Flow-Induced Crystallization of Engineering Thermoplastics

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Brief intervals of shear flow at rates exceeding the reciprocal of the Rouse time of the longest chains create precursors that nucleate orders of magnitude more crystals and change the morphology from ~30 μm spherulites to far smaller ~1 μm crystallites. This flow-induced crystallization (FIC) at low shear rates builds with shearing time and eventually saturates. In contrast, at much higher stress levels that might occur in processing flows, a second morphology transition to shish-kebabs is observed when a critical shear stress (~0.14 MPa for iPP) is exceeded. The shish-kebab transition is evident in subsequent oscillatory shear as a weak gel and as a sudden jump in the pressure needed to push the material through the die in capillary rheometry. Flow-induced crystallization is studied in detail for isotactic polypropylenes[1-3] and poly(ether ether ketone)s[4] representing flexible and semi-rigid polymers, and for Polyamide 6,6 representing a flexible polymer with strong hydrogen bonding,[5,6] to see which aspects of FIC are universal to all polymers and which aspects are polymer-specific. The fact that the precursors are quite stable allows the sheared samples to be removed from the rheometer and studied extensively with DSC and optical microscopy, while annealing at elevated temperatures allows the study of precursor stability.

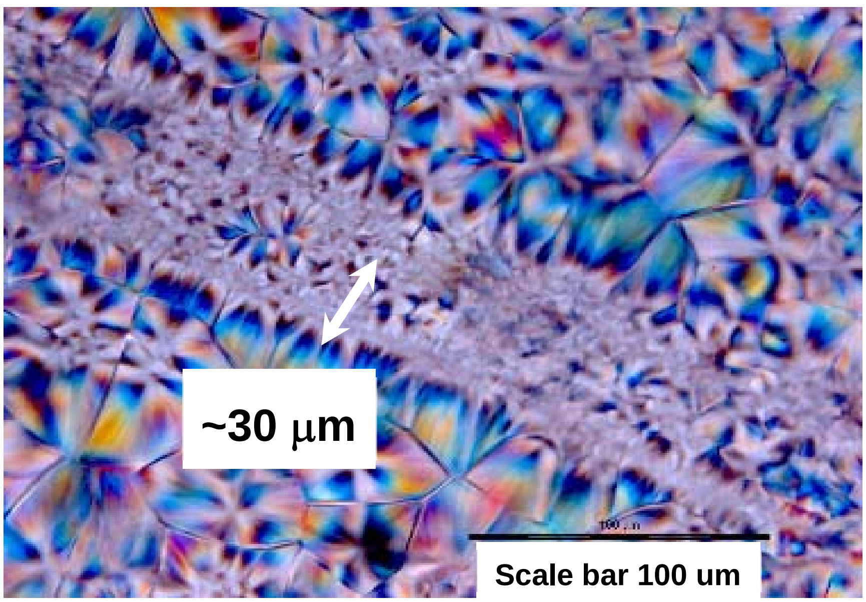

Figure 1. Polyamide 66 shish morphology after shearing at 10 s^{-1} at 270 °C for 1 minute.

References

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