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Polyvinyl chloride based polymeric nanocomposites for X-ray shielding

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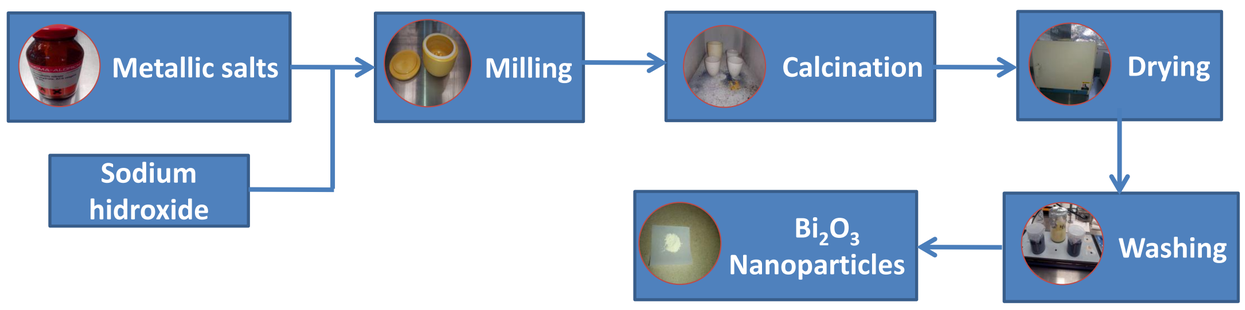
INTRODUCTION

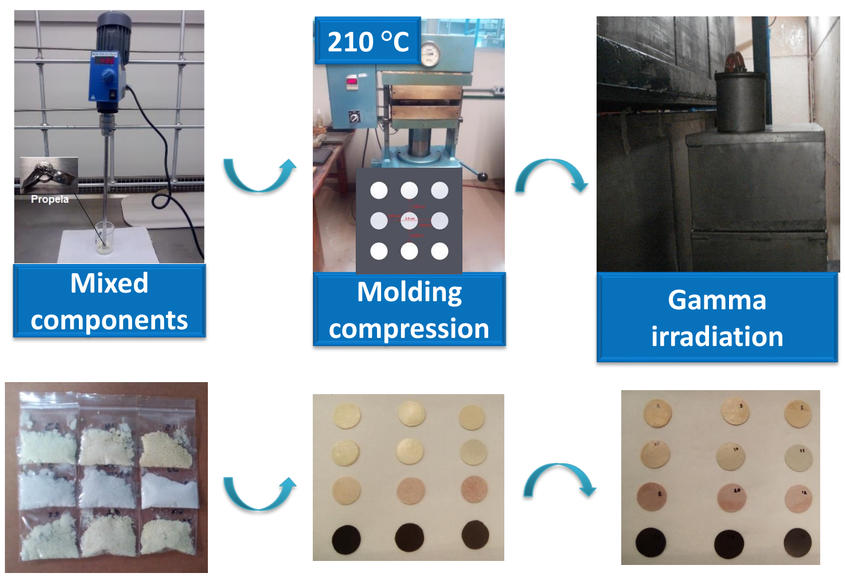
Different materials are used as barriers to protect patients and medical staff in hospital radiological areas. A suitable shielding material needs to have a high atomic number (high Z) to protect against X-ray or gamma radiation, such as lead (Pb), barium (Ba), and bismuth (Bi). However, traditional shielding materials have cost, weight, and toxicity limitations. Therefore, there is a need for alternative materials for radiation shielding, one of which could be polymeric matrix nanocomposites. These materials have important properties such as elasticity, biocompatibility, low cost, and lightness, making them good candidates for attenuating different types of radiation. This study focuses on synthesizing different oxides and their use in developing polyvinyl chloride (PVC)-based polymeric nanocomposites. The structural and morphological properties of $B_{i2}O_3$ and nanocomposites were studied using X-ray diffraction (XRD) and scanning electron microscopy (SEM). The X-ray shielding property for the radiodiagnostic energy range of 50 to 129 kV was measured according to the mass attenuation coefficient (μm), half-value layer (HVL), and tenth-value layers (TVL). The flexible nanocomposites were cross-linked with ionizing radiation treatments to enhance their toughness and further analyzed for their cytotoxic properties. This analysis involved exposing the nanocomposites to 1132sk fibroblast cells and measuring their viability, providing insight into the safety of these materials for medical applications.

METHODOLOGY

Synthesis of Bi_2O_3 by molten salts method

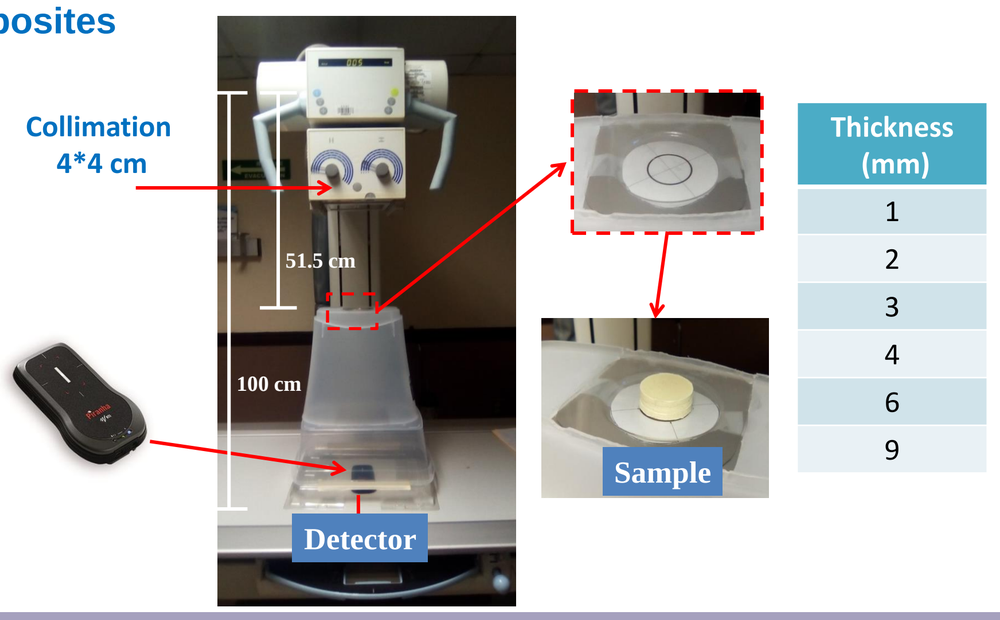


Preparation of PVC nanocomposites



Experimental setup for measuring the attenuation property of nanocomposites

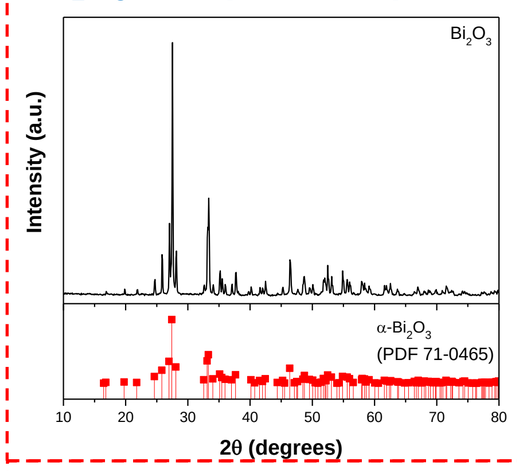
Energies (kV)
50
70
90
109
129

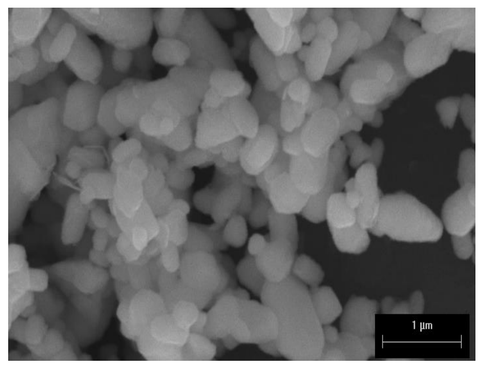


Thickness (mm)
1
2
3
4
6
9

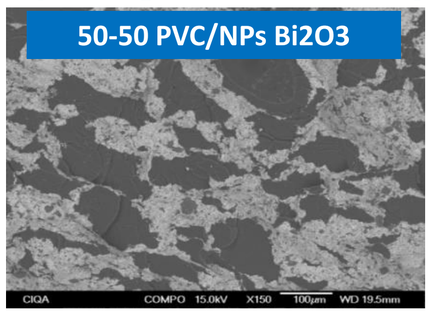
RESULTS & DISCUSSION

Bi_2O_3 nanoparticles (Structural and morphological characterization)



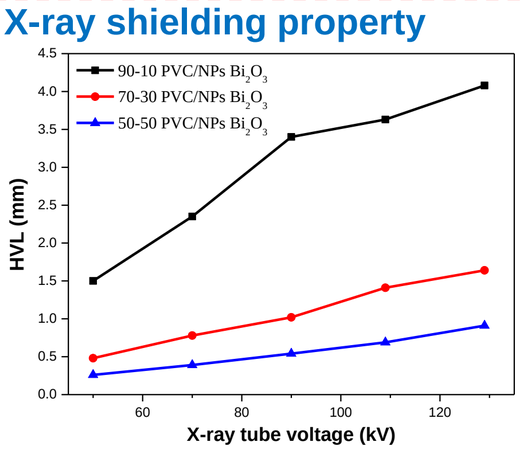


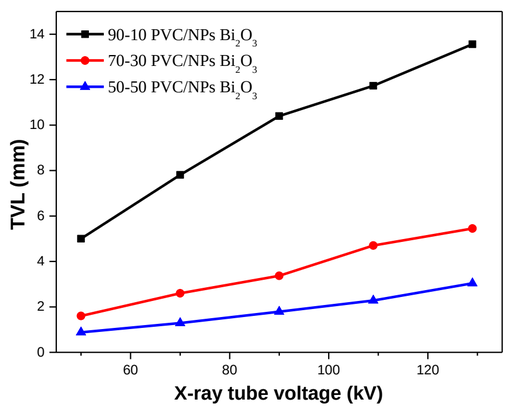
PVC/Bi_2O_3 nanocomposites Morphological and density study

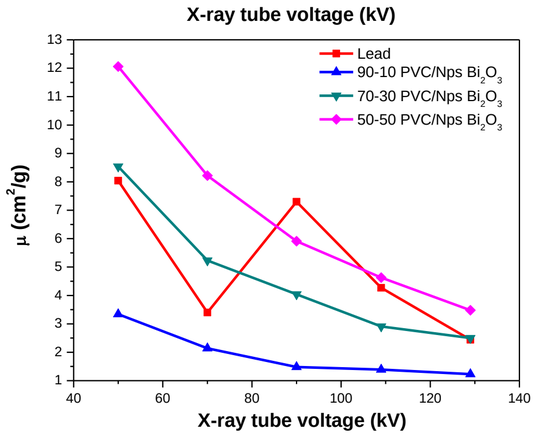


Material	Density (g/cm³)
Lead	11.35
PVC	1.28
90-10 PVC/NPs Bi_2O_3	1.38
70-30 PVC/NPs Bi_2O_3	1.69
50-50 PVC/NPs Bi_2O_3	2.17

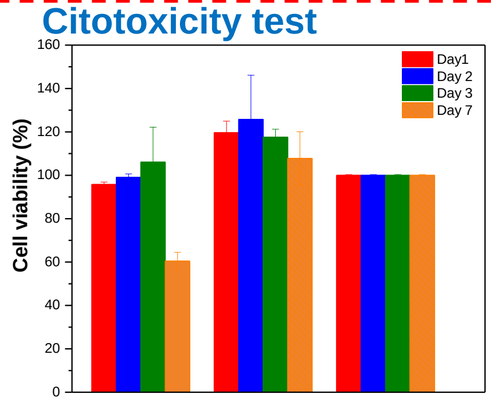
X-ray shielding property







Citotoxicity test



CONCLUSION

Bi_2O_3 nanoparticles (NPs) were uniformly dispersed at various concentrations within a plasticized and crosslinked PVC matrix, resulting in composites that exhibit excellent X-ray radiation shielding properties for energies ranging from 50 to 129 kV. As the concentration of Bi_2O_3 NPs increased, the attenuation properties of the composites improved. Notably, the nanocomposites demonstrated a mass attenuation coefficient comparable to, or even greater, that of lead across the evaluated energy range. Additionally, half-value layer (HVL) and tenth-value layer (TVL) values were lower for composites containing 50 wt% Bi_2O_3 NPs. An MTT test indicated that these composites do not have any toxic effects on human skin cells. Based on these findings, the materials developed are lightweight, durable, non-toxic, and effective in shielding against X-ray radiation. Thus, they hold significant potential for use in protective clothing designed for X-ray radiation in radiodiagnostic applications.