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Triethylenetetramine as a Corrosion Inhibitor for Zinc Metal in Acidic Solutions

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Abstract- The inhibitive action of Triethylenetetramine on zinc metal was evaluated in 0.5N HCl as corrosion medium ,using weight loss, gasometric and thermometric techniques. Parameters such as inhibition efficiency and corrosion rates were evaluated to assess the performance of the inhibitor. The results showed that the inhibitor displayed good corrosion inhibiting properties. The inhibition efficiency was found to increase with increase in the inhibitor concentration. To study the adsorption of the inhibitor on the metal surface, adsorption isotherm was plotted.

Index Terms- Triethylenetetramine, acidic solutions, zinc corrosion, weight loss, gasometry, thermometry.

I. Introduction

Corrosion of metals and alloys resulted in the loss of many important characteristics such as malleability, ductility and conductance. The strategy to be employed to control the corrosion process is to isolate the metals and alloys from the corrosive environments. Use of corrosion inhibitors is one of the many methods available for securing metals against corrosion. Organic compounds with heteroatoms, multiple bonds and aromatic rings proved to be effective inhibitors. A variety of organic compounds were used as corrosion inhibitors for zinc metal in various environments[1-11]. These inhibitors control the corrosion process by adsorption on to the metal surface. In this work, we have examined Triethylenetetramine as a corrosion inhibitor for zinc metal in 0.5N HCl acid solution by weight loss, gasometry and thermometric 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 4cm*2cm* 0.08cm were used for weight loss, gasometry and thermometry studies.. Zinc metal specimens were polished with a series of emery papers of various grades from 400-1200, degreased with absolute ethanol and dried. The inhibitor compound, Triethylenetetramine was obtained Alfa Aesar Chemicals of the United Kingdom. The corrosion medium was 0.5N HCl prepared from A.R grade HCl and deionised water.

Weight loss, gasometry and thermometric studies were carried out as reported earlier[12-16]. 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 evaluated 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 are 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 studies were conducted 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 various experiments.

Method employed	Values of I.E(%) for different concentrations (mM) of Triethylenetetramine inhibitor				
	5	10	30	50	100
Weight loss	38.0	49.2	64.9	72.8	84.2
Gasometry	37.6	48.4	64.0	71.4	83.1
Thermometry	38.4	49.8	63.4	70.8	83.9

It can be observed from the table 1 that there is very good agreement between the values of inhibition efficiency obtained from these three methods. The results also show that the inhibition efficiency increases with increase in the inhibitor concentration. The dependence of inhibition efficiency of the inhibitor on the concentration is shown in figure-1

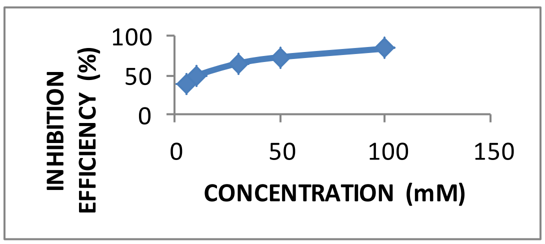

Figure 1 Variation of inhibition efficiency with concentration of the inhibitor.

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

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

Values of corrosion rates for different concentrations (mM) of Triethylenetetramine inhibitor				
5	10	30	50	100
91.0	78.4	53.2	40.6	28.1

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 inhibitor. The effect of inhibitor concentration on the corrosion rates is shown in figure-2.

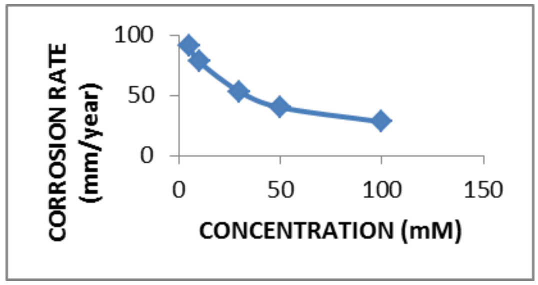

Figure 2 Variation of corrosion rates with concentration of the inhibitor.

The inhibitor molecule contains four nitrogen atoms in its molecular structure. These nitrogen atoms possess lone pairs of electrons required for the adsorption process. On adsorption, a strongly adherent layer is formed on the metal surface. This layer acts as a barrier between the metal and the environment giving protection to the metal. In addition to these, the amino groups present in the molecule can be easily protonated in acid medium to form the cationic form of the inhibitor. The chloride ions present in the acid medium gets adsorbed specifically on the positively charged metal surface due to its lesser degree of hydration leading to the creation of excess negative charges on the metal surface which enhances more adsorption and hence protection of the metal. Another factor responsible for the higher inhibition efficiency of the inhibitor is the large surface area of the inhibitor molecules which provides higher surface coverage to the metal after getting adsorbed on to the metal surface.

IV. ADSORPTION ISOTHERMS

From the weight loss measurements, the degree of surface coverage (θ) for various concentrations of the inhibitor were determined . Temkin's adsorption isotherm was tested by plotting logC vs θ which gave a straight line thereby indicating that the adsorption of the inhibitor on the surface of zinc from 0.5N HCl obeys Temkin's adsorption isotherm. Figure -3 shows the Temkin adsorption isotherm plot for zinc in 0.5N HCl containing different concentrations of the inhibitor.

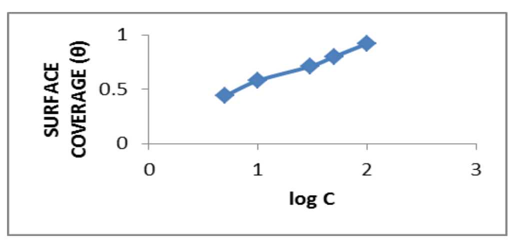

Figure 3 Temkin adsorption isotherm plot for zinc in 0.5N HCl containing different concentrations of the inhibitor.

V. CONCLUSIONS

Triethylenetetramine used as a corrosion inhibitor for zinc in 0.5N HCl performed well and gave high percentage of inhibition efficiency. The inhibition efficiency of the inhibitor increased with the increase in the concentration of the inhibitor. The adsorption of the inhibitor on to zinc surface obeyed Temkin adsorption isotherm.

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