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Variation of Flux and Energy of 14 MeV Neutrons with Variation of Matrix Around a Sample

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ABSTRACT

Here a method has been described to study the attenuation of flux and energy of the neutrons passing through different materials. Variation of activity of the irradiated and activated sample by 14 MeV neutrons was observed by changing the matrix around it. The sample was a combination of Aluminium foil and copper powder placed at 0° position (position of maximum flux) and the matrices were Air, Water, Iron, sand and carbon powder.

Key words: Matrix; Cross-section; 14 MeV neutrons; Activation method; Neutron flux; Neutron energy.

INTRODUCTION

The 14 MeV neutron generator[1] used for the present work generates neutrons of energy 14.77 MeV and has a flux of 10^8 n/cm^2/sec. When a sample is irradiated then the induced activity [2] in the sample is

$$A=N\sigma F$$

Where A, N, σ and F denote activity induced in the irradiated sample, the neutron flux, cross-section of the reaction through which activity is induced and flux of the neutrons respectively.

Now, if two samples 1 and 2 are irradiated simultaneously then the activity induced will be

$$A_1=N_1\sigma_1F \quad \text{and} \quad A_2=N_2\sigma_2F$$

F being same for both because of simultaneous irradiation. Taking the ratio of the two activities, we get

$$A_1/A_2=K\sigma_1/\sigma_2$$

Where $K=N_1/N_2$ is constant for constant weights of sample 1 and 2. A_1/A_2 is constant when σ_1/σ_2 is constant. And σ_1/σ_2 is constant when the energy of the incident neutrons is constant. As with the variation of energy both σ_1 and σ_2 vary, so does the ratio σ_1/σ_2. So knowing this ratio the value of the energy E can be found as σ_1/σ_2 has a constant value for a particular value of E. The actual neutron source is surrounded by an iron water cooling jacket. The results can help to understand the attenuation of the neutron energy and flux and corresponding corrections can be made in the cross-section values obtained from the neutron activation analysis method using these neutrons.

MATERIAL AND METHODS

For observing the variation of flux and energy of neutrons, experiment was done by irradiating two samples simultaneously and varying the matrix around it and noting the variation of activity.

The sample and matrix used along with the concerned data is given in Table 1 and 2.

The excitation curves [3, 4] are shown in figures 1 and 2. The samples taken together, Copper in powder form and Aluminium as foil within a polythene bag were irradiated with different matrices around it one by one. The time of irradiation, cooling and counting were 10, 2 and 10 minutes respectively. These two samples were taken because of the following reasons:

(a) Easily available

(b) Comparable half life[5] of the products allowed to take same irradiation time, that is, around 10 minutes.

(c) Excitation curve shows that in the energy region concerned (12-15 MeV), the slope is different (for copper it is increasing and for aluminium it is decreasing) and so σ_1/σ_2 varies with energy or we can say $d(\sigma_1/\sigma_2)/dE$ is high and easily noticeable even for small energy change.

RESULTS AND DISCUSSION

The ratio K of number of atoms of Copper to number of atoms of aluminium, that is, N_{Al}/N_{Cu} has a value of 0.34. And as such the cross-section ratio is given as

$$\sigma_{Cu}/\sigma_{Al} = (0.34)*(A_{Cu}/A_{Al})$$

Table 1: Samples used

S. No.	Sample	Weight of sample	Reaction	Half-life
1.	Aluminium foil	0.4990g	${}_{13}Al^{27}(n,p)_{12}Mg^{27}$	9.46 minutes
2.	Copper powder	0.4990g	${}_{29}Cu^{63}(n,2n)_{29}Cu^{62}$	9.76 minutes

Table 2: Matrices used

S.No.	Matrix	Density	Amount
1.	Air	0.001293gm/cc	36cc
2.	Carbon powder	2.26gm/cc	36cc
3.	Iron powder	7.86gm/cc	36cc
4.	Silica	1.59gm/cc	36cc
5.	Water	1gm/cc	36cc

Table 3: Variation of neutron energy with matrices

S. No.	Matrix	Activity of Al	Activity of Cu	A_{Cu}/A_{Al}	s_{Cu}/s_{Al}	Energy
1.	Air	27150	189650	6.98	2.46	12.6
2.	Iron powder	36397	296684	8.15	2.77	12.7
3.	Carbon powder	8109	55207	6.81	2.31	12.5-12.6
4.	Silica	20208	160609	7.95	2.70	12.6-12.7
5.	Water	43982	318174	7.23	2.46	12.6-12.7

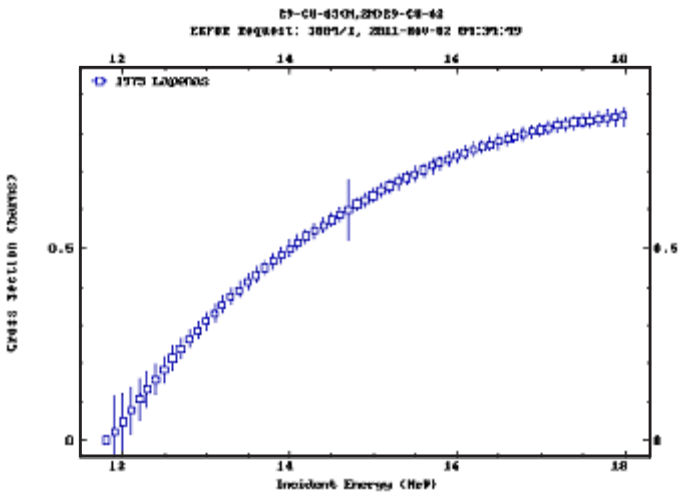

Fig. 1: Excitation curve for the reaction $Cu^{63}(n,2n)Cu^{62}$

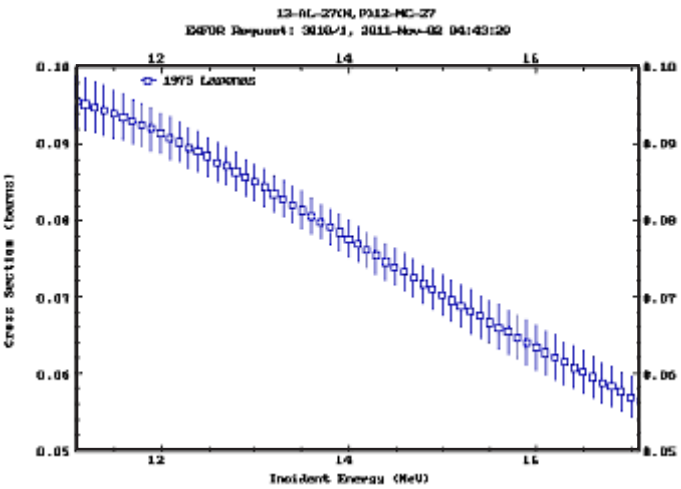

Fig. 2: Excitation curve for the reaction $Al^{27}(n,p)Mg^{27}$

Where A_{Cu} / A_{Al} is the activity ratio of copper to aluminium.The value of s_{Cu}/s_{Al} gives the value of energy of the neutrons.The variation of flux and energy of the neutrons with variation of matrix around the sample as obtained are shown in Table 3.

The maximum variation of neutron flux and energy is for carbon matrix. And the least variation is for iron powder.

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