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Nanoparticle Superlattice Engineering with DNA

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Recent developments in strategies for assembling nanomaterials have allowed us to draw a direct analogy between the assembly of solid state atomic lattices and the construction of nanoparticle superlattices. Herein, we present a set of six design rules for using DNA as a programmable linker to deliberately stabilize nine distinct colloidal crystal structures, with lattice parameters that are tailorable over the 25-150 nm size regime. These rules are analogous to those put forth by Pauling decades ago to explain the relative stability of lattices composed of atoms and small molecules. It is ideal to use DNA as a nanoscale bond to connect nanoparticles to achieve colloidal superlattice structures in this system, since its programmable nature allows for facile control over nanoparticle bond length and strength, and nanoparticle bond selectivity. This assembly method affords simultaneous and independent control over nanoparticle structure, crystallographic symmetry, and lattice parameters with nanometer scale precision. Further, we have developed a phase diagram that predicts the design parameters necessary to achieve a lattice with a given symmetry and lattice parameters a priori. The rules developed in this work present a major advance towards true materials by design, as they effectively separate the identity of a particle core (and thereby its physical properties) from the variables that control its assembly.