

DENTAL MATERIAL

GYPSUM PRODUCTS

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

Types of gypsum products:

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

APPLICATION OF GYPSUM PRODUCTS IN DENTISTRY:

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

Properties of ideal model material (gypsum products):

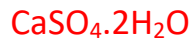
- 1- Dimensional stability, no expansion or contraction during or after setting.
- 2- High compressive strength to withstand the force applied on it.
- 3- Hardness, soft material can be easily scratched.
- 4- Reproduce the fine details.
- 5- Produce smooth surface.
- 6- Reasonable setting time.
- 7-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

MANUFACTURE OF DENTAL PLASTER, STONE, AND DIE STONE

Gypsum products are produced by partial dehydration of mineral gypsum, which is calcium sulfate di-hydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). They are supplied as powder when mixed with water they form slurry or paste, which set to form a rigid mass.

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

used in formulating model and lab plasters.



2- Chemically stone is the same as plaster that is $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ but it is made by heating gypsum in wet condition under super heat steam to 125°C (wet calcination). the crystals are dense and regular and have prismatic shape, they are called Alpha - calcium sulfate hemihydrate

3- It is produced by boiling gypsum with CaCl_2 calcium chloride. The crystals are also dense , regular and have prismatic shape, called Alpha - calcium sulfate hemihydrate

SETTING REACTION

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

The probable sequence is as following:

A- plaster, stone or die stone ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$) dissolve in water.

B- it is react with the water to form gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).

C- gypsum is less soluble in water and the solution becomes super- saturated (unstable).

D- gypsum crystallizes, allowing more particle to dissolve and to form gypsum. This will continue until all particles have been converted to gypsum($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Each crystal as it is forma becomes nucleus for crystallization. During this process part of the gypsum form a gel, which act as a cementing medium between the crystals. Then the rigid mass is formed by the interlocking network formed by the long needle- like gypsum crystals.



MANIPULATION

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

W/P ratio for plaster is 0.5 that is 50 ml of water for 100 gm of plaster powder

W/P ratio for stone is 0.3

W/P ratio for die stone is 0.2

The differences in W/P ratio is due to the difference in the bulk volume of the

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

SETTING TIME

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

FACTORS AFFECTING THE SETTING TIME:

1-W/P ratio

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

2-FINESS

The finer the particle size of the hemihydrate, the faster the mix will harden.

The rate of the solution of the hemihydrate will be increased, also the gypsum nuclei will be more numerous and therefore more rapid crystallization will occur.

3- MIXING

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

4-TEMPERATURE

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

5-IMPURITIES

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

6-RETARDERS & ACCELERATORS

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

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

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

DIMENSIONAL CHANGES ON SETTING (SETTING EXPANSION)

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

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

FACTORS AFFECTING THE SETTING EXPANSION

1-W/P ratio

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

2-Addition of chemicals (accelerators and retarders)

Both will reduce the setting expansion. The reduction of the expansion is due to that the initial rate of crystallization is so rapid that subsequent growth is

resisted with accelerators. For the retarders, the crystalline form may be changed and the crystals may become thick and short so the thrusting between the crystals is reduced so the expansion is reduced.

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

STRENGTH

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

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

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

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

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

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

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

STORAGE

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

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

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

المصادر:

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