THE PRODUCTION OF ECOFIBER FROM PALM OIL EMPTY FRUIT BUNCH (EFB)

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"Saya akui bahawa saya telah membaca karya ini dan pada pandangan
saya karya ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan
Ijazah Sarjana Muda Kejuruteraan Kimia"

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Signature	: ....
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Date	: 15 May 2008

DEDICATION

Special Dedication of This Grateful Feeling to My…

Beloved Ayah and Ummi;

Supportive Lecturer
Tn. Haji Mohd Noor Bin Nawi

My Beloved Friends
Khairul Rahimi Kamam, Mohd. Saifuddin Idris, Mohd Fauzi Ramlam, Khairul Afif Bakar@Ismail, Mohd. Izzuddin Bin Yakari, Abd. Hakim Abadi, Nabil Fikri Ya'kub and Mohd. Khairul Yaacub.

For all your love, care, support, and believe in me. Thank you so much.

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ABSTRACT

Malaysia is the world's largest producer and exporter of product based on palm oil. The oil consists of only 10% of the total biomass produced in the plantation. The other product of palm oil came in the form of residue which consists of huge amount of lignocelluloses materials such as oil palm fronds, trunks and empty fruit bunches. The conventional methods of burning these residues often create environmental problems in that it generates severe air pollution. Looking forward to a better method, an alternative way of optimizing the usage of oil palm residues were obtained as it turn into value-added product. The studies focused on the production of fiber from empty fruit bunch (EFB). The purposes of this study were to determine the yield of fiber produced from certain amount of biomass waste (oil palm wastes). Other than that, the method that was used to produce fiber from the fresh empty fruit bunch (EFB) was studied. Three sets of experiments were performed; in first set, the sample was processed in the grinder and dried to get specific moisture of the sample. On the second set, the sample then treated with hot water at 100°C and NaOH solution 2%, 4%, and 8% concentration of sodium hydroxide (NaOH) with different temperature 80°C, 100°C, 120°C for forty minutes. In the end of this experiment, the remaining oil was extracted using rotary evaporator, and the surface of the EFB fiber was observed using Scanning Electron Microscope. The third set, the tensile strength test was done to the EFB fiber.

ABSTRAK

Malaysia merupakan negara pengeluar dan pengeksport terbesar produk yang berasaskan kelapa sawit. Minyak yang terhasil daripada kelapa sawit ini hanyalah 10% daripada jumlah biomas yang dihasilkan. Selebihnya, produk-produk yang dihasilkan adalah daripada lebihan kelapa sawit itu yang mengandungi kandungan *lignocelluloses* seperti pelepah, batang, dan tandan kelapa sawit. Kaedah semasa yang digunakan untuk melupuskan hasil lebihan kelapa sawit dengan membakarnya menimbulkan masalah pencemaran udara yang serius. Kini, satu kaedah alternatif yang baru telah ditemui untuk memaksimakan penggunaan hasil lebihan kelapa sawit ini dengan menjadikan ia satu produk yang bernilai tinggi. Dalam kajian ini, fokus utama adalah penghasilan *fiber* yang berasaskan tandan kelapa sawit. Tujuan kajian ini adalah untuk menentukan kesan rawatan alkali terhadap fiber dan menentukan kekuatan fiber yang diperolehi daripada amaun tertentu tandan kelapa sawit itu. Selain itu, kaedah yang digunakan untuk menghasilkan *fiber* daripada tandan kelapa sawit itu juga dikaji. Tiga set eksperimen telah dilakukan; untuk set yang pertama, sampel tandan kelapa sawit dimasukkan ke dalam pengisar dan dikeringkan untuk mendapatkan tahap kelembapan yang tertentu. Set kedua, sampel dirawat menggunakan air panas dan juga larutan *Sodium Hydroxide* (NaOH) dengan kepekatan yang berbeza iaitu 2%, 4%, dan 8% daripada kepekatan larutan NaOH itu dengan darjah suhu yang berbeza iaitu 80°C, 100°C dan 120°C dalam jangkamasa 40 minit. Pada akhir eksperimen, lebihan minyak yang masih terdapat di dalam tandan kelapa sawit ini diekstrak menggunakan mesin Penyejat Berputar, begitu juga dengan permukaan *fiber* dilihat menggunakan *Mikroskop Pengimbas Elektron*. Set ketiga, kekuatan *fiber* yang dihasilkan diuji.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Oil Palm Fiber is a natural fiber extracted from palm oil empty fruit bunch (EFB). During the manufacturing process of Oil Palm Fiber, EFB are shredded, separated, refined and dried. The manufacturing process does not involve any chemical reaction or exposure. In the past few years, empty fruit bunches are mainly incinerated to produce bunch ash to be used back to the field as fertilizer. The conventional method of burning these residues normally creates an environmental problem as it generates severe air pollution that is prohibited by the Environment Protection Act. As a result, these residues that came from empty fruit bunch become more expensive to dispose.

The empty fruit bunch fiber (EFB) was identified as the first of the series of standards on oil palm fibers because of logistic reasons. The EFB has the highest fiber yield and is the only material commercially utilized for fiber extraction. The EFB fibers found to be strong and stable and could be processed easily into various dimensional grades to suit specific applications in mattress and cushion manufacture, soil stabilization/compaction for erosion control, landscaping and horticulture, ceramic and brick manufacture and flat fiber board manufacture.

For the purpose of commercialization, the standard recommends one grade of empty fruit bunch fiber (EFB). In quantifying the percentage proportion of fiber length, the standard has established the following numerical values:

Table 1.1: Standard percentage of fiber length

Fiber Length	**% Proportion (Oven dry weight basis)**
1) >100 mm	30
2) >50 - 100 mm	35
3) <50 mm	35

The EFB fibers are clean, biodegradable and compatible than many other fibers from other wood species. EFB fibers are suitable for the manufacture of mattress, car seat, insulation, and composite panel product and particle board. The choice and selection of fiber length is very much dependent on the nature of the manufactured product. For example, long fiber length is suitable for mattress and short fiber makes excellent particle board.

In this study empty fruit bunch (EFB) of oil palm has been chosen to be the raw material of producing fiber in this research due to its abundant and low cost rather than using other source it also clean, a nontoxic and renewable.

1.2 Aim

As a huge potential in producing an environmental-friendly fiber, this research is carried out with the objective of producing fiber from empty fruit bunch (EFB) of oil palm.

1.3 Problems statement

Worldwide, the demand of biomass is increasing rapidly. The biomass includes the oil palm trunks (OPT) and fronds (OPF), kernel shell, EFB, pressed fruit fiber (PFF) and palm oil mill effluent (POME). At present, these products are not only underutilized but frequently the causes of pollution as well. Recently, all these palm oil residues are mainly incinerated to produce bunch ash to be distributed back to the field as fertilizer and the mesocarp fiber and shell are used as boiler to produce steam and to generate power. These methods are leading to serious air pollution problems.

However, there is an alternative to optimize the utilization of oil palm residues fiber based into value-added product. For an example, because of the characteristic of the empty fruit bunch (EFB) are clean, biodegradable and compatible than many other fibers from other wood species, EFB fibers are suitable for the manufacture of mattress, car seat, insulation, composite panel product and particle board. However, there are some characteristic of the EFB that may affect the product. Inherent characteristics such as high moisture content will cause a detrimental effect on the oil palm residues. This matter will easily degrade and infect to the properties of the fibers which may lead it to deterioration. To prevent this from happening, a maximum moisture content of 15% (on wet basis) was set. This value is comparable to the moisture content for all wood-based fibers. The other EFB fiber characteristics that may cause a detrimental effect are the oil content of the fiber. The presence of a significant percentage of residual oil possess a major problem in that it will react with the moisture content hence giving rise to rancidity and ultimately fungal growth. The control limit for oil content shall not exceed 3%.

The usage of these palm oil residues fiber based into value-added product will rapidly decreases the case of air pollution that cause by palm oil residues. As such, it is an environmental benefit of using the palm oil residues into fibers than incinerate it. Lastly, the chemical treatment that used to fibers would help to maintain the quality of the fibers.

1.4 Objective

i. To study the optimum concentration and temperature of Sodium Hydroxide (NaOH) used to treat the palm oil empty fruit bunch.
ii. To study the effect of Sodium Hydroxide (NaOH) treatment to the properties palm oil empty fruit bunch fiber.

1.5 Scope of study

In order to achieve the above objective, the following scopes have been identified:

i. Determining the remaining residue oil after the alkaline treatment.
ii. Analyzing the surface of the palm oil empty fruit bunch that obtained from alkaline treatment.
iii. Determining the strength of the fiber after being treated with different concentration of alkaline.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Oil palm production is a major agricultural industry in Malaysia. It contributes about US$ 7.3 billion in export earnings each year, mostly from the export of palm oil. Currently, there are more than three million hectares of oil palm plantations. In total, about 90 million MT of renewable biomass (trunks, fronds, shells, palm press fiber and the empty fruit bunches) are produced each year (Kamarudin, Mohamad, Arifin, and Johari, 1997).

The empty fruit bunches (EFB) represent about 9% of this total. They are the residue left after the fruit bunches are pressed to extract oil at oil mills. The oil mills are located near or in the plantation itself. EFB is a suitable raw material for recycling because it is produced in large quantities in localized areas.

2.2 Empty Fruit Bunch Processing.

EFB is now a valuable resource that has been converted into fiber for the use as:-

i. Fuel for the energy or power generation

ii. Organic fertilizer or soil conditioners
iii. Filler in molded particle boards / MDF
iv. Fiber in bales for exports
v. Mulching mats
vi. Pulp and paper
vii. Biodegradable fiber wares
viii. Light weight fiber reinforced concrete
ix. Processed animal feeds

Through continual and collaborative research and development (R&D) activities using the empty fruit bunch (EFB) processing system installed in many mills, the technology has improved the performance and capability of the EFB processing machine. All the machines that have been invented are able to process EFB into fiber to suit specific uses. The fibers can be baled for export or can be used directly as fuel or steam and power generation or as organic material for composting to produce fertilizer or soil conditioner (Chew Kian Sang and Tan Kim Hai, 1997).

Processing EFB into fiber involves the basic primary process of reducing the size of the bunch followed by removing the oil and water from the resultant smaller lumps. The fiber lumps are further processed through secondary processes of washing, further size reduction, drying, pressing, and many others into fibers for specific end uses. These are basic processing of EFB:

2.2.1 Bunch reception

Fresh fruit arrives from the field as bunches or loose fruit. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked. Large installations use weighbridges to weigh materials in trucks.

The quality standard achieved is initially dependent on the quality of bunches arriving at the mill. The mill cannot improve upon this quality but can prevent or minimize further deterioration.

The field factors that affect the composition and final quality of palm oil are genetic, age of the tree, agronomic, environmental, harvesting technique, handling and transport. Many of these factors are beyond the control of a small-scale processor. Perhaps some control may be exercised over harvesting technique as well as post-harvest transport and handling.

2.2.2 Threshing (removal of fruit from the bunches)

The fresh fruit bunch consists of fruit embedded in spikelets growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelets from the bunch stem with an axe or machete and then separating the fruit from the spikelets by hand. Children and the elderly in the village earn income as casual labourers performing this activity at the factory site.

In a mechanized system a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelets on the stem. Most small-scale processors do not have the capacity to generate steam for sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelets absorb a lot of water in the cooking process. High-pressure steam is more effective in heating bunches without losing much water. Therefore, most small-scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization systems thresh bunches after heating to loosen the fruits. Small-scale operators use the bunch waste (empty bunches) as cooking fuel. In larger mills the bunch waste is incinerated and the ash, a rich source of potassium, is returned to the plantation as fertilizer.

2.2.3 Sterilization of bunches

Sterilization means the use of high-temperature wet-heat treatment of loose fruit. Cooking normally uses hot water; sterilization uses pressurized steam. The cooking action serves several purposes.

i. Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.

ii. For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine.

iii. Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure.

iv. Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process. The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.

v. The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water, when broken down by wet steam (hydrolysis), so that they can be removed during oil clarification. Starches present in the fruit are hydrolyzed and removed in this way.

vi. When high-pressure steam is used for sterilization, the heat causes the moisture in the nuts to expand. When the pressure is reduced the contraction of the nut leads to the detachment of the kernel from the shell wall, thus loosening the kernels within their shells. The detachment of the kernel from the shell wall greatly facilitates later nut cracking operations. From the foregoing, it is obvious that sterilization (cooking) is one of the most important operations in oil processing, ensuring the success of several other phases.

vii. However, during sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discolouration of palm kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake.

2.3 Natural Fibers

Recently, the use of natural fiber based on oil palm is gaining popularity in energy or power generation, filler in moulded particle board / medium density fiberboard (MDF), and organic fertilizer or soil conditioner. Natural fibers basically offer economical and environmental advantages compare to inorganic reinforcement and fillers. Natural fibers play an important role in developing high performing fully biodegradable composites, which will be a key material to solve the current ecological and environmental problems (Gurmit, Lim, and David, 1999).

Vegetable fiber is one of the varieties of natural fibers obtained from stems, leaves, roots, and seeds of plants. Vegetation is exploited for its ability to yield fibers directly from wild or natural forms.