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Comparison study for passivation of stainless steel by coating with polyaniline from two different acids

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ABSTRACT

In this paper we discuss electrodeposited polyaniline (PANI) films on stainless steel surfaces made from two different acidic (sulphuric and phosphoric) solutions containing the aniline monomer. The type of counter anion was shown to significantly affect the polymerisation reaction and the formation of an underlying oxide layer. We find that the growth rate and thickness of the $PANISO_4$ layer are much higher than those of $PANIPO_4$ layer. Both layers altered the steel potential and passivated the materials when immersed in a hot acid solution. While the oxide underneath the $PANISO_4$ layer is enriched with Cr, Fe and Ni components the under $PANIPO_4$ layer is elementally deficient, making the later a less efficient passivating agent. Finally, we show that the first oxide film is superior in protection against pitting in aggressive chloride solutions.

1. Introduction

Stainless steels (SSs) belong to a class of metals and alloys that are protected by a passive film formed on their surface. However, these alloys are susceptible to localised attack; even high alloyed steels may corrode in strong chloride solutions. The localised corrosion of SSs is one of the most serious problems facing the use of these alloys [1].

Conductive polymers (CPs) continue to be of considerable interest as components of corrosion-resistant coatings. Passivation of stainless steels is typically achieved by chemically or electrochemically coating the surface with such CPs. The polymer film passivates the electrode by holding the potential in the passive region [2–9]. The CPs induce oxide formation on the metal surface, repairing chemical degradation of the metal/oxide interface [2–12].

Polyaniline (PANI), one of the most studied CPs, has different oxidation states; the most stable one is called emeraldine. Usually aniline is polymerised using strong inorganic [2,7,9] and organic acids [14]: buffer solutions, such as acetate (pH 3.5–5) [15] and phosphate (pH 5) [16,17], also have been used to this effect. The particular dopant used will also affect the synthesis process, as much as the intrinsic molecular properties [18].

There are a number of reports on corrosion protection by PANI [8,10,13,25]. Depending on the metal used, and on the method of synthesis, different results of protection were obtained. PANI has been shown to protect SSs both when prepared with a dopant [8] and when undoped [19]. It has been suggested that PANI can protect even in a chloride medium [10,20], whereas others [21] claim that PANI does not protect in chloride medium.

Kraljić et al. [13] obtained different results for protection behavior of PANI on 420 SS in two different acidic solutions, phosphoric and sulphuric acids. Since PANI layers are porous, it was suggested that the protection depends on the quality of the induced oxide film, and on the amount of PANI used, which is usually determined by the thickness of the PANI layer. The layer deposited in a phosphate solution appears to have better protective properties than the layer deposited in a sulphate solution. Hermas [8,12] obtained high quality passive film on the SS beneath PANI layer prepared from sulphuric acid solutions.

In this work, we explore electropolymerised PANI on 304 stainless steel from concentrated sulphuric and phosphoric acid solutions; the oxide films beneath the polymer layers are investigated by using varying techniques.

2. Experimental

Aniline (BDH) was distilled before use. We used grade reagents of phosphoric acid (Fisher) and sulphuric acid (Fluka) for electropolymerisation and other measurements. Electrochemical experiments were conducted in a single compartment three

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