GYPSUM PRODUCTS

- ✓ Gypsum products include: dental plaster, stone, high-strength/high-expansion stone, and casting investment.
- ✓ Most gypsum products are obtained from natural gypsum rock. Because gypsum is the dihydrate form of calcium sulfate ($CaSO_4 \cdot 2H_2O$), on heating, it loses part of its water and converted to calcium sulfate hemihydrate ($CaSO_4 \cdot ½H_2O$). After mixing with water, the mixture reverts to gypsum ($CaSO_4 \bullet 2H_2O$; calcium sulfate dihydrate).
- ✓ $CaSO_4 \cdot ½ H_2O + 1½ H_2O \rightarrow CaSO_4 \cdot 2H_2O + 3900$. The reaction is exothermic.

Production of Gypsum Products:

1. Gypsum products are produced by grinding the gypsum and subjecting it to temperatures of 110 to 130 °C in open containers to drive off part of the crystalline water. The principal constituent of gypsum products is calcium sulfate hemihydrate. The resulting particle is a fibrous aggregate of fine crystals with capillary pores known as plaster of Paris or dental plaster in dentistry.
2. As the temperature is further raised, plaster becomes hexagonal. This process is known as calcination. When gypsum is heated in a kettle, vat, or rotary kiln that maintains a moist environment, a crystalline hemihydrate called dental stone is produced. The powders are often referred to as α-hemihydrate for dental stone and β-hemihydrate for plaster of Paris.
3. If the calcination process occurs under pressure in a 30% calcium chloride solution or in the presence of more than 1% of sodium succinate, the process yields shorter and thicker hemihydrate crystals called modified α-hemihydrate or die stone. Residual calcium chloride and sodium succinate are removed by washing the powder with hot water.

The primary applications of gypsum products in dentistry include:

1. Impression plaster is used to make impressions of edentulous mouths or to mount casts.
2. The production of study models for oral and maxillofacial structures.
3. Used as auxiliary materials for dental laboratories involved in the production of dental prostheses.
4. When refractory fillers are added, the gypsum product becomes more heat resistant and is known as a gypsum-based investment, capable of forming molds for the casting of alloys.

Property Requirements:

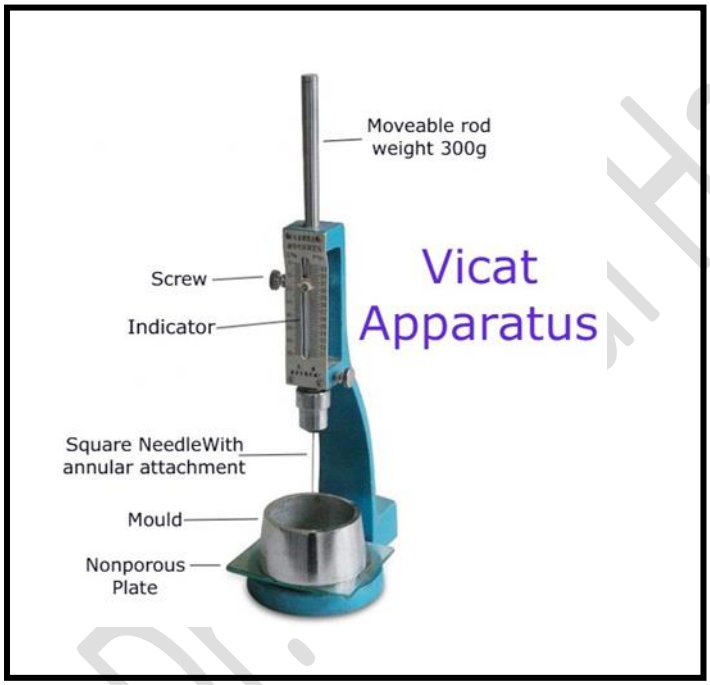
Setting Time:

- Final setting time: it is the time required for the reaction to be completed and is defined as the time at which the material can be separated from the impression without distortion or fracture . If the rate of the reaction is too fast or the material has a short setting time, the mixed mass may harden before the operator can manipulate it properly. By contrast, if the rate of reaction is too slow, an excessively long time is required to complete the operation. Therefore a proper setting time is one of the most important characteristics of gypsum materials.

- Mixing time: it is the time from the addition of powder to the water until mixing is completed. It takes 20 to 30 seconds via mechanical mixing or at least a minute of hand spatulation.
- Working time: it is the time from the start of mixing to the point when the consistency is no longer acceptable for the product's intended purpose. Generally, a 3-minute working time should allow sufficient time for mixing, pouring an impression and a spare impression, and cleaning the equipment before the gypsum becomes unworkable.
- Initial setting time: it is the time required for gypsum products to reach a certain arbitrary stage of firmness in their setting process. In the normal case, this arbitrary stage is represented by a semihard mass that has passed the working stage but is not yet completely set.

❖ Measurement of setting time:

- The loss of gloss from the surface of the mixed mass of model plaster or dental stone is an indication of this stage in the chemical reaction and is sometimes used to indicate the initial set of the mass.
- The setting time may be measured by the temperature rise of the mass, because the chemical reaction is exothermic.
- The Vicat apparatus to measure the initial setting time of gypsum products.
- Gillmore needles, can be used to obtain the initial and final setting times of gypsum materials.



❖ Control of setting time:

- The operator can alter setting time by changing the temperature of the mix water, temperature variation has little effect on the setting times of gypsum products. Experimentation has shown that increasing the temperature from room temperature of 20°C to body temperature of 37°C increases the rate of the reaction slightly and shortens the setting time. However, as the temperature is raised over 37°C, the rate of the reaction decreases, and the setting time is lengthened. At 100°C the solubilities of dihydrate and hemihydrate are equal, in which case no reaction occurs, and plaster does not set.
- By changing the degree of spatulation. Increased spatulation shortens the setting time.
- The W/P ratio can also affect setting time; using more water in the mix can prolong the setting time.
- The easiest and most reliable way to change the setting time is to add either accelerators or retarders.

  An accelerator a material added to reduce the setting time like Potassium sulfate (K_2SO_4). The use of a 2% aqueous solution of this salt rather than water reduces the setting time of model plaster from approximately 10 minutes to about 4 minutes. A small amount of set calcium sulfate dihydrate is ground and mixed with model plaster, it provides nuclei of crystallization and acts as an accelerator (the set gypsum used as an accelerator is called terra alba). Terra alba is added in small concentration (0.5 %-1%).

  A retarder like sodium citrate is added to prolong the setting time. The use of a 2% aqueous solution of borax to mix with the powder may prolong the setting time of some gypsum products to a few hours.

Viscosity:

More voids were observed in casts made from the stones with the higher viscosities. Impression plaster is used infrequently, but it has a low viscosity, which makes it possible to take impressions with a minimum of force on the soft tissues (mucostatic technique).

Compressive Strength:

- The compressive strength is inversely related to the W/P ratio of the mix. The more water used to make the mix, the lower the compressive strength.
- The wet strength is the strength of gypsum materials with some or all of the excess water present in the specimen. The dry strength is the strength of the gypsum material with all of its excess water driven out. The dry compressive strength is usually about twice that of the wet strength.
- The addition of an accelerator or retarder lowers both the wet strength and the dry strength of the gypsum product.
- The mixing time also affects the strength of the plaster. In general, an increase in mixing time increases the strength to a limit. If the mixture is overmixed, the gypsum crystals will be broken up, and the final product will hold less crystalline interlocking structure.

Surface Hardness and Abrasion Resistance:

- After the final setting occurs, the surface hardness remains practically constant until most excess water is evaporated from the surface, after which its increase is similar to the increase in compressive strength. The surface hardness increases at a faster rate than the compressive strength, because the surface of the hardened mass reaches a dry state earlier than the inner portion of the mass.
- Mixing high-strength dental stone with a commercial hardening solution containing colloidal silica (about 30%) improves the surface hardness of the set gypsum.

Reproduction of Detail:

- Air bubbles are often formed at the interface of the impression and gypsum cast because freshly mixed gypsum does not wet some elastomeric impression materials (condensation silicones) well. The incorporation of nonionic surfactants in silicone impression materials improves the wetting of the impression by slurry water.
- The use of vibration during the pouring of a cast reduces the presence of air bubbles.
- Contamination of the impression in which the gypsum die is poured by saliva or blood can also affect the detail reproduction. Rinsing the impression and blowing away excess water can improve the detail recorded by the gypsum die material.

Setting Expansion:

- When set, all gypsum products show a measurable linear expansion. The percentage of setting expansion, however, varies from one type of gypsum material to another.
- Under ordinary conditions, plasters have greater setting expansion than high-strength dental stone.
- Typically, over 75% of the expansion observed at 24 hours occurs during the first hour of setting.

❖ Control of setting expansion:

The setting expansion may be controlled by different manipulative conditions and by the addition of some chemicals.

- Mechanical mixing decreases setting expansion.
- A longer mixing time will increase the setting expansion.
- The W/P ratio of the mix also has an effect, with an increase in the ratio reducing the setting expansion.
- The addition of different chemicals affects not only the setting expansion of gypsum products, but may also change other properties. For example, the addition by the manufacturer of sodium chloride (NaCl) in a small concentration increases the setting expansion of the mass and shortens the setting time. The addition of 1% potassium sulfate, by contrast, decreases the setting time but has no effect on the setting expansion.
- If during the setting process, the gypsum materials are immersed in water, the setting expansion increases. This is called hygroscopic expansion.

Types of Gypsum Products:

1. Impression Plaster (Type I): These impression materials are composed of plaster of Paris to which modifiers have been added to regulate the setting time and setting expansion. Impression plaster is now rarely used for making dental impressions because plaster has been replaced by less rigid materials such as the hydrocolloids and elastomers.
2. Model Plaster (Type II) Model plaster or laboratory type II plaster is now used principally to fill a flask used in denture construction when setting expansion is not critical and the strength is adequate. It is also used to fabricate study casts. It is usually marketed in the natural white color, thus contrasting with stones, which are generally colored.
3. Dental Stone (Type III): It is intended for the construction of casts in the fabrication of full dentures to fit soft tissues. For this application, a slight setting expansion can be tolerated in casts that reproduce soft tissues, but not when teeth are involved. Type III stones are preferred for casts used to process dentures because the stone has enough strength for this purpose but low enough strength for separating the denture from the cast. There are at least two methods for the construction of the cast:
   (1) One method is to construct a mold by wrapping soft flat wax strips around the impression so that they extend approximately 12 mm beyond the tissue side of the impression. This process is called boxing, which forms the base of the cast. The mixture of stone and water is then poured into the impression under vibration.
   (2) Another method is to fill the impression first as described but without wrapping. The remainder of the stone–water mixture is poured on a glass plate. The filled impression is then inverted over a mound of stone, and the base is shaped with the spatula before the stone sets. Such a procedure is not indicated if the impression can easily be deformed or if the stone is "runny." The cast should not be separated from the impression until the stone has hardened. The minimal time allowed for setting varies from 45 to 60 minutes, depending on the rate of setting of the stone or plaster and the type of impression material used.
4. Dental Stone, High Strength (Type IV) The principal requisites for a die material are strength, hardness, and minimal setting expansion. To obtain these properties, modified α-hemihydrate, also called die stone, is used. A hard surface is necessary for a die stone because the tooth preparation is covered with wax and carved flush with the margins of the die. A sharp instrument is used for this purpose; therefore the stone must be resistant to abrasion. The surface hardness increases more rapidly than the compressive strength because the surface dries more rapidly. This is a real advantage in that the surface resists abrasion, whereas the core of the die is tough and less subject to accidental breakage. It is used in fabrication of crowns and bridges.
5. Dental Stone, High Strength, High Expansion (Type V) This gypsum product exhibits an even higher compressive strength than the type IV dental stone. The improved strength is attained by lowering the W/P ratio even further than that used for type IV stone. In addition, the setting expansion has been increased to compensate for the alloy solidification shrinkage. One should avoid the use of type V stones for producing dies for inlays and onlays because the higher expansion may lead to an unacceptably tight fit.

Manipulation:

When any of the gypsum products is mixed with water, it should be spatulated properly to obtain a smooth mix.

Water is dispensed into a mixing bowl of an appropriate size and design.

The powder is added and allowed to settle into the water for about 30 seconds. This technique minimizes the amount of air incorporated into the mix during initial spatulation by hand.

Spatulation can be continued by hand using a spatula with a stiff blade with the bowl on a vibrator or a power-driven mechanical spatulator. Spatulation by hand involves stirring the mixture vigorously while wiping the inside surfaces of the bowl with the spatula. Spatulation to wet and mix the powder uniformly with the water requires about 1 minute at 2 revolutions per second. Spatulation with a power-driven mechanical spatulator requires that the powder initially be wet by the water as with hand mixing. The mix is then spatulated for 20 seconds on the low-speed drive of the mixer. Vacuuming during mixing reduces the air entrapped in the mix.

Vibration immediately after mixing and during pouring of the gypsum minimizes air bubbles in the set mass.

Pouring an impression with gypsum requires care to avoid trapping air in critical areas.

The mixed gypsum should be poured slowly or added to the impression with a small instrument such as a wax spatula.

The mass should run into the rinsed impression under vibration in such a manner that it pushes air ahead of itself as it fills the impressions of the teeth.

Commonly, the teeth of a cast are poured in dental stone or highstrength dental stone, whereas the base is poured in model plaster for easier trimming.

Once poured, the gypsum material should be allowed to harden for 45 to 60 minutes before the impression and cast are separated and disinfected.

Models can be disinfected by immersion in 1:10 dilution of sodium hypochlorite for 30 minutes or with a spray of iodophor following manufacturer's instructions.

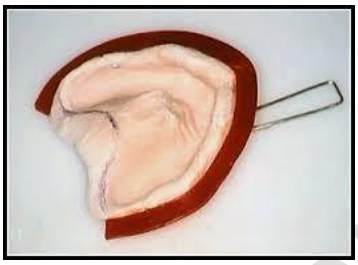




Power-driven mechanical spatulator with a vacuum attachment.

A vibrator is designed to promote the release of bubbles in the gypsum mix and to facilitate pouring of the impression.

Flexible rubber mixing bowl and metal spatula with a stiff blade.



Impression plaster

Plaster to mount dental casts on articulator

Dental plaster cast

gypsum-bonded investments

cast gypsum dies

Dental stone cast