Dental materials I

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Contents

Course Description

This course will focus on the understanding of Dental Material and its physical and mechanical properties. This involves identifying, understanding Different Dental Material and learning about their use and manipulation along with implementation and monitoring of health communication/education activities. They will also gain practical experience by applying the knowledge gained during the academic year to better understand the subject.

CoreKnowledge

By the end of this course, students should be able to:
-Define Various Dental materials.
-Differentiate between their physical and mechanical Properties.
-Define the Dental Wax and its uses along with its types and composition.
-Define the Gypsum and its uses.
-Differentiate between polymers and their reactions and types.
-Differentiation between different types of Dentures.

CoreSkills

By the end of this course, students should be able to:

• Identify different Material and its uses.

Course Overview

		Methods of Teaching/Training with Number of Total Hours per Topic				
ID	**Topics**	**Interactive Lecture**	**Field Work**	**Class Assignments**	**Research**	**Lab**
1	Understanding of Physical and Mechanical properties of various Dental material	2		1		2
2	Recognition of Different testing Methods for Various properties	3				2
3	Discussion of Adhesion and Cohesion	3		2		2
4	Identification and Specification of Dental Wax	3				2
5	Identification of Gypsum Compound	4		2		2
6	Classification of polymers and their structure	3		1		2
7	Explanation of Polymerization reaction	3				2
8	Differentiation of types, properties and processing techniques of Denture bas resins	3		2		2
TOTAL HOURS (48)		**24**		**8**		16

Chapter 1

Physical and Mechanical Properties of Dental Material:

Objectives:

-Identifying different Dental Materials and their properties

Introduction

The science of dental materials involves a study of the composition and properties of materials and the way in which they interact with the environment in which they are placed.
General Properties of Dental Materials:
All materials have physical properties like color, weight, solubility, thermal conductivity, and others, also mechanical properties like hardness or softness, strength or weakness.
There is no material till know has ideal physical or mechanical properties. Most materials have some good and bad properties and sometimes a property that is bad in one material may be good or acceptable in another.

Characteristics of ideal material:

It should be
-Biocompatible
Non-toxic, non- irritant, non-allergic
-Mechanically stable and durable
Strong resistant to fracture

-Resistant to corrosion
Does not deteriorate overtime
-Dimensionally stable
Little change by temperature
-Minimal conductivity
Insulates against thermal, electrical change
-Esthetic
Looks like oral tissue
-Easy to manipulate
Minimal/ reasonable effort and time needed
-Adheres to tissues
Retainers onto and seals tooth structure
-Tasteless and odorless
Not unpleasant to patient
-Cleanable, repairable
Easy maintained or fixed

-Cost effective
Affordability vs. benefits, disadvantage

Material used in Dentistry:

Amalgam
Also commonly named “filling”, the amalgam is a sealant made of small particles of silver, tin and copper allied with mercury. Its mechanical properties and longevity has made it a first choice for many years. Its main flaw however is the fact that it contains mercury (admittedly in a stable form). Its unaesthetic aspect is also a shortcoming. This is why its use has become very limited in todays dentistry.

Composite
The aesthetic fillings exist since a long time, but the recent development of composite resins (by 3M) made a great impact in dentistry. Today this material is the first choice in conservative restorative dentistry, thanks to the important progress made for pulp protection and in the adhesive techniques. The composite is inserted into the cavity and hardened with a polymerisation lamp. These fillings are sometimes sensitive to cold for a couple of weeks.
Composite is also used to seal permanently crowns and bridges.

Glass Ionomere
This material is used for temporary fillings of deciduous teeth.
It is also used for permanent sealing of crowns and bridges as is very well tolerated.

Gold
In dentistry gold is found in the form of gold alloys. It is an ideal material because of its harmlessness, precision, and rigidity, which is essential for important prosthetic realisations. It is mainly used for posterior reconstructions.
Grey gold is usually chosen because it is less visible.

Ceramics
Because of the vast aesthetic possibilities they offer, the ceramic restorations have become the material of choice in fixed prosthetics (Crowns and Bridges). Its drawback is that it is extremely hard and can sometimes fracture.

Steel (chrome-cobalt)
This material is used in removable prosthetics for framework and clasps.

Titanium
It is used in implantology due to its antiallergic qualities. It can also be used in rare cases of metal allergy with removable prosthetics.

Acrylic resin
It is used to make the artificial gingiva in removable dentures. The teeth of dentures are made of acrylic resin or ceramics.

Zirconium
Zirconium is mainly used for the framework of fixed prosthetics. It is a type of CADCAM ceramic used in dentistry for the last 20 years, popular due to its biologic compatibility and its aesthetic properties. However, it is very expensive due to the advanced technology it requires.
Unfortunately it has given poor results in implantology and cannot be recommended in this field.

Physical properties:

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

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

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

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

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

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

7-THERMAL CONDUCTIVITY
Generally metals are better heat conductors than non-metals. 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.

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

MECHANICAL PROPERTIES

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

Stress:

Is the force per unit area induced in a body in response to some externally applied force, It is force\area measured in kg\cm2 or pound\inch2 or Pascal.

Strength:

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

Strain:

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

Strain= final length−original length/ original length

Percentage of elongation = strain × 100%

Types of Stress:

1-Tensile stress:

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

2-Compressive strain:

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

3-SHEAR STRESS:

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

Stress/Strain Curve:

Proportional limit:

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

Elastic deformation (elastic limit):

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

Ultimate strength:

Is the greatest stress which breaks the material.

MODULUS OF ELASTISITY:

Is the constant of proportionality. It is when any stress value equal or less than the proportional limit is divided by corresponding strain value. Modulus of elasticity =x = stress/ strain kg \cm2 or PSI or Pascal

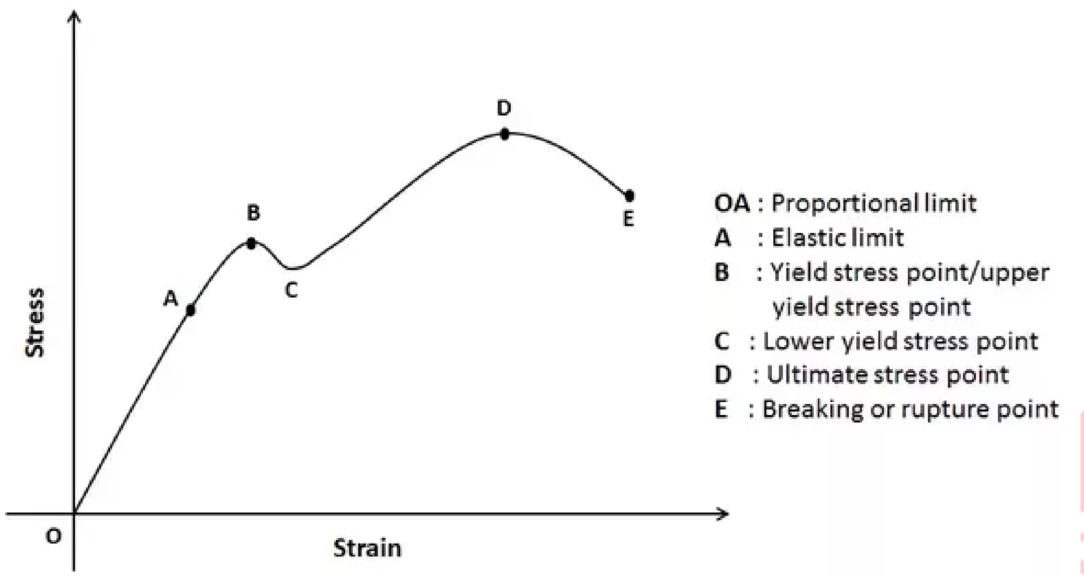
DUCTILITY:
It is the ability of the material to withstand permanent deformation under tensile stress without fracture; it depends on plasticity and tensile strength. It is the ability of the material to be drawn into a fine wire.

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

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

BRITTLENESS:
It is the opposite of ductility, it requires lack of plasticity. FLEXIBILITY The higher the strain which accrues when the material is stressed to its proportional limit.

RESILIANCE:
The amount of energy absorbed by a structure when it is stressed within the proportional limit.
HARDNESS:
It is the resistance of the material to deformation caused by penetrating or starching the surface.



Stress/strain Curve

Chapter 2
Different Testing Methods for Various properties of Dental Material:

Objectives:

-Learning about Different Testing methods for various Materials.

Different Testing Methods for Various properties of Dental Material:

Compression Testing:

Compression testing is a very common testing method that is used to establish the compressive force or crush resistance of a material and the ability of the material to recover after a specified compressive force is applied and even held over a defined period of time. Compression tests are used to determine the material behaviour under a load. The maximum stress a material can sustain over a period under a load (constant or progressive) is determined.

Deformation Testing

Deformation testing evaluates the effect that load has on the shape of a sample. It is the measurement of a sample material to withstand a permanent deformation and/or the ability of the sample to return to its original shape after deforming. Deformation is measured as the percent change in height of a sample, under a specified load, for a specified period of time.

A spring test is a type of deformation test where a spring is compressed to an L1 and L2 height and the load measurement is taken at each point and compared to a specified load. Spring rate can be determined. Ball punch deformation is used to evaluate and compare the formability of metallic sheet material used in production conditions and is used for materials with thicknesses between 0.0008 inch and 0.080 inch (0.20 mm and 2.00 mm)

Flexure strength measuring:

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'.

However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material.

Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength.

If we don't take into account defects of any kind, it is clear that the material will fail under a bending force which is smaller than the corresponding tensile force. Both of these forces will induce the same failure stress, whose value depends on the strength of the material.

- Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively call 3-Point Bend and 4-Point Bend testing.

  Maximum stress and strain are calculated on the incremental load applied. Results are shown in a graphical format with tabular results including the flexural strength (for fractured samples) and the yield strength (samples that did not fracture). Typical materials tested are plastics, composites, Metals, ceramics and Wood.

Chapter 3
Adhesion and Cohesion

Objectives:

-Differentiating between Adhesion and Cohesion and their application

Cohesion:
Is the property of like molecules (of the same substance) to stick to each other due to mutual attraction.

Adhesion:
Is the property of different molecules or surfaces to cling to each-other. For example, solids have high cohesive properties so they do not stick to the surfaces they come in contact. On the other hand, gases have weak cohesion.

Water has both cohesive and adhesive properties. Water molecules stick to each other to form a sphere. This is the result of cohesive forces. When contained in a tube, the water molecules touching the surface of the container are at a higher level.
This is due to the adhesive force between the water molecules and the molecules of the container.

	Adhesion	Cohesion
Constituents	Dissimilar molecules	Similar molecules
Effect	Capillary action, meniscus	Surface tension, capillary action and meniscus

Effects of cohesion and adhesion:

Surface Tension:

Surface tension is the result of cohesive forces between adjacent molecules.

Water molecules bead together on a wax paper because surface tension is greater than the adhesive forces between the paper and water molecules.

The surface tension of water allows objects heavier than it to float across it. When water molecules do not stick to the object (non-wettable) and the weight of the object is less than the forces due to surface tension.

Meniscus

Concave and Convex Meniscus. The meniscus is concave when adhesive forces are stronger than cohesive forces. e.g. water. It is convex when cohesion is stronger. e.g. mercury

The curved surface of a liquid inside a container is the meniscus.

- When the cohesive forces between the liquid molecules are greater than the adhesive forces between the liquid and the wall s of the container, the surface of the liquid is convex. For example, Mercury in a container.

- When the cohesive forces between the liquid are less than the adhesive forces between the liquid and the container, the surface curves up. For example, water in a glass container.

- When both adhesive and cohesive forces are equal, the surface is horizontal. For example, distilled water in a silver vessel.

Capillary action

Capillary action is the result of cohesive and adhesive forces. When a liquid flows through a narrow space, the cohesive and adhesive forces act together to lift it against the natural force of gravity. Wetting of a paper towel, water flowing up from the roots to the tip of a plant are a few examples of capillary action.

Mercury exhibits more cohesion than adhesion with glass.

Cohesion causes water to form drops, surface tension causes them to be nearly spherical, and adhesion keeps the drops in place.

Chapter 4
Dental WAX

Objectives:

-Identifying the Dental wax and Learning about its origin and Structure.

History of Dental Wax:

Wax has been a valuable commodity for over 2000 years. In ancient times beeswax was used for softening skin, binding together reeds used for flutes, coating and preserving valuable objects, candle production, and making sculptures and statues of highly regarded public figures. Beeswax was derived from secretions that bees use to build honeycombs.
Synthetic waxes are typically composed of hydrogen, carbon, oxygen, and chlorine. Synthetic waxes are more uniform than natural waxes in their organic structure and more homogeneous in composition.

Carnauba is one of the hardest and most durable waxes. It is derived from the fronds of carnauba palm trees and is one of the main components of dental **inlay wax**.

Candelilla wax, a major component of some dental waxes, is obtained from plants growing in Costa Rica, Guatemala, Mexico, Nicaragua, Panama, and the southwestern United States. In comparison to plant-derived carnauba and candelilla waxes, animal-derived beeswax, smd mineral-derived paraffin and ceresin waxes, other dental waxes are produced from components of fats, gums, oils, and resins.

REQUIREMENTS OF DENTAL WAX:

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

CLASSIFICATION OF WAXES ACCORDING TO ORIGIN
I- MINERAL
1- Paraffin wax
Refined from crude oil, has relatively low melting point (50-70°C) and relatively brittle.
2- Ceresin wax
Refined from petroleum, has medium melting range (60°C).

II- PLANTS
1- Carnauba
Obtained from palm trees, it is hard, tough, and has high melting point (80-85°C).
2- Candelilla
It is hard, tough, and has high melting point (80-85°C), used to increase the melting point and reduce flow at mouth temperature.

III- ANIMAL
1- Stearin

Obtained from beef fat, has low melting point.
2- Bees wax
Obtained from honey-comb, consist of partially crystalline natural polyester. It is brittle, has medium melting temperature (60-70°C).

IV- SYNTHETIC WAX
They are used to modify some properties of natural waxes like polyethylene.

CLASSIFICATION OF WAXES ACCORDING TO USE

I- PATTERN WAX
1- Inlay wax
It should be hard and brittle in order to fracture rather than to distort when removal from undercut areas. The wax is blue in color. They are used to make inlays, crowns and pontic replicas. They are mostly paraffin with carnauba wax. There are two types:
a- Type 1: for direct technique.
b- Type 2: for indirect technique.

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

3- Denture base plate wax (modeling wax)
It is used to form the base of the denture and in setting of teeth. It is pink in color.

II- PROCESSING WAX
Waxes are used during processing of the appliance:
1- Beading wax
It is used to make beading around the impression before pouring gypsum to protect the margins of the cast.

2- Boxing wax
It is used to make box around the impression to make pouring gypsum into the impression easier and more perfect.

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

4- White wax
It is used to make pattern simulate veneer facing in crowns.

5- Sticky wax
It is used to join and stabilize temporary broken pieces of the broken denture before repair.

III- IMPRESSION WAX

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

1- Impression wax

It is used to make the impression.

2- Corrective wax

It is used to record selected areas of soft tissues in edentulous arches.

Desirable Properties of Wax

1. The wax should be uniform when softened. It should be compounded with ingredients that blend with each other so that there are no granules on the surface and no hard spots within the surface when the wax is softened.
2. The color should contrast with die materials or prepared teeth.
3. The wax should not fragment into flakes or similar surface particles when it is molded after softening.
4. Once the wax pattern has solidified, it is necessary to carve the original tooth anatomy and the margins so that the pattern conforms precisely to the surface of the die.

Wax Distortion

Distortion of wax patterns is the most serious problem one can experience in forming and removing the pattern from a tooth or die. Distortion of a wax pattern results from occluded air in the pattern, physical deformation (during molding, carving, or removal), release of stresses "trapped" during previous cooling, excessive storage time, and extreme temperature changes during storage.

A newly made wax pattern tends to change its shape and size over time. Upon cooling it contracts and, after attaining equilibrium, reaches a state of dimensional stability. It is important that the wax pattern be retained on the die for several hours to avoid distortion and ensure that equilibrium conditions are established.

Chapter 5
Gypsum Compound

Objectives:

-Identifying
Gypsum compounds and their uses along with their technique of use.

Gypsum Products in Dentistry

– Gypsum products are supplied as fine powders that are mixed with water to form a fluid mass that can be poured and shaped and that subsequently hardens into a rigid, stable mass.

– Gypsum products are used mainly for positive reproductions or replicas of oral structures.

– These replicas are called casts, dies, or models, and they are obtained from negative reproductions, such as alginate impressions.

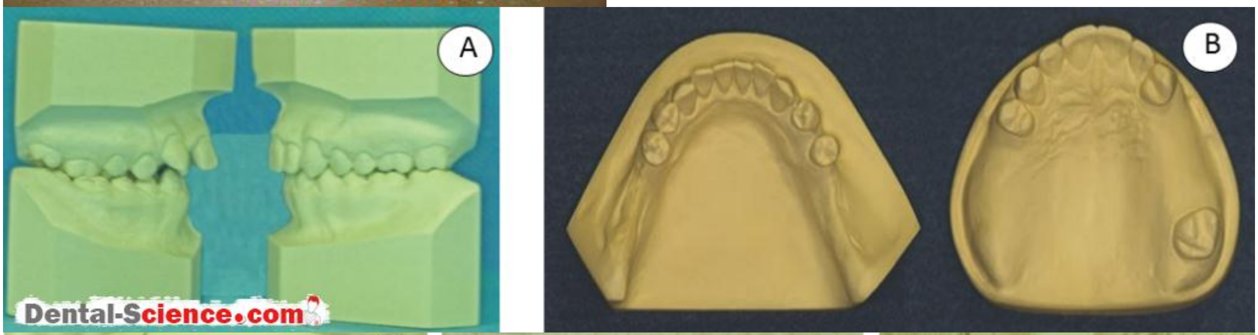
– Each replica has a specific purpose:

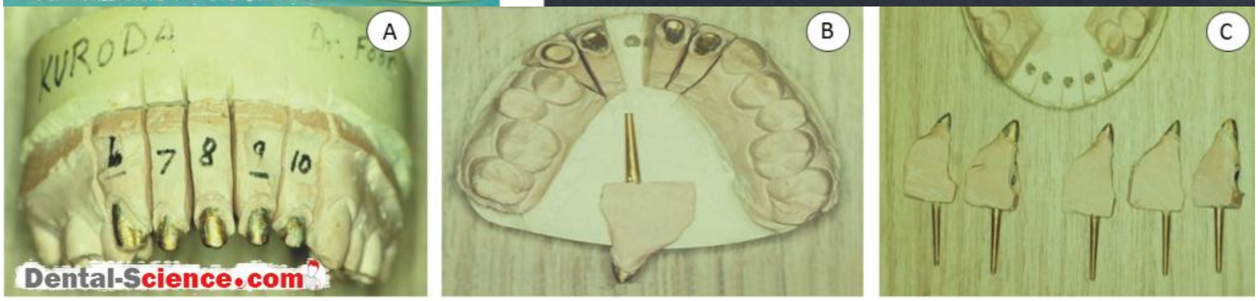
1. A study model is used to plan treatment and to observe treatment progress.
2. A cast is a replica on which a restoration or appliance is fabricated.

A cast is more accurate than a study model and is a replica of more than one tooth, such as a quadrant or a full arch. It may be partially or completely edentulous

3. A die is a working replica of a single tooth. Typically, it is a removable part of a cast.

Because indirect dental restorations are fabricated on these casts or die replicas, it is essential that the particular gypsum product be carefully manipulated to ensure an accurate restoration.





B. Desirable Properties

– Several properties are required of a material to be used for making casts, models, or dies.

– These properties are:

1. Accuracy

2. Dimensional stability

3.Ability to reproduce fine detail

4.Strength and resistance to abrasion

5.Compatibility with the impression material

6.Color

7.Biological safety

8. Ease of use

9. Cost

– Not all gypsum products display all of these desirable properties equally.

Types of Gypsum Products

– Gypsum products are made from gypsum rock, which is a mineral found in various parts of the world.

– Gypsum rock is mined, ground into a fine powder, and then processed by heating to form a variety of products.

– Chemically, gypsum rock is calcium sulfate di hydrate ($CaSO_4 \cdot 2H_2O$).

– Calcium sulfate di hydrate can also be produced synthetically.

– Pure gypsum is white, but in most deposits, it is discolored by impurities.

– Gypsum products are used in dentistry, medicine, homes, and industry.

– In homes, gypsum plaster is used to make walls; in industry, it is used to make molds.

– Chemically, all are calcium sulfate hemihydrate.

– They are produced as a result of heating gypsum and driving off part of the water of crystallization.

– This process is called calcination and is shown in the following equation:

$CaSO_4.2H_2O$ + heat >>>> $(CaSO_4)_2.H_2O$ (or $CaSO_4.\frac{1}{2}H_2O$) + $1\frac{1}{2}H_2O$

– Plaster, stone, and improved stone differ in the physical characteristics of their powder particles as a result of differing calcination methods.

– These differences in powder particles are responsible for their different properties, which make them suitable for various uses.

– The manufacturers add other chemicals to improve handling and various properties.

A. Plaster

– Plaster was the first gypsum product available for dentistry.

– It is manufactured by grinding the gypsum rock into a fine powder and then heating that powder in an open container.

– This direct and rapid heating in open air drives part of the water of crystallization from the crystal and shatters the crystal.

– The resulting powder consists of porous, irregular particles Plaster is the weakest and least expensive of the three gypsum products.

– It is used mainly when strength is not a critical requirement, such as preliminary casts for complete

dentures and attaching casts to an articulator.
– Plaster is usually white in color and sometimes is referred to as beta-hemihydrate or Type II.
– In the past, plaster was modified for use as an impression material by the addition of chemicals and was called impression plaster.

B. Stone

– Stone is made from gypsum by carefully controlled calcination under steam pressure in a closed container.
– This method of calcination slowly releases the water of crystallization from the crystal so that the resultant powder particle is more regular, more uniform in shape, and less porous compared to that of plaster.
– Stone is stronger and more expensive than plaster.
– It is used mainly in making casts for diagnostic purposes and casts for complete and partial denture construction, which require greater strength and surface hardness than that of plaster.
– The stone is usually yellow, but it can be obtained in other colors.
– It is often referred to as alpha-hemihydrate, Type III stone, or Hydrocal.

C. High-Strength or Improved Stone

– High-strength stone, or improved stone, is also made from gypsum by calcining the gypsum in a calcium chloride solution.
– This method of calcination results in a powder particle that is very dense, is cuboidal in shape, and has a reduced surface area.
– High-strength stone is the strongest and most expensive of the three gypsum products, and it is used mainly for making casts or dies for crown, bridge, and inlay fabrication.
– This material is used because high strength and surface hardness are required during the fabrication process of crowns
– High-strength stone is often referred to as Type IV stone, die stone, densite, and modified alphahemihydrate.

– A newly developed high-strength stone with a higher compressive strength than that of Type IV stone is also available.
– It displays higher setting expansion and is referred to as Type V stone.

D. Other Types of Gypsum

– Other types of gypsum products are produced for special uses, such as fast set, mounting of casts on articulators, and impressions.

Setting Reaction

– When any of the three types of calcium sulfate hemihydrate is mixed with water,
the hemihydrate is changed back to dihydrate by the process of hydration.
– Heat is liberated, as shown by the following reaction:
$CaSO_4.\frac{1}{2}H_2O + 1\cdot H_2O$ >>>>> $CaSO_4\cdot 2H_2O$ + heat
– The calcium sulfate hemihydrate dissolves in the mixing water to form the dihydrate, which is less soluble than the hemihydrate.
– The calcium sulfate dehydrate precipitates out of solution as interlocking crystals, which form a hard mass.

Setting Expansion

– All gypsum products expand externally on setting.
– Plaster expands the most, at 0.2% to 0.3%.
– Stone expands 0.08% to 0.10%. High-strength stone expands the least, at 0.05% to 0.07%.
– Theoretically, a contraction on setting can be calculated; however, the growing crystals of the gypsum push against each other and cause an outward crystal thrust.
– In turn, this thrust causes an external expansion with resulting internal porosity in the set mass.
– A minimal setting expansion is desirable to achieve accurate dimensional reproduction for most casts

and dies.

– Manufacturers modify most gypsum products that are used for casts and dies to provide for minimal expansion.

– They do this by the addition of chemicals, which also control the setting characteristics.

– Thus, a particular gypsum product has both the setting time and expansion characteristics controlled by the manufacturer.

– The setting expansion can be controlled by manipulating variables.

– A thicker mix and increased spatulation will cause an increase in the amount of setting expansion; a thinner mix and decreased spatulation will cause a decrease in the amount of setting expansion.

– In most dental offices, however, there is little need to change the expansion characteristics of gypsum products.

– If gypsum materials are immersed in or come in contact with water during the setting process, the setting expansion increases.

– This is called hygroscopic expansion, and it can be used to increase the setting expansion of casting investments.

– Although small, hygroscopic expansion is approximately twice as great as the normal setting expansion.

– Therefore, to prevent an inadvertent increase in size, routine casts should not be immersed in water during setting.

Technique of Use

– The technical use of gypsum products is relatively simple, requiring only a mixing bowl, mixing spatula, room-temperature water, and the appropriate gypsum product.

–The water and powder must be proportioned accurately for optimum properties to be obtained.

– The measuring and mixing technique can be summarized as follows.

A. Measuring the Water

– The water is usually dispensed by volume in a graduated cylinder because 1 g of water has a volume of very close to 1 ml.

B. Measuring the Powder

– The powder can be weighed in grams with a simple balance or scale.

– Use of a dietetic scale is a convenient method for weighing the powder.

– First, the water is added to the mixing bowl and it is placed on the scale.

– Second, the scale is tarred (reading is set to zero).
– Finally, the powder is added to the bowl with a suitable scoop until the desired weight of powder has been added.
– Volume dispensers may also be used.
– Volume dispensing of the powder is not as accurate, however, because of the varying packing effect on the powder.
– Weighing with the scale is a simple and convenient method to ensure accurate proportions.
– Pre-weighed envelopes are now available that control the weight of the powder to provide accuracy and reduce both wasted powder and time required.

C. Adding Powder and Water
– The preferred method of mixing is to add the measured water into the mixing bowl first, followed by gradual addition of the pre-weighed powder.
– The guesswork of repeatedly adding water and powder to achieve the proper consistency is to be avoided even though it is a common practice.
– It can result in low strength and inconsistent expansion.

D. Mixing

1. Hand Mixing
– Hand mixing is usually done in a flexible plastic or rubber bowl with a stiff-bladed spatula to combine the powder and water.
– The mix should be smooth, homogeneous, workable, and free of air bubbles.
– A minimum of air inclusion in the mixed product is desirable to prevent surface bubbles and internal defects.
– Mixing is usually accomplished with a wiping motion against the sides of the bowl (to eliminate lumps and air bubbles).
– Use of a dental vibrator will reduce bubbles in the mix.
– A smooth, homogeneous mix should be obtained in approximately 1 minute.
– A whipping motion should be avoided.

2. Vacuum Mixing
– Often, mixing is done mechanically with a vacuum mixing and investing machine.
– This provides a gypsum mix that is free of air bubbles and is homogeneous in consistency.
– Many devices are available that will mix gypsum products mechanically with or without

vacuum.
– They are used when the elimination of voids and surface bubbles is critical.

E. Filling the Impression
– When filling the impression, the gypsum mixture needs to flow slowly “ahead of itself” to prevent the entrapment of air.
– This is usually accomplished with a dental vibrator.
– This is particularly important when filling elastomeric impressions, which in many instances are water repellent.
– Vibrating the mix after mixing can also be used to bring air bubbles to the surface.
– Although relatively simple, manipulation of gypsum products requires careful attention to detail for accurate results.

Composition of Gypsum-Bonded Investments:

The ingredients of dental inlay investments employed with conventional gold casting alloys are α-hemihydrate of gypsum, and quartz, or cristobalite, which are forms of silica. Most investments contain the α-hemihydrate of gypsum because of its greater strength. This gypsum product serves as a binder for the other ingredients and to provide rigidity. The strength of the investment is dependent on the amount of binder used. The investment powder may contain 25% to 45% of calcium sulfate hemihydrate. The remainder consists of silica allotropes and controlling chemicals.

Gypsum-Bonded Investments

The α-hemihydrate form of gypsum is generally the binder for investments used in casting gold-containing alloys with melting ranges below 1000 °C. When this material is heated at temperatures sufficiently high to completely dehydrate the investment and to ensure complete castings, it shrinks considerably and occasionally fractures.

The thermal expansion curves for the three common forms of gypsum products. All forms shrink considerably after dehydration between 200 °C and 400 °C. A slight expansion takes place between 400 °C and approximately 700 °C, and a large contraction then occurs. This latter shrinkage is most likely caused by decomposition and the release of sulfur dioxide. This decomposition not only causes shrinkage but also contaminates the castings with the sulfides of the non-noble alloying elements, such as silver and copper. Thus, it is imperative that gypsum investments not be heated above 700 °C. However, for gypsum products containing carbon, the maximum temperature is 650 °C. In this way proper fit and uncontaminated alloys are obtained.

Chapter 6

Polymers

Objectives:

-Identifying the Polymers and their uses in Dentistry.

Introduction:

The term polymer denotes 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. Thus poly (methy1 methacrylate) is a polymer having chemical structural units derived from methyl methacrylate.

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

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

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

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

MOLECULAR WEIGHT:

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

PHYSICAL PROPERTIES OF POLYMERS:

1) Deformation & in viscoelastic, recovery occurs over time.

a) Plastic deformation: Permanent change, applied forces within polymers produces Recovery.
b) Elastic: Reversible
c) Viscoelastic: Combination of both Therheometry, or flow behavior, of solid polymers involves a combination of elastic

2) Rheometric properties & plastic deformation (viscous flow) & elastic recovery when stresses are eliminated.

3) Thermal properties: Higher the temperature, The softer & weaker the polymer.

The term POLYMERIZATION:
is the process by which the monomers convert into polymers, but the DEGREE OF POLYMERIZATION is defined as the total number of mers in a polymer molecule.

Uses of polymers:

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

Chapter 7

Polymerization Reactions

Objectives:

-Identifying different types and mechanisms of Polymerization reactions.

POLYMERIZATION

Polymerization reactions fall into two basic types:

1- Addition polymerization.
2- Condensation polymerization.

ADDITION POLYMERIZATION (Free-Radical Polymerization)
Most dental resins are polymerized by addition polymerization which simply involves the joining together of monomer molecules to form polymer chain. In this type of reaction, no byproduct is obtained.
The reaction takes place in three CHEMICAL STAGES:
1- Initiation stage.
2- Propagation stage.
3- Termination stage.

1- Activation and initiation stage

To start the addition polymerization process a free radicals must be present. (Free radicals are very reactive chemical species that have an unpaired electron).
The free radicals are produced by reactive agents called initiators.
(Initiators are molecules which contain one relatively weak bond which is able to undergo decomposition to form two reactive species (free radical), the decomposition of bond of initiator need source of energy (activator) such as heat, chemical compound, light, electromagnetic radiation).
Initiator is used extensively in dental polymers is (Benzoyl peroxide).
Addition polymerization reaction is initiated when the free radical reacts with monomer molecules producing another active free radical species which is capable of further reaction.

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

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

CONDENSATION POLYMERIZATION

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

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

Chapter 8

Denture base material

Objectives:

-Identifying different Materials used in manufacturing of Denture base and their properties

Introduction

Since first polymerized by Walter Bauer in 1936, acrylic resin denture base gradually took the place of traditional metal base and became most commonly used denture base material in clinical fabrication.

Poly (methylmethacrylate) is still the most predominantly used denture base material because of its excellent esthetics, ease of processing and repair and being economical. It is a combination of advantages rather than one excellent aspect that accounts for its wide usage, including its popularity in satisfying aesthetic demands and clearly defined processing method in dentistry application.
However, this material is not ideal in every respect, especially when meeting with mechanical requirements of prosthesis. Fracture of acrylic resin denture base happens frequently because of the fatigue and chemical degradation of base material, which is reflected by a large number of denture repairs annually. Thus, to overcome these drawbacks, there has been much new advancement in the field of acrylics. Resins have been reinforced using different materials to improve strength. The hypoallergenic resins overcome the problems of monomer allergy. Other physical properties have also been improved by using different additives in resins. Several modified poly (methyl methacrylate) materials have been used for denture base applications. These include the pour type of denture resins, rapid heat polymerized acrylics, light activated denture base materials and high impact resins . This article reviews the various advancements in the field of acrylics.

Types of Denture Base:
Plastic: Acrylic - hot cure - cold cure - light cure
Metal
Gold
Co-Cr
Titanium
Vitallium

Metal Denture base
Indications:
Tooth supported partial dentures Inadequate inter-arch space Structural details Designed with optimum extension Thinner base than plastic resin Avoid sharp margins
Advantages:
• Accuracy & performance of form
• Compatible tissue response
• Thermal conductivity
• Weight & Bulk

Tissue response:
Inherent cleanliness of cast metal base contributes to health of oral tissue.
Bacteriostatic activity – ionization and oxidization of metal base.

Metal base naturally cleaner than an acrylic resin base.

Thermal conductivity:
Temperature changes transmitted though metal to the underlying help to maintain health of that tissue.
Weight and bulk:
-Metal alloy may be cast thinner than acrylic resin and still have adequate strength.
-Certain situations demands use of acrylic denture base

Metal Base-Disadvantages:
- Esthetics
- Enhancement of retention not possible – lack of weight of metal base
- Relining difficult
- Restoration of normal facial contour cannot be achieved

Acrylic denture base:

Acrylic denture base- Indications:
-Extension base partial denture.
-Long span edentulous ridges.
-Contour restoration.

Mechanical properties:

The tensile strength of acrylic resin is typically no more than 50mpa , the elastic modulus is low , the flexure modulus being in the region of 2200 – 2500 mpa .When this is combined with lack of fracture toughness , it perhaps not surprising that dentures are prone to fracture .An alternative approach for strengthening of acrylic dentures is incorporation of fibers so as to produce a fiber – reinforced composite.

Physical properties:
-Thermal conductivity:- acrylic has low coefficient of thermal conductivity , from a patient point of view , it will isolate the oral soft tissues from any sensation of temperature.

-Coefficient of thermal expansion:- it's quite high about 80 ppm / c , in general it does not present any problem except that there is possibility that porcelain teeth set in denture base resin may gradually loosen and lost due to different expansion and contraction.

-Water sorption and solubility:- resin molecule absorbs water due to its polar nature , in practice this helps to compensate for the slight processing shrinkage.

-Biocompatibility:- acrylic is highly biocompatible and patients suffer few problems , nevertheless some patients will show an allergic reaction and this is most probably associated with the various leachable components in the denture such as any residual monomer or benzoic acid .

New Types:

1. Reinforced Resins
a. Fibre-Reinforced
b. High Impact Resins

2. Hypoallergenic Resins
3. Resins with Modified Chemical Structure
4. Thermoplastic Resins
5. Enigma Gum Toning In Denture Bases

Reinforced resins

1-Reinforced Resins Fiber

Primary problem with PMMA is low impact strength & low fatigue resistance. To improve the physical and mechanical properties of acrylic resin. Fiber reinforcement result in a 1000% strength increase over nonreinforced (if there is proper bonding). It was reinforced with embedded metal forms Fibres have been used in three forms, namely, continuous parallel, chopped and woven.

2-High impact resins Rubber reinforced (butadiene-styrene polymethyl methacrylate).
Rubber particles grafted to MMA for better bond with PMMA. They are so-called because of greater impact strength and fatigue properties, hence indicated for patients who drop their dentures repeatedly e.g. Parkinsonism, senility. Available as powder-liquid system & processing is same as heat cure resins.

3- Metal fiber reinforced:
Not widely used because unesthetic, expensive, poor adhesion between wire and acrylic resin and metal being prone to corrosion. Using full lengths of metal fibers offers the best reinforcement .

4- Carbon / graphite fiber reinforced: Carbon fibers (65-70 mm length, 5% by weight and treated with silane coupling agent) are placed during packing. Carbon Graphite fibres are available as-chopped, continuous, woven, braided and tubular but tubes of braided fibres provide a more even distribution of reinforcement, high filler loading and easy handling because fibre bundles at different angles are advantageous when multiaxial forces are present (e.g. in implant supported prosthesis) .

5- Aramid fiber reinforced: Aramid fiber reinforcement increases the strength but again they are unesthetic& difficult to polish so limited to locations where aesthetics is not important.

6-Polyethylene fiber reinforced: Multifibered polyethylene strands cut to 65 mm length and surface treated with epoxy-resin (to improve adhesion)

ReferencesandRecommendedReadings

Textbooks:

1-"introduction to dental materials " van noort
2-"clinical aspects of dental materials " gladwin

Periodicals and websites:

-Journal of dental materials
-Journal of dentistry
-Journal of prosthodontics

Book Coordinator **; Mostafa Fathallah**

General Directorate of Technical Education for Health