Advances in Physics Theories and Applications
ISSN 2224-719X (Paper) ISSN 2225-0638 (Online)
Vol.46, 2015

The Effect of the Concentration Chang of Reinforcing Materials on the Values of Some Theoretical Attenuation Parameters

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Abstract:

In this paper, some theoretical attenuation parameters was calculated for shields made up of composite materials basis polymer (Epoxy) with added materials (C,Ni,PbO,Bi) with different concentrations (10,20,30,40,50)wt% , where the effect of concentrations variation on the attenuation coefficients values , effective atomic number and shields density has been studying. The computer program code X-Com was used to calculate the attenuation parameter values at different energies (0.662,1.173,1.332)MeV .Results shows that there is a clear change in the values of these parameters with the change of concentration ratios.

1.Introduction

In general, shields used to reduce exposure to nuclear radiation and their secondary interactions with the material and to minimize the effects on human tissue [1]. There are many shielding materials designed against various harmful rays to the human body. The polymer based composites such as polyethylene, polystyrene and epoxy have been selected in the field of radiation protection[2].In the recent years, composite materials employed in the gamma-ray shielding and showed good efficiency in this field, Composite materials are multi-phase materials obtained by artificial combination of different materials, so as to attain properties that the individual components by themselves cannot attain [3]. Epoxy is a adhesive resin that is resistant against water and acids and do not lose strength over time, and have a good thermal and mechanical properties[4]. Reinforcement materials played the important role to improve the matrix properties. With the good choice of metallic fi llers, gamma rays shielded[5]. Therefore, in this study, we attempted to prepare and characterize the polymer based composite radiation shields using epoxy as a matrix and C,Ni,PbO and Bi metals as fillers. Then, the effect of fillers concentrations variation on some attenuation parameters was studied.

2.Theory

2.1Mass attenuation coefficient

Mass attenuation coefficient (μ_m) is one of the most important factors that describe the gamma rays penetrate through the target material [6].It is a measure of the average number of interactions that occurs between incident photons and matter of unit mass per unit area[7]. It is the fundamental parameter to derive many other parameters such as effective atomic number, electron density and half-thickness[8].

Calculations of the mass attenuation coefficients of all investigated samples at the energy 0.661,1332 keV were performed using the XCOM program which can generate cross sections and attenuation coefficients for elements, compounds or mixtures in the energy range between 1 keV and 100 GeV in the form of total cross-sections and attenuation coefficients [9].

2.2 Volume fraction and Density of composite shields

The volume fraction of the composite material is the important factors to be controlled [10], and can be calculated from the following equation [11]:

$$V_f = 1/\left[1+\left(\frac{1-\psi}{\psi}\right).\frac{\rho_f}{\rho_m}\right] \quad (1)$$

Where ψ : is the fraction weighted for reinforcement materials.

ρ_f , ρ_m : Density of reinforcement and matrix material respectively.

Vf : volume fraction.

While the density of composite materials can be calculated from the following equation [12]:

$$\rho_c = V_f * \rho_f + (1 - V_f)\rho_m \quad (2)$$

Where ρ_c : is the density of composite material.

2.3 Effective atomic number

In composite materials, the scattering and absorption of gamma radiation are related to the effective atomic number (Zeff) and the effective electron density (Nel) [13]. The effective atomic number which is a very useful parameter for many fields of scientific, technological and engineering applications [14]. The effective atomic number of the different shield composites is based on the determination of total attenuation cross section for gamma-ray interaction and it can be commonly obtained by the relation [15]:

$$Z_{epoxy} = \frac{\sigma_a}{\sigma_{el}} \quad (3)$$

Where σ_a and σ_{el} represent total atomic cross section and total electric cross section respectively.
The Z_{eff} in equation (3) it's for matrix material (epoxy polymer in this paper) , and the total Zeff of composite material shield calculated by the relation[16] :

$$Z_{eff} = \sum_{i=1}^{2} Wi\ Zi \quad (4)$$

Were Wi and Zi represent the weight percentage of each substance in Shield and the atomic number of each substance in the shield respectively.

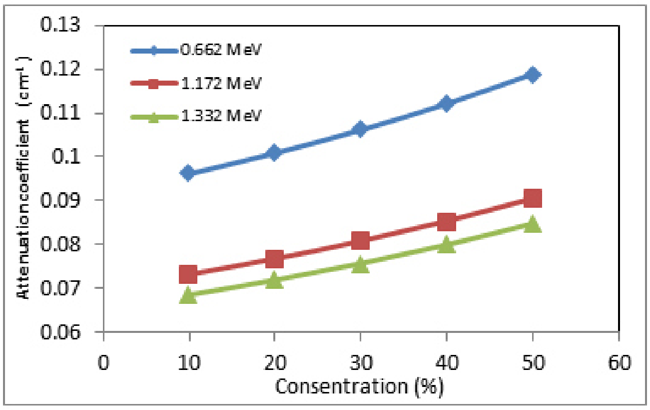
3.Results and discussion

The mass attenuation coefficient, effective atomic number and density for each shield were calculated. The effect of increasing the filler concentration in the composite on these parameters was studied. The relationship between mass attenuation coefficient and concentration of the fillers shows in figures (1,2,3,4) . From this figures , the value of attenuation coefficients increase when the concentration increase .This refer that there is an improvement in the behavior of the epoxy and the composites properties moving towards concentration properties. As well known, the absorbance of metal to radiation is higher than the polymer, thus, composite materials become suitable to use as a shields against gamma rays.

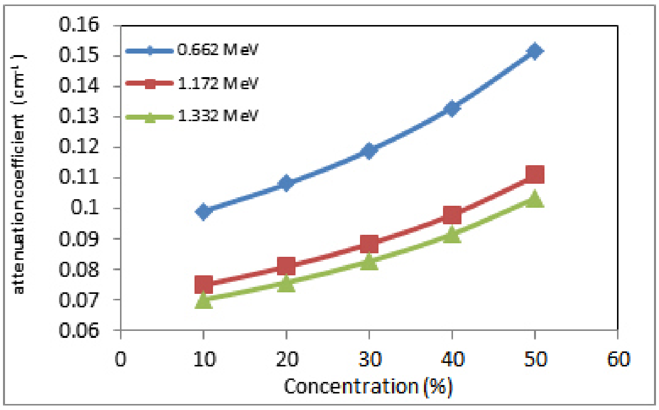
Figure (5) represents the relation between concentration and effective atomic number. We can see form this figure , the effective atomic number increase with increasing of filler concentration , and this lead to increase the attenuation coefficient .We can explain this as, when effective atomic number increase , the probability of interaction of gamma rays with the shield material via photoelectric effect and scattering and attenuation will be high, as well as when the effective atomic number is law, the probability of penetrating gamma rays will be high and therefore have law attenuation. Figure (6) shows the relation between filler concentration and shield density. It obvious from this figure that the shield density increases with with increasing of filler concentration and this lead also to increasing the attenuation coefficient. The low density of the shield material will give rise to less attenuation than a high density , since the chances of an interaction between the radiation and the atoms of the shield are relatively lower.

4.**Conclusion**

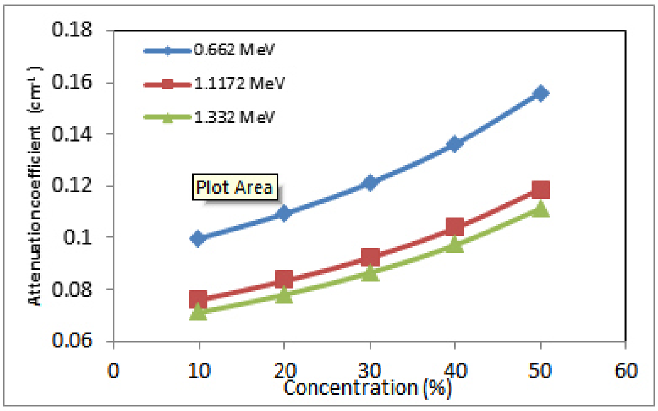
We can conclude that increasing the concentration of reinforcement materials in composite materials affect the attenuation parameters, and this leading to improve the properties of composite materials and make them suitable for use as shields in nuclear applications.



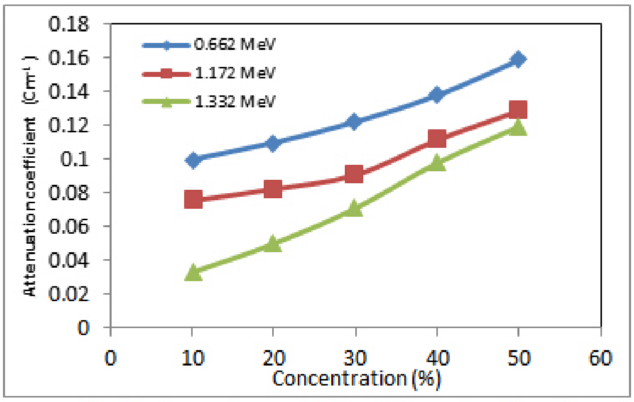
Fig(1).Attenuation coefficient (μ) as a function of concentration (%) for (C).



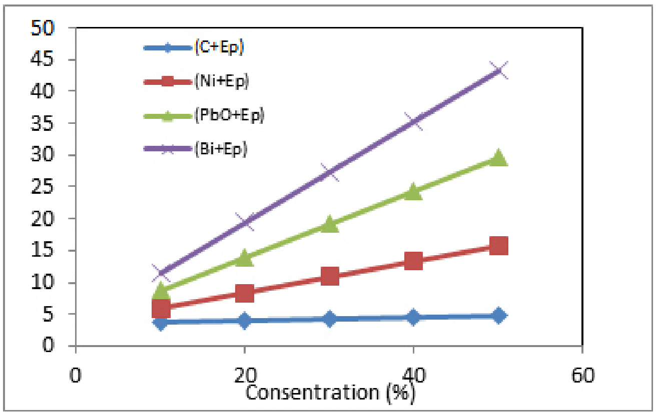
Fig(2).Attenuation coefficient (μ) as a function of concentration (%) for (Ni).



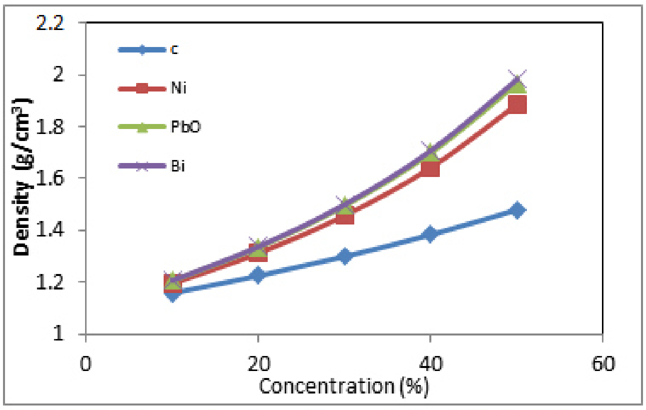
Fig(3).Attenuation coefficient (μ) as a function of concentration (%) for (PbO).



Fig(4).Attenuation coefficient (μ) as a function of concentration (%) for (Bi).



Fig(5).Effective atomic number as a function of concentration (%) for different composites.



Fig(6).Density as a function of concentration (%) for different composites.

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