The Corrosion Behaviour of Passive Multi-Phase Metallic Nuclear Wasteforms

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Used nuclear fuel processing requires the immobilization of radioactive fission products in stable wasteforms. Due to its high environmental mobility the long-lived β-emitter ^{99}Tc is of particular concern, and one proposed host wasteform is a stainless steel based alloy. These alloys also contain Zr from fuel cladding hulls and noble metals from the reprocessed waste. As a consequence, the waste form exhibits a complex microstructure with up to six separate phases, with the ^{99}Tc associated predominantly with the stainless steel matrix phase.

We have been studying the electrochemical and corrosion behaviour of a ^{99}Tc-containing alloy and an alloy of similar composition containing the Tc surrogate, Re. Due to the multi-phase structure, and the presence of noble metals, there is a strong possibility of microgalvanic coupling, which may, or may not, assist the stabilization of ^{99}Tc (Re) within the passive stainless steel matrix phase.

To investigate these possibilities we have been studying these alloys using a range of conventional electrochemical techniques, microelectrochemical cell measurements to investigate the behaviour of individual phases, and scanning electrochemical microscopy to determine the possibilities for microgalvanic coupling of cathodic and anodic phases.

The alloys have been studied in a number of solutions ranging from acidic to alkaline with and without chloride. Using microscopic surface analyses (scanning electron microscopy, x-ray energy dispersive spectroscopy, x-ray photoelectron spectroscopy, time of flight mass spectroscopy) , the chemical nature of the surface oxides on specific phases are being elucidated and their influence on the location of corrosion determined. In addition, β emission causing the production of radiolytic oxidants and reductants leads to an observable difference in behaviour between the Re- and ^{99}Tc-containing alloys.