Original Article

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Dentistry Section

Colour Stability of Heat and Cold Cure Acrylic Resins

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ABSTRACT

Introduction: To evaluate the colour stability of heat and cold cure acrylic resins under simulated oral conditions with different colorants.

Materials and Methods: Three different brands of heat cure acrylic resin and two rapid cure auto polymerizing acrylic resin of commercial products such as Trevelon Heat Cure (THC), DPI Heat cure (DHC), Pyrax Heat Cure (PHC), DPI Cold cure (DCC) and Acralyn-R-Cold cure (ACC) have been evaluated for discoloration and colour variation on subjecting it to three different, commonly employed food colorants such as Erythrosine, Tartarizine and Sunset yellow. In order to simulate the oral condition the food colorants were diluted with artificial saliva to the samples taken up for the study. These were further kept in an incubator at 37°C ± 1°C. The UV-visible spectrophotometer has been utilized to evaluate the study on the basis of CIE L* a* b* system. The prepared samples for standard evaluation have been grouped as control group, which has been tested with a white as standard, which is applicable for testing the colour variants.

Results: The least colour changes was found to be with Sunset Yellow showing AE* value of 3.55 with heat cure acrylic resin branded as PHC material and the highest colour absorption with Tartarizine showing AE* value of 12.43 in rapid cure autopolymerzing acrylic resin material branded as ACC material.

Conclusion: ACC which is a self cure acrylic resin shows a higher colour variation to the tartarizine food coloration. There were not much of discoloration values shown on the denture base resins as the food colorants are of organic azodyes.

Keywords: Colorants, Calorimetry, Heat cure acrylic resins, Self cure acrylic resins, Spectrophotometer

INTRODUCTION

Acrylic resins are mostly used as denture base material in dental practice. These are available in different forms according to the polymerization reaction as heat cure acrylic resin, rapid cure auto polymerizing acrylic resin, light cure resin and specialized form resins used for microwave processing. These materials have adequate strength to withstand the masticatory forces, maintains the dimensional stability, adequate resiliency, biocompatibility and high polishability.

Denture base acrylic resins are available in powder and liquid form for its usage and processing. The powders are pure polymers, which are clear and are adaptable to wide range of pigments. The pigments, which are used to obtain the various tissues like shades, are compounds such as mercuric sulfide, cadmium sulfide, cadmium selenide and ferric oxide. These pigments may be locked into the polymer beads by addition during the commercial polymerization or they may be mechanically mixed with the polymer beads after polymerization. Generally, the later method is used and the uneven distribution of the pigments in the final denture gives a mottled, more natural appearing denture than if the pigment were evenly dispersed. Dyes as well as pigments, which are occasionally used, are not as satisfactory, since they tend to leach out of the plastic by the oral fluids, which result in a gradual lightening of the shade. In addition to the colouring agents, zinc or titanium oxides are used as opacifiers, with titanium dioxide being most effective. Dyed synthetic fibers made from nylon or acrylic usually are added to the denture material to stimulate the minute blood vessels underlying the oral mucosa [1-3].

As this acrylic resin denture base material is used for intraoral applications, as in dentures has to be present in an atmosphere having variations in oral temperature, pH of saliva and their constituents. Further it has to be in contact with various food materials and beverages, which are taken at extremes of temperature. During its time the acrylic resin is likely to absorb various contaminants changing its physical structure and appearance. Further the acrylic resin constitutes organic materials and it is likely to undergo deterioration of its translucency and colour [4-8]. The discoloration or deterioration of colour pose an aesthetic problem and critically viewed on the point of acceptance from the patients' side challenging the prosthodontic workability and skill. Hence this study has been done to determine the colour stability of different brands of heat cure and cold cure acrylic resins under simulated oral condition when immersed in food colorants.

MATERIALS AND METHODS

Seventy five wax patterns were fabricated from the metal die with the following dimension: 2cm in length, 1 cm in width and 1.6mm in depth. Forty-five heat cure acrylic samples and 30 self cure autopolymerizing resin samples was prepared by compression moulding technique and the acrylic samples was trimmed to a final thickness of 1.5 ± 0.1 mm, which is regarded as the most appropriate surface roughness to conduct the study.

Three grams of each colour such as Erythrosine, Tartarizine, and Sunset yellow are taken in separate conical beaker. Hundred ml of distilled water was added to each beaker. To stimulate natural oral environment, artificial saliva was added about 50 ml in each beaker. Five sets of solution were prepared for each colorant, as there are five different materials were to be tested. The specimens were first divided into three groups and each group contains samples from each brand of material of both heat cure and cold cure acrylic resins selected for the study. Five samples of each group are soaked in each solution of different food colorants such as "E" for Erythrosine, "T" for Tartarizine and Y" for Sunset Yellow thereby 15 samples of the same group were soaked in three different solutions. Each group of the specimens was kept separately to avoid specimen-to-specimen contact. Each group of the samples before soaking it in colour solutions was coded accordingly. The coding was done to represent the specimen for colour variants after it is tested for

Colorants	THC	DHC	PHC	DCC	ACC
E	3.61	3.65	4.68	3.60	4.15
T	4.65	3.94	6.23	5.18	6.99
Y	3.61	5.89	2.37	5.93	3.54

[Table/Fig-1]: Table shows the mean ae values obtained from the samples soaked in erythrosine (e), tartarizine (t), sunset yellow (y) on 10th day

Colorants	THC	DHC	PHC	DCC	ACC
E	4.12	4.93	5.00	7.11	7.21
T	5.92	6.65	8.71	7.57	9.58
Y	5.77	6.41	2.94	9.21	5.11

[Table/Fig-2]: Table shows the mean ae values obtained from the samples soaked in erythrosine (e), tartarizine (t), sunset yellow (y) on 20™ day

Colorants	THC	DHC	PHC	DCC	ACC
E	5.54	6.65	7.86	8.86	10.99
T	8.06	7.93	11.02	10.69	12.43
Y	6.35	10.24	3.55	10.52	7.15

[Table/Fig-3]: Table shows the mean ae values obtained from the samples soaked in erythrosine (e) tartarizine (t), sunset yellow (y) on 30th day

10th, 20th, 30th days. The coding of each group with colour was represented by sample group then followed by colour group. Thus THC in colour Erythrosine is designated as THC-E. The coded samples are numbered on the back of the specimen for later identification and calculations. Before soaking it in colour solution one acrylic sample was taken from each group randomly and Initial Base Value reading was recorded. This reading was considered as control group value. These values were obtained by testing in computer controlled UV-Visible Spectrophotometer Hitachi U-3210. The spectrophotometer has standard values for the colours of the samples tested for the study. It was recorded with the samples to obtain the standard values before soaking it in coloured solutions. They were considered as the control group standard values for each brand of material.

The coded samples from each group are then soaked in different colorant solution. The coloured solutions are mixed with artificial saliva and kept in incubator at 37°C ± 1°C to simulate the oral environmental conditions. The colour solutions are prepared in three different beakers in which one contains solution of Erythrosine colour, another beaker contains solution of Tartarizine and the third beaker has a solution of Sunset Yellow. The coded samples of each batch containing five samples in each group are tied together and soaked completely in to each of the food colorants solutions. Thus each beaker has soaked samples of total number of 25 samples. The beaker was closed with aluminum foil and kept in the incubator at a temperature of 37°C ± 1°C.

After 10th day each group of samples are taken out of the coloured solution. The samples are washed in distilled water and dried with tissue paper. The samples were then ready for taking up for the readings. Each of the acrylic samples was placed in the vent provided in the cardboard. The slit was closed and kept in the spectrophotometer. Spectrophotometer contains tungsten bulb emitting light, which gives source of light to the testing specimen. The light passes through the acrylic resin samples and the readings are recorded in computer as nm verses time graph on the monitor. The time taken for one reading was one minute per sample. After the recordings are taken the specimens were placed back in respective solutions and stored in the incubator at 37°C ± 1°C. The procedure is repeated for 20th and 30th day for all the acrylic samples.

The colour measurement is done by instrumental technic where curves of spectral reflectance versus wavelength can be obtained over the visible range (400 to 700 nm) with a recording spectorphotometer and integrating sphere. Typical curves for an acrylic resin can be obtained before and after 30 d of accelerated aging in a weathering chamber. From the reflectance values and tabulated colour- matching functions, the tristimulus values (X, Y, Z) can be computed relative to a particular light source. These tristimulus values are required to give, by additive mixture, a match with the colour being considered. Typically, the tristimulus values are computed relative to the Commission Internationale de l'Eclairage (CIE). The ratios of each tristimulus value of a colour to their sum are called the chromaticity coordinates (xyz). The reflectance values obtained from the spectrophotometer for the dyed fabrics were used to find the tristimulus value by using CIE 1931 tristimulus equation viz., by multiplying the reflectance factor R^ with Sx, the relative spectral power distribution of the illuminant and each of three colour matching functions X and Z^. Their summations were then made over the chosen range of wavelength 400 - 700nm at 20nm interval.

RESULTS

[Table/Fig-1] shows the mean AE values obtained from the samples soaked in Erythrosine(E), Tartarizine(T), Sunset Yellow(Y) on 10th day. Shows Mean AE* value for 10th day has shown that the highest value of 6.23 has been shown in Heat Cure acrylic resin of PHC and 6.99 in Self Cure acrylic resin in ACC. The minimum values obtained are 2.37 in PHC and minimum value of 3.54 in ACC. Further it shows that correspondingly higher value have been obtained with Tartarizine in the entire same group with Heat Cure acrylic resin.

[Table/Fig-2] shows the mean AE values obtained from the samples soaked in Erythrosine(E), Tartarizine(T), Sunset Yellow(Y) on 20th day. It has been shown as highest value of 9.58 has been shown with the ACC sample soaked in T. Correspondingly higher values have been obtained from DCC material with sunset yellow as 9.21. Both these values have been obtained with self-cure autopolymerizing acrylic resin. However, with regarding heat cure acrylic resin samples PHC material has shown higher mean values of 8.71 have been obtained with material soaked in Tartarizine. Correspondingly higher mean values obtained as 6.65 with DHC, 5.92 values with THC soaked only in Tartarizine compared to the materials, which are soaked in sunset yellow. The lowest value of 2.94 has been shown with PHC soaked in sunset yellow. All the heat cure acrylic resin samples soaked in erythrosine also have shown a lesser values of 4.12 with THC, 4.93 with DHC and 5.00 with PHC. Looking at the table self cure autopolymerizing samples soaked in all three different colour solutions have shown the marked increase in colour changes in values when compared to the heat cure acrylic resin when the records were made after 20th day.

[Table/Fig-3] shows the mean AE values obtained from the samples soaked in Erythrosine(E), Tartarizine(T), Sunset Yellow(Y) on 30th day. The table shows the higher values of colour changes have been shown with all the materials of both heat cure and self-cure acrylic resin samples. It has been shown as 12.43 with ACC, which is self-cure acrylic resin sample, and 11.02 with PHC, which is heat cure acrylic resin sample. Among the samples soaked in sunset yellow, DCC material have shown colour changes as 10.52 value followed with DHC which is 10.24 and the least of colour values of 3.55 with PHC. In the same way ACC, which is self-cure acrylic resin sample, have shown the value of 10.99. When soaked in E, followed with DCC, which is also self-cure acrylic resin sample shows a value of 8.86. On the contrary, all the values of heat cure samples have lesser values of 7.86 with PHC, 6.65 with DHC and 5.54 with THC.

DISCUSSION

The most common problem associated with acrylic resins is the colour instability that may affect the patient's acceptance. Discolorations of acrylic resins can result in aesthetic problems. Acrylic resins are subjected to sorption and also the process of absorption and adsorption of the material and also the media, which

is in contact. The absorption of liquids depends on environmental conditions. Also, if the contacting solutions are pigmented, discoloration, deterioration of colour and lessening of translucency are possible [9]. Discoloration of the denture base polymers may be caused by the oxidation of accelerator if it is of tertiary amine type as in case of self-cure autopolymerzing acrylic resin or by the penetration of coloured solutions [10]. Colour changes of denture base materials during exposure to oral fluids, and denture cleaners also have been reported [11]. Few of the investigators have also claimed that beverages such as tea, coffee and wine significantly increase the development of stains on enamel of the tooth and acrylic resin [12-15]. However, there are few reports on discoloration of denture base materials to various food colorants that can affect the aesthetic value of denture bases. The structure of the material due to its inherited minor porous content, normal wear and tear of the material, there is a tendency of the processed denture bases to form external stains or discoloration or deterioration of colour as and when it is in contact with coloured external pigments. There are five different groups of acrylic resins which have been taken in the study to evaluate the absorption and staining characteristics. Among the five groups, three groups were of heat cure acrylic denture base resins and two groups were rapid cure auto polymerizing acrylic denture base resins. Both these materials of heat cure and self-cure acrylic resin materials are used as denture base material and also used for repair and addition as and when required. So it is logical to make up a study of these different groups of materials.

The calorimetry is a branch of colour science and is based on the digital expression of the colour perceived from the object. In assessing chromatic differences two colour systems are used such as Munsell colour system and Commission Internationale de l' Eclairage (CIE Lab). The later system was followed for our study. In CIE Lab system the three dimension of colour have been arranged at almost equal intervals and chromatic differences among the colours used [16]. In this study the spectrophotometry measuring techniques were used to determine the colour of five types of acrylic resins in three food colorant media. The advantage of this colour system is that its arrangement is an approximately uniform three dimensional colour space whose elements are equally spaced on the basis of visual colour perception. The unit change in each of the three colour parameters is approximately equally perceived. The quality L* correlates to lightness similar to the value in the Munsell system. The a* and b* coordinates describe the chromatic components.

The three food colorants used in the study have charged and ionizable group in the chemical structure. All the materials are water-soluble organic azodyes and are stable with heat, alkalies and acids [16]. The results of the study shows that among the samples of denture base resins the least colour changes was found to be with Sunset Yellow showing AE* value of 3.55 with heat cure acrylic resin branded as PHC material and the highest colour absorption with Tartarizine showing AE* value of 12.43 in rapid cure autopolymerzing acrylic resin material branded as ACC material. The Poly methyl methacrylate denture base resins were hydrophilic that attract more water soluble dyes on the surface and staining which occurs as a result of electrostatic changes.

All the five resins used in this study have the same base chemical structures; however each of them contained small quantities of different cross-linking agents and plastizers, pigments, which may explain the differences in staining properties (hydrophilicity) of resins. There also seemed to be some molecular interactions between colorants and denture polymers that resulted in slight discoloration in acrylic resins. Erythrosine (MW=879.9) and Tartarizine (MW=534.4) have electro statically charge groups on the molecules when ionized, however sunset yellow contains two ionizable groups in the molecules which may explain why it did not stain as much as the other two dyes.

Colour changes of resin materials can occur through formation of coloured degradation product, change in surface structure due to wear, and by extrinsic staining. The causative factors that contribute to the change in colour of aesthetics restorative materials include stain accumulation, anhydration, water sorption, leakage, poor bonding and surface roughness, wear or chemical degradation, oxidation of the reacted carbon-carbon double bonds that produces coloured peroxide compounds, and continuing formation of the coloured degradation products. The surface deterioration has been shown to increase lightness and decrease chroma of denture base resins.

It should be noted that water sorption of the chemically cured acrylic resin is between 0.5 and 0.7 mg / cm^2. However, the solubility is about 0.05 mg/cm^2 for the chemically cured typed compared with 0.02 mg/cm^2' for the heat cure type. This large value for solubility is caused by the loss of residual monomer from the chemically cured acrylic resin. There were reports in literature that the molecular weight distribution has a pronounced effect on the physical properties of the denture base polymers. In addition to the chemical composition and molecular weight, the physical or special structure of the polymer molecules is also important in determining the properties of the polymer. The difference in staining characteristics is attributed to the differences in water sorptions exhibited by the different groups of acrylic materials.

The results of the study revealed that there was a corresponding change in colour absorbent values on self-cure acrylic resin compared to heat cure acrylic resins to various food colorants tested. The reason for higher values obtained in rapid cure acrylic resin would have been due to molecular disintegration of the initiator at higher temperature of curing which has lesser affinity for colour absorption in its deeper layers.

It was also noted that the surface staining was apparently more immediately after taking it out from the food colorants. It was also to be noted that only a higher grade abrasives such as 600 grit sand papers was utilized for obtaining the uniform thickness of the materials and no further polishing was done. It can be analyzed form this fact that food colorant mixed in the media in contact with denture bases may show more colour variance, if it is not washed. However, there is every tendency of the denture wearer to wash the dentures after every meal and so the external discoloration may likely to get washed off. On this basis the test was also conducted after washing the material in distilled water. This could have prevented the penetration of the colorant material in to deeper structures when aged for a prolonged period.

CONCLUSION

Within the limitations of this study, it can be concluded that heat cure acrylic resins are more colour stable than self cure acrylic resins. Tartrazine has the maximum colouring effect while the least colouring effect was observed in sunset yellow colorants for both the heat cure and self cure acrylic samples.

REFERENCES

[1] Moon A, Powers JM, Kiat-Amnuay S. Colour stability of denture teeth and acrylic base resin subjected daily to various consumer cleansers. *J Esthet Restor Dent.* 2014;26(4):247-55.
[2] Jin C, Nikawa H, Makihira S, Hamada T, Furukawa M, Murata H. Changes in surface roughness and colour stability of soft denture lining materials caused by denture cleansers. *J Oral Rehabil.* 2003;30(2):125-30.
[3] Handa RK, Jagger DC, Vowles RW. Denture cleansers, soft lining materials and water temperature: what is the effect? *Prim Dent Care.* 2008;15(2):53-58.
[4] Watanabe H, Kim E, Piskorski NL, Sarsland J, Covey DA, Johnson WW. Mechanical properties and colour stability of provisional restoration resins. *Am J Dent.* 2013;26(5):265-70.
[5] Malekipour MR, Sharafi A, Kazemi S, Khazaei S, Shirani F. Comparison of colour stability of a composite resin in different colour media. *Dent Res J (Isfahan).* 2012;9(4):441-46.
[6] Jalali H, Dorriz H, Hoseinkhezri F, Emadian Razavi SF. In vitro colour stability of provisional restorative materials. *Indian J Dent Res.* 2012;23(3):388-92.

[7] Sham AS, Chu FC, Chai J, Chow TW. Colour stability of provisional prosthodontic materials. *J Prosthet Dent.* 2004;91(5):447-52.
[8] Wozniak WT, Muller TP, Silverman R, Moser JB. Photographic assessment of colour changes in cold and heat-cure resins. *J Oral Rehabil.* 1981;8(4):333-39.
[9] Gupta G, Gupta T. Evaluation of the effect of various beverages and food material on the colour stability of provisional materials - An in vitro study. *J Conserv Dent.* 2011;14(3):287-92.
[10] Patil SS, MRD, Gujjari AK. Effect of cigarette smoke on acrylic resin teeth. *J Clin Diagn Res*. 2013;7(9):2056-59.
[11] Haug SP, Andres CJ, Moore BK. Colour stability and colourant effect on maxillofacial elastomers. Part I: colourant effect on physical properties. *J Prosthet Dent.* 1999;81(4):418-22.
[12] Oguz S, Mutluay MM, Dogan OM, Bek B. Colour change evaluation of denture soft lining materials in coffee and tea. *Dent Mater J.* 2007;26(2):209-16.
[13] Imirzalioglu P, Karacaer O, Yilmaz B, Ozmen Msc I. Colour stability of denture acrylic resins and a soft lining material against tea, coffee, and nicotine. *J Prosthodont.* 2010;19(2):118-24.
[14] Goiato MC, Nóbrega AS, dos Santos DM, Andreotti AM, Moreno A. Effect of different solutions on colour stability of acrylic resin-based dentures. *Braz Oral Res.* 2014;28(1) pii: S1806-83242013005000033.
[15] Emmanouil JK, Kavouras P, Kehagias T. The effect of photo-activated glazes on the microhardness of acrylic baseplate resins. *J Dent.* 2002;30(1):7-10.
[16] Singh SV, Aggarwal P. Effect of tea, coffee and turmeric solutions on the colour of denture base acrylic resin: an in vitro study. *J Indian Prosthodont Soc*. 2012;12(3):149-53.

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