

Water sorption of light-cured composites

Ammar Kh Al-Nori
BDS, MSc (Assist Lect)

Department of Prosthetic Dentistry
College of Dentistry, University of Mosul

ABSTRACT

The aim of the present research was to study the percentage water sorption and solubility of Esthet composite resin based on an ethoxylated bisphenol A glycol dimethacrylate (Bis-EMA) and Heliomolar composite resin based on bisphenol A glycol dimethacrylate (Bis-GMA). Six specimens were prepared for each material using aluminum disc 15 mm in diameter and 1 mm in thickness between two glass slides; then they were light cured for 80 seconds on each side. Percentage water sorption and solubility were measured after one week and one month. The results showed that water sorption after 1 week for Esthet composite and Heliomolar composite were 0.433 and 1.12, respectively and solubility were 0.074 and 1.066, respectively; while water sorption after 1 month were 0.517 and 2.57, respectively and solubility were 0.176 and 2.689, respectively.

It could be concluded that the percentage sorption and solubility of composite based on Bis-EMA were significantly lower than that based on Bis-GMA.

Key Words: Water sorption, composite resin, water solubility.

Al-Nori AKh. Water sorption of light-cured composites. *Al-Rafidain Dent J.* 2005; 5(1): 1-5.

Received:

3/8/2004

Sent to Referees:

5/8/2004

Accepted for Publication:

14/9/2004

INTRODUCTION

Dental composite resin exhibit water sorption property in oral cavity.⁽¹⁾ Mechanical properties such as strength, hardness, elastic modulus and dimensional stability are affected by water sorption.⁽²⁻⁵⁾ These reductions of mechanical properties have been attributed to the hydrolytic degradation of the polymer matrix and of filler and to water induced filler-matrix bond failure.^(6, 7)

In an effort to overcome the composite material resistance to flow (high viscosity), manufacturers reported the dilution of composites with unfilled resin to facilitate placement during restorative procedures. The most widely used resin in dental composites is that based on the copolymer prepared from a combination of bisphenol A glycol dimethacrylate (Bis-GMA) and triethylene dimethacrylate (TEGMA). TEGMA is usually added to Bis-GMA in

order to achieve workable viscosity limits since the latter monomer possesses very high viscosity due to intermolecular hydrogen bonding.^(8, 9) Bis-GMA monomers are hydrophilic; there is growing need to a lower water uptake. The ethoxylated bisphenol A glycol dimethacrylate (Bis-EMA) has been proposed as less hydrophilic monomer.^(10, 11)

The aim of the present research was to determine the water sorption and solubility characteristics of light - cured composite resins based on Bis - GMA or Bis-EMA.

MATERIALS AND METHODS

Two visible light-cured composite resins were used: Esthet composite resin (Dentsply Caulk, Dentsply International Inc, Milford, USA), which is a hybrid composite resin. The monomer matrix is

composed of Bis-EMA. The inorganic filler 79 weight % with particle size 0.04 μm; and Heliomolar composite resin (Vivadent, Schaan, Liechtenstein), which is a microfilled composite. The monomer matrix is composed of Bis-GMA. The inorganic filler 77.8 weight % with particle size 0.04 μm.

Specimens were prepared using aluminum discs 15 mm in diameter and 1 mm in thickness between two glass slides; then they were irradiated for 80 seconds on each side with dental curing unit (Quayle Dental, Derotor House, Dominion Way, UK).

Six specimens were prepared of each material. These were dried over silica gel in a desiccator at 37 °C and weighted daily to an accuracy of 0.001 gm using a digital balance (Sartorius AG, Germany). Specimens were re-weighted at regular intervals every 24 hours until constant weight was

achieved. All specimens were found to be stable after 48 hours. This was considered to be the initial weight of the specimens (W₁). Specimens were then immersed in distilled water in an incubator at 37 ± 2 °C. The specimens were subsequently removed from their containers at one week and one month. Excess water was removed by blotting with filter paper and the weight of the specimen was recorded (W₂) at each occasion. This represented the weight of the specimen after sorption or desorption of distilled water after one week and one month immersion in distilled water.

The specimens were then transferred to a drying desiccator at 37 °C and weighted daily until constant weight was achieved and the amount of soluble material lost was measured after each sorption or desorption cycle and recorded (W₃).

The percentage sorption and solubility were determined as follows:

1)

$$\text{Sorption \%} = \frac{W_2 - W_3}{W_1} \times 100$$

$$\text{Sorption \%} = \frac{\text{Weight after sorption or desorption} - \text{Final weight after desiccation}}{\text{Initial weight}} \times 100$$

2)

$$\text{Solubility \%} = \frac{W_1 - W_3}{W_1} \times 100$$

$$\text{Solubility \%} = \frac{\text{Initial weight} - \text{Final weight after desiccation}}{\text{Initial weight}} \times 100$$

Student's t-test was used to compare the effect of one week and one month immersion in distilled water on percentage sorption and solubility of Esthet and Heliomolar composites. Also t-test was used to compare the effect of Bis-GMA and Bis-EMA on percentage sorption and solubility. A level of $p > 0.05$ was regarded as non significant.

RESULTS

The means of the percentage sorption

and percentage solubility in distilled water are summarized in Table (1) and the Figure.

Tables (2) and (3) show the differences in the percentage sorption and solubility after one week and one month immersion in distilled water. For Esthet composite, there was no statistical difference between one week and one month. For Heliomolar composite, the percentage sorption and solubility after one month was significantly greater than after one week ($p < 0.001$).

Table (1): Means of percentage sorption and percentage solubility of Esthet and Heliomolar composite resin

Material	Percentage Sorption		Percentage Solubility	
	1 Week	1 Month	1 Week	1 Month
Esthet	0.433	0.517	0.074	0.176
Heliomolar	1.12	2.57	1.066	2.689

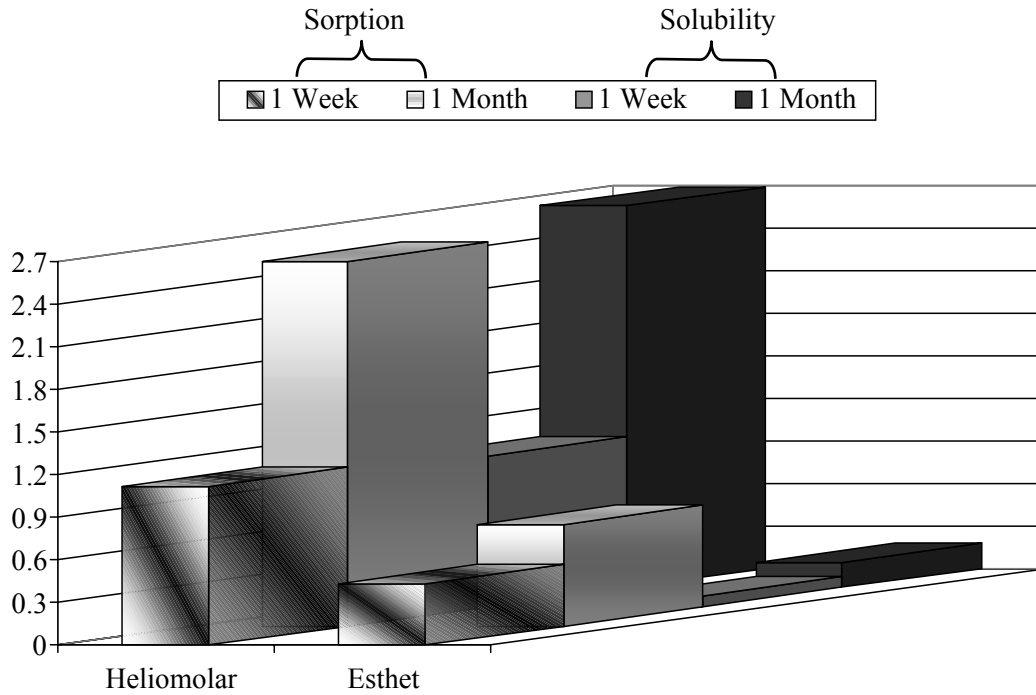


Figure: Percentage sorption and solubility after one week and one month for Esthet and Heliomolar composite resins

Table (2): Student's t-test comparing between one week and one month sorption of Esthet and Heliomolar

Material	1 Week		1 Month		t-value	Significance
	Mean	± SD	Mean	± SD		
Esthet	0.433	0.07	0.517	0.11	-2.57	$p > 0.05$
Heliomolar	1.12	0.46	2.57	0.57	-18.782	$p < 0.001$

SD: Standard deviation.

Table (3): Student's t-test comparing between one week and one month solubility of Esthet and Heliomolar

Material	1 Week		1 Month		t-value	Significance
	Mean	± SD	Mean	± SD		
Esthet	0.074	0.056	0.176	0.041	-2.168	$p > 0.05$
Heliomolar	1.066	0.324	2.689	0.090	7.52	$p < 0.001$

SD: Standard deviation.

Tables (4) and (5) show that the percentage sorption and solubility at one week and one month for Esthet composite

based on Bis-EMA was significantly lower than that of Heliomolar composite based on Bis-GMA ($p < 0.001$).

Table (4): Student's t-test comparing between percentage sorption of Esthet and Heliomolar at one week and one month

Time	Esthet		Heliomolar		t-value	Significance
	Mean	± SD	Mean	± SD		
1 Week	0.433	0.07	1.12	0.46	-10.739	$p < 0.001$
1 Month	0.517	0.11	2.57	0.57	-17.577	$p < 0.001$

SD: Standard deviation.

Table (5): Student's t-test comparing between percentage solubility of Esthet and Heliomolar at one week and one month

Time	Esthet		Heliomolar		t-value	Significance
	Mean	± SD	Mean	± SD		
1 Week	0.074	0.056	1.066	0.320	-24.634	$p < 0.001$
1 Month	0.176	0.041	2.689	0.090	-4.432	$p < 0.001$

SD: Standard deviation.

DISCUSSION

The sorption of water by the composite resin is dependent on the matrix resin and fillers.^(12, 13) The matrix resin of Esthet composite was based on Bis-EMA; while for Heliomolar composite, the matrix resin was based on Bis-GMA. This Bis-GMA is considered as a hydrophilic material and has the ability to form hydrogen bond which increase the hydrophilic feature of Bis-GMA.⁽¹⁴⁾ So, the Heliomolar composite exhibit significant higher water sorption.

The Bis-EMA has been proposed as a less hydrophilic monomer,^(10, 11) and this may be due to the structure of Bis-EMA that is similar to the structure of Bis-GMA but without the two hydrophilic (-OH) groups.⁽¹⁵⁾ So, the water sorption and solubility of light cured composite based on Bis-EMA was significantly lower than that based on Bis-GMA and this finding has come in agreement with other studies.^(9, 16)

The composite resin based on Bis-GMA exhibit greater solubility than the composite resin based on Bis-EMA. This may be due to the fact that the most probable site for accumulation of additional water was considered the interface between the inorganic filler particles and the

polymer matrix^(9, 15) that cause swelling stress and small volumetric changes that may weaken the filler-matrix interface⁽¹⁷⁾ which facilitate the leaching of the filler particles and increasing the solubility of Bis-GMA based composite resin. For composite based on Bis-EMA the accumulation of additional water at the interface between fillers and matrix is smaller than that of Bis-GMA composite because water sorption of Bis-EMA is significantly smaller than Bis-GMA composite. So, the filler matrix interface was not affected and the solubility was reduced.

CONCLUSIONS

It was concluded that the water sorption of Esthet composite resin based on Bis-EMA was significantly lower than that of Heliomolar composite resin based on Bis-GMA. Also, it was concluded that the water sorption and solubility of composite based on Bis-GMA after one month was significantly greater than after one week immersion in distilled water and there is no statistical difference between one month and one week for the composite resin based on Bis-EMA.

It was also concluded that the solubility of Heliomolar composite resin based on Bis-GMA was significantly greater than that of Esthet composite resin based on Bis-EMA and the solubility after one month was significantly greater than one week for Bis-GMA based composite while for Bis-EMA based composite there was no statistical difference at the two times (one week and one month).

REFERENCES

- 1) Craig RD. Restorative Dental Materials. 10th ed. CV Mosby Co. St Louis. 1997; p: 254.
- 2) Swartz ML, Moore BK, Phillips RW. Direct restorative resins. A comparative study. *J Prosthet Dent.* 1982; 47: 163-170.
- 3) Momoi Y, McCabe J. Hygroscopic expansion of resin based composites during 6 months of water storage. *Br Dent J.* 1994; 176: 91-96.
- 4) Rays SD. The effect of water on polymer matrix and composite wear. *Dent Mater.* 1994; 10: 6-10.
- 5) Ferracane J, Berge H, Condon J. *In vitro* aging of dental composite in water—effect of degree of conversion, filling volume, and filler / matrix coupling. *J Biomed Mater Res.* 1998; 42: 465-472.
- 6) Koike T, Hasegawa T, Manabe A, Itoh K, Wakumoto S. Effect of water sorption and thermal stress on cavity adaptation of dental composites. *Dent Mater.* 1990; 3: 178-180.
- 7) Calais J, Soderholm K. Influence of filler type and water exposure on flexural strength of experimental composite resins. *J Dent Res.* 1988; 67: 836-840.
- 8) Sankarapandian M, Shobha H, Kalachandra S, McGrath J, Taylor D. Characterization of some aromatic dimethacrylates for dental composite applications. *J Dent Mater.* 1997; 8: 465-468.
- 9) Sideridou I, Achilias S, Chrysa S, Karobela M. Water sorption characteristics of light-cured dental resins and composites based on Bis-EMA / PC-DMA. *J Biomater.* 2004; 25: 367-376.
- 10) Wang G, Culbertson B, Xie D, Seghi R. Effect of fluorinated triethylene glycol dimethacrylate on the properties of unfilled light cured dental resins. *Biomater.* 1999; 36: 237-252.
- 11) Moszner N, Rich S. New developments of polymeric dental composites. *J Prosthet Dent.* 2001; 86: 535-570.
- 12) Oysaed H, Ruyter T. Water sorption and filler characteristics of composites for use in posterior teeth. *J Dent Res.* 1986; 65: 1315-1318.
- 13) Braden M, Davy K. Water sorption characteristics of some unfilled resins. *J Biomater.* 1986; 7: 474-476.
- 14) Martin N, Jedynakiewicz N. Measurement of water sorption in dental composites. *J Biomater.* 1998; 19: 77-82.
- 15) Skrtic D, Antonucci M. Effect of bifunctional comonomers on mechanical strength and water sorption of amorphous calcium phosphate and silanized glass filled Bis-GMA based composites. *J Biomater.* 2003; 24: 2881-2888.
- 16) Pagniano P, Johnston M. Three year effect of unfilled resin dilution on water sorption of a light cured microfil and hybrid composite resin. *J Prosthet Dent.* 1996; 75: 364-366.
- 17) Burrow MF, Inokoshi S, Tagamic J. Water sorption of several bonding resins. *Am J Dent.* 1999; 12: 295-298.