Journal of Electroanalytical Chemistry 633 (2009) 240–245

Contents lists available at ScienceDirect

Journal of Electroanalytical Chemistry

journal homepage: www.elsevier.com/locate/jelechem

Electrochemical potential noise analysis of Cu–BTA system using wavelet transformation

Mehdi Attarchi [a,b], Majid S. Roshan [c], Saleh Norouzi [a], S.K. Sadrnezhaad [a,d,*], Abdolhamid Jafari [b]

[a] Materials and Energy Research Center, P.O. Box 14155-4777, Tehran, Iran
[b] Department of Materials Science and Engineering, Bahonar University, Kerman, Iran
[c] Advanced Dynamic Control Systems Laboratory, Faculty of Mechanical Engineering, College of Engineering, University of Tehran, Tehran, Iran
[d] Department of Materials Science and Engineering, Sharif University of Technology, Tehran, Iran

ARTICLE INFO

Article history:
Received 16 January 2009
Received in revised form 29 May 2009
Accepted 11 June 2009
Available online 14 June 2009

Keywords:
Electrochemical noise analysis
Potential noise
Inhibition
Benzotriazole

ABSTRACT

Electrochemical potential noise analysis was used to investigate corrosion behavior of copper electrodes in presence of 0.001, 0.005, 0.01 and 0.02 M benzotriazole (BTA) inhibitor. Energy distribution of the potential noise was obtained from wavelet transformation using the 4th order Daubechies pattern. Two lowest frequencies were added-up and fitted to the impulse response of the first order circuit to achieve the time-constant vs. concentration (*T–C*) diagram. *T–C* diagram can be used either as a conventional diagram of inhibition efficiency or a tool for evaluation of the surface film dielectric constant. The assumptions made in this treatment were confirmed by EIS method.

1. Introduction

Benzotriazole (BTA) is recently known as an effective inhibitor for copper and copper alloys exposed to different environmental conditions. Inhibitor-less immersion of copper does not result in formation of protective insulation. When BTA is added to the solution, the inhibitor reacts with the electrode to form [Cu(I)–BTA]. An insoluble protective film is produced by polymerization process. In presence of BTA, oxygen reduction is controlled by charge-transfer through the film. A complex film is formed in presence of BTA inhibitor which has a dielectric nature. Corrosion rate decreases and film thickness increases as time elapses and/or concentration increases. In a de-aerated solution, less protective film is producible [1–3].

Coulometric measurements by Ammeloot et al. [4] have shown that in the absence of an inhibitor, Cu_2O layer thickness increases with immersion time of at least 3 days. With surface oxidation before the immersion, the film formation becomes faster [3]. BTA film formation is also easier on Cu_2O than on CuO [5]. Qafsaoui et al. [6] have mentioned that in presence of BTA, film thickness decreases on CuO but increases on Cu_2O. This is of course attributed to the anodic polarization of copper. When Cu_2O covers the surface of copper, addition of BTA to the environment resulted in rapid formation of film, until all Cu_2O is consumed. Then the formation rate reduces to a specific value which is determined by the dissolved oxygen in the solution [3]. A quantitative ESCA analysis of a chemically pretreated Cu–BTA complex by Hashemi and Hogarth [7] has illustrated that in the absence of chloride ions, the stoichiometric ratio of Cu and BTA is equal to 1. In acidic media, the BTA is adsorbed by the Frumkin isotherm in which both inhibitor–inhibitor and inhibitor–electrode surface interactions occur [8–10]. From microscopic point of view, ΔG of formation of the film is a complex quantity which results from constituents such as interaction between the inhibitor and electrode, the inhibitor and solution, the inhibitor and itself, and the energy stored by double layers [11,12].

Electrochemical noise analysis (ENA) is a newly developed way utilized for investigation of many applied cases like inhibition system [13–15], crack initiation [16,17], pitting and crevice corrosion [18–22]. The potential noise measurements have been used to estimate the electrode morphological state, Al corrosion and etc. [23,24]. Electrochemical noise occurs naturally in the electrolyte/electrode interface due to the random ion movements. It indicates a change in the thermodynamic and kinetic states of the interface. Inhibition studies by ENA have also been practiced earlier, but many parameters have remained unknown [25–29]. In most cases, noise impedance as well as electrochemical impedance spectroscopy (EIS) or super imposed diagrams (noise impedance and EIS) and spectral noise resistances are rigorously evaluated [30–33]. This research comprises an innovative method devised for assessment of the electrochemical noise analysis data as compared to the EIS results of the inhibition systems.

* Corresponding author. Address: Department of Materials Science and Engineering, Sharif University of Technology, Tehran, Iran. Tel./fax: +98 2616201881.
E-mail address: Attarchi@gmail.com (M. Attarchi).

0022-0728/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.jelechem.2009.06.008