



Do You Want Biodiesel With That?



RICK STROMBOSKI

Maybe you've heard the story—using oil from a fast food restaurant or local greasy spoon to run your car (and the French fry smell of the exhaust makes you hungry!) Is this for real or something cooked up by the tabloids to get your attention? How can cooking oil get you to the mall for some serious shopping on a Saturday night?

Used cooking oil by itself is not a great fuel, especially not straight out of the deep fryer—but converting cooking oil to biodiesel provides an alternative to gasoline. Biodiesel is the general name given to a variety of cleaner-burning fuels made from different animal and vegetable oils, such as soybean and sunflower oils. Because most of these oils come from plants, biodiesel can be made from renewable resources. Biodiesel offers several advantages over diesel: it burns cleaner, is biodegradable, and is nontoxic.

The diesel engine (invented by Dr. Rudolph Diesel over 100 years ago) is used in buses, trucks, farm equipment, and some cars. You may have noticed a separate pump for diesel the last time you were at the gas station. Both gasoline and diesel are made from crude oil—so what's the difference between them? The hydrocarbon chains in diesel fuel (10–20 carbons) are longer than those in gasoline (5–10 carbons). Dr. Diesel used a variety of fuels to run his engine—in fact, when he unveiled his

By Mary Kirchhoff

invention at the World Exhibition in 1900, it ran on peanut oil! Existing diesel engines do not need to be modified in switching from diesel to biodiesel as the fuel. You just pump and go!

Why do some cars use gasoline while others run on diesel? The answer lies in the different types of engines used in these vehicles. Diesel engines are compression ignition engines. When air is quickly and dramatically compressed, its temperature rises. In a diesel engine the air in the combustion chamber is compressed to such an extent that it becomes quite hot—hot enough to ignite the fuel that is then injected into the chamber. No external spark is required. In contrast, a spark ignites the fuel/air mixture in a gasoline, or spark ignition, engine. Because of the difference in how the engines work, diesel engines can use thicker fuels than gasoline engines.

Soybean oil and used cooking grease are the primary sources of biodiesel in the United States. Soybeans are about 20% oil by weight, and approximately 7.3 pounds of soybean oil are needed to produce one gallon of biodiesel. This means that 36.5 pounds of soybeans are required to make one gallon of biodiesel. On the plus side, you can grow a new crop of soybeans each year (try doing that with crude oil!) Currently, biodiesel is available in about half the country.

Transesterification—the biodiesel reaction

Biodiesel is made simply by heating vegetable oil with an alcohol, usually methanol (CH_3OH) or ethanol ($\text{CH}_3\text{CH}_2\text{OH}$), in the presence of a catalyst, such as sodium or potassium hydroxide. Vegetable oil is a triglyceride that undergoes a transesterification (converting one ester into another) reaction in forming biodiesel. The byproduct of this reaction, glycerol, is an ingredient in numerous consumer products, including pharmaceuticals and makeup.

What are the environmental benefits of biodiesel? Burning biodiesel does not result in a net increase in carbon dioxide (CO_2) in the atmosphere. You're familiar with carbon dioxide—it's the gas you exhale during respiration and the gas that puts the fizz in soda pop. Carbon dioxide is also a gas that is linked to global warming, the gradual heating of the Earth, due in large part to the combustion of fossil fuels. Energy sources that do not add more CO_2 to the atmosphere are better for the environment.

The use of biodiesel can dramatically reduce the amount of carbon dioxide released into the atmosphere. This is environmentally beneficial. Although biodiesel releases CO_2 into the atmosphere when burned, CO_2 was absorbed from the atmosphere to grow the plants used to make the biodiesel. These two effects basically cancel each other, and although biodiesel fuel is often blended with regular diesel fuel, there still remains a significant reduction in the net release of CO_2 .

Biodiesel offers several safety advantages. First, it has a higher flash point than regular diesel, meaning it won't ignite as easily. The flash point for biodiesel is 300 °F, compared with 125 °F for petroleum diesel. Second, it's as biodegradable and nontoxic as vegetable oil; in case of an accidental spill, biodiesel will not persist in the environment.

Biodiesel is one of the alternative fuels identified in the Energy Policy Act (EPAct), passed in 1993 and amended in 1998 to include biodiesel. EPAct addresses the need to improve both our energy security and environmental quality. It encourages the use of alternative fuels, including ethanol, natural gas, hydrogen, and propane. Under EPAct, federal and state governments are required to include alternative fuel vehicles in their fleets of light-duty vehicles.



Biodiesel can be made from waste vegetable oil.

Who uses biodiesel?

In the United States, the military is the largest consumer of biodiesel. The Defense Energy Support Center coordinates the federal government's fuel purchases and has been using B20 to fuel vehicles on a number of bases for the past three years. B20 is a blend of 20% biodiesel with 80% petroleum diesel. School buses in Las Vegas, NV, also use B20. Casinos in Las Vegas contribute their waste grease (about 6 gallons per resident per year) to make biodiesel, which fuels over 1,200 of the district's school buses.

Yellowstone National Park has adopted a "Greening the Environment" program that includes the use of biodiesel in its diesel trucks. An issue unique to Yellowstone was bears—would the French fry odor of the fuel attract bears? The "bear attraction test" demonstrated that this was not the case; trucks using biodiesel will not be attacked by bears craving French fries!

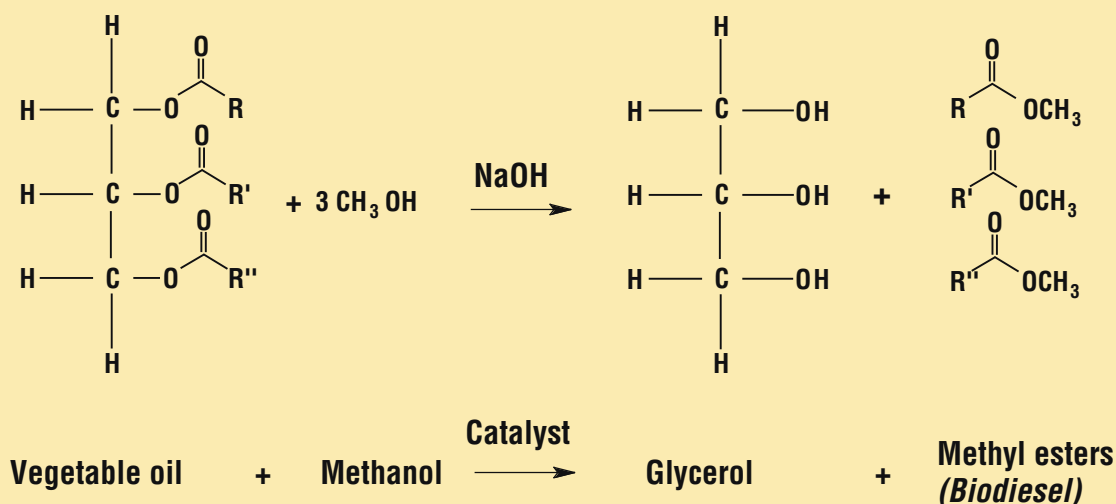
Many other countries are taking advantage of biodiesel. Rapeseed oil is the source of most of the biodiesel produced in Europe, which has been using biodiesel for more than 20 years. Germany is the largest biodiesel market

in the world, consuming more than 1 million metric tonnes (1000 kg) in 2004. Members of the European Union are planning to use biodiesel to meet 2% of their fuel needs in 2005, with a target of 5.75% in 2010.



Biodiesel filling stations are cropping up all over the place. If your car runs on diesel, you can use biodiesel too!

Transesterification—the biodiesel reaction



Not just vegetable oil

Vegetable oil is not the only source of biodiesel, however. A project in Alaska uses fish oil to make biodiesel blends for use in generator engines, a power source for many rural areas in Alaska. The Unalaska/Dutch Harbor community in the Aleutian Islands produces 3.5 million gallons of fish oil each year. Pure fish oil and 50:50 blends of fish oil and diesel fuel have been tested, with the blends delivering comparable performance to straight diesel fuel. Fish oil blends make economic sense, too, for local residents in Alaska—fish oil sells for 25¢ per gallon, while diesel has been retailing at more than \$2 per gallon.

If biodiesel is better for the environment, why aren't we filling up our cars and trucks with it? Cost is one factor—even at \$2 per gallon, gasoline and conventional diesel are still cheaper than commercially made biodiesel.

Another difficulty in using biodiesel is that it is more viscous (thicker) than gasoline. This can be a problem in cold climates, where your fuel can turn into a gel in the winter. Biodiesel also has about a 10% lower energy content than petroleum diesel. And while carbon dioxide emissions decline, emissions of nitrous oxides (NO_x), which contribute to air pollution, may increase.

The benefits of biodiesel have prompted increased investment in this alternative fuel. The potential market for biodiesel led to the recent announcement by Blue Sun Biodiesel that it will



Biodiesel is often mixed with petroleum diesel to make its price closer to conventional diesel. At the pump B100 is pure biodiesel. B20 is 20% biodiesel.

construct the first high-volume blending terminal and processing plant in the United States. With support from the U.S. Department of Agriculture, this plant will be built in Alamosa, CO, near the San Luis Valley. This agricultural region will supply the canola oil needed to make biodiesel blend B20. The plant should be completed in May 2005.

Green chemistry

Using biodiesel to run a car or power a generator illustrates one of the basic principles of green chemistry, the use of renewable starting materials. Green chemistry focuses on designing chemical products and processes that are more environmentally friendly. We know that petroleum is a nonrenewable resource, which we will run out of at some point. Developing alternatives to petroleum-based fuels, such as biodiesel, may provide us with a long-term, renewable energy source.

So, the next time you're eating some French fries at your favorite fast food restaurant, think about the grease that was used to cook those fries. Instead of being thrown out, it may be converted into biodiesel to fuel your car! ▲

Mary Kirchhoff is an Assistant Director in the Education Division at ACS and formerly taught at Trinity College in Washington, DC.