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First Primary Reference Material for Uranium Age Dating in Nuclear Forensics

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Nuclear forensics is a relatively young science, which develops and applies thorough, interpretative and comparative (radio-) analytical methodologies to investigate the origin and intended use of nuclear or other radioactive material intercepted from illicit trafficking. The parameters to be investigated are inherent to the material and range from isotopic composition, microstructure, chemical impurities to decay products [1].

Among these parameters, the elapsed time since the production of the material (commonly referred to as the "age" of the material) is measured for nuclear materials. This age - i.e. the time elapsed since the last chemical separation of the daughter nuclides from the mother radionuclide (typically U and Pu) - supports the identification of the origin of unknown material. To establish the accurate age of a nuclear material validated mass spectrometric or radiometric methods are indispensable. Therefore reference materials certified for production date or last chemical separation date of nuclear material are indispensable.

In this paper, the preparation and certification of a uranium reference material certified for the production date based on the 230Th/234U radiochronometer is described. The project is jointly implemented by the European Commission - Joint Research Centre Institute for Transuranium Elements (preparation of the material) and the EC JRC Institute for Reference Materials and Measurements (certification and distribution of the CRM as IRMM-1000). The CRM was prepared from a low-enriched uranium solution after complete separation of thorium decay products (zeroing the initial daughter nuclide concentration) at a well-known time and allowing the ingrowth of the daughter nuclides [2]. The complete elimination of thorium from the initial material, which is the key parameter to determine the age of the material, was verified by gamma spectrometry after each separation step and by mass spectrometry adding 232Th as tracer. The reference value was confirmed on 6 randomly selected units using mass spectrometry and comparing the calculated age of the material based on the measured 230Th/234U ratio and given half-lives with the known age of IRMM-1000. The homogeneity of the batch was assessed in the same way using 10 randomly selected items. Two unit sizes were produced containing 20 mg and 50 mg uranium.

IRMM-1000 has been produced in compliance with ISO Guide 34 and will be available beginning of 2015. However, prior to its release, the EC-JRC-IRMM launched REIMEP-22 inter-laboratory comparison "U Age Dating - Determination of the production date of a uranium certified test sample" within the framework of the IRMM Regular European Inter-laboratory Measurement Evaluation Programme using the same material.

References

[1] K. Mayer, M. Wallenius et al. (2011). Nuclear Forensics: A method applicable to Nuclear Security and to Non-Proliferation. INPC2010, Journal of Physics: Conference Series 312 doi:10.1088/1742-6596/312/6/062003.

[2] Z. Varga, A. Nicholl, M. Wallenius and K. Mayer (2012). Development and validation of a methodology for uranium radiochronometry reference material preparation. Analytica Chimica Acta 718, 25–31.

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