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PRODUCTION OF CELLULOSIC ETHANOL FROM SUGARCANE BAGASSE - AN APPROACH TO SUSTAINABLE DEVELOPMENT

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ABSTRACT

Sugarcane processing involves a large left over volume of bagasse and its disposal is critical from both agricultural and environmental aspects. The study includes processing of sugarcane bagasse, which is a renewable resource that can be used to produce ethanol, which later can be used in blending or as potable and industrial alcohol. In this work, the process of ethanol production from sugarcane bagasse was studied considering the use of alkaline hydrogen peroxide and acid hydrolysis simultaneously. Yeast named Sachharomyces cerevisiae was used for fermentation under optimum condition- pH 4.5 and temperature around 32ºC-35ºC. The pretreatment involved increases the accessibility of sugar trapped, without the use of any cellulose enzymes. Sugar presence before and after fermentation was determined and the fermented samples collected at regular intervals was monitored using Gas Chromatography for ethanol production analysis. Significant removal of lignin was achieved in this study, which resulted in quite favorable production of ethanol around 64.3 g/l, about 8-9% by volume. The result indicates that it is possible to reuse the sugarcane bagasse left as residue for production of ethanol with easily available raw materials and equipments as the basic aim was low cost ethanol production using lignocellulosic materials.

Keywords – Acid Hydrolysis, Bagasse, Ethanol, Fermentation, Gas Chromatography

I.INTRODUCTION

Population growth results increase in energy consumption. This increase is not proportional with supply in the world. People dependency on fossil energy, which is non renewable and polluter, for so many years, now direct towards the search of a new alternative energy resources which need to be renewable, sustainable, efficient, cost effective, convenient and safe. In recent years, efforts have increased toward the commercial production of ethanol, considering the most promising biofuel from renewable resources. The development of second generation bioethanol made from lignocellulosic biomass can increase the sustainability of feedstock production without harming the regular food production or the cultivation of farmland. Although the process is very costly in terms of energy input required, it can be helpful in minimizing the utilization of fossil energy sources and reusing the excess material and byproducts available. As, the conventional sources of energy drying up at faster rate, the alternate sources be explored, examined and implemented in no time.

Among the various agricultural crop residues, sugarcane bagasse is the most abundant lignocellulosic material found in tropical countries. In India, approx. 1 ton of sugarcane generates 300 kg of bagasse. Being the second largest sugar producing country of the world after Brazil and second largest agro-based industry after cotton textiles, there are about 664 sugar factories in total with a Rs. 7000 billion annual turnover. And a large proportion of bagasse is generated. This sugarcane bagasse, being renewable resource, can be used to produce ethanol and other value added products [1]. In India, around 70% of this is used in cogeneration of heat and electricity, whereas, the remaining 30% considered as waste that goes to landfill or is allowed to decay. The 30%, which is considered as waste is basically lingo-cellulosic biomass, containing sugar in form of cellulose, hemi-cellulose and lignin. These sugars are not easily retrievable and hence the most challenging part in the production of ethanol [2].

Cellulosic ethanol is the alcohol produced from the feedstock available in wide variety of plant materials and agricultural residues, which are unsuitable for human consumption. Plant wastes like straw, corn stover, lingo-cellulosic raw materials and other by-products are used [3]. In this research, sugarcane baggase is used because of its easy availability, low cost and the ethanol produced proves to have low greenhouse gas emission, higher net energy content, high efficiency, when compared to other lingo- cellulosic materials like wheat straw, rice straw, etc [4,5]. Hence, this makes the ethanol produced, cheaper than other bio-ethanol. Only 12-15% ethanol at its maximum can be produced from sugarcane bagasse [6].

With major drawback of continuous flow of energy from single source, new energy sources are very much essential in India and global context. India and some other countries are looking into the production of cellulosic ethanol as a potential option to cut down their energy dependency on food crops by utilizing locally available raw material. In this work, ethanol is prepared using batch fermentation process and its quantification is done by Gas Chromatography, with standard ethanol.

II.MATERIALS AND METHOD ADOPTED

2.1. Preparation of sugarcane bagasse

The sugarcane was obtained from the local market from a sugarcane juice seller. They were the residue of the freshly prepared juice. The bagasse was dried openly under the Sun. Once dried, it was cut into small fragments manually. Sealed in a poly-bag and stored in room temperature.

2.2. Delignification of the mixture prepared

200 g sugarcane bagasse was weighed and placed in a container. Making solid – liquid ratio 1:20, alkaline Hydrogen Peroxide (H_2O_2) of 2% (v/v) concentration was added, adjusting the pH of the mixture 11.5 using 1N Sodium Hydroxide (NaOH) solution. And the mixture obtained was allowed to soak for 48 hrs. Later the filtration is done, separating liquid fraction and allowing the solid one for further processing.

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2.3. Hydrolysis

Dilute sulphuric acid of 1M was added to the solid fraction, making optimum required pH 4.5. And again the mixture was left to soak for 24 hrs further. Filtration is carried out finally.

2.4. Fermentation of the filtrate

After undergoing the pretreatment step and H_2SO_4 addition, the liquors obtained goes for fermentation. In fermentation process, *Saccharomyces cerevisiea* (Baker's yeast) was used to ferment the sugar present to ethanol and carbon dioxide. Urea was added as the nutrient for yeast growth. The optimum condition- pH 4.5 and temperature around 32ºC to 37ºC was maintained. The process continued until the specific gravity tested in fixed interval was approximately same. And this was done with the help of hydrometer. Samples were collected at fixed interval of time and later sent for analysis.

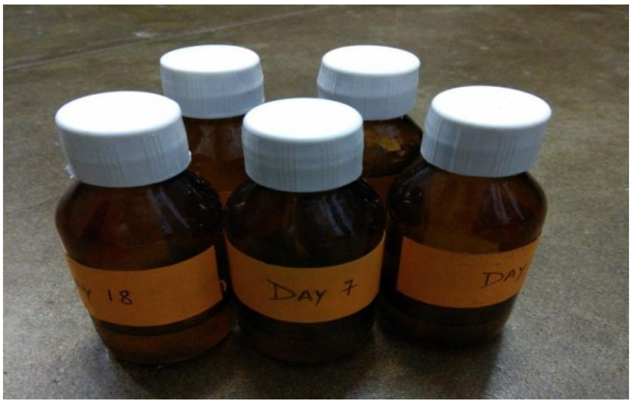

Figure 1: Photographic image of the fermented samples collected in the experiment

2.5. Analysis

The fermented samples were analyzed by the Agilent 7890B GC (Gas Chromatography) equipped with FID (Flame Ionization Detector). The parameters involved were:

1µl of the sample was injected into the GC system.

Column HP -5 30 m × 0.32 mm × 0.25 µm with temperature range 60ºC-325ºC.

Oven temperature: 80ºC

Injector temperature: 270ºC

Detector temperature; 280ºC

Carrier gas: N_2

Carrier gas flow rate: 15ml/min

Quantification of ethanol was done using standard ethanol.

III. RESULT AND DISCUSSION

Bagasse, being a lignocellulosic material, consists of cellulose, hemicelluloses and lignin. Separation of all these have been very difficult but the involvement of the ideal four steps make it possible, which are- pretreatment, hydrolysis, fermentation and finally distillation for product recovery.

Pretreatment is the process of converting biomass to fermentable sugars and the most used technologies are pretreatment with lime and pretreatment with alkaline H_2O_2 [7]. In this work, hydrogen peroxide is used as it was seen to remove most of the lignin content [8] with the advantage of not leaving residues in the biomass by degrading into oxygen and water. H_2O_2 pretreatments have been studied in many cases [7] whether the raw material is wheat straw, rice straw, other crop residues or any other lingo-cellulosic material, all can be readily fermented to ethanol with greater than 90% efficiency [9].In this study, the sugarcane residue pretreated with 2% H_2O_2 concentration at pH 11.5 for 2 days and hydrolyzed with H_2SO_4 for 1 day.

The weight before and after the processing was weighed and the decrease in weight percentage was calculated which is found to be 51.5%. This percentage decrease shows the effect of pretreatments on lignin removal. Greater weight loss indicates more lignin removal and thus increases the total sugar content in the solution. (Considering the fact that the sugar concentration encountered in the pretreatment varies with the presence of cellulose content in the feedstock used.) This can be helpful in determining the better pre-treatment methods to be followed.

For further fermentation process, the optimum condition- pH 4.5 and temperature around 35ºC was employed [10]. The process was carried out with baker yeast and as supplement urea was used. At regular intervals, the fermented samples were drawn and specific gravity was found using Triple Scale Hydrometer. The hydrometer was used to ensure the working of the system and production of alcohol. With every increase in number of days, the specific gravity of the solution drops as more sugar is converted to alcohol. Denser the liquid (more sugar in it), higher is the gravity reading. ABV (Alcohol By Volume) was calculated to be 9.2% [13], stating the rough estimate of maximum alcohol that can be produced through the prepared sample. After filtering two to three times, the sample collected was injected into GC for monitoring the ethanol production, and later found to be 8-9% (approx) by volume.

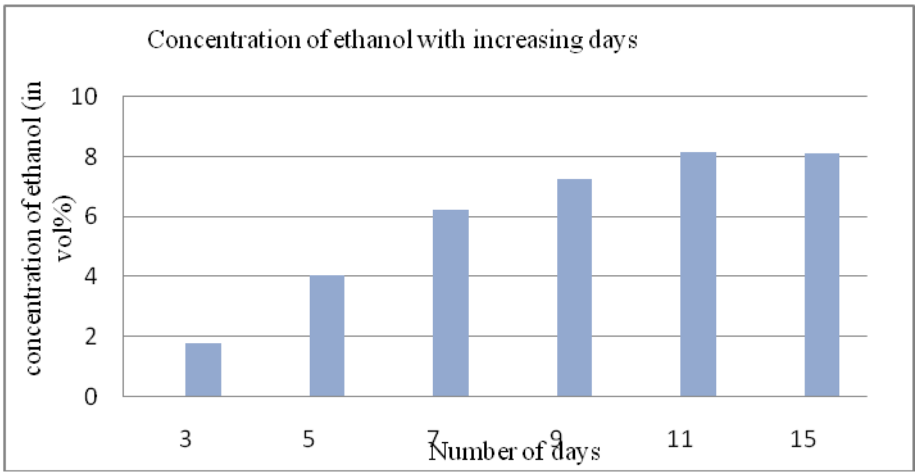

Figure 2: Comparison of ethanol content with increasing no. of days

IV.CONCLUSION

This study involves the batch process with no special enzymes, buffer or any advanced equipments and not even cultured yeast with different supplements. In name of supplement, only urea was used. It was a process, with easily available equipment and raw material, plus cost effective. The combination of alkaline delignification with steam explosion increase the surface area and reduction of the lignin content at its best. With this, advanced hydrolysis and fermentation like fed-batch hydrolysis helps in greater ethanol production [11]. Nevertheless, we aren't letting the bagasse go wasted. The residue obtained can be used for biogas production or heat generation. So basically almost everything is used. But still the problem of availability of raw material prevails, which accounts for a proper channel for the supply of bagasse. In addition to this incorporating distillation and cogeneration plants within the sugar mill can reduce this unavailability problem to a greater extent [12].

For better quantification of ethanol, GC equipped with TCD (Thermal Conductivity Detector) or MSD (Mass Selective Detector) should be used as it counts water presence also or in higher terms HPLC (high pressure liquid chromatography) can be used. The study showed that the production of ethanol from sugarcane residue-bagasse is quiet possible, under the treatment with alkaline hydrogen peroxide and acid hydrolysis. With the use of hydrogen peroxide, higher lignin removal about 51.5% was found and 8-9% by volume (approx.) that is around 64.3 g/l maximum ethanol was produced as determined by GC. Thus, the use of lignocellulosic material-Sugarcane bagasse is found to be very effective substrate for ethanol production and this might be helpful for scaling up and making the process cost effective.

With proper supplements and feeding regimes, bioethanol from agricultural waste could be a promising technology though the process has several challenges and limitations such as biomass transport and handling, and efficient pretreatment methods for total delignification of lingo-celluloses. Several technological advances have already been investigated but most of them are still confined to the laboratory. It required a lot of research to confirm the best suitable technique and the best source for economically viable production system.

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