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Optimization of Process Parameters by Response Surface Methodology for Methylene Blue Removal Using Cellulose Dusts

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Abstract

This study was aimed to use Cellulose dusts (CD) produced in drying section of paper mills of paper making industry as a potential adsorbent to remove methylene blue (MB) dye from aqueous solution. The adsorbent was characterized by scanning electron microscopy and Fourier transform infrared spectrometer and X-ray Diffraction. The influences of the effective parameters including pH solution, adsorbent dosage, initial MB concentration, and contact time were optimized by CCD which stands for central composite design. The influence of these parameters on the adsorption capacity was analyzed using the batch process. The accuracy of the equation that is produced by CCD was affirmed by the variance analysis and also by calculating the correlation coefficient that connects the predicted and the empirical values of the percentage of removed MB dye. Maximum removal percentage of MB dye (98.05 %) which obtained at pH 9.84, adsorbent dosage 4.38 g L^{-1}, MB concentration 75.50 g L^{-1} and time 208.13 min. Freundlich, Temkin, Harkins-Jura and Langmuir isotherms are used to analyze the empirical data. Results revealed that the data is in a satisfying agreement with the Freundlich isotherm (R2= 0.99). Pseudo-first order, Pseudo-second-order, Elovich and Intraparticle diffusion models were used to fit the kinetic data and it is found out that MB dye's adsorption onto CD has a good agreement with the pseudo-second-order kinetic model. The results showed that CD can be an efficient and low-cost adsorbent for methylene blue adsorption.

Keywords: Cellulose Dusts; Adsorption; Optimization; Isotherm; Kinetics.

1. Introduction

Industrial activities generate large volume of wastewater containing hazardous inorganic (metals) or organic (microbes, dyes/pigments) species. Dye contaminated wastewater is one of the visual significant pollution generated from plastic, cosmetic, paper and pulp, textile, distilleries and tanneries industries [1].

Dyes usually have complex aromatic molecular structures which make them more stable and difficult to biodegrade. However, their disposal in water bodies exhibit adverse effect to the aquatic and human life by creating eutrophication, mutagenic, carcinogenic effects, dysfunction of the organs, also having effect on aquatic ecosystem by preventing sunlight from reaching into the stream [2, 3].

Azo dyes are the biggest type among several other chromogenic materials that are released by many industries [4, 5]. They are more than 70% of all commercial dyes which makes them to be undisputed major synthetic dye. They are characterized by one or more azo groups (N = N) as chromophore, with aromatic containing groups and other functional groups such as -OH and -SO_3H [6, 7]. Based on the chromophore group, 20–30 different groups of dyes are pollutant [8]. Methylene blue (MB) is one of major basic dyes, which is used for coloring purposes very much. This dye can cause permanent injury to the human eye, irritation to the gastrointestinal tract, and skin irritation. MB is a common pollutant

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