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The recovery of latent fingermarks and DNA using a silicone-based casting material

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Abstract

There are many techniques available for the recovery of fingermarks at scenes of crime including the possibility of taking casts of the marks. Casts can be advantageous in cases where other destructive recovery techniques might not be suitable, such as when recovering finger marks deposited on valued or immobile items.

In this research, Isomark™ (a silicone-based casting material) was used to recover casts of finger marks placed on a variety of substrates. Casts were enhanced using cyanoacrylate fuming. Good quality marks were successfully recovered from a range of smooth, non-porous surfaces. Recovery from semi-porous surfaces was shown to be inefficient.

DNA was subsequently extracted from the casts using QIAamp® Mini extraction kits, amplified and profiled. Full DNA profiles were obtained 34% of samples extracted.

Keywords: Forensic science; Finger mark; Casting; Isomark™; DNA profiling

1. Introduction

The enhancement of fingermark ridge detail is of paramount importance for the identification of marks deposited at scenes of crime. Much research has been carried out in this area and multiple techniques and methods are available for use, each with their own merits and disadvantages [1].

This study investigated the recovery of fingermarks using Isomark™ (Isomark Ltd., Nuneaton, Warwickshire, UK). Isomark™ is a fast curing silicone-casting material. It was first introduced for the detection of mechanical marks and specifically designed for forensic use. Most significantly, Isomark™ is reportedly non-destructive and can reproduce marks with a resolution of 0.1 μm.

Finger marks at a scene may be distorted, smudged or without enough ridge detail to make a reliable comparison of characteristics. In such cases, it is desirable to obtain a deoxyribonucleic acid (DNA) profile from the finger mark [2]. This study also aimed to ascertain whether it is possible to obtain a reliable DNA profile from the Isomark™ casts of the finger marks.

2. Materials and methods

2.1. Deposition of finger marks

Finger marks were deposited in both a controlled and a realistic manner.

Controlled finger marks were deposited onto the following six substrates: cold aluminium can (stored at 4 °C before fingermark deposition), plastic water bottle, £2 coin, waxy paper cup, 60 W light bulb and a hard plastic mobile phone case (Nokia 3330). Two volunteers were asked to wash their hands using soap and water, and then rubbed their fingers over their face. Five discrete marks (from five separate fingers) were then deposited onto each of the substrates within a designed 5 cm by 4 cm area. Each volunteer repeated the application five times per substrate ($n = 50$), under the same conditions.

Realistic finger marks were deposited on the aluminium can, bottle and cup. None of these substrates were washed before deposition. Two donors took part in this part of the study. The donors did not wash their hands before depositing

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marks. The donors were asked to drink from the can (removed from a refrigerator at 4 °C), bottle and cup as they would normally. 62 prints were subsequently analysed.

In both situations, untouched areas of each surface were sampled as negative controls.

2.2. Recovery and development of finger marks

Isomark™ was dispensed over the marks 1 h after they were deposited and spread using a plastic spreader. After recovery, the marks were left for 1 day before developing. The marks on both the Isomark™ cast and the substrate, after casting, were treated with cyanoacrylate (CNA) adhesive PERMABOND (1.2 g; Permabond Engineering Adhesives Ltd., UK). Items were treated within a MVC 3000 fume hood (Foster and Freeman Ltd., UK). Fuming took place for 20 min at 80% humidity and 120 °C.

After development, items were photographed using an Integrated Rapid Imaging System (IRIS, HOSDB).

2.3. DNA recovery

After the finger marks were recovered and enhanced with CNA, the samples (substrates and casts) were stored at 4 °C for 12 h. DNA extraction was then performed from both sample types.

The surfaces of the substrates were swabbed first with a sterile wet cotton swab (Fisher Scientific UK Ltd., UK). Residual moisture was then recovered by swabbing the surface with a dry cotton swab. Both swab heads were placed into the same 2 ml microcentrifuge tube. DNA extraction was performed using the QIAamp® DNA Mini Kit according to manufacturer's instructions (QIAgen™). The Isomark™ was sliced with a sterile scalpel and the pieces placed directly into a bijou. DNA extracted as above, with a larger volume (1.5 ml) ATL extraction buffer being added in the first step, to cover the Isomark™ cast.

The DNA was concentrated using Microcon® Ultracell YM-100 (Millipore, USA). DNA quantitation was then performed using Quantifiler™ Human DNA Quantification Kit in an ABI PRISM® 7000 (Applied Biosystems, CA, USA).

2.4. DNA amplification and profiling

DNA amplification was performed using the AmpF/STR® SGM Plus® Kit. A 28 cycle amplification was conducted following the manufacturer's protocol, in a 25-μl final reaction volume. The samples were then profiled using an ABI PRISM® 310 Genetic Analyser (both from Applied Biosystems, USA).

2.5. Statistical analysis

Statistical analysis was performed using Statistical Product and Service Solution, Inc. (SPSS, Chicago, IL, USA). Univariate analysis of variance (95% statistical level) was performed on the results in order to determine whether there was significance in the variation obtained. In cases where more than two items were compared, univariate post hoc multiple comparisons (equal variances assumed using Tukey) for observed means was performed.

3. Results

3.1. Finger mark analysis

In order to grade the marks, a classification system was used based on the number of ridge flow and characteristics observed. The marks were given a score between 0 and 8, where 0 being least and 8 the most discriminative.

3.2. Controlled finger marks

The marks deposited in a controlled manner on the six different substrates were recovered using Isomark™. Fig. 1 shows detail from finger marks recovered from each substrate using the Isomark™ and sequentially treated with cyanoacrylic (CNA) fuming.

The quality of the recovered marks was assessed. Table 1 shows the characterisation of the marks obtained from the six substrates.

As can be seen from Table 1, marks of decent quality could be successfully visualised on the Isomark™ casts of marks deposited on most surfaces tested. It was determined that the aluminium can, the bottle, the coin and the light bulb yielded marks of significantly higher quality than those recovered from the foam cup and the mobile phone case ($p < 0.01$).

Table 1
Quality of controlled marks recovered using Isomark™

Substrate	Mark quality (Iso)		Mark quality (Sub)	
	Average score	σ	Average score	σ
Aluminium can	4.2	1.10	2.4	1.34
Base of plastic bottle	4.8	2.05	5.8	2.17
£2 coin	5.0	2.00	6.0	1.87
Cup	0.6	1.34	0.0	0.00
Light bulb	4.0	0.71	3.0	0.00
Mobile phone case	0.0	0.00	0.4	0.89

A score of 0 is the least and 8 is the most discriminate. (Iso) = Marks recovered using Isomark™; (Sub) = marks on substrate after Isomark™ lifting.

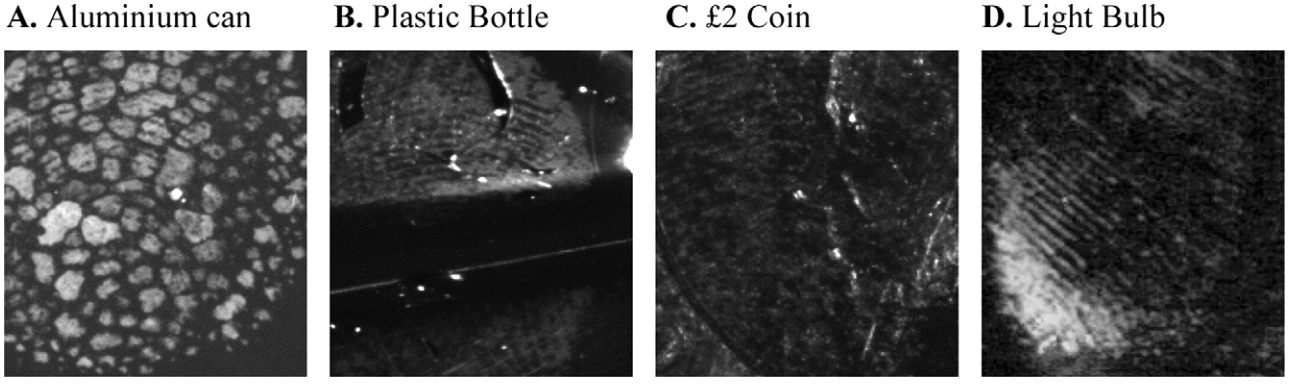

Fig. 1. CNA developed Isomark™ samples.

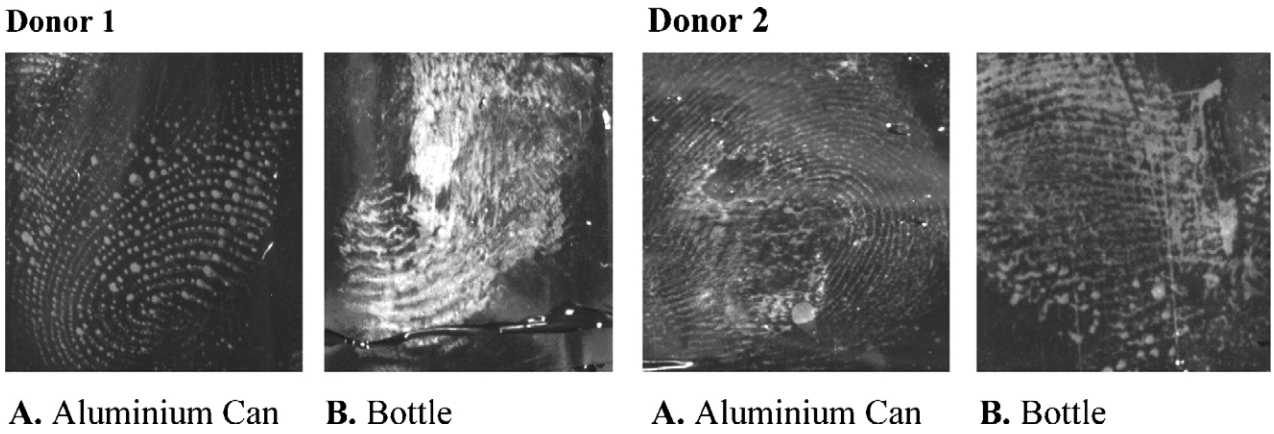

Fig. 2. CNA developed Isomark™ samples. Realistically deposited marks recovered using Isomark™ on two substrates by two donors.

No significant difference was noted between the quality of the marks remaining on the bottle coin, cup or mobile phone case, when compared to the respective Isomark™ recovered mark. The marks left on the aluminium can were, however, of lesser quality than those recovered in the Isomark™ lift.

The Isomark™ method did not yield clear marks from the cup or mobile phone case.

3.3. Realistic finger marks

The marks recovered by the Isomark™ and those left on the different substrates were mostly of similar quality, with a slight trend for marks recovered by the Isomark™ being of higher quality than the marks remaining on the object. Fig. 2 shows realistic finger marks recovered using Isomark™. No finger mark detail was recovered from the cup.

As in the controlled test, a significant difference was noted between the substrates used and the quality of the mark casts obtained. Table 2 shows the scores of the marks obtained from the substrates used.

4. DNA analysis

4.1. Controlled finger marks

The amount of DNA found using Quantifiler™ Human DNA Quantification Kit, is depicted in Fig. 3 below.

It was noted that significantly larger quantities of DNA were being recovered from the Isomark™ casts of marks deposited on the light bulb and the mobile phone case, compared to marks deposited on other surfaces. It was found that the amount of DNA remaining on the light bulb and phone case was significantly lower than the amount recovered by the Isomark™ ($p < 0.01$).

Table 2
Characterisation of realistic marks recovered using Isomark™

Object	Mark quality (Iso)		Mark quality (Sub)	
	Average score	σ	Average score	σ
Aluminium can	7.00	1.55	5.83	2.48
Base of plastic bottle	4.33	2.66	2.83	1.60
Cup	0.00	0.00	0.00	0.00

A score of 0 is the least and 8 is the most discriminate. (Iso) = Marks recovered using Isomark™; (Sub) = marks on substrate after Isomark™ lifting.

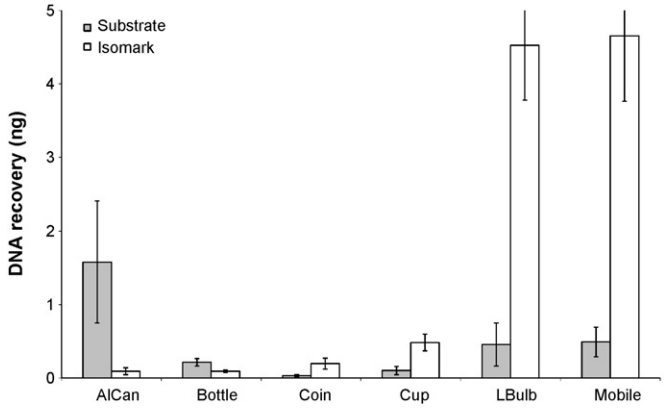

Fig. 3. Average amount of DNA (ng) recovered from controlled finger marks. The marks obtained were from a single donor ($n = 5$). DNA was recovered from both the original object and the Isomark™. Error bars depict standard error.

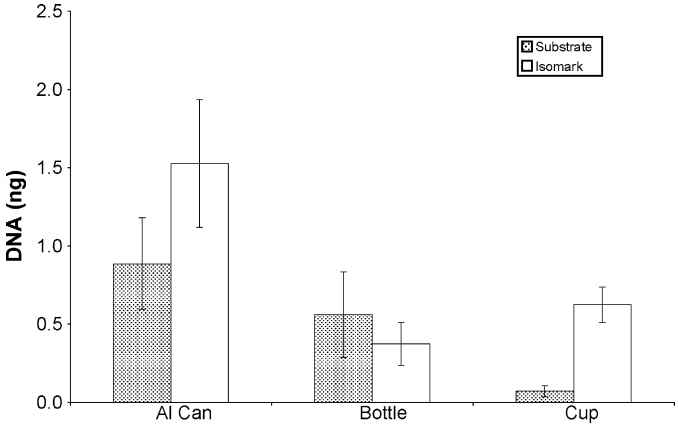

Fig. 4. The amount of DNA recovered from realistic marks. The marks obtained were from two donors ($n = 6$). DNA was recovered from both the original object and the Isomark™. The average amount of DNA is given. Error bars show standard error.

4.2. Realistic finger marks

The amount of DNA recovered is depicted in Fig. 4. DNA recovery was found to be highly variable and ranging from 0.1 to 2.3 ng. The substrate, donor, or method of recovery were found to have no significant effect on the amount of DNA recovered.

Samples that yielded enough DNA (0.1 ng μl^{-1}) were profiled. This corresponded to 42% of the total number of samples tested. Full profiles were obtained from 82% of these samples (34% of the total), with the rest yielding partial profiles. No mixed profiles were obtained, with all alleles matching the donor's.

5. Discussion

5.1. Finger mark analysis

It was observed that the detection of latent finger marks cast in Isomark™ was made easier using CNA fuming. The only marks not visible even after CNA fuming were those on the cup and the mobile phone case. These results show that Isomark™ is not suitable for the recovery of finger marks from these semi-porous surfaces. Smooth non-porous substrates yielded the best marks.

The aluminium cans were stored at 4 °C, resulting in condensation on their surface, consequently, the marks recovered and developed were 'blotchy' in appearance. This was done to simulate a more realistic scenario whereby the aluminium cans would not have been left out to dry before finger mark deposition, and conversely taken straight from a fridge. Nonetheless, sufficient ridge detail was observed in some cases to make identification possible.

The marks that were developed on the Isomark™ and those that remained on the substrates were of similar quality. This is advantageous because there is potentially enough finger mark detail being recovered by the Isomark™ for individual identification. Furthermore, there is enough mark detail remaining on the substrate, that in the event that the Isomark™ is damaged, it is possible to go back to and analyse the original substrate. The quality of the finger marks recovered may also be affected by the presence of air bubbles in the Isomark™ cast, caused whilst spreading the Isomark™ over the substrate. An air bubble is visible on the cast of the plastic bottle in Fig. 1.

5.2. DNA analysis

The results and negative controls showed that DNA from finger marks was being recovered by the Isomark™.

Although every effort was made to deposit identical marks in all of the repeats, there is a high variation between the amounts of DNA obtained. A number of factors are thought to be responsible for this, including: uneven distribution of latent residues on the fingertips, uneven pressure application, natural variation in DNA shedding amongst individuals, and other factors which cannot be controlled directly [3,4].

It was observed that, in the majority of cases, more DNA could be recovered from the Isomark™ cast of smooth non-porous surfaces, compared with what was left on the substrate. It can be inferred that this is due to the fact that both these surfaces are non-porous and do not retain epithelial cells well [5,6]. The aluminium can surface retained significantly more DNA than was recovered by the Isomark™, despite being non-porous, smooth surface. This is an important observation, which implies that it can be unpredictable whether the DNA is recovered in the cast, and highlights the importance of swabbing the area of interest after casting.

Relatively large amounts of DNA were being recovered from the casts taken from the mobile phone case and the light bulb. It is believed that these results reflect the variation in DNA deposition, rather than substrate effects. This study highlights how even in these controlled conditions, DNA deposition in finger marks is highly variable and particularly difficult to predict.

5.3. Realistic finger marks

On a whole, less DNA was recovered for these realistic marks than for the controlled finger marks. Although more marks were deposited for the realistic scenario, special handling needs to be performed in order to recover trace DNA. Although less DNA was recovered, for some of the samples there was sufficient DNA for amplification and profiling.

The fact that DNA profiles were obtained is advantageous because in the event that the fingermark is damaged, there is potential for identification of the depositor. A disadvantage of this is that there is a possibility that secondary transfer of DNA can occur [4].

Although the results obtained are promising in terms of the impact on finger mark and DNA recovery, it needs to be noted that crime scene factors may contribute to less efficient results. For instance, it has been shown previously that the strongest profile obtained from a touched surface is not always that of the person who last held the object, but is dependent on the sheddability of the individual [2]. Therefore, genetic identification and finger mark analysis should be used in conjunction with one another. However, if the finger marks found at the crime scene cannot be analysed, it is our belief that the mark can still be used as a source of DNA.

6. Conclusion

Isomark™ can be used to recover finger marks left on aluminium can, plastic bottle, £2 coin and glass light bulb. Although further tests need to be performed, the results show that Isomark™ is not suitable for recovering finger marks from semi-porous surfaces such as the cup and mobile phone cover. This research also showed that it was possible to recover DNA from Isomark™ casts made on all substrates tested. No link was noted between the quality of finger marks obtained and the amount of DNA extracted from them. This is because surfaces that recover good marks are usually non-porous and DNA is retained better by more porous surfaces. The results obtained suggest that Isomark™ can be used by

scene of crimes officers as an alternative to powdering on irregularly shaped surfaces. Isomark™ may be used alongside methods used for the initial detection of marks, such as oblique and special light sources. Furthermore, good quality DNA is obtainable from the recovered marks. This method therefore brings together DNA and finger marks; both powerful forms of evidence.

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