Frequently Asked Questions

1. Is it the volume contraction of the UDMA resin affects the dimensional variations of FiberForce CST braids before and after polymerization?

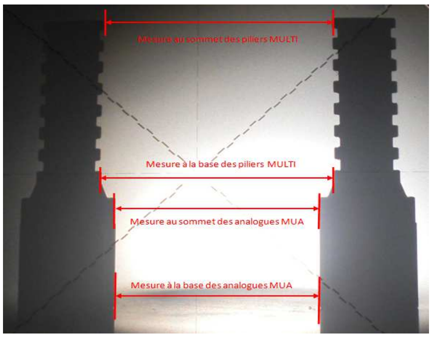
Summary

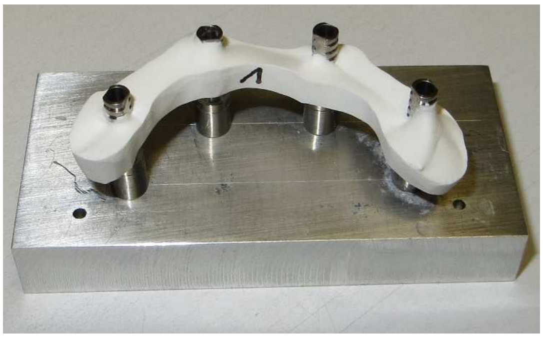
After polymerization of FiberForce CST braids, spatial stability of the fiber structure is insured by optimum reorganization of the resin. This organization provides a chemical and dimensional stability of the system.

For further informations :

a. Connection with passivity

Tests performed before and after polymerization show **shrinkage of 6%** in the width direction and **axial expansion resulting in a lengthening of 0.06%** (observed at the end of the braid) in the direction of the length. These results confirm the results obtained in tests of spatial stability [1]. Measured differences between the pillars before / after polymerization are about **fifty micrometers**. These results demonstrate that **a structure CST remains passive after polymerization**.



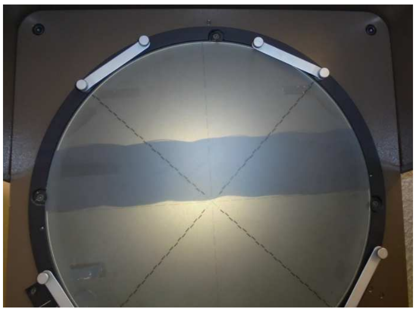


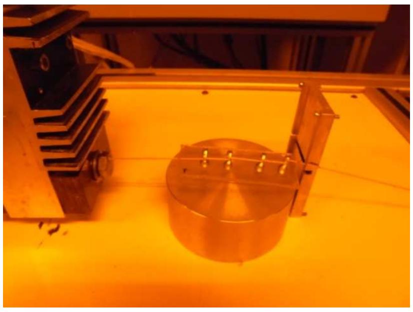
Picture 1 and 2: Measure between pillars and plaster key for Sheffield test

b. In vitro tests

Volume contraction of resins is a fundamental element for the practitioner because it informs on dimensional stability of composite and its impermeability. This contraction allows to obtain a **denser structure** and results in a decrease in material's volume. The amplitude of the polymerization shrinkage is dependent on various factors such as **formulation of the resin** or the **type of polymerization.**

In the case of **Fiber Force CST**, UDMA (urethane dimethacrylate) resin combines the advantages of urethane chemistry and methacrylate with a retraction with a 5 to 9%. This shrinkage is less than PMMA resin; which achieve 21% [2] [3]. In addition, the resin is not used alone but in synergy with hybrid glass braids known for their excellent dimensional stability and easy processing. So initial measurements on hybrid braids uncured and cured present a **removal rate of 6%** (in width). This rate represents a decrease of 0.1 mm for a braid impregnated with 1.32 mm (= braid + resin). Measurements were performed after 1 day and 7 days, they show a slight increase of the width that can be attributed to **stress relaxation** after reorganization molecular chains. Other tests on preimpregnated length showed an "**expansion**" resulting in a lengthening of braids of **0.06%** (0, 2 mm of 350 mm). After 7 days, there is no significant change [4] [5].





Picture 3 and 4: Test of volume contraction

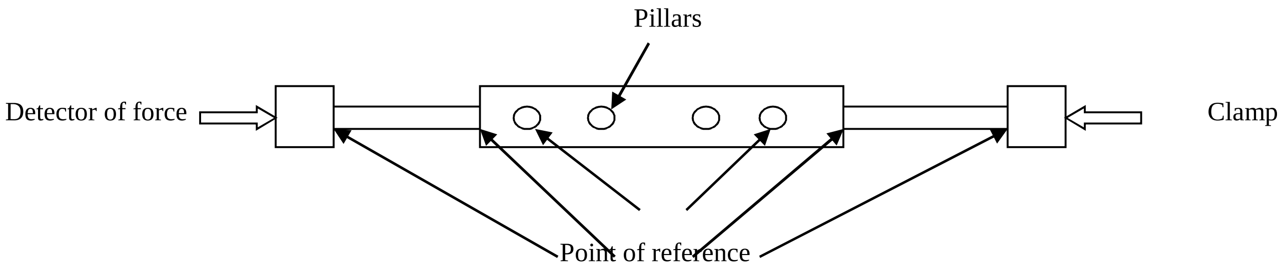


Illustration 1: Schematic representation of test

c. Conclusion:

Contraction and expansion's phenomena can be explained by fundamental laws in physics and chemistry: the **conservation of mass** (conservation of mass and the number of elements of each chemical species) and **thermodynamic stability**.

Indeed, during contraction, all chemical species are kept and reduce their spaces between them to obtain a level of maximum thermodynamic stability. The retraction is mainly in the width direction because the resin has more freedom to reorganize using the least energy possible. Then, the contraction is performed simultaneously with the dilation because the molecules are reorganized close to the fiber and it is no longer possible to continue the contraction in the width direction. To achieve a thermodynamic stability (a lowest energy level possible), the resin "distributes" on the length. Indeed it is easier to expand when the thickness is thinner. These steps will allow the system to be placed in a stable condition to insure stability in time.

We must not forget that the quantity of resin between glass fibers is calibrated using a pultrusion die (diameter 2 mm). So CST braid has a constant diameter and the rate of light-curing resin is stable along the braid. The quantity of resin on the braids is low and represents only 6% of the system (by volume). This quantity explains the weak rate of shrinkage in width and the weak expansion resulting by a lengthening of CST fibers.

Picture 5 : Preimpregnated fiber

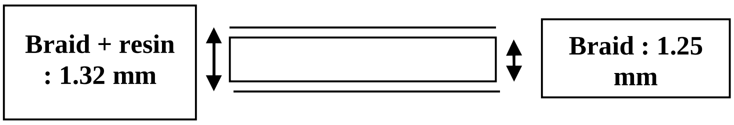


Illustration 2: Schematic representation of preimpregnated braid

2. How can FiberForce fibers chemically bind to implant abutments?

In the FiberForce CST process, several steps are specified in the part "Preparing implant pillars" to safeguard the stability of the connection between fibers and pillars. These three steps are essential to protect optimal chemical link and guarantee this connection in the future.

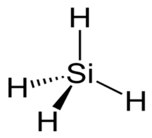
a) Sand blast the pillars using aluminium oxide :

⇒ This first step creates **a titanium-aluminum oxide bond**. Titanium abutment's surface can exist in different oxidation states as a many transition metals. In our case, it will be in the form of **TiO** through liaison with aluminum oxide.

$$Al_2O_3 + TiO_2 \longrightarrow Al_2O_4 + TiO$$

Illustration 3: Chemical reaction between pillar and aluminum oxide

Apply a silane on pillar



⇒ The **silane** is a « bridge molecule » (transition molecule), it allows forming bonds between organic and inorganic chemistry. This second step makes it possible to establish links between the aluminum oxide and silane.

b) Coat the pillars with a dental adhesive

⇒ The silane, bound to the aluminum oxide, will enable achieving connection with the **dental adhesive** (methacrylate polymer). Then this adhesive binds to pre-impregnated fibers which have similar chemistry.

In conclusion, the different steps to prepare implants abutments allow to create the link between braids and pillars and to obtain a durable bond in time.

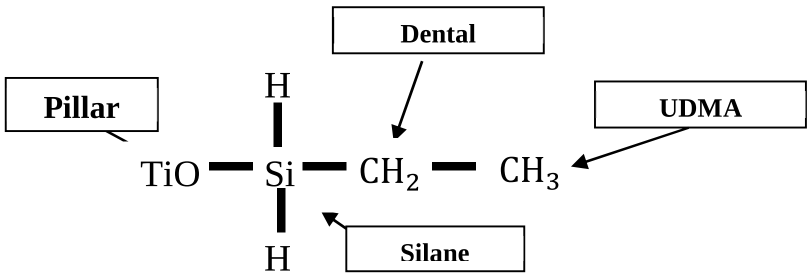


Illustration 4: Link between different elements

3. How can fiberglass bind to UDMA resin and then to PMMA?

a) Glass fibers and surface treatment

Glass fibers are obtained from sand (silica) and various additives. So silicon dioxide (or silica) **SiO2 is the main element of these fibers**. In addition, they undergo a surface treatment for adding a protective coating to permit agglomeration of the filaments and to facilitate integration into polymers. This treatment is called silanation made using silane molecules.

b) What is the silane and how it binds?

Silane is a small molecule; the basic atom is silicon (Si).

This molecule is capable of forming **organosilanes bonds**, it can be used as "bridge molecule" between the organic and inorganic chemistry. In our case, the organic chemistry is the UDMA resin and inorganic chemistry is represented by the glass fibers.

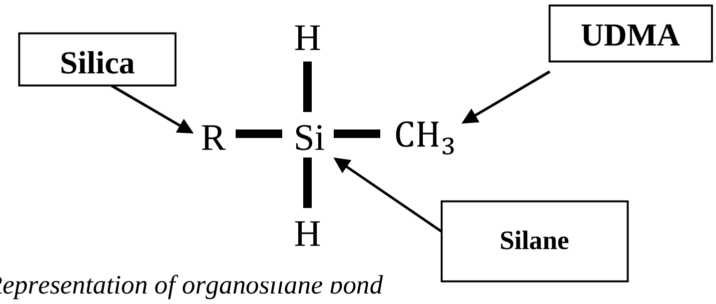


Illustration 5 : Representation of organosilane bond

Then UDMA resin can bind to PMMA resin used for making acrylic prosthesis because they are chemically compatible.

***Bibliography* :**

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[2] CHARTON Christophe. Experimental matrices for dental use; formulation, development, characterization and influences on the contraction's stresses. National Polytechnic Institute of Lorraine specialty engineering processes and products, 2012, 215 p.

[3] CHAUMONT Pierre-Emmanuel. Light curing composite resins: current data. Faculty of Dentistry, University of Lorraine. 2012, 104 p.

[4] PETER-SORENCEN Sandrine. Volume contraction of CST braids 1. BCM, 2014, 9p.

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Glossary:

Volume contraction or shrinkage: it is the replacement of Van der Waals bonds (0.4 nm) by covalent bonds (0.15 nm) during the formation of three-dimensional network.

Van der Waals interaction: electrical interaction of low intensity between atoms, molecules, or between molecules.

Covalent bond: strong bond in which two atoms share two electrons to form an electron doublet linking two atoms.

UDMA = urethane dimetachrylate

PMMA = polymethyl methacrylate

Oxidation States: A molecule may be in different oxidation states, it may lose one or more electrons.

Organic Chemistry: is the chemistry of carbon and its compounds, natural or synthetic. These compounds are able to bind to each other, by covalent bonds to form carbon chains of great diversity.

Inorganic chemistry: also called inorganic chemistry, involves the study of the various simple substances existing in nature or artificially obtained and these compounds (example: minerals, alloys, etc ...