INVERSTIGATION ON PROPERTIES OF RECLAIMED CARBON COMPOSITE FOR ASSISTIVE TENODESIS APPLICATION

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

by

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I hereby, declared this report entitled “Investigation On Properties Of Reclaimed Carbon Composite For Assistive Tenodesis Application” is the result of my own research except as cited in references.

Signature : ……

Author’s Name : LAU SIE LIN

Date : 20 June 2019

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

…….....

(Dr. Zurina Binti Shamsudin) – Signature and Sign

ABSTRAK

Gentian karbon digunakan secara meluas dalam aplikasi-aplikasi kejuruteraan. Disebabkan oleh peranti bantuan yang sedia ada itu berat, mahal dan tidak boleh dikitar semula, penebusan semula gentian karbon dengan pengisian asid polilaktik komposit telah dibuat dengan menggunakan pencampur dalaman dan penyemperit berdasarkan peratusan berlainan berat nisbah . Kesan nisbah berat gentian karbon tebus guna dan ciri-ciri mekanik komposit akan ditentukan. Dalam penyelidikan ini, nisbah berat gentian karbon tebus guna ialah 0 berat.%, 10 berat.%, 20 berat.% dan 30 berat.%. Selepas itu, panel-panel komposit akan dipotong dengan mengikut dimensi teringin spesimen berdasarkan standard ASTM. Kemudian, ciri-ciri morfologi dan sifat mekanik akan dikaji. Dari data yang dikumpulkan, ia telah menyimpulkan bahawa ketumpatan, ciri-ciri tegang dan ciri-ciri lenturan akan menambah apabila pemuatan serat bertambah. Karbon, oksigen, sulfur dan zirkonium telah didapati muncul dalam serbuk karbon tebus guna apabila prarawatan serbuk karbon tebus guna disiasat dengan menggunakan spektrometer sinar-x dispersif tenaga. Sisipan gentian karbon dan serat akan diperhatikan dengan menggunakan mikroskop elektron penskanan. Bagi komposisi dengan 30 wt.%, gentian karbon telah didapati terserak sepenuhnya di sekitar PLA kerana tiada keporosan dikesan dalam imej mikrograf. Dengan hal yang demikian, ia mempunyai kekuatan tegangan tertinggi jika berbanding dengan gubahan lain.

ABSTRACT

Carbon fiber is widely used in engineering applications. As existing assistive device is heavy, expensive and non-recyclable, reclaimed carbon fiber reinforced polylactic acid composite with different weight percentage of ratio is fabricated by using internal mixer and extruder. The effect of reclaimed carbon fiber and physico-mechanical properties of composite were studied. In this research, the weight ratio of reclaimed carbon fiber is 0 wt.%, 10 wt.%, 20 wt.% and 30 wt.%. After that, the composite panels are cut to desired dimension of specimen according to ASTM standard. Then, morphology properties and mechanical properties are studied. From the data collected, it concluded that the density, tensile properties and flexural properties of the composite are increasing along with the increasing fiber loading. Carbon, oxygen, sulfur and zirconium element are present in the reclaimed carbon powder when the pretreatment of reclaimed carbon powder are investigated by using energy dispersive x-ray spectrometer. The dispersed of carbon fiber and fiber pullout are observed by using scanning electron microscope. For the composition with 30 wt.%, the carbon fiber is fully dispersive and melt around the PLA because there is no porosity detected in the micrograph image. Therefore, it has the highest tensile strength if compare with other composition.

DEDICATION

Only

my beloved father, Lau Hieng Yew

my appreciated mother, Tang Chuoi Tieh

my adored brother and sister, Sie Lee, Sie Yee

To my supervisor, Dr Zurina Binti Shamsudin

My beloved friends, Toby, Di Quan, and Peter

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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LIST OF ABBREVIATION

ASTM	-	America Society for Testing and Materials Standards
CMC	-	Ceramic Matrix Composites
FRP	-	Fiber-Reinforced Polymer
GFRP	-	Glass Fiber-Reinforced Polymer
MMC	-	Metal Matrix Composites
PMC	-	Polymer Matrix Composites
PLA	-	Polylactic Acid
rCF	-	Reclaimed Carbon Fiber

LIST OF SYMBOLS

wt (%)	-	Weight Percentage
S	-	Engineering Stress
P	-	Load
A	-	Cross-sectional area
L	-	Change in length
L_0	-	Original length
e	-	Engineering strain
σ_f	-	Flexural stress
F	-	Load
L	-	Length of span
b	-	Width of the specimen
h	-	Thickness of the specimen
E_f	-	Flexural modulus of elasticity
d	-	Central deflection
m	-	Mass
v	-	Volume
mm	-	Millimetre
MPa	-	Megapascal
N	-	Newton

CHAPTER 1
INTRODUCTION

In this chapter, the background of study, problem statement, objectives, scope of the study, important of study, organization of the report are presented in this chapter as well as the summary of the chapter.

1.1 Background of Study

In recent years, carbon fiber composite has a wide range of engineering application. For example, the frame of the cars, bikes, and other applications. Carbon fiber composite is a strong and light composite material as it made of a polymer matrix reinforced with fibers (Alberto, 2013). However, there is a key problem of the carbon fiber composite which it cannot be melted down easily. This is because carbon fiber composites obtain their strength from long, precisely aligned carbon fibers, secured in a glue-like polymer at high temperatures and pressures (Harris, 2017). Once healed, most of these hard polymers do not melt and need to be burnt off or chemically dissolved to recover the valuable fibers that requires the high recycling cost. In the end, the products which made up of carbon fiber composite will be sending to landfill as it requires high recycling cost.

To solve this problem, a variety of technologies have been studied for recycling the high value carbon fiber from scrap polymer composites. In general, there are three types of waste treatments of thermoset composites (Sun et al., 2015). Firstly, the waste is lacerated and grinded to be used in the new composites production by undergoing mechanical recycling. Secondly, the organic compounds can be recovered by chemical recycling through the chemical reaction. Lastly, the caloric content of the polymer can be received through energy recovery. Among these treatments, mechanical recycling can recover both

fibers and resin as the composite is cutting into smaller pieces and grinding it to become the particulate materials. There is no usage of any dangerous materials and pre-treatment of the waste produced by the mechanical recycling. Therefore, the reclaimed carbon fiber can be used to solve the limitation of assistive device in term of weight and cost (Sun et al., 2015).

The purpose of assistive devices is to enhance the lifestyle of people with disabilities and aging symptoms. It helps the people to be independence and reconnect to sociality again. In the year of 2050, there is a global approximate of 800 million older people needs the assistive device due to the weakness of muscle strength as getting older (Garçon et al., 2016). With the help of assistive devices, the older people able to move around freely without depend on their family or friends. According to Garcon et al.,(2016), there is around 20% at age 70 up to 90% at age 90 requires the use of the assistive device. It shows that the number of assistive device user is keep increasing by age. The characteristic of assistive device such as safety, durability and ease of use are importance and need to be improved by time to time due to increment of aging population (Sang-Heon Lee, 2014).

1.2 Problem Statement

The major barriers of the current assistive tenodesis device is high cost required as it imported from other countries. Besides, the device is highly relied on the user injury level and age as the device is too heavy for user to move around. According to Leonard (2017), the common material which used in most of the assistive device is steel. Therefore, a lightweight device which made up of reclaimed carbon composite is suggested. Reclaimed carbon fiber is a composite has high potential than the metal due to its lightweight and possess good mechanical properties. The density of the composite is lower than the steel. The toughness and strength of composite is higher than the steel. Thus, it is expected that this device can let user to move freely without the burden of care and movement limitation.

1.3 Objectives

The objectives of this study are as follows:

1. To investigate the fiber loading of reclaimed carbon filler on physico-mechanical properties composite via polymer processing.

2. To correlate the effect of reclaimed carbon filler loading with physico-mechanical properties on morphological via scanning electron microscope.

1.4 Scope

The scope of this study is mainly focusing on the material selection of polymer and manufacturing process of reclaimed carbon composite by using the internal mixer and extruder. The characterization of the reclaimed carbon filler is conducted via particle size analyser, x-ray diffraction, scanning electron microscope and energy dispersive x-ray spectrometer. Mechanical testing such as density, tensile test and flexure testing is carried out on difference ratio of reclaimed carbon composite. The result of testing is analysed based on their toughness and strengthens. The dispersion of the reclaimed carbon among the polymer and interface bonding was observed by using scanning electron microscope.

1.5 Important of Study

There are some potential benefits that can be gained after the completion of this study. The patient would not become the burden of their family as they can move freely. Besides, the device application would not be limited as it can adapt to patient age or injury level due to its flexibility. Moreover, it also would not become the financial problem for patient as it is using recyclable material to fabricate.

1.6 Organization of the Report

This study is done with 5 main chapters which are introduction, literature review, methodology, result and discussion. Conclusion and recommendation is the final part of this study. Chapter 1 briefly explained the background of study, problem statements, objective, scope, importance of study and summary of the chapter. Chapter 2 is discussed about the theory of composite, definition and ratio of reclaimed carbon composite and manufacturing process of reclaimed carbon composite. Mechanical testing on the reclaimed carbon composite and some previous research for reclaimed carbon composite also discussed in Chapter 2 as well. Chapter 3 is discussed about the process flow of reclaimed carbon composite. This chapter also included the test and analysis for the product. In Chapter 4, all the result based on the test of the specimens is attached. There are some discussions done regarding to the result that obtained. For the Chapter 5, conclusion is made by referring to the result that obtained and objective as well as recommendation for the future work.

1.7 Summary

In background of study, the carbon fiber composite is a major issue for the environment as it is difficult to be melt down due to its alignment. Due to the high cost of recycling, normally the carbon fiber composite will send for landfill. For the carbon fiber composite, three main treatments are the mechanical recycling, chemical recycling and energy recovery. Mechanical recycling is the best treatment among these three treatments as it can recover the fibers and resin. For the problem statement, the limitation of the device such as the weight of the device, highly expensive and non-recyclable is the main problem of this project. Therefore, the objective is to create a type of reclaimed carbon composite which is lightweight and recyclable. The scope of the project is focusing on the manufacturing process of the reclaimed carbon composite by using the internal mixer and extruder. Besides, the mechanical testing is carried on difference ratio of the composites to determine the toughness and strengthens of the material. The important of study is to reduce the patient burden toward on their family members and reduce the financial problem. There are five chapters consists inside the organization of the report which are introduction, literature review, methodology, result and discussion.