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Comparative Study on Mild Steel in Acidic Medium Using 5-Amino-2-chloro-3-picoline as Inhibitor

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Based on the survey of corrosion studies on mild steel, 5-amino-2-chloro-3-picoline compound has been chosen as corrosion inhibitor on controlling the rate of mild steel material on both H_2SO_4 and HCl acidic medium at 303 K. By weight loss method and electrochemical studies the rate of corrosion and inhibitor efficiency were calculated. The result revealed that the efficiency of the inhibitor increases as the concentration of the inhibitor increases. Based on the analysis and result it shows that the corrosion inhibition behaviour of 5-amino-2-chloro-3-picoline is high in H_2SO_4 than HCl.

Keywords: Mild steel, Inhibitor, Electrochemical impedance spectroscopy, 5-Amino-2-chloro-3-picoline, Impedance.

INTRODUCTION

Corrosion is known as an oxidizing process. According to theory the damages and characteristic change in nature of particular metal (loss in its weight) due to chemical or electrochemical reaction from surroundings. Further chemical or electrochemical reactions may be accompanied with physical damages termed as corrosion-erosion, corrosive-wear or fretting-corrosion [1,2].

For major economic loss of an country corrosion plays a major role and efforts were taken to minimize the rate of corrosion. Every day demand for metals by mankind is increasing rapidly. While processing and in transportation tonnage of metals like stainless steel, Cu, Al, Pb and Zn is lost due to corrosion [3]. It is highly necessary to take actions against corrosion to retain the economic value of such metals [4,5]. The loss of corrosion is calculated around \$ 40 billion every year, which is around 6 % of the GDP in India. Electron density is high due to presence of nitrogen atom in the heterocyclic organic compounds help the organic molecules to get chemisorbed on to the metal surface. Due to the aggressiveness of sulphuric acid and hydrochloric acid solution against mild steel materials used in construction purpose, such as stainless steel and mild steel. Utilizing the organic based inhibitors will minimize the corrosion attack [6-10]. Therefore, in this investigation, the corrosion inhibition of mild steel in 1.12 N H_2SO_4 and 1.11 N HCl solution in the absence and presence of 5-amino-2-chloro-3-picoline at 303 K temperatures have been studied by weight loss method and electrochemical studied.

EXPERIMENTAL

Mild steel strips were cut into pieces of 5 cm × 1 cm having the following percentage composition Fe = 99.710, Ni = 0.013, Mo = 0.011, Cr = 0.037, S = 0.014, p = 0.009, Si = 0.006, Mn = 0.183, C = 0.017. Mild steel plate 1 cm × 1 cm × 0.3 cm dimensions were cut for electrochemical studies. The one face of the conductor was concealed with araldite, so as to expose an area of 1 cm^2. The surface of the electrodes were polished effectively on the emery papers of grade 400-1200 grit then degreased with acetone [11].

Set up of impedance cell: Using double walled glass tube cell which has a capacity of around 200 mL were used. The tube having provisions of filled inlet of nitrogen gas, working electrode and platinum electrode were kept in luggin capillary. Through the luggin capillary the SCE electrode potential were measured under the room temperature.

Preparation of acid mediums

Hydrochloric acid and sulphuric acid: The acids namely hydrochloric acid and sulphuric acid solution was prepared using double distilled water. Both the acids were standardized by titrating against Na_2CO_3 solution.

Preparation of inhibitor: Inhibitor solution of 5-amino-2-chloro-3-picoline was prepared by dissolving 0.1 g of 5-amino-2-chloro-3-picoline in 100 mL of test solution. Similarly 0.2, 0.3, 0.4 and 0.5 % solutions were prepared.

RESULTS AND DISCUSSION

Weight loss measurement: The corrosion behaviour and inhibition efficiency of mild steel in 1.12 N H_2SO_4 and 1.11 N HCl with 5-amino-2-chloro-3-picoline at 303 K were shown in Fig. 1(a & b). From the graph, it was revealed that the weight loss of mild steel based on the corrosion rate decreases in the acids and efficiency of the inhibitor increases by increasing the concentration of 5-amino-2-chloro-3-picoline in both the acids. From the data of weight lost method, the corrosion rate (CR) was calculated using the equation:

$$CR = \frac{87.6 \times W}{D \times A \times T}$$

where W, D, A and T are weight loss (mg), density of mild steel (7.86 g/cm^3), area of the specimen in cm^2 and exposure time (h), respectively.

Efficiency of the inhibitor was calculated using the equation:

$$\text{Inhibition efficiency (\%)} = \frac{W_o - W_i}{W_o} \times 100$$

where W_o and W_i are the values of the weight loss (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 1.12 N H_2SO_4 and 1.11 N HCl solutions at 303 K for 2 h were given in Table-1.

From Table-1, it was clear that the rate of corrosion decreases with the addition of increasing the concentration of inhibitor. In addition, the maximum corrosion inhibition efficiency of 5-amino-2-chloro-3-picoline was 89.96 %, respectively in 1.12 N H_2SO_4 at 0.5 % concentration of the inhibitor whereas in 1.11 N HCl the efficiency was 85.39 % at 303 K. On comparing both the acid medium, the efficiency is high in sulphuric acid than hydrochloric acid due to its dibasic nature.

TABLE-1
CORROSION INHIBITION BEHAVIOUR OF MILD STEEL IN 1.12 N H_2SO_4 AND 1.11 N HCl SOLUTION IN ABSENCE AND PRESENCE 5-AMINO-2-CHLORO-3-PICOLOINE INHIBITOR

Conc. of inhibitor (%)	Corrosion rate (mmpy)		Inhibition efficiency (%)	
	1.12 N H_2SO_4	1.11 N HCl	1.12 N H_2SO_4	1.11 N HCl
Blank	26.636	19.838	–	–
0.1	7.5786	7.133	71.55	64.04
0.2	6.018	6.464	77.40	67.41
0.3	5.238	5.461	80.33	72.47
0.4	4.792	4.123	82.00	79.21
0.5	2.674	2.897	89.96	85.39

Electrochemical studies

Electrochemical impedance studies: AC impedance measurements were carried out at room temperature for corrosion of mild steel in 1.12 N H_2SO_4 and 1.11 N HCl after immersion of electrodes, the Nyquist plots for mild steel in uninhibited acid and for the all concentrations of studied inhibitors are shown in Fig. 2(a & b). The impedance parameters and the IE % are given in Table-2. The charge transfer resistance (R_{ct}) value for mild steel in uninhibited 1.12 N H_2SO_4 and 1.11 N HCl shows very low value and significantly changes after the addition of inhibitor. The R_{ct} values increases by the addition of studied inhibitors at optimum concentration. The fact is advocated by the increase in inhibitor efficiency. The semicircular nature of Nyquist plots obtained for all experiments indicates that the corrosion of mild steel is controlled by charge transfer process [12].

Generally on the metal side, electrons control the charge distribution whereas on the solution side is controlled by ions.

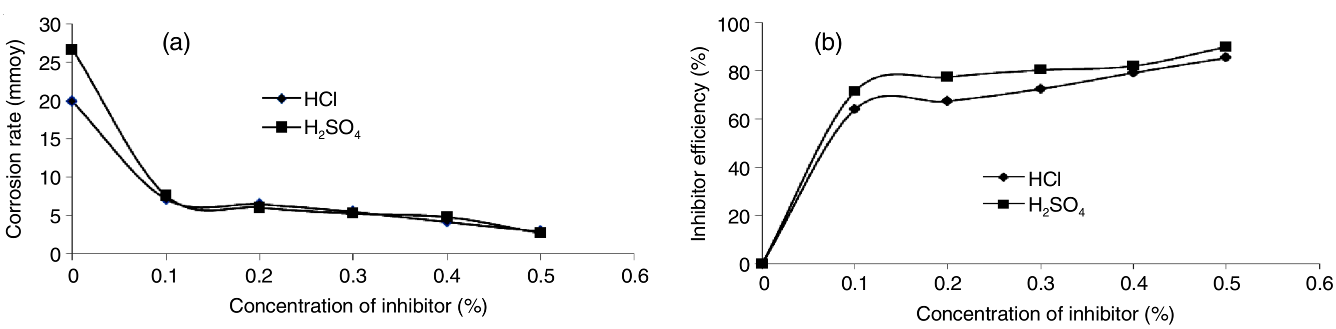

Fig. 1. (a) Comparison of corrosion rate (CR) with concentration of 5-amino-2-chloro-3-picoline (%) in 1.11N HCl and 1.12 N H_2SO_4 solution at 303 K (b) Comparison of inhibition efficiency (IE) with concentration of 5-amino-2-chloro-3-picoline (%) in 1.11 N HCl and 1.12 N H_2SO_4 solution at 303 K

TABLE-2
AC IMPEDANCE PARAMETERS OF MILD STEEL ELECTRODE IMMERSED IN DIFFERENT ACIDS IN THE ABSENCE AND PRESENCE OF INHIBITOR

Inhibitors	R_{ct} (ohm cm^2)		C_{dl} (μF × 10^{-5})		Inhibition efficiency (%)	
	1.12 N H_2SO_4	1.11 N HCl	1.12 N H_2SO_4	1.11 N HCl	1.12 N H_2SO_4	1.11 N HCl
Blank	62.22	72.72	4.289	4.118	–	–
0.1N	161.21	159.40	1.966	1.872	61.41	56.10
0.2 N	169.41	167.24	1.880	1.772	62.02	56.59
0.3 N	206.70	197.25	1.817	1.713	69.89	63.23
0.4 N	218.10	242.00	1.697	1.534	70.49	71.02
0.5 N	280.00	274.80	1.514	1.592	77.77	73.57

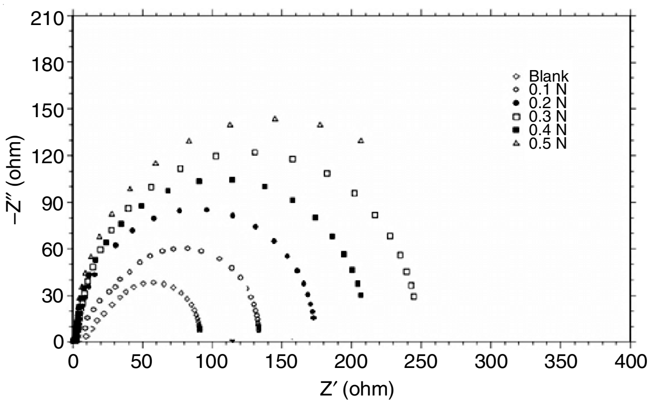

Fig. 2(a). Nyquist plots for mild steel in 1.12 N H_2SO_4 with 5-amino-2-chloro-3-picoline inhibitor

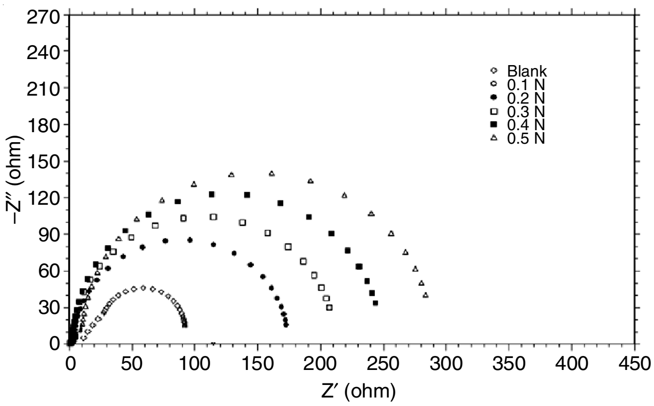

Fig. 2(b). Nyquist plots for mild steel in 1.11 N HCl with 5-amino-2-chloro-3-picoline inhibitor

From the Table-2 the capacitance of the electrical double layer (C_{dl}) decreases in the presence of the inhibitors.

Decrease in capacitance of the electrical double layer which can result from a decrease in local dielectric constant and/or an increase in the thickness of the electrical double layer, suggests that the inhibitor molecule may act by adsorption at the metal/solution interface.

Conclusion

According to the literature review, when corrosion reaction occurs the metals loss its useful properties, due to this reason a chemical or electrochemical reaction takes place with the environment. Organic based inhibitor 5-amino-2-chloro-3-picoline was used as corrosion inhibitor. When comparing the inhibition efficiency of 5-amino-2-chloro-3-picoline, it shows 89.96 % in 1.12 N sulphuric acid and 85.39 % in 1.11 N HCl at 303 K, weight loss results were confirmed by electrochemical analysis like AC impedance measurement. From the AC impedance study it has been revealed that the inhibitor efficiency of 5-amino-2-chloro-3-picoline was 77.77 % in 1.12 N H_2SO_4 whereas in 1.11 N HCl shows 73.57 % at 0.5 % concentration.

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