RAPID DETERMINATION OF THORIUM IN URINE BY QUADRUPOLE ICP-MS

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Thorium (Th) is a radionuclide that occurs naturally at low concentrations in the earth's crust. It exists ubiquitously in numerous minerals such as silica in all rocks, soil, plants, animals and water. In addition to its importance as nuclear fuel, thorium has wide industrial application in processes such as heat-resistant materials and welding rods. Thorium is highly toxic due to its chemical and radiological characteristics. The major pathways for contamination with thorium are ingestion of food and water containing thorium and inhalation of thorium-contaminated dust. Similar to other radionuclides, the primary health effect of thorium is the risk of lifetime cancer mortality, particularly for bone cancer. Thorium is poorly absorbed by digestive tract and most ingested thorium is eliminated in the urine. Therefore, there is a substantial need for determination of thorium in urine to evaluate the internal exposure during a radiological emergency, as well as for monitoring occupational workers and populations that live in areas with high background levels of thorium.

People normally excrete low levels of thorium (ng/L levels). This requires that thorium analytical methods have low detection limits, and high sensitivity and accuracy. Several analytical techniques have been reported for thorium analysis, including alpha spectrometry, neutron activation analysis, and thermal ionization mass spectrometry. However, these methods are hindered by tedious, time-consuming sample preparation and limited availability of the analytical equipment. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) has commonly been used for high sensitivity materials analysis since late 1990s because of its excellent detection limits, short analysis time and multi-isotope capability. Sector field and quadrupole are the two types of ICP-MS. While the former has higher sensitivity and lower detection limits, it is more expensive than the latter. However, both types of ICP-MS are hampered by thorium's memory effect in their sample introduction systems, which is therefore an issue for this ICP-MS application. This study's purpose is to develop a thorium analytical method, using a new generation of quadrupole ICP-MS which eliminates the memory effect without using hazardous hydrofluoric acid.

The method developed in this study meets CDC's requirements for a rapid, high throughput, simple method that is easily transferable to other laboratories. It uses a new generation of quadrupole ICP-MS, PerkinElmer's NexION® 300D that has a unique triple cone interface, a Universal Cell ion-filtering design and 90° ion path, and is equipped with Pt cones. This method does not require complex sample preparation. A half mL of urine is diluted directly by a factor of 10 with diluent containing 2% nitric acid and 1 µg/L ^{233}U as an internal standard. No polyatomic interferences from the urine matrix were detected. Use of a rinse solution containing 5% nitric acid and 0.025 M oxalic acid significantly reduced the Th memory effect. The preliminary result for the method detection limit is comparable with that for previously published sector field ICP-MS methods (~ 1 ng/L). The detailed analytical process and validation results will be described.