Microbial degradation of cellulose and its alkali hydrolysis products: Implications for radwaste geodisposal

NAJI M. BASSIL*, JONATHAN R. LLOYD

Research Centre for Radwaste Disposal & Williamson Research Centre for Molecular Environmental Science, School of Earth and Environmental Sciences, The University of Manchester, Oxford Road, Manchester M13 9PL, UK (*correspondence: naji.bassil@manchester.ac.uk, jon.lloyd@manchester.ac.uk)

Intermediate-level radioactive waste from the nuclear fuel cycle, which is expected to contain cellulosic material encapsulated in cement, will be disposed of in a cementitious deep geological disposal facility (GDF). Under the hyperalkaline conditions imposed by the resaturation of cement with groundwater, cellulose will be chemically hydrolysed to short chain organic acids. The most abundant hydrolysis product is isosaccharinic acid (ISA), which has been shown to bind to and mobilise various radionuclides, thereby increasing the probability of their release from the GDF. However, alkaliphilic microorganisms may survive in such extreme environments potentially using these organics as a carbon and energy source.

Microcosms poised at pH 12.2, and inoculated using sediments from a legacy lime-workings, showed biodegradation of added cellulose and fermentation of the degradation products into acetate, while halting ISA production from abiotic cellulose hydrolysis. Tissue paper irradiation enhanced the rate of the abiotic hydrolysis of cellulose by alkaline, and further increased the microbial degradation of cellulose and the fermentation of the degradation products. Enrichment cultures prepared at pH 10 and inoculated with sediments from the same site showed that alkaliphilic bacteria degrade ISA under aerobic and anaerobic conditions. An ISA-oxidising obligate alkaliphile belonging to the genus *Anaerobacillus* was isolated from these cultures, and was found to precipitate radionuclides, including soluble U(VI) from solution. Comparative genome and transcriptome analysis, coupled to transmission electron microscopy and X-ray absorption spectroscopy are helping identify the mechanisms of ISA degradation and radionuclide precipitation by this novel bacterium. Taken together, these results highlight the role that microorganisms may play in stabilising radioactive waste in the subsurface, and help reduce uncertainties in the long-term performance assessment of the GDF for radioactive wastes.