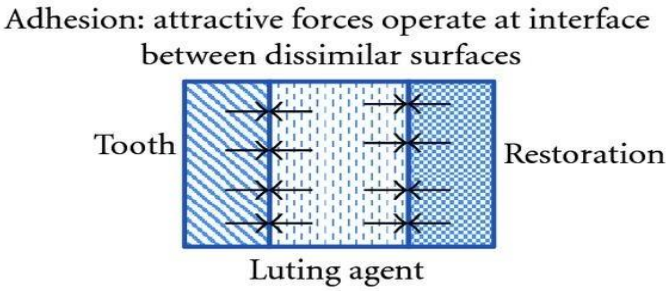
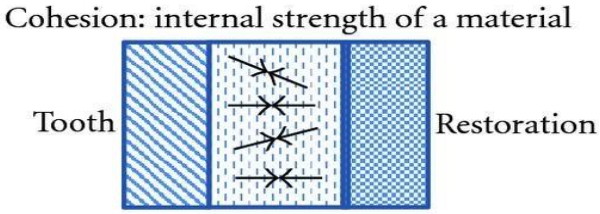
Physical properties of dental material (Adhesion and Cohesion)

Adhesion is the force which causes two or more **different** substances to attach when they are brought in contact with one another.

Cohesion forces make molecules of **the same** substances hold together.



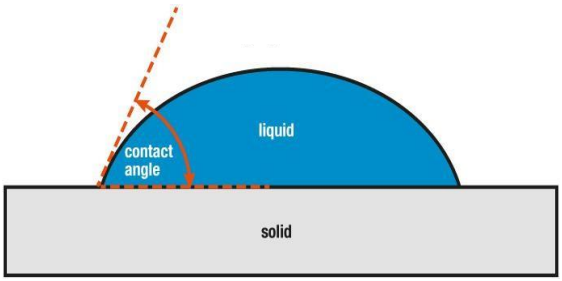


Mechanisms of Adhesion

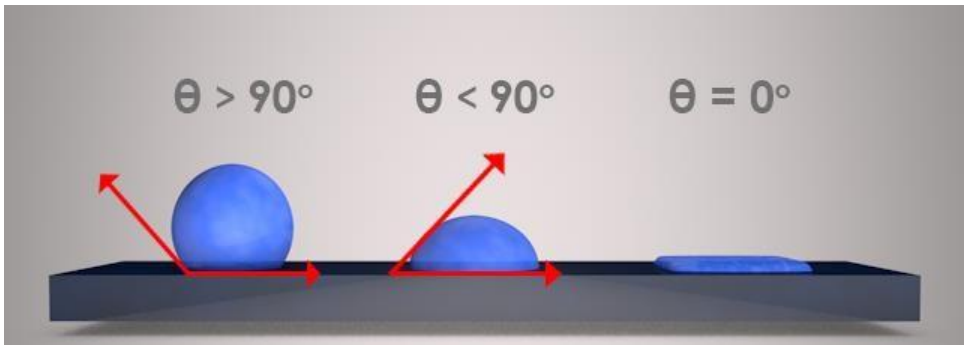
The strength of the adhesion between two materials depends on the interactions between the two materials, and the surface area over which the two materials are in contact. ***As a result, a number of factors enter into the overall adhesion system.***

1-Contact Angle and Surface Tension: Materials that wet against each other tend to have a larger contact area than those that do not, however, wetting depends on the relative surface energies of the adhesive and substrate materials.

Wetting is the ability of a liquid to form an interface with a solid surface and the degree of wetting is evaluated as the contact angle θ formed between the liquid and the solid substrate surface. ***The smaller the contact angle and the lower the surface tension of the liquid, the greater the degree of wetting***



• Clean surface allows good wetting (contact angle **θ** is close to 0°)
• a slightly contaminated surface (contact angle **θ** is greater than 0° but less than 90°)
• a contaminated surface (contact angle exceed 90°)



- A small contact angle indicates more adhesion is present because there is a large contact area between the adhesive and the substrate, resulting in a greater overall substrate surface energy and a high interactive force between the liquid and the substrate.

2. Chemical Adhesion:

If the adhesive and substrate can form *a compound* at their interface or union, ***the ionic or covalent bonds*** that are formed result in a strong bond between the two materials.
• To achieve chemical bonding the surfaces brought very close together and remain in this proximity for the bond to be stable.

3. Dispersive Adhesion:

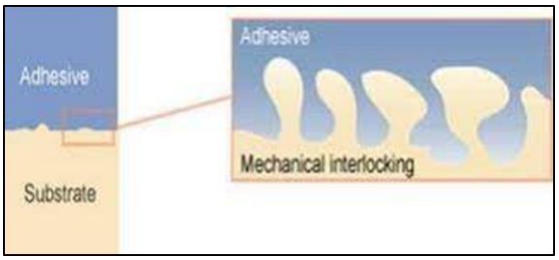
In dispersive adhesion, the surfaces of two materials are held together by ***van der Waals forces*** (they are the attractive forces between two molecules)

4. Diffusive Adhesion:

Diffusive bonding occurs when atoms from one surface penetrate into an adjacent surface while still being bound to their surface of origin. Like polymer chains where one end of a molecule can diffuse into the other material.
Example:
• when a fractured denture is repaired with acrylic resin.
• when metal or ceramic powders are compressed and heated so that atoms diffuse from one particle to the next to produce a solid mass.

5. Mechanical Adhesion:

When adhesives flow over the substrate, filling the voids and pores of the surface and attach or "bond" to that surface by mechanical interlocking. This is often referred to as micromechanical adhesion.



Physical properties of dental material (Thermal properties)

Thermal properties:

Thermal properties are the response of a material to the application of heat.

Thermal conductivity (κ):

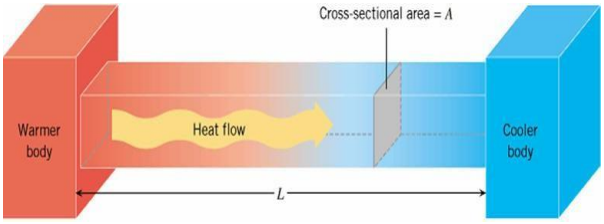
It is the rate at which heat flows through a material over time.

• Materials that have a high thermal conductivity are called **conductors,** whereas materials of low thermal conductivity are called **insulators.**

Thermal diffusivity:

It is the measure of the speed with which a temperature change will spread through an object when one surface is heated.

• Thermal diffusivity is the thermal conductivity divided by density and specific heat capacity at constant pressure.



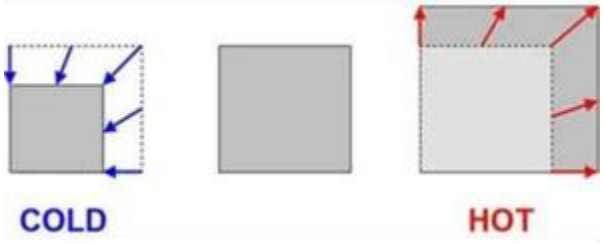
• A material with a high density and high specific heat will have a low thermal diffusivity (temperature changes very slowly through the material).

• A material with low heat capacity and high thermal conductivity lead to high diffusivity (temperature changes rapidly through the material).

Thermal expansion:

Thermal expansion is the tendency of matter to change its shape, area, volume, and density in response to a change in temperature.

• Thermal expansion of the material occurs after increasing the temperature is due to increase the kinetic energy of the atoms and increase the vibration which lead to increase the inter atomic spacing, as a result the material expands. After cooling the material contracts.



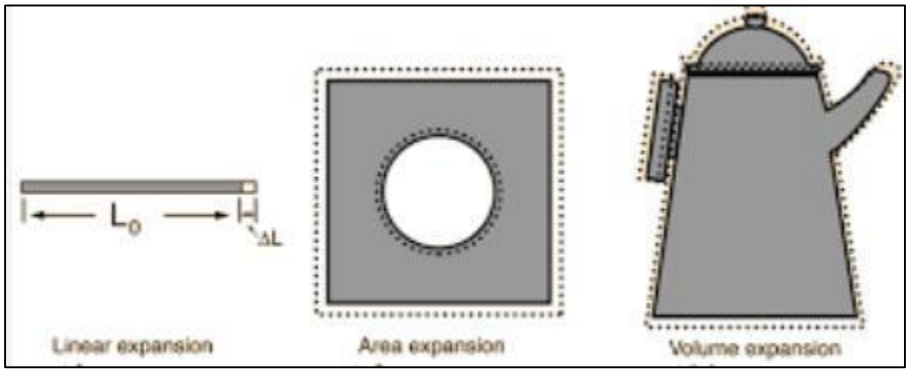
Coefficient of thermal expansion (CTE):

It is defined as the change in length per unit of the original length of a material when the temperature of this material is raised 1 °C.

Measurement of CTE

Several types of coefficients have been developed - ***volumetric, area, and linear***. Which depends on the application.

- For solids, it concerned with the change in length, or area.
- For fluids and gases, it concerned with the change in volume.



- It is calculated as follows:

$$\alpha = \frac{\Delta L}{L \times \Delta T} \qquad \alpha = \frac{\text{final length (cm) - original length (cm)}}{\text{original length (cm) * temperature change (°C)}} \quad (\text{cm/cm.}^0\text{C})$$

α (alpha) is CTE
L is original length of material
ΔL (delta L) is change in length
ΔT (delta T) is change in temperature