Available online at www.sciencedirect.com
ScienceDirect
Journal of Hazardous Materials 154 (2008) 337–346
Journal of Hazardous Materials
www.elsevier.com/locate/jhazmat

Adsorption of basic dye on high-surface-area activated carbon prepared from coconut husk: Equilibrium, kinetic and thermodynamic studies

I.A.W. Tan, A.L. Ahmad, B.H. Hameed *

School of Chemical Engineering, Universiti Sains Malaysia, Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia

Received 21 August 2007; received in revised form 5 October 2007; accepted 8 October 2007
Available online 13 October 2007

Abstract

Adsorption isotherm and kinetics of methylene blue on activated carbon prepared from coconut husk were determined from batch tests. The effects of contact time (1–30 h), initial dye concentration (50–500 mg/l) and solution temperature (30–50 °C) were investigated. Equilibrium data were fitted to Langmuir, Freundlich, Temkin and Dubinin–Radushkevich isotherm models. The equilibrium data were best represented by Langmuir isotherm model, showing maximum monolayer adsorption capacity of 434.78 mg/g. The kinetic data were fitted to pseudo-first-order, pseudo-second-order and intraparticle diffusion models, and was found to follow closely the pseudo-second-order kinetic model. Thermodynamic parameters such as standard enthalpy (ΔH°), standard entropy (ΔS°) and standard free energy (ΔG°) were evaluated. The adsorption interaction was found to be exothermic in nature. Coconut husk-based activated carbon was shown to be a promising adsorbent for removal of methylene blue from aqueous solutions.

Keywords: Coconut husk activated carbon; Basic dye; Adsorption isotherm; Equilibrium; Kinetics

1. Introduction

The presence of dyes in effluents is a major concern due to their adverse effect to many forms of life. The discharge of dyes in the environment is worrying for both toxicological and esthetical reasons [1]. Industries such as textile, leather, paper, plastics, etc., are some of the sources for dye effluents [2]. It is estimated that more than 100,000 commercially available dyes with over 7×10^5 tonnes of dyestuff produced annually [3]. Methylene blue (MB) is the most commonly used substance for dying cotton, wood and silk. MB can cause eye burns which may be responsible for permanent injury to the eyes of human and animals. On inhalation, it can give rise to short periods of rapid or difficult breathing while ingestion through the mouth produces a burning sensation and may cause nausea, vomiting, profuse sweating, mental confusion and methemoglobinemia [4]. Therefore, the treatment of effluent containing such dye is of interest due to its harmful impacts on receiving waters.

Among several chemical and physical methods, the adsorption has been found to be superior compared to other techniques for wastewater treatment in terms of its capability for efficiently adsorbing a broad range of adsorbates and its simplicity of design. Colour removal from industrial wastewaters by adsorption techniques has been of growing importance due to the chemical and biological stability of dyestuffs to conventional water treatment methods and the growing need for high quality treatment [5]. However, commercially available activated carbons are still considered as expensive materials for many countries due to the use of non-renewable and relatively expensive starting material such as coal, which is unjustified in pollution control applications [6,7]. Therefore, in recent years, this has prompted a growing research interest in the production of activated carbons from renewable and cheaper precursors which are mainly industrial and agricultural by-products, such as apricot shell [8], male flower of coconut tree [9], jute fiber [10], rubber wood sawdust [11,12], corncob [13], bamboo [14] and oil palm fibre [15].

Coconut husk is the mesocarp of coconut and a coconut consists of 33–35% of husk. In Malaysia, about 151,000 ha of land was being used for coconut plantation in year 2001. It was estimated that 5280 kg of dry husks will become available per

* Corresponding author. Fax: +60 4594 1013.
E-mail address: chbassim@eng.usm.my (B.H. Hameed).

0304-3894/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jhazmat.2007.10.031