Egyptian Journal of Petroleum (2015) 24, 405–409

HOSTED BY

Egyptian Petroleum Research Institute

Egyptian Journal of Petroleum

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FULL LENGTH ARTICLE

Semiconducting behavior of pure copper in alkaline solutions

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Received 19 June 2014; revised 14 August 2014; accepted 2 September 2014
Available online 2 November 2015

KEYWORDS

Copper;
Mott–Schottky;
Passive film;
Alkaline solution

Abstract The corrosion resistance of passive film is correlated with its semiconducting properties, which can be measured by the Mott–Schottky analysis in high frequency domain. In this study, the semiconducting behavior of passive films formed on pure copper in aqueous NaOH solutions was investigated using Mott–Schottky analysis. The polarization curves suggested that pure copper shows comparable passive behavior in NaOH solutions with different concentrations. Also, the potentiodynamic polarization curves showed corrosion current densities reduction with decrease in concentration of NaOH solutions. In Mott–Schottky analysis, no evidence of *n*-type semiconducting behavior was found, indicating that oxygen vacancies and copper interstitials do not have a significant population density in the passive film. Also, this analysis indicated that with the decrease of NaOH concentration in the solution, the acceptor density of passive films increases.

1. Introduction

Copper is extensively used in industrial and corrosion prevention applications. This metal is the most common multi-component construction material used in the chemical and petrochemical industries. Therefore, there is a permanent interest in studying the passivation of this metal in different corrosive environments. The passivation of copper in alkaline solutions is of great interest because of the scientific importance of this phenomenon [1–3].

During the last decade, the passivation behavior of the copper in alkaline solutions has been investigated in relation to the protective characteristics of passive films and the electrochemical production of copper oxide layers [4–6]. Studies on the copper oxide passive films using different characterization methods such as X-ray diffraction, and X-ray photoemission spectroscopy have indicated that the composition of the copper oxide passive films depends on many variables such as pH, presence of aggressive anions, and aerating conditions [7–9].

Generally, there are many industrial processes in which copper has to withstand corrosive conditions in solutions of high to medium concentrations of hydroxides while these concentrated solutions can affect the passivation behavior. Therefore, the passivation behavior of copper in the alkaline solutions needs to be fully understood [9].

The main objective of this study is to investigate the semiconducting behavior of passive films, formed on pure copper in NaOH solutions, by using Mott–Schottky analysis.

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Peer review under responsibility of Egyptian Petroleum Research Institute.

http://dx.doi.org/10.1016/j.ejpe.2014.09.012
1110-0621

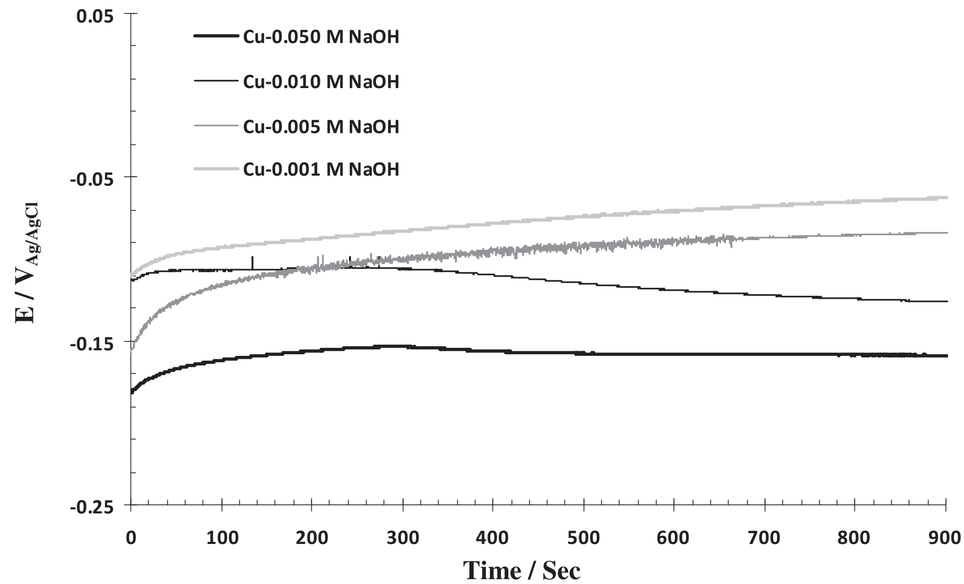

Figure 1 OCP plots of pure copper in NaOH solutions.

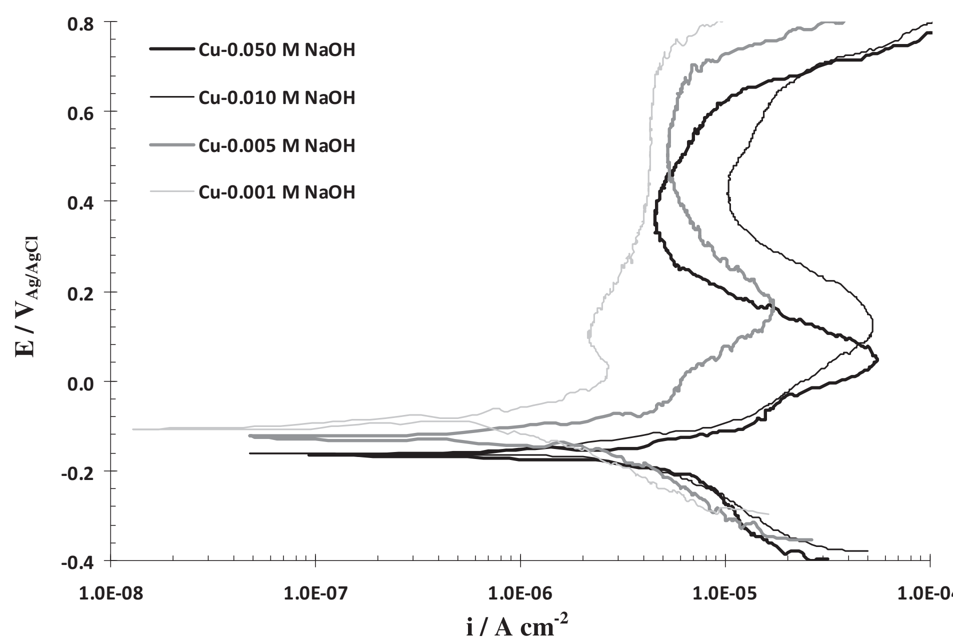

Figure 2 Potentiodynamic polarization curves of pure copper in NaOH solutions.

Furthermore, the point defect model (PDM) is used to determine the experimental data. This work includes investigation of the passive region of copper in NaOH solutions, determination of the semiconductor character, and estimation of the dopant levels in the passive films.

2. Experimental procedures

All pure copper (99.99 wt.%) samples were polished up to 1200 grit, rinsed in distilled water, and dried with air just before each electrochemical measurement. The electrochemical measurements were carried out in aerated alkaline solutions with four different NaOH concentrations (0.050, 0.010, 0.005, and 0.001 M) at 25 ± 1 °C using a conventional three-electrode flat cell.

The counter electrode was a Pt plate, while the reference electrode was Ag/AgCl saturated in KCl. Electrochemical measurements were obtained by using the μAutolab Type III/FRA2 system. Also, for the data analysis, the NOVA software was used.

Prior to electrochemical measurements, working electrodes were immersed at open circuit potential (OCP) for 900 s to form a steady-state passive film. Potentiodynamic polarization