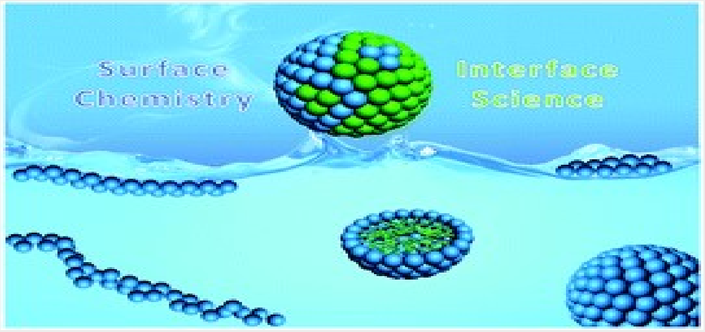
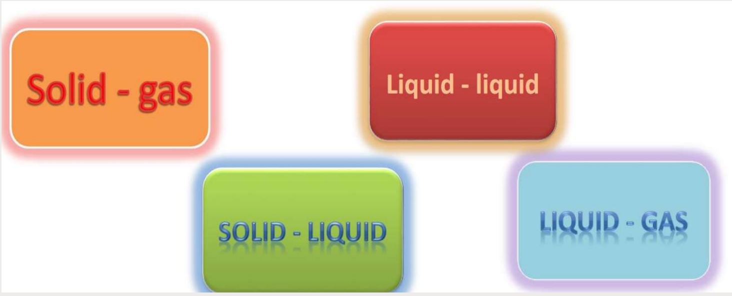
SURFACE CHEMISTRY

Surface Chemistry



- The branch of chemistry concerned with the processes occurring at interfaces between phases.
- Chemical phenomena that occur at the interface of two phases, including solid–liquid interfaces, solid–gas interfaces, solid–vacuum interfaces, and liquid-gas interfaces.
- surface chemistry, surface physics and surface engineering



Phenomena taking place on the surface of a substance

Phenomena work on this principle such as:

- Adsorption
- Colloid Formation
- Heterogeneous Catalysis
- Corrosion
- Electrode Reactions
- Chromatography

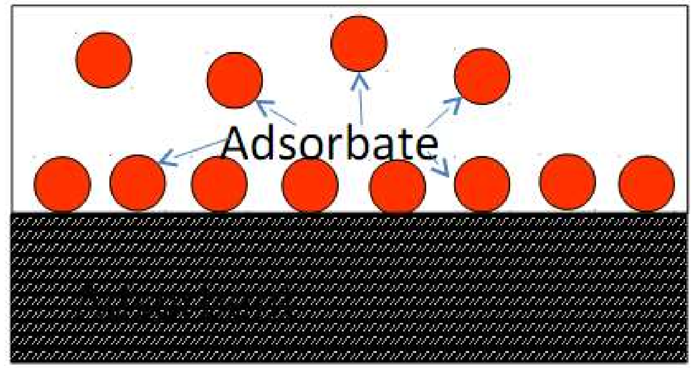
Applications of Surface Chemistry

Surface Chemistry has a major role in various chemical processes such as:

- Enzymatic reactions at the biological interfaces found in the cell walls and membranes
- In the electronics industry, the use in the surface and interface of microchips used in computers.
- In automobile exhausts, the heterogeneous catalysts found in the catalytic converter for cleaning emissions.

•ADSORPTION: is the adhesion of atoms, ions, biomolecules or molecules of gas, liquid, or dissolved solids to a surface.

Adsorption



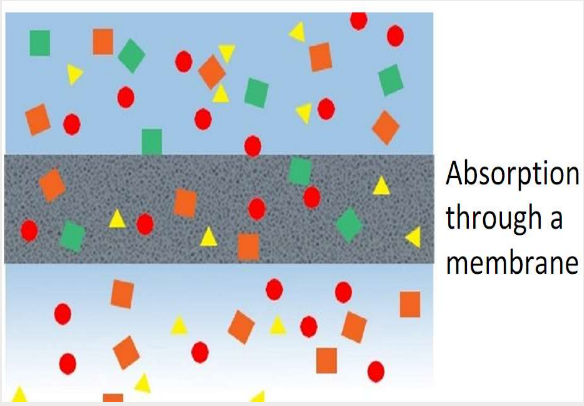
Adsorbent, Adsorbate and Interface

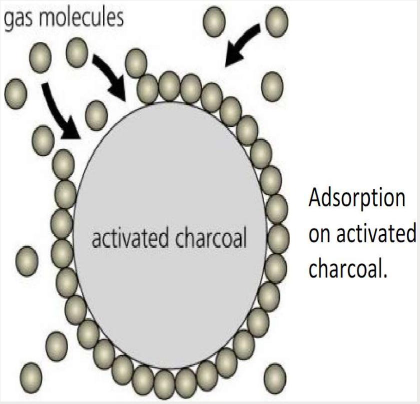
- The substances upon whose surface the change of concentration occurs, is called ***absorbent***
- The substance taken up on the surface is call ***adsorbate***.
- The common surface between the two phases where the adsorbed molecules concentrate is called the ***interface.***

Role of Adsorption in Surface Chemistry

- Accumulation of species on higher concentration on the surface of a substance due to intermolecular force is known as adsorption. For Example, gases such as H_2, O_2, N_2 adsorbs on the surface of activated charcoal.

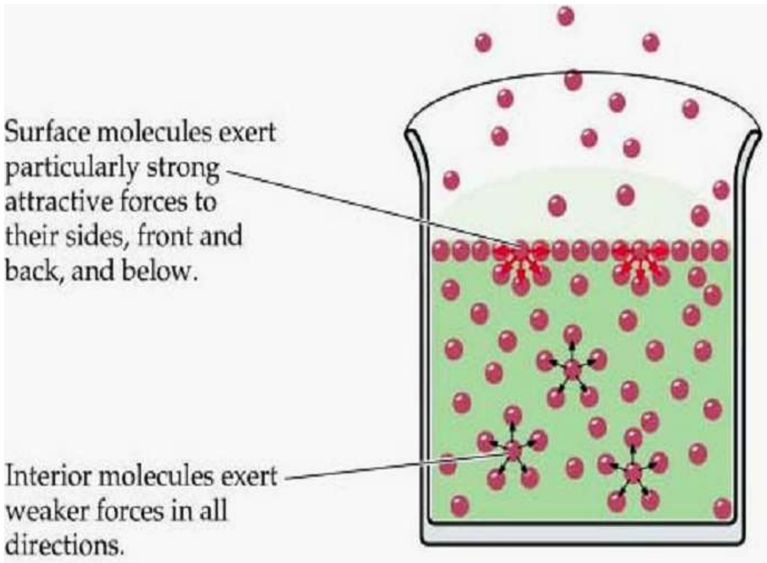
- Enthalpy of Adsorption: Amount of heat energy liberated when one mole of gas is adsorbed on the unit surface area of adsorbent is known as enthalpy of adsorption.





Causes of Adsorption

- Dislike of Water Phase – 'Hydrophobicity'
- Attraction to the Sorbent Surface
  – van der Waals forces: physical attraction
  – electrostatic forces (surface charge interaction)
  – chemical forces (e.g., π- and hydrogen bonding)



Types of Adsorption

- Due to the force of interaction between adsorbate and adsorbent, adsorption in surface chemistry is classified into two types.

1. Physical Adsorption or Physisorption
2. Chemical Adsorption or Chemisorption

Physisorption and Chemosorption:

Physisorption	Chemisorption
Only van der Waals force are present between adsorbate and surface of adsorbent	Chemical bonds are formed between adsorbate and surface of adsorbent
Low enthalpy of adsorption ie, in the order of 20 kjmol-1.	High enthalpy of adsorption i.e, order of 200 kjmol-1.
Reversible	Irreversible
It is usually takes place at **low temperature** and does not require any activation energy.	It takes place at **high temperature** and require activation energy..
Multi molecular layer of adsorbate are formed on the surface	Only **monomolecular layers** are formed.
Not specific.	Highly specific.

Emulsions in Surface Chemistry

- **Example:** Paints, dyes, milk, vanishing cream. On the basis of dispersion medium emulsions in surface chemistry are classified into two types:
- Oil in Water Emulsions

In this, the oil or fat droplets are dispersed in water. **Example:** Milk.

- Water in Oil Emulsions

In this, the water droplets are dispersed in oil. **Example:** Vanishing cream.

- Emulsions are unstable, to increase the stability another substance called as emulsifiers are added. **Example:** Milk contains natural emulsion casein.

Emulsions in Surface Chemistry

The colloidal solutions in which both dispersed phase and dispersion medium are liquids are called as Emulsions.

On the basis of dispersion medium emulsions in surface chemistry are classified into two types

- **Emulsion of oil in water:** Those emulsions in which the dispersed phase is oil and water is the dispersion medium. These emulsion are generally represented as O in W = emulsions. Examples are milk, vanishing cream etc.
- **Emulsions of water in oil:** Those emulsion in which the dispersed phase is water while oil is the dispersion medium. These emulsion are generally represented as W in O emulsions. Examples are butter, ice cream etc.

Applications of Emulsions

- These are used in syrups
- Paints
- Toothpaste
- Digestion of fats
- Pigment and dye

Colloid

- A colloid is a mixture in which one substance of microscopically dispersed insoluble or soluble particles is suspended throughout another substance

- A **colloid** is a mixture that has particles ranging between 1 and 1000 nanometers in diameter, yet are still able to remain evenly distributed throughout the solution.

Milk is an emulsified colloid of liquid butterfat globules dispersed within a water-based solution.

Classification of colloids

Classification is based on following criteria

Physical state of dispersed phase and dispersion medium.

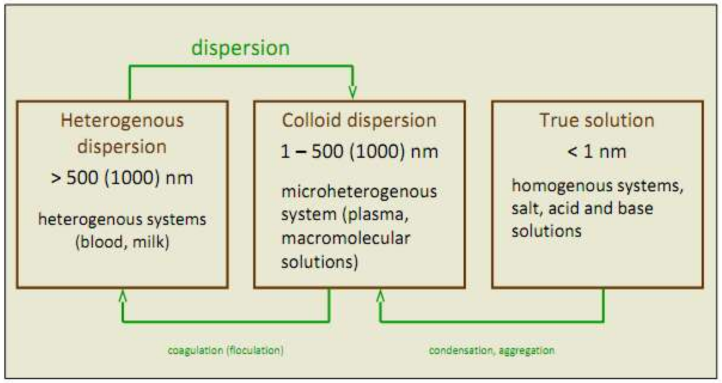
Nature of interaction between dispersed phase
and dispersion medium.
Types of particles of the dispersed phase.

Dispersed Phase	Dispersion Medium	Name	Typical example
Solid	Liquid	Sol	Gold sol, Mud, $Fe(OH)_3$ sol,
Solid	Solid	Solid sol	Gems, Ruby glass, Minerals
Solid	Gas	Aero sols	Smoke (Carbon in air) Volcanic dust
Liquid	Solid	Gel	Curd, Cheese, Jellies
Liquid	Liquid	Emulsion	Milk, water in benzene, cream
Liquid	Gas	Liquid aero sol	Clouds, fog (water in air) mist
Gas	Solid	Solid foam	Lava, Pumica
Gas	Liquid	Foam	Froth on beer , whipped cream

Disperse systems

- The term "Disperse System" refers to a system in which one substance (**the dispersed phase**) is distributed, in discrete units, throughout a second substance (**the continuous phase** or vehicle).
- Each phase can exist in solid, liquid, or gaseous state .

Types of disperse systems



- **Dispersed Phase:**

  The phase which is dispersed or scattered through the dispersion medium is called Dispersed phase or discontinuous phase.
- **Dispersion Medium:**
- The phase in which the scattering is done is called the dispersion medium or continuous medium.

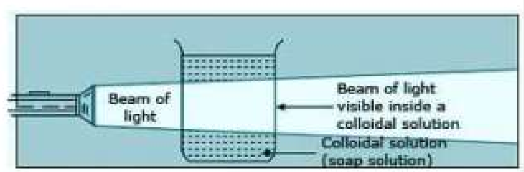
Difference between True Solutions, Suspension & Colloids:

True solution	Suspension	Colloid
Homogenous	Heterogeneous	Heterogeneous
Particle size less than 1nm	Particle size more than 1000nm	Particle size between 1-1000nm
Don't settle down	Settle down under the influence of gravity	Don't settle down
Complements cannot be separated out by filtration	Can be filtered	Can be filtered using special filter papers
Don't show 'Tyndall' effect	Show 'Tyndall' effect	Show 'Tyndall' effect

TYNDALL EFFECT

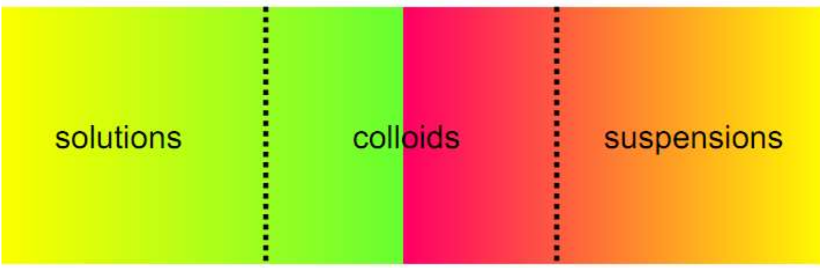
When an intense converging beam of light is passed through a colloidal solution kept in dark, the path of the beam gets illuminated with a bluish light.

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

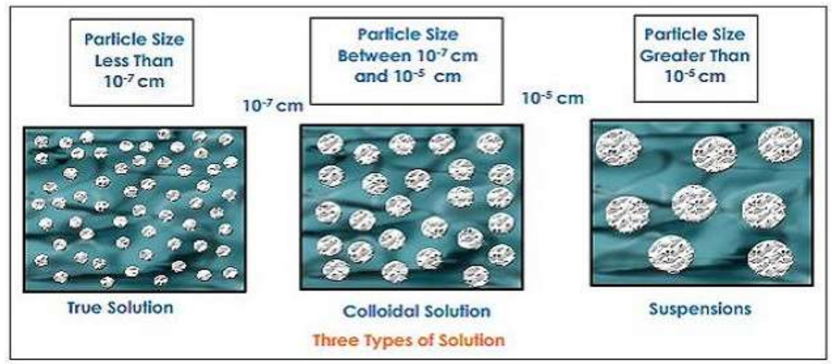


Comparison of Solutions, Colloids, and Suspensions

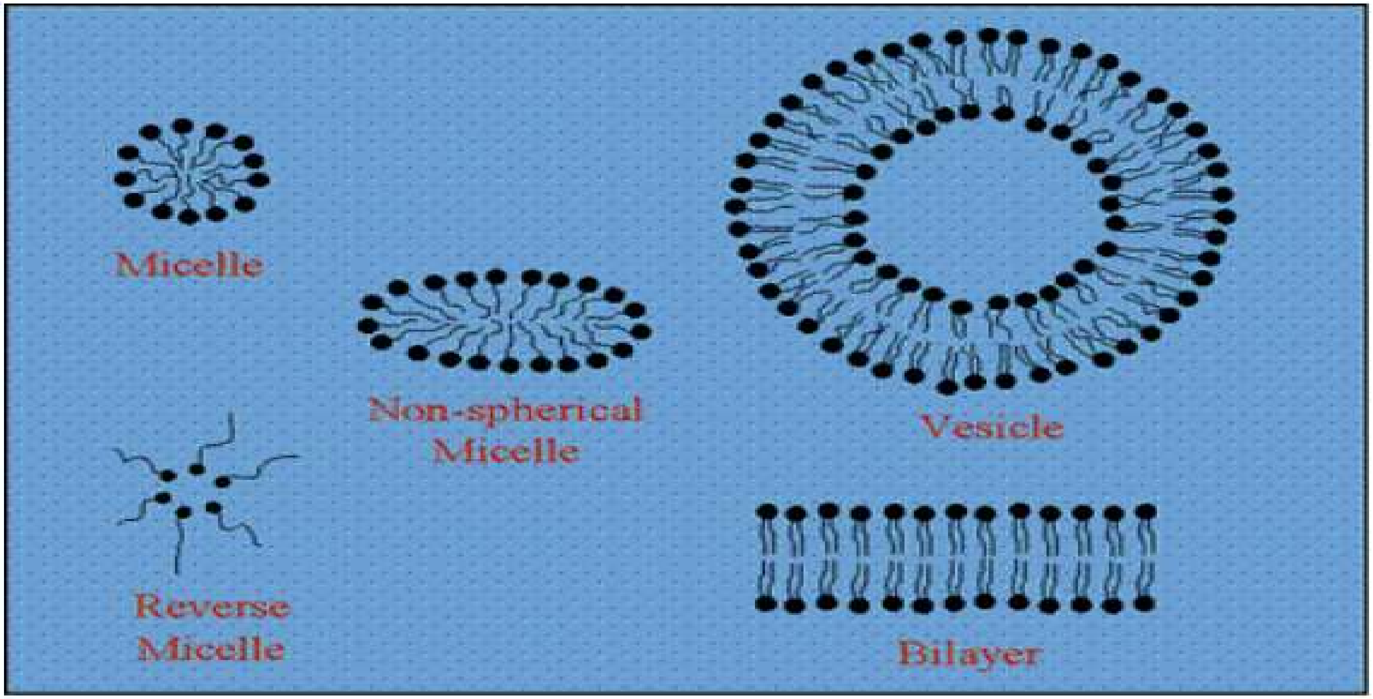
< 1 nm > 100 nm



-single atoms -small molecules -ions -polyatomic ions	-aggregates of atoms, molecules or ions -macromolecules (proteins)	-clumps of particles, -mineral grains such as sand



Association Colloids



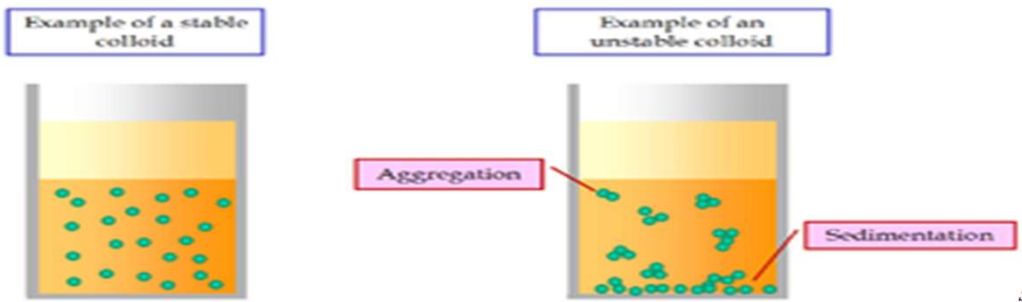
Methods of Preparation

There are two principal ways of preparation of colloids:

- Dispersion of large particles or droplets to the colloidal dimensions by milling, spraying, or application of shear (e.g., shaking, mixing, or high shear mixing).
- Condensation of small dissolved molecules into larger colloidal particles by precipitation, condensation, or redox reactions. Such processes are used in the preparation of colloidal silica or gold.

Stabilization of Colloids

The colloid is said to be stable when particles remain suspended in the solution without settling down i.e. the dispersed phase. Stability is hindered by aggregation and sedimentation phenomena, which are driven by the colloid's tendency to reduce surface energy. In order to stabilize the colloidal system, we need to reduce the interfacial tension between the colloidal particles.



Source: Wikipedia

Aggregation is due to the sum of the interaction forces between particles. If attractive forces (such as van der Waals forces) prevail over the repulsive ones (such as the electrostatic ones) particles aggregate in clusters. Electrostatic stabilization and steric stabilization are the two main mechanisms for stabilization against aggregation.

- ***Electrostatic stabilization*** is based on the mutual repulsion of like electrical charges. In general, different phases have different charge affinities, so that an electrical double layer forms at any interface. Small particle sizes lead to enormous surface areas, and this effect is greatly amplified in colloids. In a stable colloid, the mass of a dispersed phase is so low that its buoyancy or kinetic energy is too weak to overcome the electrostatic repulsion between charged layers of the dispersing phase.
- ***Steric stabilization*** consists in covering the particles in polymers which prevents the particle to get close in the range of attractive forces.

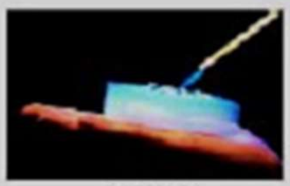
Examples of colloidal systems from daily life

Foams

Milk

Fog, smoke

Detergents



Aerogel

Blood

Paints

Cosmetics

Applications of colloidal solutions:

1- Therapy--- Colloidal system are used as therapeutic agents in different areas.

e.g- Silver colloid-germicidal
Copper colloid-anticancer
Mercury colloid-Antisyphilis

2- Stability---e.g. lyophobic colloids prevent flocculation in suspensions.

e.g- Colloidal dispersion of gelatin is used in coating over tablets and granules which upon drying leaves a uniform dry film over them and protect them from adverse conditions of the atmosphere.

4- Absorption--- As colloidal dimensions are small enough, they have a huge surface area. Hence, the drug constituted colloidal form is released in large amount.

e.g- sulphur colloid gives a large quantity of sulphur and this often leads to sulphur toxicity

5-Targeted Drug Delivery--- Liposomes are of colloidal dimensions and are preferentially taken up by the liver and spleen.

Applications of colloidal solutions:

6- Photography:

A colloidal solution of silver bromide in gelatine is applied on glass plates or celluloid films to form sensitive plates in photography.

7- Clotting of blood:

- Blood is a colloidal solution and is negatively charged.
- On applying a solution of $Fecl_3$ bleeding stops and blood clotting occurs as Fe^{+3} ions neutralize the ion charges on the colloidal particles.