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Synthesis and characterization of Nb_2O_5 for adsorption of Mn^{2+} in aqueous solution

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The increasing presence of heavy metals in waste waters poses a significant environmental challenge due to their persistence and potential for bioaccumulation [1]. To address this issue, this work explores the design and synthesis of three-dimensional (3D) Nb_2O_5 nanoparticles as a functional material for the removal of Mn^{2+} from aqueous solutions through adsorption. Nb_2O_5 nanoparticles were synthed using the peroxide oxidation method at 100 °C for varying durations (4, 12, and 24 hours). Structural characterization by XRD confirmed the orthorhombic phase, while TG/DSC analysis revealed substantial mass loss below 500 °C, attributed to the removal of adsorbed and coordinated water. The 3D structure of the nanoparticles, confirmed by Field emission electron scanning microscopy, is evidenced by the presence of grains on the order of 10 nm, which are aligned forming rods on the order of 1 µm. High surface areas were confirmed by nitrogen physisorption analysis, measuring 174 m^2/g for the 4-hour synthesis, 163 m^2/g for the 12-hour synthesis, and 174 m^2/g for the 24-hour synthesis, facilitating efficient adsorption. Adsorption capacities for Mn^{2+} reached 69%, 67%, and 79% for the 4-hour, 12-hour, and 24-hour samples, respectively. The Langmuir model provided a good fit for the isotherms, suggesting chemical monolayer adsorption with a maximum capacity of 1.472 mg/g. This study demonstrates the potential of Nb_2O_5 nanoparticles as an effective adsorbent for Mn^{2+} removal, offering a promising strategy for remediating heavy metal contamination in industrial and environmental settings.

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[1] Shah, M. P., Ed. Sustainable Industrial Wastewater Treatment and Pollution Control; Springer Nature Singapore: Singapore, 2023. https://doi.org/10.1007/978-981-99-2560-5