Activation cross sections of ^{7}Li-induced reactions on ^{nat}Ni

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Copper radionuclides can be used in nuclear medicine.[1)] ^{64}Cu ($T_{1/2}$ = 12.70 h) and ^{67}Cu ($T_{1/2}$ = 61.83 h) are used for positron emission tomography (PET) and β^--particle therapy, respectively. Their combination may provide theranostic treatments. ^{62}Cu ($T_{1/2}$ = 9.672 min) is another positron emitter (I_{β^-} = 97.83%) suitable for PET, which can be produced via the ^{62}Zn/^{62}Cu generator.[2)] The parent nucleus, ^{62}Zn ($T_{1/2}$ = 9.193 h), is synthesized through charged-particle-induced reactions on copper and nickel targets. One such reaction for ^{62}Zn production is the ^{7}Li-induced reaction on ^{nat}Ni. This reaction is also a candidate for a monitor reaction, for which we have started a systematical study.[3,4)]

Three experiments were performed at the AVF cyclotron at RIKEN: two to determine excitation functions and one to measure thick target yields. All irradiations were performed using 71-MeV ^{7}Li beams, employing stacked-foil activation and γ-ray spectrometry.

Three separate targets were prepared for these experiments. Targets #1 and #2, used for measuring excitation functions, consisted of thin metallic foils of ^{nat}Ni (4.33 ± 0.04 mg/cm^2), ^{nat}Cu (4.49 ± 0.04 mg/cm^2), ^{nat}Ti (2.34 ± 0.02 mg/cm^2), and ^{27}Al (1.82 ± 0.02 mg/cm^2). The two targets comprised fourteen sets of Ni-Al-Cu-Al foils and sixteen sets of Ni-Al-Ti-Al foils. The ^{27}Al foils were interleaved to catch recoiled reaction products from adjacent target foils. Target #3 was composed of five thick ^{nat}Ni foils (44.3 ± 0.4 mg/cm^2) to measure thick target yields.

The three targets were irradiated with ^{7}Li beams for 30 min each. The average beam currents, measured by Faraday cups, were 298 ± 15 electric nA (enA) for target #1, 297 ± 15 electric nA (enA) for target #2, and 313 ± 15 electric nA (enA) for target #3. The incident beam energy was 71.4 ± 0.4 MeV for all irradiations. Energy degradation in the stacked targets was calculated based on stopping powers derived using the SRIM code.[5)] γ rays emitted from the activated foils were detected using two high-purity germanium (HPGe) detectors. One detector was assigned to targets #1 and #3, while the other was assigned to targets #2 and #3. Each foil was measured five to six times to monitor the decay of products with different half-lives. Nuclear data for the γ-ray spectrometry were obtained from the online databases NuDat 3.0[6)] and LiveChart.[7)]

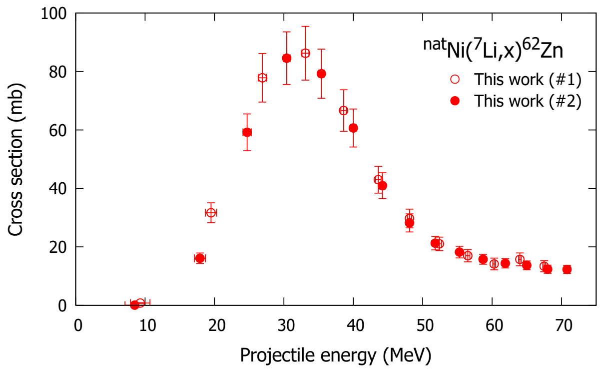

Fig. 1. Cross sections of ^{nat}Ni(^{7}Li, x)^{62}Zn reaction.

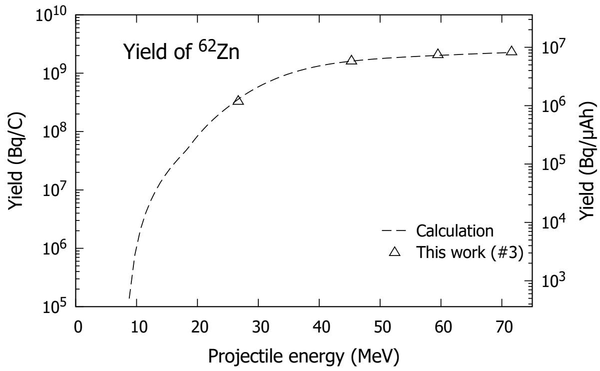

Fig. 2. Physical thick target yield of ^{62}Zn.

Production cross sections of ^{62}Zn ($T_{1/2}$ = 9.186 h) derived from the γ line at 596.56 keV (I_γ = 26%) are presented in Fig. 1. The parent nucleus, ^{62}Ga ($T_{1/2}$ = 116.123 ms), decayed shortly after the end of bombardment. The cumulative cross sections measured with targets #1 and #2 agree with each other. The physical thick target yield for ^{62}Zn was also determined using target #3. The experimental yield was compared with calculated values based on the measured cross sections, as shown in Fig. 2. The good agreement between these values enhances the reliability of both the experimental cross sections and the thick target yield.

The excitation function shows a smooth curve with a peak around 30 MeV. This characteristic suggests that the reaction is a suitable ^{7}Li-induced monitor reaction. However, the γ-ray intensity at 596.56 keV has a relatively large uncertainty of $\Delta I_\gamma / I_\gamma$ = 7.7%. The

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intensity is expected to be determined more accurately in future measurements. The data analysis will be finalized, and updated results will be published in the near future.

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