

# BIOCHEMISTRY COLLOIDS

# COLLOIDAL STATE

- ⦿ Colloids are a type of mixture. It is composed of two phases:
- ⦿ Dispersion medium and dispersed phase.

- ⦿ Colloids are the mixtures in which dispersion **phase** is evenly distributed in the dispersion **medium**.

- ⦿ Colloidal system = Dispersion phase + Dispersion medium

- ⦿ Brownian movement may be used to distinguish between solutions and colloids.
- ⦿ It is the random movement of colloidal particles suspended in dispersion phase or medium

- ⦿ Particles of colloids are larger than that of solutions that they resist settling rapidly to the bottom of a vessel due to Brownian motion.

- ⦿ **Colloids** (Greek word, kolla, meaning glue-like) : They have slower rate of diffusion and can not diffused from parchment paper.
- ⦿ Colloidal system can be solid, liquid or gaseous.
- ⦿ Examples :Starch, gelatin, gums, and hemoglobin etc.

Examples of systems which are colloidal are:

Aerosols

Agrochemicals

Cement

Cosmetics

Dyestuffs

Emulsions

Fabrics

Foams

Foodstuffs

Ink

Paint

Paper

Pharmaceuticals

Plastics

Rubber

Soil



Examples of processes which rely heavily on the application of colloid /surface phenomena are:

Adhesion

Ore flotation

Chromatography

Precipitation

Detergency

Road surfacing

Electrophoretic deposition

Sewage disposal

Emulsion polymerization

Soil conditioning

Food processing

Sugar refining

Grinding

Water clarification

Heterogeneous catalysis

Water evaporation control

Ion exchange

Water repellency

Lubrication

Wetting

Oil-well drilling

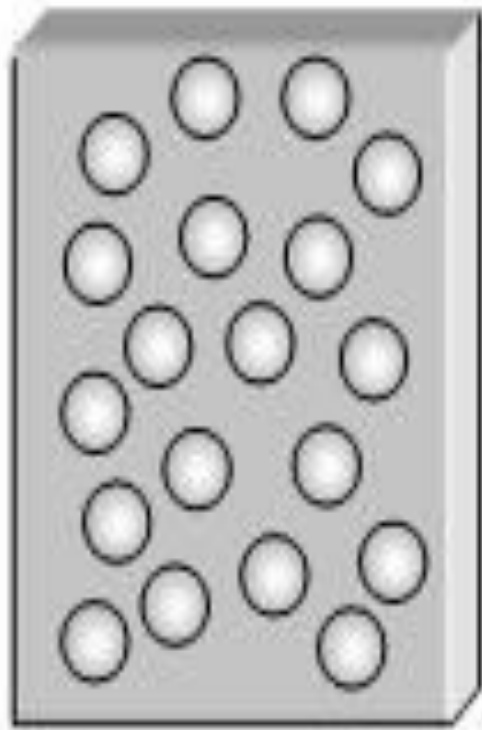
- ① Any substance can be brought into colloidal state.
- ① The colloidal state depends on the particle size.
- ① It is regarded as an intermediate state between true solution and suspension.

⦿ the factors which contribute most to the overall nature of a colloidal system are:

1. Particle size
2. Particle shape and flexibility
3. Surface (including electrical) properties
4. Particle—particle interactions
5. Particle—solvent interactions

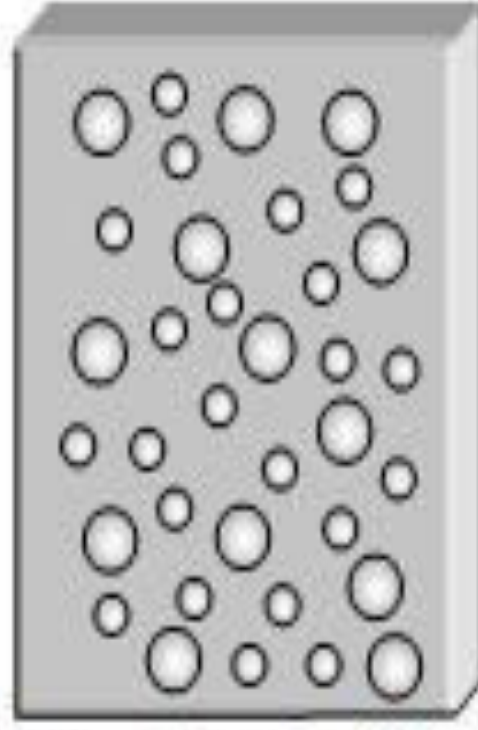
Property	Suspension	Colloid solution	True solution
Nature	Heterogeneous	Heterogeneous	Homogeneous
Particle size	$> 100 \text{ nm}$	$1 \text{ nm} - 100 \text{ nm}$	$< 1 \text{ nm}$
Separation by (i) Ordinary filtration	Possible	Not possible	Not possible
(ii) Ultra- filtration	Possible	Possible	Not possible
Settling of particles	Settle under gravity	Settle only on centrifugation	Do not settle
Appearance	Opaque	Generally transparent	Transparent

Tyndall effect	Shows	Shows	Does not show
Diffusion of particles	Does not diffuse	Diffuses slowly	Diffuses rapidly
Brownian movement	May show	Shows	Negligible



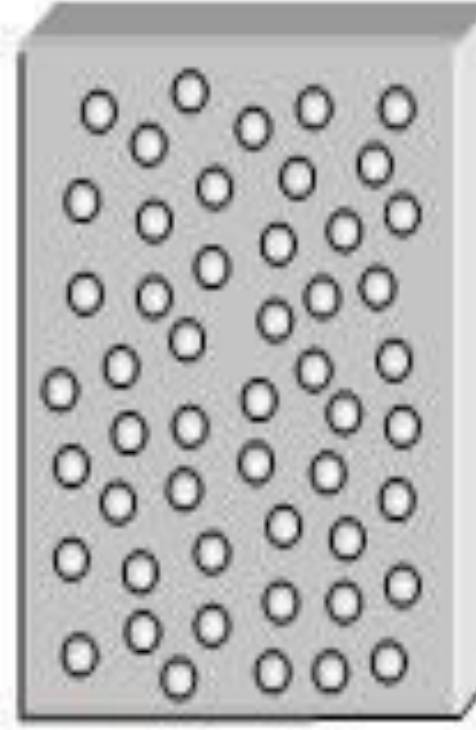
Suspension

Size  $> 100 \text{ nm}$



Colloidal solution

Size between  
 $1-100 \text{ nm}$



True

Size  $< 1 \text{ nm}$

**Three types solutions**

# Colligative Properties of Colloidal Solutions

- ⦿ Lowering of vapour pressure,
- ⦿ Elevation in boiling point,
- ⦿ Depression in freezing point and
- ⦿ Osmotic pressure.

# Mechanical Properties of Colloidal Solutions

1. Colloidal particles present in a colloidal solution exhibit a very important property called **Brownian movement**.
  - ⦿ When a colloidal solution is viewed under an ultra microscope, the colloidal particles are seen continuously moving in a zigzag path. It may be defined as follows.



- ⦿ The continuous zigzag movement of the colloidal particles in the dispersion medium in a colloidal solution is called Brownian movement.

- ⦿ The property was discovered by a botanist Robert Brown in 1827, when he observed that pollen grains suspended in water exhibit random zigzag motion. After the name of the discoverer, the property was named as Brownian movement.

# General Physical Properties of Colloidal Solutions

- ⦿ The important properties of colloidal solutions are described below.

**1. Heterogeneity:** Colloidal solutions are heterogeneous in nature and consist of two phases-dispersed phase and dispersion medium.

## **2. Visibility of dispersed particles:**

Although colloidal solutions are heterogeneous in nature, yet the dispersed particles present in them are not visible to the naked eye and they appear homogenous. This is because colloidal particles are too small to be visible to the naked eye.

**3. Filterability:** Due to very small size, the colloidal particles pass through an ordinary filter paper. However, they can be retained by animal membranes, cellophane membrane and ultrafilters.

4. **Stability:** Lyophilic sols in general and lyophobic sols in the absence of substantial concentrations of electrolytes are quite stable and the dispersed particles present in them do not settle down even on keeping. However, on standing for a long time, a few colloidal particles of comparatively larger size may get sedimented slowly.

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**5. Colour:** The colour of a colloidal solution depends upon the size of colloidal particles present in it. Larger particles absorb the light of longer wavelength and therefore transmit light of shorter wavelength.

# Optical Properties (Tyndall Effect)

- ⦿ When an intense converging beam of light is passed through a colloidal solution kept in dark, the path of the beam gets illuminated with a bluish light.



- ⦿ This phenomenon is called Tyndall effect and the illuminated path is known as **Tyndall cone**. The phenomenon was first observed by Tyndall in 1869.

- The Tyndall effect is due to the scattering of light by colloidal particles. Tyndall observed that the zone of scattered light is much larger than the particle itself. This is why colloidal particles look like bright spots when viewed with a microscope at right angles to the beam of light .

- Tyndall effect is not exhibited by true solutions. This is because the particles (ions or molecules) present in a true solution are too small to scatter light. Thus, Tyndall effect can be used to distinguish a colloidal solution from a true solution.

- ① The phenomenon has also been used to devise an instrument known as ultra microscope. The instrument is used for the detection of the particles of colloidal dimensions. Tyndall effect also establishes the fact that colloidal systems are heterogeneous in nature.

# Electrical Properties of Colloidal Solutions

## Presence of electrical charge on colloidal particles :

- One of the most important properties of colloidal solutions is that colloidal particles possess a definite type of electrical charge.

- ⦿ In a particular colloidal solution, all the colloidal particles carry the same type of charge, while the dispersion medium has an equal but opposite charge.

- ⦿ Thus, the charge on colloidal particles is balanced by that of the dispersion medium and the colloidal solution as a whole is electrically neutral. For example, in a ferric hydroxide sol, the colloidal ferric hydroxide particles are positively charged, while the dispersion medium carries an equal and opposite negative charge.

## Stability of sols:

- The stability of a colloidal solution is mainly due to the presence a particular type of charge on all the colloidal present in it.



- ⦿ Due to the presence of similar and equal charges, the colloidal particles repel one another and are thus unable to combine together to form larger particles.

- ⦿ This keeps them dispersed in the medium and the colloidal remains stable. This is why sol particles do not settle down even on standing for a long time.

# Protective Colloids and Gold Number

- Lyophobic sols such as those of metals (e.g. Au, Ag, Pt etc.) are not very stable in the sense that they get easily coagulated (precipitated) in the presence of an electrolyte.

- ⦿ This poses a big problem in their storage and usage. Contrary to this, lyophilic sols are much more stable and do not get coagulated easily under similar conditions.

- It has been observed that in the presence of certain lyophilic colloids such as gum Arabic, gelatin, starch etc. the hydrophobic sols acquire greater stability towards coagulation, i.e. they get protected and do not get coagulated easily when an electrolyte is added.

- ⦿ The process of protecting a lyophobic sol from being coagulated (precipitated) on addition of an electrolyte by the use of a lyophilic colloids is called protection and the lyophilic colloid used for purpose is called a protective colloid.

- ⦿ For example, the addition of gelatin (a lyophilic colloid) to a gold sol (lyophobic sol) protects the latter from being coagulated on addition of sodium chloride solution

- ① **Gold Number:** The protective power a lyophilic colloid is usually expressed in terms of a number called gold number introduced by Zsigmondy (1901). It may be defined as follows.



- ◎ **The gold number of a protective colloid is its minimum amount in milligrams which is just sufficient to prevent the coagulation of 10 ml of a gold sol on the addition of 1 mL of 10% sodium chloride solution.**

# Lyophilic and lyophobic systems

- ⦿ The terms *lyophilic* (liquid-loving)
- ⦿ and *lyophobic* (liquid-hating).
- ⦿ (If the liquid medium is aqueous, the terms *hydrophilic* and *hydrophobic* are used)

- ⦿ Ultrafiltration is the application of pressure or suction to force the solvent and small particles across a membrane while the larger particles are retained. The membrane is normally supported between fine wire screens or deposited in a highly porous support such as a sintered glass disc

# Dialysis and gel filtration

- ⦿ The use of membranes for separating particles of colloidal dimensions is termed dialysis.
- ⦿ Dialysis is particularly useful for removing small dissolved molecules from colloidal solutions or dispersions- e.g. extraneous electrolyte such as  $\text{KNO}_3$  from  $\text{AgI}$  sol.

- ⦿ The process is hastened by stirring so as to maintain a high concentration gradient of diffusible molecules across the membrane and by renewing the outer liquid from time to time.

# Applications of Colloids

- 1. Food stuffs and medicines:** Many of our food stuffs are colloidal in nature. Milk, butter, whipped cream, fruit jellies, ice cream, bread etc. are all colloidal in nature.

- For example, milk is an emulsion of butter fat in water, stabilized by milk protein (casein). Ice cream is a dispersion of colloidal ice particles in cream. Similarly, bread consists of air dispersed in baked dough.

- ⦿ Colloidal medicines are more effective and are easily absorbed by the body system. Therefore a large number of pharmaceutical preparations are emulsions.



- ① .Halibut-liver oil, cod-liver oil, skin ointments etc. are emulsions.
- ① Antibiotics such as penicillin, streptomycin etc. are usually injected in the body in colloidal form. Several metal sols are also used as medicines.

**2. Purification of water:** In water works, water is usually purified by the addition of certain electrolytes such as potash alum, aluminium sulphate etc. This involves the phenomenon of coagulation.

- ◎ The impure water usually contains dispersed colloidal particles which cannot be removed by filtration. When potash alum is added to impure water, the negatively charged colloidal particles of impurities get coagulated by the action of  $\text{Al}^{3+}$  ions furnished by the alum and can be removed by filtration or decantation.