Activation cross sections of deuteron-induced reactions on niobium up to 24 MeV†

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One of the potential radioisotopes for nuclear medicine is ^{93m}Mo.[1)] Several reactions to produce ^{93m}Mo were studied, for example, proton- and deuteron-induced reactions on Nb, α-induced reactions on Zr, and ^{7}Li-induced reactions on Y. In this paper, we focus on the deuteron-induced reactions on Nb because the cross sections of these reactions are about four times larger than those of the proton-induced reactions.[2)] Four experimental data sets up to 50 MeV[2–5)] were found in a literature survey, and they were scattered over several tens of mb at a peak of around 17 MeV. Therefore, we performed an experiment to measure the cross sections of the ^{93}Nb(d, 2n)^{93m}Mo reaction.

We used standard methods such as the stacked-foil activation method and off-line γ-ray spectrometry. The stacked target of the experiment was composed of thin metallic foils of ^{93}Nb (27.11 mg/cm^2, 99.9% purity, Nilaco Corp., Japan) and ^{nat}Ti (9.13 mg/cm^2, 99.6% purity, Nilaco Corp., Japan). The ^{nat}Ti foils were used to monitor the beam parameters. The target was irradiated by a 23.6-MeV deuteron beam at the AVF cyclotron of the RIKEN RI Beam Factory. The incident beam energy was measured by the time-of-flight method using a plastic scintillator monitor.[6)] The irradiation lasted for 30 min with an average intensity of 200.3 nA, which was measured using a Faraday cup. The energy degradation of the beam in the stacked target was calculated using the SRIM code.[7)] The beam parameters and the target thicknesses were assessed by the ^{nat}Ti(d, x)^{48}V monitor reaction. The γ lines from the foils were measured by using a high-resolution HPGe detector.

The 263.049-keV γ line (I_γ = 57.4%) from the ^{93m}Mo IT decay ($T_{1/2} = 6.85$ h) was measured after a cooling time of about 10 h. The excitation function of the ^{93}Nb(d, 2n)^{93m}Mo reaction was derived from the measurement. The result is shown in Fig. 1 together with the earlier experimental data[3–5)] and the TENDL-2017 data.[8)] Our result shows good agreement with the other experimental data in the entire energy region. The theoretical calculation overestimates the experimental data.

The physical yield of ^{93m}Mo from the ^{93}Nb(d, 2n)^{93m}Mo reaction was calculated from the excitation function using the spline fitting shown in Fig. 1 and the stopping power calculated by the SRIM code.[7)] The result, together with the other experimental data,[2,9)] is shown in Fig. 2. Our result is consistent with the two data studied earlier.[2,9)]

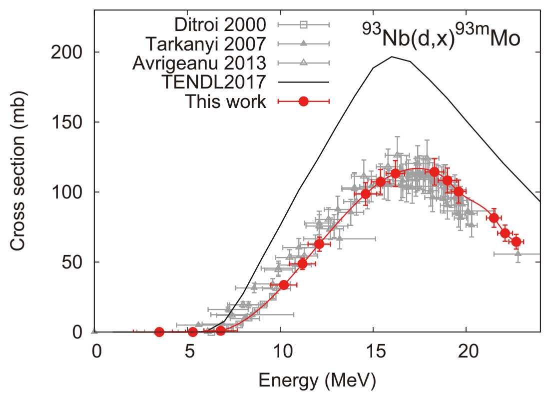

Fig. 1. Excitation function of the ^{93}Nb(d, 2n)^{93m}Mo reaction.

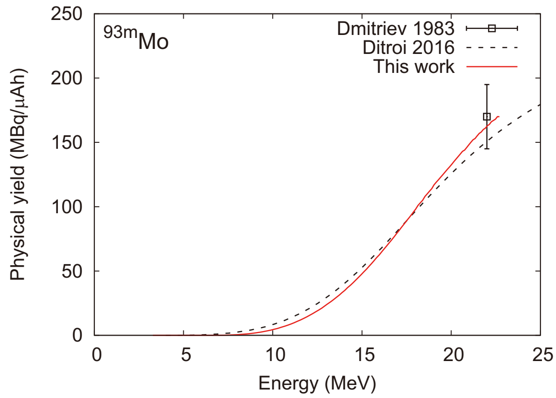

Fig. 2. Physical yield of ^{93m}Mo.

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