

Improvement of the toughness of PMMA-based acrylic resin for dental application by adding small amounts of graphene nanoparticles

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Polymer nanocomposites have received much attention due to their enhanced mechanical, thermal, optical and gas barrier properties in comparison to conventional composites. Incorporation of small quantities of graphene nanoparticles causes noticeable improvement in the properties of the nanocomposites as long as a homogeneous dispersion of the nanoparticles in the matrix is achieved [1]. The adequate dispersion requires the creation of strong interactions between the graphene nanoparticles and the polymer matrix and this involves the destruction of the strong van der Waals forces between the graphene nanoparticles [2]. Graphene nanofibers have higher aspect ratio than graphene nanoplatelets but these are difficult to disperse because they interact more effectively with polymers containing aromatic rings in their structure.

In this study the influence of the addition of different small amounts of graphene nanofibers and graphene nanoplatelets to a self-polymerizing two-component polymethyl methacrylate (PMMA)-based acrylic resin for dental application were studied, paying particular attention to the improvement in toughness of the acrylic nanocomposite. The nanoparticles and the solid component of the acrylic resin mixtures were prepared in orbital double centrifugal Speed Mixer[®] equipment at 3400 rpm for 6 minutes. Transmission electron microscopy (TEM) was used to analyze the distribution of nanoparticles in the polymer matrix. The residual polymerization of the nanocomposites was determined by differential scanning calorimetry (DSC), the viscoelastic properties were obtained by dynamic mechanical thermal analysis (DMA) and mechanical properties 3-point bending tests.

The graphene nanoplatelets disperse worse in the acrylic matrix than graphene nanofibers (Figure 1), promoting lower degree of polymerization and higher extent of crack formation under compression stresses, probably due to inadequate nanoparticle-matrix interaction. On the other hand, the addition of small quantities of graphene nanofibers (0.12-0.46 wt%) improves the toughness of the nanocomposites avoiding crack formation without altering its degree of polymerization. Optimal properties of the nanocomposites (greater increase in elastic modulus at 37°C, absence of cracking and less dimensional variation under compressive stresses) are obtained by adding 0.49 wt% of graphene nanofibers to the PMMA-based acrylic resin.

References

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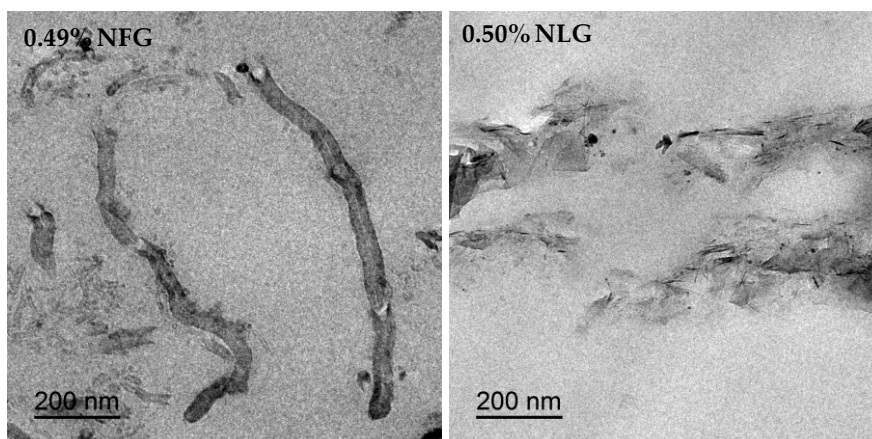


Figure 1. TEM micrographs of PMMA nanocomposites containing 0.49 wt% graphene nanofibers (left) and 0.50 wt% graphene nanosheets (right).