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### **Tuning Nanoparticle Dispersion in Polymer Hosts and their Consequences on Properties**

There is considerable on-going interest in controlling the spatial dispersion of nanoparticles (NP) in a polymer matrix to create materials with significantly improved properties. We begin with the idea that NPs grafted with polymer chains behave akin to surfactants and assemble into a variety of structures when they are placed in amorphous polymer hosts. The consequences of these different dispersion states on mechanical properties, especially how these results are affected by the glassiness of the matrix are probed next. We then go beyond these equilibrium, surfactant-inspired paradigms and show that the isothermal crystallization rate of a polymer host can be used to dramatically vary NP spatial organization. Since the resulting nacre-like NP self-assembly significantly improves the polymer's mechanical properties, we conclude that crystal growth kinetics represents an underappreciated handle to tailor the NP spatial dispersion and hence the properties of this class of commercially relevant polymer nanocomposites. We finally explore the application of these materials in the context of gas separation membranes. Grafting polymer chains to NPs increases gas permeability without affecting selectivity. We conjecture, based on experiments and theory, that these results arise because the grafting process is a facile means of controlling the free volume of these polymers.

**Sanat K. Kumar** creates, analyzes, and models new classes of polymer-based materials with improved properties. A particular focus is on hybrid materials (polymer with inorganic filler) with relevance to biomimicry, and energy storage and conversion. His research interests are in Polymers, Polymer nanocomposites, batteries, fuel cells, biomimetic materials. Kumar's group has been the pioneer over the last decade in the practically relevant topic of Polymer Nanocomposites where inorganic nanoparticles are added to polymers to obtain materials with synergistic properties. Kumar received a BTech in chemical engineering from the Indian Institute of Technology, Madras in 1981 and a ScD in chemical engineering from the Massachusetts Institute of Technology, in 1987.