Performing Enhanced Rheological Tests in Oscillation with the Thermo Scientific HAAKE Viscotester iQ Air

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Key words
Oscillatory testing, QC rheometer, Viscoelastic behavior, Linear viscoelastic regime

Introduction

Oscillatory measurement techniques are ideal to quantify the amount of viscous and elastic behaviour hidden in a material's structure as a function of time, temperature, deformation or characteristic speed. 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 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, please refer to Application Note V279 - Oscillatory Rheology for Quality Control.

Materials and Methods

All tests were performed with a Thermo Scientific HAAKE Viscotester iQ Air with Peltier temperature control (Fig. 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). The rheometer can be equipped with various types of measuring geometries, ranging from coaxial cylinders over 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 (e.g. water, see application note V280 - Testing Low Viscosity Fluids with the HAAKE Viscotester iQ Air) to stiff pastes. In oscillatory mode low to high viscous samples can be tested in contrast to the standard HAAKE Viscotester iQ. All samples used for the performed tests are commercially available products. The PDMS shown later was provided by NIST (Gaithersburg, USA).

Fig. 1: Thermo Scientific HAAKE Viscotester iQ Air with Peltier temperature control.

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

Results and Discussion

To demonstrate the enhanced capabilities of the HAAKE Viscotester iQ Air, amplitude sweeps have been performed in order to determine the linear viscoelastic regime (LVR) of various consumer goods. The results of the amplitude sweeps done with both HAAKE Viscotester iQ units are shown in Figure 2. 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 m m plate rotor. For all tests the measuring gap was set to 0.5 mm. The test temperature was 20 °C.

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

Unit	Viscotester iQ	Viscotester iQ Air
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 (optional)
Maximum oscillatory frequency	20 Hz (optional)	50 Hz (optional)

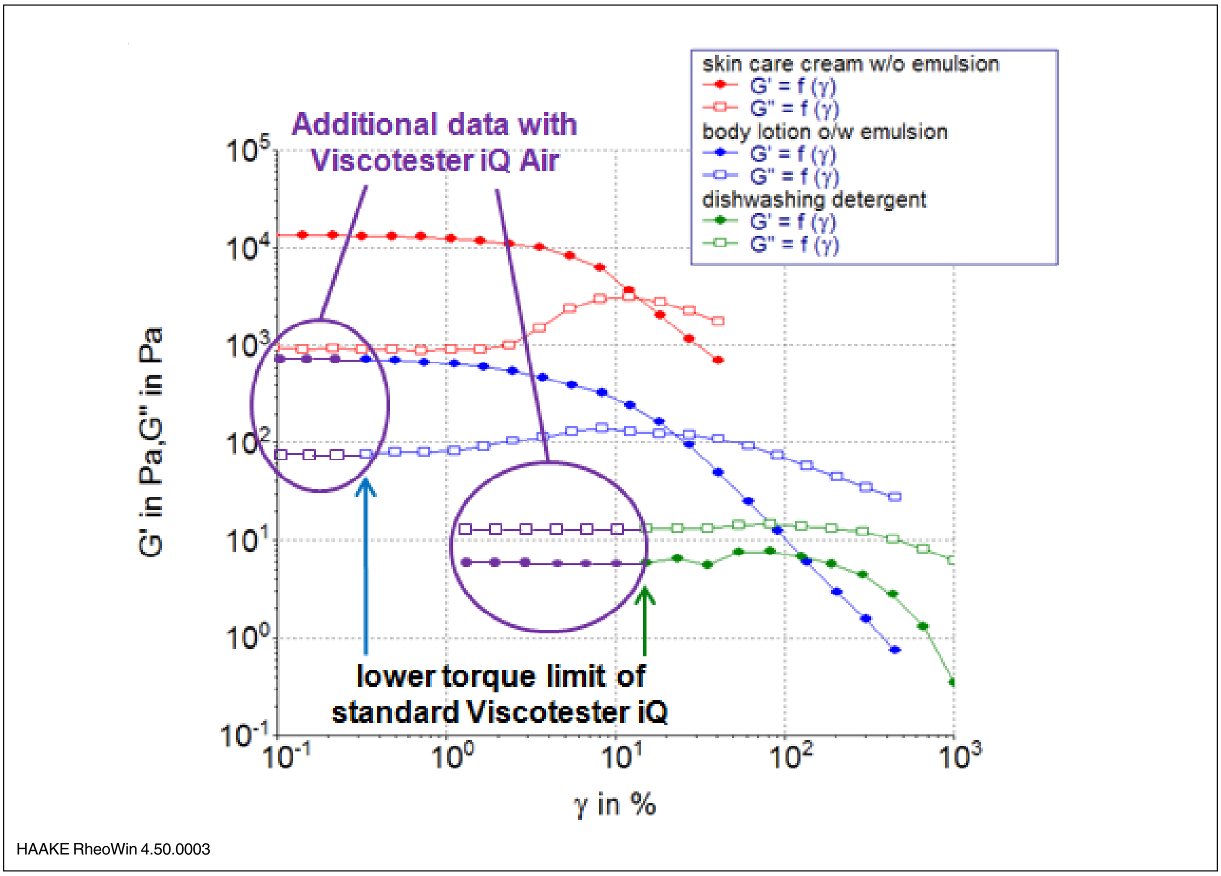

Fig. 2: Storage modulus G' and loss modulus G" as a function of deformation γ for different consumer products at 25 °C.

As one can see in Figure 2, the HAAKE Viscotester iQ Air allows to go down to much lower deformations than the standard HAAKE Viscotester iQ. For high to medium viscelastic materials like the skin care cream or the body lotion this does not add too much value, however for low viscoelastic materials like the dishwashing detergent, the HAAKE Viscotester iQ Air can add more than one order of magnitude to lower deformations, thus enabling the user to smoothly determine the LVR.

This becomes even more obvious when having a look at a more delicate sample like tomato ketchup. The results of the amplitude sweeps done with both HAAKE Viscotester iQ units are shown in Figure 3.

As one can see the difference between both HAAKE Viscotester iQ units becomes more obvious. Where the standard unit was not able to determine the LVR at all, the HAAKE Viscotester iQ Air again proves its worth by doing exactly that via adding one order of magnitude down to lower deformations.

To demonstrate the performance of the HAAKE Viscotester iQ Air 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.

As one can see in Figure 4, the results obtained with the previous mentioned instruments are almost identical. The largest deviation coming in at approx. 3%. This is a clear indication that even with an entry-level QC rheometer like the HAAKE Viscotester iQ Air, high quality results can be obtained in oscillation.

Conclusions

It was demonstrated that oscillatory experiments can be performed better with the air-bearing unit HAAKE Viscotester iQ Air than with the mechanical-bearing unit HAAKE Viscotester iQ. Due to the lower torque limit of the instrument, more than one order of magnitude can be added to lower deformations. Also, when comparing data from frequency sweep experiments with those coming from a research grade rheometer, it becomes obvious that the HAAKE Viscotester iQ Air delivers fast and precise results.

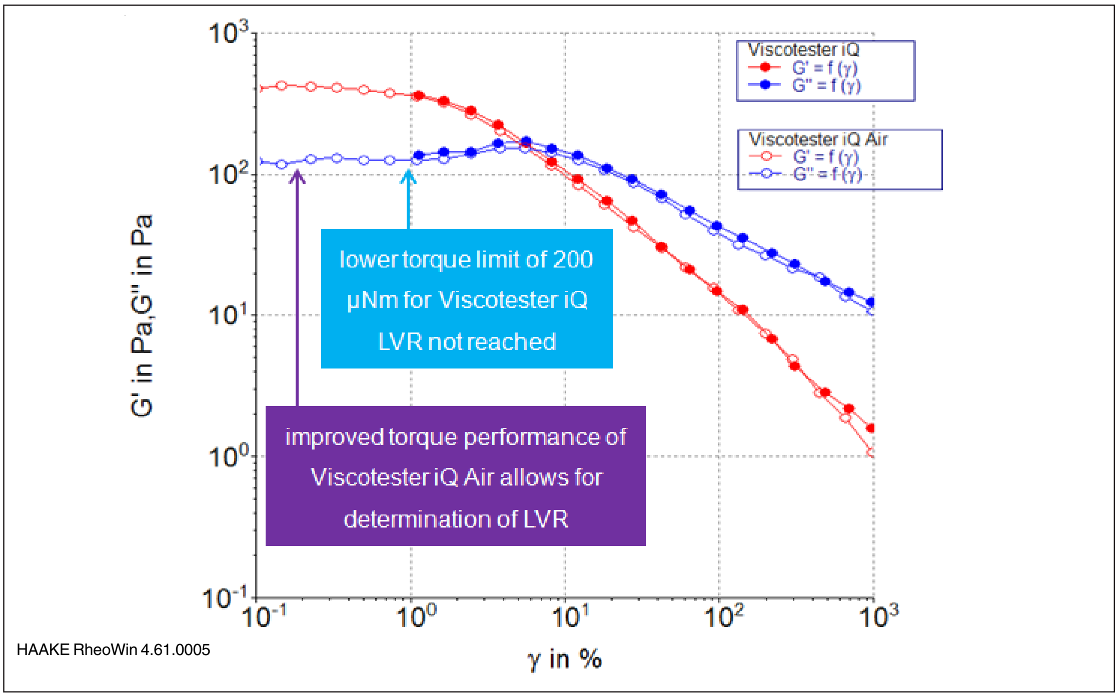

Fig. 3: Storage modulus G' and loss modulus G" as a function of deformation γ for tomato ketchup at 25 °C.

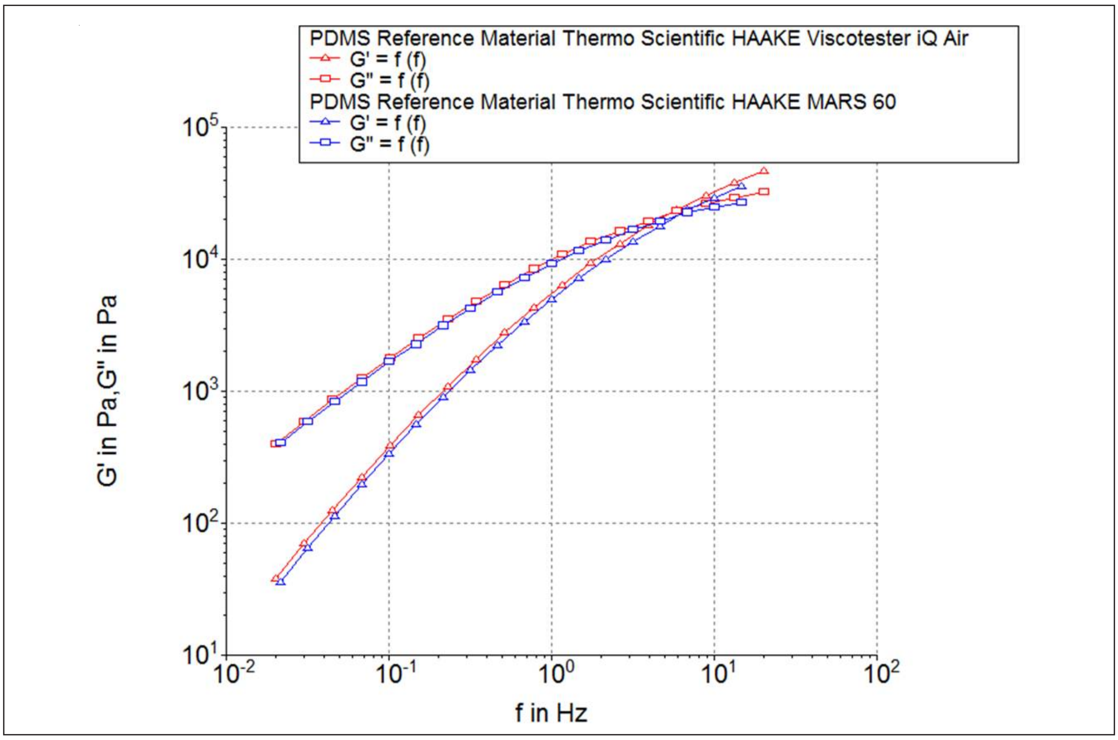

Fig. 4: Storage modulus G' and loss modulus G" as a function of frequency f for a PDMS reference material at 25 °C.

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