

## ANALYTICAL CURRENTS

**MerR protein-based biosensors**

Researchers at the University of Chicago have taken sensory protein binding reactions from nature and coupled them to a fluorescent signal to create highly sensitive and selective biosensors. The new sensors, which are built on a platform of MerR proteins, can detect a wide range of metal ions and small molecules.

In nature, the MerR family proteins have evolved to sense and control metal ions down to femtomolar levels with high selectivity. MerR proteins bind to specific DNA sequences, leaving them intact until a target analyte is present. When the protein binds with its target analyte, it unwinds the DNA and breaks two central base pairs.

Chuan He and Peng Chen created one sensor with *E. coli* CueR, a protein that regulates intracellular  $\text{Cu}^+$  concentrations. Pyrrolo-C, which tightly pairs with G in a duplex DNA, was used as the fluorescent reporter. When pyrrolo-C binds with G, the fluorescence is quenched, and when the two unpair, it is enhanced.

The researchers synthesized DNA containing the CueR binding sequence with pyrrolo-C incorporated in the middle of the sequence. In the presence of  $\text{Cu}^+$ , the fluorescence intensity increased within seconds. The enhanced fluorescence was directly proportional to the concentration of  $\text{Cu}^+$  in solution down to nanomolar levels.

The CueR sensor exhibited only weak fluorescence in the presence of divalent metal ions; however, it did respond to  $\text{Ag}^+$  and  $\text{Au}^+$ .

Applying the same strategy, the researchers also developed a sensor with the *E. coli* MerR protein, which has a high affinity for  $\text{Hg}^{2+}$ . Although the MerR sensor was highly selective for  $\text{Hg}^{2+}$  over other metal ions, it also responded to  $\text{Cd}^{2+}$ . It should be possible to design sensors for different analytes simply by replacing the protein with a MerR-type protein that regulates the analyte of interest. Nature has created such proteins for a broad range of metal ions as well as some toxic organic chemicals. (*J. Am. Chem. Soc.* **2004**, *126*, 728–729)

**Detecting sulfur gases near the source**

A shift in wind direction is all it takes to make air-monitoring instruments go from measuring high levels of an air pollutant to background levels. To get such a large dynamic range, multiple instruments are often needed, particularly when indirect methods are used.

Field-portable instruments for measuring  $\text{H}_2\text{S}$ , a prominent sulfur gas found in reduced environments, suffer from a limited dynamic range and cannot differentiate between  $\text{H}_2\text{S}$  and methanethiol ( $\text{CH}_3\text{SH}$ ), a reduced sulfur gas commonly found with  $\text{H}_2\text{S}$ . Instead of operating several instruments in parallel, Kei Toda and colleagues at Kumamoto University (Japan) and Purnendu “Sandy” Dasgupta of Texas Tech University designed a portable system with a large dynamic range that can monitor both  $\text{H}_2\text{S}$  and  $\text{CH}_3\text{SH}$  simultaneously. As a bonus, the device is coupled to an  $\text{SO}_2$  analyzer for continuous measurement of all three sulfur compounds.

To differentiate between  $\text{H}_2\text{S}$  and  $\text{CH}_3\text{SH}$ , the instrument contains two diffusion scrubbers—one made of Nafion that selectively collects  $\text{H}_2\text{S}$  and another made of porous poly(tetrafluoroethylene) that collects both  $\text{H}_2\text{S}$  and  $\text{CH}_3\text{SH}$ . Both gases are measured by the decrease in fluorescence that occurs when they react with fluorescein mercuric acetate.

To overcome the limited dynamic range, two scrubber units are used—one with a long scrubber and one with a short, less efficient scrubber. The two scrubber units are aligned in series. The less efficient one is positioned upstream to reduce reagent consumption, and a fluorescence detector is placed after each unit.

The researchers envision using the instrument to survey geochemical and biogenic sources of sulfur gases, such as volcanoes and septic tanks. They demonstrate the portability and large dynamic range of the instrument for  $\text{H}_2\text{S}$  and  $\text{SO}_2$  near



A field-portable sulfur analyzer is tested near the crater of Mt. Aso, a volcano in Japan.

the crater of Mt. Aso, a volcano in Kumamoto, Japan. In addition, they test the system by monitoring the headspace of a large septic tank. (*Environ. Sci. Technol.* **2004**, *38*, 1529–1536)