UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF KENAF (Hibiscus cannabinus L.) PAPER IMPREGNATED WITH DIFFERENT FORMULATIONS OF SYNTHETIC WOOD PULP AND POLYACRYLAMIDE

NURUL IZZATI BINTI MOHD ZAWAWI

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By

NURUL IZZATI BINTI MOHD ZAWAWI

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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February 2013

Chairman : Professor Luqman Chuah Abdullah, PhD

Institute : Institute of Tropical Forestry and Forest Products

Kenaf fibre has been identified as an alternative fibre source due to its advantages in terms of physical and mechanical properties. It is found suitable to be utilized in the industry of pulp and papermaking. The goals of the study are to produce water resistant paper by impregnation method and to determine its water resistant, physical and mechanical properties. Effects of polyacrylamide (PAM) addition to the water resistant paper produced are also determined. Important materials used throughout the study are kenaf whole stem, high and low branched of synthetic wood pulp (SWP); low and high molecular weight of PAM. The kenaf fibre was impregnated with SWP in order to create its water resistant character. In the first part of this study, kenaf fibre was impregnated with five different percentage of SWP at 10%,

20%, 30%, 40% and 50%. The second part of this study was carried out to impregnate the SWPs with the addition of PAM as retention aid and dry strength agent. Water resistant, physical and mechanical test were carried out. The results showed that papers with water resistant property were successfully produced. The highest reading of water contact angle obtained was 84.3°. It is also found that a minimum of 20% SWP enough to meet the requirement for Cobb test as referred to Malaysian Standard. Higher amount of SWP was identified to reduce its mechanical properties especially the low branched SWP. Therefore, PAM was added to increase the strength of water resistant produced. Addition of PAM successfully increase water resistant property, however, PAM addition did not increase strength properties of water resistant paper produced. As conclusion, impregnation method is identified applicable to produce such water resistant paper from kenaf fibre provided that the amount and type of SWP are controlled.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

CIRI-CIRI KERTAS KENAF (*Hibiscus cannabinus* L.) DIIMPREGNASI DENGAN FORMULASI PULPA KAYU SINTETIK DAN POLIAKRILAMIDA YANG BERLAINAN

Oleh

NURUL IZZATI BINTI MOHD ZAWAWI

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Gentian kenaf telah dikenalpasti sebagai sumber gentian alternatif kerana kelebihan dari segi ciri fizikal dan mekanikal gentiannya. Kenaf sesuai untuk digunakan di dalam industri pulpa dan pembuatan kertas. Objektif kajian ini adalah untuk menghasilkan kertas kalis air melalui kaedah impregnasi dan untuk mengkaji ciri-ciri kalis air, fizikal dan mekanikal kertas yang dihasilkan. Kesan penambahan poliakrilamida (PAM) kepada kertas kalis air yang dihasilkan juga dikaji. Bahan penting yang digunakan sepanjang kajian adalah batang kenaf, pulpa kayu sintetik (SWP) bercabang dan kurang bercabang dan PAM dengan berat molekul tinggi dan rendah. Gentian kenaf diimpregnasi dengan SWP untuk mewujudkan ciri kalis airnya. Dalam bahagian pertama kajian ini, gentian kenaf telah diimpregnasi dengan lima

peratusan SWP yang berbeza iaitu 10%, 20%, 30%, 40% dan 50%. Bahagian kedua kajian ini dijalankan dengan melakukan impregnasi SWP bersama penambahan PAM sebagai retention aid dan agen penguat kering. Ujian kalis air, fizikal dan mekanikal telah dijalankan. Keputusan menunjukkan kertas kalis air telah berjaya dihasilkan. Bacaan sudut sentuh air (WCA) yang paling tinggi diperoleh adalah 84.3°. Keputusan juga menunjukkan dengan penambahan minima 20% cukup untuk memenuhi piawai yang ditetapkan oleh Piawaian Malaysia. Kandungan SWP yang lebih tinggi dikenalpasti mengurangkan kekuatan mekanikal terutamanya dengan penggunaan SWP kurang bercabang. Penambahan PAM telah berjaya meningkatkan ciri kalis air tetapi tidak meningkatkan kekuatan kertas yang dihasilkan. Kesimpulannya, kaedah impregnasi boleh digunakan untuk menghasilkan kertas kalis air daripada gentian kenaf dengan syarat jumlah dan jenis SWP dikawal.

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This dissertation is dedicated to all with love.

I certify that an Examination Committee has met on **6 February 2013** to conduct the final examination of Nurul Izzati binti Mohd Zawawi on her master **degree** thesis entitled Properties of Kenaf Paper Impregnated with Synthetic Wood Pulp and Polyacrylamide in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I declare that this thesis is my original work except for quotations and citations which have been duly acknowledged. I also, declare that has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

NURUL IZZATI BINTI MOHD ZAWAWI

Date: 6 February 2013

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CFC	Common Funds Commodities
ECER	East Coast Economic Region
G	Gram
H	Hour
HB	Highly branched
HM	High molecular
IJSG	International Jute Study Group
INTROP	Institute of Tropical Forestry and Forest Products
ISO	International Organization for Standardization
LB	Lowly branched
LM	Low molecular
MS	Malaysian Standard
MSA	Methanesulfonic acid
MTIB	Malaysia Timber and Industry Board
NKTB	National Kenaf and Tobacco Berhad
o.d.	Oven-dry
PAM	Polyacrylamide
PGW	Pressure Ground Wood
PRMP	Pressurized Refiner Mechanical Pulping

RMP	Refiner Mechanical Pulp
SEM	Scanning Electron Microscope
SGW	Stone Ground Wood
SWP	Synthetic Wood Pulp
STW	Schwarzwälder Textile-Werke
TAPPI	Technical Association of the Pulp and Paper Industry
TMP	Thermo Mechanical Pulping
UKM	Universiti Kebangsaan Malaysia
UNIDO	United Nations Industrial Development Organisation
UPM	Universiti Putra Malaysia
WCA	Water contact angle

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of study

Paper can be defined in terms of its method of production, as a sheet material made up of a network of natural cellulosic fibres which have been deposited from an aqueous suspension (Roberts, 1996). Paper plays a large role in many applications such as information storage medium, packaging materials, media and communications. This shows that paper is very important in assisting human in daily activities.

Paper is made from cellulosic material and one of its nature characters is hydrophilic which literally means water loving. Absorption of water and moisture reduces physical and mechanical strength of paper products as it caused corruption of fibre and fibre bonding. Hence, many usages of paper products such as paperboard, packaging and specialty papers favour water resistance property to ensure quality, strength and long lasting products (Thawornwiriyanan *et al*., 2009; Zeshan *et al*., 2009).

Water or moisture proof paper can be produced by using impregnation or coating method (Gotoh *et al*., 1977). Generally, coating is performed by

applying a relatively high concentration of a dispersion of a pigment to the surface of a base paper while impregnation method used when additive being added and lies between fibres in paper. Additive used in papermaking for a variety of different reasons during wet formation process to impart specific sheet properties (Roberts, 1996).

The usage of non-wood fibres as raw material for paper products has gained importance due to diminishing forest and limitation on enlarging man made forest, causes shortage of wood fibre supply to industry (Ganapathy, 1997; Velveris *et al*., 2003). Non-wood plants offer several advantages as alternative fibre source including short growth cycles, moderate irrigation and fertilization requirements and low lignin content resulting energy and chemical reducing during pulping process (Hurtur and Riccio, 1998).

Softwood and hardwood have distinct fibre properties which produced different characteristics of paper product. Kenaf can be substitute to both softwood and hardwood due to kenaf has two types of fibre which is bast and core (Ververis *et al*., 2004). Kenaf bast fibre has long fibre, similar to softwood and core has shorter fibre similar to hardwood (Abdul Khalil *et al*., 2010). This characteristic makes kenaf as favourable alternative raw materials for pulp and paper industry.

The first world's commercial kenaf pulp mill was built in 1982 in Khon Kaen, Thailand, and named Phoenix Pulp and Paper Co. Ltd. (Han, 1999). This mill pulped kenaf whole stem, with an annual production capacity over 70,000 tonnes (Leehka & Thapar, 1983). In 1992, Vision Paper mill located in Albuquerque, New Mexico, started using kenaf as their raw material (Rymsza, 2001).

Kenaf has been chosen because of its fast growth which can bring economic benefits to farmers and rural communities. Kenaf utilization will reduce the demand for tree fibre. Therefore, the need to cut trees especially in natural forests will be reduced. Kenaf also consumes fewer amounts of chemical and energy during the pulping process compared to trees. Kenaf absorbs a high amount of carbon dioxide, CO_2, compared to trees, which helps in reducing global warming (Rymsza, 2001).

Kenaf was first brought to Malaysia as an animal feed in a year of 2000. Subsequently in 2004, Malaysia government introduced kenaf as a new alternative crop to tobacco which is in line with promoting a healthy life style. National Tobacco Board (NTB) which was previously responsible for the tobacco industry in Malaysia has been dissolved and re-established as National Kenaf and Tobacco (NKTB) to promote and develop kenaf industry in Malaysia (Datuk Peter Chin Fah Kui, 2009).

Many researches and development project has been carried out and many still undergoing in order to explore and maximize the usage of kenaf plant in Malaysia (Abdul Khalil 2010; Azizi 2010; Alireza 2004; Mohd Noor 2004). Since year 2000, RM48.8 millions was allocated by Malaysia Economic Planning Unit (EPU), focus on kenaf-based research for both upstream and downstream sector (Paridah *et* al., 2010).

Government also put an initial investment of RM35.5 million to four companies under East Coast Economic Region (ECER) on 2008. These four companies will form the anchor company which will work closely with NKTB in developing a collecting, processing, marketing and collection centre (CPMC) for kenaf (Rupa, 2008).

1.2 Problem Statement

With regards to the wood fibre shortage and high price of paper based products, kenaf has the potential as a raw material for producing pulp in Malaysia (Mohd Nor, 1994). Kenaf pulp has its own market niche whether the pulp is made up from bast, core or from whole stem because it can be used for a wide range of paper products. As example, kenaf bast fibre can be used as fibre source to specialty papers like tea bags, filters for oil and air and cigarette paper (Mohd Nor, 2005). Kenaf has become a favourable alternative

source not only due to its fibre properties, but also due shorter harvesting rotation. Further research on kenaf uses need to be conducted to maximize the usage of this potential crop especially in the pulp and paper industry. This research was conducted in order to produce specialty paper namely water resistant paper from kenaf whole stem fibres. Kenaf fibres were impregnated with synthetic wood pulp (SWP) to create hydrophobic properties.

1.3 Research Objective

The ultimate goal of this research is to determine the suitability of kenaf fibre variety V36 cultivated in Malaysia for the production of water resistant paper, a kind of specialty paper. The research objectives are listed as below:

1) To determine the effect of SWP chains on the physical and mechanical properties of the water resistant paper.
2) To investigate the effect of PAM addition on the physical and mechanical properties of the water resistant paper.

1.4 Thesis Outline

This thesis is divided into five chapters. Chapter 1 contains the introduction on the pulp and paper industry worldwide, the usage of kenaf as an alternative source of fibre, problem statement and list of objectives for this research. Chapter 2 presents the literature review related to this research. Chapter 3 is about the materials and methods used throughout the experiments. Chapter 4 shows and discusses the results obtained while chapter 5 presents the conclusion of this research and recommendation for future research.

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