Development of polymeric vesicles as bio-inspired mineralisation microreactors

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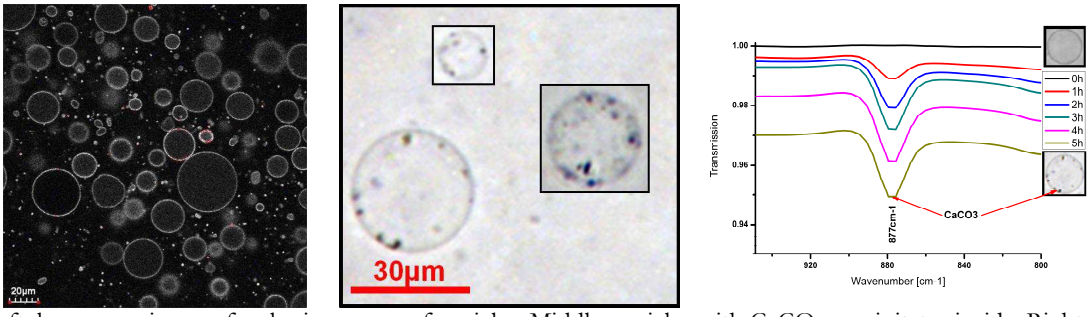
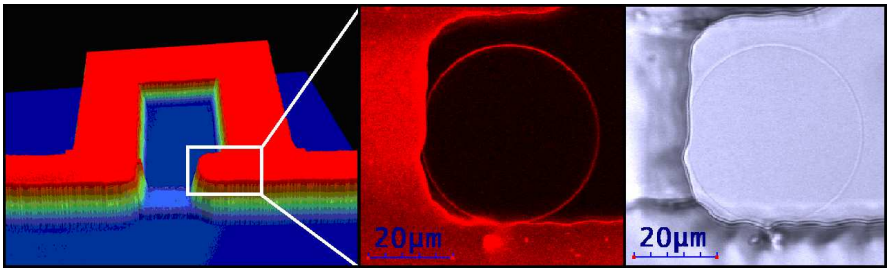
The understanding of the formation mechanisms of biocomposites such as bones or mollusc shells is of great importance for medical applications as well as for materials synthesis. The aim of this project is to develop an experimental model system that includes a major feature of biomineralization: the need for a closed organic environment that allows a fine tuning of the physico-chemical conditions of the mineral precipitation. More precisely, we are forming polymeric vesicles, also called polymersomes, by using diblock and triblock copolymers with a hydrophobic moiety and a hydrophilic moiety.
The membrane composition of these polymeric vesicles has been adjusted to vary the membrane permeability with respect to salts. Controlled precipitation of calcium carbonate ($CaCO_3$) inside the vesicles was already successfully achieved and proved by IR-Spectroscopy [1].



Left: laser scanning confocal microscopy of vesicles. Middle: vesicles with $CaCO_3$ precipitates inside. Right: IR-Spectroscopy kinetics of precipitating $CaCO_3$.

Another main focus of our project is to operate with vesicles in microfluidics systems. Such devices allow us to trap and control chosen vesicles, and then to easily change the outer fluid of the vesicles in order to explore vesicle properties in response to changing conditions (osmotic shocks in particular) [2]: this way we can measure the permeability of a single vesicle to different ions or molecules and induce mineral precipitation inside the vesicles.



Left: optical interferometry 3D picture of the microfluidic trap. Middle: laser scanning confocal microscopy of a trapped vesicle. Right: the same vesicle observed with oblique illumination.

References:

[1] A. Picker, H. Nuss, P. Guenoun and C. Chevallard, Polymer vesicles as microreactors for bio-inspired calcium carbonate precipitation, Langmuir, 2011, *27* (7), pp 3213–3218

[2] H. Nuss, C. Chevallard, P. Guenoun and F. Malloggi, Microfluidic trap-and-release system for lab-on-a-chip-based studies on giant vesicles, Lab Chip, 2012, 12, 5257–5261