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Bioethanol Production from Different Raw Materials in India –A Review

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ABSTRACT
Negative impact of fossil fuels on the environment, particularly greenhouse gas emissions has put the pressure on society to find renewable fuel alternatives. Most common of them is bioethanol produced from sugar (sugarcane, sugar-beet, corn), grains (which are rotten or wasted). However this raw material base will not be sufficient. Certainly future large scale production has to be based on production from lignocellulosic materials such as wood, agricultural and forest residue (e.g. softwood in Northern Hemisphere, wheat straw) and the most common form of renewable energy i.e. Biomass. Wheat straw is an ample residue with less commercial value so an appropriate utilisation of it to produce bioethanol is a good option. High cost of current technology is creating hindrance in commercialization of the process but in recent year's progress has been made in developing more effective pre-treatment and hydrolysis process. Secondly Biomass is the conversion of plant material into a suitable form of energy like electricity or fuel. Latterly much attention has been focused on identifying suitable biomass species which can provide high energy outputs, to replace conventional fossil fuels. The type of biomass required is largely determined by the energy conversion process and the form in which energy is required. One of the major challenges in the above processes is to optimize the integration of process engineering, fermentation technology, enzyme and metabolic engineering.
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I. INTRODUCTION

The liquid or gaseous fuel for the transport sector that a produce from biomass are known as biofuel. Biofuel are generally considered as offering many priorities including sustainability greenhouse gas emission reduction regional development security of supply. Emissions of carbon dioxide, SOx and NOx from fossil fuel combustion are the main causes of atmospheric Pollution. Worldwide energy consumption has increased 17 times in the last century. Non-renewable energy resources that is fossil fuels represents the most exploited form of energy today, hence there is a need to developed and implement technologies for the production of alternative renewable energy. Production of bioethanol is not competitive with cheap fossil fuels available. Despite this some research continuous because of the abundance of raw materials.

1.1 Bioethanol as Sustainable Fuel.

The global demand for energy is increasing sharply; soon energy shortage would be a global problem. Bioethanol is considered as an important renewable fuel to partly replace fossil fuels. The world production of bioethanol increased from 50 million m3 in 2007 to 100 million m3 in 2012. Brazil and United States represent approx. 80% of the world supply.[1] Bioethanol is typically derived from plant waste, agricultural waste such as crop residue, herbaceous plants, forest residue and animal waste feedstock sources such as wheat, sugarcane, corn, straw and wood. However main problem with the production of bioethanol is that despite the range of feedstock, the raw material availability varies considerably from season to season, as there is no systematic framework. This is the reason why in developing economies food related feedstock is preferably replaced by non-food raw materials such as sweet sorghum or cassava. The use of common biomass could significantly increase the bioethanol production.

II. METHODS OF PREPARATION OF BIOETHANOL

2.1 Bioethanol from feedstock World faces the progressive depletion of its energetic resources mainly based on non renewable fuels. At the same time energy consumption grows at rising rate. In addition, the intensive utilisation of fossil fuels has led to the increase in the generation of polluting gases released into the atmosphere, which have caused changes in the global climate. The solution to this problem depends on the use of renewable energetic resources such as energy crops and lignocellulosic residues [1]. The utilisation of edible agricultural crops exclusively for biofuel production conflict with food and feed production. Sucrose is a common, naturally occurring carrying carbohydrate found in many plants and plant parts. The molecule is a disaccharide combination of the monosaccharides glucose and fructose. Sugarcane, sugar beet and sweet sorghum are the main sucrose-containing feedstocks for bioethanol production with feedstock yields of 62 - 74tonnes·ha−1, 54 - 111 tonnes·ha−1 and 50 - 62 tonnes·ha−1, respectively, and are mostly exploited in Brazil, India, France and Germany [2].

2.1.1 Production from sugarcane

Main feedstock for ethanol production is sugarcane (saccharumofficinarum) in form of either cane juice or molasses. It is native to warm temperate to tropical regions of South Asia. Aneconomically important forage crop is also used for ethanol production. Molasses, bagasse, rum, being its important products. Sugarcane molasses is composed of 9.8% fermentable sugars, 42% cellulose, 25% hemicellulose, 20% lignin where as energy can consist of 43% cellulose, 24% hemicellulose, 22% lignin [3]. Significant amount of sugarcane bagasse remain after juice is pressed from stalks. The amount of bagasse available from 1 tonne of sugarcane ranges between 25 and 300kg [3]. Bagasse also offers many advantages for use in the bioconversion process using micro-organism due to its relatively low ash content (4.8%) [4]. The most employed microorganism Saccharomyces cerevisiae due to its capability to hydrolyse cane sucrose into glucose and fructose, to easily assimilable hexoses. Among bacteria, the most promising microorganism is Zymomonasmobilis, which has a low energy efficiency resulting in a higher ethanol yield (up to 97% of the oretical maximum). However, its range of fermentable substrates is too narrow (glucose, fructose and sucrose).

The Melle-Boinot process is the typical Batch and semi-continuous process for ethanol production by batch fermentation. This process comprises the weight and sterilization of feedstock, followed by the adjustment of pH. The produced wine is decanted, centrifuged and sent to ethanol separation stage, whereas the yeasts are recycled to the fermentation. Fed-batch culture implies low levels of substrate concentration during the course of fermentation, while ethanol is accumulating in the medium. In continuous fermentation process have allowed the implementation of more cost effective process. These have several advantages compare two conventional batch process mainly due to the reduced construction cost of the bioreactors, lower maintenance and operation requirements, higher productivities. For this reason, 30% of ethanol production in Brazil employ continuous fermentation process. The stability of the culture is an important issue regarding continuous fermentation [1].

2.1.2 Production from sweetsorghum

Crop plants are one of the renewable energy resources which can be used as a feedstock for biofuel production [5].The juice extracted from the fresh stem is composed of sucrose, glucose, and fructose and can therefore be readily fermented to alcohol. The solid fraction left behind, the so-called bagasse, is a lignocellulosic residue which can also be processed to ethanol.[6] It is the only crop that provides grain and stem that can be used for sugar, alcohol, syrup, jaggery, fodder, fuel, bedding, roofing, fencing, paper and chewing. Sweet sorghum juices usually contain approximately 16–18% fermentable sugar, which can be directly fermented into ethanol by yeast. It has higher tolerance to salt and drought comparing to sugarcane and corn. Sweet sorghum juices usually contain approximately 16–18% fermentable sugar, which can be directly fermented into ethanol by yeast. Sweet sorghum is currently being looked for the production of bioethanol due to its several advantages over other crops: 1. It contains large amounts of sugars in its stalk that are directly fermentable, 2. It has a short growing period of 4–5 months, 3. It not only tolerates drought but also grows in colder regions of the temperate zones and hence has wider growing areas. 4. The whole plant (grain, stalk juice and lignocellulosic biomass) can be used for fuel ethanol production. Previous barriers to commercialization of sweet sorghum to ethanol have primarily been the high capital cost involved in building a central processing plant that may be operated only seasonally [5].

2.1.3 Starch containing feedstock for bioethanol production

Starch or amylum is a polymeric carbohydrate consisting of a large no. of glucose units joined by glycosidic bonds. This polysaccharide is produced by most green plants as an energy store. It is the most common carbohydrate in staple foods like wheat, maize, rice, cassava. In industry, starch is converted into sugars or fermented to produce ethanol [3]. Starch exists as insoluble, partially crystalline granules in the endosperm of the corn kernel. Starch cannot be metabolized directly by yeast, but must first be broken down into simple six carbon sugars prior to fermentation. To accomplish this conversion, the pH of the mash is adjusted to 6.0[7]. Corn, wheat and cassava are the most employed starch-containing feedstocks in bioethanol production in North America, Europe and tropical countries. The conversion of starch-containing feedstock to obtain fermentable sugars is mainly comprised of three operations which are: (i) milling, (ii) liquefaction and (iii) saccharification using enzymes.

2.1.3.1 Production from corn.

Corn is milled for extracting starch, which is enzymatically treated for obtaining glucose syrup. Then, this syrup is fermented into ethanol. There are two types of corn milling in the industry: wet and dry [1].Today, most fuel ethanol is produced from corn by either the dry grind (67%) or the wet mill (33%) process. The key distinction between wet mill and dry grind facilities is the focus of the resourcing. In the case of a dry grind plant, the focus is maximizing the capital return per gallon of ethanol. In the case of a wet mill plant, capital investments allow for the separation of other valuable components in the grain before fermentation to ethanol [7].

2.1.3.2 Production from cassava

Cassava represents an important alternative source of starch not only for ethanol production, but also for production of glucose syrups. Ethanol production from cassava can be accomplished using either the whole cassava tuber or the starch extracted from it. The production of cassava with high starch content (85–90% dry matter) and less protein and minerals content is relatively simple. Cassava starch has a lower gelatinization temperature and offers a higher solubility for amylases in comparison to corn starch. However, it is considered that cassava ethanol would have better economic indicators if the whole tuber is used as feedstock, especially when small producers are involved. Fuel ethanol production from whole cassava is equivalent to ethanol production from corn by dry-milling technology. The farmers send the cassava roots to small chipping factories where they are peeled and chopped into small pieces. The chips are sun-dried during 2–3 days. The final moisture content is about 14% and the starch content reaches 65%.

2.1.3.3 Production from wheat straw

Wheat straw is an abundant agricultural residue with low commercial value. An attractive alternative is utilization of wheat straw for bioethanol production. However, production costs based on the current technology are still too high, preventing commercialization of process. In recent year's progress has been made in developing more effective pre-treatment and hydrolysis processes leading to higher yield of sugars [8].

2.2 Production of bioethanol from lignocellulose:

Ethanol is produced from various lignocellulose materials such as wood, agriculture and forest residue are the potential to be a valuable substituent for, or complement to gasoline. Lignocellulose consists of three main components: cellulose, hemicellulose and lignin first two of them consist of chain of sugar molecules. These chains can be hydrolysed to produce monomeric sugars some of which can be fermented using ordinary baker's yeast [9]. Ethanol can be produced from lignocellulose materials in various ways. All processes comprise the same main components: hydrolysis of hemicellulose and the cellulose to monomer sugar, fermentation and product recovery and concentration by distillation. Some Process are more or less the same, independent of the hydrolysis method used. For example, enzyme production will be omitted in an acid hydrolysis process [10].

2.3 Production of bioethanol from syngas fermentation

Syngas fermentation is a hybrid thermochemical/biochemical platform that takes advantage of the simplicity of the gasification process and the specificity of the fermentation process to deliver ethanol and potentially other chemicals. Biomass is converted to ethanol through the thermochemical platform, i.e., gasification and the biological platform, i.e., fermentation in syngas fermentation. Energy-rich biomass and waste materials are converted by gasification to syngas, which consists of CO, H2 and CO2. These gases are then converted to ethanol and other chemicals by acetogenicautotrophic microbes. These microorganisms, "possess a very valuable (trait)" have "the ability to grow in strict autotrophy" and "to produce added-value compounds" [15]. Syngas fermentation is an indirect conversion process for the production of alcohols, organic acids and other products. Unlike hydrolysis fermentation processes, syngas fermentation is referred to as an indirect fermentation because the feedstocks are not directly fed in the fermentor to form products. Feedstocks are first gasified into syngas, which is then cleaned and cooled before it is fed into the fermentor to make products. Non-food based feedstocks such as agricultural residue, municipal solid wastes, energy crops, coal, and petcoke can be gasified to produce syngas [16].

III. PROPERTIES OF BIO ETHANOL

The various properties of the fuel are density, API gravity, viscosity, flash and fire point, cloud point, heat of combustion and distillation. Various apparatus are employed in the determination of fuel properties. Bioethanol has a higher octane number, broader flammability limits, higher flame speed and higher heats of vaporization then gasoline. This property allows for the higher compression ratio, shorter burn time and learner burn engine in an IC engine [13]. Limitations of bioethanol includes its lower energy density then gasoline (bioethanol has 66% of the energy then gasoline has), its corrosiveness, low flame luminosity, lower vapour pressure miscibility with water, and the toxicity to ecosystem [14]. The presence of oxygen in bioethanol improves combustion and therefore reduces hydrocarbon, carbon monoxide, and particulate emissions; but oxygenated fuels also tend to increase nitrogen oxide emissions. Bioethanol is appropriate for the mixed fuel in the gasoline engine because of its high octane number, and its low cetane number and high heat of vaporization impede self-ignition in the diesel engine. So, ignition improver, glow-plug, surface ignition, and pilot injection are applied to promote self-ignition by using diesel–bioethanol blended fuel [15].

Biofuel sources are geographically more evenly distributed than the fossil fuels; thus, the sources of energy will, to a larger extent, be domestic and provide security of supply. Lignocellulosic raw materials minimize the potential conflict between land use for food (and feed) production and energy feedstock production. The raw material is less expensive than conventional agricultural feedstock and can be produced with lower input of fertilizers, pesticides, and energy. Biofuels from lignocellulose generate low net greenhouse gas emissions, reducing environmental impacts, particularly climate change. Biofuels might also provide employment in rural areas

IV. CONCLUSION

The massive utilization of fuel ethanol in the world requires that its production technology be cost-effective and environmentally sustainable. In particular, ethanol production costs should be lowered. For current technologies employed at commercial level, the main share in the cost structure corresponds to the feedstocks (above 60%) followed by the processing expenditures. In general, the use of sucrose-containing materials as cane molasses allows producing ethanol with the lowest costs compared to the starchy materials (mostly grains). Particularly, although the ethanol yield from corn is higher than that from sugarcane, the lower annual yield of corn per cultivated hectare makes it necessary to use larger cropping areas. On the other hand, the lignocellulosic biomass represents the most prospective feedstock for ethanol production. The availability and low cost of a wide range of lignocellulosic materials offer many possibilities for the development of bio-industries that could support the growth of the international biofuel market and contribute to the reduction of greenhouse gas emissions worldwide

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