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

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Abstract: This research work was focused on the effects of process parameters on mildsteel corrosion inhibition by ethyl ester of castor seed oil. This was motivated by the necessity of creating a formidable alternative (through castor oil generation) to deal with the menace of corrosion in our industries, and to assess the sensitive factors that affect the corrosion process. Standard methods were employed during the oil generation and its subsequent performing ability enhancement through acid esterification. Corrosion study conducted at varying reaction conditions of concentration, temperature and dosage showed that corrosion rate increases in the direction of increased process parameters; the least value of the weight loss (2.3146g) was recorded at the lowest concentration (10g/L), temperature (40^{o}C) and Dosage (50% stroke), while the highest weight loss (37.1825g) was recorded at the highest concentration (20g/L), temperature (60^{o}C) and Dosage (70% stroke). Corrosion rate was also found to increase with time, and was more established in cases of blank conditions when compared with those with inhibitors. Generally, the castor seed oil was found to have ability of inhibiting mildsteel corrosion substantively, and as such is recommended for advanced chemical engineering applications.

Keyword: Effect, Process Parameter, Mildsteel, Corrosion Inhibition, Castor Seed Oil.

INTRODUCTION

Castor oil is derived from the seed of *Ricinus Communis L.* (the castor plant), which grows in tropical or subtropical regions such as Asia, Tanzania, Brazil and Southern Kazakhstan. It occurs as a perennial or annual plant, and is a drought resistant crop (especially in India). Unfortunately in 1972, economic pressures created circumstances which led to the United States losing its domestic supply of the oil and as such became dependent on foreign countries for supply of both the seed and the oil (Mutlu and Meier, 2010)). According to the report, the U.S. became many years behind in the oil expression technology. However, the expression from the castor seed is done in a similar manner to most other oil seeds. The seeds are collected when ripe, and then opened and discharged. The seeds are cleaned, decorticated, cooked and dried prior to extraction. Cooking is done in order to coagulate the protein, which is necessary to permit efficient extraction, and to free the oil after efficient pressing. It is usually done within a moderate temperature (about 80°C), under airtight conditions. After cooking, the material is dried at 100°C, to remove the moisture content of approximately 4 percent. Once the oil has been expressed from the seed, it is necessary to remove any impurities from the oil that may distort its performance efficiency. The oil is essentially a pure triglyceride, and contains almost 90% of glyceryl tricinoleate and tricinoleic triglyceride that is needed to produce high quality performance. Some of the important features that characterize the castor oil include high density, viscosity and reactivity, compared to the triglycerides of other similar vegetable oils. These properties are exploited when refining the oil from the impurities. Castor oil affords a wide range of reaction in the oleochemical industry, and unique chemicals are derivable from it. These derivates are on par with petrochemical products for use in several industrial applications. In fact, they are considerably superior since they are from renewable

sources, biodegradable and eco-friendly (Wilson *et al*, 1998).

The oil is regarded as one of the most applicable vegetable oils in the field of medicine; it forms clean, light-coloured soap, which dries and hardens well. It is an excellent solvent of pure alkaloid in such solutions of Atropin, Cocaine, and so on, as are used in ophthalmic surgery. Above all, castor seed oil also finds increasing uses in the industrial applications such as in corrosion inhibition of metallic materials, the manufacture of artificial leather used in upholstery, and also furnishes the colouring for butter. The recent use of the oil for corrosion inhibition applications is as a result of established phytochemical features in the oil sample (Harbone, 1998). Castor oil is an essential component in artificial rubber-making, in various descriptions of celluloid, and in making of certain waterproof preparations, as well as in the manufacture of transparent soaps. It also furnishes sebacic acid, which is employed in the manufacture of candles.

MATERIALS AND METHOD

Castor Seed Oil Preparation

The castor seeds, from which the oil sample was extracted, were bought at a local market in Ekwulobia-Aguata in Anambra State of Nigeria. The seeds were sun-dried, deshelled and ground into fine powder. 2346.1538g of ground (powdered) castor seed was impregnated in 2.5litres of n-hexane for 24hours, and the mixture was subjected to mechanical pressure. The *'solvent-solute'* mixture was then fed to a soxhlet extractor for 8hours at 60°C; the heating mantle was used to supply the required heat content. The solvent was afterwards recovered from the mixture as a condensate.

The oil collected was further subjected to hot-water degumming, which is intended to remove hydratable gums, as well as other hydrophilic substances (such as carbohydrates). During the process, 3.7ml of hot water (2%-volume of total oil) was added to the oil at a temperature between 60°C, such that the water and the oil are mixed for about 10minutes. While the phospholipids absorb the water (thus

becoming insoluble in the oil), the insoluble phospholipids inter-combine to form the gum. The gum was then separated through centrifugation, giving rise to a pure sample of the oil.

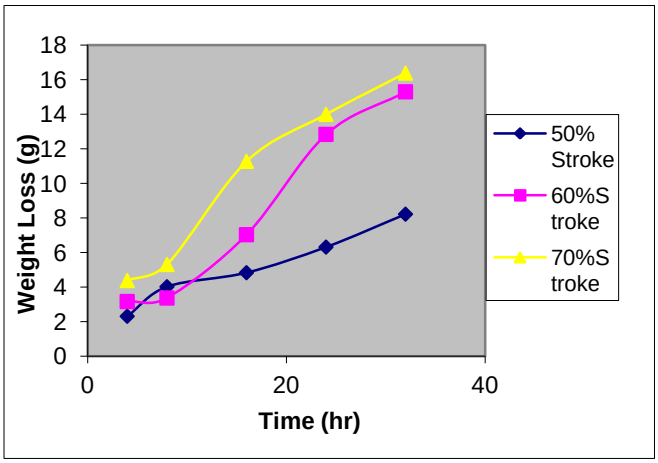
Acid Esterification of the Oil Sample

The oil sample was converted to esters for better performance as inhibitor of mildsteel corrosion. The esterification of oil sample was achieved following procedure reported in Yordanov and Petkov (2008). 100ml of the Sample (Castor Seed Oil) was measured into a volumetric flask, and heated up to 60°C. Then 45% volume per volume (v/v) methanol was added to the preheated sample and stirred for 3minutes by means of magnetic stirrer. 0.5% sulphuric acid was added to the mixture; 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 carefully collected from the funnel.

Corrosion Inhibition Assessment

The corrosion inhibition assessment of the mildsteel material by the Ethyl Ester of Castor Seed Oil (EECSO) was conducted using weight loss analysis in a flow system. The process parameters considered are Temperature, Concentration and Dosage. In the flow system, both ends of the mildsteel pipe, of weight, W_1, were fused into different points of a sizeable hose, connected to a dozing pump. The hose is held firmly in position by means retort stand. Another hose, used as 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 (EECSO) 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 medium circulation (through the

system), the steel pipe was removed, 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*.

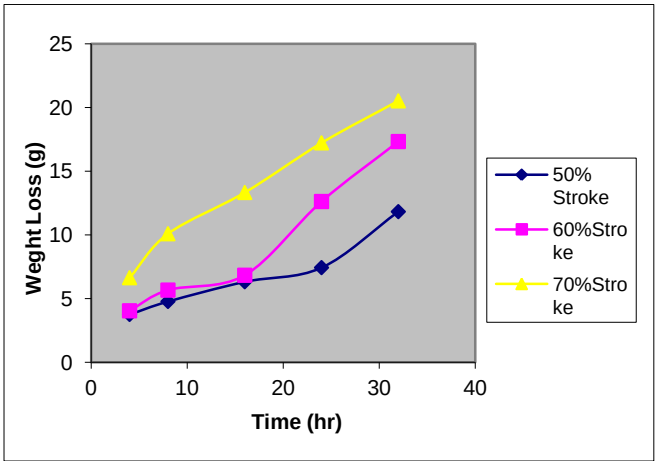


(a) With Inhibitor

washed gently (with distilled water),

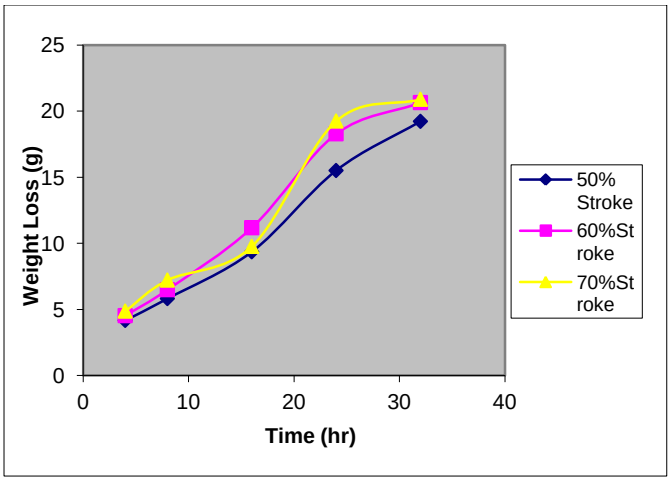
RESULT AND DISCUSION

The linear relationship between the Weight Loss and the Process Time (at the various temperatures and concentrations) were plotted using *MS-Excel software*. The results of the curves of cases with inhibitors are placed side-by-side with those at blank conditions for appropriate comparison. The results of the cases are presented in *Figures 1, 2 and 3* for Concentrations of 10g/L *(Temp.= 40°C)*, 15g/L *(Temp.= 50°C)* and 20g/L *(Temp.= 60°C)* respectively.

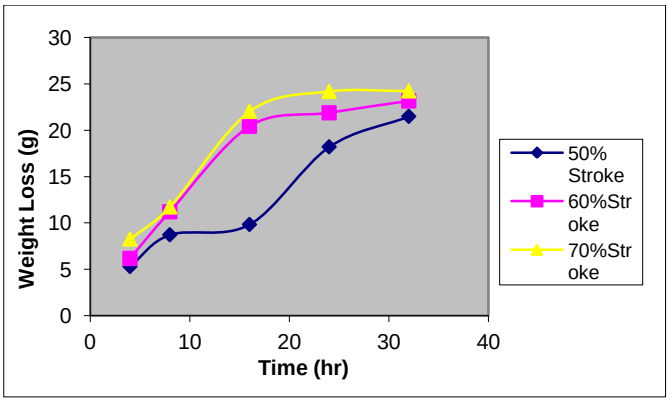


(b) Without Inhibitor

Fig. 1: Weight Loss vs Time at Varying Dosages *(Conc.=10g/L, Temp.=40°C)*

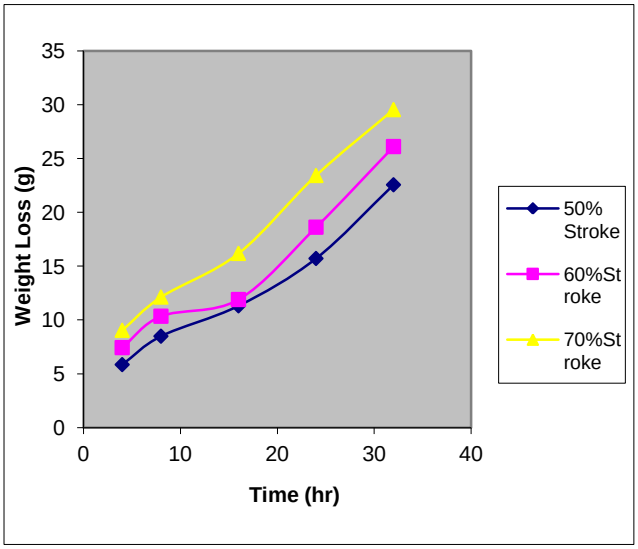


(a) With Inhibitor

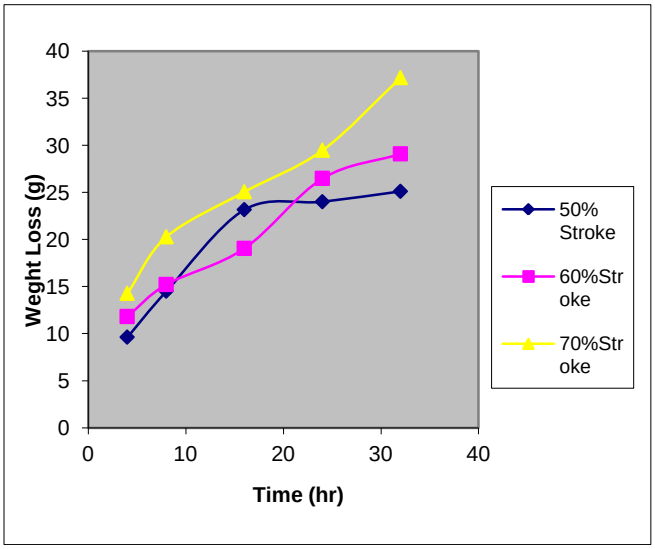


(b) Without Inhibitor

Fig. 2: Weight Loss vs Time at Varying Dosages *(Conc.=15g/L, Temp.=50°C)*



(a) With Inhibitor



(b) Without Inhibitor

Fig. 3: Weight Loss vs Time at Varying Dosages *(Conc.=20g/L, Temp.=60°C)*

The plots of *Figures 1-3* show that *Weight Loss* increases with increase in *Time* at all reaction conditions for the study sample. The curves demonstrate that there is a continuous (direct) proportionality between the weight loss and the reaction time. For each of the cases, it could also be observed that weight loss was higher at blank conditions when compared with the ones with inhibitors. This shows that ethyl ester of castor seed oil has the ability of inhibiting mildsteel corrosion at the

given conditions; a similar finding was made by Undiandeye *et al* (2014).

Also, the *Weight Loss* was observed to be increase in the direction of increasing dosage. In other words, corrosion rate was highest at 70% stroke for all cases assessed, and least at 50% stroke. This is traceable to the fact that increase in rate of dosage increases the rate of bombardment of fluid molecules (entering the steel pipe), thereby increasing the kinetic energy of the system; this manifests in the higher degradation impact observed on the material at blank conditions. It could be observed also that the weight loss increases with increase in the reaction temperature for all the cases studied; this normally applies to corrosion as applicable to most exothermic reactions. Weight loss was also observed to be highest *(29.5454g and 37.1825g respectively for presence of inhibitor and at blank)* when temperature is highest (*60°C*), but least *(2.3146g and 3.7453g respectively for presence of inhibitor and at blank)* when temperature is least (*40°C*)

CONCLUSION

The present study shows that corrosion process in a given time, as well as its inhibition, is affected by process parameters such as inhibitor concentration, temperature and dosage. Corrosion of a material (with time), in given corrosion environment, increases in the direction of increasing concentration of inhibitor, temperature and dosage. Corrosion rate was found to be higher in cases where inhibitors are not present (that is at blank conditions). With the proportionality of temperature factor and the response factor (that is corrosion rate), corrosion was once more proven to be exothermic in nature.

Generally, the study shows that ethyl ester of castor seed oil is able to inhibit mildsteel corrosion under the stipulated study conditions, and is thus recommended for advanced applications in chemical engineering.

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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	*2.3146*	*3.1681*	*4.3813*
2	8	*4.0219*	*3.3716*	*5.3106*
3	16	*4.8346*	*7.0348*	*11.2753*
4	24	*6.3172*	*12.8365*	*13.9926*
5	32	*8.2214*	*15.3012*	*16.3827*

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

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	*3.7453*	*4.0317*	*6.6281*
2	8	*4.7664*	*5.6551*	*10.0816*
3	16	*6.3128*	*6.8224*	*13.3188*
4	24	*7.4217*	*12.6103*	*17.2140*
5	32	*11.8161*	*17.3168*	*20.5111*

(C) 15g/l at 50°C *(with inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	*4.1671*	*4.5263*	*4.8694*
2	8	*5.8174*	*6.4907*	*7.2153*
3	16	*9.3566*	*11.1778*	*9.7629*
4	24	*15.5027*	*18.2817*	*19.2471*
5	32	*19.2218*	*20.6418*	*20.8918*

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

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	*5.2993*	*6.1715*	*8.2592*
2	8	*8.7232*	*11.2010*	*11.7149*
3	16	*9.8341*	*20.4134*	*22.0146*
4	24	*18.2005*	*21.8703*	*24.1755*
5	32	*21.4840*	*23.1465*	*24.2222*

(E) 20g/l at 60°C *(with inhibitor)*

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	*5.8514*	*7.4317*	*9.0422*
2	8	*8.4915*	*10.3484*	*12.1285*
3	16	*11.3118*	*11.8996*	*16.1819*
4	24	*15.7144*	*18.6218*	*23.4251*
5	32	*22.5619*	*26.1153*	*29.5454*

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

S/N	TIME (hr)	PERCENT STROKE		
		50%	60%	70%
1	4	*9.6221*	*11.8126*	*14.2647*
2	8	*14.5052*	*15.2115*	*20.2776*
3	16	*23.1624*	*19.0473*	*25.0618*
4	24	*24.0043*	*26.4816*	*29.4751*
5	32	*25.1057*	*29.0887*	*37.1825*

Reference to this paper should be made as follows: Offurum, J.C.; Nwakaudu, M.S.; Ndukwe O.C. and Kamalu C.I.O. (2017), Effects of Process Parameters on Mildsteel Corrosion Inhibition by Ethyl Ester of Castor Seed Oil. *J. of Engineering and Applied Scientific Research*, Vol. 9, No. 1, Pp. 35 - 45