AL- Mustaqpal University

Science College

Dep. Medical Biotechnology

First 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.

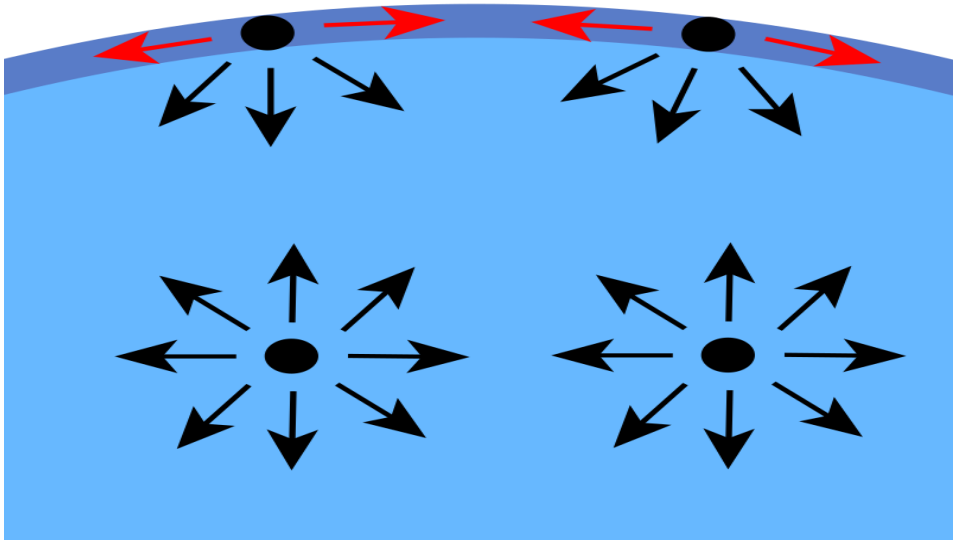
At liquid–air interfaces, surface tension results from the greater attraction of liquid molecules to each other (due to cohesion) than to the molecules in the air (due to adhesion). There are two basic mechanisms in this matter. One is the internal force acting on the surface molecules causing the liquid 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).

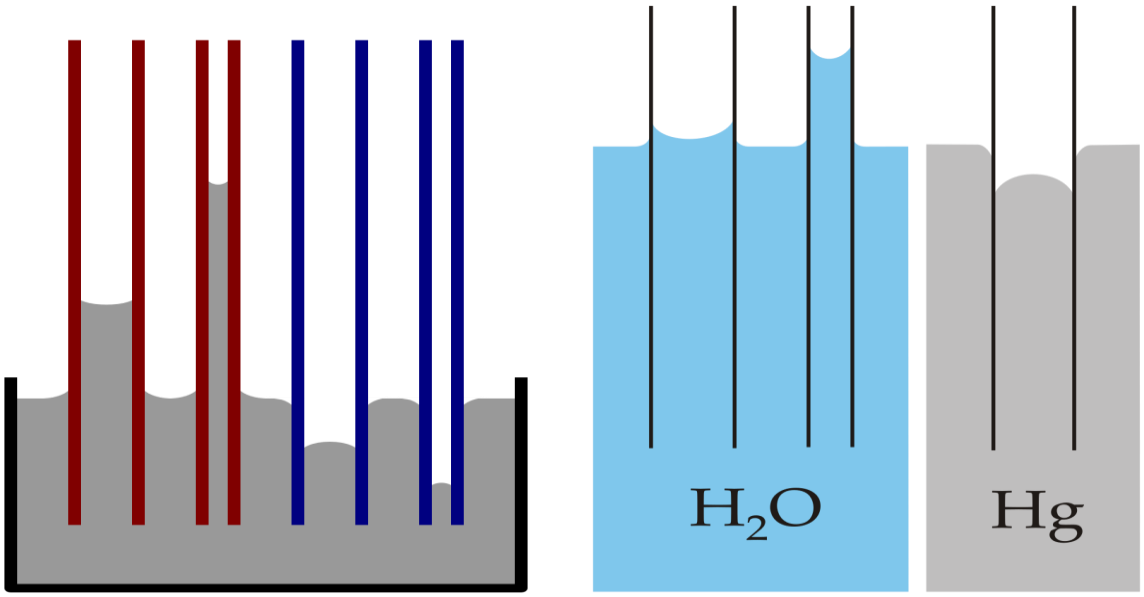
Surface tension is responsible for the shape of liquid droplets. Although easily deformed, droplets of water tend to be pulled into a spherical shape by the imbalance in cohesive forces of the surface layer. In the absence of other forces, drops of virtually all liquids would be approximately spherical. 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?**

   a) The resistance to flow in a liquid

   b) The ability of a liquid to expand its surface area

   c) The tendency of liquid surfaces at rest to shrink to the minimum surface area

   d) The force acting parallel to the liquid surface

   e) None of the above

   Correct answer: c

2. **Why can water striders walk on water?**

   a) They are lighter than water
   b) Due to surface tension acting as an elastic film
   c) Adhesion is stronger than cohesion
   d) Their legs repel water
   e) They use gravity to their advantage

   Correct answer: b

3. **What causes surface tension at the liquid–air interface?**

   a) Adhesion between liquid and air molecules

   b) Cohesion between liquid molecules

   c) Gravitational forces

   d) Internal pressure of the liquid

   e) None of the above

   Correct answer: b

4. **What is the SI unit of surface tension?**

   a) N/m

   b) Pa

   c) J

   d) m^2

   e) Nm^2

   Correct answer: a

5. **Why does water have a higher surface tension than most other liquids?**
   a) Its molecules have weak cohesion
   b) It has strong hydrogen bonds
   c) It has a lower molecular weight
   d) Its adhesion is higher than cohesion
   e) None of the above
   Correct answer: b
6. **What shape does a liquid droplet naturally form due to surface tension?**
   a) Cube
   b) Cylinder
   c) Sphere
   d) Ellipsoid
   e) Pyramid
   Correct answer: c
7. **What is capillary action caused by?**
   a) Surface tension and adhesion
   b) Gravitational forces
   c) Centrifugal forces
   d) Thermal expansion
   e) Magnetic attraction
   Correct answer: a
8. **What is the contact angle if adhesion dominates over cohesion?**
   a) Zero
   b) Acute
   c) Right
   d) Obtuse
   e) Undefined
   Correct answer: b

9. **What determines the shape of the meniscus in a capillary tube?**

   a) Volume of liquid

   b) Atmospheric pressure

   c) Balance between cohesion and adhesion

   d) Shape of the container

   e) Temperature

   Correct answer: c

10. **Which force is stronger if a liquid forms a convex meniscus?**

   a) Adhesion

   b) Cohesion

   c) Gravity

   d) Elasticity

   e) Friction

   Correct answer: b

11. **What happens to surface tension as temperature increases?**

   a) It increases

   b) It decreases

   c) It remains constant

   d) It fluctuates

   e) It becomes zero

   Correct answer: b

12. **Which property minimizes the surface area of a liquid?**

   a) Adhesion

   b) Surface tension

   c) Viscosity

   d) Gravity

   e) Capillarity

   Correct answer: b

13. **Which phenomenon allows plants to transport water upward in their stems?**

    a) Gravity

    b) Capillary action

    c) Surface tension

    d) Adhesion

    e) None of the above

    Correct answer: b

14. **What is surface energy?**

    a) Energy per unit volume

    b) Energy per unit area

    c) Energy per unit mass

    d) Energy per unit length

    e) None of the above

    Correct answer: b

15. **What happens to a soap bubble due to surface tension?**

    a) It bursts

    b) It shrinks

    c) It takes a spherical shape

    d) It flattens out

    e) None of the above

    Correct answer: c

16. **Which force causes liquids to rise in narrow tubes?**

    a) Centrifugal force

    b) Gravitational force

    c) Adhesion and cohesion forces

    d) Frictional force

    e) None of the above

    Correct answer: c

17. **What happens to the surface tension of a liquid with impurities?**

a) Always increases

b) Always decreases

c) May increase or decrease

d) Remains constant

e) Becomes zero

Correct answer: c

18. **What role does surface tension play in cleaning oil spills?**

a) Breaking hydrogen bonds

b) Controlling oil spread on water

c) Increasing water adhesion to oil

d) Decreasing oil density

e) None of the above

Correct answer: b

19. **Which property explains why mercury forms a convex meniscus?**

a) High adhesion

b) Low adhesion compared to cohesion

c) High surface area

d) Low surface energy

e) None of the above

Correct answer: b

20. **Which liquid property influences whipped cream production?**

a) Surface tension

b) Viscosity

c) Capillarity

d) Elasticity

e) Density

Correct answer: a

21. **Why do liquids form droplets?**

a) Adhesion

b) Viscosity

c) Gravity

d) Surface tension

e) None of the above

Correct answer: d

22. **Which industrial process uses surface tension?**

a) Plastic manufacturing

b) Food packaging

c) Textile production

d) Both a and c

e) None of the above

Correct answer: d

23. **What is the surface tension of water at 20°C?**

a) 60 millinewtons /m

b) 68.2 millinewtons /m

c) 72.8 millinewtons /m

d) 75 millinewtons /m

e) 80 millinewtons /m

Correct answer: c

24. **What happens when cohesive forces dominate over adhesive forces?**

a) Liquid spreads easily

b) Low wetting occurs

c) High capillary rise occurs

d) Flat meniscus forms

e) None of the above

Correct answer: b

25. **Which of the following is NOT affected by surface tension?**

a) Shape of liquid droplets

b) Capillary rise

c) Viscosity of liquids

d) Formation of soap bubbles

e) Floating of small objects

Correct answer: c