Molecular Engineering for Multi-Functional Hybrid Nano-Materials

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The assembly of ligand coated particles and colloids into two- and three-dimensional array structures has attracted considerable interest owing to the potential applications (such as novel optical materials) that derive from the interactions within particle superlattice structures. A common challenge in the solution-based assembly of particle superlattice structures is the propensity of hard-sphere type particle assemblies to crack formation and brittle fracture during solvent evaporation. Recent progress in controlled radical polymerization offers novel opportunities for polymer-stabilized particle systems as building blocks of particle superlattice structures. In particular, it has been shown that chain entanglements between surface-grafted chains significantly increase the cohesive interaction within particle array structures and give rise to fracture through polymer-like crazing thus increasing the toughness and flexibility of particle assembly structures by orders of magnitude.
In this contribution, we establish using a combined experimental and theoretical approach the effect of polymer-graft architecture (i.e. the density and degree of polymerization of surface-grafted chains as well as the particle radius) on the ability of polymer-grafted particle systems to organize into ordered yet tough particle array structures. We demonstrate that strategic choice of particle system and polymer graft modification facilitates the assembly of plastic colloidal crystal structures that combine high rejection levels of light with mechanical robustness and polymer-like processibility. The implication of results on the design of particle brush systems for applications such as photonic coatings, paints or inks will be discussed.