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EVALUATION OF GARCINIA KOLA (BITTER KOLA NUT EXTRACT) AS ANTI-CORROSION AGENT ON MILD STEEL IN SEAWATER.

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ABSTRACT :

Mild steel been more prevalently used alloys industrially today because of its outstanding properties such as durability, high strength, availability, and inexpensive etc. However, corrosive environments such as air, moisture and soil corrodes the metal through direct chemical and electrochemical reaction. This causes enormous adverse effect on the productivity of industries and countries. Hence there is need to apply eco-friendly material to inhibit corrosion. The inhibition of corrosion of mild steel in bitter kola nut extract solution in sea water has been evaluated by using weight loss measurement. By adding different dose of different of bitter kola nut extract solution as an inhibitor was studied at room temperature. The specimen was cut into five pieces and immersed in a container labeled A to E with container A having 10% of the inhibitor in the presence of seawater, B having 20% of the inhibitor in the presence of seawater, C having 30% of the inhibitor in the presence of seawater, D having 40% of the inhibitor in the presence of seawater while that of E container only seawater. After an interval of seven (7) days each specimen is dried up and brushed to remove results, reweighed to calculate weight loss. This was done for 28 days. It was observed that the weight loss is highest in the container that does not contain bitter kola nut extract also, the lesser the inhibitor, the higher the weight loss and so the corrosion increase. The data proves that percentage of inhibitor used are for reduction of corrosion rate and that the effect of bitter kola nut extract increases with an increase in its concentration. It shows maximum inhibitor efficiency at percentage of 30% and 40% inhibition of a 500ml concentration of the inhibition and 500ml of sweater. The characterization of specimen shows that the alloy consists mainly of Iron (Fe-98.61% ±0.287) and other additives such as Manganese (Mn-0.64±0.053), Chromium (Cr-0.27% ±0.019), Copper (Cu-0.18% ±0.026) and Titanium (Ti- 0.17±0.030).

Introduction

Seawater is aggressive and of course a complex media for metals. Marine corrosion actually depends on quite a number of interdependent values and factors that combines mechanically, chemically and biologically. The knowledge of the benefits derived from the values and factors is very important to the structures of metals used in aqueous environments and also the right step to the optimization of corrosion mitigation methods and materials performance (Chaves et al, 2013; Liu et al, 2018). However, localized corrosion became particularly an insidious declined phenomenon and very dangerous for the integrity of the metals structurally. Several restricted deterioration cases may cause major industrial failures even with a little intake of small quantity of materials but in seawater as a result of various combined factors such as mixed materials **(grain boundaries, welds and inclusions**), differential aeration, and processes that are biological; the corrosion effects though commonly addressed as being uniform, are often localized and the well-known Accelerated Low Water Corrosion (ALWC), resulting in differential aeration and bacteria effect which validates this point (Liduino et al, 2018). For marine involvement, carbon steels are widely applied because they are massively produced (~1.8 × 109 tons worldwide in 2018) and are actually less costly even while they are of good properties mechanically, but mild steels on the other hand offers to be the most commonly applied industrial materials in various units due to their mechanical strength, easy to manufacture, weldability, formability and low cost. They also mainly suffer uniform corrosion in more severe and aggressive environment such as marine or seawater due to their insufficiency and have been carried out for decades so that their corrosion rate can be modeled and their lifetime predicted right in various environments. (Edwin, B. 2019, Malik et al, 1999).

The different factors that affects chemical system of harsh media and immersion of metals to aggressive environments such as the use of acid solutions for pickling and the removal of dirt from oil refinery equipment, oil well acidizing and acid descaling usually lead to loss of the metal as a result of corrosion in which mild steel is of no exception. and this gives rise to seawater with different corrosion rates dependent on the area of activity of the bulk seawater mass (**Jones, 1992).** is as a result of the concentration of minor ions, salinity, biological activity and pollutants, concentration and access of dissolved oxygen. Much income has been spent on corrosion prevention, maintenance and replacement of lost products or contamination considering this fact, corrosion damage has been put as approximately 5% of any industrialized countries income. Thus, corrosion stands out as one of the greatest problem to the economy of any industrialized nation and corrosion of mild steel in seawater is also a major issue for many industries, including offshore oil and gas, marine transportation, and coastal infrastructure. Several reports have shown that inhibitive methods have been used to mitigate against corrosion effect and the use of inhibitors have revealed to be excellent and effective in the prevention of corrosion. Green inhibitors as a replacement of inorganic inhibitors which are now been discouraged as a result of environmental restriction, toxicity and costly are now been studied. Organic compounds contain hetero atoms such as O, S, N, polar group's π electrons which have been found to be inhibitive effectively in metallic corrosion when adsorbed

in surfaces of metals (Dass, et al. 2015). The recent trend is to save the environment and human being by using eco- friendly inhibitors. Studies carried out by researchers on the plant extracts and their derived organic species shows more relevance environmentally and readily available, renewable and acceptable source for a wide range of inhibitors(Mesbah et al.2007), (Okafor, et al. 2007) .For preventive measures towards combating corrosion, several efforts have been made using preventive practices and the use of green inhibitors. (Anuradha et al. (2008).These plant extracts are rich in molecules which have high inhibitive efficiency and so termed as "Green inhibitors (Bothi & Sethuraman 2008). Green inhibitors are biodegradable and are devoid of heavy metals or toxic compounds ((Shama et al). Some researcher have presented ghood use of naturally available green inhibitors to mitigate corrosion of metals in both alkaline and acidic environment (Valak, L. & Martinez, S. 2007, Ehteram, N.A. 2008**).** Plant extracts are good inhibitors (Amise et al., 2016) and as revealed from studies are biodegradable, less toxic and environmentally friendly (Papavinasam, 2016); Otunyo & Charles, 2018; Ezeugo, 2019; Verna et al., 2018). In a study **by** Oguzie et al. (2005**),** the inhibitory performance of bitter kola nut extract was compared to that of 2-aminobenzothiazole (ABT) and 2-mercaptobenzimidazole (MBI) for mild steel in seawater. The results showed that bitter kola nut extract had a higher inhibition efficiency compared to ABT and MBI at all concentrations tested also another study was conducted by Ahamad et al (2010**)** compared the inhibitory performance of bitter kola nut extract with that of benzotriazole (BTA) and 8-hydroxyquinoline (8-HQ) for mild steel in seawater which showed that bitter kola nut extract had a higher inhibition efficiency compared to BTA and 8HQ at all concentrations tested. in addition, Okafor et al. (2007) did a study on the inhibitory performance of bitter kola nut extract and compared it to that of 2-mercaptobenzothiazole (MBT) and N,N'dimethylaminoethanol (DMAE) for mild steel in seawater. The results showed that bitter kola nut extract had a higher inhibition efficiency compared to MBT and DMAE at all concentrations tested. This study takes a look at the Evaluation of Garcinia kola (bitter kola nut extract) as anti-corrosion agent on mild steel in seawater.

2. Experimental

2.1 Materials Selection and preparation

The materials were used for this work are Mild steel coupons , Plastic Bowls, Plastic Beaker (Container), Masking Tape ,Plastic brush ,Sand Paper (rough and smooth),Seawater ,Distilled Water ,Inhibitor (Bitter Kola) ,Jerry Can ,Methylated Spirit ,Clean Tap Water ,Weight balance and Fish line. Mild steel coupons were used as the corrosion testing specimen. They were obtained from commercial steel material outfit in Warri, Delta State. The shape of the mild steel rod is a rectangular cuboid which has length= 55mm, height = 12mm and breadth = 12mm. A 2mm diameter hole was drilled at the upper edge of the specimen.

Plate 1.0 Mild steel Commercial Outfit

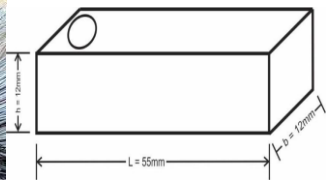

Figure 1.0 Mild Steel Coupon

Therefore, the surface area for each of the mild steel rectangular cuboid is obtained by adding the areas of its six (6) faces.
The Total Surface area (SA) is given by:
SA = 2 (L x B) + 2 (L x B) + 2 (B x H) (3.1)
SA = 2 (55x12) + 2 (55x 12) + 2 (12 x 12)
SA = 2928 mm2 = 29.28cm2
Where;

L= Coupon length (mm)
W = Coupon Width (mm)
H = Coupon Height (mm)
A = Total surface area of metal (mm^2)

2.2 Chemical Composition Testing

A positive material identification (PMI) testing was performed on the mild steel coupons at Turret Engineering Limited, Port Harcourt using XFT 7500 Positive identification instrument with details of the chemical composition as shown below.

Table 1.0 Positive Material Identification of C- 1026

Element	Fr%	Mn%	Cr %	Cu%	Ti%	Co%
98.61	0.62	0.27	0.18	0.17	0.13	
±	0.287	0.053	0.019	0.026	0.030	0.043

2.3 Weight Loss Experiment

The weight loss analysis was done for all the samples per week. i.e. at 7 days intervals for 42 days. period.. The inhibitor concentration in weight loss study was in the range (50, 100, 150, and 200) ml and percentage concentration of inhibitor was calculated to be 10%, 20%, 30%, 40%. The as received metals were cleaned mechanically with various grades of emery paper both rough and smooth, washed, cleaned, rinsed and dried in air for every round and then the process repeated. Weight loss analysis been carried out and the result recorded. This test was done continually until the end of the 42 days and used to determine the corrosion rate for the different samples

Plate. 2 Arrangement of Experiment Samples set-up

3.0 RESULTS AND DISCUSSION

Results

The weight loss and corrosion rate of metals depends to a large extent on a number of factors which have been in the material and methods. The chemical composition testing is as shown in fig. 1 and the weight loss and corrosion rate of different mild steel coupons samples are evaluated and discussed below.

3.1 Weight Loss and Corrosion Rate determination

The weight loss and corrosion rate of metals depends large extent on a number of factors which have been discussed in chapter two. The weight loss and corrosion rate of different mild steel samples are tabulated.

Weight Loss: the weight loss is estimated by subtracting the final weight from initial weight.

$$\text{Weight Loss } (\Delta W) = Wo - W1 \quad (1)$$

Where Wo = initial weight

W1 = sample final weight

Corrosion Rate: The rate of corrosion calculated between 7 to 42days was obtained using the corrosion rate formula:

$$\text{Corrosion rate C.R.} = \frac{K \times W}{A \times T \times D} \quad (2)$$

Where:

K= constant with value= 8.76x104

T = immersion time (hr)

W = Weight (g)

A = Area of sample (cm2)

D = Density of metal (7.85g/cm3)

Table 2 Weight Loss of samples (ΔW) and corrosion rate (C.R) of sample A with 10% inhibitor concentration

Sample A	Time	Initial Weight	Final Weight	Weight loss ΔW(g)	Corrosion Rate (mpy)
A1	7 Days	63.99	64.04	-0.05	-0.113
A2	14 Days	63.99	63.86	0.13	0.147
A3	21 Days	63.99	63.85	0.14	0.107
A4	28 Days	63.99	63.80	0.19	0.108
A5	35 Days	63.99	63.74	0.25	0.113

A6	42 Days	63.99	63.76	0.23	0.087

Table 3 Weight Loss of samples (ΔW) and corrosion rate of sample B with 20% inhibitor concentration

Sample B	Time (Days)	Initial Weight	Final Weight	Change Weight (ΔW)	Corrosion Rate (mpy)
B1	7days	67.32	67.26	0.06	0.136
B2	14 days	67.32	67.12	0.20	0.227
B3	21 days	67.32	67.05	0.27	0.204
B4	28 days	67.32	67.01	0.31	0.177
B5	35 days	67.32	67.38	-0.06	-0.027
B6	42 days	67.32	66.96	-0.36	-0.136

Table 4 Weight Loss of samples (ΔW) and corrosion rate of sample C with 30% inhibitor concentration

Sample C	Time (Days)	Initial Weight	Final Weight	Weightloss (ΔW)	Corrosion rate (mpy)
C1	7days	63.35	63.33	0.02	0.045
C2	14 days	63.35	63.19	0.16	0.182
C3	21 days	63.35	63.11	0.24	0.170
C4	28 days	63.35	63.05	0.3	0.113
C5	35 days	63.35	63.11	0.24	0.109
C6	42 days	63.35	63.10	0.25	0.095

Table 5. Weight Loss of samples (ΔW) and corrosion rate of sample D with 40% inhibitor concentration

Sample D	Time (Days)	Initial Weight	Final Weight	Weight loss (ΔW)	Corrosion Rate (mpy)
D1	7 days	62.79	62.72	0.07	0.159
D2	14 days	62.79	62.67	0.12	0.136
D3	21 days	62.79	62.52	0.27	0.204
D4	28days	62.79	62.53	0.26	0.148
D5	35 days	62.79	62.55	0.24	0.109
D6	42 days	62.79	62.55	0.24	0.091

Sample E	**Time (Days)**	**Initial Weigh t**	**Final Weight**	**Weight loss (ΔW)**	**Corrosion rate (mpy)**
E1	**7**	**67.05**	**66.96**	**0.09**	**0.204**
E2	**14**	**67.05**	**66.88**	**0.17**	**0.193**
E3	**21 Days**	**67.05**	**66.85**	**0.2**	**0.151**
E4	**28 Days**	**67.05**	**66.66**	**0.39**	**0.221**
E5	**35 Days**	**67.05**	**66.50**	**0.55**	**0.25**

Table 6.Weight Loss of samples (ΔW) and corrosion rate of sample E with 0% inhibitor concentration

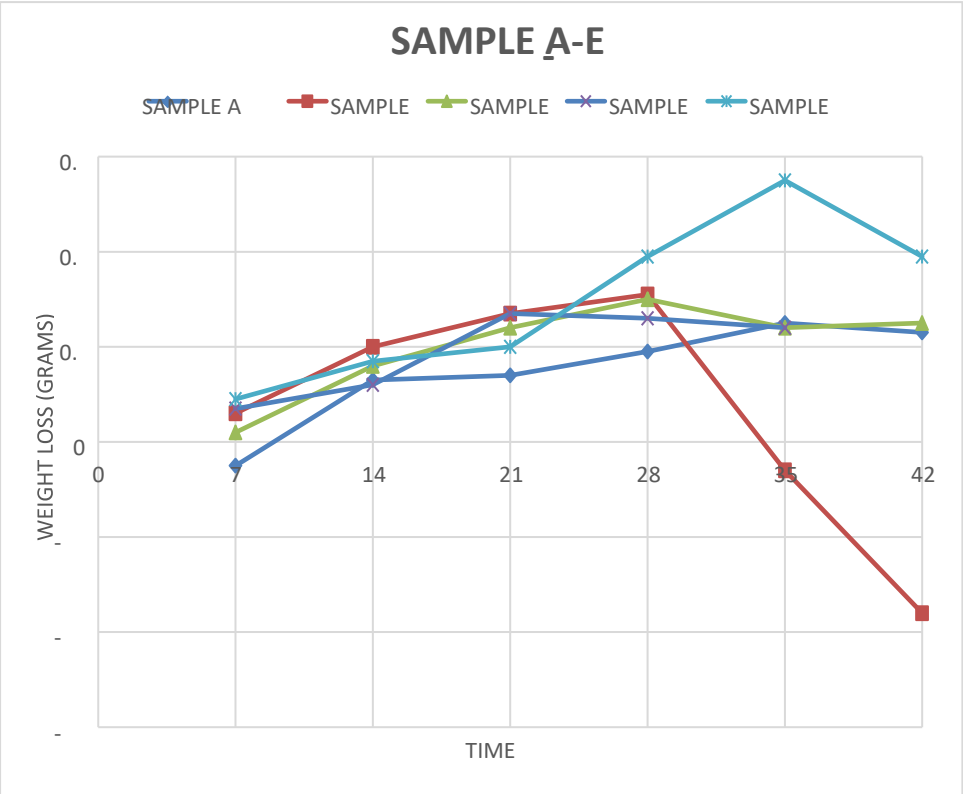

Fig.2 Weight loss variation against Time (days) of Samples A-E

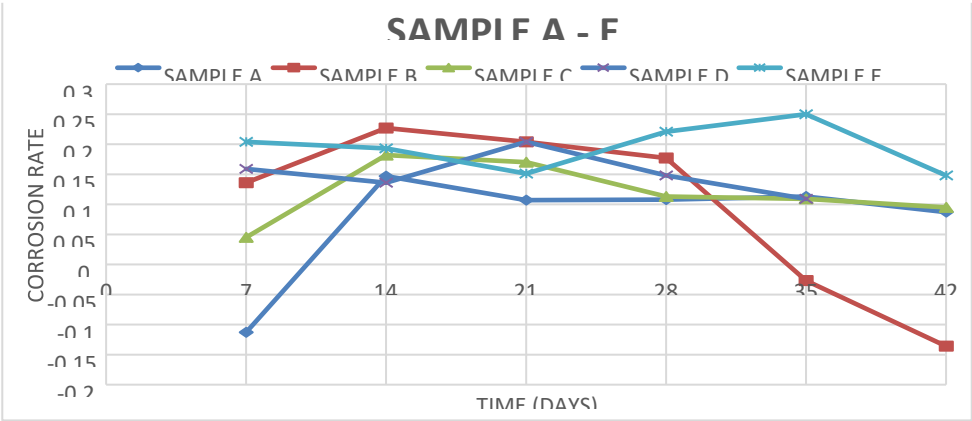

Fig. 3 Corrosion rate variation with time (days) for the various samples A - E

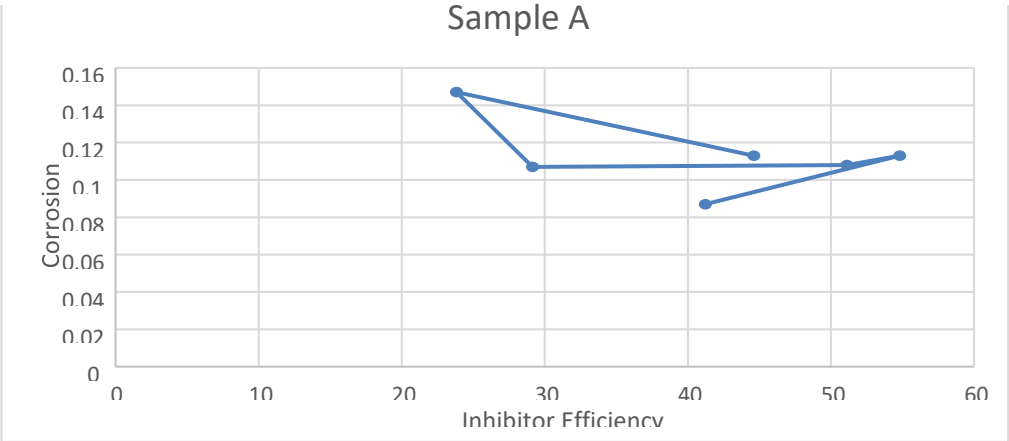

Fig.4 Corrosion rate (mpy) against inhibition Efficiency of sample A

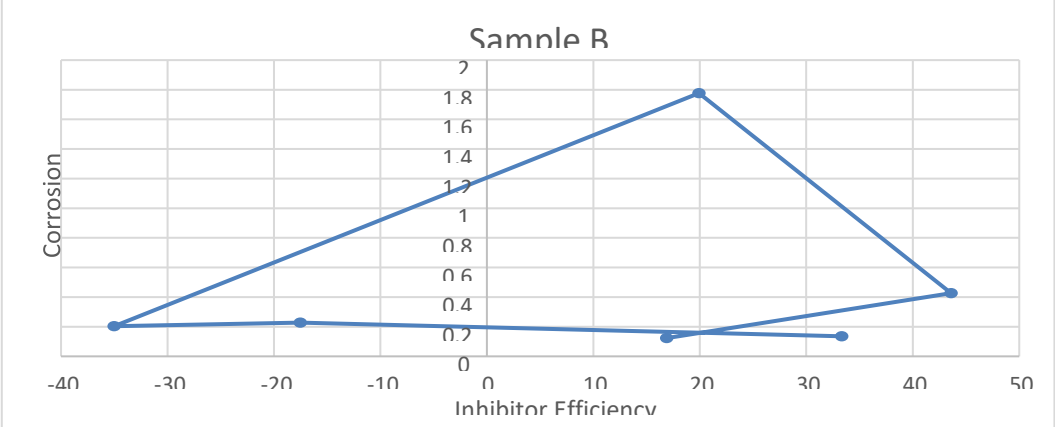

Fig. 5 Corrosion rate (mpy) against inhibition efficiency of Sample B

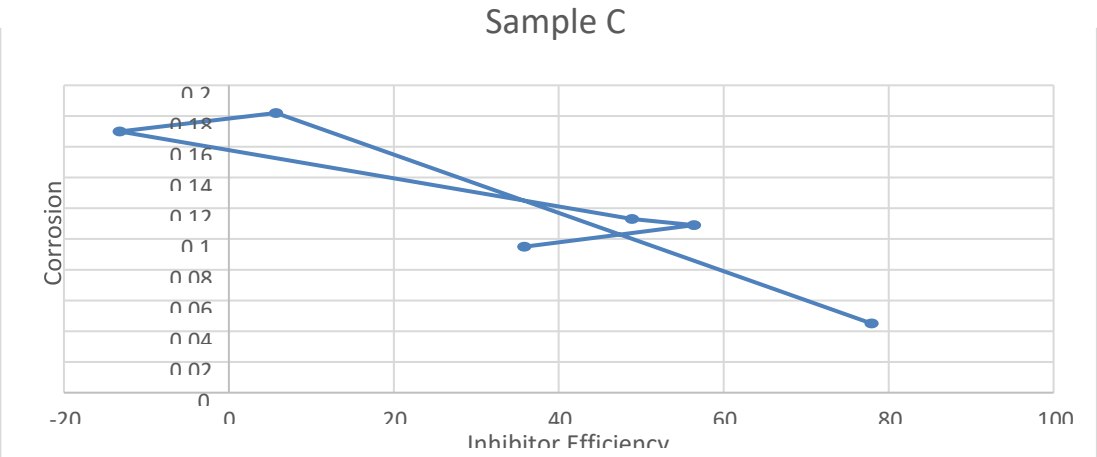

Fig. 6 Corrosion rate (mpy) against inhibition efficiency of Sample C

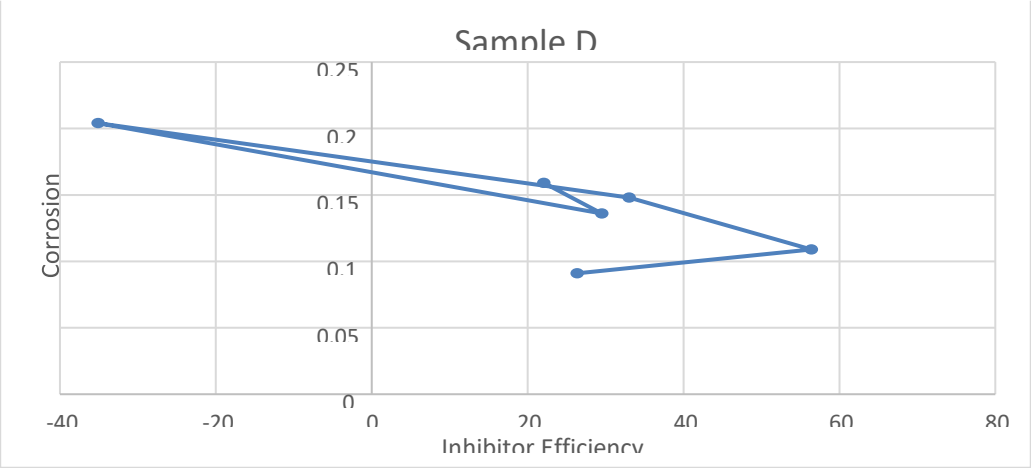

Fig. 7 Corrosion rate (mpy) against inhibition efficiency of Sample D

The table (2 – 6), shows us the weight of each metal after extraction for a stipulated period. We observe samples A and B had fairly significant weight loss at the end of week. Sample A gain 0.08 grams form the first week to the second week and sample B gain 0.14grams. Sample A continued to gain weight till the end of the experiment, while sample B gained weight until the fourth week. Weight was lost from the fourth week to sixth week as shown in fig 1 and 2.

Samples C and D shows a very interesting case, as aforementioned they have 150ml and 200ml of inhibitors added to their environment respectively and we observe weight gain of both metals after the first week of immersion. From the graph Sample C showed weight loss form the first 4 weeks followed by a noticeable weight gain for the rest weeks. For sample D weight gain for the first and second week was minimal followed by a gain in weight from the second to the third week. Weight was the lost from the third week to the fifth week and a minimal gain of weight from the fifth week to the sixth week. Sample E, where no inhibitor was added to the environment consistently suffered weight gain, from the graph, it shows drastic weight loss form the first to the fifth week followed by a drastic weight loss from the fifth to sixth week. Back to sample C and D, when the weight increase was detected our first hypothesis was that the weight increase was due to the inhibitor coating the metal. So a cleaning was employed using rubber brush to clean the metal and still we observe weight increase after every immersion. We can say therefore that the inhibitor tightly adhere to the metal, preventing corrosion which is the cause of weight loss of the metal. And from this experiment, we can see that the most effective inhibitor quantities are the one in sample C and D i.e. 150ml and 200ml with concentration 30% and 40% of 500ml of the inhibitor respectively per 500ml of seawater. From the data's on tables 2 - 5), the least corrosion rate for samples A, occurred at the interval of 7 days. For sample B, it had the least corrosion rate at 35 days. The sample C was at the lowest corrosion rate after the initial 7 days with C.R OF 0.045mpy30 % inhibition concentration. Sample D with concentration of40% inhibition concentration at the end of 42 days interval with C.R. of 0.091mpy. For the uninhibited sample and at the end 42 days the least corrosion rate was 0.148mpy. From this, it can be deduced that sample D which was immersed in 40% inhibition concentration had the lowest corrosion rate (Table 4.) This trend is seen further that from fig. 3 and fig.4 and also from fig.8. that the inhibition efficiency is put at 58% validating that the sample D in 40% inhibition concentration is more reliable foe the Bitter kola nut extract ion mild steel in seawater environment

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