The Future of Bio Diesel

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Abstract— Fuels are of great importance in our daily life because they can be burned to produce significant amounts of energy. Fossil fuel contributes about 80% of the world's energy needs. Most industries use diesel machines for the production process. In the transportation sector, private vehicles, buses, trucks, and ships also consume significant amounts of diesel and gasoline. Fossil oils are fuels which come from ancient animals and microorganisms. Fossil fuel formation requires millions of years. Thus, fossil oils belong to non-renewable energy sources. It is necessary to look for alternatives fuels which can be produced from resources available in atmosphere within country such as alcohol, bio diesel, vegetable oil etc. Biodiesel production is a important field of research because the relevance it gains from the rising petroleum price and its environmental advantages. This paper reviews the recent developments of Biodiesel, including the different types of biodiesel, resources of bio diesel conversion technologies and production of bio diesel. The challenges of biodiesel industry development and the biodiesel policy are discussed as well.

Key words: Biodiesel, policy, Trans esterification

I. INTRODUCTION

Bio fuels are becoming increasingly interesting as an alternative to fossil fuels due to increasing population, depletion of fossil fuels, global warming, and fluctuations of the crude oil prices. Biodiesel is an acceptable alternative fuel for diesel engine, due to its technical, environmental and strategic advantages. Biodiesel is well known chemically as the mono-alkyl esters of long chain fatty acids and is produced from several types of conventional and non-conventional vegetable oils and animal fats (Knothe et al., 2005). In addition to its renewability, other advantages of biodiesel include non-carcinogenic and non-mutagenic properties and its biodegradability, miscibility with petroleum diesel, lubricity, high flash point and cetane number, m and absence of aromatics. The characteristics of biodiesel reduce the emissions of carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM) in the exhaust gas as compared with petroleum diesel, so is environmentally beneficial Because of the small oil yield extracted from plant sources, however, a great deal of feedstock is needed for the commercialization of biodiesel fuel. This requires large areas of land, and can result in competition with food crops [3].

Biodiesel as one promising alternative to fossil fuel for diesel engines has become increasingly important due to environmental consequences of petroleum-fuelled diesel engines and the decreasing petroleum resources. Biodiesel can be produced by chemically combining any natural oil or fat with an alcohol such as methanol or ethanol. Methanol has been the most commonly used alcohol in the commercial production of biodiesel. Lots of researches on biodiesel have shown that the fuel made by vegetable oil can be used properly on diesel engines. In fact the energy density of biodiesel is quite close to regular diesel. Biodiesel can be produced by soybean and methanol via transesterification in the presence of acid catalysts. [1] Many research programs are going on to replace diesel fuel with a suitable alternative fuel like biodiesel. [4]

II. BIO DIESEL

Biodiesel is defined as the mono alkyl esters of vegetable oils or animal fat (American Society for Testing and Materials (ASTM) Standard D6751) and can be produced from various sources such as algae, used frying oil, soy beans, palm kernels, or rapeseed. The choice of feedstock thereby strongly Influences the composition of a biodiesel, which in turn influences its quality as a fuel. [5]

The best way to use vegetable oil as fuel is to convert it in to bio diesel. Bio diesel is the name of a clean burning mono alkyl eater based oxygenated fuel made from natural, renewable sources such as new/used vegetable oil and animal fats. The resulting bio diesel is quite similar to conventional diesel in its main characteristics. Bio diesel contains no petroleum products, but it is compatible with conventional diesel and can be blended in any proportion with mineral diesel to create a stable bio diesel blend. Bio diesel viscosity comes very close to that of mineral diesel hence no problems in the exist in fuel handling system. Flash point of the bio diesel gets lowered after esterification and the cetane number gets improved. [2]

Fig. 1: Bio diesel samples with source jatropa seeds [2]

Even lower concentrations of bio diesel act as cetane number improver for bio diesel blend. Calorific value of bio diesel is also found to be very close to mineral diesel. Some typical observation from the engine tests suggested that the thermal efficiency of the engine generally improves; cooling losses and exhaust gas temperature increase, smoke opacity generally gets lower for bio diesel blends. Possible reason may be additional lubricity properties of the bio diesel; hence reduced frictional losses (FHP). The energy thus saved increases thermal efficiency, cooling losses and exhaust losses from the engine. The thermal efficiency starts reducing after a certain concentration of bio diesel. Flash point, density, pour point, cetane number, calorific value of bio diesel comes in very close range to that of mineral diesel. [2]

III. BIO DIESEL PRODUCTION

Biodiesel production is based on transesterification of vegetable oils and fats through the addition of methanol (or other alcohols) and a catalyst, giving glycerol as a co-product. Feedstock includes rapeseeds, sunflower seeds, soy seeds and palm oil seeds from which the oil is extracted chemically or mechanically. [6]

A. Process

Advanced processes include the replacement of methanol of fossil origin, by bio ethanol to produce fatty acid ethyl ester instead of fatty acid methyl ether (the latter being the traditional biodiesel). In order to expand the relatively small resource base of biodiesel, new processes have been developed to use recycled cooking oils and animal fats though these are limited in volume. Hydrogenation of oils and fats is a new process that is entering the market. It can produce a biodiesel that can be blended with fossil diesel up to 50% without any engine modifications. The largest biodiesel producer is Germany, which accounts for 50% of global production. Biodiesel is currently most often used in 5%-20% blends (B5, B20) with conventional diesel, or even in pure B100 form. [6]

B. Energy input and emission

Energy input and overall emissions for **biodiesel** production also depend on feedstock and process. Typical values are fossil fuel inputs of 30% and CO2 emission reductions of 40%-60% vs. diesel. Using recycled oils and animal fats reduces the CO2 emissions. [6]

C. Cost

Biodiesel from animal fat is currently the cheapest option ($0.4- $0.5/lde) while traditional trans-esterification of vegetable oil is at present around $0.6-$0.8/lde. Cost reductions of $0.1-$0.3/lde are expected from economies of scale for new processes. The cost of BTL diesel from ligno-cellulose is more than $0.9/lde (feedstock $3.6/GJ), with a potential reduction to $0.7- $0.8/lde. [6]

D. Status and potential

Biodiesel offers full blending potential with conventional diesel, a high cetane number giving improved combustion in compression ignition engines, and low emissions of sulphur and particulates. Biodiesel is the fastest growing bio fuel but from a lower base than ethanol. Global production passed from 2.1 bnl in 2004 to 3.9 bnl in 2005, increasing by 75% in Germany, France, Italy, and Poland and tripling in the United States. The potential market for biodiesel is estimated to be in the order of 20 EJ by 2050, assuming development of synthetic bio fuel production technologies. Several countries have adopted policies such as tax exemptions, mandates and incentives for bio fuels in 2005–2006. For example, France targets 5.75% bio fuels by 2008 and 10% by 2015; Germany requires 2% ethanol and 4.4% biodiesel in 2007, increasing to 5.75% by 2010; Italy mandates 1% blend for both ethanol and biodiesel in 2006; and in the beginning of 2007, the European Commission proposed a 10% target by 2020. In the US, fuel distributors are required to increase the annual volume of bio fuels up to nearly 30 bnl by 2012 with the targets for "renewable and alternative fuels" raised in 2007 to 140 bnl by 2017. Targets and mandates also exist in non OECD countries (e.g., Brasil, China). [6]

E. Barriers

Biodiesel production depends on feedstock and land availability even more than bio ethanol production. The Fischer-Tropsch BTL technology and other advanced processes hold the potential to increase biofuels production basis. [6]

IV. ADVANTAGES OF EMISSIONS PRODUCED BY BIODIESEL

Biodiesel can replace fossil fuel as a "clean energy source". It can protect the environment by reducing CO2, SO2, CO, HC.[1] The carbon cycle of Biodiesel is dynamic through the photosynthesis process as shown in figure 3. Plants absorb CO2, which is more than those discharged by the biodiesel combustion process. Thus, using biodiesel can more effectively reduce the emission of CO2, protect the natural environment and maintain the ecological balance, compared to the use of fossil fuel.[7]

The emission of SO2 in the combustion process of biodiesel is much lower than normal diesel oil because of the low sulphur content in it [8]. Thus, the use of biodiesel instead of normal diesel oil will effectively reduce acid rain, which represents a serious threat to the environment and human infrastructure in forms of acidification of soil, surface and ground water forest and vegetation damage, and increased corrosion of buildings and historical monuments made from calcium containing stones. Furthermore, CO, HC and particulate matters will be less discharged, because ester compounds in biodiesel contains oxygen promoting clean burning. [1]

V. RESOURCES

Non-edible sources like Mahua oil, Karanja oil, Neem oil, Jatropha oil, Simarouba oil etc. are being investigated for biodiesel production. Fatty acids like stearic, palmitic, oleic, linoleic and linolenic acid are commonly found in non edible oils [9]. Vegetable oil blended with diesel in various proportions has been experimentally tested by a number of researchers in several countries.[4] In the case of biodiesel, the main feed stocks are vegetable oils from rapeseed, mustard, peanut, pongamia, micro algae, waste cooking oil, soybean, sunflower and palm oil. [10]

Pure sodium hydroxide as alkaline catalyst, anhydrous sodium sulfate, chloroform and methanol were purchased from Merck Co. (Germany). All other chemicals used for the preparation of cultivation medium were of analytical grade. Commercial Egyptian petro-diesel sample was obtained from a local fueling station.[3]

VI. CHALLENGES OF BIODIESEL INDUSTRY DEVELOPMENT

Bio fuel policies play an important role in the development of the energy sector. The profitability of bio fuel production is significantly influenced by policies affecting multiple sectors such as agriculture, research, industry and trade. [10]

A. Blending Mandates

Imposing quantitative targets in the form of blending mandates is the key driver in the development and growth of the bio fuel industry. The blending mandate of 5% ethanol with gasoline in nine states of India in 2003 was enhanced to include 20 states in 2006. In 2010, the National Policy on Bio fuels approved a target 20% blending with bio fuels by 2017. [10]

B. Input Support (Subsidies)

The justification for providing policy support to a new sector is based on its ability to overcome initial costs of technological innovation and market development required to make it competitive. This is the "infant industry" argument for providing subsidies. However, providing subsidies to a sector that will not ultimately achieve economic viability is not sustainable and may only serve the purpose of transferring wealth from one group to another while imposing costs on the economy as a whole (FAO 2008). [10]

C. Output Support

Besides production support, output support for the purchase of bio fuels is critical. The National Bio fuels Policy proposes a Minimum Support Price mechanism for *Jatropha* whose seed is used to produce biodiesel. In the case of sugarcane, the existing statutory minimum price provides effective protection to growers. [10]

D. Distribution and Marketing of Bio fuels

India's bio fuel policy exempts the bio fuel sector from central taxes and duties. While biodiesel is exempt from excise duty, bio ethanol enjoys a concessional excise duty of 16%.While these policies promote the bio fuel sector, those promoting the production of feedstock need to be highlighted in order to fully realize the benefits provided on the processing front, since production and processing are interdependent. Though the policy mentions exemption of central taxes and duties on bio fuels, sales tax, license fee, permit fee and import taxes still exist, hindering the growth and development of the industry.[10]

E. Consumption Support

The bio fuel policy's thrust is on the supply side even though demand side factors also play a major role in promoting bio fuels. For example, many countries actively promote flex-fuel vehicles designed to use a higher percentage blend of ethanol with petrol than ordinary vehicles through reduced registration fees and road tax exemptions. Similarly, support is provided to purchase bio fuels, co-products and flex-fuel vehicles. [10]

F. Financial and Fiscal Incentives

Apex financial institutions like the National Bank for Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency (IREDA) and Small Industries Development Bank of India (SIDBI) have refinancing provisions to set up biodiesel plantations, oil expelling/ extraction units, and infrastructure for storage and distribution The lending towards these sectors would be classified as priority sector lending. The policy states the consideration of subsidies and grants upon merit for new and second generation feed stocks; advanced technologies and conversion processes; and production units based on new and second generation feed stocks. Similar emphasis explicitly mentioning bio ethanol would benefit the ethanol industry. [10]

G. Research & Development

The policy's major thrust is innovation, Research & Development (R&D) and demonstration. It focuses on R&D efforts in processing and production technologies and maximizing efficiencies and utilization of by products along the bio fuel value chain. Demonstration projects are to be set up for biodiesel and bio ethanol production, focusing on conversion technologies through Public Private Partnership (PPP). Grants are to be provided to academic institutions, research organizations, specialized centers and industry for promising R&D and demonstration projects. [10]

H. Institutional Mechanisms

Among institutional policies that promote the bio fuel industry are international cooperation through technical collaboration in production, conversion and utilization; trade in bio fuels; state participation in planning and implementing bio fuel programs; and capacity building for dissemination and creating awareness. Though India has a policy on promoting bio fuels at various stages of the supply chain, the government's initiatives on the production and commercialization fronts have not taken off as anticipated to meet the energy demand for ethanol and biodiesel**. [10]**

VII. BIO DIESEL PRODUCTION TECHNOLOGY

There are four different ways through which non-edible oils can be converted into methyl esters are transesterification, blending, emulsion and pyrolysis out of which transesterification is the most commonly used Method. [4]

A. Trans esterification

Transesterification is a chemical reaction that occurs between triglyceride and alcohol in presence of catalyst to obtain methyl ester and glycerol as by product. Transesterification mainly depends upon the amount of alcohol and catalyst, pressure, time, FFA and amount of water. Oils with large amount of free fatty acid are difficult to pass through the conversion process because it will form soap solution in presence of the catalyst. This further prevents separation of methyl ester from glycerol [11] . Acid catalyzed transesterification is most commonly used process because it is a reversible reaction. In the transesterification process methanol and ethanol are more common. Methanol is more extensively used due to its low cost and physiochemical advantages with triglycerides and alkali are dissolved in it [13] Studies have been carried out on different oils like Soyabean, Sunflower, Jathropa, Karanja, Neem etc. Mostly biodiesel is produced by base catalyzed transesterification process of vegetable oil and it is more economical. Here the process is a reaction of triglyceride with alcohol to form mono ester commonly known as biodiesel and glycerol as by product. The main reason for doing titration to is to find out the amount alkaline needed to completely neutralize any free fatty acid present, thus ensuring a complete transesterification [12].

B. Blending

Blending biodiesel with petroleum compensates for many cold flow problems through dilution. As mentioned earlier, the cold flow properties associated with a particular methyl ester are the result of its feedstock. At this time, there are no additives in the marketplace for pure soy methyl esters that can reliably affect these properties as significantly as can be achieved in petroleum diesel. Biodiesel may also need to be warmed prior to blending. To ensure successful blending into a single mixture, the biodiesel and petroleum should be blended at similar temperatures. Blending products that are at extreme temperature differences will not promote homogeneity within the final blend. The B100 will lend itself to easier mixing with diesel when the biodiesel is at temperatures of at least 25-30° F above the reported Cloud Point. [14]

C. Emulsion

Emulsion is defined as a process where the initially mutually immiscible materials, such as water and oil, are mixed to form and maintain a temporary suspension by reducing their particulate sizes. The rate at which the emulsion returns to a two-phase mixture depends on the types, viscosities, particulate size, and composition of mixed materials and the temperature. A higher ratio of water to oil content results in an oil-in-water type suspension, while a reverse ratio results in a water-in-oil type. The water-in-oil type emulsion fuel may improve combustion efficiency when burned. The smaller size would give oil particles more contact area with the surrounding oxygen and would eventually improve combustion efficiency.

The decrease in emissions achieved by properly designed diesel-water emulsification is universal regardless of engine. The primary benefit of water-diesel emulsions in diesel engines is a notable reduction in NOx emissions. It was found that brake power, engine power and also the engine torque were improved with the emulsified fuels for both diesel and benzene till addition of 25% water. Adding water to diesel-benzene could reduce bad emissions of the vehicles. The emulsion method had higher potential of simultaneous reduction of NO and smoke emission at all loads than water injection method. [15]

D. Pyrolysis

Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. The word is derived from the Greek words “pyro” meaning fire and “lysis” meaning decomposition or breaking down into constituent parts. Pyrolysis has also been used to produce tar for caulking boats and certain embalming agents in ancient Egyptian. use of pyrolysis processes has been increasing and is widely used for charcoal and coke production. This is because only the burning of charcoal allowed the necessary temperatures to be reached to melt tin with copper to produce bronze. Pyrolysis technology has the capability to produce bio-fuel with high fuel-to-feed ratios. Therefore, pyrolysis has been receiving more attention as an efficient method in converting biomass into bio-fuel during recent decades. The ultimate goal of this technology is to produce high-value bio-oil for competing with and eventually replacing non-renewable fossil fuels. However, the development of advanced technologies is the next challenge for pyrolysis researchers to achieve this target. It is necessary to convert biomass into liquid fuels for direct use in vehicles, trains, ships and aero planes to replace petrol and diesel. [16]

VIII. THE BIO DIESEL POLICY

In recent years, incentives exist within energy-, climate- and agricultural policies in several countries to promote further progress in the use of biodiesel [17]. The policy and government incentives will directly influence the development of biodiesel industry. As a policymaker, government play an essential role in determining the course, and crucially, the scale, of biodiesel development, in particular by means of the proper incentives such as tax exemptions, price controls, targets and direct subsidies. Now, there are many incentives that can be offered by a government to spur the development of biodiesel industry and maintain its sustainability, they are given below [18, 19]:

- Crop plantation in abandoned and fallowed agricultural lands;
- Subsidizing the cultivation of non-food crops or the usage of waste oil as feedstock;
- Implementation of carbon tax;
- Exemption from the oil tax;
- Mandatory biodiesel blend use in gas station.

While governments are focusing on the ways to improve bio diesel production and consumption, they should give enough attention to unresolved issues like rainforest depletion, food prices increase. Without taking into account these, their policies might have detrimental effects on climate change. [1]

A. Word overview

Biodiesel made from oil-seed crops is the other well-known first-generation bio fuel. As of 2005, Germany led the world in production (primarily from rapeseed and sunflower) with about 2.3 billion litres produced [20]. Production worldwide has been growing rapidly since 2005. In the United States, biodiesel production (primarily from soybeans) rose from an estimated 284 million litres in 2005 to 950 million litres in 2006. In Brazil, the Government has mandated the addition of 2 per cent biodiesel to conventional diesel starting in 2008, with the percentage increasing to 5 per cent in 2013. Meeting the 2008 goal will require about 800 million litres of biodiesel. As of the end of 2006, Brazil’s installed biodiesel production capacity was about 590 million litres/year, and this capacity is expected to more than double this year [21]. Interest in palm biodiesel is growing, especially in South- East Asia (Malaysia, Indonesia and Thailand) where the majority of the world’s palm oil for food use is made. Jatropha, a non-edible-oil tree, is drawing attention for its ability to produce oil seeds on lands of widely varying quality. In India, Jatropha biodiesel is being pursued as part of a wasteland reclamation strategy [22]. From the perspective of petroleum substitution or carbon emissions reductions potential, biodiesel derived from oil-bearing seeds are – like starch-based alcohol fuels –limited, as discussed later.

B. Biodiesel policies in India

India has to address the simultaneous challenges of energy security, climate change and rural development. Biodiesel bears strong potentials – but also risks – for all of these challenges. Despite these potentials, a biodiesel market has not yet fully developed in India due to by a series of market failures: Biodiesel cannot yet compete with fossil fuels, as the prices of the latter do not reflect the negative environmental externalities which they cause. If these costs were internalised, biodiesel with its higher production but lower environmental costs would be more competitive. At the same time, positive externalities of R&D efforts in biodiesel and of processes of self-discovery cannot be fully appropriated by investors and farmers. The vast part of this knowledge will constitute non patentable incremental innovations that can be freely appropriated by anyone. A number of market failures specifically prevent the poor in remote areas to benefit from the opportunities of the sector. Since TBO-based biodiesel production is a new activity, cultivators are not informed about cultivation methods and required inputs, expected yields, available support measures and the development of the market. Because of the high risk and long-term nature of investments – many TBOs can only be used for the production of non-edible oil and have a long gestation period - information is a prerequisite for investment. However, access to information is often lacking in remote areas. [23]

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