

# Reactive Blue Dye as a Novel Corrosion Inhibitor for Mild Steel in Acidic Solutions

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**Abstract-** The anti-corrosion characteristics of reactive blue dye for mild steel in 1N H<sub>2</sub>SO<sub>4</sub> was investigated using weight loss and potentiodynamic polarization studies. Corrosion parameters such as inhibition efficiency, corrosion rates, corrosion potential corrosion current and Tafel slopes were evaluated. The inhibition efficiency was found to increase with increase in the inhibitor concentration.

**Index Terms-** Reactive blue dye, acidic solutions, mild steel corrosion, weight loss, potentiodynamic polarization.

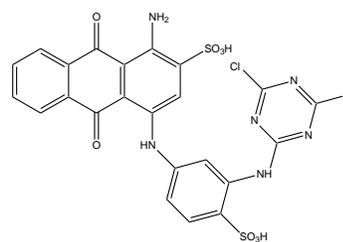
## I. INTRODUCTION

In industries, acid solutions are widely used in cleaning, oil well acidification and pickling processes. The corrosion of steel in such environments is of great importance, since it involves loss of material and wastage of acids. For the inhibition of mild steel in acid solutions organic inhibitors has been extensively studied. Literature survey reveals the fact that most organic compounds employed as corrosion inhibitors adsorb on the metal surface through hetero atoms such as nitrogen, oxygen, sulfur and phosphorus, multiple bonds or aromatic rings and block the active sites leading to the decrease in corrosion rate<sup>1-15</sup>.

Many organic dyes possess the above mentioned characteristics and that initiated us to use reactive blue dye as a novel corrosion inhibitor for mild steel in hydrochloric acid solutions. In this work, the inhibitive activity of reactive blue dye as a corrosion inhibitor for mild steel in 1N H<sub>2</sub>SO<sub>4</sub> acid solution was examined by weight loss and potentiodynamic polarization studies.

## 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 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. For polarization studies mild steel rod of the same composition, embedded in araldite, with an exposed area of 0.502 cm<sup>2</sup> was used. The inhibitor compound, reactive blue dye was obtained from the Alfa-Aesar chemicals of UK.. The corrosion medium was 1N H<sub>2</sub>SO<sub>4</sub> prepared from A.R grade H<sub>2</sub>SO<sub>4</sub> and deionised water. The structure of the reactive blue dye is given below.



Weight loss studies were carried out as reported earlier<sup>16</sup>. From the weight loss experiments the % inhibition efficiency (I.E) and the degree of surface coverage ( $\theta$ ) were calculated by using the following equations.

$$I.E = \frac{W_o - W_i}{W_o} \times 100$$

$$\theta = \frac{W_o - W_i}{W_o}$$

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<sup>2</sup>),  $t$  is the exposure time (h) and  $D$  is the density of the mild steel (g/cm<sup>3</sup>).

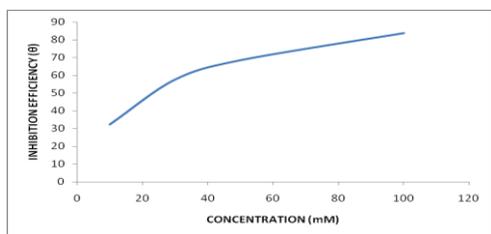
## III. RESULTS AND DISCUSSION

Weight loss studies were carried out at four different concentrations of the inhibitor and the inhibition efficiency(%) and corrosion rate values were calculated and are presented in table-1.

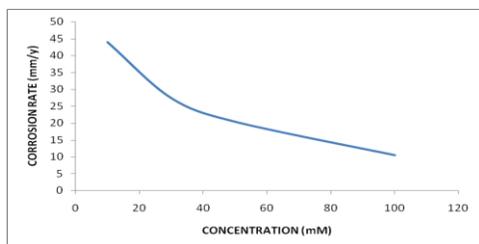
**Table 1** Values of inhibition efficiency (%) and corrosion rates (mm/y) obtained from the weight loss experiments for the corrosion of mild steel in 1N H<sub>2</sub>SO<sub>4</sub> in the presence of different concentrations of the inhibitor.

Parameter	Reactive blue dye concentration (mM)			
	10	30	50	100
Inhibition efficiency	32.2	57.6	68.5	83.8
Corrosion rates	43.9	27.4	20.4	10.5

The results show that with the increase in concentration of the inhibitor, the inhibition efficiency increases and corrosion rates decrease. The dependence of inhibition efficiency and corrosion rates on the concentration of the inhibitor is shown in figures-1 and 2.



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



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

The various corrosion kinetic parameters such as corrosion potential ( $E_{corr}$ ), corrosion current ( $I_{corr}$ ) and anodic and cathodic Tafel slopes ( $b_a$  and  $b_c$ ) obtained from the potentiodynamic polarization studies are presented in the table-2.

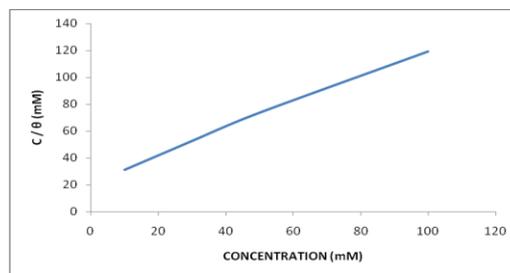
Inhibitor conc. (mM)	$E_{corr}$ mV	Tafel slopes $mV dec^{-1}$		$I_{corr}$ mA $cm^{-1}$	I.E (%)
		$b_c$	$b_a$		
Blank	-916	126	78	1.76	-
10	-880	149	83	1.18	33.0
30	-886	158	89	0.76	56.8
50	-898	176	92	0.57	67.6
100	-909	191	97	0.30	84.6

**Table-2** The corrosion kinetic parameters obtained from polarization studies.

From the table it can be seen that the values of  $E_{corr}$  for mild steel becomes less negative with increase in the concentration of the inhibitor compound. This indicates the strong adsorption of the inhibitor molecules on the metal surface leading to the formation of a layer, preventing the contact of the mild steel with the acid, which results in the reduction of the corrosion of the metal. The values of  $I_{corr}$  decreases with the increase in the concentration of the inhibitor. This also indicates the reduction in the corrosion of the mild steel in the presence of the inhibitor. The values of both  $b_a$  and  $b_c$  increases with increase in the concentration of the inhibitor. This suggests that the inhibitor reduces both the anodic dissolution and cathodic hydrogen evolution reactions. But it can be observed that increase in the value of  $b_c$  is more than that for  $b_a$  which indicates that the corrosion of mild steel in 1N H<sub>2</sub>SO<sub>4</sub> is under mixed control, but predominantly under cathodic control.

#### IV. ADSORPTION ISOTHERMS

From the weight loss measurements the degree of surface coverage ( $\theta$ ) for various concentrations of the inhibitor were evaluated. Langmuir's isotherm was tested by plotting  $C/\theta$  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 H<sub>2</sub>SO<sub>4</sub> obey Langmuir's adsorption isotherm. Figure -3 shows the Langmuir's adsorption isotherm plot for mild steel in 1N H<sub>2</sub>SO<sub>4</sub> containing different concentrations of the inhibitor.



**Figure 3** Langmuir's adsorption isotherm plot for mild steel in 1N H<sub>2</sub>SO<sub>4</sub> containing different concentrations of the inhibitor

#### V. CONCLUSIONS

The reactive blue dye used as a corrosion inhibitor for mild steel in 1N H<sub>2</sub>SO<sub>4</sub> 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 corrosion of mild steel in 1N H<sub>2</sub>SO<sub>4</sub> is under mixed control, but predominantly under cathodic control. The adsorption of the inhibitor on mild steel surface obeyed Langmuir's adsorption isotherm.

#### REFERENCES

- [1] G. Schmitt, Br. Corros. J. 19 (1984) 165.
- [2] F. Zucchi, G. TrabANELLI, G. Brunoro, Corros. Sci. 36 (1994) 1683.

- [3] J.M. Bastidas, J.L. Polo, E. Cano, J. Appl. Electrochem. 30 (2000)1173.
- [4] P.K. Ghosh, D.K. Guhasarkar, V.S. Gupta, Br. Corros. J. 18 (1983)
- [5] W.W. Frenier, F.B. Growcock, V.R. Lopp, Corrosion 44 (1988) 590.
- [6] M.A. Quraishi, D. Jamal, Corrosion 56 (2000) 156.
- [7] R. Derek, M. Ballwin, US Patent 3,673,196 (1972).
- [8] G. Benerjee, S.N. Malhotra, Corrosion 48 (1992) 10.
- [9] A. El-Sayed, J. Appl. Electrochem. 27 (1997) 193.
- [10] S. Rengamani, S. Muralidharan, M. AnbuKulandainathan, S.VenkatakrishnaIyer, J. Appl. Electrochem. 24 (1994) 355.
- [11] R. Agrwal, T.K.G. Namboodhiri, J. Appl. Electrochem.22 (1992)383.
- [12] C. Fiaud, A.Harch, D.Mallouh, M. Tzinmann, Corros. Sci.35 (1993) 1437.
- [13] M.A. Quraishi, S. Ahmad, M.Q. Ansari, Br. Corros. J. 32 (1997) 297
- [14] F. Bentiss, M. Traisnel, L. Gengembre, M. Lagrenée, Appl. Surf. Sci. 161 (2000) 194.
- [15] S. El Hajjaji, A. Lgamri, D. Aziane, A. Guenbour, E.M. Essassi, M.Akssira, A. Ben Bachir, Progr. Org. Coat. 38 (2000) 207.
- [16] S.Muralidharan M.A.Quraishi and VenkatakrishnaIyer, Corros.Sci.,37(1995) 1739.

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