Rapid Uranium Isotopic Analysis using Ultrafiltration and Alpha Spectroscopy

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Clandestine activities involving the separation, concentration or manipulation of special nuclear material for the express purpose of developing a weapon of mass destruction is likely to result in the contamination of environmental water sources. The capability to conduct isotopic analyses for waterborne special nuclear material (SNM) would be a powerful nuclear forensics tool. Despite widespread interest, there currently is no fieldable measurement system available for low-level quantification or isotopic determination of waterborne uranium.

This contribution describes our efforts to develop a high throughput analytical technique for waterborne isotopic analysis with the following procedure: (1) deposition of ligand-containing, water-soluble polymer film on an ultrafiltration membrane; (2) separation of the uranium from near-neutral pH water by filtration through the selective film; and (3) isotopic analysis of the uranium-containing polymer film with high resolution alpha spectroscopy. The uranium-selective, water soluble polymer was prepared by the copolymerization of 2-hydroxylethyl methacrylate and 2-ethylene glycol methacrylate phosphate. The polymer was characterized by Fourier-transform infrared spectroscopy and nuclear magnetic resonance spectroscopy to support the incorporation of the ligand into the polymer backbone. Film morphology and thickness were observed by atomic force microscopy and laser scanning profilometry after deposition of the polymer onto the ultrafiltration membrane.

The effect of membrane type, membrane pore size and polymer film thickness on peak resolution in the alpha spectrum was investigated for pure uranium containing solutions at pH = 6. To mimic more realistic conditions, the selectivity of the membrane was tested using natural uranium in simulated groundwater. Uranium-coated membranes prepared from distilled water and simulated groundwater both showed resolutions of 60 keV in the alpha spectrum and detection efficiencies of 12% for uranium-233. The high resolution is attributed in part to the concentration of uranium on the surface of the thin polymer coating. Using a thin coating also was important for maintaining high membrane permeability. The permeability of the polymer coated, polyethersulfone ultrafiltration membranes (MWCO 50 kDa) was determined to be 780 LMH/bar. The results of this research are laying the foundation for the development of a novel rapid, field portable method for isotopic identification of SNM in environmental media.