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RESEARCH PAPER

A single channel capillary microviscometer

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Abstract We have developed a microviscometer analyzing the fluid dynamics in a single channel glass microfluidic chip with a closed end. The device is able to test sample volumes of a few microliters by inserting one drop in the inlet. The fluid enters the channel driven by capillary pressure and an optical sensor registers the motion. The equation that describes the fluid dynamics is function of the channel geometry, atmospheric pressure, fluid viscosity, and capillary pressure. Knowing the first two, the last parameters can be obtained as fitting parameters from the meniscus position as a function of time plot. We have successfully tested Newtonian fluids with different viscosities and capillary pressure.

Keywords Microviscometer · Glass micromachining · Closed channel

1 Introduction

In the past 10 years, several developments of viscosity sensors using microfluidic chips have been reported by Han et al. (2007), Chevalier and Ayelaa (2008), and Lee and Tripathi (2005). The chips's main feature of using small amount of fluid (≈1 μL) for sample testing makes these microviscometers quite attractive for clinical analysis purposes, as well as in applications such as ink, oil, food, and pharmaceutical industries.

Viscometers has been built using different working principles: from flows established by optically rotating particles (Parkin et al. 2007), hydrodynamic focusing (Nguyen et al. 2008), to miniaturizing the capillary viscometers using microchannels. In their review, Pipe and McKinley (2009) discuss many works about microfluidics rheometry, and two kinds of approaches were highlighted. The first one analyzes the fluid dynamics by setting a pressure difference and measuring the flow rate or velocity. The second approach fixes a flow rate and measures the resulting pressure difference. Following the first, Srivastava et al. (2005) and Srivastava and Burns (2006) reported the fabrication of a microviscometer using the capillary pressure as a driving force of a fluid. The working principle is based on measuring the meniscus position as a function of time for a liquid entering an open microchannel driven only by capillarity. With both ends of the microchannel at atmospheric pressure, a fully developed Poiseuille is established and the liquid viscosity can be obtained. However, an independent and reliable measurement of the capillary pressure must be obtained. In their work, Srivastava et al. obtain this value measuring the final position for the liquid entering a second channel with a closed end. The fluid enters the closed channel by capillarity until the air pressure inside equals the atmospheric plus the capillary pressure. Thus by knowing the channel geometry, the rest position of the fluid column is directly related to the capillary pressure.

The dynamic of a fluid entering a closed channel also depends on the viscosity μ and the capillary pressure. Therefore, by studying these dynamics, the parameters could be directly obtained. Following this idea, we present

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