World Academy of Science, Engineering and Technology
International Journal of Nuclear and Quantum Engineering
Vol:11, No:06, 2017

Determination of Rare Earth Element Patterns in Uranium Matrix for Nuclear Forensics Application: Method Development for Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Measurements

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Abstract : During the last 50 years, the worldwide permeation of the nuclear techniques induces several new problems in the environmental and in the human life. Nowadays, due to the increasing of the risk of terrorism worldwide, the potential occurrence of terrorist attacks using also weapon of mass destruction containing radioactive or nuclear materials as e.g. dirty bombs, is a real threat. For instance, the uranium pellets are one of the potential nuclear materials which are suitable for making special weapons. The nuclear forensics mainly focuses on the determination of the origin of the confiscated or found nuclear and other radioactive materials, which could be used for making any radioactive dispersive device. One of the most important signatures in nuclear forensics to find the origin of the material is the determination of the rare earth element patterns (REE) in the seized or found radioactive or nuclear samples. The concentration and the normalized pattern of the REE can be used as an evidence of uranium origin. The REE are the fourteen Lanthanides in addition scandium and yttrium what are mostly found together and really low concentration in uranium pellets. The problems of the REE determination using ICP-MS technique are the uranium matrix (high concentration of uranium) and the interferences among Lanthanides. In this work, our aim was to develop an effective chemical sample preparation process using extraction chromatography for separation the uranium matrix and the rare earth elements from each other following some publications can be found in the literature and modified them. Secondly, our purpose was the optimization of the ICP-MS measuring process for REE concentration. During method development, in the first step, a REE model solution was used in two different types of extraction chromatographic resins (LN® and TRU®) and different acidic media for environmental testing the Lanthanides separation. Uranium matrix was added to the model solution and was proved in the same conditions. Methods were tested and validated using REE UOC (uranium ore concentrate) reference materials. Samples were analyzed by sector field mass spectrometer (ICP-SFMS).

Keywords : extraction chromatography, nuclear forensics, rare earth elements, uranium
Conference Title : ICNRRM 2017 : International Conference on Nuclear, Radiochemical and Radiobiological Measurements
Conference Location : Copenhagen, Denmark
Conference Dates : June 11-12, 2017