Activation cross sections of ^{7}Li-induced reactions on ^{nat}Ti: Implications for monitor reactions†

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Radionuclides can be produced in charged-particle-induced reactions for medical applications. Among the projectiles, ^{7}Li may offer new pathways to producing medical radionuclides, *e.g.*, ^{211}Rn for the ^{211}Rn/^{211}At generator.[1)] Practical production of ^{211}Rn requires maximizing its yield while minimizing unnecessary by-products. For these requirements, the optimization of target thickness and beam parameters, which requires reliable monitor reactions, is essential. However, suitable monitor reactions for ^{7}Li-induced reactions have not yet been identified. Therefore, we started a systematic study of potential monitor reactions for ^{7}Li projectiles.[2)]

Titanium is a target material for monitor reactions induced by some other charged particles. It is also considered a promising target for ^{7}Li-induced monitor reactions. In a literature survey using the EXFOR library, we found an absence of experimental data on the cross sections of the reactions. Therefore, we conducted experiments with ^{7}Li beams to determine the activation cross sections and physical thick target yields. The experimental yields were compared with calculated values derived from the measured cross sections to validate our results. The reactions were evaluated for their suitability for monitoring ^{7}Li beam energy and intensity.

Three targets, comprising two for the excitation functions and one for the thick target yields, were irradiated at the AVF cyclotron at RIKEN. All experiments utilized 72-MeV ^{7}Li beams and employed the stacked-foil activation technique. To identify the radioactive products, off-line γ-ray spectrometry was used.

Targets #1 and #2, which were prepared for the excitation function measurements, consisted of thin metallic foils of ^{nat}Ti (2.34 ± 0.02 mg/cm^2), ^{nat}Cu (4.49 ± 0.04 mg/cm^2), and ^{27}Al (1.21 ± 0.01 mg/cm^2). The targets were 17 sets of Cu-Al-Ti-Al and Ti-Al-Cu-Al foils. The ^{27}Al foils were interleaved to catch recoiled products from the adjacent ^{nat}Cu or ^{nat}Ti foils. Target #3, for the thick target yields, consisted of seven thick ^{nat}Ti foils (22.7 ± 0.2 mg/cm^2).

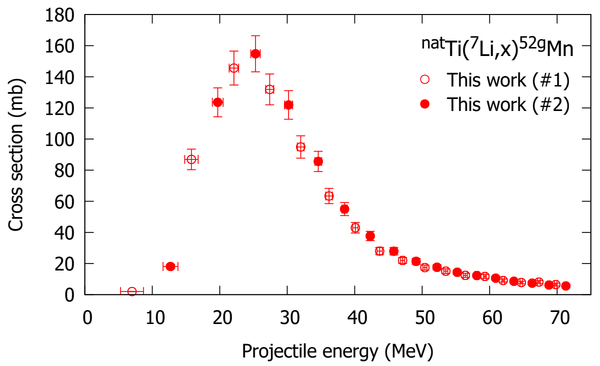

Fig. 1. Cross sections of ^{nat}Ti(^{7}Li, x)^{52g}Mn reaction.

All the targets were irradiated with ^{7}Li beams for 60, 60, and 30 min, respectively. The average beam currents measured by the Faraday cups were 314 ± 16 nA (target #1), 321 ± 16 nA (target #2), and 309 ± 15 nA (target #3). The incident beam energy was 71.6 ± 0.4 MeV. The energy degradation in the targets was calculated using stopping powers derived using the SRIM code.[3)]

γ rays emitted from the activated foils were measured using two high-purity germanium detectors. One detector was assigned to targets #1 and #3, and the other to targets #2 and #3. Each foil was measured three or four times to follow the decay of the reaction products. The nuclear data for the γ-ray spectrometry were retrieved from the online databases NuDat 3.0[4)] and LiveChart.[5)]

Production cross sections for ^{54,52g}Mn, ^{51,49,48}Cr, ^{48}V, and ^{48,47,46}Sc were determined. The cross sections obtained using targets #1 and #2 agree with each other within the uncertainty. The physical thick target yields for ^{54,52g}Mn, ^{51}Cr, ^{48}V, and ^{48,47,46}Sc were also determined using target #3. The yields were compared with the calculated values using the measured cross sections. The good agreement between them enhances the reliability of both the experimental cross sections and thick target yields.

The production cross sections of ^{52g}Mn ($T_{1/2}$ = 5.591 d) derived from 744.23-keV ($I_\gamma = 90.0\%$) γ rays are shown in Fig. 1. The properties of the excitation function indicate that the reaction is suitable for monitoring ^{7}Li beams. In addition, the reactions producing ^{54}Mn and ^{51}Cr are also good candidates for monitor

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reactions.

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