POLYMERS

م د. عباس ابراهيم حسين

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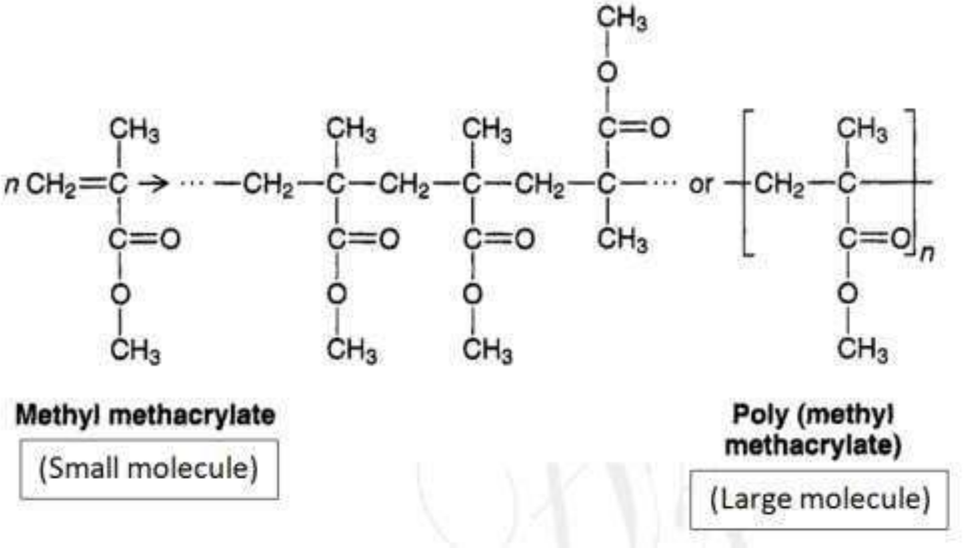
polymer is a chemical compound consisting of giant molecule formed by the union of many (poly) smaller repeatingn parts (mers).

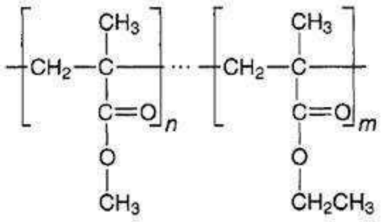
Monomer (one part): It is a molecule that forms the basic unit for polymers, and can combine with others of the same kind to form a polymer (homopolymer).



Copolymer: It is a polymer made by reaction of two different monomers. Have better physical property.

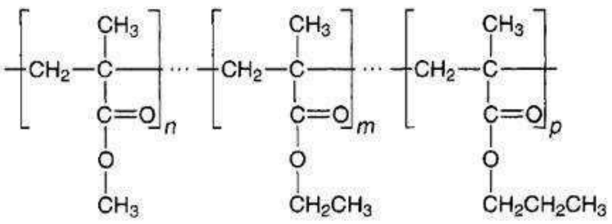
Terpolymer: It is a polymer synthesized from three different monomers.

- Mers connected in a linear sequence => linear polymers
- Mers arranged in a branched fashion => branched polymer
- Mers chains that are cross connected by permanant links between them => cross linked polymer (network polymer). This restricting the motion of the chains and improve the rigidity of polymer, icrease thermal and wear resistances and decrease water sorption and solubility.



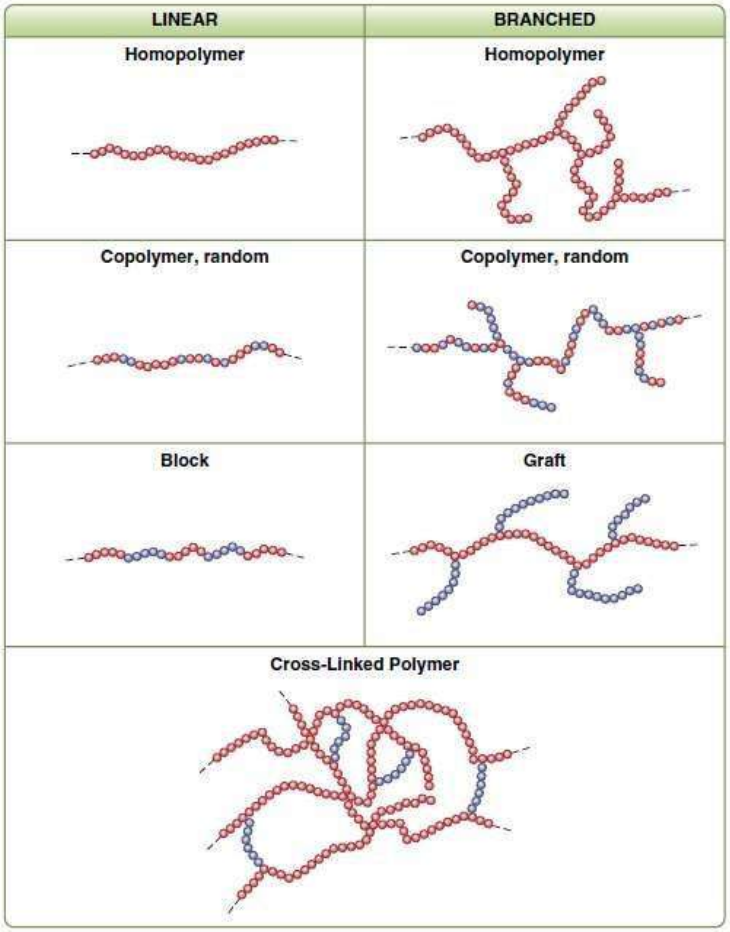
$$\left[CH_2-C(CH_3)(C{=}O)(OCH_3)\right]_n\cdots\left[CH_2-C(CH_3)(C{=}O)(OCH_2CH_3)\right]_m$$

Methyl methacrylate–ethyl methacrylate copolymer



$$\left[CH_2-C(CH_3)(C{=}O)(OCH_3)\right]_n\cdots\left[CH_2-C(CH_3)(C{=}O)(OCH_2CH_3)\right]_m\cdots\left[CH_2-C(CH_3)(C{=}O)(OCH_2CH_2CH_3)\right]_p$$

Methyl-, ethyl-, propyl methacrylate terpolymers



MOLECULAR WEIGHT

The molecular weight of the polymer molecule equals the molecular weight of the various mers multiplied by the number of the mers. The higher the molecular weight of the polymer, the higher the degree of polymerization.

The term POLYMERIZATION is the chemical process by which the monomers convert into polymers, but the DEGREE OF POLYMERIZATION is defined as the total number of mers in a polymer molecule. The higher the degree of polymerization, the better will be the physical properties and increasing the strength of the resin and its resistance to solubility.

POLYMERIZATION types:

1. ADDITION POLYMERIZATION (Free-Radical Polymerization)

Most dental resins are polymerized by addition polymerization which simply involves the joining together of monomer molecules to form polymers chain with no change in composition of the monomers. In this type of reaction, no byproduct is obtained.

The reaction takes place in three CHEMICAL STAGES:

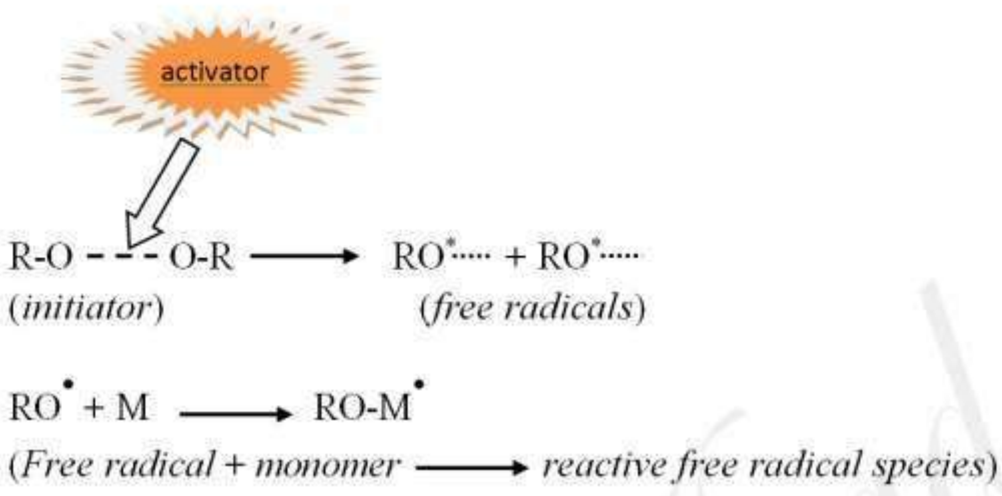
1- Activation and initiation stage

The addition polymerization process is start when free radicals are present. (Free radicals are very reactive chemical species that have an unpaired electron).

The free radicals are produced by reactive agents called initiators. Initiators are molecules which contain one weak bond which is able to undergo decomposition to form two reactive species (free radical), the decomposition of bond of initiator need source of energy (activator) such as heat, chemical compound, light, electromagnetic radiation.

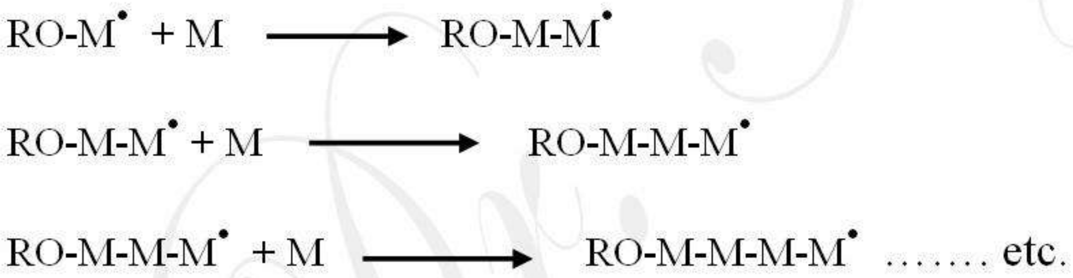
Initiator is used extensively in dental polymers is (Benzoyl peroxide).

Addition polymerization reaction is initiated when the free radical reacts with monomer molecules producing another active free radical species which is capable of further reaction.



2- Propagation stage

The initiation stage is followed by the rapid addition of other monomer molecules to the free radical and the shifting of the free electron to the end of the growing chain.



3- Termination stage

This propagation reaction continues until the growing free radical is terminated either by: a- Reaction of two growing chains to form one dead chain b- Reaction of growing chains with inhibitors as (hydroquinone, eugenol, impurities, or large amounts of oxygen).

2. CONDENSATION POLYMERIZATION

A condensation reaction involves two different molecules reacting together to form a third, large molecule with production of byproduct such as water, halogen, acid, and ammonia. Condensation reaction progresses by the same mechanism of chemical reaction between two or more simple molecules.

Factors control the structure and the properties of polymers:

1- The molecular structure of repeating units including the use of copolymer.
2- Molecular weight or chain length.
3- The degree of chain branching (Linear, network, 3D).
4- The presence of cross-linking agent.
5- Presence of plasticizers or fillers.

Uses of polymers in dentistry:

Polymers are either natural or synthetic.

1- Denture base, special tray, record base.
2- Artificial teeth.
3- Obturators for cleft palate.
4- Composite tooth restoration.
5- Orthodontic space maintainer and brackets.
6- Crown and bridge.
7- rubber dams.
8- Impressions.
9- Maxillofacial prosthesis.
10- Dies.
11- Endodontic filling material.
12- Splints and stents. 13- Athletic mouth protectors. 14- Cements.

15- bonding agents.

16- relining materials and tissue conditioners.

Denture base materials

1- Metallic denture base
  a. Cobalt chromium
  b. Gold alloys
  c. Aluminium
  d. Stainless steel
2- Non-metallic denture base
  a. Cellulose products
  b. Phenol formaldehyde
  c. Vinyl resin
  d. Vulcanite rubber
  e. Acrylic resin (poly methyl methacrylate PMMA)
  This is the material of choice nowadays as denture base material due to its good esthetic qualities, easy manipulation and processing and cheap prices.

DENTURE BASE RESINS

The following list indicates the requirements for a clinically acceptable denture base material:

1- High strength, stiffness, hardness, toughness, and durability.
2- Good thermal conductivity.
3- Processing accuracy and dimensional stability. 4- Chemical stability (unprocessed as well as processed material).
5- Insolubility in and low sorption of oral fluids.

6- Absence of taste and odor.
7- Biocompatible.
8- Natural appearance.
9- Color stability.
10- Adhesion to plastics, metals, and porcelain.
11- Ease of fabrication and repair.
12- Moderate cost.
13- Accurate reproduction of surface detail.
14- Resistance to bacterial growth.
15- Radiopaque.
16- Easy to clean.

17- light in weight.

18- good shelf life.

Types:

1- Heat cured resin.
2- Cold cured resin.
3- Visible light cured resin.
4- Microwave activated resin.

HEAT CURED ACRYLIC & COLD CURED ACRYLIC)

COMPOSITION:

POWDER

1- Poly methyl methacrylate granules. With only chemical cured acrylic the granules are smaller in size and have a lower molecular weight.
2- Initiator as benzoyl peroxide to initiate the polymerization of the monomer
3- Pigments as cadmium sulfate is used to obtain the various tissue-like shades.
4- Titanium oxides are used as opacifiers.
5- Nylon or acrylic fibers are usually added to simulate the minute blood vessels of oral mucosa=> natural appearance.

LIQUID

1- Methyl methacrylate monomer: it is clear, colorless, low viscosity liquid, boiling point is 100.3°C, and distinct odor exaggerated by a high vapor pressure at room temperature. Care should be taken to avoid breathing the monomer vapor. Animal studies have shown that the monomer can affect respiration, cardiac function, and blood pressure.

2- Hydroquinone inhibitors are added to give the liquid an adequate shelf life. The inhibitor is a chemical material added to prevent polymerization during storage and in order to provide enough working time.

3- Plasticizers are sometimes added to produce a softer, more resilient polymer. They are relatively low-molecular weight esters, such as dibutyl phthalate.

4- If a cross-linked polymer is desired, organic compounds such as Ethylene glycol dimethacrylate (EGDMA) are added to the monomer, using cross-linking agents (chemical bonds between different chains) provides greater resistance to minute surface cracking, termed crazing, and may decrease solubility and water sorption.

5- <u>With only chemical cured acrylic</u> an accelerator is included in the liquid. These accelerators are tertiary amines (N,N-dimethylpara-toluidine). These acrylics also called self-curing, cold-curing, or autopolymerizing resins.

$$\underbrace{\text{Polymer} + \text{Peroxide initiator}}_{\text{Powder}} + \underbrace{\text{Monomer} + \text{Inhibitor}}_{\text{Liquid}} + \underset{\text{(external)}}{\overset{\text{(Activator)}}{\text{Heat}}} \longrightarrow \text{Polymer} + \underset{\text{(reaction)}}{\text{Heat}}$$

$$\underbrace{\text{Polymer} + \text{Peroxide initiator}}_{\text{Powder}} + \underbrace{\text{Monomer} + \text{Inhibitor} + \text{Amine accelerator}}_{\text{Liquid}} \longrightarrow \text{Polymer} + \underset{\text{(reaction)}}{\text{Heat}}$$

POLYMER/MONOMER INTERACTION

The liquid placed in clean, dry mixing jar followed by slow addition of powder, allowing each powder particle to become wetted by monomer. After mixing the powder with liquid the mixture is left until it reaches a consistency suitable for packing. During this period, a lid should be placed on the mixing jar to prevent evaporation of monomer. The type of reaction is addition polymerization reaction.

The resultant mixture will pass into 5 STAGES:

(1) Sandy stage.

The polymer gradually settles into the monomer forming a fluid, incoherent mass.

(2) Stringy or sticky stage.

The monomer attacks the polymer by penetrating into the polymer. The mass is sticky and stringy (cobweb like) when touched or pulled apart.

(3) Dough stage.

As the monomer diffuses further into the polymer, it becomes smooth and dough like. It does not adhere to the wall of the jar. It consists of undissolved polymer particles suspended in a plastic matrix of monomer and dissolved polymer. The mass is plastic and homogenous and can be packed into the mold at this stage.

(4) Rubbery stage.

The monomer disappears by further penetration into the polymer and/or evaporation. The mass is rubber like, non-plastic, and cannot be molded.

(5) Stiff stage. on standing for a period, the mixture becomes stiff and very dry.

Working time: the time that a denture base material remains in dough like stage to remain moldable for at least 5 minutes.

FOLLOWING ARE THE RECOMMENDED CURING CYCLES:

- LONG CYCLE: heat the flask in water at 60-70 °C for 9 hours.
- SHORT CYCLE: heat the flask in water at 74 °C for 90 minutes

In comparison to heat cured acrylic; The cold cured acrylic has:

1. Lower molecular weight
2. Processed denture has more residual monomer => allergy and toxicity
3. Shorter working time
4. Lower dimensional change (lower shrinkage)
5. Lower hardness, impact strength, compression strength and tensile strength
6. Lower modulus of elasticity (lower stiffness)
7. Lower color stability

LIGHT CURED DENTURE PLASTICS

It consists of:
1- Urethane dimethacrylate matrix.
2- Acrylic copolymer.
3- Microfine silica filler.
4- Camphoroquinone-amine photo initiator system.

5- inhibitors
It is supplied in premixed sheets (single component) having clay like consistency. It is provided in opaque light-tight packages to avoid premature polymerization. The denture base material is adapted to the cast while it is in a plastic state. It is polymerized in a light chamber (curing unit) with blue light of 400-500 nm from high intensity quartz-halogen bulbs. The denture is rotated continuously in the chamber to provide uniform exposure to the light source.

Microwave polymerized polymer

Using specially formed acrylic resin processed in microwave by using non-metallic flask. The advantages of this process are cleaner and faster , shorter processing time and better accuracy and properties tha that of heat cured material

Flexible dentures (thermoplastic polymer)

Is a plastic becomes moldable above a specific temparature and returns to a solid state upon cooling.

Types:

1. Thermoplastic acetal
2. Thermoplastic acrylic
3. Thermoplastic polycarbonate
4. Thermoplastic nylon : because of its flexibility it is indicated in every case has an undercut, tilted teeth, patient has allergy to acrylic monomer and/on nickel, reduced mouth opening and when high esthetic is in demand.

Properties of flexible dentures:

1. High strength
2. Excellant flexibility and ductility
3. Semi translucent and provides excellent esthetic since no metal clasps appearrance on the tooth surface
4. Biocompatible because of free of monomer and metal that cause allergic reaction
5. High fracture resistance and impact properties, unbreakable even if thrown from height
6. Lower water sorption than PMMA resin
7. Good resistance to most chemicals but affected by strong acids and alcohols
8. Light weight
9. Apply minimal stress on abutments and underlying bone
10. Difficult to adjust, polish and repair
11. Aprone to creep
12. Minimal bonding strength to artificial teeth and to relining materials
13. Tendency to deteriorate, stain and develop a rough surface after short period of time

Processing errors

1. Porosity

   Presence of bubbles in/on the surface of resin lead to: a. Unsightly appearance of the denture base

b. Improper cleaning of the denture => denture and oral hygiene are suffered

c. Weaken the denture base Types:

Internal porosity	External porosity
voids or bubbles within the mass of polymerized acrylic confined to the thick portion of denture base.	White color voids localized on surface and subsurface
Due to vaporization of monomer when the temp.of resin increases above the boiling point of monomer (100.8C) in thick portion	Due to: 1. Lack of homogenity, this result from inadequate mixing of powder and liquid components lead to not homogeous dough at time of polymerization=> more shrinkage 2. Lack of adequate pressure during polymerization or inadequate amount of dough in mold during final closure=> irregular bubbles

Avoided by using long low temp.curing cycle for thick dentures	Avoided by: 1. using proper powder/liquid ratio and mixing it well to be more homogenousin dough stage 2. Using the required amount of dough in flask and check for exess during closure.

2.Crazing

Is formation of surface cracks on the denture base. These lead to:

Reduce esthetic quality and Weaken the denture and can cause fracture .
Causes:

a.Mechanical stresses

b.Attack by solvent (alcohol)

c.Incorporation of water during processing

3.Denture warpage

Is the deformation of denture or change in shapethat affect the fit of the denture.

Causes:

A.Release of stresses in denture during processing are curing shrinkage, rapid cooling, packing of acrylic in rubber stage or improper deflasking

b.Rise in temp.during polishing

c.Recuring of denture after addition of relining material

d.Repeated wetting and drying of denture

care of acrylic denture

stored in water when not used

brushed carefully with soft brush

no hot water used

no abrasive toothpaste or houshold cleansers used

PREVENTIVE MATERIALS Dr. Abbas Ibrahim Hussein

Fluoride was documented as a chemotherapeutic measure providing resistance in tooth enamel to in vivo demineralization.

Fluoride can also be provided systemically as a dietary supplement to inhibit caries where drinking water is not fluoridated.

For patients who are at high risk for the development of caries in spite of systemic fluoride administration, various means of topical application have been developed to increase caries protection, such as tooth pastes, mouth rinses, gels, and varnishes.

CHEMOTHERAPEUTIC AGENTS Toothpaste

The major function of toothpaste is to enhance cleaning of the exposed tooth surfaces and removal of pellicle, plaque, and debris left from salivary deposits and the mastication of food.

As a secondary function, toothpaste can be used as a carrier for fluorides, detergents, abrasives, and whitening agents to improve the quality and esthetics of erupted teeth.

COMPOSITION

The general composition of most tooth pastes include the following:

1- Colloidal binding agent

This agent acts as a carrier for the more active ingredients. Sodium alginate or methylcellulose will thicken the vehicle and prevent separation of the components in the tube during storage.

2- Humectants

An example is glycerin, which is used to stabilize the composition and reduce water loss by evaporation.

3- Preservatives

Preservatives are used to inhibit bacterial growth within the material.

4- Flavoring agents

Peppermint, wintergreen, and cinnamon are added to enhance consumer appeal and to combat oral malodors.

5- Abrasives

Abrasives are incorporated into all pastes to aid in the removal of heavy plaque, adhered stains, and calculus deposits. Calcium pyrophosphate, dicalcium phosphate, calcium carbonate, hydrated silica, and sodium bicarbonate are used in varying amounts to obtain this effect.

6- Detergents

An example is sodium lauryl sulfate, which is used to reduce surface tension and enhance the removal of debris from the tooth surface.

7- Therapeutic agents

The use of stannous fluorides has been demonstrated effective in the uptake of the fluoride ion and improved resistance of fluorapatite to acid demineralization in the initiation of carious lesions.

8- Other chemicals

Minor miscellaneous ingredients are included to reduce tube corrosion, stabilize viscosity, and provide pleasing coloration. Minor amounts of peroxides are included in some pastes, with marketing claims that they will remove innate discolorations and improve esthetics.

Mouthwash

Mouthwash is a liquid solution that is applied as a rinse on a regular basis to enhance oral health, esthetics, and breath freshening. Mouthwashes are most effective when applied in the morning or the evening following mechanical cleansing of the tooth surfaces with a brush and toothpaste.

COMPOSITION

Mouthwashes are composed of three main ingredients.

1- An active agent is selected for a specific health care benefit, such as anticaries activity (fluoride), antimicrobial effect (Chlorhexidine 0.1% and 0.2%), and reduction of plaque adhesion.
2- Surfactants are also added to most mouthwashes to help remove debris from the teeth and dissolve other ingredients, like sodium lauryl sulfate.
3- Flavoring agents added for breath freshening include eucalyptol, menthol, thymol, and methyl salicylate.

Fluoride varnishes

Fluoride containing varnishes provide an additional means of delivering fluoride topically to the surfaces of teeth in patients at risk for caries. The one advantage of the varnish mode of application is the extended time of exposure for the active fluoride ingredient against the tooth surface; it may be hours before a varnish wears off, instead of seconds, as with a mouthwash.

Pit and fissure sealants

Pits and fissures in the occlusal surfaces of permanent teeth are particularly susceptible to decay, and fluoride treatments have been least effective in preventing caries in these areas.

RESIN SEALANTS

The most common sealants are based on Bis-GMA resin and are light cured, although some self-cured products are still available. Also Glass Ionomer sealants are available.

MANIPULATION OF SEALANTS Enamel Surface Preparation

The wettability of the enamel by the sealant is improved by etching (with a solution or a gel of 35% to 40% phosphoric acid), and some advocate pretreatment with silanes in a volatile solvent.

Sealant Application

The sealant may best be applied with a thin brush, a ball applicator, or a syringe. Take care to avoid the buildup of excess material that could interfere with developing occlusion.

Athletic mouth protectors

The use of athletic mouth protectors in contact sports has increased rapidly; they are routinely used in football, soccer, ice hockey, basketball, wrestling, field hockey, softball, and other sports. Injuries to teeth from trauma caused by athletic activity have involved pulpitis, pulpal necrosis, resorption, replacement resorption, internal hemorrhage, pulp canal obliteration, and inflammatory resorption.

FABRICATIONOF CUSTOM-MADE PROTECTORS

The fabrication of a custom-made mouth protector involves the following general steps:

1- Making an alginate impression of the maxillary arch. 2-
Pouring a dental stone or high-strength stone model into the impression, minus the palate.
3- Vacuum-forming a heated thermoplastic sheet.
4- Trimming the excess around the model.
5- Smoothing the edges of the mouth protector.

OTHER APPLICATIONS FOR VACUUM-FORMING

In addition to athletic mouth protectors, vacuum forming is used to prepare trays for: impression materials, fluoride treatments, bleaching procedures, surgical splints, and orthodontic retainer.

المصادر:

1. PHILLIPS SCIENCE OF DENTAL MATERIALS-KENNETH J.ANUSAVICE,D.M.D,Ph.D.

2. RESTORATIVE DENTAL MATERIALS- ROBERT G. GRAIG, Ph.D.

RELINING MATERIALS Dr. Abbas Ibrahim Hussein

Relining is the procedure used to resurface the tissue-side of the denture with new base material to make it fit more accurately.

Classification

1-Tissue conditioner.
2- Soft liners.
3- Hard reline materials.

Tissue conditioner

They are soft plastic materials used primarily to treat irritated mucosa supporting the denture. They are used for short term application and should be replaced every 3 days.

The purpose of using tissue conditioners is to absorb some of the energy produced by the impact of masticatory forces. It serves as shock absorber between the occlusal surface of the denture and the underlying oral tissue therefore they promote healing of the inflamed tissue.

INDICATION AND USES:

1- It allows the patient to adapt to the new denture with minimum discomfort.
2- Tissue conditioning before denture fabrication.
3- Record base stabilization.

4- Improve soft tissue healing underneath the denture.
5- Functional impression.

COMPOSITION:

I- Powder (Polyethyl methacrylate).
II- Liquid (Ester plasticizer as butyl phthalate, butyl gluconate, and ethyl alcohol up to 30 %).

They are mixed and placed in the inner side of the denture and seated in the patient mouth. The mix passes into several phases from mixing to gelation to elastic phase which lasts for several days then become hard and rough as the plasticizer and alcohol are leached rapidly and water is absorbed. There is weight loss of 4-9 % after 24 hours.

Soft liner

REQUIREMENTS:

1- High bond strength to the denture base.
2- Dimensional stability of the liner during and after processing.
3- Low solubility and water absorption.
4- Permanent softness and resiliency.
5- Color stability.
6- Easy manipulation and process.
7- Biocompatible to tissue.
8- Absence of odor and taste.

Soft liners are **classified into two types:**
a- Silicon elastomer (autopolymerized or heat polymerized). b- Soft acrylic (autopolymerized or heat polymerized).

SOFT ELASTOMER LINER:

It is the most successful material for soft liners, they are not dependent on leachable plasticizer therefore, they retain resiliency for prolonged period they are well tolerated by oral mucosa, odorless, tasteless, excellent elastic properties but they have poor adhesion to polymethyl methacrylate denture.
Autocured silicon is supplied as paste and liquid.

Composition:

I- Paste (Hydroxyl terminated polydimethyl siloxane).
II- Liquid (Tetraethyl silicate and dibutyl tindilurate).
Setting is condensation reaction. Heat cured silicon liner is supplied as one component system.

SOFT ACRYLIC LINER:

They are composed of plasticized acrylic polymers or copolymers which could be chemically activated or heat activated. Self-cure type is supplied as powder and liquid.

Composition:

I- Powder (Polymethyl or polyethyl methacrylate and peroxide initiator).
II- Liquid (Ester such as dibutyl phthalate and methyl methacrylate and tertiary amine activator).
They are similar to tissue conditioner but they are not as soft as them and retain their softness for longer time.

USES OF SOFT LINERS:

1- Improve the comfort or fit of old denture until the new denture is made for a period of several weeks.
2- Provide comfort for patients who cannot tolerate occlusal pressure

such as in case of (alveolar ridge resorption, knife edge ridge, and sharp lingual mylohyoid ridge when surgery is contraindicated), chronic soreness because of (heavy bruxism, poor health, vitamin deficiency, with oral cancer).

3- Treatment of congenital or acquired defects of palate.

- None of soft liners is permanent; it may last 6 months.

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Dr.Abbas Ibrahim Hussein الثانية المرحلة

Temporary filling material

1- It should be non-toxic, and non-irritant to pulp and tissue. **2-** It
should be insoluble in saliva and liquid.
3- Mechanical properties must meet the requirements for their particular application.
4- Protection of the pulp:

- Thermal insulation.
- Chemical protection. Electrical insulation.

5_Optical properties.
6- Cements should be adhesive to tooth structures and restorations, but not to dental instruments.

7- Should be bacteriostatic.

8- Should have soothing effect on the pulp.

9- The luting cement should have low viscosity to give a low film thickness.

ZINC OXIDE EUGENOL

PROPERTIES

1 - It has a sedative effect on exposed dentin. It is the least irritating of all dental cements.

2- It has reasonable sealing of the cavity.
~- It is the cement of low strength, low abrasive resistance, and low flow after setting, so placement of zinc oxide eugenol temporary filling should not be more than few days, maximum few weeks. The strength and abrasive resistance could be improved by adding 20-40 % weight of fine polymer particles and treating the surface of zinc oxide particles with carboxylic acid (reinforced zinc oxide eugenol type).
4- Sufficient powder should be added to the liquid to achieve putty consistency.
5- It is the material of choice as temporary filling.

~COMPOSITION

POWDER

,. Zinc oxide (principal ingredient).

~' Zinc stearate (accelerator, plasticizer).

~' Zinc acetate (accelerator, improve strength).

,. White rosin (to reduce brittleness of set cement). **LIQUID**

,. Eugenol (react with zinc oxide). ,. Olive oil (plasticizer).

- *Setting time* 4-10 minutes (zinc oxide eugenol cement sets quickly in the mouth due to moisture and heat).
- *Powder/liquid ratio* (4/l to 6/1 by weight).

FACTORS AFFECTING THE REACTION

1- Particle size: smaller particles set faster.

2- Heat: cool the glass slab slows the reaction.

3- Powder /liquid ratio: higher the ratio, faster the setting reaction. 4- Water acts as accelerator.

5- Glycerin acts as retarder.

ZINC-PHOSPHATE CEMENTS

APPLICATION

1- Luting of restorations (cementation).

2- High strength bases.

3- Temporary restoration.

4- Luting of orthodontic bands.

PROPERTIES

1- Has higher strength and abrasive resistance than zinc oxide eugenol, and has a relatively low solubility in oral fluids, but still has low abrasive resistance in area subjected to high load of mastication.

2- Higher powder/ liquid ratio is required for low acidity and high strength.

3- Reinforced zinc phosphate is more durable and could be used when longer time for temporary filling is required.

COMPOSITIO~

Powder

Zinc oxide (principal constituent).

Magnesium oxide (aids in sintering).

Calcium oxide (improves smoothness of mix).

Silica (filler).

liquid

Phosphoric acid (react with zinc oxide).

Water (control rate of reaction).

Aluminum phosphate (buffers, to reduce rate of reaction).

Aluminum (cohesive).

○ ***Mixing time*** 15 seconds (maximum **1** minute). ○ ***Setting time*** 5-9 minutes.

Factors affecting the reaction

Temperature: higher temperature will accelerate the reaction. Powder/liquid ratio: (**1.4** g/0.5 ml) more the liquid, slower the reaction.

Rate of addition of powder is incorporated slowly.
Mixing time: the longer mixing time (within practical limits), the slower is

the rate of reaction.

GLASS IONOMER CEMENT

They are adhesive teeth colored anticariogenic cements. It was named **glass ionomer** because, the powder is glass and the setting reaction and adhesive bonding to tooth structure is due to ionic bond.

APPLICATION

1- Anterior esthetic restorative material for class III cavities.
2- For eroded areas and class V restorations.
3_As luting agent.

4- As liners and bases.
It is not recommended for class II and class IV restorations, since they lack fracture toughness and are susceptible to wear.

COMPOSITIO

powder

Silica.

Alumina

Aluminum florid (AIF_3). ~

Calcium florid (CaF_2). } Act as ceramic flux.

Sodium florid (NaF).

Aluminum phosphate ($A1Po_4$). **Barium** (provide radiopacity).

Liquid

Polyacrylic acid (increase reaction, decrease viscosity). ,.

Tartaric acid (increase working time).

Water (it is the medium of reaction and it hydrates the reaction products). o ***Setting time*** 5-7 minutes.

MANPULATION

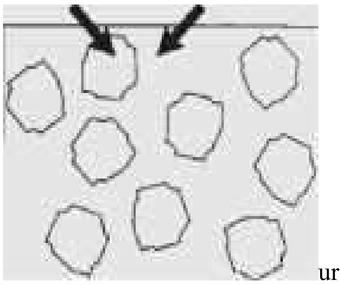
1- Conditioning of the tooth surface.

2- Proper manipulation.

3_ Protection of cement during setting.

4- Finishing.

acid from liquid component glass core matrix



attacks glass urface of glass reacts releasing

cations eg calcium and aluminium) and fluoride

cations cross-link polyacid molecules giving salt matrix and unreacted glass cores

POLYCARBOXYLATECEME~

This cement contains two main reactive ingredients, **zinc oxide** and **polyacrylic acid** and both are in the powder; the bottle is filled with water by the dentist. Powder and water are dispensed onto the mixing pad and mixed

with a spatula.

In other products the powder contains only the **zinc oxide** and the liquid is an aqueous solution of **polyacid.**

Figure (7-3):
Polycarboxyla te cement.

APPLICATION

1- Primary for luting permanent restorations. **2-** As liners and bases.
3_Used in cementation of orthodontic bands.
4- Also used as root canal fillings in endodontics.

COMPOSITION

POWDER

Zinc oxide (basic ingredient). ,.

Magnesium oxide (modifier).

Stannous fluoride (increase strength; anticariogenic).

LIQUID

Polyacrylic acid.

Unsaturated carboxylic acid (iticonic acid, maleic acid).

○ ***Mixing time*** 30-40 seconds. ○ ***Setling time*** 7-9 minutes (can be increased by cooling the glass slab). ○ ***Powder/ Uquid ratio*** **l** .5 powder: **1** liquid by weight.

RESIN CEMENTS

A chemically active resin luting cement which is used to bond laboratory made dental appliances and restorations to teeth.

APPLICATION

1 - Cementation of crowns and bridges (etched cast restorations).

2- Cementation of porcelain veneers and inlay. **3-** For bonding of orthodontic brackets to acid etched enamel.

COMPOSITION

POWDER

Resin matrix.

Inorganic fillers.

Coupling agent.

,. Chemical or photo initiators and activators.

LIQUID

Chemically by peroxide-amine system.

By light activation.

Dual cure (by both chemical and light activation).

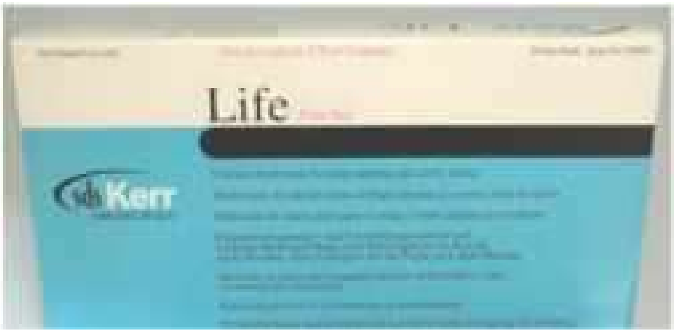
MANIPULATION

1- Etching the restoration.
2- Etching the tooth surface.
3- Cementing the restoration.

CALCIUM HYDROXIDE CEMENT (DYCAL[

This material is provided as two pastes. Approximately equal amounts of each paste are dispensed onto the mixing pad and mixed with a spatula. One of the active ingredients is a **salicylate compound** which has a very

distinctive 'medicated' odor.



APPLICATION

1- Direct and indirect pulp capping.
2- As bases beneath composite restoration for pulp protection.
3_ Apexification procedure in young permanent teeth where root formation is incomplete.

COMPOSITION BASE

Glycol salicylate (react with $CaOH_2$).

Titanium dioxide (inert filler, pigment).

Barium sulfate (radiopacity).

Calcium sulfate. CATALYST

Zinc oxide.

Zinc stearate (accelerator).

Sulfonamide (oily compound act as carrier). ,.

Ethylene toluene.

- *Setling time* 2.5-5.5 minutes.

Factors affecting setling time: The reaction is accelerated by moisture and accelerators. It therefore sets fast in the oral cavity.

- *Effect on pulp:* The cement is alkaline in nature. The high pH is due to the

presence of free $CaOH_2$ in the set cement. The pH ranges from (9.2 to 11.7). ○ *Formation of secondary dentin:* The high alkaline and antibacterial and protein lysing effect helps in the formation of reparative dentin.

MANIPULATION

Equal length of the two pastes are dispensed on a paper and mixed to a uniform color, then use dycal applicator (a ball ended instrument) to carry the mixed material and apply to deep area of the cavity or directly over mildly exposed pulp (contraindicated if there is active bleeding).

CAVITY LINER AND VARNISH

A cavity liner and cavity varnish is used to provide a barrier against the passage of irritants from cements or other restorative materials and to reduce the sensitivity of freshly cut dentin, and to reduce microleakage.

It is a suspension of calcium hydroxide in a volatile solvent upon the evaporation of the solvent, the liner form a thin film on the prepared tooth surface.
A variety of fonnulation e.g. glass ionomer cement liner, zinc oxide eugenol liner.
Supplied as solution, powder and liquid, or light cured paste in tube.

CAVITY VARNISH

It is a solution of one or more resins which applied onto the cavity wall, evaporates leaving a thin resin film, that serve as a barrier between the restoration and the dentinal tubules.
Supplied as liquid in dark colored tightly capped bottles.

المصادر:

1. PHILLIPS SCIENCE OF DENTAL MATERIALS-KENNETH J.ANUSAVICE,D.M.D,Ph.D.

2. RESTORATIVE DENTAL MATERIALS- ROBERT G. GRAIG, Ph.D.

Waxes

Dr. Abbas Ibrahim

The primary use of waxes in dentistry is to make a pattern of appliances prior to casting as many dental restorations are made by lost-wax technique, in which a pattern is made in wax and put in the mold (investment materials). After setting, the wax is burnt out and the space is filled with molten metal or plastic acrylic.

Chemically waxes are polymers consisting of hydrocarbon and their derivatives like ester and alcohol. Dental waxes are mixture of natural and synthetic waxes gums, fat, oils, natural and synthetic resins and coloring agents.

Requirements of dental waxes

1. Must conform to the exact size and shape and contour of the appliance which is to be made.
2. Should have enough flow when melted to reproduce the fine details.
3. No dimensional changes should takes place once it is formed.
4. Boiling out of the wax without any residue.
5. Easily carved and smooth surface can be produce.
6. Definite contrast in color to facilitate proper finishing of the margins.

Classification of waxes:

According to origin :

1. Mineral:

   a. **Paraffin:** Refined from crude oil, has relatively low melting point (50-70°C) and relatively brittle.

   b. **Ceresin:** Refined from petroleum, has medium melting range (60°C).

2.

Plants:

a. Carnauba: Obtained from palm trees, it is hard, tough, and has high melting point (80-85°C).

b. Candelilla: It is hard, tough, and has high melting point (80-85°C), used to increase the melting point and reduce flow at mouth temperature.

3.

Animal:

a. Stearin: Obtained from beef fat, has low melting point (50 C).

b. Bees: Obtained from honey-comb, consist of partially crystalline natural polyester. It is brittle, has medium melting temperature (60-70°C).

4.

Synthetic:

They are used to modify some properties of natural waxes like polyethylene.

According to use:

1. Pattern wax

   a. Inlay wax: It should be hard and brittle in order to fracture rather than to distort when removal from undercut areas. The wax is blue in color. They are used to make inlays, crowns and pontic replicas.

   They are mostly paraffin with carnauba wax. There are two types:

   Type 1: for direct technique.

5.

Type 2: for indirect technique.

b. **Denture casting wax:** It is used to produce the metal components of cobalt/chromium partial denture. It is based on paraffin wax with bees wax to give softness necessary for molding and stickiness necessary to ensure adhering to an investment cast material of refractory cast. It is green in color.

c. Denture base plate wax: It is used to form the base of the denture and in setting of teeth. It is pink in color.

2. Processing wax

Waxes are used during processing of the appliance.

a. Beading: It is used to make beading around the impression before pouring gypsum to protect the margins of the cast.

b. Boxing: It is used to make box around the impression to make pouring gypsum into the impression easier and more perfect.

c. Block out: It is used to block out undercut areas on cast during processing of co/cr metal framework.

d. White: It is used to make pattern simulate veneer facing in crowns.


e. Sticky: It is used to join and stabilize temporary broken pieces of the broken denture before repair.

3. Imprassion wax

They are previously used to make impression, but they distort when removal from undercut areas, they have high flow.

a. Impression wax: It is used to make the impression.

b. Corrective wax: It is used to record selected areas of soft tissues in edentulous arches.

Corrective wax

Properties

1. They are thermoplastic materials that are soft when heated and are solid at room temperature.
2. They have high coefficient of thermal expansion and contraction. They are the highest of dental materials; it is about 300*10-6 to 1000*10-6 cm/cm C. The shrinkage of wax from liquid to solid at room temperature is 0.4 %. Thermal contraction of wax is compensated by expansion of investment.
3. They are poor thermal conductivity. After softening of the wax, it is allowed to cool, which accompanied by contraction because of poor thermal conductivity only the outer layer solidify and the inner solidify later which will

produce internal stress. Relief of the stresses accrues later especially when temperature increases, greater stresses may be incorporated if the wax is not properly softened. The best way to soften the wax is to be held in the warm raising air above the flame and not in the flame itself.

4. They should have high flow when softened, but should little or no flow at room temperature or mouth temperature in order not to distort.
5. Inlay should be brittle in order to fracture rather than distort when removed from undercut of the cavity.

Dr.Abbas Ibrahim **DENTAL CEMENT** المرحلة الثانية

Temporary filling material

1- It should be non-toxic, and non-irritant to pulp and tissue.
2- It should be insoluble in saliva and liquid.
3- Mechanical properties must meet the requirements for their particular application.
4- Protection of the pulp:
  - Thermal insulation.
  - Chemical protection. Electrical insulation.

5_Optical properties.
6- Cements should be adhesive to tooth structures and restorations, but not to dental instruments.

7- Should be bacteriostatic.

8- Should have soothing effect on the pulp.

9- The luting cement should have low viscosity to give a low film thickness.

ZINC OXIDE EUGENOL

PROPERTIES

1 - It has a sedative effect on exposed dentin. It is the least irritating of all dental cements.

2- It has reasonable sealing of the cavity.

~- It is the cement of low strength, low abrasive resistance, and low flow after setting, so placement of zinc oxide eugenol temporary filling should not be more than few days, maximum few weeks. The strength and abrasive resistance could be improved by adding 20-40 % weight of fine polymer particles and treating the surface of zinc oxide particles with carboxylic acid (reinforced zinc oxide eugenol type).

4- Sufficient powder should be added to the liquid to achieve putty consistency.

5- It is the material of choice as temporary filling.

~OMPOSITION

POWDER

,. Zinc oxide (principal ingredient).

~' Zinc stearate (accelerator, plasticizer).

~' Zinc acetate (accelerator, improve strength).

,. White rosin (to reduce brittleness of set cement). **LIQUID**

,. Eugenol (react with zinc oxide). ,. Olive oil (plasticizer).

- *Setting time* 4-10 minutes (zinc oxide eugenol cement sets quickly in the mouth due to moisture and heat).
- *Powder/liquid ratio* (4/l to 6/1 by weight).

FACTORS AFFECTING THE REACTION

1- Particle size: smaller particles set faster.
2- Heat: cool the glass slab slows the reaction.
3- Powder /liquid ratio: higher the ratio, faster the setting reaction.
4- Water acts as accelerator.
5- Glycerin acts as retarder.

ZINC-PHOSPHATE CEMENTS

APPLICATION

1- Luting of restorations (cementation).
2- High strength bases.

3- Temporary restoration.
4- Luting of orthodontic bands.

PROPERTIES

1- Has higher strength and abrasive resistance than zinc oxide eugenol, and has a relatively low solubility in oral fluids, but still has low abrasive resistance in area subjected to high load of mastication.
2- Higher powder/ liquid ratio is required for low acidity and high strength.
3- Reinforced zinc phosphate is more durable and could be used when longer time for

temporary filling is required.

COMPOSITIO~

Powder

Zinc oxide (principal constituent).
Magnesium oxide (aids in sintering).
Calcium oxide (improves smoothness of mix).
Silica (filler).

liquid

Phosphoric acid (react with zinc oxide).
Water (control rate of reaction).
Aluminum phosphate (buffers, to reduce rate of reaction).
Aluminum (cohesive).

○ ***Mixing time*** 15 seconds (maximum **1** minute). ○ ***Setting time*** 5-9 minutes.

Factors affecting the reaction

Temperature: higher temperature will accelerate the reaction. Powder/liquid ratio: (**1.4** g/0.5 ml) more the liquid, slower the reaction.

Rate of addition of powder is incorporated slowly.
Mixing time: the longer mixing time (within practical limits), the slower is

the rate of reaction.

GLASS IONOMER CEMENT

They are adhesive teeth colored anticariogenic cements. It was named **glass ionomer** because, the powder is glass and the setting reaction and adhesive bonding to tooth structure is due to ionic bond.

APPLICATION

1- Anterior esthetic restorative material for class III cavities.
2- For eroded areas and class V restorations.
3_As luting agent.
4- As liners and bases.

It is not recommended for class II and class IV restorations, since they lack fracture toughness and are susceptible to wear.

COMPOSITIO

powder

Silica.

Alumina

Aluminum florid (AIF_3). ~

Calcium florid (CaF_2). } Act as ceramic flux.

Sodium florid (NaF).

Aluminum phosphate ($A1Po_4$). **Barium** (provide radiopacity).

Liquid

Polyacrylic acid (increase reaction, decrease viscosity). ,.

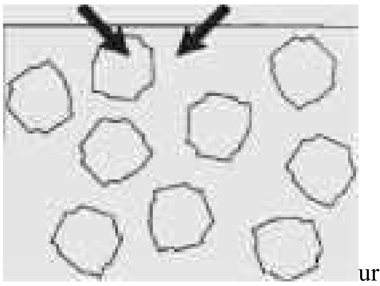
Tartaric acid (increase working time).

Water (it is the medium of reaction and it hydrates the reaction products). **o** ***Setting time*** 5-7 minutes.

MANPULATION

1- Conditioning of the tooth surface.
2- Proper manipulation.
3_ Protection of cement during setting.
4- Finishing.

acid from liquid component glass core matrix



POLYCARBOXYLATECEME~

This cement contains two main reactive ingredients, **zinc oxide** and **polyacrylic acid** and both are in the powder; the bottle is filled with water by the dentist. Powder and water are dispensed onto the mixing pad and mixed

with a spatula.

In other products the powder contains only the **zinc oxide** and the liquid is an aqueous solution of **polyacid.**

***Figure** (7-3):*
Polycarboxyla te cement.

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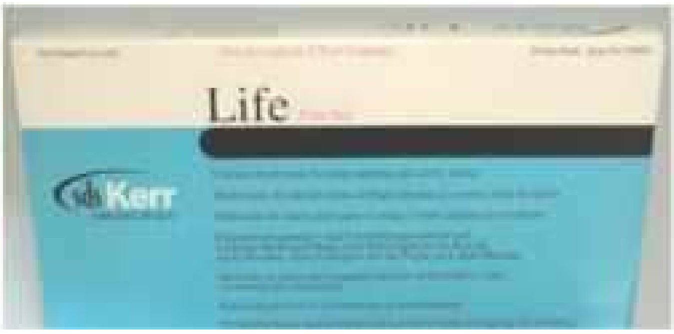

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MATERIALS-KENNETH J.ANUSAVICE,D.M.D,Ph.D.

2. RESTORATIVE DENTAL MATERIALS-ROBERT G. GRAIG, Ph.D.

2nd class

Dental Amalgam

Dr.Abbas Ibraahim Husssein

Dental amalgam is a powder of silver-tin alloy mixed with mercury.

Composition of the Conventional amalgam

(Traditional).

Silver (Ag) 65%:

Advantages: increasing strength, promoting setting when mixed with mercury(increasing the setting time ,reducing the flow and resisting the tarnish and corrosion .

Disadvantage: high degree of setting expansion.

b- Tin (Sn) 25-29%:

Advantages aids in amalgamation process because it has great affinity to mercury and decrease expansion within practical limit.

Disadvantage: Large amount of tin cause decrease strength, prolong the setting time ,decrease corrosion resistance and increase flow of amalgam. c- Copper (Cu) 6%: increase strength and hardness and setting expansion but decrease flow d- Zinc (Zn) 0-2 %:

Its presence is not essential, *advantage:* It prevents oxidation during alloy ingot manufacture.

Disadvantage: It gives rise to delayed or secondary expansion if zinc containing alloys are contaminated with moisture. e-Palladium: 0-1 %: It improves the corrosion resistance and the mechanical properties. fIndium: 0-4 %: In high copper alloy it enhances the clinical performance of amalgam restoration as it reduces the evaporation of mercury and the amount of mercury required to wet the alloy particles.

Property	Ingredient			
	Sliver	Tim	Copper	Zinc
Strength	Increases	Decreases	Increases	
Expansion	Increases	Decreases	Increases	
Flow	Decreases	Increases	Decreases	
Setting time	Decreases	Increases	Decreases	
Corrosion	Decreases	Increases	Decreases	
Workability		Increases		Increases

Classifications of the types of the amalgam according to :

I-Shape of the particles:

1-Lath-cut particles alloys(fig a) 2-S.u,herical particles alloys (fig b)

3- *admixed* particles alloys (Disperse alloy): mixture of lathe-cut with spherical alloy(fig-c) II-Zinc present

1- Zinc- containing alloys ---------------Alloy which contain more than 0.01 %

2- Zinc free; non zinc alloys). ------Alloy which contain less than 0.01% (Require inert atmosphere during manufacturing)

III-Amount of copper

1-Low copper (conventional amalgam) 2- High copper amalgam:

The copper content is increase from 6% up to 10-30%. It is of different types: a-

Fig -1- scanning electron micrographs A, lathe-cut , B,spherical, c,admixed amalgam alloys

Setting Reaction(amalgamation process):

It is a surface-reaction and take place when alloy powder and mercury is mixed, mercury wetted the particles then diffused in side the alloy particles. The reaction products crystallize ;the subsequent growth of the crystals causes amalgam to be hardened. A considerable amount of initial alloy remains un reacted.

The reaction of conventional amalgam is given by this equation:

Ag3Sn +Hg •· Ag2Hg3 + *Sn1Hg* + Ag3Sn gamma + Hg •· gamma 1 + gamma 2 + gamma

For high copper amalgam:

Ag3Sn + Cu + Hg •· Ag2Hg3 + Cusxns + Ag3Sn gamma + Cu + Hg gamma 1 + Cue'Sns + gamma

Advantages :

1- Easy to inset; are not technique sensitive . 2- Maintain anatomical form .

3- Have relatively long service life.

4- It has an adequate compressive strength :- around 45- 70,000 psi while for the enamel 58000 psi for the dentine 43000 psi for the composite 30-40000 psi this strength develops slowly it may takes 24hr after mixing and affected by type of alloy, shape and size of particles(faster with high cupper, small size, spherical), amount of mercury and the manipulation Gamma: strongest phase of hardened amalgam.

Gamma-1: second strong.

Gamma-2: least strong. Voids-have drastic effect on the strength

Gamma-2 is considered to increase corrosion and reduced the strength; to resolve this problem: a-produce amalgam with little matrix by mixing little mercury as possible b-the mixed amalgam should be compressed into cavity so that the un reacted core of particles are packed closely together and mercury rich material being brought to the surface as layer of excess material which then removed c-production of high copper alloy 5-In soluble in oral fluids .

6-Adaptability to cavity walls .

7-Compatible with the living tissues (it is not irritant).

8Easly removed because of it's color

Disadvantage

1-Weakness in tensile and shear strength:-so that why it should be supported by tooth structure, and we must have adequate bulk of amalgam whenever stress may be applied.

2- In harmonious color.

3- Creep:- A plastic permanent deformation of amalgam under static loud

Creep causes protrusion of amalgam out of the cavity , the protruded edges are unsupported and weak and may be further weakened by corrosion this lead to fracture , as a result a ditch will happened around the margin of amalgam restoration which will cause a gap and microleakage (Ditching of amalgam)

The gamma 2 phase is primarily responsible for high value of creep in conventional amalgam but it is not the only factor involved, while high copper amalgam has lower value of creep because it has a little or no gamma 2 phase .

4- High thermal and electrical conductivity:- so protective cement is required

The Coefficient of thermal expansion and contraction is three times greater than that of dentine this cause more expansion and contraction of the restoration than the surrounding tooth when patient takes cold and hot food and drinks. This leads to microleakagc around the filling. So replacement of the restoration is a must every 5 years

5- Susceptible to tarnish and corrosion :- tarnish :discoloration at the surface of the amalgam by chemical attack from component in food or saliva.

Corrosion: roughness and pitting of the surface of amalgam as a result of chemical attack from component in food or saliva.

Tarnish and corrosion may by the result of galvanism

The gamma 2 phase of conventional amalgam is the most electrochemically reactive. For higher copper amalgam the Cu_6Sn_3 phase forms the anode but less corrosion occurs than conventional amalgam because absence of gamma 2 phase.

The rate of corrosion is accelerated when the amalgam filling is contact with gold or old restorations. Corrosion will cause roughness of the amalgam which may lead to plaque and bacterial accumulation and inflammation of the soft tissue also will cause poor appearance of the filling surface and may affect the mechanical properties of amalgam.

Level of corrosion may be minimized by polishing the surface of restoration.

Corrosion has one advantage that corrosion products thought to be gathered at the restoration - tooth interface (seal the gap) to prevent or decrease microleakage.

6- Delayed expansion:- for zinc containing amalgam when contaminated with moisture during condensation zinc will react with water, hydrogen will produced as products of such reaction, hydrogen will be collected internally(voids), this cause pressure which may cause expansion which cause pain. This occurs after 3-4 days and may be after a month. This confirms the need for adequate moisture control when using this material

Contamination of amalgam with moisture during manipulation will cause :

auncontrolled expansion of amalgam. b-marginal discrepancies. c-pitted surface.

dcompression of surrounded tooth structures. e-dental pain . f-recurrent caries .

gfracture of the restoration .

To solve these problem ;we most do complete isolation and \or using of zinc-free alloy.

However ,the contamination of any type of amalgam will lead to amalgam with inferior physical properties

Factors which affect a final expansion or contraction:

a- Type of alloy b- Particle size and shape. c- Pressure used to condensed amalgam.

A standard test permit a slight expansion typically (0.2%) max. or slight contraction of. 0.1 % max. a large contraction would result in a marginal gap down which fluids could penetrate. A large expansion would result in the protrusion of the filling from the cavity.

7- Adhesion :- amalgam has no adhesion to enamel or dentin; therefore a potential micro spaces between the restoration and tooth result. Micro leakage may be reduced in the early life of restoration by coating the cavity walls with varnish. Studies suggests that the use of bonding agents with amalgam restoration provide several advantage among these: enhancement of the retention and decrease the micro leakage so the postoperative sensitivity and recurrent caries will decreased. Also fracture resistance of the tooth will increase.

8- Mercury toxicity:- highly toxic, Improper handling is health hazard.

The mercury has a bad effect on CNS also may cause contact dermatitis.

A) Freshly mixed amalgam and mercury should not be touched by hands, because mercury will be absorbed by skin.

B) Dentist: and assistant subjected to the vapor of mercury in atmosphere which increases with increasing temp, especially when sterilizing the instruments with mercury contamination. So Instruments should be cleaned well.

C) Wearing a mask and gloves will protect the dentist and the assistant from mercury toxicity. Increased Hg means increased matrix which means increased Gamma-2;the content of Hg in the final restoration is of great importance ; if it is high ;the compressive strength of the amalgam will be decreased and the setting time increased ;which will result in a great risk of fracture of the restoration in the early stage of setting. Also the corrosion tendency and creep will be increased.

المصادر:

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The science of dental materials involves a study of the composition and properties of materials and the way in which they interact with the environment in which they are placed.

General Properties of Dental Materials

All materials have physical properties like color, weight, solubility , thermal conductivity , and others , also mechanical properties like hardness or softness , strength or weakness .There is no material till know has ideal physical or mechanical properties . Most materials have some good and bad properties and sometimes a property that is bad in one material may be good or acceptable in another .

Physical properties:

1-Color

Many dental restorative materials have to look like natural teeth and should not stain or change color by time .The anterior filling and artificial tooth material should be translucent. **Translucence** is the optical property that allows the light to go short way in the material before being reflected out again . Also should like natural tooth substance at different Light conditions, such as day light and artificial light, ex, an artificial tooth may be acceptable in ordinary light but may be discovered by the relative darkness of the material in fluorescent light. For denture the material should have the same appearance of natural gum acrylic material can be made with various shades of pink to look as natural gum.

2- LINER COEFFICIENT OF THERMAL EXPANSION AND CONTRACTION

As the temperature rises, a solid material will expand and on cooling it will contract, this is measured by the liner coefficient of thermal expansion and contraction which is the change in length per unit length of a material for a 1°C change in temperature.

$$a = \frac{\text{final length}-\mathit{original\ length}\ (cm)}{\text{original length}*\mathit{temp.change}\ (cm.^\circ C}$$

Hard tooth structure has the smallest coefficient, metals are intermediate ,

polymers have the largest. Tooth $=11*10^{-6}$ cm/cm. °▯▯
Gold= $14*10^{-6}$ cm/cm. °▯▯
Impression compound = $250*10^{-6}$ cm/cm. °▯▯

Filling material should have the same coefficient as the tooth, if it does not, it will press too hard against the cavity wall on expansion and may cause pressure on the pulp or pull away from the wall when chilled by cold water. The later effect may cause the filling to leak temporarily, which may in turn may lead to further carries.

3-DIMENTIONAL STABILITY:

Many materials change shape when they set or harden. Impression materials should not change dimensions when set. Also dental materials should have no dimensional changes when set.
Amalgam is a filling material for posterior teeth, it may sometimes change shape permanently as a result of a heavy biting force. This is bad property , on the other hand , the investment materials that forms the gold for dental casting should expand for a certain amount to compensate for the contraction of the molten metal after it is cooled from the molten stage.

4-DENSITY

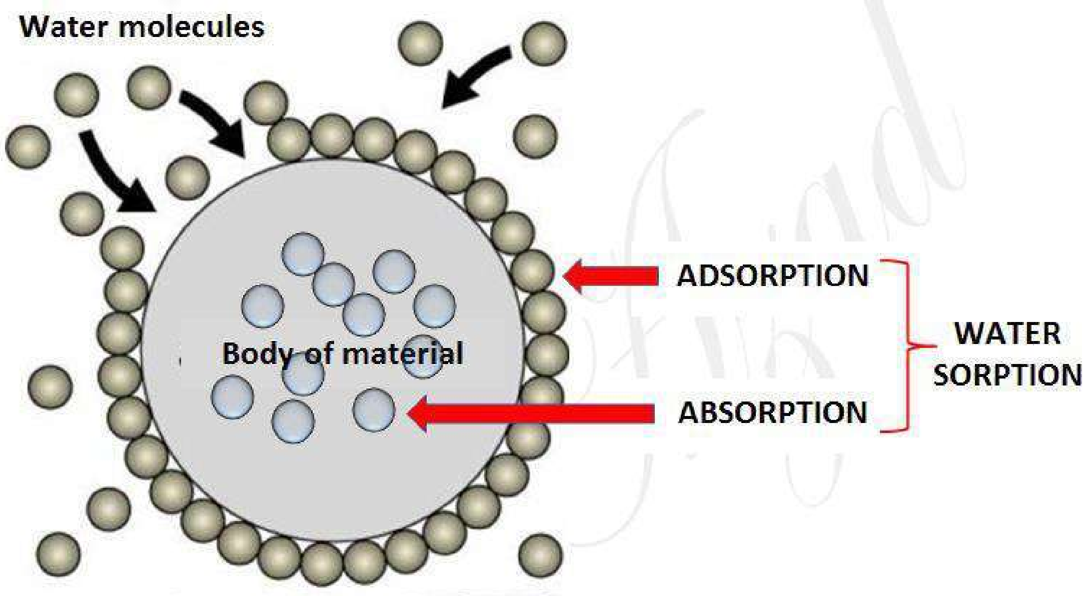
Lightness is nearly always an advantage in restorative materials, but sometimes tin or lead is used inside full lower denture to make it heavy in order to control its mobility. Density of gold = 14gm/cm
Acrylic = 1.2 gm/cm
Cromium /cobalt = 8.3gm/cm
Water = 1gm/cm

5- SOLUBILITY

Restorative materials should not dissolve in the mouth , and if it is dissolves, it should not release toxic substance.
Solubility of silicate = 0.7 -1.6%
Solubility of composite = 0.01 %

6-ABSORPTION OF FLOUIDS:

Some materials will absorb water or other fluids. If it is too much or continued for long time, this will result in serious d dimensional changes and the material will also be un hygienic. On the other hand, some materials like acrylic will absorb water for a day and stop after that, so it is acceptable



7-TISSUE REACTION

Some restorative materials are damaging to the living tissues which are in contact with, like silicate filling and zinc phosphate cement which is acid and may kill the dental pulp unless a protective lining is used. Dental materials should not show any allergic reaction to the tissues and also should not provide good culture for the growth of bacteria and candida infection, like soft lining materials.

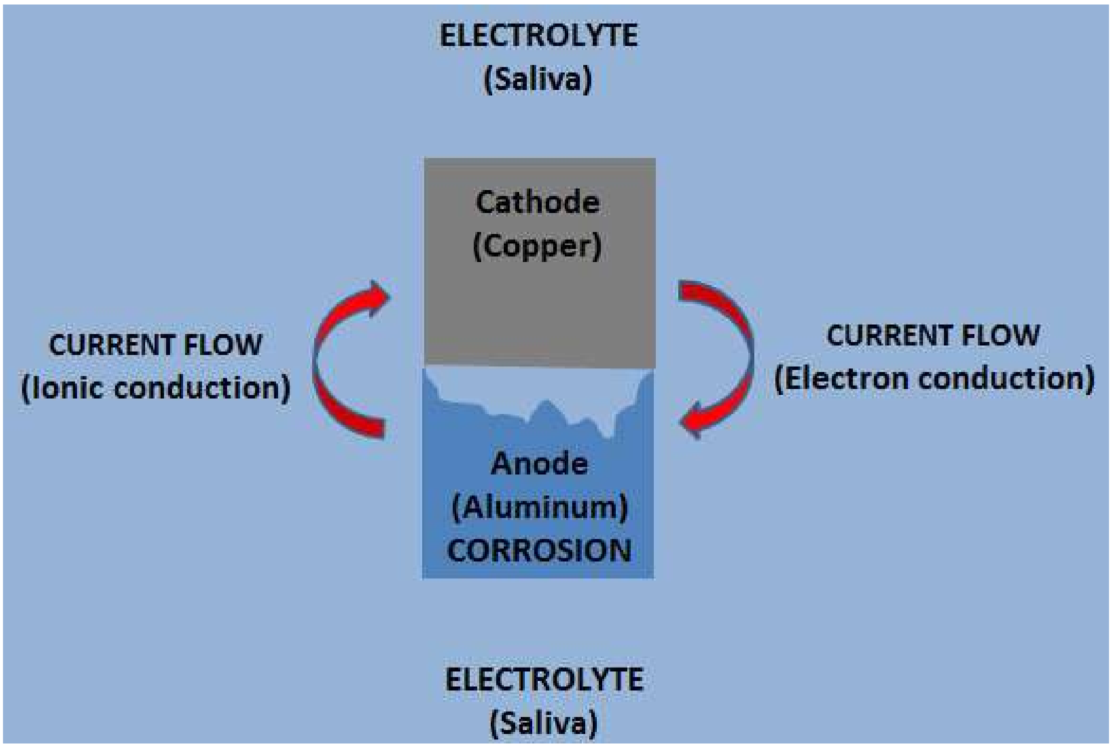
8-THERMAL CONDUCTIVITY

Generally metals are better heat conductors than non-metals. Metal filling materials like amalgam sometimes cause pulp pain by transmitting heat or cold more than natural tooth especially in deep cavities, thus they require heat insulating layer between the filling and the pulp. Here is undesirable property on the other hand the thermal conductivity of metallic denture base is an advantage as it gives feeling closer to normal condition and the patient will feel normal also it will protect him from drinking very hot drinks which may burn his mouth.

9-ELECTRICAL ACTIVITY

It is the ability of metal to ionize by losing electrons. If there is a high difference in the electrode potentials of metals in contact with the same solution like gold and aluminum an electric cell may develop and the patient may fell discomfort.

The presence of metallic restorations in the mouth may cause a phenomenon called ***galvanic action***, or ***galvanism***. This results from a difference in potential between dissimilar fillings in opposing or adjacent teeth. These fillings, in conjunction with saliva or bone fluids such as electrolytes, make up an electric cell. This cell short-circuited, and if the flow of current occurs through the pulp, the patient experiences pain and the more anodic restoration may corrode, like gold with amalgam.



10- ADHESION AND COHESION

Adhesion is the force which causes two different substances to attach when they are brought in contact with one another. When the molecules of the same substance hold together; the forces are said to be ***cohesion***.

MECHANICAL PROPERTIES

One of the most important properties of dental materials of dental materials is the ability to withstand the various mechanical forces placed on them during use as restoration, impression , models, appliances and tools.

STRESS Is the force per unit area induced in a body in response to some externally applied force. It is force\area measured in kg\cm^2 or pound\inch^2 or Pascal.

STRENGTH Is the measurement of the resistance of the material externally applied force. There are many types of stresses according to the direction of the applied force, each type of stress is accompanied by the same type of strain.

STRAIN Is the change in dimension per unit dimension caused by externally applied force.

$$\text{Strain} = \frac{\text{final length} - \text{original length}}{\text{original length}}$$

Percentage of elongation = strain × 100%

1-Tensile stress

It is the force per unit area induced in the body in response to externally applied force which tends to elongate or stretch the body, it is accompanied by tensile strain.

2-Compressive strain

It is the force per unit area induced in the body in response to externally applied force which tends to compress or shorten the body, it is accompanied by compressive strain. Investment materials, restorative materials and models should have high compressive strength.

3-SHEAR STRESS

It is the force per unit area induced in the body in response to externally applied force which is applied to one part of the body in one direction and the rest is being pushed in the opposite direction.

It is the strength of the middle of abeam, which is supported only at its end. It is important in dental bridges.

It is when the material is constantly subjected to change in shape due to frequent application of force like clasp arm of partial denture

It is the ability of the material to break on sudden impact. Low impact strength mean brittle material, like dropping of the denture.

STRESS _ STRAIN CURVE

Proportional limit

When a stress is applied to a material, the material will tend to deform (change in shape and dimension) in an amount proportional to the magnitude of applied stress. The greatest stress which may be produced in the material such that the stress is directly proportional to the strain.

Elastic deformation (elastic limit)

The greatest stress to which the material can be subjected such that it will return to its original shape and dimension when the stress is removed. If the strength is increased beyond the elastic limit or the proportional limit the material will deform and if we remove the stress the material will not return to its dimension. This is called plastic deformation. If the stress is increased more and more the material will break.

Ultimate strength

Is the greatest stress which break the material.

MODULUS OF ELASTISITY

Is the constant of proportionality. It is when any stress value equal or less than the proportional limit is devided by corresponding strain value.

Modulus of elasticity =$x = \frac{\text{stress}}{\text{strain}}$ kg \cm^2 or PSI or pascal

DUCTILITY

It is the ability of the material to withstand permanent deformation under tensile stress without fracture ; it depends on plasticity and tensile strength. It is the ability of the material to be drawn into a fine wire.

MALLIABILITY

It is the ability of the material to withstand permanent deformation under compressive stress without fracture. It is the ability of the material to be drawn into a sheet.

TOUGHNESS

It is the total work or energy required to break the material. It is the total area under the stress – strain curve. It requires strength and plasticity.

BRITTLENESS

It is the opposite of ductility, it requires lack of plasticity.

FLEXIBILITY

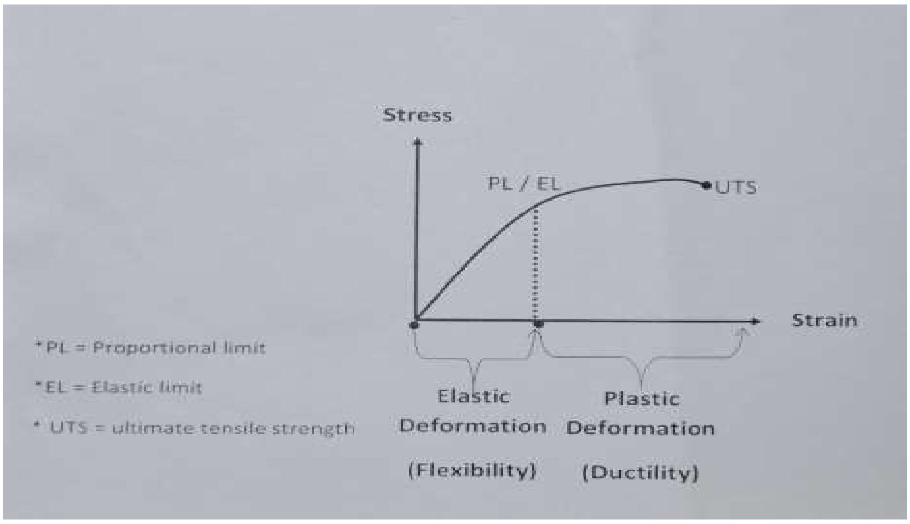
The higher the strain which accrues when the material is stressed to its proportional limit.

RESILIANCE

The amount of energy absorbed by a structure when it is stressed within the proportional limit.

HARDNESS

It is the resistance of the material to deformation caused by penetrating or starching the surface.



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2. RESTORATIVE DENTAL MATERIALS- ROBERT G. GRAIG, Ph.D.

Denture cleansers

Dr. Abbas Ibrahim Hussein

The most satisfactory method to keep the denture clean is by regular cleaning with soft brush, soap and water. Coarse abrasive cause rapid wear of denture polymer and patient should not use them.

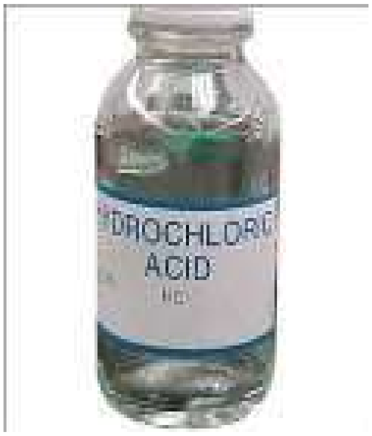
Generally, Denture Cleansers Are of Four Types:

1- Powder and paste: They consist mainly of finely divided chalk, zirconium, or pumice and flavoring agents; it is quite abrasive and should not be used vigorously over a period of time.

2- Peroxide cleansers: Powder or tablets, contain sodium perborate mixed with alkaline materials such as trisodium phosphate also detergent and flavoring. A solution is made by water and the denture is immersed in it for a period of time.

3. Dilute hypochlorite solution (chlorine): It should not be used with metals, causing tarnish. If high concentration is used it may bleach the polymers if immersed regularly in it.

4. Dilute hydrochloric acid: This dissolves calcified deposits; it is applied locally to heavily contaminated areas of denture.



House hold cleansers, bathroom abrasives, and dentifrices with chloroform are contraindicated.

How often should I clean my dentures?

It is important to treat your dentures like you would treat your natural teeth. You should keep them as clean as possible so that you don’t lose any more teeth, or have inflamed gums or bacterial and fungal infections. We usually recommend that you clean them thoroughly at least once a day, and after eating if you need to.

How should clean the dentures?

1. Dentures may break if you drop them.
2. Always clean your dentures over a bowl of water or a folded towel in case you drop them.
3. To clean your dentures, the general rule is: brush and soak every day. Brush your dentures first, to help remove any bits of food. Use a non-abrasive denture cleaner, not toothpaste. Be careful not to scrub

too hard as this may cause grooves in the surface.

4. Make sure you brush all the surfaces of the dentures, including the surface that fits against your gums. This is especially important if you use any kind of denture fixative.
5. Soak your dentures every day in a denture-cleaning solution. This will help remove any plaque and stubborn stains that are left. It will also help to disinfect your dentures, leaving them feeling fresher. Always follow the manufacturer's instructions.
6. It is important not to use any type of bleaching product to clean your dentures. Bleaching can lead to weakening of the dentures as well as making them look unsightly. Do not use very hot water to soak your dentures. Again, it can weaken the dentures causing them to break.

How should clean the dentures soft lining?

- Some people have sensitive gums and may need a softer lining made for their dentures.
- If you have one of these special linings, it is important to check with your dental team before using any cleaning products or fixatives, as some products can damage the lining.

How should clean the dentures metal denture?

- Some cleaning products can damage metal dentures, so talk to your dental team about how to clean them.
- If your denture has clasps, you need to take particular care when cleaning to avoid damage.

Don't keep your dentures in overnight unless there are specific reasons for you to keep them in.

Can my dental team clean them?

Some people get a build-up of tartar on their dentures just as they would on their natural teeth. If plaque is not removed properly, it can react with your saliva and harden into tartar. As with your own teeth, you will not be able to remove this tartar completely by yourself, and eventually it can make the denture uncomfortable and unsightly. Your dental team will be able to remove this tartar using a professional cleaning machine.

What can I do about staining?

Like natural teeth, dentures can pick up staining every day. This is especially true if you smoke, or drink a lot of tea, coffee or red wine. In most cases you should be able to remove this staining with regular cleaning. However, more stubborn stains may take a little more cleaning, which your dental team should be able to help with.

Do I still need to see the dentist?

1. It is important to visit your dental team regularly even if you don’t have any of your natural teeth.
2. Dentists do not check just your teeth, but also the soft parts of the mouth, including the tongue and cheeks.
3. These examinations are just as important, so the dental team can spot any infections, mouth conditions or even mouth cancer at the earliest stages. Your dental team will be able to tell you how often you should visit.

Denture adhesives

They are pastes, powders or adhesive pads that may be placed in dentures to help them stay in place. They are self-adjusting product used to hold a dental prosthesis in position

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Filling materials

Dr. Abbas Ibrahim

filling materials are used to replace missing parts of the tooth.

Factors causing loss of the tooth substance:

1- dental caries.

2- trauma.

3- abrasion.

Parts of teeth which require replacement by restorative materials vary in size of cavity, shape, and location in the mouth no single restorative material is suitable for all cases. for some situations, the strength and abrasion resistance of material may be the prime consideration, in other situation appearance and adhesive properties may become more important.

Requirements of an ideal filling material:

1- working time should be sufficiently long, to enable manipulation and placement of material before setting.

2- setting time should be short for comfort of both the patient and clinician.

3- the material must withstand large variation in ph and a variety of solvents which may be taken into mouth in drink food stuffs and medicaments.

4- metallic materials should not undergo excessive corrosion, or be involve in the development of electrical currents which may cause "galvanic pain".

5- filling should be good thermal insulator, protecting the dental pulp from the harmful effect of the hot and cold stimuli (low thermal diffusivity).

6- materials should have values of coefficient of thermal expansion similar to those of enamel and dentin.

7- materials should have satisfactory mechanical properties to withstand the force applied, e.g. abrasion resistance, compression and tensile strength, modulus of elasticity.

8- they should adhere well to the tooth walls and seal the margin prevent ingress of fluid and bacteria. also reduces the amount of cavity preparation required in order to achieve retention of the filling. 9- they should be harmless to the operator and to the patient and should not irritant to dental pulp and soft tissue.

10- easily polished.

11- should be bacteriostatic and anticariogenic.

12- it should be radiopaque to diagnose the marginal caries.

Classification of filling materials i- metallic filling materials

- amalgam.
- direct gold filling. ii- non-metallic filling materials
- polymeric o filled resin (composite). o unfilled resin (acrylic).
- non-polymeric: o silicate cement. o glass ionomer cement.

Other classification i- anterior filling materials (tooth colored filling).

- silicate cement.
- acrylic.
- composite.

ii- posterior filling materials.

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FINISHING AND POLISHING MATERIALS

Dr. Abbas Ibrahim Hussein

Dental restorations are finished and polished before placement in the oral cavity (except for direct filling) to provide:

1. Good oral health this is maintained by:
   a. Resisting the accumulation of food debris and pathogenic bacteria by reducing the roughness of the restoration surface.
   b. Smooth surfaces are easier to maintain in hygienic state, also with some metal restoration, tarnish and corrosion activity can be reduced if the surface is highly polished.
2. Oral function

   Function is enhanced because food glides more freely over occlusal surface and embrasure surface during mastication.
3. Esthetic

   Give gloss to the visible surface of restoration.

ABRASIVE MATERIALS

It is a material which is harder than the material which needs to be abraded (restoration or appliance). The abrasive particles should possess sharp edges that cut rough surface of the abraded material.
The abrasive particles could be bonded together to form grinding wheel or may be carried across the surface of bristles of a revolving brush or buff or bonded to a piece of cloth or paper and rubbed across the surface.

The smoothness of the surface depends on:

1. Hardness and shape of the abrasive particles.

The abrasive particles should be harder than the material which is abraded and should be strong and its elastic limit should equal to its maximum strength so that it will fracture cleanly to form new cutting edges without permanent deformation.

2. Size of the particles.

   Large particles have wide cutting edge and cut more than smaller size, start with large size then fine size.

3. Speed of movement.

   The slower speed of movement, the deeper the scratches which are produces, but in slow speed and in high speed; the total amount of material removed will be approximately the same (1450-3000 rpm). To increase the speed of the abrasion, it is suggested to use compressed air to blast an abrasive powder on to the surface (sandblasting), it is useful for cobalt/chromium alloy; or to use ultrasonic frequency vibration.

4. Pressure.

   Always, only slight guiding pressure should be applied, high pressure will lead to increase the rate of wear of the abrasive, also the heat produced.

5. Lubricant.

   Facilitate the movement of the cutting edges into the surface and carries away the debris besides cooling the restoration.

Abrasive particles

1. Diamond dust:

   It could be embedded in porcelain binder which is the most efficient abrasive for dental use.

2. Sand:

   It is an intermediate abrasive for removing the coarse scratches.

3. Quartz particles:

It is obtained by crushing sand stone and bonded to paper.

4. Carbide:
   It is extremely hard and brittle, used for cutting tooth surface and for metal, ceramic and plastic.
5. Garnet:
   It is silicate of aluminum, cobalt, or magnesium.
6. Emery:
   It is natural oxide of aluminum (carborundum).
7. Pumice:
   It is fine abrasive, the powder is obtained by crushing pumice stone; porous volcanic rock. It is excellent for denture polymer; it is suitable for gold alloy, tooth surface and amalgam. Pumice powder is mixed with water and sometimes with glycerin with low speed.

POLISHING MATERIALS

It is the material which causes the fine scratches to be filled and to produce smooth surface probably due to that; the rapid movement of the polishing agent across the surface heats the top layer of the material and cause it to flow and fill in the scratches.

Polishing materials are:

1. Rouge (iron oxide):
   It is red powder or cake, it is rather dirty to handle, but

it produces excellent shine on gold alloy, it is not used with stainless steel, instead we should use chromic oxide.

2. **Whiting (precipitated chalk):**
   It is mild abrasive used for softer materials and polymers, it is mixed with water.
3. **Tripoli:**
   It is obtained from porous rocks.
4. **Tin oxide:**
   It is extremely fine used for polishing teeth and restoration inside the mouth.

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DENTAL MATERIAL

GYPSUM PRODUCTS

A number of gypsum products are used in dentistry as adjuncts to dental operation.

Types of gypsum products:

1. Type I: Impression plaster.
2. Type II: Dental plaster.
3. Type III: Dental stone (medium strength stone).
4. Type IV: Improved stone (high strength stone) (die stone).
5. Type V: high strength/high expansion stone.

APPLICATION OF GYPSUM PRODUCTS IN DENTISTRY:

1- Impression plaster.
2- Mounting the casts to the articulation.
3- Form casts and dies.
4- Used as a binder for silica.
5- Used as a mold for processing dental polymers.
6- Used for bite registration (record centric jaw relation).

Properties of ideal model material (gypsum products):

1- Dimensional stability, no expansion or contraction during or after setting.
2- High compressive strength to withstand the force applied on it.
3- Hardness, soft material can be easily scratched.
4- Reproduce the fine details.
5- Produce smooth surface.
6- Reasonable setting time.
7- Compatible with the impression material.
8- Can be disinfected without damaging the surface.

MANUFACTURE OF DENTAL PLASTER, STONE, AND DIE STONE

Gypsum products are produced by partial dehydration of mineral gypsum, which is calcium sulfate di-hydrate ($CaSO_4.2H_2O$) . They are supplied as powder when mixed with water they form slurry or paste, which set to form a rigid mass.

1- Plasters are produced when the gypsum mineral is heated in an open kettle at a temperature of about 110° to 120°C (dry calcination). The hemihydrate produced is called *Beta-calcium sulfate hemihydrate*. Such a powder is known to have a somewhat irregular shape and is porous in nature. These plasters are used in formulating model and lab plasters.

$CaSO_4.2H_2O$ $CaSO_4.½H_2O$

2- Chemically stone is the same as plaster that is $CaSO_4.½H_2O$ but it is made by heating gypsum in wet condition under super heat steam to 125˚C (wet calcination). the crystals are dense and regular and have prismatic shape, they are called *Alpha - calcium sulfate hemihydrate*

3- It is produced by boiling gypsum with $CaCL_2$ calcium chloride. The crystals are also dense , regular and have prismatic shape, called *Alpha - calcium sulfate hemihydrate*

SETTING REACTION

When mixing any type of gypsum product (plaster, stone or die stone) with water, they are converted back to gypsum and set to a hard mass.

The probable sequence is as following:

A- plaster, stone or die stone ($CaSO_4.½H_2O$) dissolve in water.
B-it is react with the water to form gypsum ($CaSO_4.2H_2O$).
C- gypsum is less soluble in water and the solution becomes super- saturated (unstable).
D- gypsum crystallizes, allowing more particle to dissolve and to form gypsum. This will continue until all particles have been converted to gypsum($CaSO_4.2H_2O$). Each crystal as it is forma becomes nucleus for crystallization. During this process part of the gypsum form a gel, which act as a cementing medium between the crystals. Then the rigid mass is formed by the interlocking network formed by the long needle- like gypsum crystals.

$CaSO_4.½H_2O + H_2O$ $CaSO_4.2H_2O$+ HEAT(exothermic reaction)

MANIPULATION

The powder is mixed with water at a certain ratio according to the type of gypsum product.

W/P ratio for plaster is 0.5 that is 50 ml of water for 100 gm of plaster powder
W/P ratio for stone is 0.3
W/P ratio for die stone is o.2
The differences in W/P ratio is due to the difference in the bulk volume of the

powders. The water is measured and put in a clean rubber bowl then the powder is added on it gradually, allow the powder to settle then mix with clean spatula for 1 min. until creamy mix is obtained.

SETTING TIME

Is the time from the beginning of mixing the powder with water until the material hardens. The time may be measured by GILMOR DEEDLE APPARATUS or by VICAT APPARATUS in which needle of different weight and thickness is used, penetration of these needles being measured at various times during setting.

FACTORS AFFECTING THE SETTING TIME:

1-W/P ratio

The more water is used for mixing, the fewer the nuclei there will be per unit volume, and consequently the setting time will be prolonged.

2-FINESS

The finer the particle size of the hemihydrate, the faster the mix will harden. The rate of the solution of the hemihydrate will be increased, also the gypsum nuclei will be more numerous and therefor more rabid crystallization will occur.

3- MIXING

The longer and more rapidly the plaster is mixed, the shorter is the setting time. When powder is drought into contact with the water some gypsum crystals will be formed. As mixing begins, more particles will be exposed to water and thus form more crystals at the same time the crystals are broken up by mixing and they are distributed thought the mixture and result in the formation of more nuclei for crystallization thus the setting time is decreased.

4-TEMRATUR

There is little change in the setting time between 0 – 50 ˚C but if the temperature exceeds 50 ˚C the setting time will be retarded. As the temperature approaches 100˚C no setting will take place.

5-IMPURITIES

If the manufacture adds gypsum, the setting time will be shortened because of the increase in the potential nuclei for crystallization.

6-RETRADERS & ACCELERAROTS

The addition of retarders and accelerators are the most effective and practical way to control the setting time.

Retarder is the chemical material added to the gypsum product to increase the setting time ex. Glue, Borax, and Gum Arabic. It will reduce the dissolution of the hemihydrates and might deposit on the nuclei of crystallization and effectively reduce the rate of crystallization and so retard setting time.

Accelerator is the chemical material added to the gypsum product to decrease the setting time ex.Sodium Chloride and Potassium Sulfate in a certain concentration. These salts increase the rate of hemihydrate dissolution and thus the saturation of the solution occur more rapidly.

DIMENTIONAL CHANGES ON SETTING (SETTING EXPANSION)

Regardless of type of gypsum product, an expansion of the mass can be detected during the change from the hemihydrate to the dehydrate after mixing with water. This expansion could be explained on basis of the mechanism of crystallization.

There is an outward growth of crystal from nuclei of crystallization, as a result of growth, there is an enlargement and there is interception between the crystals. If on crystal intercept another, there will be stress at the point of interception in the direction of growth that impinging the crystals. If the process is repeated by thousands of crystals during growth, it is possible that the outward stress or thrust could produce expansion of the mass. The final structure immediately after setting is composed of interlocking crystals between which micro process containing excess water. On drying the excess water is lost and the total empty space is greatly increased.

FACTORS AFFECTING THE SETTING EXPANSION

1-W/P ratio

The higher W/P ratio, the less expansion; because off ewer nuclei of crystallization per unit volume are present than thicker mixes and since it can be assumed that space between nuclei will be greater in such a case, it fallow that there will be less growth interaction of the dehydrate crystals with less outward thrust result.

2-Addition of chemicals (accelerators and retarders)

Bothe will reduce the setting expansion. The reduction of the expansion is due to that the initial rate of crystallization is so rapid that subsequent growth is resisted with accelerators. For the retarders, the crystalline form may be changed and the crystals may become thick and short so the thrusting between the crystals is reduced so the expansion is reduced.

Hydroscopic expansion : if the setting process is allowed to occur under water, the setting expansion may be more than in magnitude, this is called *Hydroscopic expansion.* This increased expansion is due to the additional growth of the crystals permitted and no difference in the chemical reaction.

STRENGTH

The strength of gypsum products is generally expressed in term of compressive strength also tensile strength is also considered.

1-W/P ratio: The strength or gypsum increases rapidly as the material hardens after initial setting time. The excess water present in the set mass affect the strength. Therefore, there is wet strength and dry strength. The wet strength is when there is excess water left in the mass. The dry strength is when the excess water has been dried in air or oven in warm temperature, the dry strength may be two times greater than the wet.

Drying period	Compressive strength Kg/cm^2
2h	89
8h	118
24h	839

2-Mixing: mixing time also affect the strength. Increasing mixing increase the strength but over mixing will reduce strength because it will break up crystals which are formed and will result in less crystal interlocking.

3-Drying: the effect of drying is to remove excess water between crystals. The excess water reduce cohesion between the crystals themselves. 40% of the strength is due to cohesive force between the crystals in addition to the strength which can be attributed to the interlocking of crystals during growth.

4-Chemicals: the addition of accelerators and retarders lower both the wet and dry strength. This is due to the reduction of inter- crystalline cohesion.

5-Porocity: the set plaster or stone is porous. The greater W/P ratio the greater the porosity and the fewer the crystals.

STORAGE

Plaster and stone powder absorbs moisture, which causes gradual deterioration. Hydration begins on the surface of hemihydrate particles forming fine coat of gypsum and this will act as effective nuclei for crystallization and thus shorten the setting time.

To avoid deterioration, the plaster and stone powders should be stored in air tight waterproof containers in a dry region of the laboratory.

Gypsum product	Compressive strength Kg/Cm^2	Expansion	W/P ratio
Plaster	141-89	0.3%	0.5
Stone	891-811	0.2%	0.3
Die stone	351	0.1%	0.2

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DENTAL METARIALS

Dr. Abbas Ibrahim

Hydrocolloid impression materials the colloids are often classed as the fourth state of matter known as colloidal state, they can exist in the form of viscous liquid known as a sol, or a jelly like elastic semi-solid described as a gel.

If the particles are suspended in water, the suspension is called hydrocolloid.

Hydrocolloid impression materials are based on the colloidal suspension of polysaccharide in water.

- In sol form: there is random arrangement of polysaccharide chain.
- In gel form: the long polysaccharide chains become aligned and material becomes viscous and develops elastic properties.

Gelation: it is conversion of sol to gel.

Type of hydrocolloid impression materials based on the mode of gelation, they are classified as:

1- reversible hydrocolloids set by lowering the temperature e.g. agar. This makes them reusable.

2- Irreversible hydrocolloids set by a chemical reaction. Once set it is usually permanent e.g. alginate.

Agar

agar hydrocolloid was the first successful elastic impression material to be used in dentistry. It is an organic hydropinghilic colloid extracted from certain types of seaweed. Although it is an excellent impression material and yields accurate impressions presently it has been largely replaced by alginate hydrocolloid and rubber impression materials.

Uses

1- for cast duplication (during fabrication of cast metal removable partial denture).
2- for full mouth impressions without deep undercuts.
3- for crown and bridge impressions before elastomers came to the market.
4- as tissue conditioner.

Supplied as

1- gel in collapsible tubes (for impressions with water cooled tray).
2- A number of cylinders in a glass jar (syringe material).
3- in bulk containers (for duplication).

)

Component	purpose
Agar (12%) ☐ Potassium sulfate (1 -2 %)	Colloid It acts as dispersion medium. To improve the strength of gel. To ensure proper setting of gypsum cast against agar (accelerator for cast material) Preservative. Thixotropic material (it acts as plasticizer).

Coloring and flavoring agents (traces	

Manipulation

Agar hydrocolloid requires special equipment:

1- hydrocolloid conditioner.

2- Water cooled rim lock tray.

Agar is normally conditioned prior to use by specially designed conditioning bath (temperature controlled water bath). The conditioning bath consist of three compartments each hold at different temperature.

1- Boiling section or liquefaction section

- the tube of the gel converted to viscous liquid after 10 minutes in boiling water (100°c).
- The sol should be homogenous and free of lumps.
- Every time the material is reliquefied, 3 minutes should be added. This because it is more difficult to break down the agar brush heap structure after a previous use. • It should not be reheated more than 4 times.

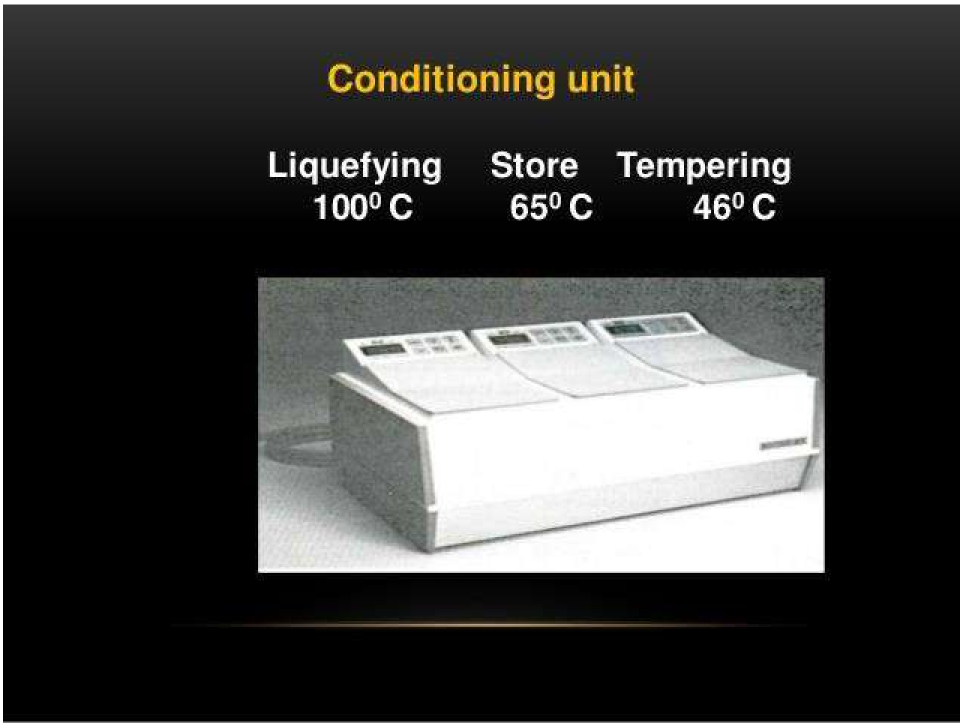
2- Storage section

- 65-68°c temperature is ideal when agar can be stored in the sol condition till needed.

3- Tempering section

- 46°c for about 2 minutes with material loaded in the tray, this is done to reduce the temperature so that it can be tolerated by the sensitive oral tissue. It also makes the material viscous.

The tray containing the tempered material is removed from the bath. The outer surface of the agar sol is scraped off, then the water supply is connected to the tray and the tray is positioned in the mouth. water is circulated at 18°c to 21°c through the tray until gelation occur, rapid cooling (ice cold water) is not recommended as it can induce distortion.



Conditioning unit

Liquefying	Store	Tempering
100^{0} C	65^{0} C	46^{0} C

Alginate alginate was developed as a substitute for agar when it became scarce due to World War II (japan was a prime source of agar).

Currently, alginate is more popular than agar for dental impression, because it has many advantages.

Types

1- fast setting.
2- Normal setting.

Supplied as a powder that is packed in bulk container (sachets), a plastic scoop is supplied for dispensing the bulk powder, and a plastic cylinder, is supplied for measuring the water.

Application

1- it is used for impression making.
- When there are undercuts.
- In mouth with excessive flow of saliva.
- For partial dentures with clasps.

2- for making preliminary impression for complete denture.
3- for impression to make study models and working casts.
4- for duplicating models

Composition

Setting reaction sodium alginate powder (soluble) dissolves in water to form a sol, that react with calcium sulfate (reactor) to form calcium alginate (insoluble gel) this reaction is too fast, there is not enough working time, so the reaction is delayed by addition of a retarder (sodium phosphate).

Properties (according to ada specification no. 18 for alginate hydrocolloids)

1- alginate has a pleasant taste and small.
2- Its flexibility is about 14 % at a stress of 1000 gm/cm2 lower w/p ratio (thick mixes) results in lower flexibility.
3- Alginate is highly elastic, but less than agar. 4- The elastic recovery is 97.3 %, permanent deformation is less if the set impression is removed from the mouth quickly.
5- Detail reproduction is also lower when compared to agar.
6- Compressive strength is 5000-8000 gm/cm2.
7- Tear strength is 350-700 mg/cm2.

Factors affecting alginate gel strength

- w/p ratio, too much or too little water reduces strength.
- mixing time, over and under mixing both reduce strength.
- Time of removal of impression, strength increases if the time of removal is delayed for few minutes after setting.

8- Set alginate has poor dimensional stability due to evaporation, syneresis, and imbibition. The alginate impression should be poured immediately. If storage is unavoidable, keeping in a humid atmosphere of 100 % relative humidity (wrap with wet paper towel). Even under these conditions storage should not be done for more than 1 hour.

9- Alginate does not adhere well to the tray. Retention to the tray is achieved by mechanical locking in the tray (rim lock, perforated tray) or by adhesive.

Ingredients	%	Functions

10- The silica particles present in the dust of alginate powder are health hazard.

11- Shelf life and storage: alginate material deteriorates rapidly at elevated temperature and humid environment.

* mixing time: 45-60 seconds.
* Working time: 1-2 minutes.
* setting time (gelation time): 2-4 minutes.

- **Control gelation time**

1- gelation is best controlled by adding retarders. (**Manufacturer s hands**).

2- **The dentist** can best control the setting time by altering the temperature of the water colder the water, longer is the setting time, even the mixing bowl and spatula can be cooled.

	WT	
1- Sodium or potassium or triethanolamine alginate.		Dissolves in water and reacts with calcium ions.
2- Calcium sulfate (reactor).		Reacts with potassium alginate and forms insoluble calcium alginate.
3- Zinc oxide.		Acts as filler.
4- Potassium titanium fluoride.		Gypsum hardener.
5- Diatomaceous earth.		Acts as filler.
6- Sodium phosphate (retarder).	traces	Reacts preferentially with calcium sulfate.
7- Coloring and flavoring agents.		e.g. wintergreen, peppermint and anise, orange etc.

- **Test for set** the alginate loses its tackiness and rebound fully when prodded with a blunt instrument some alginate are available with (color indicator), which on mixing is one color and on setting change to a different color.

Advantages

1- it is easy to mix and manipulate and need minimum equipment.

2- Flexibility of the set impression.
3- If properly handled, it gives accuracy and good surface details even in presence of saliva.
4- Low cost.
5- comfortable to the patient.
6- It is hygienic.

Disadvantages 1- it cannot be corrected.
2- Poor tear strength.
3- Distortion may occur without it being obvious if the material is not held steady while it is setting.
4- It cannot be stored for long time.
5- because of the above drawbacks and because of availability of better materials it is not recommended when high level of accuracy is required e.g. cobalt chromium rpd, crown and bridge, etc.

Technical considerations of alginate

1. Impression should not be exposed to air because some dehydration will occur and result in shrinkage.
2. Impression should be protected from dehydration by placing it in a humid atmosphere or wrapping it in a damp paper towel until a cast can be poured. To prevent volume change, this should be done within 15 minutes after removal of the impression from the mouth.
3. Impression should not be immersed in water or disinfectants, because some imbibition will occur, and result in expansion.
4. Exudate from hydrocolloid has a retarding effect on the chemical reaction of gypsum products and results in a chalky cast surface. This can be prevented by pouring the cast immediately.
5. When alginate is used, place the measured amount of water (at 18-20°c) in a clean, dry, rubber mixing bowl. Add the correct measure of powder. Stir rapidly against the side

of the bowl with a short, stiff spatula. This should be accomplished in less than (1 minute). The patient should rinse his or her mouth with cool water to eliminate excess saliva while the impression material is being mixed and the tray is being loaded.

6- To prevent internal stresses in the finished impression, do not allow the tray to move during gelation (hold the tray immobile for 3 minutes). Do not remove the impression from the mouth until the impression material has completely set (releasing the surface tension).

*** cast construction** the stone cast should not be separated for at least 45 minutes the cast should not be left in the alginate impression for too long a period because:

1- after setting the alginate can act as sponge, deprive stone from water result in a rough chalky surface.

Dried alginate becomes stiff, so removal of cast can break the teeth

. المصادر:

1. PHILLIPS SCIENCE OF DENTAL MATERIALS-KENNETH J.ANUSAVICE,D.M.D,Ph.D.

2. RESTORATIVE DENTAL MATERIALS- ROBERT G. GRAIG, Ph.D.

Method of taking impressions

Dr. Abbas Ibrahim

1- Single mix technique

: spaced special tray. regular body only.

Method

The paste is mixed and material is loaded onto the tray, the tray with material is seated over the impression area, the material is allowed to set.

2-Multiple mix technique

Tray used: spaced special tray.

☐ ***Viscosity used*** *: (a) heavy body and (b) light body.*

Method

The two viscosities are mixed simultaneously but on separate pads. The heavy body is loaded onto the tray while the light body is loaded into the syringe. The syringe material is injected onto the area of impression. The tray containing the heavy body if then seated over it. Both materials set together to produce a single impression.

3- Two stages or putty wash technique

ay used: perforated stock tray.

Viscosity used: *(a) putty (b) light body.*

Method

First a primary impression is made with putty in the stock tray. After setting it is kept aside. Light body is mixed and spread into the putty impression. The primary impression is then seated over the impression area and held till it is set.

Automatic dispensing or mixing device

Advantages

1- *More uniform mix.*
2- *Less air bubbles incorporated in mix.*
3- *Reduced working time.*

Addition silicone impression materials packaged with auto-mixed cartridges, mixing gun, and static mixing tips, and dynamic mechanical mixer.

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Casting investments

Dr. Abbas Ibrahim Hussein

Properties required of an investment:

1- Easily manipulated.
2- Sufficient strength at room temperature: To permit ease in handling and provide enough strength at higher temperatures to withstand the impact force of the molten metal.
3- Stability at higher temperatures: Investment must not decompose to give off gases that could damage the surface of the alloy.
4- Sufficient expansion: Enough to compensate for shrinkage of the wax pattern and metal that takes place during the casting procedure.
5- Beneficial casting temperatures: Preferably the thermal expansion versus temperature curve should have a plateau of the thermal expansion over a range of casting temperatures.
6- Porosity: Porous enough to permit the air or other gases.
7- Smooth surface.
8- Ease of divestment.
9- Inexpensive.

Composition

In general, an investment is a mixture of three distinct types of materials:

1- Refractory Material: This material is usually a form of silicon dioxide, such as quartz, tridymite, or cristobalite, or a mixture of these.

2- Binder Material: Because the refractory materials alone do not form a coherent solid mass, some kind of binder is needed.
3- Other Chemicals/modifiers: Usually a mixture of refractory materials and a binder alone is not enough to produce all the desirable properties required of an investment material.

Types

Calicium sulfate-bonded or gypsum-bonded investment:

The investments suitable for casting gold alloys contain (65-75 %) quartz or cristobalite, or a blend of the two, in varying proportions, (25-35 %) of α-calcium sulfate hemihydrate, and about (2-3 %) chemical modifiers. The calcium sulfate-bonded investment is usually limited to gold castings, and is not heated above 700°C. The calcium sulfate portion of the investment decomposes into sulfur dioxide and sulfur trioxide at temperatures over 700°C, tending to embrittle the casting metal. Therefore, the calcium sulfate type of binder is usually not used in investments for making castings of palladium or base metal alloys.

Phosphate-bonded investment:

It is the most common type of investment for casting highmelting point alloys. This type of investment consists of three different components. One component contains a watersoluble phosphate ion (binder). The second component reacts with phosphate ions at room temperature. The third component is a refractory, such as silica 80%. Different materials can be used in each component to develop different physical properties.

Silica-bonded investment:

Another type of binding material for investments used with casting highmelting point alloys is a silica bonding ingredient. This type of investment may derive its silica bond from ethyl silicate, an aqueous dispersion of colloidal silica, or from sodium silicate. One such investment consists of a silica refractory, which is bonded by the hydrolysis of ethyl silicate in the presence of hydrochloric acid.

Soldering investment

when soldering the parts of a restoration such as clasps on a removable partial denture, the parts must be surrounded with a suitable investment material before the heating operation. These assembled parts are temporarily held together with sticky wax untill they are surrounded with investment, after which the wax is softened and removed. The portion to be soldered is left exposed and free from investment to permit wax removal and effective heating before it is joined with solder.
These don’t have as fine particle size as the casting investment because the smoothness of the mass is less important.

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Metal and metals alloys

Dr. Abbas Ibrahim Hussein

Alloy: It is a metal containing two or more elements, at least one of which is metal, and all of which are mutually soluble in the molten state.

Noble metals: They are materials resist corrosion in the mouth. (gold, platinum, palladium, silver, rhodium, ruthenium, iridium, osmium).

- Gold: Pure gold is soft, ductile, yellow hue. The density is 19.3 gm/cm3 , melting point is 1063°C, good chemical stability, not corrode and not tarnish.
- Silver: Whitest metal, its density is 10.4 gm/cm3 , melting point is 961°C.
- Palladium: Its density is 12.02 gm/cm3 , melting point is 1552°C.
- Platinum: its density is 21.65 gm/cm3 , melting point is 1769°C.

Precious metals: This term indicates the intrinsic value of the metal. The eight noble metals are also precious metal, but all precious metals are not noble.

Base metals: These are not noble metals, (chromium, cobalt, nickel, copper,…..etc).

They are important components of dental casting alloy because:

a- Their influence on physical properties. b-
Control of the amount and type of oxidation. c-
Their strengthening effect.

Classification:

According to yield strength:

- Type I: soft
- Type II: medium
- Type III: hard
- Type IV: extra-hard

According to number of alloys' elements present:

1. Binary (2 elements).

2. Ternary (3 elements).
3. Quaternary (4 elements).

According to use:

1- Alloys for all metal; metal with resin veneer restorations.
2- Alloys for metal ceramic restorations.
3- Alloy for removable dentures.

General requirements of casting alloys:

1- It should not tarnish and corrode in the mouth.
2- It should strong.
3- Biocompatible (non-toxic, non-allergic).
4- It should be easy to fabricate (melt, cast, cut, and grind).
5- It should flow well, and duplicate fine details during casting.
6- It should have minimal shrinkage on cooling after casting.
7- It should easy to solder.
8- It should be light weight.
9- It should have high stiffness (to make the framework thin).
10- It should have good fatigue resistance.

11- It should not react to commercial denture cleanser.

12- Economical consideration.

Alloys for all metal restorations:

1- Gold alloys (composed of gold, copper, silver, platinum, palladium, and other additives).

2- Silver-palladium alloys.

3- Nickel-chromium alloys.

4- Cobalt-chromium alloys.

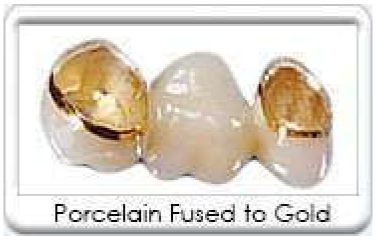


Alloys for metal ceramic restorations:

1- Gold-palladium-platinum alloys.

2- Palladium-silver alloys.

3- Nickel-chromium alloys.



HOW DOES PORCELAIN BOND TO THE ALLOY?

Ceramic adheres to metal primarily by chemical bond. A covalent bond is established by sharing 02 in the elements in the porcelain and the metal alloy. These elements include silicon dioxide (Si02) in the porcelain, and oxidizing elements such as silicon, indium, and iridium in the metal alloy.

Alloys for removable dentures:

1. Cobalt-chromium alloy:

   Composition:

   a- Cobalt (to give hardness, strength, rigidity).

   b- Chromium (to ensure corrosion resistance by passivating effect).

   c- Nickel (to decrease fusion temperature and increase ductility).

   d- Molybdenum or tungsten (to increase hardness).

   e- Iron and copper (to increase hardness).

f- Manganese and silicon (to prevent oxidation).
g- Boron (to increase hardness and deoxidizer).
h- Carbon (to strengthen the alloy).

2. Nickel-chromium alloy:

Composition:
a- Nickel.
b- Chromium.
c- Molybdenum.
d- Other minor additions like aluminum, iron, silicon, copper, manganese, tin.

The function of each ingredient is discussed previously.