"BIODIESEL PRODUCTION FROM ANIMAL FATS" AN EVER GREEN TECHNOLOGY FOR THE FUTURE ENERGY SECURITY

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INTRODUCTION

The world is on a quest for energy, the premier source of which is now petroleum. Energy is the most fundamental requirement of every nation as it progress through the ladder of development. India with 16 percent of the world population could boast of only 0.5 percent of the world oil reserves. The current level of production barely caters to 26 percent of the petroleum demand. India imports 75 percent of its crude oil requirements. The estimated crude oil import cost comes to about 10 percent of the country's G.D.P. Besides the billions spent on importing crude oil, we are also importing billions of tonnes of CO_2 and other green house gases causing climatic changes as evidenced by changing rainfall patterns, rising sea levels and temperatures. The demand for diesel is five times higher than the demand for petrol in India and any increase in diesel price immediately pushes up inflation. Therefore, the government is still incurring huge cost of subsidising diesel. With the Indian economy poised for a robust growth of 9 to 9.5 percent for the 12th plan period, energy security has become the key issue in policy formulation and planning.

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India's energy security would remain vulnerable until alternative fuels to substitute/ supplement petro-based fuels are developed based on indigenously produced renewable feedstocks. In biofuels, the country has a ray of hope. Biofuels are non-polluting and virtually in exhaustible. Biofuels can increasingly satisfy these energy needs in an environmentally benign and cost-effective manner while reducing dependence on import of fossil fuels and thereby providing a higher degree of National Energy Security (Anon. 2009).

The national biofuel policy 2009, proposed 20 percent blending of biodiesel by 2017. This huge demand cannot be met from non-edible vegetable oil feedstock alone. Therefore, development and utilization of new indigenous biomass feedstock for production of bio fuel and development of next generation of more efficient bio fuel conversion technologies are the need of the hour.

In this context, biodiesel production from animal fats offers new scope as a potential means to stimulate rural development, lower emission of harmful pollutants and decrease green house gas emission, while contributing to national energy security by reducing dependence on oil imports and mitigation of climatic changes *vis-à-vis* providing good fuel properties for the diesel engine.

Definition of Biodiesel

Biodiesel is defined as "the mono alkyl ester of long chain fatty acids derived from renewable lipid feed stock such as vegetable oil or animal fats, for use in compression ignition (diesel) engines" (National Biodiesel Board, 1996)

Blends

Blends of biodiesel and conventional hydrocarbon based diesel are products most commonly distributed for use. Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix:

- 100 percent biodiesel is referred to as B100, while
- 20 percent biodiesel is labelled B20
- 5 percent biodiesel is labelled B5

Blends of 20 per cent biodiesel with 80 per cent petroleum diesel (B20) can generally be used in all diesel engines without any modification. Biodiesel in its pure form (B100), may require certain engine modifications to avoid maintenance and performance problem.

Importance of Biodiesel

Biodiesel has good fuel properties, comparable to or even better than petroleum diesel. It has 10 percent built-in oxygen content that helps it to burn fully. Its cetane number (an indication of its fuel burning efficiency) is 72 for biodiesel derived from tallow and 72.5 for biodiesel derived from chicken oil, higher than 54.4, the cetane number of most petroleum diesels. The esters of the long-chain fatty acids of biodiesel are excellent lubricants for the fuel injection system. It has a higher flash point than diesel, making it a safer fuel. Other advantages are the almost zero sulphur content and the reduced amount of carbon monoxide, unburned hydrocarbons and particulate matter in the exhaust.

BIODIESEL PRODUCTION TECHNOLOGY

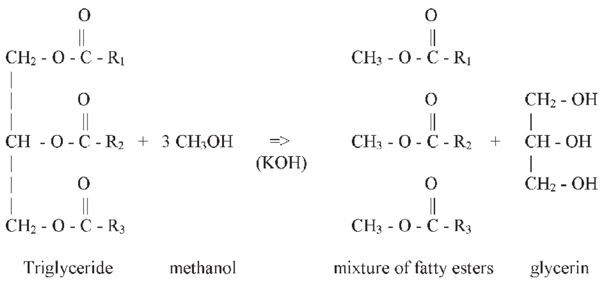
Biodiesel Feedstock

Biodiesel is typically made from vegetable oil though animal fat can also be used. Rapeseed oil has 82 percent of the share of the world's biodiesel feedstock, followed by sunflower oil (10 percent), soy bean (5 percent) and palm oil (3 percent). The choice of feed is country specific and depends on availability. Other feedstocks include waste vegetable oil (WVO), algae which can be grown using waste material and oil from halophytes such as *Slicornia bigelovii*.

Biodiesel Production Process

The major steps required to synthesise biodiesel are as follows

1. Feed stock pre-treatment : If waste vegetable oil (WVO) is used, it is filtered to remove dirt, charred food, and other non-oil material often found.
2. Determination and treatment of free fatty acids (FFA) : A sample of the cleaned feedstock oil is titrated with a standardised base solution in order to determine the concentration of free fatty acids (carboxylic acid) present in the oil sample.
3. Transesterification: Transesterification (also called alcoholysis) is the reaction of fat or oil with an alcohol to form esters and glycerol. The reaction is as shown in the equation below.



Where R_1, R_2 and R_3 are long hydrocarbon chains sometimes called fatty chain.

Alcohol

Alcohols are primary and secondary monohydric aliphatic alcohols having 1-8 carbon atoms (Sprules and Price 1950). Among the alcohols that can be used are methanol, ethanol, propanol, butanol and amyl alcohol. Methanol is most frequently used because of its low cost and its physical and chemical advantages (polar and shortest chain alcohol).

Alkali/ Base catalyst

The alkalis include Sodium hydroxide, Potassium hydroxide, Carbonates and corresponding Sodium and Potassium alkoxide such as Sodium methoxide, Sodium ethoxide, Sodium propoxide and Sodium butoxide.

Acid Catalyst

Sulphuric acid, Sulfonic acids and Hydrochloric acid are used as acid catalyst.

Lipase Enzyme

Lipases can also be used as bio-catalysts.

Alkali Catalysed Process

Alkali-catalyzed transesterification is much faster than acid-catalyzed transesterification and is most often used commercially. For an alkali-catalyzed transesterification, the glycerides and alcohol must be substantially anhydrous (Wright *et.al.,* 1944) because water makes the reaction partially change to saponication, which produces soap. Low free fatty acid content in triglycerides is required for alkali-catalyzed transesterification.

Acid Catalysed Process

Acid catalysed process are used for direct esterification of free fatty acids in a high free fatty acid (FFA) feed stock, or to make esters from soap stock (Keim, 1945).

Multiple Step Process

Canakci and Van Gerpen (2001) investigated an acid catalyzed pre-treatment step followed by a base catalyzed step as an effective conversion method for low cost raw materials. They found that by using methanol and sulfuric acid and a reaction temperature of 60°C the free fatty acid content of a feedstock could be significantly reduced.

The preferred method for high FFA feed stock is acid catalysis followed by base catalysis.

Ultrasonic-Reactor Method

In the ultrasonic reactor method, the ultrasonic waves cause the reaction mixture to produce and collapse bubbles constantly. This cavitation provides simultaneously the mixing and heating required to carry out the transesterification process. Thus using an ultrasonic reactor can drastically reduces the reaction time, reaction temperatures, and energy input.

Micro-Wave Method

Current research is being directed into using commercial microwave ovens to provide the heat needed in the transesterification process. The microwaves provide intense localized heating that may be higher than the recorded temperature of the reaction vessel.

ALTERNATE PROCESSING TECHNIQUES

Enzymes

Enzymes have shown good tolerence for the free fatty acid levels of the feedstock, but the enzymes are expensive and unable to proceed the reaction to completion. Immobilisation of enzymes and use of multiple enzymes in sequence may provide future opportunities in this area. (Nelson *et.al*., 1996)

Co-Solvent

Boocok *et.al.,* (1998) developed a novel technique for accelerating the transesterification reaction rate. He proposed the addition of co-solvent to create a single phase and this accelerates the reaction. The commonly proposed co-solvents are Tetra hydro furan and Methyl tertiary butyl ether. The major draw back of this method are the hazard level associated with the co-solvent and recovering and recycling the co-solvent.

Supercritical Methanol System

By increasing both the temperature and the pressure, a critical point is obtained at which gasses and liquids are indistinguishable fluids. Matter that exists in this new phase is called a super critical fluid (SCF). Methanol at supercritical conditions becomes an excellent solvent and dissolves the feedstock and reacts readily without a distinct catalyst, but energy costs of production are similar or less than catalytic production routes. (Saka and Kudsina, 2001).

Animal Fats for Biodiesel Production

The amount of animal fat used by the bio-diesel industry has more than doubled from 2006 to 2008. According to a report by the Informa Economics, approximately 20 percent of the bio-diesel manufactured in the United States in 2008 was produced from animal fats greases and recycled cooking oils.

Whole dead poultry carcasses and poultry slaughter wastes can be used to recover fats and oils. The dead poultry birds having an average body weight of 1.25 kg have a fat content of 14.55 percent and by solvent extraction method 96.1 percent of this fat can be recovered. A two step processing reaction, acid catalysed esterification of FFA followed by base catalysed transesterification of triglycerides could convert 97.62 percent of this fat to good quality biodiesel. A litre of biodiesel can be produced from chicken fat at the cost of 22.00 rupees. The blending of biodiesel to commercial diesel at 20 percent can substantially reduce the smoke (47.14 percent) compared to that of diesel in a CRDI engine (John Abraham, 2012). Thus the blending of biodiesel at 20 percent to commercial diesel can reduce the import of costly crude oil and simultaneously, substantially reduce the engine emission. The total weight of the dead birds available in India per year was estimated at 2.4 lakh tons as per the standard mortality of the industrial average (Chandrasekaran, 2009). Which can be converted to 8500 tonnes of biodiesel. Thus biodiesel production technology provides opportunity to produce highly valued biofuel from dead animal and birds. (Wealth from waste). At the same time, this concept can also solve the major problem of unscientific disposal of dead birds and slaughter waste. Currently a 5 million dollar plant is being built in the USA, with the intent of producing 11.4 million litres of biodiesel from an estimated one billion Kg of chicken fat produced annually at the Tyson poultry plant.

Rearing animals for meat and biodiesel can be the production objectives in days to come. This concept can revolutionise animal production sector. Especially pigs and poultry can contribute in a big way because of their excellent attributes such as prolificacy, short generation interval and quick body weight gain for slaughter. Fat less pork at a premium price is gaining consumer acceptance phenomenally. This provides the separated fat to be converted to biodiesel economically.

Conclusion

The biofuel industry is poised to make important contribution to meeting India's energy needs by supplying clean domestic fuel. Simultaneously it also provides other advantages like

- It provides a market for excess production of vegetable oils and animal fats.
- It decreases, although will not eliminate the country's dependence on imported crude oil.
- Biodiesel in renewable and does not contribute to global warming due to its closed carbon cycle.
- By biodiesel blending the overall carbon dioxide emission can be reduced by 78 percent compared with petroleum based diesel fuel.
- The exhaust emissions of carbon monoxide, unburned hydrocarbons and particulate emissions from bio-diesel are lower than with regular diesel fuel. Unfortunately there might be a slight increase in oxides of nitrogen (NO_x)
- When added to regular diesel fuel it can convert fuel with poor lubricating properties, such as modern ultra-low sulphur diesel fuel into an acceptable fuel.
- Provide good fuel properties for the diesel engines.

Biodiesel is not a replacement technology; it is a transition technology to help clean up our existing fuel and stream line distribution by keeping the manufacture and consumer of fuel as local as possible, all the while keeping the revenue in the national economy. It is not about replacing all of our petroleum imports; it is about not importing so much.

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