Properties of colloidal solutions.

The main characteristic properties of colloidal solutions are as follows.

(1) **Physical properties**

(i) **Heterogeneous nature:**Colloidal sols are heterogeneousin nature. They consists of two phases; the dispersed phase and the dispersion medium.

(ii) **Stable nature:** The colloidal solutions are quite stable. Their particles are in a state of motion and do not settle down at the bottom of the container.

(iii) **Filterability:** Colloidal particles are readily passed through the ordinary filter papers. However they can be retained by special filters known as ultrafilters (parchment paper).

(2) **Colligative properties**

(i) Due to formation of associated molecules, observed values of colligative properties like relative decrease in vapor pressure, elevation in boiling point, depression in freezing point, osmotic pressure are smaller than expected.

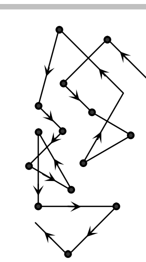
(ii) For a given colloidal sol the number of particles will be very small as compared to the true solution.

(3) **Mechanical properties**

(i) **Brownian movement**

(a) **Robert Brown,** a botanist discovered in 1827that the **pollen grains** suspended in water do not remain at rest but move about continuously and randomly in all directions.

(b) Later on, it was observed that the colloidal particles are moving at random in a **zig – zag** motion. This type of motion is called **Brownian movement.**



Brownian movement of

(c) The molecules of the dispersion medium are constantly colloiding with the particles of the dispersed phase. It was stated by **Wiener** in 1863that **the impacts of the dispersion medium particles are unequal, thus causing a zig-zag motion of the dispersed phase particles.**

(d) When a molecule of dispersion medium colloids with a colloidal particle, it is then displaced in one direction. Then another molecules strikes it, displacing it to another direction and so on. This process give rise to zig-zag motion.

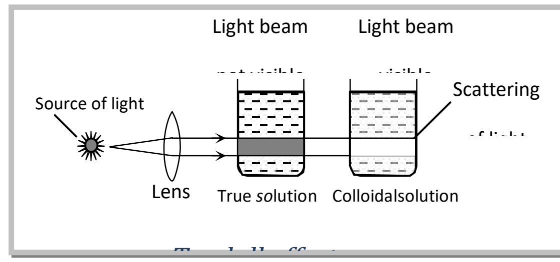
(e) This can be confirmed by the fact that the suspensions do not show any such movement due to large molecular size.

(f) Brownian movement provides a direct demonstration of the ceaseless motion of molecules as postulated by kinetic energy.

(g) The Brownian movement explains the force of gravity acting on colloidal particles. This helps in providing stability to colloidal sols by not allowing them to settle down.

(ii) **Diffusion:**The sol particles diffuse from higher concentration to lower concentration region. However, due to bigger size, they diffuse at a lesser speed.

(iii) **Sedimentation :** The colloidal particles settle down under the influence of gravity at a very slow rate. This phenomenon is used for determining the molecular mass of the macromolecules.



(4) **Optical properties: Tyandall effect**

(i) When light passes through a sol, its path becomes visible because of scattering of light by particles. It is called **Tyndall effect.** This phenomenon was studied for the first time by **Tyndall.** The illuminated path of the beam is called **Tyndall cone.**

(ii) In a true solution, there are no particles of sufficiently large diameter to scatter light and hence no Tyndall effect is observed.

(iii) The intensity of the scattered light depends on the difference between the refractive indices of the dispersed phase and the dispersion medium.

(iv) In lyophobic colloids, the difference is appreciable and, therefore, the Tyndall effect is well - defined. But in lyophilic sols, the difference is very small and the Tyndall effect is very weak.

(v) The Tyndall effect confirms the **heterogeneous nature of the colloidal solution.**

(vi) The Tyndall effect has also been observed by an instrument called **ultra – microscope.**

Note:The smoke is colloidal, so when it is viewed at an angle to the source of light, it appears blue due to Tydnall effect.

Dust in the atmosphere is often colloidal. When the sun is low down on the horizon, light from it has to pass through a great deal of dust to reach your eyes. The blue part of the light is scattered away from your eyes and you observe red part of the spectrum. Thus red sunsets are Tyndall effect on a large scale.

Tail of comets is seen as a **Tyndall cone due** to the scattering of light by the tiny solid particles left by the comet in its path.

Due to scattering the sky looks blue.

The blue color of water in the sea is due to scattering of blue light by water molecules.

Visibility of projector path and circus light.

Visibility of sharp ray of sunlight passing through a slit in dark room.

(5) **Electrical properties:** Colloidal particles carry an electric charge and the dispersion medium has an opposite and equal charge, the system as a whole being electrically neutral. The presence of equal and similar charges on colloidal particles is largely responsible in giving stability to the system because the mutual forces of repulsion between similarly charged particles prevent them from coalescing and coagulating when they come closer to one another.

(i) **Electrophoresis**

(a) The phenomenon of movement of colloidal particles under an applied electric field is called **electrophoresis.**

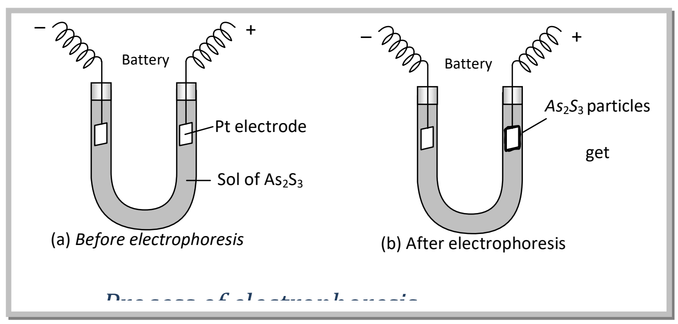
(b) If the particles accumulate near the negative electrode, the charge on the particles is **positive.**

(c) On the other hand, if the sol particles accumulate near the positive electrode, the charge on the particles is **negative.**

(d) The apparatus consists of a U-tube with two Pt-electrodes in each limb.

(e) Take a sol of As_2S_3 in the U-tube.

(f) The intensity of the color of the sol in both the arms is same. Now pass the current through the sol.



(g) After some time it is observed that the color of sol near the positive electrode become dark. This indicates that the As_2S_3 particles are negatively charged and they move towards oppositely charged electrodes.

(h) Similarly, when an electric current is passed through positively charged $Fe(OH)_3$ sol, it is observed that they move towards negatively charged electrode and get accumulated there.

(i) Thus, by observing the direction of movement of the colloidal particles, the sign of the charge carried by the particles can be determined.

(j) When electrophoresis of a sol is carried out without stirring, the bottom layer gradually becomes more concentrated while the top layer which contain pure and concentrated colloidal solution may be decanted. This is called **electro decantation**and is used for the purification as well as for concentrating the sol.

(k) The reverse of electrophoresis is called **Sedimentation potential or Dorn effect.** The sedimentation potential is setup when a particle is forced to move in a resting liquid. This phenomenon was discovered by **Dorn** and is also called **Dorn effect.**

(ii) **Electrical double layer theory**

(a) The electrical properties of colloids can also be explained by electrical double layer theory. According to this theory **a double layer of ions appear at the surface of solid.**

(b) The ion preferentially adsorbed is held in fixed part and imparts charge to colloidal particles.

(c) The second part consists of a diffuse mobile layer of ions. This second layer consists of both the type of charges. The net charge on the second layer is exactly equal to that on the fixed part.

(d) The existence of opposite sign on fixed and diffuse parts of double layer leads to appearance of a difference of potential, known as **zeta potential or electro kinetic potential.** Now when electric field is employed the particles move (electrophoresis)

(iii) **Electro-osmosis**

(a) In it the movement of the dispersed particles are prevented from moving by **semipermeable membrane.**

(b) Electro-osmosis is a phenomenon in which dispersion medium is allowed to move under the influence of an electrical field, whereas colloidal particles are not allowed to move.

(c) The existence of electro-osmosis has suggested that when liquid forced through a porous material or a capillary tube, a potential difference is setup between the two sides called as streaming potential. So the reverse of electro-osmosis is called **streaming potential.**

Note:Distance traveled by colloidal particles in one second under a potential gradient of one volt per cm is called **electrophoretic mobility** of the colloidal particles.

The principle of electrophoresis is employed for the separation of **proteins** from **nucleic acids,** removing sludge from sewage waste etc.