NUCLEAR ENERGY RESEARCH INITIATIVE

High-Performance Electrolyzers for Hybrid Thermochemical Cycles

PI: John W. Weidner, University of South Carolina

Collaborators: Sandia National Laboratory, Savannah River National Laboratory, Argonne National Laboratory

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Project Description

This project provides the scientific basis for developing high-performance electrolyzers for use in the hybrid sulfur process and the modified calcium-bromine cycle -- two thermochemical cycles identified as leading candidates for producing hydrogen from nuclear power. This project builds on the successful application of a proton exchange membrane (PEM) electrolyzer for converting H_2O and SO_2 to H_2SO_4 + H_2 and HBr to Br_2 + H_2. There are still a number of challenges in making these thermochemical cycles commercially viable. For example, reducing the high cost of platinum and ruthenium catalysts, minimizing SO_2 crossover (a serious lifetime-limiting phenomenon), and finding suitable operating conditions for optimal electrolyzer performance and cycle efficiency.

This project will explore methods of improving utilization of platinum and ruthenium in the cathodes and anodes, along with replacing them with other materials (metal alloys, silicides, mixed metal oxides, or a combination). New membranes are being developed with low gas crossover and high conductivity, mechanical stability, and temperature resistance that enable operation at higher temperatures and pressures. The most promising catalysts and membranes will be evaluated in the PEM electrolyzer over a range of conditions (i.e., 30-120°C, 1-10 atmospheres, 50-80 percent conversions) and mathematical models utilized to optimize cell and process performance.

Workscope

This project will perform the following four tasks:

- Synthesize and characterize low-cost nanostructured electrocatalysts and supports for use in the anode and cathode
- Synthesize and characterize new membranes that operate at higher temperatures and minimize SO_2 crossover
- Conduct performance studies to optimize electrolyzer operation
- Perform mathematical modeling and process simulation to optimize operation of the electrolyzer and thermochemical cycles