1. Introduction

Surface tension is the elastic tendency of a fluid surface which makes it acquire the least surface area possible. Surface tension allows insects (e.g. water striders), usually denser than water, to float and stride on a water surface.

At liquid–air interfaces, surface tension results from the greater attraction of liquid molecules to each other (due to cohesion) than to the molecules in the air (due to adhesion).

The net effect is an inward force at its surface that causes the liquid to behave as if its surface were covered with a stretched elastic membrane. Thus, the surface becomes under tension from the imbalanced forces, which is probably where the term "surface tension" came from .Because of the relatively high attraction of water molecules for each other through a web of hydrogen bonds, water has a higher surface tension (72.8 millinewtons per meter at 20°C) compared to that of most other liquids. Surface tension is an important factor in the phenomenon of capillarity.
Surface tension has the dimension of force per unit length, or of energy per unit area. The two are equivalent, but when referring to energy per unit of area, it is common to use the term surface energy, which is a more general term in the sense that it applies also to solids.

n materials science, surface tension is used for either surface stress or surface free energy.

Water beading On a leaf

Water strider walking on the water surface

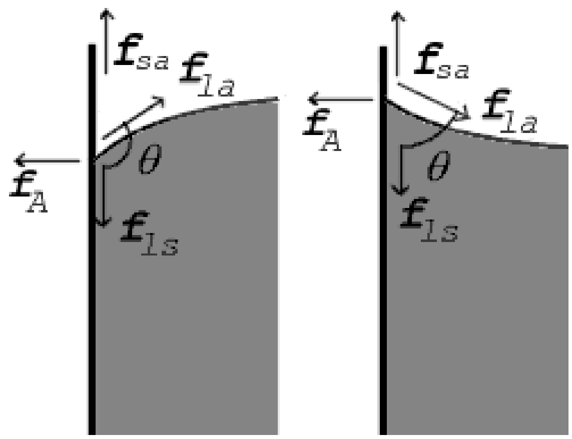
Surface Tension:

•Free surface of a liquid has tendency to contract in surface area is called surface tension.

•SI unit of Surface tension: N/m. or (J/m^2).

•Its Dimension is [$M^0L^1T^{-2}$].

•Angle of Contact : The angle measured from the side of the liquid, between the tangent to the solid surface inside the liquid and tangent to the free liquid surface at the point of contact between solid and liquid surfaces.

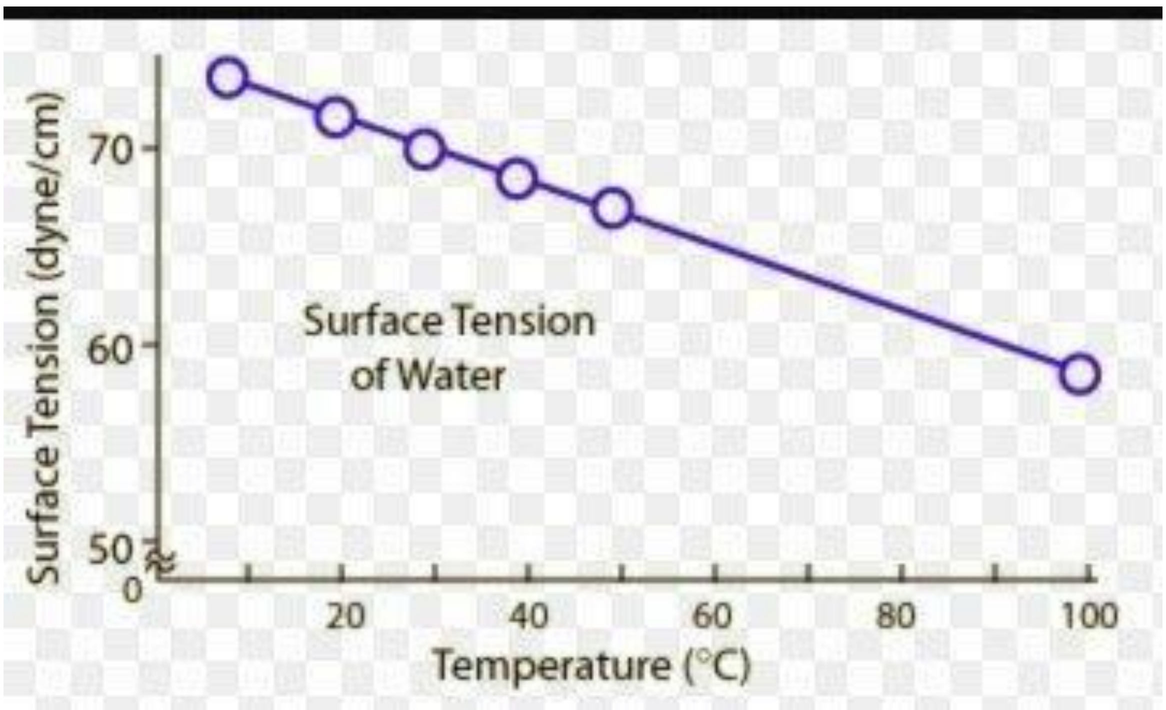


2. Factors affecting surface tension

Impurities present in a liquid appreciably affect surface tension. A highly soluble substance like salt increases the surface tension whereas sparingly soluble substances like soap decreases the surface tension.

The surface tension decreases with rise in temperature. The temperature at which the surface tension of a liquid becomes zero is called critical temperature of the liquid.

Effect of temperature: Oxygen in the atmosphere is known to decrease the surface tension of various substances



temperature ↑ surface tension ↓

- At Critical temperature Surface tension: Zero
- Critical temperature of water 3744K
- Surface tension Increase with impurity.

3. Application of surface tension:

- Surface tension of soap solution is less, it can spread over large areas and wash clothes more effectively, since the dirt particles stick to the soap molecules.
- In soldering, addition of flux reduces the surface tension of molten tin. Hence, it spreads.
- Antiseptics like dettolhave low surface tension, so that they spread faster.

• Surface tension prevents water from passing through the pores of an umbrella.

• A duck is able to float on water as its feathers secrete oil that lowers the surface tension of water.

4. problems

1) If excess pressure is balanced by a column of oil (with specific gravity 0.8) 4 *mm* high, where R = 2.0 *cm*, find the surface tension of the soap bubble.

Solution:

The excess of pressure inside the soap bubble is

$$\Delta P = P_2 - P_1 = \frac{4T}{R}$$

But $\Delta P = P_2 - P_1 = \rho g h \Rightarrow \rho g h = \frac{4T}{R}$

$\Rightarrow$ Surface tension,

$$T = \frac{\rho g h R}{4} = \frac{(800)(9.8)(4\times10^{-3})(2\times10^{-2})}{4} =$$

$$T = 15.68\times10^{-2} N m^{-1}$$

$T = 15.68 \times 10^{-2}\ N\ m^{-1}$

2) Water rises in a capillary tube to a height of 2.0cm. How much will the water rise through another capillary tube whose radius is one-third of the first tube?

Solution:

we have

h ∝ 1/r ⇒hr =constant

Consider two capillary tubes with radius $r1$ and $r2$ which on placing in a liquid, capillary rises to height $h1$ and $h2$, respectively. Then,

$$h_1 r_1 = h_2 r_2 = \text{constant}$$

$$\Rightarrow h_2 = \frac{h_1 r_1}{r_2} = \frac{(2\times10^{-2} m)\times r}{\frac{r}{3}} \Rightarrow h_2 = 6\times10^{-2} m$$

3) Mercury has an angle of contact equal to 140° with soda lime glass. A narrow tube of radius 2 *mm*, made of this glass is dipped in a trough containing mercury. By what amount does the mercury dip down in the tube relative to the liquid surface outside?. Surface tension of mercury *T*=0.456 $N m^{-1}$; Density of mercury ρ = 13.6 × 103 $kg\ m^{-3}$

Solution:

Capillary descent,

$$h = \frac{2T\cos\theta}{r\rho g} = \frac{2\times(0.465 N m^{-1})(\cos 140^0)}{(2\times10^{-3} m)(13.6\times10^3)(9.8 m s^{-2})}$$

$$\Rightarrow h = -6.89 \times 10^{-4}\ m$$

where, negative sign indicates that there is fall of mercury (mercury is depressed) in glass tube.

4) Let 2 .4×10−4 *J* of work is done to increase the area of a film of soap bubble from 50 cm2 to 100 cm2. Calculate the value of surface tension of soap solution.

Solution:

A soap bubble has two free surfaces, therefore increase in surface area $\Delta A = A2 - A1 = 2(100\text{-}50) \times 10^{-4} m^2 = 100 \times 10^{-4} m^2$.

Since, work done $W = T \times \Delta A$

$\Rightarrow T = \frac{W}{\Delta A} = \frac{2.4 \times 10^{-4} J}{100 \times 10^{-4}\ m\text{^}2} = 2.4 \times 10^{-2}$ N m^{-1}

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