SILANISING AGENTS PROMOTE COMPOSITE REPAIR

Repair of defective composite restorations, instead of full replacement, has been actualised over the last decades. The widely used composite restorations are repairable and the modern philosophy of “Minimal Intervention Dentistry” has become more rooted among dentists all over the world. This fact raises the question: Is there anything we can do to make the repair interface durable and strong enough to match the physical and biological challenges in the oral environment? This topic has been addressed in a research project performed at NIOM by the Norwegian guest scientist, Frode Staxrud, DDS.

The aim of the project was to investigate whether silanising agents could play a part in improving the strength of the repair interface in combination with commonly used bonding products. The project consisted of two parts. In part one, the repair of old composites was performed. Sixty 6-years-old test substrates made from six different composite brands, were repaired and tested according to a standard test procedure (ISO/TS 11405). The substrates were repaired with new composite using three different bonding procedures: 1) bonding agent without silane, 2) bonding agent with a separate silane step (freshly mixed 2-part silane) and 3) a bonding agent containing silane. In part two, repair of newly made composites was performed and evaluated using 66 freshly made composite substrates and the same test protocol as described for old composites.

Repair interfaces where silane was not involved showed significantly lower shear bond strength than the repair interfaces containing a silanising agent. There was no statistical difference between the two bonding procedures involving a silane. The increase in repair strength when using silane was almost 140 % for old composites and 50 % for new composites, indicating that repair of older composites has a higher potential to benefit from using silanising agents. On the other hand, repair of new composites showed significantly higher shear bond strength values and hence the potential for an increase of the bond strength at the repair interface is lower.

Clinical implications: Although in vitro studies cannot fully represent the real clinical situation, the present results indicate that the use of a silane is recommended when repairing resin composite restorations either as a separate step in the bonding procedure or incorporated in the bonding agent.

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FTIR SPECTROSCOPY FOR MEASUREMENT OF CURING

The degree of conversion (DC) is a measurement of the curing of a resin-based material. Fourier Transform Infrared spectroscopy (FTIR) may be used to determine the DC. The method calculates the conversion of reactive methacrylate groups in the material. The calculation is based on ratios of area or height of specific peaks in the FTIR-spectrum of the material.

A FTIR instrument may have different sampling techniques, generally transmission or reflection, using liquid, powder or solid samples. Attenuated total reflection (ATR) is a technique where the material is positioned directly on the top of a crystal (often a diamond) and the IR-beam penetrates through the crystal into the lower surface of the material and reflects back for detection. ATR may be used to measure a wide variety of samples without any complex sample preparation.

The ATR technique may be used to measure DC at different depths of a material, for instance a cylinder may be used to prepare samples of varying thickness. This method is particularly relevant for light-curing composite materials, where the layering of the material in the restoration is an issue. The material may then be cured from the top surface using an ordinary curing unit in a set-up resembling the in situ curing. The method can be used for evaluation of bulk-fill materials for which thicker layers (e.g. 4 mm) are used, compared to conventional composites.

A well-documented method for restorative composites uses the peak of the aliphatic C=C double bonds at 1638 cm⁻¹ of the unreacted methacrylate groups versus the stable peak of the aromatic C=C double bond at 1608 cm⁻¹ found in the Bis-GMA monomer, see equation. The method also requires a reference ratio to be measured before curing, as the degree of conversion is given as a percentage.

Equation for calculating the DC:

\[
\%DC = (1 - \frac{\text{aliphatic } C=C/\text{aromatic } C=C}{\text{polymer}}) \times 100
\]

NIOM may perform measurements of degree of conversion of restorative materials and other polymer-based biomaterials using our FTIR instrument. We have equipment for measuring transmission and reflection (ATR) as well as a DRIFT-accessory (diffuse reflectance) for powder samples.