Nano Focus

## Nanoparticle library synthesis serves as a tool to discover new materials

A fundamental tenet of nanotechnology is that nanoparticles have different optical, electronic, structural, mechanical, and chemical properties compared to the corresponding bulk materials. These property differences make nanoparticles useful for a wide range of applications, including catalysis, electronics, sensing, and energy harvesting. The ability to synthesize nanoparticles of varying size and composition, particularly those containing multiple metals, promises the ability to identify materials with new properties that could be used in new devices.

As recently reported in *Science* (doi:10.1126/science.aaf8402), Chad Mirkin and colleagues at Northwestern University have now introduced a technique for synthesizing nanoparticles containing as many as five different metals. With this method, the researchers made 31 different particles consisting of every combination of those elements, including unary, binary, ternary, quaternary and quinary nanoparticles. According to Mirkin, over half of the particles have never been made before. The researchers fixed the size of the nanoparticles and varied their composition to map how different combinations of metals phase segregated or blended into an alloy on the nanoscale.

To build each particle, the researchers used scanning probe block-copolymer lithography to place a droplet of poly(ethylene oxide)-*b*-poly(2-vinylpyridine) polymer containing one or more salts of silver, gold, copper, cobalt, or nickel on a surface. Then they thermally annealed the polymer droplet under an argon atmosphere and subsequently heated it under hydrogen to decompose the polymer and reduce the metal salts, creating metal atoms that coalesced into a particle about 40 nm in diameter.

The researchers identified the location of the metals in each particle using energy-dispersive x-ray spectroscopy. In some particles, like the gold-silver-copper particle, all the components mixed to form an alloy. In other particles, some components formed an alloy while others phase-segregated to one side of the particle. And in other particles, like one containing silver, copper, and cobalt, all the metals phase-segregated and remained in distinct locations in the particle.

This method represents a way to access new nanomaterials more rapidly than ever before, and ultimately could be a way to screen materials for interesting chemical and physical properties, Mirkin says. The next challenge is to develop ways to analyze the library for interesting properties, he says. Having a library of related particles can also allow researchers to further vary the particle structure and to follow how those changes impact its observed properties. In the future, it may be possible to create particle libraries of different sizes, compositions, and shapes, Mirkin says. In previous work, Mirkin and his colleagues have shown that the particle size can be controlled by controlling the size of the polymer droplet deposited on the surface, and the composition of the particle can be changed by varying the stoichiometry of the metal salt precursors.

Yu Huang, at the University of California, Los Angeles, who was not associated with the study, notes that it can take a long time to develop a reliable synthetic protocol to make uniform particles containing four to five elements, and varying the size and composition of those particles takes further synthetic development. She thinks this method is an exciting tool to enable fast screening of nanostructures for enhanced properties such as catalytic activity.

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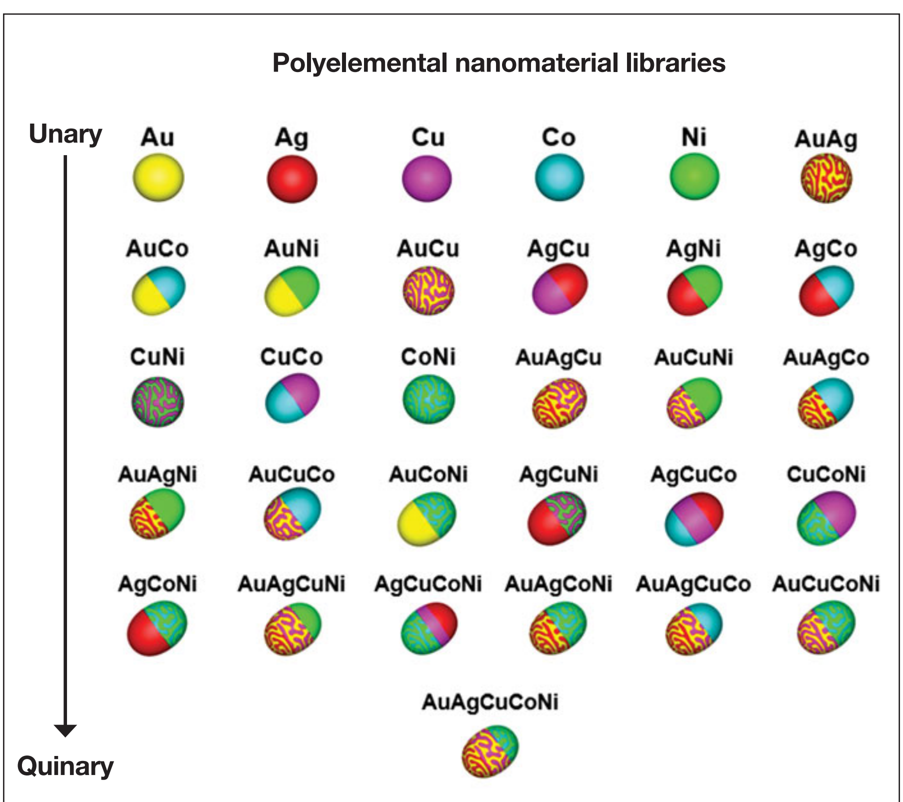


This combinatorial library of polyelemental nanoparticles was synthesized using scanning probe block-copolymer lithography. Credit: Peng-Cheng Chen/James Hedrick.



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