Real-Time *In Situ* Characterization of Molecular and Complex Ionic Species in Forced-Flow Molten Salt Loops and a Molten Salt Research Reactor

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ABSTRACT:

The objective of this proposal is to establish new and unique real-time direct chemical analysis capabilities for molten salt loops and reactors. At Abilene Christian University (ACU), the Nuclear Energy eXperimental Testing (NEXT) Lab's series of existing and planned forcedflow molten salt loops and planned molten salt reactor (MSR) provide a unique opportunity to design, build, test, demonstrate, and exploit the capabilities of an array of real-time *in situ* characterization techniques. This proposal adds Raman and gamma spectroscopies to the NEXT Lab molten salt and materials characterization tools that already include a powerful collection of other instrumentation to characterize molten salt components. This new characterization capability will be established in a new radiochemistry lab capable of handling samples with significant radioactivity (>5mr/hr@30cm).

NEXT Lab will acquire a high-resolution research-grade Raman spectrometer and build an optical interface to a forced-flow molten fluoride salt loop. This interface must be resistant to the harsh molten fluoride environment, function reliably at 700°C, and have an operational lifetime of at least one year even when exposed to the radiation in an operating reactor. Data must allow users to not only identify molecular and complex ionic species, but also reliably quantify those species over a useful range. To achieve these operational goals, this proposal will explore interfaces that have shown promise in similar settings. Optical fibers have proven effective for similar work by isolating the instrument from the harsh salt and thermal environment. A variety of modifications to the end of the optical fiber have been used to improve the signal from the sample. Various window materials have been investigated as possible interface options. Background heat in the sample reduces the effectiveness of Raman spectroscopy so Fourier transform techniques have been used to address this challenge. We will evaluate the effectiveness of many options as we seek to build a spectrometer-loop interface that provides the most reliable source of quantitative and qualitative data.

The functioning Raman spectrometer successfully interfaced to a forced-flow salt loop will be capable of monitoring molecular and complex ionic species in a flowing molten salt including corrosion products, fuel species and fission products. The Raman system will also be adapted to quantify molecular species in the off-gas from reactors and loop systems. It will also be used to investigate molecular species in quenched salt from flowing loops, allowing for a comparative study of changes due to differences in temperature and state. These capabilities will have significant value to the MSR community as initial reactors begin to move through the design and licensing processes and into operation.