Preparation of Cationized Dialdehyde Cellulose from Bamboo Pulp for Anionic Dye Adsorption

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Anionic dyes are commonly used in the paper, dyeing, petroleum, and textile industries, contributing to global water pollution that harms important microbial populations and can be carcinogenic to mammals. However, current techniques of dye removal are largely inefficient and expensive, making them infeasible for large-scale use in developing countries, where the lack of access to clean water is most severe. The goal of this research was to develop an eco-friendly, affordable, and sustainable technique for wastewater purification. The methodology developed in this study utilizes the reaction between the aldehyde groups of dialdehyde cellulose (DAC) and cationic Girard’s Reagent T to synthesize a positively charged cellulose derivative called cationized dialdehyde cellulose (cDAC). The use of cDAC as a cheap and sustainable adsorbent is considered for the removal of negatively charged dyes such as Congo Red (CR). The influences of a variety of parameters were tested, including pH, dye concentration, contact time, and cDAC concentration. The adsorption kinetics were modeled by pseudo-first-order kinetics and pseudo-second-order kinetics. Additionally, the adsorption equilibrium data conformed to the langmuir and freundlich isotherm models. Promising results were obtained for the use of cDAC as a new adsorption agent for CR, with a high adsorption capacity \( Q_m \) of 909.09 mg/g and the ability to remove 99.9% of dye from wastewater in just 15 minutes. This adsorbent opens numerous applications for sustainable and effective wastewater purification as cDAC can be used to design membranes with adsorption abilities to remove dyes, bacteria, and viruses. Furthermore, a cross-linked environment-friendly foam can be produced from cDAC that can be directly applied to the surface of contaminated water to remove contaminants. There are also applications of making the bamboo waste negatively charged so that it can be purposed to remove heavy metal ions such as arsenic (As) and lead (Pb).

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