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Inhibitive Action of Solanum Nigrum Extract on the Corrosion of Zinc in 0.5N HCl Medium

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Abstract- In this work, the extract of the leaves and berries of *solanum nigrum* was examined as a green corrosion inhibitor for zinc in 0.5N HCl by using weight loss, gasometric and thermometric methods. Results obtained showed that the extract of *solanum nigrum* offered good protection against corrosion of zinc metal and exhibited high inhibition efficiencies. 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- Solanum nigrum, acidic solutions, zinc corrosion, weight loss, gasometry, thermometry.

I. Introduction

Corrosion is defined as the deterioration of a metal due to its interaction with the environment. Due to corrosion many useful properties of a metal such as malleability, ductility and electrical conductivity are lost. Synthetic organic compounds are widely used as corrosion inhibitors for the prevention of corrosion of many metals and alloys in various aggressive environments. Because of their hazardous nature, researchers focus their attention on developing cheap, non-toxic, biodegradable and environment friendly natural products of plant origin as corrosion inhibitors[1-27].

Solanum nigrum is a plant with medicinal value, found throughout Tamil Nadu, India and belongs to the family solanaceae. The leaves and berries of *solanum nigrum* are widely used to cure mouth ulcer. In the present work we have evaluated the extract of the leaves and berries of *solanum nigrum* as a green corrosion inhibitor for zinc metal in 0.5N HCl using weight loss, gasometry and thermometry methods.

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 for weight loss gasometry and thermometric studies. Zinc metal specimens were abraded with a series of emery papers of various grades from 200- 1200, washed with distilled water ,degreased with absolute ethanol and air dried. The corrosion medium employed was 0.5N HCl prepared from A.R grade HCl and deionised water.

2.1.Preparation of the extract

The solanum nigrum plant was obtained from the local market. It is cleaned with tap water to remove mud particles. The leaves and berries of the plant were then dried in an oven for 2 hours at 100^0C 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 three 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 HCl to get the stock solution. From this stock solution, concentrations of 200, 400, 600, 800 mg/L were prepared by dilution.

2.2 Weight loss, gasometry and thermometric studies

Weight loss, gasometry and thermometric studies were carried out as reported earlier[28-32]. In order to get accurate results, the experiments were conducted in triplicate and the average of the three values is obtained. 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 is 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 from the weight loss, gasometry and thermometric experiments for the corrosion of zinc in 0.5N HCl 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	18.9	43.1	55.4	65.2	71.8
Gasometry	18.1	43.9	54.7	64.6	71.1
Thermometry	19.2	42.7	54.2	65.8	70.6

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 *solanum nigrum* extract increases with increase in the concentration. The dependence of inhibition efficiency of the extract on the concentration is shown in figure-1

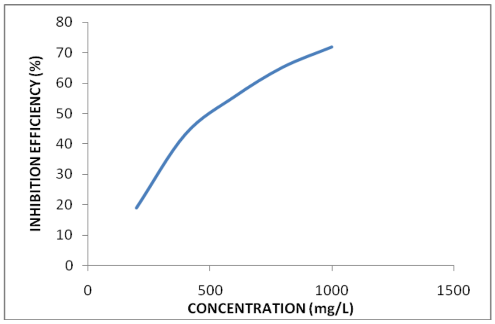


Figure 1 Variation of inhibition efficiency with concentration of the plant extract.

Values of corrosion rates obtained from the weight loss experiments for the extract for the corrosion of zinc in 0.5N HCl 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
113.5	79.7	62.4	48.7	39.5

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

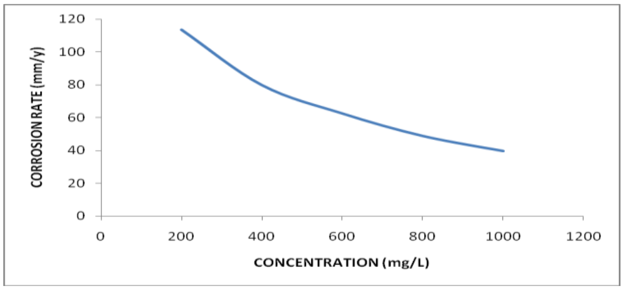
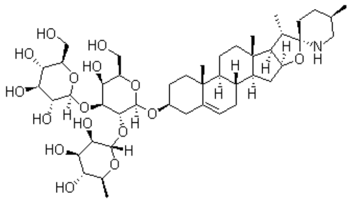
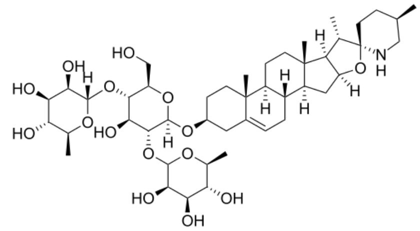


Figure 2 Variation of corrosion rates with concentration of the inhibitor.

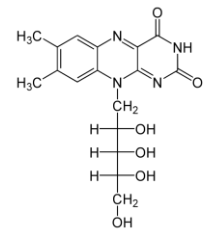
The inhibitive action of *solanum nigrum* extract can be attributed to the presence of various high molecular weight organic compounds . These include steroidal alkaloid glycosides, alpha and beta solamargine, alpha and beta solanigrine and solasonine. It also contains steroidal sapogenins: diosgenin and tigogenin; solasodine and solasodiene. The leaves contain riboflavin, nicotinic acid and vitamin-C. The molecular structure of some of these compounds are shown below.



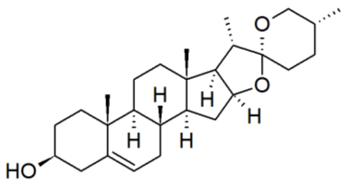
Solasonine



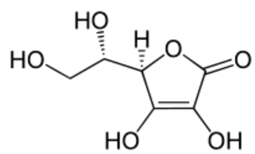
solamargine



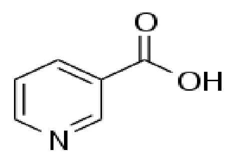
Riboflavin



Diosgenin



Vitamin-C



Nicotinic acid

The molecular structure of these compounds shows the presence of many hetero atoms , double bonds and aromatic rings which are potential adsorption centres for adsorption 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[33-37]. Since the *solanum nigrum* extract contains many organic compounds, it is very difficult to mention a particular compound for the inhibition activity. The inhibitive activity of the extract is attributed to the combined action of all the compounds present in the extract.

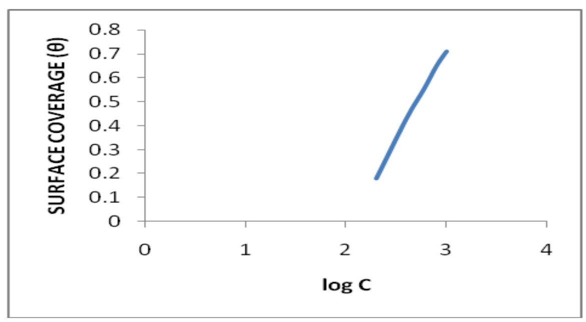


Figure 3 Temkin adsorption isotherm plot for zinc in 0.5N HCl containing differentconcentrations of the extract.

IV. Adsorption Isotherms

Inhibitors reduce the corrosion of metals by getting adsorbed on the metal surface forming a thin film which acts as a barrier between the metal and the aggressive media leading to corrosion inhibition. 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) for various concentration of extract 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.

V. Conclusions

The extract of leaves and berries of *solanum nigrum* 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 HCl follows the Temkin adsorption isotherm.

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