CHARACTERIZATION OF INDIUM ZINC OXIDE COATING ON KENAF FIBER

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

by

FATIN NADHIRAH BINTI ROZALI
B051410258
950730-11-5264

FACULTY OF MANUFACTURING ENGINEERING
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DECLARATION

I hereby, declared this report entitled "Characterization of indium zinc oxide coating on kenaf fiber" is the results of my own research except as cited in reference.

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Author's Name	:	FATIN NADHIRAH BINTI ROZALI
Date	:	8th JUNE 2018

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering with Honors. The member of the supervisory committee are as follow:

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(Principal Supervisor)

(DR. MOHD EDEEROZEY BIN ABD MANAF)

ABSTRAK

Perlindungan gangguan elektromagnet menjadi isu penting kerana peranti elektronik banyak digunakan dalam persekitaran hidup kita. Secara tradisional, bahan perisai elektromagnetik dibuat dari logam kerana sifat mekanik dan elektrik yang baik. Walau bagaimanapun, logam biasanya terdedah kepada hakisan dan tinggi dalam ketumpatan serta kos pembuatan. Penggunaan serat kenaf yang diubahsuai permukaan boleh menyelesaikan masalah ini. Tujuan kajian ini adalah untuk mencirikan serat kenaf yang dilapisi dengan indium zink oksida (IZO) sebagai kaedah untuk meningkatkan kekonduksian elektrik, yang merupakan prasyarat untuk aplikasi perisai elektromagnetik. Pelapisan filem IZO pada kenaf bukan tenunan dikaji dengan mengeksperimenkan kesan masa mencelup dalam larutan IZO pada kenaf tanpa tenunan melalui kaedah salutan sederhana. Sampel kenaf langsung dicelup ke dalam larutan zink oksida indium pada lima tempoh masa yang berbeza iaitu 10, 20, 30, 40 dan 50 minit sebelum dikeringkan. Produk akhir indium serat bersalut zink oksida dianalisis berdasarkan kajian morfologi dan elemennya. Dari hasilnya, menunjukkan bahawa salutan IZO dapat digunakan sebagai teknik untuk pemendapan indium zink oksida pada kenaf bukan tenunan sebagai salutan konduktif. Masa mencelupkan optimum untuk salutan adalah 10 minit dan suhu pengeringan ialah 150°C. Kajian ini adalah penting kerana hasil penyelidikan dijangka berpotensi digunakan sebagai bahan pelindung gangguan elektromagnet yang lebih kos efektif. Realisasi kajian ini adalah langkah pertama ke arah penerapan produk berasaskan kenaf dalam industri elektronik.

ABSTRACT

Electromagnetic interference shielding is becoming an important issue as electronic devices become more widely used in our living environments. Traditionally, electromagnetic interference shielding materials have been made mainly from metals due to their good mechanical and electrical properties. However, metals are commonly susceptible to corrosion and high in density and manufacturing cost. The use of surface modified kenaf fiber can solve these problems. The purpose of this study is to characterize kenaf fiber coated with indium zinc oxide (IZO) as a method to increase its electrical conductivity, which is prerequisite for electromagnetic interference shielding application. The coating of IZO film on non-woven kenaf was studied by experimenting the effect of dipping time in IZO solution on non-woven kenaf via simple dip coating method. Kenaf samples were directly dipped into indium zinc oxide solution at five different periods of time that is 10, 20, 30, 40 and 50 minutes before dried and annealed. The final products of indium zinc oxide coated fiber were analyzed based on its morphological and elemental studies. From the results, it shows that the simple dip coating is an applicable technique for deposition indium zinc oxide on non-woven kenaf as a conductive coating. The optimum dipping time for the coating is 10 minutes and the optimum annealing temperature is 150 °C. The study is significant as the research output is expected to be potentially used as a more sustainable, low weight and cost-effective, electromagnetic interference shielding material. Realization of this study is the first step towards the application of kenaf-based products in the electronics industry.

DEDICATION

To my beloved parents Rozali Bin Ibrahim and Faridah Binti Mohd

To my siblings Fatin Nabilah binti Rozali, Muhammad Fakhrul Izzuddin bin Rozali, Muhammad Farhan bin Rozali, Fatin Nur Izzati binti Rozali and Muhammad Faris Haziq bin Rozali

To all my friends, lecturers and supervisor

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LIST OF ABBREVIATIONS

Al	-	Aluminium
AZO	-	Aluminium Zinc Oxide
EDS	-	Energy dispersive x-ray spectroscopy
EMI	-	Electromagnetic interference
Ga	-	Gallium
ITO	-	Indium Tin Oxide
IZO	-	Indium Zinc Oxide
LKTN	-	Lembaga Kenaf dan Tembakau Negara
NaOH	-	Sodium Hydroxide
SEM	-	Scanning electron microscope
TCO	-	Transparent conducting oxide
TZO	-	Titanium Zinc Oxide
ZnO	-	Zinc Oxide

LIST OF SYMBOLS

%	-	Percentage
° C	-	Degree Celsius
at %	-	Atomic Percentage
cm	-	Centimeter
g	-	Gram
g/cm	-	Gram per cubic centimeter
Gpa	-	Giga Pascal
MPa	-	Megapascal
wt %	-	Weight Percentage
Ω/sq	-	Ohm per square

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Electromagnetic interference (EMI) is a spurious electromagnetic energy that pollutes the local environment around a noise-creating source such as power converters. EMI is a distortion on an AC or DC line sent through the conductive path of a circuit. When the region of an electromagnetic field is in the radio frequency range with another electronic gadget, the EMI interruption occurs. EMI fields can be produced by direct and high-powered wireless transmitter which can irritate the operation of electronic nearby. All the electronic hardware must work with a decent electrical ground framework to avoid problems that occur because of EMI. Particular segments, for example, line channels, capacitors, and inductors can be introduced in control strings and interconnecting links to decrease the EMI of a few frameworks.

Sometimes the circuit design is not adequate to protect against excessive levels of electromagnetic radiation from the hardware or influencing the gear. Electromagnetic shielding is an alternative that is normally utilized as a part of these cases. Electromagnetic radiation is a wave. The electromagnetic shielding can block the wave if planned appropriately. This electromagnetic shield can work in the two headings, blocking outflows from the hardware and blocking electromagnetic radiation that may influence the unit. Generally, current EMI shielding is known to be made mainly from metal, which is known to have good mechanical and electrical properties. However, metal is commonly susceptible to corrosion issue, high density and high manufacturing cost. Incorporation of adapting natural fiber as a conducting material can increase the electrical conductivity and enables its application as EMI shielding material.

Over the last few years in the manufacturing industry, there has been an interested demand for product based on natural fiber in the various application including electrical application. Natural fiber or plant fiber is a non-conductive material. The idea of adapting natural fiber as the conductive material has led to the development of natural fiber conductive material in various application such as electromagnetic interference shielding material. As highlighted by A. Shalwan et al. (2013) natural fiber has good properties in term of its relatively low weight, low cost, less damage to processing equipment and good weight-strength property. Hence, in the response to this demand, researchers had come with various techniques to integrate conductive element into a natural fiber material and the most popular technique is conductive coating technique. Dip coating process is one of the most economical and simplest techniques that is applied in many industries as a way to deposit or coat any substrate including a metal, polymer, ceramic and fibrous materials. As quoted by X. Tang et al. (2016) for fibrous material, dip coating process can be performed by several different methods including solution dip coating, sol-gel dip coating, spin-assisted dip coating, multi-layer dip coating and vacuum assisted dip coating.

Consequently, the main effort of the research is to come out with an improved way of constructing cheapest, easier manufacturing process and gives great properties for EMI shielding application with optimum characteristics. The idea of using natural fiber for EMI shielding application is expected to upshot most reliable and efficient product

1.2 Problem Statement

This research is aiming at improving the properties of traditional manufacturing of EMI shielding. Hence, the EMI shielding will be made of natural fiber material to overcome several weaknesses of present EMI shielding application. Electromagnetic interference (EMI) shielding is becoming a more important issue as electronic devices become more widely used in our living environments as well as in industrial and medical fields. Traditionally, EMI shielding materials have been made mainly from metal, which is known to have good mechanical and electrical properties. However, metal is commonly susceptible to corrosion issue, high density and high manufacturing cost. Natural fibers offer various advantages such as lightweight, non-corrosive and sustainable. However, natural fibers are intrinsically electrically non-conductive. In order to be used as EMI shielding, a material requires a certain degree of electrical conductivity. The coating is a method that can be applied to increase the electrical conductivity of natural fiber.

Indium zinc oxide (IZO) coating is preferred to be one of the methods to improve the electrical conductivity of kenaf fiber. IZO coating is chosen because compared to commonly used indium tin oxide (ITO), it is non-toxic and lowers material cost due to reduced indium content (Minami, 2008). Besides, indium zinc oxide is seen as compatible with natural fiber due to the low processing temperature that makes it suitable for low degradation temperature of kenaf.

Therefore, this research intends to study the feasibility of the IZO coating on natural fiber as to improve the electrical conductivity. The characterization of the IZO deposited on kenaf also is performed via SEM and EDS analyses. In order to analyze the characterization of the IZO coating, several parameters are used. Besides, the effects of immersion time and annealing temperature on the coating properties are also investigated. The utilization of natural fiber as a potential EMI shielding material is expected to overcome the weakness in production by providing cheaper, more sustainable and easy to manufacture the material.

1.3 Objectives

The purpose of this research are:

a) To study the viability of simple dip coating of indium zinc oxide solution on kenaf non-woven mat.

b) To investigate the effect of dipping time on morphological, physical and electrical properties of indium zinc oxide modified kenaf.

c) To examine the effect of annealing temperature on physical properties of indium zinc oxide modified kenaf.

1.4 Scope of Research

The research scopes are:

a) Preparation of IZO solution and fiber treatment of kenaf non-woven.

b) Coating of IZO onto kenaf non-woven via simple dip coating method.

c) Varying the coating parameters such as dipping time and annealing temperature.

d) Study of the morphology of the coated kenaf using scanning electron microscopy (SEM).

e) Study of the weight increase measurement of the coated kenaf fiber.

f) Study of the electrical conductivity measurement using LCR meter.

g) Elemental study of indium zinc oxide coating on kenaf fiber using EDS.

1.5 Thesis Frame

Overall, this thesis consists of five main chapters. Chapter 1 contains the overview of the whole research, objectives, scopes and problem statement. Next in chapter 2, the previous researchers related to this topic are explained including the natural fiber, transparent conductive oxide coating, indium zinc oxide coating, dip coating process, EMI shielding mechanism and EMI shielding material. Chapter 3 provides the methodology of the research involving sample preparation techniques, materials, and testing. While in Chapter 4, all the results and data are compiled to be analyzed where discussion of the result is performed in this section. At this state, all the testing results are discussed while referring to the objectives of the research. Last but not least, is Chapter 5, which contains the final conclusion of the study and recommendation of overall research.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this chapter, further reviews about the component of this research will be discussed and studied based on the associated research in order to answer the objectives of this research. Natural fiber or plant is a non-conductive material. Its broad potential usage has drawn much attention amongst in various application including electrical application. The idea of adapting natural fiber as the conductive material has led to the development of natural fiber conductive material in various application. Throughout this literature review, the elements of producing the natural fiber as a conductive material for EMI shielding application will be exposed in detail which includes the raw material, process, and testing. In addition, the major factors controlling the performance of the coating were briefly described and will be focused in an effort to gain the optimum properties for the coating.

2.2 Natural fiber

In recent years, scientists and engineers have turned over the interest on utilizing plant fibers as effectively and economically as possible. There are many types of natural fibers that have been investigated for their use in polymer such as wood fiber (Maldas et al 1995), sisal (Joseph et al 1999), kenaf (Rowell et al 1999), pineapple (Mishra et al 2001), jute (Mohanty et al 2006), banana (Pothan et al 2003) and straw (Kamel 2004). Natural fibers are derived from plants, animals and mineral source and can be classified according to their origin as shown in Figure 2.1.

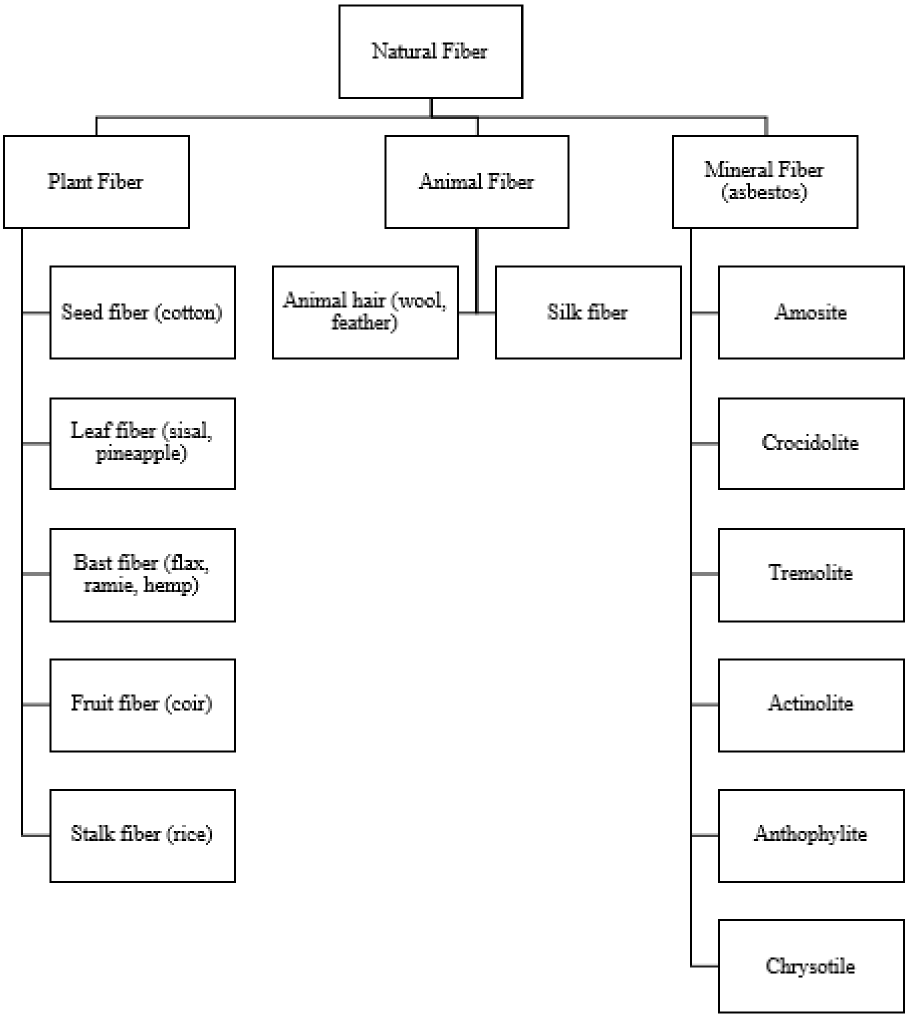

Figure 2.1: Classification of natural fibers (Mohini S. et al 2011).

2.2.1 Types of Natural fiber

These natural fibers can be split up into two categories, leaf fibers, and bast fibers. Most of the fiber is a bast fiber including kenaf fiber, Zampaloni et al., (2007). Table 2.1 shows the most used natural fibers common, scientific and family also their native region and uses.

Table 2.1: Fibers and their types, family and scientific names, Zampaloni et al., (2007)

Common Name	Scientific Name	Fiber	Family	Native Region	Uses
Flax	Linum usitatissimum	Bast (stem)	Linaceae	Eurasia	Linen fabrics, seed oil
Ramie	Boehmeria nivea	Bast (stem)	Urticaceae	Tropical Asia	Textiles (blended with cotton), paper, cordage
Hemp	Cannabis sativa	Bast (stem)	Cannabaceae	Eurasia	Cordage, nets, paper
Jute	Corchorus capsularis, Corchorus olitorius	Bast (stem)	Tiliaceae	Eurasia	Cordage, burlap bagging
Kenaf	Hibiscus cannabinus	Bast (stem)	Malvaceae	Africa, India	Paper, cordage, bagging, seed oil
Sun hemp	Crotalaria juncea	Bast (stem)	Fabaceae	Central Asia	Cordage, high-grade paper, fire hoses, sandals
Urena	Urena lobata, Urena sinuata	Bast (stem)	Malvaceae	China	Paper, bagging, cordage, upholstery
Sisal	Agave sisalana	Hard (leaf)	Agavaceae	Mexico	Cordage, bagging, coarse fabrics
Abacá	Musa textilis	Hard (leaf)	Musaceae	Philippines	Marine cordage, paper, mats
Kapok	Ceiba pentandra	Fruit trichome	Bombacaceae	Pantropical	Upholstery padding, flotation devices

2.2.2 Properties of Natural Fiber

According to a study done by Joseph et al 1999, Khandal et al 2011 and Kuchinda et al 2001 the properties of natural fibers depend mainly on the age of the plant, locality in which it is grown, the extraction method use and the nature of the plant. Also stated by Idicula et al 2005 the physical properties of natural fibers determined by their physical and chemical composition such as the degree of polymerization, the structure of fibers, the angle of fibrils, cellulose content and the structure of the fibers. Tables 2.2 and 2.3 show the mechanical properties and the chemical compositions of some of the natural fibers respectively.

Table 2.2: Mechanical properties of some natural fiber, P.Wambua et al., (2003)

Properties	Jute	Coir	Sisal	Cotton	Hemp	Ramie	Flax	Kenaf
Tensile Strength (MPa)	400-800	220	600-700	400	550-900	500	800-1500	283-800
Moisture absorption (%)	12	10	11	8-25	8	12-17	7	-
Specific (E/d)	7-21	5	29	8	47	29	26-46	-
E-Modulus (Gpa)	10-30	6	38	12	70	44	60-80	21-60
Elongation at failure (%)	1.8	15-25	2-3	3-10	1.6	2	1.2-1.6	1.6