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Rheological Behavior of Rapeseed Oil Shear Rate 3.3s^{-1} and 120s^{-1}

Ioana Stanciu*

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Abstract

Rheology is a branch of science with multiple implications in numerous sectors of industry, also constituting a generous field due to its multidisciplinary character. Thus, solving a problem in rheology calls for knowledge from modern mathematics, physics, chemistry, chemical and mechanical engineering, and materials science. Driven by the appearance of new materials (plastics and synthetic fibers, varnishes and paints, detergents, adhesives, pharmaceutical and cosmetic products, biological materials, etc.) Rapeseed ranks third in the world as a source of vegetable oil, after palm oil and soybean oil Through the exponential fit, we found a relation between the dependence of the dynamic viscosity on the temperature at different shear rates. The obtained correlation coefficients have values close to unity for all shear speeds to which the refined rapeseed oil was subjected. The found equation faithfully describes the non-Newtonian behavior of the studied oil in the temperature range. For the studied oil, the correlation coefficients have values between 0.9725 and 0.9955.

Keywords: Rapeseed, Temperature, Rheology, Shear rate

Introduction

Rheology is a branch of science with multiple implications in numerous sectors of industry, also constituting a generous field due to its multidisciplinary character. Thus, solving a problem in rheology calls for knowledge from modern mathematics, physics, chemistry, chemical and mechanical engineering, and materials science. Driven by the appearance of new materials (plastics and synthetic fibers, varnishes and paints, detergents, adhesives, pharmaceutical and cosmetic products, biological materials, etc.) and the need to process them, rheology has contributed to the deepening of these fields, developing its area of study. The flow or movement of all types of materials can also be described using specific equations that have been developed over time. Both gases and solids flow, but usually when we hear the term ”flow” we think of liquid products. Because of this, the term rheology is most often related to the flow of liquids. It also does not exclude the existence of a rheology of the gaseous state and a rheology of the solid state. The most eloquent example of solid state rheology is the mechanical properties of bodies, which represent their response to various stresses to which they are subjected. The classical theory of fluid dynamics developed through theoretical research on an ideal or perfect fluid, incompressible and devoid of viscosity and elasticity, called Pascal's fluid. Until the introduction of the boundary layer concept by Prandtl, the results of this research had limited applicability (Jaensson & Vermant, 2018; Meng *et al*., 2019; Chew *et al*., 2020; Kuzubasoglu & Bahadir 2020; Pilorgé, 2020, PHG, 2010).

Ioana Stanciu*
Department of Physical Chemistry, Faculty of Chemistry, University of Bucharest, 030018, Bucharest, Romania.

***E-mail:** istanciu75@yahoo.com

Rapeseed (Brassica oleracea) has been cultivated as a plant since the 16th century, having a distribution area both in warmer climates and colder climates (Azian *et al*., 2001; Hazar & Aydin, 2010; Thickness prediction, 2010; Stanciu, 2012; Likhanov, *et al*., 2019; Fridrihsone *et al*., 2020).

Andrade's equation is (Azian *et al*., 2001; Stanciu 2012; Likhanov *et al*., 2019):

$$\eta = A\exp^{\frac{B}{T}} \quad (1)$$

By logarithmizing equation (1) we obtain:

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

Esteban (Azian *et al*., 2001) ys Azian (Azian *et al*., 2001; Stanciu, 2012; Likhanov *et al*., 2019) introduced an equation with three constants:

$$\ln\eta = A + \frac{B}{T} + \frac{C}{T^2} \quad (3)$$

Where A, B, C - constants of the material.

Materials and Methods

The types of refined rapeseed oil used in this paper are produced in Romania.

Refined rapeseed oil was studied at increasing shear rates and temperatures between 40 and 100 ^{O}C with the Haake VT 550 viscometer. The oil has non-Newtonian behavior in the temperature range at which it was studied.

Results and Discussion

Dependence dynamic viscosity versus temperature **(Figures 1-7)** of rapeseed oil at shear rate.

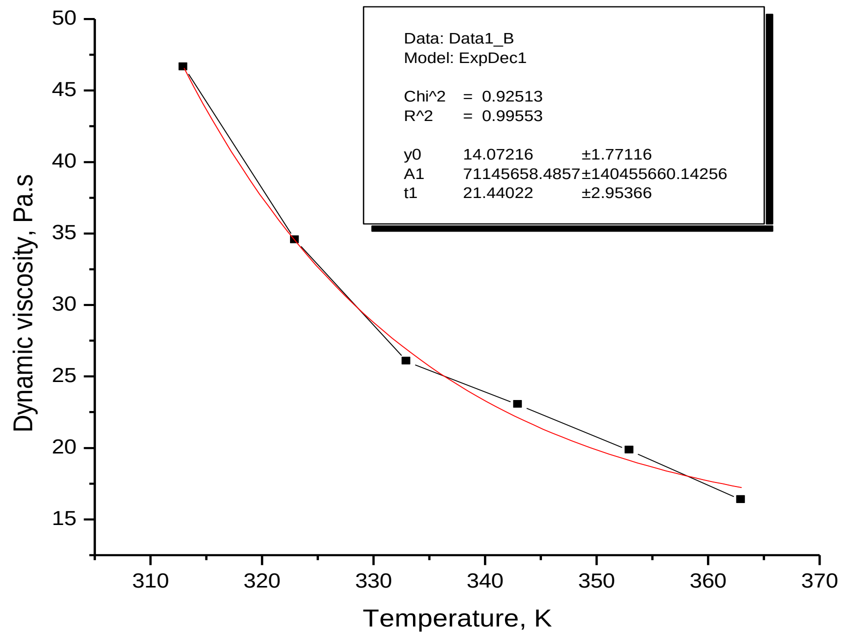

Figure 1. Dependence η =f(T) at shear rate $3.3s^{-1}$

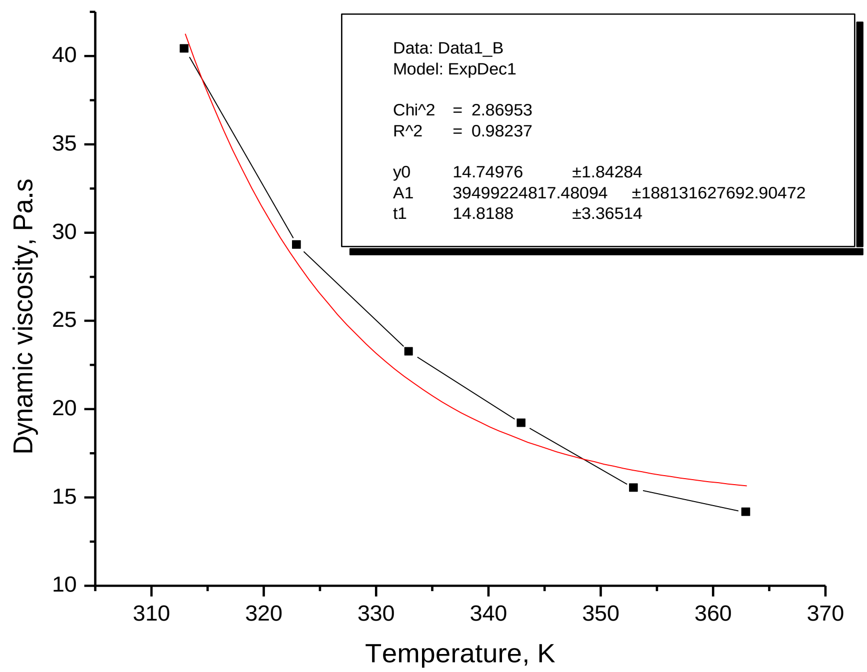

Figure 2. Dependence η =f(T) at shear rate $6s^{-1}$

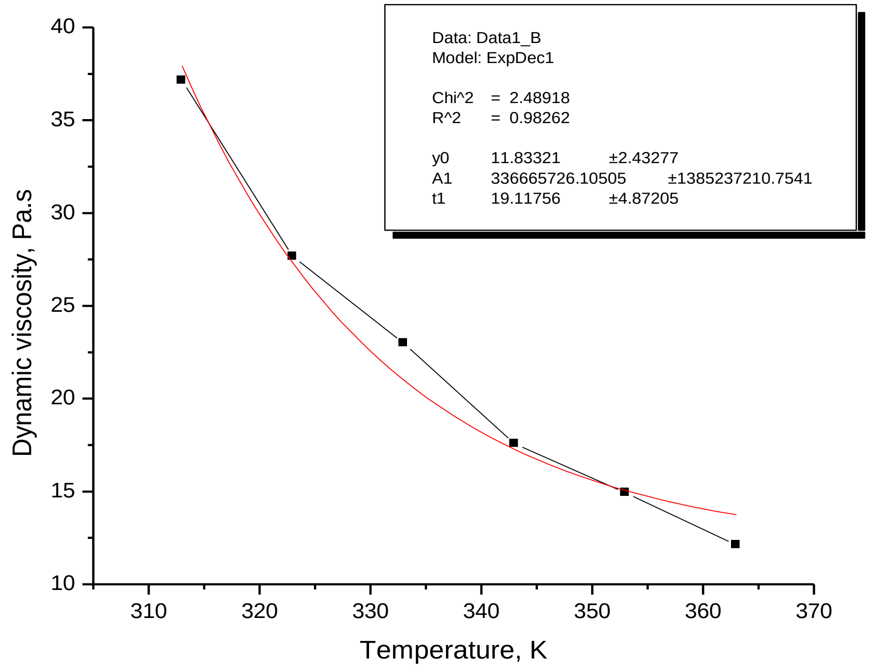

Figure 3. Dependence η =f(T) at shear rate $10.6s^{-1}$

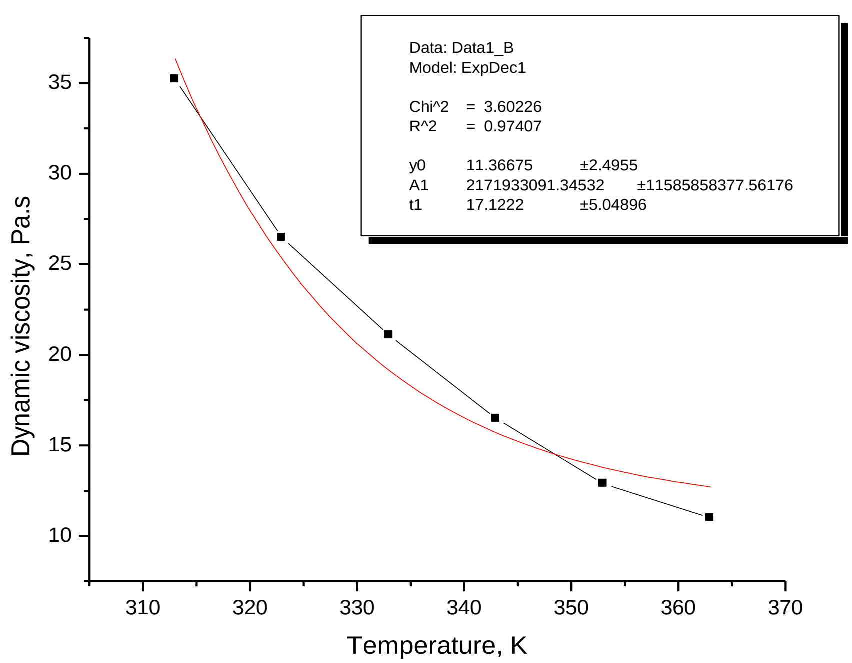

Figure 4. Dependence η =f(T) at shear rate $17.87s^{-1}$

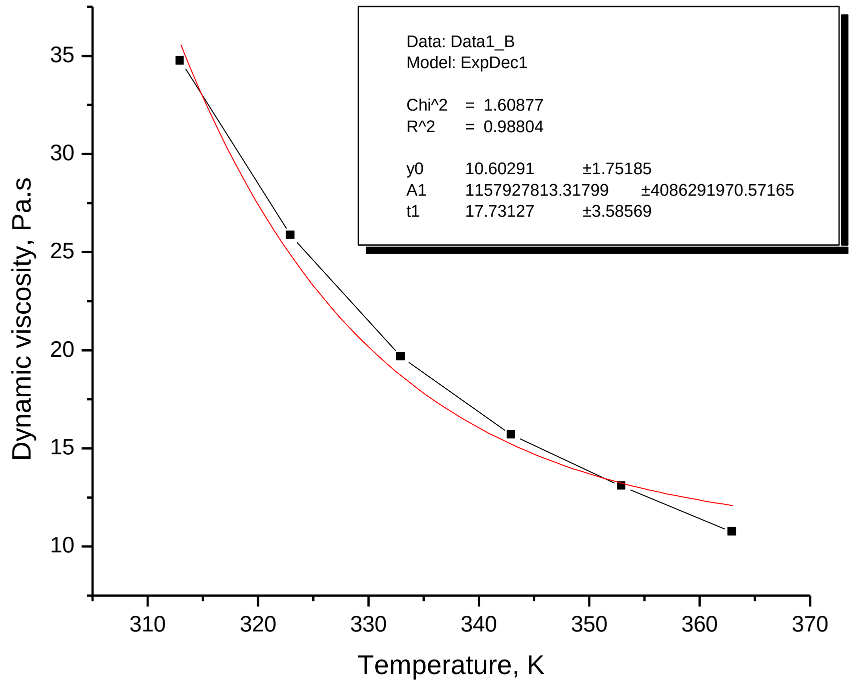

Figure 5. Dependence η =f(T) at shear rate $30s^{-1}$

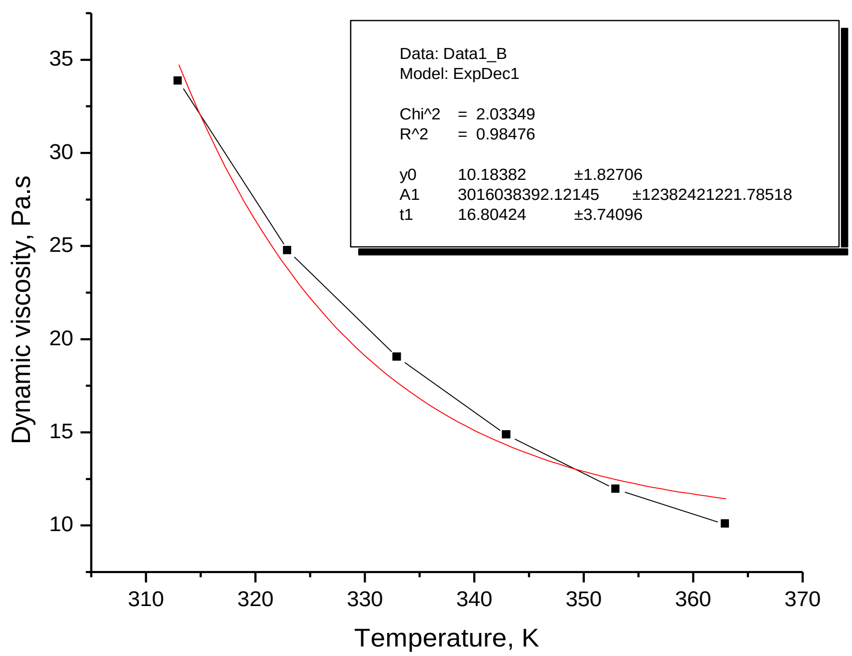

Figure 6. Dependence η =f(T) at shear rate $52.95s^{-1}$

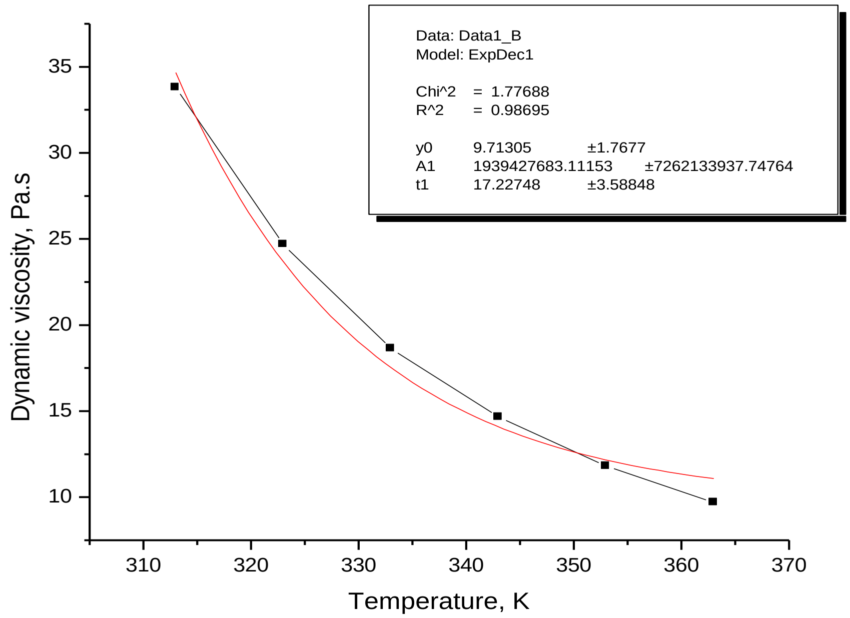

Figure 7. Dependence η =f(T) at shear rate $80 s^{-1}$

Eq. (4) for experimental data of refined rapeseed oil:

$$\eta = \eta_0 + A\exp(-T/B) \quad (4)$$

The correlation coefficients obtained with equation (4) have values between 0.9725 and 0.9955.

Conclusion

This article proposes an equation that shows the dependence of dynamic viscosity on temperature in exponential form with three parameters that depend on the studied oil. The found equation faithfully describes the non-Newtonian behavior of the studied oil in the temperature range.

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Conflict of interest: None

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Ethics statement: None

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