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Research Paper

Comparison of Viscosities of Biodiesel from Pork Lard and Soybean Oil and Blends with Petroleum Diesel

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Abstract- *Viscosity is an important fuel property of biodiesel and fossil diesel fuels. Animal fats and vegetable oils can be used as alternative fuels directly but they have a major drawback because of their high viscosity values. High viscosity causes problems in compression ignitions. Animal fats and vegetable oils can be converted into other forms of fuels, such as methyl esters. Biodiesel, the mono-alkyl esters of vegetable oils and animal fats, can serve as an alternative fuel to depleting fossil fuels and has gained more importance due to its environmental benefits, biodegradability and renewability. This work evaluated the influence on viscosity of a mixture of biodiesel fuels obtained from two different sources. A mixture of biodiesel fuels obtained from different sources did not have a significant effect on the viscosity values. Biodiesel-diesel fuel blends can serve as a feasible alternative, as they can be used in diesel engines without major modifications. In addition, the effects of blends of biodiesel at different ratios on viscosity were investigated.*

Keywords: Biodiesel, Viscosity, Blends, Pork Lard oil, Soybean oil.

Introduction

Biodiesel- Biodiesel fuel is the mono-alkyl esters of long-chain fatty acids derived from renewable lipid sources such as vegetable oil and animal fats [1]. Biodiesel is an alternative fuel for diesel engines that can be produced by chemically reacting a vegetable oil or animal fat with a short chain alcohol in presence of a suitable catalyst to produce methyl esters, which are called biodiesel [2]. Biodiesel has been identified as one of the alternative fuel sources to fill the demand gap produced by the depletion of fossil diesel fuels [3].

Biodiesel can be used alone as B100 or in a blend with petroleum diesel. A blend of 20% biodiesel with 80% diesel fuel, by volume, is known as B20 [4]. Biodiesel is a non-toxic, biodegradable and renewable biofuel that can replace diesel oil in internal combustion engines without major adjustments [5].

Use of biodiesel leads to a small decrease in performance, almost zero emissions of sulfates, a small net contribution of carbon dioxide (when the whole life-cycle of cultivation, production of oil and conversion to biodiesel is considered), and a decrease in the emission of pollutants [2].

Biodiesel has several advantages over petroleum diesel; biodiesel has improved viscosity, volatility and combustion behavior [6]. Biodiesel also has improved lubricity, a higher flash point, lower toxicity and biodegradability [4].

Composition of Feedstock

Biodiesel can be synthesized from saturated and unsaturated fats. Saturated fat is a type of triglyceride that has no double bonds along the carbon chain. Saturated fats can be used in producing biodiesel, but the major limitation is that it typically has a high melting point. Therefore, biodiesel from saturated fats are usually solid at room temperature. Pork lard is a feedstock that is high in saturated fats. The table below shows the composition of pork lard and soybean oil in terms of their various fatty acids.

* The first number designates the number of carbon atoms and the second number designates the number of double bonds.

Transesterification has been described as a chemical reaction between triglycerides and alcohol in the presence of catalyst to produce monoesters that are termed as biodiesel. It is the process of removing all glycerol and the fatty acids from the vegetable oil in the presence of a catalyst [2]

Several transesterification processes can be used to synthesize biodiesel:
(a) base-catalyzed transesterification,
(b) acid-catalyzed transesterification,
(c) enzyme-catalyzed transesterification,
(d) supercritical alcohol transesterification [9].
Saka and Kusdiana [10] and Demirbas [11] proposed that biodiesel fuels might be produced from vegetable oil via non-catalytic transesterification with supercritical methanol [12].
In Scheme 1: R is typically 16 or 18 carbons and contains zero to three carbon-carbon double bonds
The alcohol source is generally methanol, though ethanol and butanol have also been used. Other alcohols are not as reactive as methanol and do not promote transesterification [9].

Material and Methods

Biodiesel fuels used in this study were produced from the base-catalyzed transesterification reactions of pork lard and soybean oil with methanol and sodium hydroxide as an alkaline catalyst.
Pork lard was obtained from slaughterhouses. Sunola refined soybean oil was purchased from the market. The approximate densities of lard oil and soybean oil were determined by measuring the weight of a known volume. Viscosity tests were carried out on lard oil and soybean oil at various temperatures.
The reagents used during biodiesel synthesis were: Sodium hydroxide of 99% purity (analytical grade, Acros Organics), and methanol 99.8% (analytical grade, Fluka). Synthesis of biodiesel was performed in two main steps: the transesterification reaction and the purification.

Synthesis of Biodiesel by Transesterification
Synthesis of Biodiesel fuel from Pork Lard At the laboratory, the lard was melted at 150 ºC in a general-purpose drying oven in order to melt solid fats to obtain oils, eliminate residual water, remove gums, protein residues, and suspended particles. It was decanted and cooled to the reaction temperature of 65 ºC, and then 100mL of lard oil is obtained and transferred into a 400mL beaker. In a separate beaker, 35mL of methanol is mixed with 0.2965g NaOH and heated to 65 ºC. A magnetic stirrer is used to dissolve all solid NaOH particles. After 15 mins, the methanol-sodium hydroxide mixture (sodium methoxide) is transferred into the beaker containing 100ml of lard oil. The reaction is left to proceed for 90 mins at temperature of 60-65 ºC at ambient pressure. The reactor consisted of a magnetic stirrer in a 400ml Fisherbrand beaker placed on a Stuart SB162 stirrer hotplate. During the reaction, any evaporated methanol was returned to the glass container by a glass lid, placed on the beaker.
At the end of the reaction, the fatty acid methyl-esters were left to settle over-night in a 500mL Quickfit separating funnel. The product from the reaction was separated by gravity into two phases: fatty acid methyl-ester (biodiesel) and crude glycerol.

Synthesis of Biodiesel fuel from Soybean Oil
100mL of Soybean oil was obtained and heated to 65 ºC in a 400mL beaker. Synthesis of biodiesel from soybean oil was carried out using the same procedure as above.

Washing of Biodiesel Fuels
The lower layer (crude glycerol) of the two layers formed in the separating funnel was drained out. The top layer (biodiesel) and a part of the lower layer were washed with distilled water. The water settled to the bottom, and was discarded.

Centrifugation
Centrifugation was carried out on the mixture of the biodiesel layer and the crude glycerol layer, using a Centrifuge (Fisher Scientific accuSpin™ 400). The aim of the centrifugation step was to minimize the loss of biodiesel, and improve the purity. The mixture was transferred into centrifuge tubes and placed on opposite ends in the centrifuge. The centrifuge was set to 1000 r.p.m for 5 minutes, after which the layers were observed to separate distinctly. The biodiesel was decanted into a reagent bottle and stored for further analysis.
Several blends of biodiesel with petroleum diesel were prepared using the biodiesel obtained from lard oil and soybean oil. The blends of biodiesel with petroleum diesel were prepared on a volume basis in the following proportions: 10% (B10), 20% (B20), 50% (B50) and 80% (B80) (v/v).

Measurement of Viscosity
Kinematic viscosity was determined using a Rheotek TCB-7 Viscometer Bath. 15mL of each fuel oil was measured and transferred into a PSL (Poulten Selfe & Lee Ltd., Essex, England) glass capillary viscometer (3C). The fuel oils were observed over a range of temperatures, from 35 ºC to 70 ºC, with increments of 5 ºC. The time (in seconds) obtained from the viscometer was converted to kinematic viscosity in mm^2/s by multiplying by the calibration constant (3.0) of the viscometer used.

Results and Discussion

Biodiesel Yield

Biodiesel (Soybean Oil)
100mL of Soybean oil was used in the synthesis of biodiesel from soybean oil.
After synthesis and purification, 87.0mL of biodiesel was obtained

Percentage yield=87.0mL/100mL x 100
=87.0%

The yield of biodiesel from soybean oil, using NaOH as base catalyst, and methanol as the alcohol was 87%.

Biodiesel (Lard Oil)
After melting pork lard, 100mL of lard oil was obtained, and used in the synthesis of biodiesel.
After synthesis and purification, 87.0mL of biodiesel was obtained

Percentage yield=87.0mL/100mL x 100
=87.0%

The yield of biodiesel from lard oil, using NaOH as base catalyst, and methanol was 87%.

Reason for Yield Value

Saponification reaction leads to the loss of product in transesterification reactions. Water reacted with triglycerides and the cation from the base (Na+) to form sodium soaps. This led to a loss of triglycerides available for the synthesis [13].

Viscosity

Effects of Transesterification on Viscosity

The viscosity of biodiesel depends on the fatty acid composition of the oil source, as well as on the extent of oxidation and polymerization of the biodiesel [14]. The kinematic viscosities of the soybean oil and lard oil are compared with the viscosities of their respective biodiesel fuels and petroleum diesel.

Vegetable oils and oils obtained from animal sources generally have higher viscosities than petroleum diesel. However, transesterification is one of the ways the high viscosity is lowered. The viscosities of the methyl esters were observed to be much lower (about 10 times) than the viscosities of the raw oils. Soybean oil and lard oil could be used directly as fuels, but the major problem associated with the use are the high viscosity values as seen in Figure 3 and 4.

The high viscosities cause problems in compression ignition. These fuels will have inferior injection and poor atomization performance [15]. Nevertheless, the higher viscosity of biodiesel fuels offer lubrication and protection for moving parts of an engine. As a result, biodiesel fuels can be lubricating to most diesel motors [1].

Although the viscosities of the synthesized biodiesel fuels are lower than the source oil, they are higher than the viscosity of petroleum diesel. Viscosity can be used to evaluate the methyl ester contents of biodiesel samples. The higher the viscosity of the biodiesel fuel, the lower the ester content [15]. From Figure 5, it can be inferred that soybean biodiesel and lard biodiesel have similar methyl ester contents.

Effects of a Mixture of Biodiesel from Different Sources

The higher viscosities of biodiesels compared to petroleum diesel may present problems in the actual use as fuels. As a result, a mixture of the biodiesel fuels produced from soybean oil and lard oil were combined at two different ratios to observe the effect on viscosity. Viscosity test was carried out on a biodiesel mixture of 40% soybean biodiesel and 60% lard biodiesel; and a biodiesel mixture of 50% soybean biodiesel and 50% lard biodiesel.

Effects of Biodiesel Blends on Viscosity

In order to lower the viscosity to meet required standard, biodiesel fuels are blended with petroleum diesel in several ratios. An advantage of blends of biodiesel with petroleum diesel is the minimization of noxious effects on the operation of injection systems caused by the relatively high viscosity of biodiesel [14]. The viscosities of three blends (B20, B50, and B80) of soybean biodiesel with petroleum diesel, as well as lard biodiesel with petroleum diesel were observed.

Conclusion

Biodiesel fuels were synthesized from pork lard and soybean oil. It was observed that transesterification is a means of reducing the viscosity of the raw oils. Nevertheless, biodiesel fuels generally have higher viscosities than fossil diesel fuels. A mixture of biodiesel fuels obtained from different sources did not have a significant effect on the viscosity values. However, blends of biodiesel with petroleum diesel reduced the viscosity values; the lower the proportion of biodiesel in the blend, the lower the viscosity. As a result, biodiesel-diesel fuel blends can serve as a feasible alternative, as they can be used in diesel engines without major modifications.

References

1. Demirbas, A., Recent Developments in Biodiesel Fuels, Int. J Green Energy, 4, 15-26 **(2007).**
2. Huang, Y., Zheng, H., Yan, Y. J., Optimization of Lipase-Catalyzed Transesterification of Lard for Biodiesel Production Using Response Surface Methodology, Appl Biochem Biotechnol, 160, 504-515 **(2010).**
3. Zhang, J., Chen, S., Yang, R., Yan, Y., Biodiesel Production from Vegetable Oil Using Heterogenous Acid and Alkali Catalyst, Fuel, 89, 2939-2944 **(2010).**
4. Tang, H., Salley, S.O., Simon Ng, K.Y., Fuel Properties and Precipitate Formation at Low Temperature in Soy-, Cottonseed-, and Poultry Fat-Based Biodiesel Blends, Fuel, 87, 3006-3017 **(2008).**
5. Zheng, M., Mulenga, M.C., Reader, G.T., et al., Biodiesel Engine Performance and Emissions in Low Temperature Combustion, Fuel, 87, 714-722 **(2008).**
6. Bhatti, H. N., Hanif, M., Qasim, M., et al., Biodiesel Production from Waste Tallow, Fuel, 87, 2961-2966 **(2008)**.
7. Dias, J.M., Ferraz, C.A., Almeida, M.F., Using Mixtures of Waste Frying Oil and Pork Lard to Produce Biodiesel, World Acad. of Sci., Eng. and Tech., 44, 258-262 **(2008).**
8. Ferrari, R., da Silva Oliveira, V., Scabio, A., Oxidative Stability of Biodiesel from Soybean Oil Fatty Acid Ethyl Esters, Sci. Agric. (Piracicaba, Braz.), 62, 291-295 **(2005).**
9. Narasimharao, K., Lee A., Wilson K., Catalysts in Production of Biodiesel: A Review, J. Biobased Materials and Bioenergy, 1, 19-30 **(2007).**
10. Saka, S., Kusdiane, D., Biodiesel Fuel from Rapeseed Oil as Prepared in Supercritical Methanol, Fuel, 80, 225-231 **(2001).**
11. Demirbas, A., Biodiesel from Vegetable Oils via Transesterification in Supercritical Methanol,

Energy Conv. and Management, 43, 2349-56 **(2002).**

12. Bacha, J., Freel, J., Gibbs, A., et al., Diesel Fuels Technical Review, Chevron Corporation, California, 41 **(2007).**
13. Predojevic, Z. J., The Production of Biodiesel from Waste Frying Oils: A Comparison of Different Purification Steps, Fuel, 87, 3522-3528 **(2008).**
14. Candeia, R.A., Silva, M.C., Carvalho, J.R., et al., Influence of Soybean Biodiesel Content on Basic Properties of Biodiesel–Diesel Blends, Fuel, 88, 738-743 **(2009).**
15. Keera, S.T., Sabagh, S.M., Taman, A.R., Transesterification of Vegetable Oil to Biodiesel Fuel Using Alkaline Catalyst, Fuel, 90, 42-47 **(2011).**

Table 1: Composition of Fatty Acids Present in Pork Lard and Soybean Oil [7,8]

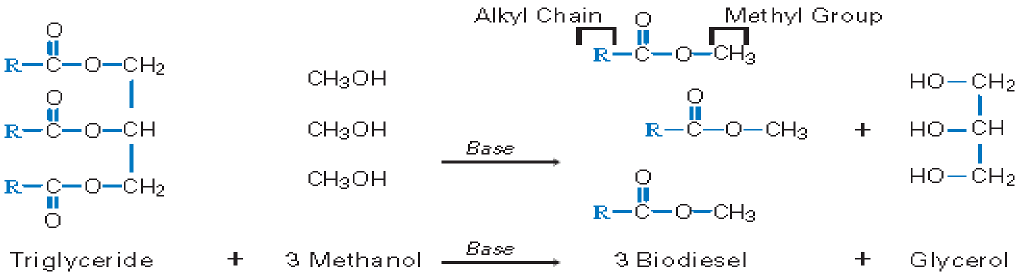
Common Names	Pork Lard	Soybean Oil
Myristic 14:0*	1.5	1.30
Palmitic 16:0	23.7	13.9
Palmitoleic 16:1	2.2	0.3
Stearic 18:0	12.9	2.1
Oleic 18:1	41.4	23.2
Linoleic 18:2	15.0	56.2
Linolenic 18:3	1.o	4.3
Arachidic 20:0	0.2	0.16
Gadoleic 20:1	0.9	-
Erucic 22:1	<0.5	-

Table 2: Kinematic viscosity values in mm^2/s

Temperature (ºC)	Soybean Oil	Lard Oil	Soybean Biodiesel	Lard Biodiesel	Petroleum Diesel	Soybean 50:50 Lard
35	42.57	46.98	6.51	6.13	5.34	6.39
40	35.16	40.98	6.17	5.64	4.83	5.85
45	30.27	34.41	5.79	5.46	4.62	5.58
50	26.61	30.00	5.58	5.19	4.23	5.40
55	23.31	25.80	5.28	4.83	3.87	5.07
60	——	——	4.89	4.53	3.60	4.65
65	——	——	4.77	4.38	3.33	4.56
70	——	——	4.56	4.14	3.12	4.47

Temp. (ºC)	Soybean 40:60 Lard	Soybean B20	Soybean B50	Soybean B80	Lard B20	Lard B50	Lard B80
35	6.57	5.39	5.93	6.27	5.51	5.83	5.95
40	5.97	5.12	5.49	5.87	4.92	5.19	5.52
45	5.73	4.75	5.20	5.59	4.79	5.03	5.30
50	5.34	4.39	4.88	5.32	4.40	4.72	5.02
55	5.10	4.19	4.58	4.98	3.98	4.30	4.65
60	4.77	3.92	4.27	4.66	3.81	4.09	4.32
65	4.50	3.60	4.08	4.50	3.59	3.84	4.21
70	4.42	3.23	3.86	4.32	3.36	3.66	3.96

Scheme 1: Transesterification Reaction of Vegetable Oil [12]



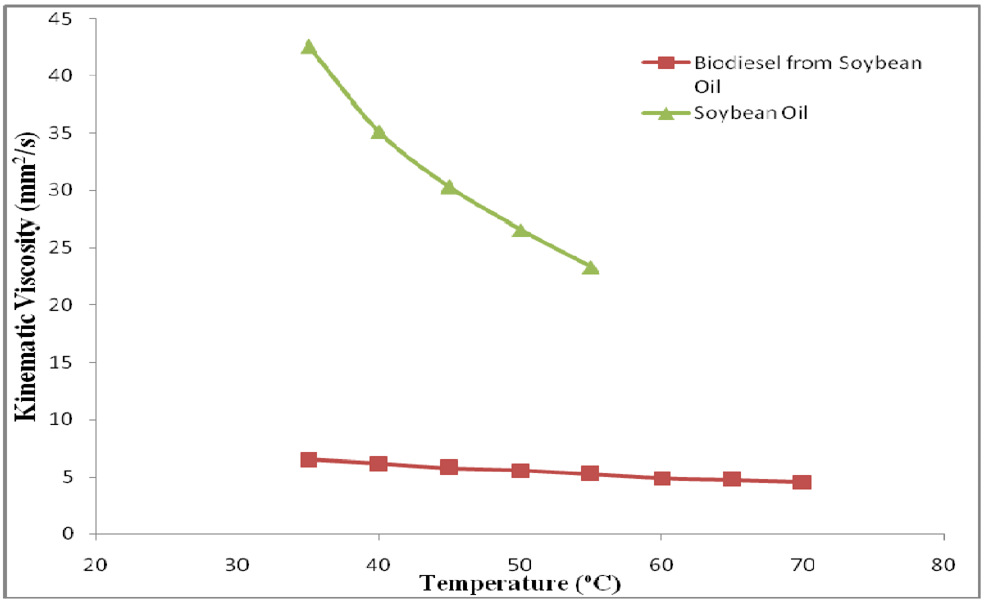


Figure 3: Kinematics viscosities of Soybean oil and Soybean Methyl Ester

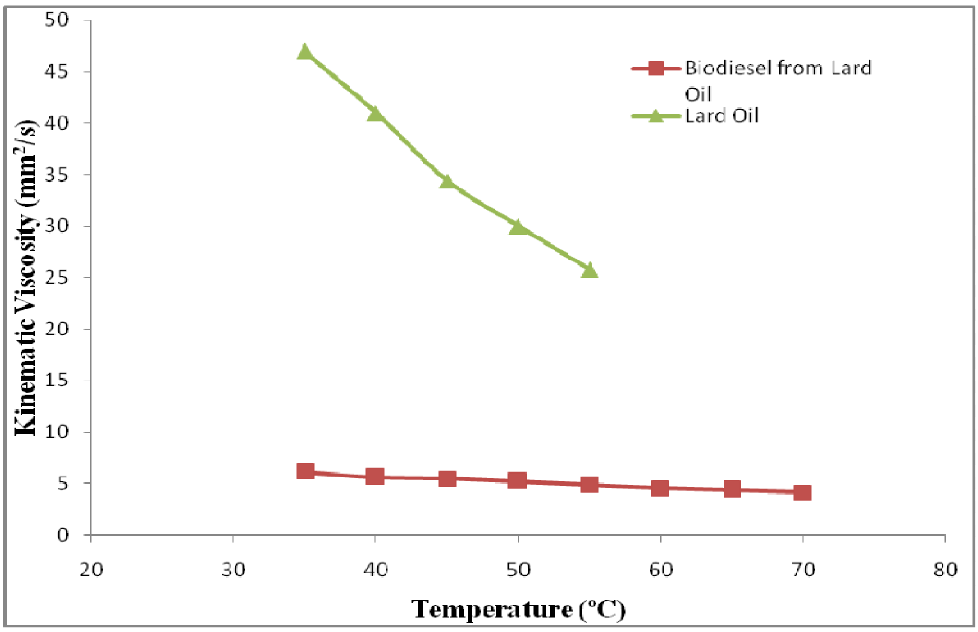


Figure 4: Kinematic viscosities of Lard oil and Lard Methyl Ester

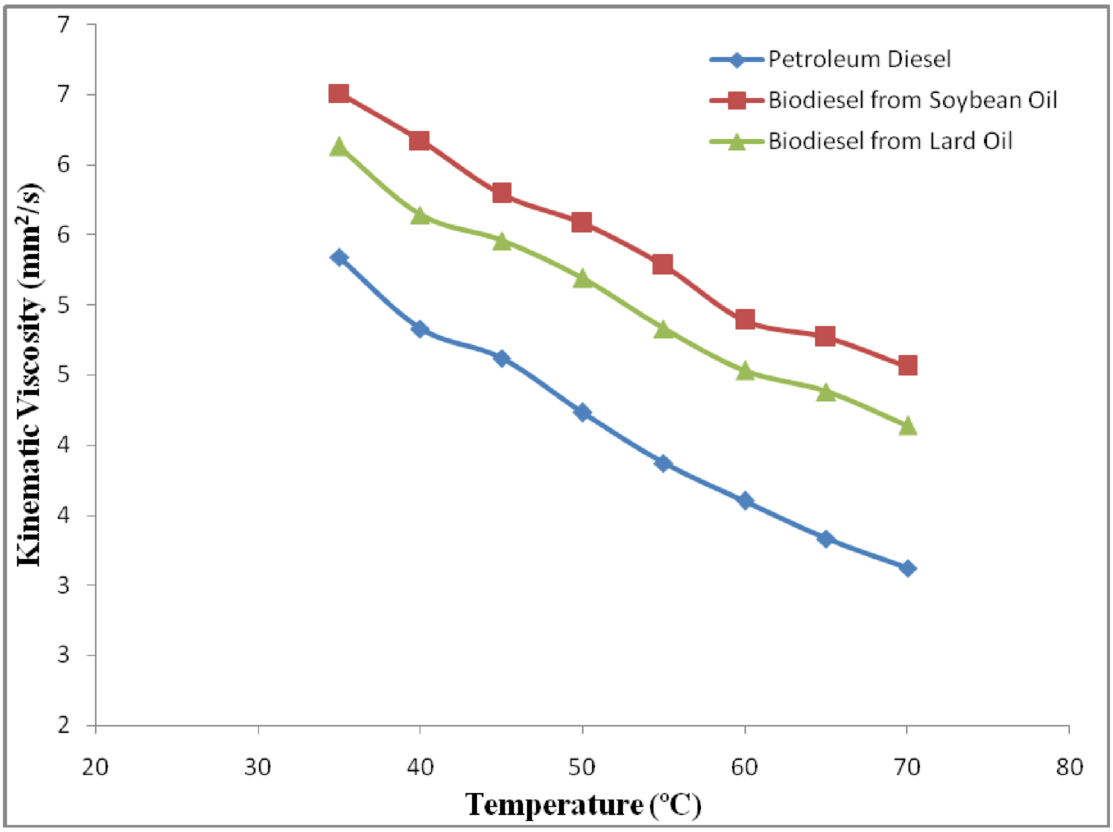


Figure 5: Comparison of the kinematic viscosities of Soybean biodiesel, Lard biodiesel and Petroleum Diesel

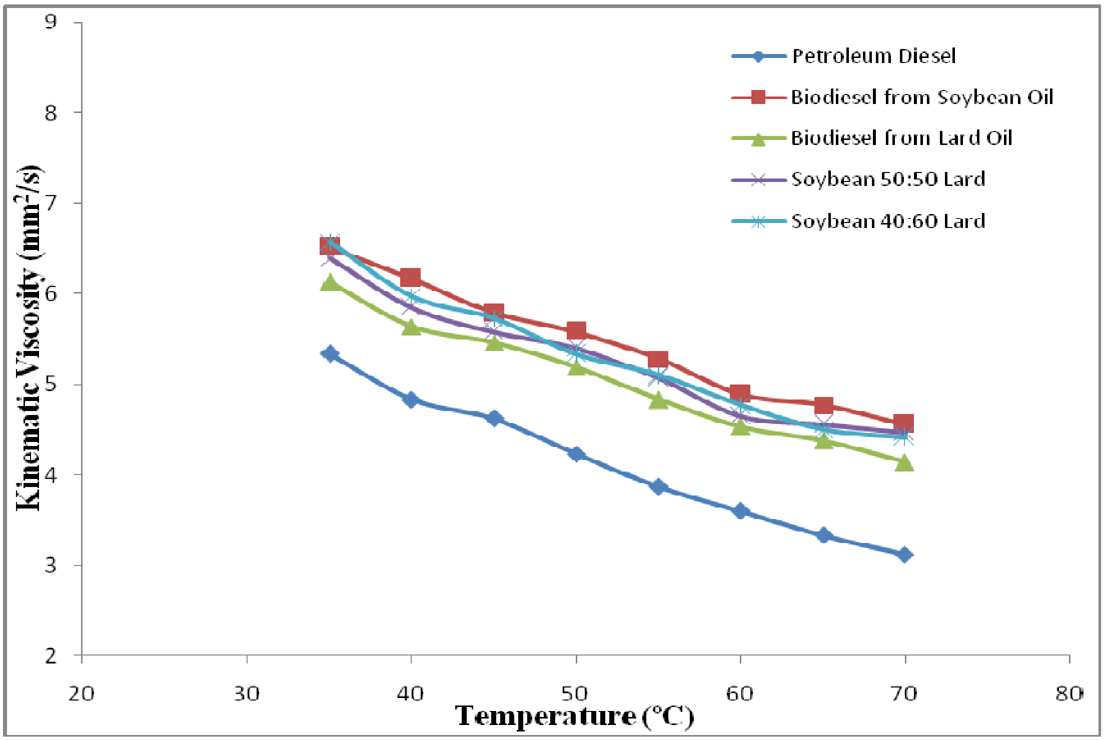


Figure 6: Comparison of the Kinematic Viscosities of Mixtures of Soybean Biodiesel with Lard Biodiesel The mixture of biodiesel synthesized from different sources had similar viscosities with the individual biodiesel fuels. As seen in Figure 6, there was no apparent reduction in the viscosities.

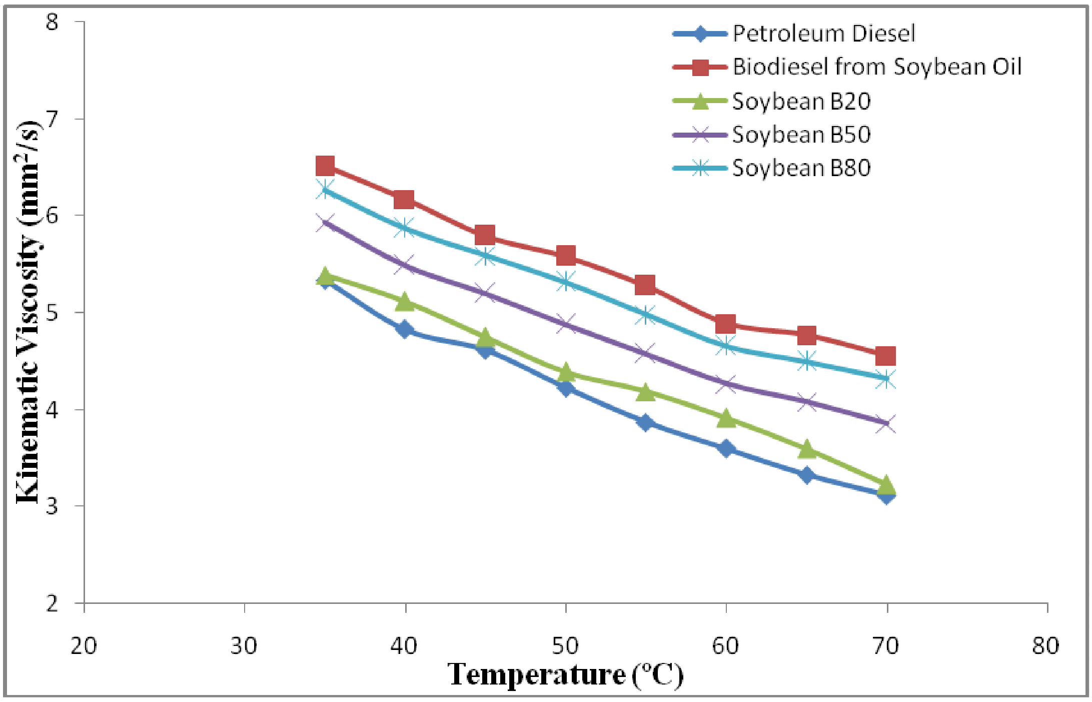


Figure 7: Comparison of the kinematic viscosities of Blends of Soybean Biodiesel with Petroleum Diesel

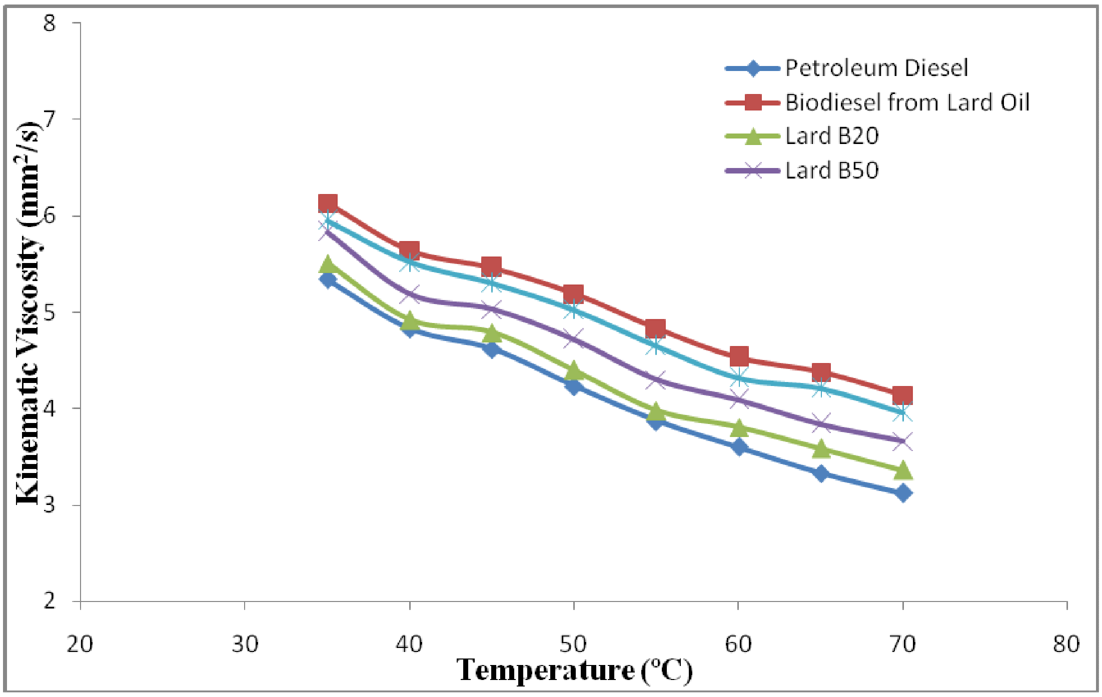


Figure 8: Comparison of the kinematic viscosities of Blends of Lard Biodiesel with Petroleum Diesel Higher ratio of petroleum diesel to biodiesel in the blends resulted in lower viscosities. From Figure 7 and 8, the viscosities approached that of petroleum diesel as the blends moved from raw biodiesel (B100) to B20. Although biodiesel has a higher viscosity than petroleum diesel, the viscosity can be decreased by mixing with petroleum diesel.