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The radiation shielding performance of concrete in the presence of tungsten oxide nanoparticles against gamma rays

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Abstract

The limitations and disadvantages of current shielding materials have led to an increased interest in nanocomposites for protection against ionizing radiation in industry and medicine. In the meantime, nanocomposites have been introduced as effective gamma ray shields. Key factors such as natural abundance, simplicity in the nanocomposite fabrication process, atomic number of constituent metals (and their effect on reducing radiation flux), as well as cost-effectiveness play an important role in the selection of shielding materials. Considering these factors, this study evaluates the performance of concrete shielding, which was prepared in the Concrete Reference Laboratory at the Standards Research Institute under the supervision of the Honorable Advisor Professor, and combined with tungsten oxide nanoparticles and resin against gamma radiation. By changing the weight percentage of tungsten oxide nanoparticles, the gamma radiation spectrum was analyzed. The results show that nanostructured shields with appropriate weight percentage and thickness can effectively replace thicker conventional concrete shields.

Keywords: *Shielding, Tungsten nanoparticle, biological hazards of radiation, Cancer*

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Extended Abstract:

1. Introduction

Today, protection against ionizing radiation is one of the most important issues in the use of these rays. Increasing the efficiency of radiation protection materials is a topical issue and of interest to scientists. In recent years, the use of X-rays and gamma rays in medicine has grown significantly, which has been significant and important in both clinical and medical fields, and in diagnostic and therapeutic applications. Since the nature of biological tissues against doses of X-ray radiation leads to short-term and long-term biological effects, such as gene changes, cancer, organ defects, etc., appropriate protection against these radiations is very important (1). Conventional shielding materials, including lead, iron, and various types of concrete, play an important role in shielding. For example, they are used in CT scan radiology and nuclear medicine and in related rooms. Lead and other materials such as bismuth tungsten have also been used for shielding. Recently, the use of polymers and concrete in combination has also been reported (2). However, effective research has not yet been done on the use of nanocomposites. Many nanoparticles are used today for protective applications, including bismuth oxide, tungsten oxide, lead to lead oxide, tetravalent lead oxide, divalent lead oxide, iron oxide and gadolinium oxide. These nanoparticles can be mixed with concrete or we can mix them with rubber or epoxies. In this project, we are looking at using epoxy resin containing tungsten nano particles with different weight percentages to be coated on concrete. This is happening for the first time in Iran. The protective properties of this compound for low-energy and high-energy radiation are investigated (1). In this way, by changing the weight percentage and calculating HVl, we evaluate the protective effect of the compound against radiation. Since epoxy coatings are used today in industry and construction to protect concrete from moisture and increase corrosion resistance, the use of these coatings for protective purposes can also be considered. Coated walls provide the ability to wash and paint on concrete. In this regard, the thickness of the epoxy used on concrete should be examined so that it is both economically viable and the protective properties of the composite can be a suitable alternative to concrete. Since the use of concrete causes numerous problems, including the high weight of the structure for radiation treatment centers, reducing the amount of concrete used and replacing it with lightweight materials can greatly reduce the dead load of the building and also make it possible to use lighter structures for medical imaging centers on floors other than the ground floor of buildings. In this project, the HVl of concrete for gamma radiation of 1.17 Mev from a cobalt source was investigated, measured, and then compared with a manufactured and epoxy-coated sample (3).

2. Materials and methods

To make the desired concrete, standard sand is needed, which is made according to the EN 196-1 standard, weighs 1350 grams and is made of Elman, along with 450 grams of cement and 250 cc of water. To measure the samples, we use a beaker and a scale, and first we zero the weight of the beaker on the scale. Then we pour a volume between 225 cc and 250 cc of water into the beaker. Then, using another beaker, we first zero the weight of the beaker and pour 450 grams of cement into the beaker and mix it with water using a mixer. After that, we add the standard sand and mix everything together using a calibrated laboratory mixer, in such a way that first we mix for one minute at slow speed, then we rest for 30 seconds and mix for one minute at high speed.

Then we prepare three 4*4*30 cm molds and pour the concrete into the molds in three stages, layer by layer, and place them in a vibrating machine. The vibrating machine vibrates the molds 60 times, and when we add the last layer, we smooth the surface of the molds with a trowel or trowel.
After the concrete molds are prepared, we place the molds in a curing machine with a special temperature and humidity for 24 hours, then open the molds and cut them to the required dimensions. After cutting the concrete samples with different thicknesses in millimeters, we weigh the samples accurately with a scale with an accuracy of 0.001 grams. Then we mix the hardener and resin in a ratio of one to two and add tungsten nanoparticles with different weight percentages of 10%, 20%, 30% and 40% by weight to the resin and hardener mixture and mix thoroughly and stir continuously for ten minutes and coat the samples as a uniform coating. The samples are usually completely dry and ready to use after two days.

3. Tests results

To measure radiation and record the energy spectrum, a detector must be used. Among them, various types of detectors are used with different mechanisms. In this study, we worked with a scintillator detector or a cesium iodide scintillator.
-The preparation steps were carried out in the following order.
-Choosing a suitable counting container and counting geometry
-Sample preparation according to laboratory instructions
• -Setup process
• -Detector test
• -Energy calibration
• -Collecting the counting spectrum
• -Sample counting and collecting gamma spectra

The MCA device was calibrated with a cobalt-60 gamma source and then the background count was measured and recorded over several 450-second intervals. In the next step, the cobalt-60 radiation intensity was placed at a distance of 4 cm from the detector surface without using a filter and without using a shield, and its gamma spectrum was collected over 450 seconds with the NTMCA software. In the next step, by placing the prepared shields, the distance between the radioactive source and the detector was measured and recorded. A stabilizer was used to precisely adjust the distance between the source and the detector surface so that the conditions were the same throughout the experiment. In this study, the shield was evaluated in two ways: 1- Investigating the energy spectrum with concrete 2- Investigating the energy spectrum of concrete containing nanomaterials with different weight percentages of Varzin. In all experiments, a cobalt-60 laboratory source was used, the physical properties of which are given in Table 1. The prepared nanomaterials were added to the concrete samples with different weight percentages. These samples included tungsten WO3 with a weight percentage of 10%, 20%, 30% and 40%. The detector used is shown in Figure 9-3-a. The experimental setup is given in Figure 9-3-b. In the MCA settings, the number of channels was 1024 and the power supply voltage was 450 V with an efficiency of 100.

4. Conclusion

In this study, the design of concrete shields with nano tungsten compounds was investigated. In this regard, different percentages of nanomaterials were added to the concrete. The results show that with increasing percentage of nanomaterials, the attenuation coefficient also increases. It is noteworthy that this type of shield can be a suitable alternative to bare and lead concrete shields. The properties of concrete used with nano tungsten were investigated and evaluated using the HVL feature. This achievement indicates that if a diagnostic center is designed, for example, on the second floor of a building, the dead load of the building will be reduced by 20%. It is hoped that by changing the composition of nanomaterials, an optimal structure for clinical applications can be achieved.

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