LIGNIN PRODUCTION FROM OIL PALM BIOMASS

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ABSTRACT

Malaysia is currently one of the world's top producers of oil palm products. The palm oil milling sector in Malaysia generates millions of metric tonne of oil palm waste annually. These include the empty fruit bunches (EFB) generated at the oil mill, the oil palm fronds (OPF) available throughout the year and the oil palm trunks (OPT) which are generated at felling. Depending on the type of residue, it is mulched, burned as fuel or burned in the fields. It makes the good reasons to fully exploit the potential use of this waste. The lignin can be used as high value-added product. This research is to extract lignin from oil palm biomass. Lignin is the most difficult component of biomass to be degraded due to its complex structure, high molecular and high insolubility. The solvent extraction method is used in this research. Various differences of the sodium hydroxide concentration are used as main parameter in this research. As the results, the different amount of lignin produced from oil palm biomass by using different concentrations of sodium hydroxide. The total yields of 5% NaOH, 10% NaOH and 20% NaOH soluble lignin from oil palm trunk and frond are 4.46% and 4.44% respectively.

PENGHASILAN LIGNIN DARIPADA SISA KELAPA SAWIT

ABSTRAK

Malaysia merupakan salah satu pengeluar utama kelapa sawit dunia. Di Malaysia, sektor pengilangn kelapa sawit menjana berjuta-juta tan metrik sisa kelapa sawit. Ini termasuk tandan buah kosong yang dihasilkan di kilang kelapa sawit, pelepah kelapa sawit boleh didapati sepanjang tahun dan batang kelapa sawit yang didapati dari kerja-kerja penebangan. Samaada sisa-sisa ini dibakar sebagai bahan api atau dibakar di ladang, ia bergantung pada jenis sisa. Ia adalah alasan terbaik untunk mengeksploitasi potensi sisa-sisa ini. Lignin boleh digunakan sebagai produk nilai tambah yang tinggi. Kajian ini adalah untuk mengekstrak lignin daripada sisa-sisa kelapa sawit. Lignin adalah komponen dalam sisa kelapa sawit yang paling susah untuk di asingkan disebabkan oleh strukturnya yang kompleks, molekul yang tinggi dan kadar ketidaklarutan yang tinggi. Kaedah pengekstrakan pelarut digunakan dalam kajian ini. Di dalam kajian ini, perbezaan kepekatan natrium hidroksida digunakan sebagai parameter. Hasilnya, jumlah lignin yang dihasilkan adalah berbeza bergantung pada jenis kepekatan natrium hiroksida. Jumlah lignin yang dihasilkan daripada batang dan pelepah kelapa sawit dengan menggunakan 5% NaOH, 10% NaOH dan 20% NaOH adalah 4.46% dan 4.44%.

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NAOH	Sodium Hydroxide
HCl	Hydrochloric Acid
OPT	Oil Palm Trunks
EPFB	Empty Palm Fruit Bunches
OPF	Oil Palm Fronds
MPOB	Malaysia Palm Oil Board
FTIR	Fourier Transform Infrared Spectroscopy

CHAPTER 1

INTRODUCTION

1.1 Background

The oil palms (Elaeis) comprise two species of the Arecaceae, or palm family. They are used in commercial agriculture in the production of palm oil. The African Oil Palm Elaeis guineensis is native to West Africa, occurring between Angola and Gambia, while the American Oil Palm Elaeis oleifera is native to tropical Central America and South America.

Approximately 15 million tons of the oil palm waste is generated by oil palm milling operation annually and part of it is burned in incinerators (Rahman, Choudhury, Ahmad, & Kamaruddin, 2007). The palm oil milling sector in Malaysia generates 9.9 millions of metric tonne of oil palm wastes annually. These include the empty fruit bunch (EFB) generated at the oil mill, the oil palm fronds (OPF) available throughout the year and the oil palm trunks (OPT) which are generated at felling. The total oil palm planted area in Malaysia has increased significantly in recent years. The large amounts of available forest and palm oil residues resulting from the harvest can be utilized. Therefore Malaysia has a great potential in turning its abundant supply of oil palm industry by-products into value-added products.

All plants contain lignin, hemicellulose and cellulose. These are complex carbohydrates which is molecules based on sugar. Currently, lignin is produced mainly as a byproduct of the paper industry, separated from trees by a chemical pulping process. Besides that, lignin is a highly consumed product with a large number of uses.

Stewart (2008) says lignin is a very effective and economical adhesive. Lignin is act as binding agent or 'glue' in pellets or compressed materials. Lignin is used to improve the pellets quality in the animal feed pellets. Consistently, the lignin helps to produce hard and durable pellets. In addition, lignin is approved by AAFCO (American Association Of Feed Control Officials) as a source of metabolisable energy in animal feeds.

Besides that, lignin holds highest energy among all natural polymeric compounds that contain carbon, hydrogen and oxygen. But, since no appropriate activation method had been found until now, fine granular lignin as a flammable high-energy fuel had been unable to serve as engine's fuel. Moreover, the application of lignin in term of energy can be seen in the storage devices such as battery. On the other hand, grease with lignin improves the corrosion protection properties. The wear resistance of the tools is increased by using grease containing hydrolytic lignin. Besides that, the lignin provides antifriction properties to grease which is to provide longer lubrication life.

1.2 Problem Statement

During the pruning operation and upon each rotation of plantation, the felled trunks, empty fruit bunches and fronds represent as waste. Depending on the type of residue, it is mulched, burned as fuel or burned in the fields. The large number of biomass produced by oil palm mill is disposed by combustion or land filling. Disposal by combustion make pollution. Nowadays, biomass is became a massive problem to many country due to its causes to environment although field burning is an economical option for disposing of waste. Many studies have been made by several scientist but not all them can solve the problem of biomass. Utilization of waste of palm material also being studied and turn them into valuable product.

Besides that, one of the problems is the cost involve in production of lignin itself. Nowadays, the high cost is needed in order to produce lignin. Therefore, the production of lignin from oil palm biomass involves reasonable cost and the problem can be solved.

In paper industry, the rising of manufacturing costs and uncertainty in wood supply in some regions due to restrictions on logging and inadequate forest resources, have caused increasing concerns over future fiber supplies. Hence, the paper production from oil palm waste is an alternative. And the lignin produced can enhance the tensile strength of the paper.

1.3 Objectives Of The Research

There are three objectives of this research:

1.3.1 To extract the lignin from oil palm biomass by using sodium hydroxide (NaOH).

1.3.2 To investigate the performance of extraction method in producing of lignin from oil palm biomass.

1.3.3 To investigate the amount of lignin produced by using the different amount of sodium hydroxide (NaOH).

1.4 Scopes Of The Research

There are three scopes of this research:

1.4.1 Use oil palm biomass such as oil palm trunks (OPT) and oil palm fronds (OPF) as alternative materials.

1.4.2 Sodium hydroxide and hydrochloric acid is two main materials. The extraction part use sodium hydroxide and the precipitation part use hydrochloric acid (HCl).

1.4.3 Use the different amount of sodium hydroxide such as 5% sodium hydroxide, 10% sodium hydroxide and 20% sodium hydroxide.

1.5 Significances Of The Research

There are significances of this research:

1.5.1 This research is important to overcome the fossil fuel energy crisis. When the limited resources of fossil fuel, the decreasing of supplies and causing the prices to soar. The production of lignin from oil palm biomass can reduce the cost of fossil-fuel energy sources.

1.5.2 The lignin used as high added value products. It is mean from the waste material can be used for the other value products. For the example, paper and paperboard.

1.5.3 This research gives benefit to the society. Increasing the use of biomass for energy could lead to improve economic development, especially in rural areas. The use of biomass for energy also generates incomes and jobs for the rural people.

1.5.4 In environment side, this production not harmed to the environment. It is because can lower the toxic pollutants in the air. Besides that, this research can reduce the global warming. It is because the burning of fossil fuels produces greenhouse gases that contribute to global warming. In addition this production can reduce greenhouse gas emissions by around 90% when compared with fossil petroleum, which is offer savings of only 20-70%.

1.5.5 Solve pollution and economical problems. Annually, 15 million tonnes of oil palm waste is generated by oil palm milling operation. The disposal of oil palm waste is through combustion or land filling. This ways of disposal of waste create pollution and economic problems. The use of waste as a renewable energy is reduce the problems.

1.5.6 This research will overcome the inadequate forest resources problem faced by many countries. Therefore the manufacturing cost will be reduced.

1.5.7 The production of lignin from oil palm waste involves reasonable cost.

CHAPTER 2

LITERATURE REVIEW

2.1 Oil Palm

2.1.1 History

The oil palm also known as Elaeis in Greek comprise two species of the Arecaceae or palm family. The African Oil Palm Elaeis guineensis is native to West and Southwest Africa, occurring between Angola and Gambia, while the American Oil Palm Elaeis oleifera is native to tropical Central America and South America.

Figure 2.1: Planting

Oil palm was introduced to Java by the Dutch in 1848 and to Malaysia in 1910 by Scotsman William Sime and English banker Henry Darby. The first plantations were mostly established and operated by British plantation owners, such as Sime Darby and Boustead.

In the Republic of the Congo, or Congo Brazzaville, precisely in the Northern part, not far from Ouesso, local people produce this oil by hand. They harvest the fruit, boil it to let the water part evaporate, then they press what its left in order to collect the reddish, orange colored oil. Federal Land Development Authority (Felda) is the world's biggest oil palm planter with planted area close to 900,000 hectares in Malaysia and Indonesia.

Oil palm

Figure 2.2: African Oil Palm (*Elaeis guineensis*)

Scientific Classification

Kingdom: Plantae

Family: Arecaceae

Subfamily: Arecoideae

Tribe: Cocoeae

Genus: *Elaeis*

The world's largest producer and exporter of palm oil today is Malaysia, producing about 47% of the world's supply of palm oil. Indonesia is the second largest world producer of palm oil producing approximately 36% of world palm oil volume. Both nations are expanding their palm oil production capacity and the market continues

to grow. Well, previously Malaysia depended much on rubber as well as tin. Malaysia currently accounts for 39% of world oil palm production and 44% of world exports. If taken into account of other oils and fats produced in the country, Malaysia accounts for 12% and 27% of the world's total production and exports of oils and fats. Being one of the biggest producers and exporters of oil palm and palm oil products, Malaysia has an important role to play in fulfilling the growing global need for oils and fats sustainably.

2.1.2 The Tree, Distribution And Habitat

The oil palm is a tropical palm tree. Average lifespan of an oil palm tree is approximately 25 years. In Malaysia, oil palm hectarage has grown at a compound growth rate of 5.9% from 1975 to 2007.

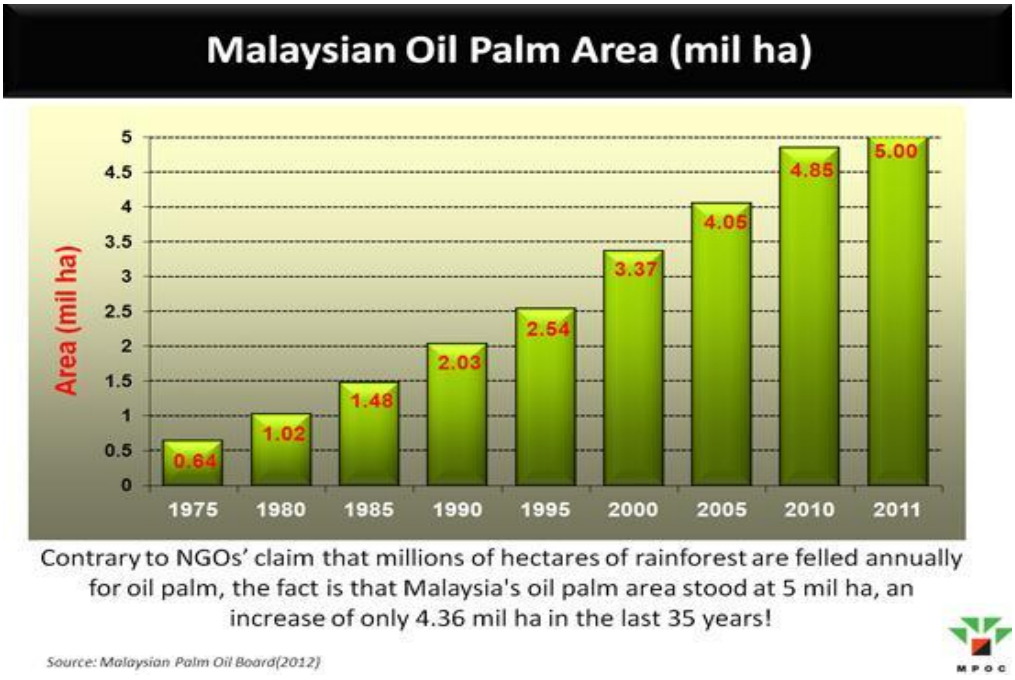

Figure 2.3: Malaysian Oil Palm Area By Year

At Peninsular Malaysia, 55% from the land is planted by oil palm while 45% from the land is planted by oil palm at East Malaysia. Oil palm is also planted by ownership. For instance, 60% is planted by private estates, 29% by government schemes such as FELDA, 11% by smallholders and 7% by state schemes. Distribution of oil palm planted area by category: 2008 & 2009 (hectares) is shown in table below.

Table 2.1: Distribution Of Oil Palm Planted Area By Category

Category	2008		2009	
	Hectares	%	Hectares	%
Private estates	2, 706, 876	60.31	2,807,210	59.84
Govt. Schemes				
FELDA	675,167	15.04	705,607	15.04
FELCRA	163,511	3.65	160,832	3.43
RISDA	80,262	1.79	78,932	1.68
State Schemes	321,947	7.17	329,543	7.03
Smallholders	540,194	12.04	609,036	12.98
TOTAL	4,487,957	100.00	4,691,160	100.00

Source: MPOB

Mature trees are single-stemmed, and grow to 20 m tall. The leaves are pinnate, and reach between 3-5 m long. A young tree produces about 30 leaves a year. Established trees over 10 years produce about 20 leaves a year. The flowers are produced in dense clusters; each individual flower is small, with three sepals and three petals.

Figure 2.4: Tropical Palm Trees

The palm fruit takes five to six months to mature from pollination to maturity. The palm fruit is reddish, about the size of a large plum and grows in large bunches. Each fruit is made up of an oily, fleshy outer layer known as the pericarp, with a single seed or the palm kernel, also rich in oil.

2.1.3 Palm Oil Production

2.1.3.1 World Production

Palm oil is the most traded oil in the world. In 2011, it is exports reached almost 39.04 million tonnes. The table below shows the production of palm oil in the world since 2009 until 2011.

Table 2.2: World Palm Oil Production (Mil. MT)

	2009	%	2010	%	2011	%
Indonesia	21.00	46.00	22.20	48.40	23.90	48.79
Malaysia	17.56	38.79	16.99	37.04	18.00	36.75
Thailand	13.10	3.00	1.34	2.92	1.45	2.96
Nigeria	0.87	1.90	0.89	1.93	0.90	1.84
Colombia	0.80	1.80	0.75	1.64	0.85	1.74
Papua N. Guinea	0.48	1.00	0.50	1.09	0.53	1.08
Cote d' Ivoire	0.35	0.80	0.30	0.65	0.32	0.65
Cameroon	0.34	0.70	0.35	0.75	0.35	0.71
World	45.27	100	45.87	100	48.99	100

Source: Oil World 2011

And, the table below shows the major exporters palm oil in the world in 1990, 1995 and 1999. From that figure, shows that Malaysia is the major exporter of palm oil in the world compare other countries.

Table 2.3: World Major Exporters Of Palm Oil (‘000 tonnes)

Country	1990	1995	1999
Malaysia	5727	6513	8802
Indonesia	1163	1856	3183
Papua New Guinea	143	220	264
Cote d’ Ivoire	156	120	75
Singapore	679	399	270
Hong Kong	51	275	94
Others	276	790	738
Total	8195	10173	13527

Source: Oil World

2.1.3.2 Malaysian Production

Palm oil production in Malaysia has increased over the years, from 4.1 million tonnes in 1985 to 6.1 million tonnes in 1990 and to 16.9 million tonnes in 2010. It reached 18.9 million tonnes in 2011. The production is projected to reach 19.4 million tonnes in 2012. The Malaysian palm oil industry easily meets the local oils and fats demand, and the