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Cocoa (*Theobroma cacao*) shell-based activated carbon by CO_2 activation in removing of Cationic dye from aqueous solution: Kinetics and equilibrium studies

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ABSTRACT

Cocoa shell (CS) was used as a low-cost precursor for production of activated carbon (AC) and evaluated for its ability to adsorb Methylene Blue (MB) dye. Cocoa shell-based pellets were carbonized at 800 °C and subjected to 850 °C under a flow of CO_2 in different activation times. The cocoa (*Theobroma cacao*) shell-based activated carbon (CSAC) showed moderate surface area with the average pore size 2.7 nm. CSAC also displays the presence of aliphatic, aromatic hydrocarbons and near absence of C–O, carboxylic acid, and the –COOH functional group. Only the presence of O–H groups was detected. The influences of adsorption time and initial dye concentration on adsorption performance have been measured in a batch system. The results are well described by the Freundlich and Langmuir isotherms. The results from the kinetic study show that MB adsorption follows pseudo-second-order and Boyd models, which indicated the MB adsorption on the CSAC was controlled by film diffusion.

Keywords: Cocoa (*Theobroma cacao*) shell; Activated carbon; Methylene Blue; Langmuir; Boyd

1. Introduction

Dyes, especially cationic dyes normally persist in the environment for a considerable time because of their resistance to chemical degradation and photo degradation. Their presence will block sunlight penetration and the inherent carcinogenic nature of many of these dyes endangers living organisms (Banat et al., 2003; Vandevivere et al., 1998; O'Neill et al., 1999; Robinson et al., 2001). Some cationic (basic) dyes have been reported to cause eye irritation, cancer, allergic dermatitis, skin irritation and even mutation in humans (Bhattacharyya and Sharma, 2004; Caritá and Marin-Morales, 2008). It is imperative to remove these substances from waste streams before they are discharged into public waterways.

Several methods exist for basic dye removal (coagulation, chemical oxidation, membrane separation, electrochemical process and adsorption techniques) (Eren and Asin, 2009). However, the adsorption process, which used activated carbon (AC), was recognized to be both a promising and a cost-effective process to remove dyes from aqueous solution (Malik et al., 2007).

MB was selected as a model compound to evaluate the capacity of activated carbon from cocoa shell for the removal of dye from its aqueous solutions, because MB has wider coloring applications, such as paper, hair colorant, cottons, wools, and coating for paper stock (Vadivelan and Vasanth, 2005).

In general, the adsorption of solutes from solution by porous adsorbents is through three consecutive mass transport steps (Faust and Aly, 1983). The adsorbate must migrate through the solution (i.e., film diffusion), followed by movement from the surface into interior sites (pore diffusion) and,

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