OMNICHROMA Flow

Technical Report

CONTENTS

1. INTRODUCTION

In direct restorations of teeth using resin-based composites, correct shade taking is an important esthetic factor. Due to positional and individual differences in natural teeth, it is necessary to consider what shade of composite is appropriate to restore a cavity in the context of the target tooth and adjacent teeth. To meet this need to restore different shades of teeth, dental manufacturers have developed various composites with different color and/or translucency. However, shade taking increases chair time and is subjective to the individual performing the shade-taking procedure, which is burdensome for both dentists and patients.

To address this issue, TOKUYAMA DENTAL has developed resin-based composites formulated on a “Wide Color Matching” concept, creating shades that can cover a wide range of natural teeth colors to reduce the time investment of shade taking and reduce the amount of composite shades needed in inventory. For example, TOKUYAMA launched ESTELITE® SIGMA QUICK in 2007, and the wide color-matching ability and esthetics of this composite have been recognized by the market. TOKUYAMA has continued to develop composite technologies designed for the simplest shade systems and has succeeded in completing a new brand, “OMNICHROMA®,” which is the culmination of more than 35 years of research and development efforts. This technical report describes the technical background, features, and material properties of OMNICHROMA FLOW the newest flowable resin composite within the OMNICHROMA line.

2. OMNICHROMA FLOW OVERVIEW

2.1 MATERIAL COMPONENTS

- UDMA, 1,9-Nonanediol Dimethacrylate
- Uniform sized supra-nano spherical filler (260nm spherical SiO_2-ZrO_2)
- Composite filler (include 260nm spherical SiO_2-ZrO_2)
- Filler loading

  70 wt% (57 vol%)

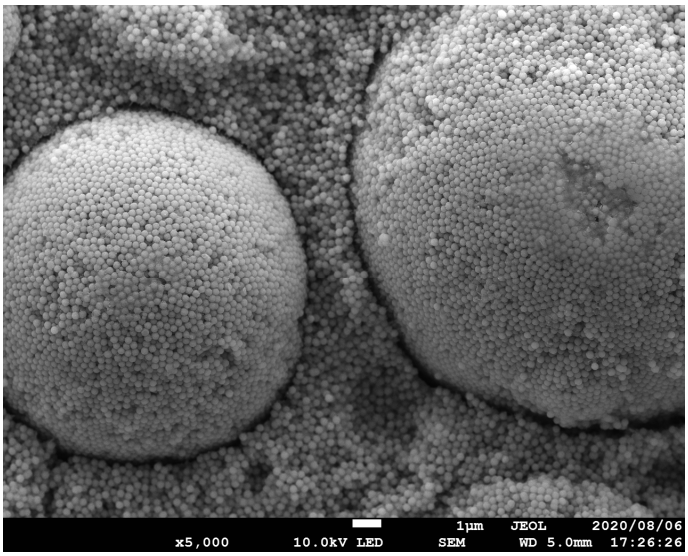


Fig.1 SEM images of the filler in OMNICHROMA FLOW at 5,000x magnification

2.2 SYSTEM

OMNICHROMA FLOW

OMNICHROMA BLOCKER FLOW

* OMNICHROMA BLOCKER FLOW is a supplementary material designed for use as a thin layer at the lingual cavity wall of extensive class III and IV restorations when there is limited surrounding dentition. The function of OMNICHROMA BLOCKER FLOW is to improve shade adaption and prevents OMNICHROMA FLOW from picking up the darkness of the oral cavity and potentially dropping in value. OMNICHROMA BLOCKER FLOW can also mask slight staining or metal or be used to reconstruct a highly opaque tooth.

Before light-curing, OMNICHROMA FLOW's uncured resin material is opaque-white, making it easy to distinguish between the uncured resin material and tooth structure. After light curing, OMNICHROMA FLOW adapts to the color of the cavity, giving it a natural look (Figure 2a). The value increases while the chroma decreases after light-curing when OMNICHROMA FLOW is used in teeth with significant discoloration.

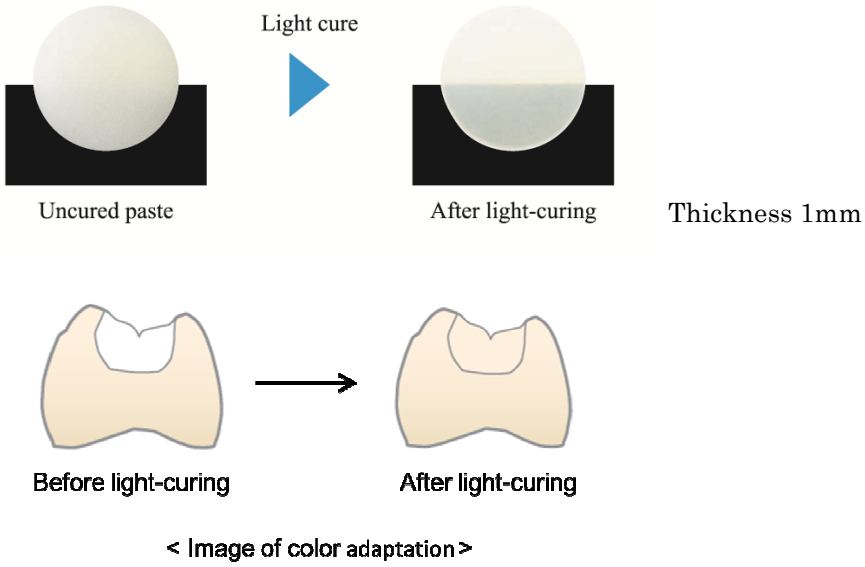


Fig.2a The color of OMNICHROMA FLOW before and after light-curing and image of color adaptation.

Use OMNICHROA BLOCKER FLOW, OMNICHROMA BLOCKER or other color masking material before filling with OMNICHROM FLOW for direct restoration of extensive Class III and IV cavities with no tooth structure, or for masking discolored teeth or metal. As shown in Figure 2b, OMNICHROMA BLOCKER FLOW masks the background color and the color of OMNICHROMA FLOW adapts to that of OMNICHROMA FLOW BLOCKER.

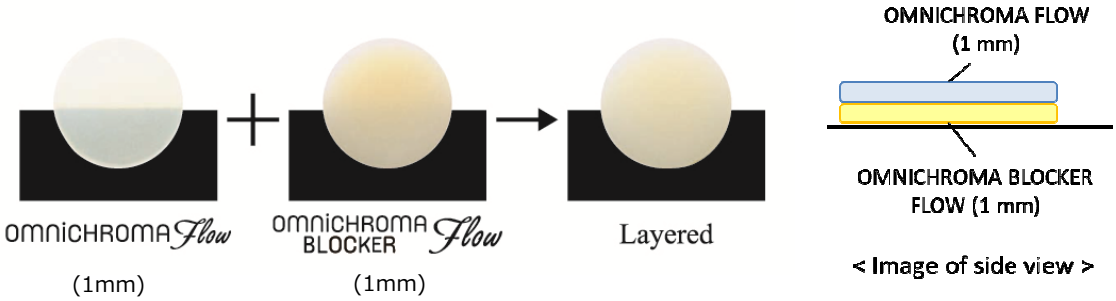


Fig.2b The color of OMNICHROMA FLOW and OMNICHROMA BLOCKER FLOW

Figure 2c presents the instruction for the restoration of extensive Class III and Class IV. Use OMNICHROMA BLOCKER FLOW, OMNICHROMA BLOCKER or other masking material before filling OMNICHROMA FLOW to prevent the restoration from appearing dark due to visible light transmission from the labial to the lingual. To enhance both esthetics and retention, add bevels to the enamel margins of anterior preparations.

Figure 2d shows the restoration of Class I or Class II with discoloration of the tooth. For masking the discoloration, use OMNICHROMA BLOCKER FLOW, OMNICHROMA BLOCKER or other masking materials as a lingual shelf before filling with OMNICHROMA FLOW. OMNICHROMA FLOW adapts to the color of the material used as lingual shelf.

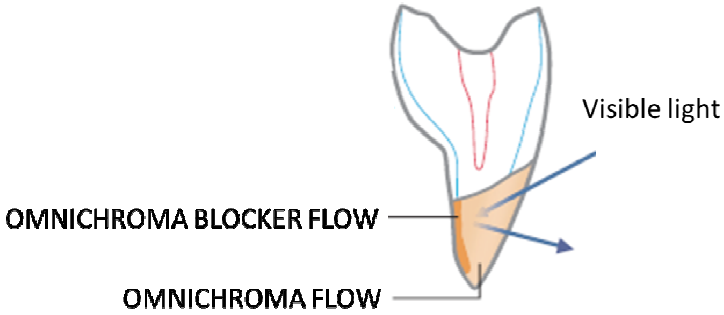


Fig.2c Instruction for extensive Class III and Class IV.

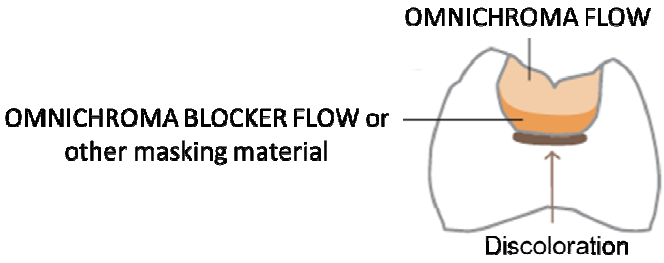


Fig.2d Instruction for discolored teeth.

2.3 CONCEPT AND FEATURES

OMNICHROMA FLOW has such a wide color-matching range that it is possible to esthetically match the 16 VITA classical shades with just one shade of composite. Therefore, no shade taking is necessary, allowing clinicians to minimize chair time, reduce composite inventory, minimize the wastage of unused composite shades, and reduce reliance on shade-matching procedures. OMNICHROMA FLOW also inherits the features of TOKUYAMA's spherical fillers from the ESTELITE series.

Excellent esthetic properties

- Unprecedented color matching
- High polishability
- High stain resistance

Excellent physical-mechanical properties

- High wear resistance
- Low polymerization shrinkage (compared with other flowable resin composite)

2.4 INDICATIONS

- Direct anterior and posterior restorations
- Cavity base or liner
- Repair of porcelain/composite

2.5 FLOWABILITY

As shown in Figure 3, there are three types of flowability, with OMNICHROMA FLOW's flowability falling into the medium range of the spectrum.

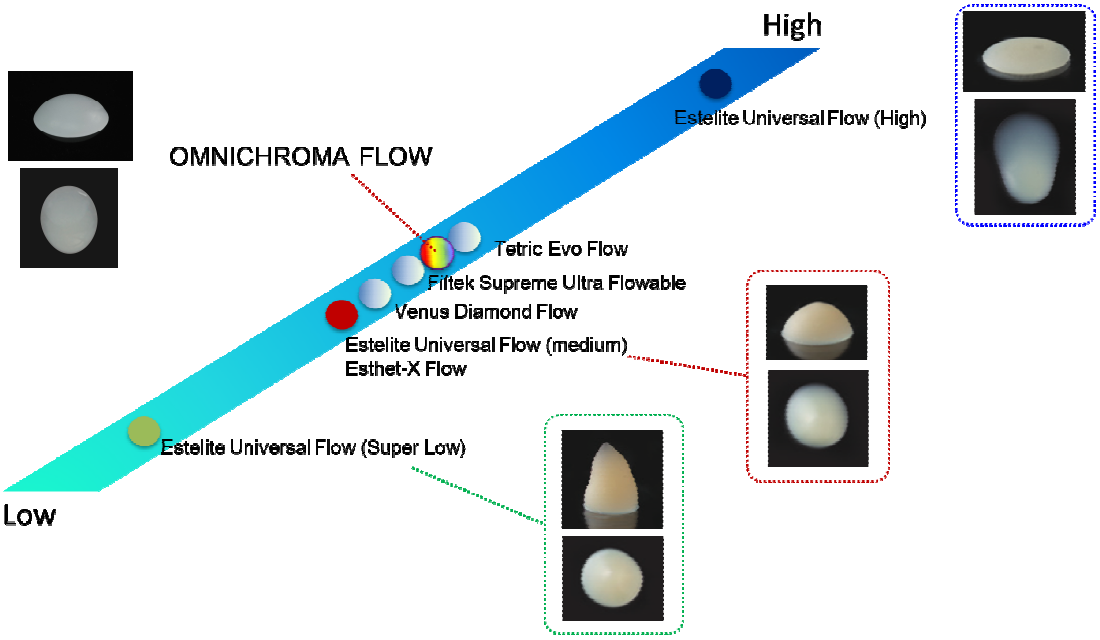


Fig.3 Comparison of flowability

3. TECHNICAL BACKGROUND

3.1 SMART CHROMATIC TECHNOLOGY

OMNICHROMA FLOW exhibits the ultimate wide-range color-matching ability, covering all 16 VITA classical shades with just one shade of composite, thanks to TOKUYAMA's Smart Chromatic Technology. The Smart Chromatic Technology is achieved through the uniformly sized 260nm supra-nano spherical fillers included in OMNICHROMA FLOW. The scientific background and mechanisms of the Smart Chromatic Technology are detailed in the following sections.

3.1.1 COLOR

There are two types of color mixing used to create color in practical purposes: additive and subtractive. Additive color mixing applies to colors produced by light. The three primary colors in additive mixing are red, green, and blue. If all three primary colors are combined, the result is white. Additive mixing is used in television and computer monitors to produce a wide range of colors using only three primary colors. On the other hand, the three primary colors in subtractive mixing are yellow, magenta, and cyan, leading to the CMYK color model widely used in color printing. In subtractive color mixing, the combination of all three primary colors creates black. Subtractive mixing is used to create a variety of colors when printing on paper and when painting by combining multiple ink colors. Subtractive color mixing is typically used for color adjustment of dental composites using pigments or dyes. Figure 4 illustrates additive (left) and subtractive (right) color mixing.

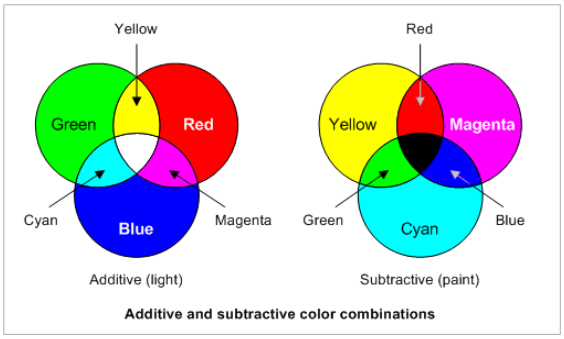


Fig.4 Additive and subtractive color mixing.

3.1.2 TOOTH COLOR

Figure 5 is a Munsell sphere that indicates the complete visible color space. As shown in Figure 6, the range of colors for natural teeth is quite limited and distributed in the narrow range of red to yellow from A1 to D4, with varying degrees of lightness, darkness, and saturation.

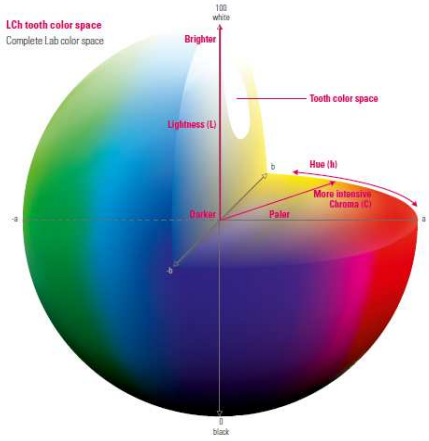


Fig. 5 Munsell sphere.

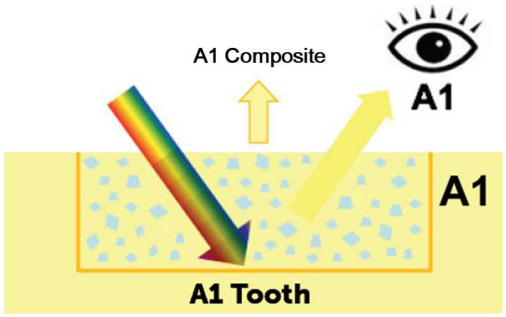
Fig.6 A1-D4 range of tooth shades.

3.1.3 MECHANISM

OMNICHROMA FLOW is a composite that achieves wide-color matching by generating red-to-yellow structural color equivalent to natural teeth in an additive color mixing system.

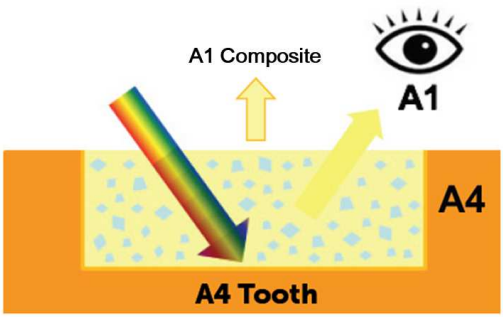
Figures 7a and 7b illustrate a color-matching image for conventional composites that utilize the chemical color of added dyes or pigments. In these cases, excellent color match can be achieved if the correct shade is selected. However, the color matching will be poor if shade-taking is performed incorrectly, as the shade-matching ability of typical composites is weak.

Figures 8a and 8b illustrate a color-matching image for OMNICHROMA FLOW. OMNICHROMA FLOW generates red-to-yellow structural color equivalent to the color elements of a natural tooth. Structural color is expressed only by the physical properties of light (diffraction, refraction, interference, scattering, etc.) without an exchange of light energy. As this red-to-yellow structural color is generated, it combines with the reflected light and color of the surrounding tooth in an additive color mixing process, maximizing OMNICHROMA FLOW's ability to match natural teeth. This use of structural color in combination with an additive color mixing system makes the use of pigments and dyes unnecessary.



Excellent color match

Fig. 7a A1 tooth restored with A1 shade composite.



Poor color match

Fig. 7b A4 tooth restored with A1 shade composite.

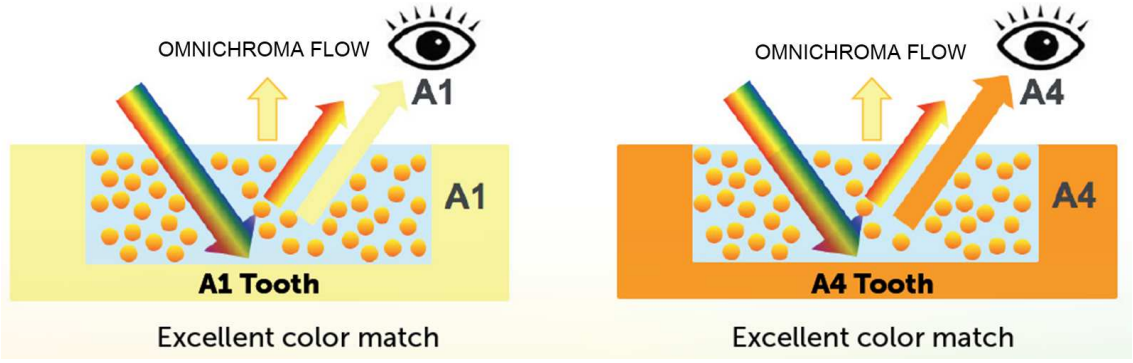


Fig. 8a A1 tooth restored with OMNICHROMA FLOW.

Fig. 8b A4 tooth restored with OMNICHROMA FLOW.

To express structural color, it is very important that the filler of the composite consists of specific, single-sized spherical particles only. To examine the relationship between particle size and shape and the structural color phenomenon, filler powders of various sizes and shapes were spread out on black and white paper backgrounds. The visible color phenomenon for each filler powder is demonstrated in Figure 9 below. Filler powder itself has no color, as demonstrated by its appearance on a white paper background. White light reflected by the white background is very strong, which is why a structural color phenomenon is not visible on the white background.

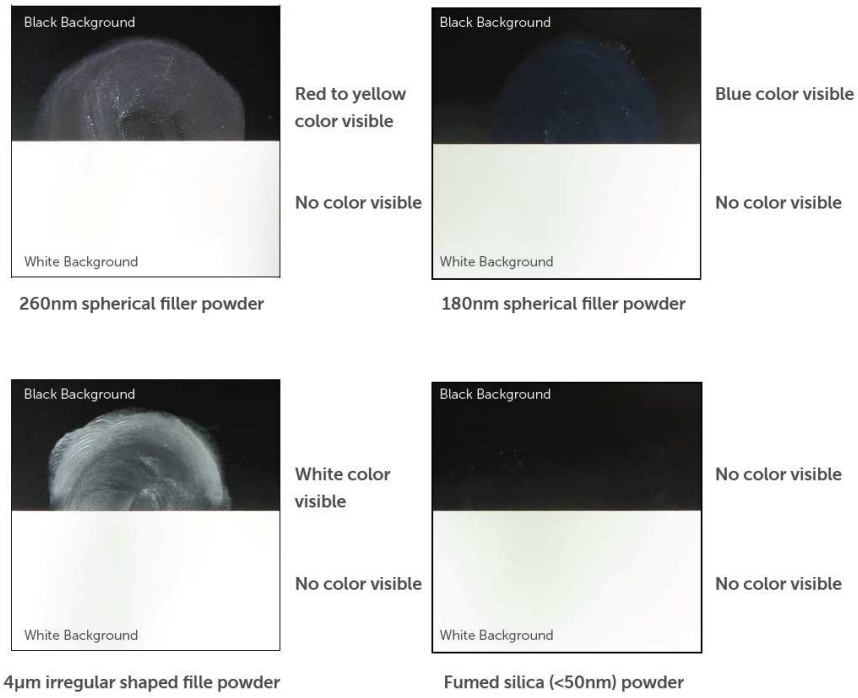


Fig. 9 Relationship between particle size and structural color phenomenon.

The relationship between the size of spherical filler and structural color in a series of resin composites is shown in Figure 10. Experimental resin composites were produced with UDMA/TEGDMA as matrix monomers, camphoquinone/amine as photoinitiator, 65 wt.% of 180, 260, and 300 nm spherical filler respectively.

As demonstrated, TOKUYAMA's research found that a 260nm spherical filler generates the red-to-yellow color necessary to match natural teeth. Variations in the size and shape of the filler material can alter the structural color phenomenon, and ultimately the composite's shade-matching ability. Therefore, OMNICHROMA FLOW uses 260nm spherical filler (OMNICHROMA Filler) exclusively.

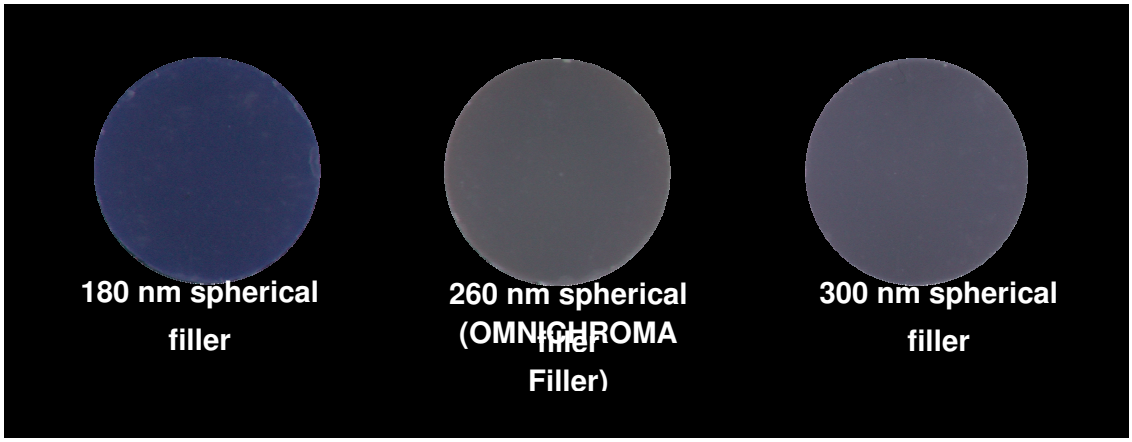


Fig. 10 Color difference of the resin composites consisted of specifically sized spherical fillers on a black background.

3.2 MANUFACTURING PROCESS

TOKUYAMA DENTAL synthesizes the uniformly sized OMNICHROMA Fillers (260nm spherical filler) using a special technique called the Sol-Gel Method. Unlike conventional filler manufacturing methods, which involve crushing glass materials until they reach a roughly desirable size, the Sol-Gel Method produces fillers from filler cores in organic solvent and allows the filler to grow gradually from the cores. This method makes it possible to produce uniform spherical fillers (Figure 11).

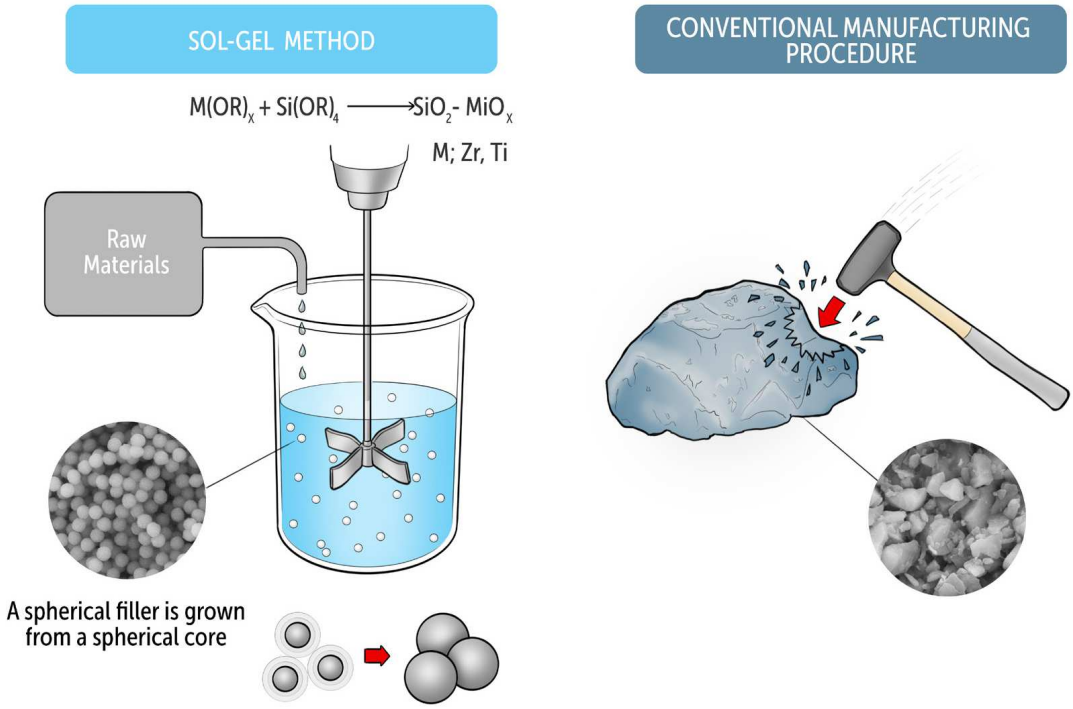


Fig.11 Sol-Gel Method vs conventional filler method.

A key benefit of the Sol-Gel Method is that the filler size can be controlled by adjusting the reaction times. In composite resins, filler size significantly affects the physical characteristics of the cured body and its esthetic aspects. Smaller filler sizes produce a superior surface glossiness but make it difficult to increase filler content. These smaller sized filler particles can lead to drawbacks such as increased polymerization shrinkage and poor physical characteristics such as reduced flexural strength.

Figure 12 shows the correlation between filler particle size, filler content, and compressive strength. The figure illustrates how filler content begins to fall significantly below 100nm but is nearly constant at sizes above that. In addition, it shows maximum compressive strength for particle sizes ranging from 100 to 500nm. Figure 13 shows the correlation between filler particle size, surface roughness, and hardness. This figure illustrates that surface roughness decreases with particle sizes down to approximately 500nm,but remains constant at sizes below 500nm. Surface hardness reaches the highest value at particle sizes ranging from 100 to 500nm. TOKUYAMA utilized these properties to develop the ideal balance between esthetics and physical characteristics with supra-nano sized particles.

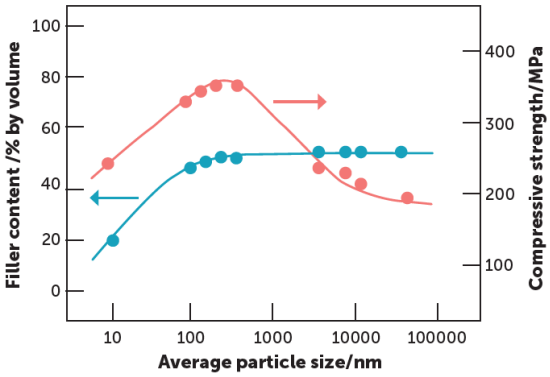


Fig.12 Correlation between particle size, filler content, and compressive strength.

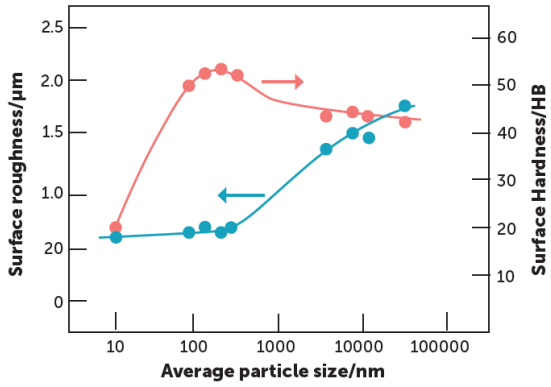


Fig. 13 Correlation between particle size, surface roughness, and surface hardness.

Another key benefit of the Sol-Gel Method is that the refractive index of the filler can be controlled by changing the type and fraction of the additive. To reproduce the semi-translucent quality of natural teeth using composite resins, we must control the difference between the refractive indices of the filler and the organic resin. Composite resins consist of fillers and organic resins containing catalysts. When the refractive indices of both materials are equal, the composite resin appears highly translucent; when the refractive indices differ significantly, the resin appears opaque.

The refractive index of resins tends to change after polymerization, and the refractive index of the cured resin (polymer) tends to be higher than that of the resin (monomer) before curing. This property of refractive indices is demonstrated graphically in Figure 14.

To express excellent color matching, OMNICHROMA FLOW has been designed to optimize the translucency of the composite body after curing. While appearing opaque-white before curing, OMNICHROMA FLOW achieves a natural look by transitioning from opaque to semi-translucent after curing.

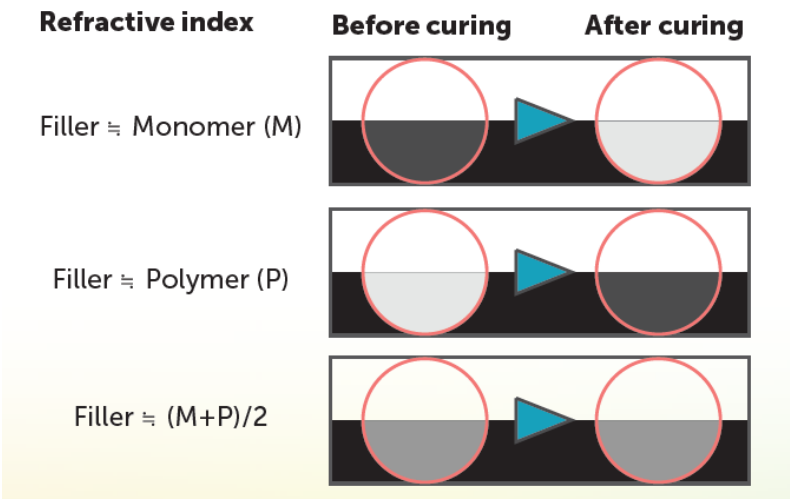
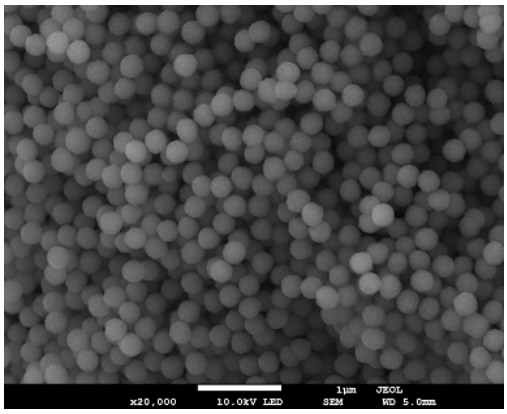


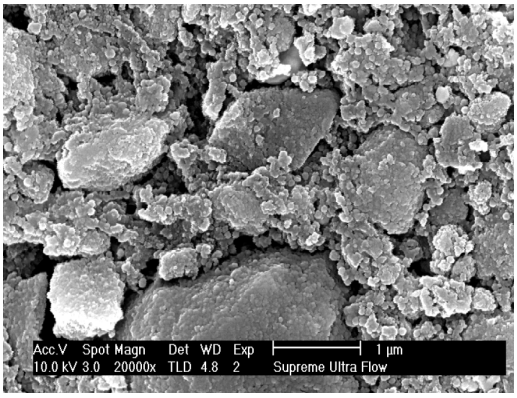
Fig. 14 Relationship with refractive index and translucency.

3.3 COMPARISONS OF FILLER MATERIALS

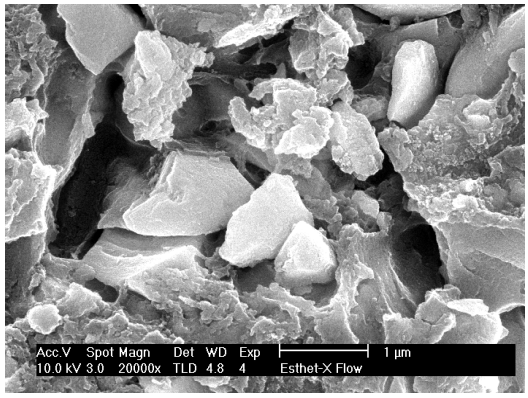
The SEM images on the following pages (20,000x magnification) show the fillers used in OMNICHROMA FLOW and in composite resins from other manufacturers.



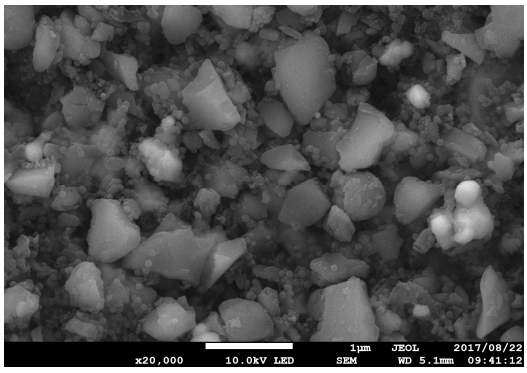
OMNICHROMA FLOW (OMNICHROMA Filler)



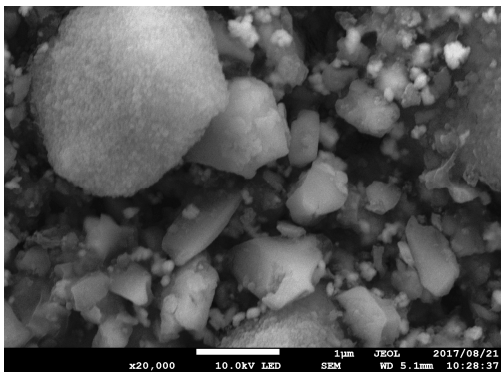
Filtek Supreme Ultra Flowable



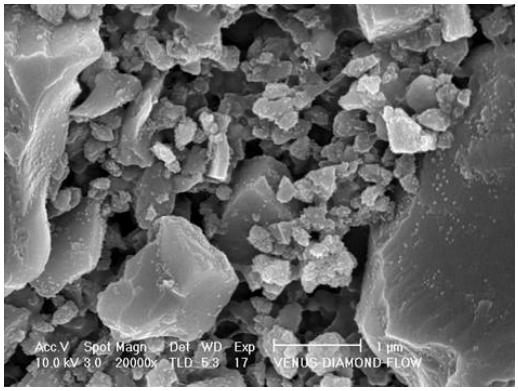
Esthet-X Flow



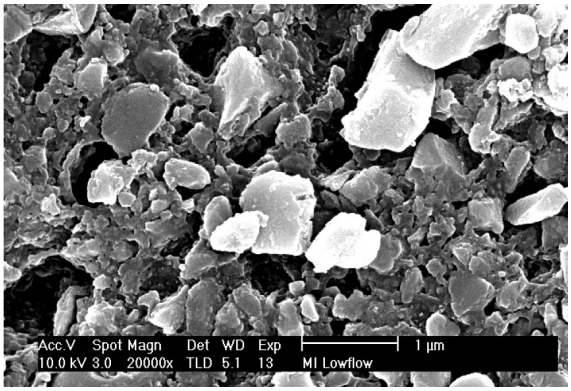
Herculite Ultra Flow



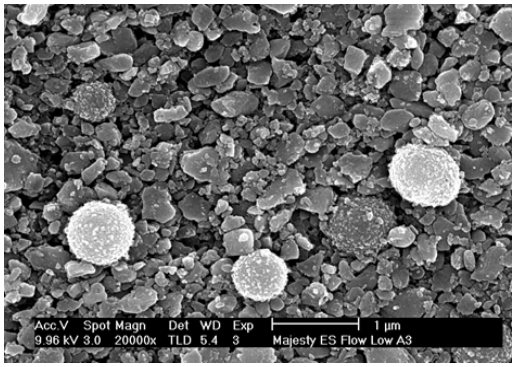
Tetric Evo Flow



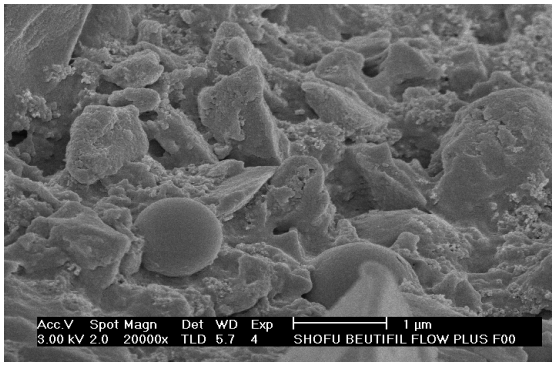
Venus Diamond Flow



G-aenial Universal Flo



Clearfil Majesty ES Flow



Beautifil Flow Plus F00

Fig.15 SEM image of the filler used in resin composite (20,000x magnification).

4. MATERIAL PROPERTIES

4.1 COLOR MATCHING

The color-matching property of OMNICHROMA FLOW is shown in Figure 16. Artificial composite resin teeth were prepared with a cavity size of 4 mm diameter and 2 mm depth, and the teeth were then filled. OMNICHROMA FLOW showed excellent color compatibility with all 16 VITA shades of artificial teeth.

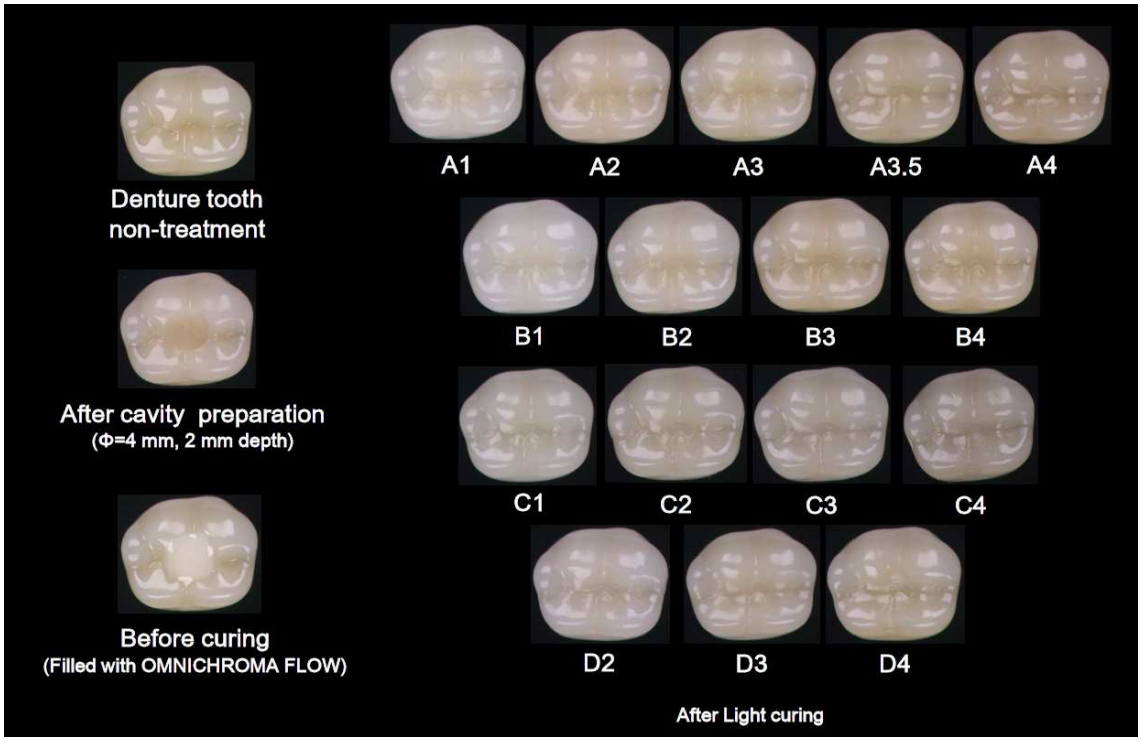


Fig.16 Restoration of Class I cavity with OMNICHROMA FLOW.

4.2 POLISHABILITY

Figure 17 shows surface glossiness after each surface of cured composite is polished with #1500 sandpaper, followed by Sof-Lex™ superfine discs (3M-ESPE) for 60 seconds under running water. The results show that OMNICHROMA FLOW produces extremely high glossiness.

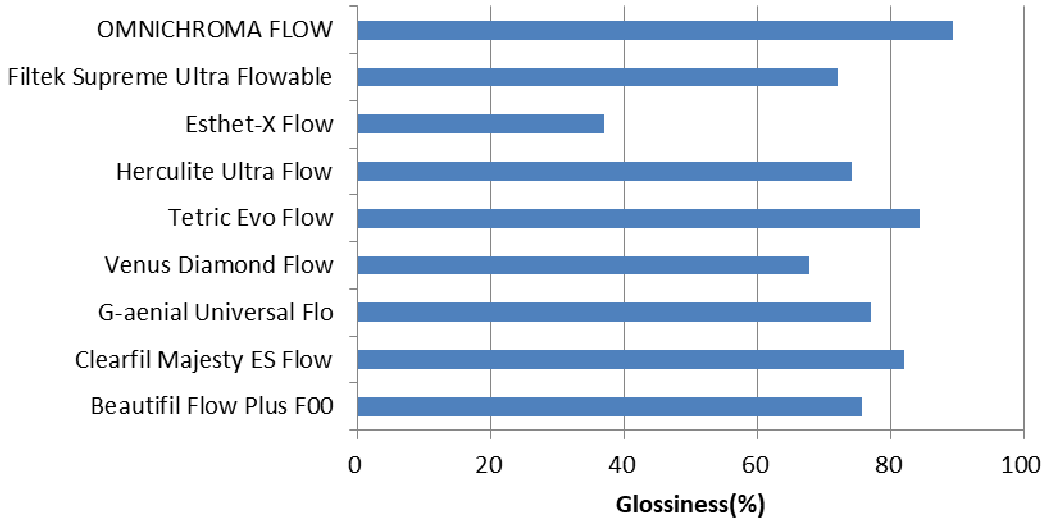


Fig.17 Surface Glossiness.

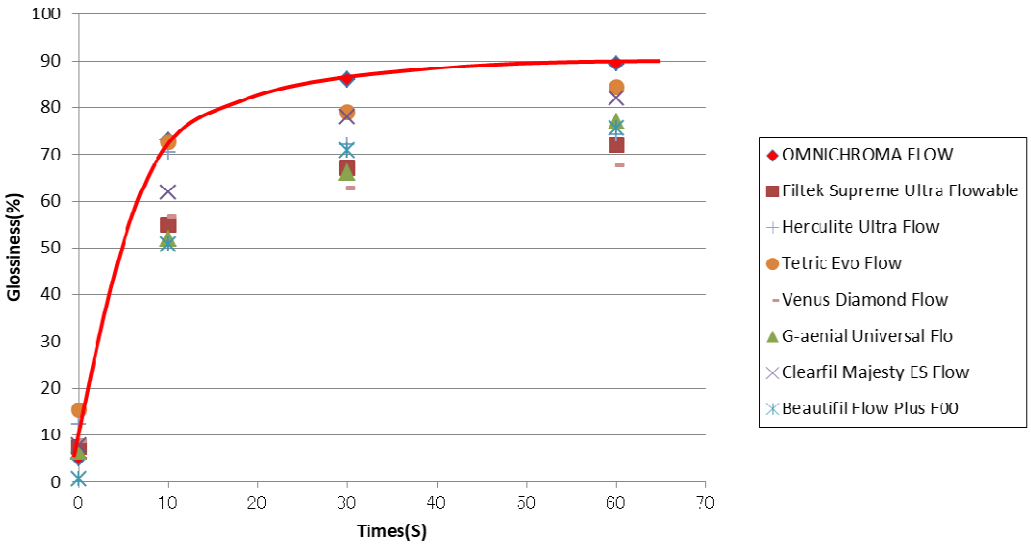


Fig.18 Relationship of surface glossiness and polishing time.

4.3 STRENGTH

Figure 19 presents the flexural strength and Figure 20 presents the compressive strength of OMNICHROMA FLOW and other commercially available flowable resin composites. The flexural strength and the compressive strength of OMNICHROMA FLOW are of average level among commercially available resin composites.

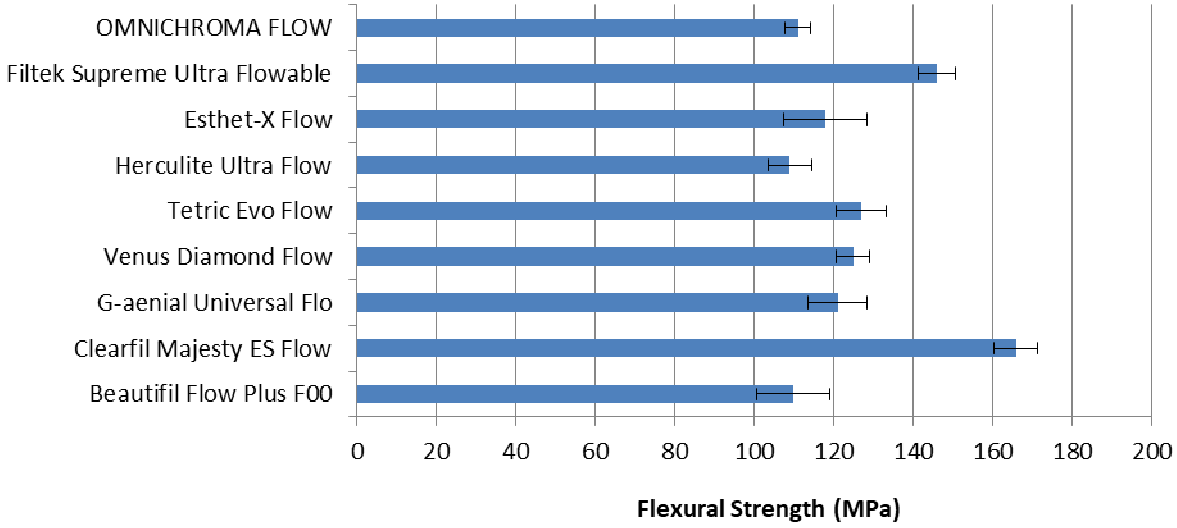


Fig.19 Flexural Strength (MPa).

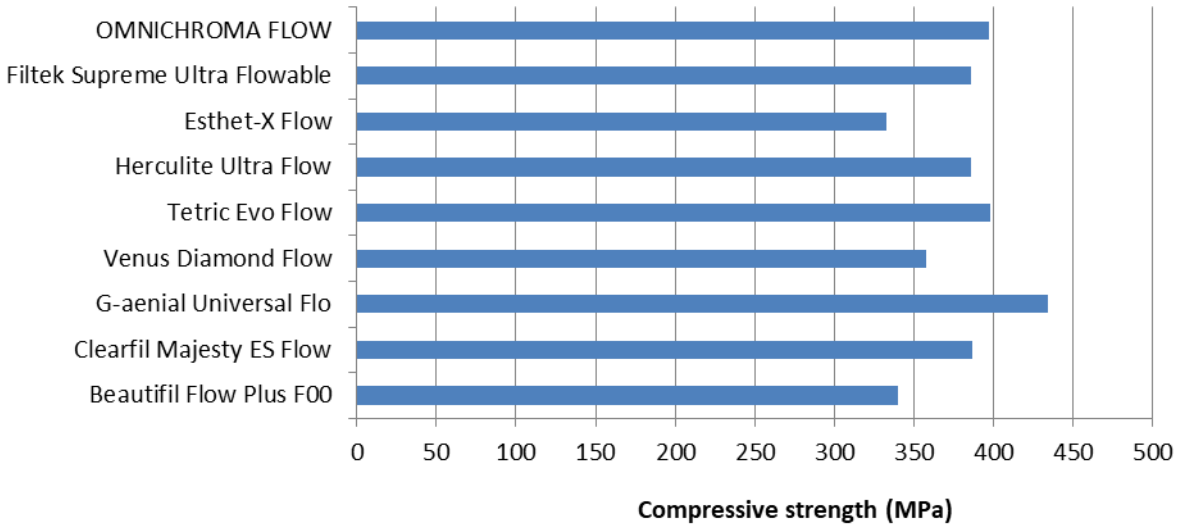


Fig.20 Compressive Strength (MPa).

4.4 WEAR CHARACTERISTICS

Wear resistance of the composite resin opposing a human tooth's occlusal surface was examined using the method shown in Figure 21. The wear resistance test detailed in Figure 22 shows the resulting wear of various commercially available flowable composites and OMICHROMA FLOW. This comparison shows that OMNICHROMA FLOW exhibits an excellent balance between volume loss of the composite resin and wear of the human tooth. OMICHROMA FLOW is a composite resin that is less likely to abrade opposing teeth while not easily becoming abraded itself.

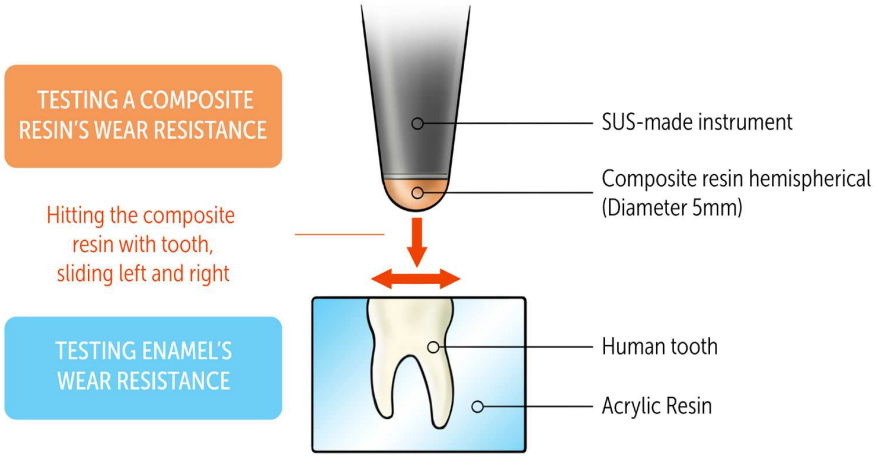


Fig.21 Method of wear resistance testing.

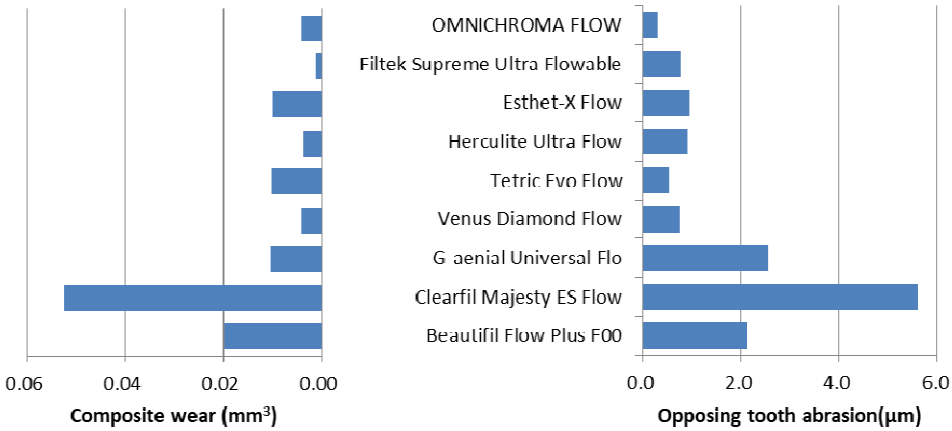


Fig.22 Wear Resistance (50,000 cycles).

4.5 POLYMERIZATION SHRINKAGE

Using the method illustrated in Figure 23 below, TOKUYAMA measured the polymerization shrinkage of OMICHROMA FLOW and other composites. This method can measure shrinkage in the cavity floor when the composite resin is placed into a cavity and exposed to light in a clinical procedure. This method permits evaluation of shrinkage under conditions close to those encountered in real clinical settings.

Figure 24 shows the linear polymerization shrinkage of OMICHROMA FLOW and other commercially available resin composites after three minutes of curing light exposure.

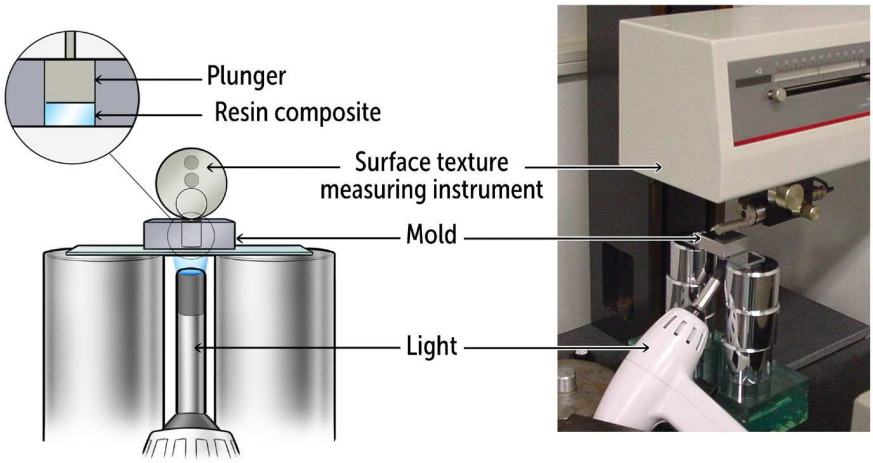


Fig.23 Method of polymerization shrinkage testing.

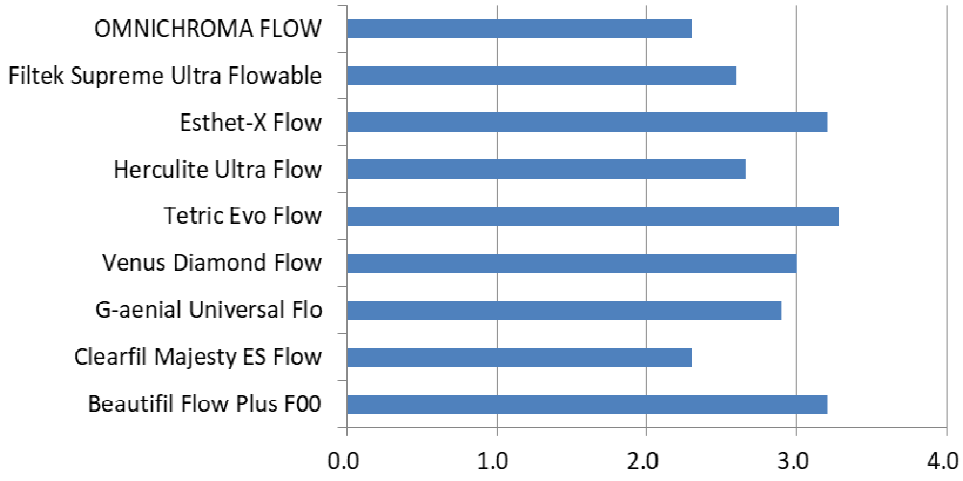


Fig.24 Polymerization Shrinkage (%linear).

4.6 STAINING RESISTANCE

If the composite resin stains more rapidly than the dentition, the resin becomes less esthetically effective. To account for this, we examined the degree of staining by coffee (immersed for 24 hours at 80° C). The stain resistance results are shown in Figure 25.

The extent of staining for OMNICHROMA FLOW after soaking in coffee was found to be low among commercially available resin composites, meaning OMNICHROMA FLOW will resist staining for the life of the restoration.

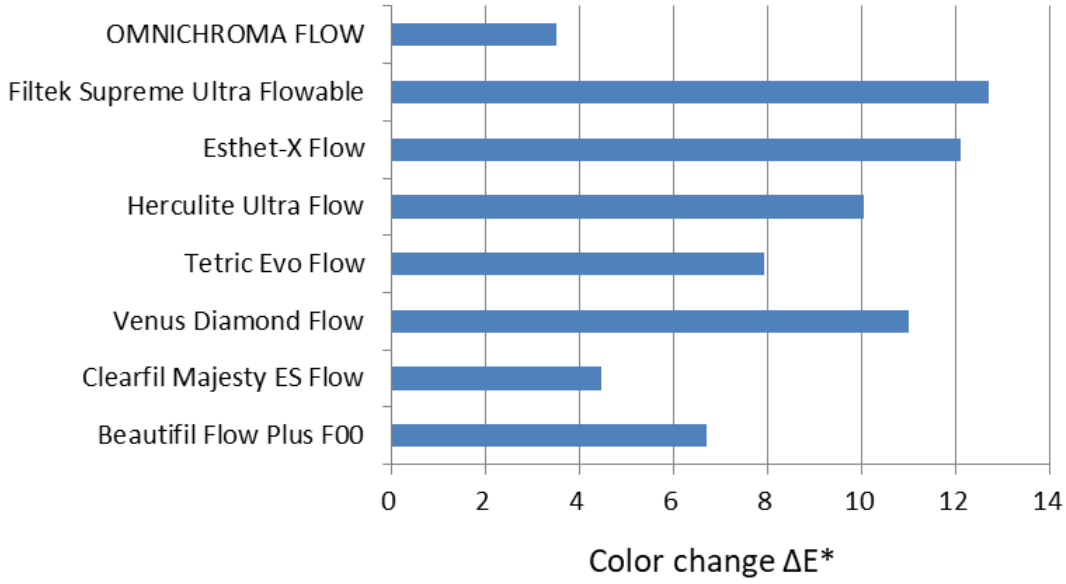


Fig.25 Stain Resistance（ΔE）.*

4.7 COLOR AND TRANSLUCENCY BEFORE AND AFTER CURING

Typically, it is desirable that a composite maintains a similar color before and after curing to prevent errors during the shade-taking process and to provide consistently predictable results. However, as OMNICHROMA FLOW is a single-shade composite with wide shade-matching ability that appears opaque-white before curing, a large change in color is measured in Figure 26 compared to other commercially available composites. Because of the nature of OMNICHROMA FLOW, this is a positive result. The initial opaque-white appearance allows doctors to easily identify the proper position for a restoration and determine where excess resin material can be removed prior to curing.

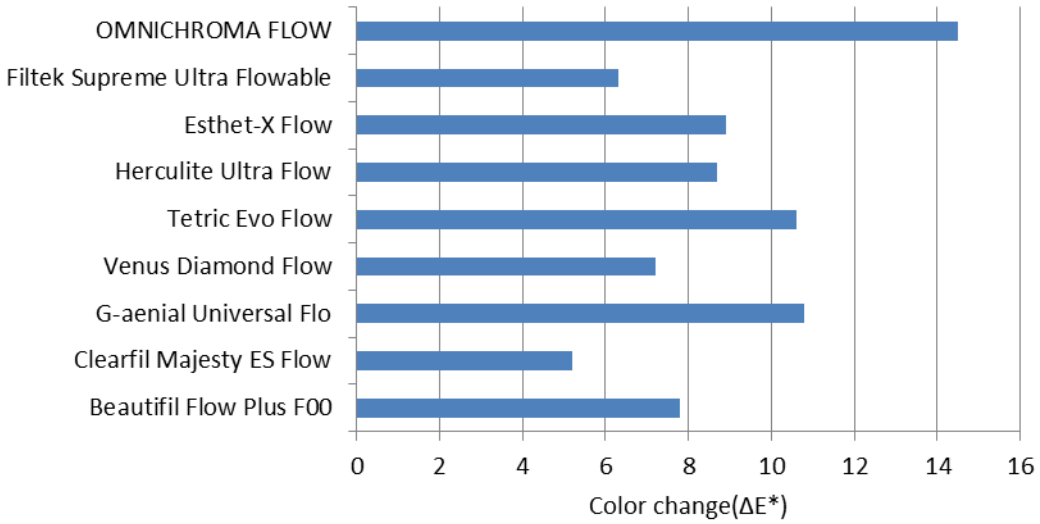


Fig.26 Change of color before and after polymerization.

Similarly, because of OMNICHROMA FLOW's opacity before curing, a strong shift in translucency is measured in Figure 27 as it transitions to semi-translucent for optimal shade matching and esthetics.

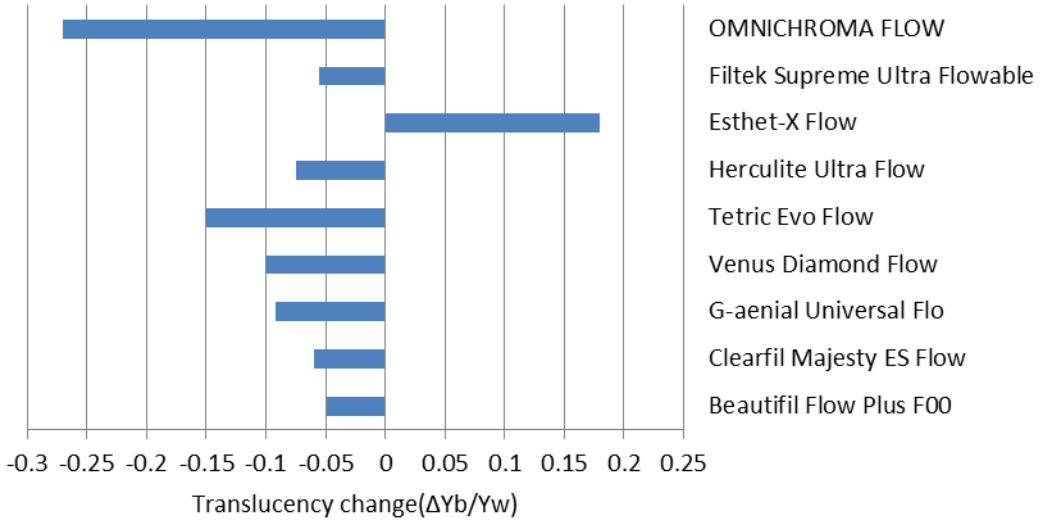


Fig.27 Change of translucency before and after polymerization.

4.8 RADIOPACITY

Radiopacity is determined by the composition of the inorganic filler and the composite's filler content. The radiopacity of a resin increases with the amount of high atomic number elements at higher filler content. However, fillers containing large amounts of high atomic number elements tend to have large refractive indices. Figure 28 shows the radiopacity of commercially available composite resins.

The radiopacity of OMNICHROMA FLOW is average and sufficient for prognosis observations.

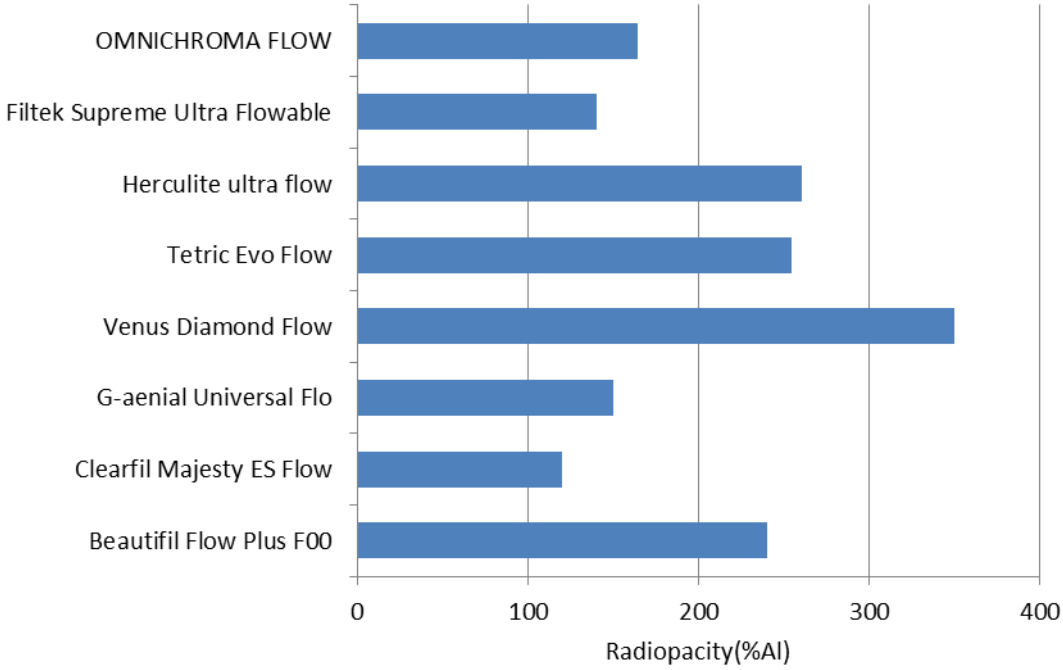


Fig.28 Radiopacity of composite resins.

5. SUMMARY

OMNICHROMA FLOW is an innovative resin composite utilizing a single-shade system that inherits and improves upon the features of TOKUYAMA's spherical fillers. OMNICHROMA FLOW's Smart Chromatic Technology is the first of its kind to take advantage of structural color technology in composite dentistry. Through the culmination of more than 35 years of research and development by TOKUYAMA, this technology allows OMNICHROMA FLOW to match the 16 VITA classical shades with just one shade of composite, simplifying the restorative procedure, and reducing the potential waste of unused composite in the process.