COLLOIDS

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COLLOIDS

- True solution
  - 0.1-1 nm is the molecular size
  - Homogeneous system
  - Cannot filter, cannot see through naked eyes or microscope, wont settle down
- Suspension
  - A heterogeneous system, diameter > 100 nm.
  - Can filter, settle rapidly under gravity, no diffusion
- Colloid
  - Diameter 1-100 nm
  - Cannot filter, wont settle down , diffusion is very low

Colloidal solution

- A heterogeneous system consisting of 2 phases-dispersed phase of colloidal particles and the dispersion medium of the solvent or medium

Phase of Colloid	Dispersing (solutelike) Substance	Dispersed (solventlike) Substance	Colloid Type	Example
Gas	Gas	Gas	—	None (all are solutions)
Gas	Gas	Liquid	Aerosol	Fog
Gas	Gas	Solid	Aerosol	Smoke
Liquid	Liquid	Gas	Foam	Whipped cream
Liquid	Liquid	Liquid	Emulsion	Milk
Liquid	Liquid	Solid	Sol	Paint
Solid	Solid	Gas	Solid foam	Marshmallow
Solid	Solid	Liquid	Solid emulsion	Butter
Solid	Solid	Solid	Solid sol	Ruby glass

SOLS

- Dispersed phase solid-dispersion medium liquid
- Eg: Colloidal suspension of starch, gelatin, gold etc.
- Classification of sols *based on dispersion medium*
  - Hydrosol, Alcosol or Benzosol
- Classification *based on affinity between phases*
  - Lyophilic (liquid loving) colloids and lyophobic colloids (liquid hating)

Differences between lyophilic and lyophobic sols

Lyophilic sol	Lyophobic sol
• Greater affinity between dispersed phase and dispersion medium	• Very little affinity between dispersed phase and dispersion medium
• Very stable	• less stable
• Can easily prepare by warming	• Preparation is difficult
• They are reversible	• They are irreversible
• Particles are heavily solvated	• Particles are poorly solvated
• No effect on adding small amount of electrolyte	• Addition of electrolyte cause precipitation of dispersed phase
• Sol has lower surface tension than the medium	• Sol has a surface tension similar to the medium
• Each sol has a viscosity greater than the medium	• Each sol has a viscosity comparable to the medium
• Eg: starch, gelatin, protein etc in water	• Eg: Gold, $Fe(OH)_3$, As_2O_3 in water

Classification of colloids

- Macromolecular Colloids- Colloidal solution of macromolecules like starch, gelatin, protein etc (lyophilic)
- Multimolecular Colloids- Aggregates of atoms or molecules in colloidal dimension. Eg: Au Sol, S sol etc. (lyophobic)
- Associated Colloids- Micelles, above cmc certain substance shows colloidal property. Eg: Soaps and detergents (lyophilic)

Preparation of sols

- Preparation of lyophilic sol
  - Usually macromolecular colloids are lyophilic
  - Easy method of preparation-just warm the substance to be dispersed in the dispersion medium
  - Eg: Gelatin or starch or soap in warm water, rubber in benzene
  - Intrinsic colloid

Preparation of lyophobic sol

- 2 methods- Condensation methods and dispersion methods

Condensation methods (Aggregation method)-

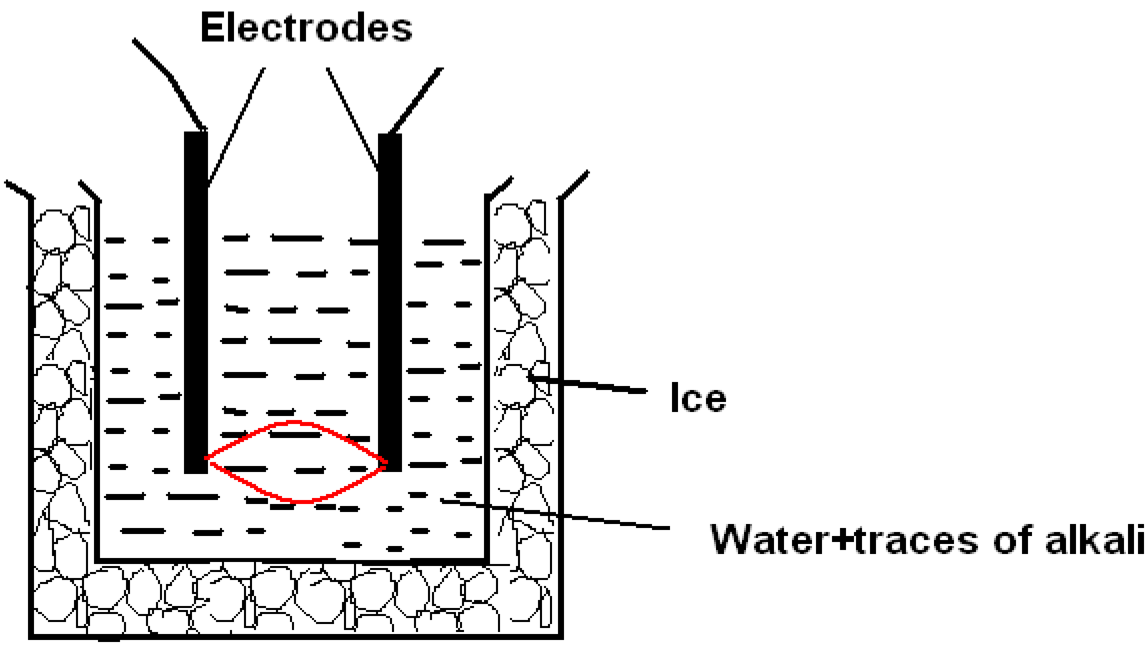
– Preparation is through aggregation of molecules by suitable physical or chemical methods

- **Chemical Method-**
  - **Double decomposition** $As_2O_3 + H_2S \rightarrow As_2S_3 + 3H_2O$
  - **Hydrolysis** $FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl$
  - **Oxidation** $2AuCl_3 + 3SnCl_2 \rightarrow 3SnCl_4 + Au$
  - **Reduction** $2H_2S + O_2 \rightarrow 2H_2O + S$
- **Physical methods-**
  - **Exchange of solvent-** Preparation of aqueous sol of S, P etc by alcoholic solution
  - **Change in physical state-** Aq. Sol of S or Hg- by passing their vapours through solution in presence of a stabiliser

Dispersion method

- Large coarse particles are broken down to smaller ones in colloidal range by dispersion
  - **Mechanical dispersion**
    - Using a colloidal mill (2 steel discs having small clearance between them-rotated in opposite direction in very high speed)
    - Preparation
  - **Electrodispersion (Bredig's Arc method)**
    - Electrical disintegration of coarse material
    - Colloidal dispersion of Au, Ag, Pt, Cu etc can prepare
  - **Peptization**
    - The process of bringing freshly precipitated substance into colloidal state by a peptizing agent

Electrodispersion (Bredig's Arc method)



- Suitable for aq. Colloidal dispersions of metals like Au, Ag etc
- 2 steps

  Dispersion step and condensation step

Peptization

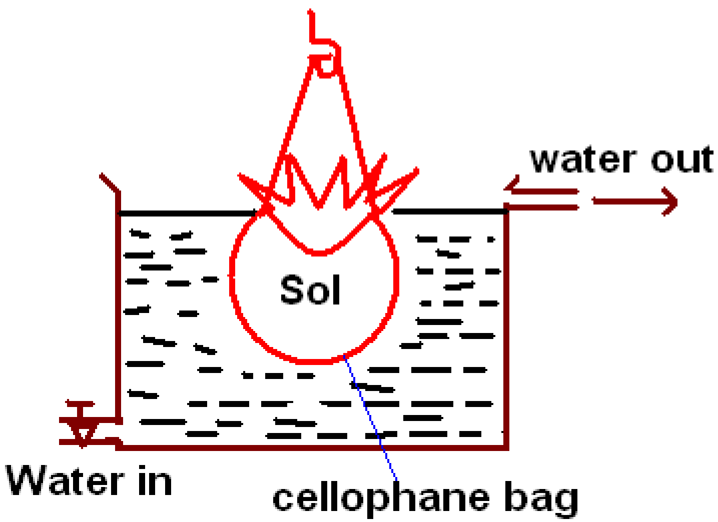
- Peptizing agent is an electrolyte which contain ions.
- One of the ion adsorb on a fresh precipitate which is held together by van der Waal's force of attraction
- Eg:

$$\underset{\text{Peptizing agent}}{FeCl_3} \longrightarrow Fe^{3+} + 3Cl^-$$

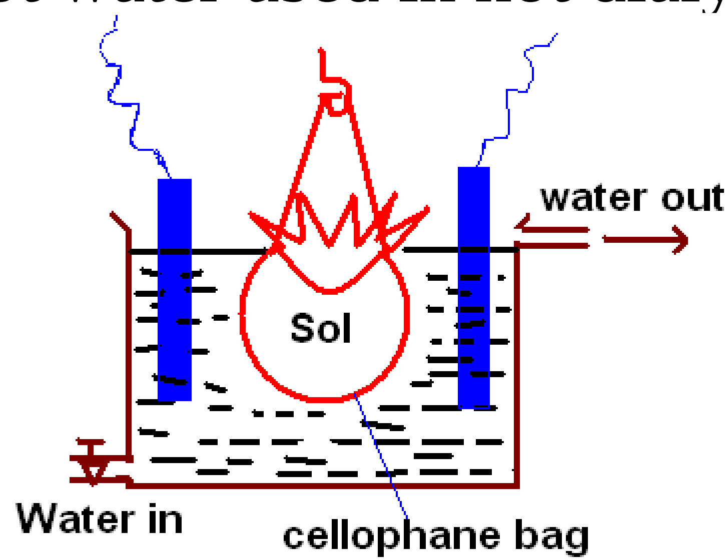
$$\underset{\text{ppt}}{Fe(OH)_3} + Fe^{3+} \longrightarrow \underset{\text{sol}}{Fe(OH)_3.Fe^{3+}}$$

Purification of sols

- 2 methods: Dialysis and ultrafiltration
- Dialysis- Diffusion of impurities through a membrane
- Apparatus used-dialyser (fig)
- If electricity is passed through the solution diffusion accelerates-Electrodialysis, hot water used in hot dialysis



DIALYSIS



ELECTRODIALYSIS

Ultrafiltration

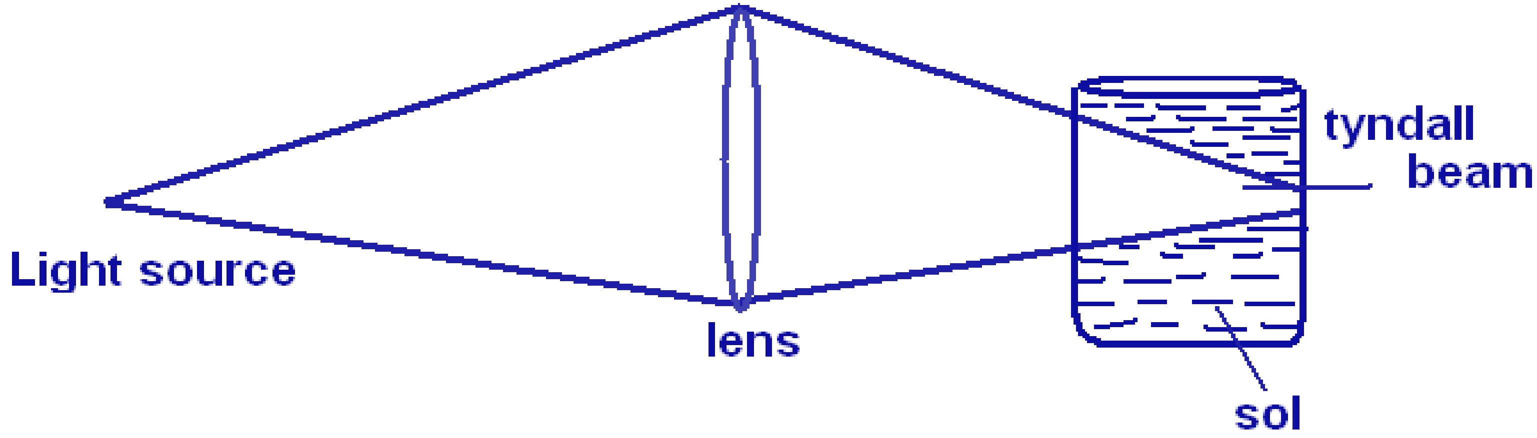
- Filtration through an ultrafilter
- Remove soluble impurities
- Commonly used ultrafilter-cellophane, pore sizes are small so that the colloids retained in the filter while impurities are filtered off

Properties of sol

- Optical property
  - Tyndall effect and ultramicroscope
- Kinetic property
  - Brownian motion
- Electrical property
  - Electric double layer and zeta potential

Optical property
Tyndall effect and ultramicroscope

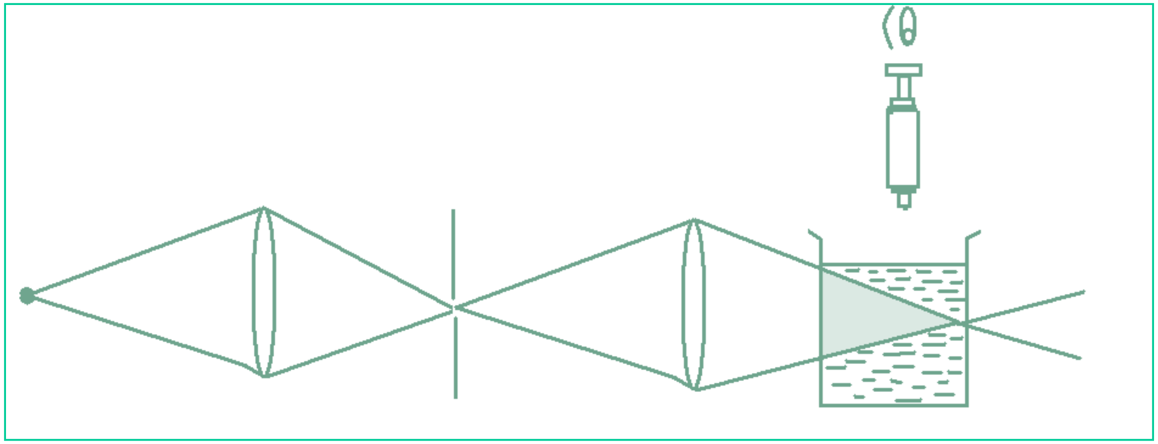
- Sols are heterogeneous, so they shows optical properties
- Scattering of light by colloidal particles is called Tyndall effect
- Eg: Cinema projector's light



- Tyndall effect is used to distinguish between true solution and colloidal solution
- Most lyophobic sols exhibit tyndall effect.
- Intense tyndall effect is observed when
  - The diameter of the dispersed particle is not much smaller than wavelenth of light used
  - There must be a large difference in the refractive indices of the dispersed phase and dispersion medium

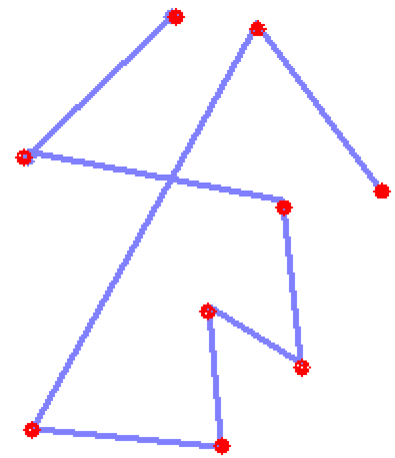
Application of Tyndall Effect- Ultramicroscope

- Tyndall beam is viewed through a microscope
- Bright spots of colloidal particle can see
- Determination of sol particles taking advantage of tyndall effect $m/d = 4\pi r^3 n/3$
- Radius of the sol particle=$(3m/4\pi dn)^{1/3}$



Kinetic property- Brownian Motion

- The ceaseless, erratic, zig-zag motion exhibited by colloidal particles
- Unequal bombardment of colloidal particles
- Stabilise colloid-counteract the force of gravity on colloidal particles
- Perrin’s Equation (size of sol by taking advantage of Brownian motion and Tyndall effect)



$$\frac{RT}{No}\ln\frac{n_1}{n_2} = \frac{4}{3}\pi r^3 g(h_2 - h_1)(d - d')$$

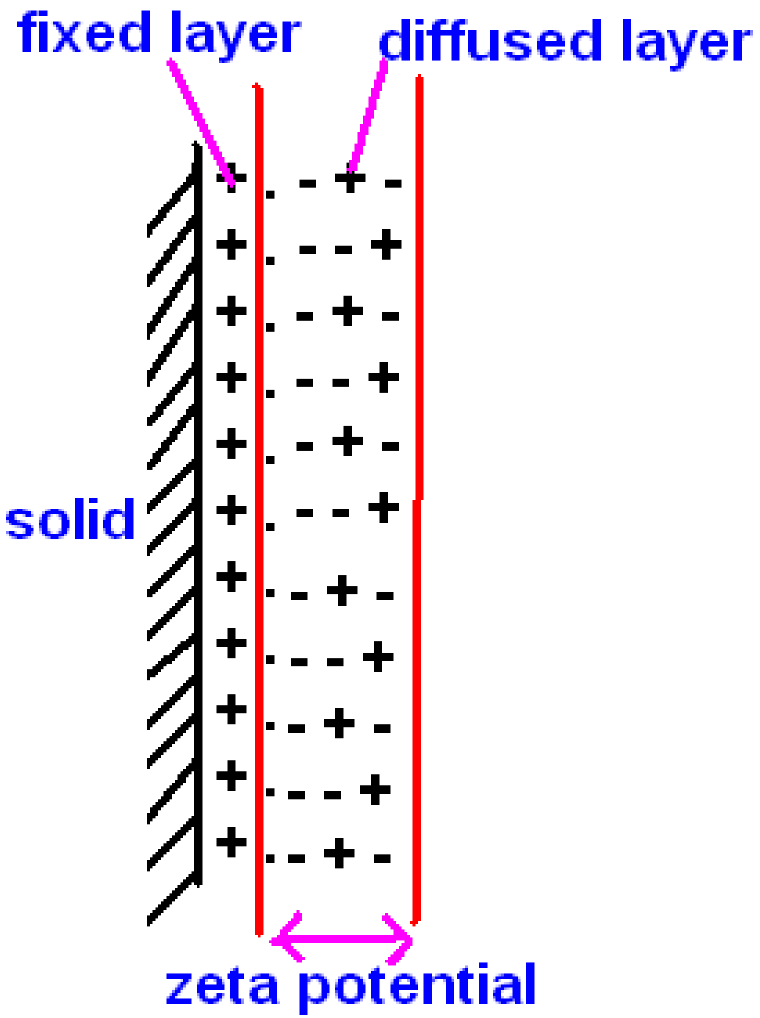
Electrical properties

- Colloidal particles are charged
- Charge originate due to preferential adsorption of ions
- Eg: $Fe(OH)_3$ adsorb Fe^{3+} ions, As_2S_3 adsorb S^{2-}
- Electrical double layer and zeta potential

Electrical double layer and zeta potential

- The difference in potential between the position of closest approach of the ions to the fixed layer at the surface and the electroneutral region of bulk liquid across the diffused layer is called Zeta potential
- **$\zeta=4\pi ed/D$**

  ζ-is the potential difference between the hypothetical plates, D-dielectric con, e-charge/cm^2, d-distance of the diffused layer

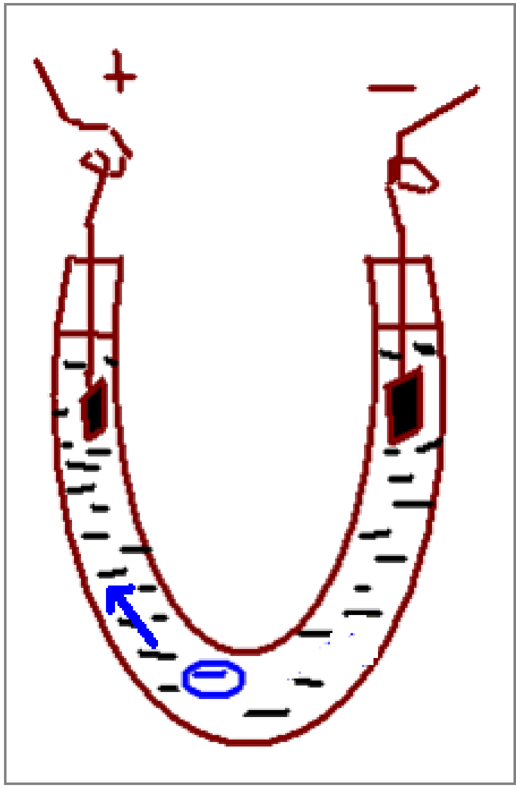


Consequences of electrical double layer

- Electrokinetic phenomenon is observed due to electrical double layer
  - **Electrophoresis**
  - **Electroosmosis**

Electrophoresis

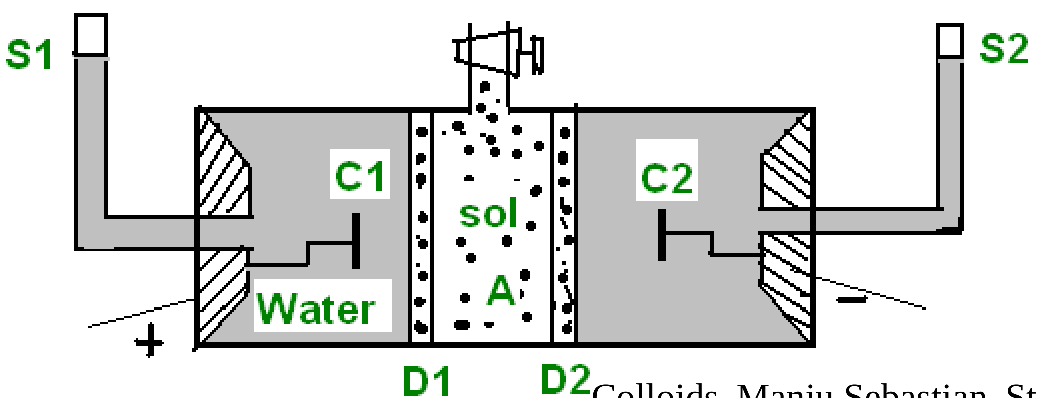
- When a colloidal particle is placed in an electric field, the electrically charged colloidal particles migrate towards the oppositely charged electrode; this phenomenon is called electrophoresis
- Type of charge can determine by checking the migration
- Electrical double layer moves in an electric field



- The pH at which sol particles of an ampholytic substance become electrically neutral and exhibit no movement in an electrical field is called **isoelectric point** of the sol

Electroosmosis electroendosmosis

- The electrophoretic motion of the dispersed particles of a sol is prevented by suitable means, the dispersion medium begins to move in an electric field; this phenomenon is called electroosmosis



Sol is taken in middle compartment
C1, C2 side compartments
D1, D2 dialysing membranes

Stability of sol

- Lyophobic sol
  - Similar charges repel, hence no aggregation
- Lyophilic sol
  - Similar charges repel, hence no aggregation
  - Extensive solvation
  - Brownian motion

Coagulation of sols

- Coagulation or flocculation is the precipitation of dispersed phase through induced aggregation
- Methods
  - Persistent electrophoresis
  - Persistent dialysis
  - Addition of oppositely charged sol
  - Addition of electrolytes

Hardy-Schulze law

- The law states that “The greater the valency of the ion bearing a charge opposite to that on sol particles, the greater is its power to cause coagulation”
- $Na^{+} < Ba^{2+} < Al^{3+}$
- $Cl- < SO_4^{2-} < PO_4^{3-} < [Fe(CN)_6]^{4-}$

Flocculation value

- The minimum concentration of an electrolyte required to cause coagulation of a sol
- Values are in agreement with Hardy Schulze rule
- $NaCl$, $BaCl_2$, $AlCl_3$ for As_2S_3--- 52, 0.69, 0.093

Protective colloids- Gold number

- A lyophilic substance that offers protection to a lyophobic sol from the precipitating effect of electrolytes is called protective colloid
- Eg: gelatin in gold sol
- The protective power of a lyophilic sol is expressed in terms of gold number
  - **Gold number of a protective colloid is defined as the weight in mg of the dry protective colloid that just prevents the coagulation of 10ml of a standard gold sol on adding 1ml of 10% NaCl solution.**
  - The smaller the gold no greater the protection
  - Gelatin 0.005-0.01, Hb 0.03-0.07, Albumin 0.1-0.2, Starch 20-25

EMULSIONS

- Dispersed phase and dispersion medium are liquids
- 2 types
  - Oil in water emulsion-oil is the dispersed phase and water is the dispersion medium , Eg: Milk
  - Water in oil emulsions- Water is the dispersed phase and oil is the dispersion medium, Eg: Butter

Tests for determining the type of emulsion

- Conductance test
  - Oil in water > Water in oil
- Dilution test
  - Addition of water
- Dye test
  - Addition of oil soluble dye (sudan III)
- Spreading test
  - Study spreading behaviour on the surface of oil. Water in oil type spreads quickly

Preparation and properties of emulsions

- **Emulsification-** shaking 2 immisible components of liquid
- **Emulsifier or emulsifiying agents** will stabilise an emulsion by lowering the interfacial tension between the two liquids and thereby preventing aggregation.(Eg: soaps and detergents are good emulsifiers; they emulsify grease with water)
- **Demulsification-** Breaking up of an emulsion

Some applications of emulsions

- Milk and water are emulsions of fat in water are used as constituents of our food.
- Pharmaceutical preparations
- Emulsion of asphalt is used in making roads
- Many superior quality paints are emulsions
- Froth floatation makes use of the process of emulsification
- Cleansing action of soap/detergent is based on their emulsifiying properties

GEL

- Dispersed phase is a liquid and dispersion medium is a solid
- Eg: Jellies, jam, cheese, silica acid gel etc.
- Structure of gel
  - Particles are united through cohesive forces to form an interlocking system known as fibrils. Fibrils hold the particle through solvation
- Preparation:
  - Cooling- Cooling an aqueous lyophilic sol like gelatin, starch etc.
  - Double decomposition- sodium silicate and HCl on mixing give silicic acid (silica gel)

Properties of gels

- Elastic and inelastic gels
- Imbibition-The process of imbibing liquid, it may follow an increase in size of gel is called swelling. It is shown by elastic gels
- Synerisis- On standing many gel give off small amount of water and experience a contraction.
- Thixotropy- some Gels on vigorous shaking changes to sol and back on standing. The reversible GEL SOL transformation is called thixotropy

Applications of gels

- Tooth paste, hair gel, boot polishes etc.
- Many food stuffs are in gel form
- Medicines
- Silica gel-remove moisture, desiccant
- Alcohol+calcium acetate gel-in picnic stove as fuel
- Gelatin, agar agar gels in lab for making liquid junction

Applications of colloids

- In foods
- In medicine
- In industry
- In sewage disposal
- In laundry
- Formation of deltas

Sedimentation potential or Dorn effect

- When the coarse particles of a suspension are allowed to settle under the influence of gravity, a potential difference develops between upper and lower layers of the liquid column through which they fall. This phenomenon is known as Dorn effect or sedimentation potential
- Reverse of electrophoresis

Donnan Membrane equilibrium

Initial state $Na^+ \; Cl^- \; : \; Na^+ \; R^-$

$c_1 \quad c_1 \quad : \quad c_2 \quad c_2$

Equilibrium state $Na^+ \; Cl^- \; : \; Na^+ \; R^- \; Cl^-$

$c_1 - x \quad c_1 - x \quad : \quad c_2 + x \quad c_2 \quad x$

$$[Na^+]_{left}[Cl^-]_{left} = [Na^+]_{right}[Cl^-]_{right}$$

$$(c_1 - x)(c_1 - x) = (c_2 + x)x$$

$$c1^2 - 2c_1x + x^2 = c_2x + x^2$$

$$c1^2 = x(c_2 + 2c1)$$

$$x = \frac{c_1^2}{(c2+2c1)}$$

$$\frac{x}{c_1} = \frac{c_1}{(c2+2c1)}$$

Significance of Donnan Equilibrium

- Biological systems – The distribution of ions between RBC and surrounding plasma
- Artificial kidney
- Tanning of leather
- Dyeing of animal fibres by acid dyes


thank you