Effect of nano-sized Al_2O_3 particles on the electrodeposition and properties of Ni/Al_2O_3 nanocomposite coatings

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Composite electrodeposition is a method of codepositing micrometer or nanometer-sized particles of metallic, non-metallic compounds or polymers in an electrodeposited metal matrix in order to improve material properties such as wear resistance, lubrication or corrosion resistance. In this sense, the codeposition of ceramic particles gives exceptional advantages in terms of mechanical properties (hardness, chemical inertia, good frictional behaviour) as compared to alloy and pure metal electroplating [1-3].

One of the most widely applied composite coatings is the Ni/Al_2O_3 system [4-6]. They have good tribological properties and have quite good anticorrosion properties. Due to their properties, they find application as coatings of engine cylinders, high-pressure valves and dies and in the production of musical instruments, drill fittings, car accessories and small aircraft and electrotechnical parts [7].

Most of the studies in this field have been focused on the use of micrometric particles, but with the emergence of nanotechnologies, interest on the codeposition of nanometer-sized particles have increased in the last years. Some studies have demonstrated that a decrease in the size of the particles from micro- to nano-scale can improve mechanical and tribological properties of electrochemically deposited composite coatings. However, first attempts showed that the percentage of nanoparticles incorporation was low and that the particles tend to form agglomerates in the electrolyte bath. To confirm this behavior, in previous studies developed in CIDETEC the Al_2O_3 nanoparticles suspended in a nickel Watts baths were analyzed using electroacoustics method in order to determine particle size. In this sense, it was observed that the nano-alumina particles were easily agglomerated into larger particles in the electrochemical electrolyte. In order to avoid this agglomeration, the use of different physical (pulse plating, ultrasounds) and chemical (additives) methods are currently being investigated by different research groups [8-10].

In the present work, Ni/Al_2O_3 composite coatings were electrodeposited galvanostatically from a Ni Watts electrolyte to which γ-Al_2O_3 nanoparticles (d_m = 50 nm) were added. The effect of physical (agitation by means of an ultrasonic horn) and chemical (addition of a cationic surfactant) dispersion methods on the electrodeposition of Ni/Al_2O_3 nanocomposite coatings and on the composite properties was analyzed.

The Ni/Al_2O_3 nanocomposite coatings obtained were characterized from the compositional (EDX), morphological (SEM) and structural (TEM) points of view. As the mechanical behavior of these systems is very important from the viewpoint of practical applications, some mechanical properties like hardness and wear resistance were also evaluated.

The results showed that both methods (ultrasonic agitation and additive addition) lead to an increase on the codeposition of Al_2O_3 particles, modify the morphology and structure of the composite coatings and improve their mechanical (hardness and wear resistance) properties. The dispersion effect was more pronounced in the case of electrodeposition under ultrasonic field.

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Figures

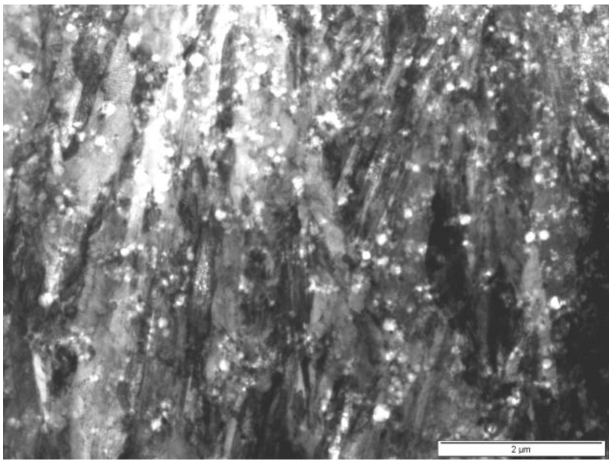

Figure 1. TEM micrograph of a cross section of a Ni/Al_2O_3 composite coating obtained under ultrasonic agitation.