FACULTY OF SCIENCE
THE UNIVERSITY OF HONG KONG
香港大學理學院

Department of Chemistry
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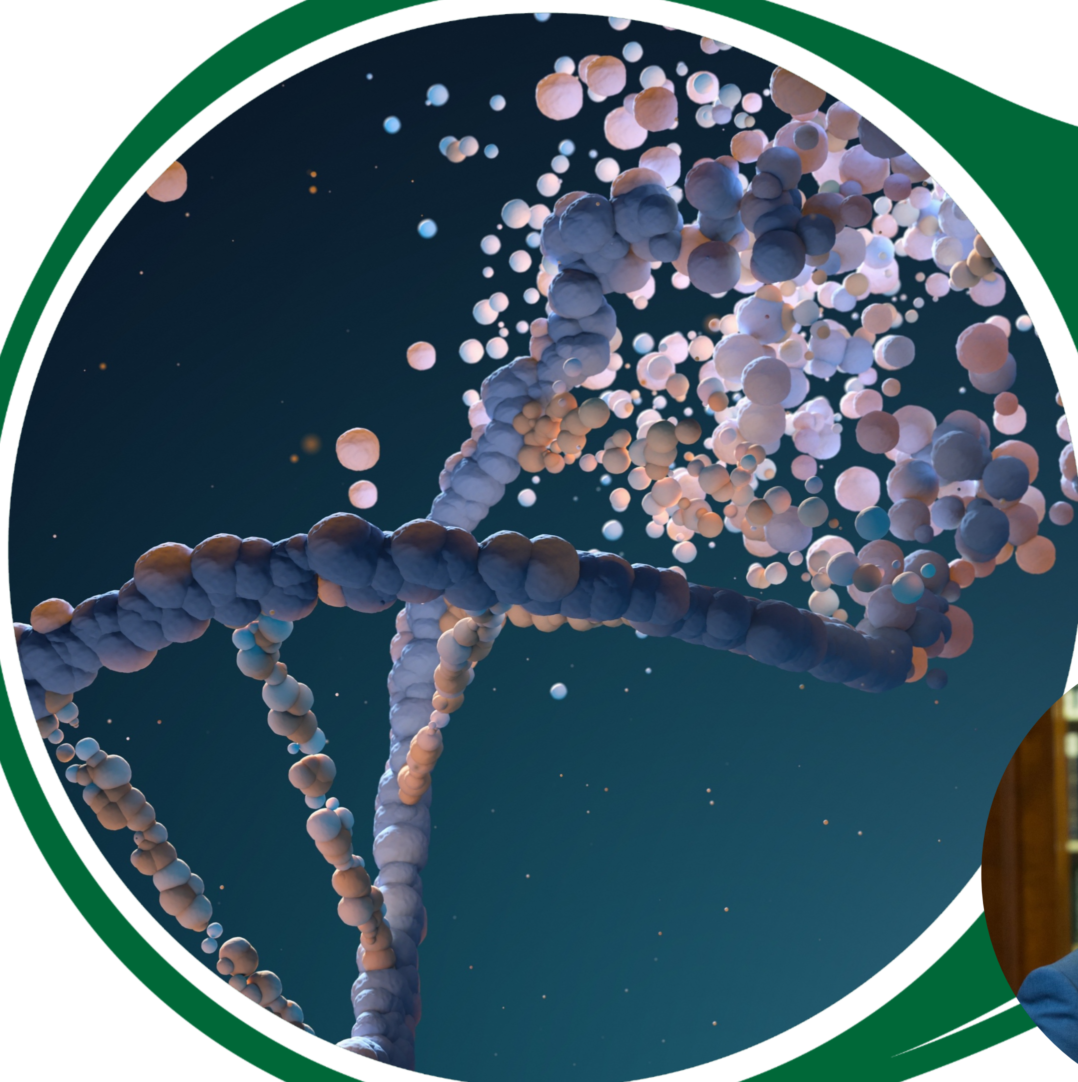
From the Blueprint of Life to Programmable Assembly: Engineering Colloidal Crystals with DNA



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CYP-P2, LG1/F, Chong Yuet Ming Physics Building, HKU

Abstract

Assembly of nanoscale building blocks into superstructures, where the emergent properties are determined not only by the properties of the building blocks but also by the symmetry, orientation, phase, and dimension of the resulting superstructures, are fundamental in expanding the understanding of material crystallization and developing functional metamaterials. However, precisely controlling the length at nanoscale remains challenging in developing crystalline materials with tailorable properties. My group uses DNA as a programmable material to guide the assembly of nanoscale building blocks into colloidal superstructures, with crystal symmetries, habits, and properties dictated by nucleic acid interactions. This programmable strategy of using DNA as "bonds" allows for easy control over nucleic acid sequences and lengths and has led us to define a powerful set of design rules for the construction of colloidal crystals with more than 78 lattice symmetries spanning the classic 14 Bravais lattices, and eight well-defined crystal habits without any atomic lattice equivalents or mineral equivalents. We have expanded this strategy to hollow nanoframes and non-space filling nanostructures to form open-channel lattices, Kagome lattices, and mechanical metamaterial with controllable topology and sizes. These programmable superstructures feature highly ordered solid nanoparticles bonded by soft, deformable DNA strands and have many remarkable physical properties and unprecedented mechanical strength distinct from individual building blocks. For example, DNA-bonded crystals have shape memory properties and restore their crystallinity and habit after 90% compression during dehydration. Exotic optical properties have also been observed in DNA-engineered colloidal crystals, including wavelength-dependent reflection, second harmonic generation, and negative refraction indicating a new milestone in the design of programmable metamaterial.

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Professor Chad A. Mirkin is the Director of the International Institute for Nanotechnology and the George B. Rathmann Professor of Chemistry, Chemical & Biological Engineering, Biomedical Engineering, Materials Science & Engineering, and Medicine at Northwestern University. He is a chemist and a world-renowned nanoscience expert, who is known for his discovery and development of spherical nucleic acids (SNAs) and SNA-based biodetection and therapeutic schemes and Dip-Pen Nanolithography (DPN) and related cantilever-free nanopatterning and materials discovery methodologies, and contributions to supramolecular chemistry and nanoparticle synthesis. Mirkin received his B.S. degree from Dickinson College (1986) and a Ph.D. degree from the Penn State University (1989). He was an NSF Postdoctoral Fellow at the MIT prior to becoming a professor at Northwestern University in 1991. He has authored over 850 manuscripts and over 1,200 patent applications worldwide (over 400 issued) and founded ten companies. Mirkin has been recognized with over 240 national and international awards, including the Kabiller Prize in Nanoscience and Nanomedicine, the SCI Perkin Medal, the Wilhelm Exner Medal, the Dan David Prize, the National Academy of Sciences Sackler Prize in Convergence Research, and the King Faisal Prize from the Kingdom of Saudi Arabia. He served for eight years on the President's Council of Advisors on Science & Technology, and he is one of very few scientists to be elected to all three US National Academies. Mirkin has served on the Editorial Advisory Boards of over 30 scholarly journals, and he is the founding editor of the journal *Small*. He was an Associate Editor of *J. Am. Chem. Soc.* and is a *Proc. Natl. Acad. Sci. USA* Editorial Board Member. He has given over 870 invited lectures and educated over 300 graduate students and postdoctoral fellows, of whom over 130 are now faculty members at top institutions around the world.