New Electronic Detector Quickly Identifies Types, Amounts of Pollutants

A revolutionary chemical detector apparently offers researchers, consultants, and remediators in the indoor environmental quality field a powerful new tool to sniff out hidden indoor pollutants.

Dubbed zNose, this detector is the first electronic "nose" capable of identifying and measuring individual chemicals mingled in a mix of chemicals. According to its manufacturer, Electronic Sensor Technology (EST) of Newbury Park, California, in just 10 seconds, zNose can determine how much of each chemical is present in concentrations as low as several parts per billion (ppb). EST offers the instrument in handheld and bench-top models. EST is a limited partnership formed by Amerasia Technology Incorporated of Westlake Village, California, and Land and General Berhad, a company in Malaysia, according to EST.

Following two years of beta testing, zNose became the first electronic nose — or "e-nose" — that the US Environmental Protection Agency (EPA) has validated to monitor wells and test soil for contaminants (see www.epa.gov/etv/verifrpt.htm#water). A key reason EPA endorses zNose is that its solid-state technology keeps it calibrated for months at EPA standards, according to EST's Ken Zeiger. Since the device also accurately identifies chemicals in the open air, the White House Office of National Drug Control Policy has sanctioned it for drug detection.

"Hearing" a Vapor Wavelength

Rather than "smelling" substances, zNose actually uses an acoustic wave detector to "hear" the wavelengths of hundreds of chemicals in an area. Since every chemical has a unique acoustic wavelength, just as people have distinct fingerprints, the new odor detector might prove invaluable at detecting and locating which volatile organic compounds (VOCs) or mold toxins are wreaking havoc with a building's indoor air quality (IAQ). So far, according to Zeiger, the food and beverage industries are the instrument's biggest users. California winemakers use it to detect trichloroanisole, a chemical that forms when moldy wine corks are washed with chlorine. Trichloroanisole and other impurities have traditionally fouled about 2% of winemakers' products.

Can zNose, however, provide a profile of the IAQ of a room or building? Zeiger cautions that nobody has specifically used zNose for that purpose, so it remains unproven that consultants could use the device this way. That said, zNose continually proves its broad and accurate powers of detection as it tackles an ever-widening array of chemical identification tasks, Zeiger says. Examples of those tasks and Zeiger's descriptions of the system's flexibility suggest it is up to the job. For instance, EST used it to identify the components of cigarette smoke in a conference room.

"Generally, our system looks for volatile organic compounds indoors, and molds and cigarettes are similar in that [we would collect] both in air samples," Zeiger says. "And their signals [measured on zNose] would generally get stronger as you got closer to their main area of growth or concentration. Having said that, we don't profess expertise in the fields our users are in. Instead, we show customers how to use our instruments to get the optimum results. We can detect gasoline, measure auto exhaust, pinpoint how long it takes a car's catalytic converter to kick in from a cold start, and show how the pollutants are affected after the catalytic converter starts. We detected cocaine and heroin in low parts per picogram [one picogram = one-trillionth of a gram]. We showed the differences between cigarette smoke and marijuana smoke, the differences between diesel and gasoline fumes, and the differences between black powder and other elements of gunpowder. So, in a given room, if we know what we're looking for, we can calibrate the system to find what you want with a high degree of accuracy."

Most pertinent to consultants trying to track down indoor mold, zNose has collected the chemical fingerprints of *Aspergillus*, *Penicillium,* and other fungi. "We're finding new things every day that we can detect," Zeiger tells ***IEQS***. "We ask customers to send us samples — preferably a good one and a bad one — and we test them for free. Then we make a PowerPoint slide show to report what each sample looks like. By having a comparison between 'good' and 'bad' samples, zNose serves extremely well as a quality control device. Let me give you a real example. A plastic manufacturer wanted to know if zNose could help identify plastic that didn't meet his company's standards. He sent us a good batch, which we used to calibrate our machine. Then, we put zNose to work at the company's manufacturing facility. We were able right away to tell a bad batch of plastic from the good batches."

Zeiger says his firm has also set zNose to collect samples of *E. coli* every 15 minutes overnight. "You could set it to take samples every 30 seconds or 5 minutes or whatever you wished," he says. This feature would be valuable to industrial hygienists, remediation specialists, and others who collect air samples to find mold. Why? Because many mold species sporulate infrequently. If you don't sample soon afterward, your sample could falsely indicate that only background levels of mold are present when there actually is considerable contamination.

How zNose Identifies Chemicals

According to the manufacturer, here's how zNose works: The product has a single surface acoustic wave (SAW) piezoelectric crystal embedded in a resonator, a programmable gate array that controls the sensor, and a capillary chromatography column that delivers sampled chemicals to the ideal detecting portion of the crystal. The zNose piezoelectric crystal has a complex electrode at one end that establishes an oscillation of close to 500 megahertz (MHz) of ultrasound waves on the crystal surface. A second electrode at the opposite end detects the sound waves of the odors or fragrances that pass across the crystal surface and then uses the fast chromatography to separate the odors into chemical and physical properties. In part, zNose can identify individual chemicals in a mixture because each substance changes the frequency of the acoustic wave, and that change in frequency is directly proportional to the concentration level of the particular chemical analyte that is leaving the chromatography column.

"We count the number of pulses coming out," Zeiger explains. "These are very stable oscillators. SAW resonators are close to atomic clocks in stability — unless something changes them." The change agents for the SAW resonator in zNose are the odors it detects. "When an analyte hits one resonator and the other one stays stable, our system can detect and identify very small differences in change. We can measure changes in frequency down to a few hertz, and we do this in milliseconds or microseconds," depending on the circumstances, he continues. "We count the number of cycles it changes with an oscillator. We calibrate zNose at the known concentration level. We know that 1 ppm [parts per million] of an element will cause a change of, say 1,000 hertz, so once you calibrate, you've got it knocked. We can speciate and quantify all the chemical elements in an odor in 10 seconds. We can also do it in as little as 5 seconds, or it might take 30 seconds, depending on what you want to do."

What finally makes individual detection of chemicals possible, however, is that zNose is the first electronic sensor with software that creates hundreds of "virtual chemical sensors," according to printed information from the manufacturer. It simultaneously creates high-resolution images of chemical odors — which EST calls "VaporPrints" — for easy identification. EPA beta tested and validated the product's performance for two years, producing "a large database of applications literature and a highly reliable electronic nose," according to the manufacturer's information. The US General Services Administration has a contract to purchase the devices for US government users.

Measures Several Orders of Magnitude

Zeiger says the food and beverage industries are big users of zNose, employing it to look for VOCs. Since most things on Earth tend to be carbon-based, EST built zNose to focus on carbon-based materials. In the world of chemistry, these substances have chains of carbon, and each chemical substance, called an "alkane," has its own molecular "C" (short for carbon chain) weight such as C1, C17.6, and so on, with the higher numbers denoting heavier molecular weights. Zeiger says, "Our instrument will detect C5-C26 in alkanes chains quickly and with great sensitivity. That range tells a chemist a lot because in chemical terms, C5-C26 is 6-7 orders of magnitude wide in vapor pressure. Every substance has a unique vapor pressure. If it has a low molecular weight such as benzene, it would fall into the C5-C7 range. As a rule of thumb though, zNose is much more sensitive to high-weight molecular orders of magnitude in vapor pressure. Our system is not a gas detector, as things stand now, but we believe that with some modifications, we could measure gases." (Gases tend to have molecular weights under C5.)

Zeiger says he and his colleagues have not heard of any other electronic system that uses the same sophisticated technological approach as zNose, which is patented. As a result, he says, none of the systems he and his colleagues have seen are as sensitive, and those other systems' calibrations tend to drift within hours. EST claims zNose is "the fastest GC [gas chromatograph] that can process in 10 seconds, test in so wide a vapor range, and can also tell you what has changed" in a given product or odor. Zeiger adds, "We can tell you right away whether a given change is due to our instrument calibration or to your product."

It can take a while to properly calibrate the machine to obtain the best results when it first encounters a previously undetected chemical, Zeiger says. In the case of the batches of plastic they tested, for example, it took EST technicians an hour to tell their customers what each sample contained, which batch was good, and which was not. "We tinker with it to find the best method by separating the batches or changing the temperature of the detector. It's more sensitive at lower temperatures in the dynamic range at detecting very low analytes versus the highest relative concentration levels — say 10 ppb versus 100 ppm, which is a huge spread. All of this is part of developing the method of measurement. Our device is very versatile in terms of the ways you can calibrate it to get optimum measuring results."

Submit Your VOC Samples

Zeiger makes an offer that an indoor air consultant might find hard to resist. Send him your samples, he says, and his company's technicians will work out the method for optimal detection.

"I don't want to sell an instrument if it doesn't do what someone wants it to do, but if someone sends me a sample and we test it and show it will perform for them, then we can work with that company or person," Zeiger says. "We will train them to use the instrument for their purposes, how to calibrate it, how to detect the minimum levels for different analytes, and so on. We include a software program that allows us to connect my computer to your zNose instrument through the Internet to help you figure out why it's not doing what you want. This gives customers the benefit of having the designers of the instrument help them make it do what the users want."

Any takers? If so, please let ***IEQS*** know how well EST's system fared at identifying your samples and whether you obtained a zNose to use in your consulting.

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PRACTICAL RESEARCH BRIEFS

Experimental Results on the Efficacy of DBNPA Against *Legionella pneumophila* in a Water System

Legionella pneumophila is a significant cause of Legionnaire's disease or *Legionella* pneumonia, which people can contract after this bacterium, which grows in cooling towers and other building water systems, becomes airborne. Cooling towers, heat rejection systems, and evaporative condensers rely on chemical biocides to control *Legionella* and other microflora and to reduce corrosion. Researchers Yang Gao, Y. Eason Lin, Janet Stout, Radisav Vidic, and Ping Zhou state that outbreaks of Legionnaire's from exposure to these commercial water systems continue to plague humankind because these water systems do not get optimal biocidal treatments. The researchers postulate that this may be due either to improper biocidal dosing or to use of biocides that have little effect against *Legionella*. The researchers wrote about their experiments in their paper, *Efficacy of DBNPA Against* Legionella pneumophila*: Experimental*