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Self-assembly of nanoparticles driven by light and chemical fuels

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Living organisms are sophisticated self-assembled structures that exist and operate far from thermodynamic equilibrium. They remain stable at highly organized (low-entropy) states owing to the continuous consumption of energy stored in “chemical fuels”, which they convert into low-energy waste [1]. Dissipative self-assembly is ubiquitous in nature, where it gives rise to complex structures and desired properties such as self-healing and camouflage [2]. In sharp contrast, nearly all man-made materials are static: they are designed to serve a given purpose rather than to exhibit different properties dependent on external conditions. In the first part of this talk, I will describe our initial steps towards realising dissipative self-assembly systems based on nanoparticulate building blocks. In these systems, self-assembly is initiated by the addition of a fuel, which initiates a chemical reaction resulting in nanoparticle aggregates [3]. These aggregates are transient and they spontaneously disassemble as the reaction reaches equilibrium. I will outline a general principle for constructing such systems based on decorating nanoparticles with catalytic moieties [4].

The second part of the talk will focus on control self-assembly of nanoparticles using light. To render nanoparticles photoresponsive, we functionalize them with monolayers of photochromic molecules, which can be transformed from one state into another using light of a specific wavelength. Depending on whether the reverse reaction requires light (of a different wavelength) or proceeds spontaneously (thermally), we can distinguish between P-type and T-type switches, respectively. In this talk, I will pose the question whether the P- and T- behavior of these switches can translate into bistable [5] vs. dissipative [6] nature of the resulting nanoparticle assemblies. Emerging applications of these light-responsive nanoparticles as transient nanoreactors [7], time-sensitive data storage media [8], and for magnetic manipulation of non-magnetic objects [9] will be discussed.

References:

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