WHITE PAPER

Cold Flow Properties of Blends of Tallow and Soybean Oil-based Biodiesel

As Presented By

Dr. Jon Van Gerpen
Department of Biological and Agricultural Engineering
University of Idaho

March 17, 2008

Introduction

Biodiesel is an alternative diesel fuel produced from vegetable oils and animal fats. In the United States, most biodiesel is produced from soybean oil. However, due to the dramatic increase in soybean oil prices since 2006, soybean oil-based biodiesel prices have risen substantially, and during 2008 soy-based biodiesel has typically traded at a substantial premium to petroleum diesel.

Other feedstocks such as other vegetable oils (i.e. palm, cottonseed, peanut, corn, canola, mustard seed, and jatropha oils), tallow (inedible beef fat), choice white grease (inedible pig fat), used cooking oils, and poultry fat can also be used to make high-quality biodiesel. Animal fats and used cooking oil feedstocks have traditionally been lower cost than soybean oil. Given the price advantage of such feedstocks compared to soy oil, there is now considerable interest in using these lower cost oils and fats to reduce biodiesel production costs. Unfortunately, animal fats and used cooking oils are higher in saturated fats, and therefore fuels produced from these materials will tend to crystallize at higher temperatures. This may make higher biodiesel blends from these feedstocks unacceptable in regions with cold climates or during colder months of the year. It has been proposed that blending biodiesel produced from these saturated feedstocks with soybean oil-based biodiesel could produce a type of biodiesel with cold temperature properties that would be more acceptable in colder climates.

At the request of Crimson Renewable Energy LP ("Crimson"), the University of Idaho has tested samples of biodiesel made from soybean oil and tallow biodiesel for their cold weather properties. Additionally, various blend levels of soybean oil biodiesel mixed with tallow biodiesel were tested for their cold weather properties. The results of these tests are provided in this research summary.

Methodology

Biodiesel was prepared from samples of biodiesel from soybean oil and tallow (i.e. inedible beef fat). The tallow (a 6% FFA grade) used to produce the biodiesel for this testing were provided by Crimson and the soybean oil was a food grade oil purchased at a local grocery store.

Biodiesel fuels from each of the feedstocks were made by mixing the oil with a 6:1 molar ratio of methanol to oil and with 0.5% sodium methylate as a catalyst. The sodium methylate was dissolved in the methanol before adding to the oil. The process was conducted in two steps with 80% of the methanol/catalyst added to the oil in the first step. The mixture was stirred for 1 hour at 140°F, and then the glycerin was allowed to settle in a separatory funnel. The glycerin was removed and the remaining 20% of the methanol/catalyst solution was added. The mixture was again stirred for 1 hour at 140°F and any remaining glycerin was settled out and removed. The fuel was then water-washed to remove methanol, soap, catalyst, and free glycerin. The washed fuel was dried by heating to 230°F for 15 minutes. The final fuel samples were analyzed for free and total glycerin and found to be in compliance with ASTM D6751, the specification for biodiesel.

Samples of B100 and B20 were prepared and the cold flow properties were measured. The biodiesel fuels that were tested included 100% soybean oil and tallow-based biodiesels as well as soybean oil-based biodiesel blended with tallow-based biodiesel in various ratios. The blend ratios tested were 0%, 20%, 40%, 60%, 80%, and 100% tallow-based biodiesel with the remainder being soybean-oil based biodiesel. The conventional diesel used in the B20 biodiesel blends was a standard # 2 diesel obtained from a service station in Idaho. The cloud point (CP), pour point (PP), and cold filter plugging point (CFPP) were measured twice and the numbers were averaged. The CP and PP data were measured in the biodiesel laboratory at the University of Idaho using the ASTM D2500 and ASTM D97 test methods respectively. The CFPP data were measured by Magellan Midstream Partners of Kansas City, Kansas.

Measuring Cold Weather Performance

Cold weather performance is measured by 3 parameters: cloud point, pour point, and cold filter plug point. The cloud point refers to the temperature at which small wax crystals in diesel or biowax in biodiesel fuels form and are first visually observed as the fuel cools. The accumulation of solidified waxes will thicken the fuel and can reach the point where fuel filters and injectors in engines become clogged. The temperature at which this happens is known as the cold filter plug point. The pour point is lowest temperature at which the fuel will pour or flow; it is a rough indication of the lowest temperature at which fuel is readily pumpable. It should be noted that CFPP for biodiesel blends is the measurement used within the biodiesel industry globally to provide a good indicator of the lowest operability temperature for diesel engines.

Soybean Oil-Tallow Biodiesel Blends

For B100 biodiesel made from varying proportions of tallow versus soybean oil-based biodiesel, the cloud point, pour point and cold filter plugging point temperatures follow similar trends and the data points for the intermediate blend levels are roughly linear between the temperatures for the 100% tallow and 100% soybean oil-based biodiesels.

Table 1 shows the cold flow data for B20 produced by mixing 80% conventional petroleum-based diesel fuel with 20% biodiesel from differing blend ratios of tallow and soybean-based biodiesel. *Because the biodiesel only composes 20% of the mixture, the effect of changing the relative amounts of tallow biodiesel and soybean biodiesel is much less than effects for B100 biodiesel.*

Table 1. Cold Flow Properties of B20 with biodiesel made from blends of soybean oil and tallow-based biodiesel

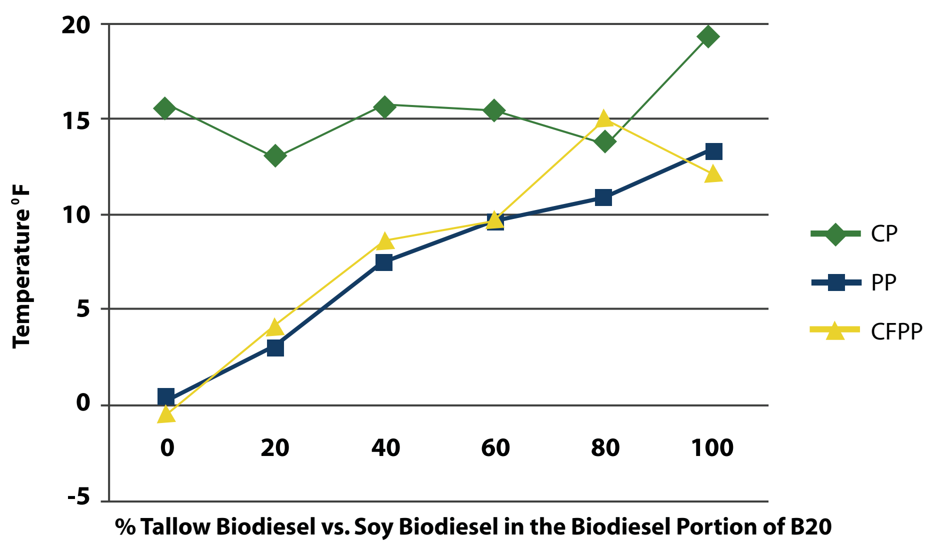
Diesel %	% Tallow	% Soy	CP (°F)	PP (°F)	CFPP (°F)
80	0	20	15.6	.3	-0.4
80	4	16	12.9	3.2	4.1
80	8	12	15.6	7.5	8.6
80	12	8	15.4	9.5	9.5
80	16	4	13.6	10.8	14.9
80	20	0	19.4	13.3	12.2

For petroleum diesel fuel: CP= -1.8°F (-18.8°C), PP=-19.1°F (-28.4°C), and CFPP=-0.4°F (-18°C)

These results from Table 1 are plotted in Figure 1. The cloud point of the B20 biodiesel fuel seems to show little effect as the ratio between the tallow and soybean oil-based biodiesel is varied; the cloud point varied less than 10 degrees between the extremes of using 100% tallow-based biodiesel or 100% soybean oil-based biodiesel for the biodiesel portion of the B20 fuel. Also the cloud point did not necessarily change in a linear fashion as the proportion of tallow-based biodiesel changed. For instance, the B20 fuel with the biodiesel portion comprised of 80% tallow / 20% soybean oil-based biodiesel showed a slightly lower cloud point than the B20 fuel with the biodiesel portion comprised of 40% tallow / 60% soybean oil-based biodiesel.

The pour point (PP) and cold filter plug point (CFPP) did show a roughly linear effect with 12.6°F to 14.4°F (7 to 8°C) of variation between the extremes. That said, the impact on the B20 PP and CFPP of going from 100% soybean oil-based biodiesel for the biodiesel portion to a 50%/50% soy-tallow biodiesel blend for the biodiesel portion was relatively modest causing an increase of approximately 8°F in PP and CFPP in the B20 fuel.

Figure 1. Cold Flow Properties of B20 with biodiesel made from blends of soybean oil and tallow-based biodiesel



For petroleum diesel fuel: CP= -1.8°F (-18.8°C), PP=-19.1°F (-28.4°C), and CFPP=-0.4°F (-18°C)

It should be noted that the CFPP temperature for a given biodiesel blend can be below the pour point temperature. This is a common observation with biodiesel fuels. While it might initially seem impossible that the fuel could still flow through a filter at a temperature below its pour point, it should be noted that the test conditions are very different for the two procedures. First, when the pour point test is conducted, the temperature is lowered in increments of 5.4°F (3°C) until a point is reached where the fuel no longer pours from a vessel. Then, 5.4°F (3°C) is added to this temperature to identify the lowest temperature at which the fuel will pour. Because of the way the pour point (PP) is defined, it is even possible for a fuel that behaves similar to a pure compound, like biodiesel, to have a pour point that is above the cloud point. This was not observed in the tests described here.

The pour point technique means the actual freezing temperature of the fuel could be between 5.4°F (3°C) and 10.8°F (6°C) below the measured pour point. Also, the rate at which the fuel is cooled can affect the observed PP and CFPP temperatures.

Conclusions

The data presented in this report indicate that blending biodiesel made from tallow (inedible beef fat) with soybean oil-based biodiesel can improve the low temperature properties of the combined biodiesel. For B100 the effect is approximately linear between the values for the pure methyl esters. The effect of changing the relative amounts of tallow-based biodiesel versus soybean oil-based biodiesel is much less for B20 biodiesel fuels than the effects for B100 biodiesel. This is due to the simple fact that in a B20 biodiesel fuel the biodiesel only composes 20% of the mixture and thus, the impact on B20 cold weather performance from changing the type of biodiesel used is greatly reduced compared to the impact on the cold weather performance of B100.

Blending tallow-based biodiesel with soybean oil-based biodiesel did not always have a linear effect on the cloud point of B20. However, roughly linear reductions in the pour point and the cold filter plugging point (CFPP) were recorded as the portions of tallow versus soybean oil-based biodiesel were adjusted. Since the CFPP is intended to provide an indicator of the lowest operability temperature for engines, it appears that blending tallow biodiesel with soybean biodiesel should allow the fuel to be used at lower temperatures.

Acknowledgements

The author would like to thank Scott Burn, Joe Thompson, and Paul Wang for their assistance in conducting the experiments that produced the data provided in this report.

For further information about biodiesel fuels, including pricing and how to purchase Crimson biodiesel in California and surrounding states, please contact Crimson Renewable Energy at biodiesel@crimsonrenewable.com.

CRIMSON
RENEWABLE ENERGY, LP

950 17th Street
Suite 2650
Denver, CO 80202
303.327.7655
info@crimsonrenewable.com

University of Idaho

Jon Van Gerpen
Department of Biological and Agricultural Engineering
University of Idaho
Moscow, Idaho 83844