Soft Matter Exercise - Chapter 9: Particles

1. Characterization of Nanoparticles

Dynamic light scattering (DLS) can be used to determine particle size from the diffusion constant. You measure the velocity of a poly(styrene) particle dispersed in water to be 2 mm/s at 25°C. Estimate the size of the particle assuming it is spherical. (Assume the density of poly(styrene) to be 1.04 g/cm^3 and the viscosity of water to be 1mPa.s)

2. Nanoparticle Stability

a. Why do nanoparticles tend to aggregate?
b. What can you do to prevent aggregation?
c. You want to intravenously inject iron oxide nanoparticles into humans to enhance the contrast in images taken with magnetic resonance, which are used to determine if a patient has cancer. How would you ensure that these nanoparticles will not clog blood vessels?

3. Effective Volume Fraction

Calculate the effective volume fraction of a suspension of 100 nm diameter SiO_2 particles that are electrostatically stabilized and dispersed at 10 vol% in an aqueous solution containing:

a. 0.005 M NaCl
b. 0.1 M NaCl
c. 1 M NaCl

To calculate the effective volume, take the volume of a sphere whose radius is the radius of the SiO_2 particle plus the Debye screening length. (Assume the temperature to be 20°C and ϵ_r of water at 20°C to be 80)

4. Steric Stabilization

You should stabilize 20 nm diameter gold nanoparticles by adsorbing poly(ethylene glycol) (PEG) with a molecular weight of 2000 g/mol. Assume the length of an ethylene glycol repeat unit to be 0.35 nm. To ensure that proteins do not adsorb at the nanoparticle surface, the steric layer should be at least 9 nm thick. (Assume PEG is dissolved in a theta solvent and the bond angle is 109°)

a. What should be the packing density of PEG on the gold nanoparticle surface to achieve this thickness?
b. If you adsorb PEG chains at this packing density, do they come in contact with their nearest neighbors? How does that influence their conformation?
c. How would you bind the PEG to the surface of gold nanoparticles?

5. Colloidal Stability

You prepare a dispersion of colloidal particles that is stable. However, when you add smaller particles, you observe sedimentation. Explain this phenomenon.

6. Colloidal Crystals

a. What is a colloidal crystal?
b. How can a colloidal crystal be made?
c. What volume fraction will 100 nm diameter spherical particles occupy if they are arranged in a close-packed, face-centered cubic structure?