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Visualising DNA transfer: Latent DNA detection using Diamond Dye

Jessica Champion[a,*], Roland A.H. van Oorschot[b,c], Adrian Linacre[a]

[a] College of Science & Engineering, Flinders University, Adelaide, SA 5042, Australia
[b] Office of the Chief Forensic Scientist, Victoria Police Forensic Services Department, 31 Forensic Drive, Macleod 3085, Australia
[c] School of Molecular Sciences, La Trobe University, Bundoora 3086, Australia

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ABSTRACT

A central question is 'how did DNA get there'? To help answer this, we visually monitored and recorded DNA transfer from one substrate to another. When an individual touches a substrate, traces of their DNA are transferred (primary/direct) which can then subsequently be transferred to a second substrate (secondary/indirect). Currently DNA transfer and how much remains can only be determined by collecting the biological material from the substrate, isolating the DNA and quantifying the amount recovered. However, Diamond™ Dye (DD) enables such DNA transfer events to be visualised by monitoring the movement of cellular material.

We examined primary and secondary DNA transfer using aluminium as a primary substrate with cotton, polyester, aluminium and plastic as secondary substrates and four contact types between two substrates (passive, pressure, friction and friction with pressure). Participants pressed their index finger against the aluminium for 15 s and then DD was applied to the area of contact; cellular material was detected via a fluorescence microscope. Contact between that substrate and a second substrate was performed, using one of the four contact types. After this contact between substrates each was viewed microscopically and transfer of cellular material was recorded.

Cellular material could be recorded as having transferred from one substrate to another. Substrate and contact type had an effect on the extent DNA transfers. DNA transferred at a high rate with aluminium as a primary substrate and cotton, polyester and aluminium as secondary substrates when pressure with friction was applied. This information expands our understanding of how DNA transfers and which factors affect it, thus assisting greatly with activity level reporting as to how DNA came to be where it was found.

1. Introduction

Extensive research is on-going focussing on factors affecting DNA transfer such as: shedder status, substrate type and contact type. Two recent reviews have however highlighted the need for more research as there remains much uncertainty [1,2]. The data and conclusions drawn from previous research are based on best assumptions using estimations of how much DNA was present on a primary substrate prior to transfer, based on DNA quantification data, and how much DNA transferred to a second substrate [3–7]. Visualisation of cellular transfer is now possible with the application of the fluorescent Diamond™ Dye (DD) [8].

Substrate type and contact (e.g. time, pressure, friction and moisture) between substrates are two of the main factors known to influence DNA transfer. We report on the transfer between substrates comprising: two absorbent/porous fabric substrates cotton and polyester polar fleece and two non-porous substrates aluminium and plastic. In this study aluminium was the primary substrate. This current study investigates the transfer between aluminium and the substrates under four different contact types: passive, pressure, friction and friction with pressure based on the contact types used by Goray et al. [6].

2. Materials and methods

Social and Behavioural Research Committee (reference 8109) at Flinders University provided approval prior to initiating this project.

Two individuals washed their hands and then resumed office activities for 15 min after which they deposited fingermarks onto pieces of aluminium for 15 s. This was then stained with 20x DD (Promega Corporation, Madison, WI, USA) diluted in 75% ethanol (v/v). They were viewed under the Dino-lite microscope (AnMo Electronics Corporation, New Taipei City, TWN) and images of cellular material were captured using 510 nm emission filter and 480 nm excitation source of blue LEDs.

The four contact types were set up as follows; passive contact where

* Corresponding author.
E-mail address: cham0167@flinders.edu.au (J. Champion).

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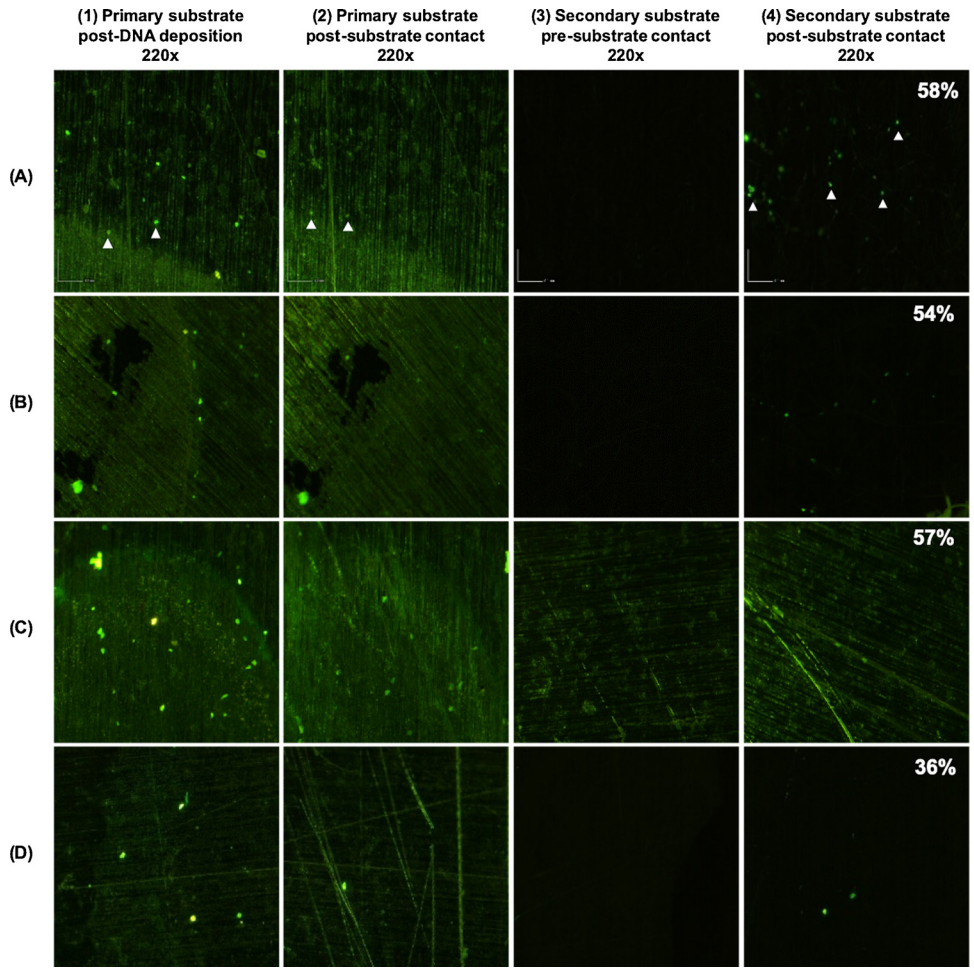

Fig. 1. Aluminium primary substrates with each of the four substrates (cotton (A), polyester (B), aluminium (C), plastic (D)) as secondary substrates for friction with pressure contact. Cellular material (pointed out by arrows in A) can be seen transferring from primary substrates to secondary substrates. Transferred cellular material percentages displayed on secondary substrate after transfer images.

the secondary substrate was on top of the primary substrate with no added weight apart from its own, pressure contact was similar with the addition of a 178 g weight on top, friction contact involved moving the secondary substrate whilst on top of the primary substrate moving in all directions (two movements per second) and friction with pressure was the combination of the friction and pressure contact methods.

Primary and secondary substrates were viewed under the microscope after contact and images were captured. Each substrate combination and contact method were replicated three times where three different locations within each fingermark were captured. Cellular material was scored, the data were averaged between the three replicates and DNA transfer percentages were calculated.

3. Results and discussion

Fig. 1 depicts cellular material transferring from aluminium (primary substrate) to all secondary substrates after friction with pressure. The combination of friction with pressure produced the greatest amount of cellular transfer, compared to all other contact types (data not shown), and was therefore the focus of further study.

Cellular material that was present on aluminium (Fig. 1, A1) before it came into contact with cotton, was no longer present after contact with cotton (Fig. 1, A2). There was no cellular material present on cotton prior to the contact with aluminium (Fig. 1, A3) but cellular material was detected after contact (Fig. 1, A4). This also occurred when polyester (Fig. 1, B), aluminium (Fig. 1, C) and plastic (Fig. 1, D) were secondary substrates.

When aluminium was the primary substrate, cellular material transferred readily onto cotton, polyester and aluminium when they were secondary substrates 58%, 54% and 57% respectively (Fig. 1, A–C). Although cellular material did transfer from aluminium to plastic (Fig. 1, D) it was found to be only 37% of the primary cellular material.

The greatest amount of cellular transfer was detected to transfer from aluminium, approximately half of the DNA present, onto cotton, polyester and aluminium. This was most likely due to the smooth, unabsorbent surface of the aluminium.

4. Conclusion

The detection of DNA transferring from one substrate to another has been achieved for the first time visually using DD. This study brings to light a new approach to investigating DNA transfer and the factors that affect it. This approach provides accurate and reliable insight into how DNA transfers from one substrate to another by being able to monitor it visually.

Declaration of Competing Interest

None.

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