

# MOLDING MATERIALS USED IN DENTISTRY (PART II) REFRACTORY MOLDING MATERIALS

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## Abstract

In modern dentistry, the technologies of casting metal alloys and molding pressing of ceramic materials are widely used. Molds for casting metal alloys and extrusion of ceramics are made of refractory molding materials. The article presents the classification of types and types of refractory molding materials used, their characteristics, and describes in detail the features of the technological process.

**Keywords:** Refractory molding materials, classification, characteristics.

## Introduction

The technological process of making dentures or their parts by pouring or pressing structural materials that are in a liquid state, into refractory molds, where they harden, is called casting. In modern dentistry, the technologies of casting metal alloys and molding pressing of ceramic materials are widely used (Fig. 1).

Molds for casting metal alloys and extrusion of ceramics are made of refractory molding materials. The term refractory materials should be understood as the property of materials to resist the effects of temperatures above 1580°C without collapsing. Refractory is characterized by the temperature at which a standard sample of material in the form of a triangular truncated pyramid with a height of 30 mm and base sides of 8 and 2 mm (Zeiger's cone) softens and deforms so that its apex touches the base.

There are 3 types of refractory materials:  
refractory materials themselves (refractoriness 1580–1770°C);  
high-flame retardant ( 1770–2000°C);  
materials of higher refractoriness (above 2000°C).

A casting refractory mold, as a melt receiver, must provide conditions for obtaining high-quality castings. Therefore, molding sands must meet certain requirements:

Be harmless when working with them.

Have a dispersion that ensures a smooth surface of the casting.

The dosage of components should be simple and convenient to use.

The mixing time and working time should be 4-6 minutes.

Refractory mixtures in the liquid phase must have high fluidity and the ability to wet wax parts without the formation of air pores.



The hardening time should be up to 60 minutes.

Possess strength, ensuring the integrity of the casting mold during its transportation and pouring. Do not collapse under the influence of temperatures exceeding the melt temperature by 200°C.

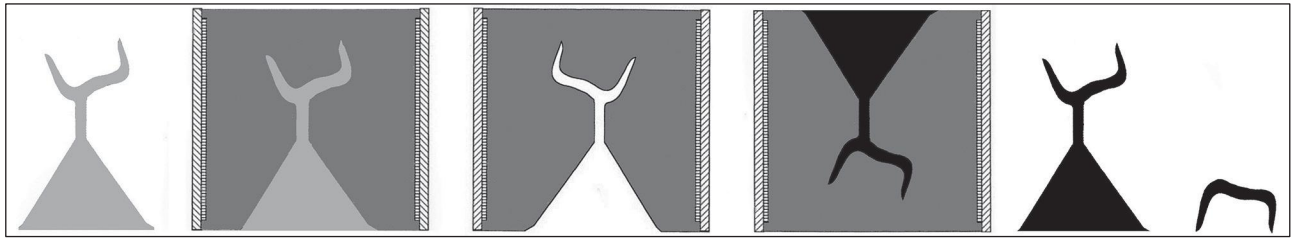


Fig. 1. Structural material casting scheme: wax pattern of artificial crown with gating system mounted on the casting cone (a), mold making from refractory material (b), mold prepared for casting after wax pattern melting (c), filling the refractory mold with molten structural material (d), mold freed casting (e), and artificial crown separated from gating system

Classification of refractory materials by chemical and mineral composition

Table

Type	Group	Mass fraction of main chemical components, %
Silica	Quartz	SiO <sub>2</sub> not less than 98
Alumina	Corundum	Al <sub>2</sub> O <sub>3</sub> over 95
Zirconia	Zirconium oxides	ZrO <sub>2</sub> over 85
Carbonaceous	Graphite	From over 96

For the manufacture of injection molds in dentistry, refractory materials classified by chemical and mineral composition are used (table).

Depending on the purpose, mixtures are divided into cladding, filling and single.

The facing mixture is of the highest quality and is used to cover the working surface of the mold in direct contact with the molten metal. The thickness of the facing sand layer depends on the type and nature of the casting (15–50 mm).

The filling mixture is poured on top of the facing mixture, has less strength and gas permeability, and Have gas permeability for the release of vapors and gases in the process of heating and casting.

Do not change the chemical composition of the melt and do not react with it chemically.

Provide the necessary expansion to compensate for alloy shrinkage.

Do not contain substances that may impair the quality of the casting by reacting with it.

Easy to separate from the casting.

A particularly important requirement for molding materials is compensation for the shrinkage of metal alloys during their solidification. Gold alloys shrink within 1.5% when solidifying, and chromium-nickel alloys - 2.4%. Consequently, shrinkage of structural alloys during their solidification must be compensated by expanding the mold by the amount of shrinkage. expanding shape is more facilitated by heating it in a muffle furnace.

Refractory materials are made mainly on the basis of mineral raw materials by forming a chemical-mineral composition and structure in the process of technological processing of raw materials. The raw materials for the production of refractories are natural materials, for example, quartzites, quartz sands, refractory clays and kaolins, bauxite, aluminum silicates, hydrated natural varieties of



aluminum, magnesites, dolomites, limestones, natural silicates and hydrosilicates of magnesium, zircon sands, graphite, etc.

The industrial production of refractory materials is carried out in the form of dry powdery masses of various degrees of grinding, the strength characteristics and refractory properties of which are laid down by the introduction of binder additives cheaper. It is prepared by processing a used molding sand with the addition (3–5%) of fresh materials.

A single mixture makes up the entire volume of the mold and is widely used in dentistry for foundry technologies. It differs from the filling mixture by a high content of fresh materials and better physical and mechanical properties.

Silica dioxide, quartz ( $\text{SiO}_2$ ) is a solid, refractory substance. The melting point of quartz is  $1800^\circ\text{C}$ . In nature, it occurs in the form of transparent crystals, which are called rock crystal. Depending on the impurities, quartz can take on different shades. Quartz crystals (Fig. 2 a) are subjected to primary firing – fritting, which results in a product called frit. As a result of the rapid cooling of the frit, high stresses are formed inside the molten quartz, which lead to extensive cracking of the mass (Fig. 2 b). The material obtained in this way is easily crushed, which is carried out to obtain a fine powder (Fig. 2 c).

Under normal conditions, silica is most often found in a polymorphic modification of  $\alpha$ -quartz, which at a temperature of  $573^\circ\text{C}$  reversibly transforms into  $\beta$ -quartz. As the temperature rises further, quartz changes to tridymite and cristobalite. Polymorphic transformations of quartz and cristobalite from the  $\alpha$   $\beta$  form are accompanied by an increase in volume and are used to compensate for the shrinkage of the casting. The melting point of  $\beta$ -quartz is  $1610^\circ\text{C}$ , and the melting point of  $\beta$ -cristobalite is  $1723^\circ\text{C}$ . The tridymite modification of quartz is not It is used in the manufacture of refractory molds, since its allotropic transition with an increase in temperature is not accompanied by a significant increase in volume.



Fig. 2. Quartz crystals (a), quartz after fritting (b), ground quartz (c)

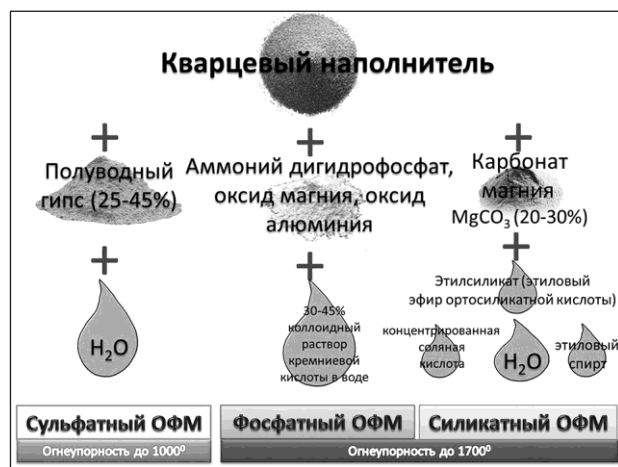


Fig. 3. Compositions of sulphate, phosphate and silicate molding refractory materials



In refractory silica-type molding materials, ground quartz (marshallite, or pulverized quartz is a finely dispersed mineral filler made of quartz sand containing at least 98% SiO<sub>2</sub>) and cristobalite (pure finely dispersed quartz sand with a crystalline structure and processed at high temperatures) are used. The high degree of dispersion of powder particles of the molding material ensures good surface cleanliness of the casting. Powder granularity from 20 to 60 μm is up to 90% of the volume of the particle size distribution of modern quartz molding materials.

Sulfate, phosphate and silicate bonds are used to bind quartz filler particles, the names of which determine the subgroups of quartz refractory molding materials (Fig. 3).

Sulfate quartz refractory molding materials consist of modifications of silicon dioxide (filler) and a binder – semi-aqueous gypsum, which is added to the filler in a volume of 25 to 45%. The molding compound mixed with water hardens within 10 to 30 minutes. During solidification, sulfate molding compounds expand within a range of 0.1 to 0.45%. In a rigid metal ring in which the molding compound is cured, A gasket made of compressible material (dry cellulose or mineral silicate wool with acrylic acid binder) should be installed so that the expansion during hardening occurs in a radial direction.

Thermal expansion of the mold is the main condition for compensating for the shrinkage of alloys during casting. To create a volumetric expansion, the mold is subjected to heat treatment before work. If the molding material contains quartz, then the mold is heated to 700°C, if cristobalite – to 450°C. The increase in thermal expansion indices is influenced by the ratio of water and powder during the kneading of the molding sand (the thicker the batch, the greater the thermal expansion of the mold) and the percentage the content of cristobalite in the filler (cristobalite causes thermal expansion of the molding material up to 1.6%, and quartz - up to 1.4%). Sulphate molding materials are characterized by low refractoriness that does not meet the required criteria. Low refractory values are due to the thermal instability of gypsum. Already at a temperature of 1000°C, gypsum decomposes into calcium and sulfur oxides. Insufficient refractoriness allows these molding materials to be used for casting gold-bearing alloys with a melting point of up to 1000°C.

Hydrolyzed ethyl silicate is obtained from silicon tetrachloride. As a component of the binder, it has a crystallographic structure close to the parameters of the crystal structure of dispersed quartz powder. Hydrolyzed ethyl silicate solution is obtained by mixing 10–50% ethyl silicate, 5–15% H<sub>2</sub>O, up to 1.0% HCl, the rest is an organic solvent (alcohol). Preparation of hydrolyzed silicate is carried out in the following sequence. Pour alcohol, water, hydrochloric acid into the hydrolyzer and stir them for 1-2 minutes. Then, stirring constantly, ethyl silicate is added to the solution. Silicate molding compounds are characterized by a high coefficient of thermal expansion and high heat resistance (up to 1700°C), which allows them to be used in casting all types of metal alloys used in dentistry with the exception of titanium.

Phosphate quartz molding materials have a refractoriness of up to 1700°C. They consist of modifications of silicon dioxide (filler) and a binder - zinc-phosphate cement. When mixing powder (quartz-cristobalite filler, ammonium dihydrogen phosphate, magnesium oxide, aluminum oxide) with a liquid (30–45% colloidal solution of silicic acid in water), phosphates are formed, which are durable. Bind particles of the filler of the molding sand with phosphate crystal hydrate. The ratio of silicon oxide sol to water in the molding pulping process affects the expansion rate of the material. As the volume of water decreases, there is a greater expansion of the molding material. Usually, a proportion of three parts of a liquid of silicon oxide sol to one part of distilled water is used. As a result of heat treatment, phosphates pass from ortho pyroform (pyrophosphate), which has high refractoriness.

For casting titanium (melting point 1660±20°C), aluminous high-refractory molding materials with an electrolumina content of more than 95% of alumina (refractory and chemically resistant material based on aluminum oxide Al<sub>2</sub>O<sub>3</sub>) are used. Ethyl silicate is used as a binder. It is possible to use



aqueous solutions of magnesium and zirconium salts as binders. In addition to aluminous materials, it is possible to create casting molds designed to fill them with molten titanium, zirconous refractory materials with a ZrO<sub>2</sub> content of more than 85%, bound by zirconium nitrate or silicate, and carbon (graphite) molding materials with a resin binder are used as a refractory material.

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