International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol.5, No.1, pp 347-352, Jan-Mar 2013

The Inhibitive Effect Of Glutamic Acid On The Corrosion Of Carbon Steel In Sea Water

S. Gowri[1]*, J. Sathiyabama[1], and S. Rajendran[1,2]

[1]PG and Research Department of Chemistry, Corrosion Research Centre, GTN Arts College, Dindigul-624 005, TamilNadu, India. Phone- +09486019574
[2]Department of Chemistry, RVS School of Engineering and Technology, Dindigul, TamilNadu, India.

***Corres.author: divisrigowri@yahoo.in, brigow@yahoo.co.in**

Abstract: The inhibition efficiency of Glutamic acid (GA) - Zn^{2+} system in controlling corrosion of carbon steel in sea water has been evaluated by weight loss method. The formulation consisting of 200 ppm of Glutamic acid and 25 ppm of Zn^{2+} has 87% IE. A synergistic effect exists between Glutamic acid and Zn^{2+}. The nature of the protective film on metal surface has been analyzed by FTIR and SEM analysis.
Keywords: Corrosion, Carbon steel, Amino acid, Glutamic acid, FTIR, SEM.

INTRODUCTION

Corrosion is an economic problem in world wide. Since corrosion can damage the materials which are used to construct automobiles, pipeline systems (water, oil), bridges and buildings, petroleum refineries etc [1]. Most of these organic compounds contain nitrogen, sulphur, oxygen and multiple bonds in the molecules which are adsorbed on the metal surface and the organic compound [2, 3]. Amino acids are nontoxic, relatively cheap, and easy to produce with purities greater than 99%. Recently, with respect to amino acid as corrosion inhibitor, many achievements have been gained in laboratory studies [4-7].

The literature presents some studies involving amino acids on the corrosion prevention of Mild steel [8], Aluminium [9], and copper [10]. Naturally occurring organic substances as corrosion inhibitors for mild steel in acid have been investigated. Potentiodynamic cathodic and anodic polarization technique was used to study the effect of some common amino acids concentration on the corrosion inhibition of mild steel in H_2O_2 [11]. In general, amino acids with longer hydrocarbon chains showed greater inhibition. Additional amino group or groups which increased electron density on the alpha amino group also increased the inhibition efficiency [12].

The present work is under taken

1. To evaluate the inhibition efficiency of Glutamic acid- Zn^{2+} system in controlling corrosion of carbon steel immersed in the absence and presence of Zn^{2+} by weight loss method.
2. To analyses the protective film by FTIR and Scanning Electron microscopy.

MATERIALS AND METHODS

Experimental

Preparation of specimen

Carbon steel specimens [0.0267 % S, 0.06 % P, 0.4 % Mn, 0.1 % C and the rest iron] of dimensions 1.0 cm x 4.0 cm x 0.2 cm were polished to a mirror finish and degreased with trichloroethylene.

Weight-loss method

Carbon steel specimens in triplicate were immersed in 100 ml of the sea water containing various concentrations of the inhibitor in the presence and absence of Zn^{2+} for one day. The

weight of the specimens before and after immersion was determined using a Shimadzu balance, model AY62. The corrosion products were cleansed with Clarke's solution [13]. The inhibition efficiency (IE) was then calculated using the equation:

$IE = 100 [1- (W_2 / W_1)] \%$

Where W_1 = corrosion rate in the absence of the inhibitor.

W_2 = corrosion rate in the presence of the inhibitor.

Surface examination study

The carbon steel specimens were immersed in various test solutions for a period of 1 day. After 1 day, the specimens were taken out and dried. The nature of the film formed on the surface of the metal specimen was analyzed by various surface analysis techniques.

FTIR spectra

The film formed on the metal surface was carefully removed and mixed thoroughly with KBr. The FTIR spectra were recorded in a perkin elmer 1600 spectrophotometer.

Scanning electron microscopic studies (SEM)

The carbon steel immersed in blank solution and in the inhibitor solution for a period of one day was removed, rinsed with double distilled water, dried and observed in a scanning electron microscope to examine the surface morphology. The surface morphology measurements of carbon steel were examined using JEOLMODEL6390 computer controlled scanning electron microscope.

RESULTS AND DISCUSSION

Analysis of Weight loss Study

Corrosion rate (CR) of carbon steel immersed in sea water in the absence and presence of inhibitors (Glutamic acid and Zn^{2+} system).

The calculated corrosion inhibition efficiency (IE) and corrosion rates (CR) of Glutamic acid in controlling corrosion of carbon steel in sea water, for a period of one day in absence and presence of zinc ion are given in Table 1.It is observed from the Table 1 the calculated value indicates the ability of Glutamic acid to be a good inhibitor. The IE is found to be enhanced in the presence of Zn^{2+} ion. Glutamic acid alone shows some inhibition efficiencies. The formulation consisting of 200 ppm of GA and 25 ppm of Zn^{2+} shows 87% of inhibition efficiency. Weight loss study reveal that GA and Zn^{2+} individually showed some IE, but exhibited better IE when applied in combination. This suggests that GA and Zn^{2+} exhibit synergistic behavior [14-20].

Table 1. Inhibition efficiencies (IE) and corrosion rates (CR) obtained from Glutamic acid - Zn^{2+} systems, when the carbon steel immersed in sea water.

Glutamic acid (ppm)	Zn^{2+} (0ppm)		Zn^{2+}(25ppm)	
	IE %	CR mm/y	IE%	CR mm/y
0	-	0.1809	64	0.0651
50	29	0.1284	69	0.0560
100	26	0.1339	69	0.0560
150	64	0.0651	69	0.0560
200	35	0.1176	87	0.0235
250	32	0.1230	64	0.0651

Analysis of FTIR Spectra

FTIR spectrometer is a power instrument that is used to determine the type of bonding for organic inhibitors adsorbed on the metal surface. FTIR spectra have been used to analyze the protective film formed on metal surface. FTIR spectrum of pure Glutamic acid is given in (Figure 2.) The CN stretching frequency appears at 1241 cm^{-1}. The C=O stretching frequency of carboxyl group appears at 1656 cm^{-1} .The NH stretching frequency appears at 3060 cm^{-1} .

The FTIR spectrum of the film formed on the metal surface after immersion in the sea water for 1 day containing 200 ppm of Glutamic acid and 25 ppm of Zn^{2+} is shown in (Figure 2a.) The CN stretching frequency has shifted from 1241 to1050 cm^{-1}. The C=O stretching frequency shifted from 1656 to 1623cm^{-1}. The NH stretching frequency shifted from 3060 to 3415 $cm^{-1.}$ This indicates that the nitrogen atom of Glutamic acid has coordinated with Fe^{2+} formed on the metal surface resulting in the formation of Fe^{2+}- Glutamic acid complex on the anodic sites of the metal surface. The peak at 1368 cm^{-1} is due to Zn-O stretching. The stretching frequency due to –OH appears at 2850 cm^{-1}.Thus FITR study leads to the conclusion that the protective film consist of Fe^{2+} - Glutamic acid complex and Zn $(OH)_2$ on the metal surface [21-22].

Figure 2. Pure Glutamic acid

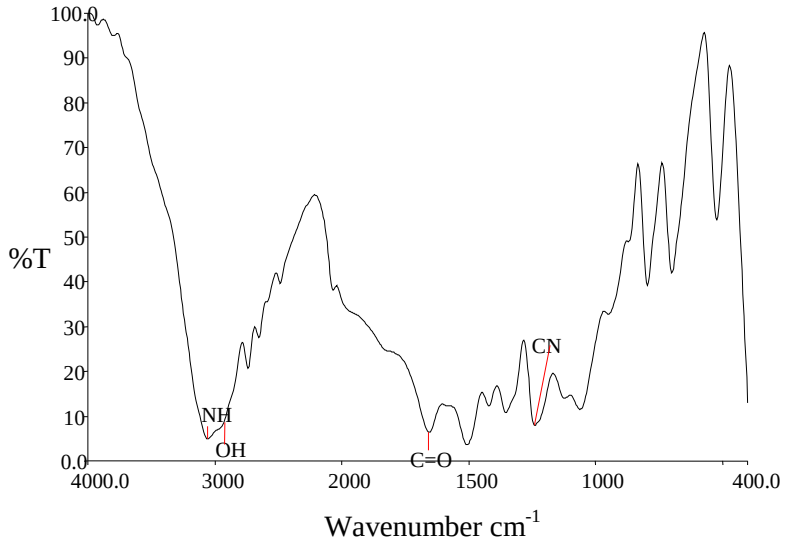
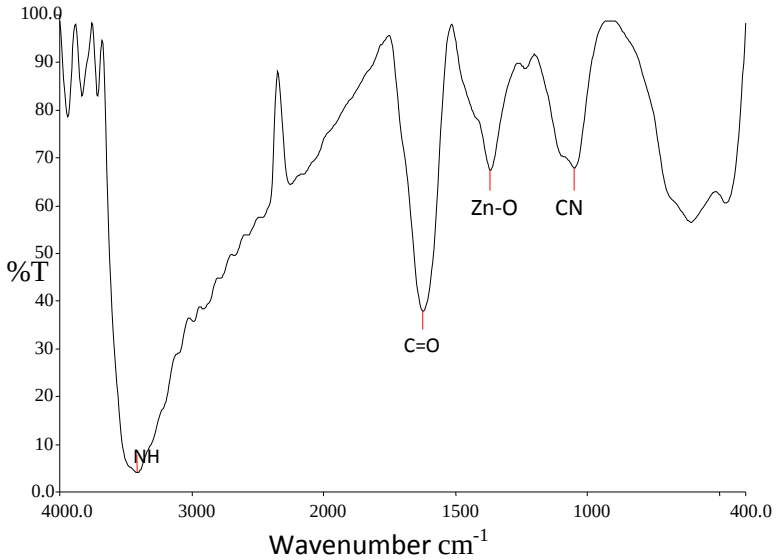


Figure 2a. Glutamic acid (200 ppm) + Zn^{2+} (25ppm)



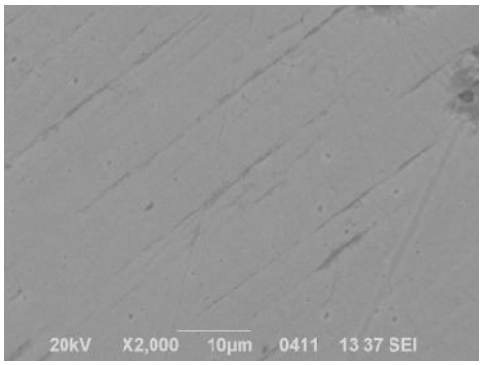
SEM Analysis of Metal Surface

The SEM image of magnification (X2000) of carbon steel specimen immersed in sea water for 1 day in the absence and presence of inhibitor system are shown in (Figure 3 images (b,c)) respectively). The SEM micrographs of polished carbon steel surface (control) in Figure.3 (a) image shows the smooth surface of the metal. This shows the absence of any corrosion products formed on the metal surface. The SEM micrographs of carbon steel surface immersed in sea water in Figure.3 image (b) shows the roughness of the metal surface which indicates the corrosion of carbon steel in sea water. Figure. 3 image (c) indicates that in presence of 200 of ppm Glutamic acid and 25 of ppm Zn^{2+} mixture in sea water, the surface coverage increases which in turn results in the formation of insoluble complex on the surface of the metal (Glutamic acid -Zn^{2+} inhibitor complex) and the surface is covered by a thin layer of inhibitors which control the dissolution of carbon steel. Such results have been reported earlier.[23-26]

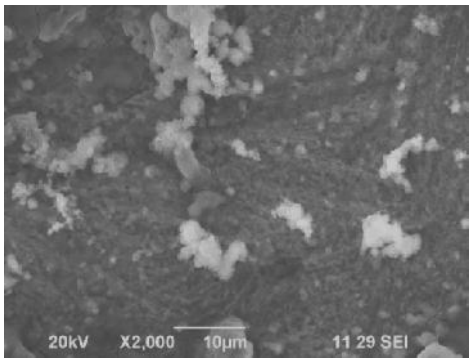
CONCLUSIONS

The present study leads to the following conclusions; the inhibition efficiency (IE) of Glutamic acid in controlling corrosion of carbon steel immersed in sea water in the absence and presence of Zn^{2+} has been evaluated by weight loss method. The formulation consisting of 200 ppm of Glutamic acid and 20 ppm of Zn^{2+} has 87% IE. The FTIR and SEM analysis reveals that the protective film is formed on the metal surface.

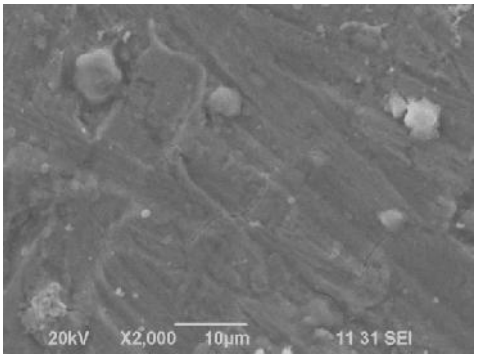
Figure 3. (a) Polished carbon steel (control) – Magnification X2000
(b) Carbon steel immersed in sea water
(c) Carbon steel immersed in sea water containing Glutamic acid 200 ppm of and 25 ppm of Zn^{2+}



(a)



(b)



(c)

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