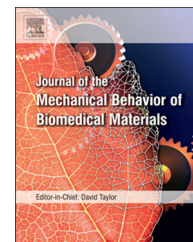


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Research Paper

Polymerization kinetics and polymerization stress in resin composites after accelerated aging as a function of the expiration date



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ABSTRACT

Objectives: To determine the effect of material condition (new, aged, and expired) on the polymerization kinetics and polymerization stress of different classifications of dental composites.

Materials and methods: Specimens were obtained according to the following factors: Composites: (3M ESPE) Filtek P60, Filtek Z250, Filtek Z350XT, and Filtek Silorane; and Material conditions: new, aged, and expired. The syringe composites underwent an accelerated aging protocol (Arrhenius model) representing approximately 9 months of aging. Infrared (IR) spectra were obtained kinetically and were analyzed for: maximum conversion rate (%/s), time into exposure when maximum rate occurred (s), conversion at maximum rate (%), and total conversion (%) at 90 s by comparison of absorption IR peak ratios before and after polymerization. Polymerization was evaluated at the bottom surface of 2.0 mm-thick specimens. Polymerization stress was determined in a tensiometer, inserting the composite between acrylic rods fixed to clamps in a universal test machine and dividing the maximum load recorded by the rods cross-sectional area. Polymerization stress (MPa) was calculated at 300 s. Data were statistically analyzed by two-way ANOVA and Tukey's post hoc test ($\alpha=0.05$).

Results: The majority of the polymerization kinetic parameters were not influenced by the material condition. Silorane composite presented significantly lower conversion rate and lower conversion at the maximum rate when expired ($p<0.05$). The nanofilled composite (Filtek Z350XT) presented a significantly higher total conversion when aged and expired

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compared to the new one ($p > 0.05$). In all conditions, Filtek Z350XT and Filtek Silorane presented significantly lower conversion rates ($p < 0.05$). Filtek Silorane also exhibited the lowest stress, irrespective of the material condition ($p < 0.05$). The polymerization stress was not influenced by the material condition ($p > 0.05$).

Conclusions: Most of the kinetic parameters are not influenced by the material condition. Filtek P60 and Filtek Z250 are more stable as both composites present similar polymerization kinetic results, irrespective of the material condition. Silorane composite presents lower stress values among the tested materials in all conditions. Aging does not affect stress development in restorative composites.

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1. Introduction

Polymerization shrinkage of resin composites remains a clinical concern because it results from complex factors, including preparation shape, bonding, environment, and the composite photoactivation technique (Loguercio et al., 2004). The kinetics of polymerization in resin composites of a given thickness is related to the efficiency of the photoinitiating system, the intensity of light transmitted through the relevant increment, and oxygen quenching (Rueggeberg, 1999). High conversion values also contribute to increased elastic modulus and cross-linking density, which are also directly related to stress (Dewaele et al., 2006). In addition, inorganic fillers also influence the magnitude of shrinkage and the elastic modulus and somehow contribute to stress development (Condon and Ferracane, 2000). Composite shrinkage is restricted by the adhesion of the material to the cavity walls, which is responsible for the stresses generated at the interface (Watts et al., 2003). The clinical consequences are marginal failures, micro-leakage, and recurrent caries (Carvalho et al., 1996). Although different approaches have been proposed to reduce polymerization shrinkage and minimize the stress of resin-based restorative materials, none of them were proven to effectively improve the longevity of resin-based composite restorations.

Different parameters must be considered to determine whether a certain product requires a shelf life and assign an expiration date (Gillen et al., 1993). Thus, this product must be analyzed to determine if it is susceptible to degradation that would lead to functional failure and the level of risk that the failure would present (Donohue and Apostolou, 1990). In addition, accelerated aging studies, combined with basic stability information on the components, may be used to support tentative expiration dates (Hemmerich, 1998). Clinicians are unaware of the consequences of the application of resin composites close to or beyond the expiry date. In this way, the clinical application of composites after aging or beyond the expiration date in terms of polymerization parameters represents a significantly clinical issue.

This paper constitutes the third part of a series; in this part the characterizations of the dental composites initiated in the previous parts, was extended as a function of the material condition (D'Alpino et al., 2014a, 2014b) therefore complementing the results with the data from studies on polymerization kinetics and polymerization stress in the

materials tested. Briefly, in all of them the parameters changed mainly for a nanofilled (Filtek Z350XT) and for a silorane-based composite (Filtek Silorane). In the first part (D'Alpino et al., 2014b), a significant increase in the mechanical properties of Filtek Z350XT after aging was accompanied by an increase in the T_g . In the second part (D'Alpino et al., 2014a), Filtek Z350XT and Filtek Silorane presented a reduction in the diffraction peaks of the organic component when aged and after expiry date. The silorane composite exhibited a distinguishing thermal behavior, a different EPR spectrum, and a lower free radical density in comparison to that of methacrylate-based composites.

In the present study, the composite syringes also underwent a simplified protocol of accelerated aging and the polymerization kinetics and polymerization stress of a variety of composites indicated for posterior application as a function of the material condition (new, aged and expired) were evaluated. The following research hypotheses were tested: (1) the material conditions will negatively influence the polymerization kinetics of the composites tested; (2) the polymerization stress will be negatively affected by the material condition in comparison to that of new composites.

2. Materials and methods

2.1. Experimental design

In this in vitro study, the different characterizations were performed according to the factors: (1) composites (3M ESPE) at four levels: Filtek P60, Filtek Z250, Filtek Z350XT, and Filtek Silorane; and (2) material condition at three levels: control ("new"), expired, and accelerated aged composites. "New" composite comprises an unexpired material, whereas "aged" were those composites which underwent an accelerated aging protocol. It is important to mention that the same lot numbers were used for the material condition levels 'new' and 'aged'. 'Expired' were those composites which the expiration date was just exceeded (< 2 years). Identical shades were tested in the present study. The characteristics of the resin composites selected are described in Table 1. Twelve groups were obtained by the product among the combinations of the factors under study.

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