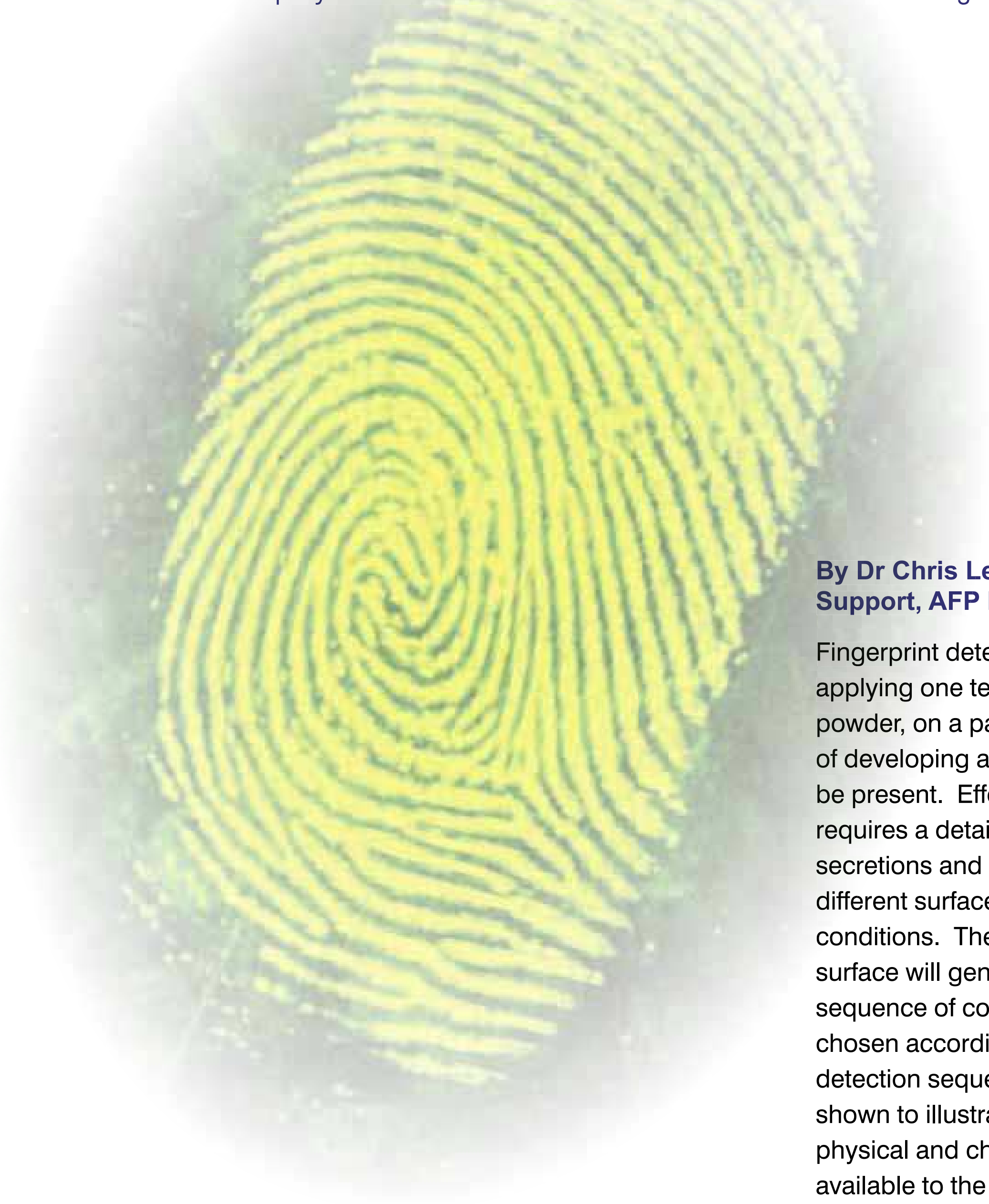
Looking for clues

Over the past 20 years, fingerprint detection techniques have improved to the extent that we are now able to develop latent marks that would previously have gone undetected. However, continued research is required to improve the sensitivity of existing techniques and to develop new procedures for fingerprint detection on more difficult surfaces. This article provides an overview of modern techniques employed for the detection and enhancement of latent fingermarks.



By Dr Chris Lennard, Director Operations Support, AFP Forensic Services

Fingerprint detection is not just a matter of applying one technique, such as a fingerprint powder, on a particular surface in the hope of developing any latent marks that might be present. Effective fingerprint detection requires a detailed understanding of natural secretions and how such deposits interact with different surfaces under different environmental conditions. The processing of a particular surface will generally involve the application of a sequence of complementary techniques that are chosen according to the circumstances. Typical detection sequences for different surfaces are shown to illustrate this point. A range of optical, physical and chemical detection techniques is available to the fingerprint technician. Modern digital image enhancement procedures are also available, but are not discussed in this article.

The AFP was heavily involved in the development of fingerprint detection techniques from the early 1980s as a result of an AFP-funded research program undertaken within the ANU Chemistry Department. When this program ceased in the late 1980s, fingerprint research continued within Forensic Services and remains active today. In addition to research conducted in collaboration with a number of academic partners, AFP Forensic Services provide advice and assistance to other law enforcement agencies and run advanced fingerprint detection workshops on request.

Latent fingermarks

When a smooth surface is touched with the bare hands, fingermarks can be deposited. These fingermarks are generally invisible, and are termed "latent" – requiring some form of physical or chemical treatment to make them visible. Latent fingermarks are made up of natural secretions and environmental contaminants deposited from the skin surface (Figure 1). In some cases (eg. fingermarks in blood), a particular contaminant may be present that produces a visible mark.

Figure 1

a. b. c.

Figure 1. Formation of a latent fingermark on a glass surface:
(a) fingertip and glass surface prior to fingermark deposition; (b) contact between the fingertip and the glass surface; (c) resulting latent fingermark.

Dr Chris Lennard

Dr Lennard obtained a PhD in chemistry in 1986 from the Australian National University (ANU) for research on new chemical reagents for the detection of latent fingerprints. He subsequently took up a postdoctoral position at the School of Forensic Science, University of Lausanne, Switzerland. While in Switzerland, he conducted research across a wide range of forensic disciplines including the chemical analysis of trace evidence and became an Associate Professor in Criminalistics in 1989.
He returned to Australia in 1994 to take up a position as Coordinator Laboratory Services, Forensic Services with the AFP.
In 2002, he took up his current position and is responsible for coordinating laboratory accreditation and forensic research and development. Since joining the AFP, Dr Lennard has maintained his interest in fingerprint detection techniques and chemical criminalistics through numerous research projects conducted in collaboration with academic and industry partners.

Figure 2

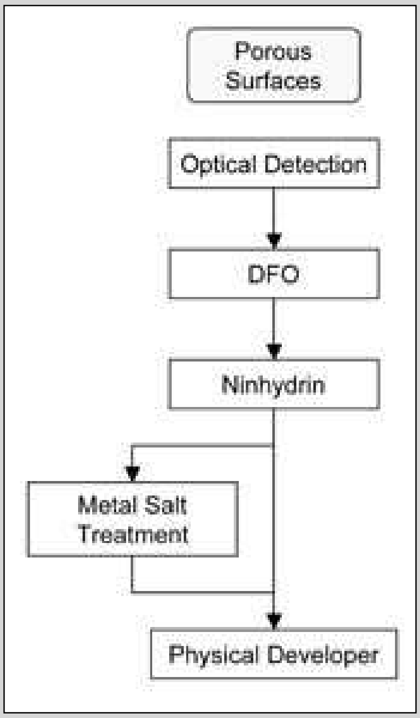


Figure 2. A typical sequence of techniques for the detection and enhancement of latent fingermarks on porous surfaces such as paper and cardboard.

Figure 3

a. b.

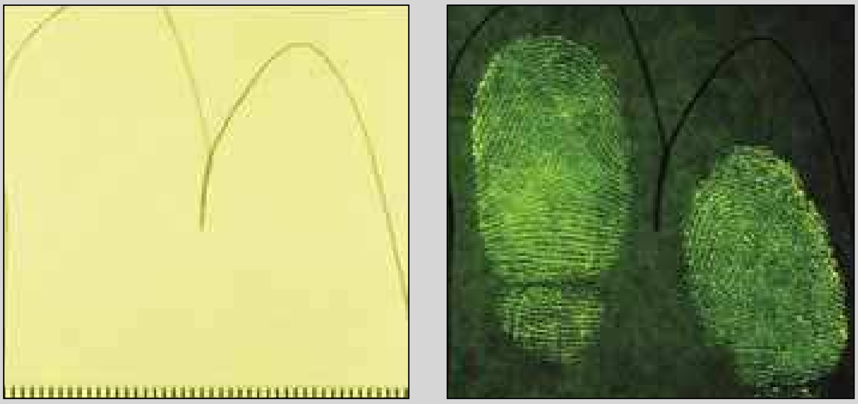


Figure 3. Latent fingermarks on white paper after treatment with DFO:
(a) observation under white light;
(b) observation in the luminescence mode under a high-intensity light source.

To effectively develop latent fingermarks, it is necessary to have a detailed understanding of the chemical composition of the skin secretions, in addition to knowledge as to how these secretions behave on different surfaces under different environmental conditions. It is important to realise that the skin secretions, and hence the resulting latent fingermarks vary significantly between individuals (being dependant on factors such as the sex, age, and diet of the individual). It is for this reason that some individuals are good fingerprint donors whereas others leave poor latent marks that are difficult to develop.

Different surfaces require the application of different fingerprint detection techniques. In general terms, surfaces can be classified as porous, non-porous, and semi-porous. On porous surfaces, such as paper and cardboard, latent fingermarks are rapidly absorbed into the substrate. At the other extreme, latent fingermarks on non-porous surfaces, such as plastic and glass, remain on the surface and are not absorbed into the substrate – the marks are therefore more fragile and easily destroyed if the surface is rubbed. Semi-porous surfaces include polymer banknotes, wax paper, and latex gloves. These surfaces have intermediate properties that make fingerprint detection problematic.

Fingerprint detection on porous surfaces

A typical sequence of techniques for fingerprint detection on porous surfaces, such as paper and cardboard, is illustrated in Figure 2. Optical techniques are initially employed to check for visible or luminescent fingermarks before applying any additional treatment. The item is then treated with a solution of the chemical reagent DFO. DFO reacts with the amino acids that are present in the fingerprint deposit to give a luminescent print (Figure 3). This luminescence is recorded under special conditions and requires the use of a high-intensity light source operating at a specific wavelength.

After DFO, the item can be treated with ninhydrin, a reagent that reacts with amino acids to give a dark-purple product. In some cases, ninhydrin can develop additional fingerprint detail not revealed by the DFO technique. Further contrast can also be achieved by treating ninhydrin-developed prints with a metal salt solution (generally zinc nitrate).

A final technique that can be applied on porous surfaces is known as physical developer (PD). The advantage of this reagent is that it reacts with components of the latent fingermark that, unlike amino acids, are insoluble in water. When a document is placed in the PD solution, silver metal is deposited on any latent fingermarks that are present, to produce developed marks that are dark grey (Figure 4). PD can develop latent marks on a document even if the document has been left several days in water. DFO and ninhydrin are ineffective in such cases.

Figure 4

Figure 4. Latent fingermarks on paper after treatment with physical developer (PD). With this reagent, silver metal is deposited along the fingerprint ridges.

Figure 5

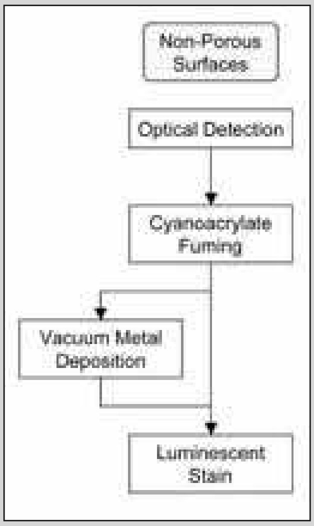


Figure 5. A typical sequence of techniques for the detection and enhancement of latent fingermarks on non-porous surfaces such as plastic and glass.

Fingerprint detection on non-porous surfaces

A typical sequence of techniques for fingerprint detection on non-porous surfaces, such as plastic and glass, is illustrated in Figure 5. As for porous surfaces, optical techniques are initially employed to check for visible or luminescent fingermarks before applying any additional treatment. Cyanoacrylate fuming is then employed as the routine laboratory technique. This involves exposure of the surface to the vapours produced by heating commercial superglue. The cyanoacrylate vapour selectively polymerises along the fingerprint ridged to give a hard white image of any latent marks (Figure 6).

Figure 6

a.

b.

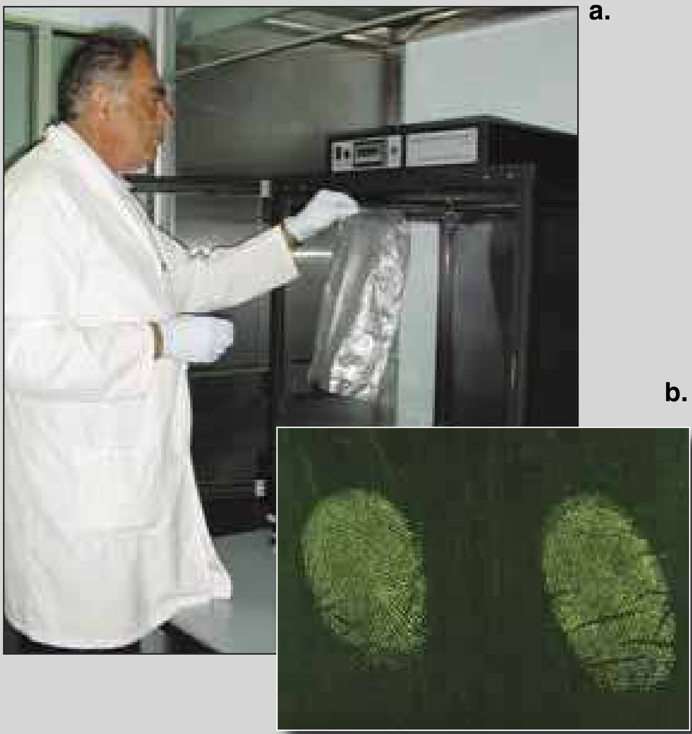


Figure 6. Fingerprint detection by cyanoacrylate fuming:
(a) Milutin Stoilovic loading an item into a commercial 'superglue' fuming chamber (developed by AFP Forensic Services in collaboration with Carter-Scott Design); (b) latent fingermarks on black plastic after treatment with cyanoacrylate vapour.

Figure 7

Figure 7. Latent fingermarks on white plastic after cyanoacrylate fuming and treatment with a luminescent stain (rhodamine 6G) – photographed in the luminescence mode under a high-intensity light source.

On some surfaces, such as white plastic, further enhancement is required due to poor contrast. This is generally achieved by treatment of the cyanoacrylate-developed prints with a luminescent stain such as rhodamine 6G (Figure 7).

Another technique that is particularly sensitive on non-porous and semi-porous surfaces is vacuum metal deposition (VMD). This technique requires the use of a special vacuum chamber that can be used to coat the item of interest with a thin layer of gold followed by a thin layer of zinc. This treatment generally results in a uniform zinc coating across the surface except where any latent fingermarks are present (Figure 8, page 34). VMD can be used to enhance prints already developed by cyanoacrylate fuming.

Fingerprint detection at the crime scene

The general principle at crime scenes is that transportable items likely to have been handled by the offender(s) are collected and forwarded to the laboratory for optimum processing. On fixed surfaces, however, a sequence of techniques must be applied at the scene to provide the best opportunity of detecting and recording any latent marks that may be present (Figure 9). Optical techniques are initially employed to check for visible or luminescent fingermarks before applying any additional treatment. While fingerprint powders remain the routine technique for fingerprint detection at crime scenes, powders lack sensitivity and will only detect relatively fresh, good-quality latent fingermarks. Other options for fingerprint processing at the crime scene include the use of portable cyanoacrylate fuming systems and an iodine-benzoflavone spray reagent.

Figure 8

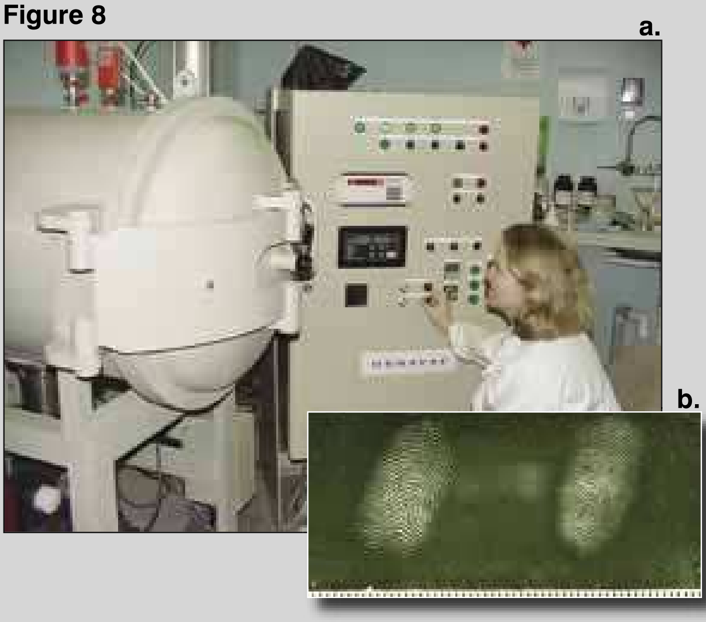


Figure 8. Fingerprint detection by vacuum metal deposition (VMD):
(a) Dr Naomi Jones operating the VMD unit located at AFP Forensic Services, Police Services Complex, Weston;
(b) 3-year-old latent fingermarks on glass after VMD treatment.

The latter technique has recently been evaluated as part of a collaborative research project between AFP Forensic Services and the University of Technology, Sydney (UTS). The iodine-benzoflavone spray was found to be superior to powdering for fingerprint detection on wallpaper, vinyl and brick surfaces at the crime scene (Figure 10).

For the enhancement of fingermarks in blood, a number of different techniques are available, including optical methods and the use of protein stains such as amido black. Blood marks treated with an amido black solution are stained dark blue and show good contrast.

Figure 9

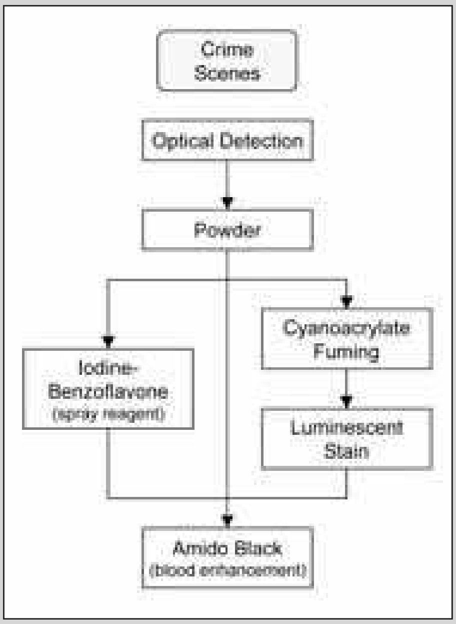


Figure 9. A typical sequence of techniques for the detection and enhancement of latent fingermarks on fixed surfaces at the crime scene.

Fingerprint detection on polymer banknotes

The introduction of polymer banknotes into Australia proved problematic for all Australian fingerprint bureaus as fingerprint detection on these banknotes is exceedingly difficult. A preliminary research project conducted by AFP Forensic Services indicated that conventional detection techniques were ineffective on this surface and that only one technique, vacuum metal deposition (VMD), showed promise. These preliminary results lead to the purchase of a large VMD unit and the undertaking of a three-year UTS PhD project to investigate the problem. This project, completed in 2002, lead to the development of an optimised fingerprint detection sequence for polymer banknotes (Figure 11) and to a better understanding of the principles behind the VMD technique. Using this optimised sequence, it is possible, under ideal circumstances, to develop aged latent fingermarks (up to at least 18 months old) on polymer banknotes. The sequence relies on cyanoacrylate fuming, followed by VMD treatment and the application of a luminescent stain (Figure 12).

Figure 10

Figure 10. Ridge detail developed on a brick surface using an iodine-benzoflavone spray solution.

Despite the advances that have been made over the last 20 years, a number of surfaces still remain where fingerprint detection is problematic.

Research and development

A range of sophisticated detection methods are available that permit the development of latent fingermarks on the various surfaces encountered by the forensic practitioner. The correct application of these techniques provides a high level of sensitivity. Regardless of this high sensitivity, an item may carry latent fingermarks that are below the detection limits of the techniques applied. Despite the fact that an item has been handled by a particular individual, identifiable prints may not be found. An absence of identifiable fingermarks is therefore not an indication that the individual under investigation did not handle the item. Research continues towards more sensitive optical, physical and chemical methods, for application both at the crime scene and in the laboratory, so that increasingly weaker fingermarks can be detected and recorded for identification purposes.

Figure 11

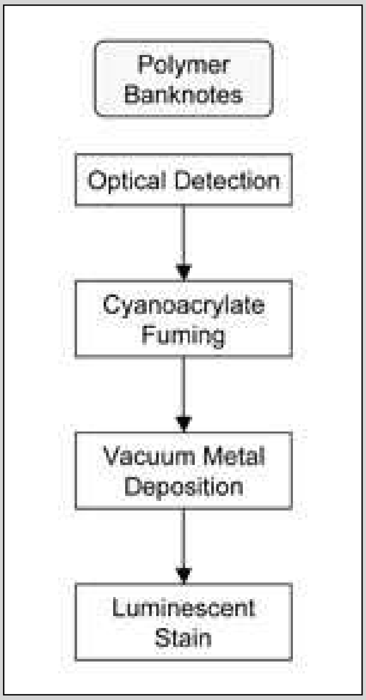


Figure 11. Recommended sequence of techniques for the detection and enhancement of latent fingermarks on polymer banknotes.

Despite the advances that have been made over the last 20 years, a number of surfaces still remain where fingerprint detection is problematic. Examples include human skin, leather, fabric and fired cartridge cases. Casework success on these surfaces, using conventional techniques, is very rare. Further research is required to develop procedures that increase the chances of detecting any latent fingermarks that may be present.

A common request is to estimate the age of a particular latent fingermark. The reason for this is clear: the best defence against fingerprint evidence is to claim previous legitimate access to the item or surface on which the latent fingermark was developed. Therefore, it may be necessary to show that a particular mark is directly related to the offence under investigation and was not deposited on a prior occasion. Unfortunately, no scientifically valid technique currently exists for determining the age of a particular latent fingermark. This remains another area where further research is required.

AFP Forensic Services will continue to undertake research in the field of fingerprint detection and enhancement, in collaboration with a number of academic partners, in an effort to address this situation.

Figure 12

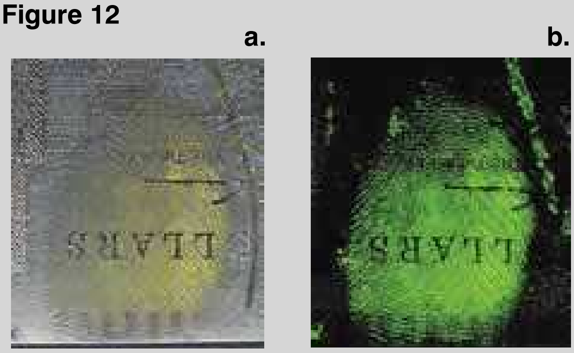


Figure 12. Fingerprint detection on polymer banknotes:
(a) latent fingermark after cyanoacrylate fuming and VMD treatment;
(b) same print after application of a luminescent stain (visualisation in the luminescence mode under a high-intensity light source).