POTENTIAL APPLICATION OF TAPIOCA STARCH / SUGAR CANE FIBER CELLULOSE GREEN COMPOSITE FOR DISPOSABLE PACKAGING FOOD CONTAINER

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

by

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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) with Honours. The member of the supervisory committee is as follow:

....................................................

(Mr. Jeefferie B. Abd Razak)
ABSTRACT

The noble aim of this research is to investigate extensively the potential application of Tapioca Starch (TS) filled Sugar Cane Fiber Cellulose (SCFC) biocomposites for disposable packaging food container. This research was started by preparing and characterizing the SCFC through various characterization tools. The effect of the optimum SCFC loading to the fabricated TS composites was studied as to establish the best formulation of the TS/SCFC biocomposites. The thin sheet of composite samples were then fabricated with different blend formulation via compression molding machine and the samples were cut into the specific dimension, according to the ASTM standard for each different testing. Further testing for various engineering properties of TS/SCFC biocomposites were carried out, such as tensile test, impact test, flexural test and hardness test. These tests were used to determine the mechanical properties of the fabricated composites. Then, it was followed by conducting the physical test such as weathering test, water absorption test and the thickness swelling test. Other than that, the Fourier Transform Infrared (FTIR) analysis was conducted as to investigate the degradation behavior of the biocomposites. In order to observe the fracture morphology of the samples, the optical microscope was utilized comprehensively. Generally, the results of this study have shown good performance for both the mechanical and physical properties of the fabricated composites. However, through the morphological observation on the mechanical and physical testing fractured surfaces, it was clearly found that the adhesion between the SCFC and TS matrix were not well attached. This study has indicated the role of fiber loading into the resulted properties of the fabricated composites. Development of this alternative container material for food packaging application will provide a great potential solution to the environmental friendly and safe packaging medium either for food, consumer or environment as a whole.
DEDICATION

For My Beloved Father Hj. Othman B. Mean
My Beloved Mother Hjh. Jami’ah Bt. Md. Salleh
My Sisters Nurul Ain and Nurul Umairah
My Younger Brother Muhammad Syukri
My Dear Friend Mohd Shafeq B. Md Sharif
My Supervisor Mr. Jeefferie B. Abd Razak
   My friends and all technicians
   Thanks for supporting me…
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In the name of Allah, the most Compassionate, the most Merciful. Alhamdulillah, thousand of thanks to Allah S.W.T for a blessing, courage and strength, I have completely done my report as it is today. Praised to Him alone for His endowment, that let me to complete this report. Finally, the report has been completed within the specified period. Although there is a lot of an obstacles and barriers that I have been through, by the assistant and guidance from my supervisor, finally I can manage it well.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ASTM  American Standard Testing of Materials
CAGR  Compound Annual Growth Rate
CMC  Ceramic Matrix Composite
DSC  Differential Scanning Calorimetry
Eg.   Example
EMC  Equilibrium moisture content
et al. and others
etc.  Et cetera
FTIR  Fourier Transform Infrared Spectroscopy (FTIR) Analyzer
HDPE  High Density Polyethylene
MAPP  Maleic-Anhydride Grafted Polypropylene
MMC  Metal Matrix Composite
PC    Polycarbonates
PHA   Polyhydroxyalkanoate
PLA   Polylactate
PMC   Polymer Matrix Composite
TS / SCFC  Tapioca starch reinforced sugar cane fiber cellulose
RH    Relative humidity
RoM   Rules of Mixtures
SCAR  Sugar Cane Agricultural Residues
SCFC  Sugar Cane Fiber Cellulose
SPC   Soy Protein Composites
SPI   Soy Protein Isolates
TS    Tapioca Starch
wt%   Percent of weight fraction
WA    Water Absorption
CHAPTER 1
INTRODUCTION

1.1 Introduction

Plastics due to their versatility are making great in the field of packaging of a variety products such as processed and convenience foods, pharmaceuticals and medicines, cosmetics and toiletries, household and agricultural chemicals, petroleum products and detergent and etc. As we know, plastic containers have actually succeeded in replacing metal, glass, tin, aluminum and paper containers in many applications. The advantages of plastics are light and less bulky than other packaging materials, can be processed into any desired shape or form such as films, sheets and pouches, it save costs of storage and transportation because of lower volume, easy for coloring, no rusting and good water resistance. Although plastic package have tremendous advantages, they have been some limitations that includes some chemical attack on particular plastics, less heat resistance, tendency to creep, lower gas barrier and lower dimensional stability (Kadoya, 1990; Athalye, 1992).

In addition, there are serious problems connected with the analytical control of such materials; toxic hazards from the modified plastics and also from their degradation products, increased costs and the possible encouragement of litter (including non plastics component). In order to reduce this problem, the application of using biodegradable material is an alternative method. Biodegradable which are often produced from renewable sources, are being increasingly sought after by food processors as part of a solution to environmental concerns over waste and the use of fossil fuels. The process is called biodegradation (Dong et al. 2008). Biodegradation is a natural process by which organic chemicals in the environment are converted to
simpler compounds, mineralized, and redistributed through the elemental cycles such as the carbon, nitrogen, and sulphur cycles through the action of naturally occurring microorganism.

In this research, biodegradable polymer matrix composites were developed. There are two natural components will be combined in the fabrication of innovative biocomposites for the application of food packaging. One is a natural biofiber utilizing sugar cane fiber cellulose (SCFC) while the other is biodegradable matrix material which is tapioca starch (TS). Sugar cane has played an important role in enhancing the composites performance as filler reinforcement. In addition, it was combined with tapioca starch that acts as matrix which has many advantages to the environment. It is anticipated that the development of this product, was contribute to the world as novel biodegradable, non-toxic and non-allergenic bio environmental friendly natural green products.

Nevertheless, there is considerable interest and noble aims in this research where to produce an alternative material by compounding tapioca starch and sugar cane fiber cellulose to replace the existing non biodegradable plastic material in the market. Thus, in overall, this research formulated the biopolymer based composites filled with an agro-waste biofiller by using the internal mixer compounding method in order to investigate and understand the behavior, mechanism and kinetic of degradation for the TS/SCFC biocomposites.

1.2 Problem Statement

Great attentions are focused on the utilization of the natural plant fibers to replace the synthetic fibers in the development of polymeric based composites materials. This is due to the advantages of renewability, low density and high specific strength as well as biodegradable and recyclable at the very reasonable cost (Ochi, 2008). These fibers outstanding properties such as high specific strength and stiffness, impact resistance, flexibility, and modulus make them an attractive alternative over the traditional materials (Sgriccia et al. 2008). Specifically, good properties of sugar cane fiber cellulose includes good specific strengths and modulus, economical
viability, low density and low weight has made them as a promising reinforcement of choice by the industry. Thus, natural fiber like sugarcane can be used as a replacement to the conventional fiber, since the global environmental issues have led to renewed interest in the development of bio-based materials (Chen and Chung, 1993).

It is important and possible to produce a new types of material that exhibit the economically and environmentally friendly benefits for packaging applications in food packaging industries. By combining two different resources, it is possible to blend, mix or process the natural fiber with other elements such as plastics or synthetics material to produce new classes of materials. The important things is to ensure that the fabrication are employed in the controlled temperature processing, because the degradation of the sugarcane will lead to the failure or poor performance to the properties of the fabricated composites (Hanlon et al. 1998). Therefore, the selection of suitable processing temperature is crucially important consideration especially when dealing with the fabrication of heat sensitive biopolymer of TS / SCFC green composites. Thus, in this research, study on the effects of the processing parameter to the final properties of the fabricated composites, will be the major focused. The potential of the composites produced to be naturally degraded will be tested, understood and studied comprehensively.

1.3 Objectives

The purposes of this study are:

1.3.1 To formulate biopolymer based composites filled with agro-waste biofiller by using an internal mixer compounding method.

1.3.2 To establish the mechanical, physical and morphological data observation for the novel fabricated TS / SCFC biocomposites in comparisons to the other biocomposites.
1.4 **Hypotheses**

1.4.1 The contents of fiber loading or proportion of SCFC used of this study will affect the final properties of the fabricated composites. It is expected that, by increasing the proportion of fiber loading, the properties of the fabricated composite will be increased correspondingly in accordance to the rules of mixture (RoM) theory.

1.4.2 Introduction of biopolymer in this study will increase the final properties of the fabricated composites provided that, good interfacial adhesion formed between the surface interaction of TS / SCFC biocomposites. Thus, it is expected that by increasing the compounding temperature and speed of the roller rotors rotation, it will improves the interfacial adhesion of the composites produced.

1.4.3 It is expected that, the biofiller used will further enhanced the rate of degradability of the composites produced. Thus, by increasing the weight percentage or SCFC loading in one matrix of TS, it will accelerate the kinetic in degradation.

1.5 **Importance of Study**

Critically, the noble aim of this research which to develop the green materials for the application of food packaging. Thus, by conducting this research, it is expected that it will be benefited to the environment that suffer with the non-degradable waste of plastic food packaging caused by uncontrolled solid waste disposal and extensive use of this necessity. Development of this novel food packaging alternative will create potential solution to the environmental friendly and safe packaging medium either for food, consumer or environment as a whole.
1.6 Scope of Study

Sugar cane fiber cellulose (SCFC), tapioca starch (TS) and glycerol were used in this research as raw materials. The study was started by preparing and characterizing the sugar cane fiber as reinforcement material. The next stage involves the drying study of SCFC. SCFC were dried in the drying oven for several period of time and the weight losses of fibers were determined accordingly. Then, TS, SCFC and glycerol were compounded by using the internal mixer. The effect of optimum filler loading to the fabricated composites will be further studied and the best formulation of composites was suggested. After that, compression molding machine was utilized to prepare the samples. The blend of fiber and matrix were pressed by using the compression molding machine to produce the thin sheet of composites samples. The fabricated composites were cut into the specific dimension according to the ASTM standard for various types of selected testing. The best compounding of TS / SCFC will be determined by one-factor-at-time (OFAT) statistical method. In order to achieve the objectives of this research, further testing analysis for various engineering properties of TS / SCFC were carried out such as tensile test, impact test and flexural test. These tests were used to determine the mechanical properties of the samples. Then, it was followed by the physical test such as weathering test, water absorption test and thickness swelling test. Other than that, the Fourier Transform Infrared (FTIR) was conducted as to investigate the degradation behavior of the composites produced. In order to observe the fracture morphology of the sample, the optical microscope was utilized. Fractured samples from the flexural testing, impact testing and hardness testing were thoroughly viewed.