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The Optoelectronic Nose: An Adventure in Molecular Recognition

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We have developed an entirely new class of lightweight chemical identification systems based on disposable colorimetric sensor arrays: essentially a digital, multidimensional extension of litmus paper. The design of the colorimetric sensor array is based on two fundamental requirements: (1) the use of chemically diverse indicators that respond to changes in their chemical environment (i.e., interact with analytes of interest), and (2) the coupling of this interaction to an intense chromophore to provide a visible readout. The first requirement implies that the interaction must not be simple physical adsorption, but rather must involve other, stronger chemical interactions. By immobilizing chemically responsive indicators (including a range of both free base porphyrins and four- and five-coordinate metalloporphyrins) within nanoporous sol-gel matrices, we have developed a cross-responsive sensor array. Although no single chemically responsive pigment is specific for any one analyte, the pattern of color change for the array proves to be a unique molecular fingerprint. For the detection of volatile organic compounds (VOCs), we have demonstrated high sensitivity (below PEL levels) for the detection of a wide range of toxic industrial chemicals (TICs). Striking visual identifications of many TICs can be made even at ppb levels, for example to hydrogen sulfide, ammonia, SO_2 and phosgene (i.e., sensitivities comparable to GC-MS detection). Classification analysis reveals that the colorimetric sensor array has an extremely high dimensionality with the consequent ability to discriminate among a large number of TICs over a wide range of concentrations. In addition, highly selective discrimination of pure analytes and of complex mixtures has been demonstrated. The technology is also particularly suitable for detecting many of the most odiferous compounds produced by bacteria. We are able to distinguish bacterial growth even at very low levels of detection and can easily identify one pathogenic bacterium from another. Finally, the arrays are highly effective at discrimination among closely related odors (e.g., subtle differences among coffees, etc.).

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