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Cetyltrimethyl Ammonium Bromide as Corrosion Inhibitor for Zinc Used in Hydrochloric Acid

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Abstract. A compound inhibitor composed of cetyltrimethyl ammonium bromide (CTAB) and bromohexadecyl pyridine was tested as corrosion inhibitor for zinc in hydrochloric acid. The results of static coupon test show that the compound inhibitor can effectively protect zinc from corrosion and the best concentration ratio is CTAB 50 mg/L and bromohexadecyl pyridine 200 mg/L. The polarization results show that the compound inhibitor will cause a negative shift of E_0 of zinc in hydrochloric acid. The EIS (electrchemical impedance spectra) results show that the inhibitor leads to a bigger radius and has one time constant. SEM results show that the CTAB and bromohexadecyl pyridine form a uniform and compact membrane on the surface of zinc that can protect zinc from corroding effectively.

1.Introduction

Galvanized sheet can be found used in different industries fields. While the galvanized metals used in water-circulating systems usually produce white rust, at the same time scale and slime formed on the surface of cooling tower packing. The scale and slime will reduce the heat transfer effect. so the method to prevent or remove white rust, scale and slime is important.[1] The effectively and quickly method to remove the rust, scale and slime is chemical cleaning. The zinc on sheet will be reaction off, so the use of inhibitors is one of the most piratical method for protection zinc against corrosion especially in acidic media.[2-3]traditional inhibitor for metal such as nitrite and chromate have adverse effects on the environment[4].Organic inhibitors with electron-donating groups such as nitrogen, sulphur and oxygen play an important part in prevent zinc from corroding.[5-7]

This work aims to study the properties of compound inhibitor composed of CTAB and bromohexadecyl pyridine used for zinc in 0.5m HCl.

2.Experimental methods

2.1Materials

Cetyltrimethyl Ammonium Bromide(CTAB); BromohexadecylPyridine; Hydrochloric Acid.

2.2. Inhibitors Prepared

1:Dissolved 4.0g CTAB in water at 70°C, then set volume to 100ml for use. 2:dissolved 1.5g bromohexadecyl pyridine at 50°C, then set volume to 250ml for use, in order to get compound inhibitors just by adding A and B to the solution to get the excepted inhibitor solutions.

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Compound: CTAB 50~ 400 mg/L,bromohexadecyl pyridine 200 mg/L;

2.3. Instrument
Potentiostat/galvanostat CS 2305, JSM-6510 scanning electron microscopy (SEM), BT224s Electronic Balance.

2.4 Experimental Procedure
*2.4.1 Weight loss test of zinc.*The corrosion of zinc in inhibitors was evaluated by using the static hanging piece test, which referenced HG/T2387-2007. The corrosion inhibition test was operated at 35°C for 96h. The basic testing solution is 0.5m hydrochloric acid. The experimental solution composed 0.5m HCl and inhibitors. The corrosion rate was calculated refereed as the followed formulas (Eq. 1)

$$K = \frac{W_1 - W_2}{S \cdot T} \qquad (1)$$

K—corrosion rate, $g/cm^2 \cdot h$;

W_1— weight of zinc plate before test, g;

W_2— weight of zinc plate after test, g;

S— area of plate, cm^2;

T— time of experimental time, h.

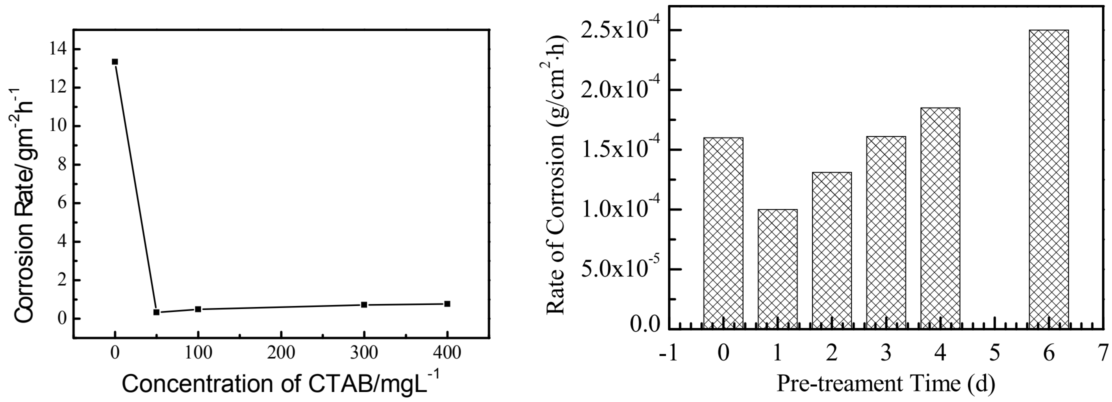
*2.4.2Pre-treatment of plate.*Before add hydrochloric acid into solution play the plate in inhibitor solution for a time. the weight loss of Zinc were tested after pre-treament refered above experimental procedure. The compound inhibitor solution composed of CTAB 300mg/L and Bromohexadecyl Pyridine 100mg/L.

2.4.3 Electrochemical test of zinc. Zinc electrodes were sealed in epoxy resin except the exposed cross-section as working surface. The zinc electrodes were embedded in epoxy resin with an exposed cross-sectional area of 1cm2. The counter electrode in the electrochemical test was platinum while saturated calomel electrode (SCE) was used as the reference electrode. The electrochemical studies were operated on the Potentiostat/galvanostat CS2305. Linear polarization measurement were carried out with a potential perturbation of ±100mV around the open circuit potential (OCP). Electrolyte was prepared by adding different inhibitors into 0.5m hydrochloric acid solution with different concentration.

2.4.4. SEM test. The zinc plates after testing were observed on SEM JSM6510. The operation parameters were set at 20 kV acceleration voltage.

3.Results and discussion

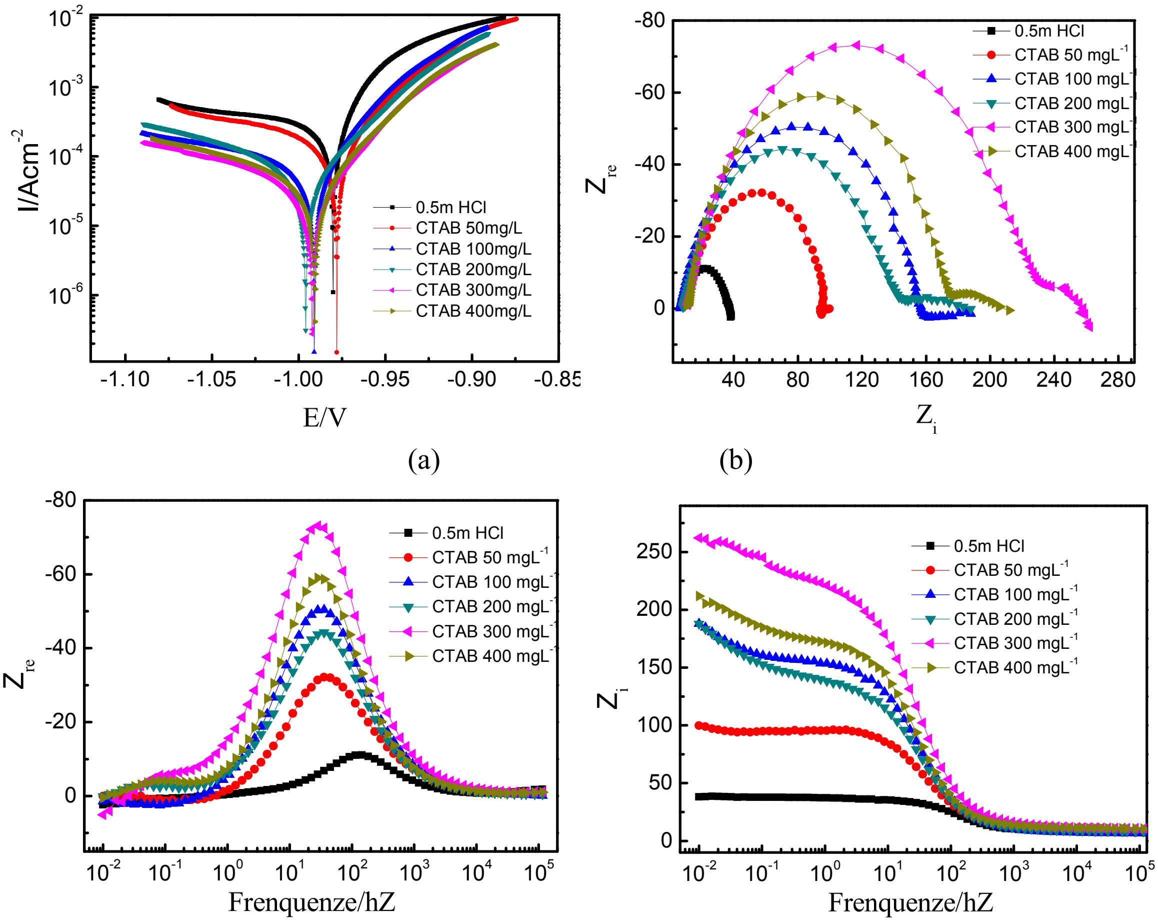
3.1 Corrosion test results
Figure 1 gives the weight loss results of Zn in inhibitor solution. The corrosion rate of Zn (figure a) in different inhibitor solutions show that the influence of concentration of CTAB on corrosion rate is not obvious within the experimental range. The influence of pre-treatment time on the corrosion rate results (figure 1b) show before expose Zn to 0.5m HCl immerse it in inhibitor solution for 1d can effectively prevent Zn from corrosion. The results of pre-treatment derived from the adsorption of inhibitor solution on the An plate surface. Adsorption film can protect the corrosive process between Zn and 0.5m HCl.



(a) (b)

Figure 1.(a) corrosion rate of Zinc in inhibitor solutions,(b) influence of pre-treatment time on the corrosion rate of Zinc

3.2 Electrochemical test results



(c) (d)

Figure 2.(a)polarization plot of Zinc in inhibitor solution,(b) EIS plot of Zinc in inhibitor solution,(c)and(d)nyqiust plots

Figure 2a gives the polarization results of Zinc in different inhibitor solution. The results show that the compound inhibitor make the E_0 of Zn in 0.5m HCl negative shift. So the compound inhibitor in the

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experimental range is cathodic corrosion inhibitor. Figure 2b shows the EIS results of Zn in 0.5mHCl with different concentration inhibitor addition amount. The compound inhibitor makes the radius of EIS bigger which indicate the addition of inhibitor enhance the anti-corrosion property of Zn in 0.5m HCl. Table 1 shows the parameters of Zn in different inhibitor solutions. The value of R_p change bigger with the increase of inhibitor concentration when the concentration below 300mg/L. R_p indicate the anti-corrosion property.

In summary the corrosion test and electrochemical test results show that the compound inhibitor has better anti-corrosion performance on Zinc in 0.5m HCl.

Table 1. paraments of Zinc obtained from EIS results

Concentration of CTAB(mg/L)	R_s	CPE-T	CPE-P	R_p
0	8.496	$8.86x10^{-5}$	0.8946	15.2
50	7.302	$1.76x10^{-4}$	0.7492	90.5
100	6.634	$1.18x10^{-4}$	0.7736	156.2
200	8.286	$1.48x10^{-4}$	0.7620	144.9
300	10.89	$9.86x10^{-5}$	0.7630	228.6
400	10.79	$9.77x10^{-5}$	0.8070	173.2

3.3 Results of SEM test

Figure.3 shows the SEM photos of zinc in different compound Inhibitor solutions for 96h at 35°C. Figure.3a shows that there are many corrosion pit on the Zn surface when the addition concentration

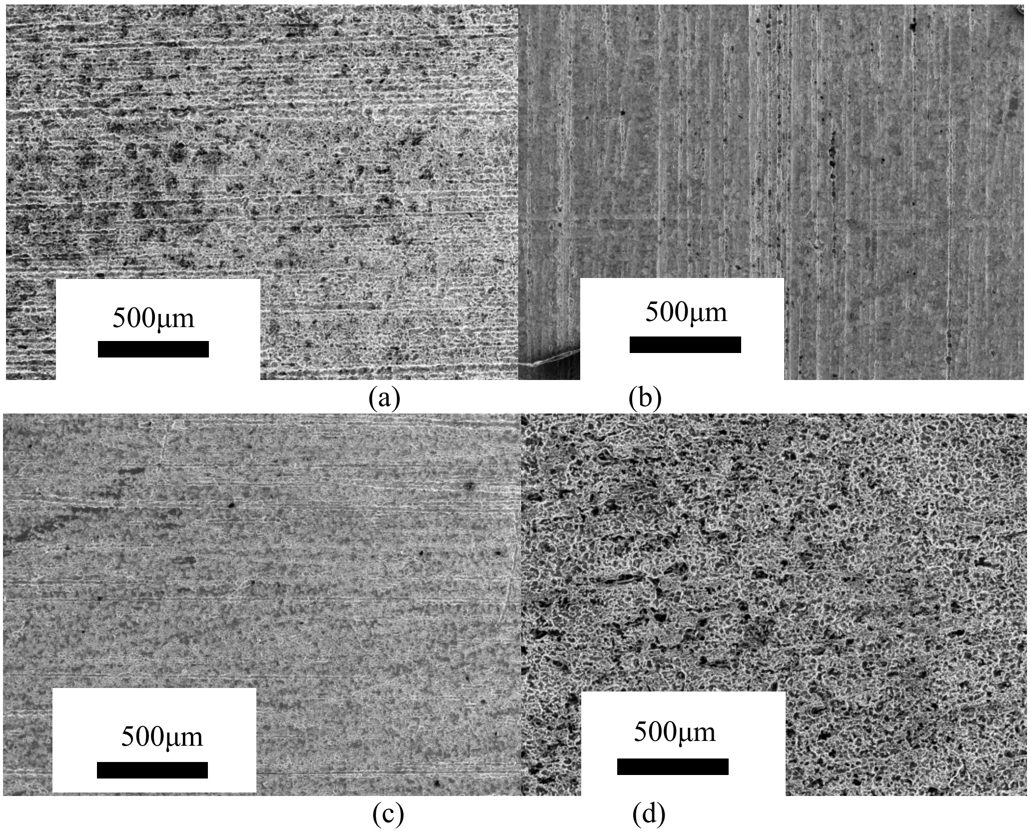

Figure 3 SEM photos of (a)CTAB 50mg/L, (b)CTAB 100mg/L,(b)CTAB 300 mg/L,(d)CTAB 400mg/L

of CTAB is 50mg/L. While the compound inhibitor with the concentration of CTAB is 100mg/L(figure 3b) and 300mg/L(figure 3c) the film on the surface of Zn is more uniform. But when the concentration of CTAB is 400mg/L(figure 3d) the film formed on the surface has many defects.

4.Conclusion

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1.Weight loss results show that CTAB had no evident effect on the weight loss results which indicate the macro corrosion of Zn in the 0.5m HCl. The pre-treatment of Zn plate in compound inhibitor solution had big effect on the weight loss results. So when the compound inhibitor solution used in practical can circulate it in the tower system before add 0.5m HCl.
2.The polarization plots and EIS results indicate that when CTAB concentration addition is 300mg/L the inhibitor had most performance anti-corrosion property.
3.SEM results show that the inhibitor solution can form a film on the surface of Zn which can protect it from corroding.

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