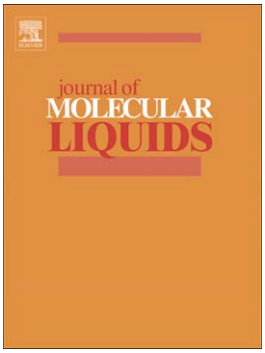

Liquid-liquid phase separation of an electrolyte at metals deposition on the surface of a steel plate under the influence of two-domain magnetic system

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PII: S0167-7322(16)32414-X
DOI: doi:10.1016/j.molliq.2016.11.024
Reference: MOLLIQ 6567

To appear in: *Journal of Molecular Liquids*

Received date: 24 August 2016
Revised date: 7 November 2016
Accepted date: 12 November 2016

Please cite this article as: .Yu. Gorobets, Yu.. Gorobets, V.P. Rospotniuk, A.A. Kyba, V.I. Grebinaha, Liquid-liquid phase separation of an electrolyte at metals deposition on the surface of a steel plate under the influence of two-domain magnetic system, *Journal of Molecular Liquids* (2016), doi:10.1016/j.molliq.2016.11.024

Liquid-liquid phase separation of an electrolyte at metals deposition on the surface of a steel plate under the influence of two-domain magnetic system

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Abstract

The formation and dynamic of expansion and deformation of the liquid-liquid interface of an electrolyte at deposition of metals from aqueous solutions $CuSO_4$ and $CuSO_4$ + $MnSO_4$ at the surface of the magnetized steel plate is considered in this paper. The electrochemical processes were investigated in the non-uniform stray magnetic field created by two-domain magnetic system. These processes are accompanied by the formation of effectively paramagnetic clusters of electrochemical products – magnions. The influence of the adding of chemically inert ions Mn^{+2} on the shape of interfacial surface and the magnitude of effective magnetic susceptibility of a magnion were investigated. Tyndall effect, optical and scanning electron microscopes were used for detection of the presence of magnions near the magnetized steel electrode in a solution. The shape of the interface separating the regions with different concentration of magnions, i.e. different magnetic susceptibilities, was described theoretically based on the equation of hydrostatic equilibrium which takes into account magnetic, hydrostatic and osmotic pressures.

Keywords

Hydrostatic equilibrium, quasi-stationary state, effective magnetic susceptibility, magnion, gradient magnetic field

1. Introduction

The interest in the study of the influence of magnetic fields on electrochemical systems is associated with the ability to affect the mass transfer near the electrode surface. It allows to control the properties of layers and metal surfaces during their electrodeposition and electrodissolution [1-4], and to control the rate of electrochemical reactions [5-10]. The main reason for a significant impact of a magnetic field on the course of electrochemical transformations is the effect of magnetohydrodynamic stirring of an electrolyte under the action of Lorentz force in a magnetic field without the passing an electric current through the electrolyte [11-15]. The most significant effects of magnetic field influence are related to electrochemical reactions on the surface, the slowest stage of which is the supply of reagents or allocating of reaction products, and also the electrolyte stirring that changes the diffusion mechanism of their transport to convective one. Therefore, the rate of electrochemical reactions, which are characterized by diffuse or mixed kinetics, significantly increases as a result of the electrolyte stirring [11]. Theoretical modeling of these magnetoelectrolysis effects is based on the common system of equations of magnetohydrodynamics for weakly conducting fluid and convective diffusion equation [16].

However, there are a number of experimental effects of the magnetic field influence on the course of the deposition, chemical etching and corrosion of metals [17-20], which cannot be explained by the action of the Lorentz force because no electric current is passing through the electrolyte. It is experiment revealed that the spatial modulation of the electrode surface properties is determined mainly by the non-uniform distribution of magnetostatic fields on the electrode surface [19-20]. For example, it was found in the paper [21] that the magnetic field can significantly affect the pitting corrosion of iron, nickel or cobalt electrodes in the form of thin films. The effect of the gradient magnetic field on the ferromagnetic metal corrosion, which