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Exploring the "Matterverse" with Nanomaterial Megalibraries

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Abstract

The progression from the stone tools used by early-man to the complex synthetic materials used today have taken centuries to evolve due to the massive parameter space that materials encompass. For example, when one considers the 91 metal elements in the periodic table, and all possible combinations of them, a nearly infinite number of possible materials exist. This is particularly true at the nanoscale where small changes in size or shape, at a fixed chemical composition, can dramatically change the material's properties. Therefore, the ability to rapidly synthesize and screen materials with desired properties is needed. We have developed a nanoscale scanning probe lithography approach that, through the deposition of polymeric nanoreactors and thermal annealing, enables the preparation of "megalibraries" of as many as 5 billion positionally encoded nanomaterials with distinct chemistries, including metallic or ionic nanoparticles and perovskites. These libraries can be tailored to encompass a wide variety of alloy and phase-separated nanoparticles that are comprised, thus far, of as many as 7 different elements with up to four phases and six interfaces. Importantly, one megalibrary contains new, well-defined inorganic materials than chemists cumulatively have produced and characterized to date and can be used to identify new materials and catalysts for important chemical transformations. In addition, important insight into how thermodynamic phases form in polyelemental nanoparticles have been obtained, and design rules for engineering heterostructures in polyelemental nanoparticles have been established. We are now developing new high-throughput structure, catalysis, and luminescence characterization techniques that match the unprecedented speed of megalibrary synthesis. Together, this approach lays the foundation for creating an inflection point in the pace at which we both explore the breadth and discover the capabilities of the matterverse.

Biography

Dr Chad A. Mirkin is the Director of the International Institute for Nanotechnology and the George B. Rathmann Prof. of Chemistry, Prof. of Chemical and Biological Engineering, Prof. of Biomedical Engineering, Prof. of Materials Science & Engineering, and Prof. of 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, the invention of Dip-Pen Nanolithography (DPN) and related cantilever-free nanopatterning and tip-based chemical synthesis and materials discovery methodologies, On-Wire Lithography (OWL), Co-Axial Lithography (COAL), and contributions to supramolecular chemistry and nanoparticle synthesis. He is the author of over 850 manuscripts and over 1,200 patent applications worldwide (over 400 issued), and the founder of multiple companies, including Nanosphere, AuraSense, TERA-print, Azul 3D, Stoicheia, Holden Pharma, and SNAP Therapeutics. He has given over 880 invited lectures and educated over 300 graduate students and postdoctoral fellows, of whom over 125 are faculty members at top institutions around the world.

Dr Mirkin has been recognized for his accomplishments with over 240 national and international awards, including MRS Medal, Faraday Medal (IET), and many more. Dr Mirkin also served as a Member of the President's Council of Advisors on Science & Technology (Obama) for eight years, and he is one of very few scientists to be elected to all three US National Academies (Medicine, Science, and Engineering).