Colloidal Dispersion

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Colloidal Dispersion

- **Definition** – Colloidal dispersions are defined as those polyphasic system where at least one dimension of the dispersed phase measures between one nm and one micrometer.

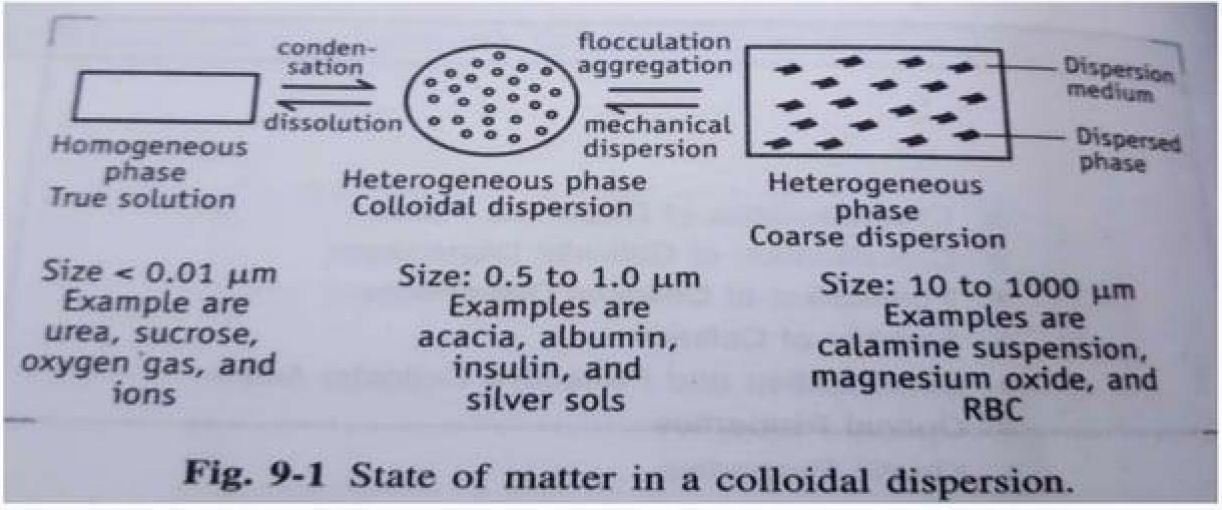


Fig. 9-1 State of matter in a colloidal dispersion.

Cont..

- Also , **Colloids is** heterogeneous dispersed system in which one substance is divided into minute particles (colloidal particle) and dispersed throughout a second substance(usually liquid).

- This mixture is also called a **colloidal system.**

- When the dispersion medium is gas, the solution is called Aerosol and when the dispersion medium is liquid, the colloidal dispersion is known as Sol. Sols can further be classified into different types depending upon the liquid used.
- If the liquid used is water, the solution is Hydrosol or Aquasol.
- If liquid used is Benzene, the solution is Benzosol
- If liquid used is Alcohol, the solution is Alcosol

Applications

- Therapy
- Absorption & toxicity
- Solubility
- Stability
- Targeting of drug to specific organs

Classification of Colloidal Dispersions

- Colloidal systems are classified into two types- **Positive and Negative colloids,** depending on the charge that the dispersed particles possess.

- **I) Based on Dispersion medium**
- **II) On the basis of interaction Between colloidal phases.**
- a) Lyophilic Colloids
- b) Lyophobic colloids
- c) Association colloids

Dispersed Phase	Dispersion Medium	Type of Colloidal Dispersions
Gas	Liquid	Foam
Gas	Solid	Solid foam
Gas	Gas	Does not exist
Liquid	Gas	Liquid Aerosol
Liquid	Liquid	Emulsions
Liquid	Solid	Gel
Solid	Gas	Solid Aerosol
Solid	Liquid	Sol or Colloidal Suspension
Solid	Solid	Solid sol(solid suspension)

It is important to note that when one gas is mixed with another gas, a homogeneous mixture is formed i.e. gases are completely miscible into each other.

Colloidal dispersions are heterogeneous in nature and gas dispersed in another gaseous medium does not form colloidal system.

A) Lyophilic Colloids

- Lyophilic means **solvent loving.**
- The term indicate that dispersed particle have a greater affinity to the dispersion medium(solvent).
- The dispersion medium forms a sheath around the colloidal particles and solvates.
- This makes the dispersion thermodynamically stable, for this reason preparation of lyophilic colloids is relatively easy.
- **Example**-Acacia, gelatin, protein, starch etc. In water. Rubber in on-aqueous solvent like benzene forms lyophilic colloids.

b) Lyophobic Colloids:

- These are dispersion in which very little attraction is possible between the dispersed particles and dispersion medium.
- When dispersion medium is water they are called hydrophobic colloids.
- These are stable because of the presence of charge on particle. The like charges on particles keep them away from each other.
- However, solvent sheath around particle is absent, therefore these dispersion are thermodynamically unstable.
- **Example**- Gold sol, silver, colloidal sulphur in suitable solvent.

- **C) Association colloids:**
- These colloids are formed when molecule of soap or other surface active agent substances are associated together to form small aggregates**(micelles)** in water.
- Colloidal aggregates are formed spontaneously when concentration of surface active agent exceeds critical micelles concentration.
- Above CMC, viscosity of system increases.
- **Examples**- Sodium lauryl sulphate, sodium stearate , cetyl trimethyl ammonium bromide etc.

Characteristics of dispersed phase

- Particle size
- Particle shape
- Surface area
- Surface charge

- **Particle size:**
- Particle size influence **the colour of a dispersion**.
- The wavelength of light absorbed by particle is approximately related to its radius.
- The larger the particle ,the shorter the wavelenghth of light transmitted. i.e violet end of spectrum.
- E.g Colloidal gold has a red colour (**650 to 750 nm**),while intermediate size is in violet colour.

Particle shape:

- The shape of particles in dispersion depend on methods of preparation and affinity of the particles to dispersion medium.
- Shape also influence the **colour of the dispersion**.
- Spherical particles of gold is indicated by **red colour**, while disc like particles of gold gives **blue colour.**
- Spherical particle produce dispersion of low viscosity, while linear particles generally produce more viscous dispersion.

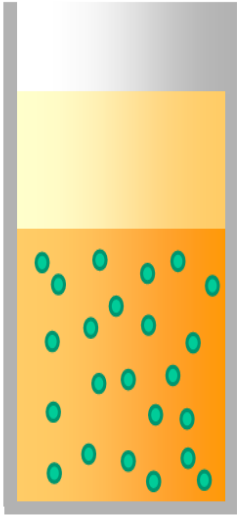
- **Surface area:**
- Size of colloidal particles is of order of few micrometers, these particle possess enormous surface area, when compared to coarser particle.
- The larger surface area enhances the solubility of drug particle.

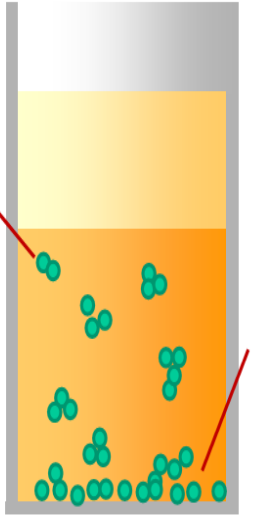
Surface charge

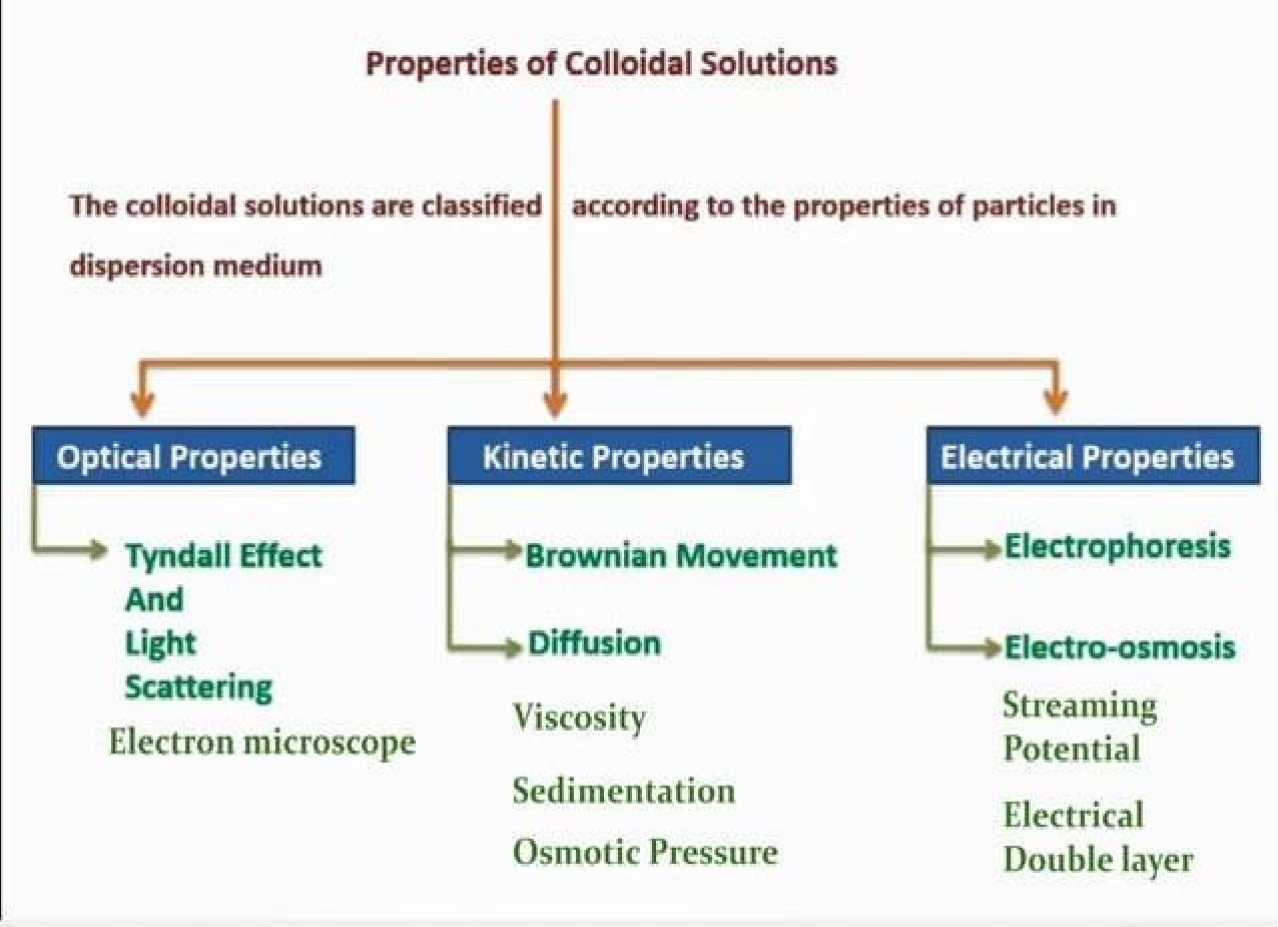
- Depending on nature of dispersion medium and ions present in colloidal solutions ,colloidal particles acquire a charge on their surfaces.
- Colloidal particles possess charge on their surfaces.
- Surface charge provides valuable information regarding the **stability of colloids.**
- Particle move continuously in random manner with collisions with each other.
- The like charges on the particles create repulsion forces.

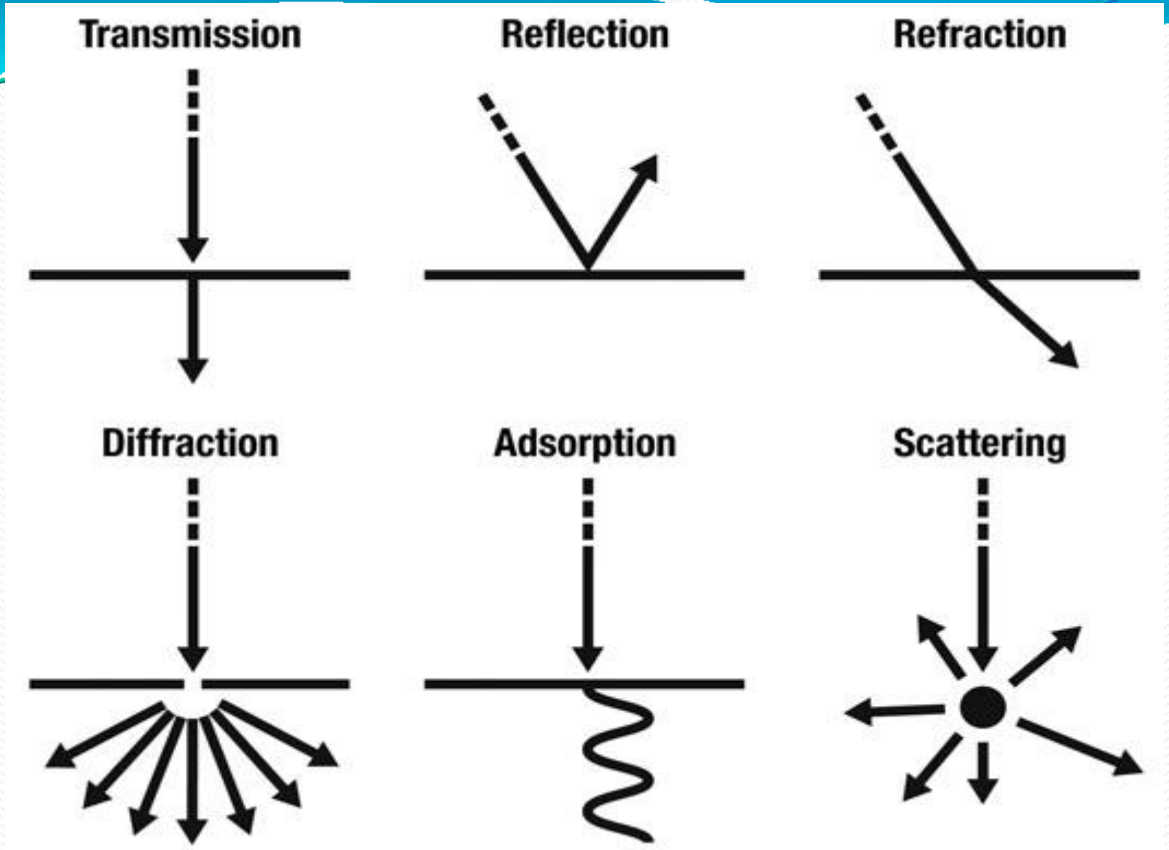
Example of a stable colloid

Example of an unstable colloid






Properties of Colloidal Solutions
The colloidal solutions are classified according to the properties of particles in dispersion medium
Optical Properties
Tyndall Effect
And
Light
Scattering
Electron microscope
Kinetic Properties
Brownian Movement
Diffusion
Viscosity
Sedimentation
Osmotic Pressure
Electrical Properties
Electrophoresis
Electro-osmosis
Streaming Potential
Electrical Double layer


Transmission
Reflection
Refraction
Diffraction
Adsorption
Scattering

Optical properties

- This study helps in obtaining information regarding the shape , size, structure and molecular weight of colloids.
- The source of light and the resolving power of the optical system mainly determine the precision and usefulness of such information.
- When beam of light strikes a particle, it polarizes the atoms and molecules in it and induce dipoles in the particle.
- The dipole emit weaker light at the same wavelength as that of the incident light. The emitted light propagates in all direction. This phenomenon is called ***light scattering.***
- **1. Tyndall Effect**- It is observed due to interaction of particles with light.
- When an intense, narrow beam of light is passed through the dispersion of colloids, its path is visible ,due to scattered light.

Cont...

- This scattered beam is known as ***Tyndall beam.***
- The same effect is noticed when a beam of sunlight enters a dark room through a slit when the beam of light become visible through the room.
- This happens due to the scattering of light by particle of dust in the air.

TYNDALL EFFECT

Ultra microscope

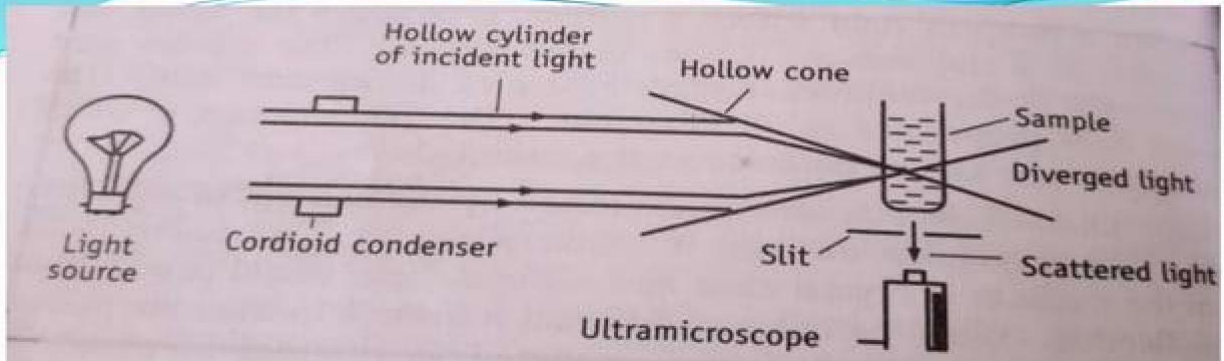


Fig. 9-24 Working principle of ultramicroscope.

- Sample is placed at the apex of cone ,where light intensity is high .after passing through the sample ,the cone of light diverges and passes outside incident light.

Some scattered light enters the objective of the microscope.

Ultra microscope is used to study the electrophoresis of charged particle, which helps in determining.

2.Elcteron microscope

- Particle size,shape and structure can be determined using an electron microscope.
- The radiation source is beam of high energy electrons having wavelength in the region of 0.1 A^0.
- Electron microscope has high resolution power.
- ***Turbidity method*** is used to estimate the concentration of dispersed particles and molecular weight of the solute.
- ***Spectrophotometer-***
- It measures the intensity of the transmitted light in the direction of the incident light.
- The relationship between turbidity & relative intensity of the transmitted light can be expressed as:
- $I/I_o = e^{-tl}$ where, I_o Intensity of incidence light, l-length of sample (ıcm)
- I-intensity of transmitted light, t- turbidity

3. Light Scattering

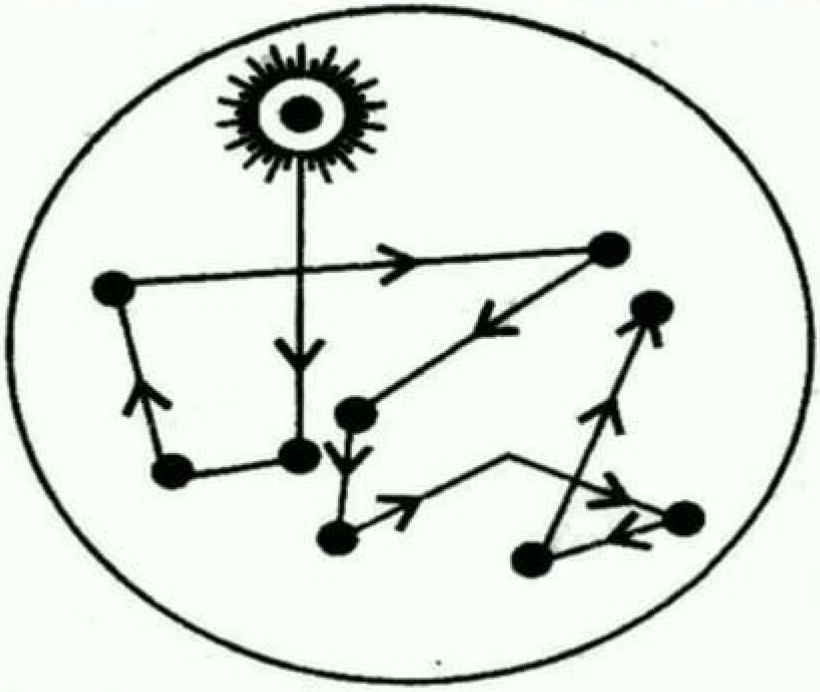
- It is used to study proteins, polymers, association colloids and lyophobic sols.
- Molecular weight of polymers and micelles can be measured.
- If the particles are spherical ,the scattering of light will be same in all directions.

3.Kinetic properties

- The study of kinetic properties of colloidal dispersion is useful in:
- a) Predicting the stability of the system.
- b) Determing the molecular weight of the particles.
- c) Studying the transport kinetics of colloidal particles.

Following are various kinetic properties in colloids ;

- **1. Brownian motion-**
- The scientist **Robert Brown** Who proposed this theory.
- Brownian motion may exhibited by particles as large as about **5 µm.**
- Thermal energy keeps particles in motion. They collide with each other and with the walls of the container.
- These collision change the direction and velocity of particles.



Brownian movement

Cont..

- These molecular collision keep particles under continuous motion. Brownian movement can be viewed by a light microscope and works against gravitational force.
- Brownian movement can be decreased or stopped by increasing viscosity of the medium. i.e. by adding glycerin.
- **2) Diffusion** - Particle diffuses spontaneously from region of higher conc to lower conc until conc of the system is uniform throughout.
- Diffusion is a direct result of Brownian motion. Diffusion can be expressed by **Fick's first law.**
- As per Ficks first law the amount of substance (**dq**) diffuses in time **dt** across the plane area of **A** is directly proportional to the change of concentration **dc** with distance traveled, **dx**

Cont..

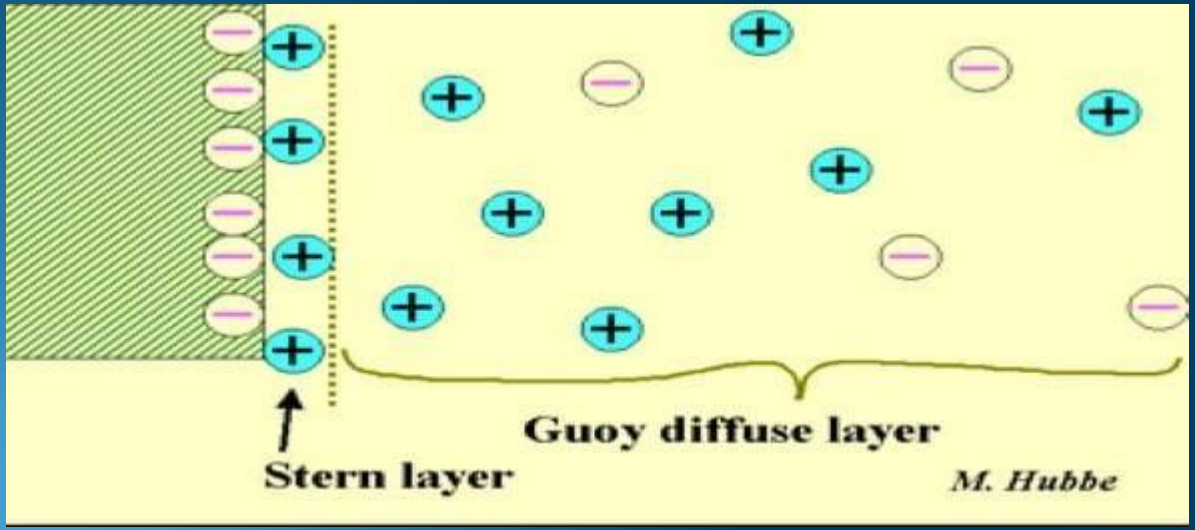
- $dq = -DA \frac{dc}{dx} dt$
- D is diffusion coefficient
- The measured diffusion coefficient can be used to determine the radius of particle or molecular weight.
- **3.Viscosity -**
- The viscosity of colloidal dispersion is affected by a variety of factors.
- **Shape of the dispersed particle**- spherical particle impart relatively low viscosity to dispersion, while particles of linear shape yield more viscous systems.

Cont..

- **Affinity of particle to the medium :**
- If linear particles are placed in a medium having low affinity for particles, these tends to assume spherical shape and the viscosity falls.
- **Type of colloids : I**n general ,lyophilic colloids have viscosities manyfold greater than that of the dispersion medium.
- Lyophobic colloids have viscosities almost equal to the dispersion medium.

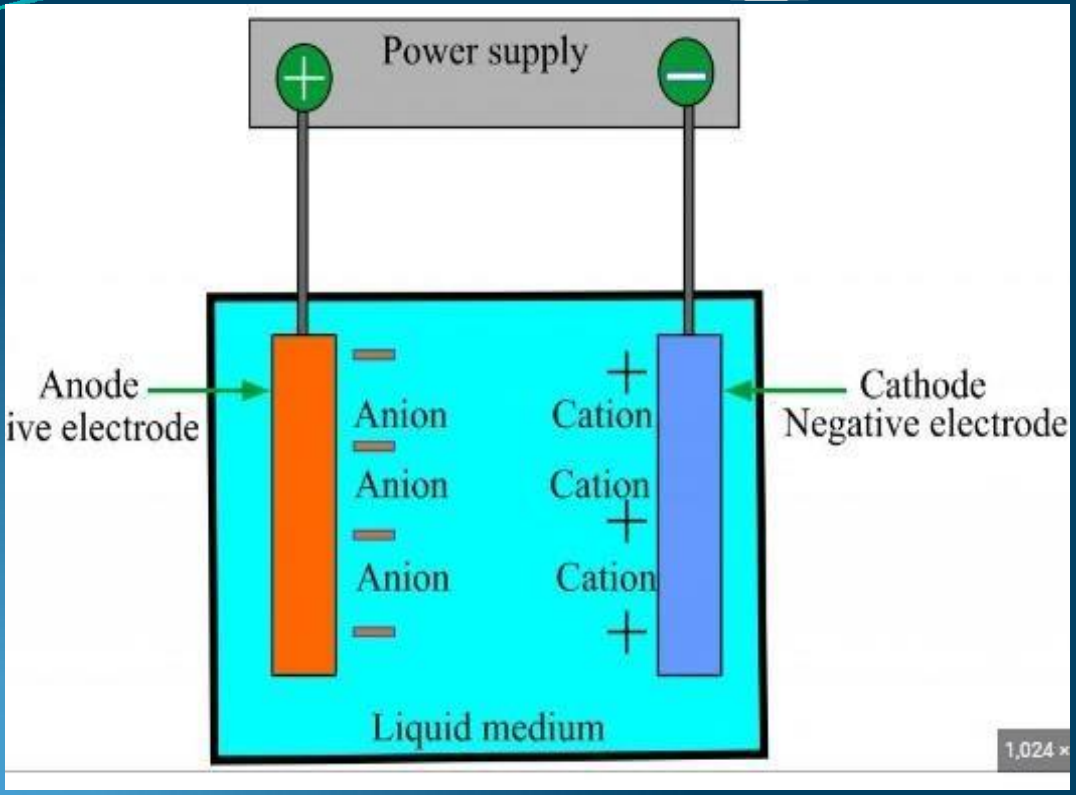
Electrical Properties:

- 1. Electrical double layer :/Surface charge :



2. Electrophoresis:

- The movement of a charged particle which is relative to liquid it is suspended under influence of an applied electric field is called as **Electrophoresis**.
- Used to measurement of **zeta potential.**
- It is electrokinetic phenomenon.
- If an electric potential is applied to a colloid, the charged colloidal particles move towards the oppositely charged electrode.
- The charge on the particle determined and gives **sign of zeta potential and rate of migration** of function of charge on particles.
- Velocity or rate of migration increases with increasing potential gradients.
- $$V = \xi \times E$$
- where, ξ = **zeta potential,**


Power supply
Anode
ive electrode
Anion
Anion
Anion
Cation
Cation
Cation
Cathode
Negative electrode
Liquid medium
1,024 ×

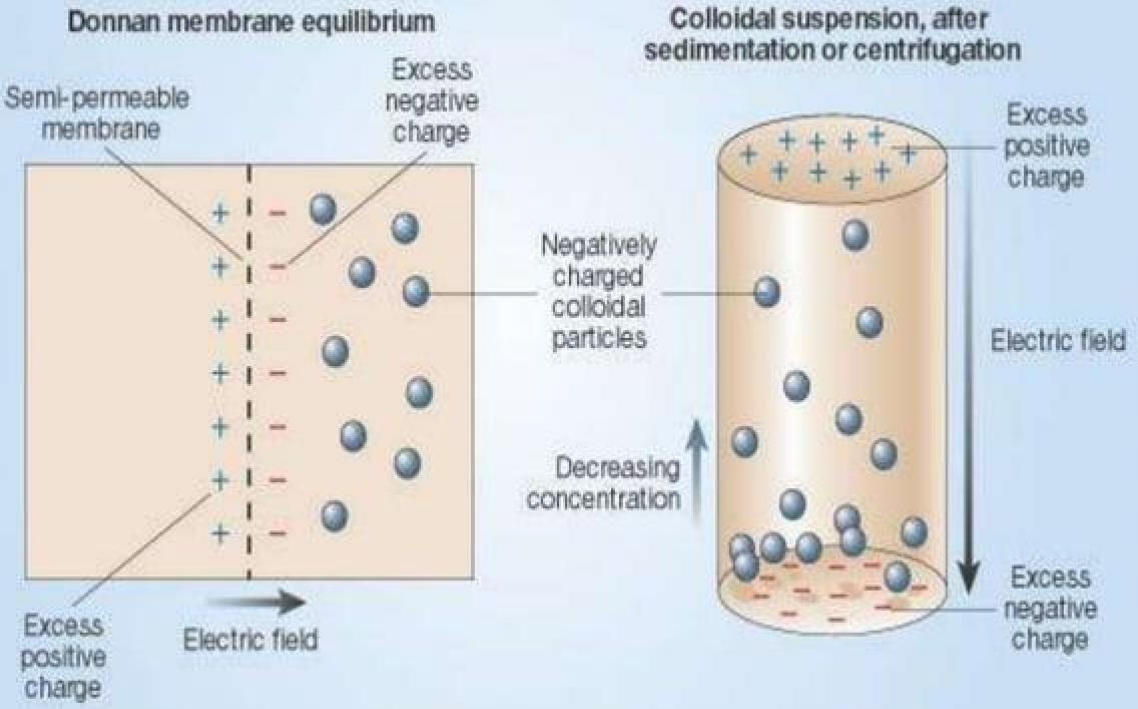
5. Sedimentation potential/Donnan Membrane Equilibrium:

- This is the potential difference set up between top and bottom of a suspension of solid particles in a liquid when the particles settle under the influence of gravity.
- **Principle :**
- A solution of **NaCl** is placed on one side of the semipermeable membrane. On the other side a solution of negatively charged colloids together with its counterion is placed.
- The volume of solution on the two side of membrane are considered to be equal.
- Na+ and Cl- ion move freely across the semipermeable membrane, but colloidal particles, colloidal particles (R-) are not diffusible soon equilibrium is attained.

Cont..

- Apply the condition of electroneutrality.
- i.e. The +ve and – ve charge on either side of the membrane must be balanced.

- At equilibrium, the osmotic pressure of two solutions will be different and if two reference electrodes such as calomel electrodes are put into the two solutions then a difference of potential will be set up.
- • **This type of equilibrium is known as DONNAN.**


Donnan membrane equilibrium
Semi-permeable membrane
Excess negative charge
Excess positive charge
Electric field
Colloidal suspension, after sedimentation or centrifugation
Excess positive charge
Negatively charged colloidal particles
Electric field
Decreasing concentration
Excess negative charge

Effect of electrolytes

- The instability in colloidal solution is characterised either by coagulation or precipitation.
- The reasons for instability of colloids are addition and removal of electrolytes, coacervation and sensitization.
- **Addition of electrolytes :**
- **In lyophobic colloids** trace amount of electrolyte addition is required for providing charge to colloidal particle which overcome the attraction forces between particles.
- Addition of excess amount of electrolyte leads to coagulation because it provides both the charges.
- Under this condition, repulsive forces are diminished with dominance of attractive forces and colloids gets coagulated.

Cont...

- In lyophobic colloids accumulation of opposite charge particle changes the zeta potential which leads to coagulation.
- **Removal of electrolytes:**
- Coagulation of colloid is observed when electrolyte is completely removed from the sol.
- This happen due to repulsive forces.
- **Addition of non-solvent :**
- Addition of less polar solvent like alcohol or acetone causes the dehydration of colloidal particles of lyophilic sols.
- If electrolyte is added in such situation it leads to precipitation of colloids.

Coacervation :

- When oppositely charged hydrophilic colloids are mixed, a colloidal rich layer separates which is called as **Coacervate.**
- This phenomenon in which separation take place on mixing two dispersions on mixing is called **Coacervation.**

- E.g Gelatin is positively charged and acacia having negatively charged particle.
- When two are mixed together ,two layers are formed ,the upper layer of low viscosity having a poor concentration of colloidal material and a lower layer of higher viscosity containing high concentration of colloidal material.

Sensitisation :

- In the presence of very small amount of hydrophilic colloids ,the hydrophobic colloids may become even more susceptible to precitation from electrolyte.

- i.e Precipitation of hydrophobic colloids by the addition very small amount of electrolyte.

Stability studies include chemical and physical stability.

- 1) Reasons for the instability of dispersion.
- 2)Suitable measures to stabilise the dispersion.

❑ **The physical stability can be achieved by maintaining the particles in Brownian motion**

The way to achieve this property are.

❑ **1) Provide electric charge on the surface of the dispersed particles.**

➔The like charges on the particles will prevent these coming closer together and thus maintaining a Brownian movement . This factors plays a significant role in case of lyophobic colloids.

2) Maintain a solvent sheath around the particle.

➔ This solvent layer prevents the particle coming closer and also maintain Brownian movement.

This factors plays an imp role in case of lyophilic colloids.

Stability of colloids :

- 1) Protection /protective colloids
- 2) Schulze –hardy rule
- 3) Gold Number
- 4) DLVO Theory.
- **1) Protection /protective colloids:**
- Larger concentration of hydrophilic colloids increase the stability of hydrophobic colloids towards precipitation of electrolytes.

- The hydrophilic colloids adsorbs on the surface of hydrophobic colloids particles and form a protective layer, Thus preventing them from precipitation on addition of an electrolyte, this phenomenon is called protection.

Cont...

- The hydrophilic solution used for the purpose of protecting the hydrophobic colloid is known as **protective colloids.**

- Larger conc. of hydrophilic colloids on hydrophobic colloids

- Protective layer on surface.

- Avoid precipitation & this hydrophilic colloids form ...

- Protective colloid, increase stability of lyophobic colloids.

3) Gold Number :

- It is a measure of the protective ability of hydrophilic colloids.

- **Def :** The number of mg of hydrophilic colloids which when added to **10** ml to red gold solution prevents the change in colour from red to violet on the addition of **1** ml of **10 %** solution of NaCl.
- **Or**
- The minimum weight in mg of protective colloids which is required to prevent a colour change from **red to violet** in 10 ml of gold sol on addition of **1** ml of **10** % solution of NaCl.

- Change in colour ⟶ Change in particle size
- Lower the gold number ⟶ Higher protective ability of colloids.

Procedure :

- Test tube containing **10** ml of gold solution are taken
- To each test tube protective colloid is added in increasing concentration.
- Then added **1** ml of **10** % sodium chloride solution.
- At higher conc. of the protective colloid the gold solution does **not change its colour** ,while at lower conc. ,the gold solution changes colour from **red to violet.**

4) DLVO Theory

- This theory developed to describe stability of lyophobic colloids.

- DLVO theory is discovered by Derjaguin and Landau Verwey Overbeek describes the stability of lyophobic colloids.
- Based on two principles:
- **1) Electrostatic repulsive force.**
- **2) Van der waal force of attraction.**
- According to this theory, the distance between two dispersed particle influences particle- particle interaction.
- In a colloidal dispersion ,the Brownian motion result in frequent collision between particle.
- Interactions like attraction and repulsion are responsible for stability of colloids.

- When attractive force are dominant, particle adhere after collision and aggregate..
- When repulsive force are dominant ,particle rebound and remain dispersed.
- It is used to determine the amount of electrolyte required to precipitate or stabilise a colloid.
- **A) Van der waal attraction forces:**
- Depend on chemical nature and size of the particle. These are London type forces (temporary attractive force)and potential energy of attraction is represented by V_A.
- **B) Electrostatic Repulsive Force:**
- Depend on density ,surface charge and thickness of double layer . Indicate magnitude of zeta potential ,represented by V_R.

Cont...

- Net energy of interaction (VT)
- $V_T = V_A + V_R$

- **Peptization :**
- For development of stable dispersion of colloids particle in dispersion medium,
- Generally it is the method of changing a precipitate in to colloidal solution via shaking with dispersion medium in presence of slight qty of electrolyte
- The electrolytes utilised in this method are known peptizing agent.

Cont...

- The precipitate adsorbs the common ion and electrically charged particles then split from the precipitate as colloidal particle.
- Normally ,Peptization is the reverse of coagulation of solution.
- E.g ferric hydroxide Fe(OH),produced a solution through adding ferric chloride.


Thank
You