

Effect of temperature on surface tension

Surface tension is inversely proportional to Temperature. For all liquids, surface tension decreases as temperature increases. With a rise in temperature, the kinetic energy of the liquid molecules increases, causing them to move more vigorously. This increased molecular motion tends to overcome or weaken the effect of intermolecular cohesive forces at the liquid surface. Consequently, the molecules experience less net attraction toward the bulk of the liquid and the surface tension decreases. The decrease continues with increasing temperature and at or near the **critical temperature** (where the distinction between the liquid and vapour phases disappears), the cohesive forces responsible for maintaining a distinct surface vanish and the **surface tension becomes zero**. Therefore, surface tension generally decreases continuously with increasing temperature and becomes zero at the critical temperature.

Applications of surface tension:

- i. It is important in the study of emulsion and colloid chemistry.
- ii. It is an essential factor in the concentration of ores by froth flotation process.
- iii. Surface tension measurements are of much importance in biological science, particularly in bacteriology.
- iv. The movement of moisture of soil and passage of sap in plants involve the surface tension.
- v. In everyday life, soaps and detergents are used for cleaning purposes. Synthetic surfactants have property of lowering the surface tension of water. Hence, they are used in preparations like tooth paste, cream, toilet soaps, washing powders, medical emulsions, etc.
- vi. Surface tension measurements are useful in knowing the presence of air bubble in blood stream and identifying the presence of bile salts in urine

Effect of Addition of Various Solutes on Surface Tension

1. Effect of Electrolytes

The addition of **electrolytes such as NaCl, KCl and CaCl₂** generally increases the surface tension of water. The ions interact strongly with water molecules and are usually preferentially attracted to the bulk of the solution rather than the surface. This strengthens the cohesive forces within the liquid and makes it more difficult for molecules to escape from the bulk to the surface. The extent of increase depends on the nature and concentration of the electrolyte.

2. Effect of Organic Non-Electrolytes

Organic non-electrolytes such as **alcohols, ethers and some organic acids** generally decrease the surface tension of water. These substances tend to accumulate at the air-water interface and

reduce the cohesive attraction between water molecules at the surface. As a result, the surface becomes less resistant to deformation and the surface tension decreases. For example, the addition of ethanol to water considerably lowers its surface tension.

3. Effect of Surface-Active Solutes

Surface-active substances or surfactants, such as soaps and detergents, produce a marked decrease in surface tension. Their molecules contain both a **hydrophilic part**, which has an affinity for water, and a **hydrophobic part**, which has little affinity for water. They preferentially accumulate at the liquid surface, where they reduce the cohesive forces between water molecules. This property allows soaps and detergents to spread easily over surfaces and improve wetting.

4. Effect of Strongly Hydrophilic Solutes

Some highly water-soluble substances can increase the surface tension of water because they are preferentially retained in the bulk rather than at the surface. Their strong interactions with water molecules make the movement of water molecules to the surface less favourable. **Inorganic salts** are common examples of solutes that can show this behaviour.

Effects of Different Solutes on Viscosity

The viscosity of a solution depends strongly on the **nature of the interaction between the solute and solvent**. Strong attractions such as hydrogen bonding, ion-dipole interactions and dipole-dipole interactions can bind or organize solvent molecules around the solute, thereby increasing resistance to flow. If these interactions are weak or disrupt the existing solvent structure, the viscosity may increase only slightly or may even decrease.

1. Effect of Non-Electrolytes

Non-electrolytes such as **sucrose, glucose, glycerol and urea** generally increase the viscosity of a solution when added to a solvent like water. This is mainly because these solute molecules interact with solvent molecules through hydrogen bonding and other intermolecular forces. As the concentration of the solute increases, the movement of solvent molecules becomes increasingly restricted, resulting in greater resistance to flow. For example, concentrated sugar solutions are much more viscous than pure water.

2. Effect of Electrolytes

Electrolytes such as **NaCl, KCl, CaCl₂ and MgCl₂** influence viscosity through interactions between their ions and solvent molecules. When an electrolyte dissolves, its ions become surrounded by solvent molecules, forming a hydration or solvation shell. This can restrict the movement of the solvent and increase the viscosity of the solution. The magnitude of the effect depends on the charge, size and degree of hydration of the ions, as well as their concentration.

3. Effect of Polymers

Polymers such as starch, cellulose derivatives, polyvinyl alcohol and gelatin can produce a very large increase in viscosity, even at relatively low concentrations. Their long-chain molecules occupy a large volume in solution and can become entangled with one another. They also interact with solvent molecules and hinder their movement. Consequently, polymer solutions often show much greater viscosity than solutions containing small solute molecules at comparable concentrations.

4. Effect of Solutes that Reduce Viscosity

Some solutes may **decrease the viscosity** of a solvent. This occurs when the solute disrupts the intermolecular interactions or structural arrangement of the solvent, making molecular movement easier. For example, the addition of certain organic liquids (such as Alcohol) to water can lower its viscosity over particular composition ranges. The exact effect depends on the nature and concentration of both the solute and solvent.

Temperature variation of viscosity of liquids and comparison with that of gases:

Temperature affects the viscosity. The viscosity of liquids decreases when the temperature increases, while the viscosity of gases increases with the increase of temperature. This is due to reason that the viscous forces in a fluid are due to cohesive forces and molecular momentum transfer. In liquids the cohesive forces are more important than the molecular momentum transfer, due to closely packed molecules and with the increase in temperature, the cohesive forces decrease with the result of decreasing viscosity. But in gases, molecular momentum transfer is more important than the cohesive forces. Molecular momentum transfer increases with the increase in temperature and hence viscosity of a gas increases. For ordinary pressure, viscosity is independent of pressure and depends upon temperature only.

(**Molecular momentum transfer** is the process by which molecules transfer their **momentum** to one another through collisions as they move from one region of a fluid to another.)