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Evaluation of Inhibition Properties of the Hibiscus Sabdariffa Calyx Extract on Mild Steel in Acidic Media

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ABSTRACT: The corrosion inhibition of mild steel in acidic media by hibiscus sabdariffa leaves extract using weight lost method was carried out. The result obtained from the studied showed that the efficiency of inhibition increase with increase in concentration of the plant extracted and decrease as the temperature rises. The adsorption of plant extract on the mild steels was found to obey Langmuir adsorption isotherm. Physical adsorption is proposed for the adsorption of the extract on the metal surface.

I. INTRODUCTION

Corrosion of a metal is due to chemical or electro-chemical reaction when it comes in contact with matter in the environment.The corrosion can be controlled by modifying the environment to stop the anodic or cathodic reaction. This can be achieved by applying an inhibitor (1). The corrosion inhibitors are substance which when added in small concentration to corrosive media, it decrease or prevent the reaction of the metal with the media (2,3). However, many synthetic compounds are used as excellent inhibitors, most of them are highly toxic to the environment. The toxic effect of these synthesis inhibitors have lead to search for an alternative source that can be used as inhibitors. The aim of this paper is toevaluate the inhibition properties of hibiscus sabdariffa calyx extract on mid steel in an acidic media.

Calyx Extract of Hibiscus Saddariffa As Corrosion Inhibitors On Mild Steel

The hibiscussaddariffa is used a corrosion inhibitors because it is natural product plants and it is important due its biodegradability, eco-friendliness, cost effectiveness, less toxic and easy availability (4,5). The mild steel is a structural material widely used in most chemical industries for fabrication of various reaction vessels, tanks pipes etc. Since mild steel is used under different condition in chemical and allied industries, it encounters severe attack from acids, due to their aggressive nature resulting in degradation (6,7).

II. EXPERIMENTAL

The mild steel was obtained from the material and metallurgical engineering workshop of Federal University of Technology Owerri, Nigeria. The sheets were cut coupons, degreased in absolute ethanol and dried in acetone and store in moisture free desiccators for the corrosion studies. The HCl used as test solution corrodent were of analytical grade. The calyx hibiscus sabdariffa extract were prepare by air drying the leaves and grinding it to powder. The filtrate obtained after extraction were concentrated using rotary evaporator. The extract of 0.1 to 0.5 g/L stock solution inhibitor was prepared. The gravimetric height loss techniques were carried at various temperatures of 30, 40, 50 and 60^{o}C. The inhibition efficiency (IE) was calculated using equation

$$IE = \frac{R_u - R_i}{R_u} \times 100$$

……
…….……..(1)

Where R_u and R_i is corrosion rate at uninhibited and inhibited acid respectively.

The surface coverage (θ) was calculated using

$$\theta = \frac{R_u - R_i}{R_u}$$

……
……(2)

The activation energy (E_a) was calculated using Arrhenius equation given by

$$K = A_e - E_a R$$

……
……..(3)

Where **K** is the rate constant
A_e is the experimental factor
E_a is the activation energy
Ris the gas constant $8.315K^{-1}mol^{-1}$
Tis the absolute temperature

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The corrosion rate was calculated from the height loss of the metal specimen during the corrosion test by the formula

Corrosion rate $(\mathbf{mdd}) = \frac{534W}{DAT}$

Where $\mathbf{W}$ = weight loss (mg)
$\mathbf{D}$ = denoity of specimen (gcm^{-2})
$\mathbf{A}$ = area of the specimen (cm^2)
$\mathbf{T}$ = exposure time in hour

III. RESULT AND DISCURSION

Experiments were performed with different concentration of the inhibitors. The value of the calculated corrosion rate, surface coverage and inhibition efficiencies are shown in the table 1.

Table 1: Concentration of Inhibitors, Corrosion Rate, Surface Coverage and Inhibition Efficiencies for Hibiscus Sabdariffa Extract.

System	Corrosion rate (g/cm^2)	Surface coverage (θ)	Inhibition efficiencies (IE)
1ml HCl (Black)	0.062	—	—
1ml HCl+0.1g/L	0.052	0.325	30.21
1ml HCl+0.2g/L	0.047	0.517	50.34
1ml HCl+0.3g/L	0.038	0.591	62.17
1ml HCl+0.4g/L	0.030	0.628	65.29
1ml HCl+0.5g/L	0.023	0.702	79.28

From the result, it shows that the corrosion rate decrease while the surface coverage (θ) and inhibition efficiencies (IE) increase with increase in concentration of the plant extract. Similarly, the extract has maximum inhibition efficiency of 79.28% at optimal concentration of 0.5g/L.

Effect of Temperature

The inhibition efficiencies decrease with increasing temperature. This is due to the increase in the rate of dissolution process of mild steel coupons and desorption of the inhibitors from the metal surface as shown in table 2.

Table 2: Temperature Increase with Decrease in Inhibition Efficiencies (IE)

Temperature (T)	Inhibition efficiencies (IE)	Activation energy (E_a)
30	4.150	21.22
40	2.010	22.65
50	0.092	24.20
60	0.060	25.34
70	0.038	26.03

The activation energy (E_a) showed an increase as the temperature increases while the inhibition efficiencies (IE) decrease as the temperature increase these can be interpreted as due to physical adsorption that occurs which causes decrease in the adsorption of the inhibitor on the mild steel as the temperature increases.

The enthalpy activation (ΔH^*) and entropy of activation (ΔS^*) for the corrosion of mild steel in the acid media was estimated using the equation

$$R_c = \frac{KT}{\hbar} \exp\left[\frac{\Delta S^*}{R}\right] \exp\left[\frac{-\Delta H^*}{RT}\right] \quad \ldots\ldots(4)$$

Where K is the Bohzman constant, $\hbar$ is the plank constant, A is the Arrhenius pre-exponential factor, T is the absolute temperature and R_c is corrosion rate. The value $\Delta H^*$and ΔS^* are given below in table 3:

Table 3: Activation Parameter of Mild Steel in Acid Media with Increase in Concentration of Extract.

System	E_a	ΔH^* kj/mol	ΔS^* kj/mol
1ml HCl+0.1g/L	21.22	09.27	30.21
1ml HCl+0.2g/L	22.65	15.06	50.34
1ml HCl+0.3g/L	24.20	20.18	62.17
1ml HCl+0.4g/L	25.34	23.26	65.29
1ml HCl+0.5g/L	26.03	30.58	79.28

From the data indicated in table 3, the values ΔH^* increase as the concentration of the plant extract increases. This indicates higher protection efficiency of the extract. The ΔS^* values shows that the activation complex in the rate

determining step represents association rather than dissociation step, meaning that a decrease is an indication of disordering take place on going from reactant to the activation complex.

Adsorption isotherm is one technique where basic information on the interaction between the inhibitor and mild steel surface can be obtained. Hence, surface coverage (θ) values at different concentration of the plant extract at the temperature ranges of $30^{o}C$ to $60^{o}C$ have been used to explain the best isotherm to determine the adsorption process. The θ value was applied to different adsorption isotherm equations and found to fit the Longmuir adsorption isotherm.

IV. CONCLUSION

The plant extract of hibiscus sabddariffa acts as a good corrosion inhibitors for mild steel in an acidic media. The highest value result for the corrosion performance was achieved at a concentration of 0.5g/L at a temperature of $70^{o}C$. The adsorption of hibiscus sabdariffa leaves extracts obeyed Longmuir adsorption isotherm. The surface coverage obtained at various concentrations with temperature range was used to explain the isotherm adsorption process. The enthalpy activation (ΔH^{*}) and the entropy (ΔS^{*})were used as an index of protection efficiency of the plant extract.

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