

# Spectrophotometric Assessment of Color Changes of Heat Cure Acrylic Resins after Exposure to Commonly Consumed Beverages

Faiza Amin<sup>1</sup>, Abdur Rehman<sup>2</sup> and Syed Azizudin<sup>3</sup>

## ABSTRACT

**Purpose:** To evaluate the effect of commonly consumed beverages on the color stability of heat cure acrylic resin (Vertex rapid simplified, Holland).

**Materials and Method:** Sixty heat cure acrylic resin specimens measuring 13.0 mm in length and 4.0 mm thickness were prepared using a stainless steel mold. Specimens were randomly allocated into 6 groups (n= 10): baseline, distilled water, coke, tea, turmeric powder solution and coffee solution. A digital spectrophotometer was used to evaluate color changes after 30-days immersion in each solution. Specimens were stored in different staining media for 24 hour/day for 30 days. L\*a\*b\* color space (CIE L\*a\*b\*) known as Commission International ed'Eclairage is used to evaluate the colour changes of the material. Analysis of data was done by using one way analysis of variance (ANOVA) for a quantitative dependent variable by a single factor (independent) variable. To identify which of the mean differed significantly, Dunnett t (2 sided) was used at 0.01 significance level at 99% confidence level. (p<0.01).

**Results:** Statistically significant differences were found in the color change ( $\Delta E$ ) among all groups ( $p < 0.001$ ) after 30 days of immersion. At baseline (0 day), trace amount of color change was observed where as appreciable changes were observed when specimens were immersed in Turmeric powder, coffee and tea. Much change in color was observed when specimen was immersed in coke. Slight amount of change in color was observed when samples were stored in distilled water.

**Conclusions:** These results of the study conclude that the color stability of denture base acrylic resin is influenced by commonly used beverages.

**Key words:** Heat cure acrylic resin. Color stability. Spectrophotometer.

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## INTRODUCTION

The ideal denture base material should possess several key physical attributes. Some of these properties include biocompatibility, good esthetics, high bond strength, with available denture teeth, radio opacity, ease of repair, and should possess adequate physical and mechanical properties.<sup>1</sup> Poly methyl-methacrylate

(PMMA) is the most popular denture base material. All dentures are fabricated from PMMA based materials. PMMA is being used in dentistry for various purposes, like making denture bases, artificial teeth, provisional restorations, surgical splints, stents and orthodontic appliances.<sup>2</sup> They are the material of choice for removable complete denture prostheses.

Color stability is one of the most important clinical properties for dental materials, and color change may be an indicator of aging or damaging of materials.<sup>3-6</sup> Furthermore, the aesthetic appearance of a prosthesis is certainly an important feature required by patients and must satisfy their expectations.

Many factors contribute towards discoloration of acrylic resin. They include dissolution of ingredients, stain accumulation, surface roughness, water sorption and degradation of intrinsic pigments.<sup>7</sup> Intrinsic factors are those factors that are involved in changes at the interface of matrix and fillers as well as within the resin matrix. Extrinsic factors involved adhesion of ions or molecules

1 Department of Science of Dental Materials, Dow Dental College, Dow University of Health Sciences, Karachi, Pakistan.

2 Department of Science of Dental Materials, Dr Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, Pakistan.

3 Tabuk Specialist Dental Center, Tabuk, Ministry of Health, Kingdom of Saudi Arabia.

**Correspondence:** Dr. Abdur Rehman, Department of Science of Dental Materials, Dr. Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, Pakistan.

**Email:** abdurrehmanmids@gmail.com

by the process of adsorption on the surface of the dental resins. Exposure of denture base resin to the commonly consumed beverages, oral fluids and denture cleansers has been demonstrated in the color changes of these materials. This is because of entry of colored mixtures into resin matrix causing oxidation of amine accelerator.<sup>8</sup> The ability of the resins to resist color changes can be affected by the structure, physical and chemical characteristics of inorganic fillers present in the resin.<sup>9</sup>

In vitro researches on colour stability has been conducted on aesthetic materials.<sup>10-12</sup> Hatim NA et al<sup>13</sup> evaluate the color change between two types of acrylic resin and flexible resin after thermo cycling where as Goiato MC et al<sup>14</sup> studied the color stability of acrylic resins after immersion in different solutions.

Evaluation of staining can be measured visually and by instrumental technique.<sup>15</sup> Visual inspection of color evaluation is psychologically and physiologically related issue. Instrumental technique greatly eliminates, the chances of error during visual interpretation of color measurement. Colorimeters and spectrophotometers are commonly used methods to evaluate change in color of dental materials.<sup>16</sup> Colorimeters are less effective in measuring accurate color change as compared to spectrophotometers. Spectrophotometers assess the curve of reflectance every 10 nm or less because they contain monochromators and photodiodes.<sup>17</sup> To eradicate possible subjective errors in color assessment, we used a spectrophotometer for color measurements in the present study.

The aim of the present study was to evaluate color changes in denture base resins after exposing them to commonly consumed beverages by means of a spectrophotometer. The null hypothesis is that there would be no difference in the color stability of heat cure acrylic resin after immersion in different beverages.

## MATERIALS & METHODS

It was an in vitro experimental study conducted at Dr. Ishrat-ul-Ebad Khan Institute of Oral Health Sciences and testing was performed at Al Karam Textiles Karachi, Pakistan during March to July 2012. The material tested in the study was heat-cure acrylic resin (Vertex rapid simplified, Holland).

Sixty rectangular specimens 13.0 mm in length and 4.0 mm thickness were prepared from stainless steel mold. The mold was placed in curing tank. (Acrydig 10 Manfredi Manfredi S.P.A 10060-S TORINO ITALY) Curing was done in thermostatically controlled water bath. This was done because material properties may

be affected by variation in the temperature. Curing was started in hot water. Mold was placed in hot water for 20 minutes at 100°C according to manufacturer's instructions. After heat polymerization by compression molding technique, samples were removed from the mold, the flash was trimmed with a carbide bur and smoothed by 200 grit sand papers with the help of a sandpaper holder. The specimens were polished on a wet rag wheel with pumice slurry. To ensure complete polymerization, after polishing, all samples were placed in distilled water at room temperature for 24 hours. 1.0 gm of turmeric powder (National Turmeric powder, National Foods Limited Pakistan) was added to 50 ml of boiling distilled water to prepare turmeric solution.<sup>2</sup> Coffee solution was prepared by using 10gm of coffee powder (Nescafe, Nestle Pakistan Limited) to 50ml of hot water. The criterion used to prepare tea was by immersing five teabags (Lipton Yellow Label Tea, Unilever, Karachi, Pakistan) into 1000 ml of boiled water. New solution of tea, coffee, coke and turmeric was prepared every day.

The samples were divided into six groups of ten specimens each: Ten samples were measured at baseline (day 0) without storage in any solution. Rest of the five groups were measured for color change after immersion in distilled water, coke, coffee, tea and turmeric solution.

The samples were kept in test solutions for 24 hour period for 30 days. After 24 hours sample was taken out from the storage solution, rinsed with distilled water and air dried. Same cycle was repeated for each group. After 30 days, change in color was evaluated after using spectrophotometer. (Data colour 650 plus 9661).

Mean values for the material were calculated. Measurements were performed according to the CIE L\*a\*b\* system. The basic CIE concept is that all colors can be matched by mixing relative amounts of the three light primaries: Red (X), Green (Y), and Blue (Z). These can then be transformed to L\*, a\*, and b\* values. L\* is a measure of lightness. The a\* value represents positions on a red-green axis. As a\* becomes more positive in value, the color is more red; as a\* becomes more negative in value, the color becomes more green. The b\* value represents positions on a yellow-blue axis. As b\* becomes more positive in value, the color becomes more yellow; as b\* becomes more negative in value, the color becomes more blue.

The equation utilized for calculating color differences in this system is

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

where  $\Delta E$  is the color difference of the two objects that can be determined by comparing the differences between individual values for each object.

National Bureau of Standards (NBS) is used to quantified the color change. Critical marks of color difference according to NBS are shown in Table 1. Following formula is used to express NBS units.<sup>18</sup>

$$\text{NBS unit} = \Delta E \times 0.92$$

Where  $\Delta E$  stands for color change

Table 1: Critical marks of color difference according to National Bureau of Standards

| Critical Marks of Color Difference | Textile Terms (NBS unit) |
|------------------------------------|--------------------------|
| Trace                              | 0.00-0.5                 |
| Slight                             | 0.5-1.5                  |
| Noticeable                         | 1.5-3.0                  |
| Appreciable                        | 3.0-6.0                  |
| Much                               | 6.0-12.0                 |
| Very much                          | >12.0                    |

Statistical Package for Social Sciences (SPSS) version-16 was used for data analysis. Analysis of the data was done by using one way analysis of variance (ANOVA) for a quantitative dependent variable by a single factor (independent) variable. To identify which of the mean differed significantly, Dunnett t (2 sided) was used at 0.01 significance level at 99% confidence level.

Fig 1: Specimens of Heat Cure Acrylic Resins



## RESULTS

Specimens showed statistically significant difference in colour change after 30 days of immersion in distilled water, coffee solution, coke, tea and turmeric powder solution. The mean values of the specimens stored in distilled water were 0.21. The mean values of the samples immersed in coffee, turmeric, coke and tea solution for 30 days were 6.24, 7.13, 5.12 and 6.13 respectively shown in Table 2. However, the highest

value of colour change was in turmeric powder and the least color change was found to be in distilled water. Significant p values <0.001 were found when stored in all the above mentioned media.

Table 2: Mean and NBS values regarding color measurement of material after exposure to different media

| Groups             | Mean $\Delta E$ | NBS                |
|--------------------|-----------------|--------------------|
| Baseline (Control) | 0.02            | 0.01 (Trace)       |
| Distilled water    | 0.21            | 0.19 (Slight)      |
| Coffee solution    | 6.24            | 5.74 (Appreciable) |
| Turmeric solution  | 7.13            | 6.55 (Much)        |
| Coke               | 5.12            | 4.71 (Appreciable) |
| Tea                | 6.13            | 5.63 (Appreciable) |

## DISCUSSION

Color change of dental materials is clinically very important for dental operator as it determines the clinical serviceability of the material. In this present study spectrophotometric evaluation was carried out to measure colour difference, to reduce chances of subjective error through visual method.

To evaluate color changes researchers have used  $\Delta E^*$  values.<sup>19,20</sup> But the results of the study vary from author to author. The NBS rating system is used to answer such alterations and discrepancies in the standards used.

Based on data obtained through the spectrophotometric evaluation the hypothesis tested in the study was rejected. After 30 days immersion in staining solution, coffee cause slightly higher change in color then tea and coke. However, the results of the present study oppose the findings by Buyukyilmaz S, Ruyter IE<sup>21</sup> who found that all the materials used in their study were at same discoloration level after 96 hours of immersion in coffee and tea solution. Similarly, in a study done by Um and Ruyter et al<sup>22</sup> demonstrated that coffee solution cause less discoloration of material then tea after 48 hours of storage of five resins based veneering materials.<sup>22</sup> According to Lai et al<sup>23</sup> the hydrophobic silicon material in the resin based material is more deeply stained by coffee solution than the tea solution. Hydrophobic staining solutions stained hydrophobic materials more easily.

Researchers have shown that polymethyl methacrylate resins attract more water soluble dyes on the surface because they are hydrophilic.<sup>24</sup> The extracts of turmeric, coffee and tea have additional ionizable groups or highly reactive secondary metabolites like phenols, tannins, saponins and flavonoids.<sup>25</sup> These are stable at high temperature and they are water soluble. Color change occurs because of the water sorption of these metabolites by the surface of the resins.<sup>26</sup>

Acrylic resins demonstrate the property of water sorption. These resins are made up of numerous interpolymeric chains which have gaps between them. The absorbed water enters these gaps and remains there. The size and number of these interpolymeric gaps conclude the quantity of water absorption.<sup>26</sup>

In the present study, appreciable staining potential was observed in coffee whereas much staining potential was found in turmeric solution. These results are in agreement with the results of the study done by Gupta et al<sup>26</sup> in which they used artificial saliva, tea, coffee, Pepsi and turmeric solution as immersing media. They immersed specimens in these media for 15 days. They found that Pepsi had a appreciable staining potential whereas turmeric solution had the much staining potential followed by coffee and tea.

Scotti et al<sup>27</sup> stated that at 10 and 30 days period synthetic saliva and tea produced lesser darkening than coffee and artificial saliva.

Highest staining and orange color of turmeric solution is due to conjugated diarylhepnoids like curcumin<sup>28</sup> Tannic acid colorant is responsible for staining capability of coffee according to Hersek N et al<sup>29</sup> Cola drink does appear to be strongly implicated in color change of resins because of the presence of phosphoric acid.

In a study conducted by Goiato MC et al,<sup>14</sup> authors evaluate the effect of coke and coffee solutions on the color stability of four different acrylic resin-based dentures and found that immersion solution affect the colour stability of these acrylic resins whereas in a study conducted by Hatim NA et al<sup>13</sup> authors evaluated the colour stability of acrylic resins and flexible resins by immersing the specimens in tea with sugar, pepsi and coffee with sugar and they found that tea was found to be the most chromatic agent, and showed unaccepted colorchange as compared with coffee, Pepsi, and artificial saliva solutions.

The limitations of this in vitro study are that all factors that contribute in the discoloration of acrylic resins like residual unpolymerized monomers resulting from incomplete polymerization, filler and monomer composition, material wear, poor oral hygiene, nutrition and surface roughness could not be assessed. In clinical situations the prosthetic restorations have anatomical grooves and pits whereas in this in vitro study experimental specimens had flat surfaces so it would be harder to accomplish proper polishing and plaque control on the prosthetic restorations. Secondly, prosthetic restoration undergoes various harsh influences in the oral environment, various proteins and enzymes are present in saliva, food products and beverages

present in the oral environment, variety of food and drink having extremes of temperature, functional and parafunctional loading, smoking and bad oral hygiene. Color changes were attributed by all these factors. Therefore, to test the oral environment influences on the color stability of provisional prosthetic material, a more comprehensive strategy should be explored in future.

## CONCLUSION

Within the limitations of this in vitro study, following conclusions were made:

- 1 Color stability of heat cure acrylic resins has influenced by the staining agents.
- 2 Turmeric powder had the highest color change which was followed by coffee among all the staining agents tested.
- 3 Appreciable changes were observed for tea and coke.

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