Research suggests cleaner air may be possible with a cold catalytic converter

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The so-called three-way catalytic converter in the exhaust system of a car consists of expensive materials and only works correctly when the exhaust gases have a temperature that is several hundred degrees Celsius.

As a result, when you start your car, or when you drive a hybrid car in which the petrol engine and electric motor alternate between driving the powertrain, the gases leaving the exhaust still contain toxic carbon monoxide. In an article in the journal*Science*, scientists led by Emiel Hensen now show that by modifying the carrier material of the catalyst, it is possible to almost completely convert toxic carbon monoxide into carbon dioxide gas even at room temperature.

Noble needs

Automotive catalysts are made by depositing noble metals such as platinum, palladium, and rhodium on a substrate of the material cerium oxide, which is also known as ceria. However, noble metals are both rare and expensive. Researchers around the world are therefore working on methods to achieve the same or even better catalytic activity through the use of less of these materials.

For example, in a previous paper, Hensen's group at TU/e proved that by dispersing the noble metal in the form of single atoms leads to not only a reduction in material use, but under certain conditions, the catalyst also functions more efficiently.

New size view

In the Ph.D. research project of lead author Valery Muravev, the researchers shifted their attention from the noble metal to the carrier material underneath (ceria in this case) to further improve the catalysts. They produced the ceria in different crystal sizes and deposited the noble metals as single atoms in the same step. Subsequently, they studied how well these combinations of materials managed to bind an extra oxygen atom to carbon monoxide.

Small ceria crystals of 4 nanometers in size turned out to remarkably improve the performance of the noble metal palladium under cold start conditions in the presence of excess carbon monoxide. This improved performance could be explained by a higher reactivity of the oxygen atoms at smaller ceria crystal sizes. Under more conventional conditions, 8 nanometers turned out to be the optimal size of ceria crystals needed to reach a high catalytic activity at temperatures below 100° Celsius.

Wider significance

This research shows for the first time that when developing catalysts, it pays to look not only at the noble metals that have to do the work. In this case, varying the size of the particles that act as the carrier for the active materials offers an interesting new possibility to further improve catalysts and with those, improve the efficiency and specificity of the chemical reactions. This is also of importance for the development of processes to combine carbon dioxide from ambient air with green hydrogen to produce fuels or compounds for the production of sustainable plastics.

Together with the British company Johnson Matthey, which produces catalysts for the automotive industry, the researchers will now further explore how to translate this finding into new products.

More information: Valery Muravev et al, Size of cerium dioxide support nanocrystals dictates reactivity of highly-dispersed palladium catalysts, *Science* (2023). DOI: 10.1126/science.adf9082. www.science.org/doi/10.1126/science.adf9082

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