

OVERVIEW OF THE APPLICATION OF FIBER OPTIC SENSORS

DAVID E. HALL

Tufts University
Department of Chemistry
Medford, MA 02155

Fiber optic sensors are being developed for clinical, environmental and process control measurements. These sensors provide stable, drift-free measurements and are immune from electromagnetic interferences. Different optical transduction schemes are being developed. The sensors sometimes incorporate a biological component, such as an enzyme or antibody, to provide the necessary selectivity. Methods are being developed to couple these transduction schemes to the optical fibers in order to create novel sensors for the various application areas.

Optical fibers are being employed increasingly as sensors. Fiber optic chemical sensors (FOCS), also referred to as optodes, offer significant advantages over conventional sensors based on electrochemical principles. They are small, free from electromagnetic interferences and can be designed to have built-in calibration.

Fiber optics operate on the principle of total internal reflection. The fiber is made of two different types of glass or plastic. The central core is surrounded by a clad material with a lower refractive index. When light is introduced into the core, it is propagated efficiently by reflection at the core-clad interface. An optical sensor is prepared by attaching an indicator to the fiber's distal tip. The indicator is chosen to change its optical properties in proportion to the concentration of an analyte in the sample being measured. These optical properties include, but are not limited to, changes in absorbance, fluorescence, refractive index and polarization.

The preparation and mode of operation of a pH optical sensor follows. A pH indicator is selected for the pH range of interest. The indicator is attached to a polymer membrane, which is fixed to the fiber, or the indicator is attached directly to the tip of an optical fiber by a coating procedure. Light is introduced into one end of the

optical fiber and is conducted to the indicator end which resides in the sample to be measured. The light is absorbed by the indicator and the amount of absorption quantitated by the intensity of light returning through a second detection fiber. Alternatively, a fluorescence indicator could emit light of a different wavelength which travels back through the same fiber and is differentiated from the incident light by some filtering scheme. The intensity of the absorbed or emitted light is proportional to the pH of the solution in which the sensor tip resides.

Many indicators have two absorption or two emission peaks. With these indicators, it is possible to perform ratiometric measurements by measuring the absorbance or fluorescence intensities at two wavelengths. Because the ratio of the two signals depends only on the particular indicator and the concentration of the analyte, ratiometric measurements are insensitive to indicator concentration. Furthermore, calibration changes due to indicator photobleaching are eliminated.

Many analytes cannot be measured using simple colorimetric indicators. In these cases, it is often necessary to couple an indicator to a catalytic or binding scheme provided by an enzyme or antibody, respectively. The enzyme and indicator can be fixed together or separately to the fiber's distal tip. In an enzyme-based biosensor, a substrate or product of the enzyme-catalyzed reaction must be detectable by the indicator. In addition, the enzyme must be stable during the sensor lifetime. Detectors or co-sensors may also be required.

Antibody-based systems require optical transduction mechanisms to operate with optical sensors. The binding event would be detectable using one of the optical properties listed above. A major problem with any antibody-based system is its inherent irreversibility.

Major areas of present research center on developing new sensitive optical transduction schemes, constructing inexpensive portable support instrumentation and discovering new

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