Improving the catalytic converters of motor vehicles

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The chemical mechanism that occurs on the surface of an automotive catalytic converter has been deciphered thanks to an observation speed record established by Frédéric Thibault-Strarzyk at the Laboratoire Catalyse et Spectrochimie in Caen (CNRS, France). This performance, achieved in collaboration with the University of Cambridge, has made it possible to characterize this key step in the reaction that ensures pollutant removal by automotive converters.

The challenge is indeed considerable: to obtain a clearer understanding of the mechanisms of removal catalysts in order to improve converters and other catalysts used by the automotive industry.

These results were published in *Science* on May 22 2009.

A catalytic converter included in a vehicle's exhaust system is a solid element that converts the toxic gases generated by the engine into a mixture of inoffensive gases. Although these catalysts are widely employed, their chemical mechanisms have hitherto been poorly understood.
In addition to improving catalytic converters, this observation technique will also help to understand many of the other pollutant removal systems used by industry.

The observation of very fleeting types of catalysts in the context of these mechanisms is particularly challenging. Until now, the most rapid observations of the surface of these catalysts using infrared methods

were around one-tenth of a second.
A novel combination of observation methods has now reduced the duration of observations by a factor of one million.

This manipulation was achieved using a femtosecond laser(1) which was focused on the surface of the solid catalyst made up of silver nanoparticles on an alumina substrate and placed in an atmosphere of toxic gases, thus recreating the conditions of a converter in an exhaust system. As soon as the reaction was triggered by the laser beam, an infrared spectrometer analyzed the surface of the catalyst at a rate of 30 million observations per second.

The key intermediate step in the removal reaction was thus observed for the first time and consisted in a cyanide flip between the silver nanoparticles and the substrate. This molecular flip only lasted 2 microseconds and indeed explains how the removal catalyst functions.

Notes:

1) This type of laser is able to emit light impulses lasting a few tens of femtoseconds. The apparatus used for these experiments is situated at the University of Cambridge.

More information: Real-Time Infrared Detection of Cyanide Flip on Silver-Alumina NOx Removal Catalyst, *Science*, 22 May 2009, Frédéric Thibault-Starzyk, Etienne Seguin, Sébastien Thomas, Marco Daturi, Heike Arnolds, David A. King

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