Temporally regulated self-assembly of peptides and their visualization with super-resolution microscopy

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One key feature of biological systems is the existence of chemically fueled, temporal regulation of structure and function. However, it has been a challenge to actively regulate the shape and function of supramolecular nanomaterials, while maintaining physiological conditions. The objective of this work is demonstration temporal control over the structure and function of peptide self-assembly and to be able to visualize nanostructures with super-resolution microscopy.

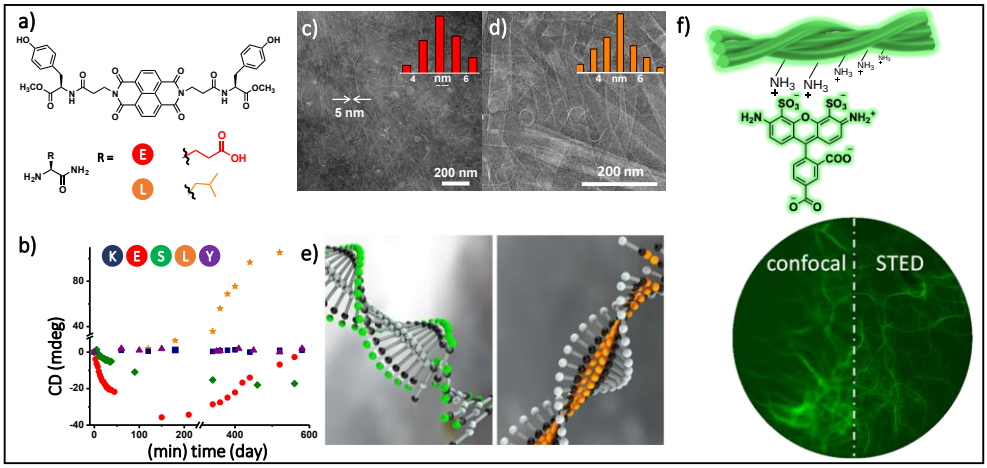

Fig. 1: a) Chemical structure of NDI derivative and various amino acid amide investigated. b) Temporally regulated CD signal upon biocatalytic self-assembly. c) and d) TEM images of the corresponding chiral nanostructures formed in presence of input amino acid E and L respectively. e) Schematic depiction of supramolecular helical inversion. f) Non-covalent dye labeling strategy and super-resolution imaging of peptide self-assembly with STED microscopy.

We designed a self-assembling naphthalenediimide (NDI) peptide conjugate (Fig. 1a).[1] The enzymatic reaction of NDI derivative in presence of different amino acids resulted in self-assembly trajectories that are time programmed by the nature of encoding amino acid. Taking advantage of the semiconducting nature of the NDI core, electronic wires could be formed and subsequently degraded, resulting in temporally regulated electro-conductivity.

To visualize self-assembled peptide nanostructures in real-time and in situ, we developed a dye conjugation strategy where electrostatic interaction between negatively charged dye and positively charged peptide was used for super-resolution imaging.[2] Just by simple mixing dye could be conjugated to a range of positively charged peptides assembly. Overall, temporal control over peptide structure and function, and ability to visualize dynamic structure, with nanoscale resolution, holds great promise towards developing material with life-like functions.

1. M. Kumar, R. V. Ulijn et al., *Nat. Chem.*, 2018, 10, 696.
2. M. Kumar, R. V. Ulijn et al., ACS Nano, 2020, 14, 11, 15056