Simultaneous carbon dioxide and oxygen sensing

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Breathing. Birds, do it, bees do it, even educated trees do it. But, only plants can make sugars from the carbon dioxide byproduct and at the same time expel oxygen during photosynthesis. This amazing skill has intrigued scientists for decades but separating out the carbon dioxide inputs and outputs while keeping tabs on oxygen levels has always proved difficult.

Now, a new type of chemical sensor, described in the journal *Advanced Materials*, could change all that. The sensor developed by Otto Wolfbeis and colleagues at the Institute of Analytical Chemistry, Chemo- and Biosensors at the University of Regensburg, Germany, will allow clearer insights into plant respiration and photosynthesis. It could also have application in the food and drink industry as well as in the biotech industry where fermentation and related plant processes are important.

Woflbeis explains that in order to unravel the intricacies of photosynthesis and respiration, two of the most important biochemical processes, scientists have to be able to measure carbon dioxide and oxygen at the same time. He and his team have now found a way to side-step the interference from which all previous sensors suffer. The team first create nanoparticles carrying a fluorescent group that react to light and glow only when they are in contact with carbon dioxide molecules.

These nanoparticles are then embedded in a layer of polymer resin. A second compound that does the same in the presence of oxygen molecules is embedded in a second layer of polymer and the two films

sandwich between them a layer of an organometallic compound containing the heavy metal iridium. This layer produces a reference signal for the detection of fluorescence triggered by the two gases. Importantly, however, it is impermeable to oxygen molecules and so its light is not quenched by interference from oxygen.

A blue light-emitting diode (LED) then provides the stimulation for the two sensitive layers to produce light, but only in the presence of their respective gases. A tiny photodetector can then measure the wavelength of light emitted, which is different from each sensor molecule. The strength of the emitted light at each wavelength correlates with the concentration of each of the two gases.

The team tested their sensor over a wide range of different carbon dioxide and oxygen concentrations produced by a growing microbial culture and found it to operate with a remarkable ±5% accuracy at concentration levels expected for real experiments. At much higher but unrealistic concentrations, accuracy deviated only by as much ±10%. Because the device is designed to be reusable rather than a one-shot dip test, the team tested its response after several hundred runs and found it to still be working at these levels of accuracy after 800 runs.

They anticipate that their composite material will become a powerful tool in biological, biotechnological, and medical research. The simultaneous sensor could also have applications in environmental monitoring of sea water and sewage and in medical diagnostics, where blood gas levels are important to understanding the progression of certain diseases.

The research will be commercialized by Presens GmbH.

“It is likely to become a powerful tool in combinatorial microbiology, in cell-based screening for drugs, and in biomonitoring in general,"

Wolfbeis explains. "In combination with fiber optic microsensors, in vivo sensing of oxygen and carbon dioxide should be possible."

Citation: Otto Wolfbeis, Composite Material for Simultaneous and Contactless Luminescent Sensing and Imaging of Oxygen and Carbon Dioxide, *Advanced Materials* 2006, 18, No. 12, 1511–1516, doi: 10.1002/adma.200600120

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