High through put measurements of rheological properties

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Rheological behaviors are key parameters in many fields, ranging from medicine, food processing to the chemical and manufacturing industries. In food industry, the stability of dressings is often obtained by increasing their viscosity. On the contrary, the viscosity of a medication must be low enough in order to be infused using a needle and a syringe. The development of these products thus requires the use of additives that tunes the viscosity of the product on to the range required by the final application. Formulation of the appropriate additives in a mixture is a tedious screening work that involves series of long trials and tests. The use of through-put techniques in this field would both increase efficiency and reduce the costs of research and development for the chemical industry. Microfluidics, which deals with methods and materials to control and handle liquid flows in length scales ranging from tens to hundreds microns, offers numerous prospects along lines. Microfluidics devices permit to prepare samples of various compositions, the first step in a screening process, using very small volumes of fluids. Infusing two fluids in the inlet of a T junction and varying the ratio of the two flow rates allows one to obtain in the outlet channel, mixtures of various compositions. However, in order to benefit from the microfluidic facilities, development of new analytical tools at the micron length scale such as for instance rheological ones is required .

In this work, a rheometer implemented on a chip is presented. The physical principle of this apparatus is to use laminar parallel flows in a microfluidic channel as a stress sensor. In such parallel flows, the fluid to study flows side by side with a reference fluid of known viscosity. By using optical microscopy, the shape of the interface between both fluids can be determined. Knowing the flow rates of the two liquids and the geometrical features of the channel, the mean shear rate sustained by the fluid and its viscosity can thus be computed. Accurate and precise rheological measurements of the entire rheological curve can be made using less than 100 microliters of fluid.

In the first part of this talk, a comprehensive study of immiscible fluids flowing after a T junction will be presented. Flow pattern diagrams obtained for various channel aspect ratios and various viscosities are performed. We analyse the stability of parallel flow after a T junction. Strikingly, the breaking of the parallel flow (ie the droplet formation) does not involve a competition between viscous forces and capillary forces but is captured in terms of a blocking-pinching mechanism. Using a simple model the conditions required to obtain parallel flow stability are quantified.

We will then present the obtained results on various complex fluids such as emulsions, surfactant solutions, polymer solutions are tested with viscosity ranging between 70000 cP to 1cP. Sliding effects and shear effects will be discussed.

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