

Editorial corner – a personal view

Controlling properties by understanding polymer crystallization

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More than half of the thermoplastic polymers used worldwide have a crystalline structure, making solidification a complex process in which polymer microstructure, additives and processing conditions together define the final optical and mechanical properties. While standard differential scanning calorimetry (DSC) or heat-stage microscopy with a limited heating and cooling rate range have dominated polymer studies for many years, conversion processes became faster and faster. Now methods have caught up, using nano-calorimetry for better heat transfer and enabling up to $10^6 \text{ K}\cdot\text{s}^{-1}$ in cooling and heating. This allows to study quenching effects and the development of metastable crystal modifications, as in case of isotactic polypropylene (iPP) or poly(ethylene terephthalate) (PET). Next steps are increasing the possible pressure and deformation rate ranges into ‘realistic’ regions – also here, instrumental challenges exist.

A better understanding of crystallization processes enabled by better data allows better conversion modelling. For injection moulding it is already widely applied for optimizing geometry and parameters, even if often with unrealistic assumptions. The situation is, however, worse for processes involving free surfaces like blown film or extrusion blow moulding, where empirical rules still dominate industrial practice. And, of course, the next step should be to relate crystalline morphology to mechanics with realistic structural models.

For years, iPP has been in the focus of polymer crystallization. For some reasons it is a good ‘model material’: Chain structure and molecular weight distribution can be varied widely, in practice for product design. iPP polymorphism has got more

diverse recently, the three forms of α -, β - and γ -iPP being expanded by the trigonal δ -form. And the combination of moderately fast crystal growth at large undercoolings together with the absence of sporadic nucleation makes it an ideal material for crystallization control by nucleating agents.

Other areas still need ‘elucidation’. For linear polyethylene (HDPE) with its trickily high crystallization rate, effects of high molecular weight fractions and flow are getting attention recently. Effects of confined crystallization in thin layers or small droplets, as well as from solid glassy- or mesophase, need to be studied. For polar polymers, there is an interaction between crystallization and hydrogen bonds – recently seen as a severe factor for iPP graft copolymers of. And urgent is the problem of crystallizing biopolymers like poly(lactic acid) (PLA), so far limiting the applicability range. It will clearly be necessary to improve the understanding of nucleation options and the effect of chain disturbances (in commercial PLA up to 3 mol% stereodefects) on growth rate.



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