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Chrysoidine Dye as a Novel Corrosion Inhibitor for Mild Steel in Acidic Solutions

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Abstract- Chrysoidine dye was examined as an inhibitor for mild steel in 1N HCl using weight loss, gasometric and thermometric methods. Parameters such as inhibition efficiency and corrosion rates were evaluated. The inhibition efficiency was found to increase with increase in the inhibitor concentration. To study the adsorption of the inhibitor on the mild steel surface, adsorption isotherm was plotted.

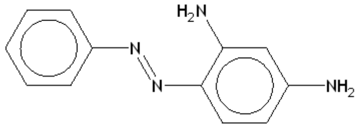
Index Terms- Chrysoidine , acidic solutions, mild steel corrosion, weight loss, gasometry, thermometry.

I. Introduction

Acid solutions are widely used various industries for acid pickling, acid cleaning and oil well cleaning applications.. In these processes the metallic materials usually undergo corrosion. Due to corrosion of metals and alloys many important properties such as malleability, ductility, conductance are lost. The use of inhibitors is an important method of protecting the metals and alloys against corrosion. A review of the literature shows that many organic compounds were used as corrosion inhibitors for mild steel in various environments[1-11]. In this work, the influence of chrysoidine dye as a corrosion inhibitor for mild steel in 1N HCl acid solution was examined by weight loss, gasometry and thermometric methods.

II. EXPERIMENTAL

The mild steel specimens of composition: carbon 0.07%, phosphorous 0.008%, manganese 0.34% and the remainder being iron and size of 5cm*2cm* 0.025cm were used for weight loss gasometry and thermometry studies. Mild steel specimens were polished with a series of emery papers of various grades from 400-1200, degreased with absolute ethanol and air dried. The inhibitor compound, chrysoidine dye was obtained from the Loba chemicals, India. The corrosion medium was 1N HCl prepared from A.R grade HCl and deionised water. The structure of the inhibitor molecule is given below.



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 mild steel in the absence and presence of the inhibitor respectively.

The corrosion rate (C.R) of the mild steel 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 mild steel (mg), A is the surface area of the mild steel specimen(cm^2), t is the exposure time (h) and D is the density of the mild steel (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 carried out at four different concentrations of the inhibitor and the inhibition efficiency(IE) values were calculated. Values of inhibition efficiency obtained from these experiments for the corrosion of mild steel in 1N HCl in the presence of different concentrations of the inhibitor 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 mild steel in 1N HCl in the presence of different concentrations of the inhibitor.

Method employed	Values of I.E(%) for different concentrations (mM) of chrysoidine inhibitor			
	10	30	50	100
Weight loss	33.1	60.2	73.3	84.2
Gasometry	33.7	60.8	72.4	84.7
Thermometry	32.4	59.7	72.9	85.4

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

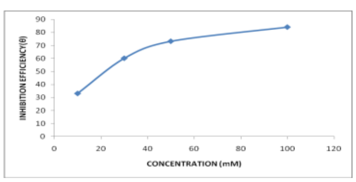


Figure 1 Variation of inhibition efficiency with concentration of the inhibitor.

Values of corrosion rates obtained from the weight loss experiments for the inhibitor for the corrosion of mild steel in 1N 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 chrysoidine inhibitor			
10	30	50	100
43.3	25.8	17.3	10.2

From the table-2 it can be seen that the corrosion rates for the corrosion of mild steel in 1N HCl decreases with increasing concentration of the inhibitor. The effect of inhibitor concentration on the corrosion rates is shown in figure-2.

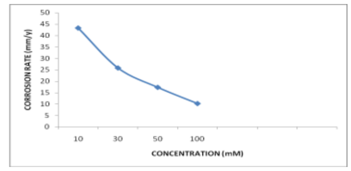


Figure 2 Variation of corrosion rates with concentration of the inhibitor.

The inhibitor molecule contains two primary amino groups, one azo group and two aromatic rings in its molecular structure. All these are potential adsorption centres, through which the inhibitor molecule can get adsorbed on the mild steel surface leading to the formation of a layer on the mild steel surface. This layer acts as a barrier between the mild steel and the corrosive media giving protection to the mild steel. In addition to these, the two primary 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 mild steel surface due to its lesser degree of hydration leading to the creation of excess negative charges on the mild steel surface which favours the adsorption of these cationic form of the inhibitor molecules on the mild steel surface resulting in the enhanced protection of mild steel. Another important 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 mild steel after getting adsorbed on the mild steel surface.

IV. ADSORPTION ISOTHERMS

Adsorption of inhibitor molecules on the mild steel surface is characterized by various adsorption isotherms such as Langmuir, Temkin, Freundlich etc., From the weight loss measurements the degree of surface coverage (θ) for various concentrations of the inhibitor were evaluated. Temkin's adsorption isotherm was tested by plotting logC vs θ and no straight line was obtained thereby showing that the adsorption of the inhibitor on the surface of mild steel from 1N HCl does not obey Temkin's adsorption isotherm. Langmuir's isotherm was tested by plotting C/ θ vs C and a straight line was obtained which indicated that the adsorption of the inhibitor on the surface of the mild steel from 1N HCl obey Langmuir's adsorption isotherm. Figure -3 shows the Langmuir's adsorption isotherm plot for mild steel in 1N HCl containing different concentrations of the inhibitor.

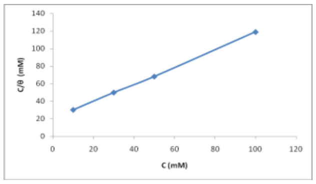


Figure 3 Langmuir's adsorption isotherm plot for mild steel in 1N HCl containing different concentrations of the inhibitor

V. CONCLUSIONS

The chrysoidine dye used as a corrosion inhibitor for mild steel in 1N HCl performed well and gave high percentage of inhibition efficiency. The inhibition efficiency of the inhibitor increases with the increase in the concentration of the inhibitor.The adsorption of the inhibitor on mild steel surface obeyed Langmuir's adsorption isotherm.

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