Influence of shade and composition in the generation of heat during the dental composite photoactivation

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Abstract
The study evaluated the effect of shade and composition in the production of heat during the dental composite photoactivation. Filtek Z 250 and Esthet X in the shades A3 and B1 and Filtek Flow and Natural Flow in the shades A3 and B2 were used. The temperature was registered using a type-K thermocouple connected to a digital thermometer with an accuracy of 0,1°C. A chemically polymerized acrylic resin base was built as thermocouple guide and support for a dentin disk, obtained from bovine tooth to simulate the remaining dentin in the cavity. On the acrylic resin base was adapted a matrix made of silicone. A light source emitted by XL 2500 halogenic lamp unit was used for a photoactivation time of 20 seconds. Eight groups were established in agreement with the interaction materials and shades (n=10). Obtained values were submitted to ANOVA and the averages to Duncan’s test (5%). The results showed that there was not statistical difference among the averages of the temperature increases in the same composite with different shades. There was statistical difference among the averages of the temperature increases in different composites in the same shades.

Key Words:
photoactivation, rise temperature, resin composites, colors

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**Introduction**

Dental composites comprehend materials constituted from the bonding between load particles and resinous matrix, by means of an agent silano. The matrix consists basically of organic monomers, a polymerization inhibitor, and a system activator-initiator. The resinous matrix is a flowing component that, when polymerized, becomes rigid. This happens due to the formation of free radicals that end up inducing bonding covalence among the organic molecules, thus generating macromolecule polymers. For the formation of these free radicals it is necessary that a system activator-initiator generates enough energy in order to promote the breaking of the molecule of the peroxide of benzoile. Usually, in the case of the photoactivated systems, a certain length of wave of the visible light excites the canphoroquinone molecule that, with a tertiary amine, it induces the breaking of the molecule of benzoile peroxide, followed by the polymerization reaction by addition.

Photo-induced polymerization is a technology in expansion that results in several advantages, because the process is free from solvent and generally economical. Of the photo-activator units available in the market, the ones that use halogenic lamps as light source are the most traditional. According to Uhl et al., the main irradiation produced by these lamps is the spectrum infra-red, which is absorbed by the composites and results in great molecular vibration and generation of heat. Like this, light sources that use halogenic lamps as light source need term-absorbent filters that reduce the passage of the infra-red energy from the light source to the tooth. However, the efficiency of these filters varies according to the manufacturer and, thus, the energy not absorbed can result in production of heat.

When a source of external heat is applied on the dental structure, a damage can be generated, therefore an increase of the temperature inside of the pulpal chamber can result in irreversible inflammatory lesions to the pulpal tissues. The polymerization of photoactivated composites using visible light generates so much temperature increase for the process of exothermal reaction (that always occurs in a polymerization process with reaction by addition) as for the energy absorbed during the irradiation with the source of photo-activator light. Several studies have been accomplished to determine the factors related to the increase of intra-pulp temperature. However, the effect of factors as the composition and color of the dental composites are still ignored. The aim of the study was to verify the effect of shade and composition of dental composites in the production of heat during photoactivation.

**Material and Methods**

For this study 4 restoring composites were used: Filtek Z250 (3M/ESPE) and Esthet X (Dentsply) in the shades A3 and B1 and Filtek Flow (3M/ESPE) and Natural Flow (DFL) in the shades A3 and B2.

As photoactivation energy was used a light source emitted by XL 2500 (3M/ESPE) halogen lamp unit. Light intensity was measured using a radiometer (Demetroion Research Corporation, Danbury, CT, USA), established in 700 mW/cm². The temperature increase was registered by means of a type-K thermocouple connected to a digital thermometer (Iopetherm 46, IOPE, São Paulo, Brazil) with accuracy of 0.1°C. A chemically polymerized resin acrylic base (Classic) was built to serve as a guide to the thermocouple and as support for a dentin disk (0.5 mm thick), obtained through the wearing of a bovine incisor tooth. This disk was used to simulate the remaining dentin of the pulpal wall of a cavity. Soon after, on the acrylic resin base a perforated matrix was adapted (Figure 1), made with Xantopren VL (Heraeus/kulzer) silicone polymerized by condensation reaction.

After insertion in the matrix, the composite and the matrix of silicone were covered with a polyester tape before the composite photoactivation for a period of 20 seconds, accomplished using photo-activator unit tip positioned on the set. Ten samples were made for each of the 8 experimental groups: 1 - Filtek Z250 (A3); 2 - Filtek Z250 (B1); 3 - Filtek Flow (A3); 4 - Filtek Flow (B1); 5 - Esthet X (A3); 6 - Esthet X (B1); 7 - Natural Flow (A3); 8 - Natural Flow (B1).

All the measurements were accomplished in environment with temperature (20°C ± 1°C) and relative humidity (50 ± 10%) controlled. After the stabilization of the temperature of the set (measured by the thermocouple) in 20°C ± 1°C the photoactivation procedures were carried out and the largest value registered by the digital thermometer was considered as the thermal pick of the polymerization reaction of the composite. To proceed, the value of the initial temperature was subtracted from the value of the thermal pick, obtaining, like this, to value of the temperature occurred in the procedure. The obtained values were submitted to ANOVA and the averages to the Duncan’s test with 5% of significance.
Results
Table 1 shows that there was no statistical difference among the averages of the temperature increases in the same composite with different shades (p>0.05), and there was statistical difference among the averages of the temperature increases in different composites in the same shades (p<0.05).

Discussion
External heat applied to the tooth can increase the pulp temperature resulting in irreversible damages \(^9\text{-}^{10}\). This trauma can be induced by the cavity preparation, exothermal reaction of cements, restoring materials or heat generated by photo-activator units \(^8\text{-}^{12}\). This way, the activation of the composites for visible light can also contribute to increase the temperature inside the pulp chamber, causing possible damages to pulp \(^11\text{-}^{13}\).

The increase of light intensity can elevate the temperature during the polymerization, due to larger radiation energy supplied by the photo-activator unit \(^14\). When the thickness of the residual dentin is minimum in cavities without lining and the intensity of the activation goes high, the time of irradiation for photoactivation should be minimum \(^12\).

The heat that reaches the pulp is affected by the thickness of dentin \(^15\). According to Loney and Price \(^16\), larger thickness reduces the temperature because the dentin has low thermal conductivity. However in areas of deep cavities, where the dentin has small thickness and the diameter of the dentin tubules is larger, the damages to the pulp are greater \(^12\). For this reason, 0.5 mm of thickness was used to simulate the remaining dentin, to standardize the distance between composite and pulp chamber, and to verify the heat that reached the pulp chamber.

Although without significant statistical difference, Table 1 shows tendency of the composites Filtek Z250 and Esthet X with darker shades in promoting larger temperatures when compared with the clearest shades. This result is coherent with the result presented in previous research \(^8\). The composites with darker shades tend to absorb larger amount of light than the ones of light shades \(^17\), what could increase the temperature during the polymerization.

The composites type Flow (Filtek and Natural) possess great amount of diluent monomers and the shade does not seem to influence in the temperatures registered by the thermocouple, being speculated that the generated heat would depend more on the composition of those materials than on the shade. As same photo-activator units were used and the same time of exhibition, the heat generated by the same light density in different composites can be considered similar.

In agreement with Harrington et al. \(^18\), differences in the composition of the monomers could alter the level of transmission of the light through the composite. Composites Flow possesses great amount of diluent monomers when compared with the conventional resins with similar monomeric association in formulation \(^19\). This way, increasing the viscosity of the material, the resulting thermal conductivity could be altered. In agreement with Lloyd and Brown \(^20\), the reaction is exothermal and it is directly related with the amount of inorganic load. This way, as smaller the amount of load, the greater will be the amount of organic matrix and consequent exothermal reaction. Except for Esthet X in the shade A3, with 60% of load in volume, the conventional composites Filtek Z250 and Esthet X, in the shade B1, both with amount of similar load, presented temperatures statistically lower than the composites type Flow (Natural with 43% and Filtek with 47% of load in volume).

Anusavice \(^3\) considers that the attenuation of the light coefficient can vary considerably in different composites, depending on the size and concentration of the inorganic load. Composites with larger loads tend to decrease the absorption of light, due to the reflection occurred in those particles. This fact was observed in this study, when Filtek Z250 (particles with 0.19 – 3.3 µm) obtained values statistically inferior to Esthet X (particles of <1 µm). Among the resins Flow, the amount of load seems to have influenced the heat that reached the thermo-electrical pair, because the composite Filtek Flow (47% of load in volume) was statistically inferior
to Natural Flow (43% of load in volume). Inside of the limitations of this work, the results seem to indicate that the heat that reached the pulpal chamber would be tolerable for the dental pulp, considering that it would be necessary to increase above 5.5°C so that it could occur pulp alterations in teeth of monkeys, temperature not observed in this study.

Based in the analyzed and discussed results it was possible to conclude that: there was no statistical difference among the averages of temperature increase in the same composite with different shades (p>0.05), there was statistical difference among the averages of temperature increase in different composites in the same shades (p<0.05).

References