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Full Length Research Paper

A new viscosity-temperature relationship for vegetable oil

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This study proposes four relationships of dynamic viscosity temperature dependence for vegetable oils. The purpose of this study was to find a polynomial or exponential dependence between temperature and dynamic viscosity of vegetable oil, using the Andrade equation changes. Equation constants A, B, C and D were determined by fitting polynomial or exponential.

Key words: Viscosity-temperature, vegetable oil, relationship.

INTRODUCTION

Viscosity is one of the most important physical properties of a fluid system (Fasina et al., 2008). Studies on viscosity have been performed on polystyrene, protein, pineapple juice, vegetable oil, dark beer, etc. (Toth et al., 2007). Viscosity changes with shear rate, temperature, pressure, moisture, and concentration; all these changes can be modeled by equations (Dak et al., 2008; Balakrishnan et al., 2007; Severa et al., 2008).

The effect of temperature is normally fitted with the Arrhenius-type relationship that is shown subsequently (Choi et al., 2009; Thodesen et al., 2009; Saeed et al., 2009):

$$\eta = Ae^{E}a/RT \quad (1)$$

where η is dynamic viscosity (Pa.s); A is the pre-exponential factor (Pa.s); Ea is the exponential constant that is known as activation energy (J/mol); R is the gas constant (J/mol/K) and T is the absolute temperature (K).

Modeling of the temperature effect on the dynamic viscosity of oils vegetable is important and has been investigated by various researchers (Noureddini et al., 1992; Kapseu et al., 1991; Lang et al., 1992; Toro-Vazquez et al., 1993).

The two-parameter were Equations 2 and 3, and three-parameter equations Equations 4 to 7 were:

$$\ln\eta = A + B\ln T \quad (2)$$

$$\ln\eta = A + B/T \quad (3)$$

$$\ln\eta = A + B/(T+C) \quad (4)$$

$$\ln\eta = A + B/T+C/T^2 \quad (5)$$

$$\ln\eta = A + B/T+CT \quad (6)$$

$$\ln\eta = A + BT+CT^2 \quad (7)$$

where A, B and C are constants, and T is absolute temperature (K).

This article proposes four new relationships of dependence of dynamic viscosity of vegetable oils temperature. Dynamic viscosity of oils was determined at temperatures and shear rates, the 90°C and the 40°C, respectively, 3.3 to 120 s^{-1}. The purpose of this study was to find a polynomial or exponential dependence between temperature and dynamic viscosity of vegetable oil no additive using Andrade equation changes. Equation constants A, B, C and D were determined by fitting polynomial or exponential.

EXPERIMENTAL

Materials

Vegetable oils no additives used in this work are provided by a company from Bucharest, Romania.

Vegetable oils were investigated using a Haake VT 550 Viscotester developing shear rates ranging between 3 and 120 s^{-1} and measuring viscosities from 10^4 to 10^6 mPa.s when the HV_1

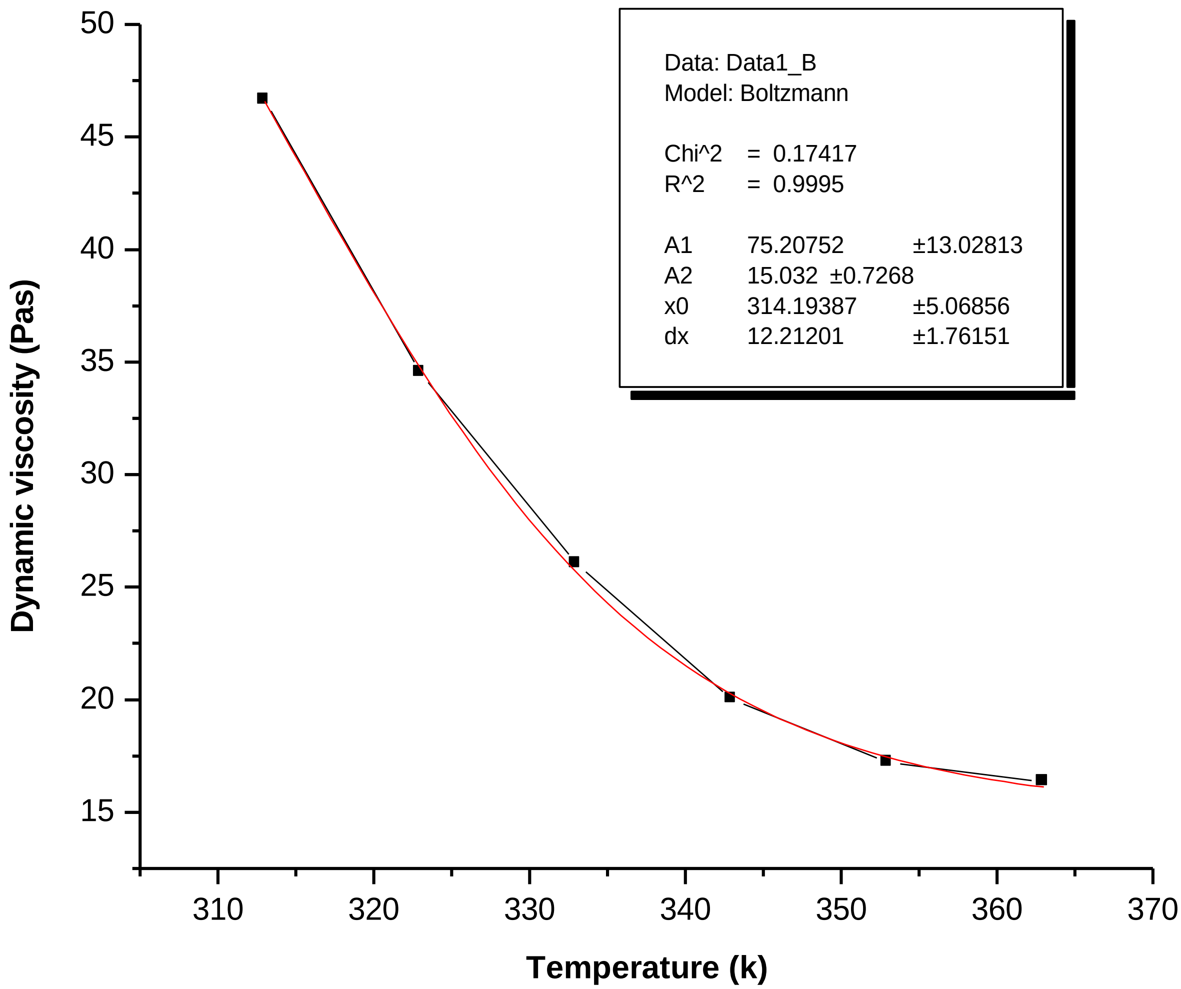

Figure 1. The viscosity dynamic of investigated oil as a function of temperature absolute of vegetable oil at shear rate 3.3 s^{-1}

viscosity sensor is used. The temperature ranging was from 40 to 90°C and the measurements were made from 10 to 10°. The accuracy of the temperature was ± 0.1°C.

RESULTS AND DISCUSSION

Figures 1 and 2 shows the dependence of dynamic viscosity temperature absolute for the same sample of vegetable oil at shear rate 3.3 and 6 s^{-1}. The behavior of vegetable oil is that the dynamic viscosity decreases with increasing temperature absolute.

This article proposes four Equations (8) to (11) temperature dependence of dynamic viscosity checked only for vegetable oils. The software Origin 6.0 was used to determine constants equation for vegetable oil. In addition, the parameters A, B, C, η_0, dT and D change with shear rate. Therefore, by imposing constant shear rate, the parameters can be determined. In order to determine the equation constants, the following steps were performed using the Origin 6.0 software: load the non-linear regression package, input experimental data, title x-label, y-label and set the required equation, perform non-linear regression and plot experimental data and best fitted curve, calculate the mean square error and coefficient of determination and show the best fitted equation constant, mean square error and coefficient of determination.

Tables 1, 2, 3 and 4 contain the constants equations polynomial and exponential (8 to 11) and the correlations coefficient for the vegetable oil. As shown in Tables 1, 2, 3 and 4, the software found it polynomial and exponential equations applied shear rate curves of vegetable oil. The root mean square error means that experimental data is spread equation. From the results of the regression tabulated in Tables 1, 2, 3 and 4, the lowest coefficient of determination and the highest mean square error were 0.9725 and 0.9999, respectively.

$$\eta = A + BT + CT^2 \quad (8)$$

$$\eta = B + (A - B)/(1 + \exp((T-T_0)/dT)) \quad (9)$$

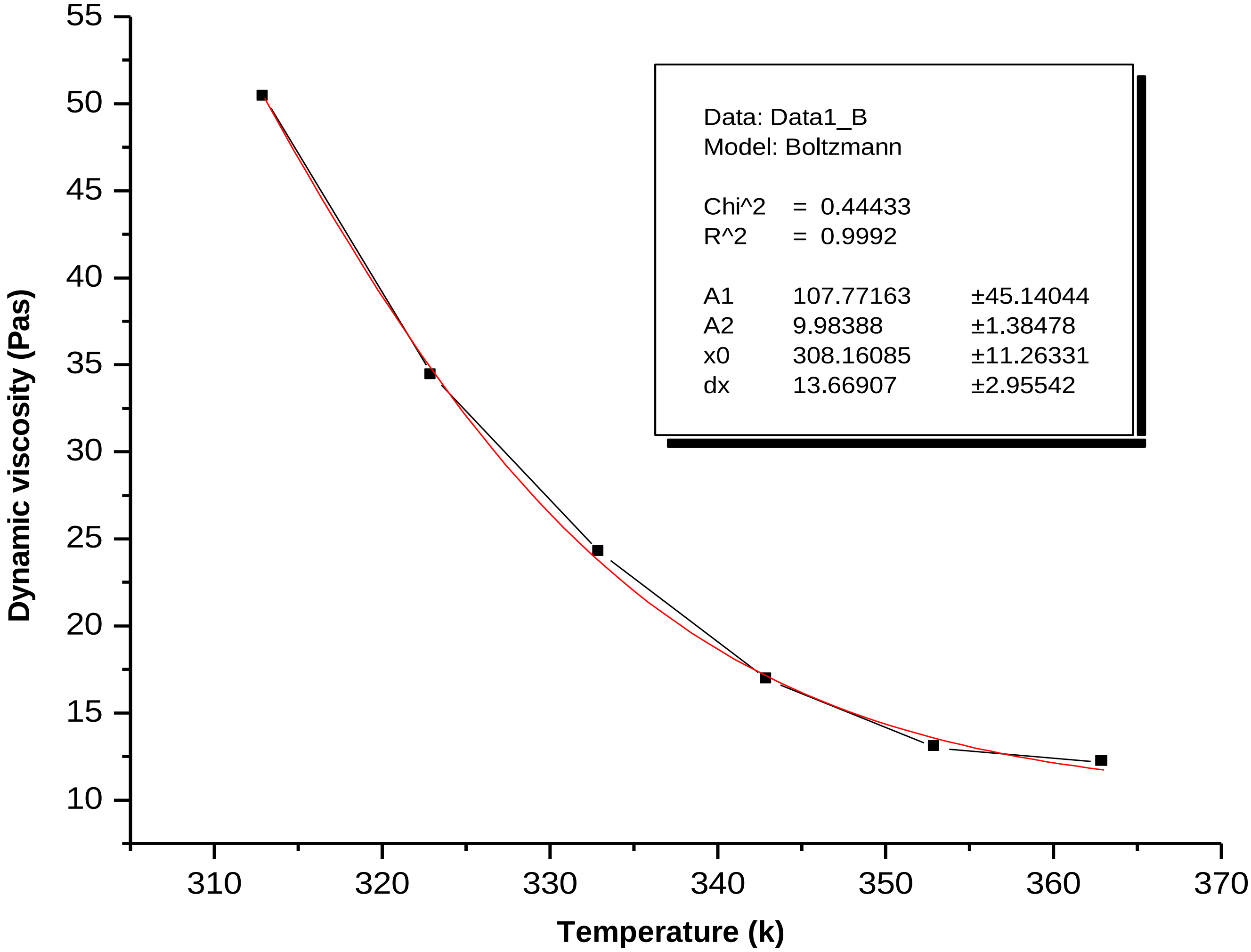

Figure 2. The viscosity dynamic of investigated oil as a function of temperature absolute of vegetable oil at shear rate 6 s^{-1}.

Table 1. The shear rate, value of parameters of the theoretical model described by Equation (8), coefficient correlation and range temperatures absolute for vegetable oil.

Shear rate (s^{-1})	Value of parameters of the theoretical model described by Equation (8)			R^2	Temp. range (K)
	A	B	C		
3.30	1836.1375	-10.1323	0.0141	0.9996	313-363
6.00	2329.3267	-12.9148	0.0180	0.9989	313-363
10.60	863.5866	-4.4560	0.0058	0.9989	313-363
17.87	1018.6742	-5.4406	0.0073	0.9991	313-363
30.00	1182.6624	-6.4256	0.0088	0.9991	313-363
52.95	1209.2660	-6.5897	0.0090	0.9989	313-363
80.00	1255.7463	-6.8596	0.0094	0.9994	313-363
120.0	856.6590	-4.5402	0.0061	0.9989	313-363

$$\eta = A + BT + CT^2 + DT^3 \quad (10)$$

$$\eta = \eta_0 + A \exp(-T/B) \quad (11)$$

where T is temperature absolute, A, B, C was constants vegetable oil and variation with shear rate, T_0 is temperature absolute to dynamic viscosity 50 Pa•s and

Table 2. The shear rate, value of parameters of the theoretical model described by Equation (9), coefficient correlation and range temperatures absolute for vegetable oil.

Shear rate (s^{-1})	Value of parameters of the theoretical model described by Equation (9)				R^2	Temp. range (K)
	A	B	T_0	dT		
3.30	75.2080	15.0320	314.1900	12.2120	0.9995	313-363
6.00	107.7700	9.9839	308.1600	13.6690	0.9992	313-363
10.60	252.1800	-1.3187	248.5400	37.3560	0.9990	313-363
17.87	222.4500	5.4663	262.5500	27.3870	0.9995	313-363
30.00	121.1200	7.7267	289.3600	20.2970	0.9999	313-363
52.95	98.4300	7.2421	296.2100	18.8600	0.9989	313-363
80.00	73.0500	7.5299	306.4100	16.2820	0.9992	313-363
120.0	432.8100	4.5940	238.8900	27.8120	0.9998	313-363

Table 3. The shear rate, value of parameters of the theoretical model described by Equation (10), coefficient correlation and range temperatures absolute for vegetable oil.

Shear rate (s^{-1})	Value of parameters of the theoretical model described by Equation (10)				R^2	Temp. range (K)
	A	B	C	D		
3.30	6364.1295	-50.9599	0.1367	-1.2259E-4	0.9999	313-363
6.00	10499.3346	-88.8027	0.2514	-2.378E-4	0.9996	313-363
10.60	5186.6121	-42.1897	0.1152	-1.0546E-4	0.9989	313-363
17.87	3768.3185	-29.9054	0.0798	-7.1389E-5	0.9990	313-363
30.00	6334.2189	-52.4365	0.1456	-1.3528E-4	0.9999	313-363
52.95	5618.0514	-46.0452	0.1266	-1.1644E-4	0.9997	313-363
80.00	6294.1093	-52.0333	0.1442	-1.3379E-4	0.9999	313-363
120.0	5014.4810	-40.9763	0.1124	-1.0333E-4	0.9999	313-363

Table 4. The shear rate, value of parameters of the theoretical model described by Equation (11), coefficient correlation and range temperatures absolute for vegetable oil.

Shear rate (s^{-1})	Value of parameters of the theoretical model described by Equation (11)			R^2	Temp. range (K)
	η_0	A	B		
3.30	9.2527	56.1092	2.4778	0.9996	313-363
6.00	11.7142	5.2391E7	21.7004	0.9987	313-363
10.60	12.3522	2.7673E9	16.9276	0.9799	313-363
17.87	11.3668	2.1719E9	17.1222	0.9740	313-363
30.00	10.6029	1.1579E9	17.7312	0.9880	313-363
52.95	10.1838	3.0160E9	16.8042	0.9847	313-363
80.00	9.7130	1.9394E9	17.2275	0.9869	313-363
120.0	9.6286	5.0556E10	14.7457	0.9725	313-363

width dT.

Conclusions

This study proposes four new relationships dynamic viscosity dependence of the absolute temperature no additive. Check the only vegetable oils. Equation constants were determined by exponential or polynomial beast curves obtained at different shear rates using the program Origin 6.0. The correlation coefficients thus obtained were 0.9725 and 0.9999 values between.

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