# Rotational Viscosity Testing of Chocolate with ViscoQC

Knowing the viscosity of chocolate is essential for a perfect performance of the final product and guarantees the perfect mouth feel. No matter if you are interested in quick single-point measurements or multiple-point rotational tests, the ViscoQC 100/300 is your perfect choice!

## 1 Introduction

Viscosity control of chocolate is essential for high quality end products and ensures optimized processing of the liquid chocolate in covering processes. Low-viscosity chocolates can be used for dipping processes or chocolate fountains. High-viscosity chocolates are ideal for creating thick chocolate layers or production of chocolate bars. An international test method to investigate the flow behavior of chocolate products is the IOCCC (International Organization of Chocolate, Cocoa and Confectionery) method, where the chocolate's flow behavior is analyzed at different shear rates followed by mathematical analysis such as the chocolate's yield point.

### 1.1 Keywords

Chocolate viscosity, IOCCC, Casson, yield point chocolate, yield stress chocolate, viscosity quality control, touch viscometer, rotational viscometer, dynamic viscosity, digital viscometer, determination of viscosity

## 2 Experiment

The viscosity of milk and dark chocolate was tested with the rotational viscometers ViscoQC 100/300. For quick single point checks a ViscoQC 100 - R was used. For the multi-point analysis as well as the shear rate control capability described in IOCCC, ViscoQC 300 - R is the instrument of choice. Depending on the type of chocolate and concentric cylinder (CC) system used, the shear rates that give readings within 10 to 100 % torque have to be evaluated. Alternatively, the H-model can be used for highly viscous chocolate samples. The instrument needs to be upgraded with the software package V-Curve to program step procedures and calculate the yield point (Casson).

| | Dark and milk chocolate | |
|---|---|---|
| **Instrument** | ViscoQC 100 - R | ViscoQC 300 - R |
| **Measurement type** | Single-point | IOCCC test / Temp. Scan |
| **Spindle** | CC12 | |
| **Speed/Shear rate** | 10 rpm | 5 $s^{-1}$ to 25 $s^{-1}$*/10 $s^{-1}$** |
| **Temperature** | +40 °C* / + 30 °C to + 50 °C** | |

*Table 1: Configuration and measurement conditions for viscosity testing of chocolate. *Settings for IOCCC test (For milk chocolate the shear rate ramp was started at 2 $s^{-1}$). ** Settings for Temp. Scan of milk chocolate.*

To control the temperature during the measurement the Peltier temperature device PTD 80 was mounted on the stand of the ViscoQC 100/300. The PTD 80 can control the temperature of DIN/SC4 spindles between + 15 °C to + 80 °C and keeps the achieved temperature stable within ± 0.1 °C.

### 2.1 Test Procedure and Conditions

Sample preparation was performed according to the regulations listed in the IOCCC standard.

Solid chocolate pieces were weighed into the CC12 measuring cup and melted at + 52 °C to + 54 °C in an oven for exactly 1 h.

After melting, the cylinder was immersed into the CC12 cup containing molten chocolate and inserted into the PTD 80. The instrument head of ViscoQC 100/300 was properly adjusted and the PTD 80 easily centered via the centering adapter.

ViscoQC 100:

For single point measurements, a speed of 10 rpm was set in the Stop at Time (@t) mode with a target time of 30 s.

ViscoQC 300:

For the measurement according to IOCCC, a method consisting of 4 steps was programmed (Table 2). Step 1 serves to homogenize and control the temperature of the sample. Step 4 is the main measuring step and is used for analyzing the yield point (Figure 1).

| Step | Measurement Mode | Set Value [ $s^{-1}$] | Target Value [s] | Set Temperature [°C] |
|---|---|---|---|---|
| 1 | Stop at Time (@t) | 5 | 480 | + 40 |
| 2 | Speed Scan (SpS) | 2/5* to 25 | 30 / 15 points | + 40 |
| 3 | Stop at Time (@t) | 25 | 60 | + 40 |
| 4 | Speed Scan (SpS) | 25 to 2/5* | 30 / 15 points | + 40 |

*Table 2: Step procedure for analyzing chocolate according to IOCCC. *Shear rate ramp started for milk chocolate: at 2 $s^{-1}$; dark chocolate: at 5 $s^{-1}$*

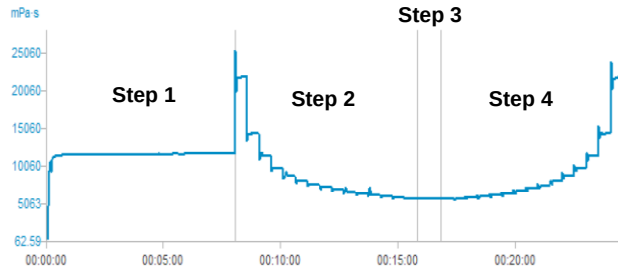


Figure 1: Real-time graph of the step test

A "Temperature Scan (TS)" was used to analyze the dependence of the viscosity of milk chocolate on temperature between + 50 °C and + 30 °C with 5 measurement points at 10 $s^{-1}$.

## 3 Results and Discussion

A measurement with ViscoQC 100 provides you with viscosity values at one certain speed for quick quality control checks of chocolate (Table 3).

| Sample | Speed [rpm] | Torque [%] | Temperature [°C] | Viscosity [mPa·s] |
|---|---|---|---|---|
| Dark chocolate | 10 | 19 | + 40 | 2256 |
| Milk chocolate | 10 | 59 | + 40 | 7179 |

*Table 3: Average viscosity values of dark and milk chocolate at 10 rpm measured with a ViscoQC 100 - R.*

Dark chocolate shows a significantly lower viscosity than milk chocolate due to the different ingredients. Monitoring the viscosity of the chocolate is important as only optimum viscosity guarantees perfect coverage of bars and optimum molding of chocolates. Furthermore, chocolate consistency is very sensitive and can vary due to climate changes (e.g. humidity in air).

With ViscoQC 300 and the activated V-Curve the viscosity at different shear rates and the yield point according to Casson (as specified in IOCCC) can be analysed (Table 4 and Figure 2). Dark chocolate shows a lower yield stress compared to milk chocolate. The yield stress is the force that needs to be applied to a sample so that it starts to flow. This means that dark chocolate will flow more easily compared to milk chocolate. Knowing the yield stress is essential during the chocolate manufacturing process to optimize the conching process and to ensure perfect coverage of chocolate surfaces when producing chocolate bars (e.g. avoiding the formation of an uneven surface). The yield stress of chocolate can be adjusted by adding emulsifiers or cocoa butter to the chocolate.

The plastic viscosity of dark chocolate is lower than of milk chocolate. It is assumed that the viscosity approaches a constant limit value at high shear rates.

| Sample | Yield Stress [$N/m^2$] | Plastic Viscosity [mPa·s] |
|---|---|---|
| Dark chocolate | 4.520 | 950.1 |
| Milk Chocolate | 18.95 | 2270 |

*Table 4: Analysis results of dark and milk chocolate using the mathematical model "Casson".*

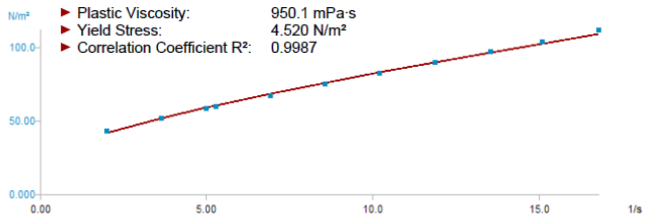


Figure 2: Flow curve and yield stress analysis of dark chocolate according to Casson using the ViscoQC 300 with V-Curve.

Using the Temperature Scan the chocolate's viscosity dependence on temperature can be visualized (Table 5). The viscosity of milk chocolate increases with decreasing temperature.

| Dyn. Vis. | Speed | Torque | Runtime | Temp. | Kin. Vis. | Shear Rate | Shear Stress | Strain | TR | W/E |
|---|---|---|---|---|---|---|---|---|---|---|
| mPa·s | rpm | % | hh:mm:ss | °C | mm²/s | 1/s | N/m² | rad | % | |
| 4805 | 7.75 | 30.7 | 00:00:30 | 50.0 | 4805 | 10.00 | 48.07 | --- | 0.0 | |
| 5384 | 7.75 | 34.4 | 00:00:30 | 45.0 | 5384 | 10.00 | 53.86 | --- | 0.0 | |
| 6214 | 7.75 | 39.7 | 00:00:30 | 40.0 | 6214 | 10.00 | 62.16 | --- | 0.0 | |
| 7309 | 7.75 | 46.7 | 00:00:30 | 35.0 | 7309 | 10.00 | 73.12 | --- | 0.0 | |
| 8734 | 7.75 | 55.8 | 00:00:30 | 30.0 | 8734 | 10.00 | 87.37 | --- | 0.0 | |

*Table 5: Temperature dependent test of milk chocolate from + 50 °C down to + 30 °C using ViscoQC 300 with V-Curve*

## 4 Summary

The rotational viscometers ViscoQC 100/300 are well suited for rotational viscosity tests of chocolate in quality control. The ViscoQC 100 can be used for quick single-point viscosity checks. Using ViscoQC 300 a speed-dependent and temperature-dependent test can be carried out. Further, the chocolate can be analyzed according to IOCCC if the instrument is upgraded with V-Curve. The yield stress determination is especially important in chocolate production, as it shows if the chocolate has the right flow behavior for further processing and a high quality end product is achieved.

If you have further questions regarding this application report, please contact your local Anton Paar representative.

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