EVOLUTION OF FLUID CHEMISTRY INSIDE A WASTE PACKAGE DUE TO CARBON STEEL, STAINLESS STEEL, AND SIMULATED HIGH-LEVEL WASTE GLASS CORROSION

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ABSTRACT

A codisposal waste package designed for the potential high-level waste repository at Yucca Mountain may contain a mix of 304L stainless steel canisters filled with high-level waste glass and U.S. Department of Energy (DOE)-owned spent nuclear fuel canisters. Both types of canisters had carbon steel inserts. Recently, DOE changed the design to a Transport, Aging, and Disposal (TAD) canister-based system, which uses stainless steel as internal components. The work on carbon steel reported in this paper was done prior to the change to TAD canister-based system.

Radionuclide release from the waste package is a complex process that depends upon the corrosion rates of the waste package and its internal metallic components; the chemical composition and flux of groundwater contacting the waste package internal metallic components and the wasteforms; the dissolution rate of high-level waste glass and spent nuclear fuel; the solubility of radionuclides; the availability and stability of colloids; and the retention of radionuclides in secondary phases and internal metallic components. Typically, the corrosion rate for carbon steel is significantly higher than for stainless steel or Alloy 22 and has a significant effect on the chemical evolution of the in-package solutions.

In this study, a series of bench-scale experiments was conducted to monitor the evolution of the chemical composition, pH, and redox potential of the fluid inside the waste package for corroding carbon steel and stainless steel samples for expected groundwater compositions. The pH of the solution controls the dissolution of wasteforms and determines the speciation and solubility of radionuclides. Results indicate that the carbon steel corrosion processes increased the pH of the solution from near neutral to alkaline (pH >9), accompanied by the formation of iron-bearing corrosion product precipitates. The addition of simulated high-level waste glass to the corroding carbon steel solution caused a further increase in pH. Follow-up control experiments indicated that the pH changes were partly due to an increase in sodium concentration over the course of the experiment and the precipitation of calcite. Similar experiments with the immersion of stainless steel specimen produced little pH change, and stainless steel corrosion was limited. No pH decrease was observed in any of the immersion tests.

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