A88 A Multichannel Microdevice for Rapid Forensic DNA Analysis

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After attending this presentation, attendees will understand the development and functionality of a system developed for integrated microfluidic forensic DNA analysis.

This presentation will impact the forensic science community by demonstrating the advantages of using a microfluidic system for DNA analysis, including reductions in analysis time, sample and reagent volumes needed and concurrent time reduction that could impact processing of future forensic DNA samples.

STR typing is the accepted gold standard for human identification and is now successfully employed in forensic, civil, and military laboratories. Although highly successful and reliable, the process typically requires 8-10 hours to complete under routine conditions, employs large sample volumes, costly reagents, and is labor-intensive. Additionally, samples are susceptible to contamination as they are exposed to the environment at multiple points during sample processing. Transitioning sample processing and analytical methods to the microscale format will permit automation, miniaturization, and integration providing the end user a system capable of expedited, cost-effective analysis in a closed system that reduces sample handling and possible contamination.

Previously, a system capable of fully-automated processing and analysis of STR loci directly from buccal swab samples was presented. The system utilized a single, integrated glass microfluidic chip, and encompassed liquid DNA purification, PCR amplification, and electrophoretic separation and detection of STR loci. Although capable of detecting 16 loci in under 75 minutes, the techniques involved were not sufficiently robust for field analysis and only allowed for analysis of one sample at a time, warranting improvements to the system. Additionally, the microchip substrate was made from glass using standard microfabrication methods which are cost-ineffective from a mass production perspective.

The work presented here highlights improvements to the integrated system. The transition to plastic microchips for multiplexed integrated STR analysis is described, allowing for more cost-effective, single-use (disposable) chips. With the improved system, expedited purification of DNA from crude samples is performed and a mixture of DNA and PCR reagents (commercially-based) are guided into chambers on a device capable of multiplexed analysis for PCR. Rapid amplification of 16-18 STR loci is achieved through use of an IR laser for non-contact heating and a non-contact method for temperature sensing. A six-fold reduction from conventional amplification time is demonstrated while still achieving STR profile quality required for forensic interpretation. Simultaneous amplification of multiple samples in the multichannel microdevice will be presented, demonstrating the capability for increasing sample throughput. Following PCR, precise fluidic control allows for movement of the amplified product into the separation domain of the device. Electrophoretic separation of the amplified fragments is performed with five-color fluorescence detection using an improved detection system capable of multiplexed detection. Single-base resolution is achieved during a separation that consumes <12 minutes, a three-fold time reduction from conventional separation and detection processes. A software analysis system, interfacing between the raw data output and the interpretable profile, allows for automated and accurate allele calling of samples processed using the integrated system from multiple donors. An overview of the functionality of the integrated instrument capable of accepting the multichannel microfluidic device will be presented, with data supporting the capability of the microfluidic system for rapid, automated, end-to-end genetic analysis for human identification.

DNA, STR, Microfluidics

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