Kairos Power
Partnered with
Pacific Northwest National Laboratory

NE-23-31236 – ICP-MS for Analysis of Lithium Isotopic Ratios in Materials Highly Enriched in 7Li

YEAR AWARDED: 2023

TOTAL PROJECT VALUE: $282K ($77K Kairos, $205K DOE)

STATUS: Complete

PRINCIPAL LAB INVESTIGATORS: Alan Kruizenga (Kairos)/Sean Scott (PNNL)

DESCRIPTION: The Kairos Power fluoride-salt-cooled, high-temperature reactor requires lithium fluoride salt highly enriched in lithium-7. The high enrichment requirements complicate quality and process control due to lack of qualified standards and instrumentation capable of meeting the required precision and accuracy. The intent of this project was to determine appropriate methodologies for analysis of lithium isotopes for 1) monitoring of isotope separations with rapid turnaround time, and 2) high-precision and high-accuracy characterization of end products, including lithium fluoride and lithium-beryllium fluoride (FLiBe). Kairos worked with the Pacific Northwest National Laboratory (PNNL), which has both the researchers and the instruments (specifically the ThermoFisher Neoma MC-ICP-MS system) required to perform this work. Accurate and rapid lithium isotopic ratio measurements allow Kairos to move toward production of highly enriched lithium for its reactor.

BENEFIT: The goal was to determine appropriate sample preparation methods for liquid and solid salt materials introduced into the inductively coupled plasma mass spectrometry (ICP-MS) system as well as optimize instrument parameters for speed and data quality. Salt digestions were successful using diluted nitric acid, and it was found that liquids and digested salts could be diluted directly into a 2%-3% nitric acid solution for analysis. Additionally, testing on a ThermoFisher iCAP TQ ICP-MS revealed that alpha factors could be determined in less than an hour, with potential to reduce this time to around 10 minutes by minimizing bracketing standard and blank analyses.

IMPACT: This finding will ultimately help lower costs associated with the manufacturing of enriched lithium-7, which is required for operation of certain designs of Generation IV nuclear reactors.

SIGNIFICANT CONCLUSIONS: Traditionally, isotopic ratio analysis requires the use of expensive, sophisticated instrumentation, often with relatively long analytical timelines. We determined that the use of cheaper, smaller, and easier-to-operate instruments such as the PerkinElmer Nexion5000 (the same instrument Kairos Power has installed in their lab) are sufficient for rapid analysis of lithium isotopes to monitor isotope separation efficiencies. In addition, we found that the analytical precision afforded by these lower-cost instruments is comparable to the more sophisticated (i.e., more expensive) instrumentation when the isotopic composition of lithium becomes highly enriched in ^{7}Li.

NEXT STEPS: Accurate and rapid lithium isotopic ratio measurements will allow Kairos to move toward production of highly enriched lithium for its reactor.