The use of extracellular DNA in uranium biomineralisation

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Bacterial extra polymeric substances (EPS) have been associated with the biomineralisation of uranium external to the cell through biosorption and enzymatic precipitation in acidic environments. Within this study we aim to identify the role of extracellular DNA (eDNA) as a precursor for uranium biomineralisation and source of phosphate for acid phosphatase mediated precipitation. Here we report the findings of uranium biomineralisation through attenuated total reflectance- fourier transform infrared (ATR-FTIR) spectroscopy and X-ray powder diffraction (XRD) analysis.

eDNA was interacted with uranium at increasing concentrations (0.0625-2 mM) within an acidic environment (pH 2-7). ATR-FTIR analysis reveals at pH 2 coordination of the uranyl ion with eDNA occurs through phosphate, amides and nucleic acids, with a decrease in the latter as the pH increases. At pH 5, uranyl ion biosorption is predominantly mediated by phopshate interactions with other functional groups accumulating uranium as the concentration of the radioactive material increases.

At pH 5-7, acid phosphatase hydrolysed inorganic phosphate (ePO_4) from eDNA for subsequent uranium precipitation at varying molar ratios of UO_2^{2+}: ePO_4, with UO_2^{2+} as the limiting factor of the reaction due to an excess of ePO_4 hydrolysed. ATR-FTIR confirms the precipitation of a uranium phosphate mineral phase similar to that precipitated through the interaction of UO_2^{2+} with NaH_2PO_4.

XRD identifies the precipitates are of a uranium phosphate atomic structure, with diffraction patterns suggesting different uranium phosphate mineral structures between uranium interactions with eDNA and ePO_4.

It can be concluded that uranium biosorption primarily happens at low pH with enzymatic phosphate precipitation occuring towards acidic to neutral conditions. These results suggest eDNA is a precursor for uranium biomineralisation within EPS.