Dental Fillings:

A Reaction in Your Mouth

By Sergio Pistoi

IF YOU HAVE HEALTHY TEETH NOW, KEEP TAKING CARE OF THEM. But don't get your hopes up too high for the future: **During a lifetime, 92% of people eventually experience tooth decay,** according to the National Institute of Dental and Craniofacial Research. You may already be familiar with the problem, as approximately half of high school students in the United States have tooth decay.

Dental fillings are the unsung heroes in the fight against tooth decay. As the name suggests, the role of these substances is to seal any parts of a tooth that are damaged or lost as a result of tooth decay, restoring the tooth's function and preventing further decay.

What materials are used in dental fillings, and what do dentists do to make them stay inside teeth for a long time?

Different types of fillings

Sealing a tooth isn't easy. An ideal dental filler needs to be soft and malleable when applied, and must harden once in place. It must be resistant to chewing (a human bite can exert up to the equivalent of 275 pounds of pressure!), chemically stable, and biocompatible.

Gold was used as dental filler in the past. As a metal, it can be melted and cast inside a cavity. Gold is extremely durable but is expensive and not everybody likes it. Unless you are among the rich and famous, your dentist probably won't offer you the gold filling option.

Amalgam fillings, also known as silver fillings, have been used since the late 19th century. They are alloys of mercury and other metals, such as silver, tin, or copper. Amalgam fillings are durable and cost-effective, and are still used today. As a drawback, the dark metal color of amalgam is unattractive in a tooth. Also, because the amalgam does not stick to the tooth, dentists sometimes need to remove healthy portions to anchor the amalgam. Concerns have been raised about mercury (a toxic metal) leaking from fillings. The American Dental Association, however, says the amount of mercury released in the mouth under the pressure of chewing and grinding is small and no cause for alarm.

Composite resins, also known as white fillings, became widespread during the 1990s and are the fillings dentists use today. White fillings look better than amalgam because they can match the patient's tooth color. Resins are soft and can be easily applied to fill the hole. Inside a tooth, resins quickly solidify to become as hard as rock, and they last a long time thanks to a chemical reaction known as polymerization.

Glue in your teeth?

Generally speaking, polymerization (Fig. 1) occurs when many individual molecules, called monomers, react to form covalent bonds and produce a bigger molecule called a polymer.

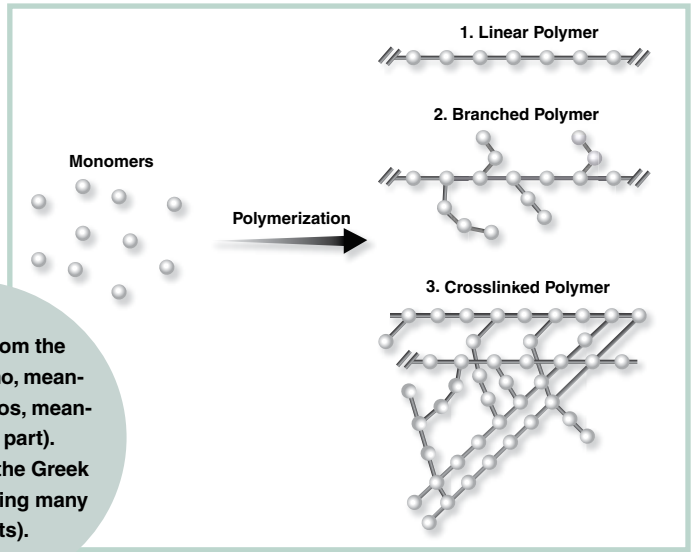
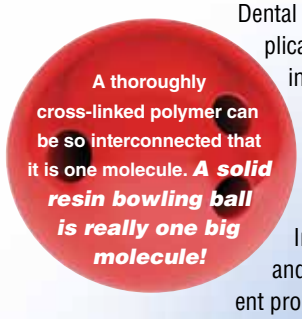


Figure 1. Individual monomers chemically combine to form one large polymer. The monomers can join: 1) to form one long chain in a linear fashion; 2) to make smaller chains that link to make a branched polymer; or 3) to make chains that form a complicated cross-linked structure.

Monomer: from the Greek word mono, meaning one, and méros, meaning part (one part).
Polymer: from the Greek word poly, meaning many (many parts).

A polymer is a chemical chain of repeating monomers, which can link hundreds, thousands, or even millions of times.

If you have ever used super glue, you have seen polymerization at work. The main component of super glue is a liquid monomer called methyl-2-cyanoacrylate. The presence of water (the moisture in the air is sufficient) starts the reaction, and the monomers join to form a solid polymer that is a strong adhesive.



Dental fillings are more complicated than super glue and involve a different monomer, but the chemistry behind their reactions works with the same polymerization principles. In both, the monomers and the polymer have different properties—before polymerization, the resin behaves like a paste, but once polymerized it becomes solid and hard.

Primers and blue light

The polymerization of the dental resin has to start with a molecule that triggers the reaction. This compound, called a primer or an initiator, works by creating free radicals—molecules with unpaired electrons—which promote the bonding of monomers. Once started, polymerization continuously happens, so only a few molecules of primer are needed to start the process.

When getting a white filling, you might have noticed a curious thing happening during the procedure. Immediately after laying the resin in the tooth, the dentist points a bright blue light close to it and asks you to remain still for a moment. As a patient, you may find it uncomfortable, but this is how polymerization is controlled. In this technique, the primer reacts only in the presence of blue light.

The advantage of such a process is that dentists can use pre-made resins that have the monomer and the primer already mixed. They use blue light to induce polymerization only when the resin is perfectly tucked inside the cavity. Since the light can travel only a few millimeters into the filling, the dentist pours a thin layer of resin first, applies the light to trigger polymerization, and then applies another layer of resin and repeats the procedure until the cavity is filled.


A hand-held wand that emits blue light is used to harden the resin within a dental patient's mouth.

Strength in diversity

Because the polymer alone would not be sturdy enough to withstand chewing, the dental resins include other materials to provide strength. Dental resin is considered a composite material, which means two or more substances form a structure that is stronger than the individual substances. Composite materials are used in many common substances—concrete and plywood are composites.

To reinforce dental resins, particles of silica-based glass are usually added. The polymer in dental resin is hydrophobic—it does not mix with water. Silica-based glass, however, is hydrophilic (it attracts water) due to a surface layer of polar hydroxyl groups (–OH) bound to the silica. Because of these opposite properties toward water, the polymer and the glass naturally repel each other; therefore, a third compound is needed to get the reaction going. This is why the composite also includes coupling agents, which are compounds that bond the polymer to the silica (Fig. 2).

A COMPOSITE is a material made from two or more constituent materials with different physical properties. The constituent materials join to produce a composite, which has different properties than the constituent materials. The composite is stronger and more rigid than the individual materials. Composites have two parts: 1) the matrix, and 2) reinforcement or filler. In the case of dental resin, the polymer is the matrix and silica is the reinforcement material—it is the substance that provides strength to the composite material.

Silanes are usually used as coupling agents. These silane molecules have a hydroxyl group on one end, and it condenses with a hydroxyl group on the surface of the glass to form an Si–O–Si link. The silanes also have a group that can bond covalently with carbon atoms in the polymer. Silanes work as a chemical bridge and hold the polymer and the silica-based glass together. Resins also include various pigments, or dyes, so the dentist can choose a shade to match their patient's tooth color.

Composite-resin fillings are sophisticated products that are constantly improving, but prevention remains the best course of action against tooth decay. Limiting the consumption of sugar and carbohydrates, brushing and flossing every day, and seeing a dental hygienist regularly are still some of the most effective ways to preserve healthy teeth, and possibly avoid the need for dental fillings altogether.

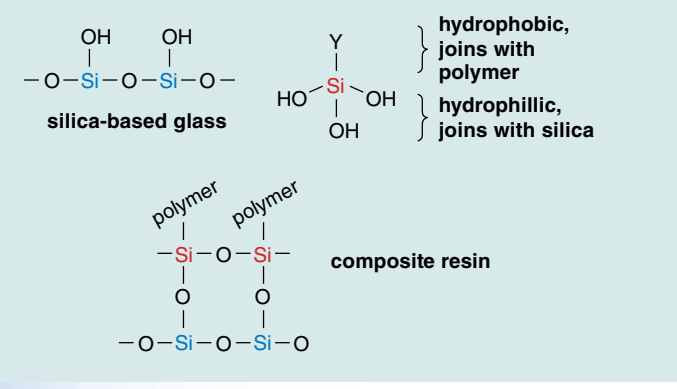


Figure 2. These are the structures of silica-based glass, the silane coupling agent, and the final composite resin. Y represents a group on the silane that can covalently bond to the polymer and provide the rigidity to a composite-resin filling.

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