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Highly Efficient catalyst of TiO_2/chitosan for Photodegradation and Sonodegradation of Organic Pollutants

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ABSTRACT

In the last decades, wastewater from the textile industry has become a major problem which leads to increase the concentration of pollution, which in turn represents environmental risks. The presence of dyes at even very low levels in effluent is highly visible and decomposition materials of these textile dyes are often carcinogenic. Due to the complex nature of synthetic dyes, conventional biological treatment processes are ineffective. Therefore there is a need of developing treatment methods that can lead to the complete degradation of the dye molecules from waste stream. Over the last few years, advanced oxidation processes (AOPs), especially sonocatalysis and photocatalysis, have proven to be effective processes for the wastewater treatment. The current study focused to develop a catalytic reactor via immobilized TiO_2 to degrade dyes in an effective method. In this research, TiO_2 nanoparticles prepared via sol–gel low-temperature method was successfully immobilized within chitosan and used as heterogeneous catalyst for the degradation of Acid Orange 7 (AO7) as an anionic dye. Transmission electron microscopy, scanning electron microscopy, and X-ray diffraction analysis were employed to characterize TiO_2/chitosan catalyst. Photodegradation and sonodegradation of AO7 by TiO_2/chitosan catalyst has been studied. XRD analysis indicated that prepared samples were 100% anatase phase and that chitosan interacted with TiO_2 nanoparticles and possessed good compatibility. TiO_2/chitosan nanocomposite showed high sonocatalytic and photocatalytic activities for the degradation of AO7. The rate constant of sonocatalysis was higher than that of photocatalysis. Sonocatalytic degradation of organic dye using prepared nanocomposite could be described by the mechanisms of hot spots and sonoluminescence. Furthermore, the photocatalytic degradation of AO7 via TiO_2/chitosan nanocomposite needs more time. Negative ΔG^0 and ΔH^0 values yielded from thermodynamic investigation proposed that the removal of AO7 via TiO_2/chitosan nanocomposite was simultaneous and exothermic in nature, respectively.

1. Introduction

The presence of organic pollutants in industrial wastewaters results in significant environmental contamination [1]. These wastewaters contain highly hazardous, carcinogenic and non-biodegradable that can cause harm to humans [2]. So, the removal of colored organic dyes from wastes is imperative. Up until now, different treatment methods have been developed for the degradation of pollutants, such as adsorption, chemical coagulation, filtration, sedimentation, and advance oxidation process (AOPs) [3-5]. Recently, AOPs are gaining significant attention because of their ability to produce a sufficient number of highly reactive radicals for effective water decontamination. Among numerous AOPs, photocatalysis and sonocatalysis with metal oxide nanoparticles have attracted increasing attention as efficient methods for the removal of pollutants [4]. In the case of photocatalytic degradation, illumination with photon energy greater than the band gap of nanoparticles leads to the generation of electron and hole pairs, which can help in the formation of highly reactive oxygen species (ROS) that eventually participate in the decomposition of pollutants [6]. It is well known that the limiting parameter for catalytic decomposition depends upon the ability to generate

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