Proton- and deuteron-induced reactions on ^{107}Pd and ^{93}Zr at 20–30 MeV/nucleon

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The nuclear transmutation of long-lived fission products (LLFPs), which are produced in nuclear reactors, is one of the candidate techniques for the reduction and/or reuse of LLFPs. To design optimum pathways for the transmutation process, several nuclear reactions have been studied by using LLFPs as secondary beams. The studies indicate that proton- and/or deuteron-induced spallation reactions at intermediate energies (100–200 MeV/nucleon) are sufficiently effective for the LLFP transmutation.[1–3] We note that protons/deuterons lose their energies in materials; therefore, measurements at lower reaction energies are definitely desired for the application of transmutation. In this study, the isotopic production cross sections of proton- and deuteron-induced reactions on ^{107}Pd and ^{93}Zr at 20–30 MeV/nucleon were measured under an inverse kinematics condition. The experiment was conducted at the OEDO[4] beamline at RIBF. This was the first physics experiment using OEDO. Detailed descriptions of the setup and procedure can be found in Ref. 5).

Figure 1 shows the preliminary results for the isotopic production cross sections of the proton-induced reactions on ^{107}Pd. Considering the energy loss of the beam in the target, the measured cross sections are the ones averaged over 25–30 MeV/nucleon. The sensitivity threshold of the measurement was 5 mb because of statistics. We determined the cross sections for five isotopes ($^{107–105}$Ag and ^{106,105}Pd).

The results show significant production of Ag isotopes; about 70% of the total cross section is exhausted by Ag isotopes. This can be understood by the compound-nuclear process: $^{107}\mathrm{Pd} + p \rightarrow ^{108}\mathrm{Ag}^*$. The Ag isotopes are probably produced by the evaporation of neutrons from the highly excited compound nucleus ^{108}Ag*. Actually, the trend is completely different from the high-energy spallation reaction case,[2] in which the contribution of Ag isotopes is less than 10%.

The curves in Fig. 1 show the excitation functions evaluated by TENDL-2017.[6] The cross sections of Ag and Pd isotopes were reasonably reproduced by the evaluation. On the other hand, the cross sections of ^{103,102}Rh were considerably overestimated; TENDL predicted significant values for ^{103,102}Rh, but they were not detected in the experiment.

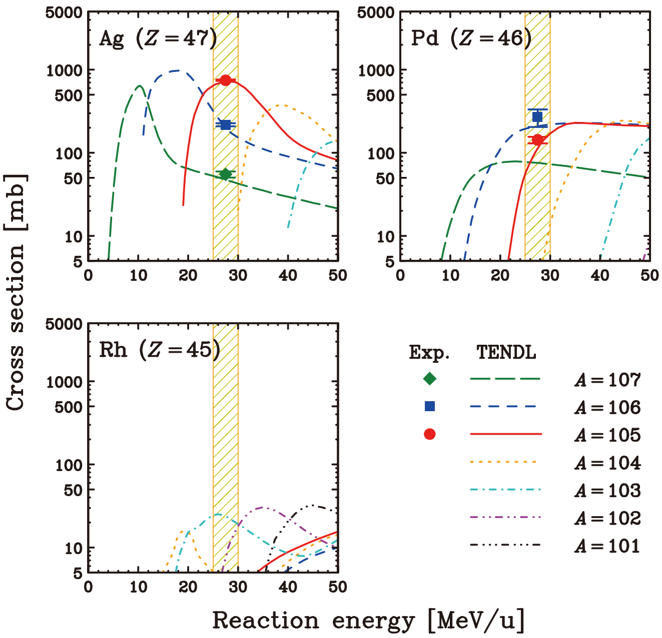

Fig. 1. Isotopic production cross sections of the proton-induced reactions on ^{107}Pd.

The present data, as well as higher-energy data, would provide an effective guideline for a possible solution of LLFP transmutation. The results will be finalized soon, and the preparation for publication is in progress. Regarding the ^{93}Zr data, the analysis for particle identification is ongoing.

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