Preparation of TiO₂-based photocatalysts and their photocatalytic degradation properties for methylene blue, rhodamine B and methyl orange

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ABSTRACT

Different kinds of nanocrystalline TiO₂-based photocatalysts, including pristine TiO₂, oxidized multi-walled carbon nanotube/TiO₂ (ox-MWCNT/TiO₂) composite and Eu³⁺-doped ox-MWCNT/TiO₂ (Eu³⁺/ox-MWCNT/TiO₂) composite, were synthesized by using tetrabutyl titanate as precursor by a sol–gel method. The colloidal solutions were heat treated at 450°C for 2 h to obtain the anatase TiO₂ nanomaterials. The photocatalysts were characterized by X-ray diffraction, high-resolution transmission electron microscopy and energy-dispersive X-ray spectroscopy. The photocatalytic activities of the TiO₂-based catalysts for the degradation of methylene blue (MB), rhodamine B (RhB) and methyl orange (MO) in aqueous solutions were investigated. To compare the photocatalytic activity of the TiO₂-based catalysts, the degradation rates for the abovementioned dyes under 365 nm ultraviolet (UV) light irradiation were calculated. And the 1% Eu³⁺/ox-MWCNT/TiO₂ composite showed higher photodegradation rate constant ($K' = 1.757$ h⁻¹) than those of pristine TiO₂ ($K' = 1.028$ h⁻¹), ox-MWCNT/TiO₂ ($K' = 1.458$ h⁻¹) and 4% Eu³⁺/ox-MWCNT/TiO₂ composite ($K' = 1.295$ h⁻¹) toward MB. Meanwhile, the 1% Eu³⁺/ox-MWCNT/TiO₂ composite possessed high photodegradation percentage of 95.77%, 97.21% and 90.72% toward RhB, MB and MO, respectively, which were higher than those of other three TiO₂-based photocatalysts. It is proposed that the higher photocatalytic activity of ox-MWCNT/Eu³⁺/TiO₂ composite might be due to the decreased band gap, the plentiful introduced hydroxyl groups and its high specific surface area.

Keywords: Methylene blue; Rhodamine B; Methyl orange; Photocatalytic degradation; TiO₂