Programming ionic colloidal crystals into nanoelectronic architectures

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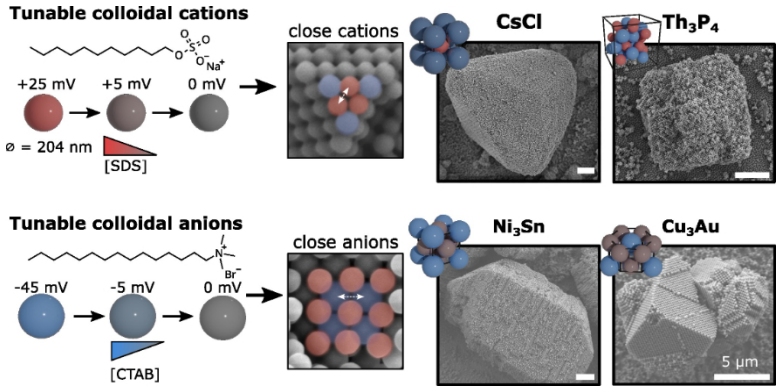
While ionic colloidal crystals can adopt a rich variety of lattice structures, controlling which specific symmetry emerges from a given pair of building blocks remains a central challenge in programmable self-assembly. We demonstrate that micromolar concentrations of small molecules, specifically, the charged amphiphiles SDS and CTAB, provide a simple yet robust mechanism for directing this process by continuously tuning the colloidal surface charge. By modulating the charge balance between oppositely charged colloids, we can steer assembly between multiple distinct crystal structures within a single particle combination. This approach reproducibly yields four lattice types: Th3P4, CsCl, Cu3Au, and Ni3Sn, the latter representing a lattice not previously observed in colloidal systems. Integrated experiments and simulations reveal that this structural selection is driven by a competition between global Coulombic attraction and lattice-specific like-charge repulsion.
Beyond these fundamentals, we explore the relevance of these controlled architectures for nanoelectronics. Specifically, discovering lattice types that map onto 3D geometries useful for memory and computation, where clusters of metallic colloids function as discrete electronic components. Our results establish surface charge as a general control knob for the self-assembly of colloidal ions, paving the way for self-assembled colloidal hardware.

Keywords:
Colloidal crystals, Surfactants, Self-assembly, Nano-electronics, Brain-inspired computing



The ζ-potential of positively charged and negatively charged colloids can be directly tuned by the addition of oppositely charged surfactants, which changes the ratio of attraction and repulsion, leading to different crystals structures

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