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Efficient removal of toxic methylene blue (MB) dye from aqueous solution using a metal-organic framework (MOF) MIL-101(Fe): isotherms, kinetics, and thermodynamic studies

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ABSTRACT

MIL-101(Fe) iron-benzene dicarboxylate based metal-organic framework (MOF) was synthesized via a solvothermal method for adsorptive removal of cationic methylene blue (MB) dye from aqueous solution. The prepared MIL-101(Fe) was characterized by X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, thermal gravimetric analyzer, X-ray photoelectron spectroscopy, and Brunauer–Emmett–Teller analysis tools. Various parameters affecting the removal efficiency were deliberated such as pH medium, contact time, solution temperature, MOF dosage, and initial MB dye concentrations. Results showed that MIL-101(Fe) has a maximum adsorption capacity of 58.82 mg/g at pH 9. Moreover, data obtained from isotherm studies were more fitted to the Langmuir isotherm model (R^2 = 0.997), while the adsorption kinetics followed the pseudo-second-order model. The thermodynamic studies proved that the adsorption process of MB dye onto MIL-101(Fe) was spontaneous and endothermic. Besides, MIL-101(Fe) showed higher adsorption ability towards cationic MB dye compared to the anionic methyl orange dye. Finally, the MIL-101(Fe) adsorbent showed excellent reusability for removing MB dye with efficiency exceeded 70% after ten consecutive cycles. Therefore, the as-prepared MIL-101(Fe) could be applied as a reusable adsorbent for removing cationic dyes from their aqueous solutions.

Keywords: Metal-organic framework; MIL-101(Fe); MB dye removal; Kinetics; Reusability

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