

# Nickel in the X-ray limelight

March 27 2018

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Credit: Teddy Yang from Pexels

Making chemicals for industrial processes often requires scientists to use a catalyst—a substance that speeds up a chemical reaction, reducing the amount of energy it takes to make different products.

Scientists have long considered palladium, a precious metal closely related to platinum, a star catalyst because of its highly active nature.

However, because palladium is so expensive, scientists have been looking for ways to substitute another metal for the majority of the palladium involved in certain catalysts.

In a new study from the U.S. Department of Energy's (DOE) Argonne National Laboratory and the University of California at Santa Barbara, scientists have identified another elemental actor that helps activate palladium while reducing the amount of the precious metal needed for reactions to occur.

By combining a smaller amount of palladium with nickel on an iron nanoparticle formation, a research team led by Argonne chemist Max Delferro and his colleague Bruce Lipshutz, a chemistry professor at the University of California-Santa Barbara, designed an inexpensive and efficient system that reduced nitro-aryl groups to amines, a chemical group important in agricultural chemicals and the pharmaceutical industry.

"Although this reduction pathway is well-known and there have been different methods to do this in the past, one of the biggest problems is that the catalysts are not sufficiently selective," Delferro said.

"Palladium is a very selective metal, but we need to use a small amount to maintain both its high selectivity and its high activity."

In their effort to "stretch palladium as far as it would go," Delferro and Lipshutz spread the palladium on the iron nanoparticles in a way that maximized the number of active sites where the palladium atoms could interact with nitro-aryl groups.

Without nickel, these small palladium clusters would tend to clump together, losing available surface area and, as a consequence, active sites. The nickel, however, prevents the precious palladium clusters from bonding with each other, keeping them highly dispersed.

"You can think of it like having magnets in a sandbox," Delferro said. "When the sandbox is empty, if you shake the sandbox, the magnets will tend to all come together. But if there is sand in the sandbox, the magnets will remain stuck and cannot move to each other."

To actually observe the arrangement, Delferro and his team used Argonne's Advanced Photon Source, a DOE Office of Science User Facility. In their experiment, the Argonne researchers monitored the catalyst under actual reaction conditions and observed palladium clumping in the version of the catalyst that did not contain nickel.

In versions of the catalyst that did contain nickel, these clumping interactions did not happen, and the [palladium](#) stayed dispersed.

The results of the study derive from a collaboration among Novartis, which initiated the project; the University of California-Santa Barbara, the institution that synthesized the catalyst; and Argonne, which characterized it at the APS. Those results are reported in an article published on December 8 in *Green Chemistry*, entitled "Synergistic effects in Fe nanoparticles doped with ppm levels of (Pd + Ni). A new [catalyst](#) for sustainable nitro group reduction."

Provided by Argonne National Laboratory

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