Synthesis and Characterization of a Novel Polymerizable Amine Co-Initiator for Dental Application: Evaluation of Polymerization Kinetics and Quantification of Leachables

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Statement of Purpose: Polymer-based composites have become the most popular material for direct restorative dentistry due to their esthetics and the phasing out of dental amalgam. Methacrylates are ubiquitous in composite formulations, but there are limitations including incomplete monomer/polymer conversion. Incomplete conversion means that residual monomer could leach into the surrounding tissues and the oral environment. [1] The release of methacrylic monomers together with compounds of the polymerization initiator system from dental materials has been considered a source of a wide variety of adverse biological reactions, including local and systemic toxicity, pulp reactions, allergic and estrogenic effects. [2] The threefold objectives of this study were: to synthesize a new polymerizable amine co-initiator containing three methacrylate-urethane groups; to compare the co-initiator with commercial co-initiators; and to study the influence of these co-initiators on photo-polymerization kinetics and the release of leachables from the polymers.

Methods: A three-component initiator system was used, containing camphorquinone (CO)0.5 wt%), diphenyliodonium hexafluorophosphate (DPIHP, 1.0 wt%) and amine co-initiator (0.5 wt% or 1.75 wt%). Three different co-initiators were studied: ethyl-4-(dimethylamino) benzoate (EDMAB, Sigma-Aldrich, St. Louis, MO), 2-(dimethylamino) ethyl methacrylate (DMAEMA, Sigma-Aldrich, St. Louis, MO) and trifunctional urethane methacrylate (TUMA, synthesized by our lab, Fig. 1). The chemical stability of the amine coinitiators in water-containing dimethyl sufoxide (DMSOd6) was studied by NMR. The monomer system contained 2, 2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl]propane (BisGMA, Polysciences, Warrington, PA) and 2hydroxyethylmethacrylate (HEMA, Acros Organics, NJ) at the mass ratio of 45/55. The degree of conversion (DC) and polymerization rate were determined by using a Spectrum 400 FTIR spectrometer (PerkinElmer, Waltham, MA). The release of amine co-initiators and unreacted monomers from samples stored in ethanol for 60 days was examined by high performance liquid chromatography (HPLC).

Results: The chemical stability study by NMR shows EDMAB and TUMA are more stable than DMAEMA. The maximum polymerization rate $(Rp/[M]_0)$ increased from 0.12 s⁻¹ to 0.17 s⁻¹ with a TUMA concentration of 1.75 wt%. The polymerization rate with the TUMA coinitiator was lower than the rate with EDMAB or DMAEMA. The DC of the polymers is comparable for all three co-initiators, ranging from 65 to 70%. The study of leachables shows that there was no detectable release of TUMA, while there was a 53.6% and 11.2% release of EDMAB and DMAEMA, respectively (Fig. 1). HPLC analysis shows that more monomer is released from polymers with a lower DC.

Conclusions: The newly synthesized co-initiator shows good chemical stability, and can depress the amine release from the initiator system. This study provides critical results that contribute to the identification of potential hazardous compounds leaching from dental materials and important information for the future development of biocompatible dentin adhesives/composites.





Figure 2. (A) Cumulative amine co-initiators release from dentin adhesive formulations as a function of incubation time in ethanol. The percentage values shown at the right of the figure represent the mean co-initiator release into ethanol at 60 days storage. (B) Calculation was done by dividing the mass values of released compounds by the mass values of the polymer samples. (N=3)

References:

1. Kostoryze EL et al. J Biomed Mater Res Part B 2009, 88B: 394-401.

2. Ye Q et al. J Biomed Mater Res Part B 2012, 100B:1086-1092

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