DoDyNet DTU Advanced Modules: Lab Course

Extensional Rheology

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Practical Information

Group 1: Consiglia Carillo, Christina Pyromali, Stefania Traettino

Group 2: Simone Sbrescia, Paola Nicolella, Larissa Hammer, Carole-Ann Charles

Group 3: Clément Coutouly, Rowane Lyons, Céline Hannecart

Group 4: Janzhu Ju, Hongwei Liu, Yanzhao Li

TA:

ARES-G2 & SER: Pengpeng Hu

ARES & EVF: Peng Shen

VADER: Wendi Wang

FSR: Qian Huang

Please read the document of ”safety in the lab” and follow the rules !

Tasks

Sample: Low-density polyethylene (LDPE)

1. Measure the linear viscoelastic (LVE) properties in small amplitude oscillatory shear (SAOS) flow using ARES-G2 (Group 1 & 2) or ARES (Group 3 & 4)

2. Measure the extensional rheology using SER (Group 1 & 2) or EVF (Group 3 & 4)

3. Measure the extensional rheology using VADER (Group 1 & 2) or FSR (Group 3 & 4)

4. Compare the results from SER / EVF with VADER / FSR

   Compare the results of extensional rheology with the LVE envelope

SAOS Measurements

Sample size: diameter 25mm, thickness 1mm

- Perform the measurements following the instructions from the TA
- Plot the storage modulus G' and loss modulus G'' as a function of angular frequency ω at the reference temperature
- Plot $3\eta^*$ as a function of $1/\omega$ as the LVE envelope; η^* is the complex viscosity
- If time allows, try to fit the G' and G'' data with the multimode Maxwell model, and calculate the LVE envelope

SER / EVF Measurements

Sample size: length 20mm, width 10mm, thickness 1mm

- Perform the measurements following the instructions from the TA
- Plot the extensional stress growth coefficient (transient extensional viscosity) as a function of time, in log-log scale; Compare the results with the LVE envelope
- Plot the transient true stress (in log scale) as a function of Hencky strain (in linear scale); Compare the results with the ones from VADER / FSR

SER / EVF Measurements

Hencky Rate

$$\frac{d}{dt}\varepsilon_H = \frac{\Omega(t)\cdot D_d}{L_s}$$

Hencky Strain

$$\varepsilon_H(t) = \frac{d}{dt}\varepsilon_H \cdot t$$

Tensile Force

$$F_s(t) = \frac{\text{Torque}(t)}{\frac{D_d}{2}}$$

Sample Area

$$A_s(t) = A_0 \cdot \left(\frac{\rho_{solid}}{\rho_{melt}}\right)^{\frac{2}{3}} \cdot e^{-\varepsilon_H(t)}$$

Extensional Stress

$$\sigma_E(t) = \frac{F_s(t)}{A_s(t)}$$

Extensional Viscosity

$$\eta_E(t) = \frac{\sigma_E(t)}{\frac{d}{dt}\varepsilon_H}$$

Variables

- **t** = Time
- **$\Omega(t)$** = Motor Speed
- **D_d** - Drum Diameter
- **L_s** = Sample Length
- **A_0** = Solid Area
- **σ_{solid}** = Solid Density
- **σ_{melt}** = Melt Density

Note that L_s is the length in-between of the axis of the two drums

VADER / FSR Measurements

Sample size: diameter 9mm, thickness 2mm – 2.5mm

- Perform the measurements following the instructions from the TA
- Plot the extensional stress growth coefficient (transient extensional viscosity) as a function of time, in log-log scale; Compare the results with the LVE envelope
- Plot the transient true stress (in log scale) as a function of Hencky strain (in linear scale); Compare the results with the ones from SER / EVF

Hencky Strain $$\epsilon(t) = -2\ln\frac{D(t)}{D_0}$$

Stress $$\sigma_E = \langle \sigma_{zz} - \sigma_{rr} \rangle = \frac{F(t) - m_f g / 2}{\pi (D(t)/2)^2}$$

D: the measured mid-filament diameter

F: the measured force

m_f: mass of the sample

g: gravitational acceleration