Quantitative Analysis of Alpha-Decaying Isotopes by Total Nuclear Reaction Energy Spectroscopy

Main author:

CROCE Mark

Co-authors:

Bennett Douglas, National Institute of Standards and Technology
Bond Evelyn, Los Alamos National Laboratory
Croce Mark, Los Alamos National Laboratory
Hays-Wehle James, National Institute of Standards and Technology
Holesinger Terry, Los Alamos National Laboratory
Hoover Andrew, Los Alamos National Laboratory
Kunde Gerd, Los Alamos National Laboratory
Rabin Michael, Los Alamos National Laboratory
Schmidt Dan, National Institute of Standards and Technology
Swetz Daniel, National Institute of Standards and Technology
Ullom Joel, National Institute of Standards and Technology
Wolfsberg Laura, Los Alamos National Laboratory

We have developed a new category of sensor for measurement of the 240Pu/239Pu mass ratio from aqueous solution samples with advantages over existing methods. Aqueous solution plutonium samples were evaporated and encapsulated inside of a gold foil absorber, and a superconducting transition-edge-sensor microcalorimeter detector was used to measure the total reaction energy (Q-value) of nuclear decays via heat generated when the energy is thermalized. Since all of the decay energy is contained in the absorber, we measure a single spectral peak for each isotope, resulting in a simple spectral analysis problem with minimal peak overlap. We found that mechanical kneading of the absorber dramatically improves spectral quality by reducing the size of radioactive inclusions within the absorber to scales below 50 nm such that decay products primarily interact with atoms of the host material. Due to the low noise performance of the microcalorimeter detector, energy resolution values of 1 keV fwhm (full width at half-maximum) at 5.5 MeV have been achieved, an order of magnitude improvement over α-spectroscopy with conventional silicon detectors. We measured the 240Pu/239Pu mass ratio of two samples and confirmed the results by comparison to mass spectrometry values. The same method can also be used for quantitative

analysis of alpha-decaying isotopes of different elements, e.g. 238Pu and 241Am. We will present results on this topic, too, discussing the potential for simultaneous analysis of multiple alpha-decaying isotopes from multiple elements. These results have implications for future measurements of trace samples of nuclear material.