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Hot isostatic pressing of ion exchange materials, from the Fukushima and Sellafield sites, to produce ceramic wasteforms.

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Decommissioning and clean up of nuclear facilities requires the development of new technologies to condition radioactive wastes, producing passively safe waste packages of minimal volume, to reduce storage and disposal costs. We have applied hot isostatic pressing to demonstrate conceptual wasteforms for ion exchange materials and sludges present on the Sellafield site, UK, and Fukushima site, Japan. These radioactive wastes pose several challenges which demand early conditioning to produce a passively safe wasteform, including: i) the materials are of a wet and granular nature, and hence dispersible as a result of loss of containment; ii) the materials are characterised by very high dose rates as a result of their selectivity for short lived radionuclides (e.g. Sr-90, Cs-137, Co-60); iii) the materials exhibit radiogenic self heating, as a result of the concentration of such lived radio nuclides; iv) the materials exhibit hydrogen production as a result of radiolysis of entrained water.

In this presentation we demonstrate the conversion of several commercial and natural inorganic ion exchange materials into multiphase ceramic wasteforms, achieving a waste loading of 100 wt% and density in excess of 97% theoretical. High resolution thermogravimetric analysis coupled with mass spectroscopy was utilised to characterise the evolution of water and volatiles during the in-can bake out step, prior to the HIP cycle. This allowed optimisation of the bake out parameters (temperature, time and vacuum) to enable complete removal of water and volatiles, affording ceramic bodies with minimal residual porosity by hot isostatic pressing at 1250oC for 4h in stainless steel cans. Characterisation of the ceramic wasteforms by SEM /EDX and X-ray diffraction revealed the nuclides of concern to be incorporated within well known natural mineral and synthetic phases, with Sr partitioning into the SrTiO3 pervoskite phase and Co, Fe, Mn and Cr partitioning into a spinel phase. Dynamic alteration experiments revealed matrix dissolution rates of less than 10-4 g m-2 d-1 under forward rate conditions at 90 oC.

Overall, hot isostatic pressing of inorganic ion exchange materials yields durable glass, glass-ceramic, and ceramic wasteforms, with minimal voidage and porosity, in which the radionuclide partitioning between glass and ceramic phases can be controlled by wasteform composition and processing parameters. The resulting ceramic wasteforms are considered to meet the disposability requirements of a UK Geological Disposal Facility for radioactive wastes.

Summary

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