

# Surface Tension

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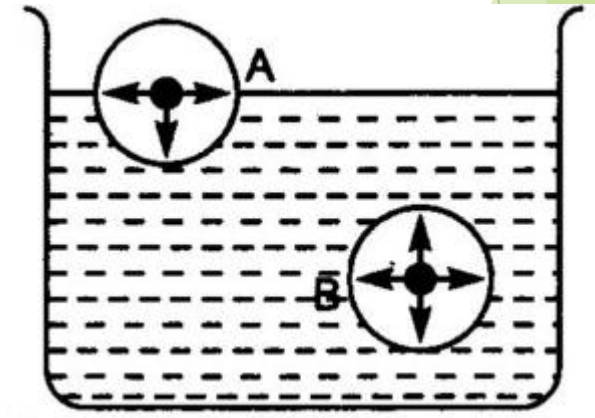
# Cohesive force and Adhesive force

- ▶ Molecules in the liquid state experience strong intermolecular attractive forces. When those forces are between like molecules, they are referred to as cohesive forces.
  - ▶ For example, the molecules of a water droplet are held together by cohesive forces, and the especially strong cohesive forces at the surface constitute surface tension.
- ▶ When the attractive forces are between unlike molecules, they are said to be adhesive forces.
  - ▶ The adhesive forces between water molecules and the walls of a glass tube are stronger than the cohesive forces lead to an upward turning meniscus at the walls of the vessel and contribute to capillary action.

# Surface tension

- ▶ Surface tension is the attractive force found in liquids which is responsible for pulling surface molecules in the rest of the liquid. Liquids tend to acquire the least surface area possible.
- ▶ The property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules.
- ▶ The cohesive forces between liquid molecules are responsible for the phenomenon known as surface tension.

Surface tension is the tension of the surface film of a liquid caused due to the attraction of the particles in the surface layer by the bulk of the liquid, which tends to minimise surface area.



surface tension is given by the formula,  $S = F/L$

*Hence surface tension can be defined as the tangential force acting per unit length to the surface of a liquid.*

*SI unit is N/m*

Surface energy = surface tension  $\times$  Area of liquid surface

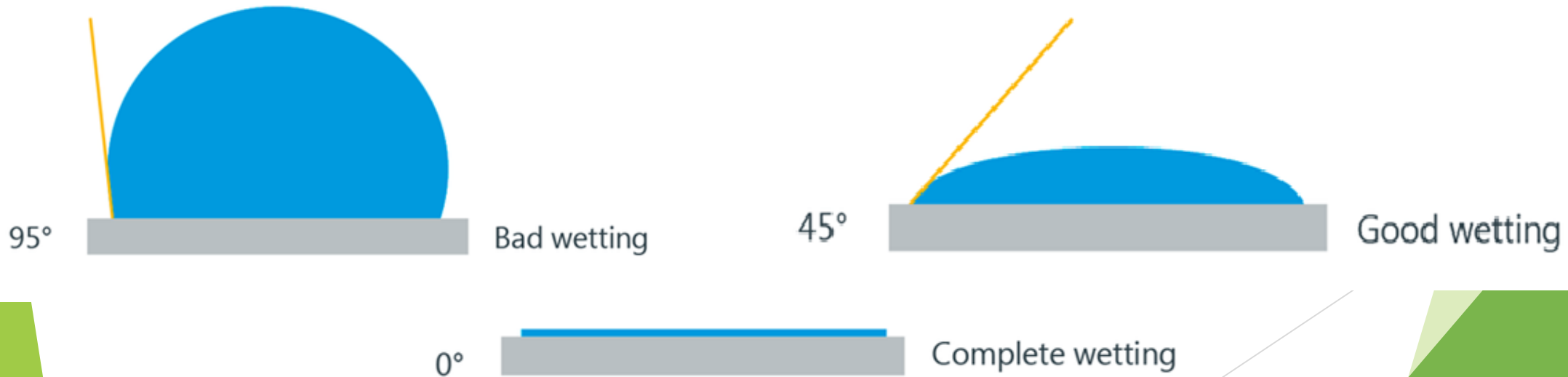
$$U = S \times A$$

$$\text{Or } S = U/A$$

Hence surface tension can be defined as the surface energy per unit area

# Angle of Contact

- ▶ The angle subtended between the tangents drawn at liquid surface and at the solid surface inside the liquid at the point of contact is called angle of contact ( $\theta$ )
- ▶ Angle of contact depends upon the nature of the liquid and solid in contact and the medium which exists above the free surface of the liquid.
- ▶ If  $\theta$  is acute angle, i.e.  $\theta < 90^\circ$ , then liquid meniscus will be concave upwards, then liquid will wet the solid surface.
- ▶ If  $\theta$  is  $90^\circ$ , then liquid meniscus will be plane.
- ▶ If  $\theta$  is obtuse, i.e.  $\theta > 90^\circ$ , then liquid meniscus will be convex upwards.  $\theta > 90^\circ$ , then liquid will not wet the solid surface.

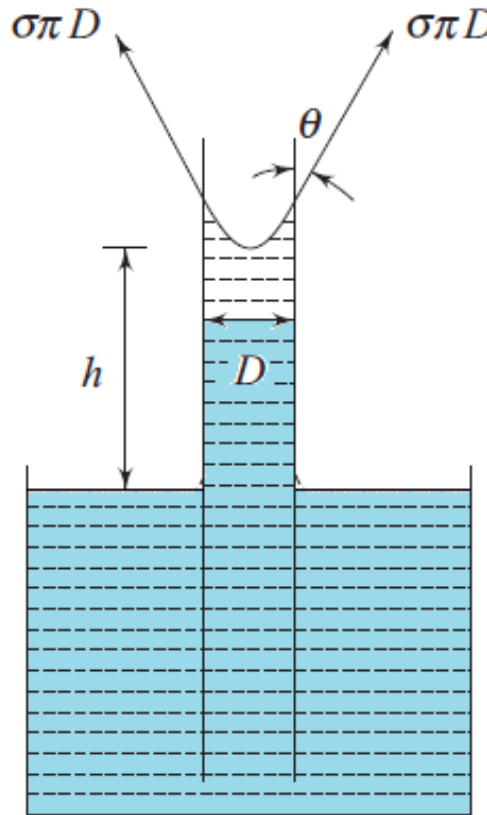


# Examples: Use of Surface Tension in daily life

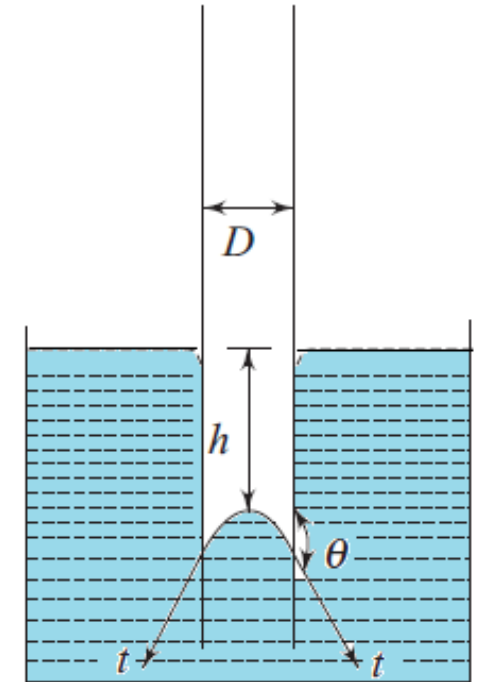
- ▶ Water striders can walk on water as their weight is considerably less to penetrate the water surface.
- ▶ Insects walking on water
- ▶ Floating a needle on the surface of the water.
- ▶ Rainproof tent materials where the surface tension of water will bridge the pores in the tent material
- ▶ Clinical test for jaundice
- ▶ Surface tension disinfectants (disinfectants are solutions of low surface tension).
- ▶ Cleaning of clothes by soaps and detergents which lowers the surface tension of the water
- ▶ Washing with cold water
- ▶ Round bubbles where the surface tension of water provides the wall tension for the formation of water bubbles.
- ▶ This phenomenon is also responsible for the shape of liquid droplets.

# Capillarity

- One of the consequence of surface tension is capillarity or capillary action.
- Capillary action occurs when the adhesion to the surface material is stronger than the cohesive forces between the water molecules.
- The height to which capillary action will take water is limited by surface tension and gravity.



Capillary rise as Adhesive force is greater than cohesive force



Capillary fall as Cohesive force is more than Adhesive force

# Ascent Formula

- The rising up of liquid through capillary tubes against gravity due to the surface tension at the boundary line of the liquid and solid tube surface. The elevation height of liquid in a capillary tube  $h$  is given by the ascent formula

$$h = \frac{2S \cos \theta}{r\rho g}$$

$S$  -----is the surface tension

$\theta$ ----- is the angle of contact between the surface of the liquid and surface of the capillary tube at the point of contact

$r$  -----is the inner radius of the capillary tube

$\rho$ ----- is the density of the liquid rising through the capillary tube

$g$ ----- is the acceleration due to gravity.

From the expression, it is clear that for a given substance, the elevation depends only on the radius of the capillary



# Application of Surface Tension

## ► Soaps and detergents

Washing detergents are surfactants, **compounds that lower the surface tension between liquids and other substances**, making it easier for them to mix. When washing clothes, they help the water mix with and loosen dirt on the fabric.

## ► Washing with cold water

The major reason for using hot water for washing is that its surface tension is lower and it is a better wetting agent. But if the detergent lowers the surface tension, the heating may be unnecessary.

## ► How does the ploughing of fields help in preservation of moisture in the soil?

This is done to **break the tiny capillaries through which water can rise and finally evaporate**. The ploughing of field helps the soil to retain the moisture.