# Future catalytic converters could give more bang for your buck

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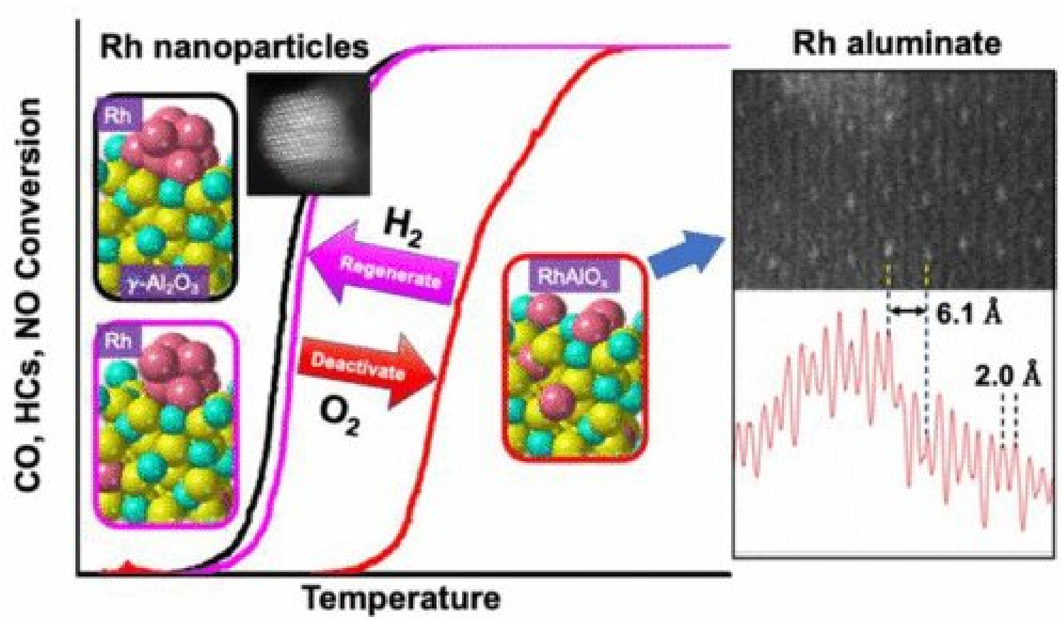


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The next generation of catalytic converters could have longer lifetimes and need fewer rare materials to operate, a new study suggests.

Catalytic converters turn harmful gases from a car's exhaust, including carbon monoxide and other pollutants, into steam and other safer byproducts, like carbon dioxide and nitrogen.

A good catalytic converter can last for more than a decade, but according to Cheng-Han Li, lead author of the study, there's always room for improvement. He said future catalytic technologies could be designed to effectively scrub pollutants for a longer period of time.

"We want to have a better lifetime for catalytic converters. Otherwise, they will have to be replaced or won't pass the government's emission tests," said Li, who is a doctoral student in materials science and engineering at The Ohio State University.

The study was published recently in the journal *Chemistry of Materials*.

Depending on where you live, federal emission standards can vary. In 1975, to combat the growing smog problem in cities across the United States, Congress passed legislation stating that all vehicles were required to have catalytic converters.

Although there are various types, modern catalytic converters use a combination of three precious metals: palladium, platinum and rhodium. These three-way catalysts can reduce nitric oxide (NO) and nitrogen dioxide ($NO_2$) emissions—two substances which if put together, can create $NO_x$, a chemical compound that has both direct and indirect harmful effects on human health.

Rising prices for the three precious metals—especially rhodium—is why criminals all over have resorted to stealing catalytic converters. Found most often in the river sands of North and South America, rhodium is considered the rarest element in the world, and is more valuable than gold and platinum.

"The cost of rhodium has risen dramatically over the past years due to increasing demand coupled with a fundamental supply deficit," says Li. That means catalytic converters can be expensive to make, and doubly expensive to replace.

And since rhodium-based catalysts are in short supply, it's imperative that they be utilized as effectively as possible. Because the catalysts have been known to deactivate at high temperatures, researchers investigated how their performance changes over time in the presence of high heat.

To do this, Li's team performed several tests on the converters, including having them endure temperatures higher than 1600 degrees Fahrenheit. While real catalysts rarely exceed such conditions in a moving car, they may experience those temperatures at least occasionally over their lifetimes, especially as the converters get older.

Researchers used a transmission electron microscope to study the microstructures of the three-way catalysts at the atomic level and how they were affected by the heat. "By observing the microstructure, we can make the connection between high heat, the converter's real performance, and its microstructure," said Li.

Li noted that rhodium catalysts are supported by oxides like alumina and ceria-zirconia, which help stabilize them.

At high heat with oxygen, rhodium dissolves into the alumina and degrades into the stable solution rhodium aluminate. This solution, however, is chemically inactive, meaning that it can't scrub away harmful pollutants and gases, making the device effectively useless.

But it is reversible.

When exposed to hydrogen some of the rhodium becomes active again, but not nearly enough to return the catalyst converter to its former efficiency.

The study's findings concluded that in the long run, establishing a new design that prevents the formation of rhodium aluminate could help get the most out of these devices. This in-depth understanding of the device's structure could also help inform better designs for future catalytic converters.

"Our results give car manufacturers a specific direction to follow to optimize the use of rhodium-based catalysts," said Li.

Co-authors were Jason Wu, Andrew Bean Getsoian and Giovanni Cavataio of the Ford Motor Company, and Joerg Jinschek, an associate professor of materials science and engineering at Ohio State.

**More information:** Cheng-Han Li et al, Direct Observation of Rhodium Aluminate (RhAlOx) and Its Role in Deactivation and Regeneration of Rh/Al2O3 under Three-Way Catalyst Conditions, *Chemistry of Materials* (2022). DOI: 10.1021/acs.chemmater.1c03513

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