DENTAL MATERIALS CURECULUM
2022-2123

No.	Title Of The Lectures
1	Introduction and physical properties of dental material □ Introduction to dental materials □ Physical, chemical and biological properties of dental materials
2	Mechanical properties
3	Gypsum materials □ Definition, requirement, types, □ gypsum bonded investment □ phosphate bonded investment □ ethyl silicate bonded
4	Impression materials □ Definition □ Ideal properties of impression materials □ Classification of impression materials □ Non elastic impression materials □ Impression plaster □ Impression compound □ Zinc oxide - eugenol □ Elastomeric impression material
5	Waxes □ Definition, □ Requirements, □ classification of wax according to origin & melting point, □ classification of wax according to uses □ Properties of dental waxes.
6	Polymers □ Polymers and polymerization □ Definition of polymer, co-polymer, cross-link polymer and Degree of polymerization □ Factors which control structure and properties of polymer □ Types of polymerization □ Heat activated acrylic □ Composition □ Properties □ Chemically activated resin □ Composition □ Properties □ Light activated resin □ Composition □ Properties □ Chemically activated resin compared to heat activated resins □ Polymers used in dentistry

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References

- Phillips applied dental material
- Restorative dental material
- Dental material their selection and use

DENTAL MATERIALS

Dental materials: it is the science which deals with the materials used in dentistry, their mechanical, physical, chemical and biological properties and their manipulation, as these properties are related to the proper selection and use them to their best advantage by a dentist.

The objective of these lectures is to learn the mechanical, physical, chemical and biological properties of some dental materials and their manipulation.

Dental materials: Besides use in the oral cavity many materials are also used in the laboratory to aid in the fabrication of dental prostheses.

Most dental treatment may be divided into three phases:

1- Prevention

2- Restoration

3- Rehabilitation

1- Prevention:

The preventive phase is probably the most important. This includes educating the patient on how to maintain his oral hygiene through regular brushing, flossing and periodic checkup at the dental office has been shown to be very effective at controlling caries as well as gum (periodontal) problems ; as well as, fluorides and fluoride therapy in the control of dental caries has been known to us for a long time.

2- Restoration:

The next stage is the actual development of dental caries and periodontal disease. Caries involves the actual demineralization and destruction of tooth structure. The next focus is to arrest the caries process. This involves removing the carious tooth structure and restoring the cavity with a suitable filling material.

Some of restorations are processed outside the mouth, in the laboratory; in case of the coronal tooth structure is entirely gone or destructed, the crown is constructed and cemented on to the prepared tooth.

Rehabilitation:

Unfortunately the reality is that often patients come too late for any kind of conservative treatment. Hopeless teeth have to be extracted. After extraction the patient often desires that it be replaced with an artificial tooth. There are many ways of replacing the tooth:

1- Implants have become very popular.

2- The fixed partial denture (bridge). Usually the teeth by the side of the missing tooth is reduced in size (prepared) in order to receive the bridge. The bridge is then cemented on to these teeth.

3- If too many teeth are missing, the removable partial denture which replaces the missing teeth but is not fixed in the mouth. It can be removed by the patient for cleaning and hygiene.

4- The final stage is when all the teeth have to be replaced, the complete denture is usually made of a type of plastic called acrylic or (fixed complete dentures are also available which are supported and retained by implants).

The following general properties are important in the study of dental materials:

A- <u>Mechanical properties:</u>

One of the most important properties of dental materials is their ability to withstand the various mechanical forces applied on the material during its use such as a restoration, impression, model and tools.

a- Stress: When an external force applies on body, tending to produce deformation, a resistance is developed within the body to this external force. The internal resistance of the body to the external force is called stress. Stress is equal and opposite in direction to the external force applied. This external force is also known as load. Stress is the force per unit area (N/M^2), (Mpa).

b- Strain: If the stress (internal resistance) produced is not sufficient to withstand the external force (load), the body undergoes a change in shape (deformation). Each type of stress is capable of producing a corresponding deformation in the body. Strain is expressed as change in length per unit of original length of the body when a stress is applied.

$$\text{Strain} = \frac{\text{Deformation or change in length}}{\text{Original length}} = \frac{E}{L}$$

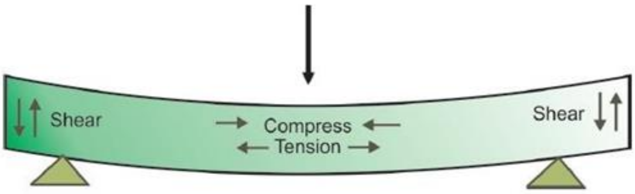
Types of stresses:

1- Tensile Stress: Results in a body when it is subjected to two sets of forces that are directed away from each other in the same straight line. The load tends to stretch or elongate a body. It's accomplished by tensile strain.

2- Compressive Stress: Results when the body is subjected to two sets of forces in the same straight line but directed towards each other. The load tends to or shortens a body. It's accomplished by compressive strain

3- **Shear Stress:** Results when two forces directed parallel to each other. The load tends to twist, or slid of one portion of a body over another. It's accomplished by shear strain.

Usually three types of stresses occur at the same time. If a piece of metal is being bending, it will exhibit tensile stress on the outer surface, compressive stress on the inner and shear stress in the middle.



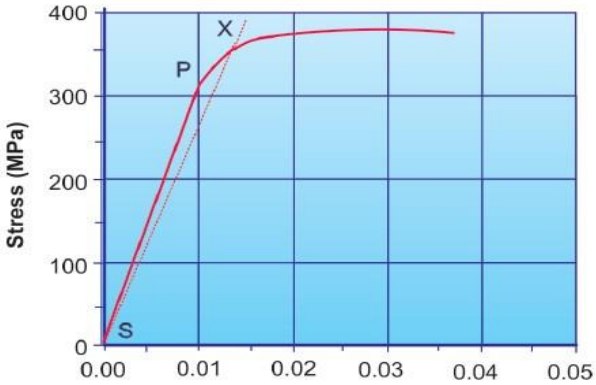
Stress-strain curve: is a straight line up to point 'P' after which it curves.

Proportional limit 'P': when the stress is applied to a material, the material will tend to deform in shape and dimension in an amount proportional to the magnitude of applied stress. The point 'P' is the proportional limit, up to point 'P' the stress is proportional to strain (Hooke's Law).

Elastic limit: the maximum stress that a material will withstand without permanent deformation (change in shape), if the load is removed the material will return to its original shape.

If the stress increased beyond the elastic or proportional limit, the material will deform and if stress is removed, the material will not return to its origin dimension, this is called plastic or permanent deformation. If the stress increased more and more, the material will break.

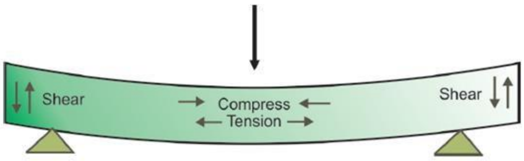
For all practical purposes, the elastic limit and the proportional limit represent the same stress. However, the fundamental concept is different, one describes the elastic behavior of the material whereas the other deals with proportionality of strain to stress in the structure.



Stress-strain curve: P-proportional limit, X-yield strength

Yield strength: it is the stress at which a material exhibits a small amount of deviation beyond proportional limit 'P'.

Transverse strength or bend strength, or fracture strength: is obtained when a load is applied in the middle of a beam supported at each end. Used to test denture base resins and long span bridges.



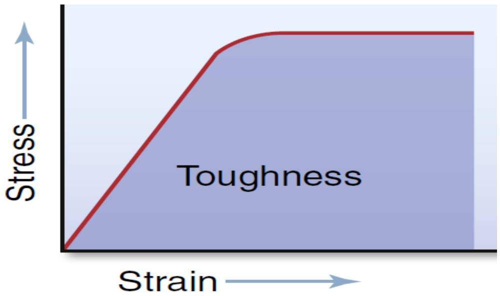
Fatigue strength: when the material is subjected to repeated stresses below its proportional limit can produce sudden failure of the structure, ex. frequent application of force like clasp arm of partial denture.

Impact strength: It is the ability of material to fracture under an impact force or sudden impact, low impact strength means brittle material, like dropping of denture, dentures should have a high impactstrength to prevent it from breaking if accidentally dropped by the patient.

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

Ductility: it is the ability of the material to withstand permanent deformation under tensile force without fracture. It is the ability of the material to be drawn into a fine wire.

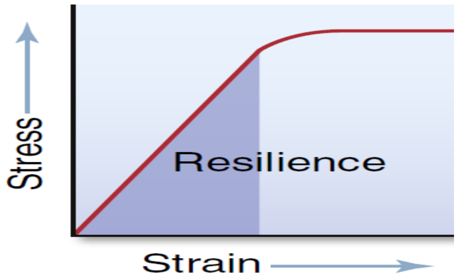
Toughness: it is the energy required to fracture a material , which describes as how difficult the material would be to break. It is a total area under the stress-strain curve.



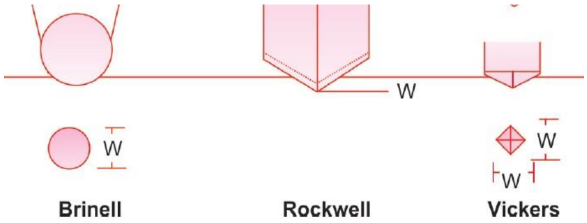
Brittleness: it is the opposite of toughness, a brittle material fractures at or near its proportional limit. Many dental materials are brittle, e.g., porcelain, cements, dental stone.

Flexibility: It is the greatest strain produced in the material when it is stressed to its proportional limit, ex: it is useful to know the flexibility of elastic impression materials to determine how easily they may be withdrawn over undercuts in the mouth.

Resilience: It is the amount of energy absorbed by a structure when it is stressed to its proportional limit.



Hardness: It is the resistance of the material to deformation caused by penetrating or scratching forces for the surface. It is done either by using steel ball (Brinell or Rockwell test) or using diamond (Vickers and Knoop test). The higher number the harder material.



B- Physical properties:

a- 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.

Translucency: Allows light to pass through as it is scattered, so objects cannot be seen through matter. Some of the translucent materials used in dentistry are ceramics, resin and acrylic.

Transparent materials: Allows light to pass through; And things can be seen clearly through them, as glass is an example of transparent materials.

Opacity: Prevents the passage of light, like opaque ceramic materials.

b- Dimensional stability: Dental materials should not be suffered dimensional change after harden; but there are many material change shapes when they set or harden, ex. impression materials; also, Amalgam is filling material for posterior teeth; it may sometimes change shape permanently as a result ofheavy biting force; this is bad property.

On the other hand, the investment material that forms the mold for dentalcasting should expand for certain amount to compensate for the contraction of the molten metal after it is cooled from the molten stage.

c- Density: lightness is always an advantage in restorative materials, but sometimes tin or lead is used inside lower complete denture to make it heavy to control its mobility.

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

e- Cohesion: when the molecules of the same substance hold together, the forces are said to be cohesion.

f- Solubility: restorative materials should not dissolve in the oral fluid, and if itdissolves, it should not release toxic substances.

g- Fluid absorption: some materials will absorb water or other fluids.

- If it is too much or continued for long time, this will result in serious dimensional changes and the material would also be unhygienic.
- On the other hand, some materials like acrylic will absorb water for a dayand stops after that, so it is acceptable.

C- Thermal properties:

a- Coefficient of thermal expansion and contraction: when the temperature rises, a solid material will expand and on cooling it will contract, this is measured by the coefficient of thermal expansion and contraction.

b- Thermal conductivity: It points to the ability of a material to transport heat from one point to another without movement of the material as a whole, the more is the **thermal conductivity** the better it conducts the heat.

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.

***D- Electrical activity*: it is the ability of metals to ionize by losing electrons. If there is a high difference in the electrode potentials of two metals in contact with the same solution like gold and aluminum, an electrolytic cell may develop and thepatient may feel discomfort.

F- Biological properties: Some restorative materials are damaging to the living tissue which is 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.

Biological requirements of dental materials:

Dental materials should:

1- Be nontoxic to the body

2- Be non-irritant to the oral or other tissues

3- Not produce allergic reactions

4- Not be carcinogenic.

Examples of hazards from chemicals in dental materials:

1- Some dental cements are acidic and may cause pulp irritation.

2- Polymer based filling materials may contain irritating chemicals such as unreacted monomers, which can irritate the pulp.

3- Phosphoric acid is used as an etchant for enamel.

4- Dust from alginate impression materials may be inhaled, some products contain lead compounds.

5- Monomer in denture base materials is a potential irritant.

6- Some people are allergic to alloys containing nickel. Dental applications of nickel alloys include orthodontic wires, fixed and removable partial dentures, etc.

7- Some dental porcelain powders contain uranium.

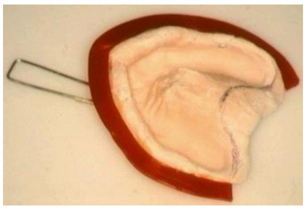
8- Eugenol in materials like restorations and impressions can cause irritation and burning in some patients.

Gypsum Products

The mineral gypsum $CaSO_4 \cdot 2H_2O$ is usually white to yellowish white in color and is found as a compact mass.

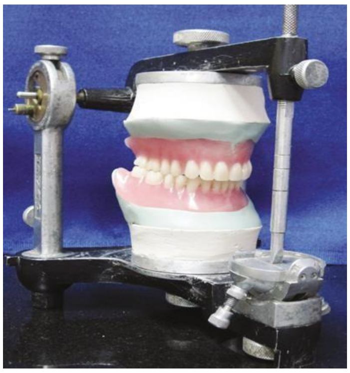
<u>The applications of gypsum products in dentistry are:</u>

1. Impression plaster was used extensively in the past for impressions of the mouthand face.



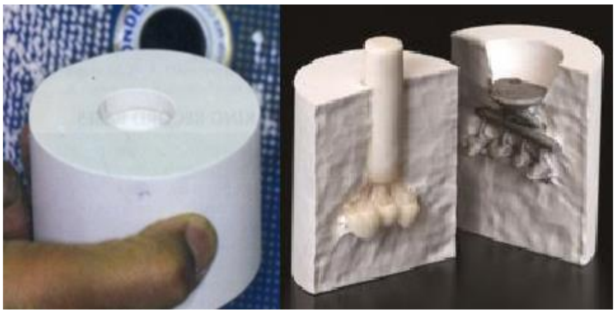
2. Various types of gypsum products are used to make casts and dies over which dental prosthesesand restorations are made.

3. To attach casts to an articulator.



4. Molds for processing dental polymers

5. Dental investments: When plaster is mixed with silica it is known as dental investment. They are used to form molds into which molten metal is cast.



The ideal properties of model material:

1- It should set rapidly but give adequate time for manipulation.
2- It should set to a very hard and strong mass.
3- It should flow into all parts of the impression and reproduce all the fine details.
4- Dimensional stability, no expansion or contraction during or after setting.
5- High compressive strength to withstand the force applied on it.
6- Produce smooth surface.
7- Compatible with impression materials.
8- Can be disinfected without damaging the surface.

Classification:

ADA/ANSI Specification No. 25/ ISO 6873:1998 classified gypsum products into:
Type 1 — Dental plaster, impression
Type 2 — Dental plaster, modelType 3 — Dental stone, model
Type 4 — Dental die stone, model, (high strength, low expansion).
Type 5 — Dental die stone, model, (high strength, high expansion).

Manufacture of gypsum products:

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.

Plaster

When the gypsum is heated in open container to 120 C, it gives part of its water to form plaster, which is **$CaSO_4.1/2H_2O$**
The crystals of plaster are irregular in shape and porous. The term β-hemihydrate is also used to refer to plaster.

	120C in air $-1½H_2O$
$CaSO_4 2H_2O$ gypsum	⟶ $CaSO_4½H_2O$ calcium sulphate hemihydrate

Stone

Chemically stone is the same as plaster that is **$CaSO_4.1/2H_2O$** but it is made by heating gypsum in wet condition under super heat steam to 125 C. the crystals are dense and regular and have prismatic shape. They are called α particles.

Die stone

It is produced by boiling gypsum with 30% **$CaC1_2$** (calcium chloride). The crystals are also dense, regular and have prismatic shape, called α particles.

Setting reaction:

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

$CaSO_4.½ H_2$ + H_2O ——> $CaSO_4.2H_2O$ + Heat (exothermic reaction)

Hemihydrate + Water ——> Dehydrate + Heat

The setting is accompanied by the following effects:

a) Evolution of heat (exothermic reaction)

b) Development of strength (interpenetration of crystallites)

c) Setting expansion

Mixing:

Instruments used for mixing:

Flexible rubber bowel and stiff bladedspatula.

Types of mixing:

1- ***Hand mixing:*** Water is taken first then the powder is sifted into water in the rubber bowel to ensure good wetting and avoid clumps, and avoid air bubbles, Vibrate the mix (using a mechanical vibrator or by repeated tapping against a bench) and pour it into the impression, taking care not to entrap air.

2- *Mechanical mixing:* Mechanical mixing under vacuum gives stronger and denser casts. However, the equipment is expensive.

Manipulation:

a-Proportioning (water/ powder ratio):

The powder is mixed with water at certain ratio according to the type of gypsum product, then the mix with clean spatula for 1 min. until creamy mix is obtained.

W/P ratio for plaster is 0.5 (50ml of water for 100gm of plaster powder). W/P ratio for stone is 0.3 and for die stone is 0.2.

b-Setting time:

The time elapsing from the beginning of mixing until the material hardens is called **setting time** it's measured byGilmore needles apparatus or by Vicat apparatus.

Gillmore Needle

Mixing time is the time from the addition the powder to the water until mixing is complete. A mixing time of 1 minute is usually sufficient.

Working time is the time available to work with the mix for the intended purpose. At the end of the working period the material thickens and is no longer workable. The freshly mixed mass is semifluid in consistency and quite free flowing. A working time of 3 minutes is usually sufficient.

Initial setting time: as the reaction proceeds, more hemihydrate crystals react to form dehydrate crystals. The material becomes rigid (but not hard). It can be carved but not molded.

Final setting time: The time at which the material can be separated from the impression without distortion or fracture.

Measurement of Setting Time

Usually by some type of penetration tests. Occasionally, other tests are used.

1. Loss of gloss method: As reaction proceeds the gloss disappears from the surface of plaster mix (sometimes used to indicate initial set).

2. Exothermic reaction: The temperature rise of the mass may also be used for measurement of setting time as the setting reaction is exothermic.

3. Penetration tests: By using penetrometers (Vicat or Gilmore needle apparatus).

Factors Affecting Setting Time of Gypsum Products:

1- ***W/P ratio:*** increase water used for mixing gypsum products will lead to decrease dehydrate generation and the setting time will be prolonged.

2- ***Fineness:*** the finer the particle size of the hemihydrate, the rate of solubility of the hemihydrate will be increased; therefore, the faster the mix will harden.

3- ***Mixing and spatulation:*** the longer and faster mixing of the gypsum products will lead to decrease setting time because nuclei of crystallization are broken and well distributed within the mass.

4- Temperature:

- On increasing from a room temperature of 20°C to a body temperature of 37°C, the rate of the reaction increases slightly and the setting time isshortened.
- As the temperature is raised above 37°C the rate of reaction decreases and the setting time is lengthened.
- At 100°C the solubility of hemihydrate and dehydrate are equal, in which case no reaction can occur and the gypsum will not set.

5- ***Modifiers (Accelerators and Retarders):*** Modifiers are chemicals added in orderto alter some of the properties and make it more acceptable to the dentist. If the chemical added decreases the setting time it is called an accelerator, whereas if itincreases the setting time it is called a retarder.

- ***Accelerator:*** is the chemical material added to gypsum product to decrease the setting time like sodium chloride or potassium sulfate they increase the rate of dissolution of hemihydrates and accelerate setting time to produce dehydrate.

- ***<u>Retarder:</u>*** is the chemical material added to gypsum product to increase the setting time like glue borax or gum Arabic they decrease the rate of dissolution of hemihydrates and retard setting time to produce dehydrate.

Setting expansion:

Setting expansion is of two types:

1. **<u>Normal setting expansion (0.05 to 0.5%)</u>**

All gypsum products show a linear expansion during setting, due to the outwardgrowing of the crystals during setting.

Importance of setting expansion: In dentistry, setting expansion may be desirable and undesirable depending on the use.

- It is undesirable in impression plaster, dental plaster and stone as it will result in an inaccurate cast or change in the occlusal relation if used for mounting.

- Increased setting expansion is desired in case of investment materials as it helps to compensate the shrinkage of the metal during casting.

Control of setting expansion

1. Mechanical mixing reduces setting expansion when compared to hand mixedstone.
2. Increase in W/P ratio reduces the setting expansion.
3. Modifiers generally reduce the setting expansion.

2. Hygroscopic setting expansion: if the setting process is allowed to occur under water the setting expansion may be more than double in magnitude this is called hygroscopic expansion. This increased expansion is due to the additional growth ofthe crystals and not to any difference in the chemical reaction.

Strength:

The strength increases rapidly as the material hardens after the initial setting.

Factors Affecting Strength

a- ***The free water content (excess water):*** increase amount of free water in the set stone will decrease strength.

b- ***W/P ratio:*** increase W/P, porosity will increase and strength will decrease.

c- ***Spatulation or mixing:*** strength increases with increased spatulation.

d- Addition of accelerators and retarders will decrease strength.

Impression Materials

A dental impression is a negative record of the tissues of the mouth .It is used to reproduce the form of the teeth and surrounding tissues .The negative reproduction of the tissues given by the impression material is filled up with dental stone or other model materials to get a positive cast .The positive reproduction of a single tooth is described as a die, and when several teeth or whole arch is reproduced, it is called a cast or model. The impression materialis carried to the mouth in a tray which is either stock or special tray.

Advantages of using a cast or model

1- Models provide a three-dimensional view of the oral structures, thus aiding in diagnosis and treatment planning.
2- Many restorations or appliances are best constructed on a casts and the technical work can be passed on to technicians by using casts.
3- Models can be used to educate the patient.
4- They serve as pre- and post- treatment records.

The desirable properties of impression materials

1. An accurate reproduction of surface details.
2. Dimensional accuracy and stability.
3. A pleasant odor, taste, and acceptable color.
4. Not toxic or allergenic to the patient.
5. No release of gas or other byproducts during the setting of the impression or cast and die materials.
6. Adequate shelf life for requirements of storage & distribution.
7. Easy to use (mix and handle) with the minimum of equipment (economic)
8. Suitable working and setting time that meets clinical requirements.
9. Adequate strength to avoid breaking or tearing upon removal from themouth.
10. Dimensional stability on setting over temperature and humidity for a longperiod enough to permit the production of a cast or die.
11. Compatibility with cast and die materials.
12. Readily disinfected without loss of accuracy.

- *No single material is ideal for all applications and none of the current materials completely satisfies the requirement.*

Classification the impression materials

The impression materials were classified according to:

1. Mode of elasticity:

The most popular classification, the set impression materials can be either rigid or elastic.

A)) rigid impression material: the material is not flexible and will fracture when deformed. They cannot engage undercuts, their use restricted to edentulous patient. (Impression plaster, impression compound, Zinc oxide eugenol and impression waxes).

B)) Elastic impression material: means that the material is flexible and can be deformed and still return to its original form when unstressed. Can engage undercuts and may be used in edentulous, partial dentate and fully dentate patients.

Elastic impression materials are subdivided into:

I: Hydrocolloid include

1)) agar (**reversible hydrocolloid**)

2)) alginate (**irreversible hydrocolloid**)

II: Elastomers include

1)) polysulphide

2)) condensation silicone

3)) additional silicone

4)) polyether

5)) hybrid impression (combination of silicon andPolyether).

2. Mode of setting:

There are two basic setting mechanisms reversible and irreversible:

A)) **set by chemical reactions (irreversible material):** chemical reactions have occurred and that the material cannot revert to a previous state in the dental office. For example, alginate, zinc oxide– eugenol (ZOE), impression plaster and elastomeric impression materials.

B)) **set by physical reaction (reversible material, thermoplastic material):** soften upon heating and solidify slightly above body temperature with no chemical change taking place such as impression compound, agar and impression waxes.

3. Viscosity of the material before set:

A)) **mucostatic:** not compress the tissue during setting of the impression. Low viscosity material.

B)) **mucocompressive:** compress the tissue during setting of the impression. High viscosity material.

Interaction of the impression materials with saliva:

A)) **hydrophilic impression materials:** the material is compatible with moisture and saliva (the impression material will absorb saliva from the patientmouth and we get full adherence between the tissue and the material).

B)) **hydrophobic impression materials**: the material is not compatible with moisture and saliva the material repel saliva (any drop of saliva within the patient mouth will make slight depression or concavity on the impressionmaterial so the patient mouth must be dried before making the impression).

Materials	***Properties***	***Reaction***	***Set***	***reaction with saliva***
Rigid				
1. Impression Plaster.	Rigid	Irrev	Chem	Hydrophilic
2. Impression Compound.	Rigid	Rev	Phys., heat	Hydrophobic
3. Zinc Oxide/ Eugenol.	Rigid	Irrev	Chem	Hydrophobic
Hydrocolloid				
4. Alginate	Elastic	Irrev	Chem	Hydrophilic
5. Agar	Elastic	Rev	Phys., heat	Hydrophilic
Elastomers				
6. Polysulfide.	Elastic	Irrev	Chem	Hydrophobic
7.Condensation Silicone.	Elastic	Irrev	Chem	Hydrophobic
8. Polyether.	Elastic	Irrev	Chem	Hydrophilic
9. Addition silicone.	Elastic	Irrev	Chem	Hydrophilic & Hydrophobic

Rigid impression material (non elastic)

1. Impression plaster.
2. Impression compound.
3. Zinc oxide eugenol impression material.
4. Impression waxes.

1. Impression Plaster

Used as mucostatic impression material for making final impressions for edentulous patients Doesn’t compress and displace tissues during seating of tray due to its fluidity, present as powder mixed with water (w/p=0.6).

Starch is added for easier separation of impression plaster from the cast (to help disintegration of impression on separation from the plaster/stone model). After cast hardens, the impression and the cast are put in hot water, the starch swells and the impression disintegrates, making it easy to separate the cast from the impression.

- **Manipulation:**

The water is placed into rubber bowel and the powder is added, mixing them till the creamy mixture is formed then the special tray (thickness of 1-1.5 mm) is filled and seated into the patient mouth where it is allowed to set.

- **USES:**

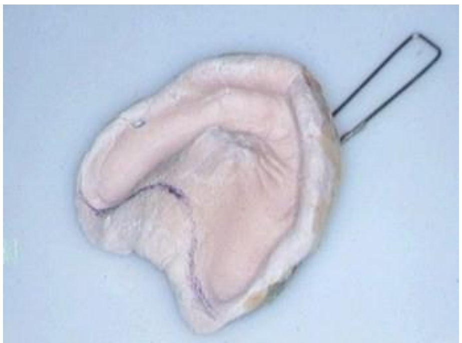
1. Making final impression in constructing complete dentures.
2. Occlusal bite registration material.
3. Maxillofacial prosthesis.

- **Properties:**

1. Setting time 3-5.
2. The mixed impression plaster has very low viscosity which makes it possible to take impressions with a minimum force on the soft tissues (mucostatic technique).
3. It is hydrophilic (patient complain very dry sensation after having impression because of water absorption nature of this material) and thus adapts readily to soft tissue recording their surface details with great accuracy.
4. The material is best used in a special try made of acrylic (1-1.5 mm spacer).
5. Very good dimensional stability (dimensional change during setting about 0.06%).
6. A separating medium must be used between the cast and the impression plaster (rinse the impression plaster with solution of sodium alginate or soap with water before pouring the cast).
7. Rarely used these days as they are brittle and fractures very easily.

- **Advantages**:

1. Very good dimensional stability.
2. Good accuracy.
3. Short setting time.
4. Easy to mix.
5. Low viscosity-mucostatic
6. Cheap.



- **Disadvantages**:

1. Cannot be used in undercut ridge (rigid impression material).
2. Heat due to reaction.
3. Rigid once set.
4. Dry sensation in the mouth.
5. Able to flow pharynges.
6. We need separator.

2)Impression compound

1- A rigid, muco-compressive impression material.

2- Reversible impression material which set by physical change.

3- Thermoplastic material (it softens when heated and on cooling it hardens).

4- 4-Making impression of edentulous mouth (primary impression).

- **Presentation:** present as sheets, sticks, cakes and cones.

- **Types of impression compound**

1. **Type I regular impression compound (lower fusing):** supplied in sheets, sticks form or cones.

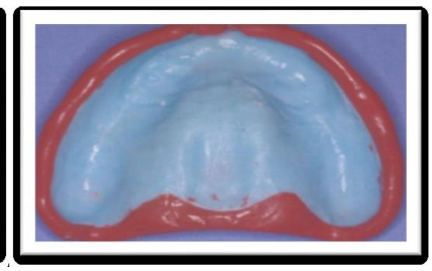
- **Sheet form material** used to take primary impression for edentulous ridges using stock tray, softened using a hot water bath (55-60) C (foundto be ideal for manipulation with fingers in order to obtain plasticitythroughout the impression compound). Storage in hot water should not be so long to prevent leaching out of important constituents, also overheating make the compound sticky and difficult to handle.

 Stick form material used for border molding of an acrylic special tray during fitting of the special tray, it's softened over flam. The compound should not allowed boiling, otherwise the plasticizer are volatilized.

2. **Type II tray compound (higher fusing):** it is stiffer and has less flow than regular impression compound. Used to make a special tray (now largely replaced by acrylic tray) into which another impression material is placed in complete edentulous arches.

 The difference in fusing temperature between type I and type II reflects a difference in the thermoplastic ingredients (waxes and resins) of each type.





 Uses:

1. For making a primary impression for edentulous ridges.
2. Border molding of special tray.
3. Make a special tray.

 Properties:

1. It is muco-compressive and it is the most viscous impression material used (high viscous), therefore the reproduction of surface details is not very good. However, the reproduction can be improved by reheating the surface of the impression material after taking the first impression and then reseated it in the patient's mouth.
2. Rigid once cooled not used to record undercuts (used for primary impression only).
3. Poor dimensional stability, the material has high value of coefficient of thermal expansion so undergoes considerable shrinkage on removal from the mouth and because pressure is applied during formation of an impression (muco-compressive), we have residual stress exists in cool impression, so the gradual relief of these internal stresses may cause distortion of impression (the cast should be poured as soon as possible within 1 hour).
4. Low thermal conductivity so it needs thorough heating and a hot water bath is

preferred to soften the impression compound. We should wait for certain time in order that all the material is softened and when we introduce it into the patient's mouth we should wait enough time till the outer and the inner portion of the compound is hard before we can remove it from patient mouth.

5. It is a physical reaction not chemical reaction so the impression compound can be reused a number of times (for the same patient) in case of error; inaccurate portions can be remade without having to remake the entire impression.

- **Advantages**:

1. Compatible with model material and not need separating medium before pouring the plaster.
2. Can be reused a number of times.
3. Not need special tray.

- **Disadvantages:**

1. The handling of impression compound material is very sensitive technique. (plasticizers can be lost on heating or low molecular weight ingredients can be lost during long immersion in a water bath)
2. High coefficient of thermal expansion leading to dimensional changes.
3. Muco-compressive material (cause displacement of the soft tissue).
4. Low detail reproduction. High viscous, low flow.
5. Rigid once set so cannot be used in undercut area.
6. Must be poured within 1 hour.

3. Zinc oxide eugenol impression material:

It's described as a rigid, mucostatic and irreversible impression material which set by chemical reaction. The combination of zinc oxide and eugenol is widely used in dentistry.

- **Types of Zinc oxide eugenol impression material**

1. Type I hard.
2. Type II soft.

- **Presentation:**

The impression material is in the form of two pastes (2 tubes):

- Base paste (white color).
- Reactor or accelerator or catalyst paste (red in color).

- **Manipulation**

Two strips of equal length are squeezed from each tube (base and catalyst) on glass slab or paper pad mixed (mixing time=1 min.) until a uniform color is observed. Then the mixture is filled into fitted special tray. No separating medium is needed before the stone model is pour, and after the stone has set it can be separated from the impression by immersion in hot water (50-60) C for 5 to 10 minutes.

- **Properties**

1. Setting time

- Type I: Initial setting time= (3-6) Min., final setting time=10 Min.
- Type II: Initial setting time= (3-6) Min., final setting time=15 Min.

Factor controlling the setting time:

- By varying the length of the two pastes (not recommended).
- Setting time can be decreased by adding zinc acetate or acetic acid or dropof water.
- Longing the mixing time, short is the setting time.
- High atmospheric temperature and humidity accelerated the setting time.
- Setting time can be delayed by cooling the mixing slab, spatula or byadding small amounts of waxes or oils.

2. Accurate registration for surface details due to good flow. The material has mucostatic properties (recording tissue in uncompressed state).
3. Rigid non-elastic once set and should not be used for partially edentulousarches, or undercut areas it's fractured when removed from undercut area.
4. It requires a special tray for impression making.
5. It has adequate adhesion to acrylic tray (no need adhesive material).
6. It has advantages of being dimensionally stable, a negligible shrinkage (less than 0.1 %) may occur during hardening.
7. No separating medium is needed before the stone model is poured because it does not stick to the cast material.
8. The paste tends to adhere to skin, so the skin around the lips and the cheek should be protected with petroleum jelly (Vaseline) to make the cleaning process much easier.
9. Although the material not toxic, Eugenol can cause burning sensation and tissue irritation.
10. It can be checked in mouth repeatedly without deformation.

- **Advantages**

1. Good adapted to the soft tissues without causing displacement of the soft tissue (mucostatic), so it has good reproduction of surface detail.
2. Good dimensional stability.
3. Well Adhere to the special tray (no need for adhesive).
4. Inexpensive.
5. Not need separating medium before the stone model is pour.
6. It can be checked in the mouth repeatedly without deformation.
7. Minor defects can be corrected locally.
8. It has enough working time to complete border molding.
9. Pour any time.

- **Disadvantages**

1. Messiness
2. Non elastic and may fracture if undercuts present.
3. Variable setting time due to temperature and humidity.
4. May irritate to soft tissue due to the eugenol.
5. It need special tray.
6. The skin around the lips and the cheek should be protected withpetroleum jelly (Vaseline).

4. Impression waxes:

Impression waxes are rarely used to record complete impressions but are normally used to correct small imperfections in other impressions especially those of the zinc oxide eugenol type. These material consist from a mixture of low melting paraffin and bees waxes in ratio about 3:1. Waxes have high coefficient of thermal expansion, so it will deform when removed from undercut area. It's used in ranging consistencies soft, medium, hard and extra hard.

Elastic impression material

It is the ideal impression materials for reproduction of tooth form and relationship, which can be with-drawn from the undercut area & return to its original form without distortion.

Types of Elastic impression material

1. Hydrocolloids Impression Materials.
2. Elastomeric Impression Materials.

1. Hydrocolloid Impression Materials (Aqueous ImpressionMaterial)

Hydrocolloid impression materials used in dentistry are based on colloidal suspensions of polysaccharides in water.

The colloid exists in two forms:

- In Sol form: (fluid, low viscosity & random arrangement ofpolysaccharide chain.)
- In Gel form: (high viscosity may develop elastic property when the long polysaccharide chains become aligned).

<u>Gelation:</u> Is the conversion of sol to gel & development of elastic propertiesthrough alignment of polysaccharide chains.

<u>Hydrocolloids are classified into two types based on mode of gelation:</u>

1. <u>Reversible:</u> called reversible because their physical state can be reversed; this make them reusable (by lowering the temperature). e.g. agar impressionmaterial.

2. <u>Irreversible:</u> once these set is usually permanents, so known as irreversible, Set by chemical reaction e.g. alginate impression material.

1. <u>Agar (reversible hydrocolloid):</u>

It is an organic hydrophilic colloid (strong affinity to water) polysaccharide extracted from certain type of seaweed. Presently, it has been largely replaced by alginate & rubber impression material (The preparation of agar to clinical use requires careful control & expensive apparatus).When agar heated they go into sol (liquefy) & on cooling they return to gel state.

- **<u>Uses:</u>**

1. Widely used at present time for cast duplication (during fabrication of cast removable partial denture).
2. Full mouth impression without deep undercut.
3. Crown & bridge impression.
4. As tissue conditioner.

- **<u>Presentation:</u>**

1. <u>Tray impression material</u>: Gel form in collapsible tube for loading the tray. Each tube has enough material to fill a full arch, water-cooled tray isneeded.
2. <u>Syringe material</u>: Packaged in plastic or glass cartridges that fit a syringe or in preloaded syringe. The syringe material has different color & it is more fluid than tray material and easy ejected from the syringe and inject around the teeth.
3. <u>In bulk container</u> (for duplication)

- **<u>Gelation of Agar:</u>**

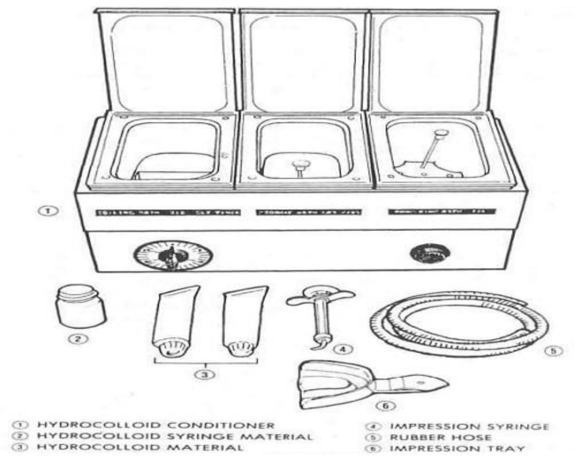
The physical change from the sol to gel & vice versa, is induced by a temperature change. The gel must be heated to a higher temperature (liquefaction temperature 100C) to return it to the sol condition. It transverses to gel at 37C to 50C (gelation temperature). If the gelation temperature is too high the heat from sol may injure the oral tissue.

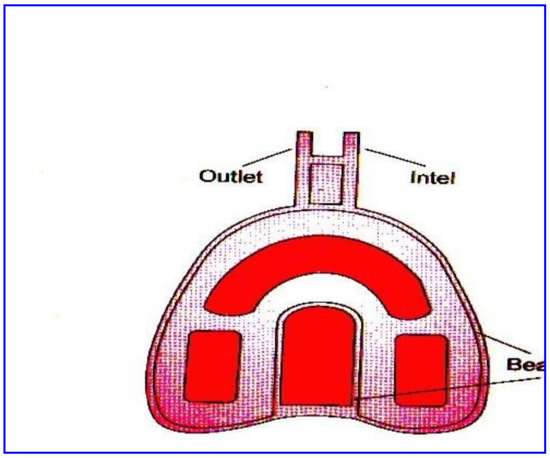
- **Manipulation**

Agar hydrocolloid requires special equipments:

A. Hydrocolloid conditioner.

B. Water cooled rim lock tray.





A. Hydrocolloid conditioner.

Agar is normally conditioned prior to use, using specially designed conditioning bath (temperature controlled water bath), the conditioning bath consists of 3 compartments each containing water hold at different temperature which are:

1. **Boiling section or liquefaction section:** The tube of gel is first placed in the 100C bath for 10 minutes; this rapidly converts the gel to sol & the content of the tube become viscous. The sol should be homogenous and free of lumps. The tube is then transferred to

2. **Storage section:** 65-68C temperature is ideal for storing the agar in the sol condition till needed.

3. **Tempering section:** 46 C for about 2 minutes with the material loaded to the tray. This is done to reduce the temperature so that it can be tolerated by the sensitive oral tissue and also make the material viscous. If the material is maintained at this stage for long time it slowly begins to revert to the gel form.

B. Water cooled rim lock tray:

Metal tray with a narrow- bore metal tube attached to outer surface. The tube is connected to a cold water supply (18 to 21) C & the circulating water reduces the temperature of the tray. The water supply is connected to the tray and the tray is positioned in the mouth, water is circulated at until gelation occur. Rapid cooling is not recommended (e.g. ice cold water) as it can induce distortion.

- **Properties of agar:**

1. It is hydrocolloid mucostatic impression.
2. It is cheap and is used in some laboratories for making duplicate models (reused up to 4 times).
3. Very accurate reproduction of surface details because in sol form the agar is sufficiently fluid.
4. In gel form it is sufficiently flexible to be easily removed.
5. Agar is highly accurate at the time of removal from the mouth. Storage of agar impression is to be avoided; the cast should be poured immediately.

Storage in air results in dehydration (shrinkage) and storage in water results in swelling of impression; it absorbs water in process known as **imbibition.** Thegel may also loose water by exuding of fluid in process known as **syneresis** (during syneresis small droplet are formed on the surface of hydrocolloid). If storage is unavoidable, it should be limited to one hour in 100% relative humidity by wrapping it in wet towel (which result in least dimensional changes)

6. Poor mechanical properties & low tear resistance but it is better than alginate.
7. It is important to remove the tray by rapid snap action that enhanced elastic recovery & decrease permanent deformation.
8. It is necessary to have sufficient thickness of impression material to limit the extent of deformation arising on removal from the undercut.
9. Working time range between 7-15 minutes & setting time about 5 minutes. Both can be controlled by regulating the flow of water through the cooling tube.

- **Advantages:**

1. Accurate impression material if the material is properly handled.
2. It has good elastic properties and reproduces most undercut areas correctly.
3. It well tolerated by the patient, and hydrophilic.
4. Cheap, no mixing required.
5. Can be reused when used as duplicating material (not commended when used as impression material).

- **Disadvantages:**

1. Need special equipment.
2. Water cooled tray is very bulky.
3. Low tear resistance.
4. Difficult to disinfect.
5. If it is not pour as soon as possible led to low dimensional stability due to imbibition and syneresis.

2. Alginate (irreversible hydrocolloid)

One of the most widely used dental impression material. It is more popular than agar for dental impression because it is simpler to use. It changes from sol to gel by chemical reaction.

- **Uses:**

1. An elastic impression material for partial & complete dental prosthesis.
2. To prepare study cast, not recommended for making impression of cavity preparation or crown and bridge (It doesn't give a high degree of accuracy).
3. For surgical splint.
4. For duplicating models.

- **Presentation:**

It's supplied as power mixed with water, A powder is packed in:

1. Bulk containers.
2. Preweighed packets for single impression.

A plastic scoop is supplied for measuring the bulk powder & plastic cylinder for measuring the water.

- **Types:**

Depending on the setting alginate can be classified into:

*Regular set.

*Fast set.

- **Setting reaction**

When alginate powder is mixed with water a chemical reaction occurs ,The calcium alginate precipitated into fibrous network with water .

Sol (powder +water) —— chemical reaction ——→ gel

- **Manipulation:**

Powder should be mixed thoroughly before use (to eliminate the segregation of component that may occur during storage).

The proper w/p (Usually one measure water with two level scoops of powder), with use of clean rubber bowel and clean spatula. The mixing is started with a stirring motion to wet the powder with water once the powder moistened rapid spatulation by swiping against the side of the bowel (when mixed powder with water a vigorous figure 8 motion is best with the mix swiped against the side of the rubber bowel with intermitted rotations of spatula to press out air bubbles). The mix should be smooth, creamy with minimum of voids and doesn't drip off the spatula when it is raised from the bowel.

After the impression set it must be removed suddenly with a snap removal. Then the impression is rinsed thoroughly with cold water to remove saliva & excess water is removed by shaking the impression and disinfected. The cast

should be poured as soon as possible to prevent dimensional changes (within 15 minutes after making the impression).

- **Properties:**

1. Alginate has well controlled working time but vary from product to product. There are regular setting & fast setting. Setting time for regular set 2-4.5 minutes, setting time for fast set 1-2 minutes. Lengthening the setting time is better accomplished by reducing the temperature of the water used with mix (18-24C).
2. The clinical setting time can be detected by the loss of tackiness of the surface.
3. The material should be left in place inside the patient mouth for 2-3 minutes after the tackiness has gone from the surface, since the tear strength and resistance to permanent deformation increase significantly during this period.

4. It is mucostatic & hydrophilic.
5. Detail reproduction is lower when compared with agar or elastomers (they are not recommended for crown and bridge; they are popular for partial denture work.
6. Set alginate is susceptible to evaporation, syneresis & imbibition (like agar), So the cast should be poured immediately, if storage is unavoidable, keeping in humid atmosphere of 100% relative humidity result in least dimensional changes (not more than 1 hour).
7. Like agar snap removal technique need to be employed in order to get an elastic response. The permanent deformation is somewhat higher than agar.
8. Has lower tear strength than agar & have poor mechanical properties.
9. Set gypsum model should not remain in contact with alginate impression for a periods of hours because it is detrimental to surface quality of model
10. Thin layer of alginate is weak; the thickness of alginate between the tray & tissue should be at least 3mm.
11. Alginate doesn't adhere well to the tray therefore perforated one or rim lock should be used.
12. Mixing time for fast set 45 seconds while for regular set 60 seconds. Over mixing result in reduction in final strength as the gel fibril is destroyed also reduction in working time. While under mixing lead to inadequate wetting & reduced strength also the mix being grainy & poor recording of detail.
13. The dentist can control the setting time by altering the temperature of the water used for mixing (colder the water the longer the setting time, warmer the water the shorter the setting time.)
14. It has pleasant taste, smell and low cost.
15. It is highly elastic but less when compare to agar

- **Advantages:**

1. It is easy to mixed and manipulation with minimal requirement of equipment.
2. It has suitable setting time.
3. Flexibility of the set impression.
4. Accuracy if properly handled, low cost.
5. Hydrophilic, comfortable to patient.

- **Disadvantages:**

1. It can't be corrected.
2. Poor dimensional stability (due to syneresis and imbibition). Poor tear strength.
3. Lower detail reproduction.
4. High permanent deformation.
5. Difficult to disinfect.

Elastomeric impression materials:

In addition to the hydrocolloids, there is another group of elastic impression material. They are soft, rubber like, stronger and more stable than the hydrocolloids. They are known as elastomers or synthetic rubbers.

Types:

According to chemistry they are divided into :

1- Polysulfide

2- Condensation polymerizing silicones

3- Addition polymerizing silicones

4- Polyether

5- Hybrid material (combination of silicone and polyether)

According to viscosity they are divided into :

Each type may be further divided into four viscosity classes:

1- Light body or syringe consistency

2- Medium or regular body

3- Heavy body or tray consistency

4- Very heavy or putty consistency

Supplied as two component (base and catalyst) systems.

<u>Uses of elastomeric impression material:</u>

1. In fixed partial dentures for impressions of prepared teeth.
2. Impressions of dentulous mouths for removable partial dentures.
3. Impressions of edentulous mouths for complete dentures.
4. Polyether is used for border molding of edentulous custom trays.
5. For bite registration.

1- Polysulfide impression material:

They are supplied as a two-paste system in collapsible tubes. The base paste is white colored, the accelerator is brown or gray.

Available in Three Viscosities:

- Light bodied
- Medium bodied
- Heavy bodied.

Properties:

1. Unpleasant odor and color.
2. These materials are extremely viscous and sticky, mixing is difficult. The mixing time is 45 seconds.
3. It has a long setting time of 12.5 minutes (at 37°C). This adds to the patient's discomfort.
4. Excellent reproduction of surface details.
5. Poor dimensional stability, The curing shrinkage is high and continues even after setting.
6. It has high tear strength.
7. It has good flexibility and low hardness, a 2 mm spacing in the tray is sufficient for making an impression.
8. It is hydrophobic so the mouth should be dried thoroughly before making an impression.
9. The shelf life is good, 2 years.

Manipulation:

Equal length of base and accelerator pastes are mixed on a paper pad by using stiff bladed spatula, they undergo condensation polymerization reaction, the mixing is continued until the mixture becomes free from streaks and uniform in color. The reaction is exothermic and there are 3-4 times rise in temperature. The reaction is sensitive to heat and moisture, increase in either one will accelerate the setting time.

A special tray (with 2mm space) is used and the inside of the tray is painted with a layer of adhesive material and allow to dry before put the impression material inthe tray, sometimes holes are drilled through the tray to provide mechanical retention for the impression material. The set material becomes solid but highly elastic, flexible and rubbery so should be removed with a steady force. Because of water evaporation that occurs during storage, polysulfide impressions should be poured as soon as possible after they were made, but because of slow recovery time of polysulfide, one should wait 30 minutes from impression making before the impression is poured. No separating medium is needed before pouring the gypsum materials.

2- Silicone impression materials:

Two types of silicone impression materials are available based on the type of polymerization reaction occurring during their setting.

- Condensation silicones
- Addition silicones

Condensation silicone:

This was the earlier of the two silicone impression materials. It is also referred to as conventional silicone.

Available in Three Viscosities

- Light bodied
- Medium bodied
- Putty

Supplied as:

1- Paste: Supplied as two pastes in unequal sized collapsible tubes. The base paste comes in a larger tube while the catalyst paste is supplied in a much smaller tube.

2- Putty: The putty is supplied in a single large plastic jar. The catalyst may be in paste form or sometimes it may be supplied as a liquid.

Setting reaction:

It is a condensation reaction. A reaction occurs as a result of cross linkage polymerization to form a three-dimensional network. The reaction is exothermic.

Properties:

1. Pleasant color and odor. Although nontoxic, direct skin contact should be avoided to prevent any allergic reactions.

2. Setting time is 6 to 9 minutes. Mixing time is 45 seconds.
3. Excellent reproduction of surface details.
4. Dimensional stability is comparatively less because of the high curing shrinkage.
5. Tear strength lower than the polysulfides.
6. It is stiffer and harder than polysulfide. The hardness increases with time. Thespacing in the tray is increased to 3 mm to compensate for the stiffness.
7. It is hydrophobic, the field should be well-dried before making an impression. Care should also be taken while pouring the cast to avoid air entrapment.
8. Shelf life is slightly less than polysulfide.

Additional silicone (polyvinyl siloxane):

These new materials had better properties when compared to the condensation silicones because their chemical reaction is an addition reaction. It is also known aspolyvinyl siloxane**.**

Available in Four Viscosities:

- Light bodied
- Medium bodied
- Heavy bodied
- Putty

Supplied as:

1- Tubes: The base and catalyst pastes come in equal sized tubes (unlike condensation silicones). The different viscosities usually come in different colors like orange, blue, green.

2- Putty jars: Two equal sized plastic jars containing the base and catalyst.

Properties:

1. Pleasant odor and color.
2. This may also cause allergic reaction so direct skin contact should be avoided.
3. Excellent reproduction of surface details.
4. Setting time ranges from 5 to 9 minutes. Mixing time is 45 seconds.
5. It has the best dimensional stability among the elastomers. It has a low curingshrinkage and the lowest permanent deformation.
6. It has good tear strength.

7. It is extremely hydrophobic, so similar care should be taken while making the impression and pouring the wet stone.

8. It has low flexibility and is harder than polysulfides. Extra spacing (3 mm) should be provided in the impression tray. Care should also be taken while removing the stone cast from the impression to avoid any breakage.

9. Shelf life ranges from 1 to 2 years.

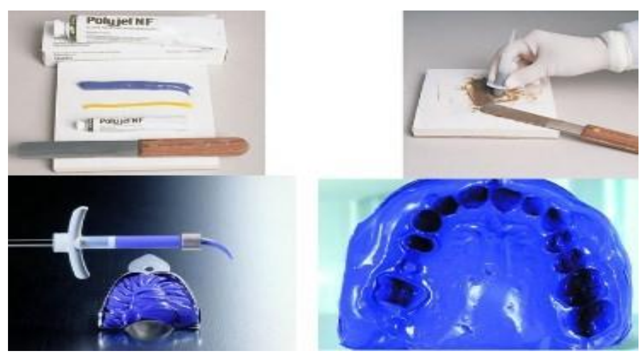
3- <u>Polyether impression material:</u>

It has good mechanical properties and dimensional stability.

Supplied as:

Base and accelerator in collapsible tubes. The accelerator tube is usually smaller. Now it is available in three viscosities:

- Light bodied
- Medium bodied
- Heavy bodied



<u>Properties:</u>

1. Pleasant odor and taste.
2. The sulfonic ester can cause skin reactions. Thorough mixing is recommended before making an impression and direct skin contact should be avoided.

3. Setting time is around 6 to 8 minutes. Mixing should be done quickly that is 30 seconds. Heat decreases the setting time.

4. Dimensional stability is very good. Curing shrinkage is low. The permanent deformation is also low. However, polyether absorb water and can change dimension. Therefore, prolonged storage in water or in humid climates are not recommended.

5. It is extremely stiff (flexibility 3%). It is harder than polysulfides and increases with time. Removing it from undercuts can be difficult, so additional spacing (4 mm) is recommended. Care should also be taken while removing the cast from the impression to avoid any breakage.

6. Good tear strength.
7. It is hydrophilic, so moisture in the impression field is not so critical. It has the best compatibility with stone among the elastomers.

8. The shelf life is excellent — more than 2 years.
9. Tray adhesion used before putting the impression in the tray.
10. Expansive.

Disadvantages:

1- Short working time.

2- The material is very stiff.3- It is expensive.

4. Hybrid impression material (combination of addition silicone andpolyether):

It is the next generation of impression material. It combined the benefits of polyether and addition silicone impression materials, available in two setting time (fast and regular) in 4 viscosities (light, medium, heavy body and putty).

Properties:

1. Pleasant tasting.
2. Excellent tear strength.
3. Adequate bond of impression material and the tray.
4. Hydrophilic, record the finer details of the tooth surface, even in a moist environment.
5. Superior elasticity, allows for easy removal without distortion.
6. Multiple pours (allows multiple pours without tearing).
7. Excellent dimensional accuracy.
8. Excellent reproduction of details.
9. Resistance to deformation.
10. Compatible with any disinfection procedure.
11. Fast setting time.
12. Excellent flow.

Technical consideration for rubber impression material:

1- The regular body and heavy body are usually made in special tray; perforated stock tray is used only for making impression in putty.

2- The spacing given in special tray between (2-4) mm.

3- Elastomers do not adhere well to the tray. An adhesive should be applied on to the tray and allow to dry before making impression except the hybrid type do not need adhesive.

4- The bulk of the impression should be made with heavier consistency (to reduce shrinkage). Light bodies should only be used in a thin layer as a wash impression over the putty or heavy body.

5- The putty type and the heavy bodied rarely could be used alone as primary impression without light body or used with light body or very light body asfinal impression.

Manipulation:

The user should dispense the correct lengths of materials onto a mixing pad orglass slab. The catalyst paste is first collected by a stainless-steel spatula and then spread over the base paste. The mixture is then spread over the mixing pad.

The mixing process is continued until the mixture becomes a uniform in color with no streaks of the base or catalyst appearing in the mixture.

If one of the components is in liquid form (such as the catalyst for condensation silicones), a length of the base is dispensed from the tube onto a mixing pad and drops of the liquid catalyst corresponding to the length of the base are added.

The two-putty systems that available for condensation and addition silicone dispended by volume using an equal number of scoops of each material. The best mixing technique is to knead the material with figures until a uniform color is obtained.

Each type of the impression is put in the tray and then inserted in the patient's mouth. The impression should not be removed from the patient's mouth until the curing has progressed sufficiently to provide adequate elasticity, so that distortion will not occur. Typically, the impression should be ready for removal within at least 10 minutes from the time of mixing. Manufacturers usually provide the optimal time for removal after mixing.

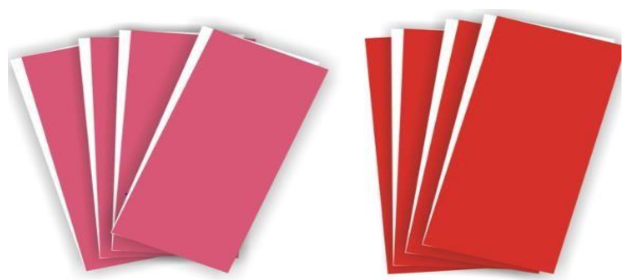
Finally, pouring the impression according to type of the material (either immediately or waiting for a period). No separating medium is needed before pouring the gypsum products.

All the type of elastomeric impression material needs tray adhesive except the hybrid impression material.

Dental Wax

They are thermoplastic materials that are soft when heated and are solid at room temperature. The primary use of the waxes in dentistry is modelling material to make pattern of appliances prior to casting as many dental restorations are made by the lost- wax technique, in which a pattern is made in wax and put in mold prepared by investment material. After setting, the wax is burn out and the space is filled with molten metal or acrylic resin.

There are many varieties of waxes used, both in the clinic and laboratory. Each have particular properties depending on what it is used for. Their basic constituents are essentially similar; their exact proportion is different.



Requirements of dental waxes:

1- Must produce to the exact size and shape and contour of the appliance which is tobe made.
2- Should have enough flow when melted to reproduce the fine details.
3- No dimensional change should takes place once it’s 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.

Characteristic Properties of Waxes

1.Melting Range: because waxes may contain several types of molecules, each having a range of molecular weight, they have melting ranges rather than melting points.

2.Softening point: For many applications of waxes the softening temperature should be just above mouth temperature. This is in order that the material may be introduced into the mouth in a moldable state but will become relatively rigid at mouth temperature.

3.Coefficient of thermal expansion: waxes expand when subjected to a rise in temperature and contract as the temperature is decreased. This expansion and contraction may be reduced by the blending of different types of waxes.

4.Thermal conductor: waxes are very poor thermal conductors.

5.Toughness and brittleness: Toughness is required for some waxes as casting wax that may require removal from the cast many times that may have slight undercuts. While brittleness is required for waxes as inlay wax where it should fracture when removed from deep undercuts rather than distort.

6.Flow: This property results from the slippage of molecules over each other. It greatly affects the ability of the wax to record details at molding temperature. The wax should ideally exhibit considerable flow at the molding temperature but show little or no flow at mouth temperature or room temperature so that they are not easily distorted.

7.Residual stress: During cooling of the wax, solidification of the surface layers of the wax occur well before the bulk becomes rigid. This produces significant internal stresses. Dimensional changes may occur due to relief of the stresses. Greater stresses may be incorporated in the wax if not properly softened before molding.

8.Ductility: like flow, ductility increases as the temperature of a wax is increased. In general, waxes with lower melting temperatures have a greater ductility than those with higher melting temperatures.

9.Warpage: Pattern wax has a high coefficient of expansion and tends to warp or distort when allowed to stand unrestrained. The distortion is increased as the temperature and time of storage are increased. This is related to the release of residual stress developed in the pattern during the process of formation. This is because the residual stress in the pattern is associated with the forces necessary to shape the wax originally. This characteristic of stress release and warpage is present in all dental waxes, but is particularly troublesome in inlay patterns because of the critical dimensional relations that must be maintained in inlay castings.

The incorporation of residual stress can be minimized by:

1. softening a wax uniformly by heating at 50°C for at least 15 minutes before use.
2. by using warmed carving instruments and a warmed die.
3. and by adding wax to the die in small amounts.

Classification of waxes according to origin:

1- Mineral waxes: A distillation products of petroleum.

a- ***Paraffin*** (melts 40-70°C) tends to be brittle.

b- ***Ceresin or Microcrystalline*** (60 - 90°C) ismore flexible and tougher.

2- Plants waxes:

a- ***Carnauba*** occurs as fine powder on the leaves of certain tropical plants. Melting range: 84 - 91°C. It is raise melting range and hardness of paraffin.

b- ***Candelilla*** (68 to 75°C). Mainly hardens paraffin wax.

3- Animal waxes:

Glyceride wax: obtained from beef fat, can be used to increase melting range and hardness ofwaxes.

4- Insect waxes:

Bees wax: obtained from honey-comb, melting range (63-73°C), its brittle at roomtemperature, plastic at body temperature.

5- Synthetic wax:

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

Classification of waxes according to use:

I. <u>Pattern wax:</u>

a- ***Inlay casting wax:*** should be hard and brittlein order to fracture rather than to distort when removed from undercut areas. The wax is mostly blue in color. They are used to make inlays, crowns and pontic replicas. They are mostly paraffin with carnauba wax.

There are 2 types:

Type 1: for direct technique: wax applied directly inside the patient mouth.

Type 2: for indirect technique: wax applied on the die.

b- ***Denture casting wax:*** use to produce the metal components of cobalt- chromium partial denture. It is based on paraffin wax with bees wax to ensure adhering to an investmentmaterial. It is mostly green sheet.

c- ***Denture base plate wax (modeling wax, sheet wax):*** It is pink in color used to form the base plate denture with bite rim and in settingof teeth.

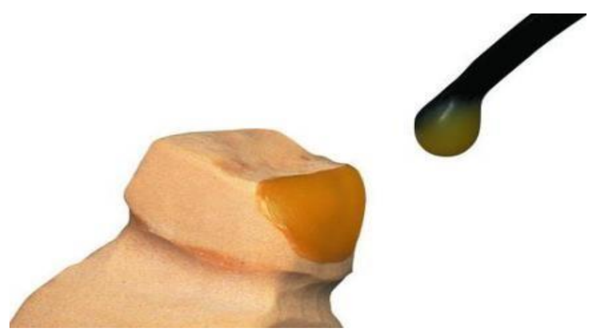
II. Processing wax: used during processing of appliance like:

a- *Beading wax:* supplied as strips, used to make beading around the impression before pouring gypsum to protect the margins of the cast.

b- *Boxing wax:* supplied as sheets, used to make box around the impression tomake pouring gypsum into the impression easier and more perfect.

c- *Block-out wax:* to block-out

undercut areas on cast during processing of Co/Cr or crown and bridge metal frameworks.



d- ***White wax:*** to make patternsimulate veneer facing in crowns.

e- ***Sticky wax:*** to join the broken pieces of the denture before repair.

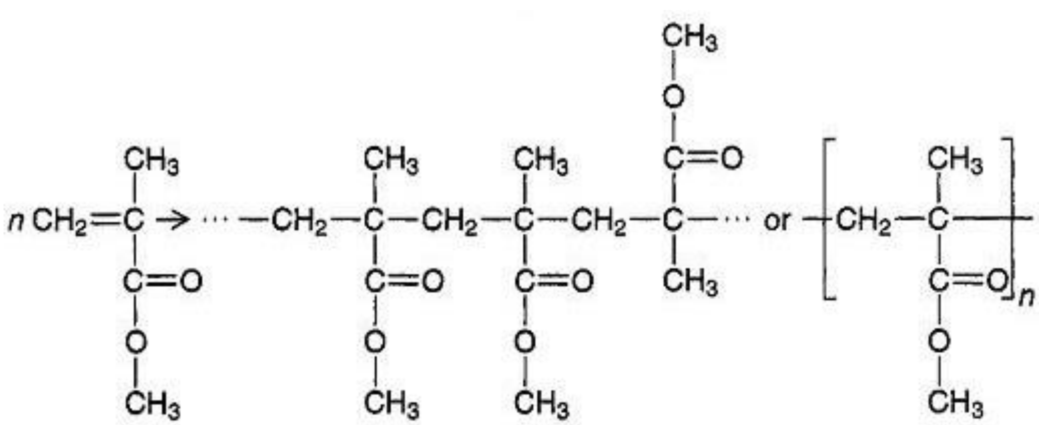
f- **Impression wax:** They are previously used to make impression but distort when removed from undercut, they have high flow.

Dental Polymers

Denture resins and polymers:

A ***polymer:*** It is a substance which has a molecular structure built up completely from a large number of similar units bonded together.

Monomer (one part)**:** The molecules from which the polymer is constructed.



Methyl methacrylate **Poly (methyl methacrylate)**

Copolymers: It is a polymer made by reaction of two different monomers.

Cross-linked polymer: provides permanent connection between the polymer chains that produced a restricting the motion of the chains and improve rigidity of polymer.

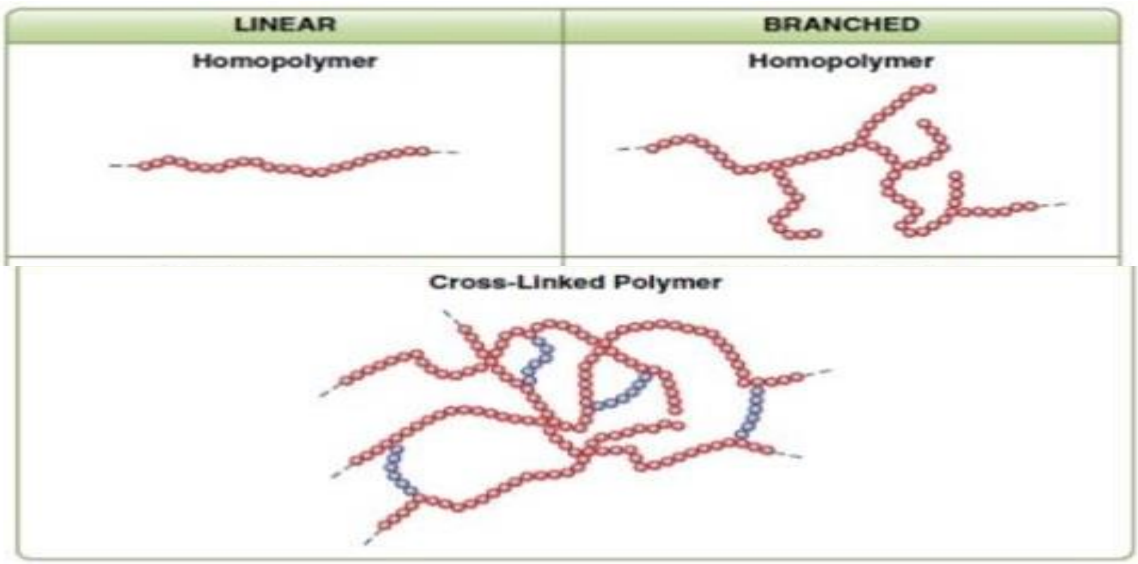
Polymerization: it's a reaction by which a polymer is formed from a group of smaller single molecules known as 'monomer'.

Degree of polymerization**:** its total number of monomers in a polymer. The strength of the resin increases with increase in the degree of polymerization.

Structure of polymers:

There are three basic structures:

1- ***Linear:*** Here the monomer units are connected to each other in a linear sequence.
2- ***Branched:*** the monomer units are arranged in a branched fashion or cross-linked.
3- ***Cross-linked:*** a polymer in which long-chain molecules are attached to each other, forming a two- or three-dimensional network.



Factors which control structure and properties of polymer.

1- The molecular structure of repeating units including the use of co-polymer.
2- Molecular weight or chain length (liner relation with moduluous of elasticity).
3- The degree of chain branching (increase branching lower Tg temperature).
4- The presence of cross –linking and cross link density (increase cross-linking increase Tg temperature)
5- Presence of plasticizers or fillers (lowering of Tg temperature and decrease in elastic modulous).

Types of polymerization:

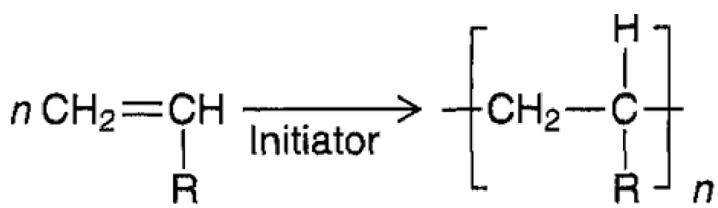
Polymers are prepared by a process called polymerization, which consists of the monomer units becoming chemically linked together to form high-molecular-weight molecules. The polymerization process may take place by several different mechanisms, but most polymerization reactions fall into two basic types: addition polymerization and condensation polymerization.

Condensation Polymerization: usually more than one type of monomer is reacted and the polymerization reaction is accomplished by repeated products of small molecules such as water, halogen acid and ammonia.

Addition Polymerization:

Important addition polymerization reactions are free-radical, ring-opening, and ionic reactions.

Free-Radical Polymerization reactions usually occur with unsaturated molecules containing double bonds, as indicated by the following equation, where



R represents any organic group, chlorine, or hydrogen.

In this type of reaction, no byproduct is obtained.

Most dental resins are polymerized by additional polymerization which is simple involves the joining together of monomer molecules to form polymers chain without change in composition.

Chemical stages of addition polymerization:

The stages in a free-radical polymerization may be summarized as follows:

1. Activation

2. Initiation

3. Propagation

4. Termination

A relevant example is the polymerization of methylmethacrylate (MMA) (BP = 100.30C) to yield polymethylmethacrylate, (PMMA).

1- ACTIVATION

Three general types of activation are common in dental materials:

a) THERMAL ACTIVATION

The activator is often dibenzoyl peroxide which decomposes on heating to yield phenyl radicals at a temperature of 65C.

b) CHEMICAL ACTIVATION

Dibenzoyl peroxide can also be chemically activated through combination with a tertiary amine such as DMPT (N.N.dimethyl-p-toludin).

c) VISIBLE-LIGHT ACTIVATION

A combination of an a-diketone (such as camphoroquinone) and an amine can absorb visible light of a specific wavelength to produce free radicals.

R-O-O-R === 2RO.
Initiator   Free radical
R= represent any organic molecular grouping

2- INITIATION

The phenyl radical attacks the 'double-bond' of the C=C linkage in methylmethacrylate Reaction of the radical with the C=C unit introduces a primary bond between the initiator and MMA and transfers the unpaired electron to the opposite end of the molecule. The combined initiator -methylmethacrylate unit is now a radical species which can add to a further molecule of MMA.

RO. + M ⟶ RO-M.

M= represent one molecule of monomer.

3- PROPAGATION

Propagation involves the successive addition of further molecules of methylmethacrylate to the growing polymer chains.

RO-M . +M ⟶ RO-M-M .
RO-M-M . +M ⟶ RO-M-M-M .
RO-M-M-M . +M ⟶ Ro-M-M-M-M .   -------etc

4- TERMINATION

Termination can result from any, or all, of the following mechanisms:
(1) Addition of a phenyl radical to a growing polymer chain.
(2) Combination of two phenyl radicals.
(3) Combination of two growing polymer chains.

Inhibitor: it is chemical materials added to prevent or delay polymerization during storage and in order to provide enough working time and decrease sensitivity to ambient light like hydroquinone.

The following factors inhibit the polymerization:

1- **Impurity** in the monomer can react with free radicals or with activated chain to prevent further growing.

2- **Oxygen:** Presence of oxygen (air) also inhibit polymerization.

CONDENSATION POLYMERIZATION

Condensation reactions result in polymerization plus the production of low-molecular-weight byproducts. Polysulfide rubbers are formed by a condensation reaction.

Ideal requirements of dental resins:

1. Be tasteless, odorless, nontoxic and non-irritant to the oral tissues.
2. Be esthetically satisfactory.
3. Be dimensionally stable.
4. Have enough strength and abrasion resistance.
5. Be insoluble to oral fluids.
6. Have a low specific gravity (light in weight).
7. Tolerate temperatures well above the temperature of any hot foods or liquids taken in the mouth without undue softening or distortion.
8. Be easy to fabricate and repair.
9. Have good thermal conductivity.
10. Be economical.

Uses of resins in dentistry:

1. Fabrication of dentures (denture base resins).
2. Artificial teeth (cross-linked acrylic resins).

3. Tooth restoration, e.g., fillings, inlays and laminates (composite resins).
4. Cementation of orthodontic brackets, crowns and FPDs (resin cements).
5. Orthodontic and pedodontic appliances.
6. Crown and FPD facings (tooth colored acrylic or composite resins).
7. Maxillofacial prostheses (e.g., obturators for cleft palates).
8. Dies (epoxy resins).
9. Provisional restorations in fixed prosthodontics.
10. Endodontic material.
11. Custom impression trays.
12. Models.

Denture base acrylic resins:

Various materials have been used to construct dentures. Acrylic resin (polymethyl methacrylate) (PMMA) is now the material of choice to use as denture base material because it is easy to process and use, cheap and good esthetic. Even so it is not ideal in all respects.

Poly methyl methacrylate:

The liquid (monomer) methyl methacrylate is mixed with the polymer (powder). The monomer dissolves the polymer to a dough like consistency which is easily molded.

Types:

Based on the method used for its activation:

- Heat activated resins
- Chemically activated resins
- Light activated resins

Heat activated denture base acrylic resins:

Heat activated polymethyl methacrylate resins are the most widely used resins forthe fabrication of complete dentures.

Composition:

Liquid *composed from:*

Methyl methacrylate: Plasticizes the polymer.

Hydroquinone: Inhibitor-prevents premature polymerization.

Powder *composed from:*

Poly (methyl methacrylate): Main component.

Benzoyl peroxide: Initiator to produce free radical.

Polymer/monomer ratio:

The acceptable ratio

3:1 by volume or 2.5:1 by weight

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 consistency suitable for packing. During this period a lid should place on the mixing jar to prevent evaporation of monomer.

The resultant mixture will pass into 5 physical stages:

Wet sand stage: The polymer gradually settles into the monomer forming a fluid, incoherent mass.

Sticky stage: The monomer attacks the polymer by penetrating into the polymer. The mass is sticky when touched or pulled apart.

Dough or gel stage: As the monomer diffuses into the polymer, it becomes smooth and dough like. It does not adhere to the walls of the jar. It can be packed into the mold at this stage.

Rubbery stage: The mass is rubberlike and cannot be molded.

Stiff stage: The mass is totally unworkable and is discarded.

Dough -forming time: the time from the beginning of mixing the polymer with the monomer until reach dough –like consistency, it’s less than 10 minutes.

Working Time: is the time elapsing between the ending of stage II and the beginning of stage IV. ADA Sp. No. 12, the dough should be moldable for at least 5 minutes.

The working time is affected by temperature. In warm weather when the working time is insufficient, the mixing jar is chilled to prolong the working time. Care is taken to avoid moisture.

Factors affecting dough time:

1- Beads (particles size): the smaller beads size of powder, the more rapid will be dissolving of powder into monomer and this will shorten the dough time.

2- Molecular weight of the powder: The lower molecular weights of powder also shorten the dough time.

3- Powder/liquid ratio: increase this ratio will shorten the dough time.

Heat activated denture resin are shaped by:

- **Injection molding technique.**
- **Compression molding technique.**

Injection molding technique: this technique required a special thermoplastic resin and special equipment. The fluid resin is contained in the injector and is forced into the mold space as needed it is kept under pressure until it has hardened.

Compression molding technique: it's widely used; it's accomplished by:

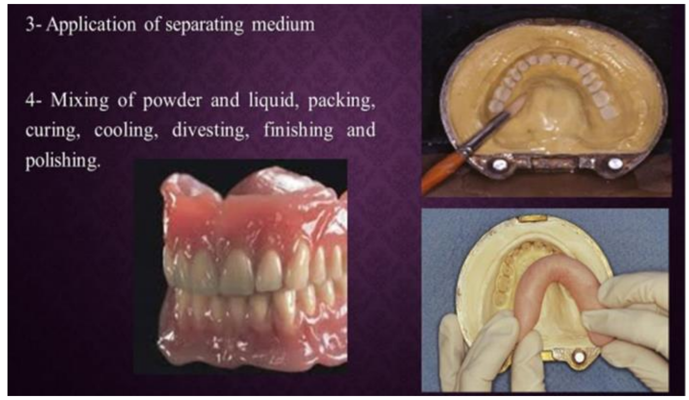
1. Preparation of the waxed denture pattern
2. Preparation of the mold
3. Application of separating medium
4. Mixing of powder and liquid
5. Packing
6. Curing (polymerization or curing cycle): it is the heating process for polymerization of the denture base material.

Curing may be done either by:

a- ***In water bath*** to raise the temperature and there are two recommendedcuring cycles:

- ***Long curing cycle:*** it is a satisfactory processing, curing in a constant temperature water bath (8hr- 10hr at 74 C).
- ***Short curing cycles:*** curing for 2hr at 74C then 1hr at 100C.

c- ***In microwave oven*** (here nonmetallic flask used).



Resins are the same as used with conventional material and are processed in a microwave by using nonmetallic flask. The properties and the accuracy of these materials have been shown to be as good as or better than those of the conventional heat cured material. The advantages of microwave curing are cleaner and faster than the water bath polymerization. Processing time is much shorter (4-5 min.).

Chemically activated acrylic resin:

Also, it is called (Self-cure, Cold-cure, Auto-polymerizing resin) denture base resin:

The main composition:

Liquid

- Methyl methacrylate (monomer).
- Chemical activator: aromatic amine (dimethyl-p-toluidine) which activatedthe

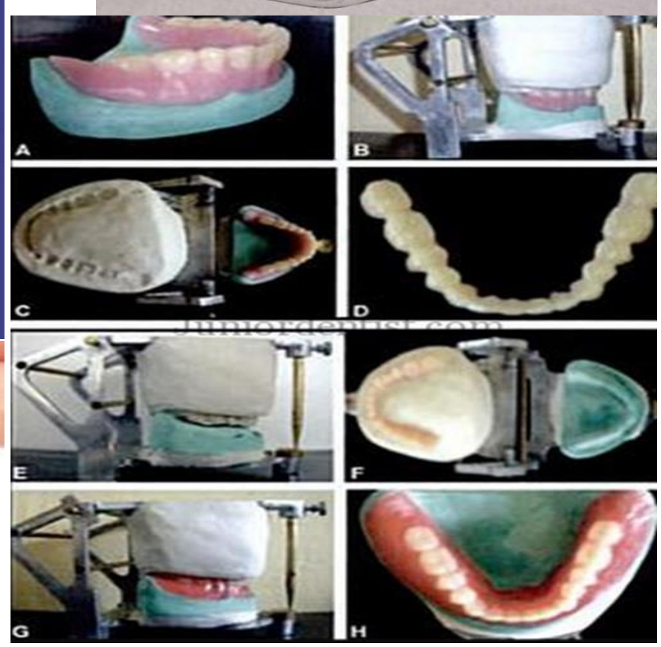
benzyl peroxide (initiator) to produce free radical so the polymerization is initiated in manner similar to that describe for heat cure acrylic.

Powder

- Poly methyl methacrylate (polymer).
- Benzoyl peroxide (initiator).

<u>USES</u>

1. For making temporary crowns and FPDs.
2. Construction of special trays.
3. For making removable orthodontic appliances.
4. For denture repair, relining and rebasing.
5. For adding a post-dam to an adjusted upper denture.



Heat cure resin	Self-cure resin
Heat is necessary for polymerization	Heat is not necessary for polymerization
Porosity is less	Porosity is greater
Higher molecular weights	low molecular weights
Lower residual monomer content	higher residual monomer content
Material is strong.	Material is not strong.
Color stability is good.	Color stability is poor.

Light activated denture base resin:

Composition:

- Matrix of urethane dimethacrylate with an acrylic copolymer.
- Microfine silica fillers.
- Light initiators (photoinitiator) for polymerization (Comphoroquinone-amine).
- In some cases, inhibitors are added to enhance its stability to room light or dental operatory light.

It is supplied in premixed sheets having a clay like consistency. It is polymerized in a light chamber (curing unit) with visible blue light and the denture is rotated continuously in the chamber to provide uniform exposure to the light source. It is provided in opaque light tight packages to avoid premature polymerization.

Denture base materials

Generally, dental resin is classified according to their thermal behavior into two basic types:

1- **Thermoplastic resin:** These are resins that can be repeatedly softened and molded under heat and pressure without any chemical change occurring. Theyare fusible and are usually soluble in organic solvents, e.g., poly methyl methacrylate, polyvinyl acrylics and polystyrene.

2- **Thermosetting resin:** This category refers to resins which can be molded only once. They set when heated. These cannot be softened by reheating like the thermoplastic resins. They are generally infusible and insoluble because of a cross-linking reaction and the formation of a spatial structure. Typical dental examples are cross-linked poly(methyl methacrylate), silicones, cis-polyisoprene, and dimethacrylates.

Thermoplastic polymer (flexible dentures):

Thermoplastic resins are used for the fabrication of flexible denture. A thermoplastic is a plastic which becomes soften, pliable and moldable on heating above a specific temperature and returns to a solid state upon cooling.

There are different kinds of thermoplastic resin like:

a- Thermoplastic acetyl.

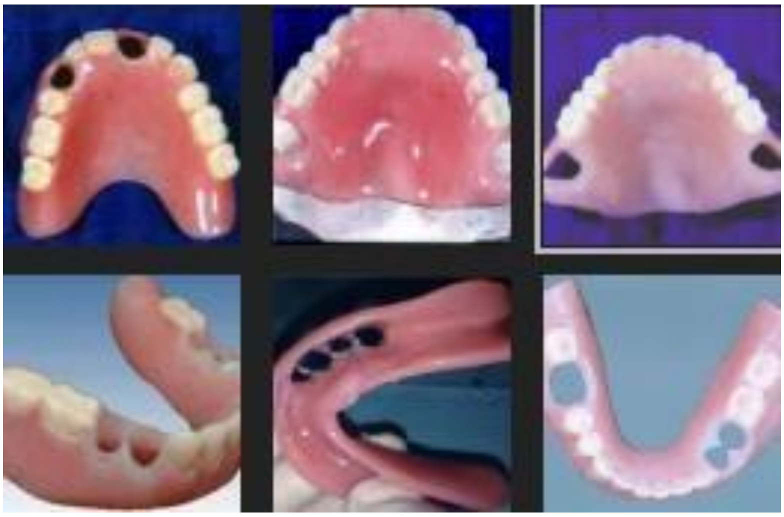
b- Thermoplastic acrylic.

c- Thermoplastic polycarbonate.

d- Thermoplastic nylon.

The thermoplastic nylon is used as a denture base in every case specially used in partial and complete dentures when there are undercuts (because of the flexibility of the material) also used in tilted teeth, patient allergy to acrylic monomer (there is no free monomer in this material), patient allergic to nickel, if there is reduced mouth opening and when need high esthetic demand.

Usually the thermoplastic nylon is supply as beads and prepared by injection molding technique (injection temperature ranges from 274-293C).



Properties of the thermoplastic nylon (flexible denture):

1- High strength.

2- Excellent flexibility and ductility.

3- It is semi translucent and provides excellent esthetic. No metal clasp appearance on the tooth surface.

4- Biocompatible (free of monomer and metal= free allergic reaction).

5- Unbreakable material, high fracture resistance and impact strength.

6- Difficult to adjust, polish and repair.

7- Lower water sorption than PMMA resin.

8- Good resistance to most chemical but they can affect by strong acids and alcohols.

9- Light weight.

10- Nylon is a prone to creep.

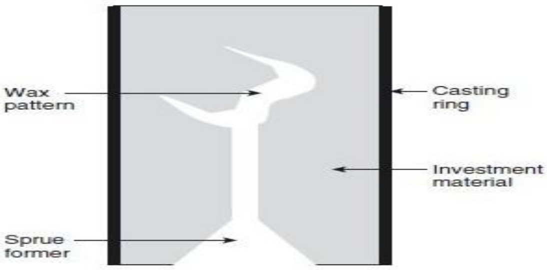
11- Minimal bonding strength to artificial teeth and to relining material.

12- After short period of time the flexible dentures deteriorate, stain and develop a rough surface.

Investment materials

Investment materials: it is a ceramic material which is suitable for forming a mold into which molten metal or alloy is cast.

The procedure for creating the mold is described as ‘investing’. These materials can withstand high temperatures. For this reason, they are also known as refractory materials.



Requirements of an ideal investment materials:

1- The investment mold must expand to compensate for the alloy shrinkage, which occurs during the cooling of the molten alloy.

2- The powder should have a fine particle size to give a smooth surface to the casting.

3- Manipulation should be easy. It should have a suitable setting time.

4- The material should have a smooth consistency when mixed.

5- The set material should be porous enough to permit air in the mold cavity to escape easily during casting.

6- At higher temperatures, the investment must not decompose to give off gases that may corrode the surface of the alloy.

7- It must have adequate strength at room temperature to permit handling, and enough strength at higher temperatures to withstand the impact force of the molten metal.

8- Casting temperatures should not be critical.

9- After casting, it should break away readily from the surface of the metal and should not react chemically with it.

10- The material should be economical.

General composition of investment:

All investment materials contain a refractory and a binder.

a- **Refractory materials:**

A material that will withstand high temperatures without decomposing or disintegrating and regulate the thermal expansion like silica dioxides such as Quartz, Tridymite and Cristobalite.

b- **Binder:**

A material which will set and bind together the particles of a refractory substance, e.g., gypsum, phosphate and silicate. The common binder used for gold alloys is dental stone (alpha-hemihydrate). The investments for casting cobalt-chromium alloys use ethyl silicate.

c- **Chemical modifiers:**

Chemicals such as sodium chloride, boric acid, potassium sulfate are added in small quantities to modify properties.

Types of investment materials:

- According to the type of binder used, there are three types of investment materials. They all contain silica as the refractory material, and the type of binder used is different.

Gypsum bonded investment

Uses; It is used to form mold for casting gold alloys for crown and bridges

Manipulation

The powder is mixed with water and poured around the wax pattern and allow to set.

Properties

1. Thermal, setting and hygroscopic expansion is about 1.3-2%
2. It will decompose to sulfur dioxide and sulfur trioxide when heated above 700ºC, therefore it is not used for casting Co-Cr or Ni-Cr alloys but used for gold alloy
3. Three types of expansion may develop; setting, thermal and hygroscopic expansion

Phosphate bonded investment:

Uses: to form mold for high temp casting like Co/Cr, Ni-Cr and palladium based alloys.

Compositions

It is composed of powder which is silica dioxide 80%, ammonium diacid phosphate 20%, and magnesium oxide.

The liquid is colloidal silica suspended in water.

The powder is mixed with the liquid and poured around the wax pattern and allowed to set for 15-30 minute it is placed in a furnace to burn out the wax pattern.

Ethyl silicate -bonded investment:

The same uses as phosphate -bonded investment. It is composed of powder which is silica dioxide, magnesium oxide. The liquid is composed of ethyl silicate and denaturized acid. Expansion is about 1.7-2.1%

- According to processing or casting temperature, dental investment classified intotwo types:

1- **High temperature casting investment:**

a- Phosphate bonded investment.

b- Ethyl Silicate bonded investment.

2- ***Low temperature casting investment:*** Gypsum bonded investment.

All ceramic crown investment:

It is phosphate bonded, contained fine-grained refractory fillers to allow accurate reproduction of details and remain undamaged during the firing of ceramic.

Soldering investment:

- It is composed of quartz and calcium sulphate hemihydrate binder for low melting point alloys.
- For high melting point alloys, phosphate bonded investment should be used.