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Investigation of DNA adsorption on goethite surface governed by mineral particle size and pore structure

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From the perspective of environmental sciences, deoxyribonucleic acids (DNA) can be divided into intracellular (iDNA) and extracellular DNA (exDNA). iDNA plays a crucial role in cell functioning and exDNA is a key component of environmental matrixes. It is widely found in sediments, biofilms, or floats freely in waters. However, in urbanized areas, due to the occurrence of antibiotic-resistance (ARGs) and virulence genes (VGs), exDNA may constitute an emerging pollutant and its dissemination is concerned as a serious threat to public health. That's why interactions of exDNA with minerals are two-fold important. Firstly mineral – DNA interactions govern the fate of exDNA by inhibition or diminution of horizontal gene transfer between microorganisms. Secondly, specific minerals may be applied as adsorbents for ARGs and VGs removal from wastewater [1].

In this study, we investigate the adsorption mechanism and aggregation of model DNA with goethite particles. Three goethite types with different, crystallinity, particle sizes and textural parameters were synthesized and reacted with DNA by adsorption experiments. DNA-Goethite conjugates were investigated using FTIR, AFM and zeta potential. Goethite with a specific surface area of 74 m^2/g shows the greatest mesoporosity which determines the highest DNA adsorption capacity. The attachment of DNA molecules to the mineral surface is facilitated by PO_4^{3-} complexation and Fe-P-O bond formation confirmed by the appearance of bands on FTIR spectra. The zeta potential of pure goethite proves to be positive in pH < 8 and decreases respectively with increasing DNA addition. AFM images of DNA-Goethite conjugates formed in low DNA concentration (1 ug/ml) show the DNA sheath shaped around G particles, whereas higher DNA concentrations (20 ug/ml) led to drastic aggregation and nebulous particle morphology. These observations allow direct visualization of goethite pore filing with DNA and indicate that DNA molecules act as electrostatic brides between goethite particles during aggregation.

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References

[1] Calderón-Franco D., van Loosdrecht M., Abeel T., Weissbrodt D. G.. (2021). *Water Research*, 189.