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Spectroscopic Investigation into Cadmium Sorption and Precipitation on Diatomaceous Earth

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There is a growing concern regarding heavy metal contamination in the environment, such as cadmium (Cd), which is used for batteries, solar cells, and metal coatings. The high level of Cd discharge from industrial wastewater has required extensive research on developing cost-effective and high-efficiency methods for removing this pollutant. This work investigates the interaction between Cd and diatomaceous earth (DE), a silica-based biosorbent, through batch adsorption experiments at various concentrations of Cd (10, 50, and 100 ppm) as a function of pH from 2 to 10. Multiple spectroscopic analyses have been used to understand the sorption mechanism, surface characteristics, and morphology. Potentiometric titrations were used to determine the point of zero charge (pzc) of DE, which is crucial for understanding its surface charge and influence on binding with Cd. Changes in the diatom's functional groups before and after binding Cd were determined through Fourier transform infrared (FTIR) spectroscopy. Inductively Coupled Plasma–Optical Emission Spectroscopy (ICP-OES) was used to quantify the Cd sorbed onto DE by measuring the Cd concentration changes from the initial Cd concentration in solution. Surface morphology and elemental composition analysis of DE was done through Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy (SEM-EDS). The pzc, identified through the common intersection point by conducting titrations at different ionic strengths, was determined to vary between pH 7.20-8.71. Data from ICP-OES shows that the amount of Cd removed by DE is greater at pH values greater than 5 and less than 10. Above pH 10, a precipitate forms, which was also seen in our negative controls. According to our FTIR spectroscopic data, there is evidence of Cd binding at the siloxane group. Understanding the mechanisms of adsorption, such as the effect of pH and the presence of ions, is important in designing an effective method to mitigate Cd and other heavy metal pollution to reduce environmental impact. Importantly, DE provides a sustainable and cost-effective method of removing pollutants in our water systems compared to other methods.