Designing Disorder

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Abstract: Understanding and controlling the properties of amorphous materials is essential in the design of new materials. Among different amorphous structures, colloidal gels play an important role. It has been established that colloidal gels are the result of a kinetically arrested system that has been quenched into a two-phase region. When short-ranged attractive colloids are quenched into the phase-separating region, density fluctuations are arrested resulting in ramified amorphous space-spanning structures that can sustain mechanical stress. We present a mechanism of aggregation through arrested demixing in binary colloidal mixtures leading to the formation of a yet unexplored class of materials—bigels. We obtain this new material using the highly specific and short-ranged attraction provided by single-stranded (ss) DNA that is grafted to colloids. As ssDNA can only bind to its complementary counterpart, we can design new colloid-colloid binding rules. Here, we choose to make green fluorescent colloids bind only to other green fluorescent ones, while red ones bind only to reds (Figure). As DNA binding is thermo-reversible a 1:1 mixture of the two colloidal species will be in the gas phase at high temperatures and demix at lower ones. We show that the resulting colloidal gel consists of two independent percolating gels. Our findings are supported by simulations.[1] Also, a variety of other new structures will be presented, all based on DNA binding.

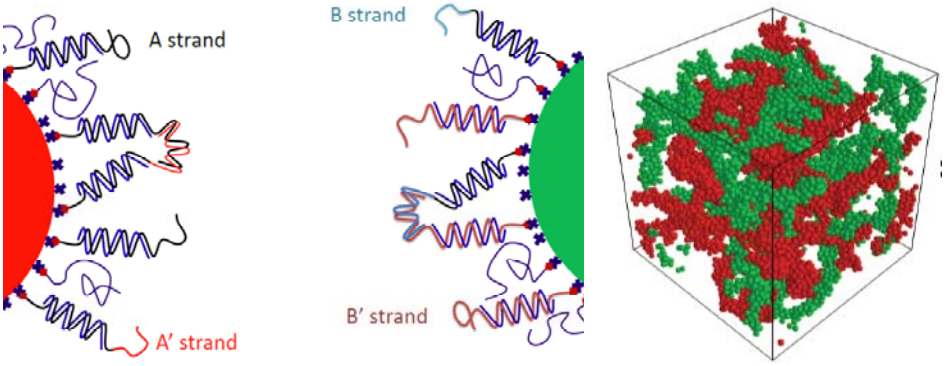

Figure: (Left) Carton of the typical colloid surfaces bound with DNA. The double strands are used as spacers, and the sticky overhangs are designed such that A and A' cannot bind to B or B'. The polymer strands in between are used to tune strength of the intra-colloidal bonds. (Right) Snapshot from a simulation of a demixed bigel.[1]

[1] F Varrato, L DI Michele, M Belushkin, N Dorsaz, SH Nathan, E Eiser, G Foffi, *PNAS*, 109, 10187 (2012).