Self-assembled nanostructured material: Mechanism of formation

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In memory of Isabelle, I choose 4 projects realized with her to illustrate how SANS can be used to determine the structure and the kinetic evolution of self-assembled nanostructured materials. In mesostructured materials made of organic surfactant (CTAB) and inorganic materials (ZrO2), SANS kinetic experiments (with a stopped-flow coupled to SANS) permitted to identify the role played by the micelles during the precipitation stages of the mesotructured material.[1] Thanks to the H/D contrast, the organic part of the hybrid material in formation can be probed by SANS. Beyond these first stopped-flow experiments, SANS is the technique of choice to characterize the organic structure in hybrid systems. We used SANS to identify the structure of the surrounded CTAB bilayers around gold nanorods dispersed in water solution.[2]
SANS is also a powerful technique to characterize self-assembling squalene based nanoparticles used for nanomedecine. SANS revealed that particles size is controlled by the solvent composition (ethanol-water) after nanoprecipitation process.[3] SANS also help to identify the specific interaction between these nanoparticles and fetal bovine serum (FBS) and bovine serum albumin (BSA), the main protein of blood plasma. In the particular case of squalene-adenosine (SqAd) nanoparticles (whose neuroprotective effect has been demonstrated in murine models[4]), we identify from a coupling of different techniques (SANS, Cryo-TEM, circular dichroism, steady-state fluorescence spectroscopy and isothermal titration calorimetry) that serum albumin partially disassembles SQAd nanoparticles with the formation of complex between BSA and SqAd monomers extracted from the nanoparticles.[5]
In each of these examples, SANS was a key technique to follow the transformation of the organic part in self-assembling nanostructured materials.

1. Né, F., Testard, F., Zemb, Th., Grillo, I., “*How does ZrO_2/surfactant mesophase nucleate? formation mechanism”* . **Langmuir (2003)**, 19, 8503-8510.
2. Gomez-Grana, S., Hubert, F., Testard, F., Guerrero-Martinez, A., Grillo, I., Liz-Marzan, L.M., Spalla, O. “*Surfactant (bi)layer on Gold Nanorods”* **Langmuir (2012)**, 28, 1453-1459.
3. Saha, D., Testard, F., Grillo, I., Zouhiri, F., Desmaele, D., Radulescu, A., Desert, S., Brulet, A., Couvreur, P., Spalla, O. “*The role of solvent swelling in the self-assembly of squalene based nanomedicines”* **Soft Matter (2015),** 1, 4173-4179.
4. Gaudin, A., Yemisci, M., Eroglu, H., Lepetre-Mouelhi, S., Turkoglu, O. F., Dönmez-Demir, B., Caban, S., Sargon, M. F., Garcia-Argote, S., Pieters, G., et al. “*Squalenoyl Adenosine Nanoparticles Provide Neuroprotection after Stroke and Spinal Cord Injury”* **Nat. Nanotechnol**. (**2014)**, *9*, (12), 1054–1062.
5. Gobeaux, F., Bizeau, J., Samson, F., Marichal, L., Grillo, I., Wien, F., Yesylevsky, S. O., Ramseyer, C., Rouquette, M., Lepêtre-Mouelhi, S., Desmaële, D., Couvreur, P., Guenoun, P., Renault, J-P., Testard, F. “*Albumin-driven disassembly of lipidic nanoparticles: the specific case of the squaleneadenosine nanodrug”* **Nanoscale (2020)**, 12, 2793-2809.