Soft Matter Exercise - Chapter 1: Introduction

1. Viscosity

The viscosity of acetone (3×10^{-4} Pa.s) is lower than that of water (10^{-3} Pa.s). Why?

2. Non-Newtonian Fluids

Give some examples of non-Newtonian fluids. How can their flow behavior be favorable or unfavorable for the processing and storage of these fluids? What does this behavior tell us about the composition of these fluids?

3. Temperature Dependence of the Viscosity of Poly(styrene)

The temperature-dependent variation of the viscosity of poly(styrene) follows the Vogel-Fulcher law with $B = 710\ K$ and $T_0 = 50°\text{C}$.

a. Plot η/η_0 as a function of temperature for $80°C < T < 150°\text{C}$. By what factor, F_1, does η vary between $T = 80°\text{C}$ and $T = 100°\text{C}$? And by what factor, F_2, does η vary between $T = 120°\text{C}$ and $T = 140°\text{C}$? Are the two factors similar? Why or why not?

b. You are asked to define the temperature at which poly(styrene) is extruded into bars. What factors do you have to consider? What would your recommended processing temperature be and what considerations did you use to make your decision?

4. Temperature Dependence of the Viscosity for Glass-Forming Liquids

Configurational re-arrangement is the rate limiting step in the flow of poly(styrene) at $T = 101.4°\text{C}$ and the experimental time scale $\tau_{exp} = 1000$ s. The relaxation time follows the Vogel-Fulcher law with $B = 710$ K and $T_0 = 50°\text{C}$.

a. What is T_g if the experimental timescale is 10 s? 100 s? 10^6 s?

b. On what timescale do you have to conduct the experiment if T_g must be 50°C above T_0? What if T_g must be 10°C above T_0?

5. Elasticity

Rubber bands are made from amorphous polymers. If a rubber band with an unstretched cross section of 0.4 mm^2 is loaded with 10 N, its length will increase by 50%. Calculate the Young's modulus. (Assume that the total volume of the rubber band remains constant.)