

Electrochemical aspects of black chromium electrodeposition in 1-butyl-3-methylimidazolium tetrafluoroborate ionic liquid

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Abstract

In the last decades the electroplating industry has paid a great deal of attention to alternative electrodeposition baths with lower environmental and health impacts. In the case of black chromium coatings, usually obtained from water-based hexavalent chromium Cr(VI) solutions, the search for aqueous alternatives has been centered on Cr(III) formulations, while attempts using non-aqueous media, including ionic liquids (ILs) solutions, have been restricted by the lack of solubility of Cr(II) and Cr(III) salts in these solvents. Literature is scarce, even though electrodeposition of Cr has been reported from an ionic liquid analogue solution consisting of choline chloride and hexahydrated chromium salt, either as an amorphous [1] or a nanocrystalline film [2]. In the present paper, the electrodeposition of black chromium thin films from a solution of trivalent chromium in 1-butyl-3-methylimidazolium tetrafluoroborate ([BMIm][BF₄]) is reported. Electrolyte preparation, electrochemical characterization of both the liquid and the electrodeposition process and the electrodeposition experiments, were all carried out under argon atmosphere in a glove box with a gas purification system capable of ensuring water and oxygen contents below 2 ppm. AISI 304 stainless steel was chosen as a substrate material. Typical cyclic voltammetry studies, performed from -2V to +2V vs Pt QRE at a scan rate of 50 mVs⁻¹, indicated redox features associated to Cr species and a crossover loop indicating a nucleation process, defining the electrochemical window for effective electrodeposition. Continuous and homogenous films with a granular morphology were obtained for deposition times up to 1 hour at -1.5V (Pt). Experimental current density-time transients obtained by chronoamperometry will be discussed in the light of available models for nucleation and growth. Experimental results showed good agreement with theoretical values indicating that nucleation of black chromium films in [BMIm][BF₄] is instantaneous and under diffusion control.

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References

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