Ethanol production from different sources in India- A Review

Rajat Kumar

Associate Professor, Chemistry Department

DAV-PG College Kanpur India 208001

ABSTRACT

To meet the energy requirement for transport, blending automotive fuels with ethanol has been mandated in India like several other countries across the globe. The entire blending requirement has to come from molasses (by-product of sugarcane). Ethanol produced from molasses will not be able to meet the blending targets due to cyclical nature of sugar cane production resulting in shortage of molasses and its competing uses (potable and pharmaceutical use). This has promoted research efforts to augment energy sources that are sustainable and economically viable. The production of ethanol from food such as corn, cassava etc. is the most predominate way of producing ethanol. This has led to a shortage in food, inbalance in food chain, increased food price and indirect land use. This thesis thus explores using another feed for the production of ethanol- hence ethanol from cellulose. Sawdust was used to carry out the experiment from the production of ethanol and two methods were considered: SHF (Separate Hydrolysis and Fermentation) and SSF (Simultaneous Saccharication and Fermentation). The SHF proved more hazardous than SSF and also had waste products that are hazardous to the environment.

Keywords: Cellulose, Ethanol, Fermentation

INTRODUCTION

The emission of greenhouse gases as a result of combustion of fossil fuels led to desire for an alternative or a fuel additive which has led to the increasing demand for ethanol. Ethanol production, however, traces back as far as the days of Noah who was believed to have built himself a vineyard in which he grew grapes that he fermented into some sort of alcoholic beverages. It is an important member of a class of organic compounds with the general name ‘Alcohols’. During those early times, ethanol was used as a constituent of alcoholic beverages. With civilization and advancement in science and technology, the benefits derivable from ethanol have continued to multiply. These include solvent, germicide, as anti-freeze, fuel and versatile intermediate for other organic chemicals. For these enormous advantages of ethanol, researchers have been geared towards the production of ethanol from various raw materials (or feedstock). However, in an attempt to save the food chain and to reduce the inflation of food prices caused by ethanol from agricultural feed (sugar or starchy crops), researches are made on production of ethanol from cellulose. Cellulose as described by biologist and chemists is a complex carbohydrate. Cellulose is a linear polysaccharide polymer with glucose monosaccharide units (300 to over 10, 00units with the formula C6H10O5).
Cellulose is the most common organic compound on earth. Cellulose sources include plant fibers (cotton (90% cellulose), hemp, flax, and jute, corn, and wood (about 42% cellulose). Since cellulose is insoluble in water and can be separated easily from other plant constituents. This acetyl linkage-beta makes it impossible for human beings to digest cellulose due to lack of necessary enzymes to break down cellulose into simpler units. This indigestible cellulose is referred to as roughages, they aid in the smooth working of the intestinal tract. Cellulose is useful in the production of paper and paper products, cotton, linen, and rayon for cloths, nitrocellulose for explosives, cellulose acetate for films, etc. it is also used as feedstock in the production of cellulosic ethanol. Asides from agricultural feed and cellulosic biomass other feed stock in the production of ethanol includes:
. Algae: rather than grow algae, harvest and ferment it, the algae grow in sunlight and produce ethanol directly which is removed without killing the algae. It is claimed the process can produce 6000 gallons per acre per year compared with 400 gallons for corn production.[17] 7

1. Sweet Sorghum for Ethanol Production

Sorghum [*Sorghum bicolor* (L) Moench] is considered to be one of the most important food and fodder crops in arid and semi-arid regions of the world. Globally, it occupies about 45 million hectares, with Africa and India accounting for about 80% of the global acreage (Reddy et al., 2009). Like grain sorghum, sweet sorghum, a warm-season crop, can be cultivated by smallholder farmers in rainfed areas. The crop can be grown successfully on clay, clay loam or sandy loam soils and can tolerate salinity and alkalinity to a large extent (Reddy et al., 2008, Rao et al., 2009). Cultivation practices of sweet sorghum are similar to that of grain sorghum. The only dissimilarity between grain sorghum and sweet sorghum is seen in the accumulation of sugars in the stalks of sweet sorghum that can be crushed to extract juice, which is finally processed into ethanol for blending. Besides the juice extracted for bio-ethanol, additional benefits are the grain harvested for food, and bagasse left after extraction of juice from the stalk, which is an excellent feed for livestock.

In view of the potential benefits of sweet sorghum as a feed stock for bio-ethanol production, a value chain approach model of sweet sorghum as a food-feed-fodder-10 fuel is being tested on a pilot basis in Andhra Pradesh to augment incomes of farmers while promoting a sustainable sweet sorghum–ethanol value chain. It is in this context, that an attempt is made in this paper to assess;

a. The financial and economic viability of ethanol production from sweet sorghum,

b. The future area requirement for sweet sorghum cultivation to meet a small proportion of mandated blending requirements if sweet sorghum is commercially exploited with policy support.

2. **STRACH ETHANOL**

Ethanol is commercially produced in one of two ways, using either the wet mill or dry mill process. This is a feed preparatory process. Although wet mill facilities were common in the industry's early days, dry mill facilities now account for more than 80 percent of industry capacity. The steps involved in the production of ethanol from cellulose are:

I. Gelatinization: is the swelling of starch granule in the presence of heat and water. The starch loses its crystallinty and becomes an amorphous gel that can be attacked by enzymes.'

II. Liquefaction: At this point, the starch or grounded grain slurry thickens considerably and would be difficult to process if an alpha- amylase were not added to partially hydrolyze the starch to dextrin. The pH is adjusted to about 5.8, and an alpha- amylase enzyme is added. The slurry is heated to 180-190 degree for 30-45 minutes to reduce viscosity. The alpha

amylase is a bacteria thermostable endo-amylase. It hydrolyzes 1.4 bonds at random points in the starch molecule to rapidly reduce the viscosity of gelatinized starch solutions. The dextrin solution is much more fluid; thus, we say the starch gel is liquefied. The alpha- amylase serves to reduce the viscosity of the solution and also to produce a lower molecular size substrate. This smaller substrate molecule is needed for the efficient action of glucoamylase.

III. Saccharification: this smaller substrate molecule is needed for the efficient action of glucoamylase which hydrolyzes the dextrin to glucose. After the flash condensation cooling, the mixture is held for 1-2 hours at 180-190 degree to give the alpha- amylase enzymes time to break down the starch into short chain dextrin. After pH and temperature adjustment, a second enzyme, glucoamylase, is added as the mixture is pumped into fermentation tanks.

IV. Fermentation: Yeast or candida tropical is added to convert the sugar to ethanol and carbon dioxide. The mash is then allowed to ferment for 50-60 hours, resulting in a mixture that contains about 15% ethanol as well as the solids from the grain and added yeast. However this will be applicable in SHF, in SSF, the glucoamylase and fermenter are added together so that saccharification can occur simultaneously.

V. Distillation: this solution is then distilled to get ethanol

ADVANTAGES OF CELLULOSIC ETHANOL OVER STARCH ETHANOL

The advantages of cellulosic ethanol over starch ethanol are as follow:

1. According to Regmi et al (2001), a 1% increase in food prices causes and average 0.75% decline in food consumption in developing countries. In addition to reducing caloric intake as food prices increase, low-income people also switch to less nutritious food by Von Braun (2007)

2. Cellulosic ethanol as a viable alternative for reducing oil dependence while protecting crops i.e. way to prevent the displacement of crops that feed humans.

3. Corn-based ethanol has been blamed by some for higher food prices and shortage because food productions are at times forced to compete with energy companies for the grain. Some also argue that the growing demand for such crops is also responsible for indirect land-use change, the destruction of rain forests and wetlands to make room for more farmland. On the other hand, proponents of cellulosic ethanol argue that because the fuel is produced from agriculture byproducts, it has no impact on the food supply or land use.

4. Cellulosic ethanol could help reduce air pollution- cellulosic ethanol not only emits less greenhouse gas than gasoline but emits fewer fine particles into the air.

5. From the analysis carried out, it is apparent that a shorter residence time is required for the production of ethanol from cellulose.

CONCLUSION

This research work based on the extraction of sugar and subsequent fermentation of the sugar from cellulose. Study was carried out on ethanol from starch and ethanol and cellulose were compared. However for the experiment the cellulosic material or biomass used is sawdust. Two methods were used to produce the cellulosic ethanol: SHF and SSF.

It can be inferred that the SHF is a very dangerous method as highly concentrated acid is being use for the hydrolysis. However it is less costly compared to SSF method due to the use of cellulose enzymes. The SSF, however, produces more ethanol compared to SHF but the difference in the ethanol production doesn't account for the difference in cost of production making the SHF more cost effective. This may not be applicable on a large scale though.

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