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Chitosan and Chitosan/Titania Beads for Reactive Red 35 Removal ⋆

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Abstract

This study investigated the adsorption capacity to remove C.I. Reactive Red 35 by three different adsorbent beads, consisting of pure chitosan and two different chitosan/titania (TiO_2) composite beads with the TiO_2 being obtained either from the sol-gel method or from added commercial TiO_2 (A100-TiO_2). From the obtained dye adsorption capacities, the chitosan/TiO_2 composite beads with A100-TiO_2 had the highest adsorption ability to remove reactive dye solution up to 97%, compared to the chitosan/TiO_2 composite beads with TiO_2 obtained from the sol-gel method (adsorption capacity of 70-45%). This maybe because the A100-TiO_2 contained in the chitosan/TiO_2-sol composite beads was in the anatase crystalline form, while the TiO_2 obtained from the sol-gel method did not form a good anatase crystalline form, as shown by X-ray diffraction patterns and SEM micrographs. The crystallization of anatase formed in the composite beads enhanced the adsorption capacity of the composite beads. Pure chitosan adsorbent also showed a good adsorption capacity (95%) due to the electrostatic interactions between chitosan and C.I. Reactive Red 35.

Keywords: Chitosan; Titania; Adsorption; Isotherm

1 Introduction

The textile industry is one of the high impact industries on the Thai economy, but this positive aspect is countered by the negative affect it has on the environment. As one of the largest industries in the world, the textile industry generates a significant quantity of effluents to the environment. The main pollutants in textile wastewater come from the dyeing and finishing processes that require a wide range of organic chemicals and dyestuffs. All these chemicals and dyestuffs are not fully bound to the textile goods and those left from the process are discarded as waste. Therefore, the textile wastewater has to be treated before discharging to the environment. So far there is still no suitable single treatment of textile effluents that yields a safe pollutant level for discharge into the environment. Rather, several techniques have been employed and these consist of physical,

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chemical and biological wastewater treatment methods. Physical treatments used to improve the wastewater are screening, sedimentation, filtration, flotation and skimming. Chemical treatments consist of several processes, such as chlorination, oxidization, neutralization, coagulation, adsorption and ion exchange. Biological treatments employ microorganisms, mostly bacteria, to convert the wastewater to carbon dioxide, water and other end products. Generally, biological treatment can be divided into aerobic and anaerobic methods. This study investigated the chemical treatment of wastewater by combining adsorption with photocatalytic oxidation. Among adsorbents with the capacity to remove dye effluents, activated carbon, chitin, chitosan and clay minerals have all been shown to effectively adsorb or remove organic compounds from textile effluents. Of these, chitosan [1-8] was selected to use as the adsorbent in this study because it is a waste biodegradable polysaccharide obtained from the deacetylation of chitin, the second most plentiful natural polymer after cellulose. Moreover, chitosan has many interesting characteristics, such as it is hydrophilic, biocompatible, biodegradable, and has an antibacterial property and a flocculating regeneration ability. These properties of chitosan have led to its widespread applications. Chitosan has been regarded as a useful material to remove transition metal ions and organic substances from waste water because the amino and hydroxyl groups on the chitosan chains serve as reaction sites. The photocatalytic oxidation process has been widely studied for degradation of several organic pollutants and has been established as having a high potential for wastewater treatment [9-11]. Titania (TiO_2) is currently the most promising photo catalyst employed to treat textile wastewater. In recent years, the use of TiO_2 as a photocatalyst has gained more attention in textile applications due to its self-cleaning and UV-protection properties. Under ultraviolet light and in the presence of water, TiO_2 forms hydroxyl radicals (OH^-) and superoxide anions (O_2^-) and these two oxidation reactants decompose (oxidize) the organic compounds to carbon dioxide and water. However, since TiO_2 is a powder it is problematic to retrieve after using it in the textile wastewater to degrade the organic pollutants. Therefore, the use of TiO_2 in the form of a composite would make its handling much easier. It was in this regard that the techniques of photodegradation and adsorption were combined to prepare chitosan/TiO_2 composite beads for use in reactive dye removal from an aqueous solution. Therefore, the objective of our research involved chitosan/TiO_2 composite beads for discoloration and degradation of textile dye aqueous solutions similar to previous research articles [12-14], but the idea for preparing chitosan/TiO_2 composite beads for dye solution removal was differently. In this study, the chitosan/TiO_2 composite beads were prepared from both the in TiO_2 formation using titanium tetraisopropoxide (TTIP) as the precursor in a sol-gel technique and also by the addition of commercial TiO_2 (A100-TiO_2). The effect of different chitosan: TiO_2 (w/w) ratios in the chitosan/TiO_2 composite beads on the level of reactive dye removal obtained were also studied, including the adsorption isotherm of the dye molecules onto the chitosan/TiO_2 composite beads and pure chitosan beads.

2 Experimental

2.1 Materials

Commercial grade high molecular weight chitosan (480 kDa) with a 90% degree of deacetylation was supplied from Bio-Line Co., Ltd. The TTIP, used as precursor for preparing TiO_2 in the sol-gel method, was purchased from A.C.S. Xenon Limited Partnership, Thailand. Glacial acetic acid from Mallinckrodt Baker, lnc. was used as a solvent for chitosan. Sodium hydroxide (NaOH) and