

Faculty of Dentistry



# GYPSUM PRODUCTS



# The outline of this presentation

- **Introduction**
- **Gypsum types**
- **Requirements of dental cast materials**
- **Composition**
- **Manipulation and setting characteristics**
- **Setting Time**
- **Control expansion**
- **Properties of setting**
- **Applications**
- **Advantages and disadvantages**
- **Infection control**
- **References**

# Introduction

- Gypsum is a naturally occurring, white powdery mineral with the chemical name calcium sulphate Di-hydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ).
- Gypsum products used in dentistry are based on calcium sulphate hemi-hydrate ( $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ). Their main uses are for casts or models, dies .

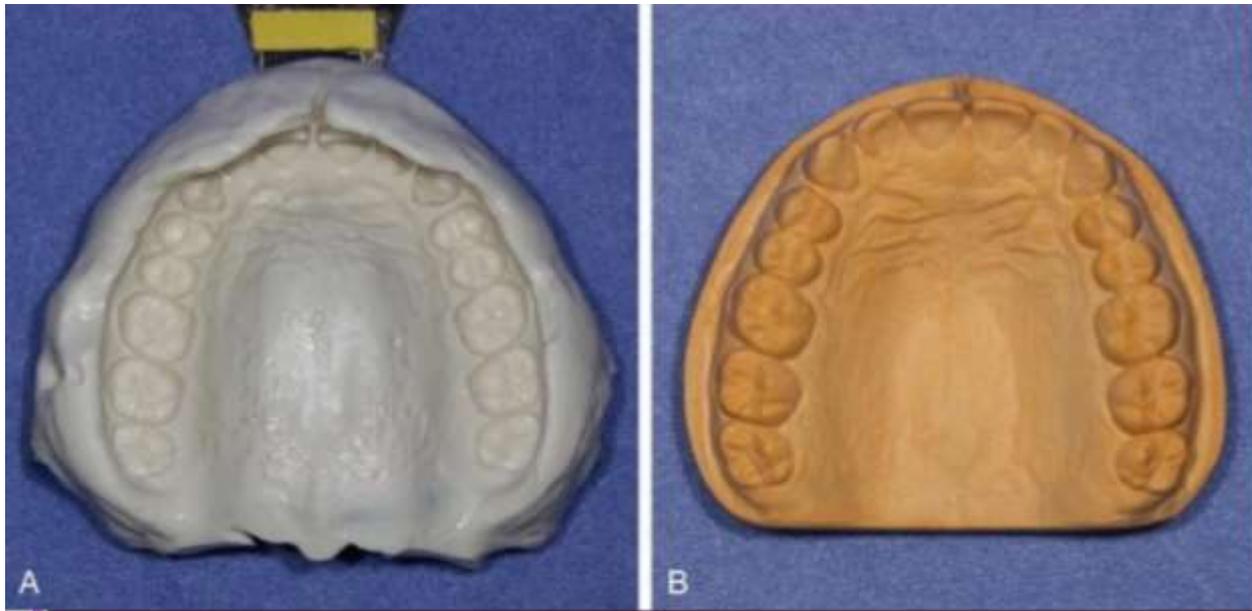




- models and dies which should be accurate replicas of the patient's hard and soft tissues.
- **model** is a replica of several teeth and their associated soft tissues or, alternatively, to an edentulous arch.
- **die** is a replica of a single tooth.



- The morphology of the hard and soft tissues is recorded in an impression and models and dies are prepared using materials



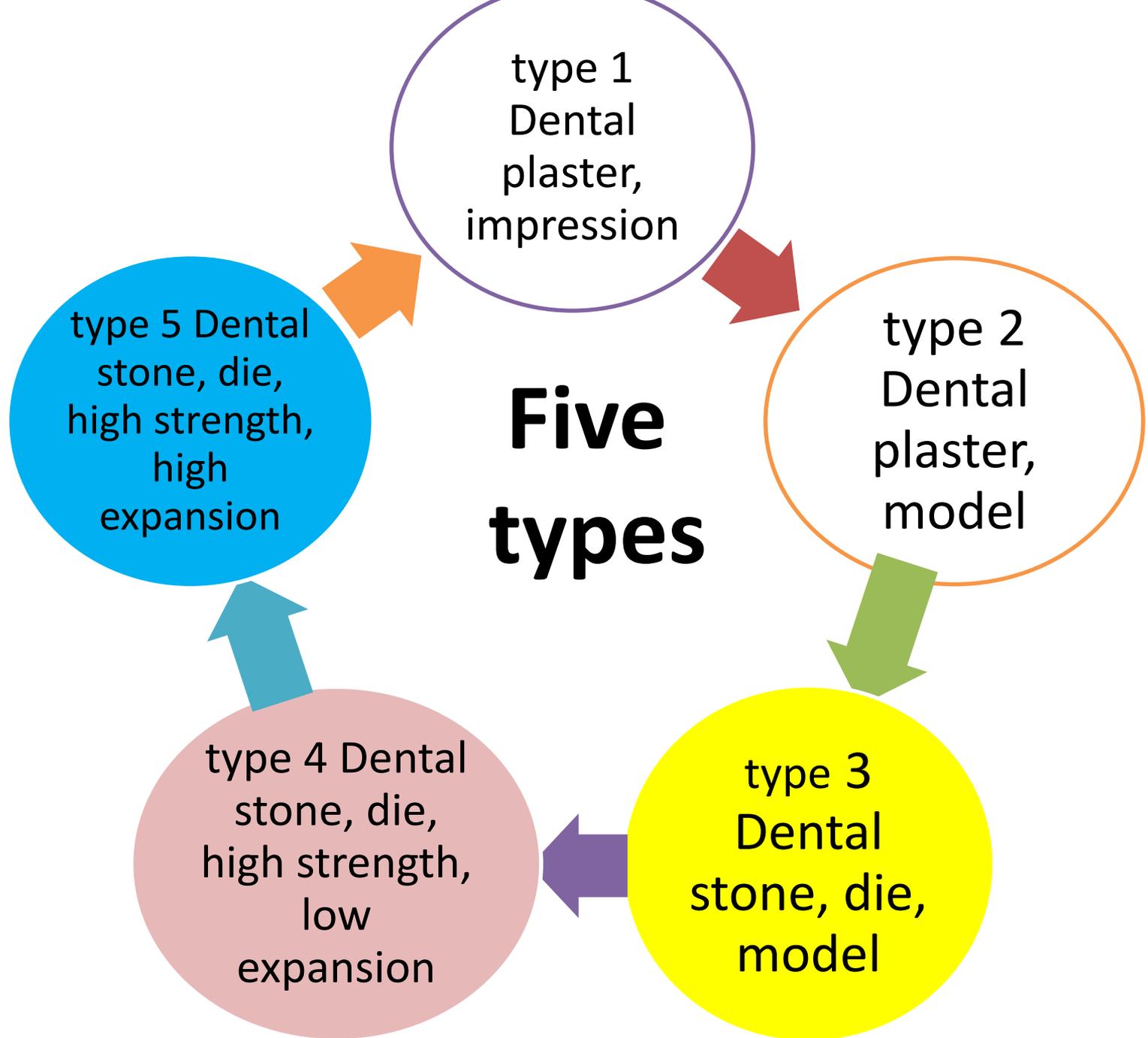
- which are initially fluid and can be poured into the impression, then harden to form a rigid replica.



# Types of Gypsum products according to current ISO

## FIVE TYPES





# REQUIREMENTS OF DENTAL CAST MATERIALS



1. dimensional accuracy
2. adequate mechanical properties
3. The material should be fluid at the time it is poured into the impression so that fine detail can be recorded
4. A low contact angle between the model and impression materials would help to minimize the presence of surface voids on the set model by encouraging surface wetting



5. The set material should be strong to resist accidental fracture and hard enough to resist abrasion during the carving of a wax pattern.
6. The material should be compatible with all the other materials with which it comes into contact.



# COMPOSITION

- Gypsum products used in dentistry are formed by driving off part of the water of crystallization from gypsum to form calcium sulphate hemihydrate.

- Gypsum → Gypsum product + water



Calcium  
sulphate  
dihydrate

Calcium  
sulphate  
hemihydrate

- Dental plaster (plaster of Paris): Dental plaster is indistinguishable from the white plaster used in orthopaedics for stabilizing fractured limbs during bone healing. Plaster is produced by a process known as calcinations.



- Gypsum is heated to a temperature of about 120°C in order to drive off part of the water of crystallization. This produces **irregular, porous particles** which are sometimes referred to as  $\beta$ -hemihydrate particles.

**Dental plaster =>  
gypsum+heat (open  
kettle ) at 120°C →  $\beta$ -  
hemihydrate calcium  
sulphate**



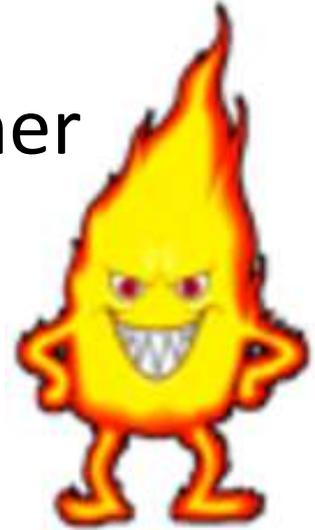
Two types of plaster

type one  
impression mate

Type two model  
plaster



- Overheating the gypsum may cause further loss of water to form calcium sulphate anhydrite ( $\text{CaSO}_4$ )
- underheating produces a significant concentration of residual dihydrate. The presence of both components has a marked influence upon the setting characteristics of the resultant plaster.



- **Dental stone => gypsom + steam & pressure at 125°C → α-hemihydrate calcium sulphate (type 3 gypsum)**



- **Dental stone(improved) => gypsom + 30% calcium chloride at 100°C →  $\alpha$ -hemihydrate calcium sulphate**  
**(type 4(die stone) & type 5 gypsum)**



- Dental stone: Dental stones may be produced by one of two methods. If gypsum is heated to about  $125^{\circ}\text{C}$  under steam pressure in an autoclave **a more regular and less porous hemihydrate** is formed. This is sometimes referred to as an  $\alpha$ -hemihydrate. Alternatively, gypsum may be boiled in a solution of a salt such as  **$\text{CaCl}_2$** . This gives a material similar to that produced by autoclaving but with even **less porosity**. Manufacturers normally add small quantities of **a dye to dental stones** in order that they may be **differentiated** from dental plaster, which is white.

Open kettle

Hi-pressure  
steam

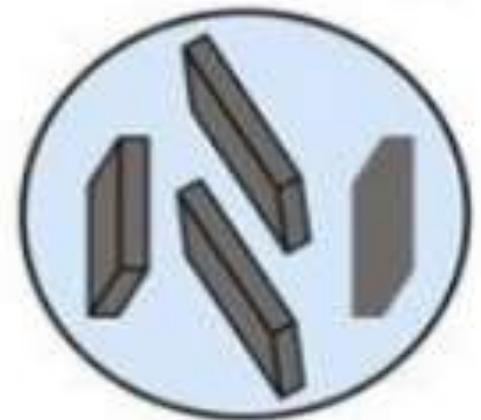
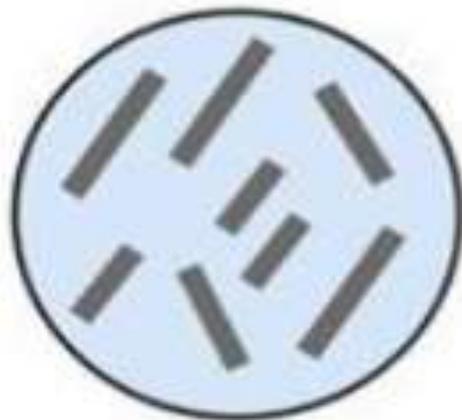
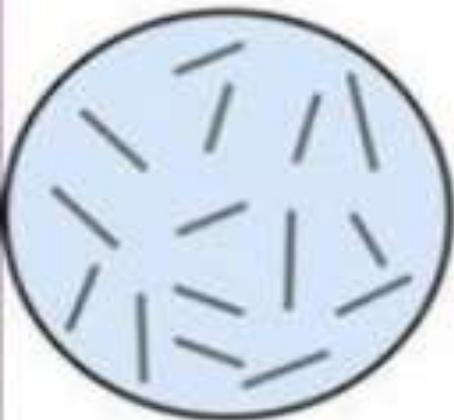
Boil,  $\text{CaCl}_2$

Type II

Type III

Type IV

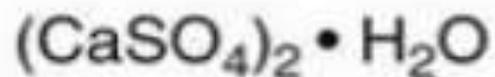
Type V

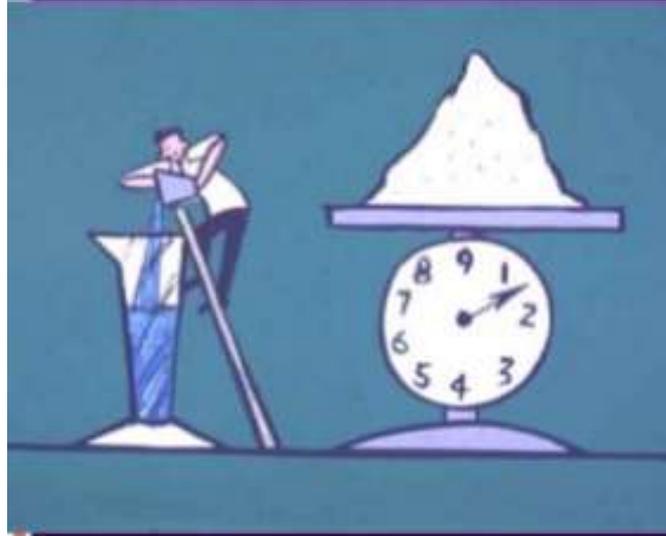


Model  
plaster

Stone

High-strength  
stone





# Manipulation and setting characteristics



Plaster and stone powders are mixed with water to produce a workable mix.

Hydration of the hemihydrate then occurs producing the gypsum model or die.



- Considerable quantities of air may be incorporated during mixing and this may lead to porosity within the set material. Air porosity may be reduced either by **vibrating** the mix of plaster or stone in order to bring air bubbles to the surface or by mixing the material mechanically under **vacuum**, or both.



- For hand mixing a clean, scratch free rubber or plastic bowl having a top diameter of about 130 mm is normally recommended.
- Should be clean because the gypsum residues in the mixing bowl can noticeably alter the working and setting characteristics



A stiff spatula with a round-edged blade of around 20–25 mm width and 100 mm length is used.



- the amount of water needed is added to a moist bowl and the powder added slowly to the water over about 10 seconds.
- mixing/spatulation carried out for around 60 seconds using a circular or figure of eight motion.
- After the material has been mixed and used, the mixing bowl should be thoroughly cleaned before the next mix is performed.



- The crystals of dihydrate are spherulitic in nature and grow from specific sites called **nuclei of crystallization**. These may be small particles of impurity, such as unconverted gypsum crystals, within the hemihydrate powder. If a thin mix of material is used, containing more water, the formation of the super-saturated solution of dihydrate which is a precursor to crystallization is delayed and the centers of nucleation are more widely dispersed by the dilution effect. The set plaster is therefore **less dense with greater spaces between crystals leading to a significant reduction in strength**.

- The material should be used as soon as possible after mixing since its **viscosity increases** to the stage where the material is **unworkable** within a few minutes.
- The setting reaction is **exothermic**



- The setting characteristics of gypsum products can be affected

1. by the presence of unconverted dihydrate

2. by the presence of anhydrite

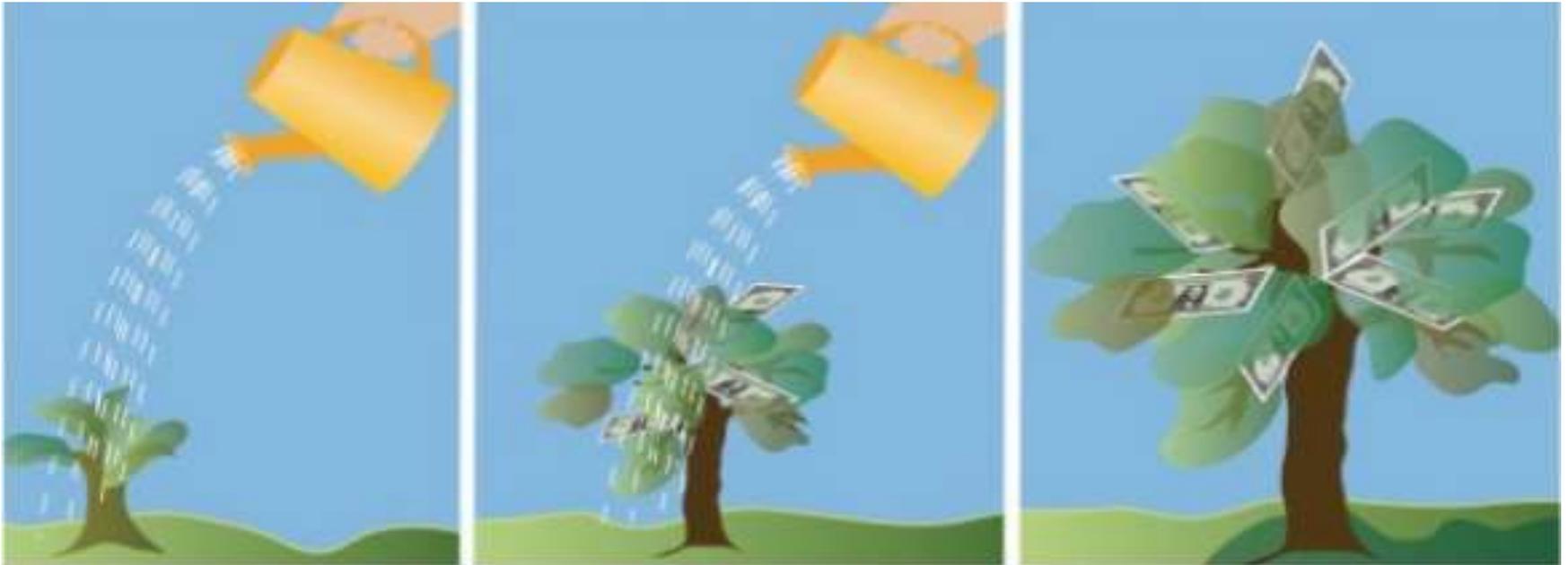
3. the age of the material

4. the storage conditions

- Small quantities of unconverted dihydrate act as centres of nucleation as mentioned earlier.

- Anhydrite reacts very rapidly with water producing a marked acceleration in setting.

- Another physical change which accompanies setting is a small expansion caused by the growing crystals



- The maximum rate of expansion occurs at the time when the temperature is increasing most rapidly. **The expansion is, in fact, only apparent since the set material contains a considerable volume of porosity.** If the material is placed in water at the initial set stage, considerably more expansion occurs during setting. This increased expansion is called hygroscopic expansion



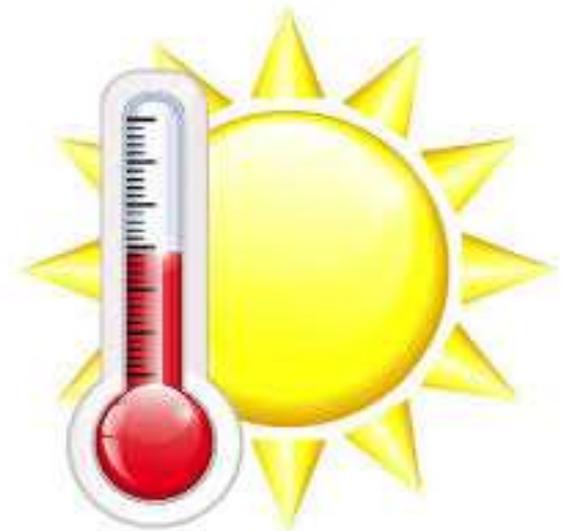
# Setting time



Factors under the control of the operator are **are**

# 1. Temperature

- Surprisingly, temperature variation has **little effect on the setting times** of gypsum products. **Increasing** the temperature **accelerates** the solution process but **retards** the crystallization.



## 2. W/P ratio

- Increasing the W/P ratio retards setting by decreasing the concentration of crystallization nuclei

- Too much water?  
( increased water powder ratio)

- Increases setting time
- Increased porosity
- Decreases strength

- Too little water?  
( decreased water powder ratio)

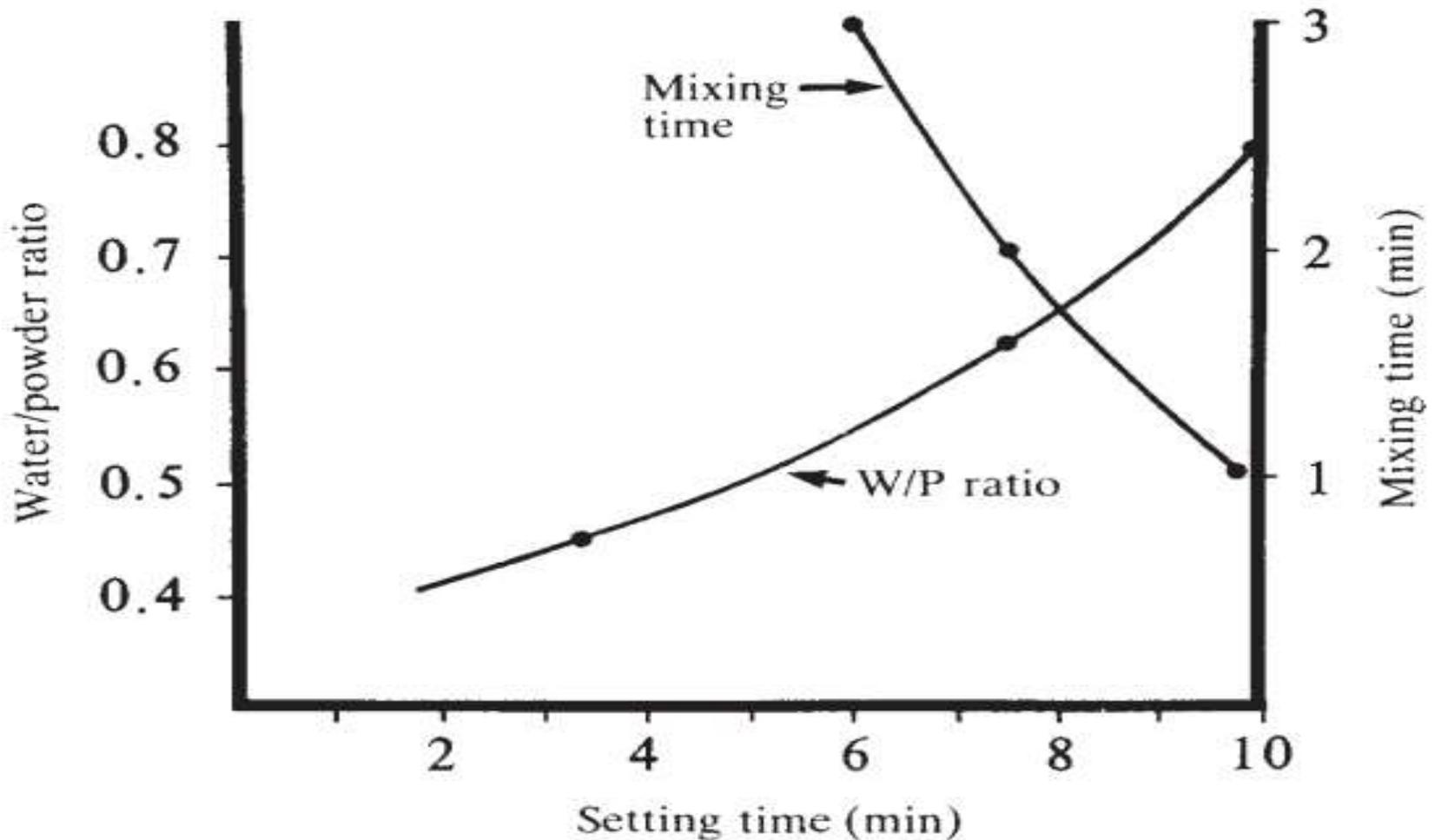
- Decreases setting time
- decreased porosity
- high strength

### 3. mixing time

- Increasing mixing time has the opposite effect. This accelerates setting by breaking up dihydrate crystals during the early stages of setting, thus producing more nuclei on which crystallization can be initiated.



**Fig. 3.6** The effect of water/powder ratio and mixing time on setting time for a typical dental plaster.



- A higher concentration of nucleating agent, produced by ageing or from unconverted calcium sulphate dihydrate, results in more rapid crystallization. Also, the manufacturers may add chemical accelerators or retarders to dental stones.
- **Potassium sulphate is a commonly used accelerator** which is thought to act by increasing the solubility of the hemihydrate. Borax is the most widely used retarder, although the mechanism by which it works is not clear.

# Control of setting expansion

- In order to produce an accurate model or die it is necessary to maintain the **setting expansion at as low a value** as possible.
- **Accelerators or retarders** which are added by manufacturers to dental stones in order to control the setting time also have the effect of reducing the setting expansion and are sometimes referred to as **antiexpansion** agents.
- Alterations in W/P ratio and mixing time have only a minimal effect on setting expansion.

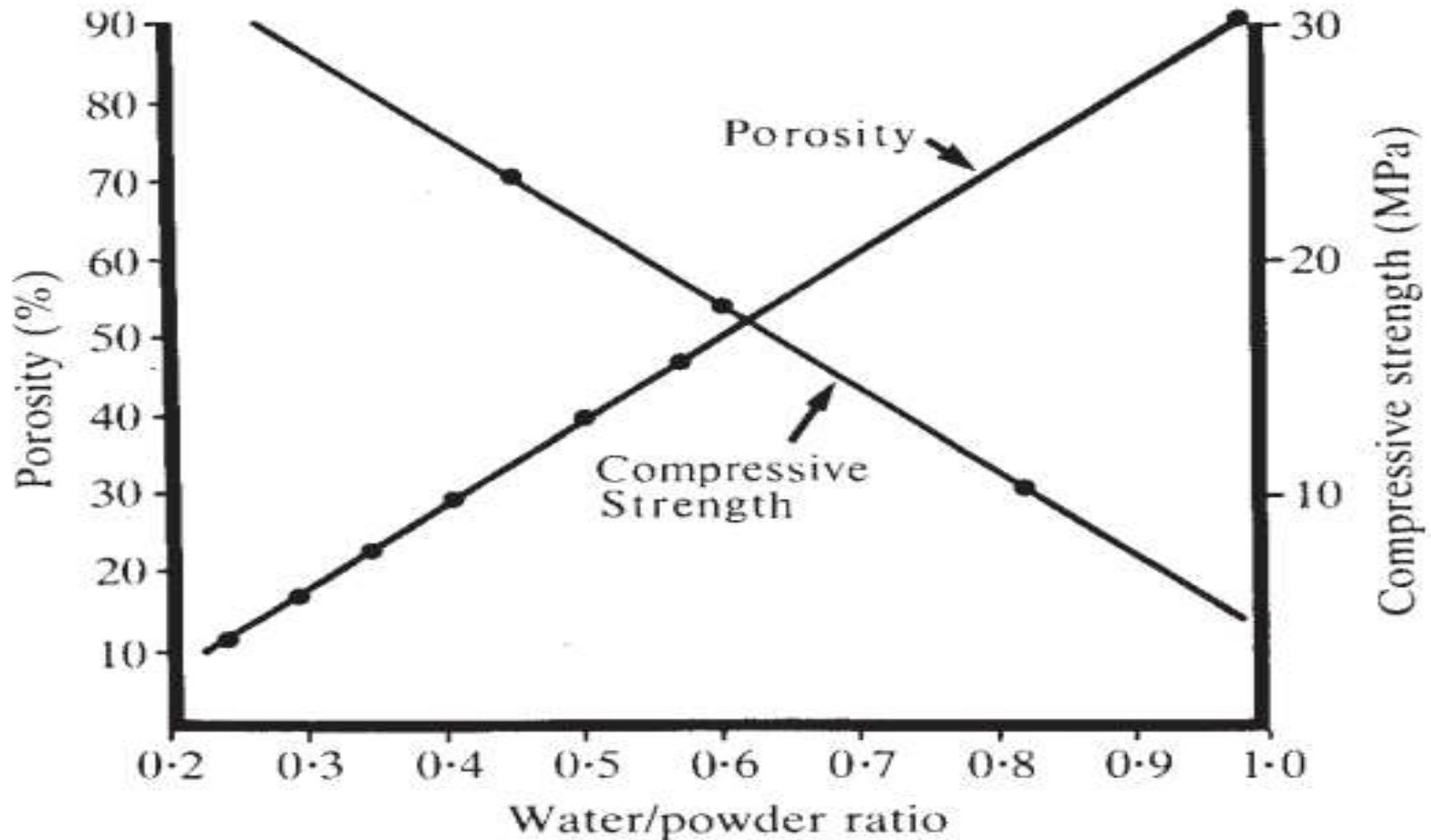
# Properties of setting



Strength

- The **strength** of gypsum depends, primarily, on the
  1. porosity of the set material
  2. the time for which the material is allowed to dry out after setting.
- The porosity, and hence the strength, is proportional to the W/P ratio
- Since stone is always mixed at a lower W/P ratio than plaster it is less porous and consequently much stronger and harder.

**Fig. 3.7** The effect of water/powder ratio on the porosity and compressive strength of gypsum products.



- Although a gypsum model or die may appear completely set within a relatively short period its strength increases significantly if it is allowed to stand for a few hours.

- Greatest surface hardness occurs when product reach its dry strength , it should be allowed to set for one or two hours preferable for night before laboratory procuders



- gypsum is a very brittle material.
- very low value of flexural strength of plaster
- Stone is less fragile but must be treated with care if fracture is to be avoided. It is relatively rigid but has a poor impact strength and is likely to fracture if dropped.
- Attempts to improve the mechanical properties have involved
  - 1.the impregnation by a polymer such as acrylic resin
  - 2.lower W/P ratio.

- **The dimensional stability of gypsum is good.**

following setting, **further changes in dimensions are immeasurable** and the materials are sufficiently rigid to resist deformations when work is being carried out upon them.



- Set plaster is slightly soluble in water.

Solubility increases with the temperature of the water and if hot water is poured over the surface of a plaster cast, as happens during the boiling out of a denture mould, a portion of the surface layer becomes dissolved leaving the surface roughened. Frequent washing of the surface with hot water should therefore be avoided.



# ■ As a summery

## ■ Dimensional accuracy:

- The higher the setting expansion, the lower the accuracy.
- Setting expansion results from the growth of crystals as they join.

## ■ Solubility:

- Set gypsum is not highly soluble
- The greater the porosity the greater the solubility.

## ■ Reproduction of detail:

- Greater porosity decreases surface detail production

# Applications

- Dental applications:
  - Impression materials
  - Constructing casts and dies



- When **strength, hardness and accuracy** are required **dental stones** are normally used in preference to dental plaster.
- The stone materials are less likely to be damaged during the laying down and carving of a wax pattern and give optimal dimensional accuracy.
- Thus, these materials are used when any work is to be carried out on the **model or die as would be the case when constructing a denture on a model or a cast alloy crown on a die.**
- When mechanical properties and accuracy are **not** of primary importance the cheaper **dental plaster** is used. Thus, plaster is often used for **mounting stone models onto articulators and sometimes for preparing study models**

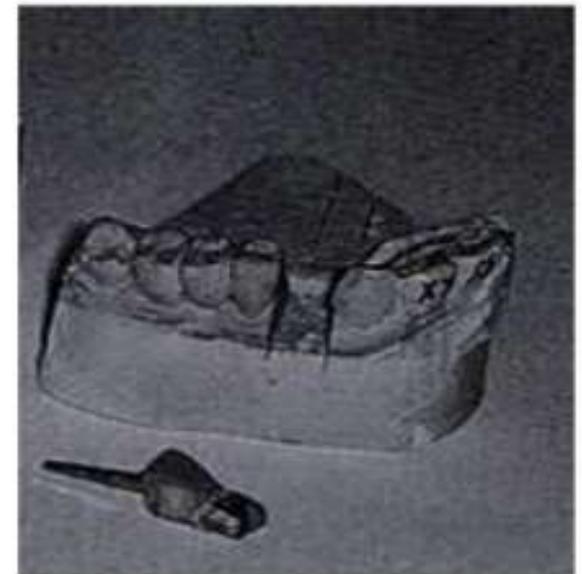
- **Type I : Impression material** rarely used  
Non-elastic impression material
- **Type II Model of plaster** used for
  1. diagnostic cast
  2. articulation of stone cast
  3. Art portion working cast
  4. Flasking procedure for acrylic denture



Plaster



- Type III Dental stone used for making
  - 1.full or partial denture model
  - 2.orthodontic model
  3. Flasking procedure for acrylic denture
- Type IV Dental stone used for
  - 1.fabricating wax patterns of cast restoration (crown and bridges)
  - 2.Implants



Die stone used in the fabrication of cast crown restoration

# Advantages and disadvantages



- Gypsum model and die materials have the **advantages** of

1. being inexpensive

2. easy to use.

3. The accuracy and dimensional stability are good

4. reproduce fine detail from the impression

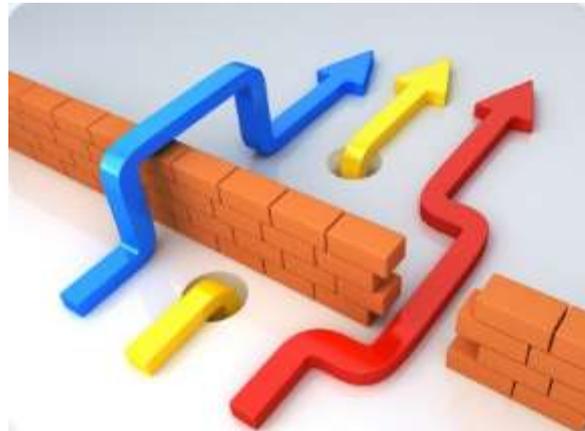
## **Disadvantages**

1. The mechanical properties are not ideal

2. the brittle nature of gypsum occasionally leads to fracture – particularly through the teeth, which form the weakest part of any model.

- Problems occasionally arise when gypsum products are used in conjunction with alginate impression.
- The surface of the model may remain relatively soft due to an apparent retarding effect which hydrocolloids have on the setting of gypsum products. It is not certain whether the retarding effect is due to borax in the hydrocolloid or to the absorption of hydrocolloid onto the gypsum crystals which act as nuclei of crystallization.
- Despite these observations it cannot be said that gypsum products are incompatible with alginate impression materials since problems arise very infrequently.

- Alternative materials for the production of models and dies exist but are hardly ever used.
- These include various **resins, cements and dental amalgam.**
- The alternatives may be **stronger** but are generally **less stable, difficult to use and more expensive.**



- Another **treatment** which has been suggested for **improving the durability of gypsum** is to partly saturate the set material in a polymerizable monomer such as **methylmethacrylate** or **styrene**.
- Polymerisation of the monomer produces a polymer phase which **increases its strength and toughness**.
- Despite these apparent advantages these techniques are **rarely** used in practice.

# Infection control

- Casts should have set for 24 hours before being disinfected if necessary.
- Spray rather than immerse.
- Disinfectants commonly used:
  - Sodium hypochlorite
  - iodophors
  - Chlorine dioxide

# references

- Applied Dental Material  
-ninth edition  
by John F McCabe & Angus  
W.G. Walls  
Chapter 3 (pages from 41-48)



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• Any Questions

