SURFACE TENSION

Important terms related to the study of surface tension of liquid:

(i) Adhesive force: It is the force of attraction acting between the molecules of different substances.

For example, water wets the surface of glass container. This is due to force of adhesion between water and glass molecules. Similarly, while writing, graphite from lead pencil sticks to the paper on account of adhesive forces. Fevicol, cement etc are useful in glueing* two surfaces together on account of adhesive forces.

* to join

Force of adhesion is different for different substances e.g. gum has a greater adhesive force for a solid surface than water.

(ii) Cohesive force: It is the force of attraction amongst the molecules of the same substance. For ex. definite shape and size of solids is due to strong forces of cohesion amongst their molecules. Liquids have a definite volume, but no definite shape. Therefore, cohesive forces in case of liquids must be weaker than the cohesive forces in case of solids. Gases, on the contrary*, have neither fixed volume, nor fixed shape. Therefore, cohesive forces amongst the molecule of a gas are minimum.

*opposite in nature

Mercury does not wet the surface of a glass container because the force of cohesion amongst molecules of mercury is stronger than the force of adhesive between molecules of mercury and glass.

(iii) Molecular range: It is the maximum distance upto which a molecule can exert* some measurable attraction on other molecules. It is different for different substances. The order of molecular range is 10^{-9} m in solids and liquids

* vigrous action a effort.

(iv) Sphere of influence: It is an imaginary sphere drawn with a molecule as centre and molecular range as radius. All the molecules in this sphere attract the molecule at the centre and vice versa.

(v) Surface film: It is the top most layer of liquid at rest with thickness equal to the molecular range.

† a container of fluid

Surface Tension

* magnitude in three dimension.

The properties of a surface are quite often markedly different from the properties of the bulk* material. A molecule well† inside a body is surrounded by similar particles from all sides. But a molecule on the surface has particles of one type on one side and of a different type on the other side. Fig.1 shows an example. A molecule of water well inside the bulk* experiences forces from water molecules from all sides ~~but a molecule~~ at the surface interacts with air molecules from above and water molecules from below. This asymmetric force distribution is responsible for surface tension.

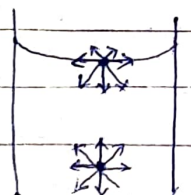
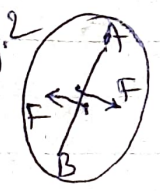


Fig-1

By a surface we shall mean a layer approximately 10-15 molecular diameters. The force between two molecules decreases as the separation between them increases. The force becomes negligible if the separation exceeds 10-15 molecular diameters. Thus, if we go 10-15 molecular diameters deep, a molecule finds equal forces from all directions.

Thus, Surface Tension is that property of a liquid by virtue of which, it behaves like an elastic stretched membrane with a tendency to contract so as to occupy a minimum surface area.

Fig.2



Imagine a line AB drawn on the surface of a liquid (Fig.2). The line divides the surface in two parts, surface on one side and the surface on the other side

of the line. Let us call them surface to the left of the line and surface to the right of the line. It is found that the two parts of the surface pull each other with a force proportional to the length of the line AB. These forces of pull are perpendicular to the line separating the two parts and are tangential to the surface. In this respect the surface of the liquid behaves like a stretched rubber sheet. The rubber sheet which is stretched from all sides is in the state of tension. Any part of the sheet pulls the adjacent part towards itself.

Let F be the common magnitude of the forces exerted on each other by the two parts of the surface across a line of length l. We define the surface tension S of the liquid as

$$S = \frac{F}{l} \quad \text{—(1)}$$

The S.I. unit of surface tension is N/m.
Dimensional formula $[MT^{-2}]$

The fact that a liquid surface has the property of surface tension can be demonstrated by a number of simple experiments.

(a) Take a ring of wire and dip it in soap solution. When the ring is taken out, a soap film bounded by the ring is formed. Now take a loop of thread, wet it and place it gently on the soap film. The loop stays on the film in an irregular fashion as it is placed. Now prick a hole in the film inside the loop with a needle. The thread is radially pulled by the film surface outside and it takes a circular shape (Fig. 3).

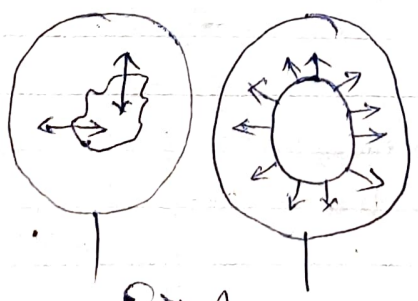


Fig. 3

Before the pricking, there were surfaces both inside and outside the thread loop. Taking any small part of the thread, surfaces on both sides pulled it and

the net force was zero. The thread could remain in any shape. Once the surface inside was punctured, the outside surface pulled the thread to take the circular shape.

(b)

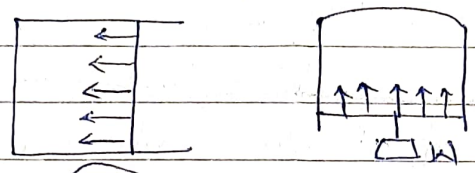


Fig. 3

Take a U-shaped frame of wire on which a light wire can slide (fig. 3). Dip the frame in a soap solution and take it out. A soap film is formed between the frame and the sliding wire. If the frame is kept in a horizontal position and the friction is negligible, the sliding wire quickly slides towards the closing arm of the frame. This shows that the soap surface in contact with the wire pulls its parallel to the surface. If the frame is kept vertical with the sliding wire at the lower position, one can hang some weight from it to keep it in equilibrium. The force due to surface tension by the surface in contact with the sliding wire balances the weight.

Examples

(i) Floating of needle ~~due to~~ on the surface of water.
(ii) Painting brush.
(iv) Liquid between two glass plates
(v) Rounding of the edge of glass rod.
(vi) water wets glass but mercury does not.
(vii) When kerosene oil sprinkled over the surface of water in the pond or in ditches the mosquitoes are destroyed.
(viii) Production of cold by spraying
(ix) warm soup is more tasty than cold one.
(x) on dropping the camphor on the surface of clear water the camphor particles begin to dance here & there on the surface of water.
(xi) Detergent and surface Tension.

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