Trace Analysis of Uranium by Laser Spectroscopy and ICP-MS

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State of the art laser spectroscopy (Resonance Ionisation Mass Spectrometry, Time Resolved Laser Inuced Fluorescence, Time Resolved Laser Induced Chemiluminecence,) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) can be very efficient for elemental and isotope composition analysis of various samples, as well as for the determination of the molecular and valence forms of uranium (speciation analysis) [1–5].

A series of RIMS measurements of reference materials with various isotope compositions ranging from depleted and natural to enriched uranium have been previously reported by our collaboration [1, 2]. Simple sample preparation process not involving any chemical separation, pre-concentration or need for chemical reactions is employed. Highly selective and efficient uranium photoionisation schemes were applied. For samples of depleted uranium the $^{235}U/^{238}U < 0.003$ ratio was determined with < 7% precision (2σ errors) for the total uranium concentrations not exceeding ~80 fg per sample [1]. The details of multi-step excitation of species and time-resolved detection of resulting luminescence (TRLIF) and chemiluminescence (TRLIC) have been evaluated and applied for analysis of biological samples. Typical concentration of uranium [4] in blood plasma for different regions is ranging $0.05 ng \cdot ml^{-1}$–$0.5 ng \cdot ml^{-1}$, and in urine is $0.2 ng \cdot ml^{-1}$–$5 ng \cdot ml^{-1}$. Without mineralization, the limit of uranyl detection (LOD) by TRLIF in blood plasma has been determined $0.1 ng \cdot ml^{-1}$. After mineralization, a lower LOD ranging $0.008 ng \cdot ml^{-1}$–$0.01 ng \cdot ml^{-1}$ has been evaluated. The limit of uranyl detection in urine in our TRLIF experiments was up to $0.005 ng \cdot ml^{-1}$. This LOD is sufficient to allow for studies the dinamics proccesses and behaviour of the of uranium in biologicas objects [3,4]. However, actinides in various valence states do not all exhibit luminescence properties. The use of chemiluminescence methods (TRLIC) for detection of actinides in solutions allows the sensitivity to reach the limit of detection (LOD) from 10^{-6} M to 10^{-13} M depending on chemical form of actinide in a solution [2–5]. TRLIC methods were applied for detection of the molecular and valence forms of uranium.

In a separate experiments, ICP-MS methods has been used for analyses [6] of the elemental and isotope composition (64 elements) of bones of dinosaurs, South mammoths, prehistoric bear and archanthropus as well as the samples of surrounding soils; everything collected in different parts of Uzbekistan. A high concentration of uranium we detected in the bones of dinosaurs (122mg/kg), South mammoth (220mg/kg), prehistoric bear (24mg/kg) and archanthropus (1.5mg/kg) compared to surrounding soils (3.7–7.8 mg/kg) and standard bones (< 0.01mg/kg) was established. The standart ratio $^{235}U/^{238}U = 0.007$ was detected for all samples, but the ^{234}U concentration differ from secular equilibrium value.

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