Chapter Eigh

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COLLOIDAL STATE✓

Colloidal State

Consist of two phases

8.1. INTRODUCTION

An ordinary solution consists of two components - a solute and a solvent. The particles of the solute are usually normal molecules or ions. For example, when sugar or common salt is added to water a true solution is formed. On the other hand when substances like sand, powdered glass etc. are added to water, they settle down. Such solutions are called *coarse suspensions*. Between these two extremes of true solutions and coarse suspensions exist systems called *colloidal solutions* or colloids. They occupy an intermediate position between true solutions on one hand and suspensions on the other. The word colloids is of Greek origin. (Kolla = glue and eiods = like). Thomas Graham is usually regarded as the founder of Colloid Science.

A colloidal solution, therefore, consists of solute particles which are larger than the normal molecules but not large enough to be seen by a microscope. However, there is no sharp line of demarcation between the true solution and the colloidal solution on one hand, and between colloidal solution and coarse suspension on the other. In a colloidal solution the particle size lies in the range 1 nm to 100 nm. Thus, the essential difference between the solutions, colloids and coarse suspensions lies in their relative particle size. A colloidal solution cannot always be distinguished from a true solution with the naked eye. The particles of a colloidal solution can pass through an ordinary filter paper. A *colloidal solution* is defined as a heterogeneous system consisting of two phases

(*i*) a dispersed phase which consists of the colloidal particles, and

(*ii*) a dispersion medium in which the dispersion of particles takes place.

The dispersion medium usually forms the large fraction of colloids. Each of the two phases making a colloid may be a gas, liquid or a solid. For example, the dispersion of As_2S_3, gold or oil in water forms a colloidal solution.

Some of the distinguishing characteristics of solution, colloid, and suspension are given in Table 8.1.

Table 8.1. Distinguishing Characteristics of Colloid, Suspension and Solution

Properties	Suspension	Colloid	Solution
Particle size	> 100 nm	1 nm - 100 nm	< 1 nm
Separation			
(i) Ordinary filtration	Possible	Not possible	Not possible
(ii) Ultrafiltration	Possible	Possible	Not possible
Settling	Settles under gravity	Settles on centrifugation	Does not settle
Appearance	Opaque	Generally clear	Clear
Diffusion	Not possible	Diffuses slowly	Diffuses rapidly
Brownian motion	Shows	Shows	Not observable
Tyndall effect	Shows	Shows	Not observable
Phase	Heterogeneous	Heterogeneous	Homogeneous
Charge on particles	Positively or negatively charged or neutral particles	Positively or negatively charged	Positive and negative ions or neutral molecules
Examples	Sand or mud suspension	Milk, blood, fog	Urea or salt solution

CLASSIFICATION OF COLLOIDS : Sols

For the classification of colloids a number of criteria have been employed. These

Based on the State of Aggregation of Two Phases :-

Based on the state of aggregation of dispersed phase and dispersion medium, colloidal solutions are classified as shown in Table 8.2. Colloidal solutions are generally sols. We shall mainly deal with colloidal systems in which the dispersed phase is solid and the dispersion medium a liquid. If the dispersion medium is water, they are hydrosols or *aquasols*.

Table 8.2. Classification of Colloidal Solutions

S.No.	Dispersion Medium	Dispersed Phase	Name Imp	Examples
1.	Gas	Liquid	Aerosol	Fog, mist, clouds
2.	"	Solid	Aerosol	Smoke, dust
3.	Liquid	Gas	Foam	Froath, whipped cream
4.	"	Liquid	Emulsion	Milk, oil in water
5.	"	Solid	Sols	AgCl, As_2S_3 in water
6.	Solid	Gas	Solid foam	Pumice stone, ice cream
7.	"	Liquid	Gels	Jellies, curd
8.	"	Solid	Solid sols	Ruby, gem

(b) Based on Interaction of Phases

On the basis of affinity between the dispersed phase and the dispersion medium sols can be divided into two categories, lyophobic and lyophilic sols. Lyophobic (solvent hating) sols have little attraction between the dispersed phase and dispersion medium. Because of the poor interactions, lyophobic sols are less stable, precipitate out easily and are obtained with difficulty. On heating or cooling such a system, solids are obtained which cannot be reconverted into sols either by adding solvent or by warming. Typical examples of such colloids are sols of metals, sulphur and silver halides. Lyophilic (solvent loving) sols on the other hand are systems in which the dispersed phase has some definite affinity for the medium. Lyophilic sols are easily formed and are generally reversible, e.g., gums, starch etc.

When the liquid dispersion medium is water, the terms employed are hydrophobic and *hydrophilic*. Other essential differences between the two types of sols are given in Table 8.3.

Table 8.3. Distinguishing Characteristics of Lyophobic and Lyophilic Sols

S. No.	Lyophobic Sols	Lyophilic Sols
1.	These are generally unstable, get easily coagulated on adding electrolytes.	These are very stable and are not easily coagulated by electrolytes.
2.	These are irreversible in character.	These are reversible in character.
3.	Prepared by indirect methods.	Usually prepared by simple solution methods.
4.	Viscosity of the colloidal dispersion is same as that of the solvent.	These are highly viscous systems.

Lyophobic Sols	Lyophilic Sols
These are generally inorganic materials i.e., metals sulphides and oxide sols.	Mostly organic materials, e.g., starch, gum and proteins.
Surface tension is similar to that of the dispersion medium.	Surface tension is lower than that of the dispersion medium.
Particles carry positive or negative charge.	Particles may have little or no charge at all.
Particles are easily detected under an ultramicroscope.	The particles cannot be readily detected under an ultramicroscope.
Examples: Gold or As_2S_3 in water.	Examples: Gum, starch, proteins.

PREPARATION OF COLLOIDAL SOLUTIONS Imp

Many substances such as gelatin, starch and other high molar mass polymers mixed with a suitable dispersion medium go into the solution form, forming a colloidal solution. Such sols are stable, reversible and are called lyophilic sols. Lyophobic sols on the other hand, are unstable, irreversible and therefore, have to be prepared by special methods. Two methods are generally used for their preparations:

Condensation methods in which the particles present in the true solution as ions or molecules are allowed to grow in size to particles of colloidal dimensions.

Dispersion methods in which the bigger particles are disintegrated into particles of colloidal dimensions which remain in the dispersion medium.

Condensation Methods :-

The substance which is to be dispersed in the medium is obtained by chemical reaction or sometimes by physical changes under controlled conditions of temperature and concentration. The various methods employed are:

Reduction. This method is generally used for the preparation of metal sols and is of historical interest. This method involves the reduction of soluble salts of metals by reducing agents such as hydrogen, formaldehyde, hydrazine, tannin etc. A silver sol may be prepared by passing a current of pure hydrogen through saturated solution of silver oxide at 50 - 60°C.

$$Ag_2O + H_2 \xrightarrow{50-60°C} Ag-Sol.$$

Oxidation. Colloidal sulphur may be prepared by the oxidation of hydrogen sulphide. H_2S is passed into a solution of sulphur dioxide in water until all the odour of sulphur dioxide has been removed.

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$$

(*iii*) **Hydrolysis.** This method is used to obtain sols of oxides or hyd weakly electropositive metals like iron, aluminum etc. A solution of ferr is prepared by adding a small quantity of ferric chloride into a large boiling water.

$$2FeCl_3 + 6H_2O \longrightarrow Fe_2O_3 \cdot 3H_2O + 6HCl$$

(*iv*) **Double Decomposition.** A silver chloride sol can be obtained by mixing solutions of $AgNO_3$ and KCl in nearly equal amounts. The precipitate of A stabilized by the excess of Ag^+ or Cl^- ions.

$$Ag^+ + Cl^- \longrightarrow AgCl_{(s)}$$

Arsenious sulphide sol is obtained by mixing solutions of arsenious oxide hydrogen sulphide.

$$2As^{3+} + 3S^{2-} \longrightarrow As_2S_{3(s)}$$

(*v*) **Exchange of Solvent.** This method is based on the principle that if a subs A is insoluble in one solvent, say X, but soluble in other solvent, say Y, then colloidal solutions of that substance is prepared by dissolving the substance Y and then pouring the solution into an excess of solvent X. This method is to prepare sulphur or phosphorus sols by first dissolving them in alcohol then pouring their alcoholic solutions into water. Such sols are unstable and stabilized by the addition of some stabilizers.

B. **Dispersion Methods** bigger partical disintegr into colloids

Various methods used in dispersion are:

(*i*) **Mechanical Disintegration.** Many substances can be disintegrated particles of colloidal size in a colloid mill. The colloid mill consists of two discs each rotating in opposite direction at a speed of about 7000 rpm. dispersion medium along with the dispersed substance and a protective subs is allowed to pass through the mill where a colloidal solution results.

(*ii*) **Peptization.** The process of dispersing a precipitate into a colloidal solution adding small quantity of an electrolyte is called *peptization*. The electr added is called a *peptizing agent*. For example, freshly precipitated Fe(OH) be peptized by a dilute solution of ferric chloride.

$$\underset{\text{}}{Fe(OH)_3 + Fe^{3+} \longrightarrow \underset{\text{Sol.}}{Fe(OH)_3Fe^{3+}}}$$

Similarly precipitates of many sulphides can be dispersed by passing through water in which they are suspended.

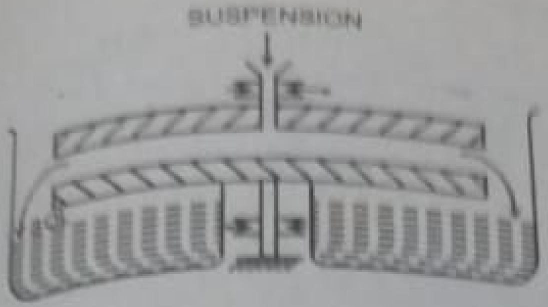

Fig. 8.1. A Colloid mill.

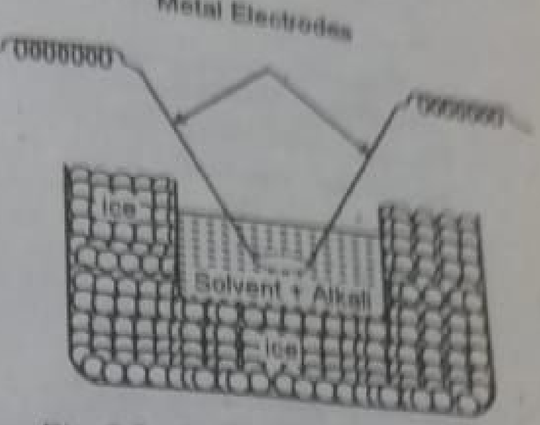

Fig. 8.2. Bredig's arc method.

Arc Method. This method is in preparing colloidal solutions like Au, Pt, Ag etc. It consists in an electric arc between the of metal in water (Fig. 8.2). of the arc evaporates the metal vapors are condensed in water. of alkali metal hydroxide are to stabilize the colloidal This method was improved by alternating current by T. who succeeded in obtaining hydrosols of metals and nonmetals.

ICATION OF COLLOIDS

prepared by any one of the above methods may often contain other the colloidal particles. It is often desirable to remove these impurities, they are electrolytes as they reduce the stability of the sol. The most employed techniques are

and (ii) Ultrafiltration.

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method makes use of the fact that there is a significant difference in size particles and the dissolved molecules or ions. The sol is placed inside consists of a vessel open at both ends. The one end can be covered by a cellophane membrane. The dialyser is nearly filled with the colloidal suspended in a vessel containing distilled water. Crystalloid gets through particles are retained. This process of removing crystalloids or other sol by diffusion through a permeable membrane is known as *dialysis*. the tank is changed periodically. The process of dialysis can be quickened electric field. This process is called *electro-dialysis* and is shown in Fig. solution along with unwanted electrolyte is placed between two