Polymer Rheology and Polymer Mixing 'on a chip'

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We present a novel microfluidic rheometer and mixer for high temperature polymer melts. In the rheological mode, it is termed a multi-sample micro slit rheometer (MMR), capable of measurements over a broad range of temperatures, viscosities and shear rates. The instrument is inherently simple as the flow is generated by external gas pressure and the shear rate is measured through optical tracking of the flow front. In the current implementation, the required volume of each sample is approximately 20 micro-liter and we measure four samples simultaneously. In the mixing mode it is a planar polymer micro-mixer (PPMM), essentially a static mixer with multiple consecutive units of splitting and recombination flow formed by stacking three stainless steel shims (50 μm thickness, 45 mm in diameter). The mixing results show an evolution of the morphology for the polystyrene/polypropylene blend, cylindrical domain/matrix or the transition of a multilayer to a domain/matrix or a co-continuous morphology depending on the channel configuration and the number of mixing unit passed by. This mixer will be particularly useful not only as a polymer melt mixer but as a multilayer processor when a limited material quantity (only 1 or 2 pellets) is available. The microfluidic platform is based on flow through shim slits and is easily reconfigurable so that it can emulate other kind of polymer melt processing such as capillary rheometer or micro-injection molder. Taken together, the two modes form the basis for a “polymer processing lab on a chip.