

Synergistic effect of TiO₂@SiO₂ coatings for photocatalytic treatment of dyes-based wastewater

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Abstract

In this research, TiO₂ and SiO₂ sols were prepared from precursor of titanium and silicon in an acetic acid-water mixture with no further chemicals to make the sol-gel method as green as possible. The TiO₂ sol was heated at 40 °C or 50 °C during preparation to study the effect of temperature over its stability and photocatalytic ability. Dip-coating technique was employed for fabrication of bare TiO₂ and multilayer silica-titania coatings over glass substrate. The stability of prepared sols over aging was assessed through DLS. The structural and morphological analysis of coatings was made through x-ray diffraction (XRD) and field emission scanning electron microscope (FE-SEM). The photocatalytic ability of coatings was tested by photodegradation of rhodamine B (RhB) dye under UV irradiance ($\lambda = 365$ nm). DLS revealed a reduction in shelf life of heat treated TiO₂ sols with respect to sols produce at ambient temperature. XRD confirmed the formation of crystalline anatase phase TiO₂ nanoparticles with an average crystalline size of 5 nm, and average particle size in the range of tens to hundreds of nanometers (evolving with aging) as provided by DLS, indicating strong agglomeration. The heating effect of TiO₂ sol improved the photocatalytic ability of coatings thanks to accelerate hydrolysis reactions, producing a larger amount of crystallites. TiO₂@SiO₂ coatings showed a crack-less and uniform morphology with 100 % photocatalytic degradation of RhB in the tested conditions and a kinetic constant of 0.01392 min⁻¹, compared to 92 % efficiency and 0.00827 min⁻¹ of bare TiO₂ coatings, respectively. Overall, the optimization of sol-gel parameters and composite material selection in TiO₂ based coatings can lead to more effective photocatalysts for environmental cleanup.

Keywords: TiO₂@SiO₂ coatings, green sol-gel method, photocatalysis, wastewater treatment.