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Photocatalytic Properties of TiO_2 Nanotubes Doped with Ag, Au and Pt or Covered by Ag, Au and Pt Nanodots[1]

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Abstract—Titania nanotube arrays have been prepared by anodic oxidation of titanium foils in an electrolyte solution containing a mixture of hydrofluoric acid, ethylene glycol, and phosphoric acid. The initially amorphous nanotubes were found to crystalize in an anatase phase upon thermal treatment at 500°C. Anatase crystalline phase showed a significant improvement in the photocatalytic properties of the prepared samples, which was evaluated by studying their efficiency towards Rhodamine B dye degradation. Additionally, the effect of doping titania nanotubes with noble metals (e.g. Ag, Pt, and Au), or covering their surface with noble metal nanoparticles, was studied regarding their capabilities towards the photocatalytic degradation of Rhodamine B dye. A positive effect when samples were doped with Ag was revealed.

Keywords: doped titania nanotubes, photocatalysis, dye degradation

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INTRODUCTION

For many years the process of anodic oxidation of titanium (Ti) in different electrolytes has been studied due to its potential in obtaining nanostructured titanium dioxide (TiO_2). This material is of great interest for many applications, such as solar energy conversions in Gratzel-type solar cells [1–3], as photocatalyst [4–7], including reactions of water electrochemical splitting (photoelectrolysis) [8–10], as an active material in gas sensors [11, 12], as well as in several biomedical applications [13, 14]. A key factor in many of those applications is the possibility of producing a nanostructured material with predetermined shapes, like porous structures, tubes, or spheres. These structures present a large active surface in a very small volume, which contributes to the enhancement of their physical and optical properties. Therefore, nanostructured TiO_2 is considered one of the most efficient, low-cost, and highly stable photocatalysts. Nevertheless, the main drawbacks of this material are its wide bandgap and high recombination rate of charge carriers. One way of overcoming these shortcomings is to produce porous materials doped with catalytic metals, which would enhance the photocatalytic properties of TiO_2 nanostructures.

The key processes responsible for both the anodic formation of nanoporous titanium dioxide structures and growing matrices of TiO_2 nanotubes seem to be the same. They are determined by the metal oxidation and the pore growth controlled by the chemical dissolution of the oxide produced under a given potential difference.

Titania nanotubes are also of especial interest as future platforms to be used as nanoengines, autonomous entities, which perform a controlled motion in the presence of certain fuels or external stimul [15–20]. While the first potential tubular nano- and micromotors were generally moving in the presence of hydrogen peroxide and showed great potentialities as microtransporters [21–27] and many other sensing and environmental applications [28, 29], their usage has been highly restricted by the toxic nature of the hydrogen peroxide fuel. One of the most interesting alternatives for the mentioned fuel has been the light-induced microengines, whose movement is promoted by a renewable energy source, and the reactions involved do not generally generate waste products. In addition to all advantages of such a motion principle, titania structures are inherently biocompatible, which

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[1] The article is published in the original.