Journal of the Association of Arab Universities for Basic and Applied Sciences (2015) **18**, 12–18

University of Bahrain
Journal of the Association of Arab Universities for Basic and Applied Sciences
www.elsevier.com/locate/jaaubas
www.sciencedirect.com

ORIGINAL ARTICLE

Effect of three component (aniline–formaldehyde and piperazine) polymer on mild steel corrosion in hydrochloric acid medium

K.R. Ansari, M.A. Quraishi *

Department of Chemistry, Indian Institute of Technology, Banaras Hindu University, Varanasi 221005, India

Received 29 August 2013; revised 4 April 2014; accepted 27 April 2014
Available online 20 June 2014

KEYWORDS
Mild steel;
EIS;
Corrosion;
Weight loss measurements

Abstract Polymeric Schiff base containing aniline, formaldehyde and piperazine (AFPP) was synthesized and investigated as corrosion inhibitor for mild steel in 1 M HCl by weight loss measurements, electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization techniques. Experimental results showed that AFPP is an effective inhibitor for mild steel in 1 M HCl and exhibited 98% inhibition efficiency. Potentiodynamic polarization studies showed that AFPP is a mixed-type inhibitor predominantly cathodic type. The adsorption of inhibitor on the mild steel surface followed Langmuir adsorption isotherm. Activation energy (E_a), standard energy of adsorption (ΔG°_{ads}), enthalpy of activation (ΔH^*), and entropy of activation (ΔS^*) of corrosion process were calculated and discussed.

1. Introduction

The corrosion inhibition of mild steel has tremendous technological importance due to its increased industrial applications (Ali et al., 2003). Corrosion is the serious problem that mankind is facing (Ahmad and MacDiarmd, 1996).

Acid has wide applications in industry such as in pickling, cleaning, decaling etc. To prevent the corrosion of the metal, inhibitors are extensively used. The selection of an inhibitor mainly depends upon its efficiency, economic feasibility and side effects on the environment.

The use of polymers as corrosion inhibitors has drawn considerable attention due to their inherent stability, cost effectiveness and better inhibition efficiency at a very low concentration (Umoren et al., 2008). Both natural and synthetic polymers have been used as corrosion inhibitors (Shukla and Quraishi, 2012). These polymers have high molecular weight and bulky structure due to this they can cover more area on the metal surface, which leads to high inhibition efficiency.

In continuation of our work on corrosion inhibition by polymers (El-Etre, 1998; Shukla et al., 2008; Quraishi and Shukla, 2009), we have reported the corrosion inhibition effect of polymer derived from aniline, formaldehyde and piperazine (AFPP) (Parveen et al., 2008) which increases the corrosion inhibition property at low concentration (100 mg L^{-1}) with inhibition efficiency of 98%.

In the present work we have studied the inhibitive effect of polymer derived from aniline, formaldehyde and piperazine (AFPP) on mild steel in 1 M hydrochloric acid (HCl) by using

* Corresponding author. Tel.: +91 9307025126; fax: +91 542 2368428.
E-mail addresses: maquraishi@rediffmail.com, maquraishi.apc@itbhu.ac.in (M.A. Quraishi).
Peer review under responsibility of University of Bahrain.

1815-3852 © 2014 Production and hosting by Elsevier B.V. on behalf of University of Bahrain.
http://dx.doi.org/10.1016/j.jaubas.2014.04.001

weight loss, electrochemical impedance spectroscopy (EIS), and potentiodynamic polarization techniques. According to literature survey, no work has been done on this compound as corrosion inhibitor.

2. Experimental

2.1. Materials and chemicals

The inhibitor under investigation has been synthesized elsewhere (Parveen et al., 2008). Its scheme of synthesis is shown in Fig. 1.

The corrosion test was performed on the mild steel strips containing (in wt.%) C: 0.076, P: 0.012, Si: 0.026, Mn: 0.192, Cr: 0.050, Cu: 0.135, Al: 0.023, Ni: 0.050 and remaining Fe. Mild steel strips used for weight loss measurement have dimension 2.5 cm × 2.0 cm × 0.025 cm. For electrochemical measurements, 7.5 cm long stem of mild steel strips with exposed surface area of 1.0 cm^2 (rest being coated with commercially available lacquer) was used. The test solution, 1 M HCl was prepared by dilution of analytical grade HCl with double distilled water. The inhibitor concentration ranges from 25 to 100 mg L^{-1}.

2.2. Methods

2.2.1. Weight loss measurements

The weight loss measurements of mild steel strips of size 2.5 cm × 2.0 cm × 0.025 cm were used in 1 M HCl without and with addition of different concentrations of inhibitor for 3 h at 308 K temperature without stirring. Following equations were used for the determination of inhibition efficiency $\eta\%$ and surface coverage (θ):

$$\eta\% = \frac{C_R - C_{R(i)}}{C_R} \times 100 \quad (1)$$

$$\theta = \frac{C_R - C_{R(i)}}{C_R} \quad (2)$$

where C_R and $C_{R(i)}$ are the values of the corrosion rates (mg cm^{-2} h^{-1}) of mild steel in the absence and presence of inhibitor, respectively.

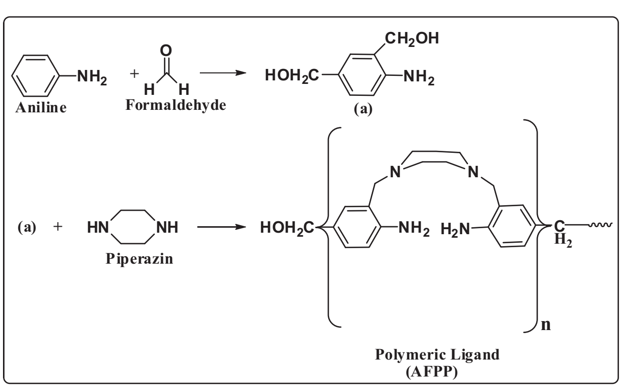

Figure 1 Scheme of ligand (AFPP) synthesis.

2.2.2. Electrochemical measurements

All electrochemical experiments were performed in Gamry electrochemical cell with three electrode cell, consisting of a mild steel rod of 1 cm^2 as working electrode, a platinum foil as counter electrode and standard calomel electrode (SCE) as a reference electrode, connected to Gamry Instrument Potentiostat/Galvanostat with a Gamry framework system based on ESA 400. Gamry applications include EIS 300 for EIS measurements, DC 105 software for corrosion and Echem Analyst (version 5.50) software package for data fitting. All potentials were measured versus SCE. The electrolyte used was 1 M HCl maintained at 308 K.

2.2.2.1. Electrochemical impedance spectroscopy (EIS). EIS measurements were carried out with Gamry Instrument Potentiostat/Galvanostat, which consists of a unit with a potentiostat and an acquisition system. The principle of this analytical technique consists of superposing a slight sinusoidal voltage $\Delta E \sin \omega t$ (10 mV peak to peak) from high to low frequency (10^5–10^{-2}Hz) to the potential applied to the sample.

2.2.2.2. Potentiodynamic polarization. Potentiodynamic polarization curves were obtained by changing the electrode potential automatically from −250 to +250 mV versus E_{OC} at a scan rate of 1 mV s^{-1}. All experiments were measured after immersion for 30 min in 1 M HCl in the absence and presence of inhibitor.

3. Experimental results and discussion

3.1. Weight loss measurements

3.1.1. Effect of inhibitor concentration

Effect of inhibitor (AFPP) concentration on the corrosion of mild steel in 1 M HCl was studied by weight loss measurement at 308 K and the results are given in Table 1.

The data in Table 1 reveal that as the concentration of AFPP increases inhibition efficiency increases (Karthikaiselvi and Subhashini, 2014) and corrosion rate decreases. This behavior can be attributed to the increase in surface area covered by the adsorbed molecules on the mild steel surface with an increase in the concentration of AFPP. The maximum efficiency of 98% was achieved at the concentration of 100 mg L^{-1}.

3.1.2. Effect of temperature

The inhibition efficiency in 1 M HCl at optimum concentration (100 mg L^{-1}) of AFPP at temperature ranging from 308 to 338 K was done and result obtained is given in Table 2.

Table 1 Parameters obtained from weight loss measurement for mild steel in 1 M HCl containing different concentrations of AFPP at 308 K.

Inhibitor	Concentration (mg L^{-1})	Corrosion rate (mg cm^{-2} h^{-1})	Surface coverage (θ)	η (%)
Blank	0.0	7.00	–	–
AFPP	25	1.60	0.771	77.1
	50	0.66	0.904	90.4
	75	0.30	0.957	95.7
	100	0.13	0.980	98.0