The Effect of Experimental Bleaching Agent on Coloured Dental Composites

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We have used light-cured experimental (Restacril, Nanopacryl, C-foto T, CP-AD1, CP-AD3) composites colouring tests "in vitro". The tests were performed on samples of 30 mm diameter and 2 mm thickness, which were immersed in coffee, red wine, and two food colouring agents (red, containing Sunset yellow (E110) and carmoisine (E122), and yellow, containing Sunset Yellow, tartrazine (E102) and Ponceau 4R (E124)). The samples were subsequently removed from the solutions, rinsed with water and dried, and then measured after three days and later after 2 months. On the 2 months-old samples, a bleaching gel was applied (G4, 35%), and the samples were again measured after three hours and after 24 h. The measurements were performed with a UNICAM UV-Vis spectrophotometer. For analyzing the color $\Delta E^* = f((L^*a^*b^*))$ *with a spectrophotometer, three discs per composite were prepared. From the reflection spectrum the color coordinates* (Δa^*, Δb^* ΔL^*) *were determined and the color difference.*

Keywords: dental composites, colour, dental bleaching

Aesthetic restorations in the frontal area are addressed an extremely wide range of pathologies, the action object of conservative odontology and a multidisciplinary in complex situations. All physiognomic materials used in various techniques for aesthetic restoration, once placed in the oral cavity undergoes degradation in time, which raises problems to the clinician upon achieving a certain roots. In the era of esthetic composite restorations, the demand for overall good color stability is increasing [1, 2]. Most anterior restorations are replaced because of unacceptable color match [3]. Several sources of discoloration have been suggested. External discoloration can be a result of plaque accumulation involving staining. Another reason is the degradation or staining within the superficial layer of resin composite related to dietary and smoking habits [4–6]. Apparent color differences also may be related to surface roughness from polishing procedures and wear, as well as chemical degradation. Discoloration in the deeper layers of the material can be due to physico-chemical reactions within the material itself that are related to the degree of black [7]. Tertiary amines contribute to discoloration, by a change in hue, from whitish to yellowish appearance [8]. A previous study reported the influence of initiators and activators on the surface hardness after the curing process [9]. The resin composition and conversion [10, 11] play major roles and, in addition, it has been shown that water acts as a carrier for staining agents in the water sorption process [12]. Oxygen inhibition at the surface and in porosities may induce staining as well [13].

Teeth whitening are a conservative solution when dealing with mild and moderate dental coloration. Restoration materials, especially those employed for frontal teeth, must resemble as closely as possible the hard dental tissues, which they must substitute and imitate as good as possible (and ideally be indistinguishable from them). Chromatic stability is one of the important properties of restorative materials and reflects the degree to which the initial color has been maintained. Color modifications may appear due to chromatic modifications within the organic phase of the restorative materials, adsorption of colored materials, the surface texture, and the texture of the composites. Discoloration of restorations may be caused by factors related to the surface treatment of the material, as well as the composition of the composites.

The scope of the present study is to prepare a series of light-cured experimental dental composites and measure their color coordinates after immersion in dye solutions and after application of a whitening gel. Composites are formulated with a variety of chemical and structural variations that may be related to their specific applications. This study evaluates the colour modifications of some composites after 3 days and 2 month immersed in coffee, red wine and alimentary juices, of some ligth –cured experimental composites (Nanopacryl, C-foto T, CP-AD1, CP-AD3 and Restacril), in contact with different natural or artificial colorants. For all composites we followed their behaviour after bleaching with experimental white bleaching gel.

Experimental part

We have used ligth–cured experimental (Restacril, Nanopacryl, C-foto T, CP-AD1, CP-AD3) composite. Five light-cured experimental composites from our laboratory were selected for this study. The experimental composites were prepared as a paste (table 1), by dispersing in the organic phase the silanized bioactive inorganic fillers with A-174 silane. The organic phase consists of a mixture of dimethacrylate monomers: Bis-GMA (75%), (synthesized in our laboratory)/TEGDMA (30%) (Aldrich), acid monomer (10%) urethane monomer (10%) (Merck) and HEMA (15%) with camphorquinone (Merck) and *N,N dimethylamino methylmethacrylate* (Aldrich) as initiator/activator system [20,22]. Characteristics of the materials are given in table 1, Coloring tests "in vitro" were performed on samples of

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Table 1
THE COMPOSITION OF THE COMPOSITE MATERIALS

Composites	Organic phase	Inorganic phase
CP-AD1	Urethane monomer, HEMA, Bis-GMA	colloidal silica, HAP, quartz, glasses with SrO and ZrO_2
CP-AD3	Acid monomer, HEMA, Bis-GMA	colloidal silica, glasses with BaO, quartz,
Restacril	Bis-GMA, TEGDMA	colloidal silica , quartz
Nanopacryl	Bis-GMA, TEGDMA, polyethylene oxide di(urethane ethyl methacrylate)	colloidal silica, glasses with BaO, SiO_2, glasses with SrO
C-fotoT	Bis-GMA, TEGDMA	colloidal silica, glasses with BaO

Bis-GMA-2,2-bis[4-(2-hydroxy-3-methacryloyloxypropoxy)phenyl]propane, HEMA – 2-hidroxietil methacrilate, TEGDMA *triethylene glycol dimethacrylate*

30 mm diameter and 2 mm thickness (where the composite resins were polymerised with a 3M XL 2500 Lamp for 40 s, from several directions), which were immersed in coffee, red wine, and two food coloring agents (red, containing Sunset yellow (E110) and carmoisine (E122), and yellow, containing Sunset Yellow, tartrazine (E102) and Ponceau 4R (E124)). The samples were elaborated so that a face of sample is rough and the other side is smooth. For obtaining the smoothest surface side we used a polyester film.

The samples were subsequently removed from the solutions, rinsed with water and dried, and then measured after three days, respectively 2 months. After 2 months, on the samples were applied a bleaching gel, (G4, 35%), and was again measured after three hours and after 24 h. The calorimeter calculates the color parameters in the L*a*b* color space, as established by the Commission International of l'Eclairage, or CIE in 1978 [16]. The CIELAB system relates to human color perception in all three dimensions or directions of color. All colors are defined by the coordinates of the three axes: L*, a* and b*. L*, which ranges from 0 (black) to 100 (white), stands for the lightness; a* stands for color and saturation on the red-green axis; and b* stands for color and saturation on the blue-yellow axis. The specimens were placed on a UNICAM 4 UV-VIS spectrometer. The coordinates (Δa^*, Δb^* Δl^*) of reflection spectrum were recorded and the colour differences ΔE^* in CIELAB system were calculated by formula:

$$\Delta E^* = (\Delta l^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2},$$

where:

Δl^* means the difference of luminosity between initial and final sample

Δa^* means the difference between the "red-green" coloured coordinate of the initial and final sample

Δb^* means the difference between the "yellow-green" coloured coordinate of the initial and final sample

Results and discussions

To overcome the composition differences, experimental materials with a controlled composition would be appropriate. The CIELAB system uses the three parameters L*a* and b* to define color [16]. Determining L*a*b* color coordinates in this way causes a shift toward green and blue relative to the actual color coordinates. The samples immersed in natural colorants were found to undergo a more intense coloration than those immersed in artificial colorants. The higher surface roughness causes more light scattering and loss of glossiness. It was reported a linear relationship between the optical scattering coefficient and the filler concentration [17]. Chemical differences among the resin components, such as purity of the oligomers/monomers and concentration/type of activators, initiators, inhibitors, oxidation of unreacted carbon–carbon double bonds and fillers may affect the color stability as well. In the present experiment, the composites with the lowest filler contents had poor color stability, supporting the results of a previous study [18].

The figures 1 and 2 shows that the samples are more intense colored on the rough side than the smooth side. Differences in color ΔE_{ab}^* is mainly due to the changes that have occurred in the color parameters after exposure of composite samples in the chemical agents: coffee and red wine, yellow and red food colorings. Our samples immersed in wine had more intensive color than those immersed in coffee and food coloring. The values obtained for the differences in color ΔE_{ab}^* of the investigated composites, are 1.69 - 17.76 for smooth side (fig. 2) and 1.13-31.28 for the rough side (fig. 1). The lowest values 1.69 and 2 were obtained, on the smooth side, for Restacril and C-foto composites immersed in yellow food coloring

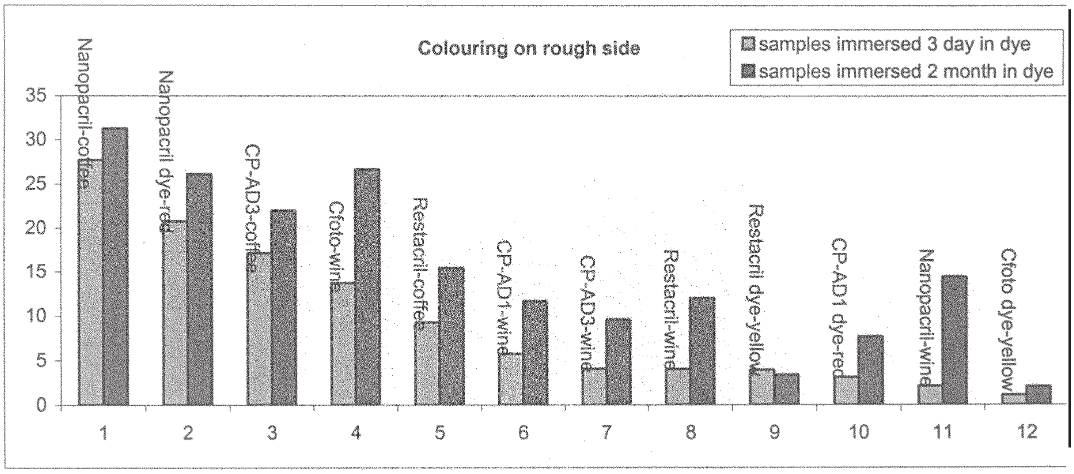

Fig. 1. Colouring on rough side

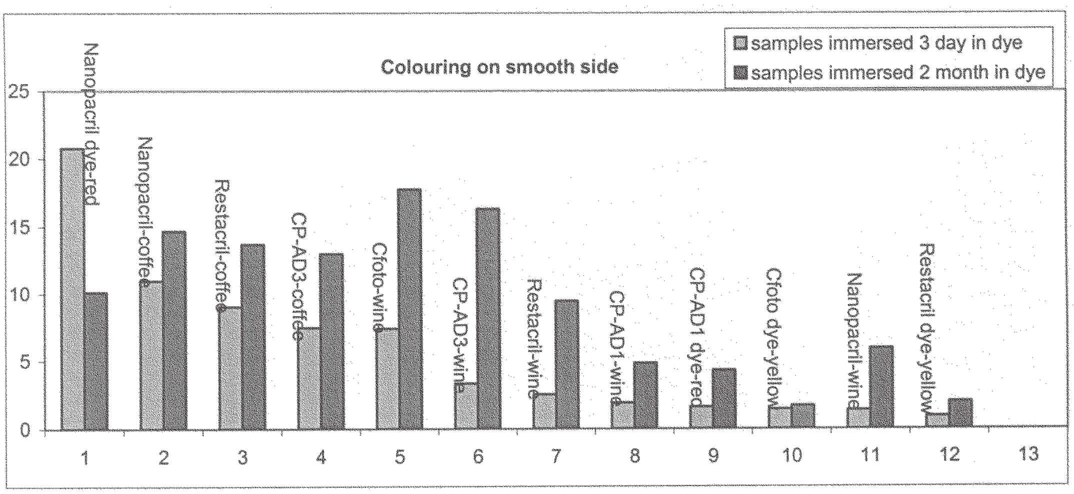

Fig. 2. Colouring on smooth side

(fig. 2). On the rough side the lowest value is 1.13 for C-foto immersed in yellow food colour. Higher values were obtained for composites immersed in wine and coffee, which have in their composition BaO. Lower values were recorded for the classic composition (Restacril) which have inorganic component formed from quartz mixed with SiO_2 and for composite CP-AD1 which has in composition glass with $SrO-ZrO_2$, quartz, HAP and SiO_2. The samples colored for 2 month, were treated with experimental white bleaching gel (G4-35%) on the both sides. After 3, respectively, 24 h bleaching, samples (figs. 3-4), rinsed with water and dried were again measured on a UNICAM UV-VIS spectrometer. It was observed a discoloration on both sides of material. A spectrophotometer is a device that measures the spectral reflectance of a body. If the spectral quality of a tooth were known and a restorative material could be fabricated to replicate or approach that quality, then shade selection and color matching could be made much more objective.

The graphs above illustrated that the samples exposed for a longer time to the bleaching gel, on the smooth side suffer the most intense discoloration.

A variety of mechanisms have been suggested for changes due to aging. Increased surface roughness after accelerated aging has been attributed to wear of the resin [1, 12] or exposure of interior porosities [11, 14]. Compared with the smooth side of the composite, rough side is more vulnerable to dyeing and bleaching. Surfaces finished with polyester film exhibit the least amount of staining.

The figures 3 and 4 shows the results obtained after bleaching for 24 h with the experimental gel containing 35% peroxide carbamide. One can see that the process is more aggressive for the rough side, than for the smooth side.

After treatment with whitening agent for 24 h, we observe a decrease of $\Delta E_{ab}*$, obtaining values between 1.14 and 13.5 (fig. 3) limits for the glossy side, and after 3 h bleaching we obtain values between 1.7 and 16.51 (fig. 3). Coffee and tea can cause severe, tenacious brown to black

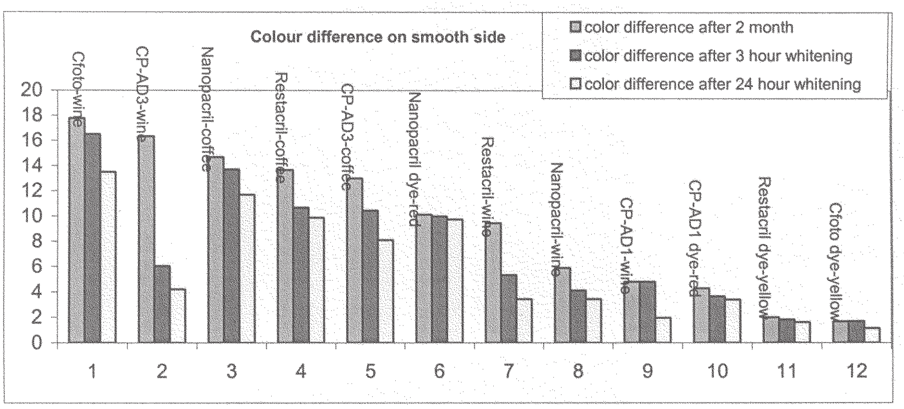

Fig. 3. Colour difference after bleaching

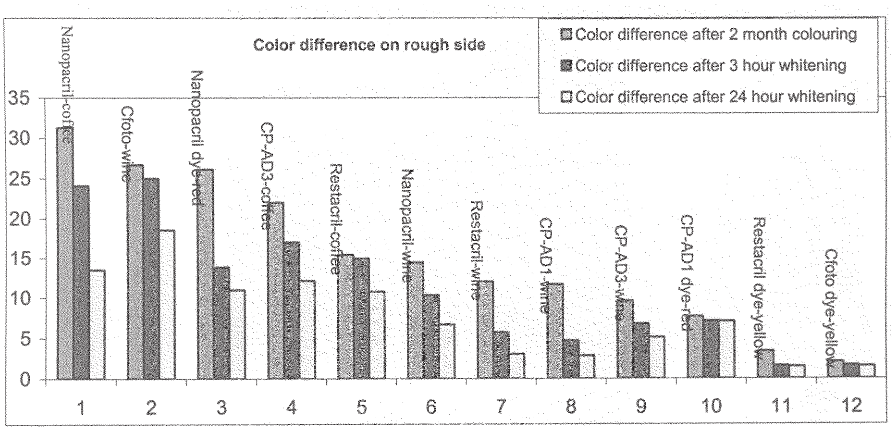

Fig. 4. Colour difference after bleaching

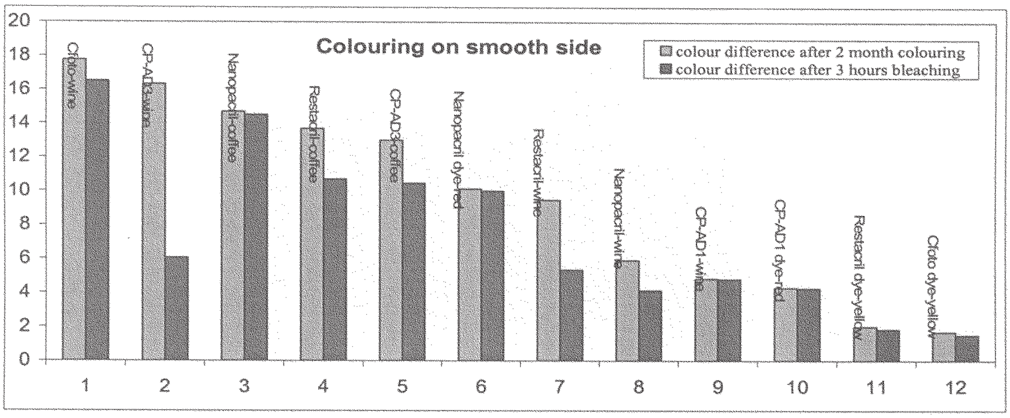

Fig. 5. Colour difference on smooth side after 3 h bleaching

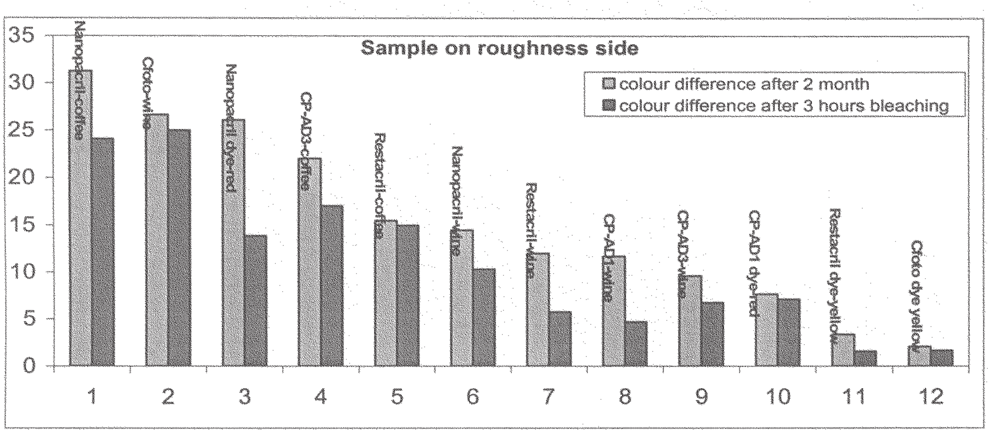

Fig. 6. Colour difference on rough side after 3 h bleaching

Table 2

COLOUR COORDINATES (INITIAL AND AFTER 24 h BLEACHING)

Smooth side	Initial colour coordinates			Colour coordinates after application of the experimental whitening gel after 24h bleaching		
Sample	L*	a*	b*	L*	a*	b*
CP-AD3-**coffee**	77.66	1.45	15.13	72,45	3.81	20.87
CP-AD3-**wine**	77.44	1.42	15.99	73.46	2.56	16.78
CP-AD1-**wine**	72.39	2.34	16.93	72.15	3.64	15.46
CP-AD1-**red**	72.51	2.15	16.92	72.15	4.68	13.05
C.foto-**yellow**	77.58	-0.21	12.58	77.12	0.68	12.03
C.foto-**wine**	77.61	-0.22	16.57	65.20	0.74	11.34
Nanopacryl-**coffee**	83.43	0.16	12.10	73.43	3.03	17.48
Nanopacryl-**wine**	83.62	0.39	11.85	81.14	0.72	14.22
Nanopacryl-**red**	84.07	0.48	10.6	80.30	8.57	5.97
Restacril-**coffee**	70.90	3.55	23.88	62.67	7.29	27.9
Restacril-**wine**	71.40	4.76	26.15	68.70	6.52	24.91
Restacril-**yellow**	70.46	5.01	25.71			

colorations. Those stains, like the ones caused by brightly colored foods, are most difficult to remove from pits, fissures, grooves, or enamel defects. The table 2 shows that the values obtained after 24 h of exposure to whitening gel, are close to the initial values measured prior to immersion in coloring agents.In particular, were noted for C-foto, CP-AD1 and Restacril colors coordinate values are much closed to the initial one. The CP-AD1 and C-foto composites immersed in red and yellow food colourings, after applying the gel G4 for 3h respectively 24h, the differences recorded on the shiny and rough side of the sample are not significant (fig. 3). At the CP-AD3 composite immersed in red wine has been observed the most pronounced discoloration on the smooth and rough sides. We also observed that the highest discoloration has been obtained for the composite immersed in Nanopacryl (fig. 4). The degree of cure has an important influence on the color stability: an improper cure makes resin-based cements prone to discoloration. Also, the hydrophilicity of the resin component of the cement is of influence.

Conclusions

Color stability of composites is important for maintaining the esthetic quality of the marginal areas around the restorations. Colored surface of the tested composites depends on the technical finishing as well as the types of dye. The samples (restorations) finished very fine are more aesthetic and more easily maintained than surface (restorations) with rough area, because the rough surfaces are more vulnerable to colorings and the accumulation of bacteria plaque. In addition, the smooth area reduce bacteria plaque retention, in this way reduces gingival irritations, patient discomfort, staining and secondary cavities. Composition of composite resins, finishing surface and bleaching are very important factors that influence the esthetic aspects for restored teeth [20]. This study indicates that the coloration is directly related with the composite resin nature, colorant medium, but also with the finishing method of the restoration. The bleaching agent with 35% carbamide peroxide is efficient also to coloured composites in natural dye and in the food colouring.

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