IBN's Mini Lab-on-a-Chip Revolutionizes Disease Detection

In keeping with the global trend towards increased automation and miniaturization, Singapore-based Institute of Bioengineering and Nanotechnology (IBN) scientists have developed a miniature lab-on-a-cartridge biosample preparation system that may transform the way diseases such as cancer are diagnosed.

Led by IBN executive director, Jackie Y. Ying, PhD, the IBN team has developed a biochip that replicates the entire sample preparation process on a 4cm x 2.7cm cartridge.

The cartridge contains the required reagents for biosample preparation, and the entire sample preparation process is performed within the cartridge automatically. Hence the risks of sample cross-contamination and human operator error are minimized.

Users would just need to place the sample into the cartridge and press a button on the desktop system to start the sample preparation process. Pure target genes can be collected for downstream analysis within six minutes.

Tests with more than 200 cartridges have shown that the cartridge prototype is able to extract high yields of pure DNA and RNA from body fluid samples and cells.

A possible use for the MicroKit is to detect the presence of infectious diseases in travelers arriving at a customs checkpoint, as demonstrated by IBN researchers including research officer Xu Guolin, postdoctoral fellow Jeremy Loh, PhD, lab officer James Hsieh Tseng-Ming, and senior lab Officer Daniel Lee, who showcased this technology at NIDays 2007 in Singapore.

A sample is obtained from the traveler via a cheek swab using a cotton bud. The cotton bud is then dipped into the sample preparation cartridge. The sample preparation cartridge is self-contained with pre-loaded reagents for sample preparation. Reagents include cell lysis reagent, gene purification reagents, and gene elute reagent.

The operator would then insert the cartridge into the desktop system and control the sample preparation process using the desktop system. The entire sample preparation process takes place within the cartridge.

These processes include cell lysing, adjustment of the gene capturing condition, gene capturing, gene purification, and gene elution. Within six minutes, purified genes can be extracted from the sample and used for analysis.

The desktop system has a built-in microPCR system for amplifying the target genes. Pure genes extracted from the sample will be taken out of the cartridge and transferred to the microPCR system for gene amplification and detection.

The gene amplification process takes about 45 minutes. The gene signal is read using an optical read head inside the microPCR. The operator can then find out whether the sample contains the flu virus.

The system uses a passive cartridge that has no moving parts, pumps, or valves. It uses external pressure and a vacuum source from the desktop system to transfer and guide the reagent flow inside the cartridge. It is cost-effective and suitable for use in disposable applications.

The current cartridge is made of polymer with an external dimension of 40mm by 27mm by 30mm. It handles body fluid samples from 100μl to 700μl. IBN researchers are currently working on biosensors that can be integrated into the cartridge for gene detection. This will remove the need for the microPCR system.

Current versions of IBN's MicroKit use body fluids as a sample. IBN researchers are currently working on a system that will be able to use tissue samples to prepare DNA/RNA.

Clinical trials with several hospitals in Singapore will be conducted soon and IBN is in talks with interested venture capitalists for future developments on the MicroKit.