

STUDY OF CHELATING AGENT AS A SURFACE MODIFIER FOR RETARDING CORROSION ATTACK ON FERROUS METAL

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Abstract

A different concentration of chelating agents in electrolyte of 3.5% NaCl was applied to bare ferrous metal and tested for their effectiveness as a corrosion retardant. The performance of the samples was measured using corrosion measurement system. The results indicated that the contribution of chelating agent was expediting the reduction of the passive film. The anodic behavior was clearly found to be influenced by the concentration of the chelating agent. It was also found that some of the corrosion was apparently converted to protective layer over a period of time. Excessive moisture caused breakdown of film by removing the unreacted chelating agent and causing regrowth of the existing rust.

Abstrak

Kepekatan *chelating agent* yang berbeza di dalam elektrolit 3.5% NaCl diaplikasikan ke atas besi logam tanpa salutan dan keefektifannya sebagai perencat kakisan diuji. Prestasi sampel diukur menggunakan sistem pengukuran kakisan. Keputusan ujikaji menunjukkan bahawa kehadiran *chelating agent* ini membantu mempercepatkan pengurangan lapisan bersifat pasif. Perilaku anodik jelas dipengaruhi oleh kepekatan *chelating agent*. Hasil ujikaji juga menunjukkan kakisan ditukarkan menjadi lapisan pelindung selepas suatu tempoh masa tertentu. Kelembapan yang berlebihan menyebabkan kerosakan kepada lapisan dengan menyingkirkan *chelating agent* yang tidak bertindakbalas dan menyebabkan karat baru wujud kembali.

Keywords/Katakunci: chelating agent, corrosion, electrolyte, ferrous metal, protective layer

INTRODUCTION

Ferrous metal is one of the most important metals used in industry due to its easy availability, easy of fabrication, low cost and good tensile strength besides various other desirable properties but corrosion causes a lot of problems in maintenance yet it will do not last as long as we wanted them to. As a ferrous metal is used in most machines and structures, we particularly want to avoid the corrosion in them.

Corrosion of ferrous metals occurs only when three conditions occur; (a) a potential difference exists. The movement of the electrons in the chemicals causes the ferrous metals to get dissolves. The potential difference is the one that causes the electrons to flow in a closed electrical circuit; (b) the surfaces are covered by an electrolyte. In galvanic series of metals, noble metals are most immune to the attack. When dissimilar metals are placed together in an electrolyte, a potential difference is created between them. The more active metal is corroded when a current flows through the electrolyte. In normal atmospheric corrosion, the concentration of the acid in the electrolyte is very low, so the rate of corrosion is slow. With a higher concentration, the corrosion is quickened; and (c) oxygen is present. Corrosion is highest at the surface of metals and contains a lot of dissolved air from the atmosphere.

There are two methods for ferrous oxide removals, namely mechanical and chemical cleanings (Kaplan and Ekis, 1984). Mechanical cleaning, which depends on procedures such as water hydroblasting and the use of abrasive sponge balls, can remove soft and loose deposits but not firmly adherent deposits. Chemical cleaning procedures that depend on suitable chelants could be considered the most effective for removing internal deposits, especially ferrous-based ones where using strong mineral acids sometimes corrodes metals even in the presence of corrosion inhibitors.



MY1204194

Chelating agents are cleaning chemicals for an on-line and off-line cleaning are frequently used (Abdul-Latif et al., 1988, Brouillette et al.). The chelants must not cause corrosion of ferrous metal. The main concern about the chemicals is their poor biodegradability. These chemicals, due to their environmental impact, are banned in some countries (Williams, 1998)

In this work, effect of inhibitor solution on ferrous metal was study using GAMRY software. Different concentration of chelating agents in 3.5% NaCl was applied to bare ferrous metal and their effectiveness as a corrosion retardant is evaluated.

EXPERIMENTAL

1- Steel test piece preparation

Steel test pieces were cut to small dimension of 70mm width and 130 mm length. Prior to use, test pieces were firstly cleaned to remove any loose rust on the surface by means mechanical brushing. The test pieces with adherent rust on the surface were degreased with acetone and kept them in desiccator before test.

2. Chelating solution preparation

1 litre of 3.5%NaCl solution was prepared using demonized water. This solution is used as an electrolyte for this study. Three different concentrations, 3 wt%, 5 wt% and 10 wt% of chelating agent in 3.5% NaCl solution were prepared. This test solution was kept for 3 days to ensure all insoluble chelating agent settle down.

3. Direct current Electrochemical testing

Gamry software is used to perform electrochemical measurements. Precleaned ferrous metals were subjected to electrolyte solution test. Ferrous metal samples were clamped in an electrochemical cell and 14.6 cm² areas were exposed to the electrolyte solution. The corrosion current and corrosion potential were calculated from Tafel plot according to ASTM G3-73 at a potential scanning rate 0.16 mV/sec.

RESULTS AND DISCUSSION

Polarization behavior of mild steel in different electrolyte is shown in Figure 1. From the shape of the polarization curves it is seen that the anodic as well as cathodic reactions are inhibited. The Tafel regions of the plot further indicate that the electrode reactions are kinetically controlled.

As increase in wt% of chelating agent, the corrosion potential (E_{corr}) is not varying much. Corrosion current (I_{corr}) decreases when the chelating agent is increases to 5 wt% from 5.13E-6 mA/cm² to 2.25E-6 mA/cm² but decreases to 3.17E-6 mA/cm² when the chelating agent is increases to 10 wt%. This is due to the adsorption of this chelating agent on the metal surface thereby blocking the surface and protecting the metal from the aggressive atmosphere. This shows the inhibitive action at 5 wt% of chelating agent used. The chelating agent used retard the corrosion process and prevents future corrosion with a durable protective barrier. It chemically converts existing rust into an inert coating that seals out moisture to prevent further rusting.

This proved by the study done by Logan, 1989, who states that solution of tannic acid stronger than 10 percent are too much concentrated. This also proved by recent treatments conducted by the Texas A&M Conservation Research Laboratory on iron artifacts recovered from 17th century French shipwreck have demonstrated that a 5 percent tannic acid solution permeates corrosion layers of the artifacts better than 10 percent solution (Logan, 1989).

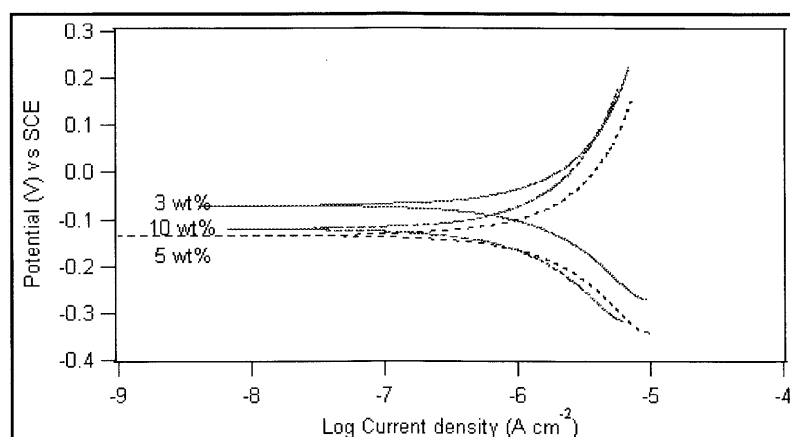


Figure 1. Electrochemical polarization curves in a 3.5% NaCl with varies quantities of chelating agent

The different of the anodic and cathodic curves reveals that dissolution of steel occurred at the anodic site in accord with the following reaction:



While the cathodic curves corresponding to the reaction of dissolved oxygen according to:

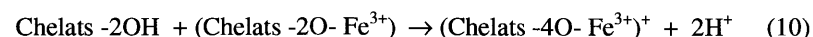
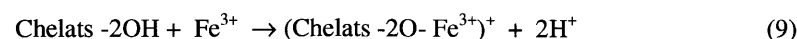
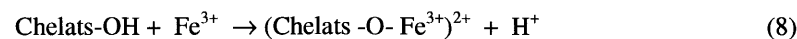
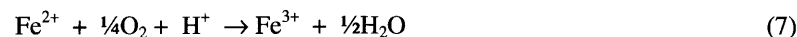
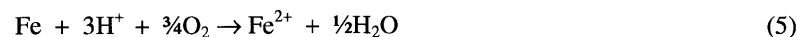


In the absence of chelating agent, chloride ions have been proposed by Rowe (1989) to catalyze the liberation of Fe²⁺ by displacement of the outer layers of the passive film:



These reactions removed the passive film at the preferred site until direct anodic dissolution of Fe²⁺ initiated a pit.

In the presents of chelating agent, the reactions are as follows:



When the electrolyte reacts with iron or iron oxide, it converts it to ferrous tannate, which oxidizes to a mechanically strong, compact, and a stable blue black colored ferric tannate (Figure 2).

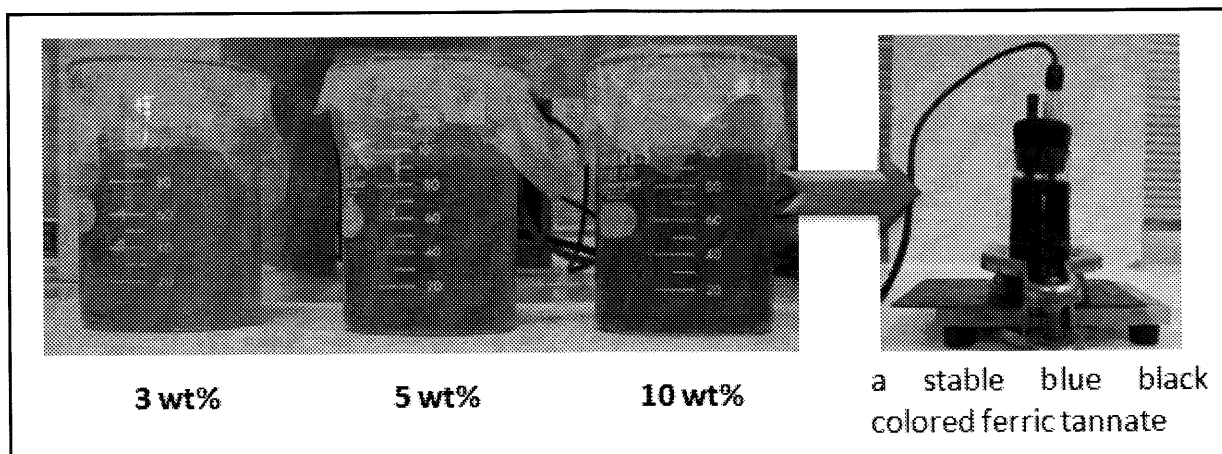


Figure 2. Solutions turns to a stable blue black colored of ferric tannate

CONCLUSION

Chelating agent used in this work acts as good corrosion retardant for mild steel in 3.5% NaCl medium. It may due to the adsorption of the chelating agent on the ferrous metal surface. Polarization studies indicate that the inhibitor to be of a mixed type inhibiting both cathodic as well as anodic reactions. The anodic behavior was clearly found to be influenced by the concentration of the chelating agent. It was also found that some of the corrosion was apparently converted to protective layer over a period of time. Excessive moisture caused breakdown of film by removing the unreacted chelating agent and causing regrowth of the existing rust.

ACKNOWLEDGEMENTS

This work was supported by Malaysian Nuclear Agency. The help extended by all staff is gratefully acknowledged.

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