An investigation of corrosion and leaching of carbide fuels in a Geological Disposal Facility (GDF) setting.

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Overview

Uranium carbide (UC) is considered an exotic fuel material which has arisen from the UK nuclear test reactor programme. This material has served as both a fuel at sites like Dounreay, Scotland and as a fission target material in facilities such as CERN.

The NDA has an inventory of irradiated uranium carbide as part of its legacy waste exotic fuel materials within its estate and therefore carries the liability for its safe management and ultimately its disposal. Uranium carbide is considered a reactive and potentially pyrophoric material with a reactivity comparable to uranium metal.

Geological disposal is considered the ultimate fate for this unique material and the current PhD project will investigate its corrosion and leaching behaviour under conditions analogous to a GDF facility both (i) pre-closure and (ii) post-closure.

Experimental Approach

Utilising virgin Uranium carbide fuel material provided by the NNL, Springfields laboratory, the current studentship will use cutting edge materials analysis techniques to provide a nano-to-micro to millimetre scale observation of carbide corrosion behaviour. Techniques will include X-ray tomography (XRT), high-speed atomic force microscopy, secondary ion mass spectrometry, high-resolution electron microscopy and X-ray diffraction. The techniques are all routinely used and available at the IAC in Bristol. To compliment the materials analysis, leaching studies will utilise solution analysis techniques such as ICP-MS and ICP-OES to determine evolving U concentrations in different GDF-analogous groundwater solutions (oxic and anoxic). In addition, the project will also utilise the unique TRLFS instrument available at the University of Surrey which is being developed for aqueous actinides analysis as part of the main TRANSCEND project.

The project will setup a series of enclosed cells experiments, using sealed, water-filled glass housings to hold small uranium carbide ‘stick’ samples in a fixed position. These special cells will permit periodic measurement of the evolving water chemistry using TRLFS and also the corrosion progression using X-ray tomography. These analysis techniques will enable a detailed study of corrosion and leaching behaviour but without disrupting the experimental system. The lower density of the oxide (10.97 g/cc) which forms from corrosion of the carbide (13.66 g/cc) means that rates of oxidation under different conditions (temperature, dissolved O_2 and water chemistry) can be determined by measuring the evolving thickness of the oxide using XRT.

Isotopic labelling of water saturated corrosion systems will also be used to determine the mechanisms for corrosion of the carbide. Residual gas analysis mass spectrometry will be used in conjunction with such experiments to determine the arising gases under GDF conditions.

The candidate

It is expected that the prospective candidate will have a 1st or 2.1 class degree in Materials Science, Mechanical Engineering, Physics or a related discipline. This project will be open to application from UK and EU applicants due to security restrictions.

This PhD project will be conducted in conjunction with the EPSRC-funded TRANSCEND project, with the student attending and presenting at annual research meetings of the consortium.

Interface Analysis Centre

For more than 20 years the IAC has been actively involved in research on materials and material surfaces. The Centre continues to provide a vibrant and stimulating environment for postgraduate study. Researchers within the Centre explore materials of all types, including strong activities in nanoscience and nuclear materials.

Further information: http://www.bristol.ac.uk/physics/research/iac/opportunities/

TRANSCEND Project

TRANSCEND is a collaborative research consortium of 11 universities and 8 industry partners. The £9.4million research programme comprises 40 projects which will address some of the key challenges within nuclear decommissioning and waste management.

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

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