B206 Towards the Integration of Cell Separation With Solid Phase Extraction on a Single Microfluidic Device

Jessica C. Voorhees, MSc, Kate Manning, Susan L.R. Barker, PhD, Jerome P. Ferrance, PhD, and James P. Landers, PhD, University of Virginia, Department of Chemistry, McCormick Road, Charlottesville, VA 22904*

The goal of this project is to integrate the separation of sperm cells from epithelial cells with subsequent on-chip DNA extraction from each cell fraction on a single microdevice. The extracted DNA from each cell type is compatible with subsequent STR analysis.

This presentation will impact the forensic community and/or humanity by presenting work that represents a major step towards the development of a fully integrated microdevice capable of total DNA analysis for forensic casework.

Microchip technology offers the potential of a rapid, cost-effective alternative to conventional DNA analysis methods. The research presented will highlight the development of integrated microdevices that combine cell separation and solid phase extraction (SPE) of DNA from the separated cells, two of the procedures necessary for analysis of sexual assault evidence where male and female DNA must be separately identified/interrogated. This presentation will demonstrate the application of microchip technology to forensic casework analysis, illustrating the significant potential impact these devices might have on the forensic community.

The proven utility of forensic DNA evidence has increased the demand for DNA analysis services. Although conventional DNA analysis techniques are effective, they are time-consuming and laborious, which has contributed to an overwhelming backlog of forensic casework samples with possible biological evidence. Research efforts have focused on the development of more rapid and efficient analytical methods, as well as the automation of existing methods, to reduce the time and cost of forensic analysis as well as the magnitude of the existing casework backlog. Techniques performed on microchips are particularly advantageous because they can be integrated with upstream or downstream analytical steps on a single microfluidic device in the form of a lab-on-a-chip or micro-total analysis systems (μTAS). These integrated systems, which incorporate all the sample processing steps required for forensic DNA analysis, will reduce analysis times, and therefore, the forensic casework backlog. Successful microchip methods for separating sperm and epithelial cells have previously been demonstrated [1, 2] These methods circumvent the most time-consuming step in DNA analysis of sexual assault evidence, the conventional differential extraction procedure. In addition, microchip-based SPE has previously been demonstrated[3] on a variety of biological materials.

The research presented here describes efforts towards integration of cell sorting and solid phase extraction of DNA on a single microdevice. The functionalities of the device are described, including the results of PCR amplification of STR fragments from genomic DNA isolated from cells sorted based on their physical properties. The sperm and epithelial cells were lysed on-chip in their separate areas, followed by isolation and purification of their respective DNA fractions; DNA amplification and separation were performed using conventional laboratory methods. Preliminary work on a second cell separation method, based on capture of cells using acoustic trapping (2) is also presented, along with initial attempts toward integration of this method with on-chip SPE. The presented work represents a major step towards the development of a fully integrated microdevice capable of total DNA analysis for forensic casework.

References:

1 Horsman KM, Barker SLR, Ferrance JP, Forrest KA, Koen KA, Landers JP. Anal Chem 2005; 77:742-749.

2 Peat M, editor. Acoustic differential extraction: a novel alternative to conventional differential extraction; 2006 Feb 20-25; Seattle. Seattle: American Academy of Forensic Sciences, 2006.

3 Bienvenue JM, Duncalf N, Marchiarullo D, Ferrance JP, Landers JP. J Forensic Sci 2006;51(2):266-273.

DNA, Solid Phase Extraction, Cell Separation

 ** Presenting Author*