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RESEARCH ARTICLE

INVESTIGATION FOR OPTIMAL INHIBITION EFFICENCY AGAINST MILD-CARBON STEEL CORRRSION IN 0.1M ACIDIC MEDIA USING CASHEW EXTRACT

Olawale O*., Akinmoladun A.I[1]., Oyawale F.A[2] and Bello, J.O[3] Neil Phillip[1]

[1]Department of Physics and Technology, Bronx Community College of the University of New York
[2] Mechanical Engineering Department, Covenant University, Otta. Nigeria
*,[3] Chemical Engineering Department, Landmark University, Omu-Aran, Kwara State, Nigeria

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ABSTRACT

Corrosion is an everyday challenge in all sectors of the economy particularly the manufacturing industry and this has led to massive economic loss. Literature is sparse on optimal Inhibition efficiency from Hydrochloric acid (HCl) and Tetra-oxo-sulphate (vi) Acid (H_2SO_4). The aim and objective of this research is to observe optimal Inhibition Efficiency from acidic media using cashew extracts as eco-friendly corrosion inhibitor. 0.1M of HCl and H_2SO_4 of 0.1M were used for the cashew extract in this research. Mild carbon steel with thickness 0.1 cm was used. It was cut into various coupons of dimensions 4 x 5 x 0.1 cm. The cashew waste extract produced was used as a corrosion inhibitor on mild carbon steel in 0.1M of HCl and H_2SO_4. It was observed that as the concentration of inhibitor increases, the inhibitor efficiency also increases. The optimal inhibition efficiency observed in HCl was 80.5% while 83.7% was in H_2SO_4. After 336 hours of test, it was concluded that H_2SO_4 is a better acidic medium.

INTRODUCTION

Corrosion is the gradual deterioration of a material by electrochemical reaction due to its interaction with its environment. It has been an everyday challenge in all sectors of the economy particularly the manufacturing industry (El-Etre, 2003). A number of ways such as material selection, cathodic or anodic protection, coatings and the use of corrosion inhibitors had been used to reduce corrosion in industries (Lebrini et al.2011; Yahazri *et al*.2011). Carbon steel is one of the most important alloys being used in a wide range of industrial applications. There are several ways of tackling the issue of corrosion in the industry and one of such ways is the use of inhibitors which is eco-friendly. According to Shanableh (2011); the use of inhibitors had been promising, inexpensive and effective. It was observed that the natural inhibitors could potentially serve as an effective substance for corrosion inhibitors without constituting risk for human health and environment in which people live in. Naturally occurring molecules exhibiting a strong affinity for metal surfaces are the focus of research oriented toward the development of environmentally friendly corrosion inhibitors; compounds showing good inhibition efficiency and low environmental risk. Many researchers have done some works on green corrosion using grape pomace (Rocha et al. 2012), apricot juice and Spirulina platensis (Okafor *et al*.2011, Aboia and James, 2011). Among the so-called ‘‘green corrosion inhibitors” are organic compounds that act by adsorption on the metal surface, such as ascorbic acid, succinic acid, try-ptamine, caffeine and extracts of natural substances (Eddy et al. 2009).The efficiency of these organic corrosion inhibitors is related to the presence of polar functional groups with S, O or N atoms in the molecule, heterocyclic compounds and pi electrons. The polar function is usually regarded as the reaction center for the establishment of the adsorption process. Studies have been conducted on natural extracts that can significantly replace synthetic compounds. One of these natural compounds is fruit (Antonijevic, *et al*.2008).Fruit is a rich source of chemicals such as vitamins, minerals, and phenolic compounds. According to Rocha *et al* (2012), banana peel, fruit peel (mango, orange and passion fruit), coffee grounds, papaya seed, seeds and peels from papaya and garlic produced inhibitors. The use of industrial wastes as corrosion inhibitors is indeed welcoming and very appealing. Many studies had been carried out to find suitable compounds useful as corrosion inhibitors for metal in different aqueous solutions (Rajendra, *et al*.2005). Juice and seed extracts of cantaloupe acted as good natural inhibitor for corrosion of cast iron in 0.1M HCl solution (Khadijah *et al.* 2015). According to Salami *et al*.2012; as the concentration of inhibitor produced increases, the corrosion rate decreases. Furthermore, their findings showed that the inhibitor had an optimum efficiency of about 71 % when Musa Sapientum peels extract was used as corrosion inhibitor. The aim and objective of this research is to observe optimal Inhibition Efficiency from acidic media of 0.1M for mild carbon steel using cashew extract as an eco-friendly inhibitor.

METHODOLOGY

MATERIALS

1. Waste fruits of cashew (*Anacardium occidentale L.*) were collected
2. ii. Mild carbon Steel

Chemicals

All the chemical and reagent used in this work were of analytical grade. They include: Hydrochloric Acid; Sulphuric Acid; Acetone and Ethanol

METHODOLOGY

Preparation of samples

The samples prepared here are the corrosion medium for the mild steel bar needed in calculating the weight loss of the material. The samples are 1M of HCl and 0.1M of H_2SO_4. The electrolytes0.1 $molL^{-1}$ HCl and 0.1 $molL^{-1}$ were solution prepared using double-distilled water. All chemicals were of analytical-grade. The experiments were carried out under non-stirred and naturally aerated conditions.

Preparation of plant extract

The 2kg of waste cashew fruits were sun dried. After sun drying them .the cashew nut was separated from the dried waste fruits; then pulverized. 150g of the ground dried waste cashew powder was weighed and soaked in 250 ml of ethanol for 24 hours, and then filtered and concentrated using rotary evaporator and water bath. The resulting extract was in semi-solid form.

Preparation of Specimen

Carbon steel strips (BDH grade) containing (weight %): C 0.2, P 0.024, Si 0.003, Mn 0.35, and rest Fe were used in this research. Coupons cut with 4 x 5 x 0.1 cm dimensions were used for weight loss measurements. 10 mild steel bars of this dimension where cut and where used for this test. These coupons were cleaned by distilled water and ethanol. These coupons were further treated using emery paper. Then, washed using distilled water and degreased with acetone and later stored in the desiccator.

Weight Loss Measurements

Weight loss measurements were conducted under total immersion using 250 ml capacity beakers containing 20-100% test solution at 30-33°C maintained in the laboratory (room temperature). The carbon steel coupons were weighed and suspended in the beaker with the help of rod and hook. For the effect of temperature on the inhibition efficiencies, all the tests were carried out in the temperature range of 30-33°C.

Procedure

The mild carbon steel specimens was immersed in 100 mL of 0.1M HCl and 0.1M H_2SO_4 con- taining various concentrations of the inhibitor (20%, 40%, 60%, 80%) in the presence and absence of the corrosion inhibitor for 336 hours. First, there were two control experiments for HCl and H_2SO_4. Then various percentages of the inhibitor were added to the other beakers containing the various test samples. The specimens were totally immersed in all ten (10) test solutions and were left for 336 hours during which readings were carried out at intervals of 48 hours.7 readings were carried out and the results recorded accordingly. The weight of the specimens before and after immersion was determined after every 48 hours using weighing balance. The corrosion products were cleansed with distilled water, dried and then weighed to determine the weights. The inhibition efficiency (IE) was calculated using the following equation.

$$\frac{(V_0 - V_1)}{V_0} \quad ....1$$

Where V_0 is the corrosion rate in the absence of the inhibitor, and V_1 is the corrosion rate in the presence of the inhibitor.

Surface Examination

For morphological study, surface features (2.0 cm x 2.0 cm x 0.15 cm) of carbon steel were examined before and after exposure to 0.1M HCl and 0.1M H_2SO_4 solutions for 336 hour with was used in examining the control experiment of HCl and H_2SO_4 and that of the optimum corrosion inhibitor in both acids.

RESULTS AND DISUCUSSION

Weight Loss Method

The corrosion of mild steel in 0.1M HCl and 0.1M H_2SO_4 solution containing various concentrations of inhibitor at room temperature was studied by weight loss measurements. The corrosion rate of mild steel was determined via the below formula.

V = (W2 - W1)/(A t) (1) where:
W1 = initial weight (prior to immersion) W2 = final weight (after immersion) A = surface area of the sampel t = exposure time Furthermore, the inhibition efficiency (IE) of each sample was calculated by using equation 2 .
IE = (V0 - V1)/V0 (2)
Vo = corrosion rate without inhibitor V1 = corrosion rate with the addition of inhibitor

$$W = \frac{\Delta M}{St} \quad ……………2$$

Where Δm is the mass loss (g)
S= $20cm^2 = 0.002m^2$[the area (cm^2)]
t= 48hours [immersion period (hours)]
The percentage inhibition efficiency [IE%] was calculated using the relationship.

$$\frac{(V_0 - V_1)}{V_0} X100\% \quad .....3$$

Where V_0 is the corrosion rate in the absence of the inhibitor, and V_1 is the corrosion rate in the presence of the inhibitor.

Table 1 Corrosion rates data of mild steel in 0.1M HCl in absence and presence of different concentrations of cashew inhibitor.

Inhibition concentration (%)	Corrosion rates ($g/m^2.hr$)	Θ	IE (%)
20	0.69	0.207	20.7%
40	0.52	0.402	40.2%
60	0.35	0.598	59.8%
80	0.17	0.805	80.5%

Table 2 Corrosion rates data of mild steel in 0.1M H_2SO_4 in absence and presence of different concentrations of cashew inhibitor.

Inhibition concentration (%)	Corrosion rates ($g/m^2.hr$)	Θ	IE (%)
0	1.04		
20	0.69	0.337	33.7%
40	0.52	0.5	50%
60	0.35	0.663	66.3%
80	0.17	0.837	83.7%

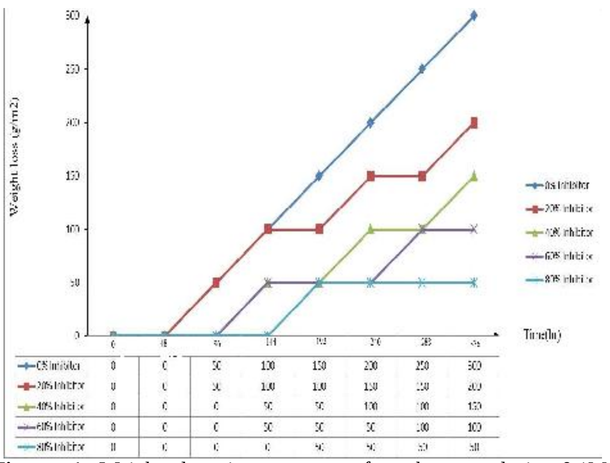

Figure 1 Weight loss-time curves of carbon steel in 0.1M H_2SO_4 in the absence and presence of different concentrations of Cashew inhibitor.

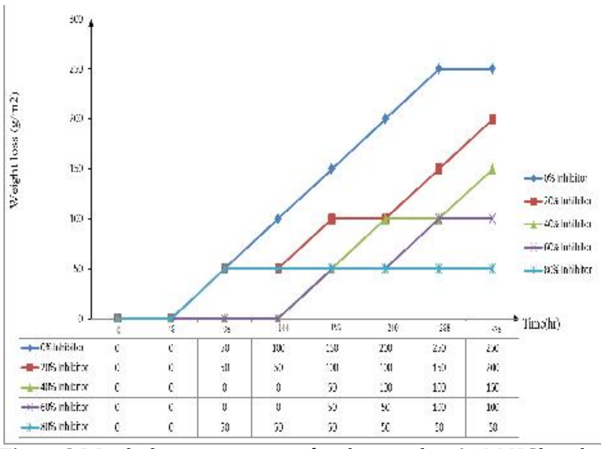

Figure.2 Weight loss-time curves of carbon steel in 0.1M HCl in the absence and presence of different concentrations of Cashew inhibitor

Surface Morphology Result

FT-IR was used to evaluate the nature of the film formed on the surface of the metal. After the concentration of the inhibitor with the highest Inhibition Efficiency (IE %) was discovered, the samples were sent to the laboratory for analysis. Figures 1-3 showed the analysis done on the metal with 0% inhibition concentration and that of 80% inhibition concentration in both 0.1M HCl and 0.1M H_2SO_4.

The strong band at approximately 3450cm^{-1} can be associated with O–H stretching of thephenolic group. The band at 2928 cm^{-1} is related to C–H stretching vibration. The strong band at 1630 cm^{-1} is assigned to conjugated C=O stretching vibration. The band at 1552 cm^{-1} can be attributed to C=C-C aromatic ring stretching. The bands between 1467 and 1431 cm^{-1} can be attributed to angular deformations of C-O-H in phenols. The band at approximately 1321 cm -1 is attributed to C-O stretching from the pyran-derived ring structure present in the flavonoids. The bands at 1083 and 1151cm^{-1} can be assigned to C-H deformations of the aromatic ring. This result indicates that cashew extract contain flavonoids in their composition, which can act as corrosion inhibitors. The FT-IR spectra for figures 4 and 5 are almost the same, so it can be concluded that the extracts have the same composition, and differ mainly on their concentration

Figure 3 FT-IR spectra of coupon with 0% inhibition concentration in 0.1M HCl

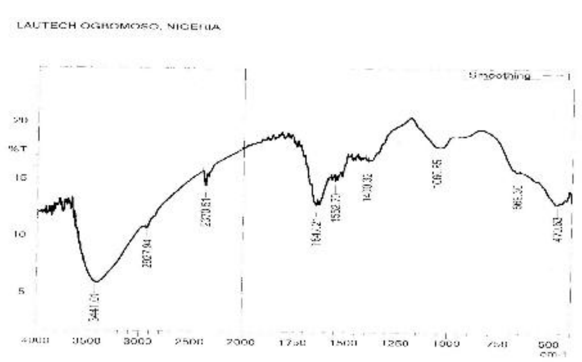

Figure 4 FT-IR spectra of coupon with 80% inhibition concentration in 0.1M HCl

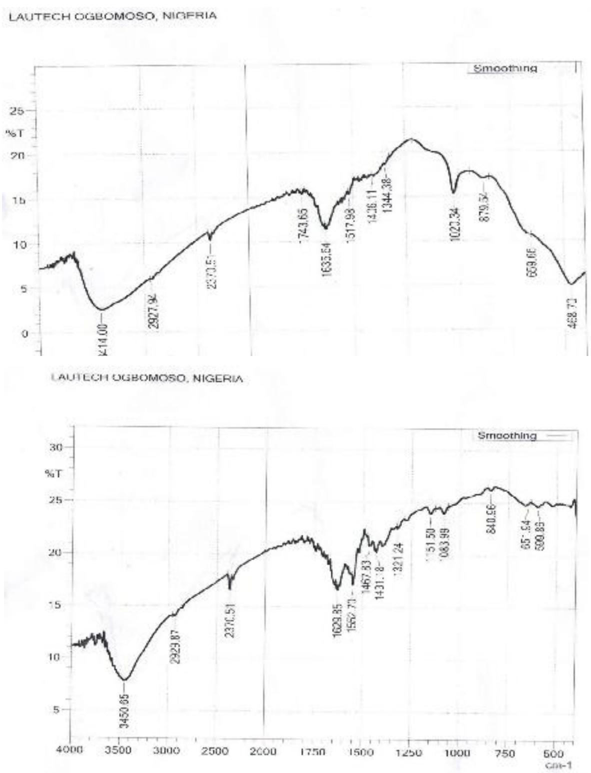

Figure 6 FT-IR spectra of coupon with 80% inhibition concentration in 0.1M H_2SO_4

Scanning electron microscopy (SEM)

Surface morphology of polished mild steel, mild steel immersed in 0.1M HCl, mild steel immersed in 0.1M H_2SO_4, mild steel immersed in 0.1M HCl with 80% corrosion inhibitor andmild steel immersed in 0.1M H_2SO_4 with 80% corrosion inhibitor were recorded and depicted in Figures .7(a) – (e).

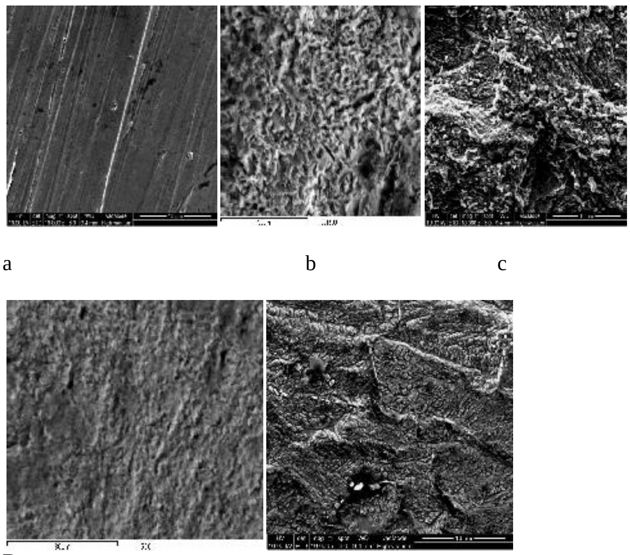

Figure 7 SEM micrographs of mild carbon steel surface (a) before immersion (b) total immersion in 0.1M HCl (c) total immersion in H_2SO_4 (d) immersion in 0.1M HCl with 80% inhibition concentration (e) immersion in 0.1M H_2SO_4 with 80% inhibition concentration.

DISCUSSION OF RESULTS

From the above, it was observed that the inhibition concentration of 80% for both 0.1M HCl and 0.1M H_2SO_4 gave the highest inhibition efficiency i.e. 80.5% and 83.7% respectively. From Figures 1-2, the graphs clearly showed that weight loss reduced as more concentrations of the corrosion inhibitor was added. Within the test hours of 336 hours, there was a 300 and 250g/m^2 of weight loss in both 0.1M HCl and 0.1M H_2SO_4 with 0% inhibition concentration, while there was just a 50g/m^2 of weight loss both 0.1M HCl and 0.1M H_2SO_4. The inhibition efficiency isdirectly proportional to the concentration of the inhibitor (i.e. inhibition efficiency increases with increased inhibition concentration). It was observed from the FT-IR result that the cashew extract contain flavonoids in their composition, which can act as corrosion inhibitors.

CONCLUSION

It was concluded that cashew waste extract was a very good eco-friendly corrosion inhibitor for mild carbon steel. At 80% concentration of the inhibitor, it was discovered that the inhibition efficiency was highest in both media at 80.5% for HCl and 83.7% for H_2SO_4. Furthermore, as the concentration of the inhibitor increases, the corrosion rate decreases and the inhibitor has an optimum efficiency of 83.7%. The result obtained from the FT-IR spectra showed flavonoids which are the active corrosion inhibiting agents in the cashew. SEM analysis showed a better passive layer against the corrosive ions on the surface of the mild steel in H_2SO_4 than in HCl. This showed that H_2SO_4 was better corrosion inhibitor.

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