Elemental Imaging of Actinides in Human Tissues Using LA-ICP-MS and SR Micro-XRF

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Introduction

The aim of this study was to evaluate the capabilities and limitations of two state-of-the-art highly sensitive analytical techniques for elemental imaging of the distribution of actinides in human tissues, in both a qualitative and a semi-quantitative manner: Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and Synchrotron Radiation (SR) micro X-Ray Fluorescence (micro-XRF) spectrometry. The United States Transuranium & Uranium Registries (USTUR) studies the uptake, the translocation and the biokinetics of actinides in humans [1]. Human tissue sections from two USTUR cases (Registrants), which were occupationally exposed to certain actinides (U, Pu, Am), were investigated in this work. Both registrants passed away in 2008, i.e. a long time after the exposure. Prior to analysis, the samples were embedded in paraffin and cut in thin slices using a microtome.

LA-ICP-MS Instrumentation

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) is based on the detection of positively charged ions generated via a high temperature plasma discharge. For these experiments, a New Wave Research UP193HE Ar+ laser ablation unit or a GeoLas 200M 193 nm Ar+ ablation unit coupled to an ELEMENT XR SF-ICP-MS instrument was applied.

Experimental conditions

- RF power: 852 W
- Flow rates He: 0.5 l/min, Ar: 0.7 l/min

Advantages of LA-ICP-MS

- Extreme sensitivity and detection limits (ppb-ppt)
- Possibility to measure isotopes and isotopic ratios
- Rapid bulk/micro-analysis of a wide variety of samples

Results: Case 1060

Several times exposed to uranium: a parabronchial lymph tissue (chest)

LA-ICP-MS results

**U**

SR micro-XRF results

U distribution derived from the high resolution scan performed on case 1060. FWHM of the beam = 13.5 µm, 2.0 eV. Pixel size: 100 (10 µm) x 350 (10 µm).

Semi-quantitative results

<table>
<thead>
<tr>
<th>LA-ICP-MS results</th>
<th>SR micro-XRF results</th>
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</thead>
<tbody>
<tr>
<td>Hotspot</td>
<td><strong>U</strong> concentration (µg/g)</td>
</tr>
<tr>
<td>1</td>
<td>9.6 ± 0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.85 ± 0.04</td>
</tr>
<tr>
<td>3</td>
<td>1.35 ± 0.06</td>
</tr>
<tr>
<td>4</td>
<td>0.89 ± 0.04</td>
</tr>
</tbody>
</table>

Semi-quantitative results were obtained using a series of standards (HAP and dried gelatine) and adjusted parameters optimally suited with U.

Conclusions

Both advanced methodologies are able to visualise the heterogeneous distributions of U and Pu on the microscopic level. The microscopic hot spots of U and Pu can be easily revealed on the trace element level. Only the LA-ICP-MS measurements could show the presence of Am in case 0407. Besides the actinides of interest also Zr microparticles and aggregates can be reported (not shown here).

References


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