Polymer and Polymerization

Prof. Dr.

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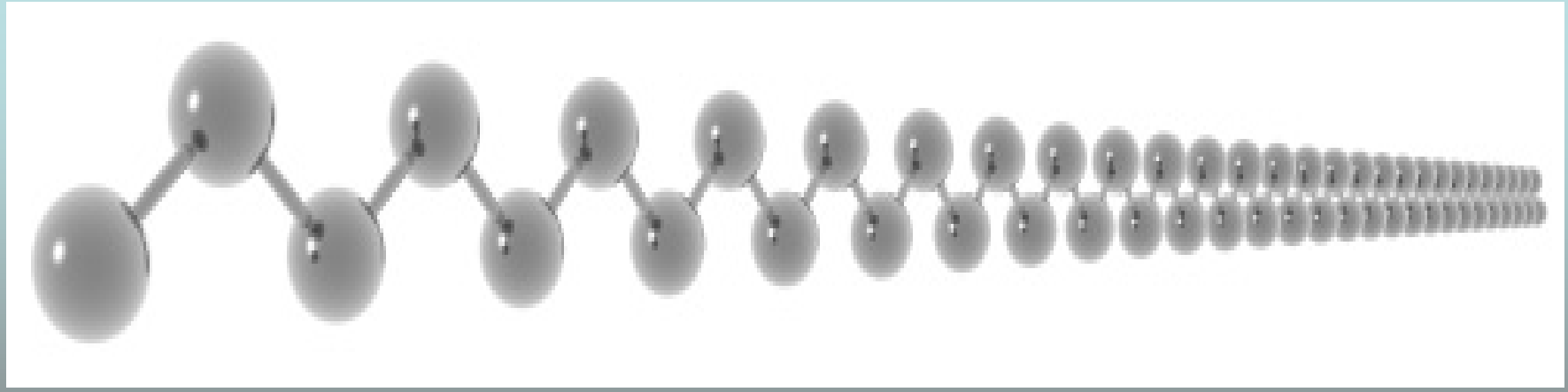
This lec…..

- **What is the meaning of polymer?**
- **What are the uses of polymers in dentistry?**
- **What are the factors which control the structure of polymer which affect the properties?**
- **What is the meaning of denture base?**
- **What are the ideal requirements of denture base material.**

Polymer:

A molecule that is made up of many (poly) parts (mers).

The mer ending represents the simplest repeating chemical structural unit from which the polymer is composed.



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The primary use of polymers in dentistry:

1. **construction of prosthetic appliances such as denture bases.**

The primary use of polymers in dentistry:

Artificial teeth,

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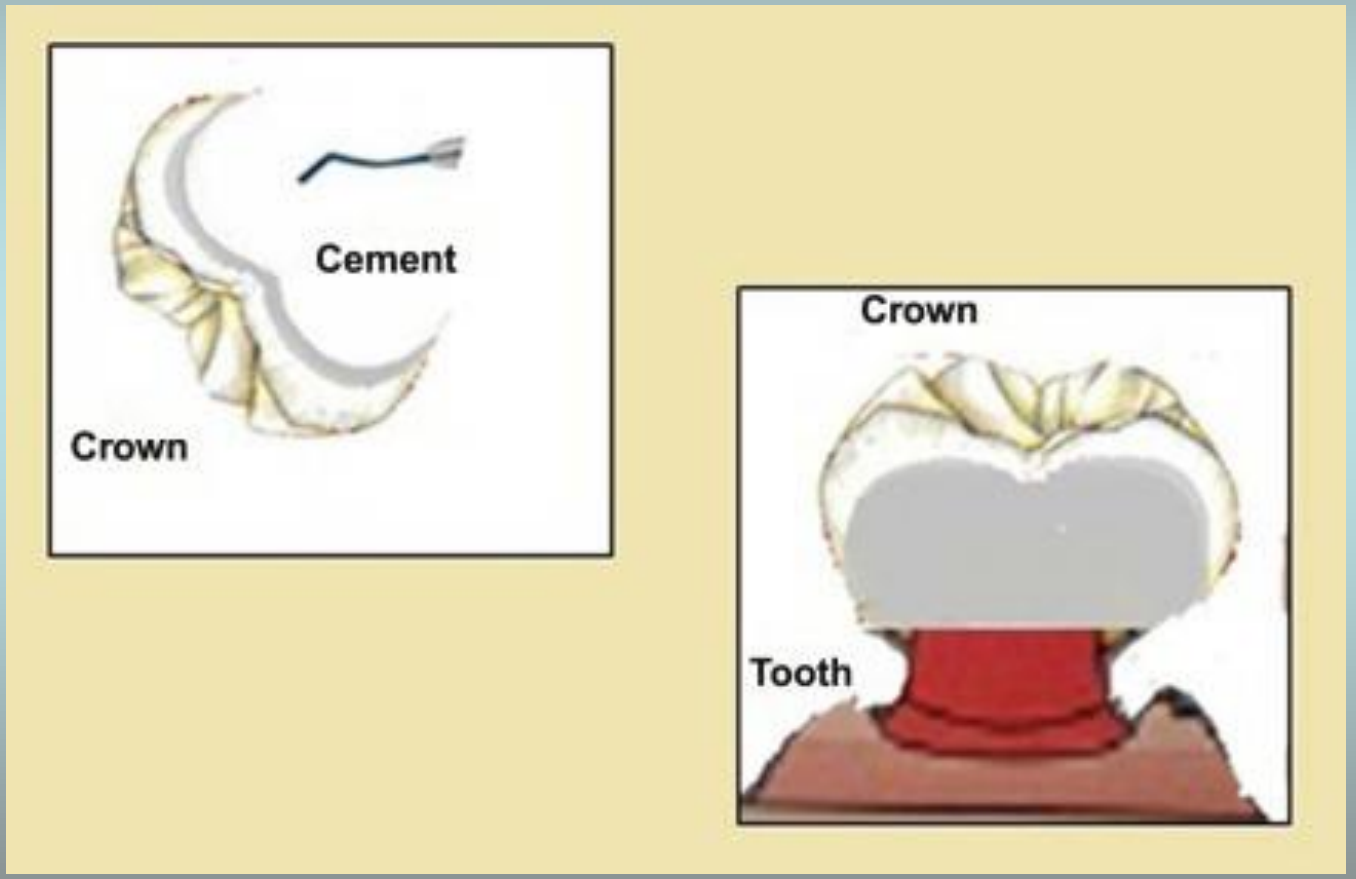
The primary use of polymers in dentistry:

Tooth restoratives,

Top: amalgam fillings; Bottom: white composite fillings

The primary use of polymers in dentistry:

Cements,



The primary use of polymers in dentistry:

Orthodontic space maintainers and elastics,

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The primary use of polymers in dentistry:

Obturators for cleft palates,

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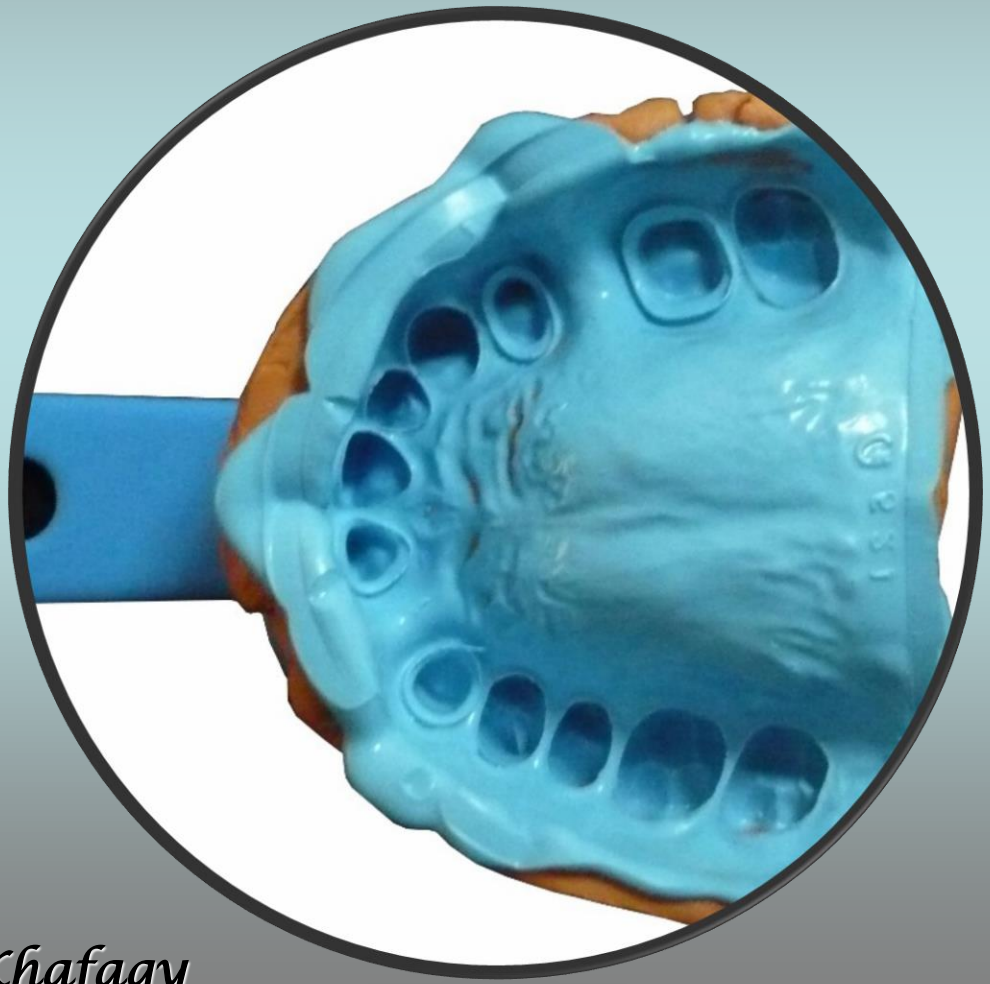
The primary use of polymers in dentistry:

crown and bridge facings,

The primary use of polymers in dentistry:

Impressions

Such as?????



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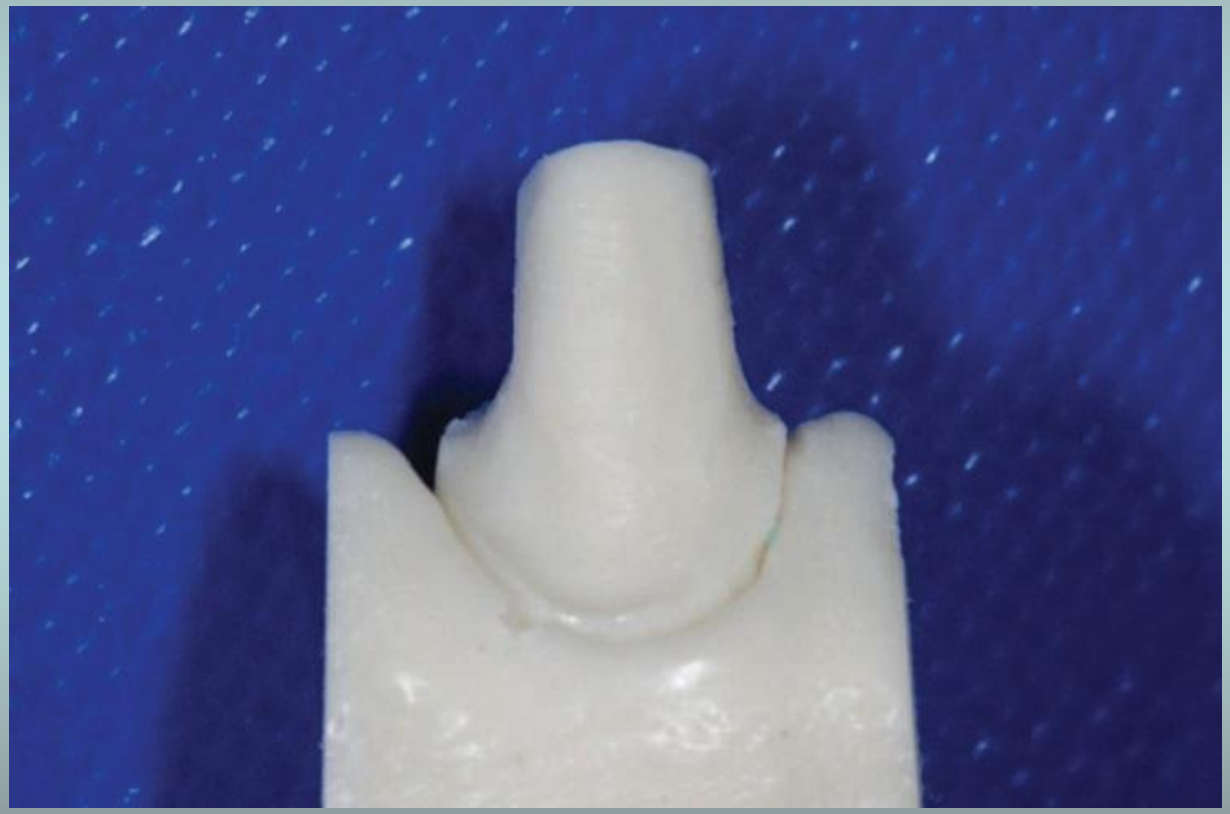
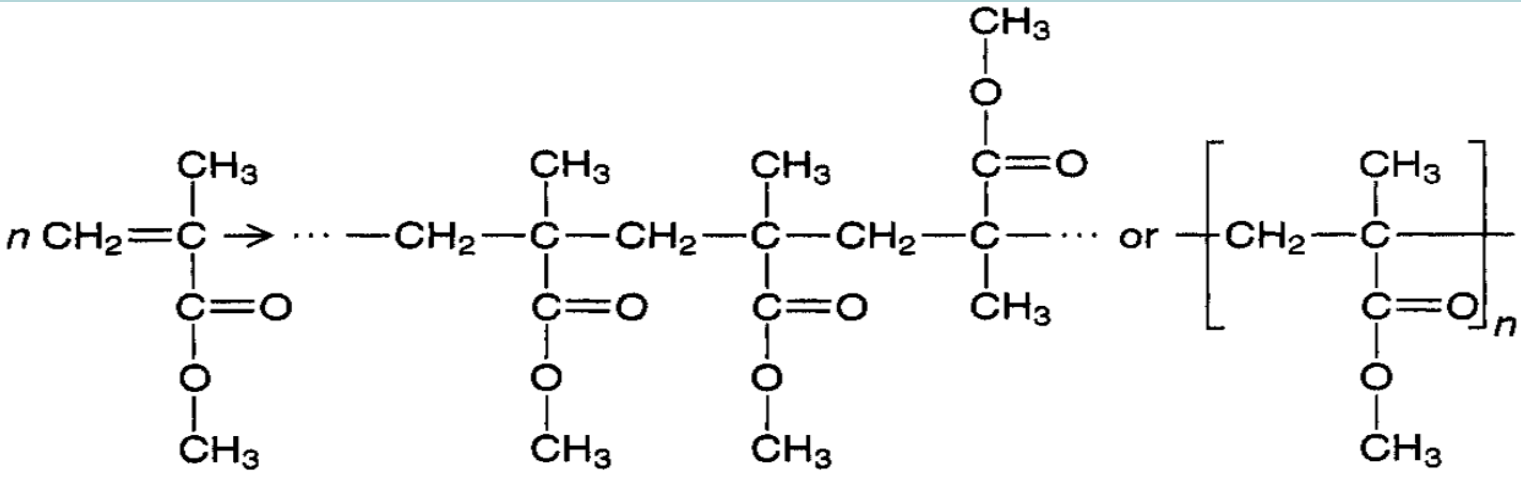
The primary use of polymers in dentistry:

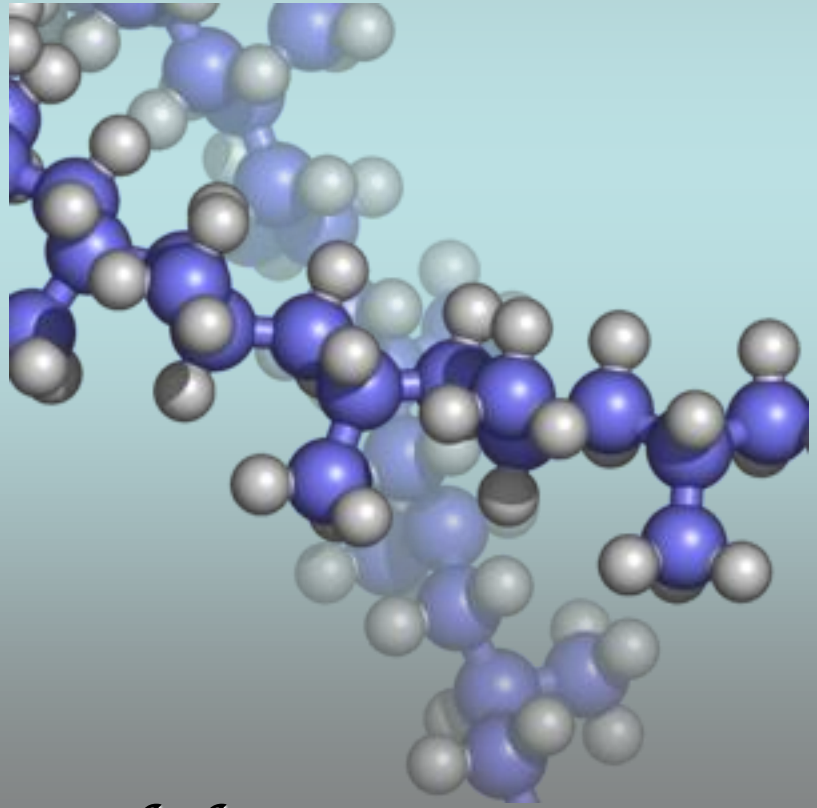
Dies,



Polymerization **:**involves the generation of relatively long molecules from smaller component units through a chemical process.



Degree of polymerization: is defined as the total number of mers in a polymer molecule.



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

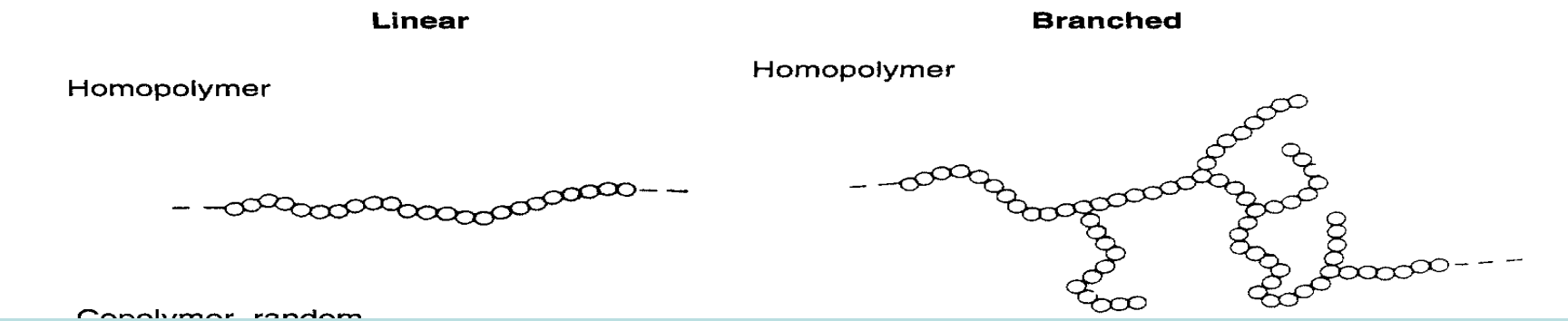
Cross-linked polymer: provides permanent connection between the polymer chains that produced a restricting the motion of the chains and improve rigidity of polymer.

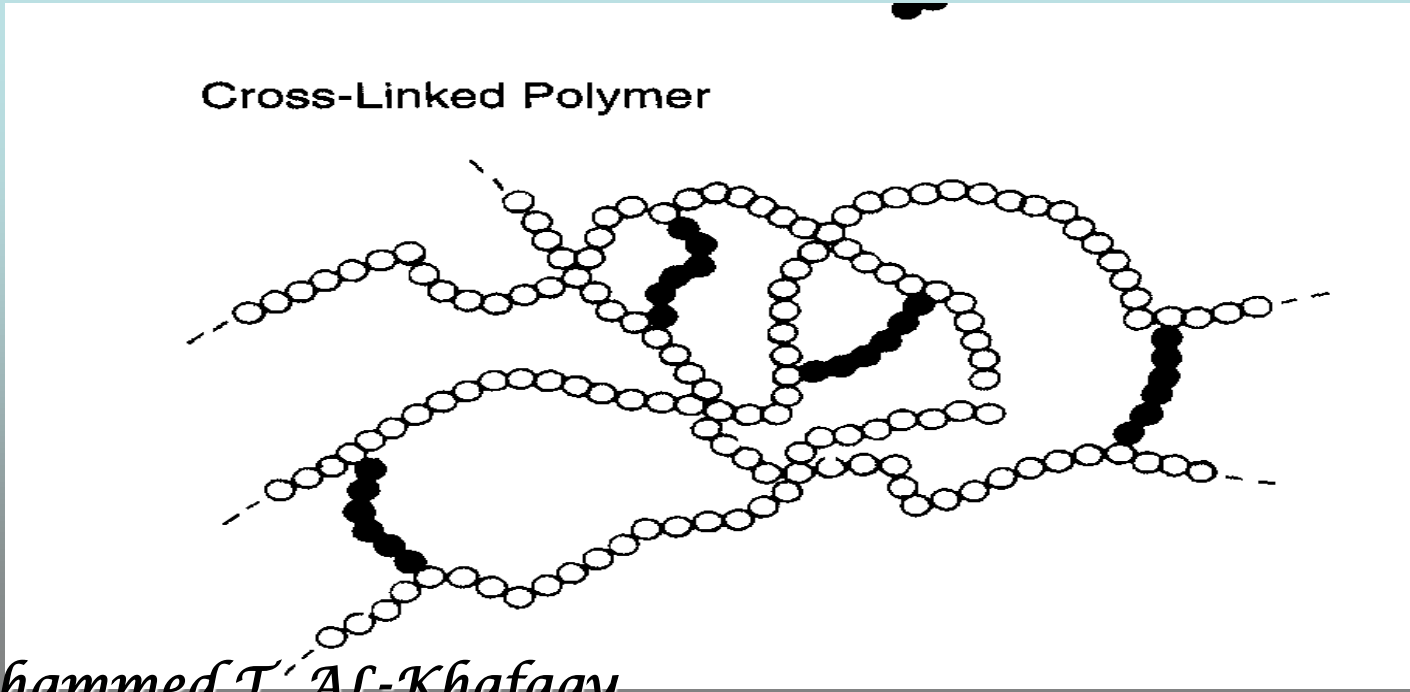
Structure of polymers

SPATIAL STRUCTURE

In addition to chemical composition and molecular weight, the physical or spatial structure of the polymer molecules is also important in ***determining the properties of the polymer.***

SPATIAL STRUCTURE





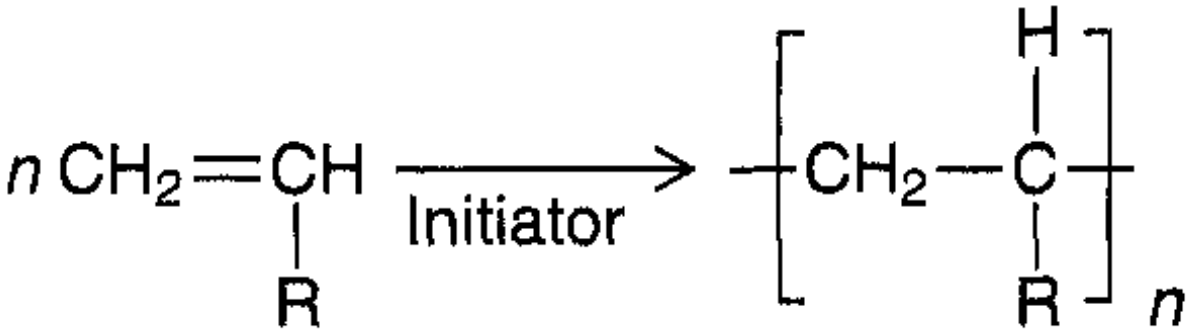
Types of polymerization:

1- ADDITION POLYMERIZATION

2- CONDENSATION POLYMERIZATION

ADDITION POLYMERIZATION

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



R represents any organic group, chlorine, or hydrogen.

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

1. **Activation**

2. **Initiation**

3. **Propagation**

4. **Termination**

1- ACTIVATION

Three general types of activation are common in dental materials:

a) THERMAL ACTIVATION

b) CHEMICAL ACTIVATION

c) VISIBLE-LIGHT ACTIVATION

1- ACTIVATION

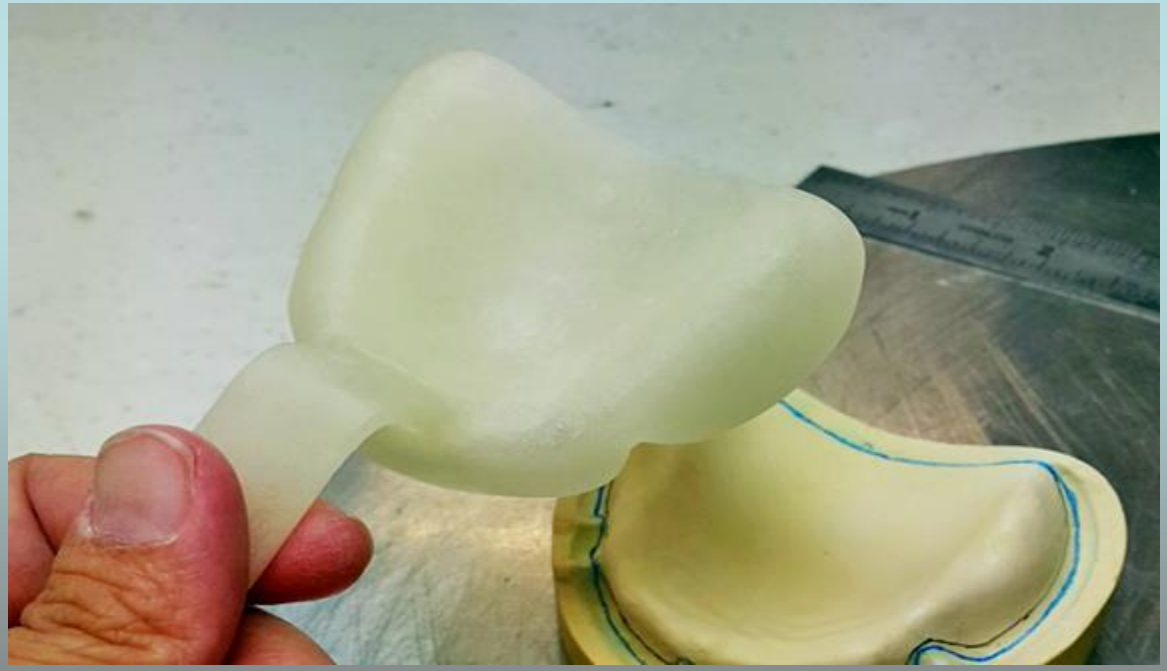
a) THERMAL ACTIVATION

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

1- ACTIVATION

b) CHEMICAL ACTIVATION

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



1- ACTIVATION

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.

1- ACTIVATION

Generally

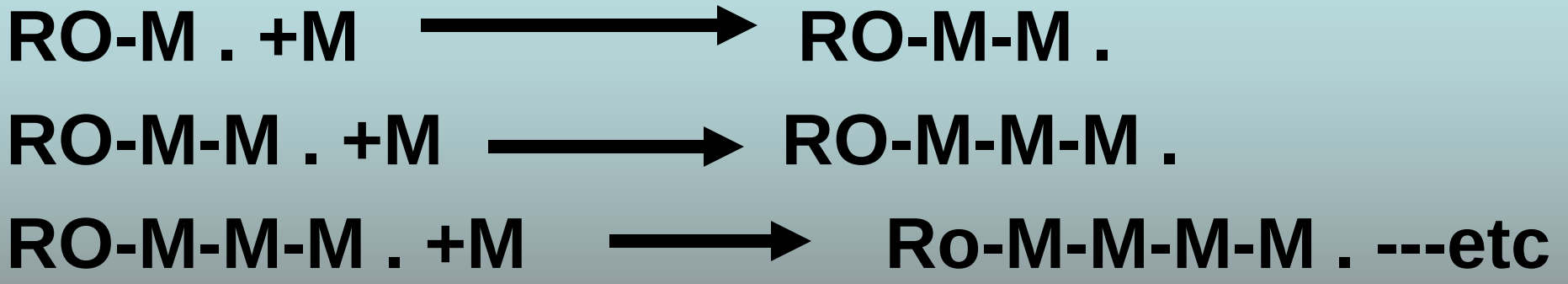
R= represent any organic molecular grouping

2- INITIATION

M= represent one molecule of monomer.

3- PROPAGATION

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



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.

Thank you

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.

Hydroquinone is the most popular inhibitor used in dental resin

The following factors inhibit the polymerization:

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

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.

Ideal requirements of dental resins:

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.

Factors which control the structure and therefore the properties of polymer include:

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).

Tg temperature :(glass transition temperature)

Is the temperature at which molecular motions become such that whole chains are able to move.

It's close to softening temperature.

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Denture base polymers

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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:

1. Heat activated resins
2. Chemically activated resins
3. Light activated resins

The requirements for a clinically acceptable denture base material.

1- Strength and durability

2- Satisfactory thermal properties

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

The requirements for a clinically acceptable denture base material.

7- Biocompatible

8- Natural appearance

9-Color stability

10- Adhesion to plastics, metals, and porcelain

11- Ease of fabrication and repair

12-Moderate cost

Polymer/monomer ratio:

The acceptable ratio

3:1 by volume

or

2.5:1 by weight

By using this ratio the volumetric shrinkage 6% linear shrinkage 0.5%.

Polymer-monomer interaction

The resultant mixture will pass into 5 stages:

1. ?
2. ?
3. ?
4. ?
5. ?

Dough -forming time:

- The time from the beginning of mixing the polymer with the monomer until reach dough –like stage.
- Practically most resin reaches a dough-like consistency in less then 10 minutes.

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.

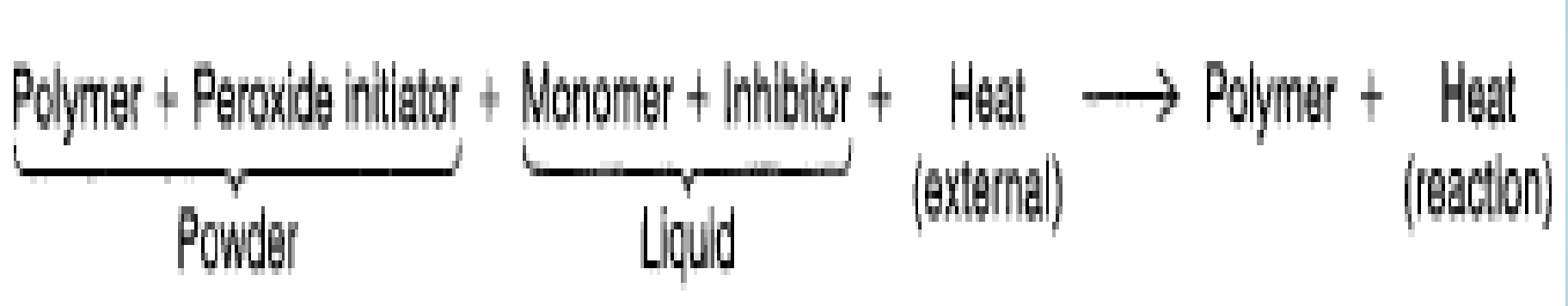
3- **Powder/liquid ratio:** increase this ratio will shorten the dough time.

Working time:

is the time that a denture base material remains in dough-like stage.

ADA specification No. 12 requires the dough to remain moldable for at least 5 minutes.

Heat- accelerated acrylic denture plastics



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:

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, packing, curing, cooling, divesting, finishing and polishing.

Curing may be done either by:

a- ***In water bath*** to raise the temperature and there are two recommended curing 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.

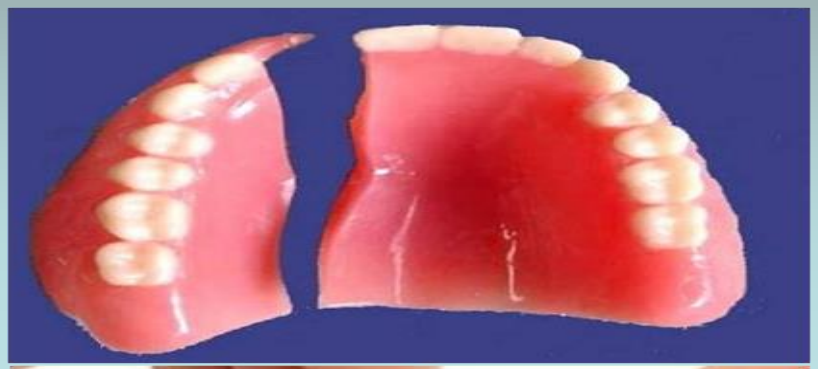
B- In microwave oven (here nonmetallic flask used).

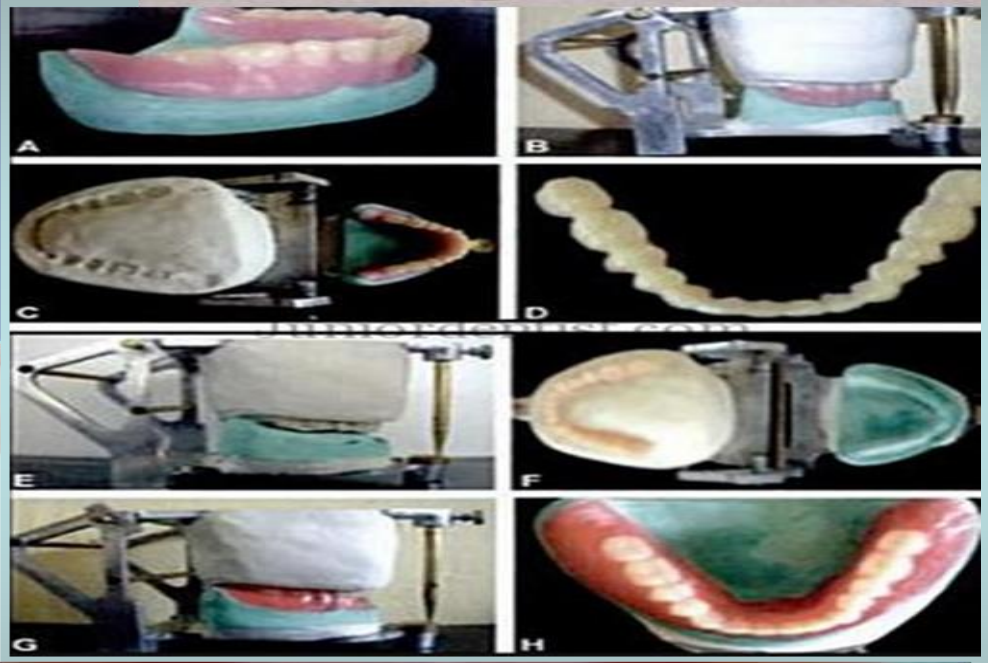
Chemically - accelerated acrylic denture plastics

Chemically - accelerated acrylic denture plastics

USES

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.




A
B
C
D
E
F
G
H


2
1
3
4

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.

Thank you

Light activated denture base resin:

Composition:

- Matrix of urethane dimethacrylate with an acrylic copolymer.
- Microfine silica fillers.
- Light initiators (photoinitiator) for polymerization (Comphoroquinone-amine).

Light activated denture base resin:

- 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.

Porosity:

Means the presence of surface and subsurface *voids* which compromise the physical, esthetic and hygienic properties of processed denture base.

Denture base materials

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

1. **Thermoplastic resin:**
2. **Thermosetting resin:**

Denture base materials

1. **Thermoplastic resin:** These are resins that can be repeatedly softened and molded under heat and pressure without any chemical change occurring.

They are fusible and are usually soluble in organic solvents.

e.g., ***poly methyl methacrylate,***

polyvinyl acrylics

polystyrene.

Denture base materials

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.

e.g. ***cross-linked poly(methyl methacrylate),***
silicones,
dimethacrylates.

Thermoplastic polymer (flexible dentures):

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

There are different kinds of thermoplastic resin like:

1.Thermoplastic acetyl.

2.Thermoplastic acrylic.

3.Thermoplastic polycarbonate.

4.Thermoplastic nylon.

The thermoplastic nylon:

Indicated in case of:

- Used in partial and complete dentures when there are undercuts (because of the flexibility of the material)
- 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
- 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).

Properties of the thermoplastic nylon (flexible denture):

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.

Properties of the thermoplastic nylon (flexible denture):

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.


THANK YOU