REVISTA SAÚDE

# COMPARISON BETWEEN HALOGEN LIGHT AND LED CURING UNITS: THE DEGREE OF CONVERSION OF ONE NANOFILLED RESIN COMPOSITE

## *COMPARAÇÃO ENTRE UNIDADES FOTOATIVADORAS DE LUZ HALÓGENA E LED: GRAU DE CONVERSÃO DE UMA RESINA COMPOSTA NANOPARTICULADA*

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**ABSTRACT:** This study evaluated the effectiveness of LED curing units (Radii, Ledition, and Optilight LD Max) and one halogen-based curing unit (Optilux 501) regarding the immediate degree of conversion (DC) of one nanofilled resin composite (RC - Filtek™ Z350- A2) using Fourier Transformed Infrared analysis (FTIR). A 2-mm thick resin composite layer was applied to the horizontal diamond ATR element in the optical bench of a FTIR spectrometer. FTIR spectrum was collected from specimen in the uncured state. The specimens were exposed to curing light for 20 s according to the manufacturer's instructions and another FTIR spectrum was collected from the cured resin composite layer immediately after light-exposure. DC values were calculated by standard methods using changes in the ratios of aliphatic-to-aromatic C=C absorption peaks in the uncured and cured states obtained from the infrared spectra. The DC data were submitted to 1-way ANOVA followed by post-hoc Tukey's test at a pre-set alpha of 5%. Specimens light-activated by Ledition and Radii showed the highest immediate DC values, while Optilight LD Max promoted the lowest DC values among all groups. Specimens light-activated by Optilux 501 showed lower DC values than those specimens light-activated by Ledition and Radii and higher DC values than those light-activated by Optilight LD Max. The monomer conversion of the nanofilled RC is rather product-dependent than related to the type of curing unit.
**KEYWORDS:** Degree of conversion. LED. Nanofilled resin composite

***RESUMO:*** *O objetivo deste estudo foi avaliar a eficiência das fontes fotoativadoras LED (Radii, Ledition e Optilight LD Max) e uma halógena (Optilux 501) no grau de conversão (GC) de uma resina composta (RC) nanoparticulada (Filtek™ Z350- A2), através da Espectroscopia Infravermelha Transformada de Fourier (FTIR). Para tanto, foi utilizada uma matriz bipartida de teflon na qual foram inseridos incrementos com 2 mm de espessura e os mesmos foram fotoativados por 20 segundos de acordo com as orientações do fabricante. Espectros FTIR foram obtidos previamente e após a fotoativação. As razões entre os picos de ligação-dupla de carbono alifáticas e aromáticas foram comparadas entre espectros obtidos antes e após polimerização para se determinar o GC (%). Os resultados foram submetidos a ANOVA fator único seguida pelo teste de Tukey (α=5%). O maior grau de conversão foi observado quando a RC foi fotoativada pelo LED Radii, não apresentando diferença estatística para o grupo fotoativado pelo Ledtion. Grupos fotoativados com Radii e Ledition apresentaram maior GC do que o grupo fotoativado com Optilux 501. O menor grau de conversão foi apresentado pelo grupo fotoativado com Optilight LD Max. Os resultados deste estudo permitiram concluir que existem diferenças entre os fotoativadores, tal diferença não se deve ao tipo de fotoativador, mas sim ao produto em si.*
***PALAVRAS-CHAVE:*** *Grau de Conversão. LED. Resina Composta Nanoparticulada.*

## INTRODUCTION

For many years, quartz-tungsten-halogen bulbs have been used as the lighting source to photo-activate visible-light cured composite resins. However, many factors may compromise the performance of halogen light curing units (LCUs), such as fluctuations in the line voltage, the condition of the bulb and filter, damage to the fiber-optic bundle as well as bulb overheating within the unit. These factors can reduce the efficiency and lifetime of halogen lamps, leading to poorly polymerized composite resins with impaired mechanical properties[1].

Blue light emitting diode (LED) technology has been indicated as an alternative to conventional halogen lights. LEDs LCUs consume little power and do not require filters to produce blue light. Moreover, the use semiconductors for light emission generate less heat and undergo less degradation

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over time than the hot metal filaments used in halogen bulbs. The gallium nitride LEDs produce a narrow wavelength peak around 470 nm, which matches the absorption peak value of camphorquinone, which is the most common photoinitiator used in dental restorative composites[2].

Some mechanical and physical properties, such as compressive and flexural strength, hardness, degree of conversion (DC) and depth of cure, of resin composites light-cured by LED have been reported in the dental literature. Although LED LCUs tends to be as effective as halogen LCUs [3-6], further studies are required to evaluate all options of LED curing units commercially available[7,8].

Despite many reports about the effects of LED on composite resins, most studies have focused on 24-hour analyses[9-12]. However, the mechanical properties of resin composites immediately after light-activation deserves some concern as the restorative material is submitted to all stress related to finishing procedures and occlusal adjusts. For this reason, it is crucial to determine the DC values of resin composites immediately after light-activation using LED curing units. This FTIR study evaluated the DC of one nanofilled resin composite light-activated with LED curing units or halogen LCUs. The null hypothesis was that there is no significant difference in the immediate DC when a nanofilled resin composite is light-activated by halogen or LED curing units.

## MATERIALS AND METHODS

One nanofilled resin composite (Filtek™ Z350- A2, 3M ESPE, USA) was used in this study. A 2-mm thick resin composite layer was applied to the horizontal diamond ATR element (Golden Gate, Specac, Woodstock, GA, USA) in the optical bench of a FTIR spectrometer (Tensor 27, Bruker Optik GmbH; Ettlingen; Germany). A mylar strip was placed on the top of the resin composite layer and infrared 16-scan FTIR spectrum was collected between 1680 and 1500 $cm^{-1}$ at 4 $cm^{-1}$ resolution from specimen in the uncured state. The specimens were exposed to curing light from the following light curing units: the halogen-based light curing unit Optilux 501 (Demetron, Kerr Co, Dandury, EUA), and 3 LED-based light curing units, Optilight LD MAX (Gnatus, Brazil), Ledition (Ivoclar Vivadent, Liechtenstein), and Radii (SDI Limited, Australia). The resin composite layer was exposed to 20-s light exposure according to the manufacturer's instructions and another FTIR spectrum was collected from the cured resin composite layer immediately after light-exposure. Light intensity from the light-curing units was constantly measured using a radiometer (Caulk, Cure Rite, Dentsply, USA). Monomer conversion was calculated by standard methods using changes in the ratios of aliphatic-to-aromatic C=C absorption peaks in the uncured and cured states obtained from the infrared spectra[13,14]. The DC data were submitted to 1-way ANOVA followed by post-hoc Tukey's test at a pre-set alpha of 5%.

## RESULTS

The results are shown in Figure 1. Among all groups, specimens light-activated by Ledition and Radii showed the highest immediate DC values, while Optilight LD Max Max promoted the lowest DC values among all groups. Specimens light-activated by Optilux 501 showed lower DC values than those specimens light-activated by Ledition and Radii and higher DC values than those light-activated by Optilight LD Max.

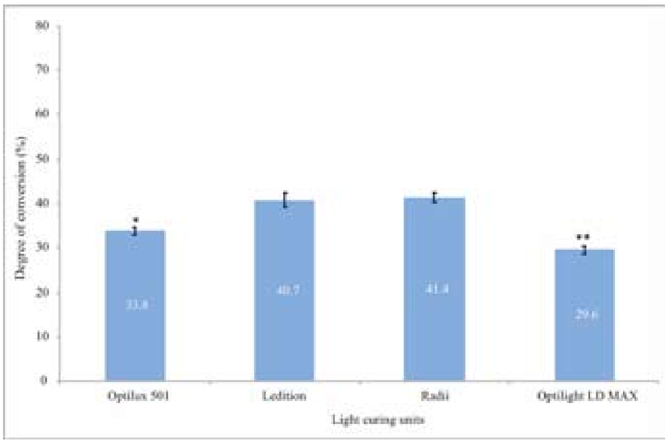


**Figure 1:** Bar graph of DC values after Filtek Z350 was exposed to curing light of Halogen- and LED-based curing units. Single and double asterisks indicate significant difference among groups ($p<0.05$).

## DISCUSSION

The results showed significant difference in immediate DC values when the resin composite was light-activated with the different LED curing units. Therefore, the null hypothesis should be rejected. Ledition and Radii exhibited higher DC values than Optilux 501. The differences in DC values may be attributed to high intensity of the curing light emitted by Ledition (approximately 1,300 $mW/cm^2$) and Radii (approximately 1,200 $mW/cm^2$), which produce higher light intensity than Optilux 501 (700 $mW/cm^2$).

Besides, the main advantage of such LED curing units is the emitted curing light with a narrow wavelength peak matching the absorption peak value of camphorquinone. In contrast, Optilux 501 emits a curing light with wide range wavelength peak, so the energy emitted by this curing unit is dispersed on heat and cannot excite camphorquinone properly. Hofmann et al.[6] observed that the hardness of some composite resins light-cured with LED curing unit emitting curing light with light intensity around 320 $mW/cm^2$ was similar to the hardness observed when the same composite resins were light-cured with halogen-based curing units. For this reason, it is possible to speculate that Ledition and Radii would promote higher DC values in resin composite than Optilux 501 even if they emitted curing light with similar light intensity.

Another factor that might explain the differences in DC promoted by LED- and halogen-based curing units are related to the differences in the temperature rise during light-activation. When a halogen-based curing unit is used, the quartz tungsten halogen bulb produces heat within the unit as well as at the tip of the light guide[8]. As a consequence, the temperature on the resin surface increases around 15.5°C to 18.6°C during the polymerization reaction, while LED rises the temperature around 8.2°C[6]. However, the new generation of LED-based curing units is capable of heating the composite during light-activation to a temperature even higher than that promoted by halogen-based curing units[15]. The heat can increase the molecular movements and the molecular collisions, which increase the rate of polymerization[16]. As a consequence, enhanced cure and improved mechanical properties are expected from the application of heat during the polymerization of a light cured material[17,18].

Based on the results demonstrated by Ledition and Radii, one could state that in general all LED-based curing units are able to promote better monomer conversion in resin composites than halogen-based curing units. However, Optilight LD Max promoted lower DC values than the other curing units, so the quality of monomer conversion did not depend on the type of curing unit evaluated in the current study. In comparison to the curing light emitted by the other LED curing units, the curing light emitted by Optilight LD Max has the lowest light intensity (240 mW/cm$^2$), so the low immediate DC values were expected.

The use of Optilight LD Max also resulted in lower immediate DC values than the use of Optilux 501. This result demonstrates that the higher excitation energy produced by an LED curing unit due to the narrow wavelength peak matching the absorption peak value of camphorquinone does not compensate for the lower light intensity in the curing light emitted by this LED curing unit in comparison to the halogen-based curing unit (Optlux 501). For this reason, the clinician should check for the light intensity of the curing light emitted by a LED curing unit to make sure that the curing unit will not only provide light with the desirable features of LED light, but also provide a curing light with proper light intensity.

The results obtained in this study are related to DC values of a nanofilled resin composite immediately after 20-second light-activation. Therefore, further polymerization of the resin composite is expected after hours or even days. It is difficult to predict if the late polymerization in a poorly polymerized resin composite will compensate for the low initial monomer conversion and provide a polymerization as effective as that observed in resin composites exhibiting high initial monomer conversion values. Further studies are required to clarify such question.

The clinical consequences of low DC values of a resin composite are unclear. However, *in vitro* studies have demonstrated that a poorly polymerized resin composite may compromise the longevity of a direct restoration as the resin has impaired mechanical properties, such as high solubility, low flexural strength and low resistance to wear[17,19-21]. On the other hand, fast rate of polymerization promoted by powerful curing units is capable of promoting high shrinkage stress[22], which in turn may compromise the bond to the cavity walls[23]. Thus, an ideal curing unit should be able to promote proper monomer conversion in a resin composite at a low initial polymerization rate.

Based on the results of this study, the effectiveness of curing units is rather product-dependent than related to the type of light source. The clinician should be aware of all features of a LED-based curing unit including the light intensity of the emitted curing light.

## CONCLUSION

In conclusion, immediate degree of conversion of a nanofilled resin composite depends on the quality of curing unit, regardless of the type of light source.

## ACKNOWLEDGMENTS

This study was supported by FAPESP grant 2008/04970-6.

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