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FROM DYNAMIC STRUCTURES TO FUNCTIONAL MATERIALS

Characterisation of Supramolecular Copolymers across Multiple Length-scales

M. Thomas[1], N. Hempel[1], J. Erlenbusch[1], P. Besenius[1]

[1] Department of Chemistry, Johannes Gutenberg University Mainz, Germany

Multicomponent supramolecular copolymers have emerged as a versatile class of biomaterials for applications ranging from vaccine delivery to regenerative medicine. Their modular architecture enables the incorporation of multiple functional building blocks into a single assembly, providing a highly adaptable platform for engineering materials with tailored biological and physicochemical properties. In particular, peptide amphiphiles have attracted considerable interest because they spontaneously self-assemble into well-defined one-dimensional nanostructures under physiological conditions while offering excellent biocompatibility and synthetic flexibility.

A defining characteristic of supramolecular peptide assemblies is their dynamic nature, arising from the reversible, non-covalent interactions that govern their formation. The continuous exchange of monomeric building blocks enables these materials to adapt to their environment, heal structural defects, and respond to external stimuli. Understanding the molecular exchange dynamics within these assemblies is therefore essential for establishing structure–property relationships and for the rational design of supramolecular biomaterials with predictable functions.

A comprehensive characterization of supramolecular dynamics requires analytical approaches that probe molecular exchange across multiple length scales. Fluorescence-based methods, such as Förster resonance energy transfer (FRET), enable direct visualization of monomer exchange, while label-free techniques including hydrogen/deuterium exchange mass spectrometry (HDX-MS) provide complementary insights into molecular dynamics. In parallel, advanced imaging methods offer detailed information on nanostructure morphology and co-assembly, whereas rheological characterization links molecular organization to the macroscopic mechanical properties of the resulting hydrogels. Together, these complementary techniques provide a powerful framework for understanding the dynamic behavior of supramolecular peptide amphiphile assemblies and guiding the development of functional biomaterials for biomedical applications.