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DNA recovery from latent fingermarks treated with an infrared fluorescent fingerprint powder

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ABSTRACT

The effect of the infrared fluorescent fingermark visualisation powder, *fp*Natural 1™, on the recovery of both the quantity and quality of touch DNA from fingerprints deposited on glass slides, was investigated using qPCR and STR typing. Four donors each deposited replicate marks, which were either left untreated (n = 5) or treated by dusting with *fp*Natural 1™ (n = 5). Each sample was swabbed using the double swab technique, before being extracted using the EZNA Forensic DNA kit and then DNA quantitated before being subjected to DNA profile analysis. Results showed that there was no significant effect of *fp*Natural 1™ on either the quantity or quality of recovered DNA. This suggests that *fp*Natural 1™ may prove a good choice of powder for regular use at crime scenes or in the laboratory. The *fp*Natural 1™ properties of low density, water immiscibility and low DNA affinity may account for these positive outcomes.

1. Introduction

Fingermarks have been used for over 100 years as a means of identifying individuals involved in crime, by virtue of the patterns deposited at crime scenes or on items of evidential value [1]. In 1997, van Oorschot and Jone [2] demonstrated that fingermark residues also provide enough DNA for the generation of DNA profiles. Technological and scientific advances have improved the ability to obtain at least partial DNA profiles from evidence handled by an individual, primarily through the increased sensitivity in DNA typing procedures. DNA recovered from handled items is commonly referred to as touch DNA [3]. Sweat, oil, and exfoliated skin cells originating from the fingertips and transferred to the surface of an object may be collected and processed for DNA [4]. Conventional approaches used to recover DNA from handled evidence is known to interfere with, and often lead to the damage of, any fingermarks present on the sample in question. Accordingly, the forensic workflow usually requires exhibits to undergo fingermark visualisation processing prior to any DNA recovery and screening.

A wide variety of fingermark visualisation techniques are available, with the choice of method dependent on the type of substrate being treated or suspected fingermark composition (oil or blood contaminants, for example). Powder dusting is a common scene-based and laboratory visualisation technique that exploits the adherence of fine particulate materials to deposited fingermark residues (usually the sebaceous oils). Accordingly, a broad variety of fingerprint powders exist, that possess a range of different colours and optical properties. Previous studies have shown that different powders may be employed without significantly adversely affecting the ability of recovered DNA to be profiled [5–8], although quantitation of recovered DNA was not presented by these researchers. In contrast, others [9] have shown that some MAGNA™ jet black powder inhibits DNA IQ™ chemistry.

One powder that has not been studied thus far, given its infancy, is the infrared (IR) fluorescent fingerprint powder recently reported by King et al. [10]. This material comprises finely milled *Spirulina platensis*, a naturally occurring and non-toxic algae which contains components capable of near-infrared (NIR) fluorescence within its matrix. This IR fluorescent powder is suitable for use on both non-porous and semi-porous smooth substrates, and is excited with blue (420–470 nm) or red (600–650 nm) wavelengths, inducing strong fluorescence in the NIR region of the electromagnetic spectrum (700–850 nm) (Fig. 1). The use of an infrared fluorescent fingerprint powder provides great benefit to the forensic investigator given its ability to fluoresce at much longer wavelengths than conventional fingerprint powder/treatments.

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Fig. 1. A latent fingermark on a polymer banknote that has been treated with *fp*Natural 1™ fingerprint powder and visualised under 600–650 nm illumination with 715 nm long-pass camera filter using a Foster + Freeman Crime-lite Imager.

Accordingly, background fluorescence is regularly suppressed which allows high contrast fingermarks to be observed against a background which typically 'drops-out' or become invisible within the NIR part of the spectrum. Notoriously troublesome or problematic backgrounds, such as those that are highly patterned and/or coloured, benefit most from treatment using an infrared fluorescent fingerprint powder as the visual disturbance is easily overcome, thereby allowing efficient interpretation of the friction ridge flow or ridge details to be recorded [10]. Herein, we report the timely and germane assessment into the compatibility of such a powder in relation to DNA typing procedures.

2. Methods and materials

2.1. Deposition of fingermarks

76 × 26 mm, 0.8–1.0 mm thick glass slides (Fisher Scientific FB58620, UK) were cleaned following the method described by Oleiwi et al. [11]. One to two hours after arriving at work (between 10–11 a.m., at the same time each day for each donor), four participants, without any explicit instructions as to behaviour, including, for example, hand washing, deposited combined middle and ring fingermarks onto a cleaned glass slide. Samples were collected by pressing both finger tips for a few seconds onto the glass slide. This process was repeated once daily until the required number of samples were accumulated. 12 slides were allocated to each participant: 5 were treated with *fp*Natural 1™ powder (powder visualised) with each donor allocated a separate brush, 5 were left untreated and served as positive controls (untreated fingermarks), and 2 were negative controls (no fingermark but processed as for fingermarks). At the end of sample collection, slides were stored for two weeks in a plastic slide box at 4 °C which had been washed in the same way as the slides.

2.2. Collection of DNA

The double swab method was used, consisting of swabbing the identified area with a DNA-free sterile cotton ear bud, UV irradiated for 15 min, which was moistened with filtered distilled water (50 μl) before swabbing the same area with a dry swab [12]. *fp*Natural 1™ powder was examined for any human DNA background by dipping a moistened cotton bud into powder. Then the *fp*Natural 1™ loaded bud underwent DNA extraction. If the *fp*Natural 1™ powder tested positive for DNA, the treated samples would have been discarded.

2.3. DNA extraction and quantification

DNA was extracted from swabbed samples using the E.Z.N.A.® Forensic DNA Kit (Omega Bio-Tek), following the standard protocol described in the manufacturer's instructions. The extracted DNA was eluted with 50 μl to maximise DNA yields. 2 μl duplicates of each sample's extracted DNA was quantified using the Investigator® Quantiplex Quantification Kit assay (QIAGEN, Crawley, UK). The quantification process was carried out following the manufacturer's instructions, using an ABI® 7500 Fast Real-Time PCR System (Applied Biosystems, USA). Results were analysed using SDS 1.9.1 software (Applied Biosystems, USA) and interpretation was based on criteria recommended by the kit manufacturer.

2.4. Profiling of DNA samples

Samples were amplified using a PowerPlex® ESI 16 Fast System (Promega, USA) for 30 cycles, following the manufacturer's 'amplification of extracted DNA' protocol. DNA samples were, when needed, diluted to obtain a maximum concentration of 0.5 ng/μl. 5 μl of DNA sample was added to 20 μl of the amplification reaction mix using the GeneAmp® PCR System 9700 (Applied Biosystems, USA). PCR products were subjected to electrophoresis using an ABI 3500 Genetic Analyser (Applied Biosystems, USA) and profiles were analysed using GeneMapper® ID v3.2 Software (Applied Biosystems, USA). The criteria used to estimate a peak as an allele are the same as those published in Oleiwi [13]. A minimum peak threshold of 50 relative fluorescent units (RFUs) was applied. A negative control was used for each STR amplification batch and, if any sample had shown positive, would have resulted in the entire batch being disregarded.

Statistical analysis

Statistical analysis of data was performed using GraphPad Prism version 7.0 for Windows, (GraphPad Software, La Jolla California, USA).

3. Results and discussion

The results showed that all negative controls yielded no recoverable DNA, confirming the care in removing contaminating DNA from the experimental areas. Both positive controls and test sample data is shown in Table 1 and Fig. 2.

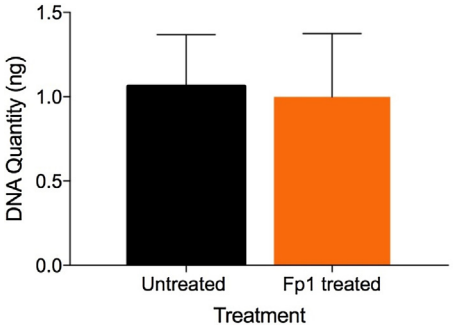

Fig. 2. Cumulated DNA quantification data for fingermarks treated with *fp*Natural 1™ when compared to untreated controls.