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THE DETERMINATION OF THERMAL NEUTRON CROSS SECTION OF ^{81} Br

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ABSTRACT

In this investigation several standard materials were used to determine the thermal neutron cross section of ^{81}Br. This nuclear parameter is an important data to perform several quantitative investigations, mainly in medical area. In other to confirm and to reduce the uncertainty, a new measurement was preformed using thermal neutron at IEA-R1 nuclear reactor of IPEN/CNEN-SP. The result obtained is compatible with the tabulated value and present small uncertainly.

1. INTRODUCTION

Bromine is an important element to be monitored in biological materials, mainly in body fluids, due the ingestion of medicines (anti depressing and somniferous) that have high prevalence in the Brazilian population. Several studies have been pointing out advantages of using the semi-parametric neutron activation analysis to study nuclear properties such as: half–life, isotopic abundances as well as thermal neutron cross-section [1-3]. This activation procedure correlates constants physics that are very well established such as: the decay constant, the atomic mass, the Avogadro's number, the neutron cross section and the isotopic fraction [4] with precise experimental data about thermal neutron flux and detector efficiency. Since that thermal neutron flux and the gamma efficiency can be determined with good precision, the determination of anyone these nuclear parameters can be evaluated. Particularly for ^{81}Br we intend to use this semi-parametric activation procedure to determine its thermal neutron cross section. This value could be used for analytical investigations in biochemistry clinical [5, 6].

For this investigation several standard reference materials (NIST 8414 *Bovine Muscle Powder*, NIST 2710, NIST 1577b *Bovine Liver*, IEA/SOIL-7, Second-generation Biological reference material Freeze-Dried Human Serum; AIEA-A-13 Freeze Dried Animal Blood) and standard solutions with very well-determined Bromine concentration were used. The result was compared with the available reported experimental data.

2. EXPERIMENTAL PROCEDURE

The neutrons used in this investigation were generated in IEA-R1 (2-4MW, pool type) nuclear reactor at IPEN/CNEN, Sao Paulo, Brazil. The experimental facilities around this research reactor included a pneumatic irradiation station used for irradiation of the targets (in the investigation the standard reference materials).

In the semi-parametric procedure each target to be investigated must be sealed into individual polyethylene bag together with the Au detector (small metallic foils ~1mg), used for measurement of the flux distribution, and irradiated in a pneumatic station allowing the simultaneous activation of these materials. After the irradiation, the activated materials were gamma-counted using a HPGe Spectrometer of High Energy Resolution (FWHM = 1.87keV at 667 keV transition of ^{137}Cs) and the areas of the peaks (411keV for ^{198}Au activation and 554keV for ^{82}Br activation) were evaluated using the IDF computer software [7]. The experimental conditions of these irradiations are described in Table 1.

Table 1. The experimental conditions of standard reference materials

Standard Reference material	Mass (mg)	T_i; T_c; T_m (minutes)	η
[1] IEA/SOIL -7	150	2; 30; 15	3
[2] Dried Human Serum[a]	200	5; 30; 30	2
[3] AIEA- A-13	250	5; 60; 30	1
[4] NIST 8414	150	2; 30; 30	1
[5] NIST 2710	150	2; 30; 30	2
[6] NIST 1577b	150	5; 30; 30	2
[7] standard solution	20 μL	1; 15; 15	1

η: number of the samples analyzed
[a] from ref. 8
T_i: irradiation time
$T_{c:}$ cooling time
$T_{m:}$ counting time

Since thermal neutron flux is obtained, the thermal neutron activation cross section can be evaluated from the relation:

$$\sigma = f/\phi \qquad \text{eq (1)}$$

where, ϕ is the neutron flux and f represents the count rates correcting for gamma ray intensity and efficiency, expressed by

$$f = \lambda C / [N\, \varepsilon\, I\gamma\, e^{-\lambda Tc} (1- e^{-\lambda Tm})(1- e^{-\lambda Ti})] \qquad \text{eq (2)}$$

where, λ the decay is constant; C is the peak area counts in the select gamma ray; N is the number of target atoms; ε is the detector efficiency; $I\gamma$ is the branching ratio of selected energy; T_c is the cooling time; T_m is the counting time and T_i is the irradiation time.

3. RESULTS

Thermal neutron cross-section of $^{81}Br(n,\gamma)^{82}Br$ reaction was measured by activation technique at thermal neutron energy. The result is shown in Table 2 as well as the data of previously established [9,10]. The radioactive ^{82}Br isotope was identified by 554keV gamma-ray. To illustrate, the results from the independent measurements are presented in Figure 1 together the weight average (dashed line) and ± 1SD (Standard Deviation).

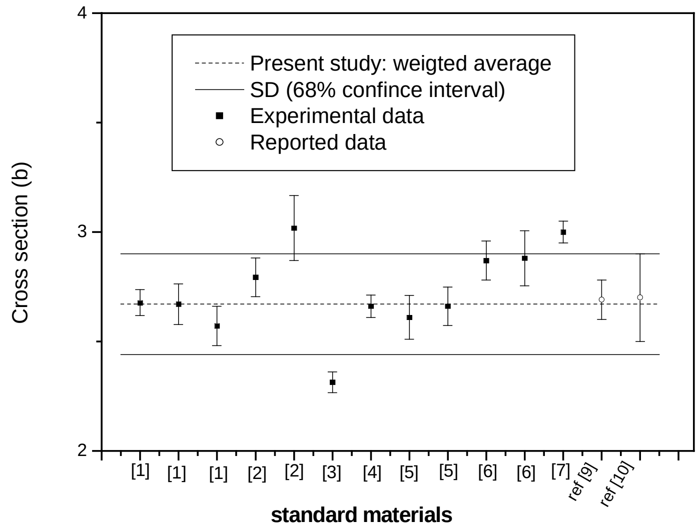

Figure 1. Results for the thermal neutron absortion cross section for ^{81}Br obtained in this study compared with available data.

Table 2. Comparison of the thermal neutron cross section from this study with the available values.

	Cross-section (barn)	Uncertainty (%)
This work	2.674 ± 0.068	2.5
INDC [9]	2.7 ± 0.2	7.4
JENDL -3.3.2002 [10]	2.69 ± 0.09	3.4

4. CONCLUSION

The thermal neutron cross-section for the $^{81}Br(n,\gamma)^{82}Br$ nuclear reaction obtained in the present investigation is consistent with the data of previously established . This value will be useful for clinical investigation of Bromine in biological material using neutron activation technique.

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