PHYSICAL PROPERTIES OF DENTAL MATERIALS

Part 2

INTRODUCTION

Physical properties are based on laws of mechanics optics , acoustics, thermodynamics ,electricity , rheology , magnetism , radiation ,atomic structure and nuclear phenomenon etc.

Physical nature of material is described by various properties , all of which play a role in defining its applications and limitations in dentistry .

(A) THERMAL AND ELECTRICAL PROPERTIES

(i) ELECRICAL PROPERTIES

Dental materials used intra orally do not need to be a conductor of electricity, those conducts, requires the use of preventive measures to insulate them from the pulp. It is possible to generates electrical currents and voltages by conducting of two metals of dissimilar compositions , this phenomenon is called GALVANISM.

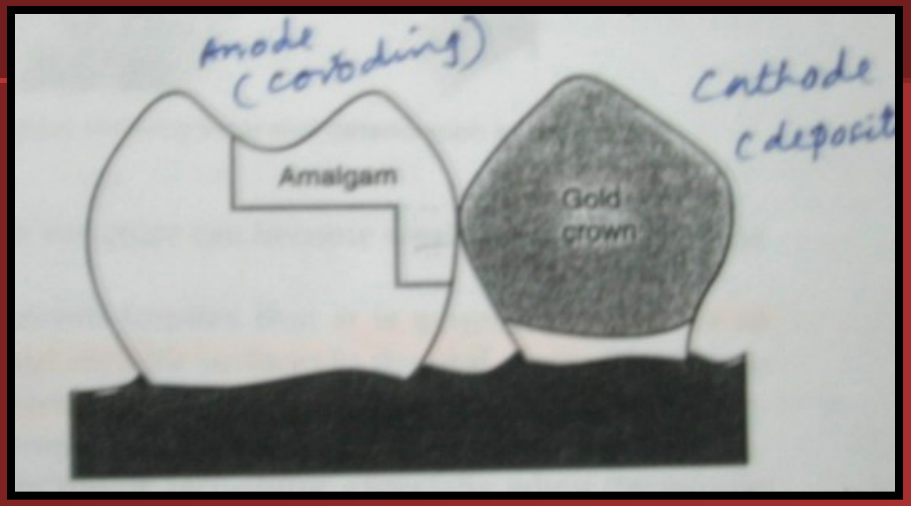
Acc. to **GPT–8** , Galvanism is defined as accelerated corrosion of a metal due to electrical contact with a more noble metal in a corrosive electrolyte. The resulting current flow can produce nerve stimulation, unpleasant taste and other physiological reaction commonly associated with this term.

Normally remaining dentin in the cavity provides a natural insulation , if dentin thickness is little due to carious activity , cement base should be used to insulate pulp. E.g. An amalgam restoration that is placed with in approximately 1 mm of pulp is often insulated with a base. Composites and ceramics are nonconductive and do not need insulation.

The greater the difference in electrode potential that is more dissimilar the metals in terms of their rate of ionisation .

The metal which is more active ,will get dissolved and will be referred as anode while the other one will be called cathode.

E.g. In a situation having class II amalgam restoration in a premolar and gold crown in an adjacent molar, the gold crown will serve as cathode and will cause corrosion of amalgam (i.e. anode) .



In this situation patient complains of metallic taste, pain in the tooth with the amalgam restoration.

Dentist places a wooden wedge between to restorations to confirm the cause to be electrochemical in nature , pain will subside when separation is achieved by wedging the teeth.

A thin layer of visible light curable adhesive bonding agent is painted over the restorations but Continued movement between the teeth will cause the resin to wear away, however the teeth will not usually become sensitive again because of oxidation of alloy surfaces that will provides natural insulation.

The electrochemical properties of dental materials causes 2 important phenomenons known as TARNISH and CORROSION.

Acc. to Skinners, **TARNISH** is defined as a process by which a metal surface is dulled in brightness or discolored through the formation of chemical film , such as sulfide and an oxide.

Acc. To (GPT – 8) **CORROSION** is defined as the action , process, or effect of corroding ; a product of corroding; the loss of elemental constituents to the adjacent environment.

A type of corrosion common in oral cavity called **CREVICE CORROSION** is having important clinical significance.

The oxygen concentration is lower around amalgam margins within the crevicular area as compared to outside, so acidity is greater and plaque accumulation further increases the acidity which causes corrosion .

Corrosion can be considered somewhat beneficial in case of amalgam because corrosion products seals the bacterial leakage from saliva thus improving the longevity of restoration by decreasing the recurrent caries.

Metallic ions may also serve as bacteriostatic and bacteriocidal agents.

However this type of deterioration can also be harmful when it occurs in thin sections at solder joints of appliances .

(i i) THERMAL PROPERTIES

Heat and electricity are conducted the same way . Any tooth susceptible to electricity stimulates pain could also experience thermally stimulated pain.

Thermal stimulus is far more frequent than the electrical and is therefore of greater concern.

(a) THERMAL CONDUCTIVITY

is the characteristic that determines the rate at which heat flow through a material. It is a function of the composition which determines the heat capacity , magnitude of the temperature change and thickness of the object.

MATERIALS	THERMAL CONDUCTIVITY (J/sec/cmsq/c/cm)
Silver	4.21
Gold	2.97
Platinum	0.69
D.Amalgam	0.23
Composite	0.011
Porcelain	0.010
Enamel	0.009
Dentin	0.006
ZOE	0.004
Acrylic resin	0.002

Good thermal conductor is preferred for denture bases to maintain good health in the supporting tissue by having the heat radially conducted to and from the tissue by the denture the denture base.

It can also be seen that dental cements have a thermal conductivity similar to those of dentin and enamel. It should be emphasized that the thickness of the cement base and its thermal conductivity are important in decreasing heat transfer to the pulp.

(b) THERMAL DIFFUSIVITY

It is a measure of the rate at which a body with a non uniform temperature reaches a state of thermal equilibrium.

Thermal insulation → Thickness of liner or base

→ 1 / thermal diffusivity

Thickness of the liner or base is more important factor

to insulate the pulp than thermal diffusivity .

(c) COEFFICIENT OF THERMAL EXPANSION

The linear coeff. of thermal expansion of material is measure of how much it expands per unit length, if heated to unit degree higher.

L.C.T.Exp is not uniform through out the entire tempt. range and it usually higher for liquids than solids.

L.C.T.Exp of a polymer changes as the polymer goes from a glassy state to a softer , rubbery material. This change in the coeff. corresponds to the glass transition tempt.

Tooth structure and restorative materials in the mouth will expand when warmed by the hot food and beverages but will contract when exposed to cold substances.Such expansion and contraction may results in breaking the marginal seal of an inlay or other restorations, esp when the difference of LCTExp is greater between tooth and restoration

MATERIAL	LCTE	LCTE (mat)/ LCTE (tooth)
Porcelain	6.6	0.58
Pure Ti	8.5	0.77
Tooth	11.4	1.00
Pure Gold	14	1.23
Amalgam	25	2.19
Composite	14 – 50	1.2 – 4.4
Denture resin	81	7.11
Inlay wax	400	35.1

In some materials and in certain situations coeff. Of thermal expansion may be equally as important as the strength , hardness, or esthetics.

(B) RHEOLOGICAL PROPERTIES

Rheology is the science of study of flow and deformation of matter.

Rheology is important in dental material as described follows –

1 - Many dental materials are mixed as fluid pastes which subsequently solidify.

2 – The mixed pastes are adapted to the required shape .

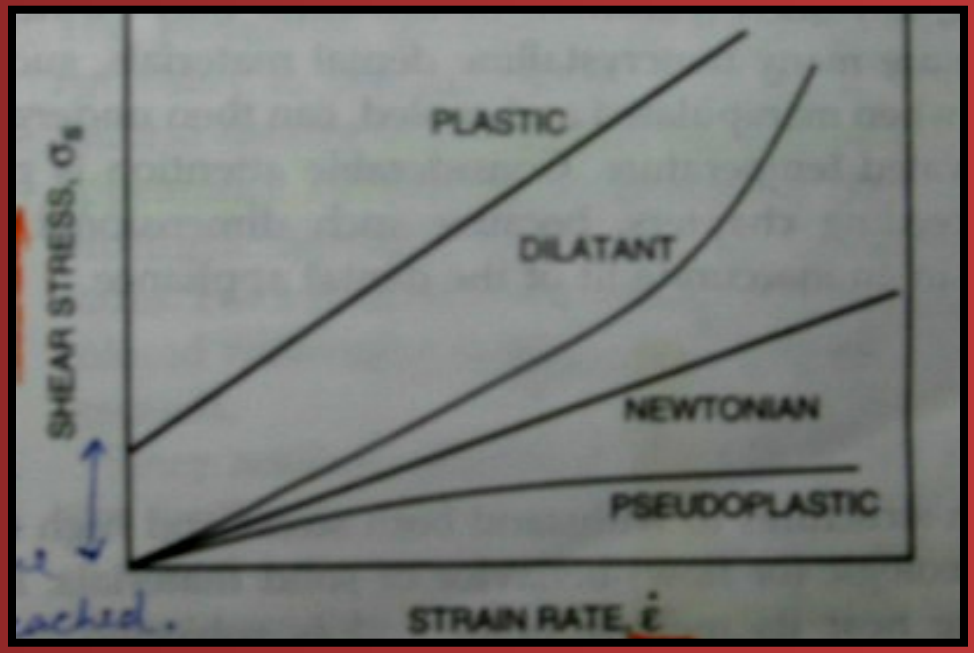
3 - The setting of such materials initially involves a change in viscosity with time and then the development of an elastic modulus on solidification

(I) VISCOSITY

Viscosity of a fluid is its resistance to flow, considering a liquid consisting of many parallel layers or laminae of materials and it is controlled by internal frictional forces within the liquids .

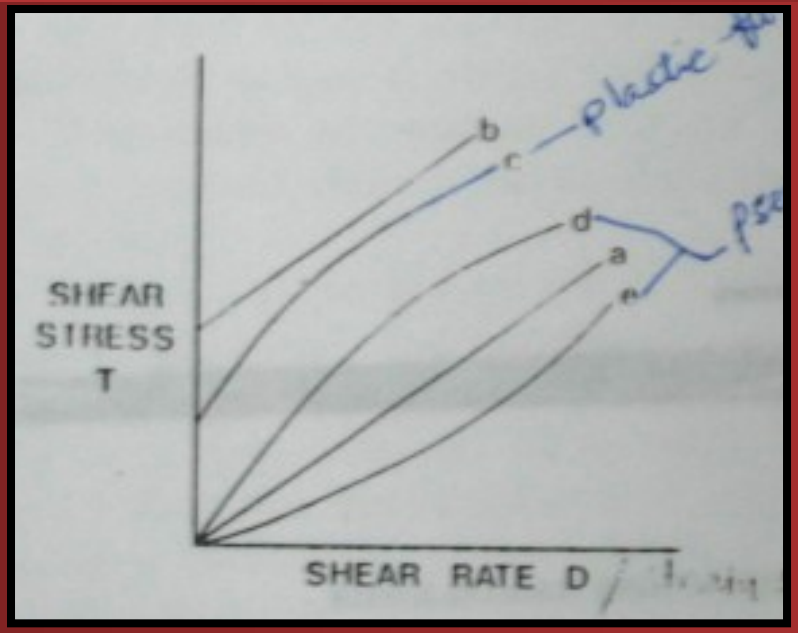
Viscosity of fliuds depands on many factors i.e. the nature of the substance, temperature , pressure , etc.

Newtonian fluid :
Ideal fluid demonstrates a shear stress that is proportional to the strain rate and thus plot a straight line



Non – Newtonian fluids.

1. Bingham flow, occurs when shear stress , shear rate plot a linear but has an intercept on the shear stress axis. E.g. Composites and clay in water.



2. Some classes of materials behave like a rigid body until minimum value of shear stress is reached known as PLASTIC. E.g. Catsup – a sharp blow to the bottle is usually required to produce an initial flow.

3. Psuedoplastic behavior-- Viscosity decreases with increasing shear until it reaches a nearly constant value (Shear thinning) e.g. polymer, natural resins , impression materials.

4. Dilatants – Materials whose viscosity increases with increasing shear rate until constant value (shear hardening) that is becomes more rigid as rate of deformation increases.

When some fluids are sheared at a steady rate viscosity decreases with time. On standing , the fluid regains its original viscosity, his is called THIXOTROPY, and is caused by structural breakdown and reformation. E.g. fluoride gels.

Flow index (n) = 1 for newtonian fluid

< 1 for pseudoplastic fluid

> 1 for dilatants

(II) CREEP

Acc. To GPT- 8 creep is defined as the slow change in the dimensions of an object due to prolonged (i.e. time dependent) exposure to stress and high temperature.

Another related phenomenon in restorative dentistry is **SAG** , which is deformation potential of long span metal bridge structures at porcelain firing temperature under the influence of the mass of the prosthesis.

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Metals used in dentistry , for cast restorations or substances for porcelain veneers have melting points that are much higher than mouth temperature, and thus are not susceptible to creep deformation.

An exception is dental amalgam having components with melting point slightly above room temperature, can slowly creep from restored tooth

(C) ADSORPTION , ABSOPRTION & SORPTION

Process of adsorption is an addition to the surface of a substance is important in the wetting process, in which substance is coated or wetted with a liquid.

In process of absorption the substance , absorbs , penetrate in to the solid material in type of diffusion process.

Absorption is a combination of penetration by diffusion and adsorption.

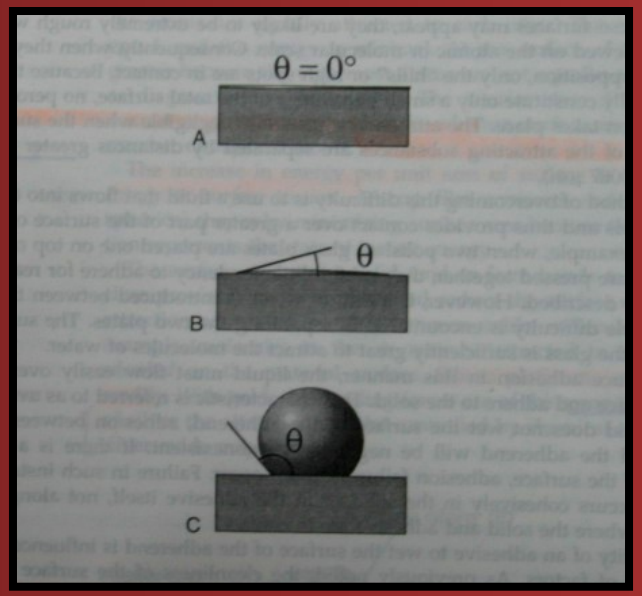
Sorption is process in which both adsorption and absorption are coexistent and it is not clear which process dominates . E.g. Sorption of moisture content by denture resin.

(I) WETTABILITY

is measure of the affinity of the liquid for a solid as indicated by spreading of a drop. E.g. Wetting of denture base by saliva , wetting of enamel by pit and fissure sealants .

Wettability of solid by a liquid can be observed by the shape of a drop of liquid on the solid surface. Shape of the drop can be identified by contact angle.

The contact angle is defined as the angle formed by the adhesive with the adherent at their interface.

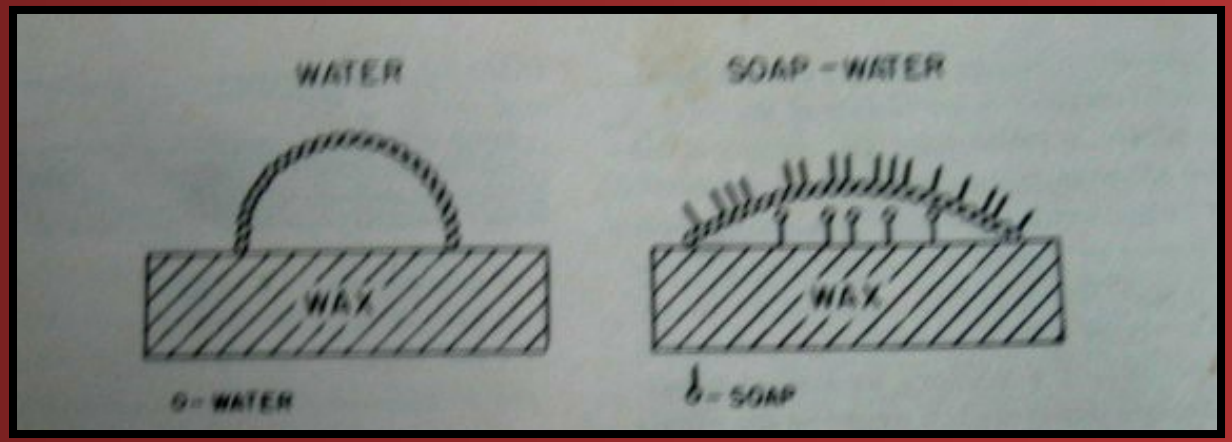


Good wetting with low contact angle i.e. less than 90 degree and poor wetting is a high contact angle i.e. more than 90. An ideal wetting is when contact angle is 0 degree.

The degree of wetting depends on the relative surface energies of the solids and liquids and on their intermolecular attraction.

High energy solids and low energy liquids encourage good wetting thus liquids generally wet higher energy solids well. E.g. water on metals and oxides.

On the other hand ,liquids bead up on the lower energy solids e.g. wax , Teflon, and polymers.



The clinical significance of contact angle is :

- The contact angle of water and saliva on denture , it relates to the retention of the denture.

  Contact angle for water on wax is about 110 deg. and for water on acrylic is around 75 deg.

  Contact angle for saliva freshly applied to the acrylic surface is 75 deg. which is same for water . When saliva was allowed to stand overnight in contact with resin the contact angle decreases to approximately 68 deg.

- The spreading of molten solder on the surface of the parts to be assembled . If the wetting is not adequate , soldering may fail , and if contact angle of solder is too great , it will not penetrate into the fine details of metals to be soldered.

(D) ADHESION AND BONDING

Acc. To GPT- 8 ADHESION is defined as the property of remaining in close proximity, as that resulting from the physical attraction of molecules to a substance or molecular attraction existing between the surface of bodies in contact.

Acc. To GPT- 8 BONDING is defined as the procedure of using an adhesive , cementing material or fusible ingredient to combine , unite , or , strengthen .

In many situations in the dentistry adhesion and bonding have important significance :

- Leakage adjacent to dental restorative material is severely affected by poor adhesion and bonding.
- Retention of artificial dentures depends upto some extent, on adhesion between the denture and saliva, and between saliva and soft tissue.
- Attachment of plaque or calculus to the tooth surface can be partially explained by adhesion attachment .

There are several reasons why it is desirable to produce primary chemical bonds between an adhesive and the substrate.

- Strong adhesion increases the likelihood that a given restoration or appliance will be retained on the teeth.
- Strong chemical adhesion eliminates the need for excessive removal of tooth structure to ensure retention , through mechanical undercuts thus chemical adhesion conserves tooth structures.
- Adhesion promotes the sealing of a margin , minimizing the chance of percolation or leakage of bacterial byproducts.

THANK YOU