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CORROSION INHIBITION OF MILD STEEL BY *FICUS EXASPERETA* LEAF EXTRACT IN HCl SOLUTION

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ABSTRACT
The inhibitive effect of Ficus exasperata extract on the corrosion of mild steel in 1M HCl solution was investigated using weight loss and electrochemical techniques. Both qualitative and quantitative phytochemical screening was used to characterize the plant extract. The concentration of the inhibitor was varied from 0.2, 0.4, 0.6, 0.8, and 1.0 g/l respectively, and the results show that the extract of Ficus exasperate (FE) is a good inhibitor for the mild steel in 1M HCl solution. The lowest corrosion rate of 1.89 mm/yr. was obtained at 30^0C, 1.0 g/l of inhibitor concentration compared to the blank with 39.01 mm/yr. The best inhibition efficiency obtained in weight loss experiment was 95.2% at 30^0C, and at a concentration of 1.0 g/l, while an efficiency of 97.4% was obtained same temperature but 0.2 g/l concentration for electrochemical methods. The linear polarization data show that the extract acted as mixed type inhibitor.

Keywords: Corrosion inhibition, mild steel, Ficus exaspereta leaves, inhibition efficiency, surface coverage

1 INTRODUCTION
Various researches have been conducted to find suitable compounds to be used as corrosion inhibitors in various corrosive media. Many works were carried out to investigate extracts of natural occurring substances suitable for this purpose. Ecofriendly extract of banana peel as corrosion inhibitor for carbon steel in seawater [1], Inhibition of mild Steel corrosion in acidic medium by allium sativum extracts [2], Inhibitory effect of adsorption parameters of extract leave as of portulaca oleracea for the corrosion of Aluminum in H_2SO_4[3], Thermodynamics and kinetics of inhibition of Aluminium in HCl acid by date palm leaf extract [4] and Dodaneae viscose (L.) leaves extract as acid corrosion inhibitor for mild steel [5] were all investigated and found to be good corrosion inhibitors in the studied conditions.

Mild steel is extensively used in many industries such as automobiles, pipes and chemical industries. However, the metal corrodes when it comes in contact with acid solutions.

Sulphuric acid is widely used as a pickling agent for iron and its alloys to remove undesirable corrosion products. These problems can be resolved by introducing appropriate inhibitor to the medium [6].Corrosion is the deterioration of metal by chemical attack or reaction with its environment. It is a constant and continuous problem, often difficult to eliminate completely. Prevention would be more practical and achievable than complete elimination [7].

Over the years, considerable efforts have been deployed to find suitable corrosion inhibitors of organic origin in various corrosive media. In organic substances such as phosphates, chromate, dichromates, silicates, borates, tungstates, molybdates have been used and found effective as inhibitors of metal corrosion. However, some of them are not biodegradable and ecofriendly, the research in the field of green or ecofriendly corrosion inhibitors has been addressed toward the goal of using cheap, effective compounds at low or zero

environmental impact [8]. An inhibitor is any compound that suppresses corrosion, regardless of which electrochemical reaction it affects. Passivators, on the other hand, are defined as compounds that reduced the corrosion rate via a preferential retardation of the anodic reaction. In this regards, an inhibitor may or may not be a passivator, but every passivator is an inhibitor [9]. Organic inhibitors generally have heteroatoms, O, N and S are found to have higher basicity and electron density and thus act as corrosion inhibitor and are found to be the active centers for the process of adsorption on the metal surface.

2.0 MATERIALS AND METHODS

2.1 Materials

Mild steel of known composition as presented in Table 1 obtained from Universal steel company Lagos, Nigeria was used for this work

2.2 Inhibitor Preparation

Ficus Exasperata (FE) leaves were collected from Malumfashi Local Government Area in Katsina State, Nigeria. Fresh leaves were cut in to small pieces and shade dried. The extract was prepared by refluxing 10 g of the powder FE leaves in 500 ml of methanol for 5 days. The extract was filtered and various concentrations 0.2, 0.4, 0.6, 0.8 and 1.0 g/l was prepared [10].

2.3 Phytochemical examination

The phytochemical screening of FE leaves extract was carried out using standard procedure [11, 12].

2.4 Weight loss measurements

The samples (10 x 10) mm were completely weighed before immersed in 250 ml of the test solution with and without the addition of different concentrations of FP extracts. The beaker was inserted into a water bath maintained at a temperature of 303k over an exposure time of 1hr, 2hrs, 3hrs, 4hrs and 5hrs respectively. After every one hour, each sample was withdrawn from the test solution, washed with water and rinsed with acetone and air dried before re-weighing. This procedure was repeated for the varied temperatures 323k and 343k. The difference in weight was recorded as the weight loss. From the weight loss, the corrosion rates (CR) were calculated using equation (1)

$$CR=\frac{87.6W}{DAT}\ \text{mm/yr} \qquad (1)$$

Where W= weight loss in mg
D= density g/cm^3
A= area in cm^2
T= exposure time in hours

From the corrosion rate, the inhibition efficiency, (IE %) was calculated using equation (2)

$$IE\%=\frac{CRo-CR}{CRo}\text{x}100 \qquad (2)$$

Where CR_o is the corrosion rate without inhibitor and CR is the corrosion rate in the presence of inhibitor. The surface coverage, Θ, was calculated from the corrosion rate as follows:

$$\Theta=\frac{CRo-CR}{CRo} \qquad (3)$$

2.5 Electrochemical measurement

The samples used for electrochemical experiments were of dimensions 10 mm x 10 mm, these were subsequently sealed with epoxy resin in such a way that only one square surface area 1.0cm^2 was left uncovered. Electrochemical study was carried out using conventional three electrode cells with larger area platinum foil as counter electrode and saturated calomel electrode (SCE) as reference electrode.

Table 1: Chemical Composition of the Mild Steel used

Element	Fe	C	Si	Mn	S	P	Cr	Ni	Cu	Al	Mo	V	Ti
Composition (%)	97.75	0.21	0.25	0.77	0.03	0.02	0.13	0.13	0.33	0.29	0.02	0.003	0.009

The corrosion sample served as the working electrode and Metrohm Autolab AUT50280 Computer Controlled was used in this study. The polarization study was made after the specimen attained a steady state potential. The polarization was carried out from a cathodic potential of -1500 mV to an anodic potential of +1500 mV with respect to the corrosion potential at a sweep rate0.012 v/s at room temperature and the data generated were recorded.

2.6 Scanning Electron Microscopy

The SEM analysis was performed using a Jeol JSM- 7500F Scanning electron microscope. The morphological studies of the Al-Si-Mg alloy surfaces were exposed to uninhibited and inhibited samples.

3.0 RESULTS AND DISCUSSION

3.1 Phytochemical screening

Phytochemical screening of the plant extract FE was carried out to identify the presence of the chemical constituents present in the leaves. It was found that the plant constituents contain tannins, saponins, flavonoids and alkaloids. The qualitative and quantitative phytochemical screening results are as shown in Table 3

3.2 Weight Loss Method of Corrosion Measurement

The effect of inhibitor concentration on the corrosion rates of Mild Steel in 1M HCl Solution was evaluated and the results obtained show that the corrosion rates decreased in the presence of the extract compared with un-inhibited samples. The results are presented in Figure 1

The decrease in corrosion rates with increase in concentration of the extracts depicts their inhibitive potentials in the medium. However, the corrosion rates increased with increase in temperature as expected since rate of reaction increase with increase in temperature and similar results have been reported [3].

Table 3: Phytochemical screening (Quantitative) result of the plant extracts

Plant extract	Tannins	Saponin	Flavonoids	Alkaloids
F.E	1.50%	9.10%	11.62%	6.60%

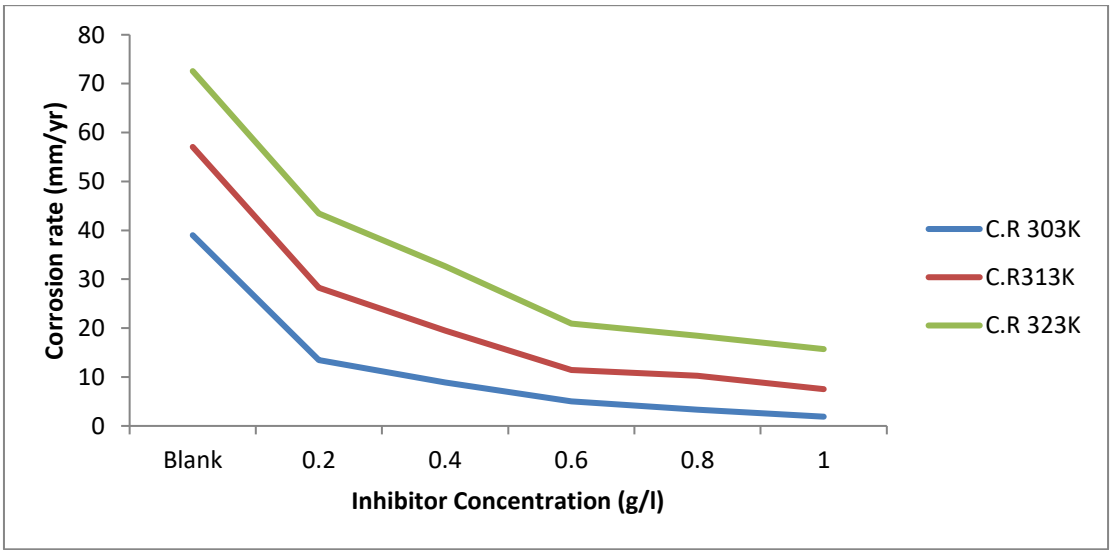

Figure 1: Variation of Corrosion rates against Inhibitor concentration of mild steel in 1M HCl solution at 303K, 313K, and 323K in 5hours exposure time in the absence ad presence of FE inhibitor.

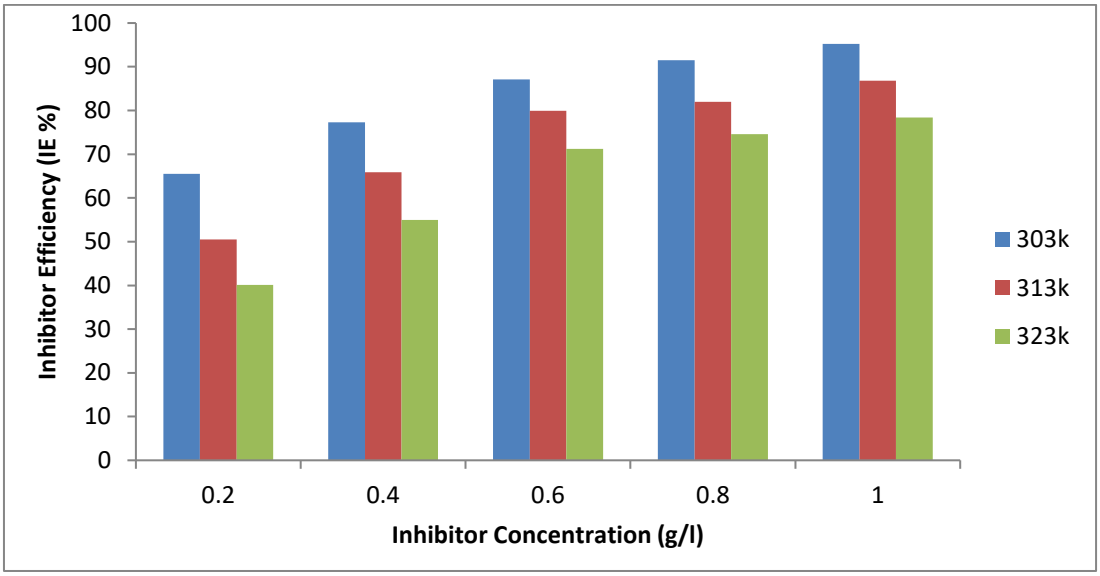

Figure 2: Inhibitor Efficiency against Inhibitor Concentration of FE in 1M HCl Solution.

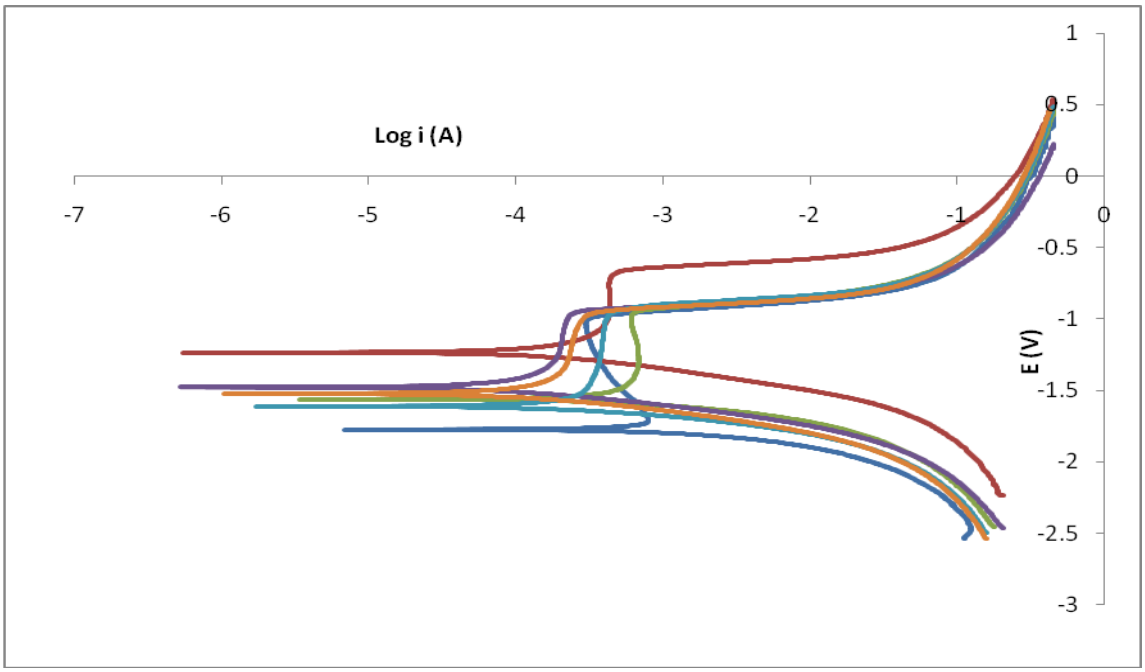

Figure 3: Inhibitor Efficiency against Inhibitor Concentration of FE in 1M HCl Solution.

The inhibitor efficiency against the inhibitor concentration is provided in Figure 2

The efficiency increases with increase in concentration of inhibitor and decreases with increase in temperature. The decrease of inhibitor efficiency with the temperature increase could be due to desorption of the inhibitor molecules from the surface of the mild steel thereby exposing it to degradation. It has been reported that the rate of metal corrosion in acid solution increases with rise in temperature [13].

3.3 Potentiodynamic Polarization

The potentiodynamic polarization curves of the corrosion of mild steel in 1M HCl solution is shown in Figure 3. The corrosion parameters such as corrosion potential (E_{corr}), corrosion current (I_{corr}), Tafel slopes (β_a, β_c) for anodic and cathodic slopes, and the linear polarization

resistance (LPR) result were obtained. The polarization curves indicated that both anodic and cathodic reactions are inhibited in the presence of FE. The values obtained show that the corrosion rates decrease with addition of inhibitor. Similarly, there is a decrease in the corrosion current (I_{corr}) in the presence of extracts as the concentration is increased. This confirms the inhibitive action of FE extract in the medium. It was also observed that in the absence of inhibitor, the corrosion potential, E_{corr} is -1.7818V versus Saturated Calomel Electrode (SCE) and in the presence of inhibitor the corrosion potential is shifted to a lower value in all the concentrations of extracts considered. This suggests that the plant extract was able to interfere with the anodic and cathodic reaction sites [14]. The R_p values increase and the corrosion current decrease generally. This implies that a protective film was formed on the alloy surface [1].

Figure 3: Polarization curve for the corrosion of mild steel in 1M HCl acid Solution in the absence and presence of various concentrations of the inhibitor at 303K of FE.

CONCLUSION

From the results and discussion, the following conclusion can be drawn:

1. The characterization of the plant extract by quantitative method revealed the presence of alkaloid, tannins, saponins, flavonoids which showed that the plant extract have the potential of being used as inhibitor for mild steel in 1M HCl solution
2. The least corrosion rates (1.89) of the mild steel at 30^0C was obtained with the addition of inhibitor concentration of 1.0 g/l
3. The inhibitor efficiency attained in this research is 95.2% with gravimetric mass-based loss method.
4. Tafel polarization curves show that the extracts acted as mixed type inhibitor

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