Evaluation of the Hardness of Cold Cured Acrylic Resin Material by Processing at Different Temperature

Amal A. Rashid, M.Sc.D.*

*** Instructor, Dental Technologies department, College of Health and Medical Technologies, Foundation of Technical Education**

المستخلص

الهدف: تهدف هذه الدراسة لتقييم الصلابة لنوعيين متوفريين تجارياً من الاكريلك البارد Vertex, PAN عند بلمرتهما بدرجات حرارة مختلفة ومقارنتهم بلمتبلمريين بالطريقة الاعتيادية (في الهواء) بدرجة ٢٣±٥ درجة سيليزية.

المنهجية: ٨٠عينه، ٤٠عينة من الاكريلك البارد نوع Vertex و٤٠عينة من الاكريلك البارد نوعPAN حضرت ووضعت في البودقه طبقا لتعليمات الصنع وقسمت الى مجاميع حسب البلمره: ٢٠عينه (١٠من الاكريلك البارد نوع Vertex و١٠عينة من الاكريلك البارد نوعPAN)بلمرت في الهواء عند٢٣± ٥ درجة سيليزية تحت الضغط لمدة ساعتين كمجموعة سيطرة.٦٠ عينة (٣٠عينة من الاكريلك البارد نوع Vertex و٣٠عينة من الاكريلك البارد نوعPAN)بلمرت بواسطه جهازIvomate تحت ضغط حراري٣٠باسكال/انج٢لمده ١٥دقيقه بدرجات حرارة مختلفة وكلاتي: ٤٠ درجة سيليزية و ٦٠ درجة سيليزية و ٨٠ درجة سيليزية (١٠ عينات لكل مجموعة). جميع العينات خضعت لاختبار الصلابةبواسطة جهاز Shore D.

النتائج: اضهرت النتائج بأن الاكريلك البارد نوع PAN الذي بلمر بدرجة حراره مرتفعه ٨٠ درجة سيليزية يمتلك قيمه \اعلى للصلابة ٨٨,٦٩٦ ثم تلي بالاكريلك البارد نوع Vertex الذي بلمر بدرجة حراره ٦٠ درجة سيليزية(٨٨,٤٧١) بينما سجل الاكريلك البارد نوع PAN الذي بلمربلهواء اقل قيمة للصلابة(٨١,٨٣). جميع المجاميع التي بلمرت بدرجات حرارة عالية ٤٠ درجة سيليزية و ٦٠ درجة سيليزية و ٨٠ درجة سيليزية تمتلك قيمة صلابه اعلى من التي بلمرت بلطريقه الاعتيادية (في الهواء)وبفروق معنويه ومعنوية عاليه .

التوصيات: الحاجة الى دراسات لدراسة تأثير زيادة الوقت والضغط عند البلمرة على صلابة الاكريلك (الراتنج) البارد،وكذلك دراسة تأثير زيادة درجة حرارة البلمرة على الخواص الفيزيائية الاخرى لماده الاكريلك (الراتنج) البارد .

Abstract

Objective(s): This study aims to evaluate the hardness of two commercially available cold cured acrylic resin material (Vertex and PAN) when polymerized at different temperature in comparison to those polymerized by conventional methods in air at 23C ± 5C.

Methodology: Eighty specimens, forty from cold cured acrylic (Vertex Type) and forty from cold cured acrylic (PAN type) were prepared, flasking and packing procedure were done according to manufacturer direction and divided according to processing as follow: 20 specimens (10 from Vertex type and 10 from PAN type) were processed in air for two hours at 23C ± 5C under press (bench curing) as a control, and 60 specimens (30 from Vertex type and 30 from PAN type) were processed by ivomat curing device containing water under air pressure 30 Pascal for 15 minutes at different temperature: 40C, 60C, and 80C (10 specimens for each groups). All specimens were tested for hardness test by shore D device.

Results: Result showed that cold cured acrylic type PAN (polymerized by elevated temperature 80˚C) show the maximum value of hardness (88.696) followed by cold cured acrylic type vertex polymerized at 60˚C (88.471). While, control group type PAN (polymerized at air bench) recorded the minimum value of hardness (81.83). All groups that polymerized at high temperature: 40C, 60C, and 80C show the higher value of hardness in comparison to those processed by conventional methods (at air bench) with significant and highly significant differences.

Recommendations: Studies need to study the effect of increasing time and pressure of curing process on the hardness of cold cure acrylic material, also to study the effect of increasing temperature of curing on the other properties of cold cure acrylic material.

Keywords: hardness, cold cure acrylic, processing temperature

Introduction:

Cold-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 [(1-4)].

The wide use of cold-cured acrylic resin in prosthetic work is mainly related to its simple technique at room temperature, less time consuming and less equipment require [(5)].

Cold-cured acrylic resin is basically the same as the heat – cured acrylic resin denture base material, varying only in the manner in which polymerization is initiated at room temperature. The composition of the liquid is varied by the addition of chemical activator in the form of tertiary amine [6].

In general the heat – cured material is significantly harder, than the cold – cured material under all conditions [7], this related to the higher residual monomer in the cold – cured type, which adversely affects the indentation hardness[8,9]. Therefore, the higher conversion of monomer into the polymer result in increasing the hardness of acrylic materials [10].

The increase in processing temperature under pressure during polymerization of acrylic materials result in a more complete polymerization reaction and thus producing a harder polymer network [11]. So this study was conducted to study the effect of increasing temperature on the hardness of two commercially available cold cure acrylic resin materials in comparison to those processed conventionally at air bench.

Materials and Methods

Preparation of mould

80 specimens from rectangular shaped metal pattern were prepared.40 specimens from cold cure acrylic(Vertex type) and 40 specimens from cold cure acrylic(PAN type) were prepared with dimension of (12mm,6mm,3mm) length, width and depth respectively .

Methods:

The conventional flasking, packing procedures were followed in the preparation of the specimens.

Curing

20 specimens (10 from cold cure acrylic (Vertex type) and 10 specimens from cold cure acrylic (PAN type) cured processed in air, bench curing method, for two hours at 23C ± 5C under (20 bar) pressure [12] (control group).

60 specimens (30 from cold cure acrylic (Vertex type) and 30 specimens from cold cure acrylic (PAN type) were polymerized by Ivomat In case of using Ivomat, flask with acrylic resin dough were transferred for curing in the Ivomat curing device containing water under air pressure 30 Pascal for 15 minutes (ADAS, No. 12, 1975) [13], at different temperature (40C, 60C, and 80C).

After completion and curing the acrylic specimens were removed carefully from the stone mold. All the acrylic resin specimens were finished and polished according to conventional procedure till glossy surface was obtained. The final measurements were obtained using the micrometer and vernier.

Distribution of the sample (Cold cure acrylic resin materials):

Group A (cold cured (vertex type))

Group A control: 10 specimens from cold cured (vertex) curing at air bench

Group A1: 10 specimens from cold cured (vertex) curing at40˚C by ivomate.

Group A2: 10 specimens from cold cured (vertex) curing at60˚C by ivomate.

Group A3: 10 specimens from cold cured (vertex) curing at80˚C by ivomate.

Group B (cold cured acrylic (PAN))

Group B control: 10 specimens from cold cured (PAN) curing at air bench

Group B1: 10 specimens from cold cured acrylic (PAN) curing at40˚C by ivomate.

Group B2: 10 specimens from cold cured acrylic (PAN) curing at60˚C by ivomate.

Group B3: 10 specimens from cold cured acrylic (PAN) curing at80˚C by ivomate.

Methods of evaluation

Shore ((D)) hardness tester was used in this study for measuring the indentation hardness of the specimens the test load was set to 50 Newton for shore ((D)) which is suitable for acrylic resin material.

The contact surface of the shore hardness tester must be parallel to the specimen support of the test stand to prevent errors in measurements.

The distance between the specimen surface and the indentor of the hardness tester was set to be 5-12 mm. During carrying out the test the contact period between the specimen and the indentor was 6 seconds.

After that the measurements were taken directly from the scale reading.

Five measurements were done on different area of each specimen and the average of five readings was calculated.

RESULTS

Table (1) show the descriptive of groups: mean, S.D, min, max values of the hardness of all eight groups.

Group B3 cold cured acrylic type PAN (polymerized by elevated temperature 80˚C) show the maximum value of hardness(88.696) followed by group A2 cold cured acrylic type vertex polymerized at 60˚C (88.471). While, group B control type PAN (polymerized at air bench) recorded the minimum value of hardness (81.83). All groups that polymerized at high temperature: 40C, 60C, and 80C show the higher value of hardness in comparison to those processed by conventional methods (at air bench).

Figure 2 show the bar chart that showing the mean of the hardness for the eight groups

Table 1. Description of groups

	Group-A (Vertex)				Group-B (PAN)			
	A1 40˚C vertex	A2 60˚C vertex	A3 80˚C vertex	A control	B1 40˚C PAN	B2 60˚C PAN	B3 80˚C PAN	B control
Mean	86.138	88.471	88.394	83.832	88.332	88.43	88.696	81.83
SD	0.3879	0.5022	0.4008	2.4808	0.3849	0.687	0.2476	2.8610
Min	85.66	87.66	87.33	79.33	88	87.33	88.33	76.66
Max	86.66	89	88.66	86	89	89	89	84

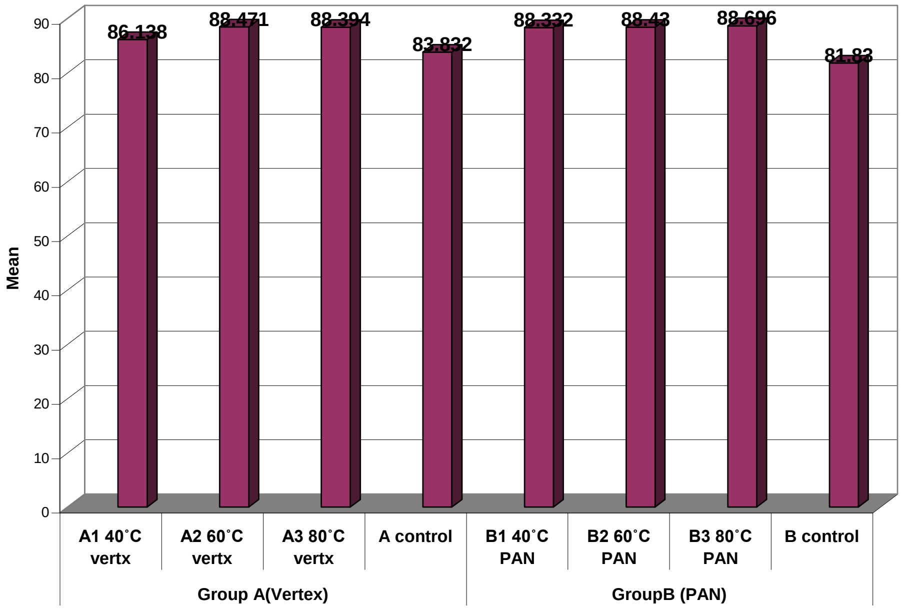

Figure 1. Bar chart showing the mean of the hardness for the eight groups

Table (2) show the ANOVA test between groups, there were highly significant differences P<0.01 between: 1- Group A (Vertex){A1,A2,A3, control A}. 2- Group B (PAN) {B1, B2, B3, control B}. 3- Group A (Vertex) with Group B (PAN).

Table (3) show the LSD between Group A (Vertex), there were highly significant differences P<0.01 between: A1 & A2, A1 & A3, A2&Control and A3&Control, and there was only significant differences P<0.05 between A1 and control, but there was non-significant differences P>0.05 between A2 and A3.

Table (4) show the LSD between Group B (PAN), there were highly significant differences P<0.01 between: B1, B2, B3 and Control, and there was only significant differences P<0.05 between B1 and B3, but there was non-significant differences P>0.05 between B1 and B2, B2 and B3.

Table 2. ANOVA test between groups

	F-test	P-value	Sig
Group-A (Vertex)	28.87	P<0.01	HS
Group-B (PAN)	50.08	P<0.01	HS
Group-A (Vertex), Group-B (PAN)	35.11	P<0.01	HS

P-value= Level of Probability; Sig= Significance

Table 3. LSD of Group A (Vertex)

	P-value	Sig
A1 and A2	P<0.01	HS
A1 and A3	P<0.01	HS
A2 and A3	0.775	NS
A1 and Control	0.017	S
A2 and Control	P<0.01	HS
A3 and Control	P<0.01	HS

P-value= Level of Probability; Sig= Significance; *P>0.05 Non significant

Table 4. LSD of Group B (PAN)

	P-value	Sig
B1 and B2	0.746	NS
B1 and B3	0.025	S
B2 and B3	0.264	NS
B1 and Control	P<0.01	HS
B2 and Control	P<0.01	HS
B3 and Control	P<0.01	HS

HS= Highly Significant; P-value= Level of Probability; Sig= Significance; *P>0.05 Non significant

Table (5) show LSD between Group A (Vertex) and Group B (PAN), there were highly significant differences P<0.01 between: 1-Group A1 with Groups: B1, B2, B3. 2- control A also with Groups: B1, B2, B3. 3- Group B control with A2, A3.

While there were significant differences P<0.05 between: A1 and B Control, and A3 and B3, but there were non-significant differences P>0.05 between 1- Group A2 with Groups: B1 .B2. B3. 2- Group A3 with Groups B 1 and B2. 3- Group A Control and Group B Control as show in this Table (5).

Table 5. LSD of Group A (Vertex) and Group B (PAN)

	P-value	Sig
A1,B1	P<0.01	HS
A1,B2	P<0.01	HS
A1,B3	P<0.01	HS
A1 and B Control	0.01	S
A2,B1	0.402	NS
A2, B2	0.904	NS
A2,B3	0.242	NS
A2 and B Control	P<0.01	HS
A3,B1	0.789	NS
A3,B2	0.817	NS
A3,B3	0.031	S
A3 and B Control	P<0.01	HS
A Control and B1	P<0.01	HS
A Control and B2	P<0.01	HS
A Control and B3	P<0.01	HS
A Control and B Control	0.211	NS

HS= Highly Significant; NS= Non-significant; S=Significant; *P<0.05 Significant; **P>0.05 Non significant; ***P<0.01 High significant

Discussion

The results show that the all groups of both types of cold cure acrylic (Vertex and PAN) that polymerized at high temperature: 40C, 60C, and 80C show the higher value of hardness in comparison to those processed by conventional methods(at air bench, control group)with significant and highly significant differences between them, the high value of hardness may be related to the more complete polymerization reaction and higher conversion of monomer into polymer thus producing harder polymer network and high molecular weight with long polymer chain length [14-15].

Also, the result showed that cold cured acrylic type PAN (polymerized by elevated temperature 80˚C) show the maximum value of hardness (88.696), in addition to that results show there were highly-significant differences between: group A1and group B1 that processed at 40C with groups that processed with higher temperature (60C, and 80C). So, the hardness increase when the temperature of processing increase, the probable explanation of the highly significance increasing of hardness in groups polymerized at high temperature can be related to the low amount of water sorption, and vice versa, the highly significance reduction of hardness in groups polymerized at low temperature can be related to the high amount of water sorption, the material with high water sorption have greater decrease in the hardness resistance this finding is confirmed by (Stafford and smith 1968) [(16)]. In that water sorption adversely affects the hardness resistance of acrylic materials, since the water increase the distance between the molecular chains [(17)], this result agrees with Al- Naimi, 2005 [(18)].

While, both control groups of cold cure acrylic type PAN and type Vertex (polymerized at air bench) recorded the minimum value of hardness (81.83) and (83.832) respectively, the explanation of the reduction of the hardness value in the specimens that polymerized at air bench might be related to the presence of porosity leading to decrease in the hardness because porosity decrease the hardness [7,19] and this result agree with (Al-Kafaji, 1998 [(5)] and Al-Naimi, 2005 [(18)].

Recommendations

Studies need to study the effect of increasing time and pressure of curing on the hardness of cold cure acrylic material, also to study the effect of increasing temperature on the other properties of cold cure acrylic material.

References

1. Cheung LK, Samman N, Tideman H. The use of modulus acrylic for restoration of the tempralis flap donor". *J. Croniomax Surg*. 1994; 22(6): 335-341.

2. Cucci AL, Giampaolo ET, Leonardi P. Vergani CE. Unrestricted linear dimensional changes of two hard chair-side reline resins and one heat-curing acrylic resin. *J Prosthet Dent*; 1996; 76(4): 414-417.

3. Replogle RE, Lanzin G, Francel P, Henson S, John JA. Acrylic craioplasty using miniplate struts. *Neurosugery;* 1996; 39(4): 747-749.

4. Ogawa T, Aizawa S, Tanaka M, Matsuya S, Hasegawa A, Koyano K. Setting characteristic of five auto polymerizing resin measured by an oscillating rheometer. *J Prosthet Dent*. 2001; 84(2): 170-179.

5. Al-Kafaji MT. *Evaluation of some Physical and mechanical properties of prefabricated self-cured acrylic form used self-cured materials*. Master Thesis, University of Baghdad, College of Dentistry, 1998.

6. Anusavice KJ, Phillips. *Science of dental materials.* 10th ed. Philadelphia W.B. Saunders company; (Ch.10; 11) p.p. 211-235, 237-271 1996.

7. Craig RG, Powers JM. *Restorative dental materials.* 11th ed. St. Louis: Mosby Company; 2002.

8. *Vonfraunhofer JA, and Schatlampончy C.* The surface characteristics of denture-base polymer*. J Dent. 1971; 3(3): 106-9.*

9. *Beech DR.* Molecular weight distribution of denture-base acrylic. *J Prosthet Dent. 1975; 3: 19-24.*

10. Jaggar RG. Effect of curing cycle on some properties of PMMA denture-base materials. *J. oral. Rehabil. 1978;* 151-157.

11. Odian C. *Principle of polymerization.* 3rd ed.; New York: 277-280. (1991)

12. Walter JD, Gloysher JK. The properties of self-curing denture-base. *Br Dent J*. 1972; 132-223.

13. American dental association (ADA) specification no. 12 for denture-base Polymers. Chicago: Council on dental materials and devices. 1975.

14. Ogawa T, Tanaka M, Koyano K. Effect of water temperature during

polymerization on strength of auto polymerization resin. *J Prosthet Dent.* 2000; 84(2): 222-224.

15. Harrison A. and Huggett R. Effect of the curing cycle on residual monomer levels of acrylic resin denture base polymers. *Journal of Prosthetic Dentistry*. 2004; volume 53, issue 3.

16. Stafford GD, and Smith DC. Some studies of the properties of denture-base polymer. *Br. Dent. J.* 1968; 125 (8): 337-45 .

17. Anderson JN, and Storer R. *Immediate and replacement dentures*, 5th ed. Oxford: Blackwell scientific publications. 1976.

18. Al-Neami Z. Effect of different water temperature during polymerization on some physical and mechanical properties of self-cured acrylic resin materials. Master thesis; College of Medical and Health Technology, Foundation of Technical Education, Iraq; 2005.

19. Davenport JN. The denture surface. *Br Dent J.* 1972; 133:101-105.