DETERMINATION OF ENVIRONMENTAL ACTINIDE NUCLIDES AND $^{210}\text{Pb (}^{210}\text{Po)}$ BY LOW-ENERGY PHOTON SPECTROMETRY WITH ALPHA-SPECTROMETRY

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(Received April 13, 1987)

Low-energy photon spectrometry with α-spectrometry was used to determine the environmental concentrations of low-level actinides and other nuclides, especially $^{210}\text{Pb}$ and $^{210}\text{Po}$. The isotopic ratio of $^{248}\text{Pu}/^{239}\text{Pu}$ was successfully determined by measuring $L_x$-ray/α-ray counting ratio. A reliable method has been developed for the determination of extremely low-level $^{237}\text{Np}$ global fallout in environmental samples. The non-destructive determination by Ge-LEPS for natural $^{210}\text{Pb}$ in various samples (tobacco leaves, commercially available tobacco, etc.) was also carried out with the determination of $^{210}\text{Po}$ by α-spectrometry using $^{209}\text{Po}$ as a yield tracer.

Introduction

The determination of low-level radioactivity in the environment, especially α-emitting transuranic nuclides, is of great interest and important from the standpoints of geochemistry and health physics, including waste disposal problems.

Although most α-emitting actinides, especially even(Z) -even(N) nuclides themselves, do not emit high or medium γ-rays, they emit low-energy γ- or x-rays of daughter elements with considerable branching ratio. In Table 1, examples of the major transuranic nuclides, including their yield tracer nuclides used for radiochemical separation, are listed along with several uranium series nuclides which are important in environmental studies. To measure these low-energy photon with high resolution, a planar type Ge detector with a beryllium window is the best.
Table 1
Low-energy gamma-rays and X-rays from major transuranics and uranium series nuclides

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Half-life</th>
<th>Gamma-ray (keV) (Branching)</th>
<th>Yield of Lx-rays from daughter nuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{243})Am*</td>
<td>7370 yr</td>
<td>74.67 (66.0%)</td>
<td>37.0%</td>
</tr>
<tr>
<td>(^{242})Pu*</td>
<td>3.76x10(^5) yr</td>
<td>44.91 (0.042%)</td>
<td>4.1%</td>
</tr>
<tr>
<td>(^{240})Pu</td>
<td>6570 yr</td>
<td>45.24 (0.045%)</td>
<td>10.8%</td>
</tr>
<tr>
<td>(^{239})Pu</td>
<td>87.74 yr</td>
<td>43.49 (0.04%)</td>
<td>10.5%</td>
</tr>
<tr>
<td>(^{239})Np*</td>
<td>2.35 d</td>
<td>106.11 (24.3%)</td>
<td></td>
</tr>
<tr>
<td>(^{237})Np</td>
<td>2.14x10(^6) yr</td>
<td>86.49 (12.6%)</td>
<td>9.1%</td>
</tr>
<tr>
<td>(^{238})U</td>
<td>4.47x10(^9) yr</td>
<td>49.55 (0.32%)</td>
<td>3.8%</td>
</tr>
<tr>
<td>(^{234})Th</td>
<td>24.1 d</td>
<td>63.29 (3.8%)</td>
<td>11.0%</td>
</tr>
<tr>
<td>(^{230})Th</td>
<td>7.70x10(^4) yr</td>
<td>67.73 (0.37%)</td>
<td>8.7%</td>
</tr>
<tr>
<td>(^{210})Pb</td>
<td>22.3 yr</td>
<td>46.50 (4.05%)</td>
<td></td>
</tr>
</tbody>
</table>

*: used as chemical yield tracer.

In our laboratory, for about the ten last years, the three detectors shown in Table 2 have been introduced for the environmental studies\(^1\). With detector No.3, which has

Table 2
Three planar type Ge-detectors in our Laboratory

<table>
<thead>
<tr>
<th>Type</th>
<th>Diameter (mm)</th>
<th>Active area (mm(^2))</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.1) Ge(Li) (ORTEC 8013)</td>
<td>16</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>No.2) Pure Ge (ORTEC 1513)</td>
<td>32</td>
<td>800</td>
<td>10</td>
</tr>
<tr>
<td>No.3) Pure Ge (IGP 1507)</td>
<td>43.7</td>
<td>1500</td>
<td>7</td>
</tr>
</tbody>
</table>