Measurements of alpha-induced cross section for ^{48}Cr and ^{49}Cr up to 50 MeV

H. Kikunaga,[*1,*2] M. Murakami,[*3,*2] Y. Komori,[*2] and H. Haba[*2]

Chromium is one of the essential trace elements in some animals but it also can be toxic in high concentrations. Understanding the behavior of chromium in animals, plants, and the environment is important and influential on the various fields such as biological sciences.

The radioactive tracer technique has been widely recognized as a powerful tool for behavior analysis of elements in trace amounts. The isotopes ^{48}Cr ($T_{1/2}$ = 21.6 h), ^{49}Cr ($T_{1/2}$ = 42.3 m), and ^{51}Cr ($T_{1/2}$ = 27.7 d) have potential as tracers because of their suitable half-lives. In this work, the cross sections for the reactions ^{nat}Ti(α, X)^{48}Cr and ^{nat}Ti(α, X)^{49}Cr up to 50 MeV were measured to produce these isotopes efficiently.

The excitation functions of these reactions were measured by the stacked-foil technique. The target stack containing 20 natural Ti foils (99.5% pure) with thickness of 20 and 40 μm were irradiated with a α-particle beam delivered from the RIKEN K70 AVF Cyclotron for 30 min. The cyclotron was operated at a beam energy of 50.4 MeV, which was confirmed by TOF measurement, with a mean current of around 0.4 μA.

After the irradiation, the target foils were enclosed in a polyethylene film separately and were subjected to γ-ray spectrometry using a high-purity germanium detector. The incident beam energy and flux were determined by activation of the monitor foil technique using the ^{nat}Ti(α, X)^{51}Cr reaction. The reference data were obtained from the IAEA Reference Data[1]. The energy loss in each foil was calculated using the TRIM code[2].

A γ-ray spectrum of a Ti foil sample at an effective energy of around 50 MeV is shown in Fig. 1. The γ-peaks of scandium, vanadium, and chromium are observed in the spectrum. During the tracer preparation, it is necessary to separate chromium from titanium and the other elements.

The cross sections for the ^{nat}Ti(α, X)^{48}Cr and ^{nat}Ti(α, X)^{49}Cr reaction obtained in this work are shown in Fig. 2. For comparison, the earlier experimental data[3–6] of the ^{nat}Ti(α, X)^{48}Cr reaction and the values calculated using the Talys 1.6 code[7] with default parameters are included in Fig. 1. The cross sections of ^{48}Cr obtained in this work is in good agreement with the earlier experimental data. The calculated values with the Talys code reproduce the experimental values of ^{48}Cr and ^{49}Cr with a reasonable accuracy although each peak position of the excitation functions is deviated slightly.

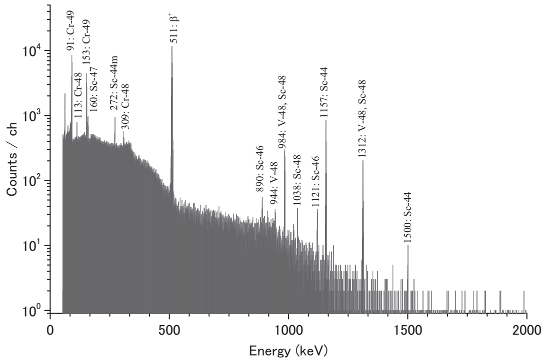

Fig. 1. A γ-ray spectrum of a Ti foil sample at an effective energy of around 50 MeV.

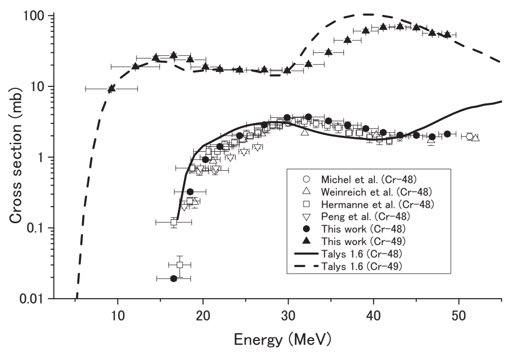

Fig. 2. Cross sections for the ^{nat}Ti(α, X)^{48}Cr and ^{nat}Ti(α, X)^{49}Cr reactions.

*1 Research Center for Electron Photon Science, Tohoku University
*2 RIKEN Nishina Center
*3 Graduate School of Science and Technology, Niigata University

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