Vesicles and red blood cells under flow in the Stokes regime

T. Biben[1], L. Elasmi[2], G. Ghigliotti[3,4], B. Kaoui[3,5], C. Misbah[3], H. Selmi[2]

[1] Université de Lyon, F-69000, France; Univ. Lyon 1, Laboratoire PMCN; CNRS, UMR 5586; F-69622 Villeurbanne Cedex, France

[2] Ecole Polytechnique de Tunisie, B.P. 743 - 2078 La Marsa, Tunisia

[3] Univ. Grenoble 1/CNRS, LIPhy (Laboratoire Interdisciplinaire de Physique) UMR5588, Grenoble, F-38041, France

[4] Present address:Dept. Chemical & Biological Engineering
University of British Columbia Vancouver, BC V6T 1Z3, CANADA, USA

[5] Present address: Technische Universiteit Eindhoven, Postbus 513, 5600 MB Eindhoven, The Netherlands

Vesicles, capsules and Red Blood Cells (RBCs) under flow know a considerable amount of attention both from the theoretical, numerical and experimental point of views. Understanding their motions and dynamics is essential both at the fundamental level as a branch of biocomplex fluids, and at the technological level, such as the lab-on-chip technologies, targeted drug delivery, and blood flow diseases.

Dynamics of biomimetic (vesicles ans capsules) and biological entities (RBCs) under a simple shear flow will be described in the Stokes regime, and the current state of the art reported both for vesicles and capsules. Comparison with available experiments will be provided.

We then discuss non standard rheology results obtained from the study of a dilute vesicle suspension that show how to unearth subtle dynamics of suspensions by superimposing a constant shear flow on top of an oscillating one.

We then present results on a longstanding dilemma of the blood microcirculatory research: why do red blood cells adopt a non symmetrical shape (called slipper shape) even in a symmetric flow? It is shown that the symmetric shape is unstable in flow conditions encountered in microvasculature. Moreover, by adopting a slipper shape, the RBC acquires a higher flow efficiency than the symmetric (parachute) shape. The basic key ingredients to resolve this dilemma, together with new progress of this issue will be discussed. Finally, dynamics of a collection of vesicles and their spatial organization under Poiseuille and cylindrical Couette flows will be discussed.

References:

1) Why Do Red Blood Cells Have Asymmetric Shapes Even in a Symmetric Flow?

Badr Kaoui, George Biros, and Chaouqi Misbah, Phys. Rev. Lett. **103**, 188101 (2009)

2) Vesicles and red blood cells in flow: From individual dynamics to rheology,
Petia M. Vlahovska, Thomas Podgorski and Chaouqi Misbah Compte Rendus Physique, **10**, 775 (2009).

3) Boundary Integral and Fast Multipole Method For Two Dimensional Vesicle Sets in Poiseuille Flow,
Hassib Selmi, Lassaad Elasmi, Giovanni Ghigliotti and Chaouqi Misbah, Discrete and Continuous Dynamical Systems Series B, **15**, 1065 (2011).

3) Vesicle Migration and Spatial Organization Driven by Flow Line Curvature

Giovanni Ghigliotti, Abtin Rahimian, George Biros, and Chaouqi Misbah Phys. Rev. Lett. **106**, 028101 (2011).