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ORIGINAL ARTICLE

Dental composites with strength after aging improved by using anodic nanoporous fillers: experimental results, modeling, and simulations

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Abstract
We fabricated resin composites based on a standard matrix system used for dental restorations incorporating a novel concept microsized filler with passing-through nanopores. The fillers were obtained from anodic porous alumina (APA), after separation from the supporting aluminum substrate and ball milling. Bending tests were carried out on as-cured and artificially aged composites, to determine the material elastic modulus and its strength for the first time. A two-scale modeling was developed; at micro scale, a finite element (FE) model of the representative volume element (RVE) including single APA and surrounding polymer was constructed. The influence of embedded APA length and APA–matrix interaction on the strength was investigated. Then, FE model of the macro-scale RVE containing numerous APA with different orientations based on stochastic modeling was constructed. The output of micro-scale model was used as the input of macro-scale model. The results of simulations allowed to understand better the behavior of the novel composite and interpret the material response deviations from those of common three-phases composites, and to validate the experimental results. The strength of the experimental composite is lower than those of commercial composites used for the same application when as-cured, but is higher after aging.

Keywords Resin composites · Inorganic reinforcing fillers · Anodic porous alumina · Finite element method · Strength · Representative volume element

1 Introduction

Every luster on average one major dental company introduces to the market a new dental restorative composite that should present higher performances as compared to the previous generation. This has been happening at least during the past half a century, yet it is difficult to detect really innovative concepts and impressive improvements in the performance of any such materials [1]. The most notable advancements have been made in the sought for aesthetic quality, which is also the main reason for the ban on amalgam. However, aesthetic quality is a questionable property [2], when also considering that its common description as of natural appearance is often erroneously called bio-mimesis, while the structure and function of artificial restorative materials are quite different from those of the native tooth materials.

Advancements in dental composites may in principle occur in either of two directions, namely the resin or the filler formulation [1, 3–5]. However, as a matter of fact the second one has been dominating in the recent history, even giving the name to the different classes of composites.

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