The construction of a magnetite electrode for measurement of the electrochemical property

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1. Introduction

Flow accelerated corrosion (FAC) causes severe damage to secondary piping systems. An accident from FAC occurred at the Oyster Creek nuclear power plant (NPP) in 1978. Other NPPs such as Surry 2 and Mihama 3 have also experienced an FAC that induced damage to the carbon steel piping [1]. FAC is influenced by many factors such as the water chemistry (temperature, pH, dissolved oxygen (D.O.) in a solution, and etc.), chemical composition of carbon steel, and fluid dynamics [2]. Magnetite is formed at the inner surface of carbon steel, and protects the integrity of pipes from damage. The magnetite has a stable state at each equilibrium condition, so that it can be dissolved into the fluid under conditions that satisfy the equilibrium state. The iron solubility can be calculated by considering the reaction equilibrium constants for prediction of the change in the magnetite layer. On the other hand, it is necessary to measure the experimental solubility to compare the theoretical data and the experimental data. In addition, the solubility of magnetite can be predicted by measuring the electrochemical experiments. However, there are few studies related to the electrochemical property of magnetite owing to the difficulty of the electrode fabrication [3-5].

In the present work, a magnetite electrode was prepared using a dipping method, and the electrochemical property of the magnetite electrode was measured in an alkaline solution.

2. Methods and Results

2.1 The experimental conditions

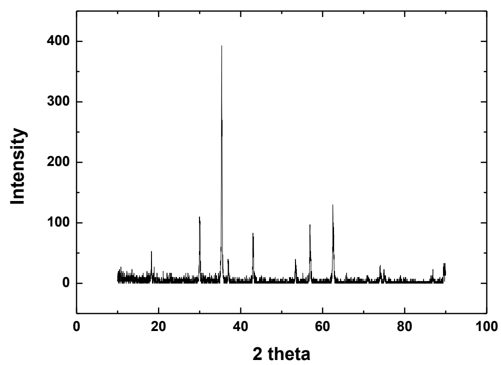
A 1 M NaOH solution was used in the electrochemical test and the bath temperature was room temperature. The solution was prepared with non-deaeration and was not agitated during the electrochemical tests. Each electrode was inserted into a 1 L five neck round flask. The lead wires to connect each electrode were a 1mm Pt, and were insulated with a Teflon heat shrink tubing.

2.2 The magnetite electrode preparation

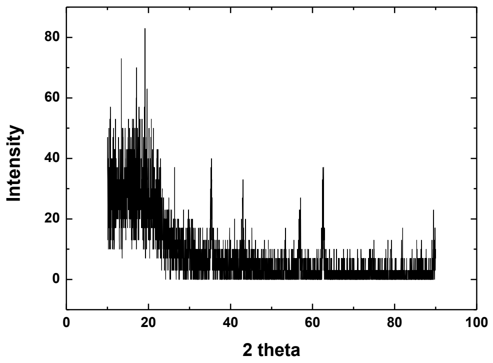
The magnetite powder (Showa) was used to fabricate the electrodes. A paste of the magnetite powder was prepared by mixing ethanol and polyvinyl butyral (PVB) as a binder. The end of the Pt wire was dipped into the mixed paste, and was dried in air. The resulting electrode had the property of magnetite as verified by the X-ray diffraction (XRD) spectrum shown in Fig. 1. The observed peaks in the spectrum were characteristic of magnetite, although there are some different peaks from other components, e.g. the binder. In addition, Fig. 2 shows the photography of the magnetite electrode. The magnetite electrodes were also prepared with carbon powder to allow the conductivity. The prepared electrodes appear in Table 1.

2.3 The electrochemical test

The electrochemical measurements were carried out on a Solartron 1260 instrument with a three electrode electrochemical cell. The reference electrode was Ag/AgCl, and the counter electrode was a 1 mm Pt wire. Cyclic Voltammograms of the magnetite electrode were measured with 0.1 mV/s scan rate, and the applied potential was from - 1.0 V to + 1.0 V. Potentiodynamic tests were also performed with a 10 mV/s scan rate and the applied potential was from - 0.1 V to + 0.5 V.



(a)



(b)

Fig. 1. X-ray diffraction patterns of (a) as-received magnetite powder (b) the prepared magnetite + binder electrode.

Fig. 2. Photograph of the prepared magnetite electrode with Pt wire.

Table I: The types of the prepared magnetite electrodes

Types	Abbreviation
Pt	P
Magnetite	M
Carbon	C
Magnetite + Carbon	MC
Binder (PVB)	B

3. Summary

The magnetite electrode was prepared using a dipping method for the measurement of the solubility of the magnetite. The prepared magnetite electrode showed the characteristic of the magnetite by an XRD spectrum. In addition five different types of the electrode were prepared to measure the electrochemical property.

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