Designing Adaptive Soft Matter via Reaction-Driven Interfacial Assembly: A SAXS/GISAXS/GISANS Study

S. Salentinig [1]

1 Department of Chemistry, University of Fribourg, Switzerland

Stefan.salentinig@unifr.ch

Responsive biointerfaces play a central role in food, pharmaceutical, and biotechnological systems, yet the mechanisms governing their formation and nanoscale organization at liquid–liquid interfaces remain insufficiently understood.

In this presentation, we explore how everyday complex fluids such as milk and coffee inspire the design of adaptive soft materials. Lipid-based interfacial nano-architectures serve as model systems to study how composition and interfacial reactions direct structure formation and, ultimately, material function. We show how reaction-driven self-assembly at oil–water interfaces enables control over physical, chemical, and biological properties. Adapting and using in operando grazing-incidence X-ray and neutron scattering, combined with electron microscopy, chemical analytics, and microbiological assays, we investigate the formation and transformation of interfacial structures under dynamic conditions. In particular, we study enzymatic triglyceride hydrolysis as a model reaction, revealing how polar lipids and polymers reorganize at interfaces to form ordered nanostructures (Figure 1) [1,2]. We highlight how such systems can be harnessed as antimicrobial nanomaterials and as confined reaction environments enabling controlled polymerization [3,4].

These results demonstrate how concepts derived from food systems can be translated into a general framework for engineering adaptive soft matter at liquid–liquid interfaces, linking interfacial structure, reactivity, and function.

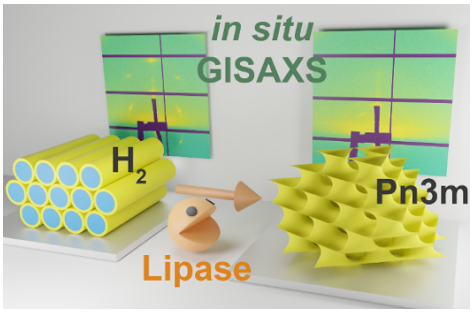


Figure 1. *Enzyme-triggered nanostructural transformations in soft, nanostructured coatings for responsive materials.*[2]

[1] M. Frigerio M., Leser M. E., Salentinig S., J. Colloid Interface Sci. 2026, 706, 1091, 139561; https://doi.org/10.1016/j.jcis.2025.139561

[2] R. V. M. Freire, B. Tran, M. Debas, M. Zabara, H. Amenitsch, and S. Salentinig ACS Appl. Mater. Interfaces 2024, 16, 61262-61271. https://doi.org/10.1021/acsami.4c12125

[3] M. Debas, D. P. T. Nguyen, A. F. M. Kilbinger, A. Glavic, H. Amenitsch, S. Salentinig ACS Appl. Mater. Interfaces 2025, 17, 17, 26013. https://doi.org/10.1021/acsami.5c02607

[4] P. Kadakia, J. D. P. Valentin, L. Hong, S. Watts, O. A. Hameed, M. Walch, S. Salentinig, Adv. Healthcare Mater. 2024, 13, 2302596. https://doi.org/10.1002/adhm.202302596