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Research Article

Examination of the radiation absorption parameters of CuO coatings prepared at different ratios

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Abstract: This article contains the results of an experimental study to investigate the radiation absorption properties of different ratios of CuO-coated glasses. A gamma spectrometer connected with an NaI(Tl) detector has been used to assess the radiation shielding abilities of glass materials coated with CuO. The shielding characteristics of a CuO-doped glass samples with PMMA at a gamma energy of 662 keV were examined in this scope. The mean free path (mfp), half value layer (HVL) and tenth value layer (TVL) parameters have been determined using the results. As a result of this study, when glass materials coated with PMMA and CuO at different ratios were compared, it was concluded that increasing the amount of CuO in PMMA decreased the absorption coefficient.

Keywords: CuO, radiation absorption parameters, gamma spectrometer

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1. Introduction

With the advancement of technology and the increasing use of radiation-based devices in almost every field, radiation protection has become even more important. Shielding, one of the most important methods of radiation protection, is the reduction of radiation intensity to minimum levels by placing a shielding material between the radioactive source and the living to protect against radiation or minimize exposure. When shielding is applied, the radiation emitted from the source interacts with the atoms of the shielding material, causing ionization and thereby losing its energy completely or partially.
While dose limitation is the most effective way to minimize the effects and damage caused by X-rays and γ-rays, new materials are being developed for radiation shielding in situations where this is not possible. In the literature, there are many materials in which radiation shielding properties are investigated such as concrete, stell, metal, etc [1-5]. In this study, glass substrates were coated with CuO at concentrations of 10%, 20%, 30%, 40%, and 50% using the spin coater method.

2. Material and Methods

The homogeneous mixture of CuO and PMMA prepared in the specified percentages, has been coated onto glass substrates using the spin coating method by spinning at a speed of 2500 r/min. The resulting glass substrates have been left to dry at room temperature.

Subsequently, radiation absorption determination of glass materials was performed experimentally using a gamma spectrometer consisting of a NaI(Tl) detector and a multichannel analyzer (Fig. 1)

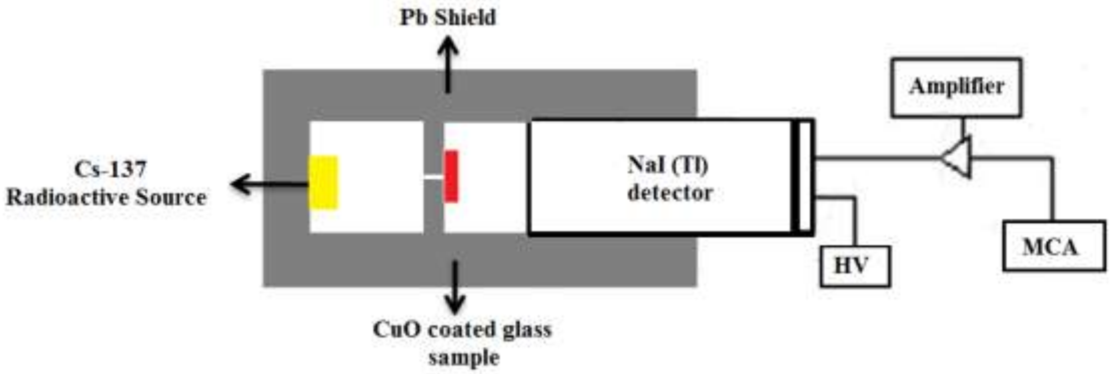

Figure 1. *The gamma-ray spectroscopy system's design*

The linear attenuation coefficient (μ) is calculated from the Beer-Lambert equation.

$$\mu = \frac{1}{x} In(\frac{N_0}{N})$$

where x is the thickness of the glass sample, N_0 and N are the net counts before and after attenuation, and μ is the linear attenuation coefficient.

The linear attenuation coefficient-energy graph measured for CuO thin films coated at different ratios is given in Fig. 2.

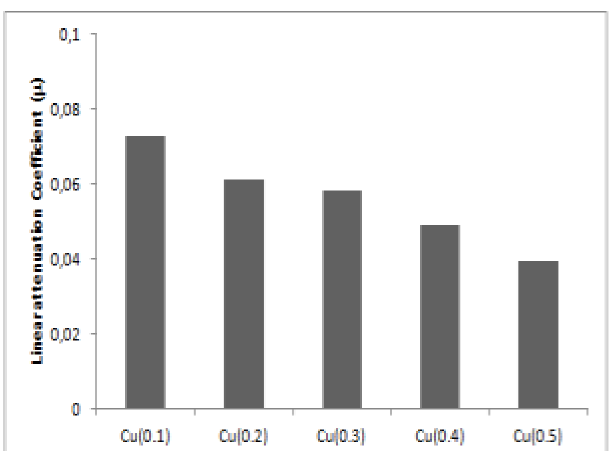

Figure 2. *Measured linear attenuation coefficient-energy change for different ratios CuO thin films*

When this figure is examined, it can be seen that in glass materials coated with different ratios of PMMA and CuO, increasing the amount of CuO in the PMMA decreases the absorption coefficient.The average free path (mfp), half value layer (HVL), and tenth value layer (TVL) are crucial theoretical characteristics that are examined for gamma ray protection [6-16].
The parameter that allows us to determine the average distance traveled by incident radiation between two interactions within a material is the mean free path (mfp). It is calculated using the following formula:

$$mfp = \frac{1}{\mu}$$

The mfp- %ratio graph measured for CuO thin films coated at different ratios is given in Fig. 3.

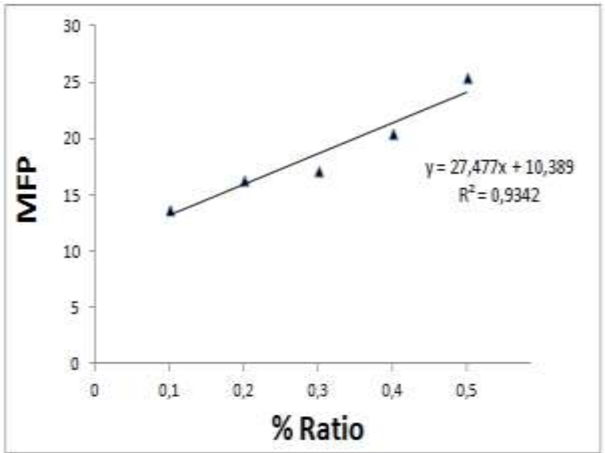

Figure 3. *Measured mfp-%ratio change for different ratios CuO thin films*

When this figure examined, the linear correlation between the % ratio of CuO samples and mfp has been seen for all samples, and R^2 was found to be over 0.90.
Half value thickness (HVL) refers to the thickness of the shielding material required for the intensity (N_0) of the incident photon to be halved before it interacts with the material ($N = N_0/2$), and the tenth value thickness (TVL) is the thickness of the shielding material that will reduce the gamma radiation to a tenth of its intensity ($N = N_0/10$). It is calculated using the following formula:

$$HVL = \frac{In2}{\mu} \qquad TVL = \frac{In10}{\mu}$$

The gamma ray transmission factor of the different ratios CuO samples as a function of material's thickness have been displayed in Fig. 4. It can be seen from this figure that the thickness of 0.5 CuO coated glass material should be kept higher than 0.1 CuO coated glass materials in order to stop gamma rays with the same energy.

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.

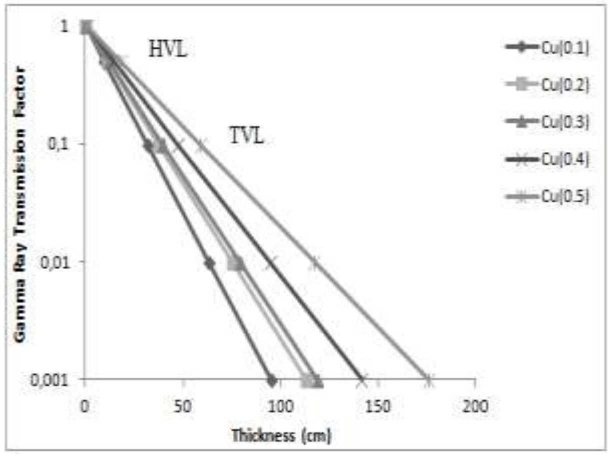

Figure 4. *Measured gamma ray transmission factor-thickness change for different ratios CuO thin films*

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