Simultaneous Interfacial Rheology and Neutron Reflectometry studies of fluid interfaces

P. Sanchez-Puga[1], J. Carrascosa-Tejedor[1], M. Rodriguez-Hakim[2], J. Tajuelo[2], A. Maestro[3], P. Gutfreund[1], M.A. Rubio[2]

[1]Institut Laue-Langevin, 38042, Grenoble (France), [2]Facultad de Ciencias, Universidad Nacional de Educacion a Distancia (UNED), E-28232, Las Rozas (Spain), [3]Centro de Física de Materiales (CSIC, UPV/EHU) - Materials Physics Center MPC, E-20018 San Sebastian (Spain) **sanchez-puga@ill.fr**

Fluid interfaces with adsorbed substances are present in many systems in nature and industrial processes. Such interfaces often have a complex structural configuration which confers them the capability to withstand deformations [1]. Consequently, they have been the object of study in recent decades both from a structural and rheological point of view. To date, there have been limited examples of simultaneous measurements of the interfacial rheology and the structure of complex fluid interfaces. This aspect holds particular significance, considering the challenge of comparing independently conducted structural and rheological experiments, where reproducing identical experimental conditions, such as temperature and/or concentration and/or compression history for monolayer at the air-water interface, is difficult. Specifically, there is great interest in the study of Langmuir monolayers of fatty acids and phospholipids which appear in many biophysical processes. This work focuses on the development, building, and exploitation of an interfacial shear rheometer, with DWR geometry [2], to be used on the neutron horizontal reflectometer FIGARO at Institut Laue-Langevin (ILL). Consequently, the instrument allows for simultaneous measurements of neutron reflectometry and interfacial rheology. In particular, a DWR probe 3D printed in titanium has been commissioned for the Anton Paar MCR702e Space rheometer available at the PSCM, and a suitable shear channel with annular geometry (machined in PTFE) has been designed and built to be used in the Langmuir trough. Notably, an improved Flow Field-Based data analysis [3] software package has been developed to properly subtract bulk phases contribution, taking into account non-linear velocity profiles. The performance of the new instrument is illustrated with a study of the isothermal compression of C19 fatty acid Langmuir monolayers (FALMs). Additionally, Brewster Angle Microscopy (BAM) has been used to observe the formation of structures above the micron scale at the interface. The studies carried out attempt to shed light on the mechanism of loss of molecules observed in condensed phases at high interfacial pressures in monolayers of fatty acids from a dynamic and structural point of view.

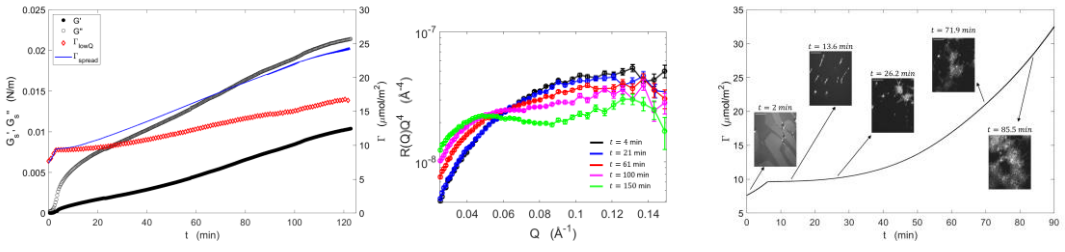

Figure 1: (a) Evolution of the interfacial shear dynamic moduli (G_s' and G_s'') and the deuterated C19 (d37) fatty acid surface excess concentration, Γ, obtained by neutron reflectometry and the apparent one obtained by the amount of spread material. (b) Neutron reflectivity curves at different times. (c) BAM images showing the formation of structures at the interface.

References

[1] – G.G. Fuller and J. Vermant, Annu. Rev. Chem. Biomol. Eng. **3:1**, 519-543 (2012).
[2] – S. Vandebril, A. Franck, G.G. Fuller, P. Moldenaers, J. Vermant, Rheol. Acta **49:**131–144 (2010).
[3] – P. Sanchez-Puga, J. Tajuelo, J. M. Pastor, M.A. Rubio, Adv. Colloid Interface Sci. **288**, 102332 (2021).