144k Development of a Microfluidic Rheometer for Measuring the Complex Viscosity of Complex Fluids

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The measurement of the rheology of complex fluids in microfluidic flows is an important technical challenge. We present our work on the development of a microfluidic rheometer based on a magnetically driven overdamped harmonic oscillator. We avoid the need for an explicit hydrodynamic model, which is typically required to infer the viscosity from the transfer function of an immersed oscillator, by relying on a hydrodynamic similarity. In the limit of low Reynolds number the fluid viscosity appears in the transfer function only through the viscous penetration depth □ = □ □̃ □ □ $^{1/2}$, where □ and □ denote fluid viscosity and density, respectively, and □ is the angular frequency. While wall effects doubtlessly influence the transfer function of an oscillator embedded in a microfluidic device, this approach implicitly accounts for those effects. Hydrodynamic similarity can be used to calibrate an oscillating body viscometer (of any shape) over a range of □ by measurements with a standard Newtonian fluid of known viscosity and density over a corresponding range of □, and hence □. The viscoelasticity of an unknown fluid is then determined by comparing the measured (complex) value of □ with the complex generalization of the calibration function. We will discuss the design and fabrication of this oscillating body microfluidic rheometer, and present results of oscillatory shear rheometry on diverse fluids.