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ABSTRACT:

Advanced Nuclear Forensic Technologies For Uranium and Plutonium Sampling, Separation, and Analysis

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Detection of the production of nuclear weapons grade materials relies on technologies that are sensitive, accurate, and precise. High precision isotope ratio mass spectrometry is the benchmark for identification of weapons grade uranium and plutonium; consequently, this technique plays a primary role in nuclear forensics. Determination of isotopic ratios via standard mass spectrometric techniques requires substantial sample preparation in the form of labor-intensive column separation and sample purification. These radiochemical separations substantially reduce sample throughput and display intermittent inconsistencies in chemical yield and degree of radioisotope purification.

Savannah River Technology Center (SRTC) and Oak Ridge National Laboratory (ORNL) have combined efforts to couple particle sampling with reliable redox-based electrochemical separation of U and Pu. The selectivity and pre-concentration attributes of electrochemical stripping make this technique ideal for on-line separation and subsequent mass spectrometric detection. The coupling of this separation method with atmospheric sampling provides a high efficiency fieldable device that will collect, separate and concentrate airborne U and Pu.

SRTC has developed a prototype, high efficiency atmospheric particle collector. The Aerosol-to-Liquid Particle Extraction System (ALPES) is an electrostatic precipitation device that collects airborne particles into a liquid. This proprietary device consists of an air intake system, an ionization section, a fluid reservoir, and a fluid pump. The ALPES circulates collection fluid from the reservoir about a charged transport tube, then back to the reservoir allowing particles to be continually collected in the recirculating fluid.

ORNL has developed an on-line separation/concentration technique termed electrochemically modulated separation (EMS) to reduce labor and cost for standard radiochemical separations. Electrochemically modulated separations are based on the ability to control the affinity of a target surface for an analyte based on the potential applied to that surface. This technique allows highly selective and rapid separations with significant signal enhancements (>100x) when employed on-line with inductively coupled plasma mass spectrometers.

The performance characteristics of EMS for the separation of U and Pu on-line with ICP-TOF-MS will be reported. The interface and application of the ALPES and the EMS systems will be described for the collection and separation of airborne radioisotopes of interest.