415c Flow-Induced Crystallization of Polypropylene-Clay Nanocomposites: Clay Disorientation Kinetics and Morphology

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This work investigates the quiescent and flow-induced crystallization kinetics and morphology of an intercalated/partially exfoliated polypropylene (PP) clay nanocomposite. A maleic anhydride functionalized PP (10 wt%) is melt-blended with an organically modified montmorillonite clay (3 wt% Cloisite 15A from Southern Clay Products) and a PP resin (MFI 12 g/10 min at 230 degrees C) in a twin screw extruder.

Quiescent kinetics are probed with isothermal differential scanning calorimetry (DSC) in conjunction and resulting morphology examined ex situ with polarizing optical microscopy (OM) and transmission electron microscopy (TEM). In the flow-induced crystallization studies, the nanocomposite is subjected to a finite shear pulse in a mini-extruder whose design is inspired by with in the research groups of Janeschitz-Kriegl and Kornfield. During and subsequent to the shear pulse, we monitor birefringence and turbidity as a function of shearing time and wall shear stress. Ex situ, both OM and TEM are utilized to examine morphology.

Results indicate that flow strongly orients clay domains, which then act as nucleation sites for crystallization; consequently, polymer crystallization kinetics are accelerated relative to the neat resin. Conversely, quiescent crystallization kinetics of the disordered clay nanocomposite are retarded, highlighting the critical role played by clay orientation. In order to further investigate the role of clay orientation on crystallization, we report on clay disorientation kinetics using DSC, mechanical rheology, and microscopy. We observe that the clay disorientation kinetics inferred from DSC data correlate with those deduced from rheological experiments. Thus, we offer strong evidence that crystallization kinetics and morphology are strongly dependent upon clay orientation, and the relaxation of flow-aligned clay particles to the original pre-shear state is slow but recoverable with sufficient annealing time.