Leaching of Glass Filler Particles from Aged Dental Composites

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Statement of Purpose:

Dental composites consist of a resin matrix coupled to a filler phase that contributes to the composite's strength and durability. Modern composites incorporate glass particles such as barium, silicon, and strontium in the filler phase.

Composites are subject to the chemical and mechanical insults of the oral cavity, which degrade their composition and durability over time. Drummond et al. (1) demonstrated that glass filler ions (Sr, Ba, or Si) leached into solutions (distilled water, 50% ethanol-50% water, and artificial saliva) when aged from 4 to 8 months, leading to a decrease in flexure strength. Zhou et al. (2) utilized x-ray wave dispersive spectrometry to measure the glass content of aged composites at their surface. This study attributed ion loss to two primary mechanisms: ion exchange and matrix dissolution leading to glass particle loss.

The purpose of this study was to measure the change in elemental composition of the glass filler particles at the top surface and a deeper layer of composites. The intent was to determine if an ion gradient exists from the top surface to deeper layers, which could characterize ion exchange occurring between the composites and solutions. Surface analysis was performed on the glass filler particles by energy dispersive x-ray (EDX) analysis utilizing a transmission electron microscope.

Methods:

Four dental composites were evaluated: Micronew (Bisco Inc., Schaumburg, IL), Renew (Bisco), Choice (Bisco), and Restolux (Lee Pharmaceutical Inc., South El Monte, CA). A total of 16 specimens 3 x 3 x 25-mm were polished with 120 and 240-grit SiC paper then aged for 8 months in artificial saliva, distilled water, 50% ethanol-50% water, and humid air (over a water bath at 37ºC). The specimens were cut into 3 x 3-mm wafers parallel to the longitudinal surface, polished with a Gatan 623 Disc Grinder (Gatan Inc., Pleasanton, CA), to a smoothness of 1 micron using Metadi Supreme diamond suspension (Buehler) on a Texmet 1500 polishing cloth (Buehler). Two wafers were analyzed from each specimen - one wafer from the top surface, and the second wafer at a depth approximately 1.5mm from the top surface. The wafers were mounted on carbon coated copper TEM grids and viewed in a transmission electron microscope,. The elemental composition of each specimen was measured by EDX analysis, performed at 14 locations on each specimen.

Results/Discussion:

The data in the table represents mean weight percent and standard deviations for 14 data points per specimen. Statistical analysis using a one-way ANOVA showed no significant differences in glass filler weight percent between zero and 1.5 mm depths.

Renew		Silicon		Barium	
	Depth	mean	stdev	mean	stdev
Air	0 mm	58.2	2.0	23.9	1.5
	1.5 mm	58.1	1.6	26.0	1.8
Alcohol	0 mm	59.1	2.0	26.3	2.6
	1.5 mm	54.6	2.5	29.6	3.3
Saliva	0 mm	59.1	1.8	25.7	1.8
	1.5 mm	61.3	1.6	23.6	1.8
Water	0 mm	59.3	0.8	24.7	0.9
	1.5 mm	57.7	1.0	26.1	1.7

Choice		Silicon		Strontium	
	Depth	mean	stdev	mean	stdev
Air	0 mm	50.4	3.7	37.4	3.3
	1.5 mm	52.1	3.5	32.7	3.9
Alcohol	0 mm	51.1	4.8	33.6	5.0
	1.5 mm	51.7	5.3	34.0	5.6
Saliva	0 mm	50.6	3.7	34.3	2.1
	1.5 mm	48.1	9.7	37.3	8.5
Water	0 mm	51.1	7.0	35.3	6.0
	1.5 mm	50.7	4.3	34.4	5.4

Restolux		Silicon		Barium	
	Depth	mean	stdev	mean	stdev
Air	0 mm	52.9	4.6	27.9	3.3
	1.5 mm	55.7	1.9	29.4	3.2
Alcohol	0 mm	51.4	4.6	30.6	7.1
	1.5 mm	54.6	2.5	29.6	3.3
Saliva	0 mm	55.7	2.0	29.2	2.1
	1.5 mm	56.8	2.7	27.4	2.9
Water	0 mm	55.0	4.0	29.3	4.7
	1.5 mm	53.8	3.2	31.7	6.4

Micronew		Silicon		Strontium	
	Depth	mean	stdev	mean	stdev
Air	0 mm	55.9	3.5	23.3	8.2
	1.5 mm	53.3	3.9	31.6	3.8
Alcohol	0 mm	57.7	4.3	23.4	9.4
	1.5 mm	54.4	6.3	24.3	8.7
Saliva	0 mm	54.5	5.6	29.1	8.5
	1.5 mm	52.1	3.4	28.1	6.5
Water	0 mm	57.3	3.3	14.8	1.6
	1.5 mm	58.8	2.1	15.6	2.1

Conclusions:

Ion levels between the top surface and a 1.5mm depth did not exhibit a significant gradient. This indicates a uniform loss of both resin and filler from the exposed surfaces to the aging media. Therefore, the main mechanism of leaching is due to matrix dissolution, rather than ion exchange.

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References:

1) Drummond J, et al. Leaching and mechanical properties characterization of dental composites. J Biomed Mat Res. 2004;71:172-180 2) Zhou M, Drummond JL, Hanley L. Barium and strontium leaching from aged glass particle/resin matrix dental composites. Dent Mater. 2004; 21:145-155