Using entropy to program self-assembly of DNA-coated colloids

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DNA is not just the stuff of our genetic code; it is also a means to build new materials [1]. For instance, grafting DNA onto small particles can, in principle, 'program' the particles with information that tells them exactly how to put themselves together—they 'self-assemble.' Recent advances in our understanding of how this information is compiled into specific interparticle forces have enabled the assembly of interesting crystal phases [2], and could be extended to the assembly of prescribed, nonperiodic structures [3]. However, structure is just one piece of the puzzle; in actuality, self-assembly describes a transition between a disordered state and an ordered state, or a pathway on a phase diagram.

In this talk, I will present experiments showing that the information stored in DNA sequences can be used to design the entire assembly pathway. Using free DNA strands that either induce or compete with binding between particles, I will show that it is possible to create suspensions with new types of phase behavior [4], enabled by our control of the entropy of the free strands [5]. I will also discuss preliminary experiments showing that we can measure directly the dynamics of transitions between different phases, using a combination of techniques from droplet-based microfluidics, video microscopy, and image analysis. Going forward, this work could prove especially useful in nanomaterials research, where a central goal is to manufacture functional materials by growing them directly from solution.

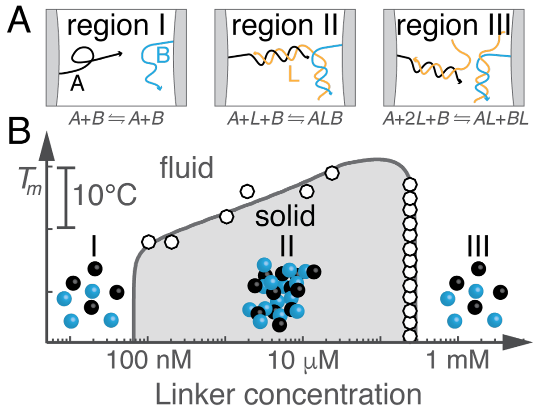

FIG. 1. DNA-coated colloids interacting via DNA strands in solution show unique phase behavior, including reentrant melting transitions and stable coexistence between solid and fluid phases.

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