

COLLOIDS

AND THEIR TYPES

Colloids and their types

A colloid, in chemistry, is a mixture in which one substance of microscopically dispersed insoluble particles is suspended throughout another substance. Sometimes the dispersed substance alone is called the colloid; the term colloidal suspension refers unambiguously to the overall mixture (although a narrower sense of the word suspension is distinguished from colloids by larger particle size). Unlike a solution, whose solute and solvent constitute only one phase, a colloid has a dispersed phase (the suspended particles) and a continuous phase (the medium of suspension). To qualify as a colloid, the mixture must be one that does not settle or would take a very long time to settle appreciably.



Milk is an emulsified colloid of liquid butterfat globules dispersed within a water-based solution.

The dispersed-phase particles have a diameter between approximately 1 and 1000 nanometers. Such particles are normally easily visible in an optical microscope, although at the smaller size range ($r < 250$ nm), an ultramicroscope or an electron microscope may be required.

Homogeneous mixtures with a dispersed phase in this size range may be called colloidal aerosols, colloidal emulsions, colloidal foams, colloidal dispersions, or hydrosols. The dispersed-phase particles or droplets are affected largely by the surface chemistry present in the colloid.

Some colloids are translucent because of the Tyndall effect, which is the scattering of light by particles in the colloid. Other colloids may be opaque or have a slight color.

Classifying Colloids :

A common method of classifying colloids is based on the phase of the dispersed substance and what phase it is dispersed in. The types of colloids includes sol, emulsion, foam, and aerosol.

1. **Sol** is a colloidal suspension with solid particles in a liquid.
2. **Emulsion** is between two liquids.
3. **Foam** is formed when many gas particles are trapped in a liquid or solid.
4. **Aerosol** contains small particles of liquid or solid dispersed in a gas.

Types of Colloids :

Colloids are characterized

- a) according to the state of the dispersed phase and the state of dispersion medium.
- b) nature of interaction between dispersed phase and dispersion medium.
- c) types of particles of the dispersed phase.

Classification Based on the State of the Dispersed Phase and Dispersion Medium

The below table lists various types of colloids with various examples.

Types of colloids :

Dispersion Medium	Dispersed Phase	Type of colloid	Example
Gas	Liquid	Aerosol	Fog, mist
Gas	Solid	Aerosol	Smoke
Liquid	Gas	Foam	Whipped cream
Liquid	Liquid	Emulsion	Mayonnaise, hair cream
Liquid	Solid	Sol	Paints, cell fluids
Solid	Gas	Foam	Pumice, plastic foams
Solid	Liquid	Gel	Jelly, cheese
Solid	Solid	Solid Sol	Ruby glass (glass with dispersed metal)

Fog and smoke are aerosol which are liquid droplets or solid particles dispersed throughout a gas. When liquid droplets are dispersed throughout another liquid phase this results in emulsion, as in the case of butterfat dispersed throughout homogenized milk. A sol consists of solid particles dispersed in a liquid. Foam consists of gas being dispersed in a liquid phase as in the case of whipped cream.

Out of the various types of colloids, sols, gels and emulsions are very common. In the later sections 'sols' and 'emulsions' are discussed in some detail.

Classification Based on the Nature of Interaction Between Dispersed Phase and Dispersion Medium:

Colloidal systems, depending on the nature of attraction between the dispersed phase and the dispersion medium are classified into lyophobic (solvent hating) and lyophilic (solvent loving). If water is the dispersion phase is water, then the colloids are either hydrophilic or hydrophobic.

1) Lyophilic colloids

In this type of colloids sols, the dispersed phase has great attraction for the dispersion medium. In such colloids, the dispersed phase does not precipitate easily and the sols are quite stable. If the dispersion medium is separated from the dispersed phase, the sol can be reconstituted by simply remixing with the dispersion medium. Hence, these sols are called reversible sols. Examples of lyophilic sols include sols of gum, gelatine, starch, proteins and certain polymers in organic solvents.

2) Lyophobic colloids

In this type of colloidal sols, the dispersed phase has little affinity for the dispersion medium. These colloids are easily precipitated on the addition of small amounts of electrolytes, by heating or by shaking and therefore are not stable. Once precipitated, it is not easy to reconstitute the sol by simple mixing with the dispersion medium. Hence, these sols are called irreversible sols. Examples of lyophobic sols include sols of metals and their insoluble compounds like sulphides and oxides. Lyophobic sols need stabilizing agents to keep the dispersed phase from precipitating out.

Hydrophobic sols are often formed when rapid crystallization takes place. With rapid crystallization, many centres of crystallization called nuclei are formed at once. Ions are attracted to these nuclei and very small crystals are formed. These small crystals are prevented from settling out by the random thermal motion of the water molecules.

Classification of Colloids Based on Type of Particles of the Dispersed Phase :

- 1) Multimolecular colloids
- 2) Macromolecular colloids
- 3) Associated colloids.

Multimolecular colloids :

In this type of colloids the colloidal particles are aggregates of atoms or small molecules with molecular size less than one nanometer (1 nm). For e.g., gold sol consists of particles of various sizes which are clusters of several gold atoms. Similarly, sulphur sol consists of colloidal particles which are aggregates of S_8 molecules. The molecules in the aggregates are held together by Van der Waal forces.

Macromolecular colloids :

Macromolecular colloidal particles are formed when on dissolution in a suitable solvent, the macromolecules have sizes which are in the colloidal range. Naturally occurring macromolecules are starch, proteins and cellulose. Man made macromolecules are polymers such as polyethylene, nylon and polystyrene. These colloids are quite stable and resemble true solutions in many respects.

Associated colloids (Micelles) :

Certain substances behave as strong electrolytes at low concentration but at higher concentrations these substances exhibit colloidal characteristics due to the formation of aggregated particles. These aggregated particles are called micelles. Micelles are called associated colloids. The formation of micelles takes place only above a particular temperature called Kraft Temperature (T_k) and above particular concentration called the Critical

micelle concentration (CMC). On dilution, these colloids revert back to individual ions. Surface active molecules such as soaps and synthetic detergents form associated colloids in water. For soaps, the CMC is about 10^{-4} to 10^{-3} mol L⁻¹. Micelles have both a lyophilic and lyophobic parts. Micelles may consists of more than 100 molecules.

Preparation :

There are two principal ways of preparation of colloids :

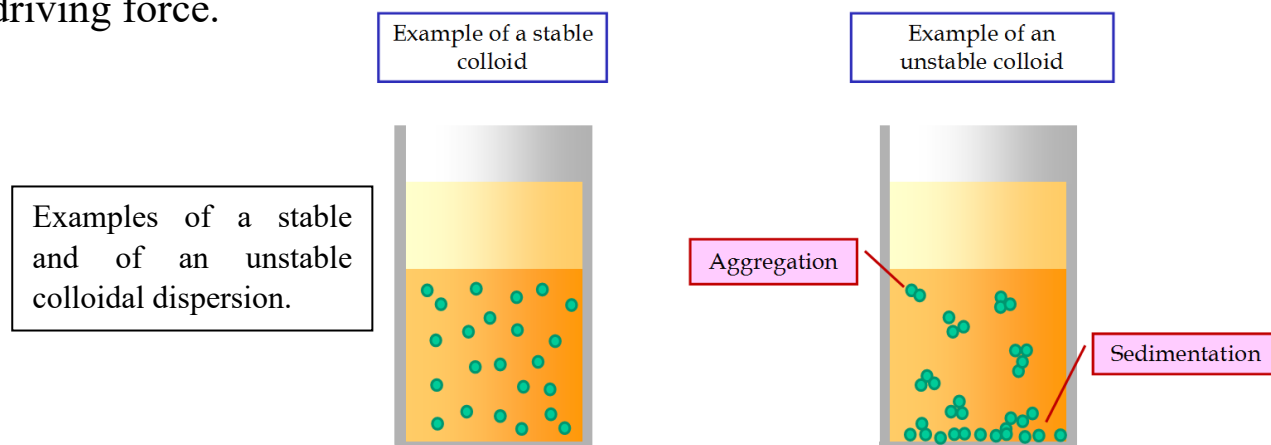
Dispersion of large particles or droplets to the colloidal dimensions by milling, spraying, or application of shear (e.g., shaking, mixing, or high shear mixing).

Condensation of small dissolved molecules into larger colloidal particles by precipitation, condensation, or redox reactions. Such processes are used in the preparation of colloidal silica or gold .

Stabilization (peptization) :

The stability of a colloidal system is defined by particles remaining suspended in solution at equilibrium.

Stability is hindered by aggregation and sedimentation phenomena, which are driven by the colloid's tendency to reduce surface energy. Reducing the interfacial tension will stabilize the colloidal system by reducing this driving force.



Aggregation is due to the sum of the interaction forces between particles. If attractive forces (such as van der Waals forces) prevail over the repulsive ones (such as the electrostatic ones) particles aggregate in clusters.

Electrostatic stabilization and steric stabilization are the two main mechanisms for stabilization against aggregation.

Electrostatic stabilization is based on the mutual repulsion of like electrical charges. In general, different phases have different charge affinities, so that an electrical double layer forms at any interface. Small particle sizes lead to enormous surface areas, and this effect is greatly amplified in colloids. In a stable colloid, mass of a dispersed phase is so low that its buoyancy or kinetic energy is too weak to overcome the electrostatic repulsion between charged layers of the dispersing phase.

Steric stabilization consists in covering the particles in polymers which prevents the particle to get close in the range of attractive forces.

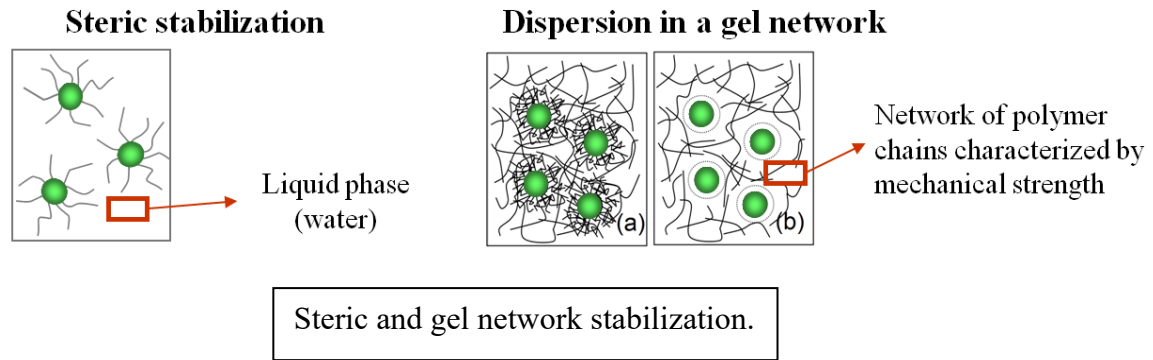
A combination of the two mechanisms is also possible (electrosteric stabilization). All the above-mentioned mechanisms for minimizing particle aggregation rely on the enhancement of the repulsive interaction forces.

Electrostatic and steric stabilization do not directly address the sedimentation/floating problem.

Particle sedimentation (and also floating, although this phenomenon is less common) arises from a difference in the density of the dispersed and of the continuous phase. The higher the difference in densities, the faster the particle settling.

The gel network stabilization represents the principal way to produce colloids stable to both aggregation and sedimentation.

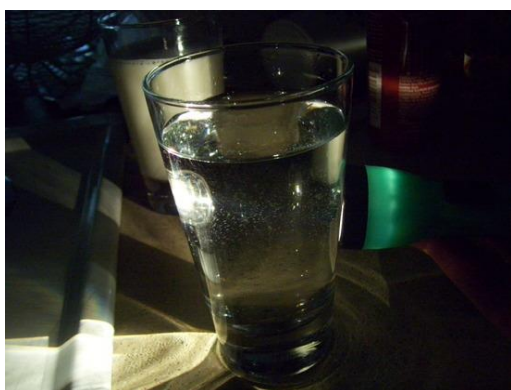
The method consists in adding to the colloidal suspension a polymer able to form a gel network and characterized by shear thinning properties. Examples of such substances are xanthan and guar gum.



Particle settling is hindered by the stiffness of the polymeric matrix where particles are trapped. In addition, the long polymeric chains can provide a steric or electrosteric stabilization to dispersed particles.

The rheological shear thinning properties find beneficial in the preparation of the suspensions and in their use, as the reduced viscosity at high shear rates facilitates deagglomeration, mixing and in general the flow of the suspensions.

An easy way of determining whether a mixture is colloidal or not is through use of the Tyndall Effect. When light is shined through a true solution, the light passes cleanly through the solution, however when light is passed through a colloidal solution, the substance in the dispersed phases scatters the light in all directions, making it readily seen. An example of this is shining a flashlight into fog. The beam of light can be easily seen because the fog is a colloid.



water



milk

Light being shined through water and milk. The light is not reflected when passing through the water because it is not a colloid. It is however reflected in all directions when it passes through the milk, which is colloidal.

Another method of determining whether a mixture is a colloid is by passing it through a semipermeable membrane. The larger dispersed particles in a colloid would be unable to pass through the membrane, while the surrounding liquid molecules can. Dialysis takes advantage of the fact that colloids cannot diffuse through semipermeable membranes to filter them out of a medium.

Notes :

1. Is dust a colloid? If so, what type is it?
2. Is whipped cream a colloid? if so, what type is it?
3. What does Sol mean?
4. When hit by light what happens to a colloidal mixture?
5. What is the mixture considered if the particles are larger than the particles of a colloidal substance

Answers

1. Dust is a colloid. It consists of a solid in a gas, so it is a aerosol.
2. Whipped cream is a colloid. It consists of a gas in a liquid, so it is a foam.
3. Sol is a colloidal suspension with solid particles in a liquid.
4. The light is reflected off the large particles and spread out.
5. It's considered a suspension if the particles are larger than 1000 nanometers.