Systematic study of nuclear data for nuclear transmutation

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Long-lived fission products (LLFPs) are problematic radioactive wastes in spent nuclear fuels. Because LLFPs have long half-lives, special techniques for safe management and disposal are required. A promising way to solve this problem is "nuclear transmutation technology". The basic concept of this technology is to change LLFPs into "short-lived nuclei" or "stable nuclei" by using various kinds of particle beams from accelerators and neutron flux in nuclear reactors. Recently, the use of an accelerator-driven system (ADS) has been studied globally for this purpose. In Japan, J-PARC[1] plans to establish ADS techniques.

From the viewpoint of nuclear data, various kinds of cross section data for LLFPs are needed to design the nuclear transmutation system reliably. Cross section data of proton, neutron, and photon induced reactions on LLFPs are required to establish more effective procedures and to estimate costs. However, as listed in Table 1, most of the experimental data are still unavailable owing to the difficulty in preparing enriched targets and in handling of activities.

Table 1. Half-lives of LLFPs and the current status of the experimental data of photon, neutron, and proton induced reactions in EXFOR[5]. Numbers with and without parentheses indicate those of the experimental works and data points of cross sections or maxwellian averaged cross section. "-" means no experimental data in EXFOR.

Nuclei	Half-life (year)	Status of experimental data		
		photon	neutron	proton
^{79}Se	65,000	-	-	-
^{90}Sr	29	-	5(5)	-
^{93}Zr	150,000	-	3(8)	-
^{99}Tc	210,000	-	16(428)	2(82)
^{107}Pd	6,500,000	-	2(2)	-
^{126}Sn	100,000	-	-	-
^{129}I	16,000,000	1(27)	5(5)	-
^{135}Cs	2,300,000	-	4(4)	-
^{137}Cs	30	-	3(3)	-
^{151}Sm	89	-	4(47)	-

One possible way to access the cross sections is the inverse reaction method. For example, neutron capture cross sections can be estimated with photo nuclear reactions[2–4]. In addition, unstable LLFP beams at the RIBF facility are strong candidates to produce related nuclear data. In order to promote nuclear transmutation technology, the sharing of knowledge and information among researchers in related fields, e.g., nuclear engineering and nuclear physics, is imperative.

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Simultaneously, management of the experimental nuclear reaction database to survey information, as shown in Table 1, and theoretical evaluations of the cross sections is also essential. Due to the lack of experimental cross sections, we performed theoretical estimation using the calculation code TALYS[6]. Figure 1 shows the total reaction cross sections induced by protons on LLFPs. We were able to determine the cross sections of the order of barn. The impact of this result must be assessed and the cost of the transmutation of LLFPs must be estimated.

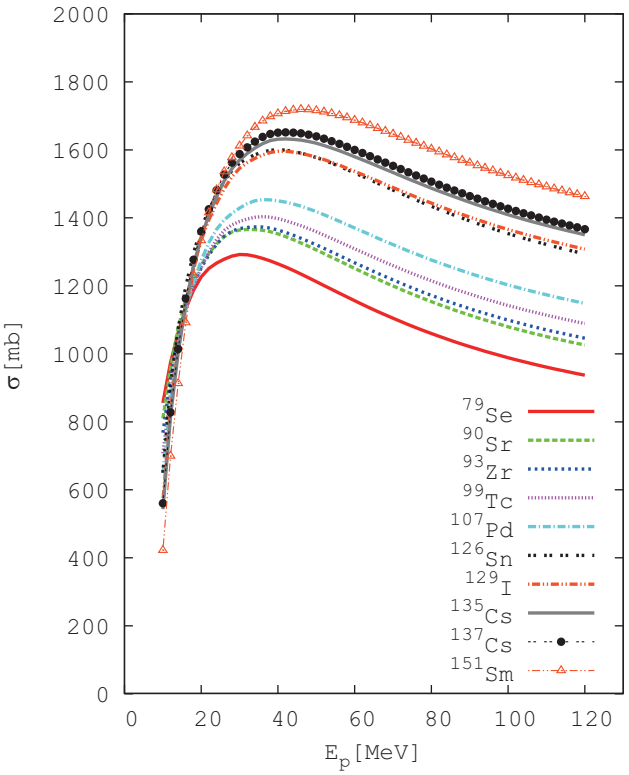

Fig. 1. Calculation of total reaction cross sections induced by protons on LLFPs by using the code TALYS.

References
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