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Re-determination of the half-life of 229Th

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229Th is an alpha-decay nuclide of the neptunium decay series. Though already extinct in nature, 229Th occurs in high amount in spent fuel as the progeny of the long-lived 237Np. 229Th is one of the most widely used tracers in geology, environmental sciences or nuclear chemistry to determine 230Th and 232Th concentrations by mass spectrometry due to the relatively long half-life and to the fact that it does not occur in nature. 229Th as an isotopic tracer plays a special role in nuclear forensics, where its uncertainty associated with its concentration is one of the most dominant components in the uncertainty budget of radiochronometry of illicit nuclear materials1. As the 229Th standards are certified by activity concentration (e.g. Bq g-1), the accurate knowledge of 229Th half-life value is of utmost importance to convert it to amount content (e.g. mol g-1) needed for mass spectrometry. The first precise half-life measurement of 229Th was accomplished by Hagemann et al.2 and gave a value of 7340 ± 160 years. However, a later measurement by Goldstein et al.3 by isotope dilution mass spectrometry reported an approximately 7% higher half-life of 7880 ± 120 years. Recently, Kikunaga et al.4 measured the 229Th half-life by alpha spectrometry. Their half-life value of 7932 ± 55 years is consistent with the result obtained by Goldstein et al., and the authors suggest that the inaccuracy of the early half-life value is attributed to incomplete separation of 233U from its impurities.
The aim of the present study is to re-measure the 229Th half-life using inductively coupled plasma mass spectrometry (ICP-MS) at lowest possible uncertainty. By the measurement of the 229Th amount content in the certified 229Th radioactivity standard (SRM 4328C), the half-life of 229Th can be calculated. The amount content of 229Th was determined by two independent methods, both traceable to SI. In the first method, the 229Th amount content was measured by isotope dilution ICP-MS technique, using a natural thorium certified reference material as a tracer. In the second method, the 229Th amount content was measured against a completely separated highly-enriched uranium solution. In this case, the applied uranium sample was completely purified from its thorium decay products beforehand at a well-known time. Thus the 230Th daughter product of the 234U, which serves actually as the tracer for the 229Th determination, can be very precisely calculated knowing the 234U content and the elapsed time between the uranium separation and 229Th determination1. Our measured 229Th half-life of 7921 years with an expanded uncertainty of 56 years (k =2) is in agreement with the latest values. Uncertainty was calculated according to the GUM (Guide for the Expression of Uncertainty in Measurement). The obtained value can help resolve the problem with 229Th half-life discrepancy, and can result in more precise age dating measurements both for geological and nuclear samples.
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