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**Araştırma/ Research Article**

# EVALUATING THE POLYMERIZATION PROPERTIES OF MOSTLY USED THREE DENTAL HARD CHAIRSIDE RELINE MATERIALS AND A SELF-CURE ACRYLIC: AN IN-VITRO STUDY

# DİŞHEKİMLİĞİ PRATİĞİNDE EN SIK KULLANILAN 3 FARKLI SERT BESLEME MATERYALİ VE 1 ADET OTO POLİMERİZAN AKRİLİK REZİNİN POLİMERİZASYON DEĞERLERİNİN ÖLÇÜLMESİ: BİR LABORATUVAR ÇALIŞMASI

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## ABSTRACT

**Aim:** We evaluated the polymerization properties of mostly used three hard chairside reline materials and a self-cure acrylic resin. By polymerizing these materials in a device simulating an intraoral area, the setting time of polymerization, polymerization temperature and change in enthalpy were established.
**Material and Method:** The denture-lining materials investigated were three hard chairside reline materials (Ufi Gel Hard, Elite Hard Relining, and GC Reline) and an autopolymerizing acrylic resin (SC Self-Cure Acrylic) at body temperature. The study was performed at Firat University, Faculty of Science. A sapphire differential scanning calorimetry device (Sapphire-DSC) was used to analyze the reline materials.
**Results:** Statistically significant differences were observed among materials with respect to a change in enthalpy ($p<0.001$) and temperature ($p<0.05$) during polymerization. However, no significant difference was established for the setting time ($p>0.05$).
**Conclusion:** The Elite Hard Reline material showed the best results in all categories. Our results indicated that the enthalpy and temperature changes in the GC Reline sample was extremely high compared to the other hard chairside materials and self-cure acrylic sample.
**Keywords:** Enthalpy change, hard chairside relining material, polymerization, self-cure acrylic resin

## ÖZET

**Amaç:** Bu çalışmamızda 3 farklı sert besleme materyali ve 1 adet oto polimerizan akrilik rezin arasındaki polimerizasyon özellikleri karşılaştırıldı. Ağız içi ortamı taklit eden bir alet vasıtasıyla, polimerizasyon süresi, polimerizasyon sıcaklığı ve entalpideki değişiklik değerlendirildi.
**Materyal ve Metot:** Çalışmamızda 3 farklı sert besleme materyali (Ufi Gel Hard, Elite Hard Relining, and GC Reline) ve 1 adet oto polimerizan akrilik rezin (SC Self-Cure Acrylic) kullanıldı. Deney Fırat Üniversitesi Fen Fakültesi'nde gerçekleştirildi. Materyallerin analizinde, diferansiyel kalorimetri tarama cihazı (Sapphire-DSC) kullanıldı.
**Sonuçlar:** Polimerizasyon esnasında entalpi değerindeki ($p<0.001$) ve sıcaklık değerindeki ($p<0.05$) değişimlerde istatistiksel olarak anlamlı sonuçlar bulundu. Sertleşme süresi açısından ($p>0.05$) ise materyaller arasında herhangi bir istatistiksel fark bulunmamıştır.
**Tartışma:** Elite Hard Reline sert besleme materyali bütün kategorilerde en iyi sonuçları göstermiştir. GC Reline sert besleme materyalinin entalpi ve sıcaklık değerlerinde göstermiş olduğu sonuçlar bütün diğer materyallere oranla oldukça yüksek bulunmuştur.
**Anahtar Kelimeler**: Entalpi değişimi, sert besleme materyali, polimerizasyon, oto polimerizan akrilik rezin

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## INTRODUCTION

Over time, dentures can become loose. Poorly fitting dentures can lead to a variety of denture-related problems. Denture relining, the best solution for loose dentures, corrects poor retention and stability and degradation of the denture base. In addition, this process can help older patients adapt to a new denture base, which would be difficult otherwise, due to a lack of denture extension into the mucobuccal fold areas[1-4].

Hard chairside reline resins have been used to improve the fit and function of existing denture bases directly in the mouth. This so-called direct reline system save time and is convenient compared to indirect (heat-polymerized) relining, allowing patients to have their dentures corrected without delay. The characteristics and properties of the hard chairside reline materials may have an effect on the long-term success of the relining procedure[1,2,4]

Because dentures are exposed to changes in temperature, as a result of ambient temperature changes and the intake of hot and cold foods, their resistance to thermal stress is an important consideration. Many studies have used thermal cycling to simulate the clinical conditions of the oral cavity [5-8]. The presence of an interface between the denture base resin and relining material may also influence the magnitude of the effect resulting from changes in temperature. Polymerizing these materials intraorally makes it possible to determine in situ the polymerization setting time, polymerization temperature difference, and change in enthalpy[5-8].

Enthalpy is a measure of the total energy of a thermodynamic system determined by the system's internal energy and the product of its pressure and volume. The unit of measurement for enthalpy in the International System of Units (SI) is the joule[9].

A change in enthalpy occurs under the condition of heat absorption (or release) by the material through a chemical reaction or by external heat transfer. The increase in enthalpy of a system is exactly equal to the energy added through heat. Enthalpy change can also be referred to as energy absorption[9].

The new-generation denture-relining materials consist of a variety of methacrylate monomers and polymers, as opposed to methyl methacrylate (MMA) and poly (methyl methacrylate) (PMMA), to control the setting time and temperature, and to reduce mucosa irritation[2,3,10,11]. Because exothermic energy is released, the temperature rise during relining can trigger the onset of mucosa irritation[2,3,12]. Bunch *et al.* reported temperature differences among self-cured hard reline materials of up to 10°C; thus, this difference may be detectable under clinical conditions[3].

The aim of this study was to evaluate the polymerization properties of mostly used three hard chairside reline materials and a self-cure acrylic resin.

## MATERIALS AND METHODS

The three hard chairside reline materials and self-cure acrylic resin used in this study are listed in Table 1.

Ufi Gel Hard (VOCO GmbH, Cuxhaven, Germany), Elite Hard Relining (Zhermack S.P.A, Barda Polesine, Rovigo, Italy), GC Reline Hard Relining (GC, USA) and SC Self-Cure Acrylic (Imicryl, Turkey) denture materials were investigated using a differential scanning calorimetry system (Sapphire-DSC, Perkin Elmer, USA) at Fırat University. Differential scanning calorimetry or DSC is a thermoanalytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Both the sample and reference are maintained at nearly the same temperature throughout the experiment. The temperature program for a DSC analysis is designed such that the sample holder temperature increases linearly as a function of time. The polymerization setting time, curing temperature difference, and enthalpy change were studied directly at intraoral environment, using the device in situ, for a body temperature of 37°C.

For the four specimen types, the powder/liquid mixing ratios were prepared, and the mixing procedures were performed as instructed by the manufacturer. The relined materials were poured into preweighed 40 μL aluminum crucibles, and then inserted into the Sapphire DSC system. The setting time (min.), curing temperature difference (°C), and change in enthalpy (mJ $mg^{-1}$) were recorded during the polymerization setting process.

## STATISTICAL ANALYSIS

IBM SPSS 21.0 for the Windows statistical software package (SPSS Inc., Chicago, USA) was used for statistical analysis of the data. Setting time, enthalpy change, and temperature difference during polymerization were compared using a one-sample t-test. Hypotheses were bidirectional, with P values less than 0.05 considered statistically significant.

## RESULTS

Figure 1 shows the polymerization parameter values for the Elite Hard Relining specimen during polymerization; the setting time was 3.68 min, the curing temperature difference was 1.43°C, and the change in enthalpy was −87.5 mJ $mg^{-1}$.(fig1)

Figure 2 shows the polymerization parameter values for the Ufi Gel Hard specimen during polymerization; the setting time was 1.58 min, the curing temperature difference was 3.68°C, and the change in enthalpy was −100.0 mJ $mg^{-1}$.(fig2)

Figure 3 shows the polymerization parameter values for the GC Reline specimen during polymerization; the setting time was 1.04 min, the curing temperature difference was 5.51°C, and the change in enthalpy was −111.0 mJ $mg^{-1}$.(fig3)

Figure 4 shows the polymerization parameter values for the Imicryl Sc Self Cure Acrylic specimen during polymerization; the setting time was 1.06 min, the curing temperature difference was 3.06°C, and the change in enthalpy was −110.0 mJ $mg^{-1}$.(fig4)

When four specimens were examined (table 2), the Elite Hard Relining sample exhibited the best results in all categories, and the GC Reline Hard Relining demonstrated the worst results in all categories. Especially temperature differences (fig.5) and enthalpy change results (fig.6) showed significant differences. Self-cure acrylic resin is mostly used in laboratory settings; however, sometimes it can be used directly intraorally. Surprisingly, the results for the self-cure acrylic resin specimen (Imicryl) were better than the GC Reline material in all categories. Results were explained in detail in Table 2.

Table 2 provides a summary of the our test results, given below:

*Curing temperature difference* ( *°C* )*:* GC>Ufi Gel>Imicryl>Elite

*Enthalpy change* ( *mJ* $mg^{-1}$ )*:* GC >Imicryl>Ufi Gel>Elite

*Setting time* ( *min*)*:* GC<Imicryl<Ufi Gel<Elite

According to the statistical results of our test:(table 3)

**ns** No significant differences in polymerization times among the four materials (*p*>0.05).

******* Highly significant differences among the four materials for enthalpy change (*p*<0.001).

***** Significant differences in temperature during polymerization among the four materials (*p*<0.05).

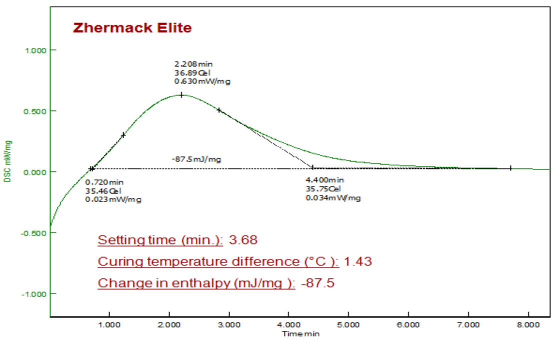


Fig. 1. Setting time, curing temperature difference, and change in enthalpy during the polymerization of the Zhermack Elite Hard Relining specimen at body temperature.

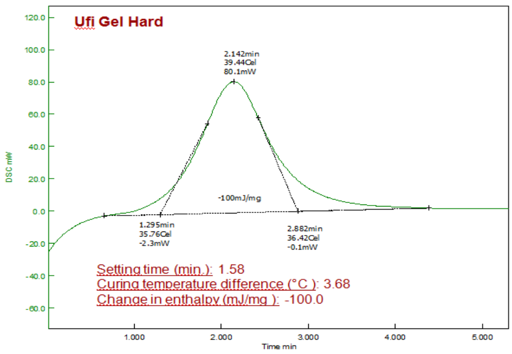


Fig. 2. Setting time, curing temperature difference, and change in enthalpy during the polymerization of the Ufi Gel Hard specimen at body temperature.

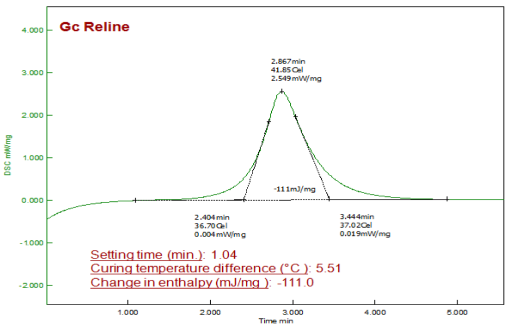


Fig. 3. Setting time, curing temperature difference, and change in enthalpy during the polymerization of the GC Reline specimen at body temperature.

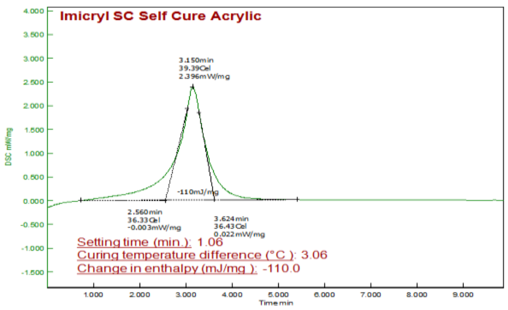


Fig. 4. Setting time, curing temperature difference, and change in enthalpy during the polymerization of the Imicryl Sc Self Cure Acrylic specimen at body temperature.

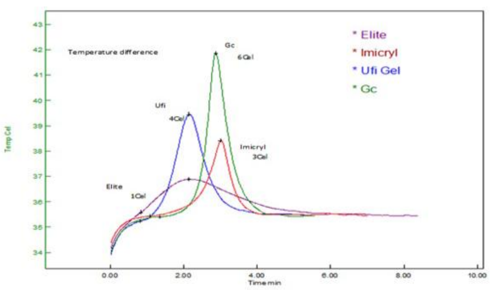


Fig. 5. Temperature difference values for all specimens at body temperature.

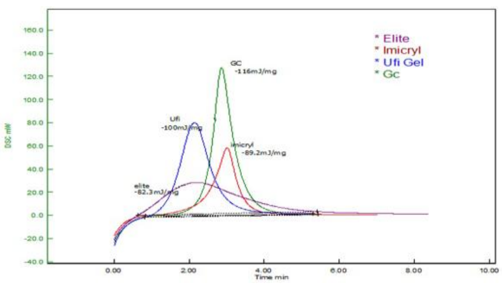


Fig. 6. Enthalpy change values for all specimens at body temperature.

Table 1. Materials used in the study

| Material | Powder | Ingredients | Manufacturer |
|---|---|---|---|
| Ufi Gel Hard | PEMA | Bis-GMA, UEDMA | VOCO Gmbh, Cuxhaven Germany |
| Elite Hard Relining | PEMA | Hexanodiol dimethacrylate dimethyl-p- toluidine | Zhermack S.P.A Barda Polesine (Rovigo), Italy |
| GC Reline Hard Relining | PEMA | Butoxyethyl-Methacrylate Benzoyl-MA, 1,6-HDDMA | GC, USA |
| Sc Self-Cure Acrylic | PMMA | Polymethylmethacrylate Benzoyl Peroxide | Imicryl, Turkey |

Table 2. Experimental results for the four specimens during polymerization in a Sapphire-DSC device according to the body temperature.

| | Elite | GC | Imicryl | Ufi |
|---|---|---|---|---|
| **Polymerization (Setting) Time (min.)** | 3.68 | 1.04 | 1.06 | 1.58 |
| **Polymerization Energy (Enthalpy Change) (mJ/mg)** | -87.5 | -111.0 | -110.0 | -100.0 |
| **Temperature Differences during Polymerization (°C)** | 1.43 | 5.51 | 3.06 | 3.68 |

Table 3. Statistical results for the four specimens during polymerization in a Sapphire-DSC device according to the body temperature. One-sample *t*-test was used; $p \leq 0.05$ was considered statistically significant

| | *p-value* |
|---|---|
| **Polymerization (Setting) Time (min.)** | 0.061$^{ns}$ |
| **Polimerization Energy (Enthalpy Change) (mJ/mg)** | 0.000*** |
| **Temperature Differences during Polymerization (°C)** | 0.027* |

## DISCUSSION

This laboratory-based study provided strong evidence for differences in energy absorption (enthalpy change) and temperature during polymerization between the hard chairside reline materials and self-cure acrylic resin. No significant differences in polymerization times among the materials were observed. Although hard chairside reline materials have been commercially available for some time, little is known about their properties. Ufi Gel Hard, Elite Hard Relining, GC Reline, and Imicryl self-cure acrylic, used directly, intraorally, were selected for this study because they are commercially available and have been on the market for several years in Turkey.

Self-cure acrylic resin is not commonly used directly, intraorally. However, in Turkey, self-cure acrylic resin is heavily used for the repair and relining of dentures and for the placement of the female part of the ball attachment to the implant-retained overdenture intraorally at the end of the process. Thus, it is necessary to show the physical effects of the self-cure acrylic resin while being used directly, intraorally, and to compare these effects to hard chairside reline materials.

Previous studies focused on the hardness and bond strength of chairside materials. For example, Haywood et al.[1] compared three hard chairside denture reline materials, and Kim et al.[13] studied the shore hardness and tensile bond strength of long-term soft denture lining materials.

Several research groups have investigated the energy absorption of reline materials; however, most of these studies considered soft-linings. Tasopulos et al.[14] evaluated the energy absorption of chairside soft-relining materials; their results showed that SoftReliner S compared favorably with Molloplast B in terms of energy absorption. Jagger et al.[15] investigated the energy absorption properties of sports mouthguard materials; the silicone materials demonstrated better energy absorption properties.

In our study, statistically high significant differences ($p$<0.001) were observed among the materials with regard to energy absorption (enthalpy change) (fig.6). Elite Hard Relining material absorbed the least amount of energy according to the results. The GC Reline material demonstrated the worst performance among the four materials tested, particularly with respect to its change in enthalpy.

At the same time, we measured the temperature behavior of these materials using a device to simulate the intraoral area. Yannikakis et al.[5] also studied the temperature rise during intraoral polymerization of self-cured hard denture base liners. They asked the question, "What is the temperature threshold that mucosa undergo permanent damage?[5] At the time, no information was available to address this issue; however, the ideal material would be the one that holds the lower peak temperature value. As such, our results indicated that the Elite Hard Relining material exhibited the lowest temperature change during polymerization among the materials tested; the difference among test samples was statistically significant (Fig.5). Similar results were obtained by Yannikakis et al.[5]

In our study, the setting time for polymerization of the Elite Hard Relining material was better than the others, but no statistically significant difference was observed among materials.

## CONCLUSIONS

Within the limitations of this study, the results showed that differences existed between the enthalpy change and temperature change during polymerization of three hard chairside reline materials and a self-cure acrylic resin.

One of the hard chairside materials, Elite Hard Relining demonstrated excellent performance for absorbing the least amount of energy and retaining mean temperature values near normal body temperature. GC Reline showed the highest enthalpy and temperature change values during the experiment. Ufi gel Hard showed similar results to those obtained for the self-cure acrylic resin.

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