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Short communication

Method optimization for viscosity measurement of cutaneous solution

Ivana Cholakova*, Elizabeta Atanaskova, Viktorija Penshovska,
Natasha Anevska Stojanovska.

Research and development department, Alkaloid AD, Buld. Aleksandar Makedonski 12, 1000 Skopje, N.Macedonia

Introduction

Viscosity can be described as the internal friction of a fluid, caused by molecular attraction, which makes it resist a tendency to flow (Brookfield, p. 15). The greater the friction, the greater the amount of force required to cause a fluid movement, which is called “shear”. Highly viscous fluids, therefore, require more force to move than less viscous materials.

Based on rheological properties, the fluids can be divided into Newtonian (same viscosity at different shear rates) and non-Newtonian (different viscosity at different shear rates).

The viscosity measurement can be affected by variables related to the instrument (viscometer) or the test fluid. Test fluid’s related variables deal with the rheological properties of the fluid, while instrument variables would include viscometer design, spindle geometry, speed of rotation, time of test measurement and measurement conditions. Therefore, in order to obtain accurate results, optimization of the viscosity measurement method for each product is required.

The purpose of this study was optimization of the method for viscosity measurement and evaluation of rheological behavior of a viscous cutaneous solution. In order to optimize the method, aforementioned instrument parameters were varied and viscosity was evaluated.

Materials and methods

Measuring equipment

The viscosity measurement was performed using rotating Brookfield DV2T RV viscometer as described in Ph.Eur. Method 2.2.10, with standard disc spindles.

“The viscometer rotates a sensing element in a fluid and measures the torque necessary to overcome the viscous resistance to the induced movement” (Brookfield, p. 3). The immersed element, called spindle, is driving through a beryllium copper spring. The degree to which the spring is wound is proportional to the viscosity of the fluid.

Materials

The current study was conducted on a laboratory trial of viscous cutaneous solution, as test solution.

Sample container and sample quantity selection

According to Brookfield manufacturer instructions, the standard spindles supplied with the DV2T RV viscometer (RV2-7) are designed to be used with the quardleg attached and 600 ml beaker.

Sample quantity of NLT 350 ml was selected as appropriate in order to cover the immersion mark of the standard disc spindle. For the purpose of confirming that even greater sample quantity than 350 ml will not influence the result, measurements of the solution viscosity using different sample quantities (400 ml and 450 ml) was performed.

*icolakova@alkaloid.com.mk

Spindle selection

The process of selecting a spindle for a fluid with unknown viscosity is normally trial and error. An appropriate selection will result in obtaining torque value between 10-100%.

According to the visual assessment of the test solution viscosity, the research team decided to use RV disc spindles. In order to select appropriate spindle for analysis, according to obtained torque values, measurements using different RV disc spindles (RV-2, 3 and 4), at different time points (1–10 minutes), with different spindle speed rotation (10-100 rpm) were performed. The measurements were carried out using previously defined conditions, namely 600 ml beaker and NLT 350 ml sample.

Rotation speed selection

The spindle speed rotation to be tested was selected based on the most acceptable torque values obtained during previously measurements for spindle geometry selection. In order to select the most appropriate rotation speed, viscosity profile measurements at different time points (1-10 minutes) using previously selected spindle geometry were performed.

Optimization of time point for single point measurement

In order to identify the most appropriate time point for further measurements, time profile viscosity measurement was made, using previously selected spindle and speed rotation and defined conditions of measurement (600 ml beaker, NLT 350 ml sample).

Optimization of temperature range

Temperature optimization measurements were performed using previously defined measurement conditions, namely selected spindle, rotation speed, time point for single point measurement and sample container and quantity. In order to evaluate the temperature effect, viscosity values of cutaneous solution were measured at three different temperatures: 20 °C, 22 °C and 25 °C. These temperatures were chosen as they represent the laboratory room temperature range, mainly known for scientific work.

Results and discussion

Fluid viscosities are found to be dependent on selected spindle/speed of rotation, time of test measurement and spindle/chamber geometry conditions. An appropriate selection of viscosity measurement conditions will result in measurements within the acceptable torque range (10-100 %). The goal is to obtain a torque between 30 % and 70 %.

The study results show that there is no difference in the obtained viscosity and torque values using different sample quantities. In relation to spindle selection, RV-2 spindle acquired the most acceptable torque values (23-108%) in comparison to RV-3 (9-46%) and RV-4 (5-24%). Therefore, RV-2 spindle is chosen as most appropriate for further measurements.

Rotation speed of 20 rpm, 30 rpm and 40 rpm are satisfactory in relation to preferred torque value of 30-70%. However, the most acceptable torque values (50%) are obtained with spindle rotation speed of 30 rpm. Therefore, 30 rpm is chosen as most appropriate spindle rotation speed. Regarding the optimization of time point for single point measurement, the results show that the viscosity values of the cutaneous solution as well as the obtained torque values display no difference in time period from 1 to 10 minutes. Therefore, time point of 1 minute is selected as suitable for further analysis.

Viscosity determination at different temperatures shows some variation in obtained viscosity values in the interval from 20 °C to 25 °C. As expected, the lowest viscosity (580 cP) was measured at temperature of 25 °C, while the highest viscosity (767 cP) was obtained at temperature of 20 °C. For that reason, determination and marking the temperature of the cutaneous solution during viscosity measurement is recommended.

Conclusion

Rheological measurements are a way to predict and control the product properties, end use performance and material behavior. The results obtained during the study show that the viscous test solution display a decreasing viscosity with an increasing shear rate. Furthermore, the test solution display no change in viscosity in time under condition of constant shear rate. Accordingly, the cutaneous solution which is a subject of this study can be categorized as time independent, non-Newtonian pseudoplastic fluid.

As per viscosity method optimization, the afore discussed measurement conditions are established as satisfactory for obtaining accurate and reproducible viscosity results.

References

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More solutions to sticky problems, Brookfield Engineering lab., Middleboro, USA.