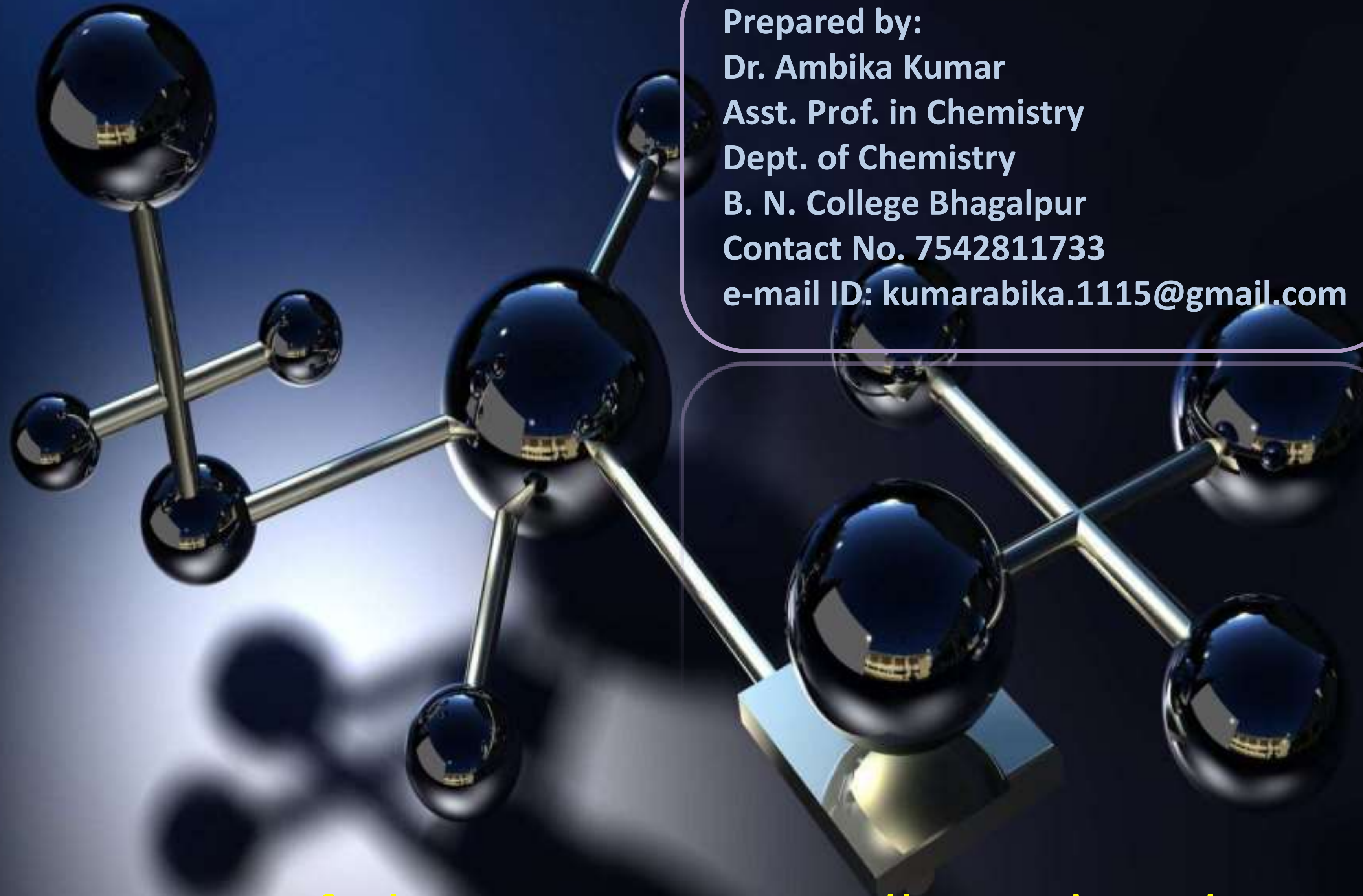

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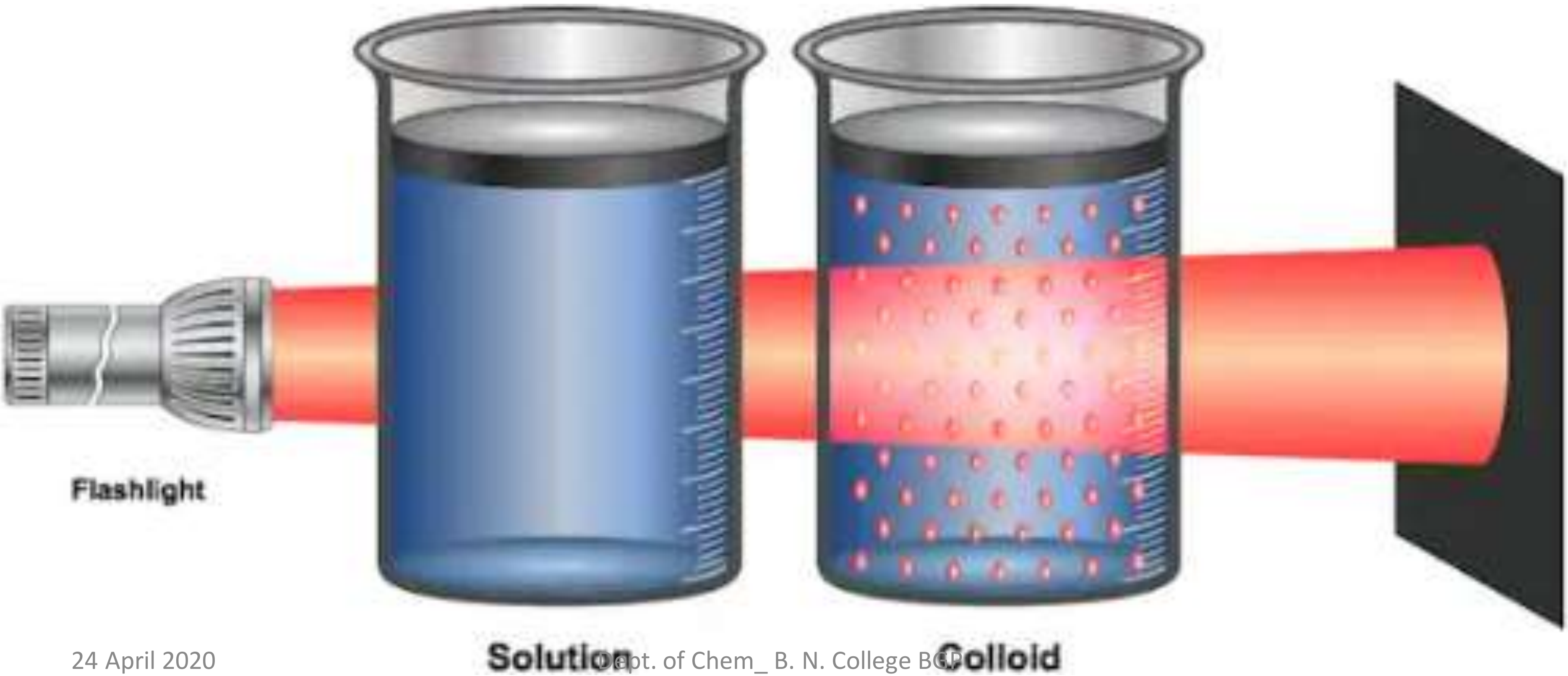
Topic: Colloidal States

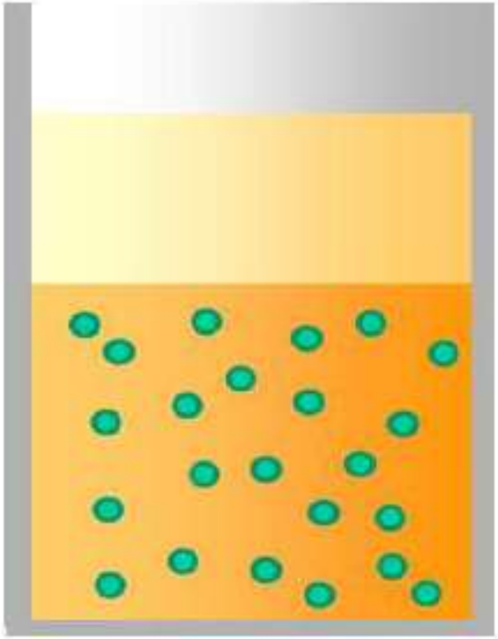


A **colloid** is a mixture in which **one substance of dispersed insoluble particles is suspended throughout another substance.** Colloidal solution refers to the overall mixture.

Unlike a solution, in which 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 be a colloid, the mixture must be one that does not settle or would take a very long time to settle.

COLLOIDS

- A colloid is a substance microscopically dispersed throughout another substance

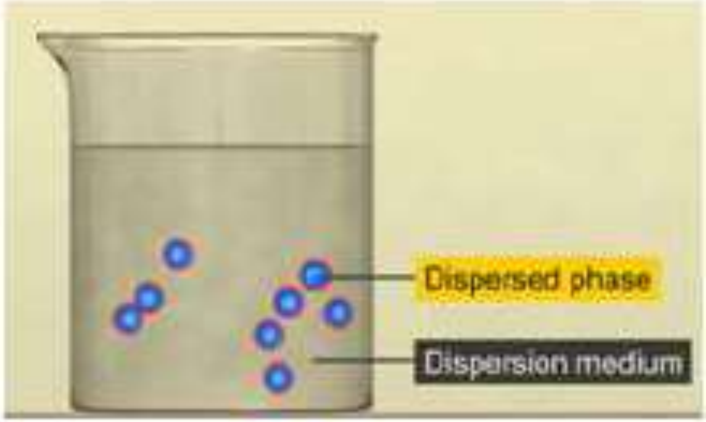


- The word colloid comes from a Greek word '**kolla**', which means glue thus colloidal particles are glue like substances.
- These particles pass through a filter pap but not through a semipermeable membrane.
- Colloids can be made settle by the process of centrifugation.

➤ The colloidal system consist of two phases:

A dispersed phase (A discontinuous phase)

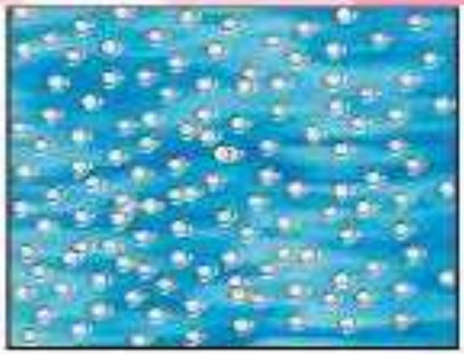
A dispersion medium (A continuous phase)



- The dispersed-phase particles have a diameter of between approximately **1nm – 100nm** .
- Such particles are normally invisible in an optical, though their presence can be confirmed with the use of an **ultramicroscope or an electron microscope.**

SOLUTIONS

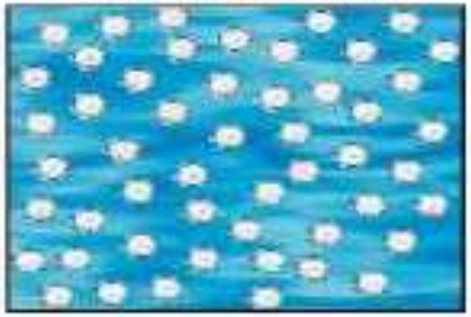
- Made up of particles or solutes and a solvent
- The solvent part of the solution is usually a liquid, but can be a gas.
- The particles are atoms, ions, or molecules that are very small in diameter.



True solution

COLLOIDAL MIXTURE

- Has particles that are not as small as a solution and not as large as a suspension.
- The particles are intermediate in size.



Colloidal solution

SUSPENSIONS

- Made up of particles and a solvent
  its particles are larger than those found in a solution.
- The particles in a suspension can be distributed throughout the suspension evenly by shaking the mixture.

Suspensions

Solution:

Table salt dissolves in water to form Salt (saline) water. A solute (salt; NaCl)is dissolved in another substance (water) known as a solvent, and this creates a solution.

Suspension:

Flour suspended in water (appears light blue because blue light is scattered off the flour particles to a greater extent than red light)

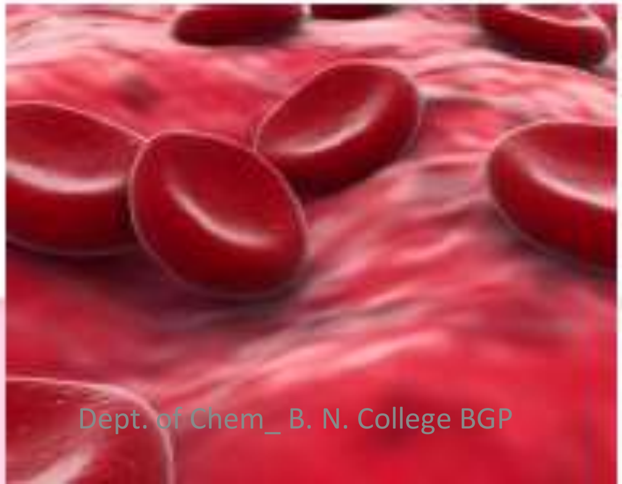
Colloid:

Milk is an emulsified colloid of liquid butterfat globules dispersed within a water based liquid. Colloids are Stabilized in suspension by Electrostatics - mutual Repulsion of like electrical Charges.

Comparison of the Properties of Solutions, Colloids, And Suspensions

Property	True Solution	Colloid	Suspension
Particle Size	Less than 1 nm	1 to 100 nm	More than 100 nm
Appearance	Clear	Cloudy	Cloudy
Homogeneity	Homogeneous	Homogeneous or Heterogeneous	Heterogeneous
Transparency	Transparent but often coloured	Often translucent and opaque but can be transparent	Often opaque but can be translucent
Separation	Does not separate	Can be seperated	Separates or settles
Filterability	Passes through filter paper	Passes through filter paper	Particles do not pass through filter paper

- Examples of colloids are milk, synthetic polymers, fog,
  blood, jam, shoe polish, smoke, etc.



CLASSIFICATION OF COLLOIDS

- Based of physical state of dispersed phase an dispersion medium.
- Based of nature of interaction between dispersed phase and dispersion medium.
- Based on molecular size in the dispersed phase.
- Based on appearance of colloids.
- Based on electric charge on dispersion phase.

Based on physical state of dispersed phase and dispersion medium

Dispersed Phase	Dispersion Medium	Name	Examples
Solid	Solid	Solid-Sol	Alloys, Cranberry glass
Solid	Liquid	Sol	Ink, Blood
Solid	Gas	Aerosol	Smoke, Ice cloud
Liquid	Solid	Gel	Jelly, Curd
Liquid	Liquid	Emulsion	Milk, Cream
Liquid	Gas	Liquid aerosol	Cloud, Fog
Gas	Solid	Solid form	Aerogel, Pumice stone
Gas	Liquid	Foam	Shaving cream
Gas	Gas	None	All gases are miscible

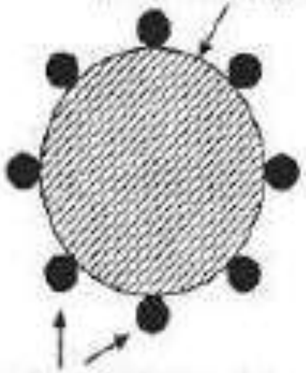
BASED ON NATURE OF INTERACTION BETWEEN DISPERSED PHASE AND DISPERSION MEDIUM

LYOPHILIC COLLOIDS

- Colloidal solution in which the dispersed phase has a great affinity for the dispersion medium.
- They are also termed as **intrinsic colloids**.
- Such substances have tendency to pass into colloidal solution when brought in contact with dispersion medium.
- If the dispersion medium is water, they are called hydrophilic or emulsoids.
- The lyophilic colloids are generally self- stabilized.
- Reversible in nature and are heavily hydrated.
- Example of lyophilic colloids are starch, gelatin, rubber, protein etc.

LYOPHOBIC COLLOIDS

- Colloidal solutions in which the dispersed phase has no affinity to the dispersion medium.
- These are also referred as extrinsic colloids.
- Such substances have no tendency to pass into colloidal solution when brought in contact with dispersion medium.
- The lyophobic colloids are relatively unstable.
- They are irreversible by nature and are stabilized by adding small amount of electrolyte.
- They are poorly hydrated.
- If the dispersion medium is water, the lyophobic colloids are called hyrophobic or suspenoids.
- Examples: sols of metals like Au, Ag, sols of metal hyroxides and sols of metal sulphides.



Based on molecular size in the dispersed phase.

- ## MULTIMOLECULAR COLLOIDS

Individual particles of the dispersed phase consists of aggregates of atoms or small molecules having diameter less than 10^{-7}cm . The particles are held by weak vander waal's forces.

Example; gold sol, sulphur sol

- ## MACROMOLECULAR COLLOIDS

The particles of dispersed phase are sufficiently large in size enough to be of colloidal solution. These are called Natural Polymers.

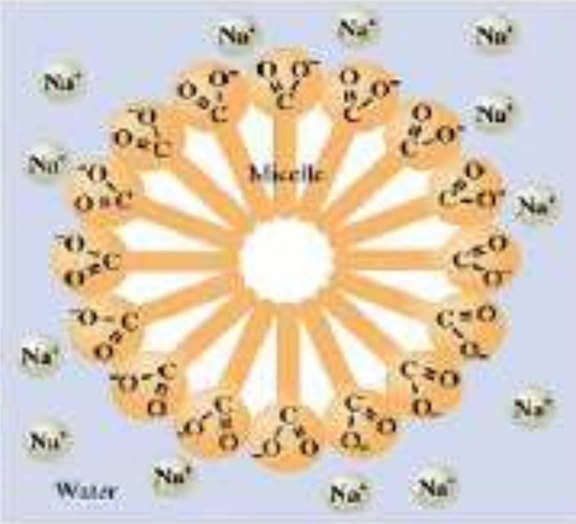
SSOCIATED COLLOIDS

These colloids behave as normal electrolytes at low concentrations but behave as colloids at higher concentrations.

These associated colloids are also referred to as micelles.

Sodium stearate ($C_{18}H_{35}NaO_2$)behave as electrolyte in dilute solution but colloid in higher concentrations.

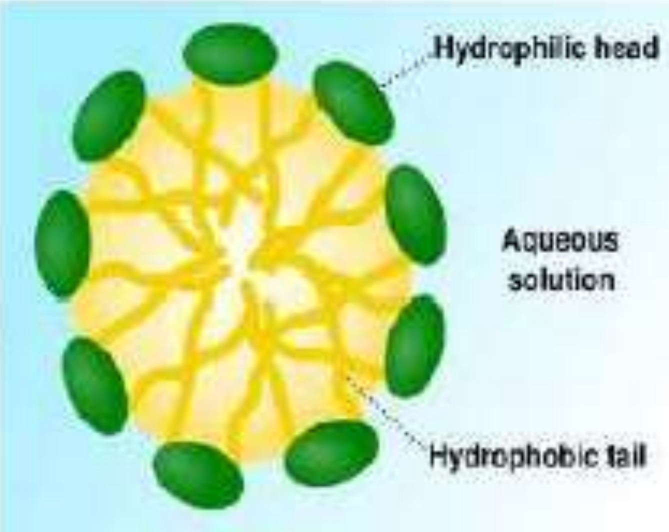
Examples: Soaps , higher alkyl sulphonates , polythene oxide.



HOW DOES SOAP WORK?

- When greasy dirt is mixed with soapy water, the soap molecules arrange themselves into tiny clusters called micelles.

- The water-loving (hydrophilic) part of the soap molecules sticks to the water and points outwards, forming the outer surface of the micelle.



- The oil-loving (hydrophobic) parts stick to the oil and trap oil in the center where it can't come into contact with the water. With the oil tucked safely in the center, the

Based on appearance of colloids

- **SOLS**

- When a colloidal solution appears as fluid.
- The sols are generally named as dispersion medium.
- When the dispersion medium is water, the sol is known as hydrosol or aquosol.
- When the dispersion medium is alcohol or benzene it is called alcosol and benzosol respectively.

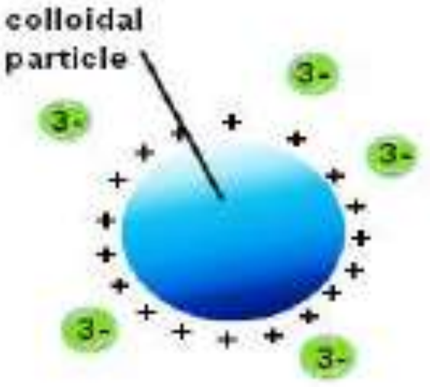
- **GELS**

- When a colloidal solution appear as solid.
- The rigidity of gel varies from substance to substance.
- Examples : jelly, butter, cheese, curd.

BASED ON ELECTRICAL CHARGE ON DISPERSION PHASE

- ## POSITIVE COLLOIDS

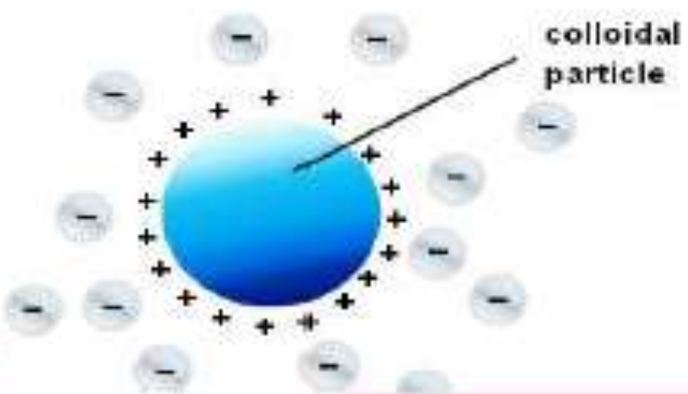
When dispersed phase in a colloidal solution carries a positive charge.



Examples : Metal hyroxides like $Fe(OH)_3$, $Al(OH)_2$, methylene blue sol etc.

- ## NEGATIVE COLLOIDS

When dispersed phase in a colloidal solution carries a negative charge.



Examples : Ag sol, Cu sol

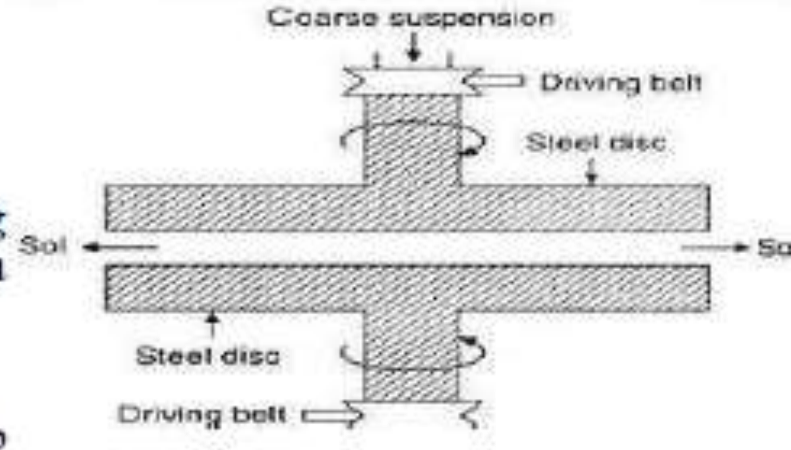
SEPERATION OF COLLOIDS

- *Mechanical Dispersion*
- *Electrical dispersion or Bredig's Arc Method*
- *Peptisation*
- *Condensation Method*

A) Mechanical dispersion:

In this method,

- The substance is first ground to coarse particles.
- It is then mixed with the dispersion medium to get a suspension.
- The suspension is then grinded in colloidal mill.
- It consists of two metallic discs nearly touching each other and rotating in opposite directions at a very high speed about 7000 revolution per minute.
- The space between the discs of the mill is so adjusted that coarse suspension is subjected to great shearing force giving rise to particles of colloidal size.
- Colloidal solutions of black ink, paints, varnishes, dyes etc. are obtained by this method.



(B) By electrical dispersion or Bredig's arc method:

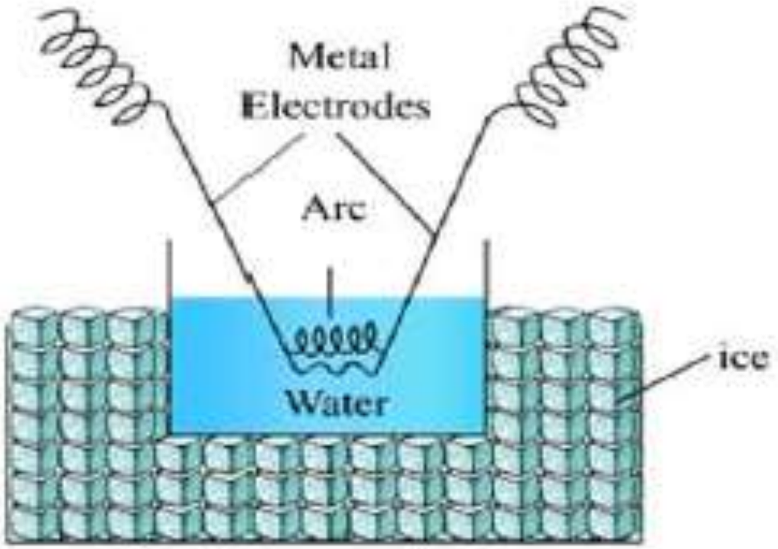
➢This method is used to prepare sols of platinum, silver, copper or gold.

➢ The metal whose sol is to be prepared is made as two electrodes which immerge in dispersion medium such as water etc.

➢The dispersion medium is kept cooled by ice.

➢An electric arc is struck between the electrodes.

➢The tremendous heat generated by this method give colloidal solution.



Bredig's arc method

➢The colloidal solution prepared is stabilized by adding a small amount of KOH to it.

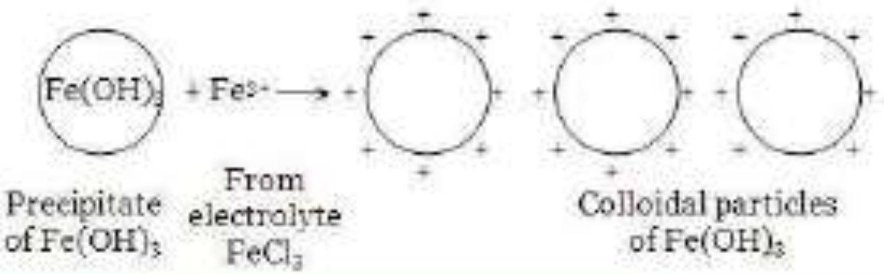
(C) By peptisation:

- The process of converting a freshly prepared precipitate into colloidal form by the addition of suitable electrolyte is called peptisation.

- Cause of peptisation is the adsorption of the ions of the electrolyte by the particles of the precipitate.

- The electrolyte used for this purpose is called peptizing agent or stabilizing agent.

- Important peptizing agents are sugar, gum, gelatin and electrolytes.



(D) Condensation method

- In condensation method, the smaller particles of the dispersed phase are aggregated to form larger particles of colloidal dimensions.
- *Some important condensation methods are described below:*

a) Solutions of substances like mercury and sulphur are prepared by passing their vapours through a cold water containing a suitable stabilizer such as ammonium salt or citrate.

b)By excessive cooling.

A colloidal solution of ice in an organic solvent like ether or chloroform can be prepared by freezing a solution of water in solvent.

The molecules of water which can no longer be held in solution, separately combine to form particles of colloidal size.

c) By exchange of solvent.

Colloidal solution of certain substances such as sulphur, phosphorus which are soluble in alcohol but insoluble in water can be prepared by pouring their alcoholic solution in excess of water.

For example alcoholic solution of sulphur on pouring into water gives milky colloidal solution of sulphur.

d) Chemical methods:

Colloids can be prepared by following chemicals methods.

1) Oxidation:

Addition of oxygen and removal of hydrogen is called oxidation.

For example: Colloidal solution of sulphur can be prepared by oxidizing an aqueous solution of H2S with a suitable oxidizing agent such as bromine water.

$$H_2S + Br_2 \rightarrow 2HBr + S$$

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

2)Reduction:

Addition of hydrogen and removal of oxygen is called reduction.

For example: Gold sol can be obtained by reducing a dilute aqueous solution of gold with stannous chloride.

$$2AuCl_3 + 3SnCl_2 \rightarrow 3SnCl_4 + 2Au$$

3) Hydrolysis:

It is the break down of water.

Sols of ferric hydroxide and aluminium hydroxide can be prepared by boiling the aqueous solution of the corresponding chlorides.

For example.

$$FeCl3 + 3H_2S \rightarrow Fe(OH)3 + 3HCl$$

4) Double Decompostion

The sols of inorganic insoluble salts such as arsenous sulphide, silver halide etc may be prepared by using double decomposition reaction.

For example: Arsenous sulphide sol can be prepared by passing H2S gas through a dilute aqueous solution of arsenous oxide.

$$As_2O_3 + 3H_2S \rightarrow As_2S_3(OH)_3 + 3H_2O$$

Purification of colloids

There are three common methods used for purification of colloids:

- Dialysis
- Electrodialysis
- Ultra filteration

Dialysis

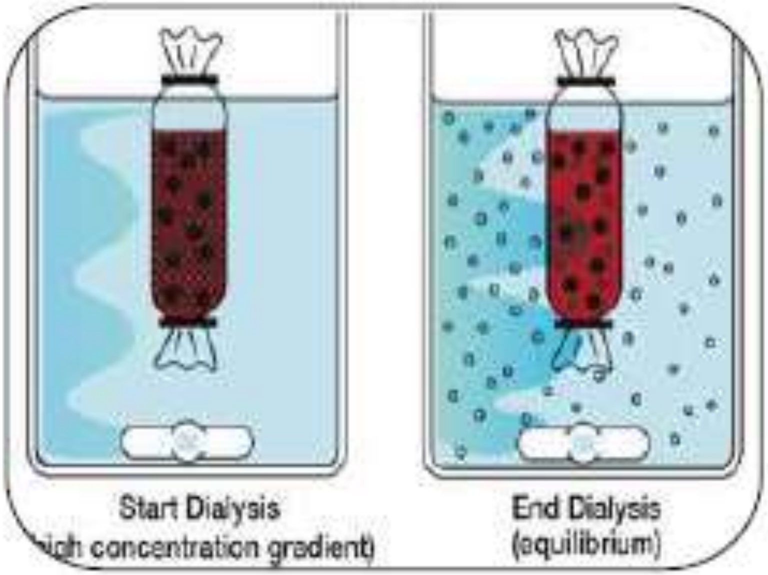
- The process of separating the particles of colloid from those of crystalloid, by means of diffusion through a suitable membrane.

- It's principle is that colloidal particles can not pass through a cellophane membrane while the ions of the electrolyte can pass through it.

- The impurities slowly diffused out of the bag leaving behind pure colloidal solution.

- The distilled water is changed frequently to avoid accumulation of the crystalloids otherwise they may start diffusing back into the bag.

- Dialysis can be used for removing HCl from the ferric hydroxide sol.

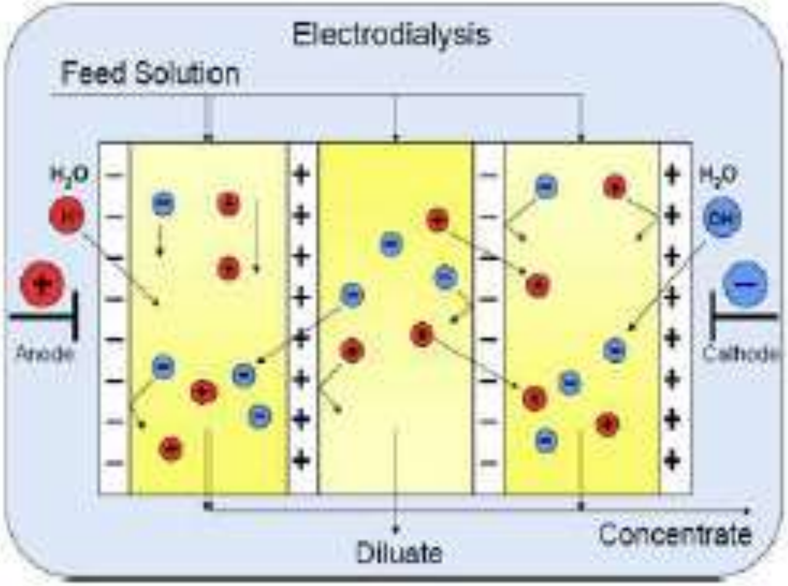


Electro dialysis

➢The process of dialysis is very slow.

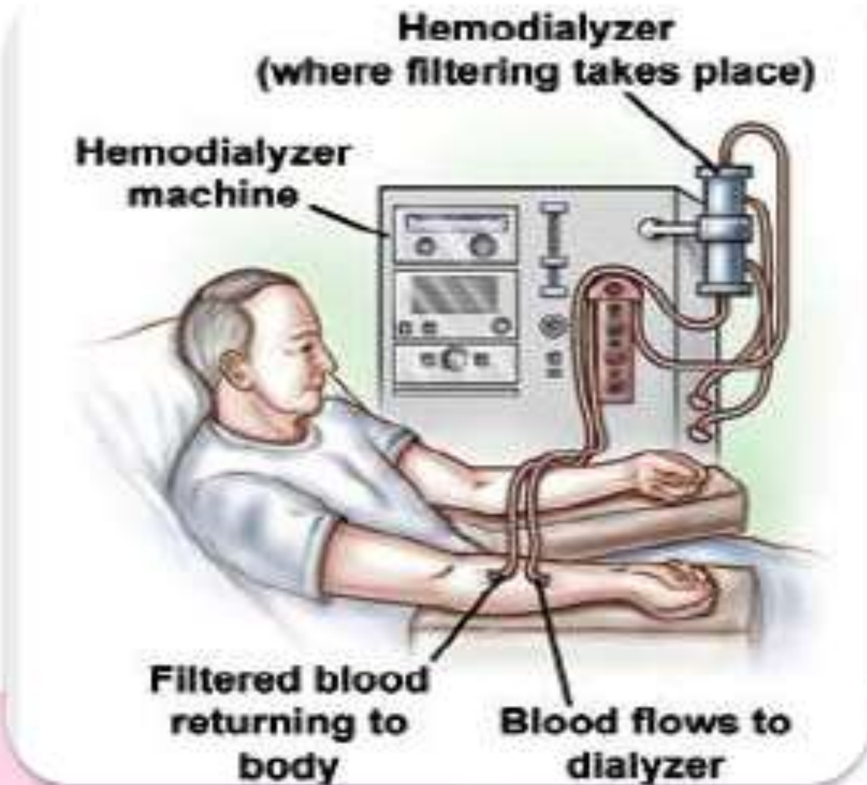
➢The process is speeded up by application of electrical potential.

➢This is called electro dialysis.



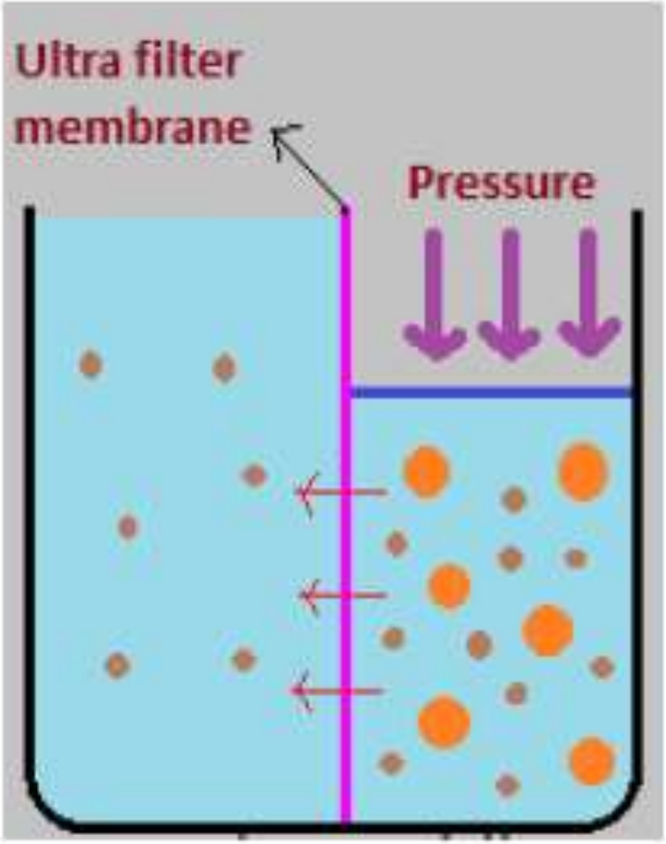
Application of electro dialysis:

Artificial kidney machine make use of electro dialysis.



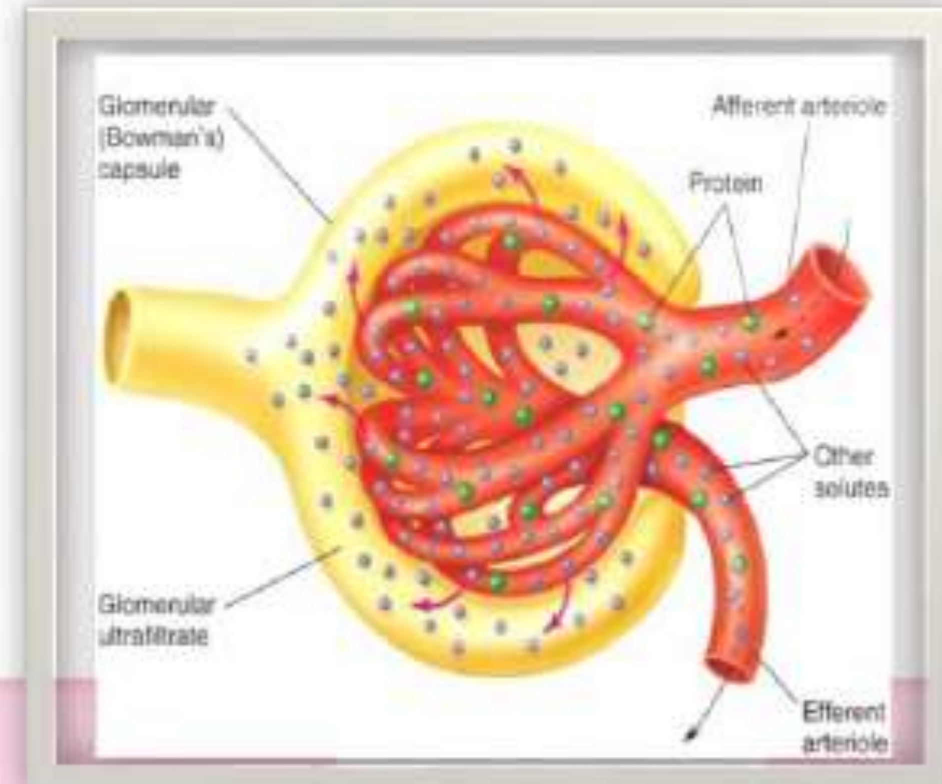
Ultra filtration

- Ultra filtration is a process of high pressure
  filtration through a semi permeable membrane
  in which colloidal particles are retained while
  the small sized solutes and the solvent are
  forced to move across the membrane by
  hydrostatic pressure forces.



Application of ultra filtration:

Ultra filtration is a vital process that takes place in the kidneys.



PROPERTIES OF COLLOIDS

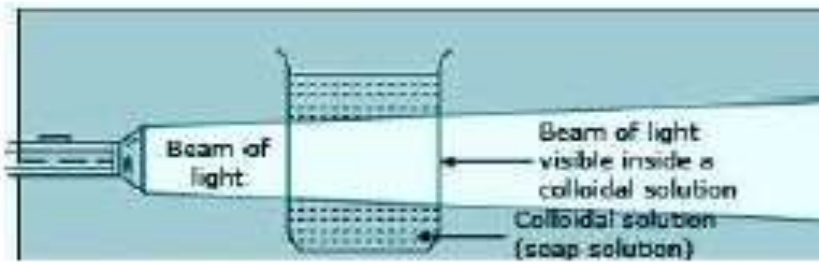
PHYSICAL PROPERTIES OF COLLOIDS

- **Heterogeneity:** Colloidal solutions consist of two phases-dispersed phase and dispersion medium.
- **Visibility of dispersed particles:** The dispersed particles present in them are not visible to the naked eye and they appear homogenous.
- **Filterability:** The colloidal particles pass through an ordinary filter paper. However, they can be retained by animal membranes, cellophane membrane and ultrafilters.
- **Stability:** Lyophilic sols in general and lyophobic sols in the absence of substantial concentrations of electrolytes are quite stable.
- **Colour:** The colour of a colloidal solution depends upon the size of colloidal particles present in it. Larger particles absorb the light of longer wavelength and therefore transmit light of shorter wavelength.

OPTICAL PROPERTIES OFCOLLOIDS

- **TYNDALL EFFECT**

- When an intense converging beam of light is passed through a colloidal solution kept in dark, the path of the beam gets illuminated with a bluish light.

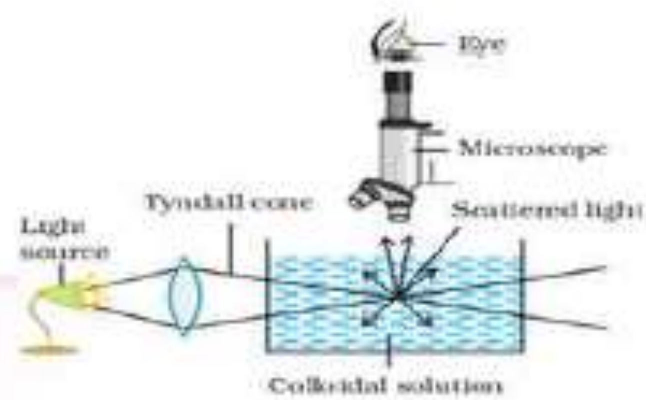


- This phenomenon is called Tyndall effect and the illuminated path is known as **Tyndall cone.**

- The Tyndall effect is due to the scattering of light by colloidal particles.

- Tyndall effect is not exhibited by true solutions. This is because the particles present in a true solution are too small to scatter light.

- Tyndall effect can be used to distinguish a colloidal solution from a true solution. The phenomenon has also been used to devise an instrument known as ultra microscope. The instrument is used for the detection of the particles of colloidal dimensions.

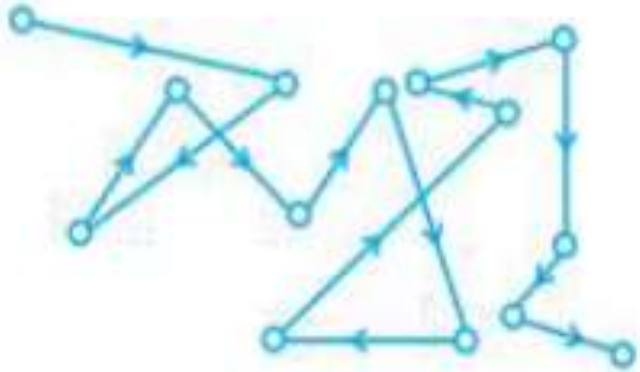


Tyndall effect

MECHANICAL PROPERTIES OF COLLOIDS

- **BROWNIAN MOVEMENT**

- The continuous zigzag movement of the colloidal particles in the dispersion medium in a colloidal solution is called Brownian movement.



- Brownian movement is due to the unequal bombardments of the moving molecules of dispersion medium on colloidal particles.

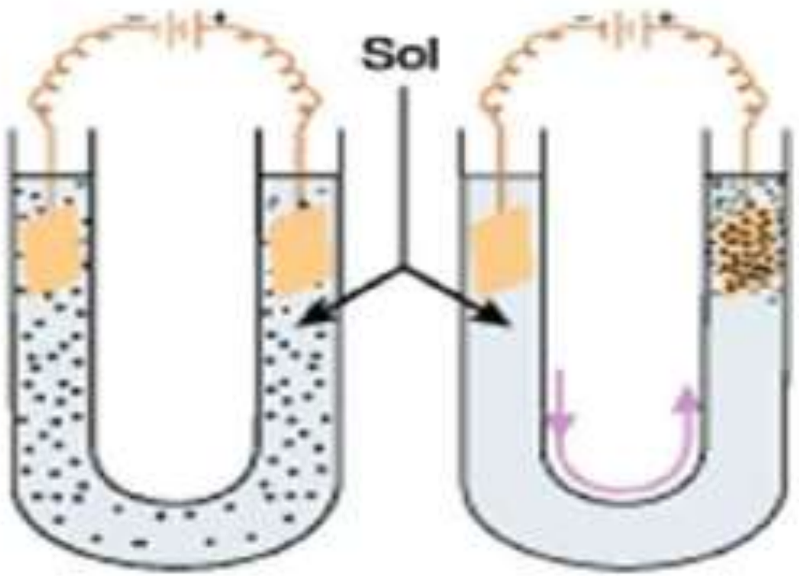
- The Brownian movement decreases with an increase in the size of colloidal particle. This is why suspensions do not exhibit this type of movement.

ELECTRICAL PROPERTIES OF COLLOIDS

- **ELECTROPHORESIS**

- The movement of colloidal particles towards a particular electrode under the influence of an electric field.

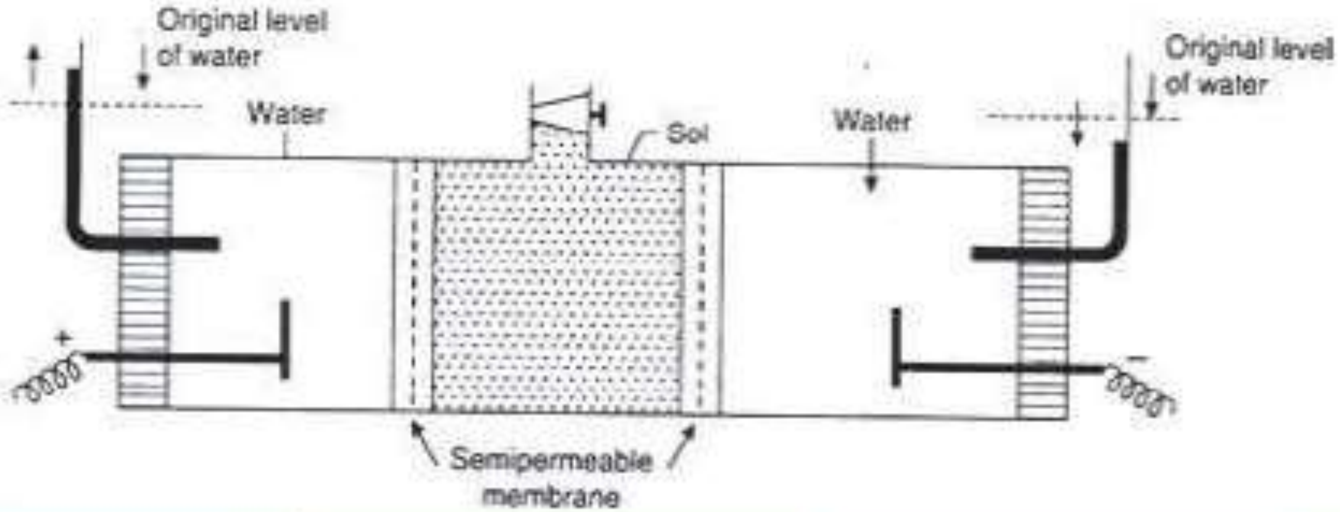
- If the colloidal particles carry positive charge, they move towards cathode when subjected to an electric field and vice versa.



• ELECTROSMOSIS

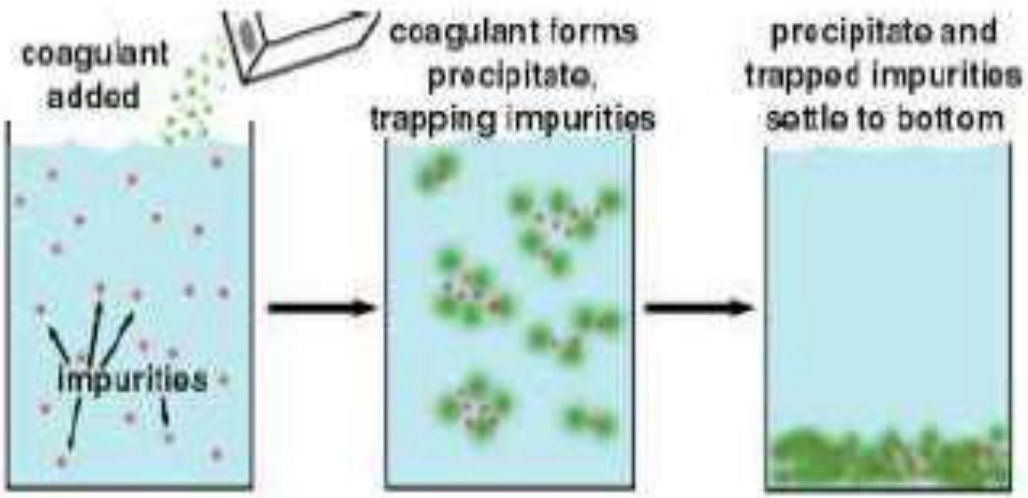
- The movement of dispersion medium under the influence of an electric field in the situation when the movement of colloidal particles is prevented with the help of a suitable membrane.

- During electrosmosis, colloidal particles are checked and it is the dispersion medium that moves towards the oppositely charged electrode.



- **COAGULATION OR FLOCCULATION**

- Coagulation may be defined as the phenomenon involving the precipitation of a colloidal solution on addition of an electrolyte.



- **Hardy-Schulze rule**

The greater is the valence of the oppositely charged ion of the electrolyte added to a

P.T.O.

Hardy Schulze Law, the main points of which may be stated as follows:

(i) The effective ions of the electrolyte in bringing about coagulation are those which carry charge opposite to that of the colloidal particles. These ions are called coagulating ions or flocculating ions.

(ii) Greater is the valency of the coagulating or the flocculating ion, greater is its power to bring about coagulation

- **Flocculation value:** The coagulating power of an electrolyte is usually expressed in terms of its flocculation value which may be defined as the minimum concentration (in millimoles per litre) of an electrolyte required to cause the coagulation of a sol.
- A smaller flocculation value indicates the greater coagulating power of the electrolyte. Thus,

$$\text{Coagulating power} \propto \frac{1}{\text{Flocculation value}}$$

- The coagulation of colloidal solution can also be achieved by any of the following methods.

By electrophoresis

By mixing two oppositely sols

By persistent dialysis

ADVANTAGES OF COLLOIDS

- Colloids allow the dispersion of normally insoluble materials, such as metallic gold or fats. These can then be used more easily, or absorbed more easily.

- Colloidal gold, for example, can be used in medicine to carry drugs and antibiotics, because it is highly non-reactive and non-toxic.

- Pharmaceutical industry makes use of colloidal solution preparation in many medicines. A wide variety of medicines are emulsions. An example is Cod Liver Oil.

- Paint industry also uses colloids in the preparation of paints.

➢In milk, the colloidal suspension of the fats prevents the milk from being thick, and allows for easy absorption of the nutrients.

➢Sewage water contains particles of dirt, mud etc. which are colloidal in nature and carry some electrical charge. These particles may be removed by using the phenomenon of electrophoresis.

➢The sky is the empty space around earth and as such has no colour. It appears blue due to the scattering of light by the colloidal dust particles present in air (Tyndall effect).

➢Asphalt emulsified in water and is used for building roads.

➢The sugar present in milk produces lactic acid on fermentation. Ions produced by acid, destroy the charge on the colloidal particles present in milk, which then coagulate and separate as curd.

➢Soap solution is colloidal in nature. It removes the dirt particles either by adsorption or by emulsifying the greasy matter sticking to the cloth.

➢Large numbers of food particles which we use in our daily life are colloidal in nature.

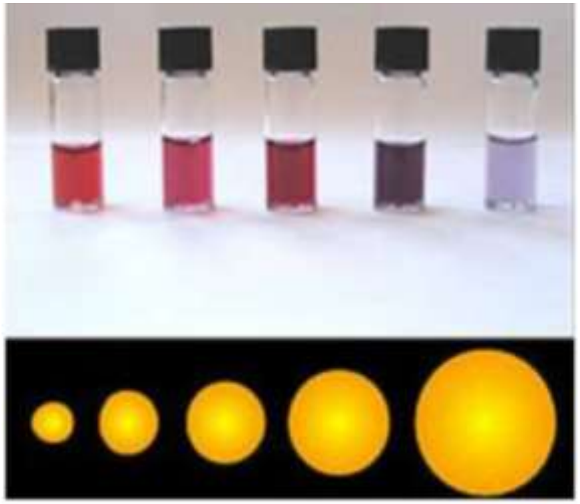
Example: Milk, butter, & ice cream etc


COLLOIDAL GOLD
CHERRY
BLOSSOM
SHOE POLISH
BLACK
glue
Colloidal Silver

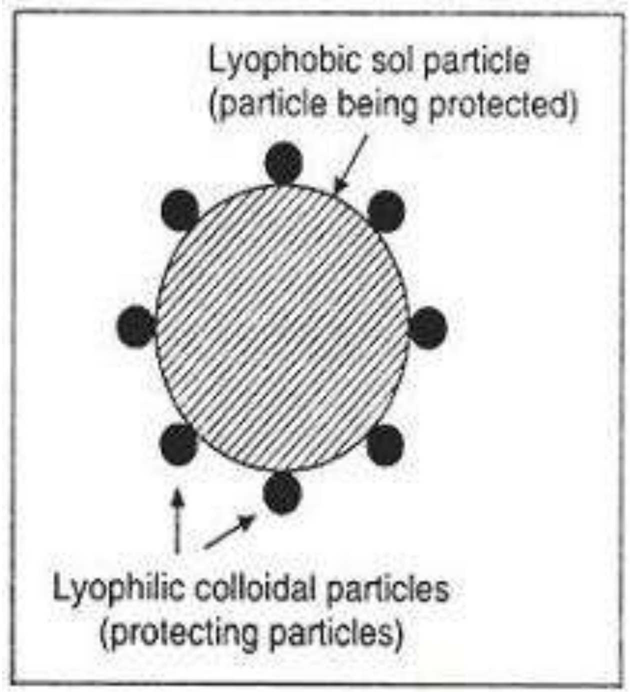
GOLD NUMBER

Gold Number is a term used in colloidal chemistry. It is defined as the **minimum amount of protective colloid* in milligrams** which prevents a color change from red to violet of 10 ml gold sol by the addition of 1 ml of 10% NaCl solution

Coagulation of gold sol is indicated by colour change from red to blue/purple when particle size just increases. More is the gold number, less is the protective power of the lyophilic colloid since it means that the amount required is more. It was first used by Richard Adolf Zsigmondy. The amount is taken in terms of weight in milligrams.



***NOTE:** A protective colloid is a **lyophilic colloid** that when present in small quantities keeps lyophobic colloids from precipitating under the coagulating action of electrolytes



Lyophilic colloid	Gold Number
Gelatin	0.005 - 0.01
Egg albumen	0.08 - 0.1
Gum arabic	0.10 - 0.15
Potato - starch	25

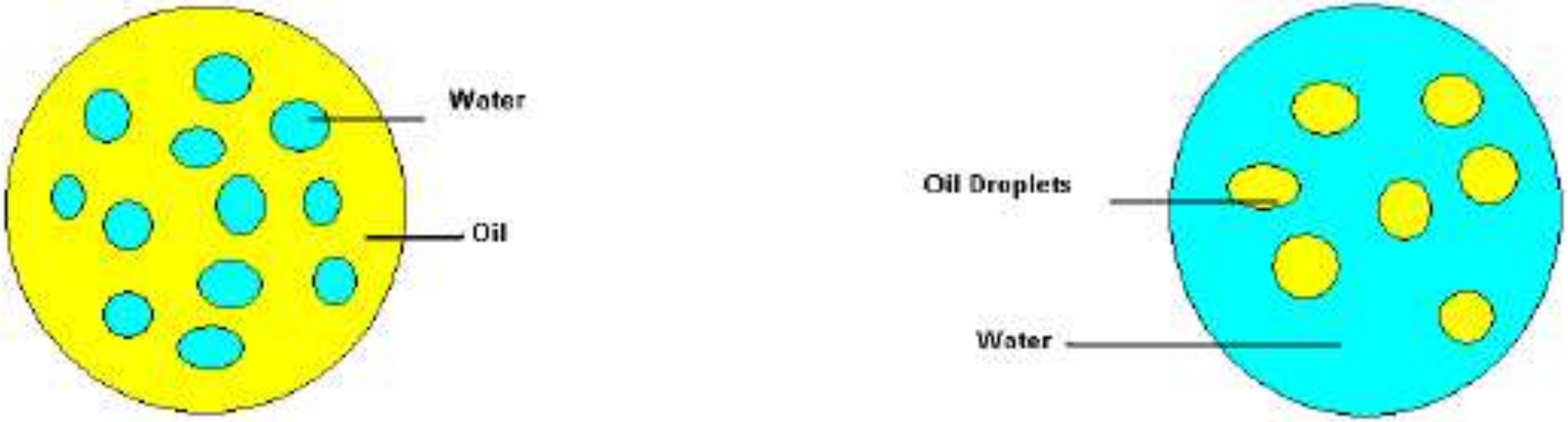
EMULSIONS

Definition

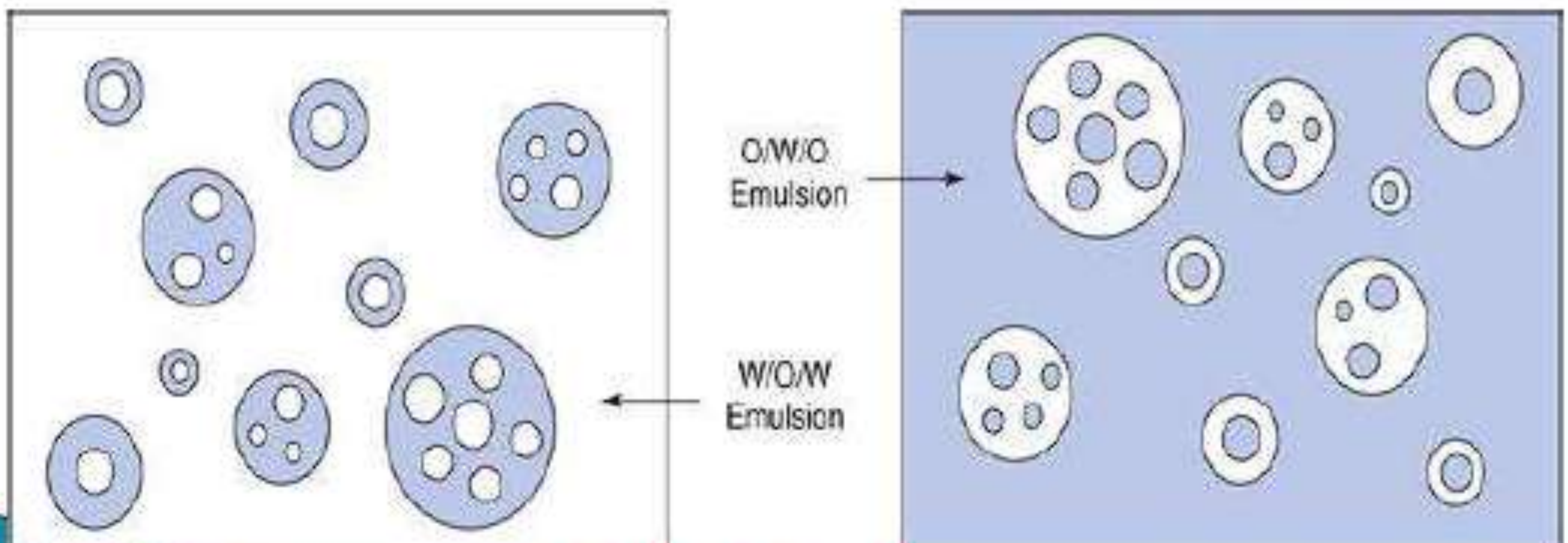
- An emulsion is a two phase system consisting of two incompletely miscible liquids, one of which is dispersed as finite globules in the other. The particle size of the globules range from 0.25 to 25 μm. An emulsifying agent and mechanical energy are needed to join the phases.

Types of Emulsion

- Based on dispersed phase
- Oil in Water (O/W): Oil droplets dispersed in water.
- Water in Oil (W/O): Water droplets dispersed in oil.
- Multiple emulsions (e.g. w/o/w emulsions).



Single Emulsion



Multiple Emulsion

Based on size of liquid droplets

- 0.2 – 50 mm Macroemulsions
- 0.01 – 0.2 mm Microemulsions
- 50 – 1000 nm Nanoemulsions

PHARMACEUTICAL EMULSIONS

DIFFERENCE BETWEEN O/W AND W/O EMULSIONS

Oil in water emulsion (o/w)	Water in oil emulsion (w/o)
Water is the dispersion medium and oil is the dispersed phase.	Oil is the dispersion medium and water is the dispersed phase.
Water soluble drugs are more quickly released from o/w emulsions.	Oil soluble drugs are more quickly released from w/o emulsions .
They are preferred for formulations meant for internal use as bitter taste of oils can be masked.	They are preferred for formulations meant for external use like creams.
They are non greasy and easily removable from the skin surface.	They are greasy and not water washable.
They are used externally to provide cooling effect e.g. vanishing cream	They are used externally to prevent evaporation of moisture from the surface of skin e.g. Cold cream.
O/W emulsions give a positive conductivity test as water is the external phase which is a good conductor of electricity.	W/O emulsions go not give a positive conductivity test as oil is the external phase which is a poor conductor of electricity.

Preparation of Emulsion

The methods commonly used to prepare emulsions can be divided into two categories

A) Trituration Method

This method consists of dry gum method and wet gum method.

- Dry Gum Method

In this method the oil is first triturated with gum with a little amount of water to form the primary emulsion. The trituration is continued till a characteristic 'clicking' sound is heard and a thick white cream is formed. Once the primary emulsion is formed, the remaining quantity of water is slowly added to form the final emulsion.

This method consists of

"4:2:1" formula

4 parts (volumes) of oil

2 parts of water

1 part of gum

- Wet Gum Method

As the name implies, in this method first gum and water are triturated together to form a mucilage. The required quantity of oil is then added gradually in small proportions with thorough trituration to form the primary emulsion.

Once the primary emulsion has been formed remaining quantity of water is added to make the final emulsion.

This method consists of

"4:2:1" formula

4 parts (volumes) of oil

2 parts of water

1 part of gum

Mortar and Pestle

Homogeniser

B) Bottle Method

- This method is employed for preparing emulsions containing volatile and other non-viscous oils. Both dry gum and wet gum methods can be employed for the preparation.
- As volatile oils have a low viscosity as compared to fixed oils, they require comparatively large quantity of gum for emulsification.
- In this method, oil or water is first shaken thoroughly and vigorously with the calculated amount of gum. Once this has emulsified completely, the second liquid (either oil or water) is then added all at once and the bottle is again shaken vigorously to form the primary emulsion. More of water is added in small portions with constant agitation after each addition to produce the final volume.

Mechanical equipment for emulsification (Agitation)

- Mechanical stirrers
- Propeller type mixers
  - -Turbine mixers
  - - Homogenizers
- Colloid mills
- Ultrasonifiers

Mechanical stirrers

Colloidal mill

Stability of Emulsion

- An emulsion is said to be stable if it remains as such after its preparation , that is the dispersed globules are uniformly distributed through out the dispersion medium during its storage. The emulsion should be chemically stable and there should not be any bacterial growth during it shelf life.
- Emulsion instability may either reversible or irreversible and manifest in the following ways:-

1) Cracking (irreversible instability)
2) Flocculation
3) Creaming
4) Phase inversion

1) Cracking:-

- Cracking means the separation of two layers of disperse and continuous phase , due to the coalescence of disperse phase globules which are difficult to redisperse by shaking.
- Cracking may occurs due to following reasons:-

i. By addition of emulsifying agent of opposite type

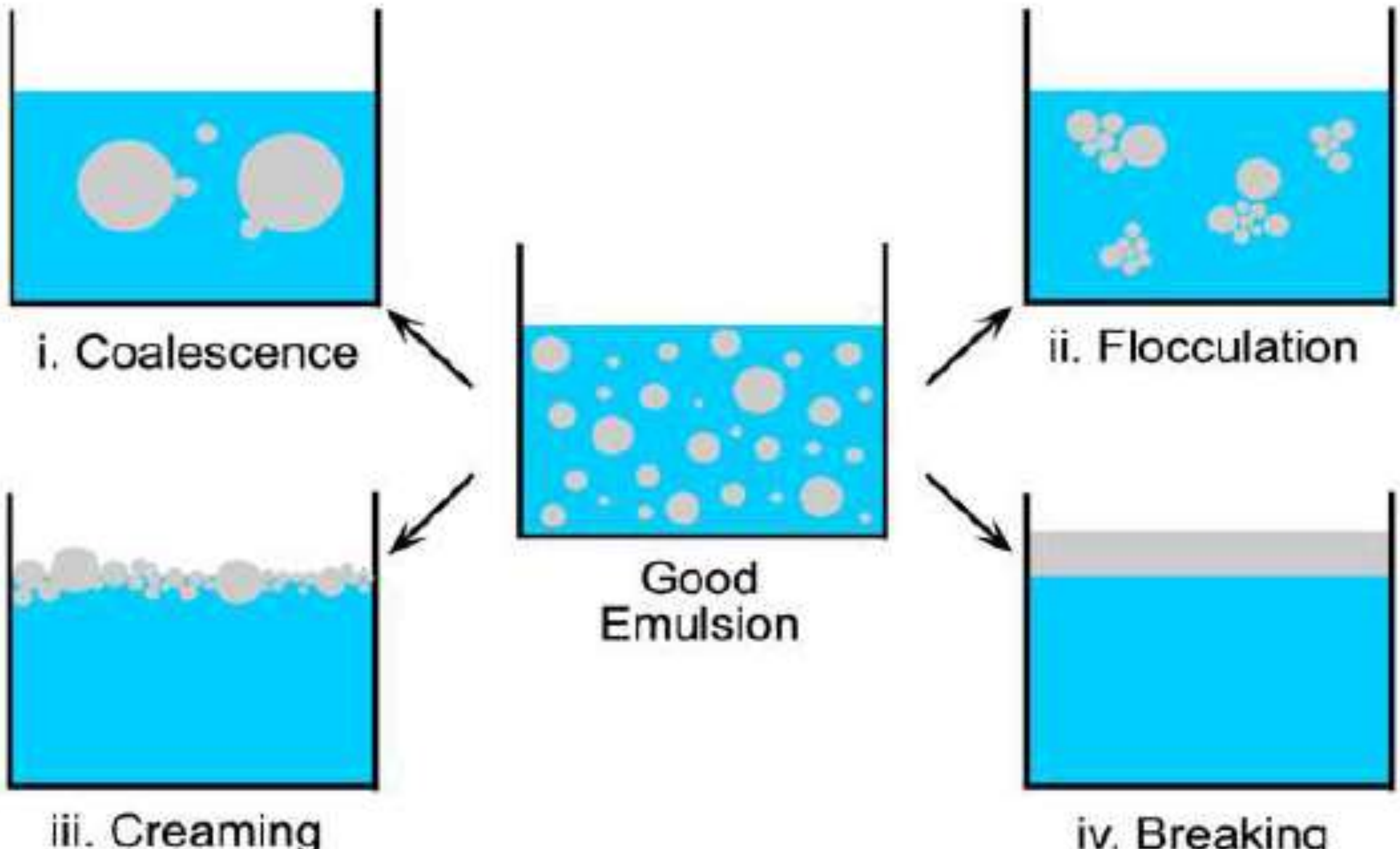
ii. By decomposition or precipitation of emulsifying agent

iii. By addition of common solvent

iv. By microorganisms

v. Change in temperature

vi. By creaming


i. Coalescence
ii. Flocculation
Good
Emulsion
iii. Creaming
iv. Breaking

2) Flocculation :-

- In flocculated state the secondary interaction (van der waals forces) maintain the droplets at a defined distance of separation.

- Application of shearing stress to the formulation (shaking) will redisperse these droplets to form a homogeneous formulation.

- Although flocculation may stabilise the formulation, there is also possibility that the close location of droplets would enable droplet coalescence to occur if the mechanical properties of the interfacial film are compromised.

3) Creaming:-

- Creaming may be defined as the upward movement of dispersed globules to form a thick layer at the surface of emulsion.
- Creaming is temporary phase because it can be re-distributed by mild shaking or stirring to get again a homogenous emulsion.
- The factors affecting creaming are described by stoke's law:

$$V = 2r^2 (d_1 - d_2) g / 9\eta$$

- Where V= rate of creaming
- r=radius of globules
- d_1= density of dispersed phase
- d_2= density of dispersion medium
- g= gravitational constant
- η = viscosity of the dispersion medium

For any doubt/query you may make a contact with me (contact details are given in very first slide)