

# Dental Materials

## Ø Properties of materials:-

### 1. Biological properties:

non toxic – non irritant – non allergic – not carcinogenic.

### 2. Chemical properties:

non dissolvable – not tarnish or corrode.

### 3. Mechanical properties:

Strain: it is the change in shape of a material due to application of force or load.

Stress: it is the internal force in a material.

Stress- strain curve: stress is directly proportional to strain in elastic deformation.

Impact strength: it is the amount of energy needed to fracture a material by application of sudden force.

Fatigue strength: it is the fracture of a material by repetitive application of small load.

Hardness: it is the resistance of a material to indentation or surface abrasion.

Creep: it is the slow deformation of a material at stresses below the yield stress.

Viscoelasticity: it is a time dependant permanent deformation.

### 4. Physical properties:

Density- thermal conductivity& diffusivity– thermal expansion– refractive index – opacity & translucency.

### 5. Surface properties & adhesion:

Surface tension- adsorption- surface wetting- surface roughness- adhesion- cohesion.

### 6. Miscellaneous properties.

## Ø Structure of solids:-

### 1. Types of interatomic bonds:

Ionic bond: formed by the transfer of an electron or electrons from one atom to another.

Covalent bond: formed by sharing of electrons.

Metallic bond: positive ions held together by a cloud of free electrons.

Van der waals forces: arise due to electrostatic attraction between molecules or atoms.

### 2. Spacing of atoms depends on:

Forces of attraction -forces of repulsion -resultant forces - equilibrium interatomic distance.

### 3. Classification of solids:

Polymers –ceramic materials –metallic materials.

## Ø Polymers:-

### 1. Classification of polymers:

Natural polymers: proteins- polyisoprenes- polysaccharides- polynucleic acids.

Synthetic polymers: Bakelite- nylon- terylene.

### 2. Polymerization reaction:

Condensation: reaction between two molecules to form a larger one with the elimination of a smaller molecule.

Addition: a reaction between two molecules to form a larger one without the elimination of a small molecule.

### 3. Stages in addition polymerization:

Activation & initiation – propagation – termination.

### 4. Methods of molding a polymer:

Condensation- compression- injection- dough technique.

### 5. Cross linking:

Chemical links between polymers chains.

## **6. Plasticizer:**

Liquids that are capable to penetrate the polymer to soften the material & make it more flexible.

## **7. Co-polymers:**

Contain two or more different types of monomer units.

## **Ø Metals:**

### **1. Characteristic properties:**

Hard- lustrous- dense- good thermal & electrical conductors- opaque- ductile & malleable.

### **2. Forming & shaping:**

Casting – cold working – powder metallurgy – electroforming – joining of metals.

### **3. Cooling of molten metal:**

Temperature time curve – structure on solidification.

### **4. Factors affecting grain size & structure:**

Rate of cooling – nucleating agents – cold working – stress relief anneal – recrystallisation – grain growth.

## **Ø Model & die materials:**

### **1. Required properties:**

Strong – produce fine details – little dimensional changes on setting – compatible with impression material – color contrast cheap & easy use.

### **2. Gypsum products:**

Plaster of paris – dental stone – improved stone.

### **3. Methods of production:**

Plaster of paris  $\implies$  obtained by prolonged heating of gypsum in open air at 120°C.

Dental stone  $\implies$  obtained by heating gypsum at 120°C-130°C in an autoclave under steam pressure.

Improved stone  $\implies$  obtained by heating gypsum in boiling 30% solution of Ca Cl<sub>2</sub> or Mg Cl<sub>2</sub>.

**4. Phases of the setting reaction:**

Mixing time – working time – setting time .

**5. Factors affecting setting time:**

Factors controlled by the manufacturer: impurities – fineness – chemicals.

Factors controlled by the operator: mixing time & rate – w/ p ratio – water temperature.

**6. Properties of gypsum products:**

Dimensional changes – effect of humidity – strength – surface hardness & abrasion resistance.

**7. Other die materials:**

Silica phosphate cement – amalgam – acrylic resin – epoxy die – ceramic die material – metal sprayed die.

**Ø Investment materials:**

They are ceramic materials used for making a mould into which the metal or alloy is cast.

**1. Requirements of investment materials:**

Easy manipulated – produce smooth surface – porous to permit escape of air – easy broken away – not attach to metal surface – sufficient strength – sufficient expansion.

**2. Components of investment material:**

Refractory material 65% - binder 30% - modifiers 5%.

**3. Types of investment material:**

- a) Gypsum bonded: the binder is calcium sulfate hemihydrates- used for casting gold alloys that melt below 1200°c.
- b) Phosphate bonded: binder is magnesium ammonium phosphate – used with base metal alloys it withstands high temperatures above 1200°c.
- c) Silicate bonded: binder is polysilicic acid – it has low porosity so venting is very important.

## **Ø Waxes:**

### **1. Sources of dental waxes:**

Mineral wax: as paraffin wax.

Insect wax: as bees wax.

Vegetable wax: as caruba wax.

### **2. Properties of waxes:**

Melting range – solid-solid transition temperature – mechanical; properties – thermal expansion & contraction – flow – internal stresses.

### **3. Types of dental waxes:**

Inlay pattern wax: used in inlays, crowns & bridge units.

Casting wax: pattern for the metallic framework of removable partial dentures.

Base wax: used on the base plate tray of complete dentures.

Boxing wax: to form a wax wall around the impression during pouring the cast.

Sticky wax: for use on dental stones & plasters.

## **Ø Impression materials:**

### **1. Requirements of impression materials:**

Ease of manipulation – good working & setting time – adequate flow – satisfactory consistency & texture – elastic properties – dimensional stability – biological compatibility – pleasant odor, taste & esthetic color – sufficient strength – accept addition & correction – compatible with cast & die materials.

### **2. Classification of impression materials:**

Inelastic: plaster – compound – zinc oxide eugenol – wax.

Elastic:

a) Hydrocolloids: agar – alginate.

b) Rubbers: polysulfide – silicon – polyether.

### **3. Plaster:**

Impression for completely edentulous patient – it has high dimensional accuracy.

### **4. Compound:**

Used in fully edentulous patient or as single impression – it is a thermoplastic material – it doesn't record fine details & not dimensionally stable.

**5. Zinc oxide eugenol:**

Used in full edentulous mouth – formed of two pastes mixed together – very accurate – eugenol has an irritation effect & adheres to the tissues.

**6. Agar:**

Used as impression or as duplicating material – it records fine details – it undergoes syneresis & imbibitions – used in thickness not less than 4-6 mm.

Agar may be used as duplicating material by making an impression of the original cast to produce a duplicate cast.

**7. Alginate:**

Used as impression material – supplied in the form of powder mixed with water – high dimensional accuracy – most flexible of all elastic impressions.

**8. Polysulfide:**

Formed of two pastes – it sets by condensation polymerization reaction – highly accurate – most flexible of all rubbers – it has the highest resistance to tear.

**9. Silicones:**

There are two types condensation & addition – addition type is more accurate because it has no reaction by product – its tear strength is low – addition type has dimensional stability even after one week.

**10. Polyether:**

Setting is by addition polymerization – it is highly accurate – it has the lowest flow of all rubbers – the least flexible – it has a hydrophilic nature.

**Ø Dental laboratory procedures:**

**1. Investing & casting:**

It is the procedure by which the wax pattern is turned into a metal.

## **2. Spruing:**

It is the channel through which the wax will be eliminated from the investment & metal will be poured into the mould, its diameter must be equivalent to the thickest portion of the wax pattern & it must be attached to that same portion.

## **3. Investing:**

It must utilize dimensional change of the wax & compensate for the metal shrinkage. It is poured in a ring around the pattern & this ring is lined by asbestos liner to allow for its expansion.

## **4. Conditioning the mold before casting:**

Burn out of wax may be done by high heat or low heat technique, incomplete wax elimination result in porosity of the casting.

## **5. Casting:**

Melting of the metal is done by gas-air blowpipe, the center cone of the flame is the part used for melting the metal because it is a reducing area.

## **6. Fluxing:**

The use of reducing flux is recommended for the protection of the metal from oxidation during melting.

## **7. Heat treatment:**

It is softening or hardening of the alloy by rapid or slow cooling.

## **Ø Dental alloys:**

### **1. Basic information about metals & alloys:**

Alloy- liquidus- solidus- grain refiner- sag.

### **2. Properties of alloys:**

Yield strength- hardness- modulus of elasticity- proportional limit- corrosion- ductility- malleability.

### **3. Old classification system of alloys:**

It is a classification according to uses into three types:

#### **a) Gold based alloys:**

It is sub classified into four types according to their function as type I soft, type II medium, type III hard, type IV extra hard.

#### **b) Metal ceramic alloys:**

They are classified into six types four containing gold & two nickel or cobalt based.

c) Alloys for removable partial denture:

Three types are used, type IV gold based alloys, chromium based alloys & cobalt based alloys.

**4. Current classification of alloys:**

It is based on physical properties & composition & has three types:

a) High noble alloys:

They are three types: gold-platinum, gold-palladium, gold-copper-silver-palladium.

b) Noble alloys:

They are three types: gold-copper-silver-palladium, palladium-copper-gallium, palladium-silver & silver-palladium.

c) Base-metal alloys:

They are four types: nickel-chromium-beryllium, nickel-chromium (high chromium), nickel-chromium (low chromium), cobalt-chromium alloys.

**Ø Resin based restorative materials:**

**1. Classification of resin based restorative materials:**

Glass ionomers- resin composites- resin modified glass ionomers- polyacid modified resin composites.

**2. Glass ionomer cements:**

It is a tooth colored restorative material which can adhere to enamel & dentin due to its rechargeable fluoride property.

**3. Resin composite restorations:**

a) They are sub classified into: microfilled- macrofilled- hybrid composites- modern hybrid composites- nanocomposites.

b) They are activated by ultraviolet light, recent advanced type cured by visible light.

c) Light curing units are quartz tungsten halogen light units (QTH), plasma arc light unit (PAC) & light emitting diodes unit (LED).



#### **4. Resin modified glass ionomer cements:**

It is formed by the addition of a small amount of (HEMA) or (BIS-GMA) in the liquid of the conventional glass ionomers.

Its setting reaction is an acid base reaction.

#### **5. Polyacid modified resin composites:**

Contains the components of composites & glass ionomer cements except for water.

There are two stages of setting reaction the first one is free radical polymerization, upon light curing the polymerizable molecules of UDMA & the patent TCB resins interconnect.

### **Ø Dental ceramics:**

#### **1. Composition of dental porcelain:**

Kaolin as binder, quartz as strengthener, feldspar which fuses forming a glass matrix, small amounts of metal oxides, starch & sugar.

#### **2. Processing:**

Compaction: porcelain powder is mixed with water into a paste, whipping or vibrating to compact the powder.

Firing: heated slowly first then placed in the furnace & burned out.

Glazing: by application of a layer of glass then fired at to fuse or by final firing which fuses the superficial layer.

#### **3. Classification of modern dental ceramics:**

Reinforced ceramic core systems: alumina reinforced porcelain-strength ceramic core system.

Resin bonded ceramics.

Metal ceramics.

### **Ø Dental cements:**

Cements are classified by their chemical composition into:

- a) Zinc phosphate cement.
- b) Polycarboxylate cement.
- c) Glass ionomer cement.
- d) Hybrid cements.
- e) Composite cements.