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COMPARISON OF THE EFFECTS OF REACTION PARAMETERS ON COLD FLOW PROPERTIES OF BIODIESEL

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Abstract

Biodiesel is biodegradable, renewable and nontoxic fuel source instead of petroleum fuel. Biodiesel has bad cold flow properties. The aim was to specify the optimum reaction parameters and obtain minimum cold flow properties. Transesterification method was preferred as the biodiesel production method. Reaction of transesterification is affected by diverse reaction parameters like as catalyst amount, molar ratio of alcohol to oil, time of reaction and temperature of reaction. In this experimental study, the impacts of operation parameters on cold flow properties of linseed oil biodiesel was compared. In production process potassium hydroxide (KOH) was chosen as catalyst and ethanol was used as alcohol. The impacts of *catalyst amount (0.3-1.1 wt%), molar ratio of ethanol to oil (4:1-8:1), reaction time (45-105 min) and reaction temperature (50-65 ºC) was investigated. The minimum cold flow property values were obtained at 0.5% catalyst concentration, 7:1 molar ratio of ethyl alcohol to oil, 90 min of reaction time, 65ºC of reaction temperature. The lowest pour point, cloud point and cold filter plugging point of linseed biodiesel were found -10 ºC, -3 ºC, and -8 ºC, respectively at optimum reaction parameters.*

Keywords

Linseed Oil, Biodiesel, Transesterification, Reaction Parameters, Cold Flow Properties

1. Introduction

Diesel engines are mostly used in transportation sector. However, the depletion of fossil fuels and environmental damages, researchers try to find alternative fuel sources (Kumar, Soni, Sharma, & Srivastava, 2016). Alternative energy sources have a major role in providing energy demand (Yadav, Soni, Sharma, & Sharma, 2017). Biodiesel is the most widely used alternative fuel because it is the source of renewable energy (Uludamar, Karaman, Yıldızhan, & Serin, 2016). Biodiesel is obtained from numerous raw materials like as vegetable oil, animal fat and waste oil (Tüccar, Tosun, Özgür, & Aydın, 2014; Suh & Lee, 2016; Swaminathan & Sarangan, 2012). It is biodegradable, nontoxic and renewable, therefore showed to be more environmentally fuel contrasted to diesel fuel (Boz & Sunal, 2009; Kılıç, Uzun, Pütün, & Pütün, 2013; Lavanya, Murthy, Nagaraj, & Mukta, 2012). The reason of economic and social non edible oil should be used instead of edible oils (Ivana, Stamenkovic, & Veljkovic, 2012). The most studied non-edible plants are: algae, castor, cotton, jatropha, jojoba, karanja, linseed, rice bran, rubber, neem, tobacco seed (Dias, Araujo, Costa, Alvim-Ferraz & Almeida, 2013; Yang, Takase, Zhang, Zhao, & Wu, 2014; Takase et. al., 2015).

Many of experimental study has been carried by researchers about the effects of transesterification reaction parameters on fuel properties of biodiesel. Kafuku & Mbarawa, (2010) produced biodiesel from moringa oleifera oil and they investigated the effects operation parameters like as ratio of catalyst, alcohol to oil molar ratio, temperature of reaction, agitation rate and time of reaction on biodiesel production. According to the results, 1.0 wt% catalyst concentration, 30 wt% methyl alcohol to oil, 60oC temperature of reaction, 400 rpm rate of agitation and 60 min time of reaction are optimum parameters for production biodiesel from moringa oleifera oil.

Abubakar et al., (2016) studied the process parameters of waste cooking oil biodiesel production. According to the results, the highest biodiesel conversion rate was acquired with 0.5% concentration of catalyst, 6:1 alcohol to oil ratio, 30°C operating temperature, 60 min transesterification time.

Buyuk & Ozgur, (2016) determined the influences of catalyst ratio and molar ratio of alcohol to oil on fuel properties such as density kinematic viscosity and cold flow properties of palm oil biodielsel. They used NaOH as a catalyst and methanol as an alcohol in transesterification reaction. According to results, they obtained the lowest cold flow characteristics at 0.7% catalyst ratio and 6:1 molar ratio of methanol to oil.

Rasimoğlu & Temur, (2014) studied the impacts of transesterification parameters on cold flow properties of biodiesel produced from corn oil. They have changed the reaction temperature between 20 to 60^{o}C, reaction time between 10 to 60 min, alcohol-to-oil ratio between 3.15:1 to 12.85:1 in moles, amount of catalyst between 0.25 to 2 gcatalyst/100 mL corn oil and stirring speed between 300 to 800 rpm. They found that CP, PP and CFPP of the corn biodiesel were -4, -10 and -12oC, respectively for the optimum levels of catalyst amount of 0.75% and methanol-to-oil ratio of 4.15:1 (in moles).

Ayetor, Sunnu, & Parbey, (2015) investigated the impacts of process parameters including methanol:oil ratio, NaOH base catalyst concentration on coconut, palm kernel and Jatropha biodiesel yield. They also studied the effects of sulphuric acid (H_2SO_4) on viscosity for the three feedstocks. According to the results that for each of the feedstock, the biodiesel yield increased with increment in NaOH concentration. The maximum yield was obtained with 1% NaOH concentration for all.

The aim of this study is investigated the impacts of reaction parameters like as catalyst amount, molar ratio of ethanol to oil, time of reaction and temperature of reaction on cold flow properties of linseed oil biodiesel.

2. Methodology

2.1 Transesterification Method

Transesterification method has been preferred in the production of biodiesel from linseed oil. Potassium hydroxide was used as catalyst and ethanol was used as alcohol. Firstly, catalyst (KOH) and alcohol (ethanol) were mixed in a separate vessel to obtain potassium ethoxide mixture. Linseed oil was heated up in the reactor according to preferred temperature. Then potassium ethoxide was added to reactor. Table top heater with a magnetic stirrer was used for heating and stirring the obtained blend. After the reaction was finished, the crude ethyl ester cooled to room temperature and it was waited at separation funnel approximately 8 hours. After 8 hours the crude glycerin was separated from crude ethyl ester and hot water used to wash the obtained crude ethyl ester. Washing process was repeated four times. After washing process, biodiesel was heated to 105oC until bright color occurred. Finally obtained ethyl ester was passed through a filter to remove water residuals. For optimization of parameters the same reaction set up was used. In this experimental tests, to examine the lowest cold flow properties, reaction parameters like as catalyst amount, ethanol to oil molar ratio, time of reaction and temperature of reaction were changed. The chosen parameter levels were shown in Table 1.1.

Table 1: *The Chosen Parameter Levels*

Parameters	Levels
Amount of catalyst (%)	0.3, 0.5, 0.7, 0.9, 1.0, 1.1
Ethanol to oil molar ratio	4:1, 5:1, 6:1, 7:1, 8:1
Time of reaction (min)	45, 60, 75, 90, 105
Temperature of reaction (°C)	50, 55, 60, 65

2.2 Analysis of Fuel Properties Method

Fuel analysis measurements were performed at the Cukurova University Automotive Engineering Laboratories. The fuel properties were measured according the standard test method. The measured fuel properties are density, kinematic viscosity, higher heating value, PP, CP and CFPP. Table 1.2 shows the specifications of fuel properties measurement devices.

Table 2: *The Specifications of Fuel Properties Measurement Device*

Property	Device	Accuracy
Density (kg/m^3)	Kyoto Electronics DA-130	±0.001 g/cm^3
Kinematic viscosity (cSt)	Tanaka AKV-202	±0.01cSt
Higher heating value (kj/kg)	IKA-Werke C2000	0.001 K
PP (°C)	Tanaka MPC 102L	±1 °C
CP (°C)	Tanaka MPC 102L	±1 °C
CFPP (°C)	Tanaka AFP 102	-

3. Result and Discussion

3.1 Catalyst Ratio

In the first reaction section, the ethanol/oil molar ratio: 6:1, temperature of reaction: 65, time of reaction: 60 minutes were kept constant and catalyst concentration was altered 0.3, 0.5, 0.7, 0.9, 1.0 and 1.1%. Impacts of catalyst concentration on cold flow properties are demonstrated in Figure 1, In the reaction of transesterification, the lowest cold flow properties are obtained at 0.5% catalyst concentration.

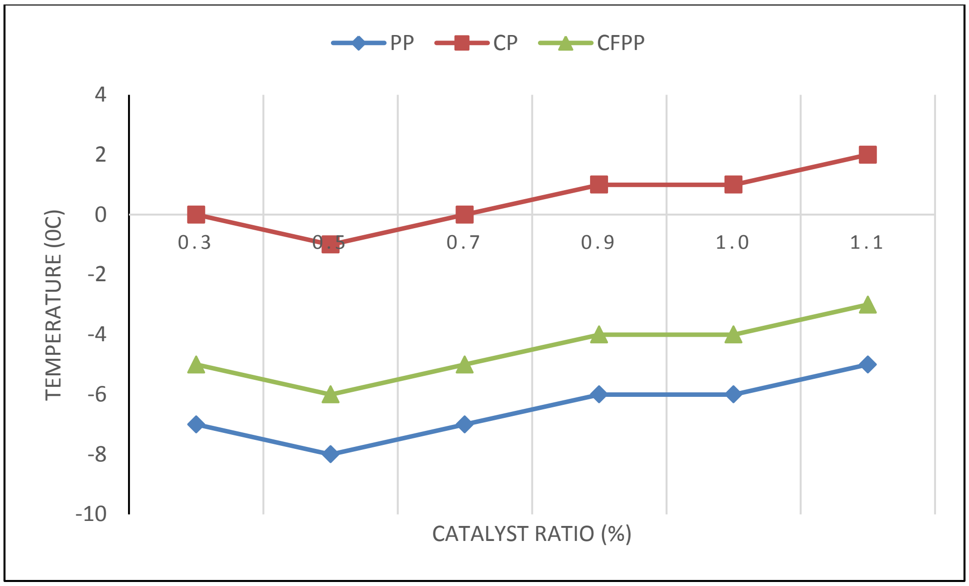

Figure 1: *The impacts of catalyst ratio on cold flow properties*

3.2 Ethanol to oil molar ratio

Figure 2 illustrates the impacts of molar ratio of ethanol/oil on PP, CP and CFPP. In transesterification reaction the lowest cold flow properties were acquired at the ethanol to oil molar ratio of 7:1.

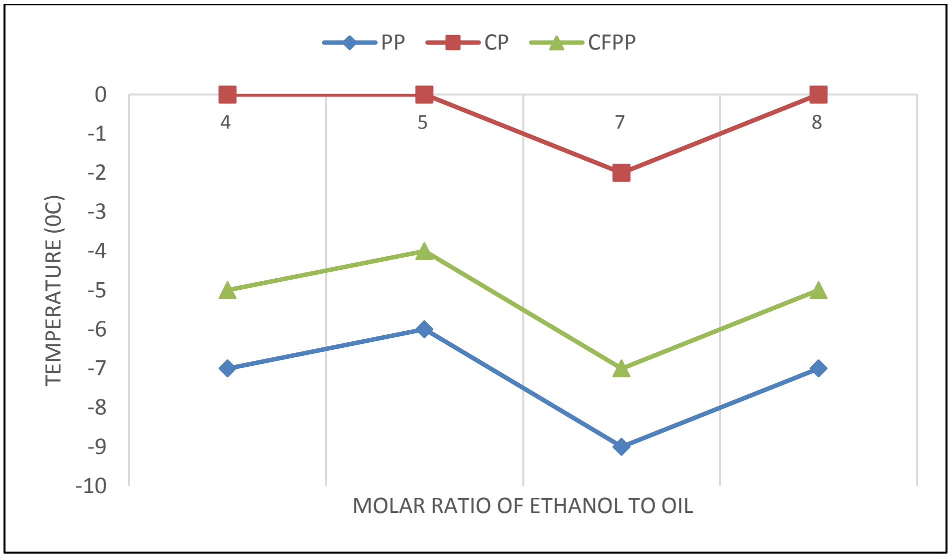

Figure 2: *The impacts of ethanol to oil molar ratio on cold flow properties*

3.3 Reaction time

The impacts of reaction time on cold flow properties is demonstrated in Figure 3. The catalyst amount and molar ratio of ethanol to oil were set 0.5% and 7:1. The temperature was kept constant at 60°C throughout the reaction. It was observed that when reaction time reaches 90 min, the lowest cold flow properties are obtained.

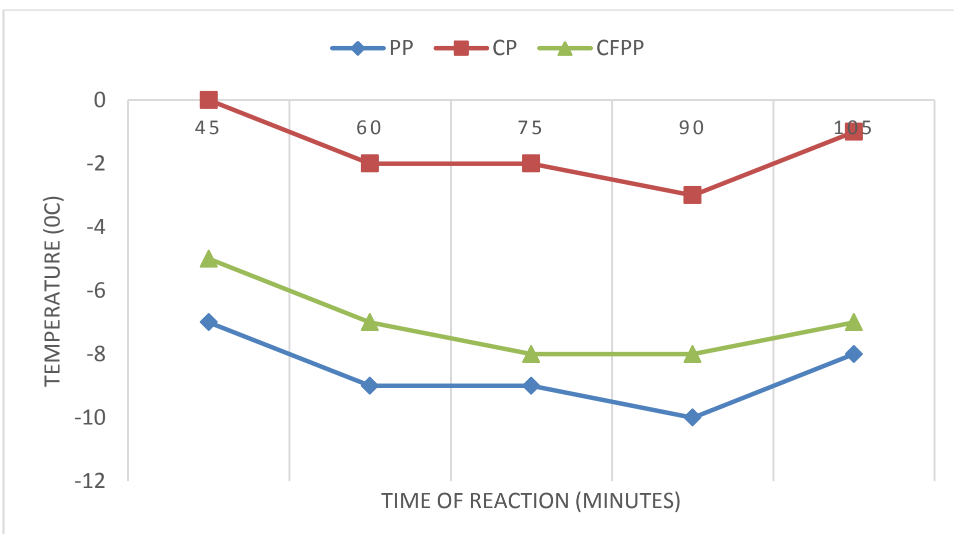

Figure 3: *The impacts of time of reaction on cold flow properties*

3.4 Reaction of temperature

Reaction temperature is one of the significant factors affecting the progress of the transesterification reaction. In the experiments the reaction time was changed between 50 ºC and 65 ºC. The impacts of the reaction temperature on the cold flow properties is shown in Figure 4.

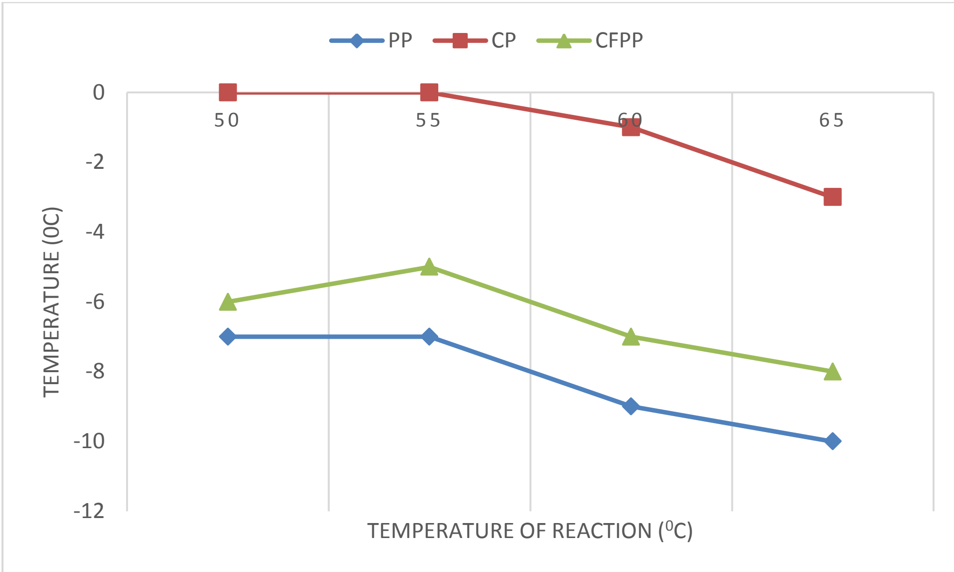

Figure 4: *The impacts of temperature of reaction on cold flow properties*

3.5 Fuel properties of Linseed biodiesel

The fuel properties of diesel fuel and the linseed biodiesel with the lowest cold flow properties which produced at optimum parameter are demonstrated in Table 1.3

Table 3: *Fuel Properties of diesel fuel and the linseed biodiesel with the lowest cold flow properties which produced at optimum parameter*

Property	Diesel	Linseed biodiesel	EN 14214
Density (kg/m^3)	836.7	892.4	860-900
Kinematic viscosity (cSt)	2.81	3.511	3.5-5
Higher heating value (kj/kg)	45855	39650	-
PP (ºC)	-14	-10	Summer < 4.0, winter < -1.0
CP (ºC)	-11	-3	-
CFPP (ºC)	-13	-8	-

4. Conclusions

Consequently, it has been observed from this work that the cold flow characteristics can be improved by changing parameter levels of transesterification reaction. In production process, the effects of catalyst amount (0.3, 0.5, 0.7, 0.9, 1.0, 1.1 wt%), molar ratio of ethanol to oil (4:1, 5:1, 6:1, 7:1, 8:1), reaction time (45, 60, 75, 90, 105 min) and reaction temperature (50, 55, 60, 65 ºC) were investigated. According to the results, the lowest cold flow characteristics were obtained at 0.5% catalyst concentration, 7:1 molar ratio of ethyl alcohol to oil, 90 min of reaction time, 65ºC of reaction temperature for KOH catalyst. Pour point, cloud point and cold filter plugging point of linseed biodiesel were found -10 ºC, -3 ºC, and -8 ºC, respectively. These outcomes can be seen very satisfactorily in the way of cold flow characteristics of linseed oil biodiesel.

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References

Abubakar, H.G., Abdulkareem, A.S., Jimoh., A., Agbajelola, O.D., Okafor, J.O. & Afolabi, E.A. (2016). Optimization of biodiesel production from waste cooking oil. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 38 (16), 2355–2361. https://doi.org/10.1080/15567036.2015.1040899

Ayetor, G.K., Sunnu, A. & Parbey, J. (2015). Effect of biodiesel production parameters on viscosity and yield of methyl esters: Jatropha curcas, Elaeis guineensis and Cocos nucifera. Alexandria Engineering Journal, 54, 1285-1290. https://doi.org/10.1016/j.aej.2015.09.011

Boz, N. & Sunal, O. (2009). Biodiesel production from canola oil over zinc oxide upported catalysts. J. Fac. Eng. Arch. Gazi Univ., 24, 389-395.

Buyuk, N. & Ozgur, T. (2016). Cold flow and fuel parameters of palm oil biodiesel. Journal of Çukurova University Science and Engineering, 34 (2), 11-20.

Dias, J.M., Araujo, J.M., Costa, J.F., Alvim-Ferraz, M.C.M. & Almeida, M.F. (2013). Biodiesel production from raw castor oil. Energy, 53, 58-66. https://doi.org/10.1016/j.energy.2013.02.018

Ivana, B.B.I., Stamenkovic, O.S. & Veljkovic, V.B. (2012). Biodiesel production from non-edible plant oils. Renewable and Sustainable Energy Reviews, 16, 3621–3647. https://doi.org/10.1016/j.rser.2012.03.002

Kafuku, G. & Mbarawa, M. (2010). Alkaline catalyzed biodiesel production from moringa oleifera oil with optimized production parameters. Applied Energy, 87, 2561–2565. https://doi.org/10.1016/j.apenergy.2010.02.026

Kılıç, M., Uzun, B.B., Pütün, A.E. & Pütün, E. (2013). Optimization of biodiesel production from castor oil using factorial design. Fuel Processıng Technology, 111, 105-110. https://doi.org/10.1016/j.fuproc.2012.05.032

Kumar, N., Soni, S.L., Sharma, D. & Srivastava, Kumar, A. (2016). Performance evaluation and emission analysis of variable compression ratio direct injection diesel engine. Matter: International Journal of Science and Technology, 2, 32-47.

Lavanya, C., Murthy, I.Y.L.N., Nagaraj, G. & Mukta, N. (2012). Prospects of castor (Ricinus communis L.) genotypes for biodiesel production in India. Biomass and Bioenergy, 39, 204-209. https://doi.org/10.1016/j.biombioe.2012.01.008

Rasimoglu, N. & Temur, H. (2014). Cold flow properties of biodiesel obtained from corn oil. Energy, 68, 57-60. https://doi.org/10.1016/j.energy.2014.02.048

Suh, H.K. & Lee, C.S. (2016). A review on atomization and exhaust emissions of a biodiesel-fuelled compression ignition engine. Renewable Sustainable Energy Rev., 58, 1601-1620. https://doi.org/10.1016/j.rser.2015.12.329

Swaminathan, C. & Sarangan, J. (2012). Performance and emission characteristics of a CI engine fuelled with biodiesel (fish oil) with DEE as additive. Biomass and Bioenergy, 39, 168-174. https://doi.org/10.1016/j.biombioe.2012.01.001

Takase, M., Zhao, T., Zhang, M., Chen, Y., Liu, H., Yang, L. & Wu, X. (2015). An expatiate review of neem, jatropha, rubber and karanja as multipurpose non-edible biodiesel resources and comparison of their fuel, engine and emission properties. Renewable and Sustainable Energy Reviews, 43, 495–520. https://doi.org/10.1016/j.rser.2014.11.049

Tuccar, G., Tosun, E., Ozgur, E. & Aydın, K. (2014). Diesel engine emissions and performance from blends of citrus sinesis biodiesel and diesel fuel. Fuel, 132, 7 – 11. https://doi.org/10.1016/j.fuel.2014.04.065

Uludamar, E., Karaman, V., Yıldızhan, Ş. & Serin, H. (2016). Improvement of density, viscosity and cold flow properties of palm oil biodiesel by alcohol addition. International Journal of Engineering Technologies, 2, 64-67. https://doi.org/10.19072/ijet.79988

Yadav, B.K., Soni, S.L., Sharma, D. & Sharma, P.K. (2017). Performance and emission analysis of constant speed SI engine operated on hythane (HCNG). Matter: International Journal of Science and Technology, 3, 64-79.

Yang, L., Takase, M., Zhang, M., Zhao, T. & Wu, X. (2014). Potential non-edible oil feedstock for biodiesel production in Africa: A survey. Renewable and Sustainable Energy Reviews, 38, 461–477. https://doi.org/10.1016/j.rser.2014.06.002