High-Throughput Melt-Based Polymer Screening

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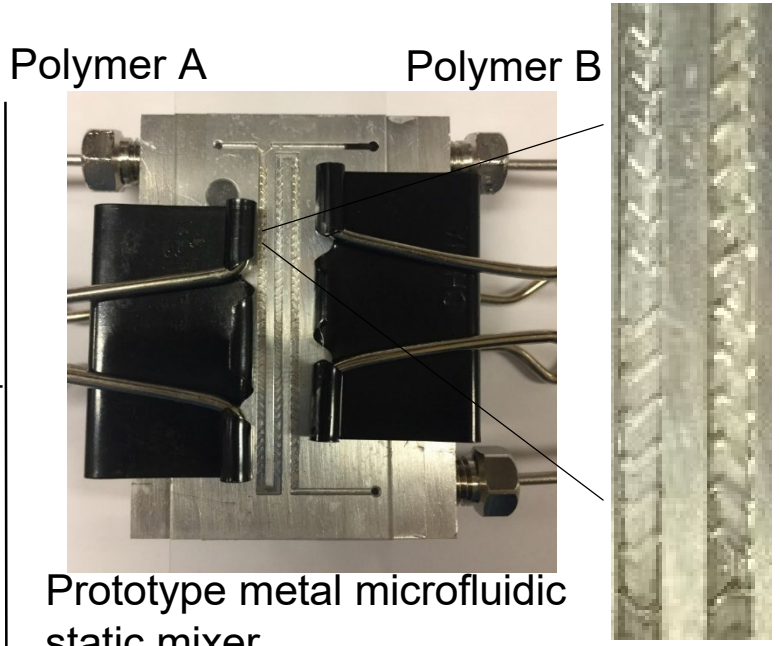
Objectives: Develop a robust method to prepare libraries of polymer-polymer or polymer-particle mixtures from the melt state, with controlled composition and temperature. The method will only require small amounts of sample, < 100 mg and will enable industrially-relevant screening of polymers, nearly all of which are processed in the melt state.

Technical Approach: The Meredith group has previously demonstrated use of specialized mixing techniques to prepare composition-gradient libraries from polymer solutions and low molecular weight polymers that react after mixing. These have been utilized to carry out high-throughput screening of polymer blends for applications ranging from tissue engineering and automotive coatings to fuel cell membranes. In this project, we will develop a novel approach based on a combination of microfluidics with scaled-down rotational mixing. Because most microfluidic devices are prepared from plastic or glass, they may not be suitable for temperatures and pressures encountered in polymer melt processing. Thus, innovations in design and fabrication of such devices from metal are required. In addition, the limitations on flow rate, pressure and shear stresses that are inherent to the problem need to be established. This will require a collaborative effort, likely combining expertise in chemical, mechanical and materials engineering.



Prototype metal microfluidic static mixer

Impact: Most commercial plastics are produced into final products through melt-based processing, including extrusion, injection molding and blow molding. The composition, temperature, shear stress and time variables interact in very complex ways that are difficult to predict quantitatively. Yet there are no generally-recognized instruments available to prepare miniaturized composition-controlled libraries of polymers from the melt state. Small batch (< 30 g) extruders exist, which are scaled-down versions of the industrial-scaled equipment. However, a technique that can prepare a series or gradient of polymer blends using only 10 to 100 mg per sample would be a disruptive innovation enabling collection of large data sets for polymer mixtures, including blends and composites.