Heavy metal and radionuclide immobilization in nuclear waste disposal via the biodegradation of isosaccharinic acid

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Isosaccharinic acid (ISA), a water-soluble organic compound, is known to be produced from the alkaline degradation of cellulosic items under conditions, such as those in cementitious Low-level (LLW) and Intermediate-level (ILW) radioactive waste repositories. ISA can form stable, soluble complexes with a range of radionuclides and metals, in particular Am(III), Eu(III), Ni(II), Np(IV), U(VI) and U(IV). As such, the impact of microbial metabolism on this substrate was investigated, to help determine the role of microorganisms in moderating the transport of radionuclides and metals from a Geological Disposal Facility (GDF).

In this study we focused on circumneutral conditions representative of the geosphere surrounding a GDF. Here we report the fate of ISA in microcosms poised under anaerobic conditions with Fe(III) or sulfate as electron acceptors for microbial metabolism. Data are presented confirming the fermentation of ISA to acetate, propionate and butyrate prior to utilization of these acids during Fe(III) and sulfate reduction. In addition, the associated microbial communities were characterised using 16S rRNA gene pyrosequencing.

Data are also be presented on ISA complex formation and breakdown under Fe(III)- and sulfate-reducing conditions poised with nickel(II) and uranium(VI), both of which are forming complexes with ISA. Uranium(VI) is a major constituent of nuclear waste. ^{238}U and ^{235}U are of greatest significance due to their substantially long half-lives. Nickel(II) is an important component of the metal alloys used in reactor components with two radioactive isotopes of concern, ^{63}Ni and ^{59}Ni. Transmission electron microscopy (TEM) and environmental scanning electron microscopy (ESEM) were applied to obtain an insight into the impact of biomineral formation. Furthermore, X-ray absorption spectroscopy (XAS) was used to identify changes in metal speciaction during ISA metabolism in order to understand metal and radionuclide solubility, and hence mobility.