XYLOSE PRODUCTION FROM OIL PALM FROND (OPF)

HAZWANI BINTI OMAR

Thesis submitted in fulfillment

of the requirements for the award of the degree of

Bachelor of Chemical Engineering

Faculty of Chemical Engineering & Natural Resources
UNIVERSITI MALAYSIA PAHANG

JANUARY 2014

ABSTRACT

The biotechnological routes increasing interests among the researchers in employing lignocellulosic biomass since these biomass are cheap, renewable and have potential as sugar sources. Oil palm frond (OPF) is one of the oil palm biomass which is available in a large amount annually worldwide in oil palm plantation. OPF is a cheap, widely available and potential renewable source for the production of xylose. This xylose is very useful as a substrate for the production of natural sweetener of xylitol. In order to recover xylose from biomass of OPF, the process of hydrolysis toward OPF need to be done together with suitable parameter as xylose will be used as medium in xylitol production for the next process. Dilute acid hydrolysis is commonly used for sugar recovery from biomass (lignocellulosic sources). In this research, dilute acid hydrolysis is applied for the treatment toward OPF and parameters of reaction time (30, 60 and 90min) and acid concentration (2%, 3% and 4%) are taken into account in order to get the optimum conditions for xylose recovery from OPF. The result shows that, highest yield of xylose concentration is at 30 minutes of reaction time and 4% of H_2SO_4 acid concentration at condition of 100^0C, solid to liquid ratio of 1:10. Besides these parameters, xylose recovery before and after detoxification process were also observed. The detoxification process help to increases the concentration of xylose at 1:10 of solid liquid ratio and temperature of 100^0C, the xylose concentration before detoxification process was 6.638g/L and 7.759 g/L after detoxification process.

ABSTRAK

Proses bioteknologi menarik perhatian ramai pengkaji dalam mengkaji bahan biomas lignosellulosic kerana proses ini murah, boleh digunasemula dan mempunyai potensi untuk dijadikan sebagai sumber gula. Pelepah sawit juga merupakan salah satu daripada biomas sawit yang mudah didapati didalam kuantiti yang banyak seluruh dunia pada setiap tahun. Pelepah sawit ini murah , mudah diperolehi dan berpotensi sebagai sumber yang bole digunasemula untuk penghasilan xylose. Xylose sangat berguna untuk dijadikan sebagai substrate untuk menghasilkan gula semulajadi iaitu xylitol. Sebagai langkah untuk menghasilkan xylose dari biomas pelepah sawit, pelepah sawit ini perlu melalui proses hidrolisis dengan keadaan yang sesuai kerana xylose akan digunakan sebagai medium didalam proses penapaian untuk menghasilkan xylitol pada proses seterusnya. Pada kebiasaannya, asid hidrolisis cair digunakan untuk menghasilkan gula dari biomas (sumber lignosellulosic). Di dalam kajian ini, asid hidrolisis cair digunakan pada rawatan pelepah sawit dengan membezakan masa tindakbalas (30, 60 dan 90 minit) dan kepekatan asid (2%, 3% dan 4%) untuk mendapatkan keadaan optimum dlam penghasilan xylose daripada tindak balas asid hidrolisis terhadap pelepah sawit. Keputusan yang didapati dari eksperimen yang dijalankan menunjukkan kepekatan xylose yang terhasil adalah pada keadaan 30 minit masa tindakbalas, 4% kepekatan asid sulfurik, pada suhu 100^0C dan 1:10 nisbah pepejal kepada cecair. Selain itu, penghasilan xylose sebelum dan selepas proses detoxifikasi. Proses ini membantu meningkatkan kepekatan xylose pada 1:10 nisbah pepejal kepada cecair, dan suhu 100^0C, nilai kepekatan xylose sebelum dan selepas detoxifikasi proses adalah 6.638 g/L dan 7.759 g/L masing- masing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

%	Percent
^0C	Degree Celcius
g/L	gram/ Litre
w/v	weight per volume
μm	micrometer

LIST OF ABBREVIATIONS

EFB	Empty fruit bunch
H_2SO_4	Sulphuric acid
HCl	Hydrochloric acid
HPLC	High performance liquid chromatogram
OPF	Oil palm frond
Wt	Weight
pH	Potential hydrogen

CHAPTER 1

INTRODUCTION

1. 0 Introduction

In this research, oil palm frond (OPF) is used as the raw material for the production of xylose. OPF is chosen because it was one renewable source in which rich in lignocellulosic material that is possible to be converted into value-added products and chemical. Besides that, the uses of lignocellulosic material may help to cut the overall cost of production because this material is cheap and easily available as it is renewable sources. More than that, the environmental problem may reduce if used lignocellulosic material as raw material.

Other than that, lignocellulosic material has three main components such as hemicelluloses, cellulose and lignin. Hemicelluloses and cellulose are referred as carbohydrate polymer while lignin as aromatic polymer. The cellulose component is known as glucose polysaccharides while hemicelluloses are divided into two type of polysaccharide with different sugars which are hexoses (glucose, mannose and galactose) and pentoses (xylose and arabinose). As for lignin, as studied by Del Rio et al (2007), it was covalently bonded to both of cellulose and hemicelluloses which provides with compressive strength and stiffness to the plant tissue and cell wall.

The lignocellulosic material undergoes acid or enzymatic hydrolysis in order to release xylose sugar from hemicelluloses. For this research, acid hydrolysis was chosen rather than enzymatic hydrolysis because acid hydrolysis is an easy method compared to enzymatic hydrolysis. Many studies show that acid treatment can be more dependable for the hemicellulosic fraction to be hydrolysed. The most important parameter in acid hydrolysis which affects the sugar yields is acid concentration while temperature is important for the degradation of various by-products from sugar such as furfural and acetic acid. Thus it is important to determine the suitable condition of acid hydrolysis in order to get high value of xylose yield.

1.1 Research background

There are several wastes represent as biomass product in Malaysia including timber, rice husk, coconut fibers, municipal wastes, sugar-cane wastes and for sure oil palm is the largest contributor of these biomass wastes. Oil palm biomass can be considered as 'green' material because of certain factors. Firstly, this biomass can be found in two ways either from plantation or the mills. Secondly, oil palm biomass is renewable that can be used for many purposes and based on studied by Mott el (1990), Dahlan (2000) and Okudaira et al (2000), biomass product can be converted into valuable products, as example, composites, pulp-paper, chemical products and other valuable products. So, it is relevant to optimizing the use of all product and by-products from oil palm biomass. Biomass that found in plantation mostly is trunks and fronds.

Oil palm frond (OPF) is a biomass that can be found largely in oil palm plantation. This waste are available throughout the year in large amount are usually left rotting between the rows of palm trees for soil soil conservation, erosion control and nutrient recycling for long-term benefits. Oil palm frond is available when the palm is pruned during harvesting of fresh fruit bunches for oil production purpose. Pollution and greenhouse gases emissions might be occurs if this waste is not treated properly, and recycling is the best way to overcome this problem. The production of xylose from OPF was chosen as raw material in this research because it is the most abundant waste in oil palm plantation beside has properties that suitable for xylose production. Other than that, it is good alternative to manage this abundant waste and next it is possible to reduce the environmental issues today. From Sulaiman et al (2011), researchers stated that a large amount of oil palm biomass resulting from the harvest can be utilize as by-products, and from this it may help to reduce environmental hazards. Moreover, OPF available at very low cost for cropping practice, collection and storage which help in cut the cost for overall production. Figure 1 shows the oil palm tree and Figure 2 shows the oil palm fibers.

Figure 1: Oil palm tree

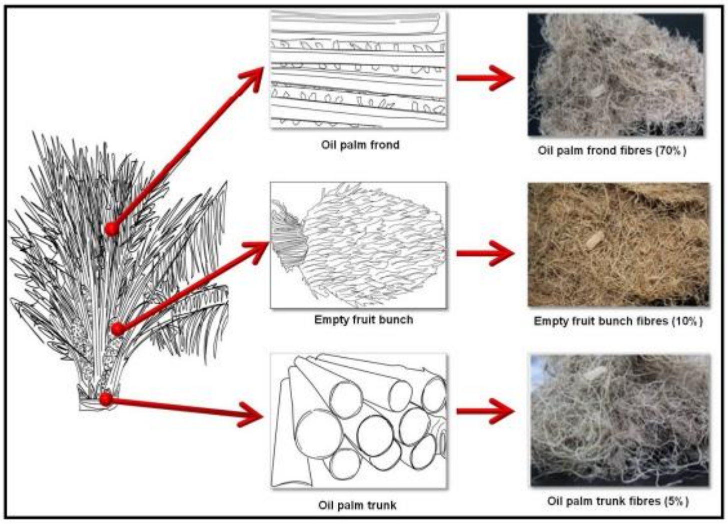

Figure 2: Fibers from oil palm industry

Xylose is very economic to be used as a substrate for variety production of specialty chemical or fuels by chemical and biochemical processes. It is a major product of the hydrolysis of hemicellulose from many plant materials. It is also a hemicellulosic sugar mainly used for its bioconversion to xylitol. Xylitol can be found naturally in some fruits and vegetables but because of its concentration in plants is relatively low, make its quantitative extraction difficult and not be economically interesting. Nowadays, xylitol is one of the substances that getting more attracting attention as increase of public awareness of health issues. It is demanding in used as a sweetener to various products and replaces sugar in confectionary.

Xylitol is highly use as a sugar substitute in confectionary used and also in providing sweetness to various products such as chewing gum, sweets, soft drinks and ice-cream. It is also can be used as dental caries reducer and also for oral health as it contain of anticariogenic properties, as rational treatment for other diseases such as erythrocytic glucose-6-phosphate dehydrogenase deficiency and act as a source of insulin-independent carbohydrate for insulin dependent diabetics.

1.2 Problem statement

Oil palm frond can be found usually after harvesting and replanting activities is an abundant waste material produced by the palm oil industry in Malaysia and become worrisome in oil palm industry because it affect the environment and what the most important is, it may lead to greenhouses gases and global warming if do not treat properly. The traditional method such as open dumping, burning and land filling of these materials for disposing purposes of this biomass are not only increasingly expensive but also impractical due to limited open space. It is beneficial by using oil palm frond as a raw material because it may overcome this problem. According to Mohamad et al (2005), the uses of oil palm biomass will protect the forests from being felled and in turn the environment, the materials are also biodegradable.

In increased of health problem and rising health concern in modern world has promoted various medicinal and natural products. Xylitol is very important since it is well known as natural sugar substitute and commercially used for various applications such as sweetener in food industry, healthcare sectors, pharmaceuticals, animal nutrition and also alternative sweetener for diabetic patients. It is become demanding as public realized how important it is and aware about health issues. Besides that, xylitol production from chemical process is expensive and required high production cost.

1.3 Objectives of research

The objectives of this research are:

1.3.1 to utilize Oil palm frond (OPF) as alternative source to produce xylose

1.3.2 to determine the effect of acid concentration and reaction time on acid hydrolysis of OPF

1.3.3 to determine the effect of detoxification process on xylose recovery

1.4 Scope of research

In order to achieve the objective, the following scopes have been identified and to be applied:

1.4.1 OPF is used as raw material for the reaction

1.4.2 used sulphuric acid, H_2SO_4 for acid hydrolysis reaction

1.4.3 2%, 3% and 4% of acid concentration are prepare

1.4.4 times taken for reaction in acid hydrolysis are 30, 60 and 90 minutes

1.4.5 activated charcoal is use for detoxification treatment

1.4.6 HPLC analysis equipment is use for analysis purpose

1.5 Rational and Significance of Study

1.5.1 The biotechnological routes are commonly used among the researchers in employing lignocellulosic biomass.

1.5.2 Oil palm frond (OPF) is a potential by-products of low-value biomass to be converted into valuable products and chemicals

1.5.3 The uses of OPF may cut total production cost as it is cheap, widely available and its handling cost is also cheap.

1.5.4 Dilute acid hydrolysis toward lignocellulosic material is more practical and easy.

1.5.5 Xylose recovery from acid hydrolysis of OPF is possible as OPF rich in hemicellulosic content

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the finding of related articles from MPOB website and I-portal is needed in order to do literature review. The literature review is research done in the past by other people and it is needed to support our research objectives. The content of this literature is divided into three (3) parts which are raw material, process or methodology and product.

Raw material used in this research is oil palm frond (OPF) which is one of the most abundant biomass waste found in oil palm plantation in Malaysia. The use of OPF is possible as it is one of the lignocellulosic material. Lignocellulosic material has three components which are cellulose, hemicelluloses and also lignin. Hemicelluloses can be treated to recover xylose and dilute acid hydrolysis is one of the reliable methods for this purpose. From this acid hydrolysis treatment, xylose sugar can be produced and is used as a substrate for the production of natural sweetener of xylitol.

2.1 Agricultural wastes availability

Malaysia is a country which is well known as it rich for its potential renewable resources such as palm oil waste, sugar cane bagasse and rice straw. In addition, renewable resources can be obtained from a large volume of waste produced from the agricultural, horticultural, food industry, forestry and others. Most of the wastes are left for rotting or be burned in the field. According to Rodríguez-Couto (2008), a serious disposal problem occurred due to a large amount of wastes from food, agricultural and forestry industry has been produced annually worldwide. Recently, the conversion of these wastes to fuels and some chemicals has been receiving much attention since they are cheap, highly available and contains large amount of carbohydrates which are hemicelluloses and cellulose. In addition, the uses of these wastes for industrial purposes may give ecological benefits by disposal of them in proper ways beside offer economic, providing additional income for farmers and also generates employment.

Most of agro waste can be converted into value added products while reducing waste generation and enhancing eco-efficiency and from this, the concept of waste to wealth has been focused and has been introduced in late 1990 (Goh et al, 2010). From Silverstein et al (2007), agricultural wastes can be used as renewable sources for the production of valued added products because agricultural wastes are mainly composed of hemicelluloses, cellulose and lignin. It is a great deal of interest in which these composed material can be treated to produced value-added products in which hemicelluloses breaks down to xylose and celluloses breaks down to glucose.

2.2 History, habitat, tree and industrial development of oil palm

The oil palm tree is a tropical palm tree under the family of *Palmae* originally come from Guinea, West Africa (Yusof, 2000) is originally illustrate by Nicholaas Jacquin in year of 1763 and hence, oil palm is known as *Elaeis guineensis Jacq* as after his name. *Elaia* is come from Greek word that means olive which indicates its fruits rich in oil. Besides that, *Elaeis guineensis* is also a member of the family *Palmae* with their subfamily, *Cocoidae* which is includes the coconut. It grows well in all tropical areas of the world and has become one of the main industrial crops. It was first time introduced in Malaysia during years 1870 as an ornamental plant. According to Anonymous (2010), until 2009 about 4.69 million ha of land which is 20% of total land area in Malaysia has been used for oil palm plantation.

The most suitable area for oil palm is soil that free from draining with low pH and does not thrive at very high pH which is greater than 7.5. Life span of a single tree of oil palm is about 25 years and its culture is well done in low altitude less than 500 m above sea level with 15˚ from the equator in the humid tropics. The soil is properly drained with distributed of rainfall of 1,800 to 2,000 mm/year but will tolerate rainfall up 5,000 mm/year. If there are three months in row, with less than 100 mm rainfall per month, productive yield will be reduced as oil palm is sensitive toward poor drainage and drought. This is one of the reason why it is agreed that oil palm *Elaeis guineensis Jacq,* is originated from equatorial tropical rain forest Africa.

A tree of oil palm includes of trunks, bunches and fronds. Oil palm is tree with height from 20 to 30m is an un-branched tree and its trunk is formed after 3 years old when the apex has reached its full diameter in the form of an inverted cone which after intermodal elongation take place. A bunches of fruit is weight about 10 to 25 kg and sometime might up to 50kg and most suitable time for harvesting ripe fruits is 5 to 6 months after flowering. A bunch of fruit may obtain the number of fruit about a total of 500 and 4000. A fruit with ovoid type shaped, have measurement of length from 2 to 5 cm and weighing scale of 3 to 30 g. From a single tree of oil palm, about 20 or more pieces of fronds can be obtained with their average weight about 5 kg.

Oil palm, *Elaeis guineensis* knowingly to become one of the most important plants in Malaysia and mainly important contributor to Malaysian economy and as studied by Abdullah et al (2009) said that Malaysia also known as the world's second largest palm oil producer after Indonesia. Malaysia planting of oil palm commercially began in year 1917 and since then, the growth of the industry in terms of planted area has been very rapid. As reported by Teoh (2002), the total area planted with oil palm was 3,499,012 hectares, 59.9% or 2,096,856 hectares being in Peninsular Malaysia, 29.4% or 1,027,329 hectares in Sabah and 10.7% or 374,828 hectares in Sarawak in 2001. Besides that, according to MPOB (2012), Malaysia had 5 million hectares of oil palm areas in year of 2011. Figure 3 shows the oil palm production in Malaysia from year 2004 to 2009.

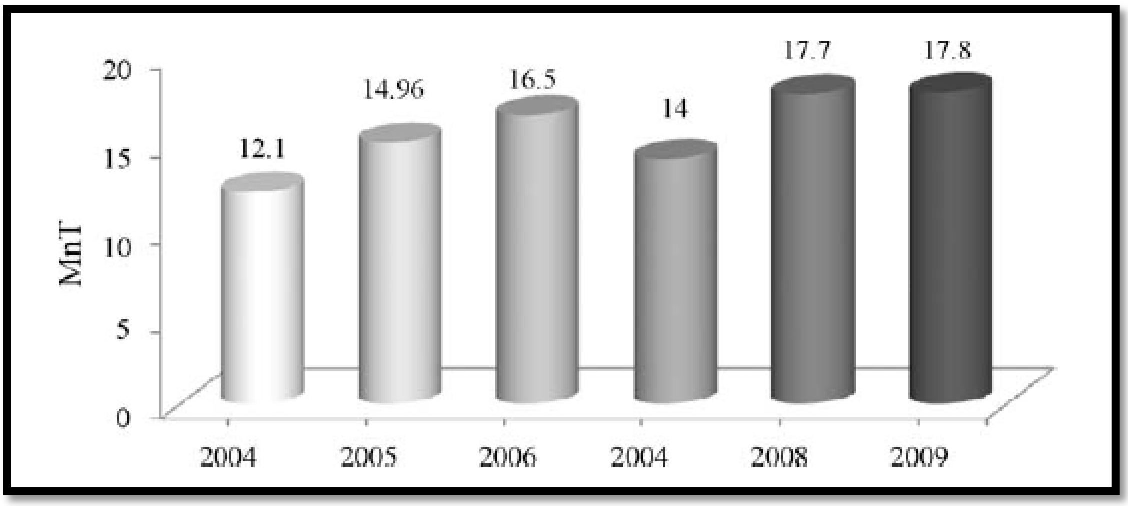

Figure 3: Palm oil production in Malaysia from 2004 – 2009

An abundant amount in millions of tons per year of biomass produced from oil palm industries, which when treated properly will not only be able to solve the disposal problem but also can create value added products from this biomass. There is no word waste from oil palm in Africa because no part of the oil palm unusable. In Africa, palm kernel cake obtained from residue after oil has been extracted is used for feeding livestock, the leaves were used for making brooms, roofing, baskets and mats. Nowadays, palm oil industry in Malaysia produced huge quantities of oil palm biomass while thicker leaves stalks were used as walls of village huts. According to Komolafe and Joy (1990), the bark of the palm frond is peeled and woven into baskets. There are many types of biomass produced from oil palm industry which are empty fruit bunch (EFBs), palm oil mill effluent, fiber, shell, wet shell, palm kernel, oil palm fronds (OPFs) and oil palm trunks (OPTs). In Figure 4, it clearly shows the types of oil palm produces in Malysia in year 2009. From studied by Shuit et al (2009), with an amount about 55.5 million tonnes of oil palm biomass were recorded which included empty fruit bunch (EFB), palm pressed fiber (PPF), oil palm trunk (OPT) and oil palm frond (OPF).

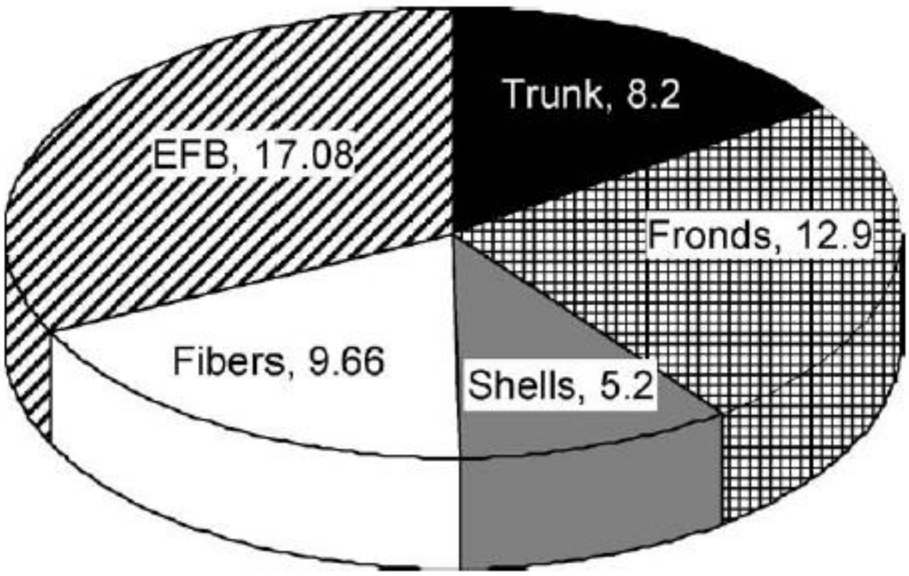

Figure 4: Types of oil palm produce in Malaysia in 2009 in MnT/year

2.3 Oil palm frond

2.3.1 Oil palm frond availability

Oil palm frond (OPF) as a by-product that are from fruit harvesting or pruning activities of fresh fruit bunches and throughout the year. From Goh et al, 2010; MPOB, 2009), oil palm frond is known as solid agro waste which is the most abundant by-products of oil palm plantation in Malaysia. Research by Khozirah S, Khoo KC, Razak AMA (1991), from a huge amount of biomass produced from oil palm industries, oil palm frond (OPF) is one the most abundant waste material produced from oil palm plantations and their biomass product is not used completely.

Other than that, according to Eng et al (2004), OPF contributed up to 77% from the overall wastes produced from oil palm industry in Malaysia. Based on Abu Hassan O, Ishida M, Shukri I, Ahmad Z (1994), the fronds got from this harvesting activity is usually left rotting on the palm oil trees as for soil conversion, erosion control and ultimately the long-term benefit of nutrient cycling. From research of Office of Agricultural Economics (1994), there are about 18 million tons of fronds a year all over the world is generated from pruning and replanting program in 1992 from production of oil palm plantation. Thus, the disposal method of this waste by direct decaying in the natural environment or by burning on site will only composed some of them. Tan et al (2011) said that, an alternative method is needed to utilize or disposed OPF since the current disposal method is not suitable and causing environmental problems.

2.3.2 Chemical composition of Oil palm frond

OPF come up with carbohydrates and together with lignocellulosic as well and its amount about 24 million tons per year discharged from oil palm mills. The chemical and physical properties of oil palm biomass vary according to their diverse origins and plant species. There are many studies reported by researchers about the nutrient content of oil palm frond. According to Hassan et al (1994) and Wan Zahari et al (2002), oil palm frond does not contain high metal contents but contain highly carbohydrate contents as a form of simple sugars, and eventually the oil palm frond part can be benefit for other uses or purposes without scarifying the nutrient recycling process.

As studied by Kosugi et al (2010), it is shows that the moisture content of freshly chopped OPF is about 70% that similarly to the amount of the outer part of oil palm trunk (OPT). In addition, OPF is also high of dietary fiber and carbohydrate about 21% and 28% respectively and low in crude protein with 3.2% only. In addition, Laemsak N & Okuma M (1996) has studied that oil palm frond content of hemicelluloses richer than that of hemicellulose content in wood. OPF consists mainly of lignocellulosic components such as cellulosed, hemicelluloses and lignin (Sjostrom, 1981). According to Misson et al (2009), Chew TL and Bhatia S (2008), major component in oil palm biomass are cellulose, hemicelluloses, lignin and ash. From Abdul Khalil et al (2006), cellulose and hemicelluloses are rich in oil palm frond with 49.8 wt% and 83.5 wt% respectively beside high in lignin composition with 20.5 wt%. These are shown in Table 1, table of chemical composition of oil palm biomass.

Table 1: Chemical composition of oil palm biomass

Chemical composition of oil palm biomass.

Component	Oil palm biomass chemical composition (wt.%)				
	EFB	Shell	Frond	Fiber	Trunk
Reference	[16]	[17]	[18]	[19]	[20]
Cellulose	38.3	20.8	49.8	34.5	37.14
Hemicellulose	35.3	22.7	83.5	31.8	31.8
Lignin	22.1	50.7	20.5	25.7	22.3
Ash	1.6	1.0	2.4	3.5	4.3

2.4 Lignocellulosic Material

Lignocellulosic biomass refers to biomass plant that is composed of cellulose, hemicelluloses and lignin. According to Tengerdy and Szakacs (2003), this lignocellulosic comprises more than 60% of plant biomass produced on earth. Cellulose is highly crystalline polymer of glucose. Hemicellulose is a branched polymer in which composing of pentose and hexose sugars under hydrolysis of mild acid to release its sugar components. According to Rao et al (2006), hemicelluloses promise the availability of hexosan and also pentosan as there are abundantly available in nature as they are found in the cell wall. Pentose sugars are including xylose and arabinose while hexose sugars are glucose, galactose and mannose. It was found that, hemicelluloses composition in oil palm frond is the highest compared to in coir, pineapple, banana and even soft and hardwood fibers (Abdul Khalil et al, 2006).

2.4.1 Hemicellulose

Hemicellulose represents up to 35% of total lignocellulosic mass which is an amorphous substance which is one of the polysaccharides with low-molecular weight which is associated in plant cell walls with cellulose and lignin. Hemicelluloses have more branches and less crystalline than cellulose but like cellulose, its monomers units also can be fermented to ethanol. Within the biomass components, hemicellulose is connected to lignin and cellulose by covalent bonds, due to only a few of covalent bonds is involved, hemicelluloses seem easier to be broken down than crystalline cellulose.

From Darvill et al (1980), hemicelluloses is usually defined as polymers that are solubilised from plant cell walls by alkali. With their physical, chemical and biological properties, this hemicellulose have great industrial potential. After alkaline extraction, most of the hemicellulose fraction is soluble in water. Usually isolation process of hemicelluloses is difficult due to the intricate physical and chemical bonding within the lignin-hemicellulose complex of the plant materials. Hemicellulose is also heteroglycans built up from a relatively sugar residues. The most common and known sugar residues are D-xylose, D-mannose, D-galactose, D-glucose, L-arabinose and D-galacturonic acid.

Nowadays, several chemical such as xylitol and gluconic acid are derived from this polysaccharides are of industrial importance. There are two simple sugars that can be extracted from hemicelluloses which are xylose and glucose. As hemicelluloses is available abundantly in nature and also a renewable resources, there are a lot of researches has been undertaken to convert hemicellulose to derived carbohydrates such as xylose.

2.5 Process Treatment

2.5.1 Acid Hydrolysis

Acid hydrolysis method is used because it is a direct hydrolysis method in conversion of biomass and can be considered as simple and single reaction vessel since it is a single stage acid hydrolysis. This method can be categorized into two general categories which are high concentration of acid hydrolysis at low temperature and low concentration of acid hydrolysis at high temperature. However, it was known that the price of strong acid is quiet expensive and it may increase the total cost production, the acid hydrolysis by high acid concentration is rarely applied commercially. Based on studies by Kosaric et al (1983) and Apriyanti (2008), out of these two ways, there are factors that should be considered such as the rate of hydrolysis, the rate of degradation, products and the total cost of production process.

In acid hydrolysis, the effect of acid concentration and temperature plays an important role. But it also stated that the amount of sugar released during hydrolysis depended on the type raw material used and the experimental operating conditions. Sulphuric acid (H_2SO_4) and hydrochloric acid (HCl) are the concentrated acids that have been used for the lignocellulosic materials treatment (Singh et al, 2011). It should be bear in mind that even though they are powerful reagents for hydrolysis treatment, they are also known with the properties of corrosion and hazardous and the resistant of corrosion are required.

Dilute acid hydrolysis has been developed for a successful pretreatment of lignocellulosic materials. Therefore, dilute acid hydrolysis pretreatment is used in order to achieve high reaction rates and significantly improve the lignocellulosic hydrolysis. From this, a single stage acid hydrolysis only used diluted acid which is less than 5% acid concentration rather than the concentrated acid. A high temperature is needed in order to achieve a maximum conversion in short period of residence time. As stated by Sun and Cheng (2002), dilute sulphuric acid or hydrochloric acid in the range of 2-5% is used in acid hydrolysis of lignocelluloses with temperature about 160˚C and pressure of 10 atm. According to Taherzadeh and Karimi (2007), acid hydrolysis is becoming more popular because it is take lower cost and greater effectiveness than enzymatic hydrolysis.

In addition, Taherzadeh and Karimi (2007) also stated that parameters such as temperature, time and acid concentration and solid-to-liquid ratio play an important role during dilute acid hydrolysis of agro residues in order to obtain the optimum sugar recovery and minimum generation of inhibitors. These parameters should be considered because they are fundamental importance in order to define optimal conditions of hydrolysis to ensure the process is a success since the hydrolysate will be used as fermentation medium (Girio et al, 2010). Research by Rahman et al (2007), the most important parameter affecting the sugar yield was the acid concentration while temperature plays an important role for the degradation of sugars to various by-products such as furfural which strongly affect the metabolism of microbial during the production of xylitol.

The hemicelluloses preparation can be done by pre-hydrolysis with mild acid to hydrolyse the hemicelluloses to xylose since it is well known about the uses of dilute acids to catalyze the hydrolysis of hemicelluloses to its constituents. From Harris et al (1945) and Gilbert et al (1952), to extract xylose, mild acid is used by hydrolyzing the hemicelluloses. Other than that, the used of very dilute acid in hemicelluloses preparation may helps to cut the overall cost production. As studied by Lynd et al (1996), alternative of current processes for hemicelluloses hydrolysis is used very dilute acid approximately 0.07% or even no-acid flow through technologies because this process might help reduce the cost of pre-treatment.

According to Sun and Cheng (2005); Balat and Balat (2008), the dilute acid hydrolysis for determination of hemicellulosic fraction is more effective and inexpensive. This statement is also proved in recent study by Shatalov and Pereira (2012) which stated that acid hydrolysis by using dilute sulphuric acid under mild conditions is a reliable method, easy to operate and low cost. More than that, dilute acid hydrolysis is found to be more effective towards complete hemicellulosic hydrolysis in short reaction time (Taherzadeh and Karimi, 2007).

2.5.2 Detoxification treatment

Detoxification treatment is a method for removing of the inhibitor from hydrolysates for their inhibitory action in the fermentation. According to Olsson, Hahn-Hägerdal (1996), detoxification treatment is a method employed for the removal of inhibitors from lignocellulosic hydrolysates prior to fermentation. There are some methods can be done in detoxification such as physic-chemical procedures, neutralization and overliming (Roberto et al, 1991), adsorption in activated charcoal (Dominguez et al, 1997) and extraction with organic solvents (Parajo et al, 1996).