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UNDERSTANDING THE USES AND FACTORS INFLUENCING BIODIESEL PRODUCTION

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ABSTRACT

Coal, lignite, petroleum, and natural gas are all non-renewable energy sources that are a part of India's energy-mix (wind, solar, small hydro, biomass, cogeneration bagasse etc). Assessing a country's capacity to satisfy its future energy demands necessitates knowledge of its stocks of non-renewable sources of energy as well as its potential for generating renewable energy sources. The country's need for energy is on the rise, and as a result, supplies of fossil fuels like oil, coal, and petroleum products are running low. Because of the country's economic downturn, many are worried about not having enough power to keep their businesses running and create new jobs. The rapid depletion of petroleum supplies has made it imperative to find replacement fuels; biodiesel is being considered as a diesel alternative due to the economy's widespread reliance on diesel. For the most part, biodiesel is made from vegetable oils, animal fats, and grease. Biodiesel is a renewable fuel that has the potential to replace diesel fuel made from petroleum. Biofuels can be an alternative fuel source if they meet many criteria. These include providing a net energy gain, having environmental advantages, being economically competitive, and being easily producible in large amounts without negatively impacting food supply. Use of biodiesel and production aspects are discussed in this overview.

Keywords: *Non-renewable, Petroleum, Energy, Feedstock, Methanol*

I. INTRODUCTION

It's important to remember that fossil fuels are a finite source of energy. In spite of their importance to the global energy supply, the development and use of these fuels have sparked heated discussions and worries about their impact on the environment. Burning fossil fuels is responsible for nearly all (98%) of the world's greenhouse gas emissions.

Due to population growth, the need for energy is rising rapidly to meet the rising number of factories and cars. Energy is derived from several resources, including fossil fuels, natural gas, coal, hydrocarbons, and nuclear fission. Using petroleum diesel contributes significantly to air pollution, which is one of the biggest drawbacks of relying on petroleum-based fuels. Greenhouse gases are released when petroleum fuel is used. Petroleum diesel is a major contributor to the release of harmful air contaminants such nitrogen oxides (NOX), sulphur oxides (SOX), carbon monoxide (CO), particulate matter (PM), and volatile organic compounds (VOCs). A number of potential diesel fuel replacements have been investigated. It has been suggested that vegetable oils, which are often generated in rural regions, might serve as viable substitutes for diesel. Self-employment possibilities exist in the production of oil from seeds.

It's not a novel idea to use biomass as fuel. In 1911, Rudolph Diesel pioneered the use of a vegetable oil (peanut oil) in a diesel engine. Reduced emissions of sulphur dioxide, carbon monoxide, and hydrofluoric acid from burning bio-fuels would have a significant impact on the rate at which the planet warms. Blends of biodiesel and diesel fuel in the 2, 5, and 20% range are common due to the former's cost savings and the latter's increased power production. Reduced carbon dioxide emissions can be achieved by increasing the percentage of biodiesel to diesel. Carbon dioxide net emissions are cut by 15.66 percent when using a blend containing 20 percent biodiesel, and they are cut to zero when using pure biodiesel.

Biodiesel is a sustainable, non-toxic alternative fuel for diesel engines that may be produced from a wide variety of vegetable oils and animal fats. Alcohols like methanol or ethanol undergo a chemical reaction with oils and fats. Fatty acid methyl esters are the byproduct of a process that calls for a catalyst, often a strong base like sodium or potassium hydroxide. Glycerine, a key raw ingredient in the chemical and pharmaceutical sectors, and potassium fertiliser, which finds use in agriculture and the fertiliser industry, are both generated as byproducts. Biodiesel may be used in any existing diesel engine, making it a highly flexible transportation fuel. Producing biodiesel from local raw material (or collecting used vegetable or frying oil) in rural regions of developing countries has the potential to have a profoundly positive effect on rural development by bolstering food security, increasing employment opportunities, and promoting long-term economic growth.

II. BIODIESEL FEEDSTOCK

Vegetable Oils

Before the introduction of petroleum-based diesel fuel in the 1920s, diesel engines could only be fueled by vegetable oil. However, petroleum distillates refined from crude oil were used as a feedstock beginning in the 1920s when gasoline was being manufactured. Petrodiesel, unlike vegetable oil, was not only more readily available but also lighter and less viscous. As a result, engine makers had to make adjustments, and vegetable oil mostly disappeared from the market as a fuel source for automobiles. The Arab oil embargo of 1973 caused an immediate spike in prices. Interest in biofuels was revived when the price of gasoline and diesel quadrupled overnight. Since 1973, several suggestions have been made for potential biodiesel supply chains. Soybean oil alone accounts for nearly 90% of all biofuel stockpiles in the US, although rapeseed oil is also widely utilised as a feedstock. Although just a few thousand gallons of gasoline were made from soybean oil annually in 1994, that number jumped to 25 million gallons by 2004. As of 2006, sales totaled 200 million gallons. The potential capacity for biodiesel production in the United States in 2007 may exceed 1.5 billion gallons if all current and planned plants ran at full tilt.

While soybean oil is commonly used as a biodiesel feedstock in North America, rapeseed and canola are more popular choices in Europe. Rapeseed oil, however, is a viable source for producing biodiesel in North America, and it is rapidly becoming a major revenue crop. Each year, 7–10 million metric tonnes (tonnes) of rapeseed are produced in Canada and the United States. Rapeseed oil production is higher per acre than soybean oil production is in these regions, which contributes to the trend. The yields of cellulosic biomass that might be produced on the same acres to make gasoline ethanol are substantially greater, but in places where ethanol feedstock cannot be cultivated or does not provide such high yields, alternate feedstocks are required to obtain biodiesel. To that end, in 1998, Beer and colleagues developed a transgenic plant variety that they claim is the most disease- and drought-resistant variety of rapeseed to date, and that, if successfully cultivated in areas where neither cellulosic biomass for ethanol production nor rapeseed was previously viable, could result in an increase in oil production.

Palm oil, which comes from the fruit of the oil palm tree, is another vegetable-based feedstock. It is the favoured oil in South and Southeast Asia and has the potential to overtake soybean oil as the most extensively produced vegetable oil in the world. Thus, several Asian governments are shifting their emphasis from palm oil to biodiesel production to meet the enormous demand in Europe.

Non-Vegetable Oils

Biodiesel produced from vegetable feedstocks has been proved to have environmental advantages, but its usage is also met with considerable scepticism. One major cause for concern is the destruction of tropical forests in countries like the Philippines and Indonesia in order to cultivate oil palm and other oil-producing crops. Furthermore, there is concern that biodiesel would put a strain on global food resources, prompting researchers to investigate the feasibility of using waste vegetable oils and animal fats as biodiesel feedstocks. Meat processing plants are the primary generators of unwanted animal fats. The two main types of waste grease used to make recycled goods are yellow grease and brown grease. Cooking with heated vegetable oil or animal fat results in a yellow grease. To get used cooking oil to the right consistency for yellow grease, renderers heat it up, remove any particles, and filter the resulting oil. The percentage of free fatty acids in yellow grease can't be higher than 15%. Brown grease, often known as trap grease, has a free fatty acid content of greater than 15%.

Biodiesel production from waste grease may be predicted to gain from a raw material cost advantage and will assist to lower total biodiesel cost since waste vegetable oil from restaurants and rendered animal fats are inexpensive compared with food-grade vegetable oil. A number of patents detail processes for making biodiesel fuel from used vegetable or animal oils and fats, methanol that doesn't require a catalyst and doesn't produce glycerol as a byproduct, and yellow grease that can be processed at a smaller plant located closer to the source of its raw materials. Using a low concentration of methanol and an acid catalyst, Hammond Earl G. and Wang Tong developed a process for transforming the free fatty acids present in acid oil and the acid fat into FAMEs (biodiesel). Specifically helpful for making biodiesel from animal fats and oils, which are rich in free fatty acids and may be used as a starting material in this process.

One alternative use designed to assist the use of waste oils and fats in biodiesel synthesis focuses on lowering the viscosity of these wastes in order to make the filtering process more manageable. In a similar vein, a portable refinery has been designed to remove impurities from spent cooking oil, such as food particles, water, and emulsified or congealed grease, by sucking the wastes into a container and heating them before straining them out. It has been suggested that waste lipids and fat be used to make fatty acid lower alcohol esters by the use of either entire microorganisms generating lipases or the purified lipases themselves.

III. USES AND PROPERTIES

It is commonly accepted that diesel engines can run on blends of 20% biodiesel and 80% petroleum diesel (B20) without any modifications. Some newer engines (made after 1994) may be able to run on mixes as high as 100% biodiesel (often known as B100), while others may require extensive modifications. Emissions of unburned hydrocarbons, carbon monoxide, sulphates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter may all be greatly reduced by switching to biodiesel in a standard diesel engine. Biodiesel's potential use as a blending stock with future ultra-clean diesel is supported by its good performance characteristics, such as enhanced cetane, high fuel lubricity, and high oxygen content. When burnt, sulphur creates sulphur dioxide, the principal component in acid rain, however biodiesel is more lubricating than diesel fuel, thus it may be used to replace sulphur as a lubricant.

With a 20% biodiesel blend, NOx emissions rise by around 2%. Various additives have showed promise in lowering the increases in nitrogen oxides produced by some biodiesels. NOx emissions from burning biodiesel depend on the temperature at which the fuel is burned. Higher combustion temperatures result in more NOx being released into the atmosphere. Biodiesel's somewhat greater heat of combustion can be attributed to its oxygen content compared to diesel fuel. Two easy strategies exist for cutting down on NOx production. Retarding the engine timing by 1-3 degrees reduces the combustion temperature and brings NOx emissions from a biodiesel-powered vehicle down to the same or lower levels as those seen when the vehicle was powered by diesel fuel. An NOx emission reduction may also be achieved with the use of a catalytic converter, a device that employs rare earth metals to break up pollutants. Because biodiesel fuel has no sulphur, potent NOx breaking catalysts that were previously ineffective may now be used.

Because of its biodegradability, biodiesel is well-suited for use not only in environmentally sensitive areas like national parks and water reserves, forestry estates, bodies of water, inland waterways, and coastal waters, but also in dense urban areas, communities with a strong commitment to sustainability, and the industries and farms that provide the raw material. Due to the close proximity of the feedstock, the production and usage of biodiesel are ecologically benign. In addition, biodiesel's high ignition temperature makes it a safe fuel for shipping.

Wax crystals can develop in diesel fuel and biodiesel after they have cooled. In extreme cases, the crystals may completely block gasoline filters and prevent any fuel from reaching the engine. For the most part, you may keep on using diesel fuel all the way down to roughly -23 degrees Celsius (-30 degrees Fahrenheit). Biodiesel generated from rapeseed may be used at temperatures as low as (- 9 degrees Celsius), biodiesel made from soy can be used at temperatures as low as (-1 degrees Celsius), and biodiesel created from leftover cooking oil or animal fat can be used between (- 30 degrees Celsius) and (- 50 degrees Celsius) (9-12 deg. C). The use of winterizing chemicals and additives, as well as engine tank and block heaters, may keep the fuel system of a diesel vehicle toasty on cold winter mornings.

Microeconomically, the use of renewable biofuels helps both the urban and rural areas, as well as the trade balance. Lowered expenses are the primary benefit of using BioDiesel in farming. The phrase "oil well on your farm" refers to an increase in the value of goods and services produced locally. Each year, oil plants regenerate. Used vegetable oils and animal fats also contribute. In any case, the goal is to lessen the environmental burden caused by regular operations in addition to supplying emergency needs. The adaptability of biodiesel plants responds to a second energy objective, the development of controllable regional supply networks.

Producing biodiesel is important for emerging nations due to the anticipated high demand for transportation fuels. The promotion of high-quality research in service of sustainable development of society encompasses topics of strategic importance to economic and social development, with the end goal of increasing energy self-sufficiency and security, along with other environmental (reducing air pollution from transportation, mitigating greenhouse gas emissions), socioeconomic, and political benefits.

IV. FACTORS AFFECTING BIODIESEL PRODUCTION

Transesterification causes a significant reduction in the viscosity of vegetable oil. Removed is the high viscosity component glycerol, leaving a product with a similar low viscosity to fossil fuels. When blended with mineral diesel, the biodiesel generated is completely interchangeable. Following transesterification, the biodiesel's flash point and cetane number both improve. Numerous process factors, such as the presence of moisture and free fatty acids (FFA), reaction duration, reaction temperature, catalyst, and molar ratio of alcohol and oil, influence biodiesel production during transesterification.

Temperature

The biodiesel production rate is significantly affected by the reaction temperature. For instance, as oils become less viscous at higher temperatures, the reaction rate is increased and the reaction time is decreased. Increasing the reaction temperature above the optimum threshold reduces biodiesel output because the saponification of triglycerides is sped up and methanol is evaporated.

To avoid losing alcohol through evaporation during the transesterification reaction, the temperature is often kept below the alcohol's boiling point. Depending on the oils or fats being utilised, the ideal reaction temperature might be anywhere between 50 and 60 degrees Celsius. Thus, for quicker conversion, the literatures prescribe a reaction temperature close to the alcohol's boiling point. This revealed that the methyl esterification of the FFAs could be carried out considerably at room temperature, but could require a longer reaction time, since up to 78% conversion was achieved after 60 minutes. But temperature was more important than pH in butyl esterification. The energy of the interacting molecules is amplified by raising the temperature, and the miscibility of the alcoholic polar media into a non-polar oily phase is enhanced.

Reaction time

A longer reaction time results in a greater percentage of fatty acid esters being converted. Because of the initial mixing and spreading of the alcohol and oil, the reaction starts off slowly. After then, everything go along at a breakneck pace. However, the highest ester conversion occurred in within 90 minutes. Extending the reaction time does not improve the yield of the final product (biodiesel/mono alkyl ester). Further, since transesterification is reversible, the loss of esters and the creation of soap as a result of prolonged reaction time reduces the final product (biodiesel).

Methanol to Oil Molar ratio

The molar ratio of alcohol to triglyceride is one of the most influential factors in biodiesel output. Transesterification requires the use of three moles of alcohol and one mole of triglyceride, according to stoichiometry, in order to produce three moles of fatty acid methyl/ethyl esters and one mole of glycerol. Moving the reaction to the right requires either adding more alcohol or taking out one of the products. Usually, it's best to go with the second choice so the reaction can finish. When using an excess of 100% methanol, the reaction rate is determined to be the maximum.

Methanol, ethanol, propanol, butanol, and amyl alcohol are all suitable for use in the transesterification process; however, methanol is employed more commonly since it is inexpensive and favourable (polar and shortest chain alcohol) over the other alcohols. In contrast to methanol, which is produced from petroleum, ethanol is a more desirable alcohol to use in the transesterification process since it is renewable and physiologically less harmful to the environment. Researchers looked at different methanol and ethanol to oil volume ratios to see what happened. The results show that the optimal oil-to-methanol ratio for producing biodiesel is 1:6. In contrast, the methanol molar ratio grows steadily, resulting in an ever-increasing biodiesel production.

Type and Amount of Catalyst

The concentration of catalyst also has a role in biodiesel production. Sodium hydroxide (NaOH) and potassium hydroxide (KOH) are the most used catalysts for making biodiesel (KOH). For the most part, the quality of the feedstock and the approach taken during transesterification determine the kind and quantity of catalyst needed. Any catalyst may be used for transesterification if the feedstock were to be purified. However, the homogeneous transesterification method is suboptimal for feedstock with high moisture and free fatty acid levels, as saponification is more likely to occur than transesterification. When more catalyst is used, more fatty acid alkyl esters are produced. This is because increasing the quantity of catalyst used in the transesterification process makes more active sites available. From a purely economic standpoint, however, using a bigger amount of catalyst might not be worthwhile. Because of this, the optimal quantity of catalyst required in the transesterification process must be determined through an optimization process, just as the ratio of oil to alcohol must be.

Mixing Intensity

Transesterification reaction is a somewhat slow process since oils and alcohols are not entirely miscible, hence reaction can only occur in the interfacial region between the liquids. So, Adequate mixing between these two forms of feedstock is required to enable interaction between these two feed stocks, and hence increase the transesterification processes to occur. According to the majority of the available literature, the reactants in a transesterification process first form a two-phase liquid solution. The mixing effect was discovered to be a major contributor to the sluggish reaction time. As phase separation breaks down, the importance of mixing decreases. Process scale-up and design are grounded in an understanding of how mixing affects the kinetics of transesterification. Depending on how much mixing is required for transesterification, the mixing pressure can be adjusted. In order to guarantee good and uniform mixing of the feedstock, the mixing intensity should be raised. In order to facilitate the mass transfer between the oil, alcohol, and catalyst when using vegetable oils with a high kinematic viscosity as the feedstock, vigorous mechanical mixing is essential.

Free fatty acid and water content

The catalyst-assisted transesterification of glycerides with alcohol is very sensitive to the FFA and moisture concentrations of the starting materials. Since soap generation and product separation become extremely challenging due to the high FFA level (>1% w/w), the resulting biodiesel product yield is poor. A further challenge in isolating glycerol from biodiesel is the emergence of gels and foams. For instance, the hydrolysis reaction can be sped up by increasing the quantity of water present in used frying oil, while the creation of ester is decreased.

Supercritical methanol was presented as a solution to this issue. It's worth noting that the supercritical methanol approach is less affected by the presence of water. It is more important for an acid-catalyzed reaction than a base-catalyzed reaction that the water concentration does not exceed 0.5%, and this is especially true when trying to get a biodiesel yield of 90%.

V. CONCLUSION

Biodiesel's positive effects on the environment, as well as its renewability, biodegradability, nontoxicity, and environmental friendliness, have garnered it international attention. It's a significant development in the field of alternate transportation fuels. Many types of fatty acid-containing feedstock, including animal fats, industrial byproducts, used cooking oils, and algae, can be converted into this product. This revolutionary strategy has the potential to pave the way for industrial production of biodiesel equivalents from renewable resources using engineered microbes, opening the door to a wider usage of biodiesel-like fuels in the future. Microdiesel, unlike ordinary biodiesel, doesn't require the use of harmful chemicals in its production. It has been suggested that waste oils might be utilised as a supply of fatty acids, negating the need to cultivate crops just for biodiesel production and so lowering the manufacturing cost of this fuel.

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