***ISSN:* 1812–1217**

The Effect of the Thermopress Curing Technique on the Water Sorption and Solubility of the Cold and Heat–Cured Acrylic Resins

Lamia T Rejab
BDS, MSc (Lect)

Department of Prosthetic Dentistry
College of Dentistry, University of Mosul

ABSTRACT

Aims: This study aims to evaluate the effect of the thermopress curing technique on the water sorption and solubility of the cold–cured and heat–cured acrylic resins and compared this technique with the bench curing technique used for the cold–cured resin and with the conventional water bath curing technique for the heat–cured resin. **Materials and Methods**: they were to measure the water sorption and solubility, the specimens were prepared as disks with a dimension according to the ADA Specification No. 12. So specimens were divided into five groups depending on the type of the resin (cold and heat–cured) methods of curing which were (thermopress, conventional water bath and bench cure) and the time of curing cycle. Specimens were weighed before and after immersion in the distilled water and after drying with silica gel using an electronic balance to measure the water sorption and solubility. One way analysis of variance (ANOVA) followed by Duncan ' s multiple range test was performed to determined the significant different between the mean values among the tested groups at ($p < 0.05$) level of significance. **Results**: There is a significant differences between the water sorption and solubility of resin that cured by the different curing methods and different curing cycle times. The water sorption and solubility of resin specimens that cured by thermopress have the higher values. **Conclusions**: The water sorption and solubility of the cold and heat–cured acrylic resins is affected by the curing method. The curing under higher pressure produces specimens with lower water sorption and solubility values.

Key words: Thermopress, water bath, bench–cured, acrylic resin.

Rejab LT. The Effect of the Thermopress Curing Technique on the Water Sorption and Solubility of the Cold and Heat–Cured Acrylic Resins. *Al–Rafidain Dent J*. 2008; 8(1): 11–17.
Received: 21/1/2007 ***Sent to Referees:*** 21/1/2007 ***Accepted for Publication:*** 27/3 /2007

INTRODUCTION

The polymethyl methacrylate because of its favorable working characteristics, processing ease, accurate fit, stability in the oral environment, superior esthetics, strong, rigid and use with inexpensive equipment is the material of choice for denture base fabrication, provisional crowns and fixed partial dentures fabrication and construction of splints(1–4). Polymerization of acrylic resins can be either heat–activated, chemical activated or light activated(5). Chemically activated acrylic resin materials have clinical applications in dentistry as denture base material, denture repair resins, custom trays and temporary crown and bridges (6–8).

Most materials used for prosthetic treatment are subject to sorption and solubility. Sorption is a process of absorption and adsorption of liquids. The absorption is undoubtedly due primarily to the polar properties of resin molecules. Solubility is the soluble substances leached during storage in water (9).

The phenomena of sorption and solubility producing deleterious effects. These effects may include volumetric changes such as swelling, physical changes such as plasticization and softening, and chemical changes such as oxidation and hydrolysis and color change(10–13). The polymethyl methacrylate resins were hydrophilic that attracted more water soluble dyes on the surface and staining, which occurs as a result of electrostatic charges (11). There is a correlation between residual monomer and water sorption. If residual monomer is present, less monomer conversion occurs and may result in increased sorption and solubility(9). Residual monomer has the potential to cause irritation, inflammation, and an allergic response of the oral mucosa [9, 12, 14, 15]. Residual monomer concentration varies with the methods and the conditions of polymerization [14,16,17].

The aims of this study were to evaluate the water sorption and solubility of the cold and heat–cured acrylic resins cured by thermopress curing technique and compared with bench curing for the cold–cured resin and with the conventional water bath curing technique for the heat–cured resin.

MATERIALS AND METHODS

The commercial cold–cured MEDICUS (E.U) and heat–cured acrylic resin Major (Major prodotti Dentari, Italy) were used in this study. The resins were mixed at powder / liquid ratio according to the manufacturer's instruction.

The specimens were prepared as disks with a dimension 50 ± 1 mm in diameter and 0.5 ± 0.1mm thickness according to the ADA Specification No. 12 [12,18]. as shown in Figure (1). Specimens were divided into five groups depending on the type of the resin, methods of curing and the time of curing cycle. Group I heat–cured resin cured by conventional water bath method. The specimens were packed at the dough stage according to the conventional dough molding method. The flasks were trial closed and then final closed under pressure to 100 bar using hydraulic press (BEGO hydrofix, Germany). Flasks then transferred to a spring–loaded clamp ready for processing. The specimens processed at polymerization cycle of 7 hours at 70°C and 1 hour at 100°C in a thermostatically controlled water bath [14,19]. Group II heat–cured resin cured by thermopress curing method using Thermopress (thermopress device and as manufacturer's instruction the curing cycle with Thermopress is at a temperature (100 ^{o}C), and under pressure (6 bar) for 20 to 30 minutes). So with Group II, flasks removed from the hydraulic press and transferred to the Thermopress (MINI 2000, Major prodotti Dentari, Italy) without of spring–loaded clamp. The curing cycle with Thermopress was at a temperature (100 ^{o}C), and under pressure (6 bar) for 20 minutes, while with Group III heat–cured resin cured by thermopress curing method using Thermopress and the curing cycle was at (100 ^{o}C) under (6 bar) of pressure for 30 minutes. Group IV cold–cured resin cured by bench curing under 100 bar of pressure with spring–loaded clamp for 25 minutes, the time to be allowed for curing vary with different materials and the initial hardening of the material will occur within 20–30 minutes after final closure of the flask [20]. Group V cold–cured resin cured by Thermopress at (100 ^{o}C) under (6 bar) of pressure without of spring–loaded clamp for 10 minutes as manufacturer's instruction. Ten specimens for each group were prepared, so the final total number was fifty.

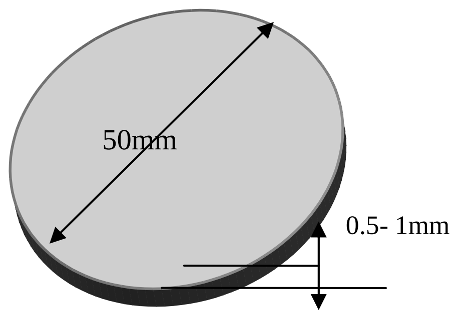

Figure (1) : Acrylic resin disk for water sorption and solubility test.

Initially, specimens were dried over silica gel in a desiccator at 37 ^{o}C and weighed to an accuracy of 0.0001 gram using an electronic balance (Mettler PM 460, Germany) until constant weight was obtained. This was considered to be the initial weight of the specimen (W1). Specimens then immersed in distilled water, each specimen being in separate containers. The specimens were removed from their containers after 7 days. Excess water was removed by blotting with filter paper and the weight of the specimen was recorded as (W2). This represent the weight of the specimen after absorption of the distilled water. Then the specimens were dried in the desiccator and the weight of the specimen after drying recorded as (W3).This represent the amount of lost soluble materials[18,21]. The percentage of absorption and solubility were determined as follow [9,22] :

$$\text{(1) Absorption}\,\% = \frac{(\,\text{W2 - W3}\,)\ \text{g}}{(\,\text{W1}\,)\ \text{g}} \times 100$$

$$= \frac{(\text{ Weight after absorption - final weight after desication })\ \text{g}}{(\text{ Initial weight })\ \text{g}} \times 100$$

$$\text{(2)Solubility}\,\% = \frac{(\text{W1} - \text{W3}\ )\ \text{g}}{(\,\text{W1}\,)\ \text{g}} \times 100$$

$$= \frac{(\text{ Initial weight - final weight after desication })\ \text{g}}{(\text{ Initial weight })\ \text{g}} \times 100$$

Mean values and standard deviation wear calculated. Mean values wear compared statistically with one way analysis of variance (ANOVA) followed by Duncan's multiple range test to determined the significant different among the tested groups at ($p <$ 0.05) level of significance.

RESULTS AND DISCUSSION

The results of ANOVA are represented in Tables (1and 2). The results in Table (1) showed there is a highly significant different between the mean value of the water sorption and solubility of the heat –cured acrylic resin when cured by conventional water bath curing method and thermopress curing technique by the Thermopress .Also the results showed there is a highly significant different between water sorption and solubility of the heat –cured acrylic resin specimens that cured by the Thermopress for 30 minutes and that cured by the Thermopress for 20 minutes.

Table (1): ANOVA for the means of the water sorption and solubility of the heat–cured resin cured by different curing methods

Source of variance	DF	Heat–cured resin cured by different curing methods					
		Water sorption ratio (weight %)			Water solubility ratio (weight %)		
		Mean of square	F–value	*P*–value	Mean of square	F–value	*P*–value
***Tested groups**	2	3.239093	7964.98	0.000	0.79792	576.53	0.000
Error	27	0.000407			0.00138		
Total	29						

*Tested groups: Group I, II and III; DF: Degree of freedom.

The results in Table (2) showed that there is a highly significant different between the mean value of the water sorption and solubility ratio of the cold–cured acrylic resin when cured by bench curing method and thermo–press curing technique. This result indicate that the type of curing method has an effect on the water sorption and solubility of the resins. This result comes in agreement with the finding of Janaina *etal.*, and others [14,16] in that the method of polymerization has decisive feature on the physical properties of the cured resin. They reported a correlation between the polymerization temperature and time, and water sorption and solubility, depending on the the polymerization temperature and time, various quantities of residual monomer are left in the polymer. If residual monomer is present, less monomer conversion occurs and may result in increased sorption and solubility.

Table (2): ANOVA for the means of the water sorption and solubility of the cold–cured resin cured by different curing methods

Source of varance		**Cold–cured resin cured by different curing methods**					
		Water sorption ratio (weight %)			**Water solubility ratio (weight %)**		
		Mean of square	**F–value**	***P*–value**	**Mean of square**	**F–value**	***P*–value**
***Tested groups**	1	0.6808050	1.5E+05	0.000	0.0708050	1841.75	0.000
Error	18	0.0000046			0.0000384		
Total	19						

*Tested groups: Group I, II and III.

The results of the Duncan's multiple range test are represented in Tables (3–6).The results in Tables (3 and 4) showed that the specimens of the heat–cured resin that cured by water bath have the lower value of water sorption and solubility ratio than those that cured by the thermopress device (Thermopress). And the values of the specimens that cured by the Thermo-press for 30 minutes were lower than the value of those that cured by the Thermo-press for 20 minutes. This result comes in agreement with the finding of Debby *etal.*,[9] in that extended polymerization time results in longer polymers so that reduced water sorption and solubility were obtained.

Table (3)**:** Duncan Multiple Range test for water sorption of the tested groups of the heat–cured resin cured by different curing methods

Tested groups	**No.**	**Cold–cured resin cured by different curing methods**			
		Water sorption ratio (weight %)		**Water solubility ratio (weight %)**	
		***Mean ± SD**	**Grouping**	***Mean ± SD**	**Grouping**
Group I	10	1.2300± 0.0346	A	0.6600± 0.0641	A
Group II	10	2.3460± 0.0032	B	1.2040± 0.0038	B
Group III	10	1.5940 ± 0.0031	c	1.0640±0.0051	c

*Means with different letters are highly significantly different at $P \leq 0.01$; No: Samples number. SD : Standard deviation; Group I : specimens cured by conventional water bath curing method; Group II: specimens cured by thermopress curing method for 20 minutes; Group III : specimens cured by thermopress curing method for 30 minutes.

Table (4)**:** Duncan Multiple Range test for water solubility of the tested groups of the heat–cured resin cured by different curing methods

Tested groups		**Cold–cured resin cured by different curing methods**			
		Water sorption ratio (weight %)		**Water solubility ratio (weight %)**	
		***Mean ± SD**	**Grouping**	***Mean ± SD**	**Grouping**
Group IV	10	1.04700± .00240	A	0.36900±0.00660	A
Group V	10	1.41600±0.00183	B	0.48800±0.00577	B

*Means with different letters are highly significantly different at $P \leq 0.01$; No: Samples number. SD : Standard deviation; Group IV: specimens cured by bench curing method ; Group V : specimens cured by thermo–press curing method for 10 minutes.

Table (5)**:** Duncan Multiple Range test for water sorption of the tested groups of the cold–cured resin cured by different curing methods

Tested Groups	**No**	**Water sorption ratio (weight %)**	
		Mean ±SD	**Grouping**
Group IV	10	1.04700±0.00240	A
Group V	10	1.41600±0.00183	B

No: Samples number; SD: Standard deviation; Group IV: specimens cured by bench curing method; Group V: specimens cured by thermo press curing method for 10 minutes.

Table (6)**:** Duncan Multiple Range test for water solubility of the tested groups of the cold–cured resin cured by different curing methods

Tested Groups	**No**	**Water solubility ratio (weight %)**	
		Mean ±SD	**Grouping**
Group IV	10	0.36900±0.00660	A
Group V	10	0.48800±0.00577	B

No: Samples number; SD : Standard deviation; Group IV : specimens cured by bench curing method; Group V : specimens cured by thermopress curing method for 10 minutes.

The results in Tables (5 and 6) showed that the specimens that bench cured have the lower value of water sorption and solubility ratio than those that cured by the Thermopress.

The higher values of water sorption and solubility of the cold and heat–cured resin specimens that cured by thermopress with Thermopress can be explained in that, the boiling point of the MMA monomer (100.8 ^{o}C) is very slightly higher than that of the water which is (100 ^{o}C), and if the temperature rises above the boiling point of the residual monomer, these components may boil with the production of bubbles [8,15,20,23]. As it was demonstrated that the pressure applied to the dental flask during denture processing prevented the boiling of the monomer, so curing under pressure was said to allow processing without the formation of porosity. Thus , increased curing pressure appeared to be a useful method to reduce porosity in acrylic resins [6,15]. Curing cycle by the conventional water bath curing method for heat–cured resin and bench cured for cold–cured resin was under high pressure 100 bars , while less pressure was applied by the Thermopress which was 6 bars at curing temperature (100 ^{o}C). Monomer vaporation associated with the exothermic reaction and inadequate compression on the flask may cause porosity in the resin specimens [23]. Water is absorb into the regions of the voids in test resin specimens [24]. So specimens that cured by Thermopress have the higher value of the water sorption and solubility. This come in agreement with the finding of Varpu *etal*., [25] in that polymerization pressure of polymer influenced water sorption values the higher the pressure the lower water sorption values.

CONCLUSSION

The curing under higher pressure produce specimens with lower water sorption and solubility values. Curing by Thermopress produce specimens with higher water sorption and solubility values than that of specimens cured by conventional water bath curing method for heat–cured resin and bench cured for cold–cured resin.

REFERENCES

1. Michael GR, Nicholas JA. Achieving an even thickness in heat polymerized permanent acrylic resin denture bases for complete dentures. *J Prosthet Dent.* 1999; 82: 359–361.
2. Jacob J, Shivaputrappa A, Ila S .Flexural strength of heat–polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. *J Prosthet Dent.* 2001; 86: 424–427.
3. Debra R. H Ana M. and Deborah V. Color stability of provisional crown and fixed partial denture resins. *J Prosthet Dent.* 2005; 93: 70–75.
4. Rosangela SS, Hiroshi M, Taizo H . Influence of thermal and mechanical stresses on the strength of intact and relined denture bases. *J Prosthet Dent.* 2006; 96: 59–67
5. Yau WFE , Cheng YY and Chow TW.Pressure and temperature changes in heat–cured acrylic resin during processing. *Dental Mat.* 2002; 18: 622–629
6. John C and Eugene P. Porosity reduction and its associated effect on the diametral tensile strength of activated acrylic resins. *J Prosthet Dent.* 1985; 53(3): 374–379.
7. Craig RG. Restorative Dental Materials. 10th ed. Mosby Co. Missouri, USA. 1997; p:543.
8. Takahiro O, Shigeru A, Kiyoshi K. Effect of water temperature on the fit of provisional crown margins during polymerization. *J Prosthet Dent.* 1999; 82: 658–661.
9. Debby MS, Leo YY, Robert KF. Effect of processing method on the dimensional accuracy and water sorption of acrylic resin dentures. *J Prosthet Dent.* 1999; 81: 300–304.
10. Peter P, Ernst–Ulrich R. Residual methyl methacrylate monomer, water sorption, and water solubility of hypoallergenic denture base materials. *J Prosthet Dent.* 2004; 92: 72–78.
11. Arthur SK, Frederick CS, Tak WC. Color stability of provisional prosthodontic materials. *J Prosthet Dent.* 2004; 91: 447–452.
12. Cristiane M, Celia M, Rodrigo LS. Influence of mechanical and chemical polishing in the solubility of acrylic resins polymerized by microwave irradiation and conventional water bath. *Dental Mat*. 2004; 20: 565–569
13. Nicolas M, Nicolas M J, Antony CF. Hygroscopic and hydrolytic effects in dental polymer networks. *Dental Mat.* 2006 ; 22: 211–222
14. Janaina H, Eunice TG, Carlos EV. Cytotoxicity of denture base acrylic resins: A literature review. *J Prosthet Dent.* 2003;90:190–3.
15. Lung CYK, Darvell BW. Minimization of the inevitable residual monomer . *Dental Mat.* 2005 ; 21: 1119–1128
16. Shim JS, Watts DC. Residual monomer concentrations in denture–base acrylic resin after an additional, soft–liner, heat–cure cycle. *Dental Mat.*

1999 15: 296–300
17. Lung CYK, Darvell BW. Methyl methacrylate monomer–polymer equilibrium in solid polymer. *J Dent.* 2005; 894–901
18. Gholamreza D, Carsten K, Edgar S . Polymerization characteristics of light– and auto–curing resins for individual splints. *Dental Mat.* 2006; 22: 426–433
19. Fumio T, Junzo T. Controlled polymerization system for fabricating precise dentures. *J Prosthet Dent.* 2000; 83: 514–520.
20. Skinner EW. Science of Dental Materials. 8th ed. W.B. Saunder Co. Philadephia, USA. 1982; Pp:188, 192.
21. Nur H, Gfilay U, Fatih Y. Color stability of denture base acrylic resins in three food colorants. *J Prosthet Dent.* 1999; 81: 375–379.
22. Amany E, James L . Comparative study of water sorption, solubility, and tensile bond strength of two soft lining materials. *J Prosthet Dent*. 2000; 83: 356–361.
23. Capagnoni MA, Barbosa DB. The effect of polymerization cycles on porosity of microwave–processed denture base resin. *J Prosthet Dent.* 2004; 91(3) : 281–285.
24. Varpu M, Pekka K Vallittu. Water sorption and solubility of glass fiber–reinforced denture polymethyl methacrylate resin. *J Prosthet Dent.* 1996; 76(5): 531–534.
25. Varpu M, Katja K. Water sorption solubility, and effect of post–curing of glass fiber reinforced polymers. *Biomaterials.* 1999; 20: 1187–1194.