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Ethanol, Methanol, and Magnesium-Treated Palm Kernel Shell Biochar for Methylene Blue Removal: Adsorption Isotherms

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ABSTRACT

Introduction: Biochar's adsorbent attributes, for instance, surface area, porous structure, surface functionality, and adsorption capacity, can be enhanced via suitable chemical modification.

Objective: This work aimed to study the effect of ethanol (EtOH), methanol (MeOH), and magnesium (Mg) treatment on adsorbent properties of palm kernel shell (PKS) biochar.

Methods: The PKS biochar was obtained through fast carbonization in a rotary kiln (800 ºC, 10 min) followed by steam activation (8 h). Both the EtOH and MeOH treated biochar were afforded via EtOH and MeOH treatment of PKS biochar, respectively, in the presence of HCl (6 h), followed by rinsing, filtering, and oven-drying. Mg treated biochar was obtained by soaking the PKS biochar with $MgSO_4.7H_2O$ at 30 ºC for 60 h. The EtOH, MeOH, and Mg treated biochars were characterized via proximate analysis, functional group analysis, surface area, and pore volume analyses. A batch adsorption study was conducted for adsorption of methylene blue (MB) by each EtOH, MeOH, and Mg treated biochar, respectively.

Results: Brunauer–Emmett–Teller (BET) analysis indicated that carbonization and chemical treatment has successfully enhanced the surface area with raw PKS (0.848 m^2g^{-1}), PKS biochar (592 m^2g^{-1}), EtOH-treated biochar (647 m^2g^{-1}), MeOH-treated biochar (663 m^2g^{-1}), and Mg-treated biochar (674 m^2g^{-1}). Batch adsorption studies showed that the highest methylene blue (MB) removal percentage for all studied biochar occurred at an initial concentration of 7 ppm (PKS biochar: 93.12%, EtOH-treated PKS biochar: 94.79%, MeOH-treated PKS biochar: 95.79%, and Mg-treated PKS biochar: 98.51%).

Conclusion: The EtOH, MeOH, and Mg treated PKS biochar gave high MB removal and thus, could potentially serve as efficient adsorbents for removal of dyes from wastewater.

Key Words: Carbonization, Biochar, Palm kernel shell, Chemical treatment, Engineered biochar

INTRODUCTION

Over 700 000 tonnes of commercial dyes are made per annum, for usage in fabrics, paper, plastic, leather, and chemical industries.[1,2] Consequently, approximately 10–15% of dyes used in the afore-mentioned industries are discharged as industrial effluent annually.[3] Severe dye pollution could cause coloured water that prevents solar radiation from entering water sources and inhibits the photosynthesis of aquatic biota.[4] Considering the globally high volume of dye production and usage, proper treatments are needed in favour of reducing the ramification of dye pollution in the ecosystem.

Methylene blue (MB) is one of the basic dyes usually applied in industries such as colouring paper, hair dye, dyeing cotton, wools, and others.[5] MB (a thiazine cationic dye) can pose numerous detrimental effects such as complications in breathing, retching, nausea, gastritis, and diarrhoea, to living things.[6] Moreover, MB can also cause permanent eye injury to humans and animals.[7] Inhaling MB can lead to cyanosis, methemoglobinemia, dyspnoea, convulsions, and tachycardia.[8] Hence, MB removal from wastewater before liberating it to water bodies is crucial in protecting human health.

Various techniques such as adsorption, ion exchange, reverse osmosis, and solvent extraction have been developed to remove dyes from wastewaters, including MB.[5,9] Among these methods, adsorption is the most preferred approach in eliminating organic contaminants from aqueous solution as it has been proven to be effective, low cost, and gives high removal

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