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Effect of Organic Acid Solutions on Color Change of Acrylic Resin Facing For Fixed Crowns and Bridges

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ABSTRACT

Aim: To evaluate the effect of the organic acid solution on color stability of the facing heat-cured acrylic resin. **Materials and methods:** Two heat-cured facing acrylic resins were used in this study. Sixty four rectangular shape specimens were prepared to evaluate the color changes of the heat-cured acrylic resin after immersion in three organic acids (acetic, citric and lactic acids). The specimens were divided into two groups according to tested resin materials, and then subdivided into four tested groups according to immersion solution, eight specimens for each subgroup. The assessment of color property (opacity) done by using ultra-violet visible spectrophotometer at wavelength 345 nm. Mean values were compared statistically with one way analysis of variance (ANOVA) followed by Duncan's multiple range test to determine the significant difference among the tested groups at (p<0.05) level of significance. **Results:** The results showed that there is a significant difference of the means value of the color change among the four tested groups for both tested materials for two different immersion periods, but there is no significant difference of color change between tested materials. Specimens immersed in acetic acid have a higher value than that immersed in other organic acids. **Conclusion:** The result of this study show that immersion in organic acids for different immersion periods had a significant effect on color stability of the facing heat-cured acrylic resin cured acrylic resin .

Key words : color change , heat-cured acrylic resin, organic acids

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INTRODUCTION

The beginning of the modern cosmetic dentistry by combining the principles of esthetic and tooth conservation[1] . Provisional crowns and fixed partial dentures are vital components of fixed prosthodontic treatments, should provide strength, protection and esthetics for teeth, which are essential factors for clinical success[2-4]. Provisional crowns and fixed partial dentures are typically fabricated from one of many available methacylate or bis-acryl resins[3-5]. Acrylic polymers have been used as facings for fixed bridges to improve the esthetic value of the restoration[6]. The principal advantages of acrylic resin when employed for these purposes are low cost ,ease of manipulation ,and ability to match tooth structure[7]. Color and translucency should be maintained during processing, and these resins should not get stained or change color in clinical use[4,8]. Staining of prostheses by colorants in service environment may be more largely responsible for color change than color instability of the material itself[9]. In the oral environment, it can be assumed that saliva, food components, beverages and interactions among these materials can degrade and age dental restorations. The resin matrices become softened with exposure to organic acids and to various food and liquid constituents[3,10]. Dietary factors and medications are commonly reported among the agents that cause discoloration of the restorative materials[11].

Therefore, color may change over time when subjected to various media, such as coffee and tea, and medicaments, such as chlorhexidine and whitening agents[5]. Discoloration of acrylic resins results in esthetic problems. Discoloration of provisional materials for fixed prosthodontics may lead to patient dissatisfaction and additional expense for replacement. This is particularly problematic when provisional restorations are subjected to prolonged exposure to colorants for long treatment. Methyl / ethyl methacrylate based and bis-acryl methacrylate based resin used as provisional materials may undergo color change when subjected to the oral environment[2,8].

The degree of color change can be affected by a number of factors including incomplete polymerization, water sorption, diet and oral hygiene[2]. Discoloration may be intrinsic or extrinsic factors. Intrinsic factors involve discoloration because of alteration of resin matrix itself or interface of matrix and fillers, oxidation or hydrolysis in resin matrix. Extrinsic factors for discoloration include staining by adsorption or absorption of colorants as a result of contamination from various exogenous sources[1,4,8].

Many organic acids occur in nature and are biologically important. They obtained from living matter, and most compounds in living matter are made up of the same few elements such as carbon, hydrogen, oxygen, nitrogen and a few others. Carbon is virtually always present. Acetic acid, citric acid and lactic acid are examples of organic acids that considered as a diet or natural fruit juice. Citric acid is added to many soft drinks and candies for flavor[3,12]. In dentistry acetic acid, and citric acid are used as chemical denture cleanser[13].

The aim of this study was to evaluate the effect of organic acids (acetic acid, citric acid and lactic acid) on the color stability of the two heat-cured acrylic resins facing fixed prostheses for two immersion periods 1 week and 1 month.

MATERIALS AND METHODS

Two different commercial heat-cured acrylic resins polymethyl methacrylate for facing of fixed prostheses were used in this study, {Major(M) Major prodotti, Italy and Quayle Dental(QD), England }. The specimens for color change testing were prepared as rectangular with length, width and thickness respectively (30 X 10 X 1.5 mm) [8], Figure (1).

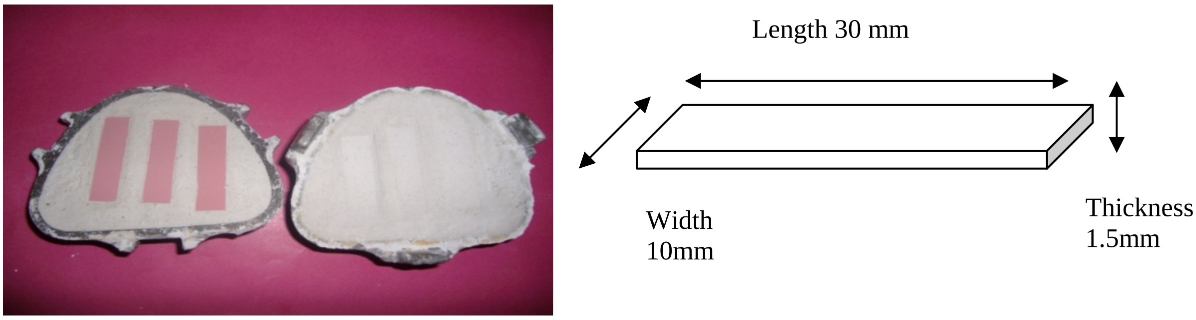

Figure (1) :Rectangular resin specimen for color testing.

The resin was mixed at powder / liquid ratio according to the manufacturer's instruction. Specimens cured with the conventional denture-flasking procedure. The specimens processed at polymerization cycle at 72°C for 1.5 hours and followed by 30 minutes at 100°C in a thermostatically controlled water bath[8].

Specimens were divided into two groups depending on the materials used. Then each group were subdivided into four subgroups depending on the organic acid solution that used, Group I (control): specimens were immersed in distilled water, according to Amirican United State Foods and Drug Administration (FDA) water chosen to simulate the oral environment provided by saliva[3]. Group II: specimens immersed in 6% (vinegar) acetic acid, acetic acid in 6% used as denture cleanser(13). Group III: specimens immersed in 2% citric acid, while Group IV: specimens immersed in 2% lactic acid to simulate the beverage in candy, syrup and fruit[3]. The immersion periods for the four tested groups were 1 week and 1 month interval at room temperature (210 C ±1) [3,9] . Sixty four specimens were prepared for testing, eight specimens for each subgroup.

According to the Colorimetry Committee ,s definition of color, it is not

strictly correct to attribute color to an object, but only to the light reflected from it. The methods of measuring the reflectance of an object at each wave length constitute one branch of the science of spectrophotometry [14,15]. The color of the object is modified by the property of opacity. Opacity is a property of materials that prevents the passage of light. An opaque material may absorb some of the light and reflect the reminder [15]. So the change of color property (opacity) was used in this study as the parameter to measure the color change. Opacity for each specimen in all subgroups was measured before and after immersion for two immersion periods (1week and 1 month) and compare the color difference between the four tested groups and between the two tested materials . The assessment of color property (opacity) was done by using ultra-violet visible spectrophotometer (CECIL, England) with accuracy up to 0.001,and at wavelength 345 nanometer (nm), Figure (2).

Figure (2) : Spectrophotometer (CECIL, England)

Spectrophotometer measure the light transmitted or reflected from colored materials[14,15].

Statistically mean values and standard deviation were calculated. Means compared with one way analysis of variance (ANOVA) followed by Duncan's multiple range test to determine the significant different among the tested groups at ($p \leq 0.05$) level of significance.

RESULTS AND DISSCUTION

The mean value of the color property (opacity) for the tested groups are shown in Table (1).

Table (1): Means of the opacity of tested groups before and after immersion for two different periods

Tested groups*		**Group I** (nm)		**Group II** (nm)		**Group III** (nm)		**Group IV** (nm)	
Immersion periods	**No**	**Major**	**QD**	**Major**	**QD**	**Major**	**QD**	**Major**	**QD**
Before immersion	**8**	1.7075	1.7200	1.7025	1.7250	1.7012	1.7213	1.7037	1.7288
1 week after immersion	**8**	1.7250	1.7425	1.7825	1.7975	1.7362	1.7500	1.7412	1.7463
1 month after immersion	**8**	1.7375	1.7662	1.8138	1.8300	1.7613	1.7788	1.7675	1.7725

***Tested groups**: Group I: control specimens immersed in distilled water. Group II: specimens immersed in acetic acid (vinegar). Group III: specimens immersed in citric acid . Group IV: specimens immersed in lactic acid . **nm =** 10^{-9} m **, No :** Samples number.

The results of ANOVA are shown in Tables (2-5). The results show there is a significant difference between the opacity of the specimens before and after immersion in the four tested groups for both tested materials (M and QD) and for both immersion periods (1 week and 1 month). This result indicate that the immersion of acrylic resin in distilled water or in an organic acid solution has an effect on the color stability of the heat-cured acrylic resin . This results come in agreement with the finding of Bagheri *etal* and others [16,17] in that staining solution, and immersion time were significant factors that affect the color stability. This result disagree with the finding of Kazanji *etal* [13] in that the color change of acrylic specimens resulting from their immersion in water was found to be insignificant, also acidic denture cleansers acetic acid (vinegar)were shown to affect insignificantly the color of acrylic resin materials.

Table (2): ANOVA for the means of the opacity of the heat- cured acrylic resins immersed in distilled water control (Group I).

Source of variation	**DF**	**Acrylic heat-cured resins**					
		Major resin			**QD resin**		
		Mean square	**F**- value	*P*-value	**Mean square**	**F**-value	*P*-value
***Immersion periods**	2	0.001817	12.31	0.000	0.004279	13.75	0.000
Error	21	0.000148			0.000311		
Total	23						

* Immersion periods :Before immersion, 1 week immersion ,1 month immersion. DF : Degree of freedom

Table (3): ANOVA for the means of the opacity of the heat-cured acrylic resins immersed in vinegar (Group II).

Source of variation	**DF**	**Acrylic heat-cured resins**					
		Major			**QD**		
		Mean square	**F**-value	*P*-value	**Mean square**	**F-value**	***P*-value**
***Immersion periods**	2	0.026337	82.70	0.000	0.023117	67.90	0.000
Error	21	0.000318			0.000340		
Total	23						

* Immersion periods :Before immersion, 1 week immersion ,1 month immersion. DF : Degree of freedom

Table (4): ANOVA for the means of the opacity of the heat-cured acrylic resins immersed in citric acid (Group III).

S.O.V	**DF**	**Acrylic heat-cured resins**					
		Major			**QD**		
		MS	**F-value**	***P*-value**	**MS**	**F-value**	***P*-value**
***Immersion periods**	2	0.007267	14.73	0.000	0.006612	14.81	0.000
Error	21	0.000493			0.000446		
Total	23						

* Immersion periods :Before immersion, 1 week immersion ,1 month immersion. DF : Degree of freedom

Table (5): ANOVA for the means of the opacity of the heat-cured acrylic resins immersed in lactic acid (Group IV).

S.O.V	**DF**	**Acrylic heat-cured resins**					
		Major			**QD**		
		MS	**F-value**	***P*-value**	**MS**	**F-value**	***P*-value**
***Immersion periods**	2	0.008212	16.87	0.000	0.003879	13.52	0.000
Error	21	0.000487			0.0002872		
Total	23						

* Immersion periods :Before immersion, 1 week immersion ,1 month immersion. P** Means are highly significant different at P≤0.01. DF : Degree of freedom, MS : Mean square, s.o.v: Source of variation .

The results of Duncan Multiple Range test for color property (opacity) are represented in Tables (6 - 9). The results show that the mean value of the opacity of the specimens in the four tested groups were increased after immersion. The increased in the opacity of the resin specimens in control Group I (immersed in distilled water) can be explain in that the polymethyl methacrylate acrylic resins were hydrophilic materials [13]. Water sorption has detrimental effect on the color stability[18] . The more color change due to higher water sorption[2,10] . Water accumulation and photo-oxidation have been reported to be responsible for internal color change. This result come in agreement with the finding of Arthur *etal* and others[2,10,19] in that water plays an important role in chemical degradation processes such as oxidation and hydrolysis and the subsequent change of the optical properties of the provisional restorative materials .

The increased in the opacity of the resin specimens that immersed in organic acids Group II (immersed in vinegar, acetic acid), Group III (immersed in citric acid) and Group IV (immersed in lactic acid) can be explain in that staining susceptibility of resin might be attributed to their degree of water sorption and hydrophilicity of the matrix resin. If the resin can absorb water , then it is also able to absorb other fluids, which results in its discoloration(13,17). The acidic solution affects degradation of resin materials. This effect has been discussed in term of matrix decomposition. The matrix decomposition is suggested to be due to the hydrolysis of the matrix. Methacrylic acid was produced as a result of the degradation process due to hydrolysis of the polymer matrix. The degradation process associated with sorption process and swelling of the matrix that cause release of the organic substances and resulting in a mass loss (20), the phenomena of sorption and solubility producing chemical changes such as oxidation and hydrolysis and color change (21,22). The weak intraoral acids (acetic acid, citric and lactic acid) have deleterious effects on the resin matrix (3) Citric acid solutions have a capability of calcium extraction from a resin matrix.(19,23).

The result in Table (1) shows that the specimens that immersed in acetic acid(vinegar) have the higher value of opacity than that of the specimens immersed in other tested groups, this high value related to the pigment of natural apple vinegar solution (24). This result come in agreement with the finding of Nur etal (8) in that polymethyl methacrylate is a hydrophilic material that attract more water soluble dyes on the surface as a result of the electrostatic charges.

Table (6): Duncan Multiple Range test for the opacity of the heat cured acrylic resins immersed in distilled water (controlled Group I).

Immersion periods	No	Acrylic heat-cured resins			
		Major		QD	
		*Mean ±SD(nm)	**Grouping**	*Mean ±SD(nm)	**Grouping**
Before immersion	8	1.7075 ± 0.0167	**A**	1.7200 ± 0.0200	**A**
1 week immersion	8	1.7250 ± 0.0107	**B**	1.7425 ± 0.0158	**B**
1 month immersion	8	1.7375 ± 0.0071	**C**	1.7662 ± 0.0169	**C**

*Means for each resin material with different letters vertically are highly significantly different. No : Samples number, SD : Standard deviation, nm = 10^{-9} m.

Table (7): Duncan Multiple Range test for the opacity of the heat-cured acrylic resins immersed in vinegar(Group II).

Immersion periods	No	Acrylic heat-cured resins			
		Major		QD	
		***Mean ±SD**(nm)	**Grouping**	***Mean ±SD**(nm)	**Grouping**
Before immersion	8	1.7012 ± 0.0270	**A**	1.7213 ± 0.0196	**A**
1 week immersion	8	1.7362 ± 0.0213	**B**	1.7500 ± 0.0239	**B**
1 month immersion	8	1.7613 ± 0.0173	**C**	1.7788 ± 0.0196	**C**

*Means for each resin material with different letters vertically are highly significantly different. No : Samples number, SD : Standard deviation, nm = 10^{-9} m .

Table (8): Duncan Multiple Range test for the opacity of the heat-cured acrylic resins immersed in citric acid (Group III).

Immersion periods	No	Acrylic heat-cured resins			
		Major		QD	
		***Mean ±SD** (nm)	**Grouping**	***Mean±SD** (nm)	**Grouping**
Before immersion	8	1.7025 ± 0.0139	**A**	1.7250 ± 0.0131	**A**
1 week immersion	8	1.7825 ± 0.0183	**B**	1.7975 ± 0.0225	**B**
1 month immersion	8	1.8138 ± 0.0207	**C**	1.8300 ± 0.0185	**C**

*Means for each resin material with different letters vertically are highly significantly different. No : Samples number, SD : Standard deviation, nm = 10^{-9} m

Table (9): Duncan Multiple Range test for the opacity of the heat-cured acrylic resins immersed in lactic acid(Group IV).

Immersion periods	No	Acrylic heat-cured resins			
		Major		QD	
		***Mean ±SD**(nm)	**Grouping**	***Mean ±SD**(nm)	**Grouping**
Before immersion	8	1.7037 ± 0.0213	**A**	1.7288 ± 0.0155	**A**
1 week immersion	8	1.7412 ± 0.0242	**B**	1.7463 ± 0.0130	**B**
1 month immersion	8	1.7675 ± 0.0212	**C**	1.7725 ± 0.0205	**C**

*Means for each resin material with different letters vertically are highly significantly different. No : Samples number, SD : Standard deviation, nm = 10^{-9} m .

The result in Tables (10 and 11) show there is a difference between the color change (opacity change) of the tested resin materials (Major and QD) after 1 week of immersion in distilled water (Group I),but the color change was not significant. The color change can be explained in that the resins used in this study had the same base chemical structures (polymethyl methacrylate); however, each of them contain small quantities of different cross linking agents, plasticizers, and pigments, which may explain the difference in staining properties (hydrophilicity) of resins [8].

Table(10) : ANOVA for the means of the opacity change of the tested heat-cured acrylic resins immersed in distilled water(Group I)after 1 week period.

Source of variation		Acrylic heat-cured resins		
		MS	**f-value**	*p-value*
***Tested materials**	1	0.000100	0.34	0.568
Error	14	0.000293		
Total	15			

*Tested materials : heat-cured acrylic resin Major and heat-cured acrylic resin QD, P** Means are not significant different at P≤0.05. DF : Degree of freedom, MS : Mean square , s.o.v: .

Table (11) : Duncan Multiple Range test for the mean of the opacity change* of the heat-cured acrylic resins immersed in distilled water(Group I) after 1 week period.

Tested materials	No	****Mean** ±**SD**(nm)	Grouping
Major	8	0.01750 ± 0.01982	**A**
QD	8	0.02250 ± 0.01389	**A**

*Opacity change = opacity mean after immersion – opacity mean before immersion, **Means: with same letter vertically are not significant different at $P \leq 0.05$. No : Samples number. SD : Standard deviation. nm = 10^{-9} m .

CONCLUSSION

The result of this study showed that there is a significant difference of the color property(opacity) of the specimens of the facing heat-cured acrylic resin before and after immersed in organic acid solution and the changes of the color are increased with the time. The color change was not significant between the tested resin.

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