UNIVERSITI TEKNOLOGI MARA

# MECHANICAL, PHYSICAL AND THERMAL PROPERTIES OF HIGH DENSITY POLYETHYLENE (HDPE) COMPOSITE FILLED WITH *Azadirachta excelsa* (Sentang) TREE WASTES FLOUR

**AINA MUNIRAH BINTI ZAKARIA**

Thesis submitted in fulfillment
of the requirements for the degree of
**Master of Science**
**(Material Science and Technology)**

**Faculty of Applied Sciences**

**February 2023**

# ABSTRACT

Forest biomass in the form of leaves, branches, broken logs, barks and stumps are becoming one of the issues that can lead to the landfill without proper management. Efficient methods should be considered in order to minimize the volume and utilized it into a valuable product. In this study, wastes flour from different parts of *Azadirachta excelsa* (Sentang) tree such as leaves, branches and trunks were combined with high density polyethylene (HDPE) polymer as a matrix and maleic anhydride as a coupling agent in order to produce HDPE composite filled with Sentang waste flour. The HDPE composite tree waste flour; HDPE composite-filled leaf flour (HDPECL), HDPE composite-filled branch flour (HDPECB) and HDPE composite-filled trunk flour (HDPECT) consisted of 25%, 35% and 45% wastes flour respectively. These HDPE composite panels were manufactured using micro-injection moulding machine under the temperature of 190 ˚C. The mechanical, physical, thermal properties and microstructure of the HDPECL, HDPECB and HDPECT at different filler loading were analysed and compared with HDPE composite. The chemical composition of trunk, branch and leaf were identified in order to correlate with the mechanical, physical and thermal properties of HDPE composite. Result shows that HDPE composite-filled trunk at 45% (T45) filler loadings had better mechanical properties, thermal properties and morphology characteristics. T45 had the highest flexural modulus, flexural strength, tensile strength and hardness with 3822.8 MPa, 65.79 MPa, 27.91 MPa and 71.0 Shore D hardness. The high holocellulose and lignin content presents inside the trunk which is 85.5% and 49.6% contributes to the enhancement properties of the composites especially in mechanical and thermal properties. The presence of trunk and branch waste flours enhanced the properties of the composite because there is no significant in terms of mechanical properties between them. This is due to the chemical composition that found inside the trunk and branch which have almost the same composition. However, leaf waste flour showed no significant difference with HDPE composite, thus, the addition of leaf waste flour to the HDPE composite has not enhanced its properties. 45% filler loading shows the significant roles in mechanical and thermal properties as it exhibited better mechanical strength and thermal stability. However, it showed lower performance in terms of physical properties as it consists of lots of hydrophilic lignocellulosic fibers compared to others. Overall, HDPECT at 45% filler loading shows better performance compared to HDPECB and HDPECL.

# ACKNOWLEDGEMENT

First and foremost, I would like to thank The Almighty Allah, for His guidance and blessing, which allow me to finish this study, Alhamdulillah.

I would like to extend my gratitude to Universiti Teknologi MARA (UiTM) for giving me the opportunity to pursue my study in master's degree and bring this research into success.

My immense gratitude and thanks go to my supervisor Dr. Shahril Anuar Bahari, who always encourage and support me while completing this study. His generosity towards sharing of knowledge, idea in assisting me, his patience and consideration has been the main momentum in completing this study. I also would like to thank Associate Professor Dr. Mohamad Ariff Jamaludin, Professor Dr. Mansur Ahmad, Dr Mohd Nazaruddin Zakaria, Dr Falah Abu, Miss Azreena Abd Karim, Dr Siti Asmah Surip and Dr Syaiful Osman for their support, knowledge and assistance.

My warm and heartfelt thanks also goes to my beloved parents and family members who always supported and encouraged me during the period of this study. To my brothers, may we fulfil our parent's dreams, guided to the right path by the remembrance of Allah and use our valuable knowledge to contribute to the society. My appreciation also goes to Mr Umar Abd Aziz, Ms Qu' Ain, Ms Nik Syazwani Nik Ahmad, Ms Marhaini Azwin Mahadzir, Ms Siti Nuramirah Rabbani, Mrs Norfazila Radiman, Mrs Dayangku Suhana Awangku Yunos, Mr Muhammad Hishamudin Amasrek, Mr Mohd Akmal Zamir Mohamad Hanapiah, Mr Azli Munjat and Mr Muhammad Zulhairy Radzi for their continuous support and invaluable contribution towards the completion of this thesis. Without their tremendous support this thesis would not have been possible.

# TABLE OF CONTENT

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background of study

Forest plantation is the most important sources in the manufacturing of wood-based materials such as in construction, paper-making, furniture, fencing, moulding, musical instrument and sports equipment. The forest plantation in Malaysia is distributed widely especially in Pahang, Kelantan, Selangor and Sarawak with the expected yield of 3.78 million $m^3$ of logs for the year 2021. Various species had been introduced to the public such as Sentang (*Azadirachta excelsa*), Acacia (*Acacia mangium*), Rubberwood (*Hevea brasiliensis*), Batai (*Paraserianthes falcataria*), Mahogany (*Khaya ivorensis*), Kelempayan (*Neolamarckia cadamba*), Teak (*Tectona grandis*) and Binuang (*Octomeles sumatrana*) (Malaysian Timber Industry Board, 2017). However, due to the excessive deforestation and timber harvesting, a lot of plantation residues and wastes were produced such as leaves, branches, roots and barks. It is preferable to convert all of these wastes into reusable material because it helps in maintaining a clean environment, reduce pollution, reduce the amount of waste in the landfills and conserve the sustainable use of resources (Malaysia Timber Council, 2014; Malaysian Timber Industry Board, 2017).

Bio-based composite materials are accepted widely due to its overall properties that is environmentally friendly and cost-effective. It is commercially known as an innovative material that had been discovered by numerous of researchers in these fields. These composite materials are made from the combination of thermosetting or thermoplastic resin as bonding matrix together with lignocellulosic materials as reinforcement. Some examples of lignocellulosic materials are wood timber, oil palm, rice husk, rice straw, coconut coir, coconut shell, kenaf, bamboo, pineapple leaf and banana fiber. These materials have an excellent properties in terms of mechanical, physical and thermal strength even though they are low density compared to solid wood (Verma & Senal, 2019). Various applications of bio-based materials have been discovered such as automotive, decking, railway sleepers, window frame, aerospace, furniture, construction, sport and packaging industries (Koivuranta et al., 2017; Sanjay