B78 Microchip-Integrated Purification and PCR Amplification of DNA for Forensic Analysis

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The goal of this research project is to integrate the extraction and PCR amplification of DNA into a single microdevice capable capable of downstream STR analysis.

This presentation will impact the forensic community and/or humanity by demonstrating discussing the use of next-generation microchip technology for forensic analysis of DNA. As the forensic community looks for more rapid and cost-effective alternatives to current methods, microdevices become an increasingly more viable option for improving analysis. This presentation will highlight the use of an integrated microdevice for solid-phase extraction and PCR amplification of DNA and its impact forensic genetic analysis.

As genetic analysis for forensic casework continues to evolve, never before has the need for fast, accurate, analysis of samples been more pressing. Current techniques for DNA analysis require labor-intensive and time-consuming processes. These methods, though effective, have led to a dramatic backlog of casework, overwhelming crime laboratories at this time. In addition, databasing efforts are hindered by this backlog of cases. And in the current condition, many cases simply go unanalyzed. As such, research efforts in forensics have focused on improving the methods associated with the analysis of DNA to develop a more rapid and efficient assay for casework profiling. As the field looks for more rapid and cost-effective alternatives to current methods, microdevices become an increasingly more viable option for improving analysis.

The application of microdevices to bioanalytical analyses has the potential to drastically reduce the time required to perform a wide variety of clinical assays. As such, microdevices are currently being designed, developed and tested to improve the efficiency of processes associated with forensic casework analysis. A fully-integrated, microchip capable of performing 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 can currently be carried out on-chip, as well as solid-phase extraction (SPE) of DNA from a variety of clinical, biohazardous, and forensically significant samples. Integration of these processes is the first step towards the creation of a device with genetic profiling capabilities.

The research presented here describes the chip-based approaches for executing DNA extraction (via SPE) and STR allele-specific amplification (via PCR), and how these two processes might be integrated in a single microdevice. The device and its functionality are described, along with results for extraction and amplification of human genomic DNA from sperm cells. Glass microchip devices were designed with domains specific for SPE and PCR. These were patterned using standard photolithographic techniques and the SPE domain vacuum-loaded with silica beads 'glued' into place with a tetraethoxysilane (TEOS) sol-gel have been shown to yield fast, efficient, solid phase extraction of DNA from a variety of biological materials. Microchip PCR amplification of forensic STR loci in sub-microliter volumes containing isolated sperm DNA is accomplished using non-contact thermocycling (infrared heating and interferometric temperature sensing). Fluidic control of the movement of purified DNA, the solutions necessary for extraction, and PCR master mix into the appropriate domains on the microchip is mediated by an elastomeric valving membrane. The work reported here investigates extraction and purification and subsequent PCR amplification of DNA from semen and/or washed sperm cells on an integrated, valved microchip. This represents one of the major steps required development of a fully integrated microdevice capable of total systematic DNA analysis for forensic casework.

DNA, Ccapillary Electrophoresis, Microchip

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