ORIGINAL PAPER

MODELING THE TEMPERATURE DEPENDENCE OF DYNAMIC VISCOSITY FOR RAPESEED OIL

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Abstract. *In this article we calculated dynamic viscosity for a number of vegetable oils (crude rapeseed oil, degummed rapessed oil, rapeseed oil dry, rapeseed oil bleached and rapeseed oil refined) at temperatures from 313K to 363K. The some empirical relations that describe the temperature dependence of dynamic viscosity were fitted to the experimental data and the correlation constants for the best fit are presented.*

Keywords: *oils, dynamic viscosity, Andrade's equation, temperature.*

1. INTRODUCTION

In the food industry, viscosity is one of the most important parameters required in the design of technological process. On the other side, viscosity is also an important factor that determines the overall quality and stability of a food system. From the physico-chemical point of view, viscosity means the resistance of one part of the fluid to move relative to another one. Therefore, viscosity must be closely correlated with the structural parameters of the fluid particles. On the basis of published data concerning flow properties of oils, the oils viscosity has a direct relationship between with some chemical characteristics of the lipids, such as the degree of unsaturation and the chain length of the fatty acids that constitute the triacylglycerols. The viscosity slightly decreases with increases degree of unsaturation and rapidly increases polymerization [1-3].

In this study we determined the viscosity of rapeseed oil in the temperature range from 313K to 363K. The empirical relations describing the dynamic viscosity variation with temperature were fitted to experimental data and correlation constants for the best fit are presented in this paper.

2. MATERIALS AND METHOD

Types of rapeseed oil used in this paper are produced from rapeseed crop produced in Romania. In our investigation we used the following sample of oil: crude rapeseed oil, degummed rape oil, rapeseed oil dry, rapeseed oil bleached and refined rapeseed oil .

The vegetable oils have 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 viscosity sensor is used. The temperature ranged between 40 and 90^{o}C and the measurements were made from 10 to 10^{o}C. The accuracy of the temperature was ± 0.1^{o}C.

3. RESULTS AND DISCUSSION

The figure 1 show the dynamic viscosity temperature dependence for samples studied: crude rapeseed oil, degummed rape oil, rapeseed oil dry, rapeseed oil bleached and refined rapeseed oil. Behavior of oil sample is that the dynamic viscosity decreases with increasing temperature.

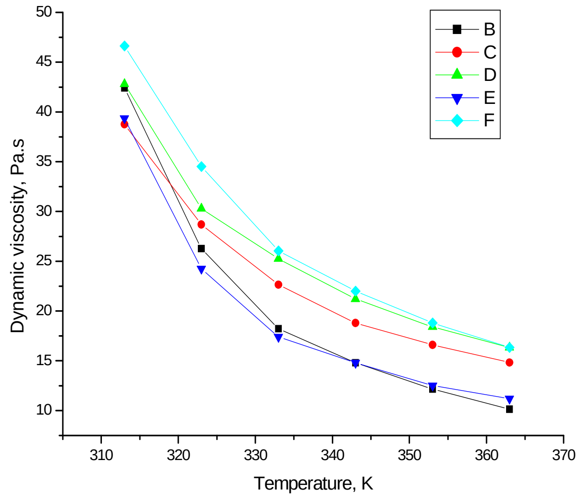

Fig. 1. The viscosities of investigated oils as a function of temperature at shear rate 3.3s^{-1}: B - crude rapeseed oil; C - degummed rape oil; D - rapeseed oil dry; E - rapeseed oil bleached; F - refined rapeseed oil.

The Fig. 2 shows the log viscosity depending on the inverse absolute temperature for these oils: crude rapeseed oil, degummed rape oil, rapeseed oil dry, rapeseed oil bleached and refined rapeseed oil.

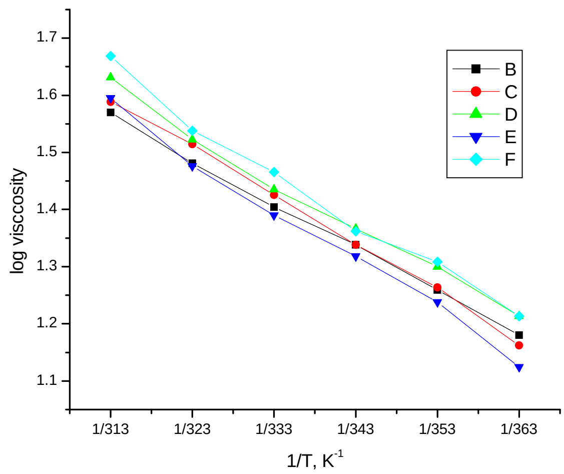

Fig. 2.The dependence log viscosity on the 1/T at shear rate 3.3s^{-1}: B - crude rapeseed oil; C - degummed rape oil; D - rapeseed oil dry; E - rapeseed oil bleached; F – refined rapeseed oil.

The vegetable oils have been proposed several empirical relationships describing the temperature dependent dynamic viscosity. The more important of these is the Andrade equation (1). Andrade [4, 5] equations are modified versions of equations (2) and (3) [6-11]:

$$\eta = A \cdot 10^{B/T} \quad (1)$$

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

and

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

To elucidate the effect of temperature on the absolute viscosity the following equations (4), (5), (6) and (7) have also been used:

$$\log \eta = A/T - B \quad (4)$$
$$\eta = A - B \log T \quad (5)$$
$$\eta \cdot v^{1/2} = A \cdot e^{B/T} \quad (6)$$
and
$$\eta = A/v - B \quad (7)$$
where v means the specific volume of the oil, T is the temperature absolute and A, B and C in the equations (1) to (7) are correlation constants. The results of regression analyses to these relations are presented in Tables 1, 2, 3 and 4.

Table 1. Values of parameters of the theoretical models described by equations (1) and (4) and the standard error of regression analysis, R

	Equation (1)			Equation (4)		
Oil vegetable	A	B	R2	A	B	R^2
crude rapeseed oil	43.6908	0.0766	0.9993	0.0766	1.6404	0.9993
rape degummed oil	47.7529	0.0848	0.9992	0.0848	1.6790	0.9991
rapeseed oil dry	49.4311	0.0807	0.9963	0.0807	1.6940	0.9963
bleached rapeseed oil	46.8705	0.0897	0.9968	0.0897	1.6709	0.9968
refined rapeseed oil	53.7031	0.0876	0.9942	0.0876	1.7300	0.9942

Table 2. Values of parameters of the theoretical model described by equation (5) and the standard error of regression analysis, R

	Equation (5)		
Oil vegetable	A	B	R^2
crude rapeseed oil	1072.0074	414.2502	0.9605
rape degummed oil	950.3065	367.0183	0.9417
rapeseed oil dry	997.2364	384.2511	0.9500
bleached rapeseed oil	937.5015	361.6683	0.9358
refined rapeseed oil	1158.3452	447.2367	0.9582

Table 3. Values of parameters of the theoretical model described by equation (2) and the standard error of regression analysis, R

	Equation (2)			
Oil vegetable	A	B	C	R^2
crude rapeseed oil	4.0082	-0.3106	0.0167	0.9876
rape degummed oil	3.8002	-0.1474	-0.0054	0.9772
rapeseed oil dry	3.9965	-0.2665	0.0126	0.9551
bleached rapeseed oil	3.8479	-0.2261	0.0045	0.9563
refined rapeseed oil	4.0968	-0.3034	0.0165	0.9494

Table 4. Values of parameters of the theoretical model described by equation (3) and the standard error of regression analysis, R

	Equation (3)			
Oil vegetable	A	B	C	R^2
crude rapeseed oil	11.7992	0.00471	0.0212	0.9892
rape degummed oil	13.3378	0.0109	0.0202	0.9751
rapeseed oil dry	12.2007	0.0086	0.0185	0.9812
bleached rapeseed oil	12.5106	0.0092	0.0191	0.9668
refined rapeseed oil	11.2831	0.0036	0.0203	0.8654

In tables 1, 2, 3 and 4 we see that the empirical relations which give the best results in this study the temperature dependence of oil viscosity is described by equations (1) and (4), where the correlation coefficient values are close by 1.00. Equation (5) is not suitable to describe the temperature dependence of oil viscosity, because the values of correlation coefficients are less than 1. Relationships (2), (3) and (5) are less suitable to describe the temperature dependence of viscosity of vegetable oil.

4. CONCLUSIONS

The equations that best describe the temperature dependent dynamic viscosity of vegetable oils studied are (1) and (4) for which correlation coefficients have values close to one. Vegetable oil dynamic viscosity decreases with increasing temperature at constant shear rate. Plotting the log of the inverse dynamic viscosity depending on temperature shows a linear decline.

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