UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF MECHANICAL AND MORPHOLOGICAL PROPERTIES OF SPENT BLEACH EARTH (SBE) REINFORCED GLASS WASTE COMPOSITE

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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I hereby declare this report entitled **INVESTIGATION OF MECHANICAL AND MORPHOLOGICAL PROPERTIES OF SPENT BLEACH EARTH (SBE) REINFORCED GLASS WASTE COMPOSITE** is the results of my own research except as cited in the references.

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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 member of the supervisory is as follows:

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Dr. Zurina Binti Shamsudin

(Project Supervisor)

ABSTRAK

Tujuan projek ini adalah untuk mengkaji sifat-sifat mekanikal dan morfologi lebihan peluntur bumi (SBE) bertetulang sisa kaca komposit. SBE adalah satu sisa pepejal yang dihasilkan daripada kilang penapis minyak sawit dan biasanya dilupuskan di tapak pelupusan begitu sahaja. Objektif projek ini adalah untuk menentukan komposisi yang ideal bagi komposit kaca dan untuk mencirikan sifat-sifat mekanikal. Selain itu, objektif projek ini adalah untuk menganalisis hubungan fasa, mikrostruktur dan sifat mekanik komposit kaca. Bahan yang digunakan dalam projek ini adalah kaca soda kapur silikat (SLSG) dan SBE di mana ianya bertindak sebagai matriks dan pengisi masing-masing. Serbuk kaca dihancurkan dan disaring untuk mendapatkan saiz 75 μm. Peratusan berat SBE dalam komposit kaca dibezakan pada 30 wt.%, 35 wt.%, dan 40 wt.%. Sampel dibakar pada suhu 750 ° C dengan kadar pemanasan 2 ° C / minit. Terdapat beberapa ujian yang terlibat dalam projek ini seperti ujian fizikal (pemerhatian fizikal, ketumpatan, keliangan, dan penyerapan air), ujian mekanikal (lenturan dan ujian kekerasan) dan analisis mikrostruktur (imbasan elektron mikroskop-SEM, dan pembelauan sinar X-XRD). Hasil kajian menunjukkan bahawa sampel 30 wt.% SBE mempunyai peratusan penyerapan air dan peratusan keliangan yang lebih rendah daripada sampel 40 wt.% SBE. Selain itu, sampel 30 wt.% SBE menunjukkan kekerasan mikro dan MOR tertinggi iaitu 4.95 GPa dan 23.62 MPa. Kesimpulannya, sampel 30 wt.% SBE mempunyai sifat fizikal yang bagus, di samping sifat mekanikal dan morfologi yang baik.

ABSTRACT

The aim of this project is to investigate the mechanical and morphological properties of spent bleach earth (SBE) reinforced glass waste composite. SBE is a solid waste generated from the palm oil refinery and usually is being simply disposed off in landfills. The objectives of this project is to determine the ideal composition of the glass composite and to characterize the mechanical properties. Besides that, the objectives is to analyze the correlation of phase, microstructure and mechanical properties of the glass composite. The material used in this project are sod lime silicate glass and SBE in which act as matrix and filler respectively. The glass powder is crush and sieved to get the size of 75 µm. The SBE weight percentage in the glass composite is varied from 30 wt.%, 35 wt.%, and 40 wt.%. The sample is sintered at 750 °C with the heating rate of 2 °C/minute. There were few testing involved in this project such as physical testing (physical observation, density, porosity, and water absorption), mechanical testing (flexural and hardness test) and microstructure analysis (scanning electron microscope-SEM, and X-ray diffraction-XRD). The results showed that 30 wt.% SBE sample has lower water absorption and porosity percentage than 40 wt.% SBE sample. Besides that, 30 wt.% SBE sample shows the highest microhardness and MOR which is 4.95 GPa and 23.62 MPa respectively. In conclusion, the 30 wt.% SBE sample has better physical properties as well as good mechanical and morphological properties than other composition.

DEDICATION

This report is dedicated to my respective parents; Mr. Khairul Bin Taib and Mrs. Faridah Binti Ahmad, my supervisor; Dr. Zurina Binti Shamsudin, my family's members and also to all my friends who have been supported and inspired me to do this research study whether direct or indirectly way for completing this project.

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I would also extend my gratitude to the Faculty of Manufacturing Engineering staff and my project partners for giving full cooperation to complete this project. Last but not least, I would thank to everyone, especially my beloved parents and family for giving me an endless support to complete this report.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ASTM	-	American Standard Testing Material
CaO	-	Calcium Oxide
GPa	-	Giga Pascal
MOR	-	Modulus of rupture
MPa	-	Mega Pascal
Na^2O	-	Natrium Oxide
SBE	-	Spent Bleach Earth
SEM	-	Scanning Electron Microscopy
SiO^2	-	Silicon Oxide, Coesite, Cristobalite
SLSG	-	Soda-lime silicate glass
XRD	-	X-ray Diffraction
Wt. %	-	Weight percentage
µm	-	Micron meter
°C	-	Degree Celsius

CHAPTER 1

INTRODUCTION

1.1 Background of study

Waste has been a major environmental issue everywhere since the industrial revolution. The waste need to be managed carefully as it can be harmful to the people. One of the waste management method is recycling. Recycling is the processing of used products to attain materials that can be used to make a new products (Morgan, 2006). For example, the glass waste such as glass food and beverage container can be recycled over and over again. This recycle glass costs less than the raw materials, prolong furnace life and saves energy since it melts at a low temperature (Trzupek, 2010).

Another waste that may also be recycled rather than being exposed is Spent Bleach Earth (SBE). SBE is a solid waste generated from the palm oil refinery and usually is being simply disposed off in landfills. (Loh et al., 2013). The SBE waste can recycled and used as a filler in a ceramic composite material.

In this research, the glass matrix composite material manufactured by a sintering process which uses waste glass as the main raw material is studied. The SBE will act as the filler in the glass composite. The samples will be prepared at different formulation and sintered at fixed temperature. The sample will be further analyzed for the material's properties which consist of mechanical properties with respect to their microstructure.

1.2 Problem statement

Nowadays, solid waste management is an important thing that need to be carried out as the solid waste can give the negative impact to environment. One of the major components of the solid waste is waste glass. Waste glass has become a considerable burden on the landfills throughout the world. Therefore, it is vital to find an ecological alternative to reuse and recycle the waste glass. Besides, the process of turning waste glass into usable products instead of discarding the glass is usually very advantageous.

It has been reported that recycle glass microstructural properties has contribute to the strong improvement of the mortar mechanical performance (Corinaldesi et al., 2005). The improvement on the mechanical properties is attractive for replacing conventional materials.

Recently, SBE performance as the cement replacement in concrete has been studied. It is reported that lower SBE concrete gives better mechanical properties than higher SBE content (Khai, 2010). Tokaman et al (2014) studied on compressive strength of concrete block with addition of SBE. Results showed the compressive strength decreased with increasing cement replacement (Torkaman, et al., 2014). Thus, this research will focus on the flexural strength of the glass waste/ SBE composite.

1.3 Objectives

The main objective of this research was to study the mechanical properties and morphological properties of the glass waste composite. The study objectives include:

i. To determine the ideal composition of the soda lime silicate glass (SLSG) waste with addition of spent bleach earth (SBE) at a fixed sintering temperature.
ii. To characterize the physical and mechanical properties of the glass composite sample.
iii. To analyze the correlation of phases, microstructure and mechanical properties of the glass composite sample.

1.4 Scope of study

This research is focusing on the thermo-mechanical properties of the glass composite samples. This study started by preparing the glass waste in powder form as the raw material and SBE as the filler. The glass powder was then mixed with the SBE in different compositions. Subsequently, the mixtures were pressed to a pellet and rectangular shape. This compaction is done using an uniaxial pressing method. The next step was sintering the samples in the furnace under specified condition. Finally, the sintered samples were subjected to sample characterization and testing. The physical and mechanical testing is conducted to analyze the properties of the glass composite. The physical analysis includes the size, color and surface roughness of the samples while the mechanical analysis includes the Vickers microhardness test and flexural test. As for the microstructure and phase analysis, scanning electron microscopy (SEM) and X-ray diffraction (XRD) technique will be used.

CHAPTER 2

LITERATURE REVIEW

This literature review provides an overview of the glass waste and natural waste. It covers the inclusive review on the material properties and their constituent. Furthermore, the characterization methodologies are also included in this literature review. It comprises the scanning electron microscopy (SEM), X-ray diffraction (XRD), flexural test, and Vickers microhardness test and density measurement.

2.1 Glass waste

2.1.1 Definition of glass

Glass is a hard, brittle and usually transparent material. In scientific term, glass refer to any rigid substance that is amorphous, with the exception of plastic and several other substances containing carbon (How Stuff Work, 2009). Glass is solid at room temperature and it is formable at approximately 1000°C. Similarly, it melts at temperatures of between 1400°C and 1650°C (Bvglas.de, 2014).

In another view, glass is created from natural and abundant raw material of sand, soda ash and limestone. The raw material is melted at very high temperature to form glass. Glass is structurally similar to liquids at high temperature though behave like solid at ambient temperature. This characteristic make glass can be poured, press and molded into various shapes (Glass Alliance Group, 2012).

2.1.2 Definition of glass waste

Glass waste is the glass product that has been discarded or no longer in use. Waste glass disposal come from glass container, flat glass and domestic glass is one of the major environmental challenges. It becomes more challenging as the quantity of waste glass increase and reducing the landfill space capacity (Rashad, A. M., 2014).

Therefore, glass product need to be reused or recycled so that environmental problems can be avoided (Ali, E.E., 2012).

2.1.3 Type of glass

Glass can be differ based on the chemical composition, the processing method or processing behavior. Commonly, glass is classified based on the chemical composition (Bvglas.de, 2014). Table 2.1 show the types and the uses of glass.

Table 2.1: Types and uses of glass (Siddique, 2008)

Type of glass	Main products
Soda lime glass	Bottles and jars Tableware Flat glass
Lead glasses	Crystal tableware Television screens and display screen equipment
Borosilicate glasses	Glass fiber Wool insulation Ovenware
Technical glasses e.g. Alumino-silicate, Alkali-barium	Scientific Frits Optical

2.1.4 Soda-lime glass

Soda lime glass is the most predominant type of glass. It is prepared by melting the raw materials in a glass furnace at temperature up to 1675°C. The raw materials for soda lime glass are soda, lime, silica, alumina and small quantities of fining agents (Jnsglass.com, 2014).

Technically, soda-lime glass can be divided into glass used for windows and glass for containers which are called float glass or flat glass and container glass respectively. Both types vary in the application, chemical composition and production method (Reade, 2014).

a) Chemical composition

Soda-lime glass typically contains 71 to 75 percent of silicon dioxide (SiO_2), 12 to 16 percent sodium oxide (Na_2O), 10 to 15 percent calcium oxide (CaO) and small quantities of other substances such as dyes (Bvglas.de, 2014). Table 2.2 shows the typical compositions of commercial soda lime glasses.

Table 2.2: Compositions of common commercial soda lime glasses (Shelby, 2005).

Component (wt %)	Windows	Containers	Incandescent Lamps
SiO_2	73	74	72
Na_2O	14	13	16
K_2O	-	0.3	1
MgO	4	0.2	4
CaO	9	11	3
Al_2O_3	0.1	1.5	2
Fe_2O_3	0.1	0.04	-
SO_2		0.2	-