Factors that influence the colour stability of composite resins

Aniruddh Menon¹, Dhanraj M. Ganapathy²*, Arunasree Vadaguru Mallikarjuna²

**ABSTRACT**

Patients seek better esthetic restorations; hence, proper color matching is important not only in the first period of service but also over a long period of time. Thus, awareness of the various factors that influence the color stability of composite restorations is beneficial. We live in a world of esthetic dentistry where esthetic tooth-colored restorations are the trend today. Composite restoration which satisfies this need of esthetic tooth-colored restorations has evolved tremendously. Although the material holds good promise in the field of esthetic dentistry, it also possesses certain disadvantages such as discoloration in the long run. This article reviews the various factors that affect the color stability of composite restorations.

**KEY WORDS:** Color stability, Composites, Discoloration, Esthetics

**INTRODUCTION**

Composite restorations are widely used as an esthetic restorative material in anterior and posterior teeth. Composite resin should retain the color and polish over a long period of time to serve as a long-term esthetic restorative material. Discoloration of composite restorations may occur due to various factors, intrinsic or extrinsic. Although the quality of composite resin restorations has improved with the advent of new technology in material science in recent years, discoloration of the composite resin materials remains to be the major long-term clinical problem.

Color stability is the ability of any dental material to be able to retain its original color. The oral cavity is a dynamic environment. With the continuous presence of microflora, saliva, and frequent intake of colored food (chromatogens), the color stability of an esthetic material may become compromised. However, the property of color stability of the esthetic dental materials is often ignored over other physical and mechanical properties while making a choice. Further, the wide array of materials available at the disposal of the clinician compounds the challenge of making a wise choice. This review gives us detailed information on the various factors that influence the color stability of composite restorations.

**FACTORS AFFECTING COLOR STABILITY OF COMPOSITE RESTORATIONS**

Different factors can be responsible for affecting the color stability in composite restorations.

The color stability of a resin composite is related to the resin matrix, dimensions of filler particles, depth of polymerization, and coloring agents.[9-11]

Discoloration of tooth-colored, resin-based materials may be caused by intrinsic or extrinsic factors. Intrinsic factors involve physicochemical discoloration reactions in the composite matrix, in surface and deeper layers of the material, triggered by UV radiation, thermal energy, or humidity. Chemical discoloration has been attributed to a change or oxidation in the amine accelerator, oxidation in the structure of the polymer matrix, and oxidation of the unreacted pendant methacrylate groups. Extrinsic factors happen due to accumulation of plaque and stains, intensity and duration of polymerization, and exposure to environmental factors including ambient and UV irradiation, heat, water, and food.
Color stability is a very important parameter for contemporary resin-based filling materials. Many factors influence the color stability of up to date light-activated materials such as the photoinitiator system, the organic compound matrix, the light-curing unit used for polymerization, and also the irradiation times.\(^\text{[3]}\)

The phenomena of action and solubility could function precursors to a spread of chemical and physical processes that make biological issues likewise as turn out harmful effects on the structure and performance of an organic compound matrix. These effects embody swelling, plasticization and softening, oxidation, and hydrolysis.\(^\text{[4]}\) As a consequence, there is a decrease of the color stability, promoting higher condition to staining.

Thus, for appropriate performance, longevity and smart clinical success of aesthetic restorations, the fabric of selection ought to gift adequate intrinsic characteristics that area unit specific for every procedure and conjointly that its polymerisation is ideal, with this facet directly associated with the light-curing units and their use.

Some LED light-curing units show an analogous performance to quartz tungsten grouping action units, whereas others appear to be less efficient. These properties enclosed depth of cure, compressive strength, flexural strength, hardness, and degree of polymerization or double-bond conversion.\(^\text{[5]}\) However, some researchers have reportable lower hardness or lesser degree of double-bond conversion in resin-based composites polymerized victimization some crystal rectifier action units\(^\text{[6]}\) and this was attributed to low power density of the first generation. For 2d and third generation of LEDs, these properties were the same as that obtained by the grouping action units.\(^\text{[1]}\)

Color match is one among the foremost necessary characteristics of esthetic restorative as well as factors such as intrinsic discoloration and extraneous staining. Color maintenance throughout the purposeful period of time of restorations is very important for the sturdiness of a treatment.\(^\text{[6]}\)

**Composite Organic Compound Discoloration is Complex as Well as Factors like Intrinsic**

Discoloration and extraneous staining. Nonetheless, a correlation is established between color stability and conversion rate, with incomplete polymerized composite resins showing reduced mechanical properties and bigger discoloration susceptibility.\(^\text{[7]}\)

Manufacturers have introduced completely different shades for restorative materials, capable of fulfilling all the necessities for surroundings lightweight sensitivity, depth or cure, color match, and stability.\(^\text{[8]}\)

The success of dental restorations depends, among alternative problems, on compressive, diametric tensile and flexural strengths, wear and fracture resistance, and polish retention. What is more, esthetics restorative materials ought to mimic the looks of natural tooth, and this reality is directly associated with the material’s color match and color stability. However, it is known that restorative composites have an inclination to discoloring once exposed to the oral environment.\(^\text{[9]}\) Despite this, color stability between composite organic compound and tooth are often full of absorption of pigments or by an factor inherent to the fabric. It is been shown that some composite organic compound parts could have a sway on discoloration phenomenon.

Many studies have shown bound beverages and foods touching the esthetics likewise because the physical properties (microhardness, surface roughness) of composite resins, undermining the standard and longevity of restorations. It should cause a discount of Knoop microhardness in composite organic compound when occasional consumption that suggests that prolonged immersion during a high-temperature resolution could result in important alterations inbound properties of the composites. These studies have shown that composite resins area unit vulnerable to color instability once exposed to numerous staining media, particularly wine, coffee, cola, tea, and whisk.\(^\text{[3]}\) Moreover, restorative material discoloration could be attributed to water action degree and matrix organic compound hydrophilicity. If a composite organic compound will absorb water, it can even absorb alternative fluids, leading to color alteration.\(^\text{[5,6]}\) In addition, filler particle size and distribution likewise as organic compound matrix composition are shown to play a very important role during this context. The photo-initiator system cannot solely influence the polymerization characteristics; however, even have impacts on the composite color stability. Some studies have reportable high surface roughness of composites, even when finishing, due to on an irregular basis organized inorganic filler particles that might lead to easier staining overtime.

Tooth surface discoloration by the deposition of extraneous stains is presently treated by skilled improvement with scaling and polishing.\(^\text{[9]}\) However, intrinsic stains on composite restorations cannot be removed superficially and would possibly demand restoration replacement. Each science and technology of composite dental restorative materials have advanced considerably.\(^\text{[10]}\) The resin-based materials that are on
the market have improved their physical properties due to new filling ideas and matrix changes. Strength and esthetic properties of the resin-based nanocomposites ought to permit the practitioners to use it.

**INTRINSIC FACTORS**

**Composition of Composite Resins**

**Matrix**

Studies have shown that resin materials using urethane dimethacrylate (UDMA) showed more color stability than resin materials using dimethacrylate as matrix. The UDMA matrix results in lower viscosity and lower water sorption.\(^{14}\) It has been found that composite-based resins can absorb water at a higher rate due to high diffusion coefficient in comparison to methyl methacrylate-based resins and thus stain more.\(^{15}\)

The bis-acryl resins showed lesser color stability as compared to the polymethyl methacrylate (PMMA) since bis-acryl polymers are more polar than PMMA polymers and, therefore, have a greater affinity toward water and other polar liquids.\(^{6,9}\)

**Fillers**

Ormocer with its rigid organic matrix containing three-dimensional linked inorganic-organic copolymers (ormocers) and additive aliphatic and aromatic dimethacrylates has high wear resistance as compared to microfilled or microhybrid composite and can resist discoloration. Excessive water sorption may decrease the life of a resin composite by expanding and plasticizing the resin component, hydrolyzing the silane, and causing microcrack formation. As a result, the microcracks or interfacial gaps at the interface between the filler and matrix allow stain penetration and discoloration.\(^{10}\) It has been shown that hydrophilic materials have a higher degree of water sorption and relatively higher discoloration value with staining solutions than hydrophobic materials.\(^{14}\) It was reported that larger filler particle size resulted in rougher surfaces.\(^{12,13,27}\) There are many composite resins have various filler size and volume. In the past decades, the size of the filler particles in dental resin composite materials has decreased considerably, from 8 to 30 μm in traditional composites to 0.7–3.6 μm for modern small particle composites.\(^{17}\) The use of composite resins with a higher small-sized filler particle content is increasing.\(^{18}\) Increased amount of filler contents, decreased filler size, and better distribution within the resin matrix result in smoother surfaces.\(^{19,20}\)

**Photoinitiators**

It is known that the efficiency of polymerization may influence discoloration since the higher degree of conversion, the smaller the amount of residual monomers available to form colored degraded products.\(^{21}\) Observing light sources as an isolated factor, it was noted that this might cause color alteration to the studied composite resin. Studies show that the LED unit showed the lowest color alteration when compared to QTH units and Jet Lite.\(^{21}\) It is believed that the advantage of LED over conventional halogen lamp was because we used a high-power density LED unit (790 mW/cm\(^2\)), which according to Bala et al. (2005) promotes a higher degree of monomer conversion and hence better results.\(^{22}\) As Jet Lite is a high-power halogen light device (greater power than Ultralume 5 and XL3000), during the accelerated curing, it can promote the formation of polymer chains with lower molecular weight and residual monomers and, consequently, partial polymerization of the material, with part of the photoinitiator remaining idle.\(^{22}\) However, there was no significant difference between light sources on promoting changes of color stability of the composite resin.\(^{22}\)

**Extrinsic Factors**

**Type of food colorant**

Various types of colorants (food and other coloring agents) that have a potential to cause color changes of dental materials such as tea and coffee (with or without sugar and milk), beverages, grape juice, wine, cherry juice, soya sauce, nicotine, and disinfecting agents used in mouth rinses have been studied over the years.\(^{23,24}\)

Chlorhexidine is widely used as a broad-spectrum topical antibacterial agent to control oral diseases. It is known to cause discoloration of the oral tissues and the restorations, especially in combination with dietary factors. It has been proposed that dietary factors containing tannin have a high chromogenic potential, particularly when used with chlorhexidine. Denatured proteins and iron from the diet contain thiol groups that provide sulfur and eventually forms iron sulfide which is responsible for the stain.\(^{23,25}\)

Consumption of certain beverages such as coffee and tea may affect the esthetic and physical properties of composite resins, thereby undermining the quality of the restoration. The consumption of aerated drinks is high in young adults and children. These aerated drinks being acidic may be detrimental to the properties of restorative resins. The effect of beverages on the properties of composite resins may also be directly related to the amount and frequency of its intake.\(^{12,26}\)

It has been shown that low pH media such as cola (pH 2.7) affect the surface integrity of materials like resins by softening of matrix and causing a loss of structural ions such as calcium, aluminum, and silicone from the glass phase.\(^{27}\) The previous studies have shown that the addition of sugar and milk powder in tea and coffee results in an increased color change,
the differences that were found to be significant.\textsuperscript{[15,26]} Coffee has been found to be a stronger chromatogen than tea or cola.\textsuperscript{[15,16,27]}

**Surface finish**

Rough surfaces of restorative materials tend to accumulate more plaque and absorb more water and food colorants. Smooth finished restorations, on the other hand, show better color stability. Surface roughness of resins is due to irregularly arranged inorganic filler particles and hence get easily stained by mechanical adsorption.\textsuperscript{[15,28]} It has been proposed that the light polymerized provisional restorative materials have higher roughness due to larger filler particles and pits resulting in more colorant particle deposition.\textsuperscript{[15]}

**Effect of bleaching on composite restorations**

Effect of staining solutions on color change of composite resins is material dependent and has been primarily attributed to basic composite formulation, type of filler particles, and particle size.\textsuperscript{[14,18,29,30]} The results of the previous studies indicate that the color change induced by the bleaching agent might be dependent on the monomer structure and volume of the resin matrix as well as the filler systems of composite materials.\textsuperscript{[30]} It has been found that hydrogen peroxide (HP) and carbamide peroxide (CP), the two most popular bleaching products, can change the physical properties of dental restorations such as their color, surface roughness, hardness, and ion leakage. Many studies have examined the changes bleaching causes within the characteristics of composite resins, a material unremarkably used for aesthetic dental treatments such as color, surface hardness and roughness, staining status, microleakage, and elution. Employing a photometer, Li et al.\textsuperscript{[16]} found important changes in the color of nanohybrid and packable composite resins when bleaching with 15\% CP. Another study found that this distinction was particularly noticeable once a high peroxide concentration (35\% HP) was used on low-density organic compounds like microfilled composite resin. The authors attributed these results to the amount of organic compound matrices and filler sort. In each study, the color amendment was clinically acceptable.\textsuperscript{[40]}

Using the Knoop hardness take a look at, Hannig et al.\textsuperscript{[41]} reported a big decrease within the surface hardness of bleached composite resins, not solely on superficial surfaces, however, within the deeper layers of the filling materials still. Similarly, another analysis study\textsuperscript{[31]} terminated that bleaching with totally different peroxide concentrations considerably reduced the surface microhardness of a microfilled composite organic compound. These results were associated with the high oxidation and degradation of the tarry matrix within the composites. Alternative investigations of microhardness reported totally different results. One study\textsuperscript{[42]} reported that bleaching with 16\% CP reduced the microhardness of a hybrid composite organic compound, whereas bleaching with 35\% had no impact thereon, alternative studies found that doing associate at home\textsuperscript{[32]} associated an in-office bleaching on totally different composite resins failed to reduce their microhardness, creating replacing fillings when bleaching excess. Although many authors reported a modification within the surface hardness of composite organic compound restorations when bleaching, most terminated that more clinical analysis was necessary to reveal the clinical relevancy of bleaching on these restorations.\textsuperscript{[33]}

On account of the type of the composite restoration, it was seen that the microfilled composite (Durafill) had a significantly greater amount of color stability in relation to the nanofilled composite (Filtek Z-350).\textsuperscript{[34]}

A recent study by Wattanapayungkul et al.\textsuperscript{[39]} demonstrated that treating composite resins with an occasional peroxide concentration considerably inflated their surface roughness. However, as a result of the surface roughness values failed to exceed 0.2 µm, that is, that the essential limit for plaque retention and accumulation, the results were not clinically important. Another study\textsuperscript{[34]} that evaluated the impact of low and high peroxide concentrations on hybrid and microfilled composite resins came to an identical conclusion.

Yu et al.\textsuperscript{[38]} found that bleached composite resins stain additional simply than undyed ones. The authors prompt that this staining may be caused by alterations within the surface of the bleached restorations. However, one study\textsuperscript{[41]} found that bleaching will take away stains from the external surface of a composite restoration, and another\textsuperscript{[44]} found that bleaching with 15\% HP is more practical than sprucing for removing stains and restoring the initial color of the composite organic compound. Not like enamel, composite restorations do not change color once bleached. Therefore, they will not need substitution to match the color of bleached enamel when teeth change of color.\textsuperscript{[35,36,43]}

Bleaching teeth with Category I composite restorations with 20\% CP does not have an effect on the occlusal margins of the restorations and, therefore, does not cause microleakage.\textsuperscript{[45]} Similar results were found at the occlusal and animal tissue margins of sophistication V restorations when they were bleached with 20\% CP and 38\% HP. Although the findings of those studies recommend that the margins of restorations are not affected when bleaching procedures, additional clinical studies are required to point out the impact of bleaching on additional in-depth Category II composite organic compound restorations.
CONCLUSION

Color stability is the ability of materials to retain their original color. Daily intake of food with staining ability such as tea, coffee, and cola can compromise esthetics of restorative materials.

Understanding the property of color stability and the comparative analysis of various restorative materials will help a clinician to choose the materials as per the diet habits of the patients and ensure predictability of success. It will also enable the clinician to educate and counsel the patient about the effects of specific chromatogenic ingredients in the diet such as tea, coffee, and wine on the color stability of the restorative material used.

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