405f Recent Advances in Redox-Based Corrosion Control in Molten Salts Suitable for Use in High Temperature Heat Transfer

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Heat transfer in emerging energy conversion systems such as Generation-IV nuclear reactors, thermochemical hydrogen production plants, and fusion systems requires fluids with favorable properties at temperatures ranging from 500 to 1000^{o}C. Molten salts are well suited for such applications due to their chemical stability, high heat capacities, low vapor pressures, low reactivity, and favorable melting points. However, the corrosiveness of these salts has been widely been recognized as a major problem, a hurdle for implementation into advanced energy systems. Recent progress in developing fusion blanket technology has, perhaps, shown the way to solving this problem. The fusion blanket must serve three purposes--heat transfer, tritium breeding, and neutron multiplication. Molten FLiBe (2LiF-BeF_2) is capable of delivering on all of these requirements. But, unfortunately, the tritium that is bred in FLiBe is in the form of TF. And the presence of TF leads to rapid corrosion of structural material. To eliminate TF from the salt and minimize corrosion, the following redox reaction with Be was investigated.

$Be + 2TF = BeF_2 + T_2$

With this reaction being very favorable thermodynamically, it appears to be an ideal approach to corrosion control for a FLiBe blanket. The produced T_2 can be recovered and recycled in the fusion system as a fuel, and the BeF_2 that is generated is already found in FLiBe. However, neither the mechanism nor the kinetics of the redox reaction was known prior to this study. To test the hypothesis that Be can be used as a redox agent in FLiBe, rapidly reacting with TF as it is formed via neutron irradiation of the salt, a series of experiments was run in which HF was bubbled through molten FLiBe--with and without Be present. It was found that Be readily dissolves into the FLiBe with a solubility limit of approximately 0.3 mol%. The rate of the redox reaction was found to correlate well with the Be concentration in the salt at any given time. A kinetic model for redox was developed and used to extrapolate the rate of reaction to conditions expected in a real blanket system. Using this method, it was estimated that the Be could successfully suppress TF in the salt to much less than 1 ppb, a level expected to be sufficient for adequately mitigating the corrosion problem. Currently, it is planned to next test this same approach to corrosion control for FLiNaK (0.465LiF-0.115NaF-0.42KF) at temperatures ranging from 800 to 1000^{o}C. This is of interest for application to the intermediate heat transfer loop between a high temperature nuclear reactor and a hydrogen production plant. While there is no TF generation expected in this system, the presence of even trace amounts of impurities is expected to lead to unacceptable corrosion at these elevated temperatures.