Using polymers to control the organizational behavior of nanoparticles

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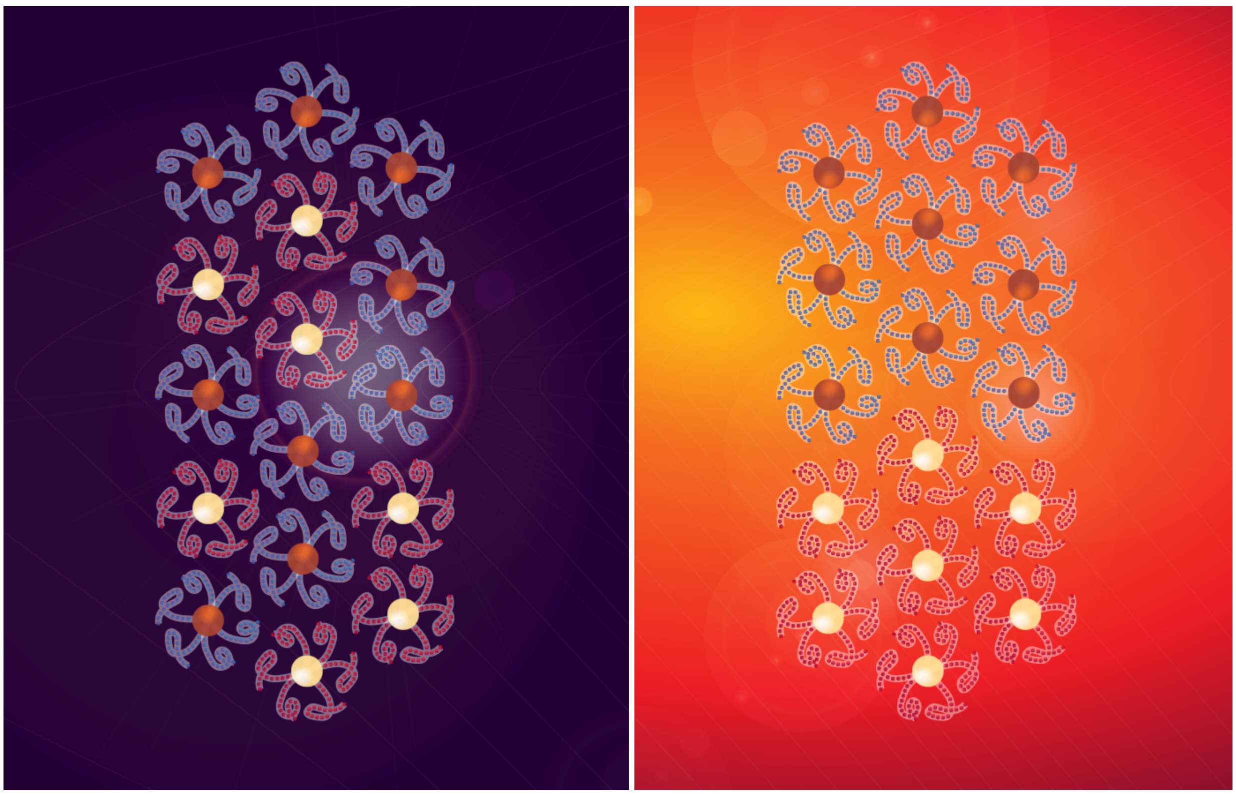

Illustration of the novel fabrication process of microstructured particle-based films for nanotechnology applications. In a first step, films containing mixtures of polymer-tethered nanoparticles are prepared by high-throughput fabrication process. Polymer ligands are indicated as colored strings; different particles are tethered with distinct polymers, respectively. Ligand-driven phase separation subsequently results in the autonomous organization of particles into ordered microdomain structures of controlled size and shape. Credit: Carnegie Mellon University College of Engineering

In order to create new nanomaterial technologies such as next-generation lighting, fundamental challenges underpinning the science and engineering of nanoparticles must be resolved. For example, many proposed technologies hinge on the organization of particles into layers, called films, that have a precise microstructure. However, fabrication of these films is a challenging feat to accomplish because it is difficult to control the structure of nanoparticle assemblies on micrometer scales.

Researchers at Carnegie Mellon University have found a solution—nanoparticles can be organized in a more predictable, organized fashion when surface-modified with polymer chains. By harnessing the intrinsic organizational properties of polymeric tethers, nanoparticles can be programmed to self-assemble into a variety of micron-sized domain structures in a reversible way. These findings were published in the December 23 issue of the journal *Science Advances*.

"We have shown that you can control interactions between nanoparticle building blocks, and therefore you now have the ability to create molecular structures with particles which were not previously possible," says Carnegie Mellon University's Professor of Materials Science and Engineering Michael Bockstaller, a lead author on the study. The researchers have demonstrated this new approach for a model particle system that will act as a synthetic testbed for a range of other nanoparticle materials. These materials are being investigated for applications in a range of nanomaterial technologies.

"No one has ever been able to control particles in this way before, so this finding is very exciting across a wide range of nanoparticle-based material technologies," says Bockstaller. The new results mark an important stepping stone to improving the efficiency of technologies such as sensors and solar panels. Because these technologies rely on the organization of particles to propagate light and heat, this new finding has the potential to dramatically change the way the materials function in the future. For example, Bockstaller explains that better control over the organization of fluorescent particles called quantum materials could result in brighter and more energy efficient television and smartphone screens.

Moving forward, the research team has plans to explore the organization of new nanoparticle systems including quantum dot materials. The team, which includes Carnegie Mellon University Chemistry Professor Krzysztof Matyjaszewski, also hopes to further extend the level of sophistication in controlling the morphology and properties of nanoparticle assembly structures.

"This fundamental research opens the door to try a whole new set of ideas in the realm of nanoparticle-based materials, from photonic to luminescent materials. Imagine if we were able to dynamically change the properties of these materials in defined ways," says Bockstaller. "With our understanding of how to organize particles, we hope to make this possible in the future."

For more information, see the *Science Advances* article: "Polymer ligand-induced autonomous sorting and reversible phase separation in binary particle blends."

More information: "Polymer ligand–induced autonomous sorting and reversible phase separation in binary particle blends" *Science Advances* 23 Dec 2016: Vol. 2, no. 12, e1601484 DOI: 10.1126/sciadv.1601484

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