Insight into the mechanism of malachite green dye adsorption on porous media: Characterization, modeling, and effects of adsorption affinity.

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Résumé

The transport of contaminated particles in porous media is an important pathway for wastewater treatment. Dye wastewater typically exhibits elevated levels of colored organic compounds and inorganic salts, making it challenging for biological processes to effectively treat (1). Adsorption is a cost-effective and efficient technology that can be utilized to eliminate dyes from water (2). Biochar, which is produced through the oxygen-limited pyrolysis of biomass and consists of carbon-rich residues, has garnered significant interest as a highly promising option for adsorption processes. This is primarily due to its numerous advantages such as its porous structure, cost-effective production, natural availability, exceptional stability, and abundance of functional groups(3). Our objective is to evaluate the feasibility of using biochar derived from soybean meal (SMB) as a cost-effective, porous biological media, for removing malachite green dye (MG) from wastewater. The biochar was characterized using the Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM). In addition, the point of zero charge pH (pzc) was determined by potentiometric pH titration, enabling us to predict the adsorption behavior of our biochar under different pH conditions. The adsorption behavior of MG was successfully fitted using the pseudo-second-order kinetic model and Langmuir isotherm model, revealing a maximum adsorption capacity of 189.99 mg/g, allowing us to say that adsorption is mainly due to chemical interactions between the adsorbent and the adsorbate and that it occurs according to an ideal process, with monomolecular adsorption on specific adsorption sites. The thermodynamic studies indicated that the adsorption of MG was an endothermic and spontaneous process at all temperatures (25-55∘C). Hence, these results suggest that SMB as a porous media has promising prospects and offers significant advantages in terms of pollutant adsorption in applications for treating wastewater and contaminated soils. Its use not only enables waste from the agri-food industry to be recycled but also contributes to sustainable and effective solutions for cleaning up the environment. Keywords: Porous Media; Adsorption; Agri-food waste recovery; Biochar; Malachite Green (MG).

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