POLONIUM-210 ASSAY USING A BACKGROUND-REJECTING EXTRACTIVE LIQUID-SCINTILLATION METHOD*

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Polonium-210, the daughter of naturally occurring uranium-238, is one of the most common alpha-emitting radionuclides found in biological and environmental materials. Further, polonium-210 is rated as a class 1 radionuclide (very high radiotoxicity); yet very few methods for determining polonium-210 levels in environmental samples have been developed. Most methods involve long chemical separation, deposition onto silver disks, and counting on surface barrier detector, and they depend on using polonium-208-209 tracers to determine polonium-210 recovery and counting efficiency (e.g., refs. 2,3).

This paper describes a procedure using a technique developed at ORNL which combines solvent extraction with alpha liquid scintillation spectrometry. Pulse shape discrimination electronics are used to reject beta and gamma pulses and lower the background count to acceptable levels.

The fact that liquid scintillation methods can be used for alpha counting has been known for some time, and the ability to obtain a useful degree of alpha energy resolution was demonstrated several years ago. However the technique of combining solvent extraction of the nuclide of interest into an extractive scintillator and counting on a high resolution scintillation spectrometer in conjunction with pulse-shape discrimination electronics (to reject beta-gamma pulses) has made alpha...
spectrometry by liquid scintillation competitive with and, in some cases, more desirable than other methods. At Oak Ridge National Laboratory (ORNL), this concept has been used extensively and has recently been given the acronym "PHRALS spectrometry" (Photon Electron Rejecting Alpha Liquid Scintillation Spectrometry). The present method for separation of Po-210 and its assay by PERALS spectrometry was developed for (and has been effectively used by Hubele in) a study of polonium distribution in uranium milling streams.

The procedure consists of three parts, a. dissolution of sample, b. extraction of polonium into extractive scintillator, and c. counting of all or an aliquot of the extractive scintillator in the PERALS spectrometer.

Concentration of polonium-210 and separation from interfering elements (such as iron) are accomplished by extraction from a solution about 7 M H₃PO₄-0.01 M HCl with 0.20 M trioctylphosphine oxide (TOPO) combined with a scintillator in toluene. The polonium-210 is determined by counting the 5.3 MeV alpha with a photon-electron rejecting alpha-liquid scintillation (PERALS) spectrometer. Extraction coefficients of over 1000 for polonium assure quantitative recovery, while all other alpha emitters in the decay chains of uranium-238, uranium-235, and thorium-232 are rejected by the extraction procedure.

Figure 1 shows the distribution coefficients for polonium and uranium from 7.4 M H₃PO₄ as a function of hydrochloric acid concentrations. Essentially 100% of the polonium is extracted over a very wide HCl concentration range. Although H₃PO₄ has little effect on polonium extraction, the uranium
and iron coefficients are suppressed by increasing $\text{H}_3\text{PO}_4$ concentration. At 0.01 M HCl and 7.4 M $\text{H}_3\text{PO}_4$ (the medium used in this separation procedure), the separation factor between polonium and uranium is about $10^6$.

Table 1 gives the sample weights, counting times, total counts and observed dpm of polonium-210 per gram for samples of a standard uranium ore. The standard deviation about the mean for the eight samples is 0.89%. The average of the eight samples assayed is 75.02 dpm polonium-210 per gram, or greater than 98% recovery of the calculated available polonium-210.

The TOPO/PERALS method is effective in separating polonium-210 from ores, mill tailings, and other materials and provides an excellent quantitative assay. Sample preparation is less complicated and requires fewer steps than in previously existing methods, with no need for tracers to calculate recovery and counting efficiency. Although the method was developed for assay of samples from uranium process streams, it could be effectively used for low-level environmental samples because of high extraction coefficients, low background, and high counting efficiency.
REFERENCES


Table 1. Counting results from samples of NBL standard No. 104 (0.0103 ± 0.004 % U)

<table>
<thead>
<tr>
<th>Sample Weight (g)</th>
<th>Total counts*</th>
<th>Observed dpm/g 210Po</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6104</td>
<td>3085</td>
<td>75.8</td>
</tr>
<tr>
<td>0.4863</td>
<td>2412</td>
<td>74.4</td>
</tr>
<tr>
<td>0.7230</td>
<td>3616</td>
<td>75.0</td>
</tr>
<tr>
<td>0.3865</td>
<td>1940</td>
<td>75.3</td>
</tr>
<tr>
<td>0.8210</td>
<td>4094</td>
<td>74.8</td>
</tr>
<tr>
<td>0.2946</td>
<td>1451</td>
<td>73.9</td>
</tr>
<tr>
<td>0.5002</td>
<td>2531</td>
<td>75.9</td>
</tr>
<tr>
<td>0.1965</td>
<td>984</td>
<td>75.1</td>
</tr>
</tbody>
</table>

*The total sample, after dissolution, was extracted into 1.5 ml of extractive scintillator, and 1.0 ml was then pipetted for counting. Total counting time for all samples was 100 min.
FIGURE CAPTIONS

Fig. 1. Polonium and uranium extraction as a function of HCl concentrations by 0.20 M TOPO in toluene.