Improvement of Particle Recovery Method for Uranium Isotope Analysis Using SIMS

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1. Introduction

In environmental samples, the isotopic ratios of nuclear particles provide the important information required for tracking undeclared nuclear activities. Secondary Ionization Mass Spectrometry (SIMS) is major technique used for measuring the isotopic ratio of individual particles, because it can specify the location of uranium particles and measure isotopic ratios in a rapid manner. The particles including nuclear materials are first detected using APM (Automated Particle Measurement) and precise isotopic analysis of individual particles are performed with microbeam. Thus, the detecting of particles of interest is important.

In our laboratory, a vacuum-suction impactor has been used to collect the uranium particles on carbon planchet for SIMS analysis (Fig. 1a.). The original design is simple and efficient, but has a limitation that the collected particles are inevitably concentrated at the center of the planchet, thus causing 'mixing effect' which is averaging out the isotopic ratios of individual particles.

In this study, we developed a new design of vacuum-suction impactor with wider inlet nozzle and outlet nozzle for guiding particles to disperse the particles on the surface of carbon planchet. We prepared simulated samples with lead dioxide and examined particle recovery yield and degree of dispersion using the conventional vacuum impactor and the newly designed ones with different inlet nozzle diameters. We evaluated the particle recovery yield by using the X-ray fluorescence spectrometry (XRF) analysis and weighing method. In addition, we observed the surface of carbon planchet using microscope to confirm the degree of dispersion of collected particles. Then, we investigated the mixing effect by analyzing the mixed uranium standard materials consisting of CRM U020 and CRM U050.

2. Experimental

We modified the inlet part of vacuum impactor to improve the degree of dispersion by increasing the diameter of the exit of inlet nozzle from 1 mm to 3 mm, 5 mm, 7 mm, and 10 mm, respectively. Then we prepared the simulated samples using PbO_2 powder for testing the recovery yield and the degree of dispersion, and uranium standard materials (CRM U020 and CRM U050) for SIMS measurement. Each sample was collected on the carbon planchets which were coated with grease material by using the conventional and modified impactors. After the particle recovery, carbon planchets were heated to remove adhesive materials at 500℃ for 15 minutes.

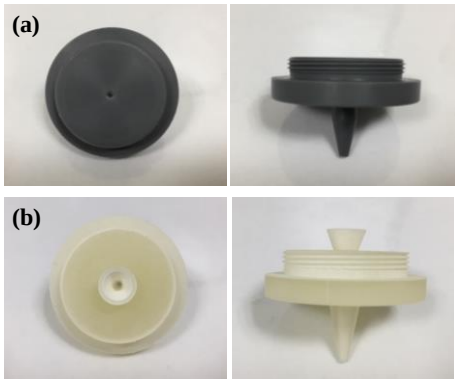

Fig.1. Inlet part of vacuum - impactor (a) conventional (1 mm inner diameter) , (b) 1 mm of the entrance of inlet nozzle, 3 mm exit of the inlet nozzle.

3. Results and discussion

3.1 Comparing particle recovery efficiency

We observed the surface of carbon planchet using microscope, and confirmed that as the diameter of the inlet nozzle became larger, the recovered particles were uniformly dispersed on the planchet.

The recovery yield of collected particles using each of impactors was estimated by comparing the relative area of Pb-Lα peak in XRF spectra. When the diameter of the exit of inlet nozzle was 3 mm or 5 mm, the recovery yield was higher than that of the conventional impactor. Considering the degree of dispersion that can reduce the mixing effect, the impactor with the exit diameter of 5 mm is considered to be suitable.

3.2 APM analysis of uranium standard materials

When the mixed uranium simulated sample consisting of CRM U020 and CRM U050 was recovered using conventional impactor, it was difficult to measure the isotope ratio distribution accurately using APM because

the uranium particles were collected densely on the center of planchet. As a result of using impactor with exit diameter of 5 mm, we can measure the isotope ratios of uranium particles with less mixing effect.

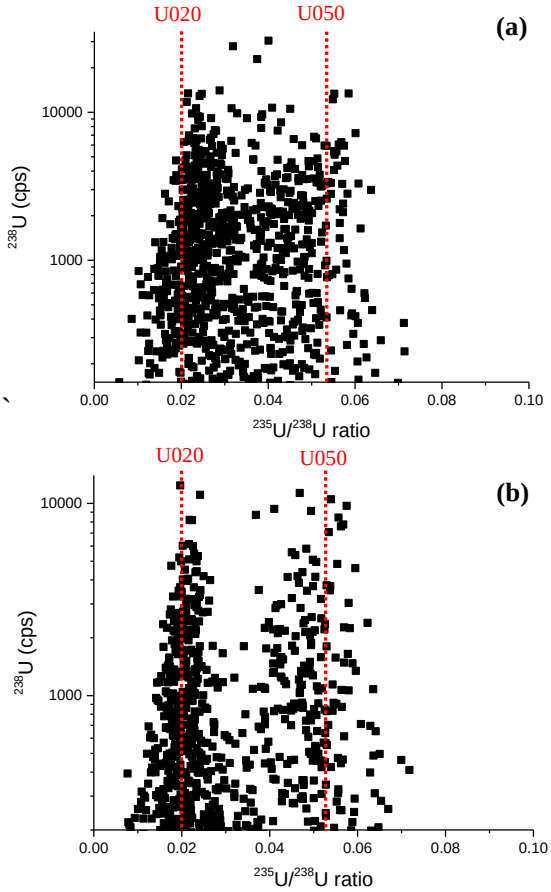

Fig.2. Isotope ratio distributions of recovered uranium particles using vacuum impactor (a) conventional, (b) 5 mm exit diameter of inlet nozzle

4. Conclusion

We tried to improve the inlet part of vacuum impactor, in order to increase the recovery yield and disperse the collected particle on carbon planchet. As the diameter of inlet nozzle became larger, the collected particles were better dispersed on planchet. In addition, when the inner diameter of the impactor was 3 mm or 5 mm, the recovery yield was higher than that of conventional impactor. Considering the degree of dispersion and recovery yield, we used the impactor with 5 mm exit diameter and recovered the mixed uranium standard materials for SIMS measurement. We were able to reduce the mixing effect and measure the isotopic ratio more accurately and precisely.

REFERENCES

[1] Esaka, F., Watanabe, K., Fukuyama, H., Onodera, T., Esaka, K. T., Magara, M., Sakurai, S., Usuda, S. (2004). *Journal of nuclear science and technology*, 41(11), 1027-1032.