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Probing the pathways of nanoscale self-assembly

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Self-assembly is at the origin of many fascinating features displayed by soft matter systems. Elucidating the energetic pathways of bottom-up self-assembly is essential for exploiting these systems and achieving their rational design. Applications of such systems include carriers for drug delivery, templates for nanomaterial fabrication, etc. The aim of this presentation is to provide an overview of recent advances in the investigation of self-assembly processes in solution using scattering methods [1]. Small-angle X-ray and neutron scattering (SAXS and SANS, respectively) techniques have been widely used to elucidate the hierarchical nanoscale structure of self-assembled systems. While the equilibrium structures of a large variety of self-assembled soft matter systems have been well understood, the transient intermediate states in the self-assembly process are only beginning to be explored [2]. This is partly because of the experimental limitations in capturing such transient structures and the complexity of kinetic modelling of the self-assembly pathways [3]. Deeper understanding of the pathways of self-assembly could pave the way to achieve control and predictive capabilities in the fabrication of well-defined nanostructures.

Probing the structural kinetics in turn could provide a better picture of the underlying nanostructure [2]. Time-resolved (TR) scattering experiments can provide valuable structural insights with model systems [1]. For example, TR-SAXS coupled to rapid stopped-flow mixing enabled to shed light on the pathways of amphiphilic self-assembly in the millisecond range and identify the intermediate steps in mixed surfactant systems [2,3]. Examples include micellization and shape transformations, formation of unilamellar vesicles, etc. The same final structure may be reached by a variety of routes depending on the thermodynamic parameters indicating the strong driving force for the formation of a unique nanostructure. Despite the complexity, the structural pathways are governed by a few system dependent thermodynamic potentials. Similar approach could be applied to more complex systems such as self-assembly of biomimetic peptide nanotubes, polyelectrolyte complexation, etc. The application of rapid pressure-jump makes more systems accessible to kinetic studies. Indeed, the advent of new generation synchrotron and neutron sources together with the development of fast detectors significantly broaden the scope of dynamic studies of self-assembled soft matter systems over much broader time and size scales.

[1] Narayanan, T. et al. (2017). Cryst. Rev. 1-67 DOI: 10.1080/0889311X.2016.1277212.
[2] Narayanan, T. et al. (2014). Adv. Planar. Lipid Bilayers Liposomes. 20, 171-196.
[3] Jensen, G.V. et al. (2016). J. Phys. Chem. Lett. 7, 2039−2043.

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