Effect of phosphate ester addition on transverse strength and hardness of heat cured acrylic denture base material

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ABSTRACT

Background: acrylic resin denture base consider a common denture base material for its acceptable cost, aesthetic and easy processing but still has disadvantages including easy of fracture and low impact strength.

Material and method: The experimental group was prepared by addition of 15% phosphoric acid 2-hydroxyethyl methacrylate ester (PA2HEME) with polymethyl methacrylate monomer; the experimental groups was compared with the control one. The specimens were prepared according to ADA specification No. 12 with dimension 65 mm x 10 mm x2.5 mm (length x width x thickness respectively). The prepared specimens were tested by three-point flexural strength utilizing Instron Universal Testing Machine (WDW, Layree Technology Co.), Shore D hardness tester used to measure hardness test. Statistical analysis used student T- test, mean and standard deviation.

Results: The result of PA2HEME group showed high significant reduction comparing to the control group for both transverse strength and hardness test.

Conclusion: Mixing 15% of PA2HEME with 85% methyl methacrylate (MMA) can reduce the mechanical properties of new modified polymethyl methacrylate (PMMA) acrylic resin.

Keyword: phosphoric acid 2-hydroxyethyl methacrylate ester, transverse strength and hardness. **(J Bagh Coll Dentistry 2018; 30(2):5-9)**

INTRODUCTION

The PMMA consider the most widely used material as denture base due to its favorable mechanical properties and its ability for modification [(1)] and the perfect resin material should have adequate biological response and mechanical properties. However, the mechanical properties of PMMA are important for function of removable denture such as compressive strength, tensile strength, dimensional stability, hardness, transverse strength and solubility [(2)]. Addition of 15% PA2HEME to the heat cure acrylic denture base significantly reduced candida albicans adhesion and porosity [(3)], however according to Park et al., 2003, They found that modifying the PMMA with methacrylic acid to produce negative charge polymer could reduce denture stomatitis but with reduction in the physical properties of material[(1)]. The aim of this study was to evaluate the effect of phosphoric acid 2-hydroxyethyl methacrylate ester containing PMMA group on following properties: Transverse strength and Hardness test.

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MATERIALS AND METHODS

Modified PMMA (mPMMA) polymer was prepared by addition phosphoric acid 2-hydroxyethyl methacrylate ester (Sigma Aldrich) to methyl methacrylate monomer in 15% ratio then mixed with powder (vertex) according to manufacturer's instruction. The P/L ratio was every 50g of PMMA was added to 22.7 ml of MMA monomer. Two groups were prepared in the present study, they were divided into group A control (vertex dental BV), group B phosphoric acid 2- hydroxyethyl methacrylate ester containing group. Ten rectangular shape samples were prepared for transverse and hardness test according to ANSI/ADA No.12, 1999 with dimension 65 mm length x 10 mm width x 2.5 mm thickness. The samples kept in distal water at 37°cfor 48 hours before testing to remove residual monomer.

The flexural strength was measured by Instron testing machine. The acrylic strip was positioned at each end of metal rollers at 50 mm distance between two ends with centrally located rod that applied the load till fracture with cross head speed 5mm/min speed. The Surface hardness was obtained by using a durometer hardness tester (shore D hardness) which consider acceptable for acrylic (plastic) material. The instrument consist of a blunt indenter (0.8 mm in diameter) that locate in cylinder (1.6 mm in diameter), which connect to a digital scale graduated from zero to 100 unit. The specimens

were prepared for each group A and B. five readings were measured for every specimen, mean of these five reading was recorded as hardness value. In Statistical analysis, the mean, standard deviation and student T- test were used for each group.

RESULTS

The PMMA and modified PMMA polymers were examined by FTIR to determine about the presence of OH group. The result of test showed a changes occurred in area between 2800- 3100 cm^{-1} of FTIR spectra of hydroxlated polymer which gave a broad band in 2950- 3050 cm^{-1} as compare to the control group. In addition, the result of FTIR showed for mPMMA that there is no humidity in the region of 2800- 3100 cm^{-1} while the humidity present in the control PMMA as in figure (1) and (2).

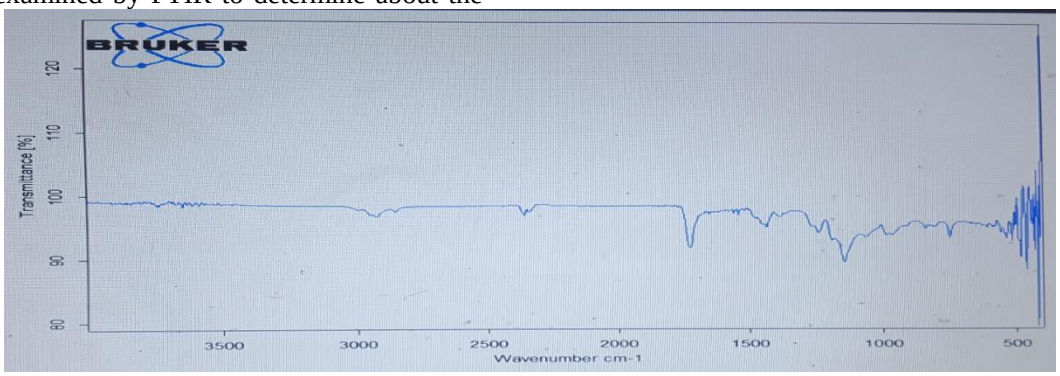

Figure (1) FTIR analysis for mPMM

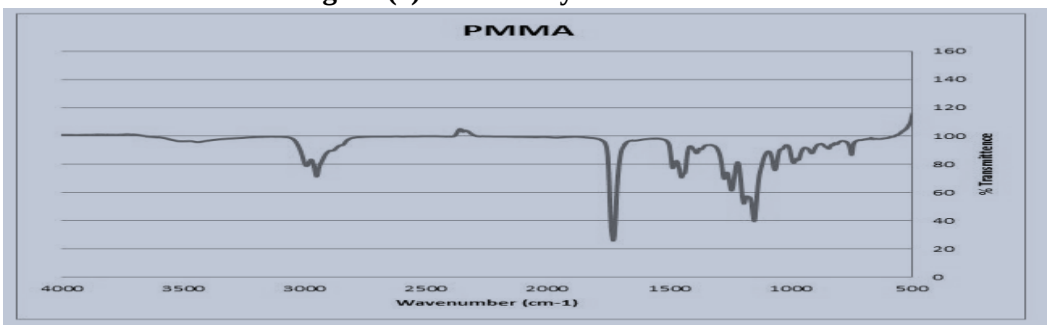

Figure (2) FTIR analysis for control PMMA

A- Transverse strength results

Means of transverse strength test for control and PA2HEME containg groups are shown in figure(3).

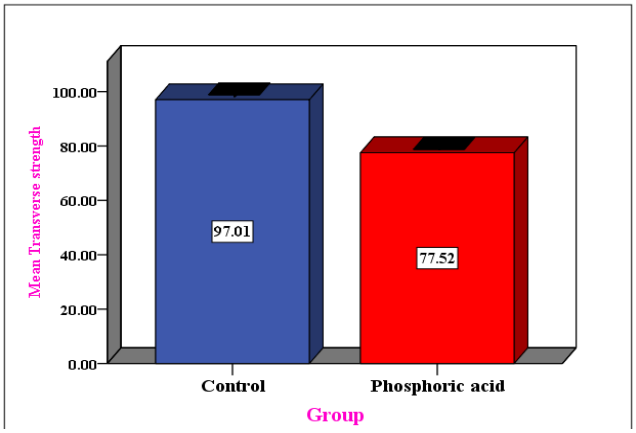

Figure (3) the mean of transverse strength by groups

The results in table (1) showed that the control group had higher transverse strength (97.014) than experimental group (77.520) with high significant differences between them when P < 0.05.

Table (1) descriptive and statistical test of transverse strength between groups

group	number	mean	SD	T	df	P- value
Control	10	97.014	1.596	34.769	18	0.000
PA2HEME	10	77.520	.773			

B-Hardness test results

The results of hardness test for control and PA2HEME groups are shown in table (2) and figure (4). The control group had higher hardness values than experimental group with high significant difference with P-value ≤0.001.

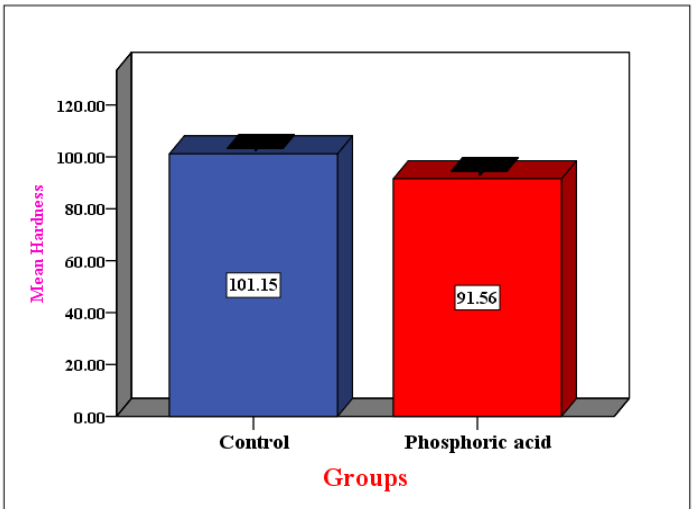

Figure (4) the mean of hardness test by groups.

Table (2) descriptive and statistical test of hardness test between groups.

group	number	mean	SD	T	df	P-value
control	10	101.150	1.773	8.804	18	0.000
PA2HEME	10	91.560	2.953			

DISCUSSION

In the present study, 15% of PA2HEME added to monomer then mixed with acrylic resin powder to produce a new modified PMMA in order to improve both biological and mechanical properties, however this addition reduced the transverse strength and hardness. In addition, changing the material in order to improve one property may lead to deteriorates effect on other properties. The effect of this addition on mechanical properties was evaluated by measuring, transverse strength and hardness test.

Mixing two different types of liquid (MMA and PA2HEME) produced new polymer with free hydroxyl group that give a negative charge to the new structure of polymer which in turn effect on mechanical properties [4].

Hardness test

The results of hardness test showed highly significant reduction with P- value ≤ 0.05 of hardness test for phosphoric acid containing group with mean comparing to control group with mean, this could be due to PA2HEME prevent enlargement of polymer chains, thus alter the physical characteristics of new PMMA [5].

Furthermore, the reduction in hardness test may result from the reduction of other components of monomer like ethylene glycol dimethacrylate (EGDMA) which is cross-linking agent [5].

The reduction in hardness of PA2HEME group may resulted from lengthen ester chain of mPMMA that increased the flexibility of material, this agree with Pavle et al., 2015 who used Itaconic acid instead of methacrylic acid for its advantageous point as a natural product [7-8] and less toxic [9], however; he found as the concentration of itaconic acid increase, both stiffness and deformation of the material increase, probably this occur due to plasticization action of aliphatic chain of itaconic acid, in addition, adding a methylene unite to increase the length of ester chain could increase the flexibility of material that cause internal plasticization of material. Although, water sorption and solubility were not measured in the present study, the negatively charged polymer increased water sorption and increase the hydrophilicity of material [1]. There is hydrophilic radicals that could enhance water sorption and water considers complex solvent that interact with polymer because its polarity and forming hydrogen bonds that enable it to cluster and lead to plasticization of material matrix [10].

Transverse strength

Theresults showed highly significant reduction in transverse strength of phosphoric acid containing group compare to control group and this probably result from the dilution of the cross-linking agent (EGDMA), since denture acrylic resin consist of powder (prepolymerized PMMA), monomer (MMA) and cross-linking agent (EGDMA), once polymerization reaction begin, the monomer partially dissolve in the polymer to produce a new larger molecular weight

Polymer with the help of cross-linking agent. The cross-linking agent add to concentration range between 5%-6% by weight, which may assist in growing the chain of polymerized polymer. However, in 1995, Arima et al., found that increasing the concentration of cross-linking agent could increase the flexural strength and modulus.

The results go in agreement with those obtained by Gunjan et al., 2007 who found that increase the concentration of experimental phosphate compound, the flexural strength and modulus decreased. Furthermore, the reduction of transverse strength of mPMMA could attributed to the repulsion forces created inside the polymer which is became obvious when the polymer is subjected to mechanical tests like transverse strength or tensile test, because these repulsion internal forces could, effect on modulus of elasticity which consider the basic response of material to subjected forces, this agree with Sang et al., 2009. . The addition of 15% of PA2HEME could reduce the transverse strength and hardness of new PMMA. However, many methods introduced to improve the mechanical properties of new PMMA in cooperation of fiber like polyethylene, carbon and glass [13-16]. Also incooperation of fiber found to be effectively increased the transverse strength of PMMA [17]. Although a pervious study suggest, addition of fiber may increase roughness of PMMA [18].

CONCLUSION

Modification of PMMA with PA2HEME cause high significant reduction in the transverse strength and hardness of mPMMA.

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الخلاصة

الخلفية: الاكريليك الراتنج لقاعدة الأسنان تعتبرواسعة الاستخدام بسبب تكلفتها مقبولة، الجمالية ،قابلة للمعالجة ولكن لا يزال لديه عيوب بما في ذلك سهولة الكسر و قوة التأثير.

المواد وطرق البحث: تم تحضير المجموعة التجريبية بإضافة 15٪ حمض الفوسفوريك 2-هيدروكسي إيثيل ميثاكريلات استر مع مونومر ميثاكريلات متعدد الميثيل. تم تحضير العينات طبقا للمواصفة رقم ADA مع البعد 65 مم × 10 مم × 2.5 مم (الطول × العرض × السماكة على التوالي). تم إعداد العينات لاختبار ثلاث نقاط اختبار قوة الثني باستخدام إنسترون العالمي اختبار آلة ، شور D اختبار صلابة تستخدم لقياس اختبار صلابة.

النتائج: أن مجموعة PA2HEME قد سجلت نسبة قليلة لقوة عرضية واختبار صلابة مقارنة مع مجموعة السيطرة.

الاستنتاج: ان خلط 15% من PA2HEME مع 85% من المونيمر قد قللت جدا نسبة التصاق الفطريات لمادة الراتنج ولكن مع تقليل الصفات الميكانيكية