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The Effect of Additional Microwave Curing Cycle on Residual Monomer Release from Different Acrylic Resin Materials.

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الخلاصة

الاهداف: تهدف الدراسة الى تقييم تأثير المعالجة بالموجات المجهرية على السائل الاكريلي المتبقي بعد الطبخ لعدة أنواع من الراتنج الاكريلي وتقييم تأثير مدة المعالجة بالموجات المجهرية. **المواد وطرائق العمل:** ثلاثة أنواع مختلفة من الراتنج الاكريلي استخدمت في البحث هي: الحراري والضوئي ونوع خاص يستخدم في اجهزة تقويم الاسنان. تم تعريض العينات لمعالجة اضافية بالموجات المجهرية وتم مقارنة السائل الاكريلي المتبقي منها مع عينات لم يتم تعريضها للموجات المجهرية.ومن تم اعتماد اختبار تحليل التباين واختبار(دنكن) لمعرفة الفروق المعنوية احصائيا. **النتائج:** اظهرت النتائج ان هناك فرق معنوي احصائيا لكمية السائل الاكريلي المتبقي بين المواد المختلفة.كذلك لايوجد هناك فرق معنوي بين فترة ٥ و١٠ دقائق بالنسبة للاكريل الحراري والاكريل التقويمي بينما هناك فرق معنوي بين فترة ٥ و ١٠ دقائق بالنسبة للاكريل الضوئي. **الاستنتاجات:** هناك مستويات مختلفة من السائل الاكريلي المتبقي للمواد المختلفة.وان معالجة كل المواد بالموجات المجهرية يساعد على تقليل السائل الاكريلي المتبقي. **الكلمات المفتاحية:** الموجات المجهرية، دورة الطبخ، السائل الكريلي المتبقي.

ABSTRACT

AIMS: to evaluate the effect of microwave post-treatment in the reduction of residual monomer of different types of acrylic resin and evaluate the effect of microwave treatment time. **MAERIALS AND MEHODS**: three different types of acrylic resin materials are used; heat cured, light cured, and orthocryl. Specimens are subjected to additional curing with microwave and compared their residual monomer with the control group. ANOVA followed by Duncan multiple range test were used to determine the significant difference at $P<0.05$ level. **RESULS**: there was a significant difference ($p<0.0001$) in the amount of residual monomer released from the three tested materials. No statistical difference were seen between 5 and 10 minute microwave treatment for the heat cured and orthocryl acrylic resin but there is significant difference between 5 and 10 minute treatment for the light cured acrylic resin. **CONCLUSIONS**: There are different levels of residual monomer when comparing the tested materials with each other. Additional treatment with microwave after curing decrease the residual monomer of all the tested acrylic resin materials.

Key Words: microwave, curing cycle, residual monomer.

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INTRODUCTION

Residual monomer release from acrylic resin relates to the degree of material polymerization and influences several physical and mechanical polymer properties.(1)

Residual monomer, resulting from incomplete conversion of monomers into polymer, has the potential to cause irritation, inflammation, and an allergic response of the oral mucosa. Clinical signs and symptoms most frequently reported include erythema, erosion of oral mucosa, and a burning sensation on the mucosa and tongue. Light-cured acrylic resins were introduced in the early 1980s. Although these resins have been reported to be nontoxic after polymerization, several studies have shown that light-cured acrylic resins have varying levels of cytotoxicity. The extent of their toxic effect appears to be related to the specific formulation of the material and polymerization time. Soaking prostheses fabricated with light-

polymerized resins for 24 hours before insertion has been recommended to minimize exposure of oral tissue to cytotoxic substances such as methyl methacrylate (monomer) [2,3]

Some authors have claimed that monomers, by reacting with molecular oxygen, may produce formaldehyde, which is known to cause hypersensitivity reactions.

Despite the inconclusive clinical trials, some studies, by cell culture technique have provided strong evidence that the cured denture base resins have a direct cytotoxic effect on cells.[4,5]

Therefore, the reduction of residual monomer content could improve the properties and reduce the cytotoxicity effects of the polymerized acrylic resins, and some post-polymerization treatments have been suggested, such as microwave irradiation and immersion in hot water.[6,7]

Some authors have suggested that conventional curing should be followed by a second cycle in a microwave oven, which is an effective method for maintaining low residual levels. The microwave energy acts on the monomer molecules, leading them to vibrate and collide with each other, thereby generating the heat required to cure the resin.[8]

It has been demonstrated that the temperature developed during the reaction is not constant: it increases quickly at the beginning, goes through a maximum and then decays, being able to reach peaks of the order of 150–200 ^{o}C, depending on the working conditions. Hence, both the power of the microwave and the time of exposition can be regulated to control the rate of polymerization and the conversion degree.[9]

After polymerization, monomer levels may decrease by two mechanisms: i) monomer diffusion from the resin bulk into the water medium; or ii) additional polymerization of the same material, as active radicals were detected among the chains that promote monomer polymerization.[1]

The aims of this research are to evaluate the effect of microwave post-treatment in the reduction of residual monomer of different types of acrylic resin and evaluate the effect of microwave treatment time.

MATERIALS & METHODS

Three different types of acrylic resin were used in this research; auto cured orthocryl acrylic resin (Dentarum, Germany), heat cured acrylic resin (Respal, Italy) and light cured acrylic resin (Megatray, Germany).

Cylindrical specimens[9] with a size of about 1.5cm^3 were manufactured choosing manufacturer's instructions in relation to the powder – liquid ratio and curing method; bench curing for the orthocryl acrylic resin, flasking and packing for the heat cured acrylic resin, and using light_ curing chamber unit for the light cured acrylic resin(Megaligth ST, MEGADENTA, Germany).

The number of specimens were 60 specimens, and three different types of acrylic resin materials are used; one third of the specimens were post-cured in a microwave oven(Panasonic, Japan) for 5 minute at 800 watt, the second third of the specimens were post-cured in microwave oven for 10 minute at 800 watt, and the last third of the specimens were left without treatment (control group).

All specimens were immersed in fresh distilled water(each specimen in a separated container with 20ml fresh distilled water) and all containers left at room temperature for 24 hours.[9]

Residual monomers were measured using a digital spectrophotometer (CECIL, CE 1021, England) at 254nm, It is a photometric device used to measure the optical density with accuracy up to 0.001.[1]

Mean values were compared with ANOVA followed by Duncan multiple range test to determine the significant difference at $P < 0.05$ level of significance.

RESULTS AND DISCUSSION

From one-way ANOVA test, there was a significant difference ($p < 0.0001$) in the amount of residual monomer released from the three tested materials(Table 1). The reason is that residual monomer concentration varies with the methods and the conditions of polymerization. The variations in chemical composition and purity of the commercially available resin systems, the degree of conversion of their constituent monomers, and manipulative

variables may all affect the biologic and physical properties of the acrylic resins.[10]

Table (1): ANOVA test of residual monomer among heat-cured, light-cured, and orthocryl acrylic resin materials

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9.717	2	4.858	190.564	.000
Within Groups	.459	18	.025		
Total	10.176	20			

There is less residual monomer in heat-cured acrylic resin (0.3493) than in auto-cured orthocryl acrylic resin (1.6257) (Figure 1). This is in agreement with Oruc *et al* and Szentpetery *et al*.[11,12]

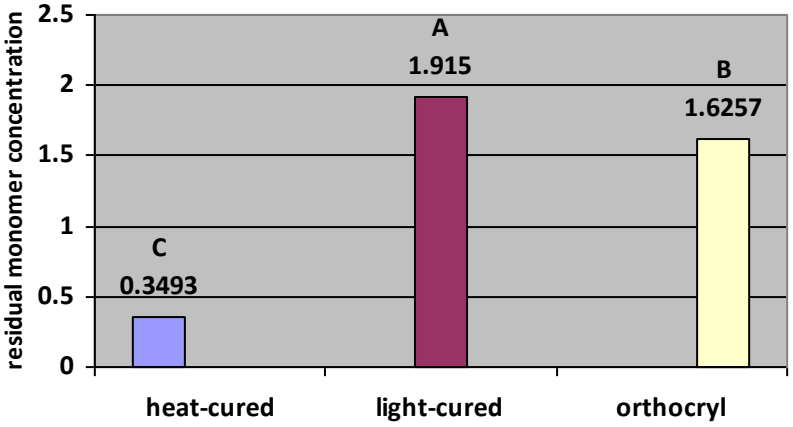

Figure (1): Duncan multiple range test for all acrylic resin materials

The reason for the higher residual monomer content in the auto-cured acrylic resin is the low degree of polymerization achieved by the use of a chemical activator as opposed to that generated by heat activation. Therefore, a larger amount of residual monomer is released into surrounding water from auto-cured acrylic resin than from heat-cured acrylic resin. Another reason is the more porous structure of auto-cured acrylic resin that facilitates diffusion.[13,14,15,16]

Light cured acrylic resin showed the highest level of residual monomer (1.915) (Figure 1). This is in agreement with Ali *et al* who show that increasing the polymerization time may decrease resin toxicity.[17]

ANOVA and Duncan multiple range test for the heat cured acrylic resin showed significant difference was seen when comparing the values of residual monomer of the microwave treated group(both 5&10 minutes) with the non treated control group (0.3493) (Table 2, Figure 2). The increased temperature was thought to precede the polymerization of the monomer, which would obviously decrease the monomer content and release from the specimen.[6,7]

Table (2): ANOVA test for heat-cured acrylic resin material

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.450	2	.225	21.870	.000
Within Groups	.185	18	.010		
Total	.635	20			

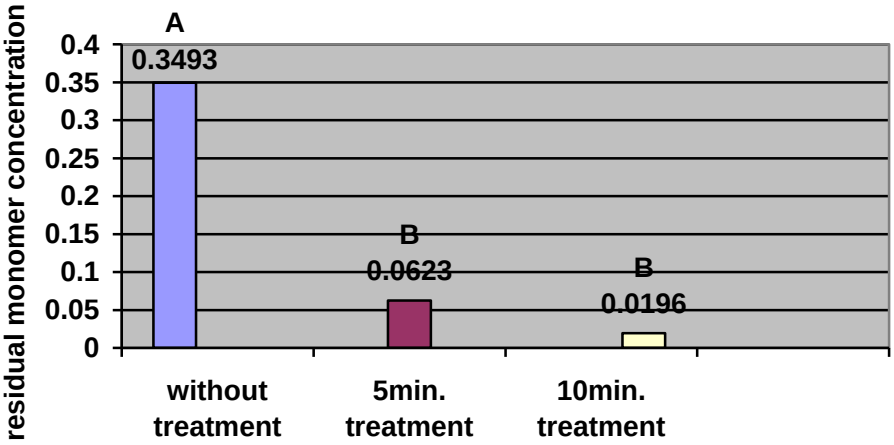

Figure (2): Duncan multiple range test for heat cured acrylic resin

No statistically significant difference were seen between 5 and 10 minute microwave treatment for the heat cured acrylic resin and this in agreement with Faltermeier *et al*.[18] The reason may be due to the completion of the polymerization of the heat cured acrylic resin at the 5 minutes causing the extra microwave _treatment to 10 minutes non significant.

ANOVA and Duncan multiple range test for the light cured acrylic resin showed statistically significant differences between all levels. Specimens treated in the microwave for 10 minute were significantly have the lowest level of residual monomer (0.5783). Control group specimens showed the highest level of residual monomer (1.915), Specimens treated for 5 minute showed an intermediate value (1.1667) (Table 3, Figure 3).

Table (3): ANOVA test for light-cured acrylic resin material

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6.284	2	3.142	70.243	.000
Within Groups	.805	18	.045		
Total	7.089	20			

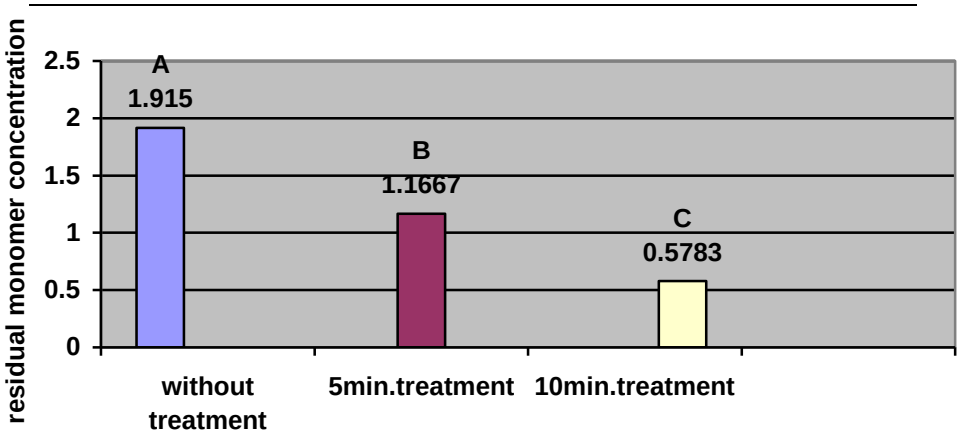

Figure (3): Duncan multiple range test for light cured acrylic resin

This behavior of light cured denture base can be understood from the thermal response of the material within the oven. In the first case, 5 minutes curing time, a high temperature is reached within the specimen so that the polymerization reaction proceeds to a high conversion. In the 10-minutes specimens, low conversion at moderate temperatures are reached. The long time of microwaves exposition at 800 Watt could enhance the rate of secondary reactions of bond breaking on the pending chains breaking bonds by free radical mechanisms, which would be competitive with the main curing reaction, increasing in this way the amount of residual monomer. Consequently, the amount of residual monomer would be lower in the specimens after being treated for 10 minutes.[9,13]

ANOVA and Duncan multiple range test for the orthocryl acrylic resin showed significant difference when compare the values of residual monomer of the microwave treated specimens with the control group (0.1625) (Table 4, Figure 4).

Table (4): ANOVA test for orthocryl acrylic resin material

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6.085	2	3.043	77.324	.000
Within Groups	.708	18	.039		
Total	6.794	20			

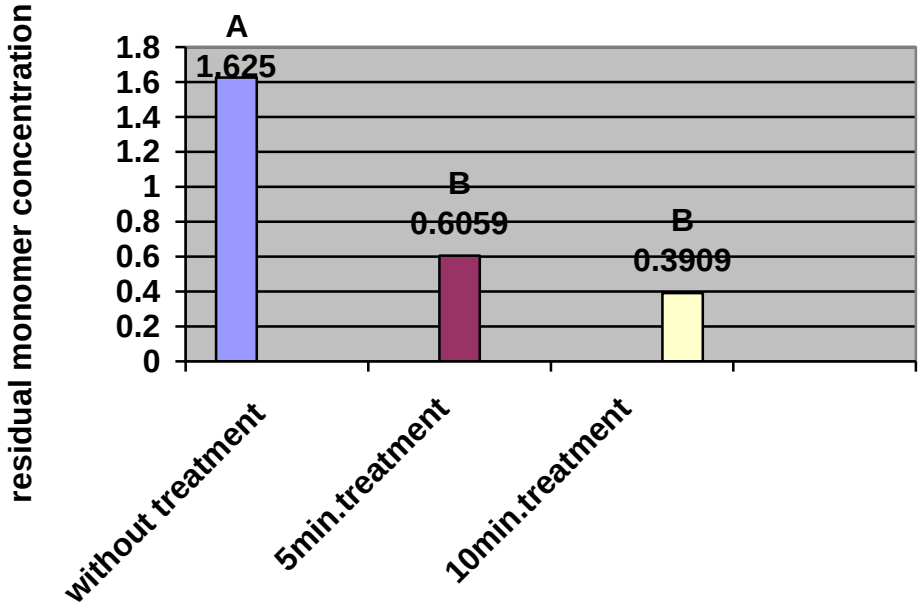

Figure (4): Duncan multiple range test for orthocryl acrylic resin

The heating generated during microwave irradiation probably provided additional polymerization, thereby reducing the residual monomer content. In addition, the decrease in residual monomer by microwave heating could have been due to monomer volatilization. The reduced amount of residual monomer is probably the result of a combination of the above mechanisms.[9]

No statistical difference were seen between 5 and 10 minutes microwave treatment for the orthocryl acrylic resin and this in agreement with Faltermeier *et al*.[18] The reason may be due to the completion of the polymerization of the or-

thocryl at the 5 minutes causing the extra microwave _treatment to 10 minutes non significant.

CONCLUSIONS

The heat cured acrylic resin showed the lowest level of residual monomer. The light cured acrylic resin showed the highest level of residual monomer. The orthocryl acrylic resin showed the intermediate level of residual monomer between heat and light cured acrylic resin.

Additional treatment with microwave after curing decrease the residual monomer of all the tested acrylic resin materials.

Increasing the time of microwave treatment from 5 to 10 minutes reduce the residual monomer of the light cured acrylic resin but does not affect the heat cured and the orthocryl acrylic resin.

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