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Clamping Down on Mercury Emissions

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Elemental mercury is highly volatile, insoluble in water, hard to capture from flue gas, and persists in the atmosphere for more than a year before it oxidizes.

Someday, those mercury warning labels posted near the fish section of supermarkets may join lead paint and asbestos as relics of a bygone era.

Berkeley Lab scientists led by Shih-Ger (Ted) Chang have developed a potentially cheap and efficient way of removing mercury from coal-fired power plant emissions. The technique, which joins a portfolio of methods the Department of Energy is pursuing to cut mercury emissions from power plants, could help prevent the toxic element from entering the environment, and a food chain that culminates at the dinner table. It could also help electric utilities meet a new Environmental Protection Agency rule aimed at curbing power plant mercury emissions.

Although Chang's mercury-slashing technique is still under development—it was recently licensed to an East Bay engineering firm called Mobotec USA, where it will undergo pilot-scale testing—early lab-based experiments indicate that it possesses the hallmarks of a successful pollution control technology.

"It promises to be effective, the capital investment would be small, and it is a relatively simple technology to implement," says Chang, an Environmental Energy Technologies Division scientist who developed the method over the last five years, with funding from DOE's National Energy Technology Laboratory.

As envisioned, his technique involves injecting a specially formulated gas into the mercury-laden flue gas of a coal-fired power plant, where it can convert elemental mercury into oxidized mercury, a form more easily captured by existing pollution control devices.

Chang's technique is just one piece to a very large puzzle. Mercury is found throughout the natural world, including many rocks such as coal. Ridding the environment of human-made mercury pollution will require several pollution-reduction strategies aimed at a range of industries, not just electric utilities. And Chang's technique won't eradicate mercury emissions from all power plants. Today's plants burn several types of coal and use myriad kinds of boilers, thwarting a one-size-fits-all approach to pollution control. But it could make a large dent in the 48 tons of mercury emitted by U.S. coal-fired power plants each year, which is the largest human source in the U.S., comprising one-third of all domestic mercury emissions.

A typical U.S. coal-fired power plant emits 48 tons of mercury a year.

The problem is also global. China's booming coal combustion industry emits more than 200 tons of mercury per year into the atmosphere, some of which drifts to the U.S.

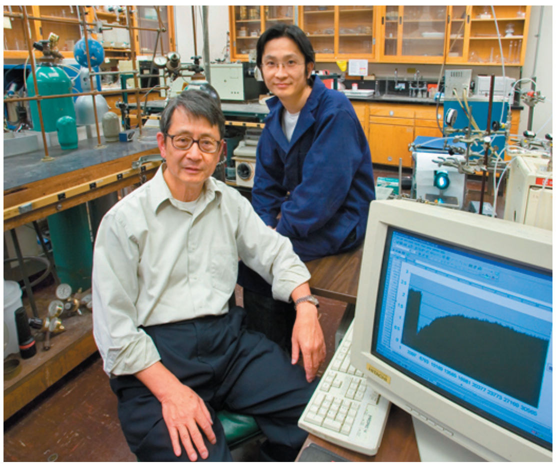
Over time some of the mercury released into the environment by power plants changes to methylmercury, a potent neurotoxin that is known to be detrimental to developing fetuses and young children. It is passed from prey to predator along the food chain, building up in certain types of fish and shellfish that people love to eat.

In fact, methylmercury can accumulate in some fish in concentrations thousands of times higher than in the waters they live in, which is why state environmental regulatory agencies often issue fish-consumption advisories.

Last year, the Environmental Protection Agency attacked the problem at its source by issuing a rule that requires an overall reduction in coal-fired power plant mercury emissions of about 70 percent by 2018.

“Although conventional controls can capture some mercury, new controls will be needed to meet the new EPA standard,” says Chang.

The push to further ratchet down mercury emissions is made difficult because the element courses through a power plant’s smokestack, or flue gas, in three forms: elemental mercury in gas form, and oxidized mercury in either particle or gas form. The latter two oxidized forms can be harvested from flue gas using existing air pollution control devices, such as particulate collectors and sulfur dioxide scrubbers. That leaves elemental mercury, which is highly volatile and insoluble in water and therefore not easily netted by today’s technologies. Making matters worse, once it gets out, elemental mercury persists in the atmosphere for more than one year before it oxidizes, giving it plenty of time to drift around the globe.



Ted Chang (left), Zan Qu, a visiting researcher from Shanghai Jiao Tong University, and their colleagues developed a method to oxidize elemental mercury in flue gas.

Rather than trying to cull the elusive elemental mercury from flue gas, which is a costly and technologically tricky endeavor, Chang decided to try to convert it to a more controllable form.

“Because oxidized mercury can be readily captured by existing methods, a logical approach is to find a cost-effective way of oxidizing elemental mercury,” says Chang.

There are techniques that can already do this, such as treating a commonly used pollution control material, called powdered activated carbon (PAC), with oxidants, and injecting this particulate mix into flue gas. But PAC treated with oxidants costs about $5,000 per pound of mercury captured. That’s cheaper than using untreated PAC, which costs $60,000 per pound of mercury removed, but still too expensive.

Instead of using PAC, Chang turned to specially prepared gasses that have the ability to selectively hunt down and oxidize elemental mercury. Once injected into a power plant’s waste stream, these gasses, either a halogen gas or a halogen-containing gas mixture, largely ignore other pollutants such as sulfur dioxide and nitrogen oxides and react mostly with elemental mercury.

“Its selective ability is very important,” says Chang. “We want the gas oxidant to quickly and mainly react with elemental mercury, because it has less than 10 seconds to do its job before the flue gas passes through the existing air pollution control devices.”

In addition, the gas oxidant adsorbs onto fly ash, which contains some unburned carbon from coal, and forms a particle that can also oxidize elemental mercury. This means that Chang’s technique is doubly efficient: elemental mercury can be oxidized by the gas oxidant as well as on the carbon in the fly ash. It also means that PAC does not have to be used, which is another cost saver. And this, in turn, yields even more savings. Fly ash from flue gas treated with PAC contains too much carbon to be sold to the cement industry, which is a significant source of revenue for power plants. With Chang’s technique, however, the fly ash remains suitable for the cement industry.

“This promises to be effective and much cheaper than many other techniques,” says Chang. “After it’s treated with the gas oxidant, existing control devices used for other pollutants can then remove the oxidized mercury from the waste stream.”

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