UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PREPARATION OF SPENT TEA LEAVES FILLED POLYURETHANE COMPOSITES FOR SUSTAINABLE SOUND ABSORBING MATERIALS

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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APPROVAL

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

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(PROF. DR. QUMRUL AHSAN)

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(MISS CHANG SIANG YEE)

ABSTRAK

Daun teh terpakai (STL) dari kilang penghasilan teh dianggap sebagai sumber baru dalam poliuretana matriks komposit sebagai bahan penyerap bunyi kerana daun teh yang kaya dengan polifenol dan hidrofilik kedua-dua bahan yang memberi manfaat kepada penyerapan bunyi dalam komposit. Laporan ini menyimpulkan penyediaan dan pencirian ke atas penyediaan daun teh terpakai (STL) diisi di dalam poliurethene (PU) komposit sebagai bahan penyerap bunyi. Objektif kajian ini adalah untuk mengkaji sifat-sifat fizikal dan kimia serta morfologi pelbagai gred daun teh terpakai, untuk membuat struktur bahan penyerap bunyi menggunakan teknologi hijau yang diperbuat daripada PU/STL komposit dengan gred dan beban daripada STL yang berbeza melalui teknik tuangan terbuka seterusnya untuk mengkaji fizikal dan kelakuan penyerapan bunyi serta morfologi PU/STL komposit. Terdapat tiga gred STL gentian yang digunakan dalam kajian ini, BM-FAE dan SW-BHE dari tangkai manakala FIBER-FAE dari daun pokok teh. PU/STL komposit telah dihasilkan melalui teknik tuangan terbuka dengan komposisi STL gentian yang berbeza yang terdiri daripada 4, 8, 12, and 16 wt%. Komposit yang dihasilkan kemudian tertakluk kepada ujian fizikal dan penyerapan bunyi serta pemerhatian mikroskopik untuk menganalisis taburan pengisi dalam komposit. Daripada kajian ini, keputusan penyerapan bunyi menunjukkan bahawa gred STL gentian yang paling halus (FIBER-FAE) memberikan pekali penyerapan bunyi yang terbaik dan meningkatkan komposis STL dalam PU mempamerkan pekali penyerapan bunyi mengurangkan secara berunsur-unsur.

ABSTRACT

Spent tea leaves (STL) from tea producing factories are considered as new resources for sound absorbing polyurethane matrix composite materials because tea leaves are rich in polyphenols and hydrophilicity of both materials which is beneficial to the sound absorption properties of the composites. This report deduces the preparation and characterization of spent tea leaves filled polyurethane (PU/STL) composites for sustainable sound absorbing materials. The objectives of this study were to study physical and chemical properties as well as morphology of various grades of spent tea leaves, to fabricate a green sound absorption structure made of PU/STL composites with different grades and loadings of the STL through open molding technique, and to investigate physical and sound absorption behavior as well as morphology of PU/STL composite. There were three grades of STL fiber used in this study, which were BM-FAE and SW-BHE from the stalk while FIBER-FAE from the leaves of the tea plant. The PU/STL composites were fabricated through open molding method by varying fiber loading ranging from 4, 8, 12, and 16 wt%. The fabricated composites were then subjected to physical and sound absorption testing as well as microscopic observations to analyze the distribution of filler in composite. From this study, the sound absorption results shown that the finest grade (FIBER-FAE) spent tea leaves provide the best sound absorption coefficient and increasing the loading of the STL to the PU foam exhibits gradual decreasing of sound absorption coefficient of the PU composite.

DEDICATION

To my beloved parents, siblings and friends for their love and support

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First and foremost, I would like to express my utmost gratitude to my supervisor, Prof Qumrul Ahsan for his guidance, advice, concern, understanding and patience throughout the research period. His supervision has helped a lot in the progression of this final year project. I am indeed very grateful to be under his supervision. Besides, I would like to express my appreciation to my co-supervisor, Miss Chang Siang Yee, who has assisted me in ensuring a successful flow throughout the completion of this final year project. In addition, I would also like to express my appreciation to Dr. Azma Putra and his master student, En. Sajidin, as they had guided me in conducting the impedance tube measurement for my final year project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM	-	American Society for Testing and Materials
BM	-	Broken mat
EHT	-	Extra High tension
FPF	-	Flexible Polyurethane Foams
FTIR	-	Fourier Transform Infrared Spectrocospy
–OH	-	Hydroxyl Ion
LaB_6	-	Lanthanum hexaboride
MP	-	Mechanical Pulp
mg KOH/g	-	Milligram of potassium hydroxide per gram
PMCs	-	Polymer Matrix Composites
PP	-	Polypropylene
PSA	-	Particle Size Analyser
PU	-	Polyurethane
KBr	-	Potassium Bromide
RPF	-	Rigid Polyurethane Foams
SEM	-	Scanning Electron Microscopy
STL	-	Spent Tea leaves
SW	-	Sweeping
TLF	-	Tea-Leaf-Fibre
USM	-	Universiti Sains Malaysia
VPSE	-	Variable Pressure Secondary Electron

CHAPTER 1

INTRODUCTION

This chapter describes the background of studies, the problem statements, the objectives and as the scopes of the studies.

1.1 Background Study

In 1987, the World Commision on Environment and Development developed a definition of sustainability which became widely known as the Brundtland Report. It stated that “Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.” From this point of view, a product can be considered sustainable if its production enables the resources from which it is made to continue to be available for future generations and has the lowest possible impact on human health as well as on the environment (Asdrubali, 2006).

At present, green technology is widely used to produce materials from agriculture products as a substitute to synthetic fibers and wood-based materials (Mohd Nor *et al.*, 2004). Organic natural fibers from agriculture are increasingly being investigated for various usages in many structural and non-structural applications such as automotive lining components and acoustic absorption barrier. For instance, coir fibers are the natural fibers used to replace synthetic fibers and wood-based materials for absorbing sound (Zulkifli *et al.*, 2008). The introduction of the natural fibers as an alternative for glass-or mineral-fiber materials used as commercially available sound absorption materials in the building construction industry is due to the geometry and properties of the fibers. The plant-based fibers have a hollow and cellular nature and thus perform well as acoustic and thermal insulators (Zulkifi *et al.*, 2008 and Chand and Fahim, 2008). Besides, these fibers are inexpensive, renewable and available in abundance, non-abrasive, does not give rise to health and safety issues during processing and handling, as well as light weight (Mohd Nor *et al.*, 2004 and Chand and Fahim, 2008).

Though so, composite materials are the most advanced and adapted engineering materials because the matrix gives a composite its shape, surface appearance, environmental tolerance and overall durability while the fibrous reinforcement carries most of the structural loads, thus giving macroscopic stiffness and strength (Sreekum and Thomas, 2008). Therefore, natural-fiber reinforced composites have been developed through the incorporation of natural fibers into a matrix material such as thermosetting plastics, thermoplastics, or biopolymers. Natural fibers can be embedded in the polymeric matrices to reinforce and achieve desired properties such as sound damping, impart strength, stiffness, low density, and texture together with eco-friendly characteristics in the composites (Huda *et al.*, 2008). It is evidenced in work done by Lopez *et al.* (2012) that the incorporation of mechanical pulp (MP), which is known as stone ground fiber, into polypropylene (PP), improvement of mechanical properties such as tensile strength and stiffness as well as sound absorption coefficient was found.

1.2 Problem Statement

Various researches had been done on the natural-fiber reinforced composites from the past as the sound absorption purpose. However, some disadvantages of using these natural fibers in the composites had been indicated such as enormous variability, poor moisture resistance, poor fire resistance, lower durability, and lack of fiber-matrix adhesion (Joseph *et al.*, 2005). Hence, in this study, spent tea leaves (STL) from tea producing factories are considered as new resources for sound absorbing composite materials because tea leaves are rich in polyphenols which are also referred as to tannins (Shu *et al.*, 2006). The plentiful phenolic extractive of tea leaves possess high durability (Yalinkilic *et al.*, 1998), high resistance to fungal and termites (Shu *et al.*, 2006), and high resistance to fire (Dittenber and GangaRao, 2012). Meanwhile, in this research, STL filled polyurethane (PU) composites may attribute excellent adhesion properties between the STL fibers and the PU matrix due to hydrophilicity of both materials (Zhao *et al.*, 2011) and this is beneficial to the sound absorption properties of the composites.

1.3 Objectives

The aims of this research include:

1. To characterize physical and chemical properties as well as morphology of various grades of spent tea leaves.

2. To fabricate a green sound absorption structure made of spent tea leaves filled polyurethane composite with different grades and loadings of the spent tea leaves through open molding technique.

3. To investigate physical and sound absorption behavior as well as morphology of spent tea leaves reinforced polyurethane composite as sound absorbing material.

1.4 Scopes

The scope of study is mainly focusing on the sound absorption behavior of thermosetting plastics composites of polyurethane reinforced with three various grades of spent tea leaves like BM-FAE, SW-BHE, and FIBER-FAE as filler respectively with four different weight ratio of the fraction of composition in the composite; 96:4, 92:8, 88:12, 84:16, and 100:0 as a control specimen. It includes the determination of physical property through density measurement and sound absorption property under impedance tube measurement. The microscopic observation on the microstructural morphology of the composites is also included in this study to evaluate the distribution of filler in composite which is related to the sound absorption properties of the composites.

CHAPTER 2

LITERATURE REVIEW

A literature review on previous research work in various areas which is relevant to this research is presented in this chapter.

2.1 Acoustic Materials

Noise pollution has becomes a common major problem to various developing nations (Mahzan *et al.*, 2010). The noise pollution generally refers to unwanted sound produced by human activities unwanted in that it interferes with communication, work, rest, recreation, or sleep (Yuhazri *et al.*, 2011). According to Ahmad and Wahid (2011), noise can cause, or be a factor in causing hearing difficulties, work-related stress, an increased risk of workplace accidents, the effects of noise on performance, interference with speech communication, sleep disturbance, cardiovascular and physiological effects, mental health effects, and effects of noise on residential behavior and annoyance. Here lies the importance of noise control, which tries to reduce the direct contact of noise to human. Various techniques have been implemented to reduce noise pollution, example wearing hearing protection, installation of sound barrier and implementing sound absorption panel (Mahzan *et al.*, 2010).

Efforts to control noise and vibration in a wide range of mechanisms and devices inevitably require the use of passive acoustical materials, as shown in Figure 2.1. Conventionally speaking, acoustic materials are those materials designed and used for the purpose of absorbing sound that might otherwise be reflected. The acoustic materials work by two processes: absorption of sound energy, which dissipates sound as heat energy, and reflection, which reflects noise away from a location where silence is desired (Ahmad and Wahid, 2011). In the science of acoustical control, two classes of acoustical treatments are used to address airborne noise – noise is propagated through the air, namely barriers and absorbers. Likewise, two classes of acoustical treatments are used to address structure-borne noise – noise is propagated through the air after being radiated by a structure, namely isolators and dampers (Parikh *et al.*, 2006). In general, effective noise control incorporates the use of both barriers and absorbers for airborne noise and both isolation and damping for structure borne noise (Ahmad and Wahid, 2011).

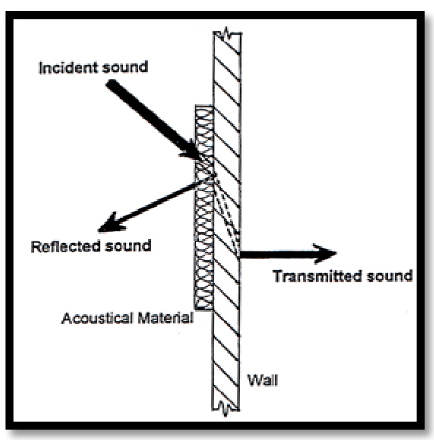

Figure 2.1: Acoustic Materials.

Source: Ahmad and Wahid (2011)

Currently, commercially available sound absorption materials for acoustic treatment used in the building construction industry consisted of mineral fiber materials (Zulkifil *et al*., 2008). The European building insulation market of a value of approximately 3.3 billion Euros has been estimated to: mineral wool (glass): 27%, mineral wool (stone): 30%, foam plastics: 40%, and other materials: 3% (Asdrubali, 2006).

2.1.1 Sound Absorbing Materials

Arenas and Crocker (2010) claimed that sound-absorbing materials undergo their function by absorbing most of the sound energy striking them and reflecting very little, making them very useful for the control of noise, as shown in Figure 2.2.

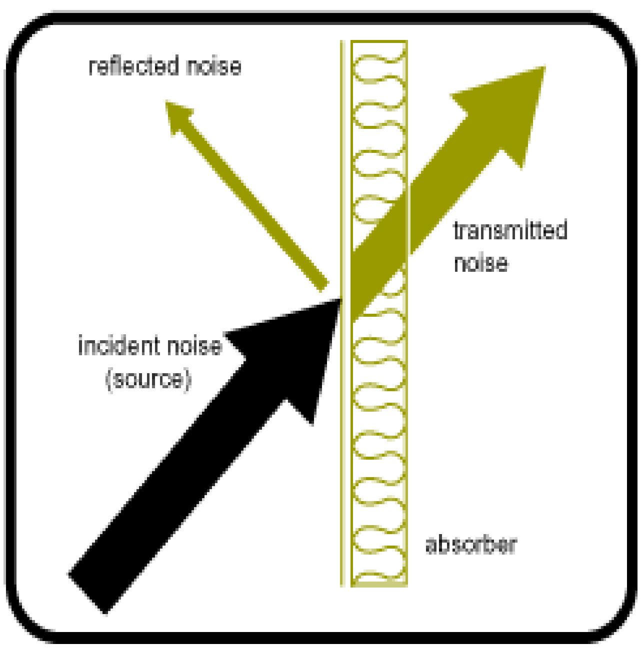

Figure 2.2: Description of Function of Sound Absorbing Materials.

Source: Retrieved November 12th, 2012 from: http://www.citysoundproofing.com/