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Fe_3O_4 loaded chitin – A promising nano adsorbent for Reactive Blue 13 dye

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ABSTRACT

Herein we report the development of easily separable, Fe_3O_4 loaded chitin nanomaterial (MCH NM) via simple Co-precipitation route, as a promising adsorbent for removal of Reactive Blue 13 (RB13) dye from aqueous solution in visible light ($\lambda \geq 420$ nm). This nanomaterial was characterized using distinctive physicochemical techniques; MCH NM show band gap energy of 2.257 eV, evaluated by Tauc's plot using UV–visible spectroscopy. MCH NM show excellent swelling property due to the tendency of the polymer chains to reach elongated configurations at equilibrium beyond which an elastic retractive force prevents further expansion. The mechanism of dye-adsorbent interaction is described on the basis of zero-point charge and zeta potential techniques. Batch adsorption studies on MCH NM show excellent adsorption activity of 199.02 mg/g in 22 min towards RB13 dye, maximum value ever reported for any reactive dye. Equilibrium adsorption data and adsorption kinetics were well fitted into Langmuir isotherm model and pseudo second order model predicting chemically rate controlled monolayer adsorption. Thermodynamic studies demonstrate that the adsorption process is spontaneous and exothermic.

Introduction

One of the most persistent problems resulting from environmental pollution is the insufficient accessibility of clean and potable water, which has become a major worldwide threat for almost all kinds of living beings since the past few decades. In this scenario, water contamination majorly through metal ions, dyes and various other elements has drawn much attention in the field of research due to its pivotal role in environmental pollution. Most importantly, pollution of water bodies through synthetic dyes is causing alarming environmental concern. Color is the main polluting ingredient in dyes. Since ages, colors have been a huge part of human life as they also play a role in the multisensory perception of flavor or taste (Ingle et al., 2020). Hence, several classes of industries have been utilizing different colors for various purposes. These industries mainly use basic, cationic, pigment, mordant and reactive dyes but textile industries mostly utilize direct and reactive dyes. Reactive dyes and "fixation" of reactive dyes (Hossain et al., 2020). Dyeing parameters particularly temperature, requirement of alkali as well as utilization of salt also depend on the nature of reactive groups (Lee et al., 2019). It is also worth mentioning here that reactive dyes have a tendency to undergo undesirable hydrolysis in solution, which hinders effective fixation of the dye on the fabric. Moreover, these dyes react through hydrogen bonding with water molecules resulting to cotton fabric having poor colorfastness. Nevertheless, the hydrophilic nature of the cellulosic fibers inherently compromises the dyeing efficiency. The size of the agglomerated dye particles may also play a significant role in the surface free energy and in the diffusion of the encapsulated dye into the fiber matrix of the cellulose. Thus, in dyeing process, whole of the dye molecules are not completely bonded with the fabric with a result that the unbound dye particles along with various other chemicals get extensively flushed recklessly into water bodies. The flushed water released into sewage channel without conventional treatment eventually