DEMONSTRATION OF RAPID STR SEPARATIONS ON POLYMERIC MICROFLUIDIC DEVICES WITH A ROBUST DETECTION SYSTEM

Brian Root[1], Ph.D., Peter Trost, Ph.D., Orion N. Scott[1], Annelise Barron[2], Ph.D., Jessica V. Norris, Ph.D., Abby Mackness[3], J.D., Paul Kinnon, B.Sc.[1], Joan M. Bienvenue[3], Ph.D., James P. Landers[4], PhD
[1]ZyGEM/MicroLab Corporation, Dale Avenue, Charlottesville, VA, 22903; [2]Stanford University, Department of Bioengineering, Palo Alto, CA; [3]Lockheed Martin, 9221 Corporate Boulevard, Rockville, MD 22407; [4]University of Virginia, Departments of Chemistry, Mechanical Engineering, and Pathology, McCormick Road, Charlottesville, VA 22904

The demand for forensic DNA analysis services has significantly increased leading to a backlog of forensic casework samples. The time-consuming and laborious conventional analysis techniques currently employed are unable to keep pace with the ever increasing number of samples. This demand is driving the development of new analytical techniques that will reduce the time and cost associated with forensic DNA analysis. Conventional STR analysis requires extraction and quantitation of the genomic DNA, multiplexed PCR amplification of the STR loci, and electrophoretic separation of the amplified STR fragments. Currently, the electrophoretic separation requires up to 40 minutes or more to complete and is performed on a large capillary electrophoresis instrument. Decreasing the time and cost associated with the process can increase the throughput of a crime laboratory.

Microfluidic devices have the potential to address both of these issues significantly impacting the forensic community. Microdevices have the ability to integrate the analytical steps required in forensic sample processing into a single device which will provide a low-cost, rapid analysis. However, to achieve the potential of these devices, the individual processes must be translated to the microfluidic platform and the hardware surround the device must be developed. Forensic STR separations can be completed in significantly less time using microfluidic chips than the conventional CE methods. To minimized the cost per analysis, the chip must be fabricated from a low-cost, single-use substrate. The work presented here compares high-resolution DNA separations on different microchip substrates using two laser-induced fluorescence (LIF) detection methods completed in less than 10 minutes.

To fully maximize the potential of microfluidic devices, a robust detection system capable of performing multiple separations simultaneously must be developed. The detection system must have the sensitivity and data acquisition rate necessary for STR analysis, as well as the flexibility to scale up to multiple microfluidic separations. Here, a detection system on which integrated STR analysis has previously been demonstrated (Proceedings of the Micro-Total Analysis Systems Conference, 2009) is compared with the next generation system capable of simultaneous multi-channel detection.

Decreasing the cost-per-analysis is also critical for increasing the throughput of crime laboratories. A significant portion of the analysis cost is the price of the consumables, notably the disposable microchip. Here, we evaluate low-cost polymeric substrates as an alternative to glass microfluidic chips. The substrates are compared on a basis separation time and resolution of commercially available STR kits. The presented work represents significant progress toward an integrated microfluidic system capable of simultaneous sample processing using low-cost microfluidic chips.