Biodiesel production

Biodiesel may be produced in small quantities for individual use or in larger quantities for commercial purposes. For smaller producers, readily available production equipment enables production of batches of 15 to 400 gallons. Commercial-scale production of biodiesel may use continuous flow equipment with annual capacities in excess of 1 million gallons. Depending on feedstock availability and consumer demand, you can build a biodiesel operation to suit your biodiesel needs.

Production basics

Biodiesel is produced by a chemical reaction known as transesterification between a vegetable oil or an animal fat, an alcohol and a catalyst. Glycerin is a byproduct of this process, because animal fats and vegetable oils are composed primarily of triglyceride molecules that are broken down in the chemical reaction. The following are common input levels for transesterification:

- **Inputs:** 100 units of vegetable oil, 10 to 15 units of alcohol and ½ to 2 units of catalyst
- **Outputs:** 100 units of biodiesel and 10 to 15 units of glycerin

These proportions may be adjusted for differences in the chemical composition of the oils and fats to be processed, the type and purity of the alcohol used, and the technology employed to facilitate the reaction.

Small-scale production process

Biodiesel production follows the same basic process, regardless of the quantity produced. However, differences in inputs, equipment and the desired quality attributes will dictate specifically how to proceed. (Some methods of producing biodiesel are not examined here. See *Additional resources* for more information on methods not discussed herein.) Biodiesel production is relatively simple, but don't overlook important process details.

Step 1

The production process begins with the pretreatment of virgin or recycled oil. Recycled oil may need to be filtered to remove particles and dried to reduce water content. Virgin oil needs to be degummed to remove waxes, phosphates and other impurities during the pretreatment process. Once the oil has been pretreated, a titration test is performed to measure several attributes of the oil. The results of the titration test are used to adjust the amount of catalyst required to successfully complete the transesterification process to ensure a high-quality final product.

Step 2

The next step is to mix a catalyst into an alcohol. If sodium hydroxide and methanol are used, the resulting mixture is referred to as sodium methoxide. The catalyst, alcohol and mixture are all hazardous materials that require careful handling. The catalyst and alcohol mixture is combined with oil to facilitate transesterification. In some cases, the catalyst, oil and alcohol are heated prior to, during or both prior to and during transesterification. Adding heat shortens the time required for processing and may increase the overall reaction rate.

Step 3

After the transesterification process is completed, the glycerin and biodiesel must be separated. Glycerin is heavier than biodiesel and settles to the bottom of a reaction vessel, allowing it to be separated from biodiesel. Larger production units may use a centrifuge to separate the two liquids, which more effectively and quickly separates the biodiesel and glycerin. At this point in the process, both the glycerin and biodiesel are contaminated with catalyst, alcohol and oil that failed to react during transesterification. Soap generated during the process also contaminates the biodiesel and glycerin. Although glycerin tends to contain a higher percentage of contaminants, significant amounts of contaminants may also be present in the biodiesel.

Step 4

Removal of these contaminants is the final step in the production process. Excess alcohol is removed by heating biodiesel or glycerin to vaporize the alcohol. Commercial operations typically condense the alcohol back into liquid to be reused in the process, but most small-scale producers opt not to recover the excess alcohol.

One method of removing contaminants from biodiesel is to wash the fuel with water. Washing and drying biodiesel improves fuel quality, but some small-scale proudcers choose not to wash biodiesel for their personal use. Washing entails misting water over biodiesel or bubbling water through it. The water droplets collect contaminants as they descend through the fuel. Finally, biodiesel is dried and filtered to complete the production process.

Input selection

You must decide what types of oil, catalyst and alcohol to use in your operation.

Oil selection

The quality of oil used to produce biodiesel affects several aspects of the production process. For example, using recycled oil adds several additional steps. First, the oil must be filtered to remove any solid contaminants such as bone and other food particles. Second, the oil's free fatty acid level and water content should be measured.

High free fatty acid or water content will cause soap to be produced during transesterification. If water content is high, the oil may need to be dried before further processing. Virgin oils are unlikely to have high free fatty acid or water levels. However, virgin oils need to be degummed before biodiesel production can occur. Virgin oils purchased from a commercial processor have probably already been degummed. The consistency and minimal contamination of virgin oils makes them ideal for biodiesel production, but they typically cost more than lower-quality recycled oils.

You should secure a reliable source of oil, regardless whether the oil is virgin or recycled. Recycled oils are usually obtained from local restaurants and food processors, often at a low cost. (Get permission from the restaurant or food processor before collecting any used oil because they may already have an agreement in place for the disposal of their used oil.) Virgin oil can be obtained by processing oilseed with small-scale processing equipment or purchased from a commercial oilseed processing facility.

Alcohol selection

Price and availability are key factors in determining which alcohol to use in the production process. Ethanol and methanol are the two most common options. High-quality methanol is often cheaper and more readily available than non-denatured ethanol and therefore used in nearly all biodiesel operations.

You can get methanol in quantities of five gallons or more from many bulk fuel distributors and from distributors of racing fuel. The price of methanol can vary substantially depending on the quantity purchased. The cost of methanol represents a relatively large component of total cost of producing biodiesel. (The production of biodiesel requires between 10 to 20 gallons of methanol for each 100 gallons of biodiesel produced.) You should also be aware of safety concerns when handling methanol or ethanol. Both are highly flammable and require careful handling to ensure a safe working environment.

Catalyst selection

A catalyst is required to facilitate the reaction between the oil and alcohol. The most common catalysts used in small-scale biodiesel production are sodium hydroxide (lye) and potassium hydroxide. Sodium methoxide and potassium methoxide are also used, though they are less common. Availability and compatibility with processing equipment are the two main determinants of catalyst selection, though price is always a factor.

Many equipment manufacturers will recommend catalysts appropriate for use with their specific equipment.

Equipment selection

Small-scale biodiesel production equipment can be purchased on a ready-to-use basis from several manufacturers. Price, capacity and functionality will be your main considerations when looking at this equipment. Consider these questions when buying production equipment:

- How many gallons can be processed per batch?
- How long does each batch take to process?
- Is the system capable of heating the oil and the alcohol-catalyst mixture?

- Does the system include methanol recovery equipment?
- Does the system have the capability to wash and dry the biodiesel?
- Does the system require extra plumbing, fittings or pumps?
- Does the manufacturer provide technical support?
- Does the system require that a specific catalyst be used?
- How much does the system cost?
- Does the quoted price of the system include shipping costs?

Final products

The transesterification process produces two products: biodiesel and glycerin.

Biodiesel

Quality depends on the inputs and processing techniques used in production. The American Society for Testing and Materials (ASTM) has developed quality standards for biodiesel. Unfortunately for small-scale producers, the cost of testing a batch of biodiesel is likely to exceed the value of the fuel produced. Fuel that has not been tested for ASTM standards generally cannot be marketed on a commercial basis. Most small-scale producers will be limited to producing biodiesel for personal use.

Lack of ASTM testing does not necessarily imply poor fuel quality. Small-scale producers must focus on accurate processing procedures to ensure fuel quality. These steps may include proper filtering, accurate catalyst measurement and fuel washing procedures.

Glycerin

Glycerin produced during the biodiesel process is crude and unrefined. There are several markets for refined glycerin, but these markets are not generally available to small producers because of the costs involved in refining glycerin. Crude glycerin produced in small-scale biodiesel operations typically contains unreacted oil, catalyst, methanol — if not recovered during processing — and some biodiesel. Glycerin and biodiesel are generally considered environmentally friendly, but the catalyst and methanol are not. Therefore, choices for disposing of crude glycerin may be limited.

One option is to use the crude glycerin as fuel oil. Another is to compost it. Large volumes of liquid glycerin are produced in the biodiesel process (10 to 15 percent of biodiesel production), so planning is required for successful composting. Some biodiesel producers also use glycerin as a dust suppressant or for making soap.

Regulatory and policy issues

Government policy affects the production of biodiesel in two ways.

The first is through regulations. Local, state and federal government agencies may require building and operating permits, licenses and registration of different aspects of the biodiesel production process. Obtaining required permits and licenses is essential for successful biodiesel production.

The second way in which government is involved is through tax and subsidy programs. State and federal agencies tax biodiesel but also offer incentives for biodiesel production.

Additional resources

Those interested in a more detailed discussion of biodiesel technology may want to read *Building a Successful Biodiesel Business* by Jon Van Gerpen, Rudy Pruszko, Davis Clements, Brent Shanks and Gerhard Knothe.

References

Van Gerpen, J., R. Pruszko, D. Clements, B. Shanks and G. Knothe. (2006). *Building a Successful Biodiesel Business.* Scottsdale: Biodiesel Basics.

Notes

Original work created by Montana State University Extension and the University of Wyoming.
Adapted with permission by University of Missouri Extension.

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