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# Total Mass Accounting in Advanced Liquid-Fueled Reactors

**PI**: Dr. L. Raymond Cao, The Ohio State University

**Collaborators**: Dr. Praneeth Kandlakunta – The Ohio State University; Dr. Shelly Li – University of Utah

**Program**: Crosscutting Technologies; CT-4

**ABSTRACT:**

***Scope and Objectives*****:** Advanced liquid-fueled reactors face several challenges in meeting materials control and accountability requirements for domestic nuclear safeguards. A liquid-fueled molten salt reactor (LFMSR) poses unique challenges for nuclear material accountancy (NMA) due to complex conditions such as homogeneous mixture of fuel, coolant, fission products and actinides, in addition to the extremely high radiation field and high temperature. The objective of this research is to validate a radioactive tracer dilution (RTD) method for fuel-bearing molten salt mass determination at a small scale to evaluate the possibilities of its deployment in NMA scenarios, e.g., in molten salt loop in LFMSRs.

***Project Description*****:** A solid fuel-bearing salt sample will be irradiated at a research reactor to introduce a full spectrum of fission products, and thereby, to simulate the NMA setting in an LFMSR. Prior to irradiation, the fuel-bearing salt will be mixed with $^{22}Na$ radioactive tracer of known activity, and heated until the tracer is completely dissolved into the salt. Small amounts of the irradiated fuel-bearing salt will be sampled, and the mass and activity of each salt sample will be measured. In the activity measurements, focus will be on high gamma-ray spectral interference from potential fission products to tracer gamma peak counts. Ratio of salt mass to tracer activity, thus derived, will be used along with the known tracer activity originally mixed with the unirradiated fuel-bearing salt to determine the salt mass (assumed unknown). The burn-up and accumulation issues associated with a tracer that are relevant to the sensitivity and uncertainty of the RTD concept will also be studied for a fuel-in-salt environment in safeguarding advanced liquid-fueled reactors.

***Potential Impact*****:** A practicable irradiation of fuel-bearing salt will answer many questions that could not be sought after with non-fuel bearing salt, such as spectral interferences, sensitivity, lowest amount of tracer that can be added, and accuracy of the RTD method. This study at a small scale using a research reactor will make a case for assessment of the suitability of RTD method to further scale-up studies and identifying new challenges. Final deployment questions such as the frequency of NMA inspections that can be allowed without a significant tracer accumulation, and the effect of tracer burn-up on the final uncertainty will be addressed.

***Major Participants*****:** Dr. L. Raymond Cao and Dr. Praneeth Kandlakunta at OSU will execute the project's tasks in irradiation, measurements, gamma spectrum analyses, burn-up, and Monte Carlo simulations. This project will leverage the expertise of Dr. Shelly Li and capabilities at the University of Utah for the preparation of a high purity fuel-bearing salt.

*Major Deliverables*:

- A final report documenting the methodology of radioactive tracer preparation, fuel-bearing salt irradiation, sampling, gamma spectroscopy measurements, and conclusions of the study.
- Peer reviewed publications and conference presentations of the research results.