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Research Article

Simulation of Neutrons Shielding Properties for Some Medical Materials

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Abstract:

Radiation is used different field and among others neutron is the one of the most hazardous particle as it is neutral and heavy. Its neutral characteristics make it more difficult particle to be shielded. In this study neutron shielding properties for some medical interested materials of water, fat and bone have been obtained using Phy-X/PSD software.

1. Introduction

The radiation is very important in space technology, nuclear engineering, radiation medicine, radiotherapy, and other fields. On the other hand the radiation requires extreme care due to its hazardous effect to human cell. Thus radiation dosimetry becomes important in science and new techniques, materials have been under study to develop as alternative to conventional materials [1-11].

The neutron with the proton is an important particle in nuclear physics and due to neutral character its shielding is more difficult than others. This is the results of weakly interaction with matter into which it can penetrate deeply. The neutron attenuation is related to the total microscopic neutron cross section (σ_t) and the interaction possibility with the material it is given as in equation 1 [12].

$$\sigma_t = \sigma_s + \sigma_a \qquad (1)$$

where σ_s is the cross section for both inelastic and elastic scattering.

While comprehensive calculations of radiation attenuation for different materials are available in the literature [13-22], the data for neutron are fairly scarce.

In this study, the fast neutron removal cross section (FNRCS) and related other parameters of mfp, HVL and TVL for water, fat and bone have been calculated.

2. Materials and Methods

The FNRCS (Σ cm^{-1}) and related other parameters have been obtained for four different types of medical interested materials. The chemical properties of

Table 1. *Chemical contents of materials (w%) [23]*

	Water	**Fat**	**Bone**	**Hydroxyapatite**
H	0.1119	0.119	0.0344	0.002
C	-	0.772	0.714	-
N	-	-	0.1827	
O	0.8881	0.109	0.0689	0.414
P	-	-	-	0.185
Ca	-	-	-	0.399

materials is listed in table 1. The simulation was done using Phy-X/PSD online code which is a free online platform [24].

3. Results and Discussions

In this study the neutron shielding properties of four different types of materials of medical interested have been obtained. This is done obtaining FNRCS (Σ cm^{-1}) and some other parameters. The obtained fast neutron removal cross section (FNRCS, Σ cm^{-1}) results is shown as a function of density of materials in Fig. 1 where it is seen that the FNRCS decreased with the increasing materials' density. As it is well known that hydrogen is important for neutron shielding and this result may be the results of different rate of hydrogen on materials. This was obtained and displayed in Fig. 2. It can clearly be seen that the FNRCS increased with the increasing hydrogen rate in materials. Some other parameters such as mfp, HVL and TVL related to FNRCS are obtained.

The *mfp* of any material is the neutron penetration length is obtained using equation 2

$$mfp = \frac{1}{\Sigma} \qquad (2)$$

The HVL and TVL are expressed as the thickness of materials to stop half (%50) and 10% of neutrons and they are obtained using by equation 3 and 4 respectively:

$$HVL = \frac{Ln(2)}{\Sigma} \qquad (3)$$

$$TVL = \frac{Ln(10)}{\Sigma} \qquad (4)$$

The obtained results of *mfp*, *HVL* and *TVL* as a function of materials' density is shown in figure 3. It can be seen from this figure that the all quantity have inverse distribution with the FNRCS.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

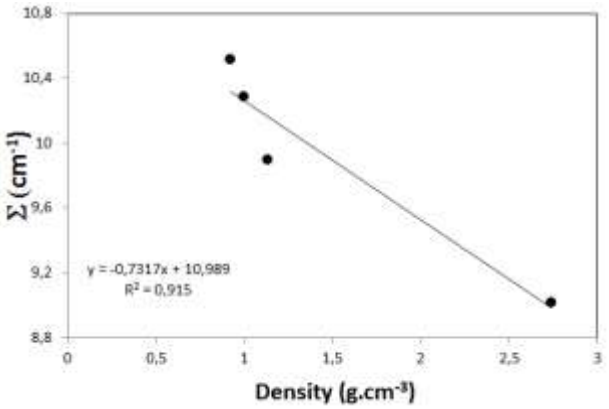

Figure 1. FNRCS *as a function of densities of material*

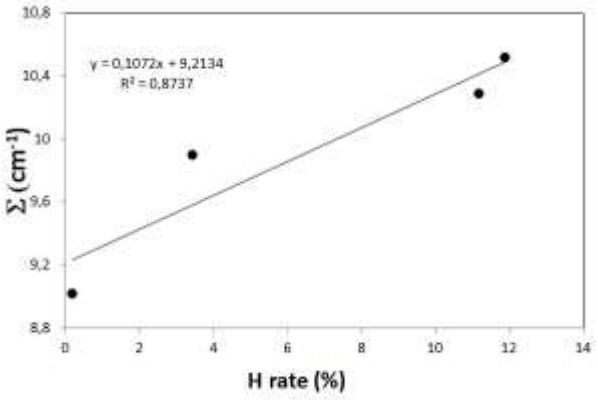

Figure 2. FNRCS *as a function of H rate in materials*

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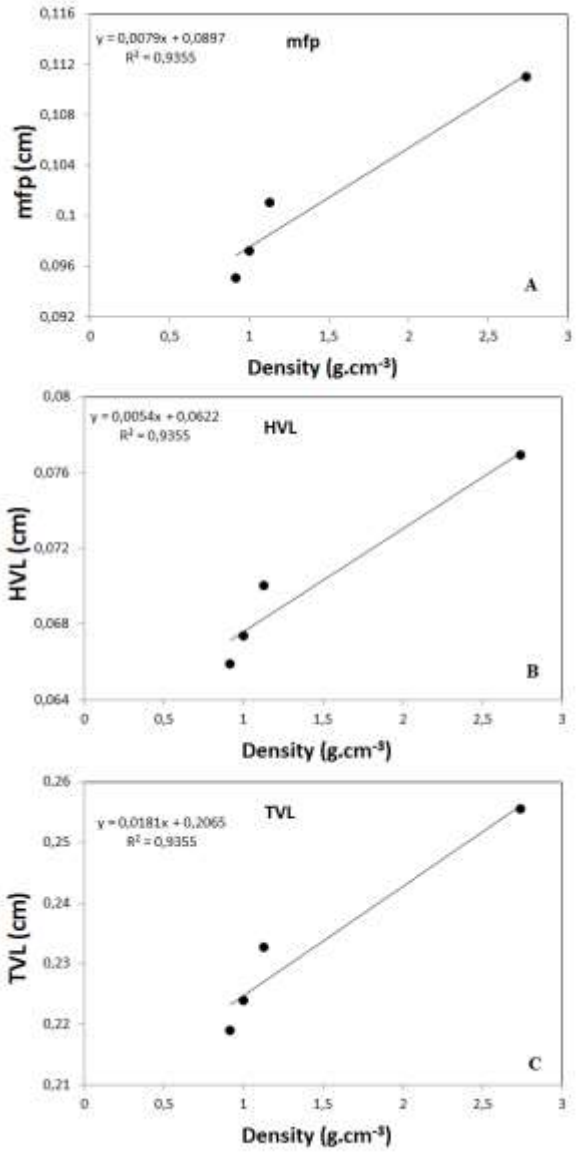

Figure 3. *mfp (in upper), HVL (in middle) and TVL (in lower) as a function of density for four types materials*

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