Production of Np isotopes in nuclear reactions for standard material in accelerator mass spectrometry

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The techniques for highly sensitive mass spectrometry, such as ICP-MS and AMS, are rapidly being developed currently. Several elements or nuclides that were not supposed to be applicable in those techniques several decades ago are now quantitatively analyzed. Especially, for long-lived actinides elements, the techniques are becoming more important as a promising alternative to radioactivity measurements. The tracer nuclide for target elements, which is non-existent in nature and absent in target samples, is necessary to establish a standard in the new techniques. Tracers for several elements are available now but the tracer for neptunium has not been developed yet. We aim to devise an efficient method for the production of Np-236 in the ground state of half life 1.54×10^5 y as a candidate for tracer nuclide.

In this study, the Np tracer production was implemented in the reactions of ^{232}Th + ^{7}Li and ^{238}U + p to measure Np-237 in environmental samples.

For irradiation, target stacks of Th metal foils of two tytpes of thickness were prepared: a thin target for the excitation function measurement and a thick target for tracer production of Np. A silver foil was irradiated at the same time to monitor the beam intensity from the radioactivity of ^{111}In generated during the irradiation with current integration using a beam course equipped with Faraday cup.

We irradiated the targets with 42 MeV ^{7}Li ions from the RIKEN AVF cyclotron. Chemical procedures were performed to isolate Np atoms from the target. As an example of the procedure, the target material was dissolved in 3 M HNO_3 with Np-239 tracer to check chemical recoveries and the sample was dried by heating. The residue was then dissolved in conc. HCl, repeatedly dried three times, and finally adjusted to 3 M HNO_3 solution of 4 ml. This solution was introduced into a TEVA resin column, subsequently treated with 3 M HNO_3 and 10 M HCl for purification, and finally treated 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.

As an example of the result, a measured γ spectrum is shown in Fig. 1, where many photopeaks of Np isotopes including Np-236m are observed. Figure 2 compares the excitation function of Np-236m obtained from this study to that obtained from the 39 MeV p + U experiment conducted in RCNP of Osaka University. Although the cross section of Th + Li is nearly two orders of magnitude lower than that of U + p, it is predicted that the isomeric ratio of Np-236g to Np-236m for the products of the former reaction is larger than that for the latter, which had been measured to be around 0.5.[1)] The analysis of the result is still in progress and additional experiments including mass spectrometry are in the planning stage at present.

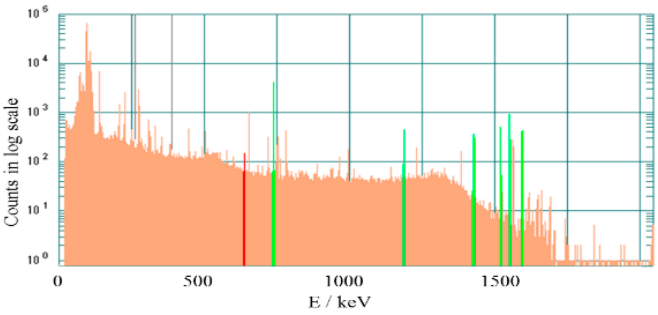

Fig. 1. Example of γ spectrum of isolated Np. (Red: Np-236m, Green: Np-234)

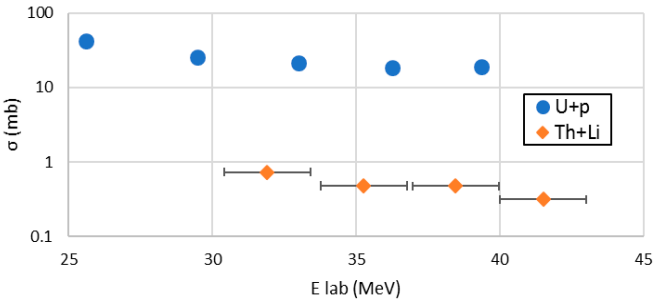

Fig. 2. Exciting functions of ^{236m}Np in reactions of ^{238}U + p and ^{232}Th + ^{7}Li.

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Reference

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