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RESEARCH ARTICLE - MEDICAL TECHNIQUES

Effect of Ethylmethacrylate and Isobutylmethacrylate on Surface Hardness and Surface Roughness of Heat-Cure Ocular Acrylic Resins

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Abstract

Background Acrylic resin is a commonly utilized material in clinical practice, including: maxillofacial prosthesis Interim prostheses, repair dentures, reline, orthodontic equipment, and record bases are only a few examples of possible applications. However, these materials have some drawbacks, for example low mechanical properties. To improve the performance of the acrylic resins, various materials have been incorporated.
Purpose: The purpose of this research is to assess the effects of adding different concentrations of copolymers of Ethyl methacrylate (EA) and Isobutyl methacrylate (IBMA) monomers on some of the mechanical properties of acrylic resin such as surface hardness and surface roughness.
Approach: 100 samples were made of acrylic resin and were divided into three groups (a control group and two experimental groups). Twenty samples were used for the control group and these samples were divided into ten samples for each group based on the tests performed. While 40 samples per experimental group (IBMA, EMA) were divided into two groups according to the added concentration (1% and 2%). Then, according to the tests performed, each group was divided into two groups with ten samples for each group. Acrylic samples were fabricated with dimensions of 65 mm x 10 mm x 2.5 lengths, width and thickness respectively according to (ADA specification, No.12, 1999). Each specimen was subjected to the surface hardness test and surface roughness test. All data were analyzed using SPSS version 20, One – way ANOVA, LSD and Post Hoc -Tukey test were utilized for detecting the significant differences and multiple comparisons.
Results: The control group had the greatest mean value of hardness compared with the experimental group while the EMA 1% group showed the lowest mean value of roughness test compared with the control and other experimental groups.
Conclusion: The incorporation of experimental groups (IBMA, EMA) in different concentrations by weight in MMA and PMMA had a decrease slightly of surface hardness of acrylic resins, and the incorporation of EMA 1% by weight in MMA and PMMA had improved surface roughness. In added EMA2%, IBMA 2% enhanced slightly the surface roughness of acrylic resins.

Keywords: Copolymers; Acrylic Resins; Surface Hardness; Surface Roughness; Artificial Eye

1. Introduction

In addition to vision loss, partial or total eye loss influences on the patient's personality and community presence. Because the eyes are such a crucial part of human relationships, one of the fundamental goals of the artificial eye is to enable reintegration into society [1, 2]. Throughout history, the technology of manufacturing eye prostheses has improved, allowing for a more aesthetically pleasing replacement of the eye [3, 4]. An ocular prosthesis is a device that imitates the shape of the eye and its surrounding tissues while retaining the socket's volume. Perfect color, contour, size, and alignment, identical to that of a natural eye, are required to produce realism and symmetry. An ocular defect can be repaired with ready- made eyes or a custom-made prosthesis [5].

Nomenclature			
EA	Ethyl methacrylate	NS	Non–Significant
P	P-Value	S	Significant
SPSS	Statistical Package for the Social Sciences	IBMA	Isobutyl methacrylate
G	gram	PMMA	Poly Methyl Methacrylate
mm	Millimeter		

The most common type of eye prosthesis is a conventional ocular prosthesis composed of heat-cured acrylic resins [6]. It has a variety of advantages including ready availability, colour stability, the ability to be relined and repaired, good strength, the ability to be fabricated with a feather margin, and two-year shelf life [7]. However, the acrylic resins have some drawbacks such as mechanical properties are insufficient [8, 9]. Therefore, various materials have been incorporated into the PMMA matrix to strengthen the acrylic prosthesis [10-12].The process of making an orbital prosthesis begins with taking an impression with a custom ocular tray to making the mold [13, 14] The scleral wax pattern was then created by pouring molten baseplate wax into the mold and then testing it in an eye socket to ensure that the contours of the eyelids were satisfactory[15, 16]. The wax pattern was flaked and processed with a heat clear acrylic resin, after complete the process of the ocular prosthesis is trimming and polishing and give the patient instructions to return for follow-ups after the ocular prosthesis has been put into the eye socket. [17, 18].
The goal of this research is to evaluate the effect of addition varying amounts of Isobutyl methacrylate (IBMA) and Ethyl methacrylate (EMA) on the surface hardness and surface roughness of the acrylic resin.

2. Materials and Methods

2.1. Samples grouping

100 samples were fabricated from clear acrylic resins and divided into three groups (control and two experimental group).

2.1.1. Group (I) (control group)

20 samples of clear acrylic resin without any addition divided into two groups with ten samples for each group according to the tests performed.

2.1.2. Group (II) (experimental groups)

40 samples of clear acrylic resin were divided into two groups based on adding different concentrations (1%, 2%) of Isobutyl methacrylate monomer (IBMA), Thereafter each group was subdivided into two groups, ten samples for each test.

2.1.3. Group (III) (experimental groups)

40 samples of clear acrylic resin divided into two groups based on adding different concentrations (1%, 2%) of Ethyl Methacrylate Monomer (EMA), Thereafter each group was subdivided into two groups, ten samples for each test.

2.2. Specimens design

The plastic pattern of the acrylic sample was constructed with a dimension of 65 mm (length), 10 mm (width), 2.5 mm (thickness) according to (ADA Standard No 12. ,1999) [19, 20] as shown in Fig. 1.

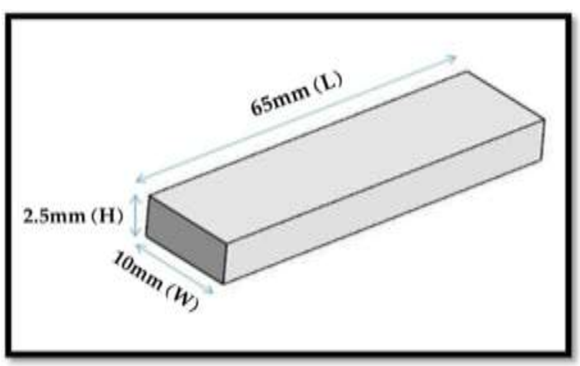

Fig. 1 Specimen for surface hardness, surface roughness

2.3. Proportioning, mixing ratio and incorporation of copolymers (EMA, IBMA) with heat- cured acrylic resin

The control group was fabricated by combining 22 g of powder with 10 ml of a liquid monomer according to the manufacturer's instructions and packed into the mold space. A clean, dry ceramic jar was used for mixing. at first, petroleum jelly was applied to the sample models before use to remove it from the stone mold, as well as the upper and lower parts of the metal flask. After that dental stone and water were mixed in

the creamy state by hand according to manufacturer's recommendations, the mixture was poured into the lower half of flask and the carefully plastic pattern was placed in the center, the half of the pattern should be visible so that they can be easily removed from the stone mold after the surface of the stone is completely set, separating medium was applied. The upper part of the flask was positioned correctly and new batch of dental stone was mixed and applied to both the patterns and the surface of the stone are left for one hour to set. then, the flask was opened carefully to remove the pattern from the mold. Acrylic specimens were packed into the mold space and the flasks were then tightened with low pressure to ensure proper material flow within the mold. Specimens were then cured in a water bath device. finally, finished and polished [21, 22]. For two days, acrylic specimens were maintained in distilled water [10].
The concentration of 1% and 2% of IBMA and EMA by the addition of volumetric to the methyl methacrylate (MMA) of acrylic resins by using Automatic pipette [23] as shown in the table 1.

Table 1 Volumetric percent of monomers

Specimens	PMMA	MMA
control acrylic specimens	22 g	10 ml MMA
Specimens of 1% EMA	22g	9.9ml MMA+0.1ml EMA
Specimens of 2% EMA	22g	9.8ml MMA+0.2ml EMA
Specimens of 1% IBMA	22g	9.9ml MMA+0.1ml IBMA
Specimens of 2% IBMA	22g	9.8ml MMA+0.2ml IBMA

2.4. Testing procedure

2.4.1. Surface hardness test

The surface hardness was tested using a Vickers microhardness tester (Digital Micro Vickers Hardness Tester TH714) with a 50 g load for 15 seconds. Three reading were taken (left, middle and right), and the average of these three readings represents the surface hardness. [19].

2.4.2. Surface roughness test

The tester was a portable digital roughness profilometer. The profilometer's diamond stylus moves in close proximity to the specimen's surface three times to collect three measurements. The roughness is measured by the average of the three readings [20, 24].

3. Statistical Analysis

3.1. Surface hardness test

A- As in Table 2 shown that the highest mean value of hardness in the control group. While, the lowest mean value in EMA 1% group, the result of the One-Way ANOVA was significant differences (P<0.05) among all tested groups.

Table 2 Descriptive statistics for hardness test of all studied group

Studied groups	N	Mean	Std. Deviation	ANOVA test
Control	10	26.5190	2.81491	***P*= 0.002 (S*)**
IBMA 1%	10	25.9100	3.33203	
IBMA 2%	10	23.3780	1.65966	
EMA 1%	10	22.9250	1.46182	
EMA 2%	10	24.0570	.58718	
Total	50	24.5578	2.54829	

****S:* significant (*P* < 0.05)**

B- The Least Significant Difference- LSD test as in table 3 revealed that non- significant differences (P>0.05) between the control group and IBMA 1% and between experimental groups (IBMA 1% and EMA 2%; IBMA 2% and EMA 1%; IBMA 2% and EMA 2%; EMA 1% and EM 2%).
Also, significant differences (P < 0.05) between the control and experimental groups (IBMA 2%; EMA1%, EMA 2 %) and between experimental groups (IBMA 1% and IBMA 2 % and IBMA 1% and EMA 1%) as shown in Table 3.

Table 3 Multiple comparisons of Hardness test using LSD test

Groups		P- Value	Sig.
Control	IBMA 1%	.540	N.S
	IBMA 2%	.003	S
	EMA 1%	.001	
	EMA 2%	.016	
IBMA 1%	IBMA 2%	.014	
	EMA 2%	.066	N.S
	EMA1%	.004	S
IBMA 2%	EMA 1%	.648	N.S
	EMA 2%	.494	
EMA 1%	EMA 2%	.257	

3.2. Surface roughness test

A- Results indicated that the control group presented the highest mean value while the EMA 2% group showed the lowest mean value, in addition, the result of the One-Way ANOVA was significant differences among all tested groups at ($P < 0.05$) as demonstrated in Table 4.

Table 4 Descriptive statistics for Surface roughness test of all groups

Studied groups	N	Mean	Std. Deviation	ANOVA test
Control	10	1.12	.32	
IBMA 1%	10	.81	.45	
IBMA 2%	10	1.04	.41	***P*= 0.011 (S*)**
EMA 1%	10	.66	.16	
EMA 2%	10	.73	.16	
Total	50	.87	.36	

***S:* significant (*P* < 0.05)**

B- Post Hoc -Tukey test revealed no significant differences (P>0.05) between the groups except EMA 1% and control groups test as shown in table 5.

Table 5 Multiple comparisons of Surface roughness using Tukey test

Groups		P- Value	*Sig.*
Control	**IBMA 1%**	.236	**N.S**
	IBMA 2%	.980	**N.S**
	EMA 2%	.071	**N.S**
	EMA 1%	.025	**S**
IBMA 1%	**IBMA 2%**	.543	**N.S**
	EMA 1%	.848	**N.S**
	EMA 2%	.976	**N.S**
IBMA 2%	**EMA 1%**	.097	**N.S**
	EMA 2%	.227	**N.S**
EMA1%	**EMA 2%**	.993	**N.S**

4. Discussion

Heat cure acrylic resins are commonly used in the fabrication of ocular prostheses [20] due to their chemical and mechanical properties, for e.g. it can be used with oral tissues, highest biocompatibility properties and it is insoluble [13]. This material is not perfect in all respects, its popularity and use are due to a variety of features rather than one desirable property and despite these benefits, the properties of this material deteriorate over time, which requires re-manufacturing of the prosthesis [13, 25]. Polymethyl methacrylate has been exposed to a variety of techniques, including the use of several types of reinforcing materials, in an attempt to improve its mechanical properties [10].

4.1. Surface hardness test (SH)

The current study's findings revealed: a significant difference ($P < 0.05$) between the control and experimental group (IBMA 2%; EMA1%, EMA 2 %), a high mean values of hardness test were obtained the control group as shown in table (2) This could be due to residual monomer content which has a negative effect on SH [26] or may be due to the crosslinking PMMA with polyfunctional monomers increases the SH [27, 28]. the SH for other samples has been decreasing can be related to the continuing polymerization reaction monomer release and the combination of monomers with free active radicals by bonding with liberated oxygen [28].

4.2. Surface roughness test

Results of the surface roughness test indicated no significant difference between the control group and experimental groups except control group and EMA 1%, a high mean value of surface roughness test was obtained in the control group as shown in table (4) The specific reason for the experimental groups' smooth surfaces is unknown, there were no published articles regarding the effect of copolymers on surface roughness of acrylic resins. surface roughness discrepancies may have been altered by the addition of EMA and IBMA comonomers. This study used the mechanical polishing technique, which produces a lower surface roughness than chemical polishing [21]. Similar research has been done on Surface roughness with monomer modifications which indicates that the incorporation of Fluoralkyl methacrylate in MMA to reduce the surface roughness of PMMA specimens, the difference was not significant When compared to the control [29].

5. Conclusion

1- The incorporation of experimental groups (IBMA, EMA) in different concentrations by weight in MMA and PMMA had slightly decreased the surface hardness of acrylic resins.

2- The incorporation of EMA 1% by weight in MMA and PMMA had improved surface roughness. While adding EMA2%, IBMA 2% enhanced slightly the surface roughness of acrylic resins.

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