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THE PROCESS OF RENDERING FINGERPRINTS ON BANKNOTES

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Abstract: *The detection of fingerprints on banknotes plays a critical role in forensic science, particularly in investigations related to corruption, counterfeiting, and money laundering. Due to the diversity of banknote materials—primarily paper and polymer—specific rendering techniques are required to identify both latent and visible prints. This article explores in detail the physical, chemical, and optical methods used in fingerprint rendering, focusing on their applicability, advantages, and limitations based on banknote surface composition.*

Physical methods include dusting with magnetic or non-magnetic powders, adapted to the substrate type and colour contrast. Chemical techniques, such as cyanoacrylate fuming, ninhydrin, DFO (1,8-diazafluoren-9-one), and indanedione, are evaluated for efficiency and compatibility with porous (paper) or non-porous (polymer) surfaces. Each method is discussed about its procedural requirements, visualisation tools, and potential effects on biological trace preservation or currency usability.

The article also identifies multiple factors affecting print detection, including the banknote's wear, exposure to chemicals, and elapsed time since handling. Practical challenges such as interference from security features or multicolour designs are also examined.

By emphasising both theoretical and operational dimensions, the study contributes to enhancing fingerprint detection procedures on banknotes, recommending that methods be applied in order of destructiveness. The article concludes that fingerprinting currency remains a complex yet indispensable forensic procedure, requiring constant adaptation to evolving materials and technologies.

Keywords: *fingerprints, banknotes, dactiloscopy, cyanoacrylate, ninhydrin, indanedione.*

Introduction. „Long-term research on the characteristics of fingerprints and their usefulness in identifying individuals has laid the foundation for an important branch of forensic science known as **dactyloscopy**" (Stancu, 2015, p.109).

The main reason fingerprints have been used to identify individuals, holding exceptional value in this process, is that not only the fingerprint as a whole, but also each

individual ridge and even the pores exhibit unique and distinct characteristics, enabling clear differentiation between individuals.

Due to their uniqueness, fingerprints are an essential method of identifying individuals. Banknotes, made from special paper or polymer, pose a distinct challenge for fingerprint detection, as they have complex surfaces —often textured, with overlapping designs — and are impregnated with chemicals that can affect print clarity. Whether the banknotes are genuine or counterfeit, fingerprints can still be detected on their surface, potentially leading to the identification of the person who handled them.

The **purpose** of this article is to provide a comprehensive perspective on both theoretical and practical aspects, pointing out various techniques that can be utilised. Through this approach, we seek to contribute to a deeper understanding of the requirements that guide fingerprint rendering on banknotes and the various factors that influence this process.

Methods and materials used. In developing this article, considering the topic and it's complexity, the following scientific research methods were employed: the logical interpretation method, the experimental method, and the comparative method.

Results and debate.

Banknotes can retain fingerprints that help identify individuals involved in illicit activities, but the rendering process requires specific techniques tailored to both the surface and the materials' composition.

„Latent palm prints are, in most cases, of better quality than visible prints, because they are formed by the deposition of a very thin layer of substance, capable of precisely reproducing the characteristic details of the fingerprint ridges and even the pores."(Moisei, Stancu, 2020, p.73).

Banknotes are made *either* ***of paper*** (cotton or flax fibres) or ***polymer*** (polypropylene), and each material presents distinct challenges in fingerprint rendering.

Factors Influencing Fingerprint Detection:

- *Material Type*: Paper partially absorbs moisture and organic components, which can blur fine details, affecting both their preservation and rendering. The smooth, glossy surface of polymer banknotes temporarily preserves fresh fingerprints, but they can be easily wiped off.

- *Graphics or Security Features:* Printed graphics or security features on banknotes may interfere with fingerprint highlighting, making it harder to distinguish the fingerprints.

- *Condition of the Banknote:* Prints may be damaged by wear from circulation, contamination with various compounds, or excessive handling.

- *Time Elapsed:* Older fingerprints are more difficult to detect due to the evaporation of oils and the degradation of the chemical components of sweat.

Methods Used for Fingerprint Detection on Banknotes

Fingerprint rendering methods on banknotes are typically divided into two main categories: physical and ***chemical methods***. These can be combined with optical methods, which are generally non-destructive to both the fingerprints and the banknotes. Optical methods include color filtering, fluorescence examination, infrared reflection, monochromatic illumination, multi-spectral imaging, UVC reflection, and examination under natural light at various incident angles.

Fingerprint rendering using physical (mechanical) methods involves the use of fine powders or dusting agents, known as **dusting** or **powdering**, applied to objects or surfaces that bear fingerprints. "Dusting an invisible print is done with a specific substance, depending on the color and nature of the object on which the print is found. The powder is always chosen to have a color that contrasts with that of the object in question." (Păşescu, Constantin, 1996, p.156).

Among the powders recommended for developing banknotes are magnetic powders (black, fluorescent, silver, bichromatic), which are applied with magnetic brushes. For polymer banknotes, due to their smooth surface, non-magnetic black powder can also be used, applied with brushes made of squirrel hair, camel hair, or zephyr brushes made of fiberglass.

"Fingerprint rendering on multicolored surfaces is a scientific method used in dactyloscopy, which implies the use of fluorescent substances. Among these substances is fluorescent yellow powder, which becomes visible under ultraviolet radiation." (Rusu, Jitariuc, 2023, p.312).

Fingerprint rendering using chemical methods

"In general, these techniques are used in laboratory conditions, as the rendering involves the use of corrosive, toxic, and even carcinogenic chemicals. Therefore, their use is only carried out with the appropriate safety measures in place."

Cyanoacrylate (superglue)

The process of fingerprint detection through cyanoacrylate fuming is one of the most effective methods for making visible and preserving fingerprints on polymer banknotes, which have non-absorbent, non-porous surfaces.

The cyanoacrylate fuming method works on most surfaces where powders are ineffective.

Typically, a latent fingerprint detection process using cyanoacrylate vapors is carried out with the help of a cyanoacrylate fuming chamber and lasts between 10 to 30 minutes, depending on the object bearing the fingerprints and the type of cyanoacrylate used.

The contrast of the fingerprints revealed by the cyanoacrylate fuming process can be enhanced by dusting with either fluorescent, black or silver powders, which can be either magnetic or non-magnetic, depending on the developed object and the base color of it's surface. Better results can be achieved by developing the cyanoacrylate-revealed prints with fluorescent pigments (Ardrox, Rhodamine 6G, Basic Red 28, Basic Yellow 40). When examining, it is recommended to use an ultraviolet light source for viewing the fingerprints.

The advantages of using this detection method lie in the fact that cyanoacrylate vapors adhere and fix very well to the fingerprint ridges, with a low risk of accidental smudging of the prints. Additionally, the application of powder can be repeated without damaging the fingerprints. This rendering method does not affect biological traces for genetic profiling, provided that the detection process was carried out with sterile tools, used for detecting a single print, and under conditions that avoid cross-contamination" (Procedures and work instructions developed).

Fig.1 – Fingerprints rendered with *cyanoacrulate* and basic yellow on a 5 Lei polymer banknote.

Ninhydrin is a chemical method that involves applying a solution to an object or surface, followed by the use of a special fuming chamber (when possible) to enhance the efficiency and speed of the reaction. Ninhydrin reacts with amino acids and other substances present in latent fingerprints to produce a violet result. It also reacts with blood compounds containing amines" (Best Practice Manual for Fingerprint Examination).

This method has been used for a long time and allows rendering very old fingerprints on objects with porous surfaces that contain cellulose, making it ideal for revealing fingerprints on paper banknotes.(Jitariuc V.Nastas A. 2022, p.121) Ninhydrin can be purchased in liquid form, as a spray, or as crystals. The ninhydrin solution can be applied to paper banknotes by immersion, light dabbing with cotton, or spraying. After applying the solution, the objects are placed on a support in a dark room for approximately 24 hours to reveal any fingerprints. If the result is not satisfactory, the detection procedure may be repeated immediately.

The ninhydrin solution can damage the surface (either partially or entirely), so the method should be used after all other relevant examinations or determinations have been conducted. Prior to ninhydrin developing, the investigating or prosecuting authority should be informed about the risks of ink dissolution, the potential for the banknotes to be dyed violet, and the possible destruction of DNA. Ninhydrin treatment is recommended for counterfeit banknotes that have no value and do not require to be put back into circulation.

Fig.2 – Fingerprints rendered using *ninhydrin* on a 50 EURO paper banknote.

DFO

DFO is a chemical method that involves applying a solution to an object or surface, followed by the use of a special fuming chamber to initiate the reaction. The resulting print is highly fluorescent and should be visualized using fluorescent light examination. "DFO is an analog of ninhydrin and reacts with aminoacids present in fingerprint secretions, being capable

of revealing 2-3 times more latent prints than when only ninhydrin is used." DFO is used in solution form —either prepared in the laboratory or purchased ready-to-use —to render latent fingerprints on paper surfaces, including banknotes.

The paper banknote is immersed in the solution for about 10 seconds. Spraying the solution is not recommended because it does not properly saturate the surface bearing the prints. The banknote is then dried by exposure to 100°C for 10 minutes. The revealed prints may or may not be visible to the naked eye, but a variable wavelength light source should always be used. For better results (stronger fluorescence), objects can be heated before photographing.

DFO developing can be followed by ninhydrin developing. In this case, DFO is applied first, followed by ninhydrin."(Procedures and work instructions developed).

Indanedione

Indanedione is a fluorescent substance that reacts with amino acids or lipids in fingerprints, making them visible. It is primarily used on paper banknotes. Indanedione is available as a powder in 1-gram vials, which must be prepared before use. The solution can be applied by spraying it onto objects until they are saturated or by immersing the object in the indanedione solution for approximately 10 seconds. (Nastas A. 2024, p.88) The objects are then allowed to dry air at room temperature. The process can be accelerated by drying the objects in a drying chamber at 100°C for 20 minutes, under dry conditions. If no fingerprints are visible after the indanedione treatment, the ninhydrin treatment should be used.

After treatment, paper banknotes may exhibit a very faint colour, either pale pink or pale yellow. The revealed fingerprints should be visualised under fluorescent light, which is advantageous because the original banknotes are not damaged and can be returned to circulation. The indanedione detection method does not affect DNA, so the banknotes can still be used for genetic profiling.

The indanedione fingerprint detection method can be used as a standalone chemical process or in sequence with ninhydrin. It is always recommended to apply ninhydrin after treating with indanedione (Laboratory Journal No. 1 dated 27.01.2020 of the Judicial Identification Service).

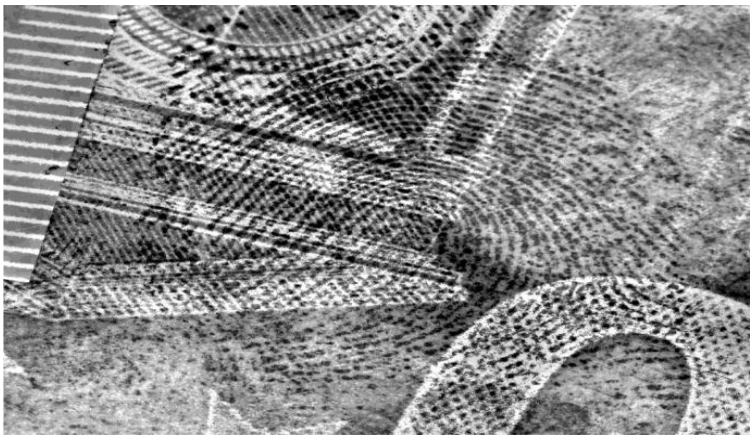

Fig.3 – Fingerprint rendered with *indandione* on a 50 EURO paper banknote, viewed with a RUVIS UIS-ImaQuest device (Universal Imaging System).

The methods used for paper banknotes include the use of DFO, indanedione, and ninhydrin. The order of application is important: DFO and indanedione should be used before ninhydrin.

Conclusions: Revealing fingerprints on paper and polymer banknotes requires an approach tailored to the banknote material and condition. The methods presented in this article are not exhaustive but were selected for their efficiency and frequency of use. They should be applied in an order that does not affect the subsequent use of other methods, starting with the least destructive, making this activity a significant challenge in forensic science.

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