Electron microscopes take first measurements of nanoscale chemistry in action

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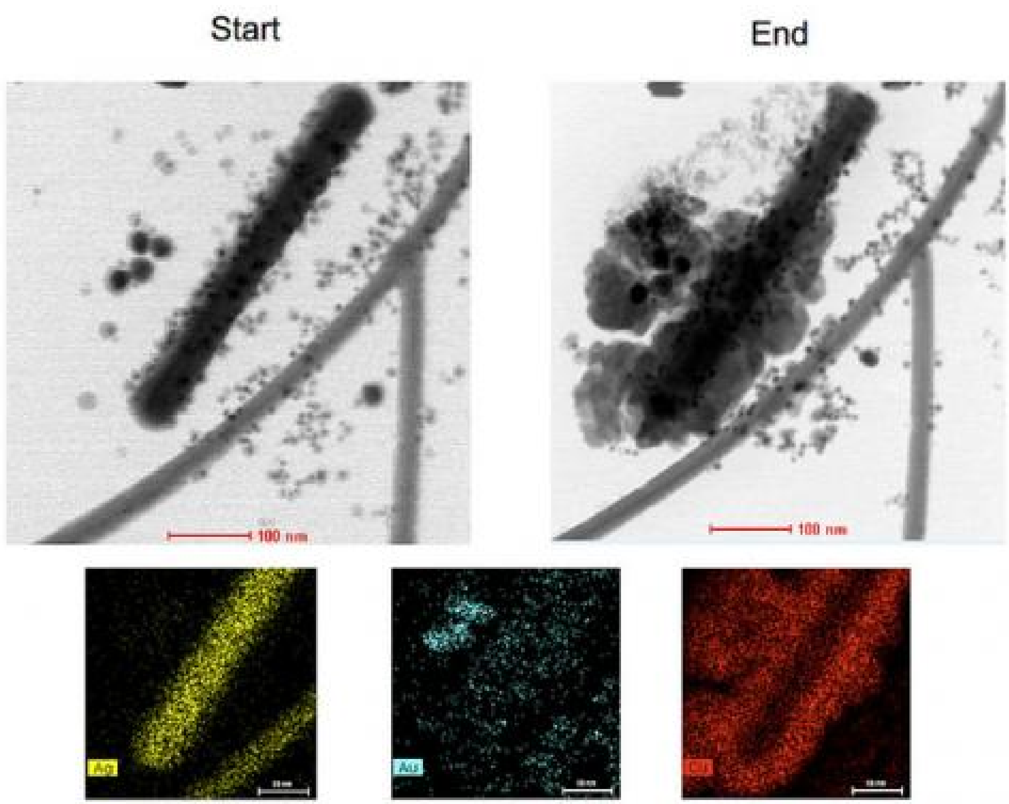

Techniques at Argonne's Electron Microscopy Center helped scientists get a complete picture of this chemical reaction. Over the course of the reaction, the nanorod on the top left is slowly covered with a growth of copper deposits from the solution. Maps showed the locations of the elements in the reaction: Ag, or yellow, representing silver; blue representing gold, Au; and Cu, copper, shown in red. Credit: Nestor Zaluzec / Argonne National Laboratory Electron Microscopy Center.

(Phys.org) —Scientists' underwater cameras got a boost this summer from the Electron Microscopy Center at the U.S. Department of Energy's Argonne National Laboratory. Along with colleagues at the University of Manchester, researchers captured the world's first real-time images and simultaneous chemical analysis of nanostructures while "underwater," or in solution.

"This technique will allow chemists and materials scientists to explore never-before-measured stages of nanoscale chemical processes in materials," said Argonne materials scientist Nestor Zaluzec, one of the paper's authors. Understanding how materials grow at the nanoscale level helps scientists tailor them for everything from batteries to solar cells.

Electron microscopes are a prized tool in a scientist's toolbox because they can see far smaller structures than regular light or X-ray microscopes. They use electrons, which are hundreds of times smaller than the wavelengths of light, to map the landscape all the way down to molecules and even atoms.

"We've been taking images at the atomic and nanoscale for decades, but it's usually done with the sample in a vacuum," Zaluzec said. When you're looking for atoms and molecules, any extra molecules, even the ones in air, can cloud the picture.

But the most interesting objects or processes on Earth generally aren't found in a vacuum, so scientists have also been pushing from the beginning to get analysis and images of materials while they're in more natural environments.

Over the last decade, developments allowed scientists to take images of materials in solution, but getting chemical analysis at the same time remained inaccessible. Imagine how helpful it would be for trainers to be able to watch a baseball player pitch with simultaneous X-ray and MRI vision to watch how their muscles and bones deform under stress, or for cooks to be able to watch how the egg whites are interacting with baking powder in the cake as it bakes in the oven.

"What we need today is to be able to fully interrogate a material—not just see what it looks like, but also measure its electronic and chemical states and even physical properties, all in real time and at the highest resolution, all under environmental conditions," Zaluzec said. "All of this helps us understand why materials behave the way they do, and ultimately, to improve their properties."

Zaluzec and his collaborators reworked the staging of the transmission electron microscope so that the specialized detectors could take a clearer look at the sample. With this innovation, the team was finally able to obtain images as well as simultaneous chemical maps of where different elements are located in the sample. This lets scientists watch as nanostructures grow and change with time during chemical reactions.

The team is now working with the manufacturer Protochips Inc. to make this capability available to the scientific community.

Argonne scientist Dean Miller is already looking ahead to incorporate this capability into the next challenge: being able to take measurements with an electric voltage across the sample in liquids. This replicates the conditions under which, for example, the next generation of batteries will operate.

"Engineering new materials to address today's societal problems is a complex and demanding agenda," Zaluzec said. "Part of our job at the Argonne Electron Microscopy Center is to anticipate the next wave of scientific questions and problems and figure out ways to study them. To meet this challenge we are developing scientific tools to tackle both today's and tomorrow's challenges in a range of areas."

The study, "Real-time imaging and local elemental analysis of nanostructures in liquids," was published in the journal *Chemical Communications* with researchers from the University of Manchester and BP.

More information: "Real-time imaging and local elemental analysis of nanostructures in liquids." Edward A. Lewis, et al. *Chem. Commun*., 2014,50, 10019-10022. DOI: 10.1039/C4CC02743D

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