Chemists make breakthrough in nanoscience research

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A team of scientists led by Eugenia Kumacheva of the Department of Chemistry at the University of Toronto has discovered a way to predict the organization of nanoparticles in larger forms by treating them much the same as ensembles of molecules formed from standard chemical reactions.

"Currently, no model exists describing the organization of nanoparticles," says Kumacheva. "Our work paves the way for the prediction of the properties of nanoparticle ensembles and for the development of new design rules for such structures."

The focus of nanoscience is gradually shifting from the synthesis of individual nanoparticles to their organization in larger structures. In order to use nanoparticle ensembles in functional devices such as memory storage devices or optical waveguides, it is important to achieve control of their structure.

According to the researchers' observations, the self-organization of nanoparticles is an efficient strategy for producing nanostructures with complex, hierarchical architectures. "The past decade has witnessed great progress in nanoscience - particularly nanoparticle self-assembly - yet the quantitative prediction of the architecture of nanoparticle ensembles and of the kinetics of their formation remains a challenge," she continues. "We report on the remarkable similarity between the self-assembly of metal nanoparticles and chemical reactions leading to the formation of polymer molecules. The nanoparticles act as

multifunctional single units, which form reversible, noncovalent bonds at specific bond angles and organize themselves into a highly ordered polymer."

"We developed a new approach that enables a quantitative prediction of the architecture of linear, branched, and cyclic self-assembled nanostructures, their aggregation numbers and size distribution, and the formation of structural isomers."

Kumacheva was joined in the research by postdoctoral fellows Kun Liu, Nana Zhao and Wei Li, and former doctoral student Zhihong Nie, along with Professor Michael Rubinstein of the University of North Carolina. As polymer chemists, the team took an unconventional look at nanoparticle organization.

"We treated them as molecules, not particles, which in a process resembling a polymerization reaction, organize themselves into polymer-like assemblies," says Kumacheva. "Using this analogy, we used the theory of polymerization and predicted the architecture of the so-called 'molecules' and also found other, unexpected features that can find interesting applications."

More information: The findings were published in a report titled "Step-Growth Polymerization of Inorganic Nanoparticles" in the July 9 issue of *Science*.

Provided by University of Toronto