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Influence of Benzotriazole on Corrosion Inhibition of Mild Steel in Citric Acid Medium

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Abstract: Benzotriazole an organic compounds has been studied as corrosion inhibition for mild steel in 1 N citric acid by weight loss method. The result showed that the corrosion inhibition efficiency of the compound was found to be varying with the temperature and acid concentration. Also it was found that the corrosion inhibition behaviour of benzotriazole is better when the concentration of inhibitor is increased. The kinetic treatment of the results shows first order kinetics.

Keywords: Mild steel, Corrosion Inhibitors, Weight loss method and Benzotriazole.

Introduction

Iron and its alloys are extremely used in many engineering application in various environments especially in inorganic and organic acid environments because of their excellent combination of properties[1-2]. Various types of inhibitors have been used as corrosion inhibitors for mild steel corrosion in acidic medium[3]. High electron density of the sulphur and nitrogen atoms in the heterocyclic organic compounds helps the organic molecules to get chemisorbed on to the metal surface[4]. Most of the earlier studies have been related to the general performance and the inhibition of mild steel corrosion in organic acid[5-6]. So in this investigation the corrosion behoviour of mild steel in 1 N citric acid medium in the absence and presence of benzotriazole at various temperature by weight loss method.

Experimental

According to ASTM method[7] as reported already cold rolled mild steel strips were cut into pieces of 5 cm × 1 cm having the following composition (in percentage) of Fe = 99.686, Ni = 0.013, Mo = 0.015, Cr = 0.043, S = 0.014, P = 0.009, Si = 0.007, Mn = 0.196 and C = 0.017.

They were pickled in pickling solution (5% H_2SO_4) for 3 minutes and washed with distilled water followed by polished with various grades of emery papers and degreased using trichloroethylene. The weight of specimen were noted and then immersed in test solution containing various concentrations of inhibitors at room temperature 303K, 353K and 403K. After the duration of 2 h in citric acid, the specimens were removed from test solutions and pickled in pickling (5% sulphuric acid) solution, dried and finally weighed. The differences in weights were noted and the corrosion rates were calculated.

Solutions

All the solutions were prepared using NICE brand AR grade chemicals in double distilled water and bubbling purified by nitrogen gas for 30 minutes to carry out de-aeration of the electrolytes. Citric acid solution was prepared by double distilled water. The corrosion inhibitor solution of 0.1 % benzotriazole was prepared by dissolving 1 g of benzotriazole in 100 mL of test solution. And also, 0.2%, 0.3%, 0.4% and 0.5% solutions of benzotriazole were prepared.

Results and Discussion

The corrosion behavior of mild steel in citric acid (Figure 1) and analyzed by weight loss method at different temperatures (303K, 353K and 403K).

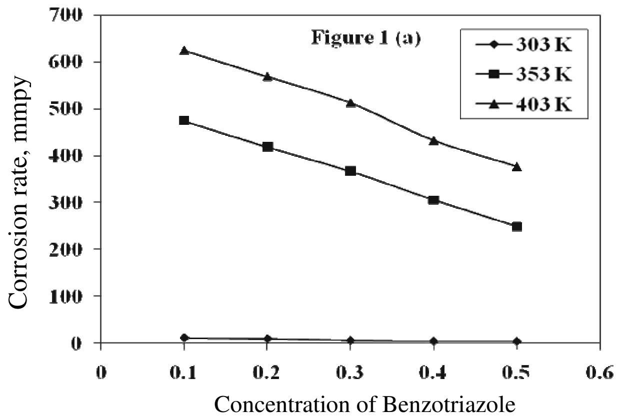


Figure 1 (a). Variation of corrosion rate (CR) with concentration of benzotriazole (in %) in citric acid solution at different temperature,

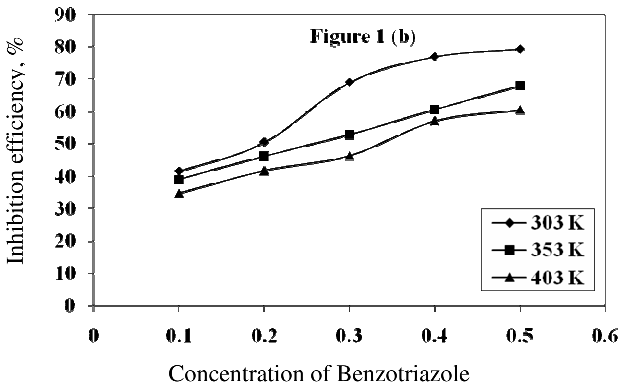


Figure 1(b). Variation of inhibition efficiency (IE) with concentration benzotriazole (in %) in citric acid solution at different temperature.

From the graph, it was observed that the weight loss of mild steel in the acid decreases with increasing concentration of additives, which suggesting that the additives are corrosion inhibitor for mild steel in 1 N citric acid. From the data of weight loss method, the corrosion rate (CR) was calculated using the equation:

$$CR= (87.6 \times W) / (D \times A \times T)$$

Where,

W, D, A and T are weight lose (in mg), density of mild steel (7.86 g/cc), area of the specimen in cm square and exposure time in hours respectively. Similarly, Inhibition efficiency was calculated using the equation,

$$IE \% = [(W_o–W_i)/W_o] \times 100$$

Where,

W_o and W_i are the values of the weight loss (in g) of mild steel in the absence and presence of inhibitor respectively. The values of corrosion rate and inhibition efficiency in absence and presence of difference concentration of inhibitor used in 1 N citric acid solution at 303, 353 and 403K for 2 h were given in Table 1.

Table 1. Corrosion inhibition behaviour of mild steel in 1N citric acid solution in absence and presence benzotriazole by weight loss measurement.

Corrosion Inhibitors	Conc. of inhibitor, %	Corrosion rate,mm/y			Inhibition Efficiency, %		
		303K	353K	403K	303K	353K	403K
Benzotiazole	Blank	20.84	680.04	858.81	-	-	-
	0.1	13.59	474.67	624.68	41.57	39.15	34.85
	0.2	9.81	418.94	568.73	50.56	46.29	41.84
	0.3	8.13	367.34	513.01	69.10	52.91	46.49
	0.4	5.57	306.49	432.76	76.97	60.71	57.18
	0.5	4.12	249.87	377.04	79.21	67.97	60.67

From Table 1, it is evident that, the corrosion rate was decreased with increasing concentration of inhibitor and inhibition efficiency increased with increasing the concentration of the inhibitor. In addition, the maximum corrosion inhibition efficiency of benzotriazole was increased 0.1% to 0.5%. Also the inhibitor efficiency is compared at 0.5% concentration the rate of efficiency is high at 303K when compared to 403K respectively in 1 N citric acid. And also, it was concluded that benzotrizole was best inhibitor in mild steel corrosion in citric acid medium at low temperature.

Kinetic studies

In addition, the experiment was conducted at different immersion time to study the rate of reaction. The plot of log (weight loss) versus immersion time as shown in Figure 2, gave a straight line indicating that it follows first order reaction. The values of the rate constant was calculated using the first order rate law,[8] $k = (2.303/t) \log ([A_o]/[A])$. Here $[A_o]$ is the initial mass of the metal and [A] is the mass corresponding to time‘t’.

The half-life ($t_{1/2}$) were calculated using the relationship,[9] $t_{1/2} = 0.693 / k$. The values of rate constant and half-life ($t_{1/2}$) obtained from the above relations were summarized in Table 2. Half life values were found to be constant at different immersion time. The constant value of the rate constant further confirmed that the corrosion of mild steel in Citric acid solution in presence of benzotriazole follows first order reaction.

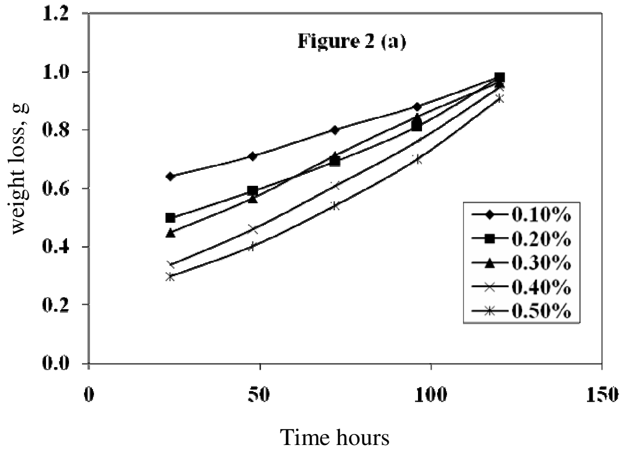


Figure 2 (a). Half life plot for weight loss with immersion time in citric acid solution in the presence of benzotriazole at 303K.

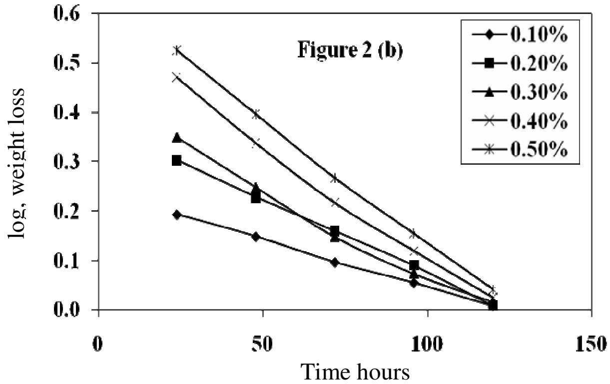
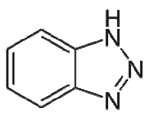


Figure 2 (b). Half life plot for log (weight loss) with immersion time in citric acid solution in the presence of benzotriazole at 303K.

Table 2. Rate of constant (k) and half-life values for the corrosion of mild steel at different immersion times in 1 N citric acid solution in absence and presence of inhibitors of different concentration at 303K.

Conc. of Inhibitor, in %		
	k (x 10^{-3}) h^{-1}	$t_{1/2}$, h
0.1	1.760595($\pm$ 0.059)	393.6
0.2	1.578338($\pm$ 0.042)	439.1
0.3	1.582695($\pm$ 0.033)	437.9
0.4	1.362773($\pm$ 0.016)	508.5
0.5	1.248923($\pm$ 0.011)	554.9

Corrosion inhibitory behaviour of benzotriazole

Since hydrazinecarboxamide groups are basic in nature due to availability of electrons on N atom, it acts as adsorption center. Hence, benzotriazole shows goods inhibitory character. Hence the N atom in benzotriazole therefore undoubtly has high electron density for adsorption on to the mild steel surface. So, inhibition behaviour of benzotriazole increases tremendously.

Conclusions

The benzotriazole showed good performance as corrosion inhibitor in Citric acid solution medium due to the presence of heteroatom and unsaturated bond that cause effective adsorption process leading to the formation of an insoluble protective surface film which suppresses the metal dissolution reaction. First order types of reaction were observed in the kinetic studies. The inhibition efficiency increased with increase in concentration of inhibitors for 0.1% to 0.5% and decreased with rise in temperature from 303K to 404K. The maximum inhibition efficiency of benzotriazole were 41.57% and 79.21% respectively in 1 N Citric acid at 303K [0.5%] for 2 h of immersion time. From this investigation effect of mild steel corrosion in benzotriazole in citric acid medium is very effective when the concentration is going on increased.

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