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Touch DNA—The prospect of DNA profiles from cables

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ABSTRACT

Metal theft in the railroad industry poses significant challenges to transport investigators. Cable sheaths left behind at crime scenes, if appropriately analysed, could provide valuable evidence in a forensic investigation, but attempts at recovering DNA are not routinely made. Experiments were set up to ascertain the success in DNA recovery from the surface of cable sheaths after deposition of (a) sweat, (b) extracted DNA and (c) fingermarks. Since investigators try to collect fingermarks and often treat the cables with cyanoacrylate fuming (CNA fuming) or wet powder suspensions (WPS) to enhance the marks this study investigated the recovery of DNA from fingermarks pre- and post-enhancement. The double-swab technique and mini-taping were compared as options to recover DNA from the cable sheaths. Results demonstrate that generally, there is no significant difference between using swabs or mini-tapes to recover the DNA from the non-porous cables ($p > 0.05$). It was also illustrated that CNA fuming performed better than WPS in terms of subsequent recovery and profiling of DNA. CNA fuming resulted in an average increase in DNA recovered via swabbing and taping (more than 4× and 8×, respectively), as compared to no treatment, with 50% of the DNA recovered after CNA fuming generating full DNA profiles.

1. Introduction

Metal theft (the stealing of items for its constituent metal parts) is becoming more prevalent due to an increase in the value of scrap metal. Main targets of metal theft are electrical equipment, construction sites and public infrastructure. The railroad industry is the biggest victim of metal theft, with more than double the incidents occurring at railways than in the communications trade. The industry estimates annual losses of tens of millions of British pound sterling from cable theft (British Transport Police, personal communications, 2015). Cable thefts are also a key disruption in rail services, not only are commuters greatly inconvenienced with train delays, but they are also potentially in danger if the theft causes the train to malfunction. The perpetrators themselves may be putting themselves at high risk of electrocution and even death.

In most cases, the cable sheaths are removed from the cable and discarded at the theft site. Since these have been handled by the perpetrators, they have the potential to provide trace evidence (in the form of touch DNA) that can then help investigators link suspects to the scene (British Transport Police, personal communications, 2015). Touch DNA is DNA transferred from a person to an object via contact with the object [1–3], which most notably in the case of metal/cable theft, comes from sweaty hands. The DNA from touch DNA arises from nucleated skin cells (keratinocytes) through incomplete degradation during the keratinocyte differentiation process, epithelial cells through contact of the hands with other body parts and cell free DNA [4–6]. There are many variables that affect the amount of touch DNA recovered from an exhibit, such as the propensity of individuals in leaving behind their DNA, the surface of interest and the time the DNA is exposed to external factors [5,7–10].

As both fingermarks and DNA can be used as evidence for identification purposes, relevant to this subject is also the ability to obtain a useful DNA profile after reagents to enhance fingermarks have been applied. In general, there are three major steps in dealing with fingermarks/DNA evidence analysis. First, there is a practical need for localisation/enhancement of the fingermark/DNA followed by recovery via a suitable technique, and finally analysis of the fingermark/DNA. The surfaces commonly encountered in cable theft are made of black plastic polymers. Latent fingermarks on this type of material are visualised through cyanoacrylate fuming (CNA fuming) or wet powder suspensions (WPS) as it has been shown that both techniques perform equally well [11]. Studies have been reported on the recovery of DNA from fingermarks deposited on different surfaces. The results often showed that the possibility to obtain genetic profiles from touched items strictly depends on the surface type [12] in addition to the enhancement technique employed [13]. Plastic materials have often been employed in such studies with donor profiling information being successfully recovered [12,14–15]. However, no studies have been conducted to investigate the deposition, recovery and profiling of touch DNA from cable sheaths after treatment with CNA and WPS. As cyanoacrylate and wet powders are not chemically destructive to the DNA [16–17], it may be more

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practical for investigators to first carry out the enhancement and recovery of latent fingermarks before pursuing the prospect of DNA evidence. Even if the development process fails to reveal any usable fingermarks, it will reveal areas on the cable where it has been grasped and therefore a potential site of DNA deposition. The present study compares the efficiency of the double-swab technique against that of mini-taping in the recovery of touch DNA from cables, and the possibility of obtaining DNA profiles from touch DNA after treatment with CNA fuming or wet powder suspensions. Results from this work can contribute to enabling targeted recovery and profiling of touch DNA.

2. Materials and methods

DNA was applied in one of three forms: deposition of sweat from a stock solution, deposition of extracted DNA from a stock solution or deposition of touch DNA (fingermarks) from donors. All the DNA sources used in the present work (sweat, extracted DNA and touch DNA) were from individuals other than those that prepared the cables, collected and processed the samples. Positive controls (i.e. buccal swabs) were collected from each of the donors involved in the study so that comparisons could be made and the origin of the DNA profiles confirmed.

2.1. Cable preparation and analysis

A 7 m long, smooth non-porous black cable (approximately 0.02 m diameter) was supplied by the British Transport Police. This cable was cut into shorter pieces varying in lengths of 0.36–0.4 m. Boxes of dimensions 1.5 cm × 3 cm were drawn on the cable using a permanent marker to highlight the areas for DNA deposition. Before DNA deposition, the cables were thoroughly cleaned with DNA-ExitusPlus™ IF (PanReac AppliChem, Germany). Double gloves were also worn in the handling of the cables in order to limit contamination risk. Negative control samples were taken and although some of them showed trace amounts of DNA at the quantification step, no profile was obtained during DNA analysis.

2.2. Collection of sweat

Sweat was collected in six 1.5 mL microcentrifuge tubes over a couple of days after a gym workout, from the volunteer's forehead and arms. The collected sweat was pooled into a larger 15 mL centrifuge tube and used as a sweat stock solution. In order to imitate real cases, sweat was used directly without prior extraction. From our preliminary studies, an average of 63.1 ng of DNA was extracted from 200 μL of sweat (data not shown). Twenty repeats of 32 μL of sweat (approximately containing 10 ng of DNA) were deposited on the cables for comparison between swabbing and taping recovery methods.

2.3. Extracted DNA

DNA was extracted from sweat and buccal swabs. The extracted DNA was pooled together then quantified to create a stock solution of 23.2 ± 2.3 ng/μL (data not shown). The extracted DNA was diluted to reproduce deposition of approximately 10 ng of extracted DNA in a 32 μL aliquot, on the cables. Similarly, twenty repeats were performed, 10 each for swabbing and taping.

2.4. Collection of touch DNA

In order to mimic real scenarios, donors were requested to deposit their fingermarks on the cables without prior washing of their hands. They were only asked to rub both hands together to reduce intra-variability. Five fingers from both hands were used, in a rolling motion, back and forth, to deposit the touch DNA. The collection was done one finger at a time. Rather than the whole finger, only the top sections of the fingers and thumbs were deposited. In this paper, a 'fingermark' is referred to as the mark left behind by the top one third of a finger (or top half of a thumb). A total of 120 fingermarks from six donors were collected on different days to assess 'pre-treatment recovery of DNA' and 'post-treatment recovery of DNA'. All fingermarks deposited were recovered on the same day of deposition and both lifts and swabs stored in the freezer in extraction tubes.

2.5. Enhancement of marks

A proportion of the fingermarks (60 marks) deposited were chemically treated with either CNA fuming or WPS to enable the latent marks to be visible, so as to achieve targeted recovery of DNA. CNA fuming was carried out in an MVC 5000 (Foster & Freeman, U.K.) superglue fuming cabinet with relative humidity between 75% and 90%. VC363 Cyanoacrylate (Tetra Scene of Crime, U.K.) was heated to 120 °C and the fumes were allowed to circulate for 13 min before being purged. Due to the black surface of the cable, White Wet Powder™ (Kjell Carlsson Innovation, Sweden), a titanium dioxide based white powder suspension was selected to provide the contrast needed for the marks to be visible. The cables were pre-rinsed with running tap water and the suspension applied with a squirrel-hair brush. The surface was exposed to the suspension for approximately 10 s before the excess was removed with running tap water. The cables were allowed to dry in a fume cupboard for 30 min before any DNA recovery work was carried out.

2.6. Recovery of DNA

Recovery of DNA from the cables was carried out with either one of two techniques: double swab technique [18] or mini-taping [19]. With the double swab technique, a wet cotton swab was used to swab the area of interest, followed by a second dry cotton swab. Both swabs were cut off and placed in the same extraction tube for downstream processes. The amount of fluid on the wet cotton swabs was standardised by pipetting 20 μL of sterile distilled water on the swab prior to swabbing. All swabs used were 6″ Forensic Woodstick Cotton Sharpened Tip sterile swabs (Technical Service Consultants, U.K.)

For mini-taping, one mini-tape (WA Products, U.K.) was applied to the area of interest with medium pressure a total of 4 times to ensure the whole area was covered. Each tape was then placed in an extraction tube in a rolled fashion, with the adhesive side facing inwards to avoid sticking to the walls of the tube. Caution was also taken to ensure that the adhesive side of the tapes were not self-sticking in the tubes.

2.7. DNA extraction and quantification

DNA recovered with swabs and mini-tapes was extracted with QIAamp® DNA Investigator Kit (Qiagen U.K.) in accordance with the manufacturer's recommendations; the final elution volume was reduced from 50 μL to 20 μL. Quantitation of DNA was carried out in the ABI Prism 7000 real-time PCR instrument using the Quantifiler® Human DNA Quantification Kit (Applied Biosystems™, U.K.), in a 14 μL reaction volume which includes 2 μL of DNA.

2.8. DNA amplification and analysis

Samples showing sufficient amounts of DNA at the quantification stage were profiled. The DNA profiling was conducted with the PowerPlex® ESI 17 Pro System (Promega, U.K.) kit in 7 μL reaction volumes, consisting of 1 μL of template DNA (0.5 ng/μL). In cases where the DNA concentration was below the optimum concentration (< 0.5 ng/μL), the amount of template DNA was increased to 5 μL, with template DNA replacing the water component in the reaction volume. Amplification was carried out as per the manufacturer's recommendations at 28 cycles, in a 9700 thermal cycler (Applied Biosystems™, U.K.). The amplified products were then run in an ABI Prism 3130 Genetic Analyzer and the profiles analysed with the GeneMapper Software