Polymorphism of Close-Packed Block Copolymer Micelles

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The structures of packed spherical particles have been intensively investigated over many decades to understand the material structures and associated properties. However, despite its equal importance, the influence of the phase transformation kinetics to the packing structures of spherical particles, referred to as polytypes, has been relatively less considered. In this talk, I will discuss the phase transformation processes and associated structures of aqueous model block copolymer micelle solutions. We investigated the phase transformations of block copolymer micelles in water at low and high micelle concentrations and discovered that two different phase transition mechanisms are employed depending on the micelle concentration. In the low-concentration solution, we identified metastable hexagonal close-packed and random stacking of two-dimensional close-packed structures of micelles formed by diffusive transformation pathways and realized that the formation of these long-lasting metastable structures is directly related to the size of crystallite domains. These metastable structures last more than several weeks as long as the size of crystallites of the metastable structures is maintained but transform to the stable face-centered cubic structures as the size of crystallites grow. In the high-concentration solution, we identified that the diffusionless martensitic shear transformation process is employed for the transition of the block copolymer micelles on face-centered cubic to hcp lattices. Careful analysis of the phase transformation process suggests that the martensitic phase transformation pathway is strongly dependent on the size of fcc crystallites. Both diffusive and diffusionless phase transformation mechanisms show that the morphology of crystallites is a critical factor for the structures and the phase transformation kinetics of materials, directly related to the polymorphism of materials.

Biography

Dr. Lee has broad research interests in the polymer-related systems ranging from the design and synthesis to the thermodynamics and phase transition behaviors of polymeric materials. His research group currently focuses on synthesis and characterization of ion-containing polymers for energy conversion and storage applications, crystallization engineering using polymers for the control of organic crystal morphology and properties, and phase transitions and structures of model block copolymer micelles for the fundamental understanding of colloid self-assembly. Dr. Lee received B.S. degree in chemical engineering from the Seoul National University in South Korea in 2002 and Ph.D. in chemical engineering from the University of Minnesota in 2011. He worked as a postdoctoral trainee at the University of Minnesota before his independent career as an assistant professor at the department of chemical and biological engineering in the Rensselaer Polytechnic Institute since 2014. He received the Cozzarelli Prize from the Proceedings of National Academy of Sciences USA in 2014 and the Best Dissertation Award in Physical Sciences and Engineering from the University of Minnesota in 2011.