Production of neutron-rich nuclei in the vicinity of $N = 126$ by means of projectile fragmentation of 345 MeV/nucleon ^{238}U

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The neutron-rich nuclei located along the neutron closed shell $N = 126$ are of great importance for investigating the evolution of $N = 126$ shell closure, as well as for understanding the r-process of stellar nucleosynthesis. Experimental information, however, are scarcely available, due to the difficulties in producing these unstable nuclei. Recently, a multi-nucleon transfer reaction with a stable beam was experimentally investigated, and it has proved to be a promising method for producing neutron-rich nuclei around $N = 126$.[1)] Another prospective reaction for producing these nuclei is the fragmentation of heavy projectiles such as lead and uranium. The lightest $N = 126$ nucleus so far, ^{202}Os, was produced by the projectile fragmentation of a 1 GeV/nucleon ^{238}U beam.[2)]

To access the unexploited region around $N = 126$, we conducted an experiment aimed at producing neutron-rich nuclei around $N = 126$ by means of the projectile fragmentation of a high-intensity 345 MeV/nucleon ^{238}U beam using the BigRIPS in-flight separator[3)] at the RIKEN RI Beam Factory.[4)] The intensity of the ^{238}U beam was 45 particle nA on average. The production target, which was made of beryllium, was 5 mm thick. The setting of the BigRIPS separator was optimized for the production of ^{200}W, where the magnetic rigidity $B\rho$ settings before and after F3 were tuned for hydrogen-like and helium-like ^{200}W ions with charge state $Q = 73$ and 72, respectively. We employed the two-stage isotope separation mode to sufficiently purify the neutron-rich isotope beams of interest, in which the aluminum degraders were installed not only at the F1 but also at the F5 foci. The details of experimental conditions are summarized in Table 1. The particle identification (PID) was obtained event by event on the basis of the ΔE-TOF-$B\rho$ method, thus deducing the atomic number Z and the mass-to-charge ratio A/Q of the fragments.[5)]

Table 1. Experimental conditions for ^{200}W setting

Production target	Be 5 mm
$B\rho$	6.8000 Tm
Degraders	Al 5 mm at F1, Al 1 mm at F5
Intensity of ^{238}U	45 pnA
Running time	8 hours
F1 slit	±32 mm (±1.5% in $\Delta p/p$)
F2 slit	±10 mm
F5 slit	±48 mm
F7 slit	±25 mm
Total rate at F1	$\approx 10^9$ Hz
Total rate at F3	2.5×10^5 Hz
Total rate at F7	30 Hz

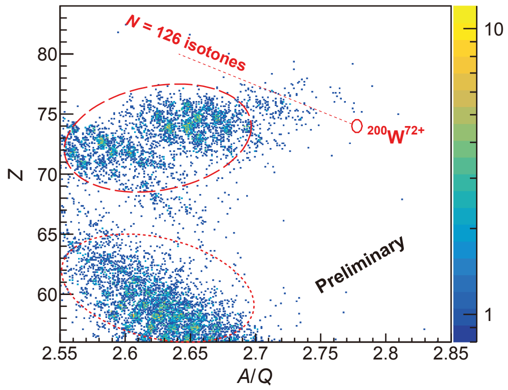

Fig. 1. Particle identification plot of Z vs A/Q for fragments produced in the ^{238}U + Be reaction. The fragments with $Z > 70$ were produced by the projectile fragmentation. The $N = 126$ isotones are expected to be located on the red dotted line. The location of ^{200}W is indicated by the red solid circle, where no events were observed. The blobs in the red dashed circle correspond to the events whose charge states change at F5. The blobs in the red dotted circle correspond to the fission-originated contaminants.

Figure 1 shows the Z vs A/Q PID plot for fragments produced in the ^{238}U+Be reaction. The neutron-rich nuclei around $N = 126$ were produced and identified as shown in the figure, although the resolving power of PID needs to be improved. No events were observed for ^{200}W in the present short-time measurement of 8 h. An elaborate data analysis is currently in progress.

References

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