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Photocatalytic degradation of Acridine orange dye and real textile wastewater via ZnO nanoparticle supported natural Tunisian clay

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ABSTRACT

Decontamination of dye molecules from polluted water through photocatalyse process is reported to be a performing technology. In this study, sol gel synthesis route was used to prepare ZnO nanoparticles and ZnO modified natural and abundant bentonitic clay. ZnO and ZnO-clay nanocomposites were characterized by X-ray diffraction, Fourier-transform infrared spectroscopy, N_2 adsorption–desorption, transmission electron microscopy techniques and tested for Acridine orange dye photodegradation using artificial UV irradiation. Experimental data indicates that ZnO-clay was an efficient photocatalyst under UV irradiation and in the presence of H_2O_2 oxidant (around 97.8% of Acridine orange removal and 82.7% mineralization were achieved after 90 min). Adsorption experiments were studied and both pseudo-second-order and pseudo-first-order for kinetics models fitted the Acridine orange adsorption data except with pure ZnO catalyst adsorption process is described only by pseudo-second-order model. Photocatalytic degradation data of Acridine orange followed the first-order removal rate with three materials: pure clay, ZnO and ZnO-clay and the apparent rate constant increased with photocatalyst performance. The mechanistic detail of the dye photodegradation was studied via the separation and identification of the products intermediates by liquid chromatography–mass spectrometry method. Obtained results suggested that the N-de-methylation mechanism of Acridine orange (AO) dye took place leading to the generation of mono-, di-, tri-, and tetra-N-de-methylated AO products during the reaction. Synthetic photocatalyst ZnO-clay was reused three times without an apparent decrease in its degradation efficiency even after 3 runs (94.7% of AO removal), proving the high stability and reutilisability. As well, ZnO-clay was tested in the treatment of a real textile effluent and obtained results (80.6% of effluent mineralization) confirm its great performance in the environmental decontamination.

Keywords: Photocatalyse; ZnO-clay; Acridine orange; Mineralization; Liquid chromatography–mass spectrometry; separation; UV irradiation

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