New methodology to study nanoparticle structures

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An up-close look at nanogold, as seen in the lab of the Department of Physics and Atmospheric Science's Kevin Hewitt. Credit: Bruce Bottomley

Nanoscience is the study of materials that measure at the scale of one-billionth of a metre in length. While "tiny" is the very nature of this scientific field, nanoscience is a huge force behind modern day technology and communication, with promise in many more fields.

Anyone who uses a cell phone or laptop has seen the outcome of materials scientists studying the mysterious chemical behaviours at the nano-scale.

Peng Zhang, a professor with Dalhousie's Department of Chemistry, leads a nanoscience research team of undergraduate and graduate students. Published this week in the prestigious scientific journal *Nature Communications*, Zhang's team's discovery on new methodology to study nanoparticle structures will make the materials science and biomedical communities buzz with excitement.

Dr. Zhang and his PhD student Daniel Padmos examined gold and silver nanoparticles—two very important materials, particularly in the future of biomedicine. At this size, gold and silver look and behave much differently than they do when they're used to make rings and necklaces.

"Only when they're very small do they begin to show new properties, and these properties can be used in many different biomedical applications," explains Dr. Zhang, lead author of the study.

Nanogold, for example, has incredible optical properties that allow it to absorb light energy very well. Currently only tested in mice, biomedical scientists have developed drugs with nanogold to target malignant tumours. The nanogold attracts light emitted from laser therapies and heats up the cancerous mass, helping to destroy the tumour. On the other hand, nanosilver could have potential applications in fighting bacterial diseases.

Uncovering shape

The shape of the surface of nanoparticles is key, because different shapes lead to different properties and different properties lead to different behaviours. To better understand the potential applications of nanogold and nanosilver in the long run, scientists must first know much more about their surface structure. But, matter on the nano-scale is challenging to observe.

"These nanoparticles are very difficult to study," explains Dr. Zhang, pointing out that ordinary techniques like electron microscopes don't provide the amount of detail necessary to understand what's happening on the surface of nanomaterials.

"We used some pretty powerful techniques to uncover this surface structure for the first time," said Dr. Zhang.

Dr. Zhang, Padmos and their collaborators from Northwestern University and University of California, Riverside combined a powerful x-ray from a mile-sized synchrotron facility with computer modelling based on density functional theory. By doing this, the team was able to comprehensively study the surface of a nanoparticle. In their nanomaterial system composed primarily of gold, silver and chloride, they even discovered more about how chloride interacts with nanogold and nanosilver, keeping them stable.

"It's a little like cooking," explains Dr. Zhang. "You throw in a bunch of ingredients, but you need to know how they go together. [Material scientists] know chloride is important, but we didn't know how it stays on the surface of nanogold and nanosilver. Our team found out how, at the atomic level."

One step closer

The Dal research team's methodology can now be used to study other nanomaterials, further expanding the knowledge in nanoscience research and designing the building blocks for groundbreaking discoveries in biomedical applications.

"This experience invigorates my interest in this type of research," said Padmos. In the future, he plans to build upon this research to develop new functional nanomaterial systems and test their biomedical potential.

More information: "The surface structure of silver-coated gold nanocrystals and its influence on shape control." *Nature Communications* 6, Article number: 7664 DOI: 10.1038/ncomms8664

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