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

PI: Kim Pamplin
Abilene Christian University
Program: Scientific Infrastructure Support

Collaborators:
Jess Dowdy — Abilene Christian University
Tim Head — Abilene Christian University
Aaron Robison — Abilene Christian University
Rusty Towell — Abilene Christian University

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 forced-flow molten salt loops and planned molten salt research reactor (MSRR) 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 ultraviolet-visible and infrared spectroscopies, electrochemistry, and mass spectrometry 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 UV-Vis and IR spectrometers and build optical interfaces in a forced-flow molten fluoride salt loop. These interfaces must be resistant to the harsh molten fluoride environment, function reliably at 700°C, and have operational lifetimes of at least one year even when exposed to the radiation in an operating reactor. NEXT Lab will also develop electrochemical capability in flowing salt loops and mass spectrometry of salt off gases. 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. Certain optical window materials have proven effective for similar work by isolating the instrument from the harsh salt and thermal environment. For the electrochemical system, the work will focus on finding electrode combinations that allow for long-term reliable detection of solute species in the flowing molten salts. The mass spectrometer will be interfaced to the off-gas system and demonstrate real-time monitoring of gas-phase species. We will evaluate the effectiveness of many options as we seek to build a spectrometer-loop interface that provides the most reliable source of data.

The functioning chemical instrumentation 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 instrumentation 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. Ultimately this system will also benefit other fields where online monitoring of molecular species in harsh environments is essential.