EFFECT OF COUPLING AGENT AND BINDER IN KENAF PAPER ON THE MECHANICAL AND MORPHOLOGICAL PROPERTIES

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In the memory of my Dear father, the hero of my life

To my beloved mother, who always taught me impossible is nothing,

Also to my dear brothers for their supports, encourages and loves

And

Special thanks to my dear aunt, Fataneh who always support me

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ABSTRACT

Insufficient supply of fiber for papermaking has necessitated the paper industry to search for alternative fiber. Kenaf has been identified as one of the potential sources for pulp and paper production. This paper investigated the effect of coupling agent in kenaf paper with respect to mechanical and morphological properties of kenaf bast paper. Facial method is applied to graft starch on kenaf bast fiber surface via the hydrogen bonding formation among the cellulose, tapioca starch, and ammonium zirconium carbonate (AZC). The optimization method was utilized to study the amount of coupling agent (ammonium zirconium carbonate) and binder (tapioca starch), which ranges between 0.5 %, 1%, 1.5%, 2 % for AZC and 2 %, 3 %, 4 %, 5 % for tapioca starch. The mechanical properties of paper sheet have been studied by performing tensile test and determined Young’s modulus and Elongation at break, and tearing resistance test. The morphological properties were observed with respect to the mechanical strength by using the microscope at 100x magnification. The paper sheet produced from pulping with 3% starch and 1 % AZC concentration shows the best properties. Higher concentration of starch and AZC reduced the mechanical and morphological properties of paper due to decreasing the grafting efficiency. It is concluded that this method can be used for papermaking due to increasing the properties of paper but the ratio of binder and coupling agent are important from the low cost point of view.

ABSTRAK

Kekurangan bekalan serat untuk membuat kertas telah mendesak industri kertas untuk mencari serat alternatif. Kenaf telah dikenalpasti sebagai salah satu sumber yang berpotensi untuk pembuatan kertas dan pulpa. Penyelidikan ini telah mengkaji kesan ejen gandingan dalam kertas kenaf berkaitan dengan sifat-sifat mekanikal dan morfologi kertas kulit kenaf. Kaedah muka telah diaplikasikan untuk mencangkuk kanji keatas serat kulit kenaf melalui pembentukan ikatan hidrogen diantara selulosa, kanji ubi kayu, dan AZC. Kaedah pengoptimuman telah digunakan untuk mengkaji jumlah ejen gandingan (ammoniumzirkoniumkarbonat) dan pengikat (kanji ubi kayu), dengan julat diantara 0.5 %, 1%, 1.5%, 2 % untuk AZC dan 2 %, 3 %, 4 %, 5 % untuk kanji ubi kayu. Sifat-sifat mekanikal helaian kertas telah dikaji dengan melaksanakan ujian tensil dan menentukan modulus Young dan pemanjangan pada takat putus, dan ujian ketahanan koyak. Sifat-sifat morfologi telah diperhatikan berkaitan dengan kekuatan mekanikal dengan menggunakan mikroskop pada pembesaran 100x. Helaian kertas yang telah dihasilkan daripada pempulpalan dengan kepekatan kanji 3% dan AZC 1% menunjukkan sifat-sifat yang terbaik. Kepekatan kanji dan AZC yang lebih tinggi telah mengurangkan sifat-sifat mekanikal dan morfologi kertas disebabkan oleh pengurangan keberkesanan cangkukan.Ini dapat disimpulkan bahawa kaedah ini boleh digunakan untuk pembuatan kertas disebabkan peningkatan sifat-sifat kertas tetapi nisbah pengikat dan ejen gandingan adalah penting dilihat dari segi kos murah.

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LIST OF ABBREVIATIONS

CTMP	-	Chemi-thermomechanical pulp
DP	-	Degree of Polymerization
FAO	-	Food and Agriculture Organization of the United Nations
PGW	-	Pressure Ground Wood
RMP	-	Refiner Mechanical Pulp
SGW	-	Stone Ground Wood Pulp
TMP	-	Thermo Mechanical Pulp
AZC	-	Ammonium zirconium carbonate

LIST OF SYMBOLS

cm	-	centimeter
g	-	gram
h	-	hour
k	-	kilogram
mins	-	minutes
mm	-	milimeter
m	-	meter
MJ	-	Mega Joule
rmp	-	revolution per minute
µm	-	micrometer
α	-	alpha
β	-	beta
%	-	percentage
˚C	-	Degree celsius
gf	-	Gram force

CHAPTER 1

INTRODUCTION

1.1 Research Background

The benefit of paper and paper product in our lifestyle is undeniable. In fact, for producing paper, vast quantities of trees consumption are required. Additionally, the wood is the raw material in pulp and paper production so pulp and paper industry has historically been considered as a major consumer of natural resources (wood). However, the demands of paper, a growing environmental awareness throughout the world and the unacceptable large ecological ways of paper production have triggered a pattern shift toward designing papers that are compatible with environment.

According to statistics announced by FAO (The United Nation Food and Agricultural Organization) consumption of paper in the world in 1913 was 14 million tons. Also in 1950 it was 40 million tons it means three times greater than thirty seven years later [1]. Moreover in 1988 production of paper was 226 million tons, average rate of growing paper and pulp in the world was 4.7 % between 1950 and 1988. FAO estimated that demand of pulp and paper by the year 2010 will raise to 620 million tones also the world paper and paperboard consumption will be grown from 210 Mt/year in 1988 to about 350 Mt/year in 2010 by the FAO [1]. Due to the increasing consumption of wood resource in paper production, finding the non-wood raw materials in papermaking industry has been given more attention. Non-wood plant is one of the alternatives for pulp and paper utilizing. It growth rapid, plenty in environment, good processing and has a good properties.

Non-wood fibers are non-woody cellulosic plant materials. They are conventionally classified as follows [2]:

Long or multiple-celled fibres

a. Soft or bast fibres: These are the soft and flexible fibres extending through the inner bark of stems or main stalks of dicotyledonous plants including jute, ramie, kenaf, roselle, sunn hemp, industrial hemp, and flex.

b. Hard or leaf fibres: These are characteristically hard and stiff in texture and extend lengthwise through the pulpy tissues of long leaf or leaf stems of monocotyledonous plants including sisal, henequen, pineapple, and abaca.

c. Miscellaneous fibres: These include minor fibres obtained from roots, stems, and seeds, like coir.

Short or one-celled fibres

These include the seed hairs or hairs produced inside the seedpods, like cotton and kapok [3].

According to above classification one of the non wood plant sources is kenaf *(Hibiscus cannabinus)* which refer to first category. Kenaf is an important cellulosic source that growth annually and it useful in different industries like paper making. Utilization of kenaf fiber as alternative pulp mill considerably enhance because of its lignocellulosic characteristic. Advantages of using kenaf fiber are economical and ecological, it means biodegradability and diminishes environmental problem, It has renewable resources, also become mature in 6 mounts, moreover paper which produce with kenaf fiber have good pulping characteristics and high strength properties [4].

Therefore, this research was devoted to the study of the effect of grafting on the physical, mechanical and morphological properties of the paper, and optimized grafting condition.

1.2 Problem Statements

Producing paper require vast of trees consumption, so it cause depleting the forest and damaging environment. Therefore study on pulp-paper has shifted to find alternative sources for environment preservation. The best alternative is non-wood fibers such as bamboo, pineapple, juts and kenaf, because they have agricultural sources, variety and in abundance which are available for pulp-paper. Kenaf is one of the alternatives that can use as cellulose fiber. By using kenaf fiber as alternative offer advantages, such as reduced environmental problem, low price, biodegradability of paper that produced and high strength paper. In this regard this research attempt to focus this study on using kenaf as alternative natural fiber to produce paper with improve quality by modifying the method of synthesis.

Paper is a sheet of material which contains bonded small discrete fibers. The nature of these fibers is usually cellulose and secondary bond held them together; most likely this secondary bond is hydrogen bond. The fibers are formed into a sheet on a fine screen from a dilute water suspension. Cellulose that use in paper manufacturing has different sources as like as hard wood, soft wood and non wood plants. In addition to the large number of wood types, there are many different manufacturing processes involved in the conversion of wood to pulp. These range from mechanical processes, by which only mechanical energy is used to separate the fiber from the wood matrix, to chemical processes, by which the bonding material, ie, lignin is chemically removed. Moreover combinations of both chemical and mechanical methods can be employed to obtain pulp. One of the aspects of paper production is modification of paper to improve the properties. There are different ways to modify paper, like using binder as like as starch

[5] to improve adhesion between cellulose fibers and also if by adding additive such as pigment. Moreover paper manufactures have used grafted starch as binder utilizing free radical copolymerization but has not yet been commercially successful [6].

Common methods of grafting like free radical copolymerization have disadvantages like purification of the product because of the grafted homopolymer, long reaction time, environmental concerns, rigorous reaction condition and high cost of this kind of reaction [7]. Therefore the purpose of this research is to produce paper by using coupling agent through grafting of starch technique onto kenaf and optimizing the paper properties and qualities. Few questions arise from this research:

1) Does grafting of starch on to kenaf using coupling agents enhance the mechanical properties of paper?

2) Does grafting increase the physical properties of paper?

3) What is the morphology of paper?

1.3 Objectives of the Study

The main objective of this research is to produce kenaf paper via grafting technique, optimize grafting method by using different amount of coupling agent (AZC) and binder (starch), and investigating its properties.

Other objective of this research can be divided into:

1. To study the effect of coupling agent and binder in the mechanical properties of paper based on tensile strength.

2. To determine the effect coupling agent and binder on physical properties of paper based on tearing test of paper.

3. To characterize the morphological properties of paper.

1.4 The Scope of Study

The scope of study can be classified to:

1. Kenaf paper preparation

Kenaf was used as fiber which involved the fallowing stages:

a) Pulping process that includes: Grinding which grind the kenaf bast fibers to 2 mm length, pulping, washing. drying and follows by grafting to modify paper.

b) Moulding: In square wooden mould

c) Drying Process

i) The paper will be dry in an oven for 80˚C

ii) The duration of drying process is 5-8 hours

d) Compression molding to obtain uniform paper.

2. Characterization of kenaf bast paper

a) Fourier Transform Infra Red (FTIR) to study interaction of materials

b) Tearing test to determine tearing strength of paper

c) Tensile test to investigate the tensile strength of paper

d) SEM to study the morphology of component

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