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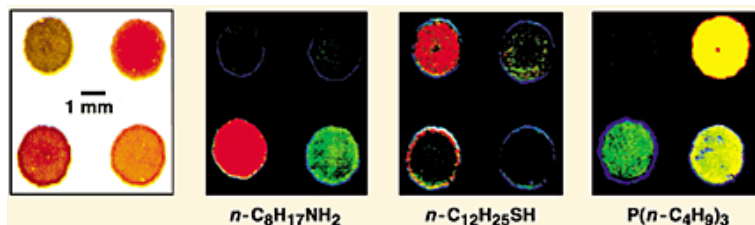
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A 'Nose' That Shows Scents In Color

Ron Dagani

The nose, working in cahoots with the brain, is so adept at detecting and classifying odors that scientists have toiled for years to mimic its capabilities in an artificial system. Although the first examples of electronic noses have already reached the marketplace, the technology is still quite primitive, leaving scientists open to alternative approaches.

The latest one comes courtesy of chemistry professor Kenneth S. Suslick and graduate student Neal A. Rakow at the University of Illinois, Urbana-Champaign. They have devised a simple, fast, and inexpensive system in which a library, or collection, of vapor-sensing dyes responds to odorant molecules by undergoing distinctive color changes. The unique "color fingerprint" that results can then be used to identify the compound or mixture that elicited it [*Nature*, **406**, 710 (2000)].



An array of four different metalloporphyrins (far left) provides a unique color fingerprint when exposed to the vapor of an amine, a thiol, or a phosphine (left to right), each at 1.8 ppm. [Reprinted by permission from *Nature* © 2000]

Suslick and Rakow use metal porphyrin complexes as the dyes. A wide variety of odorants—including alcohols, amines, arenes, ethers, halocarbons, ketones, phosphines, thioethers, and thiols—produce a color change when they coordinate to the central metal atom. The chemists spot several different dyes on a substrate and expose it to a vapor for at least 30 seconds. An inexpensive flatbed scanner or off-the-shelf digital camera is used to scan the dye array before and after exposure to the vapor.

"By subtracting the 'before' image from the 'after' image, we obtain a color-change pattern" for the compound or mixture, Suslick says. "By comparing that pattern to a library of array images, we can quickly identify and quantify the chemical compounds responsible."

This technique, which Suslick has dubbed "smell-seeing," could be used in the chemical workplace to detect and monitor toxic vapors; in the food and beverage industry to detect the presence of flavorings, additives, or spoilage; in the perfume industry to identify counterfeit products; and at customs checkpoints to detect banned produce.

In their preliminary report in *Nature*, Suslick and Rakow note that they have obtained unique color fingerprints at analyte concentrations below 2 ppm and responses to analytes below 100 ppb.



Suslick (left) and Rakow pose with their experimental "smell-camera," a digital camera that has been modified to detect odorants by the color patterns they produce in an array of dyes. [Photo by W. R. Wiegand/UIUC]

Chemistry professor David R. Walt of Tufts University, Medford, Mass., whose group reported a different kind of electronic nose in 1996, comments that "100 ppb is a very good detection limit for many common applications. It is better than some artificial nose systems but not as sensitive as others."

Suslick tells C&EN that his group's sensor array has been improved recently and can now detect certain amines down to 35 ppb. This sensitivity is comparable to that of the human nose for these amines, he adds. And he believes it is lower than the detection thresholds of most other electronic nose systems.

Besides its low detection limit, Suslick cites two other key advantages of the smell-seeing approach: It is insensitive to water vapor, which often interferes with other vapor sensors, and it requires less sophisticated data analysis than other sensing arrays. That's because the response of the metalloporphyrin dyes to a vapor is considerably more specific than the chemical interactions at the heart of some other vapor-sensing technologies, he points out.

Nevertheless, the sensor array cannot yet distinguish between electronically similar molecules such as *n*-butylamine, *n*-hexylamine, and cyclohexylamine. Suslick hopes to close this gap by augmenting the dye library with metalloporphyrins capable of distinguishing molecules on the basis of their shape.

Walt thinks the new colorimetric sensor array is "a nice addition" to the arsenal of methods for detecting and identifying odorants. It "looks quite promising, and it appears to provide a wide diversity of responses as a result of the color changes," he tells C&EN. Still, additional work will need to be done to prove the technology is practical, he says.

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