UNIT-1

Dispersion Systems

Dispersion is a mixture of two substances, wherein one phase is dispersed as sub-divided particles into the second phase (continuous phase or dispersion medium).

Basically, solute particles in the heterogeneous mixture is the dispersed phase and the solvent makes the dispersion medium.

Classification

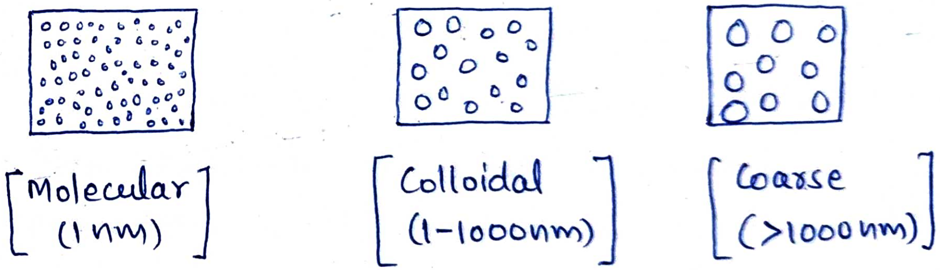
1) Molecular Dispersion → The solute is homogenously distributed throughout the solvent. Solute particle size is below 1 nm (10^{-7} cm).

For example, air is a molecular mixture of oxygen, nitrogen, etc.

2) Colloidal Dispersions → Colloids are micro-sized heterogeneous dispersed systems with dispersed phase particles ranging within 1-1000 nm size.

Milk is the emulsion (a type of colloids) of fat and other substances in water.

3) Coarse dispersion → a heterogeneous dispersed system having dispersed phase particles greater than 1000 nm in size.



Colloidal Dispersions

A mixture of dispersed phase and dispersion medium is called a colloid. Since, the particles remain dispersed in the solution and do not settle down, it is called colloidal dispersion.

Colloidal particles may occur in various shapes such as spheres and globules (e.g. surfactants), short rods and prolate ellipsoids (e.g. serum albumin), long rods and threads (e.g. TMV), loosely coiled threads, branched threads (e.g. celluloses, asbestos

Classification of Colloids

Colloidal solutions are classified based on following 3 parameters:

1) Based on the state of dispersed phase/dispersion.
   - Dispersed phase
   - Dispersion medium

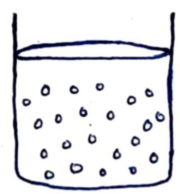
   } already discussed (def.)

Dispersed Phase	Dispersion Medium	Name	Examples
Solid	Solid	Solid-Sol	Alloys, Cranberry glass
Solid	Liquid	Sol	Ink, Blood
Solid	Gas	Aerosol	Smoke, Ice cloud
Liquid	Solid	Gel	Jelly, Curd
Liquid	Liquid	Emulsion	Milk, Cream
Liquid	Gas	Liquid aerosol	Cloud, Fog
Gas	Solid	Solid form	Aerogel, Pumice stone
Gas	Liquid	Foam	Shaving cream
Gas	Gas	None	All gases are miscible

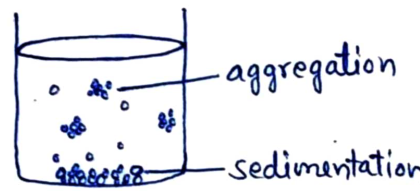
2. Based on Interaction between the phases

(A) Lyophilic colloids → These are colloidal solutions in which the dispersed phase particles have great affinity for the dispersion medium. These colloidal systems are quite stable as the dispersed phase does not precipitate out easily.
Examples – polymers in organic solvents and colloids of gums.

(B) Lyophobic Colloids → The dispersed-phase particles and dispersion medium do not have any affinity towards each other. These colloids are not stable as they get easily precipitated by adding small amount of electrolytes, by simply heating, or by shaking.
Examples – colloids of metals.



Stable colloid



Unstable colloid

Associated Colloids

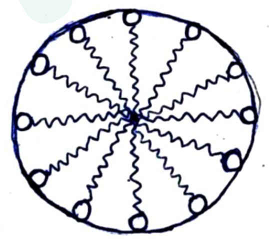
These colloids behave as normal electrolytes at low concentrations but behave as colloids at higher concentrations. These associated colloids are also referred to as micelles.

Sodium stearate behave as electrolyte in dilute solution but colloid in higher concentrations.

Examples- soaps, polythene oxide.

Miscelles are formed above a particular temperature known as the Kraft temperature (T_K) and also above a particular concentration known as Critical Miscelle Concentration (CMC).

[a surfactant molecule]



Miscelle

Comparative Account of General Properties

Table 1.4: Distinguishing Properties Between Different Types of Colloidal Dispersion System

Properties	Lyophilic Colloids	Lyophobic Colloids	Association Colloids
1) **Dispersed Phase**	Mostly organic molecules	Largely inorganic particles	Aggregation of surface active agents
2) **Nature of Interaction**	Stronger; solvent sheath around particles	Little interaction	Aggregates are solvated
3) **Presence of Charge**	Less charged; solvated	Highly charged	Charged micelles; solvated
4) **Method of Preparation**	Readily form sol	Special methods are required	Readily form when concentration is equal to CMC
5) **Viscosity of Dispersion**	Higher than that of medium alone	Nearly same as the dispersion medium	Viscosity increases, but not appreciably
6) **Presence of Electrolytes:**			
i) **At Low Concentration**	Stable	Unstable (coagulation)	Stable
ii) **At High Concentration**	Coacervation precipitates	Stable	Precipitates
7) **Reversibility**	Reversible	Irreversible	Reversible

Optical Properties

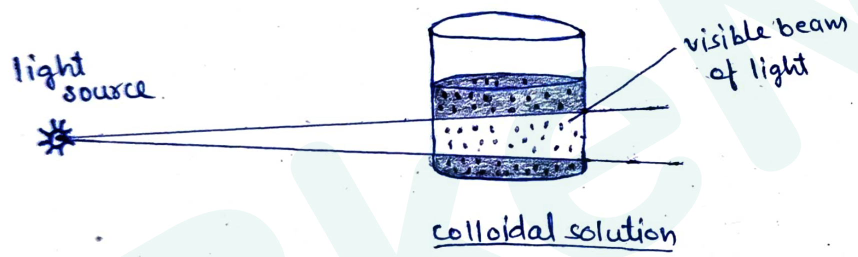
The optical properties are discussed below:

1. Tyndall Effect

A colloidal solution looks similar as a true solution but can be differentiated on the basis that a colloid scatters the light while true solution does not.

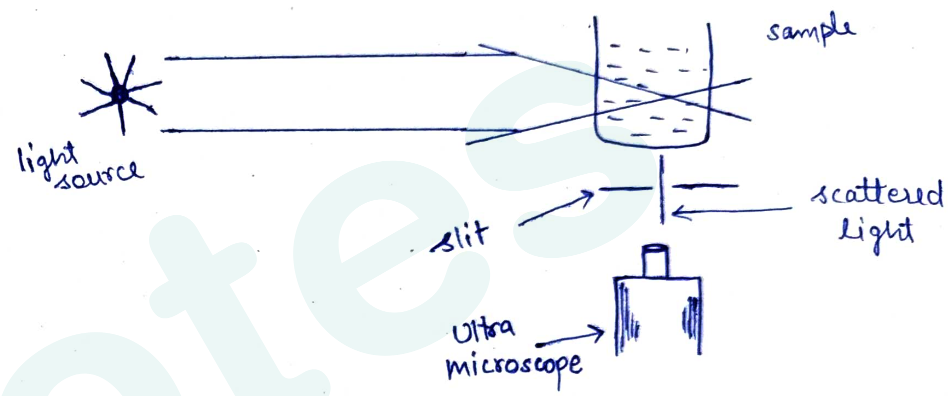
This scattering of light by colloidal particles is known as <u>Tyndall effect</u>, which was first observed by John Tyndall.

When a strong beam of light is allowed to pass through a colloidal solution in a dark surrounding, the path of beam gets illuminated and this illuminated path is called Tyndall cone.



2. Ultra-Microscopy

When a colloidal dispersion is observed under an ultra-microscope against a dark background at right angles to an intense beam of incident light, the particles appear against the dark background.



3. Electron Microscopy

When even ultramicroscope fails, to resolve some lyophilic colloids, electron microscope help in the study of size, shape and structures of colloidal particles.
Electron microscope shows the actual pictures of the particles.

4. Turbidity

The molecular weight and concentration of the dispersed particles can be determined by this method. Concentration can be determined by following two instruments.

(I) Spectrophotometer
(II) Nephelometer.

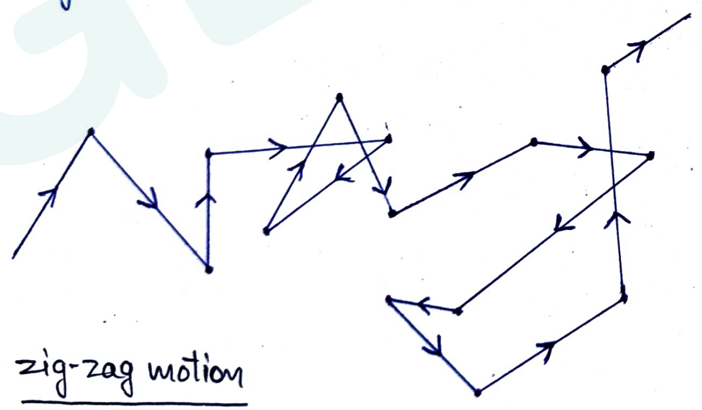
Kinetic Properties

Kinetic properties are the study of movement of colloidal particles in dispersion medium.

(I) Brownian Motion
(II) Diffusion
(III) Sedimentation
(iv) Viscosity

Brownian Motion

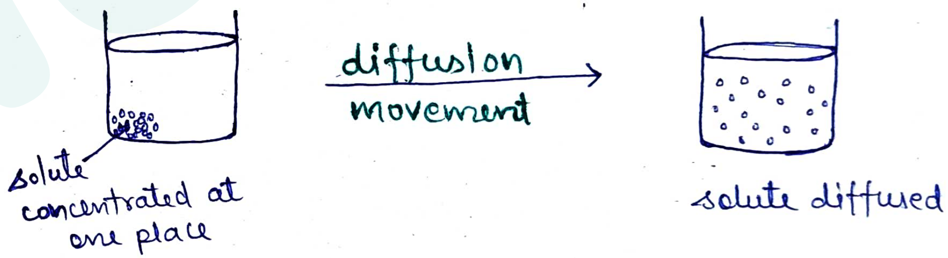
Robert Brown discovered the Brownian Motion.
The random zig-zag movement of the colloidal particles is called Brownian motion.
Smaller the particles size, greater the movement of colloidal particles and hence greater is the stability of colloid.



zig-zag motion

Diffusion

It is natural and spontaneous process of transport of ionic, atomic or molecular species, across the concentration gradient.
Rate of diffusion becomes slower when colloidal particles are bigger because of their slow movement.



Sedimentation

It is the process of settling down of particles suspended in the colloidal solution due to gravity.
Higher the molecular weight, greater sedimentation, and hence the less stability.

Viscosity

Numerous factors affect viscosity (resistance to flow of fluid):

Factors → shape & size, molecular weight of particles and affinity of particles to the medium.

- Linear shape of particles provide more viscosity to the system than spherical shaped particles.
- More the molecular weight, more will be the viscosity.

Electrical Properties

The particles of colloidal solution carry same type of charge, either positive or negative. The dispersion medium carries equal and opposite charge to that of particles so that the system can remain neutral. The colloidal particles do not combine together to form large aggregates because they repel each other due to presence of same charge.

There are various reasons due to which colloidal particles become charged:

(1) due to friction between the particles of dispersed phase and dispersion medium.
(2) The ions from the solution get adsorbed on the colloids, thereby, making them charged.
(3) Dissociation of surface molecules can cause the colloids to acquire a charge.
(4) The molecular electrolytes adsorbed on the colloidal particles dissociate to make the colloids charged.

Electrical Double Layer

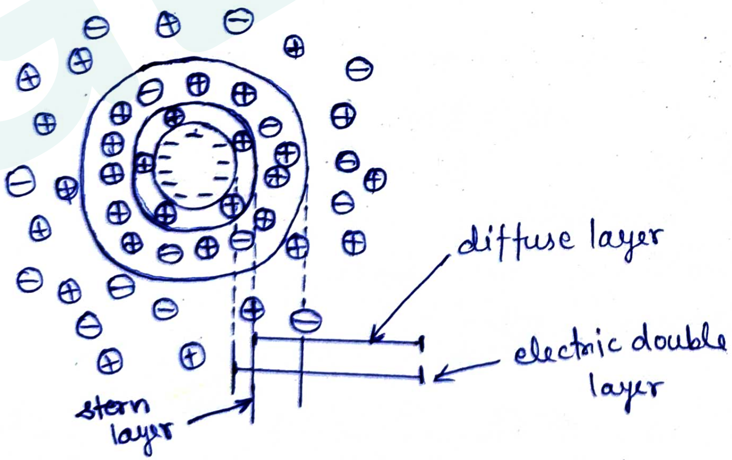
Electric Double Layer plays a fundamental role in electrostatic stabilization of colloids.
Electric Double Layer is a layer surrounding the particle of dispersed phase and including the ions adsorbed on the particle surface and a film of the oppositely charged ions of dispersion medium.
Electric Double Layer is electrically neutral.

An electric double layer consists of 3 parts:

(1) <u>surface charge</u> → charged ions (commonly negative) adsorbed on the particle surface.

(2) <u>Stern layer</u> → charge opposite to the surface charge attracted to the particle surface and closely attached to it by the electrostatic force. This is the first layer in electric bilayer.

3) <u>Diffuse layer</u> → It is a film of the dispersion medium (solvent) adjacent to the particle. The diffuse layer contains free ions with a higher concentration of ions having opposite charge as that on surface of particle.
This is the second layer on electric bilayer.



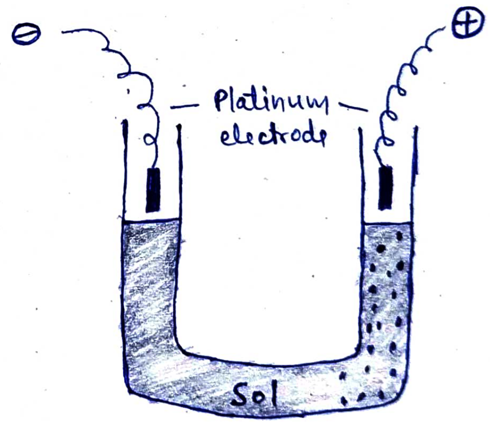
Even if there is uneven distribution of charge throughout the colloidal dispersion, the colloid as a whole remains neutral.

Electrophoresis

When a potential difference is applied between between the two electrodes in a colloidal solution, Particles move to either positive or negative electrode, depending upon their own charge.

⊕ particles ⟶ cathode(-)

⊖ particles ⟶ anode(+)

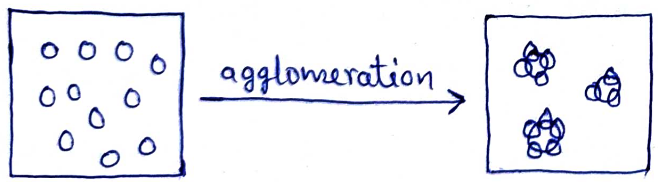


Sample of sol contain a particles of negative charge. They accumulate at the ⊕-electrode.

Stability of colloidal Dispersions

- → stabilisation serves to prevent colloids from aggregation.
- → The presence, absence or magnitude of charge on a colloidal particle is an important factor in the stability of colloids.
- → Two main mechanisms for colloid stabilization:
  - (i) Steric stabilization, i.e., surrounding each particle with a protective solvent sheath which prevent adherence due to Brownian Movement.
  - (ii) Electrostatic stabilization, i.e., providing the particles with electric charge

Colloidal stability relates to particle size change (e.g. aggregation or agglomeration). If the particles size does not show variation, the dispersion is considered colloidally stable.



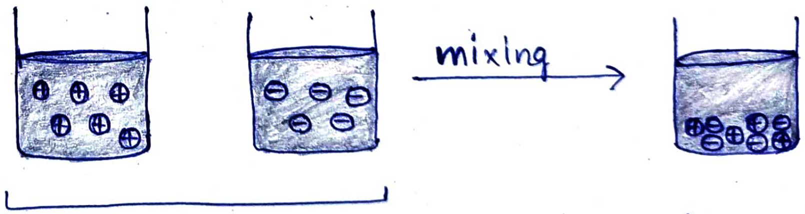
stable — unstable

Effects of Electrolytes

Addition of electrolytes beyond necessary for maximum stability results in accumulation of oppositely charged ions which results in coagulation and finally precipitation of colloids. This results in complete unstability of colloids. Colloidal stability requires a repulsion force. Like charges produce repulsion which prevents coagulation of particles and remain stable.

Coacervation

It is a process of mixing negatively and positively charged hydrophilic colloids and the particles separate from the dispersion to form a colloid rich layer (coacervate).



⊕ and ⊖ hydrophilic colloids — coacervate

Peptization

The process of converting a freshly prepared precipitate into a colloidal solution is known as peptization.

Peptization causes in the formation of stable colloids.

This is done by adding a small amount of electrolytes which act as peptizing agent.

Particles of the precipitate adsorb the ions of electrolyte and repel each other. Repelling each other causes movement of particles and formation of stable colloid.

Peptizing agents may be sugar, gelatin, etc.

Protective Action of Colloids

The addition of large amount of hydrophilic colloid (protective colloid) to a hydrophobic colloid tend to stabilize the system.

The hydrophile is adsorbed as a monomolecular layer on hydrophobic particles.

Gold number in colloidal system

Gold number is the minimum weight of a protective colloid required to prevent coagulation of 10ml of a standard hydro gold sol when 1ml of a 10% sodium chloride is added to it.