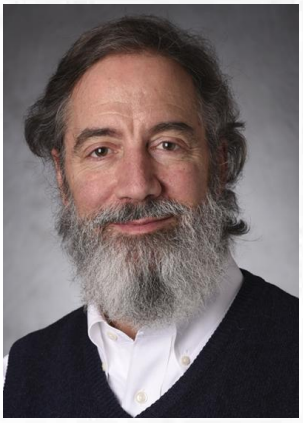

The Department of Chemical Engineering Presents:

Flow-Induced Crystallization of Engineering Thermoplastics

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Abstract: 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 polypropylenes1-3 and poly(ether ether ketone)s4 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 polymerspecific. 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.

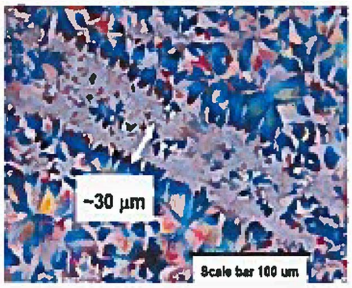

Figure 1. Polyamide 66 shish morphology after shearing at 10 s^{-1} at 270 °C for 1 minute.

References

1. F. G. Hamad, R. H. Colby and S. T. Milner, *Macromolecules* **48**, 3725 and 7286 (2015).
2. F. G. Hamad, R. H. Colby and S. T. Milner, *Macromolecules* **49**, 5561 (2016).
3. B. Nazari, H. Tran, B. Beauregard, M. Flynn-Hepford, D. Harrell, S. T. Milner and R. H. Colby, *Macromolecules* **51**, 4750 (2018).
4. B. Nazari, A. M. Rhoades, R. P. Schaake and R. H. Colby, *ACS Macro. Lett.* **5**, 849 (2016).
5. A. M. Rhoades, A. M. Gohn, J. Seo, R. Androsch and R. H. Colby, *Macromolecules* **51**, 2785(2018).
6. J. Seo, H. Takahashi, B. Nazari, A. M. Rhoades, R. P. Schaake and R. H. Colby, *Macromolecules***51**, 4269 (2018).

Bio: Ralph H. Colby received his B.S. in Materials Science and Engineering from Cornell University in 1979. After working for two years at the General Electric Company in rheology research and process development, he attended graduate school at Northwestern University, where he received his M.S. and Ph.D. in Chemical Engineering in 1983 and 1985. Graduate research focused on rheology of linear polybutadiene melts and solutions, and included 15 months as a visiting scholar in the Exxon Research and Engineering Company, Corporate Research - Science Laboratories. He then worked for ten years at the Eastman Kodak Company in their Corporate Research Laboratories. Rheology research areas over these ten years included linear polymer melts and solutions, miscible polymer blends, block copolymers, randomly branched polymers, polymer gels, liquid crystalline polymers, polyelectrolytes, proteins, surfactants and colloidal suspensions. In 1995, Dr. Colby was hired as Associate Professor of Materials Science and Engineering at the Pennsylvania State University and was promoted to Professor in 2000. He teaches an undergraduate course on Polymer Processing and a graduate course on Polymer Physics. Dr. Colby has over 130 publications and published a textbook Polymer Physics in 2003.

Wednesday, October 9, 2019 3:25 PM
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