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Unit I

Viscosity and Surface tension

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Viscosity

- Liquid or fluid has a tendency to flow which is referred to as **fluidity.**
- V**iscosity is defined as the internal resistance against the free flow of a liquid or gas due to frictional forces between the fluid layers moving over each other at different velocities.**
- **Coefficient of viscosity (η):** It is the force (dynes) required to maintain the streamline flow of one fluid layer over another, both of 1cm^2 area and separated from one another by 1cm, at the rate of 1cm/sec.

- Essentially, viscosity can be seen as the internal friction within a liquid. Different liquids exhibit varying levels of viscosity; for example, ether has a very low viscosity, while honey and blood are much more viscous.

Factors affecting Viscosity

- Several factors influence viscosity, including the liquid's density, the concentration of dissolved substances, their molecular weight, and molecular interactions.
- Higher temperatures generally reduce viscosity, whereas increased pressure tends to raise viscosity to some extent.
- Colloidal solutions, especially lyophilic colloids, typically have higher viscosity compared to true solutions.

- Viscosity of a solution varies directly with the size and asymmetry of the solute or suspended particles. A larger or elongated solute molecule imparts higher viscosity to its solution than a smaller or spherical molecule.
- Because a non spherical or larger particle exhibit a larger surface towards the direction of flow than a spherical or small particle and has a higher frictional coefficient and a higher contribution to the viscosity of the solution.

Methods of Determination of Viscosity

- 1. The falling sphere method
- 2. Ostwald viscometer
- 3. Couette viscometer

Applications of Viscosity

- **Viscosity of protein solution**: The higher the molecular weight, the molecular elongation or the concentration of protein, the greater is the viscosity.
- pH affects the viscosity of a protein solution.Viscosity is at the lowest at the isoelectric pH.
- Denaturation of a protein enhances the viscosity of a solution.

- Viscosity of blood plasma and serum: The plasma viscosity normally ranges form $1.5x10^{-3}$ to $2x10^{-3}$ Pas (15–20 mpoise) at 20°C. It is normally caused by the large and elongated molecules of solvated plasma proteins bearing surface charges.
- The larger non spherical and fibrous molecules of fibrinogen have higher frictional coefficients and contribute more to plasma viscosity than smaller, globular plasma proteins.

- A rise in fibrinogen during inflammation increases the plasma viscosity considerably.
- Increase in serum viscosity is observed in polymerization of immunoglobulin in conditions like multiple myeloma, macroglobulinemia to produce a hyperviscosity syndrome characterized by vertigo, retinal hemorrhages, congestive heart failure, seizures and coma.

- **Blood Viscosity**: Blood is approximately four times more viscous than water, mainly due to the presence of suspended blood cells and colloidal plasma proteins. Viscosity of blood is $4x10^{-3}$ Pas at 20°C.
- blood viscosity helps in the streamline blood flow through the capillaries by reducing turbulence. A fall in the blood viscosity during hypoproteinemia and anemia may increase the tendency of turbulence in circulation.

- The viscosity of blood is increased by cold. Cooling of the body to 0°C may enhance blood viscosity by a factor of 2.5. This decrease the blood velocity and leads to the reduction in the blood supply to the chilled extremities.
- Blood viscosity increases in conditions like polycythemia (higher red blood cell count).
- Increased blood viscosity leads to a higher cardiac workload, and dehydration further raises blood viscosity.

- **Viscosity in Muscle**: Muscle excitation leads to an increase in the viscosity of muscle fibers, which results in a delay in the change of tension during muscle contraction.
- **Vitreous Body**: The vitreous body is a gel-like, viscous substance located in the posterior part of the eye. It is composed primarily of albumin and hyaluronic acid gives the viscous nature.

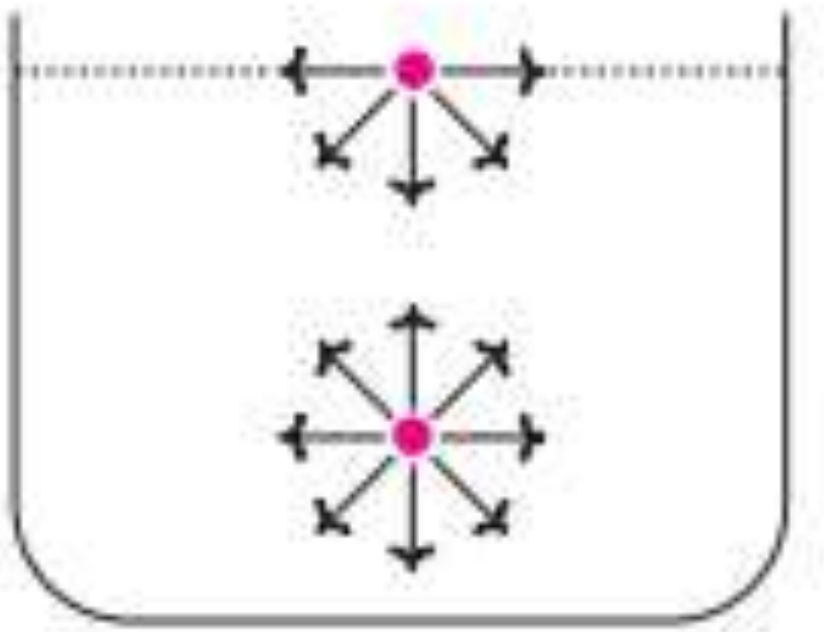
- **Synovial Fluid**: Synovial fluid contains hyaluronic acid, which contributes to its viscosity and plays a key role in lubricating the joints.
- Shearing stress at the joint decreases the viscosity of the synovial fluid by deforming its mucopolysaccharides like hyaluronic acid, which enhances the lubricating property of synovial fluid.

Surface tension

- A molecule within the bulk of a liquid is attracted to other molecules in all directions. However, a molecule at the surface is only attracted sideways and downward, not upward. This causes the surface layer to behave like a stretched film.
- Surface tension refers to the force that holds the molecules at the surface together, and it is measured in **dynes per centimeter.**

- Surface tension (γ) is expressed as the force either in dynes acting perpendicularly to a 1 cm line on the liquid surface or in newtons per metre.

Surface tension of a liquid



Factors affecting surface tension

- Surface tension decreases as temperature increases.
- As a result of surface tension, a liquid tends to occupy the smallest possible volume.
- According to the Gibbs-Thomson principle, compounds that reduce surface tension tend to accumulate at the surface (or interface), while those that increase surface tension are more likely to remain in the interior of the liquid.
- In general, organic substances like proteins and lipids decrease surface tension, while inorganic substances like NaCl and KCl increase it.

Determination of surface tension

- 1. Drop weight method
- 2. Capillary rise method
- 3. Maximum bubble pressure method
- 4. Wire loop pull method

Applications of surface tension

- **Hay’s Sulfur Test**: This is a common laboratory procedure used to detect bile salts in the urine of jaundiced patients. When sulfur powder is sprinkled on urine containing bile salts, it sinks, unlike in normal urine where the powder floats. The test relies on the principle that bile salts lower the surface tension of the urine, causing the sulfur to sink.

- **Digestion and Absorption of Fat**: Bile salts lower surface tension, acting as detergents to emulsify fats. This process breaks down fats into smaller particles, which aids in their effective digestion and absorption.

- **Surfactants and Lung Function**: The low surface tension in the alveoli prevents them from collapsing and promotes efficient gas exchange in the lungs.
- Surfactants, especially dipalmitoyl phosphatidyl choline (dipalmitoyl lecithin), are crucial for maintaining this low surface tension.
- A deficiency in surfactant leads to respiratory distress syndrome in infants.

- **Lipoprotein Complex Membranes**: The plasma membrane is made up of lipids and proteins, which reduce surface tension, facilitating the absorption of these compounds.
- **Surface Tension and Adsorption**: Adsorption is a surface phenomenon closely tied to surface tension. The combined effects of both processes contribute to the formation of complexes between proteins and lipids in biological systems.

- Plasma surface tension: Plasma has lower surface tension than water due to the presence of surfactants like lecithins and proteins. Surface tension of plasma is 50 dynes /cm.

References

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