DISENTANGLED POLYMERS AND ALL-POLYMER COMPOSITES

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Macromolecules are entangled in a melt and in an amorphous phase of solidified polymer. The presence of entanglements determines many properties of polymer and influences the crystallization from melt. The density of entanglements may be reduced by solidification of polymer from the diluted solution. Recently, we effectively disentangled polypropylene (PP) and polylactide (PLA) macromolecules by dissolution of these polymers in hot xylene and precipitation by slow cooling. The applied procedure stabilized partially disentangled structure and preserved it in solid polymer.

Polymers with reduced density of entanglements have modified properties and behaviors. The example is isothermal crystallization of PP. We observed easier diffusion of macromolecules to growing crystals. It resulted in increased growth rate of spherulites and in a shift of the transition temperature between Regime II and III, which means that more regular growth of crystals is possible at lower temperature [1].

The reduction of entanglements changes the mechanical properties of polymers. The properties of disentangled and fully entangled polypropylene were compared in tensile and compression tests. We observed enhancement of cavitation in stretched, partially disentangled PP, occur even at high temperature of 100 ^{o}C. The differences in molecular network influenced also strain hardening, where beginning was observed later in less entangled polymer and the stress increase was slower.

Microscopic observations showed that powders of partially disentangled polymers are composed from loosely agglomerated grains. It is possible to deform this grains into nanofibers during mixing with a second, molten polymer (e.g. polystyrene) at the temperature below melting of crystals in grains. When PP powder was deformed then all particles larger than 0.7 μm underwent deformation into nanofibers having the thickness 100-200 nm. Shear rate, viscosity of molten polymer, size of powder particles were important factors for effective deformation of the crystalline grains by shear during mixing. However, the crucial point was disentanglement of macromolecules. The final result of mixing process, after solidification of melt, was formation of all-polymer nanocomposites reinforced with ultra-deformed nanofibers, produced in one step compounding [2].

[1] A. Pawlak, J. Krajenta, A. Galeski, J. Polym. Sci., B. Polym. Phys. 55, 748–756 (2017).

[2] J. Krajenta, A. Pawlak, A. Galeski, J. Polym. Sci., B. Polym. Phys. 45, 1983-1994 (2016).