Novel phosphate cement chemistries and materials for safe storage of uranium-based nuclear waste

Supervisor (primary) Imperial College London: Dr. Rupert J. Myers

Supervisor (co) Imperial College London: Dr. Hong S. Wong

Applications are invited for a PhD scholarship funded by Nuclear Waste Services (NWS) (a subsidiary of the UK Nuclear Decommissioning Authority), on the project titled “Long-Term Performance of PO_4-Based Backfill Cements in Repository Environments for DNLEU Disposal (PO4DNLEU)”. The PhD student will experimentally develop and apply thermodynamic data for phosphate cements, which are promising low-pH cementitious materials for immobilising radionuclides such as uranium. These materials are important for safe disposal of nuclear waste since they can maintain a long-term chemical barrier between the nuclear waste in the storage site and the surrounding natural environment.

The PhD will be based in the Materials Section of the Department of Civil and Environmental Engineering (Skempton Building, South Kensington Campus), working closely with NWS as well as consortium partners, including the National Nuclear Laboratory (NNL), Swiss Federal Laboratories for Materials Science and Technology (Empa), and Paul Scherrer Institut (PSI). This PhD project offers a wide range of excellent training and development opportunities in a highly stimulating environment, as well as access to internationally leading academics and industrial partners, research facilities, and networks.

Project details

Through natural decay, depleted natural and low enriched uranium (DNLEU) will become the most radioactive material in the UK geological disposal facility after 1 million years, which poses a significant and challenging-to-manage long-term risk. Despite this risk, backfill materials specifically designed to immobilise UK DNLEU have not been “studied in any detail” (NWS, 2016).

This PhD project will develop the data and models needed to reliably predict the long-term performance of phosphate-based cements, which are promising backfill materials for DNLEU immobilisation. Specifically, these data/models will be validated using results from new experimental tests and applied to predict key phosphate cement material properties e.g. mineralogical composition and porosity under hydrothermal aging conditions and in the presence/absence of groundwater exposure. The PhD student will comprehensively detail the results and insights from this study in several peer-reviewed journal papers and a report to NWS that critically assesses the potential for phosphate cements to be used in DNLEU immobilisation.

By openly providing our thermodynamic data for phosphate cements, which are currently poorly reported in the scientific literature relative to other cements, this PhD project represents an initial yet essential step towards reliably predicting the fate of uranium and its decay products in the UK geological disposal facility concept. It will thus also deliver an important contribution to international cement/nuclear science.

This is a heavily experimental PhD project that will utilise the suite of state-of-the-art materials characterisation equipment available in our Advanced Infrastructure Materials, Structures, and Environmental Laboratories, which is a facility that is essentially unparalleled in terms of quality within the UK.

This PhD student will work aside another PhD student, also funded by NWS, who will characterise the long-term evolution of and interactions between composite Portland cement grouts and high-alkalinity Nirex Reference Vault Backfill (NRVB), which are also important materials for safe disposal of nuclear waste.

Academic requirements and experience

Required

- A good first class degree (or international equivalent) in a STEM subject, e.g., Chemistry, Metallurgy, Physics, Materials Science, Chemical Engineering, Environmental Science, Geology), or a course with strong emphasis on chemistry.
- A masters level degree qualification in any course with a strong emphasis on chemistry, as indicated above, alone or in addition to an undergraduate level degree.
- Laboratory experience.
- Strong interest in materials research.
- Excellent English communication skills.

How to apply

Applicants wishing to be considered for this opportunity should send the following application documents to Dr. Rupert J. Myers (r.myers@imperial.ac.uk):

1. An up-to-date CV for the applicant including degree result and, if possible, class ranking
2. Contact details of two academic referees

Application via the Imperial College Registry is not necessary at this stage.

We are looking for a candidate to start as soon as possible and applications will be continuously reviewed until the position is filled.

Administrative questions should be emailed to civilphdadmin@imperial.ac.uk. Project related questions should be emailed to r.myers@imperial.ac.uk.

Funding notes

The studentship will provide funding for 3 years including tuition fees and a tax-free stipend at the standard UKRI London rate, ~£20,062 for the 2023/24 academic year.

Full funding is available to Home students. The funding may also be used to partly support an international student.