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Photodegradation of Direct Blue-199 in carpet industry wastewater using iron-doped TiO_2 nanoparticles and regenerated photocatalyst

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Abstract

Fe-doped TiO_2, $Ti_{1-x}Fe_xO_2$ ($x = 0.00, 0.02, 0.04, 0.06, 0.08$, and 0.10), photocatalysts have been successfully synthesized via citric acid–assisted autocombustion method. The synthesized photocatalysts were characterized using different characterization techniques, such as X-ray diffraction (XRD), diffuse reflectance spectroscopy (DRS), Fourier transform infrared (FT-IR), transmission electron microscopy (TEM), energy dispersive x-ray spectroscopy (EDX), and x-ray photoelectron spectroscopy (XPS). The XRD diffraction patterns revealed that synthesized photocatalysts have the anatase phase of TiO_2. The DRS analysis indicates a slight increment in absorbance in the visible light region by the Fe doping in TiO_2. The FT-IR spectra reveal the various stretching and bending vibrational bands of the Ti-O lattice. The XPS spectra confirm the presence of elements titanium, oxygen, and iron in the synthesized samples and determine binding energy of elements. TEM analysis shows the shape of the synthesized photocatalyst, and it was used to calculate the average particle sizes of undoped and Fe-doped TiO_2 ($Ti_{0.96}Fe_{0.04}O_2$) photocatalysts using a histogram. The photocatalytic activities of synthesized photocatalysts were determined by photodegradation of dye (Direct Blue 199), contaminating carpet industry wastewater in the photochemical reactor and open pan reactor. The maximum photodegradation activity was shown by the $Ti_{0.96}Fe_{0.04}O_2$ photocatalyst among all the synthesized undoped and Fe-doped photocatalysts. The synthesized photocatalyst ($Ti_{0.96}Fe_{0.04}O_2$) had better photocatalytic activity when compared to both, undoped TiO_2 and Aeroxide (Degussa) P-25. The used Fe-doped TiO_2 photocatalyst ($Ti_{0.96}Fe_{0.04}O_2$) was regenerated five times and investigated for its photocatalytic activity.

KEYWORDS

photocatalysis, regeneration, TiO_2, wastewater

1 | INTRODUCTION

The effluents from various industries have organic pollutants, which are the cause of serious environmental problems. Among the various industrial effluents, dyes are one of the organic pollutant of water that cause coloration of water bodies and pose a serious threat to human life as well as ecosystem. The dyes are frequently used by various

Abbreviations: BOD, biochemical oxygen demand; COD, chemical oxygen demand; DRS, diffuse reflectance spectroscopy; EDX, energy dispersive x-ray spectroscopy; FT-IR, Fourier transform infrared; IR, infrared; SAED, selected area electron diffraction; TDS, total dissolved solids; TEM, transmission electron microscopy; TSS, total suspended solids; UV, ultraviolet; UV-Vis, ultraviolet-visible; XPS, x-ray photoelectron spectroscopy; XRD, x-ray diffraction

