B162 A Microfluidic Device for the Identification of Biological Sex by Analysis of Fingermarks

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Learning Overview: As a result of attending this presentation, attendees will have introductory knowledge about a novel microfluidic technique for colorimetric determination of biological sex from the biochemical analysis of fingermarks.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by introducing a non-enzymatic, cost-efficient, microfluidic colorimetric assay that was developed to measure the arginine content in fingermarks. Rapid and objective determination of the biological sex of unknown individuals was accomplished using inexpensive instrumentation. Notably, the assay described herein is unaffected by the presence of magnetic, dual-use powder; this compatibility is imperative as this powder is commonly used to visualize latent fingermarks at a crime scene prior to further analysis.

Current fingerprint analysis techniques are largely visual and exclusionary, and therefore inherently require a reference for comparison. However, biochemical analysis of fingermarks is becoming more common and provides the opportunity to obtain unique donor identifiers without comparison to a reference. Fingermarks contain metabolites from several hormone-regulated metabolic mechanisms, which can serve as biomarkers or indicators of physiological attributes of the donor, such as age, ethnicity, health status, and gender.[1-3] For instance, in most cases, amino acid concentrations in fingermarks from a female donor are approximately two-fold higher than those deposited by a male.[1] Determination of amino acid concentration in fingermark deposits can thus be used to indicate the biological sex of the donor.

To date, most research regarding amino acid detection and quantification in fingermarks relies on spectrometric methods, including Raman and infrared spectroscopy. A significant disadvantage of such methods is the requirement for the use of sophisticated and expensive instrumentation by trained personnel. Consequently, on-site, chemical analysis of fingermarks is not commonly implemented. Notwithstanding, Brunelle et al. report a colorimetric method for the determination of the biological sex of a fingermark originator using Ultraviolet/Visible (UV/Vis) spectroscopy.[4] Though this represents progress toward minimizing assay cost, the instrumentation required is still quite expensive and necessitates non-trivial user training. Consequently, there is still a need for a rapid, inexpensive, and automated method of analysis that diminishes the need for significant user training for on-site use. Biometric data obtained onsite would facilitate accelerated determination and/or elimination of suspects, thereby increasing the efficiency of time-sensitive investigations.

In this research, the Sakaguchi colorimetric test was adapted to a rotationally driven microfluidic platform and used to detect and quantify arginine in fingermarks deposited by male and female donors. Observation of a red color following the reaction is indicative of the presence of arginine in a given sample. The intensity of this color is linearly proportional to the concentration of arginine in fingermark samples. Objective detection and quantification of arginine was accomplished using open-access image analysis software based on this colorimetric result. The mean concentration obtained experimentally for samples from female donors, 79.60µM, was not statistically different from the theoretical value, 94.8µM (p=0.2562).[5] For males, the experimental value obtained was 42.2µM, which was not statistically different from the theoretical value, 54.0µM (p=0.3666).[5] Conversely, the experimental means from male and female samples were found to be statistically different from each other with $p < 0.0001$. This indicates that the microfluidic protocol could reliably be used to differentiate between male and female fingermarks.

Following initial chemical optimization, compatibility of the assay with magnetic, dual-use powder was evaluated by including a powder-dusting step prior to further analysis. The application of magnetic powder was included as a means of approximating "real world" conditions at a standard crime scene. The magnetic particles were removed following hydrolysis of the fingermark samples. It was observed that despite the inclusion of the magnetic powder, minor modifications of experimental conditions resulted in the expected development of color and intensity.

The novel microfluidic assay for determination of biological sex from fingermark deposits described herein can not only be used to reproducibly differentiate between male and female donors, but is also portable and automatable, making it conducive to use onsite by untrained personnel.

Reference(s):

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Microfluidics, Fingermarks, Colorimetric Analysis

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