Continuous Droplet Interface Crossing Encapsulation (cDICE): artificial cells and capsules

E. Loiseau[1], C. Claudet[1], M. In, T. Phou[1], J.-M. Fromental[1],T. Lopez-Leon[1], A. Rademacher[1], C. Godefroy[2], P.-E. Milhet[2], M. Abkarian[1], Gladys Massiera[1,*]

[1]*Laboratoire Charles Coulomb (L2C – UMR 5221), Université de Montpellier, France*
[2]*Centre de Biochimie structurale - CNRS-UM1-INSERM UMR 5048, Montpellier, France*

**Gladys.Massiera@umontpellier.fr*

The Continuous Droplet Interface Crossing Encapsulation (cDICE) [1] is an easy and robust method for producing, at high yield, monodisperse lipid vesicles with a controlled content as well as capsules with a designed shell . We will discuss the physical mechanisms involved in the production of both cDICE vesicles (low droplets inertia) and capsules (at high inertia), and several applications of this method, such as its use as an artificial red blood cell, or for artificial tissues.

The set-up consists of a cylindrical rotating topped-chamber, filled with a Dispersing Aqueous Solution (DAS) and a lower density lipid-in-oil solution [2] (LOS) that form a vertical interface due to the centrifugal force. A capillary is introduced in the LOS and droplets of the aqueous solution to be encapsulated (EAS) continuously drip off the capillary. As soon as they detach from the capillary, they are centrifuged towards the LOS/DAS interface. During their 'flight' across the LOS layer, a monolayer of lipids adsorbs onto the aqueous droplets, which zip with another monolayer during the crossing of the LOS/DAS interface.

For the design of original capsules, the lower density LOS solution is replaced by a low density fluid (LDF), which will *in fine* constitute the shell of the capsules. In this version of cDICE, the rotation speed of the chamber is high as the droplet inertia should be high enough to entrain LDF during the interface crossing. The LDF shell is turned solid right after the passage using either a temperature trigger or photopolymerization.

The cDICE method allows to encapsulate various biological solutions (biopolymers, hemoglobin, colloids, polymeric gels, cells. . .) in membranes that can be composite and/or assymetric, or polymeric.

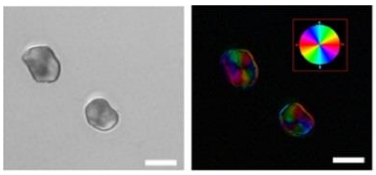

Figure 1 Articial red blood cell produced by encapsulating purified mutated hemoglobin in phospholipid membranes by the Continuous Droplet Interface Crossing Encapsulation (cDICE) method.

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[1] Loiseau E, Abkarian M, Massiera G., Soft Matter, **2011**, 7, p.4610-4614.
[2] C Claudet, M In, G Massiera, The European Physical Journal E 39 (1), 1-6.