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Dispersion control of raw and modified silica particles in PMMA. Impact on mechanical properties, from experiments to modelling

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Abstract

Structure and properties of PMMA/silica composites were characterized by various methods including SEM, TGA, rheology, microscopic level evaluation of nano-reinforcement effect on properties. Static modulus and yield strength of PMMA are enhanced with silica incorporation regardless of their dispersion or functionalization. However, composites ultimate properties are strongly affected by fillers characteristics. As expected, better performances are associated to well-dispersed and functionalized silica.

A finite element modelling with interface debonding through cohesive model and interfacial area is introduced to reproduce the sensibility of tensile test response to fillers surface functionalization. Experimental results confirmed this modelling: at constant low weight rate, ultimate composites properties are mostly affected by any microstructural changes. An analysis of local stress confirms the premature breakage of composite with pristine silica. Finally, by considering the expected properties, functionalization of silica is not always a necessity. Instead of particle functionalization, a dispersion protocol could be advantageously used to reach interesting composite properties.

Keywords: Dispersion, Silica functionalization, PMMA/Silica nanocomposites, Mechanical properties, Finite element modelling