PIBBDT: A Portable Biological Detection and Identification System

Giles Cartwright, Paul Smith, Richard Ely and James Clark,
BIRAL, PO Box2, Portishead, Bristol BS20 7 JB, UK

THE PROJECT

The Portable Integrated Battlespace Biological Detection Technology (PIBBDT) is a technical demonstrator programme for the next generation of biological detectors for the UK armed forces. The contract was awarded to Biral in April 2008 and the design, system development and construction have now all been successfully completed. The final phase, in which the system will be rigorously tested in laboratory and field trials, is about to begin at the Dstl laboratories.


PIBBDT

The objective of the programme is to build a biological detection and agent identification system that has high sensitivity with a very low incidence of false alarms but one that is also portable, adaptable and capable of autonomous operation.

The system that has now been designed and built, collects particles from the atmosphere into a concentrated liquid sample, surface-based immunogenic assays detect any agent material in the sample and intelligent software eliminates potentially false readings and raises alarms.

SYSTEM COMPONENTS

Inlet

The inlet is designed to collect particles, in the target size range, with maximum efficiency at wind velocities up to 10 metres per second. It eliminates large particles by impaction, so protecting the collector and subsequent micro-fluidics from blockage. The inlet air can be heated to prevent freezing in the collector during cold weather.

Sample Collection

Particles are collected from the air using a novel design of wetted-wall cyclone. The design has primarily focussed on maximising the concentration of sample in liquid. This is a major factor in achieving high sensitivity and fast reaction times in the sensors.

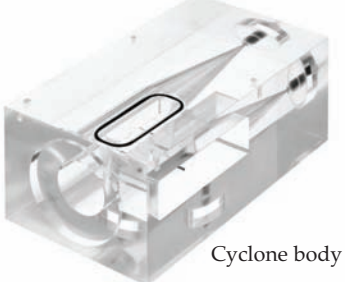
Fluidics

The design of the microfluidic systems is the key to autonomous operation. The system must continue to deliver a constant flow of liquid containing the collected sample to the sensor, whatever the changes in the environment of the sensor or the material it is collecting. At start-up the system senses the temperature (to detect freezing), provides heat if required and primes the system.

In order for the cyclone to continue to collect efficiently it must be constantly supplied with just enough liquid. If the quantity is too small then some of the particles collected will remain on the wall of the cyclone body but if it is too large the sample will be more dilute than the optimum and so the sensitivity reduced. Also the volume of liquid entering the cyclone is not the same as that exiting as the analyte. The contact between the sampled air and the liquid film results in significant evaporative losses and these can vary very significantly as the temperature and humidity changes. The volume flow rate of the sample leaving the cyclone is monitored continuously and the liquid input flow adjusted to keep the output constant.

To increase sensitivity when concentrations of both the target and the background are low, the system can be set to recycle some of the sample through the cyclone. Once the recycling requirement is set in the software then the fluidic logic controls the fresh liquid input to once again keep the output from the cyclone constant.

The fluidics system has also been designed to automatically sense blockages at the cyclone outlet or in the microfluidic transport system and initiate a rapid de-blocking procedure. It also includes a system for de-gassing the liquid flow to prevent the formation of bubbles, which have the potential to both interfere with liquid flow and the sensing process.


Cyclone body

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SYSTEM COMPONENTS continued

The Sensors

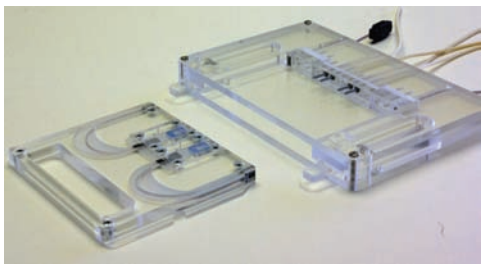
The system has been designed to operate with two different, but closely related, sensor technologies: the Light Scattering Surface Plasmon Resonance (LS-SPR) technique and SpectroSens™ microchip sensor. Both use antibodies immobilised on surfaces and employ highly sensitive optical techniques to monitor the capture of antigenic material on the surfaces

LS-SPR

Surface Plasmon Resonance is a well-established technique for the separation and quantification of molecular species, such as proteins, that can be specifically captured by antibodies immobilised on an optical surface. For larger entities such as bacteria the technique still works but lacks sensitivity as the evanescent field does not extend sufficiently far above the surface, to which the antibodies are bound, to include particles of micrometre dimensions. However some of the energy passing through the surface is coupled into captured particles and can be detected as scattered light. The combined technique can therefore offer high sensitivity for all forms of antigenic material.

SpectroSens

The SpectroSens instrument has been developed by Stratophase Ltd as a compact, robust immunogenic sensor suitable for antigenic material with unit sizes ranging from nanometres to micrometres. It uses optical microchips into which high-precision planar



SpectroSens

SpectroSens

Bragg gratings have been machined. These act as highly sensitive refractive index sensors over the surface of that portion of the microchip. Sensitivity to biological agents is conferred by functionalising the sensing surface with antibodies selected against targets of interest. Binding of target antigens to the surface-immobilised antibodies results in localised changes in refractive index. Laser interrogation of the sensing region via optical fibres senses these antibody-antigen interactions, and the consequent small changes to the refractive index. The changes to the refractive index are detected as increases in wavelength of light reflected from the Bragg grating.

FUTURE WORK

All the elements that go to make up the PIBBDT system have been designed, built and tested individually. The integrated system has now been built and extensively tested to ensure that it is fully operational. It has now been delivered to Dstl at Porton Down where a full range of laboratory and field trials are due to begin. The trials will include testing of the integrated system with a wide range of simulants and potential interferents. Additional sacrificial units, excluding the aerosol collection element, have been built for definitive testing of sensitivity levels against real agent material in high level containment.