

## COLD FLOW PROPERTIES OF BIODIESEL AND ITS BLENDS WITH DIESEL FUEL

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### SUMMARY:

The Agricultural Engineering Department at the University of Missouri-Columbia and the MFA Oil Laboratory has conducted cold flow studies of biodiesel and its blends with diesel fuel. An experimental pour point depressant made by Lubrizol, SVO, was mixed at the rates of 0%, .1%, .2%, .5%, .75%, 1%, and 2% by volume with B100, B40, B30, B20, and 100% diesel fuel. Specifically pour point, cloud point, and centistokes at 40 degrees C were measured and evaluated.

**KEYWORDS:** Biofuels, Biodiesel, Methyl-ester, Transesterification, Pour Point, Flash Point

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# COLD FLOW PROPERTIES OF BIODIESEL AND ITS BLENDS WITH DIESEL FUEL

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## ABSTRACT

The Agricultural Engineering Department at the University of Missouri-Columbia and the MFA Oil Laboratory conducted cold flow studies of biodiesel and its blends with diesel fuel. An experimental pour point enhancer, SVO, was mixed at the rates of 0%, .1%, .2%, .5%, .75%, 1%, and 2% by volume with B100, B40, B30, B20, and 100% diesel fuel. Specifically pour point, cloud point, and centistokes at 40 degrees C were measured by MFA Laboratories.

**KEYWORDS.** Biofuels, Biodiesel, Methyl-ester, Transesterification, Pour Point, Flash Point

## INTRODUCTION

Previous research conducted with diesel engines during the early 1990's in Idaho and Missouri has indicated that diesel engines could be fueled with neat biodiesel fuel and with blends of biodiesel and petroleum diesel fuel (Schumacher, et al., 1991; Peterson et al., 1995). However, the cloud and pour point of neat biodiesel differs from petroleum diesel by as much as 16.1°C (30° F). This difference in temperature significantly reduced the end user's ability to operate an engine in cold weather.

This research was intended to determine if an experimental pour point depressant which was developed by Lubrizol could be used to facilitate the use of biodiesel and biodiesel/diesel fuel blends in cold weather. The product was released for use as a pour point depressant with vegetable oils on an experimental basis. The product is now sold as Lubrizol 7671 with recommended treat levels of one to two percent. According to Lubrizol, it can be used effectively on most vegetable oils and methyl esters of vegetable oils.

## OBJECTIVES

The overall purpose of this research was to evaluate the use of the SVO additive - OS 110050, (presently sold as Lubrizol 7671) to enhance the cold weather functionality of biodiesel and blends of biodiesel/diesel fuel. Specifically, the researchers measured the: 1) pour point, 2)

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cloud point, and 3) viscosity of neat biodiesel; 20%, 30%, and 40% biodiesel/diesel fuel blends; and #2 petroleum diesel fuel.

## **MATERIALS AND METHODS**

The tests were conducted using low sulfur diesel fuel (LSD) and methyl esters of soybean oil (biodiesel). Seven concentrations of SVO additive were selected for testing by the researchers - 0%, .1%, .2%, .5%, .75%, 1% and 2% by volume. Please note that the recommended treat rate as per Lubrizol was 1% and 2%. Five blends of fuel were tested - 100% biodiesel, 100% LSD, 20% biodiesel/80% LSD, 30% biodiesel/70% LSD, and 40% biodiesel/60% LSD.

### **Mixing of the Additive with 100% Biodiesel and 100% LSD**

A liter of each fuel was measured using a graduated cylinder. The contents were emptied into a glass flask for mixing. The appropriate amount of pour point depressant was then added to each glass flask using a pipet. The amount added was 0ml, 1ml, 2ml, 5 ml, 7.5ml, 10 ml, and 20 ml (0%, .1%, .2%, .5%, .75%, 1% and 2% by volume). The mixing flask was then sealed and shaken thoroughly. Each flask was divided equally into two metal sample containers. One for analysis, the second was placed in storage for analysis at a later date.

### **Mixing of the Additive with Biodiesel/ LSD Blends**

This was done two ways. The biodiesel was either mixed with the pour point depressant before the biodiesel was added to the #2 LSD or the SVO pour point depressant was added to the mixing container after the biodiesel had been mixed with the #2 LSD.

#### **Mixing Procedure A**

200, 300, and 400 ml samples of biodiesel were measured using a graduated cylinder. The graduated cylinder was emptied into a glass flask. The appropriate amount of SVO pour point depressant was added to each flask (0ml, 1ml, 2ml, 5 ml, 7.5ml, 10 ml, and 20 ml). This mixture was mixed thoroughly. #2 LSD was measured using a graduated cylinders (800, 700, or 600 ml) and poured into the appropriate glass flask. The resulting blend was mixed thoroughly.

#### **Mixing Procedure B**

200, 300, and 400 ml samples of biodiesel were measured using a graduated cylinder. The graduated cylinder was emptied into a glass flask. #2 LSD was measured using a graduated cylinders (800, 700, or 600 ml) and poured into the appropriate glass flask.

This mixture was mixed thoroughly. The appropriate amount of SVO pour point depressant was added to each flask (0ml, 1ml, 2ml, 5 ml, 7.5ml, 10 ml, and 20 ml). The resulting blend was mixed thoroughly.

## RESULTS AND DISCUSSION

All biodiesel/petroleum diesel blends and SVO concentrations were mixed by Jerrell A. Fischer, research technician, University of Missouri, Columbia, MO. Each of the pour, cloud, and centistoke values summarized in Tables 1-3 were determined by Phillip Kelly, Director, MFA Oil Laboratories using standard ASTM testing procedures (D2500, D97). ASTM testing procedures require observations at 5 degree intervals. This explains the five degree intervals as reported in Tables 1 and 2.

Table 1. Pour point in degrees Centigrade when using SVO experimental pour point enhancer with biodiesel, biodiesel/diesel fuel blends and petroleum diesel.

Blend	Mixed with Soydiesel before mixing soydiesel with LSD #2							Soydiesel mixed with petro diesel before adding SVO product		
	0%	.1%	.2%	.5%	.75%	1%	2%	.5%	1%	2%
100% Soy	-6.7	-12.2	-12.2	-6.7	-15	-6.7	-17.7			
40% Soy	-15	-15	-17.7	-20.5	-26.1	-28.8	-17.7	-20.5	-28.8	-26.1
30% Soy	-15	-20.5	-17.7	-23.3	-28.8	-31.6	-28.8	-23.3	-28.8	-31.1
20% Soy	-20.5	-17.7	-20.5	-26.1	-28.8	-31.1	-31.1	-26.1	-28.8	-26.1
#2 LSD	-26.1	-28.8	-31.6	-31.6	-28.8	-31.6	-31.1			

Table 2. Cloud point in degrees Centigrade when using SVO experimental pour point depressant with biodiesel, biodiesel/diesel fuel blends and petroleum diesel.

Blend	Mixed with Soydiesel before mixing soydiesel with LSD #2							Soydiesel mixed with petro diesel before adding SVO product		
	0%	.1%	.2%	.5%	.75%	1%	2%	.5%	1%	2%
100% Soy	-4.4	-6.7	-6.7	-3.8	-6.7	-3.8	-6.7			
40% Soy	-12.2	-12.2	-12.2	-15	-12.2	-15	-15	-15	-15	-15
30% Soy	-12.2	-15	-12.2	-15	-15	-15	-15	-15	-15	-15
20% Soy	-15	-15	-15	-15	-15	-15	-15	-12.2	-15	-15
#2 LSD	-17.7	-17.7	-15	-15	-17.7	-12.2	-12.2			

Table 3. Centistokes or viscosity @ 40 C° using SVO experimental pour point depressant.

Blend	Mixed with Soydiesel before mixing soydiesel with LSD #2							Soydiesel mixed with petro diesel before adding SVO product		
	0%	.1%	.2%	.5%	.75%	1%	2%	.5%	1%	2%
100% Soy	4.07	3.93	3.96	3.36	4.09	3.98	4.34			
40% Soy	3.08	3.12	3.10	3.11	3.15	3.21	3.33	3.07	3.21	3.36
30% Soy	2.92	3.01	2.98	3.01	3.05	3.09	3.23	2.95	3.08	3.22
20% Soy	2.87	2.86	2.88	2.89	2.99	2.96	3.14	2.89	2.93	3.12
#2 LSD	2.65	2.88	2.66	2.73	2.52	2.77	2.92			

The researchers shared the data with representatives from the National Biodiesel Board. Three 20% Soy samples were prepared for further testing at Core Laboratories, Long Beach, CA after their review. One sample contained .1% SVO, the second contained .5%, and the third contained .75% additive. These concentrations (.1, .5, and .75) were selected due to economic issues (Note Table 5). The 20% Soy blend was selected because much research had been initiated nationally to characterize this blend. The results from Core Labs are summarized in Table 4.

Table 4. 20% Soy / 80% LSD Blend at Selected Rates of SVO Additive

Test Description	Rate of Additive		
	.1%	.5%	.75%
Heating Value (gross), BTU/lb	19,107	18,789	19,051
Gravity, API @ 60F°	34.0	34.1	34.0
Cetane Number, neat	48.6	*	52.1
Pour Point, C°	-16.1	-23.8	-30.5
Cold Filter Plug Point, C°	-17	-20	-23
Centistokes, viscosity @ 40C°	2.90	2.94	3.02

\* Could not determine; insufficient sample volume

As noted when comparing the data between Tables 1,2 and 3 with the data in Table 4, the data from Core Laboratories, Long Beach, CA. were quite similar to that measured the MFA Labs in Columbia, MO.

#### Economic Impact/Analysis:

Lubrizol estimated that the price of SVO would be \$1/lb. The density of the product is approximately 7.5 lb/gal. Therefore, the SVO product will cost approximately \$1.98/L (\$7.50/gal) or \$.00198/ml (\$.059/oz). The costs for treating fuel with the SVO additive at various rates are outlined in Table 5.

Table 5. Cost of Treating on liter (l) of fuel with SVO additive (SVO = \$1.98 / L)

Treat Rate	.1%	.2%	.5%	.75%	1.0%	2.0%
\$/L of fuel treated	.002	.004	.010	.015	.020	.040

## CONCLUSIONS

The following conclusions have been drawn after reviewing the data:

1. The Centistokes value of the biodiesel blends remained above limits established for number 2 diesel fuel when the SVO product was mixed with each blend.
2. Adding the SVO product appeared to increase the Centistokes value of the biodiesel blends tested.
3. A 20% soydiesel blend that has been treated with the SVO product at .75% should provide a safe operating range for most midwest communities.

## RECOMMENDATIONS

1. Buyers who require additional cold weather protection should consider mixing a minimum of .75% (7500 ppm) with a 20% biodiesel blend to insure a safe operating range.
2. Other commercial products should be considered as pour and cloud point depressants. The SVO product worked well at concentrations that are normally considered high when compared to the recommended levels for products such as "winter power plus".
3. Higher concentrations of other popular additives may work equally as well as the SVO product. Additional testing that allows one to easily compare various pour point additives at higher concentrations is needed. This will allow one to conduct the economic analysis that is needed to select the pour point additive that is most cost effective.

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