AL- Mustaqpal University

Science College

Dep. Medical Biotechnology

Second Stage

Lec 5

Surface Tension

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Surface Tension

Surface tension is the tendency of liquid surfaces at rest to shrink into the minimum surface area possible. Surface tension is what allows objects with a higher density than water such as razor blades and insects (e.g. water striders) to float on a water surface without becoming even partly submerged.

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). There are two basic mechanisms in this matter. One is the internal force acting on the surface molecules causing the liquid to contract. The second is the tangential force parallel to the surface of the liquid.

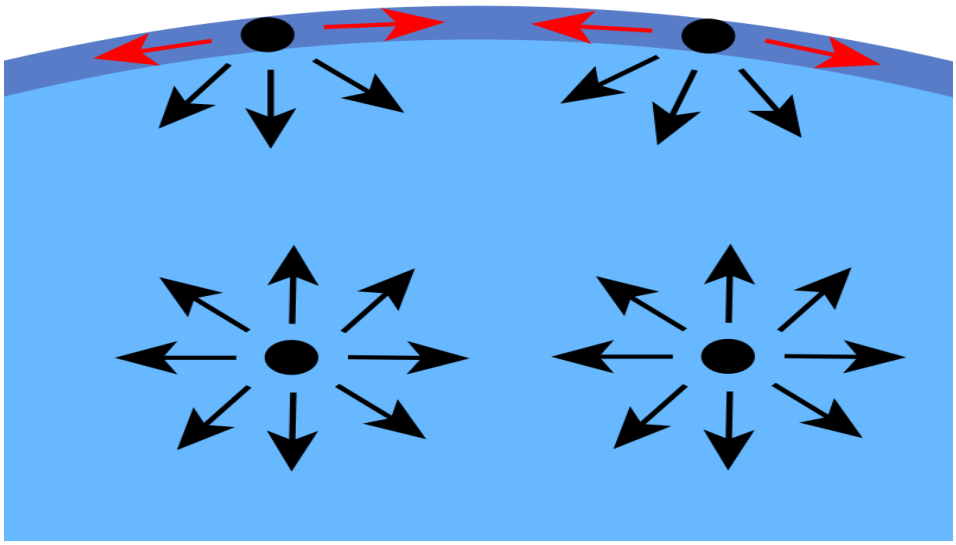
This tangential force is generally referred to as the surface tension. The net effect is the liquid behaves as if its surface were covered with a stretched elastic membrane. But this analogy must not be taken too far as the tension in an elastic membrane is dependent on the amount of deformation of the membrane while

surface tension is an inherent property of the liquid–air or liquid–vapour interface.

Because of the relatively high attraction of water molecules to each other through a web of hydrogen bonds, water has a higher surface tension (72.8 millinewtons (mN) per meter at 20 °C) than most other liquids. Surface tension is an important factor in the phenomenon of capillarity.

Surface tension has the dimen sion 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.

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



Due to the cohesive forces, a molecule located away from the surface is pulled equally in every direction by neighboring liquid molecules, resulting in a net force of zero. The molecules at the surface do not have the *same* molecules on

all sides of them and therefore are pulled inward. This creates some internal pressure and forces liquid surfaces to contract to the minimum area. here is also a tension parallel to the surface at the liquid-air interface which will resist an external force, due to the cohesive nature of water molecules.

The forces of attraction acting between molecules of the same type are called cohesive forces, while those acting between molecules of different types are called adhesive

forces. The balance between the cohesion of the liquid and its adhesion to the material of the container determines the degree of wetting, the contact angle, and the shape of meniscus. When cohesion dominates (specifically, adhesion energy is less than half of cohesion energy) the wetting is low and the meniscus is convex at a vertical wall (as for mercury in a glass container). On the other hand, when adhesion dominates (when adhesion energy is more than half of cohesion energy) the wetting is high and the similar meniscus is concave (as in water in a glass).

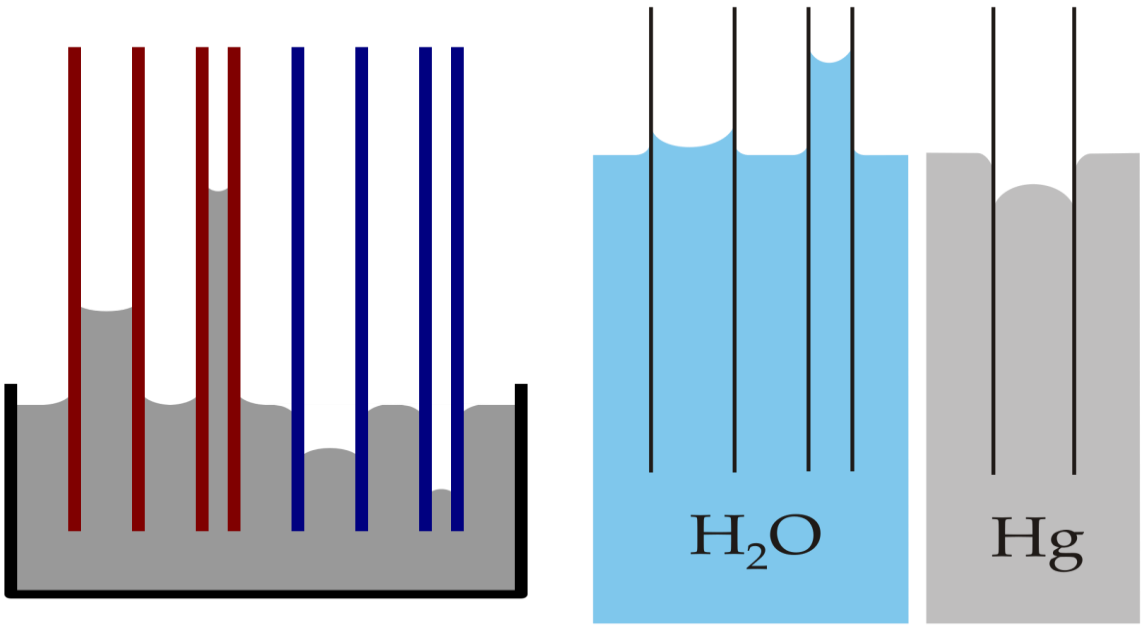
Surface tension is responsible for the shape of liquid droplets. Although easily deformed, droplets of water tend to be pulled into a spherical shape by the imbalance in cohesive forces of the surface layer. In the absence of other forces, drops of virtually all liquids would be approximately spherical. The spherical shape minimizes the necessary "wall tension" of the surface layer according to Laplace's law.

Another way to view surface tension is in terms of energy. A molecule in contact with a neighbor is in a lower state of energy than if it were alone. The interior molecules have as many neighbors as they can possibly have, but the boundary molecules are missing neighbors (compared to interior molecules) and therefore have higher energy.

For the liquid to minimize its energy state, the number of higher energy boundary molecules must be minimized. The minimized number of boundary molecules results in a minimal surface area. As a result of surface area minimization, a surface will assume a smooth shape.

Capillary Tubes

Capillary action (sometimes called capillarity, capillary motion, capillary rise, or capillary effect,) is the process of a liquid flowing in a narrow space in opposition to or at least without the assistance of any external forces like gravity. The effect can be seen in the drawing up of liquids between the hairs of a paint-brush, in a thin tube such as a straw, in porous materials such as paper and plaster, in some non-porous materials such as clay and liquefied carbon fiber, or in a biological cell. It occurs because of intermolecular forces between the liquid and surrounding solid surfaces. If the diameter of the tube is sufficiently small, then the combination of surface tension (which is caused by cohesion within the liquid) and adhesive forces between the liquid and container wall act to propel the liquid.



Cohesive force: It is the force of attraction between molecules of the same substance.

Adhesion force: It is the force of attraction between molecules of two different substances

- **If** the cohesion force between the liquid molecules is greater than the force of adhesion, the liquid takes a convex shape inside the capillary tube, as in the case of mercury.
- **If** the force of adhesion between the liquid molecules is greater than the cohesive force, the liquid takes a concave shape inside the capillary tube, as in the case of water.
- Surface tension is a property of liquids that causes the surface of the liquid to behave as if it were covered by an elastic film.

  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.
- This film is caused by the attractive forces between the molecules of the liquid.
- In materials science, surface tension is used for either surface stress or surface free energy.
- Surface tension: The net inward force acting on the molecules at the surface of a liquid.
- SI unit of Surface tension: N/m. or (J/m^2)

<u>Effects of Surface Tension</u>

* Surface tension causes liquids to form droplets.

* Surface tension causes liquids to rise in capillary tubes.

* Surface tension causes water to rise in tree trunks and stems.

* Surface tension is responsible for the shape of soap bubbles.

* Surface tension is used in many industrial processes, such as the production of textiles and plastics.

Factors that Affect Surface Tension

* The type of liquid: Different liquids have different surface tensions.

* The temperature of the liquid: The surface tension of a liquid decreases as the temperature increases.

* The presence of impurities: The presence of impurities in a liquid can increase or decrease its surface tension.

Applications of Surface Tension

- In the medical field, surface tension is used to deliver drugs to the lungs.
- In the food industry, surface tension is used to make whipped cream and other foams.
- In the environmental industry, surface tension is used to clean up oil spills.
- In the manufacturing industry, surface tension is used to produce a variety of products, such as textiles, plastics, and paints.

Conclusion

* Surface tension is a fascinating property of liquids that has many important applications in our daily lives.

* It is a complex phenomenon that is not fully understood, but scientists are continuing to learn more about it.

Discussion

1. **What is surface tension and how does it affect objects with a higher density than water?**
2. **Explain the two basic mechanisms that contribute to surface tension at liquid-air interfaces.**
3. **How does the cohesive force between liquid molecules affect the shape of liquid droplets?**
4. **What determines the degree of wetting and the shape of the meniscus in a liquid?**
5. **What is capillary action and how does it occur in narrow spaces?**

Answers:

1. Surface tension is the tendency of liquid surfaces at rest to shrink into the minimum surface area possible. It allows objects with a higher density than water, such as razor blades and insects like water striders, to float on a water surface without becoming submerged.

2. The two basic mechanisms contributing to surface tension at liquid-air interfaces are: 1) the internal force acting on surface molecules that causes the liquid to contract, and 2) the tangential force parallel to the surface of the liquid, which is referred to as surface tension.

3. The cohesive forces between liquid molecules cause droplets of water to be pulled into a spherical shape. This is due to the imbalance in cohesive forces at the surface layer, which minimizes the necessary 'wall tension' according to Laplace's law.

4. The degree of wetting and the shape of the meniscus are determined by the balance between cohesive forces of the liquid and adhesive forces to the material of the container. When cohesion dominates, the meniscus is convex; when adhesion dominates, the meniscus is concave.

5. Capillary action is the process of a liquid flowing in a narrow space without the assistance of external forces like gravity. It occurs due to intermolecular forces between the liquid and surrounding solid surfaces, where surface tension and adhesive forces work together to propel the liquid.

MCQ

Question 1

What is surface tension?

a) The ability of a liquid to change shape

b) The tendency of liquid surfaces at rest to shrink into the minimum surface area possible

c) The force that attracts molecules to each other

d) The energy required to create a liquid surface

E) None of the above

Question 2

Which of the following is an example of an object that can float on water due to surface tension?

a) A metal ball

b) A water strider

c) A glass bottle

d) A wooden block

E) None of the above

Question 3

What is the main reason for the high surface tension of water?

a) The low attraction between water molecules

b) The high attraction between water molecules through hydrogen bonds

c) The density of water

d) The viscosity of water

E) None of the above

Question 4

What is the dimension of surface tension?

a) Force per unit area

b) Energy per unit length

c) Force per unit length or energy per unit area

d) Mass per unit volume

E) None of the above

Question 5

What is capillary action?

a) The process of a liquid flowing in a narrow space with the assistance of external forces

b) The process of a liquid flowing in a narrow space in opposition to or without the assistance of any external forces

c) The process of a liquid changing shape in a narrow space

d) The process of a liquid mixing with another liquid in a narrow space

E) None of the above

Question 6

What is the force that attracts molecules of the same type?

a) Adhesion force

b) Cohesive force

c) Surface tension force

d) Viscosity force

E) None of the above

Question 7

What is the shape of a liquid droplet due to surface tension?

a) Spherical

b) Cubical

c) Rectangular

d) Irregular

E) None of the above

Question 8

What is the effect of temperature on surface tension?

a) It increases surface tension

b) It decreases surface tension

c) It has no effect on surface tension

d) It can either increase or decrease surface tension

E) None of the above

Question 9

In which industry is surface tension used to deliver drugs to the lungs?

a) Medical field

b) Food industry

c) Environmental industry

d) Manufacturing industry

E) None of the above

Question 10

What is the SI unit of surface tension?

a) N/m or J/m^2

b) Pa or kg/m

c) m/s or km/h

d) kg/m^3 or g/cm^3

E) None of the above

Correct answers :

1 .b) The tendency of liquid surfaces at rest to shrink into the minimum surface area possible

2 .b) A water strider

3 .b) The high attraction between water molecules through hydrogen bonds

4 .c) Force per unit length or energy per unit area

5 .b) The process of a liquid flowing in a narrow space in opposition to or without the assistance of any external forces

6 .b) Cohesive force

7 .a) Spherical

8 .b) It decreases surface tension

9 .a) Medical field

10. a) N/m or J/m^2