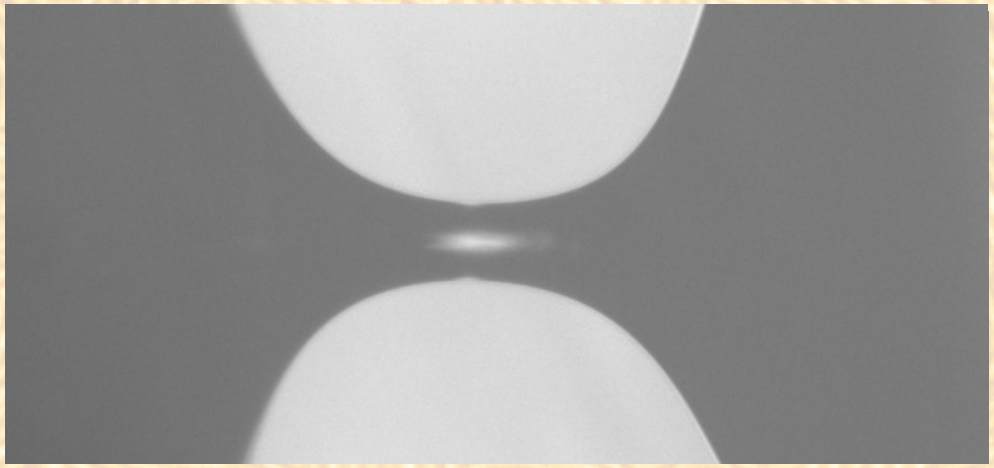
Diblock copolymer bridges: the break-up dynamics and enhanced stability of structured liquids

Robert D. Peters and Kari Dalnoki-Veress
McMaster University, Hamilton, Canada

McMaster University

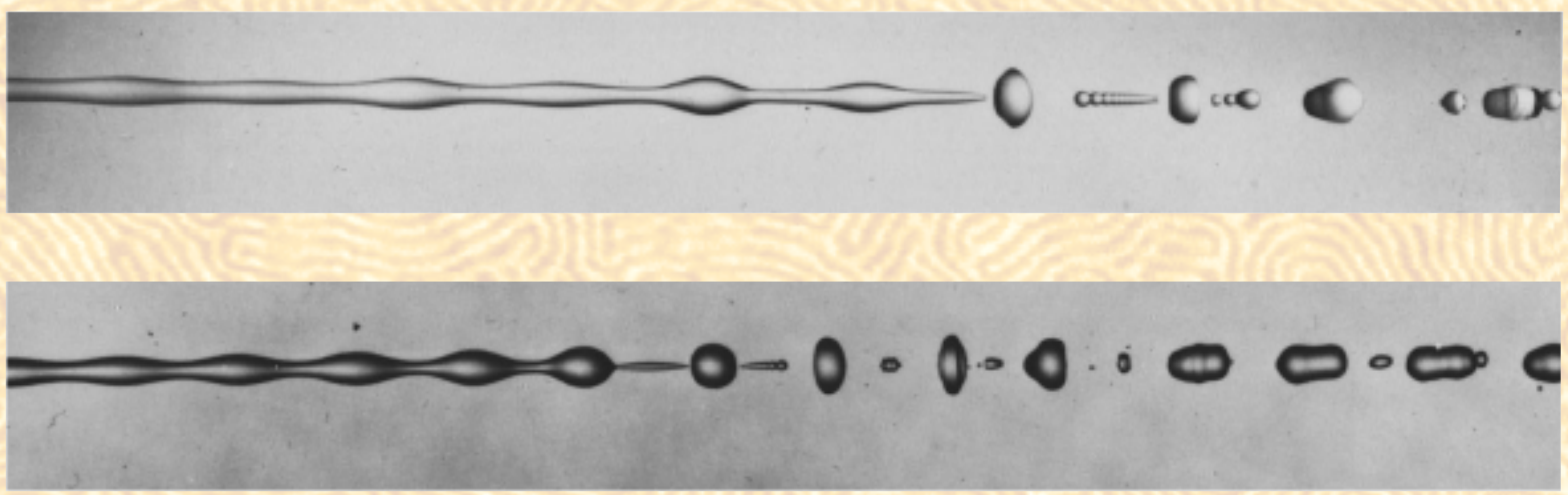


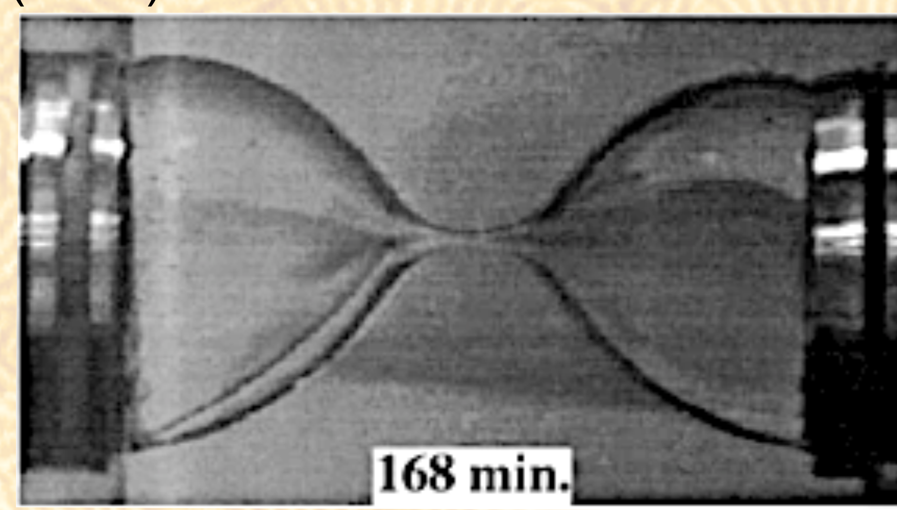
CAP Meeting 2014 - Sudbury, ON

Newtonian liquid break-up

- Background
- Creating homopolymer and diblock copolymer bridges
- Results
  - Effect of diblock copolymer microstructure on break-up dynamics

Eggers, *Reviews of Modern Physics* (1997)





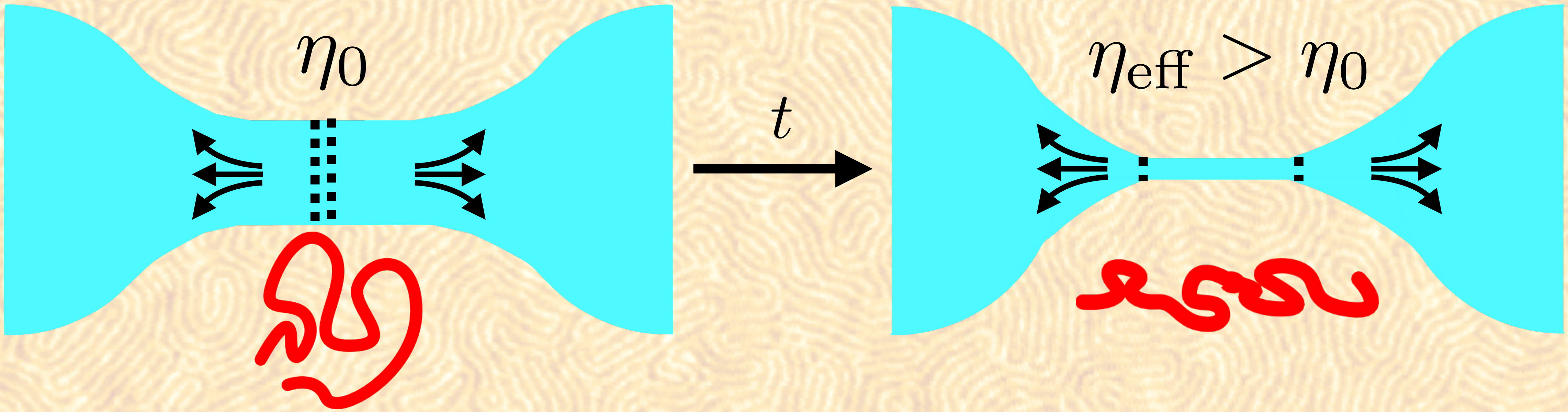
$$\lambda_c > 2\pi r$$

$$d_{min} = d_0 - \alpha\frac{\gamma}{\eta}t$$

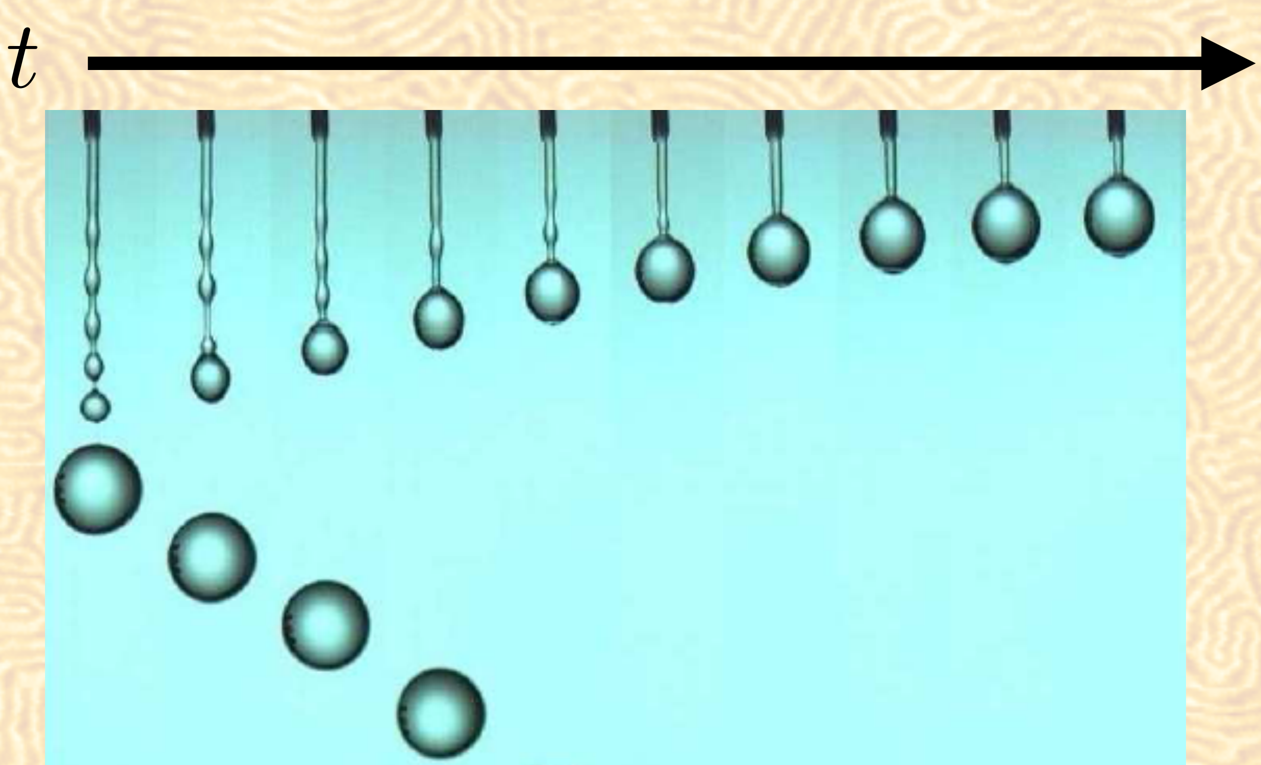
(Papageorgiou, *Phys. Fluids,* (1995)

- Physics of Newtonian liquid jets and bridges: Plateau, Rayleigh, Eggers, Bazilevsky, Renardy, Brenner, Entov, Hinch, Papageorgiou, McKinley, Tripathi, ...

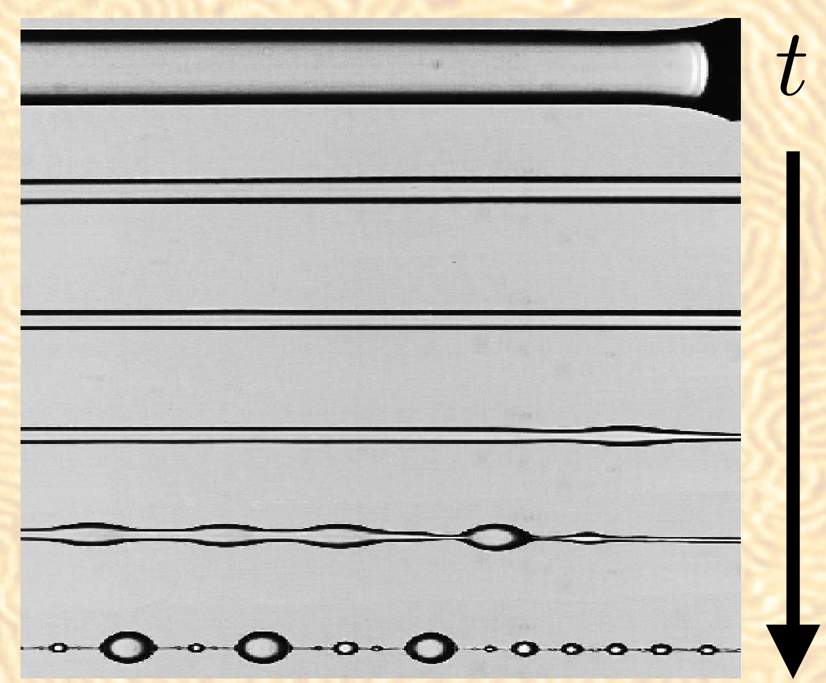
Non-newtonian liquids



- High M_w polymer solutions
  - Shear thickening due to elongational flow.

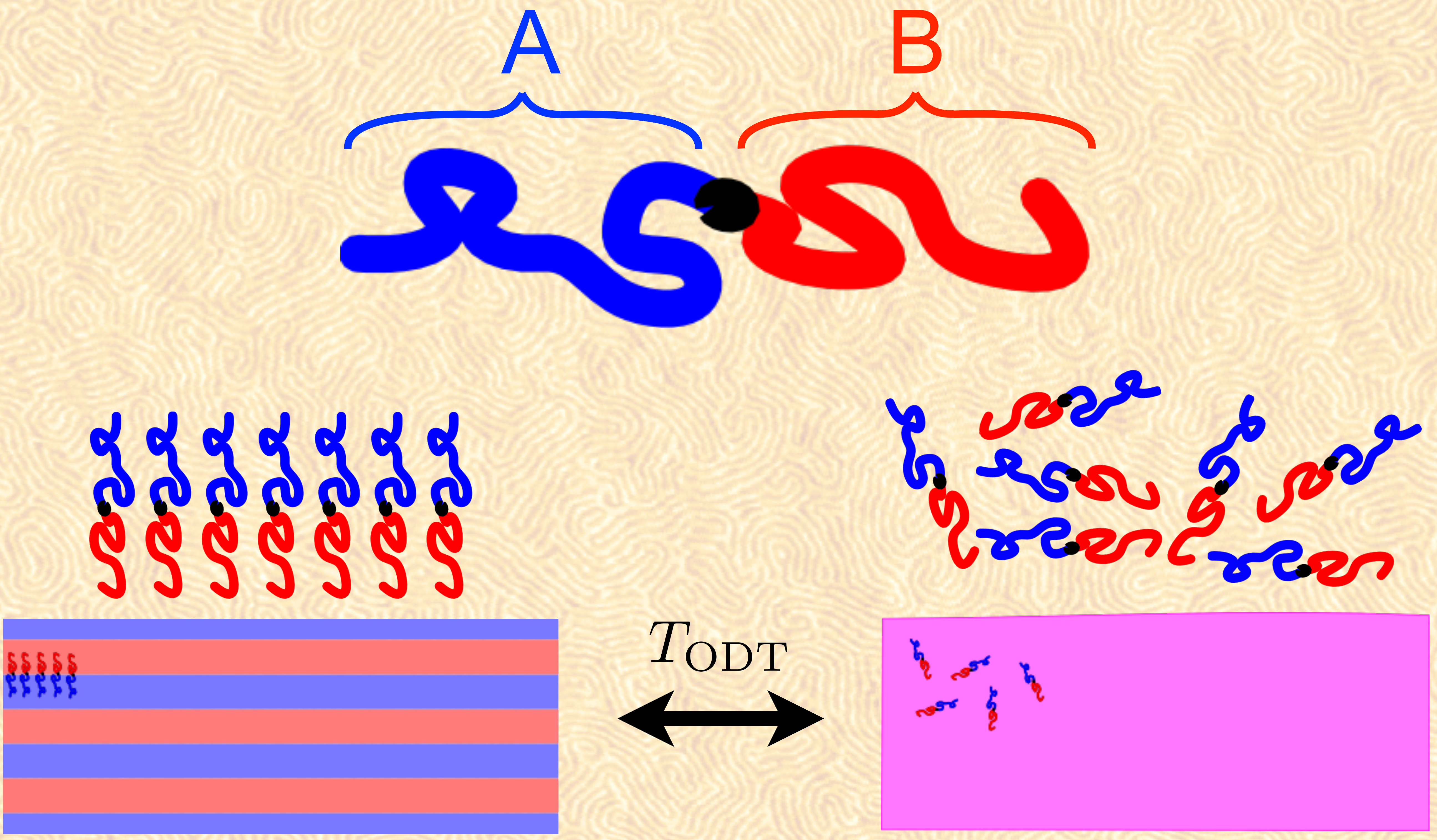


Clasen, Bico, Entov, McKinley, *J. Fluid Mech.* (2008)



Sattler, Wagner, Eggers, *PRL* (2008)

Symmetric diblock copolymers

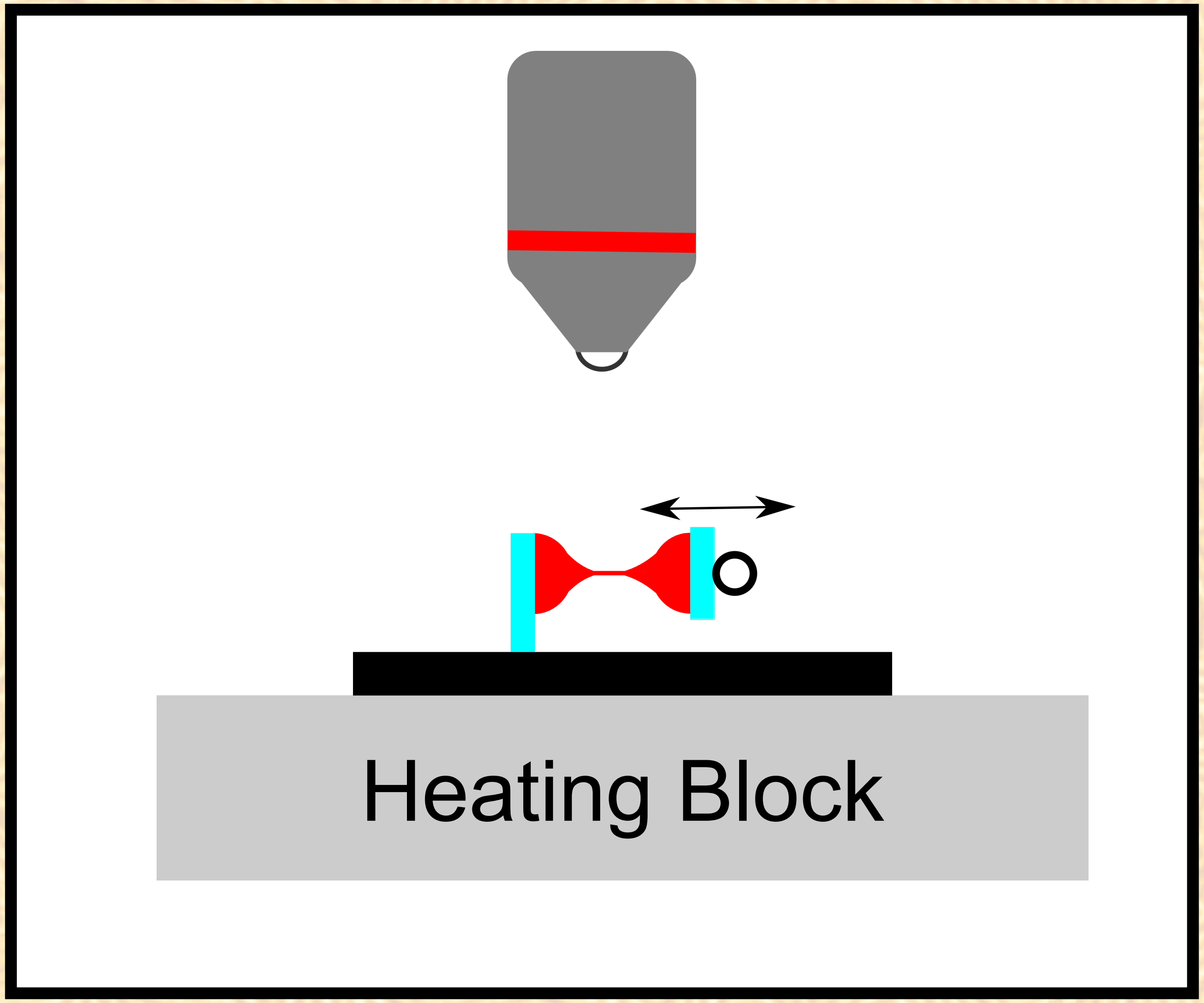


Ordered, (Low T)

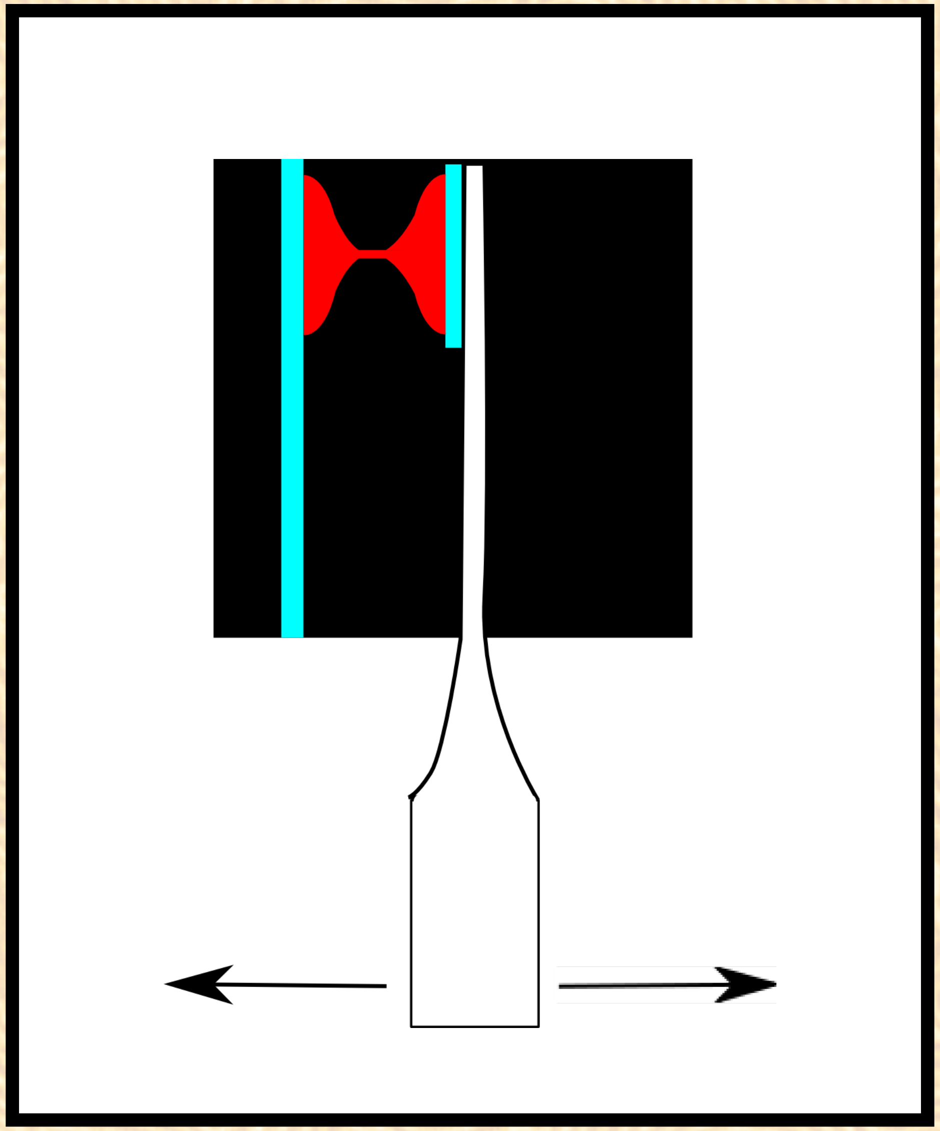
Disordered, (High T)

Experimental setup

Side View



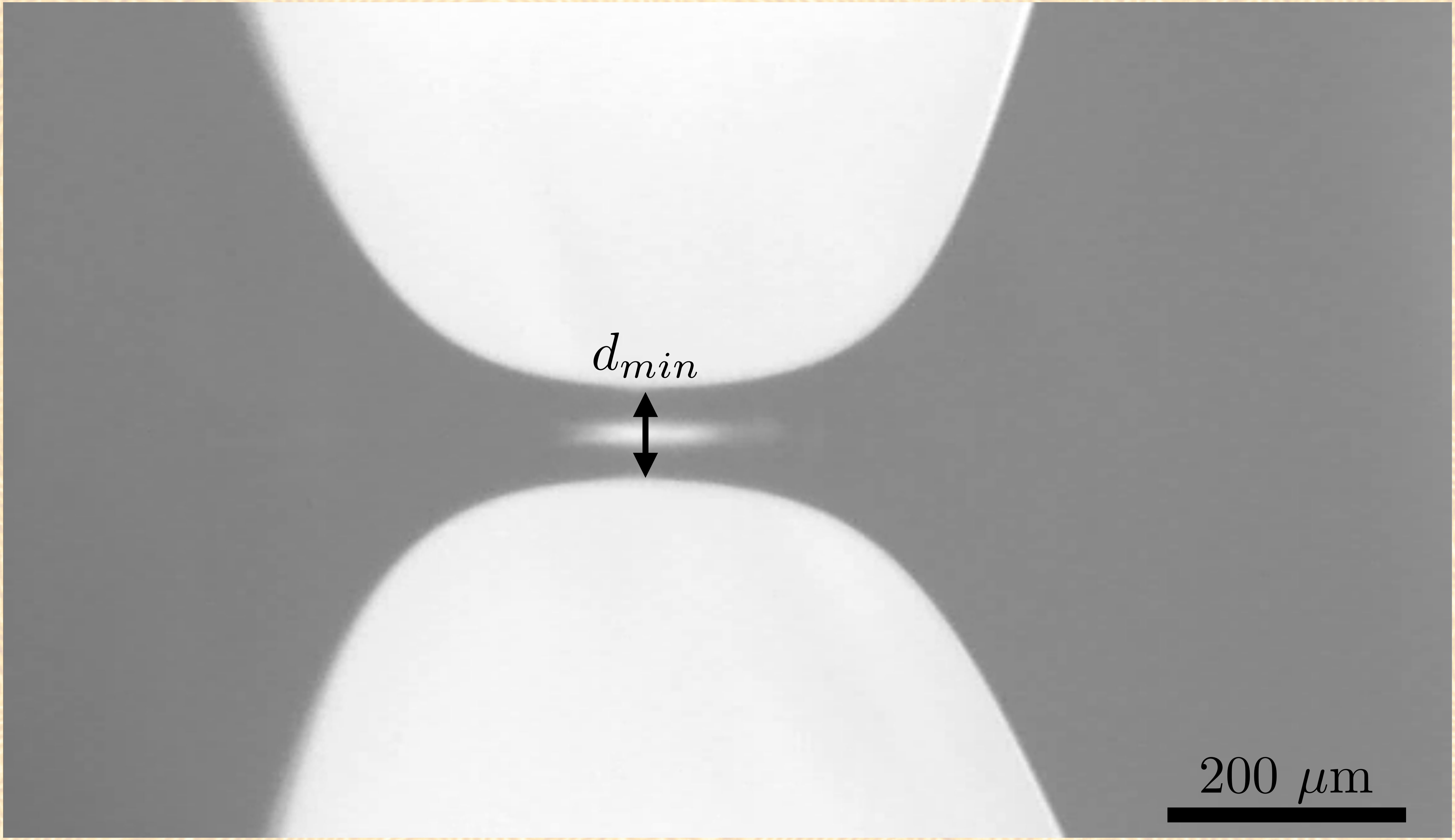
Top View



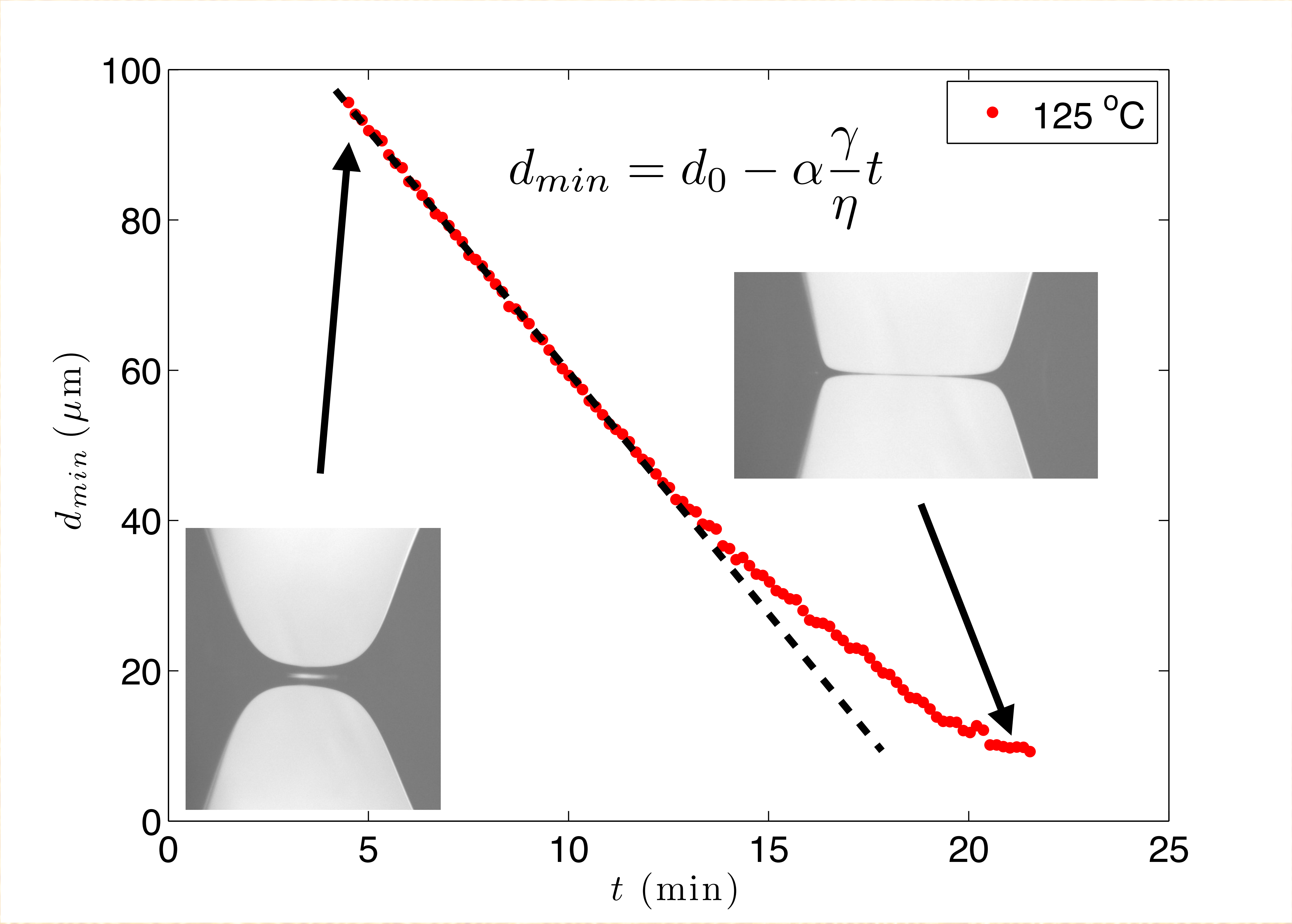
Homopolymer bridge evolution

8.8k Polystyrene annealed at $T = T_g + 35°C$

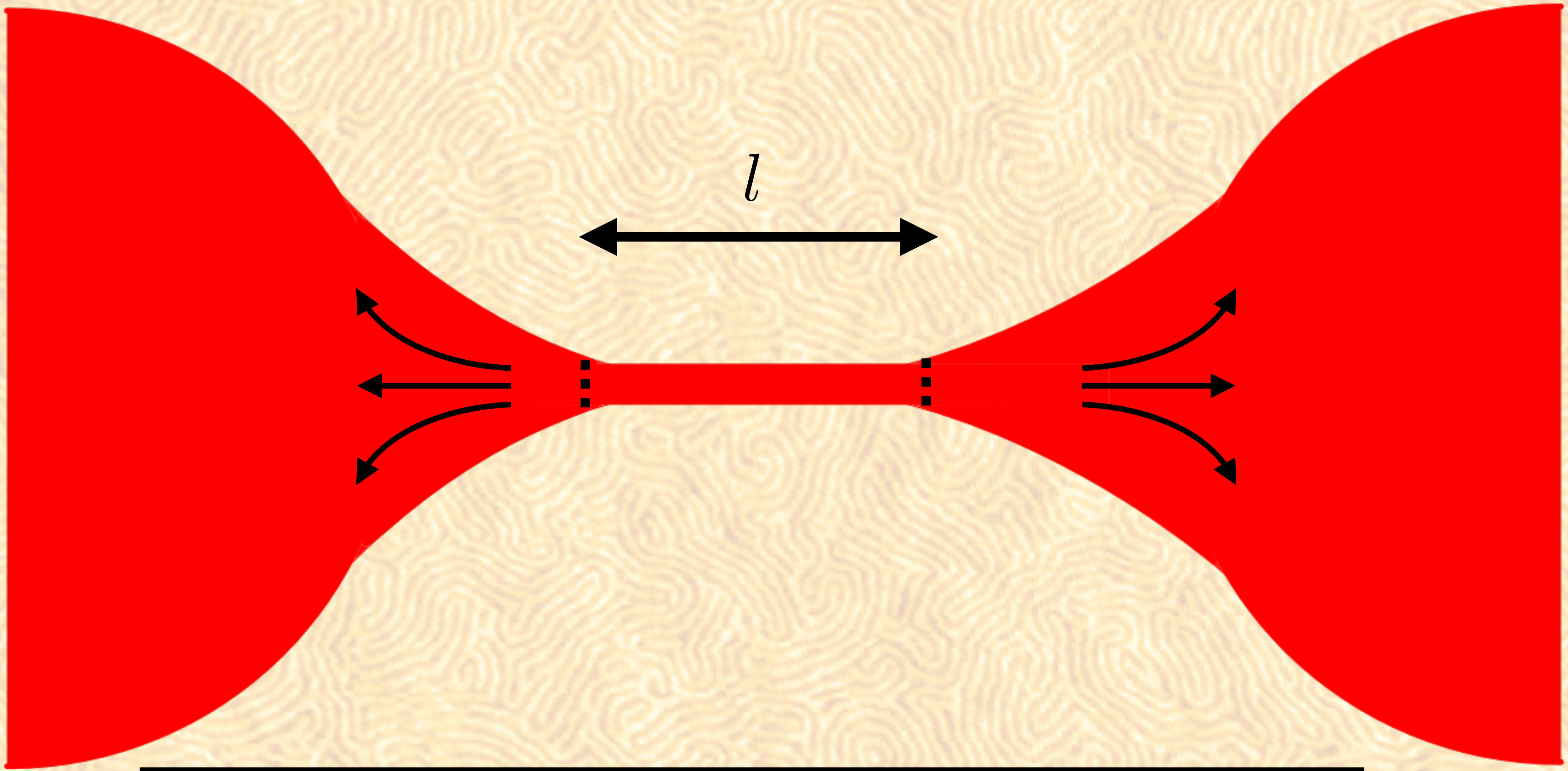
Homopolymer bridge evolution



Viscosity calculation



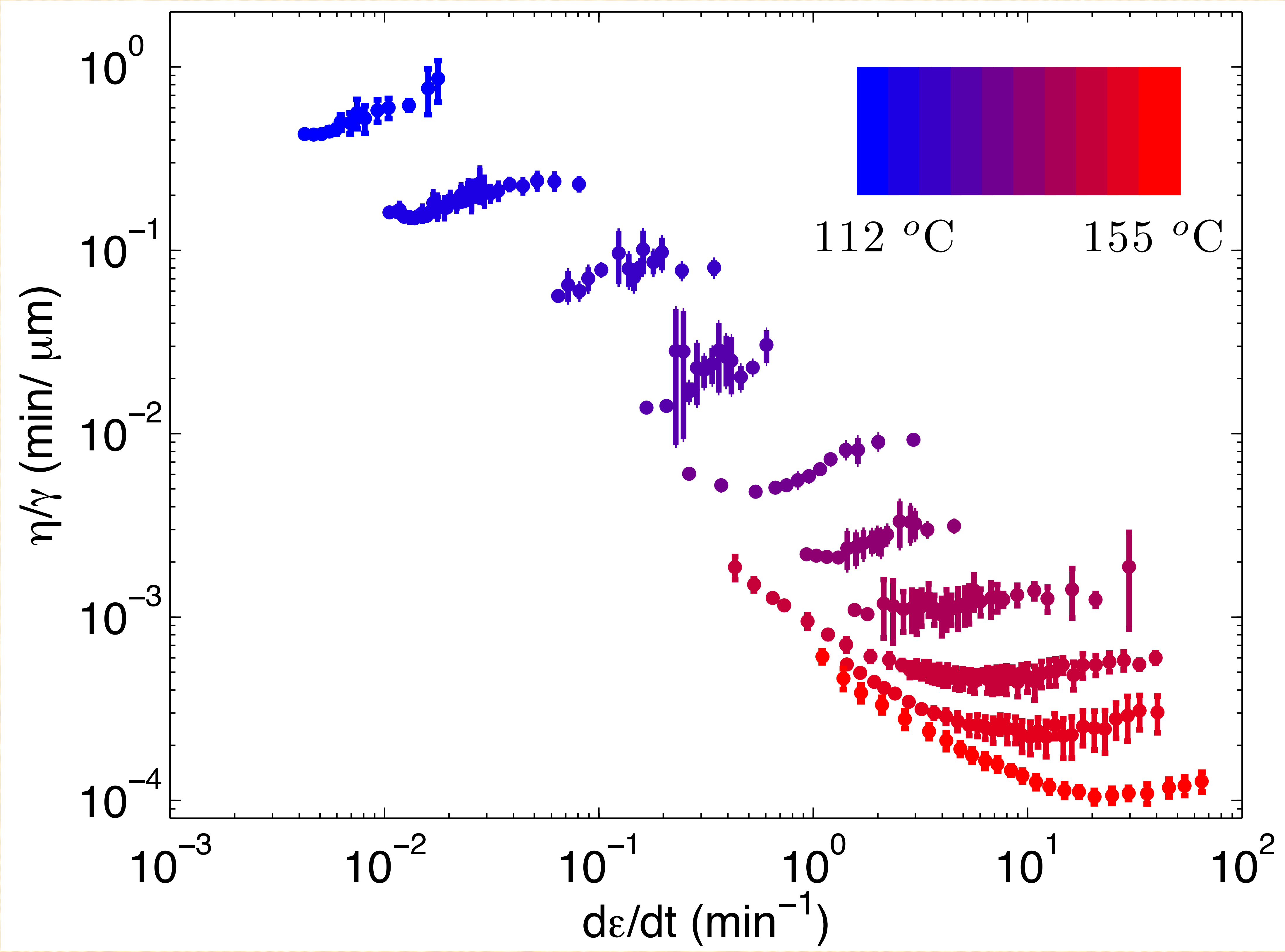
Shear rates in thinning filaments



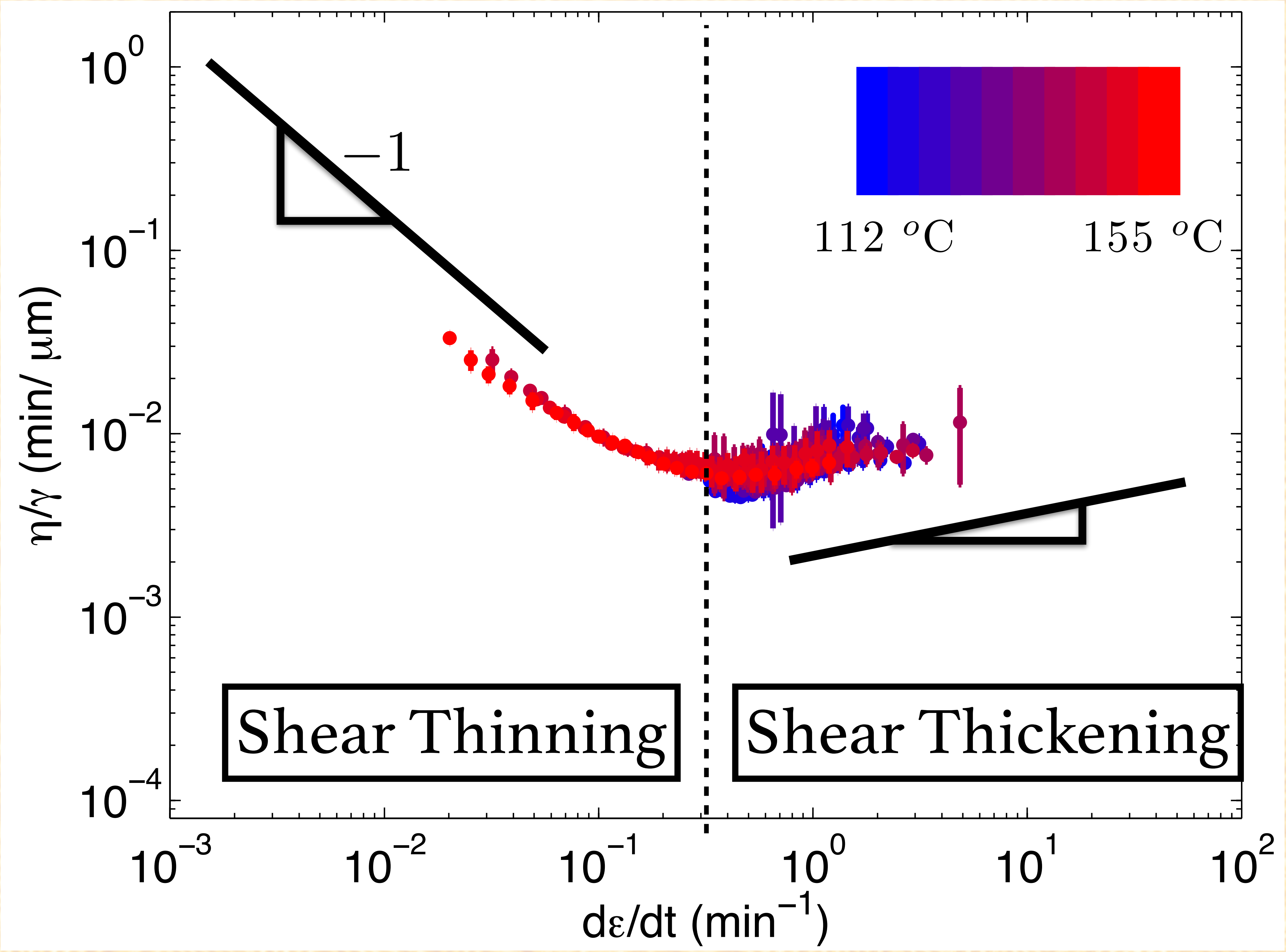
$$\therefore \frac{d\epsilon}{dt} = \frac{1}{l}\frac{dl}{dt} = -\left(\frac{2}{d_{min}}\right)\frac{d}{dt}(d_{min})$$

$$d_{min} = d_0 - \alpha\frac{\gamma}{\eta}t$$

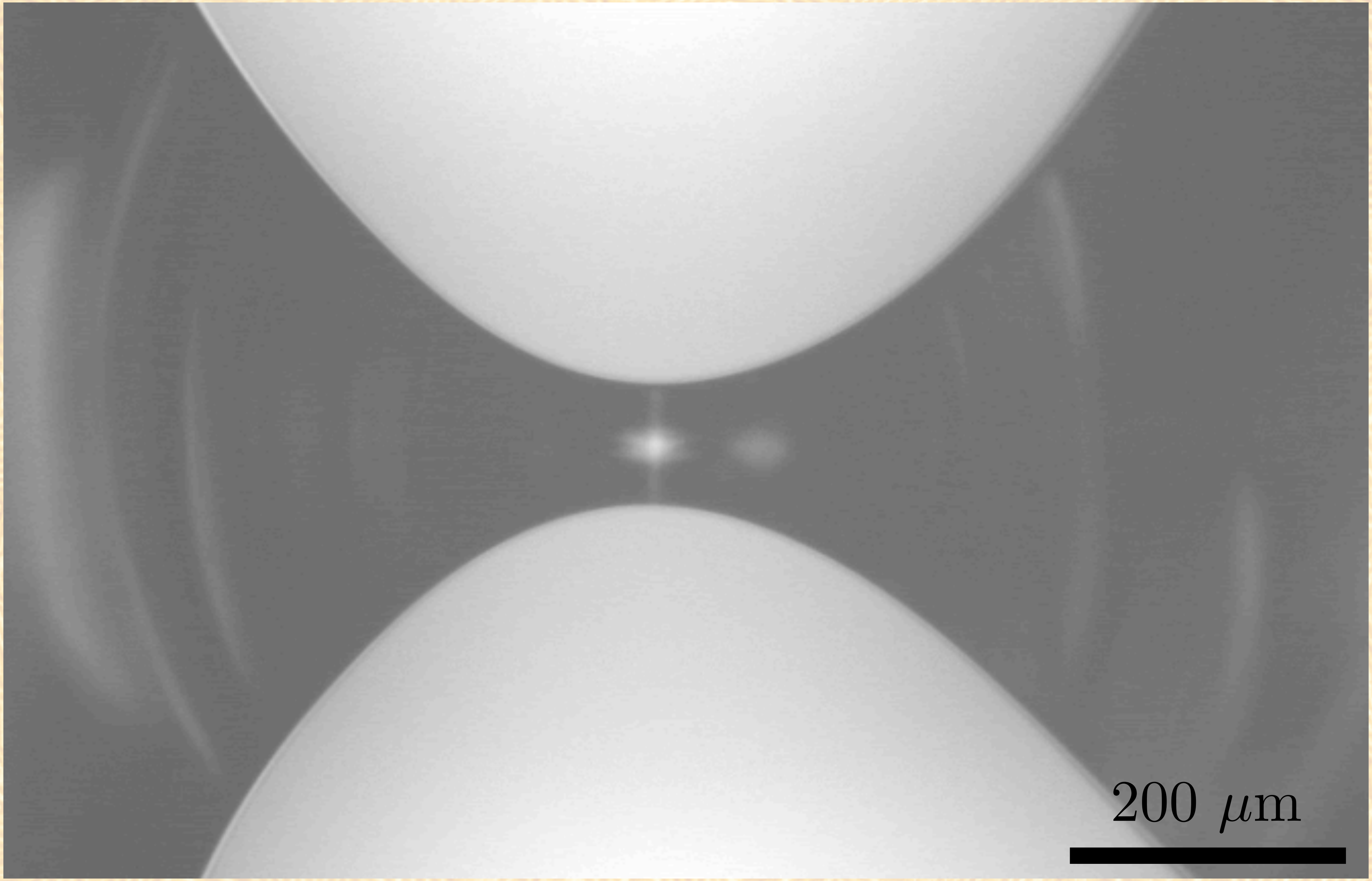
Temperature dependence



Homopolymer dynamics



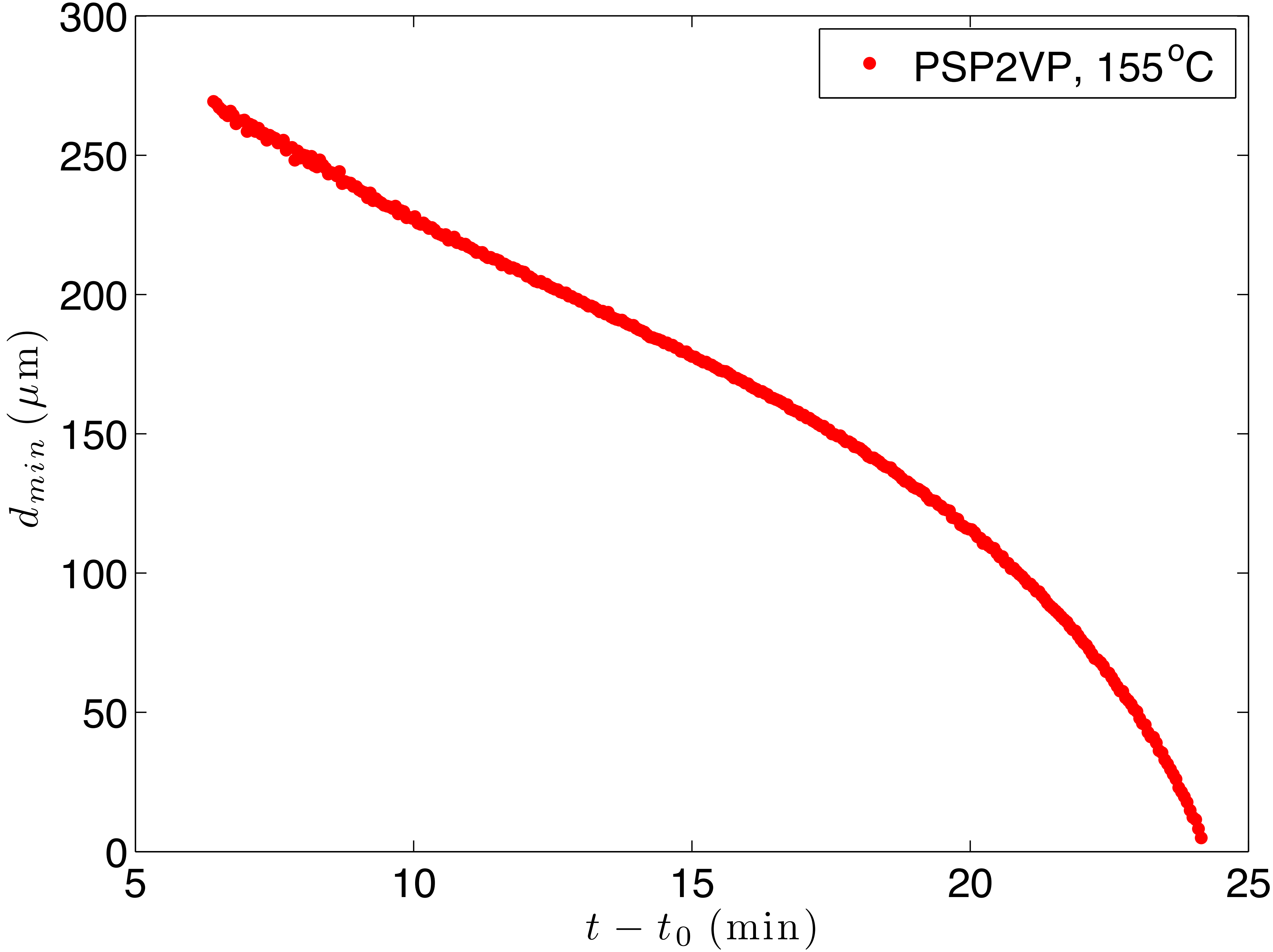
Symmetric diblock copolymer



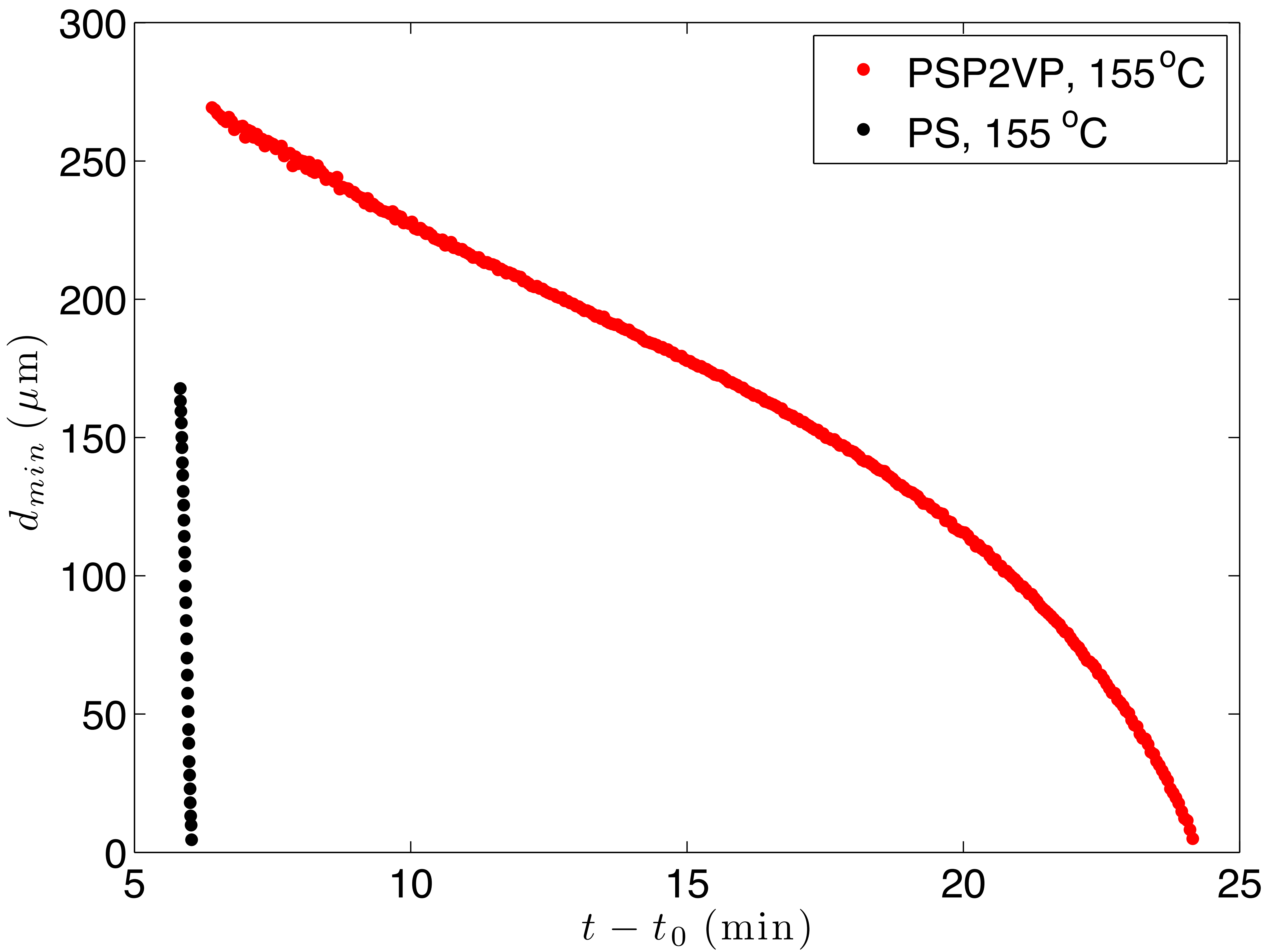
PS-b-P2VP measurement @ 155 °C,

Order-Disorder Transition ~ 160 °C

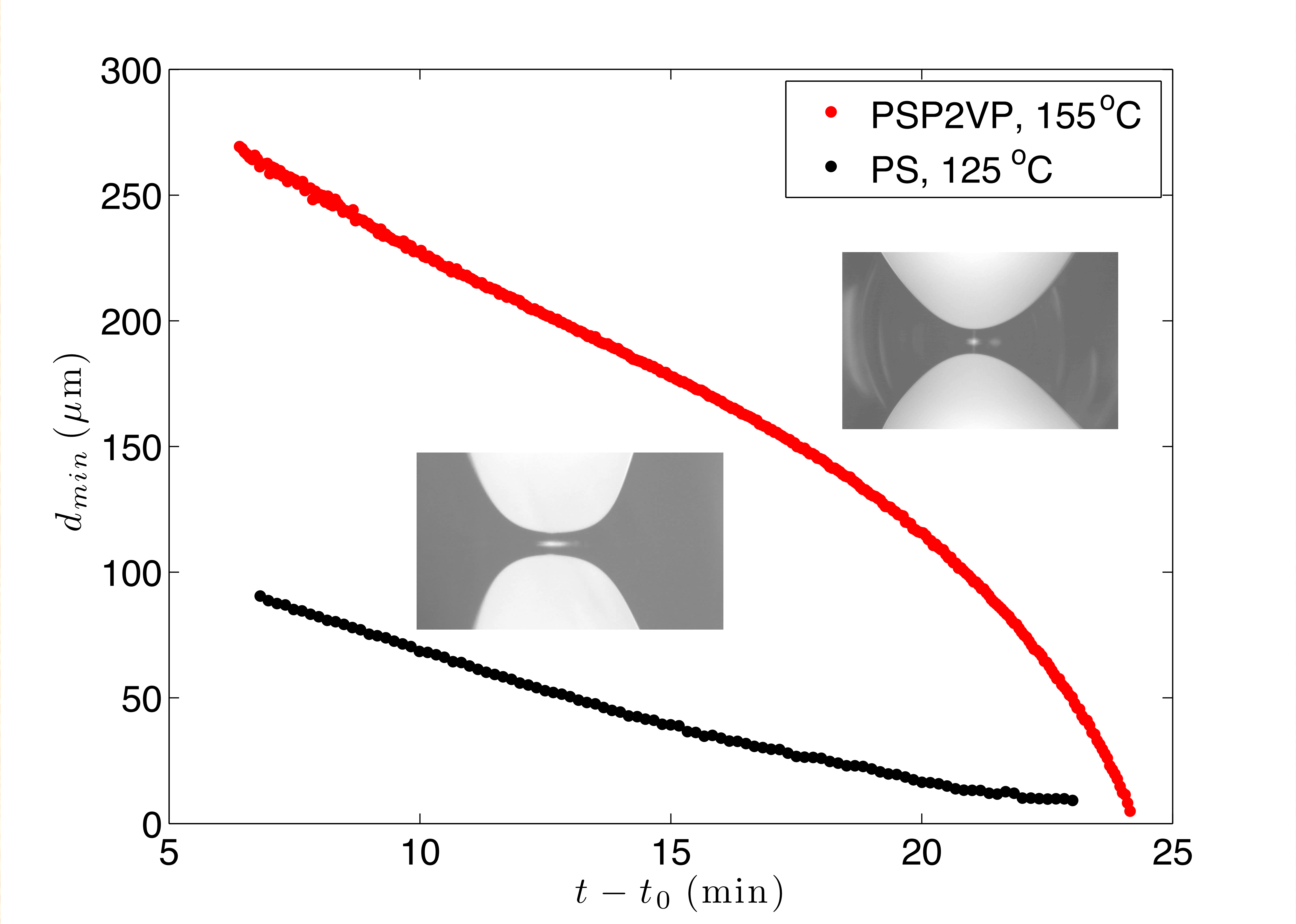
Diblock bridge evolution



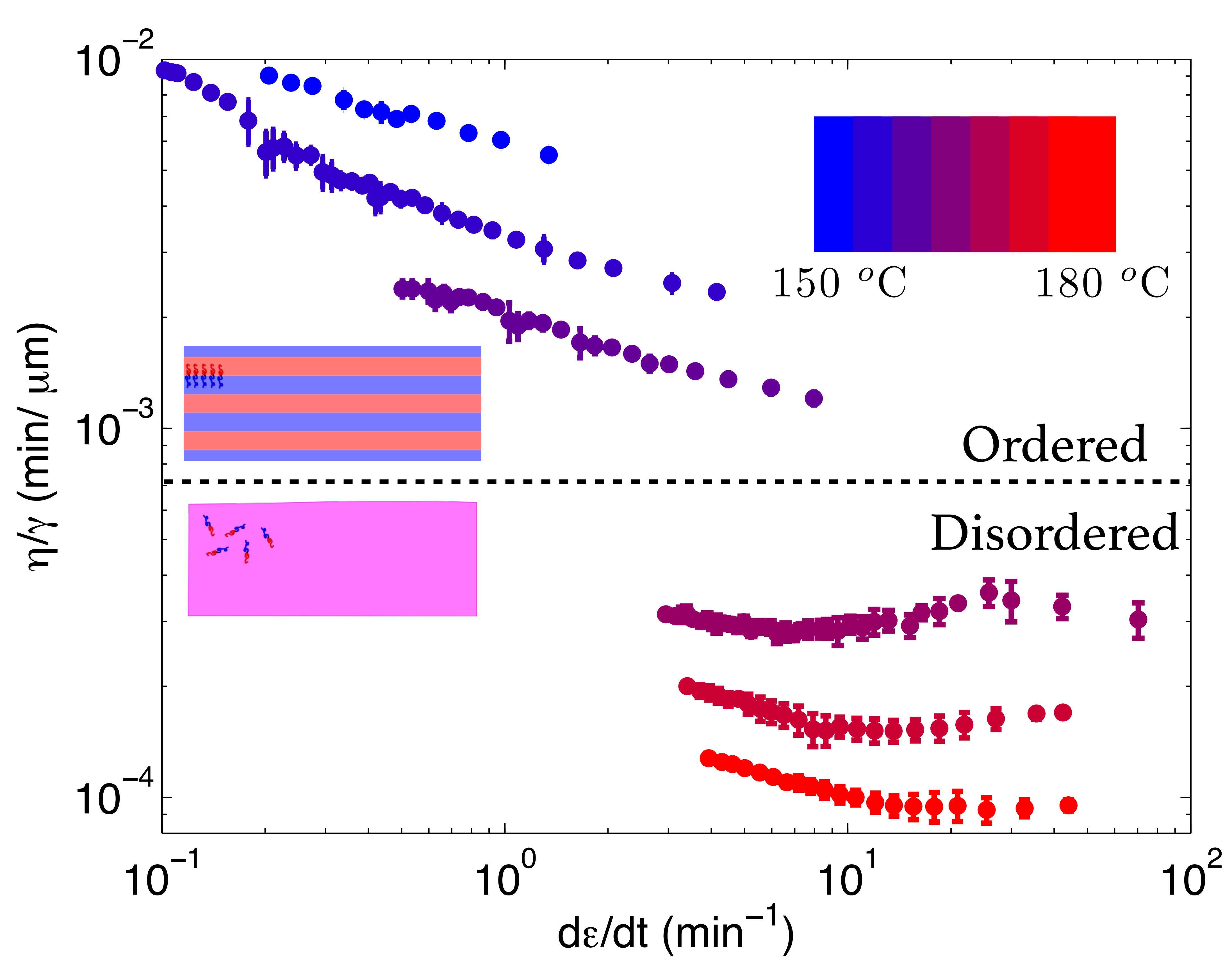
Homopolymer vs. Diblock



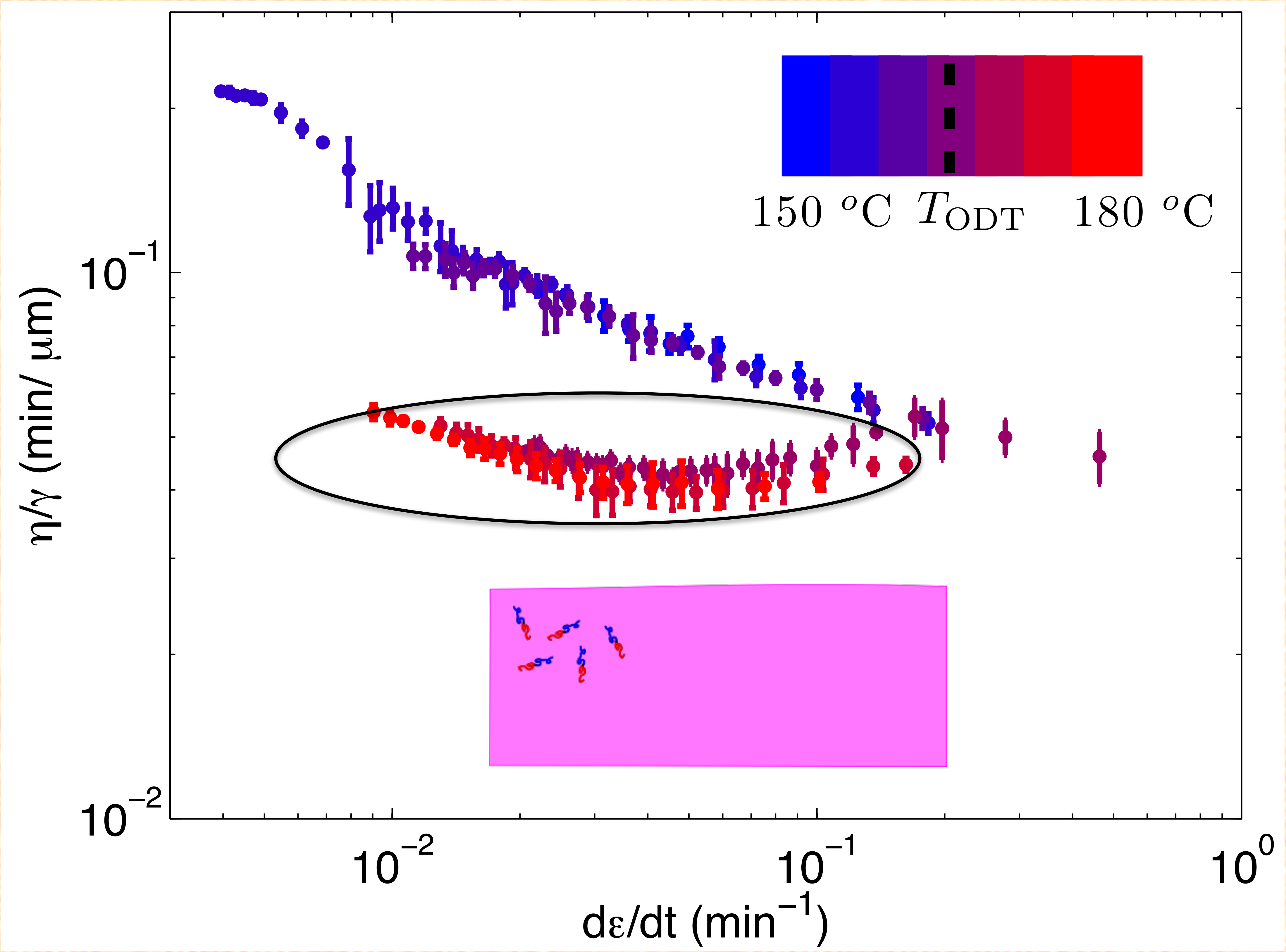
Homopolymer vs. Diblock



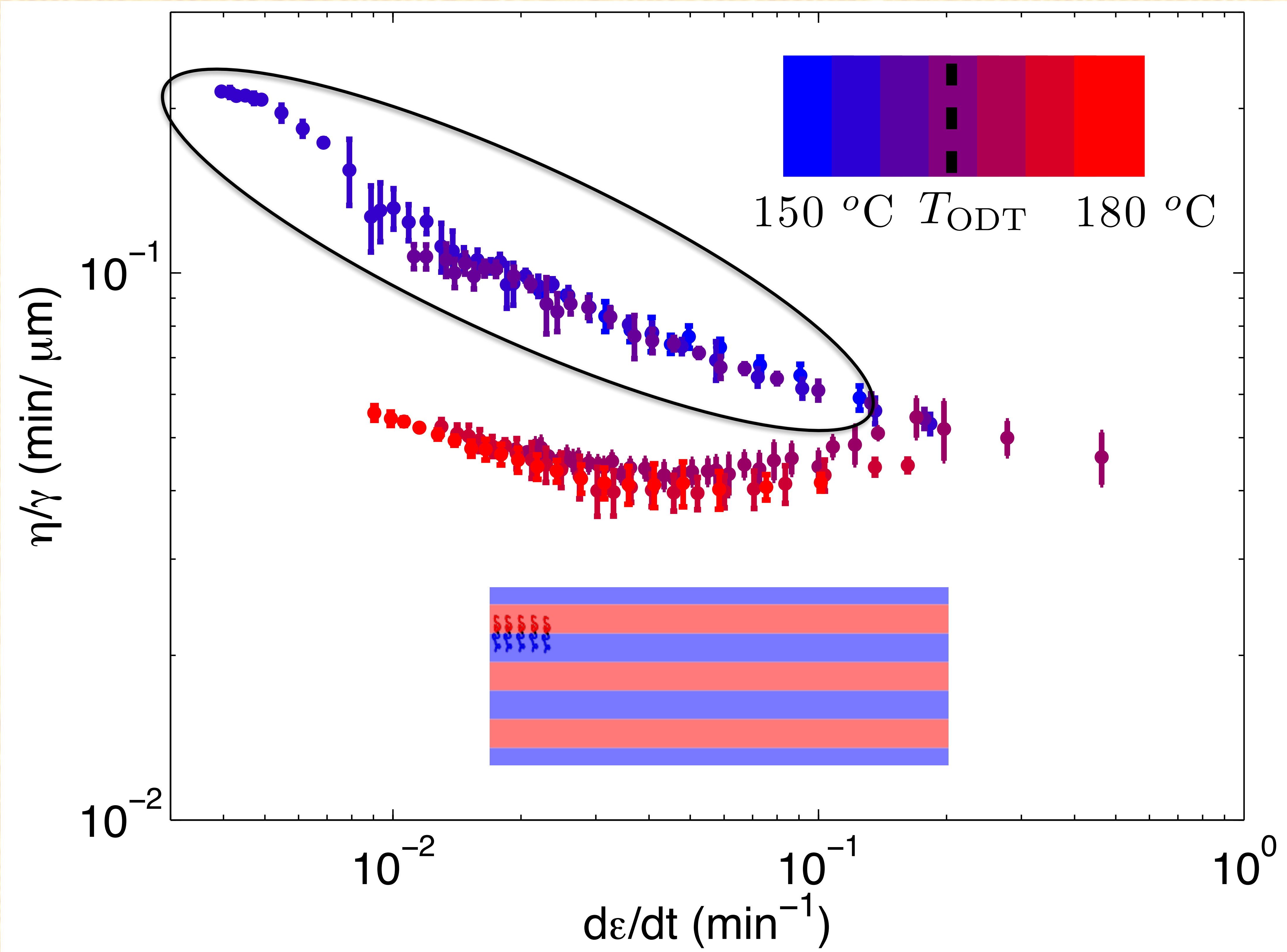
Temperature dependence



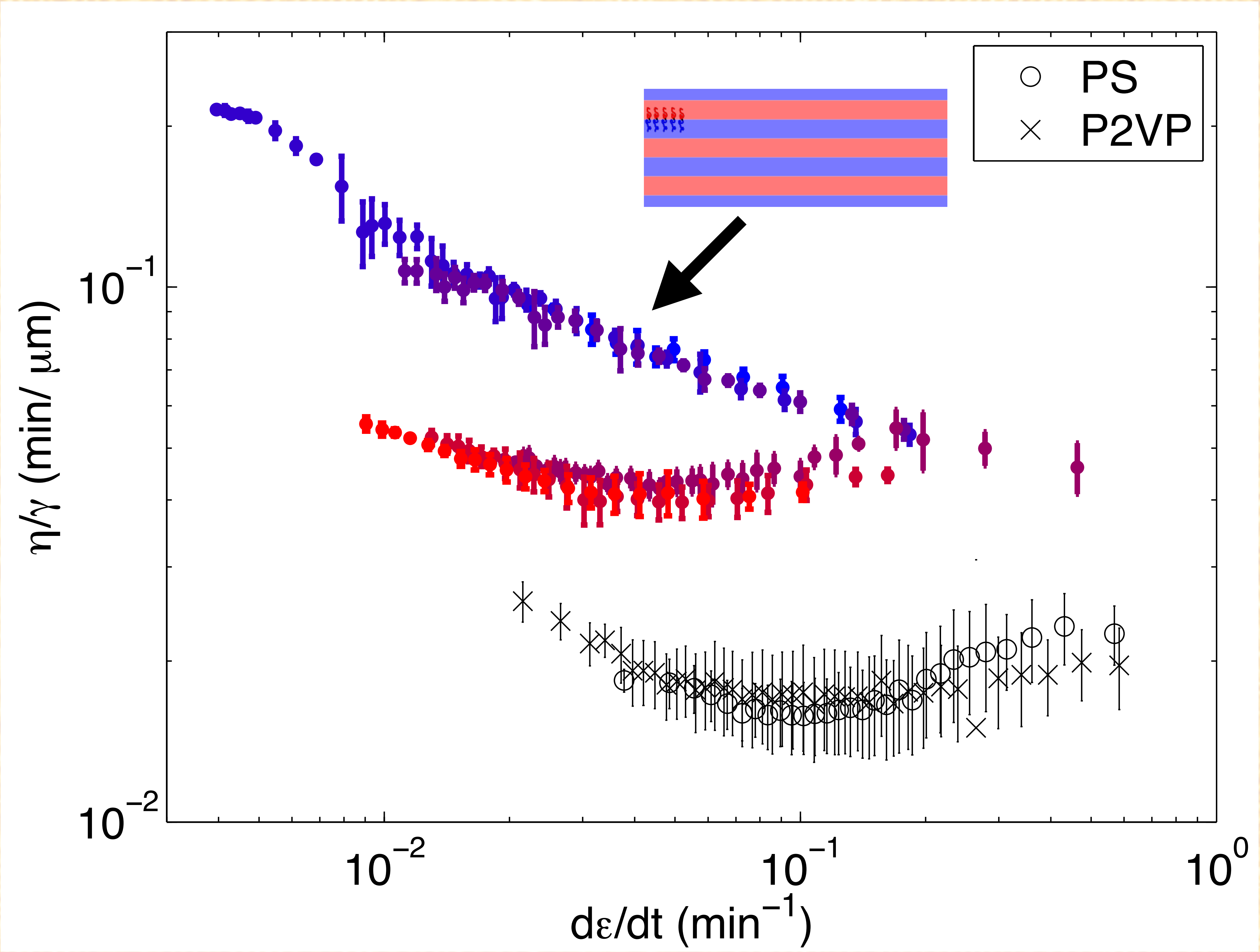
Ordering induced shear thinning



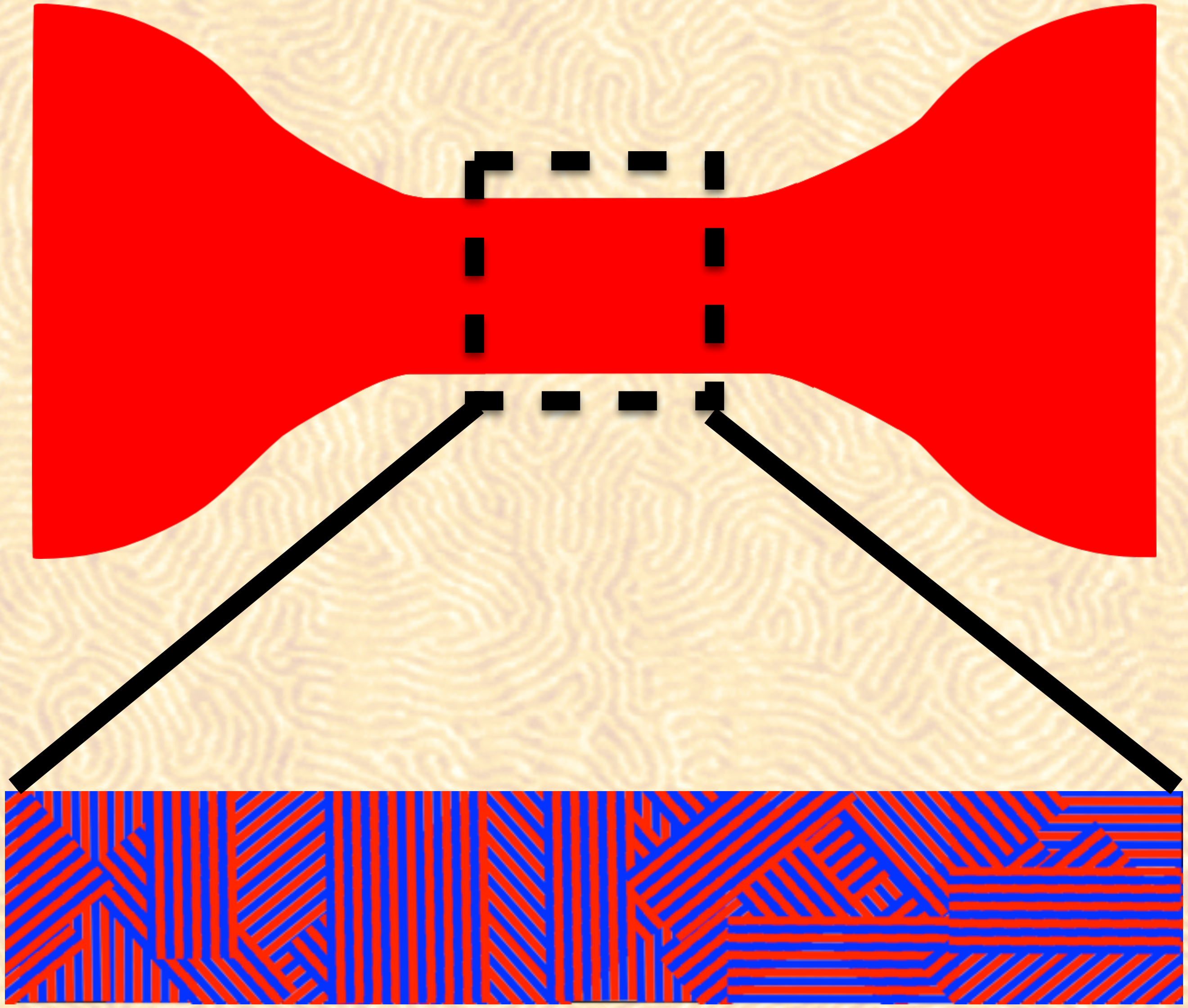
Ordering induced shear thinning



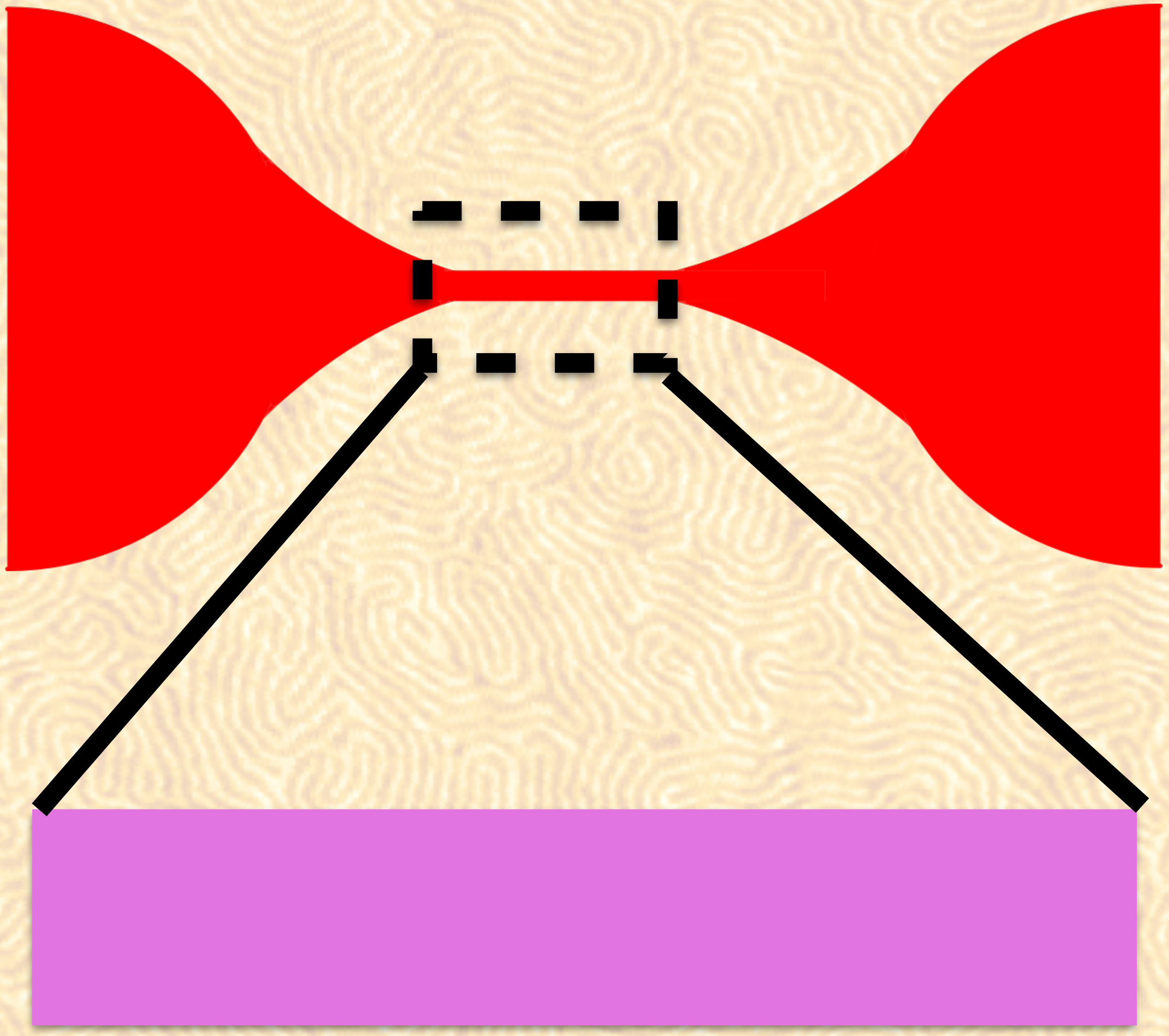
Ordering induced shear thinning



Shear induced disorder

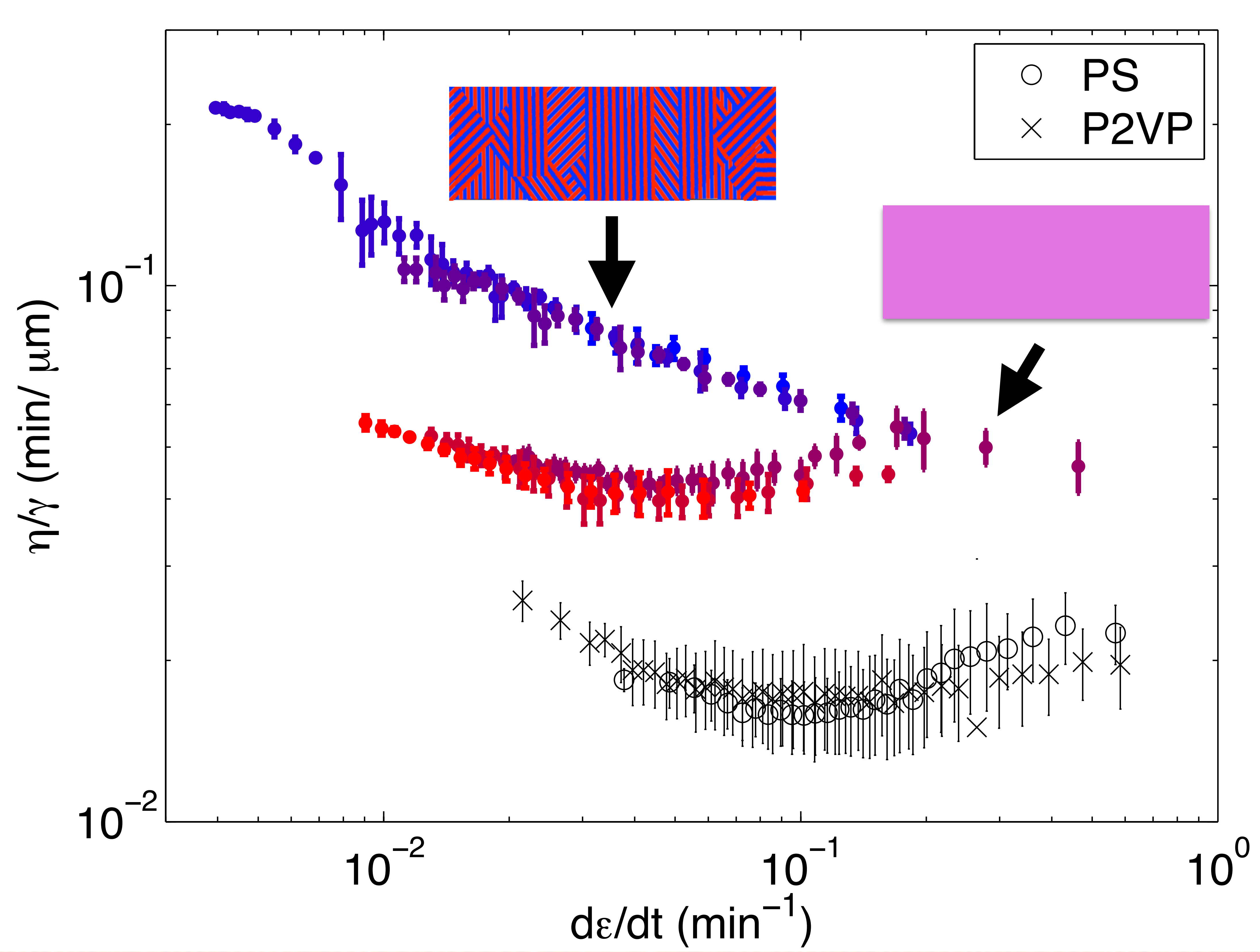


$\eta > \eta_{\mathrm{dis}}$



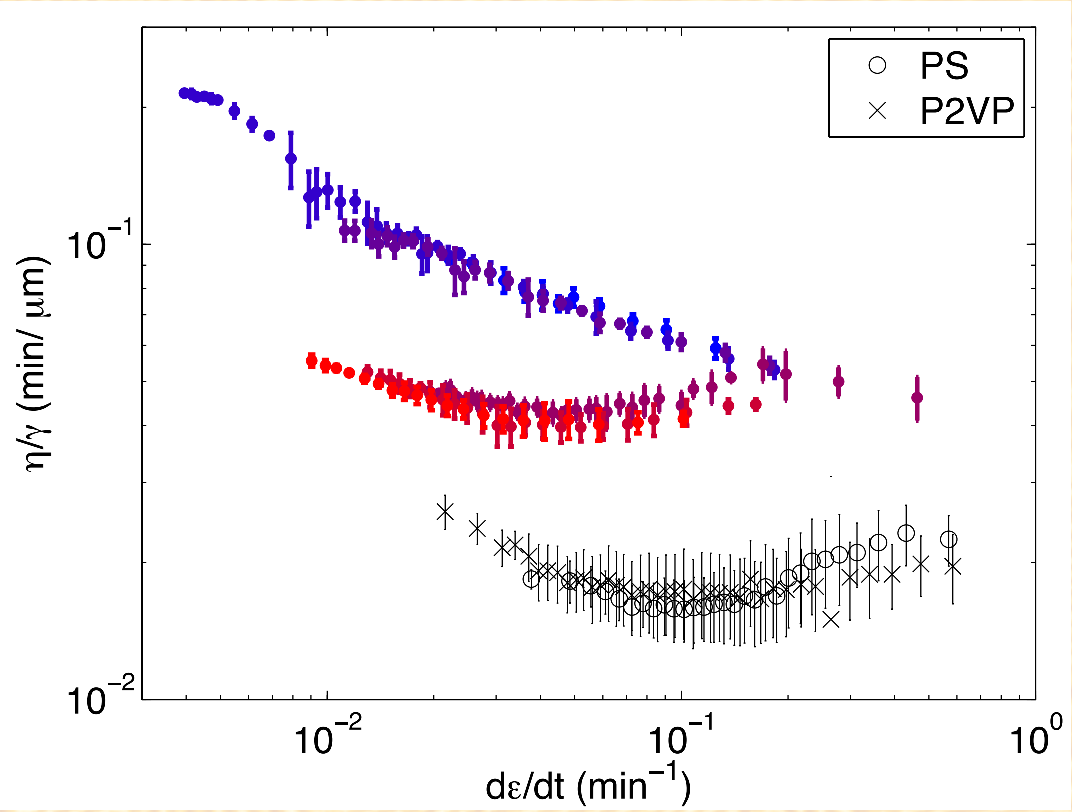
$\eta = \eta_{\mathrm{dis}}$

Shear induced disorder



Summary

- Symmetric diblock ordering stabilizes liquid bridges.
- Order of magnitude increase in effective viscosity.
- Shear thinning viscosity due to domain alignment or destruction in shear flows



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