Jonathan Stevens

Professor Henry

ENGH 0990

26 September 2009

From Fryer to Fuel Tank: A Look at Biodiesel

What is biodiesel? Biodiesel is a fuel derived from either vegetable or animal oils, though vegetable is the more prevalent of the two. Vegetable oils commonly made into biodiesel are sunflower, palm, soybean and rapeseed oil, though any vegetable oil can be used. New oil is preferred, however, used oil, such as used peanut oil from restaurant fryers, can be used to create biodiesel. Biodiesel, according to the U.S. Department of Energy, is cleaner burning, non-toxic and biodegradable, sharing similar physical characteristics with petroleum diesel ("Alternative Fuels"). Biodiesel is created through a process known as esterification, though the specific techniques vary, they share a similar process. The U.S. Department of Energy explains the basic process of converting vegetable oil into biodiesel, also known as methyl esters:

> The oils and fats are filtered and preprocessed to remove water and contaminants. If free fatty acids are present, they can be removed or transformed into biodiesel using special pretreatment technologies. The pretreated oils and fats are then mixed with an alcohol (usually methanol) and a catalyst (usually sodium hydroxide). The oil molecules (triglycerides) are broken apart and reformed into methyl esters and glycerin, which are then separated from each other and purified ("Alternate Fuels").

Methyl esters, or ethyl esters if ethanol is used, are the desired result of esterification when producing biodiesel. However, glycerin, a byproduct, has commercial uses including toothpaste, soap, lotion and explosives amongst others.

History

Vegetable oil derivatives as fuel for internal combustion engines began with the use of vegetable oil itself as fuel. Predating current debates over global warming and diminishing petroleum deposits, Rudolf Diesel, inventor of the engine bearing his name, in 1911 predicted:

> The use of vegetable oils for engine fuels may seem insignificant today, but such oils may become, in the course of time, as important as petroleum and the coal tar products of the present time... Motive power can still be produced from the heat of the sun, always available, even when the natural stores of solid and liquid fuels are completely exhausted (qtd. in Pahl 13).

Diesel failed to live to see his vision and arguably it has not happened yet. However, he did recognize, to his credit, the value of renewable energy and more specifically vegetable oil.

The innovation from vegetable oil to biodiesel was accomplished more quickly than biodiesel's more recent high profile might suggest. In 1937, G. Chavanne, of the University of Brussels, would become credited with producing biodiesel, obtaining a patent for his process. Chavanne's ethyl esters of palm oil were successfully tested in a commercial bus in 1938, a most promising start for biodiesel (Pahl 16-17). Despite Chavanne's early progresses, biodiesel would essentially be rediscovered almost 40 years later by scientists representing multiple countries. Scientists in Austria, South Africa and the United States would conduct research and come to conclusions of note.

While there are many researches who studied biodiesel there are three should be made particular mention of. First, Manfred Wörgetter, employed by Austria's Institute of Agricultural Engineering, began research in 1976 testing vegetable oil blended with petroleum diesel in tractor engines. Second, Dr. Charles Peterson, of the University of Idaho, started his research in 1979, conducting similar experiments as Wörgetter. Third, Louren du Plessis, of South Africa's Council for Scientific and Industrial, experience was similar except that South African tests began with straight vegetable oil. All three research projects experienced engine failure from using unmodified vegetable oil and concluded that either the fuel or the engine would have to be adapted to the other, esterification of vegetable oil was the universal conclusion amongst du Plessis, Peterson and Wörgetter.

Use

Currently biodiesel and petroleum diesel blends of various ratios are more commonly used than straight biodiesel. Nomenclature to communicate the ratio of biodiesel to petroleum diesel consists of "B" followed by a number indicating what percentage of biodiesel. For example, B5 would indicate a blend of 5% biodiesel and 95% petroleum based diesel, B100 would indicate 100% biodiesel. One U.S. Department of Energy informs us that B20: "can be used in nearly all diesel equipment and is compatible with most storage and distribution equipment" ("Alternative Fuel"). B20's compatibility with most storage and distribution equipment gives biodiesel an advantage in not requiring modification of existing storage of distribution equipment.

Biodisel possesses undesirable traits, one of the concerns is the tendency of diesel, both bio and petroleum to gel at low temperatures. Biodiesel, however, gels at higher temperatures than petroleum diesel, by combining the two fuels, the mixtures gelling temperature is lowered compared to straight biodiesel. As a result, according to the U.S. Department of Energy B20 and lower blends have a negligible negative impact on gelling temperatures. B20 can also be handled using the same techniques as those used for petroleum diesel ("Clean Cities"). Currently biodiesel prices are higher than petroleum diesel's, a significant barrier to biodiesel's use; this, however, can be minimized by blending. Blending allows petroleum diesel to make up the bulk of fuel costs in blends such as B20, B5 or even B2.

Despite disadvantages when comparing biodiesel to petroleum diesel, biodiesel has advantages. One of the most notable advantages is cleaner emissions than petroleum diesel. A 2002 technical draft report written by the Environmental Protection Agency found B20 had significant impact in heavy-duty highway engine emissions. The impact on B20 was determined to be 2% increase in nitrogen oxide, 10.1% decrease in particulate matter, 21.1% decrease in hydrocarbons, and an 11% decrease in carbon monoxide (“Comprehensive Analysis”). The trend in nitrogen oxide increase and, particulate matter, hydrocarbons and carbon monoxide decrease continues as the biodiesel in the biodiesel petroleum blend increases.

In addition to emissions benefits from using biodiesel there are additional benefits in it being renewable and capable of domestically production. For instance, 2/3rds of the United States' petroleum is from foreign sources and 2/3rds of this becomes gasoline and diesel for use in the nation’s cars, trucks, ships and trains (“Alternative Fuel”). Instead of importing such a high amount of petroleum, biodiesel offers the prospect of moving the United States slightly closer to energy independence. The goal of energy independence is most likely to be achieved through the harnessing of multiple energy sources and not through the sole use of biodiesel. In a world in which political instability can disrupt access to supplies of petroleum, the possibly of diminishing reliance on imported oil is appealing.

Future

One of the more promising and exciting future prospects for biodiesel is in the use of algae as a feedstock, or a source of oil, for biodiesel. Recent investigation into using algae as a feedstock shows increases in oil production per acre when we compare algae to other more traditional sources. Robert McIntyre in one article writes:

> At a small DOE plant in New Mexico, researchers produced up to 50 grams of algae per square meter per day, using native algae species that naturally took over the ponds. This might be enough to yield 6,800 gallons of oil per acre if sustained for a year. That’s 11 times more than any other biodiesel crop, including palm oil (McIntyre 26).

In addition to the benefits of increased oil yields, algae can grow in areas not suited to many other food crops. For example, ponds using salt water algae species would allow areas with abundant sources of salt water to reduce freshwater usage. Algae’s ability to grow well where some crops cannot offers a possible solution to conflict concerning land use for feedstocks over food.

Algae ponds, combined with other processes, can bring greater environmental benefits beyond reducing emissions from increased biodiesel use. As a result, McIntyre proposes a future in which carbon dioxide from coal plants, and municipal and agricultural waste water feeds biodiesel algae ponds (McIntyre 26-27). This allows algae to function as carbon scrubbers for coal plants, reducing emissions, and reduces loads on waste water treatment plants. Therefore, combining algae with unwanted carbon dioxide and waste water allows us to turn a waste into a resource, a significant benefit. While algae will not herald the arrival of Diesel’s vision or the end of petroleum fuels it does offer the prospect of increasing the use of biodiesel as a fuel source and of realizing the benefits such use entails.

Works Cited

"A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions." Biodiesel Emissions Analysis Program. *US Environmental Protection Agency*. Oct. 2002. Web. 5 Sep. 2009 <http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf>.

Alternative Fuels and Advanced Vehicles Data Center: Biodiesel . *U. S. Department of Energy*, 17 Aug. 2009. Web. 5 Sep. 2009. <http://www.afdc.energy.gov/afdc/fuels/ biodiesel.html>.

"Clean Cities." Alternative Fuels and Advanced Vehicles Data Center: Biodiesel. U.S. Department of Energy. Apr. 2008. Web. 5 Sep.2009.<http://www.afdc.energy.gov/afdc/ pdfs/ 42562.pdf>.

McIntyre, Robert. "Algae's Powerful Future." *Futurist*. Mar. 2009: 25- 32. *Academic Search Premier. EBSCO*. Web. 14 Sep. 2009 <http://search.ebscohost.com/ login.aspx?direct=true&db=aph&AN=36400455&site=ehost-live>.

Pahl, Greg. *Biodiesel: Growing a New Energy Economy*. 2nd ed. White River Junction, VT: Chelsea Green Publishing Company, 2008. Print.