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Flow-Induced Crystallization and Nucleation in Isotactic Polypropylenes

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Flow-induced crystallization (FIC) occurs when a brief interval of strong flow precedes a temperature quench; many more nuclei form, resulting in a much more fine-grained solid morphology and better material properties. Common industrial polymer processing (injection molding) depends on FIC, which has been the subject of many experimental studies, most commonly on isotactic polypropylene (iPP). The prevailing hypothesis is that FIC results from flow aligning chains in the melt, increasing the melt free energy with respect to the crystal, hence acting like undercooling. Here, I combine experimental results for FIC and homogeneous nucleation with theoretical estimates for critical nuclei, to assess the prevailing hypothesis. Current best information supports the view that chain stretching (not just alignment) is necessary and sufficient to explain the observed increase in nucleation rate. Important puzzles remain: 1) shear applied at temperatures well above the equilibrium melting temperature Tm = 187 C is effective for FIC, and 2) a sheared sample may be held for hours above Tm, and still crystallize faster when quenched.