# APPLICATION**NOTE**

## Body Lotion – Kinexus

# Determination of Yield Stress of Complex Fluids by Stress Growth Test on a Rotational Rheometer – Body Lotion

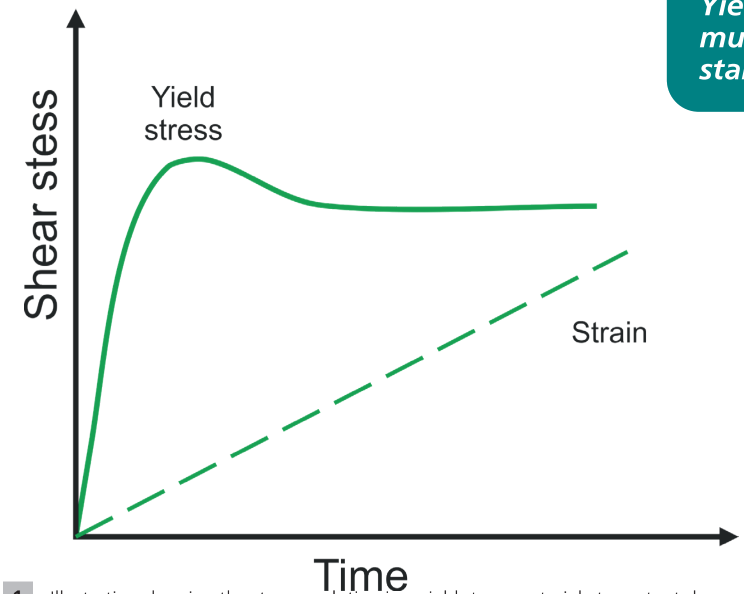
### Introduction

Many complex fluids, such as network forming polymers, surfactant mesophases and concentrated emulsions do not flow until the applied stress exceeds a certain critical value, known as the yield stress. Materials exhibiting this behavior are said to be exhibiting yield flow behavior. The yield stress is therefore defined as the stress that must be applied to the sample before it starts to flow. Below the yield stress, the sample will deform elastically (like stretching a spring), above the yield stress the sample will flow like a liquid

Most fluids with yield stress can be considered as a structural skeleton that extends over the entire volume of the system. The strength of the skeleton is governed by the structure of the dispersed phase and its interactions. Normally, the continuous phase is low in viscosity, however, high volume fractions of a dispersed phase can increase the viscosity by a thousand times and induce solid-like behavior at rest.

When a complex fluid that exhibits yield behavior is sheared at low shear rates, in the range between 0.01 - 0.1 $s^{-1}$ and below its critical strain, the system is subjected to work hardening. This is characteristic of solid-like behavior and results from elastic elements being stretched in the shear field. When such elastic elements approach their critical strain, the structure begins to break down causing shear thinning (strain softening) and subsequent flow. This coincides with a peak value in shear stress, which is equal to the yield stress. This is depicted in Figure 1.

***Yield stress is defined as the stress that must be applied to the sample before it starts to flow.***




1 Illustration showing the stress evolution in a yield stress material at constant shear rate

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Usually, a low shear rate is employed in these tests to account for time relaxation properties of the material although different shear rates can be employed depending on the application of interest. Fast processes such as dispensing occur on short timescales which corresponds with higher shear rates while stability to sedimentation/creaming occurs over longer times and is better evaluated at lower shear rates. Since yield stress is generally a time dependent property then the measured values can be different. A shear rate of 0.01 $s^{-1}$ is, however, commonly used in such a test and has been found to give good agreement with other yield stress methods such as creep testing [1].

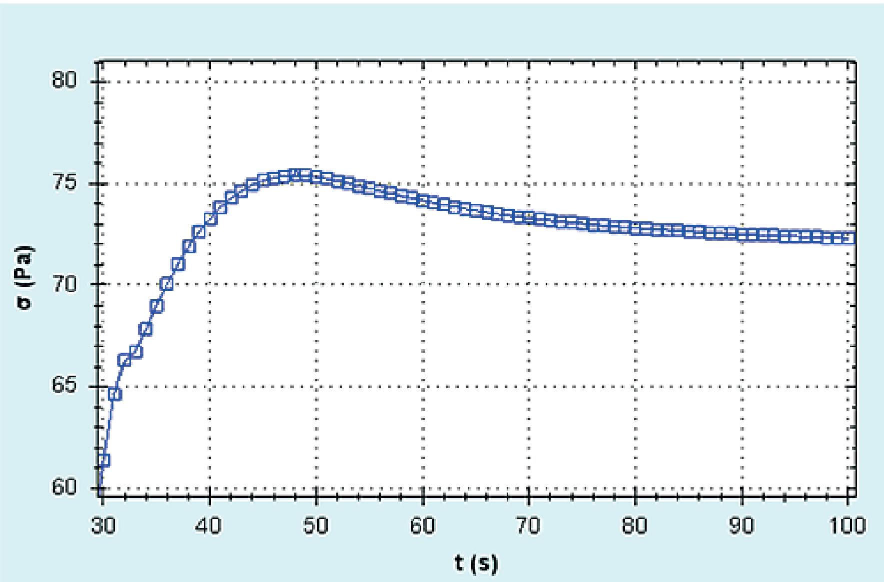
This application note shows methodology and data from a stress growth test for a body lotion.

## Experimental

- A commercial body lotion product was chosen for analysis.
- Rotational rheometer measurements were made using a Kinexus rheometer with a Peltier plate cartridge and 40 mm roughened parallel plates measuring system (to avoid sample slip at the geometry surfaces)[2], and utilizing standard pre-configured sequences in rSpace software.
- The shear position for the parallel plate geometry was set to 100% in the rSpace software (using the geometry database) so as to measure the stress at the onset of yield.
- A standard loading sequence was used to ensure that the sample was subject to a consistent and controllablee loading protocol.
- A single shear rate test was performed at a shear rate of 0.01 $s^{-1}$, and the stress evolution as a function of time was measured.
- The data was analyzed using a peak analysis to determine the yield stress.
- All rheology measurements were performed at 25°C.

## Results and Discussion

Figure 2 shows a stress versus time curve for the body lotion sample. The stress originally builds up as the strain is increased and reaches a peak value at the critical strain, which is equal to the yield stress.




2 Stress (σ) versus time curve for a body lotion sample run at a constant shear rate of 0.01 $s^{-1}$

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**Tab 1.** Peak analysis results from stress evolution curve for body lotion sample

| Sample Description | Pure Body Lotion |
|---|---|
| Experiment name | Determining yield stress by stress growth |
| Action name | Yield stress analysis |
| Point index | 1 |
| Shear stress (Pa) | 75.42 |
| Shear viscosity (Pas) | 7.53E+003 |

This peak value is determined automatically from a peak analysis and reported back in the rSpace software in tabular form as shown in Table 1. The reported yield stress value for this body lotion is 75.4 Pa and this was found to occur at a strain of approximately 0.5 (50%).

As mentioned in the introduction, for some materials the measured yield stress can be shear rate dependent, especially when significant structural relaxation occurs with time. In these instances, a higher yield stress will be observed for higher shear rates since there is less time for the structure to relax.

For example the same stress growth test performed on the same body lotion at a shear rate of 0.1 $s^{-1}$ instead of 0.01 $s^{-1}$ gave a yield stress of 82 Pa.

## Conclusion

Stress growth is a quick and accurate test for determining yield stress of a material. It is important, however, to employ a constant shear rate for comparative testing since different shear rates may give different results depending on the relaxation behavior of the material being tested.

## References

[1] White Paper – Understanding Yield Stress Measurements, NETZSCH

***[2]Please note ...***

that testing can be undertaken with cone and plate or parallel plate geometry – with the latter being preferred for dispersions and emulsions with large particle sizes. Such material types may also require the use of serrated or roughened geometries to avoid artefacts relating to slippage at the geometry surface.





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