The comparison of color stability between thermoplastic nylon resin and heat-cured acrylic resin after tea-soaking using spectrophotometer

Lisa Putri Lestari, Kosterman Usri, Renny Febrida

Department of Dental Material Science and Technology Faculty of Dentistry Universitas Padjadjaran

ABSTRACT

Color stability is one of the denture base material requirement. Nowadays, nylon thermoplastic resin and heat-cured acrylic resin which are used as denture base materials can be changed in color. One of color-changed factor is the tea drinking habit. The objective of this research was to compare the color stability between nylon thermoplastic resin and heat-cured acrylic resin after soaked in tea. Materials used for the research were nylon thermoplastic resin from Valplast and heat-cured acrylic resin QC-20, with sample size of 64x(10±0.03)x(2.5±0.03)mm. The sample would be assessed of color stability after the denture base soaked in tea for 7 days. The color measurement of each sample was done by spectrophotometer equipment (CIE lab system). Data gathered later on statistically processed with ANAVA testing. The result showed that the comparison ratio of color stability between nylon thermoplastic resin and heat-cured acrylic resin after soaked in tea was 1.9886:1.1152. The conclusion was that color stability in the nylon thermoplastic resin was lower than heat-cured acrylic resin after soaked in tea. This result was due to polymer chain of nylon thermoplastic which was lower than heat-cured acrylic resin and its porosity which was higher, so tea easily soaked into the materials.

Key words: Color stability, nylon thermoplastic resin, heat-cured acrylic resin, tea

INTRODUCTION

The most common materials that are mostly used in denture base making are acrylic and metal. But the fact, heat cured acrylic resin is used more often as the materials for making a denture base[1] due to good color stability when it is used; good thermal conductivity; low water absorption and dissolve ability; good dimension stability when it is used or even when it is in the making process; and good resistance to fracture and abrasion.[2,3]

Besides acrylic resin, some kinds of polymers have been developed as the materials for denture base, one of them is thermoplastic nylon resin, Valplast trademark.[4]

A denture base has to meet some criterias. One of them is stable to color change.[3] Color change can be caused by many factors, one of them is by imperfect polymerization reaction. Sometimes the acrylic that polymerizes with heat will form porosity that affects physic, esthetic, and hygienic natures of the acrylic. Porous acrylic has low endurance and will have fast color change after it is used for some time. Color liquid substance absorption is one of the factors that causes color change in acrylic resin.

Color change in denture base materials, whether in thermoplastic nylon resin or in heat-

Correspondence author: Lisa Putri Lestari, Department of Dental Material Science and Technology Faculty of Dentistry Universitas Padjadjaran. Jln. Sekeloa Selatan No. 1 Bandung, West Java-Indonesia, Tel./Fax: +6222-2504985/2532805

cured acrylic resin, can be caused by many factors, one of them is the habit of drinking tea. Tea is defined as a caffeined beverage which is produced originally from leaf, shoot, or stem of *Camellia sinensis* plant when some boiling water is poured into the concoction.[6,7]

Tea contains natural coloring substance. When tea is consumed regularly in big amount, it can cause color change in denture or in its base. Color change in denture base made of heat-cured acrylic resin or thermoplastic nylon resin is esthetically not good, so it is contradictive to the treatment principle in dentistry.[8]

MATERIALS AND METHODS

The materials used in this research were thermoplastic nylon resin, brand Valplast and heat-cured acrylic resin brand QC-20. The samples comprised 10 plates size 64x(10±0.03)x(2.5±0.03) mm.[9] The samples were well smoothened and polished using tripoli and pumice polishers in order to get an optimum test result.

Before the samples were soaked, color measurement were taken to them in order to get the L number (lightness), a (red-green tinder colors), and b (yellow-blue tinder colors). Then each sample was divided into two groups, one group was soaked in tea solution and another group was in made up saliva. Both were soaked in temperature 37°C for 7 days. The 7 day-soaking time was equal to 168 hours. It was assumed as equal to 2 year-use of denture and the habit of drinking tea once a day (± 15 minutes).[8] After the samples were soaked for 7 days, color measurement was taken in order to get the L number, a and b after soaking.

Color stability test procedure used spectrophotometer tester. The test was held by placing the test sample on the tester. The procedure was: nip the test sample in its holder rod by using its holder plate; wait until the light source passes the test sample which is guided through monochromator; let the sample absorbs the light; and the detector will detect the amount of light absorbed, then the light intensity will be measured by the light censor. The result was displayed on the monitor screen in the form of L number, a and b. Color measurement was conducted by measuring the amount of light reflected to each wave length.[10] The formulation was as follow:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

Note: ΔE= Color change in all dimensions ($L^x a^x b^x$); L= Lightness (represents brightness of a color range from 0 (the darkest) to 100 (the brightest); a= represents red-green tinder colors; b= represents yellow-blue tinder colors.

RESULTS

The comparison of color change number of thermoplastic nylon resin and heat-cured acrylic resin after it was soaked in tea solution for 7 days was 1.9886:1.1152, while the comparison of color change number of thermoplastic nylon resin and heat-cured acrylic resin after it was soaked in made up saliva for 7 days was 0.9267:0.494. The result showed that each sample, whether thermoplastic nylon resin or heat-cured acrylic resin underwent color change after they were soaked in tea solution and made up saliva for 7 days, as seen in Table 1.

DISCUSSION

As seen in Table 1, thermoplastic nylon resin underwent color change after it was soaked in tea solution and made up saliva. The result showed that the color change number of thermoplastic nylon resin was higher when it was soaked in tea solution than in made up saliva. This is contradictive to the statement issued by Valplast International Corporation that states thermoplastic nylon, resin brand Valplast, does not absorb color of liquid in mouth.[11] Color change in thermoplastic

Table 1. Color change measurement result data after 7 day-soaking

Solution	Thermoplastic nylon resin (*)					Average (*)	Acrylic resin heat-cured (*)					Average (*)
	1	2	3	4	5		1	2	3	4	5	
Tea	2.222	2.019	1.819	2.453	1.43	19.886	1.63	1.09	1.18	0.922	0.754	11.152
	0.609	0.971	0.984	10.537	10.157	0.9267	0.82	0.38	0.42	0.62	0.23	0.494

nylon resin after tea solution or made up saliva soaking is caused by porosity. Porosity is formed in denture base and it will facilitate liquid diffusion into resin.[12] Porosity in thermoplastic nylon resin is caused by the injection method which is not suitable with the manufacturer standard procedure and is also caused by higher monomer ratio than polymer.

The result also showed the color change of heat-cured acrylic resin after it was soaked by tea solution and made up saliva. It is caused by the porosity that occurs in heat-cured acrylic resin as the result of the existence of several monomers that are not polymerized.[2] Not all monomers change into polymers during polymerization, so that free monomer remains are produced. Those monomer remains vapor and they make fast temperature and pressure increase that create porous.[13]

Porous is bubbles formation that forms tiny holes in denture base that absorbs liquid and happens during polymerization process.[14] Porous which is formed in denture base facilitates water diffusion into polymer[12] and facilitates food remains conglomeration as well, so in patients with bad oral hygiene, this will affect color change of denture base. Extrinsic color change is more likely influenced by staining as the result of color substance absorption process or pigment contained in foods or beverages.[15,16] The amount of color change is also affected by contact period between resin and liquid.[17]

Table 1 showed that thermoplastic nylon resin and heat-cured acrylic resin had a significant difference to the color change number after they were soaked in tea solution. The result indicates that thermoplastic nylon resin had higher color change average number compared to heat-cured acrylic resin after it was soaked in tea solution. Color change that happens to thermoplastic nylon resin and heat-cured acrylic resin was caused by the absorption of tea solution color substance into thermoplastic nylon resin and heat-cured acrylic resin materials. Tea solution color substances that cause color change in denture base material were red and yellow come from anthocyanin and flavon.[18]

Color change in thermoplastic nylon resin and heat-cured acrylic resin can be caused by liquid absorption by diffusion into resin, so it will stretch the tie between molecules. The result is, tea solution color pigment will be accumulated and will be between the stretched molecules.[16] Tea solution pigment will become sediment in resin agent. This will lead to coloring in denture base. Color pigment may also be accumulated in porous cavity and may change the color of denture base.

The result of this research was in line with the study conducted by Crispin and Caputo[19] that indicated color change in denture base because of consuming tea. Haselton[17] also stated that the color in denture base can change if it is soaked in coffee, tea, chlorhexidine, and other whitener materials in certain time.

This research also indicates color change in thermoplastic nylon resin or heat-cured acrylic resin after they were soaked in made up saliva. The result showed higher color change happened to thermoplastic nylon resin because the single polymer chain was formed after polymerization. That linear chain has a weak tie between its polymer chain compared to branched chain, cross-linking chain, and network chain which are formed in polymer.[20] This makes the linear chain in thermoplastic nylon resin is easier to be degraded by liquid which is diffused into polymer.

Lower color change in heat-cures acrylic resin is mainly caused by the addition of cross-linking agent in the form of diethyl glycol dimethacrilate for 1-2%. It is aimed to enhance the mechanic nature, descend condensation and absorption to organic solvent and water.[3] Polymer which has cross-linking is harder, strong, stiff, brittle, and durable to dimension change.[2] Cross linking in polymer forms a strong three dimensional structure between the chains, so it is more durable to solvent ability and liquid absorption compared to the polymer without cross-linking agent.[20]

In line with its development, thermoplastic nylon resin has been updated into glass reinforced nylon type which is aimed to reduce liquid absorption. But this research proved that fiber glass in thermoplastic nylon resin agent does not give any effect on liquid absorption decrease. It is because the amount of the fiber glass contained in thermoplastic nylon resin (Valplast) is only 0.00001% and it has hygroscopic nature.[15]

Compared to heat-cured acrylic resin, higher color change in thermoplastic nylon resin may also caused by the difference of polymerization process of both resin materials. Polymerization

process in thermoplastic nylon resin is through condensation of reaction between adipate acid and hexamethylenadiamine that forms polyamide which the primary compound produces side product, like water. This is in line with Combe[2] who stated that the polymerized resin through condensation will produce side product, like water. Water will be absorbed by fiber glass so it will weaken the polymer chain of thermoplastic nylon resin and decrease the durable of thermoplastic nylon resin towards liquid absorption.

On the other hand, polymerization process in heat-cured acrylic resin is through addition, that is a polymerization process reaction that does not form any side product, like water.[2,12] It affects the nature of heat-cured acrylic resin agent, so the polymer chain is stronger since there is no side product that will weaken the tie between the polymer chains.

CONCLUSION

Based on the research result on the comparison of color stability between thermoplastic nylon resin and heat-cured acrylic resin after tea-soaking using spectrophotometer, a conclusion can be drawn that thermoplastic nylon resin has lower color stability than heat-cured acrylic resin after tea-soaking. Color change happens in thermoplastic nylon resin or heat-cured acrylic resin after tea-soaking.

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