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Neutron Scattering Insights Into Molecular Parameters Governing Hyperuniformity in Brush-Based Hybrid Materials

Disordered hyperuniform (DH) materials represent an 'exotic'class of materials that is characterized by the suppression of long-wavelength fluctuations (like single crystals) and the absence of long-range order (like liquids or regular amorphous materials). The concurrence of these otherwise mutually exclusive structure characteristics holds opportunities for the fabrication of heterogeneous materials with novel physical property combinations that could be relevant to a wide range of innovative material technologies. Simulation studies suggest molecular crowding in polymeric systems to favor localization and thus provide a path to realize DH materials.

This contribution will present the application of small angle neutron scattering (SANS) to elucidate the parameters promoting the emergence of disordered hyperuniformity in polymer-grafted nanoparticle (aka particle brush)-based hybrid materials. A unique material system based on hyperbranched polymer nanogel brush particles enables the controlled and independent variation of brush softness and architecture, heterogeneity, the elastic properties of the particle core as well as the neutron scattering length density of core and brush constituents. SANS analysis is used to determine the structure factor of particle brush assembly structures and degree of hyperuniformity of brush particle assembly structures as a function of chain crowding and process parameters. The results reveal 'molecular design guidelines' to realize brush architectures with hyperuniform microstructure and increased inorganic content for enhanced functionality.

Topical Area

Soft matter: polymers, and complex fluids

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