FOOD & BEVERAGES

Understanding wine viscosity

- Analyzing the influence of ingredients -

Introduction

Viscosity is an important rheological property and a quality characteristic that affects the mouthfeel and modifies other oral sensations[1]. Wines are complex products containing many ingredients with main composition: water, ethanol, glycerol and sugar. These all play significant effect on viscosity and analyzing wine with a conventional rheometer could be challenging considering the high shear rates related to the deglutition conditions[2] and the low values of wine's viscosity. Fluidicam^{RHEO} is a suitable instrument for high shear analysis but also for low viscosity value thanks to the high sensitivity of the instrument to small viscosity variations.

KEY **BENEFITS**

HIGH ACCURACY

FAST & SIMPLE

LOW SAMPLE VOLUME

In this application note, we show how Fluidicam^{RHEO} can be used for highly precise viscosity measurements to determine the impact of each wine compound on viscosity.

References:

[1] Yanniotis, S., G. Kotseridis, A. Orfanidou, and A. Petraki. 2007. 'Effect of Ethanol, Dry Extract and Glycerol on the Viscosity of Wine'. *Journal of Food Engineering* 81 (2): 399–403.
[2] Nicosia, Mark A. 2013.
[3] Siret, René, Emmanuel Madieta, Ronan Symonaux, and Frédérique Jourjon. 2008. 'Rheologic measurements of wine texture and viscosity. Correlations with sensorial analyses.', 6.

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.

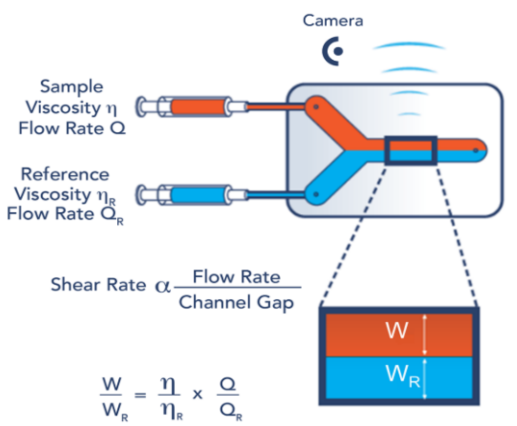
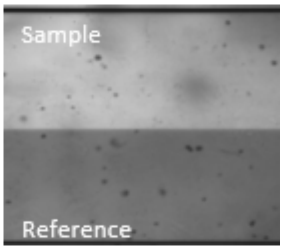


Figure 1: Fluidicam measuring principle

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



Method:

Several wines from the market of different origines have been analyzed over a range of shear rate from 300 – 100 000 s^{-1} at different temperatures from 13°C to 40 °C, using two microfluidic chips with 150 µm and 50 µm channel gap.

The fluid reference used for these test is water (DIW). Each flow curve took 3 min analysis time, and recquired less than 2 mL sample volume.

Results:

Wine viscosity vs shear and temperature.

The different wines tested (Sauternes, Rioja, Côte de Bergerac, Lusitano) show a newtonian profile over the studied shear rates.

Sauternes presents a higher viscosity η=2 mPa.s whereas Rioja, Côte de Bergerac, Lusitano all exhibit an average viscosity of 1.4 mPa.s Fig.2

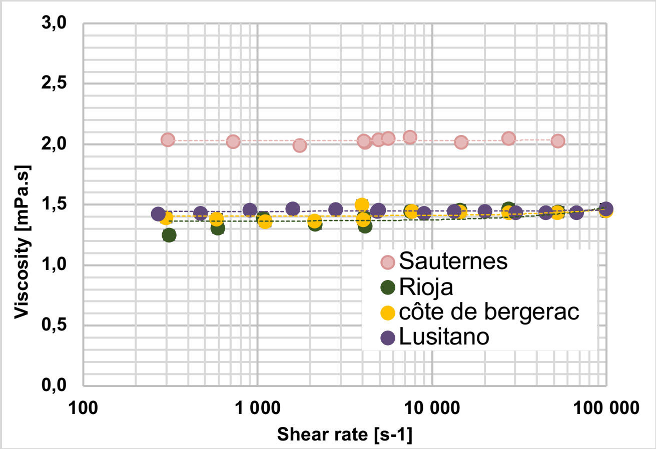


Figure 2. viscosity profil of wines as a function of shear rate.

In order to simulate product lifecyle from storage to consumption conditions, 5 wines were analysed at 13°C, 20°C, 30°C and 40°C. All 5 present a Newtonian profile and the viscosity values are calculated from the average values over the studied shear range. Figure 3 presents the temperature dependence of the 5 red wines

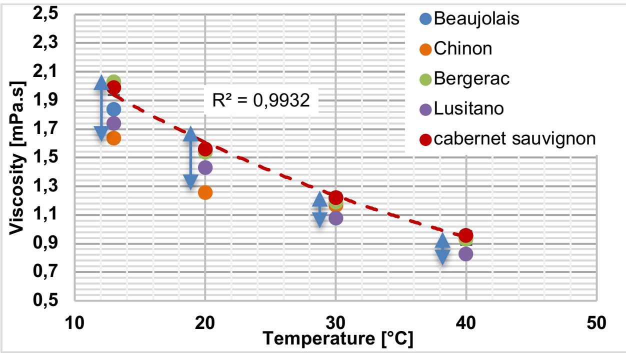


Figure 3. temperature dependence of wine viscosity.

The viscosity follows an Arrhenius law $\eta \simeq \alpha\, e^{-\beta/T}$. As the temperature increases, the viscosity of the wine decreases, in addition the differences of wine viscosities decrease at higher temperatures.

Red wine composition impact on viscosity

Typically red wines contain an alcohol content of 11° to 15°, then a variety of additional compounds are added, for example: **Glycerol (Gly): 2g/L-12 g/L – Sugar (Fructose) :2-20g/L – Polysaccharides = 0.2- 1g/L.**

To understand how the addition of these compounds impacts red wine viscosity, different formulations of wine analogs have been prepared. The following table sums up blends with the sequential addition of the Glycerol, Fructose and Polysaccharides with the following amounts.

Formulations	Composition		
	Glycerol	Fructose	Polysaccharides
F1	2g/L	0	0
F2	12g/L	0	0
F3	12g/L	20 g/L	0
F4	12g/L	20 g/L	1g/L

Table1. Sequential formulations of wine anologs.

Each formulation was prepared in a 11° and 15° alcohol content base (Water–EtOH).
All formulations have been analysed at 2000 s^{-1} and 25°C using 50 µm chip that allows to use less than 2ml of the sample for the test. The average viscosities obtained are presented in the fig.4 and compared to the real wines.

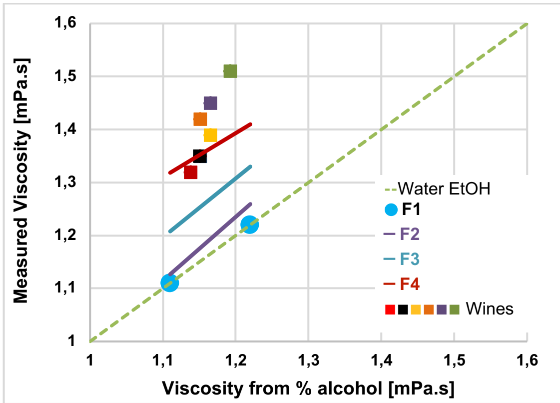


Figure 4. Wine viscosity as a function of the viscosity based on water ethanol mixtures viscosity.

The Water-Ethanol line represents the reference line. The viscosity of the **F1** remains on the reference line, no viscosity changes were observed due to 2g/L glycerol addition but at 12g/L (**F2**) the viscosity has increased by 3%. Adding 20 g/L of sugar to this formulation (**F3**) rises the viscosity by 7% as compared to **F2**. **F4** formulation has the closest values to red wine's viscosity and this is obtained by adding 1g/L of Polysacharride.

As observed from the graph, each element that composes wine, contributes to viscosity changes of wine. Most of the tested wines present viscosity values that are superior to the analog tested, this is explained by the additional components usually present in wines: wine must, acids, minerals compounds…, that were not considered in this study.

CONCLUSION

FluidicamRHEO is a perfect tool for fast comparison of mixtures with a very small viscosity variations (as small as 0.16mPa.s difference). The different tests have been conducted in less than 1h and 30 min analysis time including the resampling and the temperature regulation allowing hig performance in viscosity analysis of multiple samples in short amount of tme.