

# Comparison of Color Stability of Four Heat Cure Denture Base Resins in various Staining Solutions and Denture Cleansers: An in vitro Study

## Abstract

**AIM:** To evaluate and compare the color stability of 4 types of heat cure denture base resins in various staining solutions. Also to determine the efficacy of 2 denture cleansers in removing these stains.

**MATERIAL & METHODS:** 400 disc samples of four commercially used heat cure denture base resins (Trevalon®, DPI®, Veracril® and Pyrax®) were fabricated (100 each). These were examined for any change in optical density by immersing them in 4 staining solutions (tea, coffee, turmeric and paan) and 2 denture cleansers (Secure® and Fittydent®) for a period of 1 month and synthetic saliva. Synthetic saliva was taken as control. The denture cleansers were also evaluated for their efficacy determined by their ability to remove the stains caused by the staining solutions. **RESULT:** It was seen that Trevalon® showed least change in optical density. Trevalon® shows significant mean difference with DPI® (p=0.001) and Pyrax® (p=0.019). Also DPI® and Veracril® show significant mean difference (p=0.035). Coffee illustrated the maximum potential for staining the denture base resins and most difficult to be removed using a denture cleanser. It was seen that the mean difference of the two denture cleansers is significant (p=0.013). **CONCLUSION:** It can be concluded that Trevalon®, out of the tested heat cure denture base resins, demonstrated maximum color stability. Amongst the staining solutions coffee caused maximum stains. Secure® was found to be more efficient denture cleanser to Fittydent®.

## Key Words

Color stability; heat cure denture base resins; staining solutions; denture cleanser

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## INTRODUCTION

Heat cure denture base acrylic resins have been used for more than 60 years in the prosthodontic restoration of a completely or partially edentulous mouth due to its ease of manipulation, cost effectivity and good mechanical properties.<sup>[1]</sup> A denture base polymer, apart from having acceptable mechanical properties, should also have good aesthetics with a smooth surface and be capable of matching the natural appearance of soft tissues.<sup>[2]</sup> Best aesthetic effects are a result of adequate color stability and translucency of the resins which should be maintained during the clinical use. However,

these materials are subject to absorption and adsorption of liquids. When the contacting solution is pigmented, discoloration occurs.<sup>[3]</sup> Discoloration of denture base resins may result from several factors. It may be caused by the oxidation of amine accelerators<sup>[2]</sup> or from use of denture cleansers.<sup>[4]</sup> There is evidence that beverages such as tea and coffee significantly increase the development of stains on poly methyl methacrylate acrylic resins.<sup>[2]</sup> Also the habitual intake of fermented foods degrades the color stability of denture base acrylic resins.<sup>[5]</sup> Fluid pigments from food, beverages, drugs and nicotine are deposited in the



Fig. 1: Staining components



Fig. 2: Immersed samples in various staining solutions



Fig. 3: Visible spectrophotometer (Systronic)



Fig. 4: Leaching of samples using 30% H<sub>2</sub>O<sub>2</sub>

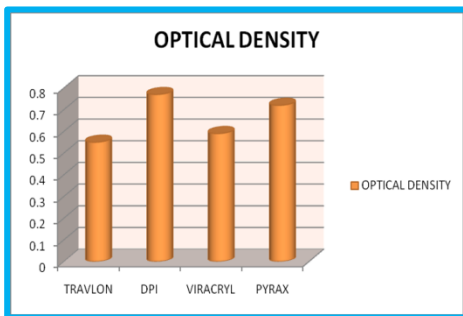


Fig. 5: Optical density of four groups

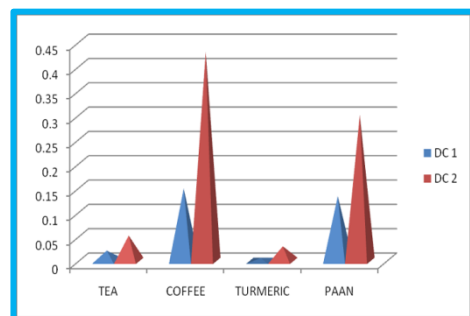


Fig. 6: Efficacy of denture cleansers in removal of various stains

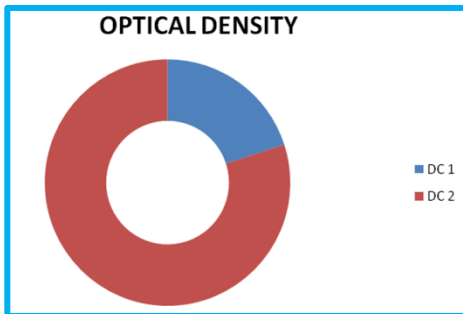


Fig. 7: Optical density after action of denture cleanser

interprismatic spaces<sup>[6]</sup> of the resin, which over a time lead to compromised aesthetics. A denture can be cleaned mechanically or chemically. Mechanical methods are the most common way for bio film removal from denture surfaces.<sup>[7]</sup> The use of chemical cleansers is usually associated to its efficacy in removing stains. The most commonly used cleansers are represented by the group of alkaline peroxides, alkaline hypochlorite, dilute organic and inorganic acids, disinfectants and enzymes.<sup>[8]</sup> They are effective to remove newly

formed bio film when used for extended immersion periods.<sup>[9]</sup> Although these products are effective in removing bio film on complete dentures<sup>[10-11]</sup> they can also be a cause of denture discoloration. Hence the selection of these agents for denture base acrylic resins is critical to preclude potentially aesthetic alterations in the prosthesis.<sup>[12]</sup> It has been shown in studies that water temperature<sup>[13-15]</sup> and immersion period<sup>[12,16,17]</sup> play an important role in maintaining denture aesthetics when complete denture cleansers are used. One of the problems frequently reported by chemical cleanser users is a whitening effect on the denture. The quantitative differences or pH differences of cleansing solutions play a role in the whitening effect.<sup>[18]</sup> Factors that may contribute to the change in the color of materials include stain accumulation, dehydration and oxidation of the reacted carbon-carbon double bonds that produces colored peroxide compounds, and continuing formation of the colored degradation products.<sup>[19]</sup>

Discoloration of these resins result in aesthetic problems. Hence maintenance of color stability of these resins is the key to long term aesthetics of the denture. Therefore this study has been designed to determine the color stability of heat cure denture base acrylic resins in commonly consumed solutions causing stains and denture cleansers.

The objectives of this study were:

- To compare the color stability of four different denture base resins after immersion in various staining solution.
- To compare the staining potential of the most commonly used beverages, turmeric and Paan stains.
- To determine the efficacy of different denture cleansers in the removal of stains from heat cure denture base resins.
- To compare the color stability of the 4 heat cured denture base resins in 2 different denture cleansers.
- To suggest or recommend the use of the most appropriate denture cleanser.

Bone around implant and soft tissue drape was accessed. Interdental bone was compared from pre op to post op on the radiograph after 6 months. Interdental papilla on mesial and distal aspect of missing tooth was compared with pre op to post op. Among 10 patients, 8 patients had good bone height and there was no recession of interdental papilla. 2 patients had recession labially, as the implants were placed slightly labially. Pink porcelain was incorporated in final prosthesis for esthetic reasons.

#### MATERIALS AND METHODS

In this study 400 discs samples of four different heat cure denture base resins were immersed in four staining solutions, two denture cleansers and synthetic saliva. The 2 denture cleansers had different composition and different mechanism of action. Synthetic saliva was used as control. A standardized disc of brass of dimension  $50 \pm 1$ mm in diameter and  $1 \pm 0.05$ mm in thickness was fabricated using precise milling instruments. This brass disc was flaked in dental flask using dental plaster to obtain a mould of the same dimension. Denture base resin belonging to group I (Trevalon®) was packed in the mould. The flask was then bench cured for 30 minutes. Curing was carried out in the acrylizer (Unident®) by immersing the flask in water at room temperature and gradually bringing it to boil in 30 minutes. After this it was continued to boil for 30 minutes (as instructed by the manufacturer for all 4 commercial

brands). 400 such samples were obtained (100 of each commercial brand). The samples were then deflasked. They were scrutinized for any type porosity. Samples with porosities were excluded from the study. Samples without porosities were trimmed and polished maintaining the dimensions of the discs. The discs were then kept in distilled water at room temperature for 24 hours to rid them off any residual monomer. The specimens were divided into four groups (Group I = Trevalon®, Dentsply, Gurgaon, India, Group II = DPI®, Bombay Burmah Trading Corporation, Mumbai, India, Group III = Veracril®, Surana Enterprises, Karnataka, India, Group IV = Pyrax®, Pyrax Polymars, Roorkee, India,) according to their commercial brand (100 in each). Each group of sample was divided into 7 subgroups (S1=tea, S2=coffee, S3=turmeric, S4=paan, S5=denture cleanser1 (Secure® from Group Pharmaceuticals, Goregaon, Mumbai, S6=denture cleanser2 (Fittydent® Group Pharmaceuticals, Tarapur, Thane), and S7=synthetic saliva) of the staining solutions. Each subgroup consisted of 16 samples except S5 and S6 which consisted of 10 samples each. Synthetic saliva was prepared by dissolving following constituents in 1000 ml distilled water.

Disodium hydrogen phosphate (0.26gm)

Sodium chloride (6-70gm)

Sodium dihydrogen phosphate (0.20gm)

Potassium chloride (1.20gm)

Sodium bicarbonate (1.50gm)

Bovine serum albumin (100mg)

Tea solution was prepared by dissolving 17.50gm (3 tablespoon) tea powder (Brooke Bond® 3 roses) in 250ml of water and then boiling it for ten minutes.

Coffee solution was also prepared by dissolving 17.50gm (3 tablespoon) coffee powder (Nescafe® sunrise) in 250ml of water and then boiling it for ten minutes. Turmeric solution was prepared by dissolving 0.5gm turmeric powder in 250ml of water and then boiling it for ten minutes. Paan solution was prepared by dissolving the 25gm paan paste in 250ml water. Denture cleanser solution was prepared by immersing 3 tablets for each group in 250ml of water. The minimum quantity of these ingredients required for adequate staining was determined by a pilot study performed prior to the commencement of the study. The pH of all the solutions was measured using a pH paper (Nualigens®) (Fig.1). From each group 16 discs were immersed in synthetic saliva, tea, coffee, turmeric solution and paan solution each. 10 discs

from each resin brand were also immersed in the 2 denture cleansers (Fig. 2). The samples were then incubated at 37 °C in an incubator and stored in a dark place for one month (to simulate oral conditions). These solutions were replaced on alternate days with fresh ones to prevent any microbial colonization and to maintain uniform concentration. After 1 month, 10 discs from each solution were evaluated for surface stain using a visible spectrophotometer (Fig. 3). The visible spectrophotometer (Systronics 106®) was used to determine the optical density of the samples. For this 30% H<sub>2</sub>O<sub>2</sub> was used to leach out the stain on the samples and this leached out solution was evaluated in the spectrophotometer. The frequency of the spectrophotometer was set by setting the maximum absorbance in the yellow- brown range (490m). Now each disc was leached by H<sub>2</sub>O<sub>2</sub> drop by drop and the collected solution was evaluated in the spectrophotometer (Fig. 4). Data was noted down for each specimen. The remaining 6 discs of each type of resin in each staining solution were washed, air dried and suspended in the two denture cleansers (3 discs from each staining solution in each cleansers) for a period of 8 hours (to simulate overnight immersion). These discs, after treatment with denture cleansers will be leached with 30% H<sub>2</sub>O<sub>2</sub> and evaluated for efficacy in the spectrophotometer. The data obtained from the present study was statistically analyzed using SPSS software version 11.

## RESULTS

Fig. 5 shows maximum optical density of DPI® (4.66) after immersion in various staining solutions. Trevalon® shows minimum optical density (3.2). Table 1 compares the optical density of all four groups using *Bonferroni Test*. It is seen that Trevalon® shows significant mean difference with DPI® (p=0.001) and Pyrax® (p=0.019). Also DPI® and Veracril® show significant mean difference (p=0.035). Fig. 6 depicts that coffee stains were the most difficult to remove as compared to other stains by both the denture cleansers. This was followed by paan stains. Stains caused by tea. Stains caused by turmeric were the most easiest to remove by either of the denture cleansers. Fig. 7 depicts the efficacy of the two denture cleansers showing a significantly higher (p= 0.013) efficacy of Secure® than Fittydent®. Table 2 depicts the pH values of the various staining solutions determined during the course of the study using a Nualigens® pH paper.

The efficacy of the two denture cleanser is compared in Table 3 using t-test. It depicts that the mean difference of the two denture cleansers is significant (p= 0.013).

## DISCUSSION

The major concern in complete denture service is the maintenance of the prosthesis. Complete dentures are made up of polymethylmethacrylate denture base resins that are subjected to the actions of various solutions in oral cavity. These gradually discolour the resin deteriorating its physical and optical properties leading to biological complications. Discoloration of these resins result in aesthetic problems. Hence maintenance of color stability of these resins is the key to long term aesthetics of the denture. Thus, this study has been designed to determine the color stability of heat cure denture base acrylic resins in commonly consumed solutions causing stains and 2 denture cleansers. Also the efficiency of these 2 denture cleansers in removing the stains is determined. The study was conducted on standardized disc samples in standardized environment. These study samples were incubated at 37°C in an incubator throughout the study. This was done to simulate the discoloration in vivo which depends on the polar properties of the resin molecules and mechanism of diffusion that abide by the laws of diffusion. The diffusion coefficient for heat cure acrylic resins is  $1.08 \times 10^{-12} \text{ m}^2/\text{sec}$  at 37°C (oral temperature). Thus, the temperature of the test samples in various solutions must be maintained at 37°C because the diffusion coefficient of a heat-cured denture acrylic resin is reduced by one half when the temperature drops from 37°C to 23°C.<sup>[30]</sup> This mechanism of diffusion fosters the process of discoloration, by adsorption and absorption of the stained solution.<sup>[2,4,21,22]</sup> The foodstuffs a patient consumes contain various acids, colours and other ingredients that result in depreciation of aesthetics and hygiene of the denture. In this study four commercially available denture base resins were evaluated for their color stability in six stain causing solutions. After continuous immersion of the samples under these solutions, their optical density was evaluated using a Visible Spectrophotometer. The values for all the samples in synthetic saliva were zero and it acted as the baseline or control for comparison. All the four types of denture base resins demonstrated near about same color stability with Travlon® having maximum followed by Viracryl®, Pyrax® and DPI® (Graph 1). It was seen that there is a

statistically significant difference only between Travlon® and DPI® (0.001), Travlon® and Pyrax® (0.019) and DPI® and Viracryl® (0.35) (Table 1). Tea and coffee are the beverages of choice of a majority of people and it is seen that they are responsible for causing discoloration of teeth as well as prosthesis. Turmeric is the major constituent of the cooked food in India. Saliva was used as a control in the study. The samples were immersed in tea, coffee, turmeric, paan and saliva for a period of 30 days to simulate the effects of intermittent contact of the dentures with the staining solutions over a long period of time. As this was an in vitro study of short duration continuous immersion accelerated the study as compared to clinical conditions. In this study coffee was seen to cause maximum staining of the samples, followed by tea. This could be attributed to the fact that coffee and tea are acidic solutions as determined during the study (Table 2). The acidic constituent of tea and coffee causes surface erosion of the acrylic which imparts it a rough surface morphology. This rough morphology sustains more discoloration from the staining solutions. These findings were in accordance with those of Robin Mathai Joseph.<sup>[20]</sup> The pH of other solutions was more towards the alkaline side causing less surface adsorption of the stain on denture resins hence reduced discoloration. Similar results were confirmed in study by Crispin and Caputo<sup>[3]</sup> who emphasized that the acidic nature of tea, coffee and grapes erode the polished surface layer of resin facilitating more stain uptake. Buyukyilmaz and Ruyter<sup>[22]</sup> also concluded that discoloration results from the adhesion of colorants to the surface. In a similar study conducted by Nur Hersek *et al.*,<sup>[2]</sup> they concluded that the effect of tannic acid present in tea and coffee caused the staining. Um and Ruyter<sup>[23]</sup> in their study reasoned the discoloration of resins by explaining the process of absorption and penetration of colorants into the organic phase of the resin materials as the compatibility of the polymer phase with the yellow colorants of coffee. The yellow colorants of coffee were less polar and thereby less hydrophilic, than the yellow colorants of tea. Hence, the discoloration caused by tea was easily removed as was also observed in the present study (Graph 2). This removable discoloration was probably due to adsorption of the polar colorants from tea at the surface of these materials. The discoloration from coffee was due both to surface adsorption and absorption of colorants. The less polar colorants

from coffee had penetrated deeper into the materials, probably because the colorants were compatible with the polymer matrices of the resin materials. Denture cleansers are the most convenient method of maintaining denture hygiene. The immersion type of denture cleansers helps in removing the stains and deposits from the denture surfaces. Fittydent® is a sodium perborate monohydrate (480mg) type of denture cleanser. It acts by the formation of hydrogen peroxide on reaction with water which releases oxygen.<sup>[24]</sup> The oxygen bubbles exert mechanical cleaning effect on the dentures. Secure® is also a sodium perborate monohydrate (700mg) type of denture cleanser. Effects of denture cleansers have been extensively researched for affecting color stability of heat cure denture base resins. In the present study two denture cleansers were evaluated for their bleaching potential as many previous studies state that denture cleansers also affect the color stability of denture resins.<sup>[1,4,19]</sup> Sarac *et al.*,<sup>[25]</sup> reported that denture cleansers cause whitening or bleaching of denture, causing loss of soluble components or water absorption in acrylic resin materials. Nikawa *et al.*,<sup>[7]</sup> reported that high peroxide content and level of oxygenation in the strongly alkaline solution is a damaging factor for denture base materials as it might cause hydrolysis and decomposition of acrylic resin itself. However, in the present study there was no significant bleaching observed. Hence the samples were found to be color stable when under denture cleansers. The evaluation of efficacy of the denture cleanser in removal of the stains of tea, coffee, turmeric and paan revealed that optical density of samples under the denture cleanser 1 (Secure®) is lesser than the ones under denture cleanser 2 (Fittydent®). This conveys that cleansing action of Secure® is better than Fittydent®. This can be attributed to the increased concentration of sodium perborate in Secure®. In the present study, samples cleansed by Secure® denture cleanser (DC1) showed lesser optical density as compared to the samples cleansed by Fittydent® (graph 3). The comparison of their efficacy showed statistically significant results ( $p=0.013$ ) (Table 3). Hence it can be deduced from the data that Secure® was a better option over Fittydent®.

## CONCLUSION

1. Travlon®, out of the tested commercially available heat cure denture base resins, demonstrated maximum color stability after its

immersion in different staining solutions and denture cleansers.

2. Coffee, owing to its acidic potential, cause maximum stains which are difficult to remove as compared to stains caused by other test solutions.
3. Although denture cleansers are known to cause alterations of color of denture resins, this study does not reveal any kind of color instability caused by denture cleansers.
4. It was inferred from the study that Secure® has better efficiency in cleaning the stains caused by tea, coffee, paan and turmeric.

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