

Application Note: Measuring Eye Drop Viscosity with VROC®

Application

RheoSense, Inc. is the leader in microviscometry with its revolutionary microfluidic and MEMS based VROC® (viscometer-rheometer-on-a-chip) chips. In this application note, eye drops viscosity is measured with the *m*-VROC®.

Eye Drops Viscosity

Dry eye is a chronic problem for many people, a medical condition that is associated with a lack of lubrication on the eye surface. In this condition, tears are not produced and there is irritation: ocular inflammation of the anterior (front) tissues of the eye. Over the counter drugs are available for treating dry eye syndrome; these drugs are usually water based liquid emulsions.

Shear rates are important for eye drops. Eyelid movements induce high shear rates. The shear rates from closing and opening eyelids vary range from 4000 to 20000ⁱ 1/s. Measuring the viscosity of eye drops at high shear rate is *very* important. Conventional rheometry tools, due to their shear rate limitations, are difficult to use for these measurements. For precise measurement and analysis, the *m*-VROC®, designed for high shear measurements, is strongly recommended for this use.

Measurements and Results

For this experiment, *Refresh Liquigel*, manufactured by Allergan, was purchased at a drugstore. 1 mL of the liquid was loaded onto a syringe. Two different tests were run on the sample. The first test was a single point measurement: determine the viscosity is at a fixed flow rate. The flow rate was 100 microliters per minute and the viscosity was 33 cP.

As these eye drops are typically shear thinning, the second measurement was conducted to determine the magnitude of thinning behavior as the shear rate increased. The rate sweep program (Rate Sweep program of *m*-VROC®) as used for this measurement.

The shear rates measured were from 1400 to 24000 1/s. Figure 1 below shows the eye drop was highly shear thinning as the shear rate was gradually increased, which indicates the eye drop is a non-Newtonian liquid. With a conventional rheometer, the practical limit of shear rate is approximately 1000 1/s. At such a low level, it can be very difficult to predict the actual shear thinning behavior of eye drop solutions.

However, *m*-VROC® is designed specifically for high shear rate measurements. This instrument is highly effective for predicting how a sample will behave at very high shear rates. At the date of publishing this document, no other data has been published about Refresh eye drops at high shear rates.

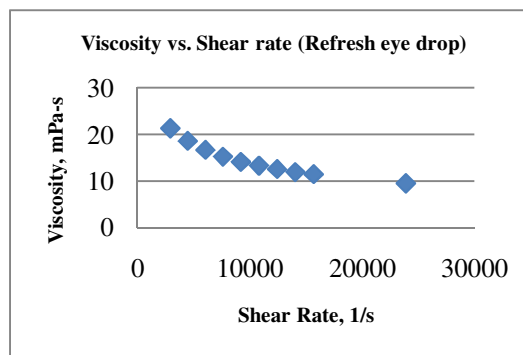


Figure 1: Refresh Eye Drop Viscosity—Function of Shear Rate.

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Table 1 below lists the data that is shown in Figure 1.

Table 1: Shear rate and Viscosity for eye drop

| True Shear Rate | True Viscosity, mPa-s |
|-----------------|-----------------------|
| 1396 | 26 |
| 2904 | 21 |
| 4450 | 19 |
| 6017 | 17 |
| 7599 | 15 |
| 9192 | 14 |
| 10801 | 13 |
| 12416 | 13 |
| 14037 | 12 |
| 15672 | 11 |
| 23887 | 9 |

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ⁱ Abhay Joshi, "Microparticulates for Ophthalmic Drug Delivery," *Journal of Ocular Pharmacology and Therapeutics*. Spring 1994, 10(1):29-45.
Doi:10.1089/jop.1994.10.29.