Use of Lipid Biofuels with Environmental Impacts for Production of low cost Fuel

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Abstract – *Biodiesel is considered as a renewable substitute for diesel oil in the compression ignition engine. But the biodiesel is more prone to oxidation due to its chemical nature. The products of the oxidation cause the biodiesel to become acidic and to form insoluble gums and sediments that can plug fuel filters. In India, biodiesel is derived from non-edible oils sources, in particular honge and jatropha oils [1]. Oil-accumulating microalgae have the potential to enable large-scale biodiesel production without competing for arable land or biodiverse natural landscapes. High lipid productivity of dominant, fast-growing algae is a major prerequisite for commercial production of microalgal oil-derived biodiesel. However, under optimal growth conditions, large amounts of algal biomass are produced, but with relatively low lipid contents, while species with high lipid contents are typically slow growing. Major advances in this areacan be made through the induction of lipid biosynthesis, e.g., by environmental stresses. Lipids, in the form of triacylglycerides typically provide a storage function in the cell that enables microalgae to endure adverse environmental conditions. Under this review paper work detailed studies will be conducted for analyzing the properties and use of lipid biofuels. Here also discuss the environmental impacts of lipid biofuels*

Key Words: Alge, Bio Diesel, Diesel, EPA, GHG, PPO, Lipids, etc

1. INTRODUCTION

Biodiesel is a clean burning alternative fuel produced from domestic, renewable resources. The fuel is a mixture of fatty acid alkyl esters made from vegetable oils, animal fats or recycled greases. Where available, biodiesel can be used in compression-ignition (diesel) engines in its pure form with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It is usually used as a petroleum diesel additive to reduce levels of particulates, carbon monoxide, hydrocarbons and air toxics from diesel-powered vehicles. When used as an additive, the resulting diesel fuel may be called B10, B20, or B30 representing the percentage of the biodiesel that is blended with petroleum diesel[2].

A large portion of biofuels can be received from lipid sources. There exist mainly two types of fuels that are based on lipids: pure plant oil(PPO) and biodiesel. Due to similar primary process steps of PPO and biodiesel, they are discussed in chapter 6 together under the title "lipid derived fuels". For example, feedstock production and oil extraction are the same process steps for both fuels. But, for the final production of PPO some additional purification steps are necessary, whereas for biodiesel the transesterification step has to be applied. Nevertheless, both end products (PPO and biodiesel) are completely different in properties.

There are many options for utilizing different feedstock types for PPO and biodiesel production. Besides dedicated oilseed crops such as e.g. rapeseed and soybean, also microalgae, animal fats and waste oil provide viable feedstock opportunities for fuel production. However, these last mentioned feedstock types are not yet used on a large scale today.

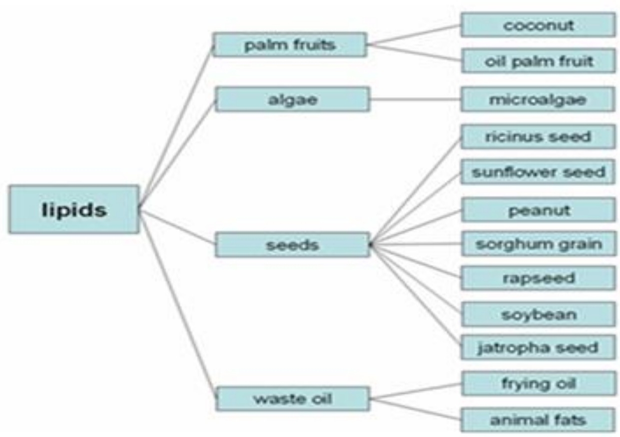

Fig -1: examples for lipid feedstock sources.

Figure .1 shows some examples for lipid feedstock sources. They can be sub-divided into palm fruits, algae, seeds and waste oil. Although the productivity of palm fruits is on of the highest, the most common feedstock sources for PPO and biodiesel production are seeds from various plants. These include seeds from ricinus, sunflower, peanut, sorghum, rapeseed, sorghum and jatropha. The choice for a dedicated feedstock is pre-determined by agricultural, geographical and climatic conditions. But it also has to be considered, that different feedstock types are characterized by different properties. For instance, the oil saturation and the fatty acid content of different oilseed species vary considerably. Biodiesel from highly saturated oils is characterized by superior oxidative stability and high Octane number, but performs poorly at low temperatures. Therefore, pure plant oil (PPO) with a high degree of saturation is more suitable as feedstock in warmer climates.

2. TRANSESTERIFICATION

The chemical transesterification process during biodiesel production changes the molecular structure of lipid molecules. There by the physical properties change. Although even refined pure plant oil (PPO) can be used in refitted diesel engines, biodiesel, which is created by a transesterification step, has several advantages. One advantage is the lower viscosity of biodiesel when compared to PPO. Increased viscosity adversely affects fuel injection duration, pressure, and atomization of diesel engines. Biodiesel is very similar to fossil diesel and thus can be consumed in common diesel engines which are refitted with only small efforts.

Transesterification, also called alcoholysis, is the process by which the refined oil molecule is "cracked" and the glycerin is removed, resulting in glycerin soap and methyl-or ethyl esters (biodiesel). Organic fats and oils are triglycerides which are three hydrocarbon chains connected by glycerol. The bonds are broken by hydrolyzing them to form free fatty acids. These fatty acids are then mixed or reacted with methanol or ethanol forming methyl or ethyl fatty acid esters (monocarbon acid esters). The mixture separates and settles out leaving the glycerin on the bottom and the biodiesel (methyl-, ethyl ester) on the top. Now the separation of these two substances has to be conducted completely and quickly to avoid a reversed reaction[3]. These transesterification reactions are often catalyzed by the addition of an acid or base. The chemical transesterification reaction is shown in Figure 2

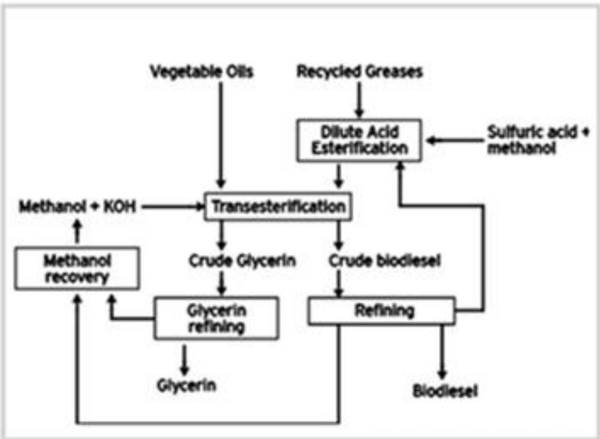

Fig -2: The chemical transesterification

For the transesterification process, mainly the alcohols methanol and ethanol are used. Theoretically transesterification can be also processed with higher or secondary alcohols. Transesterification with methanol, also called methanolysis, is the most commonly method for biodiesel production. Methanol is characterized by its lower prices and its higher reactivity as compared to other alcohols. This reaction can happen by heating a mixture of 80-90 percent oil, 10-20 percent methanol, and small amounts of a catalyst. For the reaction it is necessary to mix all ingredients well, as the solubility of methanol in vegetable oil is relatively low[4]. The received biodiesel after methanolysis is fatty acid methyl ester (FAME).

As methanol usually is a fossil product, the utilization of bioethanol in an ethanolysis reaction is often discussed as the more environmentally friendly alternative, since it allows the production of an entirely renewable fuel. In addition, ethanol is much less toxic and slightly increases the heat contents and cetane numbers of the resulting fuel. But, on the other hand, for ethanolysis much more energy is needed and problems with the separation of the ester and glycerin phases are reported more frequently. The process energy costs seem to be higher as well. Biodiesel which is received by ethanolysis is also called fatty acid ethyl ester (FAEE).

3. PROPERTIES AND USE OF LIPID BIOFUELS

Generally the characteristics of lipid derived fuels are much more variable than propertyesof bioethanol, due to its different conversion process and due to the wide variety of feedstock sources of oils and fats. Ethanol is actually one very specific molecule. In contrast, the molecules of pure plant oil, animal fat and biodiesel vary, depending on the origin of the feedstock type. Nevertheless, PPO and biodiesel must meet certain properties and standards after refining and transesterification, respectively.

Before detailed properties of biodiesel and PPO will be described in the following chapters, a general comparison of rapeseed oil, biodiesel and BtL fuels is given in Table 1. These biofuels are also compared to fossil diesel. The table shows the high viscosity and flashpoint of rapeseed oil. It shows further, that the properties of biodiesel and BtLfuels are very similar to fossil diesel.

Properties of Pure Plant Oil (PPO) Properties of pure plant oil (PPO) largely differ in its properties when they are compared to the properties of fossil diesel. For example the viscosity of PPO is much higher, especially at cooler temperatures. It is up to ten times higher than the viscosity of fossil diesel. This property leads to technical challenges in winter running and when cold starting in conventional engines. Since PPO tends to gum up at colder temperatures, it has been difficult to blend it with conventional diesel fuel. However, different types of plant oil have different properties that affect engine performance. Some tropical oils with more saturated, shorter-chained fatty acids, such as coconut oil, can be blended directly with diesel fuel, offering the potential for the use of PPO-diesel blends in unmodified engines in tropical locations.

Also the flashpoint of pure plant oil is significantly higher than that of normal diesel. It lies at around 240 ºC .often cited flashpoints over 300 °C are received by Open Crucible method; see Table 11) and is therefore particularly safe in storage and transport and easy to handle. Consequently, in Germany for example, pure plant oil is not included in any hazard classes according to the "Ordinance for Flammable

Liquids". Additionally, PPO is biodegradable in a short time in soil and watersand e.g. in Germany, it is not classified in any water hazard class. A detailed description of PPO properties is given .Because of its specific properties, the refined PPO usually cannot be used in normal diesel engines. In order to run on pure plant oil, diesel engines must either be refitted, which is often done by attaching a mechanism for preheating the oil, or a dedicated engine must be used such as the Elsbett engine. It can be concluded that in temperate counties, technical barriers generally limit the use of PPO to niche markets. However, fuel quality standards have been defined for pure rapeseed oil in Europe, and there has been some experience with the use and handling of PPO in daily operation .

4. EMISSIONS OF LIPID BIOFUELS

4.1 Greenhouse Gas Emissions

The GHG balance for lipid biofuels mainly includes emissions of biofuel production, as it was described in chapter 4.2.1. Thus, reductions depend on the type of feedstock, agricultural practices, site productivity, conversion technology, and finally on the design of the study. Nevertheless, for biodiesel most studies show a net reduction in emissions. A short summary of GHG studies is given by WWI and OECD/IEA. For instance, up to 78 % reductions in CO2 are estimated by using soybeans in the United States. Also the estimates for net GHG emissions reductions from rapeseed-derived biodiesel range from about 40% to 70% when compared to conventional diesel fuel. Besides many studies showing GHG reductions for biodiesel, the study of DELUCCHI (2003) shows an increase of GHG emissions for biodiesel from soybeans.

For PPO far fewer studies on GHG balance exist. But, as the process step of transesterification is not applied to PPO, some GHG emissions can be saved. On the other hand, the consideration of glycerin, a co-product of biodiesel production, reduces GHG emissions of biodiesel [5]. Biodiesel from rapeseed is generally more favorable in regard of GHG emissions then pure rapeseed oil, since glycerin can be used to substitute technically produced glycerin[6].

4.2 Toxic Exhaust Emissions

The major part of engine exhaust streams consists of the components nitrogen, carbon dioxide and water which are non-toxic. However, about 0.2% of diesel engine exhaust emissions are composed of more or less harmful substances to human health . These substances can be divided into those which are limited by national authorities and those which are not limited. In the European Union limited emissions are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM). Unlimited emissions for instance are aldehydes and various polycyclic aromatic compounds (PAH).

Limited emissions Since the use of PPO is not yet widely promoted in Europe, studies on pure plant oil emissions are rare. In contrast, biodiesel is much more used and thus more studies on biodiesel emissions are available than for PPO. Therefore mainly emissions of biodiesel are treated in the following sections[7].

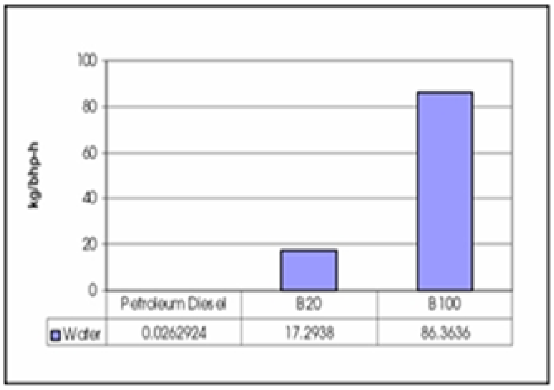

Fig -3: The average effects

Although emission of biodiesel combustion is a complex result of fuel quality, engine design and vehicle condition, it can be summarized that most pollutants are generally reduced when compared to fossil diesel. Lower emissions of particulates, sulfur, hydrocarbons, CO and toxins can be observed. Only NOx emissions slightly increase.

These reductions e.g. ´have been observed in a detailed evaluation of emission results and potential health effects by the U.S. Environmental Protection Agency (EPA 2002). EPA has surveyed the large body of biodiesel emissions studies and averaged the health effects testing results with other major studies. Since the majority of available data was collected on heavy-duty highway engines, this data formed the basis of the analysis. The average effects are shown in Figure 3.

In this EPA study it is shown that several pollutants which also affect human health are reduced by the use of biodiesel instead of fossil diesel (BIODIESEL 2006). For example the ozone forming potential of biodiesel hydrocarbons is less than diesel fuel. Sulfur emissions are essentially eliminated with pure biodiesel[8]. Further, the use of biodiesel in diesel engines results in substantial reductions of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen oxides slightly increase.

5. ENVIRONMENTAL IMPACTS OF LIPID BIO FUELS

Environmental effects of using lipid fuels such as PPO and biodiesel vary, depending on the fuel itself, vehicle technology, vehicle tuning and driving procedure. To enable the full evaluation of a certain fuel[9], also environmental effects of producing feedstock and processing the fuel have to be considered.

5.1 Water Issues

The consumption of biodiesel not only reduces tailpipe emissions when compared to fossil diesel. It also has the advantage, that biodiesel itself is much less harmful to water and soil[5]. Therefore, biodiesel is e.g. classified in class 1 after the German system of water pollution classes by the Federal Environment Agency (UBA), whereas fossil diesel is classified in class 2 "water hazard"21. The reason for this classification of biodiesel is that it is biodegradable and breaks down readily. It has been shown, that RME can biodegrade in less than half the time required for fossil diesel degradation. The RME was biodegradable to about 88 % within 28 days as opposed to only 26 % degradation for fossil diesel fuel over the same period of time. Additionally biodiesel is far more water-soluble than fossil diesel, enabling marine animals to survive in far higher concentrations if fuel spills occur. This is not only important to maritime shipping, but also to groundwater and biodiversity, agriculture and drinking water issues.

PPO is completely risk-free and no special precautions are needed as it is biodegradable in a short time in soil and water. In the German system of water pollution classes, rapeseed oil is not even classified in the lowest class 0. Besides the direct influences of biodiesel and PPO themselves on water and soil, also feedstock production and fuel processing influences water issues. For feedstock production pesticides and fertilizers are need, like for any agricultural crop. Runoff from pesticides can find its way in the groundwater, causing contamination and affecting water quality. Enhanced fertilization can cause eutrophication. In some regions and for some crops also water is needed for irrigation. This causes problems in areas where water is scarce. All these water issues of feedstock production largely depend on the various agricultural practices and have to be evaluated separately.

Processing of biodiesel and PPO can consume large quantities of water. The total water consumption for B100 is three orders of magnitude higher than petroleum diesel on a life cycle basis (Figure 4). Water is mainly consumed for washing plants and seeds as well as for removing soap and catalysts from the oil. Thereby wastewater is produced and has to be cleaned. Calculations of show that wastewater flows over the whole life-cycle of biodiesel from soybean are almost 80% lower than those of petroleum diesel (Figure 5).

5.2 Land Use and Biodiversity

Environmental problems associated with cultivating feedstock for pure plant oil and biodiesel can be very serious and it is may be the most environmentally disruptive stage of lipid biofuel production. Thereby the environmental impact of land use for PPO and biodiesel production mainly affects habitat and biodiversity as well as soil, water and air quality[9]. It depends on a variety of factors such as the choice of feedstock, what the feedstock replaces and how it is managed.

If biodiesel production is dramatically expanded in the future, the cropland requirements could become quiet significant and puts limits on biodiesel production potential. Therefore degraded lands, wastelands and set-aside lands can be further used for feedstock production. Increased biodiesel and PPO consumption would also support the agricultural sector since it represents a new distribution channel for farmers. On the other hand, setaside land is a very useful habitat for several plant and animal species and therefore the biodiversity would be reduced if all set-aside land would be converted into fields for biofuel production, such as rapeseed or sunflower.

3.3 Human Health

Arguments about impacts on human health can be effective political instruments either for or against biofuels since it influences public opinion. Therefore this topic has to be treated very sensitive. However, it has to be clarified that the use of pure plant oil and biodiesel poses indeed several risks to humans, but that the impacts of using fossil diesel are usually much larger.

For PPO and biodiesel the toxicity of the unburned fuel is generally lower than the toxicity of fossil diesel. Many vegetable oils are even edible and used for cooking purposes. Unlike this, toxic exhaust emissions of both, biodiesel and fossil diesel are suspected of having acute adverse effects on human health. The most obvious affects are irritation of the eyes and upper respiratory tract and the induction and enhancement of allergicresponses .However, impacts can be reduced by gas after treatments like catalytic converters and when compared to the emissions of fossil diesel, many tailpipe emissions of biodiesel combustion are reduced Correspondingly biodiesel also reduces many health risks associated with fossil diesel. For instance, biodiesel combustion emits fewer polycyclic aromatic hydrocarbons (PAH) and nitrated polycyclic aromatic hydrocarbons (nPAH), which have been identified as potential cancer causing compounds.

6. CONCLUSIONS

Despite continuous improvements in the production of lipid biofuels, relatively high production costs remain a critical barrier against commercial development, though technologies for PPO and biodiesel production from oilseed crops are already fairly mature .For lipid fuels from first generation feedstock the costs of oil crops are a major component of overall costs. As crop prices are highly volatile, the overall production costs of lipid fuels are varying as well. In particular, the cost of producing oil-seed derived biodiesel is dominated by the cost of the oil and by competition from high value uses like cooking.

However, generally PPO and biodiesel offer large economic advantages over fossil fuels, but direct cost comparisons are difficult. Negative externalities associated with fossil fuels tend to be poorly quantified. The most important negative externalities among others are military expenditures and costs for health and environment. However, PPO and biodiesel have the potential to generate many positive externalities, such as reduced greenhouse gas emissions, decreased air pollution, and job creation. Additionally PPO and biodiesel decrease dependency from crude oil imports. Consequently PPO and biodiesel are a more socially and environmentally desirable liquid fuel, a fact that is often neglected in direct cost calculations [10]. Therefore biofuels often look uncompetitive although a biofuel market may actually provide long-term economic benefits when comparing environmental and social cost.

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