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Research Report

Color stability of heat polymerized polymethyl methacrylate resin denture base after addition of high molecular nano chitosan

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ABSTRACT

Background: *The addition of other ingredients to maintain color stability of heat polymerized polymethylmethacrylate is being developed. One of them is by adding high molecular nano chitosan.* ***Purpose:*** *This study aimed to determine the color stability of heat polymerized polymethyl methacrylate denture base resin after an addition of high molecular nano chitosan.* ***Method:*** *30 sample pieces of acrylic plate (40x10x2 mm) were divied into 6 groups: control group and groups with the addition of chitosan nano gel percentages of 0.25, 0.50, 0.75, 1.0 and 1.50%. 2 ml chitosan nano gel was added into the mixture of acrylic resin with 23 g : 10 ml (P : L). After the mixture was inserted into a mold and then pressed and cured at 74^{o}C for 120 minutes and then 100^{o} C for 60 minutes. Acrylic plates were then released from the mold and finished. Color stability of acrylic resin were measured using UV-Vis Spectrophotometer and analyzed with a one way Anova.* ***Result:*** *The results showed significant differences in color stability after the addition of high molecular nano chitosan. The best color stability found in 1.0% the addition of chitosan nano gel group, the value was 0.07589 cm^{-1}.* ***Conclusion:*** *The chitosan nano gel can be used to maintain color stability of heat polymerized polymethyl methacrylate denture base resin.*

Keywords: *denture base; color stability; high molecular nano chitosan*

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INTRODUCTION

The use of heat polymerized polymethyl methacrylate (acrylic) resin as denture base materials is becoming more common due to its esthetic, slightly transparent color.[1-3] The ideal denture base materials should have the closest possibility to natural color. Color stability is one of the clinical characteristics that is essential to denture base. Color stability is the ability of a surface or color substance to avert degradation by environmental factors. For long-term usage, the color of heat polymerized acrylic resin will change due to degradation process in the material and disturb the esthetic of the denture.[4] The discoloration of denture base might be due to both intrinsic and extrinsic factors. The intrinsic factors include chemical changes of the material due to addition of enforcing material/substance in the composition of acrylic resin, while extrinsic factors include stain caused by absorption of colored materials in exogenous sources, such as tea, coffee, soft drink, food, nicotine, mouthwash, denture cleanser and the interaction of other chemical material in the oral environment.[4-7]

The study showed significant discoloration occurred in heat polymerized polymethyl methacrylate and acrylic resin that were injected in coffee and nicotine intermittently ($p<0,05$). PMMA showed discoloration value after 3 day soaking in several substances (coffee, saliva, tea and food colored materials).[7]

In order to maintain color stability of heat polymerized acrylic resin denture base to preserve esthetic function, substance binding with the pigment of heat polymerized acrylic resin is added to prevent its degradation. One of the materials with a good biodegradibility is chitosan. Several other special properties of chitosan include good biocompatibility, good bioadhesion, non-toxic, non-allergic,

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non-carcinogenic and safety for usage, hence its common use in biomedical application. Chitosan is a broad spectrum agent and highly active in killing gram-positive and gram-negative bacteria as it is able to change the permeability of the bacteria cell that causes cell death.

Based on its viscosity, chitosan is classified into three molecular mass, i.e. low, moderate and high molecular chitosan. High molecular chitosan is obtained from horsecrab cells with deastilization degree of 84.20% and molecular mass of 893.000 Mv. In its development, chitosan is modified in magnetic forms. Nano chitosan particles sized 100-400 nm could increase its absorption ability. The use of chitosan in nanometer scale could increase its surface area, eventually increasing its affectivity in binding with other chemical clusters. Previous studies on addition of high molecular nano chitosan in PMMA showed several benefits, such as increases of flexural strengths, tensile strengths, and Young's modulus values. It is hoped that addition of nanochitosan would increase the color stability of heat polymerized polymethyl methacrylate, as it creates stronger and more stable bond (cross link). This study aimed to determine the color stability of heat polymerized polymethyl methacrylate after the addition of high molecular nano chitosan in various concentrations.

MATERIAL AND METHODS

The study involved heat polymerized polymethylmetacrylate (QC 20 UK) and high molecular nano chitosan obtained from horsecrab to increase color stability of denture base material. Chitosan gel is made by homogenously dissolving 0.25 gr, 0.50 gr, 0.75 gr, 1.0 gr and 1.50 gr of high molecular nano chitosan powder in becker glasses filled with magnetic stirrer and 100 ml of 1 % acetate acid on 200 rpm hot plate. The solution was added with 20 drops of tripolyphosphatepotassium (TPP) and stirred for 1 hour to form emulsion. It was then placed in ultrasonic bath for 20 minutes and centrifuged for 30 minutes at 3600 rpm to break the chitosan particle to form a high molecular nano chitosan gel. To ensure the nano size of chitosan particle, the gel was measured by particle size analysis (PSA).

The study used 30 pieces sample of heat polymerized polymethyl methacrylate plate (size 40 mm x 10 mm x 2 mm) as sample. The samples were divided into 6 treatment groups, i.e. control group (with no addition of high molecular nano chitosan), and groups that were added with 0.25%, 0.50%, 0.75%, 1.0% and 1.50% of high molecular nano chitosan gel.

Molds of heat polymerized polymethyl methacrylate plate were made by mixing hard gypsum in water (300 gr gyps in 90 ml water) to fill bottom half of the cuvette. Metal plates were placed in the cuvette, their surface parallel to that of the gypsum. After the gypsum was set, the surface was applied with vaseline. The top and bottom halves of the cuvette were assembled and hard gypsum (300 gr gypsum in 90 ml water) was poured into it. The cuvette was then placed on a vibrator. After 45 minutes, the cuvette was disassembled, the plates were retrieved and the surface was applied with cold mold sealeant.

Polymer of polymethyl methacrylate was mixed with the monomer in acrylic pot (23 gr: 10 ml) and 2 ml of nano chitosan gel 0.25%, 0.50%, 0.75%, 1.0% and 1.5% were added separately with scaling pipe (control group received no addition of nano chitosan gel), the mixture was stirred with lecron to reach its dough-stage. The dough was then poured into the muld. The heat polymerized polymethyl methacrylate was covered with cellophane sheet and the top half of cuvette was assembled. The cuvette was then pressed with 1000 Psi hydraulic press, then dissembled to rid excess acrylic resin, then re-pressed with 1200 Psi press. Afterwards, the cuvette was cured. First, the cuvette was put in a 74^{o}C water bath for 120 minutes. Then, the temperature was raised to 100^{o}C for 60 minutes. The samples were taken out from the water bath. The samples were trimmed and polished to the desired size.

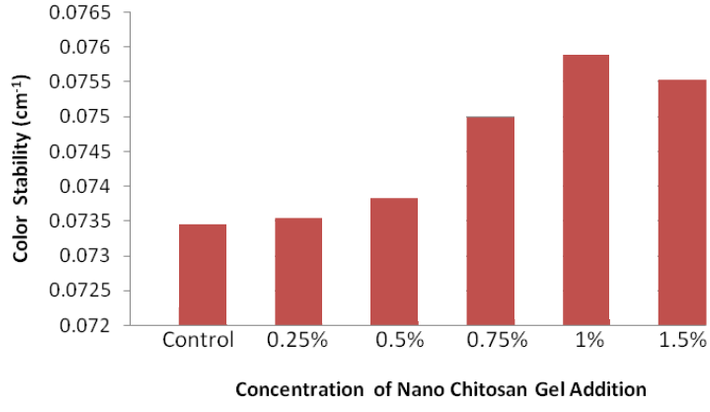

Figure 1. Graphics of color stability value of heat polymerized polymethyl methacrylate with and without addition of nano chitosan gel 0.25%, 0.50%, 0.75%, 1.0% and 1.5%.

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The samples were then ground with carbide burrs, and pounded with mortar and stamper, then 0.3 gr of the samples were put into separate vials and each dissolved in 10 ml of xylene. Color stability measurement was performed with a UV-Vis Spectrophotometer. The solution was put in tester cuvette, and the computer screen will measure its absorbance value with 552 nm wavelength. The values showed on screen were noted. The unit of measurement of this equipment was cm.

RESULTS

The color stability data from the six treatment groups were obtained in this study. Graphic of the color stability value of heat polymerized polymethyl methacrylate resin denture base with and without addition of nanochitosan gel of 0.25 %, 0.50 %, 0.75%, 1.0% and 1.5% can be seen on Figure 1.

All treatment groups showed increase of values, but the group with 1% addition of nanochitosan gel presented significant increase of color stability compared to the other groups. In the study, the influence of 0.25%, 0.50%, 0.75%, 1.0% and 1,5% nanochitosan gel additions on color stability of heat polymerized polymethyl methacrylate was tested by the one way Anova test, and show significance value of $p = 0$.

To determine difference of color stability between the control group and other treatment groups with addition of 0.25%, 0.20%, 0.75% 1.0% and 1.5% nano chitosan gel, a Least Significance Difference (LSD) test on absorption value of heat polymerized polymethylmetacrylate was performed and can be observed in Table 1.

Tabel 1. Least significance difference (LSD) test on absorption value of color stability of heat polymerized polymethyl methacrylate

(I) Group	(J) Group	Mean Difference (I-J)	Sig.
Control	0.25%	-.000088	.791
	0.5%	-.000378	.262
	0.75%	-.001546*	.000
	1.0%	-.002446*	.000
	1.5%	-.002092*	.000
0.25%	0.5%	-.000290	387
	0.75%	-.001458*	.000
	1.0%	-.002358*	.000
	1.5%	-.002004*	.000
0.5%	0.75%	-.001168*	.002
	1.0%	-.002068*	.000
	1.5%	-.001714*	.000
0.75%	1.0%	-.000900*	.012
	1.5%	-.000546	.110
1%	1.5%	.000354	.293

DISCUSSION

The differences in absorption values of heat polymerized polymethyl methacrylate resin denture base were shown in groups with and without nanochitosan gel addition. The highest color stability (0.07589 cm^{-1}) was observed in group with addition of 1.0% nanochitosan gel, and lowest color stability (0.07345 cm^{-1}) was found in group without addition of nanochitosan gel.

If the forwarded light intensity is higher than the reflected one, the wavelength will increase. Then, the results are in brighter and better stability of color. On the contrary, if forwarded light intensity is lower, wavelength will decrease which results in darker and worse stability of color.[2] In the study, color stability of groups with addition of nano chitosal gel is higher than group without addition of nano chitosan gel. This shows a better color stability of group with nano chitosan gel.

In modification process of chitosan to nanochitosan, crosslink agent (tripolyphosphatepotassium) is needed increase its stability in acid, due to its high solubility in organic acid. Addition of this material (crosslink agent) will lower the adsorption ability of chitosan, leading to higher physical endurance.[13] This will promote a better color stability of heat polymerized polymethyl methacrylate added with nanochitosan.

Several factors contributing to discoloration are chemical degradation, oxidation, oral hygiene, imperfect polymerization process, and water absorption.[14] Excessive water absorption in denture base material could cause discoloration.[15] The liquid absorbed in the process of diffusion will fill the spaces in matrix, resulting in structural and physical changes of the resin. Water absorption will dissolve some components, and will cause discoloration of a denture base materials.[4]

One of the factors that determine the color stability is the permeability of a material.[16] Absorption and desorption process are related to its environment. The material of polymer that absorbs air, both in air and water, could lead to expansion and mechanic strength changes in the material.[17] In group with addition of nano chitosan gel, greater color stability could be observed due to lower water absorption and fewer residual monomer. This is due to the fact that the addition of nano chitosan gel to the polymer material as a filler will restore the properties of polymer material. The nano size and gel form of high molecular chitosan will affect the color stability of PMMA. The smaller particle size will increase surface areas that leads to intensify the diffusion of chitosan to acrylic, eventually forming more bond of cluster –NH2 and color substance. The stronger bond formation will result in better color stability.

In the process of dissolving heat polymerized acrylic resin added with nanochitosan gel in xylene solution, the resin will not dissolve due to chitosan's insoluble properties. When this bond occurs hydrolysis reaction can not proceed and chitosan will bind the colored substances

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of heat polymerized acrylic resin denture base to $-NH_2$. This result is consistent with a study which stated that chitosan's properties, if modified with several other polymers, such as polymethyl methacrylate, will bind colored substances to NH_2.[9] Low water absorption will result in lower dissolved component and higher color stability.

The lower absorption value in group with additional 1.5% nanochitosan gel compared to the absorption value of group with addition of 1% nanochitosan gel is due to fewer bond of colored substances and $-NH_2$ between chitosan and heat polymerized acrylic. This condition occurred because the concentration of coloring substances in heat polymerized acrylic resin added with 1.5% nanochitosan gel is lower compared to resin with addition of 1.0% nanochitosan gel, which is due to higher viscosity of 1.5% nano chitosan gel that inhibit its process of diffusion to bind with the PMMA denture base material. The study concluded that addition of 1% nanochitosan gel in heat polymerized polymethyl methacrylate denture base material is suitable to maintain the stability of color.

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