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Adsorption Kinetics Study for Removal of Methylene Blue by Alginate-Activated Carbon Derived from Spent Ground Coffee

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Structured Abstract

Background: Water contaminated by dyes affects different ecosystems and aquatic life, posing a serious risk to human health and the environment. In response to the critical need for sustainable solutions, the utilization of adsorption emerges as a promising avenue for dye removal from contaminated water sources. In this research, Alginate-activated carbon (Alginate-AC) derived from spent ground coffee was prepared to be a potential adsorbent for methylene blue (MB) dye removal from an aqueous solution.

Methods: 3% of alginate solution was mixed with an activated carbon dispersion, both sonicated, then dropped into a 4% calcium chloride solution to form beads. These were filtered, washed, and dried at 50 °C for 24 hours. After that, the beads will undergo characterization by using FESEM and FTIR. The adsorption capacity of dyes employing alginate-activated carbon as adsorbents will be influenced by each parameter which are pH values of the samples, initial concentrations, contact time, mass adsorbent and temperature. The amounts of residual MB will be analyze by using a UV-Vis spectrophotometer at a wavelength of 664 nm. Finally, kinetic adsorption was determined.

Results: This study shows that the Alginate-AC is highly efficient at adsorbing dye molecules due to activated carbon have porous structure and high surface area. The optimum conditions for removing MB dye using Alginate-AC beads were at pH 11, contact time of 40 minutes, 0.45 g mass adsorbent, and 45ºC. The adsorption data of methylene blue on Alginate-AC agreed with kinetic isotherm. The kinetic data well described by pseudo-second-order kinetic model with correlation of 1 indicating the preferable mechanism of the reaction is chemisorption instead of physisorption. The adsorption process was spontaneous and endothermic in nature. The mechanism of adsorption included mainly hydrogen bonding interaction, hydrostatic interactions, electrostatic interactions, and n-Π stacking interatom.

Conclusion: In conclusion, the findings of this study indicated that alginate-activated carbon derived from spent ground coffee provides an excellent adsorption capability for removing methylene blue dye from aqueous samples. The pseudo-second-order model perfectly matched the experimental data with an R^2 of 1. Therefore, the pseudo-second-order model is more suitable for describing Methylene Blue adsorption onto alginate-activated carbon beads.

Keywords: Alginate-activated carbon, methylene blue, dyes, beads, adsorption

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