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Enhanced adsorption of acid Blue-25 dye onto chitosan/porous carbon composite modified in 1-allyl-3-methyl imidazolium bromide ionic liquid

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ABSTRACT

In this study, chitosan/porous carbon composite (C-PC) modified in 1-Allyl-3-methyl imidazolium bromide [AMIM][Br] under airtight condition was prepared for the removal of Acid Blue-25 dye (AB-25) from aqueous medium. For comparison of adsorption efficiency of C-PC, chitosan-activated carbon composite (C-AC) was also prepared in 1% acetic acid. The adsorbents were characterised using SEM, EDX, XRD, BET, TGA and FTIR. The micrograph of C-PC revealed cavities and slightly rough surfaces dominated with similar sized and irregular shaped stone-like materials which differ from the precursors' micrograph. BET analysis revealed the domination of mesopores on the C-PC and C-AC surfaces, as the hydroxyl and amino group on C-PC are the main active sites for AB-25 dye uptake. The dye was better adsorbed onto C-PC at pH 2 and C-AC at pH 4. The adsorption capacity obtained for C-PC, C-AC, activated carbon (AC) and chitosan (CH) using Langmuir isotherm model are 3333.33 mg/g, 909.90 mg/g, 909.09 mg/g and 833.33 mg/g, respectively. The experimental data are well described by Langmuir and Fruendlich isotherms for adsorption of the dye onto C-PC, AC and CH. C-AC fitted into Langmuir isotherm only. The kinetics of the adsorption fitted into pseudo-second order indicating the possibility of chemical interactions in the adsorption process.

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1. Introduction

Dyes are organic chemical compounds that have been widely applied in various fields such as textiles, printing, paper, plastics, and food processing [1,2]. It is also one of the major organic component in textile effluent that pollute the water bodies when discharge into aquatic environment as it increases the biological oxygen demand (BOD) and chemical oxygen demand (COD) [3]. In addition, dyes are harmful to human beings and aquatic organism, therefore its removal is required for treatment of pollution in our environment [4]. Different treatment approaches such as photodegradation [5–7], chemical oxidation, advanced oxidation process [8], electrochemical methods [9], reverse osmosis [10], adsorption [11–14] have applied for removing dyes from wastewater before being discharged into the aquatic environment. Adsorption had been found to be cost effective, simple and non-destructive approach for the removal of dyes [1,13,15,16].

The use of biodegradable and non-toxic biopolymer like chitosan has found a wide application as an adsorbent for anionic dyes removal [1,3,11,17]. Chitosan is composed of β-(1 → 4)-2-amino-2-deoxy-D-glucose units (deacetylated unit) and β-(1 → 4)-2-acetamido-D-glucose (acetylated unit) [18]. It has been modified through crosslinking and grafting to enhance it adsorption properties for dyes removal, as crosslinking contributes significantly to its chemical and mechanical stability [19,20]. The modifications are often carried out in organic acid, usually acetic acid and as such the stability of chitosan in acidic medium is enhanced through crosslinking process [4,18,21,22]. Most recent approaches in chitosan modification for pollutants' adsorption involve grafting, combination with solid adsorbent (such as activated carbon) as support prior to crosslinking [22–24]. Meanwhile, the commonly used crosslinkers for chitosan modification such as glutaraldehyde and epichlorohydrin have been reported to be toxic at certain concentrations [25]. Chitosan based adsorbents have been applied for the removal of anionic dyes from aqueous medium [26], but not quite high adsorption capacities have been reported for the applied adsorbent [27,28]. The instability of chitosan at low pH region has been a challenge for its application into anionic dyes' removal. Crosslinking of chitosan/chitosan based materials have been the common approach for improving the chemical and mechanical stability of chitosan/chitosan based materials at low pH region, but the commonly used crosslinkers have been reported to be toxic at certain concentration [25]. Structurally, good adsorptive features of chitosan composite have been reported [29] to arise from combined synergistic effect of well dispersed active

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