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Making Your Own Biodiesel: Brief Procedures and Safety Precautions

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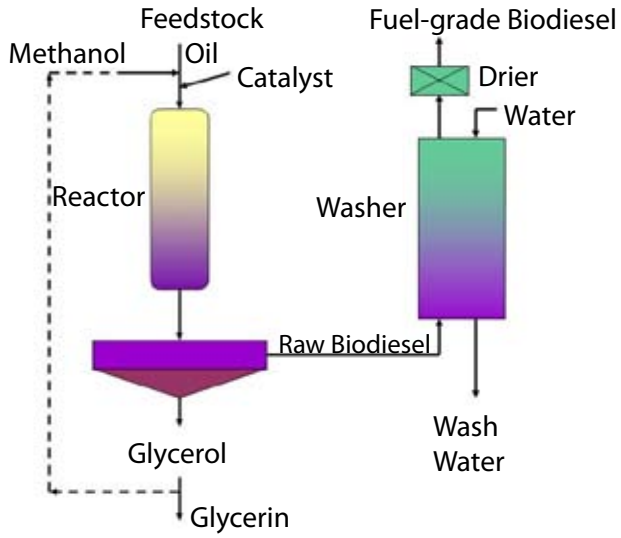
Introduction

Biodiesel is a renewable biomass alternative to petroleum-based diesel fuel. Biodiesel is converted (transesterified) biomass oil feedstock such as vegetable oil, animal fats, or used cooking oil (yellow grease). Transesterification is a chemical reaction wherein oil molecules are split, resulting in biodiesel and a crude glycerol byproduct. The American Society for Testing and Materials (ASTM) clearly specifies quality standards for biodiesel fuel.



Biodiesel works very well as fuel for any diesel engine with only minor, if any, required modifications. Diesel engines made before the early 1990's may need some modifications since many have seals and other components made with natural rubber, which degrades when in contact with biodiesel.

Biodiesel production is growing due to fuel prices, a desire for energy independence, and interest in environmentally friendly, renewable fuel production. This fact sheet is an overview of many facets involved in the production of biodiesel fuel for personal use (non-commercial), limited to less than 1,000 gallons per year in Pennsylvania without permitting. Reference 1 provides critically important details for the safe production of biodiesel as well as environmental requirements governed by state and federal laws.

Considerations for Making Biodiesel

1. Safety — Major precautions are necessary to avoid personal poisoning, fire, and contamination of soil and water resources. Methanol and lye are two dangerous chemicals that are required to convert vegetable oil into biodiesel. Methanol presents a significant fire risk and overexposure can cause neurological damage. Lye can cause skin and lung irritation and eye damage. A list of the safety gear that must be available (including goggles, respirator, gloves, eye wash, and fire extinguishers) whenever biodiesel is being produced is provided in Reference 1.

2. Compliance with Environmental Regulations — Biodiesel production facilities may be subject to regulation by the Department of Environmental Protection (PADEP) and other entities depending on their size and commercial status. Currently, small-scale, non-commercial facilities are exempt from PADEP permitting for fuel processing, but will be subject to "discretionary enforcement" if problems or complaints arise. Disposal of byproducts is regulated by the PADEP. Consult your regional DEP office for the latest guidelines.

3. Feedstock Availability — Each finished gallon of biodiesel will require at least one gallon of feedstock oil. Prospective biodiesel producers must consider the amount of fuel they hope to produce, and then be certain that they can obtain the necessary feedstock oil on a regular basis.

4. Time Commitment — Responsible fuel production is not as easy as many are led to believe and new producers often underestimate the time requirements.

Time must be allocated for:

- Maintenance of biodiesel equipment and facility
- Feedstock collection
- Securing and handling chemicals
- Fuel processing
- Water washing and air drying of the fuel
- Quality testing
- Disposal of by-products

5. Economics — An analysis should be performed of the cost of inputs versus the resultant value of the fuel produced. Accounting for labor costs is necessary if time spent on making biodiesel conflicts with income-generating work. Costs to consider include:

- Capital investment in equipment and facility
- Feedstock acquisition and transport
- Chemicals
- Electricity/ Energy
- Labor
- Permitting costs/byproduct disposal costs

6. Handling of Byproducts — Biodiesel processors will generate substantial quantities of crude glycerol byproduct (about one gallon of glycerol for every five gallons of biodiesel produced). Most processors also use water for fuel purification, and may generate as much as two gallons of waste water for each gallon of fuel produced. Compliance with environmental regulations for safe handling of byproducts adds significant time and expense to the overall process.

7. Vehicle/Equipment Performance — When a person pours the first gallon of homemade biodiesel fuel into a fuel tank, that person is most likely voiding the engine warranty. Careful attention to production chemistry and fuel quality testing is essential for acceptable engine performance.

Small-Scale Biodiesel Production

Process Description — There are many alternative methods to successfully transform feedstock oils into quality biodiesel. This section is not meant to be a "how-to" manual, but rather a summary of procedures and regulations for small-scale production in Pennsylvania. Producers are encouraged to keep up to date with new technologies for process improvements and evolving government regulations.

Simplified processing steps are:

1. Acquire feedstock oil
2. Filter oil to remove particulates
3. Check oil for water content; de-water if needed
4. Test oil for free-fatty acid content
5. Make a test batch for the particular feedstock
6. Mix the large batch using the recipe from a successful test batch.
7. Maintain accurate detailed records of all variables in each batch of fuel: oil source, mixing time, temperature, quantities of reactants, any other processing variables
8. Drain glycerol byproduct and label for further processing, temporary storage, or disposal
9. Recover excess methanol from raw biodiesel
10. Pump biodiesel to wash tanks and wash
11. Remove water from biodiesel
12. Filter the fuel prior to use or storage
13. Test fuel for quality parameters
14. Recover methanol from glycerol
15. Dispose glycerol and wash water in a safe and responsible manner

Safety — The top priority in any biodiesel operation must be safety. Users should obtain and study a copy of the Material Safety Data Sheet (MSDS) for methanol and lye, and be familiar with the safety considerations for each chemical. A "best practice" is to create a clearly labeled "safety station" within the processing facility, where the MSDSs are readily accessible. Small-scale producers should contact their local fire station to advise them of the processing and chemical storage that may be occurring on-site.

All hazardous chemicals (and any contaminated processing gear) should be kept in locked storage containers when not in use. A best practice is to use an approved metal fire cabinet for storage of flammable liquids. Another best practice is to label all storage containers, from buckets of glycerol byproduct to large tanks of used cooking oil. Container labels should indicate the fluid, distinguishing characteristics, and the date the fluid was produced or stored.

Feedstock Acquisition and Transport — Small-scale biodiesel production is easiest with high quality oil that is free from water and excessive food particles, does not smell rancid, and is low in acid due to regular fryer changes. Outdoor storage of the used cooking oil at restaurants should be securely covered to prevent water and vermin from entering containers. Storage

containers must be clearly labeled "USED COOKING OIL". Taking oil from an oil company's storage barrel is considered theft.

The PADEP regulates the collection and transportation of used cooking oil. The collection vehicle must display a sticker or magnetic sign reading "MUNICIPAL WASTE" and listing the vehicle owner's name and address. An oil collection log and fire extinguisher must be in the vehicle during oil transportation. Keeping a bucket of an absorbent "oil dry" material in the collection vehicle is recommended in case of spills. Secondary containment in the collection vehicle is important, as well as securing buckets and barrels to prevent spills during transportation. Oil should be rough-filtered by pouring it through a screen when transferring from the collection vehicle to storage. Used cooking oil can be stored in a container with minimal air space for six months to a year before processing.

Cleaning Up after Spills — Spills of hazardous materials or oil are easiest to clean up if they are limited to paved or concrete surfaces. Great effort should be made to not allow spills to migrate to soil, into storm sewers or manholes, or other surface water. If a spill enters surface water or the storm water system, it becomes a high-impact spill and must be reported to 911 for emergency cleanup response.

A spill kit must be on hand to easily deal with spills. The kit should contain loose absorbent material such as kitty litter as well as pads that are designed to absorb oils and other chemicals. Secondary containment around oil and fuel storage areas is a best management practice in anticipation of spills. A concrete curb around oil and fuel storage tanks should be sized to accommodate 110% of potentially spilled liquid.

By-Product Options — New producers must give ample consideration to how they will dispose of their byproducts before beginning a biodiesel facility. Biodiesel production will result in significant quantities of residual glycerol byproduct. Crude glycerol byproduct contains approximately 25% methanol (by volume) and is considered a hazardous waste. A person must wear gloves and goggles and avoid concentrated vapors whenever handling the crude glycerol.

Refining crude biodiesel glycerol into marketable glycerin is not considered practical on a small-scale. There is insufficient evaporation of methanol from glycerol at ambient temperatures to consider the glycerol to be uncontaminated. Glycerol stored in plastic fryer oil jugs will leak over time. Storage cannot exceed a one-year period.

Land application of glycerol with methanol is prohibited by the PADEP. A best practice is to recover the methanol to simplify handling and reduce overall process costs. Methanol recovery reduces environmental pollution and allows producers to reuse methanol. While methanol recovery is not complicated, small producers should consult experienced personnel before attempting this advanced step.

Disposal options of crude glycerol with methanol include landfill, anaerobic digestion, and industrial combustion at temperatures above 500°F. Each of these options requires special permission from the PADEP. Options for glycerol **after** effective methanol recovery include composting and using as an ingredient for soap, degreaser, dust suppressant, and animal feed. Composting and road application must follow PADEP and PADOT guidelines. When composting glycerol, small amounts of glycerol should be added to large amounts of absorbent materials such as hay, straw, leaves, or bedded manure. To prevent runoff of glycerol from the compost piles, avoid saturating piles with glycerol and/or rainwater. Consult a professional nutritionist before blending glycerol into animal feed.

Wash water from biodiesel processing presents an additional disposal and handling challenge. Unwashed biodiesel straight from the reactor typically contains soap, residual catalyst, traces of glycerol, and residual methanol if a methanol recovery stage was not performed. Washing biodiesel with water is required to "finish" the fuel. Washed fuel must be "dried" before use in equipment or transfer to storage. Drying can be accomplished by passive or active drying. With passive drying, suspended water droplets settle out of washed fuel after several days. Active drying involves separating the fuel from any settled water and then directing an air stream through the fuel.

Wash water may be disposed in a public sanitary sewer but permission is first required from the local water treatment authority and PADEP. Passing wash water through a simple grease trap will prevent excessive oils from entering the sewer system. Wash water must be prevented from entering waterways, storm sewers, and other water runoff channels! Biodiesel producers who contaminate waterways with wash water or other wastes may be held accountable by law.

Fuel Storage — An in-line filter should be used when pumping the washed biodiesel into storage containers. A 10 micron water-blocking diesel fuel filter will catch any last particles or water. A 1 micron filter is advised for newer, high pressure injection diesels.

The finished biodiesel fuel can be stored in any storage containers normally used for petroleum fuel. The fuel should be stored in a clean, dry, dark environment. Since biodiesel is an organic liquid, the use of an algaecide or fungicide additive is recommended whenever the fuel is stored during warm weather. Biodiesel gels during cold weather so blending with petroleum or an anti-gelling additive is necessary. Storage time for both biodiesel and petroleum diesel fuel should be limited to six months for best engine performance.

Fuel Quality — The prevailing quality standard for biodiesel in the U. S. is ASTM Standard D6751. Commercial ASTM testing currently costs about $1,000 per batch so it is not feasible for the small producer to conduct a complete analysis of each batch produced. However, small-scale producers can conduct a number of simple tests (such as viscosity, cloud point, and content of water, glycerol, methanol, and sediment) on the finished biodiesel. See references 2 and 3. The results of these tests will serve as good indicators of whether the biodiesel is a quality product for use in diesel engines and will provide the producer with feedback on any modifications to improve the fuel processing system.

Summary

Biodiesel fuel can be made from a number of starting materials (feedstocks) including vegetable oils, used cooking oils, and animal fats. Biodiesel (the end product in the process of transesterification of the feedstock oil) must meet quality standards for best diesel engine performance. While diesel engines may appear to "run well" on a variety of fuels for short periods of time, there is potential for both short- and long-term damage if poor quality fuel is used.

Small-scale biodiesel production can be conducted in a safe and environmentally responsible manner that generates a quality product. It is important to ensure that best management practices are followed to protect the health and safety of the producer and the environment, and to minimize the risk of vehicle/machinery problems. Each individual's facility will be different, with its own set of challenges. Staying up to date on process improvements and government regulations is essential.

The information in this fact sheet is provided as a public service; The Pennsylvania State University provides no warranty, expressed or implied, as to the accuracy, completeness, or reliability of the information contained herein.

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