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antidote to create an inexpensive litmus paper–like nerve-gas sensor emerged shortly after watching *The Rock* on DVD a few years ago.

During the climax of that 1996 Michael Bay movie, chemical weapons specialist Stanley Goodspeed (played by Nicholas Cage) injects himself in the heart with atropine to prevent certain death from VX gas. After watching the movie with his wife, Jiseok Lee became intrigued by the possibility of using the nerve-agent antidote pralidoxime (also known as 2-PAM) to detect the presence of organophosphate nerve gases such as VX and sarin.

"I was inspired to use an antidote because an antidote always has a nice affinity to poison," says Lee, now a postdoctoral associate in the Massachusetts Institute of Technology's Department of Chemical Engineering. "That was the start of this research."

Lee and his U.M. colleagues were able to detect the presence of a nerve agent related to sarin gas at a low concentration of 160 parts per billion using a litmus-like paper sensor designed to change color from blue to pink (Lee says although it looks pink, technically, it is red) within 30 seconds of exposure to trace amounts of the toxic gas. The sensor combines a group of atoms from a nerve gas antidote with a molecule that changes color when it is under stress, the researchers reported recently in the online version of *Advanced Functional Materials*.

"The test can be done using a simple filter paper, and the sensory materials can be synthesized quite easily," says Jinsang Kim, an associate professor in U.M.'s Materials Science and Engineering; Chemical Engineering; and Biomedical Engineering departments. Kim, who advised Lee and his colleagues during their research, adds that it costs about $1 for the chemical reagents and solvents used to make each filter.

"This work is very novel in that we don't need complicated lab-scale analytical devices," Lee says. "[With some] technical modification we might be able to easily commercialize the sensor with extremely low cost."

A litmus-paper test is a low-tech alternative to some of the more sophisticated chemical and radiation detection tools developed in recent years. These include self-contained mobile land and airborne laboratories for monitoring air quality, which the

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U.S. Environmental Protection Agency (EPA) has poured millions of dollars (pdf) into over the past decade. The EPA's Trace Atmospheric Gas Analyzer (TAGA) bus performs real-time sampling and analysis to detect chemicals at very low levels; and the agency's Airborne Spectral Photometric Environmental Collection Technology (ASPECT) aircraft uses chemical and radiological detectors, high-resolution digital photography, video and GPS technology combined with sophisticated software to remotely detect chemicals and radiation. In addition, handheld Chemical Agent Monitor (CAM) devices used by the military and first responders weigh several kilograms and cost upward of $6,500. CAM devices, of course, are also more sophisticated than litmus paper, detecting and discriminating between, for example, vapors of nerve and blister agents and displaying their relative concentration.

Paper-based sensors would be a more practical alternative in equipping large numbers of soldiers and first responders. Litmus paper could warn them to don gas masks, even if specific details about a particular chemical attack aren't available.

The Michigan researchers are now developing a way for sensory chemicals to self-assemble into nanofibers that could be used to make a new type of sensor device that provides three different sensory signals—color change, fluorescence development and conductivity change—that can alert to the presence of a number of chemical and even biological weapons such as anthrax, Kim says.

Perhaps the biggest litmus test lies ahead—finding a way to commercialization these technologies and put them in the hands of those who need them the most.

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