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Influence of cetylpyridiniumbromide on corrosion inhibition of mild steel in sulphuric acid medium

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ABSTRACT

Corrosion is a deterioration process where in the metals and alloys lose their integrity, functionality and appearance. Cetylpyridiniumbromide an organic compound has been used to study the corrosion rate and corrosion inhibition efficiency for mild steel in 1 M sulphuric acid medium by weight loss method. Experiments were carried out at 303K, 313K, 323K temperature by varying concentration of cetylpyridiniumbromide 0.05, 0.15, 0.25, 0.35% for 5 hours. The result shows that the corrosion inhibition efficiency of the compound increases with increasing concentration and declines at higher temperature. To evaluate rate constant and half life period experiments were conducted at different immersion time of 10, 15, 20, 25 hours for varying concentration of cetylpyridiniumbromide. The reaction between mild still and sulphuric acid follows first order rate kinetics.

KEYWORDS

Cetylpyridiniumbromide;
Corrosion inhibitors;
Reaction kinetics;
Film thickness;
Mass transfer resistance.

INTRODUCTION

Iron and its alloys are used in many engineering applications in various environments. Corrosion is a process by which materials, especially metals, are worn away by electrochemical and chemical actions. The economic loss due to corrosion is very high and remains a major concern to industries around the world, so the incentive to inhibit corrosion is enormous[1]. Though the serious consequences of corrosion can be controlled to a great extent by selection of highly corrosion resistant materials, the cost factor associated with the same, favors the use of cheap metallic materials along with efficient corrosion prevention methods in many industrial applications. In this aspect, corrosion inhibitors have ample significance as individual inhibitors or as a component in chemical formulations. Acid solutions, widely used in industrial acid cleaning, acid descaling, acid pickling, and oil well acidizing, require the use of corrosion inhibitor in order to restrict corrosion attack on metallic materials. Large number of corrosion inhibitors have been developed and used for application to various systems depending on the medium treated, the type of surface that is susceptible to corrosion, the type of corrosion encountered and the conditions to which the medium is exposed[2]. They act by forming a protective oxide film on the surface of the metal causing a large anodic shift of the corrosion potential or by selectively precipitating on cathodic areas to limit the diffusion of reducing species to the surface. Various types of inhibitors have been used as corrosion inhibitors for mild steel corrosion in acidic medium[3]. Most commercial acid inhibitors are organic compounds containing heteroatoms such as nitrogen, oxygen, sulphur, phosphorous, by which the inhibitor molecules are adsorbed on the metal surface in acidic media, thus resulting adsorption film acts as a barrier separating the metal from the corrosive medium and blocks the active sites[4-9]. High electron density of heteroatoms in these compounds helps the organic molecules to get chemisorbed on to the metal surface[10]. Various cationic surfactants can also be investigated as corrosion inhibitor[11]. The corrosion inhibition by surfactant molecule is related to surfactants ability to aggregate at interface, in solution and their effectiveness depends upon their miceller properties in particular medium. Most of the earlier studies have been related to the general performance and the inhibition of mild steel corrosion in organic acid[5,6]. The present work focuses on the effect of cetylpyridinumbromide on the corrosion behavior of mild steel in 1 M sulphuric acid medium at various temperatures studied by weight loss measurement.

EXPERIMENTAL

Cold rolled mild steel strips purchased from local market were cut into pieces of 5 cm × 3 cm. Test specimens were prepared by polishing the metal strips by emery paper then they were pickled in pickling solution (5% H_3PO_4) for 3 minutes and then washed with distilled water followed by polishing with emery papers and degreased using ethanol.

All the test solutions were prepared by using AR grade chemicals in distilled water. 1 M test solution of sulphuric acid was prepared in distilled water. The corrosion inhibitor solution of 0.05 % cetylpyridinumbromide was prepared by dissolving 0.1 gm of Cetylpyridiniumbromide in 200 ml of test solution and similarly by dissolving 0.3 gm, 0.5 gm, 0.7 gm of Cetylpyridiniumbromide 0.15%, 0.25%, 0.35% test solutions were prepared respectively.

For the evaluation of corrosion rate and corrosion inhibition efficiency of Cetylpyridiniumbromide experiments were carried out for 5 hrs. Initial weight of test specimens were noted and then immersed in test solutions containing various concentrations of Cetylpyridiniumbromide at temperature 303K, 313K and 323K. The specimens were removed from test solutions and pickled in pickling (5% H_3PO_4) solution, dried and final weight is recorded. The differences in weights were noted and the corrosion rates were calculated by using following equation (1)

$$CR = \frac{87.6 \times W}{D \times A \times T} \quad (1)$$

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^2 and exposure time in hours respectively. Similarly, Inhibition efficiency was calculated using the equation (2)

$$\eta_E = \frac{W_o - W_i}{W_o} \times 100 \quad (2)$$

Where, Wo and Wi are the values of the weight loss (in gm) of mild steel specimen 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 M sulphuric acid solution at 303, 313 and 323K for 5 h were given in TABLE 1(a) and (b).

TABLE 1(a) : Corrosion rate (mm/y) in absence and presence of cetylpyridiniumbromide in 1M sulphuric acid solution at different temperature.

Conc. of inhibitor %	Corrosion rate (mm/year)		
	303K	313K	323K
Blank	195.493	388.647	609.340
0.05	9.093	25.330	44.294
0.15	7.144	20.783	35.461
0.25	4.546	12.730	22.212
0.35	3.637	9.742	17.276

TABLE 1(b) : Corrosion efficiency in presence of cetylpyridiniumbromide in 1M sulphuric acid solution at different temperature.

Conc. of inhibitor %	Corrosion Efficiency %		
	303K	313K	323K
Blank	-	-	-
0.05	95.35	93.48	92.73
0.15	96.35	94.65	94.18
0.25	97.67	96.72	96.35
0.35	98.14	97.49	97.16

To study the rate of reaction, various experiments were conducted at different immersion time of 10, 15, 20 and 25 hrs for 0.05, 0.15, 0.25 and 0.35 % cetylpyridiniumbromide respectively. Weight loss measurement of specimens for different immersion time at varying Cetylpyridiniumbromide concentrations are recorded in TABLE 2.

TABLE 2 : Weight loss measurement of mild still for different immersion time at varying CPB concentrations at 303K.

Time	Concentration of cetylpyridiniumbromide			
	0.05%	0.15%	0.25%	0.35%
	Weight loss in gms			
5	0.07	0.055	0.035	0.028
10	0.125	0.068	0.055	0.033
15	0.193	0.102	0.073	0.043
20	0.248	0.123	0.098	0.062
25	0.339	0.148	0.133	0.109

RESULT AND DISCUSSION

The corrosion performance of mild still in 1M sulphuric acid medium and corrosion inhibition efficiency of cetylpyridiniumbromide (CPB) at 303K, 313K, 323K was analyzed by weight loss method is shown in figure 1 & 2 respectively.

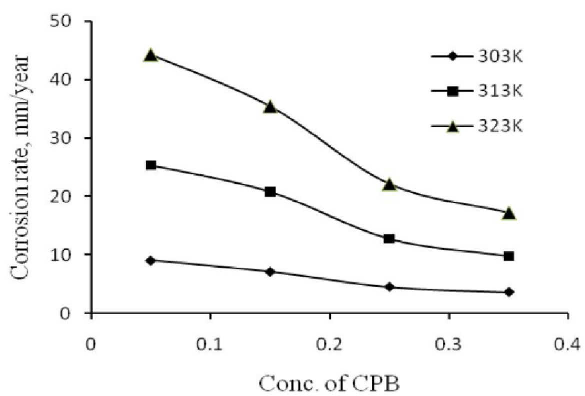

Figure 1 : Corrosion performance of mild still in 1M sulphuric acid medium at different temperature.

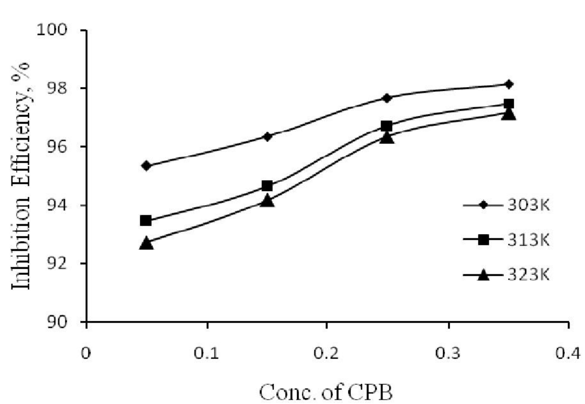

Figure 2 : Corrosion efficiency of mild still in 1M sulphuric acid medium at different temperature.

It has been observed from figure 1 that at higher concentration of cetylpyridiniumbromide, corrosion rate declines whereas it increases at higher temperature (313K and 323K). The corrosion inhibition efficiency of cetylpyridiniumbromide increases with increasing concentration of cetylpyridiniumbromide. If corrosion inhibition efficiency of 0.05% & 0.35% cetylpyridiniumbromide test solution is compared at 303K and 323K, which implies that the addition of cetylpyridiniumbromide at increasing concentration in 1 M sulphuric acid inhibits corrosion rate of mild steel at the same time it reduces at higher temperature.

Kinetic studies

The plot of log (M_t /M_0) verses immersion time for various concentrations of cetylpyridiniumbromide represent straight line indicating that the reaction between mild still and sulphuric acid is of first order, where M_0 and M_t are weight of specimen at initial and at time 't' respectively. The values of rate constant and half life period for the reaction are calculated by using first order rate law and summarized in TABLE 3. The values of rate constant at higher concentration of cetylpyridiniumbromide are fairly constant. Half life period at different immersion time were found to be constant for respective cetylpyridiniumbromide concentration test solutions. Constant values of rate constant and half life period emphasis that the reaction between mild still and sulphuric acid in presence of cetylpyridiniumbromide follows first order reaction.

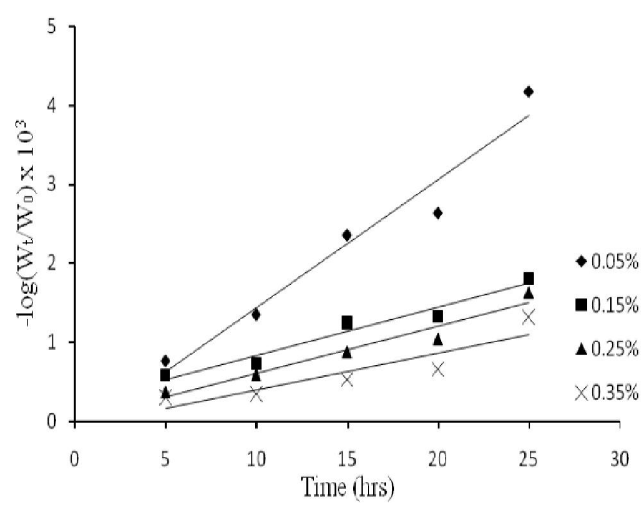

Figure 3 : The plot of log (M_t/M_0) verses immersion time for various concentrations of cetylpyridiniumbromide at temperature 303K.

TABLE 3 : Rate constant (k) and half life period for corrosion reaction of mild still and sulphuric acid at different immersion time in presence of different concentration of cetylpyridiniumbromide (CPB) inhibitor at 303K

Conc. Of CPB, %	Rate Constant, k (x 10^{-3}) h^{-1}	Half life period, $t_{1/2}$, h
0.05	0.162	17696.97
0.15	0.060	47804.41
0.25	0.059	48691.3
0.35	0.046	62621.15

CONCLUSION

The cetylpyridinumbromide exhibits good corrosion inhibition characteristics in sulphuric acid medium. The presence of N atom and unsaturation causing effective adsorption on mild still surface and forms the protective film which increases the resistance to mass transfer of acid molecule to mild still surface. Due to increase in the resistance to the mass transfer, the diffusion rate of acid molecule through film of Cetylpyridiniumbromide declines and consequently rate of corrosion reaction decreases. As the concentration of Cetylpyridiniumbromide in acid solution increases, the film thickness also increases which considerably reduces rate of mass transfer and the rate of reaction. This can also be confirmed from the rate constant values presented in TABLE 3.

The corrosion inhibition efficiency increases with increasing concentration of Cetylpyridiniumbromide. It has been observed that the percentage increase in efficiency at lower concentration of Cetylpyridiniumbromide (0.05 & 0.15%) is considerably higher than that of at higher concentration of CPB (0.25 & 0.35%).

First order types of reaction were observed for all concentration of Cetylpyridiniumbromide solutions. The experiments at higher temperature shows decrease in corrosion inhibition efficiency of Cetylpyridiniumbromide which suggest that the rate of reaction at higher temperature increases considerably. From this investigation it is concluded that the Cetylpyridiniumbromide can be effectively used to control the corrosion of mild still in 1M sulphuric acid solution.

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