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Graphite oxide/chitosan composite for reactive dye removal

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HIGHLIGHTS

- ▶ Graphite oxide/chitosan as reactive dye adsorbent.
- ▶ Characterization with FTIR, SEM, XRD, DTA, DTG, TGA.
- ▶ Adsorption evaluation of pH, isotherms, kinetics, ionic strength, desorption.
- ▶ Adsorption mechanism and explanation of interactions in dye-composite system.

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ABSTRACT

In the current work a novel composite material consisted of cross-linked chitosan (Ch) and graphite oxide (GO) (and not graphene oxide, as numerous studies deal with) was prepared for the removal of Reactive Black 5 dye. After synthesis, the full characterization with various techniques (SEM/EDAX, FTIR, XRD, DTA, DTG, TGA) was achieved revealing many possible interactions/forces of dye-composite system. Through the latter interactions, the possible adsorption mechanism was elucidated and explained. Also, the adsorption evaluation of the composite material presented high adsorption capacity (277 mg/g at 25 °C). Equilibrium experiments are also performed studying the effect of pH on adsorption (optimum 2) and desorption (optimum 12), initial dye concentration, contact time (pseudo-first, -second order equations and a generalized fractal kinetic model), temperature (isotherms at 25, 45 and 65 °C fitted to Langmuir, Freundlich, Langmuir–Freundlich model) and ionic strength. A full thermodynamic evaluation was carried out, calculating the parameters of enthalpy, free energy and entropy (ΔH^0, ΔG^0, and ΔS^0). The adsorption behavior of the composite material was also compared with the respective of its components (GO and Ch).

1. Introduction

Nowadays, one of the most promising adsorption methods for the removal of dyes is the application of chitosan. Chitosan is synthesized from chitin, which is the second most abundant polymeric material in nature after cellulose [1]. Chitin can be easily extracted from crustacean shell such as crabs, fungi, prawns, insects and other crustaceans [1]. Chitosan can be used as an adsorbent to remove cationic and/or anionic dyes due to the simultaneous presence of amino and hydroxyl groups, which can serve as active/adsorption sites [2]. The performance of chitosan as adsorbent can be improved by: (i) the use of cross-linking reagents, which stabilize chitosan in acid solutions and enhance its mechanical properties and (ii) derivatization with grafting functional groups onto the chitosan backbone, which improve its adsorption capacity [3].

Recently, chitosan composites have been developed to adsorb dyes from wastewaters [4,5]. Different kinds of substances have been used to form composite with chitosan such as graphene oxide and magnetite. These composites have been affirmed to present better adsorption capacity and resistance to acidic environment. Some works in literature dealt with highlights of the application of chitosan composites as adsorbents, including synthesis, mechanisms and other factors, which can affect its adsorption capacity [4,5].

Graphite-like nanoplatelets have recently attracted attention as viable and inexpensive filler in composite materials. These excellent properties may be relevant at the nanoscale, if graphite can be exfoliated into thin nanoplatelets, and even down to the single graphene sheet level [6]. Graphene and graphene oxide have been used as effective adsorbent toward anionic and cationic dyes [7].

Graphite oxide (GO), a precursor in the formation of graphene layers, has been studied as an adsorbent and its ability to remove

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