Case Report

Survivability of Latent Fingerprints Part I: Adhesion of Latent Fingerprints to Smooth Surfaces

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Abstract: A latent print was developed on an aluminum window frame more than two years after it had been deposited. The ability to develop a fingerprint after such a long time is probably due to a "fixation" phenomenon to the metal frame. To understand this unusual case, we simulated the event in the laboratory.

Introduction

A few years ago, a crime scene technician responded to a burglary scene at Ovnat College (Figure 1), near the Dead Sea in Israel. Latent prints were developed on an interior painted aluminum window frame (Figure 2), using black magnetic powder and lifting tape. The suspect was apprehended, following an AFIS hit, but he adamantly denied the burglary allegation. During the inquiry, he claimed and provided evidence that he had been the

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Received March 30, 2010; accepted July 21, 2010

owner of a window factory and had supplied windows to the college more than two and one-half years before the burglary. The college had been uninhabited since the construction was completed.

Although the dating or impracticality of determining the age of a latent print has been previously discounted [1–8], the possibility of developing high-quality fingerprints with powder in desert conditions, two and one-half years after the deposition, may be considered unusual and even "shocking". We went back to the scene and tried to develop fingerprints on the same frame. An unusual phenomenon was observed: the print residue seemed to have been permanently "fixed", or at least strongly adhered, to the metal frame. The same result was observed when fresh prints were deposited by the authors; brush scraping or finger smearing (i.e., using the brush or the finger on the developed fingerprint in a robust manner that usually erases the fingerprint) did not erase the print and it could be developed again and again (Figures 3, 4). On the basis of the suspect's testimony and the nature of the prints, the suspect was not prosecuted.

In the present work, we tried to simulate this effect in the lab. Potential parameters (e.g., desert climate conditions, surface type, the window mounting process, the type of print residue, and the fingerprint development technique) were examined.

Figure 1

Ovnat College in the Dead Sea area.

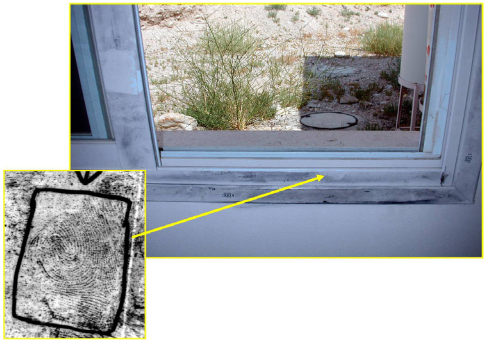

Figure 2

Fingerprint developed by black magnetic powder two years after deposition.

Figure 3

Fingerprint after brush scraping.

Figure 4

Fingerprint after finger smearing.

Materials and Methods

Sample Preparation

Several nonporous surfaces were used in this study: glass, Formica, plastic window shutters made of polyvinyl chloride (PVC), an aluminum window frame painted with a powder coating technique, and anodized aluminum window frames.

Eccrine fingerprints were obtained from donors after they had washed their hands and worn disposable plastic gloves for 15 to 20 minutes prior to depositing the prints. Sebaceous prints were prepared by wiping the finger across oily regions (forehead, nose, neck, or hair). Natural fingerprints were taken from donors without prior treatment.

Latent prints were developed using black magnetic powder, aluminum flake powder, and carbon powder (Lighting Powder Company, Inc., Jacksonville, FL).

To determine when fingerprints might be deposited during the processes that windows pass through in the factory before shipment, we looked into two possible deposition routes:

1. Rubbing the aluminum frame with organic solvents, followed by natural print deposition
2. Rubbing as above followed by cling film wrapping and print deposition on the wrapping surface

The extreme desert heat was simulated using a dry oven. A white, powder-coated aluminum frame, Formica, and glass surfaces were loaded with eccrine and sebaceous prints and were left for two cycles of 9 hours at 70 °C (the measured, summertime room temperature).

Sebaceous and eccrine prints were deposited on PVC shutters, painted and anodized aluminum frames, Formica, and glass and left overnight at room temperature.

The suspect (a window constructor) claimed that during the construction of the windows, he routinely cleaned the aluminum frames with a toluene-based paint thinner prior to wrapping with a blue cling film. In order to imitate the working routine of the constructor, we looked first into the deposition process. We deposited fingerprints after each of the steps used by the window contractor.

Results

Strong adhesion of the prints was observed in the first step but not in the second. This led to the conclusion that the origin of the “fixed” material was not from the cling film but was from touching the window frame before wrapping with the cling film.

We observed that sebaceous fingerprints were generally “fixed” only to the powder-coated aluminum frame and to the PVC shutters. “Fixation” was not observed with eccrine prints on any of the surfaces that were tested.

The effect of the temperature was also studied. Repeating the experiments at room temperature gave the same fixing results on these surfaces. This led to the conclusion that extreme conditions were not the reason for print “fixation”.

The same results were obtained using carbon powder, aluminum flake, or black magnetic powder for all of the surfaces. Therefore, the study continued using magnetic powder only.

After repeating the experiments using different temperature conditions, different powders for development, and a variety of surfaces, we found that sebaceous fingerprints were “fixed” only to the PVC shutters and the painted white aluminum frames. The sebaceous fingerprints were not fixed to the other surfaces and no “fixation” effect was observed with eccrine fingerprints.

Discussion

These experiments led us to the conclusion that the interaction between the sebaceous element of the print residue and this particular surface (PVC shutters and white painted aluminum frames) result in a “fixation” effect. This effect can occur at ambient temperatures, with fresh or old prints, but not on all types of surfaces. As far as our experiments show, this phenomenon does not occur on surfaces such as glass or noncoated aluminum. Therefore, the coating technology [9] by which powder-coated window frames and other metal parts are painted could be an important factor. The powder-coating process involves painting metal sufaces using an electrostatic spray of polymer-based dye. After spraying, the surface is heated until the polymer melts, and the metal achieves its final coated appearance. The main powder-coating ingredients are resin, curing agent, filler, pigments, and additives. The type of resin and the amount of the other ingredients are selected to fit the end product’s desired properties (water resistance, UV resistance, scratch resistance, etc.). The type of resin determines the classification of powder-coating mixtures: epoxy, TGIC-polyester, urethane-polyester, hybrid, and acrylic.

Many exhibits encountered in developing fingerprints are powder coated. We repeated the experiments to test the uniqueness of the window frame case. Latent prints were developed on other powder-coated material such as metallic surfaces on cars, toaster ovens, a toaster, a fire extinguisher, a toolbox, air conditioners, and a refrigerator. The latent print fixation effect was observed again on a refrigerator.

Limited industrial and product information from the various manufacturers revealed that the aluminum window frame involved in the present case was coated using white TGIC-polyester powder paint. Polyesters are more porous than epoxies, and a high white pigment content (usually TiO_2) increases the oils and hydrophobic agent's absorption [10]. Moreover, high water and UV resistance of the window frame are acquired by the addition of hydrophobization agents like waxes and silicones to the mixture. Based on the basic rule that hydrophobic material will dissolve in hydrophobic material and hydrophilic in hydrophilic, it is assumed that the lipid residues of the latent print can be "fixed" on the white powder-coated aluminum frame.

Regarding the PVC shutters, it is assumed that the good absorption properties of PVC might increase the adhesion of the fingerprint residues on the surface. PVC may contain plasticizers up to 50% of its weight, which leads to a high absorption property in comparison to other polymers. PVC is an amorphous polymer, making it porous and hydrophobic, which readily absorbs the lipid residues of the fingerprints deposits.

Conclusion

These experiments helped us to understand why, in the Ovnat case, it was so easy to develop fingerprints deposited two and one-half years earlier. This case also demonstrates that we must be cautious in determining the age of a fingerprint or the survivability of fingerprints in general.

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