Annals. Food Science and Technology
2013

# EXPONENTIAL DEPENDENCE OF DYNAMIC VISCOSITY-SHEAR RATE FOR VEGETABLE OIL

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***Abstract***
*The vegetable oil were carefully studied in recent years because they may constitute a raw material for biodegradable lubricants getting organic. These vegetable oils are an alternative to synthetic mineral oils. Biodegradable oils represent now an ingenious solution in lubrication engineering for equipments which work preponderantly in conditions that have high risk of environmental pollution. This refers to machines and equipments that work in agriculture, building industr, printing industry, car industry, where the environment pollution problem is of high concern, because of loss of lubricants in soil and water. The entrance on the market of these biodegradable lubricants is done in different ways, depending on the areas of applicability. 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 relations of dynamic viscosity with shear rate. Rheological characteristics of vegetable oils were measured with rotational co-axial cylinder rheometer at different temperatures of 313, 323, 333, 343, 353 and 363K. This article proposes three equations of dynamic viscosity dependence of shear rate starting from the model proposed by Al-Fariss. The proposed models were obtained by fitting exponential curves, dynamic viscosity of shear rate for vegetable oils. The best correlation coefficients were obtained for equations (3) and (4) have values between 0.9941 and 0.9999.*

**Keywords:** dynamic viscosity - shear rate, vegetable oil, equation

Submitted: 05.07.2013 Reviewed: 06.08.2013 Accepted: 26.08.2013

## 1. INTRODUCTION

The role of rheology is important in the field of cosmetic science, especially in the field of emulsions and lotions (Martin et al., 2004; Remington, 2006). Since the different creams have different consistencies and they are used for long terms, the effects of different rheological parameters of oils vegetable are studied for the understanding the performance and the system (Laba, 1993; Davenport et al., 1971; Naveed et al., 2009).
There are two principals' models of rheology, which are newtonian and non-newtonian system. Newtonian materials and products are whose viscosity remains constant by varying shear stress. This type of flow is influenced by the variation in temperature. Viscosity, shear stress, shear rate, yield value, plastic, pseudoplastic and thixotropic models, viscometer and rheometer types are the major issues discussed in rheology (Al-Fariss et al., 1987; Amin et al, 1980; Cross, 1965).
In the literature there are few dynamic rheological models linking oil dynamic viscosity with the shear rate and the temperature. Al-Fariss (Al-Fariss, 1998; Al-Fariss et al., 1992) propose equation
to account for the effect of shear rate by including the term ($\dot{\gamma}^C$) is:

$$\eta = A\, e^{B/T}\, \dot{\gamma}^C \qquad (1)$$

where A, B and C are constants that depend on the temperature and type of oil.
In this paper, i present the equations that describe the variation of the dynamic viscosity of the shear rate for vegetable oil. The equations describing the dependency of dynamic shear viscosity were determined in the exponential regression rheological curves obtained at various shear rates.

## 2. MATERIALS AND METHODS

The determinations of dynamic viscosity of vegetable oils were done a viscometer using a Haake VT 550. The dynamic viscosity was determined for shear rates ranging between 3.3 and $120 s^{-1}$, respectively, the temperature varying between 40°C and 100°C. 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

Figures 1 and 2 present the dynamic viscosity variation versus shear rate, at temperatures absolute 323K and 343K. One may notice the decreasing of viscosity at increasing shear rate for vegetable oils examined, the trend of viscosity with increasing shear rate is registered at all temperatures studied.

This article proposes the equations (2) - (4) describing the dynamic viscosity variation with shear rate for vegetable oils studied. With Origin 6.0 software determined the constants A, B, C, D, E, F and G which varies with temperature and oil type studied. For equation (2) we obtained correlation coefficients, $R^2$, between 0.9463 and 0.9899. Equations (3) and (4) have correlation coefficients close to unity, so best describe the behavior of vegetable oils.

For each of the vegetable oils investigated, the variation in dynamic viscosity was fitted to an extension of the Al-Fariss equation (1). The form of the equations is:

$$\eta = A + B\exp(-\dot{\gamma}/C) \qquad (2)$$

$$\eta = A + B\exp(-\dot{\gamma}/E) + C\exp(-\dot{\gamma}/F) \qquad (3)$$

$$\eta = A + B\exp(-\dot{\gamma}/E) + C\exp(-\dot{\gamma}/F) + D\exp(-\dot{\gamma}/G) \qquad (4)$$

Tables 1, 2 and 3 shows the temperatures, the parameters of the model described by each equation separately and correlation coefficients features vegetable oils.

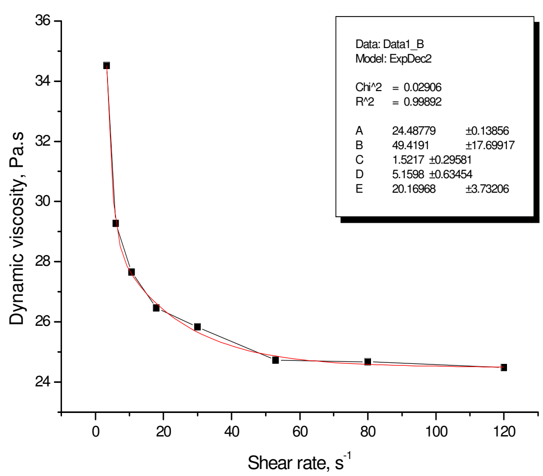


**Fig. 1 Variation of dynamic viscosity with shear rate for temperature absolute 323K**

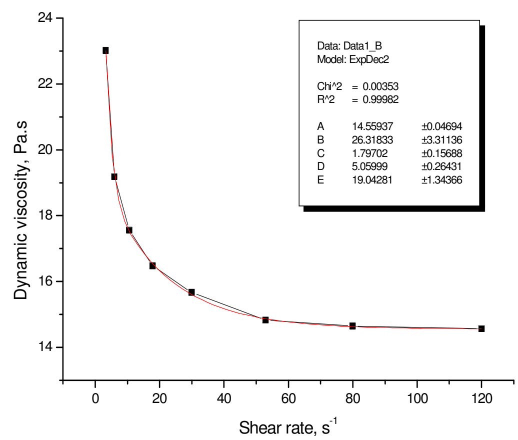


**Fig. 1 Variation of dynamic viscosity with shear rate for temperature absolute 323K**

**Table 1. The temperature, value of parameters of the theoretical model described by equation (2), coefficient correlation for vegetable oil**

| Temperature, K | Value of parameters of the theoretical model described by equation (2) | | | $R^2$ |
|---|---|---|---|---|
| | A | B | C | |
| 313 | 33.1246 | 22.8504 | 3.6385 | 0.9899 |
| 323 | 24.1247 | 15.3636 | 2.8140 | 0.9463 |
| 333 | 16.2378 | 6.5250 | 12.5793 | 0.9796 |
| 343 | 12.2789 | 10.5127 | 5.7005 | 0.9796 |
| 353 | 10.0345 | 16.1341 | 4.5902 | 0.9749 |
| 363 | 7.4369 | 7.8298 | 6.4997 | 0.9845 |

**Table 2. The temperature, value of parameters of the theoretical model described by equation (3), coefficient correlation for vegetable oil**

| Temperature, K | Value of parameters of the theoretical model described by equation (3) | | | | | $R^2$ |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| 313 | 32.7679 | 30.0123 | 4.9583 | 3.0207 | 14.9198 | 0.9999 |
| 323 | 23.5032 | 48.9537 | 4.9596 | 2.0219 | 19.0696 | 0.9999 |
| 333 | 17.9094 | 135.9530 | 7.1745 | 0.3478 | 17.0090 | 0.9996 |
| 343 | 13.5794 | 25.9368 | 4.9599 | 2.0910 | 18.9432 | 0.9898 |
| 353 | 12.1134 | 16.9976 | 1.1844 | 6.1107 | -2.9476E84 | 0.9941 |
| 363 | 7.9989 | 9.9456 | 1.9559 | 5.0843 | 66.9221 | 0.9989 |

**Table 3. The temperature, value of parameters of the theoretical model described by equation (4), coefficient correlation for vegetable oil**

| T, K | Value of parameters of the theoretical model described by equation (4) | | | | | | | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | |
| 313 | 30.9599 | 29.9219 | 4.9276 | 1.9999 | 3.0923 | 14.9786 | -0.9916E87 | 0.9999 |
| 323 | 25.2688 | 18.0134 | 0.4352 | -0.0876 | 5.0998 | -3.0536E16 | -0.9623E84 | 0.9667 |
| 333 | 18.0112 | 7.0832 | 138.2610 | 0.9919 | 19.0094 | 1.0423 | -2,0835E151 | 0.9795 |
| 343 | 12.9978 | 25.9538 | 4.9749 | 1.0734 | 2.0964 | 18.0999 | 2.6460E18 | 0.9999 |
| 353 | 10.9845 | 19.0236 | 0.9796 | 2.0020 | 4.0663 | 35.9899 | 38.0142 | 0.9953 |
| 363 | 9.0483 | 9.9881 | 3.0956 | 1.0060 | 5.0654 | 68.9956 | 8.0234E142 | 0.9999 |

## 4. CONCLUSIONS

The proposed models show dependent dynamic viscosity with shear rate and temperature and can be applied to both Newtonian fluids and non-Newtonian. The correlation coefficients were obtained by fitting curves exponential dynamic viscosity with shear rate obtained experimental of temperatures 313, 323, 333, 343, 353 and 363K. The best correlation coefficients were obtained for equations (3) and (4) and have values between 0.9941 and 0.9999.

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