Production of Np-236 in the ^{232}Th + ^{7}Li reaction for standard material in accelerator mass spectrometry

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Neptunium-236 can be a useful tracer in the determination of ^{237}Np, an isotope of minor-actinide Np, which exists in tiny quantities in the environment owing to its release from nuclear facilities. Such determination is of practical use in various earth science fields such as surface material circulation and environmental pollution assessment.[1] The measurement of ^{237}Np is expected to be quantified by accelerator mass spectrometry (AMS), although an internal standard method for Np needs an appropriate spike. Tracers for several elements are available now, but the spike for neptunium has not been developed yet. We aim to devise an efficient method for the production of ^{236}Np in the ground state of half-life 1.54×10^5 y as a candidate for the spike nuclide.

In this study, ^{236}Np tracer production was implemented in the reaction of ^{232}Th + ^{7}Li to measure ^{237}Np. In the beginning of the project, the excitation functions of Np isotopes and by-products were measured using target stacks of Th metal foils. We irradiated the targets with 42 MeV ^{7}Li ions from the RIKEN AVF cyclotron while integrating the beam current with a Faraday cup in the irradiation course. Chemical procedures were performed to isolate Np atoms from the target. The target material was dissolved in a mixed acidic solution of 0.027 M HF and 3 M HNO_3, and the sample was dried by heating. Then, the residue was adjusted to 4 mL of 3 M HNO_3 solution, reduced with ascorbic acid and Fe ions and introduced into a TEVA resin column; subsequently, it was treated with 3 M HNO_3 and 10 M HCl for purification and finally with 0.1 M HCl for the elution of Np. To remove Pa, another process with a TK 400 column was performed. To determine the yields of Np isotopes and by-products, γ-ray spectrometry was conducted for the effluents with a Ge detector. For the Np-236g measurement, samples for AMS and ICP-MS were prepared through purification with UTEVA resin after waiting for Np-236m to decay out, and they were brought to the VERA facility in the University of Vienna, with which this project is in collaboration.

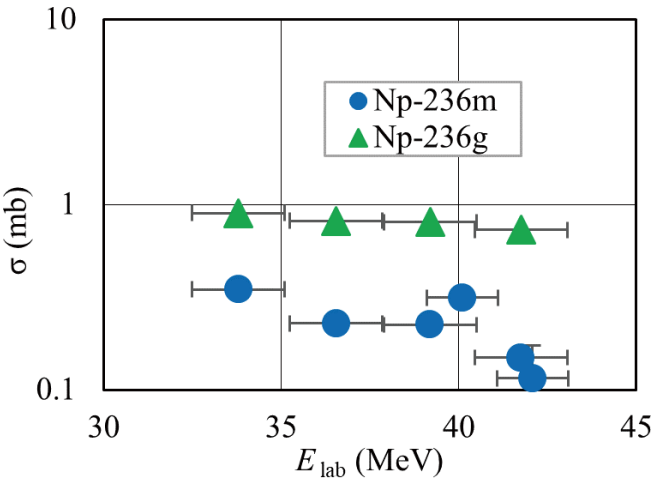

Fig. 1. Excitation functions of the production of Np-236m and Np-236g isomers.

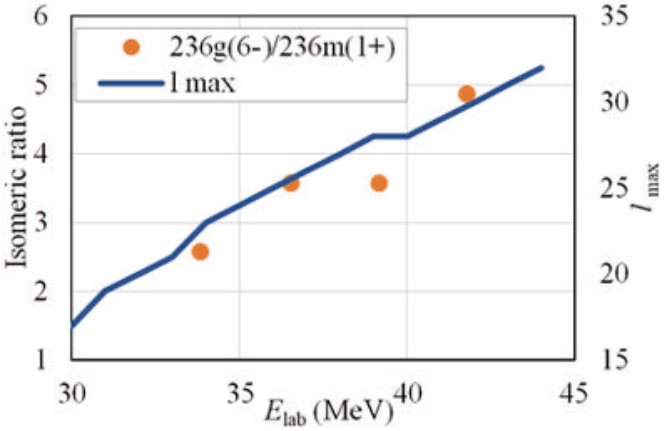

Fig. 2. Isomeric ratios of ^{236}Np and angular momenta transferred into targets.

Figure 1 shows the excitation functions of the production of Np-236m and Np-236g. The yield in the ground state (6−) was found to be larger than that in the excited state (1+) in the studied energy range, although the former data are preliminarily taken.

Isomeric yields of the product are thought to be correlated with angular momentum in the composite system if their spins substantially differ from each other. The maximum orbital angular momenta transferred to the nuclear system were estimated using the ALICE code[2] and compared to the isomeric ratios of ^{236}Np in Fig. 2. The figure shows the correlation of observation to angular momenta. The analysis of the result is in progress, and additional experiments including mass spectrometry are in planning to confirm the precision and reproducibility of the data.

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