

ADHESIVE SYSTEM, COMPOSITION AND HISTORY OF ITS CREATION

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Annotation. The adhesive system is a set of substances that are used in a fixed sequence and then ensure the adhesion of the filler. The adhesive system mainly consists of 3 different types of substances; consists of surface modified acid, primer, bonding.

Key words: adhesive system, primer, bonding, surface modified acid, orthophosphoric acid, enamel, dentin.

Introduction: An adhesive system consists of a single adhesive and a surface preparation agent or several components that are applied alternately or mixed with each other. Adhesive systems must meet the following requirements;

- ☐ Adhesion to dental tissues.
- ☐ Adhesion to filling materials or cements.
- ☐ Insoluble in oral fluid.
- ☐ Resistant to mechanical and chewing pressure.

Adhesives are simultaneously adhesive systems for enamel and enamel-dentin. By composition, the system is one-, two- or multi-component. An acid (mineral or organic mixture) is used to clean the enamel surface, dentin surface from a partially demineralized layer. A surface-modified acid is sometimes called a conditioner. For this purpose, inorganic (orthophosphoric) and organic (citric, maleic, polyacrylic) acids can be used. Primers are a complex of highly active substances, dissolved polymers, acids and other compounds that enhance adhesion. Primers can be single-component or multi-component.

The adhesive (adhesive agent, bond, bonding agent) serves to directly establish the connection between the tooth tissue and the filling material.

Adhesive systems are essential components in modern restorative dentistry. They provide the necessary bond between the tooth structure (enamel and dentin) and restorative materials such as composite resins. The development of adhesive systems has revolutionized the field of conservative dentistry, enabling minimally invasive techniques, enhanced aesthetics, and long-lasting restorations.

Composition of Adhesive Systems

An adhesive system generally consists of the following components:

Etchant (Conditioner):

Typically composed of 30–40% phosphoric acid, it removes the smear layer and demineralizes the enamel and/or dentin surface to create micro-porosities for resin infiltration.

Primer:

Contains hydrophilic monomers (e.g., HEMA – hydroxyethyl methacrylate) dissolved in solvents like ethanol, acetone, or water. The primer facilitates resin penetration into the moist dentin and helps in hybrid layer formation.

Adhesive Resin (Bonding Agent):

A low-viscosity, hydrophobic resin that bonds to the primed tooth structure and provides a strong link to the composite resin. Common monomers include Bis-GMA and UDMA.

These components may be applied in separate steps (in multi-bottle systems) or combined into fewer steps (in simplified systems).

Classification of Adhesive Systems

Adhesive systems are commonly classified into:

Etch-and-rinse systems (Total-etch):

Involve a separate etching step followed by primer and adhesive application. These systems are known for high bond strength, especially to enamel.

Self-etch systems:

Use acidic monomers that both condition and prime the tooth simultaneously, eliminating the need for a separate etch-and-rinse step. These are less technique-sensitive and better suited for dentin bonding.

Universal adhesives (Multi-mode):

These newer systems can be used in both etch-and-rinse or self-etch modes and can bond to a variety of substrates, including enamel, dentin, ceramics, and metals.

Historical Development

1950s–1960s:

The concept of adhesion in dentistry began with the introduction of acrylic-based materials.

However, bonding to tooth structure was very limited.

1970s:

Buonocore's technique of acid-etching enamel with phosphoric acid (1955) gained popularity, significantly improving enamel adhesion.

1980s:

The introduction of dentin bonding agents began. The early generations showed weak bonds due to poor understanding of dentin's moist nature and smear layer.

1990s:

Development of total-etch (4th generation) and self-etch systems (5th and 6th generations) marked significant progress. The concept of the hybrid layer and micromechanical bonding became well established.

2000s–Present:

Universal adhesives were introduced, offering versatility, ease of use, and reliable performance across different clinical scenarios. Nanotechnology and new monomer systems like 10-MDP have further improved durability and chemical bonding.

Adhesion mechanisms.

The mechanisms of adhesion to dental tissues can be divided into two groups: micromechanical and chemical.

Micromechanical adhesion occurs mainly due to the bonding of elements (enamel prisms, collagen fibers) that are isolated from the entire structure of the tooth with polymer hardeners.

Chemical adhesion occurs due to the direct relationship between the structure and adhesion of dental tissues. The main substrates for adhesion are enamel and dentin.

Enamel is a demineralized tissue. It does not contain water, contains a small amount of organic substances. Structurally, enamel is represented by enamel prisms, radially but distinctly separated from the enamel-dentin boundary. Hydroxyapatite - the main mineral substance of enamel - is prone to dissolution by acids.

With a short-term (15-30 seconds) 36% solution of orthophosphoric acid, the enamel surface becomes rough, and after drying it becomes dull and colored.

Adhesive system: consists of travitel, primer, bond.

Surface-modified acid (etchant) is a chemical substance used to clean the surface of the tooth, especially enamel and dentin, from microparticles after necrotizing, when the dentinal tubules are clogged. The main composition of Travitel: Medium Phosphoric acid (H_3PO_4) is the main active ingredient. Usually it is in a concentration of 30–40% (the most commonly used is 37%). Function: It erodes tooth enamel and dentin at a microscopic level (demineralization), which ensures good adhesion of the filling to the tooth. Stabilizers - ensure long-term storage of the product. Dental primer is a hard tooth tissue, enamel and mainly dentin tubules, after which the structure of the primer changes, and is used to restore the structure of dentin. The primer provides a strong and stable bond between the filling material and the tooth tissue.

Composition of dental primer: Monomers - this substance is the main active component of the primer. For example: HEMA (Hydroxyethyl methacrylate) TEGDMA (Triethylene glycol dimethacrylate). Solvents - provide monomers to the tooth and deeper penetration. They help keep the primer in a liquid state: Ethanol, Acetone, Water. Water - some modern primers may also contain water, especially in "self-etch" systems. pH regulators - adjust the acidity of the primer and provide the necessary environment for preparing the tooth surface. Stabilizers – ensure long-term storage of the product. Photoinitiators (if the primer is light-curable) – help start the polymerization (hardening) process. For example: Camphorquinone. Dental bonding is a special adhesive that provides a strong bond between dental tissues (mainly enamel and dentin) and composite filling materials. It can consist of a primer and an adhesive (bonding layer) or they can be combined (for example, in "universal bonding" systems). Bonding composition - Functional monomers: Bond to dental tissues chemically and micromechanically. The most commonly used: HEMA (Hydroxyethyl methacrylate). 10-MDP (10-Methacryloyloxydecyl dihydrogen phosphate). GPDM (Glycerol phosphate dimethacrylate).

Dimethacrylate monomers (main bonding layer): Provide bonding with filling materials.

For example: Bis-GMA (Bisphenol A-Glycidyl Methacrylate). UDMA (Urethane Dimethacrylate). TEGDMA (Triethylene Glycol Dimethacrylate).

Solvents: Provide deeper penetration of monomers into the tooth. Usually: Ethanol, Acetone, Water. Photoinitiators: Activated by light and initiate polymerization (hardening). For example: Camphorquinone (CQ), Ethyl 4-dimethylaminobenzoate (EDMAB). Stabilizers and inhibitors: Required for long-term storage of the product and to prevent temporary polymerization. Differences by type of bonding: Total-etch (etch-and-rinse): requires separate etching, primer, bonding. Self-etch: primer and bonding combined. Universal bonding: suitable for any technique (self-etch, total-etch, selective-etch).

Conclusion

Adhesive systems have come a long way from early, unreliable bonding agents to today's sophisticated universal adhesives. A deep understanding of their composition, mechanisms, and evolution allows clinicians to make informed decisions and deliver predictable, high-quality restorative care.

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