

UNIVERSITI TEKNOLOGI MARA

**DEVELOPMENT OF FLEXIBLE
THERMOPLASTIC ELASTOMER
COMPOSITES FOR SHIELDING
THERMAL NEUTRONS IN
RADIOTHERAPY VAULTS**

**SAJITH THOTTATHIL
ABDULRAHMAN**

PhD

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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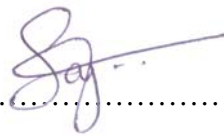
Name of Student : Sajith Thottathil Abdulrahman

Student I.D. No. : 2017845346

Programme : Doctor of Philosophy – EC950

Faculty : Civil Engineering

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Signature of Student : 

Date : June 2020

ABSTRACT

The developments in the field of neutron science and technologies lead to the generation of unwanted neutron particle emissions that often encountered in nuclear power plants, medical hospitals, and aerospace industries. The flexible materials showed a growing interest in the walls, ceilings, curved and irregular surfaces of the radiotherapy vaults to prevent the escaping neutrons. Despite of neutron shielding characteristics material should possess mechanical, thermal and damping properties in the harsh radiation environment from the long-term application point of view. Natural rubber (NR) and Ethylene-Propylene diene Monomer (EPDM) rubber-based thermoplastic elastomer composites were developed and further the vulcanization, morphology, mechanical, dynamic thermo-mechanical, thermogravimetric, and neutron shielding analysis have been performed. NR and EPDM rubber-based thermoplastic elastomer composites with thermoplastic polyethylene, reinforcing filler HAF carbon black (HAF) and neutron-absorbing fillers were fabricated using two roll mill and internal melt mixer to analyze the material properties. The investigation on the effect of HAF loading on NR/LDPE composites indicates improved vulcanization kinetics, uniform distribution of LDPE in NR matrix, enhanced mechanical, thermal and viscoelastic properties of the composites. Also, HAF reinforcement in EPDM/HDPE blends enhanced the mechanical, thermal and viscoelastic properties with higher hydrogen atomic density. The addition of neutron absorber boric acid (BA) to NR/LDPE/HAF composites results in the development of soft uniformly distributed boric acid polymer composites with enhanced thermal properties, low mechanical properties and improved neutron absorption cross-section. The mechanical properties were reduced tremendously with BA loading due to the decrease in the chemical crosslinks that was evidenced from lower cure characteristics. Higher BA filler addition enhances the flammability of composites and thereby composites achieve the category of self-extinguishable materials. Whereas borax (BO) filled NR/LDPE/HAF composites demonstrates very poor distribution of BO fillers that results in the gradual decrease in cure, mechanical and viscoelastic properties. The thermal stability of the composites was enhanced, and the composites attain slow burning material category with BO filler loading. The influence of the nano size boron carbide (BC) in the NR/LDPE/HAF and EPDM/HDPE/HAF composites displayed significant improvement in vulcanization, thermal and neutron shielding characteristics with maintaining mechanical and viscoelastic properties of the composites. While agglomeration reduced the properties of micro BC filled composites. Comparing to the commercially available flexible products the NR/LDPE/HAF/BC (100/10/30/20) and EPDM/HDPE/HAF/BC (100/30/20/20) “phr” by weight composites represents higher material properties for the application in radiotherapy vaults.

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