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Abstract

Chain-folding represents a motif configuration in lamellar polymer crystals as well as in protein beta-sheets. This report presents a survey on our current understanding about polymer chain-folding and unfolding in lamellar crystals. The origin of chain-folding was elaborated by the intramolecular crystal nucleation model, by means of free energy calculation of single-chain crystallization. Furthermore, the rate equation of polymer crystal growth was derived on the basis of reversible intramolecular secondary crystal nucleation at the lateral growth front of the lamellar crystals. Thus, many unique phenomena of polymer crystal growth can be explained, including the semi-crystalline texture, shish-kebab crystallites and the limited lamellar thickness. In addition, the folded-chain polymers perform unfolding upon crystal annealing and melting as well as strain-induced melting-recrystallization, with the microscopic mechanisms in line with polymer chain-folding. Polymer unfolding provides semi-crystalline polymers with unique thermal and mechanical properties, in particular, for synthetic fibers, plastic films and plastic bottles. Therefore, chain-folding serves as a key to unlock the secrets of crystallization and melting behaviors of polymer materials for controlling their properties. Last but not least, polymer chain-folding can be a prototype model for our understanding of fundamental problems on protein folding, misfolding and unfolding. Three corresponding examples on the fast path of protein folding, the kinetic suppression of amyloid growth, and the high toughness of spider silks, were separately introduced.

Keywords: Polymer, Protein, Free energy, Crystallization, Crystal nucleation, Crystal growth