UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THERMAL ABSORPTION PROPERTIES OF SPENT TEA LEAF FILLED POLYURETHANE COMPOSITE MATERIAL

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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2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Thermal Absorption Properties of Spent Tea leaf filled Polyurethane Composite Material

SESI PENGAJIAN: 2011/12 Semester 2

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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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(Principal Supervisor)

………………………………

(Co-Supervisor)

ABSTRAK

Pemuliharaan tenaga merupakan isu semakin serius bagi sektor kediaman pada masa kini. Oleh itu, prestasi termal bahan sistem penebat haba untuk bangunan semakin bertambah kebelakangan ini. Laporan ini dibuat untuk menganalisis kebolehan bahan polimer komposit menyerap haba dengan mancampurkan pelbagai jenis gred dan komposisi gentian dalam polimer komposit. Tujuan kajian ini dijalankan adalah untuk mencirikan dan menyiasat pelbagai jenis gred gentian dari segi sifat fizikal, kimia dan termal termasuklah ketumpatan gentian, hubungan kimia gentian, dan juga perubahan fasa gentian serta kadar pengaliran haba pada berlainan suhu (50,70,90,110°C). Terdapat tiga jenis gred gentian iaitu BM-FAE dan SW-BHE daripada batang daun pokok teh serta Fiber-FAE daripada daun teh. Polimer komposit (PU/STL) telah dibentuk melalui proses kisar dan ‘open molding’ dengan komposisi gentian 5,10,15 dan 20%. Keputusan menunjukan gentian BM-FAE adalah gentian yang kurang tumpat dengan ketumpatan 1.441g/cm^{3}disebabkan dari pada bahagian batang daun. Kehadiran komposisi lignin juga hadir dalam lingkugan 1650cm^{-1} ke 1380 cm^{-1} melalui FTIR. Untuk suhu perubahan fasa, suhunya berada diantara 70°C ke 80°C. Bagi kadar pengaliran haba pula, PU/BM-FAE komposit menunjukkan kadar pengaliran haba rendah jika dibandingkan dengan gentian yang lain disebabkan kanduangan liang yang ada dalam gentian tersebut. Daripada kajian ini, dapat dilihat bahawa dengan penambahan gentian, kadar pengaliran haba rendah bagi komposit (PU/STL). Dapat dilihat juga bahawa melebihi suhu perubahan fasa, kadar pengaliran haba meningkat disebabkan berlakunya perubahan fasa polyurethane.

ABSTRACT

Energy conservation is an increasingly important issue in the residential sector. Therefore, attention towards the thermal performance of building materials, particularly thermal insulation systems for building has grown in recent years. This report describes the thermal absorption behavior of polyurethane composites reinforced with different grades of spent tea leaves (STL) fibers at various fibers loading. The objectives of this study were to characterize the spent tea leave fibers in terms of its physical, chemical, and thermal properties as well as the rate of heat transfer of the spent tea leaves filled polyurethane (PU/STL) composite at various temperatures (i.e. 50, 70. 90, and 110°C). There were three grades of STL fibers, which are BM-FAE and SW-BHE obtained from the stalk while Fiber-FAE extracted from the leave of a tea plant. The PU/STL composite was fabricated via granulation and open molding with fiber loading ranging from 5, 10, 15, and 20% wt%. Results showed that BM-FAE has the lowest density, 1.441g/cm^3 as it comes from the stalk. These three grades of fiber have showed the presence of lignin at the wavenumber range between 1650 cm^{-1} and 1380 cm^{-1} from FTIR. For the glass transition temperature (Tg) of fibers, the value was in between 70°C and 80°C. In terms of thermal absorption behavior, it was observed that at temperature 70°C (Tg of composite), PU/BM-FAE composite showed lower heat absorption than other composites due to the porous media in fiber. It was also perceived that the addition of fiber loading reduced the heat absorption of the composite. Above the Tg of composite (90 and 110°C), the rate of heat transfer becomes higher due to the phase change of the polyurethane.

DEDICATION

To my beloved family and my siblings

ACKNOWLEDGEMENT

Completion of this project report was made possible because of numerous supports and helps given to me when I was working on it. Thus, it is a great pleasure for me to write this special acknowledgement to every single individual that helped and inspired me to finish this project. I would like to express my highest gratitude to all of them.

First and foremost, I would like to express my thankfulness and appreciation to my supervisor, Miss Chang Siang Yee, for her supervision, guidance, understanding and patience throughout this research work. Also, I would like to thank her for her precious time. Special thanks also goes to my co-supervisor, Prof. Dr. Qumrul Ahsan, for his support and encouragement. All valuable information provided by him is much appreciated. Not to forget to other lecturers, friends and lab technicians for sharing their experiences, skills, opinions, advises and guidance in handling the equipments throughout the study.

Lastly, my sincere appreciation is dedicated to my parents for their love, encouragement and continuous support particularly when I am having difficulties.

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BM	-	Broken mat
CFC	-	Chlorofluorocarbon
CO	-	Carbon oxide
CO_2	-	Carbon dioxide
DSC	-	Differential Scanning Calorimetry
EPS	-	Expanded Polystyrene
FTIR	-	Fourier Transform Infrared
HC	-	Hydrocarbon
HCFC	-	Hydrochloroflourocarbon
HCN	-	Hydrogen cyanide
HFC	-	Fycroflourocarbon
HRR	-	Heat release rate
iPP	-	Isotactic polypropylene
KBr	-	Potassium Bromide
MDI	-	Di-phenyl methane di-isocyanate
NaOH	-	Sodium Hydroxide
NFC	-	Natural Fiber Composite
NO	-	Nitrogen oxide

OH	-	Hydroxyl group
PALF/LDPE	-	Pine apple leaf fiber/Low density polyethylene
PE	-	Polyethylene
pMDI	-	Polymeric by product
PP/OMMT	-	Polypropylene/organophilic montmorillonite
PSMA	-	Polystyrene maleic anhydride
PU100	-	Pure PU
PU	-	Polyurethane
PU/BM-FAE	-	BM-FAE type of fiber filled polyurethane composite
PU/SW-BHE	-	SW-BHE type of fiber filled polyurethane composite
PU/Fiber-FAE	-	Fiber-FAE type of fiber filled polyurethane composite
PU/STL	-	Spent tea leaves filled polyurethane
SE	-	Secondary electron
SEM	-	Scanning Electron Microscope
STL	-	Spent tea leaves
SW	-	Sweeping
TDI	-	Tolune di-isocyanate
TGA	-	Thermogravimetric analysis
TI	-	Thermal insulation
WTL	-	Waste tea leaves
WTLB	-	Waste tea leaves particleboard

°C	-	degree Celcius
g	-	gram
g/cm^3	-	gram per centimeter cube
g/ml	-	gram per milliliter
µm	-	micrometer
%	-	percent
λ	-	Thermal conductivity, k-value
wt%	-	weight percentage
K	-	Kelvin
l	-	length
mm	-	millimeter
nm	-	nanometer
rpm	-	revolution per minute
Tg	-	Glass transition temperature
t	-	thickness
W/mK	-	Watt per meter Kelvin
W	-	Watt
w	-	width

CHAPTER 1

INTRODUCTION

1.1 Background of study

As global warming has become a major concern for human beings nowadays, the use of thermal insulation (TI) structure in building construction is burgeoning. TI structure is regarded as one of the most energy efficiency improvements in buildings and also an important factor to achieve thermal comfort for building occupants. In fact, the thermal insulation structure is not an independent energy production or conservation system, but part of the complex structural elements which form a building's shell. Commercial TI structures are commonly made from synthetic materials such as fiberglass, mineral wool, expanded polystyrene (EPS) and polyurethane (PU) foams. Although these materials have good physical properties such as low thermal conductivity, good moisture protection and fire resistance, they can be hazardous to human health and environment (Demant, *et al.* 1994). Fiberglass has an adverse effect on human health. When fiberglass is handled, cut or otherwise disturbed, people may be exposed to airborne fiber and resulted in skin and eye irritation or emphysema and lung cancer through inhalation

The hazard of using commercially available TI materials made of synthetic materials has spurred interest in other renewable green materials as alternative. Over the years, several researches have succeeded in developing TI materials using lignocellulosic fibers. Various lignocellulosic fibers that have been investigated as raw materials for TI purpose are coconut husk (Viswanathan *et al.* 2000; Van Dam *et al.* 2004), kenaf core (Xu *et al.* 2004), cotton (Alma *et al.* 2005), bagasse (Widyorini *et al.* 2005), oil palm (Feng *et al.* 2001; Khalil *et al.* 2007; Suradi *et al.*2010)[1], flax and hemp (Kymalainen and Sjoberg, 2008), wood, (Kawasaki and Kawai, 2006; Azizi and Faezipour, 2006; Akgul *et al.* 2007; Loh *et al.* 2010), coffee husk and hulls (Bekalo and Reinhardt, 2010), and papyrus (Tangjuank, 2011). Among these fibers, fiberboard fabricated from papyrus fiber reinforced natural rubber latex showed the most promising result with thermal conductivity values of 0.029 W/mK. This is comparable to commercially available insulating concrete foams made of EPS which shows a thermal conductivity values of 0.033 W/mK.). Despite the low thermal conductivity behavior, lignocellulosic fibers also outweigh other commercial synthetic thermal insulation materials in the regard of density. The density of natural fiber is 1.15 – 1.50 g/cm^3 whereas 2.4 g/cm^3 for fiberglass. Research shows that decreasing of the density of TI materials reduced the thermal conductivity value (Luamkanchanaphan *et al.*, 2012)

It is undeniable that natural fibrous materials exhibit numerous advantages to be functioned as TI material. A tropical country like Malaysia is rich in the production of crops such as coconut, pineapple, banana, palm oil, and rice. Tea leaves *(Camellia Sinensis)* is one of the fibrous plants available in abundance which can be found at Cameron Highlands, Pahang and Ranau, Sabah. Therefore, this study attempts to investigate on the feasibility of incorporating spent tea leaves (STL) as an alternative lignocellulosic material to produce TI materials.

1.2 Problem Statement

Natural fibers have shown to possess low thermal conductivity and density which is advantageous for thermal insulation purpose. However, when dealing with these natural fibers, an undesirable attribute of the fiber is their ability to absorb moisture from the atmosphere in comparatively large quantity (Chawla, 1998). Upon moisture absorption, most of these fibers swell and become prone to microbial attack as well as biological decay. In most buildings, the building materials are exposed to moisture due to high humidity due in the weather or the use of the air-conditioning system. The presence of moisture encourages the growth of moss or algae which may disfigure and deteriorate the properties of the building materials made of natural fibers. Spent tea leaves obtained from tea producing factories are optimistically considered as a new resource because it exhibits antimicrobial properties. Spent tea leaves are expected to show higher durability in thermal insulation applications than other natural fibers owing to the high phenolic extractive content which retards the growth of moss or algae. Hence, spent tea leaves serve a scope for further research as thermal barrier component.

1.3 Objectives

The objectives of this project were as follows:

1. To characterize various grade of spent tea leaves extracted from different parts of tea plant in terms of physical, chemical and thermal properties.
2. To fabricate thermal insulation board using various grades of spent tea leaves filled polyurethane composite through open molding technique.
3. To investigate physical and thermal properties of spent tea leaves filled polyurethane composite.