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Full Length Article

Adsorption potential of CuO-embedded chitosan bead for the removal of acid blue 25 dye

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ABSTRACT

Anthraquinone-based anionic dyes like acid blue 25 (AB25) are among the problematic class of pollutants in wastewaters that are detrimental to human health and aquatic organisms. Chitosan (CS), a biopolymer with rich amino and hydroxyl groups is a potential adsorbent for anionic dye but its instability in acidic medium is its major drawback. In this work, the potential of an innovative and sustainable chitosan-copper oxide bead (CS-CuO) developed to adsorb AB25 from aqueous environment was assessed. The batch adsorption process was studied for significant operational variables, and the CS-CuO was methodically characterised using XRD, FTIR, TGA, SEM and EDX. Unlike CS, the prepared CS-CuO was stable in an acidic and basic medium. XRD pattern of CS-CuO revealed an amorphous and crystalline phase. The micrograph of CS showed a non-porous membranous surface, while CS-CuO shows a relatively rough and irregularly shaped sheet-like structure perforated with pores network. The functional groups O−H, C═O, C−O and N−H on the CS-CuO support its attachment to AB25 dye as reflected in change of absorption signals on FTIR spectra. Electrostatic attraction between AB25 and CS-CuO was most favoured at pH 6 where highest AB25 removal occurs. The adsorption capacity of 294.1 mg/g was obtained for the adsorption process at initial dye concentration of 100 mg/L at pH 6. Langmuir isotherm model and pseudo-second-order kinetics best described the adsorption. The spent CS-CuO was better regenerated in the basic solution (0.1 M NaOH), and its reusability gave 80 % desorption capacity at 3rd cycle.

1. Introduction

Water is the most significant substance sustaining life, especially for all living things. The maintenance of the human body's vital functions, such as respiration, circulation, excretion, and reproduction, involves water as a critical and necessary substance [1]. Also, domestic and industrial activities require water as a significant substance for various operational activities. The tremendous rise in domestic and industrial activities that pollute water supplies and reduce the availability of safe water has attracted water treatment as a prerequisite for safe potable water. Surface water contamination is a worldwide issue that is of extreme concern as result of the health and environmental problems associated with contamination emanating from dye pollution [2] and excessive use of hazardous chemicals, which largely eliminates marine life 3 and also threatens human health. Recently, numerous studies have shown a high occurrence of diseases linked to water contamination, such as cholera, typhoid fever, and other waterborne diseases [3].

Dyes are highly soluble in water [4], typically "non-biodegradable", and their existence as contaminants in water systems can cause cancer or mutations in living organisms including human [5]. Their inherently carcinogenic is linked to their complex aromatic structures and non-biodegradable features [6]. The leading sources of coloured wastewaters discharge to the environment are dye industries and their end users (such as leather, paper, textile, plastic, cosmetic and food sectors) [7]. In accordance with the World Bank report, about 17–20 % of water contaminations from industrial effluents emanate from textile dyeing and processing, as this poses a serious concern to textile industries [8].

Acid blue 25 (AB25) ($C_{20}H_{13}N_2NaO_5S$) is a typical anthraquinone-structured anionic dye [7] as shown in Fig. 1.1. Anthraquinone dyes, which are mostly utilised for dyeing fabrics materials like leather, wool and polyamide are highly significant class of industrial dyes that is only second to azo-compounds [9]. Approximately 20–30 % of commercially

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