Journal of Advances in Applied Sciences and Technology

ISSN : 2393-8188 (print)
2393-8196 (online)
www.milliyasrcollege.org.journal.php

GAMMA RAYS INTERACTION STUDIES OF COMPOSITE MATERIAL: A REVIEW

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ABSTRACT: With the extensive use of gamma-active isotopes in medicine, industry and agriculture, the study of Absorption of gamma rays in the composite materials has become an interesting and exciting field of research. The photon mass attenuation coefficient, effective atomic number and electron density are the basic quantities required in determining the penetration of X-rays and gamma photons in matter. The mass attenuation coefficient (μ/ρ) is a measure of probability of interaction that occurs between Incident photons and matter per unit mass per unit area. In this paper, we studied the above parameters for composite materials

KEYWORDS: Mass attenuation coefficient, effective atomic number, electron density and composite materials.

1. INTRODUCTION

The photon attenuation coefficients of composite materials are an important parameter for characterizing the penetration and attenuation properties of x-ray and gamma rays in materials. Accurate data on photon attenuation coefficients of composite materials are required in a verity of applications in nuclear science, technology and medicine [1]. Mass attenuation coefficients and linear attenuation coefficients are two quantities widely used in the study of interaction of γ-rays with matter. the photoelectric effect ,Compton scattering and pair production processes are the predominant interactions between the photons and atoms apart from other types over a wide range of energies by irradiating the material with gamma rays ionization of the material takes place and stored energy of the material increases .[2] Accurate values of photo electric cross section from photon radiation in several composite materials are needed in solving various problem in radiation physics and radiation dosimetry it is important to note that much of the data is related on theoretical work and only few experimental results are available for comparison. It is necessary to ensure that the theoretically predicated values do indeed agree with experimental results.[3] Extensive studies have been carried out to determination gamma ray attenuation coefficients for various elements and composite materials [4-5,7-12].

Composite materials of glass and ceramics, typically associated with the most brittle materials. Bonding in ceramics and glasses use covalent and ionic-covalent types with SiO_2 (silica or sand) as a fundamental building block. Ceramics are as soft as clay and as hard as stone and concrete. Usually, they are crystalline in form. Most glasses contain a metal oxide fused with silica. At high temperatures used to prepare glass, the material is a viscous liquid. The structure of glass forms into an amorphous state upon cooling. Windowpanes and eyeglasses are important examples. Fibers of glass are also available. Scratch resistant Corning Gorilla Glass is a well-known example of the application of materials science to drastically improve the properties of common components. Diamond and carbon in its graphite form are considered to be ceramics.

Engineering ceramics are known for their stiffness and stability under high temperatures, compression and electrical stress. Alumina, silicon carbide, and tungsten carbide are made from a fine powder of their constituents in a process of sintering with a binder. Hot pressing provides higher density material. Chemical vapor deposition can place a film of a ceramic on another material. Cermets are ceramic particles containing some metals. The wear resistance of tools is derived from cemented carbides with the metal phase of cobalt and nickel typically added to modify properties.

Other examples can be seen in the "plastic" casings of television sets, cell-phones and so on.

These plastic casings are usually a composite material made up of a thermoplastic matrix such as acrylonitrile-butadiene-styrene (ABS) in whichcalcium carbonate chalk, talc, glass fibers or carbon fibers have been added for added strength, bulk, or electrostatic dispersion. These additions may be referred to as reinforcing fibers, or dispersants, depending on their purpose.

2.THEORY: The mass absorption coefficient is used alternatively with linear attenuation coefficient in calculation it is defined as,

$$I = I_0 e^{-\mu t}$$

$$I = I_0 e^{-\mu/\rho\,(\rho t)} \quad ---- \quad (1)$$

As $$\mu = \frac{1}{t} \ln\left(\frac{I_0}{I}\right) \quad ----- \quad (2)$$

And $$\mu/\rho = \frac{1}{\rho t} \ln\left(\frac{I_0}{I}\right) \quad ----- \quad (3)$$

Where I and I_0 are intensities of gamma radiation of energy E transferred through the container respectively with and without absorber of thickness t then the linear (μ) and mass (μ/ρ) attenuation coefficient are given from the above experimental law.

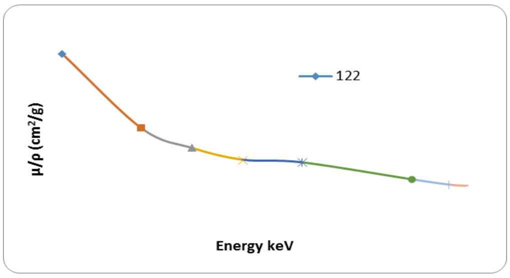

***Fig.**1 Plot of mass attenuation coefficient μ/ρ (cm^2/g) verses Energy in keV for SiO_2 Silica or Sand composite material in the energy range 122-1330keV.*

Effective atomic number (Z_{eff}) and electron density (N_e) of SiO_2 Silica or Sand composite material is as follows Effective atomic number (Z_{iff}) = 10

Electron density (N_e) = Z_{iff} /A_{eff} *N_A =10/20.0278*6.02486X10^{23} = 0.30082 X10^{24}

Where N_A is Avogadro's number and A_{eff} is effective atomic weight.

Polymers:

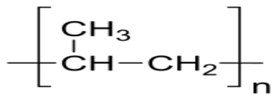

***Fig.**2 The repeating unit of the polymer polypropylene*

***Fig.**3 Expanded polystyrene polymer packaging.*

Polymers are also an important part of materials science. Polymers are the raw materials (the resins) used to make what we commonly call plastics. Plastics are really the final product, created after one or more polymers or additives have been added to a resin during processing, which is then shaped into a final form. Polymers which have been around, and which are in current widespread use, include polyethylene, polypropylene, PVC, polystyrene, nylons, polyesters, acrylics, polyurethanes, and polycarbonates. Plastics are generally classified as "commodity", "specialty" and "engineering" plastics.

PVC (polyvinyl-chloride) is widely used, inexpensive, and annual production quantities are large. It lends itself to an incredible array of applications, from artificial leather to electrical insulation and cabling, packaging and containers. Its fabrication and processing are simple and well-established. The versatility of PVC is due to the wide range of plasticisers and other additives that it accepts. The term "additives" in polymer science refers to the chemicals and compounds added to the polymer base to modify its material properties.

Polycarbonate would be normally considered an engineering plastic (other examples include PEEK, ABS). Engineering plastics are valued for their superior strengths and other special material properties. They are usually not used for disposable applications, unlike commodity plastics. Specialty plastics are materials with unique characteristics, such as ultra-high strength, electrical conductivity, electro-fluorescence, high thermal stability, etc.

The dividing lines between the various types of plastics is not based on material but rather on their properties and applications. For instance, polyethylene (PE) is a cheap, low friction polymer commonly used to make disposable shopping bags and trash bags, and is considered a commodity plastic, whereas medium-density polyethylene (MDPE) is used for underground gas and water pipes, and another variety called Ultra-high

Molecular Weight Polyethylene UHMWPE is an engineering plastic which is used extensively as the glide rails for industrial equipment and the low-friction socket in implanted hip joints[13].

Table 1: Mass attenuation coefficient μ/ρ (cm^2/g) of SiO_2 Silica or Sand composite material in the energy range 122-1330keV.

Sr. No.	Energy KeV	μ/ρ(cm^2/g)
1	122	0.155
2	360	0.098
3	511	0.083
4	662	0.074
5	840	0.072
6	1170	0.059
7	1280	0.055
8	1330	0.054

Interaction of radiation with matter:

Photoelectric (PE): Absorption of x-rays occurs when the x-ray photon is absorbed, resulting in the ejection of electrons from the outer shell of the atom, and hence the ionization of the atom. Subsequently, the ionized atom returns to the neutral state with the emission of an x-ray characteristic of the atom. This subsequent emission of lower energy photons is generally absorbed and does not contribute to (or hinder) the image making process. Photoelectron absorption is the dominant process for x-ray absorption up to energies of about 500 Kev. Photoelectron absorption is also dominant for atoms of high atomic numbers.

Compton Scattering (CS): When the incident gamma-ray photon is deflected from its original path by an interaction with an electron. The electron gains energy and is ejected from its orbital position. The x-ray photon loses energy due to the interaction but continues to travel through the material along an altered path. Since the scattered x-ray photon has less energy, it therefore has a longer wavelength than the incident photon.

Pair Production (PP): Pair production occurs when an electron and positron are created with the annihilation of the x-ray photon. Positrons are very short lived and disappear (positron annihilation) with the formation of two photons of 0.51 MeV energy pair production is of particular importance when high-energy photons pass through materials of a high atomic number.

Gamma ray shielding is usually described in terms of a parameter known as the half value layer (HVL) of the absorber. HVL is the absorber thickness that reduces the original gamma ray intensity I0 to half, the transmitted intensity [2].

3. Results and Discussion

Mass attenuation coefficient of composite materials for multi gamma ray energies (Co^{57}, Ba^{133}, Na^{22}, Mn^{54}, Cs^{137}, Co^{60},) has been studied. From Fig.1 graph it is observed that as energy increases mass attenuation coefficient of composite materials goes on decreasing. Various parameters such as mass attenuation coefficient (μ/ρ), effective atomic number (Z_{eff}) and electron density (N_e) have been obtained for composite material. Here we have studied all these parameters for only one sample of composite material like SiO_2 Silica or Sand.

4. Conclusions

The theoretical values of mass attenuation coefficient for composite materials are available from [6] confirms the contributions of various processes such as photo electric effect, Compton scattering and the pair production. The mass attenuation coefficient of composite materials are useful for radiation dosimetry and shielding purpose.

Acknowledgement:

One of the authors (PPP) is very much thankful to DAE-BRNS for giving financial support for Major Research Project on doing work on Establishment of radiological data of biomolecules using gamma ray spectrometry

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