Measurement of Neutron Emission Spectrum and Activation Cross-section on Fe and Ta for 40 MeV Deuteron Induced Reaction

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III. 2. Measurement of Neutron Emission Spectrum and Activation Cross-section on Fe and Ta for 40 MeV Deuteron Induced Reaction

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The International Fusion Materials Irradiation Facility (IFMIF) project has been proposed to establish an accelerator-based D-Li neutron source designed to produce an intense fast neutron field for high fluence irradiation test of the fusion reactor candidate materials[1)].

To establish the database required for the design and post-analysis of IFMIF, we have been conducting systematic experiments on the neutron emission spectrum and radioactivity accumulation in IFMIF structural elements from 2001[2-6)]. In the previous reports (2001, 2002, 2003), the results on lithium target for 25, 40 MeV deuterons and on carbon and aluminum targets for 40 MeV deuterons were reported. The experiments were carried out at the No.5 target room in CYRIC using the AVF cyclotron (K=110 MeV), a beam swinger system, the TOF method[7)] employed stack target[5)] was used to enable measurements of neutron spectrum and activation cross section concurrently.

In the last year, we have carried out new experiments for 40 MeV deuterons with extended techniques and obtained new results for

1) neutron emission spectrum from a thick Fe, Ta target and
2) activation cross-sections of the $^{nat}Fe(d, x)^{51}Cr$, ^{52}Mn, $^{56, 57, 58}Co$ reactions.

The experimental method was almost the same with these in previous experiments[5)]. Twenty thin targets of iron (2.0 mm thicknesses) and thirty thin targets of tantalum (1.5 mm thicknesses) with natural composition were prepared and stacked to stop the incident beam in the targets to measure not only neutron spectra from a thick Fe and Ta target but also excitation functions of the $^{nat}Fe(d, x)^{51}Cr$, ^{52}Mn, $^{56, 57, 58}Co$ reactions concurrently.

The neutron spectra were measured for almost entire range (0.5-50 MeV) of secondary neutrons at seven laboratory angles between 0- and 110-deg with the two-gain time-of-flight (TOF) method[7] using a beam swinger system. The results are shown in Fig.1. Figure 2 shows the comparison with the results of previous experiments[2-6]. The data clarified secondary neutron production spectra for the whole energy range. The lower energy limit is approximately 0.5 MeV and both spectra show almost same features. Such data are very few and will be useful for the model development of the neutron emission. The main peaks due to deuteron break-up reaction are observed around 15 MeV having strong angular dependence similar with previous results of Li(d,xn) reactions[2-6]. This yield of the main peak is decreasing with the increasing mass of target. On the other hands, the yield of neutrons emitted from the evaporation process is increasing with the mass of target. Figure 3 shows the comparison between the present data and MCNPX calculation[8]. The results of calculation significantly underestimate experimental data.

The number of radioactive nuclides accumulated in the stacked targets was measured by counting the γ-rays from the nuclides of ^{51}Cr, ^{52}Mn, $^{56, 57, 58}Co$ using a pure Ge detector. In Figs.4, 5, the results of the activation cross-sections are shown, together with other experiments[9], recommended data by the IAEA group[10] and TALYS calculation[11]. The present values for iron are consistent with other data. TALYS calculation shows fairy good agreement with the present data except for higher energy region. To estimate the radioactivity induced by deuterons with TALYS, nevertheless, improvements will be required for cross-section calculation models. Present experimental results will be used as the basic data to check the accuracy of the Monte Carlo simulation and for the shielding design of a medium energy accelerator facility such as IFMIF.

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References

1) IFMIF CDA TEAM, IFMIF Conceptual Design Activity Final Report edited by Marcello Martone, Report 96.11, Enea, Dipartimento Energia, Frascati (1996).
2) CYRIC Annual Report 2001, p. 170; 2002, p. 141; 2003, p. 43.
3) Baba M., Aoki T., Hagiwara M., et al., J. Nucl. Materials **307-311** (2002) 1715.
4) Aoki T., Hagiwara M., Baba M., et al., J. Nucl. Sci. Tech. **41** (2004) 399.
5) Hagiwara M., Itoga T., Baba M., et al., J. Nucl. Materials **329-333** (2004) 218.
6) Hagiwara M., et al., J. Fusion Sci. Tech., in press.
7) Ibaraki M., et al., Nucl. Sci. Technol. **35** (1998) 843.
8) Waters L.S. (Ed.), MCNPX User's Manual version 2.4.0, LA-CP-02-408, Los Alamos National Laboratory, Los Alamos, New Mexico, 2002.
9) EXFOR system: OECD/NEA http://www.nea.fr
10) IAEA, Charged-particle cross section database for medical radioisotope production http://www-nds.iaea.org/medical/.
11) Koning A.J., et al., TALYS: Comprehensive nuclear reaction modeling, Conf. on Nucl. Data for Sci. and Technol., Santa Fe, 2005.

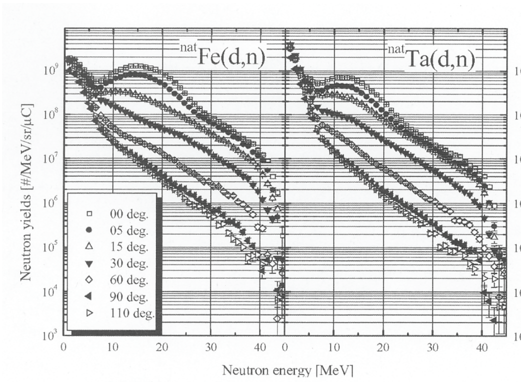

Fig. 1. Neutron spectrum for Fe and Ta .

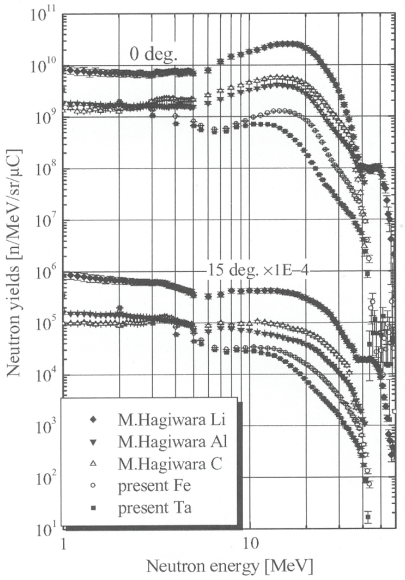

Fig.. 2. Neutron spectrum for (d,n) reactions at 40 MeV.

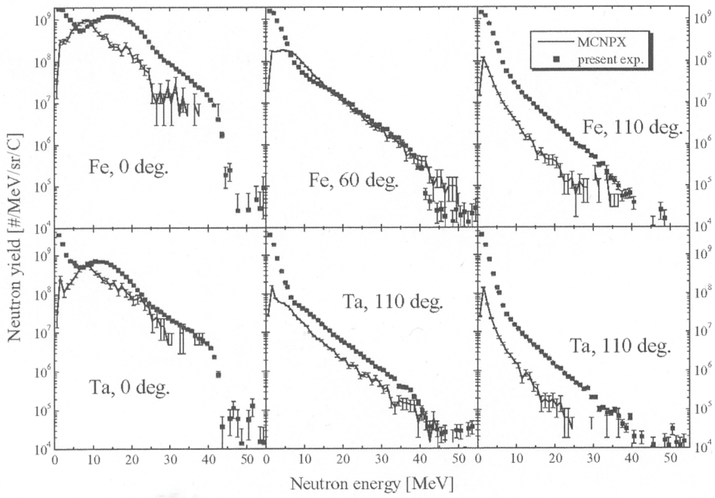

Fig. 3. Comparison with MCNPX.

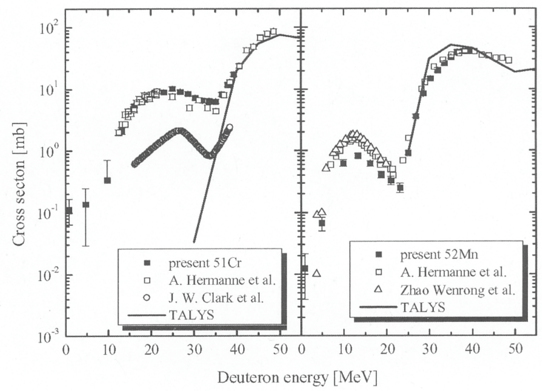

Fig. 4. Activation cross-section for $^{nat}Fe(d, x)^{51}Cr$, ^{52}Mn.

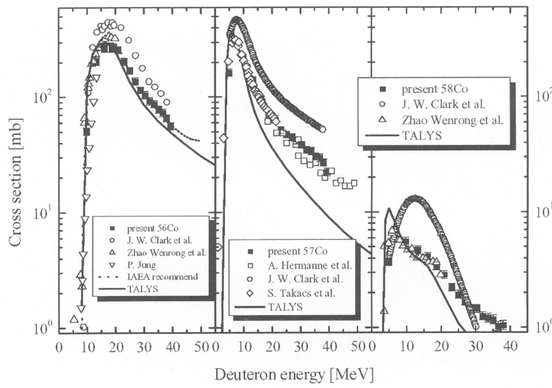

Fig. 5. Activation cross-section for $^{nat}Fe(d, x)^{56}Co$, ^{57}Co and ^{58}Co.