A Review of Recently Published Fingerprint Research

INTERNATIONAL ASSOCIATION FOR IDENTIFICATION
Cincinnati, OH

Robert Ramotowski

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Introduction

- It is difficult for most examiners to keep up with articles published in so many different journals.
- This lecture provides a brief overview of a selection of articles published since mid-2015.
- Please refer to the cited articles for more detailed information.
- Conclusions expressed in this presentation are those of the manuscript authors.

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Introduction

- de la Hunty et al. Understanding Physical Developer (PD): Part I – Is PD Targeting Lipids? Forensic Sci Int 2015;257:481-487.
- The goal of this study was to determine whether or not PD reacts with lipids or other water insoluble compounds in LP residue.
- Both groomed and ungroomed LP were used as well as chemical spot tests and solvent pre-washes.

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Understanding physical developer (PD): Part I – Is PD targeting lipids?

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ABSTRACT

Physical developer (PD) is a fingermark development technique that involves the selective reduction of silver onto fingermark residue. PD can develop marks on porous substrates even if they have been wet, leading to the logical, long held belief that the reagent targets the water insoluble constituents in the fingermark residue. The present research has tested this hypothesis as part of a broader study that aims to identify the targets of physical developer. Spot tests of some fatty acids, cholesterol and squalene, treated with PD, showed that only cholesterol produced significant silver deposition. PD is known to be particularly effective on aged marks, however cholesterol degrades over time. These observations indicate that PD reactivity with fingermarks cannot solely be due to the presence of cholesterol.

Fingermarks were deposited on paper and washed with various organic solvents before being treated with PD. PD effectiveness was intermittent on both solvent washed and unwashed sides of both natural and groomed marks; however, it was seen to effectively develop groomed samples that had been exposed to common lipid extraction solvents, shown to have removed the lipids by visualisation using the lipid stain Nile red. PD effectiveness was most affected by exposure of samples to solvents that could dissolve water soluble components, showing that the removal of these constituents (by either water, or other solvents) decreases the amount of silver deposited on the fingermark residue by the working solution.

Close observation of PD developed samples showed variation in silver deposition uniformity when comparing a developed ridge to a pore site located on that ridge. Some samples showed an absence of silver, and other showed an increase of silver at pore locations. This indicates that the material excreted by the pores on the finger has an effect on silver deposition, suggesting that PD may be specifically targeting eccrine constituents that are present along the ridges but are more concentrated at the pore locations.

These findings indicate that PD is not targeting the lipids in the fingermark residue per se, and may instead be targeting eccrine constituents or a more complex mixture of both eccrine and lipid constituents. Further investigation is underway within our group to investigate the components targeted by PD to gain a better understanding of what is a notoriously sensitive and hard to employ technique in the hope that it can be improved or simplified, or alternatives identified.

1. Introduction

Physical developer (PD) is a silver-based latent fingermark reagent that was first patented for use in fingermark development by Morris and Wells in 1979 [1]. In 1981, Hardwick detailed a stable physical developer in the first operational user's guide [2] that was developed by the Atomic Weapons Research Establishment for the Police Scientific Development Branch. The technique was recommended for use if ninhydrin yielded no useable marks. PD is an effective technique for the detection of latent fingermarks on porous surfaces and has been shown to develop marks not targeted by other fingermark development techniques [3–8], marks on substrates that have been wet or exposed to high humidity, extremely aged marks (up to 50 years old [9]) and marks on charred paper that has subsequently been wetted [10,11]. The PD solution works by selectively reducing silver ions in solution to silver metal on the fingermark residue, whilst Fe^{2+} is oxidised to Fe^{3+} in the solution in a working solution that has been extensively studied and modified from the early formulations [12]. The reason that the silver reduces onto the fingermark residue is largely unknown, despite a moderate understanding of the working solution chemistry. PD is not used

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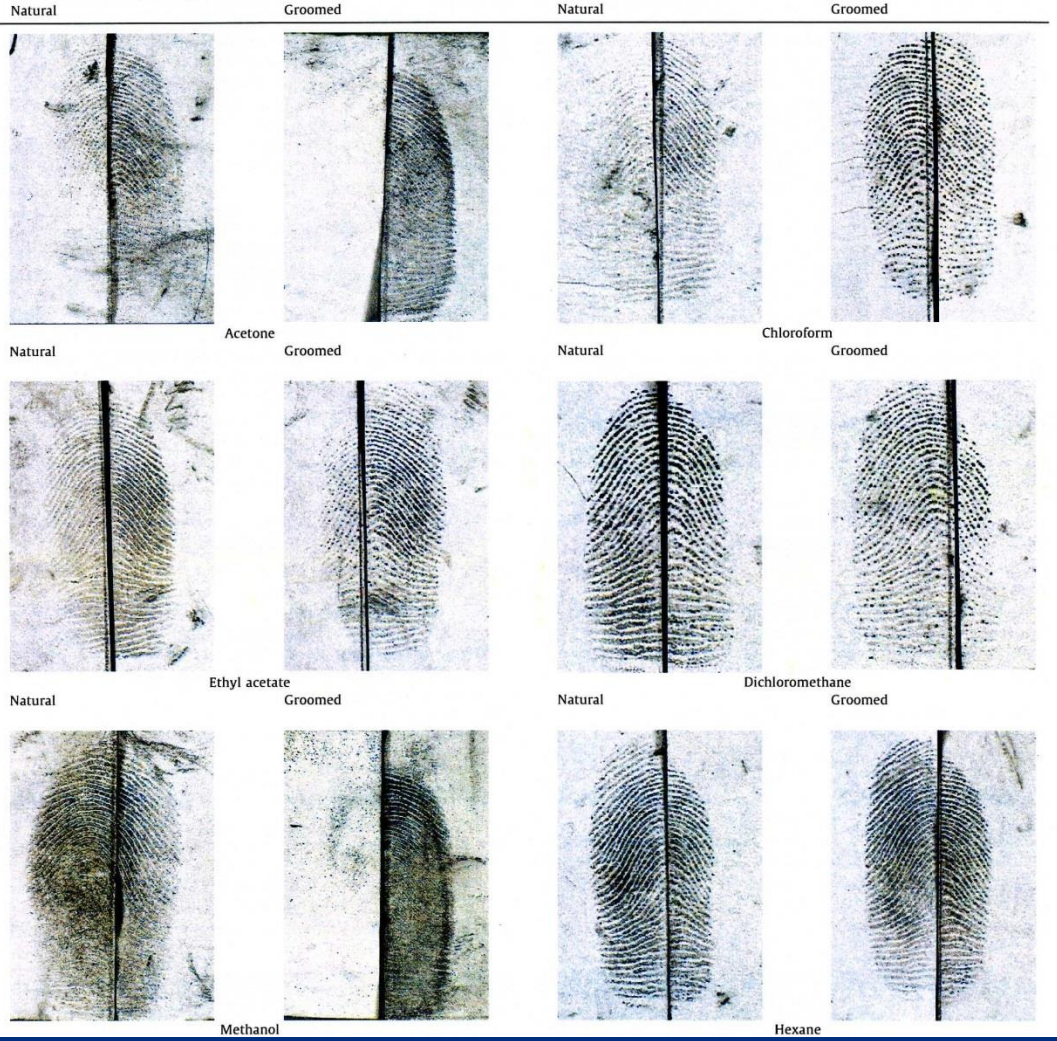
Results

- Cholesterol was the only spot to react strongly with PD (weak reactions noted with squalene and palmitic, stearic, and oleic acids).
- Lipid-specific extraction solvent washes (e.g., CH_2Cl_2, hexane) did not remove PD reactive material from LP residues.
- PD occasionally nucleated on pores; absence or presence of eccrine materials at pore site appears to have an effect on PD development.
- No idea what “eccrine” material at pore site that PD may be targeting.
- PD may target eccrine material or a combination of eccrine and lipid components.

Table 4
Natural and groomed fingermarks developed by PD after the left side was washed with acetone, chloroform, ethyl acetate, dichloromethane, methanol and hexane. Images were aquired using the VSC 6000 under white light and 7.5× magnification.



Introduction

- de la Hunty et al. Understanding Physical Developer (PD): Part II – Is PD Targeting Eccrine Constituents? Forensic Sci Int 2015;257:488-495.
- The goal of this work was to determine whether or not PD targets eccrine material in LPs.
- Eccrine material from pores appears to be critical to PD reaction.
- Lipids are important to prevent eccrine material from dissolving away.

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Understanding Physical Developer (PD): Part II – Is PD targeting eccrine constituents?

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ABSTRACT

Physical developer (PD) is a fingermark development technique that deposits silver onto fingermark ridges. It is the only technique currently in routine operational use that gives results on porous substrates that have been wet. There is a reasonable understanding of the working solution chemistry, but the chemical constituent(s) contained in fingermark residue that are specifically targeted by PD are largely unknown. A better understanding of the PD technique will permit a more informed selection of alternative or complementary detection methods, and greater usage in operational laboratories. Recent research by our group has shown that PD does not selectively target the lipids present in the residue.

This research investigated the hypothesis that PD targets the eccrine constituents in fingermark residue. This was tested by comparison of PD and indanedione-zinc (Ind-Zn) treated natural fingermarks that had been deposited successively, and marks that had been deposited with a ten second interval in between depositions. Such an interval allows for the regeneration of secretions from the pores located on the ridges of the fingers. On fingermark depletions with no time interval between depositions, PD and Ind-Zn treated depletions successively (and comparatively) decreased in development intensity as the amount of residue diminished. Short time intervals in between successive depletions resulted in additional secretions from the pores intermittently occurring, the increased development of which was visualised by treatment with both PD and Ind-Zn. The changes in development intensity were seen with both techniques on the same split depletions in a series, comparably and proportionately. These results indicate that the components targeted by PD are contained in the material excreted by the friction ridge pores through its mirrored development with Ind-Zn.

Repetition of the experiments on marks that only contained eccrine material showed good Ind-Zn development but poor results with PD. This indicates that there are other constituents contained in "natural" fingermarks that are required to be present for PD to be able to target constituents in the eccrine sweat. It may be that the required constituents in the natural residues are non-water soluble, and that these protect the eccrine constituents from solubilisation in the aqueous washes employed in the PD method.

Further research is being undertaken to determine whether PD is targeting specific compounds in the pore secretions, or a mixture of compounds consisting of the eccrine material, epidermal lipids and sebaceous lipids typically present in latent fingermark residues.

1. Introduction

The detection of latent fingermarks is an important area of forensic science. One technique, physical developer (PD), is used to develop marks on porous surfaces that have been wet, and is the only technique currently in routine use for this purpose by law enforcement agencies [1]. PD is also used as a subsequent technique to other techniques used on porous substrates such as ninhydrin, Ind-Zn and 1,8-diazafluoren-9-one (DFO) [2]. The PD working solution selectively reduces silver ions in solution to metallic silver on the fingermark residue in an autocatalytic colloidal deposition process; however, the exact mechanism is largely unknown. PD is an exceptionally unpredictable, expensive and difficult technique to employ, due to the extremely contaminant-sensitive nature of the

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Results

- PD performed much better on natural prints as opposed to eccrine-loaded ones (almost no development seen with eccrine-rich LPs).
- *(N.B. I have noted that when leaving "charged" prints, PD does not always react; however, even a casual, unintentional touch can leave a strongly developed PD print)*
- Still no idea of what specific eccrine components are being targeted by PD; however, lipids may play a role in protecting these compounds from being washed away during the PD process.
- There appears to be little direct reaction between PD and pure lipids.
- *(N.B. Colloidal silver has been used for decades as a protein stain. Proteins are water-insoluble and would be excreted from pores)*

Introduction

- Kent T. Water Content of Latent Fingerprints – Dispelling the Myth. Forensic Sci Int 2016;266:134-138.
- The goal of this review article was to correct the misconception that the majority of a latent print deposit is water.
- Although actual quantitative measurements are not taken, the author uses literature and reasoning to conclude that the weight percent of water is a deposit is << 98-99%.

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Review Article

Water content of latent fingerprints – Dispelling the myth

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ABSTRACT

Changing procedures in the handling of rare and precious documents in museums and elsewhere, based on assumptions about constituents of latent fingerprints, have led the author to an examination of available data. These changes appear to have been triggered by one paper using general biological data regarding eccrine sweat production to infer that deposited fingerprints are mostly water. Searching the fingerprint literature has revealed a number of reference works similarly quoting figures for average water content of deposited fingerprints of 98% or more.

Whilst accurate estimation is difficult there is no evidence that the residue on fingers could be anything like 98% water, even if there were no contamination from sebaceous glands. Consideration of published analytical data of real fingerprints, and several theoretical considerations regarding evaporation and replenishment rates, indicates a probable initial average water content of a fingerprint, soon after deposition, of 20% or less.

Contents

1. Background – observations on changing procedures in handling of rare and precious documents

Over the last few years conservationists and others responsible for the care of rare and precious documents, and some other artefacts, have made significant changes to their handling procedures. Previously most, if not all, museums had a policy of wearing gloves, usually clean white cotton gloves, when handling paper or velum historic manuscripts or books.

Several major museums and collections now have a 'no white glove' policy; in effect a 'no gloves' policy. The principal argument for this change would appears to be the belief that 'fingerprints are 98–99% water'. The implication being that only a small fraction of deposited material comprises potentially damaging organic or inorganic compounds.

Other arguments include that the tactile response with white cotton gloves makes page turning difficult and may result in damage to edges and corners of pages.

Researching the reasons behind this change at the British Library and British National Archive have elicited quotations from a Baker and Silverman [1] paper of 2005 (see also British Library

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Results

- Several museums worldwide have a no gloves policy for handling historic manuscripts or books.
- Gloves make page turning difficult; it can lead to corner/edge damage.
- Museum staff argue that since LP is ~99% water that leaves very little potentially damaging inorganic or organic compounds left on the item.
- Weight % water estimates likely refer to eccrine sweat in the glands.
- LP is a combination of water-soluble eccrine sweat and mostly water-free sebum.
- Author estimates that a typical ungroomed latent print would weight ~4-5 µg, of which 20% or less would be water (depending on conditions).

Results

- Sample calculations for theoretical evaporation rate values (right).
- Results vary between 10-60 nm/s.
- Values calculated by Taylor and Machado-Moreira for loss of water from palmar surfaces under normal conditions: 17-33 nm/s.
- *(N.B. The rate of evaporation is defined as the amount of water evaporated from a unit surface area per unit of time)*
- Wear gloves when handling historic items!

i. A formula provided in various ready reckoner calculator sites (such as [24]) is:

Evaporation rate $G = K(Xs - Xa)$kg/hr/m^2 where $K = 25 + 19V$ and V is velocity of air above surface

Xs = kg/kg humidity ratio in saturated air at the same temperature as the water surfaceand

Xa = kg/kg actual ratio of water in the air above surface

If water is at 20 C and the air is at 50% RH ($Xa = 1/2Xs$) with an air flow of 0.25 m/s

G = (25 + 4.75)(0.0147–0.00735) = 0.219 kg/hr/m^2
= 0.06 g/m^2/s = 6 μg/cm^2/s

or approximating density to 1g/cm^3

a water film loss = 60 nm/s

ii. An alternative formula derived from the Langmuir equation provided by a number of other reference sources such as [24] and [25] is:

G = (42.6 + 37.6 V)(Pw-Pa)/ΔH(Latent Heat of vaporisation of water at given temp kJ/kg)

Pw= Vapour Pressure of water at reservoir temperature

Pa= Partial Pressure of water in atmosphere above reservoir

= (42.6 + 9.4)(17.5 mm−12 mm)/ΔH
= 52 × 5.5/2264
= 0.126 kg/hr/m^2
= 0.035 g/m^2/s = 3.5 μg/cm^2/s
or a water film loss = 35 nm/s

iii. Some experiments have been carried out by the author in an attempt to test these predictions. Weight loss from small shallow vessels at around 20 C and 50% RH under very low convection current air flow conditions indicated evaporation rates of around 1 μg/cm^2/s, i.e. a loss of 10 nm/s from the surface. Somewhat less than calculated rates above but a similar order of magnitude.

iv. A simple experiment of wetting hands with tepid water, shaking off excess and keeping palms stationary and uppermost in indoor conditions of 20 C at an ambient RH of around 60% with no significant air movement resulted in a maximum time to apparent dryness of around 4 min. Slight hand or air movement reduced this substantially.

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Introduction

- Bolivar P-A, Tracey M, McCord B. Assessing the Risk of Secondary Transfer Via Fingerprint Brush Contamination Using Enhanced Sensitivity DNA Analysis Methods. J Forensic Sci 2016;61(1):204-211.
- The goal of this work was to determine whether or not exogenous DNA from a fingerprint brush could be detected if low copy number DNA analysis methods were used.
- LCN-DNA is typically applied to samples that contain less than 100-200 pg of DNA.

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TECHNICAL NOTE

CRIMINALISTICS

Paula-Andrea Bolivar,[1] M.S.; Martin Tracey,[1] Ph.D.; and Bruce McCord,[1] Ph.D.

Assessing the Risk of Secondary Transfer Via Fingerprint Brush Contamination Using Enhanced Sensitivity DNA Analysis Methods

ABSTRACT: Experiments were performed to determine the extent of cross-contamination of DNA resulting from secondary transfer due to fingerprint brushes used on multiple items of evidence. Analysis of both standard and low copy number (LCN) STR was performed. Two different procedures were used to enhance sensitivity, post-PCR cleanup and increased cycle number. Under standard STR typing procedures, some additional alleles were produced that were not present in the controls or blanks; however, there was insufficient data to include the contaminant donor as a contributor. Inclusion of the contaminant donor did occur for one sample using post-PCR cleanup. Detection of the contaminant donor occurred for every replicate of the 31 cycle amplifications; however, using LCN interpretation recommendations for consensus profiles, only one sample would include the contaminant donor. Our results indicate that detection of secondary transfer of DNA can occur through fingerprint brush contamination and is enhanced using LCN-DNA methods.

KEYWORDS: forensic science, fingerprint brush contamination, low copy number, secondary transfer, DNA typing, post-PCR cleanup

Fingerprint brushes can potentially collect and transfer DNA. The same brush may be used to powder different items of evidence within and between crime scenes (1,2). If a latent print is developed at a crime scene and deemed to be "no-value" for comparison purposes, the latent could be swabbed in an effort to obtain DNA results from the depositor of the print. Secondary transfer of DNA from the fingerprint brush may also be detected in the results. It has been noted that "if a brush were to add DNA-containing material to a surface containing a handprint, the proportion of the added DNA is likely to be less than that retrieved from the depositor of the print. Thus, the minor component of the mixture derived from the brush may not be detectable" (2). However, would the exogenous DNA from the fingerprint brush still be undetectable if low copy number (LCN-DNA) DNA analysis methods were applied?

Low copy number DNA generally refers to the higher sensitivity DNA analysis methods applied to samples below 100–200 pg (or low template) (3,4). To detect such low levels of samples, it is common to use higher sensitivity techniques, including increased polymerase chain reaction (PCR) amplification cycles, post-PCR cleanup, longer electrokinetic injection times, nested PCR, and other techniques (5,6). Improving the sensitivity of PCR may yield full or significant partial profiles from low template DNA samples (7–9). One such LCN analysis method is the PCR cycle number. In theory, 28 cycles of PCR can yield slightly over 260 million copies of the DNA target fragments from a single diploid cell. Increasing the cycle number to 31 cycles can theoretically improve the yield to slightly over 2 billion copies.

Simply increasing the number of PCR cycles does not correlate with an exponential increase in DNA. However, enhancing the sensitivity of the PCR does permit the detection of low-level, stochastically amplified DNA. Unfortunately, such stochastic effects include increased stutter, nonspecific amplification, allele drop-in, allele dropout, peak height imbalance, and other adverse effects which greatly complicate interpretation of results (10–12). These stochastic effects mainly originate in the early stages of the reaction and are not normally seen using standard techniques as they usually appear below analytical thresholds. Increasing the sensitivity of the reaction improves the ability of the system to see these latent problems. Because of the inherent lack of reproducibility of stochastic amplification, it is necessary to perform replicate analyses and utilize strict interpretational guidelines in order to achieve reliable results (6,11).

Another method to improve sensitivity is post-PCR amplification purification. This technique does not improve the sensitivity of amplification, but rather enhances the electrokinetic injection of amplicons into the capillary (13). Post-PCR cleanup removes many of the interfering ionic components or remnants of the PCRs, which compete with the amplified DNA for injection into the capillary. These ions may be from the buffer components, unused primers and dye molecules, and polymerase. Post-PCR cleanup allows more of the specific amplified products to enter the capillary for separation and detection and results in higher signal intensities. Similarly, increased electrokinetic injection time enables more charged molecules, including amplicons, to enter the capillary and usually results in slightly improved signal intensities.

PCRs are optimized to yield robust, reliable, and reproducible results from samples within a narrow range of input DNA. This is because inefficiencies in the reaction are exaggerated when

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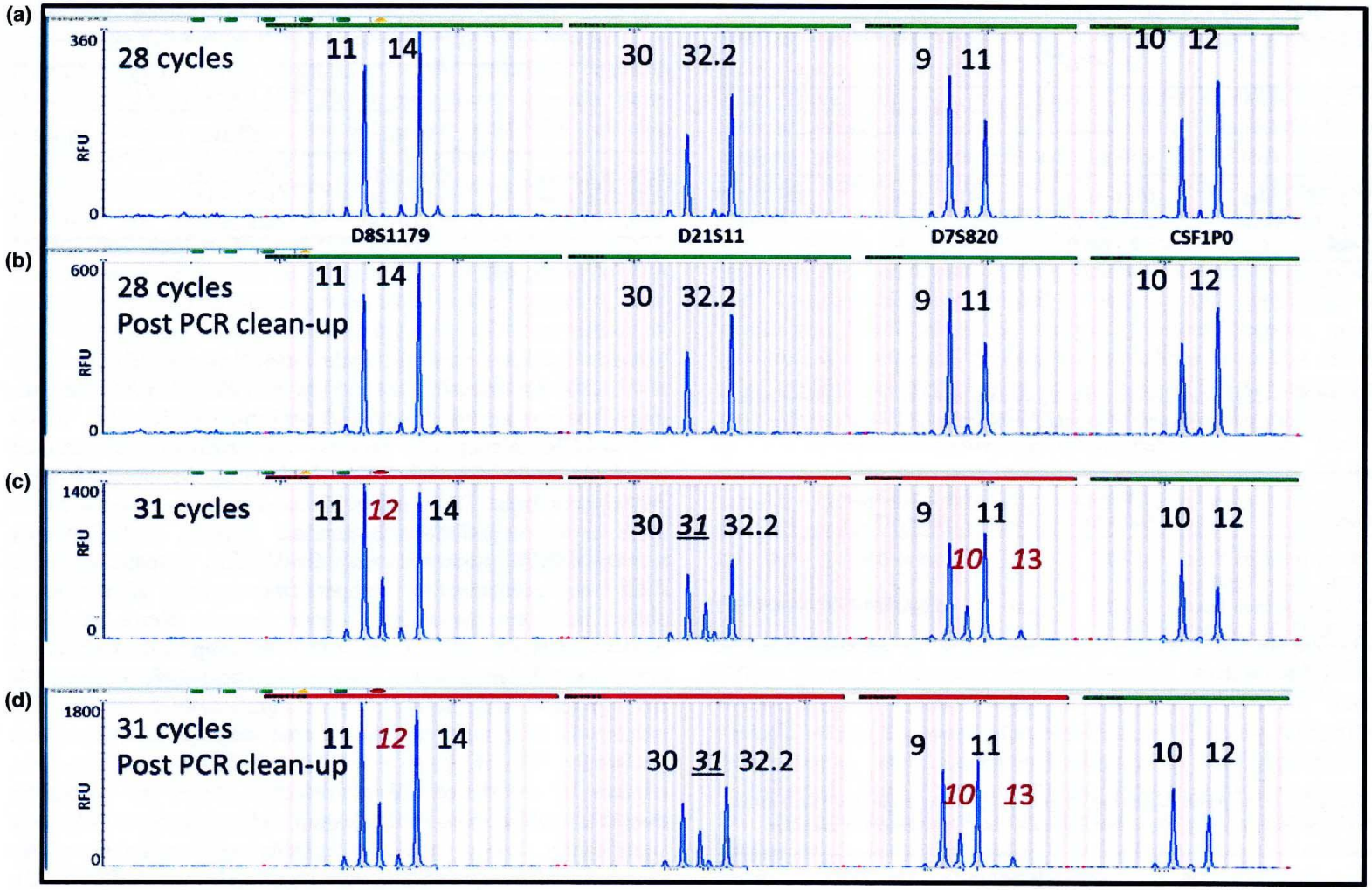
Results

- Sterilized plastic transparencies were used as substrates for the LPs.
- A FP brush (without powder) was brushed over the surface multiple times of a transparency with hand prints from donor A.
- That same brush was used to “process” (without powder) a transparency containing hand prints from donor B.
- A total of eighteen samples were examined. A sample consisted of a swab of the transparency where the LPs were deposited.
- “Detection” of the contaminating donor’s DNA was defined as detecting at least one allele from that donor above the analytical threshold.

Results

- Using standard DNA analysis, 5 out of 12 samples (42%) yielded DNA from the original donor.
- When longer electrokinetic injection times were used, contaminant DNA was detected 8 out of 12 times (67%).
- When post-PCR cleanup was used, 10 out of 12 samples (83%) were found to contain contaminant DNA.
- Even though these minor alleles were detected, there was insufficient data in most cases to identify the contributor.
- Only one sample included the donor in the mixture results (8.3%).


(a)
360
RFU
0
28 cycles
11 14
30 32.2
9 11
10 12
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D21S11
D7S820
CSF1P0
(b)
600
RFU
0
28 cycles
Post PCR clean-up
11 14
30 32.2
9 11
10 12
(c)
1400
RFU
0
31 cycles
11 12 14
30 31 32.2
9 11
10 13
10 12
(d)
1800
RFU
0
31 cycles
Post PCR clean-up
11 12 14
30 31 32.2
9 11
10 13
10 12

Introduction

- Fonneløp AE, Egeland T, Gill P. Secondary and Subsequent DNA Transfer During Criminal Investigation. Forensic Sci Int:Gen 2015;17:155-162.
- The purpose of this study was to investigate the possibility of investigator-mediated transfer (secondary and tertiary) of DNA traces with nitrile gloves and a variety of substrates during crime scene examinations.
- Based on a scenario used by defense in the Meredith Kercher case.

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Secondary and subsequent DNA transfer during criminal investigation

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ABSTRACT

With the introduction of new multiplex PCR kits and instrumentation such as the Applied Biosystems 3500xl, there has recently been a rapid change in technology that has greatly increased sensitivity of detection so that a DNA profile can routinely be obtained from only a few cells. Research to evaluate the risks of passive transfer has not kept pace with this development; hence the risk of innocent DNA transfer at the crime-scene is currently not properly understood. The purpose of this study was to investigate the possibility of investigator-mediated transfer of DNA traces with disposable nitrile-gloves used during crime-scene examinations. We investigated the primary transfer of freshly deposited DNA from touched plastic, wood or metal substrates and secondary and tertiary transfer by a person wearing disposable nitrile-gloves and onto a third object. We show that with use of the new highly sensitive technologies available in forensic DNA analysis there is an enhanced probability to obtain a DNA-profile which has not been directly deposited on the object but is an outcome of one or more transfer events. The nitrile-gloves used by investigators during exhibit examination can act as a vector for DNA transfer from one item to another. We have shown that the amount of DNA deposited on an object affects the probability of transfer. Secondly, the type of substrate material that DNA is deposited onto has an impact on transfer rates.

1. Introduction

The transfer of DNA to a crime scene or items related to the crime event can happen in several ways. Transfer may be described as "active" or "passive" [1]. Active transfer of DNA traces originating from the perpetrator occurs during the crime event itself; DNA is transferred via direct contact or aerosol e.g. from saliva spray to the surroundings. Passive transfer can be completely unrelated to the crime-event. Via this route, DNA can be transferred to crime related objects by a vector (secondary transfer) or by aerosol transfer of cells already present in the surroundings (e.g. in house-dust). Because there is an unfortunate tendency, to associate a crime-stain profile with direct evidence of the crime-activity, there are considerable dangers associated with lack of understanding of the various risks of alternative (innocent) means of transfer. This concern is gaining increased attention. Several studies have been conducted to investigate secondary transfer [2–5]. Goray et al. [6] found that the types of primary and secondary substrates, the level of moistness of the sample and the manner of contact, all played important roles in transfer of DNA. The initial deposit of DNA must be of sufficient quantity and quality to be detected and a good shedder is more likely to deposit significant amounts. Both Lowe et al. [7] and Farmen et al. [8] observed the event of secondary transfer of "touch" DNA via an individual to a second object when the first individual involved was classified as a good shedder. The surface of the substrate is a factor that was observed to have an effect on DNA depositions during contact, comparing items held for 60 s, Daly et al. [9] found that more DNA was recovered from wood than from fabric, and the least was recovered from glass. It is expected that the way the object is handled (light, force and friction) can affect the transfer rate [3]. During a study on transfer during social interactions, Goray and van Oorschot [5] observed that a jug passed between the participants acted as an efficient vector for secondary transfer. In addition they found that the individuals acted as vectors for multiple transfer events of foreign DNA. Lehman et al. [10] performed another study on multiple transfer events. With glass or cotton as a substrate they attempted to transfer DNA six times. They found that "touch" DNA produced a full profile only on the first substrate, and partial profiles from the second to the fifth substrate when the substrate was glass. When the substrate was cotton only a partial profile on the first substrate was achieved.

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1872-4973/

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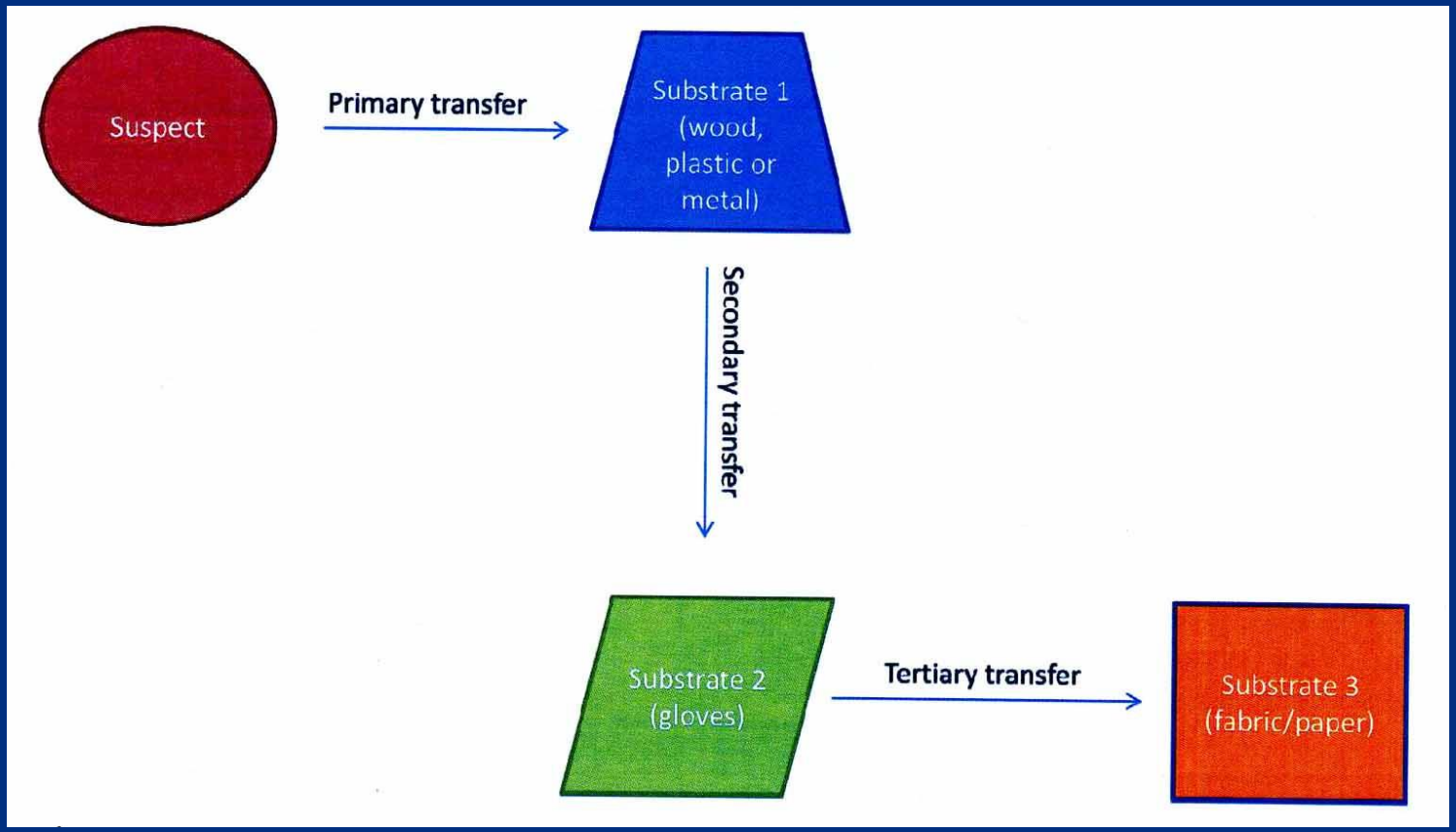

Scenario: perpetrator deposits DNA on object; object is handled by CSI wearing gloves (perpetrator DNA is now on gloves); CSI handles a different object and perpetrator's DNA is transferred there from gloves.

Results

- Primary objects included wood (oak), plastic tube, metal door handle.
- 3 donors (good shedders); objects handled for ~30 s; “investigator” with gloves handled objects for ~30 s; gloved “investigator” then touches fabric or paper; 10 min total for all contacts.
- 30 transfer chains; 90 overall samples.
- Repeated six times with a more realistic 10 s object holding time.

Table 1
The average DNA quantity (standard deviation) from the first deposit on each substrate type and the average proportion of DNA transferred (standard deviation).

	Metal	Plastic	Wood	Paper/fabric
Average DNA quantity in ng transferred donor → substrate 1	5.55 (7.68)	17.3 (11.56)	18.42 (16.00)	–
Average DNA proportion transferred substrate 1 → substrate 2	64.23 (24.97)	29.13 (16.11)	15.95 (9.31)	–
Average DNA proportion transferred substrate 2 → substrate 3	–	–	–	32.04 (26.5)

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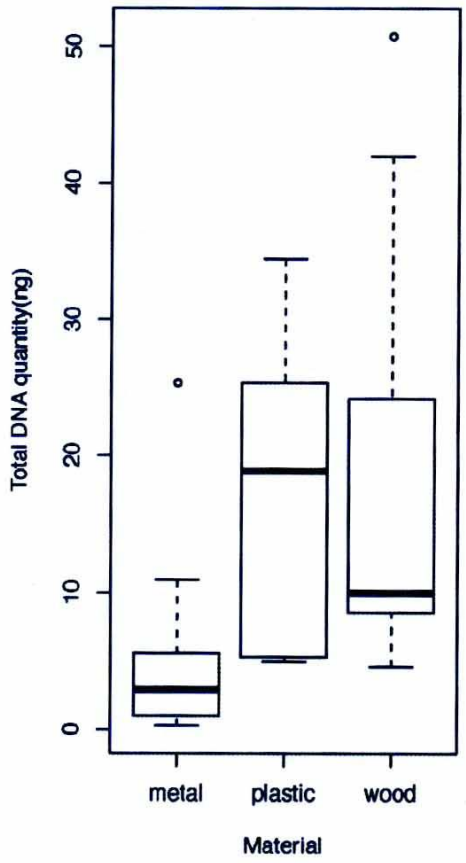
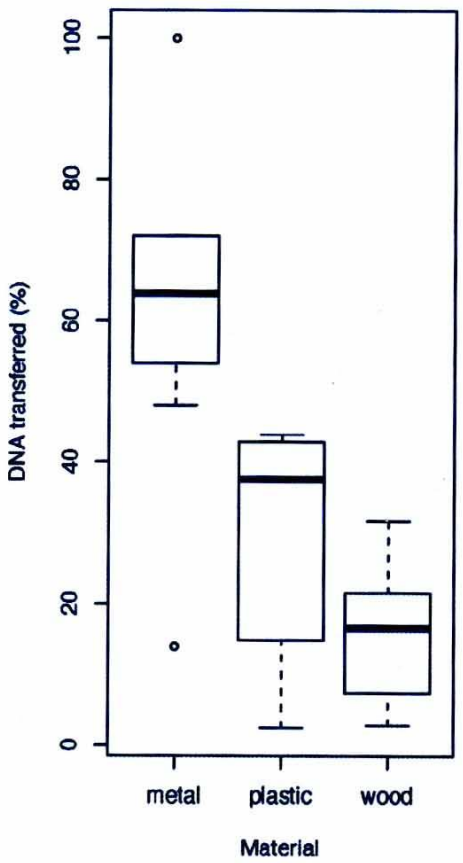
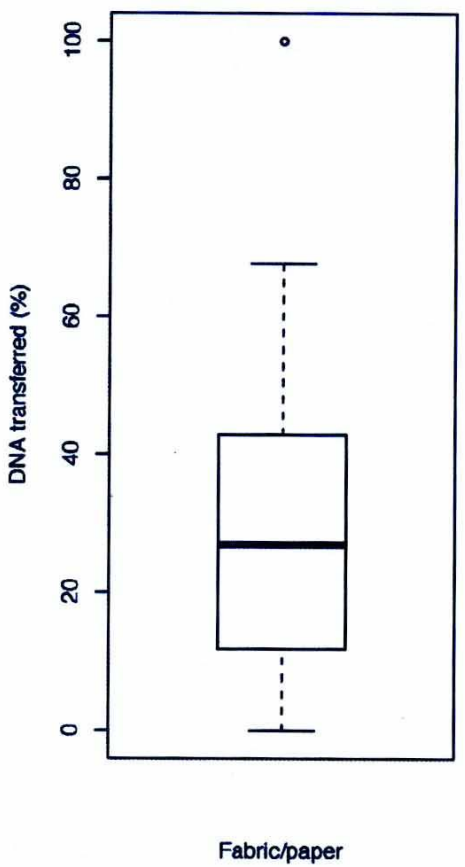

a) Total DNA deposited on substrate 1
Total DNA quantity(ng)
0
10
20
30
40
50
metal
plastic
wood
Material


b) Proportion of DNA transferred to substrate 2
DNA transferred (%)
0
20
40
60
80
100
metal
plastic
wood
Material


c) Proportion of DNA transferred to Substrate 3
DNA transferred (%)
0
20
40
60
80
100
Fabric/paper

Results

- Overall, less DNA was deposited on metal than wood/plastic objects.
- In 5 out of 30 transfer chains, sufficient high quality DNA (for case reporting and searching a database) was tertiary transferred.
- There was evidence of quarternary transfer (girlfriend of one donor).
- More DNA was transferred initially to porous/fabric surfaces, less DNA was secondarily transferred from these surfaces to the gloves.
- DNA transfer was much higher from smooth metal surfaces (door handle) to the gloves.
- Gloves were determined to be an effective vector for secondary transfer of DNA to a third surface.

Introduction

- Khuu et al. Evaluation of One-step Luminescent Cyanoacrylate Fuming. Forensic Sci Int 2016;263:126-131.
- The goal of this work was to compare: CN Yellow Crystals, PolyCyano UV, PECA Multiband, and Lumikit™ to conventional CA fuming/rhodamine 6G.
- Overall results were dependent on the age of the prints and the nature of the substrate (non-porous vs. semi-porous).

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Technical Note

Evaluation of one-step luminescent cyanoacrylate fuming

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PECA Multiband

ABSTRACT

One-step luminescent cyanoacrylates have recently been introduced as an alternative to the conventional cyanoacrylate fuming methods. These new techniques do not require the application of a luminescent post-treatment in order to enhance cyanoacrylate-developed fingermarks. In this study, three one-step polymer cyanoacrylates: CN Yellow Crystals (Aneval Inc.), PolyCyano UV (Foster + Freeman Ltd.) and PECA Multiband (BVDA), and one monomer cyanoacrylate: Lumikit™ (Crime Scene Technology), were evaluated against a conventional two-step cyanoacrylate fuming method (Cyanobloom (Foster + Freeman Ltd.) with rhodamine 6G stain). The manufacturers' recommended conditions or conditions compatible with the MVC™ 1000/D (Foster + Freeman Ltd.) were assessed with fingermarks aged for up to 8 weeks on non-porous and semi-porous substrates. Under white light, Cyanobloom generally gave better development than the one-step treatments across the substrates. Similarly when viewed under the respective luminescent conditions, Cyanobloom with rhodamine 6G stain resulted in improved contrast against the one-step treatments except on polystyrene, where PolyCyano UV and PECA Multiband gave better visualisation. Rhodamine 6G post-treatment of one-step samples did not significantly enhance the contrast of any of the one-step treatments against Cyanobloom/rhodamine 6G-treated samples.

1. Introduction

Cyanoacrylate (CA) fuming is the preferred laboratory technique for the detection of fingermarks deposited on non-porous substrates. In this technique, CA is vaporised and the fumes react with components from fingermark secretions forming a hard white polymer extending along the ridges of the fingermark [1]. Limitations arise with CA development due to the lack of contrast that occurs on light-coloured substrates, where white fingermarks can be difficult to visualise, and with the development of aged fingermarks, where transparency of the CA ridges is increased [1]. The contrast of developed fingermarks can be improved through post-treatment with luminescent stains which penetrate the CA development and become trapped within the polymer [2,3]. While contrast on non-porous substrates is generally improved, the use of post-stains is associated with a number of limitations: increased handling times [2]; absorption of stains into semi-porous substrates [4]; health and safety concerns associated with the use of hazardous chemicals during staining [5]; and the potential loss of integrity of the developed fingermark as well as the exhibit.

One-step luminescent CA fuming products incorporating a luminescent dye with CA have been researched since the early 1980s. However, it is only recently that a number of commercial products have become available including: CN Yellow Crystals (Aneval Inc.), PolyCyano UV (Foster + Freeman Ltd.), PECA Fluor Extra, PECA Multiband (BVDA), and Lumikit™ (Crime Scene Technology).

The initial report of a one-step luminescent CA was in 1993, when Weaver and Clary successfully produced luminescent fingermarks following co-sublimation of a styryl dye with CA monomer [6]. Weaver subsequently conducted work on the optimisation of CN Yellow, the first commercially available one-step luminescent CA. This product incorporates CA in a solid polymer form with yellow 43, a dye which was reported to show selectivity for CA-polymerised fingermark ridges [7]. Groeneveld et al. found that while CN-Yellow produced visible CA-developed fingermarks, luminescent contrast was poor [8]. CN-Yellow has since been superseded by CN Yellow Crystals. A review of the technical notes for the latter indicates that slow heating of the product may degrade the luminescent component [9].

More recently, PolyCyano UV and the PECA products have been developed and commercialised. Like CN-Yellow, these products are also in a solid polymer form and require a temperature of 230 °C to vaporise. The luminescent compound of PolyCyano UV and PECA formulations is *p*-dimethylaminobenzaldehyde (DMAB), which

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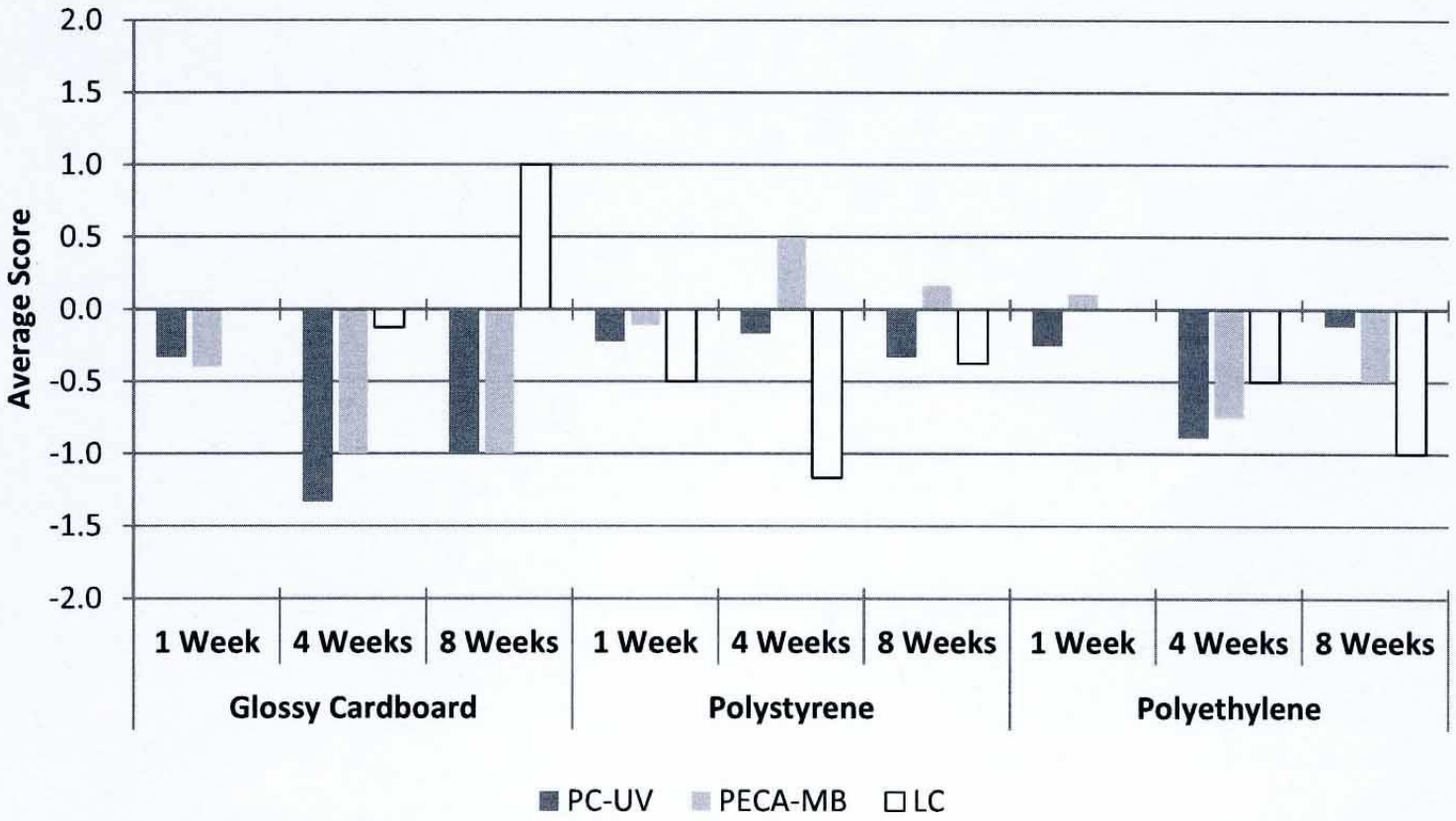
United States Secret Service

Results

- A total of 810 prints collected; aged 1/4/8 weeks; 36% ND.
- Overall, CN Yellow Crystals (Yellow 43) did not perform well compared to any of the other one-step techniques (based on pDMAB).
- Quality of development of older prints with Cyanobloom appeared to decrease with age of the print; one-step processes show more promise on older prints –especially on polystyrene.
- R6G staining resulted in more intense fluorescence across the range of substrates compared to the one-step methods.
- Post-staining the one-step luminescent treated prints with R6G lead to increased enhancement (consistent with a previous study using BY40 as a post-treatment stain after one-step methods).


2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Average Score
1 Week
4 Weeks
8 Weeks
1 Week
4 Weeks
8 Weeks
1 Week
4 Weeks
8 Weeks
Glossy Cardboard
Polystyrene
Polyethylene
PC-UV
PECA-MB
LC

Introduction

- Errington et al. Micronised Egyptian Blue Pigment: A Novel Near-infrared Luminescent Fingerprint Dusting Powder. Dyes and Pigments 2016;132:310-315.
- The goal of this project was to evaluate a new LP powder for its NIR fluorescent properties on complex, patterned backgrounds compared to other powders.
- Egyptian blue minimizes background fluroescence interference.

Dyes and Pigments 132 (2016) 310–315

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Micronised Egyptian blue pigment: A novel near-infrared luminescent fingerprint dusting powder

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NIR luminescence

ABSTRACT

In this paper we demonstrate that micronised Egyptian blue pigment can be used as a safe and simple material to visualise latent fingerprints on non-porous surfaces as near-infrared luminescent impressions. This allows the detection of latent fingerprints on highly patterned and reflective surfaces that have proven challenging with existing techniques.

1. Introduction

The detection of latent fingerprints is extremely useful in forensic investigations to establish evidence of contact between the criminal, the victim, and/or the crime scene [1–3]. To that end, a wide range of chemical and physical methods have been developed to aid in their detection and recovery, the choice of which is dependent on the nature of the surface involved [1,2]. The most common approach to detecting latent fingerprints on non-porous items has been the use of dusting powders, which work through physical adhesion to the latent fingerprint deposit [1–5]. It has been estimated that in the United Kingdom, approximately 50% of the 60,000 fingerprint identifications per annum arise from powdered fingerprints [1]. Historically, a wide range of materials have been utilised as fingerprint powders; including carbon black, iron oxide-based magnetic powder and titanium dioxide; in attempts to achieve improved visualisation across a wide variety of surfaces and conditions [1–5]. In recent times, this has included attempts to use natural products such as turmeric as safe and inexpensive powders [6]. Several commercially available powders exhibit luminescence in the visible region of the electromagnetic spectrum, which to some extent can negate the interferences exhibited by highly patterned or coloured surfaces [1,2,4]. However, there remain many fluorescent, highly patterned and/or reflective surfaces that continue to prove troublesome [7–9].

An alternative approach is to use dusting powders that exhibit near-infrared (NIR) luminescence [10–12]. As very few substrates luminesce in the NIR region of the spectrum, such powders can highlight ridge detail while avoiding interference caused by inherent background luminescence [9–13]. To date there are limited examples of such powders in the open literature. Chadwick and co-workers reported an NIR luminescent fingerprint powder based on adsorption of an organic dye (STaR 11*) on finely powdered aluminium oxide, mixed with commercial magnetic fingerprint dusting powder. However, the developed impressions were still affected by underlying patterns on the surface, and the luminescence intensity of the developed fingerprints was observed to decrease over time. In addition, the powder itself had a limited shelf life [10]. More recently, King et al. have demonstrated that a biorganic powder based upon an algae, *spirulina platensis*, can be used to develop fingerprints with imaging in the NIR region [11].

Egyptian blue (also known as cuprorivaite) is the earliest known synthetic pigment; first prepared in ancient Egypt around 3600 BCE and used extensively until the 4th century CE [14–18]. Qualitative studies by Sir Humphrey Davy and others revealed that the pigment was likely to be copper-based, and contained large

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0143-7208/

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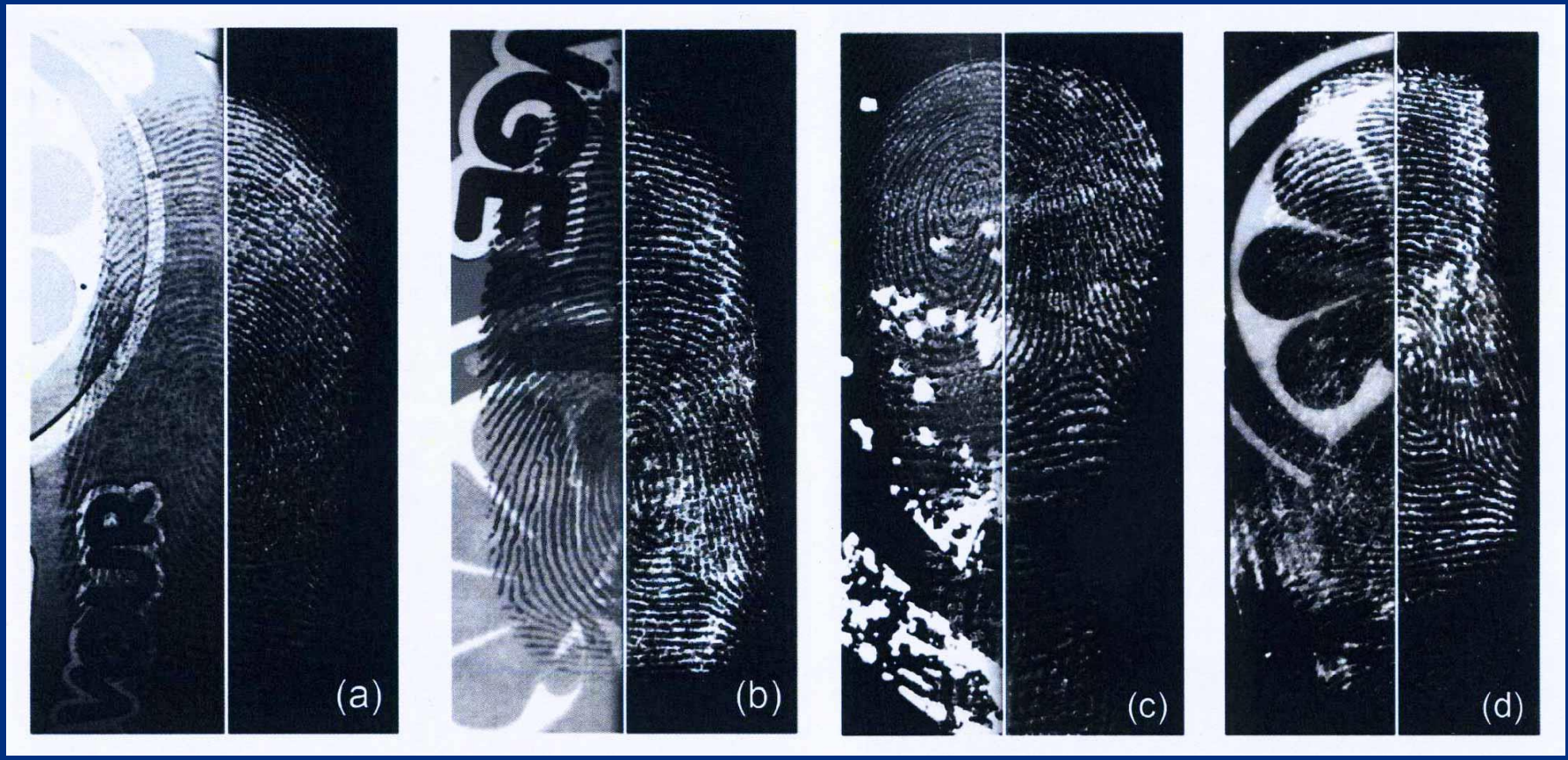
United States Secret Service

Results

- Egyptian blue is the oldest known synthetic pigment (~3600 BCE).
- Calcium copper silicate ($CaCuSi_4O_{10}$); 630 nm (ex) and 910 nm (em).
- Commercially available EB had particle sizes on the order of 50 μm (compared to 2 μm for Velvet black, a commercial LP powder).
- A micronizing mill was required to achieve proper particle sizes.
- On soda cans, EB outperformed the other powders evaluated in this study (Velvet Black, TiO_2, Blitz Red, bichromatic powder).
- EB is a very stable pigment – prints on a porcelain tile left on a window ledge for 2 years showed little degradation in NIR fluorescence.



a) bichromatic; b) Velvet Black; c) TiO_2; d) Blitz Red®

Introduction

- D'Elia V, et al. Evaluation and Comparison of 1,2-Indanedione and 1,8-Diazafluoren-9-one Solutions for the Enhancement of Latent Fingerprints on Porous Surfaces. Forensic Sci Int 2015;254:205-214.
- The goal of this project was to compare three different IND-Zn reagent formulations with a single DFO formulation.
- Overall conclusion was that IND-Zn (S3) was the best.

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Evaluation and comparison of 1,2-indanedione and 1,8-diazafluoren-9-one solutions for the enhancement of latent fingerprints on porous surfaces

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1,2-indanedione
IND–Zn

ABSTRACT

1,2-indanedione (1,2-IND) and 1,8-diazafluoren-9-one (DFO) are used in the forensic field to enhance latent fingerprints deposited on porous surfaces due to the formation of fluorescent products by reacting with the amino acids present in the papillary exudate. The study was carried out in collaboration with the Fingerprints and Photography Section of the Carabinieri Scientific Investigation Department (RIS) of Rome, in which laboratories, until now, DFO has been the most used because of its excellent enhancing properties, even if it is more expensive and relatively toxic in comparison with the 1,2-IND.

The aim of this work was then to evaluate and to compare the effectiveness of three solutions of 1,2-IND in different formulations and a DFO solution employed as single enhancing treatments, in order to assess whether it was possible to replace a reagent with the other obtaining equally satisfying results.

In this case, white office paper was selected as deposit surface since it also permitted one to observe those reaction products that appear visible to a naked eye. Beside to a qualitative study of the visual characteristic of the enhanced fingerprints, further quantitative studies were conducted on the intensity of fluorescence of the products and on the consumption of amino acids during the reaction. The analyses, which at first were conducted on standard samples, were then repeated on real samples to validate the results obtained.

The DFO confirmed its excellent enhancement properties, but also one of the three solutions of 1,2-IND showed comparable properties in terms of enhanced fingerprint definition and stability over time from the completion of a crime. As a result, we proved that a selected 1,2-IND formulation may replace with satisfactory achievements the DFO solution currently employed, providing also advantages from the point of view of safety and cost savings.

1. Introduction

Latent fingerprints refer to fingerprints not observable to a naked eye. These are often found on a crime scene on objects commonly handled or accidentally touched during a crime. Enhancement techniques are chosen according to the time passed from the deposit of fingerprints and to the characteristic of the deposit surfaces. The paper, like all the porous surfaces, absorbs very quickly the hydrosoluble component of the sweat, while the liposoluble part remains on the surface for 12–24 h. Only a small amount of secretion remains on the substrate for a longer period. Both 1,2-indanedione (1,2-IND) and 1,8-diazafluoren-9-one (DFO) react with the amino acids present in papillary exudate giving fluorescent products, even if in some cases it is possible to observe the enhanced fingerprint in the visible range too.

The 1,2-IND was synthesized for the first time in 1997 in the University of Pennsylvania by professor Madeleine Joullié and her coworkers as intermediary for the preparation of analogous of ninhydrin, already used as reagent for the enhancement of fingerprints on porous surfaces. The reaction between this molecule and the ones of amino acids leads to the formation of

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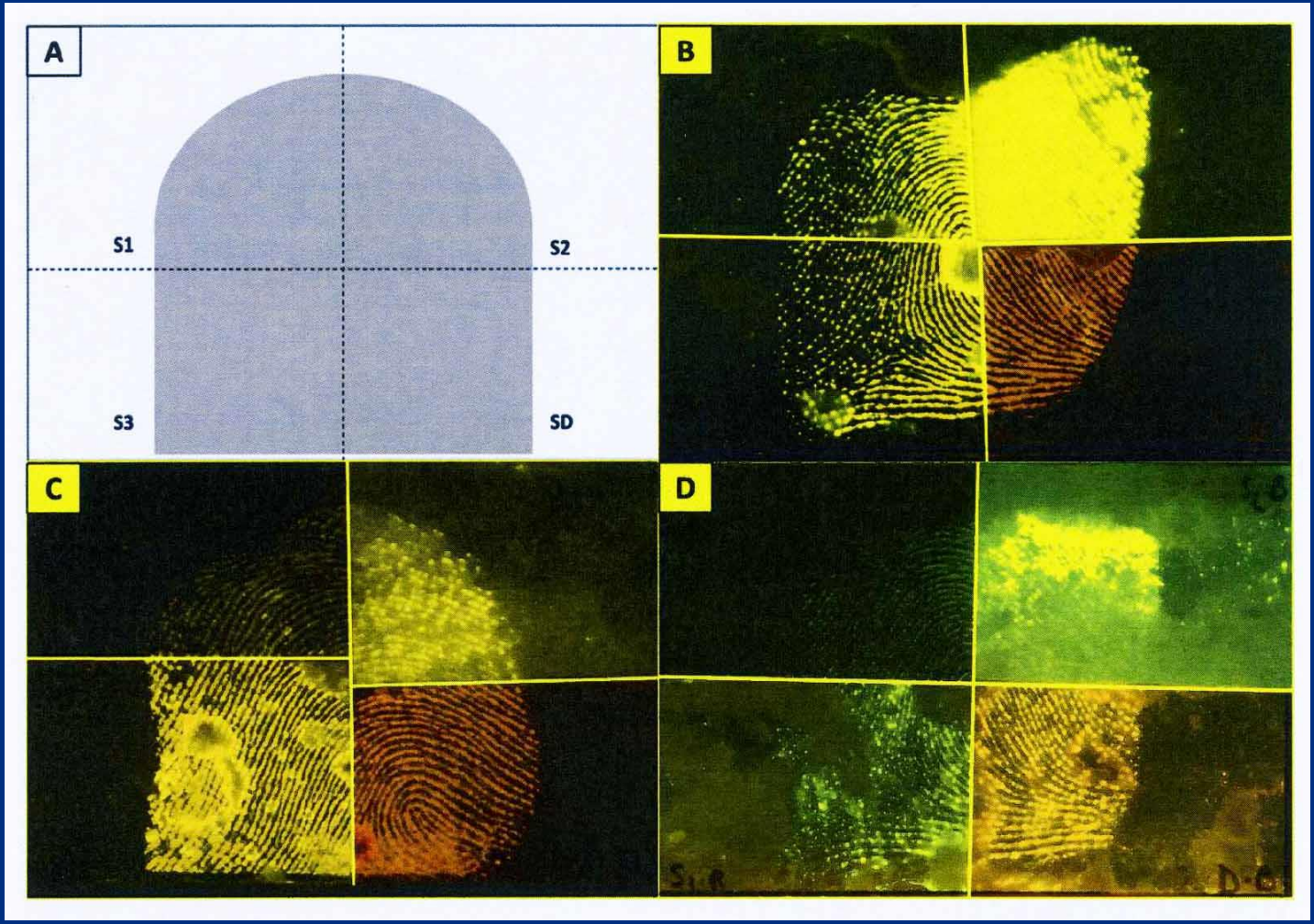
0379-0738/

U.S. Department of Homeland Security

United States Secret Service

Results

- IND-Zn (S1) = 0.1% w/v; IND-Zn (S2) = 0.024% w/v; IND-Zn (S3) = 0.08% w/v; DFO = 0.024% w/v
- IND-Zn treated prints developed in an oven for 3 min at 170°C.
- Solutions were not directly compared to each other (i.e., split depletions prints, IFRG guidelines).
- Overall results of this study indicated that S1 was the least fluorescent and stable; S2 was the strongest; and S3 and DFO were comparable.
- On split prints, a similar trend was exhibited up to 120 days – at 120 days all solutions tended to break down and exhibit decreased contrast.



a) template; b) t = 0; c) t = 75 days; d) t = 120 days

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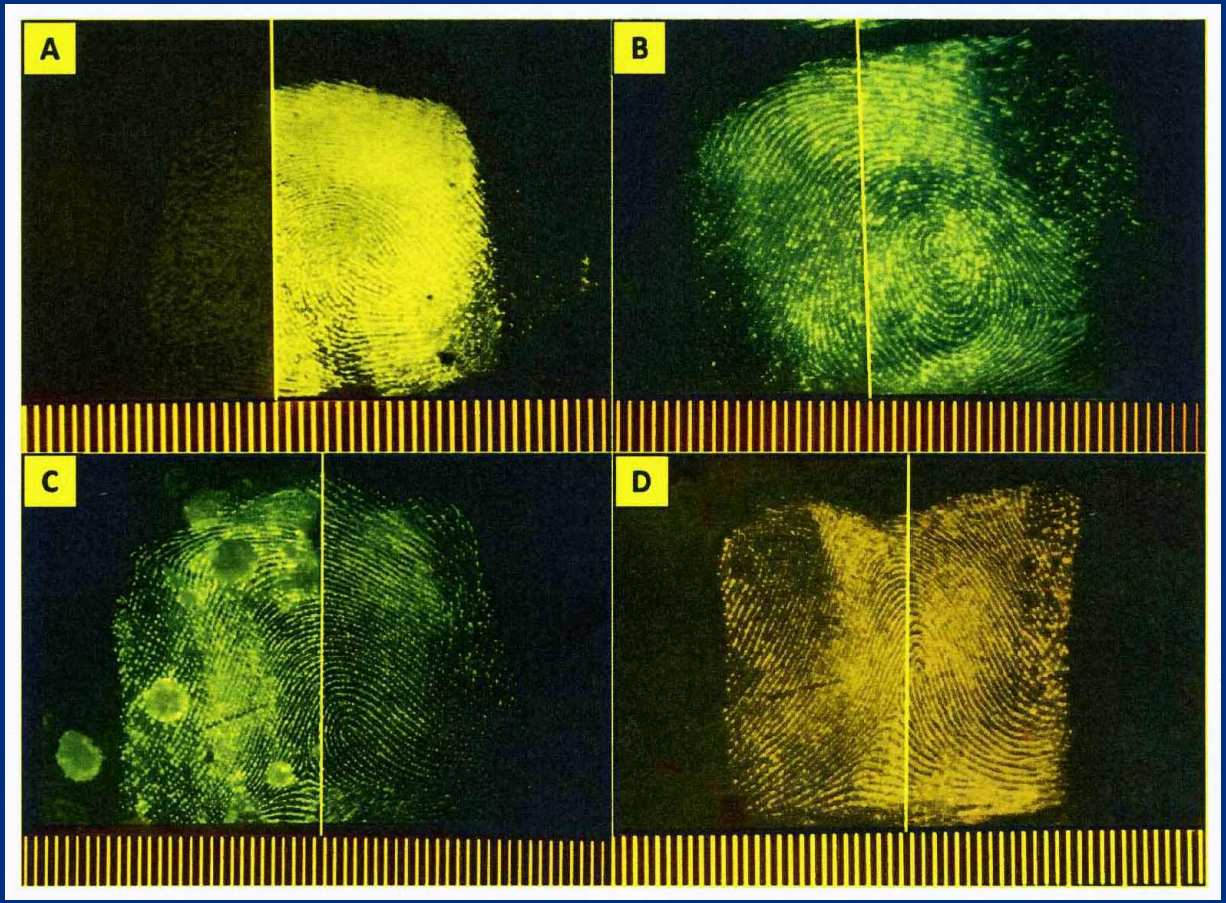
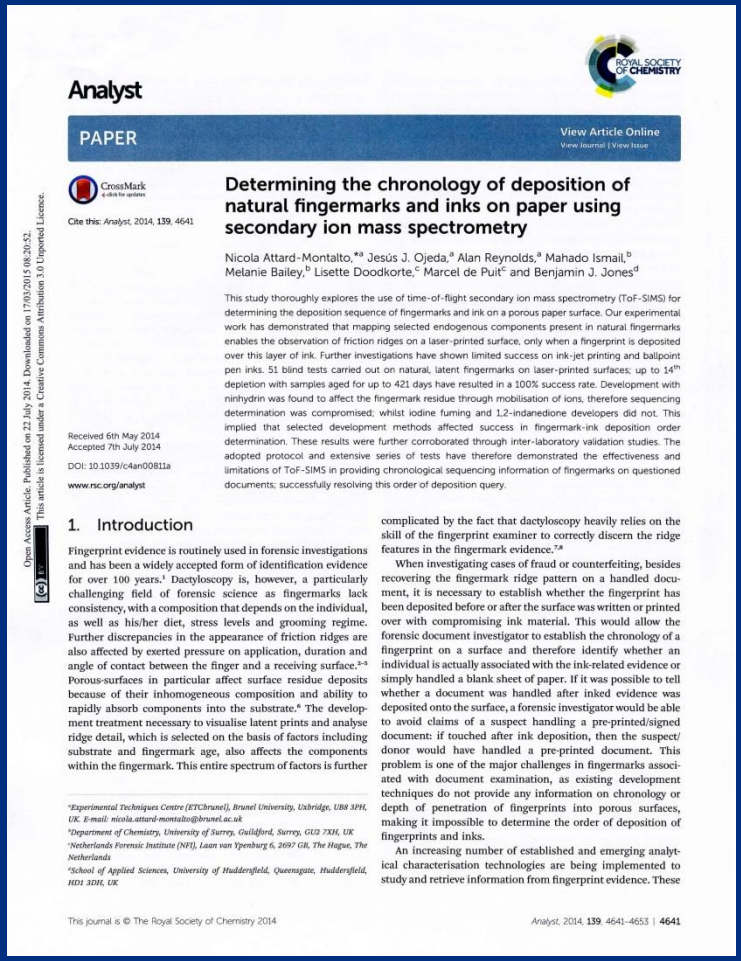


- Comparisons between fresh/aged solutions on split prints showed that after 3 months only S1 showed a significant decrease.

Introduction

- Attard-Montalto N, et al. Determining the Chronology of Deposition of Natural Fingermarks and Inks on Paper Using Secondary Ion Mass Spectrometry. Analyst 2014;139:4641-4653.
- The goal of this effort was to determine the sequence of latent print deposition and toner, inkjet, and ballpoint ink writing.
- Both latent and developed prints (aged ~1 year) were investigated.



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Determining the chronology of deposition of natural fingermarks and inks on paper using secondary ion mass spectrometry

Nicola Attard-Montalto,*[a] Jesús J. Ojeda,[a] Alan Reynolds,[a] Mahado Ismail,[b] Melanie Bailey,[b] Lisette Doodkorte,[c] Marcel de Puit[c] and Benjamin J. Jones[d]

This study thoroughly explores the use of time-of-flight secondary ion mass spectrometry (ToF-SIMS) for determining the deposition sequence of fingermarks and ink on a porous paper surface. Our experimental work has demonstrated that mapping selected endogenous components present in natural fingermarks enables the observation of friction ridges on a laser-printed surface, only when a fingerprint is deposited over this layer of ink. Further investigations have shown limited success on ink-jet printing and ballpoint pen inks. 51 blind tests carried out on natural, latent fingermarks on laser-printed surfaces; up to 14^{th} depletion with samples aged for up to 421 days have resulted in a 100% success rate. Development with ninhydrin was found to affect the fingermark residue through mobilisation of ions, therefore sequencing determination was compromised; whilst iodine fuming and 1,2-indanedione developers did not. This implied that selected development methods affected success in fingermark-ink deposition order determination. These results were further corroborated through inter-laboratory validation studies. The adopted protocol and extensive series of tests have therefore demonstrated the effectiveness and limitations of ToF-SIMS in providing chronological sequencing information of fingermarks on questioned documents; successfully resolving this order of deposition query.

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www.rsc.org/analyst

1. Introduction

Fingerprint evidence is routinely used in forensic investigations and has been a widely accepted form of identification evidence for over 100 years.[1] Dactyloscopy is, however, a particularly challenging field of forensic science as fingermarks lack consistency, with a composition that depends on the individual, as well as his/her diet, stress levels and grooming regime. Further discrepancies in the appearance of friction ridges are also affected by exerted pressure on application, duration and angle of contact between the finger and a receiving surface.[2–5] Porous-surfaces in particular affect surface residue deposits because of their inhomogeneous composition and ability to rapidly absorb components into the substrate.[6] The development treatment necessary to visualise latent prints and analyse ridge detail, which is selected on the basis of factors including substrate and fingermark age, also affects the components within the fingermark. This entire spectrum of factors is further complicated by the fact that dactyloscopy heavily relies on the skill of the fingerprint examiner to correctly discern the ridge features in the fingermark evidence.[7,8]

When investigating cases of fraud or counterfeiting, besides recovering the fingermark ridge pattern on a handled document, it is necessary to establish whether the fingerprint has been deposited before or after the surface was written or printed over with compromising ink material. This would allow the forensic document investigator to establish the chronology of a fingerprint on a surface and therefore identify whether an individual is actually associated with the ink-related evidence or simply handled a blank sheet of paper. If it was possible to tell whether a document was handled after inked evidence was deposited onto the surface, a forensic investigator would be able to avoid claims of a suspect handling a pre-printed/signed document: if touched after ink deposition, then the suspect/donor would have handled a pre-printed document. This problem is one of the major challenges in fingermarks associated with document examination, as existing development techniques do not provide any information on chronology or depth of penetration of fingerprints into porous surfaces, making it impossible to determine the order of deposition of fingerprints and inks.

An increasing number of established and emerging analytical characterisation technologies are being implemented to study and retrieve information from fingerprint evidence. These

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U.S. Department of Homeland Security

United States Secret Service

Results

- Known and blind testing was done during this experiment.
- An inter-laboratory validation experiment was conducted using blind samples developed by dipping in either ninhydrin or 1,2-indanedione.
- With toner printed documents, it was possible to determine that a print was deposited over the toner by elevated Na^+ ion counts.
- Blind testing (51 FOI/FUI samples) resulted in 100% success.
- Less success was found with inkjet printed documents. Neither fresh nor aged samples could be reliably sequenced.
- Since inkjet inks are applied as “wet” solutions, they are absorbed by the paper fibers along with the latent print residue.

Results

- With ballpoint inks, some elevated Na^+ ion levels were noted for FOI examples; overall results were somewhat inconsistent.
- Processing samples with ninhydrin lead to a smearing effect which made for inconclusive interpretations. Similar results noted with a spray version of ninhydrin.
- Iodine fuming did not negatively affect FOI/FUI determinations.
- K^+ ions present over the toner printing indicated FOI samples – even after processing with 1,2-indanedione; absence indicates FUI.
- Prediction models worked only with toner printed documents.

Introduction

- Amata B, Aprea GM, Chiuri A, Zampa F. Fingerprint on Trigger: A Real Case. Forensic Sci Int 2015;253:e25-e27.
- This is a Case Report that documents the development of a latent print on the trigger of a pistol – in this case a Mauser Werke 90 DA (9 mm Parabellum).
- The weapon was stored for eight months (in controlled conditions) prior to processing for LPs.

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Case Report

Fingerprint on trigger: A real case

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Casework

ABSTRACT

The results obtained by employing a usual technique for latent prints development on firearms are presented. A fingermark on a trigger was enhanced and this print was used to identify the person who handled the firearm. Indeed, it is not usual to find a useful fingermark in that position and, more in general, on firearms because of many different factors described in the following sections. The uniqueness of the results reported in this paper allow to consider the present casework as very interesting for the forensic community.

1. Introduction

Latent print examiners often deal with firearms used to commit several crimes. Guns are the most usual firearms recovered on a crime scene and the practitioners employed in forensic laboratories are very much interested in recovering the maximum amount of information from these evidences. Indeed they represent the object of several analysis performed by the forensic laboratories: they can be swabbed in order to look for a DNA profile, several chemical treatments can be performed in order to recover latent prints, GSR can be found if they shot, they can be analyzed by ballistic practitioners in order to identify the weapon, etc. Several publications report studies based on experimental comparison between these techniques, and discuss the correct sequence of analyses and treatments to perform when you deal with firearms [1–4] and cartridges [5].

Let us focus our attention on the fingerprint laboratories where metallic non-porous items are usually treated with super glue fuming methods [6], but these are not the only treatments proposed in literature [7]. Indeed it is unknown which process is the most effective on these substrates and it is widely recognized by the practitioners employed in the fingerprint laboratories that the probability to obtain a useful fingermark on a firearm, and more precisely on a trigger, is very low. Besides this experience reached in the forensic laboratories, the same conclusions were reported even on several scientific papers recently published. Precisely, a recent study performed on hundreds of firearms, and thousands of cartridges, showed that the print recovery rate on these evidences is very low [8]. Let us stress this point by reporting a result of this study: identifiable prints were developed only on the 13% of the treated firearms, and the rates are lower when the cartridges are considered. Even though this study cannot be thought as a universal guideline, it certainly provides a numerical description of the problems to be faced with these kind of evidences.

Factors affecting the low recovery probability of fingerprints on firearms could be classified as "external" or "technical". The first ones, widely studied and discussed in literature [8,9], are: the atmospheric conditions, environmental factors, the condition of the metal and its particular chemical/physical properties (e.g. the Glock pistols are made of polymers instead of metal), the finish (i.e. surface coating) applied to the metal surface, the packaging system, etc. The second ones are related to several peculiarities characterizing the fingermark deposition on the evidence. In fact, even though the trigger should be very probably touched by the person who handle the firearm, it is very unusual to develop useful fingermark on it. That particular area can be touched several times and this can cause the superposition of more friction ridges or their removal. Furthermore, it should be considered even the fact that the fingermarks eventually developed on the trigger are usually very small and, hence, not comparable.

All of the factors described in this section allow to conclude that firearms are usually considered as not useful evidences.

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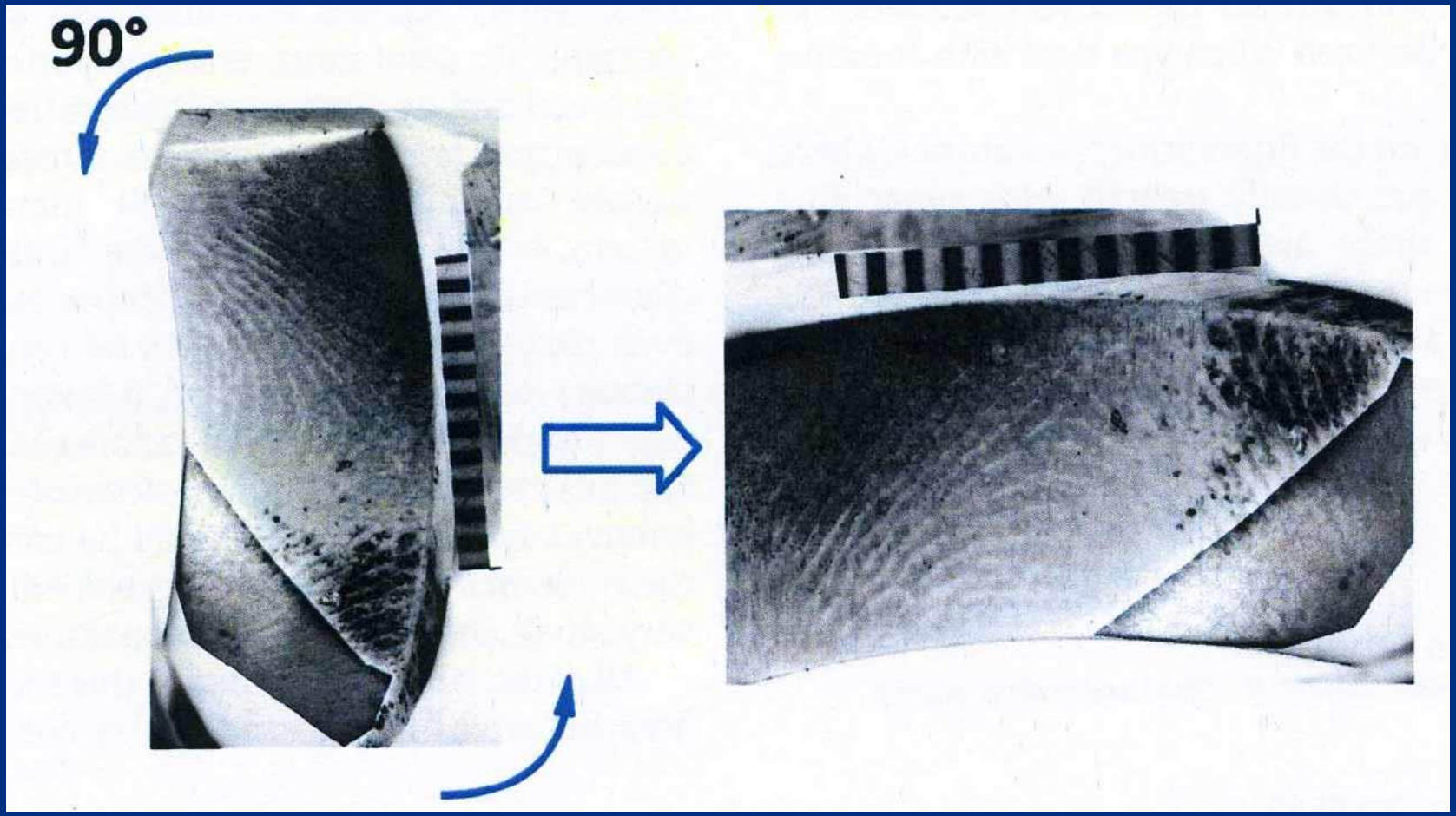
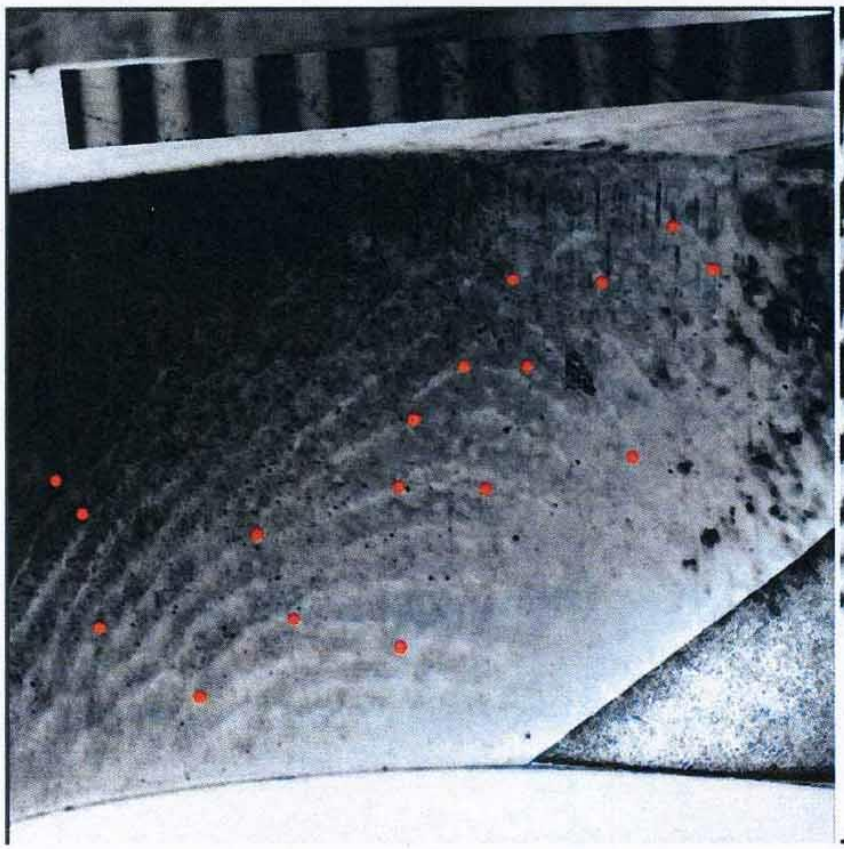
United States Secret Service

Results

- The LP recovery rates cited for weapons are quite low – typically less than 10%.
- Many factors can be responsible: environmental conditions; polymer vs. metal composition; finish/surface coating; packing conditions.
- Recovery of LPs on triggers is also difficult: small surface area and multiple overlapping impressions are possible.
- Weapon was first processed using white light and UV radiaition – no results.
- The weapon was processed with CA and a print was developed on the trigger; print was of sufficient quantity/quality to match a suspect.


90°



Introduction

- Templeton JEL et al. DNA Profiles from Fingermarks: A Mock Case Study. Forensic Sci Int:GSS 2015;5:e154-e155.
- The goal of this project was to optimize a DNA swabbing technique and to evaluate the use of direct PCR to amplify touch DNA from latent prints in mock case studies.
- Surfaces included wood knife handles; glass; masking tape; and brass/aluminum/nickel cartridge cases.

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DNA profiles from fingermarks: A mock case study

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ABSTRACT

Environmental factors and subsequent PCR inhibitors may affect the ability to retrieve DNA from handled objects. A poor quality DNA profile results from low DNA template or modifications imposed on the template (damage or degradation) prior to amplification. In this study, we show that direct PCR has the ability to amplify 'touch' DNA from uncleaned, handled, substrates following exposure to various environmental conditions. A variety of items ($n = 90$), ranging from metal cartridge cases, glass, tape and wood were touched briefly (less than 15 s) by 4 volunteers, exposed to the environment overnight, and in one case for 8 days, and tested for the presence of surviving DNA. Informative DNA profiles were obtained from 49 out of the 90 items (a success rate of 54%), with glass having the highest rate of DNA recovery.

1. Introduction

Since its inception, research on 'touch' DNA samples has suffered from the problem that preserved endogenous DNA is often limited in quantity [1] and in various states of degradation [2]. It has been found that a significant number of crime-related surfaces, even though they should have DNA present, do not necessarily yield analytically useful material [3]. In natural conditions DNA is a hydrated macromolecule but outside its natural environment DNA becomes the target of several physical and chemical reactions [4]. There may be no surviving DNA left to capture on a handled object if the DNA is exposed to elements of heat, humidity, ultra violet (UV) light and bacterial growth, typical of an outdoor environment. Under these circumstances, standard protocols for swabbing and extracting 'touch' DNA from these items often recover sub-optimal levels of trace nuclear DNA [3] that can result in a poor quality STR-based DNA profile or no profile at all. The aim of this study is to determine the value of using the optimised swabbing technique [5] and direct PCR at amplifying 'touch' DNA from fingermarks as part of a mock case study.

2. Materials and methods

A number of precautions were taken for the handling and processing of 'touch' DNA samples; these have been extensively described elsewhere [5]. Four volunteers touched various substrates (wooden knife handles, glass, masking tape, brass cartridge cases, aluminium cartridge cases and nickel cartridge cases) for less than 15 s, before the items were left out-side in a shrub bed area. An indoor glass door was touched for less than 15 s to create fingerprint; these samples were not subjected to external conditions but were left for the same time period as other samples in the study. Substrates were not cleaned prior to touching to ensure results were as realistic as possible and to determine the extent of mixed DNA profiles. Environmental conditions were monitored. Sampling was repeated in triplicate for each volunteer. Twenty four hours later, or 8 days later (sample study 5), items were collected/processed ($n = 90$) and for wood, glass and cartridge cases a targeted swabbing approach was used [5] subsequent to direct PCR. For masking tape, a 2 cm^2 section of tape was placed into a 1.5 mL Eppendorf tube containing Triton X buffer at 0.1% (Sigma, VIC, AU) and heated at 50 °C for 1 h, vortexed and 10 μL of this lysis buffer was added directly to the PCR tube in place of water/DNA. Amplification conditions followed the NGM™ Select kit (ABI, VIC, AU) guidelines in a final 25 μL reaction volume, plus 1 μL Prep-N-Go buffer™ (ABI) and 1 μL AmpliTaq Gold 360 Polymerase (ABI) per reaction. Amplification was for 30 PCR cycles. PCR products were run on the 3130xl (ABI) genetic analyser. Profiles were analysed using the GeneMapper ID v3.2 software and a peak amplitude threshold of 50 relative fluorescent units (RFU) was used to assign alleles. Informative profiles were recorded as >12 alleles called (plus Amelogenin) that match the donor.

3. Results and discussion

Certain substrates, such as brass cartridge cases (alloy of copper and zinc), present difficulties for DNA recovery (see Table 1). From

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U.S. Department of Homeland Security

United States Secret Service

Results

- DNA can be susceptible to many factors: e.g., heat, humidity, UV radiation, bacterial growth.
- Four volunteers; 15 s touch time; 24 hour/8 day aging of depositions.
- It was difficult to extract DNA from the brass surface; glass had the highest rate of DNA recovery (followed by masking tape, nickel, wood, and aluminum).
- Mixed profiles were obtained in some cases because substrates were not cleaned prior to sample deposition (however – the major donor was obtained in all of these cases).
- Optimized swabbing and direct PCR (no extraction) allowed for recovery of DNA from samples exposed briefly to UV/rain.

Table 1
Results for the number of single source profiles, mixtures, and the number of interpretable DNA profiles in each category for the NGM SElect™ directly amplified samples.

DNA types detected	Substrates handled					
	Glass	Wooden knife handles	Masking tape	Brass cartridge cases	Nickel cartridge cases	Aluminium cartridge cases
Total interpretable profiles 15 = no. of alleles	13/15 (87%)	8/15 (53%)	11/15 (73%)	0/15 (0%)	9/15 (60%)	8/15 (53%)
Informative single source profiles	38%	50%	64%	0%	89%	75%
Informative mixed profiles	62%	50%	36%	0%	11%	25%
Donor identified	87%	53%	73%	0%	60%	53%

Table 2
Summary of the mock case work conditions and overall profiling success rates for substrates exposed to varying environmental conditions over-night and in one case 8 days (study 5*).

Category	Environmental conditions during the 24 h time period or 8 days (study 5*)					Total number of samples (out of 15)	Interpretable profiles (out of 15)	Profiling success (%)
	Temp. range (°C)	Relative maximum humidity (%)	Max. wind speed (km/h)	Average rain fall (mm)	UV index			
Volunteer 1 study	11–17 Av: 15	88	30	0	4	15	14	93
Volunteer 2 study	12–17 Av: 14.5	71	39	5.8	2	15	9	60
Volunteer 3 study	5–16 Av: 10.5	58	24	0.6	3	15	8	53
Volunteer 4 study	8–16 Av: 12	61	39	4.8	2	15	11	73
Volunteer 1 study 5*	1–19 Av: 10	94	30	3.6	3	15	7	46

Introduction

- Davis LWL, Kelly PF, King RSP, Bleay SM. Visualisation of Latent Fingermarks on Polymer Banknotes Using Copper Vacuum Metal Deposition: A Preliminary Study. Forensic Sci Int 2016; article in press.
- The goal of this project was to determine whether or not copper VMD and rubeanic acid could be used to visualize latent prints on polymer banknotes.

G Model
FSI-8490; No. of Pages 7

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Rapid Communication

Visualisation of latent fingermarks on polymer banknotes using copper vacuum metal deposition: A preliminary study

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ABSTRACT

The UK's recent move to polymer banknotes has seen some of the currently used fingermark enhancement techniques for currency potentially become redundant, due to the surface characteristics of the polymer substrates. Possessing a non-porous surface with some semi-porous properties, alternate processes are required for polymer banknotes. This preliminary investigation explored the recovery of fingermarks from polymer notes *via* vacuum metal deposition using elemental copper. The study successfully demonstrated that fresh latent fingermarks, from an individual donor, could be clearly developed and imaged in the near infrared. By varying the deposition thickness of the copper, the contrast between the fingermark minutiae and the substrate could be readily optimised. Where the deposition thickness was thin enough to be visually indistinguishable, forensic gelatin lifters could be used to lift the fingermarks. These lifts could then be treated with rubeanic acid to produce a visually distinguishable mark. The technique has shown enough promise that it could be effectively utilised on other semi- and non-porous substrates.

1. Introduction

The United Kingdom's decision to change from traditional cotton paper banknotes to a biaxially orientated polypropylene (BOPP) polymer type note has three principal benefits. Being plastic, they are more resistant to dirt making them a cleaner alternative. They are harder to counterfeit due to the incorporation of advanced security features and they are more durable, meaning that, long-term, they are cheaper and more environmentally friendly. Despite polymer banknotes being non-porous, they also exhibit semi-porous qualities due to the printing materials and surface coatings used. In turn, this has the tendency to result in increased absorption/wicking of a fingermark residue from the surface. This, coupled with the fact that the notes often have complex designs and fluorescent security features, means that most traditional non-porous fingerprint techniques encounter difficulties developing marks on such substrates.

Many countries around the world have already introduced polymer banknotes in to circulation, with Australia being the first to do so in 1988. The main difficulty with polymer banknotes in terms of latent fingermark enhancement is that, although the base polymer is BOPP with an opacifying layer, changes to printing and overcoating layers introduce variables that may alter the effectiveness of the detection sequence. Accordingly, numerous fingermark enhancement investigations have been conducted since their introduction. In 1999, Flynn et al. trialled a number of fingermark enhancement techniques that were, at the time, commonly employed for fingermark enhancement on non-porous substrates and found that the majority were only effective in developing marks for a short time post-deposition. Cyanoacrylate fuming (CAF) and vacuum metal deposition (VMD) were found to be the most successful of the techniques investigated, although results were often limited by the area of the polymer note being treated. Enhancement was found to be improved when a combination of the two was used [1]. When treating polymer banknotes, it was found that fingermarks which were present on the untreated transparent security window area were developed to a greater degree than those on the printed areas [1–4]. In accordance with these findings, and following further evaluation, the processes CAST (Centre for Applied Science and Technology) currently recommend for Biaxially Orientated Polypropylene (BOPP) banknotes are depicted in Fig. 1, although the effectiveness of Powder Suspension followed by Basic Violet 3 is unknown [5].

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0379-0738/

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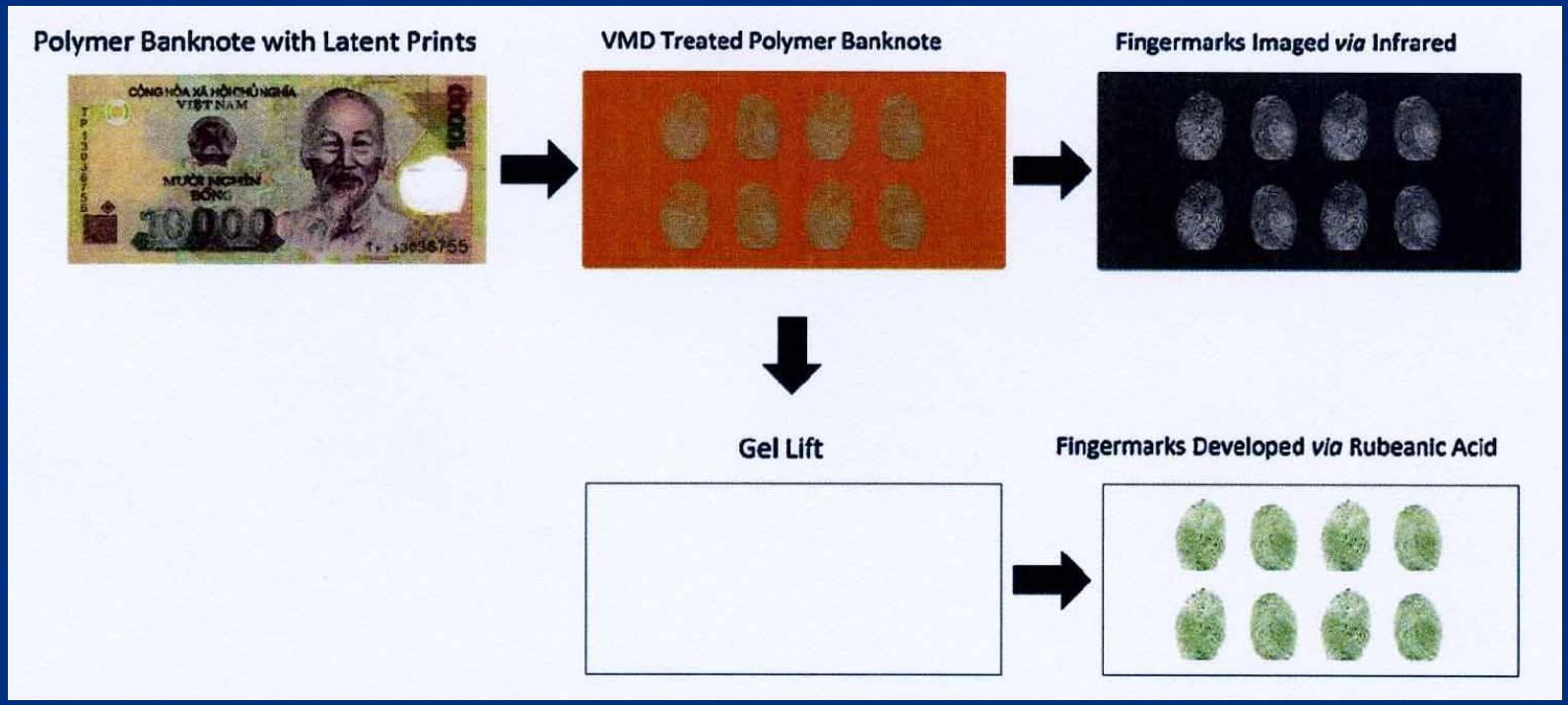
United States Secret Service

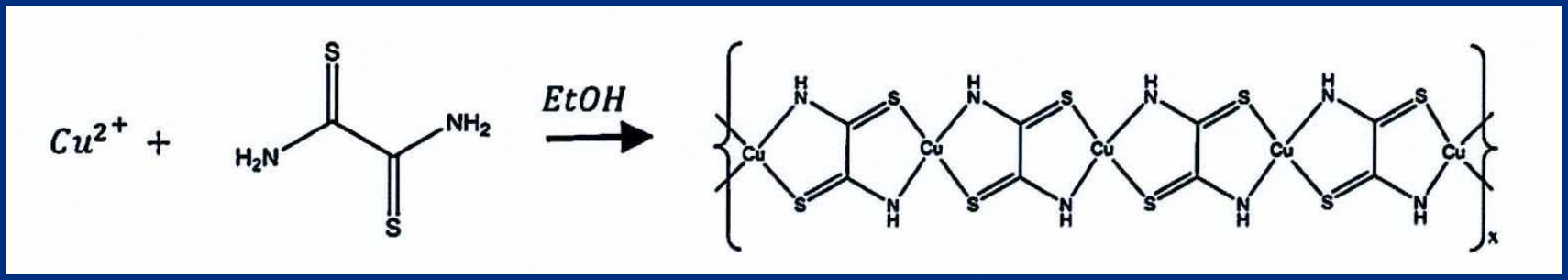
Results

- New UK polymer banknotes are made with biaxially oriented polypropylene.
- Several countries have completely switched from traditional cotton/linen paper to polymer notes (e.g., Australia, Canada).
- An Australian study published in 1999 recommended CA fuming and VMD or a combination of the two methods.
- Canadian study
- Use of NIR fluorescent powders (either Vis → NIR or NIR → NIR) reported by King et al.

Results

- 24 banknotes; one donor; total of 240 latent prints used; one day old.
- 1.0 mm copper wire used; Cu film thickness varied from 0.2 – 3.0 nm.
- Copper prints were lifted onto white gel lifters (1-2 min contact time) and then treated with 0.1% w/v rubeanic acid (dithiooxamide).
- Copper layer thicknesses above 1.6 nm worked best (at 3.0 nm overdevelopment was observed); after spraying the gel lifter, dark green polymer, copper rubeanate, is formed.
- Developed prints were imaged in the NIR (780 nm long pass filter) as reflected NIR (LPs appear white) or on gel lifter using white light (LPs appear dark green).


Polymer Banknote with Latent Prints
VMD Treated Polymer Banknote
Fingermarks Imaged *via* Infrared
Gel Lift
Fingermarks Developed *via* Rubeanic Acid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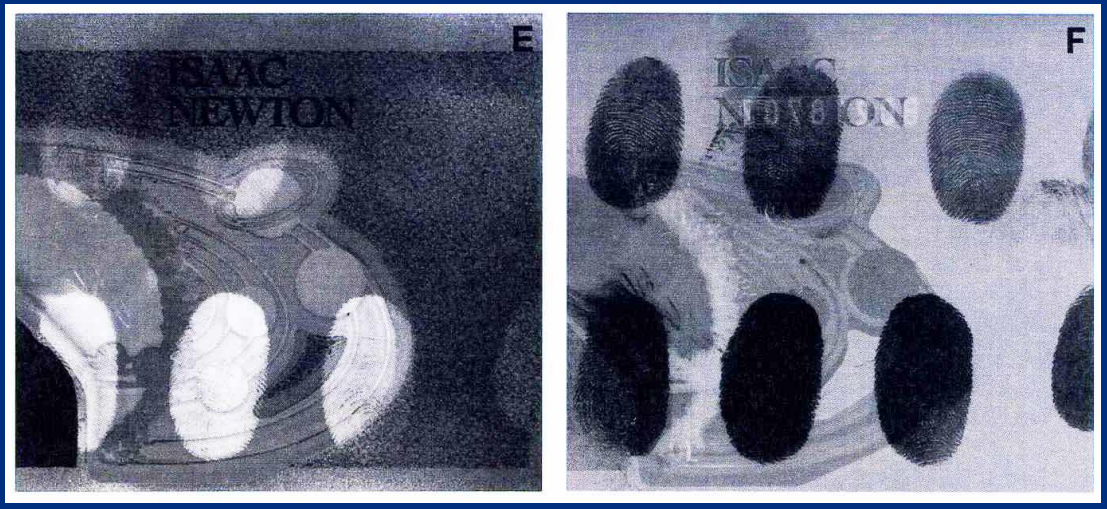
NH_2
EtOH



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Introduction

- King RSP, Hallett PM, Foster D. NIR-NIR Fluorescence: A New Genre of Fingermark Visualisation Techniques. Forensic Sci Int 2016;262:e28-e33.
- The goal of this effort was to determine the efficacy of using NIR → NIR fluorescent powders on a range of non-porous and a few porous substrates.
- NIR excitation limits background fluorescence; improves contrast.

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Rapid Communication

NIR–NIR fluorescence: A new genre of fingermark visualisation techniques

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Powder
Cuprorivaite
Polymer banknote

ABSTRACT

A preliminary study reveals that finely divided cuprorivaite powder may be used to efficiently develop and subsequently image latent fingermarks across a range of highly patterned, coloured non-porous and semi-porous substrates using near infrared illumination and imaging. Problematic multi-coloured backgrounds provide very little interference under the illumination conditions used, and invoked fluorescence observed, when using this material. This is the first reported example of a NIR–NIR fluorophore for use within latent fingermark visualisation and offers the potential for application at the scene and in the laboratory.

1. Introduction

Forensic fingerprint powders remain a crucial and effective tool in the development of latent fingermarks across a range of substrate types. Despite being one of the oldest and most widely used fingermark visualisation techniques, [1–3] fingerprint dusting powders offer significant versatility in terms of their colour, method of application and ability to, for the most part, not interfere with subsequent fingermark processing using chemical-based reagents. Fingerprint powders are exceptionally useful in their capacity to be deployed rapidly both at the crime scene and in the laboratory, whilst taking up very little space in the practitioners' arsenal. The art of powdering surfaces to develop latent fingermarks has changed little over recent years. Real advances have come in the form of their incorporation within magnetic matrices, fluorescence characteristics designed to allow greater contrast between fingermark and background and the development of more 'specific' reagents which may have some sort of affinity for a particular constituent within the latent residue. [4–6]

The most important consideration when developing latent fingermarks using traditional powders is selecting a powder that provides the maximum contrast in relation to the background surface to which it is being applied. [7] Unfortunately, in the complex environment that surrounds us, most surfaces are not of uniform colour or pattern, meaning that the choice of fingerprint powder can become extremely limited; on a black and white substrate, for example, a white or black powder would only clearly develop ridge detail that could be readily visualised on the contrasting colour to which it is applied. In an effort to overcome such barriers, research groups and manufacturers have sought to develop luminescent powders whose fluorescence can be viewed upon excitation with an appropriate light source and blocking filter (often worn in the form of goggles). [7,8] The advantage of such powders is that the (multi)coloured, or patterned, nature of the background becomes slightly less significant owing to the independent fluorescence of the powder. Therefore, it is hoped that developed fingermarks fluoresce independently to the surface they are being viewed on, thereby reducing the variable-contrast issue that would arise if non-fluorescent powders were used [9].

The majority of commercially available luminescent fingerprint powders work on the notion that their optical properties enable them to fluoresce somewhere within the visible part of the spectrum, that is 400–700 nm, usually upon excitation with ultraviolet (UV) light (such as those manufactured and/or distributed by Lightning Powder Company, Tetra Scene of Crime and Sirchie, for example). Although inherently this serves as a useful property of the bulk material itself, a major limitation and drawback arises when the powders are applied to unusually coloured, multi-coloured and/or patterned backgrounds whose intrinsic formulations (inks, binders, coatings, etc.) also cause them to fluoresce within the same area of

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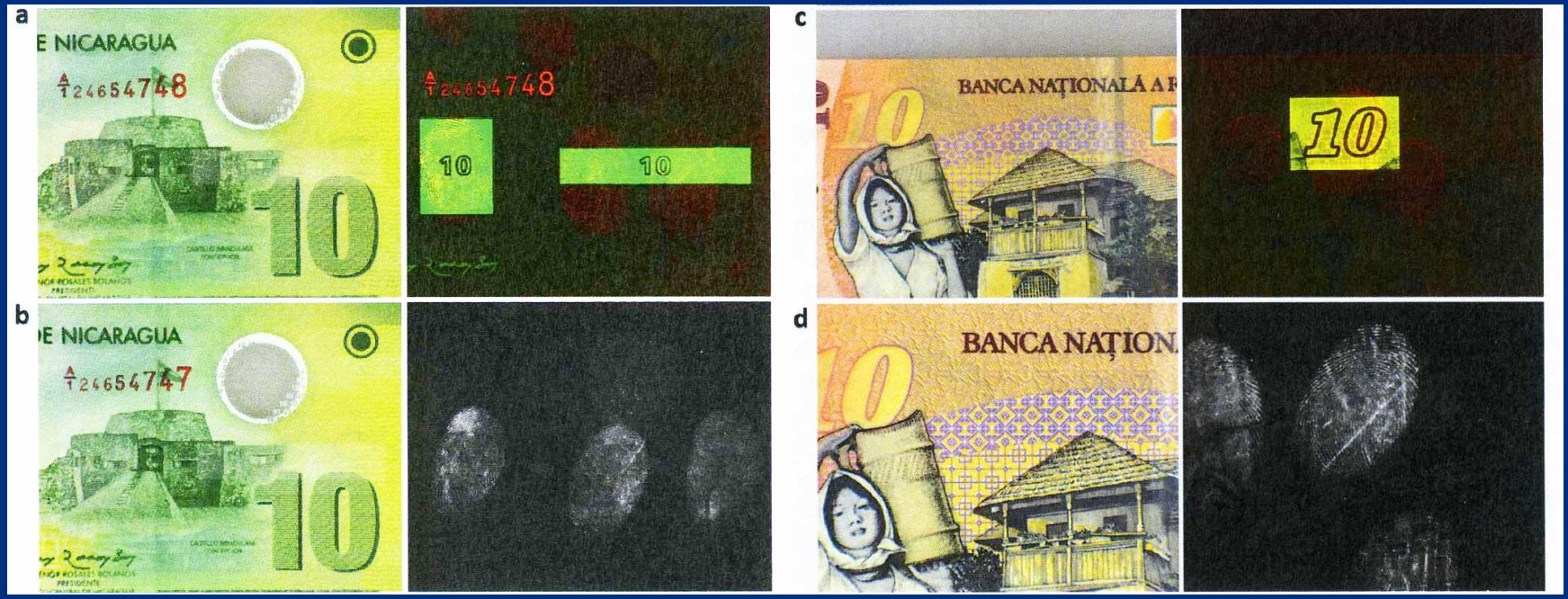
0379-0738/

U.S. Department of Homeland Security

United States Secret Service

Results

- Cuprorivaite ($CaCuSi_4O_{10}$) is a light blue colored powder that can be excited in the visible (637 nm) or NIR (780 nm); emission at 910 nm.
- Particle size: d_{50} = 6.3 µm; d_{90} = 21.1 µm; mean = 9.3 µm.
- 10 donors; ~300 LPs total; multiple substrates including: polymer banknotes, metals, glossy paper, glass, plastics, wrapping paper, etc.
- LPs were between fresh – 7 days old; aging studies using polymer banknotes developed LPs up to 17 days (3 days on paper currency).
- Strong fluorescence intensity; exceeded that of *spirulina platensis*.
- Compared to aluminum flake, black onyx, and white powders; no appreciable difference noted; superior contrast in NIR.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Introduction

- Gardner SJ, Cordingley TH, Francis SC. An Investigation into Effective Methodologies for Latent Fingerprint Enhancement on Items Recovered from Fire. Sci & Just 2016;56:241-246.
- The goal of this project was to evaluate the effectiveness of soot removal methods and latent print development techniques following exposure of LPs to fire and elevated temperatures.

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An investigation into effective methodologies for latent fingerprint enhancement on items recovered from fire

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ABSTRACT

A common assumption is that fire destroys fingerprint evidence. Recent studies have sought to challenge this assumption. This study presents a comparative evaluation of soot removal and fingerprint enhancement techniques, following fire(s) to ascertain optimal process efficacy for recovering fingerprints. Two car burns and a cremation oven were used to determine the temperature range. Temperatures of 300, 450 and 600 °C were used in simulated, controlled fires wherein cars had prints deposited on rear view mirrors. Burning occurred in a shipping container designed to approximate the variables relating to car arson. Soot removal was undertaken by tape lifting, sodium hydroxide solution, or liquid latex casting. The fingerprint enhancement techniques comprised black magnetic, aluminium and black suspension powders, or cyanoacrylate fuming with BY40 dye. A fingerprint expert classified prints as un/identifiable according to standards to be submitted as evidence in court. Multinomial logistic regression analyses were performed on the data using a p value of <0.05 to determine statistical significance. Temperature was the biggest factor affecting fingerprint recovery. There were no statistically significant differences found between any of the soot removal methods used. Higher counts of identifiable prints were recovered with black magnetic powder and cyanoacrylate/BY40 compared to the other methods used but these findings were not statistically significant. It is recommended that recovery of fire-exposed fingerprints (which are not protected) is undertaken where suspected maximum temperatures are <450 °C. Evaluation of optimal soot removal and fingerprint enhancement techniques should be conducted on a case by case basis.

1. Introduction

Arson, or the international use of fire to damage property, is a significant issue worldwide [1]. Natural fires, particularly Bushland fires in Australia are a regular occurrence, especially in the summer months, where temperatures can reach 50 °C (World Meteorological Organization (Accessed [12]).

Currently in Queensland, Scenes of Crime Officers do not collect items for prints if they have been involved in a fire largely due to the 'limited success of developing identifiable prints on surfaces subjected to fire' [8].

Previous studies have shown that fire/heat exposed fingerprints can be recovered [2–7]. Similar studies have not yet taken place in Australia.

This study aimed to look at the effectiveness of current soot removal and fingerprint enhancement techniques following the exposure of prints to fire at various temperatures and to put previous work into operational context in Australia.

A complication that is often encountered following a fire is the presence of a layer of soot, partially or completely covering the print. A range of soot removal techniques have been investigated by Bleay et al. [2] and Stow and McGurry [11]. The use of light brushing, tape lifting, silicon rubber casting, sodium hydroxide solution, an eraser and Absorene were all tested on porous and non-porous soot covered surfaces with some success.

Fingerprint components such as amino acids, lactic acid and fats possess a limited tolerance to exposure to extreme conditions [9]. In contrast, salts are capable of withstanding increased heat [10].

Dominick et al. [7] noted that temperature and time of exposure had a significant effect on fingerprints on glass and ceramic objects which exposed to direct heat and air flow did not survive temperatures of 350 °C and over.

Bleay et al. [2] stated that marks are much more likely to survive if the exhibit has not been exposed to temperatures >300 °C and if they have been protected in some way from the direct effect of heat and smoke. They also found that the effectiveness of powder and powder suspension methods decreased significantly when the print was exposed to temperatures in excess of 200 °C whilst cyanoacrylate fuming was effective until the temperature climbed >500 °C.

Deans [5] found that ridge detail was visible on prints exposed to temperatures of around 500 °C with cyanoacrylate fuming but that this was a 'noteworthy exception'.

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1355-0306/

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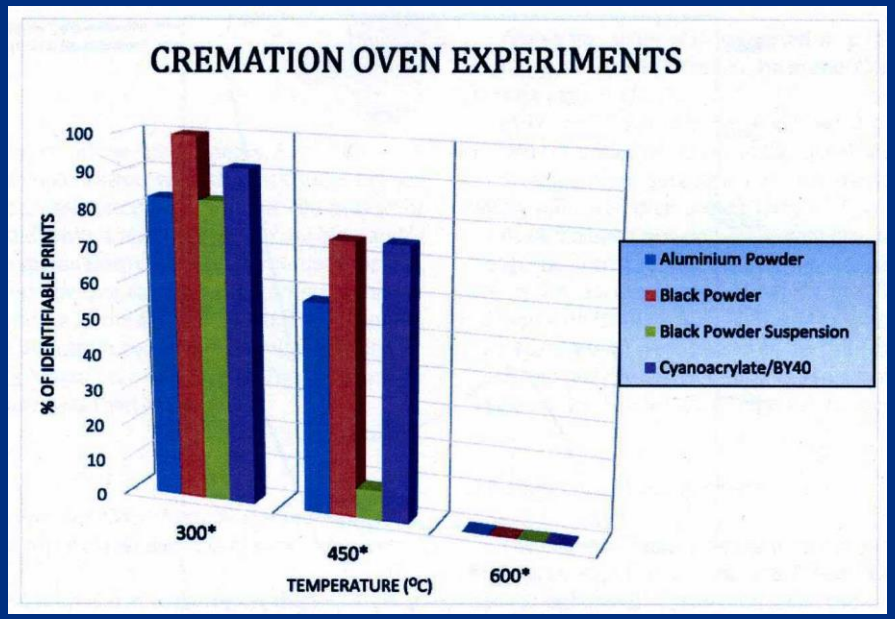
United States Secret Service

Results

- 4 donors; car rear view mirrors used as substrates; triplicate LPs.
- Additional mirrors exposed to 300°C, 450°C, or 600°C; 5-15 min.
- 5-SSA/NaOH solution, Mikrosil™, tape lifting used for soot removal.
- Black magnetic powder, aluminum powder, magnetic iron oxide powder suspension, and CA fuming/BY40 used to develop LPs.
- Magnetic powder and CA fuming recovered 30% and 29% identifiable prints; aluminum and black powders recovered19% and 16% over the range of three temperatures.
- Similar results observed the simulated fire experiments.
- No differences found in success of three methods for removing soot.


CREMATION OVEN EXPERIMENTS
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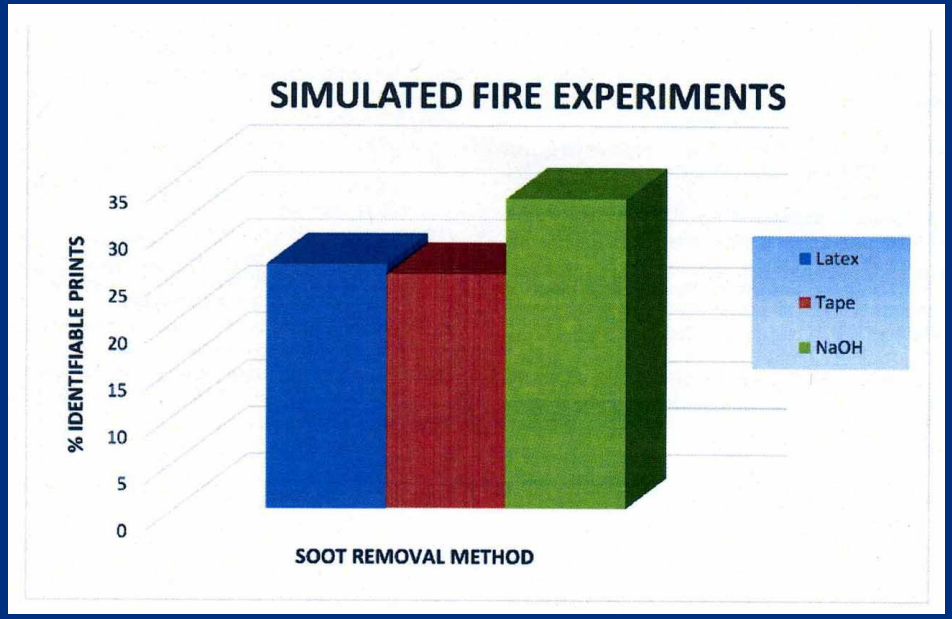
Aluminium Powder
Black Powder
Black Powder Suspension
Cyanoacrylate/BY40


SIMULATED FIRE EXPERIMENTS
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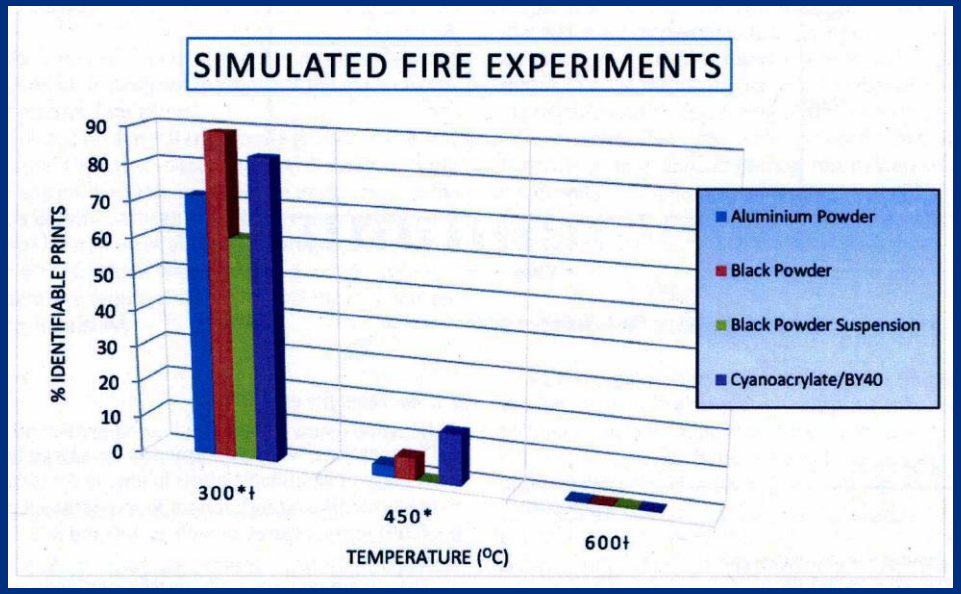

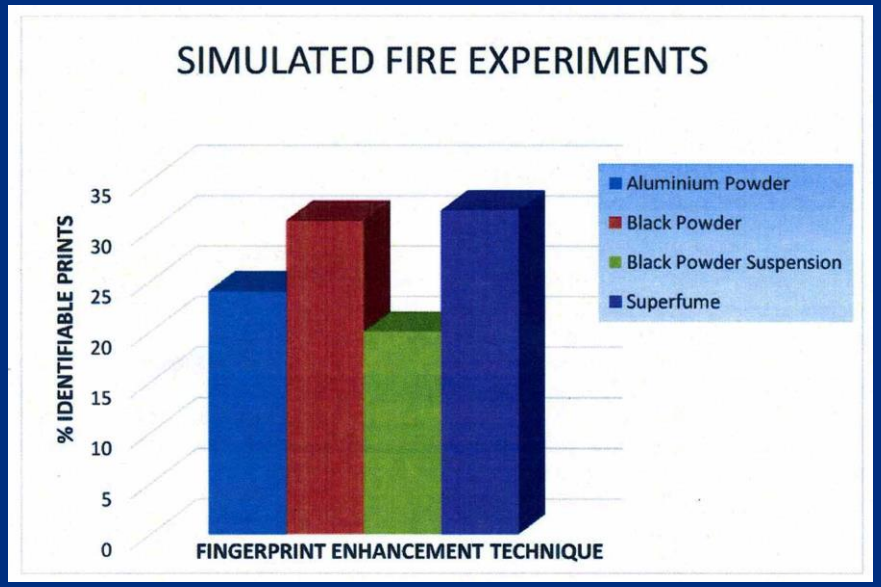

U.S. Department of Homeland Security

United States Secret Service

Introduction

- Hong S, Hong I, Han A, Yi Seo J, Namgung J. A New Method of Artificial Latent Fingerprint Creation Using Artificial Sweat and Inkjet Printer. Forensic Sci Int 2015;257:403-408.
- The goal of this project was to create a new method for creating a realistic artificial latent print using a modified sweat formulation and inkjet printer.

Forensic Science International 257 (2015) 403–408

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Technical Note

A new method of artificial latent fingerprint creation using artificial sweat and inkjet printer

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Inkjet
Amino acid
Photoluminescence

ABSTRACT

In order to study fingerprinting in the field of forensic science, it is very important to have two or more latent fingerprints with identical chemical composition and intensity. However, it is impossible to obtain identical fingerprints, in reality, because fingerprinting comes out slightly differently every time. A previous research study had proposed an artificial fingerprint creation method in which inkjet ink was replaced with amino acids and sodium chloride solution: the components of human sweat. But, this method had some drawbacks: divalent cations were not added while formulating the artificial sweat solution, and diluted solutions were used for creating weakly deposited latent fingerprint. In this study, a method was developed for overcoming the drawbacks of the methods used in the previous study. Several divalent cations were added in this study because the amino acid-ninhydrin (or some of its analogues) complex is known to react with divalent cations to produce a photoluminescent product; and, similarly, the amino acid-1,2-indanedione complex is known to be catalyzed by a small amount of zinc ions to produce a highly photoluminescent product. Also, in this study, a new technique was developed which enables to adjust the intensity when printing the latent fingerprint patterns. In this method, image processing software is used to control the intensity of the master fingerprint patterns, which adjusts the printing intensity of the latent fingerprints. This new method opened the way to produce a more realistic artificial fingerprint in various strengths with one artificial sweat working solution.

1. Introduction

Since the past 100 years, fingerprints are being used as a physical evidence for identification [1]. Despite the enormous use of DNA profiling techniques in recent times, the importance of fingerprints as a physical evidence has not diminished [2]. However, law enforcement agencies encounter many difficulties while collecting fingerprints from the crime scene, because most fingerprints at the crime scene are latent ones; so, they are invisible to the naked eye [3,4].

Paper, a porous surface, is one of the most frequently encountered physical evidence in a crime scene [5]. Many forensic scientists around the world have developed optical [6], physical [7], and/or chemical techniques [9] for the visualization of latent fingerprints from paper. In this stage, only when two or more standard latent fingerprints are deposited on the same paper can we prove the superiority of a newly developed method over the existing one. A single standard latent fingerprint on a paper can be easily prepared by touching a paper with a sweaty finger, after washing it with soap and water. However, obtaining two or more identical standard latent fingerprints is practically impossible because the amount of sweat deposited on a paper varies considerably depending on many factors, such as ambient conditions, donor states, (physical and psychological states), deposition methods, time etc. [1,10].

As the next best alternative, researchers have stamped a single natural fingerprint in the center of a surface and then divided this stamped fingerprint into several equal parts [1,2,11–13]. These divided pieces of latent fingerprints are then treated with a different process, and the results are compared. However, this method cannot ensure that the sweat of the fingerprint gets uniformly deposited on the surface of a paper, because there could be uneven distribution of sweat in a single fingerprint stamped on the paper. This uncertainty is associated with several factors, such as the variation of touching pressure, movement at the moment of touch, touch angle etc. [1,10]. To minimize this uncertainty, the test can be repeatedly performed with several fingerprints, and the results can be analyzed using statistical methods. But, this would

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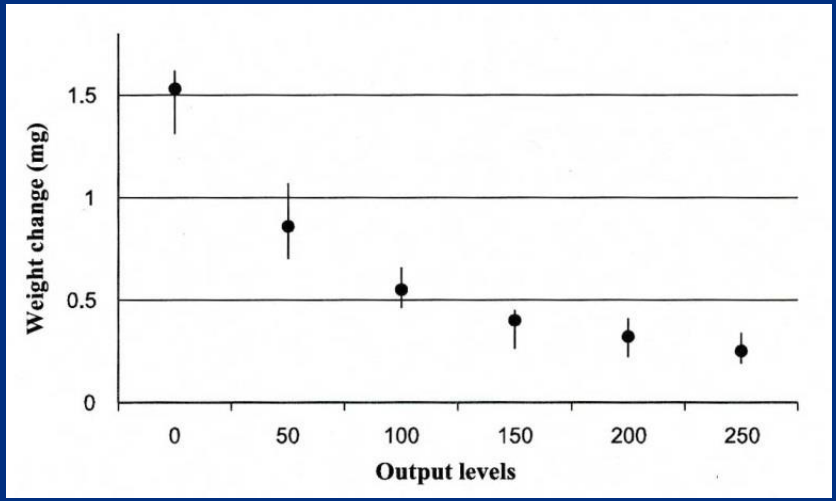
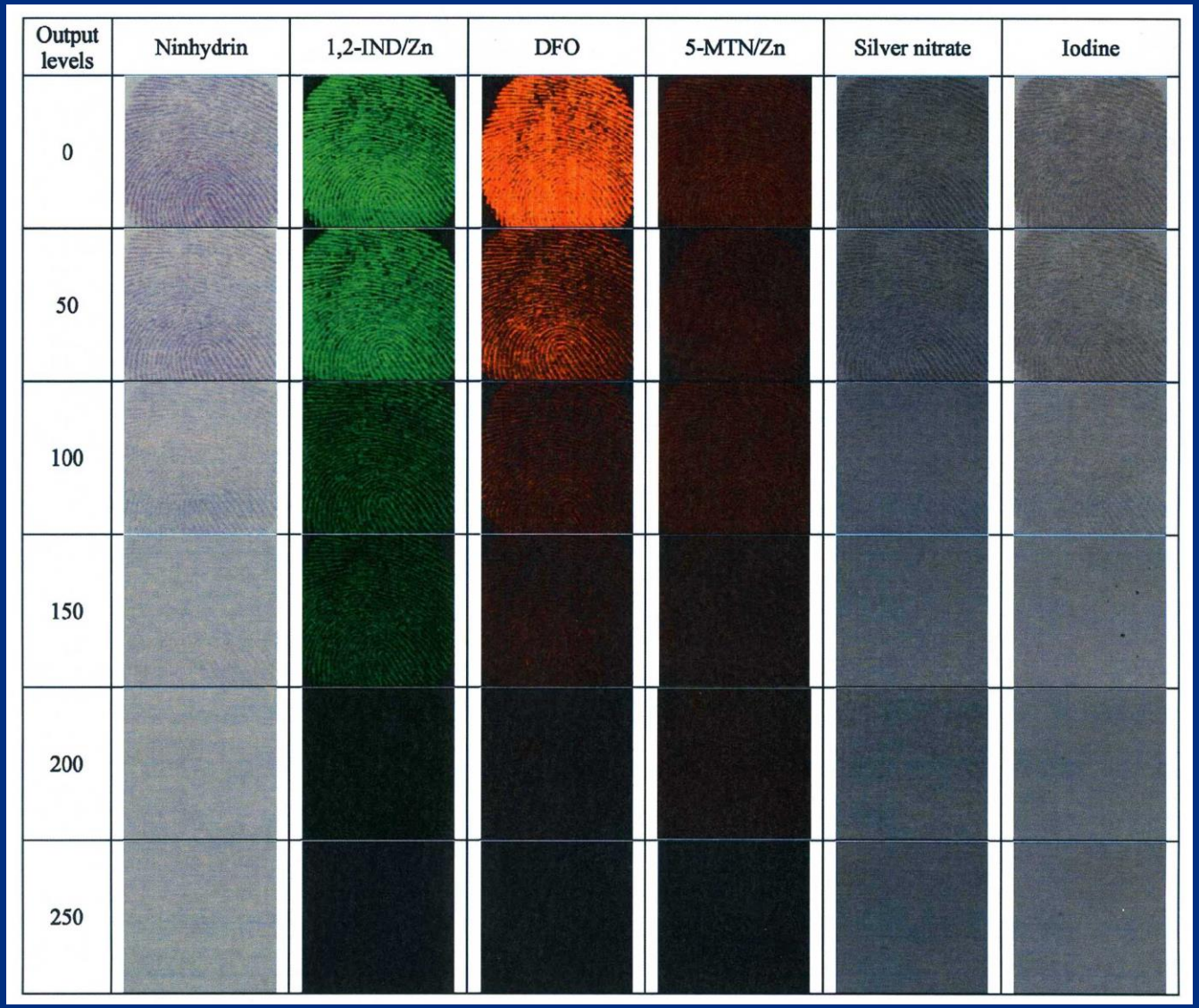
Results

- Epson K100 inkjet printer; Epson i300 refillable ink cartridges.
- Silver nitrate, DFO, ninhydrin, 5-MTN, iodine fuming, and 1,2-indanedione (post $ZnCl_2$ treatment) used to develop artificial LPs.
- Single artificial LP solution used.
- Six output levels used to simulate depleted LPs: 0, 50, 100, 150, 200, and 250 (output levels modified using Photoshop CS5).
- Printing reproducibility was found to be good:
  - level = 0: 1.426 ± 0.119 mg
  - level = 50: 0.860 ± 0.120 mg
  - level = 100: 0.548 ± 0.078 mg
  - level = 150: 0.396 ± 0.069 mg
  - level = 200: 0.322 ± 0.073 mg
  - level = 250: 0.252 ± 0.062 mg

Table 1
Formulation of artificial sweat solution.

Constituents	Concentrations (mM)	
	Schwarz's solution [14]	Our solution
Serine	9.3	9.3
Glycine	7.8	7.8
Alanine	3.3	3.3
Lysine	2.7	2.7
Threonine	1.2	1.2
Asparagin acid	1.1	1.1
Histidine	0.9	0.9
Valine	0.8	0.8
Leucine	0.7	0.7
Sodium chloride	113	113
Magnesium chloride	–	0.4
Calcium chloride	–	1.4
Zinc chloride	–	0.14
Amino acids in total	0.28	0.28
Divalent cations in total	0	1.94
Chloride anion in total	113	116.88




Output levels
Ninhydrin
1,2-IND/Zn
DFO
5-MTN/Zn
Silver nitrate
Iodine
0
50
100
150
200
250

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