^{7}Li-induced reactions on ^{nat}Cu for monitor reactions

M. Aikawa,[*1,*2] S. Goto,[*3] G. Damdinsuren,[*1] D. Ichinkhorloo,[*4] N. Ukon,[*5] and H. Haba[*2]

^{211}At ($T_{1/2}$ = 7.214 h) is a promising radionuclide for targeted alpha-particle therapy. Its longer-lived parent ^{211}Rn ($T_{1/2}$ = 14.6 h) is expected to be used in a ^{211}Rn/^{211}At generator.[1] The production of ^{211}Rn can be achieved through lithium-induced reactions on ^{209}Bi. To practically use the generator, reliable energy-dependent cross sections are required for these reactions. Although lithium-induced monitor reactions are essential for the production of ^{211}Rn and the suppression of unnecessary coproducts, currently, no established monitor reactions exist. Therefore, we focused on ^{7}Li-induced reactions on natural copper as a possible monitor reaction. Our literature survey found only one experimental study on the ^{7}Li-induced reactions.[2] We conducted experiments to ensure the reliability of energy-dependent cross sections. To evaluate the cross sections, thick target yields (TTY) for the reactions were measured and compared with calculated yields using the obtained cross sections.

We conducted the experiment at the AVF cyclotron in RIKEN. The stacked-foil activation technique and γ-ray spectrometry were used. Two targets for cross sections (#1 and #2) comprised thin metallic foils of ^{nat}Cu (0.005 × 100 × 100 mm, 99.9% purity), ^{nat}Ti (0.005 × 50 × 100 mm, 99.6% purity), and ^{27}Al (0.005 × 100 × 100 mm, >99% purity). Another target for the TTY (#3) consisted of a thicker ^{nat}Cu foil (0.025 × 100 × 100 mm, 99.9% purity). The thicknesses of the foils were determined on the basis of the measured lateral size and weight. The foils were cut into small pieces (10 × 10 mm) to stack in a target holder. The configurations of the two targets (#1 and #2) were changed to obtain cross sections at different projectile energies. Each target possessed 17 sets of Ti-Al-Cu-Al or Cu-Al-Ti-Al foils. The ^{27}Al foils were used to capture recoiled reaction products. The target for the TTY comprised eight Cu foils, which were thicker than the aforementioned foils.

Targets #1, #2, and #3 were irradiated for 60, 60, and 30 min with 72-MeV ^{7}Li beams, respectively. The primary beam energy was measured using the time-of-flight method.[3] The energy degradation was calculated on basis of thicknesses and stopping powers derived from the SRIM code.[4] The measured average beam currents were 314, 321, and 309 nA for targets #1, #2 and #3, respectively.

*1 Faculty of Science, Hokkaido University
*2 RIKEN Nishina Center
*3 Graduate School of Biomedical Science and Engineering, Hokkaido University
*4 Nuclear Research Center, National University of Mongolia
*5 Advanced Clinical Research Center, Fukushima Medical University

γ rays emitted from the irradiated foils were measured using an HPGe detector. The cross-section measurements were performed for irradiated Cu foils with the subsequent Al catcher foils. The measurements of target #3 were performed for each Cu foil with its downstream ones for the TTY.

The cross sections and TTY of ^{67}Ga ($T_{1/2}$ = 3.2617 d) are illustrated in Figs. 1 and 2. The preliminary results were determined using the 300.2-keV γ line (I_{γ} = 16.64%) emitted with the decay of ^{67}Ga. The measurements were performed after cooling for more than 43 hours.

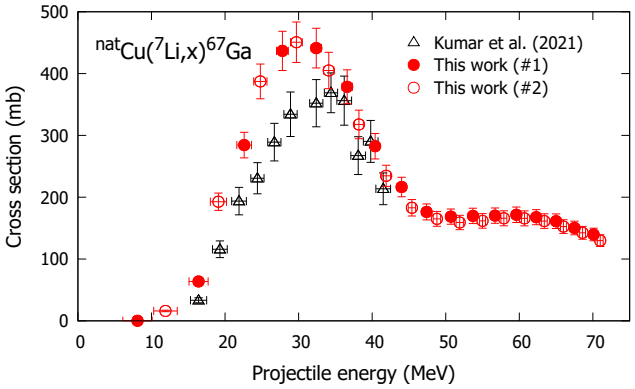

Fig. 1. Cross sections of the ^{nat}Cu(^{7}Li, x)^{67}Ga reaction with the literature data.[2]

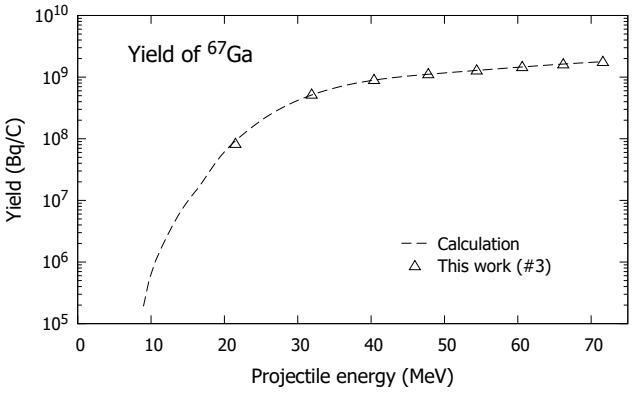

Fig. 2. Experimental and calculated TTY of ^{67}Ga.

Figure 1 shows the cross sections of the ^{nat}Cu(^{7}Li, x)^{67}Ga reaction with the literature data.[2] The literature data are apparently smaller than our results below 35 MeV. Figure 2 shows the comparison between the experimental TTY obtained in this study and the calculated yields using measured cross sections in Fig. 1. The experimental yields well agree with the calculated

DOI:10.34448/RIKEN.APR.57-026

yields. The excitation function exhibiting a smooth and clear peak indicates that the reaction can be used as a monitor reaction.

References

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