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The performance of surfactant on the surface characteristics of electroless nickel coating on magnesium alloy

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ABSTRACT

Magnesium and its alloys corrode rapidly in the electrolyte bath. Surfactants while used extensively as surface active agents in the electrolyte bath, have been little studied on magnesium surfaces. The influence of surfactants cetyltrimethyl ammonium bromide (CTAB) and sodium lauryl sulfate (SLS) on the surface properties such as roughness, morphology and topography of electroless Ni–P deposits on magnesium alloy was researched. The research reveals that the surfactant solutions has significant influence on the composition of coating, surface roughness and surface morphology. In addition, it has marginal effect on the microhardness. Electroless coatings with addition of surfactants produce a smooth surface and average roughness value of 1.412 μm for CTAB and 1.789 μm for SLS, which are less than the value (2.98 μm) without surfactant addition. There was a significant improvement in the rate of deposition. However, the surfactants influence reached maximum at critical micelle concentration and above this value it gets stabilized. The initial structure appears to be dependent upon the percent occluded surfactants. The surface microstructures are discussed in line with the experimental observations.

1. Introduction

Electroless nickel coating has received widespread acceptance as it provides a uniform deposit on irregular surfaces, direct deposition on surface activated non-conductors, formation of less porous deposits, high hardness and excellent resistance to wear, abrasion and corrosion [1]. All smooth surfaces possess some degree of roughness, even if only at the atomic level. Correct function of the fabricated component often is critically dependent on its degree of roughness. Every machining operation bequeaths some characteristic on the machined surface. This characteristic micro-irregularities left by the cutting tool which are termed as surface irregularity or surface roughness [2]. Roughness is sometimes an undesirable property, as it may cause friction, wear, drag and fatigue, but it is sometimes beneficial, as it allows surfaces to trap lubricants and prevents them from welding together. Magnesium alloys have promising properties for several industrial applications, because of their low density [3]. Magnesium alloy with metallic (electroless/electroplating) deposit are being used, in new light-weight engines which are less in weight and hence consume less energy. However, metallic coatings in magnesium are having multitudinous problems caused by surface roughness. Example of mechanical malfunction can be found in high-performance engine machine parts which are required to move or rotate at high speed without wear. Excess surface roughness can lead to unacceptably high levels of frictional heating, causing damage and even failure [4].

Surfactants are specifically added into the electrolyte bath to reduce the vertical component of surface tension forces, which binds the nickel particles to the hydrogen gas bubbles generated during the plating reaction. Due to this, uniform and pit-free coating can be obtained. Smooth and pit-free electroless Ni–P deposits were obtained by adding 150 ppm of sodium dodecyl sulfate (SDS) to the electroless nickel bath [4]. Similarly, a very brief conclusion was derived by Hagiwara et al. [5] as well, who studied the effect of three different surfactants added in the Ni–P electroless bath on the morphology of the resulting Ni–P particles. Many attempts have been made to find out the effect of surfactants on the roughness of electrodeposited Ni–P coatings. Tripathy et al. [6] and Wheeler et al. [7] studied a numerical model to explain the influence of catalytic surfactant on roughness evaluation. Alsari et al. [8] research studied on SDS effect on the electroplating deposion. Medina-Valtierra et al. [9] studied the influence of CTAB on the roughness of titania sol–gel films. Elansezhian et al. had investigated SDS and CTAB [10] and showed that there is a possibility of significant improvement in the average surface finish of electroless Ni–P deposit on mild steel. However, there was no such investigation on magnesium alloy and moreover it is complicated because of corrosive nature in the electrolyte bath.

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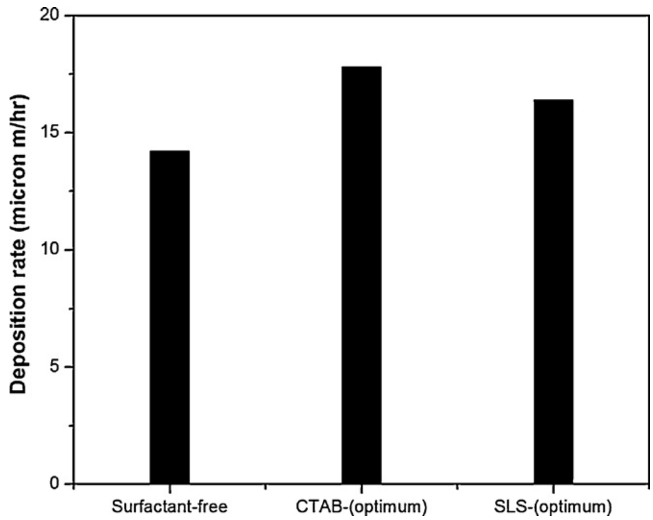

Fig. 1. Effect of added surfactant at its CMC value on the rate of the electroless Ni–P coating on magnesium alloy.

Hence, in this investigation, two types of surfactants namely sodium lauryl sulfate (SLS) and cetyl tri-methyl ammonium bromide (CTAB) were used in the electrolyte for electroless Ni–P deposit on magnesium alloy, which affects the surface tension forces between solid/liquid interfaces [11] and influencing the coating process through this mechanism. The deposition rates of the electroless Ni–P deposit depends on many factors. For example, they might be the temperature, pH of bath, bath loading, concentrations of nickel and the reducing agent, and the surface properties of the substrates. Wetting agents, such as ionic and nonionic surfactants, are often added to increase the wettability of surfaces to be deposited. Despite the complicated behavior of the deposition reactions and adsorption of surfactants to the as-deposited substrates, qualitative discussions on the effects of added surfactants (SLS and CTAB) to the plating bath solutions on the deposition rates, surface morphology, surface topography and microhardness are investigated in this study.

2. Experimental

2.1. Sample and bath preparations

The substrate mainly contained about 9.1 wt.% Al, 0.64 wt.% Zn, 0.17 wt.% Mn, 0.001 wt.% Fe and Mg balance (AZ91D die cast magnesium alloy with a size of 20 mm × 15 mm × 5 mm). All pre-process including, alkaline cleaning and chrome plus HF pre-treatment prior to electroless bath for magnesium alloy can be found in our earlier studies [12]. The treatment processing of magnesium alloys is always difficult, if the substrate covers with an oxide film. Hence,

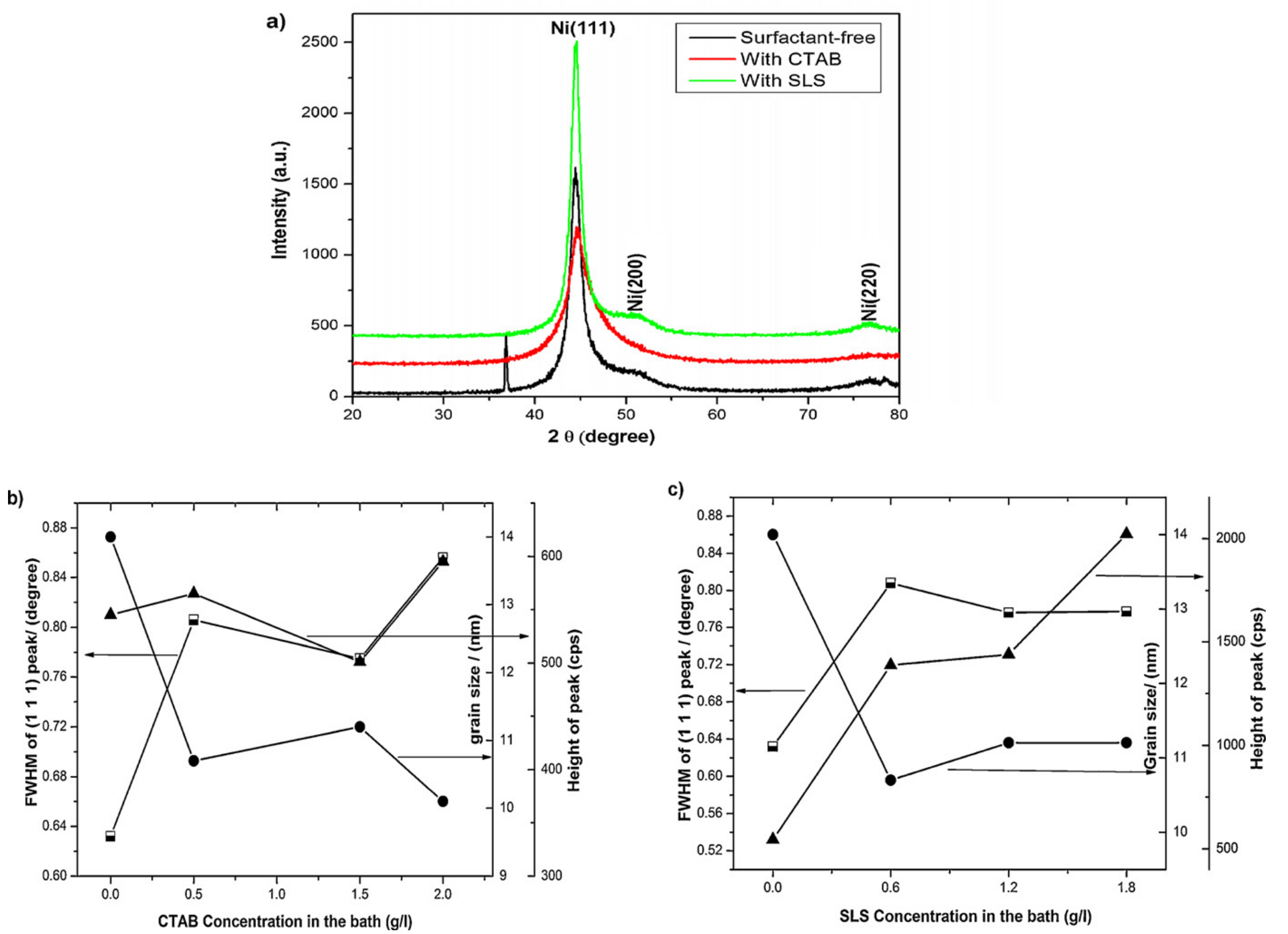

Fig. 2. (a) XRD patterns of electroless Ni–P coating with-out/with added surfactant; their parameters (b) CTAB added; (c) SLS added, electroless Ni–P deposit on magnesium alloy.