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Inhibitive Action of Phyllanthus amarus Extract on The Corrosion of Zinc in 0.5N H_2SO_4 Medium

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Abstract- In this work, the extract of the leaves of *Phyllanthus amarus* was investigated as a green corrosion inhibitor for zinc in 0.5N H_2SO_4 by using weight loss, gasometric and thermometric methods. Results obtained showed that the extract of *Phyllanthus amarus* exhibited high inhibition efficiencies against corrosion of zinc metal. The inhibition efficiency was found to increase with increase in the extract concentration. The adsorption of the inhibitor molecules on the zinc metal surface obeyed Temkin adsorption isotherm.

Index Terms- *Phyllanthus amarus*, acidic solutions, zinc corrosion, weight loss, gasometry, thermometry.

I. INTRODUCTION

Deterioration of a metal due to its interaction with the environment is referred to as corrosion. Generally organic compounds containing hetero atoms are widely used as corrosion inhibitors for many metals and alloys in various aggressive environments. The hazardous nature, non biodegradability and cost of these organic compounds motivated the researchers to focus their attention on developing cheap, non-toxic, biodegradable and environment friendly natural products of plant origin as corrosion inhibitors[1-22].

Phyllanthus amarus is a plant found throughout Tamil Nadu, India and belongs to the family euphorbiaceae. The extract of the leaves of *phyllanthus amarus* is used to cure jaundice. In the present work we have investigated the extract of the leaves of *phyllanthus amarus* as a green corrosion inhibitor for zinc metal in 0.5N H_2SO_4 employing weight loss, gasometry and thermometry techniques.

II. EXPERIMENTAL

The zinc metal specimens of composition: lead 1.03%, cadmium 0.04%, iron 0.001% and the remainder being zinc and size of 3cm*1.5cm* 0.08cm were used in all the experiments. Zinc metal specimens were polished with a series of emery papers of various grades from 200- 1200, degreased with absolute ethanol and air dried. The corrosion medium employed was 0.5N H_2SO_4 prepared from A.R grade H_2SO_4 and deionised water.

The *Phyllanthus amarus* plant was obtained from the local market. It is cleaned with tap water to remove mud particles. The leaves of the plant were first shade dried and then dried in an oven for 2 hours at 80^0C and ground to get the powder form of the material. 250 ml of alcohol was then added to 10 gram of this powder and left standing for two days with occasional shaking. The solution was then filtered and the alcohol was evaporated to get a brown sticky mass. 1 gram of this sticky mass was then dissolved in 1L of 0.5N H_2SO_4 to get the stock solution. From this stock solution concentrations of 200, 400, 600, 800 mg/L of the extract were prepared by dilution.

Weight loss, gasometry and thermometric studies were carried out as reported earlier[23-27]. The experiments were conducted in triplicate and the average of the three values is obtained to ensure accuracy of the results. From the weight loss experiments the % inhibition efficiency (I.E) and the degree of surface coverage (θ) were calculated by using the following equations.

$$I.E = \frac{Wo-Wi}{Wo} X\, 100$$

$$\theta = \frac{Wo-Wi}{WO}$$

Where W_o and W_i are the weight loss of the metal in the absence and presence of the inhibitor respectively.

The corrosion rate (C.R) of the metal was calculated by using the following equation.

$$C.R(mmy) = \frac{87.6\, W}{A\, t\, D}$$

Where W is the weight loss of the zinc metal (mg), A is the surface area of the metal specimen(cm^2), t is the exposure time (h) and D is the density of the metal (g/cm^3).

From the gasometry experiments the inhibition efficiency was calculated by using the following equation.

$$I.E = \frac{Vo-Vi}{Vo} X\, 100$$

Where V_o and V_i represent the volume of hydrogen gas evolved in the absence and presence of the inhibitor respectively.

From the thermometric studies the reaction number was first calculated by using the equation

$$RN = \frac{Tm-Ti}{t}$$

Where T_m is the maximum temperature , T_i is the initial temperature and t is the time taken to attain the maximum temperature.

The inhibition efficiency is calculated by using the following equation

$$I.E = \frac{RNo - RNi}{RNo}$$

Where RN_o is the reaction number in the absence of the inhibitor and RN_i is the reaction number in the presence of various concentrations of the inhibitor.

III. RESULTS AND DISCUSSION

Weight loss, gasometry and thermometric experiments were carried out at five different concentrations of the extract and the inhibition efficiency(IE) values were calculated. Values of inhibition efficiency obtained from these experiments are presented in the table-1

Table 1 Values of inhibition efficiency(I.E(%)) obtained experiments for the corrosion of zinc in 0.5N H_2SO_4 in the presence of different concentrations of the extract.

Method employed	Values of I.E(%) for different concentrations (mg/L) of the extract				
	200	400	600	800	1000
Weight loss	26.8	50.4	61.5	70.2	76.8
Gasometry	26.2	49.5	62.4	69.8	77.1
Thermometry	25.9	50.2	62.1	69.4	77.4

From the table it can be seen that there is very good agreement between the values of inhibition efficiency obtained from these three methods. The results also indicate that the inhibition efficiency of the *phyllanthus amarus* extract increases with increase in the concentration. The dependence of inhibition efficiency of the extract on the concentration is shown in figure-1

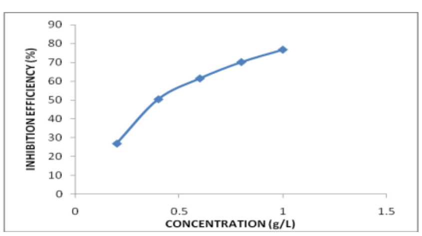


Figure 1 Variation of inhibition efficiency with concentration of the plant extract.

Values of corrosion rates obtained from the weight loss experiments for the corrosion of zinc in 0.5N H_2SO_4 in the presence of different concentrations of the extract are presented in the table-2

Table 2 Values of corrosion rates obtained from the weight loss experiments.

Values of corrosion rates (mm/y) for different concentrations (mg/L) of the extract				
200	400	600	800	1000
75.4	51.1	39.6	30.7	23.9

From the table-2 it can be seen that the corrosion rates for the corrosion of zinc in 0.5N H_2SO_4 decreases with increasing concentration of the plant extract. The effect of extract concentration on the corrosion rates is shown in figure-2.

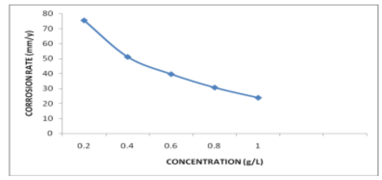
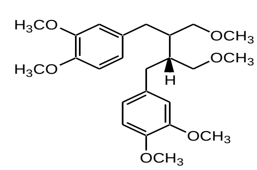
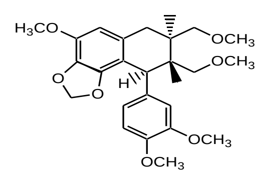


Figure 2 Variation of corrosion rates with concentration of the inhibitor.

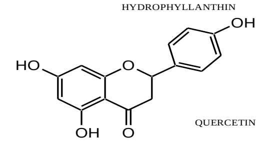
The inhibitive action of *phyllanthus amarus* extract can be attributed to the presence of various organic compounds . These include phyllanthin, hypophyllanthin, quercetin, tannins-phyllanthusiin, amariin, amarulone, amarinic acid: alkaloids- ent-norsecurinine, sobubbialine, epibubbaialine, nyrphyllin etc. The molecular structures of some of these compounds are shown below.



PHYLLATHIN



HYDROPHYLLANTHIN



QUERCETIN

From the molecular structures it can be observed that the these compounds possess lot of hetero atoms and aromatic rings which are responsible for the adsorption of these compounds on to the metal surface. Organic compounds containing π-electrons, hetero atoms and multiple bonds have been reported to function as effective inhibitors for the corrosion of many metals in various media[28-32]. Since the *phyllanthus amarus* extract contains many organic compounds, it is very difficult to mention a particular compound for the inhibition activity. The inhibitive activity of

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the extract is attributed to the combined action of all the compounds present in the extract.

IV. ADSORPTION ISOTHERMS

To study the mechanism of corrosion inhibition, attempts were made to fit the data available to the various adsorption isotherms such as Langmuir, Temkin, Freundlich, Bockris-Swinkels and Flory-Huggins. From the weight loss values the degree of surface coverage (θ) values were determined and plotted against log C of the extract which results in a straight line. This indicates that the adsorption of the inhibitor on the zinc metal surface follows Temkin adsorption isotherm. Figure 3 shows the Temkin adsorption isotherm.

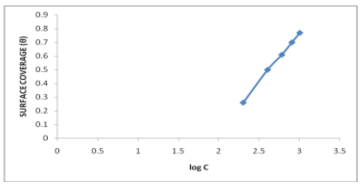

Figure 3 Temkin adsorption isotherm plot for zinc in 0.5N H_2SO_4 containing different concentrations of the extract.

V. CONCLUSIONS

The extract of the leaves of *Phyllanthus amarus* used in this work exhibited good inhibition efficiency. The inhibition efficiency increases with increase in the concentration of the extract. The adsorption of the components of the extract on to the metal surface in 0.5N H_2SO_4 follows the Temkin adsorption isotherm.

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