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Facile Synthesis of Fe_3O_4/TiO_2 Composite with Enhanced Magnetic and Photocatalytic Properties for Water Purification

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Abstract

The regeneration of TiO_2 used in water purification via photocatalytic reactions is usually carried out using flocculation, and centrifugation. However, the major drawbacks in these methods are the needs of additional process controls, equipment, and energy. Use of magnetic separation in water treatment could be highly effective in both efficiency and operating cost over the other methods. In this study, ilmenite (Fe TiO_3), a naturally available mineral widely used in TiO_2 production, is modified into Fe_3O_4/TiO_2 magnetic composite with enhanced magnetic and photo catalytic activity. The synthesized composite material was tested for photo degradation potential of a common herbicide1,2-dichlorophenoxyacetic acid. The synthesized Fe_3O_4/TiO_2 was characterized using X-ray diffraction (XRD) patterns, X-ray fluorescence (XRF) spectroscopy, and FTIR spectroscopy. The mass susceptibility values of both ilmenite and the synthesized Fe_3O_4/TiO_2 were also measured. The morphology of the composite particles was also analyzed by scanning electron microscopy (SEM).The identity of the synthesized Fe_3O_4/TiO_2 was confirmed by the XRD pattern. FTIR peaks corresponding to Fe-O-O bending and Fe-O asymmetric stretching were observed at 533 cm^{-1} and 1,384 cm^{-1}, respectively. The analysis of the synthesized Fe_3O_4/TiO_2 with XRF data revealed the presence of both Fe (54%) and Ti (44%) and trace amounts of silicon, manganese, and aluminum. SEM data showed mostly spherical particles of sub-micron size. Magnetic susceptibility measurements indicate a strong diamagnetism in the composite material with a mass susceptibility of $8.05x10^{-3}$ m^3kg which is much higher than the parent material, ilmenite ($3.01x10^{-3}$ m^3kg). According to the catalytic data the synthesised nanocomposite shows a strong propensity to remove a common herbicide, 1,2-dichlorophenoxyacetic acid, from an aqueous solution through photocatalytic degradation with approximately 65% removal efficiency. These results clearly confirms the synthesis of an environmentally significant photocatalyst with considerable magnetic properties.

Keywords: Fe_3O_4/TiO_2, Ilmenite, Organic pollutants, 1, 2-dichlorophenoxyacetic acid, Photocatalysis