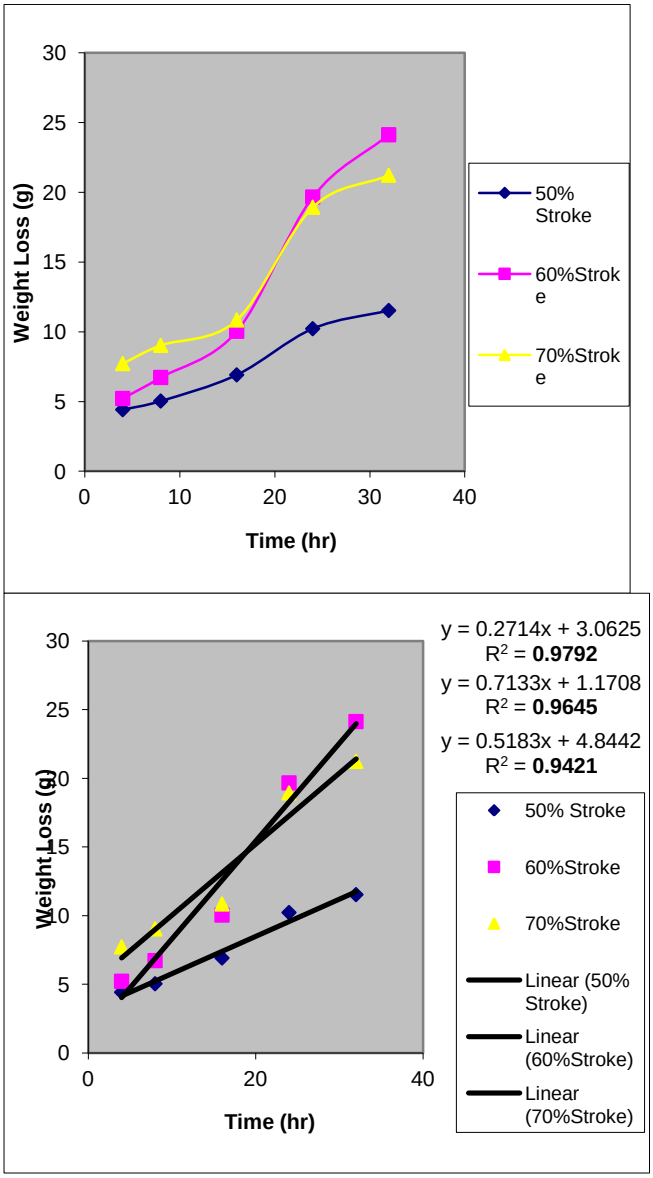
(a) Curve Fit *(b) Linear Fit*

Fig. 3: Weight Loss vs Time at Varying Dozing Rate, With Inhibitor *(for 15g/l and 50°C Conditions)*



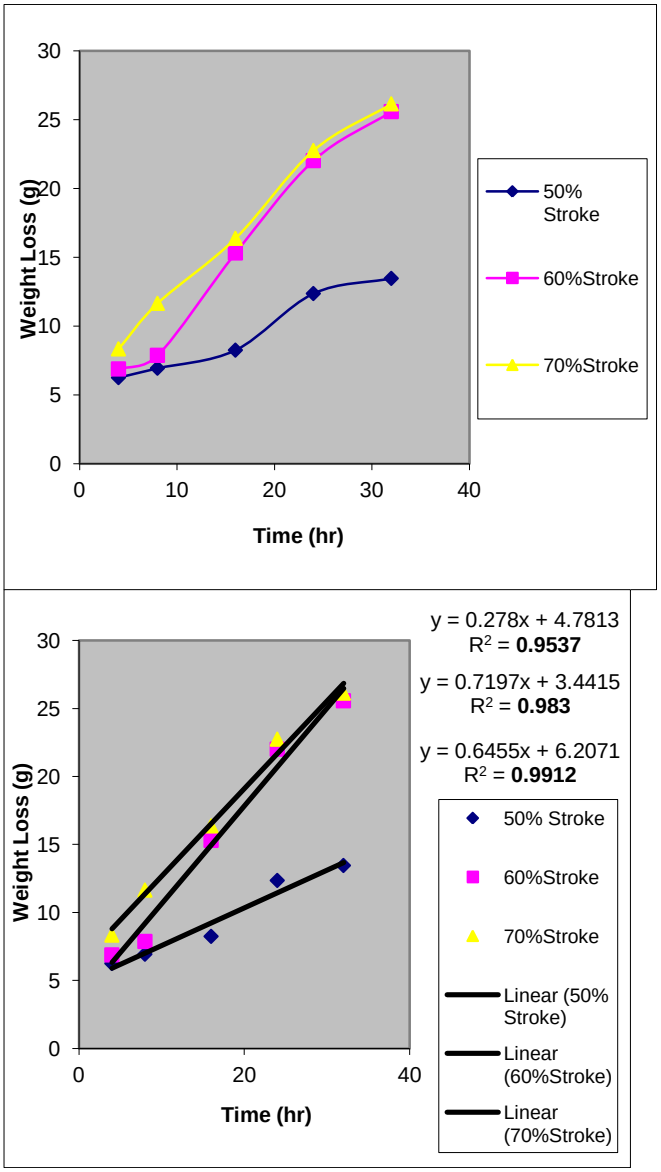
(a)Curve Fit *(b) Linear Fit*

Fig. 4: Weight Loss vs Time at Varying Dozing Rate, at Blank *(for 15g/l and 50°C Conditions)*



(a) Curve Fit *(b) Linear Fit*

Fig. 5: Weight Loss vs Time at Varying Dozing Rate, With Inhibitor *(for 20g/l and 60°C Conditions)*



(a)Curve Fit *(b) Linear Fit*

Fig. 6: Weight Loss vs Time at Varying Dozing Rate, at Blank *(for 20g/l and 60° C Conditions)*

The plots (presented in *Figures 1-6*) considered the effect of concentration, temperature and dosage on weight loss, at various times. The results show that weight loss increases with increase in the process variables (Concentration, Temperature and Dosage). This is because increase in dozing rate per unit time implies increase in volume (and of course increase in concentration) of the acid medium through the metal (mildsteel pipe). And, in agreement with the gas laws, greater concentration of the acid will lead to greater effect (Philips, 2003). On the other hand, higher temperature would always increase the reaction rate, which in turn, reduces the activation energy of the process (Solomon, 2012). This means that at higher temperature, it will take only a little time to complete the

corrosion process, and as time proceeds, more and more losses in the in the integrity of the material is witnessed; this is in conformity with the results of a similar and recent work done by Offurum *et al* (2017). The equation of the lines, for all the cases, have positive slope, with each line passing through the positive part of the vertical axis. This demonstrates a continuous (direct) proportionality between the response variable (weight loss) and the reaction time. It could, also, be observed that *Weight Loss* was highest at 70% stroke for all the cases assessed, in support for increased dosage per unit time. The R^2 values for all the cases fall between *0.7868* and *0.9922*, indicating strong fitness of the data points. Generally, corrosion rate was observed to be higher at blank cases than in cases with inhibitors; this shows that the rubber seed oil was able to inhibit mildsteel corrosion within the stipulated experimental conditions.

CONCLUSION

This study affirms that process parameters (such as concentration, temperature and dosage) affect the rate of mildsteel (metallic) corrosion at a given time interval. Increase in the process parameters considered increased the rate of corrosion, which eventually results to higher weight losses. Weight loss was found to be higher in blank conditions, when compared with the cases with inhibitor, suggesting that ethyl ester of rubber seed oil has the capacity to inhibit mildsteel corrosion.

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APPENDIX 1

(A) 10g/l at 40°C *(with inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	1.8024	2.0246	2.9221
2	8	2.3412	2.8126	4.3012
3	16	3.0681	4.2214	4.9844
4	24	4.8853	13.6010	13.8692
5	32	6.2418	14.4429	15.7724

(B)10g/l at 40°C *(without inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	2.8841	3.2426	4.5502
2	8	3.6182	4.0829	6.2133
3	16	5.0213	12.2438	7.8132
4	24	5.8898	13.8591	14.0234
5	32	9.2673	16.2860	17.2582

(C) 15g/l at 50°C *(with inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	2.1031	2.1775	4.000
2	8	2.6012	3.2876	5.6212
3	16	4.0133	6.3878	7.1121
4	24	5.6690	14.4873	15.6284
5	32	9.2419	16.3838	17.0026

(D) 15g/l at 50°C *(without inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	4.2418	4.4175	6.3024
2	8	4.9204	6.2444	6.8412
3	16	5.8916	7.6036	9.2016
4	24	8.2212	18.9128	19.0029
5	32	11.4681	22.2155	23.5816

(E) 20g/l at 60°C *(with inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	4.4161	5.2178	7.7218
2	8	5.0347	6.7234	9.0291
3	16	6.9121	10.0388	10.8469
4	24	10.2219	19.6624	19.9342
5	32	11.5263	24.1285	24.2275

(F) 20g/l at 60°C *(without inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	6.2551	6.8827	8.3403
2	8	6.9359	7.8726	11.6519
3	16	8.2480	15.3102	16.3728
4	24	12.3611	22.0182	22.7536
5	32	13.4612	25.5783	26.1404

Reference to this paper should be made as follows: Offurum, J.C.; et al (2017), Effects of Process Parameters on Mildsteel Corrosion Inhibition by Ethyl Ester of Rubber Seed Oil. *J. of Sciences and Multidisciplinary Research,* Vol. 9, No. 2, Pp. 1-13