Colloidal Dispersions.

* Drug
↓
Api (Raw materia)
↓
Active Pharmaceutical Ingredient

* Medicine

Api + Additives / Excipients
↓
Flavouring agent,
Colouring agent,
Sweetening agent,
Lubricating agent,
Bulking agent
Diluent,
Binding agent.

☆ Lab Requirement :- Practical file,
Observation copy,
Synopsis copy,
Scissor,
Sachet,
Transparent tape.

☆ Theory → Theory copy.

Q. What is pharmaceutics?

⇒ Pharmaceutics is the science of pharmacy which deals with the process of turning a new chemical entity or old drug into medication to be used safely and effectively by patient.

Pharmaceutics are also known as the science of doses form design. Pharmaceutics deals with formulation of pure drug substance into dosage form.

There are different branches of pharmaceutics:-

① Pharmaceutical formulation
② Pharmaceutical manufacturing
③ Pharmaceutical technology.
④ Dispensing pharmacy.
⑤ Physical pharmacy.
⑥ Pharmaceutical jurisprudence.

☆ Physical Pharmacy

Physical pharmacy is the branch of pharmacy that concentrate on the application of physics and chemistry to the study of pharmacy.

In other words, it is the study of the effect dosage form have on their environment by addressing issue at ~~their~~ molecular level. It forms the basis for design, manufacture and distribution of drug product and serve as the foundation for the stable and proper use of medical drugs.

Colloidal Dispersion

A Dispersed systems is defined as a system in which one phase (known as the dispersed phase) is distributed throughout a continuous phase (known as dispersion medium).

Classification of Dispersed Systems:

On the basis of mean particle diameter of the dispersed material, three types of dispersed systems are generally considered:

(a) Molecular dispersions
(b) Colloidal dispersions, and
(c) Coarse dispersions.

(a) Molecular dispersions.

Molecular dispersions are the true solutions of a solute phase in a solvent. The solute is in the form of separate molecules homogeneously distributed throughout the solvent.

Example:- aqueous solution of salts, glucose.

(b) Colloidal dispersions :

Colloidal dispersions are micro-heterogeneous dispersed systems. The dispersed phases cannot be separated under gravity or centrifugal or other forces. The particles do not mix or settle down.

Example : aqueous dispersion of natural polymer, colloidal silver sols, jelly.

(c) Coarse dispersions

Coarse dispersions are heterogenous dispersed systems in which the dispersed phase particles are larger than 0.5 µm. The concentration of dispersed phase may exceed 20%.

Example :- Pharmaceutical emulsions and suspensions.

Comparison of Characteristics Three Dispersed Systems.

		Molecular dispersion	Colloidal dispersion	Coarse dispersion
1.	Particle size	$< 1\,nm$	$1\,nm$ to $0.5\,\mu m$	$> 0.5\,\mu m$
2.	Appearance	Clear, transparent	Opalescent	Frequently opaque
3.	Visibility	Invisible in electron microscope	Visible in electron microscope	Visible under optical microscope or naked eye.
4.	Separation	Pass through semipermeable membrane, filter paper	Pass through filter paper but do not pass through semipermeable membrane	Do not pass through normal filter paper and semipermeable membrane.
5.	Diffusion	Undergo rapid diffusion	Diffuse very slowly	Do not diffuse.
6.	Sedimentation	No question of settling	Do not settle down	Fast sedimentation of dispersed phase by gravity or other.

Types of Colloidal Systems.

Based on the interaction between dispersed phase and dispersion medium, colloidal systems are classified as.

(a) Lyophilic colloids (solvent-loving).

(When the dispersion medium is water, it is called hydrophilic colloids and if the dispersion medium is an organic solvent, it is called hydrophobic colloids).

(b) Lyophobic colloids (solvent-hating).

Difference between Lyophilic colloids and Lyophobic colloids.

Lyophilic colloids	Lyophobic colloids
• Colloidal particles have greater affinity for the dispersion medium.	• Colloidal particles have little affinity for the dispersion medium.
• Owing to their affinity for the dispersion medium, the molecules disperse spontaneously to form colloidal solution.	Material does not disperse spontaneously, and hence lyophobic sols are prepared by dispersion or condensation methods.

• These colloids form "reversible sols".	• These colloids form "irreversible sols".
• Viscosity of the dispersion medium is increased greatly by the presence of the lyophobic colloidal particles.	• Viscosity of the dispersion medium is not greatly increased by the presence of lyophilic colloidal particles.
• Dispersions are ~~greatly~~ stable generally in the presence of electrolytes; they may be salted out by high concentrations of very soluble electrolytes	• Lyophobic dispersions are unstable in the presence of even small concentrations of electrolytes.
• Dispersed phase consists generally of large organic molecules such as gelatin, acacia lying within colloidal size range.	• Dispersed phase ordinarily consists of inorganic particles, such as gold or silver.

Preparation of Lyophilic Colloids.

This simple dispersion of lyophilic material in a solvent leads to the formation of lyophilic colloids. Preparation of Lyophobic Colloids. The lyophobic colloids may prepared by

(a) Dispersion method.
(b) Condensation method.

(a) Dispersion methods :

This methods involves the breakdown of larger particles into particles of colloidat dimensions. The breakdown of coarse material may be effected by the use of the Colloid mills, Ultrasonic treatment in presence of stabilizing agent such as a surface active agent.

These methods may involve the use of such mechanical methods as :

(i) Mechanical dispersion
(ii) Electro-dispersion
(iii) Ultrasonic dispersion
(iv) Peptization.

(i) Mechanical dispersion:

The substance to be dispersed is ground as finely as possible by the usual methods. It is shaken with the dispersion medium and thus obtained in the form of a coarse suspension. This suspension is now passed through a colloid mill. The simplest type of colloid mill called disc mill, consists of two metal discs nearly touching each other and rotating in opposite directions at a very high speed. The suspension passing through these rotating discs is ~~expressed~~ exposed to a powerful shearing force and the suspended particles are apart to yield particles of colloidal size. Colloid mill are widely used in the industrial preparation of paints, cement, food products, pharmaceutical products etc.

(ii) Electro-dispersion:

These methods are employed for obtaining colloidal solutions of metals like gold, silver, platinum etc. An electric arc is struck between the two metallic electrodes placed in a container of water. The intense heat of the arc converts the metal into vapours, which are condensed immediately in the cold water bath. This results in the formation of particles of colloidal size. We call it as gold sol.

(iii) Ultrasonic dispersion:

Ultrasonic vibrations (having frequency more than the frequency of audible sound) could bring about the transformation of coarse suspension to colloidal dimensions. Claus obtained mercury sol by subjecting mercury to sufficiently high frequency ultrasonic vibration.

(iv) Peptization:

Peptisation is the process of converting a freshly prepared precipitate into colloidal form by the addition of a suitable electrolyte. The electrolyte is called peptising agent. For example when Ferric chloride is added to a precipitate of ferric hydroxide, ferric hydroxide gets converted into reddish brown coloured colloidal solution. This is due to preferential adsorption of cations of the electrolyte by the precipitate. When $FeCl_3$ is added to $Fe(OH)_3$, Fe_3^+ ions from $FeCl_3$ are adsorbed by $Fe(OH)_3$

particles. Thus the $Fe(OH)^3$ particles acquire +ve charge and they start repelling each other forming a colloidal solution.

(B) Condensation method :

In this method, smaller or sub colloidal size particle are condensed together to form a colloidal size range that is achieved through chemical reaction.

(C) Association colloids

Amphiphiles are molecules or ions showing affinity towards both polar and non polar solvent. In water, they exhibit action of surface active agent in form of monomer or colloidal size. As their concentration increases these monomers come together and get aggregated. in form of micelles. Each micelles contain approx. 50 monomer of 50 A°. size and make colloidal system.

Association colloids are also further classified as :

1. Anionic - Example - Sodium lauryl sulphate

2. Cationic - Example - Cetyl trimethylammonium bromide.

3. Non ionic - Example - Tween, span.

4. Ampholytic - Example - Sulphanillic acid.

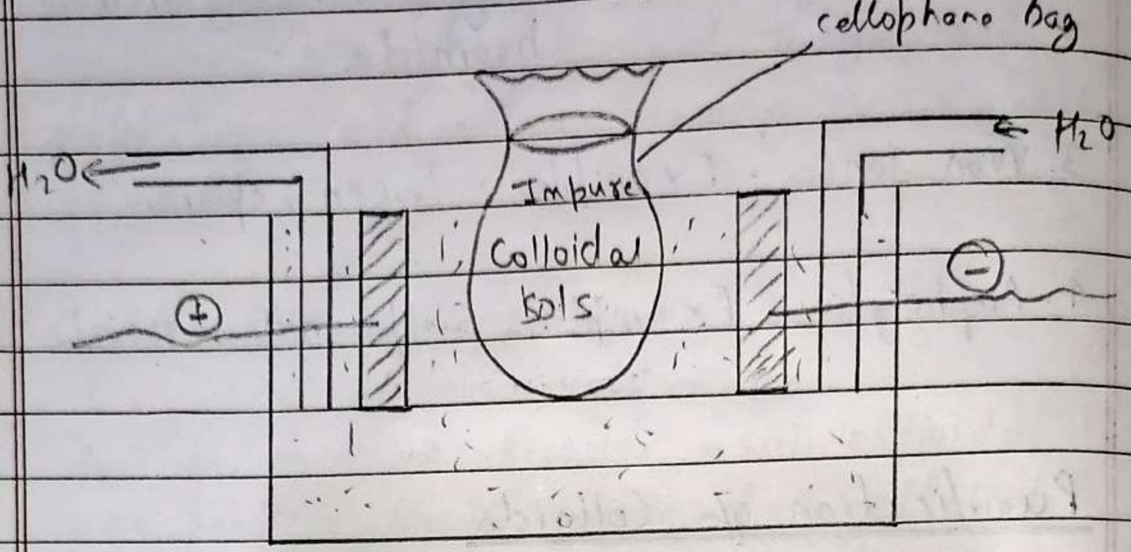
Purification of Colloids

When a colloidal solution is prepared, it often contains certain electrolytes which tend to destabilize it. The following methods are used for purification of colloids:

(a) Dialysis :

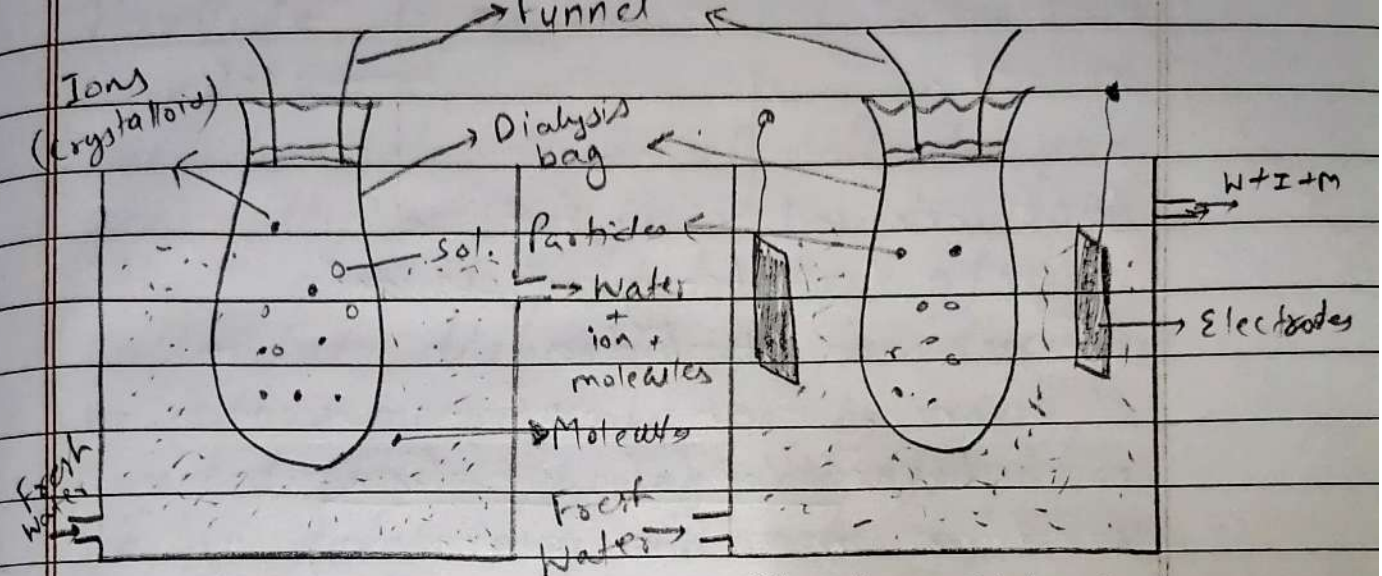
It is a process of removing a dissolved substance from a colloidal solution by diffusion through a suitable membrane in a apparatus called Dialyser.

A bag of suitable membrane like animal bladder or cellophane sheet containing the colloidal solution is suspended in vessels in which fresh water is flowing continuously. The molecule and ions diffuse through membrane into the outer water and pure colloidal solution is left behind.



(b) Electrodialysis

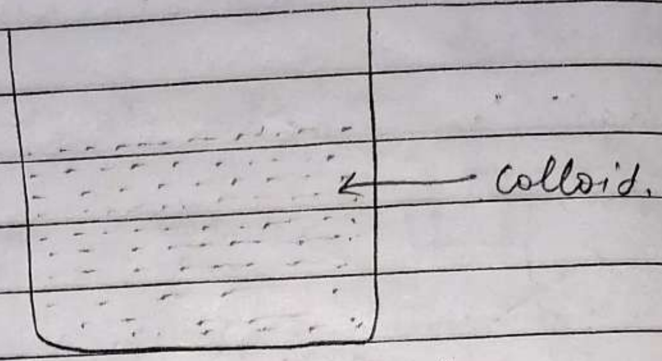
In the dialysis unit, the movement of ions across the membrane can be speeded up by applying an electric current through electrodes induced in solution. The electric potential increases the rate of movement of ionic impurities through a dialysing membrane and so provide a more rapid means of purification. The dialysis membrane allows small particles (ions) to pass through but the colloidal size particles (hemoglobin) do not pass through the membrane.



Dialysis   Electro-Dialysis

(c) Ultrafiltration

Colloidal dispersion can pass through an ordinary filter, because the pore size of the filter is large. If this filter paper is impregnated with collodion (syrupy solution of nitrocellulose), the pore size reduces. Such modified filter papers are called ultrafilters. By applying pressure (or suction) the solvent and small particles may be forced across a membrane but the larger colloidal particles are retained. This process is referred to as ultrafiltration.



Heterogenous and turbid.

Fig → Colloidal Solution

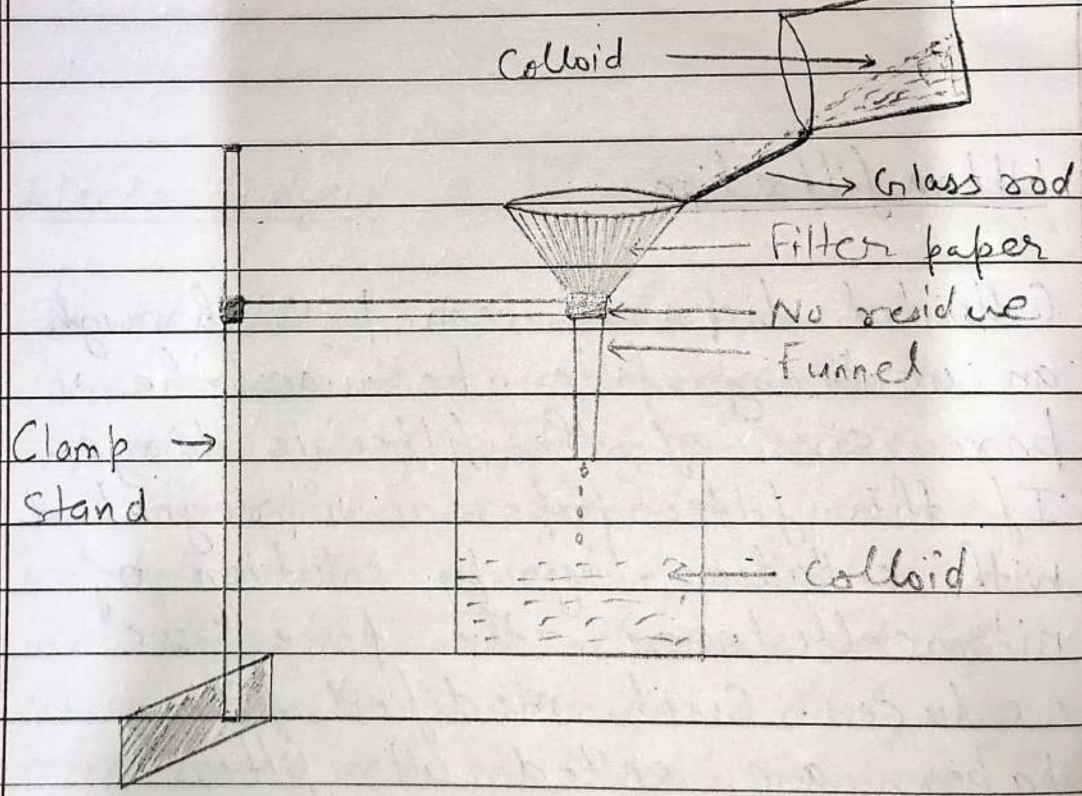


Fig → Filtration of colloidal solution

OPTICAL PROPERTIES OF COLLOIDS .

A. Particle Size :

The particle sizes of colloids are generally varies from 1nm to 100nm. The actual particle size of colloidal dispersion can be determined by ultra-microscope or by using graded filters during ultrafiltration or by determining the rate of sedimentation in a centrifuge.

B. OPTICAL PROPERTIES

1. Tyndall effect:

When a strong beam of light is passed perpendicularly through two solutions

(1) True solution
(2) Colloidal solution place against a dark background .

1.) The path of light beam is not visible in case of true solution.

2. The path of light beam is visible (scattered) in case of colloidal solution and further it is forming a shadow (beam or cone) at the

dark background. This phenomenon of scattering of light by the colloidal particles is called Tyndall effect.

Difference in refractive indices of dispersed phase and ~~dispersed~~ dispersion medium, larger the difference in the refractive indices of dispersed phase and dispersion medium, more is scattering of light. Therefore, lyophobic sols exhibit more scattering as compare to lyophilic sols.

The illuminated beam or cone formed by the ~~sols~~ sol particles is called Tyndall beam or Tyndall cone. The Tyndall effect is due to the fact that colloidal particles scatter light in all directions in space. The ~~sc~~ scattering of light illuminates the path of beam in the colloidal dispersion.

2. Ultramicroscopy.

The colloidal particles are too small to be seen with an optical microscope. However, when a cell containing a colloidal dispercion is viewed through an ultramicroscope against a dark background at right angle to an intense beam of incident light, the particles appear as bright spots against the dark background. The ultramicroscope is used in the technique of microelectrophoresis for measuring the particle size.

3. Electromicroscopy:

Ultramicroscope are sometimes not able to resolve some lyophilic colloids and hence electron microscope are employed for studying the colloidal dispersions. The electron microscope is useful in getting picture of actual particles and help in the study of the size, shape and structure of colloidal particles.

4. Light Scattering:

When beam of light is passed through a colloidal dispersion, some of its absorbed, some is scattered and the remainder is transmitted undisturbed through the sample. The absorbed light is responsible for the highly coloured nature of certain colloids.

C. KINETIC PROPERTIES

Kinetic properties of colloidal systems relate to the motion of particles with respect to the dispersion medium.

The kinetics properties are:

1. Brownian motion
2. Diffusion
3. Osmotic pressure
4. Sedimentation
5. Viscosity

The motion may be thermally induced (Brownian movement, diffusion, osmosis). Gravitational force induced (sedimentation), or applied externally (viscosity).

1. Brownian motion:

Colloidal particles undergo random collisions with the molecules of the dispersion medium and follow an irregular and complicated zigzag path. If the particles up to about 0.5 µm diameter are observed under a microscope or the light scattered by colloidal particles is viewed using an ultramicroscope, an erratic motion is seen. This movement is refferred to as Brownian motion.

2 Diffusion:

As a result of Brownian motion colloidal particles spontaneously diffuse from a region of higher concentration to one of lower concentration. The rate of diffusion is expressed by Fick's first law:

$$\frac{dq}{dt} = -DS\frac{dc}{dx}$$

According to the law, the amount, dq of substance diffusing in time, dt across a plane of area (S) is directly proportional to the change of concentration, dc, with distance travelled, dx. D is diffusion coefficient and has dimension of area per unit time, dc/dx is concentration gradient. The minus sign denotes that the diffusion takes place in the direction of decreasing concentration.

It is possible to determine the molecular weight of approximately spherical particles from the diffusion by substituting the data obtained from diffusion experiments in the following expression :

$$D = \frac{RT}{6\pi \eta r N} \cdot \frac{4\pi N}{3Mv}$$

Where,

M is the molecular weight

v is the partial specific volume

η is the viscosity of the solvent

R is the molar gas constant

T is the absolute temperature

r is the radius of spherical particle and

N is the Avagadro's number.

3. Osmotic Pressure :

Osmosis is the spontaneous net movement of solvent molecules through semipermeable into a region of higher solute concentration in the direction that tends to equalize the solute concentration on the two sides. The external pressure required to be applied so that there is no net movement of solvent across the membrane is called osmotic pressure.

The osmotic pressure can be used to calculate the molecular weight of colloidal material.

$$P = \frac{C}{M}$$

P is the osmotic pressure
C is the concentration in gram solute per liter solvent
M is the molecular weight
R is the gas constant
T is the temperature in kelvin.

4. Sedimentation

In normal dispersion, the dispersed particle tend to settle under the influence of gravity but in case of colloidal dispersion, the Brownian movement tends to offset this sedimentation but promotes mixing instead. Therefore, stronger force must be applied to bring about sedimentation of colloidal particles. Ultracentrifuge is generally used for bringing about and studying sedimentation in colloidal dispersions.

In an ultracentrifuge, the particles settle according to their ~~movement~~ molecular weight and hence this is also helpful in determing the molecular weight. The following expression is used for determining molecular weight:

$$M = \frac{RTS}{D(1 - VP_0)}$$

Where,
R is the gas constant
T is the absolute temperature
V is the partial specific volume of the polymer.
P_0 is the density of the solvent.
S is the Svedberg sedimentation coefficient determined at 20°
D is the diffusion coefficient obtained by calculation from diffusion data at 20°.

5. Viscosity:

The viscosity of colloids depends upon the shape of colloidal material. Spherical colloidal material yields dispersions of relatively low viscosity. Linear colloids are comparatively more viscous. Viscosity increase due to solvation effect. When the degree of solvation is more, the dispersion becomes more viscous. Viscosity studies provide a mean of detecting changes in the shape of flexible colloidal particles and macromolecules. Viscosity studies also provide a mean of determin, the molecular weight of colloidal particles.

Einstein equation of flow for the colloidal dispersions of spherical particles is given by:

$$\eta = \eta_0 (1 + 2.5 \phi)$$

η_0 is the viscosity of dispersion medium, η is the viscosity of dispersion when volume fraction of colloid particles is ϕ. The volume fraction is defined as the volume of the particles divided by the total volume of the dispersion.

D. ELECTRICAL PROPERTIES

The colloidal particles carry a electrical charge of either positive or negative type. Negatively charged colloidal particles include that of kaolin, sulpher and arsenious sulphide while positively charged ones include ferric oxide and other metal hydroxide colloidal dispersion. In certain colloidal dispersion such as that of protein, the charge on the particles may be positive, negative or neutral depending upon the pH of the medium.

1. Electrical double layer:

The theory of the electrical double layer deals with this distribution of ions and hence with the magnitude of the electric potentials that occur in the locality of the charged surface. Consider a solid charged surface in contact with an aqueous solution of electrolyte.

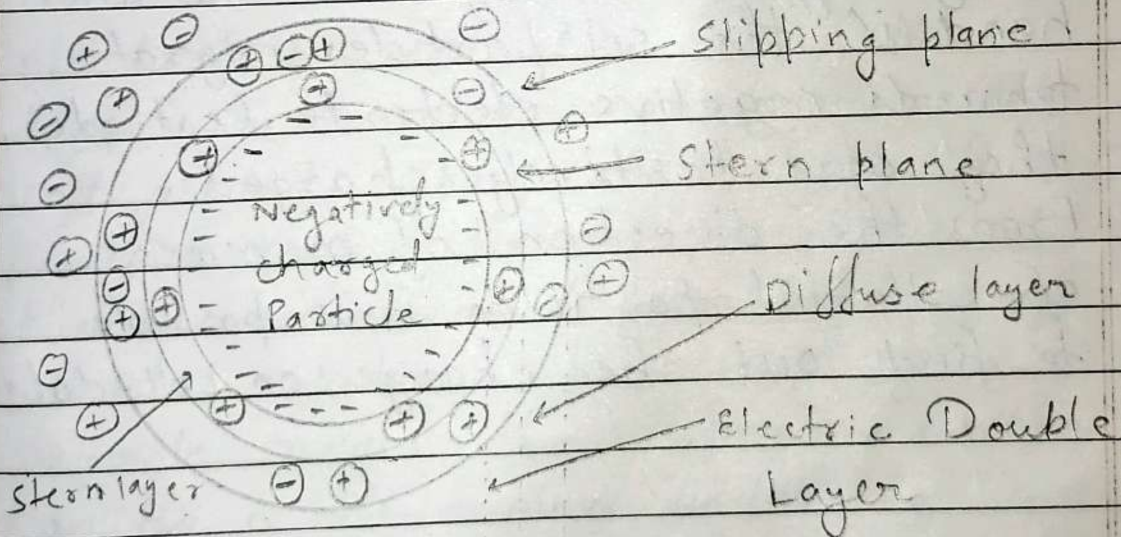
Development of a net charge at the particle surface affects the distribution of ions in the surrounding interfacial region,

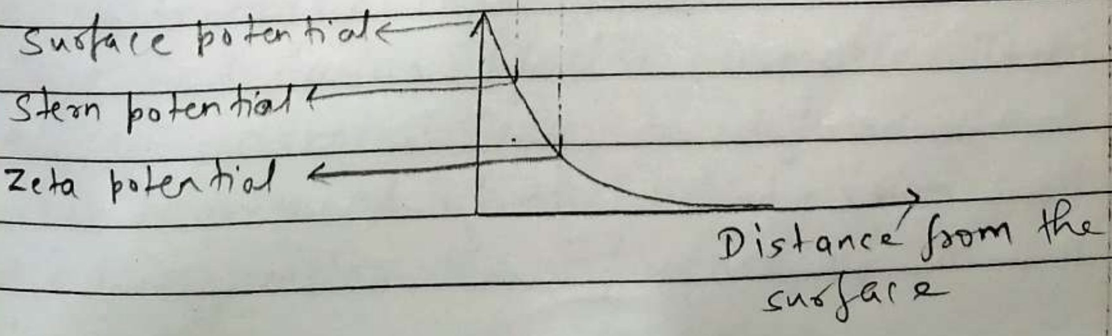
- As a result: concentration of counter ions increase at the surface,
- Thus, an electrical double layer exists around each particle.

Example - $AgNO_3 + NaI \rightarrow AgI + NaNO_3$

Silver iodide sols can be prepared by the reactions, n $AgNO_3 + NaI \rightarrow AgI + NaNO_3$.
In the bulk of AgI particles 1:1 ratio of Ag^+ and I^-.

If the reaction is carried out with an excess silver nitrate, there will be more Ag^+ than I^- ions in the surface of the particles. The particles will thus be positively charged and the counterions surrounding them will be NO_3. The combination of the positively charged surface and the atmosphere of counter ions surrounding it is called the electric double layer. If the reaction is carried out with an excess NaI, there will be more I^- than Ag^+ ions in the surface of the particles. The particles will thus be negatively charged and the counter ions surrounding them will be Na^+.





2. Electrophoresis :

When a potential difference (electric field) is applied across two platinum electrodes immersed in a colloidal solution, the particles of dispersed phase move towards either the positive or negative electrode. This observation was first discovered by Rauss in 1807 and was investigated later by Linder and Picton. The movement of colloidal particles under the action of electric field is known as Electrophoresis. If the colloidal particles move towards the positive electrode (Anode) they carry negative charge. On the other hand if the sol particles migrate towards negative electrode (cathode), they are positively charged. From the direction of movement of colloidal particles it is possible to find out the charge on colloidals.

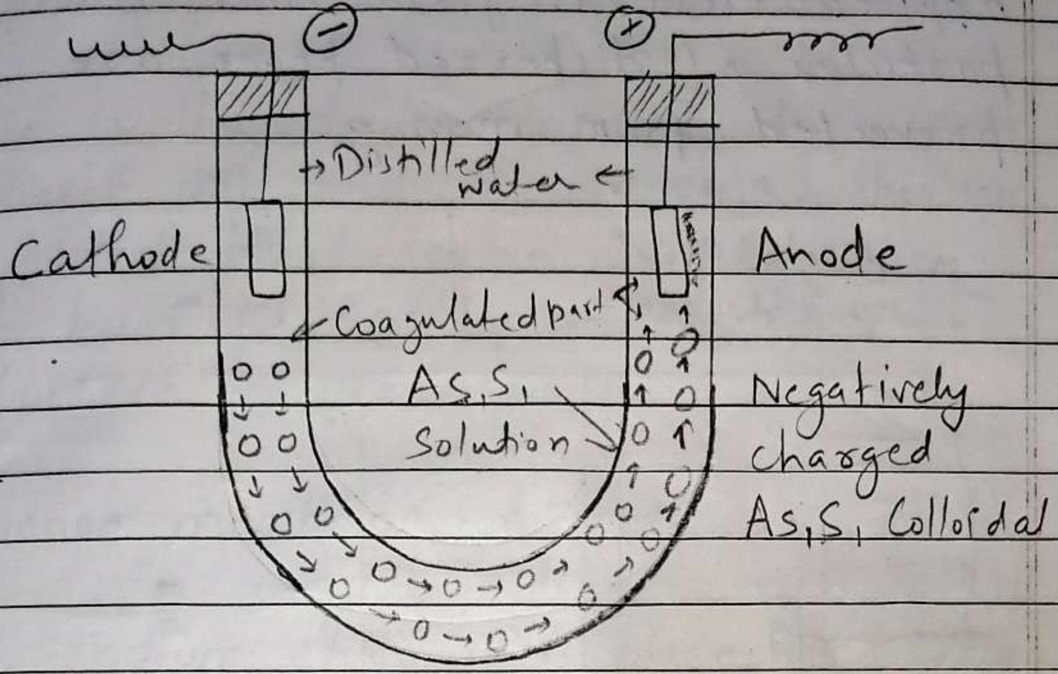


Fig → Electrophoresis.

3. Electro - Osmosis :

A colloidal solution as a whole is electrically neutral in nature i.e., dispersion medium carries an equal and opposite charge to that of the particles of dispersed phase. When the movement of dispersed phase of colloidal solution is prevented by suitable means, the dispersion medium can be made to move under the influence of an applied electric field or potential. This phenomenon is referred to as Electro - Osmosis. Thus electro - osmosis may be defined as the movement of the dispersion medium under the influence of an applied electric field when the particles of dispersed phase are prevented from moving.

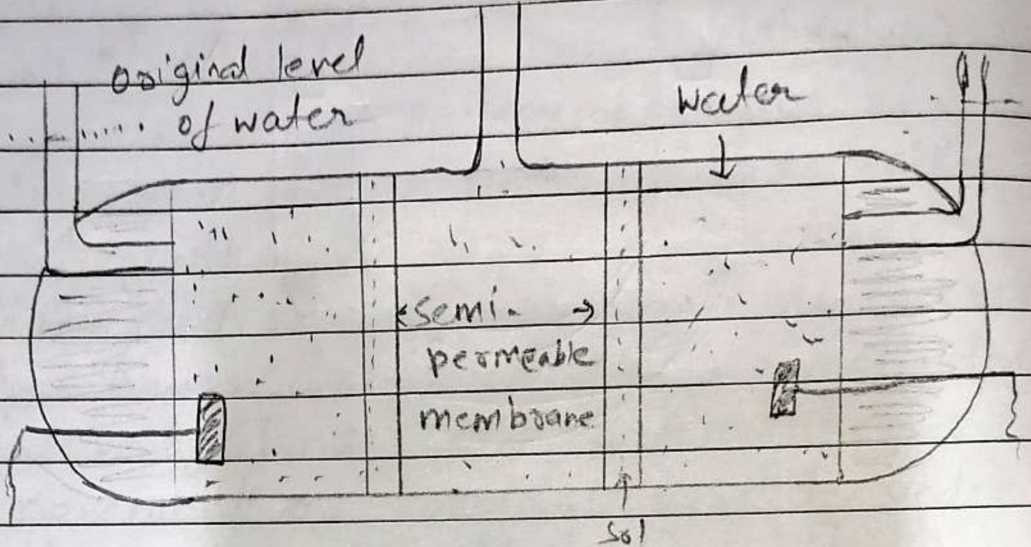


Fig- Electro-osmosis.

If the particles carry positive charge, the dispersion medium would start moving towards the anode and the level of water in the side tube T would be seen to rise, indicating the presence of negative charge on the dispersion medium. If the particles carry negative charge, the dispersion medium would be seen to move towards cathode and water in the side tube T would start rising. Electro osmosis is utilizing for ~~dewarting~~ dewatering moist clay and drying of dye pastes.

4. Sedimentation potential:

This is the 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.

5. Donnan membrane Effect:

If sodium chloride is placed in solution on one side of a semipermeable membrane and a negatively charged colloid together with its counter ions $R^- Na^+$ is placed on the other side, the sodium and chloride ions can pass freely across the barrier but not the colloidal anionic particles. The system at equilibrium is represented in the following diagram, in which R is the non-diffusible colloidal anion and the vertical line separating the various species represents the semipermeable membrane. The volumes of solution on the two sides of the membrane are considered to be equal. After equilibrium has been established, the concentration in dilute solutions (more correctly the activity) of sodium chloride must be the same on both sides of the membrane, according to the principle of escaping tendencies. Therefore,

Outside (o)	Inside (I)
Na^+	R^-
Cl^-	Na^+
	Cl^-

Na^+, Cl^- are permeable ions.
R^- is a non permeable ion

In accordance with the principle of escaping tendencies, the concentration of the drug (Na^+, Cl^-) must balance on both sides of the membrane.

i.e., $[Na^+]_o [Cl^-]_o = [Na^+]_i [Cl^-]_i$

Where o and i indicate outside and inside respectively.

Applying electroneutrality on both sides, the concentration of positively charged ions must balance the concentration of negatively charged ions.

i.e. outside : $[Na^+]_o = [Cl^-]_o$
and inside : $[Na^+]_i = [R^-]_i + [Cl^-]_i$

Substituting these in the above first equations, we obtain

$$[Cl^-]_o [Cl^-]_o = ([R^-]_i [Cl^-]_i) [Cl^-]_i.$$

$$[Cl^-]^2_o = [R^-]_i [Cl^-]_i + [Cl^-]_i [Cl^-]_i$$

$$[Cl^{-2}]_o = [Cl^-]^2_i + [R^-]_i [Cl^-]_i$$

$$= [Cl^-]^2_i \, 1 + [R^-]_i / [Cl^-]_i$$

$$\frac{[Cl^-]^2_o}{[Cl^-]^2_i} = 1 + \frac{[R^-]_i}{[Cl^-]_i}$$

or,
$$\frac{[Cl^-]_o}{[Cl^-]_i} = 1 + \frac{[R^-]_i}{[Cl^-]_i}$$

From the above equation which represents the ratio of concentrations of diffusible drug anion outside and inside the membrane at equilibrium, it may be understood that a charged polyelectrolyte (i.e., macromolecules of colloidal dimensions) inside a semi-permeable membrane sac would affect the equilibrium concentration ratio of a diffusible anion. That is, it tends to drive the ion (drug ion) of like charge on its side to the opposite side through the semipermeable membrane.

Interaction of colloids :

1. Mutual Precipitation:

When two oppositively charged hydrophilic colloid are mixed, precipitation takes place. Charges necessary for stability get neutralized by each other and attractive forces between particles dominate.

2. Coacervate formation :

When oppositively charged hydrophilic colloids are mixed, a colloid rich layer separates which is called as coacervate. This phenomenon in which macro-molecular dispersion, on mixing, separate into two liquid layers is called coacervation.

Gelatin at pH below 4.7 (iso-electric point) is positively charged while acacia is negatively charged. When the two are mixed together, two layer are formed, the upper layer of low viscosity having a poor concentration of colloidal material and lower layer of higher viscosity containing high concentration of colloidal material. Coacervation can also be brought about by the addition of alcohol, sodium sulphate or a macromolecular substance such as starch and the mechanism may not involve interaction of charged particles but mechanism such as dehydration of the solvated layer in the case of alcohol.

3. Sensitisation:

In the presence of very small amount of hydrophilic colloid, the hydrophobic colloids may become even more susceptible to precipitation from electrolytes. Sensitization is attributed to a reduction in zeta below the critical value (the value at which coagulation occur). It is also reasoned that it is due to reduction in the thickness of the ionic layer surrounding the colloidal particles.

4. Protection :

Larger concentration of hydrophilic colloids increases the stability of hydrophobic colloid towards precipitation by electrolytes. The hydrophilic colloids 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. The hydrophilic sol used for the purpose of protecting hydrophobic colloid is known as protective colloid.

Stability of Colloids

Colloidal particles, though larger than ions and molecules, yet are stable, and do not settle under gravity. There are at least three good reasons for the stability of colloidal sols.

i) Brownian motion :

Like the molecules or ions in a solution, the colloidal particles of a sol are in a state of continuous rapid motion. The intensity of Brownian motion falls rapidly with increase in the particle size, yet it is high enough to offset of gravity in case of colloidal particles.

ii). Electric Charge:

As we know that the colloidal particles in a sol are all either positively charged or negatively charged. Therefore, the force of repulsion keeps the particles scattered and even upon close approach they will not collide and coalesce. Hence similar charge on all the particles of a colloid accounts for the stability due to mutual repulsion in the solution.

iii) Solvation:

The colloidal particles of a sol are often highly hydrated in solution. The resulting hydrated "shell" prevents close contact and cohesion of colloidal particles. Comparatively the addition of small amounts of a lyophilic colloids called protective colloids.

Schulze -Hardy Rule:

Coagulation of colloidal dispersion can be brought about by the addition electrolytes which reduce the zeta-potential. The ~~difference~~ effectiveness of an electrolyte to cause precipitation depend not only on the concentration but also on the valence of the active ion (ion causing coagulation). The higher the valency of the ion, the greater is the precipitating power. This is known as Schulze-Hardy Rule.

Al_3^+ is more effective than Mg^{++} and Na^+. Negatively charged arsenious sulfide will be coagulated rapidly with a smaller concentration of $AlCl_3$ than that of $BaCl_2$ or NaCl. Similarly for positively charged sol such as $Fe(OH)_3$, PO_4^{--} is more effective than SO_4^{--} and Cl^{--}.

Generally hydrophobic colloids need very small amount of electrolyte for coagulation whereas hydrophilic colloids need a larger amount because the hydration layer surrounding the dispersed particles has to be removed.

Gold Number:

Gold Number is a measure of the protective ability of hydrophilic colloid. It is defined as the number of milligram of hydrophilic colloid which when added to 10 ml of red gold sol prevents the change in colour from red to violet on the addition of 1ml of 10% solution of sodium chloride. The change in the colour is due to the change in particle size.

The lower the gold number, higher is the protective ability of the colloid. The gold number of protective colloid, gelatin, albumin, acacia and tragacanth are 0.01, 0.1, 0.2 and 2.0 respectively. Thus, gelatin is the most effective protective colloid of the above four.

Determination of Gold number:

For the determination of gold number, a series of test tube containing 10ml of gold sol are taken. To each of the test tube is added a protective colloid in increasing concentration. To each of the test tubes is then added 1 ml of 10% sodium chloride solution. The test tubes are left undisturbed. At higher concentration of the protective colloid, the gold sol does not change its color while at lower concentration, the gold sol changes color from red to violet. The test tube containing the minimum quantity of colloid which prevents the change in color of the gold sol is the gold number of the protective colloid.

DLVO Theory:

DLVO theory is a theory of colloidal dispersion stability in which zeta potential is used to explain that as two particles approach one another their Ionic atmospheres begin to overlap and a repulsion force is developed. In this theory, two forces are considered to impact on colloidal stability: Van der Waals forces and electrical double layer forces.

The total potential energy is described as the sum of the attraction potential and the repulsion potential. When two particles approach each other, electrostatic repulsion increases and the interference between their electrical double layers increases. However, the van der Waals attraction also increases as they ~~got~~ ~~e~~ get closer. At each distance, the net potential energy of the smaller value is subtracted from the larger value.

At very close distances, the combination of these ~~factors~~ forces results in a deep attractive well, which is referred to as the primary minimum. At larger distances, the energy profile goes through a maximum, or energy barrier, and subsequently passes through a shallow minimum, which is referred to as the secondary minimum.

At the maximum of the energy barrier, repulsion is greater than attraction. Particles rebound after interparticle contact, and remain dispersed throughout the medium. The maximum energy needs to be greater than the thermal energy. Otherwise, particles will aggregate due to the attraction potential. The height of the barrier indicates how stable the system is. Since particles have to overcome this barrier in order to aggregate, two particles on a collision course must have sufficient kinetic energy due to their velocity and mass. If the barrier is cleared, then the net interaction is all attractive, and as a result the particles aggregate. This inner region is often referred to as an energy tap since the colloids can be considered to be trapped together by van der Waals forces.

For a colloidal system, the thermodynamic equilibrium state may be reached when the particles are in deep primary minimum. At primary minimum, attractive forces overpower the repulsive forces at low mdecular distances. Particles coagulate and this process is not reversible. However, when the maximum energy barrier is too high to overcome, the colloid particles may stay in the secondary minimum. ~~Particles~~ where particles are held together but more weakly than in the primary minimum. Particles form weak attractions but easily redispersed. Thus, the adhesion at secondary minimum can be reversible.

Pharmaceutical applications of colloids:

1.) Colloidal silver iodide, silver chloride and silver protein are effective germicides and not cause irritation as ionic silver salts.

2.) Colloidal copper used in cancer.

3.) Colloidal gold used as diagnostic agent.

4.) Colloidal mercury used in syphilis.

5.) Association colloids (SAA) are used to increase solubility and stability of certain compounds in aqueous and oily pharmaceutical preparations.

6.) Efficiency of certain substances is increased when used in colloidal form due to large surface area. ~~eg.~~
eg. efficiency of Kaolin in adsorbing toxins from G.I.T.
eg. efficiency of aluminium hydroxide as antacid.

7.) Blood plasma substitutes as dextran, pvp and gelatin are hydrophilic colloids used to restore or maintain blood volume.

8.) Iron-dextran complex form non-ionic hydrophilic sols used for treatment of anemia.