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TECHNICAL NOTE

CRIMINALISTICS

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A Comparison of Cleaning Regimes for the Effective Removal of Fingerprint Deposits from Brass

ABSTRACT: Effective removal of fingerprint deposits is crucial for experimentation related to the corrosion of metals by fingerprint deposits. Such removal is also necessary prior to deposition of test fingerprints. The effectiveness of four regimes in removing fingerprint deposits from brass is considered. Sustained wiping of the deposit with a tissue at applied pressures of up to *c*. 1430 Pa or rubbing while the brass was immersed in acetone both failed to remove completely all traces of fingerprint deposits. Heating the brass to 600°C was an effective remover; however, this also oxidized the surface of the metal except where inhibited by fingerprint deposits. The most effective regime, and the only one of the four that removed all traces of deposit without affecting the properties of the metal surface, was immersion in warm soapy water while rubbing with a tissue. We propose this as the preferred method for fingerprint removal.

KEYWORDS: forensic science, latent fingerprint, print visualization, metal surface, latent fingerprint components, electrochemical mechanism

When latent fingerprints are deposited on metal surfaces such as brass, common enhancement techniques include powdering, vacuum metal deposition, and various chemical treatments such as cyanoacrylate fuming, dyeing, and immersion in small particle suspensions (1). Recent research in this area has focussed on fingerprint visualization techniques that exploit the chemical reaction that can occur between the metal surface and the fingerprint deposit. This reaction, effectively a corrosion of the metal surface, results in a change to both the chemical and physical characteristics of the metal surface. Williams et al. demonstrated fingerprint visualization on metals using a Scanning Kelvin Microprobe (2,3). This technique is based on a measurement of the potential difference arising between a wire probe and the metal surface because of differences in their respective work functions, the magnitude of this potential difference being affected by fingerprint deposits and corrosion. Williams et al. reported that rubbing fingerprint deposits vigorously with a paper tissue several days after deposition had little effect on work function measurements prior to rubbing, suggesting that their visualization was resulting from (at least in part) fingerprint corrosion of the metal.

More recently, one of us (JWB) has considered the corrosion of a range of metal elements and alloys by fingerprint deposits (4,5). It was shown how fingerprint deposits on brass produced sufficient corrosion of the metal to enable the fingerprint to be visualized even after the residue of the fingerprint deposit had been removed by cleaning the metal in warm water, to which a few drops of commercial detergent had been added. Under laboratory conditions, this technique demonstrated the visualization of a latent fingerprint on a fired 9 mm shell casing that was deposited prior to loading the shell into the firearm (4).

In all of the studies referred to above, researchers have employed various cleaning regimes to remove either

- Unwanted latent fingerprints from metal prior to depositing test fingerprints

or

- Test fingerprint deposits prior to investigating the corrosion of the metal.

In this technical note, we examine the effectiveness of these various cleaning regimes in removing fingerprint deposits from brass. This is an important consideration for researchers, particularly so when investigating effects because of fingerprint corrosion of metal (4,5).

Materials

Samples of 1 mm thick, 25 mm diameter brass, 68% copper and 32% zinc, were obtained from Nobles Engineering, Northampton, U.K. Prior to fingerprint deposition, no cleaning regime was undertaken as the disks were covered with a protective polymer film that was removed immediately prior to fingerprint deposition.

Twenty minutes prior to deposition, 20 donors were asked to wash their hands with soap and water and then, immediately prior to deposition, to rub their face and hair line with their fingertips to ensure that sebaceous rich fingerprints were deposited. Each donor pressed a different finger onto five different brass disks by pressing onto the metal surface for 1–2 sec with a light pressure sufficient to ensure contact between the finger and metal. While no attempt was made to regulate the amount of pressure applied by donors,

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this procedure was intended to produce reasonably uniform deposition. After deposition the five disks from each donor were split into five batches such that each batch contained 20 samples, one from each donor. Therefore, a total of 100 samples were used in this part of the experiment. All fingerprint deposits were left for 48 h before further treatment, this being consistent with previous research (3).

Methods

This section lists four different categories of cleaning regime, together with a control category, and the reasons for selecting them. Each category of cleaning regime was applied to one of the batches of 20 disks. Following the application of a cleaning regime, all disks in that batch were powdered using a granular black powder applied with a squirrel hair brush (6). Granular black powder was selected as it gave satisfactory contrast against the metal. Each disk was then graded according to the quality of fingerprint ridge detail visible, this being used as a measure of the effectiveness of the cleaning regime (7).

- Category 1—Control. This category was intended to allow the deposition of each donor to be monitored such that, if a particular donor gave unusual results, this could be referenced back to their sample in the control category.
- Category 2—Acetone wash. Acetone is a degreaser and a polar aprotic solvent (8). Therefore, this cleaning regime was intended to assess whether an acetone wash provides effective removal of fingerprint deposits. Williams et al. (3) and Migron et al. (9) both used an acetone wash in their predeposition cleaning regimes. All disks in this category were rinsed first in distilled water (3) and then agitated in acetone for 30 sec (9). Each disk was then patted dry with a tissue.
- Category 3—Heating to 600°C. Williams et al. (2) suggested that heating metal samples to temperatures of up to 600°C would remove water and the volatile organic (lipid) components of the fingerprint deposit, leaving only the nonvolatile inorganic salt components. All disks in this category were heated, one at a time, in a propane gas burner flame with the fingerprint deposit facing away from the flame. A k-type thermocouple was placed in thermal contact with each disk and was used to monitor the disk temperature. When a disk temperature reached 600°C, it was removed from the flame and left to cool in air naturally.
- Category 4—Warm soapy water wash. This is a cleaning regime used previously by Bond (4) and a surfactant was used (washing detergent) that acts as a solvent to oils, fats, and lipids (10–12). The wash was prepared by stirring three to four drops of commercial detergent in 0.5 L of water heated to 30–40°C. Disks were immersed in the warm soapy water and then rubbed vigorously with a wet tissue in the soapy water for 30 sec. Disks were then patted dry with a tissue.
- Category 5—Wiping with a tissue. Williams et al. (2) reported that rubbing fingerprint deposits vigorously with a paper tissue several days after deposition had little effect on their work function measurements, implying that this wiping had removed some or all of the fingerprint deposit. Each disk in this category was tacked to a table with a low adhesive putty to ensure that the wiping process did not move the disk. Ten different pressures were applied, each pressure to two disks in the batch, the pressure ranging from 0 Pa (that is, no wiping) up to *c.* 1430 Pa. The pressure was applied by means of additional brass disks, placed on a polymer sheet on top of the tissue. The tissue was then dragged over each disk eight times. This number of drags was chosen as James et al. (13) stated that eight strokes of a squirrel hair brush were sufficient to obliterate fingerprint ridge detail. Also, eight drags seemed a reasonable number to equate to rubbing vigorously (2). Between disks, the tissue was discarded and replaced with a new one for the next disk.

Results and Discussion

At the conclusion of the above experiments, all 100 disks were graded according to the quality of fingerprint ridge detail visible. For this, the grading system devised by Bandey (7) was used and this is reproduced in Table 1.

Typical examples of the fingerprint ridge detail visible in each of the five batches are shown in Fig. 1. As might be expected, all 20 of the disks in category 1, the control category, shown in Fig. 1*a*, were graded as grade 4, confirming that the black granular powder adhered readily to the fingerprint deposit. Category 2, acetone wash, produced 17 out of 20 disks with a grade 3 or 4, suggesting that simply immersing and agitating the disks in acetone does not remove fingerprint deposits, Fig. 1*b*. Category 3, heating to 600°C, gave 10 disks graded at 3 or 4. However, this is thought to be because of the fingerprint deposit inhibiting oxidation of the disk when heated (14). Little granular powder was observed to adhere to the disks and that which did may well have become lodged in corrosion on the surface of the brass (4), Fig. 1*c*. The oxidation of the metal surface when heated is shown schematically in Fig. 2.

The warm soapy water wash, category 4, gave no disks graded at 3 or 4. In fact, no ridge detail was visible on any disk, Fig. 1*d*. The lipophillic surfactant in the detergent and the vigorous rubbing

TABLE 1—*Grading system for determining the quality of ridge detail for enhanced fingerprints devised by Bandey (7).*

Grade	Comments
0	No development
1	No continuous ridges. All discontinuous or dotty
2	One-third of mark continuous ridges (Rest no development, dotty)
3	Two-thirds of mark continuous ridges (Rest no development, dotty)
4	Full development. Whole mark continuous ridges

FIG. 1—*Typical examples of fingerprint ridge detail for (a) control category, (b) acetone wash, (c) heating to 600°C, (d) warm soapy water wash, and (e) wiping with a tissue.*

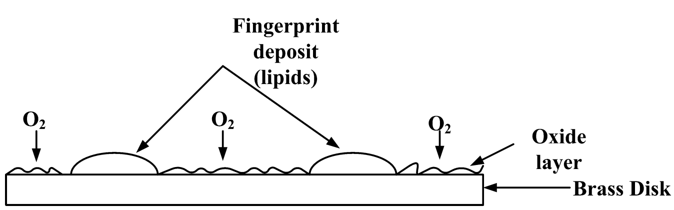

FIG. 2—*Schematic representation of a fingerprint deposit locally inhibiting the oxidation of a brass disk when heated.*

are thought likely to be the main reasons that all of the fingerprint ridge detail was removed. Finally wiping disks with a tissue, category 5, produced 19 disks graded at 3 or 4. The deposit was not removed and, as shown in Fig. 1*e*, wiping produced a "smearing" of the deposit rather than a removal. The disk shown in Fig. 1*e* is after application of the maximum pressure.

In the light of the above results, a further series of experiments were conducted, examining in more detail the acetone wash, (category 2) and wiping with a tissue (category 5) using 20 fresh fingerprint deposits for each category from the same 20 donors.

For category 2, rather than simply immersing the disks in acetone and agitating, this time they were rubbed vigorously in the same manner as the warm soapy water (category 4). Figure 3*a* shows a typical example of a disk in this category and it can be seen clearly that fingerprint ridge detail is still visible although none of the 20 disks were graded 3 or 4 following powdering. Figure 3*b* shows the same disk as in Fig. 3*a* following application of the warm soapy water wash (category 4) and a further application of black powder. Clearly, the warm soapy water wash has removed effectively all of the deposit.

Wiping with a tissue, category 5, was carried out in the same manner as previously except, this time, each disk was subjected to each of the 10 pressures in turn and was, therefore, wiped eight times for each pressure giving a total of 80 wipes. Figure 4 shows a graphical representation of the number of disks graded at 2, 3, or 4 (that is, with any ridge detail visible) plotted against applied pressure. It can be seen that the number of disks graded 3 or 4 has reduced to zero with an applied pressure of *c.* 950 Pa. This pressure was found to equate to approximately one-tenth of that applied while rubbing by hand. Therefore, wiping or rubbing by hand

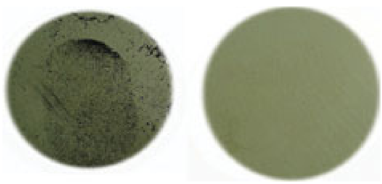

FIG. 3—*Typical example of fingerprint ridge detail for (a) enhanced acetone wash, and (b) warm soapy water wash.*

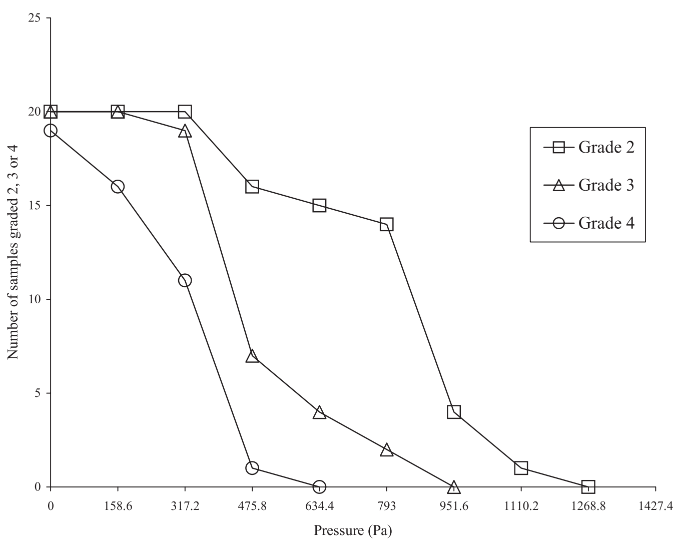

FIG. 4—*Graphical representation of the number of disks graded as 2, 3, or 4 plotted against applied pressure.*

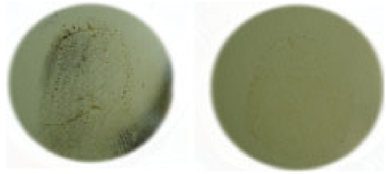

FIG. 5—*Typical example of fingerprint ridge detail for (a) enhanced wiping with a tissue and (b) warm soapy water wash.*

would be expected to remove all ridge detail although, as shown above for rubbing while immersed in acetone, this is unlikely to remove all traces of the deposit.

Figure 5*a* shows a typical example of a disk subject to the maximum applied pressure followed by black granular powdering. Powder has still clearly adhered to (mainly) the periphery of the fingerprint deposit with much of the ridge detail visible being due to corrosion of the metal by the fingerprint deposit (4). This is confirmed in Fig. 5*b* that shows the same disk as in Fig. 5*a* following application of the warm soapy water wash (category 4) and a further application of black powder. As was demonstrated above, the warm soapy water wash has removed effectively all of the deposit, the ridge detail remaining being due to corrosion of the disk, which appears as a brown discoloration of the metal (4). Such corrosion of brass as observed in Fig. 5*b* has been reported previously (4) and its appearance is affected by both the quantity and composition of a fingerprint deposit rather than the washing regimes described here.

Conclusions

Examination of three popular cleaning regimes for brass subject to fingerprint deposition (acetone wash, warm soapy water, and wiping with a tissue) has shown the most effective regime to be immersion and rubbing in warm soapy water. Sustained wiping with a tissue or rubbing while immersed in acetone failed to remove completely all traces of fingerprint deposits. Heating the metal to 600°C was found to be an effective remover of fingerprint deposits; however, this also oxidized the surface of the brass, except in areas where the fingerprint had been deposited. Therefore, heating the brass is not recommended as an appropriate cleaning regime.

Our conclusion is, therefore, that the most effective cleaning regime for brass to ensure that all traces of fingerprint deposits have been removed is immersion and rubbing in warm soapy water. This is particularly so for situations where total removal of fingerprint deposits is crucial, such as experimentation on the corrosion of metal by fingerprint deposits.

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