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The Effect of Magnetic Field on Corrosion Inhibitor of Copper in 0.5 M HCl Solution

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Abstract

Corrosion of metals within magnetic field (MF) had been actively studied for better understanding of the corrosion mechanism when the magnetic sources are presented. However, findings regarding the effect of MF on metals are inconclusive, and there is a lack of studies of MF interaction with various corrosion control techniques, such as corrosion inhibitor. In this paper, the effect of MF on the corrosion of copper in 0.5 M hydrochloric acid (HCl) solution, with or without corrosion inhibitor were studied. Benzotriazole (BTA), a common copper inhibitor, was chosen as the inhibitor for this study. To determine the effect of MF, a MF of 13 mT, generated using a pair of permanent neodymium magnet, was applied during weight loss and electrochemical tests. The results showed that corrosion inhibition efficiency of BTA decreased when it is under an applied MF. A decrease from 47% to 60% in inhibition efficiency had been observed for all samples in an applied MF. By using Tafel extrapolation technique on the polarization curves, it revealed that MF had increased the corrosion current of copper in HCl, causing a decrease in the inhibition efficiency.

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1. Introduction

The exact mechanism that governs the corrosion of metals within an applied magnetic field is very complex and it is still unclear how magnetic field interacts with the chemical reaction. Magnetic field may increases or decreases corrosion rate depends, the metals, solution and the properties of the magnetic field. Thus corrosion under magnetic field had been actively studied, as better understanding of the governing mechanism will help in developing suitable corrosion prevention strategy when the magnetic sources are presented. Several studies had determined that magnetic field can affect the mass transfer via Lorentz force[1]. This force, F_L, can be described in Eq. 1 as

$$F_L = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \quad (1)$$

where q is the electron charge, **E** is the electrical field, **v** is velocity vector of the electron and **B** is the applied magnetic field strength. Magnetic field gradient force is also shown to be significant for cases like corrosion of iron in H_2SO_4 [2]. This gradient force, F_B, can be described in Eq. 2 as

$$F_B = \chi_m c \frac{\mathbf{B}\nabla\mathbf{B}}{\mu_0} \quad (2)$$

where χ_m is the molar susceptibility, c is the concentration of bulk solution and μ_0 is the magnetic permeability of vacuum. The effect on the charge transfer is more controversial. Although it had been demonstrated that it had no effect of magnetic field on several pure redox systems[3,4], it is not clear if this case was true for all processes, such as in the case of stainless steel corrosion in $FeCl_3$ solution [5].

Corrosion of copper in chloride medium is dependent of the concentration of the chloride ions. Anodic dissolution of copper into soluble $CuCl_2$ occurred when copper reacts with excess chloride ions, and that process is controlled by both mass transport and charge transfer [6]. Several studies had been done on corrosion of copper in chloride medium with applied magnetic field [7,8], and found that magnetic field increases the corrosion rate of copper. Mass transfer had been significantly enhanced during corrosion of copper under an applied magnetic field, which induces magnetohydradynamic (MHD) flows that can be observed using holography method [9].

Benzotriazole (BTA) is a heterocyclic organic compound, with chemical formula of $C_6H_5N_3$, and molecular structure as shown in Fig. 1, is commonly used as corrosion inhibitor of copper in acidic or neutral medium. It protects the surface of copper by bonding with nitrogen atoms on the triazole ring. The inhibition mechanism is complex, but chemisorption, rearly physisorption and formation of complex Cu(I)BTA had been identified as the possible actions involved [10,11]. However, there is little research done on the effect of magnetic field on the corrosion inhibitor of metals, and if this strategy is viable when magnetic sources are nearby. The interaction between the induced MHD flows with the adsorption mechanism of benzotriazole is therefore worth exploring further.

In this study, the effect of magnetic field on corrosion efficiency of BTA when it is applied on copper in 0.5 M HCl were studied. The effect was observed via weight loss test and electrochemical test, where a pair of neodymium permanent magnet is used to generate an applied magnetic field normal to the surface of the copper.

Nomenclature

MF	magnetic field
BTA	benzotriazole
MHD	magnetohydradynamic
IE	inhibition efficiency