High-Speed Thermogravimetry Equipped with Mass Spectrometry for Thermodynamic and Kinetic Study of Nuclear Energy Materials

PI: Jianhua "Joshua" Tong, Clemson University
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Collaborators: Ming Tang, Kyle Brinkman, Rajendra Bordia, John Ballato, Fei Peng, Brain Powell– Clemson University

ABSTRACT:

Objectives: The project objective is to acquire a state-of-the-art thermal analysis infrastructure of a high-speed thermogravimetry equipped with online mass spectrometry (HS-TGMS) for the rapid and accurate thermodynamic and kinetic study of nuclear energy materials and processes. The HS-TGMS has two unique characteristics: 1) high-speed temperature variation and 2) instantaneous, simultaneous, and accurate quantification of exit species. In one word, the HS-TGMS equipment enables extremely accurate thermochemical measurements for providing insight into defect chemistry, diffusion, surface exchange coefficient, reaction mechanism, entropy, and enthalpy for nuclear energy materials and processes (including radionuclide materials). By integrating with the current Nuclear Science User Facilities (NSUF) infrastructures of high-temperature melt solution calorimeter and high-temperature atmosphere-controlled Raman microscope in the Department of Materials Science and Engineering at the Clemson University, we can build a robust thermodynamic characterization hub for nuclear energy materials and processes.This infrastructure can directly enhance the NSUF capability, support the ongoing nuclear energy-related activities at the Clemson University, and the collaborating institutions such as the Savannah River National Laboratory (SRNL), the Los Alamos National Laboratory (LANL), and the University of South Carolina).

Description: We will perform 7 research focuses. **Focus 1:** A thermochemical study of protonic ceramics for tritium waste management. We will study the hydration/dehydration, hydrogen isotope diffusion and separation properties for protonic ceramics for discovering new material systems for tritium concentration and recovery. **Focus 2:** A thermochemical study of the waste immobilization in crystalline materials. We will study the defect chemistry, phase stability, and element evolution for the single-phase and multiphase crystalline ceramics for the immobilization of nuclear waste. **Focus 3:** A thermal analysis of polymer-derived ceramics. **Focus 4:** A systematic study of thermodynamic and kinetic interplays in far-from-equilibrium optical glasses and fibers. **Focus 5:** A thermochemical study of uranium nitride. Thermochemical analyses will be carried out to understand the fundamental kinetic and thermodynamic behaviors of the reduction for the fabrication of the sol-gel-derived uranium-based fuel. **Focus 6:** Analysis of Tc sequestration in cementitious materials. We will examine the ability of cementitious material to sequester Tc while concurrently monitoring changes in the oxidation state and chemical speciation of Fe, S, and Tc. **Focus 7**. A thermochemical study of nuclear glass waste forms. We are to perform thermochemical research on various melts of glass, molten salts.

Potential Impact:

The infrastructure will directly contribute 20 on-going nuclear energy projects related the PIs at Clemson University. The other Clemson researchers who are conducting various nuclear energy material and process-related will be able to benefit from the requested HS-TGMS. The infrastructure grant for rapid, accurate, and thermodynamic and kinetic study of nuclear energy materials and processes will expand research capabilities related to nuclear materials development and technological advances. Furthermore, the proposal, if funded, could directly support several DOE research programs at SRNL of the DOE's Nuclear Energy programs and the DOE's Office of Science programs of the Energy Frontier Research Center (EFRC), LANL including DOE's Nuclear Energy Office, Ceramic Fuel programs. More generally, the proposed grant would enable fundamental thermodynamic characterization and stability for a variety of materials that are relevant across the DOE complex.