Technical Note

Comparison of the Cotton Wool Powdering Technique to Conventional Powdering with a Squirrel-Hair Brush

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Abstract: The powdering of latent fingerprints with the cotton wool powdering technique was evaluated on surfaces commonly encountered by fingerprint examiners at crime scenes. In addition, a large donor study was conducted using loaded and nonloaded samples from 20 donors. Results showed the technique to be an efficient and easy-to-use method that developed prints of comparable quality to those powdered with a squirrel-hair brush.

Introduction

The application of fingerprint powders is the most extensively used technique to detect latent fingerprints on nonporous surfaces [1]. The technique relies on adherence of the fingerprint powder to the eccrine and sebaceous components left by friction ridge skin [2]. The reason for this widespread use is that powdering is simple and inexpensive, and satisfactory results are possible with minimal training.

The main types of powders available are conventional, metallic, fluorescent, and magnetic. With the exception of magnetic powders, most were traditionally applied to the surface of interest with a squirrel-hair brush. However, brushes made from newer materials (e.g., nylon, carbon fiber, fiberglass, ostrich hair) are available.
One major disadvantage of applying fingerprint powder with a brush is that only a small area can be covered with each pass. This makes the powdering of larger surfaces, such as glass windows and motor vehicles, tedious. In addition, brushes are generally not disposable, so scene-to-scene contamination can occur if a subsequent biological examination is to be conducted.

The development of latent prints using cotton wool has been previously described as a method that is useful for powdering large surfaces [3]. The technique involves applying fingerprint powder to cotton wool and softly wiping over the surface to be analyzed. A clean-out brush (e.g., small squirrel-hair brush) can be used to enhance any developed prints, which are then photographed. This technique has the potential to dramatically reduce the amount of time spent developing prints at crime scenes, but to date, no validation data exists for this method.

This evaluation was conducted in two phases. In both phases, the cotton wool powdering technique (CPT) was evaluated against a squirrel-hair brush to provide a benchmark for comparison. In the first phase, several surface types were studied (plate glass, tempered glass, powder-coated metal lampshade, semigloss paint, unwaxed car paintwork, waxed car paintwork, glazed tile, acetate sheeting) using loaded and nonloaded prints from a single donor. In the second phase, 4800 loaded and nonloaded prints from 20 donors were evaluated over three time periods.

**Materials and Methods**

*Sample Preparation*

Prints were deposited in a five-depletion series of eight fingerprints on each of the surfaces of interest (thumbs were omitted). Depletions 1 and 2 contain more material and are referred to as strong prints as opposed to Depletions 3, 4, and 5, which contain less material and are considered weak prints (Figure 1). Loaded and nonloaded sets were obtained so that the technique could be compared on both sebum-rich and natural-mixed composition prints. To produce nonloaded prints, five successive impressions were deposited onto the test surface. Donors did not wash their hands prior to deposition so that the natural, mixed composition secretions present on their fingers could be evaluated. To produce the loaded prints, the same eight fingers were rubbed over the forehead, then five successive impressions were deposited onto the surface of interest without recharging between impressions.
For the surface-specific study, several surface types were evaluated. All were clean and debris-free prior to deposition. A nonloaded set of prints and a loaded set of prints were deposited on each surface by the same donor. The surfaces were stored at ambient environmental temperatures under realistic conditions (Table 1). Both sets of prints were developed after four weeks.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Exhibit Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate Glass</td>
<td>Glass sliding door positioned on a semi-enclosed balcony</td>
</tr>
<tr>
<td>Tempered Glass</td>
<td>Interior of vehicle window consistently used for travelling</td>
</tr>
<tr>
<td>Powder-Coated Lampshade</td>
<td>Lampshade from hydroponic crime scene stored in garage</td>
</tr>
<tr>
<td>Semigloss Paint</td>
<td>Newly painted storeroom door- interior</td>
</tr>
<tr>
<td>Car Paintwork (unwaxed)</td>
<td>Stored on semi-enclosed balcony</td>
</tr>
<tr>
<td>Car Paintwork (waxed)</td>
<td>Stored on semi-enclosed balcony</td>
</tr>
<tr>
<td>Glazed Tile</td>
<td>Laundry room</td>
</tr>
<tr>
<td>Acetate Sheeting</td>
<td>Stored in garage</td>
</tr>
</tbody>
</table>

**Table 1**  
*Storage conditions for surface study.*

For the donor study, three sets of loaded and three sets of nonloaded prints were deposited onto acetate sheets by each of the 20 donors. One set each of loaded and nonloaded prints from each donor was developed immediately, and the second and third sets were kept in a protected environment at ambient temperature for 4 weeks and 12 weeks, respectively, before development.

**Fingerprint Development**

For both phases, the impressions made with the left hand were powdered using the squirrel-hair brush [4] and the impressions made with the right hand were powdered with the cotton wool (Cutisoft), thus providing four replicate prints per depletion for evaluation of each method. Powdering using the CPT involved distributing approximately one tablespoon of black or white fingerprint powder (Sirchie) evenly over a 20 cm square of the cotton wool. The cotton wool was held using the back layers and lightly passed over the surface to be powdered to avoid obliterating any surface detail (Figure 2). The developed prints were enhanced where necessary using a clean-out brush (Optimum Technology, Monash, ACT, Australia).
Figure 1
Schematic showing depletion series of deposited prints. Left side: powdered with brush. Right side: powdered using CPT.

Figure 2
Powdering using the cotton wool powdering technique (CPT).
The ridge quality (RQ) of each print was graded [Table 2]. The mean RQ values for the four fingers at each of the five depletions were calculated for each method. Photographs were taken using a Nikon D200 digital camera.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Very few or no ridge details observed</td>
</tr>
<tr>
<td>1</td>
<td>Some ridge detail observed. Insufficient for identification.</td>
</tr>
<tr>
<td>2</td>
<td>Good ridge detail observed. Identifiable</td>
</tr>
<tr>
<td>2</td>
<td>Excellent ridge detail observed. Identifiable.</td>
</tr>
</tbody>
</table>

Table 2
Ridge quality grading system.

Results

Phase 1: Surface-Specific Study

The cotton wool powdering technique was evaluated for the development of both loaded and nonloaded prints on surfaces commonly encountered by fingerprint examiners at crime scenes. The mean ridge quality values at each of Depletions 1 through 5 are shown in Table 3. The standard deviation (SD) for most depletions was zero. Where this was not the case, the SD is provided in parentheses. Because of the large number of fingerprints developed and photographed, the results shown for each surface are limited to left and right ring fingers of the first and last depletions of both the loaded and nonloaded prints for each surface (Appendix A).

The ridge detail for the loaded and nonloaded prints developed with the cotton wool powdering technique on all surfaces, including the acetate sheeting, was excellent. The powder adhered well to the print with little or no clean-out required. This was seen for all prints with the exception of the fifth depletion series.
In addition, the results observed were comparable to those obtained with the squirrel-hair brush. With both development techniques, some smudging was observed with the loaded prints, especially at Depletions 1 and 2. The exception to the results described above was the waxed surface of the car, where the results were poor and inconsistent for both types of prints, particularly the nonloaded set.

**Phase 2: Donor Study**

To assess the effect of print age, donor variation, and print composition, both loaded and nonloaded samples from 20 donors were studied over three time periods. In total, approximately 4800 prints were analyzed. Although the RQ values from some of the donors differed from the norm, as shown by the high SD values for some data points, generally there was minimal variation in the quality of prints developed, and the prints from a single representative donor showing the ridge quality observed are provided (Appendix B). The mean RQ values for the 20 donors across the five depletions over the 12-week period are shown in Figures 3a to 3c, where each data point represents a mean of approximately 80 samples (i.e., four fingers per donor, with 20 donors).

The results observed in this experiment for the CPT mirrored those of the squirrel-hair brush. The powder adhered well, and identifiable ridge detail was developed, especially with the stronger prints (Depletions 1 and 2). The results showed that the main variation in RQ values was not method dependent but occurred between time periods and when loaded and nonloaded samples were compared. The mean RQ values for development of the loaded prints were similar regardless of time since deposition. However, there was a distinct drop in RQ values over time when aged nonloaded prints were developed. The RQ values for the weaker prints containing less material were also lower, and there was more variation in print quality as evidenced by the larger SD generally seen in these values at Depletions 4 and 5.
<table>
<thead>
<tr>
<th>Surface and Depletion Number</th>
<th>Loaded Prints</th>
<th>Nonloaded Prints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brush</td>
<td>CPT</td>
</tr>
<tr>
<td>Plate Glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2.8 (0.4)</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Tempered Glass</td>
<td></td>
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<tr>
<td>1</td>
<td>3</td>
<td>3</td>
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<td>3</td>
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<tr>
<td>5</td>
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<td>3</td>
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<tr>
<td>Powder-Coated Lampshade</td>
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<tr>
<td>1</td>
<td>3</td>
<td>3</td>
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<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Semigloss Paintwork</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>2.8 (0.4)</td>
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<td>2</td>
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<td>2.8 (0.4)</td>
<td>3</td>
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<tr>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Car Paintwork (Unwaxed)</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>3</td>
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<td>4</td>
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<td>2.8 (0.4)</td>
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<td>Car Paintwork (Waxed)</td>
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<tr>
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<td>0</td>
<td>1 (1.2)</td>
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<tr>
<td>2</td>
<td>2.8 (0.4)</td>
<td>1.5 (0.5)</td>
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<tr>
<td>3</td>
<td>3</td>
<td>1.3 (1.3)</td>
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<tr>
<td>4</td>
<td>3</td>
<td>2.5 (0.9)</td>
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<td>5</td>
<td>1.8 (1.3)</td>
<td>1 (0.7)</td>
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<tr>
<td>Glazed Tile</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>3</td>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>2.3 (0.8)</td>
<td>2 (0.8)</td>
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<tr>
<td>Acetate Sheet</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
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<td>4</td>
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<td>3</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>2.5 (0.5)</td>
</tr>
</tbody>
</table>

**Table 3**

*Mean ridge quality values for Depletions 1 through 5 on each surface.*
When powdering commenced immediately, mean RQ values for the CPT were excellent, regardless of print composition (Figure 3a) and mirrored those of the squirrel-hair brush. For the loaded samples, mean RQ values between 2.7 and 3.0 were observed for both methods. When nonloaded samples were powdered using the CPT, RQ values between 2.5 to 2.8 were recorded compared to 2.4 and 2.7 for development with the squirrel-hair brush. It was noted that with both development methods, smearing was observed in the loaded prints deposited first.

After four weeks, excellent RQ values were still observed (Figure 3b). The mean RQ values for loaded prints after development were between 2.3 to 2.8 for the CPT compared to 2.4 to 2.9 for the squirrel-hair brush. The mean RQ values for the nonloaded prints were slightly lower, with values of between 2.1 to 2.7 recorded for development with the CPT compared to 2.0 to 2.7 for those developed with the squirrel-hair brush. Separation of the graphs started occurring at this time period but was based on print composition and not development method.

At 12 weeks after deposition, there was a distinct difference in the mean RQ values. The graphs show this to be print composition rather than method dependent (Figure 3c). The mean RQ values for loaded prints developed with the CPT were between 2.1 to 2.8 compared to values between 2.3 to 2.8 for the squirrel-hair brush. These values were similar to those seen at the four-week period and represent good to excellent ridge quality that is identifiable. However, the RQ values of the nonloaded prints fell sharply, with values of 1.3 to 2.4 recorded for both methods and large standard deviations observed, especially for the weaker prints.

**Discussion**

**Phase 1: Surface-Specific Study**

The surfaces examined in this study were chosen because they represent those most commonly powdered at crime scenes. The acetate sheeting was included as a good representation of a plastic surface. There were concerns that the electrostatic properties of the sheeting may lead to an artificial increase in the longevity and quality of the prints on this surface compared to the others in this study. However, the RQ values and photos of the various surfaces were similar between the acetate sheeting and the other surfaces studied thus indicating that if any forces were acting on the acetate, they were either negligible or acted similarly on the other substrates.
Environmental factors may alter the longevity of latent prints and affect their subsequent development [5, 6]. Therefore, the surfaces were stored under realistic conditions so the cotton wool powdering method could be assessed on prints that had been subjected to the types of environmental decay consistent with the surface upon which they were deposited.

Both sebum-rich (i.e., loaded) and natural-mixed composition (i.e., nonloaded) prints were developed. In addition, the use of a depletion series ensured that both strong and weak prints were evaluated. Although some smudging was observed for the loaded prints deposited first and powdered immediately, this occurred with both methods and is due to the oily nature of sebaceous deposits. Other studies have also shown that latent deposits obtained from sebum-rich prints have a tendency to smear, with the extent of smearing decreasing with increasing print age [7].

On most surfaces developed using the cotton wool, excellent prints of identifiable quality were recovered regardless of print strength or composition. The exception to the excellent results was the waxed vehicle paintwork. Although the RQ values for the wax-free car panel were excellent, when powdering was conducted on the waxed surface, both the cotton wool and the squirrel-hair brush appeared to slide across the surface, and the resultant RQ values were inconsistent. Investigations revealed that the car panel had been recently waxed. Others have shown that prints are more susceptible to destruction on polished surfaces because of the weaker adhesive forces present [6]. In addition, the waxy components found in car polish are similar to a sebaceous print, and that could account for the large amount of background observed in the prints developed on the waxed car panel. These results were included to highlight a possible result when using the CPT to powder a waxed surface.

The results from the surface study showed the cotton wool powdering technique to be a good method for developing prints with excellent ridge quality on a variety of large, nonporous surfaces. These results were comparable to the standard method of powdering with a squirrel-hair brush. Little, if any, difference was observed in the development of strong and weak prints, indicating cotton wool may be used to powder the prints of variable quality realistically deposited at crime scenes.
Figure 3
Mean ridge quality values.
Phase 2: Large-Scale Donor Study

To undertake a comprehensive validation study, a large-scale evaluation was conducted. The variables considered were donor variation, print composition, amount of material present on fingers, and time since deposition. To evaluate the prints, a consistent surface of deposition was required between the 20 donors. Acetate was inexpensive, readily available in large quantities, easily transportable, and there was little variation between sheets. Because the results of the surface-specific study indicated that prints deposited on acetate sheeting did not appear to be affected by any measurable electrostatic forces and behaved similarly to those deposited on other hard, nonporous surfaces, it was chosen as a representative surface in the donor study. It was important to evaluate cotton wool against the squirrel-hair brush because this is the standard method for developing prints with powder and therefore provides a benchmark for comparison purposes. To further reduce the effect of any electrostatic forces generated by the acetate, the donor prints developed by each method were deposited on the same sheet so both sets of prints would be affected equally by any forces. During powdering, no evidence of static electricity was observed.

Donors

The constituents of palmar sweat and sebum vary between individuals. It was important to investigate whether the CPT could successfully develop individual prints from a variety of donors. Results showed that prints could be developed from all donors in the study. Variable ridge quality was sometimes observed between donors, but all prints were generally identifiable, with few differences observed. A large number of donors were also used to generate a statistically valid sample size. One researcher recommends using 10 donors when conducting fingerprint research [8]. In this study, 20 donors each provided 120 prints. This allowed the pooling of individual print RQ values to highlight any general trends that may be missed with a single donor. Studies have shown that fingerprint material is unevenly distributed on the ridges and takes the form of discrete areas of material or continuous ridges, depending on the nature of the deposit [9, 10]. In this study, donors did not rub their fingers together prior to deposition so that any variation in development of the fingers because of the material deposited would be more obvious. No difference was observed; each of the four donor fingers had similar amounts of material present at each depletion point and recorded similar RQ values.
Amount of Material Present at Deposition

Because the amount of material present may affect the longevity of a latent print, prints were deposited as a five-depletion series. Because a series of prints is laid down without recharging, earlier depletions have more material present than prints deposited later, thus producing a gradient from strong to weaker prints. Evaporation and other environmental factors are more likely to have a greater effect on the developed prints when less material is available for development and greater variability in the results occurs. This was observed in this study where generally, the stronger prints had higher and more consistent RQ values and lower SD values than the weaker prints. However, in most cases, especially for the loaded prints, the stronger prints developed with cotton wool were identifiable and of comparable quality to those developed with the squirrel-hair brush.

Print Composition and Time

Much work has been conducted to investigate the factors affecting the longevity of latent fingerprints, with print composition known to be a defining factor [5, 6]. Sebum-rich prints (loaded) are high in lipid components such as fatty acids, glycerides, and hydrocarbons [11]. These are nonvolatile and persist in the environment for an extended period. These prints represent an idealized situation and were included in this study to act as good “proof of principle” samples. However, the grooming used to generate loaded prints results in extra material on the fingers compared to natural prints and their sole use may lead to biased results regarding method sensitivity. Natural (nonloaded) prints are generally of mixed composition. In addition to sebum, they contain eccrine and apocrine gland secretions. These tend to be composed of volatile components such as amino acids, urea, protein, carbohydrates, and sugars that are less resistant to environmental degradation over time [11, 12]. Nonloaded prints were evaluated because the results from these prints are more representative of what is expected under realistic conditions.

At each of the time points, quality ridge detail with good clarity was more likely to be developed from loaded than from nonloaded samples. The results for the loaded prints were generally consistent over the three periods, with excellent ridge quality observed even for the weakest prints after 12 weeks. Some loaded prints that were developed immediately showed smearing because prints developed earlier contain greater amounts of sebum, which lubricates the prints. This is consis-
tent with other studies that report the tendency for sebum-rich
prints to smear readily, with the extent of smearing decreasing with increasing print age [7]. The results for the nonloaded prints that were developed immediately using the cotton wool were excellent. Ridge detail with good clarity was less likely to be developed from nonloaded samples after 4 and 12 weeks, especially for the weaker prints when less material was available for development. This was expected and is consistent with observations from other studies [13]. Nonloaded prints usually contain more water than loaded prints and are more susceptible to evaporation, therefore reducing the amount of material available for development. As fingerprints age, droplet topography changes, reducing the amount of material present [9].

For both print types, the results using the CPT mirrored those observed with the squirrel-hair brush, indicating that, over time, the loss of ridge quality was not dependent on whether the CPT was used to develop the prints, but on print composition. Prints of excellent quality can be developed using the CPT on loaded prints and nonloaded prints aged for up to 12 weeks. However, weaker, nonloaded prints aged for longer periods are subject to more variation in their development, regardless of whether the squirrel-hair brush or CPT is used.

General Considerations

The cotton wool powdering technique has several advantages over conventional powdering. Throughout this study, a larger area was covered with each pass, making the CPT 30 to 50% faster compared to powdering with the squirrel-hair brush. Studies have shown that excessive brushing can damage prints [7]. The fewer passes required when using the cotton wool could reduce the chance of damage occurring because of excessive powdering. In addition, although the ridge quality of developed prints was excellent with both methods, less background was generated when using the cotton wool. This may occur because when powder is distributed onto the cotton wool, some fibers are uncoated. These fibers may simultaneously clean out the print as powdering occurs.

Studies conducted assessing the exposure levels of crime scene personnel to fingerprint powders have found exposure levels well below the standard thresholds [14]. However, there is still a measurable amount of powder present. Although the use of dust masks and appropriate personal protection equipment reduces exposure, prolonged exposure increases the possibility
for inhalation of fingerprint powder. Therefore, the time saved
by using the cotton wool powdering technique not only increases
the efficiency of personnel at scenes but may also represent an
occupational health and safety advantage over the use of the
squirrel-hair brush.

Fingerprint brushes may represent a possible route of scene-
to-scene DNA contamination [15]. With advances in technology
and more sensitive DNA methodologies being developed, this
could present a significant contamination risk. The risk of
scene-to-scene contamination could be reduced by using the
cotton wool powdering technique because the cotton wool is
disposed of after each use.

There are some disadvantages associated with using the
CPT. Significantly more powder is required to coat the wool
compared to using a squirrel-hair brush. This, and the fact that
the cotton wool is disposable, may lead to an increase in the cost
of consumables. The large amount of powder required can make
the CPT messier than powdering with a squirrel-hair brush at
certain scenes. Although large, flat, hard, nonporous surfaces
can be powdered successfully, the CPT was not suitable for use
on surfaces that have a small surface area, are curved, intricate,
or have sharp edges. For example, control could not be easily
maintained in preliminary tests conducted on mercury vapor
light globes.

Conclusion

The cotton wool powdering technique (CPT) is ideally
suited to developing prints from a variety of large, hard, nonpo-
rous surfaces. In addition, both normal and sebum-rich prints
containing variable amounts of material can be developed up
to 12 weeks after deposition, with excellent results that are
comparable to those obtained using standard powdering with a
squirrel-hair brush. The use of the technique has the potential
to reduce the time spent at crime scenes, which represents a
savings not only in efficiency but also in terms of occupational
health and safety considerations. This method may be offered
to technicians in the field as an alternative to powdering with
the squirrel-hair brush.
Acknowledgment

I would like to extend my appreciation to Gus Viera and Anna Zajac for providing the hydroponic exhibits; Steve Willis for the car panels; Timothy Fayle for encouraging me to undertake this research; Cameron Forsyth, Scott Osborn, and Leigh Purday for reviewing this manuscript prior to submission; and the members of the NSW Police Force for providing their fingerprints.

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References


Appendix A
Surface-Specific Results

Plate glass showing first (Top) and last (Bottom) depletions of loaded prints.
Left side = brush; right side = cotton wool.
Plate glass showing first (Top) and last (Bottom) depletions of nonloaded prints.
Left side = brush; right side = cotton wool.
Tempered glass showing first (Top) and last (Bottom) depletions of loaded prints.

Left side = brush; right side = cotton wool.
Tempered glass showing first (Top) and last (Bottom) depletions of nonloaded prints.

Left side = brush; right side = cotton wool.
Powder-coated lampshades showing first (Top) and last (Bottom) depletions of loaded prints. 
Left side = brush; right side = cotton wool.
Powder-coated lampshades showing first (Top) and last (Bottom) depletions of nonloaded prints.
Left side = brush; right side = cotton wool.
Semigloss paintwork showing first (Top) and last (Bottom) depletions of loaded prints.

Left side = brush; right side = cotton wool.
Semigloss paintwork showing first (Top) and last (Bottom) depletions of nonloaded prints.
Left side = brush; right side = cotton wool.
Car paintwork (unwaxed) showing first (Top) and last (Bottom) depletions of loaded prints.
Left side = brush; right side = cotton wool.
Car paintwork (unwaxed) showing first (Top) and last (Bottom) depletions of nonloaded prints.
Left side = brush; right side = cotton wool.
Car paintwork (waxed) showing first (Top) and last (Bottom) depletions of loaded prints.
Left side = brush; right side = cotton wool.
Car paintwork (waxed) showing first (Top) and last (Bottom) depletions of nonloaded prints.
Left side = brush; right side = cotton wool.
Glazed tile showing first (Top) and last (Bottom) depletions of loaded prints.
Left side = brush; right side = cotton wool.
Glazed tile showing first (Top) and last (Bottom) depletions of nonloaded prints.

Left side = brush; right side = cotton wool.
Acetate sheet showing first (Top) and last (Bottom) depletions of loaded prints.
Left side = brush; right side = cotton wool.
Acetate sheet showing first (Top) and last (Bottom) depletions of nonloaded prints.

Left side = brush; right side = cotton wool.
Appendix B

Prints from Donor 1

Loaded prints – first depletion.
Left side = brush; right side = cotton wool.
Nonloaded prints – first depletion.
Left side = brush; right side = cotton wool.