RENEWABLE ENERGY FROM WASTE OIL PALM EMPTY FRUIT BUNCHES

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ABSTRACT

The depletion of the world petroleum supply and the increasing problem of greenhouse gas effects have strengthened the worldwide interest in alternative, nonpetroleum-based sources of energy. The use of bioenergy, specifically bioethanol and biogas will reduce the use of fossil energy while reducing environmental impacts such as green house gas emission, global warming and acid rain. Waste oil palm empty fruit bunches from oil palm industry is widely abundant along with the increasing of the growth of oil palm plantation industry in Indonesia. This study investigated the potential for utilization of waste oil palm empty fruit bunches for bioenergy, especially biogas and bioethanol. However, as lignocellulosic material, oil palm empty fruit bunches contain lignin that extremely resistant to enzymatic digestion and fermentation. Therefore, a pretreatment is necessary to disrupt lignin in order to improve digestibility. In this study, solvent propyl amine was used as pretreatment, because it is an organic solvent and relatively friendly for environment compare to alkaline and strong acid. The result show that the pretreated oil palm empty fruit bunches can be used as feed-stocks for bioethanol and biogas production. For biogas production, normal volume methane from sample which pretreated by propyl amine 3 M achieved 54% higher than untreated material. And for bioethanol production, glucose concentration on enzymatic hydrolysis of sample which pretreated by propyl amine 3 M achieved 60% higher than untreated material.

KEY WORDS: Oil palm empty fruit bunches, pre-treatment, propyl amine, biogas, bioethanol.

1. INTRODUCTION

One of the potential merits of biobased products is the utilization of renewable resources instead of non-renewable resources. Especially bioenergy from waste biomass, in addition to remove waste from environment, it can be an alternative energy to save the use of fossil energy. Utilization of biomass as an energy source will reduce the use of fossil energy resources while reducing environmental impacts such as global warming and acid rain (Chynoweth et al., 2001).

Development of technologies for effectively converting agricultural and forestry lignocellulosic residues as well as energy crops to fermentable sugars and biogas offers outstanding potential to benefit the national interest through :

1. Improved energy security
2. Decreased trade deficits
3. Healthier rural economies
4. Improves environmental quality
5. Technology exports
6. Sustainable energy resource supplies (Wyman et al., 2005).

Currently, high conversion costs, large investment risks, and a narrow economic margin between feedstock costs and product prices slow the realization of biofuel production on a large scale (Wyman et al,. 2005).

However, the production cost should be reduced in order to increase the market position of the biofuel.

This study investigated the potential for utilization of waste oil palm empty fruit bunches for bioenergy, specifically biogas and bioethanol. Oil palm empty fruit bunches is waste from oil palm industry which has not been utilized yet. This waste is abundant because every 1 ton of fresh palm bunches can produce

220-230 kg wasted oil palm empty fruit bunches.

Biomass energy currently contributes 9–13% of the global energy supply—accounting for 45±10 EJ per year (United Nation Development Programme, 2000).

Biomass energy includes both traditional uses (e.g., firing for cooking and heating) and modern uses (e.g., producing electricity and steam, and liquid biofuels).

Use of biomass energy in modern ways is estimated at 7 EJ a year, while the remainder is in traditional uses. Biomass energy is derived from renewable resources. With proper management and technologies, biomass feedstocks can be produced sustainably (Kim and Dale, 2004).

Lignocellulose is a natural resource that is abundant and cheap that in addition can be used as raw material for bioethanol and biogas, can also be processed into other chemicals, such as organic acids, acetone, and glycerol (Wyman, 1996).

Utilization of lignocellulose as raw material for bioethanol and biogas growing because its availability in abundance as a by-product of the agricultural and forestry industries. (Knauff and Moniruzzaman, 2004).

Lignocelluloses consists of a complex fibrous structure of polymeric sugars such as hemicelluloses embedded in a matrix of the aromatic polymer lignin (Mosier et al, 2005). Lignocelluloses composed of cellulose (40–50%), hemicelluloses (25–35%) and lignin (15–20%) is extremely resistant to enzymatic digestion. Therefore, a pretreatment is necessary to disrupt the plant cell wall (lignin) in order to improve enzymatic digestibility (Fan et al, 2006).

Many kind of pretreatment, such as solvent pretreatment, thermal pretreatment and biological pretreatment has been demonstrated successfully, though several research and investigation still in progress. Solvent pretreatment is a commonly pretreatment, relatively inexpensive than thermal pretreatment and disrupt lignin faster than biological pretreatment. Propyl amine is an organic solvent, friendly for environment compare to alkaline and strong acid. It's performance in disrupt lignin on oil palm empty fruit bunches was investigated in this research.

2. MATERIAL AND METHODS

Effective conversion of recalcitrant lignocellulose to monosugars for biogas and bioethanol production involves four sequential steps :

1. Size reduction, by breaking sample into fibers, followed by grinding to produce powders that pass through 125 mess screen.
2. Washing, done to remove dust from sample.
3. Drying, by taking sample in thermostat at temperature of 105^0 C to decrease moisture content not more than 3%.
4. Pretreatment, by using propyl amine solvent to break and disrupt lignin.

Solution of Propyl Amine was made in two variation of concentration: 3 Molar and 1 Molar. Materials was soaked in solution for 24 hours using water bath with temperature 25^0C, then rinse until its free from Propyl amine (pH neutral is an indicator that material already free from Propyl amine).

2.1 Biogas Production

The volume of inoculums (seed bacterial culture) used was 20 ml, 5 ml of water added, bringing the total volume of head space is ± 93 ml. Inoculum used was thermophilic anaerobic microorganism, obtained from Biogas Plant, Boras, Sweden. The reactor was stored in an incubator (thermostat) at thermophilic temperature of 550^0 C for 50 days, taken periodically and analyzed for methane content using gas chromatography (GC).

To assure anaerobic condition, each reactor was purged with a gas mixture (blended gas) consist of 80% Nitrogen and 20% Carbon Dioxide for ± 3 minutes. Along with the test reactors, three blank reactors were also operated to measure the biogas produced from the inoculums for later use in the correction of biogas produced from the testing substrate. Each of the blank reactor contained only inoculum and water.

Pure methane was used as a standard for analyzing of methane produced by raw materials. Standards should be measured before measuring the biogas, at least 2-3 times until the reading of methane content being stable as an indicator that the GC was stable and ready to be used to measure the volume of methane produced by raw materials.

The sample gas produced by raw materials retrieved using a needle (syringe) of 250 mL volume, and then injected into the gas chromatography and the wide area methane was recorded. Syringe fitted with a pressure lock to keep the pressure inside the syringe equal to the actual pressure inside the reactor. To avoid the occurrence of gas leakage due to increased pressure in the reactor, the gas released at regular intervals after the first volume was calculated.

Normal volume of methane was the volume of methane at normal temperature and pressure (25^0 C and 1 atm) for each gram of volatile solids materials on a solid raw material. Volume of methane produced was the peak GC methane readings from the reactor, while the standard area of methane was the peak area of pure methane that GC readings. It was taken by using the same syringe with the same volume. GC was used to measure the volume and levels of methane in the syringe so that it can be determined the volume of methane in the reactor.

2.2 Bioethanol Production

Enzymatic hydrolisis experiments were carried out in 125 mL Erlenmeyer flask The pH was adjusted to 4.8 with a 0.05 M citrate buffer and 30 filter paper unit (FPU) Cellulase and 60 International Unit (IU) β-glucosidase per gram cellulose. The flasks were incubated at 50 ^{0}C on a shaker water bath and agitated at 120 rpm. As a standard used pure Avicel cellulose (Avicel PH-101, Fluca Analytical).

1 mL samples were taken periodically at time point of 0, 12, 24, 36,72 and 96 hours. It were centrifuged, and the supernatants were analyzed for soluble sugars. Glucose concentration on enzymatic hydrolisis was measured using High Performance Liquid Chromatography (HPLC) at time point of 0, 12, 24, 36,72 and 96 hours.

3. RESULT AND DISCUSSION

3.1 Biogas Production

The result of biogas measurement for oil palm empty fruit bunches with propyl amine pretreatment was presented on Figure 1.

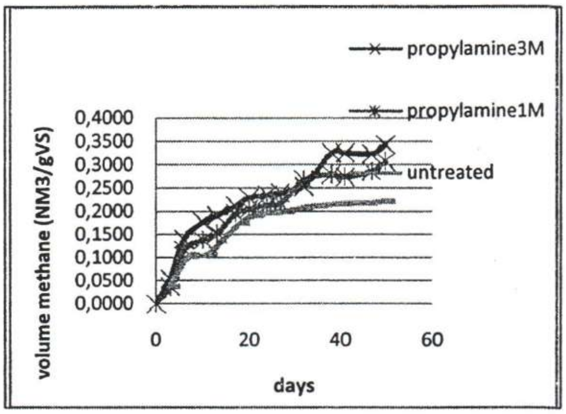

Figure 1. Normal Volume Methane After 50 days

Figure 1 show that volume of biogas production by pretreated material (propyl amine) was higher than untreated material. On day-3rd, pretreated material volume has been increased by 20-33% increments according to the increasing of fermentation time. At the end of fermentation, the increasing of volume pretreated material reached 54% compared to untreated material. Material with 3M Propyl amine pretreatment made the highest volume. It can be concluded that propyl amine pretreatment made a good progress on biogas production.

3.2 Bioethanol Production

The increasing volume of bioethanol after pretreatment was indicated by the increasing of glucose concentration in enzymatic hydrolysis, as shown in Figure 2

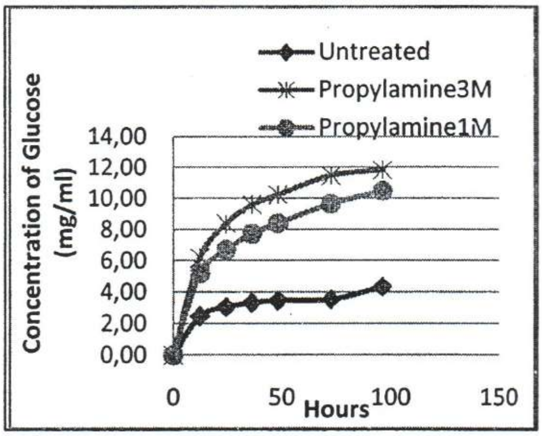

Figure 2. Enzymatic hydrolisis of oil palm empty fruit bunches

Figure 2 shows that pretreated material produce higher glucose concentration during enzymatic hydrolisis compared to untreated material. The increasing of glucose concentration reached 50% after 12 hours and 60% at the 96 hours.

It was apparent that waste oil palm empty fruit bunches can be use as a feedstock of biogas and bioethanol production and propyl amine pretreatment make the production increase significantly. But the cost of production, including cost of pretreatment compare to the price of products still need to intesvigate.

4. CONCLUSION

1. Waste oil palm empty fruit bunches showing progress as a feed-stock on biogas and bioethanol production.
2. Pretreatment is needed to increase digesbility oil palm empty fruit bunches. Pretreated material can give yield higher than untreated material.
3. Propyl amine pretreatment made a good progress on both biogas production and hydrolysis enzymatic on bioethanol production. It can ahieved 54 % increasing volume biogas compare to untreated material, and 60% increasing glucose concentration on hydrolysis enzymatic on bioethanol production.
4. Propyl amine 3 M gave the highest progress in biogas production and hydrolysis enzymatic in bioethanol production.

ACKNOWLEDGEMENTS

This work was supported by University of Boras, Sweden and sponsored by Linnaeus Palme Student Exchange Program.

REFERENCES

Brown L, and R.W. Torget. (1996). "Enzymatic Saccharification of Lignocellulosic Biomass". LAP-009. http://devafdc.nrel.gov/pdfs/9578.pdf.

Fan, Y.Zhang, Zhang,S.Hou, H,Ren.B. (2006). *Efficient Convertion of Wheat Straw Wastes into Biohydrogen Gas by Cow Dunng Compost.* Bioresorces Technology. 97(3), 500-505.

FAO, (1999). "*Prevention of Land Degradation, enhancement of carbon sequestration and conservation of biodiversity through land use change and sustainable land management with a focus on Latin America and The Carribean, International Fund of Agricultural Development*", FAO, Rome.

Hansen, T.L. (2004). *Method for Determination of Methane Potential of Solid Organic Waste.* Waste Management, 24 : 393-400.

International Energy Agency. "Biogas Production and Utilization". http://www.iea-biogas.net/Dokumente/Brochure%20final.pdf

Kim, Seungdo and Dale, Bruce.E. (2004). *Global Potential of Bioethanol from wasted crops and crop residues.* Biomass and Bioenergy 26, 361-375.

Knauff and Moniruzzaman. (2004). Lignocellulosic Biomass Processing a Perspective. *International Sugar Journal.* 106, 147-150.

Mosier, N., Wayman, C., Dale, B., Elander, R., Lee, Y.Y., Holtzapple, M., Landisch, M.. (2005). *Features Of Promising Technologies For Pretreatment of Lignocellulosic Biomass. Bioresource Tecnology.* 96, 673 – 686.

Owens, J.M and D.P Chynoweth. (1993). *Biochemical Methane Potential of Municipal Solid Waste Components*. Water Science Technology. 27 : 1-14.

Reith, J.H, R.H. Wijffels, and H.Barten. (2003). *Biomethane & Bio-hydrogen, Status and Perspectives of Biological Methane and Hydrogen Production.Dutch Biological Hydrogen Production.* Energy Research Center of Netherland.

Sluiter dkk. (2008). *Determination of Ash in Biomass. Laboratory Analytical Procedure.* National Renewable Energy Laboratory (NREL).

Speece, R.E. (1996). *Anaerobic Biotechnology for Industrial Wastewater.* Nashville, TN, Archae Press.

Themelis N.J and Uloa P.A. (2007). *Methane Generation in Landfills*. Renewable Energy. 32 :1243-1257.

United Nations Development Programme. World energy assessment. United Nations Development Programme.New York, 2000.

Wyman, C.E., 1996. "Handbook On Bioethanol; Production and Utilization". Taylor &Francis, Washington, DC.

Wyman, C.E., Dale B.E, Elander R.T, Holtzapple M, Ladisch M.R, Lee Y.Y.. (2005). *Coordinated Development of Leading Biomass Pretreatment Technologies.* Bioresources Technology. 96: 1959-1966.