Advances in Environmental Biology, 8(12) July 2014, Pages: 147-151

AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/

Kinematic Viscosity of Linseed Oil, Almond Oil and Diesel Fuel

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A R T I C L E I N F O

Article history:
Received 2 April 2014
Received in revised form
13 May 2014
Accepted 28 June 2014
Available online 23 July 2014

Keywords:
Vegetable oil, Diesel fuel, Kinematic viscosity, infinite-temperature viscosity, activation energy, Arrhenius equation.

A B S T R A C T

This work deals with the kinematic viscosity versus temperature measurements of linseed oil, almond, and diesel fuel oil at temperatures ranging from 283-343 K. There is a decrease in kinematic viscosity with increase in temperature. We have used the well-known Arrhenius-type relationship to evaluate the activation energies, and the infinite-temperature viscosities of selected oils. The experimental data were fitted and the correlation coefficients (R2) indicated good fit for the Arrhenius model.

To Cite This Article: Imane Hassanain, Maryem Belgharza, Imane Louzi, El Habib EL Azzouzi, Khouloud Lakrari, Faouzia Hlimi, Mohamed Alaoui El Belghiti, Kinematic Viscosity of Linseed Oil, Almond Oil and Diesel Fuel. ***Adv. Environ. Biol., 8(12),*** *147-151, 2014*

INTRODUCTION

The use of vegetable oil as biodiesel, has increased significantly in many countries, this oils contain an important amount of unsaturated fatty acids [1–3]. Use of vegetable oils in diesel engines leads to slightly inferior performance and higher smoke emissions due to their high viscosity. Biodiesel has high oxidation stability, and ignition heat generation is uniform. However, vegetable oil is limited in the production of biodiesel, since it is prepared from seed-oil plants, and cultivated land needed to grow enough plants is limited [4,5]. Viscosity is one of the most important oil properties. The effects of viscosity can be seen in the combustion of oil inside the engine compartment. The higher viscosity of vegetable oils compared to diesel fuel, is an inconvenient to use directly as fuels, the high viscosities of vegetable oils, are apparently responsible for premature injector, leading to poorer atomization [6]. Some researchers tried to reduce viscosity of oil by heating it and also blending it with mineral diesel [7].

The aim of this paper is to report from experimental results of viscosity, the effect of temperature on the kinematic viscosity of three oils. The effect of T on the kinematic viscosity of liquid is described by means of the Arrhenius equation (1) which describes the exponential decrease of kinematic viscosity versus T [8,9,10]:

$$\nu = A\exp(E_a/RT) \qquad (1)$$

where ν is the kinematic viscosity, A is the pre-exponential factor (m^2/s), E_a is the activation energy (J/mol), which is used to represent the stability of the liquid system, R is the gas constant (J/mol/K) and T is the temperature (K). The value of A can be approximated as the infinite-temperature viscosity (ν_∞), which is exact in the limit of infinite temperature [11].

The, equation (1) can be rewritten in the following form:

$$\ln(\nu) = \ln(A) + (E_a/RT) \qquad (2)$$

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MATERIAL AND METHODS

Materials:

The viscosity is measured by a viscometer Osswald:

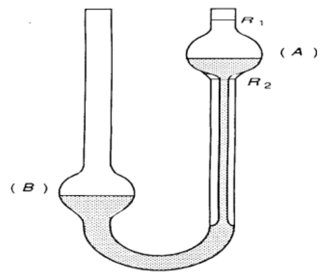

Fig. 1: Osswald viscosimeter.

Methods:

Measurement of the dynamic viscosity of vegetable oils:

Measuring the time of a flow of a volume V of fluid through a capillary tube. The kinematic viscosity is proportional to the flow time:

$(\eta = k \ \Delta t)$ (3)

The constant K of the device is given by the manufacturer of the viscometer.

RESULTS AND DISCUSSIONS

The combustion characteristics of vegetable oils and diesel are close enough at high, temperature, so as to burn the biodiesel oils in a diesel engine, two physical properties must be addressed to ensure proper operation: the viscosity and surface tension of vegetable oils must be reduced. Fortunately, the viscosity of some vegetable oils at high temperature is approximately equal to that of diesel oil.

The viscosity of all studied oils decreased as the temperature increased. This could be due to the energy obtained to surmount the resistance to flow, which may be due to the attractive forces among the oil molecules. A similar behavior is also observed for various other vegetable oil fuels [12]. A plot of ln(kinematic viscosity) versus 1/T was plotted for each oil. The slope of the straight line, the intercept and the regression coefficient were calculated using the tendency line of the plot. The activation energy value Ea was calculated as the slope of the plot multiply by the gas constant R, and the constant A was an exponential of the intercept.

From Figure 2, one can see that the variation of the kinematic viscosity of linseed oil with temperature.

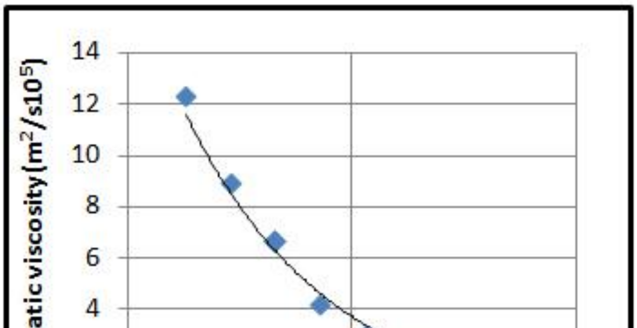

Fig. 2: Kinematic viscosity of linseed oil versus temperature.

Figure 3 shows ln(kinematic viscosity) versus 1/T using equation (2). This observation is supported with an overall R-squared value of 0.989. This suggests that the experimental data are well-fitted by the Arrhenius model. The infinite-temperature viscosity and the activation energy were determined from this plot (table 1).

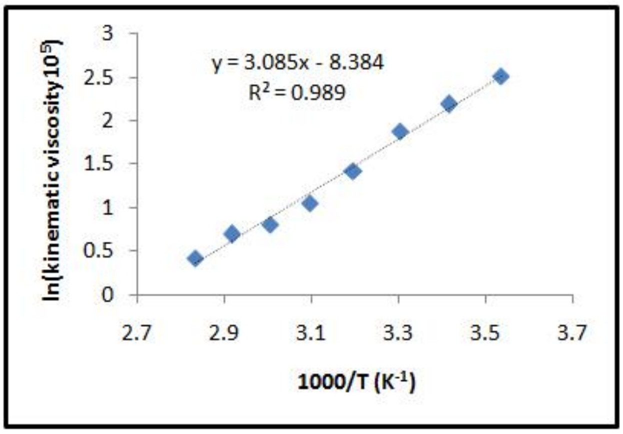

Fig. 3: Dependence of $\log_e$(kinematic viscosity) versus 1/T for Linseed vegetable oil.

The variation of kinematic viscosity with temperature is plotted in figure 4, we can observe decrease of ν when temperature augments. Figure 5, shows the variation of ln(kinematic viscosity) of almond oil with 1/T, from this curve we have deduced the activation energy and the infinite-temperature viscosity (ν_∞). R squared value is 0.983, indicating that the fit is excellent for this data.

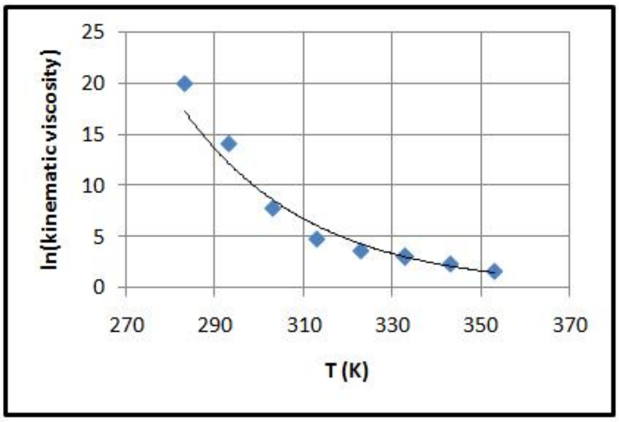

Fig. 4: Kinematic Viscosity of almond oil versus temperature.

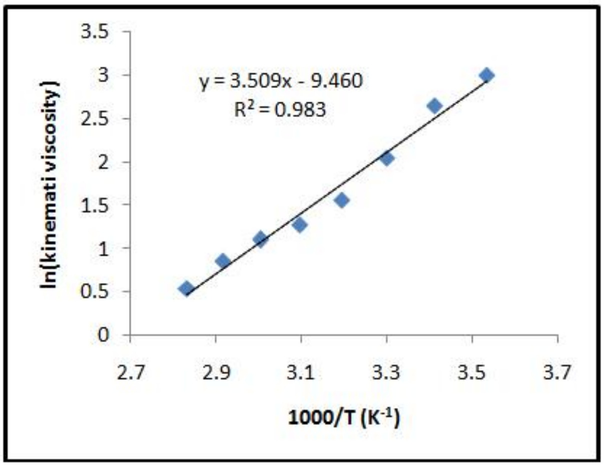

Fig. 5: Dependence of $\log_e$(kinematic viscosity) versus 1/T for almond vegetable oil.

To compare the physical properties (kinematic viscosity) of some vegetable oils, with those of diesel fuel, we have plotted in figure 6, the variation of kinematic viscosity of diesel fuel with temperature. And from the plot of ln(kinematic viscosity) of diesel oil versus 1/T (figure 7), we have deduced Ea and ($\nu\infty$) of that fuel [13].

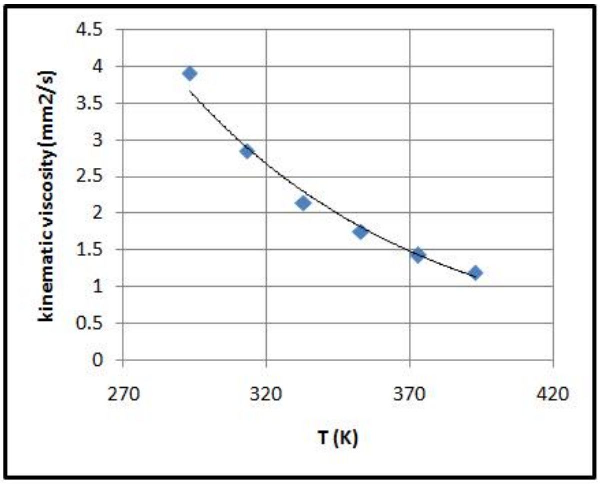

Fig. 6: Kinematic viscosity of diesel [13]

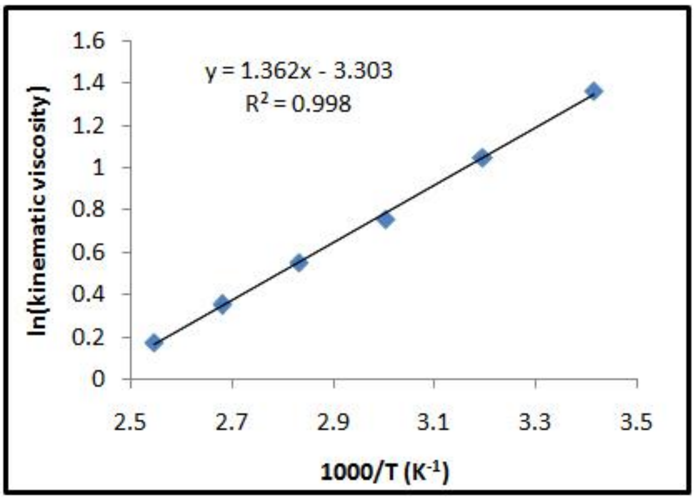

Fig. 7: Dependence of $\log_e$(kinematic viscosity) versus 1/T for diesel oil.

oil	ν_∞ (mm^2/s)	Ea(kJ/mole)	R^2
Linseed oil	0.002	25.64	0.989
Almond oil	0.001	29.16	0.983
Diesel fuel	0.37	11.32	0.998

Conclusion:

In order to investigate the effect of various temperature conditions on vegetable oil and diesel viscosity, we have studied the variation of the kinematic viscosity with the temperature. These curves allowed us to determine the activation energies, and the infinite-temperature viscosities. For our vegetable oils, the infinite viscosities are inferior to that of diesel, this result, allows us to conclude that these oils can have a viscosity required for the operation of diesel engines at high temperatures.

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