Forensic Science International 366 (2025) 112306

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

A novel approach using cyanoacrylate ester fuming on surfaces with anti-climb paint

Maia J. Davatwal [a], Andrew Langley [b], Laura J. Vera Stimpson [a,*]

[a] *School of Law, Policing and Social Sciences, and Policing, Canterbury Christ Church University, Kent, United Kingdom*
[b] *Division of Natural Sciences, University of Kent, Kent, United Kingdom*

ARTICLE INFO

Keywords:
Cyanoacrylate ester fuming
Anti-climb paint
Fingermark
Grading

ABSTRACT

The use of fingermarks as evidence in forensic science remains indispensable with these being used for identification and/or elimination purposes. A wide array of methods and techniques have been developed to enhance, recover, and preserve fingermarks from various surfaces. However, the forensic community continues to encounter challenges when dealing with certain surfaces, among them is anti-climb paint, presenting unique difficulties due to its non-drying nature. This research introduces a systematic methodology, aligned with current forensic practices, to effectively develop and recover fingermarks from surfaces coated with anti-climb paint, addressing a critical gap in forensic science.

1. Introduction

Fingerprints have been used for identification for over a century [1] and are a valuable source of evidence in forensic science [2]. These are characterized by distinct and individual patterns originating from the elevated papillary ridges on the fingertips. Ridges contain minute pores through which eccrine (sweat) and sebaceous secretions are excreted, thereby coating the surfaces of ridges. These patterns are created early in foetal development and remain unchanged throughout a person's lifetime unless deep-seated injury occurs [3,4]. Fingerprint evidence is valuable in forensic science due to its effective uniqueness and permanence, being found on various surfaces intentionally or unintentionally touched with bare hands. Faulds [5] (1880) first proposed comparing crime scene fingermarks with controlled fingerprints, noting their unique patterns. Galton [3] introduced a systematic classification system based on fingerprint patterns, and Henry [6] (1901) categorized them further, leading to the adoption of the Henry classification system [1] by UK law enforcement. Henry's work laid out the foundation of modern fingerprint identification systems such as the Automated Fingerprint Identification System (AFIS).

The significance of fingerprint evidence in the realm of forensic science is indisputable [7,8]. Nevertheless, to facilitate meaningful comparisons, the fingermark must undergo appropriate enhancement, recovery, and preservation processes. The *fingermark visualisation manual* [9] provides guidance on suitable development methods for the recovery of fingermarks from a range of surfaces. However, some surfaces such as fabrics, bricks, and certain types of painted walls present challenges in fingermark recovery [10–13]. Anti-climb paint, in particular, presents notable challenges for the recovery and preservation of fingermarks. This specialized paint, formulated with a non-drying solvent base, can be applied to various exterior surfaces such as pipes, fences, and brickwork as a deterrent against trespassers. Its inherent slipperiness facilitates marking and staining of contacted objects, as well as easy transfer of fingermarks between surfaces. These distinctive characteristics render anti-climb paint a valuable source of evidentiary material. However, the non-drying nature of the paint poses significant difficulties in the recovery and preservation of fingermarks from these surfaces or objects. In forensic practice, photographic capture has conventionally been the primary method employed for the recovery of fingermarks made in or from anti-climb paint, therefore alternative approaches to recovery and preservation are required. Thus, this paper introduces an innovative method for developing, recovering, and preserving fingermarks created in and derived from anti-climb paint, aiming to address the challenges associated with this unique substrate.

2. Materials and methods

The anti-climb paint utilised in this study was sourced from the brand 'Rapide' and was black in colour. To maintain consistency and ensure reproducibility, a standardised quantity of anti-climb paint was

* Correspondence to: School of Law, Policing, and Social Sciences, North Holmes Road Campus, Canterbury, Kent CT1 1QU, United Kingdom.
E-mail address: laura.vera-stimpson@canterbury.ac.uk (L.J. Vera Stimpson).

https://doi.org/10.1016/j.forsciint.2024.112306
Received 18 January 2024; Received in revised form 15 November 2024; Accepted 19 November 2024
Available online 20 November 2024

Table 1
Fingermark grading scale Castello et al. [13].

Grade	Description
0	No visible print
1	Poor quality, very few visible ridges
2	Poor quality, some ridge detail visible or partial mark with limited characteristics
3	Reasonable quality, ridge detail, and some characteristics visible, identification possible
4	Good quality print, ridge detail, and characteristics visible, probable identification
5	Excellent quality, full mark, very clear, and identification assured

used for each experimental test, measured using a microspatula with dimensions L X W = 2 × 2 mm. One scoop of anti-climb paint was used to mimic the average amount of substance deposition on objects. This was spread using a small square artist paintbrush.

Anti-climb paint is specifically designed for external applications; therefore, the suitability of the proposed recovery technique was also investigated under various temperatures (-18°C, 4 °C, 23 °C, and 35 °C) as well as in wet environments. For wet conditions, the exhibits were sprayed with a mist of water (approximately 0.6 ml). The anti-climb paint was aged in its respective environments for four days prior to fingerprint application and subsequent fingermark deposition.

For this research, contact, primary, and secondary transfer fingermarks were deposited onto acetate sheets using a device designed to facilitate controlled deposition of fingermarks. A contact fingermark is defined as the impression created directly by the finger upon initial contact with anti-climb paint. The first mark left on a surface after this contact is referred to as primary transfer, while the second subsequent impression deposited onto a new surface is termed secondary transfer. The deposition process maintained a uniform force and angle, set to 1.1 N and 90°, respectively.

Cyanoacrylate ester fuming (CEF), also known as cyanoacrylate fuming (CAF), was used for the chemical development of deposited fingermarks. A fuming enclosure measuring 0.07 m^3 was assembled using plastic storage boxes, vertically stacked to facilitate the introduction of the necessary components. A hot plate, beaker containing hot water, and aluminium tin cases containing ten drops of superglue (with cyanoacrylate ester active component) were placed within the enclosure. Exhibits were suspended above the hot plate during the fuming process. The seams of the enclosure were sealed during the fuming process which commenced by heating the enclosure to a temperature of 100 °C and maintained for a duration of 80 minutes.

A high-resolution dental vinylpolysiloxane silicone (Provil® novo light regular set) was employed for casting the developed fingermarks. The silicone material and catalyst were loaded into a dispensing gun equipped with a dispensing tip to ensure comprehensive mixing prior to application. The resulting mixture was then applied to the exhibit using a side-to-side motion ensuring slight overlap during the application process. Setting time is typically rapid (5 – 10 minutes) dependent upon ambient temperature. This produced a negative impression. Black ink was used to further enhance the fingermark. This was achieved by inking the cast and removing excess ink using J-lar tape.

The assessment of quality of the developed fingermarks was carried out using a grading system that was selected based upon research with a fingerprint expert. The grading system devised by Castelló et al. [13], Table 1, was employed in combination with the expertise of the fingerprint expert to objectively evaluate and categorise the clarity, detail, and overall distinctiveness of the obtained fingermarks.

A registered fingerprint identification expert conducted a detailed comparison of the friction ridge characteristics. The study was approved by the local ethics committee. To ensure participant anonymity and comply with ethical guidelines, all fingermark images have been partly obscured.

3. Results and discussion

Anti-climb paint incorporates solvents that facilitate application to surfaces, with these solvents undergoing gradual evaporation over time. To ensure complete solvent evaporation, anti-climb paint was applied to exhibit surfaces and allowed to remain undisturbed for a period of four days before fingermark application. After this period, contact, primary, and secondary transfer fingermarks were acquired for examination and analysis.

Contact transfer fingermarks (Fig. 1a) demonstrated the lowest

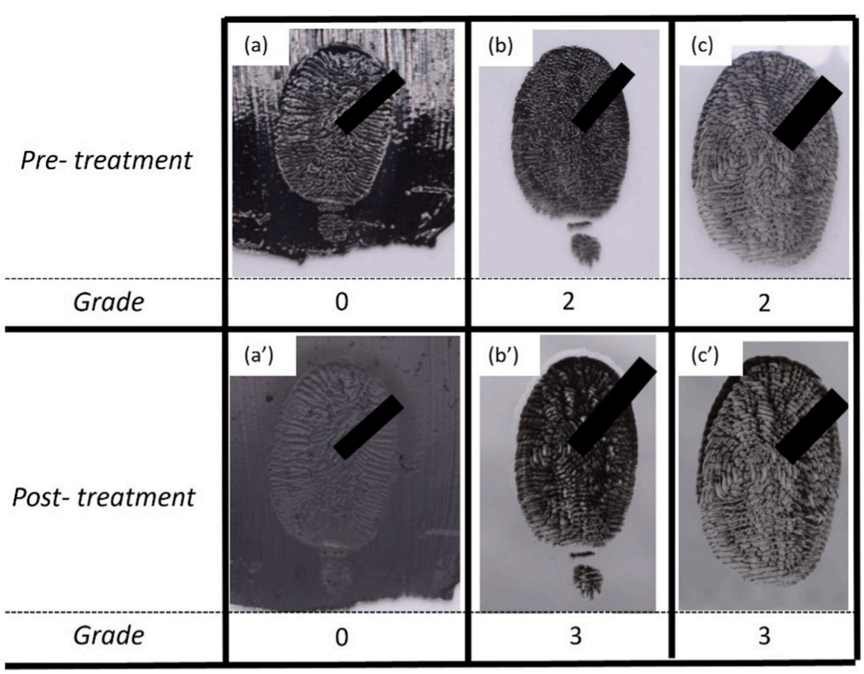

Fig. 1. Fingermarks made in and from anti-climb paint at room temperature (23 °C) both pre- and post- CEF treatment showing (a) contact, (b) primary, and (c) secondary transfer.

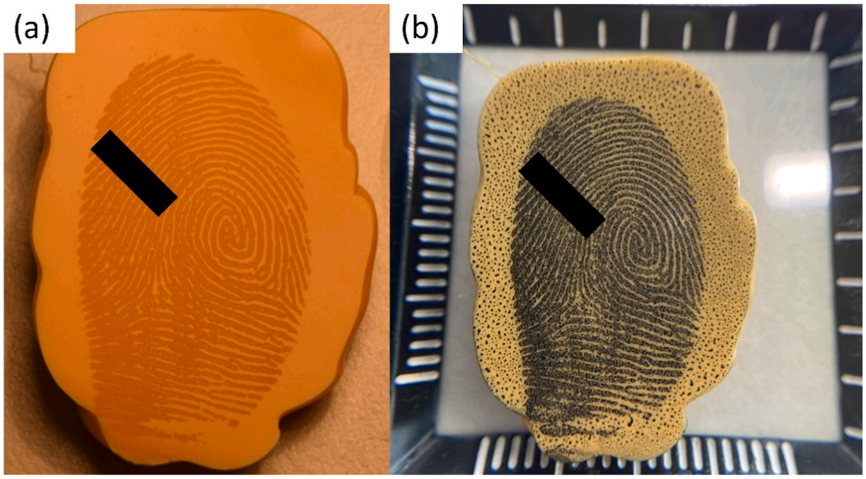

Fig. 2. Cast recovered post- CEF development where ridge visualisation is enhanced using (a) oblique white light and (b) using black ink.

quality grade (average grade = 1), characterised by limited ridge visualisation, rendering most of these unsuitable for fingermark examination. This outcome can be attributed to the non-drying characteristics of the anti-climb paint, wherein properties of adhesion and surface tension continue to be active in the material, thereby maintaining its cohesive nature and resisting deformation. Fig. 1(b – c) illustrates the average fingermarks resulting from primary (b) and secondary (c) transfers. With successive transfers, there was a noticeable enhancement in the quality of the fingermarks, subsequently reflected in improved grades. On average, a grade of 2 was achieved for both primary and secondary transfers.

Cyanoacrylate ester fuming (CEF) was used for the chemical development of these fingermarks, primarily due to its recognised ability to generate robust residues [14]. The residue consisting of polymerized cyanoacrylate results from the reaction between cyanoacrylate vapours and moisture present in the environment. This polymerized residue adheres firmly to the ridges of the fingerprint. CEF treatment of fingermarks made in and from anti-climb paint did not yield any discernible differences in the overall quality of the contact fingermarks (Fig. 1 (a')). However, a slight improvement in grade was achieved for primary and secondary transfers post-treatment (Fig. 1(b' – c')) with an average grade of 3 being assigned. This improvement may be due to the noticeable reduction in shine, with the fingermarks appearing matte post-treatment. Subsequently, both 1st and 2nd level detail were discernible, enhancing the likelihood of a positive identification if a coincident sequence [15] was to be successfully established. Furthermore, the CEF treatment imparted enhanced durability and robustness to the fingermark impressions. These showed resistance to deformation upon handling, thereby facilitating their preservation for subsequent analysis.

The robust fingermark produced post- CEF treatment allowed for the application of casting material. For this purpose, Provil® was selected as the casting medium due to its known capability of capturing details down to 1 μm [16]. This choice proved to be appropriate given that fingermark ridges typically exhibit a thickness ranging from 100 – 300 μm [17,18].

Results obtained from the casting process are shown in Fig. 2. Provil® demonstrated effectiveness in capturing detailed ridge impressions of the fingermarks. However, some minutiae visualisation problems persisted due to the poor colour contrast. White light illumination at oblique angles was employed to improve contrast (Fig. 2a) which proved effective in enhancing the visibility. In forensic practice, the cast would be photographed and corrected to show a black fingermark against a light background. Due to the robustness of the cast, it is possible to further enhance the fingermark through rolling the cast in black ink and removing any excess ink using J-Lar tape (Fig. 2b). This additional step significantly improved the visualisation of ridge detail without the need for illumination methods. Furthermore, this process eliminates the need for background correction. These enhanced casts allowed for 1st, 2nd, and 3rd level detail to be observed, thereby providing a valuable resource for forensic analysis and comparison.

In practical scenarios, anti-climb paint is inevitably subjected to various environmental conditions. Therefore, CEF treatment was applied to exhibits aged in distinct environments, spanning temperatures of 35 °C, 4 °C, −18°C, as well as in wet conditions, over a four-day period with this treatment being applied directly after removal from the respective environment.

A comparative analysis between results obtained at room

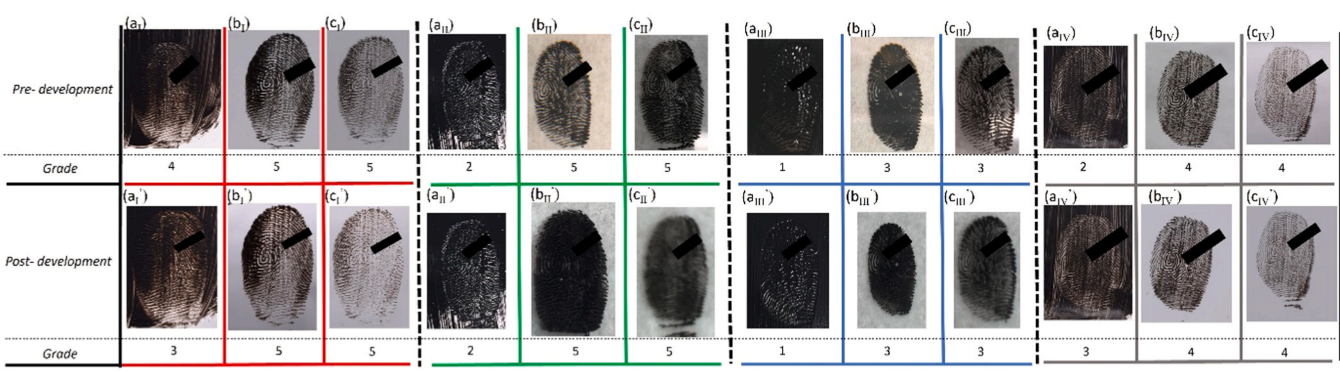

Fig. 3. Fingermarks made in and from anti-climb paint at (I) 35 °C, (II) 4 °C, (III) −18°C, and in (IV) wet conditions both pre- and post- CEF treatment showing (a) contact, (b) primary, and (c) secondary transfer.

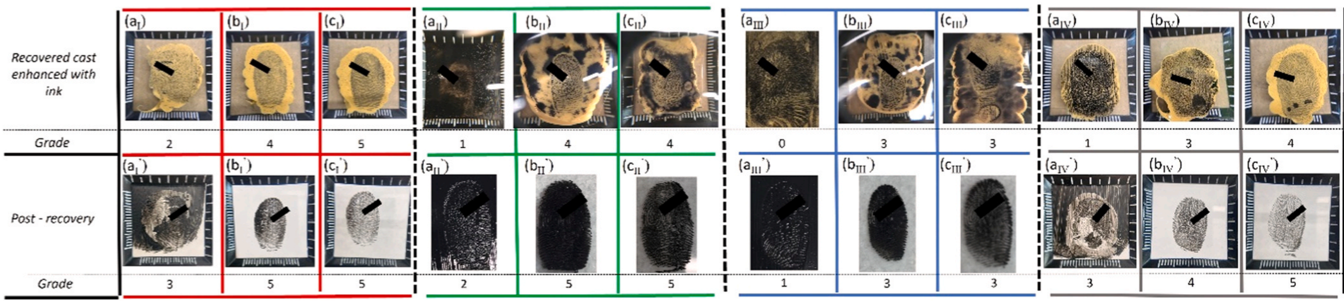

Fig. 4. Comparison between recovered casts enhanced with ink post- CEF development and fingermark residue after the recovery process where (a) contact, (b) primary, and (c) secondary transfer at (I) 35 °C, (II) 4 °C, (III) −18°C, and (IV) wet.

temperature (23 °C) (Fig. 2) and those obtained from the pre- and post-treatment under different temperatures and environmental conditions (Fig. 3) revealed consistent trends. Grade assignment improved with successive transfers; with contact fingermarks typically showing the lowest grades, as these are particularly affected by the surface tension properties of the anti-climb paint. Notably, contact fingermarks conducted at 35 °C displayed higher grades compared to those conducted at lower temperatures or under wet conditions. This difference is believed to be linked to an increased loss of adhesiveness of the anti-climb paint at this temperature prior to the deposition of the fingermark.

Some challenges in interpretation and grade assignment were encountered, primarily attributed to the contrast and artefacts generated by the anti-climb paint, which can obscure characteristics and complicate the establishment of a coincident sequence. Additionally, these artefacts have the potential to lead a fingerprint expert to incorrectly conclude the presence of two overlapping fingermarks, due to the slipperiness of the substance. Consequently, this factor must be taken into consideration during the analysis of this type of evidence.

Lower grades were typically observed for the Provil® cast recovery method when compared to the pre- and post- development stages. However, the fingermarks retained their original post-development grade (Fig. 3) or exhibited an increase in grade post-recovery (Fig. 4). Casts recovered at a temperature of 35 °C exhibited the most favourable quality grades, aligning with previous findings, although showing a slight reduction in grade when compared to the pre-development and post-recovery stages. It is important to note that the high-resolution dental vinylpolysiloxane silicone is designed to unveil existing ridge patterns. The observed discrepancy between the ink-treated recovered cast, the pre-/post- development stages as well as the post-recovery casts may potentially be attributed to the varying amounts of anti-climb paint present and consequently, may introduce bias into the obtained results. Further highlighting the need for careful consideration of this type of evidence. Additionally, the grading system used in this research may have introduced some inherent subjectivity, as individuals might interpret grading criteria differently. To enhance consistency and reliability, a registered fingerprint expert conducted a detailed comparison of friction ridge characteristics, adhering to standards commonly used across the field. In cases where part of the fingermark showed comprised detail, the expert assessed whether other areas provided sufficient ridge detail to establish a reliable coincident sequence. As a result, grades were assigned to reflect identifiable quality aspects, even if portions of the fingermark were less clear.

Some damage occurred when removing the casting material from contact fingermarks (Fig. 4a). This damage occurred in regions where brush strokes were present, as these showed greater protrusion compared to the ridge detail. Consequently, an uneven distribution of surface areas exists, requiring a higher concentration of polymerized cyanoacrylate deposition to avoid damage. However, extending the reaction time to accommodate this higher deposition led to an over-development of the ridge details. In contrast, the technique proved to be non-destructive when applied to primary and secondary transfer fingermarks (Fig. 4b – c) where multiple castings were possible. This absence of damage can be attributed to the balanced surface area in these fingermarks.

4. Conclusion

This study researched the forensic examination of fingermarks originating from surfaces coated with anti-climb paint. Traditionally, the non-drying nature of this paint has limited fingermark recovery, with photography being the sole option. However, our research demonstrates a novel approach using cyanoacrylate ester fuming to both facilitate the recovery and increase the durability of the fingermarks. Subsequent casting with a high-resolution dental vinylpolysiloxane silicone offers an effective method for recovering, preserving, and visualizing ridge patterns, with the mitigation of contrast challenges through inking. Additionally, our study delves into the influence of diverse environmental conditions on fingermark recovery. While some damage was observed in contact fingermarks, primary and secondary transfers proved to be non-destructive, highlighting the potential for multiple castings. This research additionally highlighted the potential for bias originating from the comparison of fingermarks made in and from anti-climb paint. These findings contribute valuable insights to forensic analysis whilst highlighting the need for careful consideration of environmental variables for recovery and analysis of this type of evidence.

CRediT authorship contribution statement

Laura Vera Stimpson: Writing – review & editing, Writing – original draft, Investigation. **Maia J Davatwal:** Writing - review & editing, Investigation. **Andrew Langley:** Review and editing, Investigation.

Declaration of Competing Interest

The authors have no competing interests to declare.

References

[1] Barnes, 2011. Chapters 1&5. Home | Office of Justice Programs. Available at: ⟨https://www.ojp.gov/pdffiles1/nij/225320.pdf⟩ (accessed: 25 October 2023).
[2] H. Swofford, C. Champod, A. Koertner, H. Eldridge, M. Salyards, A method for measuring the quality of friction skin impression evidence: method development and validation, Forensic Sci. Int. 320 (2021) 110703.
[3] Galton, F., 1892. Finger prints (No. 57490-57492). Cosimo Classics.
[4] S.M. Bleay, M. de Puit, Formation of fingermarks, Fingerpr. Dev. Tech. Theory Appl. (2018) 11.
[5] H. Faulds, On the skin-furrows of the hand, Nature 22 (574) (1880), 605-605.
[6] M.J. Leadbetter, Fingerprint evidence in England and Wales–The revised standard, Med. Sci. law 45 (1) (2005) 1–6.
[7] S.L. Zabell, Fingerprint evidence, JL Pol. 'Y. 13 (2005) 143.
[8] J.W. Bond, The value of fingerprint evidence in detecting crime, Int. J. Police Sci. Manag. 11 (1) (2009) 77–84.
[9] Fingermark Visualisation Manual, 2nd edition (2022). Home office.
[10] J. Fraser, K. Sturrock, P. Deacon, S. Bleay, D. Bremner, Visualisation of fingermarks and grab impressions on fabrics. Part 1: Gold/zinc vacuum metal deposition, Forensic Sci. Int. 208 (1-3) (2011) 74–78 ([online]).

[11] L. Davis, R. Fisher, Fingermark recovery from riot debris: bricks and stones, Sci. Justice 55 (2) (2015) 97–102 ([online]).
[12] J. Dawkins, L. Gautam, H. Bandey, R. Armitage, L. Ferguson, The effect of paint type on the development of latent fingermarks on walls, Forensic Sci. Int. 309 (2020) ([online]).
[13] A. Castelló, F. Francés, F. Verdú, Solving underwater crimes: development of latent prints made on submerged objects, Sci. Justice 53 (3) (2013) 328–331.
[14] G.S. Bumbrah, Cyanoacrylate fuming method for detection of latent fingermarks: a review, Egypt. J. Forensic Sci. 7 (2017) 1–8.
[15] Regulator, F.S. (2011) Fingerprint examination: Developing a Quality Standard, GOV.UK. Available at: ⟨https://www.gov.uk/government/publications/fingerprint-examination-developing-a-quality-standard⟩ (accessed: 24th October 2023).
[16] R.H. Goodall, L.P. Darras, M.A. Purnell, Accuracy and precision of silicon based impression media for quantitative areal texture analysis, Sci. Rep. 5 (1) (2015) 10800.
[17] Fingerprint Analysis and Representation. In: Handbook of Fingerprint Recognition (2003). Springer Professional Computing. Springer, New York, NY.
[18] D. Maltoni, D. Maio, A.K. Jain, J. Feng, Fingerprint analysis and representation. Handbook of Fingerprint Recognition, Springer International Publishing, Cham, 2022, pp. 115–216.