Lecture 40

Electric Properties of Colloids

The particles of a colloidal solution are similarly charged either positively or negatively charged. Particles Do not cluster together to settle down due to repulsion. The charge on colloidal particles arises due to molecular electrolyte. E.g. As_2S_3 has a negative charge. During synthesis of colloidal As_2S_3, H_2S is dissociated to H^+ and S^{-2} on the surface of colloid. $Fe(OH)_3$ is positively charged. Due to self-dissociation and loss of OH- to the medium, so they become $[Fe(OH)_3]$ to Fe^{+3}.

Electrophoresis:

The existence of the electrical charge can be shown by the process of 'Electrophoreses' which is also known as 'Cataphoresis'. It involves the movement of colloidal particles towards one or the other electrode when placed under the influence of an electric field. The movement of colloidal particles under the influence of an electric field is called Electrophoresis or Cataphoresis.

Electro-osmosis:

In electro-osmosis the movement of the dispersed particles is prevented from moving by semipermeable membrane. 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. 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. If electrodes are placed across a clay mass and a direct current is applied. Water in the clay (a porous space) is transported to the negatively charged electrode by electro-osmosis. Actually cations move toward the cathode with water molecules attached as a consequence of its dipolar nature.

Sedimentation Potential:

Sedimentation Potential occurs when dispersed particles move under the influence of either gravity or centrifugation in a medium. The sedimentation potential also called the (Donnan effect). It is the potential induced by the fall of a charged particle under an external force field. Electrophoresis in local electric field is induced as a result of its motion. If a colloidal suspension has a gradient of concentration (such as is produced in sedimentation or centrifugation) then macroscopic electric field is generated by the charge imbalance appearing at the top and bottom of the sample column.

Streaming Potential:

It is a potential which originates when an electrolyte is driven by a pressure gradient through a channel or porous plug with charged walls. It is used to determine the charged nature of fiber surfaces. Here the potential is created by forcing a liquid to flow through a plug of particles.A known pressure is used to push the liquid. A resulting voltage is measured between electrode probes on either side of the pad. This voltage is then compared with the voltage at zero applied pressure.

Stability of Colloids:

Colloidal particles collide with each other due to the Brownian motion, convection, gravity and other forces. Collisions may result in coagulation of the particles and destabilization of the colloid. If a colloidal particle is brought to a short distance to another particle, they are attracted to each other by the van der Waals force. If there is no counteracting force, the particles will aggregate and the colloidal system will be destabilized. Colloidal stability is achieved due to repulsion forces balancing the attraction forces in the way similar to the stable mechanic equilibrium {if a body is disturbed it tends to return to its former position).

According to the kind of the repulsion force two mechanisms of the colloidal stability take place:

1. Electrostatic stabilization of colloids
2. Polymeric stabilization of colloids

Electrostatic stabilization of colloids

Electrostatic stabilization of Colloids is the mechanism in which the attraction van der Waals forces are counterbalanced by the repulsive Coulomb forces acting between the negatively charged colloidal particles.

Polymeric stabilization of colloids

Polymeric stabilization of Colloids involves polymeric molecules added to the dispersion medium in order to prevent the aggregation of the colloidal particles. The polymeric molecules create a repulsive force counterbalancing the attractive van der Waals force acting on a particle approaching another particle.

Lyophobic Colloids Stability:

In Lyophobic sol, weak forces of interaction exist between colloidal particles and liquid. Hence, lyophobic sols are less stable. Addition of even small quantities of electrolytes can cause particles to precipitate. Unlike Lyophilic colloids, the precipitations of lyophobic colloids do not regain their original state as coagulated mass cannot be dispersed into colloidal form. This shows that lyophobic sols are also irreversible in nature.

Lyophilic Colloids Stability:

In Lyophilic Sol, forces of interaction between colloidal particles and liquid are quite strong. Hence, Lyophilic Sols are very stable and do not precipitate/coagulate easily. However addition of very large quantities of electrolytes can cause particles to precipitate. If large quantity of liquid is added to precipitations or the colloidal solution is stirred properly lyophilic sols can regain their original state. This shows that lyophilic sols are also reversible in nature.

Colloidal Precipitation:

This is obtained by addition of large amounts of electrolytes. Anions have precipitating power in following order

citrate > tartrate > sulfate > acetate > chloride> nitrate > bromide > iodide

The precipitation power is directly related to the hydration of the ion and the ability to separate water molecules from colloidal particles. And also can be done by addition of less polar solvent like alcohol or acetone.

Solubility of colloids:

Less polar solvent affects lyophilic colloidal solubility. The process of mixing negatively and positively charged hydrophilic colloids is called coacervation. The particles separate from the dispersion to form a layer rich in the colloidal aggregates. This aggregate is called coacervate.

Sensitization Colloidal Action:

Small amount of hydrophilic or hydrophobic colloid tend to sensitize (coagulate) a hydrophobic colloid of opposite charge. Polymer flocculants can bring out colloidal particles by attractive electrostatic interactions. Negatively-charged colloidal silica particles can be flocculated by the addition of a positively-charged polymer.

Protective Colloidal Action:

Lyophobic sols like those of metals (Au, Ag etc) are unstable and are easily coagulated by addition of electrolyte. However, it is observed that when certain lyophilic colloids such as gum, geletin, Agar – Agar etc. are added to a lyophobic sol, the stability of the lyophobic colloids is markedly increased i.e. the addition of small amount of electrolytes does not cause coagulation of lyophobic colloids. This action of lyophilic colloids to prevent the coagulation of lyophobic colloid by addition of electrolyte is called Protection of Colloidal Sol and the lyophilic colloid is called Protective Colloid.

References:

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