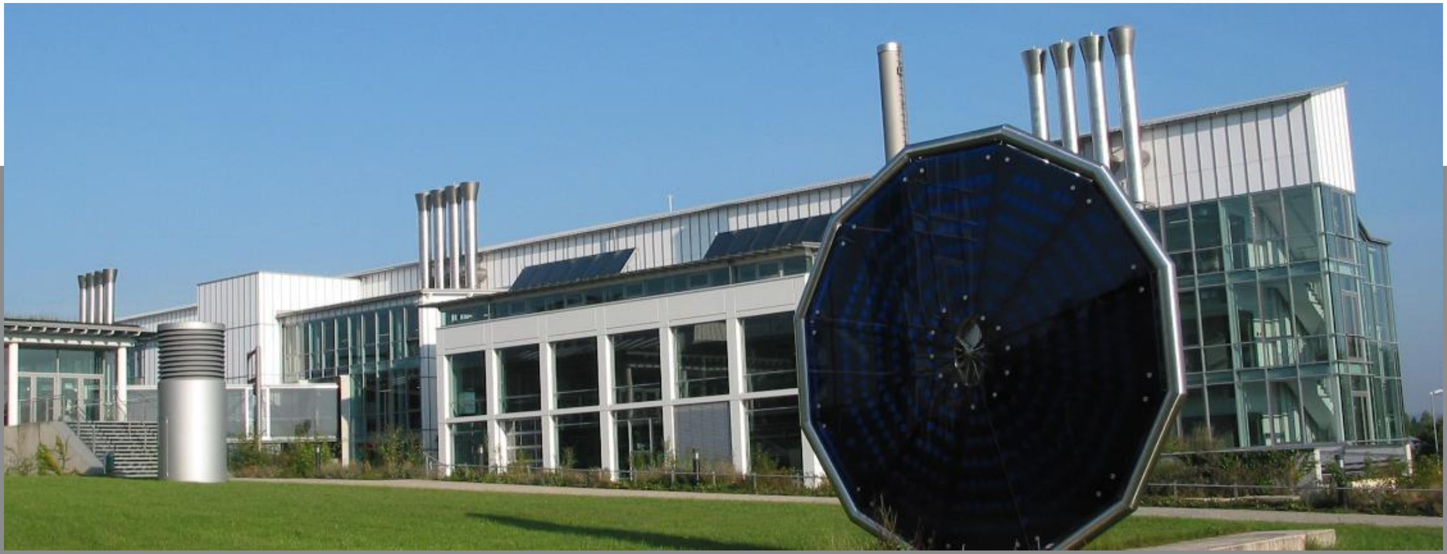


Viscosity measurements with the IMETER

Rheometry Workshop, Freiburg, 07-08 March 2018

Stephan Höhlein, Andreas König-Haagen, Dieter Brüggemann

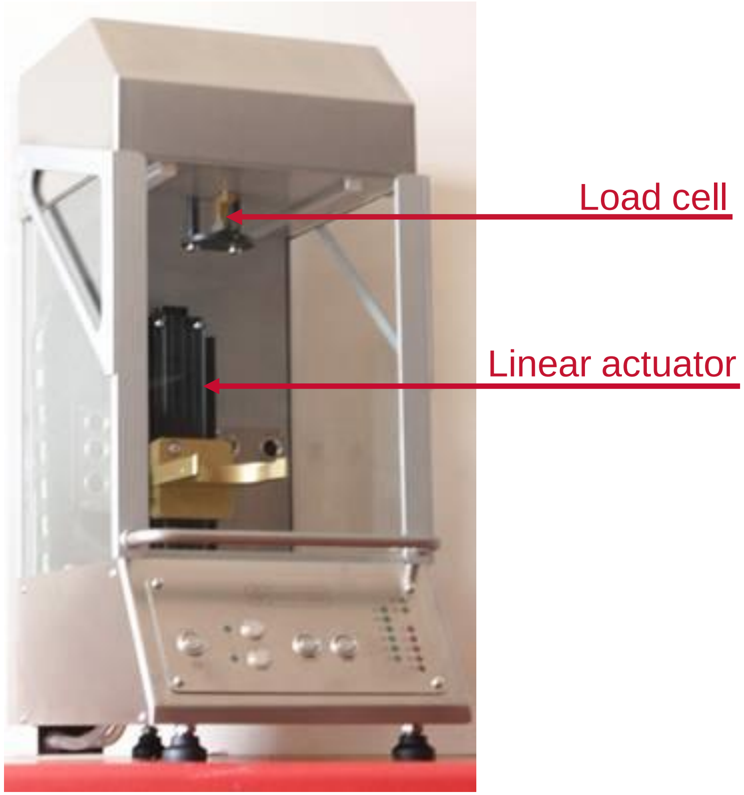
UNIVERSITÄT BAYREUTH

LEHRSTUHL FÜR TECHNISCHE THERMODYNAMIK UND TRANSPORTPROZESSE
PROF. DR.-ING. D. BRÜGGEMANN

ZET Zentrum für Energietechnik

IMETER

General setup

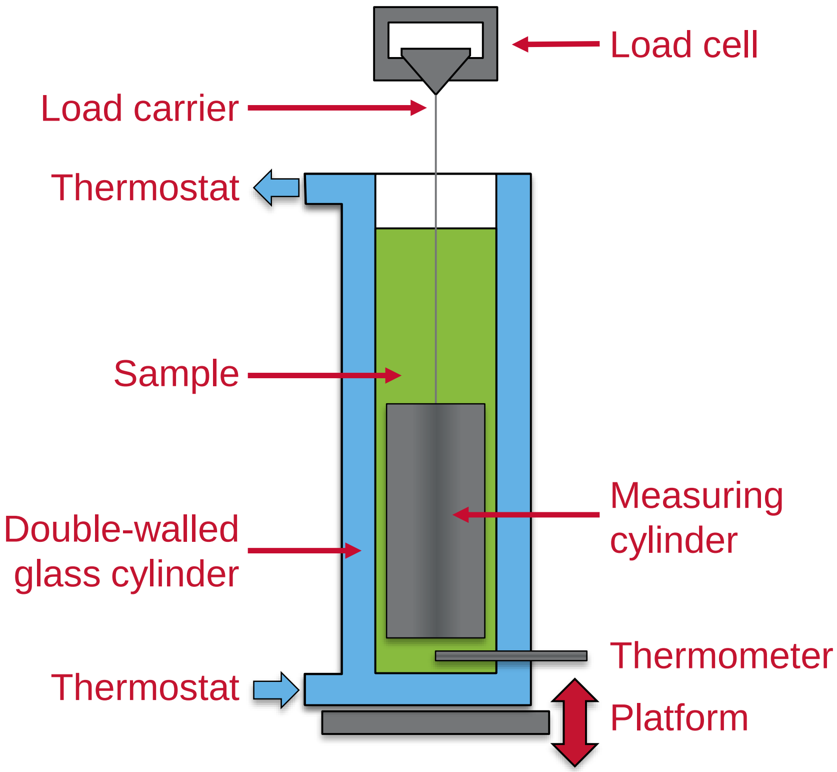


- Measuring device for various material properties based on:
  - Mass
  - Force
  - Length
  - Time
- Sensor interface for:
  - Temperature
  - Humidity
  - Pressure
- Modular design / free expandable

www.imeter.de

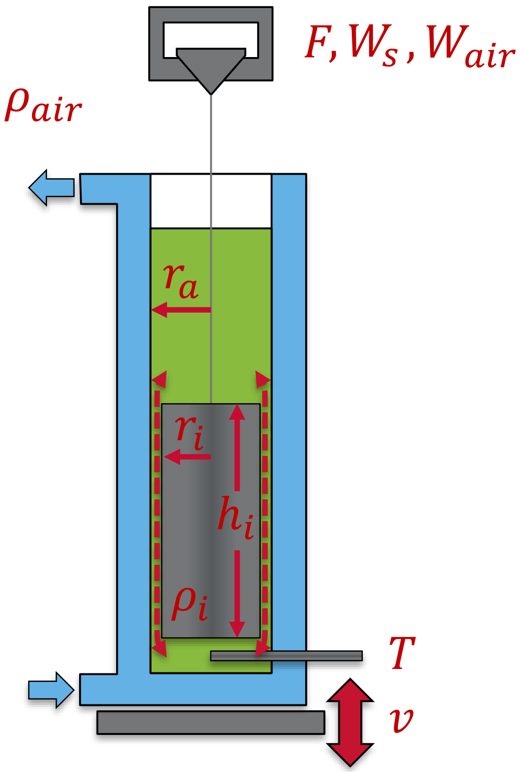
IMETER

Setup for viscosity measurements



www.imeter.de

IMETER
Determination of the viscosity



→ Analysis of the forced flow through an annulus

- Dynamic viscosity

$$\eta(T) = \frac{F}{2\pi h_i v}\left[\ln\left(\frac{r_a}{r_i}\right) + \frac{r_i^2 - r_a^2}{r_i^2 + r_a^2}\right]$$

- Density from hydrostatic weighing

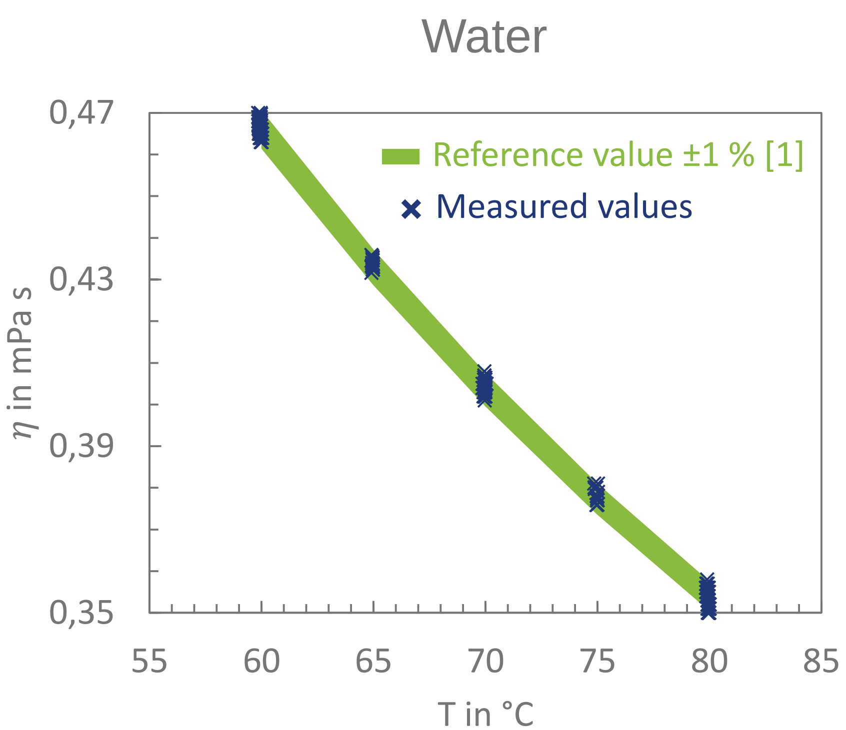
$$\rho(T) = \left[1 - \frac{W_s}{W_{air}}\right](\rho_i - \rho_{air}) + \rho_{air}$$

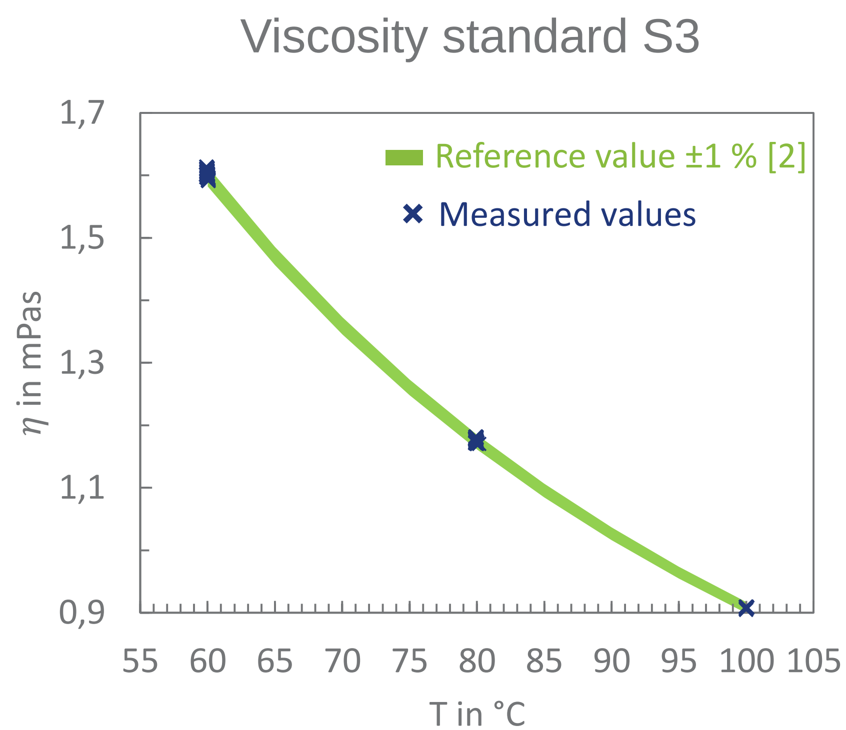
- Kinematic viscosity

$$\nu(T) = \frac{\eta(T)}{\rho(T)}$$

www.imeter.de

IMETER
Examples – Reference Standards

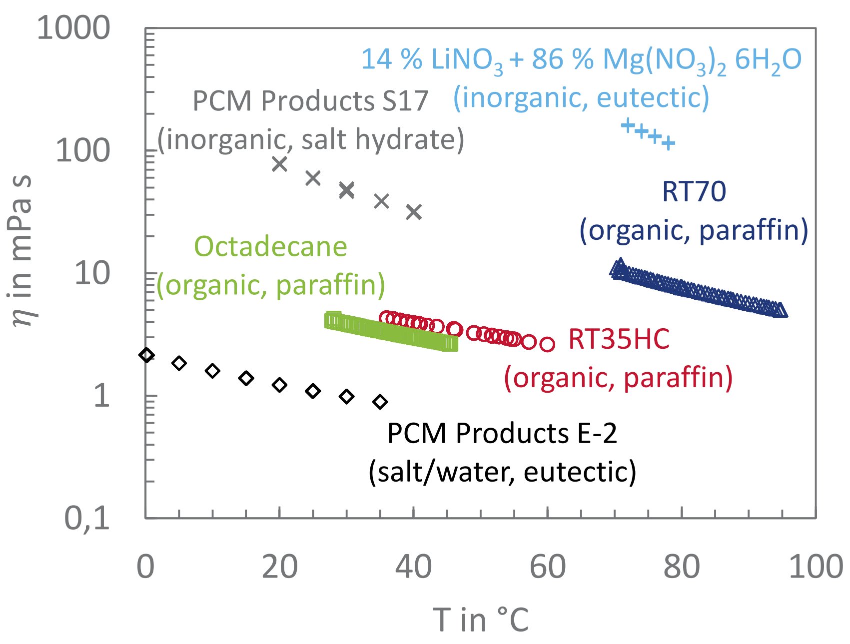


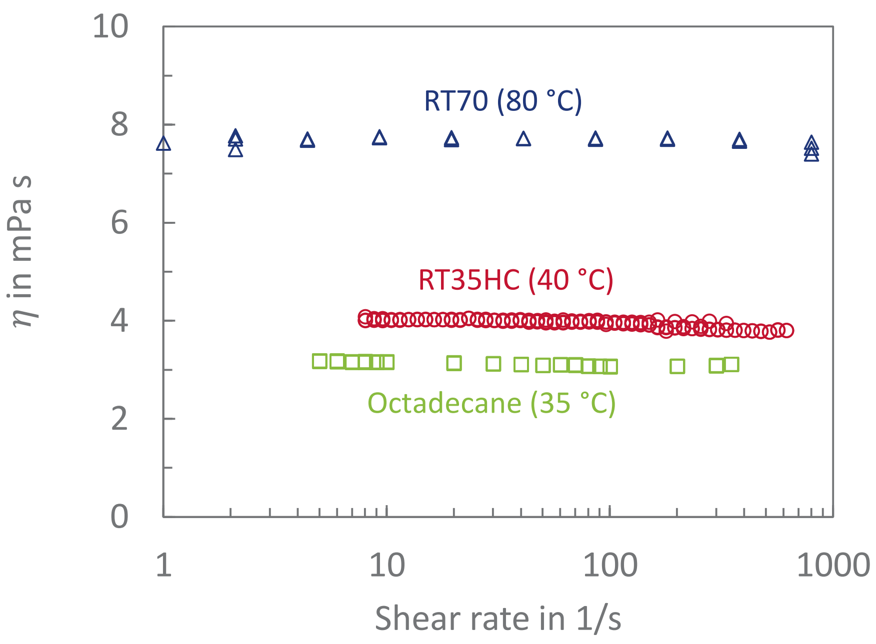


[1] *VDI Heat Atlas*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010.
[2] www.paragon-sci.com/s3-general-purpose-viscosity-standard.html

IMETER

Examples – PCM





IMETER
Summary

Range of application

- Sample size: ~ 15 ml
- Temperature range: -20 … 120 °C
- Temperature resolution: 0,001 K
- Viscosity
  - Range: 0,01 … 5000 mPa s
  - Uncertainty: 0,5 … 1 % *
  - Reproducibility: 0,2 % *
  - Shear rate: 0,03 … 850 1/s

* from measured value

Advantages

- Simple sample preparation
- Well-defined sample temperature
- Simultaneous density measurement
- Comprehensibility
- Free expandable

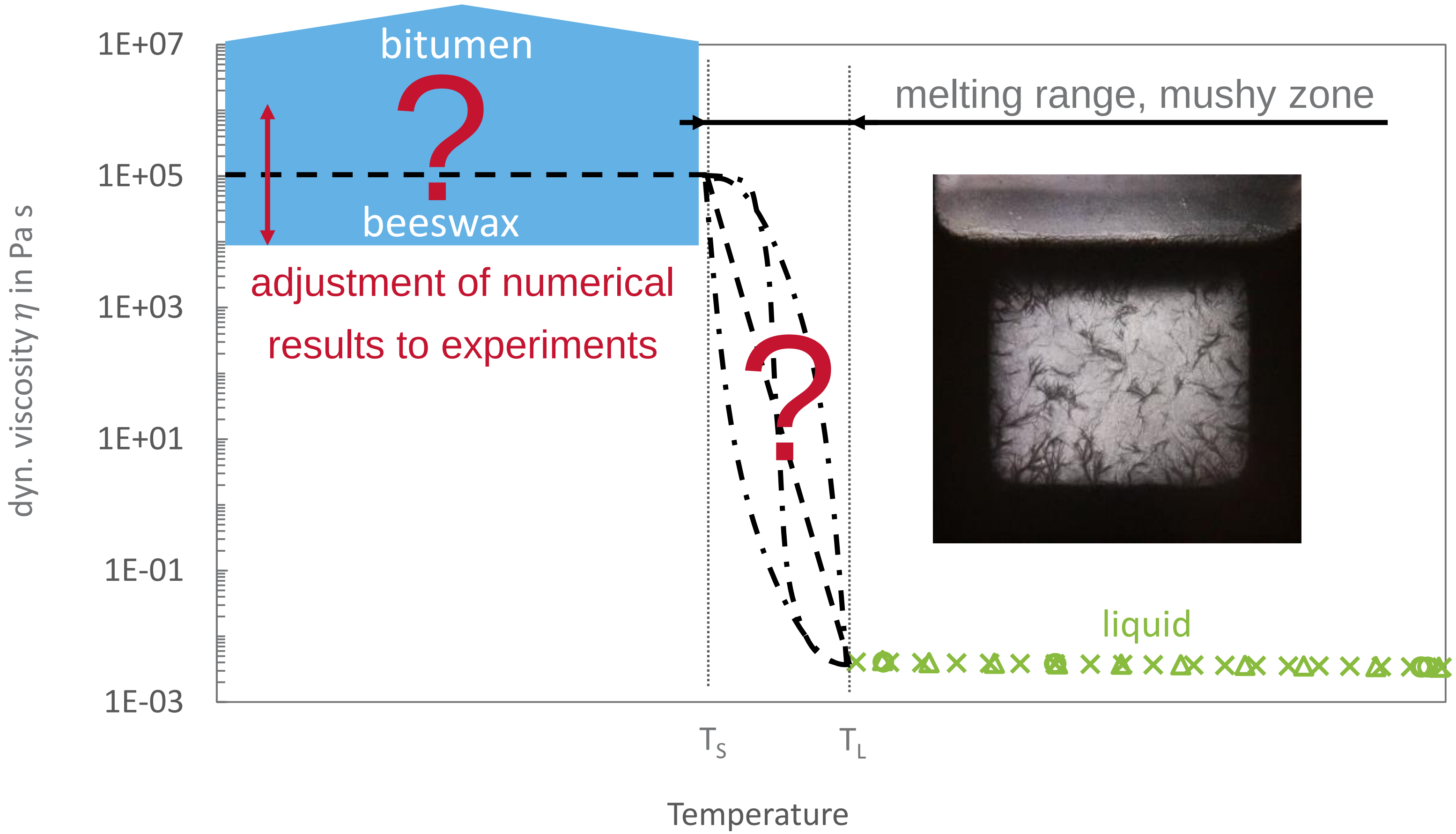
Disadvantages

- Complex alignment of the setup
- Temperature restriction

www.imeter.de

IMETER

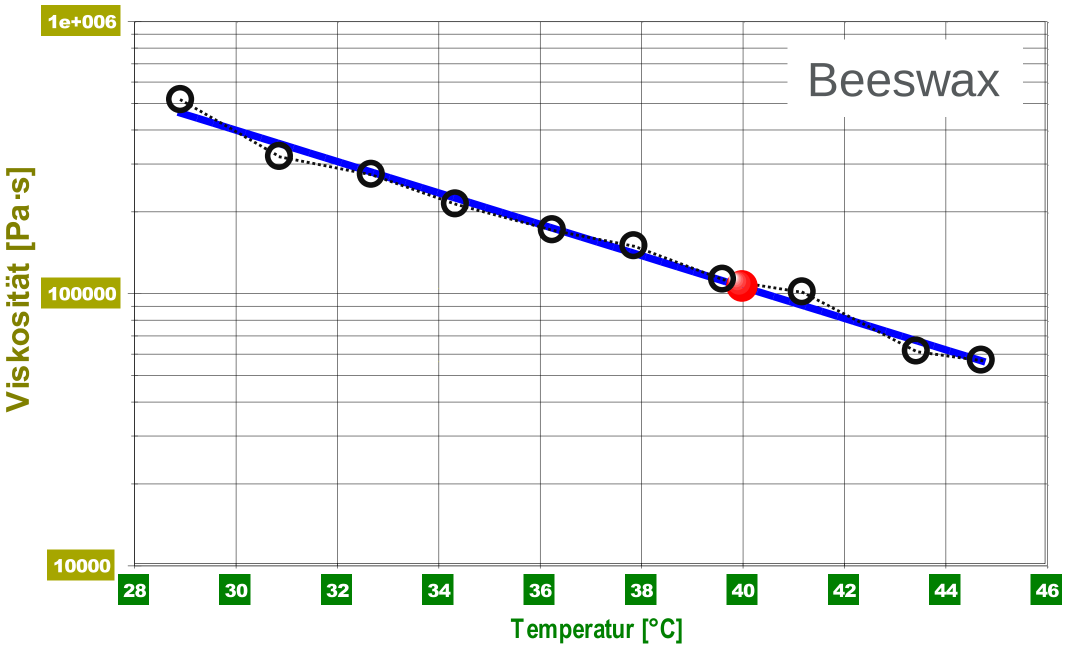
Outlook: Highly viscous measurements

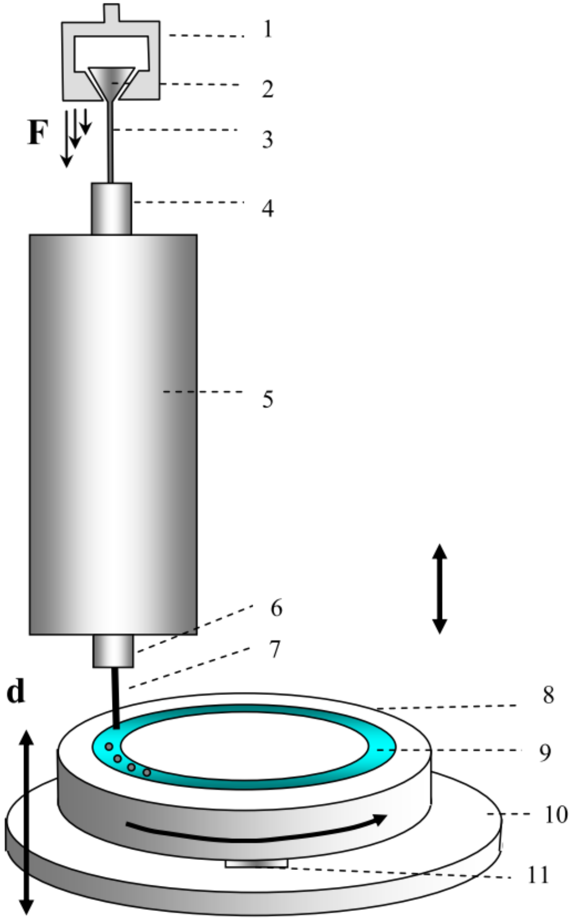


IMETER
Outlook: Highly viscous measurements

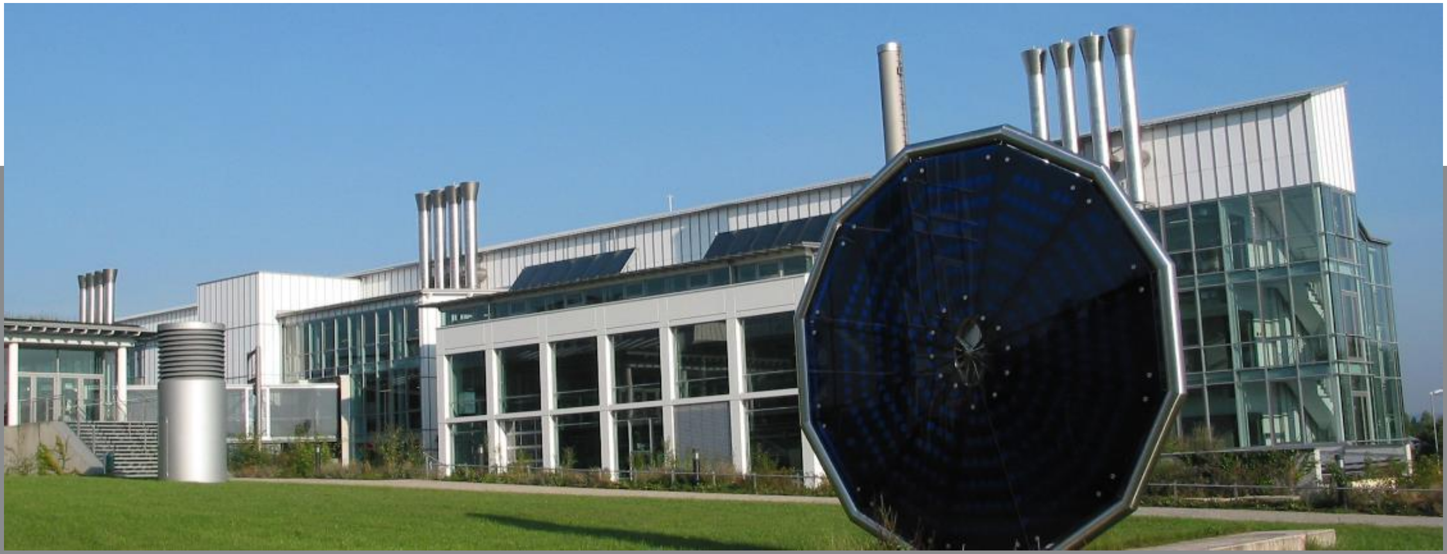
Possibility for measurement

- IMETER module: „Auto-Gillmore-Needle“
- Modified hardness measurement





www.imeter.de



Thank you

www.zet.uni-bayreuth.de

Stephan Höhlein, Andreas König-Haagen, Dieter Brüggemann