

Ferrihydrite as a potential agent for extracellular DNA immobilization

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Free-floating extracellular DNA (exDNA) present in municipal wastewater is a significant factor in the spread of antibiotic resistance genes (ARGs) and virulence factors in natural waterways. Consequently, developing innovative methods for exDNA removal has become a pressing concern. Our research focuses on ferrihydrite, a common hydrous iron oxyhydroxide, as a potential adsorbent for exDNA. A synthetic 2-line ferrihydrite ($S_{\text{BET}} = 316 \text{ m}^2/\text{g}$) was prepared following the method described by Schwertmann and Cornell (2008). Batch adsorption experiments with exDNA concentration close to environmental levels were conducted to investigate the ferrihydrite-to-exDNA ratio, adsorption kinetics, and evaluate the effects of PO_4^{3-} , Ca^{2+} , and bacterial biomass on the adsorption efficiency and mechanisms. To further explore the interactions between ferrihydrite and exDNA, we recorded FTIR spectra and measured the zeta potential after the adsorption experiments.

Our findings demonstrated the high efficiency of ferrihydrite in removing exDNA, with a sorption capacity exceeding 3 mg exDNA/g. Kinetic studies revealed that the adsorption process reached equilibrium within 60 minutes. The presence of PO_4^{3-} ions did not inhibit the exDNA adsorption efficiency, while Ca^{2+} ions enhanced it by fourfold. The presence of bacterial biomass has increased exDNA adsorption efficiency on ferrihydrite, most likely due to the formation of macromolecular complexes incorporating exDNA.

FTIR spectra obtained after the experiments revealed new bands from DNA (2958 cm^{-1} – C-H, 1644 cm^{-1} – C=O, 1458 cm^{-1} – C-C, 1054 cm^{-1} – C-O-P), indicating the embedding of exDNA within the ferrihydrite structure. The effect of bacterial biomass on the FTIR spectra was particularly noticeable, with a significant increase in the intensity of 1644 cm^{-1} , 1458 cm^{-1} and 1054 cm^{-1} bands, and the appearance of a new band at 1540 cm^{-1} corresponding to the amid II band (a combination of stretching C-N and bending N-H motions), suggesting the co-adsorption of biomolecules, particularly proteins from bacterial biomass onto the ferrihydrite surface.

This study enhances our understanding of DNA interactions with iron oxyhydroxides and highlights the complex influence of the surrounding matrix on these interactions.

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