How much squeezing power is required to get the toothpaste out of the tube? Yield stress determination using the HAAKE Viscotester iQ.

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**Introduction**

Toothpastes are viscoelastic products with a paste-like texture well known in everyday's life. They have a complex structure including many components influencing the rheological properties such as abrasives to support the mechanical cleaning effort of the toothbrush, moisture agents to prevent a drying out of the toothpaste as well as binding agents to prevent the phase separation between the liquid and the solid. Rheology plays an important role in the product development of toothpaste, the production, the filling and packaging processes as well as in fulfilling the expectation of a consumer target group [1].

This article will focus on the importance of the yield stress of different toothpastes. The yield stress characterizes the amount of force that it takes to break down the initial structure of the product and get the fluid moving. Squeezing is required to get the toothpaste out of the tube. There must be enough squeezing power to overcome the yield stress in the material. Two different toothpastes – one for adults and one for children – have been selected for this investigation. For the measurement and evaluation the preferred method described in [2] was applied.

**Measuring Setup**

For the measurements the Thermo Scientific™ HAAKE™ Viscotester™ iQ rheometer was used. This instrument equipped with an EC motor enables a variety of test methods in controlled rate (CR) and controlled stress (CS) mode in a broad measuring range. As temperature control unit a self-contained Peltier module was used, which enables a fast and reliable temperature control in the range between -5 °C and 160 °C. The tests were carried out by using a parallel plate measuring geometry with a diameter of 35 mm. To avoid slippage a measuring geometry with serrated surface has been selected. The lower measuring plate matches the upper plate in diameter and appearance and therefore ensures ideal measuring conditions and an optimal sample filling [3]. Other advantages of this geometry are a small sample volume, shorter time for temperature equilibrium and reduced cleaning effort. In addition a sample cover was put over the filled measuring geometry to minimize the evaporation and the temperature gradient within the sample.
Measurements, Results and Discussion

The measuring curves of the adult toothpaste and the children’s product are shown in Fig. 3. Two curves for each sample are included to demonstrate the high level of reproducibility. The yield stress values are summarized in Tab. 1. As expected the yield stress of the children toothpaste is with a value of approximately 55 Pa much lower than the adult product with an average of 215 Pa.

Two versions of yield stress evaluation are available in the HAAKE RheoWin software: the automatic routine and the manual mode (Fig. 4.). Using the HAAKE Viscotester as a standalone unit only the automatic evaluation routine is available.

The manual routine gives more flexibility in finding the correct value for the yield stress. The range in which the yield stress is is normally well visually detectable and the measuring ranges for the fit of the linear ranges can be selected. This mode has been used for the calculation of the yield stress values presented in Tab. 1. However, the yield stress strongly depends on sample preparation, the measuring routine itself but also on the evaluation procedure. Fig. 5 includes a comparison between both modes on a children toothpaste.
Summary

The determination of the yield stress is an important rheological parameter to understand if a toothpaste meets the expectation of the customer target group. The yield stress strongly depends on the sample history and preparation, the measuring conditions and method as well as the evaluation routine.

The HAAKE Viscotester iQ is a compact rheometer focusing on modern QC demands. The modular design enables an adaptation to individual needs thanks to a broad range of accessories. Quick coupling and recognition of the temperature module as well as the measuring geometry in combination with an intuitive instrument concept with a smart lift function, guarantees smooth handling. The HAAKE Viscotester iQ is the instrument of choice as stand-alone unit for standard measuring and evaluation routines or as fully software controlled version with the HAAKE RheoWin software for highest measuring flexibility.

Literature


Fig. 5: Yield stress evaluation using the automatic mode (61.68 Pa, green line) and the manual mode (55.39 Pa, red line)