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Technical note

Generation of DNA profiles from fingerprints developed with columnar thin film technique

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ABSTRACT

Partial-bloody fingerprints and partial fingerprints with saliva are often encountered at crime scenes, potentially enabling the combination of fingerprint and DNA analyses for absolute identification, provided that the development technique for fingerprint analysis does not inhibit DNA analysis. 36 partial-bloody fingerprints and 30 fingerprints wetted with saliva, all deposited on brass, were first developed using the columnar-thin-film (CTF) technique and then subjected to short tandem repeat (STR) DNA analysis. Equal numbers of samples were subjected to the same DNA analysis without development. Tris (8-hydroxyquinolinato) aluminum, or Alq_3, was evaporated to deposit CTFs for development of the prints. DNA was extracted from all 132 samples, quantified, and amplified with AmpFlSTR® Identifiler Plus Amplification Kit. Additionally, DNA analyses were conducted on four blood smears on un-fingerprinted brass that had been subjected to CTF deposition and four blood smears on un-fingerprinted brass that had not been subjected to CTF deposition.

Complete and concordant autosomal STR profiles of the same quality were obtained from both undeveloped and CTF-developed fingerprints, indicating that CTF development of fingerprints preserves DNA and does not inhibit subsequent DNA analysis. Even when there were no fingerprints, CTF deposition did not lead to inhibition of DNA analysis.

1. Introduction

Many development techniques exist for developing latent, patent, and plastic fingerprints [1,2]. However, when a fingerprint is made up of both patent and latent parts, developmental cascades must be used in order to visualize both parts of the fingerprint [3–6]. The formulation, selection, and implementation of a developmental cascade appropriate for a specific fingerprint can often be tedious and time-consuming [1,2]. Latent fingerprints developed with methods commonly employed in the forensic community have been successfully used for DNA analysis [7–10]. Evidence samples such as drinking straws, which often contain fingerprints and cellular material from saliva, may be consumed in the DNA analysis process. Furthermore, DNA from the fingerprint may be removed by the development process.

The columnar-thin-film (CTF) technique of fingerprint development [11,12] is useful because it can develop both the patent and latent parts of a fingerprint on several common types of forensically relevant substrates in one step [13,14]. A CTF is essentially a collection of parallel nanoscale columns [15]. These columns are deposited upright on top of the fingerprint residue, thereby preserving the topology of the fingerprint. Thus, this technique has the additional advantage of not relying on the chemical composition of the fingerprint for development. This feature allows for possible preservation of the fingerprint residue and associated body fluids and cells. It also potentially enables DNA analysis from the fingerprint.

This paper focuses on whether it is possible to obtain complete and concordant short tandem repeat (STR) DNA profiles from fingerprints wetted with body fluids such as blood and saliva after they have been developed with the CTF technique. The research also explores whether the implementation of the CTF technique results in either partial or no STR profiles and if the method introduces inhibition that may interfere with the DNA analysis process.

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2. Materials and methods

2.1. Collection of samples

Latent fingerprints with a bloody component as well as latent fingerprints with a saliva component were harvested in this research. A total of 132 fingerprints were collected, 72 with blood and 60 with saliva. For comparison purposes, 36 partial-bloody and 30 saliva-wetted fingerprints were developed with the CTF technique, while the remaining 66 fingerprints were not developed.

Fingerprints were harvested from two donors for this research. The middle finger of the right hand of each donor was used for each sample to maintain consistency. For the fingerprint collection process, each donor first washed the right hand with soap and water, waited for five minutes, and swiped the middle finger of the right hand across the face and hairline ten times. This process was chosen to ensure that both eccrine and sebaceous secretions were present in the fingerprint, mimicking the evidence found at crime scenes.

For partial-bloody samples, a finger other than the middle finger of the right hand was pricked and blood was swiped onto the middle finger of the right hand. The fingertip was then pressed onto a 1 in $\times$1 in brass substrate (Alloy 260, McMaster-Carr, Chicago, IL, USA). For wetting a fingerprint with saliva, the middle finger of the right hand was swiped inside the donor's mouth along the inside of the cheek once, and then pressed onto the brass substrate. Fig. 1 provides optical images of two representative samples. Every sample was allowed to dry for approximately a 24-hour period between collection and development by the CTF technique. This amount of time allowed the body fluid components to dry and to better simulate a crime-scene sample.

As part of this research, another study was carried out to determine if there was any inhibition due to the CTF deposition conditions. Measured amounts of blood were smeared on eight un-fingerprinted brass substrates: two substrates with 0.5 μL blood each, two with 1.0 μL, two with 2.5 μL, and two with 5 μL. One sample from each pair of substrates was developed with the CTF technique, and one was not. DNA was extracted from all eight samples and processed for STR typing. A similar attempt with saliva-wetted un-fingerprinted samples was not undertaken because the viscoelastic nature of saliva rendered it difficult to prepare samples with exact amounts of saliva. Furthermore, a reliable relationship between the volume and the number of cells in saliva samples could not be determined.

2.2. CTF deposition

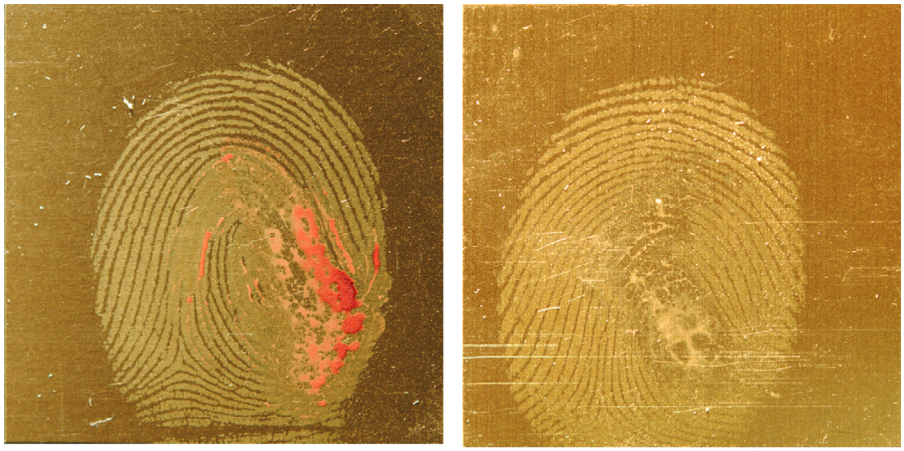
A ~50-nm-thick CTF of tris (8-hydroxyquinolinato) aluminum (Alq_3) was deposited on 66 fingerprinted substrates in 11 runs. For each run, 6 samples were affixed to a rotatable planar platform above a tungsten boat containing Alq_3. Both the custom-made platform and the boat (R.D. Mathis, Signal Hill, CA, USA) were located inside a low-pressure chamber (Torr International, New Windsor, NY, USA). A shutter between the boat and the samples was positioned to prevent a collimated vapor flux of Alq_3 from reaching the samples until desired, the chamber was closed, and the base pressure was reduced to 0.1 mTorr using a vacuum pump. Then, the platform was rotated at 180 rpm about a central normal axis passing through the platform, a current was passed through the tungsten boat so as to evaporate Alq_3 and generate a collimated vapor flux of that material, and the shutter was repositioned to let the vapor flux reach the samples. With the help of a quartz crystal monitor mounted close to the samples, the CTF deposition rate was loosely controlled at ~0.2 nm/s. During the deposition, the sample-carrying platform was oriented so that the collimated vapor flux would arrive at an angle of 20 deg with respect to the platform plane.

After the CTF had attained the required thickness, the shutter was repositioned to prevent the vapor flux from reaching the samples, the current through the boat was turned off, the platform's rotation was stopped, and the chamber was opened to the atmosphere after ~10 min.

Exactly the same CTF-deposition procedure was carried out on 4 un-fingerprinted substrates smeared with pre-determined amounts of blood.

2.3. DNA extraction and purification

132 fingerprinted and 8 un-fingerprinted samples were subjected to DNA analysis. Of these samples, 70 had been treated by the CTF technique, but 70 had not. Once the CTF development process was complete, samples were again left at room temperature for 24 h. A double-swab technique was then utilized to collect the cellular material from all 140 samples. The extraction and purification of DNA from these swabs were performed using the protocols described elsewhere [16–19]. Briefly, DNA was extracted from these swabs using EZ1 DNA Investigator Kit and Qiagen BioRobot® EZ1™ Advanced workstation. The Trace Tip Dance protocol was used, and extracts were eluted in 50 μL TE buffer [20]. All extracted samples were quantified using Quantifiler® Human Quantification Kit (Applied Biosystems, Carlsbad, CA, USA), in accordance with the recommended protocol [21].



A. Partial-bloody fingerprint on brass substrate B. Saliva-wetted fingerprint on brass substrate

Fig. 1. Optical images of (A) a partial-bloody fingerprint and (B) a saliva-wetted fingerprint on brass substrates.