

Educator's Tools: Biodiesel Lesson

Background on Biodiesel

Rudolf **Diesel**, the inventor of the diesel engine, used peanut oil in his engine at the 1900 World Exhibition in Paris, France. Diesel envisioned a world where farmers grew their own fuel for their tractors, increased profits from their crops and were energy independent. In a 1912 speech, Rudolf Diesel said "the use of vegetable oils for engine fuels may seem insignificant today, but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time."

The petroleum industry renamed a by-product of gasoline production "diesel fuel" in order to take advantage of the new market created by Rudolf Diesel's new engine. During the 1920s, diesel engine manufacturers altered their engines to utilize the lower viscosity of petroleum-based diesel fuel, which made the engines run poorly on straight vegetable oil. If there is an historical lesson to learn from this, it is that technology is often political. In this case, fuel technology developed in a direction that was a matter of policy choice and not predetermined by any clear advantage of one technology over another.

What is Biodiesel?

Biodiesel is a renewable fuel that can be made from any refined oil or fat, such as the oil found in soybeans, canola, or yellow chicken grease. These fats can be used in any diesel engine with no modifications. Biodiesel made from different sources has slightly different chemical properties, resulting in differences such as gelling points. Biodiesel is usually made from locally available crops such as soybeans.

- Because soybeans flourish in Ohio, most biodiesel in Ohio is made from soybeans. This makes soy a **renewable** energy source found, in some cases, literally in your backyard.
- Farmers start their soybean planting in late April each spring and wait to harvest till early October. Soybeans are hard, dry, and usually brown when harvested for making biodiesel.
- Some people use **straight vegetable oil (SVO)** in their cars, but this is a different fuel than biodiesel and vehicles must be modified to be able to accept straight vegetable oil.

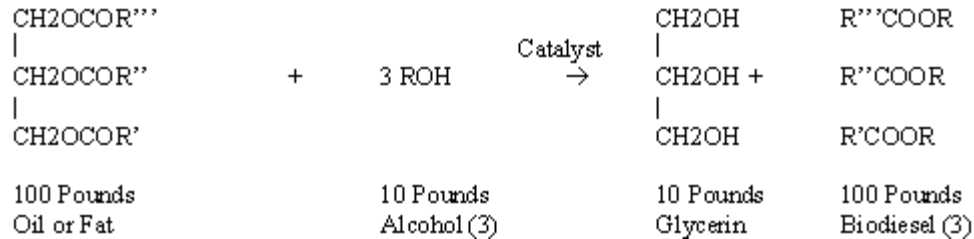
What is the Oil in Biodiesel?

Oils and greases are, like in soybeans, actually fats called triglycerides made up of three strands of carbon, hydrogen, and oxygen. Triglycerides are not only found in oils but also in your blood. Here is what a triglyceride looks like:

- It is a direct conversion to biodiesel with no intermediate compounds
- No exotic construction materials are needed.

The chemical reaction for base catalyzed biodiesel production is depicted below. Here, one hundred pounds of fat or oil (such as soybean oil) is reacted with 10 pounds of a short chain alcohol (such as ethanol or menthol) in the presence of a catalyst to produce 10 pounds of glycerin and 100 pounds of biodiesel. The catalyst, usually sodium or potassium hydroxide, has already been mixed with the methanol. R', R'', and R''' indicate the fatty acid chains associated with the oil or fat.

The Biodiesel Reaction



Final Stages of Biodiesel Production

- *Separation.* Once the reaction is complete, two major products exist: glycerin and biodiesel. The glycerin phase is much denser than biodiesel phases. The two phases can be separated by allowing the mixture sit until the glycerin settles to the bottom of the tank. The glycerin is then simply drained off the bottom of the settling vessel. In some cases, a centrifuge is used to separate the two materials faster.
- *Alcohol Removal.* Once the glycerin and biodiesel phases have been separated, the excess alcohol in each phase is removed with a flash evaporation process or by distillation. In others systems, the alcohol is removed and the mixture neutralized before the glycerin and esters have been separated. In either case, the alcohol is recovered using distillation equipment and is re-used.
- *Glycerin Neutralization.* In some cases the salt formed during this phase is recovered for use as fertilizer. In most cases, the salt is left in the glycerin. In more sophisticated operations, the glycerin is distilled to 99% or higher purity and sold into the cosmetic and pharmaceutical markets.

Biodiesel Advantages and Disadvantages

- Domestically produced
- Renewable alternative fuel for diesel engines
- Biodiesel increases engine performance by increased **cetane number**. The higher **cetane number** means that the fuel ignites in an engine more quickly (less knocking).
- High fuel **lubricity**. Engines with high lubrication run more efficiently with less wear and tear.
- High oxygen content leads to more complete combustion and fewer emissions. The use of biodiesel significantly reduces virtually all regulated emissions
- Biodiesel does not pose a threat to human health.
- Biodiesel contains no sulfur or **aromatic** compounds
- Use of biodiesel in a conventional diesel engine results in substantial reduction of unburned **hydrocarbons**, carbon monoxide and **particulate** matter. A U.S. Department of Energy study showed that the production and use of 100 percent biodiesel, compared to petroleum diesel, resulted in more than a 75% reduction in carbon dioxide emissions.
- Biodiesel has a positive **energy balance**. For every unit of energy needed to produce a gallon of biodiesel, 3.2 units of energy are gained.
- Used in its pure form, B100, biodiesel may have some problems. In the cold weather B100 can gel and clog engines if not heated. Gelling is not a problem with lower blends of biodiesel such as B20 or below. Regular diesel fuel can also gel in the winter if it's not treated properly.

Vocabulary List

Biodiesel- a renewable fuel that can be made from any oil or fat that has been refined to be used as a fuel for diesel engines

Renewable- a resource that when used can be replaced, like trees

Straight Vegetable Oil (SVO)- oil extracted from vegetables that is not refined

Triglycerides- an ester that has three fatty acids and glycerol, the main part of fats and oils

Alcohol- a compound that contains (OH) [called a hydroxyl group] and are produced by saturated hydrocarbons

Transesterification- the process that produces biodiesel from oils or fats

Catalyst- anything that can speed-up a process

Glycerol- consists of a propane molecule attached to three hydroxyl (OH) groups

Esters- formed from a reaction of an acid and an alcohol that releases water

Bxx- Blends of biodiesel are denoted by using the letter B and then the percentage

Phase- one step in a process

Aromatic compound- a hydrocarbon that has one or more benzene rings

Hydrocarbon- an organic compound that contains only hydrogen and carbon

Particulate matter- a pollutant in the atmosphere comprised of tiny solid particles

Cetane number- a number in a scale for ignition quality of diesel fuel

Lubricity- lubrication

Energy balance- this is a calculation of how much energy goes into producing something and how much energy is gained at the end of the process, a process is balanced if for every one unit of energy for production produces one unit of energy at the end of the process