Soft Matter Exercise - Chapter 10: Emulsions

1. Fabrication of Emulsions

A 1-liter can with a diameter of 1 cm is shaken with an amplitude of 20 cm at a rate of 10 s^{-1}. To do these calculations, make a few rather strong assumptions: Assume that all the liquid is displaced by the full amplitude. Moreover, assume the center of the liquid to remain stationary during a full cycle.

a. Estimate the shear rate inside the can using $\gamma = \frac{8v}{d}$, where v is the average velocity and d the diameter of the can.
b. What is the order of magnitude of the viscous stress assuming the liquid is 10 times more viscous than water that has a viscosity of 1 mPa.s?
c. The shear force pushes the air at the top of the can into the fluid and breaks it up into small bubbles. Estimate the average size of drops that form. (Assume the surface tension of the liquid to be that of clean water, 73 mN/m)
d. What is the average drop size if water is shaken with the same frequency and amplitude?

2. Stability of Emulsions

The interfacial tension between water and hexane is 50 mN/m at 20°C.

a. Is it possible to form a stable emulsion composed of 50 vol% hexane, 50 vol% water? Why or why not?
b. What is the critical surface tension to form an emulsion with a drop diameter of 20 nm if $\phi_b = 50\%$?
c. What is the critical surface tension to form an emulsion with a drop diameter of 20 nm if $\phi_b = 10\%$?
d. How could you lower the surface tension?

3. Stabilization of Emulsions

Name two possible methods to stabilize emulsions. What are the advantages and disadvantages of each method?

4. Pickering Emulsions

The removal of SiO_2 particles that are adsorbed at the drop surface costs as significant amount of energy. Why is this the case?
What is the energy in k_BT required to remove a SiO_2 particle from the surface of an oil drop in water if the interfacial tension $\gamma = 30$ mNm, when the particle diameter and contact angle are:

a. 200 nm and 90°?
b. 200 nm and 120°?
c. 20 nm and 90°?
d. 20 nm and 120°?

(Assume T = 25°C and $\rho_{H_2O} = 1$ g/cm^3)

5. Foams

Why do foams coarsen and how can the coarsening kinetics be influenced?