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Nanostructured Ceramic Membranes for Enhanced Tritium Management

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Program: Fuel Cycle Technologies, FC-1.3b Fuel Processing Off-Gas Management: Tritium Separations Technology

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ABSTRACT:

The overarching aim of this project is to develop a ceramic membrane technology for tritium separation and recovery in support of legacy decommissioning and advanced radioactive waste management in the civil nuclear fuel cycle. Tritium (half life 12.3 years) is produced naturally and in the civil nuclear fuel cycle by neutron capture reactions on hydrogen or deuterium or parasitic fission reactions. Environmental discharge of tritium is of concern due to the sufficiently long half life, rapid transport in the hydrosphere, facile isotopic exchange, and uptake by biological systems. At present, tritium is not captured and treated in current international nuclear fuel reprocessing and decommissioning scenarios, which apply a dilute and disperse approach to tritium management. However, increased tritium production as a result of world-wide expansion of civil nuclear power, may require new technologies to concentrate and contain tritium, for decay-storage, in response to more demanding environmental regulations.

The challenge to be addressed in this project is the demonstration of a ceramic composite tritium separation membrane, to facilitate tritium recovery. The project will exploit the bulk and interfacial transport of protons in nano-structured ceramic materials to develop a new family of candidate tritium separation membranes. Proton dynamics and transport will be evaluated by electrochemical impedance spectroscopy and multi nuclear solid state solid state nuclear magnetic resonance. This will be underpinned by atomistic simulations of proton adorption, diffusion and isotope exchange, to afford a mechanistic understanding of hydrogen isotope migration behaviour. These data, combined with complementary investigation, tritium exchange experiments and financial life cycle analysis, will allow us to assess the functional and economic efficacy of this potential membrane technology.

This research program is a joint collaborative enterprise between leading researchers from the US and UK who, collectively, bring mutually complementary and compatible skills, capabilities, and interests required to create, optimise and demonstrate a transformative advance in tritium membrane separation technology.