Chapter - Colloidal State

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Unit - 2

COLLOIDAL STATE

Thomas Graham classified substance into 2 categories

(1) Crystalloids →
The substance which diffuse freely through membrane or perchment paper are known as crystalloid.

Eg → NaCl, urea, sugar etc.

(2) Colloids →
The substance which does not diffuse through membrane are known as colloids.

Eg → Protein, starch, gum, gelatin etc.

NOTE → NaCl behave as crystalloid in water but becomes colloid in benzene.
Similarly soap behave as colloid in water and crystalloid in alcohol.

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Thus colloid is a state of matter in which size of particle ranging 10 A° to 1000 A°

On the basis of size of particle substance are divide into 3 parts :-

Property	True Soln	Colloids	Suspension
Size of particle	< 1 mμ < 10 A° $< 10^{-7}$ cm	1 mμ – 200 mμ 10^{-7} cm – 2×10^{-7} cm 10 A° – 2×10^{3} A°	> 200 mμ > 2×10^{3} A° > 2×10^{-5} cm
Visiblity	not visible with any of the optical instrument	visible with ultramicro-scope	visible with naked eyes
Sepration (1) with filter papes (2) with Membrane	NP NP	NP Possible	P P
Nature	Homogenous	Heterogenous	Heterogenous
Tyndall effect	doesn't Show	Show	show doesn't
Brownian movement	D.N.S	Show	May be Show

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Tyndall effect

Phase of colloids :-

Collide is a heterogenous system which consist of 2 phase

(1) Dispersion phase / medium →

The larger part of colloidal sol^n is known as dispersion medium It is also known as external phase or continuous phase.

(2) Dispersed phase / medium →

The part of colloidal sol^n which is present in lesser quantity is known as dispersed phase.

It is also known as internal phase or discontinuous phase.

Eg → In colloidal sol^n of Gold, dispersion medium is water while dispersed phase is gold.

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Classification of collidal Soln

(1) On the basis of physical state of D.P and D.M (Types of collidal system)

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D.P	D.M	Common/Special Name	Example
Solid	Gas	Solid aerosol	Smoke, dust
Solid	Liquid	Sol	Gold sol, As_2S_3 sol, Gelatin sol
Solid	Solid	Solid sol	Ruby glass, minerals, Gems
Liquid	Gas	Liquid Aerosol	FOG, Mist
Liquid	Liquid	Emulsion	Milk
Liquid	Solid	Gel	Cheese, Butter, curd
Gas	Liquid	Foam	Soap foam
Gas	Solid	Solid foam	Pumic stone

→ when dispersion med. is gas ⇒ aerosol

→ when dispersed phase is solid and D.M is liquid ⇒ Sol

→

D.M	Name
Water	Hydrosol / Aquasol
Benzene	Benzosol
Alcohol	Alcosol

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(2) On the basis of the attraction 2015 b/w DM and DP

There are of 2 types :-

① Lyophillic or Hydrophillic

The collides in which D.P and DM have great affinity then it is called Lyophillic or Hydrophillic

They can be prepared easily by mixing DP and DM

They are highly stable

They does not coagulate easily.

They are reversible in nature.

Eg → Protein, Starch, gum, etc.

② Lyophobic or Hydrophobic colloid

The collides in which D.P and D.M have great repulsion then it is called lyophobic colloid.

There are special techniques for preparation of Lyophobic sol.

They are unstable.

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They needs some Stabling agent for preservation.

They can coagulate easily on adding small amount of electrolyte.

They are irreversible in nature.

(3) On the basis of nature of colloidal particle.

① Macromolecular colloids
Macromolecular substance dissolve in suitable solvent to form particle of colloidal range.

eg → Starch, cellulose, protein, polymer, Enzymes etc.

② Multimolecular colloids
On dissolution a large number of atom or smaller molecules of a substance aggregate together to form species having size in colloidal range.
The species thus formed are called multimolecular colloid.

In these colloids the particles are held together by vanderwaal forces.

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Eg → Sulphur sol, Gold sol

③ Associate colloid

Substance whose molecules aggregate spontaneously in given solvent to form particle of colloidal range are called associate colloides.

The molecules of soap and detergent are usually smaller then the colloidal particle. However in conc. sol^n these molecules ~~is~~ associate and form aggregates of colloidal sites. These aggregates of soap and detergent molecule are called micelle.

The form^n of micelle take place only above a particular conc^n called Kritical micellur conc^n. And for soap value of CMC is 10^{-4} to 10^{-3}. These colloides are called lyophillic and lyophobic part.

$C_{17}H_{35}COONa \Rightarrow C_{17}H_{35} - \overset{O}{\overset{\|}{C}} - O^{\ominus}$

Sodium Stearate → Hydriophobic part. → Hydrophilic part

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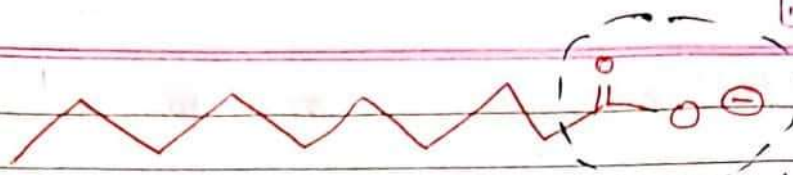
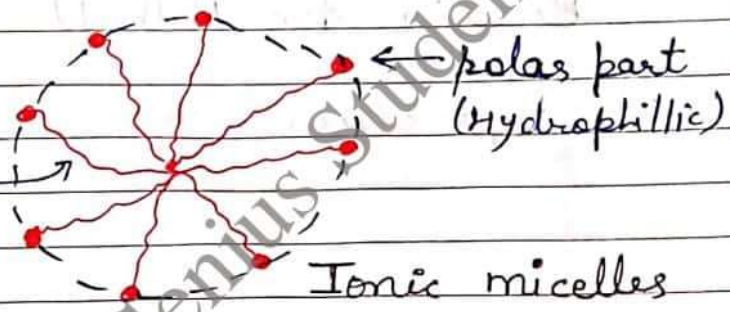


Tail (Hydro Carbon part)
$C_{17}H_{35}$
Non - polar part
Hydrophobic

Head
polar part
Hydrophillic



SOLIDS IN LIQUID (SOL)

Preparation :-

(i) preparation of lyophillic sol

The colloidal sol^n of lyophillic colloids like as starch, gum, gelatin etc can be prepared easily by dissolving these substances in water either in cold or warming

(ii) preparation of lyophobic sol

Dispersion Method — Condensation Method

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Dispersion Method	Condensation Method
(1) Mechanical dispersion	(1) By excessive cooling
(2) Electro dispersion (Bredig Arc Method)	(2) By changing phy. state of solvent
(3) Peptisation	(3) Chemical Method (a) oxidation (b) Reduction (c) double decomp^{n} (d) Hydrolysis

Dispersion Method

In this method large particle of a substance are break down into particles of colloidal range

(1) Mechanical dispersion

In this method solid material is 1st ~~finally~~ finely ground by usual method.

It is mixed with disper^{n} med^{m} which give a coarse suspens^{n} The coarse suspens^{n} is now passed through collide mill.

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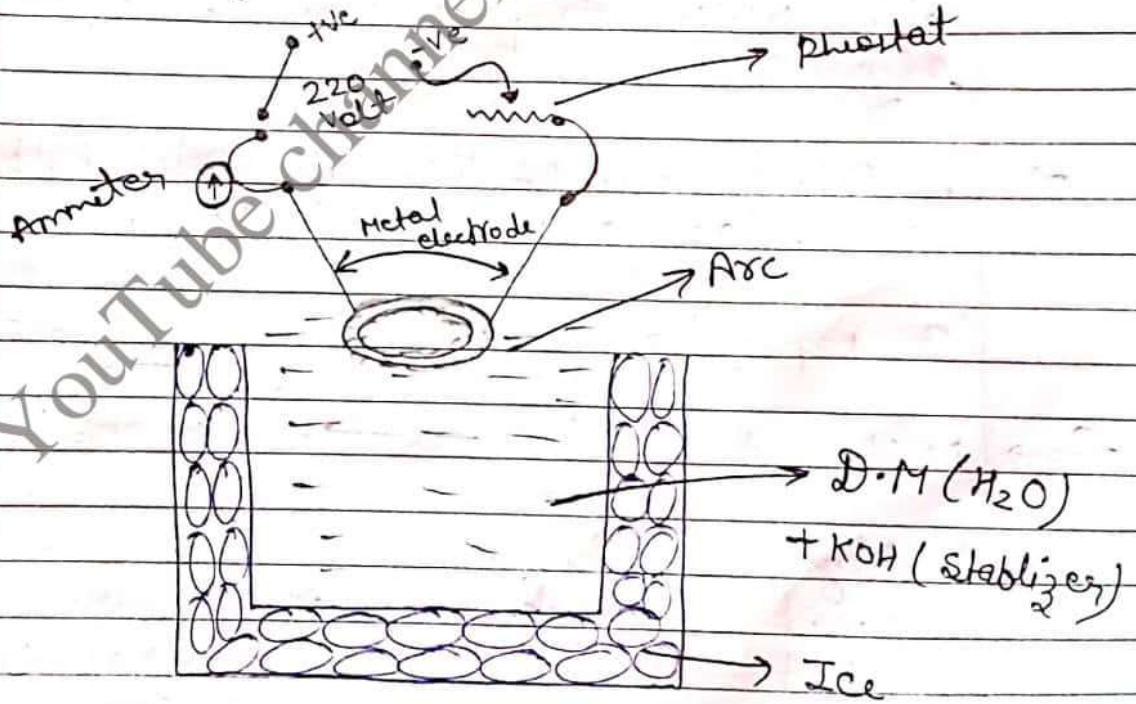
Colloidal Mill → The colloidal mill consist of 2 metal disk moving with a very high speed. (7000 rev/min)

The suspended particles are broken up into particles of colloidal sizes

Tannin → Tannin is used as stablizer in the preparⁿ of colloidal graphite and gum arabic in lamp black colloidal solⁿ (indian ink).

(2) Electro dispersion

2015 Bredig arc Method



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→ This method is used to prepare colloidal sol of metals like as Ag Au, Pt, Cu etc.

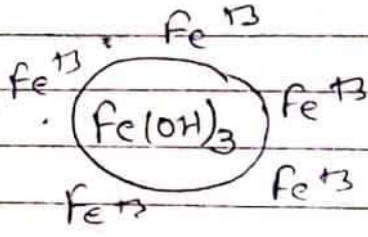
→ 2 electrodes of metals are taken which are suspended in dispersion medium generally water.

→ Electric arc is stick b/w 2 metal electrodes.

→ Due to intense heat of arc metal ~~electrodes~~ vapourised which immediatly condensed by the surrounding ice cold water to give particle of colloidal size

→ A slight trace of KOH in water helps to stablize the metal sol.

(3) Peptization

Eg → $Fe(OH)_3 + FeCl_3 \longrightarrow$ 

Freshly prepared precipitate — peptising agent — Red brown colloidal sol of $Fe(OH)_3$

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The conversion of freshly prepared precipitate into colloidal particle by the help of small amount of electrolyte is k/a peptisation.

The electrolyte that bring about peptisn is called peptising agent.

Eg→ A colloidal soln of ferric hydroxide is produced when freshly prepared ferric hydroxide is treated with a small quantity of $FeCl_3$ soln.
(rxn of previous page)

Condensation Method
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In this method small molecular or atoms condense to give particle of colloidal range.

(i) By exchange of solvent

Phenophtalein (indicator in acid-base titration) is soluble in alcohol & not in water.

If water is added to this soln a milky liquid is produced which is colloidal soln of phenophtalein in water.

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(2) By change of physical state

Colloidal sol^{n} of certain element that is mercury & sulphur are obtained by passing their vapours through cold water containing a suitable stabliser (an ammonium salt or a citrate).

(3) Chemicle Method

(a) Double Decompn^{n} →
when H_2S gas is passed through arsenic oxide sol^{n} then a yellow colored colloidal sol^{n} of arsenic sulphite is obtained.

$$As_2O_3 + 3H_2S \longrightarrow \underset{\text{(yellow colloidal sol)}}{As_2S_3} + 3H_2O$$

However the excess of H_2S gas will have to be removed by boiling & testing with lead acetate paper.

$$3K_4[Fe(CN)_6] + 4FeCl_3 \longrightarrow \underset{\text{(ferrocyanide)}}{Fe_4[FeCCN)_6]} + 12KCl$$

★ $Fe_4^{III}[Fe^{II}(CN)_6]$ → persian blue (colloidal sol)
ferri - ferro cyanide

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(b) Hydrolysis →

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

reddish brown ppt of ferric hydroxide.

OR

Reddish brown colloidal sol.

(c) Oxidation →

when H_2S is bubbled through an oxidising agent like Bromine water, Nitric acid etc then collidal sulphes is obtain.

$H_2S + Br_2 \longrightarrow S + 2HBr$ (colloidal)

$H_2S + 2HNO_3 \longrightarrow S + 2NO_2 + 2H_2O$

(d) Reduction →

$2AuCl_3 + 3SnCl_2 \longrightarrow 2Au + 3SnCl_4$ (colloidal sol)

$2AuCl_3 + 3(H-\overset{\overset{O}{\|}}{C}-H) + 3H_2O \longrightarrow$

$2Au + 3(H-\overset{\overset{O}{\|}}{C}-OH) + 6HCl$

(colloidal sol)

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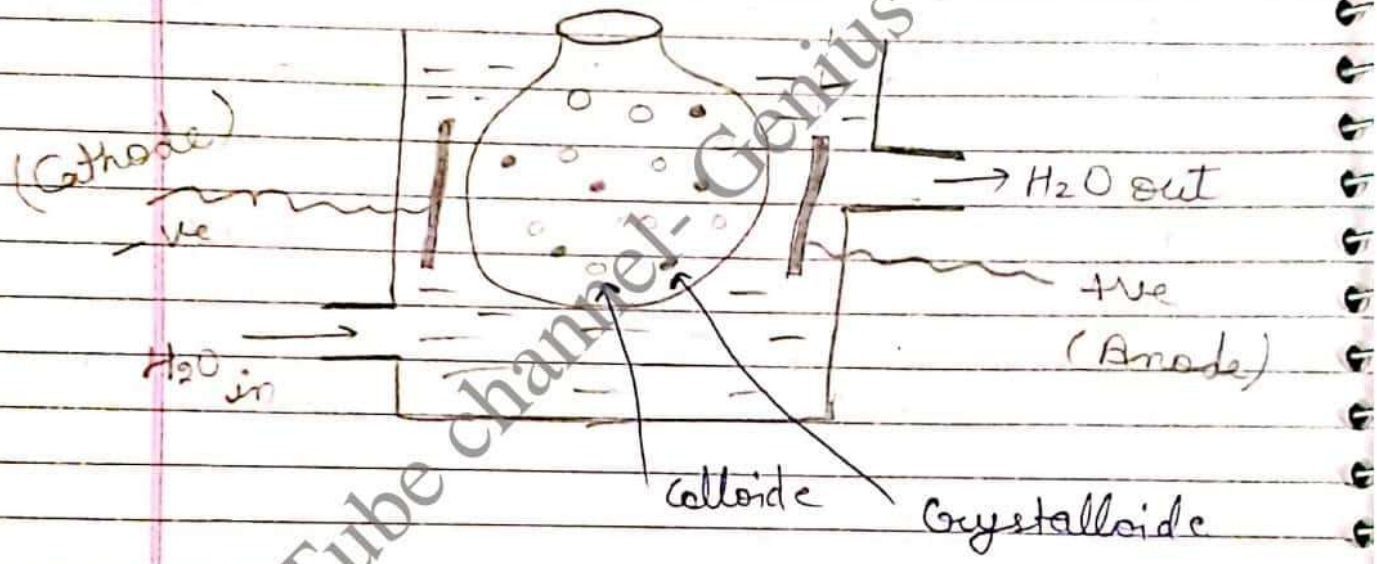
poly phenol

$AgNO_3$ + Tannic acid ⟶ Ag
(Colloidal sol)

Purification of Colloidal Sol

1. **Dialysis** → The process of sepr^n of a crystalloid from a colloide by means of diffusion through a membrane is ~~The~~ called dialysis.



The apparatus used for the purpose of dialysis is called dialyser.

The simplest form of the dialyser, consist of a perchment or cello phane bag containing the mix of a colloid and crystalloid. The bag is suspended in large trough containg distilled

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water which is continuous flowing. The impurities of crystalloid comes out from bag with water.

The process of dialysis is very slow it can be fastened by applying electric field around parchment bag. This process is known as Electrodialysis.

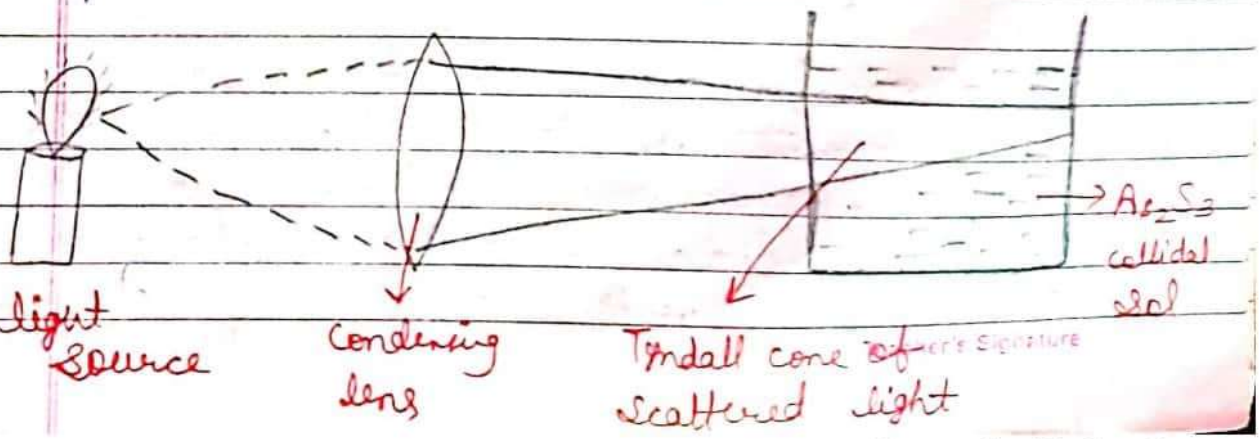
Properties of Sol :-

1. Optical property

(a) Tyndall effect →

When a beam of light is passed through colloidal sol then path of light gets ~~eliminated~~ illuminate with bluish light. This effect is known as Tyndall effect.

Tyndall effect is observed due to scattering of light by the colloidal particle.



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Condition of Tyndall effect

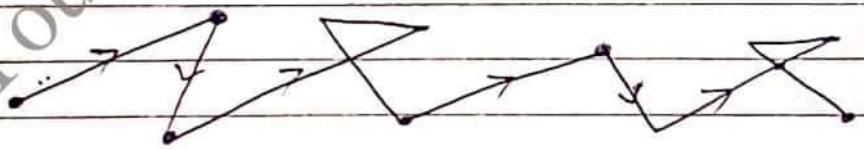
① The diameter of the dispersed particle should not be much smaller than the wavelength of light used.

② There should be a large difference b/w refractive indices of the dispersed phase and dispersed medium.

③ Since lyophobic sol only are able to full fill these cond^{n}, they show tyndall effect.

(b) **Brownian Movement →**

The irregular zig zag and random motion of colloidal particle in a dispersion med^{m} is called Brownian movement.



The explanation of Brownian movement is that the molecules of dispersion medium strike a colloidal particle from all sides with constantly changing

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Velocities and impart a translatory motion to the colloidal particles.

Brownian movement does not depend on the nature of colloidal particle. It depends on the size of colloidal particle and viscosity of dispersion medium.
Lesser the size and viscosity greater the Brownian movement.

2. Electrical property

(a) Electrophoresis →
The movement of colloidal particle towards oppositely charged electrode under the influence of electric field is known as electrophoresis.

+vely charged colloidal particle moves toward cathod which is known as cataphoresis.
While -vely charged colloidal particle moves toward anode which is known as anaphoresis.

Here cathod is ⊕ -ve charged while anode is +ve charged.

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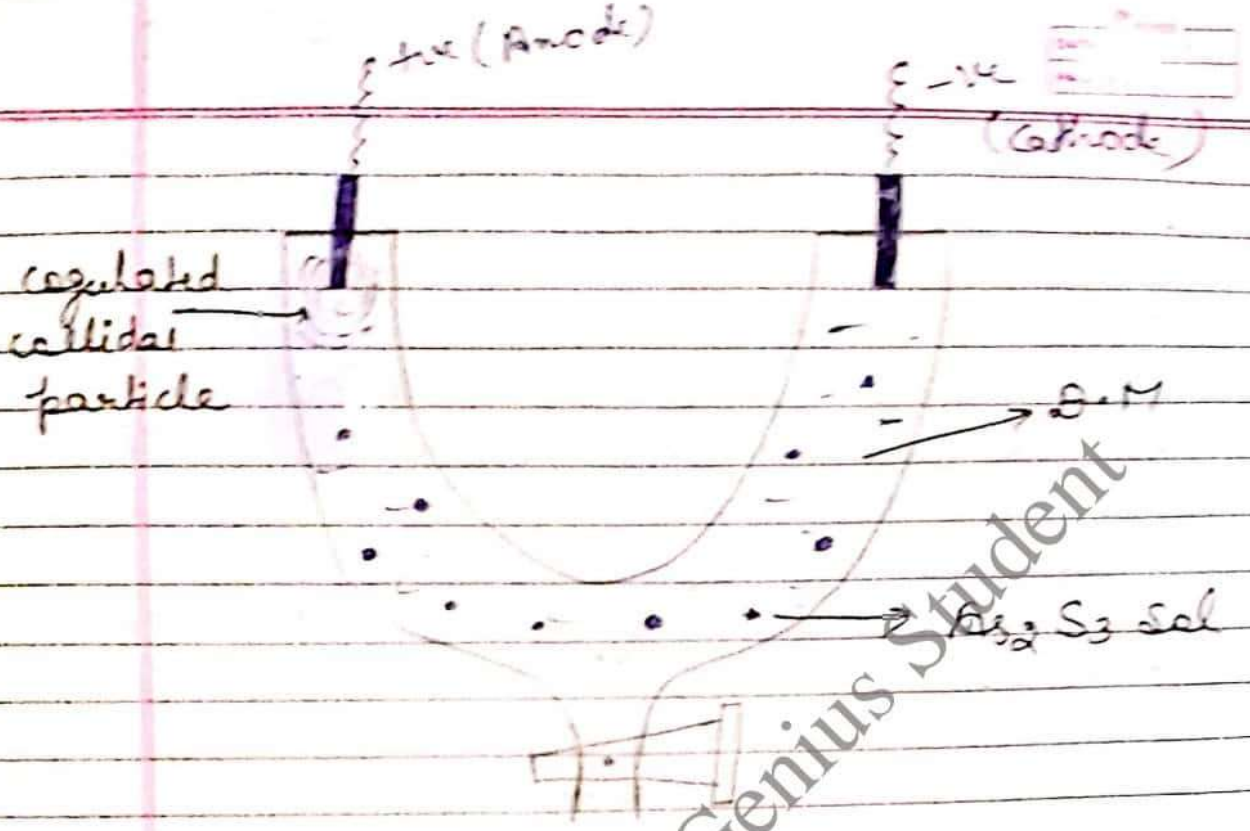

(b) Electro-osmosis →

The movement of particle of dispersion med" under the influence of electric field when the particle of dispersed phase are completely checked from moving is known as electro osmosis.

The direc" of the motion will be opp to the direc" of movement of colloidal particle.

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+vely charged sol	-vely charge sol
(1) Hydroxide sol $Fe(OH)_3$, $Al(OH)_3$	Metal sol like as Fe, Au, Ag, Pt
(2) Hydrate oxide sol $Al_2O_3 \cdot XH_2O$	Metal sulphide sol As_2S_3, CdS
(3) Oxide sol TiO_2	Colloidal sol of starch protein, sand, Gelatin
(4) Basic dyes (Methylene blue)	Blood

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Coagulation/ Flocculation :-

The process of settling down of the colloidal particle under the influence of gravity is known as coagul^n or flocculation.

Method of Coagul^n

(1) Electrophoresis

Due to electrophoresis electrically charged particle moves toward oppositely charged electrode and becomes neutral due to which theis coagulation take place.

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(2) On mixing two oppositely charged colloids

When 2 oppositely charged colloids are mixed then they becomes neutral and their coagulation take place. This is known as mutual coagulation.

(3) On mixing Electrolyte

When Electrolyte is added into electrically charged colloids then oppositely charged ion of Electro lyte is responsible for the coagulation of colloids. This ion is known as effective ion / coagulative ion.

Hardy- Schulz Rule

Acc to this rule greater the valency of coagulating ion, greater will be its coagulating power.

Coagulating power of ion for +vely charged colloids

$$[Fe(CN)_6]^{-4} > PO_4^{-3} > SO_4^{-2} > Cl^-$$

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Coagulating powers of ions for -vely Charged colloids

$Si^{+4} > Al^{+3} > Mg^{+2} > Na^{+}$

Coagulating value :-

The min^{m} con^{n} of an electrolyte in millimole / ltr required to cause ppt^{n} of a sol in 2 hours is known as coagulating value.

Coagulating value $\propto \frac{1}{Z^6}$

Z = charge on effective ion.

* Coagulating value of an ion $\propto \frac{1}{\text{Coagulating power}}$

Relative Stability of Hydrophobic and Hydrophillic sol :-

There are 2 factors which are respon-sible for the Stability of hydro phillic sols.

① Its charge

② Its hydration / Solvation

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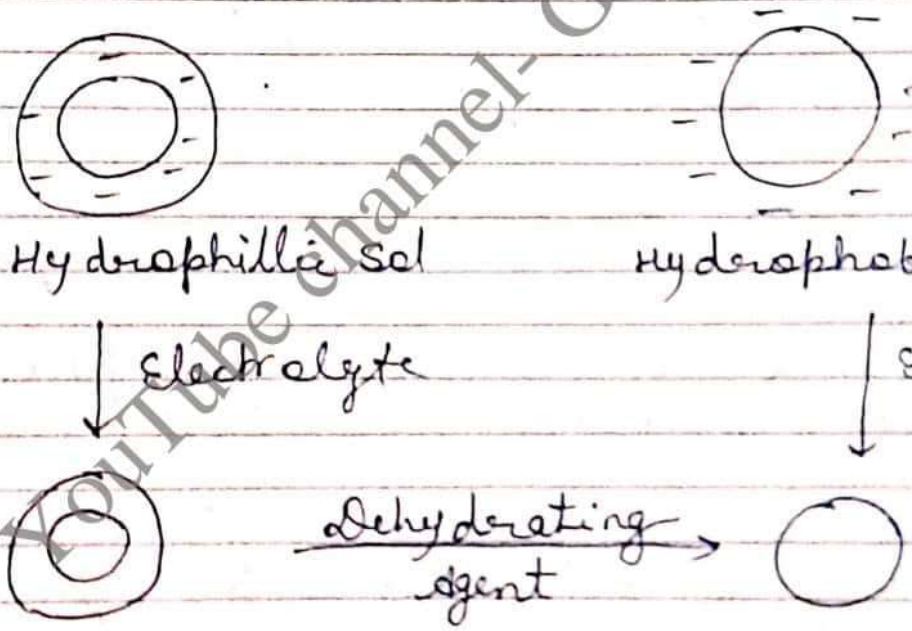
When these 2 factors are removed lyophillic sol can be coagulated

This is done:

(1) By adding Electrolyte
(2) By adding suitable dehydrating agent like alcohol and acetone

While Hydrophobic Sol are less stable and can be coagulated easily by adding small amnt of Electrolyte.



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Protection of Colloids

Lyophillic sol are more stable than lyophobic sol this is due to the fact that lyophillic colloids are extremely solvated.

Lyophillic colloid have a unique property of protecting lyophobic colloides. When a lyophillic sol is added to the lyophobic sol, the lyophillic particles form a protective layer around lyophobic particles and thus protect the later from electrolytes.

The lyophillic colloids used for such purpose are called protective colloids ~~Are known as protective co~~ and this property is known as protective acⁿ.

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Gold Number

It is defined as the no of milligram of a protective colloid which just prevents the coagulation of 10 ml of a gold sol on the addⁿ of 1 ml of 10% NaCl solⁿ.

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Milk → Caesin (Protein)

Protecting power $\propto \frac{1}{\text{Gold Number}}$

	Sol	Gold number
1.	Gelatin	0.00 – 0.01
2.	Haemoglobin	0.03 – 0.07
3.	Albumin	0.1 – 0.2
4.	Gum Arabic	0.15 – 0.25
5.	Dextrin	6 – 20
6.	Potato Starch	20 – 25

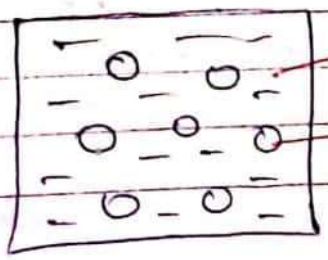
Emulsion → The heterogenous mixture of 2 immisible or partial missible liquid is known as Emulsion.

2015 ← **Types of Emulsion**

① O/W Emulsion (oil in water)

In this type of emulsion water is dispersion medium and oil is the dispersed phase.

Eg → Milk, vanishig cream



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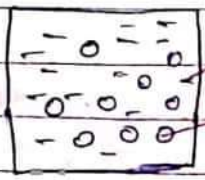
② w/o emulsion (water in oil)

In this type of emulsion oil is D.M and water is D.P.

Eg→ Butter, Ice creams.



Emulsifying agents or Emulsifiers

Emulsions are not stable and separat into 2 layers on standing. Hence to increase their stablity a 3rd compon-net is added in small amount which is known as Emulsifying agent or Emulsifiers.

There are of 3 types :-

① long chain comp^{n}d with polar groups (Soap and detergent)

② lyophillic substances (protein, gums and agar-agar)

Eg→ In milk emulsifying agent is casein protein.

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③ Certain insoluble powders like as carbon black, clay, powder glass etc.

Detection / Identific^{n} of an Emulsion

① Dye test

In this test an oil soluble dye is shaken with the emulsion and a drop is put under the microscope. If the whole Bkgound appears colored then it will be oily emulsion (water in oil) and if only some colored drops are seen then emulsion will be aq. emulsion (oil in water)

② Electrical conductivity test

Electrical conductivity of aqouse emulsion is higher than that of oily. Hence the measurment of electrical conductivity gives us information about the type of emulsion.

③ Viscosity Test

Oily emulsion are more viscous

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than aqous emulsions. Hence measurmit of viscosity gives us infor^{m} about the type of emulsion.

④ Dilution Test

An emulsion can be diluted with any amount of dispersion medium but if the dispersed phase is added it forms a seperate layer.

Thus if a given emulsion is easily diluted by add^{n} of water then it will be oil in water or Aq. emulsion.

And if layers are seperated on adding water then it will be water in oil emulsion.

D-emulsification → The process of breaking of emulsion into its 2 component is known as demulsification.

Eg → Cream is obtain from milk by centrifugation.

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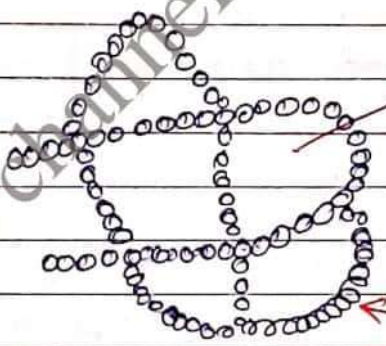
GEL

Colloidal system containg a liquid which dispersed in solid are termed as Gels.

When 2 to 5 % hot soln of Gelatin is cooled it sets to a semi solid mass which is known as Gel. during setting Gelatin molecule comes together and form bigger agregates which gives honeycomb like structure containing dispersion medium.



★ Gelation → The transformation of sol into gel is process of called Gelation.

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→ The lyophilic sols which are generally used for gelation are gelatin, agar-agar, gum-arabic.

→ While lyophilic sol which can change into gel are aluminium hydroxide $Fe(OH)_3$, $Si(OH)_4$ (Silica Acid)

Types of Gel

① Elastic Gel

They have property of elasticity, they can be stretched on applying force ~~They can be stretched on applying force~~ and if force is released, they return to their original shape.
In this type of gel molecules are held together by electrostatic force of attract.

Eg → Starch, Gelatin, jellies, fruit jams

② Non elastic / Rigid Gel

These don not have elastic property They have a network like str. due to formⁿ of chemicle bonds

Eg → Silica gel, alumina gel.

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Preparation of Gels

① On cooling the sol of appropriate conc^{n} →
When 2 to 5 % hot sol^{n} of Gelatin is cooled it sets to a semi solid mass which is known as Gel.

② By the double decompos^{n} →
From this method lyophobic gels are prepared

$Na_2SiO_3 + 2HCl \longrightarrow H_2SiO_3 \cdot xH_2O + 2NaCl$

Aq. sol of Sodium silicate

Hydrated silica Acid

↓ on cooling it set as Gel

Silica Gel

$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 \cdot xH_2O + 3NaCl$

aq. sol of Aluminium

Hydrated aluminium Hydroxide

↓ On cooling it set as gel

Alumina Gel

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Properties of Gel

① Imbibition →
Certain Gels when placed in the liquid (water) they absorb water as a result their dimensions increase. This phenomena is reffered to as Imbibition or swelling.

Elastic Gels show this property while non elastic Gels do not show this phenomena.

② Syneresis / Weeping → On standing a Gel it shrink due to loss of water held by it. This phenomena is known as weeping or syneresis of gel.

Both type of gel show this property

③ Thixotropy →
2017 Some special gels like as Gelatin and silica gel liquify on shaking and change into respective sol. The sol on standing is converted back to the gel. This phenomena of reversible sol / Gel transformation is known as Thixotropy.
And such gel are k/n as Thixotropic gels.

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Application of Colloids

Following are some important applications of colloids :-

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(1) Use of soaps and detergent in cleaning → Soap when dissolved in water gives foam, which is colloidal in nature. This adsorb the oily dirt dust and other particles and clean the clothes and utensils, when washed with water.

(2) Cleaning of sewage → All the excreations and dirt in the sewage water is in the colloidal form, which is negatively charged. The sewage water is collected at a place and electrodes are placed in it. When Electrophoresis is done, the colloidal dirt is precipitated at anode which is used for making organic manure.

(3) Tanning → Skin and leather both are gel structure where protein is in colloidal state. When it is dipped in tannin, mutual coagulation of the charged colloidal particles of leather takes place with the -vely charged particle of tannin and the leather become hard. This process is known as tanning of leather.

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