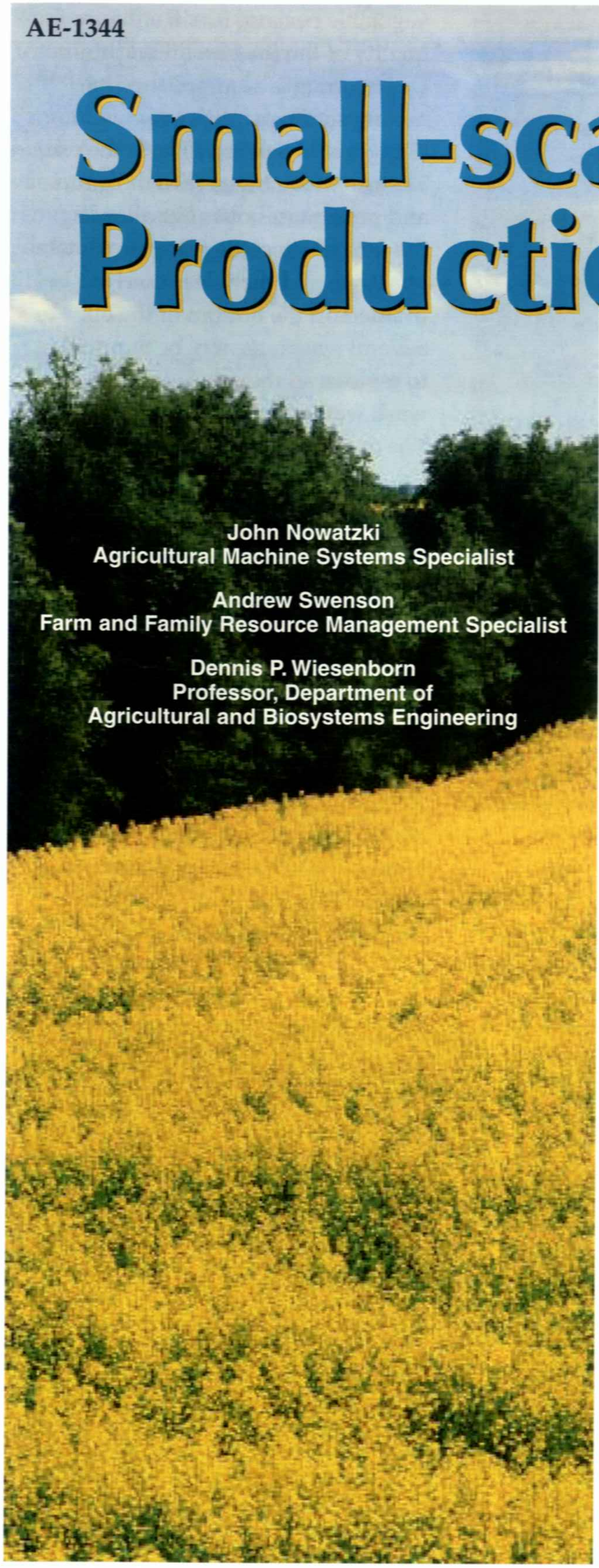
AE-1344

Small-scale Biodiesel Production and Use



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What is Biodiesel?

Biodiesel is an engine fuel made from vegetable oils or animal fats.

The term biodiesel refers to 100 percent pure fuel (B100) that meets the American Society for Testing and Materials (ASTM) requirements for biodiesel fuel in its D 6751 standard. A variety of oils can be processed into fuel for compression-ignition internal-combustion engines, including canola, soybean, sunflower, palm and safflower. Rendered animal fat and waste cooking oils also can be processed into biodiesel.

Table 1. Theoretical biodiesel yields from crops.

Crop	Yield/Acre	Gallons/cwt of Seeds	Gallons/Acre
Canola	1,375 lbs	5.9 gallons	81 gallons
Sunflowers	1,360 lbs	6 gallons	82 gallons
Soybeans	1,920 lbs	2.5 gallons	48 gallons

Oil Extraction and Preparation

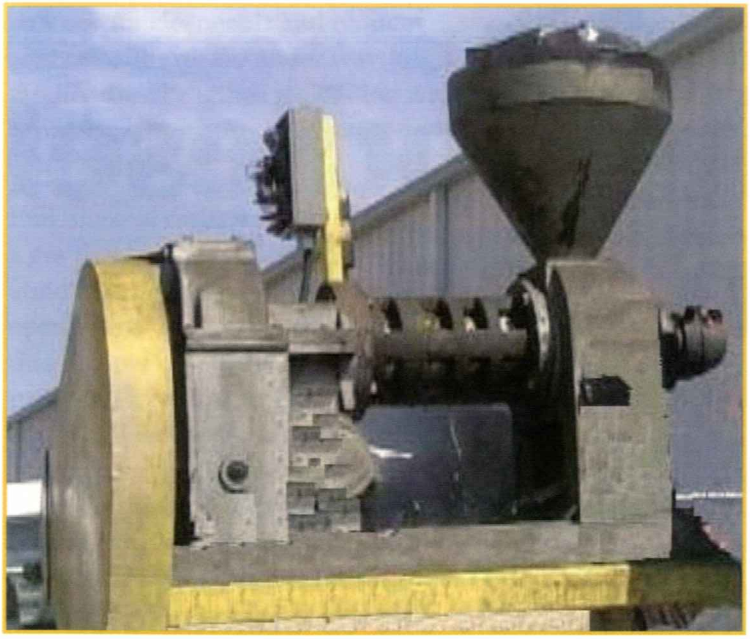
Seed preparation

Small-scale biodiesel producers can purchase vegetable oils to process into biodiesel or extract oil from crop seeds. Producers who decide to extract oil from the crop seeds need specific equipment.

Extraneous material first is removed from the harvested crop seed by screening. This is particularly important to ensure materials such as small stones are removed prior to crushing and extraction. The crop seed also should be passed over a magnet to remove metal pieces.

Oil extraction

Oil is removed from oilseed crops either by expeller pressing or solvent extraction. Small-scale biodiesel producers generally use a press extraction method because it is a simpler, less expensive and safer process. This is a process of mechanical separation of the oil from the oilseed. This process produces a crude oil and a cake meal that contains approximately 10 percent or more of the oil content of the original seeds.



Expeller press
(Photo by John Nowatzki)

Crushers are used to extract oil from oilseeds. Processors sometimes heat the seeds prior to processing to decrease the energy required to extract the oil from the seeds. Some seeds, such as soybeans, must be cooked to destroy anti-nutritional factors in the cake. The heated seeds can be crushed and flaked to further enhance oil extraction, or seeds simply can run through a cold press, also referred to as expeller pressing, to remove the oil. The material other than oil left after extracting the oil is referred to as cake. The extracted oil is referred to as "crude oil." The cake may be 10 percent to 15 percent oil, which may enhance its value as a livestock feed.

Large crushing operations use petroleum distillate to recover virtually all of the oil. However, such plants require costly safety features for operator and environmental protection, and are not recommended for small-scale extraction. A number of innovative alternatives have been reported in recent years; for example, use of supercritical carbon dioxide or hot water plus enzymes. These methods appear to be quite expensive at this time, but may be feasible in the future.

Oil preparation

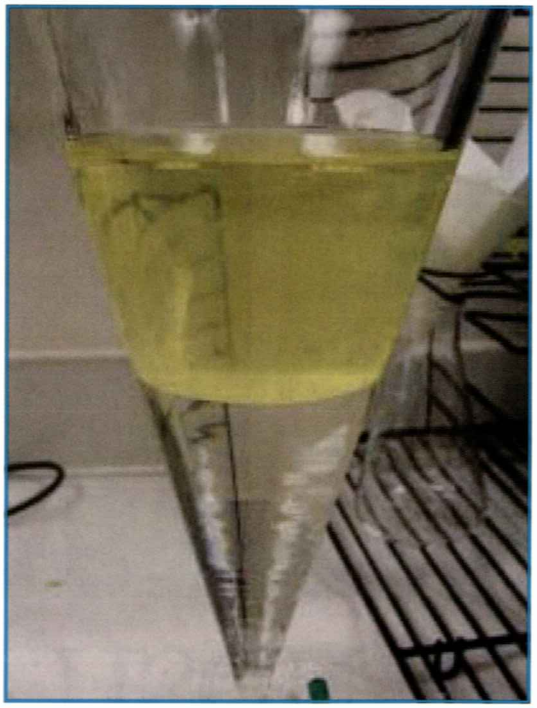
Unrefined vegetable oils (crude oil extracted from oil seeds) often contain phospholipid (gum) compounds that can make separating the glycerin at the end of the transesterification process more difficult.

Small-scale biodiesel producers may benefit from degumming crude vegetable because it will enhance the quality of the final biodiesel product. Degumming is accomplished by mixing small quantities of water (3 percent to 5 percent) with the oil. The water combines with the gums and precipitates out after allowing the mixture to settle for approximately one hour, and the water then can be drained off the bottom of the oil. Several washings may be required to remove all the gums. Initially, the wash water appears milky-colored. The degumming is complete when the water appears clear.

Gum also can be removed from oil using an acid degumming process or simply by letting the oil sit in a tank for two to three weeks and draining it off the bottom of the tank or decanting the oil off the top – leaving gum behind as a sludge-type material at the bottom.

Removing all the water from the oil before further processing is important because the presence of water will cause the fatty acids in the oil to form soaps rather than biodiesel.

Degumming oil
(Photo by John Nowatzki)



Degumming oil – clear wash-water
(Photo by John Nowatzki)

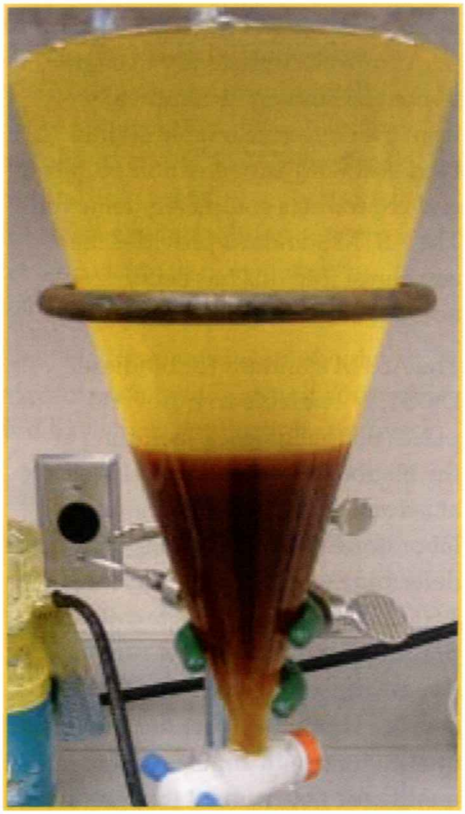
Removing the water can be accomplished by heating the oil to 120 degrees Celsius (248 degrees Fahrenheit) for approximately two hours to boil off the water. Use of a vacuum, if available, permits faster removal of water and allows for gentler heating for prolonged shelf life of the biodiesel.

Processing Crude Vegetable Oil into Biodiesel (Transesterification)

Biodiesel is the product of chemically reacting a vegetable oil or animal fat with an alcohol to produce fatty acid alkyl ester (biodiesel) and glycerol. The chemical structure of vegetable oil is a glycerin molecule with three fatty acids linked to it. The process of converting crude vegetable oil into biodiesel is called transesterification, a chemical process that removes the glycerin stem from the molecule, resulting in a much smaller molecule, called an ester, which improves its characteristics for use as an engine fuel.

In theory, the reaction requires approximately 10 parts oil to one part alcohol, which yields 10 parts biodiesel to one part glycerol, a sugar alcohol. In practice, the process requires an excess amount of alcohol (at least 20 percent of the oil by weight). The excess alcohol may be recovered at the end of the process, but alcohol recovery is not practical for small operations. Methanol commonly is used as the alcohol in the transesterification process. A catalyst is required or the conversion process would not occur. The two most common catalysts used in producing biodiesel are potassium hydroxide and sodium hydroxide.

If the preprocessed oil contains more than 5 percent free fatty acids, it will be difficult to process into biodiesel and the final product could be unsatisfactory for fuel. Free fatty acids are molecular chains that break off from the glycerol molecules prior to processing. The catalyst converts the free fatty acids to soaps, which can interfere with separation of glycerol at the end of the process. Oil samples may be titrated to determine the correct amount of catalyst for each processing batch. A sample titration process is described in the next section.



Biodiesel (top) and glycerin (bottom)
(Photo by Kristi Thostenson, NDSU)

Most biodiesel recipes recommend the amount of catalyst be 0.5 percent to 1 percent of the toal amount of oil in the batch. A common recipe for biodiesel production is to combine 100 pounds of oil with 22 pounds of methanol and 0.5 to 1 pound of sodium or potassium hydroxide. The catalyst first must be dissolved in the methanol and then the mixture is added to the oil while stirring. The mixture of catalyst and alcohol is a chemical burn hazard; operators should wear goggles and protect against splashing. The oil and methanol-catalyst mixture should be agitated continually for three hours at 40 C (102 F) in a closed container to prevent loss of methanol. Some keys to successful conversion are scrupulously dry oil and alcohol, and intensive mixing.

After the conversion is complete, the mixture should be allowed to settle for up to four hours to allow the glycerin to settle to the bottom and be drained off. The remaining liquid is biodiesel ready to be washed.

Processing Waste Cooking Oil Into Biodiesel

Waste cooking oil collected from restaurants often contains solids, water, high levels of free fatty acids and dark color. Removing the gum and water is the same process as removing them from crude vegetable oil. The solids can be removed using a screen or fabric filter.

Waste cooking oil typically contains from 2 percent to 5 percent free fatty acids. Free fatty acid levels will increase with the amount of time vegetable oil has been heated. The presence of too high a level of free fatty acids will retard or stop the transesterification reaction. To ensure a successful conversion to biodiesel, determining the exact amount of catalyst needed to neutralize the acids by performing a titration test is worthwhile. Adding too much catalyst will result in excessive amounts of soap in the final biodiesel product. If too little catalyst is added, transesterification will not occur.

Titration example for 1,000 milliliters (ml) of oil:

1. Dissolve 1 gram of sodium hydroxide in 1,000 ml of water. This is the NaOH solution.

2. Dissolve 1 ml of oil in 10 ml of isopropyl alcohol. This is the oil solution.
3. With an eyedropper, drop the diluted NaOH into the oil solution 1 milliliter at a time. Count the drops. After each ml, check the pH level of the oil solution with standard pH paper. Continue to add the NaOH solution into the oil solution a drop at a time until it reaches a pH of 8 to 9.
4. The number of drops used in step 3 plus 3.5 equals the number of grams of NaOH required for the processing 1,000 ml.

Biodiesel washing

The biodiesel needs to be washed after the transesterification process to remove remaining catalyst, methanol, glycerol, soap and gums. Water should be sprinkled gently on top of the water; the water droplets will collect at the bottom of the tank for removal. If the unwashed biodiesel is agitated during this step, removal of the wash water may be difficult. Separation of wash water from biodiesel may be helped by adding sufficient acid to neutralize the catalyst. Suitable acids include vinegar and hydrochloric acid. The washing needs to be repeated until the wash water is clear. After washing, the biodiesel is heated to 120 C (248 F) for approximately one hour to evaporate any remaining water and methanol.

Biodiesel Quality Factors

Biodiesel is an excellent diesel engine fuel if it meets American Society for Testing and Materials (ASTM) standards for biodiesel. The ASTM standard for biodiesel, D6751, specifies the parameters for 18 factors that affect biodiesel purity, storage, cold-weather properties and use in engines. The ASTM D6751 standard is for B100, which is 100 percent biodiesel before it is blended with petroleum diesel. For biodiesel to perform well consistently in engines, it must be converted completely from the source vegetable oil into biodiesel with any remaining catalyst and coproducts completely removed. The ASTM standard provides the assurance that this has been accomplished.

The ASTM standard for biodiesel, D6751, is available from several places on the Internet, including at the National Biodiesel Board Web site at *www.biodiesel.org*. Commercial laboratories provide testing services to determine whether biodiesel meets the ASTM D6751 standards. Small-scale producers need to test the fuel they make to ensure it meets the D6751 standard both to ensure the fuel quality for use in engines and to qualify for government tax incentives available to biodiesel producers.

Having all of testing done to meet ASTM D6751 standards may be prohibitively expensive for small producers; however, the most important standards for biodiesel quality are the total glycerin and the free glycerin content. Glycerin is the major coproduct in biodiesel production and is higher in density than the fatty acid alkyl ester (biodiesel). Excessive total glycerin in biodiesel indicates the reaction did not proceed to completion.

Presence of free glycerin in biodiesel indicates incomplete washing after the conversion process. The free glycerin may separate out in storage and cause problems when used in engines. The total acid number is also an important test for biodiesel. Total acid is an indicator of the level of free fatty acids present in biodiesel, as well as the presence of process acids. High acid values indicate poorly refined biodiesel, which may indicate methanol carryover in the final product, and can have negative effects on rubber seals and hoses in the engines.

Economics of Small-scale Biodiesel Production

A small-scale biodiesel producer will not use some of the equipment and steps involved in large, commercial biodiesel production because of costs and scale of operation.

Producing biodiesel from an oilseed, such as canola, first involves extracting the vegetable oil from the canola seed.

A mechanical cold press can be used to extract the oil. The presses are produced by several manufacturers worldwide and are available with different capacities and cost. In this example, a small oilseed screw press manufactured in Europe with a cost of $7,500 is used. It has an hourly throughput of about 62 pounds of seed and can be run automatically for long periods of time. Other equipment associated with oil extraction, such as oil tanks and containers for meal, is about $1,500.

After oil extraction, typically one of two processes is conducted to remove gums from the vegetable oil. The amount of gums can be reduced naturally by allowing the oil to settle for one or three weeks or the vegetable oil can be "washed" one or more times, as needed, and then "dried." In either case, the oil can be filtered to further remove impurities.

The next step is transesterification. Several turnkey small-scale systems are available to purchase. In this example, a system to make 50 gallons per batch is used at a cost of $4,000.

This analysis assumes that the on-farm small-scale biodiesel producer already has storage and moving equipment for oilseed and a building to house the oilseed press and biodiesel processing equipment. No fixed cost for these items is calculated. Also, no cost or benefit from the unrefined glycerol byproduct is assumed.

Table 2 indicates that the cost of making biodiesel is $1.37 more per gallon than the price of No. 2 petroleum diesel if canola seed is valued at 14 cents/pound and diesel at $2.40/gallon (excluding excise taxes).

Tax credits of $1 per gallon for the production of biodiesel and an additional 10 cents per gallon for biodiesel production from a qualifying small-scale plant are available. To qualify for the tax credits, the biodiesel must meet ASTM standards. Unfortunately, the cost of tests to substantiate that the quality meets ASTM standards may be cost-prohibitive for a small biodiesel producer. Information on tax incentives is available on the Web at *www.biodiesel.org*.

First, biodiesel producers should register with the IRS, using Form 637, and have their application approved. Then Form 8864 is used to apply for biodiesel income tax credits. The biodiesel definition on the first page of Form 8864 states: "Biodiesel means the monoalkyl esters of long chain fatty acids derived from plant or animal matter which meet the registration requirements for fuels and fuel additives established by the Environmental Protection Agency (EPA) under section 211 of the Clean Air Act, and the requirements of the American Society of Testing and Materials (ASTM) D6751."

Table 2. Example budget for small-scale biodiesel production, 50 gallon per batch.

Direct Cost	Amount	Unit	$/Unit	$/Batch	$/Gallon
Oil Extraction					
Canola seed[1]	1,105	Lbs	0.14	154.70	3.09
Electricity				3.50	0.07
Maintenance and supplies				2.50	0.05
Labor	1	Hr	12.00	12.00	0.24
Listed direct costs				172.70	3.45
Fixed costs of oil extraction equip[2]				13.84	0.28
Total listed costs				186.54	3.73
Credit for meal (13% oil)	725	Lbs	0.07	-50.75	-1.01
Cost of oil				135.79	2.72
Processing Oil to Biodiesel[3]					
Canola oil (from above)	50	Gal	2.72	135.79	2.72
Methanol	10	Gal	2.60	26.00	0.52
Sodium hydroxide[4]	3	Lbs	1.20	3.60	0.07
Electricity				2.50	0.05
Maintenance and supplies				2.50	0.05
Labor	1	Hr	12.00	12.00	0.24
Listed direct costs				182.39	3.65
Fixed costs of processing equip[2]				6.15	0.12
Total listed costs of biodiesel production[5]				188.54	3.77
Price of No. 2 diesel w/o excise taxes					2.40
Gain or loss relative to No. 2 diesel					-1.37

[1] Seed required for 50 gallons of oil, assuming 43 percent oil content, 80 percent oil extraction efficiency and 7.6 pounds of canola oil per gallon.

[2] Investment in oil extraction equipment is $9,000 and for biodiesel processing equipment it's $4,000. Assumes 10-year life, 10 percent salvage value, straight-line depreciation, 6 percent opportunity charge on average annual investment and annual production of 80 batches (4,000 gallons).

[3] Process uses five parts canola oil to one part methanol. Output is approximately five parts biodiesel and one part unrefined glycerol of no value.

[4] Can vary by titration test

[5] Biodiesel has about 8 percent less energy than No. 2 diesel, but has better lubricant qualities. Divide by .92 to adjust to No. 2 diesel energy equivalent.

The main variables in the economics of biodiesel production are the cost of oilseed and the price of petroleum diesel. Biodiesel production would become profitable at certain levels of oilseed and diesel prices. For example, using Table 3, biodiesel production would break even at a canola price of $.105 per pound if the price of diesel (excluding excise taxes) was $3 per gallon.

Table 4 shows the cost of biodiesel production when only direct costs are considered. After the machinery and equipment necessary for biodiesel production have been purchased, ownership costs will be incurred whether or not production occurs. In theory, until biodiesel producers divest themselves of the biodiesel equipment, they are better off continuing to produce biodiesel if all direct costs and any portion of fixed costs are covered.

Table 4 also shows the cost of biodiesel production when a charge for operator labor is not considered. Some producers of biodiesel may be motivated by more than business purposes. They may feel satisfaction in producing their own fuel and reducing the reliance on imported oil. Biodiesel could be considered a worthwhile hobby that doesn't need to show a return to labor.

Table 3. Gain (loss per gallon) from small-scale biodiesel production, excluding tax credits, per gallon, at different canola and No. 2 diesel prices.

	Canola ($/lb)						
Diesel $/Gal	0.09	0.10	0.11	0.12	0.13	0.14	0.15
(no tax)							
1.00	(1.67)	(1.89)	(2.11)	(2.33)	(2.55)	(2.77)	(2.99)
1.50	(1.17)	(1.39)	(1.61)	(1.83)	(2.05)	(2.27)	(2.49)
2.00	(0.67)	(0.89)	(1.11)	(1.33)	(1.55)	(1.77)	(1.99)
2.50	(0.17)	(0.39)	(0.61)	(0.83)	(1.05)	(1.27)	(1.49)
3.00	0.33	0.11	(0.11)	(0.33)	(0.55)	(0.77)	(0.99)
3.50	0.83	0.61	0.39	0.17	(0.05)	(0.27)	(0.49)

Table 4. Cost per gallon of biodiesel, excluding labor and fixed costs[1].

Cost excluding fixed costs	3.37
Cost excluding labor costs	3.29
Cost excluding fixed and labor costs	2.89

[1] Assumes total cost of $3.77 per gallon, 40 cents per gallon fixed costs and 48 cents per gallon labor cost.

Table 4 is based on the budget example shown in Table 2. It indicates that the direct cost, excluding labor, of producing biodiesel is $2.89. This is greater than the current price at which No. 2 diesel could be purchased. Therefore, the production of biodiesel would reduce both net income and cash flow of the farm operation.

Biodiesel Use in Engines

Biodiesel has less energy than diesel fuel. Summer petroleum diesel fuel typically contains about 140,000 British thermal units (Btu) per gallon, while biodiesel contains about 130,000 Btu per gallon. Fuels with a higher heat of combustion (Btu content) usually will produce more power per unit of fuel than lower-energy fuels. An engine using a lower-energy fuel will require more fuel to produce the same amount of power. Since biodiesel has less energy, it will require about 1.1 gallons of fuel to do the same work as 1 gallon of diesel fuel. This is about an 8 percent power reduction for B100 but proportionately less for blended fuels.

Several factors influence how well biodiesel works in diesel engines. The cetane number is a method for determining the ignition quality of a fuel. Most farm tractor engine manufacturers recommend a minimum cetane rating of 40. However, most fuel suppliers provide diesel fuel with a cetane rating of 45 to 50. A typical biodiesel cetane rating is 55. In general, high-cetane fuels permit an engine to be started more easily and provide for a faster engine warmup without producing white smoke or misfiring. A high-cetane fuel also helps reduce the rate of varnish formation and carbon deposits in engines and reduces combustion roughness or engine knock.

Viscosity has an influence on the atomization of biodiesel fuel when it is injected into the engine combustion chamber. The viscosity of summer blend petroleum diesel is generally about 3 centipoise (CP), biodiesel about 5.7 CP and vegetable oil about 40 to 50 CP. The high viscosity of raw or partially refined vegetable oil may result in excessively high pressure in the injection system and cause poor atomization of the fuel in the combustion chamber, which can cause deposits around the piston rings, valves and injectors.

Biodiesel is an excellent solvent and enhances removal of deposits in fuel systems, which in turn can plug fuel filters or cause deposits to accumulate in fuel tanks. Filters generally do not continue to plug after the initial use of biodiesel. Biodiesel may cause fuel lines, gaskets and fuel pump seals on older engines to deteriorate. Seals made from materials more biodiesel-tolerant are readily available.

Biodiesel (B100) provides excellent lubricity in diesel engine fuel systems. Since October 2006, most diesel fuel sold at retail locations in the U.S. is ultralow sulfur diesel fuel that has different lubricating qualities than diesel previously available. The processing required to reduce sulfur also removes naturally occurring lubricating agents in diesel fuel, resulting in increased wear on the various parts of the engine's fuel injection system.

The ASTM D975 standard for diesel fuel lubrication sets the maximum amount of wear on materials when tested with specific fuels or blends of fuels. The test apparatus is called a High Frequency Reciprocating Test Rig (HFRR). Both No. 1 (winter blend) and No. 2 (summer blend) diesel test results cannot exceed 460 microns of wear when tested in an HFRR. A lower wear score indicates better lubrication. Biodiesel has been tested at varying concentrations with both ultralow sulfur No. 1 and No. 2 diesel fuels. The results indicate that a 1 percent blend of biodiesel with No. 2 diesel is sufficient to reduce the HFRR micron score below the required 460 micron standard. However, a 2 percent biodiesel blend is required in No. 1 diesel to get the HFRR micron score down to 460 microns.

B20 with #2 Diesel; B20 with #1 Diesel; B100, all stored at -20 F
(Photo by Gary Willoughby, NDSU)

Cold weather issues

Two characteristics, the cloud point and the cold filter plugging point (CFPP), commonly characterize the low-temperature operability of diesel fuel and are similarly important with biodiesel. The cloud point is the temperature of the fuel at which small, solid crystals can be observed as the fuel cools. CFPP is the temperature at which a fuel filter plugs due to fuel components that have crystallized or gelled.

The cloud point of soybean biodiesel is about 30 F and the cloud point for No. 1 diesel is about 35 F. Usually, when the fuel nears the cloud point temperature, changes must be made to the fuel, such as the addition of anti-gel additives or No. 1 diesel fuel, to prevent filters from clogging. B20 that is not treated with anti-gelling additives freezes about 3 to 5 degrees Fahrenheit higher than No. 2 petroleum diesel. Studies funded by the National Biodiesel Board indicate that blends of B2 or B5 have minimal or no effect on cold-flow properties of diesel blends. Biodiesel made from various crop oils have unique cold-weather characteristics that can vary up or down by as much as 5 degrees.

Several procedures can be used to enhance biodiesel performance in cold weather, including the addition of fuel-line heaters or in-tank fuel heaters, using anti-gel additives, insulating fuel filters and fuel lines, and storing the diesel-powered equipment in heated buildings.

Engine warranties

Most agricultural equipment manufacturers do not warranty their engines operated on B100, but they do allow blends of up to 5 percent with petroleum diesel. All engine warranties from the major tractor manufacturers also require both the petroleum diesel and the blended biodiesel to meet the ASTM specifications for diesel and biodiesel fuels. Some manufacturers' warranties of farm tractors and equipment do allow higher blends, some even up to B100, so checking with the equipment dealer or manufacturer for each engine model is important.

Biodiesel "batch" producers need to be particularly concerned about the possibility of voiding engine warranties because of the difficulties of consistently producing high-quality biodiesel. This underscores the need for small-scale producers to have fuel regularly analyzed to make sure it meets ASTM D6751 standards. If the cost to have all biodiesel samples tested is prohibitive, the biodiesel could be used only in nonwarranty engines.

Engine emissions

Generally engines operated on biodiesel produce fewer harmful emissions than engines operated on petroleum diesel. The U.S. Environmental Protection Agency (EPA) conducted a comprehensive analysis of biodiesel impacts on exhaust emissions in 2002. These analyses found tailpipe emissions from engines using biodiesel are significantly lower than emissions from similar engines operated on petroleum diesel. Hydrocarbon emissions from engines operated on B100 were about 67 percent less than petroleum diesel fuel emissions. Hydrocarbon emissions from engines contribute to ozone formation and are a key component of smog.

Particulate matter and carbon monoxide emissions from engines using biodiesel were 48 percent less than petroleum diesel. Particulate matter is very fine particles that can remain suspended in the atmosphere and contribute to smog. Carbon monoxide is a poisonous gas that is most dangerous in confined areas.

Nitrogen oxide emissions are about 10 percent higher using biodiesel. Reducing nitrogen oxide emissions is a crucial component of the EPA's strategy for cleaner air and reducing acid rain. Efforts are under way to modify diesel engine combustion and exhaust systems to reduce nitrogen oxide emissions.

Emissions of carbon dioxide (CO2), a gas that is increasing in the atmosphere, are similar from engines operated on biodiesel or petroleum diesel. However, the carbon dioxide produced from burning petroleum diesel and emitted to the atmosphere comes from sources long sequestered in the earth. Oilseed crops actually take carbon from the atmosphere during their growth cycles and store that carbon in the ground, although the energy used to make biodiesel normally releases carbon into the atmosphere. When comparing the total life cycle of carbon emissions from the two fuels, petroleum diesel has a more negative effect on the environment.

A study conducted by the U.S. Department of Agriculture and Department of Energy of the biodiesel and petroleum diesel life cycles jointly found that because biodiesel production requires such small amounts of fossil fuel, its CO2 life cycle emissions are much lower than those of petroleum diesel. Biodiesel reduces net CO2 emissions by more than 78 percent, compared with petroleum diesel.

Biodiesel produces no sulfates when burned in diesel engines. Reducing sulfates is another part of the EPA's strategy for cleaner air. Since biodiesel has zero sulfates, its use in diesel engines offers an excellent alternative to even the ultralow sulfur diesel fuels mandated for use in over-the-road diesel-powered vehicles.

Storing Biodiesel

Biodiesel will have a storage life similar to diesel fuel, which usually is six months to one year. A two-year study completed at the University of Idaho found that biodiesel had slight deterioration and will store similarly to No.2 diesel fuel. Biodiesel mixtures of any blend should store during warm and cold months with little problem of separation of the biodiesel from the petroleum diesel.

Most biodiesel will begin to solidify if stored in cold conditions lower than 32 F. Since biodiesel is an excellent solvent, it may loosen tank deposits. Biodiesel should be stored in dark conditions that do not have any danger of water contamination. Biodiesel stored longer than six months should be analyzed to assure that it still meets ASTM D6751 standards.

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