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The influence of methyl esters on viscosity of biodiesel from waste and rapeseed oil blends

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ABSTRACT

Purpose: The aim of this article is to present problems in the production of energy from the renewable resources as is a biodiesel production. The use of human foods that are pure edible oils for biodiesel production is big ethical problem. This problem can be reduced with use of waste cooking oils for the biodiesel production. Besides this use of the waste cooking oils will reduce the raw material cost and also reduce the environment pollution that is a global problem.

Design/methodology/approach: This article includes analysis and estimation of the methyl esters impact to the kinematic viscosity of biodiesels produced from various percentages of waste cooking oils and crude rapeseed oil blends. One of the most important physical properties of biodiesel that affect its use value is kinematic viscosity properties which are directly dependent on the composition of raw materials. After the transesterification process mono-alkyl esters (biodiesel), glycerol (main co-product), alcohol, catalyst, free fatty acids, residual glycerides compose the final mixture of biodiesel production process. Some important issues on the biodiesel quality control involve the monitoring of transesterification process with the quantification of mono-alkyl esters.

Findings: With an increase of methyl esters content the kinematic viscosity of produced biodiesels decreases for both waste cooking oils WCO1 and WCO2, used for biodiesel production in various blends with crude rapeseed oil.

Practical implications: The results presented in the paper can be applied in the industry for estimation and selection of the optimal percentages of waste cooking oils and crude rapeseed oil blends for the biodiesel production.

Originality/value: This paper presents research of the influence of methyl esters on kinematic viscosity of biodiesels produced from the various blends of waste cooking oils and crude rapeseed oil. The further testing and improvements in waste oils purification and in transesterification process can lead to the better yield in biodiesel production.

Keywords: Biodiesel production; Waste cooking oils; Crude rapeseed oil; Methyl esters; Kinematic viscosity

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PROPERTIES

1. Introduction

Pollution of the natural environment is a global problem which demands a big effort to be reduced. Realization of these efforts is in an implementation of the waste management as soon as possible [1]. The sustainable development has become the main indicator of how to implement the principles for the protection of the environment [2]. Every technological process in general way can be described with three basics: input (raw materials and energy), output (products) and after exploitation (waste) which makes growing environmentally threat [3]. Use of waste cooking oils for biodiesel production has a big impact on the protection of environment. A major obstacle in the commercialization of biodiesel from pure vegetable oils, in comparison to petroleum-based diesel fuel, is its cost of manufacturing, primarily the raw material [4]. Biodiesel can be produced from vegetable edible and non-edible oils, waste cooking oils and animal fats or from the blends. Vegetable oils can be edible such as cottonseed, corn, rapeseed, soybean, palm oil, sunflower, peanut, coconut, etc. and no edible such as jatropha, pongamia, silk cotton tree, jojoba, and castor oil. Animal fats can be tallow, lard, and yellow grease, etc. Production of bio fuels from human nutrition sources can cause a food crisis. Therefore, the majority of researchers have focused on non-edible oils or waste cooking oils as raw material for biodiesel production. Also, use of waste cooking oils as raw materials to biodiesel production decrease cost of its production. The price of waste cooking oils (WCO) is 2-3 times cheaper than pure vegetable oils. Consequently, the total manufacturing cost of biodiesel can be significantly reduced [5]. Moreover, if these oils will be used as a raw material for biodiesel production the pollution of environment can be significantly reduced. The most widely used oil for biodiesel production in Europe is rapeseed oil. One of the major issues when using biodiesel is fuel properties.

Generally, if waste cooking oils are used for biodiesel production then the value of kinematic viscosity is differ between biodiesel fuels because of different fatty acids present in raw material. However, it may be expected that the properties of biodiesel derived from waste cooking oils or fats can differ widely. One reason is that different vegetable oils are used by different facilities. Another reason is that the oils or fats are likely exposed to varying degrees of use such as temperature and time, thus increasing the variability of composition and resulting properties even more.

The lower kinematic viscosity of mono-alkyl esters vs. the raw materials is the major reason why these raw materials are transesterified to biodiesel. The lower viscosity of biodiesel leads to reduced operational problems in diesel engines as fuel atomization in the cylinder is improved by lower viscosity. Because of that the production of diesel fuel from vegetable oils and animal fats needs a transesterification catalyzed process which converts triglycerides (oils and fats) into fatty acid methyl or ethyl esters (biodiesel) and reduces the molecular weight to one third that of the triglyceride and decreases the viscosity of vegetable oils. Biodiesel with lower kinematic viscosity values can be used as fuels for diesel engine applications without major modifications [6].

Characteristics of biodiesel strongly depend on various raw materials as an edible and non-edible oils, animal fats and waste cooking oils that affect the physical and chemical properties [7]. One of the most important parameters that affect the engine performance and the emission characteristics is the biodiesel properties of kinematic viscosity. The higher kinematic viscosity of the biodiesel in comparison to petroleum-based diesel fuel when used in a diesel engine causes poor fuel atomization during spray, increases the carbon deposition on fuel filter, demands more energy from the fuel pump and wears the fuel pumps and injectors [8,9]. The viscosities of biodiesel fuels are twice that of petroleum-based diesel fuel D2 [10]. The Fig. 1 shows chart of the kinematic viscosity for various petroleum-based diesel and biodiesel fuel standards, along with a sample of reported measurements for various types of biodiesels [11].

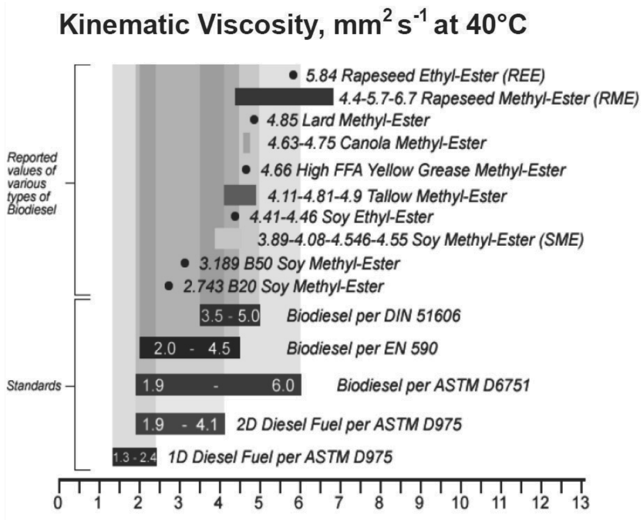

Fig. 1. Chart of the kinematic viscosity for various petroleum-based diesel and biodiesel fuel standards along with a sample of reported measurements for various types of biodiesel [11]

The main components of biodiesel and the chemical species that gives biodiesel similar petroleum-based diesel properties are esters, or more specifically fatty acid mono-alkyl esters. The total ester content is a measure of the completeness of the transesterification reaction [12]. One of the possible ways to get a cheaper biodiesel with appropriate kinematic viscosity that remain within acceptable limits is with mixing a different percentages of crude soybean oil into biodiesel. Fig. 2 shows effect of crude soybean oil in biodiesel on its kinematic viscosity [13,14]. From Fig. 2, it can be observed that the kinematic viscosity of samples increased as the soybean oil content increased. High viscosity of soybean oil is due to high molecular mass and large chemical structure. The viscosity of pure vegetable oils is 10-15 times greater than the viscosity of diesel. Transesterification of vegetable oils produces esters with a viscosity of approximately twice that of diesel. Vegetable oils have high molecular weights in the range 600–900, which are three or more times higher than petrodiesel fuels [14]. The another one of the possible ways for cheaper biodiesel production with appropriate kinematic viscosity that remain within acceptable limits is its production from blends of different percentages of various waste cooking oils and crude vegetable oil.

The quality of collected waste cooking oils can create problems in biodiesel production efficiency because of possible difference in chemical species present in these waste cooking oils [15]. An objective of this paper is to present an impact of methyl esters to the kinematic viscosity at 40°C of biodiesels produced from various percentages of waste cooking oils and crude rapeseed oil blends.

2. Materials and methods

2.1. Materials

In an experimental production of biodiesel were used as raw materials for biodiesel production: 1) WCO1 that is the waste cooking oil mixture and 2) WCO2 that is the waste cooking oil from Mc Donald's restaurants with prevalent rapeseed oil mixed with sunflower oil, palm oil and animal fats in blends with crude rapeseed oil. During cooking, edible oils are constantly exposed to chemical reactions due to their composition and external influences. Before transesterification process the purification of waste cooking oils were performed. Biodiesel was produced with use of two-step process for the oils transesterification. Process of transesterification was catalyzed by use of sodium hydroxide.

2.2. Analytical methods

The fatty acid methyl esters content was determined by a method in accordance with the CSN EN 14103 Standard. Kinematic viscosity determined at 40 °C according to the EN ISO 3104 standard.

2.3. Test procedure

After the transesterificatoin processes the samples for testing the impact of methyl esters on biodiesel kinematic viscosity were prepared, for example, as a blend of the 10% WCO1 with 90% crude rapeseed oil. Percentages of WCO1 and WCO2 were increased in the samples at 20%, 30% and 50% in the blends with crude rapeseed oil.

3. Results

The obtained results of measured kinematic viscosity at 40°C for biodiesels produced by different percentages of waste cooking oils and crude rapeseed oil blends are shown in Table 1. The values of kinematic viscosity of biodiesels produced by different waste cooking oil blends and crude rapeseed oil measured at 40°C showed no big difference between them. Also, results of measured kinematic viscosity of produced biodiesels showed no big difference between raw material type.

The influence of methyl esters contet on kinematic viscosity of produced biodiesels from waste cooking oil WCO1 and crude rapeseed oil blends is showed in Fig. 3.

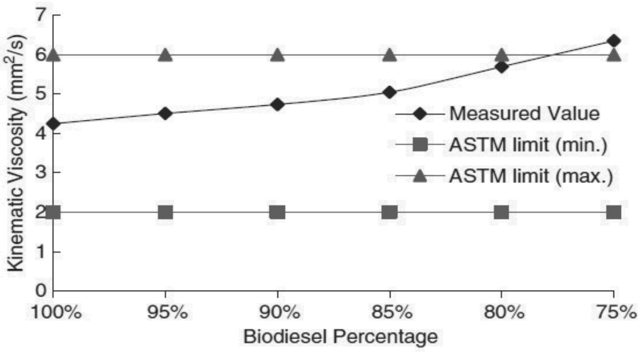

Fig. 2. Effect of raw oil presence in biodiesel on kinematic viscosity [13]

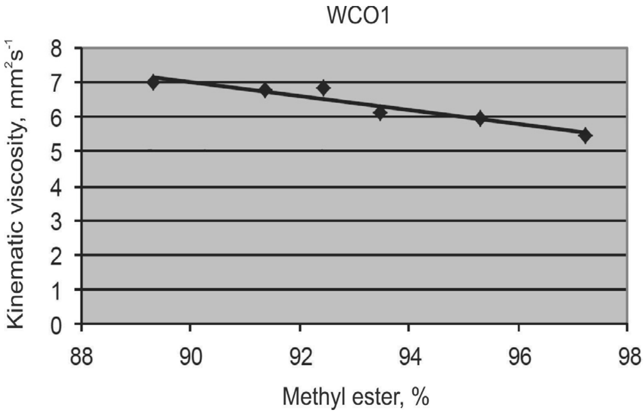

Fig. 3. The influence of methyl esters contet on kinematic viscosity of produced biodiesels from waste cooking oil WCO1 and crude rapeseed oil blends

The influence of methyl esters contet on kinematic viscosity of produced biodiesel from waste cooking oil WCO2 and crude rapeseed oil blends is showed on Fig. 4.

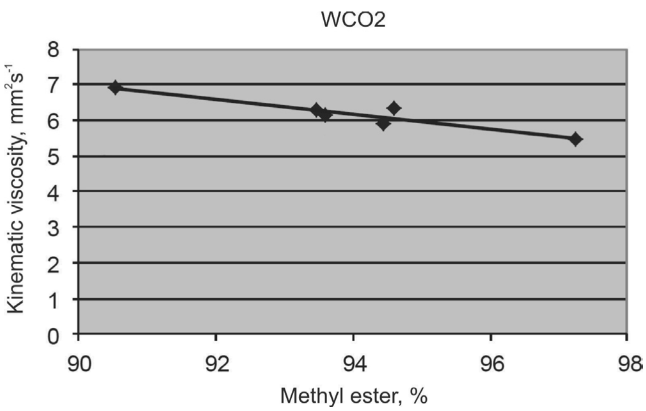

Fig. 4. The influence of methyl esters contet on kinematic viscosity of produced biodiesel from waste cooking oil WCO2 and crude rapeseed oil blends

Table 1.
Kinematic viscosity at 40°C, mm^2s^{-1} of biodiesels produced by various percentages of the waste cooking oils and crude rapeseed oil blends

Oil type	Waste cooking oil				Crude rapeseed oil
%	10	20	30	50	100
WCO1	5.90	6.14	6.28	6.35	6.91
WCO2	5.97	6.11	7.02	6.77	9.84
Crude rapeseed oil					5.94

Figs. 3 and 4 showed that for both waste cooking oils WCO1 and WCO2, used for biodiesel production in various blends with crude rapeseed oil, an increase in methyl esters contet the kinematic viscosity of produced biodiesels considerably decreases.

The influence of waste cooking oils WCO1 and WCO2 content in blends with crude rspeseed oil on the methyl esters content in produced biodiesel, i.e. on usefulness of transesterification is showed on Figs. 5 and 6.

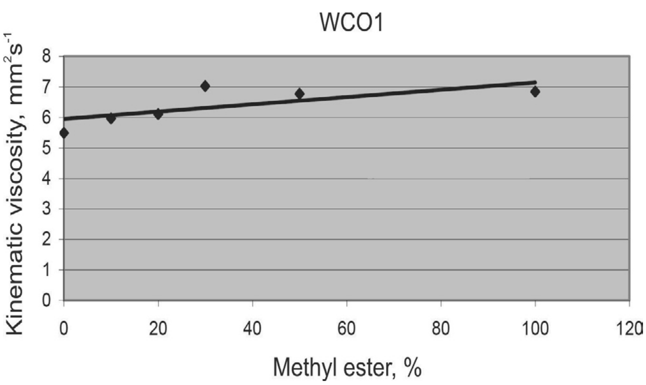

Fig. 5. The influence of waste cooking oil WCO1 content in blends with crude rspeseed oil on the methyl esters content in produced biodiesel, i.e. on usefulness of transesterification

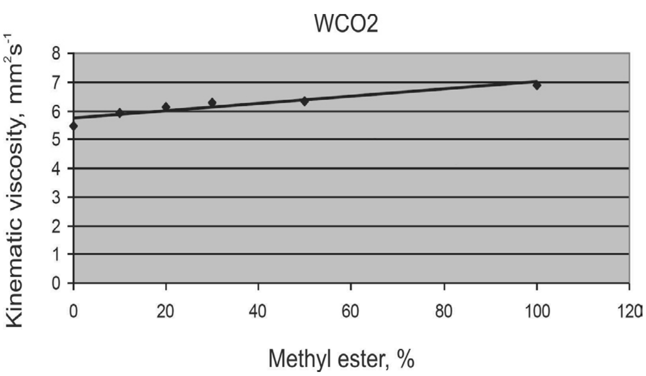

Fig. 6. The influence of waste cooking oil WCO2 content in blends with crude rspeseed oil on the methyl esters content in produced biodiesel, i.e. on usefulness of transesterification

4. Conclusions

With an increase of methyl esters content the kinematic viscosities of produced biodiesels decreases for both waste cooking oils WCO1 and WCO2, used for biodiesel production in various blends with crude rapeseed oil. The bigger percentages of waste cooking oils WCO1 and WCO2 in blends with crude rapeseed oil increase kinematic viscosity of produced biodiesels with a decrease of methyl esters content. Lower content of waste cooking oils in raw materials for biodiesel production gives better results. The obtained results showed that the kinematic viscosities of produced biodiesels depend of raw materials quality. Level of efficiency for the transesterification process is closely linked to the chemical composition of raw materials for biodiesel production. To achieve optimal biodiesel kinematic viscosity value it is need an improvement of biodiesel production from waste cooking oils. Better quality of the waste cooking oil purification lead to the optimal biodiesel kinematic viscosity values.

References

[1] R. Nowosielski, A. Zajdel, Recycling's technology, Journal of Achievements in Materials and Manufacturing Engineering 21/2 (2007) 85-88.

[2] R.H. Kozłowski, E. Kozłowska, LL.M., The polish proposal for environmental protection, Journal of Achievements in Materials and Manufacturing Engineering 55/1 (2012) 121-128.

[3] R. Nowosielski, M. Spilka, Sustainable technological process as an element of the sustainable development strategy realisation, Journal of Achievements in Materials and Manufacturing Engineering 48/2 (2011) 200-208.

[4] I.M. Atadashi, M.K. Aroua, A. Abdul Aziz, High quality biodiesel and its diesel engine application, A review Renewable and Sustainable Energy Reviews 14 (2010) 1999-2008.

[5] Y. Zhang, M.A, Dube, D.D McLean, M. Kates, Biodiesel production from waste cooking oil: 2, Economic assessment and sensitivity analysis, Bioresource Technology 90 (2003) 229-240.

[6] H. Raheman, A.G. Phadatare, Diesel engine emissions and performance from blends of karanja methyl ester and diesel, Biomass Bioenergy 27 (2004) 393-400.

[7] Z. Jurac, V. Zlatar, Optimization of raw material mixtures in the production of biodiesel from vegetable and used frying

oils regarding quality requirements in terms of cold flow properties, Fuel Processing Technology 106 (2013) 108-113.
[8] L. Meher, D.Vidya Sagar, S. Naik, Technical aspects of biodiesel production by transesterification a review, Renewable and Sustainable Energy Reviews 10/3 (2006) 248-268.
[9] R. Tate, K.C. Watts, C.A. Allen, K.I. Wilkie, The viscosities of three biodiesel fuels at temperatures up to 300°C, Fuel 85/7-8 (2006) 1010-1015.
[10] B. Tesfa, R. Mishra, F. Gua, N. Powles, Prediction models for density and viscosity of biodiesel and their effects on fuel supply system in CI engines, Renewable Energy 35 (2010) 2752-2760.
[11] B. Gutti, S.S. Bamidele, I.M. Bugaje, Biodiesel kinematics viscosity analysis of Balanite aegyptiaca seed oil, Journal of Engineering and Applied Sciences 7/ 4 (2012) 432-435.
[12] G. Knothe, K.R. Steidley, Kinematic viscosity of fatty acid methyl esters: Prediction, calculated viscosity contribution of esters with unavailable data, and carbon-oxygen equivalents, Fuel 90 (2011) 3217-3224.
[13] G. Knothe, K.R. Steidley, Kinematic viscosity of biodiesel fuel components and related compounds, Influence of compound structure and comparison to petrodiesel fuel components, Fuel 84 (2005) 1059-1065.
[14] S. Fernando, P. Karraa, R. Hernandez, S.K. Jha, Effect of incompletely converted soybean oil on biodiesel quality, Energy 32 (2007) 844-851.
[15] S. Kagawa, K. Takezono, S. Suh, Y. Kudoh, Production possibility frontier analysis of biodiesel from waste cooking oil, Energy Policy 55 (2013) 362-368.