Harvesting Bio-Fuel from Waste Papers Through Fermentation using Commercial Yeast

Background

Paper continues to play an important role in the daily lives of billions of people, even in a world of computers and cell phones [1]. Paper comes in many forms from tissue paper to cardboard packaging to stereo speakers to electrical plugs to home insulation to the sole inserts in your tennis shoes [2].

World consumption of paper has grown 400 percent in the last 40 years [2]. In 2010, United States, the world's largest paper-consuming country [3], which has less than 5% of the world's population, consumes 30% of the world's paper [4]. United States trashed enough paper to cover 26,700 football fields or 17,800 soccer fields in paper three feet deep [5]. Each person in the United States uses 749 pounds (340 kg) of paper every year (adding up to a whopping 187 billion pounds (85 billion kg) per year for the entire population, by far the largest per capita consumption rate of paper for any country in the world) [2].

The amount of paper which is consumed also represents the amount of waste paper which is produced. Waste paper is one of the most visible components in the solid waste stream and also one of the most versatile. The principal sources of waste paper comprise industries, trade, offices and households, with the largest share coming from converting industries, printing and publishing houses and major retail outlets. For example, box-manufacturing plants provide corrugated board clippings while supermarkets and retail shops discard large quantities of used corrugated containers. Paper-converting and printing houses are a source of trimmings, shavings, clippings, misprints and unsold books, newspapers and magazines. Offices generate large quantities of good-quality waste, including printing and writing papers and, especially in the recent past, growing quantities of waste from computer print-outs and photocopying machines [3].

The problem with all the paper being thrown away is not just about landfill space. Once in a landfill, paper has the potential to decompose and produce methane, a greenhouse gas with 21 times the heat-trapping power of carbon dioxide (UNEP). Finally, transportation throughout the system also has significant environmental impacts. Harvested trees or recovered paper are transported to pulp mills, rolls of paper are transported to converters, and finished paper products are transported to wholesale distributors and then on to their retail point of sale. Transportation at each of these stages consumes energy and results in greenhouse gas emissions [6].

On the other side, energy crisis becomes the main issue to be discussed. Energy crisis happens because the increasing demands of fossil fuels every year. The dependence on fossil fuels causes the depletion of fossil fuel reserves, whereas for renewal takes thousand, even millions of years [7]. Besides, the use of fossil fuels also poses serious threat: pollution due to burning of fossil fuel emissions to the environment [8].

The awareness to the serious threat which is caused by fossil fuels triggers researches to create alternative energy sources which are sustainable and environmentally friendly [8]. One of promising alternative energy is ethanol. Ethanol or ethyl alcohol C_2H_5OH is a colorless clear liquid, biodegradable, low toxicity, and not cause air pollution when leaked. The burning ethanol will release carbon dioxide (CO_2) and water (H_2O). Ethanol is high octane fuel and it can replace lead as an octane enhancer in gasoline values [9]. Ethanol can be used in the pure form or as a mixture of gasoline and hydrogen fuel [10]. By mixing ethanol and gasoline, the combustion reaction will run perfectly, thereby reducing exhaust emissions (such as carbon monoxide, CO) [9]. Ethanol has been proven as renewable fuel which has high economic value. In general, ethanol is produced by fermentation with microorganisms, therefore often called bio-ethanol [11].

Ethanol fermentation research from waste pulp cellulosic was done step by step by *Trichoderma reesei*, member of microbial fungi, and *Saccharomyoes cerevisiae*, member of yeast, for 66 hours. The first step is biodegradation of cellulose to sugar by *T. reesei* produced 1.7 mg/ml of glucose. The other step is bio-conversion of glucose to ethanol by *S. cerevisiae* produced 0.8 mg/ml of ethanol, Waste pulp cellulosic content 0,402% of cellulose. Degradable cellulosic from this waste is 0,364% with degree of success 90.5%, so in the post of fermentation still content 0,038% of cellulose [12]. Other research, converting waste paper becomes bio-ethanol using cellulose enzyme through the simultaneous process of saccharification and fermentation, inked paper, de-inked paper, and newspaper give the concentration of ethanol 1238.9, 669, and 1428 ppm [8].

Finally, this research proposes the harvesting of bio-ethanol from waste papers through fermentation using commercial yeast as the waste papers management in household.

Objective

- Determining the influence of the types of commercial yeast against alcohol content.
- Determining the influence of the concentration of yeast against alcohol content.
- Determining the influence of the time of fermentation against alcohol content.
- Optimizing the alcohol content in the fermented result as revealed by the types of commercial yeast, concentration of the yeast, and time of fermentation.
- Identifying the heat of combustion of fermented result.

Methodology

Sample Preparation *and* ***Raw Sample Pre-Analysis***

Materials which are used in this experiment are waste paper and commercial yeast. The waste papers are obtained from photocopying centre. The waste papers are sorted according to their types of paper. The waste papers are shredded and cut into pieces; size is 3-4 mm, for ease of feeding the raw materials.

Experimental Process

Preparing the Waste Paper Substrate

The substrate is prepared by mixing the waste papers with water in equal ratio. The substrate is stirred until homogenous, and then the substrate is pasteurized on temperature of 70^0C during 30 minutes.

Preparing Starter from the Commercial Yeast

The starter is commercial yeast which is grown in 1000 ml of distilled water and 100 grams of sugar (sugar concentration 10%) which are prepared in a glass beaker. Then, the substrate is homogenized using magnetic stirrer and sterilized using an autoclave at a temperature of 121^0C for 15 minutes. The substrate is allowed to cool about room temperature. After reaching the room temperature, 50 grams commercial yeast is poured into the substrate, and then incubated at 30^0C for 8 hours.

Inoculating Starter to Waste Paper Substrate

After the starters are incubated for 8 hours, then the starter readies for being inoculated in the fermentation substrate. Starter is inoculated in the fermentation substrate in aseptic conditions. The concentration of inoculated starter is based on the variation of the concentration of starter.

The Influence of the Types of Commercial Yeast against the Alcohol Content

The variations of starter are various kind of yeast which is commercial. In the end of fermentation, the alcohol content is tested for each use of yeast.

The Influence of the Concentration of Starter against the Alcohol Content

The commercial yeast which produces the higher alcohol content is being used in this experiment. The variations of the concentration of starter are 5%, 10%, and 15%. After the fermentation finishes, the alcohol content is tested.

The Influence of the Time of Fermentation against the Alcohol Content

The variations of the time of fermentation are 24, 48, 72, 96 hours. Then, in the end of fermentation, the alcohol content is tested.

The Optimizing of Alcohol Content as Revealed by the Concentration of Starter and Time of Fermentation

The optimum concentration of starter and time of fermentation is used to convert the waste papers. Then the alcohol content is tested.

Testing the Alcohol Content (Dichromate Oxidation Method)

Sample of 1 gram is weighed, and then homogenized with 100 ml aquades in 250 ml erlenmeyer. The mixture is distilled at temperature of 85^0C. Distillate is patched in 100 ml erlenmeyer which contains 25 ml $K_2Cr_2O_7$. Distillation is stopped when the volume of distillate reach 40 ml.

Distillate is diluted in aquades until reach the volume of 250 ml. The mixture of 25 ml is titrated with $FeSO_4(NH_4)_2SO_4$ until the color of the mixture turns clear green. Then, 3 drops of phenanthroline is added and titrated again until the color turns brown.

The blank solution is 25 ml $K_2C_r2O_7$ which is diluted in aquades until reach the volume of 250 ml. The mixture of 25 ml is poured in 100 ml erlenmeyer, then titrated with $FeSO_4(NH_4)_2SO_4$, like the previous procedure.

The calculation for alcohol content:

$$\text{Alcohol content (\%)} = 25 - \left(25 - \frac{c}{b}\right)$$

c = the resulting titration of sample

b = the resulting titration of blank

Testing the Heat of Combustion

Aquades of 200 ml is poured in the beaker glass. The mass of aquades and beaker glass is weighed. The mass of the sample (bio-fuel) also weighed. The temperature of aquades during heating is measured regularly (every 0.5 minute) until the temperature increases 15^0C. After heating, the mass of sample is weighed.

Significance

The production of bio-ethanol from waste papers can reduce dependence on fossil fuels while simultaneously solving the environmental problems associated with waste papers disposal. The use of bio-ethanol produced from waste papers offers an alternative source of energy, which could help overcome the current fossil fuel crisis and slow global warming. Using waste papers as raw materials for bio-ethanol production, rather than using biomass, is being researched, due to the lower costs of raw materials and to avoid competition with human needs occurring when food crops are used, as is the case for first generation production processes.

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