UNIVERSITI PUTRA MALAYSIA

FIBRE REINFORCED PLASTIC COMPOSITES: KENAF (HIBUSCUS CANNABUNUSL.) FIBRE- POLYPROPYLENE BLEND

TAN KHIM SEONG

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By

TAN KHIM SEONG

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Chairman: Jalaluddin Harun, Ph.D.

Faculty: Forestry

This study aimed to evaluate the chemical compositions, analytical and Mechanical properties of Kenaf (Hibiscus cannabinus, L.) fibres blended with polypropylene at various fibre loading and fibre length. The effects of electron beam irradiation at dose 10 kGray and 1% maleated polypropylene (MAPP) on this composite were also investigated.

Kenaf stalks with the age of 4 months obtained from MARDI, Serdamg were defibrated with two types of processing method, namely wet atmospheric pressurized refiner mechanical pulping (RMP) and dry hammermill process. The fibres and particles from these two processes were oven dried and screened into three different sizes: 1-2 mm, 0.5- 1 mm, and <0.5 mm.

Fibres with length between 0.5- 1 mm were used for chemical analysis process. Results showed that kenaf fibre has higher cellulose and lower lignin content than rubber wood fibre. The ash content of kenaf fibre was also lower than empty fruit brunch.

Fibres with different sizes were then blended with various fibre loadings (0%, 20%, 30%, 40%, and 50%) by means of Brabender Plasti Corder PL2000-6. All mixing were done for 12.5 minutes at temperature of 180 ^{0}C and rotor speed of 40 rpm. The compounded samples were then hot pressed into test samples for various analytical and mechanical assessments such as specific gravity, water absorption, thickness swelling, tensile strength, tensile modulus, flexural strength, flexural modulus, notched izod impact strength, and Rockwell hardness, in accordance with ASTM and British standards.

. Overall, as fibre loading for every fibre length category increases properties such as specific gravity, water absorption, thickness swelling, tensile modulus, flexural modulus, and notched izod impact strength were also increased. However, properties such as tensile strength, flexural strength, and Rockwell hardness decreased. The results showed that kenaf fibre produced from RMP showed better analytical and mechanical properties at the same fibre loading and fibre length category than hammermill fibre

An introduction of irradiation process was found to increase more of the analytical and mechanical properties of kenaf fibre blended with polypropylene. Composite with the composition of irradiated polypropylene and unirradiated kenaf fibre showed favourable properties compare to other composition such as irradiated polypropylene with irradiated fibre, irradiated fibre with unirradiated polypropylene, and unirradiated fibre with unirradiated polypropylene.

However, composite with the addition of 1% MAPP produces the best analytical and mechanical properties compare to other unirradiated and irradiated samples except for flexural modulus property.

Lastly, all evaluations are statistically analysed at 5% level of significance. Supportive photographic evidences of the above results are shown by Scanning Electron Micrographs.

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

KOMPOSIT GABUNGAN PLASTIK DAN GENTIAN: GENTIAN KENAF (*HIBUSCUS CANNABICUS* L)- POLIPROPILENA

Oleh

TAN KHIM SEONG

Mac 2002

Pengerusu: Jalaluddin Harun, Ph.D.

Fakulti: Perhutanan

Penyelidikan ini bertujuan untuk menilai komposisi kimia, sifat-sifat analitikal dan mekanikal gentian kenaf (***Hibiscus cannabicus***, L) dengan polipropelena dalam pelbagai komposisi dan saiz gentian. Kesan alur electron pada 10 kGray dan kehadiran 1% maleated polipropilena (MAPP) ke atas komposit in juga dikaji.

Batang kenaf yang berumur 4 bulan diperolehi dari MARDI, Serdang dicarikkan kepada gentian melalui dua kaedah memproses iaitu pengecil nekanikal pulpa bertekanan atmosfera basah (RMP) dan proses pengisar tukul. Gentian daripada dua proses in dikeringkan dan ditapis kepada tiga jenis kepanjangan iaitu: 1-2 mm, 0.5-1 mm, dan <0.5 mm.

Gentian dengan kepanjangan 0.5-1 mm diginakan untuik proses analisis komponen kimia. Keputusan menunjukkan kenaf gentian mempunyai kandungan selulosa yang lebih tinggi dan kandungan lignin yang rendah berbanding dengan

gentian kayu getah. Kandungan serbuk yang lebih tinggi berbanding dengan gentian buah kelapa sawit.

Gentian dengan kepanjangan masing-masing kemudiannya diadunkan dengan polipropilena dalam pelbagai komposisi (0%, 20%, 30%, 40%, dan 50%) dengan menggunakan mesin Brabender Plastic Corder PL2000-6. Kesemua process adunan dijalankan dengan masa adunan selama 12.5 minit pada suhu 180 ^{0}C dengan kelajuan pemutar pada 40 rpm. Kesemua kompaun adunan kemudiannya ditekan untuk membentuk sampel ujian untuk mendapatkan pelbagai maklumat analitikal dan mekanikal seperti ketumpatan bandingan, kadar penyerapan air, kadar ketebalan, kekuatan ketegangan, modulus ketegangan, kekuatan lenturan, modulus lenturan, ketahanan hentaman Izod dengan lekuk, dan kekerasan Rockwell mengikut piawaian ASTM dan British.

Secara umum, apabila komposisi gentian bertambah pada setiap kategori kepanjangan gentian, sifat-sifat seperti ketumpatan bandingan, kadar penyerapan air, kadar ketebalan, modulus ketegangan, modulus lenturan, dan ketahanan hentaman Izod dengan lekuk juga akan bertambah. Walaubagaimanapun, sifat-sifat seperti kekuatan ketegangan, kekuatan lenturan, dan kekerasan Rockwell didapati menurun. Keputusan yang diperolehi menunjukkan gentian kenaf yang diperolehi melalui RMP mempunyai kesemua sifat analitikal dan mekanikal yang lebih baik berbanding dengan gentian 'hammermill' pada setiap komposisi gentian dan kategori kepanjangan gentian.

Pengenalan process radiasi didapati menambahkan lagi sifat-sifat analitikal dan mekanikal komposit gentian kenaf yang diadun dengan polipropilena. Komposit dengan komposisi campuran polipropilena yang telah diradiasikan dengan gentian kenaf tanpa radiasi didapati menunjukkan sifat-sifat yang lebih baik berbanding dengan komposisi lain seperti radiasi polipropilena dengan radiasi gentian, radiasi gentian dengan polipropilena tanpa radiasi, dan gentian tanpa radiasi dengan polipropilena tanpa radiasi.

Walaubagaimanapun, komposit dengan kehadiran 1% MAPP didapati menghasilkan sifat-sifat analitikal dan mekanikal yang terbaik berbanding dengan sampel yang tanpa dan telah diradiasikan kecuali sifat modulus kelenturan.

Akhir sekali, kesemua penilaian dianalisa secara statistik pada tahap 5% signifikasi. Bukti sokongan untuk keputusan di atas diperkuatkan lagi melalui gambar yang diperolehi daripada "Scanning Electron Micrographs".

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASTM	American Society for Testing and Materials
CTMP	Chemi-Thermo Mechanical Pulping
DMRT	Duncan Multiple Range Test
EDXA	Dynamic Mechanical Thermal Analysis
EPDM	Ethylene Propylene Diene Rubber
FRIM	Forest Research Institute of Malaysia
FRPC	Fibre Reinforced Plastic Composite
MA	Maleated Anyhride
MAPP	Maleated Polypropylene
MFI	Melt Flow Index
MINT	Malaysian Institute for Nuclear Technology
NIIRS	Notched Izod Impact Resistance Strength
PBT	Poly(butylenes) terephthalate
PP	Polypropylene
Pph	Part perhundred
PUR	Polyurethane
RA	Reactive Additives
RMP	Refiner Mechanical Pulping
SBS	Styrene-Butadiene-Styrene
Sdn. Bhd.	Sendirian Berhad

TAPPI	Technical Association of Pulp and Paper
TEM	Transmission Electron Microscopy
UPM	Universiti Putra Malaysia
Wt	Weight

CHAPTER I

INTRODUCTION

1.1 Background of the Study

Presently, the world is losing nine million hectares of forest each year despite an increase in plantations especially in Africa, Latin America, and Asia. Although the rate of deforestation has fallen by 20% since 1995, each of the world's inhabitants was continuing to lose an average of 12 square meter of forest a year (Anon., 2001). Thus, in order to efficiently conserve the future of our forest, other non-wood lignocelluloses materials need to be explored and commercialized in order to substitute timber consumption. One of the most promising non-wood products that catch the attention of many researchers is kenaf.

Kenaf (*Hibiscus cannabinus* L.) is a herbaceous plant that originated from Africa about 4000 years ago. It is a fast growing species that can achieve the height of 5-6 m and diameter of 25-35 mm over a period of six months under good condition either in temperate and tropical climates. Generally, the primary usage of this plant was for the production of jute-type sacking, rope and cordage.

Modern research on Kenaf fibres was initiated during World War II by the United States as a result of the disruption of jute and abaca imports from

Southeast Asia. Research was also conducted on the fibres to replace hemp, whose production in the United States was outlawed in 1933 (Sellers et al., 1999). In 1960s, through extensive research, the U.S Department of Agriculture (USDA) has identified kenaf as a promising alternative fibrous raw material especially for papermaking (Bagby, 1977).

However, the usage of kenaf fibre remained unpopular until 1980s, when the technology that can separate kenaf bark and core into two distinct fractions was invented. Since then, much research and development on this plant has been done not only in United States but also other developing countries such as Thailand, India, Indonesia, Bangladesh, Myanmar (Burma), and Vietnam (Sellers et al., 1999)

Numerous commercial applications for the kenaf fibre whether it is separated or not have been discovered through product development research. These include uses for high quality animal bedding, woven and non-woven textiles, animal feed, oil absorption and fibre composite boards and paper.

A fibre composite is broadly defined as a material consisting of a large number of fibres embedded in a continuous phase or matrix, which gives it a definite shape and durable surface (Chum, 1991). Ease of forming and manufacturing process, uniformity strength distribution, low cost of raw materials, and recyclable are the several factors that make fibre composite a competitive substitute for solid wood.

Fibre reinforced plastic composite (FRPC) is an example of fibre composite. It is a mixture of thermoplastic and fibre. These fibres can be either synthetic fibre (fibreglass, carbon or graphite fibres and aramids fibre) or natural fibre (Strong, 2000). The present of these fibres will either act as a filler or reinforcement agent to the matrix. The examples of thermoplastic that can act as a matrix in FRPC are polypropylene, polystyrene and polyvinyl chloride. The major usage of FRPC are found in automobile, construction, packaging, furniture, electrical and electronics components.

At the moment, although the environment merits of cultivating agriculture fibres specifically as replacements for wood are debatable (Bowyer, 1995(a); Bowyer, 1995(b); Seber, 1995), efficient use of agricultural by products is certainly desirable especially in FRPC (Youngquist, 1995). Moreover, building materials and other daily usage products made from local agricultural fibres are attractive options in regions of the world where wood is in short supply and wood products are expensive to import (Grace, 1996; Spelter, 1996).

In Malaysia, the utilization of kenaf fibre and other agriculture fibres are still at preliminary stage as there is not much literature review on the FRPC product. Rubber wood, oil palm, and bamboo are currently being explored actively as the potential sources for agricultural fibres (Liew, 1998; Jamaludin, 1999; Low, 1999). Although there are still many other agricultural fibres that are relatively cheap and abundance in Malaysia, the emerging of kenaf fibre will surely diversify and maximize our fibre utilization more broadly and efficiently in the near future. Eventually, this will assists forest conservation that will help to minimize the deforestation activities.

1.2 Objectives of the Study

The objectives of this project are stated as below:

a. To quantify the chemical compositions of kenaf fibre used in this experiment.

b. To evaluate the mechanical and analytical properties of kenaf-PP composite at various fibre loadings and fibre lengths.

c. To investigate the effect of electron beam irradiation on the properties of kenaf-PP composite materials.

d. To assess the mechanical and analytical properties of irradiated kenaf-PP composite with the present of compatibilizer agent (MAPP).