

Pharmaceutical Technology-I

Lecture 21

Colloids

Assist. Prof. D. Wedad K. Ali

Definition

- Colloid is defined as a heterogeneous system or mixture in which the minute particles of one substance are dispersed in another substance, called the dispersion medium.
- Although there is no precise point at which the size of a particle in a dispersion can be considered to be “colloidal”, there is a generally accepted size range.
- A substance is said to be colloidal when its particles fall between 1 nm and 1 μ m (or 0.5 μ m).

Colloidal Dispersion

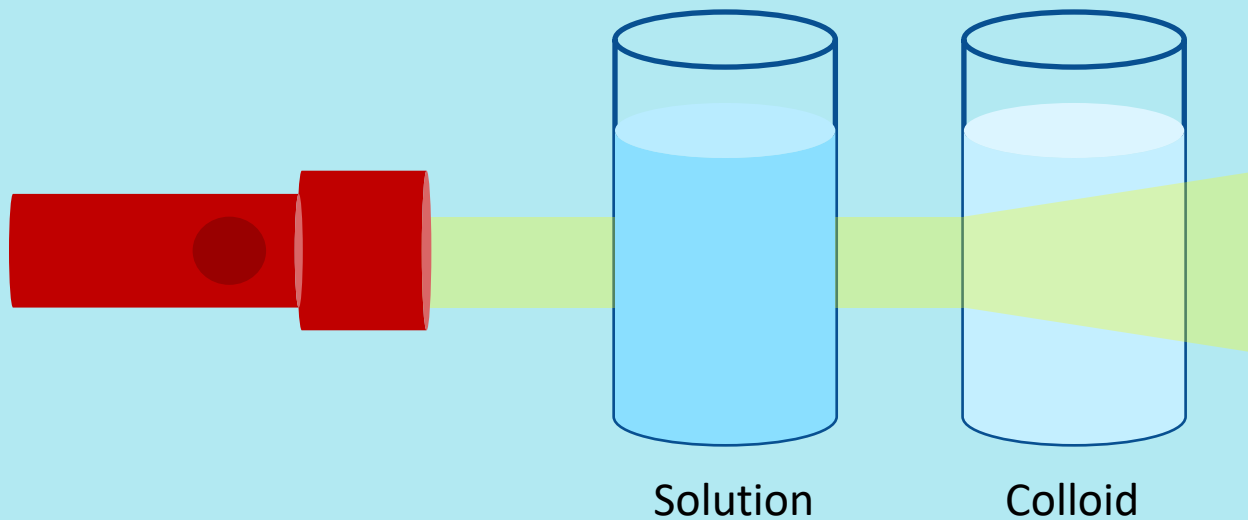
- Colloidal particles are usually larger than atoms, ions, or molecules and generally consist of aggregates of many molecules, although in certain proteins and organic polymers, single large molecules may be of colloidal dimension and form colloidal dispersions.

Differences between colloidal dispersion and true solution

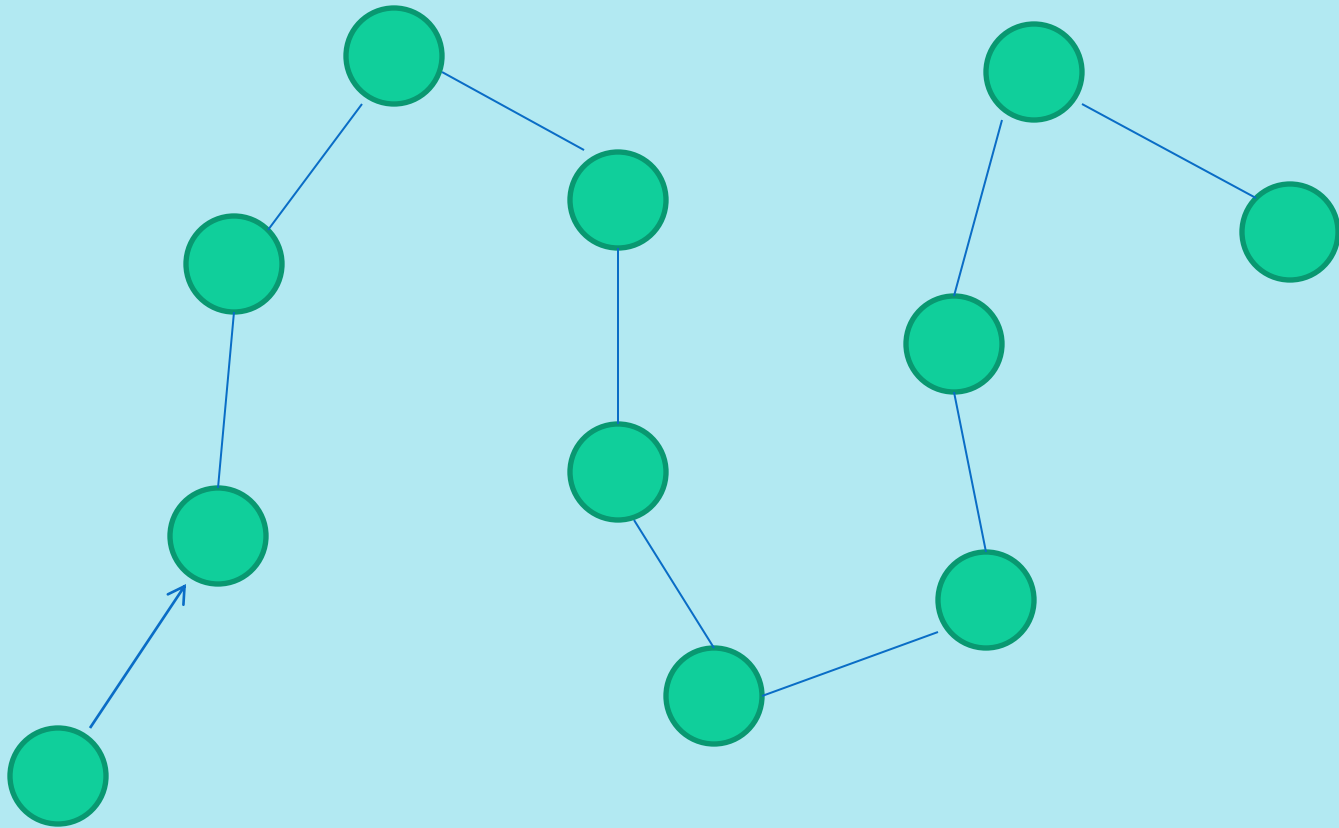
1. The particle size: the larger particle size of the disperse phase of colloidal type of preparation.
 2. The optical properties of the two systems: true solutions do not scatter light and therefore appear clear, but colloidal dispersions contain opaque particles that do scatter light and thus appear turbid.
- This turbidity is easily seen even with dilute preparations, when the dispersion is observed at right angles to a beam of light passed through the dispersion.

Tyndall Effect

- The scattering of visible light by colloidal particles is called the Tyndall effect.



Brownian movements of colloidal particles



Properties of colloidal dispersions

- Colloidal dispersions have the following properties:
 1. Visible in electron microscope and often in ultra-microscope, but invisible in ordinary microscope.
 2. Low rate of diffusion.
 3. Undergo Brownian motion.
 4. Pass through filter paper, retained by ultrafilters and dialysis membrane.
 5. Low osmotic pressure.



Question

How can you differentiate **practically** between colloidal dispersion and solution?

Terms used for colloidal dispersions

1. **Sol:** is a general term to designate a dispersion of a solid substance in either a liquid, a solid, or a gaseous dispersion medium.
2. **Hydrosol:** a prefix hydro refers to water, means the dispersion medium is water.
3. **Organosol:** dispersion of solid in organic solvent
4. **Alcosol:** a prefix alco refers to alcohol, dispersion medium.
5. **Aerosol:** term for a dispersion of solid or a liquid in a gaseous phase.

Classification of colloidal dispersion

A. Colloids can be classified according to different properties of the dispersed phase and dispersion medium.

- Firstly, based on the types of particles of the dispersed phase, colloids can be classified as:
 1. Multimolecular colloids
 2. Macromolecular colloids
 3. Associated colloids

- According to the type of dispersed particle colloid is classified to

1. Multimolecular Colloids

- When the dissolution of smaller molecules of substance or many atoms takes place, they combine to form a species whose size is in the range of colloidal size.
- The species formed is known as the multimolecular colloids.
For example, the Sulphur solution contains particles which have thousands of S_8 .

2. Macromolecular Colloids

- In this type of colloids, the macromolecules form a solution with a suitable solvent. The size of the particles of this macromolecular solution lies in the range of colloidal particles size.
- Thus, this solution is also known as the macromolecular colloids. The colloids formed here are similar to that of the actual solution in many respects and are very stable.
Example: Starch, proteins, enzymes, and cellulose are the naturally occurring macromolecular colloids whereas polyethene, synthetic rubber, etc. are the synthetic macromolecules.

3. Associated Colloids

- Some substances act as a strong electrolyte when they are in low concentrations, but they react as colloidal sols when they are in high concentration. In higher concentration, particles aggregate showing colloidal behaviour. These aggregated particles are known as the micelles. They are also known as the associated colloids.
- The formation of the micelles occurs above a particular temperature called the Kraft temperature (T_k) and also above a specific concentration called the critical micelle concentration. These colloids can be reverted by diluting it.
- Examples of some associated colloids are soaps and synthetic detergents.

B. According to the attraction or lack of attraction between the dispersion phase and dispersion medium, colloidal dispersion is divided into:

1. Lyophilic colloid:

- there is a considerable attraction between dispersed phase and dispersion medium.
- There is extensive solvation and the system is said to be solvent loving when there is high affinity between the two phases.
- If the dispersion medium is water then the system is called hydrophilic.
- For example starch, gelatin, acacia, povidone these swell, disperse, dissolve spontaneously in water.

- If the dispersion medium is of low polarity or low dielectric constant then it is called lipophilic or oleophilic.
- These have good affinity for oils or solvent of low polarity like benzen, CCl_4 .
- Examples of lipophilic dispersion: polymers like polystyrene or gum rubber, they dissolve molecularly in benzene. Magnesium or Aluminum stearate in cotton seed oil.

- Lyophilic colloidal systems are usually:
 1. Easier to prepare, formed spontaneously because of high affinity between dispersed particle and the dispersion medium.
 2. Thermodynamically stable because of high affinity will give small surface area which gives small free energy (ΔF)

$$\Delta F = \gamma \Delta A$$

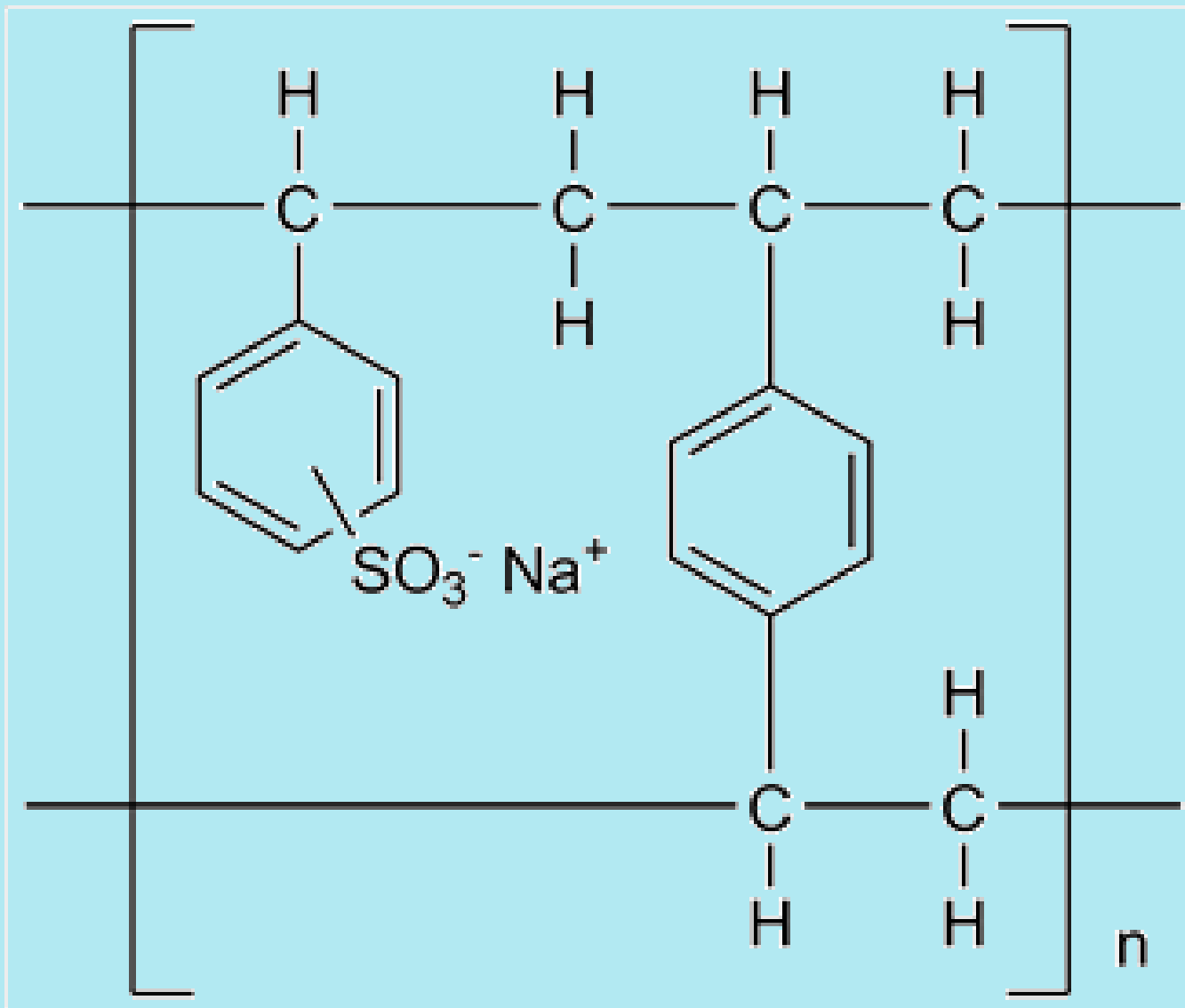
3. Reversible: even if the solvent is removed from the system and then is bring back, the system will formed spontaneously.

Hydrophilic colloidal dispersion classification

1. Soluble materials: are soluble in water whether they are linear or branched polymer. Their solution is classified as colloid because the individual molecules are in the colloidal particle size range, they exceed 50-100 Å. For example acacia, povidone.
2. Particulates: represent solids which swell in water, but their primary particles do not dissolve or break down into individual molecules or ions. One subdivision of this class composed of cross-linked polymers, their linear uncross-linked analogues are soluble in water.

Examples of Particulates

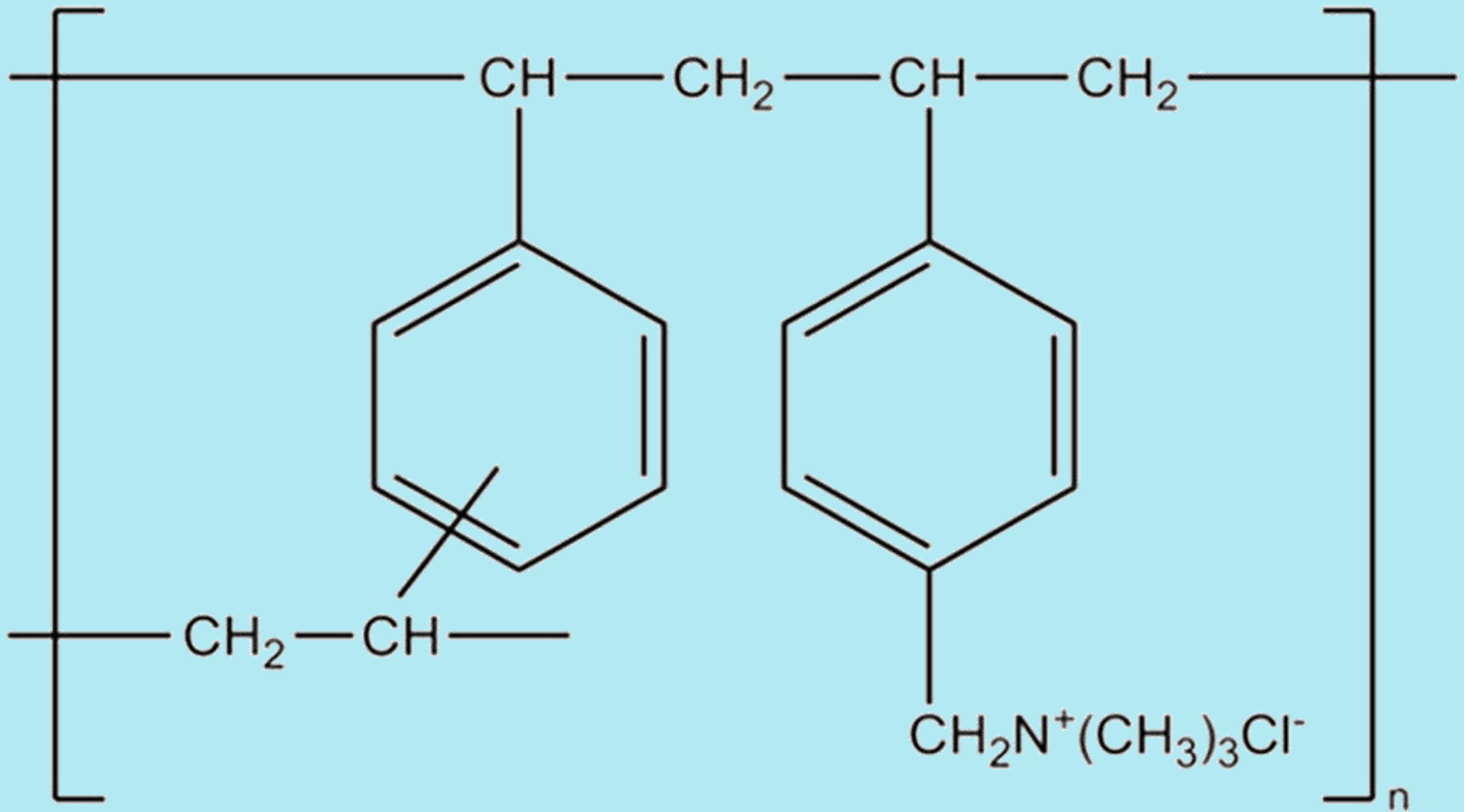
- Sodium polystyrene sulfonate which is used as cation exchange resin and it is water insoluble produced by copolymerization of styrene with few percentage of divinyl benzene and then the product is subjected to sulfonation and neutralization.
- The polymer behaves as single molecule where its atoms are linked together by vinyl bond, they are strong and resist rupture and dissolution.



Examples

- Cholestramine resin USP, which has the same backbone of the cross-linked polystyrene chain but they contain quaternary ammonium chloride group instead of sodium sulfonate group, so it acts as anion exchange resin.

Cholestyramine



3. Gels (sometimes called jellies) are semisolid systems consisting of dispersions of small or large molecules in an aqueous liquid vehicle rendered jelly like by the addition of a gelling agent.
- Among the gelling agents used are synthetic macromolecules, such as carbomer 934; cellulose derivatives, such as carboxymethylcellulose or hydroxypropyl methylcellulose; and natural gums, such as tragacanth.
 - Carbomers are high molecular weight water-soluble polymers of acrylic acid cross-linked with allyl ethers of sucrose and/ or pentaerythritol.

- There are two properties for substances to form gel:
 1. The particle must be extensively solvated
 2. They must be able to adhere to each other at the point of contact.
- A gel consists of two continuous phases mixed together and interpenetrating, the solid matrix and the immobilized liquid.
- A gel is formed when the polymer substances are present at high concentration and/ or at a temperature where their solubility is low.
- Examples of such hydrogel are gelatin and starch, which will form gel on cooling. While methylcellulose will form gel on heating.

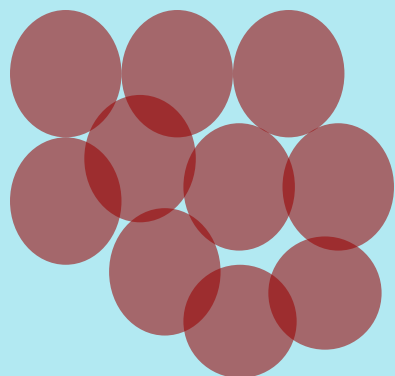
- Gel is considered as a semisolid or solid dispersion.
- Gels owe their rigidity to an intertwining network of the disperse phase which entraps and holds the dispersion medium.
- A change in the temperature can cause certain gels to resume the sol or liquid state. Also, some gels may become fluid after agitation and resume their solid or semisolid state after remaining undisturbed for a period of time, a phenomenon known as thixotropy.
- Gels may thicken on standing, forming a thixotrope, and must be shaken before use to liquefy the gel and enable pouring.

Terminology Related to Gels

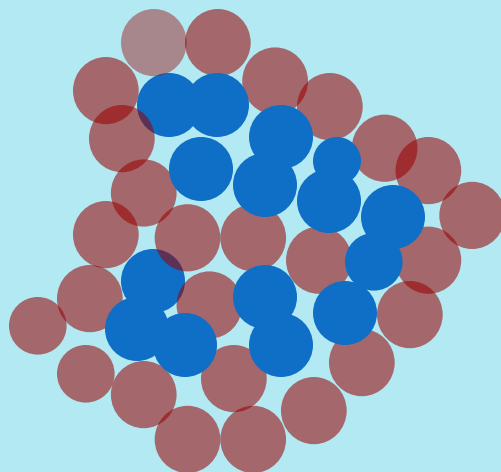
- A number of terms are commonly used in discussing some of the characteristics of gels, including imbibition, swelling, syneresis, thixotropy, and xerogel.
- **Imbibition** is the taking up of a certain amount of liquid without a measurable increase in volume.
- **Swelling** is the taking up of a liquid by a gel with an increase in volume. Only liquids that solvate a gel can cause swelling.
- The swelling of protein gels is influenced by pH and the presence of electrolytes.

- **Syneresis** occurs when the interaction between particles of the dispersed phase becomes so great that on standing, the dispersing medium is squeezed out in droplets and the gel shrinks.
- Syneresis is a form of instability in aqueous and nonaqueous gels.
- Separation of a solvent phase is thought to occur because of the elastic contraction of the polymeric molecules; in the swelling process during gel formation, the macromolecules become stretched, and the elastic forces increase as swelling proceeds.

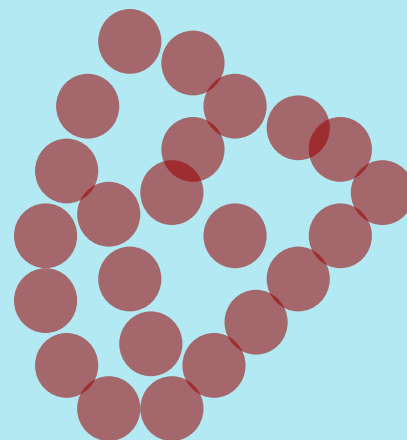
- **Thixotropy** is a reversible gel–sol formation with no change in volume or temperature, a type of non Newtonian flow.
- **A xerogel** is formed when the liquid is removed from a gel and only the framework remains.
- Examples include gelatin sheets, tragacanth ribbons, and acacia tears.
- **Aerogel** is a synthetic porous ultralight material derived from a gel, in which the liquid component for the gel has been replaced with a gas without significant collapse of the gel structure. Aerogels are produced by extracting the liquid component of a gel through supercritical drying or freeze-drying.



Xerogel



Gel



Aerogel