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Polymer Physics Prize Lecture: Self-assemblies of Giant Molecular Shape Amphiphiles as a New Platform for Engineering Structures with Sub-Nanometer Feature Sizes

STEPHEN Z.D. CHENG, University of Akron

Utilizing nano-building blocks rather than atoms to construct and engineer new structures is a fresh approach to design and develop functional materials for the purpose of transferring and amplifying microscopic functionality to macroscopic materials' property. As one of the important elements of these nano-building blocks, giant molecular shape amphiphiles (GMSAs) provide a latest platform for generating self-assembled ordered structures at nanometer scale, which are stabilized by collective physical bonds (such as collective hydrogen bonding). In this talk, two topics will be focused on. First, composed of functionalized hydrophilic molecular nanoparticles as the heads with rigid shape and fixed volume, and tethered polymer chains as the tails (such as giant molecular surfactants and lipids and other topologies), these GMSAs of various architectures can self-assemble into highly diversified, thermodynamically stable microstructures at sub-10 nm length scale in the bulk, thin film and solution states. Second, GMSAs could also be constructed solely from nanoparticles interconnected via different numbers of the rigid linkages in specific symmetry, simulating the overall shapes of small molecules but with sizes that are one-order of magnitude larger in length and three-order of magnitude larger in volume. Giant crystal structures can then be obtained from this class of "giant molecules" via supramolecular crystallization. These findings are not only scientifically intriguing in understanding the physical principles underlying their self-assembly, but also technologically relevant in industrial applications.