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Influence of Different Temperatures on the Polymerization Pre- and Post-Cured of Various Resin Materials

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Abstract

Objective: To evaluate and compered the effect of different temperatures (5°C, 37°C and room temp. ±23°C) pre- cured and post-cured for three universal- Chroma composite materials (Hybrid-Nano fillers, Supra-Nano, Nano filler) on the polymerization degree and micro-hardness.

Materials: A seventy-five disc-samples-shaped were fabricated from (Omnichroma, Vittra APS, DenFil N), for each test in different temperatures (5°C, 37°C and room temp. ±23°C) were light cured according to manufacture instruction. The Fourier trans-form infrared spectroscopy was used to the polymerization degree measured for each sample while the micro-hardness was measured by the using of Vickers hardness test. Data were analyzed using One-Way-Analysis of Variance at level $p < 0.05$.

Results: The analysis showed that there was significant difference in the polymerization degree and in the micro-hardness of the samples fabricated at the different temperatures when heated pre- and post-cured of all materials increase, in the polymerization degree and the micro-hardness of the samples.
Conclusions: Increasing three universal- Chroma composite materials (Hybrid-Nano fillers, Supra-Nano, Nano filler) temperature whether pre-cured and post-cured allows for maintaining or increasing polymerization degree and hardness of three universal- Chroma composite materials especially DentfilN Nano- filler composite.

Keywords: Temperature, Universal- Chroma composite, Degree of polymerization, Micro-hardness.

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Introduction

Composite resins (CRs) are aesthetic dental-restorative materials that can be placed directly with minimal loss of tooth structure. CRs have become the most widely used posterior tooth fillings [1].

CRs are composed of monomer converted to polymer during polymerization and can be studied with fourier transform infrared spectroscopy technique without changing typical clinical conditions [2,3]. The CR as a direct restoration can be usage facilitated via pre-heating but is still a controversy.

CR restorations are technique sensitive and are typically placed and cured in 2mm layers [4,5].

Temperature plays an important role in the polymerization process of CRs [6]. When temperature is higher, it enhances monomer mobility, due to lowered viscosity, with increased degree of conversion [7,8].

Hardness is a property of major importance for assessing the adequate setting and stability of restorative materials [9]. Refrigerating CRs appeared to decrease degree of conversion, requiring more time for curing [10,11]. Higher degree of conversion improves fracture resistance [12]. Heating CRs allow for reduction of curing time and

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less thickness, which is desirable in deep restorations [13].

The objective of this study was to evaluate and compare the effect of different temperatures (5°C, 37°C and room temperature, ±23°C) in three pre- and post-cured universal- Chroma composite materials (Hybrid-Nano fillers, Supra-Nano, Nano filler).

Materials and Methods

Table 1 and Figure 1 describe the composite resins used in the study.

Specimen Fabrication and distribution

Seventy-five samples were prepared and distributed as follows:

Group 1: refrigerated samples before curing at 5°C for 24h.

Group 2: refrigerated samples after curing at 5°C for 24h.

Group 3: pre-heated samples before curing at 37°C for 24h

Group 4: heated samples after curing at 37°Cfor 24h

Group 5: samples stored at room temperature after curing (±23°C for 24h).

All specimens were prepared by condensing the CRs into a polyethylene mold (2mm depth or height and 5mm in diameter) and then the materials were covered with cellulose strip matrix and cover glass slide. After that, specimens were cured via LED-LCU according to manufacture instructions using a digital timer. The LCU tip was placed directly over each sample (without space between them) at the top surface after that was finished and polished (TDV, Brazil) with a low-speed handpiece. Then, samples were put in a dark container in an incubator (Fisher scientific-isotemp/incubator/USA).

FTIR (Fourier trans-form infrared spectroscopy) was used to determine the degree of conversion. The spectra of CRs was recorded. The double vinyl bonds are shown by the intensity of the peak (1608-1637 cm^{-1}) referring to the C=C, then degree of conversion (DC) was calculated using the following equation:

$$DC = \{(Ao-At)/Ao\} *100.$$

where Ao = uncured resin material and At = cured resin-material. Statistical analysis was done using ANOVA.

Microhardness was measured with a Vickers diamond indenter attached as Figure 2a. A load was applied over the top of the polished surface of each specimen (300g) for 15 seconds. Two point evenly spaced indentation measurements were made. There was no instance with less than 1 mm between indentations or to the margin of the discs. Measurements were made as the diagonal lengths of the indentation mark made on the surface of each disc. Average values were calculated. The resultant dimensions were measured with the aid of an optical microscope (300 X) (Yamayo Make Tr-200) (Figure 2b).

Statistical analysis was performed with SPSS 18 software (IBM Analytics, Armonk, NY, USA), with $p < 0.05$ considered statistically significant.

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Figure 1. Materials and fabricated discs used in the study.

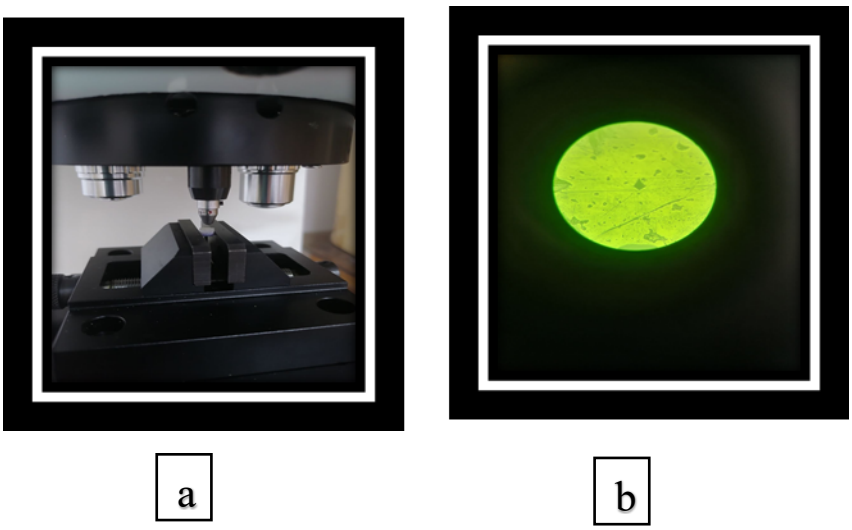

Figure 2. (a) Vickers diamond (b) indentations of Vickers micro-hardness.

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Table 1. Materials used in the study.

Material/ Shade	Type	Manufacture	Composition
Vittra APS NIQUE / Universal chroma	Hybrid-nano fillers	FGM, Brazil	Matrix: Mixture of methacrylate monomers, UDMA, TEGDMA, photo initiator compound (APS). Fillers: 72-80% by weight, 52-60% by volume boron-aluminum silicate glass.
OMNICHROMA/ Universal chroma	Supra-nano	Tokuyama Dental, Japan	Matrix: UDMA, TEGDMA. Fillers: 79% by weight uniform supra-nano spherical filler (SiO2- ZrO2 260 nm).
DenFil N / Universal chroma	Nano- filler	VERICOM, Korea	Matrix: BisGMA, TEGDMA Filler content: Barium, aluminosilicate, Fumed silica. Filler: 80% by weight

Results

Degree of Conversion (DC)

Descriptives of DC values of the three tested CRs pre-cured and post- cured at different temperatures (5°C, 37°C, and room temperature, ±23°C) are seen in Table 2. The DC values for the disc

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samples pre- and post-cured at 5°C were lower than those for disc samples pre- and post-cured at 37°C or at room temperature.

Analysis of variance ANOVA showed that there were significant differences at 37°C. The DC increased pre-and post-cured at 37°C, while there were no significant differences between DC at 5°C (Table 3).

Vickers Micro-Hardness (VH)

Vickers microhardness (VH) evaluations of the different tested composite materials before and after polymerization at different temperatures are shown in Table 4. The VH values for the disc samples at 5°C were lower than those for specimens at 37°C. This was shown for the three CR types tested with 2 mm thickness, whether pre- or post-cured.

Analysis of variance ANOVA showed that there were no significant differences at 37°C of VH of the three CR tested pre- and post-cured ($p<0.05$). The VH increased at 37°C, while there were no significant differences between VH of the three CR tested at 5°C, whether pre- and post-cured are presented in Table 5.

Discussion

The study demonstrated the influence of different temperatures on microhardness and DC on universal Chroma CR materials. No clinically relevant differences were found in the temperatures and materials studied.

Higher DC and microhardness were reached on the top aspect of samples tested whether pre- or post-cured at 37°C when compared with CRs cured at room temperature. These results may be because higher temperatures will allow for additional polymerization and increased degrees of conversion [14,15].

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Table 2. Descriptives the degree of conversion.

		N	Mean	Std. Deviation	F	p-value
degree_0f_ conversion at room temp. ±23°C	DentfilN	5	46.8000	2.16795	38.160	0.000
	Omnichroma	5	33.0000	5.70088		
	Vittra	5	53.0000	2.00000		
	Total	15	44.2667	9.30796		
pre_cure_at_37°C	DentfilN	5	54.6000	8.56154	0.175	0.842
	Omnichroma	5	52.4000	2.30217		
	Vittra	5	53.0000	5.70088		
	Total	15	53.3333	5.71548		
post_cure_at_37°C	DentfilN	5	71.4000	.89443	89.274	0.000
	Omnichroma	5	82.0000	2.00000		
	Vittra	5	89.8000	4.08656		
	Total	15	84.4000	9.87638		
pre_cure_at_5°C	DentfilN	5	34.2000	7.98123	18.635	0.000
	Omnichroma	5	17.2000	1.78885		
	Vittra	5	32.4000	1.81659		
	Total	15	27.9333	9.07482		
post_cure_at_5°C	DentfilN	5	44.4000	3.64692	152.785	0.000
	Omnichroma	5	46.0000	.70711		
	Vittra	5	21.4000	2.19089		
	Total	15	37.2667	11.85909		

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Table 3. Descriptives the Vickers Micro-Hardness.

		N	Mean	Std. Deviation	F	p-value
Vickers micro-hardness at room temp. ±23°C	DentfilN	5	72.4200	.50695	2163.804	.0000
	Omnichroma	5	47.5400	1.37949		
	Vittra	5	38.1200	.13038		
	Total	15	52.6933	14.99788		
pre_cure_at_37°C	DentfilN	5	71.5600	.25100	2920.686	0.000
	Omnichroma	5	47.7800	.80436		
	Vittra	5	50.2800	.40866		
	Total	15	56.5400	11.05550		
post_cure_at_37°C	DentfilN	5	75.0400	.11402	93128.00	0.000
	Omnichroma	5	50.6400	.11402		
	Vittra	5	51.4000	.07071		
	Total	15	59.0267	11.72534		
pre_cure_at_5°C	DentfilN	5	40.7800	.16432	4797.748	0.000
	Omnichroma	5	33.1400	.08944		
	Vittra	5	29.5400	.26077		
	Total	15	34.4867	4.85399		
post_cure_at_5°C	DentfilN	5	45.8200	.13038	17154.273	0.000
	Omnichroma	5	37.8800	.04472		
	Vittra	5	36.5400	.05477		
	Total	15	40.0800	4.23998		

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Table 4. Vickers microhardness values of the study.

		N	Mean	Standard Deviation	Standard Error
Vickers microhardness at room temperature (±23°C)	DentfilN	5	72.4200	.50695	.22672
	Omnichroma	5	47.5400	1.37949	.61693
	Vittra	5	38.1200	.13038	.05831
	Total	15	52.6933	14.99788	3.87244
Pre-cured at 37°C	DentfilN	5	71.5600	.25100	.11225
	Omnichroma	5	47.7800	.80436	.35972
	Vittra	5	50.2800	.40866	.18276
	Total	15	56.5400	11.05550	2.85452
Post-cured at 37°C	DentfilN	5	75.0400	.11402	.05099
	Omnichroma	5	50.6400	.11402	.05099
	Vittra	5	51.4000	.07071	.03162
	Total	15	59.0267	11.72534	3.02747
Pre-cured at 5°C	DentfilN	5	40.7800	.16432	.07348
	Omnichroma	5	33.1400	.08944	.04000
	Vittra	5	29.5400	.26077	.11662
	Total	15	34.4867	4.85399	1.25330
Post cured at 5°C	DentfilN	5	45.8200	.13038	.05831
	Omnichroma	5	37.8800	.04472	.02000
	Vittra	5	36.5400	.05477	.02449
	Total	15	40.0800	4.23998	1.09476

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Table 5. One-way ANOVA for Vickers microhardness.

		F	p-value
Vickers micro-hardness at room temperature (±23°C)	Between Groups	2163.804	0.000
	Within Groups		
	Total		
Pre-cured at 37°C	Between Groups	2920.686	0.000
	Within Groups		
	Total		
Post-cured at 37°C	Between Groups	93128.000	0.000
	Within Groups		
	Total		
Pre-cured at 5°C	Between Groups	4797.748	0.000
	Within Groups		
	Total		
Post-cured at 5°C	Between Groups	17154.273	0.000
	Within Groups		
	Total		

Improved flow ability of heated CRs may result in better adaptation to internal walls of deep cavity preparation. Also, curing at higher temperatures might have improved physiomechanical properties of the material [16], and higher microhardness values [15,17]. Our tests were done using accurate (FTIR) and accessible methods (VH) [18,19].

Finally, elevating CR temperature during light curing is caused by both the heat generation from CR polymerization and from the light source. This may lead to pulp tissue damage. However, the blood circulation in

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the chamber of pulp may play a role in decreasing the temperature induced by the CR polymerization [20].

Conclusions

Increasing the temperature of composite resins, whether pre- or post-cured, allows for maintaining or increasing degree of polymerization and hardness.

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