Nanocomposites and nanomaterials

Free volume structure of acrylic-type dental nanocomposites tested with annihilating positrons

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Positron annihilation lifetime (PAL) spectroscopy is known to be an advanced instrumentation tool that can explore a nanospace. In this report, the possibilities of this technique is analyzed in application to acrylic-type dental composites Charisma, possessing BisGMA (bisphenol A-diglycidyl dimethacrylate) matrix modified with nanofiller (barium aluminium fluoride and highly dispersive silicium dioxide glass).

The PAL measurements are performed for two photopolymerized samples using conventional fast-fast coincidence ORTEC system. The positron lifetime spectra were reconstructed from unconstrained three-term fitting or partially constrained four-term analysis assuming the shortest lifetime as fixed at 0.125 ns. Thus, the both spectra reconstruction protocols cover mixed trapping caused by positrons annihilating in defect-free bulk and extended free-volume defects (positron- and positronium Ps-related trapping sites).

It is concluded that correct analysis of defect-related processes in the studied nanocomposites can be developed by exploring original PALS-data treatment algorithm to account for interplay between simultaneously co-existing positron and Ps trapping channels, the three-component reconstruction procedure having some, albeit limited, physical relevance. The growing light-activated polymerization kinetics is detected for both intensities related to second and third components in PAL spectra accompanied with decrease in corresponding positron lifetimes. This process results in essentially enhanced trapping rate in defects and depressed fractional free volume with light curing. Meaningful phenomenological description of this phenomenon is proposed at the basis of semi-empirical model, which gives an adequate correlation between numerical characteristics of experimentally measured PAL spectra and physically real parameters of expected positron-Ps annihilation channels.