Critical analysis for nuclear data of thermal neutron capture cross section and the resonance integral for the reaction ^{135}Cs(n,γ)^{136}Cs from library based on neutron activation measurements

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1. Introduction

The nuclear data is a fundamental data base for nuclear technology and science. It has played an important role in the knowledge of neutron physics, development of nuclear energy, national security and nuclear astrophysics applications. Accurate neutron cross sections of radioactive fission products and transuranic elements are needed for research on nuclear transmutation methods using neutrons. In particular, the thermal neutron capture cross section (σ_0) and the resonance integral (I_0) are important for the study of transmutation methods using thermal neutrons from a high flux fission reactor, a high intensity accelerator or a high flux fusion reactor. The main purpose of this work is to make an assessment of nuclear data for ^{135}Cs(n,γ)^{136}Cs nuclear reactions, through the neutron activation and gamma ray measurements. Important fission products in the nuclear waste management are ^{137}Cs, ^{135}Cs, ^{90}Sr, ^{99}Tc and ^{129}1 because of their large fission yields [1] and long half-lives [2] (long lived fission products (LLFPs)). The problem of waste disposal for such LLFPs is a matter of great concern. Transmutation is one of the options for this waste management, since it makes it possible to reduce the volume of the repository for packages of nuclear wastes as well as the long term risk. In the study of transmutation of ^{136}Cs, accurate cross - section data are required. From the above motivation, I have analysed the thermal neutron capture cross sections and resonance integrals of the ^{135}Cs(n,γ)^{136}Cs reactions with JENDL-3.3 [3] and available experimental data.

TABLE I: Neutron flux at Dhruva reactor

	ϕ_1 or ϕ_1'(10^{12}n/cm^2.sec)	ϕ_2 or ϕ_2'(10^{12}n/cm^2.sec)
without the Cd	ϕ_1=10^{12}n/cm^2.sec	ϕ_2=0.019
with Cd	ϕ_1'=0.031	ϕ_2'=0.036

2. Analysis and results

The thermal neutron capture cross section of ^{135}Cs has been reported in two papers. Sugarman [4] reported the cross section obtained by a radiochemical method as 14.5 ($\pm$30%)barn. Baerg [5] et al. reported the cross section measured by a 4π - β counting method. The latter authors determined the amount of nuclei of ^{136}Cs only following the decay of β ray intensity from fission product Cesium samples irradiated with thermal neutron flux, and obtained the values of the neutron capture cross section and the resonance integral as 8.74$\pm$0.5 barn and 61.7$\pm$2.3 barn, respectively. The present analysis was designed to obtain more reliable values of the cross section and the resonance integral of the reaction ^{135}Cs(n,γ)^{136}Cs. Results obtained are 8.3$\pm$0.3 barn as a neutron capture cross section, and 37.9$\pm$2.7 barn as a resonance integral. The neutron flux will be monitored using ^{197}Au(n,γ)^{198}Au(T$_{1/2}$ = 2.6948 d, decay gamma energy = 411.802 keV, with intensity 95.62%) and ^{59}Co(n,γ)^{60}Co, standard cross section of ^{197}Au(n,γ)^{198}Au and ^{59}Co(n,γ)^{60}Co by the ENDF/B-7.1 [6] will be used for normalization.

Partial decay scheme of ^{136}Cs is shown in Fig.1. The ^{136}Cs have both ground state (spin and parity (J$^\pi$) = 5^+, half - life (t$_{1/2}$) = 13.04 d and decay mode β^- and isomer

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TABLE II: Thermal cross section and resonance integral data from library.

	0.0253eV	Max average	Fiss.spect.average	g-factor	(I_0)
(σ_0)	13.01(b)	13.01(b)	19.08(mb)	1.000	57.37(b)

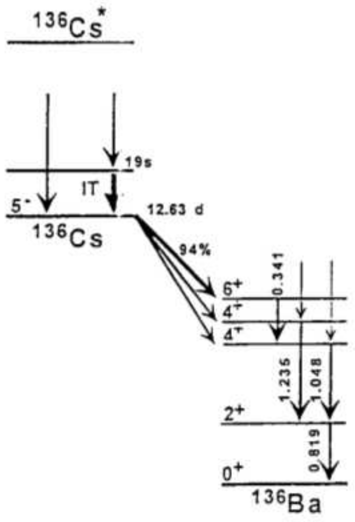

FIG. 1: Partial decay scheme of ^{136}Cs.

state (spin and parity (J^π) = 8^-, half - life ($t_{1/2}$) = 19 s and decay mode IT (isomeric transitions)>0%, β^-. Table 1 presents the thermal and epithermal neutron flux, ^{59}Co and ^{197}Au have different sensitivities to thermal and epithermal neutrons, these wires are appropriate to determine the thermal and the epithermal fractions of neutron flux with and without Cd capsule. Since ^{59}Co is insensitive to epithermal neutrons while ^{197}Au is very sensitive to them, this set of monitor wires is useful to determine the thermal and the epithermal fractions of neutron flux. The effective cross section σ is defined by equating the reaction rate R to the product of σ and n_0, where n_0 is the neutron flux in the Westcotts convention [7] with the neutron density n, including thermal and epither mal neutrons, and with the velocity of neutron v_0 = 2,200 m/s,(thermal neutrons, 0.025 eV). Table 2 shows a compilation of the evaluated data for the ^{136}Cs nuclide. Nuclear data from li-

TABLE III: Thermal cross section and resonance integral data from library. Cross sections are calculated from JENDL- 3.3 at 300 K

	Ref 4	Ref 5	JENDL 3.3
(σ_0) (b)	14.5±4	8.7±0.5	13.01
(I_0) (b)		61.7±2.3	57.37

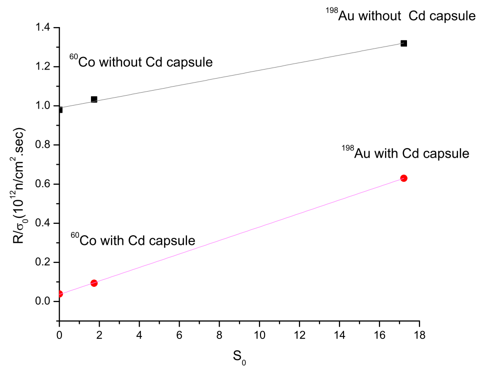

FIG. 2: Relations between R/σ_0 (or R'/σ_0) and S_0.

brary used for the comparative analysis for thermal neutron cross section and resonance integral are given in Table 3. The relation between R/σ_0 (or R'/σ_0) and S_0 is shown in Fig.2, here R is the reaction rate, σ_0 is the thermal neutron capture cross section and S_0 is the parameter in terms of neutron temperature. The details will be presented.

References

[1] Tasaka, K et al., JAERI 1320, (1990).

[2] Firestone, R.B et al., Table of Isotopes, (8th ed.), John Wiley & sons, New York, (1996).

[3] http://wwwndc.jaea.go.jp (2016).

[4] Sugarman, N.: Phys.Rev., **75**, 1473, (1949).

[5] Baerg, A.P et al., M.:Can.J.Phys., **36**, 863, (1958).

[6] http://www.nndc.bnl.gov/endf/b7.1

[7] Westcott, C.H et al., Proc. 2nd Int. Conf. Peaceful Use of Atomic Energy, Geneva, United Nations, New York, Vo1.16, **70**, (1958).