

ICP-MS Analysis of Plutonium and Other Actinides in Brain Tissue of Occupationally Exposed Individual

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The United States Transuranium and Uranium Registries (USTUR) has studied the biokinetics and tissue dosimetry of actinides in former nuclear workers. USTUR conducts autopsies and measures actinide concentrations in various organs. Acid-digested human brain sample was obtained from the USTUR. This individual was exposed to plutonium through inhalation and wounds during a glove box explosion at nuclear defense facility. The total body systemic activity of Pu, 51 years after intake, was 2,200 Bq. It is of interest to quantify Pu levels in brain tissue as current plutonium systemic biokinetic model does not include brain as an individual model compartment. Measurement of plutonium in brain is analytically challenging because of its low levels and complexity of brain tissue matrix. In this work, a direct ICP-MS method and a method with separation of actinides prior to ICP-MS were developed for measurement of ²³⁵U, ²³⁸U, ²³⁹Pu, ²⁴⁰Pu, and ²⁴¹Am. The potential interference of polyatomic isobars were evaluated for the direct method. The indirect method used TEVA, UTEVA, DGA resin cartridges to separate plutonium, uranium, and americium from the brain matrix. ²³⁹Pu, ²⁴⁰Pu, and ²⁴¹Am were analyzed by isotope dilution mass spectrometry. The uranium was analyzed using an external calibration curve. The ²³⁵U/²³⁸U as well as ²⁴⁰Pu/²³⁹Pu isotope ratios were also measured. The method limit of detection, tracer recovery, and analysis of duplicate samples were investigated. The results showed 0.69 ± 0.05 ng/kg ²³⁹Pu and 0.043 ± 0.005 ng/kg ²⁴⁰Pu in the brain tissue with the $^{240}\text{Pu}/^{239}\text{Pu} = 0.063 \pm 0.012$ reflecting weapons-grade material. U was 0.11 ± 0.01 µg/kg with the ²³⁵U/²³⁸U at 0.0068 ± 0.0004 , which is consistent with the natural isotopic composition for uranium.

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