Faculty of Manufacturing Engineering

THE EFFECT OF ALKALIZATION TREATMENT ON THE MECHANICAL PROPERTIES AND WATER ABSORPTION OF KENAF/POLYESTER BIOCOMPOSITES

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DECLARATION

I declare that this thesis entitled "The Effect of Alkalization Treatment on The Mechanical Properties and Water Absorption of Kenaf/Polyester Biocomposites" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….....

Name : PHONGSAKORN A/L PRAK TOM

Date : …….

DEDICATION

To my beloved family

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LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile Butadiene Styrene
AC	-	Acidic Chloride
AO	-	Ammonium Oxelate
ASTM	-	American Society for Testing of Materials
CCC	-	Carbon/carbon Composite
CMC	-	Ceramic Matrix Composite
FTIR	-	Fourier Transform Infra Red
FRP	-	Fiber Reinforced Polymer
GPa	-	Giga Pascal
hr	-	Hour
kGy	-	Kilogray
kJ	-	Kilo Joule
LDPE	-	Low-density Polyethylene
MAPP	-	Maleic Anhydride Grafted Polypropylene
MARDI	-	Malaysia Research and Development Institute
MEKP	-	Methyl Ethyl Ketone Peroxide
mm	-	Millimeter
MMC	-	Metal Matrix Composite
MPa	-	Mega Pascal
N	-	Newton

NaOH	-	Sodium Hydroxide
PET	-	Polyethylene Terephthalate
PHB	-	Polyhydroxybutyrate
PLLA	-	Poly-L-lactic Acid
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
RFI	-	Resin Film Infusion
RIP	-	Resin Infusion Process
RTM	-	Resin Transfer Molding
sec	-	Second
SEM	-	Scanning Electron Microscopy
UTM	-	Universal Testing Machine
VIP	-	Vacuum Infusion Process
WAXS	-	Wide-angle X-ray Scattering

LIST OF SYMBOLS

b	-	Width of the sample
$dS/d\varepsilon$	-	Slope of the stress versus strain curve
E_{abs}	-	Energy absorbed during impact
E_I	-	Initial Energy
E_k	-	Kinetic Energy
E_p	-	Potential Energy
E_r	-	Energy after rupture
E	-	Young's Modulus
E_b	-	Flexural Modulus
E_t	-	Young's Modulus in tension
g	-	Gravity
h	-	Height or thickness of the sample
L	-	Length of the sample
l_o	-	Initial gage length
m	-	Initial slope of the load versus deflection curve
P	-	Load
S	-	Stress
V	-	Velocity
W_a	-	Initial Work
W_b	-	Work after rapture

%	-	Percentage
Δl	-	Extension

ABSTRACT

Bio-composite is a material formed by resin as a matrix and a reinforcement of natural fiber. The objectives of this research are to determine the effect of chemical treatment on mechanical properties and water absorption of bio-composite kenaf fiber. The long bast kenaf fibers were treated by chemical method using sodium hydroxide (NaOH) to improve properties of fiber. The effects of the modification on fibers have been analyzed using scanning electron microscopy (SEM). Morphological analyses proved that natrium hydroxide have effective to remove impurities on the fiber surface. By using vacuum infusion process (VIP), the bio-composite kenaf fibers panel is produced. Vacuum infusion method offers benefits over hand lay-up method, which was higher fiber to resin ratio and whilst stronger composites. In this research, mechanical tests were performed to evaluate the effect of chemical treatment on the mechanical properties of bio-composite kenaf fiber. It has been found that the alkalization treatment has improved the mechanical properties of the composites. The mechanical properties of kenaf/polyester composites were found increase with increasing of NaOH concentration. Otherwise, it decrease when immerse time is up from 12 to 24 hours. The tensile and flexural strengths were achieved as high as 90.81MPa and 93.35MPa, respectively. In spite of its high tensile and flexural properties, kenaf polyester composites treated with 9% NaOH for 12 hours demonstrated relatively low impact strength. As better impact properties are demonstrated by higher failure value, it is believed that too high concentration of NaOH possibly low failure value. The ability of water absorption among the composite also have been analyzed in this study.

The percentage of moisture uptake proven that fiber treatment have positive affected on the water absorption of the composites. Lastly, it has been summarize that chemical treatment on kenaf fibers as well as manufacturing process played important role to fabricate a good mechanical properties of composites.

ABSTRAK

Bio-komposit merupakan bahan yang terbentuk daripada campuran antara resin sebagai matrik dan gentian semula jadi. Objektif kajian ini adalah untuk mengenalpasti kesan rawatan kimia gentian kenaf terhadap sifat mekanikal dan penyerapan air komposit bio gentian kenaf. Gentian kulit kenaf panjang dirawat dengan rawatan kimia menggunakan *natrium hydroxide* (NaOH) untuk meningkatkan tahap kecekapan gentian. Kesan rawatan kimia gentian kenaf dianalisis menggunakan *Scanning Electron Microscopy* (SEM). Analisis morfologi membuktikan bahawa rawatan menggunakan *natrium hydroxide* berjaya membersihkan bendasing pada permukaan gentian kenaf. Dengan menggunakan proses *vacuum infusion* (VIP), kepingan komposit gentian kenaf dihasilkan. Kelebihan proses *vacuum infusion* berbanding kaedah *hand lay-up* ialah ia menghasilkan komposit dengan nisbah gentian kepada resin yang lebih baik dan lebih kuat. Dalam penyelidikan ini, ujian mekanikal dijalankan untuk mengkaji kesan rawatan kimia gentian kenaf terhadap sifat mekanikal komposit gentian kenaf. Didapati bahawa rawatan alkali yang dijalankan dapat meningkatkan sifat mekanikal komposit. Sifat mekanikal komposit gentian kenaf didapati meningkat apabila kepekatan NaOH meningkat. Sebaliknya ia menurun dengan peningkatan masa rendaman gentian kenaf daripada 12 jam kepada 24 jam. Kekuatan tegangan dan lenturan mencapai tahap tertinggi masing-masing pada 90.81MPa dan 93.35MPa. Disebalik sifat ketegangan dan kelenturan yang tinggi, komposit gentian kenaf yang dirawat dengan 9% kepekatan NaOH dan rendaman 12 jam menunjukkan kekuatan hentaman yang rendah. Dengan sifat hentaman yang baik

menunjukkan nilai kebolehan patah yang tinggi, ia dipercayai bahawa kepekatan NaOH yang terlalu tinggi menyebabkan nilai kebolehan patah menjadi rendah. Kemampuan penyerapan air di antara komposit juga telah dianalisis dalam kajian ini. Peratusan kelembapan penyerapan telah membuktikan bahawa rawatan terhadap gentian kenaf juga memberi kesan positif dalam penyerapan air oleh komposit. Akhirnya, dapat dirumuskan bahawa rawatan kimia terhadap gentian kenaf serta proses pembuatan memainkan peranan yang penting dalam menghasilkan komposit dengan sifat mekanikal yang baik.

CHAPTER 1

INTRODUCTION

1.0 Background

Kenaf is a warm annual crop. It is a member of hibiscus family (Hibiscus cannnabinus L.) and related to cotton and jute. Kenaf is originally native in Africa. For the last 200 years, India has produced and used kenaf. In the United States, kenaf was introduced as material for the war effort during World War II. Then in 1950s, the US researchers have found that kenaf was an excellent cellulose fiber source for pulping of paper products (Webber et. al., 2002).

Kenaf plant is growing to more than 3 meters tall within 4-5 month. The stems are 2.5-3.5cm diameter and consisting of two parts, an outer fibrous bark and an inner woody core (Zhang, 2003). Raw kenaf fiber obtained from the outer fibrous bark is a bundle of lignocelluloses fibers. The core is the spongy tissue inner the bark of the plant. Figure 1.1, 1.2 and 1.3 shows the kenaf plant and its intersection.

(a) (b)

Figure 1.1 (a) Young kenaf plant and (b) adult kenaf plant

(a) (b)

Figure 1.2 (a) Kenaf flower and (b) leave

(a) (b)

Figure 1.3 (a) Kenaf bast and (b) core

Kenaf has been used to produce twine, rope and sackcloth for thousands of years (Webber, 2002). Because of its biodegradability and environmental protection, the usage of kenaf has increased recently. It has found more application. In some countries, kenaf is used as the substitute for wood to produce pulp and paper. Nowadays, there are various new applications for kenaf including automotive industry, packaging, building materials, absorbents and animal feeds (Zhang, 2003).

1.1 Statement of the Purpose

The purpose of the research is to investigate the effect of fiber treatment on the mechanical properties such as tensile, flexural and impact properties and water absorption of kenaf/polyester composite.

1.2 Hypotheses

i. Increasing either the concentration of NaOH or treatment time will affect the kenaf fiber properties.

ii. Varying the manufacturing method will affect the mechanical properties of composite.