ABSTRACT

Dyes are organic pollutants which are the cause of serious environmental problems. The dyes are used in textile, carpet, pharmaceutical, paper and pesticide industries. Over 10,000 types of commercially available synthetic dyes are consumed by these industries that create a huge amount of dye contaminated effluent. Different methods were reported to overcome this problem such as biodegradation, aerobic degradation, anaerobic degradation, electrochemical, adsorption, ozonation, coagulation and flocculation, filtration, ion exchange and photodegradation. Photocatalytic degradation of pollutants in aqueous phase is a simple and efficient technique to remove dye from the water bodies. Direct Blue 199 is one of the blue colour dye used extensively by carpet industry. The removal/reduction of this dye using TiO_2 photocatalysts by degradation has been investigated. TiO_2 is a highly efficient photocatalyst capable in degrading of the pollutants.

In present study, TiO_2 is selected as a photocatalyst and its photocatalytic activity were improved by doping of anion (iodine) and cation (iron). Sol-gel technique was used for the synthesis of the photocatalysts. Activity of the synthesized photocatalysts is determined by the kinetic studies of the dye degradation. The dye degradation process is done in two kinds of reactors namely UV-photochemical reactor and open pan reactor. In UV-photochemical reactor, photodegradation reaction was done in two types of tubes (glass and quartz). In open pan reactor, dye degradation reaction is done under direct sunlight. After degradation of the dye, the used photocatalysts was also regenerated for further use in dye degradation process.

The undoped TiO_2, Fe-doped TiO_2, $Ti_{(1-x)}Fe_xO_2$ (x = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09 and 0.10) and I doped TiO_2, $Ti_{(1-x)}I_xO_2$ (x = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09 and 0.10) photocatalysts with enhanced activity were synthesized via a citric-acid-assisted sol-gel method.

The synthesized photocatalysts were characterized by XRD, DRS, FTIR, XPS, HR-TEM and EDS analysis. The phase of synthesized photocatalysts was determined by XDR analysis. The optical response and band-gap energy of the synthesized photocatalysts were determined by DRS spectra. The functional groups which are present in the synthesized photocatalysts were determined by FTIR analysis. The binding energies and chemical states of the synthesized photocatalyst were investigated by XPS spectra. The image and particles size of synthesized photocatalysts were obtained by TEM analysis. The chemical compositions of the synthesized photocatalysts were determined by EDX analysis.

The dye degradation kinetics were studied with all the synthesized photocatalysts with two types of solution (i) simulated dye solution and (ii) industrial wastewater. These studies were done in two types of reactors (i) UV-Photochemical reactor (glass and quartz tubes) (ii) open pan reactor in sunlight.

XRD data shows that all the synthesized photocatalysts (undoped TiO_2, Fe doped TiO_2 and I doped TiO_2) have anatase phase of TiO_2. DRS analysis shows that doping of Fe and I in TiO_2 lower its band-gap energy from 3.2 to 2.0 eV and from 3.2 to 1.6 eV respectively. The FTIR spectra reveal that hydroxyl group and chemisorbed water group are present in the photocatalysts. XPS spectra of the photocatalysts shows that all the expected elements are present in their oxidation state such as Ti^{3+} , Ti^{4+} , O^{2-}, Fe^{3+}, Fe^{2+}, I^{5+} and I^-. TEM analysis indicates that all the synthesized photocatalysts have spherical shape. EDX analysis of the

photocatalysts indicates that all the elements are present in their expected chemical composition.

Kinetic studies reveal that $Ti_{0.96}Fe_{0.04}O_2$ and $Ti_{0.97}I_{0.03}O_2$ have highest photocatalytic activity. These both photocatalysts show better photocatalytic activity than the Aeroxide P-25. The photodegradation process by regenerated photocatalysts shows that the performance of catalysts reduces with number of regeneration. The XRD analysis of used catalysts reveals that presence of CuO in regenerated photocatalyst surface which decreases its photocatalytic activity with number of regeneration.