Biosensors measure airborne particulates

A new technology for studying cellular stress from air pollution

By Susan McGinley

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Smog collects over the Phoenix metropolitan area.

Monitoring air quality usually means tracking the levels of particulate matter (PM) in the air.

Researchers at the University of Arizona are studying a new way to measure particulate matter. They hope their method will help the EPA measure airborne particulate toxicity using a more precise standard than the one currently in place.

"The EPA has regulations on PM-10 and PM-2.5, but there isn't any real basis for predicting the true health impact of these particles," says Mark Riley, an assistant professor in the Department of Agricultural and Biosystems Engineering at the University of Arizona. "The regulations are based on what can be measured, but they don't necessarily tie to the health impact, although they are supposed to."

Riley says the composition of these particles has a tremendous effect on whether they do harm or are entirely benign. Asthma, emphysema, lung distress, hospital admissions, and the death rate of the elderly and of people with weakened immune systems all increase when these emissions increase. Conversely, cities with large manufacturing bases have reduced reports for these health problems when the factories and plants are shut down.

Riley's group believes that the EPA system needs to take a different approach by determining not just the size, but also the components of PM. "We're trying to tie together the chemical composition of these particles with their elicited effects in humans and animals," Riley says. They are studying two cell-based approaches for detecting and characterizing PM toxicity based on the response of cells from lung tissue exposed to certain types or components of PM.

The first uses a perpetual cell line of rat lung cells that is grown in a tiny cup small enough to fit over the end of an adult's little finger. The cells grow on a porous membrane in the cup. The scientists add different airborne particulates to the single tight layer of lung cells and track the cell's metabolism in consuming sugars and excreting wastes. "If something we add is really nasty, their metabolism stops," Riley says, "although in general we add such low amounts of PM that we don't kill the cells, but rather have a graded response.

"We have collaborators in chemical engineering—Jost Wendt, professor and department head of Chemical and Environmental Engineering—who burn fuels like oil, coal, sewage sludge and collect residues which they give to us to test for potential toxicity."

Although the project will continue for several more months, so far zinc concentrations have demonstrated a very high correlation to toxicity in these studies. The project is funded in part by the Southwest Environmental Health Sciences Center on campus, part of the National Institute of Environmental Health Science (NIEHS).

The researchers' goal is to develop this sensor system so that it can be taken out of the laboratory and used as a more local way to evaluate environmental safety. Lung tissue metabolism is measured using a light emitting diode, an inexpensive

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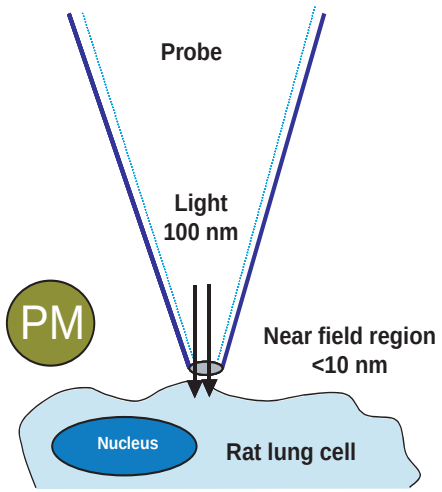
photodetector, and a dye. These components are inexpensive and may be feasible to make the device commercially available. Once the test is patented, the target audience could be growers, manufacturing plants, the military, even homeowners, who already use radon sensors in different parts of the country as an indicator of an environmental risk.

Farther down the road, the scientists would like to develop a personal early detection system that would sound an alarm for people to put on a mask, or get out of the area. The sensor itself wouldn't measure the composition of the air, but would indicate that precautions should be taken.

Riley's second approach is being developed in collaboration with Joseph Simmons, professor and department head of Materials Science and Engineering. This toxicity detection method, which is considerably more complex and more fundamental in nature, uses near- field scanning optical microscopy (NSOM) in Simmons' lab to scan alterations in the cellular proteins, organelles, and membrane of rat lung cells. ABE graduate student Dianne Boesewetter is working on this aspect of the research. Raman spectroscopy and fluorescence spectroscopy will help detect where the PM components interact with cellular components.

"We'll be looking at a very high resolution to look at changes in the cell," Riley says. "Using fiber optics several nanometers in size, we will look at how particulates get into the cell and how they affect its metabolism, including how they kill the cell." The resolution for the system is so high it will allow the researchers to collect potentially thousands of points of measure across one cell.

This is a novel approach: there are possibly only three groups across the globe doing anything similar to this, according to Riley. Researchers at Imperial College, London, are collaborating on this project, which is sponsored by the Defense Advance Research Products Association. W



Near field scanning optical microscopy probe collects information from a lung cell which has been exposed to particulate matter.The near field effect is used to provide light to 500 nanometers (nm) sampling at a resolution of less than 10 nm.

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DESIGNATIONS FOR PARTICULATE MATTER (PM)

According to the EPA, the designations PM-10 and PM-2.5 reflect the size of the particles that can deposit in the lung, but not their chemical composition.The designations PM-10 and PM-2.5 refer to particles with a mean diameter of 10 microns and 2.5 microns, respectively; these are regulated based on the mass of particles in the atmosphere.

Combustion of diesel fuel, emissions from fossil-fuel powered electrical plants, aerosolized soils, and other processes all contribute to the number and type of airborne particulates. Unfortunately, current regulations do not distinguish between harmful and harmless particulates, thus complicating the assurance of safety.

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Biosensors can help determine the amount and composition of the particles in smog.