Sorption and solubility of different light-activated composites

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Abstract

Background: The solubility of materials in the mouth and the sorption (adsorption and absorption) of oral fluids are important criteria in their selection. In addition to other parameter, these two criteria should be checked when choosing resin composite materials. Water sorption of resin composites may cause expansion of the restoration, which would be detrimental to the restoration itself, so it is important to limit the amount of absorbed water. In addition, solubility of resin-based composite materials is of concern, since inorganic ions presented as fillers within composites can leak into the surrounding environment resulting in breakdown of the restoration. The aim of this study was to evaluate and compare water sorption and solubility values of different light-activated dental composite materials. **Materials and methods:** Ten commercial light-activated dental composite materials were included in this study: Tetric Evo Ceram, Premise, Herculite, Z100, Z250, P60, SupremeXT, Quadrant Posterior Dense (QPD), Quadrant Universal LC (QULC) and Quadrant Anterior Shine (QAS). Ten specimens were prepared for each composite using a stainless steel mold 15 mm in inner diameter and 1 mm in thickness. The curing of each composite specimen was divided into five segments and each segment was photo-cured for 40 seconds (totally 200 seconds). Water sorption and solubility of the different composites were calculated by means of weighting the samples before and after immersion in water (15 days) and desiccation. Data were subjected to one-way ANOVA, test at a 0.05 significant level. **Results:** Regarding water sorption, Premise light activated composite exhibited the highest mean value, while Quadrant Anterior Shine composite exhibited the lowest mean value, with statistical significant difference between the light-activated dental composite materials which were included in this study. Regarding solubility, Premise light activated composite exhibited the highest solubility mean value, while Quadrant Posterior Dense composite exhibited the lowest solubility mean. **Conclusion:** All the composites tested in the present study exhibited sorption and solubility values within the acceptable limits. The sorption and solubility of light activated composites are highly influenced by their particular organic and inorganic composition.

Key words: composite, composite sorption, composite solubility, water sorption.

Introduction

Absorption refers to the uptake of liquid by the bulk solid. It indicates concentration of molecules at the surface of a solid or of a liquid.[1] Water sorption by dental composite materials is a diffusion-controlled process, and the water up taken occurs largely in the resin matrix.[2] The water absorbed by the polymer matrix could cause filler–matrix debonding or hydrolytic degradation of the fillers[3] and it may affect composite mechanical properties.[4,5] The hydrolytic degradation is a result of either the breaking of chemical bonds in the resin or softening through the plasticizing action of water.[6] When resin samples are immersed in water, some of the components, such as unreacted monomers or filler, dissolve and are leached out of the composites. This results in loss of weight and can be measured as material solubility.[7] Several factors contribute to the process of elution from dental composites: unreacted monomers, chemistry of the solvent and size and chemical composition of the elutable species.[8] The release of these components may influence the initial dimensional change of composite,[9] the clinical performance,[10] the aesthetic aspect of the

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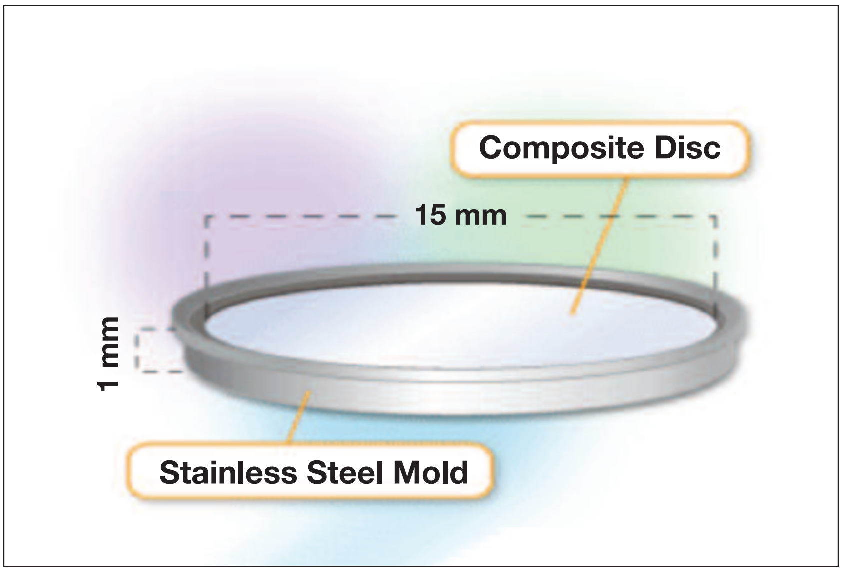

Figure 1: The stainless steel mold used for preparation of specimens in this study.

restorations[11] and the biocompatibility of the material.[8] Sorption and solubility are affecting composite restorations by two different mechanisms; the first is the up taking of water producing an increased weight and the second is the dissolution of materials (fillers or monomers) in water, leading to a weight reduction of the final conditioned samples.[10] The aim of this study was to evaluate and compare water sorption and solubility values of different light-activated dental composite materials.

Material and Methods

Ten composite materials were selected for this study, sorption and solubility of the materials were tested. The materials chosen were: Tetric Evo Ceram (Ivoclar, Vivadent AG FL-9494 Schaan/Liechtenstein), Premise (Kerr,orange,CA 92867,USA), Herculite (Kerr,Orange CA 92867,USA), Z100 (3M-ESPE,St. Paul, MN,USA), Z250 (3M-ESPE,St. Paul, MN,USA), P60 (3M-ESPE,St. Paul, MN,USA), Supreme XT (3M-ESPE,St. Paul, MN,USA), QPD (Cavex, Germany), LC (Cavex, Germany) QAS (Cavex, Germany) forming ten experimental groups (n = 10). Each composite specimen disc was 15 ± 1 mm in diameter and 1 ± 0.1 mm thick and was prepared using a stainless steel mould (Figure 1). The materials were prepared in accordance with the manufacturer's instructions, by filling the mold with the material using a plastic spatula to condense, and covering it with a piece of transparent polyester film which was placed over the mould and finally covered by a glass slide. The photocuring of each composite specimen was divided into five sections overlapping with each other and each section was photocured with the bluephase C5 (LED) (Ivoclar, Vivadent AG, FL-9494 Schaan/Liechtenstein, Austria) light curing unit for 40s. The specimens were removed from the mould and any flash if present, was removed. The specimens were transferred to an air oven (memmert,Gmbh,D-91126 schwabach, Germany) and dried for 2 hours at 37C°. Then the specimens were transferred to the desiccators containing silica gel, freshly dried for 2 hours at 20C°.

The specimens were weighed by using an analytical balance (Precisa,TYP 205A, Switzerland) with an accuracy of ± 0.1 mg. This cycle was repeated until a constant mass (m°) was obtained. The specimens were immersed in distilled water and maintained at 37 C° for 15 days. After that time, the specimens were removed, washed with water, surface water blotted away until free from visible moisture, and waved in the air for 15 seconds, then finally weighed 1 minute after being removed from the water. This mass (m1) was recorded. The specimens were placed in the desiccator using the same cycle as described above but the temperature was 58 C° to obtain (m2). This cycle was repeated until constant mass was obtained. These steps were carried out to evaluate water sorption (A) and water solubility (S) according to Oysaed & Ruyter 12 formula: $A=m1-m2/V$ and $S=m°-m2/V$, where m° is the sample weight before immersion, m1 is the sample weight after immersion and m2 is the sample weight after immersion and desiccation. V is the volume of the specimen in cubic millimeters. Data were analyzed by comparing mean values in sorption and solubility of different composite groups.

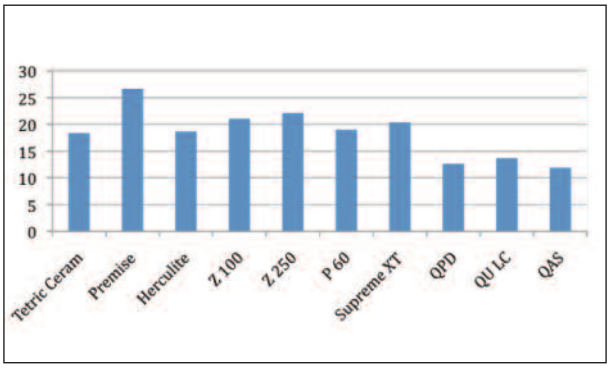

Figure 2: Mean sorption values of dental composites in μg/mm^3

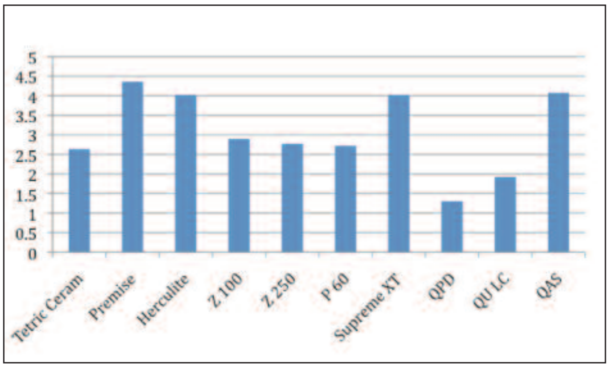

Figure 3: Mean solubility values for dental composites in μg/mm^3

Results

Water sorption and solubility means and standard deviations (in parenthesis) of Tetric Evo Ceram, Premise, Herculite, Z100, Z250, P60 and Supreme XT, QPD, QULC and QAS composites in μg/mm3 were summarized in Table 2. Data were subjected to one-way ANOVA, test at a 0.05 significant level.

Regarding water sorption, one- way ANOVA showed that water sorption was different for tested materials(F=12.19). Premise light activated composite exhibited the highest water sorption mean value, while QAS composite exhibited the lowest water sorption mean value (Figure 2). Regarding solubility, one- way ANOVA showed that water solubility was different for tested materials(F=4.61).Premise light activated composite exhibited the highest solubility mean value, while QPD composite exhibited the lowest solubility mean value (Figure 3).

Discussion

Using One-way Analysis of Variance to accept or refuse Null hypothesis, showed that there was a significant difference between the different composite groups. ADA Specification No. 27[13] requires that "the water sorption of all materials be less than or equal to 40 μg/mm^3" and "the solubility of all materials be less than or equal to 7.5 μg/mm3 within a seven day period of water storage". On the same time, resin composites indicated as restorative materials must also comply with ISO 4049:1988 for a maximum value of 40 μg/mm^3 for water sorption and 7.5 μg/mm^3 for water solubility within a seven day period of water storage.[14] It appears from the results of water sorption and solubility that all the composite materials evaluated in this study pass these two standards.

Several factors, such as the polymeric matrix composition, filler particle type and content, and the degree of curing reached after the polymerization reaction can influence the solubility and sorption behavior of dental resin composites.[3,15]

Bis-GMA–based dental composites are the common dental composite materials. The high viscosity of the polymer requires the addition of diluents monomers, which are coupled with the presence of hydroxyl groups in the Bis-GMA molecule result in high values for sorption. The possible cause behind the highest mean values in water sorption and solubility associated with Premise light activated composite could be due to the resin matrix composition since Premise light activated composite is the only tested composite that contains ethoxylated Bis-GMA resin matrix which can be considered a weak resin matrix in providing the composite adequate resistance against sorption and solubility.

The second possible cause for differences in water sorption and solubility relates to the degree of cure of the polymer network. Inadequate polymerization of dental composite probably increases the solubility and may also increase the water sorption, since the network will be less tightly cross-linked.[16] The incorporation of prepolymerized filler in the structure of Premise light activated composite might interfere with adequate curing of this composite, resulting in a high sorption and solubility mean value. This finding agreed with the findings of Pearson and Longman (1989) Ahmed A. El-Hejazi (2001), and Kim et al., (2002).[16,17,18]

The composites used in this study have a great similarity in the filler particle content by volume except for Premise light activated composite resin which exhibits the highest sorption and solubility values and this could be related to its highest filler loading by volume (69%) (Table 1). This finding in agreement with finding of Buket et al study which shows lower water sorption and solubility of Filtek A110 microfilled

Table 1: Composition of the selected composites in this study.

Composite	Organic/inorganic Matrix	Inorganic Filler	Filler size	% in Volume (Filler)
Supreme (XT)	BIS-GMA, BISEMA, UDMA and TEGDMA	Zirconia/Silica	(clusters of 0.6 to 1.4 µm particules of 5 to 20 nm)	57.7*
Z100	Bis-GMA and TEGDMA	Zirconia/Silica	0.01-3.5 µm	66*
P60	Bis-GMA, UEDMA and Bis-EMA	Zirconia/Silica	0.01-3.5 µm	61*
Z250	Bis-GMA, UEDMA and Bis-EMA	Zirconia/Silica	0.19 – 3.3 µm	60*
Premise	The ethoxylated Bis-GMA	Non-agglomerated silica nanoparticles, prepolymerized filler, 0.4 micron barium glass	0.02 µm APS	69*
Tetric Evo Ceram	Dimethacrylates (17-18% weight)	barium glass, ytterbium trifluoride, mixed oxide and prepolymer	0.04-3 µm 0.55 APS	*61-60
Herculite	Bis-GMA and TEGDMA	Barium glass and silicon dioxide	0.6 µm	59%*
Quadrant Posterior Dense	Bis-GMA UDMA and TEGDMA	Barium glass, Porus SiO_2	0.7-8 µm	57%*
Quadrant universal LC	Methacrylate-based monomers	Silica, silicate glass, fluoride fillers	0.7-8 µm	60%*
Quadrant Anterior Shine	Methacrylate-based monomers	Silica, silicate glass, fluoride fillers	0.7-8 µm	63%*

* Manufacturer's information
APS: Average particle size

composite resin which has lower filler content when compared to other resin composite specimens.[19]

Conclusions

All the composites being tested in this study have exhibited sorption and solubility values within the acceptable limits. Sorption and solubility of light activated dental composites are highly influenced by their particular composition and curing degree.

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Table 2: Sorption & solubility means and standard deviations of composites.

	Water sorption(µg/mm³)		Water solubility(µg/mm³)	
Material	**Mean**	**SD**	**Mean**	**SD**
Tetric Ceram	18.343 (4.297)	4.297	2.639 (1.331)	1.331
Premise	26.666 (6.642)	6.642	4.359 (1.534)	1.534
Herculite	18.683 (4.161)	4.161	4.020 (0.903)	0.903
Z 100	21.064 (5.319)	5.319	2.901 (1.787)	1.787
Z 250	22.137 (6.916)	6.916	2.774 (2.109)	2.109
P 60	19.023)3.149(	3.149	2.718 (1.705)	1.705
Supreme XT	20.382 (2.655)	2.655	4.020 (1.497)	1.497
QP D	12.624 (0.964)	0.964	1.302 (1.534)	1.534
QU LC	13.698 (0.696)	0.696	1.924 (1.285)	1.286
QAS	11.888 (0.534)	0.534	4.076 (0.877)	0.877

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