

The Attom High Resolution ICP-MS: Measurement of Plutonium in Seawater

Introduction

Plutonium is a radiogenic element that is principally of anthropogenic origin, though it does occur naturally in minute quantities (for example in concentrated uranium ores). Most Pu present in the environment originates from nuclear weapons tests and to a lesser degree from nuclear power station incidents. Measurement of the isotopic composition of Pu may help identify the origin.

With current mass spectrometric techniques, detection of environmental Pu has become less arduous. However, isotopic measurement is still difficult due to the low abundance of each isotope. Typically, measurements are made using instruments that detect isotopes simultaneously (e.g. MC-ICP-MS or TIMS) though the cost and complexity of such instrumentation may be prohibitive.

A potential solution is to use a high resolution ICP-MS (HR-ICP-MS) with a fast scanning system to rapidly measure each isotope sequentially. The Nu Attom has an ultrafast peak jumping that is particularly suited to isotopic measurements such as these. We report Pu measurements of a certified reference material using this peak jumping technique.



Instrumentation

The Nu Attom is a double-focusing, high-resolution magnetic sector mass spectrometer. The instrument is entirely purpose designed and built to provide the best performance and reliability coupled with flexibility and ease-of-use for precise and accurate elemental and isotope ratio analysis. A unique detector system gives the Nu Attom a large dynamic range, and its electrostatic scanning capability has the widest range in its class (40%). Furthermore, variable high resolution means that sufficient resolution for isobaric separation can be selected with minimum compromise in sensitivity.

Experiment

A pre-concentrated and radiochemistry treated sample of the certified reference material IAEA-381 (Irish Sea Water) was measured for Pu isotopes in ultrafast peak jumping mode. It was spiked with a ^{242}Pu isotopic tracer. The sample was introduced via a Nu Instruments DSN-100 desolvating nebuliser. Dwell time for ^{238}U (the remaining fraction after radiochemistry treatment) was 300 ms. Dwell times for ^{239}Pu , ^{240}Pu , ^{241}Pu and ^{242}Pu were 600 μs each. Peak jumps were made at 70 μs . Therefore, the total time for one sweep was around 3 ms. One cycle consisted of 3000 sweeps. Each run consisted of 25 cycles and thus, each run was around 225 s long. A deadtime correction of 14 ns was applied to signal intensities.

Raw isotope ratios of 5 replicate analyses are presented here demonstrating the feasibility of measuring isotope ratios in very low concentration samples with the Attom HR-ICP-MS in ultrafast peak jumping mode. The data is displayed in Table 1.



Discussion

The data shown in Table 1 below indicates that the Nu Attom is easily able to detect the low levels of Pu present in sea water. The $^{240}\text{Pu}/^{242}\text{Pu}$ isotope ratio is measured to 0.6% precision and even the $^{240}\text{Pu}/^{239}\text{Pu}$ isotope ratio (with no isotope spike) is measured to a precision of 1.2%. The speed of analysis (less than four minutes per run) makes the Nu Attom an ideal solution for the detection and quantitation of environmental plutonium.

²³⁸ U (cps)	²³⁹ Pu (cps)	²⁴⁰ Pu (cps)	²⁴¹ Pu (cps)	²⁴² Pu (cps)	²³⁹ Pu/ ²⁴² Pu	2 SE	²⁴⁰ Pu/ ²⁴² Pu	2 SE	²⁴⁰ Pu/ ²³⁹ Pu	2SE
25846	603	143	7	2927	0.205054	0.002604	0.048816	0.001496	0.240819	0.006527
25257	595	139	7	2877	0.207032	0.002958	0.048323	0.001195	0.233675	0.006638
25681	600	142	6	2920	0.204107	0.001999	0.04833	0.001404	0.236842	0.006853
27184	601	139	7	2883	0.208863	0.002947	0.04812	0.001379	0.233893	0.006866
26042	579	136	7	2788	0.207506	0.00224	0.048693	0.001399	0.237361	0.005029
Mean					0.206512		0.048456		0.236518	
SD					0.001917		0.000288		0.002928	
RSD%					0.928		0.594		1.238	

Table 1: Plutonium count rates and isotope ratios for IAEA-381 as measured on the Nu Attom

Conclusions

The Nu Attom is a high resolution ICP-MS that is ideal for the most demanding ICP-MS requirements where sensitivity, precision, and speed of analysis are paramount. Isotope ratios of plutonium can be measured rapidly, accurately and precisely even at the levels found in typical sea water samples.