200f A Novel Synthesis of Sponge-Type Carbon Doped Titania Activated under Visible-Light

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The photodecomposition of various organic pollutants by photocatalysts, using wide band-gap semiconductors, has been extensively studied. Semiconducting titania is generally accepted as a particularly good and environmentally-friendly photocatalyst because it permits the ultimate degradation of stable organic pollutants such as detergents, dyes, and pesticides to the mineralization stage in water. However, titania shows a relatively high reactivity, mainly when irradiated by ultraviolet (UV) light at wavelengths shorter than 387 nm (exceeding the 3.2 eV band gab of the anatase crystalline phase). When sunlight is used as an energy source in the photodegradation, only 2.7% of the total energy impinges on the surface of the earth. Thus, it is necessary to use energy in the visible range to enhance the photoefficiency. Since the discovery that titania catalyzes the conversion of water to hydrogen and oxygen by photo-decomposition, a number of research groups have attempted to enhance its photo-efficiency. One of the proposed techniques involves the chemical/physical modification of titania, not only to increase its photo-efficiency, but also to develop and enhance its photo-catalytic activity under visible light. To date, a number of studies have been conducted on the origin of the visible-light response for doped titania, however, no clear experimental evidence for this has been reported. In this study, we propose a novel method for the synthesis of titania modified by carbon and show that the absorption edge is shifted to a lower energy, thus increasing the overall photoreactivity in the visible-light region. The structural properties were examined by XPS, UV-Drs, TEM, BET, EPR, and elemental analysis, and the structural stability of tiania modified by carbon was evaluated by calculating the system energy at the Hartree-Fork level. The superiority of the photocatalytic reaction under visible light was verified in a photodegradation experiment using an organic pollutant. The pore size distribution curves, obtained form the desorption branch of isotherms of synthesized titania modified by carbon, exhibit a maximum in the region from 5 to 17 nm, while the Brunaure-Emmett-Teller (BET) surface area is in the range of 146 to 212 m2g-1. The average pore diameter can be controlled within the range of 5 nm to 17 nm by changing the condensation speed by appropriate temperature control and the solvent used. In order to investigate the photooxidation of carbon doped titania, phenol was examined as a substrate. Changes in phenol concentration and TOC during the decomposition of an aqueous solution of phenol was effectively oxidized under visible light (under 420 nm). Carbon doped titania materials with a sponge-like mesoporous structure were synthesized in a simple, one-step chemical synthesis. The pore characteristics could be controlled by changing the synthetic conditions. The calculation results imply that carbon can readily occupy the location of an oxygen vacancy during the synthesis. Base on these results, a possible geometrical structure of titania modified by carbon is proposed. Based on the experimental results, the synthesized carbon doped titania showed a high photooxidation activity for the decomposition of azo dyes and for an aqueous solution of phenol under visible light. The high photocatalytic activity of the carbon doped titania under visible light , at a wavelength under 550 nm can be explained by the band gap narrowing effect by carbon. It shifted the absorption edge to a lower energy, thus effectively increasing the photocatalytic activity in the visible-light region.