Heterogeneous photocatalytic chlorination of methylene blue using a newly synthesized TiO2-SiO2 photocatalyst

ABSTRACT

The titanium dioxide-silicon dioxide (TiO2-SiO2) nanocomposite used for the study was synthesized using a sol-gel method followed by UV-treatment. The physicochemical properties of the synthesized catalyst, TiO2-SiO2 were characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), ultraviolet-visible diffuse reflectance spectroscopy (UV-vis DRS) and photoluminescence (PL). The photocatalytic degradation of methylene blue (MB) dye was evaluated in the presence of TiO2-SiO2 and reactive chlorine species (RCS) under experimental conditions. By comparing the important reaction processes in the study, including photocatalysis, chlorination and photocatalytic chlorination, it was found out that the process of photocatalytic chlorination had the highest photodegradation efficiency (95% at 60 min) of the MB under optimum reaction conditions (MB = 6 mg $L^{-1}A = \pi r^2$, catalyst = 0.1 g and pH = 4). The enhanced removal of MB from the aqueous medium was identified because of the synergy between chlorination and photocatalysis activated in the presence of TiO2-SiO2. The mechanism of the photocatalytic chlorination process was scrutinized in the presence of various RCS and reactive oxygen species (ROS) scavengers. Based on the experimental data attained, Na2S2O3 exhibited the highest inhibitory effect on the degradation efficiency of MB, indicating that the RCS is the main contributor to visible light-induced photodegradation of MB.