ENHANCEMENT OF MECHANICAL PROPERTIES OF BAGASSE-FIBER PLASTIC COMPOSITE VIA NANO SILICA AND MALEIC ANHYDRIDE GRAFTED HIGH DENSITY POLYETHYLENE (MAPE) ADDITION

MOHD NAZMIR BIN ZAINI

FH 2018 63

ENHANCEMENT OF MECHANICAL PROPERTIES OF BAGASSE-FIBER PLASTIC COMPOSITE VIA NANO SILICA AND MALEIC ANHYDRIDE GRAFTED HIGH DENSITY POLYETHYLENE (MAPE) ADDITION

By

MOHD NAZMIR BIN ZAINI

A Project Report in Partial Fulfilment of the Requirements for the Degree of Bachelor of Wood Science and Technology in the Faculty of Forestry

Universiti Putra Malaysia

2018

DEDICATION

Special thanks to my beloved parents and family

Who always support me in whatever I do in my life and also always guide me in

Where I am today

ABSTRACT

Wood plastic composite using bagasse fibre and recycled high density polyethylene (rHDPE) were developed in this study. Modification of nano-silica and maleated polyethylene (MAPE) were mixed to improve interfacial bonding. The objective of this study was to determine the effect of percentage of fibre loading and modification using nano-silica filler on mechanical properties of WPC produced from bagasse fibre and recycled HDPE. The rHDPE was melted at 130°C and directly blended with bagasse fibre, nano-silica and MAPE according to various mixture percentages. The compounds materials were compressed into a mould 150mm x 150mm x 30mm. The boards were cut into test samples for mechanical assessments which is tensile testing and flexural testing in accordance with ASTM standard. It was found that fibre loading has more apparent influence on the strength properties of bagasse composites. The tensile MOR, MOE and flexural MOR decreased while flexural MOE increased with the increasing of fibre loading. The study also concluded that addition of nano-silica has significantly improved the MOR and MOE of the composite material.

ABSTRAK

Komposit kayu plastik dihasilkan dengan menggunakan gentian hampas tebu dan polietilena berketumpatan tinggi yang dikitar semula (rHDPE) telah djalankan dalam kajian ini. Penambahan bahan iaitu nano-silika dan maleated polietilena (MAPE) telah digunakan untuk meningkatkan ikatan antara permukaan. Objektif kajian ini adalah untuk menentukan kesan kadar peratusan gentian yang menggunakan nano-silika terhadap sifat mekanikal komposit kayu plastik yang dihasilkan dari gentian hampas tebu dan HDPE yang dikitar semula. RHDPE dicairkan pada suhu 130ºC dan dicampurkan dengan gentian hampas tebu, nano-silika dan MAPE mengikut kadar peratusan campuran yang telah ditetapkan. Bahan yang telah sebati dimampatkan ke dalam acuan berukuran 150mm x 150mm x 30mm. Papan dipotong mengikut ukuran sampel ujian dan dimasukkan ke dalam mesin ujian sampel untuk penilaian mekanikal iaitu kekuatan tegangan dan kekuatan lenturan mengikut piawaian ASTM. Kajian mendapati bahawa kadar peratusan gentian mempengaruhi sifat kekuatan komposit hampas tebu. Kekuatan tegangan MOR, MOE dan kekuatan lenturan MOR menurun manakala kekuatan lenturan MOE meningkat dengan penambahan kadar peratusan pemunggahan gentian. Berdasarkan kajian ini, dapat disimpulkan bahawa penambahan nano-silika menunjukkan perubahan ketara dalam peningkatan MOR dan MOE bahan komposit.

ACKNOWLEDGEMENT

In the name of Allah Most Beneficent and Most Merciful, all praise for Allah for given me strength in completing this study. Firstly, I want to express my appreciation to my supervisor Dr. Adlin Sabrina Binti Muhammad Roseley for her guidance, good management, trust, intellectual ideas, constructive criticisms, suggestions and her patience for the guidance along this research technical.

Special thanks to the staffs at Institute of Tropical Forestry and Forest Products (INTROP) and staffs at Faculty of Engineering for kindly providing the facilities finish along this research.

Last but not least, I would also to appreciate and special thanks to my beloved family and friends who have always encouraged, understanding and support me to finish this project. Special thanks to beloved friends, Mrs. Qamariah as Second Supervisor, Nur Aiman Shuhada Ab Aziz, Mohamad Zawawi Abd Rahman and Mohammad Sharuddin Palisuri who always help me from the beginning till the end of this research.

APPROVAL SHEET

I certify that this research project report entitled “Enhancement of Mechanical Properties of Bagasse-Fiber Plastic Composite via Nano Silica and Maleic Anhydride Grafted High Density Polyethylene (MAPE) Addition” by Mohd Nazmir Bin Zaini has been examined and approved as a partial fulfillment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Univeristi Putra Malaysia.

Approved by:

_____

Dr. Adlin Sabrina Binti Muhammad Roseley
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

_____

Prof. Dr. Mohamed Zakaria Bin Hussin
Dean
Faculty of Forestry
Universiti Putra Malaysia

Date: January 2018

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

WPC	Wood Plastic Composite
MAPE	Maleated Polyethylene
ASTM	American Society for Testing and Materials
HDPE	High Density Polyethylene
LLDPE	Linear-Low Density Polyethylene
MDPE	Medium Density Polyethylene
PE	Polyethylene
rHDPE	Recycle High Density Polyethylene
vHDPE	Virgin High Density Polyethylene
LDPE	Low Density Polyethylene
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
TMOR	Tensile Modulus of Rupture
TMOE	Tensile Modulus of Elasticity
MPa	Mega Pascal
NaOH	Sodium Hydroxide
FSP	Fiber Saturated Point

CHAPTER 1

INTRODUCTION

1.0 Background

Wood plastic composites (WPC) are defined as composite materials containing wood (as filler and reinforcement) and thermoplastic material. The properties and the advantages of WPC are high durability, low maintenance and acceptable relative strength and stiffness. It also has an advantage in terms of prices relative to other materials that it is natural resource (Bengtsson and Oksman 2006; Winandy *et al.,* 2004). Recently, composites based on natural fibres have a wide range of applications such as interior components in auto-motives for seat frames, side panel, and central consoles (Facca *et al.,* 2007; Torres and Cubillas, 2005; Abdelmouleh *et al.,* 2007 and Farag, 2008).

Bagasse fibre can be considered as a natural composite since it consist mainly of cellulose fibrils embedded in lignin matrix. Other than that, sugarcane is a tropical fast growing grass species in which the lateral shoots produces multiple stems of about 3 to 4 meters high. The diameter growth of each sugarcane stalk may up to 5 cm across.

The fibrous parts from sugarcane stalk can be converted into a beneficial material such as composite with the addition of polymer as a matrix resin to produce a strength composite material such as WPC. In this study, WPC boards were made using bagasse fibre and rHDPE with an addition of MAPE and nano-silica filler.

Recycle HDPE was selected as the matrix for this composite due to the exponential growth of HDPE plastics usage in daily life. HDPE plastic is the most preferable method to reduce environmental pollution. It is expected that the addition of MAPE can improve interaction and adhesion between the fibres and matrix, leading to better stress transfer between these two components, hence improving its mechanical properties. The addition of nano-silica as filler and increasing of fibre loading will increase the stiffness of the composites. This is dependent on the inherent stiffness imparted by the bagasse fibre which allows efficient stress transfer.

1.1 Problem Statement

According to a study by Shafie *et al.,* (2012), Malaysia produces 730,000 tons per hectare of sugarcane annually. For additional information, 1 tonne per hectare of sugarcane generates 280kg of bagasse in form of fibrous product after the extraction of sugarcane juice process. As reported by Sun *et al.,* (2004), approximately 54 million dry tones of bagasse were produced annually throughout the world.

Thus, a quantity of the fibrous bagasse that is not used will be subjected to open burning. This eventually caused a serious problem of air pollution around the plantation area. Therefore, a more logical usage of bagasse fibre is in need. More research is needed to optimise the usage of this readily available natural fibre and one possible application is for plastic composite. Another question that needs to be answer is the compatibility of this fibre to the polymer matrix.

HDPE is a polymer material which high stiffness and impact resistance, thus making it as suitable material for plastic composite material. However, the performance of rHDPE as composite material is still insufficiently investigated as compared to virgin HDPE. Therefore, further study needs to be done in this field, in particular in assessing rHDPE properties as WPC material.

1.2 Justification

The purpose of conducting this study is to investigate the probable usage of bagasse fibre with the objective of optimising the usage of waste material. This study uses only rind of the bagasse fibre since it is perceived as a denser and stronger part than the pith. The mechanical properties of composites using rHDPE modified using nano-silica filler and addition of MAPE will also be investigated in this study.

1.3 Objectives

1.3.1 The General Objective

To determine the effect of fibre loading and modification using nano-silica filler on mechanical properties of WPC produced from bagasse fibre and recycled HDPE.

1.3.2 The Specific Objective

1) To determine the flexural properties of WPC through combination with bagasse fibre and addition of matrix filler
2) To investigate the tensile properties of WPC involving fibre loading and modification matrix

REFERENCES

Abdelmouleh, M., Boufi, S., Belgacem, M. N., & Dufresne, A. (2007). Short natural-fibre reinforced polyethylene and natural rubber composites: Effect of silane coupling agents and fibres loading. *Composites science and technology*, *67*(7), 1627-1639.

ASTM International. (2008). Standard test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials. ASTM D790-03.

ASTM International. (2010). Standard test method for tensile properties of plastics. ASTM 638-09, ASTM D638-03.

Cao, Y., Shibata, S., & Fukumoto, I. (2006). Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatments. *Composites part A: Applied science and Manufacturing*, *37*(3), 423-429.

Farag, M. M. (2008). Quantitative methods of materials substitution: application to automotive components. *Materials & Design*, *29*(2), 374-380.

Facca, A. G., Kortschot, M. T., & Yan, N. (2007). Predicting the tensile strength of natural fibre reinforced thermoplastics. *Composites Science and Technology*, *67*(11), 2454-2466.

John, M. J., Francis, B., Varughese, K. T., & Thomas, S. (2008). Effect of chemical modification on properties of hybrid fiber biocomposites. *Composites Part A: Applied Science and Manufacturing*, *39*(2), 352-363.

Jahanilomer, Z., & Farrokhpayam, S. R. (2014). Physical and mechanical properties of flat pressed HDPE composite filled with a mixture of bagasse/rice husk. *Journal of the Indian Academy of Wood Science*, *11*(1), 50-56.

Jurinah, J. (2016). The effect of fiber loading on the mechanical properties of thermoplastic composite produced from bagsse fiber and recycles HDPE. 6-13.

Joshi, S. V., Drzal, L. T., Mohanty, A. K., & Arora, S. (2004). Are natural fiber composites environmentally superior to glass fiber reinforced composites?. *Composites Part A: Applied science and manufacturing, 35(3),* 371-376.

Munirah, M., Rahmat, A. R., & Hassan, A. (2007). Characterization and treatments of pineapple leaf fibre. Department of Polymer Engineering, Faculty of Chemical and Natural Resources Engineering, Malaysia Technology University, Johor Bharu.

Nourbakhsh, A., & Kouhpayehzadeh, M. (2009). Mechanical properties and water absorption of fiber-reinforced polypropylene composites prepared by bagasse and beech fiber. *Journal of Applied Polymer Science*, *114*(1), 653-657.

Narayan, R. (2006). Natural Fibre Reinforced Polymer Composites from Macro to Nanoscale. In Sabu, T. & Laly, A. P. (eds). *Biobased and biodegradable polymer materials: Principles, concepts and technology*, 171-195.

Li, X., Tabil, L. G., & Panigrahi, S. (2007). Chemical treatments of natural fiber for use in natural fiber-reinforced composites: a review. *Journal of Polymers and the Environment*, *15*(1), 25-33.

Pandey, A., Soccol, C. R., Nigam, P., & Soccol, V. T. (2000). Biotechnological potential of agro-industrial residues. I: sugarcane bagasse. *Bioresource technology*, *74*(1), 69-80.

Rozman, H.D., Kon, B. K., Abusamah, Kumar, R. N. Kumar (1998). Strength, elongation, impact strength and fracture energy and Z.A. 6-10.

Sanadi, A. R., Rowell, R. M., & Young, R. A. (1992). Estimation of fiber-matrix interfacial shear strengths in lignocellulosic-thermoplastic composites. *MRS Online Proceedings Library Archive*, *266*.

Simonsen, J., Jacobson, R., & Rowell, R. (1998). Properties of styrene-maleic anhydride copolymers containing wood-based fillers. *Forest products journal*, *48*(1), 89.

Tian, Li., Lei, Y., Wang, Q., Lee, S., & Wu, Q. (2013). Effect of fiber type and coupling treatment on properties of high-density polyethylene/natural fiber composites. *BioResources*, *8*(3), 4619-4632.

Torres, F. G., & Cubillas, M. L. (2005). Study of the interfacial properties of natural fibre reinforced polyethylene. *Polymer Testing*, *24*(6), 694-698.

Utracki, L. A., & Wilkie, C. A. (Eds.). (2002). *Polymer blends handbook* (Vol. 1, p. 2). Dordrecht: Kluwer academic publishers.

Zabihzadeh, S. M., Dastoorian, F., & Ebrahimi, G. (2010). Tensile properties and thermal analysis of chemimechanical pulp-reinforced HDPE composites. *Journal of Reinforced Plastics and Composites*, *29*(12), 1814-1819.