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Performing extended rheological tests in oscillation mode with the HAAKE Viscotester iQ Air Rheometer

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Keywords

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Introduction

Oscillatory measurements are the ideal rheological method to quantify the amount of viscous and elastic properties hidden in a material's structure as a function of time, temperature, deformation or frequency. This information is needed to formulate better products, as the elasticity often leads to unwanted flow characteristics (e.g. stickiness, stringiness, etc.) that therefore may lead to a bad customer experience. The intention of this application note is to demonstrate the possibilities as well as limitations for performing different kind of oscillatory experiments with the Quality Control air-bearing rheometer Thermo Scientific™ HAAKE™ Viscotester™ iQ Air. Results are compared to those achieved with a standard Thermo Scientific™ HAAKE™ Viscotester™ iQ Rheometer with a mechanical-bearing, to demonstrate the advanced capabilities of the air bearing. For details on the tests performed with the HAAKE Viscotester iQ as well as for a detailed introduction to oscillatory Rheology (1).

Materials and methods

All tests were performed with a HAAKE Viscotester iQ Air Rheometer with Peltier temperature control (Figure 1). This compact rotational rheometer is equipped with a highly dynamic Electronically Commutated (EC)-motor with air-bearing that allows for rotational rheological experiments in Controlled Stress (CS) and in Controlled Rate (CR) mode as well as oscillatory tests in CS as well as in Controlled Deformation (CD) mode. The rheometer can be equipped with various types of measuring geometries, ranging from coaxial cylinders over

Figure 1: HAAKE Viscotester iQ Air Rheometer with parallel plate geometry.

vane type rotors to parallel plates and cone & plate fixtures. This flexibility allows for testing a broad range of different samples. In rotational mode this includes materials form ultra low viscous fluids to stiff pastes (2). In contrast to the standard HAAKE Viscotester iQ Rheometer with a ball bearing, low- to high-viscosity samples can be tested in oscillation mode. All samples used for the tests performed for this report are commercially available products.

The specifications for tests in oscillation mode are listed in Table 1 together with the comparison to the standard HAAKE Viscotester iQ Rheometer.

To demonstrate the enhanced capabilities of the HAAKE Viscotester iQ Air Rheometer, amplitude sweeps have been performed in order to determine the linear viscoelastic range (LVR) of various consumer goods. The results of the amplitude sweeps carried out with both HAAKE Viscotester iQ Rheometer models are shown in Figure 2.

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Table 1: Specifications of the HAAKE Viscotester iQ (Air) Rheometer for experiments in oscillation mode.

Unit	HAAKE Viscotester iQ Rheometer	HAAKEViscotester iQ Air Rheometer
Minimum torque (CS and CD mode)	0.2 mNm	10 µNm
Maximium torque (CS and CD mode)	100 mNm	100 mNm
Minimum deflection angle (CS and CD mode)	10 µrad	10 µrad
Maximum deflection angle (CS and CD mode)	∞	∞
Minimum oscillatory frequency	0.1 Hz (optional)	0.1 Hz
Maximum oscillatory frequency	20 Hz (optional)	50 Hz

For the tests with the body lotion and the dishwashing detergent a 60 mm parallel plate rotor was used. The high viscous skin care cream was tested with a 35 mm plate rotor. For all tests the measuring gap was set to 0.5 mm. The test temperature was 25 °C.

Results end discussion

As one can see in Figure 2, the HAAKE Viscotester iQ Air Rheometer allows for measurements at much lower deformations than the standard HAAKE Viscotester iQ Rheometer. For very stiff materials like the skin care cream the difference is not so important, however for low viscoelastic materials like the body lotion and the dishwashing detergent, the HAAKE Viscotester iQ Air Rheometer can add more than one order of magnitude to lower deformations, thus enabling the accurate determination of the LVR.

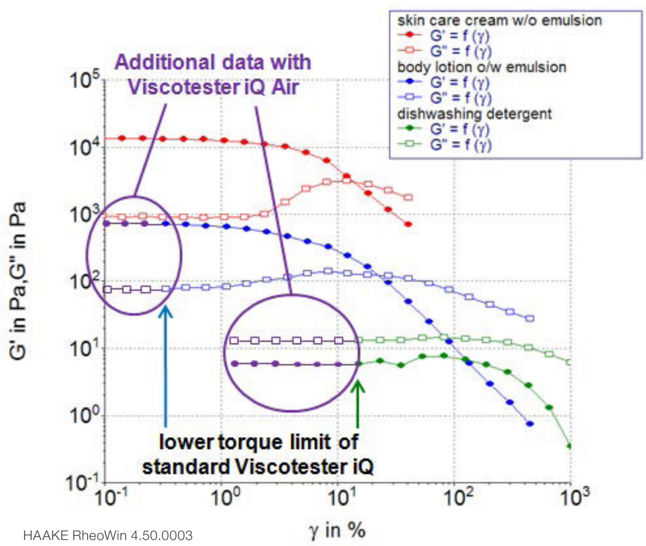

Figure 2: Storage modulus G' and loss modulus G" as a function of deformation γ for different consumer products at 25 °C.

This becomes even more obvious when testing a more delicate sample like a tomato ketchup. The results of the amplitude sweeps done with both HAAKE Viscotester iQ Rheometer models are shown in Figure 3. As one can see, the difference between the two instruments becomes more important. Where the standard model was not able to determine the LVR at all, the HAAKE Viscotester iQ Air again proves its additional value by adding one order of magnitude in lower deformations to the measuring range.

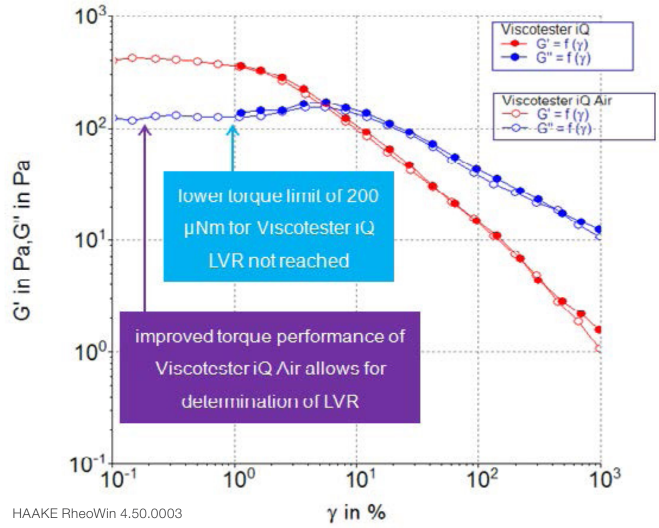

Figure 3: Storage modulus G' and loss modulus G" as a function of deformation γ for tomato ketchup at 25 °C.

To demonstrate the performance of the HAAKE Viscotester iQ Air Rheometer in a frequency sweep, Figure 4 shows the results obtained from a PDMS reference material at room temperature in comparison to those obtained on a research grade rheometer Thermo Scientific™ HAAKE™ MARS™ 60 Rheometer.

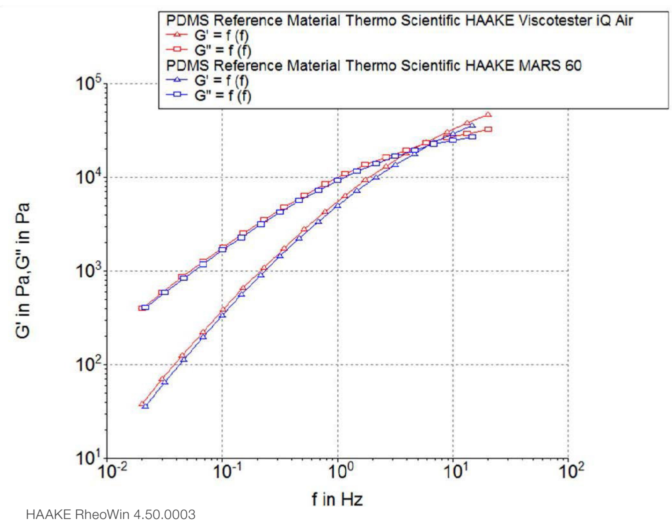

Figure 4: Storage modulus G' and loss modulus G" as a function of frequency f for a PDMS reference material at 25 °C.

As one can see in Figure 4, the results obtained with both instruments are almost identical, with the largest deviation being at around 3 %. This is a clear indication that even with an entry-level QC rheometer like the HAAKE Viscotester iQ Air Rheometer, high quality results can be obtained for oscillatory measurements.

Conclusion

It was demonstrated that oscillatory experiments can be performed in a better way with the air-bearing instrument HAAKE Viscotester iQ Air Rheometer than with the standard HAAKE Viscotester iQ Rheometer with a mechanical bearing. Due to the lower torque limit of the instrument, more than one order of magnitude in lower deformation can be added to available measuring range. Also, when comparing data from frequency sweep experiments with those coming from a research grade rheometer, it was demonstarted that the HAAKE Viscotester iQ Air Rheometer delivers accurate results over a wide frequency range results.

Reference

1. F. Meyer, "Performing rheological tests in oscillation with the HAAKE Viscotester iQ Rheometer", Thermo Fisher Scientific Application note V279.
2. J.P. Plog, "Testing low viscosity fluids with the HAAKE Viscotester iQ Air Rheometer", Thermo Fisher Scientific Application note V280.

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