Nanorheology on phospholipid monolayers

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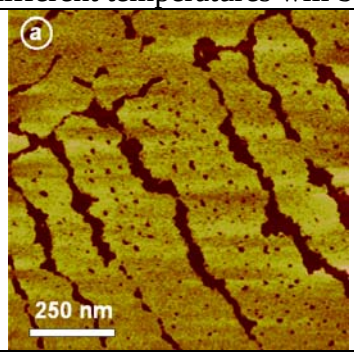
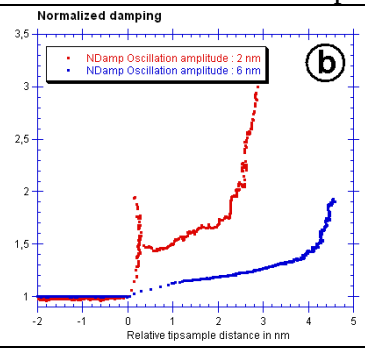
Phospholipids layers are known to be key materials regulating the cell activity, in particular the communication between the cell and its neighbourhood. Besides, there are also often used as templates to prepare 2D crystal of proteins either for electron microscopy or AFM studies. Therefore, it is of great interest to understand the interaction between proteins and phospholipids as well as between phospholipids themselves. In that context, we investigate the rheological properties of a monolayer of dipalmitoylphosphatidylcholine (DPPC). DPPC exhibits a phase transition that depends on the surface pressure and the temperature [1]. The liquid expanded (LE) and liquid condensed (LC) phases have different viscosities, what plays a crucial role for membranes fusion processes and influence the dynamic of diffusion over the cell. The Langmuir Blodgett method is used to transfer a monolayer over a mica surface, then the rheological properties are investigated with a dynamic atomic force microscope (AM and FM modes) at room temperature.

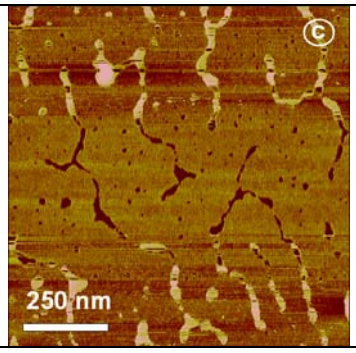
For a large surface pressure (30mN/m), we showed that the DPPC still present phase segregation at the nanometer scale (frame (a)). FM and AM approach retract curves were performed at several amplitudes on the two phases. The mechanical response of the two phases were studied and qualitatively understood, in particular jump of the damping was attributed to sudden growth of a nanoprotuberance for small amplitudes. In addition, by varying the oscillation amplitude, images were recorded showing the growth of a nanoprotuberance. We show that beyond a threshold value, a mechanical instability of the layer is observed for one phase and not for the second one. As a result, depending on the magnitude of the oscillation amplitude, height images show opposite contrasts where holes become hills and trenches are filled up. To complete our investigation, experiments at different temperatures will be performed soon and will be presented at the conference.



(a) Height image of a two phases DPPC. Constant oscillation amplitude 14 nm, full Z scale: 5 nm.



(b) Normalized damping for two oscillation amplitudes on the same phase. The effective force exerted by the oscillating tip increases as the amplitude is reduced. A low amplitude leads to a mechanical instability of the layer.



(c) Height image recorded at different oscillation amplitudes. Top and bottom of the image corresponds to the smallest amplitude. Lines of higher heights become trenches when the oscillation amplitude is increased (middle).

[1] C. W. McConlogue, T. K. Vanderlick, Langmuir **13**, 7158 (1997)