ELECTRONICS

E-Liquid Analysis

-Viscosity testing of electronic cigarette solutions -

KEY **BENEFITS**

- FAST TEMPERATURE SCREENING
- LOW VOLUME
- QUICK & SIMPLE

Introduction

Electronic cigarettes use a special solution called an e-liquid which is vaporized by a battery powered atomizer to provide smokers the same sensation of smoking as the traditional cigarette. Typical e-juice or e-liquid contains four ingredients: Propylene Glycol (PG), Vegetable Glycerin (VG), flavor, and nicotine. E-juice manufacturers mix PG and VG regarding the benefits and the characteristics of both, PG for the better throat hit sensation and VG for higher smoke density and sweetness.

The VG is a viscous compound providing vapor density and sweetness sensation to the smoke whereas PG which is less viscous modulates the throat hit. Viscosity is an important parameter to monitor in the formulation of e-liquids, as a too low viscosity of the e-liquids may lead to leaking issues.

However, with the massive expansion of the demand formulators are faced with the need to diversify available products and thus require a simple and efficient tool to analyse multiple solutions in a short amount of time, Fluidicam^{RHEO} is proven to be an excellent solution.

Reminder of the technique

Fluidicam^{RHEO} uses a co-flow microfluidic principle to measure viscosity. The sample and a reference solution are simultaneously introduced into the microfluidic channel (typically 2.2mm X 150µm) with controlled flow rates. This results in a laminar flow where the interface position between sample and reference relates the viscosity ratio and flow rates.

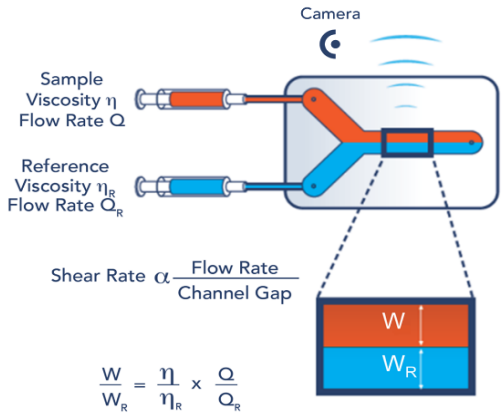
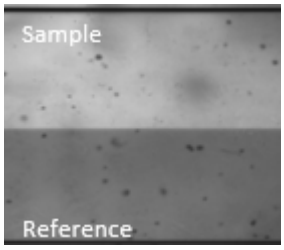


Fig. 1: Fluidicam measuring principle

Images acquired during the measurement allow the software to calculate the position of the interface and directly plot an interactive flow curve.



Method

Several mixtures of vegetable glycerin (VG) and Propylene glycol (PG) in different ratios were tested to cover the proportions that are commonly found on the market. Alongside this a variety of pre-filled off-the-shelf e-liquids were analyzed with Fluidicam^{RHEO} at a shear rate of 2000 s^{-1} using a 150 µm channel gap chip at different temperatures from 20 to 65°C.

Results

Viscosity measurements of different preparations of VG and PG:

Common e-liquid blends are composed of PG and VG mixtures in different proportions, to this flavors and nicotine are added. Figure 2, shows the viscosity variations at different temperatures against the %VG in the mixture.

Each concentration was analyzed at 4 different temperatures automatically, no resampling was needed. A single chip was used to measure all of the samples that cover a large range of viscosities.

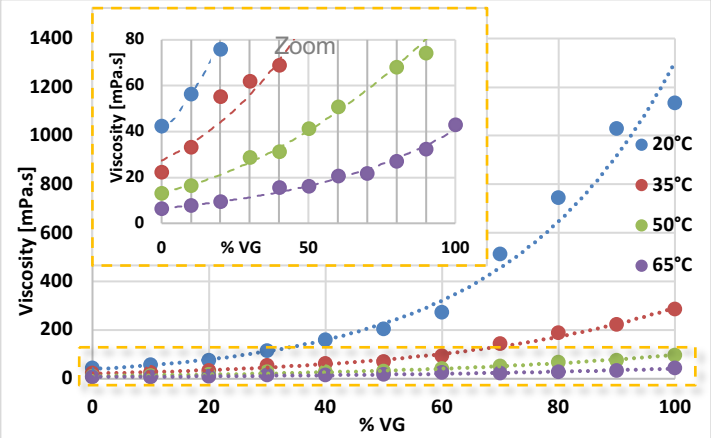


Fig 2. Viscosity as function of temperature and vegetable glycerin VG concentration.

This graph illustrates the impact of vegetable glycerin concentrations on viscosity values, as shown the viscosity of the mix increases as the VG% (wt) increases. The temperature has a large impact on the different mixtures, as expected at 20°C the highest viscosity vales are observed.

The impact of the temperature is higher at the higher concentrations of VG, the 100% VG decreases from *1133 mPa.s* at 20°C to *43 mPa.s* at 65 °C and for low VG% concentrations at 20% the zoom shows a viscosity variation from *75 mPa.s* at 20 °C to *10 mPa.s* at 65°C.

Impact of other compounds (flavors):

A prepared mixture of PG:VG=50:50 and 4 market products (Phobé products) with same 50:50 proportions, 0 mg/mL of nicotine and 4 different flavours were analyzed following the previous protocol in method. The results are shown in the figure 3 where in this case viscosity is plotted against temperature.

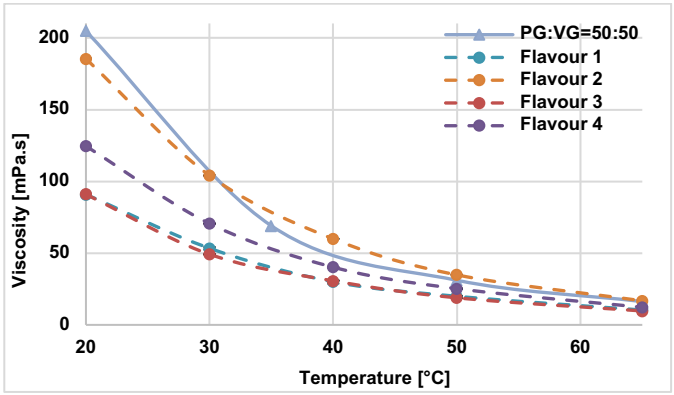


Fig 3. Visocisty plotted against temperature for 50:50 PG:VG and differet flavoured e-liquids

Figure 3 shows that the viscosity of the different flavored e-liquids can vary a lot depending on the flavors that are added, we see the largest variation at 20°C with flavor 2 being the most viscous and flavors 1 and 3 being the least. This means that the formulator must consider the viscosity impact of the flavors in the mixture when creating the e-liquid.

Additional tests were carried out to determine the impact of the nicotine on the viscosity. Very small changes were observed which, when compared to the impact of the VG:PG proportion and the different flavors, has a negligible impact on the overall viscosity of the e-liquids.

CONCLUSION

The proportion of VG and PG and the different flavors used can have a large impact on the viscosity of e-liquids. The temperature also has a large influence on the viscosity of the samples. Fluidicam^{RHEO} allows the formulator to quickly and easily test many e-liquid formulations in order to create a product with the appropriate sweetness, smoke density, throat hit and a high enough viscosity to avoid leakage.