UNIVERSITI TEKNOLOGI MARA

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

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PhD

June 2020

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.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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Thesis Title	:	Development of Flexible Thermoplastic Elastomer Composites for Shielding Thermal Neutrons in Radiotherapy Vaults
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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.

ACKNOWLEDGEMENT

I am overwhelmed with pleasure and pride to express my feelings and a sense of indebtedness, in gesture of acknowledgment to different persons for their valuable guidance and sensible direction during the course of my Doctor of Philosophy that enabled me to successfully complete my study at UiTM, Shah Alam.

First and foremost, I praise & heart fully thank the **Almighty-God**, from the bottom of my heart, which has been the unfailing source of strength, comfort & inspiration in the completion of this Doctor of Philosophy work. I bow down my head in front of the **ALMIGHTY** for his unending benevolence and blessings which enabled me to tide over the days of depression, disparaging remarks, monotonicity and stagnancy and made me prove myself with a semblance of respectability.

At the onset, I express my deep sense of gratitude to my Ph.D supervisors, **Prof. Zakia Ahmad, Prof. Sabu Thomas, Prof. Azmi Ibrahim** and **Prof. Nandakumar Kalarikkal** for their timely guidance, co-operation and for their excellent efforts regarding thesis writing. In addition to this, I would thank them immensely for giving me complete freedom in writing my papers and thesis – something that helped a lot in sharpening my thinking ability and nourishing my reasoning and analyzing skills. Though initially I faltered and stumbled, the exigencies of the situation forced me to read voraciously, learn avidly, assimilate the knowledge and then utilize it for analyzing various data to the best of my limited ability. This coupled with their valuable suggestions for improving the introductions enabled me to acquire some elegance in paper and thesis writing, the credit which I attribute entirely to them.

I gratefully remember the support offered by all the teaching and non-teaching staff members of Faculty of Civil Engineering especially Senior Lecturer **Azerai Ali Rahman.**

I also express my thanks to all my friends from Faculty of Civil Engineering, UiTM and IIUCNN, Mahatma Gandhi University for their help and encouragement during my research.

I would have never made it this far without the love, sacrifice and all-time support of my beloved family. It was their encouragement, unconditional co-operation, forbearance and moral support throughout the period of my research tenure that kept me enthusiastic for academic pursuit.

TABLE OF CONTENTS