Experimental Data (Chapter 6)

Steady shear flow

- Linear Polymers
- Limits on measurability
- Material effects - MW, MWD, branching, mixtures, copolymers
- Temperature and pressure

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later . ..

Unsteady shear flow (SAOS, step strain)
Steady elongation
Unsteady elongation

Steady shear viscosity and first normal stress coefficient

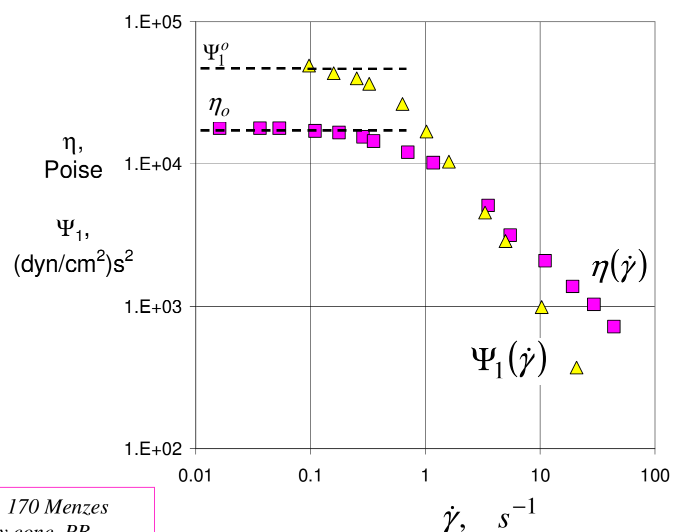


Figure 6.1, p. 170 Menzes and Graessley conc. PB solution

Steady shear viscosity and first normal stress coefficient

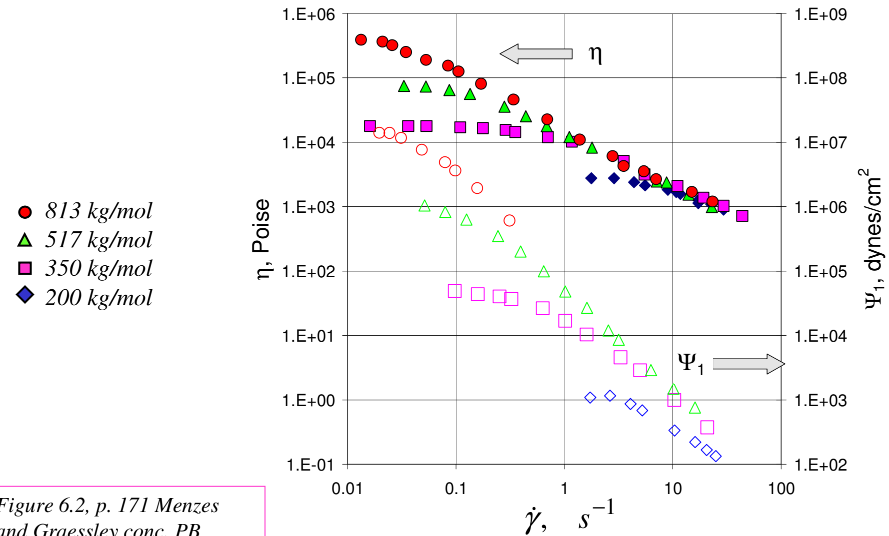


Figure 6.2, p. 171 Menzes and Graessley conc. PB solution; c=0.0676 g/cm³

Steady shear viscosity and first normal stress coefficient

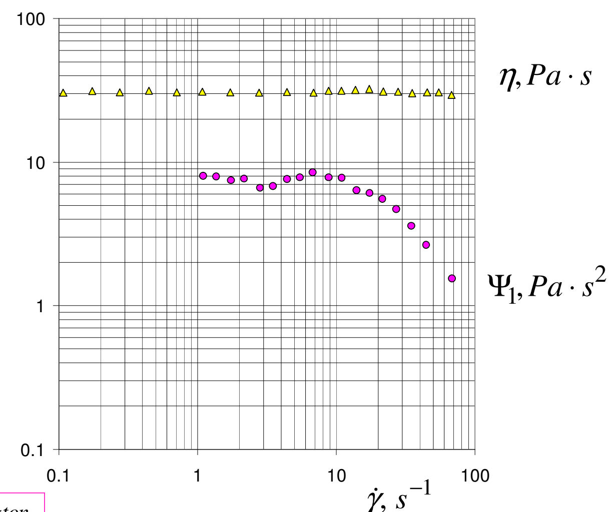
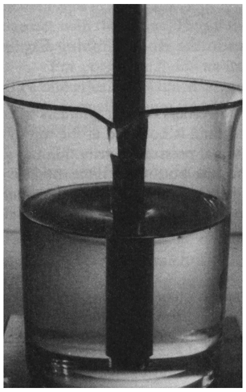


Figure 6.5, p. 173 Binnington and Boger; PIB soln

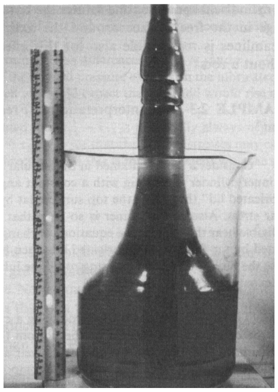
First normal stress effects: rod climbing

$$\tau_{11} - \tau_{22} < 0$$

Extra tension in the 1-direction pulls azimuthally and upward (see DPL p65).



Newtonian - glycerin



Viscoelastic - solution of polyacrylamide in glycerin

Bird, et al., <u>*Dynamics of Polymeric Fluids*</u>, vol. 1, Wiley, 1987, Figure 2.3-1 page 63. (DPL)

Steady shear viscosity and first and ***second*** normal stress coefficient

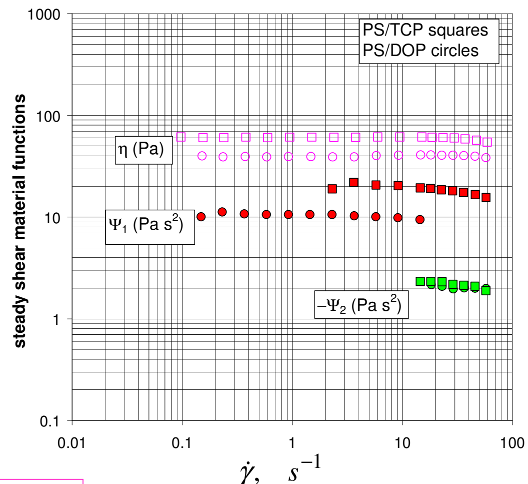
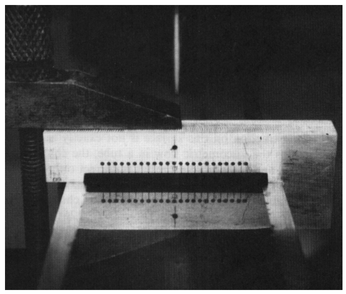


Figure 6.6, p. 174 Magda et al.; PS solns

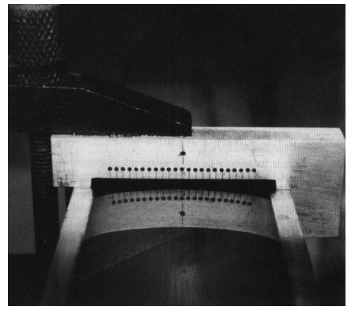
Second normal stress effects: inclined open-channel flow

$$\tau_{22} - \tau_{33} > 0$$

Extra tension in the 2-direction pulls down the free surface where dv_1/dx_2 is greatest (see DPL p65).



Newtonian - glycerin

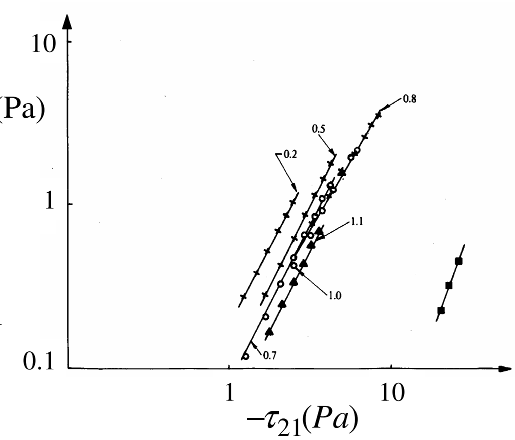


Viscoelastic - 1% soln of polyethylene oxide in water

$N_2 \simeq -N_1/10$

R. I. Tanner, *Engineering Rheology*, Oxford 1985, Figure 3.6 page 104

Second normal stress effects: inclined open-channel flow

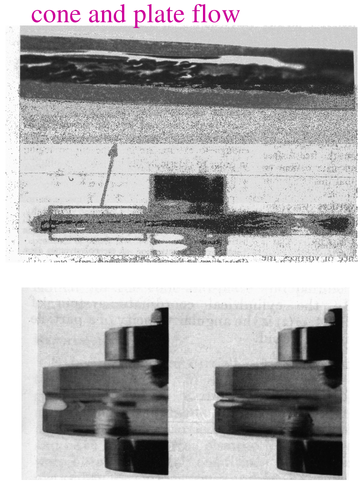


- ○ polyox WSR-301 in water
- × Separan AP-30 in water
- ▲ Oppanol B200 in cetane
- ■ NBS Nonlinear Fluid No. 1

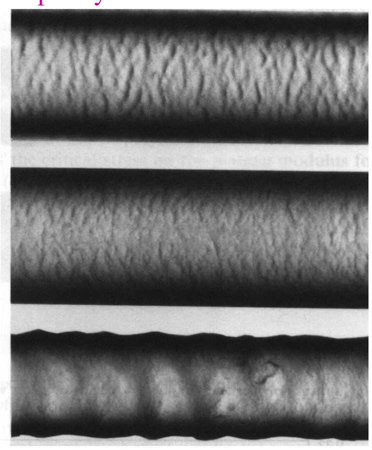
from R. I. Tanner, *Engineering Rheology*, Oxford 1985, Figure 3.7 page 105

Limits on Measurements: Flow instabilities in rheology

cone and plate flow



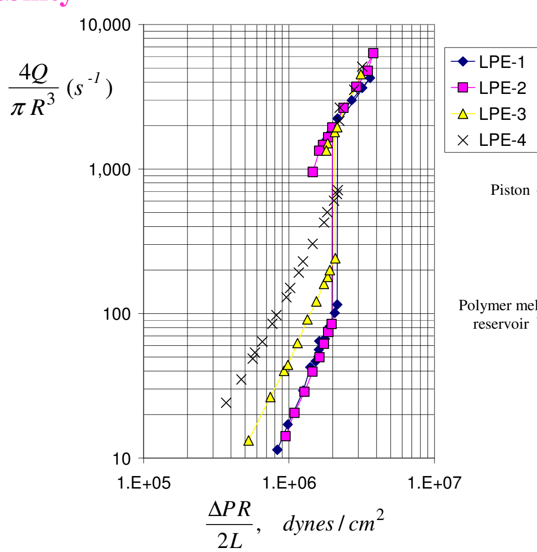
capillary flow



Figures 6.7 and 6.8, p. 175 Hutton; PDMS

Figure 6.9, p. 176 Pomar et al. LLDPE

Spurt instability



Instron capillary rheometer

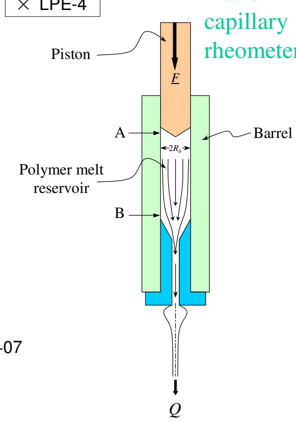


Figure 6.10, p. 177 Blyler and Hart; PE

Steady shear viscosity and first normal stress coefficient - *Molecular weight effects*

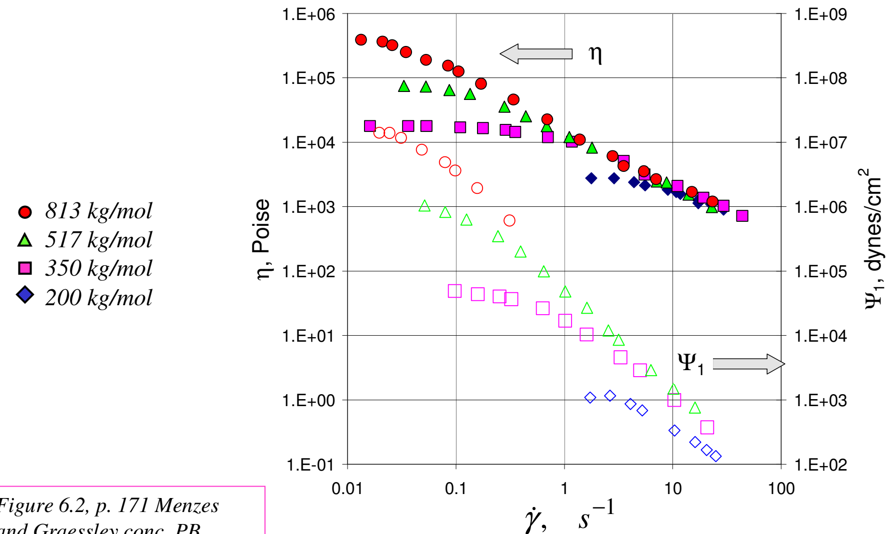


Figure 6.2, p. 171 Menzes and Graessley conc. PB solution; various MW

Variation of viscosity with molecular weight

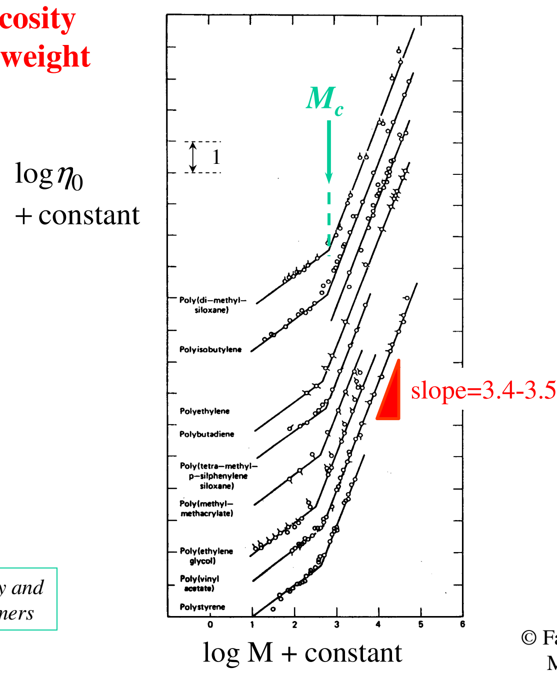
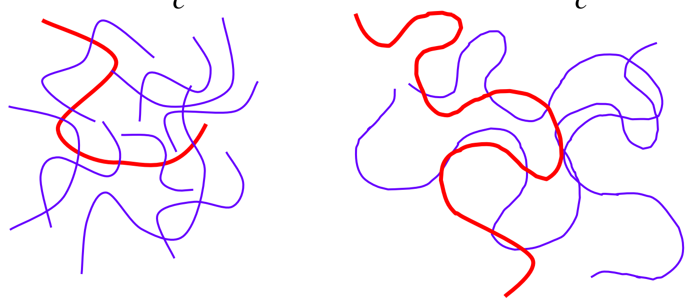


Figure 6.12, p. 178 Berry and Fox, 1968; various polymers

Entanglements strongly affect polymer relaxation

$M<M_c$ $M>M_c$



Unentangled
relaxation is rapid

Entangled
relaxation is retarded