Gypsum Products

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Lect 13 &14

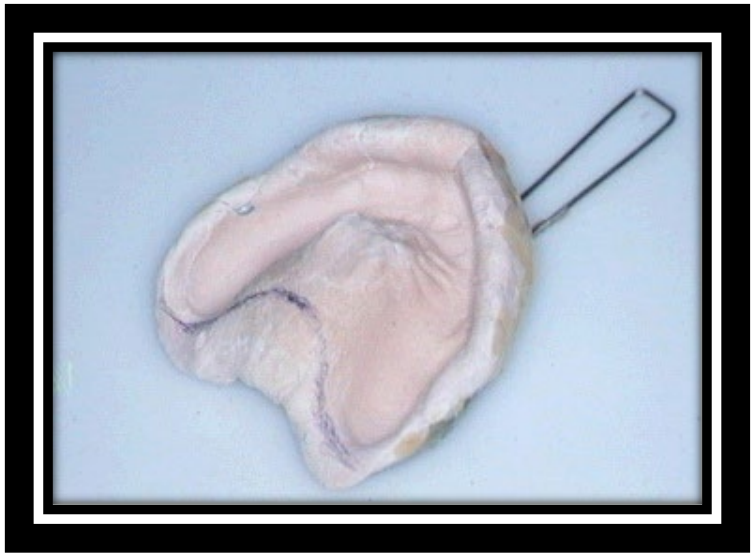
Gypsum products

Products of gypsum are used extensively in dentistry. Gypsum is a mineral mined in various parts of the world. It is an industrial byproduct and it is used, for many centuries for construction purposes.

Application in dentistry:

1. **Impression plaster was used for impressions of the mouth.**
2. **Casts and dies over which dental prostheses and restorations are made.**
3. **Mounting to the articulator.**
4. **Molds for processing dental polymers.**
5. **Dental investments: when plaster is mixed with silica it is known as dental investment. They are used to form molds into which molten metal is cast.**

Dental applications



Impression materials.



Gypsum rock



Constructing casts and dies



Making replicas



Mounting to the articulator



Moulds for processing dental polymers



Gypsum bonded investment

Properties of ideal model material

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

Types of gypsum products

- **Type I: impression plaster.**
- **Type II: plaster.**
- **Type III: stone.**
- **Type IV: die stone.**
- **Type V: High strength, high expansion dental stone.**









Manufacture of gypsum products

The process of heating gypsum to produce plaster is known as calcination. Calcium sulfate dihydrate ($CaSO_4.2H_2O$), when heated loses part of its water of crystallization and changes to calcium sulfate hemihydrates. They are supplied as a powder when mixed with water they form slurry or plaster, which set to form a rigid mass.

$$CaSO4.2H2O \xrightarrow{\text{Heat}} CaSO4.1/2\ H2O + \text{evaporation of water}$$

Plaster: when the gypsum is heated in an open container to 110-120C, it gives part of its water to form plaster which is $CaSO_4.1/2\ H_2O$. The crystals of plaster are irregular in shape and porous and called Beta.

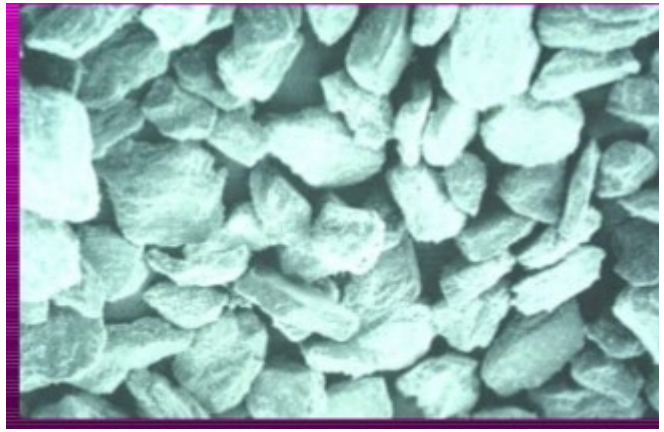
Stone: chemically stone is the same as plaster that is $CaSO_4.1/2\ H_2O$ but it is made by heating gypsum in the wet condition under superheat steam to 125 C. the crystals are dense regular and have a prismatic shape they are called alpha particles.

Die stone: it is produced by boiling gypsum with 30% CaCl (calcium chloride). The crystals are also dense regular and have a prismatic shape they are called alpha.

Plaster



plaster



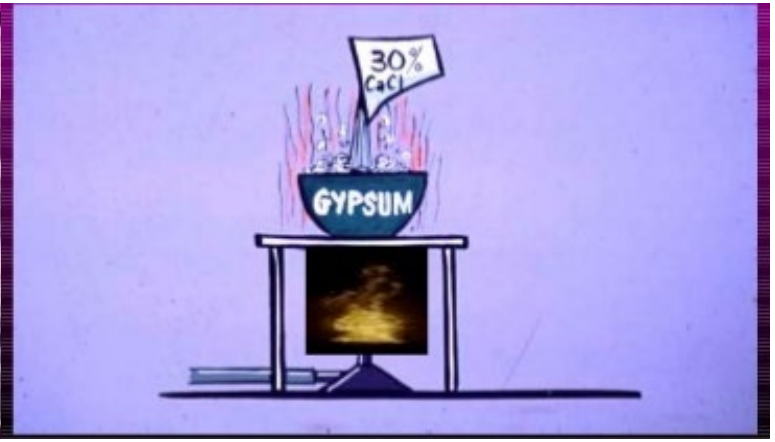
stone



stone



Die stone



Theories of setting: there two theories

1-Crystalline theory.

2-Gel theory.

Crystalline theory is more widely accepted. The setting reaction is explained on the basis of difference in solubility of hemihydrates and dihydydrate . Hemihydrate is four times more soluble than dihydrate.

Steps of reaction:

1. **Plaster or stone reacts with water to form gypsum ($CaSO_4 . 2 H_2O$).**
2. **Gypsum is less soluble in water and the solution becomes super saturated (unstable condition).**
3. **Gypsum crystallizes allowing more particles to dissolve and to form gypsum. This will continue until all the particles have been converted to gypsum ($CaSO_4 . 2 H_2O$).**

Water–powder Ratio: The W/P ratio is a very important factor in deciding the physical and chemical properties of the final product. Example: The higher the w/p ratio, the longer the setting time and weaker gypsum products, therefor w/p ratio should be kept as low as possible, but at the same time sufficient to produce a workable mix.

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 which is 50ml of water for 100gm of plaster powder.

- **W/P ratio for stone is 0.3.**
- **W/P ratio for die stone 0.2.**

Setting time

Setting time is the time from the beginning of mixing the powder with water until the material hardens.

Mixing time: is the time from the addition of the powder to the water until mixing is complete.

Working time: is the time available to make a workable mix.

Initial setting time: As the reaction proceeds, however, more hemihydrates crystals react to form dihydrate crystals. the viscosity of the mass is increased, and it can no longer be poured. The material becomes rigid (but not hard). It can be carved but not molded.

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

Measurement of setting time:

1. **Loss of gloss method: As the reaction proceeds, the gloss disappears from the surface of the plaster mix (sometimes used to indicate the initial set).**
2. **Exothermic reaction: The temperature rise of the mass may also be used for measurement of setting time, as the setting reaction is exothermic.**
3. **Penetration tests: By using penetrometers. (Vicat needle, Gillmore needles.**





Factors effecting the setting time

1. **W/P ratio: the more water is used for mixing the fewer nuclei they will be per unit volume consequently the setting will be prolonged.**
2. **Fineness: the finer the particle size of the hemihydrate the faster the mix will harden. The rate of solution of the hemihydrate will be increased, also the gypsum nuclei will be more numerous and therefore a more rapid rate of crystallization will occur.**
3. **Mixing: the longer or more faster the plaster is mixed, the shorter is the setting time.**

4. Temperature: there is little change in the setting time between 0-50C but if the temp. exceeds 50C the setting time will be retarded. As the temp. approaches 100 C no setting will take place.

5. Impurities: if the manufacturers add gypsum the setting time will be shortened because of the increase in the potential nuclei for crystallization.

6. Retarders and accelerators: the addition of accelerators and retarders are the most effective and practical for control of the setting time.

- **Retarder: is the chemical material added to gypsum product to increase the setting time. ex. glue borax and gum Arabic. It will reduce the dissolution of hemihydrates and might deposit on the nuclei of crystallization and effectively reduce the rate of crystallization so retard the 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 dissolution of hemihydrates and thus the saturation of the solution occurs more rapidly and the gypsum formation.**

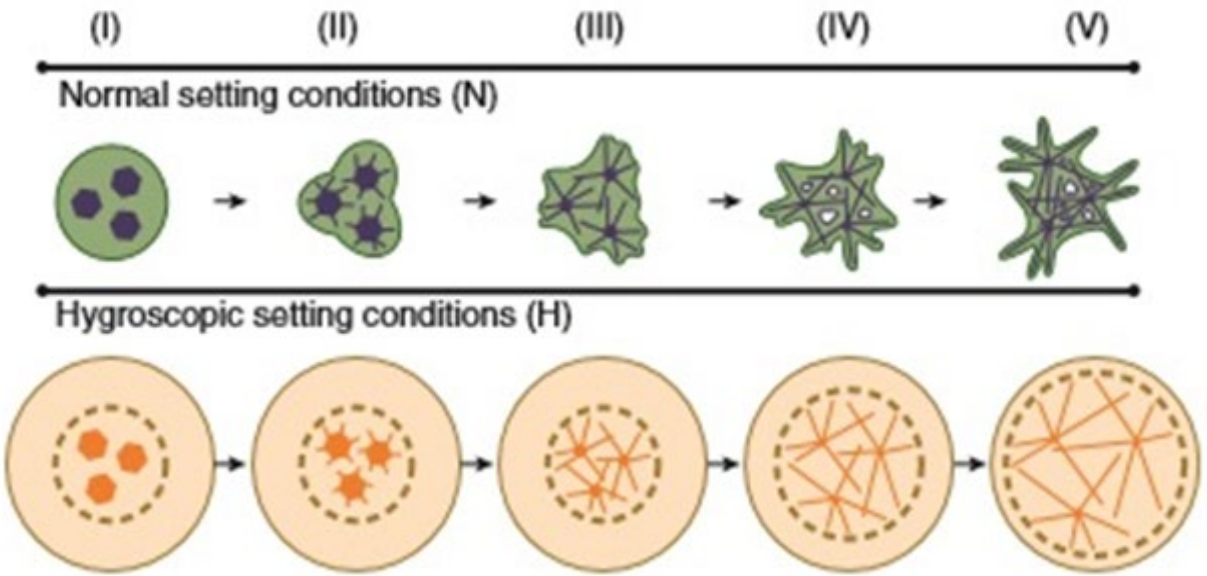
Setting expansion is of two types:

- **Normal setting expansion**
- **Hygroscopic setting expansion**

Regardless of the type of gypsum product, an expansion of the mass can be detected during the change from the hemihydrate to the dihydrate after mixing with water. This expansion could be explained based on the mechanism of crystallization. It is important in resulting in an accurate cast.

Hygroscopic expansion:

If the setting process is allowed to occur underwater the setting expansion may be more than double in magnitude this is called hygroscopic expansion. This increased expansion is due to the additional growth of the crystals permitted and not to any difference in the chemical reaction.



Strength:

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

Factors effecting the Strength:

- **W/P ratio.**
- **Mixing.**
- **Drying.**
- **Chemicals.**
- **Porosity.**