

COMPOSITE MATERIALS IN DENTISTRY: CLASSIFICATION, COMPOSITION AND CLINICAL APPLICATION

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Annotatsiya. Ushbu maqola maqsadi hozirgi davrda yuqori estetik va fizik-mexanik xususiyatlari baland bo'lgan kompozit materiallarni stomatologiyada va tibbiyotning boshqa sohalarida qo'llanilishi, kompozit materiallar turlari haqida to'liq ma'lumot berish. Stomatologlarga ularni terapevtik tanlash uchun asos bo'luvchi mezonlarni yoritish. Kompozit materiallar so'ngi 50 yil ichida shunchalik rivojlanib bordiki an'anaviy stomatologiyada tishning yoqotilgan qattiq to'qimasini qayta tiklashda amalgamma va sementlarni ortda qoldirdi. Uni boshqa stomatologik materiallardan asosiy ustuvorliklari shundaki, ajoyib estetik ko'rinish, antagonist tishlar bosimiga chidamliligi, uzoq vaqt xizmat qilishi, suvni kam singishi, ishlov berishda keng qamrovli imkoniyat mavjudligi va organizmga zararli toksik jihati yo'qligi.

Kalit so'zlar: kompozit material, antagonist, toksik

Аннотация. Цель данной статьи заключается в освещении применения композитных материалов с высокими эстетическими и физико-механическими свойствами в стоматологии и других областях медицины, а также в предоставлении полной информации о видах композитных материалов. В статье рассматриваются критерии, которые служат основой для их терапевтического выбора стоматологами. За последние 50 лет композитные материалы значительно развились и в традиционной стоматологии превзошли амальгаму и

цементы при восстановлении утраченных твердых тканей зуба. Основными преимуществами этих материалов являются высокая эстетичность, устойчивость к нагрузке со стороны антагонистических зубов, долговечность, низкое водопоглощение, широкие возможности обработки и отсутствие токсического воздействия на организм.

Ключевые слова: композитный материал, антагонист, токсичность

Abstract. The aim of this article is to provide comprehensive information about the use of composite materials with high aesthetic and physico-mechanical properties in dentistry and other fields of medicine, and about the types of composite materials, as well as to highlight the criteria that serve as a basis for their therapeutic selection by dentists. Over the past 50 years, composite materials have developed to such an extent that they have surpassed amalgam and cements in traditional dentistry for restoring lost hard dental tissue. Their main advantages over other dental materials are excellent aesthetic appearance, resistance to pressure from antagonist teeth, long service life, low water absorption, broad processing capability, and the absence of toxic effects on the body.

Keywords: composite material, antagonist, toxicity

Introduction

Until 1950, silicate cements were used for the aesthetic restoration of hard dental tissue in dentistry. In the early 1950s, polymethacrylate (PMMA) resin, made from pre-polymerized PMMA powder mixed with liquid methyl methacrylate (MMA) monomer, began to be used. These materials had a number of drawbacks, including a high degree of shrinkage, lack of bonding to the tooth, and pulp reactions caused by their toxicity. In addition, the material was quite weak and had a high coefficient of thermal expansion. Attempts were made to reduce these problems by decreasing the

amount of inorganic filler. Dr. Rafael Bowen tried introducing epoxy resins filled with crushed fused quartz particles. Epoxy had good adhesion to many surfaces, but it did not cure well under moist conditions, and the chemicals used to achieve rapid polymerization irritated the tissues. Dr. Bowen's subsequent research produced a hybrid molecule based on the reaction of methacrylate with epoxy, resulting in the Bis-GMA monomer (bisphenol A glycidyl methacrylate), often called "Bowen's resin," for which a US patent was granted in 1962, and the material was introduced into dental education literature in 1963. The appearance of this material became the foundation for the creation of modern composite materials in dentistry.

Today, 2,2-bis[4-(2-hydroxy-3-methacryloxypropyloxy)phenyl]propane (Bis-GMA) and urethane dimethacrylate (UDMA) are used as composite material ingredients. Both monomers have a reactive carbon double bond at each end of the monomer chain, which is activated during the polymerization process. The monomer has high viscosity, especially Bis-GMA, so a diluent is added. To reduce and control the viscosity of the composite material mixture, a bifunctional compound with a carbon double bond, such as Bis-EMA6 or triethylene glycol dimethacrylate (TEGDMA), is used. In 2018, a new type of methacrylic monomer was introduced to reduce the volumetric shrinkage and polymerization stress of composite material. The distance between methacrylate groups was increased in order to reduce the cross-linking density. Another approach was to increase the rigidity of the monomer. Examples of low-shrinkage monomers include dimer acid, DuPont monomer, and FIT-852.

To reduce the shrinkage and internal stress resulting from polymerization, a new monomer system called silorane was developed. The name "silorane" comes from "siloxane" and "oxirane" (epoxide). The role of the siloxane and oxirane components is to give the composite material hydrophobic properties and to enable ring-opening cross-linking through cationic polymerization. Silorane polymerization requires a special initiator system.

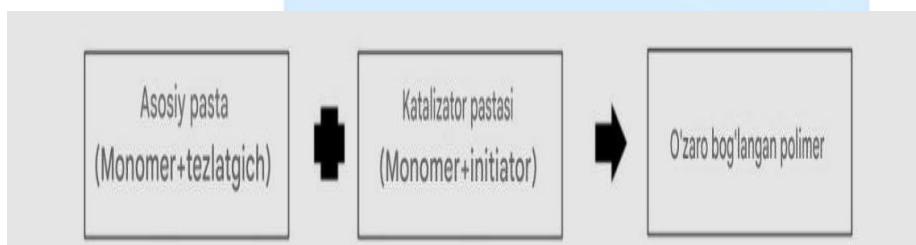
Fillers

Various transparent mineral substances are used to strengthen composite materials and to reduce shrinkage and thermal expansion during hardening. These include borosilicate, fused quartz, aluminum silicate, lithium aluminum silicate, and "soft glass" and "hard glass" composed of barium (Ba), strontium (Sr), and zinc (Zn).

Quartz is chemically inert and very hard, and it is also very difficult to reduce to fine and ultrafine particles. For this reason, composite materials are difficult to polish. Amorphous silica has the same composition and refractive index as quartz. Unlike quartz, amorphous silica is not crystalline or hard, so it can reduce the abrasiveness of the composite surface structure.

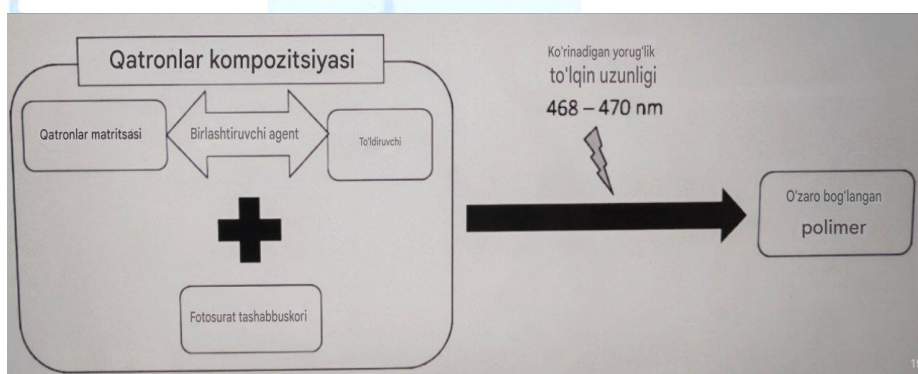
The photopolymerization process

The polymerization process of composite materials begins with the release of free radicals from the methacrylate monomer structure, which is achieved through thermal, chemical, or radiant energy. A chemically activated material consists of two pastes: a base paste and a catalyst paste, usually supplied in different colors. The base paste (Paste I) contains an oligoester acrylate binder, filler, a polymerization activator (accelerator), and pigments. The catalyst paste contains a binder, filler, and the polymerization initiator — benzoyl peroxide. Polymerization begins when the two pastes are mixed in a 1:1 ratio, during which the benzoyl peroxide initiator and the aromatic tertiary amine activator generate free radicals.



Light-activated composite material consists of a single paste, which contains a photosensitizer and an amine initiator. When the composite material paste is

illuminated with light at a wavelength of 468–470 nm, free radicals are generated in the composite material. Camphorquinone is typically used as the light-activated substance; it can absorb light at a wavelength of 400–450 nm and makes up about 0.2% of the weight of the composite material paste. The amine initiator used together with camphorquinone is dimethylaminoethyl methacrylate (DMAEMA), which makes up about 0.15% of the composite paste. When the composite material is illuminated, camphorquinone activates DMAEMA to generate free radicals.



CLASSIFICATION OF COMPOSITE FILLERS

Macrofillers.

R.L. Bowen developed a macrofiller-based composite by treating ground quartz with silane, bringing particle size down to 30 microns. Compared to earlier filling materials, this material stood out for its high aesthetic properties, good marginal adaptation, and strong physico-mechanical properties. However, the filling material has a relatively large particle size and hardness, which makes it difficult to polish, poorly responsive to finishing, and prone to a rough surface and color instability.

Advantages:

1. High strength
2. Good optical properties

3. Radiopacity

Disadvantages:

1. Difficult to work with; lacks a "dry shine"
2. High surface roughness
3. Accumulation of dental plaque
4. Lack of color stability

Indications for use:

1. Filling Class I and II carious cavities
2. Filling Class V carious cavities in posterior teeth
3. Posterior teeth where high aesthetic demands are not required
4. Restoring severely damaged anterior teeth and covering the crown surface with another filling material
5. Building up a tooth stump under an artificial crown

Microfillers.

Microfilled composites were developed in the late 1970s. They contain silicon dioxide and other fillers. The particles are spherical in shape and are produced based on the hydrolysis of silicon tetrachloride. The typical particle size is 0.04–0.4 microns, and the filler content by volume is approximately 30–50%, averaging 35–37%. Microfilled composite fillings polish to a higher shine than other fillings. Their main drawbacks are relatively low mechanical strength, a high degree of polymerization shrinkage, and a high coefficient of thermal expansion (the total filler mass of 30–60% corresponds to only 25–30% by volume).

Indications for use of microfillers:

1. Filling Class III and V carious cavities
2. Filling cavities in non-carious lesions

3. Preparing aesthetic adhesive veneers that do not cover the incisal edge of the tooth
4. Aesthetic restoration of Class IV cavities, provided the surface layer is covered with a hybrid filling material

Hybrid fillers.

Microfilled composite fillings stand out from other composite fillings for their high aesthetic effect. However, because they could not withstand the chewing pressure applied to lateral teeth and the incisal edges of anterior teeth, hybrid filling materials were developed by incorporating a larger volume and quantity of inorganic filler particles into microfilled composite material. In the original hybrids, the microparticles were about 1 micron and the macroparticles were 8–10 microns in size. As a result, the filling materials gained greater resistance to a rough surface, color changes, and mechanical loads from antagonist teeth. Microhybrid filling material, developed by combining inorganic micro- and macro-filler particles, meets all the requirements for composite materials. Examples of such filling materials include "Prisma TPH," "Z-100," "P-50" (3M), "Prodigy" (Kerr), "Tetric" (Vivadent), "Charisma," and others. Microhybrids are heavily filled, with filler content accounting for 75–80% of the material.

Advantages:

1. Good aesthetic properties
2. Sufficient strength
3. Better polishing of the filling surface compared to macrofillers
4. Radiopacity

Disadvantages:

1. Surface quality is not ideal — worse than microfillers
2. Surface polishing is insufficient

Indications for use of hybrid composites:

1. Serve as a universal filling material, though they are not effective for Class II and IV cavities
2. Used in combination with hybrid microfillers
3. Examples: Pertac-Hybrid, Visio Molar, Polofil, Polofil Molar, Compolux, Prizmafil

Nanofillers.

Nanofilled composites are currently being developed in two ways:

1. Improving the structure of microhybrid composites with nanofillers
2. Creating true nanocomposites based on various nanofillers

Properties of nanofilled composite (0.02–0.075 microns):

1. Filler makes up 79.5% of the total mass
2. High mechanical strength
3. High aesthetic properties
4. High surface polish and natural shine of the filling
5. Examples: Filtek Supreme XT, Ceram X, Grandio, Herculite XRV Ultra, Sapphire, Tetric EvoCeram, NanoPaq, and others

Conclusion.

Technological advances have driven the development of composite materials and dental restoration. Improvements in the properties of earlier composite materials, achieved by enriching them with several types of fillers, led to greater strength, aesthetic appeal, improved restoration quality, and longer service life of filling materials. This opened up the main stage in the development of modern dentistry.

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