Handheld MEMS-based detector of toxins and toxigenic organisms indicative of Harmful Algal Bloom

Louis Haerle, Stephen T. Hobson
Seacoast Science, Inc.
2151 Las Palmas Dr., Suite C. Carlsbad, CA 92011

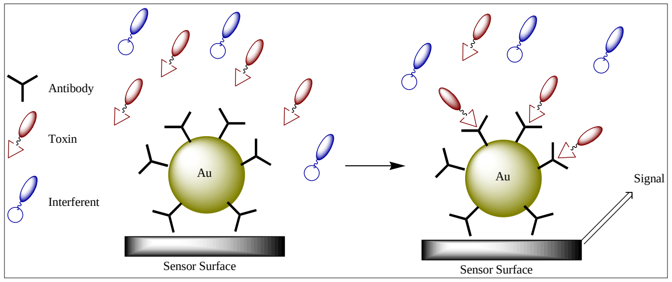
Washington, DC — U.S. EPA SBIR Phase I Kick-Off Meeting — April 5–6, 2007

Problem Statement

Cyanobacterial harmful algal blooms (cyanoHABs) are increasingly threatening fresh water sources, particularly recreational and drinking water sources. The environmental impact from a cyanoHAB include kills of commercially and recreationally important fish or shellfish species and public health risks through direct exposure to hazardous algal toxins.

Modern field detection of harmful algae blooms consists of collecting water samples for laboratory analysis. In such circumstances positive detection may take days or even weeks during which time the algae/toxins may spread, migrate or disappear. The damage from a harmful algal bloom may be complete and the time for effective management will have past during the time taken to identify the harmful blooms using current methods.

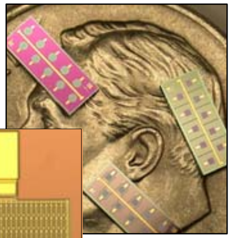
Specific to the current EPA SBIR Phase I program, there is a need for sensors that are capable of detecting toxins from cyanoHABs in a fresh water environment on a time scale of minutes or hours. Such a system must quickly sample and analyze for low levels of toxins



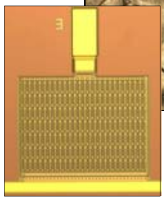
Proposed binding event for the sensing of cyanoHAB toxins in a liquid matrix

Technology Description

Seacoast Science proposes the extension of our MEMS-based sensor technology to provide near real-time detection, identification and quantification of toxins and toxigenic organisms indicative of cyanobacteria harmful algal blooms (cyanoHABs) in drinking water to provide administrators the information for public safety. Different monoclonal antibody conjugates will be mapped onto each sensor using a proprietary inkjet deposition process. Both the selective and non-selective binding of the antigen (toxin) with the mAb-C conjugate array will result in a change in dielectric properties of the sensor matrix that will be detected and processed giving appropriate readings. Specificity inherent in the antigen-antibody binding should limit the fraction of false positives (Ffp) and the use of redundant sensors should lower the fraction of false negatives (Ffn). The nature of our proposed system allows for rapid analysis (≤10 min) with immediate display and optional linking (remotely or directly) of the signal to a computer system for automated reading and storage.



Sensor arrays on a dime

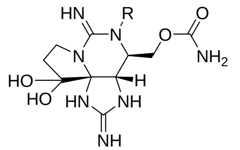


Micrograph of a Seacoast Science interdigitated electrode sensor element (~500 μm x 350 μm).

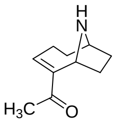
Expected Results

This project will demonstrate the feasibility of a cost-effective, MEMS-based chemical detector capable of monitoring liquid samples for specific target chemicals. The detector will measure concentrations of many chemicals in real time and will be the first application of Seacoast Science's MEMS-based sensors in a liquid matrix. The current state-of-the-art involves taking a liquid sample that is injected into either a gas or liquid chromatograph in a centralized laboratory. These instruments are expensive as is the labor required to man the instruments and collect samples. The process is subject to irreproducibility, contamination, and long time delays.

Replacing the conventional methods with an inexpensive, automated, and reproducible process will enable wide-spread deployment, rapid conveyance of information to decision makers, and fast action on possible alarms. The primary goal of the Phase I effort is to determine if the performance of the chemicapacitive sensor technology is suitable for detecting the toxins in a liquid environment. Specifically, the Phase I effort will determine the sensitivity of the sensors to these compounds, as well as the ability of this technology to discriminate between these analytes from potential interferents.



Saxitoxin (R=H)
Neosaxitoxin (R=OH)



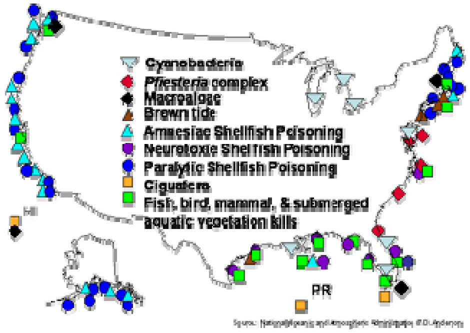
Anatoxin-a

Representative Toxins for Phase I Detection

Potential Environmental Benefits

Harmful algal blooms have long caused problems in near-shore fisheries in the US on a seasonal scale through bioaccumulation in popular food fish and shellfish and have been linked to sea lion mortality on the California coast, seafood poisoning in Hawaii and Florida, and extensive fish kills and human health risks through direct exposure in the Chesapeake Bay. The environmental impacts from a cyanoHAB may include: blocking of sunlight resulting in depletion of oxygen following by fish kills and aquatic plant destruction; production of toxins; and destruction of natural beauty.

The proposed detector will convey information to the appropriate decision makers in near real time for effective management and public health decisions in the case of a putative cyanoHAB occurrence.



Harmful algal blooms in U.S. waters (http://www.cop.noaa.gov/stressors/extremeevents/hab/habhrca/)

This research is funded by USEPA SBIR Program, Contract # EP-D-07-057