



# Estelite Posterior



Tokuyama Dental | Technical Report



**ESTELITE POSTERIOR QUICK** - TECHNICAL REPORT



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# 1 Introduction

Tokuyama Dental has developed a wide range of light-cured dental composite restorative resin products incorporating our unique sub-micron spherical filler technologies. Represented by the Palfique Estelite, Estelite Sigma, and Palfique Estelite LV, these products have won acclaim for outstanding esthetics and surface gloss.

In 2005, Tokuyama Dental introduced Estelite Flow Quick, a flowable composite resin combining a newly-developed catalyst (RAP technology) and our proprietary filler technology to reduce curing times dramatically, to nearly 1/3 that of conventional flowable resins. Incorporating RAP technology, Estelite Flow Quick features exceptionally high polymerization rates and class-leading filler content (71% by weight) compared to other commercially available flowable composite resin products. It also exhibits superior physical and engineering properties.

Now, we have applied the RAP technology used in Estelite Flow Quick to a universal composite resin to create Estelite Posterior, a new composite resin product, available commercially in Japan since November 2007. Estelite Posterior offers superb physical and mechanical properties and excellent shade-matching performance, characteristics made possible by two advances:

- 1) improved matrix polymerization rate and physical and mechanical properties, through use of RAP technology
- 2) enhanced shade-matching based on filler refraction index adjustments

Described below are the technical background of this product and its features and physical properties.

# 2 Background technology

The two major technical features of Estelite Posterior are as follows:

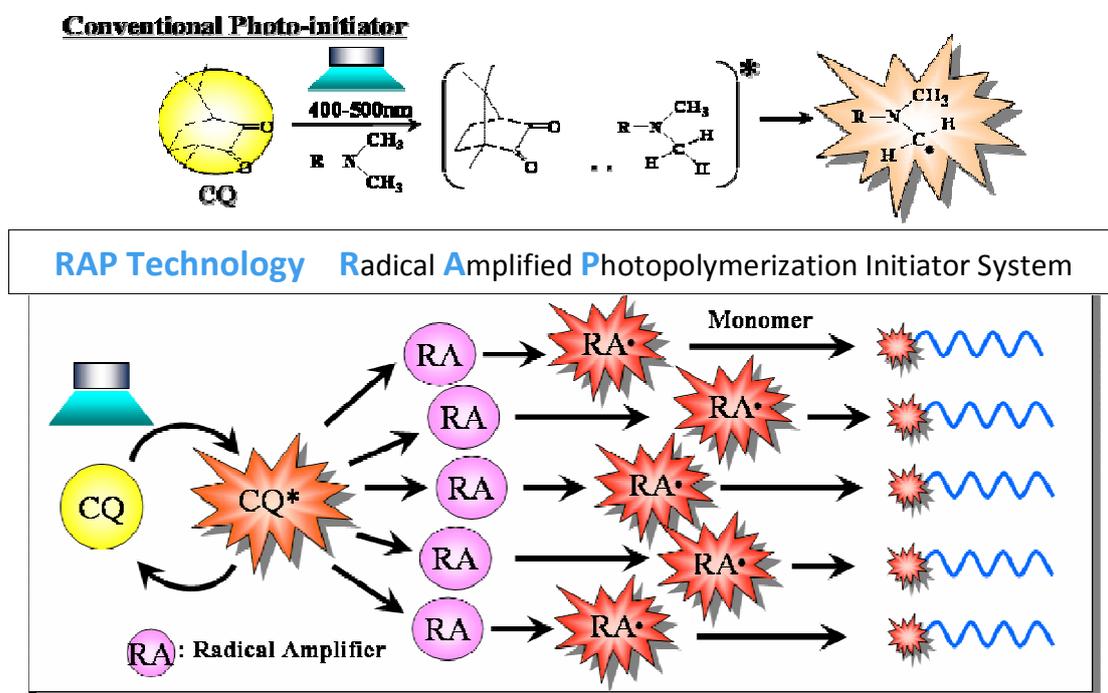
- 1) Incorporation of Radical Amplified Photopolymerization (RAP) technology
- 2) Superior shade-matching performance

The following sections discuss these features and their effects.

## 2.1 RAP TECHNOLOGY

The catalyst technology used in Estelite Posterior is the same radical amplified photopolymerization (RAP) technology used in Estelite Flow Quick. The characteristics of the photopolymerization initiator are presented in greater detail in the Estelite Flow Quick Technical Report; a brief summary is provided below. As its major feature, RAP technology balances the high polymerization activity needed to cure resins in the short exposure times (1/3 that required by conventional products) with stability under ambient lighting. These two qualities are generally considered mutually exclusive, since shorter curing times generally reduce stability. However, the present catalyst technology achieves a balance of these two factors. *Figure 1* is a schematic diagram of the RAP technology.

- 1) A single CQ molecule generates multiple initiator radicals
- 2) The transition from CQ excitation to completion of initiator radical generation is rapid

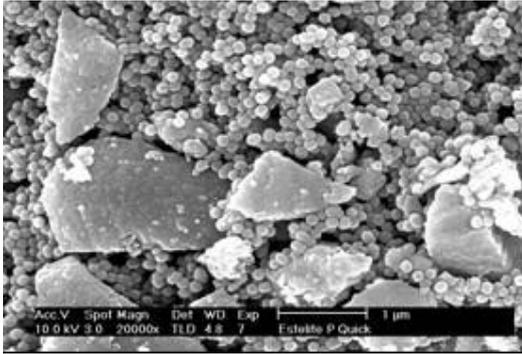


*Figure 1* Illustration of the radical amplified photopolymerization (RAP) initiator system

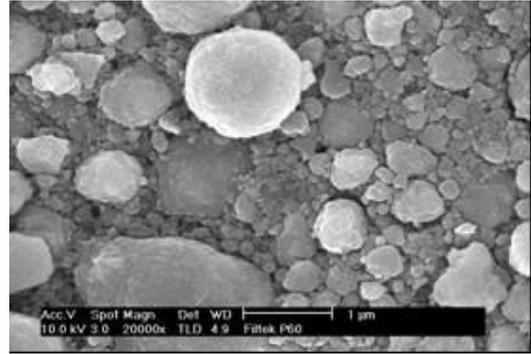
## 2.2 FILLER DESIGN

The filler design for Estelite Posterior adds irregular fillers with a mean particle size of 3  $\mu\text{m}$  to the 0.2  $\mu\text{m}$  monodispersing filler (Si-Zr) used in Estelite Sigma Quick and Estelite Sigma to disperse stress in all directions and to increase resin strength. The presence of 3  $\mu\text{m}$  irregular fillers helps adjust the refractive index and helps resist changes in resin shade after curing, contributing to superior shade-matching performance.

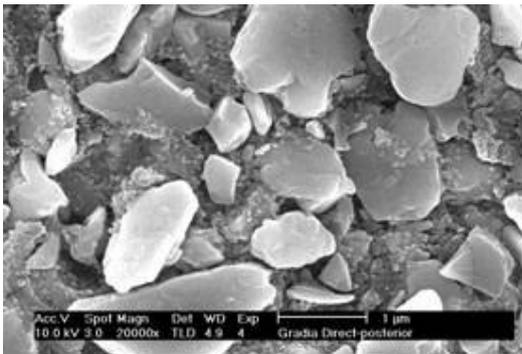
Shown below are SEM images of the filler used in Estelite Posterior and fillers used in composite resins from other manufacturers. The fillers used in other products are irregular fillers of varying particle diameters (hybrid type); the filler used in Estelite Posterior consists of 0.2  $\mu\text{m}$  monodispersing filler particles packed densely into the spaces between 3  $\mu\text{m}$  irregular fillers



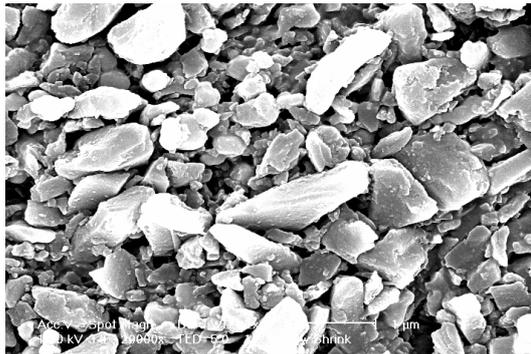
**Figure 2** Estelite Posterior 20,000xmagnification



**Figure 3** Filtek P60 20,000x magnification



**Figure 4** Gradia Direct Posterior 20,000x



**Figure 5** Filtek LS 20,000x

## 3 Features of Estelite Posterior

Estelite Posterior offers the following four key features:

- 1) Quick curing
- 2) Superior physical properties
- 3) Outstanding esthetics
- 4) Excellent handling properties

The following sections discuss these features in greater detail.

### 3.1 CURE RATE

One of Estelite Posterior's key strengths is its rapid cure rate. Depending on the shade of the paste and intensity of the light-curing unit, the irradiation time recommended for conventional composite resins is generally around 20 seconds. In contrast, the recommended

irradiation time for Estelite Posterior is 10 seconds or less. Short irradiation times are especially helpful when the restoration procedure requires incremental filling, with children, or with patients with high salivary flow.

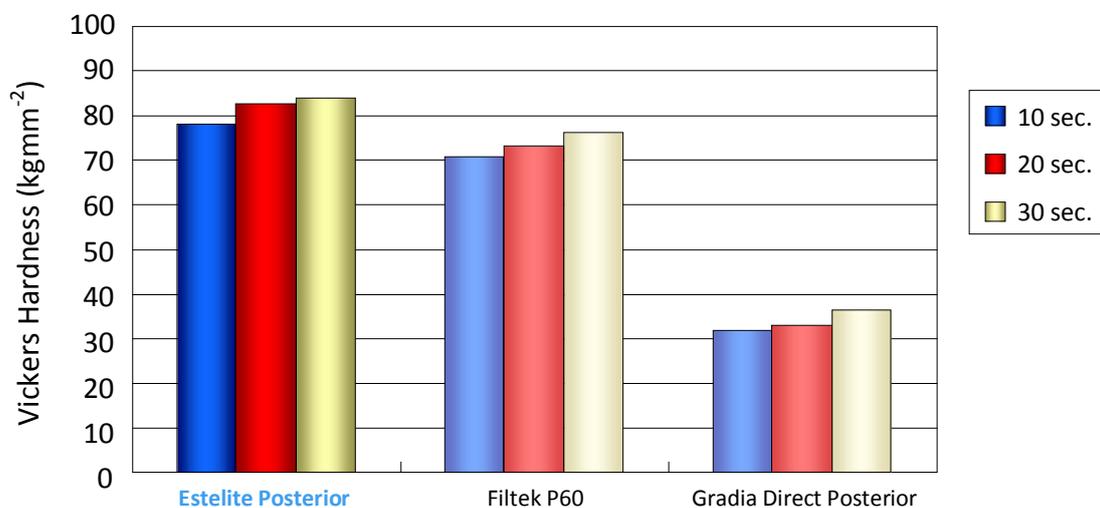
We assessed the cure rate of Estelite Posterior with respect to hardness and depth of cure with various light-curing units. Table 2 gives the specifications for the light-curing units.

**Table 1** Light-curing units: Performance and specifications

	Light Source	Wavelength (nm)	Intensity (mW/cm <sup>2</sup> )	Characteristics
Optilux LCT	Halogen	400~500	800	The most widely used dental light-curing unit

### 3.1.1 SURFACE HARDNESS

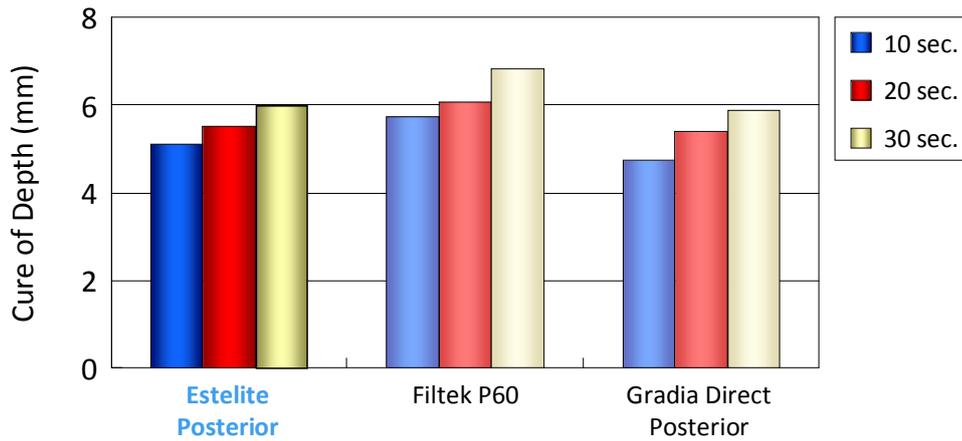
*Graphic 1* shows the correlation between irradiation time and surface hardness (Vickers hardness) for the cured resin. *Graphic 1* shows that Estelite Posterior achieves high surface hardness rapidly.



**Graphic 1** Correlation between surface hardness and irradiation time using Optilux LCT

### 3.1.2 DEPTH OF CURE

Shown here is the correlation between irradiation time and cure depth. *Graphic 2* uses the example of the shade A3 paste. In contrast to surface hardness, no significant difference is observed. Thus, the thickness of a single layer of CR must be less than 2 mm when filling a cavity with Estelite Posterior.

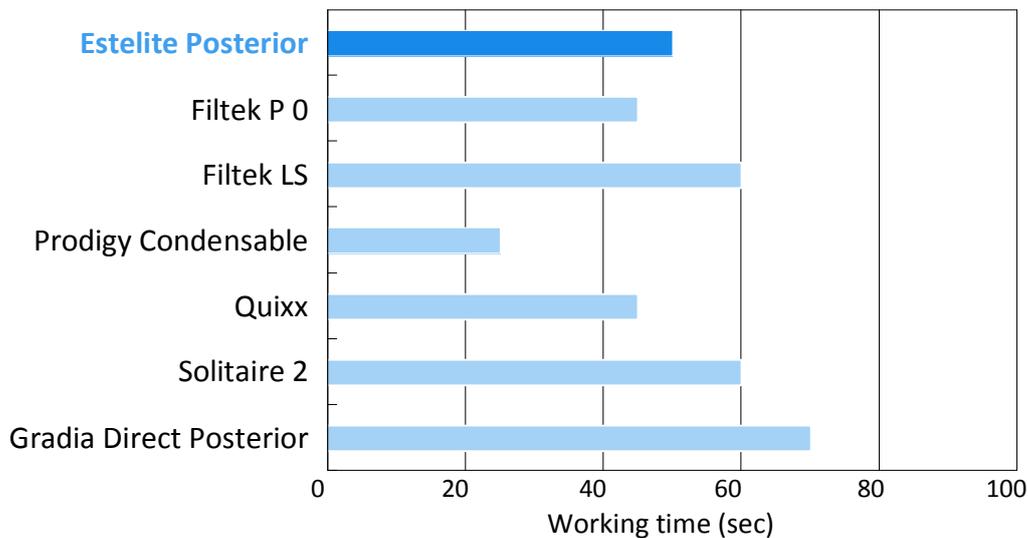


**Graphic 2** Correlation between cure depth and irradiation time using Optilux LCT

### 3.1.3 AMBIENT LIGHT STABILITY

Achieving rapid high polymerization has generally meant increasing the amount of photopolymerization initiators. However, increasing catalyst volume tends to reduce ambient light stability and to make the paste more viscous during clinical filling procedures. In certain cases, increasing catalyst volume can render resin sculpting impossible, making a second filling attempt necessary. High catalyst volumes can also significantly alter shades from before to after curing. Overall, increasing the volume of photopolymerization initiators has undesirable consequences. However, as described in 2.1, RAP technology makes it possible to achieve a balance between polymerization activity and ambient light stability.

**Graphic 3** compares ambient light stability (under 10,000x magnification and dental lighting) for Estelite Posterior and other commercially available posterior teeth composite resins. As **Graphic 3** shows, the ambient light stability of Estelite Posterior is 50 seconds, offering working times comparable to other products while curing with shorter irradiation. Estelite Posterior thus reduces the time pressures faced by clinicians when performing filling and sculpting procedures.



**Graphic 3** Ambient light stability of various composite resins

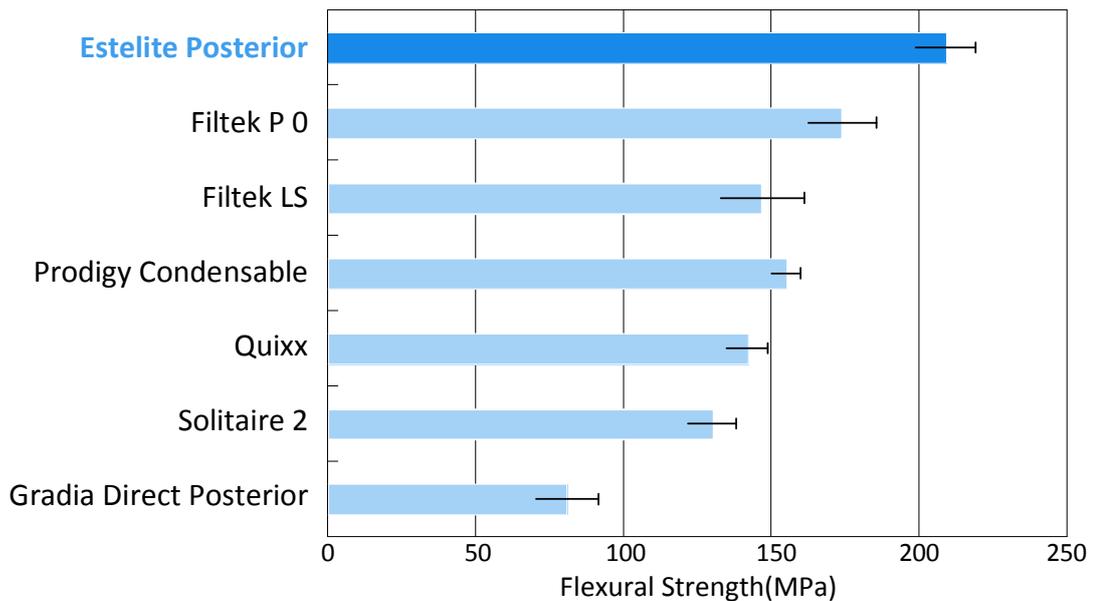
## 3.2 MATERIAL PROPERTIES

In addition to the superior polymerization characteristics attributable to RAP technology, Estelite Posterior offers a wide range of outstanding physical properties. To assess the physical properties described in the following sections, we prepared samples by light curing with an Optilux LCT light-curing unit at irradiation times of 10 seconds for Estelite Posterior and 20 seconds for other composite resins.

### 3.2.1 FLEXURAL STRENGTH

*Graphic 4* shows the flexural strength of Estelite Posterior and other commercially available composite resin products.

Among commercially available composite resins for posterior teeth restorations, Estelite Posterior falls into the category characterized by high flexural strength. This is believed to be attributable to the stress dispersal realized by the improved matrix polymerization structure conferred by RAP technology (refer to 2.1) and by the adoption of a filler design using irregular fillers with a mean particle diameter of 3  $\mu\text{m}$ .

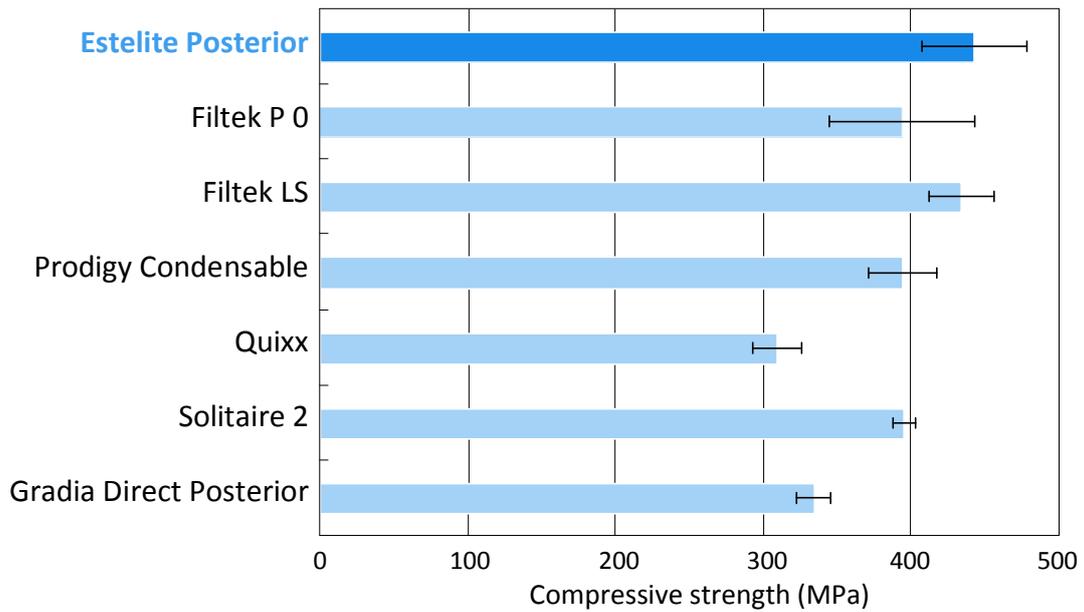


*Graphic 4* Flexural strength of various composite resins

### 3.2.2 COMPRESSIVE STRENGTH

*Graphic 5* shows the compressive strength of Estelite Posterior and other commercially available composite resin products.

Among the composite resins commercially available, Estelite Posterior falls into the category exhibiting high compressive strength. As with flexural strength, this high compressive strength is believed to be attributable to RAP technology and to the irregular filler.

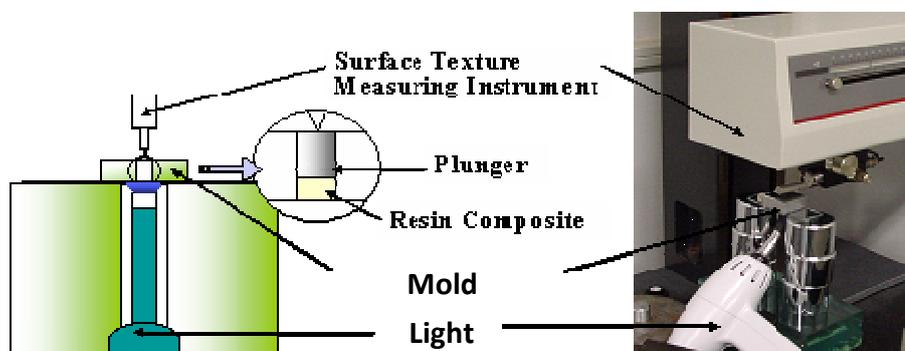


**Graphic 5** Compressive strength of various composite resins

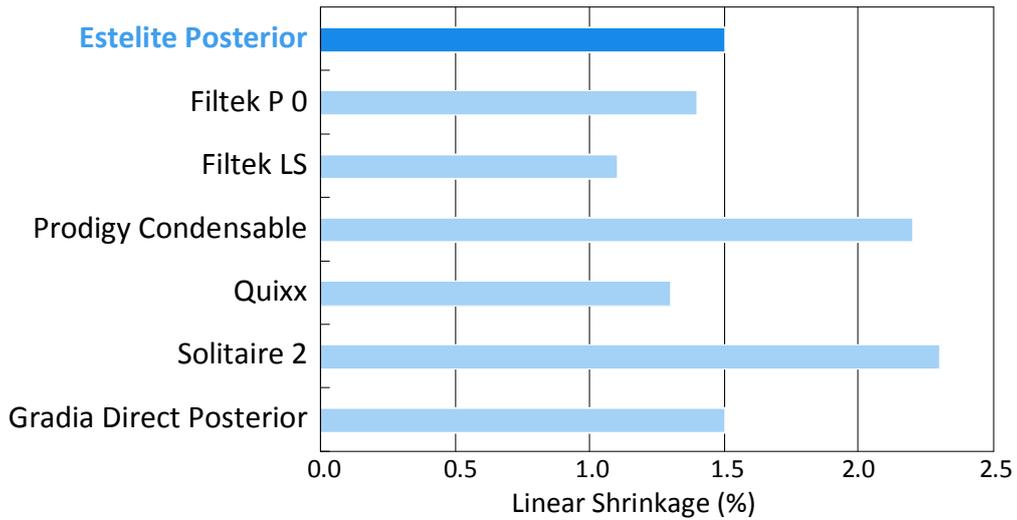
### 3.2.3 POLYMERIZATION SHRINKAGE

We applied a proprietary method to assess polymerization shrinkage rates. *Figure 6* presents a schematic diagram of the measurement system. This system makes it possible to measure the rate of shrinkage occurring in the cavity floor—at the interface between the composite resin and the plunger—when the composite resin is used to fill a cavity and is exposed to light as part of a clinical procedure. This measurement method evaluates shrinkage rates under conditions reflecting typical clinical settings.

*Graphic 6* shows polymerization shrinkage rates for Estelite Posterior and other commercial composite resin products. The graph shows shrinkage rates at 3 minutes from the start of exposure. The shrinkage rate for Estelite Posterior is 1.5%, an average figure for commercial composite resin products.



**Figure 6** Schematic diagram of system for assessing polymerization shrinkage rates

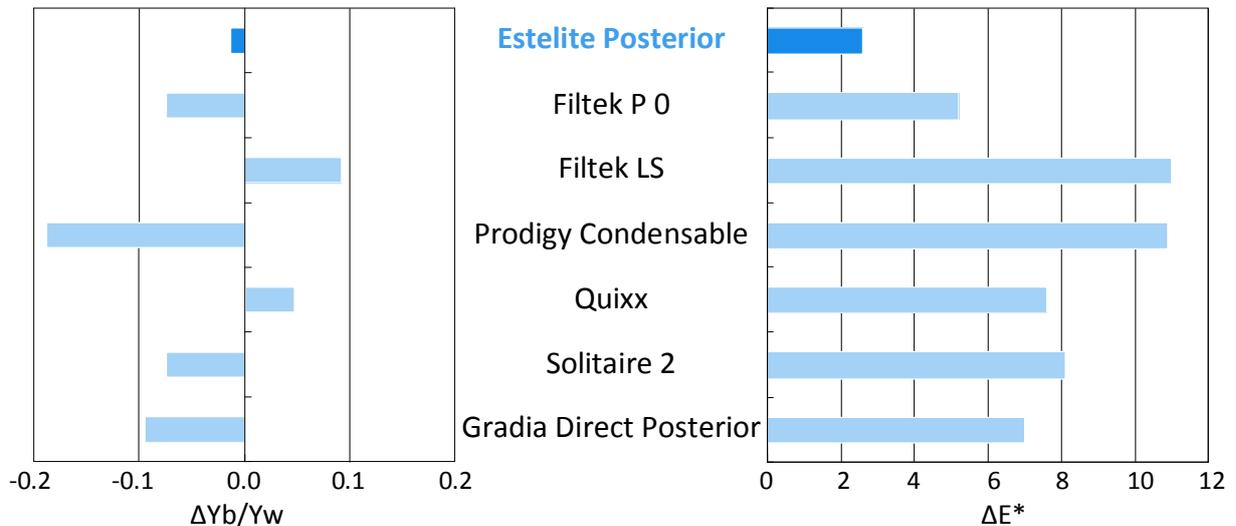


**Graphic 6** Polymerization shrinkage rates of various composite resins (linear shrinkage)

### 3.2.4 TRANSLUCENCY AND COLOR BEFORE AND AFTER CURING

Restorations using composite resins that exhibit significant change in color from before to after curing involve significant uncertainty, since the suitability of the selected shade can only be assessed after curing. If the shade of the composite resin proves a poor match for the patient's tooth color, the labor-intensive corrections require filler removal and refilling.

Estelite Posterior features relatively small changes in color and translucency from before to after curing, and the results of shade-matching can be assessed relatively accurately before curing. *Graphic 7* illustrates the changes in translucency and color occurring from before to after curing for Estelite Posterior and other commercial composite resin products. As the graphic shows, the relatively minor change in color and translucency makes shade evaluation with Estelite Posterior significantly easier and reduces the likelihood of discovering a poor shade match only after the curing process.



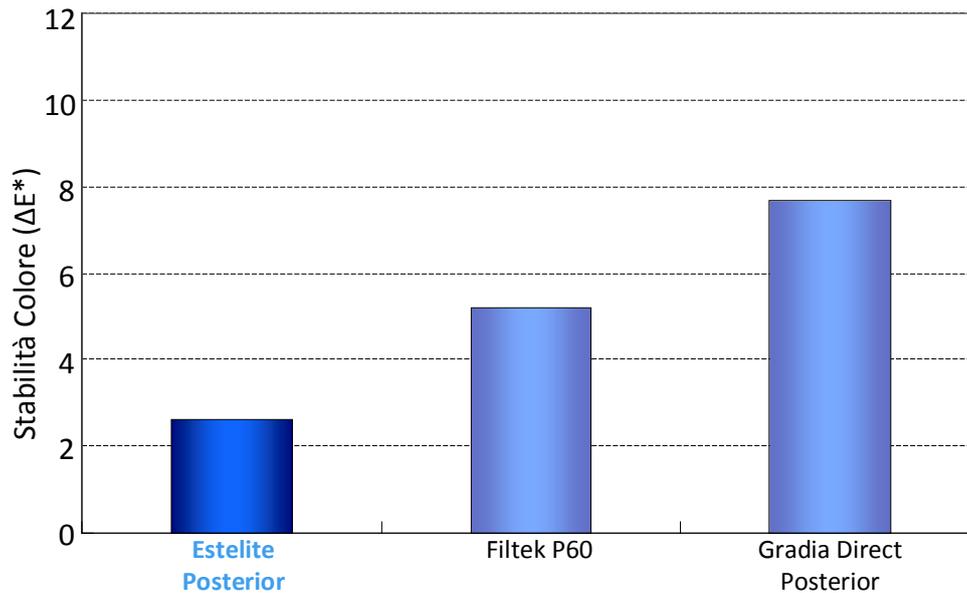
**Graphic 7** Changes in translucency and color shade from before to after curing for various composite resins

### 3.2.5 COFFEE STAINS

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Composite resins used in the oral cavity will degrade over time due to exposure to various food and drink substances. This degradation can become an esthetic defect if marked relative to the natural tooth substance. We assessed the effects of staining by coffee, using a 24 hour immersion test at 80°C. *Graphic 8* shows the results.

Following coffee immersion, Estelite Posterior exhibited relatively little change in shade compared other commercial composite resin products, suggesting that little change will occur in this characteristic in actual clinical use over the long term.



*Graphic 8* Coffee staining of various composite resins (ΔE\*)

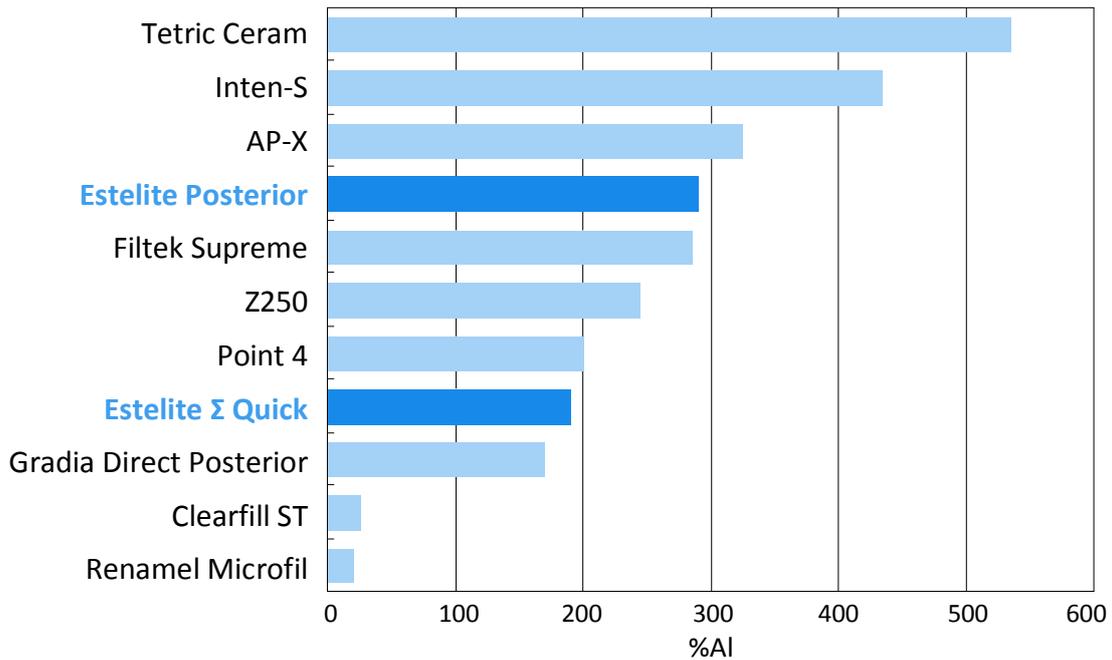
### 3.2.6 RADIOPACITY

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The radiopacity of composite resins is determined by the composition of the inorganic filler and its filler content. Resins tend to exhibit higher opacity when the filler contains larger concentrations of elements with high atomic numbers and when filler content is higher. However, fillers containing larger amounts of elements with high atomic numbers will display high refractive indices, resulting in significant changes in shade and translucency from before to after curing.

As described in *section 2.2*, the inorganic filler used in Estelite Posterior is designed to minimize changes in shade and translucency from before to after curing while achieving maximum radiopacity for a given composition. *Graphic 9* shows the radiopacity of commercially available composite resins.

Among comparable commercial composite resins, Estelite Posterior displays slightly above average radiopacity.



**Graphic 9** Radiopacity of commercially available composite resins

While average, the radiopacity exhibited by Estelite Posterior is adequate for follow-up assessments of restoration work. A clinical X-ray image of Estelite Posterior is shown to the right.



### 3.3 PASTE CHARACTERISTICS

To make it suitable for filling posterior teeth, Estelite Posterior is designed to be slightly harder and to display higher elasticity than Estelite Sigma Quick and Estelite Sigma. Since posterior restoration generally involves filling relatively large cavities, many clinicians tend to press down harder on the paste to ensure that the paste fills every corner and crevice of the cavity. (See photo at right.) The paste must be hard enough to avoid seeping around the filling instrument. The Estelite Posterior offers the hardness and elasticity required for this purpose.



The photos below show the conditions of the paste after being used to fill a SUS jig and compressed with a SUS rod at a load of 2 kgf. The photos show that Estelite Posterior paste tends to resist seeping around the filling instrument.



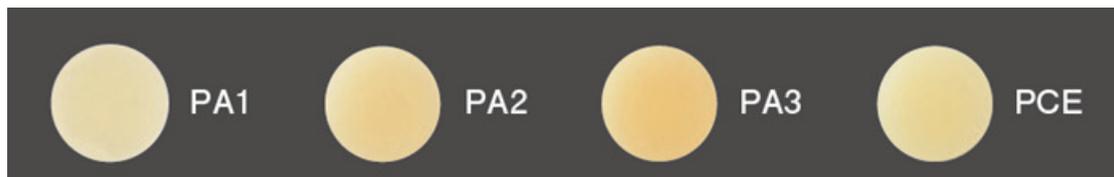
**Figure 9** Estelite Posterior



**Figure 10** Clearfil AP-X

### 3.4 SHADE VARIATIONS

Estelite Posterior is available in four shades: PA1, PA2, PA3, and PCE (clear enamel) (Figure 12). The PCE shade has a pale yellowish tone and is more translucent than the other shades, making it ideal for filling relatively small cavities and incremental filling. It should provide esthetically-pleasing results.



**Figure 11** The Estelite Posterior shade line up

The Estelite Posterior composite resin offers various outstanding characteristics, including high photopolymerization activity and esthetic qualities, achieved through the revolutionary radical amplified photopolymerization (RAP) technology incorporated into Estelite Flow Quick and a submicron monodispersing spherical filler design.

## 4 Results of Evaluations

### 4.1 EFFICACY OF RAP TECHNOLOGY

We asked Oregon Health & Science University (OHSU) to evaluate the effectiveness of RAP technology. As shown below, Estelite Posterior (EPQ-101RAP) displayed physical and engineering properties superior to conventional CQ/amine system resins (EPQ-101CQ). Note that ESQ-201RAP has the same filler composition as the Estelite Sigma Quick, which uses a CQ/amine catalyst system.

## 1610 Novel Photoinitiator System (RAP) Enhances Dental Composite Properties

J.L. FERRACANE, and L.L. FERRACANE, Oregon Health & Science University, Portland, USA

Rapid amplified photopolymerization (RAP) initiator technology has been presented to enhance light-curing efficiency of dental composites by increasing the radicals produced from each activated camphoroquinone (CQ) molecule (AADR # 1392-1393, 2006). But equivalent composites with and without the technology have not been compared.

**Objectives:** The purpose of this study was to compare the flexure strength and modulus of two light-cured dental composites with RAP and without (CQ only). The hypothesis to be tested was that the mechanical properties of the composites are enhanced when RAP is added, and that shorter curing times (lower radiant exposure) can be used for composites with RAP.

**Methods:** The flexure strength (FS) and modulus (E) of two experimental composites (Tokuyama Dental) were evaluated: ESQ-201 (82 wt% supra-nanofillers; 200 nm) and EPQ-101 (83 wt% hybrid containing supra-nanofillers). Each composite was formulated with the RAP initiator system (RAP+CQ) and without (CQ only). Specimens (25x2x2mm) were light-cured in glass tubes for either 20 or 40 seconds/side (Triad II, Dentsply) and stored 24 hours in deionized water at 37°C before testing at 0,25 mm/min in 3 point bending (n=10). Results for each composite were compared with 2-way ANOVA/Tukey's (p<0,05; interactions were not significant).

Results:	Flexure Strength (MPa)		Flexure Modulus (GPa)	
	20s	40s	20s	40s
ESQ-201 RAP	86.20 ± 9.39	98.27 ± 7.98	6.39 ± 0.60	7.42 ± 0.62
ESQ-201 CQ	73.00 ± 9.25	89.04 ± 10.8	4.69 ± 0.61	6.28 ± 0.70
EPQ-101 RAP	124.62 ± 22.66	126.12 ± 29.00	11.04 ± 1.94	15.53 ± 0.96
EPQ-101 CQ	94.55 ± 28.13	104.57 ± 34.60	8.91 ± 1.54	11.81 ± 1.34

For FS and E, the following relationships were significant for both composites: RAP>CQ; 40s>20s (except 40s=20s for EPQ-101 FS), and RAP-20s=CQ-40s (except RAP 20s≥CQ 40s for EPQ-101 FS).

**Conclusions:** This study verified that the inclusion of the RAP initiator technology improve the flexure strength and flexure modulus vs. CQ only for two experimental composites, and enabled the use of one half the curing time to produce equivalent properties. Supported by Tokuyama Dental Corporation.

*Seq #168 – Keynote Address and Polymerization Processes and Mechanisms 10:45 AM-12:15 PM, Friday, July 4, 2008 Metro Toronto Convention Centre Room 801A  
Back to the Dental Materials 5: Polymer-based Materials – Chemistry and Composition Program  
Back to the IADR 86<sup>th</sup> General Session & Exhibition*

## 1653 RAP Initiator Improves Hardness and DC of Experimental Composites

*J.L. FERRACANE, and H.B. DAVIS, Oregon Health & Science University, Portland, OR - A201 (Miami Beach Convention Centre)*

We recently reported that rapid amplified photopolymerization (RAP) initiator technology improves flexure properties of composites and enables shorter curing times (AADR # 1610, 2007).

**Objectives:** This study compared the hardness (KHN) and degree of conversion (DC) of two light-cured dental composites with RAP and without (CQ-only), to further test the hypothesis that RAP can improve properties and reduce cure times.

**Methods:** The KHN and DC on top and bottom surfaces of 2-mm thick disks of two experimental composites (Tokuyama Dental) were evaluated: ESQ201 (82 wt% supra-nanofillers; 200 nm) and EPQ101 (83 wt% hybrid containing supra-nanofillers). Composites were formulated with the RAP initiator (RAP+CQ) and without (CQ-only). Specimens (7x2mm; n=5) were light-cured from the top in PVS molds between matrices for either 20, 30 or 40 seconds (500-550 mW/cm<sup>2</sup>; Optilux 501, Kerr) and aged 24 hours in deionized water at 37°C before evaluating DC (FTIR) and KHN (200g) on top and bottom surfaces. Results for each composite were compared with 3-way ANOVA/Tukey's ( $\alpha \leq 0.05$ ).

**Results:** For KHN: RAP>CQ (except EPQ101-40s-top) and Top>Bottom (except EPQ101-40s-RAP). For DC: RAP>CQ (except EPQ101-bottom-20s/30s; ESQ201-bottom-30s) and Top>Bottom. Longer cure times were not significant for ESQ201; and for EPQ101 only for KHN-CQ and KHN-RAP-bottom.

		KHN (Kg/mm <sup>2</sup> )			DC (%)		
		20s	30s	40s	20s	30s	40s
ESQ201 RAP	Top	63 ± 4	61 ± 7	65 ± 6	49 ± 3	49 ± 3	48 ± 4
	Bottom	53 ± 9	50 ± 5	55 ± 6	45 ± 4	42 ± 6	46 ± 5
ESQ201 CQ	Top	53 ± 9	54 ± 3	46 ± 3	43 ± 2	44 ± 4	42 ± 1
	Bottom	36 ± 6	42 ± 4	38 ± 4	39 ± 3	41 ± 4	38 ± 2
EPQ101 RAP	Top	119 ± 16	127 ± 17	117 ± 10	57 ± 2	54 ± 4	57 ± 3
	Bottom	72 ± 4	76 ± 15	112 ± 9	43 ± 4	41 ± 4	54 ± 3
EPQ101 CQ	Top	84 ± 10	96 ± 5	117 ± 6	48 ± 3	49 ± 3	48 ± 2
	Bottom	44 ± 14	61 ± 5	91 ± 12	43 ± 3	44 ± 6	43 ± 3

**Conclusions:** The inclusion of RAP improved the KHN and DC vs. CQ-only for two experimental composites, and in some cases enabled shorter curing times to produce equivalent hardness or DC. Supported by Tokuyama Dental.

*Supported by Tokuyama Dental Corporation*

## 5 Summary

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- 1) Quick curing
  - Estelite Posterior requires approximately 1/3 the curing time of conventional composite resins.
  - Estelite Posterior is compatible with all widely used light-curing unit light sources, including halogen, LED, and xenon.
- 2) Superior physical properties
  - Estelite Posterior features market-leading flexural strength and compressive strength.
- 3) Excellent shade-matching performance
  - Resistant to changes in shade and translucency from before to after curing
- 4) Optimized handling properties
  - Fine sculptability

## 6 References

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- 1) J.L. FERRACANE [ *Novel photoinitiator system (RAP) enhances dental composite properties* ] IADR 2008, 1610
- 2) J.L. FERRACANE [ *RAP Initiator Improves Hardness and DC of Experimental Composites* ] IADR 2009, 1653

### ESTELITE POSTERIOR Packaging



**ESTELITE POSTERIOR** 1 syringe, 2mL (4,2g)

Available shades:

- 12911** Estelite Posterior PA1
- 12912** Estelite Posterior PA1
- 12913** Estelite Posterior PA1
- 12914** Estelite Posterior PA1



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