A Review of Recently Published Fingerprint Research

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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 2013.
- 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

- Prete C, et al. Lumicyano™: A New Fluorescent Cyanoacrylate for a One-step Luminescent Latent Fingermark Development. Forensic Sci Int 2013;233:104-112.
- The goal of this work was to create a one-step fluorescent cyanoacrylate fuming method that can be used in existing fuming chambers without any modifications (i.e., 120°C; 80% RH)

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Lumicyano™: A new fluorescent cyanoacrylate for a one-step luminescent latent fingermark development

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ABSTRACT

Latent fingermarks developed by cyanoacrylate fuming often lack contrast; therefore further enhancement is required, such as dye staining. This second step is part of the conventional detection sequences performed by forensics practitioners. Dye-staining or powder dusting aims at improving contrast and at increasing the legibility of details, yet their use may at times be limited. Indeed powder dusting may not be effective due to unexpected adherence to the background, and poor affinity to the cyanoacrylate. In the same way staining processes can dye a whole semi-porous surface or may wash the marks.

To avoid that second step, a new luminescent cyanoacrylate (Lumicyano™) which allows one-step development without changing the fuming chamber settings (80% humidity rate, 120 °C fuming temperature) was developed and assessed. This study aimed at comparing Lumicyano™ to a conventional two-step process. A detailed sensitivity study was conducted on glass slides, as well as the processing of various non-porous and semi-porous substrates, usually considered as problematic for a dye staining step.

The results indicate that Lumicyano™ detects fingermarks with equal or better sensitivity and ridge details than currently used cyanoacrylate. Secondly in luminescent mode, good ridges clarity and excellent contrast are observed, even if Lumicyano™ is sometimes less bright than the two-step process. Furthermore, conventional enhancement can still be carried out if needed. As a conclusion, Lumicyano™ makes it possible to avoid an enhancement step which can be detrimental to further examinations, particularly on rough or semi-porous surfaces.

1. Introduction

Among the lot of fingermark development techniques reported in the literature (for a review see Ref. [1] and references therein), cyanoacrylate fuming is an extremely simple and efficient method described for the first time in the late 1970s, in Japan and slightly later in UK and Canada [2,3]. Items with potential latent marks are placed in a tightly closed fumigation chamber under 80% humidity atmosphere and the cyanoacrylate evaporates upon heating at 120 °C [4]. Although the chemical process is still under debate and not well understood [5–8], the anionic polymerization of cyanoacrylate takes place, in this condition, probably initiated by a variety of compounds contained in the residue constituting the mark, such as amino acids, fatty acids and proteins. Thus, latent marks are efficiently detected on non-porous and semi-porous substrates as a sticky white material that forms along the papillary ridges.

However, the main limitation of this technique arises from the white colour taken by the detected fingermarks, which often lacks contrast with the light coloured substrates. Several post-treatments have been proposed to overcome this issue. They consist in dusting the fingermark with coloured or fluorescent dye powders [9], or staining the CA-developed marks with a fluorescent dye solution such as Ardrox [10], Basic Yellow 40, or Rhodamine 6G [11]. However, these post-treatments are time-consuming and

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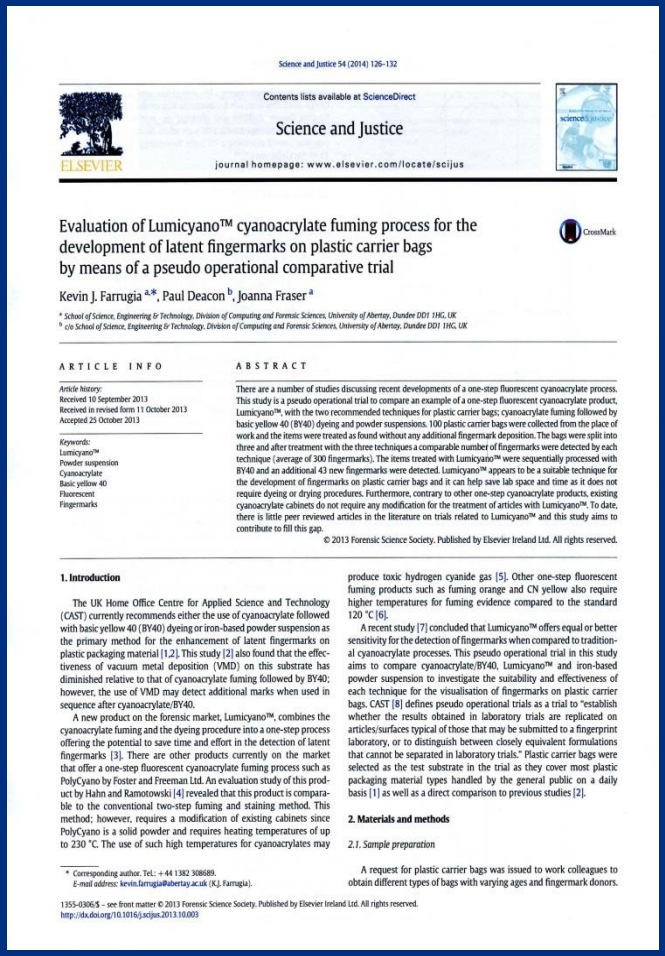
Results

- Lumicyano™ was found to develop latent prints with equal or better sensitivity and ridge details.
- The intensity of the fluorescence can be less than that achieved with the two-step process.
- Absorption maxima at 326 nm and 511 nm; emission at 562 nm.
- Fluorescence fading can occur rapidly on some substrates after 24-48 hours.
- Lumicyano™ can be used on semi-porous surfaces without staining entire background.

Introduction

- Farrugia KJ, Deacon P, Fraser J. Evaluation of Lumicyano™ Cyanoacrylate Fuming Process for the Development of Latent Fingermarks on Plastic Carrier Bags by Means of a Psuedo Operational Comparative Trial. Sci Justice 2014;54:126-132.
- The goal of this study was to evaluate Lumicyano ™ and compare it to the two step process of cyanoacrylate fuming and BY40 dye stain and an iron-based powder suspension using 100 plastic carrier bags.



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Evaluation of Lumicyano™ cyanoacrylate fuming process for the development of latent fingermarks on plastic carrier bags by means of a pseudo operational comparative trial

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ABSTRACT

There are a number of studies discussing recent developments of a one-step fluorescent cyanoacrylate process. This study is a pseudo operational trial to compare an example of a one-step fluorescent cyanoacrylate product, Lumicyano™, with the two recommended techniques for plastic carrier bags; cyanoacrylate fuming followed by basic yellow 40 (BY40) dyeing and powder suspensions. 100 plastic carrier bags were collected from the place of work and the items were treated as found without any additional fingermark deposition. The bags were split into three and after treatment with the three techniques a comparable number of fingermarks were detected by each technique (average of 300 fingermarks). The items treated with Lumicyano™ were sequentially processed with BY40 and an additional 43 new fingermarks were detected. Lumicyano™ appears to be a suitable technique for the development of fingermarks on plastic carrier bags and it can help save lab space and time as it does not require dyeing or drying procedures. Furthermore, contrary to other one-step cyanoacrylate products, existing cyanoacrylate cabinets do not require any modification for the treatment of articles with Lumicyano™. To date, there is little peer reviewed articles in the literature on trials related to Lumicyano™ and this study aims to contribute to fill this gap.

1. Introduction

The UK Home Office Centre for Applied Science and Technology (CAST) currently recommends either the use of cyanoacrylate followed with basic yellow 40 (BY40) dyeing or iron-based powder suspension as the primary method for the enhancement of latent fingermarks on plastic packaging material [1,2]. This study [2] also found that the effectiveness of vacuum metal deposition (VMD) on this substrate has diminished relative to that of cyanoacrylate fuming followed by BY40; however, the use of VMD may detect additional marks when used in sequence after cyanoacrylate/BY40.

A new product on the forensic market, Lumicyano™, combines the cyanoacrylate fuming and the dyeing procedure into a one-step process offering the potential to save time and effort in the detection of latent fingermarks [3]. There are other products currently on the market that offer a one-step fluorescent cyanoacrylate fuming process such as PolyCyano by Foster and Freeman Ltd. An evaluation study of this product by Hahn and Ramotowski [4] revealed that this product is comparable to the conventional two-step fuming and staining method. This method; however, requires a modification of existing cabinets since PolyCyano is a solid powder and requires heating temperatures of up to 230 °C. The use of such high temperatures for cyanoacrylates may produce toxic hydrogen cyanide gas [5]. Other one-step fluorescent fuming products such as fuming orange and CN yellow also require higher temperatures for fuming evidence compared to the standard 120 °C [6].

A recent study [7] concluded that Lumicyano™ offers equal or better sensitivity for the detection of fingermarks when compared to traditional cyanoacrylate processes. This pseudo operational trial in this study aims to compare cyanoacrylate/BY40, Lumicyano™ and iron-based powder suspension to investigate the suitability and effectiveness of each technique for the visualisation of fingermarks on plastic carrier bags. CAST [8] defines pseudo operational trials as a trial to "establish whether the results obtained in laboratory trials are replicated on articles/surfaces typical of those that may be submitted to a fingerprint laboratory, or to distinguish between closely equivalent formulations that cannot be separated in laboratory trials." Plastic carrier bags were selected as the test substrate in the trial as they cover most plastic packaging material types handled by the general public on a daily basis [1] as well as a direct comparison to previous studies [2].

2. Materials and methods

2.1. Sample preparation

A request for plastic carrier bags was issued to work colleagues to obtain different types of bags with varying ages and fingermark donors.

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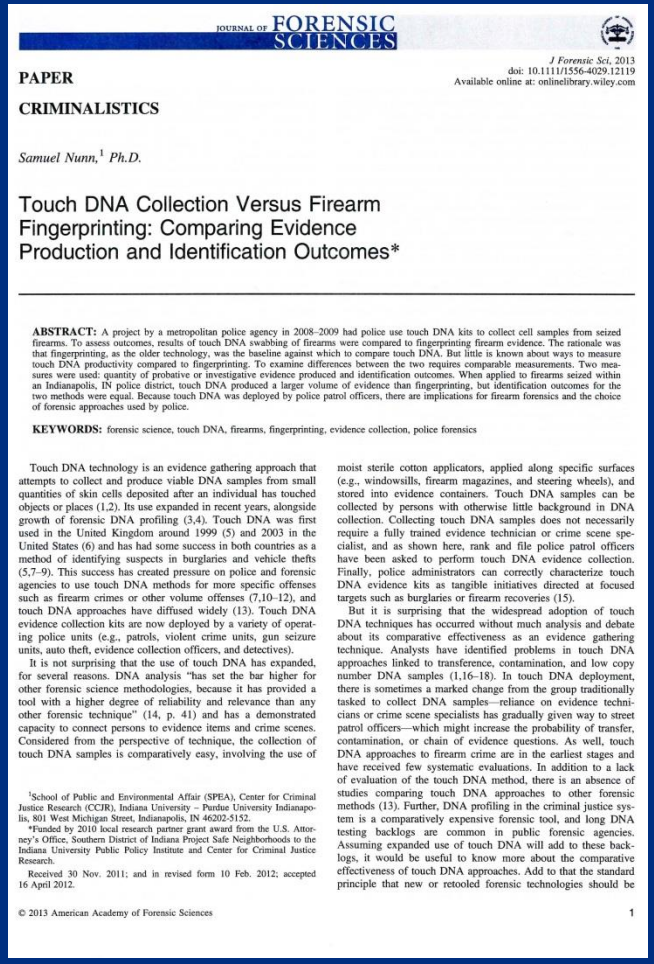
Results

- Cyanoacrylate fuming/BY40 developed 305 latent prints; Lumicyano™ developed 296 latent prints; and powder suspensions developed 297 latent prints.
- However, using BY40 after Lumicyano™ developed 43 additional prints not developed previously with Lumicyano™.
- Lumicyano™ does have flammable solvents that could interfere with DNA analysis.
- Lumicyano™ fluorescence was found to fade significantly within 24 hours under daylight conditions – after 1 week fluorescence could no longer be detected. If stored in the dark – fluorescence could be detected up to 6 months.

Introduction

- Nunn S. Touch DNA Collection Versus Firearm Fingerprinting: Comparing Evidence Production and Identification Outcomes. J Forensic Sci 2013;58(3): 601-608.
- The goal of this work was to compare the results of swabbing firearms for touch DNA (using TriggerPro) versus processing the items for fingerprints for providing a positive identification.
- Data obtained from the Indiana Metropolitan Police Agency East District/Indiana-Marion County Forensic Services Agency.



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PAPER

CRIMINALISTICS

Samuel Nunn,[1] *Ph.D.*

Touch DNA Collection Versus Firearm Fingerprinting: Comparing Evidence Production and Identification Outcomes*

ABSTRACT: A project by a metropolitan police agency in 2008–2009 had police use touch DNA kits to collect cell samples from seized firearms. To assess outcomes, results of touch DNA swabbing of firearms were compared to fingerprinting firearm evidence. The rationale was that fingerprinting, as the older technology, was the baseline against which to compare touch DNA. But little is known about ways to measure touch DNA productivity compared to fingerprinting. To examine differences between the two requires comparable measurements. Two measures were used: quantity of probative or investigative evidence produced and identification outcomes. When applied to firearms seized within an Indianapolis, IN police district, touch DNA produced a larger volume of evidence than fingerprinting, but identification outcomes for the two methods were equal. Because touch DNA was deployed by police patrol officers, there are implications for firearm forensics and the choice of forensic approaches used by police.

KEYWORDS: forensic science, touch DNA, firearms, fingerprinting, evidence collection, police forensics

Touch DNA technology is an evidence gathering approach that attempts to collect and produce viable DNA samples from small quantities of skin cells deposited after an individual has touched objects or places (1,2). Its use expanded in recent years, alongside growth of forensic DNA profiling (3,4). Touch DNA was first used in the United Kingdom around 1999 (5) and 2003 in the United States (6) and has had some success in both countries as a method of identifying suspects in burglaries and vehicle thefts (5,7–9). This success has created pressure on police and forensic agencies to use touch DNA methods for more specific offenses such as firearm crimes or other volume offenses (7,10–12), and touch DNA approaches have diffused widely (13). Touch DNA evidence collection kits are now deployed by a variety of operating police units (e.g., patrols, violent crime units, gun seizure units, auto theft, evidence collection officers, and detectives).

It is not surprising that the use of touch DNA has expanded, for several reasons. DNA analysis "has set the bar higher for other forensic science methodologies, because it has provided a tool with a higher degree of reliability and relevance than any other forensic technique" (14, p. 41) and has a demonstrated capacity to connect persons to evidence items and crime scenes. Considered from the perspective of technique, the collection of touch DNA samples is comparatively easy, involving the use of moist sterile cotton applicators, applied along specific surfaces (e.g., windowsills, firearm magazines, and steering wheels), and stored into evidence containers. Touch DNA samples can be collected by persons with otherwise little background in DNA collection. Collecting touch DNA samples does not necessarily require a fully trained evidence technician or crime scene specialist, and as shown here, rank and file police patrol officers have been asked to perform touch DNA evidence collection. Finally, police administrators can correctly characterize touch DNA evidence kits as tangible initiatives directed at focused targets such as burglaries or firearm recoveries (15).

But it is surprising that the widespread adoption of touch DNA techniques has occurred without much analysis and debate about its comparative effectiveness as an evidence gathering technique. Analysts have identified problems in touch DNA approaches linked to transference, contamination, and low copy number DNA samples (1,16–18). In touch DNA deployment, there is sometimes a marked change from the group traditionally tasked to collect DNA samples—reliance on evidence technicians or crime scene specialists has gradually given way to street patrol officers—which might increase the probability of transfer, contamination, or chain of evidence questions. As well, touch DNA approaches to firearm crime are in the earliest stages and have received few systematic evaluations. In addition to a lack of evaluation of the touch DNA method, there is an absence of studies comparing touch DNA approaches to other forensic methods (13). Further, DNA profiling in the criminal justice system is a comparatively expensive forensic tool, and long DNA testing backlogs are common in public forensic agencies. Assuming expanded use of touch DNA will add to these backlogs, it would be useful to know more about the comparative effectiveness of touch DNA approaches. Add to that the standard principle that new or retooled forensic technologies should be

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Results – Fingerprint Examinations

- Project examined results from 705 cases between July 1, 2007 and June 30, 2008 in which there were 147 fingerprint related requests during that time period.
- 21 of the 147 cases produced viable prints for examination and 4 (2.7% of the original 147) produced identifiable prints and an additional 7 (4.8%) produced prints of investigative value for a total of 7.5% of cases providing prints of probative value.
- In the cases in which a fingerprint processing request was made, a total of 503 items resulted in prints on 23 items (4.6%).
- Bullet/cartridge cases produced a success rate of <1%, holsters/ammunition cases 25%, long guns and magazines 13.6% and 10%, and pistols/revolvers 4-5%.

Results – TriggerPro Cases

- Results from 831 firearms cases between July 14, 2008 and August 31, 2009 indicated that there were complete TriggerPro data on 160 cases during that time period.
- 42% of cases resulted in mixtures, 36% produced partial profiles from one source, 5% produced a complete profile of a single individual, and 35% failed to yield enough DNA for further processing.
- Overall, touch DNA gun swab methods generate a more sizable quantity of potentially usable forensic evidence but this does not translate into more identifications (2.5% for gun swabs cases versus 2.7% in fingerprint cases).
- As a proportion of evidence items identifications were made on 3% of fingerprinted evidence and 5.2% of TriggerPro evidence.

Summary

- Overall, touch DNA gun swab methods generate a more sizable quantity of potentially usable forensic evidence but this does not translate into more identifications (2.5% for gun swabs cases versus 2.7% in fingerprint cases).
- As a proportion of evidence items, identifications were made on 3% of fingerprinted evidence and 5.2% of TriggerPro evidence.
- Overall, there was no statistically significant difference in recovery rates.
- In 2009, the IMCFSA turnaround time for latent print processing was 43.2 days compared to 72 days for DNA processing.

Introduction

- Bright NJ, et al. Chemical Changes Exhibited by Latent Fingerprints After Exposure to Vacuum Conditions. Forensic Sci Int 2013;230:81-86.
- The goal of this project was to examine changes in mass, lipid composition and water, and fatty acids and their esters after exposure to vacuum conditions to those aged under ambient conditions.

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Chemical changes exhibited by latent fingerprints after exposure to vacuum conditions☆

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ABSTRACT

The effect of vacuum exposure on latent fingerprint chemistry has been evaluated. Fingerprints were analysed using a quartz crystal microbalance to measure changes in mass, gas chromatography mass spectrometry to measure changes in lipid composition and attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR) to determine changes in the content of water, fatty acids and their esters after exposure to vacuum. The results are compared with samples aged under ambient conditions. It was found that fingerprints lose around 26% of their mass when exposed to vacuum conditions, equivalent to around 5 weeks ageing under ambient conditions. Further exposure to vacuum causes a significant reduction in the lipid composition of a fingerprint, in particular with the loss of tetradecanoic and pentadecanoic acid, that was not observed in ambient aged samples. There are therefore implications for sequence in which fingerprint development procedures (for example vacuum metal deposition) are carried out, as well as the use of vacuum based methods such as secondary ion mass spectrometry (SIMS) and matrix-assisted laser desorption ionisation (MALDI) in the study of fingerprint chemistry.

1. Introduction

Since the 1960s, low pressure systems (vacuum chambers) have been used to assist in fingerprint detection and analysis, for example in vacuum metal deposition which is used by police institutions worldwide [1]. Recently, there has been considerable interest in using chemical imaging techniques to investigate fingerprint chemistry. Recent studies have shown that chemical imaging can be used to enhance the visualisation of fingermarks [2–4] and to detect exogenous compounds [5–7], which may be used to link an individual to a particular substance. Additionally, chemical imaging techniques have been used to probe endogenous compounds in latent fingermarks, with the aim of determining intelligence information about the donor, to investigate fingermark ageing as well as to assist in the optimisation of fingerprint reagents [5,8,9]. Chemical imaging has also been used to determine the deposition sequence of fingerprints and inks on documents [8–10]. Two chemical imaging techniques that have shown promise for these applications are secondary ion mass spectrometry (SIMS) and matrix assisted laser desorption ionisation (MALDI) [5,7,11,12]. Whilst ambient pressure analogues of these techniques exist, the methodology used in prior studies requires the fingerprint to be placed in a vacuum chamber during analysis. It is well known within the vacuum technology community that fingerprints outgas when subjected to low pressures and therefore affect the ability of the vacuum chamber to reach the target pressure [13,14]. It therefore follows that vacuum pressure could affect the chemistry of a latent fingerprint. If this is the case, there are implications for the sequence in which these techniques should be applied in future casework, because changes in fingerprint chemistry may affect the efficacy of subsequent development reagents or chemical analysis of fingermarks.

In this work, we investigate the chemistry of fingerprints before and after exposure to low pressure systems using a range of analytical techniques. The effect of vacuum exposure is compared with the effect of ambient ageing on fingerprint chemistry.

2. Materials and methods

2.1. Fingerprint preparation

Donors washed their forehead with soap and warm water, and then dried their forehead with paper towels. After 30 min the donor washed their hands to remove exogenous compounds, dried them with paper towels and then put their hands in

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Results

- Fingerprints exposed to vacuum conditions (2 x 10-5 torr for 1 hour) lost approximately 26% of their mass (equivalent to 5 weeks of aging under ambient conditions).
- GCMS data indicated that their was a significant loss of lipids, in particular tetradecanoic and pentadecanoic acids as well as several fatty acids and sqalene.
- FTIR data indicates loss of water (-OH band), sebaceous material (C-H bands) and saturated esters (C=O stretch).
- Implications for vacuum based chemical imaging methods and VMD and their effect on repeatability and on subsequent latent print development.

Introduction

- Luo Y-P, Zhao Y-B, Liu S. Evaluation of DFO/PVP and its Application to Latent Fingermarks Development on Thermal Paper. Forensic Sci Int 2013;229:75-79.
- The goal of this work was to modify the traditional DFO formulation to make it less likely to cause blackening of thermal papers.
- Based on work published in 2010 by Schwarz, et al. on a polyvinyl pyrrolidine/ninhydrin reagent.

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Evaluation of DFO/PVP and its application to latent fingermarks development on thermal paper

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ABSTRACT

A new method for improved development of latent fingermarks on thermal paper by 1,8-diazafluoren-9-one (DFO) treatment is described. Compared with conventional DFO solution, the mixed solution of DFO/PVP (polyvinylpyrrolidone) described here reduces black background staining without removing the thermosensitive layer and develops fingermarks by the reaction of DFO with amino acid deposited on the thermal paper's surface.

An advantage of this approach is that the developed fluorescent fingermarks have high contrast and can be observed and photographed when excited in the 515 nm region and observed through an orange-red barrier long-pass filter with no background coloration. In addition, the method reported here does not involve any pre- or post treatment of the substrate and exhibits high sensitivity with good stability. Experimental results showed that the method was able to develop very old fingermarks, up to 154 days old, demonstrating the feasibility of using the method to develop identifiable latent fingermarks operationally.

Furthermore, we extended our experiments to various types of thermal papers. Notably, this method exhibits several very attractive features, namely time saving, simple procedures, inexpensive, convenient operation, and PVP is non-toxic and reasonably priced. Finally, in this study an attempt has been made to explain the reaction mechanism of the process and the effects of PVP.

1. Introduction

By using the color forming reaction between leuco dyes and co-reactants, thermal (thermosensitive) papers were invented by the National Cash Register Company in 1968 [1]. Since then, thermal paper has been extensively used in modern day life, especially in commerce such as fax machines, ATM receipts, store receipts, lotteries, bus tickets, some instruments readouts etc. This high usage, and subsequent handling, results in this type of paper carrying latent fingermarks as a vital piece of physical evidence commonly occurring in casework.

When subjected to heat, thermal papers produce a black coloration which is indicative of the presence of unsubstituted leuco dyes [2]. However, thermal papers cause particular problems for fingerprint development because of their complex chemical composition on the paper's surface. Treatment with conventional techniques like ninhydrin in petroleum ether or DFO solution produces a black color on the thermosensitive side [3]. This black background staining reduces the contrast of the developed fingermarks, often rendering them useless for identification purposes.

Therefore, much effort has been devoted to the latent fingermarks development and background coloration on thermal paper. For example, Takatsu reported the use of alkyl analogues of ninhydrin in 1991, but only obtained partial development of the fingermarks [4,5]. It was the same group who had reported using INON (2-hydroxy-2-(3,5,5-trimethyl-hexyloxy)-indan-1,3-dione) which can reduce the blackening of the surface [6]. By fuming of fax and other thermal papers with dimethylaminocinnamaldehyde (DMAC), Brennan was able to produce fluorescent fingermarks with no background coloration [7]. In the same way, Jasuja and coworkers reported the use of iodine fuming of thermal paper with good results, although the method has been known for many years as a general technique for paper [8]. Using ninhydrin sublimed under vacuum to minimize the blackening of the surface has been reported by Schwarz's group [9]. Recently, to enhance ninhydrin treated latent fingermarks on thermal paper, Schwarz used a solution containing pyrrolidone based compounds referred to as 'G3', to decolorize the blackened paper [10]. However, the

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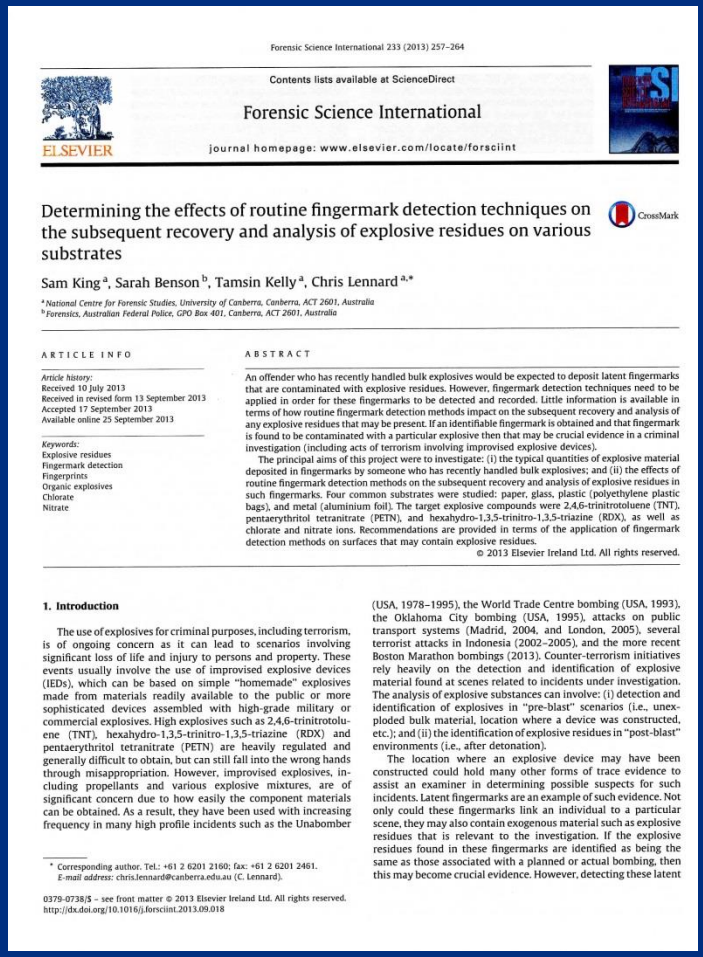
Results

- PVP is a non-ionic polymer with lower volatility than pyrrolidines previously reported in the “G3” solution.
- The DFO/PVP reagent consistently outperformed the conventional DFO reagent on 4 different types of thermal papers aged up to 15 days.

Introduction

- King S, Benson S, Kelly T, Lennard C. Determining the Effects of Routine Fingermark Detection Techniques on the Subsequent Recovery and Analysis of Explosive Residues on Various Substrates. Forensic Sci Int 2013;233:257-264.
- The goal of this project was to determine what impact chemical treatments have on recovery of explosive residues from latent prints.



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Determining the effects of routine fingermark detection techniques on the subsequent recovery and analysis of explosive residues on various substrates

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ABSTRACT

An offender who has recently handled bulk explosives would be expected to deposit latent fingermarks that are contaminated with explosive residues. However, fingermark detection techniques need to be applied in order for these fingermarks to be detected and recorded. Little information is available in terms of how routine fingermark detection methods impact on the subsequent recovery and analysis of any explosive residues that may be present. If an identifiable fingermark is obtained and that fingermark is found to be contaminated with a particular explosive then that may be crucial evidence in a criminal investigation (including acts of terrorism involving improvised explosive devices).

The principal aims of this project were to investigate: (i) the typical quantities of explosive material deposited in fingermarks by someone who has recently handled bulk explosives; and (ii) the effects of routine fingermark detection methods on the subsequent recovery and analysis of explosive residues in such fingermarks. Four common substrates were studied: paper, glass, plastic (polyethylene plastic bags), and metal (aluminium foil). The target explosive compounds were 2,4,6-trinitrotoluene (TNT), pentaerythritol tetranitrate (PETN), and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), as well as chlorate and nitrate ions. Recommendations are provided in terms of the application of fingermark detection methods on surfaces that may contain explosive residues.

1. Introduction

The use of explosives for criminal purposes, including terrorism, is of ongoing concern as it can lead to scenarios involving significant loss of life and injury to persons and property. These events usually involve the use of improvised explosive devices (IEDs), which can be based on simple "homemade" explosives made from materials readily available to the public or more sophisticated devices assembled with high-grade military or commercial explosives. High explosives such as 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and pentaerythritol tetranitrate (PETN) are heavily regulated and generally difficult to obtain, but can still fall into the wrong hands through misappropriation. However, improvised explosives, including propellants and various explosive mixtures, are of significant concern due to how easily the component materials can be obtained. As a result, they have been used with increasing frequency in many high profile incidents such as the Unabomber (USA, 1978–1995), the World Trade Centre bombing (USA, 1993), the Oklahoma City bombing (USA, 1995), attacks on public transport systems (Madrid, 2004, and London, 2005), several terrorist attacks in Indonesia (2002–2005), and the more recent Boston Marathon bombings (2013). Counter-terrorism initiatives rely heavily on the detection and identification of explosive material found at scenes related to incidents under investigation. The analysis of explosive substances can involve: (i) detection and identification of explosives in "pre-blast" scenarios (i.e., unexploded bulk material, location where a device was constructed, etc.); and (ii) the identification of explosive residues in "post-blast" environments (i.e., after detonation).

The location where an explosive device may have been constructed could hold many other forms of trace evidence to assist an examiner in determining possible suspects for such incidents. Latent fingermarks are an example of such evidence. Not only could these fingermarks link an individual to a particular scene, they may also contain exogenous material such as explosive residues that is relevant to the investigation. If the explosive residues found in these fingermarks are identified as being the same as those associated with a planned or actual bombing, then this may become crucial evidence. However, detecting these latent

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Results

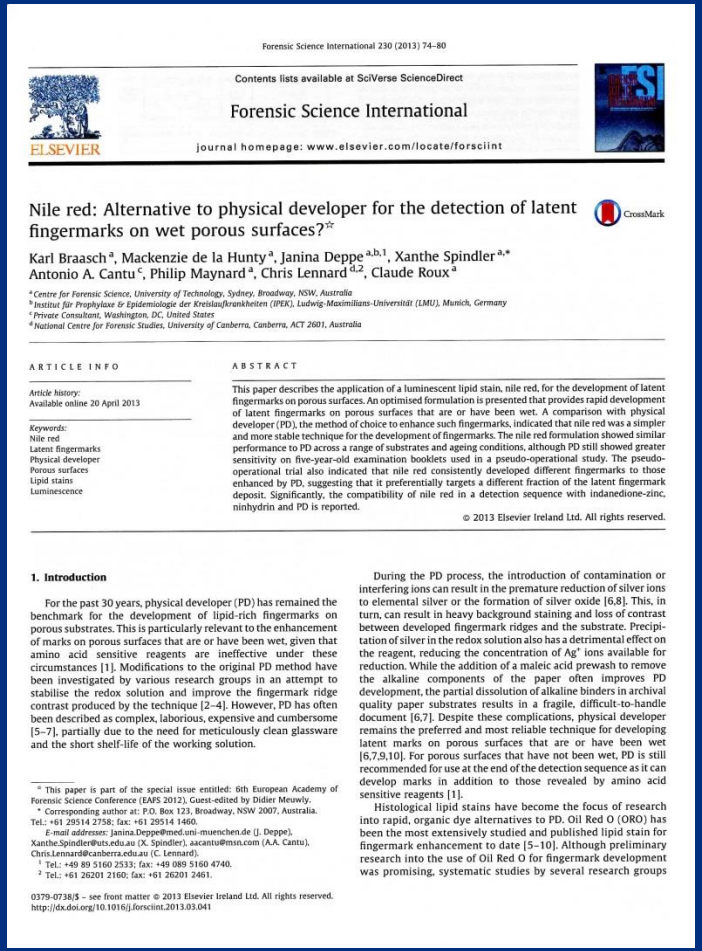
- Substrates included glass, aluminum foil, clear polyethylene, and paper. Explosives included TNT (15 µg), PETN (15 µg), RDX (15 µg), potassium chlorate (30 µg), and ammonium nitrate (60 µg).
- Porous treatments included IND-Zn, ninhydrin, PD, and the sequences IND-Zn + ninhydrin and IND-Zn + ninhydrin + PD.
- Non-porous treatments included black magnetic powder, CA fuming, and CA fuming + rhodamine 6G staining.
- For black magnetic powder, a minimal effect on explosives was noted.
- CA fuming had a minimal impact on glass, but some losses were noted on plastic and aluminum foil (trapped by polymer).

Results

- Chlorates and nitrates did not survive the water-based R6G process. The use of non-aqueous R6G and skipping the water rinse is advised.
- For paper, some losses were noted for ninhydrin and IND-Zn (especially for nitrate and organic explosives). The use of a fine spray and ambient development conditions is advised.
- For PD (nitrate and chlorate were assumed to not survive and were not tested), only PETN could be detected (but at 40% of its pretreatment level). TNT and RDX were not detected.
- Sequential treatments magnify potential losses.

Introduction

- Braasch K, et al. Nile Red: Alternative to Physical Developer for the Detection of Latent Fingermarks on Wet Porous Surfaces. Forensic Sci Int 2013;230:74-80.
- The goal of this project was to determine whether or not lipid stains like Nile Red can replace PD.



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Nile red: Alternative to physical developer for the detection of latent fingermarks on wet porous surfaces?☆

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ABSTRACT

This paper describes the application of a luminescent lipid stain, nile red, for the development of latent fingermarks on porous surfaces. An optimised formulation is presented that provides rapid development of latent fingermarks on porous surfaces that are or have been wet. A comparison with physical developer (PD), the method of choice to enhance such fingermarks, indicated that nile red was a simpler and more stable technique for the development of fingermarks. The nile red formulation showed similar performance to PD across a range of substrates and ageing conditions, although PD still showed greater sensitivity on five-year-old examination booklets used in a pseudo-operational study. The pseudo-operational trial also indicated that nile red consistently developed different fingermarks to those enhanced by PD, suggesting that it preferentially targets a different fraction of the latent fingermark deposit. Significantly, the compatibility of nile red in a detection sequence with indanedione-zinc, ninhydrin and PD is reported.

1. Introduction

For the past 30 years, physical developer (PD) has remained the benchmark for the development of lipid-rich fingermarks on porous substrates. This is particularly relevant to the enhancement of marks on porous surfaces that are or have been wet, given that amino acid sensitive reagents are ineffective under these circumstances [1]. Modifications to the original PD method have been investigated by various research groups in an attempt to stabilise the redox solution and improve the fingermark ridge contrast produced by the technique [2–4]. However, PD has often been described as complex, laborious, expensive and cumbersome [5–7], partially due to the need for meticulously clean glassware and the short shelf-life of the working solution.

During the PD process, the introduction of contamination or interfering ions can result in the premature reduction of silver ions to elemental silver or the formation of silver oxide [6,8]. This, in turn, can result in heavy background staining and loss of contrast between developed fingermark ridges and the substrate. Precipitation of silver in the redox solution also has a detrimental effect on the reagent, reducing the concentration of Ag^+ ions available for reduction. While the addition of a maleic acid prewash to remove the alkaline components of the paper often improves PD development, the partial dissolution of alkaline binders in archival quality paper substrates results in a fragile, difficult-to-handle document [6,7]. Despite these complications, physical developer remains the preferred and most reliable technique for developing latent marks on porous surfaces that are or have been wet [6,7,9,10]. For porous surfaces that have not been wet, PD is still recommended for use at the end of the detection sequence as it can develop marks in addition to those revealed by amino acid sensitive reagents [1].

Histological lipid stains have become the focus of research into rapid, organic dye alternatives to PD. Oil Red O (ORO) has been the most extensively studied and published lipid stain for fingermark enhancement to date [5–10]. Although preliminary research into the use of Oil Red O for fingermark development was promising, systematic studies by several research groups

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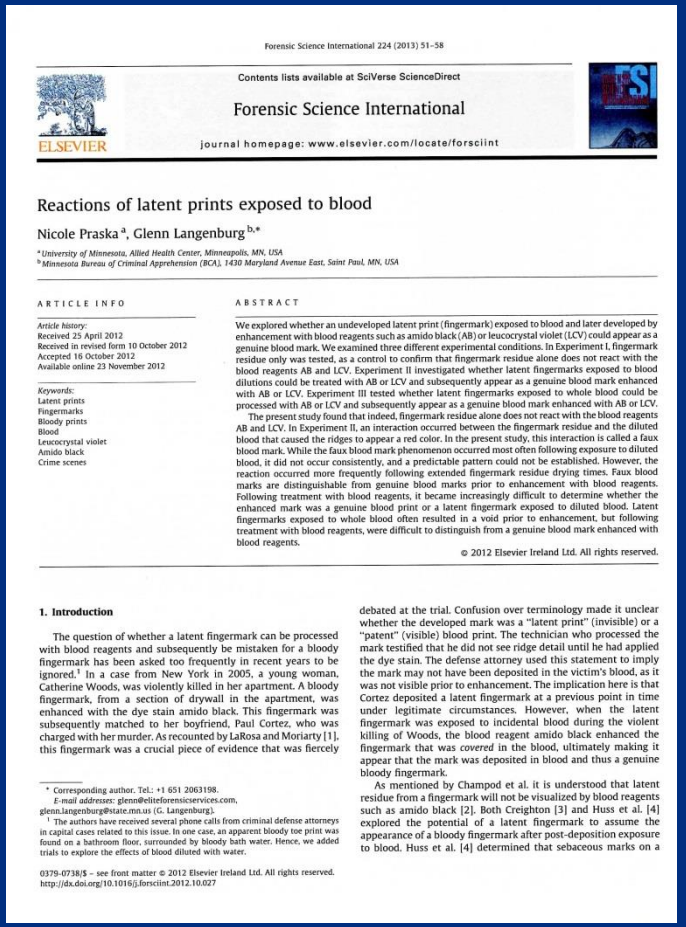
Results

- Nile Red was initially investigated by George Saunders in 1990s.
- Modified Nile red reagent (increased methanol concentration and alkaline pH) performed better than unmodified one.
- Nile red did better on calendared papers while PD did well on all paper types (except black cardboard – neither method did well).
- Although it could be found to develop a print aged 5 years, Nile red worked better on prints less than 1 month old.
- Additional fluorescent detail could be developed when Nile red was used after PD (compared to using Nile red before PD).
- In a direct comparison, PD generally outperformed Nile red except when fresh, sebaceous prints were used.

Introduction

- Praska N, Langenburg G. Reactions of Latent Prints Exposed to Blood. Forensic Sci Int 2013;224:51-58.
- The goal of this project was to determine whether a latent print exposed to blood and later treated with amido black or LCV could appear or be interpreted as a genuine blood print.
- Was the print deposited under legitimate circumstances prior to exposure to blood at a later time?



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Reactions of latent prints exposed to blood

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ABSTRACT

We explored whether an undeveloped latent print (fingermark) exposed to blood and later developed by enhancement with blood reagents such as amido black (AB) or leucocrystal violet (LCV) could appear as a genuine blood mark. We examined three different experimental conditions. In Experiment I, fingermark residue only was tested, as a control to confirm that fingermark residue alone does not react with the blood reagents AB and LCV. Experiment II investigated whether latent fingermarks exposed to blood dilutions could be treated with AB or LCV and subsequently appear as a genuine blood mark enhanced with AB or LCV. Experiment III tested whether latent fingermarks exposed to whole blood could be processed with AB or LCV and subsequently appear as a genuine blood mark enhanced with AB or LCV.

The present study found that indeed, fingermark residue alone does not react with the blood reagents AB and LCV. In Experiment II, an interaction occurred between the fingermark residue and the diluted blood that caused the ridges to appear a red color. In the present study, this interaction is called a faux blood mark. While the faux blood mark phenomenon occurred most often following exposure to diluted blood, it did not occur consistently, and a predictable pattern could not be established. However, the reaction occurred more frequently following extended fingermark residue drying times. Faux blood marks are distinguishable from genuine blood marks prior to enhancement with blood reagents. Following treatment with blood reagents, it became increasingly difficult to determine whether the enhanced mark was a genuine blood print or a latent fingermark exposed to diluted blood. Latent fingermarks exposed to whole blood often resulted in a void prior to enhancement, but following treatment with blood reagents, were difficult to distinguish from a genuine blood mark enhanced with blood reagents.

1. Introduction

The question of whether a latent fingermark can be processed with blood reagents and subsequently be mistaken for a bloody fingermark has been asked too frequently in recent years to be ignored.[1] In a case from New York in 2005, a young woman, Catherine Woods, was violently killed in her apartment. A bloody fingermark, from a section of drywall in the apartment, was enhanced with the dye stain amido black. This fingermark was subsequently matched to her boyfriend, Paul Cortez, who was charged with her murder. As recounted by LaRosa and Moriarty [1], this fingermark was a crucial piece of evidence that was fiercely debated at the trial. Confusion over terminology made it unclear whether the developed mark was a "latent print" (invisible) or a "patent" (visible) blood print. The technician who processed the mark testified that he did not see ridge detail until he had applied the dye stain. The defense attorney used this statement to imply the mark may not have been deposited in the victim's blood, as it was not visible prior to enhancement. The implication here is that Cortez deposited a latent fingermark at a previous point in time under legitimate circumstances. However, when the latent fingermark was exposed to incidental blood during the violent killing of Woods, the blood reagent amido black enhanced the fingermark that was *covered* in the blood, ultimately making it appear that the mark was deposited in blood and thus a genuine bloody fingermark.

As mentioned by Champod et al. it is understood that latent residue from a fingermark will not be visualized by blood reagents such as amido black [2]. Both Creighton [3] and Huss et al. [4] explored the potential of a latent fingermark to assume the appearance of a bloody fingermark after post-deposition exposure to blood. Huss et al. [4] determined that sebaceous marks on a

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[1] The authors have received several phone calls from criminal defense attorneys in capital cases related to this issue. In one case, an apparent bloody toe print was found on a bathroom floor, surrounded by bloody bath water. Hence, we added trials to explore the effects of blood diluted with water.

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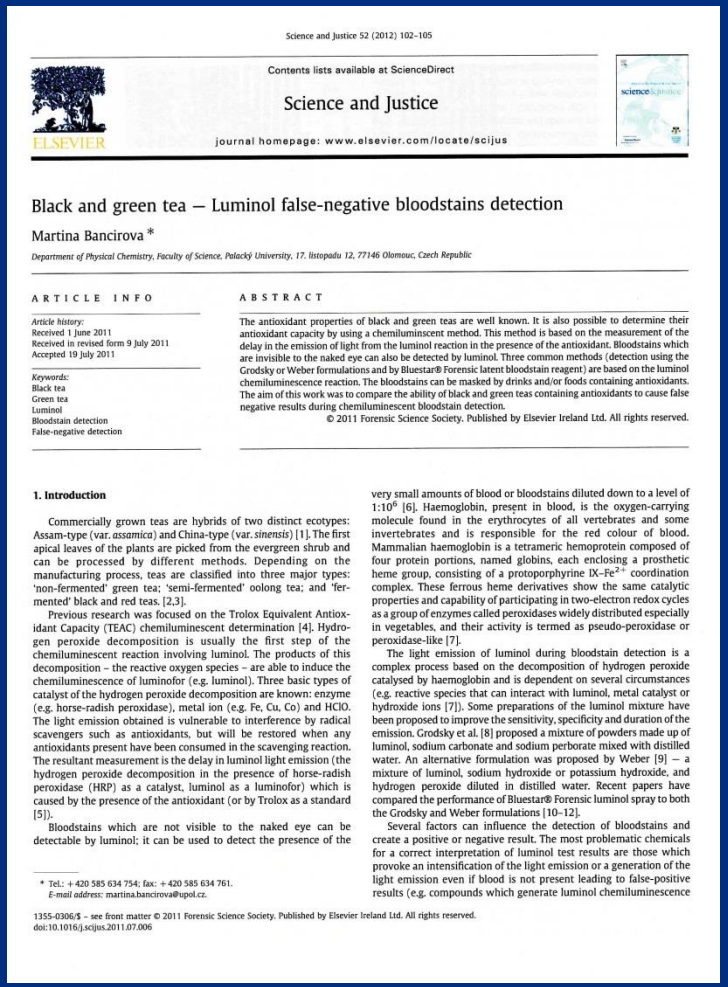
Results

- Latent prints do not react with amido black or LCV.
- A mixture of latent print residue and diluted blood caused the residue to exhibit a red color on an inconsistent basis (a “faux blood mark”).
- A negative blood mark is an invisible mark seen when a latent mark is exposed to blood (a void or halo forms around the latent fingermark).
- The “faux blood marks” occurred more frequently as residue aged.
- Following treatment with blood reagents, it became difficult to determine whether the print was a genuine blood print or a latent print exposed to dilute blood.

Introduction

- Bancirova M. Black and Green tea – Luminol False-negative Bloodstains Detection. Sci Justice 2012;52:102-105.
- Three basic types of catalysts for the hydrogen peroxide decomposition reaction are known: enzymes (e.g., horse radish peroxidase), metal ions (e.g., Fe, Cu, Co), and HClO.
- Can common materials lead to false negative reactions?



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Black and green tea – Luminol false-negative bloodstains detection

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ABSTRACT

The antioxidant properties of black and green teas are well known. It is also possible to determine their antioxidant capacity by using a chemiluminscent method. This method is based on the measurement of the delay in the emission of light from the luminol reaction in the presence of the antioxidant. Bloodstains which are invisible to the naked eye can also be detected by luminol. Three common methods (detection using the Grodsky or Weber formulations and by Bluestar® Forensic latent bloodstain reagent) are based on the luminol chemiluminescence reaction. The bloodstains can be masked by drinks and/or foods containing antioxidants. The aim of this work was to compare the ability of black and green teas containing antioxidants to cause false negative results during chemiluminescent bloodstain detection.

1. Introduction

Commercially grown teas are hybrids of two distinct ecotypes: Assam-type (var. *assamica*) and China-type (var. *sinensis*) [1]. The first apical leaves of the plants are picked from the evergreen shrub and can be processed by different methods. Depending on the manufacturing process, teas are classified into three major types: 'non-fermented' green tea; 'semi-fermented' oolong tea; and 'fermented' black and red teas. [2,3].

Previous research was focused on the Trolox Equivalent Antioxidant Capacity (TEAC) chemiluminescent determination [4]. Hydrogen peroxide decomposition is usually the first step of the chemiluminescent reaction involving luminol. The products of this decomposition – the reactive oxygen species – are able to induce the chemiluminescence of luminofor (e.g. luminol). Three basic types of catalyst of the hydrogen peroxide decomposition are known: enzyme (e.g. horse-radish peroxidase), metal ion (e.g. Fe, Cu, Co) and HClO. The light emission obtained is vulnerable to interference by radical scavengers such as antioxidants, but will be restored when any antioxidants present have been consumed in the scavenging reaction. The resultant measurement is the delay in luminol light emission (the hydrogen peroxide decomposition in the presence of horse-radish peroxidase (HRP) as a catalyst, luminol as a luminofor) which is caused by the presence of the antioxidant (or by Trolox as a standard [5]).

Bloodstains which are not visible to the naked eye can be detectable by luminol; it can be used to detect the presence of the very small amounts of blood or bloodstains diluted down to a level of $1{:}10^6$ [6]. Haemoglobin, present in blood, is the oxygen-carrying molecule found in the erythrocytes of all vertebrates and some invertebrates and is responsible for the red colour of blood. Mammalian haemoglobin is a tetrameric hemoprotein composed of four protein portions, named globins, each enclosing a prosthetic heme group, consisting of a protoporphyrine IX–Fe^{2+} coordination complex. These ferrous heme derivatives show the same catalytic properties and capability of participating in two-electron redox cycles as a group of enzymes called peroxidases widely distributed especially in vegetables, and their activity is termed as pseudo-peroxidase or peroxidase-like [7].

The light emission of luminol during bloodstain detection is a complex process based on the decomposition of hydrogen peroxide catalysed by haemoglobin and is dependent on several circumstances (e.g. reactive species that can interact with luminol, metal catalyst or hydroxide ions [7]). Some preparations of the luminol mixture have been proposed to improve the sensitivity, specificity and duration of the emission. Grodsky et al. [8] proposed a mixture of powders made up of luminol, sodium carbonate and sodium perborate mixed with distilled water. An alternative formulation was proposed by Weber [9] – a mixture of luminol, sodium hydroxide or potassium hydroxide, and hydrogen peroxide diluted in distilled water. Recent papers have compared the performance of Bluestar® Forensic luminol spray to both the Grodsky and Weber formulations [10–12].

Several factors can influence the detection of bloodstains and create a positive or negative result. The most problematic chemicals for a correct interpretation of luminol test results are those which provoke an intensification of the light emission or a generation of the light emission even if blood is not present leading to false-positive results (e.g. compounds which generate luminol chemiluminescence

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Results

- Food containing antioxidants can mask the luminol reaction.
- Emission intensity and duration can be used to distinguish false positives from true blood reactions.
- Antioxidants present in many beverages (e.g., tea, coffee, wine, beer) can effect the strength of the chemiluminescent reaction.
- Black and green teas (green tea in particular) were found to decrease the intensity of chemiluminescent reactions produced with the Grosky, Weber, and Bluestar® formulations, especially within the first minute.
- The detection ability of Bluestar® was found to be the least effected by the presence of green and black teas.

Introduction

- Ferguson S, Nicholson L, Farrugia K, Bremner D, Gentles D. A Preliminary Investigation into the Acquisition of Fingerprints on Food. Sci Justice 2013;53:67-72.
- The goal of this project was to determine how successful the use of several detection methods were in developing latent prints on a variety of foodstuffs at different time intervals.

Science and Justice 53 (2013) 67–72

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Technical note

A preliminary investigation into the acquisition of fingerprints on food

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ABSTRACT

The potential for enhancement and recovery of latent fingerprints on a variety of foodstuffs has been investigated. In general, black magnetic powder and black powder suspensions appear to be the most successful enhancement techniques with a high number of ridge detail-developed prints over a selected time scale. Banana, apple and tomato surfaces showed enhancement of latent prints but potato and egg surfaces proved to be less successful.

1. Introduction

The surface onto which a fingerprint is deposited is often the primary decider as to which technique is selected for enhancement [1]. There is a vast range of such surfaces and specific enhancement techniques are selected based on the surface type and its porosity, the condition of the latent mark and the level of contamination which has occurred. Items of evidence that may retain fingerprints are often overlooked due to the belief that the item in question will not retain any fingerprints. This is mainly due to limited research on 'difficult surfaces' such as food, skin and fabric.

Singh et al. [2] determined that fingerprints could be successfully enhanced and recovered from food surfaces such as banana, apple and potato when using black powders although iodine fuming was also successful on apples. A further study by Trapecar and Vinkovic [3] focused on similar fruits and vegetables with some successful results. It was concluded that Swedish Black powder followed by special silver powder yielded the best quality of friction ridge detail and characteristics despite varying surface types. The process of cyanoacrylate fuming was also investigated [3] however results proved less successful. The food items were also graded in terms of their surface suitability with the tomato proving the most appropriate, followed by apple and banana, with the poorest results recorded on potatoes [3].

The surfaces of food items vary greatly not only in their texture and colouration, but also in their porosity and, like any item or surface undergoing development, each of these factors will undoubtedly affect the quality of visualisation achieved. The main aim of this study was to investigate a range of amelioration processes and ascertain which, if any, would be the most suitable for enhancing latent marks on specific food items.

2. Materials and methods

2.1. Food items

Three fruits (apple, banana and tomato), three vegetables (onion, potato and pepper) and a dairy product (eggs) were selected as surfaces for testing. All substrates were collected in fresh form, stored in a refrigerator and used within a few days. Prior to fingerprint deposition, the food items were rinsed thoroughly with tap water and gently dried using clean, chemical free blue paper towel to ensure their surface was completely clean and free from any contaminants and unintended fingerprints. Finally the items were allowed to reach ambient conditions for about 24 h. The food items were then marked off into five clearly labelled sections; one for each of the five fingerprint donors. Following fingerprint deposition, all food articles were stored at room temperature in normal lighting conditions awaiting enhancement at the allocated time intervals.

2.2. Fingerprint deposition

Donor suitability was checked by successful enhancement of fingerprints on a sheet of blank A4 paper with black magnetic powder. Five fingerprint donors were selected: 3 male (donors 1, 2, and 5) and 2 female (donors 3 and 4) who were instructed not to wash their hands at least an hour prior to the deposition of the print. Furthermore,

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Results

- Processing techniques included: black magnetic powder, superglue fuming, ninhydrin, SPR, Wetwop™, iron oxide black powder suspension, titanium dioxide white powder suspension.
- Foodstuffs included apple, banana, tomato, potato, onion, pepper, and eggs. Negative and positive controls were used.
- Prints were aged for 2 h, and for 1, 2, 3, 4, 7, and 14 days.
- Black magnetic powder, SPR, and black powder suspension prepared with distilled water produced the best results. 51% of prints showed the highest assessment scores with black magnetic powder.
- White powder suspension produced poor enhancement.

Results

- No prints were visualized with CA fuming, but indistinct/distorted development indicated where the print was deposited. The detail did tend to improve after 10-15 minutes.
- No development of prints was observed when ninhydrin was used.
- Bananas and onions exhibited the highest number of high grades while potato and egg showed the lowest number of high grades.
- Freshly prepared iron oxide black powder suspensions produced the best results on the aged prints.

Introduction

- Castelló A, Francés F, Verdú F. Solving Underwater Crimes: Development of Latent Prints Made on Submerged Objects. Sci Justice 2013;53:328-331.
- The goal of this project was to determine how prints left on glass and plastic submerged in water for 1-15 days effected the subsequent recovery of those prints.

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Solving underwater crimes: Development of latent prints made on submerged objects

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ABSTRACT

Underwater crime scenes always present a challenge for forensic researchers, as the destructive effect of water considerably complicates the chances of recovering material of evidential value. The aim of this study is to tackle the problem of developing marks that have been left on submerged objects. Fingermark deposition was randomly made on two surfaces – glass and plastic whilst the material was submerged under tap water and then left for one to fifteen days before drying and development. For their later development, various reagents – Black Powder, Silver Metallic Powder, Fluorescent Powder, Sudan Black (powder and solution) and Small Particle Reagent – were used and the effectiveness of each of them on this particular type of evidence was then evaluated.
The results show the possibility of obtaining good quality developed marks, even under such adverse circumstances. Further and wider research should, therefore, be undertaken in which other variables are introduced such as different substrates, other types of liquids, and environmental or time factors.

1. Introduction

Currently, fingermarks continue to be one of the most interesting types of evidence for criminal investigation. As a result of advances made in instrumental analysis techniques, much more information is provided than that which used to be gathered from their dactyloscopic study. For example, they are a possible source of DNA (nuclear and mitochondrial) [1,2] and it is also possible to detect and analyze exogenous material which the donor of the print has been in contact with. Remains of explosives, drugs and any substance that has been retained can be gathered and examined in order to determine what is referred to as the chemical print, providing quite useful data for the investigation [3–5].

Moreover, the chemical study of fingermarks is of interest for understanding variability in the different components between individuals [6]. This information allows an evaluation based on the study of the type and proportion of the lipids that make up the print, whether its author is a child or an adult [7]. Likewise, data can sometimes be obtained on an illness the donor may be suffering from or even on his/her diet [8]. More recently, research was published on the possibility of evaluating the age of the print, focusing on the loss of electrostatic charge that occurs over time [9], or by means of non-invasive optic procedures [10,11].

The potential of fingermarks as sources of information in criminal investigations justifies the continuous search for new reagents that are suited to the characteristics of the surfaces on which the work is to be undertaken. Consequently, interesting studies have been published that describe, for example, how to reveal marks on especially difficult surfaces, such as human skin [12,13], or the possibility of obtaining them from paper, even if, after being formed, they have come into contact with water [14–16]. Indeed, results have been achieved even following the effects of fire [17,18].

In order to fully take advantage of these products, work procedures have been elaborated that describe, for each type of substrate and depending on the conditions where they are found, an ordered application sequence for reagents, so that each step depends on the results obtained in the previous one [19,20]. Taking into account the procedures proposed by the manual, one of the most effective reagents for the treatment of surfaces that have been wet is the small particle reagent. This reagent has been used to reveal marks deposited on objects that have remained under water. Different investigations have been carried out, producing marks on different types of surfaces and later submerging them in water in order to evaluate the effectiveness of the reagents under these circumstances. However, the protocols recommend their use as a last choice option due to their damaging effect on DNA [19–23].

Nevertheless, no reference has been found to the possibility of developing marks that were made under water, or, in other words, obtaining marks deposited on a submerged object.

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Results

- Prints were deposited on submerged glass slides and transparent plastic cards. 20 samples were used for each reagent, time, and surface.
- Samples were retrieved for development after 1, 3, 5, 7, 10, and 15 days and allowed to dry for 24 hours before processing.
- Reagents used in his experiment included black powder, silver magnetic powder, fluorescent powder, Sudan black powder, and SPR.
- All reagents had a similar effectiveness after 3 days of immersion.
- For glass, black powder, Sudan black powder, and SPR worked best. No results were obtained with silver magnetic or fluorescent powders.

Results

- On plastic, all reagents except black powder performed poorly after immersion for more than 7 days.
- Black powder performed the best on both surfaces, followed by Sudan black powder and SPR.
- The Bluemax™ light source and ultraviolet radiation failed to detect prints on any of the submerged objects.

Introduction

- Cadd SJ, Bleay SM, Sears VG. Evaluation of the Solvent Black 3 Fingermark Enhancement Reagent: Part 2 – Investigation of the Optimum Formulation and Application. Sci Justice 2013;53:131-143.
- The goal of this project was to compare an ethanol-based formula of Solvent Black 3 (Sudan Black B) with a lower flammability version based on 1-methoxy-2-propanol (PGME).

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Evaluation of the solvent black 3 fingermark enhancement reagent: Part 2 – Investigation of the optimum formulation and application parameters

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ABSTRACT

A comparison is reported of the relative effectiveness to two formulations of the solvent black 3 (Sudan Black) reagent used to enhance grease contaminated fingermarks. These experiments compared the currently recommended ethanol-based formulation with a lower flammability system based on 1-methoxy-2-propanol (PGME) using natural, deliberately sebaceous and grease contaminated marks across a range of surfaces. It is shown that overall the PGME-based formulation was significantly better at producing good ridge detail on most surfaces for both natural and deliberately sebaceous prints, and for contaminated prints the ridge detail obtained with the PGME-based formulation was as good or better than that obtained with the ethanol formulation.
Several smaller experiments were also carried out in order to provide additional information on the solvent black 3 process. These showed that solutions of age up to 2 years can still develop good ridge detail, but the colour of the stained mark may vary. It was also demonstrated that the currently recommended 2 minute treatment time often resulted in very heavy background staining and in practice significantly reduced treatment times can be recommended according to the nature of the surface present.

1. Introduction

Solvent black 3, alternatively known as Sudan Black B, is currently recommended as a fingermark enhancement reagent for use on grease contaminated surfaces. Although the process is a simple one, it is probably the least researched and reported of all widely recommended enhancement processes.

Solvent black 3 is a diazo dye composed of two naphthalene rings bound by an azo bond (N=N) as shown in Fig. 1. One naphthalene ring is coupled to a phenyl ring by a second azo bond and the other to two secondary amino groups, which are bound to a quaternary carbon holding two methyl groups. Solvent black 3 consists of a mixture of two isomers (para- and ortho-), the para isomer being more strongly basic than the ortho- form because the ortho-isomer can form intramolecular hydrogen bonds. Para-ortho isomerisation can be initiated by visible light, giving the molecule strong absorption across in the visible region of the spectrum. In its solid form solvent black is a dark brown-black powder with a maximum absorption of 596–605 nm [1], when dissolved in solvents it is a deep blue-black colour.

Although related compounds such as Sudan III (solvent red 23) and Sudan IV (solvent red 24) were synthesised and commercially available in the late 1800s/early 1900s, solvent black 3 was not introduced until the mid-1930s. Industrially, the dye is used for the colouration of organic solvents, printing inks, laquers and a range of fats and wax substances [1].

Soon after its introduction the dye was proposed as a stain for fats and various other microbiological applications and has been successfully utilised in this role to this date. The use of the dye as a biological stain results in fatty matter being stained a deep blue/black colour. When used as a stain, solvent black 3 is applied from a solvent in which it is sparingly soluble. As solvent black 3 comes into contact with materials in which it is strongly soluble (such as fats), the lipophilic dye molecules preferentially transfer into the fat from the solution. Although the primary action of solvent black 3 is to stain lipids by dissolving in them, it can also stain materials ionically. This may result in some background staining.

The first published use of solvent black 3 for the development of latent fingermarks was by Mitsui et al. in 1980 [2], who used solvent black 3 in a mixture of ethylene glycol, ethanol and water to develop marks on water-soaked paper items. The performance of solvent black 3 was found to be superior to ninhydrin on this type of article. A further study by Stone and Metzger [3] compared solvent black 3 with black magna powder to develop marks on wetted porous items. In this comparison magna powder was found to give the best results.

In the early 1980s the Home Office Central Research Establishment (HO CRE) conducted an evaluation of over 60 biological dyes for their ability to develop latent fingermarks on both paper and thin polythene surfaces such as carrier bags [4]. These studies identified solvent black 3 as having particular potential for the development of fingermarks, in

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Results

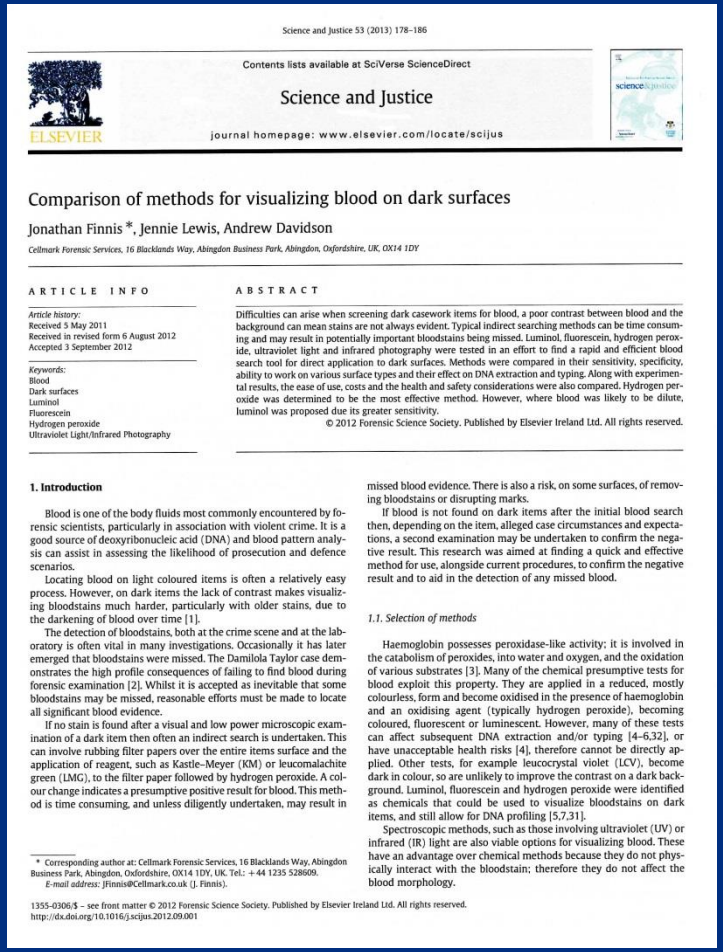
- Contaminants used in this study included olive oil, butter, vegetable fat spread, and hand cream.
- Prints were aged 1 day, 1 week, and 1 month prior to treatment.
- With natural prints the PGME-based formulation produced more ridge detail and better contrast.
- With aged prints the overall trend favored the PGME-based formulation (more prints developed and better contrast).
- The PGME-based formulation performed as well or better across all ages of solutions tested (up to 2 years).
- Prints enhanced with older solutions could exhibit slight color changes.

Results

- Prints became visible after 10 seconds, indicating that the recommended 2 minute staining time may be excessive – this can cause a significant background staining issue for some surfaces.
- Although some contaminant/surface combinations produced better results with the ethanol-based formulation, overall, the PGME-based method is now recommended.
- The lower flammability of the PGME-based formulation allows use at crime scenes.

Introduction

- Finnis J, Lewis J, Davidson A. Comparison of Methods for Visualizing Blood on Dark Surfaces. Sci Justice 2013;53:178-186.
- The goal of this project was to evaluate Bluestar, fluorescein, Haemascein™, hydrogen peroxide, ultraviolet absorbance, and IR photography as rapid and efficient searching tools for blood on dark surfaces.



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Comparison of methods for visualizing blood on dark surfaces

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ABSTRACT

Difficulties can arise when screening dark casework items for blood, a poor contrast between blood and the background can mean stains are not always evident. Typical indirect searching methods can be time consuming and may result in potentially important bloodstains being missed. Luminol, fluorescein, hydrogen peroxide, ultraviolet light and infrared photography were tested in an effort to find a rapid and efficient blood search tool for direct application to dark surfaces. Methods were compared in their sensitivity, specificity, ability to work on various surface types and their effect on DNA extraction and typing. Along with experimental results, the ease of use, costs and the health and safety considerations were also compared. Hydrogen peroxide was determined to be the most effective method. However, where blood was likely to be dilute, luminol was proposed due its greater sensitivity.

1. Introduction

Blood is one of the body fluids most commonly encountered by forensic scientists, particularly in association with violent crime. It is a good source of deoxyribonucleic acid (DNA) and blood pattern analysis can assist in assessing the likelihood of prosecution and defence scenarios.

Locating blood on light coloured items is often a relatively easy process. However, on dark items the lack of contrast makes visualizing bloodstains much harder, particularly with older stains, due to the darkening of blood over time [1].

The detection of bloodstains, both at the crime scene and at the laboratory is often vital in many investigations. Occasionally it has later emerged that bloodstains were missed. The Damilola Taylor case demonstrates the high profile consequences of failing to find blood during forensic examination [2]. Whilst it is accepted as inevitable that some bloodstains may be missed, reasonable efforts must be made to locate all significant blood evidence.

If no stain is found after a visual and low power microscopic examination of a dark item then often an indirect search is undertaken. This can involve rubbing filter papers over the entire items surface and the application of reagent, such as Kastle–Meyer (KM) or leucomalachite green (LMG), to the filter paper followed by hydrogen peroxide. A colour change indicates a presumptive positive result for blood. This method is time consuming, and unless diligently undertaken, may result in missed blood evidence. There is also a risk, on some surfaces, of removing bloodstains or disrupting marks.

If blood is not found on dark items after the initial blood search then, depending on the item, alleged case circumstances and expectations, a second examination may be undertaken to confirm the negative result. This research was aimed at finding a quick and effective method for use, alongside current procedures, to confirm the negative result and to aid in the detection of any missed blood.

1.1. Selection of methods

Haemoglobin possesses peroxidase-like activity; it is involved in the catabolism of peroxides, into water and oxygen, and the oxidation of various substrates [3]. Many of the chemical presumptive tests for blood exploit this property. They are applied in a reduced, mostly colourless, form and become oxidised in the presence of haemoglobin and an oxidising agent (typically hydrogen peroxide), becoming coloured, fluorescent or luminescent. However, many of these tests can affect subsequent DNA extraction and/or typing [4–6,32], or have unacceptable health risks [4], therefore cannot be directly applied. Other tests, for example leucocrystal violet (LCV), become dark in colour, so are unlikely to improve the contrast on a dark background. Luminol, fluorescein and hydrogen peroxide were identified as chemicals that could be used to visualize bloodstains on dark items, and still allow for DNA profiling [5,7,31].

Spectroscopic methods, such as those involving ultraviolet (UV) or infrared (IR) light are also viable options for visualizing blood. These have an advantage over chemical methods because they do not physically interact with the bloodstain; therefore they do not affect the blood morphology.

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Results

- Substrates included white and black cotton, a leather jacket, vinyl floor tiles, carpet, hammer with a rubber grip, and suede sneakers.
- Blood samples ranged from neat to a dilution of 1:100,000 in water.
- Bluestar and fluorescein achieved a sensitivity of 1:1000.
- Hemascein achieved a sensitivity of 1:100.
- All peroxide concentrations achieved a sensitivity of 1:10.
- IR photography achieved a sensitivity of 1:10.
- Ultraviolet radiation achieved a sensitivity of 1:100.

Results

- Hydrogen peroxide and Bluestar (and to a lesser extent UV radiation) allowed for detection of blood on all surfaces tested.
- IR photography worked better on porous than non-porous surfaces.
- Overall, where samples have been washed or become dilute, Bluestar was found to work best.
- Hydrogen peroxide was found to be less sensitive, but an inexpensive and viable option.
- Long term exposure of blood samples to Bluestar and hydrogen peroxide over a period of 1-30 days did not effect DNA extractions.

Introduction

- Abraham J, Champod C, Lennard C, Roux C. Modern Statistical Models for Forensic Fingerprint Examinations: A Critical Review. Forensic Sci Int 2013;232:131-150.
- The goal of this effort was to provide a practical and theoretical perspective of recent Probability of Correspondence (PRC) and Likelihood Ratio (LR) statistical models.

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Review article

Modern statistical models for forensic fingerprint examinations: A critical review

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ABSTRACT

Over the last decade, the development of statistical models in support of forensic fingerprint identification has been the subject of increasing research attention, spurned on recently by commentators who claim that the scientific basis for fingerprint identification has not been adequately demonstrated. Such models are increasingly seen as useful tools in support of the fingerprint identification process within or in addition to the ACE-V framework.

This paper provides a critical review of recent statistical models from both a practical and theoretical perspective. This includes analysis of models of two different methodologies: Probability of Random Correspondence (PRC) models that focus on calculating probabilities of the occurrence of fingerprint configurations for a given population, and Likelihood Ratio (LR) models which use analysis of corresponding features of fingerprints to derive a likelihood value representing the evidential weighting for a potential source.

Contents

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Results – PRC Models

- PRC models are designed to represent statistical characteristics of minutiae detail (spatial and directional) by constructing feature models from which random samples are generated and PRC values calculated.
- PRC models evaluate the rarity of feature configurations.
- No PRC model explicitly considers aspects of FP identification, such as skin distortion characteristics and variances in marking minutiae location by human examiners.
- Most PRC models lack the application of a sound evaluation framework (most have not reported a thorough evaluation or rely on non-robust goodness-of-fit statistics for evaluating feature model fit.

Results – LR Models

- LR models provide a more practically based analysis of minutiae configurations, since empirical data is directly used for an evidentially focused analysis.
- LR models may include real world considerations, such as the effects of skin distortion and impact of the examiner.
- Feature vector LR models focus on the intrinsic spatial detail of a configuration, which somewhat mimics a human expert.
- AFIS based LR models are models from which the practical integration with an AFIS is straight forward (The AFIS can be treated as a black box onto which the LR model is built).

Results

- Both LR and PRC models have excelled in sophistication and practicality in recent years and will have a role to play in the near future to assist fingerprint experts.
- The authors favor models leading to assignments of LRs over models computing PRCs (due to allowance for distortion and examiner variation).
- LR models can assist in the analysis phase of ACE-V where fingerprints need to be assessed for suitability.
- LR models offer a mechanism to assign a weight of support to prints that would otherwise be inconclusive (in favor of the prosecution or defense theories).

Introduction

- Christensen AM, Crowder CM, Ousley SD, Houck MM. Error and Its Meaning in Forensic Science. J Forensic Sci 2014;59(1):123-126.
- The goal of this effort was to discuss the difference between practitioner errors, instrument errors, statistical errors, and method errors.

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PAPER

GENERAL

Angi M. Christensen,[1] Ph.D.; Christian M. Crowder,[2] Ph.D.; Stephen D. Ousley,[3] Ph.D.; and Max M. Houck,[4] Ph.D.

Error and its Meaning in Forensic Science*

ABSTRACT: The discussion of "error" has gained momentum in forensic science in the wake of the *Daubert* guidelines and has intensified with the National Academy of Sciences' Report. Error has many different meanings, and too often, forensic practitioners themselves as well as the courts misunderstand scientific error and statistical error rates, often confusing them with practitioner error (or *mistakes*). Here, we present an overview of these concepts as they pertain to forensic science applications, discussing the difference between practitioner error (including mistakes), instrument error, statistical error, and method error. We urge forensic practitioners to ensure that potential sources of error and method limitations are understood and clearly communicated and advocate that the legal community be informed regarding the differences between interobserver errors, uncertainty, variation, and mistakes.

KEYWORDS: forensic science, error, limitation, forensic anthropology, *Daubert*, mistake

Discussion regarding "error" in forensic science analyses gained momentum following the *Daubert* ruling (1) and has intensified with the National Academy of Sciences' National Research Council Report *Strengthening Forensic Science in the United States: A Path Forward* (2). The role of science within the judicial system is nothing novel; however, the focus has shifted to include the evaluation of methods and techniques rather than simply the expert's interpretation of the results. Establishing scientific validity is challenging within the forensic sciences considering that the concept of error has different meanings and functions in the courtroom compared with the research setting (3). Estimating method validity and understanding error are important, however, regardless of whether conclusions end up in court.

The concept of error has been problematic, and too often, the courts as well as forensic practitioners misunderstand the meaning of error as it relates to forensic science research, procedures, and techniques. Error can be defined in a number of ways including the following: an act, assertion, or belief that unintentionally deviates from what is correct, right, or true; the condition of having incorrect or false knowledge; the act or an instance of deviating from an accepted code of behavior; or a mistake. Mathematically and statistically, error may refer to the difference between a computed or measured value and a true or theoretically correct value.

Considering these definitions, it is apparent that error in the forensic science realm can result from a number of different causes, contributing to the complexity in understanding the potential source(s) of error. The convergence of science and law has made the identification and interpretation of error in the courtroom an even greater challenge, especially as officers of the court typically lack a scientific background and specific knowledge regarding error analysis. Thus, the concept of error is often vague and subject to a variety of interpretations.

Admissibility criteria for expert testimony in the United States were redefined in the 1993 Supreme Court *Daubert* decision (1) resulting in significant changes in and interpretation of the Federal Rules of Evidence Rule 702 (4). The *Daubert* criteria were intended to provide guidelines for admitting scientific expert testimony to ensure its reliability and validity. In federal cases and in states that have adopted the *Daubert* criteria, trial judges might consider the following factors to assess the admissibility of scientific or technical expert testimony: (i) whether the theory or technique in question can be (and has been) scientifically tested, (ii) whether it has been subjected to peer review and publication, (iii) its known or potential error rate, (iv) the existence and maintenance of standards controlling its operation, and (v) whether it has attracted widespread acceptance within a relevant scientific community (1:593-94).

While the tumult surrounding the potential impact of the *Daubert* ruling on the forensic sciences seemingly began to dissipate over the years, the challenge to the forensic science community was renewed with the release of the National Academy of Sciences' National Research Council Report *Strengthening Forensic Science in the United States: A Path Forward* (2). This document outlined the scientific and technical challenges that must be met in order for the forensic science enterprise in the United States to operate at its full potential. In the Council's opinion, some disciplines were found to lack scientific rigor, leading

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Results

- The concept of error has different meanings and functions in the courtroom compared to the research environment.
- Error can be defined as an act, assertion, or belief that deviates from what is correct, right or true; the condition of having incorrect knowledge; the act of deviating from an accepted code of behavior; or a mistake.
- Statistically or mathematically, error may refer to the difference between a computed or measured value and a true or theortically correct value.
- The known rate of error provides a scientific measure of a method's validity.

Results

- Practitioner error is a mistake or operator (human) error. It can be random or systematic, may be related to negligence or incompetence, and can be unintentional and unquantifiable.
- Practitioner error can be reduced through QA systems, training, proficiency testing, peer review, and adhering to validated protocols.
- Instrument errors can be defined as the difference between an indicated instrument value and the actual (true) value.
- Instrument error can be minimized (but not completely eliminated) by proper maintenance and calibration of instruments as part of a QA program. Some acceptable amount of error is recognized to exist.

Results

- Statistical error expresses normal variability and is inherent in measurements based on the properties of the sample. The actual value of a measurement may fall outside of he prediction interval.
- Method error relates to inherent limitations that have nothing to do with practitioner error or breakdown in technology.
- These limitations affect the sensitivity or resolving power, probative value, and ultimately the validity of the method.
- There is no way to minimize method error as it exists as a function of inherent variation in the material itself; such limitations should be acknowledged and communicated in courtroom testimony.
- There is always a non-zero rate of error and limitations should be acknowledged and reported.

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