The role of extracellular DNA in uranium precipitation and biomineralisation

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We present here the findings of the bioprecipitation leading to biomineralisation of uranium with extracellular DNA (eDNA), used as a model biomolecule representative of extra polymeric substances from bacteria. The biomineralisation reaction was investigated as a function of pH, ionic strength and varying concentrations of reactants. The role of phosphate moieties in the biomineralisation mechanism was studied by enzymatically releasing phosphate (ePO_4) from eDNA compared to abiotic phosphate (aPO_4). The eDNA-uranium precipitates and uranium minerals obtained were characterised by Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FT-IR) Spectroscopy, Scanning Electron Microscopy- Energy Dispersive X-Ray Analysis (SEM-EDX), X-Ray Powder Diffraction (XRD) and X-Ray Photoelectron Spectroscopy (XPS). ATR-FT-IR showed that at pH 5, the eDNA-uranium precipitation mechanism was predominantly mediated by interactions with phosphate moieties from eDNA. At pH 2, the uranium interactions with eDNA occur through phosphate and the nitrogenous bases. The solubility equilibrium was dependent on pH with the formation of precipitate reduced as the pH increased. The XRD data confirmed the formation of a uranium phosphate precipitate when synthesised using ePO_4. XPS and SEM-EDX studies showed the incorporation of contaminants such as carbon and nitrogen from the enzymatic orthophosphate hydrolysis on the obtained precipitated. These results suggested that eDNA within EPS can precipitate uranium from solution as a uranium phosphate mineral of the type $(UO_2HPO_4)\bullet\ xH_2O$. This demonstrated that eDNA from bacterial EPS is a key contributor to uranium biomineralisation.