Bottom-up designed, triggerable soft matter systems: from DNA and protein regulation to responsive membranes and light-driven microfluidics

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We follow a bottom-up approach to design various kinds of triggerable soft matter systems allowing the control of a large variety of properties and functions in response to an external stimulus, such as light. At the molecular scale, the photocontrol of nucleic acid (DNA, RNA) higher-order structure [1,2] enables the photocontrol of gene expression at both transcription and translation levels, in a sequence-independent and reversible manner [3,4], with applications for the photocontrol of enzymatic reactions [5]. Enzymatic activity can also be controlled through regulated higher-order structural changes of giant DNA-protein star-shaped conjugates [6]. At the supramolecular level, we are engineering well-defined cell models in the form of giant liposomes, which can be i) photo-stimulated to analyze the membrane mechanical properties [7] or ii) functionalized with triggerable membrane proteins by using a synthetic biological approach. Finally, at the micro- to macro-scales, we develop laser-free methods where a simple light illumination stimulus (e.g., from a LED device) is used to manipulate [8], divide [9], mix [10] or merge continuous micro-scale flows (light-driven microfluidics) or discrete nL- to µL-sized droplets (digital optofluidics), with high spatio-temporal resolution, in a cost-effective, portable and robust manner.

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