

Corrosion inhibition of acidic corrosion of mild steel in acidic medium by cetyl trimethyl ammonium chloride

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ABSTRACT

The inhibition effect of Cetyl trimethyl ammonium chloride (CTMAC) on the corrosion of mild steel in 0.5M hydrochloric acid solution was investigated at different temperatures using weight loss measurement, electrochemical polarization and scanning electron microscopy. Weight loss measurement and electrochemical polarization curves revealed that this surfactant inhibits the mild steel corrosion and inhibition efficiencies up to 98% can be obtained. The inhibition efficiency calculated from these techniques is in reasonably good agreement. The observed corrosion data indicate that the inhibition of mild steel corrosion is due to the adsorption of the inhibitor molecules on the mild steel surface. The surface morphology of mild steel samples in absence and presence of the inhibitor was examined using scanning electron microscopy.

Key words: Corrosion Inhibition, Inhibition efficiency, mild steel and electrochemical polarization

INTRODUCTION

Acid corrosion inhibitors find wide application in several industries, during the pickling of metals, cleaning of boilers, acidification of oil wells etc. most of the efficient inhibitors¹⁻³ used in industry are organic compounds having multiple bonds in their molecules which mainly contain nitrogen, sulphur atoms through which they are adsorbed on the metal surface. Rozenfeld et al⁴ have studied the inhibiting action of amines, monoethanolamines, diethanolamines and triethanolamines and their mixture with potassium chromate on the corrosion of steel in sodium chloride solutions. Tetraethyl ammonium chloride, tetrabutyl ammonium chloride, benzyltrimethyl, ammonium chloride, benzyltriethyl ammonium chloride, tetradecyl trimethyl ammonium bromide and cetyl trimethyl ammonium bromide shown good inhibition efficiency in HCl⁵. Lebrini et al⁶ studied the inhibition of mild steel corrosion in acidic solution by 2,5-bis (4-pyridyl) -1,3,4

thiadiazole. Many surfactants⁷⁻¹¹ have been synthesized and a considerable number of investigations have been reported on their unusual physicochemical properties, including their high surface activity, unusual changes of viscosity, unusual micelle structure and aberrant aggregation behavior. The presence of a hydroxyl group can increase the solubility of the inhibitor leading to higher inhibition efficiency¹². In most inhibition studies the formation of donor acceptor surface complexes between free or π electrons of an inhibitor and vacant d-orbital of a metal were postulated¹³. Rozenfeld et al¹⁴ have studied the inhibiting action of amines, monoethanol-amines, diethanolamines and triethanolamines and their mixture with potassium chromate on the corrosion of steel in sodium chloride solutions. Various inorganic acids ethanolamine salts could protect efficiently steel, iron nickel, aluminum, copper and other metals and alloys⁴. Alkanolamine salts, triethanolamine oleate, tetratriethanolamine mono

oleiate, tetratriethanol-amine trioleiate and tetratriethanolamine tetraoleiate established their performance in NaCl containing solutions and the efficiency exceeded 95 percent¹⁵. The present paper deals with the study of inhibiting action of cetyl trimethyl ammonium chloride in acidic solution using weight loss, electrochemical polarization techniques and scanning electron microscopy.

EXPERIMENT

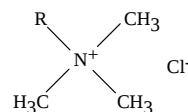
Mild steel specimens with the following composition were used C=0.14, Si=0.03, Mn=0.32, S=0.05, P=0.20, Ni=0.01, Cu=0.01, Cr=0.01 and Fe= Balance (wt %) for weight loss measurement mild steel spiciness of 3.0 cm × 1.5cm size were cut from the 0.25mm thick sheet whereas for electrochemical polarization investigates specimen of sizes 5.0cm × 1.5cm were used. All the samples were polished successively with emery papers of various grades (150,320 and 600) thoroughly cleaned with soap water, rinsed with distilled water and then with alcohol and dried in air. The dried and cleaned specimens were kept in desiccators over silica gel. Cetyl trimethyl ammonium chloride (CTMAC) was used as corrosion inhibitor of mild steel. Name structural formula and molecular mass of the inhibitor are gives in Table 1.

The aggressive solution used were made of AR grade HCl. Appropriate concentrations of the acid were prepared using double distilled water. Inhibitor concentrations ranging from 50 to 250 ppm in 0.5M HCl solutions were prepared.

Weight loss measurements of mild steel samples in the acidic solutions with and without the optimal concentration of the inhibitor was performed at various temperatures ranging from 25° to 45°C for 48 hours exposure time. The inhibition efficiency (%) of CTMAC was calculated by using the following equation.

$$IE (\%) = \frac{CR_0 - CR_1}{CR_0} \times 100$$

Table 1: Name and molecular structures of the Cetyl Trimethyl Ammonium Chloride (CTMAC)



Where R is mainly C₁₆.

Molecular weight = 320

Empirical formula = C₁₉H₄₂ClN

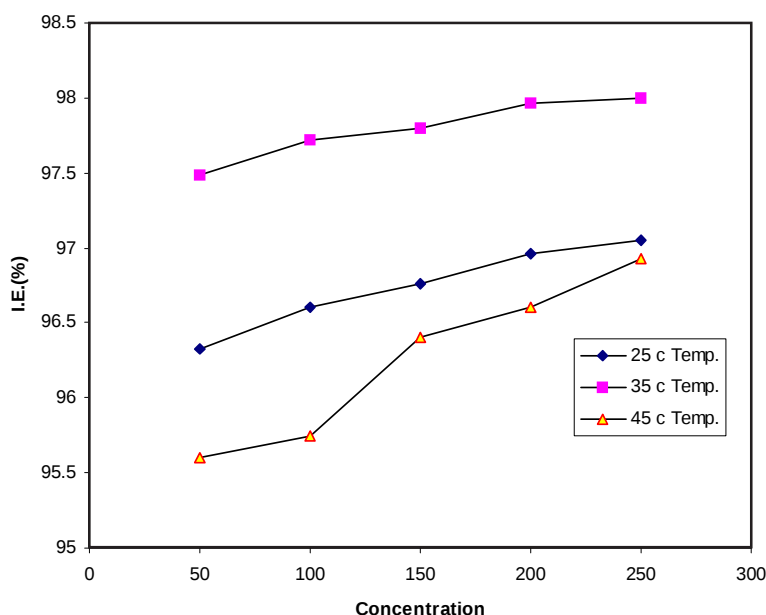


Fig. 1: Variation of inhibition efficiency with inhibitor concentration

Table 2: Corrosion parameters for mild steel in 0.5M HCl acid in the absence and presence of different concentrations of CTMAC at various temperatures for 48 hours from weight loss data

Temperature	Inhibitor Conc. (ppm)	Corrosion Rate (mpy)	% Inhibition Efficiency
25° C	Zero	612.46	Blank
25° C	50	22.47	96.33
25° C	100	20.85	96.60
25° C	150	19.84	96.76
25° C	200	18.62	96.96
25° C	250	18.01	97.05
35° C	Zero	889.14	Blank
35° C	50	22.26	97.49
35° C	100	20.24	97.72
35° C	150	19.63	97.80
35° C	200	18.02	97.97
35° C	250	17.81	98.00
45° C	Zero	1423.88	Blank
45° C	50	62.54	95.60
45° C	100	60.52	95.75
45° C	150	51.00	96.41
45° C	200	48.37	96.60
45° C	250	43.72	96.93

CR_0 : - Corrosion rate with out Inhibitor

CR_1 : - Corrosion rate with Inhibitor

For electrochemical polarization studies, mild steel samples of same composition coated with commercially available lacquer (Lakme) with an exposed area of 1.0cm² were used and the experiments were carried out in 0.5M HCl solutions at 35 ± 1°C with different concentration of CTMAC. Electrochemical experiments were carried out using a potentiostat/ galvanostat PGS 201T (Radiometer Analytical). All the potentials were measured against a saturated calomel electrode. Initially open circuit potential (OCP) was measured as a function of time after that the specimen was polarized in cathodic direction from the OCP value. The specimens were again left under open circuit condition till steady state corrosion potential value was again reached. Then anodic polarization curves was recorded potentiostatically, generally duplicate experiments were performed to confirm the consistency of the results. To study the morphology of corroded surface of metal after exposing it to 0.5M HCl solution and break down of the passive film, scanning electron microscope (JSM – 840 J EOL) was used. All the micrographs were taken at magnification of × 400.

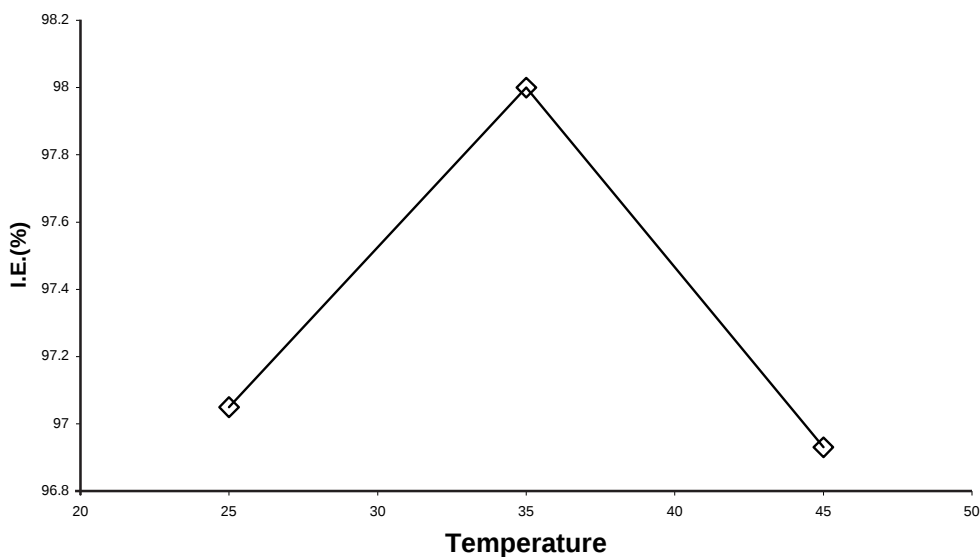


Fig. 2: Variation of inhibition efficiency with temperature

RESULTS AND DISCUSSION

Corrosion rate measured by immersion test for mild steel in 0.5M HCl solutions at 25°, 35° and 45°C have been recorded in Table 2. It is seen that CTMAC inhibit corrosion of mild steel in 0.5M HCl solutions at all concentration under study. It has been observed that IE (%) increases with increase in concentration as shown in Fig 1. Maximum inhibition efficiency of each compound within the range of chosen concentration was achieved at

250ppm and a further increase in concentration did not show any appreciable change in the performance of the inhibitor. The influence of temperature on IE (%) at 250 ppm of CTMAC is shown in Fig-2. It is observed that IE increases with increase in temperature from 25 to 35°C after that it decreases when the temperature is increased from 35 to 45°C. The decrease of IE (%) with temperature is attributed to desorption of the inhibitor molecules from metal surface at higher temperatures.

Table 3: Electrochemical polarization parameters for the corrosion of mild steel in 0.5M HCl with different concentrations of CTMAC at 25°C

Concentration	β_a mV/decades	β_c mV/decades	R_p (ohm $\times 10^{-3}$)	i_{corr} mA/cm ²	Corrosion Rate (mpy)	%IE
Blank	1.97	2.46	0.371	1310	610.10	Blank
50	75.00	120.10	402.20	47	22.64	96.28
100	109.29	102.35	498.19	43	19.98	96.72
150	110.00	101.46	535.29	39	19.24	96.84
200	106.31	108.29	627.41	35	18.56	96.95
250	104.23	111.26	787.16	28	17.35	97.15

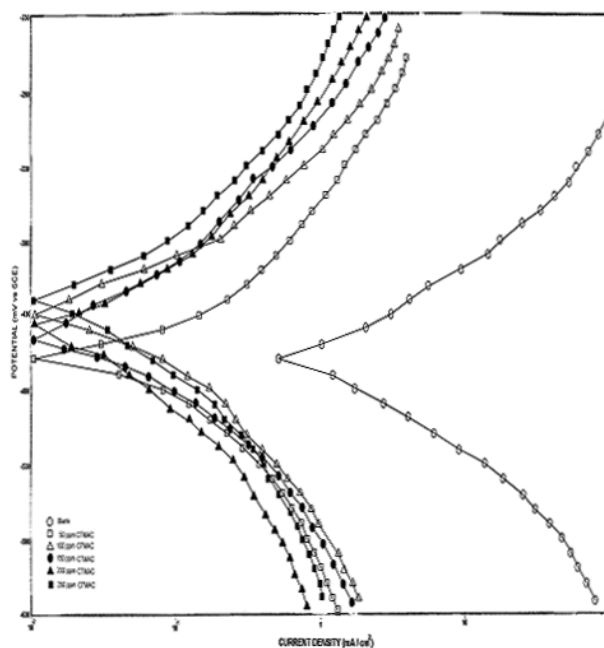


Fig. 3: Polarization curves of mild steel in 0.5M HCl in the absence and presence of various concentrations of CTMAC

The polarization behavior of mild steel in 0.5M HCl in the absence and presence of various concentrations of CTMAC is shown in Fig 3. Various parameters like corrosion current density I_{corr} , anodic tafel's polarization β_a , cathodic tafel's polarization β_c , corrosion rate IE (%) are recorded in Table 3. The maximum decrease in I_{corr} was observed at 250 ppm concentration of CTMAC. The inhibition of corrosion of mild steel in the 0.5 M HCl solution can be explained on the basis of adsorption.

In order to evaluate the condition of mild steel surfaces on contact with acid solutions, a superficial analysis was carried out. The SEM micrograph of the specimens in presence of HCl at 35°C is shown in Fig 4. The influence of the CTMAC addition (250 ppm) on the mild steel in HCl solution at 35°C is shown in Fig 5. The surface roughness of the mild steel surface appears lowers with addition of inhibitor than that with out addition. The roughness is found to be more uniform after treatment with acidic solution that contains inhibitor.



Fig. 4: Micrograph of mild steel surface attacked by 0.5M HCl solution with 48 h immersion at 25°C



Fig. 5: Micrograph of mild steel surface attacked by 0.5M HCl solution with 48 h immersion in the presence of 250 ppm CTMAC at 25°C

CONCLUSION

Cetyl trimethyl ammonium chloride inhibited mild steel corrosion in 0.5M HCl acid solutions. CTMAC act as mixed type of inhibitor for mild steel in 0.5 HCl solutions.

Inhibition efficiency increases up to 35°C and then decreases at higher temperatures. The efficiency of CTMAC increases with concentration up to 250ppm.

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