PRESENTATION

BY

Dr.V.A.Kalantre

Colloidal State

Introduction

The soluble substances divided into two classes as below:

1. Crystalloids: Crystalline substances like sugar, urea, salts etc., when dissolved in water, diffuse easily through the parchment (animal or vegetable) membrane are called as crystalloid.

2. Colloids: Amorphous substances like starch, gelatin, gum etc., when dissolved in water, do not diffuse easily through the parchment (animal or vegetable) membranes are called as colloids.

Colloidal state of matter

Depending upon the particle size, there are three types of solutions as below:

1) True solution : It is the clear and transparent solution of a substance whose particle size is less than 10^{-9} m. They can not be seen through highest degree microscope. It is homogeneous. It does not exhibit properties like Tyndall effect, Brownian motion etc.

2) Colloidal solution : It is turbid solution of a substance whose particle size is between 10^{-7} to 10^{-9} m. They can be seen through highest degree microscope. It exhibit properties like Tyndall effect, Brownian motion etc.

3) Suspension : It is solution of a substance whose particle size is grater than 10^{-7} m. Particles can be seen through microscope or naked eyes. On standing these particles are settle down. It is heterogeneous.

Dispersed phase and dispersion medium:

Colloidal solution is a heterogeneous system, so solvent particles and solute particles can be distinguished form each other. So in colloidal chemistry following terms are used for solute, solvent and solution.

1) Dispersed phase (discontinuous or inner phase) : It indicates solute. It can be solid, liquid or gas.

2) Dispersion medium (continuous or outer phase) : It indicates solvent. It can be solid, liquid or gas.

3) Colloidal dispersion: It indicates solution

Types of colloidal systems: Depending upon the state of dispersed phase and dispersion medium, there are nine types of colloidal systems as below

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Sr. No.	Dispersed phase	Dispersion medium	Name of colloidal solution or sol	Examples
1.	Solid	Liquid or water	Sol or hydrosol or aquasol	Solution of gum, gelatin, gold silver in water, blood etc.
2.	Solid	Organic solvent	Organosol	I)Sol in alcohol (alcosol) II)Sol in benzene (benzosol)
3.	Solid	Solid	Solid sol	Coloured glasses, gems, alloys, pastes.
4.	Solid	Gas	Aerosol	Smoke, dust, fumes.
5.	Liquid	Liquid	Emulsion	Milk, water in oil, creams, oil paints, egg albumin.
6.	Liquid	Solid	Gel (Solid emulsion)	Jellies, Jams, butter, curd, boot polish, agar-agar, badami halwa.
7.	Liquid	Gas	liquid aerosol	Rain, clouds, mist, fog.
8.	Gas	Liquid	Foam	Soap-leather, foam
9.	Gas	Solid	Solid foam	Pumice stone, sponge, rubber cake.

Based on the affinity of for the dispersion medium colloids are classified as:

1) **Lyophilic sols:** They are solvent loving sols. After precipitation they can be converted back to colloidal form. So they are also called as reversible sols. e. g. sol of starch, gelatin, gum,Proteins in water etc. .

2) **Lyophobic sols:** They are solvent hating sols. After precipitation they can not be converted back to colloids. So they are also called as irreversible sols. e. g. sol of metals, metal sulphides, metal hydroxides,Silver halides in water etc.

Solids in liquids (Sols)

Preparation of Sols: - Two different types of method used for preparation of sols are, dispersion and aggregation methods.

Dispersion methods (Physical methods) : In these methods, bigger particles are broken down to a colloidal particles by some mechanical means. Dispersion can be achieved by various ways as follows

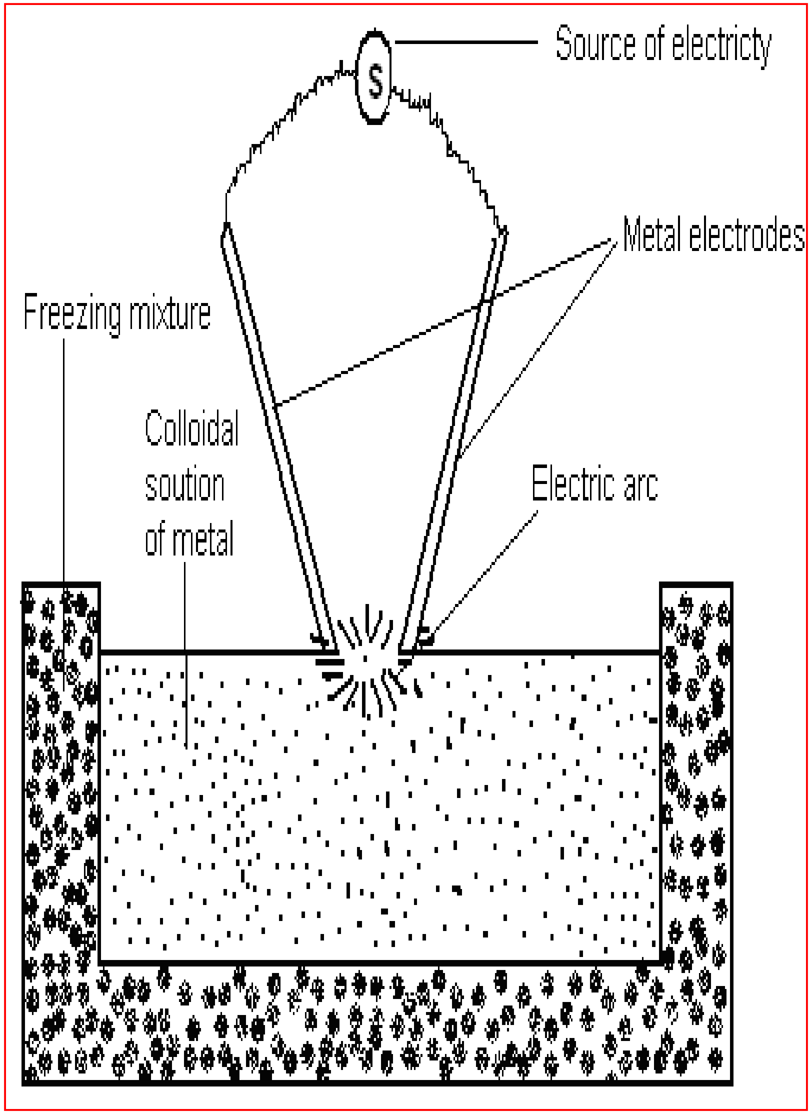


Fig. electrical dispersion

i)Electrical dispersion method :

Electrodes are made up of metals whose colloidal solution is to be prepared. These electrodes are immersed and kept close together in a dispersion medium. The dispersion medium is cooled by freezing mixture. The electrodes are connected to source of electricity. On passing electric current, an arc is struck between the electrodes. The heat of arc vaporises the substance and these vapours are suddenly cooled by freezing mixture. As a result particles get condensed to form colloidal solution.

By this method colloidal solution of gold, silver and platinum are obtained.

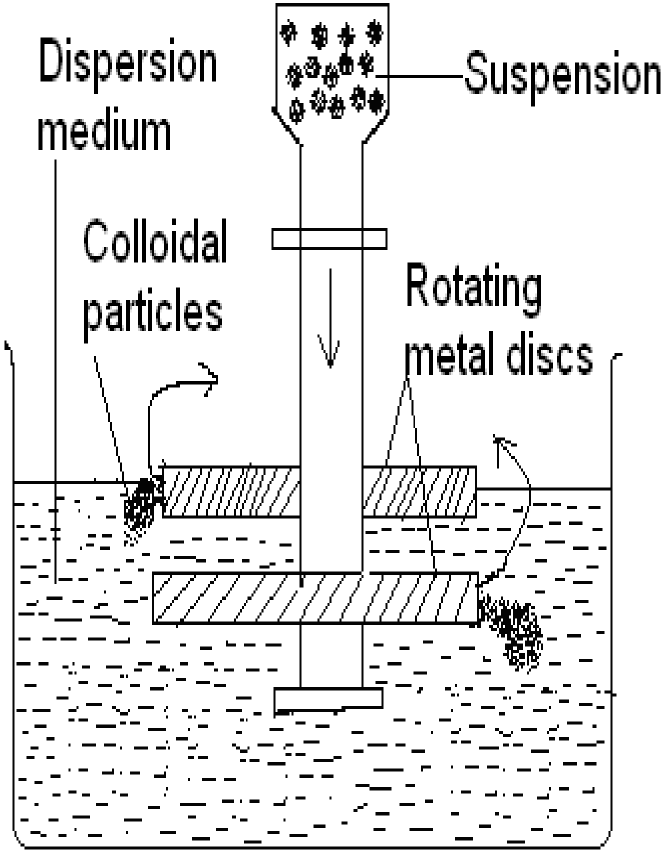


Fig. Colloidal mill

ii) Mechanical dispersion method: The substance whose colloidal solution is to be prepared is ground to fine powder. A suspension is obtained by shaking with dispersion medium. This suspension is then passed through a colloidal mill. Colloidal mill consist of two metal discs kept close together and rotated in opposite direction. In the mill, bigger particles of suspension are break down to colloidal size particles and dropped into dispersion medium to form colloidal solution.

By this method colloidal solution of ink, sulphur, indigo etc. are obtained.

iii) Peptization: In peptization, dispersion is caused by chemical action. It is reverse of precipitation. Here precipitate is kept warm at about 323 K for long time in presence of electrolyte. The electrolyte must have common ion with the precipitate. This electrolyte is known as peptizing agent.

e. g.

i) $Fe(OH)_3$ precipitate can be peptized by $FeCl_3$. Here Fe^{3+} ions are common ions.

ii) AgCl precipitate can be peptized by $AgNO_3$ or NaCl or KCl.

2. Aggregation methods (Condensation or chemical methods) : In these methods, the small size particles are made to condense together by chemical action or change of solvent to produce of colloidal particles.

i) Oxidation: Oxidation of H_2S solution with air (O) or SO_2 gives colloidal solution of sulphur.

$$H_2S + [O] \longrightarrow H_2O + S \text{ (colloidal)}$$

$$2H_2S + SO_2 \rightarrow 2H_2O + 3S \text{ (colloidal)}$$

ii) Reduction: This method is used to prepare sols of gold, silver, platinum etc. The dilute solutions of metal salts are reduced by the reducing agents like formaldhyde, tannin, $SnCl_2$, H_2 etc.

e. g. Colloidal solution of gold can be prepared as

$$2AuCl_3 + 3HCHO + 3H_2O \longrightarrow \underset{\text{(colloidal)}}{2Au} + 3HCOOH + 6HCl$$

$$2AuCl_3 + 3SnCl_2 \longrightarrow \underset{\text{(colloidal)}}{2Au} + 3SnCl_4$$

iii) Hydrolysis: This method is used to prepare sols of oxides and hydroxides. e.g. sol of ferric hydroxide can be obtained by adding a small quantity of ferric chloride to the boiling water.

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3 + 3HCl$$

iv) Double decomposition : Very dilute solutions of the reactants when mixed slowly and stirred, produce colloidal solution instead of precipitate.

$$As_2O_3 + 3H_2S \longrightarrow As_2S_3 + 3H_2O$$

v) Exchange of solvent :

Sols can also obtained by exchange of solvents. e. g. When concentrated solution of sulphur in alcohol is poured in large amount of boiling water, colloidal solution of sulphur is obtain due to evaporation of alcohol.

B) Purification of Sols

Colloidal solution prepared by above methods contains excess quantities of electrolytes and some other soluble impurities. Excess quantity of electrolytes causes precipitation of sols. However, small quantities of these electrolytes are needed for stabilisation of sols. Different methods employed to reduce concentration of electrolytes are as below

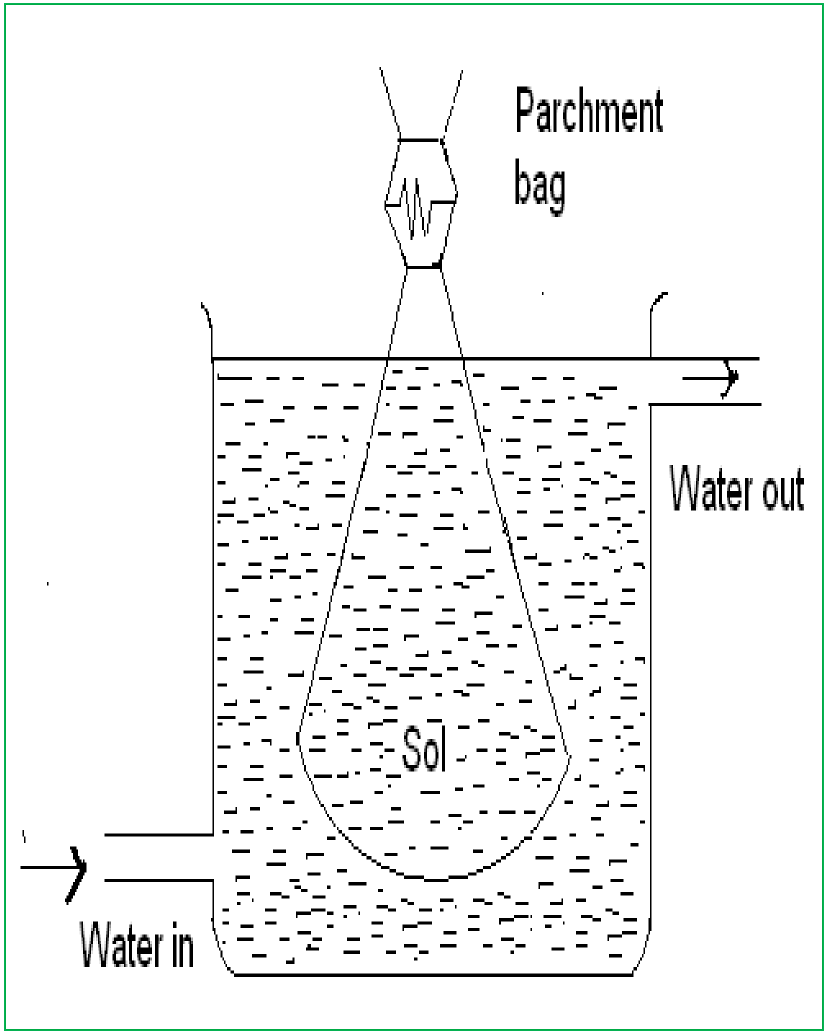


Fig. Dialysis

1. Dialysis : The sol is enclosed in parchment or cellophane bag and suspended in running water in a trough as shown in following figure. The soluble impurities pass out from parchment or cellophane bag leaving behind the pure sol in it. This process of purification is known as dialysis. The rate of dialysis can be increased by using hot water instead of cold water.

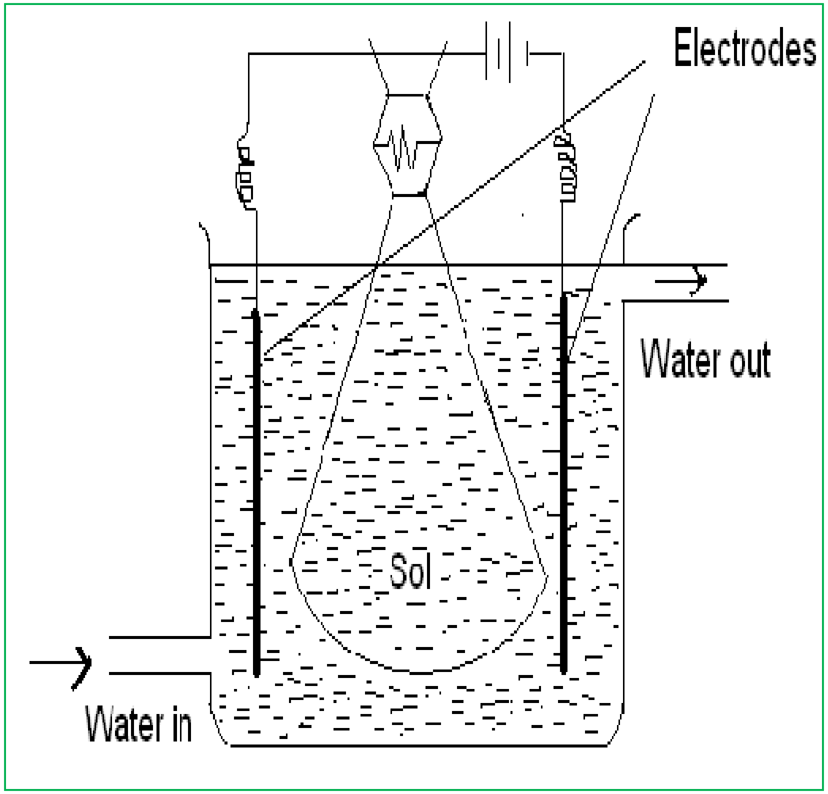


Fig. electrodialysis

2. Electrodialysis : Here dialysis is carried out under the influence of electric field. By applying the electric field, the ions of electrolyte migrate towards oppositely charged electrodes while colloidal particles are remained in parchment or cellophane bag. Electrodialysis is not possible in case of non-electrolyte impurities like sugar, urea etc.

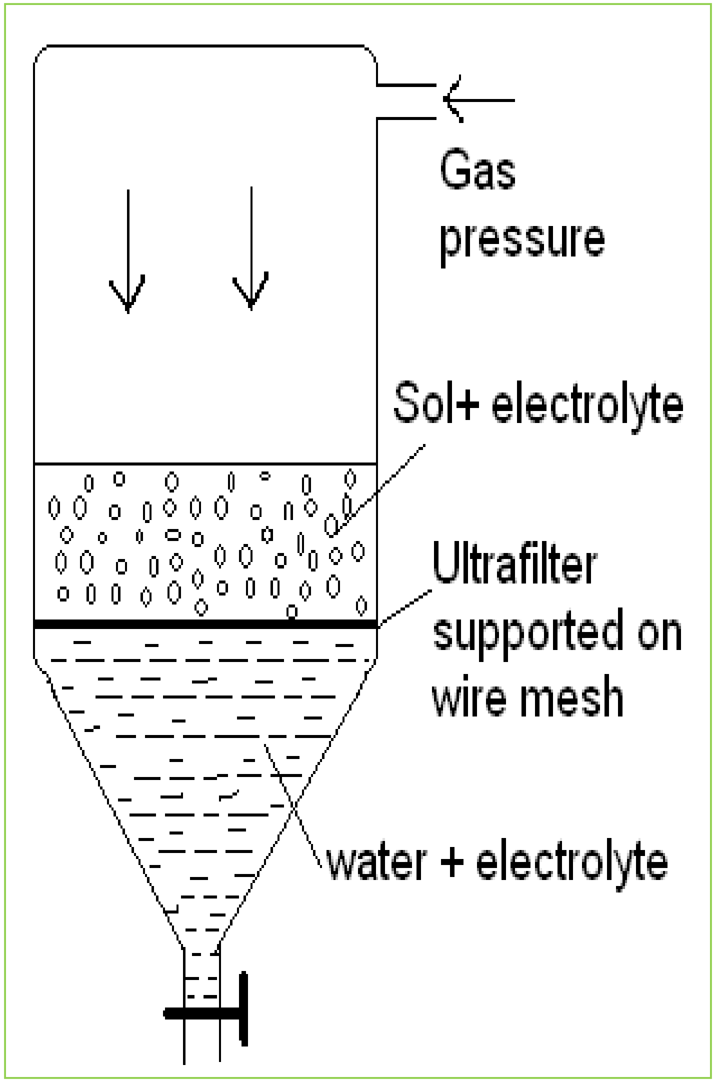


Fig. Ultrafilteration

3. Ultrafilteration : The separation of sol particles from the liquid medium by filtration through a modified filter paper (known as ultrafilter) is called utrafilteration.

To speed up ultrafilteration process gas pressure or suction has to be applied. The colloidal particles are left on the ultrafilter in the form of slime. The slime can be stirred into fresh solvent to get back the pure sol.

Liquids in liquids (Emulsions)

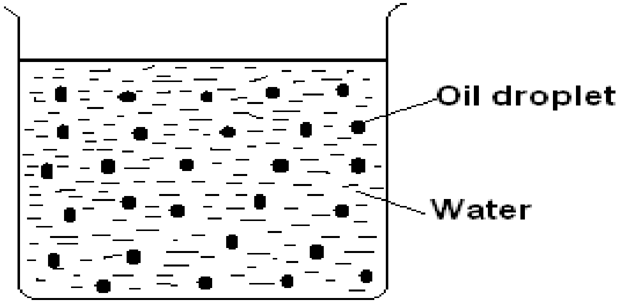
Emulsions are colloidal systems of two immiscible liquids. Both disperse phase and dispersion medium are liquids. e.g. milk, cod-liver oil.

Types of emulsion: emulsions are classified into two types depending on the relative proportion of two liquids as below

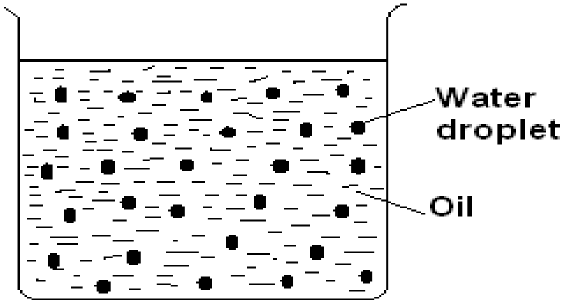
1) Oil in water: Small quantity of oil (disperse phase) is dispersed in large quantity of water (dispersion medium) e.g. milk, vanishing cream etc.

2) Water in oil: Small quantity of water (disperse phase) is dispersed in large quantity of oil (dispersion medium) e.g. cod-liver oil, cold cream etc.

Oil in water

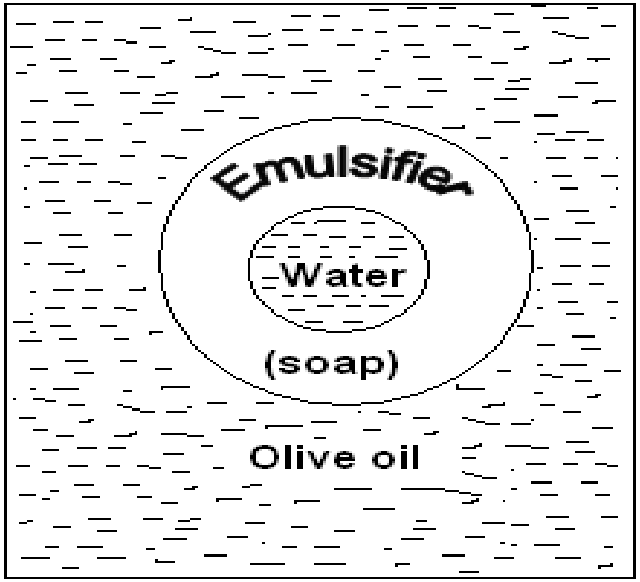


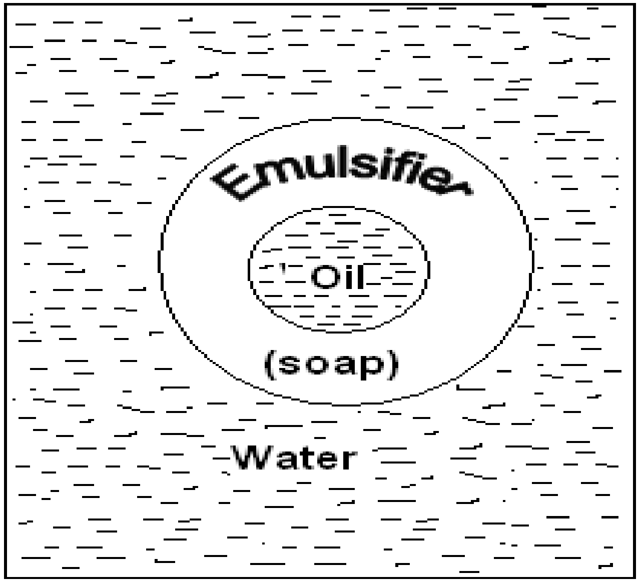
Water in oil



Preparation of emulsions and emulsifiers: If a pair of immiscible liquids are mixed and shaken, a dispersion of very fine droplets of one liquid in the other is result is termed as emulsion.

Emulsions are unstable and separate into two layers on keeping. To obtain stable emulsions, small quantity of an emulsifier or emulsifying agent (soap) is added. The emulsifier decreases the interfacial tension between the two liquids and becomes concentrated at the interface. Thus soap forms a protective layer on the oil or water drops and prevents union of droplets as shown in figure.





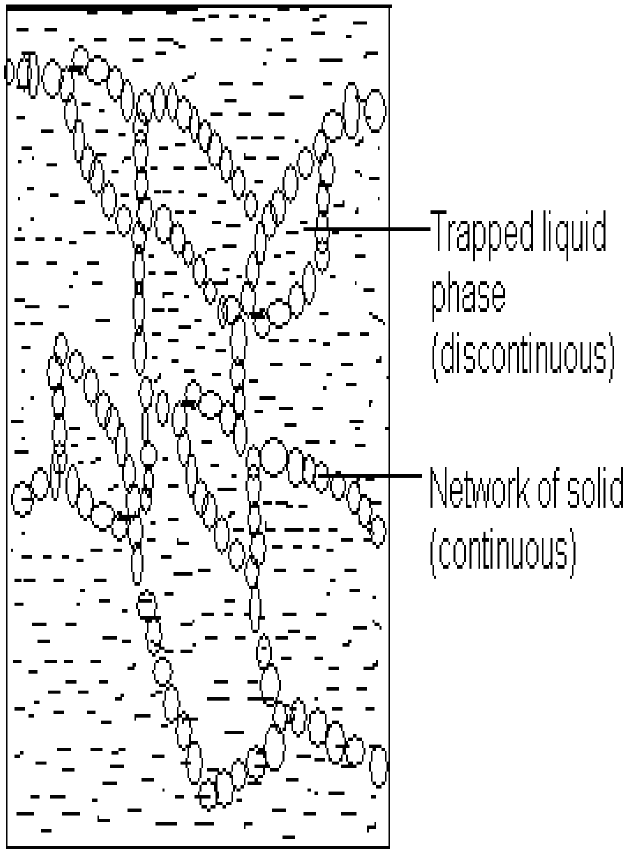


Fig. Structure of gel

Liquids in solids (Gels)

In gels, liquid is dispersed in solid dispersion medium. e.g. jellies, jams, agar-agar, curd etc.

Preparation of gels: In gel formation, colloidal particles aggregate and grow in size. This growth is continuous, particles touch each other and network of bigger particles is formed. The network of particles trapped liquid phase. Thus, liquid forms discontinuous (dispersed) phase and solid forms continuous phase (dispersion medium). The process of gel formation is known as gelation.

Types or classification of gels:

Gels are classified into two types.

i) Elastic gels: Gels which shrink by losing liquid, retain their elastic properties and can retain the original form by adding liquids are known as elastic gels. Elastic gels are reversible and exhibit imbibitions. e. g. gelatine, fruit jams, agar-agar etc.

ii) Non-elastic gels: Gels which shrink by losing liquid, lose their elastic properties and can not retain the original form by adding liquids are known as Non-elastic gels. Non-elastic gels are irreversible and do not exhibit imbibitions. e.g. silica gel, solid alcohol gel etc.

Properties of gels:

Gels shows following three specific properties

i) Imbibition: Swelling of the gel by absorbing liquid is known as imbibition.

ii) Syneresis: Shrinking of gels by losing water when exposed to atmosphere is known as syneresis.

iii) Thixotropy: Some gels form sol on shaking and reset on standing. This reversible gel-sol transformation is known as thixotropy.

c) Properties of Sols **1. Colour**

Colloidal particles are bigger in size. They reflect the light falling on them. The colour of sol depends upon the particle size. A given sol has different colours depending on particle size.

e. g. i) Gold particles having smallest size are red in colour. It changes to purple to blue with increase of particle sizes.

ii) Colloidal particles present in cloud scatter only blue coloured light, hence the sky is blue. As the particle size changes colour of the sky also changes.

2. Optical properties

Tyndall effect:

When a beam of light is passed through the true solution, its path does not become visible. However, if same beam of light is passed through the colloidal solution, its path becomes visible. This phenomenon is known as Tyndall effect. The cone of light which becomes visible is known as Tyndall cone or Tyndall beam. Tyndall effect is observed due to 1) scattering of light by colloidal particles 2) difference in refractive indices of dispersion medium and colloidal particles.

In case of true solution complete darkness is observed because true solution contains the particles which are smaller than the wavelength of visible light.

Applications: Tyndall effect is used 1. to distinguish true solution from colloidal solution

2. to count the number of colloidal particles in a given volume of sol.

3. to test the purity of SO_2 gas used in the manufacture of H_2SO_4.

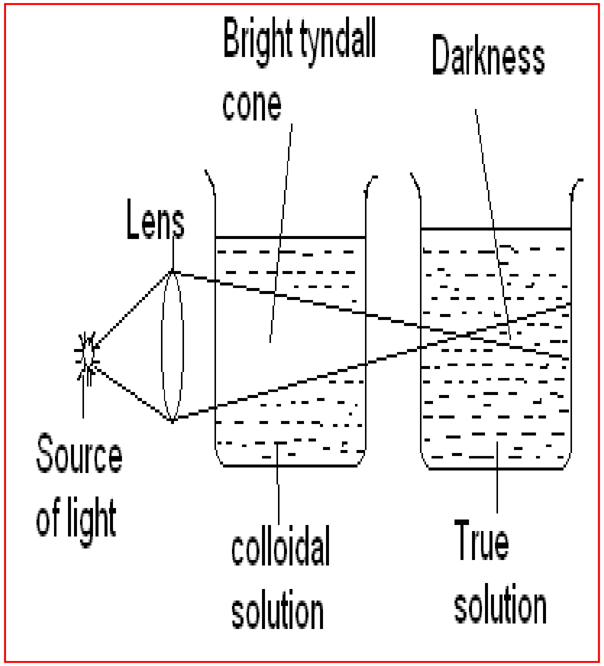


Fig. Tyndall phenomenon

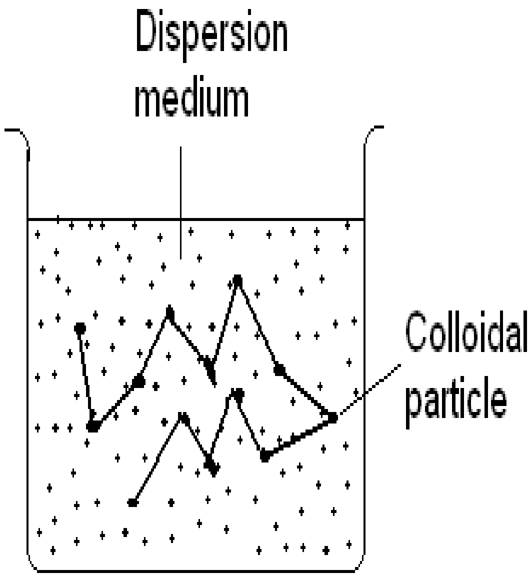


Fig. Brownian motion

3. Kinetic or mechanical properties

Brownian movement: Robert brown observed that colloidal particles (e.g. pollen grains) when suspended in water, shows continuous and zig-zag motion. This zig-zag motion of colloidal particles in all direction along straight line path is called Brownian movement.

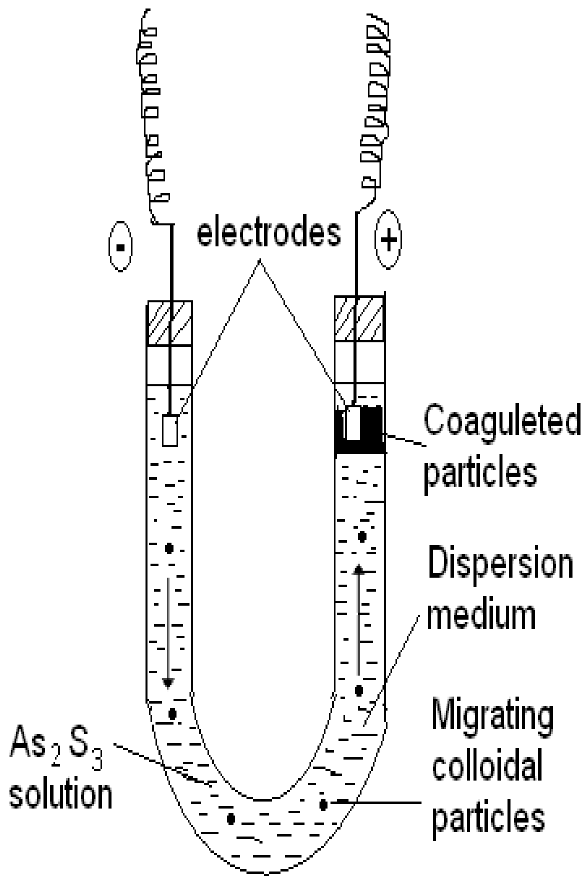
Brownian movement is due to

1) continuous bombardment of colloidal particles with the particles of dispersion medium or wall of container 2) repulsion between colloidal particles due to same charge.

Brownian motion is independent of the nature of colloidal particles and dispersion medium. It depends on viscosity of the solution and size of the particles.

Applications: 1. Brownian motion is responsible for stability of sol.

2. Avogadro's number can be determined by Brownian motion.



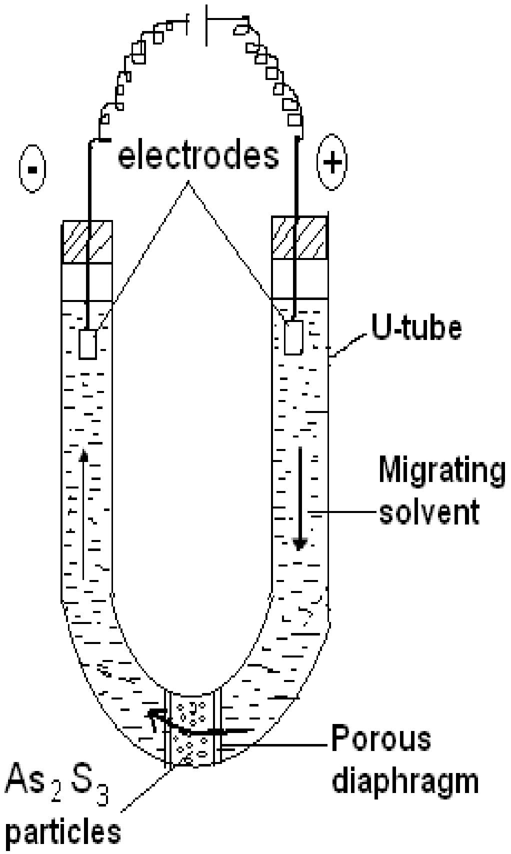
4. Electrical properties: All colloidal particles in a particular sol have the same charge (either +ve or –ve) and shows following electrical properties.

1. Electrophoresis: It is the migration of colloidal particles towards oppositely charged electrodes under the influence of electric field.

Procedure: Take As_2S_3 sol in a ‘U’ tube. To the two ends of ‘U’ tube, insert two platinum electrodes through rubber cork. On passing electric currents As_2S_3 particles move towards the positive electrode and get colleted on it. This indicates that As_2S_3 particles are negatively charged.

Applications: electrophoresis is used

1. to determine the charge of colloidal particles.
2. to prepare rubber cloth.
3. to remove dust and smoke form chimney gases.
4. to separate the proteins from mixtures.



2. Electroosmosis: It is the process of migration of dispersion medium towards the respective electrode through a semi-permeable membrane and under the influence of electric field.

Procedure: In this process, a porous diaphragm of colloidal particles is fixed at the base of 'U' tube containing water or dispersion medium. When a potential is applied across the two electrodes immersed in water, water will migrate towards anode or cathode depending on the charge of colloidal particles.

Applications: Electroosmosis can be used

1. to determine charge of colloidal particles.
2. in drying of dye-pastes, in dewatering moist clay.
3. to remove water from peat.

D) Stability of Sols

The stability of sols is mainly due to two factors

1. Presence of same charge on sol particles: Due to the same charge, colloidal particles repel each other and resist joining together. Therefore sol remains stable.

2. Presence of solvent layer around sol particles: Due to presence of solvent layer around sol particles colloidal particles can not combine or aggregate. Thus precipitation is prevented and colloidal solution remains stable.

Protective action : Lyophobic sols are stabilized by the addition of lyophilic sols. This property of lyophilic sol to prevent the precipitation of lyophobic sol is called protective action and lyophilic sol is called protective colloid.

e. g. Small amount of gelatin (hydrophilic sol) is added to a gold sol (hydrophobic sol), to prevent the precipitation of gold sol.

The particles of lyophobic sol adsorb the particles of lyophilic sol. Thus the lyophilic sol forms a coating around the lyophobic sol particles. Therefore lyophobic sol behaves as lyophilic sol and is less precipitated by electrolytes.

Precipitation of sol is called coagulation.

Hardy-Schulze law : The charge of colloidal particles can be neutralized by the oppositely charged ion of the added electrolyte and coagulation takes place. A certain minimum amount of electrolytes in millimoles required to coagulate $1dm^3$ of any standard sol is known as precipitation or flocculation value. Lower the precipitation value, more is the efficiency of electrolyte for precipitation. The relation between two can be studied with the help of Hardy-Schulze law as below

1. An ion having a charge opposite to that of the colloid is only responsible for the coagulation. e. g. cation of added electrolyte coagulates –ve sol while anion coagulates +ve sol.

2. The coagulation power of an ion increases with its valency (oxidation state). Coagulation power increases in the following order

$Na^{+} < Ba^{++} < Al^{+++}$

and $Cl^{-} < SO_4^{--} < PO_4^{---}$

Gold number :

The term gold number was introduced to measure the protective powers of different protective colloids.

The gold number is defined as, the number of millligrams of protective colloid which prevent the precipitation of 10 ml of a gold hydrosol on adding 1 ml of 10% solution of NaCl.

The smaller the gold number of a lyophilic colloid, the greater is its protective power. e. g. gelatine has a small gold number while potato starch has high gold number.

General applications of colloids

The most important applications of colloidal chemistry are as follows

1. Foods: The various food stuffs are colloidal in nature

e. g. i) milk is an emulsion of oil dispersed in water.

ii) Ice cream is a dispersion of ice in cream where gelatin is added as protective agent.

iii) Jams, Jellies, Curd, Cheese, eggs etc. are colloidal in nature.

2. Medicines: Colloidal medicines are finely divided; therefore they are more effective and easily absorbed in human system.

e. g. i) Colloidal solutions of gold, calcium, manganese, iron etc. are used to raise the vitality of human systems, for treatment of stomach acidity.

ii) Colloidal sulphur is used to kill the germs in plants.

iv) Antibiotics like penicillin and streptomycin in colloidal forms are suitable for injection.

v) Cod-liver oil used as medicine.

3. Sewage precipitation: Sewage water contains colloidal particles of dirt, mud, rubbish etc. and can be separated by electrophoresis. They can also be precipitated out by adding oppositely charged sols, electrolytes etc.

4. Precipitation of smoke : In industry it is necessary to purify air from smoke to avoid air pollution. Smoke contains negatively charged colloidal particles of carbon dispersed in air. This smoke is passed through metallic electrodes and potential is applied across the electrodes. The colloidal particles move towards oppositely charged electrode and get precipitated.

5. Tanning of leather : Hide contains positively charged colloidal particles and hence when treated with tannins, coagulation of colloidal particles takes place which is then finished by other treatments. The process is called as tanning of leather.

6. Industrial goods : Many industrial goods are colloidal in nature. e.g. Soaps and detergents, paints, varnishes, resins, gums, adhesives etc.

7. Rubber plating : Rubber latex contains negatively charged colloidal particles. Therefore rubber articles can be prepared by electrophoresis of rubber sol.

8. Separation of proteins : Electrophoresis is used for separation of proteins. Human blood contain three types of protein and can be separated form each other by electrophoresis.

9. Colloidal substances are also used in purification of water, dyeing, artificial rain, artificial kidney machine, smoke screens etc.

Koyana Education Society's,

BALASAHEB DESAI COLLEGE, PATAN DIST- SATARA

AND

S. G. M. COLLEGE, KARAD, DIST- SATARA, (LEAD COLLEGE)

ONE DAY WORKSHOP ON

Celebration of International year of Chemistry

On Friday 23rd September, 2011.

10.00 – 10.30 a m Registration of Students and Teachers

SESSION – I

10.30 – 12.00 a m :

Welcome : Dr.M.R. Kadam

Introduction : Dr.V.A.Kalantre

Head, Department of Chemistry B.D.College,Patan

Member of B.O.S. & Faculty of Science

S.U.Kolhapur

Chief Guest : Prof.Dr.G.S.Gokavi

Department of Chemistry

Member of B.O.S. & Faculty of Science

S.U.Kolhapur

Chair person : Prin.G.S.Zulzule

Principal,B.D.College,Patan

Vote of Thanks : Dr. P.D.Kamble

12.00 to 1.00 p.m. Tea and Refreshment

SESSION – II

1.00- 3.00 pm Programme to create scientific awareness

Organized by Chemistry Association

Vote of Thanks : Mrs. R. R. Patil

Thank You
From
Miss Lohar D.A.
B.Sc I