Lecture notes

Gypsum product

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It occurs naturally in the earth and uses in many purposes in dentistry after specific processing.

Chemically named (calcium sulphate dihydrate). and its chemical structure is \((\text{CaSO}_4 \cdot 2\text{H}_2\text{O})\).

When it is heat-treated it will produce calcium sulphate hemihydrate \((\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O})\) (plaster or stone).
Gypsum products are used in dentistry based on:

“Calcium sulphate hemihydrates”
(powder of plaster or stone).

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The main use of gypsum material in dentistry is;

pouring impression after removal form the patient mouth in order to produce a cast or model.

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Composition

Both of plaster and stone are called gypsum material products.

They are identical in their consistency but differ in the method of manufacturing.

They are produced by processing natural gypsum when it is driven-off part of the water as follow:

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Production of Gypsum

Natural gypsums + Heat \rightarrow \text{gypsum product + water}

\( \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \) \( \text{calcium sulphate dihydrate} \) \( \rightarrow \) \( \text{(CaSO}_4^{-\frac{1}{2}}\text{H}_2\text{O}) \) \( \text{calc. Sulph. Hemihydrate Powder} \) + \( 3\text{H}_2\text{O} \) \( \text{Water} \)

To convert the reaction by mixing gypsum product (powder) with water:

\[ \text{CaSO}_4^{-\frac{1}{2}}\text{H}_2\text{O} + \frac{2}{3}\text{H}_2\text{O} \leftrightarrow [\text{CaSO}_4^{-2}\text{H}_2\text{O}] + \text{[Heat]} \]
Methods of manufacturing

Method No.1

Gypsum $\rightarrow$ 110-120 °C (driven-off water) $\rightarrow$ $\beta$-calci. sulph. hemihyd. $\rightarrow$ Plaster of paris

white, brittle and large crystal

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Method No. 2

Gypsum $\xrightarrow{120 \, ^\circ\text{C steam pressure}}$ α-calcium sulphate hemihydrates $\xrightarrow{}$ dye stone

yellow, regular, fine and less porous

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Method No.3

Gypsum \( \text{Boiling +CaCl}_2 \ 30\% \) \rightarrow \text{Modified } \alpha\text{-calcium sulph. hemi.hyd.} \rightarrow \text{Dye stone}

- green or pink
- high strength dense fine crystals

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Classification of Gypsum products

Type I       Impression Plaster
Type II      Model Plaster
Type III     Dental Stone
Type IV      Die Stone, Low Expansion
Type V       Die Stone, High Expansion

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Uses and application

Stone is used when ever accuracy is needed, while plaster is used when ever there accuracy is not needed.

Primary impression pours with plaster study cast
Final impression pours with stone working cast

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Manipulation

Mixture of plaster or stone could be manipulated manually or automatically.

In manually mixing a rubber **bowl and spatula** are used to mix the powder with water in a determine mixing ratio and **automatically** mixing is done by using vacuum mixing machine.
Mixing ratio

Powder / Water

p/w mixing ratio for stone : 100g/30ml
P/w mixing ratio for plaster : 100g/50ml

Or according to the manufacturer instructions for each material.

Before pouring the impression with plaster or stone the mixture should be vibrated by vibrator machine in order to allow air bubbles to escape out side the mixture.
Requirements for gypsum model

- Accuracy and dimensional stability of prosthetic and dental appliances depend on the accuracy of cast or model.
- Setting expansion should be acceptable (0.1-0.03 mm)
- Cast should be abrasive resistance and have good strength to resist fracture.
- It should be compatible with the all types of impression material.
- It should be removed easily form the impression with stable details.
- It should have reasonable setting time.

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Stone and plaster have ability to react with water to form suspension then it will convert to hard substance according to the following mechanism:
When plaster or stone (hemihydrates) are mixed with water, suspension is formed (workable and semi-fluid).

It dissolves and form a saturated solution then supersaturated, then it converts to Dihydrate and Gypsum Nuclei is formed.

The process of converting hemihydrate to dihydrate is continued by more dissolve to form more nuclei or crystals until there is no more dihydrate precipitate out.

As much as nuclei are formed the crystals or crystallization will be more, so that the mixture should be used as soon as possible after mixing (workable).

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setting time

The material has two stages to get setting time:

A) Initial setting time: it is the time of possibility to carve the soft material with knife.

B) Final setting time: it is that time of cast or model to be hard and strong enough to be worked upon.

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The setting time is measured by the ability of the mixture to resist penetration by needle.

Vicat & Gillmore needle instruments are used to test or measure the ability of penetration.

The setting reaction is exothermic and the maximum temperature being when there is final hardening of the mixture material.
**Setting expansion**

All gypsum material expandable in a time when the crystals grow to form nuclei (crystallization) that the crystals push each other outward and this process can not be eliminated, but the manufacturer could reduce it by adding an accelerator and retarders in a balanced quantity so the rate of crystallization will increase.

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Mixing time

It is the time from the moment of adding powder to the water until the mixing process is completed.

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**Working time**

It is the time might be required from beginning of mixing until the material harden. This time is measured by using some types of penetration test by using special instruments represent needle penetration:  

**Vicat test or Gillmor needle test.**

a) Material still not set  
b) Material has been set
Factors control the setting time

Either control by manufacturer

Control by operator

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Factors under manufacturer control

- Adding small amount of original gypsum to plaster or stone work as nucleating agent to fasten the setting time.

- Adding accelerator (potassium sulphate $K_2SO_4$) which is act to increase the solubility or they add retarder (Borax) to delay setting time.

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Factors under the operator control

- Increasing water/powder ratio retards the setting time by decreasing the concentration of crystallization nuclei.

- Increasing mixing time will accelerate the setting time due to continuous break-up of the crystals and that will lead to more nuclei on which more crystallization can be initiated.

- Change temperature has less effect due to the increase temp. accelerate the solution process but retard the crystallization.

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Change temperature

0-30 °C has normal effect

100 °C there will be no crystals.

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Expansion

0.1 % expansions are normal for stone.

0.4 % expansion is normal for plaster.

Alteration in w/p ratio, mixing time have a minimal effect on setting expansion.

**Hygroscopic expansion**: An expansion takes place during absorption of water from the gypsum material during setting time.

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The properties of set material

The strength of gypsum depends on dryness after setting and porosity.

Stone is stronger and less porous than plaster.

The strength of the model will be more after few hours after final setting time.

Gypsum cast is relatively rigid but has poor impact strength and may be fractured if dropped.

The dimensional stability of gypsum is good.

It has sufficient resistance to the deformation when work is carried out upon them.

Type IV gypsum materials are frequently incompatible with alginate impression materials because the alginate produces a soft surface on the cast. Often, fluoride is added to the impression material as a strengthening agent to prevent this.
Thank You