Improving Biodiesel

Richard A. Larson
Professor Emeritus, NRES, UIUC

presented at Illinois Conference on Soil and Water Science, September 16,2008

1. Biofuels and Land Use

Quite a large fraction of cropland in the United States is devoted to biofuel production. For example, of the 83 million acres currently devoted to corn production, about 22% is used to provide 10 billion gallons of ethanol. Similarly, 13% of the 75 million acres in soybeans gives rise to biodiesel (about 0.5 million gallons/year). The energy bill passed by Congress in 2007, however, calls for a massive increase of biofuel production, to the extent of 36 billion gallons annually by 2022. The measure calls for most of the new production to be "advanced biofuels," for example cellulosic ethanol, which hardly exist today.

2. Ethanol

Ethanol can be produced from sources other than corn. Brazil, for example, has successfully converted a majority of their vehicles to burn ethanol. The country makes 42% of the world's fuel ethanol; it is made entirely from sugar cane fermentation. The long growing season and high per-acre yield of this crop are especially favorable in Brazil. Because of protectionist barriers, export of either sugar or ethanol to the US is currently not feasible. The US sugar industry keeps the price of domestic sugar high to protect it from cheaper foreign sugar, and the importation of ethanol is effectively blocked by a high tariff (currently 54¢/gallon).

Sugar beets are another potential source of ethanol, and beet sugar to ethanol plants have opened in several countries, including the UK, Germany, and China - but not in the US.

3. Alternatives to Soy Biodiesel

A. Other Oilseeds

Soy oil is relatively low in the content of lipids (including the triglycerides from which biodiesel is made: Table 1. Safflower, whose seeds have the highest concentration of oil, must be grown in semiarid regions; too much water can damage its roots. It can tolerate saline soils, however.

Peanut oil was used by Rudolf Diesel to power his original engine; but it is relatively expensive. Rapeseed oil (also called Canola in North America) is the commonest source for biodiesel in Europe, and production worldwide is increasing rapidly. China and India are large producers, and Canada also has extensive acreage. It is scarcely grown in the US. Although the oil costs more than soy oil, it has a higher yield of oil per acre.

Jatropha is a shrub that is native to poor soils in India and Africa. Its seed has attracted much attention in the popular press, especially for being a "miracle biofuel" that is supposedly "usable in any diesel engine without modification." This is a gross exaggeration; not only are jatropha lipids essentially triglycerides, like almost all other plant-derived oils, but the raw oil has a high (14%) content of free fatty acids, which can cause engine damage if not removed or converted to esters. Nevertheless, jatropha plantations are being planted in many countries, including the US. A south Florida company, "My Dream Fuel LLC" began operations in May of 2008.

B. Waste Cooking Oil

The waste oil from restaurants has attracted attention as a cheap and available source of diesel. It has been given the name of "McDiesel" to reflect its sources from venues such as McDonalds. May claim that it can be used directly, without hydrolysis and esterification, but this normally requires extensive engine modification. It is claimed that vast amounts of this material are available, but as more is being used there are reports of thefts around the country. One small chain of diesel stations, "Biofuel Express" in Berkeley, California, sells recycled vegetable oil at its three locations. The cost is $6/gallon, not that much more expensive than petroleum diesel.

C. Animal Fats

The bulk of animal fat available is from chicken processing. Tyson Foods and Perdue Farms are among the large producers that make chicken fat available for 19¢/lb, compared to soy oil's price of 33¢. Nearby in Dexter, Missouri the company Global Fuels began using a mixture of Tyson chicken fat and soy oil for biodiesel synthesis. Animal fats by themselves would be problematic as a fuel because of their high cloud point (the temperature where solid materials begin to separate), which would limit its use in colder climates. Incidentally, a recent debate has taken place as to whether vegetarians could use biodiesel derived from animal fats.

D. Algae

It has long been known that algae store either starches or lipids. Suggestions made in the early 1970s that algal oil could be used to alleviate the fuel crisis of that time were greeted as jokes, but the idea has been revived in the last few years. Certain algae store up to 30% of their body weight as lipid, and clever pilot-plants have been developed in which algae grow in stacked panels (vertical bioreactors) of moving plastic bags exposed to artificial sunlight. Another intriguing alga is *Botryococcus*, in which the storage lipid is made up of pure hydrocarbons of the terpene class. Such a mixture might actually be utilizable as fuel without further processing.

Table 1. Lipid Content of Some Oilseeds

	% Dry Weight
Safflower	60
Peanut	48
Rapeseed	45
Sunflower	42
Cottonseed	40
Jatropha	38
Flax (Linseed)	35
Palm	35
Olive	20
Soybean	20
Pomegranate	13
Tamarind	7
Corn	4

4. Improving Biodiesel

A. Biodiesel in Winter

In most pure biodiesels, the freezing point of some of the esters ("cloud point") is within the normal range of winter low temperatures of much of the US. The separation of these waxy crystals from the medium can lead to engine problems related to the clogging of filters and nozzles. Partial solutions for these problems include: 1) adding materials such as petroleum biodiesel and pour-point additives; 2) deliberately freezing the product and separating the solids for summertime use; or 3) storing and using the product in heated environments. However, the latter practice can yield problems of its own –

B. Biodiesel Degradation during Storage

Biodiesel degrades more rapidly than petroleum diesel on storage and use – especially at higher temperatures. The degradation products include peroxides, acids, ketones, polymers, and gums which cause extensive engine problems including deposit in the fuel lines and cylinders. The potential solution, the use of antioxidants, has been briefly examined. Typically, the antioxidnat sused are the same as used for petroleum diesels, but biodiesel may need antioxidants with different characteristics. Careful kinetically-based determinations such as the Barclay-Ingold-Niki lag-period technique are needed to establish optimal protective conditions for biodiesels from different sources.

5. Conclusion

Renewable fuels are likely to become more important in the future. Biodiesel especially seems likely to be a major contributor. With luck and research, we can produce more and better fuel products and move significantly away from our dependance on fossil fuels.