APPLICATION NOTE

How to control the surface pressure of an interface

INTRODUCTION

The presence of surface- active molecules at an interface changes its physico-chemical properties. The amplitude of these changes, that can be characterized by surface pressure, depends strongly on the surface concentration.
The surface pressure (Π) is defined as the difference of interfacial tension between a pure interface and an interface in the presence of surface-active molecules.

$$\Pi = \gamma_0 - \gamma$$

Where γ_0 corresponds to the interfacial tension between the two pure phases and γ the measured surface tension.

A good understanding of surface-active laden interfaces as a function of surface pressure requires varying the surface concentration. The control of this concentration can be complex. Indeed, the surface pressure at the equilibrium is governed by the adsorption kinetics of the molecules and their initial concentration.

Phospholipids are major components of lipid droplet monolayers and biological membranes and play a significant role in their structuring and stabilization.

An oil/water interface coated with phospholipids has been used to produce interfaces with different surface pressures, as shown in Figure 1.

The drop tensiometer Tracker™ allows precise real-time control and modulation of the surface pressure of the interfaces.

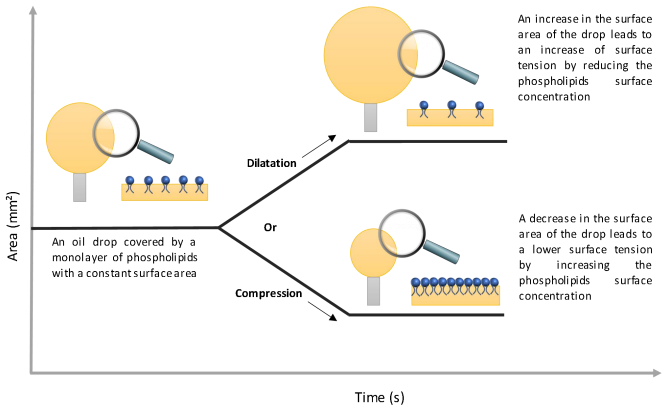

Figure 1 : Drop area as function of the time of a phospholipid-coated oil/water interface during an experiment

EXPERIMENTAL PROTOCOL

The protocol consists of a series of 4 steps:

1. An oil drop (triolein) is formed in a buffer solution.
2. At t = 100 sec, a preparation of unilamellar (100 nm) large vesicles of phospholipids is injected to reach a concentration of 0.005% (w/w) in the buffer solution
3. After an adsorption time of 1500 sec, the aqueous phase is replaced by a fresh buffer solution to remove non-adsorbed phospholipids.
4. The surface pressure is then simply controlled by increasing or decreasing the drop volume, i.e. the interface surface area.

RESULTS

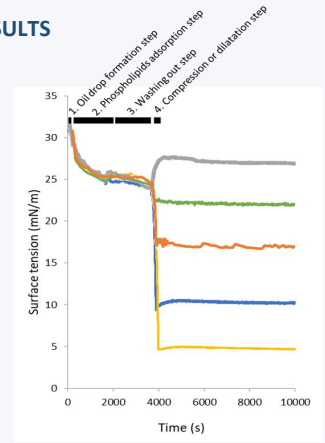

Figure 2: Variation of the interfacial tension at the triolein/water interface as a function of time. Surface pressure reaches final values of (grey) 5 mN/m, (green) 9 mN/m, (orange) 16 mN/m, (blue) 22 mN/m and (yellow) 28 mM/m .

Figure 2 shows the surface tension as a function of time for an oil/water interface. The initial tension is 32 mN/m and is consistent with the literature [1-4].

After injection of the phospholipids, the surface tension decreases slowly over time; the phospholipids adsorb at the interface. Exchanging the aqueous phase stops the phospholipids adsorption and only the variation of the drop surface area allows to modify the surface concentration and thus the surface pressure of the phospholipid monolayer. In this example, one expansion of the drop area was performed to decrease the surface pressure (i.e. increase the tension); and four compressions were performed to increase the surface pressure (i.e. decrease the tension).

CONCLUSION

The surface pressure of an interface can be controlled using the drop tensiometer Tracker. Specific or custom-made interfaces can be made to mimic different interfacial systems and to study rheological properties at different interfacial pressures. Thus, it is possible to figure out the building-blocks of an interface and to study the adsorption of one or several molecules sequentially added or to determine the exclusion pressure of molecules.

References

[1] Ledford, A. S.; Cook, V. A.; Shelness, G. S.; Weinberg, R. B., Structural and dynamic interfacial properties of the lipoprotein initiating domain of apolipoprotein B. Journal of lipid research 2009, 50 (1), 108-115.

[2] Meyers, N. L.; Larsson, M.; Olivecrona, G.; Small, D. M., A pressure-dependent model for the regulation of lipoprotein lipase by apolipoprotein C-II. Journal of Biological Chemistry 2015, 290 (29), 18029-18044.

[3] Bénarouche, A.; Habchi, J.; Cagna, A.; Maniti, O.; Girard-Egrot, A.; Cavalier, J.-F.; Longhi, S.; Carriere, F., Interfacial properties of NTAIL, an intrinsically disordered protein. Biophysical journal 2017, 113 (12), 2723-2735.

[4] Xu, T.; Rodriguez-Martinez, V.; Sahasrabudhe, S. N.; Farkas, B. E.; Dungan, S. R., Effects of Temperature, Time and Composition on Food Oil Surface Tension. Food Biophysics 2017, 12 (1), 88-96.