Oxidation of Tristructured Isotropic fuel forms in low oxygen and steam partial pressures and the role of matrix burn off in the oxidation rate at high temperature

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ABSTRACT:

Tristructured isotropic (TRISO) particles are the fuel form proposed for high-temperature gas-cooled reactors (HTGRs) and very high temperature gas-cooled reactors (VHTRs). Under certain accident scenarios, appreciable amounts of air and water can be introduced into the helium coolant. The effects of these oxidants, specifically steam in appreciable amounts, on the integrity of the fuel form must be well understood. The research proposed here will take a systematic approach to investigating the oxidation behavior of TRISO particles under a range of atmospheres that incorporate incremental additions of H_2O, O_2, H_2, and CO_2 at high temperature (800°C≤T≤1700°C). The corrosion behavior will be observed, dynamics calculated, and the transition from active to passive and passive to active oxidation in steam with and without additions of other oxidants will be mapped as functions of temperature and oxidant/contaminant partial pressure.

For the scope of work proposed, surrogate TRISO particles and unirradiated matrix material samples will be received from the DOE Advanced Gas Reactor Program. Steam oxidation testing of the matrix material utilizing a mass spectrometer on the gas exhaust of a flowing steam thermal analysis unit will be performed to map the evolution of matrix corrosion products as functions of the partial pressure of H_2O, O_2, (pH_2O, pO_2) and temperature to 1250°C. Thermodynamic assessments of SiC in low partial pressures of steam indicate that at 0.05 atm steam in a temperature range from 800-1600°C the pO_2 in steam is sufficient to observe both passive and active oxidation, with the transition occurring between 1100-1200°C. Additionally, at 0.10 atm steam, the pO_2 is sufficient to observe an active to carbon forming oxidation transition occurring around 1300°C.

Thus, thermogravimetric analysis of TRISO particles will be performed at T=800-1250°C in steam atmospheres containing additional oxidants at partial pressures identified during matrix material corrosion. Each experiment will be followed by a rigorous microstructural investigation of the SiC regression and microstructural failure mechanisms. Lastly, high temperature, (1250-1700°C), low concentration (2-10%) steam testing of TRISO particles will be performed. The determination of microstructural degradation, corrosion kinetics, and SiC recession rate of the TRISO particles tested under all conditions will be performed to map the sensitively of these particles to systematically varied gas environments and temperatures.