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BIOFUEL: A STEP TOWARDS THE CLEANER FUEL: A BRIEF REVIEW

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ABSTRACT

The paper has discussed about the biofuels its characteristics, historical perspectives, different generation of biofuels and their sources in context that day to day level of CO_2 is increasing in the atmosphere leading to climatic changes; hence there arises a need for exploration of more options for reducing the impact of GHG with different degree of success. Therefore, need for renewable sources of liquid fuel are receiving greater attention, and much of this attention has been focused on biomass-derived liquid fuels or biofuels. Due to the positive effects on exhaust gas emissions, especially on the reduction of the greenhouse gas, (CO_2) emissions, biofuels show a great potential in present and the future perspects. The biofuels are mainly used to provide cleaner fuels for cooking & electricity, but production of new bio-fuels for transportation should also become a main area of focus in present scenario. The development of second, third and fourth generation of biofuels will increase the efficiency in production and reduce the drawbacks. Thus, Biofuels may have significant benefits and can offer attractive alternatives for developing countries with the right climate and available land.

Keywords: Biofuel, Biomass, Green house gas(GHG), Global warming

INTRODUCTION

The major anthropogenic sources responsible of greenhouse emissions are transportation, energy and agriculture sectors [1]. With the development of new growing economies, such as India and China, it is expected that the global consumption of energy will raise and lead to extra environmental damage [2]. Green house gas not only contributing to global warming but also has a negative impact on the environment and human life. Day to day level of CO_2 is increasing in the atmosphere leading to global warming, altering the water pH to more acidic which might be the reason for quick loss of coral reefs and of marine ecosystems and consequently in earth life [3] Presently many options are being explored with different degrees of success for reducing the impact of GHG. Some of the examples of such studies are solar-energy, thermal or photovoltaic, hydroelectric, geothermal, wind, and carbon sequestration. [4,5]. But ironically the objective of all renewable energy sources are focused on electricity generation, while the majority of world energy consumption is from liquid fuels. The need for renewable sources of liquid fuel is starting to receive greater attention, and much of this attention has been focused on biomass-derived liquid fuels, or biofuels. They can be produced from sources such as agricultural, and forest products, and the biodegradable portion of industrial and municipal waste. In today's society biofuel are gaining increased public and scientific attention due to its environmental friendly nature and can be summarized as -.

1. **Biofuels are replenishable**: Biofuels are an inexhaustible resource since the stock which can be replenished through agriculture.

2. **Biofuels can reduce carbon (C) emissions**: Bio-fuels are also considered as a solution to climate change because the direct carbon emissions from combustion of bio-fuels are insignificant evaluated to fossil fuels.

3. **Biofuels can increase farm income**: Growing one or more types of crops for biofuels will increase the farm income which will provide a platform for most of the countries to meet either domestic or foreign demand or both [6].

4. **Biofuels can get better energy security**: The above fact also means that countries can produce their own fuel, and reduce their dependence on foreign resources for energy. [5]

5. **Biofuels can create new jobs**: Biofuels are labor intensive as compared to other energy technologies on per unit of energy delivered basis which will provide job to majority of peoples [7].

6. **Biofuels have physical and chemical properties similar to oil**: Moreover, physical and chemical properties of bio-fuels such as their liquid state, specific energy density, viscosity, and combustion properties

are similarly to gasoline or diesel. They are combustible in existing internal combustion engines with some minor modifications. As a result, adapting to biofuel-based infrastructure (at least at low level of blending like (10% or 20%) can be achieved more cost effectively than adapting to hydrogen, battery or natural gas based automobiles [8].

7. **Biofuels are simple and familiar**: Finally, biofuels are more common, simple and familiar to consumers, producers, and policy makers. Since last two decades ethanol has been used as an additive or as a blend with gasoline in several countries.

HISTORICAL PERSPECTIVE ON BIOFUELS

Long before the industrial revolution, biomass satisfied approximately all of the human energy needs worldwide. The burning of wood and charcoal supplied energy for household activities like heating and cooking, while draft animals supplied the energy for tilling of field and transportation. Growing urbanization caused the replacement of animal power with machine power is claimed to have freed up 80 million acres of U.S. land—land that had been used to grow grassland and differ feed for the millions of animals used by humans.[9]. With the use of coal and petroleum in the middle and late 19th century, respectively, the developed world rapidly moved away from the use of biomass for almost all last part of uses like household, commercial, industrial, and transportation applications. Economic increase has resulted in a decline in the share of biomass energy and increases in the use of modern fuels. Statistical data from various countries also showed that per capita income and share of modern fuels are positively correlated [10]. It has been seen that when a country’s per capita income is less than $300 (in US dollars), typically 90% or extra of the population uses fire wood and dung for cooking [11]. Once incomes have exceeded $1000 per capita, most people commonly switch to modern fuels, and substitution is nearly complete. For commercial and industrial heating, the trend is shifted to more efficient use of biomass, as well as to modern fuels. However, modern fuel sources are still out of reach from poor people in developing countries. According about 94% of the rural life population depends on woods and 73% of the urban population depends on woods and charcoals as the major source of energy in Africa [12]. In India, less than 40% of rural households are connected to the electric grid and less than 10% of the rural households have accession to clean burning fuels like liquefied petroleum gas or liquefied natural gas. In China, despite of rapid economic increase, 80% of households continue to rely on biomass or coal as their primary cooking and burning fuels [13]. Therefore there arises a need for providing cleaner fuels for cooking & electricity which can be produced from biomass should also be a main area of focus for policy in such countries, along with producing new bio-fuels for transportation.

DIFFERENT GENERATION OF BIOFUELS

Biofuels can be categorized into four generation depending on the type of production and raw material selection:

First Generation Biofuels (2000-2010):

The dramatic increase in oil prices seen in the last decade has also enabled liquid bio-fuels to become cost-competitive with petroleum based transportation fuels and this has led to a surge in research and produce around the world. The three important type of first generation biofuels used commercially are **biodiesel (bio-esters), ethanol**, and **biogas**.

Biodiesel

Biodiesel is a fatty acid methyl ester derivative from vegetable oils and animal fats, waste oils and residues in compliance with EN (14214) standards. Esterification technology is used in biodiesel production with minor engine modification. The oil resources that can be used in biodiesel production are vegetables oils (Sunflower, soybean, rape, safflower, cotton, & palm oils), recycled oils (By product of the vegetable oil industry (Soap stock, waste oil), urban waste and industrial waste based recycled oil (Brown grease, Black grease), animal fats (Tallow, fish oils and poultry oils), waste vegetable oils (Yellow grease) and algae. [14]. Biodiesel used as fuels in engine either directly or through blending with diesel fuel at certain ratio (B20, B50, etc.). Biodiesel does not needs any modifications on the engine design to be used in current diesel engines. Malaysia comes first in terms of its biodiesel manufacture potential [15].

Important properties of biodiesel are as follows [16]:

It is obtained from renewable raw materials sources.

Decrease the dependence on petroleum products.

- Considerably decreases emissions.
- Does not contain sulfur.
- Has good lubricant properties and increases the lubricant effect when blended with diesel fuel.

- Have safe transportation, storage and simple usage properties due to its high ignition temperature.
- Has a calorific value close up to that of diesel fuel and a higher cetane number than diesel fuel.
- The use of biodiesel fuel causes the reduction in the amount of PM, CO and HC concentration in exhaust gases.

Bioethanol

Bioethanol is a biofuel obtained through the fermentation of plants containing sugar and starch or the acidic hydrolysis of cellulosic sources. Biomass for ethanol production harvested from crops mean for food industry, either in form of cereal grains i.e. corn, wheat or as crops residues such as wheat straw or corn Stover_etc. Other sources of bio-ethanol include crops which gives the by product as substitute for bio-ethanol such as molasses and sugarcane bagasse from the sugarcane industry [17]. Bioethanol is more convenient to be used in gasoline engines due to high octane number. However, bioethanol has a considerably low cetane number, limiting its use in diesel engines. Main characteristics of bioethanol can be listed as follows [18].

Important characteristics of bioethanol can be listed as follow

- It is obtained from renewable raw material resource.
- Decreases the dependence on petroleum products.
- Considerably decreases emissions.
- Increases the octane number of the fuels.
- It facilitates more efficient and cleaner combustion of gasoline because of its oxygen content.

Biogas

Biogas or bio-methane is another alternative resource of renewable energy. It is produced when biomass is subjected to biological gasification. A methane-rich gas produced from the anaerobic digestion of organic material can be used in gasoline vehicles with some minor modifications. The gas is produced in a three (3) phase process namely; hydrolysis, acid-forming and methane-forming phases that can be looked at a biological engineering process in which a complex set of environmentally sensitive micro-organisms are involved. Biogas contains 60-70% methane (CH_4), 30-40% carbon dioxide (CO_2), 0-2% hydrogen sulfide (H_2S) and a very small amount of nitrogen (N_2) and hydrogen (H_2). Cow dung has high nitrogen content and due to pre-fermentation in the stomach of ruminant it has been observed to be most suitable material for high yield of biogas through the study made over the years [19].

Biohydrogen

When hydrogen (H_2) is used as a fuel, it generates no pollutants but its produces water. In comparison with fossils fuel, hydrogen (H_2) has a higher energy yield [20]. Lignocellulosic materials such as wood & wood products, food and starch based materials, organic industry wastewater, household wastewater and biodiesel industry waste could be potentials sources for biohydrogen production and as a cost effective energy production process [21]. Major technologies which can be used for biohydrogen production includes chemicals, biological, electrolytic, photolytic and thermo chemicals. Few technologies are in a different stage of development, and each offer unique opportunities, benefit and challenges. A variety of factors affecting the hydrogen (H_2) production include local accessibility of feedstock, the development of the technology, market applications and demands, policy issues, and costs of production. However, due to the high renewable hydrogen production and storage costs, the potential of hydrogen as alternative fuel of future has yet to be realized.

Second Generation Biofuels (2010-2030):

Second-generation biofuels are being produced from lignocellulosic biomass, the use of less cost, non-edible feedstock's, thereby limiting direct food verses fuel competition. Second generation biofuels can be further classified in terms of the process used to convert the biomass to fuel; Biochemical or thermo-chemicals. Second generation biofuel such as ethanol or butanol made through biochemical processing, while all other are made via thermo-chemicals processing. Many second-generation thermo-chemicals fuel such as methanol, refined Fischer Tropsch Liquids (FTL), and Dimethyl ether (DME) are being made commercially from fossil fuels. These thermo-chemically produced fuels are getting considerable attention in different parts of the world.

Fischer-Tropsch liquid (FTL) is a mixture of primarily straight-chain hydrocarbon compounds (olefins and paraffins) that have resemblance with a semi-refined crude oil. The mixture can either be transport to a conventional petroleum refinery for processing or refined on site into "clean diesel," jet fuel, naphtha, and other fractions. Earlier, FTL is synthesized by catalytically reacting CO and H_2. Thus, the feedstock that can be converted into CO and H_2 can be used to produce FTL. Coal, natural gas and other biomass can also be used as a feedstock for FTL production.

Dimethyl ether (DME) is a colourless gas at normal temperatures and pressures, with ethereal odour. Its physical properties make it a superior substitute (or blending agent) for liquefied petroleum gas (LPG, a mixture of propane and butane). DME is also an outstanding diesel engine fuel due to its elevated cetane number and lack of soot production during combustion. It is not feasible to mix DME with conventional diesel fuel in existing engines, because DME must be store up below mild pressure to maintain a liquid state. In China, however, some DME will also be used in buses. Commercial improvement of DME buses is underway and amount production is anticipated before the end of this decade [22]. Improvement of heavy-duty vehicles (trucks and buses) fuelled with DME is also underway in Sweden [23]**.** Most important efforts in Japan are also ongoing to commercialize heavy-duty DME road vehicles [24].

Alcohol fuel (Ethanol and Butanol or their blend) that made via syngas processing is drawing significant attention of scientists. Butanol and the "mixed alcohol" fuel have the potential similar to ethanol to be used today for blending with gasoline. These are characterized by high volumetric energy densities and lower vapor pressures than ethanol, which make them extra attractive as a fuel or blending agent. Syngas can be changed into a mixture of alcohols by catalytic synthesis. Clean syngas is passed over a catalyst, forming a mixture of alcohol molecules. A number of different catalysts for mixed alcohol formation from syngas were patented in the late 1970s and early 1980s [25]. But development efforts were abandoned after oil price fell in the mid-1980s. High oil prices have reignited its significance. Apart from patents and patent applications, relatively little published information is available concerning these private-sector activities. Pure ethanol (or pure butanol) can also be made from syngas by micro-organisms that ferment the gas [26]. This combined thermo/biochemical route to a pure alcohol, if it can be made commercially viable, would enable the lignin in the biomass feedstock, as well as the hemicelluloses and cellulose, to be converted to fuel, unlike the case for purely biochemical "cellulosic ethanol" discussed earlier. At least one private company (BRI Energy, Inc.) is actively seeking to commercialize technology for fermentation of syngas [27]. They have announced their intention to build two commercial facilities near Oak Ridge, Tennessee, United States. One facility would convert coal-derived syngas to ethanol, and the other would convert municipal solid waste via gasification to ethanol [28]. BRI was also recently awarded a grant from the United States Department of Energy in support of a commercial-scale demonstration project. But little detailed documentation is publicly available to enable an independent evaluation of (BRI's) technology.

Third Generation Biofuels or advanced fuel (After 2030):

One of the major goals of third generation biofuels, which are also named as "Advanced Fuels", is biofuel production using genetically altered plants containing higher amounts of oil and cellulose and algae through a shift from lignocellulosic resources to cellulosic sources and the use of integrated bio-refinery technologies. Third generation biofuel include those where algae serves as feedstock for biofuel production and these fuel are referred as 'oilgae'. Algae are typically low input biomass with high yield potential. Since past few years microalgae are the important sources of clean and renewable energy [29]. Microalgae are better source as biofuel producers as they possess short life cycles, can perform photosynthesis, and can utilize saline or waste-water for growth, as well as non-arable land. *Chlamydomonas reinhardtii*, the green algae has been genetically modified to express several important traits of biofuels [30]. But low biomass production rates and lipid contents in most of the model strains have prevented them from becoming industrially relevant. Many Green algal sp., such as *Chlorella, Parachlorella, Nannochloropsis, Scenedesmus, Botryococcus*, and *Neochloris* have been identified as being rich in lipids content and thus as potential candidates for biofuel production. Blue-green algae or (cyanobacteria) in recent year also explored as source of biofuel but due to low lipids content as compared to the green algaes, they are not considered as a good source biofuel production. However, cyanobacteria may be engineered to produce other significant biofuel related molecules due to their ability to grown in extreme environment and the relative ease of their genetic transformation. In cyanobacteria, technology such as genetic engineering has been carried out in model organism, *Synechocystis* species PCC 6803, *Synechococcus elongatus* species PCC 7492, *Synechococcus* species PCC 7002 and *Anabaena* species PCC 7120. However, the ideal production host remains difficult to predict. [31].

Fourth Generation Biofuels (after 2030):

Fourth Generations Biofuels will be produced from genetically optimized raw materials. Carbon monoxide in the pipe and exhaust gas of the biofuel will not be released to the atmosphere through being held by carbon (C) holding and storing technologies. For such biofuels, which are also known as “Carbon (C) Negative Biofuels”, extensive studies will be conducted on improving carbon holding and storing capacity within the scope of clean coal technologies. In adding, it is aimed to remove carbon dioxide (CO_2) by using certain microorganisms to transform it into substances like sugar and consequently to fuel like ethanol and hydrogen. [32].

COMMON CONVERSION TECHNOLOGIES FOR BIOFUEL

A number of conversion technologies are available depending on the type of feedstock, fuel, and the desired use of fuels. [33]. Here a brief description of few processes is given:

1. Direct combustion: This is among the most common and oldest form of conversion involving burning organic matter in an oxygen-rich environment mainly for the production of heat. The most common use of this heat is in the production of steam or electricity generations for home and industries. In some cases, the goal of burning simply meant reduction in the volume of waste without energy recovery such as burning of biomass like wood, dung, and agricultural wastes in homes for cooking and heating, co firing of biomass with coal in electricity production, the burning of wood for process heat in chemical industries.

2. **Thermo-chemical conversion**: Involves conversion utilizes heat and pressure in an oxygen-deficient environment to produce “synthetic gas” or “syngas”. Syngas is composed mainly of carbon monoxide and hydrogen. These can either be combusted to produce heat or converted to other fuels like ethanol and hydrogen. Thermo-chemical conversion is cleaner compared to other conversion and includes processes such as gasification, pyrolysis, plasma arc, and catalytic cracking etc.

3. **Biochemical conversion**: In contrast to thermal and thermo-chemical processes, biochemical conversion processes occur at lower temperatures and have lower reaction rates. Higher moisture containing feedstock is more easily converted through biochemical processes. The common types of biochemical conversion include fermentation and anaerobic digestion. The main use of fermentation is in conversion of sugar and starch, found in crops like sugarcane, corn, wheat, etc., to ethanol yielding co-products like distiller dried grains, which can be used

as feed for livestock. Anaerobic digestion involves the bacterial breakdown of biodegradable organic material in the absence of oxygen over a temperature range from about 50° to 160° F and the main end product of these processes is called biogas, which is mainly composed of methane (CH_4) and carbon dioxide (CO_2) with some impurities such as hydrogen sulfide (H_2S). Biogas can be used in many places as fuel for engines, gas turbines, fuel cells, boilers, and industrial heaters, and as a feedstock for chemicals (with emissions and impacts commensurate with those from natural gas feedstock) [34]. Another type of biochemical process is conversion of cellulosic feedstock using acid or enzymatic hydrolysis is which is expected to become commercially very important in the future.

4. **Transesterification**:

Transesterification also known as alcoholysis, is a chemical process by which vegetable oils (like soy, canola, palm, etc.) can be converted to methyl or ethyl esters of fatty acids. It is the most common method of producing biodiesel today. Since, biodiesel is physically and chemically similar to petro-diesel and so it could be substitutable in diesel engines. Transesterification also results in the production of byproducts glycerin, a chemical compound with diverse commercial uses. This process is mainly carried out at a temperature of 60° C to 80° C.

CONCLUSIONS

The paper has discussed about the biofuels its characteristics, historical perspectives, different generation of biofuels and their sources. Rising prices of fuel coupled with concern about carbon emission are making biofuel production more cost competitive and attractive over fossil fuel. Due to their positive effects on exhaust gas emissions, especially on the reduction of the greenhouse gas (CO_2) emissions, biofuels show a great potential in present and the future perspects. The development of second, third and fourth generation of biofuels will increase the efficiency in production and reduce the drawbacks, e.g. the influence of biofuel industry on food-production resulting in less debate over the social and environmental impacts of biofuel production. Biofuels, however, may have significant benefits and can offer attractive alternatives for developing countries with the right climate and available land. With dedicated biofuels programs, such developing countries can create much needed employment in rural areas, increase their access to energy and lessen their precarious dependence on the oil market.

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