UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON SUPERHYDROPHOBIC SURFACE OF GREEN MAGNETIC SHEET FROM DURIAN SHELL USING LUMEN LOADING TECHNIQUE

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

by

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DECLARATION

I hereby, declared this report entitled 'Study on Superhydrophobic Surface of Green Magnetic Composite Sheet from Durian Shell Using Lumen Loading Technique' is the results of my own research except as cited in references.

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the Degree of Manufacturing Engineering (Engineering Materials) (Hons.). The members of the supervisory committee are as follows:

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ABSTRAK

Industri pembuatan kertas pada masa kini kebanyakannya diperbuat daripada kayu lembut dan kayu keras dan ianya menjurus kepada kekurangan sumber utama hutan. Satu penyelesaian alternatif telah diperkembangkan di mana bahan buangan daripada sumber semulajadi seperti kulit durian digunakan sebagai bahan mentah utama dalam membuat pelbagai jenis gred kertas. Penyelesaian ini berpotensi dalam menghasilkan produk biodegradasi yang lebih mudah terurai dan mesra alam. Walaubagaimanapun, ciri-ciri kertas yang sedia ada iaitu sifat mudah menyerap air dan sifat mekanikal yang lemah menyebabkan kertas tersebut mempunyai kualiti rendah dan terhad penggunaannya. Oleh itu, dalam kajian ini, kulit durian telah dipilih sebagai bahan utama untuk tujuan membuat kepingan permukaan kertas magnet kalis air. Tiga teknik untuk menghasilkan permukaan kalis air iaitu salutan celup dengan asid stearik, polimer pengadunan melalui teknik perpecahan, dan lapisan celup penyelesaian campuran yang terdiri daripada ubahsuai zarah silika dan polistirena (PS) emulsi akan diaplikasikan ke atas kertas magnet. Kemudian, kepingan kertas magnet tersebut dianalisiskan bedasarkan morfologi dan tahap penyerapan air. Teknik terbaik telah dipilih untuk menghasilkan permukaan kalis air kepingan kertas magnet iaitu salutan celup dengan asid stearik kerana pencapaian sudut air bersentuhan sangat tinggi dan melebihi 150^{o}, dengan penerimaan nilai ciri mekanikal dari segi ujian tegangan (4.7133 Nm/g) dan koyakan (3.0476 $m.Nm^2/g$). Dengan terhasilnya kepingan kertas magnet kalis air, kajian ini akan menyumbang kepada aplikasi kertas dinding yang mempunyai kebolehan serapan tenaga gelombang bunyi serta kelebihan ciri-ciri penolakan air. Oleh itu, kepingan kertas dinding kalis air tersebut boleh digunakan dalam pelbagai jenis persekitaran termasuk persekitaran lembap dan sekaligus menjadi produk mesra alam yang mengurangkan kesan persekitaran berbahaya kepada generasi akan datang.

ABSTRACT

The papermaking industry nowadays mainly made from softwood and hardwood causes many trees are cut down and tends to lose a main resource of forest. An alternative solution is made by using the biomass waste from natural resources like durian shell is used as the raw material in producing variety type grades of paper. This alternative way has potential in producing a biodegradable product that can easily decompose and contribute to the sustainable development. However, the properties of existing paper that are easily to absorb water, and also low in mechanical properties made the paper has low quality and limited in application. Thus, in this study, durian shell is used as the main raw material with the aim to make a superhydrophobic surface of green magnetic sheet. Three techniques of fabricating superhydrophobic surface which are dip coating using stearic acid, blending polymer via disintegration technique, and drop-coating the mixed solution comprising of modified silica particles and polystyrene (PS) emulsion are applied to the green magnetic sheet. Then, the green magnetic sheets are characterized in term of surface morphology and water absorption. The best potential technique of dip coating using stearic acid has been selected due to the achievement of superhydrophobic water contact angle that exceed 150^{o}, with the acceptable mechanical properties of tensile index (4.7133 Nm/g) and tear index value (3.0476 m.Nm^2/g). By forming superhydrophobic surface of green magnetic sheet, this research contributes in future for the application of wallpaper that has ability to absorb sound or wave energy with the specialty characteristic of waterproof. Thus, the waterproof wallpaper can be used in variety environment, including moist environment and directly act as a sustainable product that minimize environmental impact on the future generation .

DEDICATION

To my beloved parents and family, I have devoted all my effort in order to accomplish Projek Sarjana Muda (PSM) report. The reason why I devote all my effort in this report is because I want my family to know especially my beloved mother and father that I have done my best in order for me to fully fill the bachelor degree program. On top of that, I dedicate this report to my supervisor which has helped me throughout this whole semester to complete my full thesis.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Alum	-	Aluminum Sulphate
CMC	-	Carboxymethylcellulose
DSAC	-	Durian Shell Activated Carbon
Fe_3O_4	-	Magnetite
HP	-	Hydrophobic Paper
IPA	-	Isopropyl Alcohol
KOH	-	Potassium Hydroxide
NaOH	-	Sodium Hydroxide
PE	-	Polyethylene
PEI	-	Polyethylenimine
PP	-	Polypropylene
PS	-	Polystyrene
PS	-	Potassium Stearate
PCC	-	Precipitate Calcium Carbonate
SA	-	Stearic acid
SEM	-	Scanning Electron Microscope
SiO_2	-	Silicon dioxide

SMCA	-	Sodium Monochloroacetate
SHP	-	Superhydrophobic Paper
TEOS	-	Tetraethyl Orthosilicate
TiO_2	-	Titanium dioxide
THF	-	Tetrahydrofuran
UP	-	Untreated Paper
α-Fe_2O_3	-	Hematite
β-FeOOH	-	Ferric Hydroxide
γ-Fe_2O_3	-	Maghemite

CHAPTER 1

INTRODUCTION

This chapter details describe the background, problem statement, objectives, scope of the study, and project potential.

1.1 Background of Study

The green magnetic sheet is one of the composite sheet type which is a flat piece of two or more phase material that can be obtained from two sources which are artificial and natural fiber. The green magnetic sheet that is made from natural fibers such as cellulose fiber, usually has properties of environmentally friendly and good mechanical performances. One of the common applications, from natural fiber composite sheet is paper (Madsen and Gamstedt, 2013). The composite paper was made by mixing the heterogeneous pulp and slag-wool fiber, and can be also added with or without composite addictive. In addition, the composite sheet of paper also can be prepared with high photocatalytic performance that fabricated using natural zeolite (Ko *et al.,* 2009).

Paper is a basic requirement in daily life especially for many types of written communications from letters to bills to advertising medium, receipts, paperwork, documentation, paper money, and also in food packaging industries. The history of paper started when an emperor's eunuch in China known as Ts'ai Lun invented the paper making from bamboo in 105 C.E. The refined process of paper by Ts'ai Lun had been spread widely about 615 papers making to Japan, in the Arab regions

around 750, and reached in Egypt and Morocco in the 10th century (Flowers, 2009). In this new decade, there are several types' grades of paper produced including green magnetic sheet that are developed widely to be produced using magnetic particle materials (Chia *et al.,* 2009). Thus, nowadays papers made more futuristic, flexible, durable, and extremely versatile since the existing on green magnetic sheet have started to be used widely in many applications such as making business cards, military field as the inner layer of the wall, printed sports, sign system, and printed paper.

The green magnetic sheet is prepared with the adding of ferrite into the amorphous area of the pulp fibers. Then, it undergoes processing of lumen loading and in situ synthesis (Chia *et al.,* 2006). As compared to other magnetic material, green magnetic sheet has some incredible properties such as softness, renewable use, and folding resistance (Gao *et al.,* 2014). Pacurariu *et al.,* (2014) used magnetic nanoparticles in making green magnetic sheet by using in situ and lumen loading method. This made the green magnetic sheet to be more super paramagnetic behavior and known as security paper which can be used for printing valuable documents such as banknotes, bank checks, identity cards, and passports.

The properties of green magnetic sheet can be improved by having superhydrophobic behavior. The high tensile strength at high relative humidity condition can be kept by having this superhydrophobic properties and produce resistance to bacterial contamination (Yang and Deng, 2008). In addition, Nurul Izzati *et al.,* (2013) reported that papermaking usually using natural fibers for woody and non-woody. But, the paper made from natural fiber such as kenaf still have disadvantages since the presence of hydrophilic groups such as hydroxyl, carboxyl, and sulfonic group in the cellulosic paper make the rate absorption of water or moisture high.

The specialty durian shell has its own characteristics that suite to be used in green magnetic sheet making. It contains of 9.24 % of moisture content, 4.34 % of ash content, and 6.43 % of fixed carbon. By using the durian shell in making superhydrophobic green magnetic sheet, the waste can be reduced and saving cost (Wilaipon, 2011). Thus, it can reduce the landfill area for disposal and pollution which sustain to the health of environment.

Therefore, in this study, different methods of making the superhydrophobic surface of green magnetic sheet from the durian shell is investigated. The inner part of the white durian shell is taken to be used as raw material. Then, the process of making green magnetic sheet is carried out by using lumen loading technique before three fabrication techniques of superhydrophobic surface is being applied. The techniques are dip coating using stearic acid, blending polymer via disintegration technique, and drop-coating using modified silica particles and polystyrene (PS) emulsion. Lastly, the best potential fabrication of the superhydrophobic surface will be selected based on the material characterization and analysis.

1.2 Problem Statement

The green magnetic sheet used nowadays usually made from natural fiber due to sustainable ability, low cost packaging needed, high biodegradability and renewability. The well-known property of natural fiber is its typical hydrophilic natural materials that form green magnetic sheet to have high water and moisture absorptions. In addition, the hygroscopic properties and low of water vapor barrier in natural fiber made the green magnetic sheet have low mechanical properties. The high hygroscopicity causes the green magnetic sheet to absorb water vapor easily from the environment and loss its valuable mechanical properties. According to Derluyn *et al.,* (2007) the water vapor resistance factor decreases at higher relative humidity for all types composite sheet of paper including green magnetic sheet.

Thus, this current problem needs to be improved by having superhydrophobic property of green magnetic sheet from durian shell. Durian shell is the new improvement to be made since the properties of the durian shell that have good pore distribution for a large amount of magnetic particles to enter into the lumen fibre. Thus, it suite to be used in making green magnetic sheet and in order to increase mechanical property. As to reduce waste and saving cost, durian shell is the most suitable raw material to be used in making green magnetic sheet.

1.3 Objective

There are several objectives of this study:

(a) To use pulp from durian shells waste and combine with magnetic particles to produce green magnetic sheet.

(b) To characterize in terms of surface morphology and water absorption of surface green magnetic sheet after using three techniques to form superhydrophobic surface of green magnetic sheet.

(c) To determine the best potential technique in producing superhydrophobic surface of green magnetic sheet from durian shell and analyse the mechanical properties of the superhydrophobic green magnetic sheet.

1.4 Scope

The study will focus on fabricating of superhydrophobic surface in green magnetic sheet from durian shell. Durian shell will be used as the main raw material to make green magnetic sheet by using lumen loading technique after the soda pulping process. Soda pulping is used in making the paper pulp and ensuring the separation between cellulose and lignin. The green magnetic sheet then is produced through lumen loading whereby the magnetic particles are inserted into the lumen of cellulose fibers. After the magnetic sheet paper formed, three superhydrophobic techniques will be applied in order to screen the best potential method that suite the durian shell. The techniques are dip coating using stearic acid, blending polymer via disintegration technique, and drop coating using modified silica particles and polystyrene (PS) emulsion.

Next, all of the green magnetic sheet after being applied three techniques will be characterized through morphological analysis and water contact angle analysis. Lastly, the mechanical testing will be done on the superhydrophobic surface of green magnetic sheet.