## Abstract

**Project Code:** MRG6180029

**Project Title:** Material Development for Radiation Shielding Applications: Neutron Attenuation, Electrical, and Mechanical Properties of UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ Composites

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**Abstract:**

This project aimed to develop and to investigate properties of UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ composites for potential use in thermal neutron shielding applications. The results indicated that that increases in the contents of $Sm_2O_3$ and $B_2O_3$ significantly improved the thermal neutron shielding properties of the UHMWPE composites, with higher efficiency found in the composites with $Sm_2O_3$. The results also showed different effects of $Sm_2O_3$ contents on mechanical and dielectric properties, in which tensile modulus, flexural modulus, flexural strength, and hardness (Shore D) increased with increasing $Sm_2O_3$ contents, but tensile strength, elongation at break, toughness, and dielectric strength decreased with increasing $Sm_2O_3$ contents. Furthermore, gamma irradiation led to the decreases in elongation at break and toughness, but the increases in flexural strength, flexural modulus, hardness (Shore D), and dielectric strength compared with the non-irradiated UHMWPE composites. In summary, the overall properties suggested that the developed UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ composites could be effectively used as durable thermal neutron shielding materials with $Sm_2O_3$ and $B_2O_3$ played important roles in the enhancement of thermal neutron attenuation.

**Keyword:** UHMWPE, $Sm_2O_3$, $B_2O_3$, Neutron shielding, Mechanical properties

## 1. Abstract

This project aimed to develop and to investigate properties of UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ composites for potential use in thermal neutron shielding applications. The results indicated that that increases in the contents of $Sm_2O_3$ and $B_2O_3$ significantly improved the thermal neutron shielding properties of the UHMWPE composites, with higher efficiency found in the composites with $Sm_2O_3$. The results also showed different effects of $Sm_2O_3$ contents on mechanical and dielectric properties, in which tensile modulus, flexural modulus, flexural strength, and hardness (Shore D) increased with increasing $Sm_2O_3$ contents, but tensile strength, elongation at break, toughness, and dielectric strength decreased with increasing $Sm_2O_3$ contents. Furthermore, gamma irradiation led to the decreases in elongation at break and toughness, but the increases in flexural strength, flexural modulus, hardness (Shore D), and dielectric strength compared with the non-irradiated UHMWPE composites. In summary, the overall properties suggested that the developed UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ composites could be effectively used as durable thermal neutron shielding materials with $Sm_2O_3$ and $B_2O_3$ played important roles in the enhancement of thermal neutron attenuation.


## 2. Executive summary

This project aimed to develop and to investigate properties of UHMWPE/$Sm_2O_3$ and UHMWPE/$B_2O_3$ composites for potential use in thermal neutron shielding applications, of which properties of interest included mechanical (tensile and flexural), physical (hardness (Shore D) and morphology), electrical (dielectric strength), and thermal neutron shielding (linear attenuation coefficient, half-value layer, and tenth-value layer) properties. The outcomes of this project would not only develop a new and more efficient neutron shielding materials from UHMWPE composites but also bring two different research fields, namely nuclear science and materials science, to expand knowledge and technologies for better and wider uses in various applications. UHMWPE powder was used as the main matrix for this work, with the additions of either $Sm_2O_3$ or $B_2O_3$ particles (maximum content up to 50 wt%), paraffinic oil (lubricant), and n-Haxane (paraffinic oil dissolver). All chemicals were mixed/compounded using a twin-screw extruder and compression molded using a hot press. The specimens with the surface area of 18 cm x 18 cm and varying thicknesses of 5 mm, 2, mm, and 1 mm were used for thermal neutron shielding, mechanical, and dielectric strength tests, respectively. Furthermore, since it is possible that the developed materials would be used in gamma-rich environment, especially in nuclear and radiation facilities, effects of gamma