Journal of Kerbala University , Vol. 8 No.1 Scientific . 2010

Effect of Different Polymerization curing times and Water Temperatures on Transverse Strength of Self-Cure Acrylic Resin Material

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Abstract

The self-cured acrylic resin is inferior to heat cured acrylic resin from stand point of strength and degree of polymerization. Many attempts have been made to improve these properties.

Because heat affects maturity of the chemical reaction of acrylic resin therefore its maintenance during polymerization will affect the mechanical properties of cured resin. This study was carried out to evaluate the effect of different curing time and heat application during polymerization of the self-cured acrylic resin on transverse strength compared with that polymerized in air at 23°C ± 5°C.

Nineteen (90) Self-cured acrylic resin specimens were prepared and divided as follow:- (10) specimens polymerized in air at 23°C ± 5°C under press (bench curing) as a control group. (40) specimens polymerized in water at 20°C, 40°C, 60°C, and 80°C, under (30 psi) pressure for 15 minutes . (40) specimens polymerized in water at 20°C, 40°C, 60°C, and 80°C, under (30 psi) pressure for 30 minutes. All specimens were tested for transverse strength.

Results showed that self-cured acrylic resin specimens polymerized in 15 minutes has a significant lower transverse strength than polymerized in 30 minutes. The transverse strength of the test specimens polymerized in water at 20°C lower than control group, while all degree of polymerization improved transverse strength, however, in 80°C highest transverse strength compared with the other temperatures control group.

It can be concluded that increasing curing time and water temperature during polymerization will improve transverse strength of self-cured acrylic resin.

الخلاصة:-

يعتبر الاكريل الراتنجي المعالج ذاتيا أدنى من الاكريل الراتنجي المعالج حراريًا في نقطة ثابتة من القوه واكتمال البلمره .وقد جرت العديد من المحاولات لتحسين هذه الصفات. بسبب تأثيرات الحرارة على نضوج التفاعل الكيميائي للاكريل الراتنجي لذلك وجودها اثناء البلمره سوف تؤثر على الخواص الميكانيكية للراتنج المتبلمر. هذه الدراسة أجريت لتقيم تأثير اختلاف وقت الطبخ واستخدام الحرارة أثناء تبلمر الاكريل الراتنجي المعالج ذاتيا على مقاومة الانحناء ومقارنتها مع ذلك المتبلمر في الهواء عند 5 ±23 درجة سيليزية. تسعون عينة اكريلك (90) حضرت وقسمت كالأتي (10) بلمرة في الهواء عند 5±23 درجة سيليزية تحت الضغط كمجموعة سيطرة , (40) عينة بلمرت في الماء عند 20 درجة سيليزية و40 درجة سيليزية و 60 درجة سيليزية و 80 درجة سيليزية تحت ضغط (30باسسكال /أنج^2) لمدة 15 دقيقة, (40) عينة بلمرت في الماء عند 20 درجة سيليزية و40 درجة سيليزية و 60 درجة سيليزية و 80 درجة سيليزية تحت ضغط (30باسسكال /أنج^2) لمد 30 دقيقة . فحصت قوة الانحناء باستخدام جهاز الاختبار Instron.

أظهرت النتائج أن الاكريل الراتنجي المعالج ذاتيا والمتبلمر في 15 دقيقة يملك قوة انحناء اقل تاثير ($P < 0.05$) من الاكريل الراتنجي المبلمر في 30 دقيقة وان قوة الانحناء لعينات الاختبار المبلمرة عند 20 درجة سيليزية كانت اضعف من مجموعة السيطرة , بينما كل درجات البلمرة حسنت قوة الانحناء , تم الحصول على اعلى قيمة موثرة لقوة الانحناء عند 80 درجة سيليزية مقارنة مع درجات الحرارة الاخرى ومجموعة السيطرة .

يمكن الاستنتاج بان زيادة وقت الطبخ ودرجة الحرارة اثناء عملية البلمرة سوف تحسن قوة الانحناء للاكريل الراتنجي المعالج الذاتيا

Introduction

Self-cured acrylic resin is one of the most frequently used materials in dentistry for repairs, relines, orthodontic appliances, maxillofacial prosthesis in addition to its use in crown and bridge work as a temporary coverage of prepared tooth [1,2,3,4].

The wide use of self-cured acrylic resin in prosthetic work is mainly related to its simple technique at room temperature, less time consuming and less equipment required [5]. While the strength properties of the self-cured acrylic resin is lower than that of the heat cured type due to lower degree of polymerization of the self-cured acrylic resin with high residual monomer which act as a plasticizer and lower its strength properties [6,7,8,9], residual monomer concentration resulting from incomplete conversion of monomers into polymers varies with the method and the condition of polymerization [10,11]

Although the cold-curing acrylic resins have less polymerization shrinkage and less dimensional change during curing, they leave more porous surface on denture, therefore many investigation have been reported to study the effect of curing method on the porosity of the self-cured acrylic resin [12,13,14] referred that the porosity of chemically activated acrylic resin can be reduced by polymerizing under pressure and elevated temperature.

Because heat activates the chemical reaction of the acrylic resin therefore, placing the provisional resin restoration in hot water is an accepted procedure and often is recommended in the manufacturer's direction [15].

Several studies were obtained less residual monomer in the resin whenever the effect of time, heat and pressure on polymerization reaction and strength of the self-cured acrylic resin was concluded a greater degree of conversion [16,17,18,15].

Materials and Methods:

Methods:

(90) Specimens were prepared from pink cold-cure acrylic resin denture base as follow:-

Group A: (10 samples) Self-cure acrylic resin processed in air, bench curing method, for two hours at 23°C ± 5°C [19] under (20 bar) pressure [20] (control group).

Group B1: (40 samples)subdivided into 4 groups(10 for each) self-cure acrylic resin processed in Ivomat curing method, under 30 psi pressure for 15 minutes[21] , at different water temperatures (20°C, 40°C, 60°C, 80°C).

Group B2:(40samples) subdivided into 4 groups(10 for each) self-cure acrylic resin processed in Ivomat curing method, under 30 psi pressure for 30 minutes, at different water temperatures(20°C, 40°C, 60°C, 80°C).

Specimens were constructed according to ADA specification No12(1999),a rectangular metal pattern specimens were prepared with dimension of(65mm x 10mm x 2.5 ± 0.03mm)length, width, thickness respectively and then a mould was prepared by using dental flask which was filled with dental stone mixed according to manufacture, s instruction (i.e 31 ml/ 100 gm) allayer of stone mix was placed on metal flask to avoid trapping of air when inserting the metal specimen into the stone mix after coating with separating medium after stone setting, both the stone and metal patterns was coated with separating medium. The upper half of the flask was then positioned on top of the lower portion and filled with stone then covered.

Stone was allowed to harden for 60 minutes before the flask was opened. The flask was then opened and metal patterns were removed from the mould carefully, mould was packed with pink cold-cured acrylic mixed according to manufacturers instruction (2.5:1) by volume, curing procedure was performed for each group as follow,(group A)cold- cure acrylic resin dough was left to cure in air for two hours in a bench under press at 23°C ± 5°C [19] . (group B1) of samples, flasks with acrylic resin dough were transferred for curing in the ivomat curing device, as shown in Figure (1) containing water under air pressure 30 psi for 15 minutes [21] at different water temperature (20°C, 40°C, 60°C,and 80°C),same procture for preparing(group B2)except using 30 minutes for curing. After complete curing, bench cooling and deflasking was done and then finishing and

polishing was performed Figure (2), all the tested specimens were conditioned in distilled water at 37°C ± 1°C for 2 days before testing.

Transverse strength of acrylic resin specimens were measured in air by three points bending using an Instron testing machine. The device was supplied with a central loading plunger and two supporting rollers of 3.2mm in diameter and (10 mm) in length. The supports were parallel to each other and perpendicular to the longitudinal center line. The distance between the centers of the supports was (50mm) as shown in Figure (3).

Tested specimen was held at each end of two supports, with a constant cross head speed (5mm/minute) and the load was measured by a compression load cell of maximum capacity (5 KN). Transverse strength value was calculated according to the following equation:

$$S = \frac{3PI}{2bd^2}$$

where

S = Transverse strength (N/mm^2).
P = Maximum force exerted on specimen (N).
I = Distance between the supports (mm).
b = Width of a specimen (mm).
d = Depth of a specimen (mm).

Figure (1): Ivomat curing device.

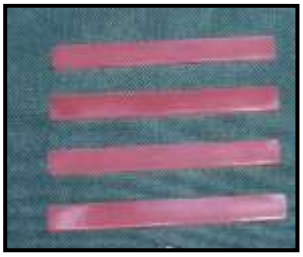

Figure (2): Tested specimens for transverse strength

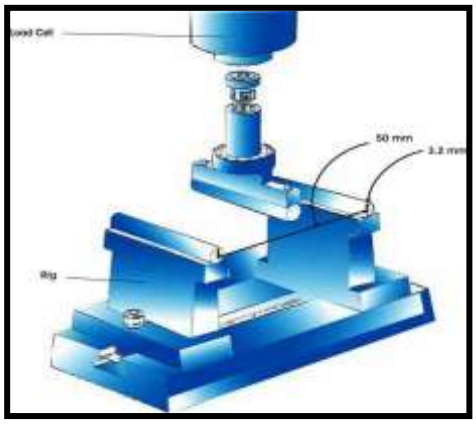

Figure (3): Three point transverse testing machine

Results:

The highest mean values of transverse strength were obtained in specimens cured in (15and 30) minutes at 80°C (78.91 N/ mm^2, 82.78 N/mm^2), while the lowest mean values of transverse strength were obtained in specimens cured in (15and 30) minutes at 20°C(55.73 N/ mm^2,59.46 N/ mm^2)respectively as presented in Table(2) and Figure(4).

One way ANOVA with LSD of multiple comparison test, showed that there was a significant difference at ($P<0.05$) between the two curing time in favour of cured in 30 minutes over the cured in15 minutes in all tested groups. In addition to that, multiple comparison tests between tested groups in each curing time are included, the results indicate a significant difference at ($P<0.05$) between different water temperature and control group as shown in Table (3).

Table (2): Descriptive and inferential statistics for transverse strength of control and specimens polymerized at different curing times and water temperatures.

Number = 10

Groups / Curing Time	Statistics	Control	20°C	40°C	60°C	80°C
Ivomat curing (I.C.) (15 minutes)	Mean	62.86	55.73	68.34	75.20	78.91
	SD	0.794	1.041	0.546	1.059	0.926
	Min.	60.95	53.20	64.35	72.94	76.25
	Max.	64.25	57.75	70.57	78.11	81.39
Ivomat curing (I.C.) (30 minutes)	Mean	62.86	59.46	71.85	80.41	82.78
	SD	0.794	0.640	0.737	1.202	0.877
	Min.	60.95	58.71	69.76	77.80	80.73
	Max.	64.25	61.43	73.68	82.24	84.52

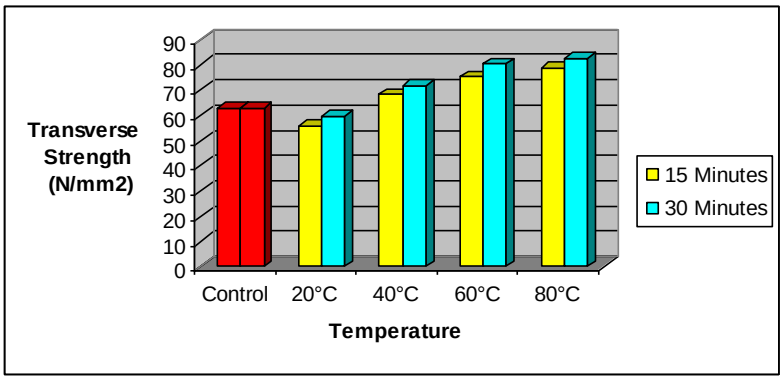

Figure (1): Bar chart for transverse strength mean values of control and specimens polymerized at different curing times and water temperatures.

Table (3): One way ANOVA with LSD of multiple comparisons tests.

Groups / Curing Time		Control (air)	20°C	40°C	60°C	80°C
I.C. 15 x I.C. 30			S.	S.	S.	S.
Ivomat curing (I.C.) (15 minutes)	air		S.	S.	S.	S.
	20°C			S.	S.	S.
	40°C				S.	S.
	60°C					S.
Ivomat curing (I.C.) 30 minutes	air		S.	S.	S.	S.
	20°C			S.	S.	S.
	40°C				S.	S.
	60°C					S.

P < 0.05 Significant (S.)

Discussion

The result showed that the transverse strength was significantly improved in specimens polymerized in water at elevated temperature in both curing time compared with that polymerized in air. Similar results were observed by other worker Leong and Grant(1971);Ogawa et al.,(2000). While McCrorie and Anderson (1960); Smith et al.,(1961) and Furnish et al.,(1983)found no significant changes in transverse strength of self cured acrylic resin when polymerized in water under pressure and elevated temperature.

The transverse strength was significant improved in specimens polymerized in water at elevated temperature in 30 minutes compared with that polymerized in 15 minutes, it might be due to increased time of exposure to heat could which produce greater degree of conversion of monomer into polymer and less residual monomer level that may increase the transverse strength Beech (1975); Ruter and Sevendson (1980); Al- Doori (1987) and Ogawa et al .,(2000).

The increase in transverse strength of specimens polymerized in both curing time at 40°C, 60°C, and 80°C in comparison with that polymerized in air could be related to the high molecular weight and long polymer chain length resulted from more complete polymerization at these temperatures that would increase the transverse strength. This explanation is agreed with work done by Ray (1998).

The significant reduction of transverse strength in specimens polymerized in water at 20°C might be due to high water sorption in specimens polymerized at this temperature. Thus increasing the distance between the molecular chains which may lower the transverse strength. This is in agreement with Davenport (1972). Other explanation could be related to the presence of porosity in specimens cured at this temperature. This agreed with Davenport (1972); Al-Kafaji (1998); Harcout et al.,(2007);El-Hadary and Drummond.,(2008); Berg and Gjerdet.,(2008) who found that if porosity reaches the surface the transverse strength will be lowered, also may be related to the presence of higher residual monomer resulted from lower temperature of polymerization which acts as plasticizer which may be responsible for lowering the transverse strength. This explanation agreed with Lamb et al., (2006) and Yaw et al., (2008).

Conclusions:

1.The curing time have a considerable influence on the transverse strength of self-cured acrylic resin.
2.Acrylic resin specimens cured in 15 minutes had a lower transverse strength compared with that cured in 30 minutes.
3.Acrylic resin specimens processed in water at 20°C produce lower transverse strength for both curing time when compared with other temperature and control group while specimens processed in water at 80°C was significantly superior to other specimens cured at(20°C,40°C,and 60°C) and control group.
4.Polymerizing of the self-cured acrylic resin in water at 40°C, 60°C and 80°C in both curing time improved transverse strength.

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