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Review

Systematic review of the chemical composition of contemporary dental adhesives

Kirsten L. Van Landuyt[a], Johan Snauwaert[b], Jan De Munck[a], Marleen Peumans[a], Yasuhiro Yoshida[c], André Poitevin[a], Eduardo Coutinho[a], Kazuomi Suzuki[c], Paul Lambrechts[a], Bart Van Meerbeek[a,*]

[a]*Leuven BIOMAT Research Cluster, Department of Conservative Dentistry, School of Dentistry, Oral Pathology and Maxillo-Facial Surgery, Catholic University of Leuven, Kapucijnenvoer 7, B 3000 Leuven, Belgium*
[b]*Laboratory of Solid-State Physics and Magnetism, Department of Physics and Department of Chemics, Catholic University of Leuven, Celestijnenlaan 200D and 200G, B 3001 Heverlee, Belgium*
[c]*Department of Biomaterials, Graduate School of Medicine and Dentistry, Okayama University, 2-5-1 Shikata-cho, Okayama 700 8525, Japan*

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Abstract

Dental adhesives are designed to bond composite resins to enamel and dentin. Their chemical formulation determines to a large extent their adhesive performance in clinic. Irrespective of the number of bottles, an adhesive system typically contains resin monomers, curing initiators, inhibitors or stabilizers, solvents and sometimes inorganic filler. Each one of these components has a specific function.

The aim of this article is to systematically review the ingredients commonly used in current dental adhesives as well as the properties of these ingredients. This paper includes an extensive table with the chemical formulation of contemporary dental adhesives.

Keywords: Dental adhesive; Chemical composition; Resin; Initiator; Inhibitor; Filler

Contents

*Corresponding author. Tel.: +32 16 33 75 87; fax: +32 16 33 27 52.
E-mail address: bart.vanmeerbeek@med.kuleuven.ac.be (B. Van Meerbeek).

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1. Introduction

The primary aim of dental adhesives is to provide retention to composite fillings or composite cements. In addition to withstanding mechanical forces, and in particular shrinkage stress from the lining composite, a good adhesive also should be able to prevent leakage along the restoration's margins. Clinically, failure of restorations occurs more often due to inadequate sealing, with subsequent discoloration of the cavity margins, than due to loss of retention [1,2].

The adhesive capacity of dental adhesives is based on a twofold adhesion. First, the adhesive adheres to enamel and dentin, and second, the adhesive binds the lining composite. The latter has been shown to be a process of co-polymerization of residual double bonds (–C═C–) in the oxygen inhibition layer. As for the bond to enamel and dentin, micromechanical adhesion is assumed to be the prime bonding mechanism [3]. This is achieved by an exchange process by which inorganic tooth material is replaced by resin monomers that become interlocked in the retentions upon curing [4,5]. Diffusion and capillarity are the primary mechanisms to obtain micro-mechanical retention. Microscopically, this process is called 'hybridization' [6]. Whereas this process entails simple interlocking of resin in etch-pits in enamel, entanglement of resin within the exposed collagen lattice occurs in dentin. However, recent self-etch adhesives with a mild (relatively high) pH do not completely expose collagen anymore. An additional mechanism of ionic bonding of acidic monomers and calcium in hydroxyapatite was recently established [7], which may explain the good clinical performance of some of these mild self-etch adhesives [8].

Considering these underlying bonding mechanisms, one can define some requirements for adhesive systems. Micromechanical interlocking will occur after consecutive demineralization, resin infiltration and polymer setting. As a consequence, adequately removing the smear layer together with demineralizing enamel and dentin to a small extent, good wetting, diffusion, penetration and good polymerization of the resin components are all important. Chemical bonding can be achieved by adding specific monomers with affinity for hydroxyapatite. Last, sufficient co-polymerization between the adhesive and the lining composite will provide good adhesion to the composite.

The chemical composition of adhesives is (—or at least should be—) aimed at fulfilling all above-mentioned processes. Even though dental adhesives can be classified in two main groups, i.e. etch&rinse (E&Rs) and self-etch adhesives (SEAs) (Fig. 1), they all contain similar ingredients, irrespective of the number of bottles of which an adhesive consists. Nevertheless, the proportional composition differs between the different classes of adhesives. Traditionally, adhesives contain acrylic resin monomers, organic solvents, initiators and inhibitors, and sometimes filler particles. It is self-evident that every component has a specific function. Good insights in the chemical properties of the adhesives' components are paramount to understand or even predict their behavior.

The objective of this review article is to gather information on the properties of chemical components of which contemporary adhesives commonly consist. Regrettably, specific information about some chemical components of adhesives is scarce, like for example for the proprietary monomers. In addition, manufacturers are usually reluctant to reveal the composition of their adhesives. In order to avoid disclosure of the components, they often use descriptive terms. Unbiased research as to the composition of adhesives is also limited (or maybe not always published when performed by manufacturers themselves).

Factors related to common ingredients, such as resin, initiator, inhibitor, solvent and filler particles will be reviewed. After some general information, some specific ingredients will be discussed. Table 1 lists the chemical formulation of current dental adhesives according to the aforementioned classification, as gathered from commercial manufacturers (abbreviations Table 2).

2. Chemical composition

2.1. Resin components

In order to assure a good covalent bond between the adhesive and the lining composite, dental adhesives contain