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Original Article

Effect of home bleaching agents on the hardness and surface roughness of resin composites

Farahiyah Mohamad Taib, Zuryati Ab Ghani*, Dasmawati Mohamad

School of Dental Sciences, Health Campus, Universiti Sains Malaysia, 16150, Kubang Kerian, Kelantan, Malaysia.

* Corresponding author: zuryati@kb.usm.my

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Abstract Ten percent carbamide peroxide is an effective, safe home bleaching agent. Higher concentrations are more effective, but there are mixed reports on their hardness and surface roughness effects on resin composites. To evaluate the effect of home bleaching agents; Opalescence Now 10% carbamide peroxide (Ultradent Products, USA) and Perfect Bleach 17% carbamide peroxide (Voco, Germany) on the surface hardness of microhybrid resin composites; Filtek Z250 (3M ESPE, USA) and Point 4 (Kerr, USA) and their surface roughness of selected treatment. Thirty specimens were prepared using acrylic moulds (4mm diameter x 2mm thick). N=5 controls placed in distilled water for 14 days. N=5 treated with Opalescence, and n=5 treated with Perfect Bleach for 2 hours every day for 14 days. Surface hardness was tested using Vickers hardness tester FV-7 (Future Tech Corp, Japan). Data analyzed with Mann-Whitney test with (P<0.05) considered significant. One specimen from 10% carbamide peroxide group was randomly selected for surface roughness, (Ra) evaluation using Atomic Force Microscopy (Ambios Technology, California, USA). All tested materials showed no significant changes in surface hardness after 14 days bleaching with 10% and 17% carbamide peroxide. However, AFM evaluation revealed an increase in Ra in both composites with 10% carbamide peroxide. Fourteen days bleaching using 10% and 17% carbamide peroxide did not have different effect on the surface hardness of Point 4 and Filtek Z250. The Ra increased after bleaching in both composites. The AFM surface roughness evaluation observed in 3D images shows to be a promising technique.

Keywords: Bleaching, composite, hardness, surface roughness.

Introduction

Bleaching is one of the options to improve aesthetics in a dental restorative treatment. The use of bleaching has widened after the introduction of home bleaching treatment systems in the 1990s (Haywood and Heymann, 1989), almost a century after the first use of bleach to whiten teeth in the late 1870s (Fasanaro, 1992).

Bleaching agent works by the decomposition of peroxides from hydrogen peroxide or its compounds such as carbamide peroxide (CP) into unstable free radicals. These radicals further breakdown into large pigmented molecules either through oxidation or reduction reaction. The oxidation or reduction process changes the chemical structure of interacting organic substances of tooth, which result in colour change (Greenwall, 2001).

The types of bleaching methods include non vital bleaching, in-office professional bleaching and home bleaching. Night guard home bleaching uses a relatively low level of whitening agent, usually 10% CP and applied to the teeth via a custom fabricated mouth guard and is worn at night for at least 2 weeks duration. This relatively low concentration was proven to have minimal effects on the soft tissues of the mouth (Kelleher and Roe, 1999) and also accepted by the American Dental Association as the standard bleaching concentration (American Dental Association, 2006). Studies had confirmed that higher concentration of bleaching agents will whiten the tooth faster (Kihn *et al.* 2000; Braun *et al.* 2007). It is then imperative to study the impact of higher concentration bleaching to teeth and the surrounding tissues.

Tooth coloured restorations especially resin composites accommodate a wide range of application for both anterior and posterior restorations, and they require long term durability in the oral cavity (Okada *et al.*, 2001). A type of widely used resin composites is known as microhybrid. These materials incorporate a high volume fraction of filler particles, with a mean size < 1 μm and narrow particle size distribution.

There are concerns regarding the safety of bleaching agents on the existing resin composites used as restorative materials. The safety and effectiveness of bleaching on tooth structures have been confirmed (Kugel and Kastali, 2000). However, reports on the effects of home bleaching agents on the surface hardness of resin composites have been conflicting (Attin *et al.*, 2004). Some authors had reported that home bleaching agents may soften the resin composites (Bailey and Swift, 1992; Taher, 2005) whilst other authors found the opposite results (García-Godoy *et al.*, 2002; Yap and Wattanapayungkul, 2002).

Surface hardness indicates the compressive strength and abrasion resistance, and is one of the most important physical properties of resin composite (Okada *et al*., 2001). It is the ability of a material to resist indentation or penetration (O'Brien, 1997). Hannig *et al*. (2007) reported that resin composites with reduced physical properties are more prone to abrasion. The effect may lead to failure of the restoration which may have to be replaced by the dentist.

The surface texture is another property that might be affected by bleaching. Smooth surface, apart from enhancing the aesthetic result, prevents the formation of discolouring films and plaque retention. Furthermore, surface smoothness decreases the coefficient of friction and this may reduce wear rate (Tjan and Chan, 1989). Atomic Force Microscopy (AFM) is a new cutting edge technique in dentistry especially in dental materials field, which is capable of providing three-dimensional images of surface roughness at nanometer resolution (Mahmoud *et al.*, 2010). The present study employed AFM to evaluate the roughness of bleached surfaces of microhybrid composites.

There is limited research on the effect of different concentration of bleaching agents on the surface hardness of resin composites and they were inconclusive (Hannig *et al*., 2007; Mujdeci and Gokay, 2006; Taher, 2005; Yap and Wattanapayungkul, 2002). The present study evaluated the effects of different concentrations of home bleaching agents on the surface hardness of resin composites.

Materials and methods

Thirty specimens discs were prepared using two microhybrid resin composites; Filtek Z250 (3M ESPE, USA) and Point 4 (Kerr, USA) by injecting them into acrylic moulds having internal dimension of 4 mm in diameter x 2 mm in thickness. Both composites are of shade A2. Both the bottom and the top surfaces of the moulds were covered with mylar strips, and a glass slab was placed on top of the mould to remove excess. The specimens were then light cured for 20 seconds according to the manufacturer's instruction with QTH 75™ light curing unit (Dentsply, UK).

Five specimens (n=5) from each type of resin composites were stored in distilled water at 37^{o}C in an incubator MIR-253 (Sanyo, Japan) for 2 weeks as the control group (Group 1). Another 5 specimens were subjected to Opalescence Now 10% CP (Ultradent Product, USA) which made group 2. The remaining 5 specimens were in Group 3 and subjected to Perfect Bleach 17% CP (Voco, Germany). The details of the resin composites and bleaching agents used in the present study are presented in Table 1. For Groups 2 and 3, they were stored in distilled water for 24 hours at 37°C in the incubator prior to commencement of bleaching procedure. The samples were dried thoroughly with air jet spray for 60 seconds once they were taken out from the incubator. The bleaching agent was then applied on one surface of the sample with micro brush (Kerr, USA) and left for 2 hours on a tray. After 2 hours, the bleached samples were washed with water jet spray for 60 seconds, stored back in distilled water and incubated at 37oC ready for the next bleaching procedure. Bleaching procedure was carried out for 2 hours per day for 14 days.

All 30 samples were subjected to hardness testing using Vickers Hardness Tester FV-7 (Future Tech Corp, Japan) (Taher, 2005) after 14 days. Specimens were placed underneath the indenter and a 300g load was applied through the indenter for a dwell time of 15 seconds. Every sample was indented for 5 times at 5 different points and the mean readings were recorded. One specimen from each treatment group of 10% carbamide peroxide bleaching agent was randomly selected for the surface roughness, (Ra) evaluation using Atomic Force Microscopy (AFM) (Ambios Technology, California, USA). Furthermore, surface texture evaluation of 3D images was obtained using the AFM. The data collected were analyzed using SPSS version 12.0 (SPSS Inc, 2002). All statistical analysis were conducted at a significance level of $p<0.05$ using Mann-Whitney test.

Table 1 Resin composites and bleaching agents tested

Materials	Manufacturer	Composition	Batch No
Filtek Z250 (shade A2)	3M ESPE, USA	• Inorganic filler loading is 60% by volume • Particle size is 0.01 to 3.5 microns • BIS-GMA, UDMA, BIS-EMA	1370A2
Point 4 (shade A2)	Kerr Corporation, USA	• Inorganic filler is 57% by volume • An average particle size of 0.4microns	CA 92867
Opalescence Now	Ultradent product, USA	10% carbarmide peroxide	1074
Perfect Bleach	Voco, Germany	17% carbarmide peroxide	1664

Table 2 Median Vickers Hardness Number (HVN) and Interquartile range (IQR) of tested resin composites when treated with Opalescence Now 10% CP home bleaching agent

Materials	Control, (*n*=5) Median (IQR)	10% CP, (*n*=5) Median (IQR)	Z statistic[a]	*p* value[a]
Filtek Z250	62.800 (5.900)	61.000 (6.420)	-0.104	0.917
Point 4	26.560 (8.510)	25.860 (7.540)	-0.313	0.754

[a] Mann-Whitney test

Table 3 Median Vickers Hardness Number (HVN) and Interquartile range (IQR) of tested resin composites when treated with Perfect Bleach 17% CP home bleaching agent

Materials	Control, (*n*=5) Median (IQR)	17% CP, (*n*=5) Median (IQR)	Z statistic[a]	*p* value[a]
Filtek Z250	62.800 (5.900)	62.340 (1.550)	-0.731	0.465
Point 4	26.560 (8.510)	25.720 (3.000)	-0.522	0.602

[a] Mann-Whitney test

Table 4 Surface roughness values (Ra) from one specimen of Z250 and Point 4 bleached with 10% CP

Materials	Bleaching treatment	Surface roughness, Ra(nm)
Z250	10% CP	15.61
	Control	7.51
Point 4	10% CP	83.77
	Control	33.77

Results

The results of the Vickers hardness testing are presented in Table 2 and Table 3. The statistical analysis showed no significant difference ($p>0.05$) in Vickers hardness number of Filtek Z250 when comparing those subjected to 10% CP with those of the control group. Similarly, there was no significant difference in the hardness of Point 4 after treatment with 10% CP when compared with the control group. Both Filtek Z250 and Point 4 also showed no significant hardness changes after 14 days bleaching with 17% CP. However, AFM evaluation revealed an increase in Ra values in both composites after subjecting to 10% CP when compared to the control group (Table 4). The 3-D AFM image of Z250 control specimen revealed uniformly distributed surface with peaks and valleys of fillers (Fig. 1). While the 3-D AFM image of Z250 after bleaching with 10% CP showed the irregular and more prominent fillers (Fig. 2).

Discussion

Ten percent and 17% CP bleaching agent used in the present study caused no significant difference in hardness between the control group and bleached groups for both microhybrid composites. Hence, it can be deduced that the use of home bleaching agent at 10% and 17% CP does not cause significant chemical softening of microhybrid composites restoratives, which is consistent with previous findings (García-Godoy *et al.*, 2002; Yap and Wattanapayungkul, 2002). The latter author also reported that the resin composites are also not significantly affected by the use of in-office tooth whiteners employing the use of strong oxidizing agents.

The integrity of the surface hardness of composite materials used in the present study may be contributed by a few factors. One of the factors that may cause the decrease in the surface hardness of resin composite after bleaching treatment may be due to the oxidation and degradation of resinous matrix (Taher, 2005). In the present study, Filtek Z250 consists of 60% by volume of inorganic filler loading (3M ESPE, Germany), and Point contains 57% by volume of inorganic filler loading (Kerr, USA). The inorganic filler loading of both materials are quite similar (Craig *et al.*, 2004) and may be high enough to be closely packed together to resist to the oxidation and degradation of resinous matrix, hence resist the softening effect of the bleaching agents.

Another factor that may affect the integrity of resin composite surface hardness is the degree of which the filler is bonded to the resin matrix. In the present study, the bonding of the inorganic fillers to the resin matrix in both Filtek Z250 and Point 4 are adequate to resist the effect of bleaching treatment. Resin composites are also reported to be highly susceptible to chemical softening due to presence of Bis-GMA monomer if the chemicals have the solubility parameter ranging from 1.82×10^4 to 2.97×10^4 $(J/m^3)^{1/2}$ (Wu and McKinney, 1982). However, the results of the present study proof that the presence of Bis-GMA in both Filtek Z250 and Point 4 is not high enough to cause significant reduction in surface hardness after bleaching treatment.

Based on the result of the present study, dentists may be able to use higher concentration of home bleaching instead of regularly used 10% CP, in order to achieve faster effect (Kihn *et al.*, 2000) without affecting the surface hardness of the existing microhybrid resin composites. Kakaboura *et al*. (2007) found Ra of Point 4 without bleaching treatment was 50 nm, which is quite close to this finding, 34 nm. The result shows that Ra for Point 4 is much higher than Z250. Filler size is one of the factors that determines the surface roughness and polishability of the restorative materials (Yalcin and Gürgan, 2005). It could be that, even though Point 4 has a lower filler size of 0.4 µm compared to Z250 which is 0.6 µm, the Z250 has much higher filler composition which is 60% whereas the filler loading of point 4 is 57%. Hence it is assumed that with less filler loading, the cantilever sensor of AFM senses the irregularities between the resin and fillers as higher and vice versa.

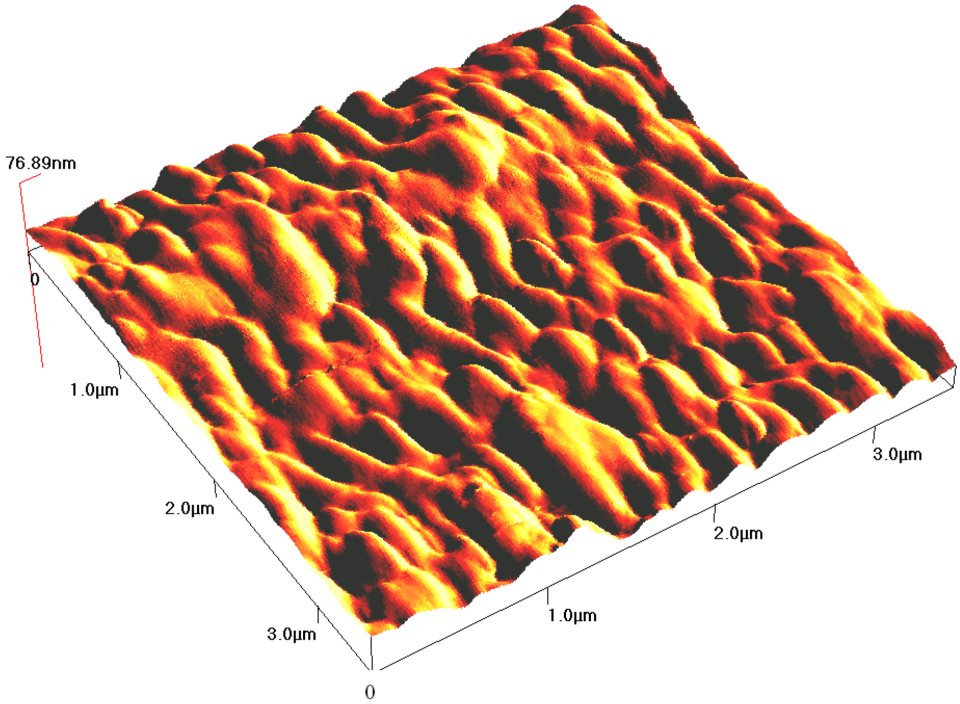

Figure 1 3-D AFM image of Z250 without bleaching treatment (control).

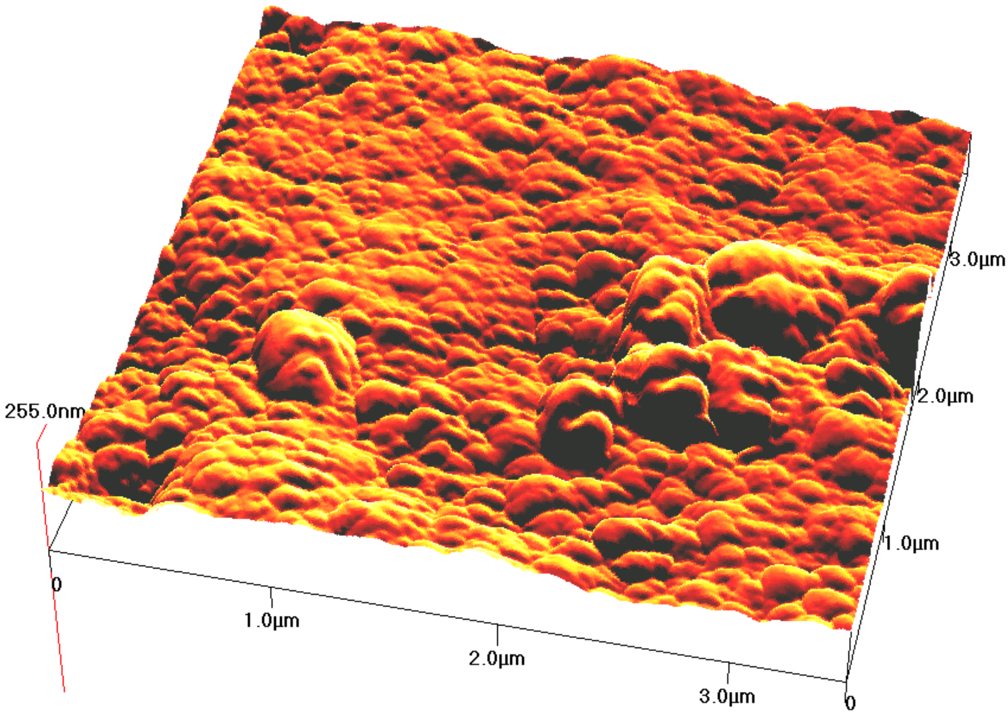

Figure 2 3-D AFM image of Z250 after 10% CP bleaching treatment.

The 3-D images show the surface of the bleached composites with coarse filler particles exposed resulting in a rougher surface. The 'erosion' effect of the bleaching agent cause irregularities of the peak and valleys of the composite. Generally, the surface roughness for both microfilled composites tested has readings below than 0.2 µm. Bollen *et al.* (1997) reported that Ra above 0.2 µm results in an increase in plaque accumulation and higher risk for caries and periodontal inflammation. According to Chung (1994), when Ra was lower than 1µm the surfaces were visibly smooth. Therefore, both of the microhybrid composites surfaces evaluated after bleaching have demonstrated a smooth surface, which from the clinical point of view, presents no risk of plaque accumulation.

The results showed no significant changes in both composites, and this could be attributed to the same classification of the composites. However, they were manufactured from two different companies. Furthermore, these two composites were regularly used in the clinic. From the present study, it can be inferred that following home bleaching with 10% and 17% CP, Filtek Z250 and Point 4 composite restorations do not need to be replaced, but this has to be further investigated with the use of larger samples and clinical studies. Furthermore, future study with the use of different types of composite is recommended. It is believed that AFM is a useful tool for assessing surface roughness and for viewing 3-D images.

Conclusion

It can be concluded that fourteen days bleaching using 10% and 17% CP did not alter the hardness of Point 4 and Filtek Z250. The AFM surface roughness evaluation showed that bleaching at 10% CP increases the surface roughness but the values are below 0.2 µm which poses no risk of plaque accumulation.

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