



ALTERNATE FUEL TECHNOLOGY

Biodiesel: What's the Story?



Editor's note: In this article author Bob Rodriguez explains the basics of biodiesel, along with the how and why it's becoming a valuable alternative to petroleum. Read earlier TechNews article about Clean Alternative Fuels (Spring 2003) at www.ASE.com under "Service Professionals / Clean Fuels/Clean Vehicle Technology."

We've been hearing a lot about "biofuels" as a replacement for petroleum. Research and development continues around the world to find alternatives, and one is biodiesel. Domestic use of biofuels can help reduce petroleum imports, support our domestic farm economy, help clean the air, reduce global warming, and more. With low-sulfur diesel fuel now mandated, we can expect a surge of clean diesel vehicles to enter the U.S. market, and some of these vehicles are even delivered with a blend of biodiesel in the tank.

We can expect vehicle owners to begin asking questions: What is **biodiesel**? What's it made of? Is it safe? Does it affect a vehicle's warranty? What's the advantage? Is it more expensive? Where can I buy it?

What's the Difference between Petrodiesel and Biodiesel?

Back in 1900 Rudolf Diesel demonstrated his compression ignition engine with biodiesel (peanut oil). Fast-forward 100 years, and we're again using biodiesel. According to online sources, "The term [petrodiesel] typically refers to fuel that has been processed from petroleum, but increasingly, alternatives such as **biodiesel** or **biomass to liquid (BTL)** or **gas to**

liquid (GTL) diesel that are not derived from petroleum are being developed and adopted."¹

Most biodiesel in the U.S. comes from soybeans. But other "energy crops" include corn, cottonseed, canola (rapeseed), flax, and sunflower. Fir tree bark, sawdust and shavings can be used, as can animal tallow, white grease (lard), poultry fat and yellow grease; in short, most any source of triglyceride. (Caution: biodiesel is not the same thing as raw vegetable oil. Untreated vegetable oils can ruin an engine; see below). Other countries grow energy crops suited to their region and economy.

Why Use Biofuels and Biodiesel?

The National Biodiesel Board sees a number of benefits to using biofuels. They guarantee the longevity of the supply system; biofuels are produced domestically, and the feedstocks for them are grown domestically, which helps reduce our country's trade deficit and creates jobs. The agricultural sector benefits, since biofuels are made from crops and agricultural residues providing options and new valuable uses. Using biofuels helps clean the environment and reduce carbon emissions since biofuels are "renewable," meaning they can be replaced by growing more. The National Renewable Energy Lab (NREL) observes, "[T]here is enough feedstock to supply 1.9 billion gallons of biodiesel (under policies designed to encourage biodiesel use). This represents roughly five percent of on-road diesel used in the United States."²

With little or no modification (depending on the age of the engine's fuel system), biodiesel can be blended in any concentration with petroleum diesel fuel (petrodiesel) from one, two or five to 20 percent (20 percent biodiesel mixed with 80 percent petrodiesel)

to maximize the cost/benefit. Some operators use 100 percent biodiesel.

How is Biodiesel Made?

Biodiesel is produced by pre-processing oils and fats (feedstock) to remove water and contaminants. A "trans-esterification" process then reacts it with alcohol (typically methanol). "The process leaves behind two products—methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products)."³

Some people "home-brew" biodiesel and swear by it. Kits are sold for on-board heating and use of "raw" vegetable oil. But be aware that the glycerin in "unrefined" vegetable oil, greases, oils and fats and can prove harmful to fuel systems and engines even if used at levels as low as 10 to 20 percent. Long-term engine deposits, ring sticking, lube oil gelling, other maintenance problems and reduced engine life may result.⁴

Fuel-grade biodiesel must be produced to strict industry specifications (ASTM D6751) in order to ensure proper performance; raw vegetable oil cannot meet these biodiesel fuel specifications. Furthermore, home brewed diesel fuel is not registered with the EPA and is not a legal motor fuel.

Biodiesel Properties and Precautions

Biodiesel has a high BTU heat value, somewhere between No. 1 and No. 2 petrodiesel and has similar physical properties. Biodiesel is sulfur-free and offers excellent lubricating qualities. Lubricity is what keeps extremely fine-tolerance fuel injection components moving (unlike today's Ultra Low Sulfur Diesel, or ULSD; see below). Reportedly, a one percent blend of biodiesel increases the lubricity of petrodiesel by 60 percent.

Depending upon the blend, at colder temperatures biodiesel is slightly more viscous (thicker) than diesel No.2, which may cause problems. Also, as temperatures drop, clouding (solidifying) may occur (depending on the blend) to clog fuel filters.

Further, biodiesel acts like a detergent to loosen and dissolve fuel tank sediment, which can clog fuel filters—as operators of diesel powered vehicles and boats have discovered the hard way! And higher concentrations (above B20) of biodiesel can act like a solvent to cause swelling and leaking on older fuel systems which use rubber seals, hoses, etc.

The bottom line: always check with the engine manufacturer to determine what blend is safe to use.

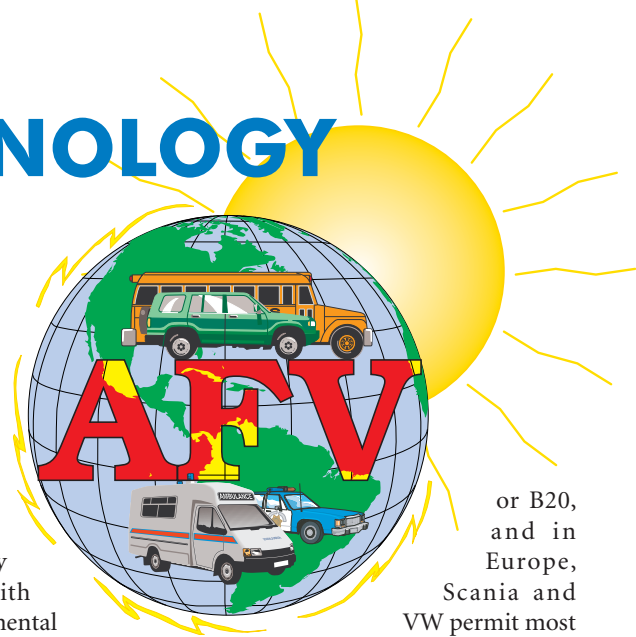
Is Biodiesel Safe?

According to the National Biodiesel Board (NBB), "Biodiesel is the only alternative fuel to have fully completed the health effects testing requirements of the 1990

Clean Air Act Amendments. Biodiesel that meets ASTM D6751 and is legally registered with the Environmental Protection Agency is a legal motor fuel for sale and distribution." Biodiesel is biodegradable (in case of spill) and non-toxic if ingested, so there's no threat to human health.

What about Engine Warranties?

According to the NBB, "Most engine companies have adopted D6751 to define biodiesel and provide information to customers regarding biodiesel. Other 'bio-derived' materials that do not meet D 6751 may cause engine and fuel system problems and void engine warranties." VW's TDI equipped vehicles, DaimlerChrysler's Jeep Liberty, and others come with B5 from the factory. Most engine manufacturers approve use of B5. Some OEMs permit use of higher concentrations such as B10



or B20, and in Europe, Scania and VW permit most of their diesel engines to operate on 100 percent bio (so-called "neat" biodiesel).

Does It Cost More?

The cost of biodiesel has tended to be a few cents per gallon higher than petrodiesel. The price difference depends upon crude oil prices; biodiesel feedstock market supply and demand; federal, state and local incentives for using alternate fuels, etc.

Compared to costs associated with other alternative fuels and systems, fleet managers have found biodiesel to be a low-cost means of complying with state and federal EPA regulations. Use of biodiesel does not require major engine modifications, so operators can keep using existing diesel vehicles and parts. Also, (continued on next page)

Biodiesel Fuel Talking Points

Biodiesel Advantages

- Can be used with the current fueling infrastructure
- Adds lubricity (helpful when using ULSD); a 1% blend increases lubricity by 60%
- Reliable engine performance—high cetane number and flash point
- Reduced engine combustion "rattle" when cold and at idle.
- Safe to handle—is less toxic than table salt and it biodegrades faster than sugar
- Less offensive exhaust smell (reportedly like french fries or popcorn)
- Offers emissions benefits—lower greenhouse gas emissions than petroleum-diesel fuel: no sulfur oxides or sulfates
- Is registered as a fuel/fuel additive with the EPA; meets CARB clean diesel standards
- Recognized by the US-DOE and DOT as an alternate fuel
- EPA / EPA credits available to suppliers and users
- Domestic renewable / sustainable fuel supply
- Reduces foreign energy dependence and contributes to the domestic economy

Possible Drawbacks to Biodiesel

- Fuel economy may be lower with higher blends (B20 or more)
- On older diesels, biodiesel can chemically affect rubber seals, hoses and O-rings to cause leaks
- Acts as a solvent to possibly cause filters to clog with (petrodiesel) residue from tanks and fuel lines
- Colder temperatures raise biodiesel viscosity compared to petrodiesel; flow properties increase by about 5 degrees for B20; could possibly clog nozzles / injectors (causing poor atomization)
- Cloud point tends to be higher with biodiesel. Use of anti-gelling additives and/or engine block heater may be advised.

Biodiesel's Physical Characteristics

Specific gravity	0.87 to 0.89
Kinematic viscosity @ 40°C	3.7 to 5.8
Cetane number	46 to 70
Higher heating value (btu/lb)	16,928 to 17,996
Sulfur, wt%	0.0 to 0.0024
Cloud point °C	-11 to 16
Pour point °C	-15 to 13
Iodine number	60 to 135
Lower heating value (btu/lb)	15,700 to 16,735

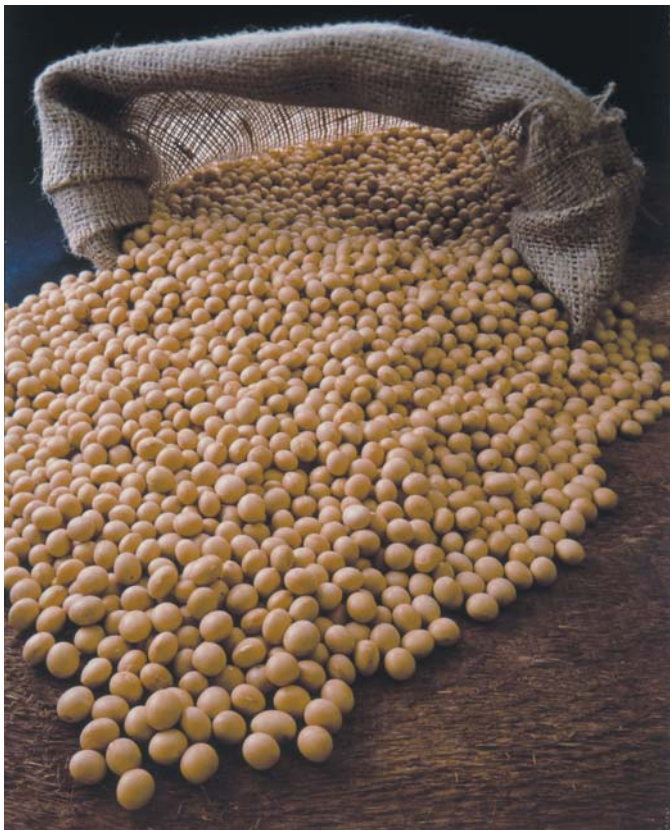


Photo: Courtesy NAFTC

Most biodiesel in the U.S. comes from soybeans.

Part of a continuing series on alternate fuel vehicles and advanced vehicle technology; all past articles in this series are available at www.ase.com. If you have comments or questions, contact ASE's Bob Rodriguez at 703-669-6634 or brodriguez@ase.com.

Biodiesel: What's the Story? (continued)

refueling stations remain the same, but their tanks will need cleaning. Using biodiesel requires no special training.

Where Can I Buy Biodiesel?

From a marketing perspective, it makes sense to promote domestically produced fuels, and companies are aggressively bringing biodiesel to market. The U.S. Navy and Marines are big users of biodiesel. Archer Daniels Midland and others have invested heavily in soybean growth and production facilities.

Fleet owners can purchase biodiesel in bulk from suppliers, and motorists can buy it at filling stations; albeit mostly in Southern and Midwest grain-belt states. Yet according to the National Biodiesel Board (NBB), biodiesel can be made available anywhere in the U.S. The NBB (www.nbb.org) maintains a list of registered fuel marketers.⁵

Emissions and Global Warming

Most agree that biofuels contribute fewer harmful emissions to the atmosphere during production and use than petroleum, in part thanks to their completing the “closed carbon cycle.”⁶ A 1998 biodiesel lifecycle study, jointly sponsored by the U.S. Department of Energy and the U.S. Dept. of Agriculture, concluded [that] 100 percent biodiesel reduces net CO₂ emissions by 78 percent [as] compared to petroleum diesel.

Additionally, biodiesel offers 95 percent lower HC; 50 percent lower CO; 30 percent lower particulate/min-



Waste vegetable oils, fats, and greases are all suitable for making biodiesel.

imized soot/black smoke; and no sulfur oxides or sulfates (which form acid rain).⁷ According to the Alternative Fuels Data Center (AFDC), “Emissions of nitrogen oxides [NO_x] increase with the concentration of biodiesel in the fuel...roughly two percent for B20. Some biodiesel produces more nitrogen oxides than other, and some additives have shown promise in reducing the increases. Additional research and development is needed to resolve this issue.”⁸

Biodiesel is registered with the EPA as a fuel and as a fuel additive. It meets CARB clean diesel standards. The U.S. Dept. of Energy recognizes 100 percent (“neat”) biodiesel as an alternative fuel for EPA credit purposes. Some states require a minimal blend of (B2) biodiesel in petrodiesel sold at the pump.

Further Thoughts

Starting late in 2006, Ultra Low Sulfur Diesel fuel (ULSD) became mandatory for on-road diesel vehicles. With sulfur content reduced from 500 to 15 ppm, ULSD has enabled diesel engine manufacturers to install NO_x and particulate filters to meet tightened EPA emissions standards. But when the sulfur is steam-processed out of petrodiesel, lubricity is lost. To remedy this, vehicle owners and operators can add as little as one percent biodiesel to restore lubricity, or use fuel additives to protect their equipment.⁹

Along with on-road diesel vehicles, biodiesel holds clean air promises for non-road applications like construction and ag equipment; for ships and railroad applications, for use in underground mining equipment, and more. Oil heat fuel suppliers, in an attempt to “clean up” their product (and image), have reduced the sulfur content of No. 2 heating oil from 2000 to 500 ppm. Soy-based “bioheat” fuel oil can be blended 5 percent with low-sulfur petroleum heating oil to burn clean with less soot and residue—a real plus to homeowners.

All told, using biodiesel in efficient clean diesel vehicles appears to be a win-win for our economy, our environment, and our security.

Footnotes

- ¹ Wikipedia: go to <http://en.wikipedia.org/wiki/Biodiesel>
- ² NREL: go to www.eere.energy.gov/afdc/altfuel/bio_made.html
- ³ NBB: go to www.biodiesel.org/resources/faqs/default.shtm and www.biodiesel.org/pdf_files/fuelsheets/Production.PDF and www.bq-9000.org
- ⁴ U of M: go to <http://muextension.missouri.edu/explore/ag-guides/agengin/g01991.htm>
- ⁵ Visit the NBB website at www.biodiesel.org/resources/faqs/default.shtm or call the NBB at (800) 841-5849
- ⁶ CO₂ is taken out of the atmosphere as plants grow. The crops are then processed for fuel, and CO₂ is released back to the atmosphere when the fuel is burned. For more info go to www.biodiesel.org/resources/faqs/default.shtm
- ⁷ For detailed emissions data, go to www.biodiesel.org/pdf_files/fuelsheets/emissions.pdf
- ⁸ EERE: go to www.eere.energy.gov/afdc/altfuel/whatis_biodiesel.html For more biodiesel basics info go to <http://www.earthbiofuels.com/faq.php>
- ⁹ Stanadyne and other companies offer quality diesel fuel additives, including lubricity enhancers. Visit www.stanadyne.com/new/ppt/ppt_dfa.asp