A dispersion (system)

Colloidal solutions

High molecular mass compounds
Outline

- Types of dispersions
- Characteristics of main types of dispersions
- Properties of colloidal solutions
- Structure of colloidal particle
- Stability of colloidal solutions (coagulation of colloids)
- Properties of solutions of biopolymers
  Colloidal solutions
A dispersions (dispersal system)

• A dispersion is a system (not necessarily a solution) in which particles are dispersed in a continuous phase of a different composition (or state).

• Size of particles is described by a term dispersal degree, which is opposite to diameter (in cm) of a particle:

$$D = \frac{1}{\alpha} \text{ cm}^{-1}$$
Types of dispersal systems

Homogeneous – composed of molecules and/or ions. For example, a real solution is a fine dispersal system, where there is no a contact surface between solute and solvent.

Heterogenous – composed of particles and medium, it means those phases have contact surface. A minor phases is dispersal phase, a major/dominant phase is dispersal medium.
Classification of heterogeneous dispersion (systems)

- Low dispersion systems, when diameter of particles is bigger than 100 nm (10\(^{-7}\)m). Example: suspensions, emulsions.

- Colloidal dispersion system contains particles with diameter between 1 and 100 nm. Dispersal phase in colloidal solutions is represented by large aggregates of molecules called micelles.

- Solutions of high molecular mass compounds (size of molecules – 1-10 nm). For example, solutions of proteins, nucleic acids, and starch.
# Heterogeneous dispersion systems - Colloid

<table>
<thead>
<tr>
<th>Colloid Type</th>
<th>Dispersal Phase</th>
<th>Dispersing Medium</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosol</td>
<td>Liquid</td>
<td>Gas</td>
<td>Fog</td>
</tr>
<tr>
<td>Aerosol</td>
<td>Solid</td>
<td>Gas</td>
<td>Smoke</td>
</tr>
<tr>
<td>Foam</td>
<td>Gas</td>
<td>Liquid</td>
<td>Whipped Cream</td>
</tr>
<tr>
<td>Solid foam</td>
<td>Gas</td>
<td>Solid</td>
<td>Marshmallow</td>
</tr>
<tr>
<td>Emulsion</td>
<td>Liquid</td>
<td>Liquid</td>
<td>Milk</td>
</tr>
<tr>
<td>Solid emulsion</td>
<td>Liquid</td>
<td>Solid</td>
<td>Butter</td>
</tr>
<tr>
<td>Sol</td>
<td>Solid</td>
<td>Liquid</td>
<td>Blood; cell fluid</td>
</tr>
<tr>
<td>Solid sol</td>
<td>Solid</td>
<td>Solid</td>
<td>Opal</td>
</tr>
</tbody>
</table>
Comparing solutions, colloids and suspensions

<table>
<thead>
<tr>
<th>Property</th>
<th>Low dispersion system</th>
<th>Colloidal system</th>
<th>Real solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency</td>
<td>No</td>
<td>Low (opalescent)</td>
<td>Transparent</td>
</tr>
<tr>
<td>Passage through the paper filter</td>
<td>Do not pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Passage through semipermeable membrane</td>
<td>Do not pass</td>
<td>Do not pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
<td>Homogeneous</td>
</tr>
<tr>
<td>Light dispersion</td>
<td>Disperses</td>
<td>Tyndall effect</td>
<td>No dispersion</td>
</tr>
<tr>
<td>Stability</td>
<td>Non stable</td>
<td>Slightly stable</td>
<td>Stable</td>
</tr>
</tbody>
</table>
Comparing the properties of solutions, colloids and suspensions

- a) Suspensions settle
- b) Filters separate suspensions but not solutions or colloids
- c) Only solution particles go through semipermeable membranes.
Suspensions

- Contain very large particles that are visible
- Settle out rapidly
- Can be separated by filters
Colloids

Colloidal dispersions are mixtures that

- Contain medium-sized particles (1-100 nm) called colloids.
- Cannot be separated by filters.
- Can be separated by semipermeable membranes.
- Scatter light (Tyndall effect) because the particle size is similar to the wavelength of light.
Tyndall effect

- A beam of light going through a colloid is visible because the light is scattered by the large solute particles.
- The Tyndall effect does not occur with solutions.
Cspecific properties of colloidal solutions come from
A) High degree of dispersity $D = \frac{1}{\alpha}$ cm$^{-1}$, which is opposite to diameter of a particle
B) Microheterogeneity – huge contact area between phases
C) Instability without a stabilizer
Properties of colloidal solutions

- *Kinetic properties*
- Brownian movement.
- Osmotic pressure and diffusion.
- Sedimentation
- Coagulation
- Migration in electric field
- *Optical properties*
- Light dispersion:
  - **Diffraction** is observed, if the wavelength of light is bigger than the size of colloid, but the diameter of the particle is about a half of the wavelength.
  - **Opalescence** - light diffraction and changing of color.
  - **Refraction** - light dissipation when the size of colloidal particle is bigger than the wavelength of light.
Types of colloidal solutions

<table>
<thead>
<tr>
<th>Dispersal medium</th>
<th>Dispersal phase</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid</td>
<td>Solid</td>
<td>Solver sole</td>
</tr>
<tr>
<td>Liquid</td>
<td>Liquid</td>
<td>Milk</td>
</tr>
<tr>
<td>Liquid</td>
<td>Gas</td>
<td>Foam</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Ruby</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
<td>Perl</td>
</tr>
</tbody>
</table>
Preparation of colloidal solutions

- **Dispergation** – colloidal-size particles are obtained when a solid material is minced into tiny particles in ultra-mills.

- **Condensation** – colloidal-size particles come by joining of atoms, ions and molecules. Colloidal-size particles can be formed only when concentrations of those solutions are low or high. You will make this in chemistry lab.
Purification of colloidal solutions (sole)

- Dialysis
- Dialysis - a way to separate solution particles from colloids through a semi-permeable membrane.
Principle of hemodialysis

Blood Subjected to dialysis

Cleaning solution

Clean blood

Pump

Waste compounds

Semipermeable membrane

Pump
Structure and stability of colloids

- **Micelle** is an electrically neutral particle, which contains a colloidal particle as the nucleus (core) and two layers of ions as the shell.

- Why don’t colloidal particles aggregate, form larger particles and settle out?

- Particles have charged surfaces which repel other particles.
Colloidal particle

- The layer of ions closer to the nucleus - adsorbtional layer.
- The outer layer - diffusional layer.
- Granule has an electrokinetic potential - zeta ($\xi$) potential.
- Zeta-potential is responsible for the stability of colloidal solutions.
Factors affecting coagulation of colloidal solutions

- Heating colloidal solutions.
- Increasing concentration of colloidal solutions.
- Adding electrolytes - decreases electrostatic repulsion.
- Adding another colloid containing oppositely charged particles.
Effect of electrolytes on coagulation of colloidal solutions

A - before coagulation beginning

B - beginning of coagulation; \( \xi \)-potential dissapers; the particle lacks electrical charge.
Orders of coagulation inducing efficiency

- Ions with valency 3 > ions with valency 2 > ions with valency 1
- $\text{Cs}^+ > \text{Rb}^+ > \text{K}^+ > \text{Na}^+ > \text{Li}^+$ – cations with valency +1
- $\text{Ba}^{2+} > \text{Sr}^{2+} > \text{Ca}^{2+} > \text{Mg}^{2+}$ – cations with valency +2
- $\text{Cl}^- > \text{Br}^- > \text{NO}_3^- > \text{I}^- > \text{CSN}^-$ – anions with valency -1
Coagulation rate

- Hidden phase
- Slow phase
- Fast phase

The rate of coagulation

The ζ-potential
High-molecular mass compounds

• High-molecular mass compounds are of two origins:
  • Cellular origin high-molecular mass compounds are called biopolymers, e.g. nucleic acids, proteins and polysaccharides.
  • Synthetic/artificial high-molecular mass compounds.

• Biopolymers share some properties with colloidal solutions and some properties with real solutions.
Properties of solutions of biopolymers

Properties that are common with colloidal solutions:

- Size of molecules of biomolecules is similar to the size of colloidal particle.
- Solutions of biopolymers have slow rate of diffusion.
- Molecules of biopolymers cannot pass through semi-permeable membrane. Their solutions have low osmotic pressure. The osmotic pressure of those solutions depends only on the number of biopolymer molecules.
Properties of solutions of biopolymers

Properties that are common with real solutions:

- Do not form micelles, i.e. they are solutions of a single phase (homogeneous systems).
- Solutions of biopolymers with linear structure do not show Tyndall effect.
- Solutions of biopolymers are stable systems. They do not show sedimentation phenomenon.

Specific properties of biopolymer solutions.

- Biopolymers swell before dissolving. Under swelling, the solvent surrounds the molecule of the biopolymer, then it moves into the empty spaces of the molecule, so that the volume of the molecule increases.