Characterization of the Chemistry of NaCl-$NaNO_3$-KNO_3 Mixtures at Elevated Temperatures

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The waste package design proposed for the disposal of high-level waste at the potential repository at Yucca Mountain, Nevada, consists of an outer container of a highly corrosion resistant Ni-Cr-Mo alloy (Alloy 22) surrounding a thicker Type 316 nuclear-grade stainless steel inner container. Aqueous corrosion processes may compromise the integrity of the waste package. Likely sources of potentially corrosive aqueous solutions are hygroscopic salts found in dusts generated during repository construction or entrained with ventilation air during the operational stage of the repository. These salts will sorb moisture from the atmosphere and form a brine phase when the relative humidity in the drift is near or above the deliquescence relative humidity of the salt mixture.

In this study, experiments were conducted to characterize the evolution of the chemistry of NaCl-$NaNO_3$-KNO_3 mixtures at elevated temperatures. These mixtures are considered by the U.S. Department of Energy to be the salt assemblages most likely to be deposited on the waste package surfaces within the potential repository at Yucca Mountain, Nevada. Some studies indicate that brines formed by the deliquescence of these salt mixtures could be stable up to the highest temperatures envisioned for the Yucca Mountain repository. For example, experiments conducted at Lawrence Livermore National Laboratory indicate that, for the NaCl-$NaNO_3$-KNO_3 system, liquid solutions exist in equilibrium with the solid phase up to the melting point of ~220 °C [428 °F] at ambient pressure. The presence of a high-temperature brine in contact with the waste package surface has important implications to repository performance because the waste package material may be more susceptible to localized corrosion or may have high general corrosion rates at elevated temperatures.

The experiments were conducted at a temperature range of 130 to 180 °C [266 to 356 °F] in a glass vessel vented to the atmosphere, simulating the potential repository drift condition. The vapor phase venting out of the glass vessel was collected using a condenser, and the condensed phase was sampled periodically for measurements of pH and chemical composition. The results show the condensate had low pH, suggesting the NaCl-$NaNO_3$-KNO_3 salt mixture decomposed slowly to form acid gases. The measured compositions of the condensate showed that nitric acid was the primary acidic component.