

The Chemistry of Dentistry

Understanding the chemistry behind modern restorative techniques in dentistry.

Introduction

When weighing the factors that go into the testing of restorative dental materials, it is important to consider what would be the ideal material that would be most compatible with the oral cavity; to mimic the advantages of and minimizing the disadvantages of natural tooth. Natural tooth is degenerated by the lactic acid produced by bacteria metabolism, leading to cavities. Composite resin material used in dental restoration is composed of bulky methacrylate monomers and is heavily filled with a finely divided ceramics. Common composite resins provide good esthetics, mechanical strength, and wear resistance; however, when used in restorations such as fillings, it can experience setting shrinkage, water uptake, and monomer leaching: which can cause decay and the failure of fillings.

Objective

Explore ideal chemical qualities of a restorative dental material that allows for resistance against shrinkage and decay.

Background

Common organic composite resins solve some of the presented issues in restorative materials, but still present disadvantages. Urethane demethacrylate and bisGMA are used to decrease polymerization shrinkage (figure 1). However, these structures have a high viscosity, making them difficult to incorporate into fillings. To counteract this viscosity, smaller monomers of lower molecular weight, such as EGDMA or TEGDMA) are used as diluents in resin formation (figure 1).

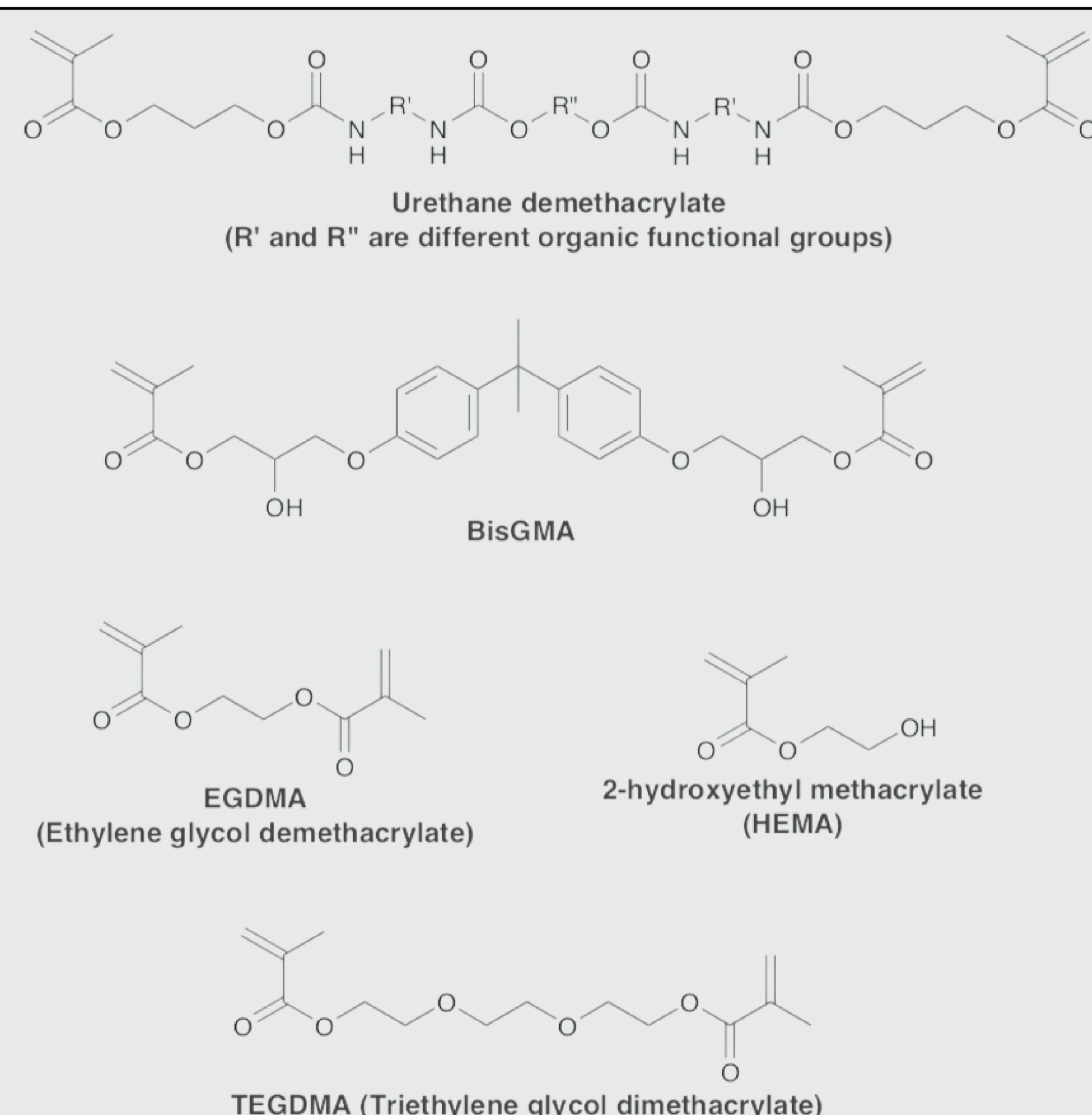


Figure 1. Structures of organic monomers commonly used in composite resin filling materials.

Background

Biological disadvantages have been observed from the use of organic composite resins such as cytotoxicity, genotoxicity, and cariogenicity.

Vitrebond, a common cement used in organic restorations, bonds with the tooth by a neutralization and polymerization reaction in accordance with figure 2.

European researchers created a dental polymer that is biologically compatible with the environment of the oral cavity. These polymers are known as organically modified ceramics, or ORMOCERS® for short. The first developed ORMOCER® was launched under the name Admira Fusion in 2016.

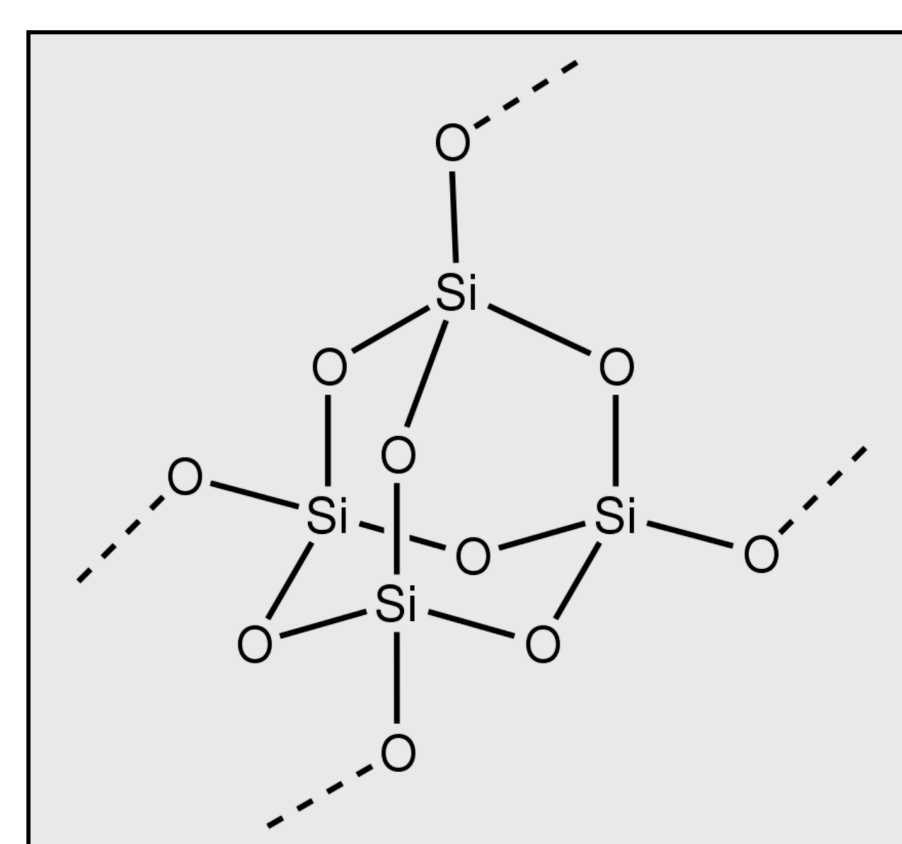


Figure 3. Silicon dioxide structure.

Admira Fusion consists of large, inorganic polymer molecules of silicon dioxide which readily photopolymerize; thus reducing setting shrinkage (figure 3). Admira is typically used with its corresponding bond, which bonds to enamel via photopolymerization.

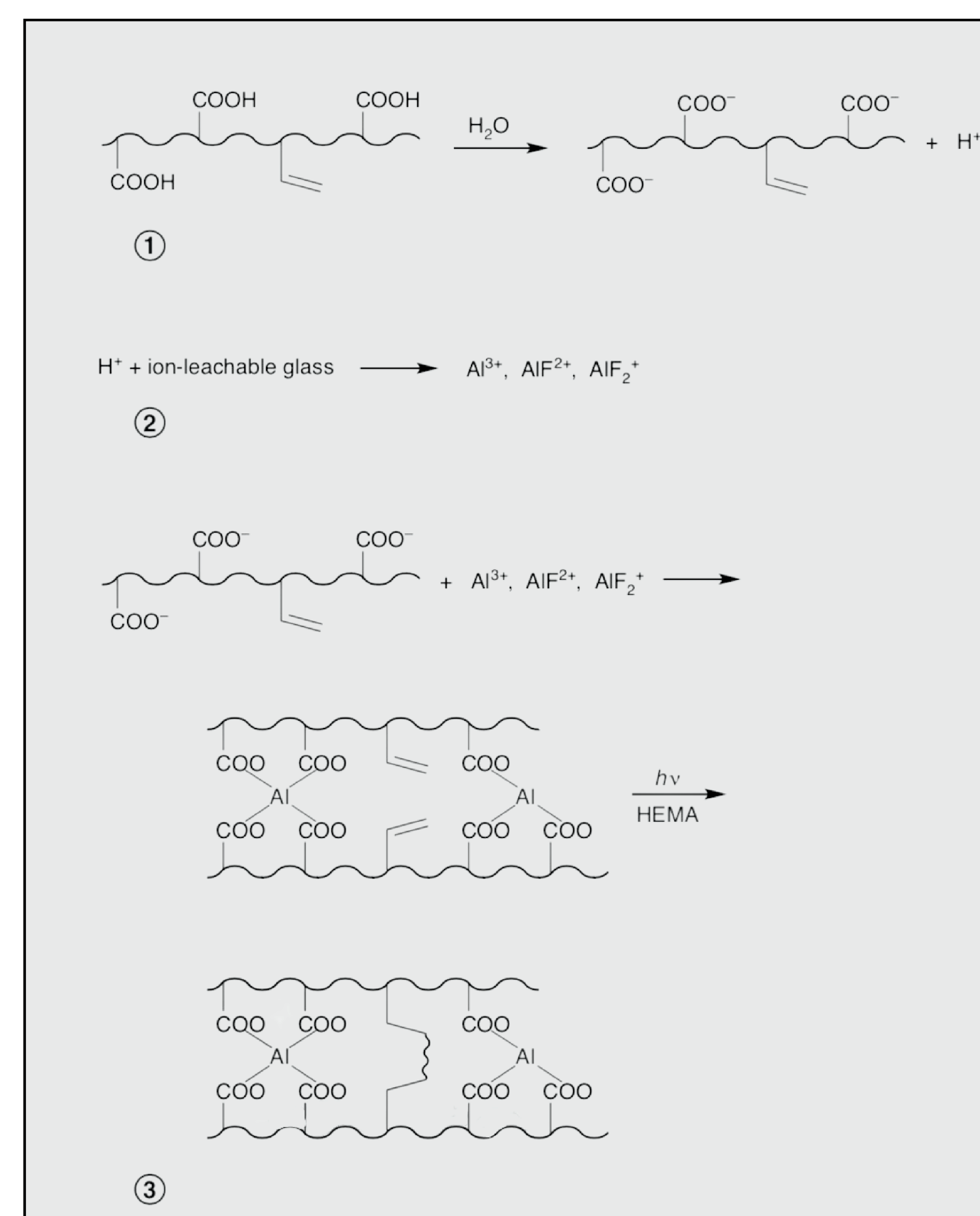


Figure 2. Bonding scheme for simplified version of the setting reaction of Vitrebond.

Methods

- Fifty four extracted human premolars, extracted for orthodontic reasons and without showing decay or cracks, were separated into four testing groups of twelve teeth each and two control groups containing three teeth each. The group distribution is shown below in table 2.

GROUP NUMBER	ADHESIVE	RESTORATIVE MATERIAL
I	Prime and Bond NT	Spectrum TPH
II	Admira Bond	Spectrum TPH
III	Prime and Bond NT	Admira
IV	Admira Bond	Admira
V	Prime and Bond NT	Spectrum TPH (positive control)
VI	Prime and Bond NT	Spectrum TPH (negative control)

Table 1. Group distribution by adhesion and restorative material in the in vitro study.

- Spectrum TPH is an organic methacrylate monomer resin containing bis-GMA and EDGMA. Prime and Bond NT is a conventional bonding agent used in restorations.
- Each tooth was prepared and restored as denoted in table 2.
- Each tooth was then covered in 2% solution of methylene blue dye for 48 hours.

Results

GROUP NUMBER	MATERIAL	MEAN DYE PENETRATION
I	Prime and Bond NT + Spectrum TPH	0.250 mm
II	Admira Bond + Spectrum TPH	0.433 mm
III	Prime and Bond NT + Admira	0.308 mm
IV	Admira Bond + Admira	0.200 mm
V	Positive Control	1.500 mm
VI	Negative Control	0.000 mm

Table 2. Measured mean dye penetration underneath restoration for each group and control.

When each restoration was analyzed, the mean dye penetration underneath the restoration was measured in millimeters. From these measured values, the mean for each sector was calculated (table 2).

Group IV, which contained restorations completed using Admira Bond and Admira, exhibited the lowest mean dye penetration: 0.200 ± 0.160 mm (table 2). Admira Bond alongside Spectrum TPH exhibited the highest dye penetration: 0.433 ± 0.240 mm.

Findings

Admira Bond when used with Admira showed the lowest measurement of mean dye penetration when compared with the other presented groups. This is considered one of the main advantages of ORMOCERS®. Their silicon dioxide structure could potentially lead to lower amounts of setting shrinkage, due to its large surface area when compared to organic composite resins. However, the dye penetration is not statistically significantly lower than the dye penetration for group I, which used organic composite resin alongside its corresponding bond.

Conclusion

Although significant advancements have been made in the development of organically modified ceramics, the use of this material does not ensure a lack of bacterial leakage. ORCOMERS® show advantages over organic composite resins, as organic composite resins can exhibit significant shrinkage and biological disadvantages. The advantages of ORCOMERS® have been attributed to the characteristics of included inorganic polymers such as silicon dioxide.

Sources

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- Kalra, S.; Singh, A.; Gupta, M.; Chadha, V. Ormocer: An aesthetic direct restorative material; an in vitro study comparing the marginal sealing ability of organically modified ceramics and a hybrid composite using an ormocer-based bonding agent and a conventional fifth-generation bonding agent. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3341759/>.