

Biodiesel Tech

Homebrewing Biodiesel

Biodiesel has been produced in the United States since the early 1980's. While the recent explosion in the number of commercial producers (well over 100 operating plants in January 2007) has drawn most of the media attention, individuals have been making biodiesel for their personal use for at least 15 years. This TechNote intends to provide guidance to these individuals so they can safely produce high quality biodiesel. It is not intended to be the sole source of information on the process to make biodiesel, but it covers some of the areas that are common problems for small producers.

Additional details on biodiesel production are available on our website: www.BiodieselEducation.org.

Biodiesel is easy to make and uses materials that are relatively easy to buy. While processors for personal use can be purchased for \$2,000 to \$8,000, many individuals have constructed their own. Salesmen marketing processors claim that biodiesel can be produced for as little as \$0.35/gallon but this generally only includes the cost of the alcohol and catalyst. It does not include the cost of the processor and the time needed to gather the oil and convert it to biodiesel. Even with current high petroleum prices, it is likely that biodiesel produced at home will cost more than conventional diesel fuel at the pump. In spite of the higher cost, many individuals, called "homebrewers" because of their similarity to those who brew beer at home, choose to adopt biodiesel production as a hobby. They enjoy using a fuel they have produced themselves and also appreciate that biodiesel burns cleaner and contributes less to global warming than petroleum-based diesel fuel.

An alternative to biodiesel production is the use of straight vegetable oil, or SVO. This involves taking the oil, either extracted from oilseeds such as soybeans or canola, or used frying oils from restaurants, and adding it directly to the vehicle's fuel tank.

Often the vehicle is modified so that the oil can be warmed using engine coolant and the engine is started and stopped on

conventional diesel fuel. Engine manufacturers do not recommend the use of SVO because most tests have shown long-term engine damage due to deposit accumulation on the injectors and piston rings.

Feedstocks

Most homebrewed biodiesel is made from waste vegetable oil (WVO) collected from restaurants or from raw as-pressed vegetable oils. The WVO often contains water and high levels of free fatty acids as well as solids and other contaminants. The solids can be filtered out, but the water must be removed by heating the oil to above 212°F for an extended period (several hours) to drive the water from the oil. WVO typically contains from 2 to 5% free fatty acids.

If the free fatty acid level is above this amount, it is very difficult to produce biodiesel without an acid esterification process first that most homebrewers do not have the capability to implement. The free fatty acid level is determined by a titration process. A full description of this process would take more explanation than is possible in this TechNote, but a detailed description is provided at our website: www.BiodieselEducation.org.

Raw vegetable oils that are produced by pressing oilseeds such as canola, mustard, or soybeans can be converted to biodiesel.

The free fatty acid level of these raw oils is usually 0.5% or less, which is low enough not to pose a problem. However, the oils may contain gum compounds that can create sludge deposits in the processing equipment and can make it more difficult to separate the glycerin at the end of the reaction. The easiest way for homebrewers to reduce the gum level in their oil is to let the oil sit in a tank for 2 to 3 weeks before converting it to biodiesel.

The oil will undergo natural degumming and reach a low enough gum level that conversion to biodiesel is not a problem. If some gums remain in the oil, they will generally be removed with the glycerin or during the wash process.

The common recipe for biodiesel production is to combine 100 lbs of oil with 22 lbs of methanol and 0.5 to 1.0 lbs of sodium or potassium hydroxide. Additional sodium or potassium hydroxide is added to neutralize the free fatty acids if present, based on the titration described above. Generally, the catalyst is dissolved in the alcohol and then the mixture is added to the oil while stirring.

This mixture is heated to about 140°F and stirred for one to two hours. A frequent mistake of homebrewers is to add too little methanol or not allow sufficient time. Reports of as little as 13 to 15% methanol (compared with the 22% recommended here) are heard frequently. This is unlikely to produce a good quality biodiesel. Although it can be difficult for homebrewers to confirm that their product meets the specifications of the ASTM standard, this is a goal that we recommend they strive to achieve. In addition to adding enough alcohol, it is important for homebrewers

to provide enough agitation, enough temperature, and enough time for the reaction to reach completion. We recommend that the reaction be allowed 1-2 hours at 140°F, 2-4 hours at 105°F, or 4-8 hours at 70°F. We recommend that the oil, alcohol, and catalyst be stirred vigorously throughout the reaction period.

One approach that is usually successful is to do the reaction in two steps. This involves adding 80% of the methanol and catalyst in the first reaction step, separating and removing any glycerin that has formed, and then adding the remaining 20% of the methanol and catalyst for a second reaction.

At the end of the reaction period, the biodiesel should be allowed to settle for several hours. Overnight is even better. A clearly defined line should exist between the biodiesel layer on top and the darker glycerin layer on the bottom. The glycerin can be drawn off leaving biodiesel that is ready for washing. A common observation by homebrewers is that instead of a sharp separation between the biodiesel and glycerin, they end up with a semi-solid, gelatinous mixture that cannot be used as fuel. This is an indication that the oil contained excessive free fatty acids and/or water.

The glycerin by-product is usually a disposal problem for small producers. It may contain up to 40% methanol so it is flammable, and releases methanol to the atmosphere. The methanol is an air pollutant and a potential ground water contaminant if the glycerin is spread on the ground. Methanol is also toxic to human beings and animals. A possible answer is for several homebrewers to combine their glycerin so there is enough to justify the expense of a methanol recovery system. A cooperative of small producers would be a good way to do this. After the methanol has been removed, the glycerin can be used as a composting accelerant, fed to animals, or further refined for other uses. A good way to dispose of glycerin is to add it to an anaerobic digester that produces methane gas from animal waste.

Washing consists of adding an amount of water equal to about 50 to 100% of the biodiesel volume to the biodiesel and gently agitating the mixture. Then, the water is allowed to settle so it can be separated. The process is repeated until the water is clear when it is removed. A good quality reaction can usually be washed in 3 to 4 steps.

Disposal of the wash water is a similar problem to glycerin disposal for small producers. It can probably be put into a municipal sewer system although before doing this, you should visit them and explain what you intend to do.

After the biodiesel has been washed, it may be cloudy due to small water droplets suspended in the fuel. If the fuel is allowed to sit for several days, these will settle out. Or, if the fuel is heated to 160-210°F, it will become clear. At this point, the fuel should be ready to use, either as a pure fuel, or in blends with petroleum diesel fuel.

Some homebrewers have argued that washing is optional. We always recommend washing biodiesel because of the presence of soaps, residual free glycerin, catalyst, and methanol that remain in the biodiesel. These are easily removed with water washing and a very pure product will result.

Safety

While the oils and fats used to make biodiesel and the biodiesel itself are non-toxic and not very flammable, the methanol and catalyst present several safety concerns.

Methanol is very toxic and while ingestion is particularly dangerous, long term inhalation or skin exposure should be avoided. All processing work with methanol should be done in covered containers in well-ventilated areas, preferably out-of-doors. Methanol vapors can be ignited by sparks or exposed flames so use explosion-proof motors for agitation. If these are not available, recirculating air pumps or hydraulic motors can also be used. Methanol burns with an invisible flame so serious burns are possible before you even know there is a fire. Explosions have occurred when tanks that have held methanol are exposed to welding arcs and cutting torches. All used tanks should be filled with water before cutting or welding.

Sodium and potassium hydroxide are strong bases that can cause burns to exposed skin and potentially life-threatening injury if their dust is inhaled. Full chemical protective clothing and gloves along with a respirator are recommended when handling these dangerous materials. Always add the catalyst slowly to the alcohol so that any heat that is generated has a chance to dissipate.

Both sodium and potassium hydroxide will absorb moisture from the air so they should be kept in sealed containers until they are to be used. The alcohol-catalyst mixture should also be protected from contact with air until it is added to the oil.

UPCOMING EVENTS

Biodiesel Production Technology Workshop

July 23-27, 2007 in Ames, Iowa
October 15-19, 2007 in Ames, Iowa
March 10 - 14, 2008 in Moscow, Idaho

Topics to be covered:

<i>Economics</i>	<i>Federal Regulations</i>
<i>Plant Design</i>	<i>Feed Stocks</i>
<i>Chemistry</i>	<i>By products</i>
<i>Business plans</i>	<i>History of Industry</i>