

Frustrated nanoparticles and their metamorphosis

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ABSTRACT

Understanding of phase behaviors of diblock copolymers in confined spaces is one of the significant problems in the fields of polymer and soft matter physics. Unique microphase separated structures of diblock copolymers emerged in three-dimensionally confined spaces called the “frustrated phases” have been investigated experimentally by using an electron microscopy and have theoretically simulated with cell dynamics simulation etc., however, still little is known on how frustrated phases are directly related to the parameters of a free energy functional. Here we present a mathematical model based on a set of Cahn-Hilliard equations to illustrate the relationship between the free energies and morphologies of diblock copolymers confined in small particles. This new model has a great predictive power and consistent with the experimental results. We also discuss about the annealing of copolymers which become a tool of great importance to reconfigure nanoparticles. We present experimental results of annealing copolymer nanoparticles to describe the morphological transformation from lamellae to onion based on the above coupled Cahn-Hilliard equations. A good correspondence between experimental findings and predictions of the model is observed. We illustrate a couple of examples showing the predictive power of the model including the reverse onion shape.

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