Photocurable nanocomposites for the use of synthetic cartilage replacements

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Photocurable nanocomposites have great potential within advanced manufacturing, multifunctional materials, and most specifically tissue engineering. The properties and characteristics of these nanocomposites can be tailored to mimic those of various tissues and/or cartilage, allowing the bio-inspired synthetic materials to replace them. This project investigates the effect of methacrylate-functionalized (MA-SiO_2) and vinyl-functionalized (V-SiO_2) silica nanoparticle loading content on the thermal, mechanical, physical, and morphological characteristics of PEG nanocomposites. It was discovered that both V-SiO_2 and MA-SiO_2 did not considerably impact the glass-transition temperature or hydrophilicity of the material. The gel fraction of composites containing V-SiO_2 decreases with the initial addition of 3.8 wt%, but then displays an increase with further addition (>7.4 wt%) until it reaches a plateau at 10.7 wt%. Whereas the MA-SiO_2 induced no significant changes in gel fraction with increased loading. An increase in mechanical properties was also observed with increasing concentration for both sets of series. However, due to the higher crosslink density, MA-SiO_2 reached its ultimate mechanical stress threshold at a lower concentration of 7.4 wt%, while V-SiO_2 maxed out at 10.7 wt%. Transmission electron microscopy coupled with small-angle X-ray scattering revealed that V-SiO_2 displayed a bimodal size distribution, while MA-SiO_2 displayed only one. Ultimately, the MA-SiO_2 containing composites offer superior mechanical and morphological characteristics in comparison to the V-SiO_2 loaded samples.