Dynamics and controlled assembly of solid lipid domains at interfaces

Benjamin Oliva [1], Hyunyou Kim [2], Lionel Buisson [1], Ivo Buttinoni [2], Jean-Paul Chapel [1], Laura Alvarez [1]

[1] Univ. Bordeaux, CNRS, CRPP, UMR 5031, F-33600 Pessac, France.
[2] Institute for Experimental Physics of Condensed Matter,
Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany

benjamin.oliva.d@gmail.com

Lipid monolayers are of significant interest due to their presence in several biological systems, where they perform essential protective and structural functions. In the respiratory system, the alveolar surface is lined with a pulmonary surfactant monolayer, which prevents the lungs from collapsing during breathing. This monolayer is primarily a mixture of neutral lipids and proteins, as well as phospholipids of which DPPC is the major component [1]. On the other hand, micron-sized pollutants deposited in the lung surfactant may alter its performance. Therefore, understanding the micro and macroscopic behavior of pure DPPC monolayers as a minimal model for biointerfaces as well as its interaction with micro-particles as a model for pollutants, hold considerable physiological relevance. Using a Langmuir-Blodgett trough coupled to an in-house optical microscopy setup (figure 1a), we vary the surface pressure while visualizing the lipid behavior thanks to the presence of a fluorescent lipid [2]. The DPPC monolayer undergoes phase transitions from gas to liquid to solid with increasing surface pressure, displaying a coexistence region where solid DPPC domains form within the liquid DPPC phase (figure 1b) [3]. In this work, we analyze the self-organization and dynamics of these lipid domains by characterizing their size, separation and area fraction while also measuring their dynamics as a function of surface pressure. We also observed the formation of solid domains in a case where aminated silica microparticles were deposited at the water/air interface. Different treatments of microparticles can promote (figure 1c) or hinder (figure 1d) the interaction between them and the solid DPPC domains. These observations will allow us to understand the monolayer's fluidity properties at a fundamental level and study the effect that model micropollutants have on the monolayer's phase behavior.

Keywords:
Phospholipids, monolayer, microparticles, phase behavior, lung surfactant

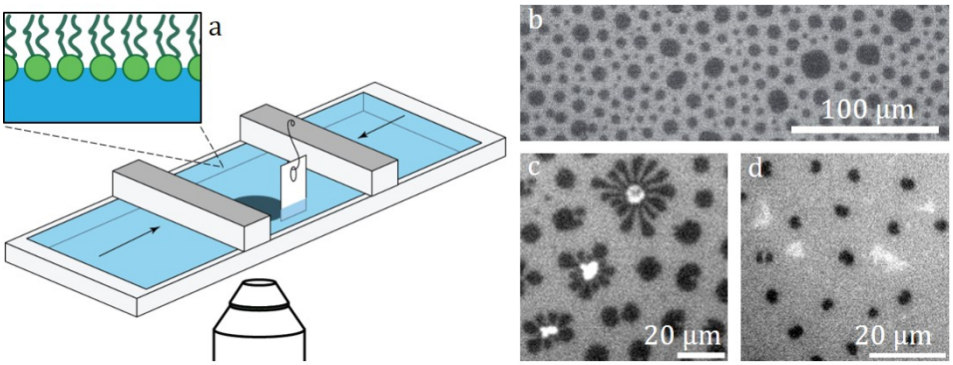

Figure 1: a. Diagram of the Langmuir trough. b. Solid DPPC domains immersed in the liquid phase in the water/air interface. Domains forming around (c) and far from (d) clusters of aminated silica microparticles.

References:

[1] Parra, E., & Pérez-Gil, J. Chemistry and physics of lipids 2015, 185, 153-175.
[2] Pantelis Mpourazanis, Hyunyou Kim, Benjamín Oliva, Jean-Paul Chapel, Laura Alvarez, Ivo Buttinoni 2025, submitted.
[3] McConlogue, C. W., & Vanderlick, T. K. Langmuir 1997, 13(26), 7158-7164.