3. RECENT TRENDS IN BIODIESEL

An impetus in development of renewable sources of energy has resulted in biodiesel development from raw materials such as vegetable and waste cooking oils. Biodiesel is synthesized by reaction of triglycerides with alcohol in the transesterification reaction. The commonly used alcohol is methanol due to low cost and the biodiesel is thus fatty acid methyl ester. New generation biodiesel intends to derive raw material from algae and other feedstock which will provide sustainability to the energy sources needed to adequately supplement the biodiesel industry. The process that is being adopted worldwide for biodiesel synthesis is transesterification. In the transesterification reaction, the ester group from the triglyceride is detached to form three alkyl ester molecules. The feedstock for biodiesel preparation at industrial level comprises of edible as well as non-edible vegetable oils. Irrespective of the feedstock used for biodiesel production, a catalyst is needed to complete the reactions in a considerable time. The only case where catalyst is not needed for biodiesel synthesis is when alcohol and oil are used in supercritical conditions. Though there are recent reports on the use of catalyst even in supercritical conditions¹.

Rapid depletion of the petroleum reserves makes exploration of alternate sources of energy mandatory. In recent years, fatty acid methyl esters derived from vegetable oil, commonly known as biodiesel, have gained importance as alternate fuel for diesel engines. Biodiesel is produced
through the process of transesterification, in which animal fats or vegetable oils such as soybean oil, rapeseed oil, or oils from nonedible oilseed species such as Karanja (*Pongamia pinnata*) and Jatropha (*Jatropha curcas*) are reacted with a short-chain alcohol such as methanol in the presence of a suitable base catalyst at raised temperature$^2$.

The world has been confronted with environmental and energetic crises due to depletion of resources and increased population as well as environmental pollution. Other than energy sources such as hydroelectricity and nuclear power, energy production from renewable energy source has been increased worldwide for transportation purposes. Hence, it is important to search for an alternate low-cost fuel for every day usage, which should be sustainable and also friendly to the environment.

Many efforts have been underway to develop clean fuel in many countries like wind and solar energy. Among the many possible sources, biodiesel derived from vegetable oil attracts attention as a promising one for substitution or blending with conventional diesel-based fuels. If pure or blend biodiesel is used as fuel, the net production of carbon dioxide can be suppressed$^3$.

The current world energy demand and decrease of energy consumption based on use of fossil fuels has been recognized as a top priority for both developed and developing nations. Alternative energy sources are therefore urgently sought in response to both diminishing world
oil reserves and increasing environmental concerns over global climate change. To be truly viable such alternative energy sources must be sustainable, that is ‘have the ability to meet 21st century energy needs without compromising those of future generations’. While a number of sustainable technologies are currently receiving heavy investment, the most easily implemented and low cost solutions for transportation needs are those based upon biomass derived fuels. Spearheading such renewable fuels is biodiesel – a biodegradable, non-toxic fuel synthesized from animal fats or plant oils extracted from cereal or non-food crops.4

Biodiesel, an alternative renewable fuel made from transesterification of vegetable oil with alcohol, has been accepted for use in blends with conventional diesel fuel for transportation applications. However, even during times of skyrocketing crude oil prices, biodiesel was not cost competitive to diesel. The primary cost component in biodiesel is the vegetable oil and their availability is of concern, due to increasing demand for edible purposes. Soybean and Rapeseed are common feedstock for biodiesel production in USA and Europe, respectively. Likewise, Palm is being exploited in South East Asia. It is estimated that even if all the edible oils are used for biodiesel production, even then they will not be sufficient for meeting fuel demand.5

The burning of fossil fuels during the past century has dramatically increased the levels of carbon dioxide and other ‘greenhouse gases’ that trap
heat in atmosphere. Their implications are hotly debated, but the levels of these gases have unquestionably risen at unprecedented rates in the context of geological time. Mixture of fatty acid methyl esters or biodiesel obtained in reaction of methanol and triglycerides, i.e. vegetable oil is being widely used today. Biodiesel and mineral diesel production processes are almost equally efficient at converting raw energy resources (in this case, e.g. soybean oil and crude oil) into fuels. Biodiesel can play a role in reducing emissions of many air pollutants, especially those targeted by Environmental Protection Agency in urban areas: particulate matter, carbon monoxide, hydrocarbons, sulphur oxides, nitrogen oxides and air toxics.

Due to the limited resources of fossil fuel, increasing prices of crude oil and environmental concerns over the past couple decades, alternative fuels have recently gained significant attention. Biodiesel, consisting of methyl esters of fatty acids produced by alcoholysis of vegetable oils or animal fats in presence of a catalyst, is an excellent substitute for conventional virgin diesel fuels produced from crude oil. It is non toxic, biodegradable and made from renewable sources. Besides, it also decreases the emission of carbon monoxide, unburned hydrocarbons and particulates during the combustion process when compared with fossil fuels.

Due to the potential shortage of fossil fuels and environmental concerns, the synthesis of biodiesel i.e., fatty acid methyl esters from the transesterification of triglycerides (the main component of vegetable oils or
animal fats) and the esterification of free fatty acid with methanol have drawn intense attention. A wide variety of vegetable oils (e.g., soybean oil and rapeseed oil) can be employed as the raw material for the production of biodiesel.

There is increasing interest worldwide in the development of liquid transport fuels from biomass to displace fossil fuels. Recent political and research and development trends show a clear move towards lignocellulosic feedstocks for these biofuels. Lignocellulosic feedstocks mitigate competition for land and water used for food production, increase biomass production per unit of land and reduce the inputs needed to grow the biomass. Currently, there are two main technological pathways to convert lignocellulosic biomass to biofuels: a thermochemical route via gasification, and a biochemical route using enzymes. A key challenge for biofuel production systems is to develop efficient conversion technologies which are able to compete economically with fossil fuels. As with other energy technologies, thermodynamic analysis provides a powerful tool to guide technology selection and research efforts towards more efficient biofuels production systems. However, conventional energy analysis based only on the first-law of thermodynamics cannot be used reliably for these purposes as it does not embody second law constraints on energy conversion and erroneously treats all energy types as equal. An exergy analysis of bioethanol production process from lignocellulosic feedstock via a
biochemical process to assess the overall thermodynamic efficiency and identify the main loss processes\textsuperscript{17}.

Derivatives of animal and plant fatty materials have been considered possible fuels since the development of the diesel engine. It was demonstrated in the first half of the 20th century that vegetable oils can be used as fuels in prechamber diesel engines\textsuperscript{18}, but engine failure can occur in modern engines due to their high viscosity, density, and deposit buildup. The higher price of these materials and the low price of petroleum fuel distillates further discouraged the use of fatty materials, except when crude petroleum was in short supply\textsuperscript{19}.

Recent concerns about depleting petroleum reserves and global warming in the last few years have led several governments around the world to encourage the use and production of biofuels\textsuperscript{20-22}. Methyl esters (biodiesel) through transesterification and hydrocarbons (pyrodiesel) through pyrolysis of fats and vegetable oils have been suggested as suitable fuels for diesel engines\textsuperscript{23}. Most common method to produce biodiesel is transesterification, where the triacylglycerol structures of oil are reacted with a mono-alcohol to produce biodiesel\textsuperscript{24-34}. Although transesterification is the most popular route, it is not without drawbacks, such as requirement of high quality raw-material and large amount of alcohol. An alternate route to produce biofuel from triglycerides is thermal cracking (also called pyrolysis) of fatty materials. Pyrolysis of oils and fats is well studied\textsuperscript{35-42}. 

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A recent report described a method for the synthesis of pyrodiesel with physical and chemical properties that match diesel fuel specifications\textsuperscript{43}. With the current food and fuel issue of edible vegetable oils, the pyrolysis process have an advantage of using a variety of feed stocks (both edible and inedible). Apart from non-food vegetable oils and fats, leftover byproducts of biodiesel process, i.e. soap stock, trap grease, sewage grease could be more economically converted to biofuels using pyrolysis process. The process dates back 60 years\textsuperscript{44,45}, and has shown its industrial applicability by the fact that fuel of this type made from animal fats may soon be incorporated into a large industrial scale process in a joint collaboration between a food industry giant and a large petrochemical producer in USA\textsuperscript{46}, and by a large petroleum company in Brazil\textsuperscript{47}. To be considered viable transportation fuels, this alternative fuel must meet stringent quality standards. The physico-chemical properties of biodiesel have already been extensively studied and specific standards have been established in several countries including Europe, USA and Brazil. However, pyrodiesel and its physico-chemical properties have been scarcely studied and no requirements have been established yet. For this reason, several studies must be performed before pyrodiesel can be used as fuel.

It is focused that the investigation of pyrodiesel and the effect of blending with low sulfur and high sulfur diesel fuels on the performance properties of the blends. Recently, it is reported some of the properties such
as density, viscosity, surface tension and lubricity of blends of pyrodiesel and biodiesel with low and high sulfur content diesel. It is observed that when adding biofuels to the petrodiesel fuels, the properties related to the injection and lubrication of the fuel in the engines were enhanced. Here, it is discussed the performance properties such as oxidation stability, low temperature and corrosion properties of the biofuels and their blends with petrodiesels. These pyrodiesel samples were compared with soy biodiesel samples. All the biofuels and their blends with high sulfur and low sulfur diesel fuels were evaluated by measuring a number of fuel properties.
Usage of Biodiesel
References


11. IEA, 2008. From 1st to 2nd generation biofuel technologies. An overview of current industry and RD&D activities. IEA-OECD.


