

## Performance of a Steel/Oxide Composite Waste Form for Combined Waste Streams from Advanced Electrochemical Processes over Geologic Time Scales

PI: J. Ernesto Indacochea, University of Illinois at Chicago Collaborators: William L. Ebert-Argonne National Laboratory

**Program**: FCR&D: Advanced Waste Forms

## **ABSTRACT:**

Reprocessing of used nuclear can improve nuclear waste management by enhancing the recovery of reusable fissile materials in a proliferation-resistant manner and efficiently immobilizing the remaining radionuclides in durable waste forms for safe repository disposal. Combining waste streams from reprocessing operations in a small number of waste forms can decrease the number of unit operations, reduce costs, simplify performance assessments, and make efficient use of disposal systems. The objective of the proposed investigation is to develop and validate a mechanistically based corrosion model that can be used to assess source terms for radionuclide release during the degradation of waste forms made by encapsulating oxides within alloy over geologic time scales. Although cermet-type waste forms were first proposed several decades ago, the lack of an appropriate testing protocol and modeling approach for predicting long-term performance has impeded their development and acceptance. The proposed research extends the study of alloy/oxide composite materials by investigating the corrosion behaviors of the alloy/oxide phase boundaries and assessing the impact of the oxides on modeling alloy degradation. The innovative aspect of the proposed work is application of electrochemical testing and modeling methods to composite materials to address the behavior of the metal/oxide phase boundaries and evaluate waste form performance with regard to both the degradation of the alloy and oxide host phases and radionuclide release. Because the alloy is the continuous phase and degradation of alloy phases will control the overall performance of the waste form, the proposed testing methods are similar to those developed to study alloy degradation with added attention to phase boundaries.

The composite to be studied experimentally represents the combination of two electrochemical processing waste streams: lanthanide oxides generated during lanthanide draw down and hulls and fuel wastes recovered from the electrorefiner. The material will be comprised of small amounts of oxide phases dispersed in a multi-phase alloy of iron-based intermetallics. The behavior of Mo will be used as a surrogate for Tc, which is the key radionuclide in the alloy phases, and the behaviors of Nd, Ce, and La will be used to represent all lanthanide oxide phases. Testing will include modified ASTM C1308 immersion tests to measure the kinetics of releases of radionuclide surrogates species from the alloy and oxide phases and various electrochemical tests under potentiodynamic, potentiostatic, and open circuit conditions to measure the oxidation kinetics of the alloy phases in solutions representing a wide range of potential groundwater environments. Detailed optical and electron microscopy will be used to study changes in the composite surface during corrosion to identify active phases, assess the importance of pitting and localized corrosion at phase boundaries, including crevice corrosion. Additional studies will be conducted with an atomic force microscope to study localize changes in the corrosion potentials that occur during corrosion to assess the role of galvanic corrosion.

The expected outcomes from this investigation are: (1) a procedure to evaluate the relative importance of oxide inclusions and alloy/oxide phase boundaries on the overall performance of the waste form; (2) an experimental database for the degradation of alloy/oxide composites in environments representing potential disposal systems that includes electrochemical, microscopic, and solution characteristics; (3) a conceptual corrosion model for providing radionuclide source terms for the degradation of the alloy/oxide composite waste forms over geological times; and (4) a general approach for evaluating the suitability any combination of glass, ceramic, and metal phases hosting radionuclides.