An Evaluation of Some Mechanical Properties of Autopolymerizing Acrylic Resin with the Modified One after Changing the Curing Environment: (*In vitro* Study)

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ABSTRACT

Background: Studying and investigating the transverse strength(Ts), impact strength(Is), hardness (Hr) and surface roughness(Ra) of conventional and modified autopolymerizing acrylic resin with different weight percentages of biopolymer kraftlignin, after curing in different water temperatures; 40°C and 80°C.

Material and Methods: Standard acrylic specimens were fabricated according to ADA specification No.12 for transverse strength, ISO 179 was used for impact testing, Shore D for hardness and profilometerfor surface roughness. The material lignin first dispersed in the monomer, then the powder PMMA is immediately added. Lignin added in different weight percentages. Then cured using pressure pot (Ivomet) in two temperatures;40°C and 80°C under 2 bar pressure, for 30 minutes.Atotal of 144samples were prepared for this study. Ts, Is, Ra, and Hr were tested, by using Instron universal testing machine, charpy impact tester, shore D tester, and profilometer respectively.

Results: The transverse strength increased in both the conventional and modified onewhen compared with that cured in air. The addition of 0.5wt% lignin gave the higher effect (78.0017MPa) with highly significant difference found between groups at 40°C polymerizing temperature. While the impact strength in both temperatures in the modified resin revealed increased results than conventional one, 1.25wt% of kraft lignin gave the highest value (12.7355KJ/m²) with highly significant differences found between groups at 80°C polymerizing temperature. Hardness and surface roughness showed also highly significant differences found between groups at 40°C polymerizing temperature, all the groups had increased Hr. than the control one (78.95), while the Ra. decreased for 1.0% ,1.25,1.50 and 1.75 wt% lignin content to (0.26,0.10,0.063, 0.12µm) respectively in 40°C polymerizing temperature, the lowest value present in 1.75 wt% lignin (0.05 µm) at 80°Cpolymerizing temperature.

Conclusions: It seems that increasing the polymerizing temperature to 40°C had a positive effect on the mechanical properties of autopolymerizing acrylic resin and the one enforced by kraft lignin biopolymer in low percentages. Increasing the polymerizing temperature to 80°C will doesn't have much positive effect but it doesn't deteriorate the mechanical properties. However, when submitted to increasing the temperature to 80°C, specimens showed a significantincrease in impact strength.

Key words: Autopolymerizing acrylic, Kraft lignin, curing temperature. (J Bagh Coll Dentistry 2015; 27(4):62-71).

INTRODUCTION

Denture fracture is a common problem in Prosthodontics (1). Autopolymerized (2), heat polymerized (3), visible light polymerized (2,3), and microwave polymerized acrylic resins (3) have been used to repair fractured dentures. Although various materials have been proposed for repairing fractured denture bases, autopolymerizing acrylic repair resin is still usedfor denture repair materials in daily practice, so that the repairs can be easily employed at room temperature in a short time (4,5).

Nowadays, studies were developed on potential of natural fibers as reinforcement in thermoplastics.There are many fibers that have been explored as reinforcement for polymer matrix(6). Lignin in plants is the most abundant organic polymer after cellulose, lignin is non-toxic source and rich in renewable resources, so it is widely used in industry. It is mainly used as raw materials and additives such as adhesives, dispersant, chelating agent and emulsifier (7).

Previous quantitative research done by Ismail(8) showed that addition of copolymer produced from lignin-graft-PMMA, in concentration of 3.0wt% and less, produced favourable mechanical properties for the denture base acrylic resin. Further study done by Ismail et,al.,(9) evaluated the transverse strength and impact strength of autopolymerizing acrylic resin polymerized in air, after modified with kraft lignin from 0.25wt% to 1.5wt%. The results revealed that modified autopolymerizing resin exhibited significantly higher impact strength, the transverse strength of the modified specimenswas increased only on o.25wt% addition of lignin. These positive findings made the new modified denture resins attractive for future dental applications.

It should be mentioned that repairing with autopolymerized resin is much weaker than the originally used heat polymerized denture resin (5). Attempts have been made to improve the mechanical properties of the repaired sites by changing either the joint surface contours (10), the processing methods (10,11), optimizing the distance between repaired sites (12-14). One of the problems withdenture repair, however, is that it is weaker than the original prosthesis and may re-fracture

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within ashort period of time. Often it occurs at the interface junction of the original base and repair materials(15). Ogawa et,al.,(16) reported that changing of polymerization temperature had a significant effect on both the transverse strength and modulus of the resin, both increased with an increase in water temperature. They concluded that Polymerization of the resin in hot water greatly increased its mechanical properties. Machado et, al.,(17) reported better results may be expected when autopolymerizing acrylics are cured under controlled heat and pressure state.

Different polymerization techniques have been used to increase the degree of conversion of autopolymerize orthodonting acrylic and enhance their properties.” Donovan et, al., (18) reported that an acrylic cured under 20 psi pressure presented increase transversal strength and lesser porosity. The results of another study showed a decrease in the residual monomer and an increase of resin strength when the water temperature was raised from 20°C to 30°C. (19) Likewise, a lower amount of residual monomer has been observed in resins polymerized at 60°C (20). The temperature elevation with pressure has been shown to increase the microhardness (21) and flexural strength (11) of acrylic resins.

Surface hardness could be related to degradation of the restoration, since this property is directly related to the quality of polymerization and cross-link density of thematerial, and specifically for resin composites, to its filler content(22). The presence of a rough surface on the restoration favours bacterial adhesion and dental biofilm formation, resulting in gingival inflammation and periodontal bone resorption (23). Furthermore, a rougher surface affects light reflection and brightness of the restorative material, as well as favoursdiscoloration and staining.

Clinical success and longevity of complete dentures depend on physical and mechanical properties of polymers. One of the most important properties of a denture base is strength, the denture base must be able to withstand high impact forces and normal masticatory forces (24,25) conducted a study to determine how the polymerization at different temperatures and for the various length of time affects the transverse strength of autopolymerizing PMMA and glass-fiber composite, for this purpose they were cured for various length of time at different temperatures, the results revealed that the highest transverse strength for the PMMA-glass fiber composite was obtained by curing for 120 min at 100°C and lowest strength was obtained by polymerizing at 150°C.

Kuharand and Funduk (26) observed that surface roughness of acrylic denture base resins depends on the polishing technique utilized.Alves et al(27)conducted a laboratory evaluation of the surface roughness of acrylic resins after different curing and polishing techniques.

The present study aims at:

1. To evaluate the effectiveness of changing polymerizing temperature in water and adding pressure on the autopolymerizing acrylic resin and modified PMMA auto resin with lignin, and then compare the transverse strength and impact strength of autopolymerizing acrylic specimens with one reinforced with lignin in different percentages (0.5, 1.0, 1.25, 1.5, 1.75 wt%).
2. Surface roughness and hardness are important factors in determining the serviceability of provisional restorations, so we evaluate these properties in those conditions, for its application as denture base repair resin in the same percentages.

MATERIALS AND METHODS

The present study conducted in the Department of Prosthodontics, the materials used in current study include: self-cured polymethyl methacrylate (powder and liquid), kraft lignin alkali (powder, Aldrich company). The following equipment were used in the current study:

1. Stainless steel specimens for mould preparation.
2. Modeling Wax
3. Dental stone
4. Aprobesonicated apparatus.(Fig1.a)
5. Pressure pot (Ivomet) (Fig 1.c)
6. Dental flask and clamp (Fig 1.d)
7. Cold mould seal
8. Vernier callipers
9. Sand paper, diamond disc , stone burs and rag wheel
10. Bench press (Germany).

a. Apparatus **b. Monemer Inside A** **c. Ivomet** **d. Samples in flask**

Figure (1): The Instruments Used in the Experimental Study.

Combinations of the three curing factors of temperature, pressure, curing environment (water) were adjusted during the fabrication of autopolymerized specimens.

Synthesis of Modified PMMA Polymers:

Modified PMMA polymers were made by polymerization of mixtures of varying proportions of methyl methacrylate (MMA) and kraft lignin, they included from 0.5,1.0,1.25,1.5 and 1.75wt% of lignin,to optimize resin material and assure adequate impregnation of lignin within the monomer, lignin was mixed for three minutes bya probe sonication apparatus figure (1-a, 1-b) which gives ultrasound waves leading to more dispersion of lignin in the monomer, then the powder was mixed 12gm/6ml wt/v according to manufacturer instructions until reaching the dough stage, then packed directly in the flask within a previously prepared moulds from stainless steel specimens, the two halves of the flask closed within ten seconds and placed under press (Hydrolic press- Germany) with application of pressure until all the access go out the flask. After releasing immediately, put it in (ivomet) pressure potfigure (1-c) in 40°C and 2bar for 30minutes, all the specimens cured in this manner, then the other groups cured to 80°C,2bar for 30minuts. A total of 144 specimens were fabricated for this study, six specimens for each test to all percentages. All the specimens were finished using the usual way of finishing dentures, polishing done using rag wheel with pumice, each sample was marked by its material group (from A- F)and sample number.

Each plate group strips were finished to the calibrated dimensions [65 mm (L) x 10 mm (W) × 2.5 mm (D)] for Ts, Hr,Ra, and 55mm long, 10.0 ± 0.03 mm broad and 10.0 ±0.03mm thick for Is were used. The samples were simply polished to minimize surface roughness. The samples were washed with distilled water to remove any residual monomer and then stored in distilled water at 37°C for 48 ± 2 hours before testing.

Transverse strength test was done by Instron universal testing machine and impact resistance test was done by Charpy-type machine, hardness tested by Shore-D device, and surface roughness by Prolifelometer.

Evaluation of Transverse Strength:

Utilizing a 3-point flexural test, using Instron Universal testing machine. The specimens were tested for transverse strength at a uniform cross head speed of 2mm / min and span length of 50mm with maximum load of 50kg.The load was applied to the centre of specimen until fracture occurred. The amount of deflection and the load at fracture were noted. The transverse strength was calculated using the following formula.

$Transverse\ strength\ (S) = 3\ PL\ (2bd^2)^{-1} = \mathrm{MPa}$

P = Fracture Load (N)

L = Span Length (mm)

b = Sample Width (mm)

d = Sample Thickness(mm)

Evaluation of Impact Strength:

Impact Strength Test:

Charpy impact strength of unnotched specimens was adopted, the impact energy absorbed in breaking an unnotched specimen, according to ISO 179- 1982.The specimens were supported horizontally at two ends and a swinging pendulum had struck in its middle by a 2 joules, free swinging, pendulum which is released from a fixed height. And digital display to show the impact energy. A pendulum of testing capacity was used. Some samples offered resistance to the shock, without fracture therefore; five joules pendulum was used.

$Impact\ strength = E(b \times d)^{-1} \times 10^3 = KJ\ m^{-2}$

E = is the impact energy in joules.

b= is the width dimension, in millimeters, of the test specimen.

d = is the height dimension, in millimeters, of the test specimen.

Measuring Surface Roughness (Ra):

Surface roughness of the acrylic resin specimens after simple finishing by sand paper was measured using a contact profilometer (Taylor Hobson Form TalysurfPGI-840, USA). Surface roughness (Ra), measured in µm, was determined by the instrument's diamond stylus as it moved across the specimen surface. The path of the diamond stylus was perpendicular to the direction of finishing. The cut off length of each tracing was 2 mm. Three measurements of surface roughness were performed for specimen, and mean average Ra values were used for the statistical analysis.

Indentation Hardness Test:

The plates of the test were prepared as in transverse strength specimens, thickness of 2.5mm±0.03. Each plate was measuring 65mm x10mm x 2.5mm±0.03mm, length, width and depth respectively.

"An instrument called Shore "D" Durometer, which is suitable for acrylic resin material is used. The instrument consists of blunt-pointed indenter 0.8mm in diameter that tapers to a cylinder 1.6mm. The indenter is attached to a digital scale that is graduated from 0 to 100 units."(8).The usual method is to press down firmly and quickly on the indenter and record the maximum reading as the Shore "D" hardness. After that the measurements were taken directly from the scale reading. Five measurements were done on different areas of each specimen and an average of five readings was calculated

Statistical Analysis:

Statistical analyses were done by using SPSS version 16 (statistical package for social science).

RESULTS

The present in-vitro study was conducted to evaluate and compare the transverse and impact strength, surface roughness and hardness of conventional and modified autopolymerizing cure resin test specimens.

Evaluation of Transverse Strength:

Table 1 showed mean and standard deviation for Transverse strength (MPa) of control Group and all other groups.

Addition of lignin in 0.5wt%, give the higher effect (78.0017MPa). The results then showed decreasing in the range but it still higher than in air polymerization (56.1475 MPa)from previous study (9) also (28). So increasing the polymerizing temperature to 40°C with pressure 2 Bar in ivomet curing unit, lead to increase in the transverse strength in all groups than the curing in air. Using ANOVA test revealed highly significant differences between the tested groups, while increasing the curing temperature to 80°C with 2bar pressure led to increase the transverse strength of all groups in comparison with air polymerization but it's somewhat deceased at80°C than 40°C polymerizing temperature, in the control (64.9582MPa), 0.5(63.6421MPa) and 1.0 wt% and increased in 1.5(67.7557 MPa) as shown in. using ANOVA test revealed no significant differences between the tested groups , when using Donett-t test for more comparison between each tested group and the control, showed highly significance differences in all of 40°C groups accept of 1.0% as shown in Table 2.

Table 2 showed statistical comparison (Donnet t-test) of the mean Transverse strength (MPa) of samples of control group, with the samples of different concentration of kraft lignin in 40°C.

Impact Strength test Results:

The alteration of polymerizing conditions revealed that the impact strength in the control group less than in the air polymerizing from the previous study, which are (9.2525 Kj/m^2) and (15.2100 Kj/m^2) for the 0.75 wt% lignin addition, which is the highest level, while in this study the results revealed (7.2166Kj/m^2)for the control group ,and (8.5957Kj/m^2)at 1.0wt% group, then the results tend to decrease to (6.9082Kj/m^2)at 1.75wt% of lignin when using 40°C water temperature at 2Bar pressure for 30minutes as shown in Table(3).applying ANOVA test between groups produced a highly significant differences. Resin polymerized in 80°C water demonstrated higher impact strength at 0.5,1.0,1.25,1.5wt% than that cured in 40°C water temperature, highly sig. differences were found between groups ($P<0.05$) when applying ANOVA test ,as appeared in table (3). The highest level of impact strength was (12.7354Kj/m^2) at 1.25 wt% of lignin addition. Applying multiple comparisons Post Hoc test using Donnett t test between each group and the control one revealed that there is no sig. difference in all groups accept 1.0 wt% (sig.0.009) in 40°C curing, but highly sig. differences in 1.0 wt and 1.25 wt% groups in curing temperature 80°C.as shown in table 4.

Indentation Hardness Test:

Measurement of the hardness initially gave some indication of the wear resistance. The Shore "D" hardness number is directly related to the indentation hardness of the tested material. Six specimens from each mixtures of both autopolymerizing resin and the one modified by

KL with acrylic resin material were tested to determine their hardness number. The results of test, which are shown in table 7, indicated that indentation resistance increases with the concentration of KL0.5% which had the highest mean value (85.125) while for the lowest KL modified PMMA1.50wt% value (82.625) followed by 1.25wt% which had (83.100) indentation hardness number . ANOVA test in table 7 reveals that there is highly significant difference in mean hardness between groups in the modified polymer with KL content cured in 40°C water temperature, while the 80°C groups had no significant differences between the groups.

Applying multiple comparisons Post Hoc test using Dunnett t test between each group and the control one revealed that there is highly significant difference in all groups accept 1.5 wt% (sig.0.022) in 40°C curing, as shown in table 6).

Surface Roughness:

The surface roughness was influenced greatly by the addition procedure. In general, autopolymerizing resin specimens exhibited significantly ($p < 0.01$) higher surface roughness (Ra = 0.27 µm) compared to modified acrylic resin (Ra = 0.12 µm) in 1.75 wt% specimens. In autopolymerizing resin specimens, surface roughness reduced significantly ($p < 0.01$) after polymerizing in 40°C and 2Bar pressure. Among the different groups, specimens with1.50 wt% KL exhibited significantly ($p < 0.01$) lower roughness (Ra = 0.06 µm) followed by 1.25% (Ra = 0.10 µm) and 1.75 wt% KL smoothest (Ra = 0.12 µm) surfaces. However, in curing temperature 80°C, no significant difference found between groups. The least surface roughness found in 1.75 wt% group (0.05µm) followed by 1.5 wt% (0.09 µm) as shown in table 7.

Applying multiple comparisons Post Hoc test using Dunnett t test between each group and the control one revealed that there is highly significant difference in groups 1.25,1.5 and 1.75wt% in 40°C curing, as shown in table 8.

Table (1): Mean, Standard Deviation and ANOVA Test Results of Transverse Strength Related to Kraft Lignin wt % at Different Cured Temperatures.

Tested groups		Mean	Std. Deviation	Minimum	Maximum
Tr.St.at cur. temp(40°C)	Control	71.3420	.75228	70.61	72.00
	0.5	78.0017	2.15873	75.67	80.53
	1	68.6512	.71231	67.89	69.57
	1.25	59.3448	.82814	58.76	60.54
	1.5	65.8436	3.32925	62.36	69.40
	1.75	61.2275	1.40108	59.49	62.78
Tr.St.at cur. temp(80°C)	control	64.9582	2.80920	61.17	67.41
	0.5	63.6421	2.47269	60.10	65.72
	1	64.2732	6.71705	56.30	69.98
	1.25	62.3860	3.50122	58.65	67.03
	1.5	67.7557	1.43254	66.05	69.55
	1.75	61.9765	2.34123	59.87	65.29

ANOVA

		Sum of Square	df	Mean Square	F	Sig.
Tr.St.at cur.temp(40°C)	Bet. Groups	939.640	5	187.928	57.925	HS
Tr.St.at cur.temp(80°C)	Bet. Groups	87.049	5	17.410	1.324	NS

Table (2): Multiple Comparison of Transverse Strength (Mpa) Test Result

Dunnett t (2sided) Dependent Variable	(I) Kraft lignin (wt%)	(J)Control	Mean Difference (I-J)	Std. Error	Sig.
Tr.St.at cur. temp(40°C)	0.5	control	6.65973*	1.27365	.000
	1	control	-2.69074	1.27365	.171
	1.25	control	-11.99722*	1.27365	.000
	1.5	control	-5.49837*	1.27365	.002
	1.75	control	-10.11447*	1.27365	.000

*. The mean difference is significant at the 0.05 level.

Table (3): Descriptive Data and ANOVA Result of Impact Strength Related to Different Curing Temperatures.

		Mean	Std. Deviation	Minimum	Maximum
Impact (Kj/m^2) cur.temp(40°C)	control	7.216620	.2943576	6.8420	7.4831
	0.5	7.017650	.1194793	6.8711	7.1390
	1	8.595648	.5276480	7.9650	9.2507
	1.25	7.831500	.6986683	7.3476	8.8650
	1.5	7.466675	.5117103	6.8602	7.9621
	1.75	6.908218	.7969522	5.9472	7.8923
Impact (Kj/m^2) cur.temp(80°C)	control	6.682400	.2576400	6.3458	6.9591
	0.5	7.813900	.7265660	6.8773	8.6441
	1	9.541425	.4041328	8.9421	9.8197
	1.25	12.735425	.8844335	11.7378	13.4848
	1.5	7.829800	.5509666	7.1349	8.4832
	1.75	6.653600	.5426205	6.1995	7.3394

ANOVA

Impact strength (Kj/m^2)	Sum of Squ.	df	Mean Sq.	F	Sig.
cur.temp(40°C) BetweenGroups	7.898	5	1.580	5.371	.003
cur.temp(80°C) Between Groups	106.581	5	21.316	59.826	.000

Table (4): Multiple Comparisons of Impact Strength Test at Different Curing Temperatures.

Dunnett t (2sided) dependent Variable	(I) KL(wt%)	(J)Control	Mean Difference (I-J)	Std. Error	Sig.
Impact (Kj/m^2) at cur.temp(40°C)	0.5	control	-.1989700	.3834549	.978
	1	control	1.3790275*	.3834549	.009
	1.25	control	.6148800	.3834549	.387
	1.5	control	.2500550	.3834549	.945
	1.75	control	-.3084025	.3834549	.884
Impact(Kj/m^2)at cur.temp(80°C)	0.5	control	1.1315000	.4220805	.059
	1	control	2.8590250*	.4220805	.000
	1.25	control	6.0530250*	.4220805	.000
	1.5	control	1.1474000	.4220805	.054
	1.75	control	-.0288000	.4220805	1.000
*. The mean difference is significant at the 0.05 level.					

Table (5): Mean, standard Deviation, and ANOVA Test Results of Hardness Test Related to Kraft Lignin wt % at Different Cured Temperatures (40˚C, 80˚C).

		Mean	Std. Deviation	Minimum	Maximum
Hardness at cur.temp (40°C)	control	78.9500	3.20260	75.20	82.70
	0.5	85.1250	1.08436	83.90	86.50
	1	84.5250	.84212	83.50	85.50
	1.25	83.1000	1.44453	81.00	84.30
	1.5	82.6250	1.13541	81.00	83.50
	1.75	84.5750	.79739	83.70	85.30
Hardness at cur.temp (80°C)	control	84.5250	.56789	83.70	84.90
	0.5	84.7250	1.65000	82.40	85.90
	1	82.8250	1.51959	81.00	84.70
	1.25	82.9750	3.90502	80.00	88.30
	1.5	83.9000	1.61038	82.20	85.90
	1.75	83.4500	2.11739	81.00	85.90

ANOVA

Hardness No.	Sum of Squares	df	Mean Square	F	Sig.
atcur.temp. (40°C) Between Groups	102.960	5	20.592	7.649E0	.001
at cur.temp(80°C) Between Groups	12.473	5	2.495	.541	.743

Table (6): Multiple Comparisons of Hardness Test at Different Curing Temperature.

Dunnett t (2-sided) dependent Variable	(I) Kraft lignin(wt%)	(J) Control	Mean Difference (I-J)	Std. Error	Sig.
Hardness at cur.temp(40°C)	0.5	Control	6.17500*	1.16022	.000
	1	Control	5.57500*	1.16022	.001
	1.25	Control	4.15000*	1.16022	.009
	1.5	Control	3.67500*	1.16022	.022
	1.75	Control	5.62500*	1.16022	.001
*. The mean difference is significant at the 0.05 level.					

Table (7): Mean, Standard Deviation and ANOVA test Results of Surface Roughness Related to Kraft Lignin wt% at Deferent Cured Temperatures (40˚C, 80˚C).

		Mean	Std. Deviation	Minimum	Maximum
Sur.Roughness at cur.temp(40c)	control	.27350	.021886	.242	.291
	0.5	.27925	.024309	.253	.310
	1	.26250	.124698	.088	.384
	1.25	.10275	.060550	.061	.192
	1.5	.06350	.020290	.044	.092
	1.75	.12175	.045051	.081	.180
Sur.Roughness at cur.temp(80c)	control	.44750	.261082	.098	.718
	0.5	.22200	.318693	.058	.700
	1	.21575	.176791	.088	.465
	1.25	.27700	.130468	.093	.400
	1.5	.09975	.026538	.074	.135
	1.75	.05532	.007156	.048	.064

ANOVA

Surface Roughness	Sum of Sq.	df	Mean Sq.	F	Sig.
cur.temp. (40°C) Between Groups	.193	5	.039	10.189	.000
cur.temp. (80°C) Between Groups	.386	5	.077	2.120	.110

Table (8): Multiple Comparisons of Surface Roughness Test at Different Curing Temperatures.

Dunnett t (2-sided) Dependent Variable	(I) KLwt%	(J) Control	Mean Difference (I-J)	Std. Error	Sig.
Sur.Roughcur.temp(40°C)	0.5	control	.005750	.043519	1.000
	1	control	-.011000	.043519	.999
	1.25	control	-.170750*	.043519	.004
	1.5	control	-.210000*	.043519	.001
	1.75	control	-.151750*	.043519	.011
*. The mean difference is significant at the 0.05 level.					

DISCUSSION

This in vitro study with its limitations revealed that mechanical properties of autopolymerizing resin and the modified one by kraft lignin affected by the polymerizing temperature and pressure applied during polymerization in water.

The autopolymerizing acrylic resin was polymerized under pressure in water and at 40ºC. It could have improved the fracture strength of auto acrylic resin. Heat may have activated the chemical reaction between the monomer and polymer components of the resin and produced almost complete polymerization. This mechanism may explain why hot water conditions improved the mechanical properties of the autopolymerizing acrylic resin, so this lead to decrease the residual monomer, this is agreed with (16,20).

The 0.5% lignin- auto PMMA group produced a higher transverse strength (78.0017MPa), than the conventional dental resin; however, it was statistically highly significant. This may be attributed to the method of fabrication of the modified resin samples. It was notable that the 0.5% lignin-auto PMMA sample. This increase in transverse strength may be due to the more polymerization of residual monomer.) but increasing the temperature to 80°C leading to decease in the first three groups and increase in the (1.5wt%) resulted groups. This may be related to chemical composition of the resulted material, which may be crosslinking which occurred and the bonds, may be affected by elevating heat.

In the present study, pre-polymerizing two different types of polymers, methacrylate, and kraft lignin may produce a composite. Kraft lignin molecule with a free carboxyl group, as this altering the structure of polymer and its properties, by creating an ionic molecule. This is agreed with Park et, al., (29) the negative internal forces also affect the impact strength. This study indicated that the 0.5% lignin-autoPMMA group exhibited the highest transverse strength at 40°Cand the 1.25wt% group had greatest impact strength at 80°C. However, the sample's dimensions and the presence of notches, this test can result in different values of impact strength(30) increasing the polymerizing temperature had no effect on impact strength of the control group, but it affect the modified groups mostly to positive results. Applying Dunnett t test revealed that highly significance difference between the control and the (1.0wt%) at 40°C and (1.0 and1.25 wt%) groups at 80°C. This may be related to the more dispersion of the material and good curing when increased the temperature. The reduced results may be related to aggregation of the unreacted lignin particles, which act as stress concentration area which lead to decrease the strength. This is agreed with the (31) who studied the effect of fiber reinforcements and reported that changes in the impact and transverse strength should be due to difference in stress distribution, fiber structure, volume fraction and adherence to the matrix. the impact strength in this study less in both the control and the modified groups than that in the previous study done in air by (9). The cause may be as explained by (16) who reported that, by using hot water during polymerization, the stiffness of the material will be increased. On the other hand, heat stimulation induces the increase in contraction of the resin during polymerization (32).

Surface hardness of a material is its ability to resist abrasion or wear while this is measured by the material's ability to resist indentation. In the present study, surface hardness of acrylic resins was measured using shore D Hardness Tester. Surface hardness of a material is influenced by many factors, including surface roughness. The higher surface hardness values can be attributed to higher degree of polymerization in heat-cured acrylic resin. The high degree of residual monomer content and generalized porous surface of autopolymerized acrylic resin may contribute to its lesser value of surface hardness. (33) They found that Ra of auto polymerizing resin 0.36µm when using pumice slurry and 0.10 µm when using universal polishing paste. The surface roughness is significantly reduced by polishing procedures.

It has been reported that surface hardness of composite resins is influenced by both the organic matrix (monomers) and the inorganic filler. With regard to the organic matrix, hardness depends on the density and structure of the polymer formed and the degree of conversion after the polymerization(34). It is known that the presence of aromatic groups in the monomers provides a polymeric structure with higher rigidity. Hardness has also been used as an indirect method to measure the degree of conversion of resin. The results have revealed increase in the hardness value in both the control and the other groups at 40°C with highly significance difference, but more increasing in the temperature not changing the values significantly.

The increase in the roughness of the resin may be attributed to the stress at the filler-matrix interface. As a consequence, the filler particles located at the surface of the material would debond and the grooves created would promote the increase in the roughness, as this not observed in this study.

According to Bolin et, al., (35), surface roughness values higher than 0.2 µmcause microbial adhesion both in vitro and in vivo studies. Although the results exhibited roughness higher than 0.2 µm, the materials evaluated in this study may be considered as materials with low roughness according to (36), once the materials' roughness ranged from 0.7 to 3.4 µm.

In the present study the lowest Ra value found in 1.5 wt% lignin addition (0.063µm).increasing the temperature leading to decrease of the Ra for 1.25wt% in the different temperatures.

Comparisons of Ra values with other studies cannot be done because of differences in the experimental techniques, procedure used for polishing as well as measuring the surface roughness, and differences in the type of the materials used. The results here are lying within the range reported (37) and less.

The high surface hardness in heat cured acrylic resin can be attributed to higher degree of polymerization. The high degree of residual monomer content and generalized porous surface of autopolymerized acrylic resin may contribute to its lesser value of surface hardness. This may be related to the incomplete polymerization and presence of residual monomer (33). But in this study mean that less residual monomer and higher degree of polymerization has been occurred.

It appears from the literature that the roughness of dental acrylic resins is mainly affected by material inherent features and polishing procedures (38).

The surface roughness of denture base acrylic resin depends on the processing technique viz heat cure or cold cure and the type of polishing media used (27). The polishing procedure involves gradual elimination of rough layers. This process may affect the physical properties of acrylic resin, such as surface hardness (26).

On conclusions, it seems that increasing the polymerizing temperature to 40°C had appositive effect on the mechanical properties of autopolymerizing acrylic resin and the one enforced by kraft lignin biopolymer in low percentages. Increasing more the polymerizing temperature to 80°C will had no much positive effect ,but it has not deteriorate the mechanical properties. So Polymerization under hot-water bath and pressure results in specimens with better properties for autopolymerizing acrylic resins.

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