Colloidal Chemistry

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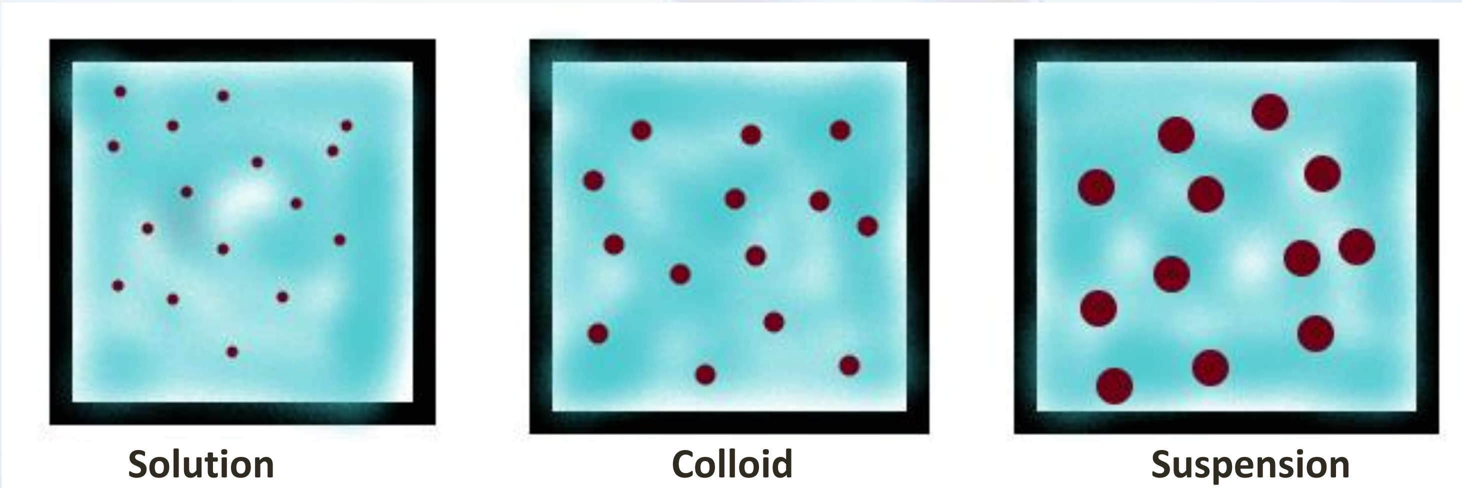
Solution, Suspensions and Colloids



A solution is homogenous mixture of two or more substances. It is made up by dissolving solute in dispersion medium known as solvent

A colloid is formed when a substance of microscopically dispersed insoluble or soluble particles is suspended throughout another substance.

A suspension contains solid particles that are sufficiently large for sedimentation. These particles may be visible to the naked eye, usually must be larger than one micrometer

Introduction to colloids

- According to the IUPAC definition *Colloid* is the Short synonym for colloidal system and the Colloidal State is the subdivision in which the molecules or polymolecular particles dispersed in a medium have at least one dimension between approximately 1 nm and 1 μm, or that in a system discontinuities are found at distances of that order.
- A colloid is any substance which is dispersed throughout another substance very evenly, to the point of even distribution on the microscopic level. To attain such order of distribution the colloidal mixture is broken down into very small particles, called colloidal particles, which are too small to be directly seen by a conventional microscope.
- The colloidal particles size is obtained in two ways. It is either prepared by reducing large particles to colloidal size (generally between 1 nm and 1 micron), or increasing small particles (usually single molecules) to the size of colloidal particles through process of agglomeration.

Common life examples of colloids

http://chemistrylearning.com/wp-content/uploads/2009/07/Milk.jpg

http://www.chemistrylearning.com/wp-content/uploads/2009/07/Jellies.jpg

https://www.thoughtco.com/thmb/nMgypuiBcYifw9oCmnUexK3OZAQ=/2800x1867/filters:fill(auto,1)/pumice-stone-detail-isolated-on-white-119398150-5c7be1f2c9e77c00011c839e.jpg

http://chemistrylearning.com/wp-content/uploads/2009/07/Whipped-Cream.jpg

https://this.deakin.edu.au/wp-content/uploads/2017/09/Blood-crop.jpg

Our daily life is full of colloids about which we have no idea about

Classification of colloids

Colloids are classifies in various types on the basis of different physical characteristics:

- ✓ On the basis of interaction of dispersed phase and dispersion medium.
- ✓ On the basis of dispersed phase and dispersion medium.
- ✓ On the basis of molecular size of dispersed particles.
- ✓ On the basis of appearance of colloid.
- ✓ On the basis of electrostatic charge on the surface of colloids.

Lyophilic and Lyophobic colloids

(Basis of interaction of dispersed phase and dispersion medium)

- Lyophilic colloids are liquid loving colloids (Lyo means solvent and philic means loving).
- Their sols are easy to prepare and directly prepared by mixing the colloid with liquid.
- Sols of organic substances like gelatin, gum, starch and proteins.

- Lyophobic colloids are liquid hating colloids (Lyo means solvent and phobic means hating).
- Tough to prepare and require special methods and addition of stabilizers during synthesis
- Sols of inorganic substances like Arsenic (As2S3), Iron (Fe(OH)3) and Platinum.

Lyophilic vs. Lyophobic

Properties	Lyophilic	Lyophobic
Stability	High Stability	Low Stability
Charge	Depends on the pH	Positive or negative
Viscosity	Highly viscous	Same as medium
Reversibility	Colloid can be re-obtained	Once colloid changes to other form its difficult to reverse
Electrophoresis	May migrate to cathode or anode or may not move at all	May either move to cathode or anode
Surface Tension	Less than dispersion media	Nearly same as dispersion media

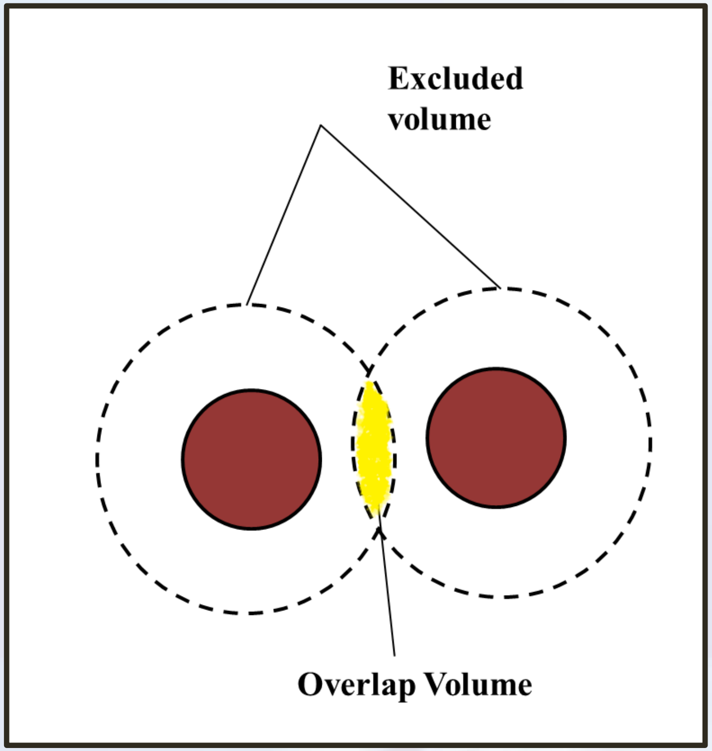
Classification of colloids on the basis of dispersed phase and dispersion media

Medium/ Phase		Dispersed Phase		
		Gas	Liquid	Solid
Dispersion medium	Gas	No such colloids are known except for He and Ne mixture of gases	Liquid Aerosols Fog, mists or hair sprays	Solid Aerosol Smoke or ice cloud
	Liquid	Foam Whipped or shaving cream	Emulsion Milk or hand cream	Sol Pigmented ink or blood
	Solid	Solid foam Pumice stone	Gel Agar or gelatin	Solid Sol Cranberry glass

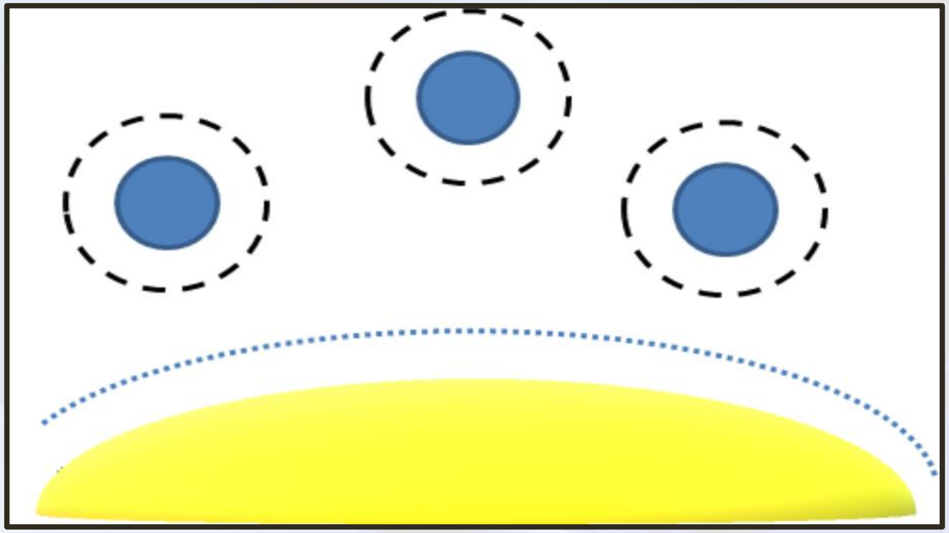
Interaction between particles

(Forces that occur in colloids)

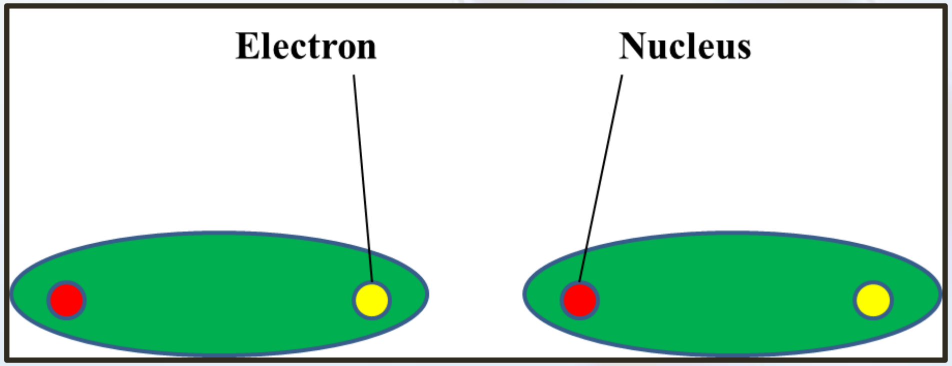
Excluded volume repulsion: It is impossibility of any overlap between hard particles.



Electrostatic interaction: The particles in colloids sometimes carry an electrical charge and hence attract or repel each other. The charge and mobility of continuous and the dispersed phases are factors affecting this interaction.

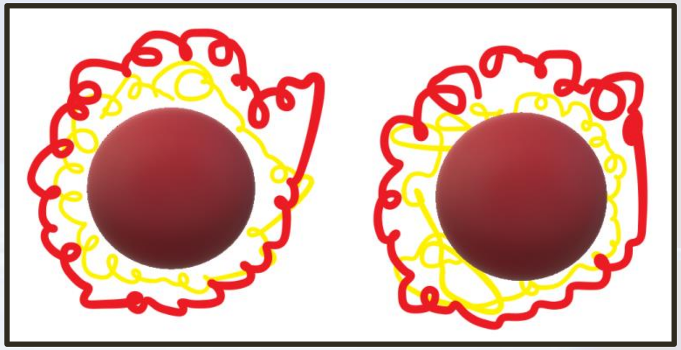


Van der Waal forces: The interaction between two dipoles that are either permanent or induced. Even the fluctuations of the electron density gives rise to a temporary dipole in a particle in the absence of permanent dipole. The temporary dipole and induced dipoles are attracted to each other.



Entropic Forces: Any system progresses towards the state of maximum entropy and it results in effective forces even between hard spheres.

Steric Forces: Mostly seen in polymers. Creates an additional steric repulsive force (entropic) or an attractive depletion force between them.



Classification on the basis of particle size in dispersed phase

- **Multimolecular Colloids:** Individual particles of dispersed phase consists of aggregates of atoms or small molecules having diameter less than 10^{-7} cm and held together by weak Vander Waal forces of attraction. Eg. Gold sol, sulphur sol.
- **Macromolecular Colloids:** The particles of dispersed phase are large enough in size to be of colloidal solution. Eg. Natural polymers.
- **Associated Colloids:** They are normal electrolytes but act as colloids at higher concentration. They are also known as **micelles.** Eg. Soaps (sodium lauryl sulphates)

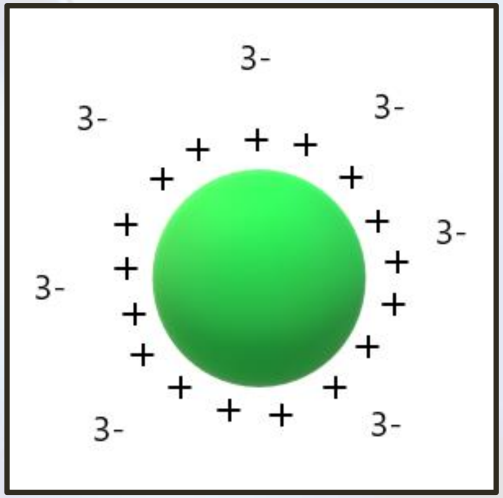
Classification on the basis of appearance of colloids

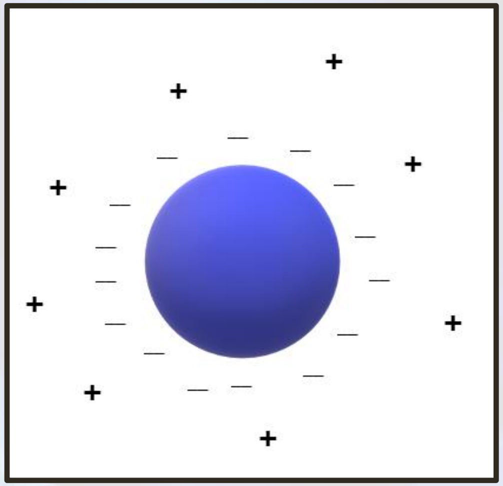
They are categorized as sols and gels on the basis of surface appearance.

- **Sols:** When a colloidal solution appears as a fluid. Sols are generally named as dispersion medium. Aquasol or Hydrosols are having dispersion medium as water. Alcosol are having dispersion medium as alcohal.
- **Gels:** The colloidal solution appears as solids. This colloid varies in rigidity from substance to substances. Eg. Jelly, butter, cheese etc.

Based on the electrical charge in dispersion

- **Positive Colloids:** When the dispersed phase in the colloidal solution carries a positive charge. Eg. Metal hydroxides such $Fe(OH)_2$, $Al(OH)_3$.
- **Negative Colloids:** When the dispersed phase in the colloidal solution carries a negative charge. Eg. Ag sol, Cu sol.

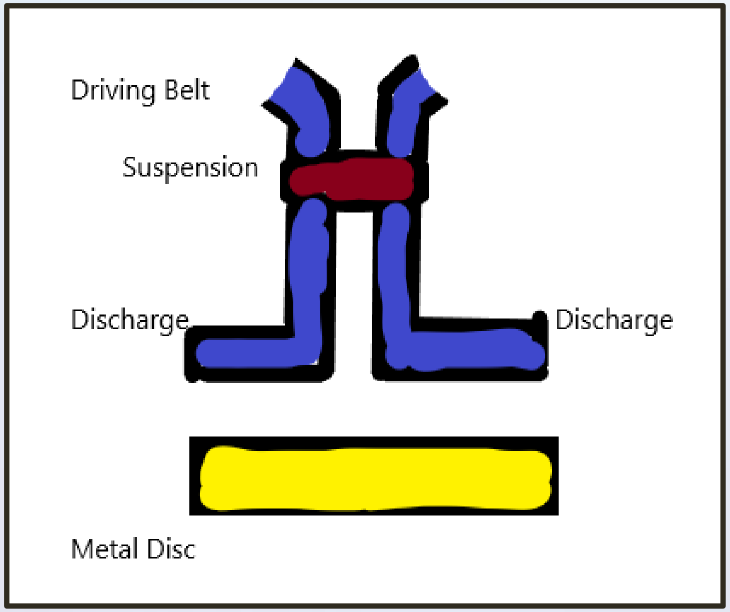




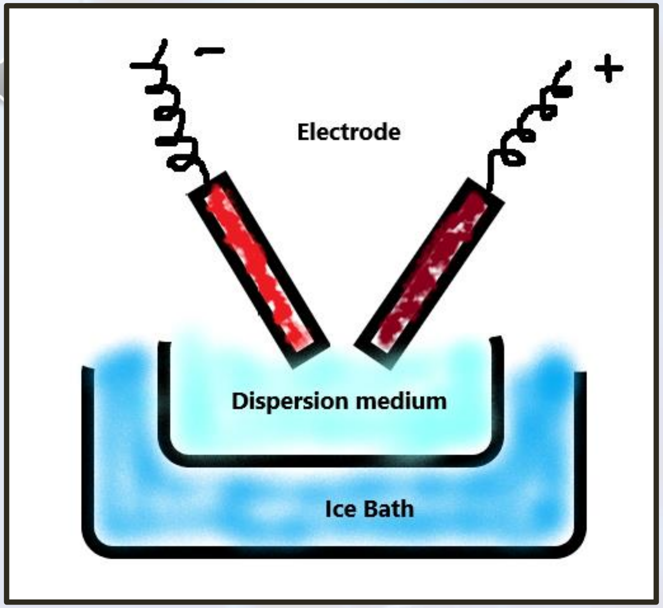
Preparation of colloids

Colloid formation can be done by two ways

Dispersion method involves the reduction of larger particles to colloidal size occurs, e.g. by mechanical subdivision of larger particles or by dissolution in the case of lyophilic sols.



Mechanical Dispersion



Electrical dispersion

Mechanical Dispersion methods:

- The substance is grounded into coarse particles and mixed with dispersion medium to get a suspension.
- The suspension is then grinded in colloidal mill which consists of two metallic discs in touch with each other as shown in figure.
- These discs rotates in opposite directions at a very high speed of around 7000 revolutions per minute.
- The great shearing force created between the discs breaks the suspension into colloidal particles.
- Such methods are used for dyes, paints and inks.

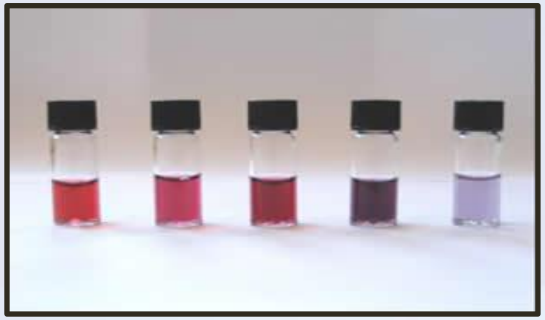
Electrical Dispersion or Bredig's Arc Method

- Metal sol to be made is used as electrode in dispersion medium as shown in figure.
- The dispersion medium is kept cool by using ice and an electric arc is struck between the electrodes.
- The heat generated in this system gives rise to colloidal particles.
- The solution that has been prepared is stabilized using KOH solution.
- Most of the metals colloids such as Ag, Au, Pt etc. are prepared by this method.

Condensation method takes place due to the condensation of smaller particles (e.g., molecules) into colloidal particles occurs, e.g. from supersaturated solutions or as the product of chemical reactions

- **Change of physical state**
- **Exchange of solid**
- **Chemical methods as in**

1. **Double decomposition**
2. **Oxidation**
3. **Reduction**
4. **Hydrolysis**



https://upload.wikimedia.org/wikipedia/commons/4/4d/Gold255.jpg

1. Colloidal sulphur is prepared through **oxidation method:**

$$2H_2S + O_2 \rightarrow 2H_2O + 2S$$

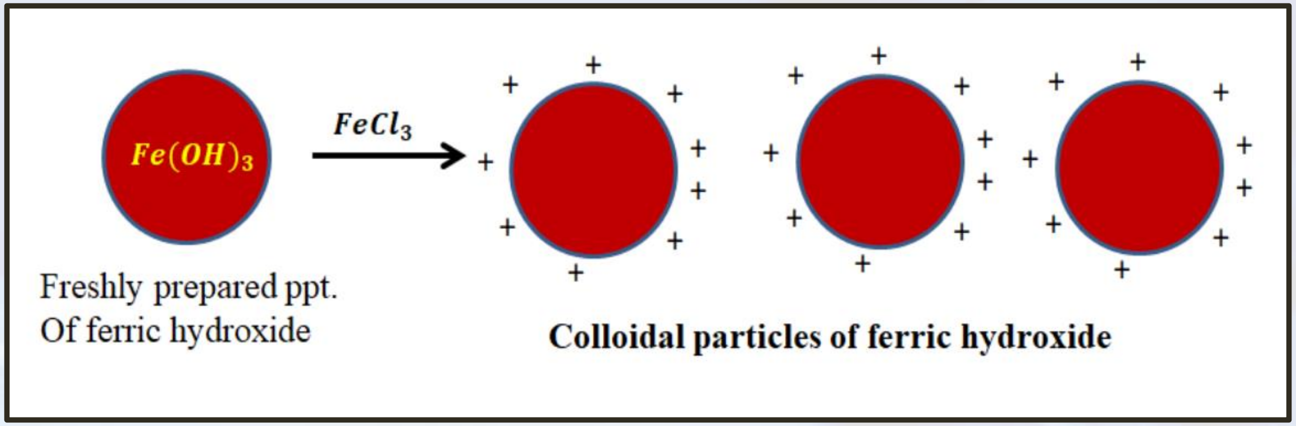
2. Ag, Au or Pt sols are prepared by the **reduction** of their aqueous solution of salts by reducing agents such as formaldehyde, phenyl hydrazine etc.

3. Ferric and aluminium hydroxides sols can be prepared by boiling aqueous solutions of their chlorides **(Hydrolysis)**.

4. Arsenous sulfide sol can be prepared by passing Hydrogen sulfide gas is passed to create arsenous oxide sol through **double decomposition.**

Peptization

- In simple terms it can be defined as process of converting precipitate into colloid after shaking it with an electrolyte. This is mainly for aqueous solution.
- It is due to the adsorption of ions of the electrolyte by the surface of the precipitate.
- The electrolytes used in peptization methods are known as stabilizing agents or peptizing agents.
- Sugar, gum, gelatins are some of the common example of such stabilizing agents.



Properties of colloid:

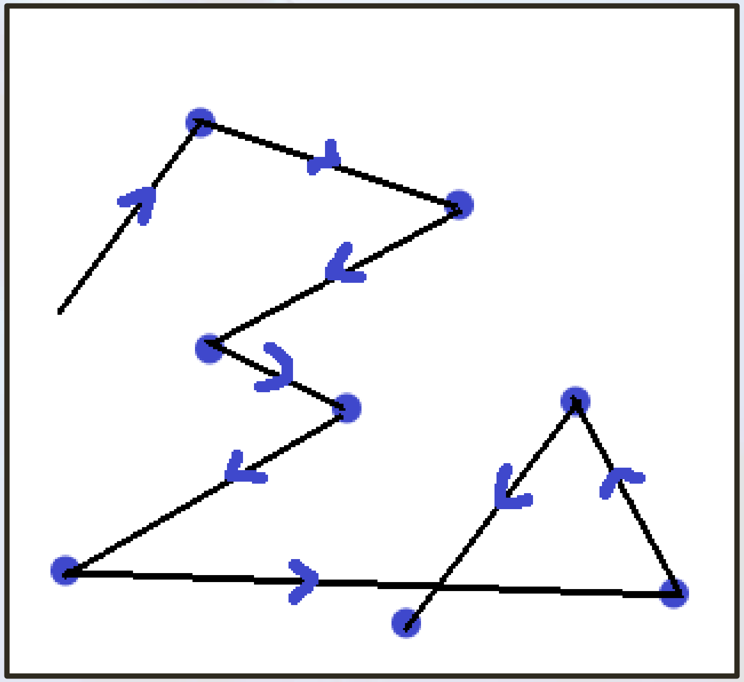
- **Heterogeneity:** Colloidal systems are clearly divided into two phases- dispersed phase and dispersion medium.
- **Visibility of dispersed particles:** The dispersed particles are not visible under naked eyes and hence it appears homogenous.
- **Filterability:** The colloidal particles easily pass through filter paper but are separable though animal or cellophane membranes and ultrafilters.
- **Stability:** Lyophilic sols are more stable than lyophobic sols.
- **Colour:** The colour of the colloid depends on the size of particles that is dispersed. The larger the size of particle more it absorbs and hence transmits shorter wavelength.

Optical Properties of Colloids:

- The colloidal particles are large enough to scatter a light beam and this phenomenon is called **the Tyndall effect**. This effect makes a colloidal mixtures appear cloudy or opaque, such as the searchlight beams.
- The Tyndall effect is due to the scattering of light by colloid particles which is not observable in solutions. Therefore it can be applied as one of the method to distinguish colloids from the solution.
- This idea is the key point behind the ultra-microscopes which measures the size of colloidal particles.

Mechanical Properties of colloids

- The colloidal particles move in a continuous but zig-zag motion in dispersion medium. This motion is known as **Brownian motion.**
- This is due to the unequal bombardment of moving colloidal particles.
- This motion is inversely linked with size of particles. Larger particles size like in suspensions do not exhibit Brownian Motion.



Electrical Properties of colloids

- **Electrophoresis:** The movement of colloidal particles under the influence of electric field. This property is termed as electrophoresis. Positively charged particles move towards cathode and negatively charged particles moves to anode.
- **Electrosmosis:** The movement of dispersion medium under the influence of electrical field when the movement of colloidal particles is restricted by the application of suitable membranes. The dispersion medium moves towards the oppositely charged electrodes.

To be continued