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Guest Editorial

Chemical sensing is a critical aspect of life. Our ability to sense the environment is essential for gustation, vision, reproduction, olfaction, and auditory and tactile stimulation. The field of chemical sensors, while rooted in chemistry, is highly interdisciplinary. Molecular recognition, materials science, information science, and chemical and physical transduction are all essential aspects of the field and draw upon the traditional areas of chemistry, including inorganic, organic, physical, analytical, polymer, and biological. Fully integrated sensing systems typically encompass numerous other technologies and sciences. Our intent in this thematic issue is to capture the vitality of the burgeoning field of chemical sensors, from the perspective of the chemical sciences, through reviews of key areas of sensor research and development.

In selecting the topics of this thematic issue of *Chemical Reviews*, we focused on the development of new materials and how they could be integrated into sensors. Chemical sensing is accomplished by combining a recognition element with a transduction element. New materials are essential for both recognition and transduction. The first step in the process of chemical sensing is the recognition step, addressed by several articles in this issue. Hamilton and co-workers describe the design of molecules for both peptide and protein recognition. This approach couples the tools of traditional organic chemistry with elegant structural design. In addition to providing sensing capability, such strategies have important applicability to drug design and biomolecular recognition. Mosbach and co-workers describe efforts to employ molecularly imprinted polymers for chemical sensing. Such polymers are created by using a small molecule as a template around which the polymer forms to create a cavity for molecular recognition. The technique imparts selectivity to molecular binding materials using shape recognition. Ellis and co-workers review the use of prototypical II−VI and III−V semiconductors for chemical sensing, with a focus on understanding how the surface adsorption chemistry of these materials can be engineered to serve a particular recognition function. Such sensor platforms also provide transduction capability through adsorbate-induced perturbation of the semiconductor's electro-optical properties. Swager and co-workers describe sensors based on the use of conducting polymers with recognition sites. When molecular binding occurs, the conformation of the polymer is perturbed, causing a significant change in the electrical or optical properties of the material. This work is an elegant demonstration of how binding and transduction can be integrated into functional materials such that the two functions are coupled to enhance sensitivity. As an alternative to binding-based recognition, biological systems often employ selective transport mechanisms in which only the desired species can cross a membrane. Bayley and Martin describe how both protein-based channels and nanoscopic gold tubules can be used for selective transport and sensing.

The conventional approach to chemical sensing is to strive for selective recognition. Another methodology is employed by the olfactory system. In the olfactory system, multiple cross-reactive sensors are coupled to sophisticated pattern recognition systems. This approach has been mimicked in recent years with chemical sensing arrays known as artificial or electronic noses. The approach is potentially powerful in that it eliminates the need to synthesize a selective recognition material for every analyte. Three papers in this issue discuss the area of cross-reactive arrays. Lewis, Walt, and co-workers review the numerous approaches to such sensing. Grate discusses the importance of molecular interactions and sensor materials in defining the inherent dimensionality and information content of sensor arrays. Finally, Jurs and co-workers focus attention on the various computational approaches used to extract chemical information from the array signals.

A rapidly growing area of chemical sensing is microfabrication. Madou describes how the field has gone from silicon and integrated approaches to nonsilicon and modular approaches. The article stresses the importance of integrating miniaturized sensor systems with additional functions such as sample preparation and calibration. Wilson and co-author drive this point home in their review of the most commercially successful sensor—the glucose biosensor. They describe the present status and future challenges of employing glucose sensors for in-vivo measurements, one of the most demanding sensing tasks. In this application, biocompatibility is a con-

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tinuing problem. Although this subject has been studied for some time, there is very little fundamental information relevant to in-vivo sensing, and this is currently a focus of a number of groups.

Finally, Daunert brings us full circle and shows how sensing systems can be designed, using genetic engineering, to introduce recognition, amplification, and transduction functions directly into living cells. These sensors are self-replicating and highly sensitive. The ultimate utility of such biosensors will rest with how robustly they can be integrated into devices.

As the articles in this issue convincingly demonstrate, the development of chemical sensors both embraces fundamental chemical research and provides an enabling technology for society with the potential to allow us to monitor our health, environment, and security on a continuous basis. We believe this thematic issue provides compelling illustrations of how chemists are defining the field of chemical sensors, and we hope that these examples will stimulate additional effort and contributions to this exciting field.

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