COLLOIDS and COLLOIDAL DISPERSIONS

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DISPERSED SYSTEMS

- The term «colloid» include a wide range of substances such as
- suspensions of solids in liquids,
- emulsified liquids,
- gels,
- solutions of soap..

- These compounds did not crystallize and they diffuse very slowly when dissolved or dispersed in water.

- Colloidal dispersions consist at least two discrete phases, thus they are called colloidal dispersions.

Dispersed system:

- They consist of particulate matter, known as the **dispersed phase** (internal phase), distributed throughout a **dispersion medium** (continuous phase, external phase or vehicle)

What is phase?

- It is a physically distinct part of a system, separated by boundaries from other parts of the system.

  EXAMPLE:

  Water and vapour are phases for water vapour system

- The dispersed material may range in size from particles of atomic and molecular dimensions to particles whose size is measured in millimeters.

All kinds of dispersed phases might form colloids in all possible kinds of media, except for a gas-gas combination.

Dispersion medium	Dispersed phase	Colloid type
Solid	Solid	solid sol
Solid	Liquid	solid emulsion
Solid	Gas	solid foam
Liquid	Solid	sol, gel
Liquid	Liquid	emulsion
Liquid	Gas	foam
Gas	Solid	solid aerosols
Gas	Liquid	liquid aerosols

* Gas in a gas always produces a solution

Types of Colloidal Dispersions

Dispersions can be classified in various ways;

- Molecular or Micellar
- According to their particle shape
- According to their particle size
  Molecular/colloidal/coarse
- According to the interaction of dispersed phase with the medium.
  Lyophilic/lyophobic/amphiphilic

- Based on the size of the dispersed phase, dispersed systems are generally considered as:

a) **Molecular dispersions,**

b) **Colloidal dispersions,**

c) **Coarse dispersions.**

MOLECULAR DISPERSION	COLLOIDAL DISPERSION	COARSE DISPERSION
-Particles invisible in electron microscope.	-Particles resolved by electron microscope.	-Particles are visible under ordinary microscope.
-Pass through semipermeable membranes and filter paper.	- Pass through filter paper but not pass through semipermeable membrane.	- Do not pass through filter paper or semipermeable membrane.

Less than 1 nm
Ordinary ions

1 nm to 0.5µm
polymers

greater than 0.5µm
Emulsions/suspensions

- Colloidal systems are best classified into three groups on the basis of the interaction of the particles, molecules, or ions of the dispersed phase with the molecules of the dispersion medium.

a) Lyophilic colloids
b) Lyophobic colloids
c) Association (amphiphilic) colloids

Lyophilic Colloids

- Systems containing colloidal particles that interact to an appreciable extent with the dispersion medium.
- Also known as **solvent-loving colloids**.
- Owing to their affinity for the dispersion medium, such materials form **colloidal dispersions**, or **sols,**

  (Sol is the colloidal dispersion of a solid in liquid or gaseous medium. Sols are fluid.)

- Lyophilic colloidal sols are usually obtained simply by dissolving the material in the solvent being used.
- For example, the dissolution of acacia or gelatin in water or celluloid in amyl acetate leads to the formation of a sol.

The various properties of this class of colloids are due to the attraction between the dispersed phase and the dispersion medium, which leads to **solvation**, the attachment of solvent molecules to the molecules of the dispersed phase.

In the case of hydrophilic colloids, in which water is dispersion medium, this is termed as **hydration**.

Most lyophilic colloids are organic molecules, such as

gelatin
acacia
insulin
Albumin

hydrophilic sols

Produce lyophilic colloids in aqueous dispersion media

rubber
polystyrene

lipophilic colloids

They form lyophilic colloids in non-aqueous, organic solvents

Lyophobic Colloids

- These colloids are composed of materials that have little attraction for the dispersion medium
- also called as **solvent-hating colloids** and they are hydrophobic
- Their properties differ from those of the lyophilic colloids; primary difference is due to <u>the absence of a solvent sheath around the particle.</u>
- They are generally composed of inorganic particles dispersed in water, such as

  Gold
  Silver
  Sulfur
  Arsenous sulfide
  Silver iodide

In contrast to lyophilic colloids, it is necessary to use special methods to prepare lyophobic colloids.

These are;

- **Dispersion methods**

coarse particles are reduced in size

- **Condensation methods**

materials of subcolloidal dimensions are caused to aggregate into particles within the colloidal size range.

Dispersion

- Mechanical methods

milling and grinding processes can be used, however their efficiency is low.

- High-intensity ultrasonic generators

they can operate at frequencies in excess of 20.000 cycles per second and ultrasonic waves occur

- Production of an electric arc within a liquid.

Owing to the intense heat generated by the arc, some of the metal of the electrodes is dispersed as vapor, which condenses to form colloidal particles.

Condensation

- Supersaturation

Supersaturation can be provided by a change in solvent system or reduction in temperature.

- Chemical reactions

Hydrolysis, oxidation or double decomposition can be used. Bu double decomposition an undissolved salt can be formed. (Such as colloidal silver chloride)

Association Colloids

(Micelles and the Critical Micelles Concentration)

- Also called as **amphiphilic colloids**
- Certain molecules or ions, termed **amphiphiles** or **surface-active agents**, are characterized by having two distinct regions of opposing solution affinities **(hydrophilic and hydrophobic)** within the same molecule or ion.

Amphiphiles may be **anionic ,**
cationic,
nonionic,
ampholytic (zwitterionic)

- When present in a liquid medium at low concentrations, the amphiphiles exist separately and are of such a size as to be subcolloidal.
- As the concentration is increased, aggregation, occurs over a narrow concentration range.
- These aggregates, which may contain 50 or more monomers, are called Micelles. Because the diameter of each micelle is of the order of 50Å, micelles lie within the size range we have designated as colloidal. The concentration of monomer at which micelles form is termed the critical micelle concentration (CMC).
- The number of monomers that aggregates to form micelle is known as the aggregation number of the micelle.

The phenomenon of micelle formation can be explained as follows:

- As the total concentration of amphiphilic material is increased they undergo adsorption at the air-water interface.
- Eventually, a point is reached at which both the interface and the bulk phase become saturated with monomers. This is the CMC.
- Any further amphiphile added in excess of this concentration aggregates to form micelles in the bulk phase, and, in this manner, the free energy of the system is reduced.

Properties of Colloidal Systems

A. Optical Properties of Colloids

- ✓ The Faraday-Tyndall Effect
- ✓ Light Scattering

B. Kinetic Properties of Colloids

- ✓ Brownian Motion
- ✓ Diffusion
- ✓ Osmotic pressure
- ✓ Sedimentation
- ✓ Viscosity

C. Electrical Properties of Colloids

- ✓ Electric double layer
- ✓ Nernst and Zeta potential

The Faraday-Tyndall Effect

- When a strong beam of light is passed through a colloidal sol, a visible cone, resulting from the scattering of light by the colloidal particles, is formed. This is the Faraday-Tyndall
- An intense light beam is passed through the sol against a dark background at right angles to the plane of observation, and, although the particles cannot be seen directly, the bright spots corresponding to particles can be observed and counted.
- The ultramicroscope/electronmicroscope can be used to examine the light points responsible for the Tyndall cone. Electron microscope resolution is about 0.5 nm (5 Å)

Light Scattering

- This property depends on the Faraday-Tyndall effect
- It is used for determining the molecular weight of colloids.
- It can also be used to obtain information on the shape and size of these particles.
- Scattering can be described in terms of **turbidity** (τ).

Turbidity

is fractional decrease in intensity due to scattering as the incident light passes through 1 cm of solution.

- **At a given concentration of dispersed phase, the turbidity is proportional to the molecular weight of the lyophilic colloid.**

The molecular weight of the colloid can be obtained from the following equation:

$$\frac{Hc}{\tau} = \frac{1}{M} + 2Bc$$

τ : the turbidity (cm^{-1})

c : the concentration of solute in g/cm^3 of solution,

M : weight-average molecular weight (g/mol or dalton),

B : interaction constant

H : constant for a particular system

$$H = \frac{32\pi^3 n^2 (dn/dc)^2}{3\lambda^4 N}$$

N : refractive index

c : concentration (g/cm^3)

λ : wavelength (cm^{-1})

dn/dc : change in refractive index with concentration

N : Avogadro's number.