Gypsum Products

DR. AHMED MAGDY SAYED

LECTURER OF DENTAL BIOMATERIALS

Definitions

Model or Cast:

- It is the positive replica of the teeth and surrounding structure

Definitions

Die:

- It is a model of a single tooth

Definitions

Gypsum:

- It is a natural mineral.
- Its name is driven from Greek word “gypso” which means chalk or plaster

Ideal Requirements of Model and Die Material

1. It should have high strength to withstand manipulation steps.
2. It should have high hardness to resist scratching during use.
3. It should have good working time and short setting time.
4. It should reproduce fine details of the impression.

Ideal Requirements of Model and Die Material

5. It should have no dimensional changes during setting and storage.
6. It should have color matching with impression material.
7. Ease of use.
8. Cheap.

Gypsum products

Many materials have been used for model and die construction. But this chapter will discuss gypsum products as they are the mostly used materials in dentistry.

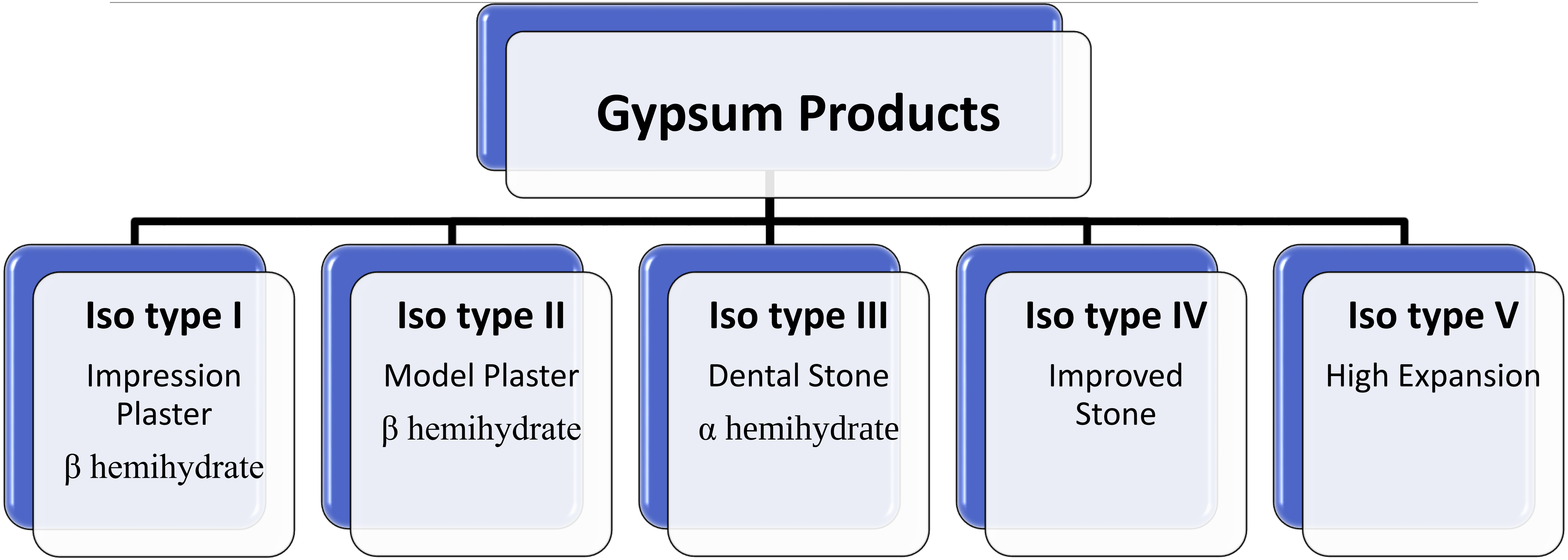
Gypsum products

- Gypsum is found naturally in mines in most countries. For centuries, it has been used in constructions and building statues.
- Alabaster is a form of gypsum that is white in color.

Gypsum products

- Gypsum is used in orthopedics for splinting the fractured bone.
- It is called *plaster of Paris* as it was obtained by burning the gypsum from deposits near Paris, France.

Classification of Gypsum Products



Gypsum Products

- All the forms have the same chemical composition. They differ in the method of manufacturing. So, they differ in properties and uses.
- Gypsum is found naturally in the form of calcium sulfate dihydrate ($CaSO_4 . 2H_2O$).

Gypsum Products

- All the products are manufactured by a heating the gypsum (calcination) at 110 -130 °C to get rid of part of water that convert calcium sulfate dihydrate to calcium sulfate hemihydrate.

Gypsum Products

Heating

$$CaSO_4 . 2H_2O \longrightarrow CaSO_4 . \tfrac{1}{2} H_2O + H_2O$$

110 -130 °C

Gypsum Products

- The calcium sulfate hemihydrate is supplied to dental professionals to be mixed with water.
- It obtains the water lost during manufacturing.

Gypsum Products

$$CaSO_4 . \tfrac{1}{2} H_2O + H_2O \longrightarrow CaSO_4 . 2H_2O + Heat$$

Gypsum Products

- The amount of water of crystallization (essential water) (required for the chemical reaction) for different products is the same (each 100 g of $CaSO_4$. ½ H_2O requires 18.6 g of water).
- Practically, excess water is needed to form homogenous workable mix. This excess water differs among the different gypsum products.

Gypsum Products

- **N.B:** *The excess water will evaporate in about 7 days leaving porous material.*

Gypsum Products

The amount of water required for 100 g of different types of gypsum:

- Plaster of Paris = 55 g
- Dental Stone = 30 g
- Improved Stone = 22 g

Gypsum Products

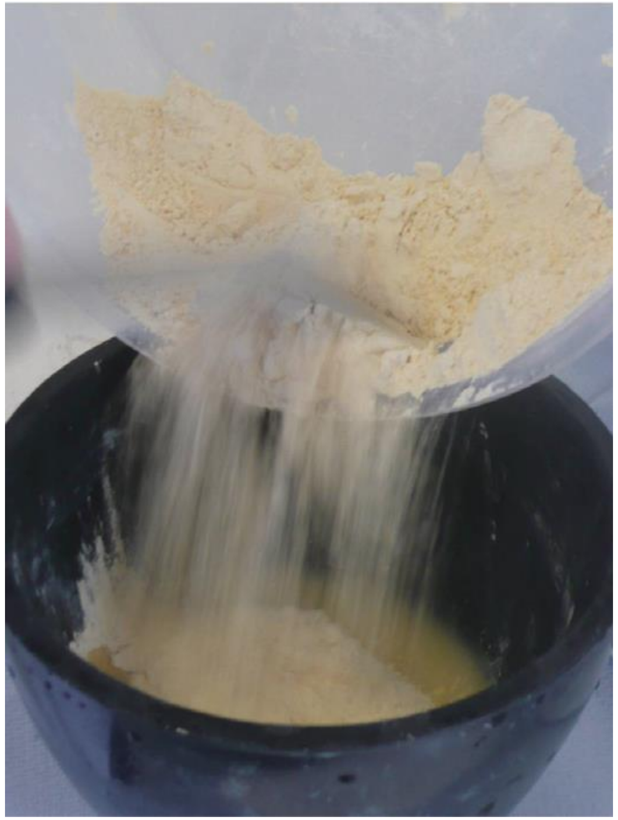
- The released heat from different products is equal to the heat used during manufacturing and it is the same in the different products.

Manipulation

- The suitable water/powder ratio is proportioned.
- Mixing is done using rubber bowl and rigid wide spatula.

Manipulation

- Water is dispensed first then the powder is added.
- The powder is allowed to settle for about 30 seconds to reduce air incorporation.



Manipulation

- Mix vigorously with wiping the inside surface of the bowl until obtaining homogenous mix (about 1 minute).

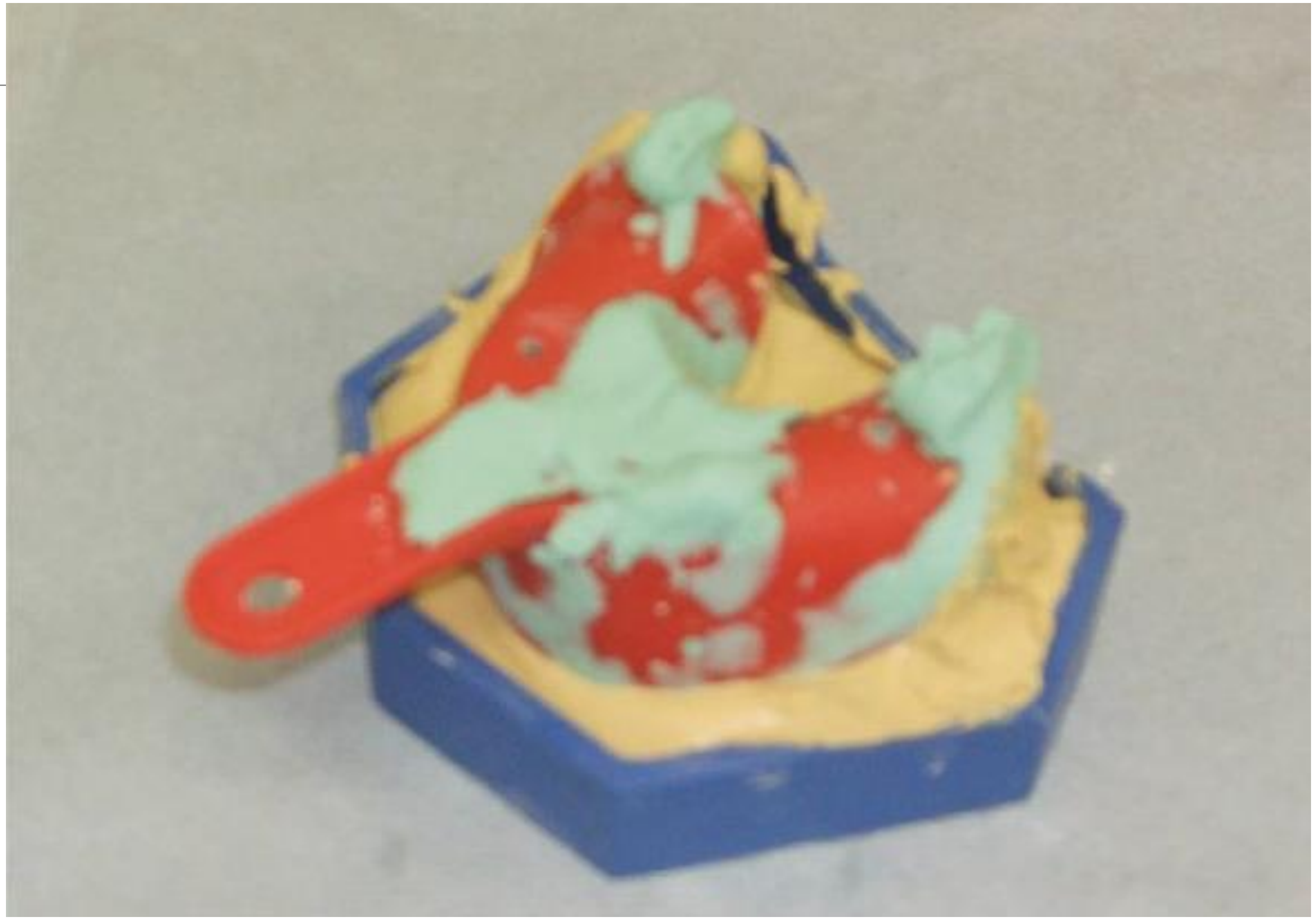
Manipulation

- Vibrate the mix using vibrator or by tapping the bowl against the bench.

Manipulation

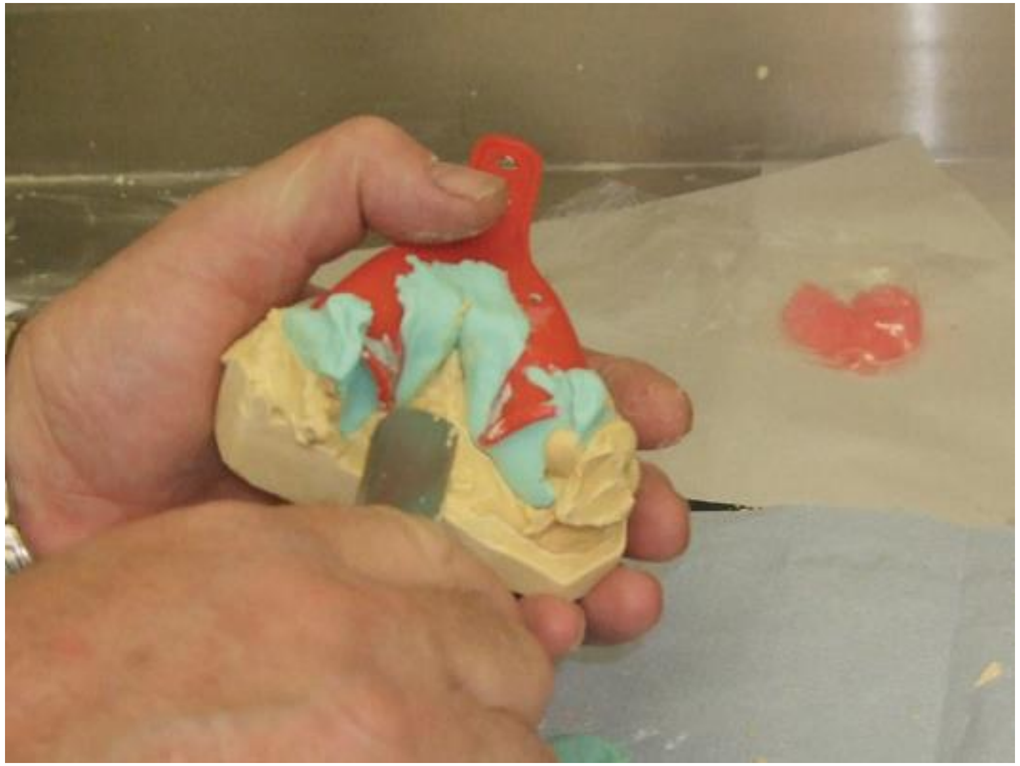
- Pour the impression with care to entrap no air bubbles.

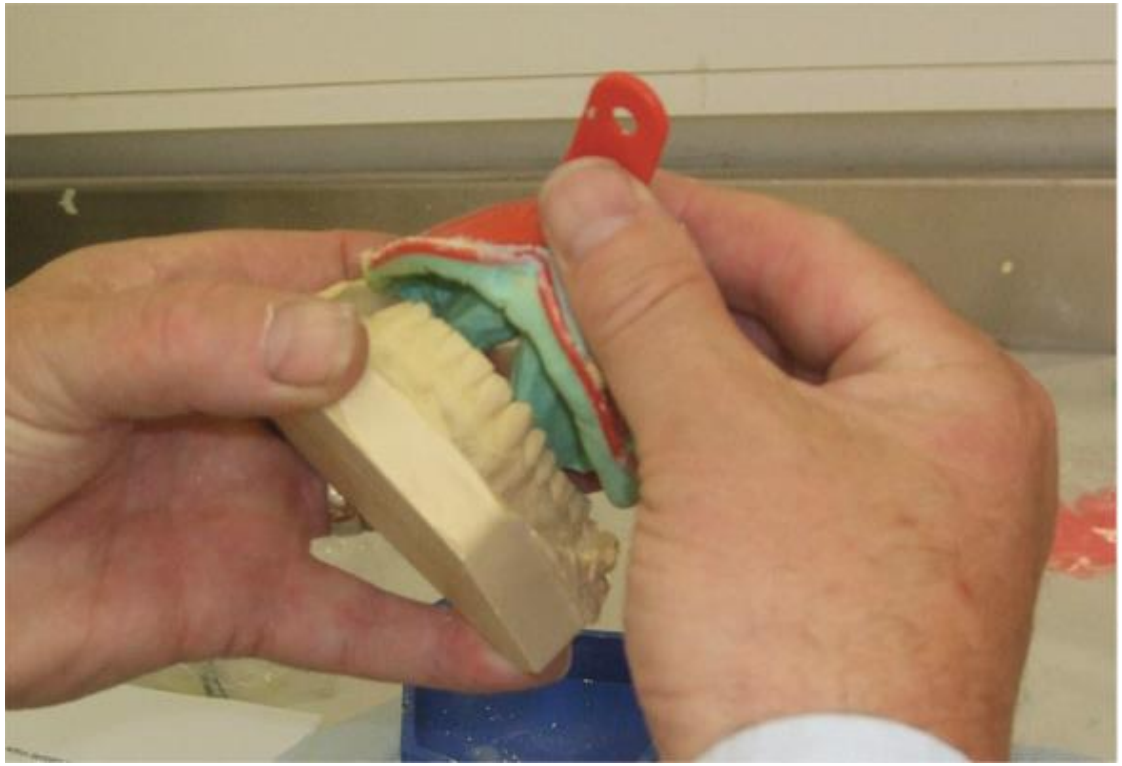
Manipulation



Manipulation

- After 1 hour, separate the impression from the cast.





Manipulation

- Mechanical mixers are available.
- They mix the gypsum under vacuum.

Manipulation

Be sure that the bowl and spatula should be clean. Remnants from previous mixing accelerate the setting reaction by acting as nuclei of crystallization.

Setting theory

<u>Crystallization theory:</u>

- It is originated by Le Chatelier and supported by Van’t Hoff.
- The theory refers setting of gypsum due to difference in solubility rate between $CaSO_4$. ½ H_2O and $CaSO_4$. 2 H_2O.

Setting theory

Crystallization theory:

- Part of $CaSO_4 . \frac{1}{2} H_2O$ dissolve in water ⇨ Ca^{++} and SO_4^{--}
- Ca^{++} and SO_4^{--} reacts to form $CaSO_4 . 2 H_2O$.
- The solubility of $CaSO_4 . \frac{1}{2} H_2O > CaSO_4 . 2 H_2O$

Setting theory

Crystallization theory:

- The amount of $CaSO_4$. ½ H_2O decreased
- The amount of $CaSO_4$. 2 H_2O increased.
- $CaSO_4$. 2 H_2O forms supersaturated solution ⇨ precipitated

Setting theory

Crystallization theory:

- $CaSO_4$. 2 H_2O precipitation starts as nuclei of crystallization ⇨ grows to form crystals (**spherulites**).

Properties

1. **Setting time:**

- It the time needed for completion of the setting reaction. It is divided into:

Time	From	Until	Minutes
Mixing time	Add powder to water	Obtain homogenous workable mix	1 minute
Working time		Having even consistency	3 minutes
Initial setting		Material not flow. It can be carved	12 minutes
Ready to use		Can separate the impression	30 minutes
Final setting		Complete the reaction	7 days

Properties

1. **<u>Setting time:</u>**

➢ Measuring setting time:

a) *<u>Loss of surface gloss:</u>*

   ➢ The mix starts to loss its gloss. It indicates initial setting. The impression should not be removed at this stage.

Properties

1. **Setting time:**

- Measuring setting time:

b) Temperature rise:

  - There is an increase in the temperature as the reaction is exothermic

Properties

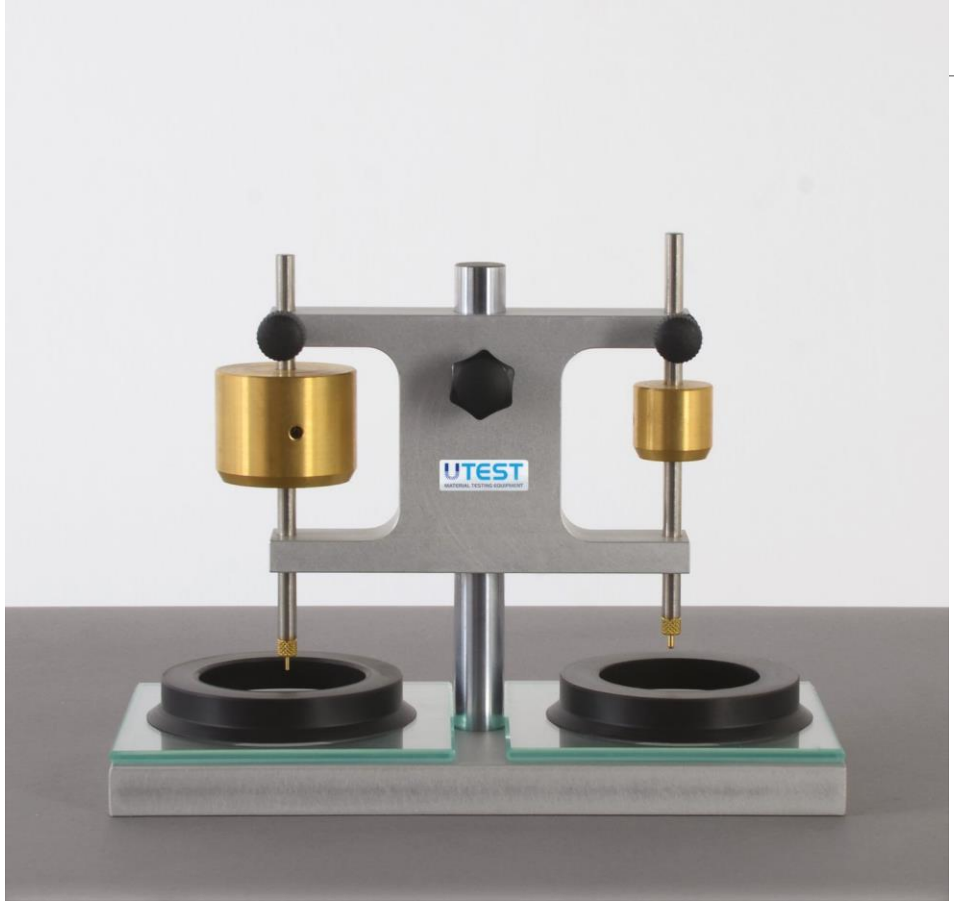
1. **<u>Setting time:</u>**

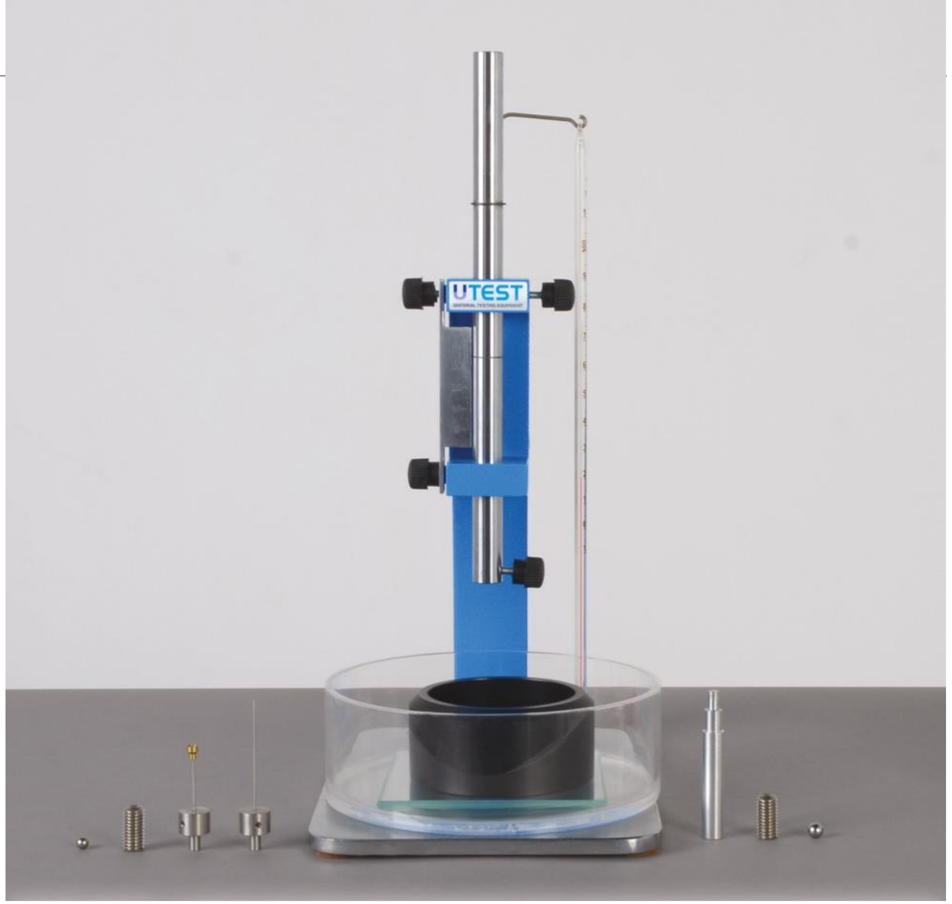
- Measuring setting time:

c) *<u>Penetration test:</u>*

   - It is the accurate method to measure the setting time.
   - As the material set, it will resist needle penetration.
   - Example: Vicate test and Gillmore test.

Properties





Properties

1. **Setting time:**

- Factors affecting setting time:

a) *Fineness of the powder:*

  - Finer powder → accelerate the reaction

Properties

1. **<u>Setting time:</u>**

- Factors affecting setting time:

b) *<u>Impurities :</u>*

  - Such as calcium sulfate dihydrate
  - They results from incomplete calcination or from uncleaned mixing instruments) → accelerate the reaction.

Properties

1. **Setting time:**

- Factors affecting setting time:

c) *Accelerators:*

   - Such as potassium sulfate.

Properties

1. **Setting time:**

➢ Factors affecting setting time:

d) *Retarders:*

  ➢ such as borax (from hydrocolloids), blood and saliva (from unclean impressions).

Properties

1. **<u>Setting time:</u>**

- Factors affecting setting time:

e) *<u>Water/powder ratio:</u>*

  - ↑ W/P → retard reaction

Properties

1. **<u>Setting time:</u>**

➢ Factors affecting setting time:

f. <u>↑ *Mixing time and rate* (within limits):</u>

   ➢ Accelerate the reaction

Properties

1. **<u>Setting time:</u>**

➢ Factors affecting setting time:

g. *<u>Water temperature</u>*:

- ➢ 20 :50 °C → accelerate the reaction.
- ➢ Above 50 °C → retard the reaction.
- ➢ 100°C → no reaction.

Properties

2. **Dimensional changes:**

a) Setting expansion:

- Theoretically, the dihydrate crystals volume is less than hemihydrate crystals volume by 7%.
- Actually, gypsum setting is accompanied by expansion.

Properties

2. **<u>Dimensional changes:</u>**

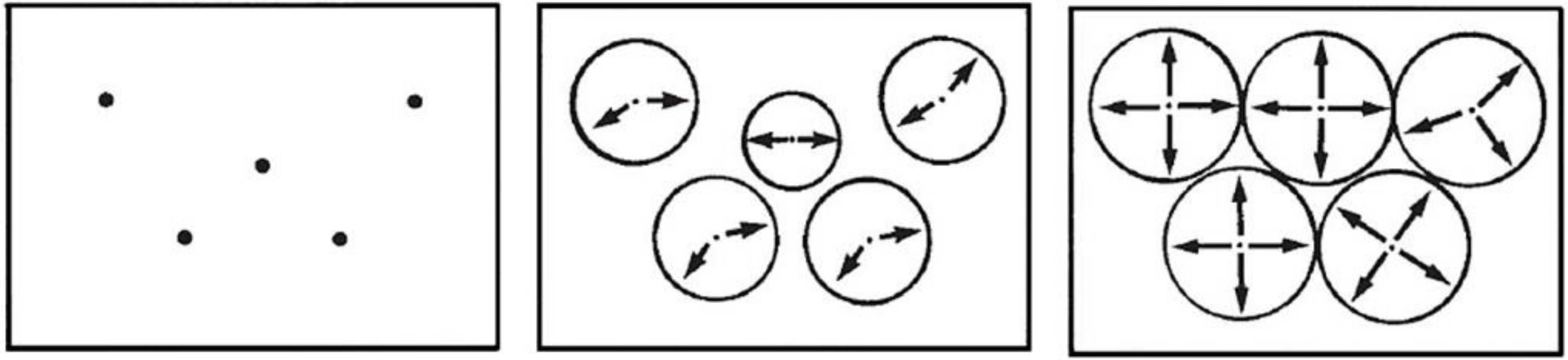
a) Setting expansion:

- This expansion is due to outward thrusting action of the growing crystals.
- i.e.: the crystals pushing each other apart during they growth.

Properties

2. **Dimensional changes:**

a) Setting expansion:

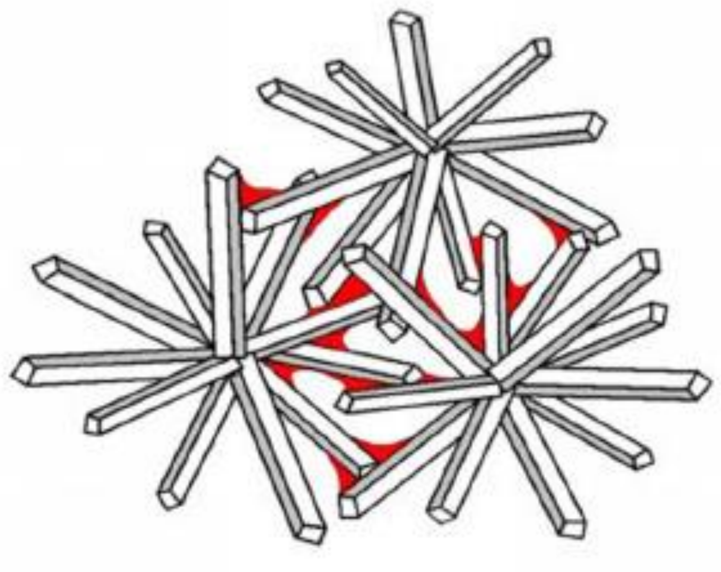


(a) the nuclei from which crystals grow

(b) spherulitic growth

(c) the outward thrust as spherulites make contact.

Properties



2. Dimensional changes:

a) Setting expansion:

- The set gypsum is composed of interlocking crystals and pores containing excess water used to obtain homogenous workable mix.
- The amount of expansion and porosity differs according to gypsum product. (The more excess water, the more pores, the more expansion).

Properties

2. **<u>Dimensional changes:</u>**

<u>The setting expansion of different types of gypsum:</u>

- Plaster of Paris = 0.3 %
- Dental Stone = 0.08 %
- Improved Stone = 0.06 %

Properties

2. **Dimensional changes:**

b) Hygroscopic expansion:

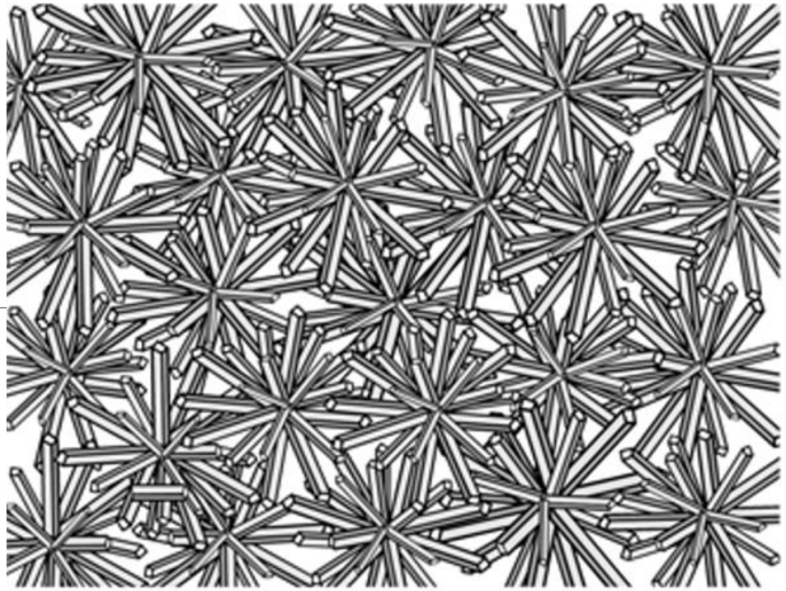
- It is the expansion occurs if the gypsum is allowed to set under water during initial setting.
- It may reach double the setting expansion.

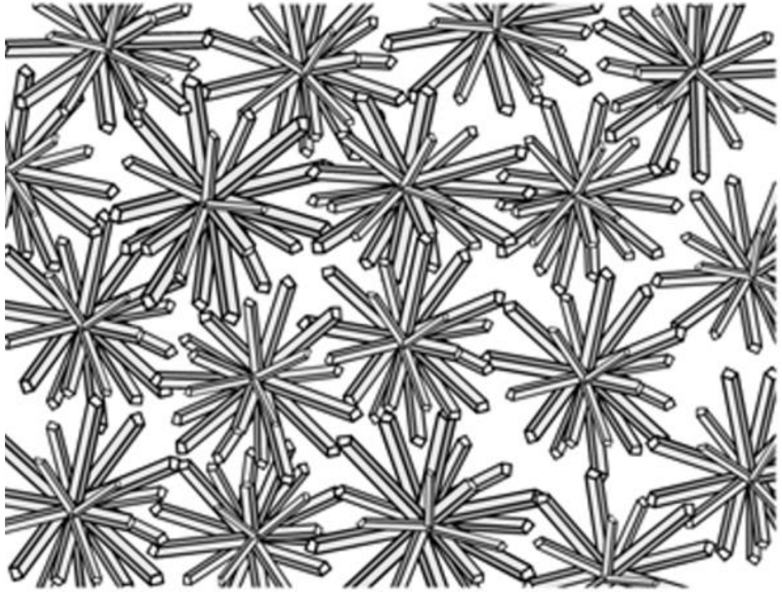
Properties

2. **<u>Dimensional changes:</u>**

b) <u>Hygroscopic expansion:</u>

- This occurs due to excess water provides more spaces for growing crystals to push each other outwardly.
- It is used in gypsum bonded investment.





Properties

3. **<u>Strength:</u>**

- Gypsum products are brittle materials.
- There are two types of strength according to presence of excess water:
  a. Wet strength.
  b. Dry strength.

Properties

3. **Strength:**

   a. Wet strength (1-hour strength) (green strength):

   - It is the strength with excess water.

Properties

3. **Strength:**

   b. Dry strength (7-days strength):

   - It is the strength after evaporation of excess water.
   - It is double wet strength

Properties

3. **<u>Strength:</u>**

<u>Factors affecting strength:</u>

1. ↑ *Water/powder ratio* ➔ ↓ strength.
2. ↑ *Mixing time and rate* ➔ ↑ strength.
3. *Chemicals* (regulate particles shape → decrease interlocking between particles ➔ ↓ strength).

Properties

3. **Strength:**

Factors affecting strength:

4. Types of gypsum product: (improved stone is stronger than dental stone and plaster is the weaker).
5. Time (wet strength is less than dry strength)

Properties

3. **Strength:**

The 1-hour compressive strength of different types of gypsum:

- Plaster of Paris = 9 MPa
- Dental Stone = 20 MPa
- Improved Stone = 35 MPa

Properties

4. **<u>Surface hardness:</u>**

- Gypsum products have low surface hardness and liable to scratching.

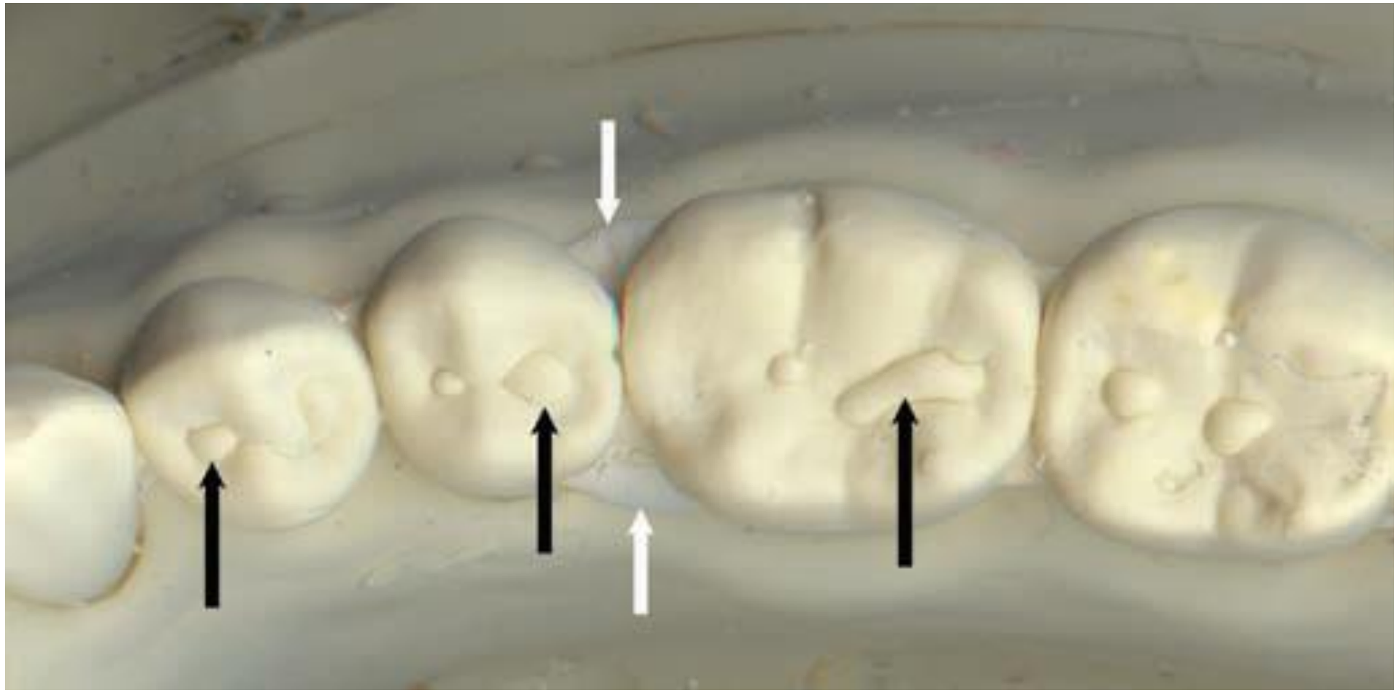
Properties

5. **<u>Reproduction of fine details:</u>**

- Gypsum products is not ideal to reproduce fine details due to presence of porosity at the <u>microscopic</u> level.
- According to ISO requirements, they are sufficient to reproduce fine details.
- Use of vibrator during pouring the impression reduce the presence of air bubbles.

Properties

5. **Reproduction of fine details:**



Properties

6. **Disinfection:**

- Disinfection of the impression is of prime concern.
- Immersion is 1/10 solution of sodium hypochlorite for 3 minutes is sufficient.

Properties

<u>High strength, high expansion stone (Type V):</u>

- It is manufactured by heating calcium sulfate dihydrate under pressure in presence of more than 1% sodium succinate.
- It requires less water than improved stone.
- It shows higher expansion than improved stone.
- It is used to construct die with more expansion to compensate for solidification shrinkage of new base metal alloys.

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Method of manufacturing	Heating in open air at 120 °C	Heating in an autoclave (under steam pressure) at 120 -130°C	Boiling in 30% $CaCl_2$

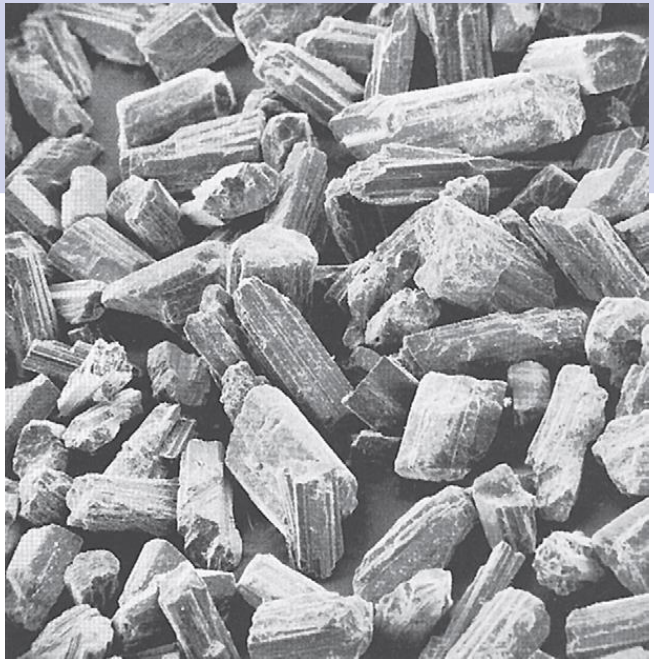
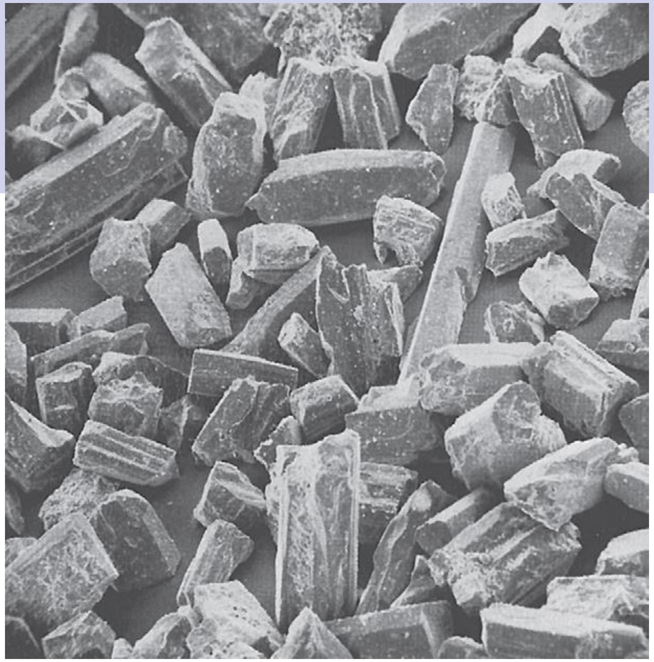
Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Setting reaction	$CaSO_4 . \frac{1}{2} H_2O + H_2O \longrightarrow CaSO_4 . 2 H_2O + Heat$		

Gypsum products

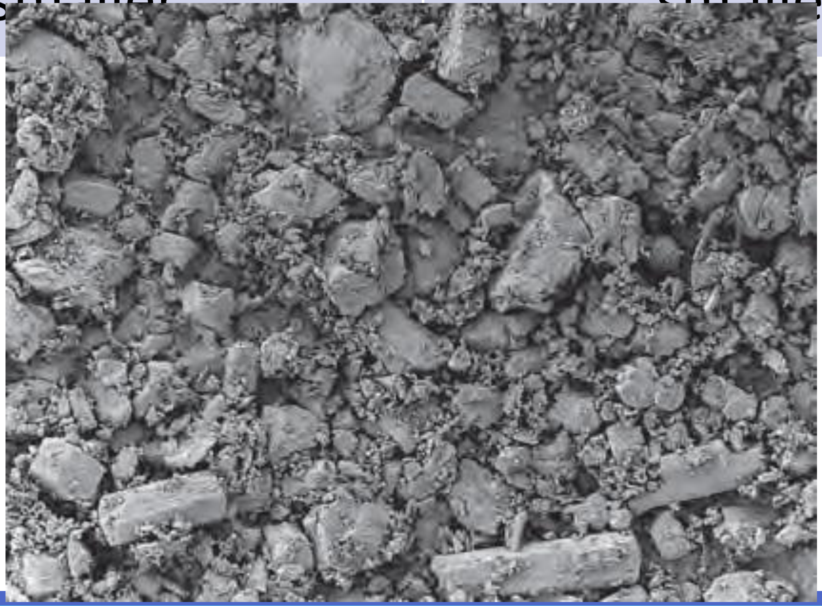
	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Particles shape	Irregular and large	More regular and smaller	The most regular and smallest

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Particles shape			

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Particles shape	Irregular and large	More regular and smaller	The most regular and smallest



Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Water of crystallization	18.6 g for 100 g of powder	18.6 g for 100 g of powder	18.6 g for 100 g of powder

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
W/P ratio for homogenous workable mix	50 – 60 g for 100 g of powder	30 g for 100 g of powder	22 g for 100 g of powder

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Heat evolved		The same	

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Heat felt	Least due to more excess water	Moderate	Highest due to less excess water

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Porosity	45%	15%	10%

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Setting expansion	0.2 -0.3	0.08	0.05 – 0.07

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Hygroscopic expansion	Highest	Moderate	Lowest

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Compressive Strength (1 h)	9 MPa	20 MPa	35 MPa

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Hardness	15 RHN	60 RHN	80 RHN

Gypsum products

	Plaster of Paris	Dental Stone (hydrocal)	Improved Stone (Densite)
Uses	• Making primary edentulous cast. • Mounting cast on articulator. • Filling the flask during denture construction.	• Making secondary edentulous cast. • Making primary and secondary dentulous cast for RPD. • Making primary casts for fixed restorations.	• Making secondary cast for fixed restorations

Thank You