ORIGINAL PAPER

STUDIES CONCERNING VEGETABLE OILS USED AS BIODEGRADABLE LUBRICANT

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Abstract. *Biodegradable oils are at present a powerful performance in the field of lubrication of machinery and machines that work predominantly under conditions that make it possible to pollute the environment. This refers to machinery and equipment in agriculture, construction industry, marine, forestry, printing, drilling, railways, automotive, and food industries, where environmental pollution is reduced as a result of losses of lubricants on soil or water.*

Viscosity, shear stress, shear rate, yield value, plastic, pseudoplastic and thixotropic models, viscometer and rheometer types are the major issues discussed in rheology. This article proposes several dependency of dynamic viscosity with shear rate. Rheological characteristics of vegetable oils were measured with rotational co-axial cylinder rheometer at different temperatures of 40-90 °C.

Keywords: *vegetable oil, viscosity, lubricant.*

1. INTRODUCTION

The physical and chemical properties of vegetable oils greatly influence the quality of the final product as well as the processing procedures. Rheological properties have an important role. Rheological properties are very often determined to demonstrate the behavior of solutions, suspensions and mixtures [1-4]. Vegetable oils are a typical example of such material. A basic parameter obtained during the rheological study of vegetable oils is the viscosity used to characterize the fluid texture [5-7]. Another important factor is temperature, which occurs frequently in rheological equations [8]. In the case of vegetable oils, viscosity increases with the chain length of triglyceride fatty acids and decreases with unsaturation, which decreases with hydrogenation. Viscosity is a function of the size and orientation of molecules [9, 10]. The physical properties (including viscosity) of short chain pure triglycerides were evaluated in previous studies [11-13]. These studies have tried to develop models when using triglyceride oils to replace them as diesel. Studies on the rheological properties of binary triglyceride mixtures have been published [14-16]. These investigations have attempted to understand how these compounds interact with each other and how the chain triglyceride length affects the physical properties of edible oils. Studies related to the properties of pure chain triglycerides in pure state and simple blends can be very useful in the development of different valuable products. On the other hand, natural vegetable oils are not composed of pure triglycerides or simple binary mixtures of triglycerides. They are complex mixtures of many triglycerides with different chain lengths. The physical properties of short-chain triglycerides obtained from a natural source have recently been evaluated. The

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rheological properties of two complex mixtures of short chain triglycerides were experimentally determined in a temperature range of 25-80 °C [15-21].

In the present paper presents the variation of the dynamic viscosity with the shear stress for to non-additive vegetable oils: sunflower, soybean and coconut.

2. MATERIALS AND METHODS

The determinations of dynamic viscosity of vegetable oils (oil sunflower, oil soybean, oil coconut) were done a viscometer using a Haake VT 550. The dynamic viscosity was determined for shear rates ranging between 3.3 and 120 s^{-1}, the temperature varying between 40 °C and 100 °C, respectively. In order to change and control the working temperature value, a thermostatic bath was used. Measurements were done starting from 40 °C and at each 10 °C more, till the temperature of 100 °C was reached.

3. RESULTS AND DISCUSSION

Table 1 shows composition of these three vegetable oils: oil sunflower, oil soybean and oil coconut.

Table 1. GC Fatty acid distribution in the investigated oils.

Fatty acid	Sunflower oil	Soybean oil	Coconut oil
C14	0.1543	0.0734	19.9000
C16	8.9809	10.3189	-
C16: 1cls9	0.1813	0.1011	-
C17	-	0.5440	-
C18	3.4523	5.5077	2.7000
C18:1cls9	28.3845	22.7286	-
C18:1cls11	0.7991	1.5124	-
C18:1cls13	-	0.0668	-
C18: 2trans	0.1453	0.1375	-
C18: 2cis	57.4021	50.8705	1.6000
C18: 3trans	-	0.1998	-
C18: 3cis	0.3521	6.6735	-
C20	-	0.5684	-
C20:1	-	0.4230	-
C22	-	0.5430	-

The results are presented in Figs. 1-5. From analyzing these figures it is noticed that viscosity has the some decrease with the increase shear rate for all the three oils studied at different temperatures. This viscosity decreases with the increase of the shear rate shows that these oils have the properties of some pseudoplastic non-Newtonian fluids.

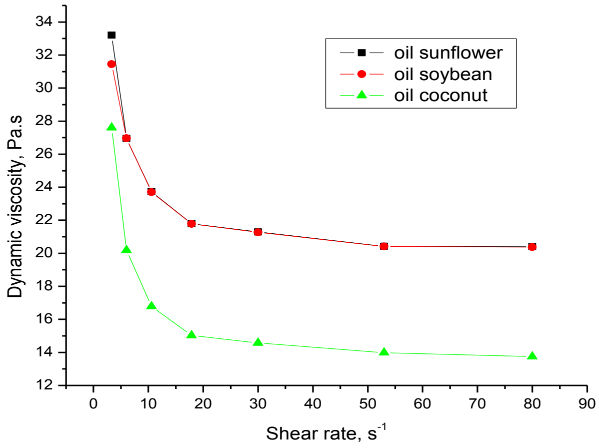

Figure 1. Dependence dynamic viscosity versus shear rate at temperature 40 °C.

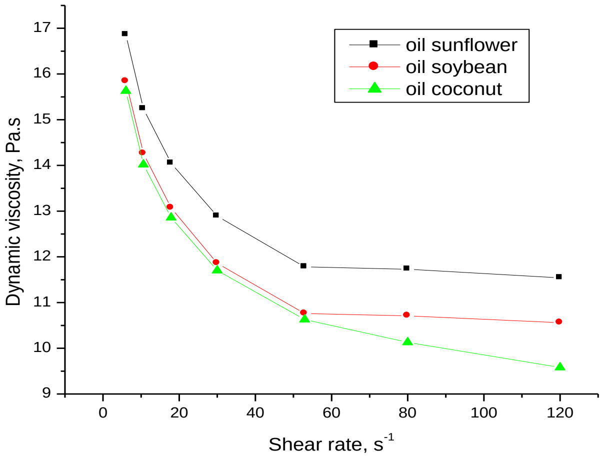

Figure 2. Dependence dynamic viscosity versus shear rate at temperature 50 °C.

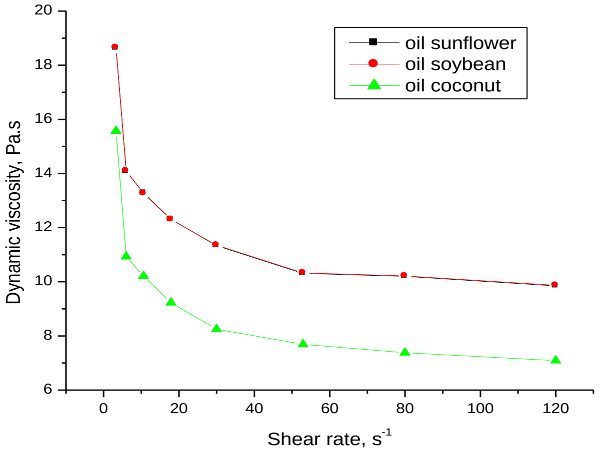

Figure 3. Dependence dynamic viscosity versus shear rate at temperature 60 °C.

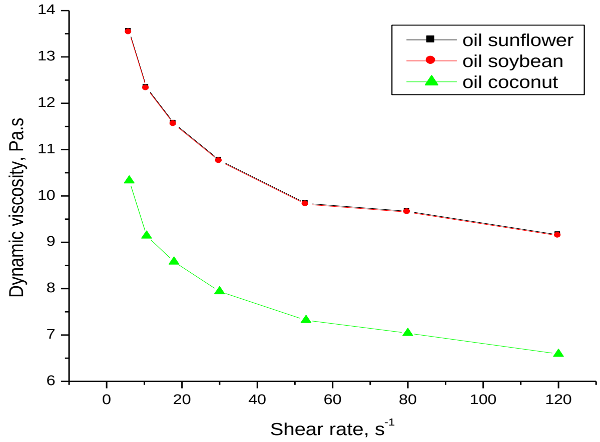

Figure 4. Dependence dynamic viscosity versus shear rate at temperature 70 °C.

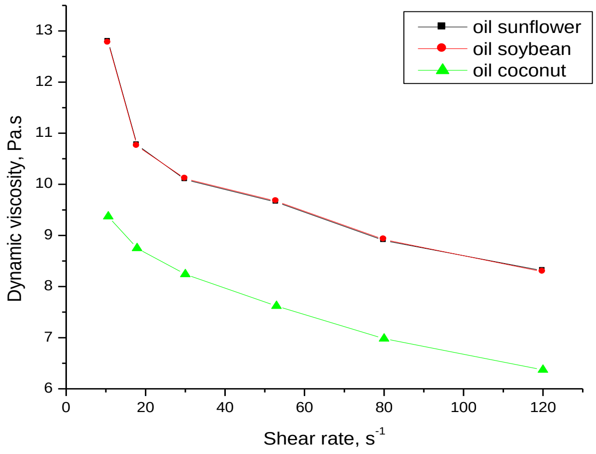

Figure 5. Dependence dynamic viscosity versus shear rate at temperature 90 °C.

In Figs. 6-8 it was represented, according to the experimental determination, the variation of the viscosity with temperature for three shear rate 10.6, 30, 80 s^{-1}, respectively. Analyzing the three figures we can see that the viscosity decreases with the temperature for all the three shear rates and for all three studied oils.

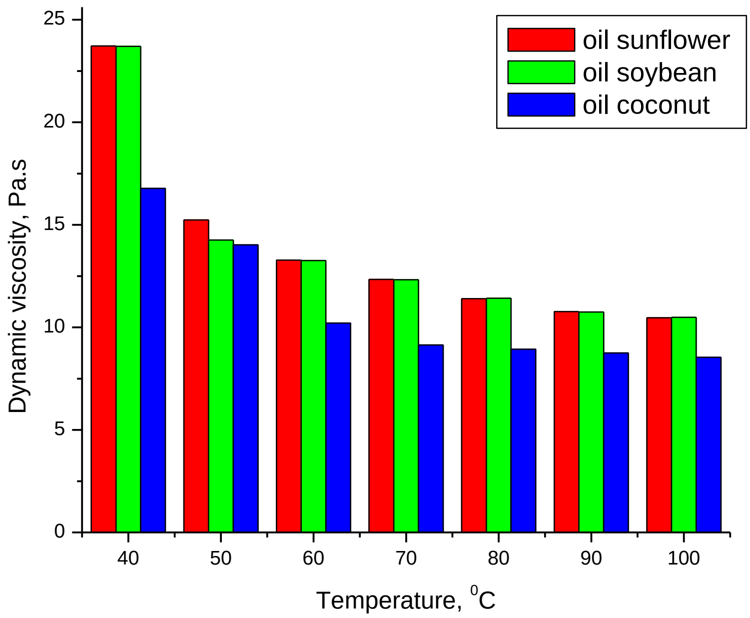

Figure 6. Viscosity dynamic versus temperature at shear rate 10.6 s^{-1}.

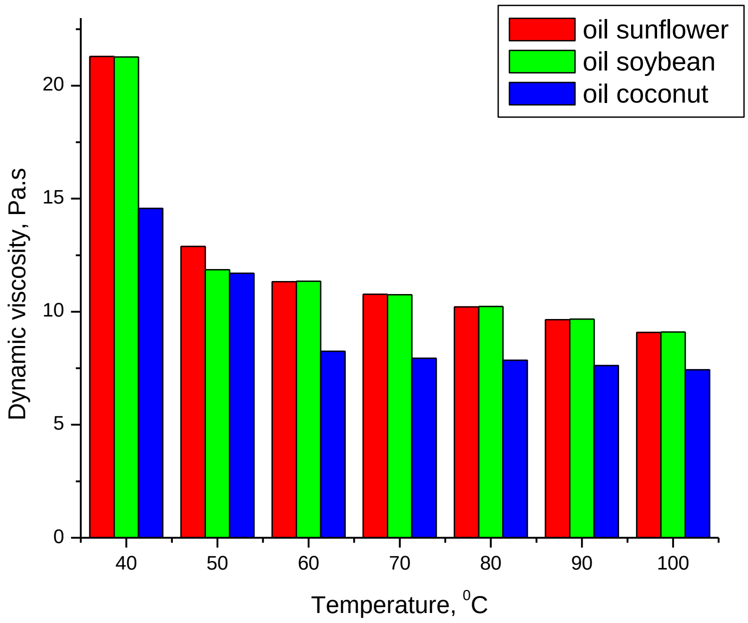

Figure 7. Viscosity dynamic versus temperature at shear rate 30 s^{-1}.

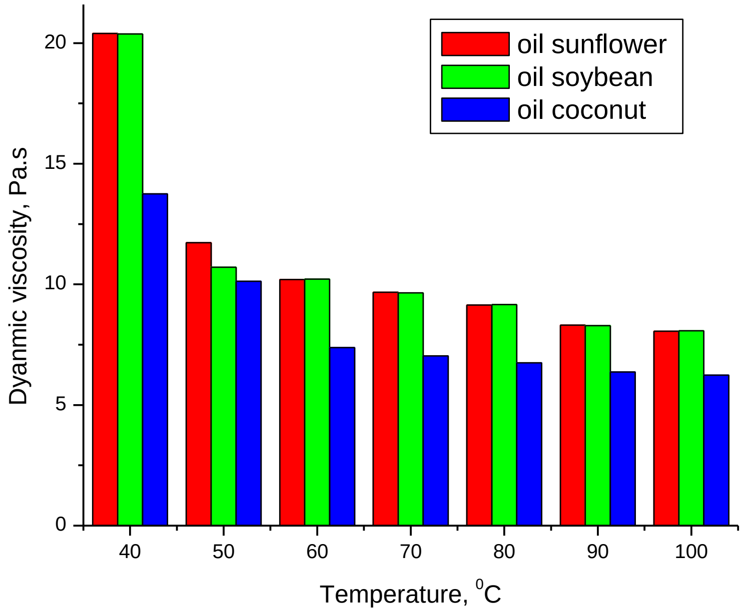

Figure 8. Viscosity dynamic versus temperature at shear rate 80 s^{-1}.

4. CONCLUSION

Biodegradable oils based on vegetable oils are of particular interest lately in view of the protection of the environment. The characteristics of biodegradable oils are comparable, in some cases even better than mineral oils used for the same applications. The paper presented the behavior of oil sunflower, oil soybean and oil coconut for their use as ecological lubricants.

REFERENCES

[1] Murarescu, O. et al., *Rev. Chimie (Bucharest)*, **69**(5), 1037, 2018.
[2] Murarescu, O., Pehoiu, G., *Proceedings of the 5th IASME/WSEAS Water Resources, Hydraulics & Hydrology, Energy and Environmental Engineering Series*, 84, 2010.
[3] Murarescu, O., Pehoiu, G., Frinculeasa, M., Muratoreanu, G., Balneary potential of the mineral waters from Vulcana Bai, Dambovita County (Romania), Political Sciences, Law, Finance, Economics and Tourism, Vol. IV, *International Multidisciplinary Scientific Conferences on Social Sciences and Arts*, 59, 2014.
[4] Sencovici, M., Pehoiu, G., Environmental factors' interaction in the Subcarpathian basin landscape of Ialomita River (the Moroieni-Pucioasa sector), Ecology, Economics, Education and Legislation Conference Proceedings, Vol. I, *International Multidisciplinary Scientific GeoConference-SGEM*, 277, 2016.
[5] Alonso, M.L., Garzon, E., Melcon, B., Zapico, J, *Alimentaria*, **27**(213), 53, 1990.
[6] Rao, M.A., *Journal Texture Studies*, **8**, 135, 1977.
[7] Rao, M.A., Cooley, J.H., *Journal Texture Studies*, **23**, 415, 1992.
[8] Rosen, R.M., Forster, W.E., *Journal Coating Technology*, **50**, 456, 1978.
[9] Stanciu, I., *Journal of Science and Arts*, **1**(42), 197, 2018.
[10] Moretto, E., Fett, R., *Tecnologia de oleos e gorduras vegetais na industria de alimentos*, Sao Paolo, Varela, p. 43-156, 1998.
[11] Santos, J.C.O., Santos, I.M.G., Souza, A.G., *Journal of Food Engineering*, **67**, 401, 2005.
[12] Eiteman, M.A., Goodrum, J.W., *Transactions ASAE*, **36**, 503, 1993.
[13] Eiteman, M.A., Goodrum, J.W., *Journal of American Oil Chemist's Society*, **71**, 1261, 1994.
[14] Stanciu, I., *Journal of Science and Arts*, **2**(43), 453, 2018.
[15] Femlab, Chemical Engineering Module, Version 2.3.COMSOL AB.2002.
[16] Goodrum, J.W., Geller, D.P., Lee, S.A., *Thermochimica Acta*, **311**, 71, 1998.
[17] Geller, D.P., Goodrum, J.W., Knapp, S.J., *Industrial Crops Production*, **9**, 85, 1999.
[18] Stanciu, I., *Journal of Science and Arts*, **3**(44), 711, 2018.
[19] Valeri, D., Meirelles, A.J.A., *Journal of American Oil Chemist's Society*, **74**, 1221, 1997
[20] Severa, L., Havlíček, M., Buchar, J., Křivánek, I., Acta *Universitatis Agriculturae et Silviculturae Mendelinadae Brunesis*, **LIV**(1), 83, 2006.
[21] Stanciu, I., *Journal of Science and Arts*, **3**(20), 331, 2012.