This curriculum was developed through a Southern SARE grant and collaboration between Tennessee State University, the University of Tennessee, eXtension.org, and USDA-Rural Development. The objective of this curriculum is to provide training on biomass energy to extension agents and local officials so that they may deliver this information to their stakeholders.
Biomass Energy Training Curriculum

Collaborators: Jason de Koff, Ramona Nelson, Adia Holland, Tim Prather, Sue Hawkins

Cover design: Brett Seybert

Funding was provided through the Southern Sustainable Agriculture Research and Education (SARE) Program

Tennessee State University
3500 John A. Merritt Blvd.
Nashville, TN 37209

TSU-16-0269(A)-14-17095  Tennessee State University does not discriminate against students, employees, or applicants for admission or employment on the basis of race, color, religion, creed, national origin, sex, sexual orientation, gender identity/expression, disability, age, status as a protected veteran, genetic information, or any other legally protected class with respect to all employment, programs and activities sponsored by Tennessee State University. The following person has been designated to handle inquiries regarding non-discrimination policies: Tiffany Cox, Director, Office of Equity and Inclusion, tcox9@tnstate.edu, or Justin Harris, Assistant Director, Office of Equity and Inclusion, jharri11@tnstate.edu, 3500 John Merritt Blvd., McWherter Administration Building, Suite 260, Nashville, TN 37209, 615-963-7435. The Tennessee State University policy on nondiscrimination can be found at www.tnstate.edu/nondiscrimination.

This curriculum and supporting documents can be accessed online (in full and as separate modules) at

http://articles.extension.org/pages/73919

These training resources [the curriculum, not the references and additional resources] are freely available for educational purposes under the terms of Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. Attribution: Biomass Energy Training Curriculum by Jason de Koff, Tennessee State University, funded by Southern SARE.

If you wish to adapt these curriculum materials for your own educational purposes, please contact the Curriculum Author for permission and files:

Jason P. de Koff, Ph.D.
(615) 963-4929
jdekoff@tnstate.edu
Learning objectives:

- Participants will be able to explain the biodiesel production process
- Participants will be able to identify the chemicals required to produce biodiesel
- Participants will be able to outline the chemical safety hazards involved in the biodiesel production process

Materials:

- PowerPoint® slides “Biodiesel production”
- Lesson guide: Use the notes in this lesson guide to present information for each slide.
- Videos:
  - “Biodiesel Production – Part 1 Producing oil from oilseeds”
    https://www.youtube.com/watch?v=a1E8Nb4H_0I
  - “Biodiesel Production – Part 2 The degumming process”
    https://www.youtube.com/watch?v=fFqrAvnihEM
  - “Biodiesel Production – Part 3 Determining the amount of chemicals”
    https://www.youtube.com/watch?v=YzdILuogQpE
  - “Biodiesel Production – Part 4 Making biodiesel”
    https://www.youtube.com/watch?v=NXWyfUTJ_50
  - “Biodiesel Production – Part 5 Separating and cleaning the biodiesel”
    https://www.youtube.com/watch?v=M_6WAN50w5A
- Factsheets:
  - “Small-Scale Biodiesel Production”
  - “Maximizing the Biodiesel Process”
    http://www.tnstate.edu/extension/documents/MaximizingProduction.pdf

Copies of both publications can also be found in the Appendix.
Questions found at the end of this lesson guide can be used to test participants’ knowledge at the end of the presentation. This can be combined with clickers to improve audience engagement and create discussion.

An evaluation of the presentation can be found in this lesson guide following the lesson questions.

Topics:

Importance of bioenergy
Biodiesel conversion process
Equipment for biodiesel production
Advantages and disadvantages of biodiesel
Slide 1
This section will cover how biodiesel can be made on the farm and the equipment that is needed to produce biodiesel. It will also discuss the advantages and disadvantages of biodiesel.

Slide 2
This part of the curriculum is based on a series of workshops developed using a mobile biodiesel demonstration that shows the equipment needed for biodiesel production and allows participants to see the pressing of oilseed to make oil and the process involved in converting that oil into biodiesel. This mobile demonstration can be brought to a meeting that you are having to provide additional assistance in describing the overall process of making biodiesel. There is also a Twitter account, Facebook page and website with additional updates and resources.

Slide 3
U.S. fuel consumption is dominated by fossil fuels at 83% of total consumption (37% Petroleum, 25% Natural Gas, 21% Coal) with nuclear energy at 9% and renewable energy at 8%. To manage risk involved in the volatility of this market, it is important to diversify our energy sources. When we manage risk we can look to something like a retirement plan which shows the number of sources involved to prevent major risks from having a significant impact.
Slide 4
This slide shows the recent projections for diesel fuel prices. You can see the large decrease in overall prices that we saw in the early part of 2015. They are expected to rise as consumption increases, particularly for diesel fuel, to around $2.50/gallon by the end of 2017.

Slide 5
This slide shows the top 5 countries that export their crude oil to the U.S. Saudi Arabia and Venezuela are both part of OPEC that has given us problems in the past. Recently, Saudi Arabia has worked to depress oil prices so that they are too low for fracking to be economically viable. This directly affects our production capability.

Slide 6
The Renewable Fuels Standard is a mandate established by the federal government to help create an incentive for biofuel production. This mandate requires increasing amounts of biofuels to be used for transportation fuels. It is expected that by 2022, about 36 billion gallons of transportation fuel will come from biofuels each year. This is expected to decrease oil imports by $41.5 billion by 2022. Cellulosic ethanol and advanced biofuels use are mandated to increase over time (even if it has to be imported). Advanced biofuels are those that rely on newer technology and may also include biodiesel production.
**Slide 7**
This graph shows the recent production of biodiesel on a commercial basis. It is still very small in comparison to ethanol production. The kind of biodiesel production we will be talking about will most likely not be on a commercial basis. Biodiesel produced on the farm can be used by the farmer without having to meet any specific regulations. If it is sold commercially, however, it has to be tested to meet specific standards which would cost money.

**Slide 8**
The chemical process used to produce biodiesel is called transesterification. Vegetable oils and animal fats are primarily triglycerides which contain three fatty acids that are esters and one glycerol molecule. These triglycerides are large bulky molecules and the oils are usually thicker than regular diesel that is normally used for fuel in a diesel engine. Therefore, we have to break apart this molecule to create a thinner product.

**Slide 9**
This slide shows what the large, bulky triglyceride molecule looks like. The triglyceride reacts with the alcohol (usually methanol), the alcohol removes the glycerol molecule and creates three esters that are methyl or ethyl esters (depending on the alcohol used). The slide shows how the molecule is broken apart. A chemical catalyst (usually sodium or potassium hydroxide) similar to lye is also used to help break apart the oil molecules.
Slide 10
The final products are the methyl or ethyl esters that are created (biodiesel) and the glycerol.

Glycerol is used to make soap, paints, resins.

Slide 11
This slide shows the mobile demonstration that has been used in a number of counties in Tennessee to show producers how they can make their own fuel on the farm. It contains a seed press (left) for crushing the oilseeds and releasing the oil and the biodiesel processor (right) for converting the oil into biodiesel.

Slide 12
For the screw press, seed is fed into the machine using the hopper you can see above the equipment. Oil drips from the holes you can see on the right-hand side and canola meal (everything that is left over, similar to soybean meal) is extruded out the far right hand side.

Our video of this process can be found at: https://www.youtube.com/watch?v=a1E8Nb4H_0I

The price for these presses is variable based on the size of the press (i.e. the amount that can be processed in one day) and the country where the press is produced. Prices usually range from $2,000 (China) to $14,000 (Germany). The one used in the mobile biodiesel demonstration (shown in the slide) was around $8500 and came from the Oil Press Company in the U.S.
As will the presses, biodiesel processors can range in price depending upon the capacity and the company. The range for these is between $3,000 and $10,000. The one that is used in the mobile biodiesel demonstration (shown in the slide) was around $3,000 and can produce batches between 20 and 40 gallons in size.

Prior to converting the oil to biodiesel, the oil should go through a degumming process where the oil is washed with water. This helps to remove natural gums from the oil which could make it difficult to separate the biodiesel from the glycerol product and reduce yields. The equipment used to convert the oil to biodiesel can be used for this degumming step. The oil to be used is poured through a filter attached to the gray 55 gallon drum behind the processor and then pumped up into the large 110 gallon tank on the processor shown in the picture. This processor has an attachment at the top where a garden hose can be attached an allow water into the system so that it can flow down through the oil and remove the gums present. After waiting for the water to settle to the bottom of the tank, a valve at the bottom can be opened to release the water. This can be done as many times as it takes for the water that is released to look clear rather than milky. The lab examples on the left section of the slide show this difference.

Our video of this process can be found at: https://www.youtube.com/watch?v=fFqrAynihEM

Once degumming has been done, the oil can be heated to remove any excess water and prepare the oil for the chemical reaction. Heating will enhance the speed of the reaction. Prior to adding the required chemicals, a sample of the oil will need to be tested with titration kits that usually come with the equipment to determine the amount of catalyst (sodium or potassium hydroxide) that is required.

Our video of this titration process can be found at: https://www.youtube.com/watch?v=YzdILuogQpE

The catalyst and the alcohol (usually methanol and usually 25% of the volume of oil to be converted) are mixed in the smaller tank on the processor and then pumped into the larger tank where the reaction will take place for about 2 hours. It is important to note that the catalyst and alcohol used in this process are considered health hazards and care must be taken to use the proper protective equipment in a proper working environment.

Our video of this titration process can be found at: https://www.youtube.com/watch?v=NXWYfUTI_50
After about 2 hours, the pump circulating the material can be turned off and the biodiesel can be allowed to settle out and separate from one another. This is usually something that requires a number of hours to ensure proper separation occurs for maximum yield. Many times, it can be allowed to separate overnight. As shown in the laboratory image on the right side of the slide, the dark-colored glycerol will settle to the bottom and the lighter, yellow-colored biodiesel will remain above. The glycerol can be removed using the valve at the bottom of the tank and the biodiesel can be washed with water (similar to the degumming process above) to remove any impurities that may remain from unused catalyst or alcohol. After this, the biodiesel can be heated to remove any excess water.

Our video of this process can be found at: https://www.youtube.com/watch?v=M_6WAN50w5A

The glycerol byproduct is considered a hazardous waste because of the remaining catalyst and alcohol that it may contain. The glycerol is a material that is used by a number of industries to produce soaps, paints and resins so a local industry may be able to purify and use this material. Also, there are methanol recovery systems ($3500) that can remove the methanol (which can be reused to produce more biodiesel) and increase the purity of the material.

Biodiesel produced on the farm to be used by the producer does not need to meet specific standards as selling on the commercial market would. To determine the quality of the biodiesel produced, there are test kits available that do not cost as much as the specific lab tests and are simple and basic and rely on color indicators relative quality of biodiesel produced (3 parts of ASTM standard). While it does not go through all of the quality tests, it can give an idea of the quality before it is used. Just keep in mind that if it does harm the engine, the warranty will be void. Another alternative is to have a laboratory test a batch and if it passes then, presumably, if the process is carried out the same way for future batches, it should be of good quality.

Slide 14
This slide shows a list of questions that should be asked when selecting a biodiesel processor.

In Question #4 a methanol transfer system allows for the transfer of methanol from a 55 gallon drum into the small tank without having to pour or measure the material. The system shown previously has this which uses a hand pump to measure out the correct amount of methanol into the tank. This is an important safety feature to have.

In Question #7, some systems rely on an acid rather than a base as their catalyst. The acid catalyst system usually takes longer to produce biodiesel and is not really recommended.
Question #8 is probably the most important question so that when you buy one of these processors you have someone to contact when something goes wrong.

Slide 15
There are a number of advantages and disadvantages in the use of biodiesel.

The advantages include:

1. Environmentally friendly: lower sulfur (20-50 times less) and aromatic content, reduced particulate matter by 75-83%, non-toxic, renewable, high flash point compared with petrodiesel. This reduces risks of handling, transporting and storing
2. Biodegradable: 4 times faster than petrodiesel (like sugar)
3. Good lubricant: 66% better than petrodiesel, reduces long term wear in diesel engines (less than half the wear of engines running low sulfur petrodiesel). Even levels below 1% biodiesel can provide 30% increase in lubricity
4. Increased combustion efficiency: High oxygen content of molecules increases combustion efficiency
5. Higher cetane number: relates to diesel quality, shorter ignition delay

The disadvantages include:

2. Higher consumption values: due to higher oxygen content
3. Higher cloud and pour point can affect cold start
4. Higher viscosity can affect fuel pumping and copper strip corrosion

A lot of these disadvantages can be mitigated by blending biodiesel with regular diesel. There are currently a number of stations that offer B5 (5% biodiesel) or B20 (20% biodiesel).
Test their Knowledge - Questions for the audience

T or F Biodiesel produced on the farm can be used by the farmer without having to meet any specific regulations.

Methoxide, potassium hydroxide and sodium hydroxide can cause **chemical burns**.

Methanol can cause **blindness**.

Methanol can be **absorbed** directly through the skin as vapors.

Methanol is also **flammable**.

Q: What are some advantages and disadvantages of biodiesel?
A: Advantages: environmentally friendly; 20-50 times less sulfur than petrodiesel; reduced aromatic content; reduced risks of handling; transporting and storing; biodegradable; 66% better lubricant than petrodiesel, increased combustion efficiency; shorter ignition delay
Disadvantages: 5% reduction in power, higher consumption values, higher cloud and pour point can affect cold start; higher viscosity can affect fuel pumping and copper strip corrosion.
# Evaluation

Please give us your feedback regarding this activity. Your feedback will help us improve the activities you attend in the future.

**Name of Activity:** Biodiesel production  
**Date of Activity:**

## A. Instruction

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The specialist was well prepared.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2. The specialist presented the subject matter clearly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

## B. General Learning and Change

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have a deeper understanding of the subject matter as a result of this session.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2. I have situations in which I can use what I have learned in this session.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3. I will change my practices based on what I learned from this session.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

## C. Specific Learning

<table>
<thead>
<tr>
<th></th>
<th>Before this program I knew...</th>
<th>Now I know....</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much <strong>did you / do you</strong> know about these subjects?</td>
<td>Very little</td>
<td>Little</td>
</tr>
<tr>
<td>1. How biodiesel is produced</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2. The importance of chemical safety in biodiesel production</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. The advantages and disadvantages of biodiesel use</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

## D. Specific Practices

<table>
<thead>
<tr>
<th></th>
<th>Before this program I did...</th>
<th>In the future I will realistically do....</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what degree <strong>did you / will you</strong> do the following?</td>
<td>Very little</td>
<td>Little</td>
</tr>
<tr>
<td>1. Seek information related to biodiesel and biodiesel production</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2. Produce biodiesel</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. Use biodiesel</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

## E. Satisfaction with Activity

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I would recommend this program to others.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

## F. Other comments?

Thank you for completing this survey!
“The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it.” Rudolf Diesel, 1911

The production of biodiesel from vegetable oil is a viable process to create fuel that can replace traditional diesel used in existing engines. Many large biodiesel production facilities in Tennessee are using waste oils (fast food frying oils, for example) for biodiesel production, but the oil from pressed oilseed crops (i.e soybean, canola, sunflower) can also be converted to biodiesel on the farm by a farmer or farmer cooperative.

Based on estimates, a typical farm uses around 2 to 6 gallons of diesel fuel per acre per year. Depending on the oilseed crop and yield, a farmer could devote 1 to 15% of the farm acreage to producing oilseed crops for biodiesel production, and become totally self-sufficient in their diesel fuel use. This fact sheet discusses the process and equipment involved in biodiesel production and some important quality and safety issues.

Biodiesel conversion

The original diesel engines were designed to use various types of fuels, including seed oils. Over time, the diesel engine was modified to use the lower-grade byproduct of petroleum refinement. Therefore, unless retrofitted to run on straight vegetable oils, the oils must first be converted to biodiesel.

Creating biodiesel from waste or pressed vegetable oils involves a process called transesterification. This process was used in the mid-1800s in the U.S. for making glycerin soap and the esters (biodiesel) produced were considered a byproduct. Transesterification basically involves the reaction of the oil with lye (sodium hydroxide) and alcohol (methanol) to remove glycerin. The glycerin sinks to the bottom and the biodiesel floats to the top. Removing the glycerin from the oil makes the original oil thinner so that it can be used in a diesel engine.

Biodiesel equipment and supplies

Certain equipment is required to create biodiesel. Due to the hazardous nature of the chemicals involved, it is recommended to purchase this equipment rather than building your own. It is also recommended that you consult a professional to avoid production issues. Groups such as TSU Extension and the National Biodiesel Board (www.biodiesel.org) can provide contacts and information regarding biodiesel production.

Seed press: A seed press (Fig. 1) will allow for the extraction of oil from a number of different types of seeds. Prices usually range $3,000 - $12,000 depending on the manufacturer and the processing volume/speed. In addition to oil, the press also produces residual meal that can be used as an animal feed.

Biodiesel processor: The processor (Fig. 2) can hold and mix the oil and chemicals, allowing them to react and produce biodiesel. Processors usually contain some type of agitator and heating device to allow for faster reaction of the material and typically produce 40-80 gallons of biodiesel at a time. Prices can range $1,500 - $10,000 depending on the manufacturer and capacity.
Other miscellaneous equipment: Filtering equipment or a centrifuge is advised (particularly if using waste vegetable oil) to remove particulates prior to loading oil into the biodiesel processor as some of these particulates could end up in the final product.

Alcohol: Methanol is the type of alcohol that is used in this process because it is generally cheaper than ethanol and usually has a more predictable reaction. Methanol does have safety issues that relate to its flammability and other health hazards so it is important to use it under the correct conditions with the correct personal protective equipment. Methanol usually costs around $200 (plus taxes and shipping) for a 55 gallon drum which can produce about 275 gallons of biodiesel.

Lye (catalyst): Sodium hydroxide (NaOH) is usually the chemical of choice due to its lower cost. Potassium hydroxide (KOH) can be used instead but a larger amount will be needed. As with methanol, these chemicals are also a health hazard and the proper guidelines should be followed in their use. The sodium hydroxide costs about $60 (plus taxes and shipping) for 55 lbs. which can be used to produce about 724 gallons of biodiesel.

Quality

It is important to ensure the best quality biodiesel before using it in your equipment. To legally sell biodiesel to others, the biodiesel must pass specific testing standards (ASTM 6751 for 100% biodiesel, ASTM 7467 for 6-20% biodiesel). If using biodiesel in your personal equipment, it does not have to be tested but will void the engine warranty.

Standard tests can be costly but simpler, easy tests kits are available that can give some idea of biodiesel quality. In the absence of standard tests it is even more important to ensure that proper techniques (filtration, correct ratio of chemicals, allowing enough time for conversion and proper separation of glycerin from biodiesel, “washing” and “drying” of biodiesel, proper storage) are being used to produce good quality biodiesel.

Safety

Safety is extremely important when handling the chemicals involved in producing biodiesel. Always follow the guidelines that come with the chemicals. In addition, other good resources are available that relate to safety issues involving biodiesel production. A couple of examples are below:

http://pubs.cas.psu.edu/freepubs/pdfs/agrs103.pdf
http://pubs.ext.vt.edu/442/442-885/442-885.html

Waste Disposal

There is wastewater and contaminated glycerol that is produced as part of the process that must be disposed in an environmentally sound and lawful way. For more information on proper disposal methods in Tennessee, contact the Division of Solid and Hazardous Waste Management at (615)532-0780. There is also an annually updated list of permitted hazardous waste transporters at http://www.tn.gov/environment/swm/pdf/transporter.pdf

Additional Resources


Dean - Dr. Chandra Reddy, Associate Dean for Extension - Dr. Latif Lighari

TSU-13-0068(A)-15-17095 Tennessee State University is an AA/EEO employer and does not discriminate on the basis of race, color, national origin, sex, disability or age in its programs and activities. The following person has been designated to handle inquiries regarding the non-discrimination policies: Ms. Tiffany Baker-Cox, Director of Equity, Diversity and Compliance, 3500 John A. Merritt Boulevard, Nashville, TN 37209, (615) 963-7435.
Vegetable oils, whether from used cooking oil or oilseeds, are transformed into biodiesel with the help of a chemical reaction called transesterification. The main reason we use the transesterification process is to thin these oils so that they are more suitable for use in diesel engines. To do this, the oil molecules, made up primarily of triglycerides (Fig. 1) are broken apart into glycerol (Fig. 2) and fatty acid esters (Fig. 3).

The fatty acid esters are the biodiesel and can be easily separated from the glycerol that is also formed because the biodiesel is less dense and floats on top (similar to oil and vinegar). Breaking the triglyceride molecules apart requires an alcohol (usually methanol) and a catalyst (usually sodium or potassium hydroxide, similar to lye). The catalyst is used to help speed up the reaction. In addition to the catalyst, a number of other factors that affect the reaction process are time, heat, type of catalyst, feedstock, alcohol, and mixing.

**Time**

The time allowed for transesterification is important in producing a high quality biodiesel with good yields. Using basic catalysts (i.e. sodium or potassium hydroxide), the reaction generally proceeds very rapidly in the beginning and then slows as more biodiesel is produced and there are fewer materials to react. A study by Freedman et al. (1984) identified yields of around 55% for peanut and cottonseed oil and 80% for sunflower and soybean oil after only one minute of reaction time. Since the reaction slows down after this, it is usually advised to allow the reaction to take place for 1.5 to 2 hours to maximize yield and quality.
Heat

The addition of heat is always useful for making reactions go faster. In biodiesel production, increasing temperature will increase how quickly biodiesel is produced. A study by Freedman et al. (1984) with soybean oil found that a temperature of 140°F could produce 94% of the total biodiesel yield in about 6 minutes versus a yield of 64% at 90°F (Fig. 4).

Type of catalyst

Basic catalysts, like sodium or potassium hydroxide, are good at increasing the rate of the reaction for producing biodiesel. Another option is a sodium methylate (also known as sodium methoxide) solution already dissolved in methanol. This solution can produce higher yields, require less catalyst and improve safety (due to lower exposure to corrosive dust).

Feedstock

The type of oil feedstock you use may depend on the level of free fatty acids (FFAs) it contains. Free fatty acids are large molecules containing many carbon atoms with an acid group at one end. These FFAs can interact with the basic catalyst to form soap which will cause problems separating the two end products; biodiesel and glycerol. In general, a FFA level greater than 5% will cause this. If this occurs, an extra processing step will be necessary which will involve using an acidic catalyst to convert the FFAs to biodiesel before the transesterification process can take place.

Alcohol

The transesterification reaction requires 1-1.5 gallons methanol for every 10 gallons of oil used to make biodiesel (oil-to-methanol ratio of 8:1). For maximum yield, however, more alcohol is usually used. Generally, about 2.5 gallons of methanol for every 10 gallons of oil (or an oil-to-methanol ratio of 4:1) is used since it gives the best yields (Fig. 5).

Mixing

In the reaction mixture, the catalyst will dissolve in the alcohol but the oil and alcohol are not soluble in one another. Therefore, mixing is important for initiating the reaction. Also, a slower rate of mixing can reduce the overall reaction rate.

Additional Resources


Dean - Dr. Chandra Reddy, Associate Dean for Extension - Dr. Latif Lighari