Measurement of activation cross section of (n, p) and (n, α) reactions in the energy range of 3.5 to 5.9 MeV using a deuterium gas target

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A database of activation cross sections for neutron energy up to 20 MeV is required for neutron dosimetry, the design of D-T fusion reactors and neutron shielding in an accelerator facility. A lot of experimental cross section data have been reported in the neutron energy of around 14 MeV. On the other hand, there are insufficient data around 5.0 MeV because there are few appropriate neutron sources for the measurement of cross sections. In this work, we have studied to measure activation cross section around 5.0 MeV and to propose the systematics on the basis of the present results.

Activation cross sections of (n, p) and (n, α) reactions were measured by means of the activation method in the neutron energy range of 3.5 to 5.9 MeV. The irradiated target isotopes were ^{27}Al, $^{28, 29}$Si, ^{41}K, ^{51}V, ^{61}Ni, ^{65}Cu, $^{64, 67}$Zn, ^{69}Ga, ^{79}Br, ^{92}Mo and ^{93}Nb. All cross section values were determined relative to those of the ^{115}In (n, n') ^{115m}In reactions. The γ-rays emitted from the irradiated samples were measured with a well-type HPGe detector. The d-D neutrons were generated by the deuterium gas target at the Van de Graaff accelerator at Nagoya University. A pneumatic sample transport system was used for the irradiation. Typical neutron flux at the irradiation position was approximately 2×10^6 n/cm^2/s. The fluctuation of the neutron flux was monitored by a NE213 liquid scintillation detector using the Multi-Channel Scaling method.

The cross section data of twelve (n, p) reactions and two (n, α) reactions were obtained. Those of four (n, p) reactions for the ^{29}Si, ^{67}Zn, ^{69}Ga and ^{79}Br, and one (n, α) reaction for the ^{69}Ga were obtained for the first time in the energy range of 3.5 to 5.9 MeV. The evaluated data libraries on the basis of the theoretical calculations agree with the present results within 40% or less, as shown in Fig. 1. In Fig. 2, the systematics of the cross sections at the neutron energy of 5.0 MeV in the mass range between 27 and 92 were proposed for the first time on the basis of the present results by using parameters of $(A^{1/3} + 1)^2$ and $(E_{th}+V_p)$ within the framework of the compound nuclear reaction model. The solid and dotted lines were obtained to fit the data for the case of an even-odd or odd-even nucleus and of an even-even one, respectively. Those fitting lines can predict the cross sections within an accuracy of a factor of 1.6.

[1] Shimizu, T. et al., Ann. Nucl. Energy, 31, 975-990 (2004).

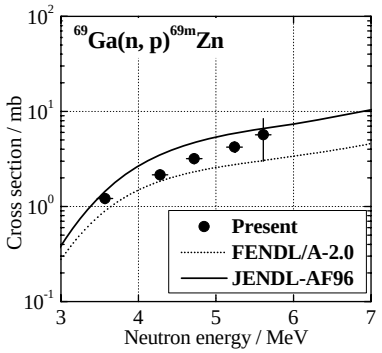

Fig.1 The excitation functions of the ^{69}Ga (n, p) ^{69m}Zn reaction. The data in JENDL-AF96 and FENDL/A-2.0 agree with the present results within 35%.

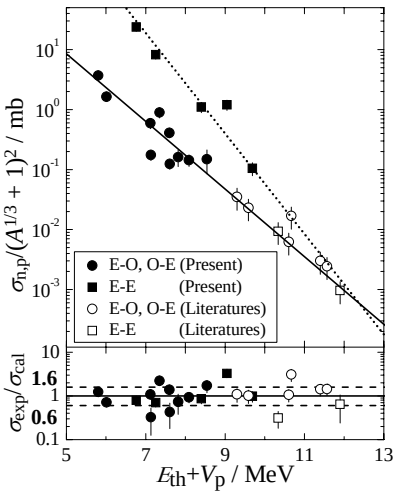

Fig.2 The relationship between $\sigma_{n,p}/(A^{1/3} + 1)^2$ and $(E_{th} + V_p)$ at an energy of 5.0 MeV, where $\sigma_{n,p}$, A and $(E_{th} + V_p)$ are the cross section of the (n, p) reaction, the mass number, and sum of threshold energy and the Coulomb barrier, respectively.