New catalyst helps eliminate NOx from diesel exhaust

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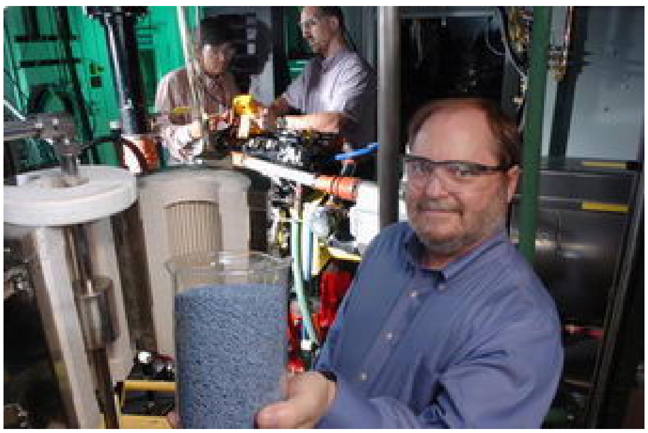

A catalyst developed by Argonne researchers could help diesel truck manufacturers eliminate harmful nitrogen-oxide emissions from diesel exhausts. The catalyst, currently being tested in the form of extrudates, is shown here by researcher Chris Marshall. Having performed well in lab tests, the next step is to subject the catalyst to testing using real diesel exhaust. These tests will take place soon at Argonne&acutes Diesel Engine Test Facility. The catalyst will be placed in the reactor at left which is then connected to the diesel engine pictured in the background with post-doctoral researcher Sundar Krishnan, left, and Argonne researcher Steve Ciatti. Photo by George Joch.

A catalyst developed by Argonne researchers could help diesel truck manufacturers eliminate harmful nitrogen-oxide emissions from diesel exhausts.

The technology — which has a patent pending — appears so promising that multiple large and small companies have expressed interest in licensing it and working with Argonne researchers to scale up the technology and bring it to market. Argonne researcher Christopher Marshall, one of the technology's developers, believes there could be a commercially available product within two to three years.

Nitrogen oxides — collectively called “NO_x” — contribute to smog, acid rain and global warming. Yet they are among the most difficult pollutants to eliminate from diesel exhaust. For example, many technologies that reduce NO_x result in increases in undesirable particulate emissions.

"For diesel engines, we envision manufacturers placing ceramic catalytic reactors in the exhaust pipes, where they will convert NO_x emissions into nitrogen," said Marshall, who works in Argonne's Chemical Engineering Division. Nitrogen, or N_2, is a harmless gas that makes up more than 80 percent of the Earth's atmosphere.

"Our most promising catalyst for diesel engines," Marshall said, "is Cu-ZSM-5 with an external coating of cerium oxide." Cu-ZSM-5 is a zeolite with copper ions attached within its micropore structure. Zeolites are common catalysts in the petroleum industry.

Those working previously with Cu-ZSM-5 and similar catalysts, he said, found that they performed poorly at removing NOx from diesel exhaust. They require temperatures higher than normal diesel exhaust temperatures and don't work well in the presence of water vapor, which is almost always found in engine exhausts.

With the help of the Advanced Photon Source at Argonne to analyze the structure and performance of various catalysts, Marshall's group at Argonne developed an additive that allows Cu-ZSM-5 and similar catalysts to overcome these difficulties.

"Our new cerium-oxide additive," Marshall said, "is the breakthrough that makes it work. When it's combined with Cu-ZSM-5, the resulting catalyst works at normal exhaust temperatures and is actually more effective with water vapor than without it. With a lean fuel-air mixture, it removes as much as 95-100 percent of NO_x emissions."

Argonne's new catalyst also avoids the problems associated with ammonia, which competing catalysts utilize as the reductant. The Argonne catalyst uses the diesel fuel that is already on board thereby requiring no additional tankage.

"Another type of technology is ammonia-selective catalytic reduction, using a material called urea as the ammonia source," Marshall said. "Ammonia is toxic, and unless all of it is converted during the process, whatever remains could be released to the atmosphere. While some European diesel manufacturers are taking the urea approach, U.S. diesel manufacturers are looking for alternatives." Since a system using the new catalyst would not require an on-board urea storage tank and uses the onboard diesel fuel as the reductive material, the new catalyst is considered safer and more energy-efficient.

Another alternative for U.S. manufacturers is the use of NO_x traps. These are platinum-based systems that work well if they don't come into contact with sulfur, which is present in most commercial diesel fuel. Since the Argonne-developed catalyst contains no platinum, it is degraded far less by the fuel borne sulfur.

Marshall says the Argonne catalyst has been tested and performed well with a number of diesel and diesel-type fuels, including standard diesel, synthetic diesel, bio-diesel and JP8, which is a jet fuel preferred by the military. Having performed well in these tests, the next step is to subject the catalyst to engine testing. This will take place soon at Argonne's Diesel Engine Test Facility. Marshall expects these tests will show that in addition to its other advantages, the Argonne catalyst has a greater life expectancy than other catalysts currently on the market.

Marshall and his colleagues are also working with the Chemical Engineering Division's fuel cell research group. Using a reformer developed by this group could provide better fuel for the catalyst, said Marshall. "Our catalyst already works well, but it would work even better with the smaller hydrocarbons produced by a reformer. Collaborations like this and access to Argonne's unique facilities allow us to work together on projects in a way that couldn't be done anywhere else," he said.

Source: Argonne National Laboratory

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