Out-of-equilibrium self-assembly approaches in supramolecular materials

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Abstract:

The use of self-assembly has proven powerful for the field of materials science resulting in a variety of new structures to address challenges in fields like healthcare and energy conversion. However, when it comes to functionality, such artificial supramolecular materials are vastly outcompeted by the highly sophisticated and complex self-assembled machinery found in natural systems, including the biological cell.

In this talk, I will identify two approaches to create more sophisticated supramolecular materials inspired by the complexity of the biological cell. For instance, one crucial difference between biological structures and man-made materials lies in their energy balance. While most materials are at a thermodynamic minimum, biological architectures are open and can only be maintained by constant consumption of energy. I will discuss materials inspired by this non-equilbrium nature of biology which resulted in active, intrinsically dynamic structures that can be controlled over space and time.

The topic of a second part of this talk remains out-of-equilibrium, however, closer to a thermodynamic minimum. Inspired by protein folding as observed biology, we have set out to explore the energy landscapes of self-assembled materials. We found that, similar to proteins, self-assembled structures can exist in one of several thermodynamically favored minimums, that are separated from one another by an energy barrier. This energy landscape implies that a single self-assembling building block that, under the exact same conditions (pH, temperature, concentration), can from more than one nanostructure. Naturally, each assembled architecture has drastically different material properties.

Friday, April 15th, 2015, 13:00

Room PH 127

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