Measurements and Modeling of Tritium Retention Mechanisms in Nuclear Graphite Irradiated in Molten Fluoride Salt

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Advanced reactor designs with a lithium or beryllium bearing primary molten salt will need a solution for mitigating the environmental release of tritium. In a Fluoride-Salt-Cooled High-Temperature Reactor (FHR), which uses TRISO coated particle fuel and a molten flibe coolant (2LiF-BeF_2), the graphite fuel elements and core moderator can potentially be leveraged as a capturing material for tritium generated in the salt. However, predicting the expected tritium uptake in graphite is challenging since few studies have examined the combined effects of molten flibe, tritium, and graphite at relevant FHR temperatures and tritium partial pressures. The three in-core fluoride salt irradiations completed at the Massachusetts Institute of Technology Reactor (MITR) provide a useful parallel for studying tritium transport phenomena in a representative FHR environment. During the third irradiation (FS-3), tritium release from the in-core assembly was collected and monitored during the 1000 hour irradiation period. Compared to a calculated total tritium generation of 589 mCi, 459 mCi was released from the experiment, while the unreleased 22% can be explained by tritium retention in the graphite crucible and samples in contact with the FS-3 salt. Post-irradiation examination of IG-110U graphite from the first MITR irradiation has shown that a similar fraction of tritium retention occurred in the FS-1 experiment. Thermal desorption analysis of the graphite samples suggests that the tritium was retained at high-energy trapping sites, and that the retention occurred predominantly near the surface region at the graphite-salt interface. Measured desorption profiles also provide a means for benchmarking the integrated effects of tritium generation, transport in molten flibe, and retention into graphite. In this work, a method for modeling tritium transport in the FS-1 experiment is described and the current results are summarized. This research aims to identify the data needs to accurately model tritium transport at the FHR system level. Accurately modeling the transport of tritium in molten flibe and graphite systems is an essential aspect of determining the expected tritium distribution in FHR designs.