Corrosion Inhibitive Effects of Siam Weed Extract on Mild Steel in 1M H_2SO_4 Medium

A.A. Ayoola* and E.P. Joseph

Chemical Engineering Department, Covenant University, Ota, Ogun State, Nigeria

Abstract: Corrosion inhibitive effects of Siam weed extract on A36 mild steel in 1M H_2SO_4 medium was investigated at two corrosion reaction of 278 and 320K. Better inhibitive performance of the Siam weed extract was noticed at 278K. The results of the gravimetric tests revealed that the Siam weed extract was a good corrosion inhibitor for the mild steel with Langmuir adsorption isotherm mechanism, spontaneous and physiosorption in nature.

Keywords: Corrosion, Inhibitor, Mild steel, Siam weed extract.

1. INTRODUCTION

Corrosion is a destructive phenomenon, which is being experienced by metallic materials located in any corrosive environment. The economic impacts of metal corrosion are very heavy in aviation, automobile, petroleum, chemical and food processing industries. And the major causative factors responsible for metal corrosion are the presence of moisture and or electrolyte in an environment of the metal [1].

Research has shown that metal protection from corrosion can be achieved through the adoption of certain techniques that hinder or prevent corrosion reactions (between the metal and its corrosive environment) from taking place easily. One of the commonly used technologies in combating corrosion problems involves the use of inhibitors. A corrosion inhibitor is a chemical compound that is introduced in a small amount to the corrosive environment of metal so as to prevent the occurrence of the corrosion reactions [2-3]. Its mode of application is simple, convenient and economical. Metal surfaces adsorb the inhibitor, causing a formation of a protective barrier, thereby causes a decrease in the oxidation and reduction of corrosion reaction [4-5].

Based on the chemical constituents, corrosion inhibitors can be grouped into two: organic and inorganic inhibitors. If based on performance, the inhibitors can be classified as passivators precipitators, vapour phase, cathodic, anodic, neutralizing and absorbents [6].

Certain plant extracts are very effective as organic corrosion inhibitors [7-8]. In this research study, the focus is on the use of the extract from the Siam weeds as organic corrosion inhibitor during the weight loss analysis of A36 mild steel subjected to 1M H_2SO_4 medium, at two different temperatures (278 and 320K).

2. MATERIALS AND METHODS

2.1. Metal Preparation for the Experiment

The A36 mild steel was utilised in the course of this research work. The metal bar was cut into small pieces with a constant dimension of2cm by 2cm dimension to ensure the smooth running of the weight loss experiment. A small hole was inserted on each metal piece (through boring) at the upper part of the sample to achieve the suspension of the sample in the acidic medium. Each sample was then subjected to pre-treatment process, by first polishing each metal piece using emery paper (to achieve smooth surface) and then dipped in dilute solution of ethanol before being rinsed in acetone followed by distilled water (to completely remove any trace of impurity on the surface. The samples are then kept in a desiccator before utilisation.

2.2. Preparation of the Inhibitor

The leaves of the fresh Siam weeds obtained were dried at a constant temperature of 50ºC for 5 days and then pulverized into nano-sized powder. The acid extraction of the corrosion-inhibitive compounds in the powder was carried out by adding 50g of the powder form in every 500mL of 1M HCl, and the mixture was heated at a constant temperature of 90ºC for 3 hours. The content was then cooled, and a clear solution of the required inhibitor was obtained through filtration.

2.3. Phytochemical Analysis of the Inhibitor

Phytochemical analysis of the extract was carried out by adopting the method of [9]. Tanin, flavonoids,

*Address correspondence to this author at the Department of Chemical Engineering, College of Engineering, Covenant University, KM 10 Idi iroko road, Ota, Ogun State, Nigeria;
E-mail: ayodeji.ayoola@covenantuniversity.edu.ng

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alkaloid, and phenolic compouds were the phytochemical compounds analysed.

2.4. Weight-Loss Experiment

The conventional weight loss method engaged involves the weighing of metal samples before immersion in corrosive medium (H_2SO_4) and then re-weighing after the pre-determined duration of the corrosion test. Varied concentrations of the inhibitor (0 – 4 %vol./vol.), at corrosion reaction temperature of 278 and 320K, were considered in the course of this research work. The weight loss experiment was conducted according to ASTM G 1-03 standard procedure.

The data obtained was used to determine the weight loss, corrosion rate and inhibitor efficiency (IE)using Equations 1 – 2.

$$\text{Corrosion rate } \left(\frac{mm}{yr}\right) = 87.6\frac{w}{A*t*D} \quad (1)$$

$$\text{Inhibitor Efficiency (\%)} = 1 - \frac{CRp}{CRa} \times 100 \quad (2)$$

where W = weight loss (mg) in the absence of inhibitor, W_1 = weight loss (mg) in the presence of inhibitor, A = Area of sample (cm^2), t = immersion time (hrs), Density of metal (g/cm^3), CR_p and CR_a are the corrosion rates in the presence and absence of inhibitor respectively.

2.5. Adsorption of Inhibitor on Metal Surface

The suitability of the adsorption isotherm in the description of the adsorption mechanism of the inhibitor on the metal sample surface was determined by using the data obtained from the weight loss, inhibitor efficiency and surface coverage. The different adsorption isotherms considered are Langmuir, Freundlich and Tempklinisotherms.

2.6. Thermodynamic Gibbs Free Energy of the Study

The useful work energy loss to the environment, Gibbs free energy of the study (ΔG_{ads}), was evaluated using Equation 3.

$$\Delta G_{ads} = 2.303RT\log(55.5\ K_{ads}) \quad (3)$$

where K_{ads} is the adsorption constant

3. RESULTS AND DISCUSSION

3.1. Chemical Composition of the Inhibitor

The chemical analysis of the inhibitor revealed the following antioxidants. Antioxidants are chemical substances that retard or prevent oxidation process (corrosion process). That is, these compounds inhibit the oxygen molecules from reacting easily thereby preventing radicals from forming [10].

3.1.1. Test for Flavonoids

Additon of four drops of 1% Ammonia (NH_3) solution to the aqueous solution of the inhibitor in a test tube gave a yellow colour solution, an indication of the presence of flavonoid in the inhibitor.

3.1.2. Test for Tannins

About 2mL of the inhibitor was added and continuously stirred in 60mL of distilled water, and five drops of ferric chloride reagent were then added to the mixture. A blue-green precipitate formed indicated the presence of tannin.

3.1.3. Test for Alkaloid

About 2mL of the inhibitor was continuously stirred and added to 5mL aqueous solution of HCl in a steam water bath. The formation of an orange red precipitate obtained after 2mL of the filtrate was treated with few drops of Dragendorf reagent, indicated the presence of alkaloids.

3.1.4. Test for Phenolic Compounds

2mL of the extract was added and stirred together with a solution of 1% $FeCl_3$. A formation of violet colour obtained indicated the presence of phenolic compounds.

3.2. Gravimetry Test Results

Figures **1** - **2** revealed the weight loss results obtained for different concentrations of Siam weed inhibitor at 278 and 320K. In general, it was noticed that the weight loss of A36 metal increased as the corrosion time increased, but the weight loss reduced as the inhibitor concentration increased. This implied that increased inhibitor concentration resulted in areduction in corrosion reactions through the formation of thin-film adsorbed on the metal surface [11].

Also, it was observed that weight loss increased as the corrosion reaction temperature increased. That is, an increase in temperature favoured corrosion

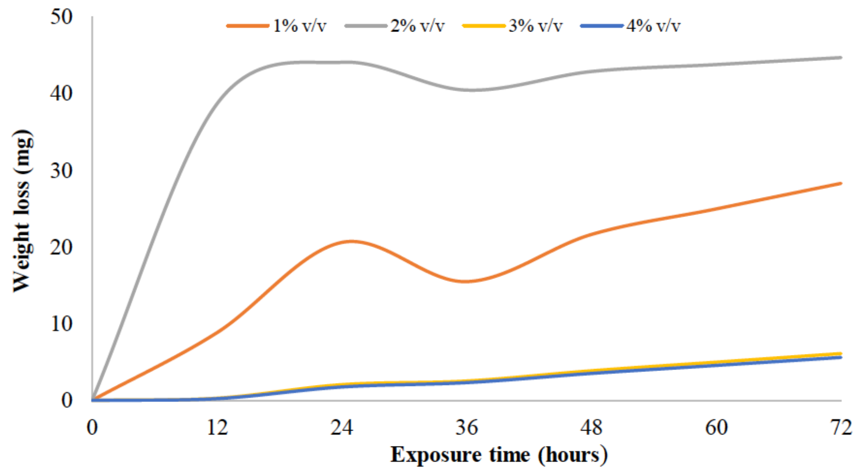

Figure 1: Weight loss (mg) against time (h) operated at 278K for different concentrations of Siam weed.

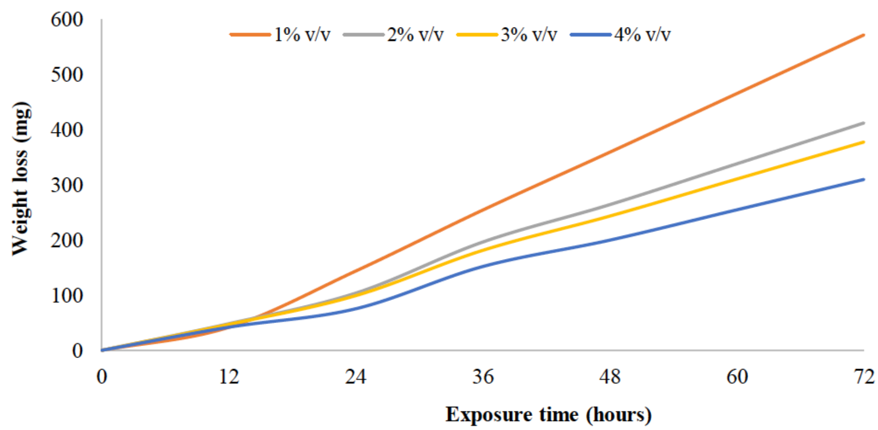

Figure 2: Weight loss (mg) against time (h) operated at 320K for different concentrations of Siam weed.

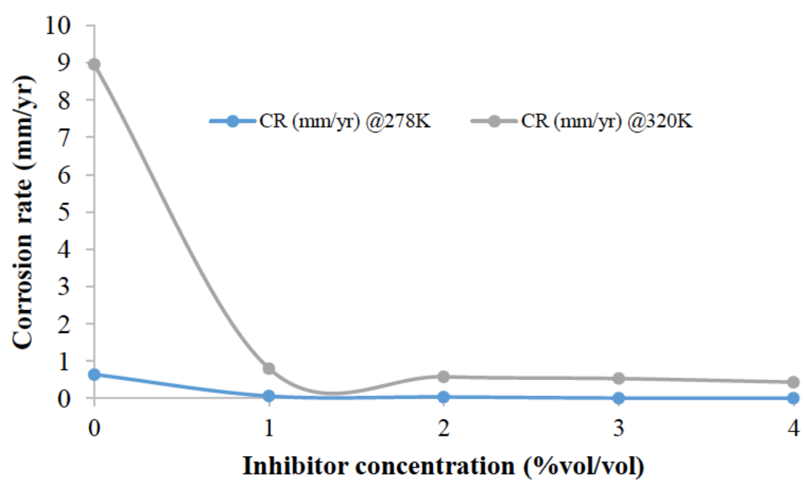

Figure 3: Corrosion rate of the mild steel at different temperatures and concentrations of the Siam weed inhibitor.

reactions, this is in line with the Arrhenius principle that says that reactions proceed in the direction of increased temperature [12].

Figure **3** shows the results of the A36 mild steel corrosion rate obtained at varied concentrations (0 – 4 %vol/vol) of the inhibitor at two different temperatures of 278 and 320K. The results showed that the corrosion

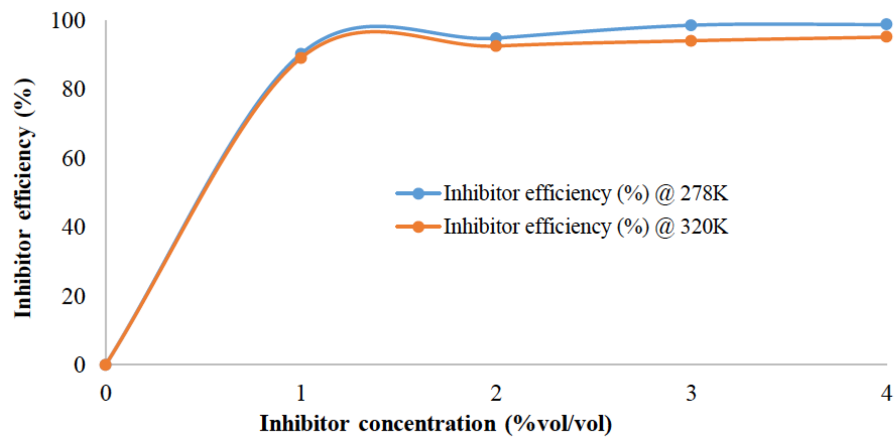

Figure 4: Inhibitor efficiency and varied concentrations of the inhibitor at different temperatures.

rate reduced as the inhibitor concentration increased. An indication that the inhibitor succeeded to slow down the corrosion reaction as the inhibitor concentration increased. This was accomplished through increased formation of the inhibitive protective film on the metal surface as the inhibitor concentration increased [13].

Also, it can be observed that the corrosion rate was higher at 320K temperatures, compared to the results obtained at the temperature of 278K. That is, an increase in temperature resulted in increase in the corrosion rate. The increased kinetic energy gained by the metal ions (due to increased temperature) speed up their rate of dissociation, thereby increased corrosion reaction of the metal samples. This result is in conformity with the Arrhenius equation that says that product formation in any given reaction is generally favoured by increased temperature [14].

In Figure **4**, the inhibitor efficiency increased with increased concentration of the Siam weed inhibitor. That is, increased inhibitor concentration amounted to increase in a protective layer on metal surface thereby slowing down the corrosion activities on the surface. Also, at lower reaction temperature of 278K, higher inhibitor efficiency was obtained when compared to the results obtained at 320K. These results agreed with the results obtained from weight loss and corrosion rate.

3.3. Thermodynamic Results of Siam Weed Inhibitor

Figure **5** revealed the Langmuir adsorption plot obtained for Siam weed inhibitor adsorbed on the metal surface, at corrosion reaction temperatures of 278 and 320K. The correlation results of approximately one (0.9998 at 278K and 0.9973 at 320K) showed that

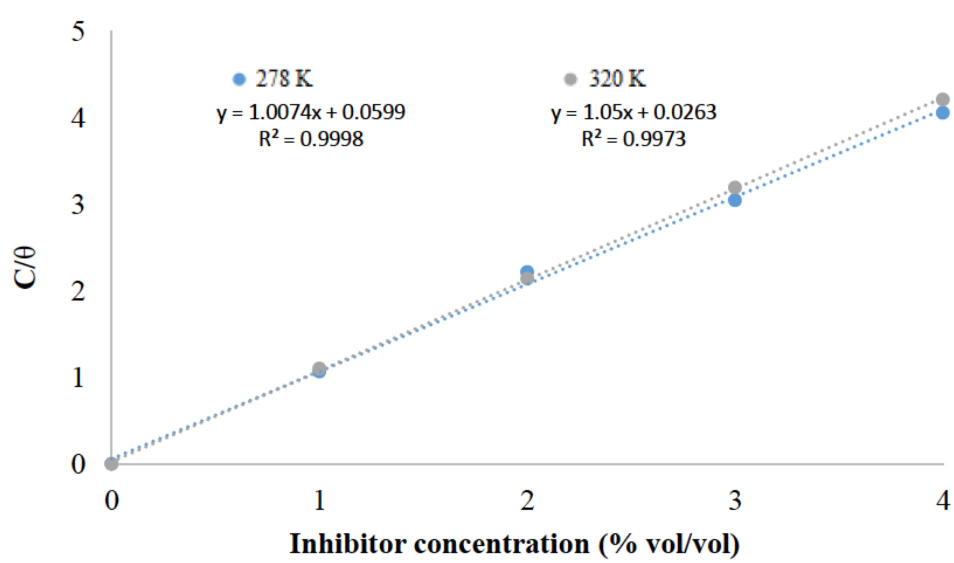

Figure 5: Langmuir adsorption plot for the inhibitor at 278 and 320K.

Table 1: Langmuir Adsorption Parametersat Different Temperatures

Temperature (K)	Slope (R^2)	Adsorption Equilibrium Constant (K_{ads})	Change in Gibbs Free Energy ΔG_{ads} (kJ/mol)
278	0.9998	16.6945	-15.8009
320	0.9973	38.0228	-20.5690

Langmuir adsorption isotherm accurately predicted the adsorption mechanism of the Siam weed inhibitor on the metal surface.

Table **1** showed the Langmuir adsorption parametersat different temperatures. The adsorption equilibrium constant (K_{ads}) of greater than one (1) obtained indicated that the adsorption process is physiosorption in nature. Also, the change in Gibbs free energy (ΔG_{ads}, work energy lost to the environment due to corrosion) at the two temperatures considered have negative values. This is an indication that the adsorption process is spontaneous and physiosorption [15].

CONCLUSION

a. The results of the gravimetric tests revealed that the Siam weed extract was a good corrosion inhibitor for A36 mild steel in 1M H_2SO_4medium

b. Corrosion inhibitive performance of Siam weed extract was obtained at the inhibitor concentration of 4 %vol./vol. with inhibitor efficiency of 95% and 93% at corrosion temperatures of 278 and 320K respectively.

c. Langmuir adsorption isotherm accurately predicted the adsorption mechanism of Siam weed extract on the metal surface with correlation values of 0.9998 and 0.9973 at the corrosion temperatures of 278 and 320K respectively.

d. The negative value of ΔG_{ads} and the adsorption equilibrium constant (K_{ads}) of greater than one showed both the spontaneous and physiosorption nature of the adsorbed Siam weed extract.

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