Novel Methods of Tritium Sequestration: High Temperature Getting and Separation Membrane Materials Discovery for Nuclear Energy Systems

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ABSTRACT

This proposal is aimed at addressing issues related to tritium sequestration in next-generation nuclear energy systems. A technical hurdle to the use of heat from the high-temperature exhaust produced in the next-generation nuclear processes in commercial applications such as nuclear hydrogen production is the trace levels of tritium present in the exhaust gas streams. This presents a significant challenge since the removal of tritium (usually accomplished at low temperatures) from the high-temperature gas stream must be accomplished at elevated temperatures in order to subsequently make use of this heat in downstream processing. Hydrogen isotope gettering using metal hydride materials is typically employed in low-temperature processes; however few hydrides are stable at elevated temperatures. One aspect of the current proposal is to extend the techniques and knowledge base for metal hydride materials being developed for the "hydrogen economy" based on low-temperature desorption of hydrogen to develop materials with adequate thermal stability and a high-temperature affinity for hydrogen and its isotopes. The second focus area of this proposal is to evaluate conductive ceramics with high-temperature proton conductivity as hydrogen isotope separation membranes. The common theme between both branches of research is the emphasis on both composition and micro/nanostructure on the performance properties of sequestration materials. First-principles modeling will be performed to develop a fundamental understanding of hydrogen isotope behavior in metal hydride and metal oxide systems, which will guide material synthesis to develop advanced high-temperature gettering and membrane separation materials for tritium sequestration in next-generation nuclear energy systems.