Study of TiO_2 nanostructures as photoactive elements for water decontamination

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In this work, we compare the antibacterial activity and hydroxyl radical generation of different TiO_2 nanostructures: immobilized titania nanoparticles, nanotubes, thin and ultra-thin films in presence of UV-light. We studied the optimum morphology and processing conditions that could enhance their antibacterial response when this kind of material is used in catalyst fixed-bed reactors design. It was demonstrated that photocatalytic activity not only depends on direct contact of the catalyst with the pathogen but also on the concentration of oxidizing species that can be generated within the nanostructured material. With the combination of the above-mentioned fabrication methods, we also proved that it is possible to take advantage of materials morphology and a synergistic effect with the combination of TiO_2 polymorphs in the design of new materials that seek to enhance their photocatalytic activity. Additionally, a series of experimental determinations of hydroxyl radical during UV light irradiation of TiO_2/SiO_2 composites and TiO_2 nanoparticles suspensions in presence of several ROS scavengers (hole, electron, hydrogen peroxide, and superoxide radical) were performed and rate constants for a kinetic of the pseudo-first order were calculated. From the variation in kinetic rate constants in the presence and absence of each scavenger, we propose a relationship between hydroxyl radical formation and its corresponding charge carrier transfer mechanism, where the electron/hole transfer occurs between defect levels in amorphous SiO_2 matrix and the embedded TiO_2 NPs with different crystalline phases and agglomeration degrees. From the results obtained so far, we show that is possible to modulate de photocatalytic activity of the TiO_2 nanostructures developed as antibacterial surfaces. This is quite relevant for the design of advanced antibacterial surfaces that could be implemented in fixed bed reactors at specific stages of the disinfection process in water treatment plants.

Keywords

TiO_2, nanoparticles, nanotubes, thin films, photocatalysis.