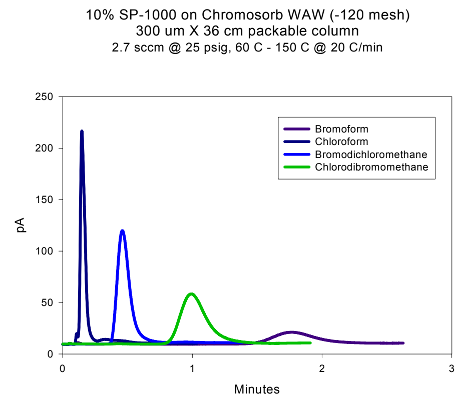
Sensor Development

Micro-analytical Solutions for Water Monitoring Applications

Background

The measurement of various indicators of water quality continues to be an important aspect of any water management program. Safe water from the perspective of public health involves periodic measurements of a variety of chemical and biological contaminants quite often in the context of either a federal or state regulatory framework. Water security within a typical public-use water system includes the need for timely indications of intentional contamination throughout the various zones of a typical public-use water system including: source water, treatment plants, distribution networks and waste treatment plants. Finally, water management programs aimed at the sustainability of water resources also require a considerable body of measurement data that define such water use parameters as river stage, stream flow, urban runoff, surface water quality, consumer consumption patterns and aquifer content. Clearly water monitoring technologies are strongly cross cutting across all aspects of a water management program and consequently, monitoring technology development is an important component of Sandia's Water Initiative.



A variety of technological challenges are faced in the development of water monitoring technologies:

- The list of regulated contaminants is growing thereby creating a greater incentive for automated monitoring.
- Water utilities are usually financially constrained and generally unable to invest in expensive monitoring systems, hence low-cost systems are needed.
- Furthermore, from a water security aspect, many measurement points are needed within a typical urban water distribution network. This further substantiates the need for low-cost systems that are data-networked for maximum effectiveness.
- For water security applications, timely measurements (on the order of tens of minutes) are needed in order to provide adequate time to respond to the threat prior to the consumption of contaminated water by system users.
- The list of potential contaminants is lengthy, particularly from the perspective of water system sabotage, and thus considerable diversity in measurement technologies is required to cover the analytical spectrum.
- Infective doses of many biological contaminants may exist at dilute concentration levels—a fact which poses considerable challenges for sample pre-concentration technologies.
- False positive and negative measurement rates must be low for any monitoring technology to be useful to the water industry for the purposes of detect-to-warn. Consequently, monitor performance must be reliable and well understood.

Approach

In light of the various foregoing challenges, Sandia researchers have identified micro-analytical systems as the corner stone of an ambitious water sensor research and development program. Micro-analytical systems that utilize mass fabrication technologies offer significant advantages in terms of both analytical speed and production costs. We are further leveraging resources that are available for the development of micro-analytical technologies in media such as air that are closely related to water. Some examples of Sandia technologies under development follow:

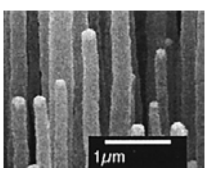
Gas-Phase MicroChemLab

Using the micro-analytical approach, Sandia has developed a hand-held gas chromatograph on a silicon chip that is optimized for monitoring volatile and semi-volatile organic species in air. This system is currently at the field prototype stage. We are presently developing a variety or front-end modules that will further expand the use of this instrument into the analysis of water samples for volatile and non-volatile organic species. Intended water monitoring applications include automated on-site measurement of trihalomethanes and petroleum hydrocarbon contaminants as well chemical warfare agents and their hydrolysis products.

Liquid-Phase MicroChemLab

A parallel technology development program is also underway to develop a hand-held analyzer that utilizes various chip-based technological innovations such as microfluidics, capillary gel and zone electrophoresis columns that are combined with small laser induced fluorescence detectors for the analysis of biotoxins and other proteinaceous materials in water. This system, which also exists at the field prototype stage, can be further optimized for the analysis of other inorganic and high molecular weight chemical contaminants. We are also exploring the use of dielectrophoretic trapping in micro-fabricated silicon arrays as a means to pre-concentrate and sort various water-borne biological species prior to subsequent analysis on micro-analytical platforms. This type of technologies will be a key component of any system designed to monitor biological species in water at dilute concentration levels.

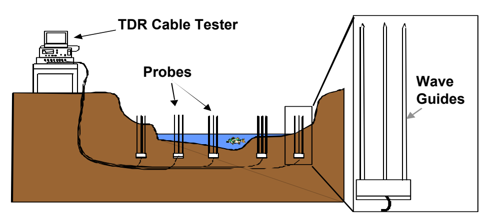
Micro-fabricated Nanoelectrodes



Sandia investigators are exploring the use of carbon nano-tubes as low cost and highly efficient electrodes for the analysis of electro-active water contaminants such as arsenic, lead, selenium and chromium. Our initial efforts are focused on the development of a low-cost hand-held analyzer that requires no reagents for the measurement of arsenic.

Stream Flow Monitoring

Sandia researchers are also developing a stream-bed probe that uses time-domain reflectometry (much like radar along a wire) to detect water flow, stream bed scour and erosion around bridge pilings.



For additional information contact:

Wayne Einfeld
Sandia National Laboratories
P.O. Box 5800, MS 0755
Albuquerque, NM 87185-0755
Telephone: 505/845-8314
Fax: 505/844-0968
email: weinfel@sandia.gov

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