Radionuclide uptake during iron oxide nanoparticle precipitation: Underpinning effluent clean up in nuclear decommissioning.

The processing of materials (e.g. spent fuel) at nuclear facilities across the world has generated large quantities of acidic radioactive effluents from both reprocessing and decommissioning operations. In the UK, a key treatment facility for these effluents neutralises the acidic effluents to form iron (oxyhydr)oxide nanoparticles which remove radionuclides from solution (Figure 1). This precipitate is then separated from the solution in an ultrafiltration process and ultimately will be a radioactive waste. This PhD will focus on the behaviour of radionuclides during iron (oxyhydr)oxide formation and crystallisation to inform radionuclide removal during radioactive effluent treatment, and more generally in environmental conditions where iron (oxyhydr)oxide nanoparticles and radionuclides are present.

Figure 1. The Enhanced Actinide Removal Plant.

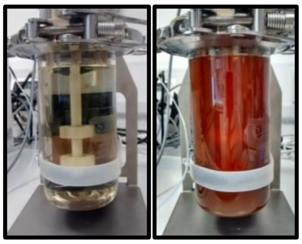

Figure 2. Controlled iron oxyhydroxide formation in the lab during neutralisation of acidic effluent. Iron oxyhydroxides are important in natural and engineered environments.

The facility which treats acidic radioactive effluents from spent fuel reprocessing in the UK is the Enhanced Actinide Removal Plant (EARP; Figure 1) located at the Sellafield Nuclear Licenced Site. Our recent pioneering studies have developed the use of a lab-based system which can mimic the effluent treatment process (mini-EARP; Figure 2) and characterise particle formation at the nanoscale using synchrotron based techniques (www.diamond.ac.uk). This has allowed a fundamental understanding of the iron (oxyhydr)oxide nanoparticle nucleation, growth and aggregation processes operating during effluent neutralisation (Weatherill et al., 2016). In addition, we have determined the atomic scale mechanisms of actinides (U and Np) incorporation into the structures of key iron oxide phases (Roberts, et al., 2017, Marshall et al. 2014, and Bots et al., 2016). This PhD project extends these initial studies to understand the behaviour of radionuclides during the nanoparticle formation formation and aggregation, and during ultrafiltration. Crucially, the research will look forward to examine the impact of changes in the effluent stream on radionuclide uptake by the iron (oxyhydr)oxide as post operational clean out of the site infrastructure occurs from ~2020 onwards. Indeed, timely clean out of defunct facilities at Sellafield is a national prority to reduce risks and hazards on site. The fully funded project is sponsored by Sellafield and the National Nuclear Laboratory and is available from Sept 2018 for 3.5 years, the stipend is at standard RCUK rate.

Training: This industrially sponsored PhD project will be based in the highly successful nuclear environment and waste group within the School of Earth & Environmental Sciences at The University of Manchester. The projects will be experimental in scope, and the successful candidates will join a group of 20+ PhD and postdoctoral researchers focussed on issues in the nuclear environmental sciences including radioactive effluent treatment. The project will also benefit from the excellent facilities within the Williamson Research Centre for Molecular Environmental Science to perform chemical, radiochemical, mineralogical and colloidal characterisation of samples. The student will also have access to advanced facilities available within The University of Manchester (e.g. electron microscopy, X-ray photo electron spectroscopy, mass spectrometry) as well as national and international facilities where we routinely analyse radioactive samples e.g. Diamond Light Source (http://www.diamond.ac.uk). Finally, the students will work closely with industrial supervisors within the National Nuclear Laboratory and Sellafield Ltd. to ensure their research is focussed on the real world application.

Specification: This project is experimental in scope and the successful candidates should have a strong background in the Chemical and Environmental Sciences (BSc / Masters in Chemistry, Environmental Chemistry, Geochemistry, Geology or similar). If you require further details about the project, please contact the supervisors, Prof. Sam Shaw (sam.shaw@manchester.ac.uk) and/or Prof. Katherine Morris (kath.morris@manchester.ac.uk). Applications can be made through The University of Manchester site http://www.manchester.ac.uk/study/postgraduate-research/admissions/

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