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BIODIESEL AS BIOFUEL

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Abstract: Biodiesel is a form of diesel fuel derived from plants or animals and consisting of long-chain fatty acid esters. It is typically made by chemically reacting lipids such as animal fat (tallow), soybean oil, or some other vegetable oil with an alcohol, producing a methyl, ethyl or propyl ester by the process of trans esterification.

Keywords: fatty acid ester, trans esterification, biodiesel, biofuel

Introduction: Unlike the vegetable and waste oils used to fuel converted diesel engines, biodiesel is a drop-in biofuel, meaning it is compatible with existing diesel engines and distribution infrastructure.[1-5] However, it is usually blended with petrodiesel (typically to less than 10%) since most engines cannot run on pure biodiesel without modification. Biodiesel blends can also be used as heating oil. The US National Biodiesel Board defines "biodiesel" as a mono-alkyl ester.[6]

Figure-: Biodiesel

Biodiesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease. Biodiesel meets both the biomass-based diesel and overall advanced biofuel requirement of the Renewable Fuel Standard. Biodiesel is produced in the United States and used in conventional diesel engines, directly substituting for or extending supplies of traditional petroleum diesel. Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, or animal fats. The fuel is produced by transesterification—a process that converts fats and oils into biodiesel and glycerin (a coproduct). The most common are B5 (up to 5% biodiesel) and B20 (6% to 20% biodiesel). B100 (pure biodiesel) is typically used as a blendstock to produce lower percentage blends and is rarely used as a transportation fuel. Biodiesel can be made from oils which have been extracted from plants such as palm, soybean, oilseed rape, or sunflower.[7]

Lower CO_2 emissions help reduce the impacts of global warming. Energy Balance & Security Biodiesel production and use at home, biodiesel helps reduce the need for foreign oil. Toxicity, Biodegradability, Safety & Recycling Less toxic than table salt, biodiesel has minimal environmental impact. The two most common types of biofuels in use today are ethanol and biodiesel, both of which represent the first generation of biofuel technology. The Bioenergy Technologies Office (BETO) is collaborating with industry to develop next-generation biofuels made from wastes, cellulosic biomass, and algae-based resources.[8]

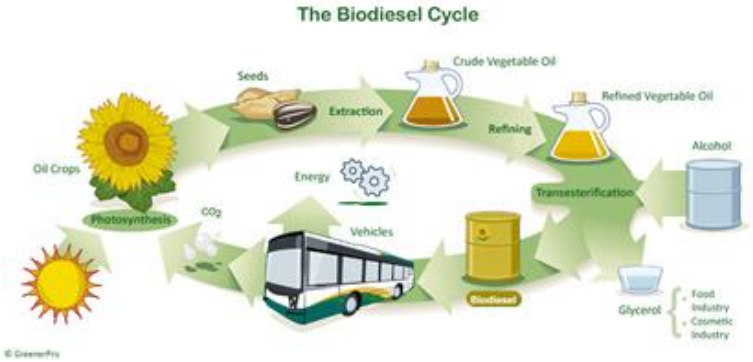

Figure-2: Biodiesel cycle

Esters are a class of compounds derived from the reaction of an acid and an alcohol. For example, the reaction of fatty acids and methanol produce methyl esters, or biodiesel. The molecular formula for a methyl ester is RCO_2CH_3, where R represents a fatty acid. Triglycerides are also a type of ester. Biodiesel can be produced from a wide variety of oilseed crops and animal fats. In Europe, rapeseed oil is the major biodiesel feedstock. In the United States, soybeans are the dominant biodiesel feedstock.[9] The main components of the biodiesel are methyl stearate, methyl palmitate, methyl oleate, and methyl linoleate, with an average content of 92.18%. The color of biodiesel ranges from clear to golden to dark brown, depending on the production method and the feedstock used to make the fuel. This also changes the resulting fuel properties. In general, biodiesel is slightly miscible with water, has a high boiling point and low vapor pressure. However, B5 (a biodiesel blend of 5% biodiesel, 95% diesel) is also commonly used in fleet vehicles. B20 and lower-level blends can be used in many diesel vehicles without any engine modification. Biodiesel raises the cetane number of the fuel and improves fuel lubricity. While biogas is produced mostly from waste materials (landfills, manure, sludge from wastewater treatment, agricultural waste), biodiesel in the EU is mostly produced from rapeseed or other oil crops that are used as food, which raises the 'food or fuel' concerns. Jatropha oil is produced from the seeds of the *Jatropha curcas*, a plant that can grow in wastelands across India, and the oil is considered to be an excellent source of bio-diesel.[10] Sugarcane and corn are used to make ethanol, which is often used as an additive to gasoline, while soybeans and rapeseed (canola) are used to create biodiesel. These plant-derived fuels can be used on their own to drive combustion engines but more often they are blended with traditional gasoline or diesel. Biodiesel is: Cleaner: Fewer pollutants, less soot, hydrocarbons, carbon monoxide, and sulfur dioxide are produced. It is non-toxic and biodegradable. Safer: Petroleum diesel has a flash point of 52°C, so storing and transporting it can be hazardous. Environmentalists also calculate whether biodiesel's pros outweigh its cons.[11]

Figure-3: Jatropha plane

Advantages of Biodiesel

Better for engines
Biodiesel is expensive
Fuel efficiency
Reduce foreign oil dependence
Reduce greenhouse gases
Renewable
Air quality
Biodiesel helps extends engine lifespan
Safety
Cleaner biofuel refinery
Positive economic impact
Support for Renewables. The first benefit of biodiesel is its renewable resource integration.
Compatible with Current Technologies.
Fewer Greenhouse Gas Emissions.
Only Suitable for Warm Climates.
Water and Food Shortages.
Biodiesel is Expensive.

Disadvantages of Biodiesel

Variation in the Quality of Biodiesel.
Not Suitable for Use in Low Temperatures.
Biodiesel Could Harm the Rubber Houses of Some Engines.
Biodiesel is Way More Expensive than Petroleum.
Food Shortage.
Increased use of Fertilizers.
Clogging in Engine.
Regional Suitability.

Figure-4: Rudolph Diesel

Rudolph Diesel [18 March 1858 – 29 September 1913] himself developed biodiesel in 1890, wherein pure vegetable oils were used in diesel engines for agriculture, where petroleum diesel was not available. Biodiesel is a renewable alternative to petroleum-based diesel fuel (hereafter referred to as "petrodiesel"). Biodiesel contains no petroleum, but it can be blended at any level with petrodiesel.[12] Biodiesel can be made from any plant oil, animal oil, or even used cooking oil. Biodiesel and renewable diesel are mostly produced for use in diesel engines, but they can also be used as heating fuels. While these fuels are made from biomass or materials derived from biomass, they differ in how they are produced and in their physical properties. Biodiesel is produced from vegetable oils or animal fats and an alcohol, through a transesterification reaction.

This chemical reaction converts an ester (vegetable oil or animal fat) into a mixture of esters of the fatty acids that makes up the oil (or fat). Biodiesel is a mixture of fatty acid alkyl esters, whereas green diesel is a paraffinic that contain, C12 − C18 which is what petroleum diesel has. Both the conventional biodiesel, also called FAME (Fatty acid methyl esters) and the green diesel reduce the GHG emissions. Unlike petroleum diesel, which contains sulfur and carcinogenic benzene, two components the state emissions boards and EPA regulate, biodiesel is nontoxic and biodegradable.

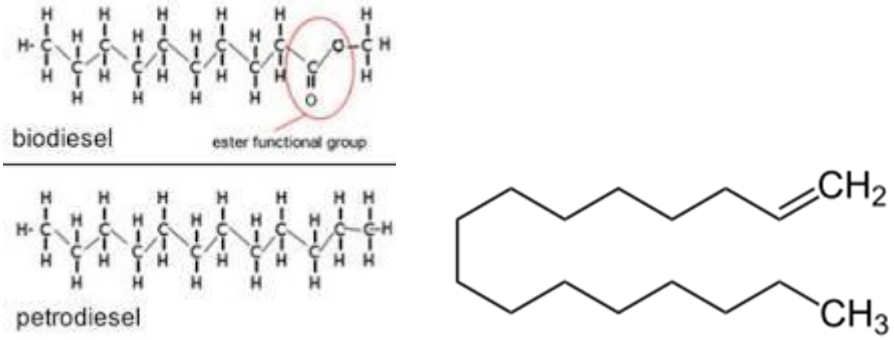

Figure-5: Biodiesel and cetene [1-hexadecene] structure

Because of its lower emissions and the national drive to reduce reliance on petroleum, biodiesel is the U.S. government's preferred fuel type. Animal fats like tallow, lard, yellow grease, chicken fat, fish oils (after separation of omega-3 fatty acids), and also fish waste, have also been used.[13] Used or waste cooking oils from restaurants are important source of raw materials for biodiesel manufacture. Coconut oil can be used for biodiesel production due to its availability and lower free fatty acid (FFA) content when compared to non-edible oils. Besides, coconut biodiesel has better lubricity and a similar flash point to that of diesel fuel. Currently, rapeseed (canola) is the dominant feedstock for biodiesel in Europe, and soybeans are the dominant feedstock for biodiesel in the United States. Warmer countries such as Malaysia often use palm oil for biodiesel production. Ethanol belongs to the alcohol group and biodiesel mainly belongs to the ester group. Biodiesel causes less harm to the environment than ethanol.[14] Biodiesel energy production is higher compared to that of ethanol. There are two main types of biofuel used in cars: bioethanol and biodiesel. Bioethanol is an alcohol made from corn and sugarcane, whereas biodiesel is made using vegetable oils and animal fats. Both offer alternatives to non-renewable crude-oil derived fuels like petrol and diesel. Glycerol is formed and has to be separated from the biodiesel. Both glycerol and biodiesel need to have alcohol removed and recycled in the process. Water is added to both the biodiesel and glycerol to remove unwanted side products, particularly glycerol, that may remain in the biodiesel. Dyed diesel fuel often looks pink or red due to the added dye used to distinguish it from regular diesel fuel. It is illegal to used dyed diesel fuel in licensed trucks or automobiles that drive on public roads. In the United States of America, the Environmental Protection Agency mandates use of a red dye to identify fuels for off-road use. Solvent Red 26 is used in the United States as a standard, though it is often replaced with Solvent Red 164, which is similar to Solvent Red 26 but with longer alkyl chains. Biodiesel has similar properties to conventional diesel but with lower emissions of exhaust gases. It reduces the greenhouse gas effect due to its lower sulfur and carbon content. It is also capable of reducing air toxicity due to its lower content of particulate matter in ambient air.[15] Biodiesel is well known as an alternative diesel fuel. The raw materials for biodiesel production now mainly include biological sources such as vegetable seed oil, soybean oil and some recovered animal fats. The acceptable viscosity range for biodiesel according to ASTM D6751 is between 1.9 and 6.0 mm^2/s. Biodiesel is also nontoxic and biodegradable. Using biodiesel lowers particulate matter by 47%, reduces hydrocarbon emissions by up to 67%, and reduces smog. It's environmental benefits don't stop there. The production of biodiesel, in lieu of petroleum diesel, reduces wastewater by 79% and hazardous waste by 96%. Biodiesel is recycled cooking oil that has gone through a chemical process which removes the glycerin contained in the oil. Once the glycerin is removed, the biodiesel fuel can be used directly in any home heating oil burner or diesel engine without modification. The United States consumed some 1.66 billion gallons of biodiesel in 2022. If the natural gas under pressure comes from hydrocarbons extracted from the ground by hydraulic fracturing or drilling (such as shale gas for example), it cannot be considered a biofuel. When biofuels are burned, they release energy. That energy source is then converted into motion or heat. For industrial facilities that use biomass and biofuel, the energy source can create more output or can simply heat buildings. Biofuels require complex processing. Biodiesel is a substitute to diesel fuel derived from the triglycerides of vegetable oils or animal fats. Biodiesel can be produce from various vegetable oils such as palm oil, sunflower, soybean, rapeseed and castor oil using different types of catalysts. Biodiesel is an alternative fuel created from plant and living matter that is converted to a usable energy source. Biodiesel fuel is used in standard diesel engines and is different from the vegetable and waste oils used in converted diesel engines. "The feedstock inputs you need for biodiesel are more expensive than petroleum is," Jones Prather said. "On top of that, the processes for producing the fuel aren't yet efficient enough so that you can produce it very cheaply." The most common problems with fuel quality are (1) the biodiesel may contain some "unconverted"vegetable oil (incomplete processing), (2) traces of chemicals from the making of the biodiesel (e.g., methanol, lye) can remain in the biodiesel, (3) products of the reaction (e.g., glycerin, soaps) may not be completely.[16] The main problem is that biofuels are less stable than petrodiesel, and they deteriorate over time. Light, temperature and humidity increase the rate of

deterioration. Biodiesel emits 11% less carbon monoxide and 10% less particulate matter compared to diesel. The carbon footprint is further offset by the carbon absorption caused by the plants grown to create the biomass used in the fuel. Biodiesel itself is also nontoxic and biodegradable. 1) Biodegradable and Renewable Fuel. 2) Safer to use and has low toxicity compared to fossil diesel fuel. 3) Lower exhaust emission rate than normal diesel fuel. Biodiesel is a domestically produced, clean-burning, renewable substitute for petroleum diesel. Using biodiesel as a vehicle fuel increases energy security, improves air quality and the environment, and provides safety benefits.[17]

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

Blends:

100% biodiesel is referred to as B100
20% biodiesel, 80% petrodiesel is labeled B20
10% biodiesel, 90% petrodiesel is labeled B10
7% biodiesel, 93% petrodiesel is labeled B7
5% biodiesel, 95% petrodiesel is labeled B5
2% biodiesel, 98% petrodiesel is labeled B2

Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, although certain manufacturers do not extend warranty coverage if equipment is damaged by these blends. The B6 to B20 blends are covered by the ASTM D7467 specification. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. Blending B100 with petroleum diesel may be accomplished by:

Mixing in tanks at manufacturing point prior to delivery to tanker truck
Splash mixing in the tanker truck (adding specific percentages of biodiesel and petroleum diesel)
In-line mixing, two components arrive at tanker truck simultaneously.
Metered pump mixing, petroleum diesel and biodiesel meters are set to X total volume

Colour: The color of biodiesel ranges from clear to golden to dark brown, depending on the production method and the feedstock used to make the fuel. This also changes the resulting fuel properties. In general, biodiesel is slightly miscible with water, has a high boiling point and low vapor pressure. The flash point of biodiesel can exceed 130 °C (266 °F), significantly higher than that of petroleum diesel which may be as low as 52 °C (126 °F). Biodiesel has a density around ~0.88 g/cm^3, higher than petrodiesel (~0.85 g/cm^3).[18]

Conclusion: Jatropha oil is produced from the seeds of the *Jatropha curcas*, a plant that can grow in wastelands across India, and the oil is considered to be an excellent source of bio-diesel. This is primarily due to the 20% saturated fat content of jatropha, compared with 15% saturated fat in soybean oil, and 6% in canola. Biodiesel from saturated fats tends to gel at higher temperatures. Jatropha oil has a high cetane rating and low sulfur content, both of which are beneficial for biodiesel production. One can conclude that the chemical structure of the biodiesel is $C_{19}H_{36}O_2$

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