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RESEARCH PAPER

Synthesis and characterization of nano Bi2O3 for radiology shield

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ABSTRACT

Objective (s): Recently, the use of nanoparticles in medicine has increased for radiation protection purpose. So the aim of this study was application of nano Bi2O3 in prepared shield for dose reduction during medical imaging.

Materials and Methods: Nano Bi2O3 shield with 90% silicon and 10% nano Bi2O3 was prepared and dosimetry test was down in radiology by PTW DIADOS E dosimeter.

Results: The mean dose without using nano Bi2O3 shields were 421 µGy, 733 µGy and 1110 µGy for 60, 80 and 100 kVp , respectively. After using 0.5 mm thickness of nano Bi2O3 shield dose reduction in 60, 80 and 100 kVp was 42%, 35% and 31%. A comparison between increasing energy from 60 to 100 kVp and dose reduction showed a significant reverse effect.

Conclusion: The results indicate that the new shields containing nano Bi2O3 particles have a high X-rays attenuation ability but the attenuation property of the shields was decreased by the increasing of the energy. Based on the results, this new shield can help social health and decline the radiation risk.

Keywords: *Attenuation, Nano Bi2O3, Shields, Radiography*

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INTRODUCTION

Radiation devices play an important role in the diagnosis of diseases. Although ionizing radiation help to solve of patients problem but it has possibility to damage to sensitive organs of the body [1]. Data showed that radiation can increase the risk of breast cancer which is one of the most common cancers among women [2]. Also it is dangerous for the eyes and thyroid and increases the risk of thyroid cancer and cataracts in the eye [3, 4].

One of the way to protect staff and patient from radiation is using of shields [5]. It seems, use of shielding to protect the thyroid, eye and breast as superficial organs could be a good suggestion. These shields are placed over the patient organs during examination [6].

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The organ dose in radiology tests was recorded lower but stochastic effects is important problem now. This problem regarding to sensitivity of women is much concern for female against male [7, 8]. Shields made of various materials such as lead, tungsten and bismuth compounds in different sizes are commonly used to protect sensitive organs against X-rays. Different atomic numbers of these materials also show different radiation attenuation behavior [9-12].

Recently, nanoparticles are used for dental applications, antibacterial agents, drug delivery systems, MRI contrast agents and nano bismuth have been introduced as a contrast agent in CT [13-28]. In a study, nano bismuth composites were used to reduce X-rays biological damage effect and showed high ability to protect radiation effects. According to the report of Nambiar et al. nano bismuth oxide in the composite was

able to attenuate most of the scattered X-rays in a 60 kVp [27]. Another study showed that nano Bi_2O_3 composite with starch matrix presented better X-ray shielding ability than its micro Bi_2O_3 composites without starch [28].

The decreasing of bismuth metal size can effect on the mass attenuation coefficient for different photon energies so that it induce more dose reduction for nano particles compared to the micro particles.

The aim of this study is synthesis of nano Bi_2O_3 for radiation damage or induce cancer effects decline in imaging methods as well as radiology such as radiography and CT scan.

MATERIALS AND METHODS

Preparation of nano Bi_2O_3

10 g of $Bi(NO_3)_3{\cdot}5H_2O$ was dissolved in 60ml nitric acid (1M) and 50 ml of aqueous suspension of starch was added under vigorously stirring, and heated up to 60°C for 2h. Then the pH of the solution fixed at 10 by adding NaOH (3M). Finally, the as-synthesized yellow participate were separated from the solid-liquid mixture by the high-speed centrifugation, washed for several times, dried and calcined at 500°C for 4h, and the Bi_2O_3 nanoparticles were obtained.

The as synthesized nano Bi_2O_3 and Silicon rubber were used to manufacture nano Bismuth shields. For preparing shields, first nano Bi_2O_3 (10 wt. %) and Silicon (90 wt. %) were mixed gently for thirty minutes. Then in order to remove the air bubbles, the obtained mixture were placed in vacuumed for 10 minutes. Shields were made in 20*20 cm dimensions with 0.5 or 1.5 mm thickness. To test validity of the nano Bi_2O_3 shields, a conventional radiography device (VARIAN tube type) and a PTW DIADOS E (T11035-0206) were used. Shields were placed at a distance of one meter from the X-ray tube and the dosimeter was placed below the shield (Fig 1). To calculate the attenuation quantity of the shields, the tests were performed once in the absence of the shields and once in the presence of the shields and through the following formula (1), the attenuation was measured.

$$\text{attenuation\%} = \frac{\text{dose measured in without shield} - \text{dose measured in presented shield}}{\text{dose measured in without shield}} \times 100$$

Morphology of shield and physical dosimetric map used for presenting new shield quality in related to nano particles distribution in matrix. To test the uniformity of the nano particles, the attenuation amount obtained in different parts of the shield with a dosimeter in 5 placements and for 3 times and compared for with each 5 parts together (Fig 1**)**.

All of the tests for measuring dose were taken at three different energies of 60, 80, 100 kVp and 16 mAs and three time for each energy.

Fig 1. The photo of X-ray tube, setup of dosimeter and nano Bi2O3 shield to measure dose reduction ability and uniformity. A: radiography device with probe of dosimeter, B: physical dosimetric map for 5 recording placements of dose in air, C: similar physical dosimetric map for 5 recording placements with shield, D: dosimetric device called DIADOS E (PTW) that measured dose µGy) for showing dose reduction uniformity

RESULTS

Fig 2 shows the powder X-ray diffraction (XRD) of the as prepared sample in the diffraction angle (2θ) range from 4° to 70°, the spectra are indexed to the crystal planes of the monoclinic system of the Bi_2O_3 (JCPDS Card No. 41-1449).

As shown in Fig 3, SEM micrograph, the obtained Bi_2O_3 sample is the approximate spherical polycrystalline particles with mean size of 30 nm.

The results indicate that there wasn't any difference in attenuation between different parts of the shield that represents the uniformity of the nano particles in different parts of the shield matrix for three different energies measured separately in this study.

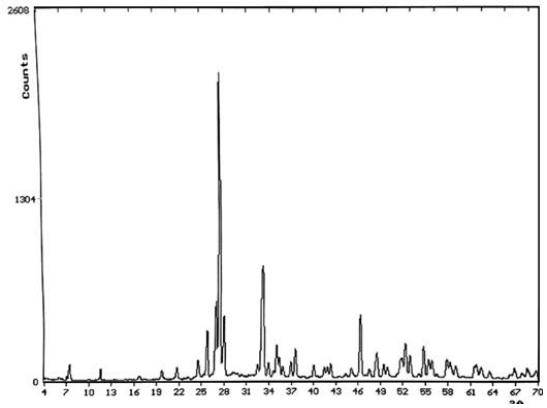

Fig 2.XRD analysis of the nano Bi2O3

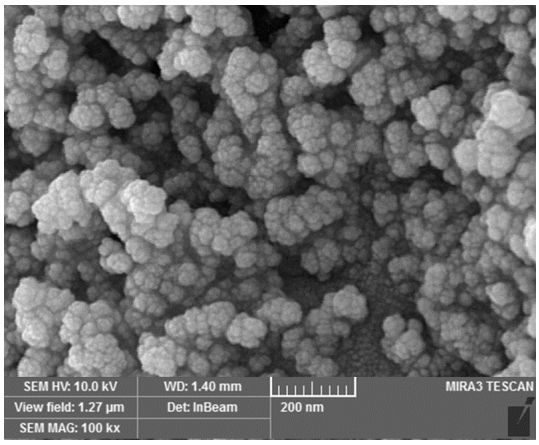

Fig 3. SEM image of the Bi2O3 nanoparticles

The mean dose without using nano Bi_2O_3 shields were 421 µGy, 733 µGy and 1110 µGy for 60, 80 and 100 kVp respectively. Results showed that by using nano Bi_2O_3 shield with0.5 mmthickness the average dose in 60 kVp was 240.3±7.09 µGy. It was 475.66±6.02 µGyin 80 kVp and 763.66 ± 13.05 µGyin 100 kVp. When the thickness increased to 1.5 mm nano Bi_2O_3 shield the average dose decreased to 192.6±4.04 µGy, 402±8.54 µGyand 676.66±4.58 µGyin 60, 80 and 100 kVp respectively.

By using the formula (1), the attenuation percent for all three energy and two thickness was calculated. The effect of different tube energies and shield thickness on the attenuation was shown in Fig 4. The results revealed that dose reductions in 60 kVp for both thickness of nano Bi_2O_3 shields are higher than 100 kVp. The dose reduction percentages for 1.5 mm thickness of nano Bi_2O_3 shield were 54% and 39% using 60 kVp and 100 kVp, respectively.

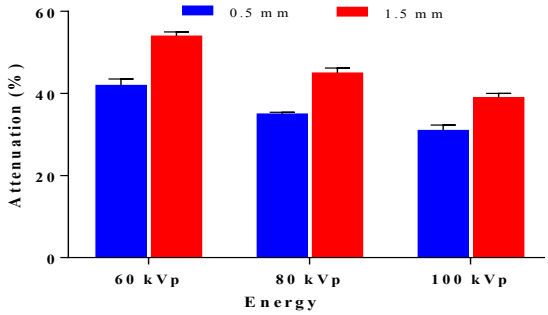

Fig 4. Dose reduction of shields with different thicknesses (0.5 and 1.5 mm) at different energy

DISCUSSION

This study showed that nano Bi_2O_3 has potential for dose reduction in radiology. Dose measurement for three energy of X-ray tube showed that this shield has ability to attenuation dose depend on the energy (kVp) and shield thickness.

Today, there is an increasing in the using of nanoparticles in medicine especially in diagnosis imaging [22, 29]. In the field of radiation protection some studies have been done on the effects of different materials such as micro Bismuth and Tungsten on the attenuation of X-rays in radiography.

A study presented the use of nano particles instead of micro-particles of CuO could increase the ability of shield to attenuation of the X-rays by up to 14% in low energies [30].

In the present study with increasing energy of the X-ray tube from 60 to 100 kV, the efficiency of the shield to attenuation beams was reduced but by increasing the shield thickness, the ability of shield for dose reduction can be increases. The study by Nambiar et al showed in nano bismuth (BO) shield by increasing tube voltage from 70 to 150 kVp the attenuation decreased from 73 % to 50 % and with increase thickness from 1.29 mm to 4.92 mm the attenuation increased from 60% to 87% at 100 kVp [28].

In this study silicon materials used as a base material in the manufacture of shields due to their low atomic number.

The main factors in absorbing X-rays within the shield and its attenuation is existence of nano Bi_2O_3 particles and the particle size of the Bi_2O_3. Studies have been shown that in low-energy X-rays, shields containing nano particles that they exhibited a greater effect on the attenuation of X-rays than microparticle shields but this property

was reduced by increasing the kilo voltage [29, 31]. The use of nano Bi_2O_3 in powder form allows nano particles to be well distributed in the Silicon matrix and provide a good uniformity. The uniform distribution of nano Bi_2O_3 powder at any point of the shield makes it possible to increase the efficiency and attenuation when X-rays pass through different place of the shield.

CONCLUSION

The synthesized nano Bi_2O_3 were homogeneously mixed with silicon. From the result new shields made of nano Bi_2O_3 particles have a high ability to attenuation X-rays and help to social health and decline the radiation risk. Also by increasing the energy from 60 to 100 kVp, the attenuation property of shields, decreased.

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