B205 Microfluidic Systems for Forensic Genetic Analysis

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After attending this presentation, attendees will understand the advancements being made in microfluidics towards the development of a fully-automated genetic analysis system for forensic casework processing.

This presentation will impact the forensic community and/or humanity by through the overview of some of the recent developments in the field of microfluidics and come away with a better understanding of the state of microdevices for forensic applications.

Over the past several years, developments in microfluidic technology advance us toward a full microscale integration of the processes associated with genetic analysis. En route to such a device, the ever-increasing complexity of the microdevices is matched only by the ever-improving capabilities of these microchip systems. Nanoliter pumping, on-chip valving, and novel passive flow control now enable precise sample manipulation and highly controlled fluidic handling in these systems. These advances have allowed for the drastic reduction of the time required for analysis, the volume of reagents consumed, and the cost associated with performing a wide variety of sample processing steps (including DNA extraction, PCR amplification and the separation and detection of target amplicons) and, recently, a single integrated microchip capable of accomplishing all of these analysis steps in less than 30 minutes has been reported.[1] In addition to their probable application to clinical diagnostics, microdevices are becoming an increasingly more viable option as a rapid and cost-effective method for improving forensic DNA analysis. In fact, inexpensive glass microchips are already being developed and evaluated in forensic laboratories to improve the efficiency, reproducibility, and automation of current time- consuming bench-top processes. As a result of these advancements, multi-component microfluidic genetic analysis has been realized.

The research presented here describes the recent progress made towards the development of microfluidic systems for forensic genetic analysis. It will highlight the current advancement of device design and methodologies for a variety of sample processing steps, including cell- sorting, PCR amplification, and separation and detection of PCR products. The devices and associated methods presented exploit elastomeric valving systems for precise fluidic control of solution flow throughout the device, allowing on-chip pumping and multiple process isolation. Novel techniques for DNA extraction and cell sorting are described and results from rapid, non-contact, IR-mediated PCR amplification of STR fragments are also presented. In addition, a multi-color detection scheme for microfluidic STR analysis will be described. Methods for integrating sample processing steps for the analysis of STRs from forensically relevant samples are discussed, highlighting integrated SPE-PCR systems capable of interfacing with conventional laboratory instrumentation and novel approaches for carrying out chip- based differential extraction. The aim in presenting these research advances is to provide a more global understanding of integrated microfluidic systems to the forensic community so that development efforts yield functional microfluidic systems specifically tailored to forensic DNA analysis. As a result, the work reported here is meant to emphasize the flexibility of these devices and designs for both application and sample type, as well as provide a platform to engage the forensic community in facilitating the development of this new genetic analysis system.

Reference:

[1] Easley, CJ, Karlinsey, JM, Bienvenue, J.M., Legendre, L.A., Roper, M.G., Feldman, SH, Hughes, MA, Hewlett, EL, Merkel, TJ, Ferrance, J.P. and Landers, J.P. “A Fully-Integrated Microfluidic Genetic Analysis System with Sample in-Answer out Capability”. PNAS (in revision).

Microchip, DNA, Integration

 ** Presenting Author*