

ANR OsmoChip: Probing complex fluid transport properties by osmotic micro-fluidic measurements

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Keywords: microfluidics, physico-chemistry, osmotic pressure, collective diffusion coefficient

Introduction

Chemical companies are facing today with an increasing demand for **investigating new formulations** (water-borne or based on green solvents with limited environmental footprints) made of mixtures of polymers, colloids and/or surfactants, and for applications ranging from agrochemicals, coatings, home & personal care, to energy storage. Screening the properties of these new products (phase diagrams, rheology, stability, etc.) is an important day-to-day task in R&D physical-chemistry with many direct economic implications. For instance, screening the phase diagrams of such formulations is indeed *a priori* a simple task, but it is also very tedious and time consuming. For a typical Solvay R&D center, screening the complete phase diagram of a formulation is associated to large costs, between 20 and 80 k€, and to very long experimental times, from 1 to 4 months, which often prevent from developing rapid innovations in products and processes.

A common strategy to study chemicals in dense regimes is to use continuous approaches to concentrate them, such as solvent exchange by dialyzing the formulations under study against reservoirs of known osmotic pressure, see Fig. 1(a). This osmotic compression technique is employed to obtain the equation of state of suspensions and their phase diagrams, using dialysis bags with a characteristic dimension ~ 1 cm. Due to this large dimension, the characteristic time scale to reach thermodynamic equilibrium ranges from days to weeks. In this project, the microfluidic analog to these experiments will be designed in order to access equations of state, phase diagrams, but also transport properties of complex fluids on time scales ranging from minutes to hours.

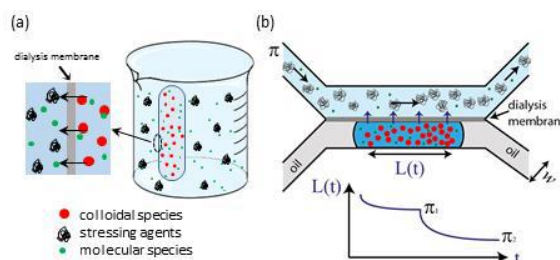


Figure 1 Fig 1. (a) macroscopic vs. (b) microfluidic osmotic compression in the case of a colloidal dispersion. The typical transverse dimension of the channel is $w < 100 \mu\text{m}$.

Description of the post-doc objectives

The objectives of the project are part of a long-term academic and technological proposal for the development of microfluidic devices probing complex fluids transport properties at the nanoliter scale. (<https://lgc.cnrs.fr/les-projets/osmochip/>)

The first goal is to design microfluidic experiments mimicking the classical osmotic compression technique but on length scales smaller than $100 \mu\text{m}$ so the equilibration time scale now ranges from minutes to hours. With these microsystems at hand, it is also possible to measure concentration and concentration gradients during the transient regime before equilibration. With these data at hand and suitable modelling, it becomes possible, in principle, to measure transport properties of concentrated suspensions such as the collective diffusion coefficient D . Open questions to achieve this second goal are at the center of this post-doc proposal: what are the best microfluidic chip design and operating conditions to obtain data with low enough noise, and on a concentration range as large as possible? Depending on these design and conditions, what model should be used to extract D from these data?

Several microfluidic systems based on osmotic compression have already been developed recently by partners of this project to measure equilibrium colloidal properties in a very short time compared to classical techniques. In particular, we have been able to **measure the equation of state of colloidal dispersions** accurately in a few

POST-DOCTORAL POSITION

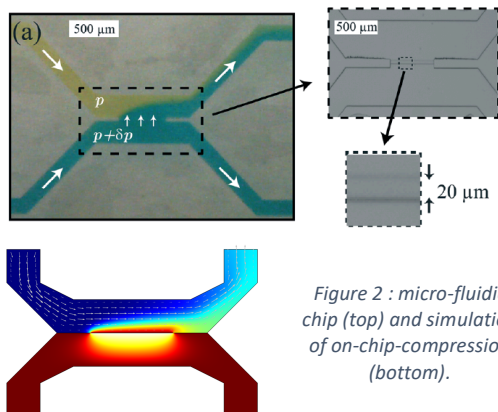


Figure 2 : micro-fluidic chip (top) and simulation of on-chip-compression (bottom).

hours with two different operation modes, namely drop compression or frontal filtration. These measurements have been validated when the suspension in the chip is always close to equilibrium (vanishing Péclet number).

There is also a strong interest for driving the system farther away from equilibrium. In particular, this would enable us to obtain equations of state even faster, and it could give access to the measurement of dynamic quantities such as the **collective diffusion coefficient** of the suspension D . This raises however questions concerning the interpretation of observations. In particular, D is often supposed to be a function of the volume fraction only, with the hypothesis that ions are always in

thermodynamic equilibrium although colloids are not (adiabatic hypothesis). Depending on the chip design and operation mode, this hypothesis may have to be revised and electrokinetic or diffusiophoretic effects may come into play.

The project has three main objectives: (i) **Understand** the link between chip operating conditions (filtration mode, drop compression mode...) and the breakdown of the adiabatic hypothesis; (ii) **Develop** new chip designs that will enable dynamical measurements; (iii) **Measure** collective diffusion coefficients and rationalize the respective roles of hydrodynamics and electrostatics in their forms. This theoretical and experimental work will benefit from comparisons with numerical simulations undertaken in the group.

Candidate profile

Skills in **microfluidics, physics, hydrodynamics, soft matter, or physico-chemistry** will be appreciated (Ph.D. in **physics, fluid mechanics, chemical engineering**...). The person recruited should have a solid background in **microfluidic experiments**. Further experiences in the following domains will be appreciated: microscopy, image analysis, light scattering techniques, numerical simulation.

Context

The position is part of the OsmoChip ANR project involving the LGC laboratory in Toulouse, and the LOF laboratory and the Solvay company in Bordeaux. The person recruited will work at **LGC Toulouse** in the [Interfaces and Divided Media](#) department / [Soft Matter Engineering](#) group. He/She will interact closely with Jean-Baptiste Salmon at LOF and Matthieu Guirardel at Solvay.

Starting date : anytime.
Duration : 18 months
Net salary : ~2200 €/month.
Advisors : Yannick Hallez, Patrice Bacchin and Martine Meireles

Contact and Application

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