A New Paradigm for Understanding Multiphase Ceramic Waste Form Performance

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ABSTRACT:

Durable ceramic waste forms that incorporate a wide range of radionuclides have the potential to broaden the available disposal options and to lower the storage and disposal costs associated with advanced fuel cycles. Assemblages of several titanate phases have been successfully demonstrated to incorporate radioactive waste elements, and the multiphase nature of these materials allows them to accommodate variation in the waste composition. A major technical hurdle to the use of multiphase oxide waste forms is the ability to characterize the complex elemental partitioning that occurs, particularly at the grain boundary interface in crystalline systems, as well as to predict the long-term performance of these material systems. This work aims to systematically fabricate and characterize multi-phase waste form compositions with varied microstructures followed by advanced 3D characterization of their interconnected network, including residual porosity. Material system modeling will incorporate elemental release and the interconnected microstructural network of phases to better understand the material systems' performance and degradation. This approach of using atomic level inputs and intrinsic single-phase material properties will be combined with actual microstructure and measurements, enabling the output of constitutive "properties" of complex multiphase systems such as ceramic waste forms that can be used to accelerate waste form acceptance in repository settings and reduce the reliance on engineered and natural barrier systems.