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Diphenyl Sulphide as Corrosion Inhibitor for Zinc Metal in Acid Solutions

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Abstract- This work deals with the evaluation of diphenyl sulphide as a corrosion inhibitor for zinc in 0.5N HCl and 0.5N H_2SO_4 by conventional weight loss and gasometric methods. Results indicate that diphenyl sulphide exhibited high inhibition efficiencies in both the acids but performed better in 0.5N H_2SO_4 than in 0.5N HCl. The inhibition efficiency was found to increase with increase in the inhibitor concentration. The adsorption of the inhibitor molecules on the zinc metal surface obeyed Temkin adsorption isotherm.

Index Terms- Diphenyl sulphide, acidic solutions, zinc corrosion, weight loss, gasometry.

I. Introduction

Acid pickling, acid cleaning and acid descaling are some of the industrial process in which metals are exposed to different acids of various concentrations. In order to reduce the metal loss and acid consumption corrosion inhibitors are added to the acid solutions[1-8]. Organic compounds containing nitrogen, oxygen and sulphur in their molecular structures have been reported to function as effective inhibitors for various metals in different corrosive media. The efficiency of these compounds as corrosion inhibitors is attributed to the number of mobile electron pairs present[9], the π-orbital character of the electrons[10] and the electron density around the hetero atoms[11]. The efficiency of the corrosion inhibitors are also reported to be influenced by their molecular structure, molecular size and the nature of the substituent groups[12, 13]. These compounds minimize the corrosion rate of the metals by getting adsorbed on the metal surface thereby blocking the active sites on the metals.

In the present work, we have evaluated diphenyl sulphide as an inhibitor for zinc corrosion in 0.5N HCl and 0.5N H_2SO_4 using the conventional weight loss and gasometry methods. The efficiency of the inhibitor was evaluated at four different concentrations.

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 with a small hole of approximately 3mm near the end of the specimen were used for weight loss and gasometry studies. Zinc metal 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, diphenyl sulphide was imported from the Fluka AG of Switzerland. The corrosion medium was 0.5N HCl and 0.5N H_2SO_4 prepared from A.R grade HCl and H_2SO_4 and deionised water.

III. Weight Loss and Gasometry Studies

Weight loss and gasometry studies were conducted as reported earlier[14,15].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 are the volume of hydrogen gas evolved in the absence and presence of the inhibitor respectively.

IV. Results and Discussion

Values of inhibition efficiency obtained from the weight loss and gasometry experiments for the inhibitor for the corrosion of zinc in 0.5N HCl and 0.5N H_2SO_4 in the presence of different concentrations of dipheny sulphide are presented in the tables 1and 2 respectively.

Table 1 Values of inhibition efficiency obtained from the weight loss experiments.

Corrosive medium	Values of I.E(%) for different concentrations (mM) of diphenyl sulphide				
	5	10	30	50	100
0.5N HCl	31.2	41.9	60.3	67.8	75.1
0.5N H_2SO_4	38.1	48.8	66.1	72.3	79.2

Table 2 Values of inhibition efficiency obtained from the gasometry experiments.

Corrosive medium	Values of I.E(%) for different concentrations (mM) of diphenyl sulphide				
	5	10	30	50	100
0.5N HCl	31.8	42.1	61.0	67.2	75.6
0.5N H_2SO_4	38.7	48.2	66.9	71.8	78.6

The results presented in the tables1 and 2 shows that the inhibition efficiencies increase with increase in the inhibitor concentration. It can also be seen from these tables that diphenyl sulphide performed better in 0.5N H_2SO_4 than in 0.5N HCl. A similar observation has already been made by several authors[16-21].

The inhibitor used in this study contains two phenyl rings in its molecular structure which are rich sources of electrons apart from the sulphur atom which contains two lone pairs of electrons. The adsorption of this inhibitor molecule on the surface of zinc metal surface can occur in the following ways. (i).The sulphur atom with its two lone pair of electrons can act as an efficient adsorption centre and get adsorbed on the positively charged metal surface leading to the formation of a protective layer on the metal surface. This protective layer acts as a barrier between the zinc metal and the corrosive media thus bringing down the corrosion rate of the metal. (ii.)The two phenyl groups with their π-electrons can also get adsorbed on the metal surface leading to the protection of the metal. (iii).The two phenyl groups being bulky in nature, on adsorption on the metal surface offers good surface coverage to the metal surface against attack by the corrosive media. (iv).The sulphur atom in the molecule in acid medium can be protonated to some extent to form the cationic form of the inhibitor.The chloride and sulphate ions in the corrosive medium with less degree of hydration gets specifically adsorbed on the positively charged metal surface leading to the creation of excess negative charges on the metal surface. This situation highly favours the adsorption of the inhibitor molecules on the metal surface resulting in reduced corrosion rate. Infrared spectrum confirm that a metal sulphur bond may exist between the sulphur atom and the metal[22]. The dependence of inhibition efficiency of the inhibitor on its concentration is shown in figure 1.

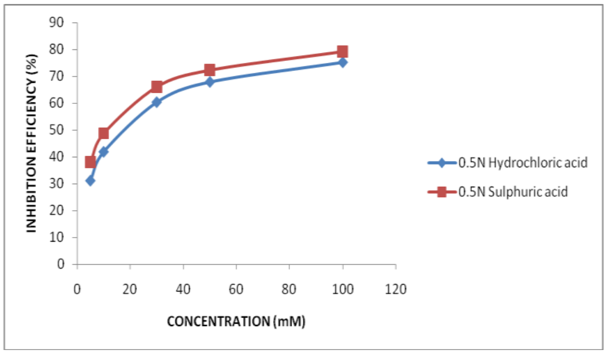

Figure- 1 Variation of inhibition efficiency with concentration of the diphenyl sulphide inhibitor for zinc in 0.5N HCl

Values of corrosion rates(mm/year) obtained from the weight loss experiments for the inhibition of the corrosion of zinc in 0.5N HCl and 0.5N H_2SO_4 in the presence of different concentrations of diphenyl sulphide is presented in the table 3.

Table 3 Values of corrosion rates(mm/year) from the weight loss measurements

Corrosive medium	Values of corrosion rates(mm/year) for different concentrations (mM) of diphenyl sulphide				
	5	10	30	50	100
0.5N HCl	96.3	81.3	55.6	45.1	34.9
0.5N H_2SO_4	63.8	52.7	34.9	28.5	21.4

From the table 3 it can be observed that the corrosion rates for the corrosion of zinc in 0.5N HCl and 0.5N H_2SO_4 decreases with increasing concentration of the inhibitor. The effect of inhibitor concentration on the corrosion rates is shown in figure 2.

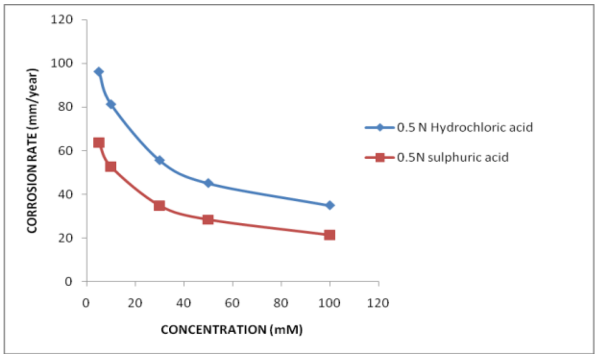

Figure- 2 Variation of corrosion rates with concentration of the diphenyl sulphide inhibitor for zinc in 0.5N HCl.

Adsorption isotherms

Adsorption isotherms play an important role in the understanding of the mechanism of inhibition of corrosion of metals. From the weight loss values the degree of surface coverage (θ) for various concentration of diphenyl sulphide inhibitor were determined and plotted against log C for different concentrations of the inhibitor. A straight line was obtained indicating that the adsorption of the inhibitor on the zinc metal surface follows Temkin adsorption isotherm. Figure 3 shows the Temkin adsorption isotherm.

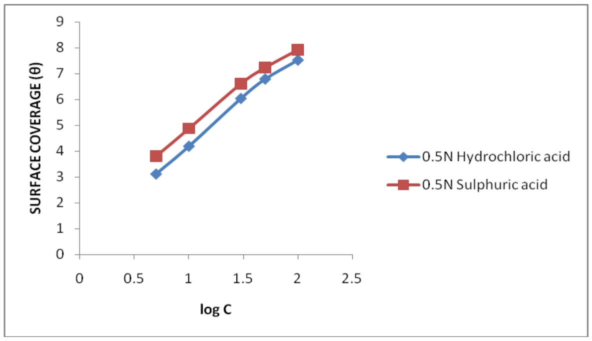

Figure-3 Temkin adsorption isotherm plot for corrosion of zinc in 0.5N HCl containing different concentrations of inhibitor.

V. Conclusions

The inhibitor diphenyl sulphide used in this work exhibited good inhibition efficiency.Inhibition efficiency increases with increase in inhibitor concentration.The inhibitor performed better in 0.5N H_2SO_4 than in 0.5N HCl.The adsorption of the inhibitor molecules on the metal surface obeys Temkin's adsorption isotherm.

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