B86 Integrated Microfluidic Sample Preparatory Systems: Towards a Fully Automated Genetic Analyzer

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The goal of this research project is to integrate the methods associated with forensic genetic analysis into microdevices capable of multiple sample processing steps. The attendee can expect to learn about recent advancements made in microfluidics for forensic genetic analysis.

This presentation will impact the forensic community and/or humanity by highlighting advancements in microchip technology, pro- viding insight into potential applications for genetic analysis in the forensics community. Integration of multiple sample processing steps into a single, automated device will allow for less expensive, faster analyses, with less risk of contamination, potentially having a positive impact on current casework backlogs.

With a view towards more rapid and cost-effective analysis methods, microdevices become an increasingly more viable option for improving forensic DNA analysis. Microdevices have the potential to drastically reduce the time, reagents, and cost required to perform a wide variety of the processes associated with genetic analysis, including DNA extraction, PCR amplification, and separation and detection of STR amplicons. Inexpensive glass microchips are being developed and tested to improve the efficiency, reproducibility, and automation of the current time-con- suming bench-top processes. A fully-integrated, microchip capable of per- forming the steps normally carried out at the bench would not only reduce the time required to perform these tasks, but would also eliminate user intervention and potential sources of contamination, preserving more of the sample for future analysis.

PCR and high-resolution DNA separations are now readily carried out on-chip, as well as solid-phase extraction (SPE) of DNA from a variety of clinical, biohazardous, and forensically-significant samples. With suc- cessful microchip adaptation of these processes now commonplace, research focus has shifted towards integration of these methods with other sample processing steps (cell sorting, volume reduction, DNA quantifi- cation)—the first step towards creation of a stand alone device with full- genetic profiling capabilities. Due to the multi-step nature of the DNA analysis process, careful consideration of solution compatibility, sample size, and fluidic interfacing must be taken in order to seamlessly integrate these technologies. As a result, attention is now being paid to device design and concept, and multi-component microchip analysis is now becoming a reality.

The research presented here describes the advancement of integrated sample analysis in microfluidic devices for forensic application. With a focus on the fabrication and implementation of integrated glass microde- vices for extraction, PCR amplification, and separation of DNA (as well as other analysis steps), particular attention is devoted to device design and sample handling considerations. Patterned using standard photolitho- graphic techniques, these devices include elastomeric valves for fluidic control of solution flow throughout the device, through each functional domain; development of methodologies for on-chip pumping and sample isolation are also presented. DNA extraction is accomplished using a silica solid phase followed by PCR amplification using IR-mediated, non-contact thermocycling and temperature detection. Methods for integrated DNA extraction and PCR amplification of STRs from forensically-relevant samples are discussed. The work reported here highlights the applicability of integrated microdevices to a variety of sample types, with data presented to demonstrate the versatility of these designs, as well as their easy manip- ulation to handle a wide-variety of sample sources. This work represents the advancement of fully integrated microdevices capable of total systematic DNA analysis.

PCR, DNA Extraction, Microchip

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