US Environmental Protection Agency

Biosensors for Environmental Monitoring

Introduction

National Exposure Research Laboratory in Las Vegas (NERL-LV) is conducting research on biosensors for environmental monitoring applications. This research is designed to address a critical and growing need for real-time and in situ monitoring devices which can be used at Superfund sites and RCRA facilities, as well as for ground water monitoring. Because biosensor technology lends itself to fast, economical and continuous monitoring capabilities, development of these systems to complement classical analytical measurements is expected to result in a substantial cost benefit, especially when sample turnaround time and cost per analysis are important issues. Biosensors are currently being considered for development for detection of environmental pollutants such as phenols, genotoxins, and pesticides such as organophosphates, 2,4-D, etc.

Background

A biosensor is an analytical device composed of a biological sensing element (enzyme, receptor antibody or DNA) in intimate contact with a physical transducer (optical, mass or electrochemical) which together relate the concentration of an analyte to a measurable electrical signal. In theory, and verified to a certain extent in the literature, any biological sensing element may be paired with any physical transducer. The majority of reported biosensor research has been directed toward development of devices for clinical markets; however, driven by a need for better methods for environmental surveillance, research into this technology is also expanding to encompass environmental applications.

Potential Uses

The unique characteristics of biosensors will allow these devices to complement current field screening and monitoring methods such as immunoassay test kits and chemical sensors. For example, enzyme-based biosensors show the potential for continuous monitoring of compounds such as phenolics in process streams, effluents and groundwater. Further, since certain of these devices can operate in high concentrations of organics such as methanol and acetonitrile, these biosensors show promise for in situ monitoring of mixed organic wastes. Other potential applications include down-hole or perimeter groundwater surveillance as well as process stream monitoring for remediation procedures.

Antibody-based biosensors show the potential for coupling immunochemical specificity with recent advances in fiber-optics and microelectronics. These biosensors may yield instantaneous analysis of a wide variety of analytes without the need for multiple reagents and incubation steps required for immunoassay kits.

Future Development

A variety of laboratory prototype biosensors have been reported which measure a fairly broad spectrum of environmental pollutants. Although specific requirements must be met for each field monitoring scenario, some general requirements for biosensors used in environmental applications are listed in the following table.

Requirement	Specification Range
Cost	$1-15 per analysis
Portability	Can be carried by one person; no external power
Assay time	1-60 minutes
Personnel training	Can be operated after 1-2 hour training period
Format	Reversible, continuous, in situ
Matrix	Minimal preparation for groundwater, soil extract, blood and urine
Sensitivity	Parts per million to parts per billion
Dynamic range	At least two orders of magnitude
Specificity	*Enzymes/receptors/nucleic acids:* specific to one or more groups of related compounds *Antibodies:* specific to one compound or closely related group of compounds

Future Research

In addition to the basic and applied research conducted through NERL-LV, efforts are currently underway through the EPA Regional offices for field testing of commercial biosensors in preliminary stages of development as well as those which are "in the queue" for introduction into the commercial market.

Biosensors for Environmental Monitoring

Reference

Environmental Biosensors: A Status Report, K. R. Rogers and C. L. Gerlach, (1996) Environ. Sci. Technol. 30, 486A-491A.

For Further Information

For further information about biosensors for environmental monitoring, contact:

Dr. Kim R. Rogers
U.S. Environmental Protection Agency
National Exposure Research Laboratory
Exposure Dose Research Branch
P.O. Box 93478
Las Vegas, NV 89193-3478

Tel.: (702) 798-2299
Email: rogers.kim@epa.gov

For information about the Technology Support Center at ESD, contact:

J. Gareth Pearson
Director
Technology Support Center
U.S. Environmental Protection Agency
National Exposure Research Laboratory
Environmental Sciences Division
P.O. Box 93478
Las Vegas, NV 89193-3478

Tel.: (702) 798-2270
Fax: (702) 798-3146

Updated March 2003