Corrosion Inhibition of Mild Steel Using Rhodamine-B in Distinct Media

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The effectiveness of rhodamine-B [RHB] as corrosion inhibitor for mild steel [MS] in distinct media/solution has been studied by weight loss, electrochemical and voltammetric methods. Adsorption of rhodamine-B on mild steel surface obeys Langmuir adsorption isotherm. Precentage inhibition efficiency of rhodamine-B for mild steel in aqueous, acidic and basic media has been calculated by weight loss method. The data revealed that RHB is a very effective inhibitor for MS in acidic media even at extremely low level of concentration 1×10^{-4} mol dm^{-3}. Inhibition efficiency increased with the concentration of RHB and decreased with temperature. Heat of adsorption of rhodamine-B values ranging from 4.2 to 11.6 kcal in the entire range of study signifies that the physical adsorption of the dye occurs over the metal surface. Cathodic and anodic polarization curves of mild steel in presence of different concentrations of RHB at 30°C reveal that it is a mixed type of inhibitor with slight predominance over cathodic character. There is a good agreement between inhibitor efficiency values as calculated from weight loss and polarization technique with slight deviation in data computed. Dependence of corrosion behaviour of MS on thermodynamic instability, adsorption, time, polarization and temperature is discussed in detail.

Key Words: Corrosion inhibition, Mild steel, Rhodamine-B.

INTRODUCTION

Mild steel is one of the major materials of construction, extensively used in industries due to its versatility and low cost. It is highly reactive in presence of aggressive environment. It is necessary to understand its corrosion behaviour in distinct media and to develop suitable methods to prevent corrosion. Literature reports on corrosion inhibition of mild steel[1–4]. However, organic compounds containing nitrogen, sulphur and oxygen atoms form coordinate type of bond between the metal and lone pair of electrons[5–7]. With this idea, we have undertaken our laboratory programme to use a dye as corrosion inhibitor. Rhodamine-B not only reduces the dissolution rate of metal but it may function as a corrosion inhibitor in a distinct mode as studied from weight loss method and electrochemical measurements. The detailed voltammetric behaviour of rhodamine-B is reported[8].

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EXPERIMENTAL

Mild steel (MS) sheets used for this corrosion study had the following composition:

Element	C	Mn	S	Si	P	Cr
%	0.14	0.28	0.02	0.03	0.10	0.01

For weight loss experiments MS specimens of size 2 × 4 cms were used and for electrochemical polarization measurements specimens of 1 × 1 cm with a 4 cm long stem were taken. The specimens were polished to mirror finish and degreased with trichloroethylene.

All the chemicals used were of AR grade and bidistilled water was used for preparing solutions. Weight loss experiments were carried out using 100 to 800 ppm of rhodamine-B in 1.0 M solution of Na_2SO_4, H_2SO_4, NaCl, $CaCl_2$ and HCl at 30, 40 and 50°C temperature. Corrosion rate and inhibitor efficiency (IE) were determined from weight loss determination using standard expression. Linear polarization measurements were carried out galvanostatically. Inhibitor efficiency (IE%) was calculated as

$$IE\% = \frac{I_{corr\,(w)} - I_{corr\,(inh)} \times 100}{I_{corr\,(w)}}$$

where $I_{corr\,(w)}$ = Corrosion current density in absence of inhibitor

$I_{corr\,(inh)}$ = Corresponding current density in presence of inhibitor

RESULTS AND DISCUSSION

Experimental results using mild-steel specimens obtained by weight loss method at different concentrations and media is presented in Table-1. Data revealed that rhodamine-B is a very effective inhibitor even at the extremly low concentration of 100 ppm. IE is found to increase with increase in concentration of rhodamine-B. However, decrease with rise in tempterature [Fig. 1 (a) and (b)] proves that RHB is a mixed type of inhibitor with slight predominance of cathodic character. Energy parameters are reported in Table-2. Values are higher in presence of RHB than in its absence suggesting RHB belongs to the first category of inhibitors in all media, which also supplements Putilovaes[9] view. Adsorption of RHB molecule on the surface of mild steel increases the activation energy for the ion dissolution reaction and thus decreases the corrosion rate (Fig. 2) suggesting that Langmuir adsorption isotherm governs the adsorption of RHB at 30, 40, 50°C temperature in H_2SO_4 and $CaCl_2$ media. The molecular structure of rhodamine-B is shown in Fig. 3. High inhibition efficiency of RHB can be explained on the basis of presence of oxygen in ring B. Due to high electronegativity of oxygen, electrondensity will be maximum at oxygen in the central ring in comparison to other parts of the molecule. Due to these points in the planar structure of the molecule of RHB, *i.e.*, two nitrogen and one oxygen atom, rigidity facilitates adsorption of RHB on mild steel thus providing higher coverage and good protection layer to the surface.

TABLE-1
INHIBITION EFFICIENCY OF RHODAMINE-B FOR MILD STEEL

Conc. of RHB (ppm)	Temp. (°C)	H_2SO_4		HCl		Na_2SO_4		NaCl		$CaCl_2$	
		Wt. loss (mg)	Inhibition efficiency	Wt. loss (mg)	Inhibition efficiency	Wt. loss (mg)	Inhibition efficiency	Wt. loss (mg)	Inhibition efficiency	Wt. loss (mg)	Inhibition efficiency
100	30	19.4	89.2	3.3	81.4	18.4	86.2	3.4	80.2	3.2	80.4
200	30	14.2	92.1	2.9	83.7	13.8	90.1	2.8	82.7	2.8	82.7
400	30	10.3	94.2	2.4	86.5	10.2	92.2	2.6	85.4	2.3	85.5
600	40	17.5	93.8	3.5	85.2	17.1	91.4	3.2	85.2	3.4	85.2
800	50	19.6	94.5	2.1	88.2	18.2	92.6	2.3	87.2	2.2	87.2

TABLE-2
ENERGY PARAMETERS FOR ADSORPTION OF RHODAMINE-B OVER MILD STEEL SURFACE IN 1 M-Na_2SO_4, H_2SO_4, NaCl, $CaCl_2$ AND HCl

Conc. of RHB (ppm)	H_2SO_4		HCl		Na_2SO_4		NaCl		$CaCl_2$	
	$-\Delta H$ (kcal)	(kcal) E_a (kcal)	$-\Delta H$ (kcal)	(kcal) E_a (kcal)	$-\Delta H$ (kcal)	(kcal) E_a (kcal)	$-\Delta H$ (kcal)	(kcal) E_a (kcal)	$-\Delta H$ (kcal)	(kcal) E_a (kcal)
100	8 .6	8.9	4.1	13.0	7.5	7.8	7.4	7.9	7.2	7.8
200	9.1	10.2	4.9	15.2	8.1	9.2	8.0	9.1	7.9	8.2
400	10.2	12.5	5.4	17.4	9.2	11.5	8.7	10.5	8.4	10.4
600	10.4	12.9	5.6	18.1	9.8	11.9	9.1	11.4	9.4	11.6
800	11.6	13.8	5.8	18.9	10.9	12.9	10.4	12.2	10.2	12.6

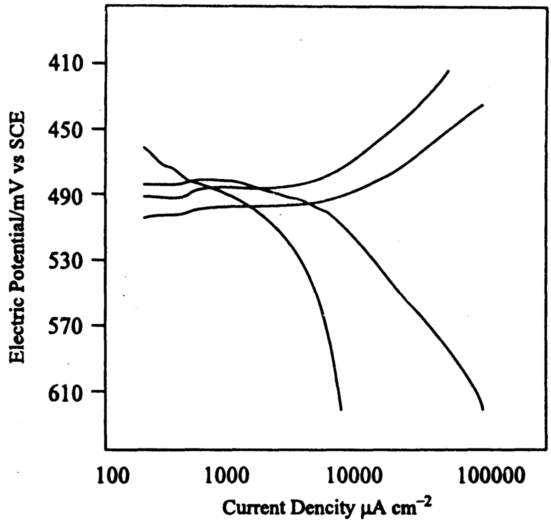

Fig. 1. (a) Polarization curves of (MS) in presence of different concentrations of RHB in 1 M H_2SO_4.

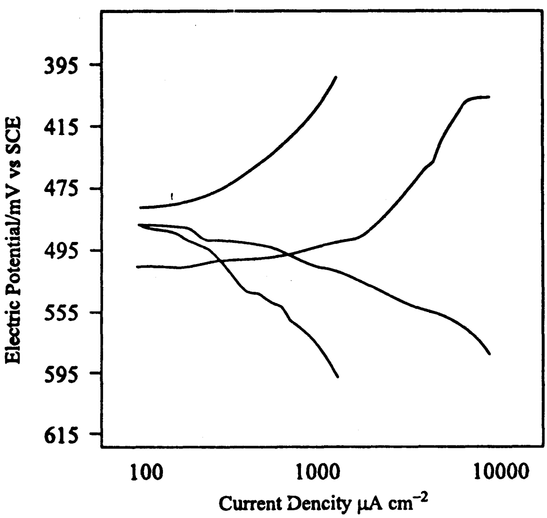

Fig. 1. (b) Polarization curves of (MS) in presence of different concentrations of RHB in 1 M $CaCl_2$

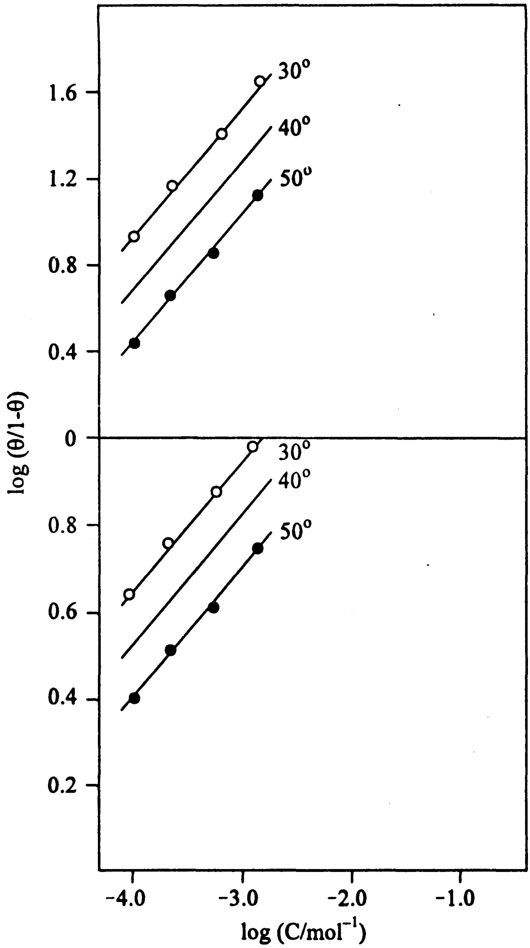

Fig. 2. Langmuir plots for adsorption of rhodamine-B on the surface of MS

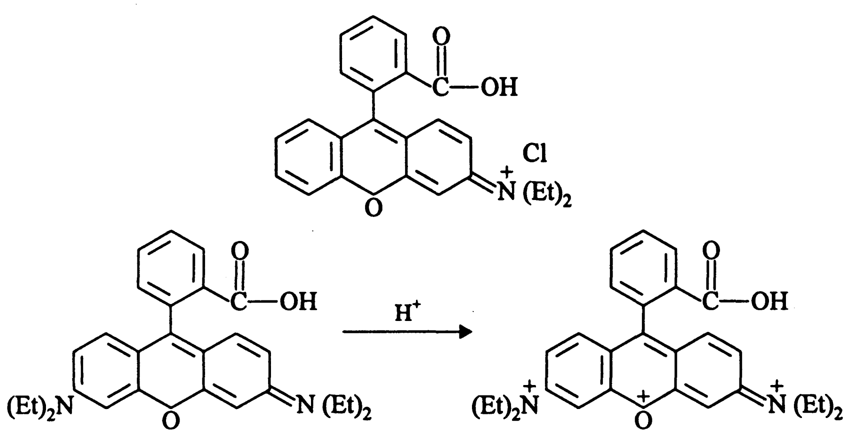

Fig. 3. Molecular structure of rhodamine-B to explain high IE

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