§8. Analyses of Reaction Rates and Tritium Production Rate Measured in Li/V-alloy Assembly under DT Neutron Irradiation

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For an accuracy evaluation of the neutronics design of the liquid Li cooled blanket system, DT neutron irradiation experiments using solid Li block assemblies have been conducted at the FNS facility of JAEA. Objectives of the present study are improvement of neutron measurement methods in the irradiation experiments and an accuracy evaluation of the neutronics design by comparison between experimental data and neutron transport calculations.

Results of the irradiation experiment using a Li/V-alloy assembly, which was performed in the year of 2007, have been analyzed in this year. In the experiment, an assembly of 45 x 50 x 50 cm^3 was constructed with the solid Li blocks. A layer of V-alloy of 23 x 19 x 5 cm^3 was placed inside of the assembly for a simulation of a structural material. Activation foils of Nb, Ni, In and Au were installed in the assembly and the reaction rates of the $^{93}Nb(n,2n)^{92m}Nb$, $^{58}Ni(n,p)^{58}Co$, $^{115}In(n,n')^{115m}In$, $^{115}In(n,\gamma)^{116m}In$ and $^{197}Au(n,\gamma)^{198}Au$ reactions were measured. The distribution of tritium production rates from the $^{6}Li(n,\alpha)T$ reaction was also measured in the assembly with Li glass scintillation detectors. The details of the experiment were reported in ref. 1. The results of the measurements have been compared with those obtained by using the MCNP5 code and the libraries of JENDL-3.3, JENDL Dosimetry File 99 and FENDL/A-2.0.

As to the $^{93}Nb(n,2n)^{92m}Nb$ reaction which has the threshold energy of 8.9 MeV and the $^{58}Ni(n,p)^{58}Co$ reaction which is sensitive to neutrons >1 MeV, the difference between measured and calculated reaction rates was less than ~3 %. Differences in the reaction rates of the $^{115}In(n,n')^{115m}In$ reaction whose threshold energy is 0.34 MeV and $^{115}In(n,\gamma)^{116m}In$ reaction which is sensitive to low energy neutrons are less than 10 % as shown in Figs. 1 (a) and (b). In the reaction rate of $^{197}Au(n,\gamma)^{198}Au$, which is also sensitive to low energy neutrons, the maximum difference is ~15 % at the surface of the V-alloy layer as shown in Fig. 1 (c). This discrepancy probably comes from a problem in V cross section data, which was pointed out in the V benchmark experiment at FNS[2]. The relation between the results in the previous V assembly and the present Li/V-alloy is being studied at present. Impact on the tritium production in the Li cooled blanket system is also required to be studied.

The tritium production rate in the Li/V-alloy assembly was measured by subtracting responses of the ^{7}Li enriched detector from those of the ^{6}Li enriched detector.[3] The result shows the enhancement of tritium production around the V-alloy layer (Fig. 2), which is considered due to the elastic and inelastic collisions and the (n,2n) reaction of neutrons with vanadium. However, the measured tritium production rate is lower than the calculation result by ~30%.

The validity of our present measurement methods with the Li glass scintillation detectors has been examined by a DT neutron irradiation on a Li_2O cylindrical assembly (60 cmϕ x 60 cm) in this year. Also in the Li_2O assembly, the measured tritium production rate at the position of 0-10 cm from the front surface was lower than the calculated one. The same measurement with the Li_2O assembly has been performed previously at the FNS facility and a similar tendency has been reported.[4] For improvement of the measurement and analysis accuracies in the Li/V-alloy assembly, a source of the large differences between the analyzed and calculated tritium production rates is being studied by focusing on influences of gamma-rays and fast neutrons in the detector responses.

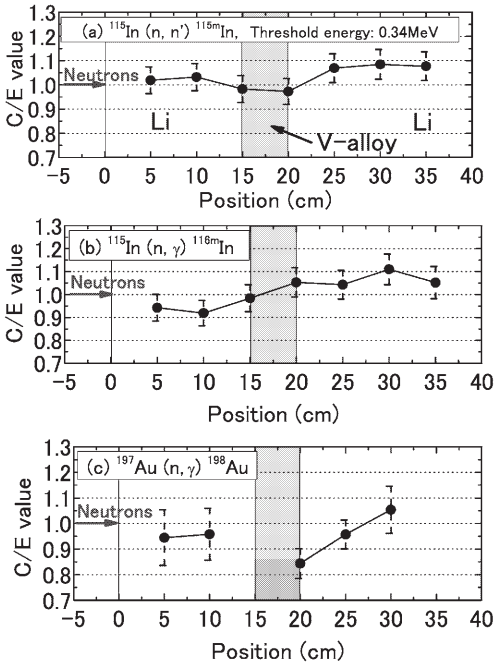

Fig. 1 Ratios of calculated and measured reaction rates (C/E values) in Li/V-alloy assembly.

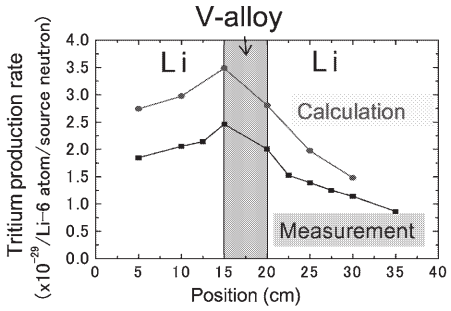

Fig. 2 Distribution of calculated and measured tritium production rates from $^{6}Li(n,\alpha)T$ reaction in Li/V-alloy assembly. Improvement of measurement and analysis accuracies is being studied in present study.

1) T. Iida *et al.*, NIFS annual report April 2007-March 2008, 253.
2) F. Maekawa *et al.*, Fusion Technology 34(1998)1018-1022.
3) S. Yamaguchi *et al.*, Nucl. Instr. and Meth. A254 (1982) 413-418.
4) H. Maekawa *et al.*, JAERI-M 86-182.