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Enhanced removal of Methyl red dye from aqueous solutions using Zirconium oxide impregnated Royal palm fiber Activated carbon (ZrO2-RPAC)

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In recent years, the removal of organic dyes from wastewater has gained significant attention due to its negative impacts on the environment and human health. In view of that, this work seeks to investigate the possibility of using zirconium oxide impregnated royal palm fiber activated carbon (ZrO2-RPAC) to remove methyl red dye from aqueous solutions and determine the effectiveness of the composite as an alternative eco-friendly and cost-effective adsorbent for dye removal in wastewater. The ZrO2-RPAC composite was prepared through a simple impregnation technique by combining the properties of royal palm fiber activated carbon (RPAC) and zirconium oxide nanoparticle (ZrO2). Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction spectroscopy (XRD), and other analytical techniques were used to analyze the morphology and structural properties of the composite. The effects of parameters such as initial dye concentration, contact time, pH, and adsorbent dosage were examined. The results showed that under optimum conditions, the ZrO2-RPAC composite exhibited an improved removal capacity of methyl red dye. The adsorption equilibrium data were analyzed using the Langmuir and Freundlich isotherm models, with the Freundlich isotherm providing a superior fit. The kinetics of adsorption also showed pseudo-second-order model as the best from the experimental data. The improved performance in adsorption can be attributed to the presence of zirconium oxide nanoparticles, which increases the surface area and provide extra active sites for dye adsorption. Furthermore, the presence of functional groups on the surface of RPAC allows for strong electrostatic interactions with methyl red dye molecules. This study shows that ZrO2-RPAC has the potential to be a possible alternative adsorbent for the removal of methyl red dye from wastewater.

Keywords: Royal palm activated carbon; zirconium oxide; adsorption; methyl red dye

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Abstract Category

Materials Physics

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