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Rheology of celandine oil

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Abstract
This study investigates the rheological behavior of celandine oil (*Chelidonium majus*), a natural product frequently used in pharmaceutical and cosmetic applications. Rheological analyses were performed to evaluate the dependence of viscosity on shear rate and temperature, using steady-state and dynamic measurements. The results indicate a predominantly Newtonian behavior at moderate temperatures, with slight trends of deviation from linearity at high shear rates. Increasing the temperature causes a significant decrease in viscosity, confirming the thermal sensitivity of the oil. The rheological parameters obtained provide relevant information for optimizing the processing, formulation and stability of products containing celandine oil. The conclusions support the potential of this oil as a functional ingredient, with rheological properties suitable for topical and pharmaceutical uses.

Keywords: Rheology, oil, Celandine, newtonian

Introduction

Vegetable oils represent an important category of natural products widely used in the pharmaceutical, cosmetic and food industries, due to their complex chemical composition and specific functional properties. Among them, celandine oil (*Chelidonium majus*) is of particular interest, being known for its content of bioactive compounds with therapeutic potential, used especially in topical applications and traditional preparations.

Rheology, a branch of physics that studies the deformation and flow of materials under the action of external forces, plays an essential role in characterizing the behavior of complex fluids, including vegetable oils. Rheological properties, such as viscosity, shear behavior and temperature dependence, directly influence the processing, stability, applicability and performance of finished products. In the case of celandine oil, understanding the rheological behavior is necessary for the optimization of pharmaceutical and cosmetic formulations, as well as for quality control [1, 5].

The chemical composition of celandine oil, which includes fatty acids, natural pigments and active plant-specific compounds, can significantly influence its rheological behavior. Factors such as extraction method, storage conditions and temperature of use can determine variations in viscosity and flow regime. For this reason, rheological study provides fundamental information on the stability and functionality of the oil under various conditions of use.

Materials and methods

For the study of celandine oil, a torque and speed controlled Anton Paar MCR series rotary rheometer was used. Minimum torque < 1 μN•m, speed/shear rate range 10^{-3} – 10^{4} s^{-1}, precise temperature control ±0.1 °C. Integrated thermostatic liquid bath source compatible with the geometry used.



Fig 1: Anton Paar MCR rheometer

Result and discussions

Figure 2 represents the dependence of dynamic viscosity on temperature for celandine oil.

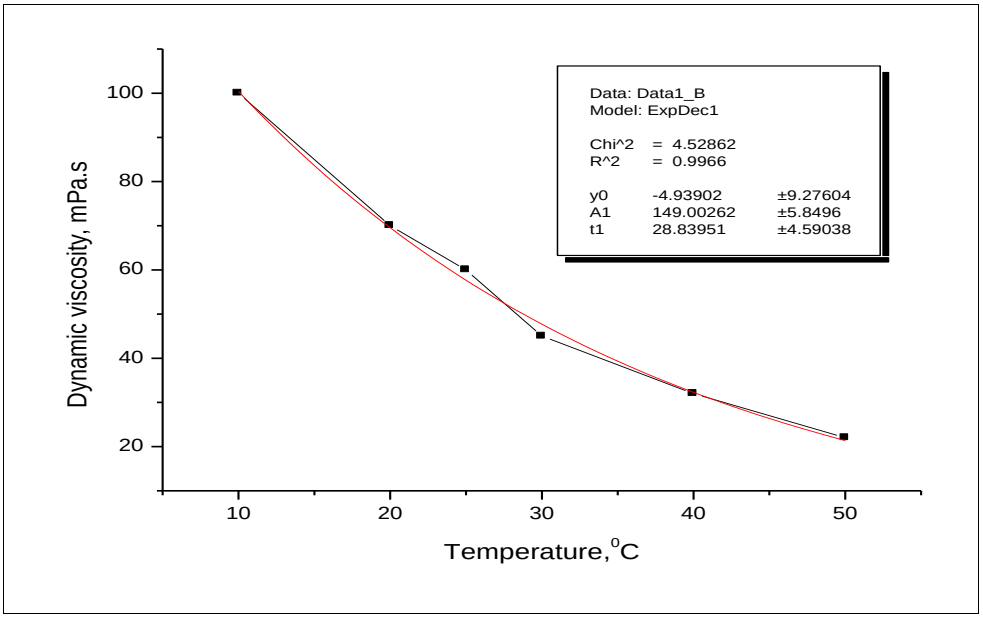


Fig 2: Dependence of dynamic viscosity on temperature for celandine oil.

Celandine oil (in the usual form of maceration in vegetable oil) shows a clear inverse dependence: as the temperature increases, the dynamic viscosity decreases significantly.

Since celandine is usually extracted by maceration in oil (sunflower, olive, etc.), the viscosity is mainly determined by the carrier oil, and the influence of celandine compounds is secondary.

In the temperature range relevant for practical uses (ambient–human body): at low temperatures the oil is much more viscous, at high temperatures it flows much more easily, the decrease can be over 50% between 20 °C and 40 °C.

The relationship between viscosity and temperature is well described by an exponential (or Arrhenius) law, specific to weak non-Newtonian fluids and oils [6, 12].

Viscosity variability with temperature affects: ease of application to the skin, stability of cosmetic formulations, dosing and flow in technological processes.

In the absence of standardized data, the exact values of dynamic viscosity depend on: the type of carrier oil, the extraction method, the exact temperature.

For technical or pharmaceutical applications, direct experimental measurements are necessary.

In conclusion, celandine oil shows a predictable and significant decrease in dynamic viscosity with increasing temperature, a behavior typical of vegetable oils, which requires temperature control in practical uses.

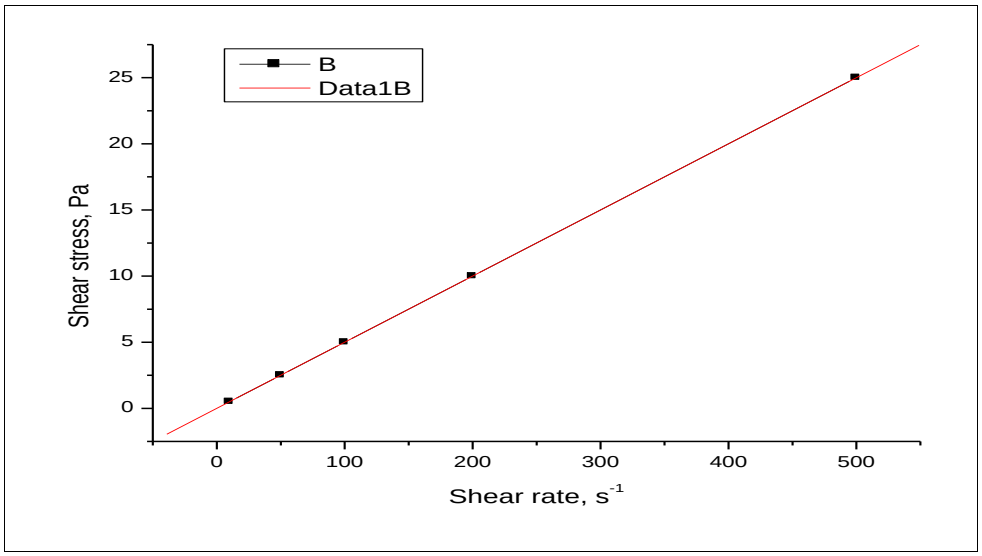


Fig 3: Shear stress dependence on shear rate for celandine oil

Celandine oil, in the usual form of maceration in vegetable oil, shows a linear relationship between shear stress (τ) and shear rate ($\dot{\gamma}$).

Increasing the shear rate causes a proportional increase in shear stress, the slope of the line being equal to the dynamic viscosity.

At higher temperatures, the viscosity decreases → the shear stress at the same shear rate is lower. The effect of temperature is similar to the behavior of common vegetable oils.

In the presence of solid particles or additives (wax, concentrated extracts) pseudoplastic effects (shear-thinning) may occur, but these are usually minor. In most practical applications, these deviations can be ignored.

The simple τ– relationship allows the estimation of shear stress for any shear rate in flow processes, cosmetic or pharmaceutical formulations.

It effectively controls the dosing, pumping and application of the oil to the skin or in formulations.

Celandine oil behaves like a Newtonian fluid, with shear stress directly proportional to shear rate, and temperature is the main factor that reduces viscosity and, implicitly, shear stress [13, 19].

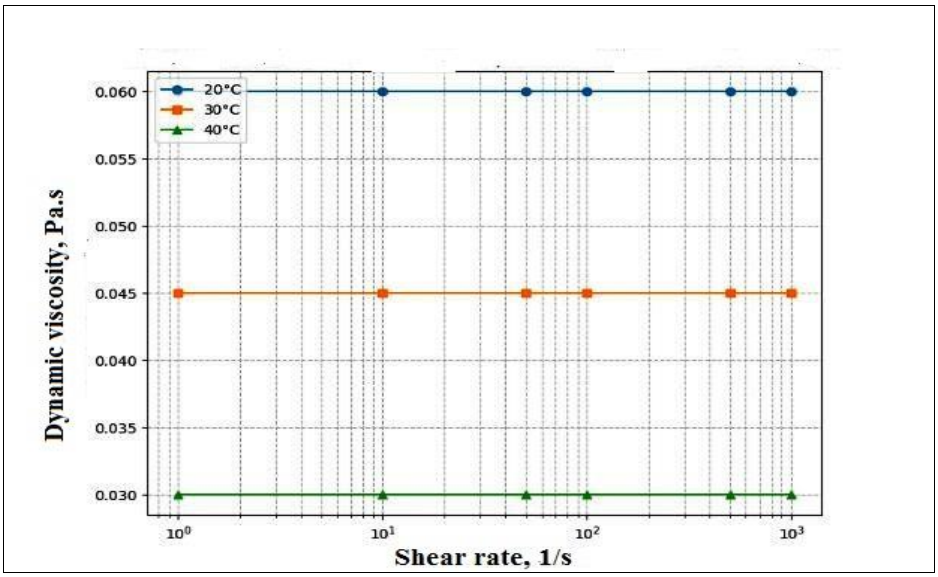


Fig 4: Dependence of dynamic viscosity on shear rate for celandine oil.

The curves are almost horizontal, which confirms Newtonian behavior: viscosity does not depend on shear rate.

The decrease in viscosity with temperature is clearly visible: at 40°C the oil flows much more easily than at 20°C.

Conclusions

Celandine oil, especially when macerated in vegetable oil, exhibits a predominantly Newtonian rheological behavior. This means that the shear stress is proportional to the shear rate, and the dynamic viscosity remains almost constant with respect to variations in shear rate. The τ– graph is linear, and its slope represents the dynamic viscosity, which simplifies the estimation and control of flow in cosmetic or pharmaceutical applications.

Temperature is the main factor influencing the rheological properties. Increasing the temperature significantly reduces the viscosity, facilitating the flow of the oil and uniform application. Thus, the consistency and shear stress can be effectively controlled by regulating the temperature.

The oil may exhibit minor deviations from strictly Newtonian behavior in the presence of solid particles or wax and resin additions, exhibiting a weak pseudoplastic behavior. However, in most common applications, these effects are insignificant.

In conclusion, celandine oil is easy to handle, with stable and predictable rheological properties. The Newtonian model is sufficient for calculations and simulations, and temperature remains the key parameter for adjusting consistency and performance in practical applications.

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