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INVESTIGATION OF SHIELDING PARAMETERS TO FABRICATED SHIELDS FROM POLYMER WITH NANO-BARIUM OXIDE MATERIALS

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Abstract:

Researchers have long been involved in improving new and effective radiation-protection materials. In this study, we will verify the measurement of the attenuation coefficient of gamma rays, which is considered one of the most important points of protection from ionizing radiation, by fabricating a radiation-protective shield made by combining pol unsaturated polyester as a base material for the shield and reinforced by varying concentrations of the nano- barium oxide (BaO) in different proportions (15,25,35 and 45) %. Making use of an ultrasonic stirrer, and the radiation shielding properties of gamma rays are presented for the energies shown in this article. The results reveal that nanostructured samples are preferable at the linear and mass attenuation coefficients (LAC and MAC), the value of the shield's electronic density(Ne), and the value of radiation protection effectiveness (PRE) increased with the increase of reference material, which are considered good materials in radiation protection, but decreased with the increase in gamma ray energy.

Keywords: BAO, LAC, MAC, NE, PRE.

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INTRODUCTION:

Nuclear technology is now being applied in a variety of advanced aspects of our everyday lives. Which is dependent on the usage of certain valuable and significant uses of various types of radiation in the fields of medicine, science, industry, agriculture, and scientific research. The problem of these benign applications of radiation is that this technology creates various types of radiation that are harmful, such as neutron and gamma rays. As a result, it is essential to evaluate these hazards, determine the degree of radiation exposure, and devise measures to safeguard against dangerous radiation [1]. As a result of polymers' special qualities, such as their capacity to form complex shapes, low density, processibility, easy processing, and good high hardness, X-ray technologists become more interested in strengthening polymers with reinforced materials in radiation protection. [2-4]. The MAC) μ/ρ (is a measurement of the mean proportion of interactions between radiation which is incoming and materials that can place in a particular mass-per-unit area width of the contacted materials [5-8]. A unique atomic number is a property of an element but does not accurately characterize the atomic number of a composite material in all energy levels due to the photon interaction cross-section for elements of the composite material. hence, the actual atomic number [9] Z_{eff}, proposed by is a new quantity for composite materials that changes according to energy. In various technological applications and nuclear medicine, determining the effective atomic number, Z_{eff}, and the effective electron number per unit mass, Ne, which is another crucial factor for composite materials, is necessary for dose estimation in radiation therapy and medical imaging [11,12] The parameter can be used to check the prepared composite sample's shielding effectiveness. According to the net count rate (inter intensity) with and without the prepared composite during the measurement, the so-called radiation protection efficiency (RPE) [12-15]. In this work, we developed a novel, environmentally friendly, and lightweight polymeric composite by using an unsaturated polymer with of the nano- barium oxide as reinforcement to improve the composite's ability to protect against radiation. Because it is a metal oxide with a high density and atomic number, it is predicted to absorb high intensity radiation. Furthermore, certain important characteristics of ionizing radiation shielding are discussed.

Experimental Work

The required amount of unsaturated polyester was then weighed based on the volume fraction of the reinforcing materials, taking into account the weight of the hardener. The nano-barium oxide powders were weighed, and the corresponding volume fraction was calculated for each weight percentage of the powder (15,25,35 and 45) %. It is included in the weight of the unsaturated polyester base material and is added at a rate of (2%). In order to prevent the formation of bubbles during the mixing process that takes place at room temperature, the weighted amount of unsaturated polyester was mixed with the added hardener at a ratio of (2gm) for each (100g) of the resin. The mixture was then continuously and slowly mixed using a glass rod. During this stage, a certain amount of the powder is gradually added to the mixture. After its addition and the completion of the mixing process for it, which lasts for a period of time ranging from (10-20) minutes, the mixture is well homogeneous and the temperature of the mixture rises, which is evidence of the beginning of the reaction process. Then the compound is transferred. Conduct the necessary shielding tests after transferring the mixture to specific molds and allowing it to dry for 48 hours.

RESULTS AND DISCUSSION

The LAC and MAC values vary with concentration, and their values increase as concentration increases. This can be explained by the fact that as additive concentrations increase, the base material's distribution of the additive will also do so, increasing the additive's absorption processes, which in turn raises the shields' overall density. Attenuation coefficients will increase as a result. Unsaturated polyester by itself isn't appropriate for used as a gamma ray shielding, but only when reinforced elements are added to it, it is possible to employ unsaturated polyester as a shield against gamma rays. The Figures (1, 2) illustrate that as the incident photons' energy rises, The LAC and MAC decrease. limited energy photons are the main source of the dominant photoelectric effect, and the Compton effect's linear attenuation coefficient (LAC) is smaller than that of the photoelectric effect. Unless the energy is higher than the pair does not occur at all (1.022 MeV). Factors that could cause radiation measurements to produce inaccurate results. These considerations include the type and geometry of the radioactive source, whose internal absorption has an impact on the amount of radiation it emits, particularly at low energy. The precision of the experimental results is significantly influenced by the physical medium that is present between the source and the detector.

It was observed that the electron density (Ne) of the prepared shields increases with the increase in the concentration of the reinforced material. Ne contrast with the energy of the incident photon as shown in Figure (3) The study uses three energy domains where the dominating events are, respectively, photoelectric absorption, compound scatter, and pair production. Low energies are where photoelectric absorption predominates and is dependent on the amount of initial energy used. In the mean energies, scattering dominates and varies depending on how much initial energy is there. The variance values of the electron density values in three different energy bands were investigated. At higher energies, the output from the pair changes with attenuation due to the presence of sharp motions in the Ne values in specific energy regions.

Figure (4) illustrates the radiation protection efficiency of the constructed shield (RPE) as a function of the concentration of barium oxide nanoparticles. The RPE increases as the concentrations while decreasing with increasing incident photon energy (for each concentration alone). This reduced slope is due to the shields' decreasing ability to effectively filter incoming radiation. The higher energy photons' improved penetrating strength is what causes this drop. These findings reveal that adding BaO to the unsaturated polyester enhances the polymer's ability to protect when the values are contrasted with one another. The attenuation ability of the samples is improved by increasing the BaO concentration in the produced shield, according to this to a certain concentration.

Table (1):The Values Of LAC , MAC, Ne and RPE of fabricating shield

Parameter	Concentrations of BaO	662 (KeV)	1173 (KeV)	1332 (KeV))
LAC *(cm^{-1})*	0%	0.0843	0.0613	0.0573
	15%	0.1313	0.0973	0.0903
	25%	0.1893	0.1363	0.1283
	35%	0.2733	0.1973	0.1833
	45%	0.3623	0.2633	0.2463
MAC *(cm^2/g)*	0%	0.07025	0.051083	0.04775
	15%	0.10727	0.079493	0.07377
	25%	0.14572	0.104927	0.09876
	35%	0.19690	0.142147	0.13206
	45%	0.24529	0.178267	0.16675
N_e	0%	0.2810	0.204333	0.191
	15%	0.429085	0.317974	0.295098039
	25%	0.58291	0.419707	0.395073133
	35%	0.787608	0.568588	0.528242075
	45%	0.981178	0.713067	0.667027759
RPE)%(	0%	8.084453	5.945896	5.568926635
	15%	12.30454	9.271622	8.634295296
	25%	17.24618	12.74192	12.04105373
	35%	23.91355	17.90557	16.74816372
	45%	30.39265	23.14887	21.83123166

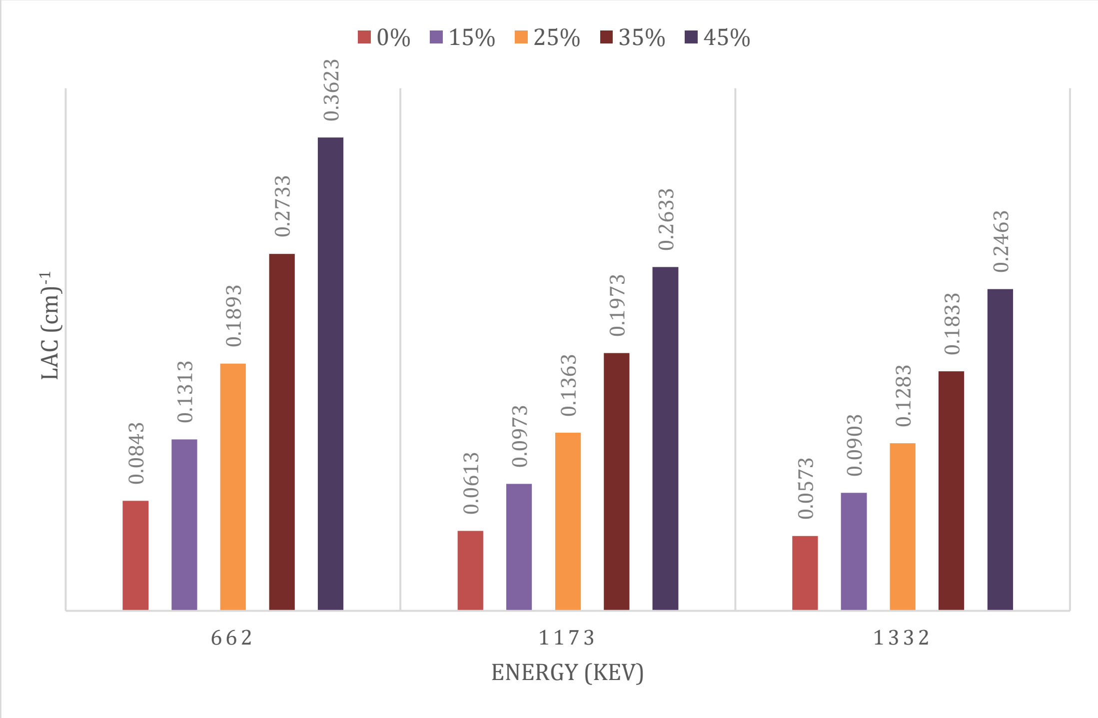

Figure -1: The LAC of prepared shields as a function of energy in (KeV)

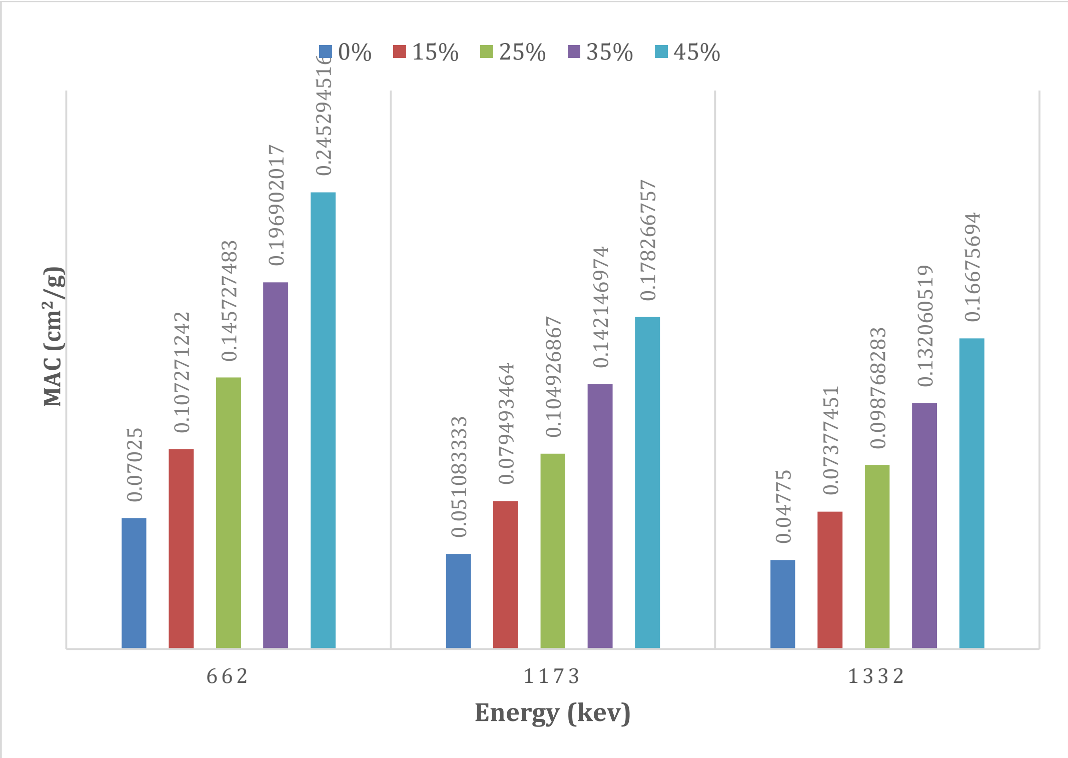

Figure -2: The MAC of prepared shields as a function of energy in (KeV)

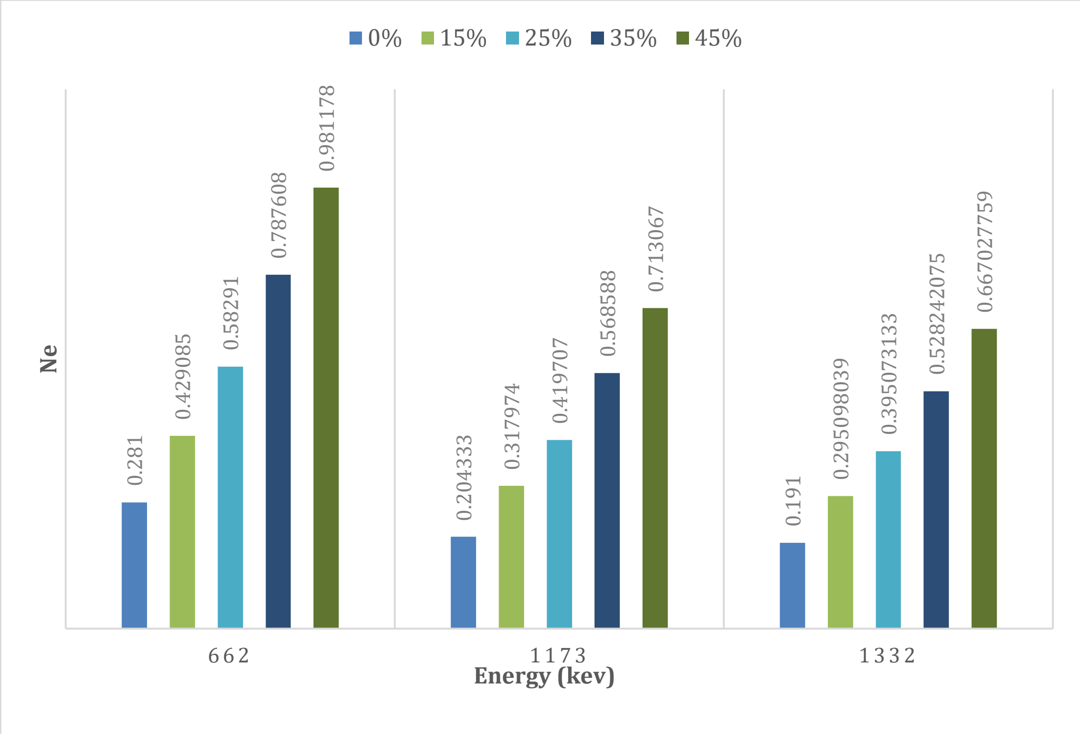

Figure -3: The Ne of prepared shields as a function of energy in (KeV)

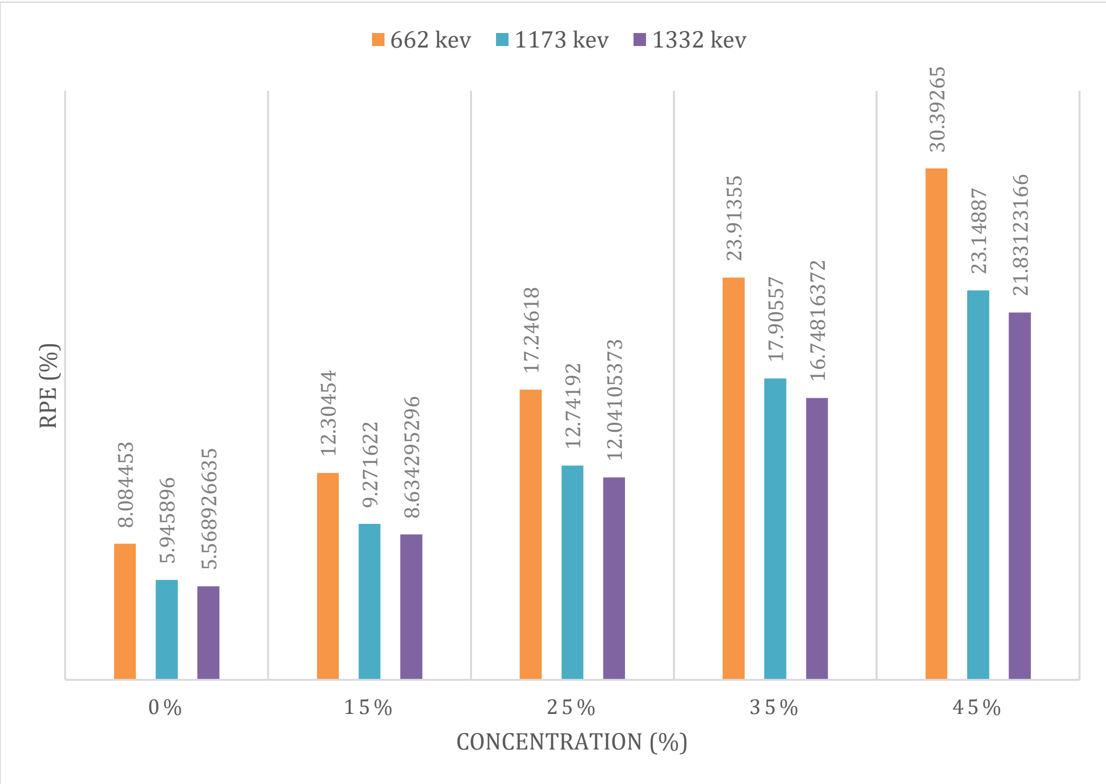

Figure -4: The RPE of prepared shields as a function of concentration of BaO in (%)

CONCLUSIONS:

1- The usage of nanomaterials has opened up brand-new possibilities for the creation of affordable and efficient radiation shielding materials that act as photon attenuators.
2- Even while photon energies affect both the linear and mass attenuation coefficients, they have less of an impact on electron density.
3- The efficiency of radiation protection reduces with increasing incident photon energy and increases as the concentration of the reinforced material.
4- This study finds that the current polymers can be employed alone at low energy or in combination with other high Z materials for high energy gamma ray shielding.

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