LIBS Investigation of Nickel-Chromium Alloys Exposed to Molten Salt

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Molten salt reactors (MSRs) provide multiple potential advantages when compared to light water reactors: they produce lower amounts of faster-decaying waste, they operate at high temperatures enabling better thermodynamic efficiency, and their lower pressure conditions are favorable for safety. MSRs also enable the possibility of utilizing Thorium for fuel. However, corrosion of structural materials can be limiting, as corrosion of salt-facing alloys by Cr-depletion is common to both fluoride and chloride-based systems. While this has been observed in many works, the mechanisms are not well understood.

In this work, model Ni-16%Cr alloys were exposed to high temperature molten salt environments to investigate the physical processes occurring during corrosion. Samples were exposed to a eutectic KCl-$MgCl_2$ salt at 700-800°C for up to 2500 hours in static testing capsules. Weight change measurements and microstructure analysis were conducted. As expected, samples were depleted in Cr near the salt-interface. Laser-induced breakdown spectroscopy (LIBS) was used to analyze the depths of Cr depletion and salt penetration into the surface. Profiles generated showed the severity of Cr depletion, and that there is significant salt infiltration. Additionally, K is found in the alloy to some depth. This implies that K is soluble in the Ni-Cr alloy and may change the alloy properties over time, reducing predictability of the system.

This work will discuss new insights into Ni-Cr alloys exposed to molten chloride salt and demonstrate how LIBS may be used to understand the de-alloying and salt infiltration processes that occur in salt-facing alloys.