**Production cross sections of 45Ti via deuteron-induced reaction on 45Sc**

Tsoodol ZOLBADRAL1,2\*, Masayuki AIKAWA1,3, Dagvadorj Ichinkhorloo2,3, Khishigjargal TEGSHJARGAL4, Yukiko KOMORI5, Hiromitsu HABA5, Sándor TAKÁCS6, Ferenc DITRÓI6, Zoltán SZŰCS6

1 Graduate School of Biomedical Science and Engineering, Hokkaido University, Sapporo 060-8638, Japan

2 Nuclear Research Center, National University of Mongolia, Ulaanbaatar 13330, Mongolia

3 Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan

4 School of Engineering and Applied Sciences, National University of Mongolia, Ulaanbaatar 14201, Mongolia

5 Nishina Center for Accelerator-Based Science, RIKEN, Wako 351-0198, Japan

6 Institute for Nuclear Research (ATOMKI), 4026 Debrecen, Hungary

\*E-mail: zolbadral@nds.sci.hokudai.ac.jp

Production cross sections of the medical radionuclide 45Ti with the deuteron-induced reactions on 45Sc were investigated. The stacked foil activation method and γ-ray spectrometry were used. The physical yield of 45Ti was deduced from the measured cross sections. Our results are consistent with previous experimental data.

1. **Introduction**

The radinuclide 45Ti has a half-life of 184.8 min and is a positron emitter ($E\_{max}=$ 1040 keV, $E\_{ave}=$ 439 keV, $I\_{β^{+}}=$ 84.8%) [1]. The emitted positrons followed its decay are suitable for positron emission tomography (PET) [2]. The deuteron-induced reaction on a 45Sc target is a possible route to produce this radionuclide at cyclotrons. However, only one experimental study [3] on the cross sections of the 45Sc(d,2n)45Ti reaction is available in the literature. Therefore, we measured the cross sections of the 45Sc(d,2n)45Ti reaction.

1. **Experimental methods**

The experiment was performed at the AVF cyclotron of the RIKEN RI Beam Factory. The stacked-foil activation technique and γ-ray spectrometry were adopted to measure the cross sections.

The stacked target consisted of metallic foils of 45Sc (25 m thick, 99.0% purity, Nilaco Corp., Japan and 250 m thick, 99.9% purity, Johnson Matthey Alfa Products company, USA), 27Al (99.6% purity, Nilaco Corp., Japan) and natTi (99.6% purity, Nilaco Corp., Japan). The size and weight of the foils were measured to determine the average thicknesses of the foils. The derived thicknesses were 7.71 and 76.0 mg/cm2 for 45Sc, 4.99 mg/cm2 for 27Al and 9.13 mg/cm2 for natTi, respectively. The foils were cut for the size of 8×8 mm to fit a target holder served also as a Faraday cup.

The target was irradiated for 30 min with a 24-MeV deuteron beam. The incident beam energy was measured by the time-of-flight method [4]. The energy degradation in the stacked target was calculated by the SRIM code [5]. The beam intensity was determined by collecting the charge in the Faraday cup. γ-rays were measured for each irradiated foil by a high-resolution HPGe detector. The detector was calibrated by a mixed standard γ-ray point source. The dead time was kept less than 7% in the measurements.

The cross sections of the natTi(d,x)48V monitor reaction were used to assess the beam parameters. The cross sections were derived from measurements of the 983.5-keV γ-ray (Iγ = 99.98%) emitted with the 48V decay (T1/2 = 15.9735 d), and the result was compared with the IAEA recommended values [6]. The beam intensity measured by the Faraday-cup was decreased by 3.0 % to have good agreement among the derived and the recommended excitation function of the natTi(d,x)48V reaction (Fig. 1). The corrected beam intensity (175.2 nA) was adopted in the data assessment for the cross sections.



Fig. 1. The excitation function of the natTi(d,x)48V monitor reaction compared with the recommended values [6].

1. **Results and Discussion**

The cross sections of the 45Sc(d,2n)45Ti reaction were derived from the measurement of the 719.6-keV γ-ray ($I\_{γ}$ = 0.154 %) emitted in the decay of 45Ti, and are shown in Fig. 2 in comparison with the previous data [3] and the theoretical estimation of TENDL-2017 [7]. Our result is consistent with the previous data. The peak position of the TENDL-2017 data [7] is slightly shifted to the lower energy than those of the two experimental datasets.



Fig. 2. Excitation function of the 45Sc(d,2n)45Ti reaction.

The physical yield of 45Ti was deduced from a spline fitted curve of the measured excitation function and stopping power calculated using the SRIM code [5]. The derived yield is shown in Fig. 3 in comparison with the only experimental data [8]. The present yield curve of 45Ti is slightly larger than the experimental data at 22 MeV [8].



Fig. 3. Physical yield of 45Ti via the deuteron-induced reactions on 45Sc.

There are no isotopic impurities produced below 15.3 MeV, which is the threshold energy of the 45Sc(d,3n)44Ti reaction. Production of 45Ti without radio-contamination is possible by using the 45Sc(d,2n)45Ti reaction in the energy range from 15 to 5 MeV. Only the stable 46Ti is co-produced in the (d,n) reaction in comparable quantity by the prediction based on the cross section of the (d,n) reaction taken from the TENDL-2017 data library.

1. **Conclusion**

The excitation function of the 45Sc(d,2n)45Ti reaction was measured up to 24 MeV. The stacked-foil activation technique and the high-resolution γ-ray spectrometry were used for the cross section measurements. The obtained data were compared with the previous experimental data and the TENDL-2017 data. The derived excitation function of the 45Sc(d,2n)45Ti reaction is consistent with the data of Hermanne et al. (2012). The physical yield deduced from measured cross sections is slightly larger than the experimental data of Dmitriev et al. (1983). The production of radioactive-contamination-free 45Ti can be obtained via the 45Sc(d,2n)45Ti reaction using cyclotrons in the energy region below 15 MeV.

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