High Temperature Melt Solution Calorimeter: The Thermodynamic Characterization of Oxides in Nuclear Energy

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ABSTRACT:

This project proposes the acquisition of a High Temperature Melt Solution Calorimeter to support existing DOE-NE programs at Clemson University as well as advanced characterization of ceramics in related nuclear and commercial arenas. The technical focus areas will be (i) ceramic waste forms (ii) ceramic fuels and composites and (iii) complex oxides including thermoelectrics and electroceramics. All of the proposed activities require significant advancement in addressing basic science questions of the role of dopants in the ceramic structure and the stability of the materials. Ceramic materials play an essential role in a number of energy conversion systems including nuclear waste form storage, materials for next generation fuels and power plants, solid oxide fuel cells (SOFC), Li-air batteries, oxygen separation and permeation membranes for oxygen production, partial oxidation of methane and clean coal production via oxy-combustion resulting in significant reductions in CO_2 emissions from coal fired power plants. High temperature oxide melt solution calorimetry is a versatile technique for studying the energetics of formation, solid solution mixing, phase transition, and order/disorder in ceramics making it a general tool with diverse applications in nuclear materials, geochemistry, mineralogy, materials science, ceramics, and solid-state chemistry. Through this infrastructure grant we will (i) expand and augment the existing research program at Clemson on ceramic waste forms to include experimental facilities for determination of thermodynamic properties that complement existing DOE funded activities (ii) strengthen the focus on advanced ceramics in nuclear energy by expanding ceramic work to fuels, composites and coatings in nuclear energy; and (iii) establish a strong research activity focused on the impact of dopants on phase formation and stability in ceramic based materials for energy conversion and storage including Solid Oxide Fuel Cells (SOFCs), Mixed Ionic and Electronic Conducting Membranes (MIEC) membranes, batteries and thermoelectrics; and (iv) form new collaborations by establishing Clemson as a leader in structure/property relations of advanced ceramics in the Southeast.