A REVIEW ON BIOETHANOL FROM CELLULOSIC MATERIALS: A BIOMASS-BASED RENEWABLE MOTOR FUEL

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ABSTRACT

The most commonly utilized liquid biofuel is ethanol. It's an alcoholic beverage that's made from sugars, starches, or cellulosic biomass. Bioethanol may be made from cellulosic resources. Bioethanol is a significant renewable liquid fuel for automobiles. Bioethanol production from biomass is one method to decrease crude oil use while also reducing pollution. Conversion methods for generating ethanol from cellulosic biomass resources including forest materials, agricultural leftovers, and urban wastes are still in the works and have yet to be commercialized. A pretreatment procedure is used to decrease the sample size, break it down the hemicelluloses to sugars, or open up the framework of the cellulose component in order to generate bioethanol from cellulosic biomass. Acids or enzymes undergo hydrolysis the cellulose to produce glucose sugar, which is fermented to produce bioethanol. Hemicellulose sugars are also fermented to produce bioethanol. The usage of bioethanol as a motor fuel dates back to the invention of the automobile. It all started with the introduction of ethanol into internal combustion engines.

KEYWORDS: *Bioethanol, Biomass, Ethyl Alcohol, Fermentation, Hydrolysis, Sugar.*

1. INTRODUCTION

Given the ever-increasing expense of petroleum or our reliance on fossil fuel supplies, alternative energy sources have received a lot of attention. The ethanol production, also known as ethyl alcohol (CH3CH2OH), from biomass is one method to decrease both crude oil use and pollution. The manufacture of ethyl alcohol from renewable resources is a primary issue, as is determining the economic and technological viability of utilizing alcohol as an automobile fuel mixed with gasoline. Ethanol is a significant renewable liquid fuel for automobiles. For a variety of reasons, the usage of gasohol (a combination of ethanol or gasoline) as an alternative motor fuel has been gradually growing throughout the globe. Domestic ethanol production and usage as a fuel may help to minimize reliance on foreign oil, reduce trade imbalances, generate employment in rural regions, reduce air pollution, or reduce global warming carbon dioxide accumulation. Ethanol, unlike gasoline, is a 35 percent oxygenated fuel, which lowers particle and NOx emissions during burning. When fermented ethanol is burnt, there is no net increase in carbon dioxide in the environment. It's an octane-booster that also eliminates free water, which may clog gasoline lines in cold weather **[1].**

The most commonly utilized liquid biofuel is ethanol. It's an alcoholic beverage that's made from sugars, starches, as well as cellulosic biomass. Because starches and cellulosic biomass need costly pretreatment, the majority of commercial ethanol production comes from sugar cane or sugar beet. It is utilized as a renewable energy source, as well as for the manufacturing of cosmetics, medicines, and alcoholic drinks. Ethyl alcohol is not only the oldest but also one of the most significant synthesized organic chemicals utilized by humans. An previous research looked at the physiological effects of inhibitors on ethanol produced from lignocellulosic materials and fermentation methods. For example, yeast-based fermentation has produced ethanol from sugar or crops. The commercial manufacture of ethanol from sugar fermentation is well established, but new research may lead to advancements in reactors or separation systems. At the demonstration as well as industrial scales, hydrolyzing lignocellosic materials before fermentation is required to generate ethanol. Enzymatic hydrolysis is still in its infancy, necessitating much basic study **[2].**

Conversion methods for generating bioethanol from cellulosic biomass resources such as forest materials, agricultural leftovers, and municipal wastes are still in the works and have yet to be commercialized. Private investment in such facilities is hampered by uncertainty about commercial scale performance and profitability, as well as an uncertain market forecast in the long run. In 1998, the global ethanol output was projected to be 33.3 billion liters. Synthetic ethanol accounts for around 9% of total ethanol production, thus fermentation accounts for 91 percent of worldwide ethanol production. Brazil is the world's largest producer of alcohol, with 16.1 billion liters produced in 1998. Bioethanol manufacturing on various continents. The goals of this research are to identify the kinds of biomass that may be utilized to make bioethanol, assess biomass-to-ethanol possibilities, and explore the sugars that can be converted to bioethanol through fermentation from both cellulose and hemicelluloses **[3].**

1.1. Resources for Cellulosic Biomass:

Cellulosic materials, such as paper, cardboard, wood, agricultural wastes, and other fibrous plant material, are common and plentiful. Forests, for example, account for about 80% of global biomass. Ethanol may be made from a variety of different basic sources. The agricultural raw materials are separated into three categories: simple sugars, starch, and cellulose. Cellulosic biomass materials may be obtained at a cheap cost from a number of sources. Based on the kind of resource, they may be divided into four categories: wood, municipal solid waste, waste-paper, and agricultural residual resources. Different kinds of cellulosic biomass materials have different structural compositions **[4].**

Cellulosic materials are very cheap feedstock for ethanol production since they are plentiful and outside the human food chain. Lignin, hemicelluloses, and cellulose make up cellulosic materials, which are also known as lignocellulosic materials. Cellulose molecules, like starch molecules, are made up of long chains of glucose molecules (6-carbon sugars), but their structural arrangement is distinct. Cellulosic materials are more difficult to hydrolyze than starchy materials due to their structural features and lignin encapsulation. Hemicelluloses are made up of long chains of sugar molecules, but instead of glucose, they include pentoses. In the carbohydrate fraction of wood, the relative quantity of particular sugars **[5].**

1.2. Bioethanol is being used as a transportation fuel:

The use of ethanol as a motor fuel has a lengthy history, almost as old as the automobile itself. It all started with Nikolas Otto's invention of the internal combustion engine in 1897. (Rothman et al., 1983). Since the invention of the car, alcohol has been utilized as a fuel. Alcohol is a word that has been used to refer to either ethanol or methanol as a fuel. Following the oil crisis of the 1970s, ethanol gained traction as a viable alternative fuel. Many nations have begun research and development projects to produce fuels from readily accessible basic materials in a cost-effective manner (Paul, 1979). The attention faded as the price of oil fell, until 1979, when another oil crisis occurred. Ethanol has been explored as an alternative fuel in several nations since the 1980s. Brazil and the United States have long supported local bioethanol production. Aside from the energy considerations **[6].**

In the United States, ethanol/gasoline blends were marketed as an ecologically friendly technique, first as an octane booster to replace lead in gasoline. Ethanol is also useful as an oxygenate in clean-burning gasoline, which helps to decrease car emissions. Ethanol works effectively as a vehicle fuel, either on its own or in combination with gasoline. Aside from ethanol/gasoline blend markets, ethanol has several other motor fuel applications, including: (1) use as E85, which is 85 percent ethanol and 15 percent gasoline; (2) use as E100, which is 100 percent ethanol with or without a fuel additive; as well as (3) use as oxy-diesel, which is typically a blend of 80 percent diesel fuel, 10% ethanol, and 10% additives and blending agents.

Concerns about the greenhouse effect are one cause for interest in renewable energy sources. The development of ethanol as a vehicle fuel may help to meet this goal. Reduced greenhouse gas emissions should be calculated on a yearly basis. Where the values vary substantially from year to year, they should be stated on a yearly basis. When bioethanol made from biomass is used to power a light-duty vehicle, the net CO2 emissions are less than 7% of those produced by the same vehicle when reformulated gasoline is utilized **[7].**

1.3. Methods of Ethanol Production:

The simple alcohols that form the backbone of aliphatic chemical synthesis may be obtained in three ways (Morrison and Boyd, 1983). These are: (a) hydration of alkanes derived from petroleum cracking; (b) hydrolysis of cellulosic materials; and (c) carbohydrate fermentation.

1.4. Processes for Making Synthetic Ethanol:

The hydration of ethylene is the oldest of the two main ethanol manufacturing techniques from ethylene (CH2=CH2), having been developed over a century ago. Using sulfuric acid, ethanol is made from ethylene in a three-step process (H2SO4). In the first stage, 35–95 percent ethylene hydrocarbon feedstock is exposed to 95–98 percent sulfuric acid in a column reactor to produce mono-sulfate:

$$CH_2{=}CH_2 + H_2SO_4 \rightarrow CH_3CH_2OSO_3H \quad (1)$$

It is subsequently hydrolyzed with enough water to give 50–60% aqueous sulfuric acidsolution:

$$CH_3CH_2OSO_3H + H_2O \rightarrow CH_3CH_2OH + H_2SO_4 \quad (2)$$

In a stripper column, the ethanol is separated from the dilutes sulfuric acid. The sulfuric acid is then concentrated and recycled back into the process as the last stage. In the direct hydration method, an ethylene-rich gas is mixed with water and passed through a fixed-bed catalyst reactor, where ethanol is produced using the reaction described below.

$$CH_2{=}CH_2 + H_2O \rightarrow CH_3CH_2OH \quad (3)$$

The ethanol is then recovered in a distillation system. Ethanol can be obtained from acetylene process in the presence of the proper catalystsuch as H_2SO_4 and $HgSO_4$, ethylene reacts with water to yield acetaldehyde:

$$C_2H_2 + H_2O \rightarrow CH_3CHO \quad (4)$$

Acetaldehyde can be readily reduced by catalytic hydrogenation to ethyl alcohol:

$$CH_3CHO + H_2 \rightarrow CH_3CH_2OH \quad (5)$$

The classical catalyst is octacarbonyldicobalt, $Co_2(CO)_8$, formed by reaction of metalliccobalt with carbon monoxide**.**

1.5. Carbohydrate Fermentation for Bioethanol Production:

All five main biomass sugars will be used in fermentation utilizing genetically modified yeast or bacteria: glucose, xylose, mannose, galactose, as well as arabinose. Direct fermenting of sugars or other carbohydrates that could be converted to sugar, including such starch and cellulose, may be used to make bioethanol. The earliest synthetic chemical process utilized by man, yeast ferment of carbohydrates, is still crucial for the production of ethyl alcohol. The sugars originate from a number of sources, mainly molasses from sugar cane or starch from different grains; ethyl alcohol is known as a "grain alcohol" because of this. Simple sugars from sugar cane, sugarcane, molasses, including fruit; starch from grains, potatoes, and root crops; as well as cellulose from wood, agricultural residue,waste papers, municipal solid wastes, or crop leftovers are the three types of agricultural raw materials. Although certain sugars may be converted directly to bioethanol, starch and cellulose must first be hydrolyzed to sugar before being converted to bioethanol. The majority of polymeric raw materials are less expensive than refined sugars **[8].**

The fermentation technique typically involves three steps: (a) forming a solution of fermentable sugars, (b) fermenting these sugars to bioethanol, and (c) separating and purifying the ethanol, usually via distillation. Fermentation is a process in which bacteria utilize fermentable carbohydrates as food and create ethyl alcohol as well as other byproducts. The 6-carbon carbohydrates, of which glucose is one of the most prevalent, are usually used by these bacteria. As a result, cellulosic biomass materials that contain a lot of glucose or glucose precursors are the simplest to convert to ethanol. Ethanologens are microorganisms that convert a small percentage of the carbohydrates in biomass to ethanol. Although fungi, bacteria, and yeast microorganisms may be used to ferment glucose to bioethanol, a particular yeast (Saccharomyces cerevisiae, commonly known as Bakers' yeast) is usually employed **[9].**

1.6. Hydrolysis of Cellulosic Biomass Materials to Produce Bioethanol:

Pretreatment techniques relate to the solubilization and separation of one or more of the four primary components of biomass (hemicellulose, cellulose, lignin, and extractives) so that the remaining solid biomass may be treated chemically or biologically. The hydrogen bonds in the hemicellulose and cellulose fractions are broken down into their sugar components, pentoses and hexoses, during hydrolysis (saccharification). After that, the sugars may be fermented to produce bioethanol. There are two kinds of methods for hydrolyzing cellulosic biomass for fermentation into bioethanol after the pretreatment procedure. Chemical hydrolysis (both dilute and concentrated acid hydrolysis) and enzymatic hydrolysis are the two most frequently used techniques. There are also several additional hydrolysis techniques that do not need the use of chemicals or enzymes. Lignocellulose may be hydrolyzed by gamma-ray, electron-beam, or microwave irradiation, for example. Those procedures, however, are irrelevant in terms of business.Pretreatment is required for both enzymatic or chemical hydrolyses to improve the sensitivity of cellulosic materials. The pretreatment and hydrolysis may both be done in one phase using chemical hydrolysis. There are two main kinds of acid hydrolysis procedures that are frequently used. dilute acid and concentrated acid, each of which have their own set of advantages and disadvantages **[10].**

2. DISCUSSION

The use of enzyme or acid-catalyzed hydrolysis to produce compounds like ethanol, reducing sugars, and furfural from biomass leftovers accessible from agricultural and forest processes is a possibility. Domestic cellulosic biomass resources such as herbaceous and woody plants, agricultural and forestry leftovers, and a significant part of municipal solid waste and industrial waste streams may all be used to make bioethanol. Researchers are looking at specialized energy crops, timber, and grass species that have been chosen for high yields to guarantee that a low-cost energy feedstock is available. A pretreatment procedure is used to decrease the sample size, break down the hemicellulose to sugars, and open up the structure of the cellulose component in order to generate bioethanol from cellulosic biomass.

3. CONCLUSION

Enzymes hydrolyze the cellulose component into glucose sugar, which is fermented to produce bioethanol. The hemicellulose sugars are also fermented to produce bioethanol. The drive to decrease greenhouse gas emissions across the globe will lead to a surge in interest in renewable energy sources. Among the possibilities for utilization as a renewable resource are cellulosic biomass materials. Ethanol offers excellent qualities for use as a fuel, either alone or in combination with gasoline. Bioethanol is a liquid fuel made in the United States from cellulosic biomass resources. It's a high-octane gasoline that can make a significant contribution to the automobile fuel supply. Ethanol has the potential to be a clean-burning fuel that lowers pollution and carbon monoxide emissions. For a variety of reasons, the usage of gasohol (a combination of ethanol and gasoline) as an alternative motor fuel has been gradually growing throughout the globe. Domestic ethanol production and usage as a fuel may help to minimize reliance on foreign oil, reduce trade imbalances, generate employment in rural regions, reduce air pollution, and reduce global warming carbon dioxide accumulation. Ethanol, unlike gasoline, is a 35 percent oxygenated fuel, which lowers particle and NOx emissions during burning.

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