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Comparison of practical techniques to develop latent fingermarks on fired and unfired cartridge cases

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ABSTRACT

We have tested some widely used and practical fingermark enhancement techniques such as powdering (regular powder dusting and magnetic powder application), cyanoacrylate fuming, fluorescent dying (basic yellow 40), gun blueing solutions and acidified hydrogen peroxide solutions. The results were evaluated and compared in order to establish best procedures on processing cartridge cases. The tests were performed on brass discs subjected to three different temperatures (room temperature, 63 and 200 °C), and on fired and unfired cartridge cases. All the samples were processed after three different periods of time (24 h, 7 days and 14 days) after deposition. The best results for both fired and unfired cartridge cases were obtained by the sequential application of cyanoacrylate, gun blueing solution and basic yellow 40. Some stages of the firing process were isolated in order to identify their effects over the final amount and quality of the remaining latent fingermarks on cartridge cases. Good state fingermarks were developed on unfired cartridge cases cycled through the gun, showing that friction inside the gun without firing does not cause significant damage to the fingermarks. On the other hand, fired cartridge cases are significantly affected by the firing effects, exhibiting low quality ridge details which are mainly located next to base. An unexpected phenomenon was observed on most of the brass discs heated to 200 °C and developed with gun blueing solutions; they presented a reverse development compared to the expected one, with darkening of the ridges instead of the background.

1. Introduction

The fingermark recovery on fired cartridge cases is a challenge. There are discussions about the best methods to be used and a small proportion of cases with positive identification of suspects are reported [1–5]. Some important fingermark enhancement techniques are cyanoacrylate fuming (CA) [3–11], regular powder dusting (RP) and magnetic powder application (MP) [2,5,6,8,12], fluorescent dying [3,4,6–8,11] such as basic yellow 40 (BY40), gun blueing mixtures (GB) [6,7,9–11], acidified hydrogen peroxide (AHP) [8,9], vacuum metal deposition [6,13,14], palladium salts [7,10], electrolysis [6,15,16], electrostatic deposition [1,10,17] and scanning Kelvin probe [18–20]. Some of these techniques and developers are expensive and require technical refinements that are not available for routine forensic applications, such as mentioned by Williams [19] for the use of scanning Kelvin probe. The use of CA as a primary enhancement technique is required for the application of some techniques such as fluorescent dying with BY40, and is recommended for others such as powdering and GB.

The aim of this study was to gather and evaluate under the same conditions some widely used and available fingermark enhancement techniques to recovery latent fingermarks from fired and unfired cartridge cases. The results can be used in order to optimize procedures for latent fingermark experts when processing this kind of evidence. A number of experiments were performed on different substrates under various conditions, aiming at isolating some stages of the firing process to determine their influence on the quantity and quality of the remaining latent fingermarks in fired cartridge cases.

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2. Material and methods

2.1. Techniques and developers

The development sequences used are referred to as:

- CA + RP: cyanoacrylate followed by regular powder dusting;
- CA + MP: cyanoacrylate followed by magnetic powder application;
- CA + GB: cyanoacrylate followed by gun blue solution;
- CA + BY40: cyanoacrylate followed by basic yellow 40 dying;
- GB: gun blue solution;
- AHP: acidified hydrogen peroxide, using glacial acetic acid (AHP1) or a household vinegar (AHP2).

The CA fuming was performed on a fuming chamber with dimensions of 36, 56 and 31 cm, at room temperature and ambient pressure, using 20 drops of CA (Sirchie cat. N° CNA103) for each set of 16 discs or 60 cartridge cases, during 30 min. To improve the polymerization, receptacles with hot water (temperature ≈80 °C, volume ≈200 ml, evaporating surface area ≈130 cm^2) were placed inside the chamber during the fuming process, increasing the relative humidity to the range of 80–90%. These parameters were chosen based on preliminary tests and were used for all samples in this work (discs and cartridge cases). The relative humidity is a crucial factor for the effectiveness of the CA process [21] and should be controlled whenever possible to allow for better results.

RP (Sirchie cat. N° SB201L) and MP (Sirchie cat. N° BPM114L) were applied using Marabou Feather Duster black (Sirchie cat. N° 123LB) and Magnetic Powder Applicator (Sirchie cat. N° 125L), respectively.

The GB solutions were prepared using a 1:40 volume ratio of GB (Tetra Gun–Liquid Blue) in deionized water. This concentration is based on previous work [7,9–11] and allows a gradual and controllable development of fingermarks. After fully immersing each sample in the solution, the gradual development was monitored visually until a desired stage. The samples were then rinsed with deionized water, interrupting the development, and left to dry on paper towels. The developing time was typically between 5 and 10 min.

The BY40 solution was obtained dissolving 2 g of basic yellow 40 (Sirchie cat. N° LV507) in 1000 ml of methanol [10,22]. The samples were sprayed with the solution and, after a few seconds, rinsed with deionized water and left to dry on paper towel.

The AHP1 solutions were obtained by diluting 5.2 ml of glacial acetic acid and 12.6 ml of a 35% hydrogen peroxide solution with deionized water giving a total volume of 250 ml [8,9]. The AHP2 solutions were prepared similarly to the AHP1 solution, but using 104 ml of household 5% vinegar instead of the glacial acetic acid. The samples submitted to this technique were fully immersed into the solution and gently stirred to release the little bubbles formed on the surface. After several seconds, they were removed and lightly rinsed with deionized water and left do dry on paper towels. A third AHP formulation [9], composed by household 5% vinegar and household 3% hydrogen peroxide at the volume ratio of 14.1:20 was tested aside to verify the possibility of employing this more homemade formulation.

The latent fingermarks were photographed immediately before and after each development stage [11,23] using a Nikon D70s camera, equipped with macro lens and mounted on a forensic photographic table, applying direct and oblique illumination. To capture fluorescent latent fingermarks developed by BY40, a Lumatec Superlite 400 light source was used with blue light (460 nm) and an orange viewing filter.

A scanning electron microscope (SEM) was used to obtain more details about the effects of the development methods on the brass surfaces. SEM images were provided by a Shimadzu SSX-550 operating at low voltage (1–5 kV) by secondary electron imaging.

2.2. Experiments on brass discs

Alpha brass discs 0.9 mm thick were cut by stamping to 50 mm diameter flat discs. Alpha phase brass is a low zinc content brass (30% Zn/70% Cu in weight) similar to that used in cartridge cases. The discs were washed with warm water (30–40 °C) containing 3–4 drops of a commercial detergent for each 500 ml of water, being vigorously rubbed by fabric for 30 s, followed by a rinse with deionized water and left to dry to the air, resting over paper towels [24].

Each disc received a natural fingermark from a donor that washed the hands with soap and waited 20 min before the deposition, without any artificial stimulus other than rubbing one hand against the other in order to homogenize the sweat distribution. Two individuals donated the fingermarks from their right thumbs and forefingers, generating groups with 4 discs. Each set of discs was exposed to a different temperature: room temperature (RT = 22 ± 4 °C), 63 and 200 °C. The heating to attain the temperatures of 63 and 200 °C was performed on a hot plate within 1 h after the fingermarks deposition. The temperature measurements were performed with a K-type thermocouple in contact with the metallic surface where the fingermark was deposited. The heating times to reach the desired temperatures were about 10 s for 63 °C and 1 min for 200 °C. The samples were left to cool down naturally in ambient air. The 63 °C temperature was chosen because it is the maximum external temperature achieved by the surface of brass cartridge cases (cal. 9 mm) fired from regular pistol immediately after firing [25]. The 200 °C temperature was chosen to highlight the possible occurrence of some phenomena not clearly observed in the case of the samples heated up to 63 °C and it is also useful for comparison to results reported by other researchers [10,17,23,26,27].

The latent fingermarks developments using each one of the 7 techniques, for each temperature, was carried out after 3 time periods between the deposition of the fingermark and the developing process: 24 h, 7 days and 14 days. These time intervals can be considered reasonable when compared to real cases [23]. During these time intervals, the samples were subjected to the laboratory conditions (22 ± 4 °C and 50 ± 15% of relative humidity).

The total number of discs processed was 252, which corresponds to the product of (4 discs/group) × (3 temperatures) × (7 techniques) × (3 time intervals).

The fingermarks developed on brass discs were evaluated by two independent experts following a 0 4 grading scale devised by Bandey [21,28]:

0—No ridge detail;
1—Less than 1/3 clear ridge detail;
2—Less than 2/3 clear ridge detail;
3—Incomplete (but > 2/3) clear ridge detail;
4—Complete clear ridge detail.

2.3. Experiments on unfired cartridge cases

Unfired cartridge cases (live rounds) of brass (cal. 9 mm; manufactured by Companhia Brasileira de Cartuchos (CBC); model NTA) were separated as control samples. Natural fingermarks, obtained as described in Section 2.2, were carefully posted at the lateral surface of the cartridges. Then, they were developed by all techniques and after the same time intervals mentioned above (24 h, 7 and 14 days). Since they were new cartridges, no cleaning was performed before depositing the fingermarks; this was done to