



Contribution ID: 32

Type: Poster

Novel Method for Rapid Extract of Radionuclides Using Polymer Ligand Film for Nuclear Forensics Applications

Wednesday 9 July 2014 13:00 (1 hour)

Accurate and fast determination of the activity of radionuclides in a sample is critical for nuclear forensics analysis. Radioanalytical techniques are well established for radionuclides measurement; however, they are slow and labor intensive, requiring extensive radiochemical separations and purification prior to analysis. With these limitations, there is great interest for a new technique to rapidly process samples. This paper presents a development of Polymer Ligand Film (PLF) for rapid extraction of plutonium and uranium. The PLF is a thin polymer medium with ligands incorporated onto its structure to enable selective extraction of analytes from a solution. The PLFs developed in this research were designed to facilitate fast isolation of radionuclides from solutions for screening samples. The main focus was to shorten and simplify the procedure for separating radionuclides from solutions onto a surface appropriate for radiometric counting. To achieve this goal, PLFs were synthesized to perform direct sorption of analytes onto its surface for direct counting using radiometric techniques. The new technique combined column chromatography and electrodeposition into a single step for samples.

H₂DEH[MDP] and polystyrene were used to synthesize the PLF used in this study. Polystyrene provided structure support and H₂DEH[MDP] ligands provided active sites for analyte extraction on the film surface. The PLF composition is described as the ratio between ligand and the entire solid mass. For example stock solution with one part ligand and one part polystyrene was assigned 1:2 (w/w) ratio.

The PLF system used in this study was consistently effective for plutonium and uranium extraction. The analyte recovery by PLFs has shown dependency on both solution acidity and PLF composition. PLF was capable of co-extracting or selectively extracting plutonium over uranium depending on the PLF composition. The overall analyte recovery was lower than the electrodeposited samples. 50% of plutonium was extracted using the PLF system compared to 80-90% for electrodeposition. However, PLF is designed to be a rapid field deployable screening technique and consistency is more important than recovery. H₂DEH[MDP] PLFs had shown consistent plutonium recovery that are similar to the consistency seen in electrodeposition samples.

The PLFs were further tested with environmental samples to fully understand the capabilities and limitations of the PLF in relevant environments. The extraction system was very effective in extracting plutonium from environmental samples collected from Mortandad Canyon at Los Alamos National Laboratory with minimal sample processing. For the water sample, about 41% of plutonium was recovered by first acidifying the water sample with nitric acid then stippling onto PLF. For the soil samples, analytes were first leached from the soil matrices by placing it in nitric acid bath. Once analytes were in the solution, PLF was placed in a direct contact with the solution. Small quantity of plutonium was extracted from nitric solution using the PLF extraction system.

The PLF technique simplified the procedure and offered considerably reduced sample analysis time. The entire sample preparation to analysis was done within one to two days. The classical method takes two days to a week in comparison. The technique also requires minimal chemicals and it is also field deployable. The reduction in time and simplified procedure make this technique ideal for the post-detonation nuclear forensics.

This document had been reviewed and assigned publication number: LA-UR-13-29011

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Session Classification: Poster Session II