ANALYSIS OF SOUND ABSORPTION PROPERTIES OF SPENT TEA LEAVES-POLYPROPYLENE COMPOSITES

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

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2016

DECLARATION

I hereby, declared this report entitled "Analysis of Sound Absorption Properties of Spent Tea Leaves-Polypropylene Composites" is the results of my own research except as cited in references.

Signature : ....

Author's Name : WONG YUNG CHENG

Date : 22nd JUNE 2016

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Manufacturing Engineering (Engineering Materials) (Hons.). The member of the supervisory committee is as follow:

……………………………………

(Project Supervisor)

(PROF. DR. QUMRUL AHSAN)

ABSTRAK

Kajian ini memberi tumpuan kepada sifat penyerapan bunyi komposit mengandungi sisa daun teh bertujuan untuk penyerapan bunyi. Sisa daun teh (STL) adalah bahan buangan dari kilang pemprosesan teh dan merupakan sumber semula jadi baru untuk bahan penyerapan bunyi daripada komposit polypropylene. Tujuan kajian ini adalah untuk menghasilkan, mencirikan dan mengkaji sifat penyerapan bunyi komposit polypropylene mengandungi sisa daun teh. Tiga gred STL yang digunakan dalam kajian ini adalah BHE-SW (serat halus), BHE-BM (serat sederhana) dan SPE-SW (serat kasar) dari tangkai pokok teh. Sebahagian daripada STL dirawat dengan alkali. Komposit yang dihasilkan telah menjalani FTIR spektroskopi, ujian tiub impedans dan kajian mikroskopik. Dapatan kajian penyerapan bunyi telah menunjukkan bahawa saiz serat dan rawatan kimia memberi kesan pada sifat penyerapan bunyi. Dari segi saiz serat, komposit serat halus adalah penyerap bunyi yang baik pada frekuensi sederhana (1000 – 2500 Hz), manakala komposit serat sederhana dan kasar adalah lebih baik dalam menyerap bunyi frekuensi tinggi (2500 – 4500 Hz). Dari segi rawatan kimia, komposit serat yang tidak dirawat adalah penyerap bunyi yang baik pada frekuensi sederhana, manakala komposit serat yang dirawat adalah lebih baik dalam menyerap bunyi frekuensi tinggi. Oleh itu, komposit polypropylene mengandungi sisa daun teh boleh digunakan mengikut keperluan aplikasi.

ABSTRACT

This research focuses on the sound absorption properties of spent tea leaves composites materials for sound absorption. Spent tea leaves (STL) are waste materials from tea processing plants, and are considered as new natural resources for sound absorbing polypropylene composite materials. The aims of this research are to synthesize, characterize and study the sound absorption properties of spent tea leaves filled polypropylene composites. Three grades of STL are used in this research, which are BHE-SW (fine fiber), BHE-BM (medium fiber) and SPE-SW (coarse fiber) from the stalk of the tea plant. Portions of STL are subjected to alkalization treatment. The fabricated composites are subjected to FTIR spectroscopy, impedance tube test and microscopic examination. From this research, the sound absorption results have shown that fiber size and treatment conditions have pronounced effects on the sound absorption properties. In term of fiber size, fine fiber composites are good sound absorbers at medium frequency range (1000 – 2500 Hz), while medium and coarse fibers composites are good at absorbing high frequency sound (2500 – 4500 Hz). In term of treatment conditions, untreated fiber composites are good sound absorbers at medium frequency range, while treated fiber composites are good at absorbing high frequency sound. Thus, spent tea leaves filled polypropylene composites can be employed according to the demands of the application.

DEDICATION

Dedicated to

my beloved father, Wong Kong Kiong

my treasured mother, Thien Nyet Mee

and my adored siblings, Wong Hui Shan and Wong Yung Zhi

for giving me advice, understanding, encouragement and also moral support.

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Last but not least, I would like to thank friends who helped and guided me during moments of difficulty. Their cooperation and encouragement during the project period were highly appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BHE-BM	-	Medium spent tea leaves grade
BHE-SW	-	Fine spent tea leaves grade
C	-	Coarse fiber (STL grade SPE-SW)
F	-	Fine fiber (STL grade BHE-SW)
FE	-	Flax fiber filled epoxy composite
FTIR	-	Fourier Transform Infrared Spectroscopy
GE	-	E-glass fiber filled epoxy composite
GFE	-	Flax/E-glass fiber filled epoxy composite
HDPE	-	High-density polyethylene
KBr	-	Potassium bromide
M	-	Medium fiber (STL grade BHE-BM)
MAPP	-	Maleic anhydride grafted polypropylene
MPTC	-	Treated coarse fiber filled maleic anhydride grafted polypropylene composite
MPTF	-	Treated fine fiber filled maleic anhydride grafted polypropylene composite
MPTM	-	Treated medium fiber filled maleic anhydride grafted polypropylene composite
NaOH	-	Sodium hydroxide
PE	-	Polyethylene
PET	-	Polyethylene terephthalate
PNF	-	Polypropylene based non-woven fiber
PP	-	Polypropylene
PPTC	-	Treated coarse fiber filled polypropylene composite
PPTF	-	Treated fine fiber filled polypropylene composite
PPTM	-	Treated medium fiber filled polypropylene composite

PPUC	-	Untreated coarse fiber filled polypropylene composite
PPUF	-	Untreated fine fiber filled polypropylene composite
PPUM	-	Untreated medium fiber filled polypropylene composite
PS	-	Polystyrene
SAC	-	Sound absorption coefficient
SEM	-	Scanning Electron Microscopy
SPE-SW	-	Coarse spent tea leaves grade
STL	-	Spent tea leaves
TC	-	Treated coarse fiber (STL grade SPE-SW)
TF	-	Treated fine fiber (STL grade BHE-SW)
TLF	-	Tea leaf fiber
TM	-	Treated medium fiber (STL grade BHE-BM)
UC	-	Untreated coarse fiber (STL grade SPE-SW)
UF	-	Untreated fine fiber (STL grade BHE-SW)
UM	-	Untreated medium fiber (STL grade BHE-BM)
WCC	-	Woven cotton cloth

LIST OF SYMBOLS

%	-	percent
°	-	degree
°C	-	degree Celsius
µm	-	micrometer
cm	-	centimeter
cm^{-1}	-	reciprocal of centimeter
g	-	gram
g/cm^3	-	gram per cubic centimeter
g/mol	-	gram per mole
Hz	-	Hertz
kgf/cm^2	-	kilogram-force per square centimeter
mg	-	milligram
ml	-	milliliter
mm	-	millimeter
MPa	-	mega Pascal
Pa	-	Pascal
wt%	-	weight percentage
X	-	times

CHAPTER 1

INTRODUCTION

This chapter describes the background of study, the problem statement, the objectives, and the scope of study.

1.1 Background of Study

Sound is a vibration that produces mechanical movement or wave which propagates through a medium such as air (Zhu *et al*., 2013). To further explain, sound wave is a vibrational system in which the wave creates pressure during propagation as a result of the nature of fluctuation within a material (Fouladi *et al*., 2013). Excessive sound beyond a certain limit will produce noise. Noise is an irregular and chaotic sound which disturbs people's works and causes health issues (Veerakumar and Selvakumar, 2012). Nowadays, noise pollution has become a critical issue with increasing urbanization (Fatima and Mohanty, 2011). According to Al-Rahman *et al.* (2012), some of the sources of unwanted noise are the sound emitted from factories, heavy machineries and vehicles. Long-term exposure to continuous noises can cause discomfort which may lead to various health problems such as nerve weakness, heart problems, high blood pressure, and even hearing loss. In worse scenarios, the noise-induced stress develops tension within an individual and contributes to mental illness (Yuhazri *et al*., 2010).

Therefore, sound absorbing material is needed to reduce noise emission which can cause adverse effects on human health. Nowadays, sound absorption application is considered an important requirement for human comfort. Sound absorbing material or sound absorber is used to absorb as much sound energy as possible and to reflect very little. Various categories of sound absorber are available up-to-date, these include porous absorber, membrane absorber and resonator absorber (Jacobsen *et al*., 2011). Basically, the porous absorber is good at absorbing high-frequency sound in which the sound absorption coefficient enhances with the increased material thickness. On the other hand, the membrane absorber performs efficiently in low-frequency sound absorption, while the resonator absorber best absorbs sound at narrow mid-frequency range. According to Jayamani *et al*. (2015), sound absorption occurs by converting sound energy that travels through a material into heat energy, yielding a reduction in sound pressure.

In current market, the common sound insulation and absorption materials are usually made of synthetic materials that include foam, glass wool, mineral fibers and their composites. However, natural fibers including jute, coir and hemp are slowly replacing these synthetic fibers as sound absorbing materials (Fatima and Mohanty, 2011). The use of natural fibers including tea leaves is getting more attention due to their attractive benefits such as economic price, lightweight, adequate strength, biodegradability, renewability and abundant supply (Mohanty *et al*., 2005). On the flip side, few major drawbacks are always present in natural fibers. One of the concerned issues is the inconsistency of fiber quality due to the existence of hydroxyl and polar groups, causing poor moisture resistance. In addition, the poor compatibility between the hydrophilic natural fibers and hydrophobic polymer causes a weak fiber-matrix interfacial adhesion (Thakur, 2014). Overall, the present study focuses on the sound absorption properties of chemically treated and untreated spent tea leaves in polypropylene.

1.2 Problem Statement

The existing scenario is that synthetic sound absorbing materials made of glass wool, rock wool, and polyurethane are basically petrochemicals-based, and are expensive to produce (Berardi and Iannace, 2015). Manufacturing of synthetic sound absorbing materials poses serious environmental issues. According to Arenas and Crocker (2010), the synthetic sound absorbing materials made from polymers and minerals are manufactured through high-temperature extrusion and industrial processes based on petrochemicals. The processing of synthetic chemicals leads to the emission of greenhouse gases such as carbon dioxide, nitrous oxide and methane from the manufacturing plant, posing a great impact on our environment. Therefore, it can be seen that synthetic sound absorption materials are high in cost and incur sustainability issue such as biodegradability problem. On the other hand, green materials are environmentally-friendly, involves less contamination and can be recycled.

Although natural fiber is an ideal filler material to be used in sound absorber, there is still one limitation in which the natural fiber possesses rotting characteristic upon making contact with water. They decay gradually by a natural process over time due to moisture absorption. Therefore, in this project, spent tea leaves are used instead. Tea leaves are superior to other natural fibers due to their excellent rot-retardant properties. They possess high resistance to fungus and termite (Shi *et al*., 2006), high durability obtained from the polyphenols extract known as tannins (Yalinkilic *et al*., 1998), and high resistance to fire (Dittenber and GangaRao, 2012). Besides, tea leaves have fresh scent that can eliminate unpleasant smell. These distinctive features of tea leaves, thus, are important in manufacturing a durable sound absorbing material which can last longer than other natural fiber sound absorption materials.

In addition, there is not much understanding on the distribution of spent tea leaves in polypropylene based on previous researches. Microscopic examination can be performed to evaluate the morphology of spent tea leaves-polypropylene composites, especially the fiber distribution in the polymer matrix. Jayamani *et al*. (2015) had studied the morphology of rice straw stem fibers reinforced polypropylene composite to correlate the fiber-to-matrix adhesion to its sound absorption behaviour. They concluded that good sound absorption relied upon a proper adhesion between the natural fiber and polymer matrix. This was because proper fiber-to-matrix adhesion gave a good distribution of natural fibers in the matrix, which in turn improving the acoustic absorption properties. Therefore, further studies on the distribution of natural fibers in polymer and its effects on sound absorption properties are necessary.

From the above highlighted statements, it can be seen that spent tea leaves are highly competent materials to be used as sound absorbing materials as they can address the environmental and cost issues. Moreover, the superior properties of spent tea leaves help in enhancing the durability of sound absorbing materials manufactured. These superior properties may not be found in other natural fibers. Although there are studies conducted on the tea leaves materials for sound absorption, the distribution of tea leaves in polymer is seldom investigated. Considering all the stated problems, the main challenge of this project is the possibility of using spent tea leaves in polypropylene matrix as sound absorption materials.

1.3 Objectives

The objectives of this research are:

(a) To synthesize and characterize the sodium-hydroxide treated and untreated spent tea leaves in polypropylene (PP) and in maleic anhydride grafted polypropylene (MAPP) matrix.

(b) To study the sound absorption properties of the spent tea leaves filled polypropylene composites through impedance tube method.